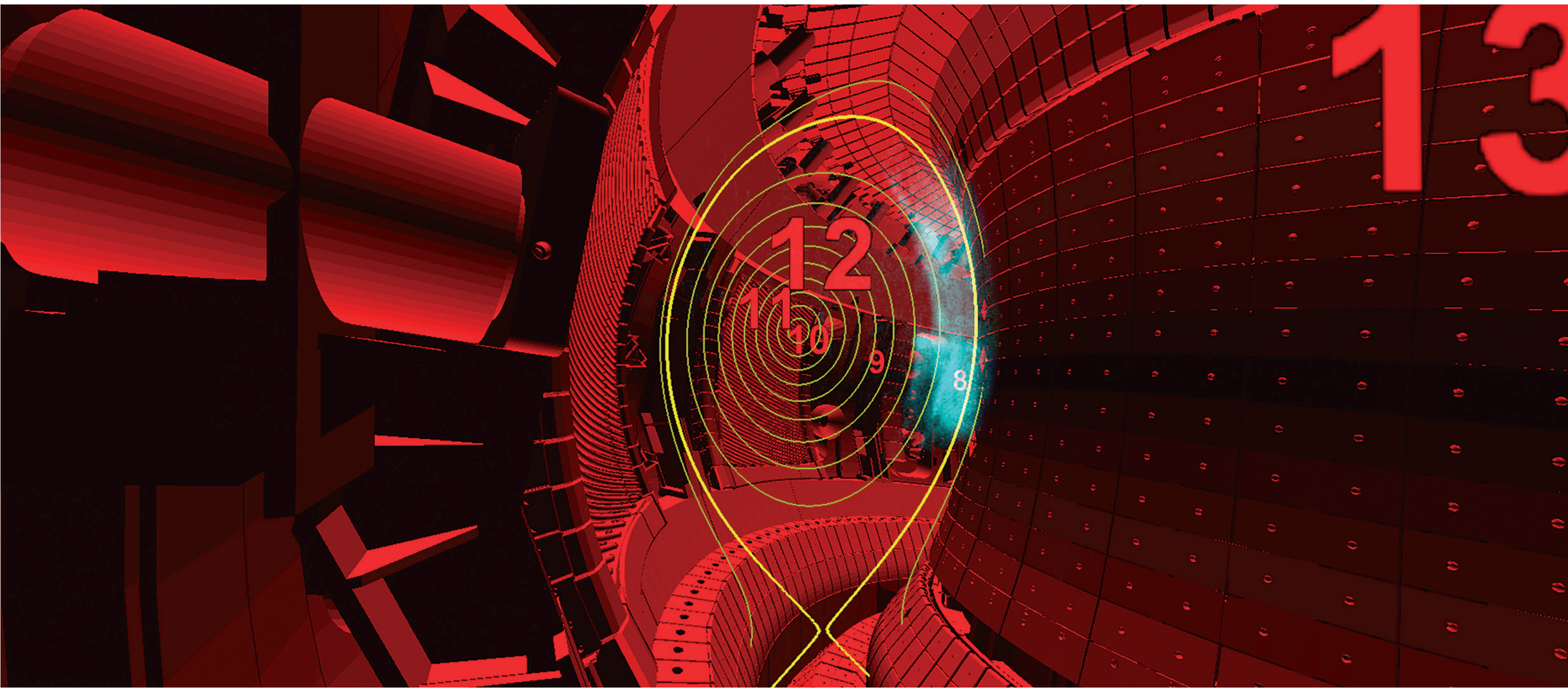
Max-Planck-Institut für Plasmaphysik

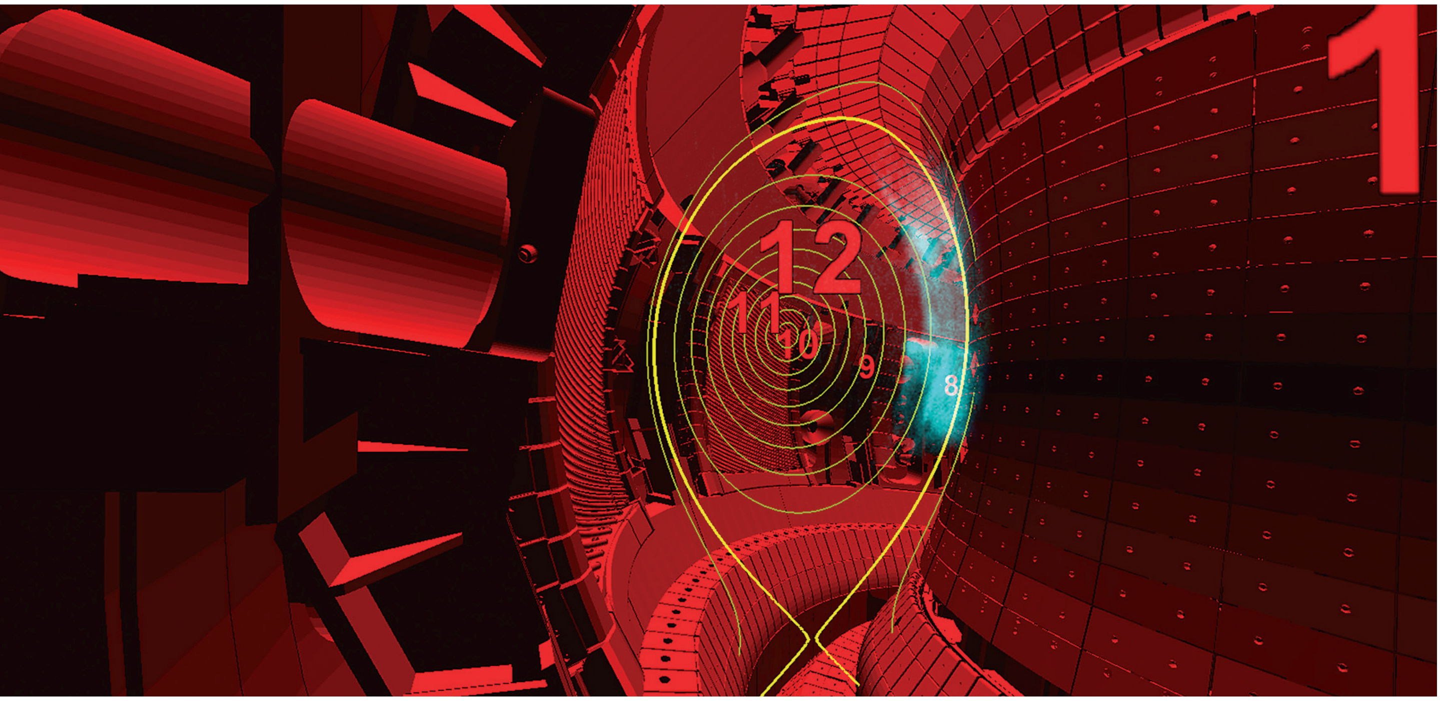
# Annual Report 2008




MAX-PLANCK-GESELLSCHAFT

HELMHOLTZ GEMEINSCHAFT

EURATOM Association




Wide-angle view into the ASDEX Upgrade plasma chamber. In-vessel structures according to CAD construction drawings are outlined in red. The numbers 8 to 13 indicate the different vessel sectors. The yellow lines illustrate open and closed magnetic flux surfaces. The thickest line represents the separatrix, i.e. the surface between the magnetically confined core plasma and the scrape-off layer characterized by open magnetic field lines. This artificial image is overlayed with a camera image recording Helium II light (cyan) during a fast plasma current quench. Helium gas is routinely injected into plasmas with impending current quenches to reduce the enormous transient mechanical forces on the vessel which are caused by the quench.

Max-Planck-Institut für Plasmaphysik

# Annual Report 2008

The Max-Planck-Institut für Plasmaphysik is an institute of the Max Planck Gesellschaft, part of the European Fusion Programme (Euratom) and an associate member of the Helmholtz-Gemeinschaft Deutscher Forschungszentren.

The Max Planck Institute for Plasma Physics (IPP) is well equipped to meet the challenges of the future. This was demonstrated by the results of the Facilities Review, an assessment made by international fusion experts and European scientists on behalf of the European Commission. The experts assigned the ASDEX Upgrade tokamak a “very high priority” for ITER within the European Fusion Research Programme. By virtue of its importance for the subsequent DEMO demonstration power plant, the large-scale Wendelstein 7-X superconducting stellarator now being built at the Greifswald site of IPP was also given the best grading.

The individual research activities at IPP in 2008 span a broad range of topics: The assembly of Wendelstein 7-X made significant progress in the past year. Major milestones were achieved. Two of the five magnetic modules were assembled. The coil installation of the third module is nearing completion. All seventy coils have been manufactured and more than three-quarters of these coils have successfully passed the final acceptance tests. Major new work packages, such as the installation of the superconducting bus and the cryo-piping supplying the coils with liquid helium, were started. The first parts of the outer cryostat vessel are being prepared for the installation of the cryo-insulation. All these components have to be fitted within a very limited space inside the cryostat requiring demanding tolerance checks to avoid collisions when the magnetic field is applied. To make assembly procedures as smooth as possible, decision-making was adapted accordingly. Completion of the assembly is envisaged for mid-2014. Plasma operation will start with a temporary divertor and limited pulse duration. The first two years will focus on demonstration of the physics optimization of Wendelstein 7-X and preparation of the high-power steady-state operation, which will follow completion of the actively cooled in-vessel components.

The experimental programme on ASDEX Upgrade in 2008 continued to address key ITER needs. The operational space with a fully tungsten-covered wall was further enlarged, despite the limitations in generator power caused by the unavailability of one of three flywheel generators. A highlight was the first demonstration of ‘improved H-mode’ discharges with the fully tungsten-covered first wall. Stationary discharges with confinement times more than 20 per cent above the ITER baseline were run using impurity seeding to protect the divertor. A set of discharges helping to prepare the first phase of ITER operation was also carried out, at the request of the ITER team. Numerous other results were obtained in the areas of transport, stability and exhaust. Experiments in 2009 should largely benefit from being able to use the full generator power again, opening up the possibility of extending the operational space towards ITER-relevant conditions, namely higher current and shaping of the plasma cross-section.

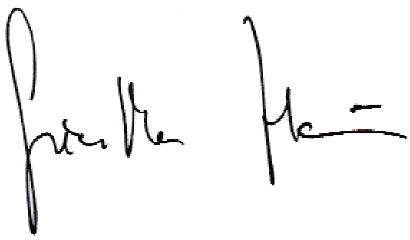
In 2008 JET had a very active experimental phase leading to many new results of direct relevance to ITER. The flexibility of JET’s magnetic field coils made it possible to change the level of toroidal magnetic field ripple and to investigate its impact on energy and particle confinement. These studies resulted in recommendations regarding the level of ripple which should be allowed in ITER. IPP’s contributions concentrated, in particular, on the realisation of the AUG-JET-ITER step-ladder approach, leading to the achievement of high confinement in JET Hybrid scenarios. Besides conducting experiments, IPP was also involved in hardware enhancement and management of JET.

The scientific goal of plasma theory at the Max Planck Institute for Plasma Physics is to obtain an *ab initio* understanding of all relevant phenomena associated with magnetically confined plasmas. Conclusions and predictions can be verified on existing experiments and applied to the planning for Wendelstein 7-X, ITER and the projected DEMO demonstration reactor. A main thrust is the development of rigorous gyrofluid and gyrokinetic models for direct simulation of plasma turbulence and the resulting energy and particle transport. The analysis of large-scale magnetic perturbations also recently became a focus of attention, not only due to the future possibility of active feedback control but also because of the novel physics arising from the interaction with fast fusion-produced $\alpha$-particles. More empirically based, but motivated by an overwhelming practical need, are IPP's contributions to edge and divertor-plasma modelling.

IPP's expertise in support of ITER was in demand in a wide range of activities, based not only on the results from ASDEX Upgrade but also on know-how from the Technology, Theory, Materials and Stellarator Divisions. This work ranges from studies of plasma scenarios to the development of specific technical systems. For the ITER bolometer diagnostic an enhanced prototype sensor was developed. The development of a radio frequency driven source for the Negative Ion Neutral Beam Injection (NNBI) made it possible to extract a homogeneous beam over several 100 seconds. IPP took part in drawing up the first version of the ITER research plan and actively contributes to the physics definition of ITER via the International Tokamak Physics Activity (ITPA).

Within the "Plasma-facing Materials and Components" project the areas of plasma-wall interaction studies, material modification under plasma exposures and development of new plasma-facing materials and their characterisation were merged to form a field of competence at IPP. The work here supports the development of fusion devices at the Institute and also generates basic expertise with regard to plasma-facing components in ITER and fusion reactors. The activities are strongly embedded in the European Plasma Surface Interaction community: the Max Planck Institute for Plasma Physics heads the European Task Force on Plasma-Wall Interactions, coordinates the large "ExtreMat" EU Integrated Project with 37 partners and manages the FEMaS (Fusion Energy Materials Science) EU Coordination Action.

On behalf of the Directorate and the Scientific Board I would like to take this opportunity of thanking our staff for their dedication and the excellent research results obtained in all divisions.



Scientific Director Günther Hasinger

# Content

# Tokamak Research

# ASDEX Upgrade

**Head: Dr. Otto Gruber**

The ASDEX Upgrade programme supports design and prepares physics of ITER and DEMO. Highlights in 2008 were the demonstration of improved H-modes with un-boronized tungsten wall and energy confinement exceeding more than 20 % the ITER baseline using impurity seeding. Progress was achieved in preparing reliable ITER operation and in the physics of H-mode edge barrier and transition. Technical extensions (ECRF, active in-vessel coils for ELM/MHD control) are proceeding.

## 1 Overview

### 1.1 Scientific Aims and Operation

The fusion experiment ASDEX Upgrade (AUG) is a medium size divertor tokamak (major radius R=1.65 m, minor radius a=0.5 m, plasma current $I_p$ up to 1.4 MA, toroidal magnetic field $B_t$ up to 3.1 T) with an ITER-like configuration, high shaping capability (single null and double-null divertor, elongation up to 1.9, triangularity δ up to 0.5) and a versatile heating system. The design combines the successful divertor concept with the requirements of a next step fusion reactor, in particular the need for an elongated plasma shape and poloidal magnetic field coils outside the toroidal magnetic field coils. AUG is close to ITER in its magnetic and divertor geometry and in particular the relative length of both divertor legs compared to the plasma dimensions. The installed heating power of up to 28 MW ensures ITER equivalent power fluxes to the wall and divertor. Even the P/R ratio, relevant for divertor similarity, is close to ITER values. The scientific programme gives priority to support the design (heating, fuelling, first wall materials) of ITER, to prepare the physics basis and reliable operation of ITER, and to explore regimes beyond the baseline of ITER and even of DEMO. The studies were co-ordinated by four Task Forces (TF) consisting of

- ITER base-line scenario, the ELMy H-mode, and the advanced “improved H-mode” scenario with enhanced performance and longer inductive pulse lengths,
- H-mode pedestal physics and ELM mitigation and control,
- Magnetohydrodynamic (MHD) stability, active stabilisation of limiting instabilities, avoidance and mitigation of disruptions,
- Scrape-off layer and divertor physics to optimize power exhaust and particle control and qualification of tungsten as first wall material.

The shape and divertor similarity of AUG with JET and ITER at absolute length scaling 1:2:4 is the basis for extrapolation of plasma scenarios developed at AUG as well as core and edge physics results towards ITER (step-ladder approach). AUG is particularly suited to test control strategies for shape, plasma performance and MHD modes. Our programme largely covers the high priority physics research areas provided by the ITER team and ITPA Co-ordinating Committee. Again, several items have been investigated in joint experiments at all major tokamaks as proposed by the ITPA Topical Groups. In summary, the AUG programme in close collaboration within the EU fusion programme is embedded in a framework of national (see section 9 on Stuttgart University contributions) and international collaborations (see section 10).

The AUG Programme Committee (PC) established in 2001 enables the Associations to take responsibility for our programme. This PC defines the TFs responsible for the different elements of our programme, and approves the experimental programme. Furthermore, the bodies that work out the programme proposals are open to external participants, and remote participation in the meetings is used. With this structure, we have achieved a compromise between the international involvement and the flexibility that has so far been typical for the AUG programme. For the 2008 experimental campaign out of the 171 proposals 51 were from outside IPP from 14 EURATOM Associates, the US and Japan. Correspondingly, the fraction of AUG related publications in refereed journals with an external first-author stays at 35 %.

The heating and current drive systems of AUG include all three day-one systems foreseen for ITER. These consist first of the neutral beam heating (NBI) with 10 MW at 60 keV, 10 MW at 93 keV including 5 MW tangential off-axis deposition. The ion cyclotron resonance system (ICRF) is capable of routinely coupling up to 6 MW compatible with type I ELMs using 3 db-couplers, but is restricted with tungsten (W) walls by W sputtering caused by ICRF accelerated light impurities. The electron cyclotron system ECRH-1 can couple 1.6 MW (2 s pulse length), and a first new 1 MW-class gyrotron works at two frequencies (105 and 140 GHz) allowing pure electron heating (ECRH) and current drive (ECCD). The large installed heating power provides a high flexibility for heat deposition, current drive and torque input.

Stationary discharges with up to 10 s flat-top allow steady state investigations not only on the transport and MHD time scales but also for up to 10 current diffusion times. The fast integrated control and data acquisition system (CODAC) is specially adapted to ITER needs with its machine-independent design, its integrated discharge scenario control and protection functions and the large number of real-time diagnostics with integrated data analysis (section 6.3).

The repair of the flywheel generator EZ4 (supplied a part of the poloidal field coils and heating systems) which was damaged in 2006 was finished in autumn 2008 and the re-installation will be completed in April 2009. This accident has given rise to check and to substantially improve the safety installations of all three generators. Additional electrical brakes for generators EZ2 and EZ3 were built in 2007/8. The operation of AUG with the remaining generators EZ2 (for the TF coils) and EZ3 (poloidal field coils and heating systems) was advanced towards acceptable restrictions by optimized use of generator power consumption by reducing inductive loads and new shape and scenario evolutions accounting better for PF coil interactions. Increasing the power from EZ3 from 105 to 140 MVA in 2008 allowed plasma currents up to 1.2 MA and heating powers above 10 MW, but at still limited triangular plasma shapes.

In spring 2007 the transition of the AUG vessel to fully tungsten coated plasma facing surfaces (PFCs) was completed, providing a unique opportunity to study the compatibility of high performance plasma scenarios with tungsten. After a full year of operation in an all-metal machine without prior boronizations a cleaning of all tiles was performed at end 2007 to remove re-deposited carbon layers. In 2008, AUG finished its second experimental campaign with full tungsten coverage, again with two restarts after vessel vents without boronization. Plasma operation was accomplished from February to July and September to December. We conducted 69 long shifts at high availability with a total of 1605 pulses (technical tests, diagnostic calibrations and plasma discharges).

### 1.2 ITER Relevant Results in 2008

The AUG experimental programme in 2008 continued to address key ITER needs. The operational space with fully tungsten-covered wall was further enlarged, despite the limitations in available generator power. The transition from a graphite device to a full tungsten device was demonstrated with a reduction by an order of magnitude in both the carbon deposition and deuterium retention. Even without boronization, stationary ITER baseline H-modes ($H_{98}$~1, $\beta_N$~2), with W concentrations below $3 \cdot 10^{-5}$ were routinely achieved up to 1.2 MA plasma current. The tungsten concentrations could be kept at an acceptable level by central heating (from NBI and the upgraded ECRH system) increasing the turbulent outward transport and ELM pacing forced by gas puffing. ICRH can only be used after boronizations, which reduce the W influx and were accomplished again in 2008.

A highlight was the first demonstration of the compatibility of high performance improved H-modes with the unboronized W wall achieving $H_{98}$=1.1 and $\beta_N$ up to 2.6 at modest triangularities $\delta \leq 0.3$ as required for advanced scenarios in ITER. With boronization the light impurities and the radiated power was reduced and the divertor tiles had to be protected by nitrogen seeding. This resulted in considerably enhanced performance of improved H-mode discharges with energy confinement times more than 20 % above ITER baseline values ($\beta_N$~2.7) exceeding the best values, which have been obtained in the carbon-dominated machine. Preliminary investigations show that this improvement is due to higher temperatures rather than to peaking of the electron density profile.

The AUG programme in 2008 also addressed immediate requests from the ITER team. First, the H-mode threshold in helium was found to be hardly different from the one in deuterium both for ECRH and H beam heating and possesses a pronounced minimum at line-averaged densities of $4.5 \cdot 10^{19}$ $m^{-3}$. This opens the possibility for an early H-mode operation phase in the non-nuclear ITER operation phase. Second, ITER discharge scenario tests included the demonstration of ECRF assisted low voltage plasma start-up and current rise to $q_{95}$=3 at toroidal electric fields below 0.3 V/m, to achieve an ITER compatible range of plasma internal inductance of 0.71-0.97.

The ITER physics basis was extended in the areas of transport, stability and exhaust. Concerning confinement, impurity ion transport across the pedestal is neoclassical, explaining the strong inward pinch of high-Z impurities in between ELMs. In improved H-mode, the width of the temperature pedestal increases with heating power, consistent with a $\beta^{1/2}_{pol,ped}$ scaling. In the area of MHD instabilities, disruption mitigation experiments using massive Ne injection reach volume averaged values of the total electron density close to those required for runaway electron suppression in ITER. ECRH at the q=2 surface was successfully applied to delay density limit disruptions. The characterisation of fast particle losses due to MHD has shown the importance of different loss mechanisms for NTMs, TAEs and BAEs. The new results reported here form the basis to further enhance the operational space of AUG with the full tungsten wall and strongly support tungsten as a first wall material solution.

### 1.3 Programme in 2009 and Technical Enhancements

The restart of AUG is planned for April 2009, again without boronization and with main emphasis on reactor relevant scenarios in an all-metal machine. These experiments will largely benefit from using the full generator power again, opening up the possibility to extend the operational space towards ITER relevant conditions, namely higher current and shaping of the plasma cross-section. Assessment of plasma performance, divertor properties, C retention, erosion, hydrogen and noble gas balance and operation without intrinsic C radiation are the issues. For the 2009 campaign 164 experimental proposals have been submitted by 76 scientists, with 34 % proposals and 50 % authors from outside IPP. A prioritized programme including 44 ITPA joint experiments is prepared and will be conducted by the four task forces. With the experience gained during last years the AUG operation even could be boosted into shaped plasma operation with up to 1.6 MA and more than 20 MW heating power at pulse lengths lasting for 10 s. This is supported by reliable tokamak operation including active NTM control, ELM and disruption mitigation.

In order to achieve AUG's programmatic goals and to maintain a leading position parallel to the ITER construction, it is necessary to continuously upgrade the AUG diagnostic and technical systems (section 6). The successfully improved H-mode operation with an all-tungsten wall has set a milestone. The preparations of the next major hardware extensions are well underway with support from other EU Associations. Fast ion loss detectors for the spatial distribution of

fast ion losses, CTS (from the Danish Association, RIS∅), and beam fluctuation measurements (from the Hungarian Association, HAS) are the next operating new diagnostics. Our ECRF system is presently being upgraded in power (4 MW provided by 4 gyrotrons), pulse length (10 s) and large deposition variability (tuneable frequency 105-140 GHz, toroidally and real-time poloidally steerable mirrors). The next two 2-frequency gyrotrons will be delivered in 2009. Central heating, suppression of NTMs and diagnostic support are the main issues.
A powerful system of 24 active in-vessel coils shall produce error fields up to toroidal mode number n=4 for ELM suppression, tearing mode and rotation control. The first 8 coils will be installed beginning 2010. In connection with a close conducting shell structure they will open up the road for resistive wall mode stabilization in advanced scenarios. For those we are considering LHCD with up to 0.5 MA driven current for current profile control and fully non-inductive current drive. The compatibility of ICRF with the tungsten wall might be improved by imbedding 4-strap antennas in extended wall structures. A first test will be done in 2010. Finally, doubling the plasma volume with plasma currents above 2 MA in AUG could be the solution for an EU ITER satellite in this range of plasma current.
In summary, the success and the expected future contributions of the AUG programme were honoured by the report of the EU Facility Review, which attributes AUG a very high importance for ITER and still a medium importance for the future DEMO device. AUG should support ITER well into the next decade and even longer unless a similar device would become available to the fusion programme.

## 2 Advanced Scenario Development with Full W Wall

### 2.1 Dependence of Central W Density Control on ECRH Deposition Location

Central heating with ECRH is routinely used to suppress tungsten accumulation in H-modes with moderate gas puff. A dedicated scan of the deposition location was performed to investigate the mechanism providing central impurity control with ECRH. The deposition was scanned vertically by changing the poloidal launching angle during the discharge or horizontally by variation of the toroidal magnetic field. Figure 1 shows time traces during a variation of the fast poloidal mirror of the new system. The ECRH deposition is moved upwards starting with a heat deposition close to the magnetic axis. At about 5.0 s the tungsten concentration c(W) in the plasma center increases and the stored energy drops due to a reduction in core temperature. The launching conditions at the beginning of the discharge and at 5.0 s are indicated in the bottom part of the figure as A and B respectively. A similar observation was made using a toroidal magnetic field variation to vary the ECRH deposition.

Starting in configuration A (-2.55 T) the plasma becomes unstable when the toroidal field reaches -2.4 T corresponding to launching condition C. In both cases the plasma becomes unstable when the deposition is roughly at the same flux surface (dashed line) situated in the vicinity of the flux surface for which the safety factor q equals unity. Actually, at least two mechanisms seem to link W accumulation and ECRH. A clear change in (1,1) MHD activity and sawteeth is seen comparing launching conditions A and B indicating a direct effect of the MHD on the heavy impurities. It is well known that such MHD modes are sensitive to the location of the ECRH with respect to the q=1 surface. Depositing ECRH just outside the q=1 surface still is beneficial as compared to no ECRH. This indicates that central ECRH has an additional effect on the impurity transport outside the q=1 surface. This has previously been explained by an increased diffusivity due to an increased turbulence level due to the central heating and by an increased neoclassical inward pinch for heavy impurities as the deuterium density peaks.

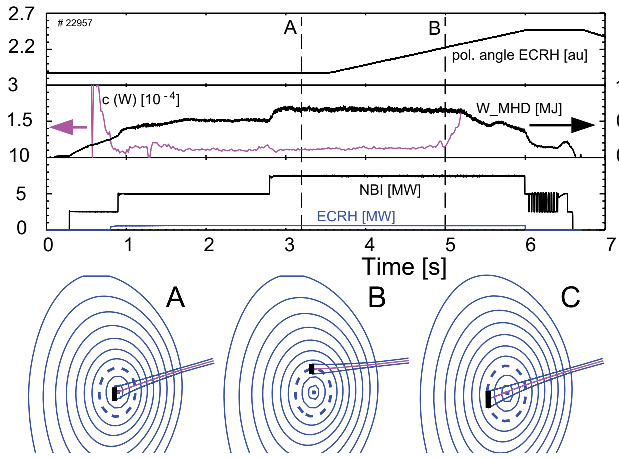



*Figure 1: Variation of the ECRH deposition during H-mode operation. Launching condition C corresponds to a different pulse with -2.4 T.*

The latter can be excluded as a driver in case of figure 1, since measurable changes in the peaking of the electron density are only observed after the W-concentration has risen sharply. An analysis of centrally ECR heated discharges with the gyrokinetic code GS2 indicates the excitation of unstable modes in the plasma center which are generated by the non-adiabatic response of the passing electrons. These modes imply an outward pinch of impurities, which could also explain the suppression of W accumulation. These modes can be unstable only if $R/L_{Te} >> R/L_{Ti}$, as is usually found in the very center of ECR heated plasmas.

### 2.2 Feedback Controlled $N_2$ Seeding for Divertor Protection

Besides the usual measures of central heating and deuterium gas puffing for ELM frequency control, high power H-mode discharges after the first boronization required active divertor cooling for protection of a few lower quality VPS coated outer divertor tiles. To facilitate this, a previously developed feedback control procedure using an electric current measurement has been upgraded and implemented into standard operation for discharges with more than about 8 MW heating power. The current is measured by shunts in the outer divertor. The total inter-ELM charge flux at each target is interpreted to be thermoelectric and mainly driven by the electron temperature difference between outer and inner divertor plasma. For standard toroidal field direction, there is net electron flux into the outer and net ion flux towards the inner target. The current loop is closed along the SOL plasma, the inner divertor and the conducting divertor structure. Since the relevant quantity for divertor protection, i.e. the time-averaged peak power load at the outer divertor, scales roughly with the divertor temperature, the easily available shunt measurement of the target current is a very appropriate diagnostic for feedback control.

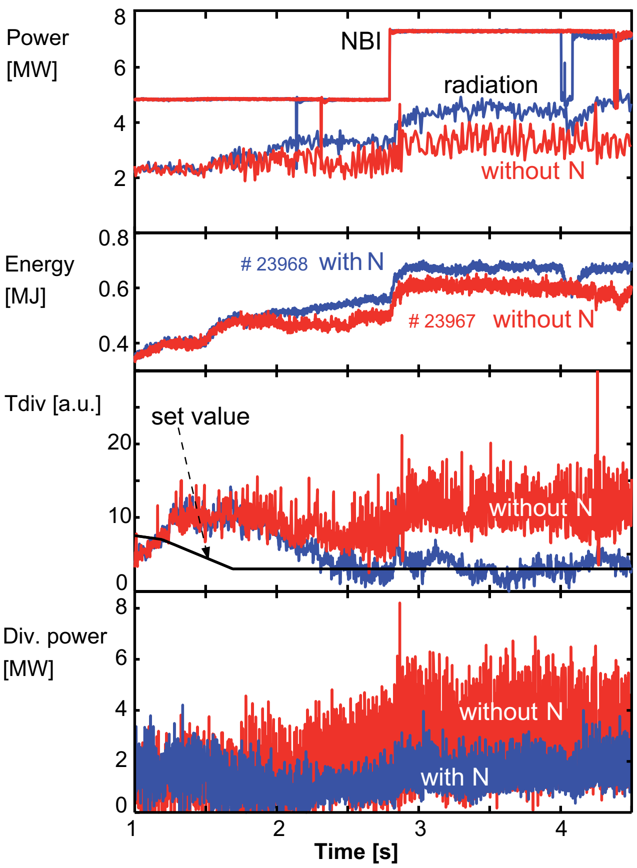



*Figure 2: Comparison of time traces for 2 discharges with and without $N_2$ seeding. From top to bottom are shown the NBI heating power and total radiated power from bolometry, stored energy, target current signal, Tdiv, and its set value for feedback control as well as outer divertor power load from IR thermography. Both discharges have 1.5 MW central ECRH for central W control.*

Real time processing of the target signal which is acquired at 100 kHz using LabVIEW RT allowed to remove the effect of ELMs by a median filter with a cycle time of 1 ms. Nitrogen has been chosen as radiating species since its radiative loss function peaks at lower temperatures compared to Ne and Ar. The nitrogen gas is injected through 8 toroidally distributed nozzles through the divertor roof baffle towards the X-point. Figure 2 compares two otherwise identical discharges with and without nitrogen seeding for target load control.

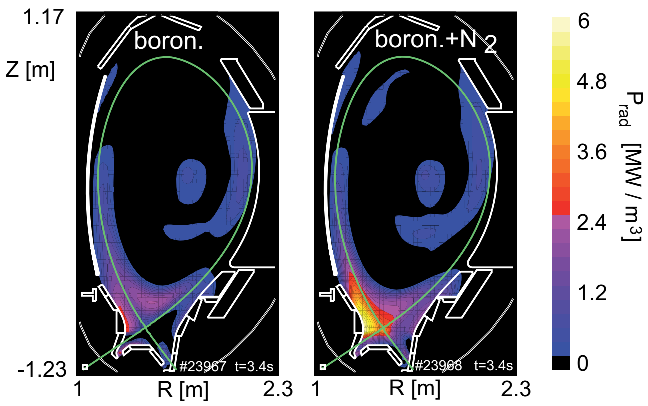



*Figure 3: Spatial radiation distribution from bolometer deconvolution without and with $N_2$ seeding for the discharges shown in figure 2.*

IR thermography shows reduced inter-ELM as well as ELM induced power load and shorter ELM duration with $N_2$ seeding. Analysis of target Langmuir probe data revealed reduced electron temperatures throughout the outer divertor with $N_2$ seeding and partial detachment on the first 2 cm outside the outer strike point. The inner target is fully detached for both conditions. Surprisingly, the discharges with radiative cooling exhibit improved energy confinement in comparison to unseeded discharges (see next section). Figure 3 displays the radiation distribution of the discharges shown in figure 2. Nitrogen enhances in particular the divertor and scrape-off layer radiation, resulting in a similar total radiated power compared to an unboronized discharge without $N_2$ seeding, but with less core radiated power.

## 2.3 Improved H-mode Performance with W Walls

"Improved H-mode" discharges in AUG are characterized by enhanced confinement factors $H_{98}>1$, total $\beta_N$=2-3.5 and a q-profile with ~zero shear in the core of the plasma at q(0)~1. Before 2007, the highest confinement factors ($H_{98}$=1.2-1.4) were obtained at the lowest values of the plasma collisionality achievable at low or zero gas puff level and after wall conditioning by boronization. A major goal of the 2008 campaign was to demonstrate the compatibility of the improved H-mode scenario with a W wall. At first, the experiments have concentrated on establishing stationary high performance H-mode discharges without boronization in a full W wall. ECRH is applied for the prevention of W accumulation for 4 s at ~1.6 MW, deposited within $\rho_{tor}$=0.2, and gas fuelling from the main chamber is used to control the ELM frequency. In otherwise constant conditions, this gas fuelling rate was varied from a high level, $\phi_{D,puff}$=15·10$^{21}$/s, to a low level of $\phi_{D,puff}$~2·10$^{21}$/s in successive discharges, resulting in a decrease of the ELM frequency from ~100 to ~60 Hz. 2·10$^{21}$/s is the lowest deuterium fuelling rate for which stable W concentrations during the discharge are obtained, using the available 1.6 MW ECRH. Figure 4 shows the variation of the confinement enhancement factor with the gas fuelling. The reduction of $H_{98}$ at higher densities (higher deuterium fuelling rates) is clearly seen.

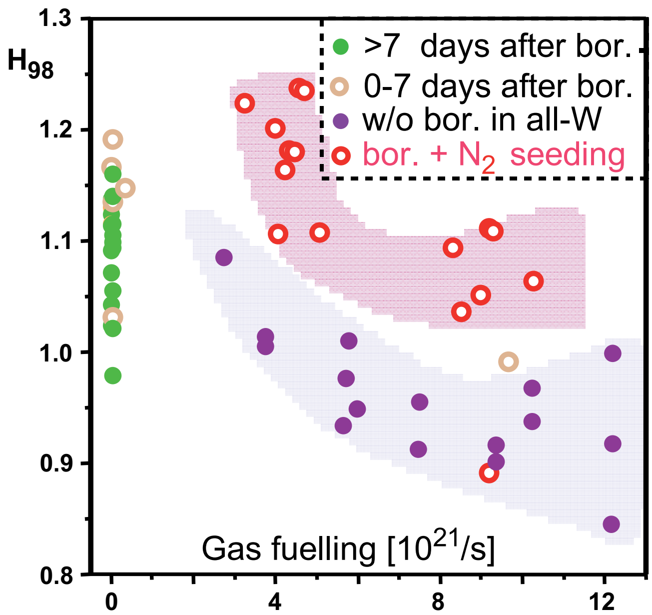



*Figure 4: Dependence of $H_{98}$ on the level of gas fuelling used for improved H-mode discharges. Discharges from the 2008 campaign are with gas fuelling, while all discharges from 2003-2006 have zero gas fuelling levels (discharges done within 7 calendar days of a boronization: orange circles; discharges afterwards: green points). For 2008 discharges the violet symbols refer to unboronized W walls, while the red circles are with $N_2$ seeding and boronized walls. All discharges are at 1 MA, 2.3-2.6T, δ<0.32 and have a total additional heating power of 10-12 MW.*

For improved H-mode discharges, the boronization resulted in a ~10 % reduced performance (stored energy, $H_{98}$ and β), which is partly explained by less peaked density profiles. With boronization, stable discharges without deuterium fuelling (achieving lower density and collisionality) are obtained again, as the tungsten influxes from the outer limiter are (temporarily) suppressed. As expected, the confinement increased by 5-10 % and the observed reduced confinement level at higher deuterium fuelling rates could be partly compensated. As a positive surprise it turned out that $N_2$ seeding does not only protect the coatings of divertor tiles, but also significantly improves the performance of discharges (see figure 4). The performance improvement with nitrogen seeding holds for all fuelling rates and leads to energy confinements exceeding thereby the best values which have been obtained in a carbon-dominated machine in the years 2002-2006 with more than 10 MW of additional heating. First investigations show that the observed confinement improvement is due to higher core temperatures rather than to peaking of the electron density profile. The latter would evidently lead to W accumulation at the observed good confinement properties. The $N_2$ seeded discharges also exhibit a changed core MHD behavior, where now fishbones are dominating. This is a strong indicator that the flat central q region, a main requisite for the improved H-mode regime, has broadened and the confinement improved.

## 3 Preparation of ITER Non-Nuclear Operation Phase

The AUG programme in 2008 also addressed two immediate ITER research needs in view of its non-nuclear operation phase. ITER discharge scenarios were tested to demonstrate ECRF assisted low voltage plasma start-up and subsequent current rise to $q_{95}$=3 at toroidal electric fields below 0.3 V/m and to achieve an ITER compatible range of plasma internal inductance of 0.7-1. The L→H transition in helium plasmas was studied showing that the H-mode threshold in helium is hardly different from the one in deuterium both for ECRH and H beam heating and possesses a pronounced minimum at line-averaged densities of 4.5·10$^{19}$ m$^{-3}$. This is of great importance for the first operating phase of ITER without radioactive activation to exploit the possibility for an early H-mode operation phase.

A detailed study of an ITER-like plasma breakdown and subsequent plasma current ramp-up to $q_{95}$=3 was performed with low loop voltage, validating these scenarios for a full tungsten first wall. For these experiments, operation without using switching resistors in the ohmic heating circuits was newly developed, reducing the loop electrical field on axis down to E~0.25 V/m (ITER plans to use 0.32 V/m). ECRH was used for pre-ionisation at the 2$^{nd}$ harmonic X-mode (105 GHz at 1.7 T, or 140 GHz at 2.3 T) and fundamental O-mode (105 GHz at 3.2 T), positioning the resonance on the high field side. ECRH alone (≤ 1 MW) or a combination of ECRH and ICRH (up to 400 kW coupled power using fundamental hydrogen resonance heating) was used in the pre-ionisation phase. Successful pre-ionisation at power levels up to 1 MW (mainly ECRH) was achieved, without damage to the tungsten surfaces, or diagnostics by ECR stray radiation. The fundamental O-mode experiments at 105 GHz (3.2 T) achieved the best pre-ionisation and subsequent current rise phase, and are analogous to using the main 170 GHz gyrotrons for breakdown assist in ITER at 5.2-5.3 T. No dedicated gyrotrons are needed at half field as the same gyrotrons can be used in the X2 mode. Using low voltage schemes, breakdown was still achievable after high current ($q_{95}$=3) disruptions. Good disruption recovery is generally observed in AUG after the transition to full tungsten.

Following the breakdown phase, continued ramping to full plasma current (1.0 MA at 1.7 T) in 1.0-1.2 s was achieved. In some experiments, ECRH was used to pre-ionise and heat the current rise at low plasma density ($<3\cdot10^{19}$ m$^{-3}$) with good plasma performance even with E<0.3 V/m (figure 5).

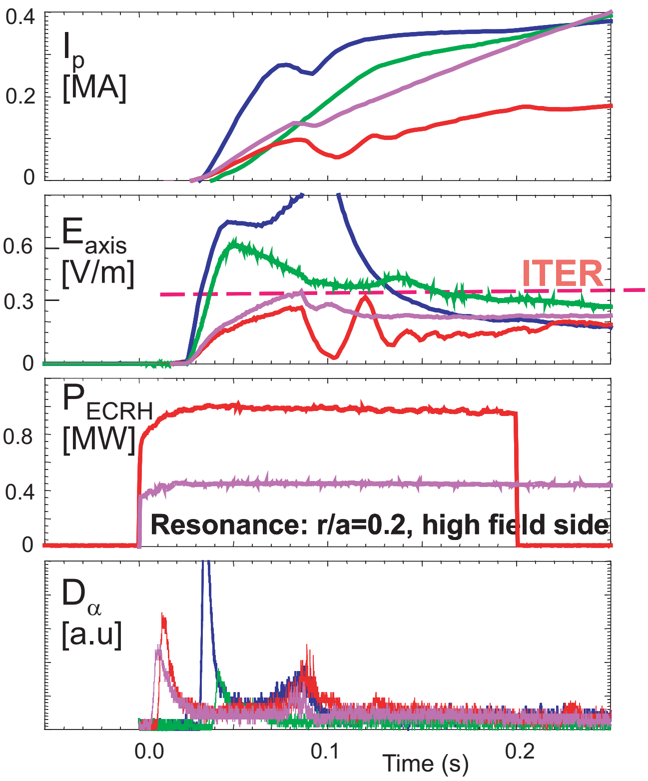



*Figure 5: ECRH start and ramp-up assist. The minimum required electrical field on axis is reduced to ~0.2 V/m using 0.3-0.9 MW ECRH (X2).*

Focus of the current rise experiments was on control of the plasma inductance $l_i$, with the various available heating schemes. NBI was used with on-axis and off-axis injection up to 5 MW and ECRH was used at 0.5 MW. A clear result from these experiments is that the amount of electron heating during the current rise determines the current diffusion, with the capability of varying the internal inductance $l_i$ significantly from 0.71 to 0.97 at fixed plasma current rise rate $dI_p/dt$=0.66 MA/s (figure 6). This is within the foreseen operational boundaries ($l_i$=0.7-1.0) for 15 MA operation in ITER given mainly from vertical position control and the OH flux limits. A prerequisite for this low $l_i$ ramp-up is the early transition to a full bore plasma shape, where the breakdown occurs close to the HFS limiter, followed by an LFS limiter ramp-up and an early X-point formation at about 0.5 s. An even earlier divertor transition will be possible with full generator power in the next campaign. The ramp-down is done in an inverse sequence and by avoiding both an early H→L back-transition using additional heating and an inboard limiter contact.

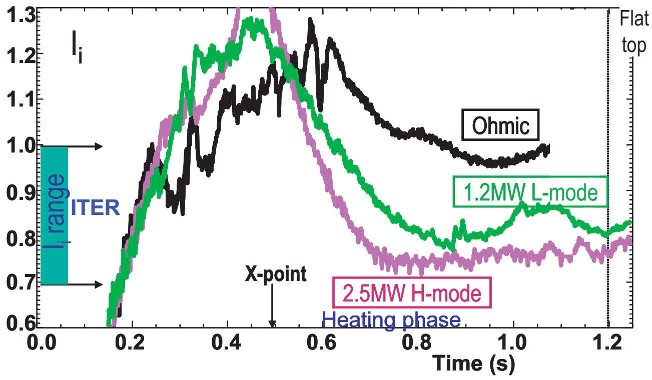



*Figure 6: Internal inductance during plasma current ramp-up for different heating powers and confinement modes*

These experiments on AUG were confirmed by similar ones at JET and DIII-D and together they form a reliable basis for the plasma ramp-up scenarios planned at ITER.

The H-mode is at present the baseline scenario foreseen for ITER. The H-mode threshold power ($P_{thr}$) in ITER is predicted by the recent scaling expression deduced from the ITPA database which reads $P_{thr}=0.049\ B_t^{0.80}\ n_e^{0.72}\ S^{0.94}$ for deuterium, the units being MW, T, $10^{20}$ m$^{-3}$ and S the plasma surface area in m$^2$. The predicted value in ITER is about 50 MW in deuterium at a density of $5\cdot10^{19}$ m$^{-3}$ and a factor of about 2 larger in hydrogen. As emphasized recently, achieving the H-mode regime in the non-nuclear phase of ITER, i.e. in hydrogen or helium plasmas, is highly desirable to assess several physical and technical issues. As the value of $P_{thr}$ in hydrogen predicted for ITER is largely above the installed power, helium could be envisaged. Following the Joint Experiments proposal (TC-4) made by the ITPA Transport and Confinement Topical Group, a helium campaign has been carried out in AUG in July 2008 to investigate in detail H-mode threshold and confinement in helium. The existence of a minimum of $P_{thr}$ at a given density $n_{min}$ has been observed in several devices, but not well documented in AUG. The strong increase of $P_{thr}$ at densities below $n_{min}$ might be an issue for ITER. This topic is also the subject of ITPA Joint Experiments (TC-3) and has been addressed in the 2008 campaign as well.

To study $P_{thr}$ in AUG, $B_t$ and $n_e$ scans have been carried out in deuterium and helium ($^4$He), with emphasis on a wide density scan and good documentation of edge parameters. The heating methods were NBI and ECRH, whereas the recent extension of the ECRH power up to 2.3 MW provided, for the first time in AUG, a wide operational window in H-mode with ECRH only. In particular, it allowed to investigate extensively the low density branch. The threshold power is the net heating power at the L→H transition, defined as $P_{net}=P_{Ohm}+P_{heat}-P_{losses}-dW/dt$. Here $P_{Ohm}$ is the residual Ohmic power, $P_{heat}$ the auxiliary heating power, whereas $P_{losses}$ accounts for all the NBI fast ion losses and W is the plasma energy content. Previous results from non-systematic data in helium indicated $P_{thr}(^4He)\approx 1.4\cdot P_{thr}(D)$. Surprisingly, the 2008 data set shows that $P_{thr}$ is the same in both gases, as illustrated by the density dependence in figure 7. The threshold minimum appears very clearly at $n_{min}\approx 4.5\cdot 10^{19}$ $m^{-3}$ for both $^4He$ and D. Moreover, within the error bars, $P_{thr}$ seems to be independent of the heating method in these experiments, but this needs to be confirmed by further experiments in D. It should also be emphasized that the values of $P_{thr}$ obtained here are at the lower boundary of all AUG threshold data, indicating that the present full tungsten wall has certainly no deleterious effect on the threshold power. Whether this also explains the similarity of the threshold in the two gases remains to be clarified in further studies.

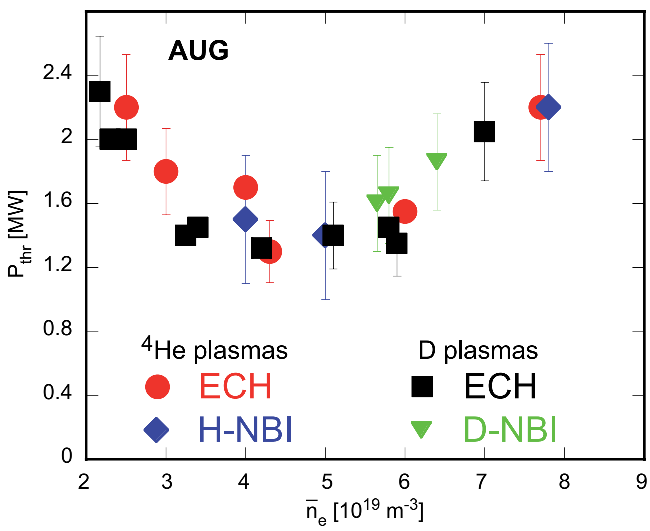



*Figure 7: Power threshold in He and D with ECRH and NBI, H-NBI into He, D-NBI into D. Density scan at $B_t$=2.3 T.*

The analysis of the edge data at the L→H transition is still in progress. Presently, electron temperature, density and pressure are available. The electron temperature increases strongly towards low density below $n_{min}$, in agreement with the increasing heating power. This indicates that increase of $P_{thr}$ is not caused by a strong transport degradation. Interestingly, the electron pressure is almost independent of density and gas species. The ion data are still under investigation.
Confinement time in $^4He$ is about 40 % lower than in D, in agreement with previous results. The analysis of kinetic data shows that this is due to the lower ion energy content due to $Z_{eff}\approx 2$, with a further small contribution linked to the lower pedestal pressure and high ELM frequency in $^4He$.

## 4 Inverse Shear of Toroidal Rotation Found in H-mode by Edge-CXRS Measurements

The edge charge exchange recombination spectroscopy (CXRS) system at the outboard side of AUG has been adjusted to high spatial resolution (up to 3 mm) and fast temporal resolution (1.9 ms) such that the steep region of the edge transport barrier can be studied despite the frequent occurrence of ELMs. The evaluation of spectral lines emitted following a CX reaction is used to obtain local information about the ion temperature $T_i$ and toroidal rotation $v_{tor}$, which are evaluated from Doppler broadening and line shift.

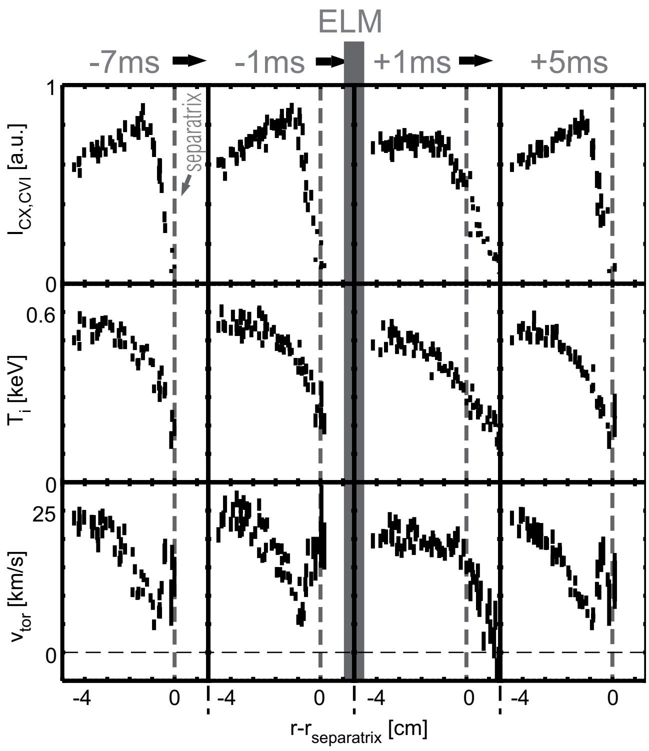



*Figure 8: Measurements derived from the active CX-component between beam neutrals and fully-stripped C. The data were obtained from a 300 ms long phase in which the plasma was horizontally swept by 2 cm. The intensity of the CX-component $I_{CX,CVI}$, $T_i$ and the $v_{tor}$ (positive is in co-direction) of the plasma are depicted in different phases of an ELM-cycle.*

Figure 8 depicts the CX-line intensity of CVI owing to CX of $C^{6+}$, $T_i$ and $v_{tor}$ for an H-mode discharge (# 22273) with type-I ELMs. In this discharge, one neutral beam source ($P_{NBI}$=2.5 MW), electron cyclotron heating ($P_{ECRH}$=1.4 MW) and ohmic heating ($P_{OH}$=0.4 MW) were used to obtain H-mode at a line integrated electron density $n_e$ of about $8\cdot 10^{19}$ $m^{-3}$, plasma current $I_p$ of 1 MA and a magnetic field $B_t$ of 2.4 T resulting in an ELM-frequency of about 65 Hz. The temporal resolution of 1.9 ms allowed for the synchronization of the data to the occurrence of ELMs.

In figure 8 four columns are presented labelled with '-7ms', '-1ms', '+1ms' and '+5ms' denoting the relative time to the following or preceding ELM at which the measurements are taken, while light is included ±1.45 ms around these time points. The plasma radius of the measurement location is determined by a numerical integration along the LOS, which determines the CX emission intensity in the observed plasma volumes. The separatrix determination is improved by an alignment of $T_i$- and $T_e$-profiles, which leaves an uncertainty of 2-3 mm. The effects of the ELM can be studied for all quantities, though in the following paragraph the focus is put on the $v_{tor}$-profile. In between ELMs it exhibits a local minimum at 1 cm inside the separatrix. In the last centimetre of the confined plasma $v_{tor}$ increases by about 10-20 km/s reaching about 25 km/s at the separatrix. This feature is visible during the whole ELM cycle, and is only interrupted for about 2-3 ms by the ELM. The behaviour during the ELM cannot be judged by the measurements, because the exposure time of 1.9 ms is too long. Still, it is remarkable, that in figure 8 no data points indicate the dip in rotation velocity for the time labelled '+1ms'. In all other frames the dip is clearly visible and also for the time frame '+3ms' (omitted in figure 8) a dip is there. While the statistical uncertainties are given as symmetric error bars the systematic uncertainties are smaller than 5 km/s for the absolute values and 1-2 km/s for the relative comparison between different lines of sight. Further measurements on $H^+$, $He^{2+}$ and $B^{5+}$ clearly show that this feature is of the same shape and size for all considered ions. The projection of the diamagnetic velocity and the E×B-flow onto the LOS have been quantified taking plasma profiles and typical electric fields into account and appear to be much too small to explain the measurement. However, both velocities lead to a Pfirsch-Schlüter flow parallel to the magnetic field lines, which is of sufficient size to explain the measurement. Still, these flows are predicted to be different for $H^+$, $He^{2+}$, $B^{5+}$ and $C^{6+}$ owing to the fact that the diamagnetic velocities for each species are different. Possibly the friction between the species leads to an equilibration of the velocities. Further investigations aim towards this question and possible implications for H-mode formation. Independently, the feature in rotation is difficult to explain in terms of momentum transport unless the strong rotation in the co-direction at the separatrix on the outboard side coincides with a corresponding counter-rotation at the inboard side, such that the flux surface averaged rotation is close to zero. A Pfirsch-Schlüter flow would exhibit such a structure.

## 5 Disruption Avoidance and Mitigation

ITER will not be able to afford many unmitigated disruptions and therefore methods to avoid and mitigate them must be developed. A significant effort is devoted in AUG to: (1) avoiding or at least mitigating a forthcoming disruption and (2) proving that the runaway electrons can be suppressed.

(1) One possible approach for mitigating the impact of disruptions or even avoiding disruptions has been carried out with the ECRH system and its upgraded control system. Motivated by results from FTU, local ECRH has been applied at the resonant surface of the dominant tearing mode preceding the disruption. The ECRH is triggered by the feedback system when the measured loop voltage reaches a predefined threshold. These experiments were done in high $q_{95}$≈6.5 discharges with dedicated density limit disruptions as a proof of principle experiment in an elliptical divertor plasma. In discharges with ECRH the disruption was delayed up to 120 ms (see figure 9). The highest efficiency was achieved, with ECRH deposition at the q=2 surface. During the delay phase the density could be kept at or even above the Greenwald density. With a refined feedback control of the density complete avoidance of the disruption and a safe shutdown of the discharge was achieved. Both the delay for alternative safe shutdown techniques as well as complete disruption avoidance offer interesting and important possibilities for disruption free operation in ITER.

Experiments were conducted in discharges with typically 1 MW of Ohmic heating. In these cases an ECRH threshold power of 0.6 MW for the delay or avoidance of the disruption was found. An extension towards beam heated H-mode discharges at ITER like $q_{95}$ values (<4) is intended for the future.

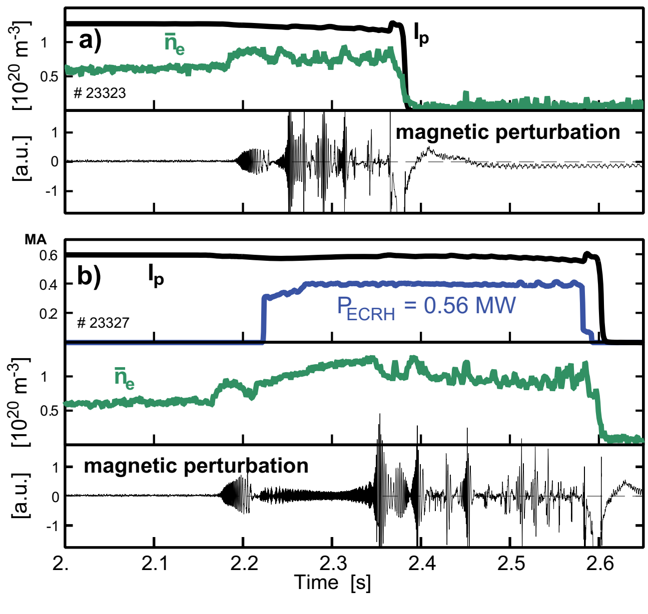



*Figure 9: Density limit experiments: a) reference disruption; b) with ECRH injection on the q=2 surface.*

(2) According to our present knowledge, a disruption in ITER would convert a large fraction of the plasma current into a beam of highly energetic runaway electrons. In order

to prevent the generation of the runaway electrons, the total (free plus bound) electron density, $n_{e,\ tot}$, must be increased up to the so-called "Rosenbluth density" $n_R \approx 1\text{-}10 \cdot 10^{22}\ m^{-3}$, which is 2-3 orders of magnitude larger than the nominal one. Such a density would significantly affect the design of the pumping system and therefore it is important to understand which processes control the assimilation of the injected gas by the plasma and its transport into the plasma core, in order to maximize them.

This year the dependence of the fuelling efficiency, $F_{eff}$, of the in-vessel fast valve on plasma and gas parameters was documented. $F_{eff}$, the increase in the free electron number divided by the number of injected gas atoms, was found to be almost independent of the amount of injected gas, of the plasma energy, and of the gas pressure, in the range of parameters scanned. $F_{eff}$ reaches larger values than the ones observed in other tokamaks, because of the proximity of the valve to the plasma. It ranges between 40 % and 60 % for He and between 20 % and 40 % for Ne. Line average electron densities above $10^{21}\ m^{-3}$ and around $0.85 \cdot 10^{21}\ m^{-3}$ have been reached with injection of He and Ne respectively (see figure 10).

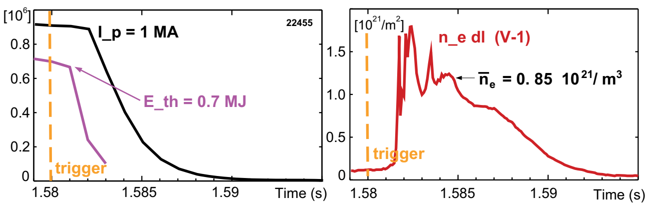



*Figure 10: Time evolution of current, thermal energy and density after the injection of $4 \cdot 10^{22}$ Ne atoms*

The bound electrons as well as the free electrons contribute to the stopping power of the plasma for runaways. The number of bound electrons can only be computed with the 2D transport code SOLPS as a sum of the contributions from the partially ionized atoms and from the neutrals. Preliminary simulations show that the injected impurities, Ne or He, after the thermal quench, are mostly singly ionized and that a significant number of neutral particles are present in the plasma. For the maximum amount of Ne atoms (Z=10) injected up to now, which amounts to 1.6 bar·L, i.e. $4 \cdot 10^{22}$ atoms, the calculated average total electron density increase is $\Delta n_{e,tot} \approx n_{e,tot} = 10^{22}\ m^{-3}$. The calculation assumed a plasma volume (core+SOL) of 17 $m^3$ and assumed a 45 % assimilation of the injected atoms, which is consistent with the SOLPS simulation. The in-vessel valve allows the injection of 4 bar·L of gas, equivalent to $10^{23}$ atoms. In the case of Ne injection and assimilation of 45 %, the expected $\Delta n_{e,tot}$ is larger than $n_R$.

We conclude that a total (free plus bound) electron density, of the order of magnitude of the "Rosenbluth density" can be reached in AUG after the injection of Ne with the in-vessel fast valve. This result supports the possibility of suppressing runaway electrons generated during the current quench in ITER by the simple method of massive gas injection.

## 6 Technical Systems

In 2008, experiments in a tokamak with a full tungsten first wall were continued with an extended operational space due to the modified power supply. The experiment was in operation for 69 days (including 4 technical shot days) performing 1605 shots in total with 1084 shots useful for the physics program, which was focussed on the investigation of plasma-tungsten interaction and on the compatibility of a tungsten first wall with improved H-mode plasmas. 206 discharges were performed with a heating power $P_{heat} \geq 10$ MW. The change from detached to attached divertor conditions due to boronization for otherwise comparable discharges resulted in a target heat load above the limit qualified by high heat flux tests (100-200 cycles with 10 $MW/m^2$ for 3.5 s). The 200 µm thick tungsten coating delaminated at 2 out of 128 tiles and escaping flakes accidentally caused disruptions. An unscheduled opening of 3 days was thus necessary in April to replace the damaged tiles. The scheduled Summer opening was used to replace pre-damaged tiles with new ones. The new tiles have a 10 µm tungsten coating on FGG 6701 and a 3 µm Mo interlayer in addition. Inspection of the in-vessel components during the scheduled opening in Winter 2008 reveals no new problems with the coating. Small damages were observed at the outer corners of the roof baffle. As in former campaigns, significant arc tracks were found at the transition and retention modules of the inner divertor. In contrast to the 2007 campaign, the carbon deposition was increased.

### 6.1 Preparation for the ELM Control Coils

The next step in the enhancement of AUG will be the installation of ELM control coils inside the vessel. Three sets of coils will be installed – the so called B-coils in front of the upper and lower part of the passive stabilizing loop and the A-coils around the A-ports. According to stage 2 of the proposal for the B-coils, approved by the European Commission, the installation of the coils will be performed stepwise in accordance with the manufacturing of the coils. In order to start as soon as possible with the scientific program, the B-coils will be installed in 2 steps. In 2009/10 the first 4 out of 8 upper and lower B-coils will be installed. First experiments are envisaged for 2010. The B-coil installation will be completed in 2011. The interference of the B-coils with diagnostics and infrastructure systems, such as the pumping and vessel conditioning system, has been investigated in 2008. The following problems have been identified and options for solutions were developed.

Powering of the upper B-coils is realized by current feed throughs located in the upper C-ports of the even section.

This solution results in conflicts with a set of diagnostics, in particular the wave guides for the reflectometry antennas that has to be redesigned and the re-entrance ports for the vessel viewing systems, that has to be removed in S3, 8 and 10. They will be replaced by new re-entrance ports designed for the smaller lenses and image guides so that they can coexists with the current feed through.
The current feed throughs for the lower B-coils are not distributed regularly around the torus because the lower C-ports are in use for the turbo pumping and the boronization system. A compromise was found, which on one side keeps the boronization system as it is (licensing) and minimizes the reduction of the over all pumping speed and on the other side requires no more than 2 different types of current feed throughs.
Inside the vessel 3 areas of conflict were identified at different poloidal locations. (i) The field of view of some diagnostics is shadowed by the B-coils installed in front of the PSL. Individual solutions for each diagnostic have to be found. Either the location of the detector heads inside the vessel has to be adapted (SXRS) or new detector heads have to be designed (bolometry). The toroidal gaps between the B-coils were adjusted to the viewing geometry of the Li-beam, which uses fixed ports in the vessel that cannot be modified. (ii) ICRH frame limiters are at present the first elements of the plasma wall contact for most of the magnetic configurations. To maintain this also with the installed B-coils requires adaptation of the ICRH frame limiters to the modified in vessel contour. Different options that include an improvement of the ICRH coupling and a reduction of E-fields in front of the antenna to reduce tungsten sputtering are under discussion. The minimum effort requires a modification of the carbon tiles in the upper part of the ICRH frame limiter, resulting in a deeper shadow for the ICRH antenna that is disadvantageous for the antenna coupling. (iii) The lower B-coils are in conflict with the retention module of the lower divertor. The transition between the lower outer divertor and the ICRH antenna will be more continuous compared to the present situation. The retention module will be replaced by modified carbon tiles for the transition module and the new shielding of the B-coils. The design will be finalized in 2009.

### 6.2 Torus Pumping and Gas Inlet System

As the manufacturer of the currently used type of turbo molecular pumps (TMP) no longer provides maintenance services for their product, a replacement was necessary. During the 2008 campaign already 5 TMPs of a new type (Pfeiffer-Vacuum TPU 2301 P N) were operational. No serious problems occurred with the new pump type during plasma operation, confirming results from laboratory tests. The presently remaining TMPs of the old type will be replaced in future AUG reconstruction phases. An appropriate number of TMPs was ordered and will be delivered in Spring 2009.

A new anode for glow discharge cleaning (GDC), originally developed for W7-X, was in operation during the whole campaign. The currents and voltages during the GDC were monitored and studied in view of starting GDC using this new type of anode. The observed operational performance was very satisfying, but the breakdown of the GD is not compatible with the current AUG operational procedure. Therefore, further investigations, especially of the ignition behaviour and technical measures for improving reliable breakdown, are needed. This will be done in laboratory experiments and also during AUG operation.
Examination of the Tritium inventory inside the vessel is a very important issue in preparation for the ITER licensing. To investigate the balance between inflows from different sources and exhaust via the pumping system, it is inevitable to have very accurate data for pumping speed, leak rates and flow rates of the components. Therefore, the calibration procedures to determine these values for the TMPs, the cryo pump and the fast piezoelectric valves have been improved. In the 2008 campaign, gas injection experiments with different gases required a frequent change of the gas species for the piezoelectric valves in the divertor region. This necessary change between successive pulses was only possible using the valve matrix, which was installed two years ago.

### 6.3 Integration of Real-Time Data Acquisition and Control

Active stabilization of resonant MHD modes is the present cutting edge control application. Instead of implementing a dedicated solution, a general framework with standards for real-time diagnostics, real-time communication and operation model is being devised. Development of the serial I/O (SIO) computer interface, featuring a broad range of sampling rates up to 2 MHz and a number of up to 1024 channels, was carried out. It is to become the general AUG standard for diagnostics. Transferring data from the periphery directly into the main memory of the DAQ computer enables real time operation and the collection of up to several gigabytes of data.

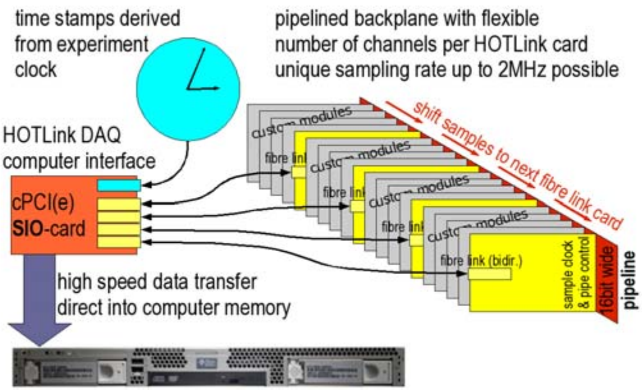



*Figure 11: Typical SIO set-up for high speed sampling featuring a backplane divided into four separate pipelines with a dedicated link each*

Custom modules may be event counters, single, double, and quad channel ADCs, or special purpose cards like bus displays and CCD camera interfaces. Due to hard latency requirements, plasma controllers run in the VxWorks real-time operating system. If necessary, diagnostics may use non-standard LabView or LINUX implementations. The generic communication mechanism, decoupling communication boards (Bit3 and VMIC shared memory) and application processes (control and diagnostic), allows free exchange of real-time data between diagnostics and controllers with microsecond latencies. The in-house-developed experiment time network (with nanosecond resolution) synchronizes latency critical distributed applications into common (~milliseconds) cycles. A standard operation model defines common phases for configuration and execution of the real-time diagnostics and controllers. A supervisory software issues phase (state) information to all applications and monitors their operation. While most of the standards were defined and implemented in 2008, integration is planned for the first quarter of 2009, and prototype demonstration of the methods for MHD stabilization for the second quarter.

### 6.4 Neutral Beam Heating

Neutral beam injection (NBI) provided heating for 961 of the 1084 useful plasma shots in 2008. Despite the continued limitations due to the absence of the EZ4 flywheel generator, up to 17 of the 20 MW installed NBI heating power was actually injected in shots of substantial duration. Initially, 7 of the 8 ion sources, installed in 2 beam lines, were fully operational. Conditioning of the remaining source, which had started before the previous campaign after the source had been newly installed, was continued and the source could be brought to reliable operation at full acceleration voltage toward the end of the campaign.

Overall, NBI was reliably available with only one mayor exception: on October 10$^{th}$ a leak in the water-cooled ion dump of source 1 of beam line 2 led to a strong vacuum pressure increase and the beam line went temporarily out of operation. Evacuation of the cooling circuit with a roughing pump proved effective enough to resume plasma heating with the remaining 3 sources on November 4$^{th}$. After the end of the campaign the defective part could soon be identified and replaced. Major improvements were achieved regarding the behaviour of beam line 1 in low-frequency pulsed operation. Previously, the response of the controllers of the high voltage supplies after the end of a single pulse had caused the acceleration voltage to drop significantly below the preset value during the first several ten milliseconds of the following pulse. Amended settings of the controllers could mitigate the problem under the most frequently demanded pulsed scenarios. Additionally, higher-frequency pulsed operation for ramp up and ramp down of heating power had been suffering from serious oscillations of the arc sources' arc current with a corresponding effect on the extracted beam current. Changes to the arc-current controllers' hardware were able to reduce the effect to an acceptable level. Maintenance was started directly after the end of the campaign. The main tasks are refitting the titanium evaporator pumps, installation of prototypes of slightly modified calorimeter target plates for testing and the installation of a newly designed shield in the beam duct of injector 2.

### 6.5 Ion Cyclotron Resonance Heating

At the beginning of the year, only 4 tetrodes were remaining for the 4 AUG generators, with no spares left. One of the tetrodes, originally bought for and used in the early 1980s in an ASDEX generator and installed in an AUG generator since 2007, showed a continuous reduction in power capability. This led to restrictions on the available power from the ICRF system. Since the generators are connected in pairs with 3 dB couplers, the loss of power in one generator results in a total power reduction which is larger than the power reduction from one generator alone. At the end of the year, the affected generator was completely taken out of the system, the connection through the 3 dB coupler removed and the system operated with 3 generators only. In order to restore the power capability of the system, the tetrode was sent to a company for refurbishing if this is still possible.

Since the production of the original tetrode has been stopped and no more spares are available, the modification of the generators with commercially available tetrodes has thus become a necessity. Contacts with GA in San Diego and with PPPL have been established, who have experience with the modification of similar generators. Cooperation with the Institute for Plasma Research (IPR), India, responsible for the ITER generators is envisaged. A joint visit of the IPR and ICRF group of IPP to GA to draw on the experience of the GA and PPPL colleagues in the modification of the generators was very fruitful. Proposals and plans of modifications have been thoroughly discussed with them. Contract negotiations with IPR are ongoing.

A new vacuum chamber, which forms part of the extension of the ICRF test bed to be installed in the L7 experimental hall, was delivered. This test bed, ICARuS (Ion Cyclotron Advanced Research Vacuum System) will allow testing of wider antennas. Further progress was also made in modernising the ICRF system and updating its documentation, for example by digitising all electrical diagrams of the generators, taking into operation new compressors and upgrading the cooling circuit of the generators.

### 6.6 Electron Cyclotron Resonance Heating

The ECRH system was operational with four units of the old system (4×0.4 MW at 140 GHz for 2 s) and one unit of the new system (0.8 MW at 140 GHz or 0.5 MW at 105 GHz both for 10 s). Standard operation was provided with central heating (X2, 140 GHz) with 1.6 MW for 4 s to suppress W accumulation in the majority of all pulses in the 2008 campaign. Other heating schemes (O2 and X3) have been successfully developed together with IPF Stuttgart. They will allow limitations on $B_t$ and $n_e$ to be overcome in the next campaign (see section 9.2).

In the first pulses after machine vents, ECRH was used successfully to sustain plasma breakdown in the current rise phase. As described in section 3, ECRH has also been used for pre-ionisation of the gas prior to the current rise. These new modes of ECRH operation do not guarantee 100 % single pass absorption. Therefore the installation of sniffer probes of the W7-AS/-X type is envisaged to monitor the in-vessel stray radiation and to switch off the ECRH if necessary. First successful results including a safety-loop have been obtained using a provisionally mounted sniffer probe of W7-X. Three similar probes will be installed in 2009 in collaboration with CNR-Milano in the framework of an EFDA task on minimizing ECRH stray radiation in ITER. With these probes, all sectors containing ECRH antennae can be surveyed. These signals will be combined in an interlock system also increasing machine safety for the case of wrong polarizer settings for standard X2 heating. The completion of the new ECRH system is hampered by problems with the gyrotrons. These were originally planned as 4-frequency (4-f) gyrotrons using a Brewster-type output window. The factory test in July failed since a diamond window broke during commissioning. As a consequence, gyrotrons 2 and 3 will become 2-f only. Meanwhile, an improvement of the 4-f solution has to be discussed, eventually to be built into gyrotron 4. For the 2-f solution, a change of the window geometry is necessary. The cuffs and disks are presently being brazed and gyrotrons 2 and 3 will be delivered respectively 3 and 6 months after completion of the brazing. A major goal with the new ECRH system is the feed-back control of NTMs. Preparatory tests with a combined data acquisition system for ECE and Mirnov signals were completed successfully in 2008. Closed-loop NTM suppression is envisioned for the 2009 campaign.

## 7 Core Plasma Physics

### 7.1 Development of Carbon Content

In the course of the stepwise replacement of the C first-wall by W-coated carbon tiles the C content of the plasmas is of special interest. In figure 12 a) the history of the C concentrations ($c_C$) at the pedestal-top as measured by CXRS is presented. Although the full main chamber has been progressively coated with W up to the campaign 2005/2006, only a slight reduction of the $c_C$ is observed, while C net erosion was reduced by more than a factor of 5 (from ~14.6 g to ~2.2 g per 3000 s of plasma) as known from post-mortem surface analysis and in-situ quartz micro-balance probes. This hints towards an enhanced recycling of C atoms, which enables a small net source to cause nearly as high $c_C$ as before. In 2007 the restart with an unboronized full W wall was performed and another slight reduction of $c_C$ is observed, while the net sources have become even smaller (~1 g). After a boronization in the 2008 campaign a drastic drop of more than one order of magnitude is observed in the $c_C$ (figure 12 c), which is not observed after earlier boronizations (figure 12 b). It seems that the reduced C sources and the possibly cleaner boron layer suppress the fast onset of C recycling following a boronization. It may be noted that oxygen might play an important role for mobilizing C with a full W wall without boronization (2007, 2008).

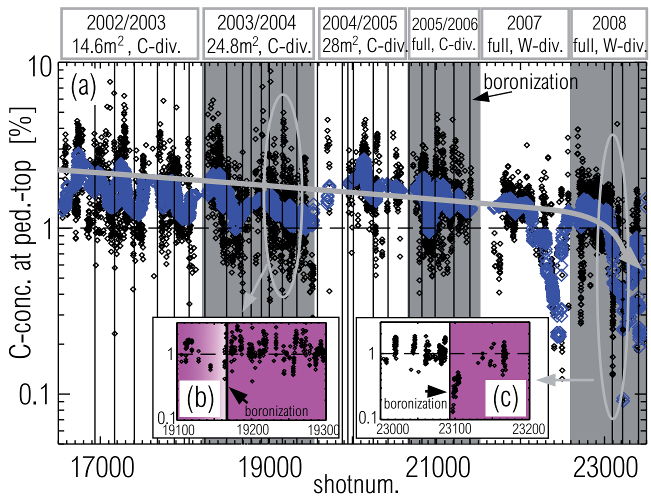



*Figure 12: Development of C concentrations. On the top, the year of the campaigns, the coverage of the first wall by W and the divertor material is given. The data points are given individually (black, small) and smoothed (dark grey).*

### 7.2 Comparison of AUG and DIII-D Hybrid Scenarios

A comparative experimental study of power scans in AUG and DIII-D hybrid scenarios has been performed in the last two years. Both devices show an increase of the $H_{IPB98(y,2)}$ factor with increasing total $\beta$, but while in AUG the total $\beta$ increases with increasing pedestal $\beta$, in DIII-D, in the high triangularity shape, the total $\beta$ increases despite very limited variation of the pedestal $\beta$. Gyrokinetic calculations of core transport in these plasmas reveal that electromagnetic effects have sizable stabilizing impact on the instabilities, and that AUG core conditions are closer to the destabilization of kinetic ballooning modes than DIII-D conditions. A linear MHD stability analysis is being carried out for the pre-ELM equilibria in form of j-$\alpha$ diagrams. First results indicate that the MHD edge instabilities are coupled peeling-ballooning modes, in agreement with the expectations for type-I ELMs.

### 7.3 Fast Particle Driven Alfvén Modes

Shear Alfvén waves are ubiquitous in laboratory as well as in astrophysical plasmas. In magnetically confined fusion plasmas, shear Alfvén waves like Reversed Shear Alfvén Eigenmodes (RSAE) and Toroidal Alfvén Eigenmodes (TAE) are usually driven unstable by externally launched waves and fast ions. In ICRF heated discharges, several aspects of fast ion-driven TAE stability were explored, such as the effect of magnetic shear and density, the decay and growth rate of individual TAEs, and the fast ion drive rates. In particular, the dependence of the ICRF power-density threshold on the toroidal mode number n has been established. Furthermore, fast ion pressure profiles generated by the ICRF power deposition codes PION and TORIC, and the equilibrium code CLISTE were used to estimate the TAE fast ion drive rates, and to benchmark a newly proposed formula for volume averaged $\beta_{fast}$ in ICRH-only plasmas. The fast ion transport induced by shear Alfvén eigenmodes has been investigated in ICRF heated discharges with reversed shear q-profiles using the FILD system. RSAEs cause severe losses of fast ions, with energies up to 1.5 MeV, as they interact with acoustic, Alfvén-acoustic and/or TAE modes.

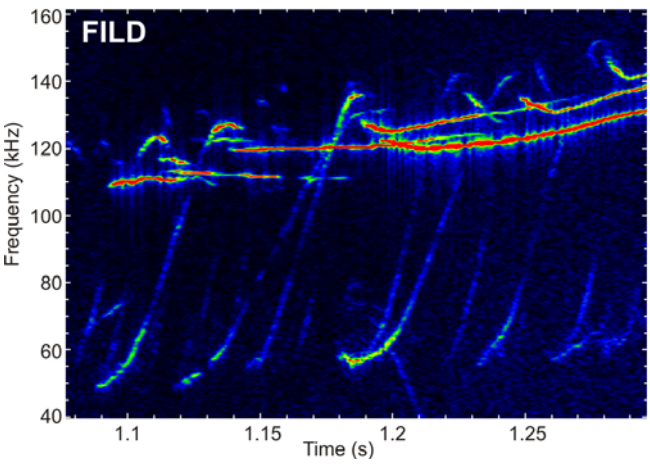



*Figure 13: Spectrogram of fast ion losses with energies ~1 MeV. TAEs at ~110-140 kHz and RSAEs sweeping in frequency from ~50 kHz up the TAE frequency are visible.*

The FILD spectrogram in figure 13 shows the expulsion of fast ions due to several TAEs and RSAEs (Alfvén cascades) which are sweeping up in frequency from the acoustic branch up to the TAE gap. The RSAE-TAE transition generates a Global Toroidal Alfvén Eigenmode (GTAE) which leads to a large fast ion channelling towards the vacuum wall. On the other hand, the interaction of RSAEs with the acoustic branch acts as a fast ion channel too, causing important fast ion losses even if the mode amplitude is not large, as inferred from the correlation between FILD, magnetic pick up coils and SXR measurements.

### 7.4 ICRH Beat-Wave Excitation of Alfvénic MHD Activity

Experiments on the excitation of Alfvén type of MHD instabilities and their effect on fast particles have been continued and extended. A significant extension of the measurements of fast particle effects with enhanced diagnostic capabilities (Fast Ion Loss Detector, Collective Thomson Scattering and Neutral Particle Analyzer) has been implemented. In addition to the mainly ICRH-generated fast particle excitation an indirect excitation scheme with so-called beatwaves, also generated by the ICRH system, has been re-established and widely used. Two ICRH launchers are operated with slightly de-tuned frequencies, so that the two waves are mixed within the plasma and form a beating standing wave. A time-dependent variation of the applied frequency difference allows a dedicated scan for Alfvén or any other resonances within the plasma. Previously a perturbative variation of plasma parameters, such as density or magnetic field, has been used to vary the resonances themselves. A frequency range from 50 kHz to 400 kHz has been applied in order to scan a variety of resonances. This spans the low to intermediate frequency TAE activity located close to the plasma edge ($\rho_{pol}$~0.7-0.8) at around 100-150 kHz, the usual high frequency TAE activity at ~200 kHz deeper inside the plasma and the high frequency n=0 kinetic Alfvén modes at 350-400 kHz (collaboration with Univ. of Sao Paulo, Brasilia).

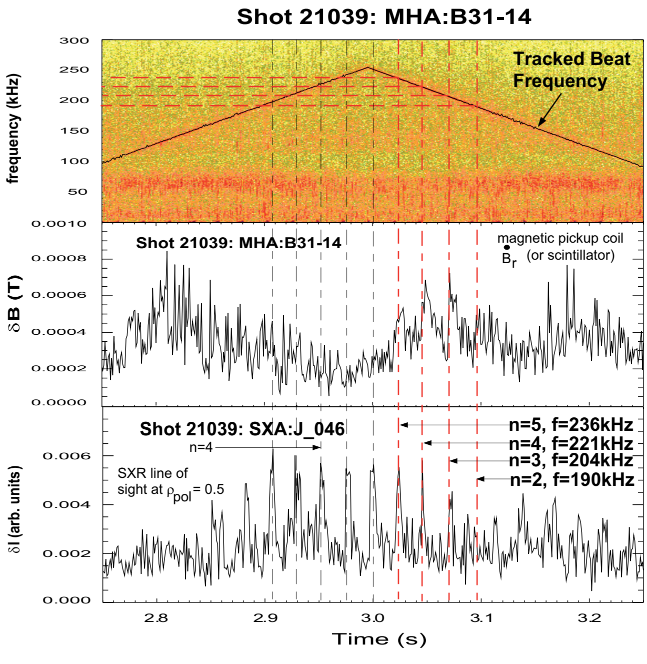



*Figure 14: Spectrogram of a line of sight of Soft X-ray through the maximum of the TAE eigenfunction and a magnetic pick-up coil at the low field side. Both signals show the externally driven beatwave. The amplitude of the tracked beatwave frequency, especially on the Soft X-ray diode, shows the Alfvénic plasma resonances.*

A typical example is shown in figure 14, where the TAE resonances could be clearly observed on the Soft X-ray diagnostic and less distinctly on the magnetic measurements. Another type of instability under investigation is the β-induced Alfvén activity, which includes kinetic effects of the ions. The observed resonances are the same as the purely fast particle-driven TAEs. In both excitation schemes the localisation of these modes has been used for an improved q-profile reconstruction (collaboration with Univ. of Cork, Ireland). The identification of resonances excited by the beatwaves, which are not excited by the fast particles alone, is an ongoing task not yet completed. In all beatwave experiments fast ion losses have been observed between the resonances.

### 7.5 Fast Particle Destabilised Sawteeth

The sawtooth crash is one of the fundamental instabilities in tokamaks which is a result of growing (1,1) modes. Long period sawteeth have been observed to result in the low-β triggering of neoclassical tearing modes (NTMs), which can significantly degrade plasma confinement. Such big sawteeth were first observed in JET and called “monster sawteeth”. Experiments in AUG also demonstrate triggering of NTMs by “monster sawteeth”. In ITER, the stabilising effects of the fusion-born α particles are likely to exacerbate this.

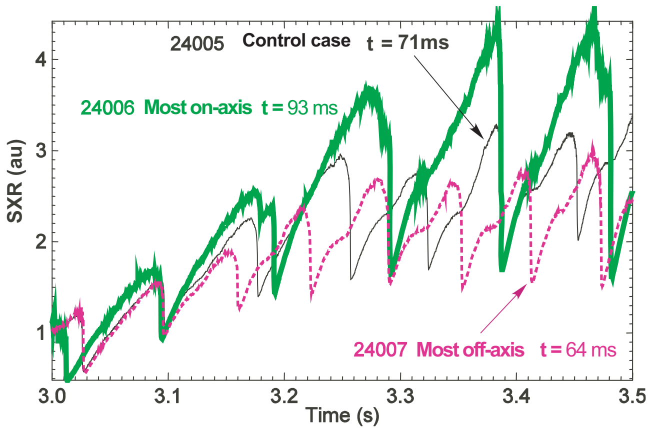



*Figure 15: Signal from a central SXR chord for discharges with different direction of NBI. The dominant position of NBI produced fast particles is indicated. In all cases the distribution of fast particles from ICRH is mainly on axis. The most off-axis case has most frequent and the smallest sawteeth.*

Consequently, in order to avoid triggering NTMs, many techniques have been proposed to control, and in particular, to destabilise the sawtooth oscillations. During last year’s experiments in AUG, the fusion born α particles were simulated with ICRH heated ions. Such heating leads to long periods between the crashes and big amplitudes of the crash. The NBI fast particles were deposited inside and outside the q=1 surface to investigate the influence of the energetic particles on the sawtooth crash. The position of the fast particle deposition with respect to the q=1 surface was changed in two different ways: (i) by changing the toroidal magnetic field; (ii) by changing NBI direction geometry. It is found that the energetic particles born outside the q=1 surface due to off-axis NBI can destabilise the sawteeth, even in the presence of stabilising on-axis fast particles as shown in figure 15.

### 7.6 Mechanism of the Sawtooth Crash

In spite of the long history of the sawtooth research and development of robust techniques for triggering of the sawteeth, the exact mechanism of the crash is still an area of active research and no final model of the crash is available. Detailed studies of the pre-crash phase in AUG show that in some cases this phase has characteristic signatures of the transition into a stochastic stage. This transition corresponds to the quasiperiodic variant with two independent frequencies, one of which is the frequency of the sawtooth precursor instability. This supports results of previous investigations, i.e. that the amplitude of the perturbations before the crash is sufficient for creation of a stochastic region.

### 7.7 Fast ECE and Mirnov Measurements for Real-Time NTM Control

A feedback control system for the real-time detection and suppression of MHD modes such as neoclassical tearing modes (NTMs) is being implemented. The control loop determines mode locations using real-time diagnostics and updates ECRH mirror angles accordingly such that heating power is deposited at the mode. The loop time must be less than 100 ms, a typical growth time for NTMs on AUG. NTMs are located using the 60-channel electron cyclotron emission (ECE) radiometer. A radial electron temperature profile is measured with spatial resolution ~1 cm and sampling rate 1-2 MHz. $T_e$ fluctuations at the NTM rotation frequency (~25 kHz) are observed. These fluctuations exhibit 180 degrees phase difference across the NTM, and the ECE channel in the middle of this phase jump is associated with the center of the mode. For a robust measurement of this ECE signature in real-time, the radiometer signals are correlated with mode-specific Mirnov coil signals. The phase jump manifests as a zero-crossing of the correlation profile. Simultaneous measurement of the ECE and Mirnov signals using a single data acquisition system was accomplished for the first time in 2008, and the correlation algorithm to be used in real-time was applied off-line to these data. The result was successful, stable tracking of (3,2) NTMs (see figure 16). The ECE channel number is passed to a real-time equilibrium solver, yielding physical coordinates of the mode location. Real-time ECRH beam tracing predictions then lead to an updated mirror angle, completing the loop. Closed-loop NTM suppression is envisioned for the 2009 campaign.

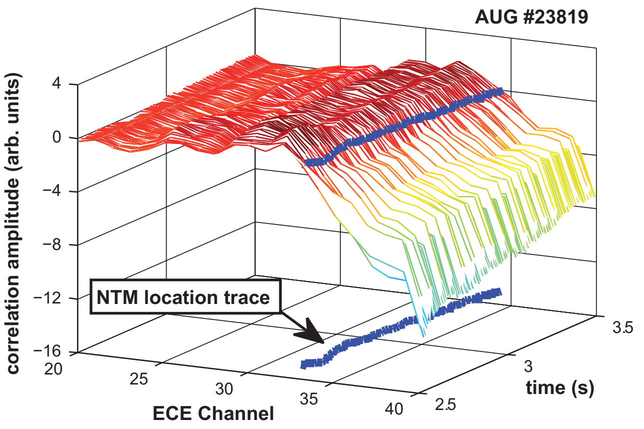



*Figure 16: Time series of ECE-Mirnov correlation profiles for a discharge with a (3,2) NTM. The ECE channel closest to the center of the NTM is shown by the blue trace, which follows the evolution of the zero-crossing of the profile.*

### 7.8 Profile Analysis

The concept of Integrated Data Analysis (IDA) within the framework of Bayesian probability theory was applied to the combined analysis of Lithium beam emission spectroscopy, DCN interferometry, electron cyclotron emission, and Thomson scattering spectroscopy. The 4 heterogeneous diagnostics enable the simultaneous estimation of electron density and temperature profiles. The analysis of Lithium beam and DCN interferometry data results in full density profiles with a temporal resolution of 50 µs, thereby enabling to resolve spatial and temporal fine structures during ELMs (see figure 17).

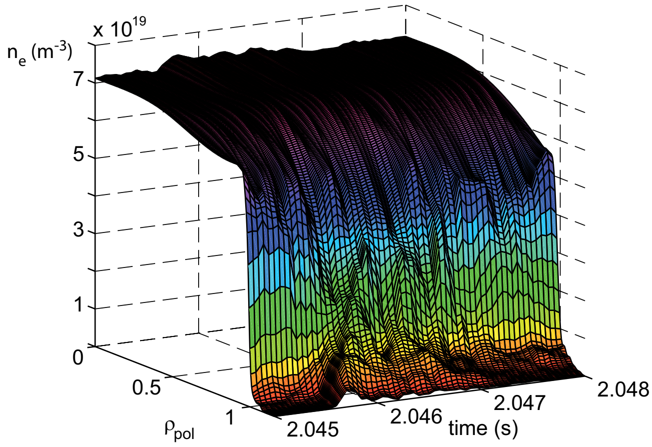



*Figure 17: Temporal evolution of the density profile of an ELM (# 22561, t=2.044-2.048 s) from the combined analysis of LIB and DCN interferometry data with a time resolution of 50 µs*

The combined analysis of the 4 profile diagnostics allows to consider diagnostic interdependencies correlating both profiles, e.g. ECE shine through. The diagnostics are mapped on a common coordinate system with Cliste equilibria with a temporal resolution of 1 ms, which have been written routinely into the AUG data base for some time now. A necessary and sufficient condition for IDA is a forward model and a systematic and unified error analysis of the diagnostics measurements. IDA provides error propagation beyond single diagnostics and more reliable results due to larger data sets exploiting data interdependencies and synergism. Redundancies provided by the joined analysis of heterogeneous diagnostics allows one to resolve data inconsistencies for obtaining global data consistency among a set of diagnostics.

### 7.9 Turbulence *k*-spectra & GAMs

The GAM amplitude (an $E \times B$ oscillation) – studied using Doppler reflectometry – is a complex function of turbulence drive, collisional/Landau damping, geodesic & sound-wave coupling. The GAM amplitude rises with $q$ (consistent with theory) for circular plasmas, but is reduced with elongation – implying a magnetic shear role. With the turbulence drive (flux normalized $\nabla T_e$) the GAM increases linearly through Ohmic and L-mode, with a corresponding decrease in energy confinement, up to the H-mode transition. The GAM amplitude prior to the transition is substantial, >30 % of the mean $E \times B$ flow which, as predicted by turbulence simulations, should moderate the turbulence radial correlation length. However, the causality between turbulence and the GAM, and its role in triggering turbulence self suppression in H-mode remains unclear. The turbulence $k$-spectra behaviour has been studied in the plasma edge & mid-core using the steerable antenna and W-band reflectometer. The $k_\perp$-spectra have a power law $k^{-\alpha}$ dependence with $\alpha$~4 across the L-mode edge/core, but rising to 7 in the H-mode core. The turbulence also falls towards the core, occurring entirely at low $k_\perp$ in L-mode, while in H-mode both low and high $k_\perp$ are reduced (by factor of 10) across the core. The expected turbulence suppression in the H-mode gradient region occurs also at low $k_\perp$, but is accompanied by an increase at high $k_\perp$ – indicating enhanced $E \times B$ velocity shearing breaking up the turbulent eddies. The additional high $k_\perp$ reduction in the H-mode core may result from the density profile flattening inside the pedestal, which essentially reduces the drive for TEM-like turbulence and/or non-linear effects such as spectral energy transfer/cascade and geodesic coupling to GAMs.

## 8 Pedestal, Edge and Divertor

### 8.1 Arc Investigations

In-vessel inspections of AUG reveal arc tracks at different locations. In particular at the transition and retention module of the inner divertor, they were found around the whole toroidal circumference. A representative tile was investigated with profilometry, SEM, EDX, RBS, and colorimetry. Arc tracks with a direction nearly perpendicular to the inclination of the local magnetic field and an area fraction of 12 % were found in a 10 mm wide region near the edge of the exposed part of the tilted target. Here the tungsten coating (3-4 µm) is removed in the arc tracks and a small amount of carbon (max. depth 1-2 µm) is eroded (see figure 18). Droplets are detected at the surface. Extrapolating from a single tile to the whole divertor, 2 g tungsten or 108 droplets (5 µm diam.) are eroded in the inner divertor. The region of the inner divertor where the arcs are observed shows a local enhancement of plasma density, $n_e \approx 10^{20}$ $m^{-3}$, and neutral pressure, 0.1 mbar, favouring the arc ignition. A high sheath potential at the beginning of an ELM might trigger the arc. The arc pattern and the target load as measured with a fast IR-camera coincide.

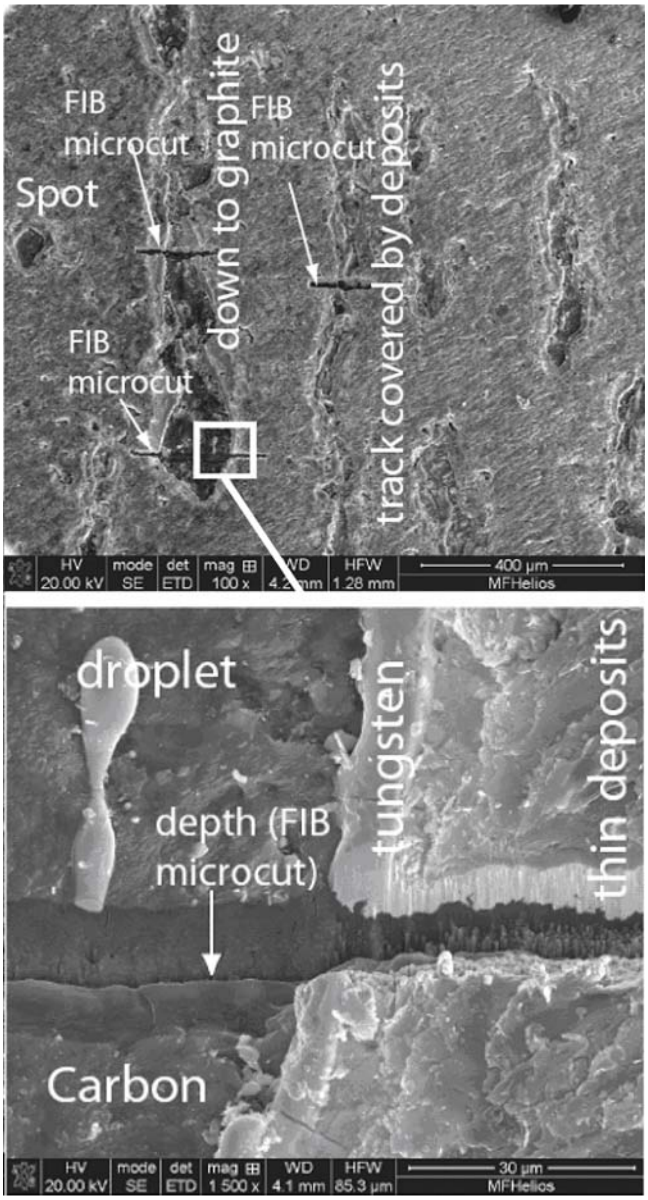



*Figure 18: SEM pictures of the divertor region with arcs and FIB cross-section (zoom) showing that there is almost no erosion of carbon at the bottom of the arc track*

### 8.2 Measurements of Neutral Gas Flux Density

The pressure gauge system has been recently upgraded. It now includes 2 new flux measurements in the inner divertor region for a total of 20 gauges. In particular, two gauges are connected to the front of the (inner and outer) target plates through a chimney and measure directly the recycling in front of the targets. Detailed neutral flux density distributions have been obtained in L-mode plasmas at low and high plasma density (with respect to the threshold density for outer target detachment). At low density, the inner target is the dominant source of neutrals to the sub-divertor, resulting in an in-out asymmetry of neutrals in the divertor in qualitative agreement with numerical simulations. At high density the outer target becomes the dominant source of neutrals in qualitative contradiction with the simulations which predict still larger fluxes in the inner divertor.

### 8.3 Divertor Plasmas While Going from C to W PFCs

The influence of the PFC material on the outer divertor plasma was investigated. Only plasmas more than 40 discharges after boronisation are taken into account in order to exclude related artefacts. For the comparison of C and W PFCs H-mode discharges with $I_p$=1 MA, $B_t$=-2.5 T, $n_e$=8.2·$10^{19}$ $m^{-3}$ and $P_{NBI}$=5 MW with constant $W_{mhd}$ were used. After reaching a full W machine the scatter in the ion saturation current ($j_{sat}$) and $T_e$ was stronger than before as measured at the LFS limiters and the divertor, indicating a stronger variation of the divertor plasma with ELMs. Looking at time averaged profiles the peak values of $j_{sat}$ increased by about 20 % with the W coverage of the LFS limiters. While the $n_e$ peak value stayed about the same, both the $j_{sat}$ and $n_e$ profiles broadened. The most obvious change occurred for $T_e$ going from a rather flat profile with a maximum outside the separatrix at 7 eV to a peaked profile with a peak value of about 14 eV. Concerning the detachment in Ohmic discharges during $n_e$ ramps, there was no change in $n_e$ at the time when the $j_{sat}$ roll-over sets in going from C to W PFCs.

### 8.4 Divertor Detachment

For Ohmic discharges experimentally the qualitative behaviour of the peak ion flux density at the outer and inner target is independent of the material of the plasma facing component. At the outer target the peak ion flux density increases with rising line averaged density, saturates and then decreases, signalling detachment, whilst at the inner target it decreases steadily ultimately reaching complete detachment.

Simulating detachment has been continued using the SOLPS5.0 code package. A limited conductivity below the dome of the divertor for neutrals combined with activated drift terms establishes an asymmetry in the peak ion flux density between the inner and outer target. Neutrals connect the behaviour of the plasma at the inner to the outer target. For the outer divertor target a roll over of the peak ion flux density can be simulated and the absolute value can be adjusted, using parameters not yet experimentally verified. However for the inner target a decrease of the peak and integral ion fluxes cannot be obtained in the model. The role of enhanced radial transport in the detachment at the inner target is being studied.

### 8.5 ELM Power Load Asymmetry

The observation of the larger fraction of ELM loss energy to be deposited on the inboard divertor with normal (i.e. ion B×∇B drift towards active X-point) field direction in AUG and other devices is not understood. Making use of the unique possibility in AUG to inverse solely the toroidal magnetic field in upper X-point magnetic configuration the ELM power loading is found also to inverse the observed inboard/outboard balance. A possible explanation of the ELM power load asymmetry is elaborated by taking into account the pedestal plasma rotation setting the initial Mach number of released particles during ELMs when projected SOL field line inclination. A simple expression is derived describing the power deposition at the divertor target plates in the limit of entirely force free convective transport of particles along open field lines in the SOL taking the initial Mach number into account. This model of free streaming of a Maxwellian distribution released on a negligible time and parallel distribution length compares reasonably well with experimental data.

### 8.6 ELM Resolved Edge Profile Measurements

Electron density profiles from IDA (integrated data analysis of Lithium beam measurements and DCN interferometry) exhibit largely reduced pedestal top uncertainties with profiles available every 50 µs. The high resolution equilibrium reconstruction, taking into account scrape off layer tile currents, renders equilibria on a 1 ms time base. These equilibria are used to map IDA $n_e$ profiles together with electron temperature profiles from the ECE diagnostic to the midplane, providing a new quality of datasets for investigations of fast events such as ELMs. Detailed analysis, taking into account the complex changes in equilibrium and the concurrent reduction in plasma size, suggests that after an ELM crash $T_e$ profiles adjust very quickly to the new separatrix position, with not only the gradient but also the absolute values already recovered when the density gradient is still flat. Such data will allow distinguishing between ELM models, such as convective or conductive regimes.

### 8.7 Pressure Balance between Midplane and Divertor

The good edge diagnostic coverage allowed comparison of the electron pressure in the outer midplane and along the divertor target for different degrees of partial detachment as shown in figure 19. The divertor pressure $n_eT_e$ obtained from the Langmuir probes has been multiplied by a factor of 2 to take into account the dynamic pressure of a Mach=1 flow. While quite good pressure balance is obtained in the outer SOL for inter-ELM conditions, a strong pressure drop around the strike point is observed which extends further into the SOL with increasing neutral flux or decreasing heating power. The inner divertor is fully detached for the conditions of figure 19.

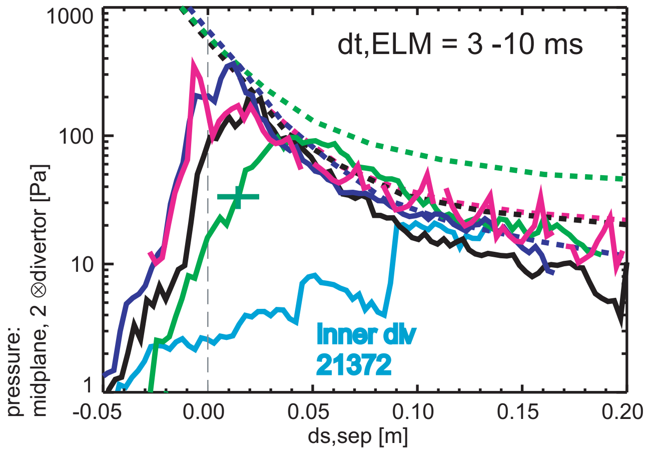



*Figure 19: Inter-ELM electron pressure in the outer midplane mapped to the outer divertor target (dashed lines) versus 2 times the divertor electron pressure from Langmuir probe measurements (solid lines) for different gas puff levels. The pressure along the inner divertor target is shown for a similar discharge for comparison.*

### 8.8 Tungsten Influx and Penetration

Campaign integrated spectroscopic tungsten erosion fluences in the outer divertor were compared with the net W erosion obtained from Rutherford backscattering measurements of marker tiles with a thin tungsten stripe on carbon. The fluences from the two measurement methods were in very good agreement giving further confidence in the spectroscopic influx determination. The largest erosion rates of tungsten due to plasma impact are observed at the strike point tile of the outer divertor. The ratio of erosion during ELMs to erosion in-between ELMs depends mainly on the target temperature in-between ELMs and varies between 40 % for low recycling discharges to >80 % for high recycling conditions.

In the main chamber, the most important tungsten sources originate from the central column and the limiters at the low-field side. The central column is the larger W-source in the majority of the discharges, because it is usually situated on a flux surface with lower distance to the separatrix. Correspondingly, when the plasma column is shifted to the low-field side, such that the outboard limiters become the first limiting structure, the behaviour is reversed. During such a shift, the tungsten concentration in the main plasma varies in phase with the modulation of the influx from the low-field side limiters (figure 20). Thus, the tungsten penetration from the low-field side plasma facing components is more efficient than from the central column.

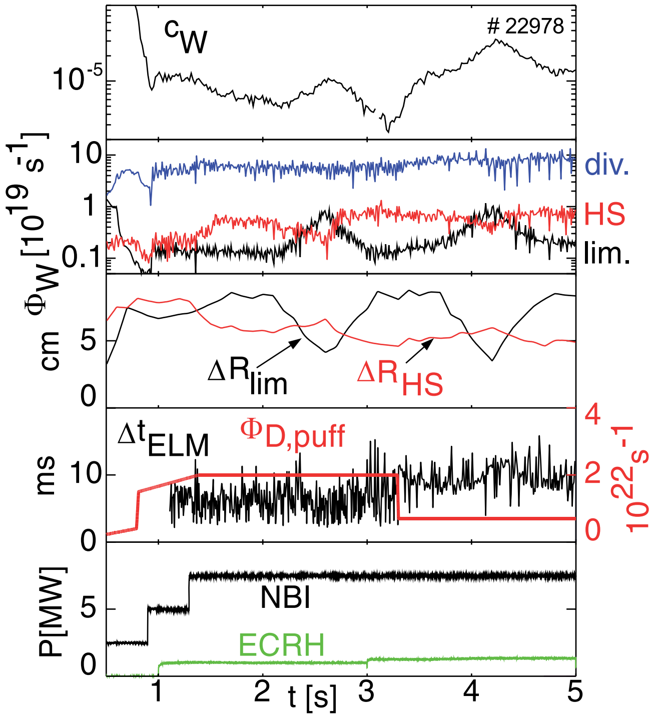



*Figure 20: Time traces for discharge # 22978 with variations of the outer separatrix radius at two levels of gas puffing. The W concentration $c_W$ varies in phase with the W-source rate $\Phi_W$ from the outer limiter. After reducing the puff level, the source rates are at the same level, however, the ELM period and $c_W$ increase pointing to an enhanced penetration.*

### 8.9 W Sputtering due to ICRF

Four experimental ways were found that to some extent decrease W concentration during operation of ICRF: 1) increase separatrix-antenna clearance; 2) increase gas puff; 3) optimize phase difference between two neighbouring antennas; 4) decrease content of intrinsic light impurities. Spectroscopic measurements confirm the result from HFSS code calculations, that the box currents play a dominant role in formation of parallel voltages on the magnetic field lines connected to the antennas. Furthermore, a reasonable agreement can be found between shapes of the vertical profiles of the measured effective sputtering yields and the predicted parallel voltages. This encourages using the calculations to design an antenna with reduced parallel near-fields $E_{||}$ and the following approaches should be used: 1) avoid radially protruding antenna elements; 2) implement surfaces parallel to the magnetic field where possible to impose $E_{||}=0$ boundary condition; 3) increase the average distance between antenna straps and box; 4) balance the counteracting (0 $\pi$)-phased contributions of the image currents on the antenna box.

### 8.10 Scale Lengths of inter-ELM Fluctuations

Large scale fluctuations of electron density and temperature in the pedestal were analysed by Thomson scattering measurements: The histograms of the fluctuations are symmetric roughly in the middle of the pedestal and have negative, or positive, skewness further inwards, or outwards, respectively. The radial diameters of the fluctuating structures scale with the large hybrid scale between ideal and resistive MHD. Additionally, the heat transport in the pedestal was analysed. No strong correlations between the heat diffusivity and the large scale fluctuations of electron density or temperature were found. The heat diffusivity, however, scales well with the smallest available scales of the underlying turbulence. In summary, two different turbulent phenomena were investigated, which act simultaneously, but on different scales, as predicted by simulations of drift-Alfvén turbulence.

## 9 Stuttgart University

### 9.1 Blob Dynamics around the Separatrix

The generation and propagation of intermittent structures or blobs close to the separatrix and in the SOL was investigated in ECRH heated L-mode, an ELM-free H-mode and Ohmic discharges at two different density levels. A reciprocating Langmuir probe array crossed the separatrix by one centimetre and measured profiles and fluctuations of ion-saturation current and floating potential as well as the electron temperature. Additional fluctuation data was obtained by fast imaging of the probe head in the visible and IR range. The results suggest an interchange mechanism that generates blobs and holes slightly inside the separatrix. Poloidal propagation velocities of density perturbations are obtained from correlation analyses of the probe data. Two discrete values dominate the radial profile with a crossover region where both phase velocities are present. Similar results were obtained from experiments in the low-temperature plasma of the torsatron TJ-K in Stuttgart.

### 9.2 O2 and X3 Heating

ITER-relevant plasmas with a safety factor of $q_{95}$ of about 3 have rather high densities, and the 140 GHz ECRH in X2-mode goes into cut-off. A remedy is to launch ECRH in O2- or X3-mode (for lower magnetic field). Both modes have the disadvantage of an imperfect absorption. Therefore, a holographic reflector at the inner wall is needed to refocus the reflected beam in the correct polarisation and into the desired direction for a second pass through the plasma. In this scenario, absorption of approximately 93 % are achievable. For the next campaign, two such reflectors have been designed especially for long-pulse O2-mode heating. With the X3-mode, a new secure operation regime at an on-axis magnetic field of 1.8 T was accomplished. Here, the X2-resonance lies at the high-field side and acts as beam dump for the non-absorbed X3-power.

### 9.3 Doppler Reflectometry Simulations

Doppler reflectometry is an important diagnostic for density fluctuations and poloidal flows on fusion experiments. For the interpretation of fluctuation data, the dependence of scattered power on the fluctuation strength needs to be calculated with numerical methods. IPF-FD3D is a fullwave code that simulates wave propagation and scattering in magnetised plasmas. In 2008, extensive simulations for O- and X-mode in slab geometry were carried out that show that the scattering efficiency depends strongly and non-linearly on the density gradient length, the probed wave number, the polarisation, and the density fluctuation strength. These results make it possible to recover the original turbulent density fluctuation spectrum from a Doppler reflectometry measurement. Similar simulations of plasmas in AUG geometry have been carried out for several plasma parameters. They will be used to refine experimental results for density fluctuation spectra.

## 10 International & European Co-operations

### 10.1 IEA Implementing Agreement

The role of the Implementing Agreements (IA) as a vehicle to enable joint experiments proposed by ITPA is a very important one. AUG contributed to many joint experiments in 2008. In addition, the AUG programme responded quickly to urgent ITER research needs. A detailed study of plasma breakdown and current ramp-up with low loop voltage using ECRH assist for breakdown was conducted. The latter showed reliable ECRH breakdown in the ITER scenario (scaling to O1 ECRH at 170 GHz) and ramp-up at low electric field of 0.25 V/m (ITER design value: 0.33 V/m). These experiments were done together with visiting scientist from FZ Jülich/ERKM, IST and KAERI (South Korea). Together with similar experiments at JET and DIII-D they form a sound basis for the ITER plasma ramp-up scenario.

The AUG programme also reacted promptly to the ITER request to study the L→H transition in hydrogen and helium plasmas. Plasmas of this kind are of great importance for the first operating phase of ITER without radioactive activation. In July a phase with helium plasmas was accomplished. The results show that the H-mode threshold in helium is hardly different from the one in deuterium and possesses a pronounced minimum at line-averaged densities of $4.5 \cdot 10^{19}$ $m^{-3}$.

### 10.2 EURATOM Associations

The participation of scientists from 14 EURATOM Associations in the 2008 AUG experimental campaign continued to stay on a similar level as in previous years. In the last two years the fraction of AUG related publications in referred journals with an external first-author, mainly from EU fusion labs, has reached 35 % and demonstrates the sustained high level of EU participation in the AUG programme.

**DCU – University College Cork:**

Progress made during 2008 in the context of the ongoing collaboration is summarized as follows: The CLISTE code has been converted to FORTRAN 90 as a first step in complying with the EFDA ITM taskforce software standards, including data i/o structures. Work has commenced on making the code machine independent by removing AUG-specific data structures embedded in the code. The predictive Garching Equilibrium Code, a subset of CLISTE, now stores SOL profile information in AUG shotfiles for both AUG and ITER equilibrium calculations.

Several aspects of fast ion excited TAEs were explored, such as the effect of magnetic shear and density on the observed toroidal mode numbers, and the decay and growth rate of individual TAEs. In particular, the ICRF power-density TAE threshold was observed to be dependent on the toroidal mode number n. Additionally, fast ion pressure profiles generated by the ICRF power deposition codes PION and TORIC, and the equilibrium code CLISTE were used to estimate the TAE fast ion drive rates. In addition to the well known fast ion broadband excitation of TAE, an indirect selective excitation scheme through ICRF beatwaves has been shown to provide the means to scan for Alfvén resonances within the plasma. Once the observed TAE, either excited by fast ions or driven by ICRF beatwaves, were identified and localised, q-profile information was extracted and successfully used to constrain CLISTE equilibrium reconstructions.

Work has commenced on a PhD topic to study the influence of fast particles distributions on the beta limit using gyrokinetic simulations and the CLISTE code.

**ENEA:**

A technique to delay the occurrence of disruptions by localized deposition of ECRH power has been tested on AUG. More details can be found in section 5.

**HAS – RMKI, Budapest:**

The ongoing collaboration between IPP and EURATOM HAS resulted in the following main advances:

The triggering mechanism of ELMs was investigated by comparing the pellet-induced MHD activity in ohmic, type-III and type-I ELMy discharges. The signals of magnetic pick-up coils were studied by Fourier, wavelet and mode number analysis. Pellets were observed to induce broadband Alfvén waves, and decrease the dominant frequency of a stable TAE oscillation in Ohmic plasmas. The installation and successful commissioning of the blower gun pellet injector allowed the injection of slow pellets from the LFS. Type-I ELM triggers with LFS injected pellets were observed.

The effect of pellet injection on the temperature profile was studied with the ECE radiometer diagnostic. The cooling effect of the pellet was distributed on the flux surfaces on a 10 µs timescale, and a cooling front was observed, travelling radially inward together with the pellet. A temperature drop up to few hundred eV was detected even on the 0.9 poloidal flux surface.

The HFS pellet ablation database was complemented by two single parameter scans: the magnetic field ($B_t$=1.8-3 T) and the electron temperature ($T_e^{edge}$=0.26-0.79 keV) were varied and the other plasma parameters have been kept as constant as possible. The results confirmed the importance of the magnetic field in the pellet penetration depth scaling.

A new heater element and thermoionic emission material was developed with the aim to provide higher intensity for Li-beam diagnostics. The source could produce currents in the range 8-10 mA, but further testing is needed to find the optimal setup. For Li-beam emission spectroscopy a fast 4-channel photomultiplier system was built for plasma turbulence measurements and observation of other fast phenomena like ELMs. The analysis of these new measurements on AUG is pending.

**Hellas:**

A significant effort was invested to re-establish a reliable NTM scenario in a low triangularity purely beam heated conventional ELMy H-mode scenario. The latter was not only intended to serve for NTM physics investigations, but in particular as one of the target scenarios for NTM stabilisation experiments. The excitation of either a (3,2) or (2,1)-NTM was successful. However, it was not possible to keep these modes long enough stationary for NTM stabilisation experiments. Most of the discharges suffered from increasing radiation and density peaking. To avoid this problem discharges were performed after a fresh boronisation. However, this was leading to a critically high heat load in the divertor, which was mitigated by dedicated $N_2$ puffs. But all this measures were still not leading to stable conditions.

**IST – Centro de Fusão Nuclear:**

Operation of the swept FMCW reflectometer system was limited in the last campaign by the ongoing absence of 105 GHz waveguide protection filters, which necessitated the switching-off of the system during some periods of ECRH operation. HFS data was also restricted to two channels due to radiation damage in two vessel waveguide couplers. An ECRH compatible FM system with bistatic antennas using X-mode operation has been proposed. The installation of new AUG control coils beginning 2010 will necessitate rerouting of the in-vessel HFS/LFS waveguides. Alternate options were studied.

New tools for density profile evaluation were developed to provide monotonic density profiles routinely with estimates of measurement error bars. Significant effort has been devoted to the development of a dedicated acquisition and processing system for real time evaluation of the plasma position, aiming at a full demonstration of reflectometry usage for control purposes, as foreseen for ITER. The experiments should be performed by mid-2009. Main plasma physics studies during 2008 were: (i) Finalizing the investigation of HFS/LFS density profile changes during pellet induced ELMs and their impact on confinement; (ii) Analysis of edge MHD modes in H-mode discharges with different heating power (ICRH and NBI) in LSN discharges; (iii) First measurements of the poloidal velocity of edge modes using poloidal correlation techniques.

Experiments with Alfvén wave (AW) excitation by ICRH beatwaves were conducted, see section 7.4 for more details.

**RISØ:**

Collective Thomson scattering (CTS) provides spatially and temporally resolved measurements of the 1-D fast ion velocity distribution. The hardware commissioning of the CTS diagnostic at AUG was successfully completed in early 2008. Overlap scan experiments have shown that the alignment agrees to within 1° between experiment and calculation. A significant portion of experiments in 2008 was dedicated to study the unexpected spurious signals that appear in the scattering data. Dedicated experiments were carried out and identified some physics behind the spurious signals and also concluded that their presence is compatible to CTS's capability to measure fast ions at different scattering geometries and heating powers of up to 7 MW. Preliminary scattering experiments were then done to study ion physics for different NBI sources at two different pitch angles and scattering volume locations.

**ÖAW – University of Innsbruck:**

In collaboration with ENEA-RFX and RISØ a new probe head with six Langmuir pins and one triple magnetic pick-up coil was developed and mounted on the AUG midplane manipulator. In February and May 2008 measurements with this probe head in 11 successful shots were made. The Langmuir pins are mounted in the front side of the graphite probe head. The magnetic pick-up coil is mounted inside the graphite case about 20 mm behind the front. With this arrangement the radial turbulent transport and the plasma density were determined and correlated in particular with the poloidal and radial magnetic signals and with the $D_\alpha$-line intensity at the inner and outer divertor during several H-mode shots. During one shot an H→L-mode transition was captured.

Several series of type I ELMs with a repetition frequency of about 100 Hz were investigated. The steepness of the integrated flux yields excellent insight into the strong difference of flux during ELMs and in between ELMs. On an extended time scale it was shown that each ELM consists of about 10 single events interpreted as current filaments moving radially and toroidally. It is remarkable that strong positive current filaments, indicating strong radial transport, are usually immediately followed by (less) strong negative (inward) transport. Using the radial and poloidal magnetic fluctuation data of shot # 23161 it was also shown that ELM current filaments indeed appear as loops in the poloidal-radial magnetic fluctuation plane indicating current filaments roughly perpendicular to this plane. An oral contribution was presented at the International Congress on Plasma Physics in September 2008 in Fukukoa, Japan.

In collaboration with the IPP.CZ also a ball-pen probe with four probe collectors, retracted with various depths, was used in the edge region of AUG. The floating potential of the probe collectors assume the value of the plasma potential when the magnitudes of the electron saturation current become equal to those of the ion saturation current due to the screening effect of the probe head in the toroidal magnetic field. A contribution was presented at the Plasma Surface Interaction Conference in May 2008 in Toledo, Spain.

**TEKES:**
The collaboration with the Finish Association in 2008 can be subdivided in plasma wall interaction studies and in fast particle physics activities. Global $^{13}C$-puffing experiment were conducted in July. In addition, a series of ion-beam measurements related to erosion and deposition studies were done at the accelerator lab of IPP. In particular, one collector probe and six samples of the wall tiles, previously analyzed with the SIMS technique, were investigated using nuclear reaction analysis (NRA). In addition, a new version of DIVIMP was developed, with generous help from IPP's MF department, to model the global migration of carbon in the $^{13}C$-puffing experiments at AUG. Local $^{13}C$-puffing methane injection experiments have been conducted in the divertor region, and the resulting carbon deposition pattern has been measured with both NRA and colorimetry. Corresponding numerical modelling with the 3D code ERO were carried out, employing a plasma background calculated with SOLPS.
Together with IPP experts TEKES has been involved in the improvement of the data acquisition system (DAQ) of the FILD diagnostics and automated the fast DAQ system for the NPA diagnostics. With the latter the search for signals due to MHD-instabilities and edge radial electric field has started.
Motivated by results from DIII-D an experimental proposal was devised to try and achieve Quiescent H-mode (QHM) operation at AUG with NBI co-injection. Following the DIII-D recipe very low density with a maximum of edge rotation was required. Such discharges were tried right after a boronization. Unfortunately, the QHM session was plagued by various problems, and the only ELM-free phases achieved were of classical type.
Issues related to upgrades ASCOT concerning the inclusion of non-neoclassical effects (MHD and anomalous transport) in fast ion modelling were studied, together with experts from the Tokamak Theory division of IPP.

**UKAEA:**
Collaboration between the AUG and MAST teams in 2008 was centred on three main activities linked to co-ordinated experiments in support of the ITPA, under the auspices of the IEA Implementing Agreements. Experiments in support of PEP-06 'Pedestal structure and ELM stability in DN' have been performed on AUG. A new stable DN (double null) scenario was developed at 1 MA for the limited power available in this campaign. The confinement in the DN phase increased with respect to the upper SN (single null) phase leading to overheating of the lower divertor tiles with subsequent tungsten influx and radiative collapse in the DN phase. In later experiments, the divertor temperature was controlled by $N_2$ seeding, but this led to confinement that was too good in DN, such that density peaking could not be avoided with the available ECRH power. This again led to impurity accumulation and radiative collapse. Further experiments will be carried out with increased ECRH power.
In support of PEP-10.1 'Relationship between the fraction of ELM power arriving at the target and filament radial propagation', measurements of the radial velocity of ELM filaments have been made using several techniques and as a function of ELM size, including measurements in the $N_2$ seeded discharges. The radial velocity was found to have a weak dependence on ELM size but to increase with the density of an individual filament.
Experiments have also been carried out in support of MDC-5 'Comparison of sawtooth control methods for neoclassical tearing mode suppression'. Since long sawteeth are more likely to trigger deleterious NTMs, techniques have been developed to deliberately destabilise them, including off-axis NBI. AUG is equipped with two tangential NBI sources, which provide a source of fast ions near the plasma mid-radius. The angle of injection has been varied in order to scan the fast ion deposition location. As the deposition was moved further off-axis the sawtooth period decreased, in good accordance with analytic theory that predicts enhanced destabilisation due to passing energetic ions outside the mode's rational surface.

## 11 Scientific Staff

**Tokamak Scenario Development (E1):** C. Aubanel, K. Behler, N. Berger, H. Blank, J. Boom, A. Buhler, A. Cardella, P. Cierpka, I. Classen, G. D. Conway, R. Drube, M. Ebner, H. Eixenberger, K. Engelhardt, H. U. Fahrbach, A. Flaws, J. C. Fuchs, M. García Muñoz, L. Giannone, B. Gmeiner, O. Gruber, A. Gude, T. Härtl, A. Herrmann, J. Hobirk, V. Igochine, K. Iraschko, M. Kaufmann, B. Kleinschwärzer, H. Kollotzek, H. Kroiss, P. T. Lang, P. Leitenstern, F. Leuterer, A. Lohs, K. Mank, M. Maraschek, K. McCormick, B. Mendelevich, R. Merkel, V. Mertens, A. Mlynek, F. Monaco, P. Müller, M. Münich, U. Mszanowski, G. Neu, J. Neumann, A. Peacock, G. Prausner, M. Prechtl, G. Raupp, M. Reich, M. Rott, F. Ryter, G. Schall, G. Schramm, K.-H. Schuhbeck, J. Schweinzer, U. Seidel, G. Sellmair, O. Sigalov, A. C. C. Sips, R. Stephan, J. Stober, B. Streibl, G. Tardini, W. Treutterer, C. Tröster, L. Urso, T. Vierle, F. Volpe, S. Vorbrugg, D. Wagner, W. Weissbart, C. Wittmann, M. Wolf, D. Zasche, T. Zehetbauer, H. Zohm.

**Tokamak Edge and Divertor Physics (E2):** K. Behringer, R. Dux, T. Eich, J. Fink, R. Fischer, M. Gemisic Adamov, G. Haas, J. Harhausen, N. Hicks, L. Horton, M. Janzer, A. Kallenbach, B. Kurzan, B. Langer, T. Lunt, C. Maggi, P. de Marné, H. Meister, H. W. Müller, H. D. Murmann, R. Neu, J. Neuhauser, T. Pütterich, R. Pugno, B. Reiter, V. Rohde, W. Sandmann, A. Scarabosio, A. Schmid, M. Sertoli, K.-H. Steuer, W. Suttrop, M. Wischmeier, E. Wolfrum, D. Yadikin.
**Tokamak Physics Division:** C. Angioni, V. Belmondo, A. Bergmann, R. Bilato, A. Bottino, T. Breu, M. Brüdgam, A. Chankin, D. P. Coster, T. Görler, S. Gori, S. Günter, T. Hauff, T. Hein, M. Hölzl, F. Jenko, O. Kardaun, H.-J. Klingshirn, C. Konz, K. Lackner, P. Lauber, P. Martin, P. Merkel, F. Merz, G. Pautasso, G. Pereverzev, E. Poli, M. J. Püschel, T. Ribeiro, W. Schneider, E. Schwarz, B. Scott, M. Sempf, M. Siccinio, E. Strumberger, C. Tichmann, D. Told, C. Wigger, Q. Yu.
**Technology Division:** S. Assas, W. Becker, V. Bobkov, F. Braun, R. D'Inca, H. Faugel, P. Franzen, M. Fröschle, B. Heinemann, C. Hopf, M. Kick, L. Liu, C. Martens, J.-M. Noterdaeme, S. Obermayer, A. Onyshchenko, R. Riedl, J. Schäffler, E. Speth, A. Stäbler, P. Turba, E. Würsching.
**Garching Computer Centre:** C. Guggenberger, P. Heimann, J. Maier, H. Reuter, M. Zilker.
**Central Technical Services:** F. Ascher, R. Blokker, T. Franke, I. Goldstein, E. Grois, M. Huart, C. Jacob, R. Jung, C.-P. Käsemann, M. Kircher, K. Klaster, M. Kluger, J. Lex, G. Lexa, J. Maier, H. Nguyen, G. Raitmeir, U. Schneider, F. Stobbe, F. Zeus.
**Materials Research:** M. Balden, H. Greuner, W. Jacob, K. Krieger, S. Lindig, H. Maier, M. Mayer, J. Roth, K. Schmid, K. Sugiyama.
**IPP Greifswald:** M. Laux, E. Pasch, J. Sachtleben.
**IPF University of Stuttgart:** G. Birkenmeier, H. Höhnle, E. Holzhauer, W. Kasparek, B. Nold, M. Ramisch, U. Stroth.
**Humboldt University, Berlin:** C. Biedermann, R. Radtke.
**FZ Jülich:** S. Brenzinsek, O. Neubauer, V. Phillips, A. Pospieszczyk.
**ÖAW, University of Innsbruck, Austria:** C. Ionita, F. Mehlmann, R. Schrittwieser.
**ERM/KMS, Brussels, Belgium:** A. Lyssoivan.
**University of Sao Paulo, Sao Paulo, Brasilia:** A. Elfimov.
**IPP, Praha, Czech Republic:** J. Adamek, V. Weinzettl.
**RISØ, Roskilde, Denmark:** J. H. Holm, M. Jessen, F. Leipold, F. Meo, D. Moseev.
**TEKES, HUT, Espoo, Finland:** L. Aho-Mantila, M. Airila, V. Hynönen, S. Jämsä, T. Kurki-Suonio, M. Mantsinen.
**TEKES, VTT, Espoo, Finland:** A. H. Hakola, J. Likonen.
**CEA, Cadarache, France:** S. H. Hong, C. Grisolia, T. Loarer.
**EFDA Close Support Unit, Garching:** D. Borba.
**EURATOM HAS, Budapest, Hungary:** É. Belonohy, K. Gál, S. Kálvin, G. Kócsis, T. Szepesi, S. Zoletnik.
**DCU, University College Cork, Ireland:** P. McCarthy, K. Sassenberg.
**ENEA, C.R. Frascati, Italy:** B. Esposito.
**ENEA, IFP, CNR, Milano, Italy:** S. Cirant, G. Granucci.
**ENEA, Consorzio RFX, Padua, Italy:** R. Cavazzana, E. Gaio, M. Gobbin, L. Marelli, P. Martin, P. Piovesan, V. Toigo, N. Vianello, M. Zuin.
**University of Latvia, Riga, Latvia:** O. Dumbrajs.
**American University of Beirut, Beirut, Libanon:** G. Antar.
**FOM, Rijnhuizen, The Netherlands:** M. v. Hellermann, J. Rapp, G. van Rooij.
**IPPLM, Warsaw, Poland:** P. Gasior, J. Wolowski.
**Warsaw University of Technology, Warsaw, Poland:** E. Fortuna.
**IST Lisbon, Portugal:** L. Cupido, S. da Graca, M.-E. Manso, C. Mariz, V. Plyusnin, J. Santos, F. Serra, A. Silva, P. Varela.
**NILPRP, Bucharest, Romania:** C. V. Atanasiu.
**Kstar, South Korea:** Y. Su Na, J. Kim, J. C. Seol.
**VR, Stockholm, Sweden:** P. Brunsell.
**CRPP, Lausanne, Switzerland:** E. Fable.
**UKAEA Culham, Abingdon, United Kingdom:** C. Challis, I. Chapman, D. Howell, A. Kirk, H. Meyer.
**University of Strathclyde, Glasgow, United Kingdom:** M. G. O'Mullane, H. P. Summers, A. D. Whiteford.
**MIT, Cambridge, USA:** P. Woskow.
**INEEL, Idaho, USA:** P. Sharpe.
**University of Wisconsin, Madison, USA:** C. Forest.
**Johns Hopkins University, Maryland, USA:** M. Finkenthal.
**PPPL, Princeton, USA:** C. H. Skinner.
**DIII-D (GA), San Diego, USA:** R. Groebner, R. Prater.

# JET Cooperation

**Head: Dr. Josef Schweinzer**

After the final EP-1 shutdown, JET had a very active experimental phase leading to many new results of direct relevance to ITER. IPP's contributions concentrated in particular on the realisation of the step-ladder approach AUG-JET-ITER. IPP has also been involved in further JET upgrades. To allow for their proper scientific exploitation JET operation beyond 2010 is mandatory. This was unanimously approved in a resolution of the EFDA Steering Committee.

## Introduction

At the beginning of 2008 a machine refurbishment and enhancement phase was completed. It was mainly dedicated to the in-vessel installation of diagnostics and the ITER-like ICRH antenna all of which was developed in the framework of the Enhancement Programme 1 (EP-1). Following, JET was then in operation on more than 170 days (Campaigns C20-C25, April-December). A considerable fraction of the experimental time was devoted to the commissioning of the ITER-like antenna. A significant number of other experiments were carried out, yielding many key results of direct relevance to ITER. From the IPP point of view the achievement of high confinement in JET Hybrid scenarios was an outstanding success.

The commissioning of a new pellet injector was also on the 2008 agenda. One of the scientific aims was to conduct experiments to control ELMs by pellet pace making. However, due to a series of technical problems the demonstration of this method on JET had to be postponed to 2009.

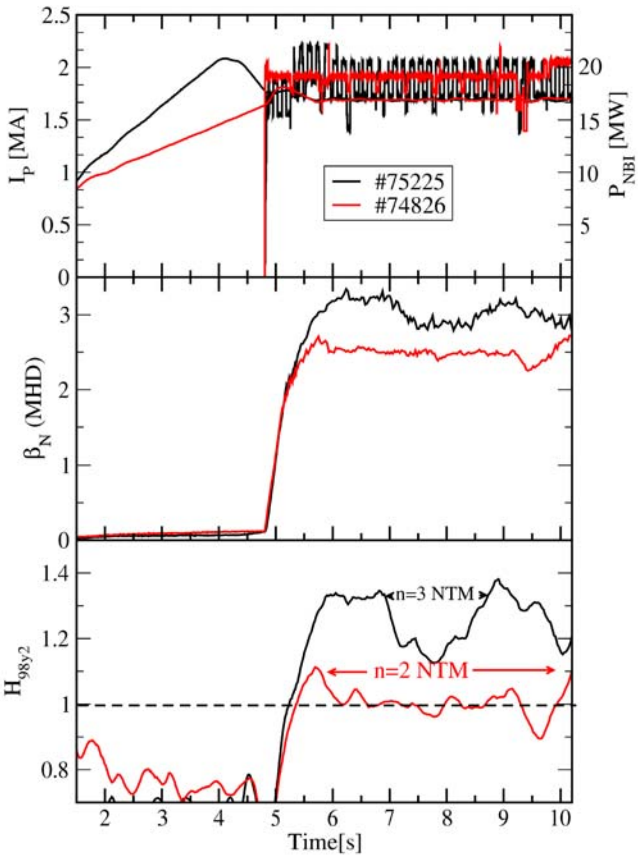



*Figure 1: Comparison of Hybrid and H-mode Scenario*

Two IPP scientists worked as deputy leaders of the JET Task Forces S1 ("Standard H-mode Scenario") and E ("Plasma Edge & Divertor"). 22 IPP scientists from several departments have participated in C20-C25. The majority had one or more visits of a few weeks. Three long term secondments supported the operation and exploitation of diagnostics such as magnetics, IR divertor camera (KL9) and the scintillator lost alpha probe (KA3). Altogether the IPP participated with an equivalent of almost 8 ppy in the 2008 JET campaigns. Additionally, IPP also supported the JET Close Support Unit with three long term secondments. Instead of attempting a comprehensive overview of IPP's contributions to JET in 2008, only selected examples for contributions to the campaigns as well as to JET enhancement activities are given in the following.

## High Confinement achieved in JET Hybrid Scenario

The aim of this JET task (S2-2.2.2) was to explore how q-profile modifications influence the confinement of the Hybrid scenario. On smaller machines (AUG, DIII-D) the key to reach this regime has been a stationary q-profile with a central value $q_0$ close to 1 and a low central magnetic shear. The first experiments used different methods to modify mainly the core part of the q-profile. This did not change the confinement significantly. The main effect has been a deterioration of the confinement with increasing $q_0$. By careful analysis and based on many TRANSP runs the strategy of how to form a broader q-profile was changed. It emerged that some edge current is also needed to enhance the q-profile broadening. Therefore, a fast current ramp up (to produce an elevated q-profile which is broad) was combined with a current ramp down to reduce the edge current and to further broaden the q-profile. This strategy was immediately successful by producing a transient H-factor of 1.4, limited by occurrence of a NTM.

In further developments the q-profile and particle fuelling were optimised in order to improve the MHD stability. By doing so an improved confinement of H=1.35 was maintained for maximum NBI duration (#75225). For reference a pulse with a standard H-mode q-profile and confinement (#74826) was produced. With this experiment a clear correlation between a modified q-profile and improved confinement has been shown for the first time on JET.

This proves that the Hybrid scenario discovered on AUG and DIII-D is not limited to high $\rho^*$ values, but can be obtained on larger machines and must be considered as one of the most promising regimes for ITER.

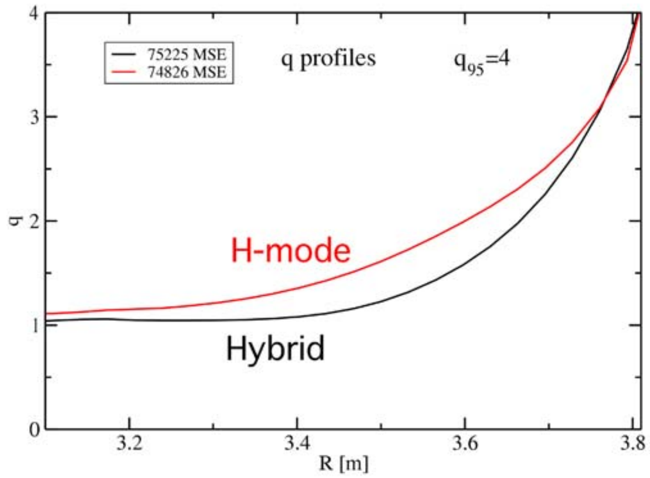



*Figure 2: q-profiles for Hybrid and H-mode Scenario*

## Enhancements

In the frame of the JET-EP2 project a new high resolution divertor infrared camera (KL9) has been installed at JET. The commissioning of this state-of-the-art thermography system was finished by the start of C20. The new IR camera combines high spatial resolution and high acquisition frame rate even for long pulses. Due to the high sensitivity of the detector, the signal dynamics are adequate even on a 20 µs time base, which allows resolution of striations in the target power loads. Such striations are caused by the filamentary nature of ELMs.

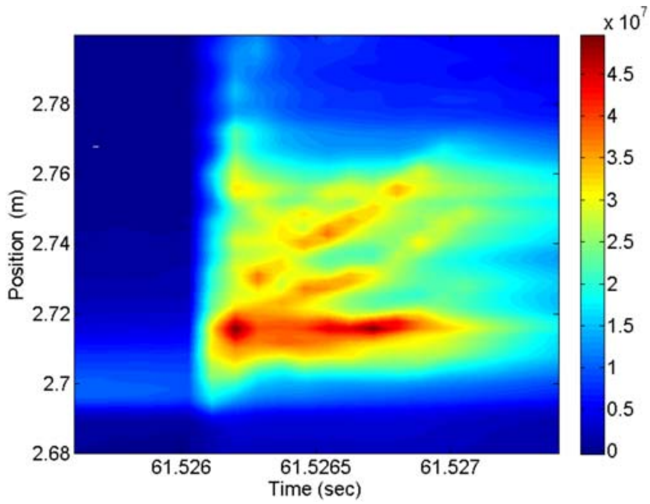



*Figure 3: Striations observed in the power load to the outer divertor during a type-I ELM. In this particular case they appear close to the separatrix and then move radially outwards on a typical time scale of 1 ms.*

In JET the toroidal mode number associated with these ELM filaments has been found to vary between 4 and 12 with a maximum at around 8. This is very similar to results of AUG. Dedicated sessions were conducted to characterize the power loads to the divertor in-between and during regular large ELMs. The radial power decay length on the divertor target in-between ELMs turned out to be typically 8 mm for low current plasma at 1.1MA/1.0T. Even smaller values of 4 mm have been measured in high power H-Modes at 2.5MA/2.5T. This radial power decay length increases by a factor of two during ELMs compared to the inter-ELM value. Higher gas puff levels also lead to an increase of the inter-ELM radial decay length by a factor of two. The ELM and the inter-ELM wetted areas, however, have been found to scale differently with toroidal field and gas puff rates.

In 2008, the focus of the tungsten coating activities for the ITER-like Wall Project moved to large tiles with shapes which are similar to JET divertor tiles. After this step, testing in IPP's high heat flux facility GLADIS revealed that an upscaling of the selected coating method, i.e. vacuum plasma spraying, was not possible without significant further research efforts. Therefore, the work on this coating method was abandoned and the backup solution of physical vapour deposition of a rhenium/tungsten multilayer was pursued. Rhenium interlayers are supposed to be beneficial for the suppression of tungsten carbide formation, which can occur at high temperatures, as well as for mitigating thermomechanical problems due to the brittleness of tungsten. High heat flux tests of such multilayers on realistic CFC test tiles in GLADIS indicated an acceptable performance of these multilayers under repetitive loading even up to a total coating thickness of 30 µm. However, it turned out, that storage in ambient air longer than one month leads to unexpected formation of rhenium oxides. At IPP this was verified by extensive analysis work using x-ray photoelectron spectroscopy and analytical electron microscopy. In this context the topic of tungsten carbide formation also had to be investigated to clarify the role of interlayers. This was performed using the HELIOS device (see section 'Plasma-Facing Materials and Components') to prepare focussed ion beam cross sections of heat-treated samples and analysing the resulting surfaces by electron backscatter diffraction. This investigation was complemented by X-ray diffraction analysis. The thermomechanical performance of heat-treated samples was studied by high heat flux tests in GLADIS.

## Scientific Staff

**Campaigns C20-C25:** V. Bobkov, S. Devaux, Th. Eich, J. Hobirk, L. D. Horton, M. Jakubowski, K. Krieger, P. T. Lang, C. Maggi, H. W. Müller, K. McCormick, C. Perez v. Thun, M. Reich, A. Scarabosio, M. Sertoli, A. C. C. Sips, J. Svensson, J. Stober, G. Tardini, H. Thomsen.
**Modeling:** A. Chankin, D. P. Coster, Ch. Konz, M. Wischmeier.
**Enhancements:** B. Böswirth, Th. Eich, H. Greuner, H. Maier, G. Matern, M. Mayer, R. Neu, J-M. Noterdaeme, A. Stäbler, W. Treutterer, W. Zeidner.

# Stellarator Research

# Wendelstein 7-X

**Heads: Dr. Remmelt Haange, Prof. Thomas Klinger**

In 2008, the construction of Wendelstein 7-X made significant progress. Fabrication of all superconducting coils was concluded in March and delivery of all other components also progressed well. In spring 2007, pre-assembly of the first two magnet system half-modules was finished and in autumn of 2008 the next two half-modules were completed. A robust schedule has been implemented and is being followed with completion of the device in mid 2014.

## 1 Introduction

In 2008 the organisation of the project Wendelstein 7-X has experienced further developments. From January 2008 on, a dedicated sub-division in Garching was formed to conduct the work on the in-vessel components. The new sub-division head was formerly leading the assembly technology department. The other groups of the former sub-division "supply systems and divertor" have been re-located into the "magnets and cryostat" sub-division. At the same time the ECRH- and ICRH-departments within the "physics" sub-division have been combined into a "high frequency-heating" department. The three "physics" departments dealing with control, data acquisition and data evaluation were combined in the new CODAC department.

Design and manufacturing of the different components of the basic device have considerably progressed, as described in chapters 2 to 4. The accompanying efforts of the engineering subdivision (chapter 5) and the design and configuration control (chapter 6) are still indispensable. The assembly of the stellarator device and the development of the related technologies have made great progress, as described in chapter 7. Diagnostics developments (chapter 8) and the set-up of heating systems (chapter 9) as well as the development of control systems have continued. The Wendelstein 7-X device consists of five identical modules (M1 to M5), each of them consisting of two flip-symmetric half-modules each (M10, M11, M20…). Assembly started with module 5; the assembly sequence is M5-M1-M4-M2-M3.

### 1.1 Quality Management

The Quality Management (QM) department reports directly to the project directors via the associate director coordination. The department organises the QM system within the project W7-X and supports the supervision of all external contractors. It has taken over responsibilities for quality assurance during the assembly phase of Wendelstein 7-X. The QM system has meanwhile been updated and adjusted according to the ISO 9001:2000 standard. The new rules are more concerned with processes and not anymore with products, much better suited for a project like Wendelstein 7-X.

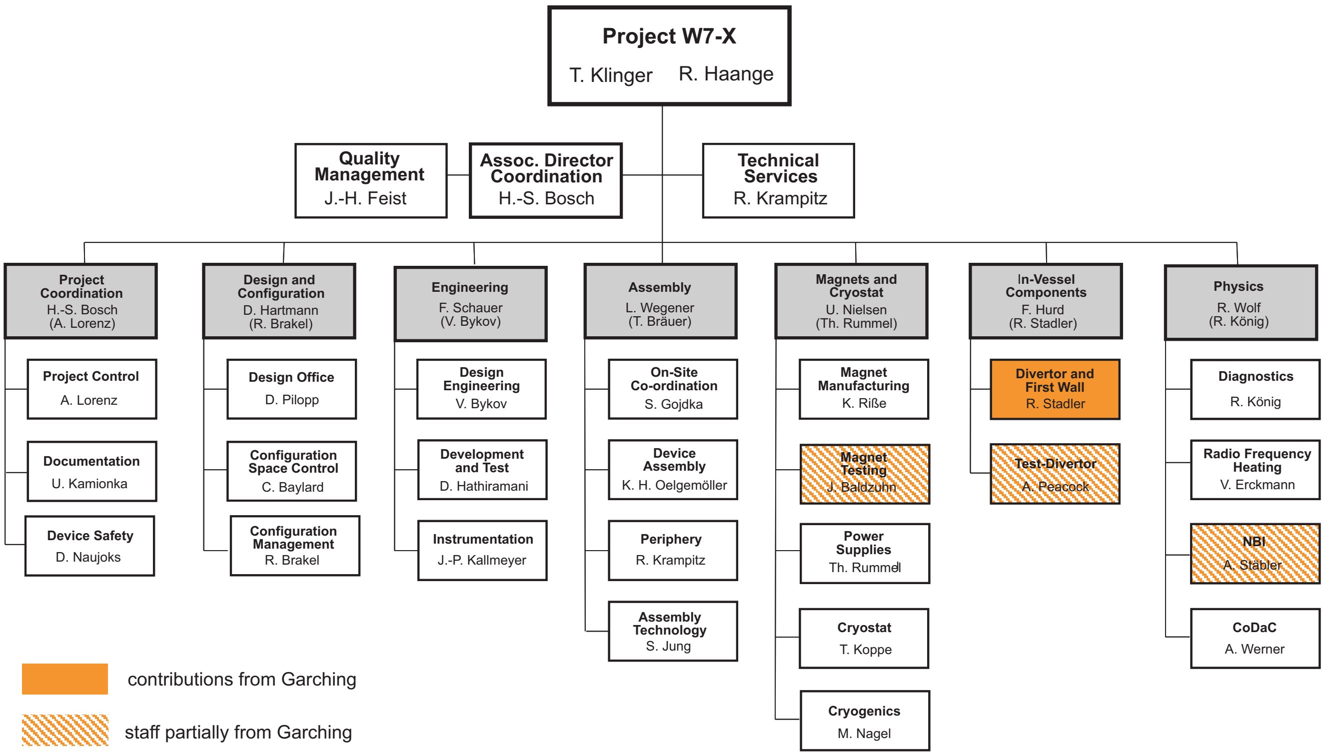



*Figure 1: Organigramme of the Wendelstein 7-X project as of 31 December, 2008*

### 1.2 Project Coordination

This subdivision comprises three departments dealing with coordination activities for the project Wendelstein 7-X:
(I) The project control department is responsible for the financial planning of the project and for the control of the expenditures, time planning of all activities within the project as well as of the external contracts. The department supports the component responsible officers in the handling of industry contracts as well as in organisational aspects of the project and in the reporting to all external supervising bodies, especially the Project Council ("Projektrat"), the supervising body of the financing institutions. The development of a new integrated planning tool, based on MS Project 2007, was continued in 2008. It is designed to integrate time and financial planning into one software solution with a dedicated interface to the already established SAP system. This allows one to obtain automatic financial reporting to both the management and the supervising bodies. The concept has been jointly developed with the IPP administration and an external consultant. In the spring of 2008, the concept was completed and the programming work of the software company tecneos started. All future users were introduced into the new user software. The respective planning projects were set up. In the autumn of 2008, the first version of the tool was running and a detailed testing phase started which is now getting close to end.
(II) The documentation department is responsible for an independent check of all technical drawings and CAD-models and for archiving all documents relevant to the project. An electronic documentation system (agile-PLM) is used for archiving documents and CAD models (in CADDS5-format). Because of the increased use of CATIA v5 for design and collision investigations, a prototype interface has been implemented. In the autumn of 2008 a prototype of this interface became operational and tests started.
(III) The device safety department plans, implements and leads the processes that are required to ensure safe operation of the Wendelstein 7-X device with its interacting components and supply systems. The most critical problems are defined and corresponding actions are implemented to reduce the risks associated with hazards. This device safety department is also responsible for the preparation of the safety report, requested to obtain the operation permit for Wendelstein 7-X.

### 1.3 Schedule

In 2008, the time schedule of the co-called "scenario 3" (developed in 2007) was followed. The agreed milestones in 2008 were all achieved in time. By the end of 2008, the first magnet module was almost finished, waiting for the cryo-piping and final assembly of the busbars. The second module is in the second pre-assembly stage: the plasma vessel and support structure half-modules have been connected, the busbars have been pre-assembled and measured. On the half-modules of the third module, most of the coils have been assembled. Due to a delay in fabrication of the cryo-piping (see below in 2.2.4 and 7.2.3), it became clear in the autumn of 2008 that the next milestone (first module finished on assembly rig III) in the spring of 2009 could not be achieved. Therefore, the assembly sequence was re-arranged and work packages were shifted to modify the overall schedule in a way such that the end of assembly and start of commissioning still can be achieved in May 2014.

## 2 Magnets and Cryostat

### 2.1 Magnet

#### 2.1.1 Superconducting Coil Manufacturing

The superconducting coil system of Wendelstein 7-X consists of 50 non-planar coils and 20 planar coils. The coils are wound from a specially developed cable-in-conduit superconductor which is composed of an NbTi cable enclosed by an aluminium jacket. The non-planar coils were manufactured by a consortium formed by Babcock Noell GmbH (Germany) and ASG Superconductors S.p.A. (Italy). Fabrication of the non-planar coils has been completed in the spring of 2008. 36 of them are accepted to be assembled at IPP Greifswald, two coils are under tests and 12 coils are waiting to be tested in the cold test facility of the Commissariat a l'Énergie Atomique (CEA) Saclay (France). The manufacturing of the 20 planar coils at Tesla Engineering Ltd. has been finished in 2007. 19 planar coils passed successfully the acceptance tests at cryogenic conditions. The remaining planar coil will be tested at CEA at the beginning of 2009.

#### 2.1.2 Superconducting Coil Testing

As mentioned above, each superconducting coil for Wendelstein 7-X is tested in the cryogenic coil test facility of the CEA. In 2008, a total number of 16 non-planar and 12 planar coils could be tested. Two planar coils (AAC23 and AAC42) had to be tested twice which means a total throughput of 16 non-planar and 10 planar tested coils. This is the highest number of coils ever tested within one year in that test facility. This goal has been reached, among other things, due to measures implemented by CEA aimed at increasing the reliability of the test facility. In parallel to the standard tests, the new IPP quench detection electronics could be thoroughly tested during dedicated quench experiments. During the test of the planar coil AAC23 an electrical arc ignited between the facility joints during a fast current ramp-down after a standard quench. This external discharge was caused by a local helium gas leak close to the external joints. The damages on the test facility, caused by the arc itself, could be repaired within a few days. The coil remained unaffected by this event, neither by the arc itself nor by the increased current decay time resulting from the arc discharge.

### 2.1.3 Coil Support Structure

The support of magnet system is composed of 2 main components, the coil support structure and the cryolegs. The coil support structure is being manufactured by the Spanish contractor Equipos Nucleares, S.A. (ENSA, Spain). It consists of ten identical sectors with a total weight of 72 t made from steel plates and cast extensions. The final accurate machining is done by the subcontractor Rovera C.M. (Italy). The first two half-modules (M5) were completed and delivered to IPP in 2007 and meanwhile assembled with the coils and assembled to a module. The 2nd module (M1) was delivered in February 2008 and assembled with the coils (see figure 2).

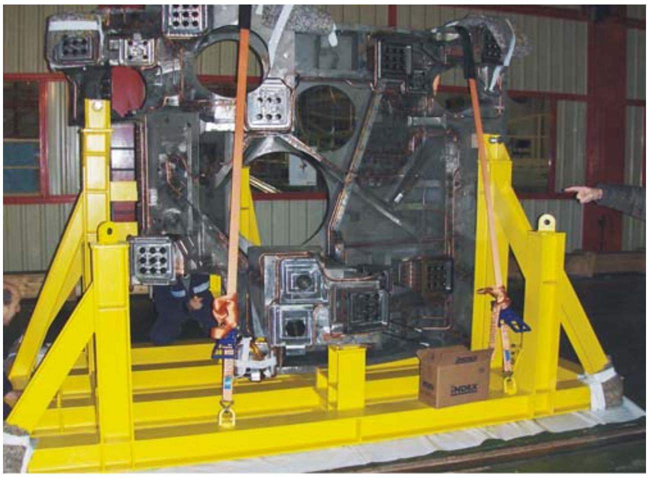


*Figure 2: HM20 prepared for transportation to IPP*

The 3rd module (M4) was delivered in October 2008 and is presently in assembly preparation. The 4th module (M2) is in the final fabrication stage at ENSA and will be delivered at the end of January 2009 to Zeitz for an additional cleaning and finally to IPP in March 2009. For the last module (M3) Rovera has already started final machining. This module will be delivered to IPP in October 2009.


*Figure 3: Acceptance test of Cryolegs M1 1*

The coil support structure is vertically supported by 10 cryolegs (2 per module). Three contracts have been awarded for the research and development and the manufacturing of the cryolegs: to Zanon s.pa. (Italy) for the metallic structure and final assembly, to IMA (Germany) for the glass fibre compound bushes, and to SKF (England) for the sliding and spherical bearings. Delivery of the prototype and the first two cryolegs (M5) was finished in 2008. The acceptance test of the remaining 8 cryolegs (M1-M4) (see figure 3) will take place in January 2009.

### 2.1.4 Inter-Coil Supports

Different types of support elements connect the coils with each other (see figure 4). The narrow support elements (NSE) between non-planar coils take up pressure loads while simultaneously allowing sliding and tilting. All the NSE-pads and -frames of M5 have been completed and assembled. The HM 10 and 11 have also been assembled except for the NSE between the respective half-modules.

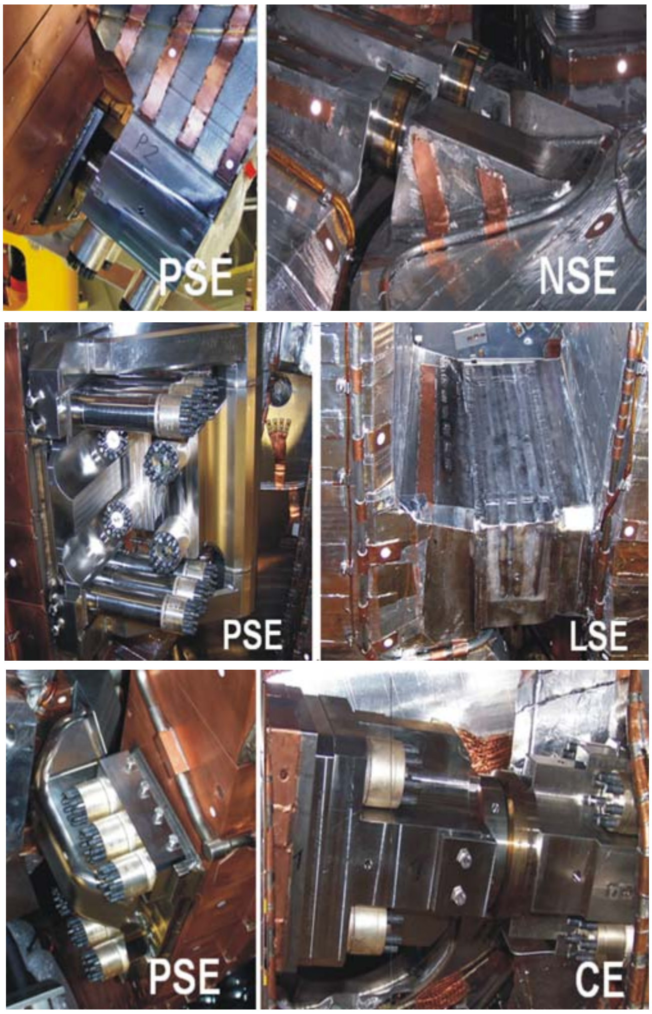



*Figure 4: Different inter coil supports of Wendelstein 7-X*

The NSE-pads and frames of M4 are prefabricated and will be assembled at the beginning of 2009. In order to streamline assembly preparation and to allow for the optimized selection of the pad-frame combinations, the coating of pads was changed from just-in-time into series fabrication. The lateral support elements (LSE) join the non-planar coils on the outer side of the torus by welding. The semi products of all LSE's (with one exception at the module separation plane) have been manufactured. The final measurement, custom machining and assembly for M5 and M1 were successfully completed. The planar support elements (PSE) connect the planar coils to the non-planar coils. For the first two modules all PSEs (besides one to be assembled later) have been delivered and assembled. For M4 the prefabrication (welding) of the PSEs at the company Josch (Germany) has started. The remaining blocs are being prefabricated. The contact elements (CE) support the non-planar coils at the half-module separation plane and at the module separation plane. In M5, the CE has been assembled and for M1 it has been prefabricated. The design of the other CE was started in December 2008.

### 2.2 Cryostat

The plasma is surrounded by the plasma vessel which constitutes the first ultra-high-vacuum barrier. The entire superconducting coil system is assembled between the plasma vessel and the outer vessel, which function as a cryostat keeping the magnet system at cryogenic temperature and constitute the boundary between the Wendelstein 7-X main device and the external environment. 254 ports give access to the plasma vessel for diagnostics, additional heating and supply lines. The Deggendorfer Werft und Eisenbau GmbH (MAN DWE, Germany) are responsible for manufacturing the plasma vessel, the outer vessel and the thermal insulation. The company Romabau Gerinox (Switzerland) has delivered the ports.

#### 2.2.1 Plasma Vessel

The plasma vessel (PV) is composed of ten half-modules which are divided into two sectors to allow stringing of the innermost coil during assembly. The construction of the plasma vessel required 200 steel rings to be bent to the designed shape and carefully welded to represent the changing cross-section of the vessel with an accuracy of 3 to 7 mm. Vacuum tightness of the welds was checked by an integral helium leak test of the vessel segments prior to cutting the holes for the ports. Water pipes around the vessel allow control of its temperature during plasma operation and for bake-out at 150 °C. Manufacture of all ten half-modules was completed in 2005 and installation of the thermal insulation has started. Rogowski and saddle coils which are used for the magnetic diagnostics have been mounted on the outside of the first vessel sector during assembly preparation. Four half-modules (HM50, 51, 10, 11) have been integrated with all the coils and thermal insulation. In each case two sectors forming the half-modules were welded with very low distortion applying the results of the research and development performed in 2006 to optimise and qualify the procedure. The cooling pipe inlet and outlet lines of these four half-modules have been manufactured and assembled. The three main brackets of the PV-moduls were assembled. Their design had to be modified because of collisions and interface problems with the thermal insulation. All 15 vertical supports of the plasma vessel (three types/module) were delivered by MAN DWE. The first tree vertical supports were welded successfully to the lower shell of outer vessel M5 by IPP. For the horizontal support/centering system the design, the calculation of horizontal adjustment (University of Rostock, Germany) and the technical specifications were completed. The standard parts have been ordered.

#### 2.2.2 Outer Vessel

The outer vessel is assembled from five lower and upper half-shells and is designed to have 524 domes for ports, supply lines, access ports, instrumentation feed through, and magnetic diagnostics. Three modules already passed the works acceptance test, the tests on the fourth module are ongoing. Two lower shells (M4, M5) and one upper shell (M5) have been delivered in 2008 by MAN DWE. A pre-assembly of the first module (M5) lower and upper shells was done successfully in IPP (see figure 5). With the installation of the plasma vessel support and start of the installation of thermal insulation, pre-assembly of the M5 outer vessel has started.

*Figure 5: Pre-assembled lower and upper shells of module 5*

Following outer vessel parts will be delivered in CW03/09:
- M1 upper shell - M1 lower shell - M4 upper shell.

#### 2.2.3 Ports

A total of 254 ports are foreseen for (I) pumping the plasma vessel, (II) plasma diagnostics and heating, (III) for water/Helium supply lines, power lines and sensor cables. The cross sections of the ports range between 100 mm circular up to 400×1000 mm² square. Each port is equipped with a bellow to compensate for deformations and displacements of the plasma vessel with respect to the outer vessel. All ports are surrounded by water pipes in the bellows area to control their temperature. The ports and their fixing tool were delivered in 2007 and the contract with Romabau Gerinox was successfully concluded (see figure 6). In 2008 measuring and assembly preparation of the ports has started.

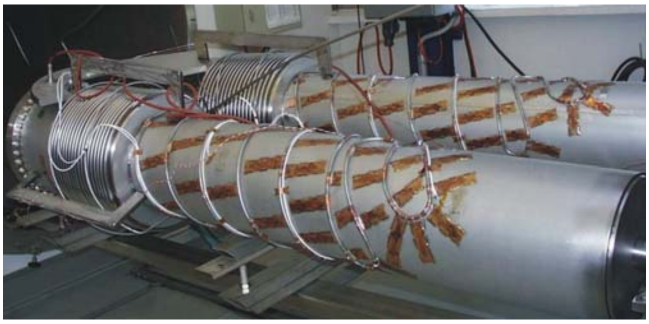


*Figure 6: Diagnostic ports of Wendelstein 7-X during a leak test*

#### 2.2.4 Cryo-pipes

In January 2008 the order to manufacture the cryo-pipes for all modules has been placed with Romabau Gerinox. Detailed design as well as manufacturing of the pipes of each module is subdivided into eight lots (1 to 4, 6-8), brackets are all in lot 5. At the same time the fabrication design of the cryo-pipes for module 5 (the first to be installed) was started in a crash-action, involving both IPP and q sub-contractor of Romabau Gerinox. It is now nearly completed and with FEM-calculations controlled to be free of collisions with other components. The very limited assembly-space available for the cryo pipes made a layout necessary that is far more elaborated than anticipated. This in turn forced the manufacturer to build nearly 60 bending tools which was far more than the originally assumed total of 18. This delayed the production process further, although alternative workshops helped substantially to get the work done. Due to this and internal reasons at Romabau Gerinox the manufacturing milestones are all overrun. To improve the situation, IPP – by using external experts – helped to optimize the production process at Romabau Gerinox; the company will increase the production capacity by a factor of four in the first quarter of 2009. In parallel the design has been revised to speed up the bending and welding of the cryo-pipes for module 1 and the following modules. The “similarity” of the pipe structures is estimated to be 80 % between different modules. The layout of this revised piping for lots 1 to 4 (for module 1) is being finished and the detailed drawings are near to completion, again with the substantial support of IPP. More measures to improve the situation have been started.

#### 2.2.5 Thermal Insulation

Assembly of the thermal insulation on the plasma vessel is ongoing and significant progress was achieved in 2008. The insulation panels on the half modules 40, 41 and 11 were assembled. The respective cooling pipes were positioned and soldered, the insulation on the plasma vessel pocket and the bracket was done, and the inlet and outlets for the water pipes on the plasma vessel were installed. The works on the thermal insulation of the outer vessel was further accelerated in 2008. The outer vessel shield will be made of 3 mm brass plates instead of copper, as originally foreseen. This has the advantage to reduce the eddy currents and the resulting mechanical loads within the shield panels. The design of the non-locating and solid bearings for the shield panels was developed and proven by mechanical load calculations. The design work on M5 started with the definition of the openings in the outer vessel. Due to the very small distance between some ports, more specialized solutions than expected must be found for the transition area between the outer vessel shields and the port shields. MAN DWE is the contractor for the detailed manufacturing design, the actual manufacturing, and the assembly of the thermal insulation of the outer vessel and the ports. The design for the thermal insulation of the outer vessel of M5 is almost fixed, the manufacturing is ongoing and the assembly already started in September 2008. 3 of 11 shield panels on the lower half shell of the OV and two cryogenic leg insulations were assembled. The very narrow space situation on the port insulations requires a time consuming configuration control of the 3D models. This has resulted in time delays. The design work on the thermal insulation for M1 started in December 2008.

## 3 Supply Systems

### 3.1 Helium Refrigerator

Most of the Helium refrigerator components have been installed; the acceptance test box with test heaters is under fabrication. The recent version of the control program received from Linde (Switzerland) was checked by IPP. The heater control cabinets for the test heaters – to be provided by IPP – are under manufacturing. The heater for simulation of the current lead was procured. The piping connections were designed. The commissioning was planned to be finished by June 2008 but was slightly delayed by Linde.

### 3.2 Current Leads

After approval of the final design drawings for prototype leads, FZK submitted the revised 3D model. FZK has procured most of the components needed for the prototype leads. While doing mock-up tests of stack soldering, problems occurred for the high temperature superconducting (HTSC) material, which FZK is trying to solve together with the HTSC material supplier. The discussion for finalising the electrical insulation at the cold end is presently in progress. For the mechanical tests of radial and cryostat flanges, a test facility was found at IMA (Dresden, Germany). A common agreement about the set-up at IMA was reached and the tests are being prepared. FZK has manufactured the mock-up assembly required for the mechanical tests of flanges. These mock-up tests were built with the electrical insulations to qualify the insulation design for Paschen tightness. The first Paschen tests carried out by FZK at room temperatures were successful. For the development of the test facility for testing the prototype leads, FZK decided to manufacture the valve box, control box and test box within the FZK workshop. FZK provided the milestone May 2010 as the date for completion of the test facility. The prototype leads are scheduled to be ready by the end of September 2009. Therefore investigations have been started if alternative test facilities can be made available for the prototype test. Mechanical support of current leads is planned (a) horizontally by rods between coil support structure and a fixing box and (b) vertically by support structure to the Outer vessel. Because later there is no accessibility to the coil support structure the rods have to be installed soon. The draft for a horizontal design of the rods was finished in 11/08 and commissioned afterwards. The finishing is planned in February 2009 by the company Dräger (Germany).

### 3.3 Magnet Power Supply

The superconducting magnet system is divided into seven electrical circuits, containing five circuits with ten non-planar coils each and two circuits with 10 planar coils each. Seven independent power supplies provide direct currents of up to 20 kA at voltages of up to 30  V. Fast and reliable discharge of the superconducting magnets in case of quenching or severe faults is realised by fast circuit switches which short-circuit the coils and dump the magnetic energy to nickel resistors. After the declaration of the acceptance in mid 2007, several test campaigns were performed to train the staff and to identify possible weak points. Based on these tests some auxiliary components had to be replaced and some service procedures have been updated. At the end of the bus bars crow bars have been installed which are suitable for full current operation at steady state conditions. Now the power supplies can be operated with full current without interfeering with the assembly activities of the basic machine in the experimental hall. The aim is to test the system up to five days in steady state as a foreseen for the later W7-X operation.

### 3.4 Quench Detection System

The quench detection system of W7-X will consist of 360 quench detection units which permanently check the differential voltages across the double layers of the coils, all sectors of the bus system and the superconducting part of the current leads. The system has to reliably detect millivolt signals in a broadband noise environment and operate at high voltages during a rapid shutdown of the magnets. The first QD subsystem was developed in co-operation with FZK/IPE (Institut für Prozessdatenerfassung und Elektronik). It comprises 72 quench detection units, a data acquisition system and an internal battery buffered AC-DC power converter. It has successfully passed functional tests and was accepted and delivered to Greifswald. The final tests were performed during the coil tests in CEA/Saclay, where quenches in non-planar as well as in planar coils were induced. The quench detection units detected all the quenches within the required time of less than 250 ms. There was no faulty activation. After the successful completion of the prototype development, the series production of the quench detection units was released.

## 4 In-Vessel Components

The in-vessel components consist of the divertor target plates, baffles, panels and heat shields, control coils, cryo-pumps, port protection and special port liners for the NBI and DNBI and the complex system of cooling water supply lines. Plansee SE is manufacturing the High Heat Flux (HHF) target elements, MAN DWE the wall protection panels and BNG the control coils which were delivered and tested in 2008. The horizontal and vertical target modules of the HHF divertor are designed to withstand power fluxes of up to 10 MW/m$^2$. The baffles, which prevent the neutrals from re-entering the main plasma chamber, receive power fluxes of up to 0.5 MW/m$^2$. The remaining first wall components are subject to neutral particles and plasma radiation in the range of up to 0.3 MW/m$^2$. In 2007 it was decided to start operation of Wendelstein 7-X with a test divertor unit (TDU) without water cooling. The TDU is designed for short pulses of 6.25 seconds at a maximum heating power of 8 MW. The recovery time between pulses at maximum load shall be 20 minutes. Assembly of the target modules from target elements for both the TDU and HHF Divertors, the fabrication of the TDU frames and module structures, baffles, heat shields, the cryo-pumps and of the supply lines is performed by the central technical services of IPP in Garching. Due to the high work load specialized companies perform the vacuum brazing, pipe bending, specialist welding processes and machining. All in-vessel components are to be tested in Garching (geometry, He-leak tests and hydraulic tests) before delivery to Greifswald. For the first operational period with the TDU it is foreseen to operate with a limited number of cooled components. These include the control coils and some special areas close to diagnostics and heating systems. However, in order to reduce the length of the subsequent shut down, all the other components and their cooling circuits necessary for long pulse operation will be installed.

Only the cryo pump, the HHF divertor and their water supply lines will be omitted for this first operation phase. The input parameters for the cooling requirements during the first operation period are presently assessed in detail and fixed by a working group.

### 4.1 Target Modules

The ten divertor units of the HHF target are designed to remove 10 MW convective stationary power load. The ten units consist of two main areas: the first with an area of 19 m² which can be loaded up to 10 MW/m² and the second with an area of 5.4 m² which can be loaded up to 1 MW/m². Each divertor unit is assembled from 12 separate target modules. The highly loaded target modules are assembled from sets of bar-like target elements which are supplied by cooling water in parallel and fixed on a common frame. The supports of these modules are adjustable within a range of a few millimetres to allow for compensation of manufacturing and assembly tolerances of the plasma vessel or uneven heat-loading during plasma operation. For the higher-loaded area 890 target elements are required. Their surface closely follows the 3-D shape of the plasma boundary and will be machined before assembly of a module. The decision to introduce the TDU in the first operation period has meant significant additional design and testing. The TDU will have the same surface contour as the HHF divertor. Some of the mounting frames and the intermediate area modules will be the same components to save time and cost. The TDU will use un-cooled fine grain graphite elements and is expected to withstand up to 8 MW/m² for 6.25 seconds. A total energy input limit of 50 MJ has been set for the design phase. The design of the first modules and their support frames with adjustment mechanisms has been completed in 2008. A prototype module with graphite from several different manufacturers has been manufactured and will be tested in GLADIS early in 2009. In addition a prototype frame and adjusters will be manufactured and tested by the assembly division. The design of the divertor modules of the lower loaded area uses graphite tiles clamped on a CuCrZr heat sink with a graphite paper (Sigraflex) interlayer. Cooling is provided by stainless steel tubes brazed onto the backside of the heat sink and these will be included in the TDU phase. In the HHF divertor 8 mm thick CFC tiles made of SEPCARB® NB31, produced by SNECMA Propulsion Solide, are joined to a water-cooled CuCrZr heat sink. In order to optimize the manufacturing route and to reduce the stress at the interface between the CFC and the cooling structure, additional pre series target elements will be manufactured by Plansee SE to optimise the technology including the addition of a compliant copper layer between the AMC® interlayer and the CuCrZr heat sink. Extensive high heat flux tests in the GLADIS facility at IPP (see further information in section "Plasma-facing Materials and Components") will confirm the benefit of the additional optimisation phase. The problems identified with the CuCrZr cooling structure resulting in a by-pass flow between the cooling channels and hence reduced heat transfer has been addressed and the IPP proposal will be included in the further optimised elements. The results of the high heat flux tests will also be used to correlate the GLADIS results with the predictions from infrared measurements carried out in the ARGUS facility of Plansee SE and in the SATIR facility of CEA-Cadarache. The correlation shall form the basis of the acceptance criteria for the target elements of the serial fabrication along with further GLADIS tests.

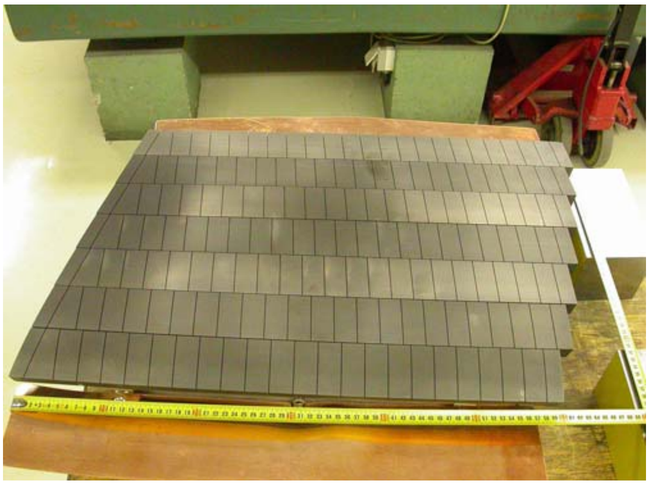


*Figure 7: TDU prototype module*

### 4.2 Baffle Modules

The baffle modules prevent back-streaming of the neutralised gas from the target plates into the central plasma and protect the water manifolds of the target modules. The design uses graphite tiles which are clamped onto a cooling structure made of CuCrZr. Water cooling is achieved by stainless steel tubes which are vacuum brazed to the backside of the heat sink. The fixing screws for the graphite tiles are made from titanium zirconium molybdenum (TZM) alloy. In total there are 170 Baffle modules, 50 % of the cooling structures have been manufactured by the IPP workshop in Garching, and the fourth lot of graphite tiles has been ordered. Two batches have been delivered and accepted.

### 4.3 Wall Protection

About 70 m² of the plasma vessel surface is covered by double-wall stainless steel panels with integrated water-cooling. In total 250 panels have been delivered, all panels except those for the pumping gap and an additional 50 panels required due to the Scenario 3 changes have been delivered by MAN DWE. The majority have been tested and accepted. The inner wall of the plasma vessel is protected by heat shields. These heat shields use graphite tiles which are clamped to a cooling structure using a similar design as for the baffles.

The design also has to integrate several plasma diagnostic components as well as an NBI beam dump and mirrors for ECR heating. By the end of 2008 a total of 105 of the 162 heat shields cooling structures have been fabricated in the IPP workshops. During steady state and full power plasma operation, the inner surfaces of the ports need to be protected in the same way as the plasma vessel. For budgetary reasons, construction of the port protection panels has been postponed to a later date.

*Figure 8: Test assembly of pipe work and panels in the wooden mock up*

Nevertheless, the design of these protection elements was continued to fix their interfaces and define the routing of the cooling water lines. Since the space behind the wall protection is very restricted, all port protection panels will be later supplied from outside. The NBI ports as well as the port for the diagnostic injector need to be protected against energetic particles by CFC and graphite tiles from the beginning. The design work has progressed and the manufacturing drawings are in preparation.

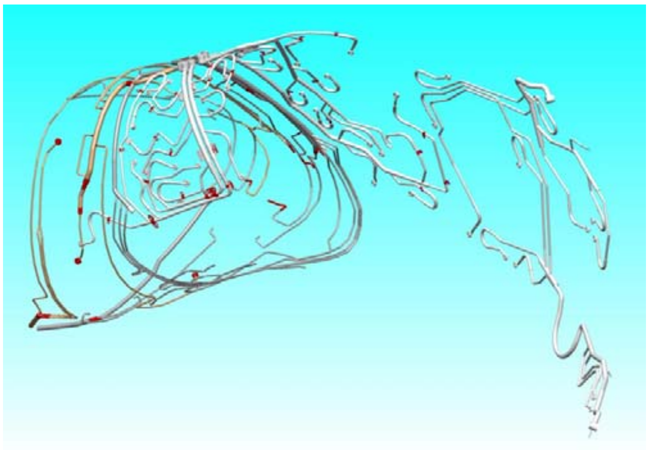


*Figure 9: Water pipe work for panel circuit*

### 4.4 Cryo-Pumps

Ten cryo-pumps are located behind the target plates to increase the pumping capacity for hydrogen and deuterium up to 75 m³/s during high-density plasma discharges. The cryo-pumps are composed of a cryo-panel cooled with single phase helium, a Chevron baffle cooled with liquid nitrogen and an additional water cooled baffle. Fabrication of the cryo-pumps is well advanced, however, the cryo-pumps will be installed only after the first operation phase. Therefore fabrication activities have stopped in ordner to optimize the use of fabrication resources.

### 4.5 Control Coils

Ten control coils will be installed behind the baffle plates. These coils will be used to correct small field errors at the plasma edge, to optimize the position and extent of the islands and dynamically sweep the power across the target plate. The coils have been fabricated by the company BNG. Each coil is made of eight turns of a hollow copper conductor and is water cooled. All control coils have been tested and accepted. All ten control coils have been delivered to Greifswald. The control coils are supplied by power supplies which are able to provide direct currents of up to 2500 A and alternating currents up to 625 A with frequencies between one and 20 Hertz in parallel. After having demonstrated the function of the power supplies the final acceptance was declared by IPP. Test campaigns to run the system under different scenarios are under preparation.

### 4.6 Water Supply Lines inside the Plasma Vessel

Cooling for the in-vessel components is provided from the main water system through 80 supply ports in the different W7-X modules. The interface between the supply lines and the cooling loops inside the plasma vessel is achieved by so called plug-ins which are groups of pipes and cables that can be installed as a single assembly with the port flange. The water cooling loops inside the plasma vessel form a very complex network of pipes with a total length of about 4000 m. Routing of the water pipes has to take account of the 3D-shape of the plasma vessel, avoid the diagnostics and heating systems port openings, take into account the restricted space behind the wall protection panels and identify appropriate attachment points. In addition, the design of the cooling circuits has to consider many interfaces with the diagnostics and heating systems. The detail design and the manufacturing process of the pipe work was qualified by the use of a full size prototype installed in the W7-X wooden model. Significant progress has been made in the detail design of the cooling circuits. The design of the first sets of cooling circuits is complete. A contract has been placed for the manifolds, the branches and the flexible hoses for the first 20 circuits.

## 4.7 Glow Discharge Electrodes

The conditioning of the W7-X plasma vessel will be performed by glow discharges. Ten glow discharge electrodes will be permanently placed inside the vessel. These electrodes are available for installation in W7-X. One prototype was tested in ASDEX Upgrade and was operated successfully for 4 months. Some small design changes will be made to the fixation of the glow discharges. A second test is planned in 2009. Each glow discharge electrode is supplied by a separate power supply delivering a voltage of up to 3 kV and a current of up to 3 A. The technical specification for these power supplies was agreed, the tender action was finished end of 2008 and the contract was placed in industry.

# 5 Engineering

The sub-division Engineering (EN) provides engineering support to the Wendelstein 7-X project. EN is organized in three departments: Design Engineering (DE), Development and Test (DT), and Instrumentation (IN).

## 5.1 Design Engineering

### 5.1.1 Structural Analysis and Design

Design Engineering continued to investigate the mechanical behaviour of the W7-X structure system and its components during various assembly stages and modes of operation. Since the whole structure is by far too complex to be described in detail by a single finite element (FE) model, it is necessary to use coarse global and detailed local models. The latter can be run independently with boundary conditions extracted from the global models (GM). Two separate global models are necessary for the whole W7-X basic machine structural analysis: the magnet system global model and the cryostat global model. The global models include elastic material properties only; however, they take into account nonlinearities like friction and gaps. In addition to structural calculations, also fracture mechanics investigations were performed in order to assess the remaining steel casting defects of the coil casings as well as cracks in welds and weld influence zones which occurred particularly during welding of the inter-coil structure. These evaluations were performed with analytical and semi-empirical methods which were previously confirmed with the help of FE tools. As a result of the completion of the basic model developments, the number of external FE analysis contracts with other institutions and companies has been reduced.

#### 5.1.1.1 Magnet System Global Analysis

The magnet system GM encompasses the non-planar and planar coils (NPC and PLC, respectively), the central support structure (CSS) including the extensions for coil support, and the inter-coil support structure. The latter comprises the ”narrow support elements“ (NSE) on the high field side between non-planar coils, the ”lateral support elements” (LSE) on the low field side between the non-planar coils, the “contact elements” (CTE) between the half-modules and modules, and the ”planar support elements” (PSE) between planar and non-planar coils. The narrow and part of the planar support elements as well as the CTE basically consist of sliding aluminium bronze pads, held by steel pad frames, and corresponding steel counter-faces. The highly loaded interfaces between the CSS and the coils, the so-called central support elements (CSE), comprise the complex bolted and wedged flange connections which partially open during operation. Two global model variants for the W7-X basic machine were developed and are routinely in use: The 36°-GM encompasses one half-module ($1/10^{th}$) of the machine and thus represents the elementary cell of W7-X symmetry, each containing all seven coil types. With this 36°-model, bolt loads, cool-down, and magnetic loads can be simulated. The influence of the neighbouring half-modules is accounted for by special flip-symmetrical boundary conditions. This model is reasonably manageable and fast; however, it cannot be used for the final analysis due to presence of loads which are not in accordance with the stellarator symmetry like gravity and the reaction forces of the cryo-legs. Therefore, a 72°-GM is needed which represents one module ($1/5^{th}$); it is coupled to the rest of the torus by cyclic boundary conditions. Operation of this model is quite involved and time-consuming. For loads not even complying with the five-fold torus symmetry, like asymmetries caused by module misalignments (whether as a consequence of assembly tolerances or on purpose for field corrections) or trim coil fields, a complete 360° model is required. Such a third GM variant – a simplified model which can be handled with reasonable effort – is currently under development. Due to the complexity of the structure, including many frictional sliding elements, the magnet GM behaves extremely nonlinear and is very sensitive to variations of initial parameters and boundary conditions. In order to get sufficient confidence in the results, at least two independent global FE-models are indispensable. As a consequence of earlier developments and due to special requirements, currently three FE-GMs are under development and use: The ANSYS GM as the furthest developed one, with fully operational 36° and 72° variants and a 360° one under development, the ABAQUS GM in the 36° and 72° variants, and the ADINA GM in the 36° variant. The ANSYS GM, since about five years the main FE-tool for the magnet system structural analysis, was originally created with the help of the Efremov Institute (St. Petersburg, Russia). Development activities, i.e. continuous updating as well as improvement of the model and its structure and postprocessing procedures, are still ongoing. In addition, systematic documentation of the models – to such an extent that they can also be used by newcomers and external experts – was initiated in 2008.

The 36° ANSYS GM as well as the 72° model are the workhorses which are heavily used for all kind of magnet system analyses. Unfortunately, the module model requires enormous resources. One run takes up to one week for full load history which includes bolt preload, dead weight, cool-down, EM force application, and optionally the effect of winding pack (WP) embedding. With this model, there are still some minor open issues concerning convergence under particular friction conditions at the cryo-legs but some clues to solve the problem were found already. However, the practical functionality is fully available. The ABAQUS GM emerged from a simplified model used for predicting magnet system deformations during different assembly steps. Starting from this it took relatively small effort by LTC comp., Italy, to create a 36° and later a 72° fully functional model with extended post-processing tools. These models have been in operation for almost a year and are used for benchmarking, comparative studies of special structural questions and for special tasks for which this code is better suited (e.g. for frictional study of cryo-legs and for large deformations). The ADINA code has been for many years the only tool for magnet structure design. A 36° model has now been recreated from scratch with partial support from IBK company (Germany); it is completely independent from the ANSYS and ABAQUS versions. Contrary to the latter, some elements like NSEs and PLC were created quite detailed and most of the components were modelled in one piece with contact interfaces only at places where these exist also in reality. With this 36°-model, bolt loads, cool-down and magnetic load can be simulated, and even the stress distribution of the narrow support element gliding pads, including the tilting effect, as well as the shear pins of the planar coil casings can be captured directly. The coil and inter-coil structure models are already completed, and benchmarking was started using a preliminary model of the central support structure (CSS) imported from the ANSYS model. Due to the limitation of resources, the complete model was again somewhat delayed, it will be available within the first quarter of 2009. Benchmarking with the three FE codes proved to be extremely important and helpful for their developments and updating. Examples are the discovery of incorrect representations of the PLC casing shear pins and PSE gaps in the ANSYS model, the assessment of the influence of the code dependent contact settings, the optimisation and correction of the CSE bolt representation in ABAQUS and correction of numerous minor postprocessing bugs. This resulted in corrections of displacements as bases for configuration control, and of force and moment interface definitions for the sub-models. In summary, the benchmarking between the three models showed so far good agreements, and deviations are within the safety factors chosen for structural analysis. Some checks are still required particularly concerning the loading of the pins and bolts of the PLC casings.

The principal GM applications are calculation of stresses, deformations, and forces/moments in the main structural elements which occur during different modes of operation such as bolt tightening at room temperature, dead weight, cooling, and electromagnetic loads. Also the influences of the winding pack embedding pre-stresses, different friction factors at the gliding elements, tolerance deviations, NSE and PSE gap variations, assembly procedures, etc., are simulated. Using the GM, and based on the experiences gained during assembly of the first module, the tolerances for the NSE gaps were finally defined. Since the required tolerances are about twice as large as previously assumed, this point has to be particularly considered when the operational limits of the machine will be finally exploited.

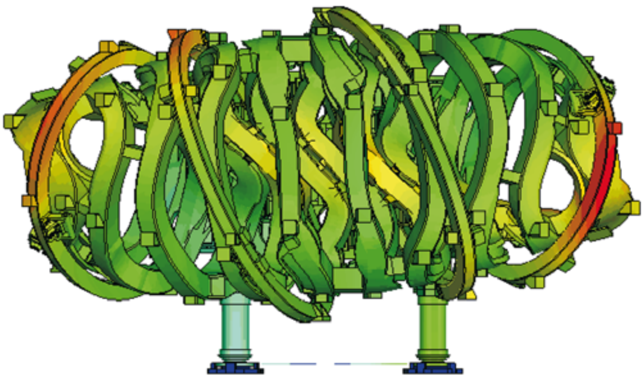


*Figure 10: Deformation of the magnet system [m]. Benchmarking results for 72 degree ABAQUS and ANSYS models after bolt preload, dead weight, cool-down and EM load application (agreement within 5 % for non-planar and 10 % for planar coils).*

Such studies are planned after completion of assembly when all design changes, non-conformities, achieved tolerances, material characteristics, etc., will be known in detail. No significant limitations of the W7-X operational space are expected due to the relaxed NSE gap tolerances, in the worst case some extreme field configurations with 3 T at the plasma axis might not be completely accessible.

#### 5.1.1.2 Detailed Analysis of Magnet System Components

A number of local FE models use input data from the global models to scrutinize in detail the behaviour of critical components. These local models are continuously updated in agreement with final component design and production, and adapted to the different machine modules which are generally not completely symmetrical. Development, refinement and updating work was done mainly at IPP, but also by other institutes in the framework of international contracts: Forschungszentrum Jülich (FZJ) is working on the bus system and Warsaw Technical University (WUT) on the CSEs and the lateral support elements at the module interfaces.

### 5.1.1.2.1 Coils

Besides updating and refining the coil models according to as-built geometries, much analysis work became necessary as a consequence of geometry non-conformities as well as due to questions emerging from collision analyses and during assembly. Further work was done in the course of evaluation of the strain gauge and coil deformation measurements in Saclay. GM mechanical data concerning the coils were also requested as inputs for fracture mechanical and dynamic analyses. Dynamic FE studies were continued at IPP, the corresponding contracts with KRP, Germany and LTC, Italy companies were closed. Main issue was the understanding of coil oscillations, triggered by mechanical impact due to possible stick slip events on NSE and CSE gliding surfaces, and their comparability to the impacts of pendulum hits at the planned “MQ-test” in Saclay, France (s. below). The design of the trim coils was also accompanied by FE structural analyses until the conceptual design was finished.

### 5.1.1.2.2 Central Support Structure (CSS)

Most of the FE-calculations regarding the CSS were performed concerning non-conformities with respect to geometrical deviations; the results were needed for decisions concerning material removals and/or local reinforcements. Another issue was the question whether tolerance deviations of shear pins or pin-holes at the step-flange between half-modules were acceptable or not. Still not finally decided is the problem of sliding and displacements of the module connection flanges and the means to avoid this – either by insertion of a key with high accuracy or by increasing the friction factor between the flange surfaces. Following from the FE analyses, the latter version is preferable from the structural integrity point of view. Commercial foils for insertion between the flanges are available (s. below).

### 5.1.1.2.3 Cryo-Legs

FE calculations with the 72° GM as well as local analyses were performed in support of the cryo-leg detail design as well as for the mechanical test program of the fibre glass reinforced epoxy tube which is shrink-fitted into steel flanges at both ends. With the now known final material data, the test results agreed well with the FE model, and the required safety margins have been confirmed.

### 5.1.1.2.4 Central Support Elements (CSE)

Each coil is suspended on the central support structure via two bolted connections to the corresponding extensions of the central support structure. These connections are typically made of a thick single or of a matrix of up to nine long, elastic Inconel 718 bolts which are pre-loaded at room temperature and keep a high pre-load also after cool-down. Stainless steel wedges and shim plates are inserted between the coil attachment blocks and the shoulders of the CSS extension flanges.

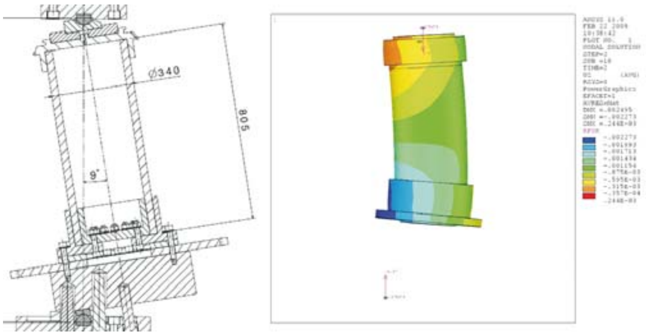



*Figure 11: Set up of the GRP tube test (left), and vertical displacements [m] from FE simulation (right)*

The creation of detailed parametric models for all 14 connections, in close cooperation with Warsaw Technical University, has been completed in 2008. These FE models were, and continue to be, quite useful for analysing the consequences of tolerance deviations of the wedges and shims. The mechanical integrity of the CSE connections is very sensitive to these tolerances, and in order to achieve them, several assembly corrections became necessary. The models were also heavily used in connection with the evaluation of series of non-conformities concerning the unevenness and poor machining of some contact surfaces for the bolt sleeves at the CSS back-side.

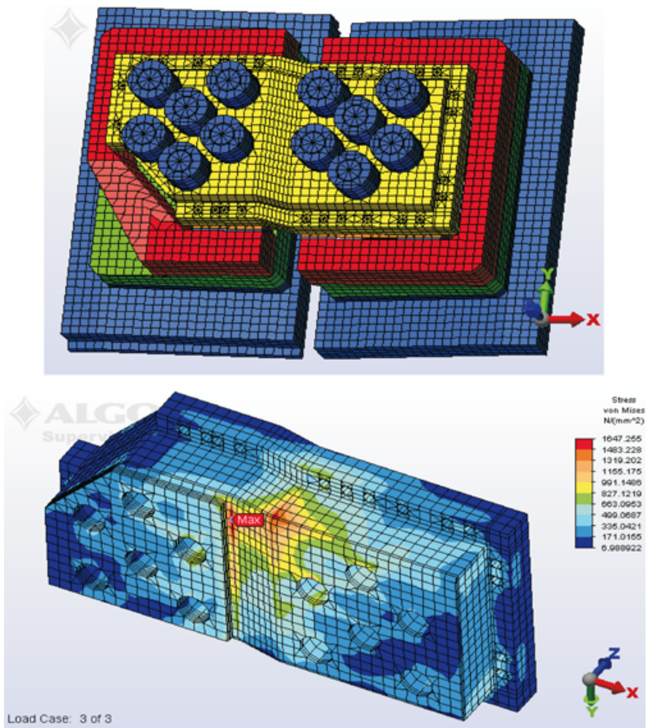



*Figure 12: Lateral Support Element 5-5; option with “kinked” Inconel bridge. FE-model (top) and results (bottom).*

#### 5.1.1.2.5 Lateral Support Elements (LSE)

The lateral support elements are located on the low field outboard side. They transmit tensile, compressive and shear forces up to 1.7 MN, and bending moments up to 200 kNm, resp. For the non-planar coil pairs 1-1, 1-2, 2-3, 3-4, and 4-5 the corresponding LSEs are welded, for the LSE between the coils 5-5 at the module boundary a bolted solution was adopted. The design of the highly loaded and complex LSE 5-5 was completed and its final functional specification issued. A detailed parametric FE model is being created by Warsaw Technical University.

#### 5.1.1.2.6 Current Lead Suspension (CLS)

The FE model of the current lead suspension was used to support the final design of this ”fixing box”, and was updated several times. Main challenges were the interfaces to the current leads where the warm flanges need sliding supports, to the bus system which is quite sensitive to mechanical loads and deformations, and to the cryo-pipe system with a considerable number of flexible hoses in the region. Adequate bus support positions had to be determined in close cooperation with FZJ. Since every current lead pair to bus interface needs to be treated individually, this work is continuing.

#### 5.1.1.3 Fracture Mechanics

Fracture mechanical evaluations were continued due to repeatedly occurring surface cracks, particularly during welding of the LSEs. The cracks generally appear in the coil casing cast material adjacent to the weld and not within the weld or the LSE material itself. The analyses were performed with analytical, semi-empirical methods with worst case assumptions and high safety margins. Fortunately, none of the concerned welds had to be re-welded which would have been a very difficult task with anyway questionable expectations on the results. Acceptance criteria were issued which cover the vast majority of such cracks; the few remaining ones were treated individually. The final documentation of the residual coil housing defects was obtained from the manufacturer. These cavities were conservatively treated as cracks, and their influence on the mechanical integrity has been evaluated. None of the defects needed repair or affects the operation characteristics of W7-X. These investigations are now closed.

#### 5.1.1.4 Cryo-Piping

FE-modelling (in ANSYS) of the cryo-piping was completed for the first module to be assembled (module 5). The aim of this work was to determine mechanical loads and deformations of the complex piping system as a consequence of the magnet system movements during cool-down and magnet excitation. The analyses were performed iteratively in parallel with the proceeding piping and pipe support design, and the model was continuously updated. Since an enormous number of components, non-linear supports, flexible elements, and interfaces have to be considered, this was quite a tedious work. The effect of internal pressure was implemented in a few components where some pressure impact is conceivable.

#### 5.1.1.5 Cryostat

The main application of the ANSYS cryostat global model was the study of a number of assembly load cases of the outer vessel half-shells. They are relatively soft before they are connected to single modules and finally the torus, and their stiffness also depends on the number of ports assembled at a certain moment. In addition, the upper shells are rotated by 180° for application of the thermal insulation. In all these cases the shells are not allowed to deform significantly and thus need to be supported during handling. With the help of the FE model adequate assembly support structures and handling procedures are defined. This work is ongoing and has to be performed for all shells due to the asymmetry of the modules. Another application of the model was to create the force/moment boundary conditions for evaluation of the weld strengths of the ports at the plasma and outer vessels. Several weld seams had to be reinforced as a consequence of design changes and special assembly procedures for the ports.

#### 5.1.1.6 In-Vessel Components

The analyses of different test divertor unit (TDU) options have been performed in support of Scenario 3 activities. In addition, several FE calculations were carried out in the course of the design of diagnostics components.

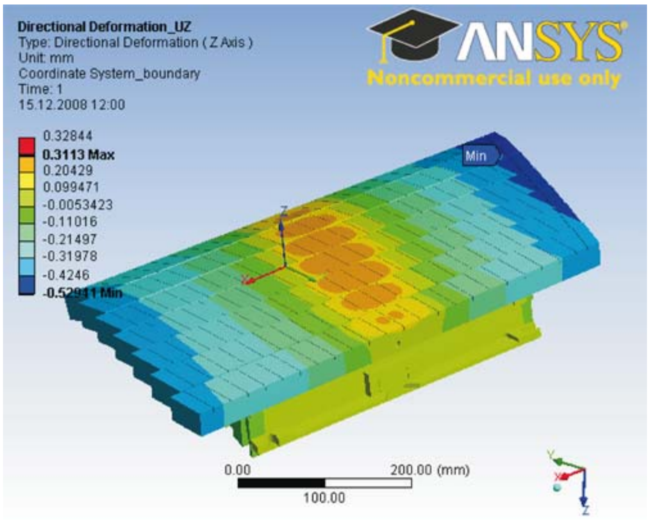



*Figure 13: Vertical deflection of the test divertor unit (TDU) under thermal load of 8 MW/m² for 6.5 s at the tile centres*

#### 5.1.2 Electromagnetic Analyses

Simulation of fault scenarios like current imbalances during emergency magnet switch-off and shorts was continued. In addition, numerous calculations were performed in support of other activities: Forces as input for the bus design, forces on coils during tests in Saclay, on coil headers, and on thermal shields. Further, fields in NBI injection areas, and coil AC current simulations for impedance spectrum tests were analysed. Fault scenarios of the W7-X magnet system as well as eddy currents and forces in the copper lids of the QD-ports were assessed, an electric fault during the coil test in Saclay was simulated and thus clarified, and stray fields in the vicinity of diagnostic equipment was assessed. The analysis of fabrication errors of all fabricated winding packages (WPs) confirmed the presence of a large systematic contribution to the shape deviations. The corresponding statistical portion of the deflections is of the order of 1 mm which corresponds to a normalized magnetic field perturbation of $0.5 \cdot 10^{-4}$ - $1.5 \cdot 10^{-4}$, dependent on the coil placement sequence. A statistical analysis of existing uncertainties was developed, and a coil positioning optimization process for the remaining half modules was developed in order to compensate field errors at an early stage. The conceptual design of the trim coils was accompanied with field and force calculations.

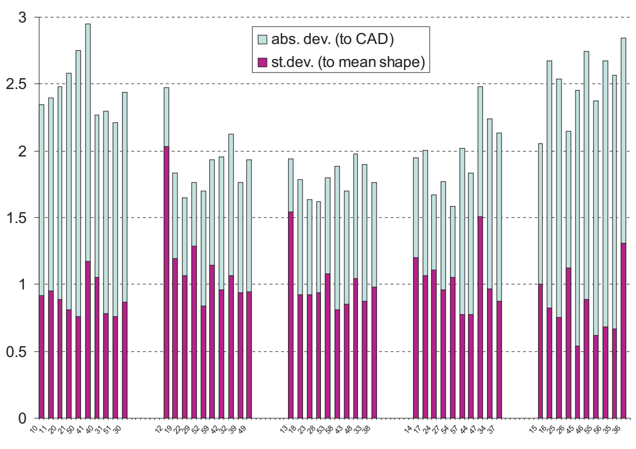



*Figure 14: Average absolute and statistical deviations of the manufactured shapes of the non-planar winding packs*

## 5.2 Development and Test

### 5.2.1 Coil Support Elements

Even though the test program in support of component development is already completed, further tests are continuously required for final design confirmations, definition of operation limits, for qualification of new materials, and for preparing decisions concerning non-conformities.

#### 5.2.1.1 Central Support Elements

The functionality of the central support element (CSE) bolted connections with respect to mechanical loads, as well as assembly procedures and instrumentation, was tested in a long-term 3-bolt test program over the past years; the main results were already presented in the previous report. In this reporting period the test program was finally reviewed and documented in an executive summary. The EN-DT dept. was still involved in supporting the assembly of the CSEs by helping to prepare and update the respective work instructions and to evaluate the achieved tolerances. Furthermore, non-conformities were assessed in close collaboration with the assembly sub-division, and the final quality control was developed and established. In all cases the assembly steps could be adapted, and in some cases corrected in order to guarantee the requirements. Another ongoing routine work was to check drawings of the connection elements before ordering the parts.

#### 5.2.1.2 Sliding Contact Elements

Due to lack of Al bronze for the pad production of the sliding bearings (NSE, several PSEs, CE) which complied fully to specification, a new material had to be qualified. The functionality of pads using the new Al bronze was shown in cryo-vacuum at 77 K on full-scale friction tests, including a relative tilting of 1° at full load. The expected operating cycles of W7-X were simulated at different normal forces. Two experiments were performed with pad materials only partially according to specification – one with the yield limit, and the other with the ultimate strain below the requested values. For the pad material complying with the yield limit specification smooth sliding for more than 4000 load cycles could be demonstrated at maximal forces corresponding to the NSE maximum design load. Only at normal forces far above that the coefficient of friction started to increase significantly and stick-slips occurred after about 200 load cycles. These positive results provided the basis for acceptance of reduced ultimate strains >10 % (instead of originally specified 14 %) and for yield-limit grading of the available material according to the expected loads. All remaining full-scale NSE friction experiments were successfully executed at KRP company, and this program was terminated. The test equipment was disassembled and is now stored at IPP Garching. A document exists describing a re-assembly of the experimental setup if necessary in future. In order to solve still open questions like the detailed friction behaviour at 4 K, and for possibly up-coming issues regarding operational limits of the sliding bearings concerning magnetic field configuration changes during operation, an alternative friction test device is available for scaled down NSE-samples at Bundesanstalt für Materialforschung (BAM) in Berlin. Other open questions which could be investigated here, are related to non-conformities and ageing. Some preliminary tests with the BAM equipment were performed already in liquid nitrogen and helium baths, but no final conclusion can be drawn from these experiments. Therefore, the experimental setup was upgraded from a bath-cryostat to vacuum operation at 5 K and 80 K, respectively.

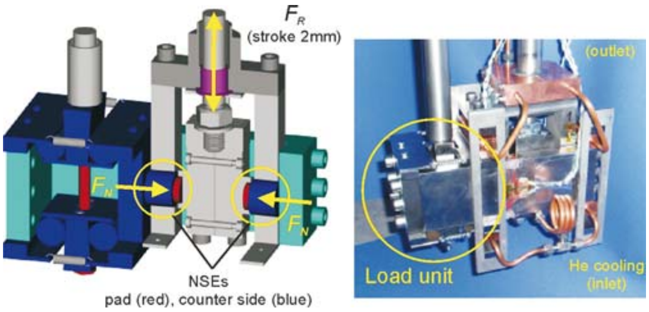



*Figure 15: Friction test device (core unit) for scaled-down NSE samples at BAM. Left side: cross section through CAD model. Arrows indicating the normal (FN) and friction (FR) forces acting on the NSEs. Right side: photograph of the test device.*

Systematic pad and counter-side $MoS_2$ layer ageing experiments were continued at different temperature and humidity levels in order to estimate possible impact of the long-term exposure to air during the W7-X assembly phase. In order to reduce such ageing risks, in the assembly as well as the torus hall the air humidity level is kept below 50 %. Further activities were the supervision of NSE pad and counter-side layer applications, and evaluation of non-conformities as well as the corresponding preparation of decisions. For out of tolerance defects on sliding surfaces, a repair process by application of laser welding was qualified and successfully applied on several NSE sliding surfaces.

### 5.2.2 Central Support Structure (CSS)

The first assembly of the bolted connections of the step flange of the CSS was supported by cooperation in preparing the respective work instructions, in qualifying the reaming of the shear pin holes, in developing the quality control, and in finding solutions for non-conformities. Together with the QM department, the reliability of the measured bolt pre-loads using a bolt-mike was studied in detail. In this context the influence of the bending of the bolts was investigated. $MoS_2$ spray coating was introduced on the shear bolts in order to allow – if necessary – pulling out of shrink fitted bolts. A qualification program was started for commercially available friction foils and surface layers which could significantly increase the friction factor of the surfaces between the CSS flanges. First test results are very promising, and in case of a successful qualification, these friction layers could avoid the necessity of highly accurate wedges in corresponding grooves between the CSS flanges. As a consequence, the assembly would be facilitated and, more important, any gliding of the flange parts on each other would be avoided resulting in an increased long-term integrity of the flanges.

### 5.2.3 Coil Quench Experiment

The objective of the mechanical quench (MQ) test is to simulate the impact of possible stick-slip events, originating from structural components, on the W7-X coils during operation. It shall be explored whether the associated dynamic loads are able to trigger large enough elastic energy releases and displacements of the superconductor strands to cause quenches by frictional heat. The dynamic test loads will be applied by a pendulum via a transfer rod to the casing of a cold and energized non-planar type 2 coil within the cryostat of the CEA magnet test facility at Saclay. In summary, the MQ test shall provide information about the coil stability with respect to mechanical disturbances. The required experimental setup was developed, pre-assembled, and a CAD model was created. The force profiles generated by the impact unit were studied in detail and used in FE simulations of the MQ test. The crew responsible for the execution of the MQ test was trained on a separate room temperature setup at the disused DEMO coil. Due to other priorities and schedule problems the MQ experiment at Saclay was postponed, and is now planned for summer 2009 at the end of the coil acceptance test program.

### 5.2.4 Materials

Orthotropic mechanical characteristics (stress-strain relations as well as thermal contraction) of fibre-glass epoxy insulation cap samples of the bus-bar joint to cable interfaces were determined at 5.2 K. Cryogenic tensile tests of a PLC winding pack sample were performed perpendicularly to the cable axes. Microstructure investigations and cryogenic tensile tests were finished for the new Al-bronze alloy for NSE/PSE/CE pad materials, and based on the KRP experimental results (s. above) the different charges were categorised in three groups. Cryogenic tensile tests of the weld influence zones of the conductor jacket material were prepared for determining mechanical characteristics dependent on position. All cryogenic tests were carried out at FZK. The material data base was maintained and continuously supplemented as an ongoing activity. After agreement with Tempelmann and P&S companies, the data from a series of tensile tests on Inconel 718 (2.4668) have been transferred from the test laboratory at FZK to IPP. A test program for better understanding the quality of the cable jacket welds and weld influence zones was started. This includes the allocation of an experimental setup for the 100-sample test program which was performed together with MC, tensile tests at RT and 4.2 K of small Al weld seam samples as well as full size Conductor-in-Conduit jacket samples, and initiation and support of a corresponding diploma work which was supervised by the QM department. This latter study concerned dynamic load tests of the cable to joint weld area, covered with the fibre-glass epoxy insulation, at $LN_2$ – temperature with simultaneous leak rate determination. Finally, a room temperature tensile test development was started in order to provide quick statements on the weld quality which are required to check welds and welders at the start of every welding campaign without delay. Collection and classification of coil housing cast defects were completed.

### 5.3 Instrumentation

Investigation and development of improved strain gauge systems for application in W7-X was successfully completed. The new system consisting of Type CFCA gauges from TML comp., with copper coated compensation blocks, significantly reduced the temperature dependence in cryogenic environment. The apparent strain signal generated by self heating was reduced by a factor of five, and the apparent signal due to temperature imbalances during cool down at least by a factor of three. It was decided to replace all strain gauges on the PLCs with the new system, and this was achieved up to now by more than 50 %. Further, all sensors on the NPCs to be changed or repaired due to malfunction for any reason are replaced by the new system. Also all CSS sections delivered are instrumented with the new sensors, as well as all the remaining structural elements. Cantilever systems, based on full-bridge strain gauges, are used as displacement sensors. The advantage is that such cantilevers are commercially available, and due to the in-house experience with strain gauges the development work was minimal. In addition, uniform electronics can be used for data collection. Such displacement sensors are applied to monitor the opening of the highly loaded CSE flanges, and the relative displacements of the coils with respect to each other. Development and qualification of the flange opening measurement system has been completed, and all critical flanges of module 5 are already equipped.

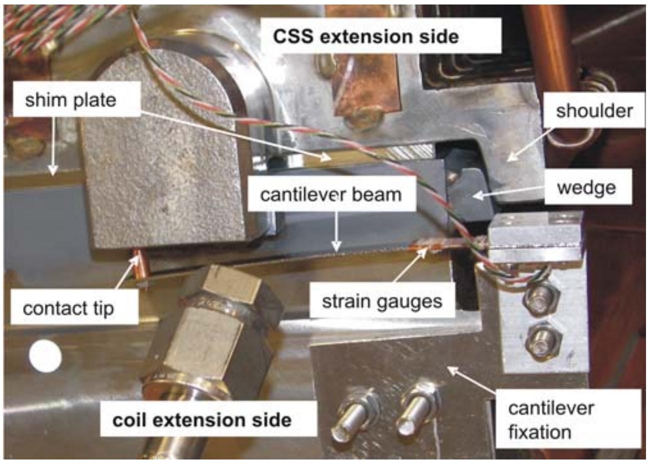



*Figure 16: Cantilever system for monitoring the CSE flange opening, applied on PLCA-Z1. The cantilever is attached at the "open" of the three sides of the CSS extension where the shoulder and wedge are missing. The shim plate between the flange sides and one of the three shoulder and wedge matings can be seen from their narrow sides. The cantilever beam is fixed to the coil extension. Its contact tip follows the movement of the CSS extension at the other side of the flange.*

Development of the cantilever-based coil displacement sensors is close to completion. Basically, a cantilever equipped with strain gauges is fixed on top of one coil, and the displacement with regard to the neighbouring one is transferred via a stainless steel wire. Tests under realistic cryogenic conditions were performed at Saclay by measuring the deformation of a planar coil during cool-down and energization. In parallel, strains at two highly loaded positions were measured with the new strain gauge sensors. The coil dilatation and strain measurements correspond well with finite element model results within 10 %. The additionally measured torsion of the coil cross sections is still under evaluation. In addition, the preparation of the test equipment for the MQ-test was supported. The transfer rod for transferring the impact from the pendulum into the cryostat and further to the coil was instrumented with strain gauges in order measure the direct and reflected pressure waves for evaluation of the impact characteristics. Together with the adapted electronics a time resolution of 10 µs could be achieved which allowed a detailed measurement of the impulse shapes during the pre-tests. The cantilever system, including the electronics, was also adapted to measure coil oscillations (as a complement to accelerometers) by monitoring relative distance changes across the coil. The main issue was to overcome resonances of the measurement equipment which was solved by a suitable damping system. Several pre-tests were performed – statically at cryogenic temperatures in Saclay, and dynamically at room temperature on real coils and the disused Demo-coil. It was demonstrated that the system works up to displacement frequencies of 300 Hz which covers the most relevant oscillatory eigenmodes of the coils. In order to coordinate all instrumentation activities concerning the basic machine (except plasma diagnostics), the "Extended Instrumentation Group" was installed. It is chaired by the head of the instrumentation dept. and encompasses members from all involved sub-divisions.

## 6 Design and Configuration

The subdivision "Design & Configuration" is responsible for configuration management of W7-X, thus for establishing data structures and data change processes that at any time provide a complete and up-to-date data set of all components of W7-X, for configuration control of the components in the cryostat, the plasma vessel and the components in the experimental area and for providing design capacities and design standards for most of the components of W7-X. These tasks are taken care of in the three departments "Configuration Management", "Configuration Control" and "Design Office".

### 6.1 Configuration Management

The tasks of the department Configuration Management (CM) are to provide complete and up to-date system identification of all components of W7-X and to ensure proper change and deviation management. System identification of the components is based on various documents. The Ringbuch documents provide overall information on any major component and refer to all relevant documents concerning specification, interfaces to other components, change requests, non-conformity reports etc. Maximum use of existing tools is made wherever possible. The product lifecycle management (PLM) system is simultaneously used as a documentation data base, as a navigation platform to the specification of W7-X and its components and for notification on new releases of CM-relevant documents. Links between the CM-relevant documents in the PLM-system support the consistency of the system documentation including the impact of design changes and variances. This navigation structure is shown in figure 17.

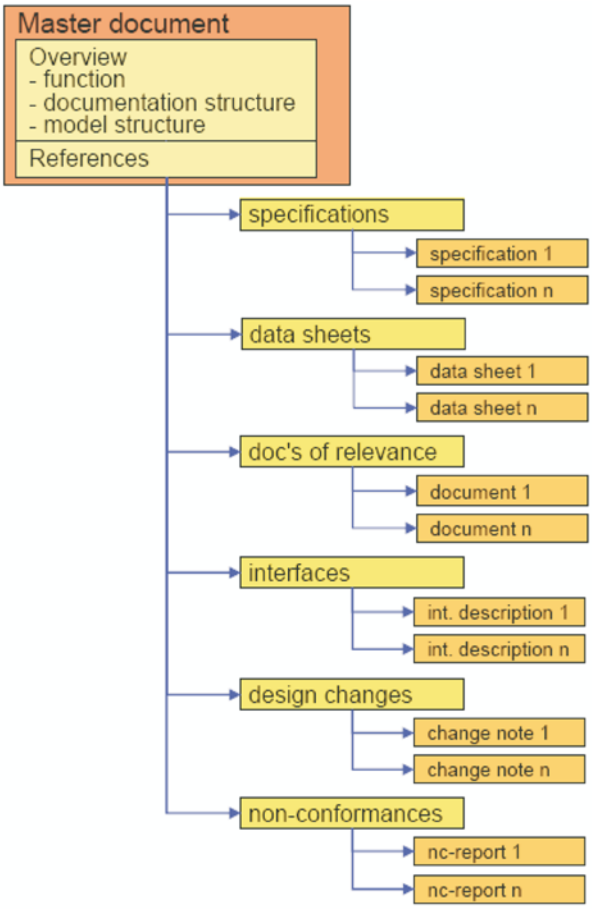



*Figure 17: Standardized navigation structure for documentation items of a W7-X component*

Implementation for the various components has been started. Permanent control of the various CM processes is supported by specific process data bases. Currently, status and open issues of change requests, quality deviation reports and interface descriptions, are monitored thereby. Thus decision processes have generally been accelerated and decisions, their rationales and impacts are efficiently communicated within the project. An organizational structure has been established with escalating decision paths which lead from the occurrence of a change request or detection of a non-conformance to the implementation of the corresponding measures (see figure 18). These paths are adapted to the criticality of the individual problem. Critical processes are led by CM and are decided by the configuration control board (CCB). All problems that have been time critical with respect to the assembly schedule could be decided without delay being introduced by the decision process itself. A potential impact of any design change and residual non-conformance on later operation of W7-X is independently assessed by CM and the device safety department. The results of this risk analysis are included in the change and non-conformance data base. The data base will be helpful in exploring the boundaries of the accessible operational space and will support trouble shooting in case of system failures.

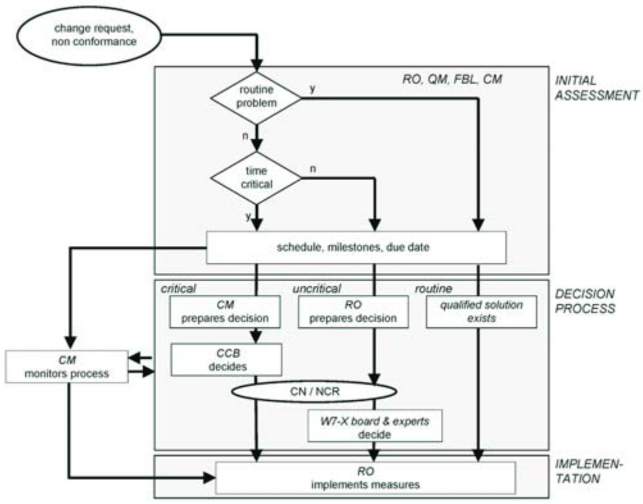



*Figure 18: Decision paths for change and non-conformance processes. Critical processes are led by CM and decided by the configuration control board.*

## 6.2 Configuration Control

The main missions of the department Configuration Control (CC) are to ensure collision-free operation of W7-X for all modes of operation and to coordinate the space requests of peripheral components in the torus hall and adjacent buildings. In 2007, tools and procedures were established, to improve the speed, reliability and accuracy of the investigations. The configuration control procedures for the components of the magnet system (coils, central support ring and cable trays for instrumentation) are implemented; work is progressing accordingly to the schedule. Close, fruitful and established collaboration with other departments facilitates to quickly find viable solutions for detected collision conflicts and implement these solutions. Configuration control of the other components in the cryostat (cryo lines, busbar system, cryo shields) is not yet done to the same level of completeness and accuracy. This is due to missing or late information on the deformation of those components, due to a lack of engineers able to perform the sophisticated investigations and due to the complexity of the components. For example, the cryostat of one module of W7-X contains more than 130 pipes, 45 thermal insulations of ports, 20 insulation panels for the outer vessel, etc. this results in approximately more than 2000 constriction areas that need to be evaluated. To deal with this issue, some risk management decisions have been taken where the load cases were approximated, some design changes of e.g. the thermal insulation of the ports were implemented on a worst case assumption, and no configuration control for the cryopipes was done when it was clear that the likelihood of a thermal bridge in any of the load cases was considered small.

#### 6.2.1 Geometrical Data Handling

The group Back Office handles geometrical data, performs “reverse engineering” activities, assesses measurement data and provides measurement data and results of calculations of movements or deformations of components. Since recently the Back Office provides CAD models positioned at the actual locations as obtained from assembly. Thus the as-built CAD models, e.g. of the coils that are obtained from laser-scan data, are also positioned at the as-built location. With this information, the group Design Space Analysis can assess constriction areas due to non-conformities in the coil positions and can evaluate the consequence of a possible optimisation of the magnetic field through some minor changes of coils positions. Back Office also continues to improve existing tools (like CATIA mirror, collision report tools). Some new tools are in preparation: visualisation with 3dxml, automatic sub versioning of CATIA mirror, etc.

#### 6.2.2 Design Space Analysis

The main mission of this group is to perform configuration checks of the components in the cryostat to ensure collision-free operation. In 2007 about 300 collision reports were issued for e.g. the planar and non-planar coils of module 5, the central support ring, the port cryo insulation, the busbars. The complete configuration control (with definition of the rework neccessary) of coils and central support ring for modules 1 and 4 was achieved.

#### 6.2.3 Torus Hall Layout

The main mission of the group System Layout is to provide and document the space reservation of all the components outside of the cryostat in the torus hall and adjacent buildings. This is done by grouping all the components in the torus hall into about 70 main components. The space that these components occupy is being investigated following a sequence that takes into account the size of the components, the ability to adjust to restricted surroundings etc. Within this sequence 18 space reservations of components were revised and are now collision free, e.g. the space needed for the heating systems, current leads, etc. 10 change notes were processed that were triggered either by the requests for additional space in the torus hall for new components or to eliminate a collision between components that was detected in the system layout process.

### 6.3 Design Office

The tasks of the department Design Office are developing design solutions and providing fabrication drawings for components, supports, and tools for W7-X in close cooperation with the responsible officers in other departments. Additional tasks are defining and implementing design guidelines for working with CAD programmes and maintaining a proper structure of the CAD models in the data base. The numbers of designers had to be increased in order to cope with the additional tasks. Those tasks arose when originally externally designed components were decided to be designed in-house or when the challenges in finding design solutions turned out to be more time-consuming than originally estimated. In order to accomplish these tasks the design office is organized in five design groups that focus on those areas with most design activities: structural components in the cryostat, supply components in the cryostat, components in the plasma vessel, diagnostic components and components outside of the cryostat. Each group has a technical group leader (in one case the head of the design office) who coordinates the work, maintains the design standards and provides the project with an overall view of what additional resources are needed to accomplished the still outstanding design activities. Care is taken that for particularly time-critical design activities a sufficient number of properly trained designers is available. The CAD tool of W7-X is CADDS5 and in selected areas CATIA V5. Good progress has been made to update and properly position all models and components of W7-X in the CAD-PLM documentation system. The introduction of a coordinated approach to the design of all components in W7-X has been defined and coordinated. The Design Office is responsible for creating coarse design concepts and – depending of the components – also detailed design concepts, fabrication drawings and even supporting the responsible engineer in the material selection and interaction with the machine shop. The group Components in the Cryostat focussed on the following tasks: The plasma vessel CAD models were adjusted to take into account the latest design changes. The CAD models of the structural support elements, i.e. the Planar Support Elements/Lateral Support Elements and Contact Support Elements, were completed and detailed manufacturing drawings were provided based on the on-site measurements of the distances between the coils. The design of the cryo legs was finished in close coordination with the responsible officer. The detailed design of the current leads support was modified to incorporate the interface to the central support structure and the manufacturing drawings were completed for the first part. The group Cryostat focussed on generating a set of models of the helium supply lines, the thermal insulation, the bus-system and the cable routing in module 5 and partly module 1. Collision-free design under all configurations is achieved in close collaboration with Configuration Control. The detail modelling of the cryopipes for module 5 was developed in close coordination with the responsible officer and passed to the subcontractor. The integration of the database of the bus system in the PLM system was designed for the module 5 and module 1 completed. The design of the cable routing had to be adopted to the location of the other components in the cryostat and all manufacturing drawings for the first modules were created. The coarse design of the cryo shields of some of the ports, the cryo shields of the outer vessel and the helium lines on the outer vessel in module 5 were generated in close collaboration with Configuration Control and the requests from DWE. The group Components in the Plasma vessel focussed on completing the detailed design of the housing of the diamagnetic loops, the model design of the water supply lines to the wall panels, baffle and targets and the manufacturing drawings of the wall panels. This group interacts closely with the division KiP in Garching. Its main activity was the incorporation of the design changes in the components from the scenario 3. Various iterations were necessary in particular for the water line routing after some significant design changes had to be made as a result of insufficient installation space. The group Diagnostics focussed on those components that are to be installed earliest according to the assembly schedule. These are the Rogowski coils, the Mirnov coils, the bolometer, the diamagnetic loops, the neutral gas manometer and some components of Thomsen scattering. In close coordination with the schedule of the physics departments the design of the ECE diagnostics and the diagnostic injector was commenced. For the bolometer system different design solutions were investigated and approved in a design review. Following that, the manufacturing drawings were developed and created. On the neutral gas manometer two design variants were investigated, approved and fabrication drawings were passed to the machine shop.

## 7 Assembly

In 2008 the preparation of the assembly sites, the assembly equipment and extensive assembly trials have been continued. An additional assembly area (storage and preparation hall for outer vessel shells in Lubmin) was put in operation. The first and second magnet module finished successfully the mechanical pre-assembly. The first module has already been moved to the experimental hall. The third module is in the status of the half-module pre-assembly. Further complex assembly devices for the final assembly (assembly ramps, vessel rigs) have been delivered and commissioned. The mounting stand IIIa was delivered and installed as planned. As a result the spatial and temporal possibility for the assembly of busbars and helium pipes has been extended significantly. The manufacturing of the bus-bar system (co-operation with FZ Jülich) was continued as planned; the first 24 bus-bars and the associated mechanical supports for the first module were pre-assembled successfully. The preparation of plasma-vessel sectors, coils and support structures runs routinely. The mechanical preparation of the first two outer vessel shells (including the complex plasma vessel supports) was finished as planned and within the expected accuracy. Assembly trials with ports and with in-vessel components (KiP) have been performed to ensure the mountability. Welding procedures for ports were developed further to minimise the welding-shrinkage during the port assembly. The assembly sequence and technology for ports and KiP were optimised; accessibility problems at the module separation planes could be solved successfully. Several new engineers and craftsmen started their work. The assembly process planning, process documentation and work safety system continue to operate reliably.

### 7.1 Busbar System

The manufacturing of busbars and the associated complex mechanical supports operates routinely. Bus-bars and supports for the first module have already been installed. At the moment these works are continued at the second module. The design of the supports was iteratively optimised to avoid clashes with neighbouring components in the very narrow installation space. Practical installation trials have been made under real on-site conditions. The assembly time needed exceeded the original assumptions considerably. The main reason for it are the iterations necessary for the precise 3D-alignment of the very complex supports by the use of laser trackers and the on-site adaptation of supports to the real geometry of coil headers. Though many improvements in tools and in the assembly process were made, only the massive increase of working time and resources could ensure the needed assembly progress. The procurement of the pre-manufactured insulation parts for bus-bar joints caused severe problems. Prototypes showed cracks after thermal cycling under operational conditions. After several attempts and improvements the supplier gave up despite generous assistance by IPP engineers and the involvement of external test labs. Since there was no time to seek an alternative supplier and to start the development program again, an alternative insulation procedure was developed by the use of the existing knowledge of the coil manufacturer.

Up to now all pre-tests of this manual insulation procedure showed encouraging results. Since the manual procedure is more time-consuming and the manual wet wrapping is hampered by the limited access to the bus-bar joints a comprehensive training program was started for technicians who will be involved in this work. Construction work for the current lead joint-prototype and associated practical tests were continued in 2008. The design for the test piece that simulates the connection between current leads and bus-bar system was started. The test piece is used for the acceptance tests of built current leads and it serves the qualification of assembly procedures for that connection. This work is continued in 2009. The specification for the wiring and insulation of the quench detection system was further developed.

*Figure 19: Trial assembly of bus-bars in the first module*

The bus-bar preparation was put in operation; the associated work runs routinely. Engineers and technicians from INP in Krakow have been trained and a solid bus-bar assembly team was formed with them. The achievable quality on aluminium welds was statistically investigated. It was confirmed that the strength achieved is compatible with the requirements during operation. In terms of the assembly schedule more bus-bar work was moved to mounting stand IIIa. That avoids bottlenecks in the assembly sequences.

## 7.2 Vacuum Technology

The work packages of the vacuum technology group in 2008 were continued as in 2007. Main tasks were: leak detection on single components and monitoring of leak tests at suppliers as well as leak and Paschen tests on coils and on cryo piping in the component preparation and assembly. Local leak tests with diverse test chambers for superconductor connections and cooling pipes at room temperature and at 77 K (if technically necessary) are routinely implemented during assembly. A comprehensive development program for the use of shielding gas during the port welding and the associating leak testing was successfully carried out. Suitable materials and equipment for that process were qualified. The specification of the vacuum systems depends on the progress of the layout in the torus hall. It is therefore proceeding gradually.

## 7.3 W7-X Assembly

### 7.3.1 Component Preparation

The work in the component preparation, especially on coils and plasma vessel sectors, has been continued as planned. Meanwhile components for the fourth module (figure 20) are being prepared. To cope with inadmissible contour deviation at already delivered support structures an external firm was qualified for high-precision re-machining on-site. The same solution is used for the reaming of pin holes in the step flange between neighbouring half-modules during the mechanical pre-assembly. This quick and professional cooperation with industrial partners made the development of an own complex reaming machine dispensable.

*Figure 20: Preparation outer vessel shells*

The preparation work on the ports was continued in an external hall. The scope of this preparation was extended by the adaptation of the cooling/heating pipes of the ports. A special welding process was successfully developed to connect ports with copper foil. That will guarantee the demanded cooling qualities of ports. Outer vessel shells are separately prepared outside the IPP since enormous space is needed for the storage and preparation. The first module of the outer vessel was delivered and stored in a separate preparation area of about 3000 $m^2$. This module is divided horizontally into two shells, a bottom shell and an upper one. A shell weighs about 14 tons and is rather flexible due to many openings. At the inside of the shells the thermal insulation and the thermal shield (TI) will be fastened. To not damage the TI during the handling and assembly of the outer vessel shells they must be stiffened and reinforced. The design of the TI requires that any deformation at the shells is limited to less than 5 mm during all transportation and assembly operations.

The stiffening system required for it (TMV) consists of a steel framework. Tensioning pieces hold the shell within the framework and enable the adjustment of the geometrical contour of the shell. About 20 reference points and laser tracker measurements are used to control the adjustment. The shell remains in its TMV until both shells have been welded together in the final assembly. The timely design, analysis and procurement of these module-adapted rigs required large engineering resources. During the outer vessel preparation heavy plasma vessel supports (PGA) are precisely aligned and welded.. Three supports each are assembled into every bottom shell. They carry a module (a fifth) of the entire plasma vessel later. 5 adjustable bearings will hold the vessel in horizontal direction. This enables a controlled movement of the vessel during baking to 150 °C for example. In the first bottom shell the three supports were successfully installed. For the achievement of the specified geometrical accuracy (less than +/-2 mm at the top) the welding procedure with controlled shrinkage behaviour was essential. The welding experiences at the structure components in the pre-assembly could be applied here. The above preparation work was successfully completed at the first two shells (first module). The main task during the outer vessel preparation comprises the installation of the thermal insulation including the thermal shield. This will be carried out by the supplier of the thermal insulation, MAN DWE GmbH. The work started in the autumn of 2008 and will last more than 6 months per shell, at least for the first shells.

#### 7.3.2 Pre-Assembly

Already two magnet modules (out of 5) have been completed mechanically in the pre-assembly. This work is continued at the third module (third pair of half-modules). This operation can now be considered routine. The cooperation between all particpants, including the parts of the external supplier MAN DWE, works well and within the planned times. The first module was moved to the experimental hall (MST IIIa). On both first magnet modules the bus-bar system, the helium pipe system and the instrumentation are being completed. The installation of the helium-pipe system has turned out to be as demanding as the bus-bar system. Batches of pipes known as “lots” are positioned above and below the bus-bar system. A lot comprises up to 50 single pipes (∅ 10 to 50 mm; lengths about 2 m) which are precisely pre-bent (+/- 2 mm) by the manufacturer according to the 3D CAD model. The pipes are fastened at the coils and structural elements. G10 spacers in the support bearings prevent inadmissible heat conduction flows between neighbouring pipes at different temperature levels (inlets, outlets). The bus-bar and helium pipe work are much more time-consuming than originally planned. According to our present experiences this additional time is compensated by schedule contingencies. On the other hand these extended assembly times block the affected mounting stands for following modules. To cope with that bottelneck some work was shifted from MST II to MST IIIa and MST IIIa was comprehensively upgraded. In addition, a temporary mounting stand is planned on the already erected machine base. Despite the considerable increase in work packages in the pre-assembly the quality level of this work could be kept. Corrective actions for deviations in quality were immediately decided with the help of the configuration control board.

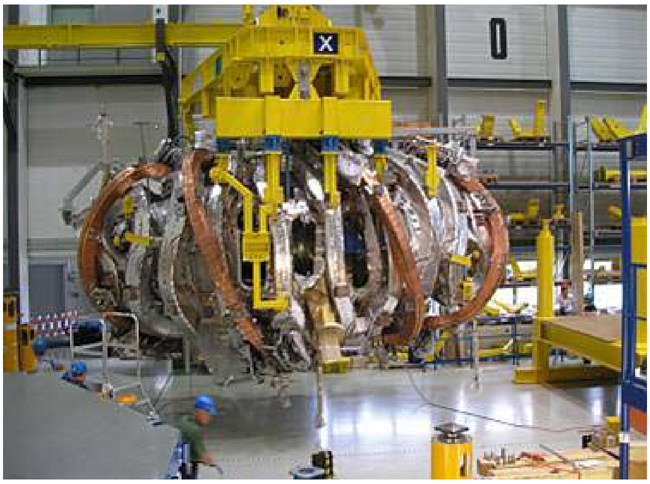


*Figure 21: First magnet module accomplished on the way into the experimental hall*

#### 7.3.3 Final Assembly

In the final assembly the construction work has not started yet. However, the technological preparation was continued as planned. For the assembly of the individual vessel modules most of the required procedures and equipment have already been obtained. The handling and positioning of the 100 t magnet modules and the proper functioning of the associated equipment was successfully tested with a 1:1 mock up. The achieved position and contour accuracy was better than 1.5 mm which is much better than originally estimated. During these tests valuable information was gained about improvements for the cranes. For the assembly of ports the equipment is manufactured in the industry at present. A heavy port-assembly bridge spans three sides of the module. It will be delivered mid February 2009. The bridge takes a port assembly ramp, which enables the precise alignment of ports in all 6 degrees of freedom. To be able to install ports also from the bottom side, a second port ramp is operated from the floor. In the standard procedure a port is simply fitted into the existing “as built” holes in the “as positioned” vessels. No extra alignment to the theoretical CAD co-ordinates is made. But the “as assembled” position of the port is measured and documented. The first port assembly-ramp was delivered in 2008 by FANTINI/Italy and commissioned and the personnel were trained with it.

Unfortunately, the expected positioning accuracy of the tool was not achievable. Therefore, the handling procedure for it was modified and an additional position control system is to be integrated. A second ramp, with an optimised design to improve the above accuracy, was ordered. This optimised design enables also the timely assembly of ports situated at the module separation plane. For almost all ports this method will be sufficient, but in some special cases it can become necessary to install the ports at accurately pre-defined positions instead of fitting them simply into existing vessel holes. The cause for it can be, for example, tolerance deviations or a very restricted installation space. These will be treated as individual cases. For the neutral beam injection port (NBI port) such an alternative installation procedure was developed. Welding the ports to the vessels is a special challenge since vessels have a poor stability due to many openings. Standard welding procedures can not assure that the welding shrinkage does not deform the vessel contour by more than a few millimetres. Per module a welded seam length of about 150 metres must be made. The weld seam thickness is between 8 and 12 mm. The welding sequence and proper temperature control are required to avoid inadmissible deformations of the vessel. Welders must be changed regularly due to the typical work height in the plasma vessel of only 1.5 m. Also the well insulated vessel must be cooled during welding. Suitable methods for the leak test and for the placement of the shielding gas to the rear side of the welded seams were recently tested successfully. First port welding tests by means of the DEMO vessel have been performed. The first aim is to define the welding procedure that guarantees, under on-site conditions, the minimum weld-shrinkage at the vessels. First results look promising. These developments are ongoing in 2009. MAN DWE, the supplier of the thermal insulation, proposed the assembly technology for the insulation of ports. This requires more resources and is more time-consuming than considered in the IPP-planning. The extended assembly time is to be compensated with technological contingencies in the schedule. With respect to the additional resources a third port assembly-ramp and parts of a second port assembly bridge are being considered at the moment. Trials and simulations are planned together with MAN DWE to qualify this technology in detail. With the installation of the ports a single module of the W7-X is completed with the exception of the plasma facing components. Once three modules have been completed the connection of neighbouring modules (module separation plane) can start at the earliest in the middle of 2011. The concept for the connection of neighbouring magnet modules (shim plates, bolts, fitting elements) was already worked out. This work is similar to that successfully applied in the pre-assembly. Tools and work procedures have to be qualified and described in detail. These tasks are assessed to be not critical at the moment. In contrast to this, the work to connect neighbouring vessel modules is challenging. Splice plates are machined to size and shape, precisely positioned in the gap between the modules and welded. On the cryostat side, the thermal insulation must be completed. Both work packages are carried out by the supplier of the vessels. However, the engineering for it and the work itself must be integrated into the IPP work flow. The wall thickness of the plasma vessel is 17 mm and of the outer vessel 25 mm. Welds of the plasma vessel can only be made from the inside whereas the outer vessel is welded from the outside. In addition some ports are directly located in the splice plate area. A detailed strategy was worked out to minimise the deformation due to the weld shrinkage. After the welding of the vessel modules the standard procedure (bridge and ramps) will be used to install the remaining ports in that area. Other assembly work at the module separation plane including the connection of bus-bars, helium pipes or instrumentation cables has still to be worked out. Another main work package will be the installation of the 7 pairs of the current leads. When all 5 modules have been connected the base machine of W7-X is complete except for the machine periphery and the in-vessel components.

*Figure 22: Assembly, welding and leak test of pre-band He-pipes*

The co-operation with the colleagues from Garching in the field of conceptual planning of the assembly of the KiP has been continued in 2008. Further assembly equipment for in-vessel components was designed, provided and tested in the assembly area. Trial assemblies with wall panels and sweep coils have been performed successfully. The system of platforms and cranes for the handling of components was developed further. An additional measurement arm for the alignment of targets and components was procured and tested. The achievable overall accuracies for in-vessel components was defined and tested. The implementation of these results in the running design activities is ongoing. A comprehensive review of the assembly technology for in-vessel components was held in July 2008. Main questions raised concerned the compatibility between vessel-assemblies, port-assemblies and in-vessel-assemblies and the achievable accuracies vs. design requirements. Most of these questions have been answered adequately by now, at least conceptually. However, many questions in terms of logistics, tooling and procedures still need to be worked in the time. In conjunction with the review, the entire KiP assembly sequence was completely revised and adapted to the delivery milestones and to compatibility requirements from other, parallel assembly processes. KiP assembly shall now start earliest after the first module separation plane has been completed and shall be carried out per module in one run. In the original planning the KiP assembly was divided in many work packages and distributed over the entire assembly period.

*Figure 23: Assembly trials with in-vessel components (sweep coils)*

The work on cryo instrumentation has been further continued. At the first magnet module about 50 % of the instrumentation has already been installed. At present, this work proceeds routinely and without special problems. Installation work of the extension of the low voltage power supply system is continued. The detail planning for the concept of the grounding area in the torus hall and diagnostic was finished. The first construction stage of the cooling system is nearly complete. The assembly control and the planning work routinely as before. Again additional resources had to be allotted to cope with the increased work. The advanced weekly and 4-weekly plans are used as standardised tools. Further improvements are planned. The preparation of the assembly documentation (QAAP, work and test instructions) is ongoing without any severe problems. In 2008 a first forecast for a refined resource planning was attempted. However, that system needs to become more extended and more reliable. As before, quality deviations are reliably handled. The assembly schedule was updated as described above. Main changes are: extended assembly times for bus-bars, and helium pipes and the thermal insulation; adaptation of the assembly sequence for KiP and for the module separation planes. Furthermore, the installation of the final periphery (cables, cooling pipes, vacuum lines, platforms) was brought forward. With that the commissioning date was kept constant on the middle of 2014 but the work density during the final assembly has increased further. Again staff for the assembly was increased (metrology, mechanics, insulation specialists) with personnel from industry. Three more responsible officers (helium pipe assembly, bus-bar assembly, planning) took up their employment. More external staff was recruited to ensure the partial two-shift-system and extended working times in the assembly. Additional engineering staff started the work for the development and qualification of technologies for the final assembly. A co-operation with engineers and technicians of the Polish Academy of Sciences was established. Altogether, assembly has reached the planned progress in 2008. Further new assembly technologies were qualified and successfully tested. The preparation of outer vessel shells was put in operation. The assembly technologies for the mechanical pre-assembly of magnet modules are now stable. The device assembly ran continuously and timely as planned but the expected learning curve effects could not be observed in the desired scope. Additional resources for engineering tasks and additional technicians for assembly works were hired to cope with the challenging schedule.


*Figure 24: The port assembly ramp*

Additional storage and preparation space was put in operation. New work packages for the technology development of the final assembly (for ports, module separation planes and KiP) were launched. The procurement of equipment for the final assembly was continued (rigs, laser tracker, measurement arm, welding technique) as well as the installation of peripheral equipment (cooling circuit, electronics, vacuum etc.). The assembly control with the planning and the documentation of assembly was further refined and works furthermore experienced and reliably. The co-operation with external partners who provide skilled and well-trained technicians and engineers for the realisation of the assembly work on W7-X works smoothly.

## 8 DIAGNOSTICS

### 8.1 Overview

The work concentrates on the “start-up diagnostics” set necessary for safe operation and control of the machine and those diagnostics adapted to and being indispensable during the initial operation phases of the experiment. Time, financial and manpower planning is adjusted to the agreed modified time schedules of the W7-X assembly. The diagnostics department is divided into nine expert groups and groups on technical coordination, documentation and control. A temporary working group within the project covers R&D on the development of heat-resistant plasma facing optical components.

### 8.2 Reports of Expert Groups

The following sections briefly summarise the main activities within the expert groups of the project. Due to assigned priorities there were no activities in 2007 in the subgroups on fluctuations, fusion products and heavy ion beam probe and fast particles.

#### 8.2.1 Edge and Divertor Diagnostics

After studying several possible mechanisms for driving the probe array for the Test Divertor Unit (TDU) and the High Heat flux Divertor (HHF), the idea of a unique solution for both applications was abandoned, mainly because of the very high operational temperature foreseen for the TDU. Since distinct arrays are envisioned, the integration of several non-movable probe tips directly into the graphite targets seems to be the favourable proposal for the TDU. A target strip imbedding such flush-mounted inlay tips was designed to check its thermal and mechanical behaviour using FE calculations. The graphite tips are insulated from the surrounding target by Aluminium nitride plates and, therefore, the heat transition coefficient between graphite and AlN has been experimentally determined as an essential input parameter for the calculations. For the tips of the HHF-array a piezoelectric drive seems to be an alternative to the existing non-flexible pneumatic solution. A feasibility study is initiated that will hopefully result in a bakeable prototype piezodrive for a single probe tip. The attempt to manufacture the first prototype of a manometer cannula revealed several weak technological points. Therefore, the solution was revisited and improved. As a byproduct the stiffness of the cannula was enlarged to avoid any additional support in the vessel. New manufacturing drawings are produced and semi-finished parts have been selected and ordered. As a result of the investigations of the noise in the manometer signals obtained with the newly developed digital electronics an insufficient sample rate was identified as a major drawback. This difficulty will be overcome by the application of a faster measuring card that, simultaneousl, allows for a more intelligent processing of the raw data.

#### 8.2.2 Microwave Diagnostics

The group prepares the classical microwave diagnostics, ECE, interferometry, polarimetry and reflectometry. A high priority task is the design and development of all in-vessel components in particular the high-heatload retroreflectors, which have to be integrated into the tiles of the first wall heat shield. The diagnostic group also installed and operates the Microwave StRay Radiation Launch facility (MISTRAL), which allows for the testing of diagnostic- and other in-vessel components in the environment of a strong microwave background radiation, as it will occur under certain ECRH heating scenarios. In the framework of the European Fusion Training Scheme (EFTS), IPP Greifswald is the home institute for one out of four trainees of the program Microwave Diagnostic Engineering for ITER (MDEI), set up together with IST (Lisbon, Portugal), CEA (Cadarache, France) and CIEMAT (Madrid, Spain). ECE is one of the most powerful diagnostics in W7-X, where during the first campaigns heating to a high degree relies on microwave heating of the electrons. The ECE diagnostic in preparation for W7-X uses the radiometer system formerly used at W7-AS. Its adaptation to the conditions and in particular the sightline at W7-X has been prepared. Moreover the broadband Gaussian in-vessel viewing optics has been designed and will be manufactured early in 2009. For density feedback at W7-X a single-channel two-frequency $CO_2$-CO laser interferometer is being developed, tested and qualified in the laboratory. It is being designed to share its sightline with the Thomson scattering laser to allow for a direct cross calibration. The cooperation with CIEMAT, where a two-colour ($CO_2$-YAG) interferometer is operated at the stellarator TJ-II, is being continued. Besides interferometry, a polarimeter channel is being developed for redundancy of the density control diagnostics. Studies for electron density measurements by polarimetry in the complex magnetic geometry of W7-X are conducted in cooperation with the Akademia Morska, Szczecin, Poland and the Technical University of Szczecin. For later multichannel applications, required to track the development of the density profile shape, a modular multichannel dispersion interferometer system is being investigated by a PostDoc at TEXTOR in Jülich as an option for W7-X and ITER. Dispersion interferometry employs frequency doubling in non-linear crystals, to obtain the second wavelength required to cope with vibrations and thermal drifts. This scheme offers a promising alternative in particular for steady state density control, as in general it is not sensitive to an intermittent loss of the signal, which causes the well-known fringe jumps. Operation of the ECRH stray radiation chamber MISTRAL started in August 2008 and was continued with a first experimental campaign in November. Besides whole diagnostics components, the focus was on vacuum windows and cable insulation under microwave irradiation levels, comparable to what needs to be expected in W7-X.

First results showed the necessity to shield all kinds of microwave absorbing materials, even if the power density is comparatively small, like expected e.g. behind the first wall tiles. Besides direct impact of microwaves, also the heating of the uncooled cable shielding may destroy the insulation. The latter investigations are continued with high priority.

#### 8.2.3 Charge Exchange Diagnostics

The responsible group is developing and accompanying the construction of the Russian Diagnostic beam (RuDI-X) needed for active CXRS and CX-NPA measurements in co-operation with FZ-Jülich and the Budker-Institute of Nuclear Physics (BINP), Novosibirsk. The first version of the high voltage dc power supply did not fulfil the specified parameters and needs to be re-designed. Infrastructure work (cooling water supply, power supply, collision studies, etc.) for the installation of the diagnostic beam is being continued. It has been decided to use a closed circuit cryogenic pump systems, which has in the meantime been specified and the corresponding technical specification of which has been completed, so that the tender action can now be started. Reports on the status of RuDI-X were presented by participants from BINP, FZJ and IPP-MPG in a meeting in Greifswald in August 2008, where also the final design was fixed. The workshop drawings for the vacuum tank were delivered by BINP and construction of the hardware components for it started end of 2008. The utilisability of CX-NPA diagnostics was tested at MAST with respect to the influence of neutron radiation on the background NPA-signal. A first comparison of the results of NPA measurements with the compact analyser from IOFFE and CXRS measurements at MAST was carried out and good agreement was found at the intersection point from CX-NPA and CXRS sightlines 20 cm away from the plasma centre. The IOFFE Institute St. Petersburg finished the upgrade of a former 10 channel analyser into an ACORD-24 analyser, which is now foreseen for the recalibration equipment for ACORD-type analysers in the charge exchange laboratory and later for the multiple analyser set-up on W7-X. The installation of this recalibration source was further supplemented by a magnetic mass separator.

#### 8.2.4 Spectroscopy

The test operation of the high-efficiency XUV overview spectrometer system (HEXOS) on TEXTOR-DED (FZ Jülich) has been continued successfully. With the support of HEXOS scientific experimental programs, related to the transport properties of Argon and Iron in plasmas with resonant magnetic perturbations at the plasma edge inferred by the DED, were conducted. Due to its good time resolution, the survey spectra provided by HEXOS in four spectral sub-ranges could be used for the analysis of transient impurity injection experiments. A PhD work addressing these issues and the calibration of HEXOS will be finished soon. The remote control system is basically completed and final adaptation work to W7-X standards is planned for the next time. In the frame of the cooperation between IPP and the University Opole (Poland) concerning the development of a C/O monitor diagnostic for W7-X, various detector types were tested using the W7-AS crystal spectrometer and X-ray source. Based on these results, the use of proportional counters were decided as well as the application of crystals or multilayer mirrors as dispersive elements. For the bulk plasma bolometer system in the triangular plane the design of the prototype camera head for the AEU30-camera has been completed. FE calculations (ANSYS) of these designs have been performed to evaluate the temperature of the camera components for W7-X steady state operation conditions (~50 kW/m$^2$). A sufficient water cooling efficiency for the aperture plate as well as for the detector holder has been confirmed. Manufacture drawings of the prototype have been produced. Furthermore, a first design of the vacuum feed through of the AEU30-camera has been completed. The design of the water cooling system for the camera in the AEV30 port is in progress. The detailed design of the video diagnostics – which is being developed by EURATOM HAS (Budapest, Hungary) – was finished in 2008. For the video observation the 10 equivalent tangential AEQ-ports of the W7-X vacuum vessel will be used, giving nearly full coverage of the entire plasma vessel. In the elaborated design, the Sensor Module (SM) of the Event Detection Intelligent Camera (EDICAM) is located at the plasma end of the ports. The ports are under atmospheric pressure and the diagnostic front end is protected by a water cooled plasma facing front plate with a pinhole. In 2008 two concepts of an objective performing the imaging through the pinhole were developed: both radiation resistive and conventional optical glasses were used. The optics developed of non -radiation resistive glasses showed better performance (better spatial resolution, wider spectral applicability) therefore probably this version will be manufactured. The mechanics that transports and docks the camera SM to the front window was manufactured and its mechanical and thermal tests were started in the mock-up port, showing that the design is basically good. The docking mechanism seems to function well and the scattering of the pointing of the view was found to be satisfactory. Thermal simulations aiming to determine the temperature distribution of the plasma facing components were performed for the case when W7-X is operated in pulsed mode with limited built in cooling capability. It was obtained that the components of the present design are able to withstand the heat loads expected under scenario 3 conditions. The design of the new version of the camera SM (this version will correct the problem with reference voltage of the ADCs and will contain a 10 Gbit optical link) was completed and the preparation of the manufacturing started.

For the diagnostic thermal helium beam, which can also be utilised as a divertor gas puff system, an ANSYS model has been created, which will be used in the next step to simulate the thermal loads of the plasma onto the gas nozzles. The final design of the nozzles will be adapted accordingly to the simulation results. Investigations have been started to check whether the nozzles could be extended by on-axis skimmers to achieve a better collimated (supersonic) gas beam. Together with responsible officers of other laser-based diagnostics discussions have been started on a common system for automatic laser beam steering for the laser-induced fluorescence (LIF), the interferometer and the Thomson scattering diagnostic. The laser path of the LIF diagnostic was adapted (avoiding collisions with other installations in the torus hall) and extended in order to allow the laser entrance into the torus through the ports AEL50 and AEL51.

### 8.2.5 Thomson Scattering

The design of a polychromator prototype for analysing the scattered light was continued and successfully tested at ASDEX-Upgrade. A water cooled shutter was designed, to protect the vacuum window in front of the observation port. A design study for the observation optics has been performed with the optical design program ZEMAX. The optical analysing system for the Thomson scattering diagnostic was optimized to minimise losses of the scattered light. Therefore in 2008 three possible polychromator set-ups has been investigated by simulations with ZEMAX program and by laboratory measurements. The main difference between these designs was the usage of relay and field lenses. The performance of each set-up was published at the SOFT conference 2008 in Rostock.

### 8.2.6 Soft X-Ray and Magnetic Diagnostics

The realisation of the in-vessel X-ray tomography camera system (XMCTS) required continuous R&D activities. Two prototypes of a compact vacuum-tight electronic box (for accommodation of the preamplifier boards) could be manufactured. However, welding of the stainless steel support plate, containing the custom-made multi-pin vacuum feed through into the bottom of the electronic box, led to vacuum leaks at the pins due to excessive heat input. This problem will hopefully be solved by applying a laser beam welding technique. Probably a small change of the design of the electronic box has to be made in order to improve sealing of the cover plate. The layout of the electronic preamplifier boards was optimised in several steps. A compact stack of two double-layer boards has been designed and manufactured. A first version could successfully be tested; however, it had to be modified slightly to allow sufficient space for mounting into the electronic box. Next steps will be to test the preamplifiers fitted into the electronic box. At the same time also cooling tests have to be performed by connecting the electronic box to a water-cooled copper plate in the presence of ambient temperatures as expected in the experiment. Also cooling tests of the pinhole cameras, which are connected to the opposite side of the cooled base plates and which are placed between additional cooled copper side plates, will be a main task. For this purpose stainless steel tubes have to be attached to copper plates by vacuum brazing. The compact design of the water cooled cameras (including the electronics) required sharp 3D bends of the cooling pipes which led to delays until manufacturing with sufficient precision could be achieved. In 2009 completion of the final design, further mechanical and electronic tests, and the manufacture of a complete camera prototype are major tasks. The numerical software package for data analysis was extended by combining different equilibrium-, transport- and radiation codes for simulations of realistic X-ray signals from W7-X plasmas. In particular, a fast reconstruction algorithm based on neural networks was tested and validated by simulated data. In doing so, the neural network was trained by 140 simulated datasets including a beta scan and different poloidal mode perturbations. In addition, different levels of noise were added to the data. The collaboration contract with the IPPLM in Warsaw on X-ray pulse height analysis and on an electron temperature monitor system based on a multi-filter foil method has been extended. First tests of a Si-drift-detector for X-ray pulse height analysis have been performed at IPPLM. The conceptual design of these diagnostics systems has been started and progress concerning the development of simulation and analysis software been made. A particular challenge is to improve the transfer of CAD data and the communication between IPP and IPPLM. The construction and manufacturing of the magnetic diagnostics was continued. With the progress of plasma vessel preparation, the saddle coils and outer Rogowski coils in further modules were installed and tested successfully. As the first diagnostic system, a prototype of the diamagnetic loop was tested in the ECRH stray radiation test chamber MISTRAL after its removal to the Greifswald site. The tests revealed that it will be rather challenging to harden the in-vessel magnetic diagnostics (diamagnetic loops, Rogowski and Mirnov coils) as well as the in-vessel cabling against the expected stray radiation levels. The routing of the in-vessel cables to the (in part newly – due to scenario 3) assigned feed through ports was started. In preparation of the magnetic flux surface diagnostic, experiments on the WEGA stellarator have been performed. Various designs of electron guns have been tested in order to optimize the electron beam characteristic with respect to emissivity and the fraction of electrons emitted parallel to the local magnetic field vector. Due to inelastic collisions of the electron beam with a background gas, the magnetic field lines have been visualized in WEGA for vacuum conditions. Systematic studies have been undertaken to determine the length of the trace in dependence on gas pressure, working gas and magnetic field strength.

### 8.2.7 Technical Coordination

15 saddle coils were assembled on the small half sectors of the half modules 10, 11, 40, 41 and 20 and on the large half sectors of the half modules 40, 41 and 21. The second outer Rogowski coil was assembled on the small half sector of the half module 40. The first two outer magnetic probes were assembled on the large half sectors of the half modules 40 and 21. All these diagnostics were successfully tested. Temporary shields were mounted or dismounted where applicable. All this was performed in time before the assembly of the thermal insulation. A template of the diamagnetic loop was trial rigged in the plasma vessel. Regarding the electrical racks for diagnostics, the components of the standard configuration were identified.

### 8.2.8 Integrated Data Analysis and Diagnostics Design

Efforts on Integrated Data Analysis were continued in collaboration with ASDEX Upgrade. A simulation code for Thomson scattering has been handed over to the diagnostic RO. The analysis of spectroscopic data was continued and results for the reconstruction of electron energy distribution functions were obtained. The method was also applied to regions of large spatial gradients. Moreover, a comprehensive assessment of spectroscopic data allowed validating atomic physics calculations (Co-operations with Drake-U, Des Moines IA, W7-X Diagnostics and ASDEX Upgrade).

### 8.2.9 International Stellarator/Heliotron Confinement and Profile Database

Within an international collaboration (IEA implementing agreement) the International Stellarator/Heliotron Confinement and Profile Database was continued and extended. Maintenance of the database was continued and regular working group meetings have been established. Comparative studies on impurity transport, high-beta operation, divertor physics, neoclassical effects, MHD and global energy confinement were performed and documented (NIFS, CIEMAT, U-Kyoto, ANU, U-Wisconsin, PPPL, ORNL, U-Stuttgart). The International Stellarator/Heliotron Profile Database (ISHPDB) has been launched to be operational as a publicly accessible resource. ISHPDB is jointly hosted by IPP and NIFS (cf. www.ipp.mpg.de/ISHPDB).

### 8.2.10 Experimental cooperations

DIII-D: A fast infra-red camera has been installed at the DIII-D tokamak. The camera has been used to study a) the heat loads to the lower divertor due to Type-I ELMs and b) changes in the heat flux to the lower divertor in ELM suppressed phase of an H-mode discharge. It has been found out that the width of the deposition pattern in ELMy H-mode depends linearly on the ELM deposited energy. Striated patterns of heat loads show dynamic changes in first few hundreds microseconds. Afterwards they decay to the pre-ELM level within 1 ms. Application of n=3 resonant magnetic perturbation (RMP) at first reduces ELM amplitudes by about factor of two and, after 200 ms, eliminates them completely. All ELMs have very similar power deposition patterns independent on their size. At the same time, low electron pedestal collisionality discharges show increase of the total power reaching the divertor surface by about 15% and decrease power radiated in the scrape-off layer. This is due to hot electrons from the pedestal area guided by the stochastic field lines to the target plates. These electrons decrease the sheath potential significantly and thus increase the ratio of power deposited by ions. At high electron pedestal collisionalities the sheath potential and the power flux to the divertor in RMP phase remain the same as in non-RMP phase of the discharge. JET: Extended analysis of the spatial structure of the filament footprints during type-I ELMs on the main chamber plasma facing components was performed. The data have been obtained with a fast wide-angle infrared diagnostic for Type-I ELMs with a wide energy range. The typical width of a Type-I ELM filament footprint is about 4-10 degrees on the outer limiters and 1-4 degrees on the outer dump plates with weak linear dependence on the ELM size. Their quasi-toroidal mode numbers are in the range of 30-40 and 20-30, respectively. These structures follow pre-ELM magnetic field lines, i.e. they do not noticeably disturb/distort the SOL magnetic field.

## 8.3. Collaborations

The diagnostics are being developed in close collaboration with FZ-Jülich. In particular in case of the HEXOS VUV spectrometer and the development of the diagnostic neutral beam FZ-J is heading the projects. The Budker Institute in Novosibirsk, Russia, is developing and constructing the diagnostic neutral beam injection system, EURATOM HAS in Budapest, Hungary, is developing and constructing the video diagnostic systems for W7-X, IPPLM, Warsaw is developing a neutron activation system and performing MCP calculations for W7-X, the university of Opole, Poland is preparing a C/O monitor diagnostic and the Akademia Morska, Szczecin, Poland and the Szczecin University of Technology are investigating the sightline of the Interfero-Polarimeter and different microwave based polarimeter and interferometer methods, CIEMAT investigates potential and components for $CO_2$-Intefereromety, IST/CFN, Lisbon participates in developing fast tomographic inversion methods (P. Carvalho 1 months stay in Greifswald) and is developing ADC/DAQ stations being linked to XDV, PTB, Braunschweig is performing preparatory work for a contract on the development of a Neutron-Counter System for W7-X and IOFFE Institute St. Petersburg, the Culham Science Centre (UKAEA) and CIEMAT in Madrid are collaborating in the field of CX-Neutral Particle Analysis.

## 9 Heating

### 9.1 Project Microwave Heating for W7-X (PMW)

The Electron Cyclotron Resonance Heating (ECRH) system for W7-X is being developed and built by FZ Karlsruhe (FZK) as a joint project with IPP and IPF Stuttgart. The "Project Microwave Heating for W7-X (PMW)" coordinates all engineering and scientific activities in the collaborating laboratories and in industry and is responsible for the entire ECRH system for W7-X. ECRH is designed for a microwave power of 10 MW in continuous wave (CW) operation (30 min) at 140 GHz, which is resonant with the W7-X magnetic field of 2.5 T. It will consist of ten Gyrotrons with 1 MW power each, a low loss quasi-optical transmission line and a versatile in-vessel launching system. ECRH will support also operation of W7-X at reduced magnetic field, because the gyrotrons can be tuned to 103.6 GHz radiation emission with about half the output power. This is of particular importance during the commissioning phase of W7-X and for confinement studies. PMW is strongly involved in advanced and ITER related R&D activities within the frame of the virtual institute "Advanced ECRH for ITER" (collaboration between IPP Garching and Greifswald, FZK Karlsruhe, IHE Karlsruhe, IPF Stuttgart, IAP Nizhny Novgorod, and IFP Milano), which is supported by the Helmholtz-Gemeinschaft deutscher Forschungszentren.

#### 9.1.1 The W7-X Gyrotrons (FZK)

The first (SN1) out of seven series gyrotrons from Thales Electron Devices (TED) had been tested at FZK and IPP in 2005 after successful completion of the gyrotron R&D. All the specifications were met and no specific limitations were observed during the acceptance test. In order to keep the warranty, the SN1 gyrotron has been sealed while the two prototype gyrotrons were routinely used for experiments. The next series gyrotrons showed, however, a different behavior with respect to parasitic oscillations excited in the beam tunnel region, which is sketched in figure 25, left. The beam tunnel has a sandwich structure composed of ceramic and metallic rings with a shaped inner contour. The oscillations were observed mainly in the maximum power/maximum current operation range thus indicating a threshold nature. An excessive heating of the beam tunnel components, in particular of the absorbing ceramic rings is the consequence. All gyrotrons, which were re-opened after operation, showed significant damages due to overheating at the ceramic rings and the brazing layer between the rings. In a first attempt to improve the situation, the manufacturer opened the series gyrotrons SN2 and SN3 and installed ceramic rings with a better brazing (SN2a, SN3a) and changed the sequence of the ceramic rings with different inner diameter (SN5). Both measures did not improve the situation significantly. Therefore, FZK started in 2008 with first redesign considerations to overcome the problems and to arrive at a more robust beam tunnel, which suppresses the excitation of parasitic oscillations more efficiently. In order to validate a new beam tunnel design within the experimental possibilities, it is planned to perform short pulse tests with a coaxial cavity gyrotron and a frequency step tunable gyrotron at the FZK test stand. A structurally modified beam tunnel, which represents only a small change in the existing design will be incorporated (see figure 25, right) and compared to a standard TED-beam tunnel. A beam tunnel design will be used, which is as close as possible to the TED-design to avoid additional complications during integration in the high power cw-gyrotrons. Of course, final validation of the chosen design can only be demonstrated in one of the series gyrotrons. During the beam-tunnel R&D at FZK, series production at TED will be on hold. The following experimental results were obtained with the TED series gyrotrons SN2a, SN3a and SN5, all equipped with the original beam tunnel. In 2008 the factory acceptance tests (FATs) have been continued with the repaired serial gyrotron SN2a at IPP Greifswald. The tube achieved 830 kW at 3 min and 704 kW at 25 min operation. During conditioning, however, the pressure level in the tube increased gradually and the performance degraded. The acceptance tests were stopped finally by a crack of the output window. The gyrotron was sent back to the manufacturer for opening and detailed failure analysis. The diamond disk was also investigated by experts from IMF I at FZK.

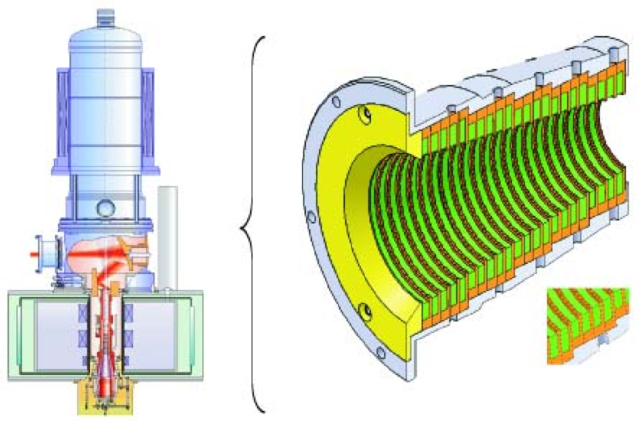


*Figure 25: Left: Principal Sketch of the TED Gyrotron. The position of the beam tunnel is indicated. Right: New beam tunnel design with corrugated copper rings.*

The results of the analysis showed a partial destruction of the beam tunnel, a vacuum leak at the relief window (sapphire window), pollution and corrosion at different parts of the gyrotron. Severe corrosion was found at the brazing of the diamond window and in the cooling circuit of the window assembly. The inner (vacuum) side of the diamond disk showed a copper layer, which increases the RF losses by a factor of 10. The enhanced losses of the diamond disk as well as the crack structure support the assumption of a window failure due to thermal overheating. The (repaired) serial gyrotron SN3a has been tested at FZK in short pulse (~ ms) and long pulse (up to 30 min) operation with power levels of up to 800 kW and 500 kW, respectively. The output beam pattern has been measured and analyzed. The beam parameters are very close to those obtained in the first version of the gyrotron, which indicates, that the quasi-optical output system is based on a stable and reliable design. Parasitic oscillations in the frequency range 120-130 GHz were observed, which are supposed to be excited in the beam tunnel region and limit the performance of the gyrotron. After long conditioning of the gyrotron, operation with a maximum power of about 720 kW for 3 min and 500 kW for 30 min was achieved, the specified 900 kW output power could, however, not be demonstrated. Acceptance tests of the serial gyrotron SN5 were started at FZK. This tube is equipped with a beam tunnel with small contour modifications, which should complicate the excitation of parasitic oscillations. In short pulse operation the gyrotron delivered up to 950 kW. However, parasitic oscillations were still limiting the performance of the tube. Furthermore and independent from the beam tunnel issue, the parameter optimization of this gyrotron had to be stopped as a shift of the RF output beam at the window caused frequent arcing, raising the risk of a failure of the diamond disk. Also spurious oscillations in the frequency range 120-130 GHz were observed. It was agreed with TED to stop the series production until mid 2009 and focus the activities on a coordinated beam-tunnel R&D.

### 9.1.2 Transmission System (IPF)

The transmission line consists of single-beam waveguide (SBWG) and multi-beam waveguide (MBWG) elements. For each gyrotron, a beam conditioning assembly of five single-beam mirrors is used. Two of these mirrors match the gyrotron output to a Gaussian beam with the correct beam parameters, two others are used to set the appropriate polarization needed for optimum absorption of the radiation in the plasma. A fifth mirror directs the beam to a plane mirror array, the beam combining optics, which is situated at the input plane of a multi-beam waveguide. This MBWG is designed to transmit up to seven beams (five 140 GHz beams, one 70 GHz beam plus an additional spare channel) from the gyrotron area (entrance plane) to the stellarator hall (exit plane). At the output plane of the MBWG, a mirror array separates the beams again and distributes them via CVD-diamond vacuum barrier windows to individually movable antennas (launchers) in the torus. The long distance transmission is provided by two symmetrically arranged MBWGs. Tests of the entire transmission line can only be performed, once the W7-X construction is completed and access to the main torus hall is provided. We have therefore installed retro-reflectors in the underground beam-duct in the image plane at half distance of the MBWG transmission line. Long distance transmission can then be simulated and tested by transmitting the high power beams half way in forward direction and then back via the reflectors to the dummy load. First calorimetric high power measurements are shown in figure 26, where the calorimetrically measured transmitted power is plotted vs. the incident power. As a guide for the eye, we have plotted the ‘no-loss’ line also. Total losses of about 3 % were measured for 10 reflections on the 2×3 MBWG-mirrors and the 4 additional guiding mirrors over a total length of about 40 m.

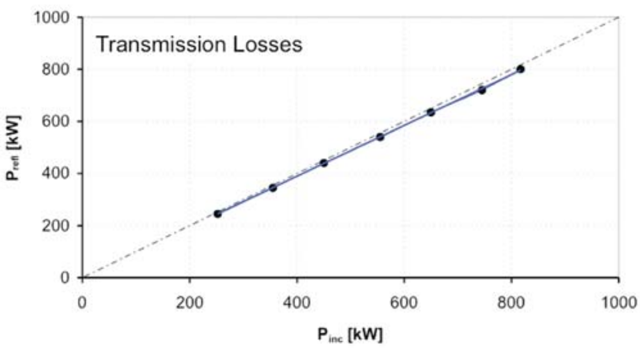



*Figure 26: Calorimetric measurement of the rf-power Prefl after transmission through 10 mirrors as a function of the incident rf-power Pinc. The dashed-dotted line indicates no-loss transmission.*

The measured total losses are in good agreement with calculations and previous low power measurements. This result confirms the high quality of the quasi-optical concept for high power, long distance transmission. All optical elements for beam redistribution near the torus ports are arranged in two ‘towers’, which will be installed in front of the equatorial ECRH-ports in the W7-X modules 1 and 5, respectively. The towers have a heavy structure and provide microwave shielding and a stable basis for the optics. In 2008, the manufacturing of the transmission system near the torus was completed. This comprises the reflectors type M13 and M14, which test-wise have been already installed in the two towers. The fabrication of these towers was finished, including the installation of control systems for reflectors and launchers, granite absorbing plates and support structures for reflectors type M12, M13 and M14 as well as the retro-reflectors SR. Present work concentrates on the shielding structures on top of the towers, the interfaces to the stellarator ports, absorbing screens and the transmission diagnostics. An absolute power measurement is foreseen at the entrance (M1) and the front end (M14) of the transmission line. The diagnostic modules at the entrance receive a probe beam, which is diffracted from a holographic grating on the first matching mirror M1;

an internal power splitter couples the sample power to a Bolometer for integral power measurement, as well as to a high-quality gaussian beam receiver for mode selective power measurement in the nominal mode. The diagnostic modules as shown in figure 27 are equipped with newly developed multi-mode horns (see IPF-Stuttgart part for details) for power monitoring. All ten modules were manufactured after having passed the hot test in Greifswald.

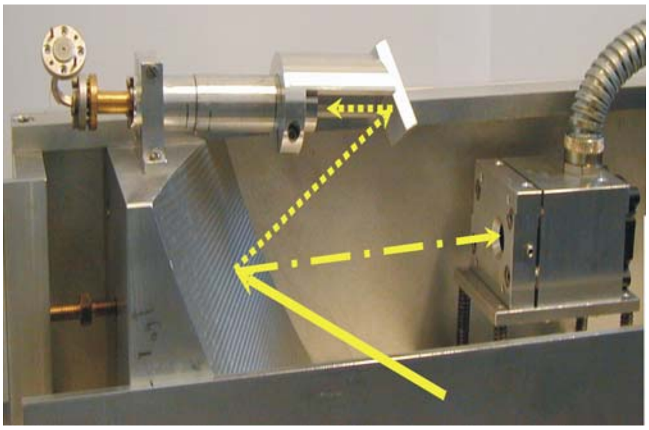


*Figure 27: Diagnostic module for absolute-power monitoring at the entrance of the Single Beam Waveguide Section. The grating mirror (beam splitter) is seen on the lower left side, the mode selective horn and the bolometer block are seen on the upper left and the right side, respectively.*

Grating couplers are also integrated at the front end of the transmission line into the surfaces of the mirrors M15. Figure 28 shows the ellipsoidal surface of such a mirror with two overlaid holographic phase gratings (the amplitudes are exaggerated). Here, the long-period grating diffracts a focussed sample of the high-power 140 GHz beam for power measurement; the short-period grating will be used for alignment control with a low-power 188 GHz probe beam and CW FM reflectometry.

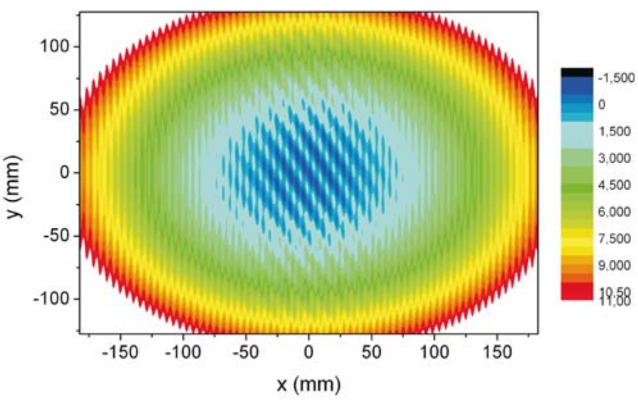



*Figure 28: Contour plot of the ellipsoidal surface of a mirror M14 with two overlaid holographic phase gratings. Note that the amplitudes are strongly enlarged for visibility.*

As gyrotrons have slightly different output beam parameters the matching optics unit has to be specially designed for each individual gyrotron. The beam profiles of gyrotrons are thermographically recorded, and subsequently, phase retrieval is performed. In 2008, the TED series gyrotron SN3a, and the prototype gyrotron from Communications & Power Industries (CPI) were measured, both after major repairs. Since the beam parameters did not change significantly, the pre-repair correction mirrors were reused. All W7-X gyrotrons exhibit a pronounced downward frequency chirp of several hundred MHz during about 1 s after switch-on, caused by the thermal expansion of the cavity. The matching mirrors from the gyrotrons to the transmission line are always designed on the basis of beam measurements during the first few milliseconds of a pulse. Any noticeable change in beam direction after switch-on would, however, preclude the use of phase-shaping mirrors, which are currently in consideration for the final design. To investigate any beam wandering effects, a high-temperature Si3N4 target was subjected to a 350 ms pulse from the TED prototype gyrotron. The displacement of the beam centre is plotted in figure 29 While a clear displacement can be seen, the data scatter is too strong to decide whether or not the beam returns to its original position after 300 ms. Further measurements are planned for 2009 with an improved measurement set-up.

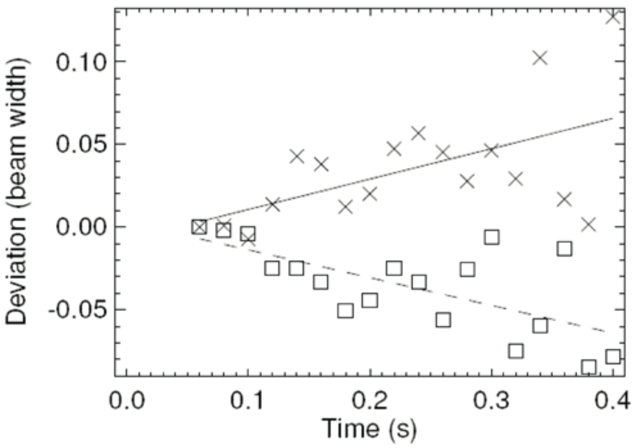



*Figure 29: Displacement of the high-power beam centre on a high temperature target in the x- (crosses) and y- (squares) direction as a function of time*

Owing to frequent problems with the commercial CW loads, which are based on thin dielectric absorbing layers on metallic surfaces, some work was dedicated to the development of a new and simple load, which is based on metallic wall absorption only. This so called 'long load' consists of a straight long (>20 m) waveguide with smooth walls made from stainless steel, where the power is coupled as a Gaussian beam. By appropriate down tapering, the absorption of the waveguide is matched to the power loss along the guide. A first test with thermal imaging of the waveguide wall shows the expected beat structure of $TE_{11}$ and $TM_{11}$, which are excited by the Gaussian input beam, as seen from figure 30. The simple mock-up system using standard water tubes with welded connections suffered, however, from strong arcing and only short pulse tests could be performed. In the next step, electro-polished tubes with flanged connections will be investigated.

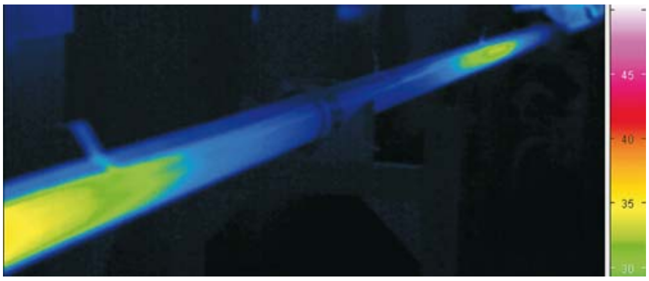



*Figure 30: Thermal image of the wall of a mock-up of the 'Long Load' showing the beat structure of the $TE_{11}$ and $TM_{11}$ waveguide modes excited from the input beam*

### 9.1.3 HV-Systems (IPF Stuttgart)

For the operation of gyrotrons with depressed collector, a precisely controlled beam acceleration voltage is necessary, which is supplied by the body-voltage modulator. The beam current of the gyrotrons is controlled by the cathode heater supply, which is on cathode potential (about -55 kV).

*Figure 31: Modulator/heater/crowbar unit installed in the gyrotron hall in Greifswald. The modular structure of the HV-modulator (background), the thyratron crowbar unit with the cathode heater cabinet (centre), and ignition coil for the thyratron (foreground) are shown.*

In case of arcing inside the gyrotron, a thyratron crowbar protects the tubes from being damaged. The body-voltage modulators and the protection units were designed by and built at IPF Stuttgart. All ten systems are now installed at W7-X and are ready for operation. An additional protection unit was integrated to enable the exact location of the source of a fault in case of malfunction of the gyrotron. The prototype modulator was upgraded to meet the same specifications as the series systems. At present, some final optimization concerning the system diagnostics in case of a gyrotron fault is implemented. Figure 31 shows a complete modulator/crowbar unit installed in the gyrotron hall in Greifswald.

### 9.1.4 In-Vessel-Components (IPP)

The ECRH System for W7-X must provide plasma start-up and operation at full performance in the first short pulse period (5-10 s) with the test divertor unit (TDU) as well as in long pulse operation up to 30 min with the high power steady state divertor. The plasma start-up will be initiated by ECRH at the resonant magnetic field strength for both operating frequencies at 105 and 140 GHz. The control of the rotational transform profile during the density build-up requires a highly flexible launching and power control system.

*Figure 32: ECRH front steering antenna module during final assembly at the central workshop of FZK. The three beamlines are clearly seen, each of them is equipped with independent bi-axially movable front mirrors.*

As soon as the plasma density approaches the X2 cut-off density, a well-controlled transition from the strongly absorbed second harmonic extraordinary mode (X2) to a multi-pass second harmonic ordinary mode (O2) heating heating scenario must be performed. The key elements are the four front steering ECRH-antennas in the outboard mid-plane A- and E-type ports. All parts of the antennas are expected to experience a high power loading by either direct microwave irradiation, in particular the mirrors and diamond vacuum windows, or by strong microwave stray radiation at the screening and support elements. Therefore all components require active cooling and/or screening. The design of the antennas was frozen after successful tests of several critical subcomponents. The first out of four plug-in antennas modules is almost completed as seen in figure 32, pre-assembly of the additional 3 modules is in progress and tests are in preparation.

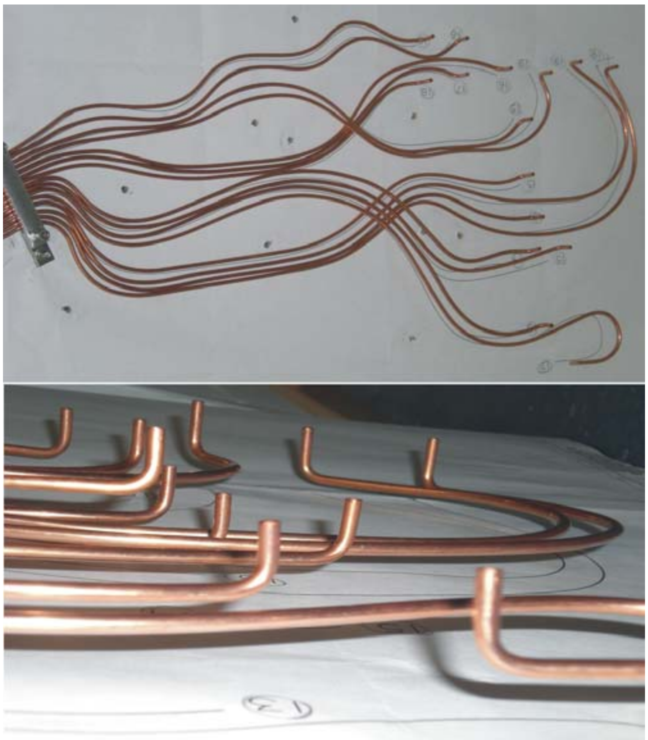


*Figure 33: Top: Preformed waveguide bundle for the ECRH transmission diagnostic. Bottom: Circular pick-up antennas.*

The non-absorbed power at the heat shield of the vessel wall opposite to the launchers as well as the beam position and its polarisation will be measured by an array of altogether 126 small pick-up antennas. They are integrated in the shield structure and are connected with the vacuum interface at four B-type ports by mono-mode circular waveguides. The complicated 3D in-vessel routing of the waveguides from the inboards wall towards the B-ports was completed and a prototype waveguide bundle, which is shown in figure 33, was build and is ready for assembly tests in the first W7-X vacuum vessel module. All in-vessel elements in W7-X have to sustain a high microwave stray radiation level. A power density level of several hundreds of $kW/m^2$ is expected in the vicinity of the ECRH antennas especially for heating scenarios with O2 or X3 mode, where the single pass absorption is only 40–80 %. A power density of several tens of $kW/m^2$ has to be considered even far-off the ECRH antennas. As most of the in-vessel components are reflective for microwaves the stray radiation can "creep" even behind the first wall protection elements and deeply into ports in contrast to the plasma radiation. As long as the discharge length is short (<10 s) the stray radiation is not a severe problem, but for long ECRH operation (>100 s) any absorbing and insufficiently cooled component can be thermally damaged. Therefore all in-vessel components have to be tested in a special Microwave Stray Radiation Loading (MISTRAL) test chamber, which was build up in the ECRH hall in collaboration with the W7-X diagnostic group. The microwave feeding of the MISTRAL chamber is provided by a switching unit in the optical transmission line, which couples the microwave beams of the gyrotrons in the "BRAVO" sockets into a closed waveguide, which is connected with the MISTRAL chamber. The coupling structure is shown in figure 35. Typically 20 kW average microwave power has been feed into the chamber in already two campaigns in 2008, which simulates the expected background radiation in W7-X.

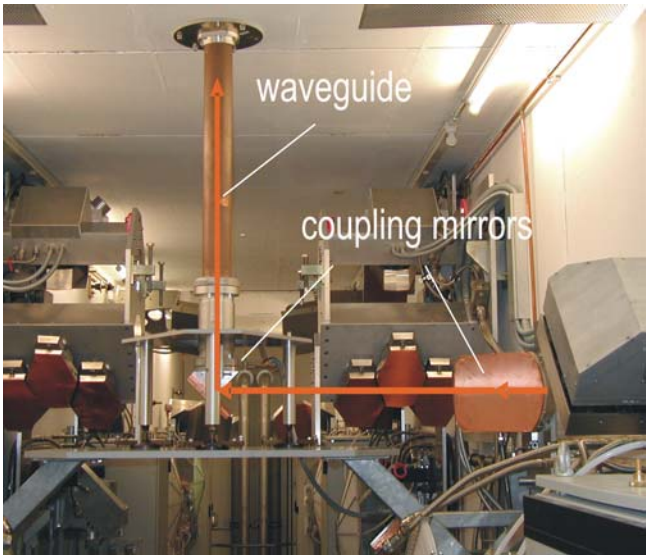



*Figure 34: Coupling structure of the ECRH-beam in the beam duct towards the circular waveguide to the MISTRAL chamber*

### 9.1.5 Advanced components and ITER-related R&D (HGF activity)

The ECRH system was extensively used for tests and development of advanced ECRH components. Among others, a new test campaign was dedicated to the investigation of the high-power diplexer, which is developed for use as a combiner for the power of two gyrotrons as well as a fast directional switch (FADIS) between two outputs. FADIS is a novel concept and will allow switching and/or combining high power microwave beams on a fast timescale (< ms) without mechanically moving parts. The possibility to combine two or more beams into one transmission line and/or switching them to different launchers may become of particular importance for future large scale ECRH installations like those for W7-X and ITER.

The FADIS device is based on a small frequency-shift keying of a Gyrotron (some tens of MHz), and a narrow-band diplexer, which switches the Gyrotron input beam to one of the two output channels. This work is carried out in the frame of the virtual institute ”Advanced ECRH for ITER” (collaboration between IPP Garching and Greifswald, FZK Karlsruhe, IHE Karlsruhe, IPF Stuttgart, IAP Nizhny Novgorod, and IFP Milano), which is supported by the Helmholtz-Gemeinschaft deutscher Forschungszentren. After successful and encouraging demonstration of fast switching of the high power microwave beam from one gyrotron between two outputs in 2007, a power combination experiment using the beams from two gyrotrons was performed in 2008**.** The resonance of the FADIS was adjusted such that Gyrotron B1 was transmitted through the resonant channel, gyrotron B5 was non-resonant, leading to a power combination with an efficiency of better than 90 % in the common output (OUT 5), see figure 35.

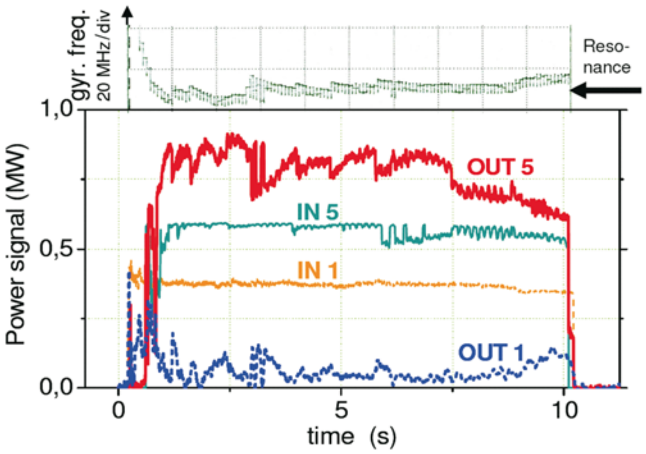



*Figure 35: A 10-s power combination experiment. Top trace: Frequency of Gyrotron B1 as a function of time relative to the resonance of the diplexer (note the scale). Bottom traces: IN1 and IN5 denote the input power of gyrotrons B1 and B5, respectively. OUT1 and OUT5 denote the output power from the diplexer coupled to the loads, respectively.*

Note, that the power of both gyrotrons had to chosen such, that the combined output power did not exceed 1 MW, because this is the power limit of the load. The residual power in OUT1 is mainly caused by spontaneous jumps and a slow increase of the B1 gyrotron frequency near the end of the pulse, which pulls B1 slightly out of resonance. By modulating the frequency of the two gyrotrons, toggling of the combined power between the outputs in the kHz range could be demonstrated. The use of the diplexer as a variable attenuator/power splitter could be shown by quasi-analogue frequency modulation of the gyrotrons. In these proof-of-principle experiments, the efficiency was mainly limited by fluctuations of the gyrotron frequency, as can be seen from the similarity of gyrotron frequency and output power signals in figure 35. The pulse length was limited to <10 s to avoid overheating of the uncooled Al mirrors. Both problems will be tackled in the new compact resonant diplexer, which has been built in 2008. This MkII diplexer will use a motorized resonator tuning with the aim of developing a frequency tracking system and massive copper mirrors for longer pulses.

### 9.1.6 Staff

Staff at IPP (W7-X-P and ZTE): B. Berndt, H. Braune, V. Erckmann, F. Hollmann, L. Jonitz, H.P. Laqua, G. Michel, F. Noke, F. Purps, T. Schulz, P. Uhren, M. Weissgerber.
Staff at FZK (IHM): A. Arnold, K. Baumann, G. Dammertz, J. Flamm, G. Gantenbein, R. Heidinger (IMF I), M. Huber, H. Hunger, S. Illy, J. Jin, S. Kern, M. Kupper, R. Lang, W. Leonhardt, D. Mellein, S. Miksch, B. Piosczyk, H. O. Prinz, T. Rzesnicki, A. Samartsev, M. Schmid, W. Spiess, J. Szczesny, M. Thumm, J. Weggen.
Staff at IPF (Stuttgart University): P. Brand, H. Höhnle, W. Kasparek, M. Krämer, H. Kumric, C. Lechte, F. Müller, R. Munk, B. Plaum, S. Prets, P. Salzmann, K.-H. Schlüter, U. Stroth, D. Wimmer.

## 9.2 Neutral Beam Injection

Heating by neutral beam injection (NBI) is foreseen to be available right from the beginning of the plasma experiments on Wendelstein 7-X. Initially, a total heating power of up to 7 MW in hydrogen and 10 MW in deuterium, respectively, will be provided from two injectors with two beam sources each. In a later stage, a doubling of this power is possible by adding two further sources to each of the injectors. The NBI system is in many respects identical to the one of the ASDEX Upgrade tokamak; its construction is a common task of NBI personnel at Greifswald and Garching. In addition, the NBI project is supposed to be realised in close co-operation with partners from research institutes in Poland. Work on design and on manufacturing of test samples has been started at IPJ Swierk with financial support of the Polish government. The aim of these activities is to compile a detailed proposal to the Polish Ministry of Science for the delivery of components like cooling systems, ion deflection magnets, torus valves and injector support structures. The co-operation with WTP Wroclaw with respect to cryo pumps and cryo supply has not yet reached such an advanced state. Both injector boxes have been set up in the NBI hall and leak tested. Here, the pre-assembly of the injectors with many major components is foreseen prior to their transport into the torus hall. The assembly of the RF sources with many parts being manufactured in house is nearly completed and the construction of the ion dumps was initiated. In addition, detailed planning of the layout of the electro-technical components as well as of the concepts for control and data acquisition was started. In order to prevent the NBI duct as well as the plasma vessel from being damaged by the neutral beams duct protection and inner wall heat shields are required. Extensive power deposition calculations have been carried out in order to provide the In-Vessel Components group with the necessary input for the design of these protections. The stellarator stray magnetic field inside the injectors has to be kept below a tolerable level in order to minimise its effect on the ion trajectories in the region of neutralisers, magnet and ion dumps. The concept of a corresponding magnetic shielding has been established. Further activities during the last year were related to the planning of the NBI installation area in the torus hall including the investigation of possible collisions with other components.

### 9.3 Ion Cyclotron Resonance Heating

The design and development of the ICRH system has been further postponed since ICRH will not be part of the start configuration of W7-X. However, some activities were started to provide W7-X with the needed system for wall conditioning via radio frequency generated helium plasmas. There, a trainee within the European Fusion Training programme started his work on RF electronics and two used short-wave steady-state generators with 1 MW output power each were purchased from General Atomics.

## Scientific and Technical Staff

### W7-X Subdivisions:

#### Project Coordination

H.-S. Bosch, A. Berg, H.-J. Bramow, J. Dedic, W. Fay, J.-H. Feist, G. Gliege, M. Gottschewsky, D. Grünberg, K.-H. Hanausch, D. Haus, R. Herrmann, U. Kamionka, T. Kluck, B. Kursinski, A. Lorenz, D. Naujoks, F. Sabathier*, R.-C. Schmidt, M. Schröder, R. Vilbrandt.

#### Engineering

F. Schauer, T. Andreeva, Th. Bergmann, V. Bykov, C. Caldwell-Nichols*, P. Chen, W. Chen, P. Czarkowski*, W. Dänner*, A. Dübner, A. Dudek, K. Egorov, J. Fellinger, St. Freundt, D. Hathiramani, N. Jaksic, J. Kallmeyer, M. Köppen, J. Lingertat*, M. Nitz, F. Scherwenke, L. Sonnerup*, A. Tereshchenko, S. Weber, D. Zacharias, M. Ye.

#### Design and Configuration

D. Hartmann, G. Adam, M. Banduch, C. Baylard*, D. Beiersdorf, A. Bergmann, P. Biedunkiewicz, R. Binder, R. Blumenthal, R. Brakel, T. Broszat, C. Brun*, P. v. Eeten, N. Fuchs, H. Greve, N. Hajnal, K. Henkelmann, F. Herold, A. Holtz, C. Klug, J. Knauer, U. Krybus, R. Laube, A. Müller, K. Müller, A. Okkenga-Wolf, D. Pilopp, T. Rajna*, S. Renard*, N. Rüter, P. Scholz, K.-U. Seidler, B. Sitkowski, F. Starke, M. Steffen, A. Vetterlein, A. Vorköper, J. Wendorf, U. Wenzel, K. Zimmermann.

#### Magnets and Cryostat

U. Nielsen*, H. Bau, M. Bednarek, D. Birus, A. Braatz, D. Chauvin*, G. Croari*, C. Dhard, G. Ehrke, A. Friedrich, F. Füllenbach, D. Gustke, E. Hahnke, A. Hansen, B. Hein, D. Hermann, K. Hertel, A. Hölting, M. Ihrke, H. Jenzsch, T. Koppe, R. Krause, B. Missal, St. Mohr, T. Mönnich, M. Nagel, B. Petersen-Zarling, M. Pietsch, K. Riße, Th. Rummel, M. Schneider, M. Schrader, D. Theuerkauf, S. Thiel, H. Viebke.

#### Assembly

L. Wegener, J. Ahmels, A. Benndorf, T. Bräuer, M. Czerwinski, A. Domscheidt, H. Dutz, M. Endler, S. Gojdka, H. Grote, H. Grunwald, A. Hübschmann, D. Jassmann, A. John, S. Jung, A. Junge, R. Krampitz, F. Kunkel, H. Lentz, H. Modrow, E. Müller, J. Müller, S. Müller, U. Neumann, B. Prieß, D. Rademann, L. Reinke, K. Rummel, D. Schinkel, W. Schneider, U. Schultz, E. Schwarzkopf, Ch. von Sehren, O. Volzke, K.-D. Wiegand.

#### KIP

F. Hurd*, A. Cardella*, M. Czerwinski, D. Grünberg, P. Junghans, U. Krybus, Peacock*, P. Scholz, M. Smirnow*, R. Vilbrandt, A. Vorköper.
**E1:** J. Boscary, C. Li, B. Mendelevitch, B. Petzold, R. Stadler, G. Zangl.
**MF:** B. Böswirth, H. Greuner.
**ZTE:** F. Ascher, N. Dekorsy, H. Pirsch, K. Pfefferle, O. Sellmeier, J. Springer, H. Tittes, J. Tretter, F. Zeus.

#### Physics

R. Wolf, J. Baldzuhn, T. Bluhm, H. Braune, R. Burhenn, J. Cantarini*, A. Dinklage, H. Dreier, M. Endler, V. Erckmann, S. Gross, H.-J. Hartfuß*, C. Hennig, U. Herbst, D. Hildebrandt, M. Hirsch, M. Jakubowski, L. Jonitz, R. König, P. Kornejev, M. Krychowiak, G. Kühner, A. Kus, H. Laqua, H. P. Laqua, M. Laux, M. Lewerentz, G. Michel, I. Müller, U. Neuner, F. Noke, E. Pasch, S. Pingel, F. Purps, T. Richert, H. Riemann, J. Schacht, W. Schneider, R. Schroeder, A. Schütz, A. Spring, H. Thomsen, P. Uhren, S. Valet, A. Weller, A. Werner, A. Wölk, D. Zhang.

#### Technical Services (TD)

R. Krampitz, M. Braun, K. Gallowski, M. Haas, M. Hagen, S. Heinrich, S. König, M. Marquardt, M. Müller, J. Sachtleben, M. Stöcker, V. Schwuchow, M. Winkler.

### IPP Garching

**Experimental Plasma Physics I (E1):** K. Behler, N. Berger, H. Eixenberger, L. Giannone, T. Härtl, H. Kroiss, B. Kurzan, H. Murmann, G. Neu, U. Ortner, G. Raupp, V. Rohde, M. Rott, A. Scarabosio, R. Stephan, B. Streibl, R. Tivey, W. Treutterer, S. Vorbrugg.
**Materials Research (MF):** M. Balden, K. Bald-Soliman, R. Brüderl, J. Kißlinger, F. Koch, S. Lindig, G. Matern.

**Technology (TE)**: W. Becker, B. Eckert, H. Faugel, F. Fischer, B. Heinemann, D. Holtum, M. Kammerloher, M. Kick, L. Liu, C. Martens, P. McNeely, J. M. Noterdaeme, S. Obermayer, R. Riedl, N. Rust, G. Siegl, E. Speth, A. Stäbler, P. Turba, E. Würsching.
**Computer Center Garching (RZG):** P. Heimann, J. Maier, M. Zilker.
**Central Technical Services (ZTE) Garching:** B. Brucker, R. Holzthüm, M. Huart, N. Jaksic, M. Kluger, G. Lex, J. Maier, J. Simon-Weidner, M. Weissgerber.

## Cooperating Research Institutions

**Forschungszentrum Jülich (FZJ):** W. Behr, G. Bertschinger, W. Biel, A. Charl, J. Collienne, G. Czymek, A. Freund, B. Giesen, D. Harting, H. Jaegers, H. T. Lambertz, M. Lennartz, Ph. Mertens, O. Neubauer, A. Panin, M. Pap, A. Pospieszczyk, U. Reisgen, D. Reiter, J. Remmel, M. Sauer, W. Schalt, L. Scheibl, O. Schmitz, G. Schröder, J. Schruff, B. Schweer, W. Sergienko, R. Sievering, R. Uhlemann, J. Wolters.
**Forschungszentrum Karlsruhe (FZK):** A. Arnold, K. Baumann, G. Dammertz, W. Fietz, J. Flamm, G. Gantenbein, R. Heidinger, R. Heller, M. Huber, H. Hunger, S. Illy, J. Jin, S. Kern, M. Kupper, R. Lang, W. Leonhardt, D. Mellein, S. Miksch, K. Petry, B. Piosczyk, O. Prinz, T. Rzesnicki, A. Samartsev, M. Schmid, W. Spiess, J. Szczesny, M. Thumm, J. Weggen.
**Universität Stuttgart, Institut für Plasmaforschung, Germany:** P. Brand, H. Höhnle, W. Kasparek, M. Krämer, H. Kumric, C. Lechte, F. Müller, R. Munk, B. Plaum, S. Prets, P. Salzmann, K.-H. Schlüter, U. Stroth, D. Wimmer.
**Universität Stuttgart, Institut für Kunststoffprüfung und Kunststoffkunde, Germany:** G. Busse.
**Ernst-Moritz-Arndt-Universität Greifswald, Germany:** B. Pompe.
**Universität Rostock, Germany:** A. Holst.
**Universität Düsseldorf, Germany:** T. Kudyakov.
**Institut für Physikalische Hochtechnologie e.V., Jena, Germany:** W. Ecke, K. Fischer, V. Schultze.
**Pysikalische Technische Bundesanstalt Braunschweig, Germany:** H. Schumacher, B. Wiegel.
**UKAEA, Culham, UK:** B. Brade, W. Fundamenski, M. Turnyanskiy.
**CEA, Saclay, France:** A. Daël, L. Genini, T. Schild.
**CRIL Group, Aloytech, France:** D. Galindo, G. Vitupier.
**CIEMAT, Madrid, Spain:** E. Ascasibar, R. Balbin, P. Castejon, L. Esteban, T. Estrada, J. M. Fontdecaba Climent, C. Hidalgo, E. Jiménez, D. Lopez-Bruna, M. Sanchez, V. Tribaldos, J. Vega.
**IST/CFN, Lisbon, Portugal:** P. Carvalho.
**LT Calcoli, Italy:** F. Lucca.
**ENEA Centro Ricerche Energia, Frascati, Italy:** A. Capriccioli, G. Mazzone, L. Semiraro.
**CNR Istituto di Fisica del Plasma, Milano, Italy:** A. Bruschi, M. Romé.
**CRPP Ecole Polytechnique Federale de Lausanne, Switzerland:** K. Appert, D. Eremin.
**Technical University Graz, Austria:** W. Kernbichler.
**University of Opole, Poland:** F. Musielok, I. Ksiazek.
**Maria Curie Sklodowska University, Lublin, Poland:** J. Sielanko.
**Technical University Szczecin, Poland:** P. Berszynski, I. Kruk.
**The Henryk Niewodniczanski Instiute of Nuclear Physics, Kraków, Poland:** M. Jezabek, M. Stodulski, Z. Zulek.
**Wroclaw Technical University and Wroclaw Technology Park, Poland:** M. Chorowski.
**Soltan Institute for Nuclear Studies, Otwock-Swierk, Poland:** G. Wrochna.
**Maritime University of Szczecin (Akademia Morska), Poland:** B. Bieg, Y. Kravtsov.
**INP, Krakow, Poland:** K. Drozdowicz, G. Tracz.
**IPPLM Institute of Plasma Physics and Laser Microfusion Warsaw, Poland:** A. Galkowski, S. Jablonski, S. Jednorog, J. Kaczmarczyk, M. Kubkowska, R. Propowicz, R. Prokopowicz, L. Ryc, M. Scholz, J. Wolowski, Zzydlowski.
**University of Ljubljana, Faculty of Mechanical Engineering, Ljubljana, Slovenia:** J. Duhovnik, T. Kolsek.
**Budker Institute of Nuclear Physics, Novosibirsk; Russia:** V. I. Davydenko, A. Ivanov, I. V. Shikhovtsev.
**Efremov Institute, St. Petersburg, Russia:** A. Alekseev, A. Malkov.
**A. F. Ioffe Physico-Technical Institute of the Russian Academy of Sciences, Russia:** S. Petrov.
**Technical University, St. Petersburg, Russia:** S. J. Sergeev.
**Kurchatov Institute, Moscow, Russia:** M. Iasev.
**Institute of Applied Physics (IAP), Nizhnynovgorod, Russia:** L. Lubyako, J. Koshurinov, M. Petelin, A. Shalashov.
**Institute for Nuclear Research, Kiev, Ukraine:** Y. I. Kolesnichenko, V. V. Lutsenko, Y. V. Yakovenko.
**Kharkov Institute of Physics and Technology, Ukraine:** L. Krupnik, A. Melnikov, D. Perfilov.
**Research Institute for Particle and Nuclear Physics, Budapest, Hungary:** G. Kocsis, A. Molnár, S. Récsei, J. Sárközi, V. Szabó, A. Szappanos, Sz. Tulipán, S. Zoletnik.
**Princeton Plasma Physics Laboratory, Princeton, USA:** S. Hudson, D. Mikkelsen, A. Reiman, M. Zarnstorff.
**Oak Ridge National Laboratory, USA:** J. H. Harris, D. A. Spong.
**University of Wisconsin, Madison, USA:** J. Talmadge.
**General Atomics, San Diego, USA:** T. Evans.
**Lawrence Livermore National Laboratory, USA:** C. Lasnier.
**Kyoto University, Japan:** H. Mizuuchi, S. Murakami, K. Nagasaki, F. Sano.
**National Institute for Fusion Science (NIFS), Toki, Japan:** T. Funaba, S. Ohdachi S. Okamura, S. Sato, Sakakibara, Y. Suzuki, K. Toi, K. Y. Watanabe, H. Yamada, M. Yokoyama.
**Australian National University, Australia:** B. Blackwell, D. Pretty.

# Laboratory Plasma Devices WEGA and VINETA

On WEGA advanced experiments on electron cyclotron wave heating have been performed. For 28 GHz ECRH operation an increasing number of contactless diagnostic is used. The prototype of the W7-X control system is now operational. In VINETA the plasma operation regime has been extended by inductive plasma heating. The focus of the investigations was on the dispersion behaviour of whistler and Alfvén waves and the control of drift wave turbulence.

## WEGA

**Head: Dr. Matthias Otte**

### Electron Cyclotron Wave Heating and Current Drive

The ECRH system consists of two 2.45 GHz magnetrons with 26 kW power in total and a 28 GHz gyrotron with 10 kW power. The first is routinely used for plasma generation at a low magnetic field strength of 57 mT, where over-dense plasma operation is achieved by electron Bernstein wave (EBW) generation due to OXB-mode conversion. The complicated ray propagation and absorption can be calculated by 3D ray-tracing in collaboration with IPP Prague/Czech Republic and was extended to EBW current drive calculations. WEGA offers the unique opportunity to prove the ray-tracing predictions for EBW driven current in detail. In addition to the total EBW driven toroidal current measured by an external Rogowski coil, the low temperature plasma allows to measure the current density profile by a small movable internal Rogowski coil inside the plasma, too. The measured current density profile could be qualitatively reproduced by ray-tracing calculation. The 2.45 GHz system was also successfully used for non-resonant plasma heating. Here, the plasma start-up must be performed either by resonant ECRH at 0.87 T or by additional 28 GHz ECRH at 0.5 T. Once the plasma was generated, the over-dense plasma could be sustained by the 2.45 GHz at any magnetic field strength. The 28 GHz ECRH system is now operating at 0.5 T in two regimes, i.e. second harmonic extraordinary mode (X2-mode) at densities below the X2 cutoff ($n_e<4.9\times10^{18}$ m$^{-3}$) and EBW heating by OXB mode conversion at densities above the 28 GHz O-mode cutoff ($n_e>1\times10^{19}$ m$^{-3}$). Because of the low X2 single pass absorption of only 10-20 %, a multi-pass heating scheme was established. Inside the vacuum vessel additional reflectors were installed to guarantee at least three controlled beam passes through the plasma centre. Peaked radiation profiles could be measured by the bolometer camera indicating high central power absorption of >50 %. The establishment of the EBW heating at 28 GHz was a real breakthrough in ECRH physics. For the first time, an overdense magnetised plasma was sustained by controlled OXB-mode conversion heating using millimetre waves exclusively. First, the plasma density was increased by non-resonant 2.45 GHz heating to reach the 28 GHz O-mode cutoff density, which is necessary for the OXB mode conversion. Then EBW heating took over and the 2.45 GHz could be switched off. A total power absorption of 87 % was estimated from the microwave stray radiation level. The radiation profile measured by a bolometer camera changed from a broad into a strongly peaked profile indicating central absorption. The OXB-conversion was confirmed by scans of the beam polarisation and the magnetic field strength. The results are consistent with the ray-tracing prediction. The radiation peaking could be enhanced furthermore with the help of an inductively driven toroidal current of 1 kA in co-direction. The confinement was very sensitive to the induced toroidal current direction. With plasma current induced in counter direction, the rotational transform could be reduced down to zero, where the plasma confinement was totally lost.

### Diagnostic Development and W7-X Control System

With the Heavy Ion Beam Probe diagnostic it is now possible to investigate the region of magnetic islands and the X-point at the low field side without changing the magnetic configuration. First measurements showed the necessity of additional coordinate mapping corrections. The beam position was measured using an internal detector array in various magnetic configurations. A discrepancy between the position of the calculated beam trace and the measured one was found. As possible reason an improper simulation of the helical field coils in the ray tracing code is assumed. Measurements with the ECE diagnostic at non-resonant 2.45 GHz ECRH for 0.5 T were performed. A qualitative proof of cyclotron emission at $T_e < 5$ eV was possible. However, the main part of the emission (> 90 %) was identified as bremsstrahlung. The investigations were complemented by transmission measurements to determine the maximum plasma density. Systematic investigations of the field line visualisation to optimize the visibility of the light trace have been performed varying the electron beam energy and intensity as well as the used gases and the gas pressure. Currently two bolometers, a gold-resistive type and a 16-channel Si-photodiode array, are installed investigating the influence of the neutral gas-pressure as well as neutral particle charge exchange effects on the gold foil detectors. Software for the reconstruction of emission profiles from the 12-channel bolometer signals was developed utilizing a maximum entropy based Abel-inversion algorithm. The first phase of the prototype installation of the W7-X control system was successfully completed. The objective of the succeeding second phase is the realization of a technical and physical orientated programme for a practical qualifying and acceptance assessment of the new control system. The capabilities of this control system have been demonstrated during a one hour segment based plasma experiment with the 2.45 GHz microwave heating system.

### Scientific Staff

D. Andruczyk, P. Drewelow, H. P. Laqua, O. Lischtschenko, S. Marsen, Y. Podoba, T. Stange, F. Wagner, D. Zhang.

## VINETA

### Head: Prof. Dr. Olaf Grulke

### Device and Operational Parameters

A non-resonant rf m=1 helicon wave heating operated at VINETA provides high plasma densities at relatively low electron temperatures ( $n \leq 10^{19}\,m^{-3}$, Te≈3 eV for a rf frequency $f_{rf}$=13.56 MHz, rf power of $P_{rf} \leq 5$ kW, and magnetic field B=0.1T). The main diagnostic tools are electrostatic and magnetic probes. The time-averaged plasma profiles are benchmarked with a 160 GHz heterodyne microwave interferometer. In addition to the helicon heating a new plasma source has been installed and successfully tested using a spiral coil for inductive plasma heating. This new setup essentially doubles the plasma radius, which is an important aspect to avoid eigenmode structures of plasma waves due to the radial boundary conditions. Interestingly, at large input rf power the excitation of helicon waves also with the spiral coil is observed and a transition from inductive to helicon wave heating is found also with this configuration.

### Dispersion Behaviour of Whistler and Alfvén Waves

In previous studies the excitation of whistler waves in VINETA has been demonstrated. Measurements of the dispersion behaviour reveal that at least in the high-frequency regime $f \geq 0.3\omega_{ce}$ the whistler wave follows the linear unbounded dispersion relation.The investigations in 2008 focussed on the damping mechanisms. The frequency dependence of the whistler wave damping is shown in figure 1a. It displays the superposition of a frequency independent part, which is ascribed to collisional damping, and the strongly frequency dependent kinetic cyclotron damping, which dominates already for frequencies $f \geq 0.6\omega_{ce}$ due to Doppler shift. The comparison with linear Vlasov calculations, shown in figure 1a.), is in excellent agreement. In the low-frequency regime Alfvén waves can be externally excited. Since the excitation is not polarization dependent the wave field is found to be a superposition of right- and left-hand polarization.

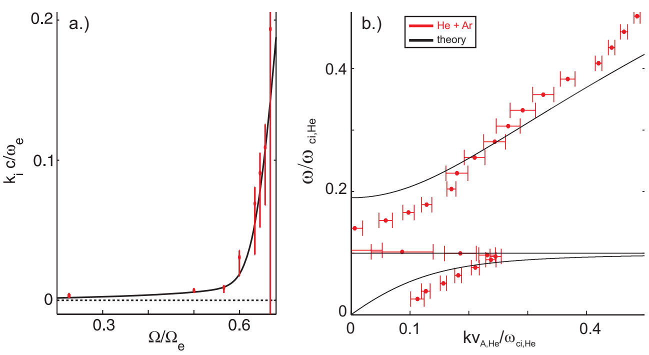



*Figure 1: Measurements of the damping of whistler waves (a) and the dispersion behavior of shear Alfvén waves in a multi-species plasma consisting of Argon and Helium ions. The measurements (marker) are compared to the respective theoretical predictions (solid lines).*

Decomposition into the individual wave fields yields the simultaneous excitation and propagation of a shear and fast Alfvén wave. The shear Alfvén wave dispersion shows the expected behaviour for variations of the plasma density and magnetic field. The investigations have been extended also to multi-species plasmas. The measurement of the dispersion relation of the shear Alfvén wave for an Argon-Helium plasma and the comparison with linear dispersion calculations is depicted in figure 1b.). The dispersion displays two branches, corresponding to the two ion species. The Argon resonance is clearly seen at the respective cyclotron frequency. Deviations are addressed to uncertainties in the determination of the respective ion densities.

### Control of Drift Wave Turbulence

The investigations of spatiotemporal control of weakly developed drift wave turbulence have been continued. It was demonstrated that single coherent drift wave modes can be synchronized by driven parallel plasma current patterns. The currents are driven using an array of electrodes or magnetic field coils, respectively. Nonlinear interaction between drift wave mode and control signal is seen in the spectral evolution of density fluctuations. In weakly developed drift wave turbulence the control pattern induces the growth of a single coherent drift wave mode with low mode number to the expense of the broad-band turbulent fluctuations, which amplitude is considerably reduced. Although the mode amplitude is comparable to the low-frequency turbulent fluctuations, the control scheme has a strong effect on the fluctuation-induced cross-field transport. In figure 2 the phase spectra between plasma density and potential fluctuations in the two cases are compared. In the left diagram turbulent fluctuations dominate in the frequency range 7-12 kHz. In the controlled situation the fluctuations in the drift wave regime 5-10 kHz display a small phase shift between density and potential fluctuations, figure 2 (right). Consequently, the cross-field transport is considerably reduced by the spatiotemporal control.

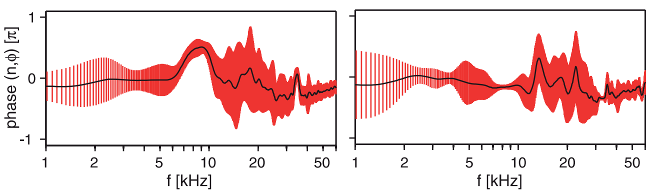



*Figure 2: Phase spectra of plasma density and potential fluctuations in weakly developed drift wave turbulence (left) and the controlled situation (right)*

## Scientific Staff

C. Brandt, O. Grulke, T. Klinger, J. Pfannmöller, K. Rahbarnia, A. Stark, N. Sydorenko, S. Ullrich, T. Windisch.

*Part of the VINETA program is carried out under the auspices of the Transregional Special Collaborative Research Center SFB-TR24 "Fundamentals of Complex Plasmas".*

ITER

# ITER Cooperation Project

Head: Dr. Hans Meister

## Introduction

The IPP contributes to the ITER Project in a wide range of activities. Tasks range from R&D for heating systems and diagnostics to development of integrated plasma scenarios. In addition, the IPP is playing a leading role in contributing to the ITER physics definition and objectives via contributions to the International Tokamak Physics Activity and the activities following the ITER design review.

In 2008 ITER managed to complete a major part of the design changes which came up as a result of the design review from 2007. Now, ITER is gradually moving towards the procurement phase; first procurement arrangements have been signed. Additionally, the European Fusion Development Agreement (EFDA) has changed in 2008. Its part related to the development of technology for ITER has been integrated into the European Joint Undertaking for ITER and the Development of Fusion (F4E). With EFDA remain the tasks related to fundamental fusion research. These changes also affect the ITER Cooperation Project at IPP. The contributions which have begun under EFDA in 2007 or earlier could be finalised or are about to be finished. Many of the new tasks launched by EFDA in late 2008 feature a significant contribution by IPP. The larger, long-term projects for the heating systems and the diagnostics are being organised under F4E. First steps include the setting up of consortia with strong or leading participation of IPP, new development contracts with F4E, so-called Grants, and the successful application for additional grants from national funding schemes. The following sections report on the results achieved during projects where IPP expertise in support of ITER was in demand. The work is based on ASDEX Upgrade experience as well as on know-how in the Technology, Theory, Materials and Stellarator Divisions and varies from studies of plasma scenarios to the development of specific technical systems. Additionally, IPP took part in drawing up the first version of the ITER research plan and contributes actively to the physics definition of ITER via the International Tokamak Physics Activity (ITPA).

## Heating Systems

### Development of RF Driven Negative Hydrogen Ion Sources for ITER

The long pulse stability of the source performance at the test facility MANITU could be increased drastically by coating of all relevant source surfaces with a ~3 μm Mo layer. This strongly reduced the impurity content of the source and stable pulses of several 100 seconds with an ITER-relevant amount of co-extracted electrons could be achieved routinely in hydrogen (figure 1), but also in deuterium with pulse lengths of up to 100 s. Together with an improved coil insulation long pulse operation with high RF power is now possible in order to increase the ion current. The homogeneity of the beam is measured with a spatially resolved $H_\alpha$ Doppler shift spectroscopy system; first results indicate an improvement with increasing RF power with an rms deviation of less than 15 % at power levels above 60 kW.

The experiments are strongly supported by realistic modelling, i.e. taking into account the 3D-structure of the magnetic and electrical fields and the geometry of the sources, leading to an improved understanding of the processes of the generation and extraction of negative hydrogen ions. A self consistent PIC model showed that at typical source parameters the amount of negative ions that can leave the plasma grid is space charge limited for the available amount of positive charges ($H_x^+$, $Cs^+$). The extraction probability of the negative ions depends on their starting energy, on the magnetic field structure near the plasma, as well as on the detailed geometry of the aperture and the ratio of conversion to aperture area.

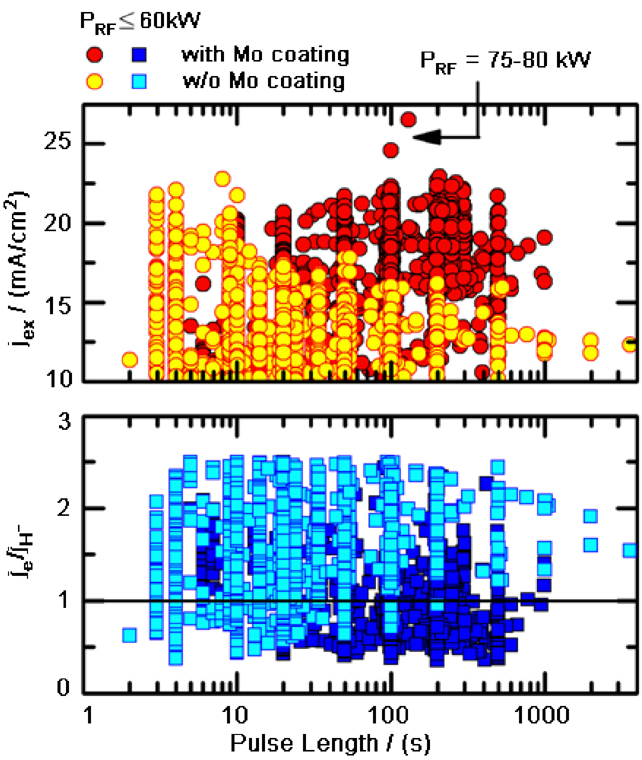



*Figure 1: Comparison of the long pulse performance of MANITU w/o and with Mo coating of the source*

The ion source test facility RADI aims to demonstrate the required plasma homogeneity of a large RF source; its modular driver concept will allow an extrapolation to the full size ITER source. Pulses in an ITER-relevant power level showed that a large size deuterium plasma, driven by four drivers, is sufficiently homogeneous in non-cesiated conditions. Operation with Cs at ITER-relevant parameters is foreseen in spring 2009. IPP continued to contribute to the design of the planned neutral

beam injector test plant in Padua, Italy. IPP provides support in the framework of an F4E Grant in the design of the full size RF source, the RF circuit and the layout of source and beam diagnostics, also by training of personnel at the IPP test facilities.
The design of the new test facility ELISE for the extraction from a half-size ITER source, an important step between the present small scale IPP extraction experiments and the full size ITER neutral beam system, is almost finished. A crucial part was the main insulator with a new concept for HV insulation of a large ion source, including mock-up tests of up to 100 kV, so that the source can be operated in air. Due to this concept and other measures, ELISE has a larger experimental flexibility and wider operational margins than the sources at the test facilities in Padua. The support of ELISE is part of the F4E work plan; the contract is expected in the next months. The integrated commissioning with the first pulses is expected about 2 years after the start of the procurement activities.

### ICRF Antenna Consortium

Progress continued in setting up CYCLE, a consortium of ERM/KMS, CEA, IPP, Politechnico de Torino and UKAEA, related to the collaboration on the ion cyclotron antenna system for ITER. By the end of the year, an agreement had been reached between all partners and F4E on the formulation of the legal document, which is now ready for signature.
The ICRF group has bid successfully for an EFDA task on the improvement and qualification of ICRF arc detection systems, and will be coordinator for the Task involving ERM/KMS, CEA and Politechnico de Torino.

### Optimization of the Upper ECRH Launcher

For the optimization of the “front-steering” launcher, corrugated $HE_{11}$ – $TEM_{00}$ converters have been designed, which reach a Gaussian beam efficiency of better than 99.5 %, and thus a strong reduction of stray radiation in the launcher. The influence of spurious modes in the waveguide was investigated, showing that high mode purity is required to guarantee a beam squint of less than 0.1 degrees. Investigations of the surface of mirror samples which had been exposed to fusion plasmas revealed that mainly surface roughness is responsible for the increased absorption; coatings play a minor role. For the present version of the “remote-steering” launcher, the input optics to the square corrugated waveguide was analyzed and a phase-correcting steering mirror for optimum beam performance was designed; However due to several constraints, an improvement of the antenna performance of only 4 % could be obtained relative to the reference design.

## Physics Integration

### ECRH Physics Integration

IPP continued to lead the ‘physics integration’ activity in the EFDA/F4E programme to develop the Upper Launcher, coordinating work from several Associations (CNR, EPFL, FOM, IPP). Joint work proceeded to optimise the physics functionality of the full ECRH system, combining Upper and Equatorial Launcher for various applications. Joint work proceeds to clarify the limitations to beam focussing arising from several effects. A new item studied by IPP was the application of ECCD to potentially trigger FIR NTMs or ELMs.

### Erosion/Redeposition Studies in PSI-2

The scavenger effect, i.e. the influence of nitrogen injection on the formation of a-C:H films in areas far away from the plasma as well as close to the plasma boundary, was studied in the PSI-2 device for different collector temperatures. Small amounts of $N_2$ ($\Phi(N_2) \approx \Phi(CH_4) \approx 2\ \%\ \Phi(H_2)$) strongly reduce the net growth rate in $H_2/CH_4$ mixtures. While $N_2$ injection does not influence the erosion far away from the plasma it increases the erosion close to the plasma boundary. The experiments show clear evidence for a scavenger effect due to the injected $N_2$. The conversion from $N_2$ to active species takes place in the hot plasma region. A similar influence was not found in cases of Ar or Ne injection. The reactions are not caused by $N_2$ alone but are rather related to H and N carrying species as a consequence of plasma chemical reactions. Despite the encouraging results found in this study, the beneficial use of $N_2$ injection into fusion devices is not guaranteed yet, unless the enhanced erosion of the divertor plates by $N_2$ can be shown to be tolerable.

### Non-axisymmetric Stability & Resistive Wall Modes

The STARWALL code, which computes the growth rates of resistive wall modes in presence of 3D multiply-connected resistive walls, has been improved by introducing a non-equidistant grid in radial direction. This avoids unphysical spikes in the eigenfunctions and the accuracy of the eigenvalues is improved. The STARWALL code has been successfully benchmarked with the CarMa and VALEN codes for closed resistive walls, walls with holes and walls with holes and port plug extensions. As expected, holes in the walls deteriorate the stabilizing effect of the walls, but the extensions partly compensate this reduction of the stabilization leading to only slightly higher growth rates than the ones obtained with closed walls. Using two walls with holes and port plug extensions, and feedback coils located inside the inner wall, feedback stabilization could be achieved for ITER equilibria of Scenario 4 type up to $\beta_N$=3.14.

### 3D Analysis of Impurity Transport for ITER Limiter Start-up Configurations

A plasma density scan for three different configurations and transport coefficients during current ramp-up has been analysed with respect to the scaling of the plasma recycling fluxes, $\Phi_{recy}$, and the Be density, $n_{Be,LCFS}$. For each configuration, $\Phi_{recy}$ is found to increase with both the plasma upstream density, $n_{up}$, and the diffusion coefficient, $D_\perp$, scaling roughly as $\Phi_{recy} \propto D_{\perp}^{1/2} n_{up}$, as expected. Owing to the linear coupling of $n_{Be,LCFS}$ with $\Phi_{recy}$ in the test-particle approximation, a higher $n_{up}$ raises $n_{Be,LCFS}$, as well. A larger $D_{\perp}$ for the background plasma raises $\Phi_{recy}$, thereby increasing $n_{Be,LCFS}$. On the other hand, a simultaneous co-increase in $D_{\perp}$ for Be will reduce $n_{Be,LCFS}$. Thus, a co-variation of $D_{\perp}$ for both the background plasma and the Be impurities leads to a trade-off between two competing processes, source and transport, in determining $n_{Be,LCFS}$. This makes an estimation of the $D_{\perp}$ impact on $n_{Be,LCFS}$ very difficult. Additional effects such as the Be neutral source distribution as well as the parallel Be-ion transport in the limiter SOL may become important for determining the scaling of $n_{Be,LCFS}$ with $D_{\perp}$. A dedicated study on this issue is presently under way.

## Diagnostics

### ITER Procurement Package 21

The ITER Procurement Package 21 (PP21) consists mainly of the bolometer and the neutral pressure measurement diagnostics, but also of all diagnostic hardware associated with lower port 16, including that of other "client" diagnostics. Early in 2008, the draft project plan for the full development of PP21 was completed by a consortium of the Euratom Fusion Associations IPP, HAS, FZK, CEA and CIEMAT under the lead of IPP and submitted to F4E for consideration. Based on experience and further interests of the participants, a consortium of HAS and FZK under the lead of IPP is being formed for the further development of PP21. Due to other priorities, CIEMAT and CEA will not participate on an official basis in this consortium. Thus, its main focus will be the bolometer diagnostic. In order to continue and adequately support the R&D activities necessary for the development of the ITER bolometer diagnostic and the diagnostic integration, IPP submitted a proposal for additional funding to the German government. The proposal was approved in fall 2008 granting IPP additional funds of 5.7 M€ for the next 3 years for detector development,

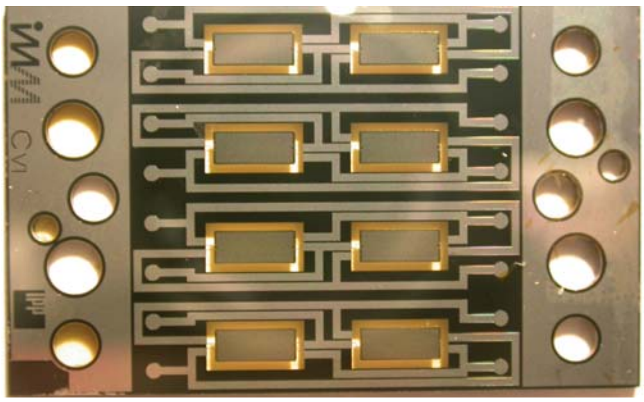


*Figure 2: Bolometer detector foil with 4 channels (each with measurement and reference sensor) developed by IMM*

building and testing of prototypes and the development of the diagnostic integration in ITER. By the end of 2008, the procurement of hardware and the employment of additional staff started.

The development of a radiation hard bolometer sensor continued in 2008. Within a newly established cooperation with IMM (Institut für Mikrotechnik Mainz GmbH) a sensor was developed featuring a 4 µm thick Pt-absorber on a SiN membrane and Pt meanders (figure 2). New processes developed by IMM allowed the stress-reduced galvanic deposition of the absorber, in contrast to sputtering used in previous developments, because galvanic deposition is the only viable option for reaching absorber thicknesses of at least 12 µm which are required for ITER. This cooperation will be continued to develop thick absorbers and to optimise them for the operation in ITER.

Investigations, as a task of the JET TF FT, of the failure causes of bolometers recently removed from JET showed that the bonded contacts used worked well. Most failures were due to failing crimped contacts. This lesson learned will influence the design of the ITER bolometers.The distribution of the bolometer mini-cameras, as developed in 2007, was further improved and updated according to the recent design changes of the ITER divertor cassettes and blanket modules. The CATIA models of the mini-cameras in the divertor were submitted to ITER and integrated in their CAD database. In cooperation with the ITER design office a CATIA model of the distribution of mini-cameras in the vacuum vessel was generated and also integrated in the CAD database. Additionally, a first distribution of mini-cameras within equatorial port plug 1 was submitted to the corresponding lead Association (CEA).

### In-Vessel Neutral Pressure Measurement

A numerical code has been developed recently to simulate the ASDEX pressure gauge, the reference detector type for ITER, in order to optimise the design and performance, and to cope with ITER requirements for neutral flux measurements. Using the Monte-Carlo technique, this code calculates the electric currents on the electrodes in a realistic geometry and electromagnetic configuration. The first simulations suggest several small changes which should lead to a higher pressure limit.

### Test of a Compact Soft X-Ray Spectrometer

The ITER prototype compact SXR spectrometer designed at the Kurchatov Institute in Moscow has been acquiring data successfully for the complete 2008 ASDEX Upgrade campaign. As during 2007, the spectra of the Argon He-like resonance lines were acquired for one vertical line of sight at high resolving power ($\lambda/\Delta\lambda \approx 6800$). Ar concentration, temperature and poloidal rotation have been evaluated routinely. At the end of 2008 the diagnostic has been upgraded to 4 ms time resolution (from 8 ms in 2007). Due to its high luminosity all the measurements can be achieved even with an Argon concentration as low as $\sim 10^{-5}$, depending on plasma parameters.

### Dust Measurement

Investigations in AUG indicate that most of the dust originates from in-vessel work and imperfect design of components. To discriminate dust in the plasma from debris produced during maintenance, dust collectors were applied and analysed. Beside C/B agglomerates, W spheres are observed with diameters of ~5 µm. Extrapolating, this yields about 10 g W in the whole torus, much more than expected from physical sputtering. Detailed analyses of dust particles indicate that arcs may be the origin of W. Investigations of video observations show that huge amounts of dust are observed after vents, but vanish during the wall conditioning phase. The investigation of the movement of dust particles with a fast camera showed for normal operation only a few dust events, but many after a disruption. Typical trajectories are straight lines, indicating uncharged particles. During untypical discharges with high clearance to the limiters, particles interacting with the plasma and magnetic field are observed.

## ITER Design Review and Support

### Experimental Studies of ITER Demonstration Discharges

Key parts of the ITER scenario are determined by the capability of the proposed poloidal field coil set. They include the plasma initiation at low voltage, the current rise phase, the performance during the flat top phase, and a ramp down of the plasma. New data obtained from dedicated experiments in ASDEX Upgrade show that breakdown for $E_{axis} < 0.23$-$0.33$ V/m is possible with ECRH assist and without the need for an additional dedicated system in ITER. For the current ramp up, good control of $l_i$ is obtained using a full bore plasma shape with early X-point formation. Additional heating keeps $l_i(3) < 0.85$, a rise phase with an H-mode transition achieves $l_i(3) < 0.7$ at the start of the flat top. Studies of the H-mode reference scenario at $q_{95}$~3 concentrated on aspects like the transition to H-mode and the evolution of $l_i$ during the flat top phase. For the ITER ramp down it is important to remain diverted and to reduce the elongation. Keeping the discharge in H-mode during most of the ramp down helps, too.

### ITER-specific Tasks in PWI-TF

An extrapolation to tritium retention in ITER was performed by the EU PWI TF on the basis of detailed laboratory analysis of the underlying retention processes in the different ITER wall materials. Co-deposition with C is the dominating retention process for an all-C machine, limiting the number of discharges to few hundred, while the inventory due to implantation and bulk retention in an all-W device reaches the limit in about 10.000 discharges. Large uncertainties remain due to unknown effects of n-irradiation. A similar assessment within the ITPA SOL/DIV sub-section used scaling laws and simplified erosion and implantation data to calculate the retention in ITER, yielding very similar results. The initial material choice with CFC as divertor strike point tiles, W divertor and baffle cladding and a Be first wall will require tritium recovery methods about every 1000 to 2000 discharges.

### Trainee Programmes

The EnTicE Project (European Network for Training Ion Cyclotron Engineers), part of the Euratom Training Scheme, continued successfully in its second year with 6 Trainees and 8 Partners. During 2008 one of the trainees was given a permanent position. The ICRF group of IPP is leading the project funded with 1.2 M€. The ICRF Group of IPP also participates with the LITE project in the sequel to the Euratom Training Scheme, now called the Goal Oriented Training Programme. Additionally, IPP participates in the European Fusion Education Network (FUSENET) for education in fusion science and technology, in order to increase, enhance, and broaden fusion training and education activities in Europe. The project consists of eleven focused work packages, with a total budget of 2 M€. The project brings together a broad representation of the European fusion community with 36 participants from 18 countries, of which 22 Universities and 14 Euratom Associations. IPP participates in several areas, leading one work package and one task.

## Scientific Staff

**NNBI:** M. Berger, S. Christ-Koch, H. Falter, U. Fantz, P. Franzen, M. Fröschle, R. Gutser, B. Heinemann, D. Holtum, W. Kraus, C. Martens, P. McNeely, R. Nocentini, S. Obermayer, R. Riedl, A. Stäbler, E. Speth, P. Turba, D. Wünderlich; T. Jiang (SWIP, ChengDu, China).
**ICRF:** S. Assas, W. Becker, V. Bobkov, F. Braun, R. D'Inca, H. Faugel, F. Fischer, J.-M. Noterdaeme, A. Onyshchenko, M. Prechtl, G. Siegl, I. Zammuto.
**ECRH Launcher:** E. Häberle, W. Kasparek, H. Kumric, B. Plaum (all IPF).
**ECRH Physics:** E. Poli, H. Zohm.
**Erosion/Redeposition:** M. Baudach, W. Bohmeyer, A. Cwiklinski, G. Fußmann, A. Markin.
**RWM:** P. Merkel, M. Sempf, E. Strumberger.
**3D SOL Modelling:** Y. Feng, F. Sardei, X. Zha.
**ITER PP21:** L. Giannone, L. D. Horton, H. Meister, G. Raupp, W. Zeidner; G. Grunda, S. Kalvin, G. Veres (HAS); U. Fischer, A. Serikov (FZK); R. Reichle (CEA); F. Tabares (CIEMAT).
**Pressure Gauges:** G. Haas, P. Sauter, A. Scarabosio.
**Soft-X Spectrometer:** R. Neu, M. Sertoli.
**Dust:** M. Balden, T. Lunt, V. Rohde; S. H. Hong (CEA).
**ITER Demonstration Discharges:** L. D. Horton, G. Sips.
**PWI-TF Tasks:** A. Kallenbach, M. Mayer, O. Ogorodnikova, J. Roth, K Schmid.

# Plasma-wall-interactions and Materials

# Plasma-facing Materials and Components

**Head: Dr. Joachim Roth (acting)**

Within the project "Plasma-facing Materials and Components" the areas of plasma-wall interaction studies, material modification under plasma exposure, development of new plasma-facing materials and their characterisation have been merged to form a field of competence at IPP. The work supports exploration and further development of the fusion devices of IPP and also generates basic expertise with regard to PFC-related questions in ITER and fusion reactors.

## Surface Processes on Plasma-Exposed Materials

### Simultaneous Irradiation of Tungsten with Deuterium and Carbon at Elevated Temperatures

The planned use of carbon (C) strike plates located directly adjacent to tungsten (W) tiles in the ITER divertor will lead to C impurities in the incident flux of fuel ions. The resulting simultaneous bombardment of W surfaces with both fuel and C impurity ions causes a competition of erosion and deposition processes that is significantly different from H-only or C-only bombardment. Of particular importance for fusion research is the prediction of the transition point from erosion to deposition as it separates areas of continuous erosion from areas of continuous growth of a C layers. To investigate the temperature dependence of W sputtering and C layer growth behaviour, W films deposited on nickel substrates were simultaneously irradiated by C and D ions at temperatures between 400 and 600 °C with in-situ ion beam analysis between irradiation steps.

In general, simultaneous C and D irradiation of W results in one of two principal regimes where either W erosion or C deposition dominates depending on the C fraction in the total incident flux ($f_C$). In the W erosion regime, the surface remains a mixture of W and C, while in the C deposition regime, a pure C layer forms above the initially mixed W-C surface; the results are summarized in figures 1a and 1b, respectively. Figure 1a shows for $f_C$=11 % a clear reduction in C amount with *increasing* temperature, which is opposite to the trend for chemical erosion in mixed W-C systems. This C reduction is due primarily to the increase in C self-sputtering yield with increasing temperature. For W erosion regime, the increase in C self-sputtering at elevated temperatures is the dominant mechanism for C removal with negligible contribution from chemical effects. C fractions of 11 % and higher result in the C deposition regime, but again a strong temperature dependence is seen due to increased C self-sputtering. The effect of D is significant only above a threshold of about $0.2\times10^{22}$ m$^{-2}$ of implanted C as seen in figure 1b. This appears to be the minimum C amount above which the build-up of C layer develops. Comparison to TRIDYN simulations indicates that the rate of C layer build-up is reduced in amount equal to the chemical sputter yield of pure C caused by the D ion bombardment. For simultaneous irradiations at 600 °C, the transition point from W erosion to C deposition shifts to $f_C$>14 %.

In the W ersosion regime, chemical erosion effects are negligible and the sputtering behaviour is collision dominated. In the C deposition regime, the influence of D is small compared to the increased C self-sputtering and is only observed after the onset of a C layer build-up. Therefore, at elevated temperatures the temperature dependent C self-sputtering yields have a larger impact in the implantation and sputtering behaviour of a mixed W-C system under simultaneous irradiation than D chemical effects.

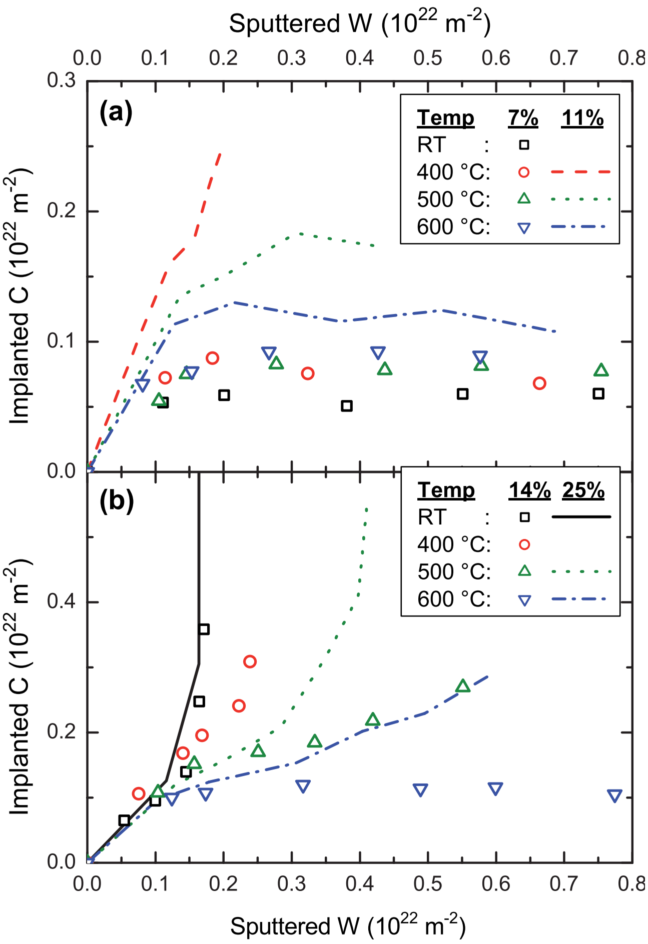



*Figure 1: Implantation sputtering curves for simultaneous C and D irradiation in: (a) W erosion regime and; (b) C deposition regime, as a function of $f_C$ at different temperatures.*

### Molecular Dynamics Modelling of Chemical Erosion of Hydrocarbon Films

An atomistic understanding of the erosion mechanism in co-bombardment (hydrogen and energetic particles) situations is urgently desired for robust predictions of the chemical sputtering of carbon plasma-facing materials. A molecular dynamics simulation code, Hydrocarbon Parallel Cascade

(HCParCas version V3.22), has been used to prepare a-C:H samples with the volume of 14×14×28 Å$^3$ and an H/(H+C) ratio of 0.38 which were subsequently exposed to a variety of different impinging flux conditions.

a) Hydrogen only

In the case of low-energy H-alone simulations the number of carbon atoms of the initial sample is unchanged by the additionally offered hydrogen, i.e., no erosion occurred. The increase in the hydrogen content is restricted to the upper part of the sample (3 Å), forming a thin, hydrogen-enriched layer which has also been observed in other simulations. Nevertheless, a comparison of the C-C bond statistics between the initial sample and the sample after H exposure reveals that the carbon network is not affected by this increase of surface H content, because most of the hydrogen atoms are added to the already existing open bonds in the initial sample.

b) Argon only

In the case of physical sputtering by 150 eV Ar bombardment an erosion yield of 0.8 C/Ar was found. The Ar bombardment increases the number of carbon atoms with a lower carbon coordination number at the expense of 4-fold coordinated carbon atoms. At the same time, the near-surface region is depleted of hydrogen since the average loss ratio is C:H=1:2.

c) Argon and hydrogen co-bombardment

Here on average a loss of 1.7 C/Ar occurred. The incident hydrogen is incorporated into the surface layer maintaining its supersaturated condition as can be deduced from the $N_H/N_C$ ratio raising from initially 0.62 to 0.72 in the upper half of the sample. The bond distribution also indicates an increased appearance of terminal C atoms in addition to the changes induced by the physical sputtering processes, i.e., the numbers of singly and doubly coordinated atoms are increased at the expense of 3-fold and 4-fold coordinated atoms. The analysis of the simulations (with respect to the time and energy distribution of the different emitted species) convincingly shows that the eventual ejection of $C_xH_y$ radicals is entirely a momentum transfer effect (impact induced). However, the steric repulsion which arises due to excess hydrogen in the surface layer is purely chemical in origin and is the key for the increased sputtering yield.

### Deuterium Retention in Carbon- and Self-Implanted Tungsten

Ion-driven deuterium retention in polycrystalline tungsten has been studied by ion beam analysis (IBA) and thermo-desorption spectroscopy (TDS) for different pre-implantation and pre-annealing treatments. The purpose was to investigate the influence of ion-induced defects and carbon implantation on the D inventory in tungsten. Three kinds of tungsten samples were investigated: (i) as-received, (ii) outgased and (ii) re-crystallized. Such prepared substrates were implanted with W (self implantation) and C ions. Then they were irradiated with 200 eV D ions at the IPP High Current Source at room temperature. The obtained results were compared with those from pure tungsten. A comparison of the results for W and C pre-implantation allows discriminating between chemical effects and damage-induced changes of the D retention due to pre-implantation.

In self-implanted W a high D concentration (~10 at%) up to 500 nm and diffusion into the bulk was observed. Nevertheless, it still displays similar behaviour as pure W. The ratio of retained D determined by NRA and TDS is comparable for these two cases. The results indicate that C implanted into W introduces additional trapping sites compared to W implantation and acts as a barrier for D diffusion. The maximum local D concentration is higher in C implanted samples, but the total retained amount is comparable with that in pure W. This suggests that the effective diffusion coefficient is lower not because of additional defects, but due to tungsten subcarbide formation, which has lower diffusion coefficient.

### Investigation of Chemical Phase Formation in the Ternary System Beryllium, Carbon and Tungsten with Depth-Resolved Photoelectron Spectroscopy

The interaction between the materials Be, C, and W, being planned for the first wall of ITER, is of major interest as it strongly influence fusion-relevant material properties such as erosion behavior, melting point and hydrogen inventory. Model systems with thin elemental layers of a few nm in thickness are prepared, annealed and analyzed by X-ray photoelectron spectroscopy (XPS). For the characterization of temperature-driven diffusion and reaction processes, synchrotron radiation is applied, yielding depth-resolved chemical compositions in a non-destructive way.

A layered system of beryllium, carbon and tungsten is prepared, annealed and analyzed. Five temperature steps are performed in order to analyze the kinetic processes and chemical states, namely 300, 530, 850, 1020 and 1200 K. After each temperature treatment, the sample composition is analyzed using four different information depths. Beryllium diffusion through carbon to the surface and BeO formation is observed at room temperature. The beryllium carbide formation starts at the interface and expands to the surface. It is complete at 850 K. Carbon diffuses into the bulk and starts forming $W_2C$ at 850 K. At 1020 K, the surface morphology begins to change. The formation of a $Be_2W$ alloy is observed at room temperature. The alloy amount increases at 530 K; as the temperature rises to 850 K, the alloy amount is decreasing, whereas the amount of $W_2C$ increases. The amount of tungsten carbide increases up to the last temperature 1200 K.

The results are consistent with the analysis of binary systems. In experiments with carbon layers on a beryllium substrate, beryllium diffusion from the interface to the surface is observed.

At 770 K, $Be_2C$ formation is complete. Experiments with beryllium layers of a few nm in thickness on a pyrolytic graphite substrate show island formation at 1070 K. In the ternary system, beginning formation of island-like structures is observed at 1020 K. Experiments with carbon layers on tungsten show C diffusion into the bulk material and $W_2C$ formation starting at 870 K. Alloy formation at room temperature is also observed in the binary system Be/W.

## Migration of Materials in Fusion Devices

### Deuterium Inventory in the All-Tungsten ASDEX Upgrade

In the time period from 1999 to 2007 ASDEX Upgrade was changed from an all-carbon to an all-tungsten device by steadily increasing the area of tungsten plasma-facing components. The walls were cleaned from residual carbon and boron layers prior to the 2007 campaign, and no boronizations were applied during that campaign.
In the carbon-dominated machine deuterium was mainly trapped by co-deposition with carbon (and to a minor extend with boron) on the inner divertor tiles and in remote areas. 3-4 % of the total deuterium input was retained during each campaign. The ICRH antennae protection limiters in the main chamber were identified as main carbon sources: After coating these limiters with tungsten before the 2005/2006 campaign the carbon deposition decreased by a factor of about 4. The still remaining carbon originated mainly from erosion at the outer divertor strike point, which was still made from carbon. Transition to the all-tungsten machine in the campaign 2007 resulted in a further decrease of the carbon deposition by another factor of about 4, see figure 2. The remaining carbon probably originates from chemical erosion by hydrogen or oxygen in tile gaps and at tile back sides. Furthermore, electrical arcs may also play a role.

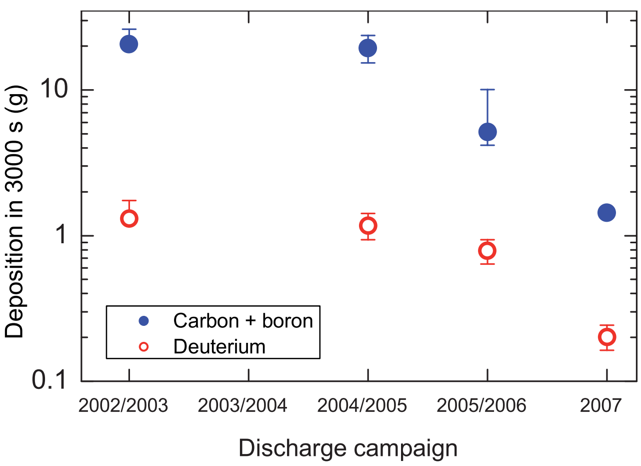



*Figure 2: Deposition of carbon plus boron and deuterium in the divertor and in remote areas of ASDEX Upgrade during different discharge campaigns, as determined by ion beam analysis of removed tiles*

The retained amount of deuterium decreased from about 1.3 g per discharge campaign for the all carbon machine to about 0.2 g in the all-tungsten machine; see figure 2. The latter value corresponds to about 0.4 % of the total deuterium input. This decrease of long-term deuterium retention in the all-tungsten device is due to a transition to a different retention mechanism: In the carbon-dominated machine deuterium retention was governed by co-deposition mainly on the inner divertor tiles. In the all-tungsten machine the inner divertor still shows some co-deposition with remaining carbon, while retention in the outer divertor is mainly determined by deuterium implantation, diffusion and trapping in ion-induced and natural defects in tungsten. The deuterium distribution in the divertor is shown in figure 3.

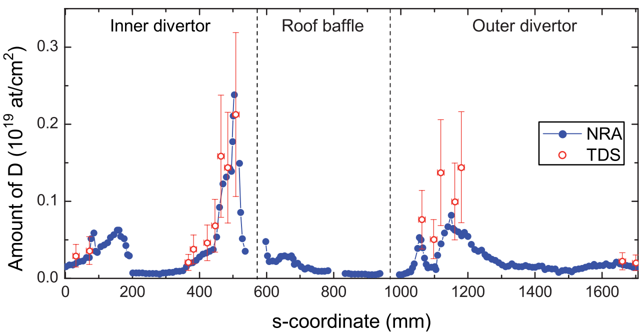



*Figure 3: Deuterium distribution in the all-tungsten divertor of ASDEX Upgrade after the 2007 campaign determined by nuclear reaction analysis (NRA) and by thermal desorption spectroscopy (TDS). With NRA the top 3 µm of the tungsten sample surface can be analysed while TDS measures the total amount.*

While surface analysis provides information about the integrated deuterium retention during whole campaigns, gas balance offers the possibility to measure retained amounts for individual discharges. Semi-detached H-mode scenarios are most relevant for ITER. In ASDEX Upgrade these scenarios require puffing rates of $3\times10^{22}$ at/s, an example is shown in figure 4. At the beginning of the discharge most of the injected gas is retained in the wall, and almost no gas is removed. Although the gas input is kept constant during the plasma flat top phase the amount of removed gas is increasing till 2.9 s. Then a stable phase is reached in which the pumped amount is almost equal to the injected amount (p = p in figure 4). During this phase 1.5 +/- 3.5 % of the injected gas is retained. After the discharge strong outgassing starts and almost all gas puffed during the discharge is recovered within 15 min. Summing up the gas balance till 15 s after a discharge, 2 % of the injected gas is retained for the all-tungsten device, compared to 18 % for the carbon-dominated machine. This relative decrease of retained deuterium found by gas-balance measurements is in good agreement with the results obtained by surface analysis.

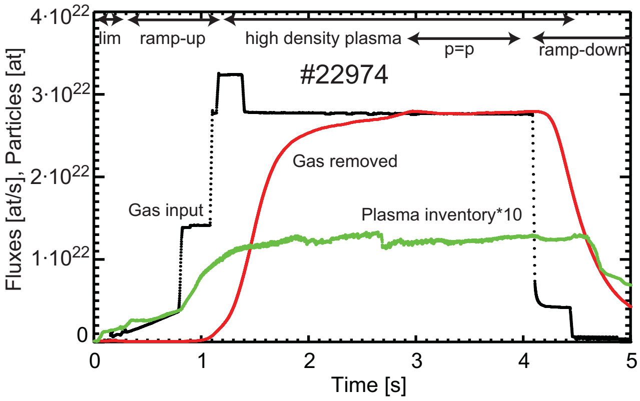



*Figure 4: Gas balance for an individual ASDEX Upgrade discharge*

### $^{13}$C Experiments in AUG

Local transport and redeposition of chemically eroded carbon close to the source location are important processes to evaluate both the dissociation and ionisation of the correspondingly produced hydrocarbon molecules and the screening efficiency of the divertor for the eroded material. These processes were investigated by puffing trace amounts of $^{13}CH_4$ isotopic methane at a target plate of the outer divertor of ASDEX Upgrade and subsequent determination of the $^{13}C$ spatial deposition distribution on the retrieved tile by Nuclear Reaction Analysis. Previous experiments with graphite target plates showed $^{13}C$ redeposition mainly in toroidal direction along magnetic field lines downstream of the puffing valve with an additional poloidal shift attributed to E×B drift, which was confirmed by an additional experiment with reversed B-field in 2008. In contrast to the previous results on graphite target plates, a new, similar, experiment carried out in the full tungsten wall configuration of ASDEX Upgrade showed also significant transport and redeposition of $^{13}C$ towards the upstream direction. Colorimetric analysis of the redeposited layers revealed that deposition occurred mainly at downstream facing slopes of the microscopic surface topology of the W-coated tiles. The observed difference to the previous experiments can be partly attributed to this surface topology feature. Modelling with the ERO Monte-Carlo transport code has also shown that the upstream redeposition fraction is also influenced by the local plasma parameters.

## Tritium Inventory – Understanding and Control

### T Inventory in ITER

In the framework of the EU PWI TF different processes leading to fuel retention in tokamaks, such as co-deposition of tritium with C and Be and retention after implantation and diffusion in C, Be and W, have been investigated and quantified in laboratory experiments. The physical understanding and modelling of the laboratory results allows an extrapolation to tokamak wall conditions which cannot be reproduced in simulation experiments. An extrapolation to tritium retention in ITER was performed by the EU PWI TF on the basis of the analysis of the underlying retention processes and a scaling of plasma conditions in front of the PFCs to ITER. Wall erosion, the initial process leading to co-deposition, was estimated using codes like DIVIMP (wall erosion) and ERO (divertor erosion). Co-deposition with C resulted in the dominating retention process for an all-C machine, limiting the number of discharges to a few hundred before the in-vessel limit of 700 g for tritium is reached. The inventory due to implantation and bulk retention in an all-W device reaches the limit in about 10.000 discharges. Large uncertainties remain due to unknown effects of n-irradiation on the tritium trap concentration in the bulk material at long wall exposure times in ITER. For the initial material choice with CFC as divertor strike point tiles, W divertor and baffle cladding and a Be first wall, co-deposition with Be from the large wall areas contributes about the same amount as co-deposition with carbon eroded in the divertor. Using this material choice in the D/T phase of ITER will require tritium recovery methods about every 500 to 2000 discharges.

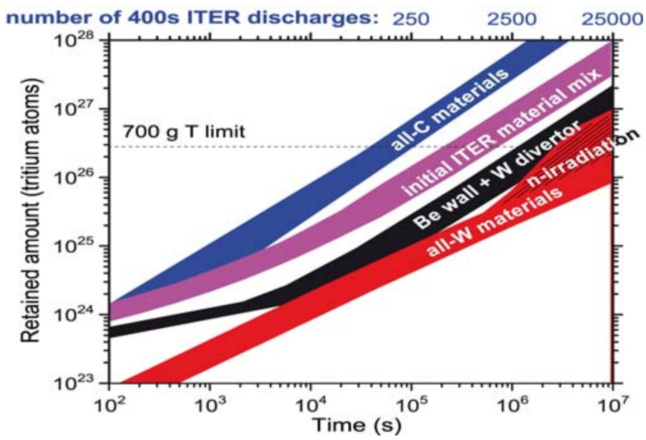



*Figure 5: Tritium inventory in ITER for the all-C (blue line) and all-W (red line) options, the initial material choice (magenta) and a full-W divertor and Be first wall (black line)*

Figure 5 shows the retained amount of tritium as function of operation time of ITER for the different material options. The uncertainties represented by the width of the bands result mainly from the uncertainties in wall and divertor fluxes. Further uncertainties especially in the wall temperatures influencing both co-deposition and implantation retention contribute additional errors.

### Modelling of Deuterium Behaviour in Tungsten and Molybdenum

A model including deuterium implantation, diffusion, trapping and second order desorption was used to understand deuterium inventory and release kinetics in W and Mo. D is trapped in ion-induced and natural traps with trap energies of 0.85±0.05 eV and 1.45±0.05 eV. An additional trap production mechanism for low energy deuterium implantation was developed, where ion-induced traps are produced by the stress field induced by the incident ion flux. The rate of ion-induced defect production depends on the energy of the incident ions, ion flux, target temperature and exposure time.

### Carbon Removal from Tile-gap Structures with Oxygen Glow Discharges

The removal of redeposited carbon layers from ITER-like tile gap structures with oxygen plasmas was investigated in laboratory plasma experiments. As a model system for redeposited carbon layers well characterized, plasma-deposited hard amorphous hydrogenated carbon (a-C:H) thin films were used. Tile gap test structures (TGTS) with variable aspect ratio were exposed at room temperature to low temperature plasmas using pure oxygen as working gas. All relevant surfaces of the TGTS were covered with these a-C:H films. To disentangle the role of reactive neutral species from the role of energetic ions the TGTS were exposed to different low-temperature plasmas. An ion energy of 300 eV was adjusted during the exposure in a capacitively coupled rf plasma, while an ion energy of 15 eV was maintained during the exposure to an electron cyclotron resonance (ECR) plasma. In a third experiment using remote exposure in an ECR plasma only reactive neutrals with low energy hit the surfaces of the TGTS. Erosion of the inner surfaces was measured ex-situ with ellipsometry.

The experiments clearly show that removal of redeposited carbon layers inside the gaps is possible. The total eroded amount integrated over the whole inner gap surface is even larger than the amount that would be eroded on a directly exposed flat witness surface with the size of the gap entrance. However, the local erosion rates inside the TGTS are largely reduced compared to a directly exposed flat witness surface. For all cases investigated, erosion at the side walls of the gaps dominates the total eroded amount. Because side wall erosion decays nearly exponentially with the distance from the top with a decay length comparable to the gap width, film removal deep inside the gaps is inefficient at room temperature. Bottom erosion is largely reduced compared to the flat surface, but increases linearly with gap width. Bottom erosion is only effective when particles with substantial energies hit the surface. If deposition patterns in tile gaps exposed to fusion edge plasmas show similar or faster decay lengths than the erosion patterns then oxygen glow discharge cleaning can be a candidate for tritium removal from carbon containing films in tile gaps of plasma-facing surfaces. Further investigations will focus on the temperature dependence of the erosion rate.

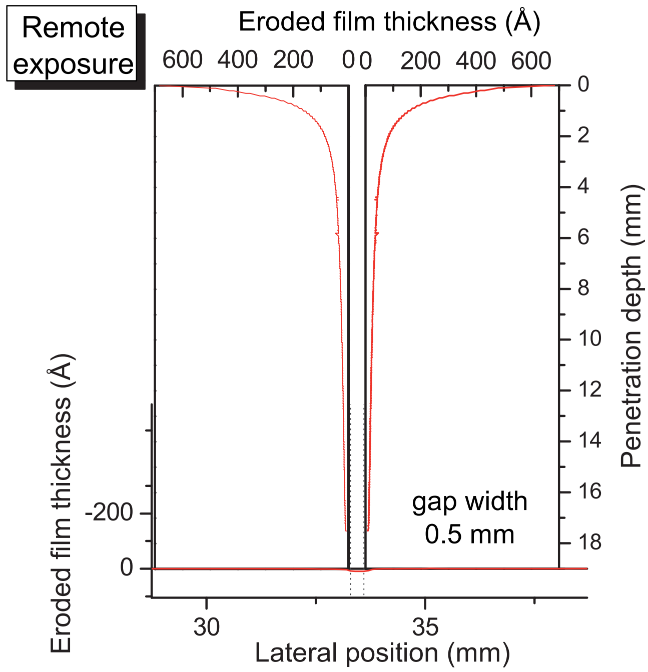



*Figure 6: Measured a-C:H erosion at the bottom and on the side wall of a 0.5 mm wide and 19 mm deep gap exposed remotely to an ECR discharge in oxygen at 1 Pa. The eroded film thickness on the gap sidewalls decreases from about 70 nm at the top to below 1nm at the end. At the bottom of the gap it is about 0.8 nm.*

### Deuterium Inventory in Tore Supra

The Materials Research department is heavily involved in the DITS project (Deuterium Inventory in Tore Supra). In the beginning of 2008 the deuterium inventory and deuterium depth profiles of 46 samples from different areas of Tore Supra limiter tiles were measured by Nuclear Reaction Analysis using the Tandem Accelerator. The data evaluation is ongoing. First analyses show that a substantial amount of deuterium is trapped in co-deposits in tile gaps. In addition, the deuterium inventory was measured by thermal desorption analysis in the TESS device for a selected set of samples.

## Materials – Processing and Characterisation

### Deuterium Retention in W-doped Carbon Films

Fluence dependence measurements on deuterium retention of tungsten-doped carbon films were performed and compared to measurements on pure carbon films and pyrolytic graphite. The total amount of retained deuterium, implanted at ~300 K and 200 eV per D, was obtained by NRA (800 keV $D(^3He,p)^4He$). Implantations were performed at different fluences ($\leq 10^{24}$ $D/m^2$), dopant concentrations (≤15 at%) and pre-annealing temperatures (≤1300 K). The two later parameters influence the structure of the carbon matrix and the formation of tungsten carbide crystallites (see Annual Report 2007).

Pure carbon films show the known slow increase with fluence as pyrolytic graphite. This indicates that the carbon structure does not have influence on the retention. The doped films exhibit a lowering of that increase, which saturates at 7.5 at% W with a maximal reduction of the retained D by a factor of two at a fluence of $10^{24}$ D/m$^2$ compared to pure carbon. Pre-annealing does not show any effects on the retention. In general, doping seems to hinder near-surface implantation and diffusion into the bulk.

### Subsurface Structure of Blisters due to D in W Investigated with New Device HELIOS

In December 2007, a new powerful device combining a high resolution scanning electron microscope (SEM) with a focused ion beam (FIB) as an in-situ cutting tool was installed. In 2008, this commercial device (HELIOS Nanolab 600, FEI) was put into routine operation. It is additionally equipped with X-ray spectrometer (EDX) and electron diffraction detector (EBSD) for analysing the elemental composition and crystallographic orientation, respectively, down to the nanometer level.
The combination of field emission electron gun with Ga ion source allows selecting a special micrometer-sized feature on a sample, investigating its surface topography and analysing its morphology underneath the surface by cross-sectioning it with the FIB. SEM images with up to 1 nm resolution can be obtained. The position of the cut with FIB is controlled with a precision of tens of nanometers. By sequential cutting (FIB) and imaging (SEM), the three-dimensionality of structures can be analysed. Thin lamellas can be prepared to thicknesses below 100 nm with the help of a nanomanipulator. These lamellas are applicable for further studies with transmission electron microscopes (TEM), but they can also be studied in the HELIOS with a STEM-detector (scanning TEM) using 30 keV electrons.
The HELIOS device was already applied to various PSI problems, e.g., inner morphology of dust particles from AUG, nanostructure of coatings for adhesion increase, diffusion barriers, and bonding optimisation (W-Cu, $Er_2O_3$, Ti-TiC), grain growth on nanometer and micrometer scale, and subsurface morphology changes of tungsten by hydrogen exposure. Figure 7 shows SEM images of tungsten loaded at 600 K by a high flux of deuterium ions from a plasma source. The surface with the large W grains and with blisters is nicely visible (figure 7a). The cross-section through the largest blister is given in figure 7b. At 600 K implantation temperature defects, introduced by implanted D, accumulate at the grain boundaries and form cavities easily reaching depths beyond 20 µm, while at lower temperatures they lead to strongly stressed regions (hundreds of cubic microns) and fine cracks inside the crystallites are observed (e.g. at 350 K: width: ~0.1 µm, length: ~5 µm). A correlation between blisters on the surface, the position of defects underneath, and crystallite orientation exists in many cases.

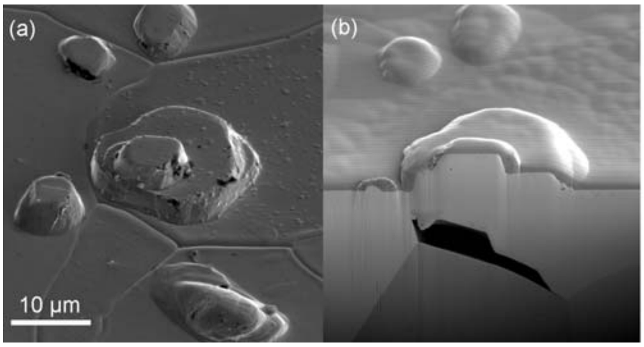



*Figure 7: Polycrystalline tungsten loaded at ~600 K with a flux of $10^{22}$ D/m$^2$s (~40 eV per D) up to a total fluence of $10^{27}$ D/m$^2$. a) Surface topography b) Cross-section of one blister (surface covered with a protection layer). A large cavity is pined at a grain boundary far below the blister.*

### Metal Matrix Composites

The divertor plasma-facing components of future fusion reactors like DEMO, should be able to withstand heat fluxes of 10-20 MW/m² in stationary operation. To increase the strength and reliability of the interface between the W monoblock and the CuCr1Zr tubes, a novel $W_{fiber}$/Cu metal matrix composite (MMC) with improved mechanical performance at high temperatures was developed for operation temperatures up to 550 °C.
Based on the optimization results from lab experiments, a continuously graded W/$Cu_{PVD}$ interlayer on chemically etched fibers plus a subsequent 800 °C heat treatment were chosen to enhance the adhesion between fibre and matrix. The novel advanced $W_{fibre}$/Cu MMC was implemented by hot isostatic pressing and brazing process in monoblock mock-ups reinforcing the interface between the plasma-facing material and the cooling channel. Its suitability as an efficient heat sink material for water-cooled divertors in future fusion reactors was tested in the high heat flux facility GLADIS.
FEM simulations were performed to predict the temperature within the mock-up to understand the thermal behaviour of the component under high heat fluxes. Two optimized mock-ups were investigated: The experimental temperature data and optical investigation of the first mock-up indicated that two of four W tiles were optimally bonded. Their thermal behaviours showed good agreement with the predicted temperatures during the heat flux experiments with increasing power density. At the highest heat flux of 10.5 MW/m$^2$ one of these W tiles remained bonded and showed an optimal stable thermal behaviour. The second mock-up was able to confirm the achieved results of the first mock-up. After additional cycling tests at 10.5 MW/m$^2$ it showed unstable thermal behaviour. The weak point of the monoblock mock-up under heat flux tests was the bonding technology between W and $W_{fibre}$/Cu MMC.

Furthermore, microscopic investigation showed that the implementation of the novel $W_{fibre}$/Cu MMC was successful. The synthesis method can be applied to implement $W_{fibre}$/Cu MMC as reinforcement or eventually as replacement of CuCr1Zr material for the cooling tube. The fibres remained stably embedded in the matrix under high heat fluxes guaranteeing good performance of the whole component.

## Component Behaviour

### Direct-Mapping Finite-Element Simulations

A new advanced simulation procedure has been established in order to better simulate the thermomechanical response of fusion-relevant micro structured materials. This procedure allows 2D FEM simulations on photorealistic cross-sections of a certain solid material and local solution of thermomechanical problems. It requires digital image processing techniques in combination with the OOF2 software[1] for mesh generation and the commercial FEM Solver ABAQUS. The direct mapping (DM) procedure has been extended and applied to vacuum-plasma-sprayed tungsten (VPS-W), a coating candidate for first wall components. VPS-W is a challenging material for micromechanical modelling due to its complex dual-scale morphology. The chosen numerical approach is "high resolution mesoscale direct mapping" where globular pores, interlamellar thin voids and boundary contact zones between lamellae are mapped in the finite element input. Two kinds of simulation were performed to numerically estimate thermal diffusivity: first, simulation of a realistic laser-flash pulse applied to the bottom side with diffusivity derived from the temperature change over time at the top boundary (see figure 8) and second, conventional steady-state analysis, to validate the first method, with fixed boundary temperatures at the top and the bottom side, with diffusivity derived from the average flux across the region.
First results based on a limited set of mapped cross sections are qualitatively matched between the two methods and confirm the dramatic decrease of thermal diffusivity between bulk W and VPS-W.
A computational investigation based on DM-FEM has also been started for W-Cu composites[2], candidate material for the interface zone between plasma-facing tungsten and water-cooled heat sink. First results of compression tests based on thermoelastoplastic model have to be experimentally validated.
Extension of both projects is planned and further investigations are required. These will include influence of local mesh refinement on the numerical results, statistical morphological analysis and 3D simulations based on synchrotron computer tomography data.

[1] *National Institute of Standards and Technology (NIST), USA*
[2] *DFG-Project in cooperation with IFAM-Dresden*

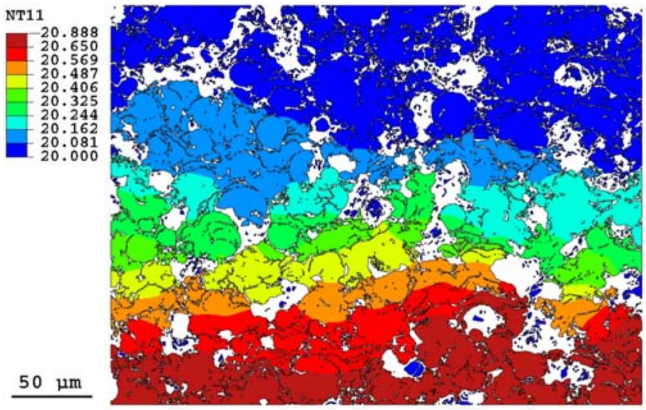



*Figure 8: Temperature field of a simulated laser flash pulse across a mesoscale region of VPS-W at 20 °C taken after 0.10 ms. The region is 230 µm high and 25 % porous (2D-porosity). The colour scale indicates the local temperature in °C.*

### High Heat Flux Test Facility GLADIS

The high heat flux test facility GLADIS offers to test large water-cooled plasma-facing components (PFCs) as well as small samples with heat and particle loads similar to the expected operating conditions in current and future fusion experiments. A newly installed vacuum lock system, designed for water-cooled components up to 600 mm length, reduces the pumping-down time to reach the operational pressure of $<10^{-6}$ mbar from previously required 6 h to 30 min. The major field of activity in 2008 was the extensive testing and investigation of further improved W7-X pre-series target elements. Additionally, GLADIS was strongly involved in the evaluation of the thermo-mechanical behaviour of proposed techniques of W coating on first wall prototypes in the frame of the JET ITER-like Wall Project (see chapter JET Cooperation).
As reported in 2007, the pre-series development of the W7-X divertor targets resulted in a significant higher reliability of the CFC/Cu bonding due to the introduction of the bi-layer technology. In 2008, ten new prototypes, so called pre-series IV, were tested and examined to establish the industrial manufacturing process. The investigation was focussed on the long-term reliability of the CFC /Cu bonding as the most critical issue of the component. In pre-series IV 99.4 % of the CFC tiles remained free of debonding defects after HHF loading of 10 MW/m² for 100 cycles. As the most important result in respect of the expected lifetime, a pre-series IV element survived an extremely extended cycling of 10,000 cycles at 10 MW/m² without failures or CFC delaminations. This number of cycles goes far beyond the previously available data of CFC armoured PFCs.
During operation, thermally induced mechanical stress at the CFC/Cu interface is most important with respect to lifetime predictions of the component. Besides mechanical stress, new chemical compounds formed at the interface by

heat loads can lead to additional stress. In particular, possible carbide formation would change the mechanical properties and enhance the brittleness of the interface. In order to confirm the chemical stability of the Cu interface close to the CFC after long term loading and to improve the understanding of the mechanism of crack propagation, a comparative micro-chemical analysis of the interface was performed. An unloaded sample and samples which received 1,000 and 5,000 pulses, respectively, of 10 MW/m² for 10 s, were micro-chemically investigated. AES analysis and SIMS sputter depth profiles confirmed the chemical composition determined by EDX. The unloaded and the mostly loaded samples were further investigated by XPS. This method can quantify the amount of carbides. Emphasis was placed on TiC and Ti subcarbides, because the presence of titanium is essential in order to generate a carbide layer which can be wetted by copper. Analysis of the intensities in the Ti 2p, C 1s, and Cu 2p binding energy regions resulted in 5-6 at% of carbidic carbon (both TiC and $Ti_xC_y$) in the unloaded sample and ~ 9 at% in the sample after 5,000 cycles. Despite the high number of 5,000 thermal cycles, the carbidic peaks increase only to 9 at%, compared to the 5-6 at% in the unloaded state. These results of the micro-chemical analysis of the CFC/Cu interface confirm the long-term chemical stability of the CFC/Cu bonding.

## Integration of and Collaboration in EU Programs

### EU Task Force on Plasma-Wall Interaction

PWI research in IPP is well embedded in the EU Task Force on Plasma-Wall Interaction which coordinates corresponding research within the European Associations. The leading role of the Project in the PWI TF has continued in 2008. IPP provides the TF leader, the leader of the expert group *High-Z Materials* and contributes strongly to the experts groups *Gas Balance and Fuel Retention*, *Fuel Removal*, *Material Migration* and *Mixed Materials*. Within the EFDA Fusion Programme the Project contributes two mid-size facilities: The High-Heat-Flux Test Facility GLADIS and the Integrated PWI Facility.

### ExtreMat – New Materials for Extreme Environments (an EU Integrated Project in FP 6)

The European research project ExtreMat is coordinated by IPP and brings together 37 European partners from industry, research centres and universities with the aim to develop new materials for very demanding applications. Application fields besides fusion are advanced fission, electronics and space applications, as well as gas turbine compounds, brake systems, X-ray generators etc. as spin-off applications. Common requirements are the basis for the development of self-passivating protection materials, new heat sinks, radiation-resistant materials and of compounds integrating these materials with their favourable properties.
The fourth project year was devoted to the Industrialization phase of the project. In this phase the developed materials and technologies from various partner institutions are combined to mock-ups and test samples which demonstrate the generated added value of the ExtreMat development activities.

### FEMaS – Fusion Energy Materials Science (an EU Coordination Action in FP7)

In October 2008, the Kick-off Meeting for the EU Coordination Action "Fusion Energy Materials Science" initiated the exchange of researchers between 27 fusion research institutes, universities and research centres, including large-scale facilities providing neutron and synchrotron radiation analysis techniques. This project is coordinated by IPP and aims at an accelerated fusion energy materials development by the integration of new partners in the fusion research community.

### Helmholtz-Russia Joint Research Group

The joint research group "Hydrogen Isotopes Retention in First-Wall Materials for ITER and Fusion Power Reactors" comprises scientists from IPP, from Moscow Engineering and Physics Institute (MEPhI), and from Kurchatov Institute (both located in Moscow, Russia). The research group started its work in 2008 and is funded by the Helmholtz Association. The group investigates the accumulation, diffusion and permeation of hydrogen isotopes in plasma-facing materials foreseen for ITER and future fusion power plants in laboratory experiments and by computer simulations.

## Scientific Staff

Ch. Adelhelm, V. Alimov, A. Anghel, K. Bald-Soliman, M. Balden, B. Böswirth, W. Bohmeyer, H. Bolt, J. Boscary, A. Brendel, R. Brüderl, K. Chaoui, T. Chikada, J. Dorner, J. Du, T. Dürbeck, A. Eggeling, K. Ertl, M. Fusseder, Y. Gasparyan, F. Genoese, A. Golczewski, H. Greuner, I. Guridi-Segues, R. Hartwich, Al. Herrmann, Au. Herrmann, C. Höschen, T. Höschen, R. Hoffmann, W. Hohlenburger, A. Holzer, E. Huber, W. Jacob, M. Jungermann, J. Kisslinger, M. Köppen, F. Koch, F. Kost, K. Krieger, R. Lang, C. Lavergne, M. Laux, H. T. Lee, P. Leitenstern, Ch. Lenser, S. Lindig, Ch. Linsmeier, I. López-Galilea, H. Maier, P. N. Maya, G. Matern, P. Matern, M. Mayer, M. Mezger, E. Neitzert, R. Neu, M. Oberkofler, O. Ogorodnikova, V. Paffenholz, T. Pickert, R. Piechoczek, M. Rasinski, M. Reinelt, V. Rohde, M. Roppelt, J. Roth, P. A. Sauter, J. Schäftner, M. Schlüter, K. Schmid, T. Schwarz-Selinger, M. Smirnow, R. Strasser, K. Sugiyama, K. Tichmann, M. Triendl, B. Tyburska, U. von Toussaint, G. Waizmann, A. Weghorn, A. Wiltner, P. Worbs, J.-H. You, A. Zivelonghi.

# Plasma Theory

# Theoretical Plasma Physics

**Head: Prof. Dr. Sibylle Günter**

The project "Theoretical Plasma Physics" is devoted to first-principle based model developments and combines the corresponding efforts of the divisions Tokamak Physics and Stellarator Theory, of the Junior Research Groups "Turbulence in Magnetized Plasmas", "Theory and Ab Initio Simulation of Plasma Turbulence", and "Computational Material Science", and the EURYI Research Group "Zonal Flows". It is headed by one theorist on the board of scientific directors at a time.

## Tokamak Physics Division

**Head: Prof. Dr. Sibylle Günter**

### Tokamak Edge Physics Group

Work in the group continues the balancing act of using existing codes (mainly SOLPS) to understand phenomena in the edge plasma (or to identify discrepancies between code and experiment), and the improvement of the codes.

SOLPS code validation activity was continued by detailed modelling of AUG Ohmic shot #21320, for which both upstream (midplane SOL) and downstream (divertor) good quality data exists, including coverage of strike points by spectroscopic arrays. The tendency of SOLPS to overestimate the divertor density and underestimate its temperature was confirmed. A more realistic model for neutral transport in the vacuum vessel was implemented by using a baffle in the sub-divertor region that enabled the reconstruction of neutral pressures both in the sub-divertor and neutral pumping regions. It was also demonstrated in this modelling that neither neutral pressure in the divertor, nor the location of the plasma particle source (ionization of externally puffed gas, or plasma flux from the core) had a significant impact on the divertor solution, provided the input power into the numerical grid, the electron separatrix density, and the perpendicular transport coefficients were unchanged. This conclusion is important for future modelling activity, as it identifies the main input code parameters that determine the divertor solution.

When exploring edge-core effects in simulations, three approaches have been used: *direct* coupling where a 2D edge code is coupled at a surface (usually the separatrix) to the 1D core code; *mediated* coupling where the 2D results are parameterized in some form and are then used to provide better boundary conditions for the 1D core code; and *avoided* where the 2D edge code is used over the whole domain. This third approach has been used to look at the effects of ELM size on the whole plasma for AUG simulations. One of the key results was that the energy expelled during the ELM was affected by the transport enhancement factor during the ELM event, but that the total energy content of the plasma was most strongly affected by the depth into the plasma of the enhanced transport coefficients.

Further progress was made on the SOLPS 6.0 project aimed at enabling mesh adaptation for the B2 code. A software library was developed that enables efficient handling of unstructured logically rectangular coordinate-mapped meshes, including advanced algorithms for anisotropic mesh refinement and coarsening. The library was applied to B2 grid benchmark cases to study adaptation control criteria and interpolation schemes. An extension to the present B2 finite volume base discretization was developed. The result is a deferred-correction type high-order FVM scheme. Current work concentrates on verifying the new solver and integration into the main B2 code.

SOLPS has been used together with the Monte Carlo module EIRENE to simulate massive gas injection experiments in AUG. The gas valve was treated as a point source. The heat and particle transport coefficients were varied to test their influence on the fuelling efficiency. The dependence of the fuelling efficiency on the amount of injected gas, the gas species and valve position was found to correspond to experimental observations.

In collaboration with LIMHP-CNRS, SOLPS has been modified so that a bundled charge state model can be used. It is now possible to simulate realistically AUG with its full-W wall configuration.

In collaboration with St Petersburg State Polytechnical University, significant improvements to the treatment of drifts in SOLPS were made.

Other edge modelling activities include work on detachment (E2), L-H transition (E2), disruptions (TOK-MHD group).

### MHD Theory Group

#### Heat transport induced by resonant magnetic field perturbations (RMPs)

Numerical studies of heat diffusion induced by RMPs were extended to realistic toroidal geometry. Both, plasma core and boundary can be investigated at realistic parameters using unsheared helical flux-coordinate systems not fully aligned to the magnetic field. Magnetic islands, ergodic layers and an ergodic edge were examined. In particular, a possible explanation for the fast amplitude drop of neoclassical tearing modes in the frequently interrupted regime (FIR-NTMs) has been given. A 3/2 NTM and an additional 4/3 perturbation were studied. At realistic values of the heat diffusion anisotropy ($\chi \geq 10^9$), already for a moderate ergodization of the NTM (Chirikov parameter $\sigma_{Ch} \geq 1.5$), the resonant bootstrap current perturbation of the 3/2 island vanishes almost completely. Assuming the 4/3 perturbation originates from a fast growing ideal mode, the drop of the island drive is on the time scale of parallel heat transport reducing the island width abruptly as experimentally observed.

#### Resistive Wall Mode (RWM) Studies

The ITER Scenario 4 equilibrium has been modified to increase the bootstrap current fraction and to improve its stability properties with respect to external kink modes. For this equilibrium, a theoretical no wall $\beta$-limit of $\beta_N \approx 2.55$

and ideal wall limit of $\beta_N \approx 4.2$ could be achieved. Resistive walls reduce the growth rates of external kink modes by orders of magnitude such that active feedback stabilization of resistive wall modes (RWMs) becomes technologically feasible. Given a set of sensors and control coils, the coils have to be connected to the sensors by means of some feedback logics or controller.

A novel model reduction technique has been developed which is employed to truncate state space models of the RWM feedback control system as obtained from the STARWALL code. The reduced models are used by the OPTIM code for controller optimization. The reduction technique is based on orthogonal projections and dramatically increases both accuracy and smallness of the models. The speed of the controller optimization computations has been increased by orders of magnitude. Using two resistive walls with holes and port plug extensions and these novel controller optimization computations, feedback stabilization of the modified ITER scenario 4 could be achieved up to $\beta_N \approx 4$.

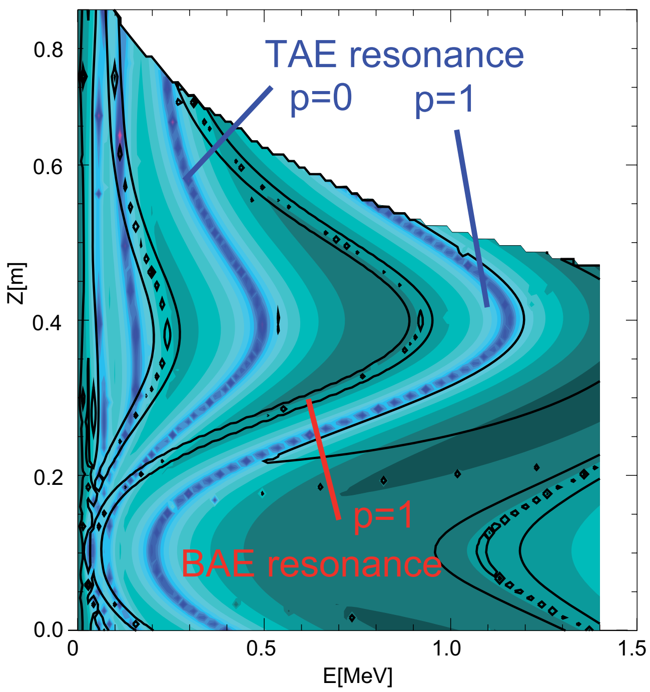



*Figure 1: The resonance condition $\omega$-$\omega_{prec}$-$p\omega_b$ for a BAE and a n=4 TAE. The BAE transports resonant particles (p=1) radially outwards (arrow) and enhances the amplitude of the TAE mode via the p=0 resonance.*

## Fast particle losses in ITER

In addition to the magnetic field ripple in tokamaks field perturbations caused by magnetic islands and perturbation fields can cause losses of fast ions. To study these effects we have followed 3.5 MeV $\alpha$ particles and 1 MeV deuterons in the ITER equilibrium Scenario 2, investigating the combined effect of field ripple, perturbation field caused by a (2,1) neoclassical tearing mode, and the perturbation field produced by ELM control coils. A considerable synergistic effect of NTM perturbation and ELM control fields has been found. Both fields together lead to an enhanced loss of passing particles, while the loss of trapped particles is predominantly caused by the field ripple and therefore strongly reduced by the ferritic inserts.

## Kinetic MHD and Fast Particle Physics

Via the inclusion of core ion compressibility in the linear gyrokinetic model underlying the LIGKA code, it was shown analytically that the relevant limits of the kinetic ballooning theory can be recovered. This allowed studying the dispersion relation of the BAE/KBM branch and comparing with the experimentally measured mode properties: the evolution of an intermediate frequency (~80 kHz) fast particle driven mode at ASDEX Upgrade could be explained by the kinetic BAE dispersion relation that takes diamagnetic effects into account.

From experimental measurements with the fast ion loss detector (FILD) it was concluded, that the presence of this BAE mode significantly enhances the fast ion losses due to the n=3-7 TAE modes. Using the drift-kinetic HAGIS code, the resonance conditions of both BAE and TAEs with the ICRH-generated energetic ion population were investigated. As shown in figure 1 the ions fulfilling the BAE resonance condition are transported radially outwards, providing an additional drive for the TAE. This 'channelling' effect is presently investigated quantitatively, relying also on a direct comparison of the FILD signal to the results of an extended HAGIS version including the vacuum region and gyro-orbit effects.

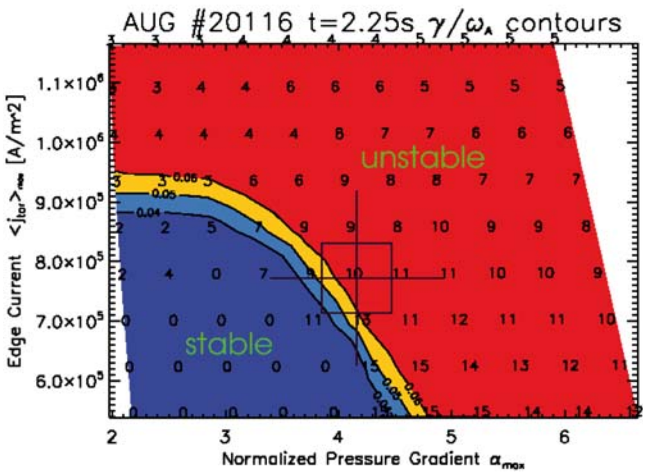



*Figure 2: First j-$\alpha$-diagram for ASDEX Upgrade showing stable and unstable regions (threshold $\gamma/\omega_A > 0.05$ with growth rate $\gamma$ and Alfvén frequency $\omega_A$) together with toroidal mode number of fastest growing modes and operational point of the experiment (cross and error bars).*

### Linear MHD Stability Analysis

The fixed boundary equilibrium code HELENA has been modified to solve the Grad-Shafranov equation for any two of the following three source functions: the pressure derivative p', the derivative of the diamagnetic function FF', and the flux surface averaged toroidal current density $\langle j_{tor} \rangle$. With these changes, pedestal height and edge current modifications of experimental reference equilibria are now possible while maintaining the total thermal energy $W_{MHD}$ and the total current $I_p$ of the plasma.

With this new feature the first j-$\alpha$ diagram (figure 2) for ASDEX Upgrade for an ELMy H-mode discharge just before the onset of the ELM has been calculated using the linear MHD stability code ILSA. The experimental reference point lies just outside the stability boundary with a toroidal mode number that is in agreement with the peeling-ballooning model for ELMs.

A comparative stability analysis between ASDEX Upgrade and DIII-D is being carried out for a series of similarity shots.

### Stability Analysis of Vertical Displacement Events

A linear ideal MHD code has been developed to calculate the stability of axisymmetric modes in the vicinity of an ideally conducting wall and passive stabilizing loops (PSL), allowing non-rigid displacements of the plasma column. A strong dependence on the X-point and the resistivity of both plasma and conductors has been found.

A new non-linear, higher order finite element code has been designed that includes resistivity of the plasma and the conductors (PSL). It will be further developed for simulation of the time evolution of stable and unstable plasmas on resistive time scales.

### Non-linear MHD Studies

The effect of a resonant helical field perturbation on plasma rotation was investigated based on two-fluid equations. It was found in agreement with experimental results that: (a) For a small field amplitude the rotation is sped up by a static helical field if the original rotation is in the ion diamagnetic drift direction with a frequency smaller than the electron drift frequency, but it is slowed down otherwise. (b) For sufficiently large field amplitude, the absolute value of the plasma rotation frequency approaches the electron diamagnetic drift frequency but rotation is in the ion drift direction. As the diamagnetic drift velocity is very large in the pedestal region of H-mode plasmas, a local fast plasma rotation could be generated by a static helical field of appropriate amplitude.

## Transport Analysis Group

Previous investigations on particle and impurity transport in the core have been extended to the non-linear regime, addressing specifically the problem of the transport of energetic $\alpha$ particles and He ash produced by electrostatic turbulence in ITER relevant conditions. Three gyrokinetic codes have been used: GYRO, GS2, and the recently developed GKW. In the new non-linear gyrokinetic simulations, the convective part of impurity fluxes is typically directed inwards for ion heat fluxes which exceed or are equal to the electron heat flux, but can reverse direction if the electron heat flux significantly exceeds the ion heat flux. The electrostatic turbulent transport of energetic $\alpha$ particles was computed with both linear and non-linear gyrokinetic simulations and with both Maxwellian and slowing down unperturbed distribution functions. It was found to be negligible in ITER transport modelling. Deviations from the linear results produced by non-linear decorrelation mechanisms in fast particle transport are found to be negligible for particle transport, while they are sizable for energy transport. Energy transport remains, however, one order of magnitude smaller than particle transport. In addition, the transport of He ash was investigated, and found to have a convective particle flux directed inwards for plasma conditions as those expected in the ITER standard scenario. ITER transport modelling with ASTRA and GLF23, where the transport of minority species is included by means of formulae which fit the gyrokinetic results, show that He ash diffusivity is large enough to avoid strong accumulation despite the presence of the central He particle source produced by $\alpha$ slowing down. The He density profile is predicted to be close to that of the electron density for expected values of the He concentration.

Non-linear gyrokinetic simulations of core turbulence with GYRO reveal a complex dependence of the electron particle flux as a function of the turbulent spatial scale and of the velocity space as the collisionality is increased. At experimental values of the collisionality, the particle flux is close to zero, in agreement with the experiment, due to the balance between inward and outward contributions at small and large scales respectively. These simulations provide full support in terms of fundamental kinetic theory to the prediction of a peaked density profile in the ITER standard scenario, previously based only on empirical scalings and simplified theoretical models.

## Kinetic Theory and Wave Physics Group

The FELHS code has been extended to calculate coupling and spectrum of multi-junction launchers in the LH frequency range. Applying the Mode-Matching method, a new module exactly calculates, in the limit of launcher geometry with sharp edges, the reflection and transmission coefficients at the discontinuities along the launcher, up to the matching with the plasma scattering matrix.

A feasibility study of an Electron Bernstein current drive system for RFX-mod has been carried out employing a 2D full-wave solver for the calculation of the OX mode-conversion efficiency. For a realistic RFX-mod setup, a transmission coefficient of approximately 55 % can be achieved.

The TORIC full-wave code has been extended to non-Maxwellian distribution functions to consistently take into account the effects of ICRH and NBI heating on the propagation and absorption of IC waves. A study has been performed to verify the applicability of the paraxial WKB technique under critical conditions. Exact solutions of a scalar wave equation, used as a benchmark, have been obtained in planar models which mimic the cases of Doppler reflectometry and oblique injection onto the resonance. It is found that the pWKB method is applicable with a large margin, thus confirming that the beam-tracing code TORBEAM can be safely used for interpretation and prediction of experiments. The parallel current in small rotating magnetic islands has been studied including the contributions of electrons and ions, as well as the electric field associated with island rotation. Numerical simulations show that the size of the bootstrap current in small islands depends strongly on its rotation frequency: If the island is rotating at the ion diamagnetic frequency the current is very small while in the case of rotation at the electron diamagnetic frequency a large fraction of the unperturbed bootstrap current is preserved.

In an analytic drift-kinetic treatment, the range of frequencies has been extended down to the precession frequency of trapped ions. The calculations, based on a double parameter expansion, show that a current due to the change of the precessional motion induced by the island potential can compete with the standard polarization current if the island rotation frequency is comparable or below the diamagnetic frequency.

The influence of a magnetic island on the behaviour of turbulence in a tokamak is investigated employing global gyrokinetic PIC simulations. Low mode numbers in the energy spectrum of the potential disturbances, corresponding to the MHD perturbation, are amplified by non-linear coupling to the microinstabilities and influence the transport properties in the vicinity of the island.

### Development of Mathematical Tools

Finite difference schemes lose accuracy when free boundaries cross over rectangular spatial grids. In previous work for a class of second order elliptic equations, the leading error term at such a boundary was eliminated by a simple correction strategy. This correction strategy works in any number of space dimensions and offers an alternative to (more costly and complicated) adaptive grid techniques. This correction strategy was revisited. A generalization to parabolic equations with moving boundaries (and arbitrary number of spatial dimensions) is under investigation.

### Turbulence Theory Group

We continue to study low frequency fluid like drift turbulence employing gyrofluid models extended to capture important kinetic effects such as Landau damping and finite gyroradius (FLR), as well as gyrokinetic models, treating all phenomena at the scales of interest (1 mm to 10 cm, 10 kHz to 1 MHz). Both types of model have been recast for greater accuracy within a wider set of parameter regimes. The gyrofluid model GEM and the gyrokinetic model FEFI treat equilibrium and turbulence phenomena together at all collisional regimes, intended primarily for the tokamak edge. The gyrokinetic particle in cell (PIC) code ORB5 treats global core turbulence and will become electromagnetic in 2009.

### Gyrokinetic/Gyrofluid Studies of Core Turbulence

Themostatting, a method for providing small scale dissipation in PIC models first proposed by Krommes in a series of papers a decade ago, was implemented into the ORB5 code via collaboration between IPP Garching and CRPP Lausanne. For the first time, the thermal flux due to small scale turbulence was thereby found to saturate for indefinite time regardless of system size above the threshold where gyro-Bohm convergence is found (i.e., the flux scales as the square of the gyroradius to minor radius ratio $\rho_*$). The flux does not decay sharply with time as was previously found. Diagnostics for measuring particle noise in ORB5 show that the noise also saturates, which was not found before. The noise remains at low levels provided the resolution is adequate. The results on global ion temperature gradient driven (ITG) turbulence are now qualitatively the same as those found in grid-based gyrofluid or gyrokinetic models: saturation is at robust flux level along with both gradient drive and subgrid turbulence dissipation rates. The control variate techniques for solving the gyrokinetic Ampère's law developed in Greifswald have been incorporated into ORB5 and initial electromagnetic tests are now in progress.

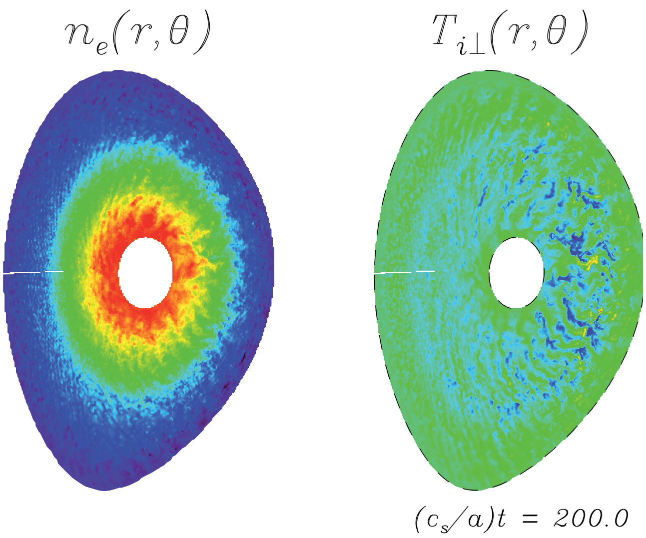



*Figure 3: Colour contours of the electron density (left) and of fluctuations in the ion temperature (right) in the poloidal plane. Most of the fluctuation activity is on the outboard midplane side (to the right).*

Global electromagnetic computations of ITG/Alfvén turbulence were run using GEM for shaped tokamak geometry using the HELENA equilibrium code (see figure 3). The rotation remains to be determined by the equilibrium forcing mechanisms and not by the turbulence. A large series of parameter scans (various gradients, plasma beta, and magnetic shear) were done. As long as the dynamics is driven dominantly by the ion temperature gradient the results are close to the gyrokinetic ones. Strong stabilisation with beta is found; dynamically this is due to the increasing role of magnetic induction in determining the fluctuations of parallel current. The low transport results found in experiments are at least partially explained by this effect. A study of self consistent dynamics of electromagnetic turbulence and magnetic islands was begun. Control cases with cylindrical geometry showed the model able to treat tearing mode islands well into the non-linear regime. In tokamak geometry the toroidal effects are stabilising to the island. The tendency of the island to flatten gradients is largely confined to the electrons, so any application of such studies to experiments must keep the ion temperature dynamics. At the same time the radial resolution must reach the collision skin depth scale, so the model must work for arbitrary ion gyroradii, as the GEM model does.

### Gyrofluid/Gyrokinetic Studies of Edge Turbulence

A large series of edge turbulence parameter scalings was run with the fluxtube delta-f gyrokinetic model delta-FEFI. Energetic diagnostics which are routinely done in GEM were incorporated into delta-FEFI, and the resulting consistency checks showed that more resolution is needed in velocity space than is typically kept, particularly in the magnetic moment coordinate. The energy conservation is now as sound as that in GEM. The current status is that the results of delta-FEFI and GEM agree qualitatively, with the transport somewhat enhanced by trapped electron effects at values of beta lower than the experimental ones. No major surprises due to kinetic effects are indicated, once the energetic consistency checks are passed.
The FEFI code was developed with the ultimate goal of simulating the tokamak pedestal. This is a fully non-linear total-f electromagnetic gyrokinetic model. The global geodesic Alfvén oscillation was demonstrated and turbulent cases were obtained. Before direct pedestal simulation is possible, the velocity space grid will have to be stretched to follow strong spatial temperature contrast.
The mathematics of X-point geometry was revisited to derive an analytical model for fluxtube gyrofluid simulations. A high resolution study of the competition between drift wave and interchange physics in edge turbulence was done in such shaped tokamak geometry. In agreement with previous studies, the main effect is to make the parallel gradient terms proportionally stronger in the equations, resulting in a higher threshold for resistive ballooning in collisionality than previously found. The tokamak edge is in the drift wave regime according to electron dynamics. This becomes qualitatively ITG-like with a strong Alfvén component as the ion temperature becomes the strongest player for realistic gradient scale ratios.
An effort to derive new coordinate systems which retain the necessary properties for edge turbulence computations while also allowing the treatment of flux surfaces arbitrarily close to the X-point was continued.

### Fundamental Theory

The origins of the total-f gyrokinetic model as a Lagrangian field theory were re-examined with a new ordering valid for E×B flows with similar energy density as the thermal plasma. The choice of Lie transform was done differently than usual, to end with all terms involving time-dependent potentials in the Hamiltonian such that only the main time derivative of the gyrocenter distribution function appears in its phase space equation. This makes the theory more suitable for computation than previous strong flow models, making the basis for the FEFI code.

### JET

A possible cause for discrepancies between experimental results and 2D edge fluid code predictions is the role of turbulence which is ignored in today's 2D fluid codes. This was investigated using the output of the turbulence code ESEL for electron temperature fluctuations in the SOL of JET. It was concluded that time-averaged plasma parameters invoked from experimental measurements can be used to set up cases for the fluid codes, and that the omission of turbulence is not a critical drawback of the codes, as far as time-averaged parameters (e.g. ne, Te, heat fluxes) are of interest.
Work has started on the simulation of the thermal quench phase of JET shot #73122, which was part of an experimental session to study power deposition on PFCs during disruptions at JET, using the B2 SOLPS suite of codes.
Work continued on the edge code-code benchmark concentrating on cases with drifts and for the general support of edge modeling at JET.
For the vertical divertor target configuration at JET, with increasing line averaged density and forward field an increasing asymmetry of the peak ion flux density is observed between the inner and outer targets. Using a well diagnosed L-mode discharge at JET the connection between enhanced radial transport and detachment at the inner and outer divertor targets is studied as a function of line averaged density. Various transport models have been implemented with promising results.

### EFDA Task Force on Integrated Tokamak Modelling (ITM)

Among the contributions to the EFDA Task Force on Integrated Tokamak Modelling are: providing Project Leaders for IMP3 and IMP4 and the Deputy Project leader for IMP1; porting of the ITM-FLUSH Library to the EFDA Gateway Cluster; development of an interface for ITM codes to Atomic, Molecular, Nuclear and Surface (AMNS) data; upgrading the CLISTE equilibrium code to fortran 90; benchmarking of turbulence codes.

### EFDA Goal Oriented Training in Theory (GOTiT)

IPP is the coordinator of the EFDA GOTiT programme which aims to "train modellers (amongst others) to the most recent mathematical and numerical methods and best practice in the use of high performance computers as well as to the state-of-the-art theoretical models developed and applied by the fusion community". The programme has three legs: a number of "trainees" which will be hired by the 6 participating Associations; a series of High Level Courses (the first of which was a two week course on gyrokinetics held at IPP with Bruce Scott); and a montly e-seminar series.

### EU FOR Iter Applications (EUFORIA)

IPP is a member of the EUFORIA project funded under the 7th Framework Programme of the Commission. IPP is playing a major role in the management of the project and in the development of fusion relevant workflows based on Kepler, GRID, and HPC technologies.

## Scientific Staff

C. Angioni, A. Bergmann, V. Belmondo, R. Bilato, A. Bottino, T. Breu, M. Brüdgam, A. Chankin, D. Coster, A. Dodhy-Würsching, S. Gori, S. Günter, T. Hein, M. Hölzl, O. Kardaun, H.-J. Klingshirn, C. Konz, K. Lackner, P. Lauber, P. Martin, P. Merkel, R. Meyer-Spasche, G. Pautasso, G. Pereverzev, E. Poli, T. Ribeiro, W. Schneider, E. Schwarz, B. Scott, M. Sempf, M. Siccinio, H. Siddiqui, G. Stromayer, E. Strumberger, C. Tichmann, C. Wigger, Q. Yu, R. Zille

## Guests

D. Apostolaki, Univ. of Ioannina, GR; C. V. Atanasiu, Inst. of Atomic Physics, Bukarest, RO; D. Curran, Univ. College, Cork, IR; W. Hornsby, Univ. of Warwick, UK; O. Maj, Univ. of Pavia, IT; P. McCarthy, Univ. College, Cork, IR; N. Miyato, JAEA Naka, JP; V. Rozhansky, Techn. Univ., St. Petersburg, RU; G. Sias, RFX Consorzio, IT; G. N. Throumoulopoulos, Univ. of Ioannina, GR; S. Voskoboynikov, Techn. Univ., St. Petersburg, RU; H. Weitzner, Courant Inst., New York, USA.

## Stellarator Theory Division

**Head: Prof. Dr. Per Helander**

### Ideal MHD

In its version as a perturbed equilibrium code, the ideal MHD stability code CAS3D was successfully benchmarked vs. the PIES code by application to a finite plasma-beta W7-X configuration. While PIES non-linearly treats the full magnetic field structure with islands and ergodic regions, the linear CAS3D code perturbatively determines surface currents and from them the respective island widths for VMEC equilibria which nested surfaces are a priori assumed in. A further benchmark vs. the IPEC code, which treats perturbed tokamak equilibria, confirmed CAS3D as a perturbed equilibrium code. Within the collaboration with ANU, CAS3D was used in its version as a stability code to study low shear H1 equilibria with respect to GAEs.

### Global Particle-in-Cell Simulations of Alfvénic Modes

Global linear gyrokinetic particle-in-cell simulations of Alfvénic modes in pinch and tokamak geometries have been performed using the code GYGLES. Global Alfvén Eigenmodes (GAE), Mirror Alfvén Eigenmodes (MAE), Toroidal Alfvén Eigenmodes (TAE) and Kinetic Ballooning Modes (KBM) have been simulated. Also, fast particle destabilization of the TAE modes has been studied as well as their modification to Energetic Particle Modes. Extension of these simulations to non-linear and non-axisymmetric regimes (stellarator geometry) is planned using the code EUTERPE. The associated physics is important because these instabilities can lead to a significant loss of fast particles in a fusion reactor. Another application for these modes is the so-called MHD spectroscopy, where basic properties of the magnetic equilibrium (such as the safety factor profile) can be diagnosed by measuring the Alfvénic activity.

### Kinetic MHD

Efforts have been made to better understand which modes will be most susceptible to fast particle driven instabilities in W7-X. Within a local perturbative theory, it has been found that modes at low frequencies and open gaps are most likely to be destabilized. For W7-X these are TAE and HAE {5,-1} modes. To improve the calculation of growth rates, a collaboration with D. Spong (ORNL) has begun. A perturbative calculation of the growth rate shall be done using a PIC method to overcome restrictions with respect to the radial orbit width which are inherent to CAS3D-K. Meanwhile, the CKA code has been re-organized such that it is now possible to calculate kinetic Alfvén waves. The results will be benchmarked with the LIGKA code from the Tokamak Theory Division.

### Beta-induced Alfvén Acoustic Eigenmodes (BAAEs) in toroidal plasmas with low beta

Alfvénic oscillations in the lowest part of the Alfvénic spectrum in toroidal devices can couple to acoustic branches. This leads to the emergence of BAAEs, which have recently been discovered for tokamak geometry, both experimentally and theoretically. BAAEs can be easily destabilized by the energetic particle drive and usually lead to undesired fast particle losses. An analysis employing a reduced ideal MHD framework for general toroidal plasmas determines conditions for such modes to arise. One such condition is that the BAAEs reside close to the extrema of the modified Alfvén-acoustic continua. Numerical solutions of the reduced ideal MHD equations show that, although the BAAEs are often subject to resonances with the acoustic and Alfvén-acoustic continua resulting in the continuum damping, the latter turns out to be relatively small because the mode eigenfunctions are small in the resonant regions. Inclusion of the parallel electric field to resolve the singularities, caused by the continuum interaction in MHD, demonstrates that in the kinetic picture the eigenfunctions of the least damped modes are close to the BAAEs predicted in the MHD analysis. The analysis developed in the work predicts a BAAE at the same frequency as an observed (and previously unexplained) unstable mode in the HSX quasi-helical stellarator. BAAEs are generic in toroidal plasmas and could be important in W7-X.

### Monte Carlo Code Development

A new code for the Monte Carlo simulation of particle orbits in general magnetic fields has been developed. The primary purpose of the code is to calculate the heat load on the inner vessel of W-7X from lost neutral beam injected particles. Further applications include the effects from $\alpha$ particles and ion cyclotron resonance heating, as well as comparisons with existing $\delta f$ codes.

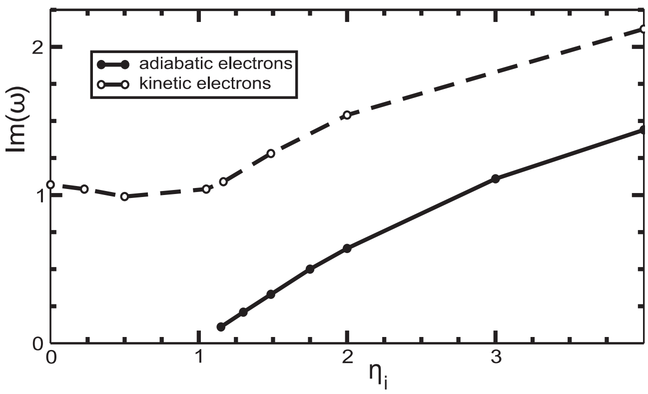



*Figure 4: Comparison of ITG growth rates with and without kinetic electrons*

### Gyrokinetic Particle-in-Cell Simulations

The global 3D gyrokinetic PIC code EUTERPE has been extended by including multiple gyrokinetic species in collaboration with the Garching computing centre RZG. The extension allows including electron dynamics, fast particles and impurity ions and is also a prerequisite for a further extension towards solving the electromagnetic gyrokinetic equation. Simulations are thus no longer restricted to the assumption of adiabatic electrons. Trapped electron modes and the influence of kinetic electrons on ion temperature gradient modes can be studied. The latter is illustrated in figure 4, which shows the growth rates of an ITG instability in an $A$=3 tokamak (no electron temperature gradient, fixed density profile) with and without kinetic electrons. To provide accurate and reliable input data for the simulations, a new mapping program has been developed. EUTERPE uses a magnetic coordinate system (PEST coordinates) for solving the field equation. Thus the result of an equilibrium VMEC calculation has to be transformed to these magnetic coordinates. Since the results of VMEC can be erratic near the magnetic axis (which can be detrimental for the particle orbits there) the accuracy is improved by fitting only a minimum set of quantities taken from VMEC with a highly flexible smoothing spline before consistently calculating all the other required data. Collisions have been added to EUTERPE by using a two-weight scheme. This has been implemented into the code together with a Monte Carlo realisation of the collision operator (pitch angle scattering).

### Benchmark of Gyrokinetic Codes

In the context of linear gyrokinetic simulations, an analysis of the application of field aligned coordinate systems generated numerically from magnetohydrodynamic equilibria has been carried out. Gyrokinetic solvers often differ in the choice of coordinates. The proper transformations were therefore demonstrated to compare physics results, and benchmarks of a linear ITG microinstability were performed between the gyrokinetic codes GENE and GS2 for a realistic DIII-D equilibrium. Effort was also put on the verification of the special properties of the generated coordinate systems through certain diagnostics. A similar benchmark will be done in the context of stellarators, also including the flux tube gyrokinetic code GKV which is maintained at NIFS.

### Bootstrap Current in Optimised Stellarators

It is the aim of stellarator optimisation to reduce the so-called “neoclassical” transport arising from incompletely confined orbits as much as possible. In the limit of perfect optimisation, where all particle orbits return to their original flux surfaces, the kinetic equation governing neoclassical phenomena is remarkably similar to that in tokamaks. In devices where trapped particles undergo poloidal precession, the neoclassical distribution function consists of two parts: one that can be calculated exactly (for any collision operator) and does not carry any net parallel current, and one that is proportional to the total toroidal current and is determined by an equation that is identical to that solved in tokamak theory. Results from the latter can therefore be carried over to the corresponding stellarator situation. Specifically, if the total toroidal current enclosed by a flux surface vanishes, then the net bootstrap current on that surface also vanishes. It is therefore consistent to optimise a stellarator in such a way that the bootstrap current and neoclassical transport are simultaneously minimised, as has been done for Wendelstein 7-X.

### Intrinsic Ambipolarity in Stellarators

An important characteristic of a magnetically confined plasma is whether it is able to rotate. It is well known that an axisymmetric tokamak plasma can rotate (almost) freely in the toroidal direction, but poloidal rotation turns out to be inhibited. This is because poloidal rotation is damped by ion collisions through parallel viscosity on the collision time scale, while toroidal rotation is damped only by cross-field viscosity. The latter operates on the confinement time scale and is typically at least two orders of magnitude longer than the collision time. The fact that collisions do not lead to rapid damping of toroidal rotation is expressed by the statement that "neoclassical transport is intrinsically ambipolar". This means that the radial current vanishes in leading order and is independent of the radial electric field. The latter can therefore assume any value, which means that the plasma can rotate at any speed. It is not obvious a priori what the corresponding situation should be in a stellarator, but it has now been established that the *only* magnetic configurations where intrinsic ambipolarity holds are perfectly quasisymmetric ones. In other configurations, the cross-field transport rates of ions and electrons are unequal unless the electric field is fixed at a certain value. The rotation is thus clamped at the corresponding speed, at least on time scales longer than the ion collision time. In fact, both its direction and magnitude are fixed, and are unlikely to be affected by turbulence. On a radial average taken over many gyroradii, the Reynolds stress from standard (electrostatic) gyrokinetic turbulence is too weak to significantly influence the radial electric field. Only if the level of turbulent transport is much higher than implied by the standard gyrokinetic orderings the Reynolds stress is of significance, unless the magnetic field is quasisymmetric. On the other hand, in a quasisymmetric field no amount of turbulence can produce parallel viscous damping of plasma rotation in leading order.

### Zonal Flow Damping in Tokamaks

In tokamaks, collisional damping might be one of the relevant damping mechanisms for zonal flows. The effect of impurity ions, which tend to be more collisional than the bulk ions, on the damping time was studied and found to be enhanced by slightly more than a factor $Z_{eff}$. The results were compared with simulation results of the NEO code and found to be in good agreement within the area of validity of the theory.

### International Collaboration on Neoclassical Transport in Stellarators (ICNTS)

Benchmarking of the three „mono-energetic" neoclassical transport coefficients has been concluded for the thirteen magnetic configurations considered within the ICNTS. This includes results from recently developed numerical methods which calculate the coefficients associated with the bootstrap current and parallel conductivity. With the benchmarking of mono-energetic transport coefficients completed, the emphasis of the ICNTS is now placed on developing the theoretical and numerical tools required for practical application of the results.

### Momentum Conservation

Methods have been developed to redress the neglect of momentum conservation in solutions of the kinetic equation which simplify the linearised collision operator by assuming only pitch angle scattering. The importance of parallel momentum conservation is well known in calculations of the electric conductivity and is commonly treated by introducing the so-called Spitzer function. A generalization of this approach has been developed with exact collisional and collisionless limits. It makes use of the mono-energetic results at finite collisionality to model the fraction of trapped particles. A similar formalism can be employed to determine the bootstrap current. Results from these calculations have been successfully benchmarked with those obtained using a generalized "momentum correction" technique, the implementation of which is especially attractive for a 1D transport code as parallel momentum conservation is recovered by solving a small system of linear equations in which the parallel flows of all particle species are properly coupled by means of expressions which may be easily determined from the mono-energetic transport coefficients.

### Advanced Current Drive Calculations

A new model for electron cyclotron current drive calculations which conserves parallel momentum has been implemented in the ray-tracing code TRAVIS. A generalized formulation based on the non-relativistic solution of the mono-energetic drift-kinetic equation allows for arbitrary collisionalities and recovers known analytical results in both the collisional and the collisionless limits. This approach is fruitful and indeed necessary for current drive calculations in plasmas with moderate electron temperatures, $T_e/m_e c^2$<0.01. The integral weight of the collisional effects strongly depends on the specific ECRH scenario and magnetic configuration, and in the case when only bulk electrons ($\upsilon/\upsilon_{th}$<1) are involved in the cyclotron interaction, the collisional effects can contribute up to 20 % to the current drive. For current drive calculations in plasmas with higher temperatures, the Spitzer problem must be solved with relativistic effects taken into account, which are especially important for scenarios when supra-thermal electrons ($\upsilon/\upsilon_{th}$>2) are responsible for the current drive. A weakly relativistic extension of the variational principle for the collisionless Spitzer problem, appropriate up to $T_e/m_e c^2<0.05$, has been derived, and a numerical fit has been constructed that approximates the exact solution quite accurately in the range $\upsilon/\upsilon_h<4$, which covers completely the relevant range for electron cyclotron interaction.

### Predictive Transport Modelling

Improved kinetic models with momentum conservation included in the collision operator and a generalized formulation of the trapped particle fraction have been added to the transport code. Using these improvements, predictive transport modelling of electron cyclotron resonance (ECR) heated plasmas in W7-X has been carried out and the bootstrap current has been calculated. The ion and electron energy balance equations, with neoclassical fluxes, are solved self-consistently with the equation for the ambipolar radial electric field. Anomalous contributions to the heat fluxes are also included but dominate only at outer radii where the neoclassical fluxes are small due to the low temperature. The assumption of mainly neoclassical transport leads to an upper limit for the bootstrap current and the temperatures. The modelling performed for 10 MW X2-mode ECR heated plasmas of $10^{20}$ m$^{-3}$ density has shown that the bootstrap current value is reduced by roughly 20 % in all important magnetic configurations (low-, standard-, and high-mirror) compared with the calculations done without momentum conservation. The bootstrap current is maximal in the low-mirror configuration and has the value $I_b$=88 kA with momentum correction and $I_b$ =104 kA without. For the high-mirror case, the bootstrap current with momentum correction is $I_b$=19.5 kA and $I_b$=28.4 kA without.

### Configuration Studies for W7-X

The investigation of the configuration space of W7-X with respect to the mirror ratio (*mr*), defined as half the variation of B on axis, has been extended from MHD considerations (Shafranov-shift and local stability) to neoclassical transport properties. Consistently with the optimization points, configurations with *mr* close to the standard configuration (*mr*=5 %) or below have the lowest neoclassical transport whereas the bootstrap current is reduced most efficiently for *mr*=10 %, corresponding to the high-mirror configuration. Values of *mr* below 10 % result in a tokamak-like sign of the bootstrap current coefficients while values above 10 % result in a reversed current.

### W7-X Configurations with Bootstrap Current

Deviation from the optimum configuration results in reduced but finite bootstrap currents $I_{bs}$. For proper island divertor operation this is problematic as, e.g., in the standard configuration realistic bootstrap currents of 40 kA ($B_0$=2.5 T) raise the boundary-$\iota$ value $\iota_b$ by ca. 0.07, leading to limiter conditions. Therefore, control of the value of $\iota_b$ is essential and may be established either through current drive or by adjusting the vacuum field configuration properly. As both approaches have difficulties, the latter, as the easier of the two, was investigated for a high-performance scenario in the standard configuration: 7 MW O2-ECRH, $n_{e0}$=1.5·10$^{20}$ m$^{-3}$, $T_{e0}$=5 keV, $T_{i0}$=4 keV and $I_{bs}$=43 kA. The time evolution of the configuration was simulated by assuming an instantaneous build-up of plasma profiles. The bootstrap current is initially shielded by a current driven by the self induced loop voltage. The initially non-uniform loop voltage equilibrates on the time scale of the internal skin time, which is of the order of a second, and then decays on the slower *L/R*-time (10-30 s). Equilibrium calculations with VMEC2000 for an assumed plasma size of a=48 cm were performed to study the evolution of the configuration in connection with the island divertor. The field outside the VMEC2000-region was calculated with the EXTENDER-code. A proper adjustment of the vacuum field configuration included a compensation of the $\iota$-change ($\iota_{ax,vac}$=0.856→0.783) and a re-centring of the plasma within the divertor structures (inward-shift). Figure 5 shows the evolution of the initial limiter configuration as the shielding current decays to 3/4, 1/2, 1/4 and 0 of its initial value and turns into the final island divertor configuration.

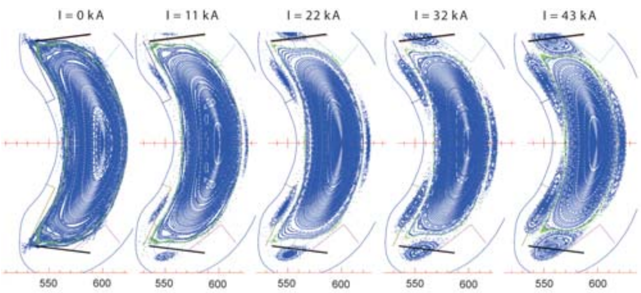



*Figure 5: Time evolution of the configuration as the shielding current decays and the bootstrap current becomes dominant, establishing an island divertor compatible configuration. The vacuum vessel and the divertor components are also shown.*

### Finite-beta MHD equilibria for W7-X with toroidal current

The VMEC/MFBE code package has been used to compute ideal MHD equilibria for the W7-X standard configuration by taking into account various current and pressure profiles with beta ranging from 1 % to 5 %. Several parameter studies have been performed to study the effect of monotonic toroidal current profiles (up to 80 kA) and flat pressure profiles on the rotational transform.

### 3D SOL Transport Studies

Numerical studies of edge physics in W7-X, LHD and ITER have been carried out.

W7-X: The essential transport features of the W7-X standard island divertor configuration have been investigated and compared with those of the W7-AS island divertor and the helical divertor in LHD. A high recycling regime, which is absent from W7-AS and LHD, is predicted to exist for W7-X. A divertor retention effect of intrinsic impurities is also predicted for W7-X at high SOL collisionalities, as previously observed in both W7-AS and LHD.

LHD: A more quantitative study of the SOL impurity transport has been made for the helical divertor in LHD through direct comparisons in carbon line radiation between spectroscopic measurements and 3D simulations under different SOL density conditions.

ITER: The transport behaviour and production processes of intrinsic beryllium impurities were studied in ITER startup plasmas bounded by two port limiters, as well as the misalignment induced asymmetric power load distributions over the ITER blanket modules.

### Plasma Edge Physics

### Transport modelling at the tokamak edge with screening of resonant magnetic field perturbations

An interface has been constructed for coupling the Monte-Carlo fluid code E3D with a kinetic model for resonant magnetic field penetration. Using this tool, heat conduction modelling has been performed taking the shielding of the RMPs into account. The model shows a strong reduction in the RMP induced radial transport because of the screening of the perturbations by the plasma, which is closer to experimental observations in D-IIID than previous modelling.

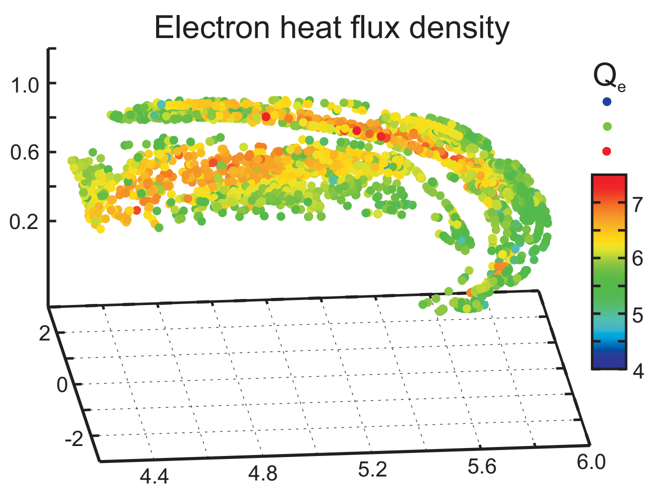



*Figure 6: Electron heat flux density in one section on the target plates of W7-X*

### Plasma Edge Transport Modelling

The finite difference code for 3D plasma edge modelling (FINDIF) was extended to include density and momentum equations. The code allows treatment of complex 3D geometries and ergodic structure of field lines in the plasma edge. The problem of power loads at the divertor plates, including the influence of ergodicity and 3D configuration of the field on the heat transport was studied on TEXTOR-DED and W7-X.

## Scientific Staff

C. D. Beidler, M. Borchardt, S. Braun, A. Dodhy-Würsching, M. Drevlak, D. Eremin, T. Feher, Y. Feng, J. Geiger; P. Helander, F. Herrnegger, K. Kauffmann, R. Kleiber, A. Könies, R. Liu, H. Maaßberg, N. Marushchenko, A. Mishchenko, C. Nührenberg, J. Nührenberg, J. Riemann, A. Runov, F. Sardei, A. Sengupta, Yu. Turkin, P. Xanthopoulos, X. Zha.

## Guests

B. Blackwell (Uni Canberra), A. Boozer (Columbia Uni), P. Catto (MIT), A. Cooper (CRPP&EPFL), S. Cowley (UKAEA), T. Fülöp (TU Chalmers Göteborg), R. J. Hastie (UKAEA), G. Kagan (MIT), S. Kasilov (TU Graz), E. Leeb-Lundberg (TU Chalmers Göteborg), H. Lindroth (TU Chalmers Göteborg), M. Mikhailov (Kurchatov Institute), D. Mikkelsen (PPPL), F. Parra (MIT), M. Rome (Uni Milano), E. Sanchez (CIEMAT), A. Simakov (LANL), H. Smith (Uni Warwick), D. Spong (ORNL), Y. Suzuki (NIFS), J. B. Taylor, D. Ward (UKAEA).

## Max Planck Junior Research Group "Turbulence in Magnetized Plasmas"

**Head: Dr. Wolf-Christian Müller**

### Lagrangian Statistics of Turbulence

Lagrangian statistics give insight into the diffusive properties as well as the phenomenological description of turbulence. The modification of the simple as well as the relative diffusion process in magnetohydrodynamic turbulence by the presence of the magnetic field is investigated in various configurations such as the macroscopically isotropic case, the MHD case under the influence of a strong mean magnetic field, and the two-dimensional MHD case. Especially the single particle statistics are sensitive to the large scale behaviour of the system. Therefore, the effects of various large scale forcing methods on turbulence statistics are being studied.

The Lagrangian velocity frequency spectrum is a promising new diagnostic for the investigation of the characteristic time scales involved in the turbulent energy cascade. Simulations in the two-dimensional MHD case have shown agreement with the scaling law predicted using the Iroshnikov-Kraichnan phenomenology. In the three-dimensional case no definite scaling laws have been obtained due to the limited Reynolds numbers attained in the current simulations. Higher resolution simulations with an extended scaling range are planned. This work is conducted in collaboration with G. Gogoberidze (Centre for Plasma Astrophysics, Leuven, Belgium).

### Compressible Turbulence

Within the Cluster of Excellence 'Origin and Structure of the Universe' the efforts to study supersonic turbulence focus on turbulent dynamics which is probably of importance for star- and structure-formation in the interstellar medium. To this end, a new numerical framework has been developed to work reliably on turbulent configurations with Mach numbers greater than five.

The Kurganov-Tadmor base scheme has been complemented by the Constraint Transport method to maintain a divergence free update of the magnetic field. The 3D MHD code has been parallelized in two space dimensions and allows for simulations with resolutions up to $1024^3$. The experimental order of convergence was measured as $O(\Delta x^3)$. With the current setup, decaying supersonic compressible turbulence simulations at $512^3$ resolution have been run for up to 10 large Eddie turnover times. The kinetic energy spectrum shows an inertial range that spreads over one decade in spectral space, showing a Kolmogorov-like scaling exponent and but not revealing a bottleneck effect as it is present in PPM simulations. Currently an Ornstein-Uhlenbeck forcing method is added to drive the turbulence at small wave numbers and to enable the investigation of steady-state turbulence properties.

### Structure Formation in MHD Turbulence

We continue our study of the inverse cascade behaviour of magnetic helicity, i.e., the self-similar spectral transport from small scales to large scales by means of direct numerical simulations of 3D MHD turbulence. A numerical simulation was set up, in which both the initial condition and forcing are placed in the small scales. Self-similar scaling is found in several quantities which hitherto were not known to show power law behaviour. Also different values of the power law exponents for quantities, which were already known to scale, are observed, except for the total energy which shows the expected $k^{-5/3}$ power law in spatial wave number $k$. Dimensional analysis of EDQNM (eddy damped quasi normal Markovian approximation) equations using these power laws, leads to the relation $E^M \sim (k^2 H^M E^V)/H^V$, which suggests that the increase in the magnetic energy is due to an interaction between the magnetic and kinetic helicities, where $E^M$, $H^M$, $E^V$, $H^V$ respectively represent magnetic energy, magnetic helicity, kinetic energy, and kinetic helicity. This relationship is also valid for decaying 3D MHD turbulence case.

From real space structure studies of these simulations, we conclude that the forcing used in the simulations only helps in clumping of the plasma but does not really form large scale magnetic structures. To form large scale structures, one needs to switch off the forcing at a certain point in the evolution of the inverse cascade spectrum where the decaying turbulence takes over and results in large scale magnetic structure formation. Here reconnection plays a significant role.

### Fundamental Properties of Turbulence

The investigation of anisotropic cascade dynamics in MHD turbulence has shown that the widely accepted Goldreich-Sridhar model is not applicable to flows permeated by a mean magnetic field. Further studies have also shown the invalidity of the Boldyrev model. Efforts are taken to build a comprehensive phenomenological framework that is largely based on the Iroshnikov-Kraichnan ansatz.

By studying non-linear triad interactions in three-dimensional Navier-Stokes turbulence it is shown that the cascades of energy and kinetic helicity are based on local non-linear interaction of turbulent fluctuations. Work on anisotropic MHD turbulence is going on.

Furthermore, work on the statistical properties of rotating three-dimensional MHD turbulence has begun.

## Scientific staff

A. Busse, M. Haslehner, S. Malapaka, S. Nagel, D. Škandera, Y. Rammah, C. Vogel.

## Helmholtz University Research Group "Theory and Ab Initio Simulation of Plasma Turbulence"

**Head: Prof. Dr. Frank Jenko**

The main goal of our research group, in close collaboration with various universities (including, in particular, the University of Münster) and laboratories, is to better understand the important unsolved problem of turbulence in magnetized plasmas. To this end, we also employ and extend ideas from fluid turbulence, non-linear dynamics, and statistical physics. Spanning a wide range of approaches, from simple analytical models to simulations on massively parallel computers, we address both fundamental issues as well as applications to specific experiments. Beyond this, we hope that our research helps to improve the general dialogue and cross fertilization between plasma physics and neighbouring fields of science.

### Further Development of the GENE Code

Over the last several years, we have been developing the non-linear gyrokinetic continuum code GENE, which is well benchmarked and physically comprehensive – including, e.g., an arbitrary number of fully gyrokinetic particle species, magnetic field fluctuations (finite $\alpha$ effects), collisional scattering in pitch angle and energy, as well as general toroidal geometry via interfaces to various 2D (tokamak) and 3D (stellarator) MHD equilibrium codes. Nonlocal effects have recently been included into GENE, such that it can now be run both as a local (flux-tube) and as a global (full-torus) code. GENE runs on a multitude of massively parallel platforms and has been shown to scale almost linearly up to 32,768 processors on IBM's BlueGene architecture. It is thus suited for high resolution runs containing most of the physics which is currently considered important for turbulence and transport in the core and inner edge regions of magnetized fusion plasmas.

### Exceptional Points in Linear Gyrokinetics

It was generally assumed that microinstabilities driving turbulent transport could always be identified by tracing them – in a high-dimensional parameter space – to a regime in which their nature is unambiguous. In contrast, we have found that this is often not possible. The reason is that the linear gyrokinetic eigenvalue problem is non-Hermitian, allowing for so-called Exceptional Points (EPs) which lead to quite counterintuitive behaviour. E.g., if one finds two unstable modes at a certain point in a 2D parameter space, a continuous change of the plasma parameters – encircling the EP – leads to an exchange of their identities. Thus, seemingly different modes are connected this way, making a clear identification difficult in the neighbourhood of EPs. Right at the EP, the two eigenvalues and eigenmodes coincide – unlike in many quantum mechanics problems with degeneracy, where only the eigenvalues coincide. In general, every N-dimensional parameter space exhibits (N-2)-dimensional EP structures, showing that EPs are a rather common phenomenon. Moreover, the existence of EPs highlights interesting connections between plasma physics and other branches of physics.

### The Role of Sub-Ion-Gyroradius Scales

Up to now, virtually all non-linear gyrokinetic simulations were restricted to one spatial-temporal scale, thus implying an artificial decoupling of slow large scale (e.g., ITG or TEM) and fast small scale (e.g., ETG or microtearing) turbulence, or assuming a negligible contribution of the latter. However, we found cases showing strong evidence for cross-scale coupling effects and non negligible small scale contributions in simulations which covered both scales self-consistently. Especially in regimes corresponding to strong electron heating, significant or even dominant small wavelength contributions have been observed. Corresponding density fluctuation spectra have also been calculated, allowing experimentalists to better interpret their data, obtained, e.g., from wave scattering diagnostics. Such simulations are thus needed to help interpret recent experimental studies indicating that sub-ion scales can play an important role, especially in H-mode discharges. In particular, GENE simulations show that the residual level of electron heat transport in an edge barrier can be explained by high wave number turbulence driven by so-called ETG modes.

### Turbulence at High Plasma Beta

Most high-performance discharges in fusion devices are performed at high beta values, i.e., rather close to the onset of so-called MHD ballooning modes. At present, however, there is no consensus on the experimental scaling of turbulent transport with beta, and simulations are quite challenging in this regime. By means of carefully prepared GENE simulations, we were able to obtain the first beta scan (keeping all other dimensionless plasma parameters fixed) extending all the way into the kinetic ballooning mode regime. For 'Cyclone Base Case' parameters, it was found that at high beta values, ITG turbulence is strongly reduced, and that this phenomenon cannot be explained via quasi-linear theory. A non-linear destructive interference between ITG modes and trapped electron modes is likely to be mainly responsible for it, while enhanced zonal flow activity contributes only moderately. The field lines exhibit a diffusive behaviour, and the resulting magnetic transport can be explained by a Rechester-Rosenbluth-type model. Trapped electron mode turbulence, on the other hand, exhibits much weaker beta dependence. The non-linear scaling again deviates from quasi-linear expectations, but this time zonal flow dynamics is the key agent.

### Scientific staff

T. Görler, T. Hauff, F. Merz, M. Püschel, K. Reuter, D. Told.

## Helmholtz Junior Research Group "Computational Material Science"

**Head: Dr. Ralf Schneider**

The group studies effects on materials in contact with either fusion or low-temperature plasmas by developing and applying computational physics tools.

### Development of a Multi-scale Model for the Interaction of Hydrogen with Graphite

To study the flux dependence of chemical erosion, a simple multi-scale model has been developed. Due to the shielding of the carbon atoms in the lower layers only few surface layers are accessible by the incoming hydrogen ions. This sets an upper limit on the released carbon flux in agreement with experiments. A local chemical reaction model for the hydrocarbon molecule formation has been coupled with the collisonal cascade code TRIM. The release probability is determined within the collision cascade algorithm in TRIM.

### Morphological Changes of Surfaces

The collisoinal cascade code TRIM was extended to 2D allowing the studies of morphological changes of surfaces due to sputtering. Simultaneous bombardment of a rough tungsten surface with 6 keV carbon and 3 keV deuterium ions was investigated by simulations and compared with experiments. For same bombardment conditions a rough surface produces higher sputter yields and higher area densities of implanted C than in the case of a smooth surface. For co-axial flux arrangement bombarding a rough surface under 45°, the surface tends to prevent W sputtering by aligning the surface profiles to the perpendicular and parallel directions of the impinging C and D ion fluxes (see figure 7).

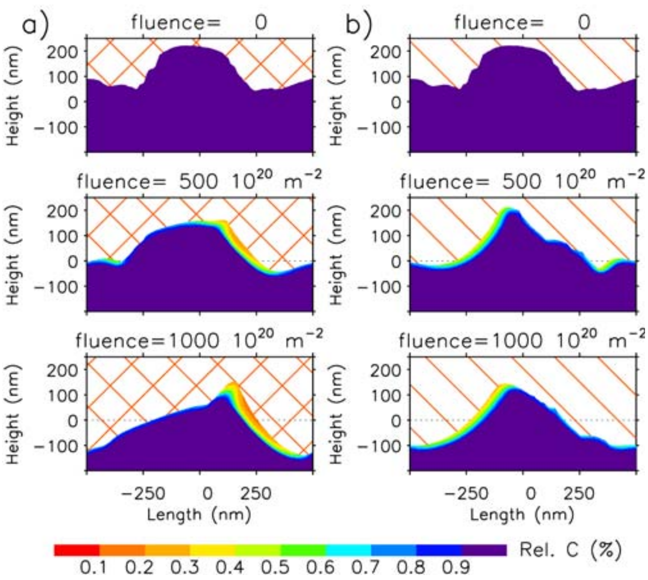



*Figure 7: Evolution of the surface morphology under simultaneous bombardment with 6 keV C and 3 keV D ions for an angle of incidence of 45°. (a) symmetrical bombardment of surface; (b) co-axial bombardment of surface. The lines show the trajectories of the projectiles before the collision with the surface. The colour corresponds to the relative C concentration.*

### Atomistic Description with Ab-initio Methods

A general approach has been developed to obtain spectroscopic data for polyatomic molecules satisfying the requirements of astrophysics in terms of completeness and accuracy. Highly accurate global potential energy and dipole moment surfaces for $CH_4$ were generated using ab-initio methods. They agree with experimental spectroscopic frequencies within several $cm^{-1}$. A complete list of rotational-vibrational transition probabilities were calculated up to an upper state energy of 6200 $cm^{-1}$. Spectra generated using this database do not show artificial gaps like other databases (HITRAN) avoiding thus systematic errors in the computed model structures in stellar atmosphere simulations (figure 8).

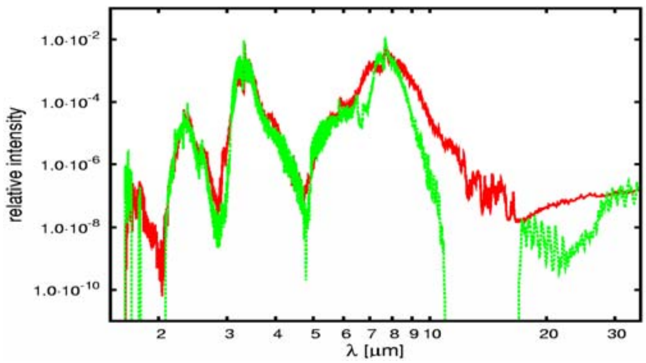



*Figure 8: Relative intensities of our database (straight) and HITRAN (dotted) for methane*

### Kinetic Modelling of Complex Plasmas

Kinetic modelling of plasmas with PIC methods was done in close collaborations with experiments at the Ernst-Moritz-Arndt University in Greifswald within the Transregio TR-24. The charging of a spherical, conducting dust grain confined in the sheath potential close to the wall was simulated. The ion drag force resulting from dust grain collisions with the streaming ions was calculated self-consistently.

A kinetic grid-free 1d3v hierarchical treecode resolving both electron and ion dynamics was developed and benchmarked for collisionless edge plasmas.

## Scientific Staff

K. Matyash, A. Rai, R. Schneider, R. Warmbier.

## Guests

B. Braams, A.R. Sharma (Emory University Atlanta), F. Taccogna (University of Bari), D. Tskhakaya (University of Innsbruck).

## EURYI Research Group "Zonal Flows"

**Head: Priv.-Doz. Dr. Klaus Hallatschek**

Poloidal rotation in the form of stationary zonal flows (ZF) and oscillating geodesic acoustic modes (GAM) is a ubiquitous phenomenon in many magnetic confinement devices (AUG, CHS, H-1, HL-2A, JFT-2M, JET, JIPP-T2, TEXTOR, TJ-2, T-10).

### Geodesic Acoustic Mode Studies: Propagation Speed from Radial Free Energy Flux

The wave number dependency of the GAM frequency gives rise to a non-zero group velocity, i.e., a propagation of the GAMs away from their point of origin (see figure 9). Radial propagation of GAMs is an important effect to consider in relation to the radial windows of GAM activity observed for certain safety factors. Moreover it could resolve the discrepancy between theoretical local GAM frequencies and the measured frequencies, as the GAMs may originate from a different radial location. The propagation velocities also control the formation of global eigenmodes and the wave number dependent frequency shift.

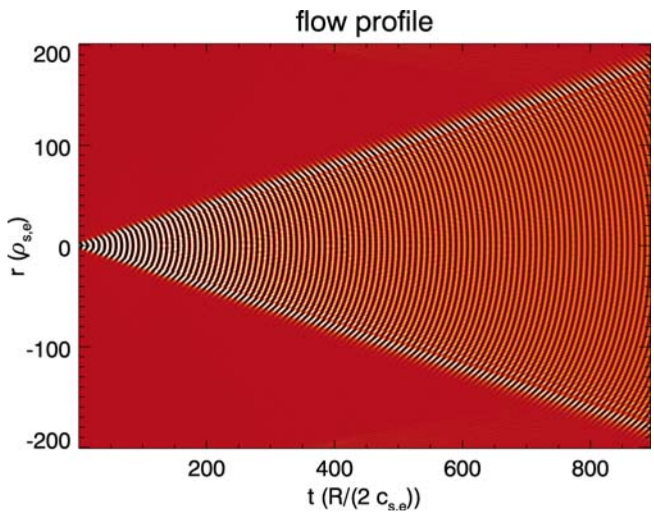



*Figure 9: Colour coded poloidal flow velocity; radial propagation of GAMs computed with linear fluid code NLET for Ti=0.*

Alas, directly computing the group velocity as a derivative of the frequency is sensitive to details of the dispersion relation and difficult to do in realistic geometry including ambient turbulence. As a more robust method, we have calculated the ratio of free-energy flow (i.e., a type of Poynting flux) to free-energy density of the GAM. Reliable upper and lower limits of the propagation speed can therefore be readily obtained by computing the corresponding bounds for the energy flux. The procedure has been carried out in a fluid or a gyrokinetic framework. In both cases the energy flow has components from neoclassical flow of fluctuation energy, hydraulic energy flux due to polarization drifts, and finite ion Larmor radius contributions, such as from gyro-viscosity. Resonances can occur either with the parallel sound waves, or, for relatively high radial wave numbers of order of the inverse ion sound Larmor radius, with the curvature and grad-B drifts. In either case, the fluctuation energy outweighs the kinetic energy of the poloidal rotation, whence the mode in question loses the character of a GAM and becomes a parallel sound wave or a drift mode, whose radial propagation speed can be computed. The calculations have been corroborated by comparison with derivatives of analytic expansions of the GAM frequency as well as linear fluid and gyrokinetic code results (NLET and GYRO).

Apart from serving as an estimate, the discussion of the GAM energy fluxes gives a physical explanation of the radial propagation and is extensible to non-linear situations by including the energy transport due to the turbulence.

### Zonal Flow Studies: Reynolds Stress Functional

To obtain full information (including scale lengths and possible meta-stable states) about the evolution of Zonal Flows beyond specific self-consistent turbulence simulations it is necessary to determine the non-linear functional of the flow pattern controlling the Reynolds stress. Using large computational domains, it has been verified that the ZFs evolve in fact deterministically. As shown in figure 10, the flow pattern continuously expands (controlled by the boundary conditions) while maintaining the radial scale length by generating new flow maxima.

Apart from restrictions by the symmetries of the system, it is known that the Reynolds stress functional drives flows in a certain wave number range for small flows, damps them for large flows, and that for flow shears in the range of self-consistent simulations, a preferred flow wavelength is growing, while the others are damped. To account for this property, the preliminary functional used for the studies has to be augmented with additional scale lengths, which are currently being determined by NLET runs.

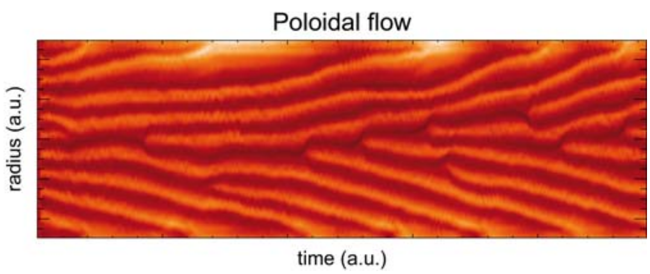



*Figure 10: Colour coded poloidal flow velocity of Zonal Flows in NLET simulation of ITG turbulence*

## Scientific Staff

N. Gürtler, R. Hager, A. Kammel.

# Supercomputing and other Research Fields

# Computer Center Garching

**Head: Dipl.-Inf. Stefan Heinzel**

## Introduction

The Rechenzentrum Garching (RZG) traditionally provides supercomputing power and archival services for the IPP and other Max Planck Institutes throughout Germany. Besides operation of the systems, application support is given to Max Planck Institutes with high-end computing needs in fusion research, materials science, astrophysics, and other fields. Large amounts of experimental data from the fusion devices of the IPP, satellite data of the MPI for Extraterrestrial Physics (MPE) at the Garching site, and data from supercomputer simulations are administered and stored with high lifetimes. In addition, the RZG provides network and standard services for the IPP and part of the other MPIs at the Garching site. The experimental data acquisition software development group XDV for both the W7-X fusion experiment and the current ASDEX Upgrade fusion experiment operates as part of the RZG. Furthermore, the RZG is engaged in several large national and international projects in collaboration with other scientific institutions.

A major task has been the optimization of complex applications from plasma physics, materials science and other disciplines. The data acquisition system of W7-X is in operation on the smaller WEGA device, and the concepts of continuous operation have been proven successfully. The RZG is engaged in several large national and international projects in collaboration with other scientific institutions.

## Major Hardware Changes

In July 2008 a new IBM supercomputer system has been installed which replaces the former IBM pSeries 690 based Regatta system: 207 compute nodes with 32 processors each and a fast 8-plane-InfiniBand communication network yield a peak performance of 120 TFlop/s; the machine was assigned place 23 in the list of world's TOP500 supercomputers in November 2008. The IBM Blue Gene/P system with PowerPC@850MHz-based cores has been augmented with another two racks and now consists of 4096 quad-core nodes (16 384 cores) corresponding to a peak performance of 55 TFlop/s (place 57 in the TOP500 list). Furthermore, an IBM p575-based cluster of 8-way nodes and a series of Linux clusters with Intel Xeon and AMD Opteron processors are operated. Besides the generally available systems, dedicated compute servers are operated and maintained for: IPP, Fritz-Haber-Institute, MPI for Astrophysics, MPI for Polymer Research, MPI for Quantum Optics, MPI for Extraterrestrial Physics, MPI for Biochemistry, MPI for Chemical Physics of Solids, MPI for Physics and MPI for Astronomy. In the mass storage area, the capacity of the automated tape library Sun SL8500 has been extended to 7.2 PB of compressed data. Both LTO4 and LTO3 tape drives are supported.

## Developments for High-End Computing

The application group of the RZG gives support in the field of high-performance computing. This includes supervising the start-up of new parallel codes, giving advice in case of software and performance problems as well as providing development software for the different platforms. One of the major tasks, however, is the optimization of complex codes from plasma physics, materials sciences and other disciplines on the respective, in general parallel high-performance target architecture. This requires a deep understanding and algorithmic knowledge and is usually done in close collaboration with the authors from the respective disciplines. In what follows selected optimization projects are presented in more detail.

### GYGLES Code

The GYGLES (GYrokinetic Global LinEar Solver) code solves linear gyrokinetic equations for electrons and one or more ion species in tokamak geometry. In the original version the code suffered from a pronounced load-imbalance problem with the result that good parallel scaling properties could only be reached up to 64 processors. Investigations showed that this was caused by the kind in which the particles were mapped onto the different processors. As the intrinsic work load of each particle differs with its radial position, particles have to be distributed randomly over the processors regarding their radial position to avoid this kind of load imbalance. A further run-time reduction could be achieved by means of efficiency improvement: Two different time-integrator schemes for particle position and weight as well as a costly calculation of the diagnostic output could be integrated in the same loop. Furthermore, the data structure of the particle array was adapted with a focus lying on good cache performance. Finally, a reduction of the execution time by a factor of three could be achieved for a parallel 32-processor run.
Executing the new code version on an IBM p690 with POWER4@1.3 GHz processors very good scaling properties with a parallel efficiency of 95 % were achieved when scaling from 32 to 256 processors. The strong scaling was done with a realistic electromagnetic simulation with $16 \cdot 10^6$ electrons, $4 \cdot 10^6$ ions and a grid of 64×32 quadratic B-splines. For even larger numbers of processors, however, the work load per processor became so small that the noise caused by system processes as e. g. interrupts again led to a load imbalance. In this respect the conditions on the IBM Blue Gene/P with PowerPC450@850 MHz processors are much better. On the one hand, the communication network is much faster compared to the compute power of the single processors and on the other hand, the overhead of the operating system, a so-called "light-weight kernel", is significantly lower. The same simulation shows here a parallel efficiency of 85 % when scaling from 32 to 1024 cores in "quad-core mode".

Thus, on the IBM Blue Gene/P at RZG the new code version of GYGLES runs twenty times faster than the old one. This reduction in run-time is highly appreciated as electromagnetic particle-in-cell simulations are very costly.

### GENE Code

The GENE code from the IPP plasma theory is a so-called continuum or Vlasov code for turbulence simulations. Nonlinear gyrokinetic equations are solved on a fixed grid in five-dimensional phase space. All differential operators in phase space are discretised by fourth-order (compact) finite differences. GENE can deal with arbitrary toroidal geometry (tokamaks or stellarators) and retains full ion/electron dynamics as well as magnetic field fluctuations. At present, GENE is the only plasma turbulence code in Europe with such capabilities.
Absolute performance and scalability of version 11 of the GENE code have been measured on different large European supercomputers. Runs with 8000 processor cores on the new international UK supercomputer Cray XT4, with 8000 cores on the HLRB machine SGI Altix 4700 and with up to 32 000 cores on the IBM Blue Gene/P machine at IDRIS (France) have been performed showing that the GENE code is well capable for usage on scalable systems with several tens of thousands of processors.

### ORB5 Code

The particle-in-cell code ORB5 from the IPP plasma theory is able to simulate plasmas of high complexity and has high relevance for ITER. Special effort was given to the ORB5 code to enable it to run with high scalability on thousands of processors. Benchmarks with up to 32 000 cores have been carried out for different test cases on the Blue Gene/P at IDRIS, France showing good scaling properties (see figure 1).

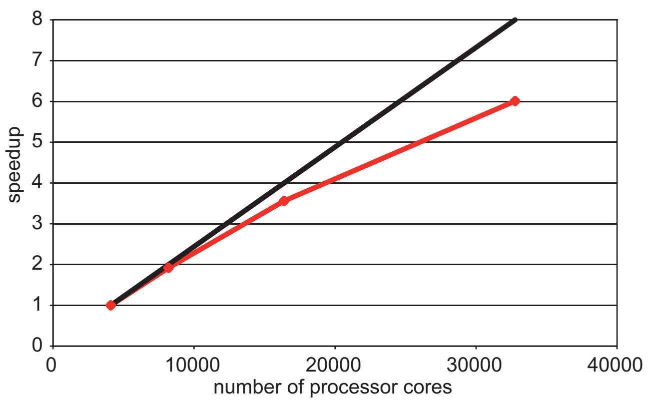



*Figure 1: Strong scaling of the ORB5 code on a Blue Gene/P machine at IDRIS, France (measurements in virtual-node mode)*

## Visualization

RZG has started to establish central data visualization services for HPC users of the Max Planck Society and the IPP. This comprises building up a suitable compute infrastructure, as well as offering guidance for the selection, adoption and application of visualization and data analysis tools and for the instrumentation of simulation codes (see http://www.rzg.mpg.de/visualisation/). To this end relevant software and hardware products are currently evaluated with a particular focus on their scalability on parallel systems and "remote visualization" capabilities. Being able to utilize distributed memory and processing power of many processor cores has become indispensable for visualising massive datasets. "Remote visualization" briefly means that the memory and compute intensive parts of a rendering task execute on specialized graphics hardware operated in the "cold room" of a computing centre, which also hosts the potentially huge amounts of original data to be analysed. Specific software accounts for the efficient transmission of the graphical display over the network and handles the communication of user interaction. So far, promising experiences have been made with the VisIt tool for parallel visualization and data analysis (open source, developed by LLNL). Using a "fat" node of the newly installed IBM Power6 system, efficient parallel volume rendering could be demonstrated for MHD turbulence simulation data with a grid size of up to $2048^3$ (W. C. Müller, IPP, see figure 2). Currently, VisIt and comparable software like ParaView, Avizo, … are investigated concerning their performance on large particle-based datasets which are frequently encountered, e. g. in astrophysics simulations.

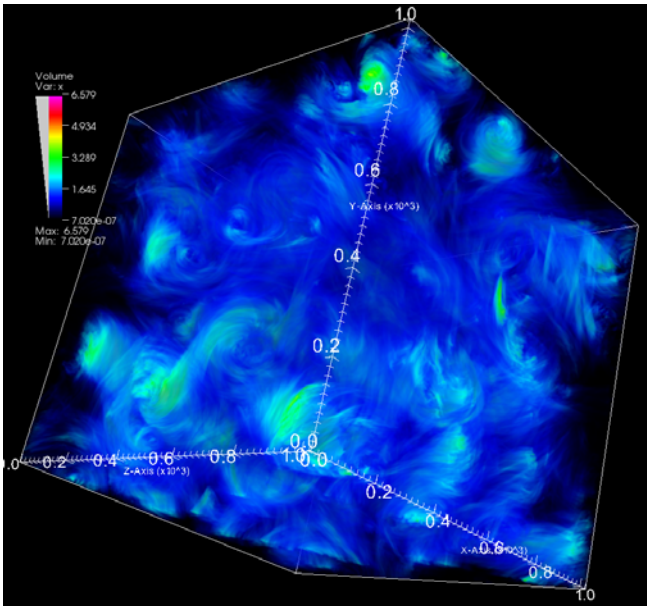



*Figure 2: Snapshot of an MHD turbulence simulation (W. C. Müller, IPP) showing a volume rendering (ray casting) of the magnetic field strength*

These activities are complemented by continuing our dedicated support for a number of particularly challenging visualization projects. Currently, these tasks originate mostly from plasma physics and astrophysics simulations performed on RZG's HPC systems (e. g. Jenko/Püschl, IPP; Hillebrandt/

Röpke, White/Springel, MPA). The particular structure of the simulation data, their sheer amount, or specific requirements for their (interactive) exploration requires developing tailored and highly optimized solutions for such cases (e. g. Röpke & Bruckschen, NJP 10, 2008).

## The Munich-ATLAS-Tier2 Project

Collaborating research groups from the Max Planck Institute of Physics (MPP) and from the Ludwig Maximilian University (LMU) play a significant role in the ATLAS project of the Large-Hadron-Collider (LHC) experiment at the international European Centre for Particle Physics (Cern). ATLAS is one particular detector, which is going to provide huge amounts of data once the experiments start, and about 140 institutes all over the world consider working with these data. In order to make this feasible, a hierarchical network of so-called Tier centres has been established, by which the data is shared and replicated in a reasonable fashion and the workload is distributed to the centres. In Munich, a Tier2 centre was set up by the MPP, the Physics department of the LMU and the associated computing centres LRZ and RZG. The tasks of a Tier2 centre are to provide a certain amount of compute and memory resources, which are placed at the disposal of all sites taking part in the WLCG (world-wide LHC Computing Grid) community, and to establish sufficient memory bandwidth and services for the data exchange with the associated Tier1 centre.

## The DEISA2 Project

The DEISA Consortium, which has deployed and operated the *Distributed European Infrastructure for Supercomputing Applications* as an EU FP6 project from 2004 to 2008, continues to support and further develop the distributed high-performance computing infrastructure and its services in the EU FP7 project DEISA2 for three years until April 2011, coordinated by RZG/IPP. Activities and services relevant for Applications Enabling, Operation, and Technologies are continued and further enhanced, as these are indispensable for the effective support of computational sciences in the HPC area. The service provisioning model is extended from one that supports single projects to one supporting European science communities as e. g. the Fusion community. Collaborative activities will also be carried out with new European and other international initiatives. Of strategic importance is the cooperation with the PRACE project which is preparing for the installation of a limited number of leadership-class Tier-0 supercomputers in Europe. The key role and aim of DEISA2 will be to deliver a turnkey operational solution for a future persistent European HPC infrastructure, as suggested by ESFRI. This infrastructure will integrate national Tier-1 centres and the new Tier-0 centres.

## Bioinformatics/Computational Biology

Within the MIGenAS project joined by several Max Planck Institutes, the RZG has established an infrastructure comprising dedicated hardware, software and data sources for computational biology applications. With the help of two scientific positions provided by the Max Planck Society, the RZG hosts various bioinformatics services for project-internal and public use, offers application support for bioinformatics projects of the Max Planck Society, contributes original software development and participates in various research projects. Meanwhile, many computational biology projects (including research groups which were not part of the original MIGenAS consortium) are taking advantage of these centralized services. During the last few years an appreciable number of microbial genomes, among them some highly relevant model organisms, were "finished" and published with the help of the computational pipeline established at RZG. The pipeline supports the initial assembly of the genome sequences, the subsequent automatic prediction of genes and assignment of their function, followed by distributed manual annotation by experts for the final publication, release to public databases and further analysis. Several genome projects are currently in progress.
Concerning bioinformatics software development, the reimplementation and functional extension of HaloLex has been successfully completed. HaloLex is a software system for the central management, integration, curation, and web-based visualization of genomic and other related "omics" experimental data (e. g. proteomics). The new HaloLex system and some key applications were recently published in *Archives of Microbiology* (Vol. 190, 2008). HaloLex is routinely used by different collaborations for data analysis and curation of various microbial genomes.

## Authentication-and-authorization Project of the MPG

The authentication-and-authorization project of the MPG (MPG-AAI) the RZG participates in has the goal to establish an MPG-wide authentication-and-authorization infrastructure to give scientists, students and staff a better, i. e. easier and more consistent way to access both external and internal online resources like publications, primary data or services. Users should be enabled to access such data and services at best with a single login of their unique identity (Single-Sign-On). To this end a pilot MPG-AAI Federation has been set up employing the distributed approach of the known Shibboleth Framework and SAML protocol: It consists of so-called Identity Providers at each participating institute's site, which are queried securely from remote Service Providers about any accessing users' authentication status and authorization information. All involved federation parties know and trust each other by means of metadata. To integrate MPG-AAI easily with further, similar Shibboleth Federations like DFN-AAI, an Identity Provider Proxy has been developed as a kind of gateway. In order to incorporate publishers to the MPG-AAI federation who don't use Shibboleth at all, we've evaluated and set up a special Shibboleth-enabled web proxy.

## Videoconferencing (VC)

The VC conference load further increased to 10364 h (7152 h in 2007). The Gatekeeper worked without breakdowns. There are about 350 registered endpoints, where up to 75 have been active simultaneously. Presentation sharing using the ITU substandard H.239 has surpassed the VNC. EFDA-TV is common for EFDA people. The HD (720P so far) capable Codian MCUs of the DFNVC service delivered a very reliable and high-quality performance, about 42 % of all calls via the RZG Gatekeeper were multi-point. The DEISA project held about 200 conferences, some with 1-3 audio-only participants, served via the ISDN-IP gateway of the DFNVC. Six EFDA VC-Tier multipoint meetings with 15-20 sites have been organized by RZG's video group.
Today seven high-definition systems are available: one in Greifswald in the directorate area, two in Garching in building H1, one in the AUG control room, two at RZG and one in the technology division. In addition, 15 Tandberg systems and about 90 Polycom software clients are in regular use. The booking system covering 28 rooms worked stable throughout the year.

## Data Network

The data network is based on the concept of a "collapsed backbone" consisting of high-level switches at a few central locations which directly connect to all endpoints via links based on copper or fibre – eliminating the need of limiting switches at workgroup or story level. This structure greatly enhances overall network performance, for most of the connections between centralized switches are at a speed of 1 Gigabit/s (Gigabit Ethernet technology) and a few have even been raised to 10 Gigabit/s on demand, numbers increasing. With this structure security and integrity of data have also been improved because eavesdropping is almost impossible.
For logical security based on the functionality of the internet protocol suite TCP/IP a packet filter firewall combined with stateful inspection at the access point to the internet (a Cisco 6509 router with hardware-based firewall module) is implemented, where all the incoming/outgoing packets are checked against a set of blocking or granting rules. Additionally, all incoming electronic mail is scanned for viruses and only clean and unobjectionable data (based on known problems) will be passed to the internal network, the rest gets quarantined. Spam mail marking is also active. Based on a level of probability users can define and set filter threshold values at their PC's email client. In addition, the individual activation of "greylisting" drastically reduces the incoming of unwanted emails.

After successful renovation of the old building of the computer centre a very flexible passive network structure with fixed and hidden loose cables has been installed. The active part of the data network is made up of a state-of-the-art high-performance switch-router Foundry MLX, where all the supercomputer and server nodes get attached with the highest performance available. The coupling of the new Blue Gene/P system with the storage subsystems was realized with a 10-Gigabit-only Force10-E600 switch-router, while the newly installed Power6 system is directly attached to a Cisco Catalyst 6509.

## Data Acquisition and Data Bases for Plasma Fusion Experiments

The XDV group at the computer center in Garching is responsible for the development of the data acquisition and data storage system of the W7-X experiment in Greifswald. In 2008 the work concentrated mainly on the development of user interfaces to define discharges for the experiment from a physicist's point of view. The already introduced abstraction layers for technical parameters have been developed further and led to the design and implementation of new editors, which are now available as web applications. The number of available transformation functions that are necessary to generate the technical parameters from the abstract layer has been considerably extended.
The prototype of the complete control and data acquisition system of W7-X on an existing, but simpler device (WEGA) successfully reached its milestone in April 2008 and showed that it can operate as planned. In the meantime discharges of 1 hour were successfully maintained and proved the concepts for continuous operation. In the next phase of this prototype the number of controlled elements and diagnostics will be increased. In addition, this prototype system is very helpful to develop and improve the necessary user interfaces for planning and operating long discharges.

## Staff

A. Altbauer, V. Bludov, G. Bronold, R. Bruckschen, J. Daschner, K. Desinger, R. Dohmen, M. Egger, R. Eisert[1], I. Fischer, S. Groß*, K. Gross, C. Guggenberger, A. Hackl, C. Hanitsch, C. Hanke, R. Hatzky, S. Heinzel, F. Hinterland, M. Kölbl, G. Kühner*, H. Lederer, K. Lehnberger, J. Mejia, K. Näckel*, W. Nagel, M. Panea-Doblado, F. Paulus, A. Porter-Sborowski, M. Rampp, J. Reetz, H. Reuter, K. Ritter, S. Sagawe*, A. Schmidt, A. Schott, H. Schürmann*, J. Schuster, U. Schwenn, T. Soddemann, R. Tišma, S. Valet*, I. Weidl, K. Zilker.
**Data Acquisition Group**: T. Bluhm*, P. Heimann, C. Hennig*, G. Kühner*, H. Riemann*, J. Maier, Ch. Meyer, M. Zilker.

[1] *IPP Greifswald*

# Energy and System Studies

Head: Dr. Thomas Hamacher

## Global energy models

### EFDA-TIMES Model

One of our central activities is the construction of a global energy scenario model with a particular focus on the role of fusion power in the 21st century. This is part of a pan-European effort carried out within the framework of the EFDA SERF programme. EFDA-TIMES is a global multi-regional technology explicit partial equilibrium energy model which employs the TIMES energy modelling framework. It uses linear programming techniques in order to maximize the total economic surplus under certain constraints such as energy conservation, resource constraints, renewable energy potentials, growth constraints. Recently the impact of different methods to project future energy needs induced by transportation activities has been investigated. Whereas the effects on the electricity market albeit the strong coupling via the turnover from conventional technologies towards an electricity infrastructure and the extensive use of electric high-speed trains remain small, variably restrictive climate policies have turned out to show a high impact on the contribution of fusion power. This is illustrated in figure 1 which shows the level of electricity generation within a 450 ppm scenario. This effect materializes in the long term because of the restrictions on fossil fuel use, the steep investment learning curves to be expected for the emerging fusion technology and the increasing nuclear fuel costs due to the growing scarcity of Uranium towards the end of the 21st century.

What role energy and high energy prices played in the financial crisis beginning in 2008 needs still to be analysed. The crisis raises a number of questions and concerns which might change the energy markets in the future. Money to make the transformation to a carbon free energy economy is even scarcer these days. Still governments push investments in the energy and energy saving sectors to accelerate economic activities again.

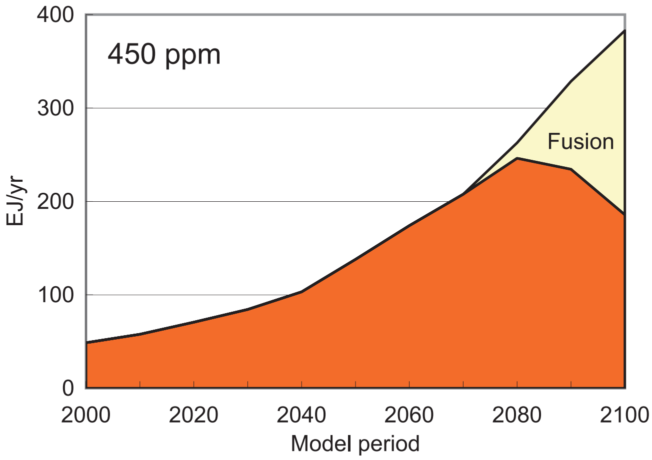



*Figure 1: Total level of electricity generation*

## Modelling approach to understand the electricity markets of the future

### Stochastic modelling

A stochastic linear model of the German electricity system was developed. With stochastic programming techniques uncertainties can be taken into account, by replacing the uncertain constant parameters by a random variable. With this model the unpredictable gas price development, the variation of $CO_2$ certificates prices and the wind fluctuations were considered in the optimization model of the power system.

### Multi-agent modelling

Multi-agent modelling techniques were used to develop a simulation model of the electric power system. The agent base approach allows implementing behavioural pattern. The agents are the utilities and the electricity consumers. The interaction of demand and supply provokes electricity trading. Within the model a power exchange is implemented where the matches of the cumulative demand and supply curve determines the market price. The main part of the model is an investment and finance program that optimizes the behaviour of the agents on a long-term and is executed by each agent separately once a year. Input for the optimization is the current state and the specific assumption of the agents, with this data the optimal finance and investment plan is calculated.

### European Supergrid

The intermittent and geographically dispersed nature of most Renewable Energy resources implies difficulties concerning their integration into the electricity grid, e.g. the need of back up capacities. To answer these difficulties extensions of the European network are proposed. Dispersed generation of Renewable Energies entails less intermittency, but also transport losses. Can a European supergrid, i.e. increased crossborder interconnection on a high voltage level, facilitate the use of Renewable Energies? With a model containing detailed meteorological data, latest standard generation and transport technologies, optimal European grid extensions shall be determined.

## Cooperation with the University of Greifswald

The central goal of the project is to understand under which circumstances and perspectives in the future an investor will be willing to spend several billion Euros to construct and operate a fusion power plant. A refined economic methodology was developed, based on the general investment theory in economy. The methodology is currently implemented; first results are expected to be presented in 2009. The special value of this project is that most energy models optimise the welfare of the whole society while this approach focuses on the rationality of an individual firm.

## Energy and cities

### Greifswald

The cooperation with the city of Greifswald was continued. The IPP is leading a working group of the main actors within the city which tries to define a major roadmap for the city to include more sustainable energy technologies.

### Salzburg

The first challenge in this project is to deal with development of the demand for heating energy working on a highly space-resolved level. Therefore statistical data including information about the building structure and the industry as well as the tertiary sector were analysed. First results like the possible decline of the heating demand due to renovation activity are illustrated on maps. The next challenge is to model the development of the district heating grid structure. The Models therefore have to feature a highly geographical resolution, which requires the use of mixed integer programming.

### Augsburg

A cooperation between WZU, Stadtwerke and IPP was established. Due to a decrease in space heat demand, the areas which can be supplied by energy networks will shrink. This opens up the opportunity for heat pumps to become a dominant heat source in the city. A detailed analysis on the effects of heat pumps on the heat balance within the surface of the area was launched. A subtle heat transport simulation model was developed.

### Oldenburg

Oldenburg did successfully participate in the BMBF competition "Energy Efficient Cities". The IPP was one of the scientific members in this consortium. The main emphasis of the analysis will be new services to reduce the energy demand and the energy demand of the service sector.

## Econophysics

### Transition in transport

A particular field of econophysics tries to describe radical economic or technologic changes with the calculus of phase transitions. In the near future it is possible that fundamental changes happen in the transport sector. One possibility to face the increasing demand for crude oil is a transition in a forward-looking transport system. Such a transition from conventional to forward-looking transport technologies could be described by sociodynamic models.

### City structure

Applying the theory of sociodynamics on city systems gives a dynamic understanding of city-structure-development through self-organization. In this work, the structures arise from the interaction between a population, consisting of many equal individuals, and immobile services. Due to the stochastic approach in the model individuals have freedom of decision, which leads to more realistic results than optimization techniques. On average, individuals minimize their costs of mobility and housing by migration between defined squares. The number of services per square is adapting until revenue per service has reached a defined value. Assuming low transport costs (tc) and a low living cost level (lcl) one result is an American-like city structure, a commercial centre and a suburban population. High tc and a high lcl lead to a structure of sharp separated commercial centres combined with congruent high population densities (figure 2). Structural changes, evolving of rising energy prices, can thus be modelled. Using empirical data for various subpopulations and extending assumptions should provide a more detailed valuation of these changes.

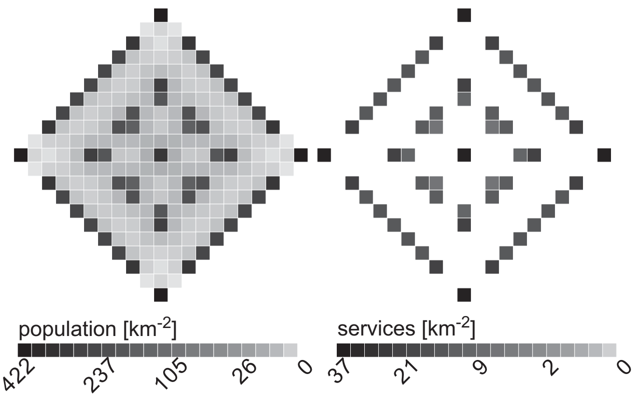



*Figure 2: Characteristic densities of population and services in modelled area*

## European Physical Society

The EPS established in 2008 a group overlooking the energy activities of the society. This group is headed by the energy and system study group of the IPP. EPS will now launch a conference series covering the whole of the energy sector.

## Outlook

The group for energy and system analysis will keep its two pillars: long term global energy models and urban and regional short term models. Contacts outside Europe are necessary to really discuss the global aspects especially of fusion. The group will in the medium term also develop a fusion plant model which can be used to make economic and technical assessments.

## Scientific Staff

Group: P. Böhme, S. Braun, T. Hamacher, N. Heitmann, P. Mühlich, K. Schaber, Uni Augsburg: F. Botzenhart, B. Grotz, A. Hämmerle, T. Hartmann, J. Herrmann, C. Linder, Uni Greifswald: M. Bartelt, M. Busch, P. Kurz.

# Electron Spectroscopy

**Head: PD Dr. Uwe Hergenhahn**

The electron spectroscopy group currently focuses on the study of the photoionization dynamics of atoms, molecules and free clusters using VUV and X-ray radiation. As light source the intense and tuneable photon beams generated by third generation synchrotron radiation sources, such as BESSY (Berlin), are used. The results are also important for advancing the application of electron spectroscopy as a technique in plasma physics and technology.

## Autoionization in Water Clusters

Synchrotron radiation has proven to be a valuable tool for investigating the electronic dynamics of weakly bound systems, such as hydrogen-bonded clusters. Here, we report on a non-local autoionization channel which has hitherto not been observed in water experimentally: After photoionization of an inner valence electron the remaining hole is filled by relaxation of an outer valence electron. The energy released is transferred to neighbouring molecule within the same cluster where it suffices to ionise another outer valence electron. About a decade ago, this process was predicted theoretically and later, this so-called Interatomic or Intermolecular Coulombic Decay (ICD) was discovered in rare gas systems by the IPP group. Water clusters were generated by expanding water vapour through a conical nozzle into an evacuated volume. The clusters were then ionised with synchrotron radiation, and the emitted photoelectrons were detected together with the ICD electrons. The expected energy range of these ICD electrons lies between 0 and 8 eV, but as other processes such as intra-cluster inelastic electron scattering generate an unstructured distribution of "secondary" electrons in this kinetic energy range, it is unlikely that simple non-coincident electron energy spectra will reveal an unambiguous signature of the ICD process. Thus, an electron-electron coincidence set-up was chosen in order to discriminate between low kinetic energy electrons emitted as a result of inner valence photoionization and secondary electrons resulting from scattering. A magnetic bottle type time-of-flight spectrometer was used to detect electrons of kinetic energies down to 100 meV from an acceptance solid angle of almost 4π sR. Experiments were performed in single bunch mode at the synchrotron radiation source BESSY II in Berlin. In the two-dimensional map of the figure the coincident events detected for any combination of photoelectron kinetic energy ($e_1$) and corresponding second electron kinetic energy ($e_2$) are shown. Random coincidences have been subtracted. The two red lines indicate the range of the photoelectron kinetic energies in which ICD electron-photoelectron pairs are expected. Integrating the number of events in this region leads to the energy spectrum of ICD shown in the top panel. Its shape is determined by a convolution of initial and final state energies. Calculations for small water clusters led to a similar spectrum, e.g. peaking at low kinetic energies. The red curve in the left graph displays the total number of coincidences for each photoelectron kinetic energy. Summing-up electron pairs of constant total energy (green line in the coincidence map) results in the green graph, corresponding final state energies being given on the left axis.

As expected, results obtained in technically identical measurements on water monomers, but not presented here, show no intensity in the ICD region because the latter needs two or more participating molecules in the form of a hydrogen-bonded cluster or in a condensed phase. In the case of clusters the high intensity feature at very low $e_2$-energies and around an $e_1$-energy of 14 eV in the figure does shift linearly with photon energy on the $e_1$-energy scale, but not in $e_2$. We can therefore definitely assign these transitions to the ICD of an inner valence vacancy. The origin of the considerable intensity of very low-kinetic energy electron-pairs could not yet be fully determined, but we assume that it partially results from scattering processes which release more than two electrons and partially from apparatus effects. In conclusion, we have demonstrated the existence of ICD in water for the first time. The low energetic electrons generated in this autoionization process may have to be considered for DNA damage produced by ionising radiation in tissue.

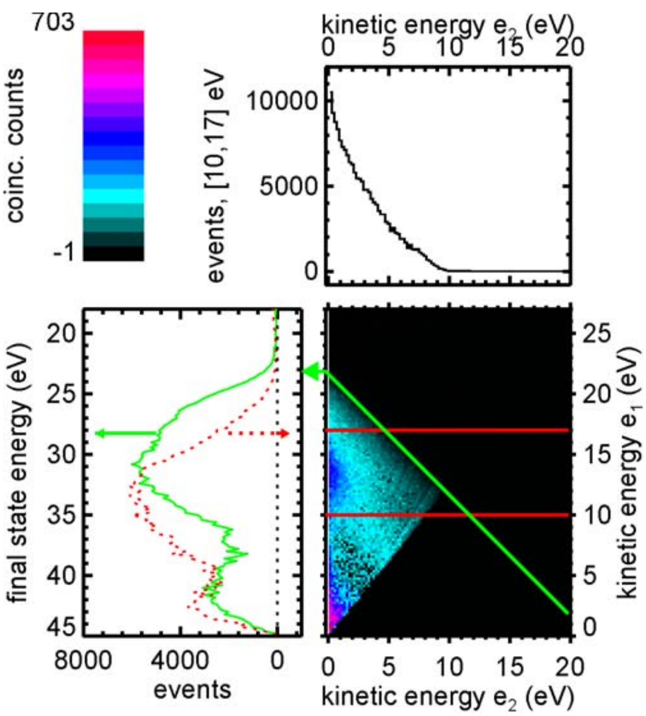



*Figure: Emission probability of coincident electron-electron pairs from free water clusters with a mean size of <N>=40 irradiated with 45 eV photons*

## Scientific Staff

M. Mucke, M. Förstel, T. Lischke, T. Arion (7-12/08), A. M. Bradshaw, U. Hergenhahn.

# University Contributions to IPP Programme

# Cooperation with Universities

Author: Dr. Axel Kampke

Many important goals in plasma physics, technology and materials science have to be attained on the way to a fusion power plant. Since this process will last another generation, IPP attaches great importance to training young scientists. Close interaction with universities in teaching and research is therefore an important part of IPP's mission. Moreover, joint projects with several universities form an integral part of IPP's research programme.

## Teaching and Mentoring

Since fusion-relevant physics and engineering are not the most prevalent subjects in Germany's academic landscape, IPP is interested in sparking students' interest in high-energy plasma physics and other fusion-relevant fields. Therefore, teaching at universities has a sound tradition at IPP. In 2008 members of IPP conducted 110 contact hours at universities or universities of applied sciences in Germany and neighbouring countries: Augsburg, Bayreuth, Berlin, Ghent, Greifswald, Helsinki, Mol, Munich, Tübingen, Ulm and Vienna.

Lecturing at and cooperation with universities is supplemented by IPP's Summer University in Plasma Physics: one week of lectures given by IPP staff and lecturers from partner institutes providing detailed tuition in nuclear fusion – in 2008 for the 23rd time at Garching. Most of the participants were from Europe – Austria, the Czech Republic, Germany, Greece, Hungary, Italy, Malta, Portugal, Rumania, Russia, Spain, Switzerland, Sweden, UK, Ukraine – some even from India and South Korea.

| Country | Postgraduates | | Postdocs | |
|---|---|---|---|---|
| | male | female | male | female |
| Australia | | | 1 | |
| Canada | 1 | | | |
| Chile | | 1 | | |
| France | | | 2 | |
| Germany | 27 | 5 | 11 | 1 |
| Hungary | 1 | | | |
| India | 1 | | 1 | 1 |
| Italy | 4 | 1 | 1 | |
| Netherlands | | | 1 | |
| New Zealand | 1 | | | |
| Poland | | | 1 | |
| Portugal | | | 1 | |
| Romania | | | 1 | 1 |
| Russia | 1 | | 1 | |
| Serbia | | | | 1 |
| Spain | | | 1 | |
| Ukraine | | | 4 | |
| United States of America | | | 1 | |
| | 36 | 7 | 27 | 4 |
| | 43 | | 31 | |

*Table: Countries of origin and sex of the 43 postgraduates and 31 postdocs at IPP (31.12.2008)*

The international character of fusion research is also reflected in the countries of origin of graduate students at IPP: a quarter of the postgraduates and 60 per cent of the postdocs are from abroad. The table shows the distribution with respect to country and sex of the 43 postgraduates and 31 postdocs at the end of 2008. A total of 62 postgraduates were supervised in 2008.

## Joint Appointments, Grown and Growing Cooperation

IPP cooperates closely with some universities in respect of joint appointments. But due to the retirement of seven Scientific Fellows within the last two years, at present there are joint appointments only with Greifswald University: Prof. Klinger and Prof. Helander as Scientific Fellows and Prof. Grulke whose junior professorship was recently extended into 2011. After Prof. Fußmann retired in 2007, the cooperation with the Humboldt-Universität zu Berlin was continued on a provisional arrangement that phases out in 2009. In the meantime IPP and the Technical University of Berlin reached an agreement that provides two joint appointments in the fields of plasma physics/stellarator optimisation and plasma astrophysics, respectively. Both positions are expected to be filled in 2009. Besides existing cooperation with the Technical University of Munich, joint appointments are in the definition phase. The best example of very close cooperation without joint appointments is that with Stuttgart University due to its essential contributions to development of heating systems for W7-X as well as for ITER. The development of a negative-ion source for the neutral-beam injection for ITER – awarded the Schrödinger Prize 2006 of the Helmholtz Association – is being continued with Augsburg University; re-orientation of further cooperation is in progress. With Bayreuth University, where Prof. Küppers worked on surface physics till he retired in September 2008, a future cooperation in plasma theory is more likely at the moment.

## Networking

In addition, IPP uses specific instruments developed by the Max Planck Society, the Helmholtz Association, Deutsche Forschungsgemeinschaft (DFG), Leibniz-Gemeinschaft or the German government for more intensive networking with universities on a constitutional basis – partly in conjunction with non-university research partners and industrial partners.

Organisation of or participation in graduate schools:

- the International Max Planck Research School on Bounded Plasmas at Greifswald in cooperation with Greifswald University,
- the International Leibniz Graduate School for Gravity Waves and Turbulence in the Atmosphere and Ocean started 2008 in cooperation with Leibniz Institute of Atmospheric Physics, Kühlungsborn, Leibniz Institute for Baltic Sea Research, Warnemünde, and Rostock University.

Young investigators groups:

- Max Planck Young Investigators Group, Turbulence in Magnetised Plasmas, headed by Dr. Wolf-Christian Müller-Nutzinger,
- Helmholtz Young Investigators Group, Computer-aided Materials Sciences, headed by Dr. Ralf Schneider, in cooperation with Greifswald University,
- Helmholtz Young Investigators Group, Theory and Ab Initio Simulation of Plasma Turbulence, headed by Dr. Frank Jenko, in cooperation with Münster University,
- European Young Investigator Award Group, Zonal Flows, headed by Dr. Klaus Hallatschek,
- Helmholtz Russia Joint Research Group, Hydrogen Isotopes Retention in First-Wall Materials for ITER and Fusion Power Reactors, headed by Dr. Matej Mayer as Helmholtz Principle Investigator and Dr. Anna V. Golubeva from Moscow Engineering and Physics Institute, which started its three years' work in April 2008.

Research partnerships:

- participation in the DFG Collaborative Research Centre Transregio 24, Fundamentals of Complex Plasmas, together with Greifswald University, Kiel University and Leibniz Institute for Plasma Science and Technology, Greifswald,
- Helmholtz Virtual Institute, Advanced ECRH for ITER, together with the Universities of Stuttgart and Karlsruhe and Karlsruhe Research Centre.

Participation in Clusters of Excellence in the context of the German government's Excellence Initiative in cooperation with Ludwig Maximilian's University and Technical University Munich:

- Munich Centre for Advanced Photonics, together with Universität der Bundeswehr München, Max Planck Institute of Quantum Optics, Max Planck Institute for Extraterrestrial Physics, Semiconductor Laboratory and Max Planck Institute of Biochemistry as scientific partners and Siemens AG/Healthcare as industrial partner,
- Origin and Structure of the Universe, together with Max Planck Institute for Astrophysics, Max Planck Institute for Extraterrestrial Physics, Semiconductor Laboratory and Max Planck Institute for Physics and the European Southern Observatory.

A few years after its formation IPP joined the European Fusion Development Agreement as a Euratom Association. When the decision was made to build ITER, it became clear that training of young scientists and engineers had to be intensified. A European Fusion Education Network (FUSENET) was therefore formed in FP7. FUSENET consists of 14 Euratom associations – one of them IPP – and 22 universities from 18 European countries and started work in November 2008. FUSENET shall provide education material and training opportunities in fusion science and technology covering all education levels, from secondary school through Bachelor and Master level to PhD.

# University of Augsburg
# Lehrstuhl für Experimentelle Plasmaphysik

**Head: Prof. Dr.-Ing. Ursel Fantz (acting)**

The research at the University of Augsburg focuses on the development and application of diagnostic methods for low temperature plasmas, in particular for negative hydrogen ion sources, and on studies of plasma-surface interaction processes. The work is carried out in close collaboration with several divisions of the IPP.

## Low Temperature Hydrogen Plasmas

Low temperature, low pressure plasmas with hydrogen (or deuterium) are generated by inductively rf heating, microwave heating and electron cyclotron resonance heating. The plasma sources operate in a wide range of pressure and input power covering a wide plasma parameter range. Investigations are carried out on basic atomic and molecular plasma physics, on the development and application of diagnostic methods with emphasis on applications to the cold plasma edge of ASDEX Upgrade and the negative ion source test facilities at IPP. The focus is laid on optical emission and absorption spectroscopy as non-invasive and easy-to-handle diagnostic methods.

In continuation of the investigations of the rf-driven positive hydrogen ion sources at the neutral beam injection systems at ASDEX Upgrade and at the high heat flux test facility GLADIS, the measured composition of the ion species has been started to be modelled by solving a 0-dim rate equation system. Figure 1 shows the relative densities of $H^+$, $H_2^+$ and $H_3^+$ as a function of electron density (corresponding to a power variation in the experiments) for two different molecular hydrogen densities, corresponding to a variation in pressure. As seen in the GLADIS experiment (typical electron density 2-5×$10^{17}$ $m^{-3}$) the $H_3^+$ density decreases with decreasing pressure and increasing power for the benefit of $H_2^+$ and $H^+$, respectively. The principle agreement allows the extrapolation to the parameter regime of negative hydrogen ion sources (lower pressure and higher power) where the densities of the positive ion species are important parameters in source optimisation but not accessible by available diagnostic techniques.

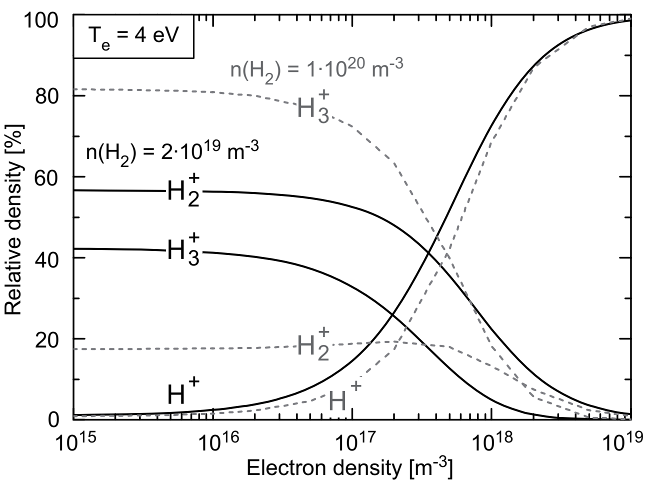



*Figure 1: Calculation of the positive ion composition in hydrogen plasmas for two different molecular hydrogen densities*

The verification of the collisional radiative (CR) model for molecular and atomic hydrogen has made remarkable progress. Vibrationally resolved measurements of molecular population densities have been carried out for three electronically excited states in the triplet and in the singlet system. The comparison with the CR model showed that in particular calculations for the triplet system depend strongly on the selected set of cross sections. Therefore, the determination of molecular densities in ion sources and in the divertor plasma of ASDEX Upgrade has been significantly improved using the adequate set of cross sections. In case of atomic hydrogen, the underlying cross sections for electron impact excitation of the ground state have been critically reviewed, initiated by discrepancies between measurements and calculations of $H_\gamma$ emission. As reported in the last years, the $H_\beta/H_\gamma$ line ratio is a suitable tool to obtain the line-of-sight integrated electron density. Figure 2 shows a comparison of electron densities measured by microwave interferometry and by a double Langmuir probe system with densities determined from measured $H_\beta/H_\gamma$ line ratio using the original and the improved CR model for the analysis. The verification of the improved model is an important step towards an online monitoring of the electron density in negative hydrogen ion sources.

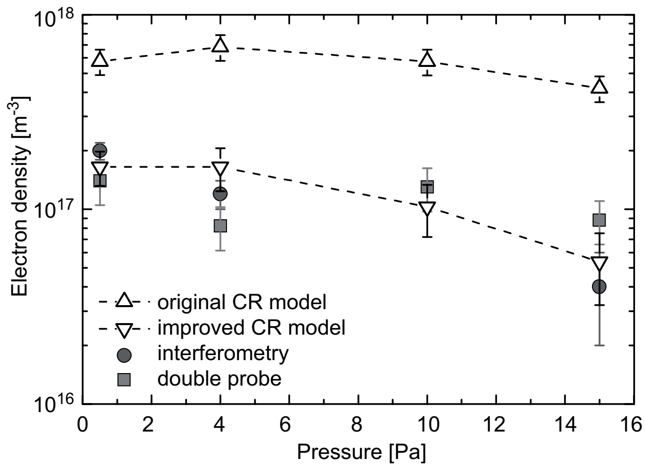



*Figure 2: Improvement of the CR model of atomic hydrogen for the determination of the electron density by comparison with results from other diagnostic techniques*

Since evaporation of cesium plays a key role in negative hydrogen ion sources for long pulse stability and uniformity of the negative ion density, basic investigations on the Cs dynamics in hydrogen plasmas are investigated. The amount of cesium in the source is currently measured solely during a discharge by emission spectroscopy. In order to investigate the dynamics of the cesium in the vacuum phase also, a light absorption diagnostic is currently in preparation. A first example of absorption spectra is shown in figure 3 where the principle feasibility of the method for relevant cesium densities is demonstrated in vacuum and also in plasma operation.

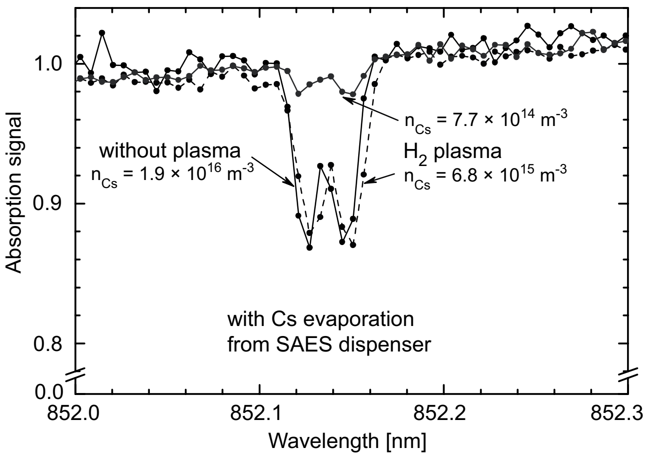



*Figure 3: Feasibility experiments on cesium absorption spectroscopy in vacuum and plasma operation*

The method has been successfully applied to follow the evaporation dynamics of Cs from alkali-metal dispensers and from the ovens used at IPP which is in particular important for better Cs control.

## Plasma Surface Interaction Studies

In strong collaboration with the materials research group at IPP, within the framework of the ExtreMat project, newly developed doped carbon materials were exposed to low pressure ICP deuterium plasmas and investigated with different diagnostic methods. In-situ measurements of the fluence resolved erosion yield were carried out by optical emission spectroscopy (CH and $C_2$ band emission) in combination with weight loss measurements. The incident particle fluxes towards the surface are well known from other diagnostic techniques. As shown in previous investigations doping of carbon leads to a reduction of the effective carbon surface and thus to a reduced erosion yield in hydrogen plasmas. Most commonly, the dopant material is present in the form of carbide grains inside of a graphite bulk material. Compared to ion beam experiments, the erosion yields are higher in plasmas due to the existence of atomic hydrogen which leads on the one hand to a synergistic effect of the erosion mechanisms. On the other hand an undercut is observed and therefore the uncontrollable drop off of carbide grains increases the weight loss.

Figure 4 shows an example of fluence resolved erosion yields of plasma treated final materials. A Ti-doped 3D-CFC material with a dopant concentration of ~0.5 at% (triangles) is compared to Ti-doped amorphous carbon (circles, Ti ~4 at%) and undoped graphite for two different surface temperatures at a fixed ion energy of 30 eV. All doped materials show a strong reduction of the erosion yield, depending on surface temperature and dopant concentration. The slope of the CFC-curve is smaller than the one of the bulk material due to a more inhomogeneous dopant distribution and lower concentration.

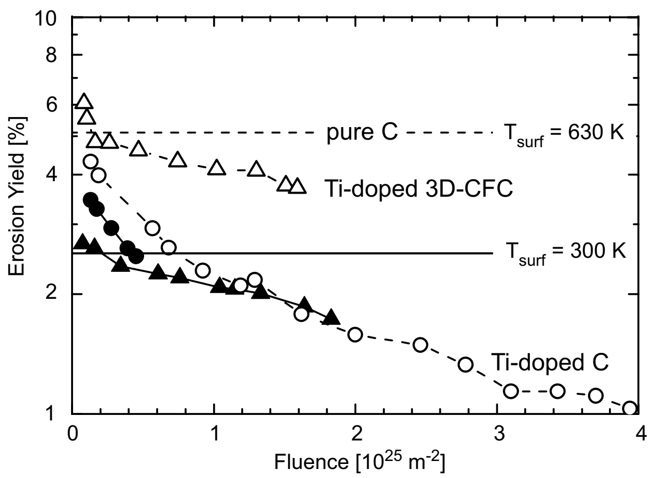



*Figure 4: Comparison of the erosion yields of different Ti-doped materials (from the ExtreMat project) with different surface temperatures in deuterium plasmas*

## Diploma Theses

A. Manhard: Spectroscopic studies on positive ion based neutral beam injection systems.
S. König: Untersuchungen der Eigenschaften cäsierter Oberflächen in Wasserstoffplasmen.
S. Briefi: Spektroskopische Diagnostik an HF-angeregten Niederdruckplasmen mit Indiumbromid.
D. Filimonov: Energieauflösende Massenspektrometrie an Wasserstoffplasmen in Wechselwirkung mit Kohlenstoffmaterialien.

## Scientific Staff

U. Fantz, P. Starke, S. Dietrich, S. Briefi, D. Filimonov, R. Friedl, S. König, A. Manhard, T. Maier, P. Schmidt, C. Wimmer.
Energy scenarios group: F. Botzenhart, J. Herrmann, T. Hartmann, B. Grotz.

# Humboldt-University of Berlin
# Arbeitsgruppe Plasmaphysik

**Head: Prof. Dr. Gerd Fußmann**

The research conducted by the plasma physics group at the Humboldt University focuses on basic plasma physics, plasma-material interactions and highly charged ions. Two experimental devices are available: The plasma generator PSI-2 and an electron beam ion trap EBIT. In 2008, investigations focused on the PSI-2 experiment.

In 2007 it was decided to reform the plasma physics group by integrating the EBIT personal at the PSI-2 experiment. After 12 years of successful operation, the EBIT was shut down in October 2007.

To complement earlier PSI-2 work, measurements were made of the ion velocity distribution function (ivdf) of $Ar^+$ ions at oblique plasma incidence. This item is of great relevance for nuclear fusion experiments since it is connected with the question of how particle and energy fluxes to plasma facing components can be spread over a large area. Theoretically, the problem was first addressed by Chodura (Phys. of Fluids **25**, 1628 (1982)) who has predicted supersonic streaming velocities in the so-called magnetic pre-sheath, a region between the usual sheath and the pre-sheath extending over several ion gyro-radii (12 mm). Measurements of the ivdf were made in an argon plasma ($n_e$=2.5·$10^{18}$ $m^{-3}$, $T_e$=3.3 eV, $T_i$=1.7 eV) using laser-induced fluorescence. From the results we infer that the streaming velocity u is significantly larger than the (isothermal) speed of sound $c_s=[(T_e+T_i)/m_i]^{1/2}$ in agreement with the prediction. However, the size of the magnetic pre-sheath is much smaller than predicted from the theoretical model and the streaming velocity was found to decrease much faster to subsonic values (Mach number $M=u/c_s<1$) as a function of distance from the target. It is likely that this disagreement is due to the effect of collisions which are ignored in the Chodura model.

To improve understanding of specific phenomena in the PSI-2 plasma generator, measurements were made of fast plasma fluctuations using optical emission spectroscopy. We have carried out these measurements in the shadow behind of a limiter inserted into the 8-cm-diameter plasma column. Earlier investigation of shadow effects in magnetized plasmas has disclosed an enhanced transport into the shadowed region. This could only be explained by relying on very high values for the perpendicular diffusion coefficient (D=4 $m^2$/s) indicating anomalous transport driven by turbulence. To confirm this assumption by experiments, we have inserted a rectangular tungsten limiter into an argon plasma and observed the edge region of the shadowed plasma. The emission from the plasma was recorded with high temporal and spatial resolution using a focusing optics attached to a multi-anode photomultiplier. Our measurements revealed different types of plasma fluctuations: Periodic fluctuations which originate from the rotation of the whole plasma column and, in addition turbulent fluctuations. The latter manifest in small blobs of plasma moving across the edge region into the plasma shadow. It is quite evident that the turbulent fluctuations result in a strong particle transport and thus might explain the density distribution measured in the shadow region behind limiters.

A further activity was visible spectroscopy of tungsten (W). Tungsten is foreseen as target or wall material in nuclear fusion devices and one issue of crucial importance is a thorough spectroscopic diagnostic of the W influx and the W content in the central fusion plasma. The tungsten influx into the plasma is generally determined from a measurement of a WI transition at 400.9 nm. However, this wavelength does not permit long transmission lines via optical fibres and thus an extension of the method to longer wavelengths is highly desirable. In search of appropriate WI lines and to study the tungsten spectrum in more detail, a variety of different measurements were performed on W targets exposed to helium and argon plasmas. Using a cooled tungsten block, a survey of the WI spectrum could be conducted as a function of the tungsten surface temperature $T_T$ (50-650 °C). The influence of $T_T$ was investigated by comparing line intensity ratios instead of absolute line intensities. The figure is an example showing data points for the line ratio R=I(400.9 nm)/I(498.3 nm) and the result from a calculation using a collisional-radiative (CR) model. The six lowest WI levels were assumed to be populated according to a Boltzmann distribution with a temperature $T_B$. $T_B$ was assessed by fitting the calculated line ratios to the experimental data assuming $T_B=\alpha\, T_T$. For the example in the figure, we find $\alpha$=1.6. This value close to one confirms that the sputtered tungsten atoms leave the surface in an excited state.

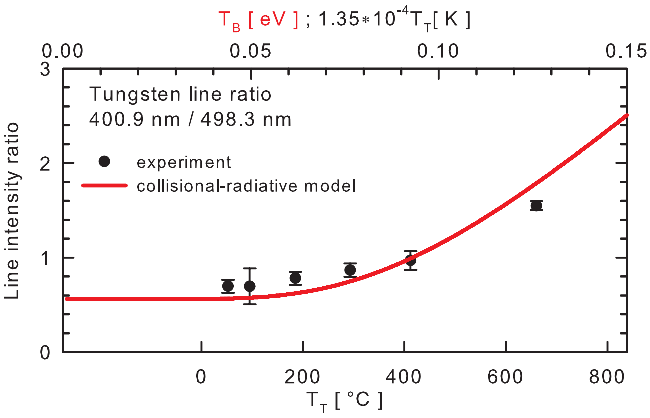



*Figure: Line ratio R=I(400.9 nm)/I(498.3 nm) as a function of the tungsten surface temperature $T_T$. The solid line represents a calculation using a CR model.*

## Scientific Staff

M. Baudach[1], C. Biedermann[2], W. Bohmeyer[2], T. Lunt[1], A. Markin[3], R. Radtke[2], O. Waldmann[2].

*[1]Humboldt University, Berlin, [2]IPP, Garching/Greifswald, [3]Ac. Sci. Inst. of Chemistry, Russia*

# Technical University of Munich
# Lehrstuhl für Messsystem- und Sensortechnik

**Head: Prof. Dr.-Ing. Alexander W. Koch**

The cooperation of IPP and Technische Universität München is concentrated on the field of thermography measurement techniques. Thermography is a means for contactless temperature measurement of a surface by monitoring the emitted infrared radiation. The heat flux calculation is improved by applying a jitter correction to the acquired temporal temperature evolution.

## Thermography Influenced by Jitter

At ASDEX Upgrade, thermographic measurements are used to monitor the surface temperature of in-vessel components during plasma discharges with one- and two-dimensional IR detectors. The power deposition to the components is calculated from the measured temperature evolution using the THEODOR code. In order to obtain correct heat flux calculations, it is necessary that always the same area is imaged on a pixel of the detector. This requirement is normally not fulfilled, since the recorded data is often affected by jitter. This fact leads to distorted power deposition results in case of temperature gradients on the monitored surfaces. The jitter can be in the subpixel range for normal operation parameters, for example due to vibrations of the vessel. During disruptions, when the energy stored in the plasma exits very fast and when it is therefore of great interest to know the heat load for safety reasons, the jitter is significant stronger. Also planned movements, for example strokes of probes mounted on the midplane manipulator, can be treated like jitter and must be considered for the power calculations.

## Jitter Correction

The jitter between two consecutive frames is normally less than one pixel. To be able to deal with this subpixel jitter, the recorded data is expanded by means of an interpolation, usually by a factor of ten in every dimension. Without this step it might happen that new artefacts are introduced to the calculated power deposition due to the correction, leading to even worse results than without correction. The determination of the jitter needs a reference that is assumed to be stationary. The chosen reference pattern must be a part of the observed structure and may not be a temperature pattern, since temperature patterns can move due to operation, for example the strike point in the divertor. These movements, caused by the plasma behaviour, should not be corrected. The position of the reference is detected by correlation analysis. For both 1D diagnostics, edges between tiles are imaged on the line cameras and can be used as reference points. A parabolic curve is shifted over the section of the line frame where the edge should be located, searching for the position of maximum correlation. For the 2D cameras, a reference region must be defined on the basis of the field of view. The detection of the maximum is performed using correlation tests and fine corrections. A correlation test is done for the unexpanded data to detect large deviations. These large jumps in data are unusual and are normally caused by errors, for example in the camera synchronization. To minimize the needed computing time for the following fine correction, the correlation is only calculated iterative for a 3×3 subpixel neighbourhood unless the maximum is in the centre. The position of the maximum correlation regarding the original position of the reference area is used as shifting value. After applying the shift, the data is confined to its original size.

## Example

The figure shows a short extract of the power deposition from one of the 1D cameras in the lower divertor of ASDEX Upgrade during shot 21372. The upper plot shows the result for power deposition calculation based on uncorrected temperature data. Using corrected temperature data gives the heat flux results shown in the lower plot. The jitter itself can be seen as a wavy pattern around position 1.16 m in the upper plot which has disappeared in the lower plot. For correction of 2D measurements similar results have been achieved. In a laboratory experiment, a CFC target was heated with a laser pulse of known power and temporal evolution. Without correction of the temperature data the calculated power deposition increased to values of up to twice as high as expected and also high negative values occurred. After applying the correction algorithm, the results were much more reasonable.

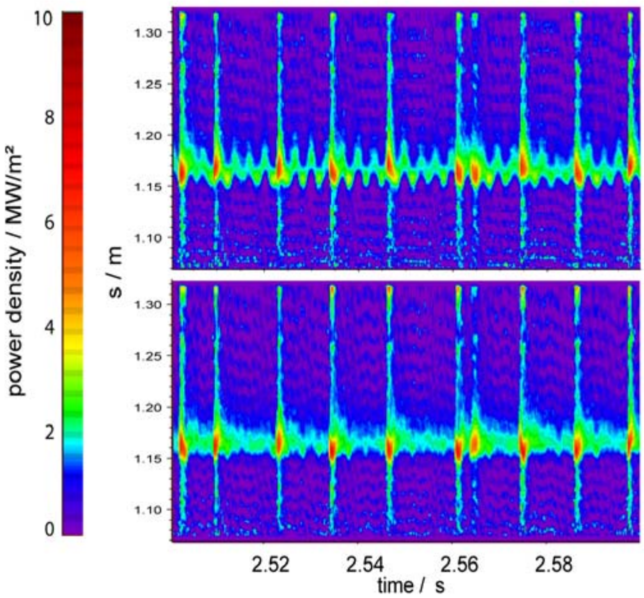



*Figure: Calculated power deposition without (top) and with (bottom) correction of the temperature data*

## Scientific Staff

M. Jakobi, P. de Marné.

# University of Stuttgart
# Institut für Plasmaforschung (IPF)

**Head: Prof. Dr. Ulrich Stroth**

The joint program between IPF and IPP on ECRH systems for ASDEX Upgrade, W7-X, and ITER can be found on the respective pages of this annual report. Here is summarized the part of the program carried out at IPF, which is the development of new mm-wave components, investigations of plasma waves and turbulent transport. Experiments are carried out on the torsatron TJ-K, which is operated with a magnetically confined low-temperature plasma.

## ECRH in Over-Dense Plasmas

The 2.45 GHz heating scenario in TJ-K has been intensively studied with the full-wave code IPF-FDMC. A clear enhancement in the wave electric field at the upper hybrid layer (UHR) has been found. It has also been found that the gap between the vacuum vessel wall and the plasma boundary acts as a kind of waveguide which distributes the incident microwave over the toroidal circumference of TJ-K. With monopole antennas, the enhancement at the UHR has been experimentally verified. In power-modulation experiments, the plasma breakdown has been directly observed with a multiple Langmuir probe array. It has been found that the breakdown happens at the fundamental resonance layer and that the position of the heating then moves to the plasma boundary. A net toroidal current of the order of 10 A has been found, which could be related to Bernstein-wave current drive.
A new operational regime at a magnetic field of 300 mT and a heating frequency of 2.45 GHz has been found. From the time-traces, shown in figure 1, it can be seen that the resonant 8.3 GHz is used to start the plasma. Switching on 2.45 GHz leads to additional heating even after the 8.3 GHz is turned off.

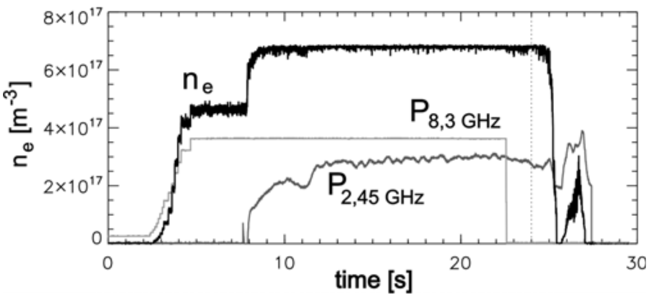



*Figure 1: Time traces of the new high-density regime in TJ-K*

The code IPF-FDMC has been used to optimize the O-X-B heating scenario in the TJ-II stellarator. It has been found that matching the curvature of the phase front of the incident microwave onto the conversion layer is an important parameter, which can highly increase the conversion efficiency. This is especially true for the heating scenario in the poloidal cross section of the 8.3 GHz in TJ-K. The strong plasma curvature here is non-optimal for mode conversion. Simulations with dielectric lenses in front of the antenna showed that the curvature of the incident microwave can be partially matched to the conversion layer and therefore increase the conversion efficiency. Numerical investigation of the O-X-B heating scenario in RFX-mod has been started, in order to explore the possibility and efficiency of this heating scenario.

## Global Turbulence and Confinement Studies

In 2008, the development and extension of Langmuir-probe electronics has been completed to supply 128 probes. A novel 128 probe array has been constructed to access fluctuations poloidally on four adjacent surfaces at the same time. The probes are arranged in such a way that the radial derivative of the turbulent Reynolds stress (RS) as a possible drive of turbulence generated zonal flows can be measured on the full poloidal circumference of a flux surface. First measurements point to the turbulent drive and the poloidal mean flow being substantially correlated on the low-field side of the plasma.

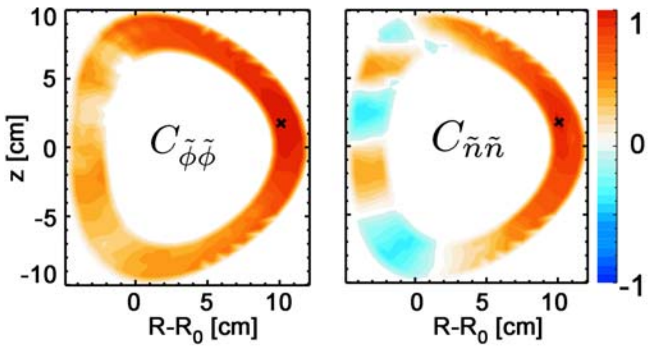



*Figure 2: Cross-correlation of potential and density fluctuations during biasing*

When strong shear flows are externally induced by plasma biasing, long-range correlations in low-frequency potential fluctuations, which are proposed as an indicator of zonal flows, are found to be strongly amplified with high correlation values over the entire flux surface (see figure 2, left). Density fluctuations, on the other hand, are dominated by an m=3 mode. For an appraisal of the RS, the poloidal momentum balance needs to be examined in a next step.
First experiments on the influence of the magnetic field geometry on the signatures of drift-wave turbulence have been carried out. Fluctuation levels in the density and the potential as well as turbulent transport are found to be poloidally asymmetric with maximum values in the region of unfavourable magnetic field curvature on the low-field side. Increased and decreased density-potential cross-phases are found on the low-field and high-field side, respectively, which points to the influence of curvature drive on drift-wave turbulence.
The global confinement and radial transport coefficients have been studied in experiments with heating-power modulation and during plasma start-up and switch-off phases.The diffusion coefficients are in agreement with those obtained from fluctuation measurements. Together with measured power-deposition

profiles, the data have been compared to a combined energy and particle balance. Equilibrium profiles can be described by means of the diffusion coefficients obtained from the switch-off phase.

## Optimisation of Horn Antennas

A code has been developed for optimising the geometry of horn antennas. It varies the taper geometry *r(z)* in order to maximize the overlap integral of the aperture field and the ideal Gaussian pattern. The calculation of the mode-conversion is done with the scattering matrix method or the coupled mode equation. The optimisation is done by a hybrid simulated annealing/downhill simplex method.
Various smooth wall horns have been designed and manufactured. Figure 3 shows the measured far-field of a horn at 160 GHz at a distance of 20 cm. One can see that side-lobes and cross polarisation are ≈ -30 dB, which agrees well with the calculation. For low-power applications smooth wall antennas (fed by a $TE_{11}$ waveguide) are preferred, because they can easily be manufactured. For high-power applications, corrugated horns are used, which are fed by a corrugated $HE_{11}$ waveguide. Such high-power horns are foreseen for the ITER upper launcher, where the improved coupling efficiency reduces the stray radiation in the launcher, and for integrating the quasi-optical FADIS variant into an $HE_{11}$ waveguide system.

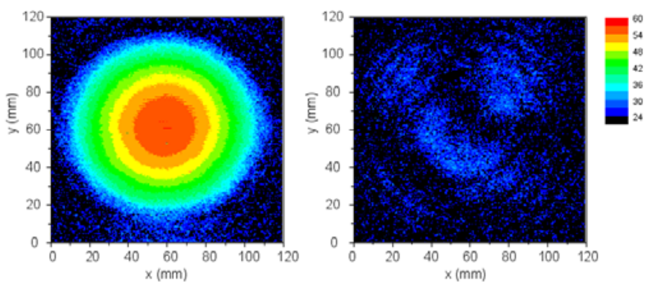



*Figure. 3: Measured far field of an optimised Gaussian beam antenna at 160 GHz in Co- (left) and cross-polarisation (right)*

## Metamaterial-Based Guiding Structures and Leaky-Wave Antennas

The concept of Composite Right-handed-Left-handed (CRLH) transmission lines is widely used for different microwave devices such as directional couplers, hybrid junctions and leaky-wave antennas. Most published designs are based on planar structures and there are very few studies that deal with waveguide structures capable of handling high power levels. Numerical investigations of waveguide based components were confirmed and the development of components for applications in plasma physics is underway.
Depending on the type of coupling (capacitive or inductive), the structure in the waveguide supports either the backward-wave propagation or the forward-wave propagation.

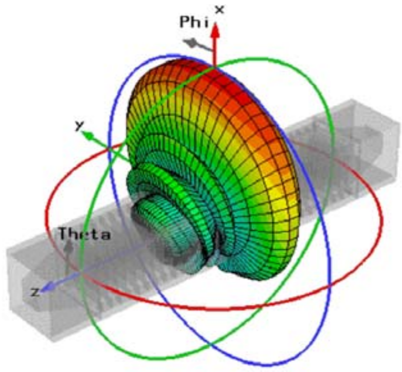



*Figure 4: Backward-wave based leaky-wave antenna with broadside radiation pattern*

If the guiding structure is optimized at the resonant frequency, the existence of a third mode of propagation becomes interesting: the mode with infinite wavelength. Combining that property with slots in the waveguide wall, line antennas with broadside direction of radiation can be designed.

## Characterization of the Coatings of Plasma Exposed Mirrors

Infrared reflection spectroscopy and measurements on surface roughness were performed to characterize coatings on mirror samples, which were exposed to plasma in fusion experiments. A possible source of enhanced absorption of the mirror is the roughness of the surface. The surface structure of the samples was investigated with a surface profile meter and by a scanning electron microscope. The measurements show no distinct difference between the two directions parallel and perpendicular to the plane of incidence. The irregular structure of the surface profile probably is caused by plasma interaction. The surface shows dents with transverse dimension of up to 100 µm. Furthermore, some depositions of particles are seen. These could originate from melted stainless steel parts, which were sputtered onto the surface. Furthermore, the surface coatings were analysed by Fourier-transform infrared reflection spectroscopy (FTIR) as well as electron dispersive X-ray spectroscopy (EDX). The spectrum from the sample nearest to the plasma during operation (L2) has the most pronounced structure. The analysis of the EDX spectra shows that the main elements, which are deposited on the surface, are boron and carbon. The elements nitrogen and oxygen stem from the long exposure in air, and presumably, iron and nickel are deposited from evaporation processes in the plasma. Silver is a contamination of the gold coating, which of course constitutes the major part of the surface components.

## Scientific Staff

P. Brand, G. Birkenmeier, E. Holzhauer, H. Höhnle, W. Kasparek, A. Köhn, H. Kumric, C. Lechte, P. Manz, B. Nold, B. Plaum, M. Ramisch, L. Stollenwerk, U. Stroth.

# Publications

# Publications

## Articles, Books and Inbooks


*Adelhelm, C., M. Balden, F. Kost, A. Herrmann and S. Lindig:* Thermal induced structural changes of a-C and a-C:Ti films analyzed by NEXAFS and XPS. Journal of Physics: Conference Series **100**, 062033 (2008).

*Adelhelm, C., R. Niessner, U. Pöschl and T. Letzel:* Analysis of large oxygenated and nitrated polycyclic aromatic hydrocarbons formed under simulated diesel engine exhaust conditions (by compound fingerprints with SPE/LC-API-MS). Analytical and Bioanalytical Chemistry **391**, 2599-2608 (2008).

*Aho-Mantila, L. K., T. Kurki-Suonio, A. V. Chankin, D. P. Coster and S. K. Sipilä:* ASCOT simulations of electron energy distribution at the divertor targets in an ASDEX Upgrade H-mode discharge. Plasma Physics and Controlled Fusion **50**, 065021 (2008).

*Alimov, V. K., J. Roth, R. A. Causey, D. A. Komarov, C. Linsmeier, A. Wiltner, F. Kost and S. Lindig:* Deuterium retention in tungsten exposed to low-energy, high-flux clean and carbon-seeded deuterium plasmas. Journal of Nuclear Materials **375**, 192-201 (2008).

*Alimov, V. K., J. Roth and S. Lindig:* Surface modifications and deuterium depth profiles in molybdenum irradiated with low-energy D ions. Journal of Nuclear Materials **381**, 267-270 (2008).

*Allen, F. I., C. Biedermann, R. Radtke, G. Fußmann and S. Fritzsche:* Energy dependence of angular momentum capture states in charge exchange collisions between slow highly charged argon ions and argon neutrals. Physical Review A **78**, 032705 (2008).

*Allouche, A. and C. Linsmeier:* Quantum study of tungsten interaction with beryllium (0001). Journal of Physics: Conference Series **117**, 012002 (2008).

*Alonso, A., P. Andrew, A. Neto, J. L. de Pablos, E. de la Cal, H. Fernandes, J. Gafert, P. Heesterman, C. Hidalgo, G. Kocsis, A. Manzanares, A. Murari, G. Petravich, L. Rios, C. Silva and P. D. Thomas:* Fast visible camera installation and operation in JET. Burning Plasma Diagnostics: An International Conference. (Eds.) G. Gorini, F. P. Orsitto, E. Sindoni, M. Tardocchi. AIP Conference Proceedings **988**. American Institute of Physics, Melville, NY, 185-188 (2008).

*Angelino, P., X. Garbet, T. Villard, A. Bottino, S. Jolliet, P. Ghendrih, V. Grandgirard, B. F. McMillan, Y. Sarazin, G. Dif-Pradalier and T. M. Tran:* The role of plasma elongation on the linear damping of zonal flows. Physics of Plasmas **15**, 062306 (2008).

*Angioni, C. and A.G. Peeters:* Gyrokinetic calculations of diffusive and convective transport of $\alpha$ particles with a slowing down distribution function. Physics of Plasmas **15**, 052307 (2008).

*Antar, G. Y., M. Tsalas, E. Wolfrum, V. Rohde and ASDEX Upgrade Team:* Turbulence during H- and L-mode plasmas in the scrape-off layer of the ASDEX Upgrade tokamak. Plasma Physics and Controlled Fusion **50**, 095012 (2008).

*Arnèodo, A., R. Benzi, J. Berg, L. Biferale, E. Bodenschatz, A. Busse, E. Calzavarini, B. Castaing, M. Cencini, L. Chevillard, R. T. Fisher, R. Grauer, H. Homann, D. Lamb, A. S. Lanotte, E. Lévèque, B. Lüthi, J. Mann, N. Mordant, W.-C. Müller, S. Ott, N. T. Oullette, J.-F. Pinton, S. B. Pope, S. G. Roux, F. Toschi, H. Xu and P. K. Yeung:* Universal Intermittent Properties of Particle Trajectories in Highly Turbulent Flows. Physical Review Letters **100**, 254504 (2008).

*Arshad, S. A., J. G. Cordey, D. C. McDonald, J. Farthing, E. Joffrin, M. von Hellerman, C. M. Roach and J. Svensson:* Chapter 11: Data Validation, Analysis, and Applications for Fusion Plasmas. Fusion Science and Technology **53**, 667-698 (2008).

*Artelt, C., M. Rott, W. Peukert, T. Höschen, K. Behringer and H. Bolt:* Particle generation in pulsed plasmas. Plasma Devices and Operations **16**, 11-24 (2008).

*Atanasiu, C. V., S. Günter, K. Lackner, A. Moraru, L. E. Zakharov and A. A. Subbotin:* The energy principle applied to diverted Tokamak configurations. Romanian Reports in Physics **60**, 635-646 (2008).

*Baldzuhn, J., H. Ehmler, L. Genini, K. Hertel, A. Hölting, C. Sborchia and T. Schild:* Cold Tests of the Superconducting Coils for the Stellarator W7-X. IEEE Transactions on Applied Superconductivity **18**, 509-512 (2008).

*Barradas, N. P., K. Arstila, G. Battistig, M. Bianconi, N. Dytlewski, C. Jeynes, E. Kotai, G. Lulli, M. Mayer, E. Rauhala, E. Szilagyi and M. Thompson:* Summary of "IAEA intercomparison of IBA software". Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms **266**, 1338-1342 (2008).

*Behler, K., H. Blank, H. Eixenberger, A. Lohs, K. Lüddecke, R. Merkel, G. Raupp, G. Schramm, W. Treutterer, M. Zilker and ASDEX Upgrade Team:* Real-time diagnostics at ASDEX Upgrade – Architecture and operation. Fusion Engineering and Design **83**, 304-311 (2008).

*Behringer, K. and T. Höschen:* Spectroscopic diagnostics of pulsed arc plasmas for particle generation. Contributions to Plasma Physics **48**, 561-568 (2008).

*Belonohy, E., O. J. W. F. Kardaun, T. Fehér, K. Gál, S. Kálvin, G. Kocsis, K. Lackner, P. T. Lang, J. Neuhauser and ASDEX Upgrade Team:* A high field side pellet penetration depth scaling derived for ASDEX Upgrade. Nuclear Fusion **48**, 065009 (2008).

*Belonohy, E., G. Pokol, K. McCormick, G. Papp, S. Zoletnik and W7-AS Team:* A Systematic Study of the Quasi-Coherent Mode in the High Density H-Mode Regime of Wendelstein 7-AS. PLASMA 2007: The International Conference Research and Application of Plasmas; 4th German-Polish Conference on Plasma Diagnostics for Fusion and Applications; 6th French-Polish Seminar on Thermal Plasma in Space and Laboratory. (Eds.) H.-J. Hartfuß, M. Dudeck, J. Musielok, M. J. Sadowski. AIP Conference Proceedings **993**. American Institute of Physics, Melville, NY, 39-42 (2008).

*Bergmann, A., E. Poli and A. G. Peeters:* Simulations of the bootstrap current in small rotating magnetic islands. Theory of Fusion Plasmas. (Eds.) O. Sauter, X. Garbet, E. Sindoni. AIP Conference Proceedings **1069**. American Institute of Physics, Melville, NY, 253-258 (2008).

*Bertelli, N., O. Maj, E. Poli, G. Pereverzev, Y. Peysson and J. Decker:* Analysis of the spectral width and validation of the LHBEAM code. Theory of Fusion Plasmas. (Eds.) O. Sauter, X. Garbet, E. Sindoni. AIP Conference Proceedings **1069**. American Institute of Physics, Melville, NY, 259-264 (2008).

*Beurskens, M. N. A., G. Arnoux, A. S. Brezinsek, C. D. Challis, P. C. de Vries, C. Grioud, A. Huber, S. Jachmich, K. McCormick, R. A. Pitts, F. G. Rimini, A. Alfier, E. de la Luna, W. Fundamenski, S. Gerasimov, E. Giovannozzi, E. Joffrin, M. Kempenaars, X. Litaudon, T. Loarer, P. Lomas, J. Mailloux, R. Pasqualotto, V. Pericoli-Ridolfini, R. Pugno, E. Rachlew, S. Saarelma, E. Solano, M. Walsh, L. Zabeo, K.-D. Zastrow and JET-EFDA Contributors:* Pedestal and ELM response to impurity seeding in JET advanced scenario plasmas. Nuclear Fusion **48**, 095004 (2008).

*Bilato, R. and M. Brambilla:* On the nature of "collisionless" Landau damping. Communications in Nonlinear Science and Numerical Simulation **13**, 18-23 (2008).

*Bizyukov, I., A. Mutzke, R. Schneider, A. Gigler and K. Krieger:* Morphology and changes of elemental surface composition of tungsten bombarded with carbon ions. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms **266**, 1979-1986 (2008).

*Blacksell, M., J. Wach, D. Anderson, J. Howard, B. D. Blackwell, D. Andruczyk and B. W. James:* Imaging photomultiplier array with integrated amplifiers and high-speed USB interface. Review of Scientific Instruments **79**, 10F506 (2008).

*Bluhm, T., R. Heimann, C. Hennig, H. Kroiss, G. Kühner, J. Maier, H. Riemann and M. Zilker:* Data access and its implementation at Wendelstein 7-X. Fusion Engineering and Design **83**, 387-392 (2008).

*Böhm, H. J. and S. Nogales:* Mori-Tanaka models for the thermal conductivity of composites with interfacial resistance and particle size distributions. Composites Science and Technology **68**, 1181-1187 (2008).

*Bolzonella, T., V. Igochine, S. C. Guo, D. Yadikin, M. Baruzzo and H. Zohm:* Resistive-Wall-Mode Active Rotation in the RFX-Mod Device. Physical Review Letters **101**, 165003 (2008).

*Bovshuk, V., A. Cooper, M. Mikhailov, J. Nührenberg and V. Shafranov:* Search for Very-High-β MHD Stable Quasi-Isodynamic Configurations. Plasma and Fusion Research **3**, S1046 (2008).

*Bozhenkov, S. A., M. Lehnen, K. H. Finken, M. W. Jakubowski, R. C. Wolf, R. Jaspers, M. Kantor, O. V. Marchuk, E. Uzgel, G. Van Wassenhove, O. Zimmermann, D. Reiter and TEXTOR Team:* Generation and suppression of runaway electrons in disruption mitigation experiments in TEXTOR. Plasma Physics and Controlled Fusion **50**, 105007 (2008).

*Bradshaw, A.:* Energy and Energy Research. Europhysics News **39**, 4-7 (2008).

*Bradshaw, A. M.:* Der Weg zu einer nachhaltigen Energiequelle: Die Erforschung der Kernfusion. Die Zukunft der Energie. Die Antwort der Wissenschaft. Ein Report der Max-Planck-Gesellschaft. (Eds.) P. Gruss, F. Schüth. Verlag C. H. Beck, München, 295-309 (2008).

*Busse, A. and W.-C. Müller:* Diffusion and dispersion in magnetohydrodynamic turbulence: The influence of mean magnetic fields. Astronomische Nachrichten **329**, 714-716 (2008).

*Cantarini, J., D. Hildebrandt, R. König, F. Klinkhamer, K. Moddemeijer, W. Vliegenthart and R. Wolf:* Optical design study of an infrared visible viewing system for Wendelstein 7-X divertor observation and control. Review of Scientific Instruments **79**, 10F513 (2008).

*Cantarini, J., J. P. Knauer and E. Pasch:* Design and Study of the Observation Optics for the Thomson Scattering System Planned at Wendelstein 7-X. PLASMA 2007: The International Conference Research and Application of Plasmas; 4th German-Polish Conference on Plasma Diagnostics for Fusion and

Applications; 6th French-Polish Seminar on Thermal Plasma in Space and Laboratory. (Eds.) H.-J. Hartfuß, M. Dudeck, J. Musielok, M. J. Sadowski. AIP Conference Proceedings **993**. American Institute of Physics, Melville, NY, 191-194 (2008).

*Carvalho, P. J., H. Thomsen, S. Gori, U. von Toussaint, J. Geiger, A. Weller, R. Coelho and H. Fernandes:* Comparison of fast tomographic methods for application on the Soft X-Ray Tomography System on Wendelstein 7-X stellarator. PLASMA 2007: The International Conference Research and Application of Plasmas; 4th German-Polish Conference on Plasma Diagnostics for Fusion and Applications; 6th French-Polish Seminar on Thermal Plasma in Space and Laboratory. (Eds.) H.-J. Hartfuß, M. Dudeck, J. Musielok, M. J. Sadowski. AIP Conference Proceedings **993**. American Institute of Physics, Melville, NY, 167-170 (2008).

*Carvalho, P. J., H. Thomsen, S. Gori, U. von Toussaint, A. Weller, R. Coelho, A. Neto, T. Pereira, C. Silva and H. Fernandes:* Fast tomographic methods for the tokamak ISTTOK. Plasma and Fucion Science: 17th IAEA Technical Meeting on Research Using Small Fusion Devices. (Eds.) C. Varandas, C. Silva. AIP Conference Proceedings **996**. American Institute of Physics, Melville, NY, 199-206 (2008).

*Chauhan, N., A. Mittal, D. Wagner, M. V. Kartikeyan and M. K. Thumm:* Design and Optimization of Nonlinear Tapers using Particle Swarm Optimization. International Journal of Infrared and Millimeter Waves **29**, 792-798 (2008).

*Constantinescu, D., O. Dumbrajs, V. Igochine and B. Weyssow:* On the accuracy of some mapping techniques used to study the magnetic field dynamics in tokamaks. Nuclear Fusion **48**, 024017 (2008).

*Conway, G. D.:* Turbulence measurements in fusion plasmas. Plasma Physics and Controlled Fusion **50**, 124026 (2008).

*Conway, G. D. and ASDEX Upgrade Team:* Amplitude behaviour of geodesic acoustic modes in the ASDEX Upgrade tokamak. Plasma Physics and Controlled Fusion **50**, 085005 (2008).

*Conway, G. D., C. Tröster, B. Scott, K. Hallatschek and ASDEX Upgrade Team:* Frequency scaling and localization of geodesic acoustic modes in ASDEX Upgrade. Plasma Physics and Controlled Fusion **50**, 055009 (2008).

*Cooper, A., J. P. Graves, S. P. Hirshman, P. Merkel, J. Kisslinger, H. F. G. Wobig, K. Y. Watanabe and Y. Narushima:* 3D Plasma Equilibrium and Stability with Hot Particle Anisotropic Pressure. Theory of Fusion Plasmas. (Eds.) O. Sauter, X. Garbet, E. Sindoni. AIP Conference Proceedings **1069**. American Institute of Physics, Melville, NY, 40-52 (2008).

*Corre, Y., E. Joffrin, P. Monier-Garbet, Y. Andrew, G. Arnoux, M. Beurskens, S. Brezinsek, M. Brix, R. Buttery, I. Coffey, K. Crombe, E. de la Luna, R. Felton, C. Giroud, S. Hacquin, J. Hobirk, A. Huber, F. Imbeaux, S. Jachmich, M. Kempenaars, X. Litaudon, H. Leggate, T. Loarer, G. Maddison, E. Rachlew, J. Rapp, O. Sauter, A. Savchkov, G. Telesca, A. Widdowson, K. D. Zastrow, O. Zimmermann and JET-EFDA Collaborators:* Hybrid H-mode scenario with nitrogen seeding and type III ELMs in JET. Plasma Physics and Controlled Fusion **50**, 115012 (2008).

*Cwilinski, A., A. Markin, M. Baudach and W. Bohmeyer:* Interaction between Nitrogen and Hydrocarbons in Magnetized Plasmas. PLASMA 2007: The International Conference Research and Application of Plasmas; 4th German-Polish Conference on Plasma Diagnostics for Fusion and Applications; 6th French-Polish Seminar on Thermal Plasma in Space and Laboratory. (Eds.) H.-J. Hartfuß, M. Dudeck, J. Musielok, M. J. Sadowski. AIP Conference Proceedings **993**. American Institute of Physics, Melville, NY, 399-402 (2008).

*Dannert, T., S. Günter, T. Hauff, F. Jenko, X. Lapillonne and P. Lauber:* Turbulent transport of beam ions. Physics of Plasmas **15**, 062508 (2008).

*D'Antona, G., S. Cirant, D. Farina, F. Gandini, E. Lazzaro, W. Treutterer and A. Mainic:* Algorithms for the Control of NTM by Localized ECRH. Principles and Requirements of the Real Time Diagnostic and Control System. Burning Plasma Diagnostics: An International Conference. (Eds.) G. Gorini, F. P. Orsitto, E. Sindoni, M. Tardocchi. AIP Conference Proceedings **988**. American Institute of Physics, Melville, NY, 450-453 (2008).

*De Temmermann, G., M. J. Baldwin, R. P. Doerner, D. Nishijima and K. Schmid:* An empirical scaling for deuterium retention in co-deposited beryllium layers. Nuclear Fusion **48**, 075008 (2008).

*De Vries, P. C., E. Joffrin, N. C. Hawkes, X. Litaudon, C. D. Challis, Y. Andrew, M. Beurskens, M. Brix, J. Brzozowski, K. Crombe, C. Giroud, J. Hobirk, T. Johnson, J. Jönnroth, A. Salmi, T. Tala, V. Yavorskij, K.-D. Zastrow and JET EFDA Contributors:* Effect of toroidal field ripple on the formation of internal transport barriers. Plasma Physics and Controlled Fusion **50**, 065008 (2008).

*Dieterich, P., R. Klages, R. Preuss and A. Schwab:* Anomalous dynamics of cell migration. PNAS – Proceedings of the National Academy of Sciences of the United States of America **105**, 459-463 (2008).

*Dinklage, A., B. Bruhn, H. Testrich and C. Wilke:* Hysteresis of ionization waves. Physics of Plasmas **15**, 063502 (2008).

*Dinklage, A., H. Dreier, R. Fischer, S. Gori, R. Preuss and U. von Toussaint:* Integrated Data Analysis for Fusion: A Bayesian Tutorial for Fusion Diagnosticians. Burning Plasma Diagnostics: An International Conference. (Eds.) G. Gorini, F. P. Orsitto, E. Sindoni, M. Tardocchi. AIP Conference Proceedings **988**. American Institute of Physics, Melville, NY, 471-480 (2008).

*Dodt, D., A. Dinklage, R. Fischer, K. Bartschat and O. Zatsarinny:* Form-Free Reconstruction of an Electron Energy Distribution Function from Optical Emission Spectroscopy. PLASMA 2007: The International Conference Research and Application of Plasmas; 4th German-Polish Conference on Plasma Diagnostics for Fusion and Applications; 6th French-Polish Seminar on Thermal Plasma in Space and Laboratory. (Eds.) H.-J. Hartfuß, M. Dudeck, J. Musielok, M. J. Sadowski. AIP Conference Proceedings **993**. American Institute of Physics, Melville, NY, 203-210 (2008).

*Dodt, D., A. Dinklage, R. Fischer, K. Bartschat, O. Zatsarinny and D. Loffhagen:* Reconstruction of an electron energy distribution function using integrated data analysis. Journal of Physics D: Applied Physics **41**, 205207 (2008).

*Dreier, H., A. Dinklage, R. Fischer, M. Hirsch and P. Kornejew:* Bayesian experimental design of a multichannel interferometer for Wendelstein 7-X. Review of Scientific Instruments **79**, 10E712 (2008).

*Dreier, H., A. Dinklage, R. Fischer, M. Hirsch and P. Kornejew:* Comparative studies to the design of the interferometer at W7-X with respect to technical boundary conditions. PLASMA 2007: The International Conference Research and Application of Plasmas; 4th German-Polish Conference on Plasma Diagnostics for Fusion and Applications; 6th French-Polish Seminar on Thermal Plasma in Space and Laboratory. (Eds.) H.-J. Hartfuß, M. Dudeck, J. Musielok, M. J. Sadowski. AIP Conference Proceedings **993**. American Institute of Physics, Melville, NY, 183-186 (2008).

*Dumbrajs, O., V. Igochine, H. Zohm and ASDEX Upgrade Team:* Diffusion in a stochastic magnetic field in ASDEX Upgrade. Nuclear Fusion **48**, 024011 (2008).

*Eckstein, W.:* Sputtering Yields. Vacuum **82**, 9, 930-934 (2008).

*Eich, T. and A. Werner:* Numerical studies on radiative heat loads to plasma-facing components for the W7-X stellarator. Fusion Science and Technology **53**, 761-779 (2008).

*Eremin, D. Yu.:* Unstable drift-kinetic Alfvén modes with helicity close to the rotational transform. Plasma Physics and Controlled Fusion **50**, 095005 (2008).

*Eule, S., R. Friedrich and F. Jenko:* Anomalous transport in a one-dimensional Lorentz gas model. Journal of Chemical Physics **129**, 174308 (2008).

*Evans, T. E., M. E. Fenstermacher, R. A. Moyer, T. H. Osborne, J. G. Watkins, P. Gohil, I. Joseph, M. J. Schaffer, L. R. Baylor, M. Becoulet, J. A. Boedo, K. H. Burrell, J. S. DeGrassie, K. H. Finken, T. Jernigan, M. W. Jakubowski, C. J. Lasnier, M. Lehnen, A. W. Leonard, J. Lonnroth, E. Nardon, V. Parail, O. Schmitz, B. Unterberg and W. P. West:* RMP ELM suppression in DIII-D plasmas with ITER similar shapes and collisionalities. Nuclear Fusion **48**, 024002 (2008).

*Fable, E., C. Angioni and O. Sauter:* Gyrokinetic calculations of steady-state particle transport in electron internal transport barriers. Plasma Physics and Controlled Fusion **50**, 115005 (2008).

*Fable, E., C. Angioni and O. Sauter:* Parametric dependence of particle pinch coefficients for electron particle transport in linear gyrokinetic theory. Theory of Fusion Plasmas. (Eds.) O. Sauter, X. Garbet, E. Sindoni. AIP Conference Proceedings **1069**. American Institute of Physics, Melville, NY, 64-75 (2008).

*Falchetto, G. L., B. D. Scott, P. Angelino, A. Bottino, T. Dannert, V. Grandgirard, S. Janhunen, F. Jenko, S. Jolliet, A. Kendl, B. F. McMillan, V. Naulin, A. H. Nielsen, M. Ottaviani, A. G. Peeters, M. J. Pueschel, D. Reiser, T. T. Ribeiro and M. Romanelli:* The European turbulence code benchmarking effort: turbulence driven by thermal gradients in magnetically confined plasmas. Plasma Physics and Controlled Fusion **50**, 124015 (2008).

*Fantz, U., P. Franzen, W. Kraus, H. D. Falter, M. Berger, S. Christ-Koch, M. Fröschle, R. Gutser, B. Heinemann, C. Martens, P. McNeely, R. Riedl, E. Speth and D. Wünderlich:* Low Pressure and High Power RF Sources for Negative Hydrogen Ions for Fusion Applications (ITER neutral beam injection) (invited). Review of Scientific Instruments **79**, 02A511 (2008).

*Fantz, U. and D. Wünderlich:* Effective rate coefficients for molecular processes of hydrogen and hydrocarbons in edge plasmas. Atomic and Plasma-Material Interaction Data for Fusion (APID Series), Vol. 14. (Ed.) R. E. H. Clark. International Atomic Energy Agency, Vienna, 56-63 (2008).

*Fattorini, L., P. T. Lang, M. E. Manso, J. Santos, L. D. Horton, G. D. Conway and ASDEX Upgrade Team:* High temporal and spatial resolution reflectometry investigations of type-I ELMs induced edge barrier collapse at ASDEX Upgrade. Plasma Physics and Controlled Fusion **50**, 125001 (2008).

*Feng, Y., M. Kobayashi, T. Morisaki, S. Masuzaki, J. Miyazawa, B. J. Peterson, S. Morita, M. Shoji, K. Ida, I. Yamada, K. Narihara, N. Ashikawa, H. Yamada, N. Ohyabu, A. Komori, O. Morojima, F. Sardei, D. Reiter and LHD Experimental Group:* Fluid features of the stochastic layer transport in LHD. Nuclear Fusion **48**, 024012 (2008).

*Finken, K. H., T. E. Evans, D. Reiter, K. H. Spatschek and W. Suttrop:* Summary of the third workshop on Stochasticity in Fusion Plasmas (SFP) (Jülich, Germany, 5-7 March 2007). Nuclear Fusion **48**, 024001 (2008).

*Fischer, R., E. Wolfrum, J. Schweinzer and ASDEX Upgrade Team:* Probalistic lithium beam data analysis. Plasma Physics and Controlled Fusion **50**, 085009 (2008).

*Ford, O., J. Svensson, A. Boboc, D. C. McDonald and JET-EFDA Contributors:* Forward modeling of JET polarimetry diagnostic. Review of Scientific Instruments **79**, 10F324 (2008).

*Franzen, P., U. Fantz, W. Kraus, M. Berger, S. Christ-Koch, M. Fröschle, R. Gutser, B. Heinemann, C. Martens, F. Maisberger, P. McNeely, R. Riedl, E. Speth, D. Wünderlich and T. Zacharias:* The IPP RF Source: A High Power, Low Pressure Negative Ion Source for the Neutral Beam Injection System of ITER. PLASMA 2007: The International Conference Research and Application of Plasmas; 4th German-Polish Conference on Plasma Diagnostics for Fusion and Applications; 6th French-Polish Seminar on Thermal Plasma in Space and Laboratory. (Eds.) H.-J. Hartfuß, M. Dudeck, J. Musielok, M. J. Sadowski. AIP Conference Proceedings **993**. American Institute of Physics, Melville, NY, 51-54 (2008).

*Fülöp, T., I. Pusztai and P. Helander:* Collisionality dependence of the quasilinear particle flux due to microinstabilities. Physics of Plasmas **15**, 072308 (2008).

*Fundamenski, W., D. P. Coster, M. Airila, P. Belo, X. Bonnin, A. Chankin, G. Corrigan, S. K. Erents, O. E. Garcia, S. Glowacz, B. Gulejova, A. Kirschner, V. Naulin, A. Nielsen, G. Kirnev, V. Kotov, C. Konz, J. J. Rasmussen, R. A. Pitts, D. Reiter, T. Ribeiro, B. D. Scott, J. D. Strachan, F. Subba, E. Tsitrone, D. Tskhakabaya, S. Wiesen, M. Wischmeier, R. Zagórski and EFDA-JET Contributors:* Progress in Edge Plasma Transport Modeling on JET. Contributions to Plasma Physics **48**, 190-195 (2008).

*Fußmann, G.:* Künstlicher Kugelblitz. Leuchtende Plasmabälle im Labor. Physik in unserer Zeit **39**, 5, 246-252 (2008).

*Gál, K., E. Belohnohy, G. Kocsis, P. T. Lang, G. Veres and ASDEX Upgrade Team:* Role of shielding in modelling cryogenic deuterium pellet ablation. Nuclear Fusion **48**, 085005 (2008).

*Gál, K., T. Fehér, H. Smith, T. Fülöp and P. Helander:* Runaway electron generation during plasma shutdown by killer pellet injection. Plasma Physics and Controlled Fusion **50**, 055006 (2008).

*Garcia-Munoz, M., H.-U. Fahrbach, S. Günter, V. Igochine, M. J. Mantsinen, M. Maraschek, P. Martin, P. Piovesan, K. Sassenberg and H. Zohm:* Fast-Ion Losses due to High-Frequency MHD Perturbations in the ASDEX Upgrade Tokamak. Physical Review Letters **100**, 055005 (2008).

*Görler, T. and F. Jenko:* Multiscale features of density and frequency spectra from nonlinear gyrokinetics. Physics of Plasmas **15**, 102508 (2008).

*Görler, T. and F. Jenko:* Scale separation between electron and ion thermal transport. Physical Review Letters **100**, 185002 (2008).

*Gormezano, C., C. D. Challis, E. Joffrin, X. Litaudon and A. C. C. Sips:* Advanced Tokamak Scenario Development at JET. Fusion Science and Technology **53**, 958-988 (2008).

*Graswinckel, M. F., W. A. Bongers, M. R. De Baar, M. A. van den Berg, G. Denisov, A. J. H. Donne, B. S. Q. Elzendoorn, A. P. H. Goede, R. Heidinger, S. Kuzikov, O. G. Kruijt, B. Kruizinger, A. Moro, E. Poli, D. M. S. Ronden, G. Saibene and D. J. Thoen:* Advanced launcher design options for electron cyclotron current drive on ITER based on remote steering. Nuclear Fusion **48**, 054015 (2008).

*Greiche, A., W. Biel, O. Marchuk and R. Burhenn:* Absolute intensity calibration of the Wendelstein 7-X high efficiency extreme ultraviolet overview spectrometer system. Review of Scientific Instruments **79**, 093504 (2008).

*Grulke, O., S. Ullrich, T. Windisch and T. Klinger:* Spatio-temporal dynamics of drift wave turbulence in a helicon discharge. PLASMA 2007: The International Conference Research and Application of Plasmas; 4th German-Polish Conference on Plasma Diagnostics for Fusion and Applications; 6th French-Polish Seminar on Thermal Plasma in Space and Laboratory. (Eds.) H.-J. Hartfuß, M. Dudeck, J. Musielok, M. J. Sadowski. AIP Conference Proceedings **993**. American Institute of Physics, Melville, NY, 87-92 (2008).

*Günter, S., P. Lauber, P. Merkel, M. Sempf, E. Strumberger, D. Tekle and K. Lackner:* Three-dimensional effects in tokamaks. Plasma Physics and Controlled Fusion **50**, 124004 (2008).

*Günter, S. and I. Milch:* Fusionsplasmen im magnetischen Käfig. Welt der Physik (2008). http://www.weltderphysik.de/de/6772.php

*Gurbich, A. F., I. Bogdanovic-Radovic, M. Chiari, C. Jeynes, M. Kokkoris, A. R. Ramos, M. Mayer, E. Rauhala, O. Schwerer, Shi Liqun and I. Vickridge:* Status of the problem of nuclear cross section data for IBA. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms **266**, 1198-1202 (2008).

*Hartfuß, H.-J., M. Dudeck, J. Musielok and M. J. Sadowski (Eds.):* PLASMA 2007: The International Conference Research and Application of Plasmas; 4th German-Polish Conference on Plasma Diagnostics for Fusion and Applications; 6th French-Polish Seminar on Thermal Plasma in Space and Laboratory. AIP Conference Proceedings **993**. American Institute of Physics, Melville, NY, 472 p. (2008).

*Harting, D., D. Reiter, Y. Feng, O. Schmitz, D. Reiser and H. Ferichs:* 3D edge transport studies with EMC3-EIRENE for the Dynamic Ergodic Divertor (DED) at TEXTOR. Contributions to Plasma Physics **48**, 99-105 (2008).

*Hartmann, D. A.:* Stellarators. Fusion Science and Technology **53**, 2T, 44-55 (2008).

*Hatzky, R., R. Tisma and R. Lederer:* Joint Research Activities – Plasma physics. DEISA Advancing Science in Europe. (Eds.) V. Alessandrini, H. Lederer, A. Streit, S. Värttö, G. J. Pringle. 74-75 (2008).

*Hauff, T. and F. Jenko:* Mechanisms and scalings of energetic ion transport via tokamak microturbulence. Physics of Plasmas **15**, 112307 (2008).

*Heimann, P., T. Bluhm, C. Hennig, H. Kroiss, G. Kühner, J. Maier, H. Riemann and M. Zilker:* Database structures and interfaces for W7-X. Fusion Engineering and Design **83**, 393-396 (2008).

*Helander, P. and A. Simakov:* Intrinsic Ambipolarity and Rotation in Stellarators. Physical Review Letters **101**, 145003 (2008).

*Henderson, M. A., R. Heidinger, D. Strauss, R. Bertizzolo, A. Bruschi, R. Chavan, E. Ciattaglia, S. Cirant, A. Collazos, I. Danilov, F. Dolizy, J. Duron, D. Farina, U. Fischer, G. Gantenbein, G. Hailfinger, W. Kasparek, K. Kleefeldt, J.-D. Landis, A. Meier, A. Moro, P. Platania, B. Plaum, E. Poli, G. Ramponi, G. Saibene, F. Sanchez, O. Sauter, A. Serikov, H. Shidara, C. Sozzi, P. Spaeh, V. S. Udintsev, H. Zohm and C. Zucca:* Overview of the ITER EC upper launcher. Nuclear Fusion **48**, 054013 (2008).

*Hennig, C., A. Werner, M. Marquardt, T. Bluhm, H. Kroiss, G. Kühner, P. Heimann, J. Maier, H. Riemann and M. Zilker:* Continuous data acquisition with online analysis for the Wendelstein 7-X magnetic diagnostics. Fusion Engineering and Design **83**, 2-3, 321-325 (2008).

*Heyn, M. F., I. B. Ivanov, S. V. Kasilov, W. Kernbichler, I. Joseph, R. A. Moyer and A. M. Runov:* Kinetic estimate of the shielding of resonant magnetic field perturbations by the plasma in DIII-D. Nuclear Fusion **48**, 024005 (2008).

*Hirsch, M., J. Baldzuhn, C. Beidler, R. Brakel, R. Burhenn, A. Dinklage, H. Ehmler, M. Endler, V. Erckmann, Y. Feng, J. Geiger, L. Giannone, G. Grieger, P. Grigull, H.-J. Hartfuß, D. Hartmann, R. Jaenicke, R. König, H. Laqua, H. Maaßberg, K. McCormick, F. Seidei, E. Speth, U. Stroth, F. Wagner, A. Weller, A. Werner, S. Zoletnik and W7-AS Team:* Major results from the stellarator Wendelstein 7-AS (Review Article). Plasma Physics and Controlled Fusion **50**, 053001 (2008).

*Hölzl, M., S. Günter and ASDEX Upgrade Team:* Heat diffusion across magnetic islands and ergodized plasma regions in realistic tokamak geometry. Physics of Plasmas **15**, 072514 (2008).

*Hopf, C., W. Jacob and V. Rohde:* Oxygen glow discharge cleaning in nuclear fusion devices. Journal of Nuclear Materials **374**, 413-421 (2008).

*Hopf, C., M. Schlüter and W. Jacob:* Chemical sputtering of a-C:H films by simultaneous exposure to energetic $Ar^+$ ions and water vapor. Journal of Physics: Conference Series **100**, 062012 (2008).

*Hopf, C., M. Schlüter, T. Schwarz-Selinger, U. von Toussaint and W. Jacob:* Chemical sputtering of carbon films by simultaneous irradiation with argon ions and molecular oxygen. New Journal of Physics **10**, 093022 (2008).
http://www.iop.org/EJ/abstract/1367-2630/10/5/053037

*Horton, L. D.:* Physics Issues for Demo. Fusion Science and Technology **53**, 2T, 468-473 (2008).

*Hoshino, K., M. Toma, A. Hatayama, D. P. Coster, X. Bonnin, R. Schneider, H. Kawashima, N. Asakura and Y. Suzuki:* Benchmarking Kinetic and Fluid Neutral Models with Drift Effects. Contributions to Plasma Physics **48**, 136-140 (2008).

*Hoshino, M., R. Montuoro, R. R. Lucchese, A. De Fanis, U. Hergenhahn, G. Prümper, T. Tanaka, H. Tanaka and K. Ueda:* Vibrationally resolved partial cross sections and asymmetry parameters for nitrogen K-shell photoionization of the NO molecule. Journal of Physics B: Atomic, Molecular and Optical Physics **41**, 085105 (2008).

*Hynönen, V., T. Kurki-Suonio, W. Suttrop, A. Stäbler and ASDEX Upgrade Team:* Effect of radial electric field and ripple edge neutral beam ion distribution in ASDEX Upgrade. Plasma Physics and Controlled Fusion **50**, 035014 (2008).

*Igenbergs, K., J. Schweinzer, I. Bray, D. Bridi and F. Aumayr:* Database for inelastic collisions of sodium atoms with electrons, protons, and multiply charged ions. Atomic Data and Nuclear Data Tables **94**, 981-1014 (2008).

*Igochine, V., O. Dumbrajs, H. Zohm and ASDEX Upgrade Team:* Transition from quasiperiodicity to chaos just before sawtooth crash in the ASDEX Upgrade tokamak. Nuclear Fusion **48**, 062001 (2008).

*Ikeda, K., K. Nagaoka, Y. Takeiri, U. Fantz, O. Kaneko, M. Osakabe, Y. Oka and K. Tsumori:* Optical measurement of Cs distribution in the large negative ion source. Review of Scientific Instruments **79**, 02A518 (2008).

*Ikkurthi, R., K. Matyash, A. Melzer and R. Schneider:* Computation of dust charge and potential on a static spherical dust grain immersed in rf discharges. Physics of Plasmas **15**, 123704 (2008).

*Ikkurthi, V. R., K. Matyash, R. Schneider and A. Melzer:* Study of effect of grain size on dust charging in an RF plasma using three-dimensional PIC-MCC simulations. PLASMA 2007: The International Conference Research and Application of Plasmas; 4$^{th}$ German-Polish Conference on Plasma Diagnostics for Fusion and Applications; 6$^{th}$ French-Polish Seminar on Thermal Plasma in Space and Laboratory. (Eds.) H.-J. Hartfuß, M. Dudeck, J. Musielok, M. J. Sadowski. AIP Conference Proceedings **993**. American Institute of Physics, Melville, NY, 83-86 (2008).

*Ionita, C., P. Balan, T. Windisch, C. Brandt, O. Grulke, T. Klinger and R. Schrittwieser:* New Results on a Laser-Heated Emissive Probe. Contributions to Plasma Physics **48**, 453-460 (2008).

*Jenzsch, H., A. Cardella, J. Reich, W. Gardebrecht, M. Bednarek, P. Sanchez and M. Schrader:* Final design and manufacturing of the Cryolegs of the W7-X-superconducting coil support system. Fusion Engineering and Design **83**, 1600-1604 (2008).

*Jiménez-Rey, D., B. Zurro, G. García, A. Baciero, L. Rodríguez-Barquero and M. García-Muñoz:* Ionoluminescent response of several phosphor screens to keV ions of different masses. Journal of Applied Physics **104**, 064911 (2008).

*Jiménez-Rey, D., B. Zurro, J. Guasp, M. Liniers, A. Baciero, M. García-Muñoz, A. Fernández, G. García, L. Rodríguez-Barquero and J. M. Fontdecaba:* A flexible luminescent probe to monitor fast ion losses at the edge of the TJ-II stellarator. Review of Scientific Instruments **79**, 093511 (2008).

*Joseph, I., T. E. Evans, A. M. Runov, M. E. Fenstermacher, M. Groth, S. V. Kasilov, C. J. Lasnier, R. A. Moyer, G. D. Porter, M. J. Schaffer, R. Schneider and J. G. Watkins:* Calculation of stochastic thermal transport due to resonant magnetic perturbations in DIII-D. Nuclear Fusion **48**, 045009 (2008).

*Kallenbach, A., R. Dux, T. Eich, R. Fischer, L. Giannone, J. Harhausern, A. Herrmann, H. W. Müller, G. Pautasso, M. Wischmeier and ASDEX Upgrade Team:* Divertor power and particle fluxes between and during type-I ELMs in the ASDEX Upgrade. Nuclear Fusion **48**, 085008 (2008).

*Kammerer, M., F. Merz and F. Jenko:* Exceptional Points in Linear Gyrokinetics. Physics of Plasmas **15**, 052102 (2008).

*Kardaun, O., K. Thomsen and A. Chudnovskiy:* Corrigenda. Correction to a sequence of papers in Nuclear Fusion. Nuclear Fusion **48**, 099801 (2008).

*Kasparek, W., M. Petelin, D. Shchegolkov, V. Erckmann, B. Plaum, A. Bruschi, ECRH Groups at IPP Greifswald, FZK Karlsruhe and IPF Stuttgart:* A fast switch, combiner and narrow-band filter for high-power millimetre wave beams. Nuclear Fusion **48**, 054010 (2008).

*Kervalishvili, G. N., P. Kleiber, R. Schneider, B. D. Scott, O. Grulke and T. Windisch:* Intermittent turbulence in the linear VINETA device. Contributions to Plasma Physics **48**, 32-36 (2008).

*Kiptily, G., D. Borba, F. E. Cecil, M. Cecconello, D. Darrow, V. Golobrod'ko, K. Hill, T. Johnson, A. Murari, F. Nabais, S. D. Pinches, M. Reich, S. E. Sharapov, V. Yavorskij, I. N. Chugunov, D. B. Gin, G. Gorini, A. E. Shevelev, D. B. Syme and V. Zoitam:* Fast ion JET diagnostics: confinement and losses. Burning Plasma Diagnostics: An International Conference. (Eds.) G. Gorini, F. P. Orsitto, E. Sindoni, M. Tardocchi. AIP Conference Proceedings **988**. American Institute of Physics, Melville, NY, 283-290 (2008).

*Kirk, A., N. Asakura, J. A. Boedo, M. Beurskens, G. F. Counsell, T. Eich, W. Fundamenski, A. Herrmann, Y. Kamada, A. W. Leonard, S. Lisgo, A. Loarte, N. Oyama, R. A. Pitts, A. Schmid and H. R. Wilson:* Comparison of the spatial and temporal structure of type-I ELMs. Journal of Physics: Conference Series **123**, 012011 (2008).

*Kirk, A., A. Herrmann, B. Ayed, T. Eich, H. W. Müller, G. F. Counsell, S. Lisgo, M. Price, A. Schmid, S. Tallents and H. Wilson:* Comparison of the filament behaviour observed during type I ELMs in ASDEX Upgrade and MAST. Journal of Physics: Conference Series **123**, 012012 (2008).

*Knözinger, H. and E. Taglauer:* Spreading and Wetting. Handbook of Heterogeneous Catalysis, Vol. 1. (Eds.) G. Ertl, H. Knözinger, F. Schüth, J. Weikamp. Wiley-VCH, Weinheim, 555-571 (2008).

*Kobayashi, M., Y. Feng, S. Masuzaki, T. Morisaki, N. Ohyabu, H. Yamada, A. Komori, O. Motoyima and LHD Experimental Group:* Modelling of Impurity Transport in Ergodic Layer of LHD. Contributions to Plasma Physics **48**, 255-259 (2008).

*Könies, A., A. Mishchenko and R. Hatzky:* From kinetic MHD in stellarators to a fully kinetic description of wave particle interaction. Theory of Fusion Plasmas. (Eds.) O. Sauter, X. Garbet, E. Sindoni. AIP Conference Proceedings **1069**. American Institute of Physics, Melville, NY, 133-143 (2008).

*König, R., J. Cantarini, H. Dreier, V. Erckmann, D. Hildebrandt, M. Hirsch, G. Kocsis, P. Kornejew, M. Laux, H. Laqua, E. Pasch, S. Recsei, V. Szabó, H. Thomsen, A. Weller, A. Werner, R. Wolf, M. Y. Ye and S. Zoletnik:* Diagnostic developments for quasi-continuous operation of the Wendelstein 7-X stellarator. Review of Scientific Instruments **79**, 10F337 (2008).

*Kolesnichenko, Y., V. V. Lutsenko, A. Weller, A. Werner, Y. Yakovenko and J. Geiger:* On low frequency Alvén instabilities in stellarators. Ukrainian Journal of Physics **53**, 477-481 (2008).

*Kotov, V., D. Reiter, R. A. Pitts, S. Jachmich, A. Huber, D. Coster and JET EFDA Contributors:* Numerical modelling of high density JET divertor plasma with the SOLPS4.2 (B2-EIRENE) code. Plasma Physics and Controlled Fusion **50**, 105012 (2008).

*Kraus, W., H.-D. Falter, U. Fantz, P. Franzen, B. Heinemann, P. McNeely, R. Riedl and E. Speth:* Long pulse large area beam extraction with an RF driven H-/D- source. Review of Scientific Instruments **79**, 02C108 (2008).

*Kravtsov, Yu. A., B. Bieg, K. Yu. Bliokh and M. Hirsch:* Basic Theoretical Methods in Microwave Plasma Polarimetry: Quasi-Isotropic Approximation, Stokes Vector Formalism and Complex Polarization Angle Method. PLASMA 2007: The International Conference Research and Application of Plasmas; 4th German-Polish Conference on Plasma Diagnostics for Fusion and Applications; 6th French-Polish Seminar on Thermal Plasma in Space and Laboratory. (Eds.) H.-J. Hartfuß, M. Dudeck, J. Musielok, M. J. Sadowski. AIP Conference Proceedings **993**. American Institute of Physics, Melville, NY, 143-150 (2008).

*Kreter, A., S. Brezinsek, T. Hirai, A. Kirschner, K. Krieger, M. Mayer, V. Philipps, A. Pospieszczyk, U. Samm, O. Schmitz, B. Schweer, G. Sergienko, K. Sugiyama, T. Tanabe, Y. Ueda, P. Wienhold and TEXTOR Team:* Effect of surface roughness and substrate material on carbon deposition in tokamak TEXTOR. Plasma Physics and Controlled Fusion **50**, 095008 (2008).

*Krychowiak, M., D. Dodt, H. Dreier, R. König and R. Wolf:* Development of a virtual $Z_{eff}$ diagnostic for the W7-X stellarator. Review of Scientific Instruments **79**, 10F512 (2008).

*Krychowiak, M., Ph. Mertens, R. König, B. Schweer, S. Brezinek, O. Schmitz, M. Brix, U. Samm and T. Klinger:* LIF measurements on an atomic helium beam in the edge of a fusion plasma. Plasma Physics and Controlled Fusion **50**, 065015 (2008).

*Krychowiak, M., Ph. Mertens, B. Schweer, S. Brezinsek, R. König, O. Schmitz, M. Brix, U. Samm and T. Klinger:* LIF measurements on an atomic helium beam in the edge of a fusion plasma – possible derivation of the electron density. PLASMA 2007: The International Conference Research and Application of Plasmas; 4th German-Polish Conference on Plasma Diagnostics for Fusion and Applications; 6th French-Polish Seminar on Thermal Plasma in Space and Laboratory. (Eds.) H.-J. Hartfuß, M. Dudeck, J. Musielok, M. J. Sadowski. AIP Conference Proceedings **993**. American Institute of Physics, Melville, NY, 179-182 (2008).

*Kudyakov, T., K. H. Finken, M. Jakubowski, M. Lehnen, Y. Xu, B. Schweer, T. Toncian, G. Van Wassenhove, O. Willi and TEXTOR Team:* Spatially and temporally resolved measurements of runaway electrons in the TEXTOR tokamak. Nuclear Fusion **48**, 122002 (2008).

*Kudyakov, T., K.H. Finken, M. Jakubowski, M. Lehnen, Y. Xu and O. Willi:* Spectral measurements of runaway electrons by a scanning probe in the TEXTOR tokamak. Review of Scientific Instruments **79**, 10F126 (2008).

*Kurihara, K., J. B. Lister, D. A. Humphrey, J. R. Ferron, W. Treutterer, F. Sartori, R. Felton, S. Brémond, P. Moreau and JET EFDA Contributors:* Plasma control systems relevant to ITER and fusion power plants. Fusion Engineering and Design **83**, 959-970 (2008).

*Kus, A., A. Dinklage, R. Preuss, E. Ascasibar, J. H. Harris, S. Okamura, F. Sano, U. Stroth, J. Talmadge and H. Yamada:* Cluster Analysis of the International Stellarator Confinement Database. PLASMA 2007: The International Conference Research and Application of Plasmas; 4th German-Polish Conference on Plasma Diagnostics for Fusion and Applications; 6th French-Polish Seminar on Thermal Plasma in Space and Laboratory. (Eds.) H.-J. Hartfuß, M. Dudeck, J. Musielok,

M. J. Sadowski. AIP Conference Proceedings **993**. American Institute of Physics, Melville, NY, 47-50 (2008).

*Kus, A., A. Krüger, A. Dinklage, T. Bluhm, C. G. Hanke, G. Kühner, A. Werner, C. Hennig, J. Geiger, M. Lewerentz, Y. Turkin and W7-X Team:* Unified software repositories for Wendelstein 7-X: Workflow elements for fusion software development. Fusion Engineering and Design **83**, 410-412 (2008).

*Lackner, K.:* Dimensionless engineering variables for measuring the ITER and reactor relevance of TOKAMAK experiments. Fusion Science and Technology **54**, 989-993 (2008).

*Lackner, K.:* 50 Jahre Fusionsforschung für den Frieden. Plasmaphysik und Fusionsforschung an der Universität Innsbruck 1958-2008. (Ed.) A. Kendl. Science Live & Exhibitions. Innsbruck University Press, Innsbruck, 81-93 (2008).

*Lässer, R., E. Diegele, J. L. Boutard and A. Peacock:* The long term development of fusion materials in the EU: achievements and open issues. Journal of Optoelectronics and Advanced Materials **10**, 727-731 (2008).

*Lalousis, P. J., L. L. Lengyel and R. Schneider:* Two ('plus one')-dimensional simulation of pellet cloud evolution in the poloidal plane with a prescribed neutral particle source strength. Plasma Physics and Controlled Fusion **50**, 085001 (2008).

*Lang, P. T., K. Lackner, A. Kallenbach, M. Maraschek, C. P. Perez von Thun, W. Suttrop and ASDEX Upgrade Team:* Investigation of Pellet-Triggered MHD Events in the ASDEX Upgrade. Plasma Physics Reports **34**, 771-775 (2008).

*Lang, P. T., K. Lackner, M. Maraschek, B. Alper, E. Belonohy, K. Gál, J. Hobirk, A. Kallenbach, S. Kálvin, G. Kocsis, C. P. Perez von Thun, W. Suttrop, T. Szepesi, R. Wenninger, H. Zohm, ASDEX Upgrade Team and JET-EFDA Contributors:* Investigation of pellet-triggered MHD events in ASDEX Upgrade and JET. Nuclear Fusion **48**, 095007 (2008).

*Lapillonne, X., T. Dannert, S. Brunner, A. Marioni, S. Jolliet, L. Villard, F. Jenko, T. Görler and F. Merz:* Effects of geometry on linear and non-linear gyrokinetic simulations, and development of a global version of the GENE code. Theory of Fusion Plasmas. (Eds.) O. Sauter, X. Garbet, E. Sindoni. AIP Conference Proceedings **1069**. American Institute of Physics, Melville, NY, 289-294 (2008).

*Lasker, B. M., M. G. Lattanzi, B. J. McLean, B. Bucciarelli, R. Drimmel, J. Garcia, G. Greene, F. Guglielmetti, C. Hanley, G. Hawkins, V. G. Laidler, C. Loomis, M. Meakes, R. Mignani, R. Morbidelli, J. Morrison, R. Pannunzio, A. Rosenberg, M. Sarasso, R. L. Smart, A. Spagna, C. R. Sturch, A. Volpicelli, R. L. White, D. Wolfe and A. Zacchei:* The Second-Generation Guide Star Catalog: Description and Properties. The Astronomical Journal **136**, 735-766 (2008).

*Lauber, P. and S. Günter:* Damping and drive of low frequency modes in tokamak plasmas. Nuclear Fusion **48**, 084002 (2008).

*Lederer, H.:* DEISA2: Supporting and developing a European high-performance computing ecosystem. Journal of Physics: Conference Series **125**, 011003 (2008).

*Lederer, H., H.-G. Hegering, T. Lippert and M. Resch:* DECI – The DEISA Extreme Computing Initiative. Inside **7**, 42-43 (2008).

*Lederer, H. and S. Heinzel:* DEISA to enhance the European HPC Infrastructure in FP7. Inside **6**, 40 (2008).

*Lee, G. S., Y.-S. Na, A. Becoulet, S. Ide, C. E. Kessel, A. Komori, B. V. Kuteev, G. Mank, R. A. Olstad, B. Sarkar, A. C. C. Sips, D. van Houtte and V. L. Vdovin:* Summary of the 5th IAEA Technical Meeting on Steady State Operation of Magnetic Fusion Devices (Daejeon, Republic of Korea, 14-17 May 2007). Nuclear Fusion **48**, 087001 (2008).

*Lehnen, M., S. A. Bozhenkov, S. S. Abdullaev, TEXTOR Team and M. W. Jakubowski:* Suppression of Runaway Electrons by Resonant Magnetic Perturbations in TEXTOR Disruptions. Physical Review Letters **100**, 255003 (2008).

*Lengyel, L., R. Schneider, O. J. W. F. Kardaun, R. Burhenn, H. P. Zehrfeld, I. Yu. Veselova, I. Yu. Senichenkov, V. A. Rozhansky and P. J. Lalousis:* Pellet-Plasma Interaction: an Analysis of Pellet Injection Experiments by Means of a Multi-Dimensional MHD Pellet Code. Contributions to Plasma Physics **48**, 623-656 (2008).

*Levchuk, D., H. Bolt, M. Döbeli, S. Eggenberger, B. Widrig and J. Ramm:* Al-Cr-O thin films as an efficient hydrogen barrier. Surface and Coatings Technology **202**, 5043-5047 (2008).

*Linsmeier, C.:* Verlustleistung abführen: Einsatztemperaturen von über 2000 °C sind geplant. elektrotechnik (2008). http://www.elektrotechnik.vogel.de/strategie-unternehmensfuehrung/articles/110649/?ACMP=DMC-beleg

*Linsmeier, C., C. Garcia-Rosales, F. Simancik, N. Baluc and C. Gualco:* Pushing the limit. Materials World **16**, 10, (2008).

*Lizunov, A., P. Bagryansky, Y. Khilchenko, Yu. V. Kovalenko, A. Solomakhin, W. Biel, H. T. Lambertz, Yu. Krasikov, M. Mitri, B. Schweer and H. Dreier:* Development of a multichannel dispersion interferometer at TEXTOR. Review of Scientific Instruments **79**, 10E708 (2008).

*Lorenzetto, P., B. Boireau, C. Boudot, Ph. Bucci, P. E. Frayssines, A. Furmanek, P. Hajek, O. Gillia, A. Peacock, I. Ricapito, M. Roedig, P. Sherlock, F. Schmalz and S. Tähtinen:* Status of the EU R&D programme on the blanket-shield modules for ITER. Fusion Engineering and Design **83**, 1015-1019 (2008).

*Lunt, T., G. Fußmann and O. Waldmann:* Experimental Investigation of the Plasma-Wall Transition. Physical Review Letters **100**, 175004 (2008).

*Manz, P., M. Ramisch, U. Stroth, V. Naulin and B. D. Scott:* Bispectral experimental estimation of the nonlinear energy transfer in two-dimensional plasma turbulence. Plasma Physics and Controlled Fusion **50**, 035008 (2008).

*Marsen, S., M. Otte and F. Wagner:* Three Dimensional Structure of Turbulence in the WEGA Stellarator. Contributions to Plasma Physics **48**, 467-472 (2008).

*Marushchenko, N. B., H. Maaßberg and Y. Turkin:* Electron cyclotron current drive calculated for ITER conditions using different models. Nuclear Fusion **48**, 054002 (2008).

*Matyash, K., R. Schneider, R. Sydora and F. Taccogna:* Application of a Grid-Free Kinetic Model to the Collisionless Sheath. Contributions to Plasma Physics **48**, 116-120 (2008).

*Maya, P. N., U. Von Toussaint and C. Hopf:* Synergistic erosion process of hydrocarbon films: a molecular dynamics study. New Journal of Physics **10**, 023002 (2008).
http://www.iop.org/EJ/abstract/1367-2630/10/2/023002

*Mayer, M.:* RESOLNRA: A new program for optimizing the achievable depth resolution of ion beam analysis methods. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms **266**, 1852-1857 (2008).

*McDonald, D. C., L. Laborde, J. C. DeBoo, F. Ryter, M. Brix, C. D. Challis, P. de Vries, C. Giroud, J. Hobirk, D. Howell, E. Joffrin, T. C. Luce, J. Mailloux, V. Pericoli-Ridolfini, A. C. C. Sips, K. Thomsen and JET EFDA Contributors:* JET confinement studies and their scaling to high $\beta_N$, ITER scenarios. Plasma Physics and Controlled Fusion **50**, 124013 (2008).

*McMillan, B. F., S. Jolliet, T. M. Tran, L. Villard, A. Bottino and P. Angelino:* Long global gyrokinetic simulations: Source terms and particle noise control. Physics of Plasmas **15**, 052308 (2008).

*Meister, H., L. Giannone, L. D. Horton, G. Raupp, W. Zeidner, G. Grunda, S. Kalvin, U. Fischer, A. Serikov, S. Stickel and R. Reichle:* The ITER bolometer diagnostic – Status and plans. Review of Scientific Instruments **79**, 10F511 (2008).

*Menzel, A., N. Estrella, W. Heitland, A. Susnik, C. Schleip and V. Dose:* Bayesian analysis of the species-specific lengthening of the growing season in two European countries and the influence of an insect pest. International Journal of Biometeorology **52**, 209-218 (2008).

*Meo, F., H. Bindslev, S. B. Korsholm, V. Furtula, F. Leuterer, F. Leipold, P. K. Michelsen, S. K. Nielsen, M. Salewski, J. Stober, D. Wagner and P. Woskov:* Commissioning activities and first results from the collective Thomson scattering diagnostic on ASDEX Upgrade (invited). Review of Scientific Instruments **79**, 10E501 (2008).

*Merz, F. and F. Jenko:* Nonlinear saturation of trapped electron modes via perpendicular particle diffusion. Physical Review Letters **100**, 035005 (2008).

*Milch, I.:* Fusionsreaktoren. Physik Oberstufe. Gesamtband Kursstufe – Schülerbuch mit CD-ROM. (Eds.) B. Diehl, R. Erb, C. Schmalhofer, L. H. Schön, P. Tillmanns, R. Winter. Cornelsen Verlag, Berlin, 405 (2008).

*Milch, I.:* Sonnenfeuer im Labor. Exzellente Forschung in Bayern. Bayerisches Staatsministerium für Wissenschaft, Forschung und Kunst, München, 68-74 (2008).

*Mishchenko, A., R. Hatzky and A. Könies:* Global particle-in-cell simulations of Alfvénic modes. Physics of Plasmas **15**, 112106 (2008).

*Mishchenko, A., R. Hatzky and A. Könies:* Global particle-in-cell simulations of Alfvénic modes. Theory of Fusion Plasmas. (Eds.) O. Sauter, X. Garbet, E. Sindoni. AIP Conference Proceedings **1069**. American Institute of Physics, Melville, NY, 301-306 (2008).

*Mishchenko, A., P. Helander and A. Könies:* Collisionless dynamics of zonal flows in stellarator geometry. Physics of Plasmas **15**, 072309 (2008).

*Mishchenko, A., P. Helander and A. Könies:* Collisionless dynamics of zonal flows in stellarator geometry. Theory of Fusion Plasmas. (Eds.) O. Sauter, X. Garbet, E. Sindoni. AIP Conference Proceedings **1069**. American Institute of Physics, Melville, NY, 165-175 (2008).

*Miskiewicz, M. and J. H. You:* Impact of plastic softening of over-aged CuCrZr alloy heat sink tube on the structural reliability of a plasma-facing component. Fusion Engineering and Design **83**, 66-71 (2008).

*Missal, B., A. Cardella, M. Schrader, T. Koppe and P. Friedrich:* Mechanical experiments about pendulum support of vacuum vessel W7-X. Fusion Engineering and Design **83**, 1610-1613 (2008).

*Momeni, M. and W.-C. Müller:* Probability distributions of turbulent energy. Physical Review E **77**, 056401 (2008).

*Murari, A., J. Vega, A. Alonso, E. De LaLuna, J. Farthing, C. Hidalgo, G. A. Rattá, J. Svensson and G. Vagliasindi:* How to Extract Information and Knowledge from Fusion Massive Databases. Burning Plasma Diagnostics: An International Conference. (Eds.) G. Gorini, F. P. Orsitto, E. Sindoni, M. Tardocchi. AIP Conference Proceedings **988**. American Institute of Physics, Melville, NY, 457-470 (2008).

*Mutzke, A. and W. Eckstein:* Ion fluence dependence of the Si sputtering yield by noble gas ion bombardment. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms **266**, 872-876 (2008).

*Naulin, V., T. Windisch and O. Grulke:* Three-dimensional global fluid simulations of cylindrical magnetized plasmas. Physics of Plasmas **15**, 012307 (2008).

*Neu, R., R. Dux, A. Kallenbach and ASDEX Upgrade Team:* Plasma operation with high-Z environment. Journal of Physics: Conference Series **100**, 062001 (2008).

*Neuhauser, J., V. Bobkov, G. D. Conway, R. Dux, T. Eich, M. Garcia-Munoz, A. Herrmann, L. D. Horton, A. Kallenbach, S. Kalvin, G. Kocsis, B. Kurzan, P. T. Lang, M. Maraschek, H. W. Müller, H. D. Murmann, R. Neu, A. G. Peeters, M. Reich, V. Rohde, A. Schmid, W. Suttrop, M. Tsalas, E. Wolfrum and ASDEX Upgrade Team:* Structure and dynamics of spontaneous and induced ELMs on ASDEX Upgrade. Nuclear Fusion **48**, 045005 (2008).

*Noack, S., A. Versteegh, B. Jüttner and G. Fußmann:* Analysis of Long-living Plasmoids at Atmospheric Pressure. PLASMA 2007: The International Conference Research and Application of Plasmas; 4$^{th}$ German-Polish Conference on Plasma Diagnostics for Fusion and Applications; 6$^{th}$ French-Polish Seminar on Thermal Plasma in Space and Laboratory. (Eds.) H.-J. Hartfuß, M. Dudeck, J. Musielok, M. J. Sadowski. AIP Conference Proceedings **993**. American Institute of Physics, Melville, NY, 129-132 (2008).

*Nogales, S. and J. Böhm:* Modeling of the thermal conductivity and thermomechanical behavior of diamond reinforced composites. International Journal of Engineering Science **46**, 606-619 (2008).

*Noterdaeme, J. M., L. G. Eriksson, M. Mantsinen, M. L. Mayoral, D. Van Eester, J. Mailloux, C. Gormezano and T. Jones:* Physics Studies with the Additional Heating Systems in JET. Fusion Science and Technology **53**, 1103-1151 (2008).

*Nührenberg, J., R. Zille, M. I. Mikhailov and V. D. Shafranov:* Neoclassical Transport in Stellarators without Collisionless Ion Loss. Plasma Physics Reports **34**, 525-527 (2008).

*Ogorodnikova, O. V., J. Roth and M. Mayer:* Ion-driven deuterium retention in tungsten. Journal of Applied Physics **103**, 034902 (2008).

*Ogorodnikova, O. V., J. Roth and M. Mayer:* Pre-implantation and pre-annealing effects on deuterium retention in tungsten. Journal of Nuclear Materials **373**, 254-258 (2008).

*Otte, M., D. Andruczyk, E. Holzhauer, J. Howard, R. König, L. Krupnik, H. P. Laqua, O. Lischtschenko, S. Marsen, J. Schacht, J. Urban, Y. Y. Podoba, J. Preinhalter, F. Wagner, G. B. Warr and A. Zhezhera:* The WEGA Stellarator: Results and Prospects. PLASMA 2007: The International Conference Research and Application of Plasmas; 4$^{th}$ German-Polish Conference on Plasma Diagnostics for Fusion and Applications; 6$^{th}$ French-Polish Seminar on Thermal Plasma in Space and Laboratory. (Eds.) H.-J. Hartfuß, M. Dudeck, J. Musielok, M. J. Sadowski. AIP Conference Proceedings **993**. American Institute of Physics, Melville, NY, 3-10 (2008).

*Pereverzev, G. V. and G. Corrigan:* Stable numeric scheme for diffusion equation with a stiff transport. Computer Physics Communication **179**, 579-585 (2008).

*Perez von Thun, C., M. Maraschek, S. Da Graca, R. J. Buttery, A. Herrmann, J. Stober, G. Conway, T. Eich, J. C. Fuchs, L. D. Horton, V. Igochine, A. Kallenbach, A. Loarte, H. W. Müller, I. Nunes, G. Saibene, R. Sartori, A. C. C. Sips, W. Suttrop, E. Wolfrum and ASDEX Upgrade Team:* Identifying the MHD signature and power deposition characteristics associated with type-II ELMs in ASDEX Upgrade. Plasma Physics and Controlled Fusion **50**, 065018 (2008).

*Pfeiffer, F., A. Broicher, T. Gillich, K. Klee, J. Mejía, M. Rampp and D. Oesterhelt:* Genome information management and integrated data analysis with HaloLex. Archives of Microbiology **190**, 281-299 (2008).

*Piovesan, P., V. Igochine, P. Lauber, K. Sassenberg, A. Flaws, M. Garcia-Munoz, S. Günter, M. Maraschek, L. Marrelli, P. Martin, P. J. McCarthy and AUG Team:* TAE internal structure through high-resolution soft x-ray measurements in ASDEX Upgrade. Nuclear Fusion **48**, 065001 (2008).

*Podoba, Y., M. Otte, F. Wagner, I. Bondarenko, A. Chmyga, G. Deshko, A. Komarov, A. Kozachek, L. Krupnik, S. Khrebtov, A. Zhezhera, A. Melnikov, S. Perfilov and M. Schubert:* First HIBP results on the WEGA Stellarator. PLASMA 2007: The International Conference Research and Application of Plasmas; 4th German-Polish Conference on Plasma Diagnostics for Fusion and Applications; 6th French-Polish Seminar on Thermal Plasma in Space and Laboratory. (Eds.) H.-J. Hartfuß, M. Dudeck, J. Musielok, M. J. Sadowski. AIP Conference Proceedings **993**. American Institute of Physics, Melville, NY, 235-238 (2008).

*Pokol, G., G. Papp, G. Por, S. Zoletnik, A. Weller and W7-AS Team:* Experimental Study and Simulation of W7-AS Transient MHD Modes. PLASMA 2007: The International Conference Research and Application of Plasmas; 4th German-Polish Conference on Plasma Diagnostics for Fusion and Applications; 6th French-Polish Seminar on Thermal Plasma in Space and Laboratory. (Eds.) H.-J. Hartfuß, M. Dudeck, J. Musielok, M. J. Sadowski. AIP Conference Proceedings **993**. American Institute of Physics, Melville, NY, 215-218 (2008).

*Poli, E.:* Recent Developments in the Theory of Electron Cyclotron Waves. Fusion Science and Technology **53**, 1-11 (2008).

*Poli, E., M. Garcia-Munoz, H.-U. Fahrbach, S. Günter and ASDEX Upgrade Team:* Observation and modeling of fast trapped ions losses due to neoclassical tearing modes. Physics of Plasmas **15**, 032501 (2008).

*Powis, I., C. J. Harding, S. Barth, S. Joshi, V. Ulrich and U. Hergenhahn:* Chiral Asymmetry in the Angle-Resolved O and C 1s-1 Core Photoemissions of the R Enantiomer of Glycidol. Physical Review A **78**, 052501 (2008).

*Prater, R., D. Farina, Y. Gribov, R. W. Harvey, A. K. Ram, Y.-R. Lin-Liu, E. Poli, A. P. Smirnov, F. Volpe, E. Westerhof, A. Zvonkov and ITPA Steady State Operation Topical Group:* Benchmarking of codes for electron cyclotron heating and electron cyclotron current drive under ITER conditions. Nuclear Fusion **48**, 035006 (2008).

*Preuss, R., H. Dreier, A. Dinklage and V. Dose:* Data adaptive control parameter estimation for scaling laws for magnetic fusion devices. Europhysics Letters **81**, 55001 (2008).

*Primetzhofer, D., S. N. Markin, M. Draxler, R. Beikler, E. Taglauer and P. Bauer:* Strength of the interatomic potential derived from angular scans in LEIS. Surface Science **602**, 2921-2926 (2008).

*Primetzhofer, D., S. N. Markin, J. I. Juaristi, E. Taglauer and P. Bauer:* Crystal Effects in the Neutralization of $He^+$ Ions in the Low Energy Ion Scattering Regime. Physical Review Letters **100**, 213201 (2008).

*Pueschel, M. J., M. Kammerer and F. Jenko:* Gyrokinetic turbulence simulations at high plasma beta. Physics of Plasmas **15**, 102310 (2008).

*Pütterich, T., R. Neu, R. Dux, A. D. Whiteford, M. G. O'Mullane and ASDEX Upgrade Team:* Modelling of measured tungsten spectra from ASDEX Upgrade and predictions for ITER. Plasma Physics and Controlled Fusion **50**, 085016 (2008).

*Pugno, R., K. Schmid, M. J. Baldwin, R. Doerner, J. Hanna, D. Nishijima, V. Rohde and J. Roth:* Saturation in deuterium retention of CFC graphite targets exposed to beryllium-seeded plasmas on PISCES-B. Journal of Nuclear Materials **375**, 168-172 (2008).

*Rahbarnia, K., E. Holzhauer, N. Mahdizadeh, M. Ramisch and U. Stroth:* Experimental study of the electromagnetic component of drift-wave turbulence. Plasma Physics and Controlled Fusion **50**, 085008 (2008).

*Rai, A., R. Schneider and M. Warrier:* Hydrogen release and retention from porous graphite. Journal of Nuclear Materials **374**, 304-312 (2008).

*Ramponi, G., D. Farina, M. A. Henderson, E. Poli, O. Sauter, G. Saibene, H. Zohm and C. Zucca:* Physics analysis of the ITER ECW system for an optimized performance. Nuclear Fusion **48**, 054012 (2008).

*Reuter, K., F. Jenko, C. B. Forest and R. A. Bayliss:* A parallel implementation of an MHD code for the simulation of mechanically driven, turbulent dynamos in spherical geometry. Computer Physics Communications **179**, 245-249 (2008).

*Ribeiro, T. T. and B. Scott:* Gyrofluid turbulence studies of the effect of the poloidal position of an axisymmetric Debye sheath. Plasma Physics and Controlled Fusion **50**, 055007 (2008).

*Roach, C. M., M. Walters, R. V. Budny, F. Imbeaux, T. W. Fredian, M. Greenwald, J. A. Stillermann, D. A. Alexander, J. Carlsson, J. R. Cary, F. Ryter, J. Stober, P. Gohil, C. Greenfield, M. Murakami, G. Bracco, B. Esposito, M. Romanelli, V. Parail, P. Stubberfield, I. Voitsekhovitch, C. Brickley, A. R. Field, Y. Sakamoto, T. Fujita, T. Fukuda, N. Haysahi, G. M. D. Hogeweij, A. Chudnovskiy, N. A. Kinerva, C. E. Kessel, T. Aniel, G. T. Hoang, J. Ongena, E. J. Doyle, W. A. Houlberg, A. R. Polevoi, ITPA Confinement Database and Modelling Topical Group and ITPA Transport Physics Topical Group:* The 2008 public release of the international multi-tokamak confinement profile database. Nuclear Fusion **48**, 125001 (2008).

*Röpke, F. K. and R. Bruckschen:* Thermonuclear supernovae: a multi-scale astrophysical problem challenging numerical simulations and visualization. New Journal of Physics **10**, 125009 (2008).
http://www.iop.org/EJ/abstract/1367-2630/10/12/125009

*Roth, J., E. Tsitrone, T. Loarer, V. Philipps, S. Brezinsek, A. Loarte, G. F. Counsell, R. P. Doerner, K. Schmid, O. V. Ogorodnikova and R. A. Causey:* Tritium inventory in ITER plasma-facing materials and tritium removal procedures. Plasma Physics and Controlled Fusion **50**, 103001 (2008).

*Roth, J., E. Tsitrone and A. Loarte:* Plasma-wall interaction: a complex combination of surface processes critical for thermonuclear fusion. Journal of Physics: Conference Series **100**, 062003 (2008).

*Rozhansky, V., E. Kaveeva, S. Voskoboynikova, D. Coster and ASDEX Upgrade Team:* Modelling of the radial electric field in the ASDEX Upgrade Ohmic shots. Contributions to Plasma Physics **48**, 73-76 (2008).

*Ryter, F., J. C. Fuchs, W. Schneider, A. C. C. Sips, A. Stäbler, J. Stober and ASDEX Upgrade Team:* H-mode confinement properties close to the power threshold in ASDEX Upgrade. Journal of Physics: Conference Series **123**, 012035 (2008).

*Saarelma, S., R. Akers, M. Reshko, C. M. Roach, M. Romanelli, A. Thyagarajaa, A. Peeters, A. Bottino and S. Jolliet:* Global Turbulence Simulations of CYCLONE Base Case and MAST Plasmas. Theory of Fusion Plasmas. (Eds.) O. Sauter, X. Garbet, E. Sindoni. AIP Conference Proceedings **1069**. American Institute of Physics, Melville, NY, 200-210 (2008).

*Sagra, A., O. Mitarai, T. Tanaka, S. Imagawa, Y. Kozaki, M. Kobayashi, T. Morisaki, T. Watanabe, H. Tamura, N. Yanagi, K. Nishimura, H. Chikaraishi, S. Yamada, S. Fikada, S. Masuzaki, A. Shishkin, Y. Igitkhanov, T. Goto, Y. Ogawa, T. Muroga, T. Mito, O. Motojima and FFHR Design Group:* Optimization activities on design studies of LHD-type reactor FFHR. Fusion Engineering and Design **83**, 1690-1695 (2008).

*Sakakibara, S., K. Y. Watanabe, Y. Suzuki, Y. Narushima, S. Ohdachi, N. Nakajima, F. Watanabe, L. Garcia, A. Weller, K. Toi, I. Yamada, K. Tanaka, T. Tokuzawa, K. Ida, H. Yamada, A. Komori, O. Motojima and LHD Experimental Group:* MHD study of the reactor-relevant high-beta regime in the Large Helical Device. Plasma Physics and Controlled Fusion **50**, 124014 (2008).

*Salancon, E., T. Dürbeck, T. Schwarz-Selinger, F. Genoese and W. Jacob:* Redeposition of amorphous hydrogenated carbon films during thermal decomposition. Journal of Nuclear Materials **376**, 160-168 (2008).

*Sánchez, M., L. Esteban, P. Kornejew and M. Hirsch:* Admissible Crosstalk Limits in a Two Colour Interferometers for Plasma Density Diagnostics. A Reduction Algorithm. PLASMA 2007: The International Conference Research and Application of Plasmas; 4th German-Polish Conference on Plasma Diagnostics for Fusion and Applications; 6th French-Polish Seminar on Thermal Plasma in Space and Laboratory. (Eds.) H.-J. Hartfuß, M. Dudeck, J. Musielok, M. J. Sadowski. AIP Conference Proceedings **993**. American Institute of Physics, Melville, NY, 187-190 (2008).

*Sárközi, J., K. Grosser, G. Kocsis, R. König, U. Neuner, A. Molnár, G. Petravich, G. Por, G. Porempovics, S. Recsei, V. Szabó, A. Szappanos and S. Zoletnik:* Video Diagnostic for W7-X Stellarator. PLASMA 2007: The International Conference Research and Application of Plasmas; 4th German-Polish Conference on Plasma Diagnostics for Fusion and Applications; 6th French-Polish Seminar on Thermal Plasma in Space and Laboratory. (Eds.) H.-J. Hartfuß, M. Dudeck, J. Musielok, M. J. Sadowski. AIP Conference Proceedings **993**. American Institute of Physics, Melville, NY, 175-178 (2008).

*Scarabosio, A. and G. Haas:* Behaviour of the ASDEX pressure gauge at high neutral gas pressure and applications for ITER. Burning Plasma Diagnostics: An International Conference. (Eds.) G. Gorini, F. P. Orsitto, E. Sindoni, M. Tardocchi. AIP Conference Proceedings **988**. American Institute of Physics, Melville, NY, 238-242 (2008).

*Schacht, J., D. Aßmus, T. Bluhm, A. Dinklage, S. Heinrich, C. Hennig, U. Herbst, R. König, H. Laqua, M. Lewerentz, I. Müller, M. Otte, S. Pingel, J. Sachtleben, A. Spring, A. Werner and A. Wölk:* Stellarator WEGA as a test-bed for the WENDELSTEIN 7-X control system concepts. Fusion Engineering and Design **83**, 228-235 (2008).

*Schacht, J., H. Laqua, M. Lewerentz, A. Spring, S. Pingel and G. Kühner:* Standardized Communication in the Control System of the Experiment Wendelstein 7-X. IEEE Transactions on Nuclear Science **55**, 322-327 (2008).

*Schleip, C., A. Menzel and V. Dose:* Norway spruce (Picea abies): Bayesian analysis of the relationship between temperature and bud burst. Agricultural and Forest Meteorology **148**, 631-643 (2008).

*Schlüter, M., C. Hopf and W. Jacob:* Chemical sputtering of carbon by combined exposure to nitrogen ions and atomic hydrogen. New Journal of Physics **10**, 053037 (2008).
http://www.iop.org/EJ/abstract/1367-2630/10/5/053037

*Schlüter, M., C. Hopf, T. Schwarz-Selinger and W. Jacob:* Temperature dependence of the chemical sputtering of amorphous hydrogenated carbon films by hydrogen. Journal of Nuclear Materials **376**, 33-37 (2008).

*Schmid, A., A. Herrmann, H. W. Müller and ASDEX Upgrade Team:* Experimental observation of the radial propagation of ELM induced filaments on ASDEX Upgrade. Plasma Physics and Controlled Fusion **50**, 045007 (2008).

*Schmid, K.:* Beryllium flux distribution and layer deposition in the ITER divertor. Nuclear Fusion **48**, 105004 (2008).

*Schmitz, O., I. L. Beigman, L. A. Vainshtein, B. Schweer, M. Kantor, A. Pospieszczyk, Y. Xu, M. Krychowiak, M. Lehnen, U. Samm, B. Unterberg and TEXTOR Team:* Status of electron temperature and density measurement with beam emission spectroscopy on thermal helium at TEXTOR. Plasma Physics and Controlled Fusion **50**, 115004 (2008).

*Schmitz, O., S. Brezinsek, I. Classen, M. Clever, J. W. Coenen, E. Delabie, K. H. Finken, M. W. Jakubowski, M. Kantor, A. Krämer-Flecken, U. Kruezi, M. Lehnen, Y. Liang, D. Reiter, U. Samm, B. Schweer, G. W. Spakman, H. Stoschus, G. Telesca, B. Unterberg, E. Uzgel and TEXTOR Team:* Application of advanced edge diagnostics for transport studies in the stochastic boundary of TEXTOR-DED. PLASMA 2007: The International Conference Research and Application of Plasmas; 4th German-Polish Conference on Plasma Diagnostics for Fusion and Applications; 6th French-Polish Seminar on Thermal Plasma in Space and Laboratory. (Eds.) H.-J. Hartfuß, M. Dudeck, J. Musielok, M. J. Sadowski. AIP Conference Proceedings **993**. American Institute of Physics, Melville, NY, 135-142 (2008).

*Schmitz, O., T. E. Evans, M. E. Fenstermacher, H. Frerichs, M. W. Jakubowski, M. J. Schaffer, A. Wingen, W. P. West, N. H. Brooks, K. H. Burrell, J. S. deGrassie, Y. Feng, K. H. Finken, P. Gohil, M. Groth, I. Joseph, C. J. Lasnier, M. Lehnen, A. W. Leonard, S. Mordijck, R. A. Moyer, A. Nicolai, T. H. Osborne, D. Reiter, U. Samm, K. H. Spatschek, H. Stoschus, B. Unterberg, E. A. Unterberg, J. G. Watkins, R. Wolf, DIII-D Team and TEXTOR Team:* Aspects of three dimensional transport for ELM control experiments in ITER-similar shape plasmas at low collisionality in DIII-D. Plasma Physics and Controlled Fusion **50**, 124029 (2008).

*Schmitz, O., M. W. Jakubowski, H. Frerichs, D. Harting, M. Lehnen, B. Unterberg, S. S. Abduallaev, S. Brezinsek, I. Classen, T. Evans, Y. Feng, K. H. Finken, M. Kantor, D. Reiter, U. Samm, B. Schweer, G. Sergienko, G. W. Spakman, M. Tokar, E. Uzgel, R. C. Wolf and TEXTOR Team:* Identification and analysis of transport domains in the stochastic boundary of TEXTOR-DED for different mode spectra. Nuclear Fusion **48**, 024009 (2008).

*Schmuck, S., A. Dinklage, R. Fischer, J. P. Knauer, B. Kurzan, H.-D. Murmann and E. Pasch:* Design and Calibration of a Polychromator for the Thomson Scattering at Wendelstein 7-X. PLASMA 2007: The International Conference Research and Application of Plasmas; 4th German-Polish Conference on Plasma Diagnostics for Fusion and Applications; 6th French-Polish Seminar on Thermal Plasma in Space and Laboratory. (Eds.) H.-J. Hartfuß, M. Dudeck, J. Musielok, M. J. Sadowski. AIP Conference Proceedings **993**. American Institute of Physics, Melville, NY, 195-198 (2008).

*Schneider, R., A. R. Sharma and A. Rai:* Introduction to molecular dynamics. Computational Many-Particle Physics. (Eds.) H. Fehske, R. Schneider, A. Weiße. Lecture Notes in Physics **739**. Springer, Berlin, Heidelberg, 3-40 (2008).

*Schneider, W., M. R. Turnyanskiy, F. V. Chernyshev, V. I. Afanasyev, M. Kick and T. Richert:* Comparison of the IOFFE neutral particle analyser with the Princeton analyser on the Mega Amp Spherical Tokamak. Vacuum **83**, 752-756 (2008).

*Schrittwieser, R., C. Ionita, P. Balan, R. Gstrein, O. Grulke, T. Klinger, R. Madani, G. Amarandei and A. K. Sarma:* Laser-heated emissive plasma probe. Review of Scientific Instruments **79**, 083508 (2008).

*Scott, B. D.:* Basics of turbulence computation for magnetically confined plasmas. Turbulent Transport in Fusion Plasma: First ITER International Summer School. (Ed.) S. Benkadda. AIP Conference Proceedings **1013**. American Institute of Physics, Melville, NY, 316-334 (2008).

*Scott, B. D.:* Introduction to Turbulence in Magnetised Plasmas. Turbulent Transport in Fusion Plasma: First ITER International Summer School. (Ed.) S. Benkadda. AIP Conference Proceedings **1013**. American Institute of Physics, Melville, NY, 20-45 (2008).

*Shimizu, S., B.M. Annaratone, T. Shimizu, W. Jacob, H. Thomas and G. E. Morfill:* Environment with reduced ion bombardment energy for levitated particles in an rf plasma. Plasma Sources Science and Technology **17**, 035014 (2008).

*Siccinio, M. and E. Poli:* Kinetic Effects on Slowly Rotating Magnetic Islands in Tokamaks. Theory of Fusion Plasmas. (Eds.) O. Sauter, X. Garbet, E. Sindoni. AIP Conference Proceedings **1069**. American Institute of Physics, Melville, NY, 337-342 (2008).

*Sips, A. C. C., O. Gruber and ASDEX Upgrade Team:* Compatibility of ITER scenarios with an all-W wall. Plasma Physics and Controlled Fusion **50**, 124028 (2008).

*Skinner, C. H., A. A. Haasz, V. K. Alimov, N. Bekris, R. A. Causey, R. E. H. Clark, J. P. Coad, J. W. Davis, R. P. Doerner, M. Mayer, A. Pisarev, J. Roth and T. Tanabe:* Recent Advances on Hydrogen Retention in ITER's Plasma Facing Materials: Beryllium, Carbon, and Tungsten. Fusion Science and Technology **54**, 891-945 (2008).

*Soddemann, T., J. Reetz, A. Schmidt and H. Lederer:* Joint Research Activities: Materials Science. DEISA Advancing Science in Europe. (Eds.) V. Alessandrini, H. Lederer, A. Streit, S. Värttö, G. J. Pringle. 70-71 (2008).

*Strachan, J. D., J. Likonen, P. Coad, M. Rubel, A. Widdowson, M. Airila, P. Andrew, S. Brezinsek, H. Corrigan, H. G. Esser, S. Jachmich, A. Kallenbach, A. Kirschner, A. Kreter, G. F. Matthews, V. Philipps, R. A. Pitts, J. Spence, M. Stamp, S. Wiesen and JET-EFDA Contributors:* Modelling of carbon migration during JET 13C injection experiments. Nuclear Fusion **48**, 105002 (2008).

*Strumberger, E., S. Günter, E. Schwarz, C. Tichmann and ASDEX Upgrade Team:* Fast particle losses due to NTMs and magnetic field ripple. New Journal of Physics **10**, 023017 (2008). http://www.iop.org/EJ/abstract/1367-2630/10/2/023017

*Strumberger, E., P. Merkel, M. Sempf and S. Günter:* On Fully Three-dimensional Resistive Wall Mode and Feedback Stabilization Computations. Physics of Plasmas **15**, 056110 (2008).

*Subba, F., X. Bonnin, D. Coster and R. Zanino:* 2D fluid modeling of the ASDEX upgrade scrape-off layer up to the first wall. Computer Physics Communication **179**, 194-198 (2008).

*Suzuki, Y., H. Kawashima, D. P. Coster, S. Sakurai, K. Shimizu and T. Takizuka:* Simulation Study of Radiative Cooling in the Divertor on JT-60 Super Advanced (JT-60SA). Contributions to Plasma Physics **48**, 169-173 (2008).

*Svensson, J., A. Werner and JET-EFDA Contributors:* Current tomography for axisymmetric plasmas. Plasma Physics and Controlled Fusion **50**, 085002 (2008).

*Szepesi, T., S. Kalvin, G. Kocsis, P. T. Lang and C. Wittmann:* Volume measurement of cryogenic deuterium pellets by Bayesian analysis of single shadowgraphy images. Review of Scientific Instruments **79**, 033501 (2008).

*Taccogna, F., S. Longo and M. Capitelli:* Ion-Neutral Collision Effects in Langmuir Probe Theory. Contributions to Plasma Physics **48**, 509-514 (2008).

*Taccogna, F., S. Longo, M. Capitelli and R. Schneider:* Negative-Ion-Source Modeling: From Expansion to Extraction Region. IEEE Transactions on Plasma Science **36**, 1589-1599 (2008).

*Taccogna, F., S. Longo, M. Capitelli and R. Schneider:* Surface-Driven Asymmetry and Instability in the Acceleration Region of Hall Thruster. Contributions to Plasma Physics **48**, 375-386 (2008).

*Taccogna, F., R. Schneider, S. Longo and M. Capitelli:* Kinetic simulations of a plasma thruster. Plasma Sources Science and Technology **17**, 024003 (2008).

*Taccogna, F., R. Schneider, S. Longo and M. Capitelli:* Modeling of a negative ion source. II. Plasma-gas coupling in the extraction region. Physics of Plasmas **15**, 103502 (2008).

*Taccogna, F., R. Schneider, S. Longo and M. Capitelli:* Modeling of surface-dominated plasmas: From electric thruster to negative ion source. Review of Scientific Instruments **79**, 02B903 (2008).

*Taccogna, F., R. Schneider, K. Matyash, S. Longo, M. Capitelli and D. Tshakaya:* Plasma-Neutral Interaction in Kinetic Models for the Divertor Region. Contributions to Plasma Physics **48**, 147-152 (2008).

*Taglauer, E.:* Surface Chemical Composition. Handbook of Heterogeneous Catalysis, Vol. 2. (Eds.) G. Ertl, H. Knözinger, F. Schüth, J. Weitkamp. Wiley-VCH, Weinheim, 1014-1029 (2008).

*Thomsen, H., T. Broszat, P. Carvalho, S. Mohr, A. Weller and M. Y. Ye:* The Steady State Challenge for Soft X-Ray Diagnostics on Wendelstein 7-X Stellarator. PLASMA 2007: The International Conference Research and Application of Plasmas; 4th German-Polish Conference on Plasma Diagnostics for Fusion and Applications; 6th French-Polish Seminar on Thermal Plasma in Space and Laboratory. (Eds.) H.-J. Hartfuß, M. Dudeck, J. Musielok, M. J. Sadowski. AIP Conference Proceedings **993**. American Institute of Physics, Melville, NY, 163-166 (2008).

*Throumoulopoulos, G. N., H. Tasso and G. Poulipoulis:* Side-conditioned axisymmetric equilibria with incompressible flows. Journal of Plasma Physics **74**, 327-344 (2008).

*Thumm, M., P. Brand, H. Braune, G. Dammertz, V. Erckmann, G. Gantenbein, S. Illy, W. Kasparek, H. P. Laqua, C. Lechte, W. Leonhardt, G. Michel, G. Neffe, B. Piosczyk, M. Schmid and M. Weissgerber:* Progress in the 10-MW 140-GHz ECH System for the Stellarator W7-X. IEEE Transactions on Plasma Science **36**, 341-355 (2008).

*Told, D., F. Jenko, P. Xanthopoulos, L. D. Horton, E. Wolfrum and ASDEX Upgrade Team:* Gyrokinetic microinstabilities in ASDEX Uprade edge plasmas. Physics of Plasmas **15**, 102306 (2008).

*Treutterer, W., K. Behler, L. Giannone, N. Hicks, A. Manini, M. Maraschek, G. Raupp, M. Reich, A. C. C. Sips, J. Stober, W. Suttrop and ASDEX Upgrade Team:* Real-time diagnostics at ASDEX Upgrade – Integration with MHD feedback control. Fusion Engineering and Design **83**, 300-303 (2008).

*Tskhakaya, D., S. Kuhn, Y. Tomita, K. Matyash, R. Schneider and F. Taccogna:* Self-Consistent Simulations of the Plasma-Wall Transition Layer. Contributions to Plasma Physics **48**, 121-125 (2008).

*Tskhakaya, D., F. Subba, X. Bonnin, D. Coster, W. Fundamenski, R. A. Pitts and JET EFDA Contributors:* On kinetic effects during the parallel transport in the SOL. Contributions to Plasma Physics **48**, 89-93 (2008).

*Udintsev, V. S., O. Sauter, E. Asp, E. Fable, T. P. Goodman, G. Turri, J. P. Graves, A. Scarabosio, G. Zhuang, C. Zucca and TCV Team:* Global plasma oscillations in electron internal transport barriers in TCV. Plasma Physics and Controlled Fusion **50**, 124052 (2008).

*Ulrich, V., S. Barth, S. Joshi, U. Hergenhahn, E. Mikajlo, C. J. Harding and I. Powis:* Giant Chiral Asymmetry in the C 1s Core Level Photoemission from Randomly Oriented Fenchone Enantiomers. Journal of Physical Chemistry A **112**, 3544-3549 (2008).

*Ulrich, V., S. Barth, S. Joshi, T. Lischke, A. M. Bradshaw and U. Hergenhahn:* Separating the Vibrationally Resolved Auger Decay Channels for a CO Core Hole State. Physical Review Letters **100**, 143003 (2008).

*Valisa, M., T. Bolzonella, P. Buratti, L. Carraro, R. Cavazzana, S. Dal Bello, P. Martin, R. Pasqualotto, J. S. Sarff, M. Spolaore, P. Zanca, L. Zanotto, M. Agostini, A. Alfier, V. Antoni, L. Apolloni, F. Auriemma, O. Barana, M. Baruzzo, P. Bettini, D. Bonfiglio, F. Bonomo, M. Brombin, A. Buffa, A. Canton, S. Capello, M. Cavinato, G. Chitarin, A. De Lorenzi, G. De Masi, D. F. Escande, A. Fassina, P. Franz, E. Gaio, E. Gazza, L. Giudicotti, F. Gnesotto, M. Gobbin, L. Grando, L. Guazzotto, S. C. Guo, V. Igochine, P. Innocente, R. Lorenzini, A. Luchetta, G. Manduchi, G. Marchiori, D. Marcuzzi, L. Marrelli, S. Martini, E. Matines, K. McCollam, F. Milani, M. Moresco, L. Novello, S. Ortolani, R. Paccagnella, S. Peruzzo, R. Piovan, L. Piron, A. Pizzimenti, P. Piovesan, N. Pomaro, I. Predebon, M. E. Piuatti, G. Rostagni, F. Sattin, P. Scarin, G. Serianni, P. Sonato, E. Spada, A. Soppelsa, S. Spagnolo, G. Spizzo, C. Taliercio, D. Terranova, V. Toigo, N. Vianello, D. Yadikin, P. Zaccaria, B. Zaniol, E. Zilli and M. Zuin:* High current regimes in RFX-mod. Plasma Physics and Controlled Fusion **50**, 124031 (2008).

*Vermare, L., C. Angioni, A. Bottino, A. G. Peeters and ASDEX Upgrade Team:* β dependence of micro-instabilities using linear gyrokinetic simulations. Journal of Physics: Conference Series **123**, 012040 (2008).

*Versteegh, A., K. Behringer, U. Fantz, G. Fußmann, B. Jüttner and S. Noach:* Long-living plasmoids from an atmospheric water discharge. Plasma Sources Science and Technology **17**, 024014 (2008).

*Von Toussaint, U., T. Schwarz-Selinger and S. Gori:* Optimizing Nuclear Reaction Analysis (NRA) using Bayesian Experimental Design. Bayesian Inference and Maximum Entropy Methods in Science and Engineering: Proceedings of the 28th International Workshop on Bayesian Inference and Maximum Entropy Methods in Science and Engineering. (Eds.) M. de Souza Lauretto, C. A. de Braganca Pereira, J. M. Stern. AIP Conference Proceedings **1073**. American Institute of Physics, Melville, NY, 348-358 (2008).

*Wagner, D., G. Grunwald, F. Leuterer, A. Manini, F. Monaco, M. Münich, H. Schütz, H. Zohm, T. Franke, M. Thumm, R. Heidinger, G. Gantenbein, A. Meier, W. Kasparek, C. Lechte, A. Litvak, G. Denisov, A. Chirkov, E. M. Tai, L. G. Popov, V. O. Nichiporenko, V. E. Myasnikov, E. A. Solyanova, S. A. Malygin, F. Meo and P. Woskov:* Present Status of the New Multifrequency ECRH System for ASDEX Upgrade. IEEE Transactions on Plasma Science **36**, 324-331 (2008).

*Wagner, D., G. Grunwald, F. Leuterer, A. Manini, F. Monaco, M. Münich, H. Schütz, H. Zohm, T. Franke, M. Thumm, R. Heidinger, G. Gantenbein, A. Meier, W. Kasparek, C. Lechte, A. Litvak, G. Denisov, A. Chirkov, E. M. Tai, L. G. Popov, V. O. Nichiporenko, V. E. Myasnikov, E. A. Solyanova, S. A. Malygin, F. Meo and P. Woskov:* Status of the new multi-frequency ECRH system for ASDEX Upgrade. Nuclear Fusion **48**, 054006 (2008).

*Wagner, F.:* Physics of and achievements with the H-mode. Turbulent Transport in Fusion Plasma: First ITER International Summer School. (Ed.) S. Benkadda. AIP Conference Proceedings **1013**. American Institute of Physics, Melville, NY, 143-165 (2008).

*Waldmann, O. and G. Fußmann:* Influence of the Langmuir probe shaft on measuring plasma parameters. Contributions to Plasma Physics **48**, 534-539 (2008).

*Werner, A., M. Endler, J. Geiger and R. König:* W7-X magnetic diagnostics: Rogowski coil performance for very long pulses. Review of Scientific Instruments **79**, 10F122 (2008).

*Wilczek, M., F. Jenko and R. Freidrich:* Lagrangian particle statistics in turbulent flows from a simple vortex model. Physical Review E **77**, 056301 (2008).

*Wiltner, A. and C. Linsmeier:* Thermally induced reaction and diffusion of carbon films on Ni(111) and Ni(100). Surface Science, 602, 3623-3631 (2008).

*Wiltner, A., C. Linsmeier and T. Jacob:* Carbon reaction and diffusion on Ni(111), Ni(100) and Fe(110): Kinetic parameters from x-ray photoelectron spectroscopy and density functional theory analysis. Journal of Chemical Physics **129**, 084704 (2008).

*Windisch, T., O. Grulke, R. Schneider and G. Kervalishvili:* Formation and propagation of turbulent structures in drift-wave turbulence. Contributions to Plasma Physics **48**, 58-62 (2008).

*Wischmeier, M., X. Bonnin, D. P. Coster, A. V. Chankin, A. Kallenbach, H. W. Müller and ASDEX Upgrade Team:* Simulating the Role of Intrinsic Carbon Impurities in the Divertor Detachment of ASDEX Upgrade. Contributions to Plasma Physics **48**, 249-254 (2008).

*Wolf, R. and A. Dinklage:* Wendelstein 7-X progress report. Stellarator News **117**, 1-2 (2008).

*Wolf, R. and W7-X Team:* A stellarator reactor based on the optimization criteria of Wendelstein 7-X. Fusion Engineering and Design **83**, 990-996 (2008).

*Wright, J. C., E. J. Valeo, C. K. Phillips, P. T. Bonoli and M. Brambilla:* Full Wave Simulations of Lower Hybrid Waves in Toroidal Geometry with Non-Maxwellian Electrons. Communications in Computational Physics **4**, 545-555 (2008).

*Xanthopoulos, P., D. Mikkelsen, F. Jenko, W. Dorland and O. Kalentev:* Verification and application of numerically generated magnetic coordinate systems in gyrokinetics. Physics of Plasmas **15**, 122108 (2008).

*Xanthopoulos, P. and G. E. Zouraris:* A linearly implicit finite difference method for a Klein-Gordon-Schrodinger system modeling electron-ion plasma waves. Discrete and Continuous Dynamical Systems – Series B **10**, 239-263 (2008).

*Ye, M. Y., A. Werner, M. Hirsch, H. Thomsen, A. Weller and R. König:* Thermal-Mechanical Analysis for in-Vessel Diagnostic Components in W7-X. PLASMA 2007: The International Conference Research and Application of Plasmas; 4th German-Polish Conference on Plasma Diagnostics for Fusion and Applications; 6th French-Polish Seminar on Thermal Plasma in Space and Laboratory. (Eds.) H.-J. Hartfuß, M. Dudeck, J. Musielok, M. J. Sadowski. AIP Conference Proceedings **993**. American Institute of Physics, Melville, NY, 211-214 (2008).

*You, J. H. and I. Komarova:* Probabilistic failure analysis of a water-cooled tungsten mono-block divertor: Impact of embrittlement on failure behaviour. Journal of Nuclear Materials **375**, 283-289 (2008).

*You, J.-H. and M. Miskiewicz:* Material parameters of copper and CuCrZr alloy for cyclic plasticity at elevated temperatures. Journal of Nuclear Materials **373**, 269-274 (2008).

*Yu, Q. and S. Günter:* Locking of neoclassical tearing modes by error fields and its stabilization by RF current. Nuclear Fusion **48**, 065004 (2008).

*Yu, Q., S. Günter, Y. Kikuchi and K. H. Finken:* Numerical modelling of error field penetration. Nuclear Fusion **48**, 024007 (2008).

*Zagorski, R., M. W. Jakubowski, A. Kalentev, O. Schmitz, R. Schneider and W. Stepniewski:* 3D numerical simulations of energy transport in the stochastic boundary of TEXTOR-DED with a finite difference method. Nuclear Fusion **48**, 024013 (2008).

*Zhang, D., L. Giannone, O. Grulke, M. Piechotka, T. Windisch, A. Stark and T. Klinger:* Investigation of the Neutral Gas Pressure Effect on the Metal Resistive Bolometer. PLASMA 2007: The International Conference Research and Application of Plasmas; 4th German-Polish Conference on Plasma Diagnostics for Fusion and Applications; 6th French-Polish Seminar on Thermal Plasma in Space and Laboratory. (Eds.) H.-J. Hartfuß, M. Dudeck, J. Musielok, M. J. Sadowski. AIP Conference Proceedings **993**. American Institute of Physics, Melville, NY, 199-202 (2008).

*Zucca, C., O. Sauter, M. A. Henderson, E. Fable, D. Farina, A. Polevoi, G. Ramponi, G. Saibene and H. Zohm:* Safety-factor profile tailoring by improved electron cyclotron system for sawtooth control and reverse shear scenarios in ITER. Theory of Fusion Plasmas. (Eds.) O. Sauter, X. Garbet, E. Sindoni. AIP Conference Proceedings **1069**. American Institute of Physics, Melville, NY, 361-367 (2008).

## Conference Papers

*Angelino, P., X. Garbet, L. Villard, A. Bottino, S. Jolliet, Ph. Ghendrih, V. Grandgirard, B. F. McMillan, Y. Sarazin, G. Dif-Pradalier and T.* M. Tran: Effects of plasma current on drift wave turbulence. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-4.033 (2008).

*Apostolaki, D., G. N. Throumoulopoulos and H. Tasso:* A contribution to the equilibrium and stability of axisymmetric plasmas with field aligned flow. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.057 (2008).

*Assas, S. C., L.-G. Eriksson, G. D. Conway, C. F. Maggi, M. Maraschek, Vl. V. Bobkov, J.-M. Noterdaeme and ASDEX Upgrade Team:* Toroidal rotation in ICRF only heated ASDEX Upgrade plasmas. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-4.041 (2008).

*Beidler, C. D., J. Geiger, H. Maaßberg, N. B. Marushchenko, Yu. Turkin and W7-AS Team:* Transport Modeling for W7-X on the Basis of W7-AS Experimental Results. Joint Conference of 17th International Toki Conference on Physics of Flows and Turbulence in Plasmas and 16th International Stellarator/Heliotron Workshop 2007. Proceedings (I) National Institute for Fusion Science (NIFS), Toki, I-21 (2008) 133-138.

*Belonohy, E., M. Hirsch, K. McCormick, G. Papp, G. Pokol, H. Thomsen, A. Werner, S. Zoletnik and W7-AS Team:* Edge instabilities in the high density H-mode operation of W7-AS. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.034 (2008).

*Bilato, R. and M. Brambilla:* FELHS code for Lower-Hybrid launcher coupling and near fields. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-5.094 (2008).

*Bilato, R., E. Poli, F. Volpe, D. Farina, R. Paccagnella and M. Brambilla:* ECCD Feasibility Study for RFX-mod. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-5.095 (2008).

*Bobkov, V., F. Braun, J.-M. Noterdaeme and ASDEX Upgrade Team:* Calculations of Near-Fields of ICRF Antenna for ASDEX Upgrade. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-5.005 (2008).

*Bozhenkov, S. A., M. Lehnen, K. H. Finken, M. W. Jakubowski, R. Jaspers, R. C. Wolf, S. Abdullaev, M. Kantor, G. van Wassenhove, D. Reiter and TEXTOR Team:* Runaway electrons after massive gas injections in TEXTOR: importance of the gas mixing and of the resonant magnetic perturbations 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-1.079 (2008).

*Canik, J., R. Maingi, E. A. Unterberg, Y. Feng, D. Monticello, F. Sardei and M. C. Zarnstorff:* Application of EMC3-EIRENE to NCSX. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.013 (2008).

*Coenen, J. W., M. Clever, K. H. Finken, H. Frerichs, M. W. Jakubowski, M. Lehnen, M. Mitri, U. Samm, B. Schweer, O. Schmitz, H. Stoschus, B. Unterberg and TEXTOR Team:* Spectroscopic Measurements of the radial electric field under conditions of improved particle confinement (IPC) with the Dynamic Ergodic Divertor (DED) in the Tokamak TEXTOR. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-4.016 (2008).

*Cooper, W. A., J. P. Graves, S. P. Hirshman and P. Merkel:* Free Boundary Three-Dimensional Anisotropic Pressure Equilibria. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-4.061 (2008).

*Da Graca, S., G. D. Conway, M. Maraschek, A. Silva, E. Wolfrum, R. Fischer, L. Cupido, F. Serra, M. E. Manso, CFN Reflecto-*

*metry Group and ASDEX Upgrade Team:* Studies of edge MHD modes in H-mode discharges in ASDEX Upgrade using reflectometry. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-4.032 (2008).

*Dinklage, A., E. Ascasibar, C. D. Beidler, R. Brakel, R. Burhenn, F. Castejon, T. Estrada, H. Funaba, Y. Feng, J. Geiger, J. H. Harris, C. Hidalgo, K. Ida, M. Kobayashi, R. König, G. Kühner, A. Kus, D. Lopez Bruna, H. Maaßberg, D. Mikkelsen, T. Mizuuchi, N. Nakajima, R. Preuss, S. Sakakibara, F. Sano, F. Sardei, U. Stroth, Y. Suzuki, J. Talmadge, H. Thomsen, B. P. Van Milligen, K. Y. Watanabe, A. Weller, A. Werner, R. Wolf, H. Yamada and M. Yokoyama:* Status of the International Stellarator/Heliotron Profile Database. Joint Conference of 17th International Toki Conference on Physics of Flows and Turbulence in Plasmas and 16th International Stellarator/Heliotron Workshop 2007. Proceedings (I) National Institute of Fusion Science (NIFS), Toki, P1-037, 317-320 (2008).

*Dodt, D., A. Dinklage, R. Fischer, K. Bartschat and O. Zatsarinny:* Integrated Data Analysis of Spectroscopic Data. Joint Conference of 17th International Toki Conference on Physics of Flows and Turbulence in Plasmas and 16th International Stellarator/Heliotron Workshop 2007. Proceedings (II) National Institute for Fusion Science (NIFS), Toki, P2-094, 841-844 (2008).

*Dreier, H., R. Preuss, A. Dinklage and V. Dose:* Physical data assessment for energy confinement scaling laws. Joint Conference of 17th International Toki Conference on Physics of Flows and Turbulence in Plasmas and 16th International Stellarator/Heliotron Workshop 2007. Proceedings (II) National Institute for Fusion Science (NIFS), Toki, P2-093, 837-840 (2008).

*Eremin, D. Y.:* Unstable drift-kinetic Alfven modes in the lowest part of the Alfvenic spectrum. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-5.051 (2008).

*Fehér, T., K. Gál, H. M. Smith, T. Fülöp and P. Helander:* Simulation of runaway electron generation during plasma shutdown by doped pellet injection. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-4.077 (2008).

*Feng, Y., J. Kisslinger, F. Sardei and D. Reiter:* EMC3/EIRENE Transport Modelling of the Island Divertor in W7-X. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.085 (2008).

*Feng, Y., M. Kobayashi, N. Ashikawa, L. Giannone, R. König, LHD Experimental Group, S. Masuzaki, K. McCormick, J. Miyazawa, T. Morisaki, S. Morita, O. Motojima, Y. Nakamura, K. Narihara, N. Ohyabu, B. J. Peterson, F. Sardei, K. Sato, M. Shoji, N. Tamura, H. Thomsen, M. Tokitani, F. Wagner, U. Wenzel, H. Yamada and I. Yamada:* Comparative Divertor-Transport Study for W7-AS and LHD. Joint Conference of 17th International Toki Conference on Physics of Flows and Turbulence in Plasmas and 16th International Stellarator/Heliotron Workshop 2007. Proceedings (I) National Institute for Fusion Science (NIFS), Toki, I-06, 54-59 (2008).

*Fesenyuk, O. P., A. Weller, A. Werner, Y. V. Yakovenko and Y. I. Kolesnichenko:* Generation of kinetic Alfvén waves by Non-conventional Global Alfvén Eigenmodes. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-4.072 (2008).

*Fischer, R. and A. Dinklage:* Integrated Data Analysis for Nuclear Fusion. Computational Intelligence in Decision and Control. Proceedings of the 8th International FLINS Conference, (Eds.) Ruan, D.; Montero, J.; Lu, J.; Martinez, L.; D'hondt, P.; Kerre, E. E. World Scientific Proceedings Series on Computer Engineering and Information Science **1**. World Scientific Publishing, Singapore, 37-42 (2008).

*Fischer, R., E. Wolfrum, Ch. Fuchs and ASDEX Upgrade Team:* Integrated density profile analysis in ASDEX Upgrade H-modes. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-4.010 (2008).

*Frerichs, H. G, O. Schmitz, D. Harting, D. Reiter, B. Unterberg, Y. Feng, T. E. Evans, M. E. Fenstermacher, I. Joseph and R. A. Moyer:* 3D numerical analysis of magnetic topology and edge transport for RMP limiter scenarios at TEXTOR and DIII-D. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.009 (2008).

*Fuchs, J. C., T. Eich, L. Giannone, A. Herrmann, W. Sandmann and ASDEX Upgrade Team:* Radiation Distribution in the Full Tungsten ASDEX Upgrade. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.012 (2008).

*Fülöp, T., G. Pokol, H. M. Smith, P. Helander and M. Lisak:* Magnetic field threshold for runaway generation in tokamak disruptions. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.078 (2008).

*Funaba, H., A. Dinklage, H. Yamada, M. Yokoyama, K. Watanabe, K. Narihara, I. Yamada, K. Tanaka, T. Tokuzawa, S. Murakami, M. Osakabe, K. Kawahata and LHD Experimental Group:* Data Structure for LHD Plasmas in the International Stellarator/Heliotron Profile Database. Joint Conference of 17th International Toki Conference on Physics of Flows and Turbulence in Plasmas and 16th International Stellarator/Heliotron Workshop 2007. Proceedings (I) National Institute for Fusion Science (NIFS), Toki, P1-040, 329-331 (2008).

*García-Muñoz, M., H.-U. Fahrbach, M. Brüdgam, S. Günter, V. Igochine, Ph. Lauber, M. J. Mantsinen, M. Maraschek, P. Martin, S. D. Pinches, P. Piovesan, K. Sassenberg, H. Zohm and AUG Team:* Observation and modeling of fast-ion losses due to high frequency MHD instabilities in the ASDEX Upgrade tokamak. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-1.055 (2008).

*Geiger, J.:* Stability analysis of Wendelstein 7-X configurations with increased mirror ratio. Joint Conference of 17th International Toki Conference on Physics of Flows and Turbulence in Plasmas and 16th International Stellarator/Heliotron Workshop 2007. Proceedings (I) National Institute for Fusion Science (NIFS), Toki, P1-041, 332-335 (2008).

*Geiger, J., H. Maaßberg and C. D. Beidler:* Investigation of Wendelstein 7-X Configurations with Increased Toroidal Mirror. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.062 (2008).

*Gemisic Adamov, M., B. Kurzan, H. Murmann, W. Suttrop and ASDEX Upgrade Team:* ELM synchronized Thomson scattering measurements on ASDEX Upgrade. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-4.002 (2008).

*Grasso, D., R. J. Hastie and P. Helander:* Effect of a runaway electron current on tearing modes. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.116 (2008).

*Hallatschek, K.:* Diamagnetic GAM Drive Mechanism. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-1.036 (2008).

*Helander, P.:* On rapid rotation in stellarators. Joint Conference of 17th International Toki Conference on Physics of Flows and Turbulence in Plasmas and 16th International Stellarator/Heliotron Workshop 2007. Proceedings (II) National Institue for Fusion Science (NIFS), Toki, P2-004l, 533-536 (2008).

*Hicks, N. K., W. Suttrop, J. Stober, S. Cirant, M. Maraschek, K. Behler, L. Giannone, A. Manini, G. Raupp, M. Reich, A. C. C. Sips, W. Treutterer, F. Volpe and ASDEX Upgrade Team:* Measurement of NTMs, Modulated ECRH Deposition, and Current Ramp-Up MHD Activity Using the Upgraded 1 MHz ECE Radiometer on ASDEX Upgrade. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-4.082 (2008).

*Hölzl, M., S. Günter and ASDEX Upgrade Team:* Heat Diffusion Across Magnetic Islands and Ergodized Plasma Regions in Realistic Tokamak Geometry. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.064 (2008).

*Hogeweij, G. M. D., J. Hobirk, F. Imbeaux, F. Köchl, X. Litaudon, V. Parail, A. C. C. Sips and Contributors to the EFDA ITM-TF Work Programme:* Simulation of the current ramp-up phase of ITER discharges. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-5.034 (2008).

*Huber, A., R. A. Pitts, A. Loarte, V. Philipps, P. Andrew, G. Arnoux, S. Brezinsek, P. Coad, J. C. Fuchs, W. Fundamenski, S. Jachmich, A. Korotkov, G. F. Matthews, K. McCormick, Ph. Mertens, J. Rapp, G. Sergienko, M. Stamp and JET EFDA Contributors:* Plasma radiation during transient events in JET. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, O-4.033 (2008).

*Igochine, V., T. Bolzonella, S. C. Guo, M. Baruzzo, G. Marchiori, A. Soppelsa, D. Yadikin and H. Zohm:* Externally Induced Rotation of the Resistive Wall Modes in RFX-mod. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.066 (2008).

*Igochine, V., O. Dumbrajs, H. Zohm and ASDEX Upgrade Team:* Sawtooth Crash as a Result of Quasiperiodic Transition to Chaos in ASDEX Upgrade. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-1.062 (2008).

*Imbeaux, F., J. B. Lister, G. T. A. Huysmans, L. Appel, W. Zwingmann, M. Airaj, V. Basiuk, D. Coster, B. Guillerminet, D. Kalupin, C. Konz, G. Manduchi, G. Pereverzev, Y. Peysson, L.-G. Eriksson, M. Romanelli, P. Strand and Contributors to the ITM-TF Work Programme:* Data Structure for the European Integrated Tokamak Modelling Task Force. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.112 (2008).

*Kalupin, D., J. F. Artaud, D. Coster, S. Glowacz, S. Moradi, G. Perverzev, R. Stankiewicz, M. Tokar, V. Basiuk, G. Huysmans, F. Imbeaux, Y. Peysson, L.-G. Erikkson, M. Romanelli, P. Strand and Contributors to the ITM-TF Work Programme:* Construction of the European Transport Solver under the European Integrated Tokamak Modelling Task Force. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-5.027 (2008).

*Kendl, A. and B. D. Scott:* Gyrofluid Simulation of the Ideal Ballooning Mode ELM Scenario. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-1.018 (2008).

*Kleiber, R. and H. W. Müller (Eds.):* IPP Summer University for Plasma Physics, September 22-26, 2008 Garching. (IPP Summer University for Plasma Physics, 2008-09-22 to 2008-09-26, Garching). .

*Kocsis, G., A. Aranyi, V. Igochine, S. Kalvin, K. Lackner, P. T. Lang, M. Maraschek, V. Mertens, G. Pokol, G. Por, T. Szepesi and ASDEX Upgrade Team:* Investigation of pellet-driven plasma perturbations for ELM triggering studies. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.070 (2008).

*Konz, C., P. B. Snyder, N. Aiba, L. D. Horton, C. F. Maggi, S. Günter, P. J. McCarthy, ASDEX Upgrade Team and DIII-D Team:* Cross-Machine and Cross-Code Comparisons in Linear MHD Stability Analysis for Tokamaks. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.071 (2008).

*Koskela, T., O. Asunta, V. Hynönen, T. Johnson, T. Kurki-Suonio, J. Lönnroth, V. Parail, M. Roccella, G. Saibene, A. Salmi, S. Sipilä and K. Lackner:* Alpha particle orbits in a locally perturbed ITER 3D magnetic field. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-5.001 (2008).

*Krämer-Flecken, A., S. Soldatov, D. Reiser, M. W. Jakubowski and TEXTOR Team:* Effect of resonant magnetic perturbations on zonal flows and ambient turbulence. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.016 (2008).

*Kraus, W., M. Berger, H.-D. Falter, U. Fantz, P. Franzen, B. Heinemann, P. McNeely, R. Riedl, E. Speth, A. Stäbler and D. Wünderlich:* Development of RF driven $H^-/D^-$ sources for ITER. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-1.103 (2008).

*Kudyakov, T., K. H. Finken, M. Jakubowski, M. Lehnen, Y. Xu, S. A. Bozhenkov, O. Willi, G. van Wassenhove and TEXTOR Team:* Measurements of runaway electrons in the TEXTOR tokamak. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-1.089 (2008).

*Kurzan, B., A. Scarabosio, M. Gemisic-Adamov and ASDEX Upgrade Team:* Large scale inter-ELM fluctuations in the pedestal and the density limit in ASDEX Upgrade. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.001 (2008).

*Kus, A., D. Pretty, E. Ascasibar, C. D. Beidler, B. D. Blackwell, R. Brakel, R. Burhenn, F. Castejon, A. Dinklage, T. Estrada, Y. Feng, A. Fujisawa, H. Funaba, J. Geiger, J. H. Harris, C. Hidalgo, K. Ida, M. Kobayashi, R. König, G. Kühner, D. Lopez Bruna, H. Maaßberg, K. McCarthy, D. Mikkelsen, T. Minami, T. Mizuuchi, S. Murakami, N. Nakajima, S. Okamura, R. Preuss, S. Sakakibara, F. Sano, F. Sardei, T. Shimozuma, U. Stroth, Y. Suzuki, Y. Takeiri, J. Talmadge, H. Thomsen, Y. A. Turkin, J. Vega, K. Y. Watanabe, A. Weller, A. Wenrer, R. Wolf, H. Yamada and M. Yokoyama:* Status of the International Stellarator/Heliotron Profile Database. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.113 (2008).

*Lang, P. T., B. Alper, E. Belonohy, D. Frigione, G. Kocsis, K. Lackner, T. Loarer, M. Maraschek, F. M. Poli, G. Saibene, S. E. Sharapov, T. Szepesi, R. Wenninger, H. Zohm, ASDEX Upgrade Team and JET EFDA Contributors:* Pellet investigations related to ITER ELM pacing and particle fuelling. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-1.101 (2008).

*Lauber, Ph., M. Brüdgam, H. L. Berk, S. Günter, M. Garcia Munoz, V. Igochine, M. Maraschek, S. D. Pinches and ASDEX Upgrade Team:* Fast Particle Driven Modes at ASDEX-Upgrade. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-4.030 (2008).

*Lederer, H. and V. Alessandrini:* DEISA: Enabling Cooperative Extreme Computing in Europe. Parallel Computing: Architectures, Algorithms and Applications. Proceedings of the International Conference ParCo 2007, (Eds.) C. Bischof, M. Bücker, P. Gibbon, G. Joubert, T. Lippert, B. Mohr, F. Peters. Advances in Parallel Computing **15**. IOS Press, Amsterdam, 689-696 (2008).

*Lederer, H., G. J. Pringle, D. Girou, M. A. Hermanns and G. Erbacci:* DEISA: Extreme Computing in an Advanced Supercomputing Environment. Parallel Computing: Architectures, Algorithms and Applications. Proceedings of the International Conference ParCo 2007, (Eds.) C. Bischof, M. Bücker, P. Gibbon, G. Joubert, T. Lippert, B. Mohr, F. Peters. Advances in Parallel Computing **15**. IOS Press, Amsterdam, 687-688 (2008).

*Lederer, H., R. Tisma, R. Hatzky, A. Bottino and F. Jenko:* Application Enabling in DEISA: Petascaling of Plasma Turbulence Codes. Parallel Computing: Architectures, Algorithms and Applications. Proceedings of the International Conference ParCo 2007, (Eds.) C. Bischof, M. Bücker, P. Gibbon, G. Joubert, T. Lippert, B. Mohr, F. Peters. Advances in Parallel Computing **15**. IOS Press, Amsterdam, 713-720 (2008).

*Linsmeier, C. and H. Bolt:* Materials issues for ITER, DEMO and the European coordination action FEMaS-CA. Energy Materials. Advances in Characterization, Modelling and Application, (Eds.) N. H. Andersen, M. Eldrup, N. Hansen, D. Juul Jensen, E. M. Nielsen, S. F. Nielsen, B. F. Sorensen, A. S. Pedersen, T. Vegge, S. S. West. Riso National Laboratory, Roskilde, 93-100 (2008).

*Lunt, T., O. Waldmann and G. Fußmann:* Laser induced fluorescence measurements in an argon plasma in front of a tungsten target under oblique incidence. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-5.002 (2008).

*Maggi, C. F., R. J. Groebner, C. Angioni, J. Candy, C. Konz, A. W. Leonard, T. Hein, L. D. Horton, C. C. Petty, A. C. C. Sips, R. E. Waltz, ASDEX Upgrade Team and DIII-D Team:* The role of the H-mode pedestal on global confinement in hybrid scenarios in DIII-D and ASDEX Upgrade. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.024 (2008).

*Marsen, S., M. Endler, M. Otte and F. Wagner:* Overview of Turbulence Studies in the WEGA Stellarator. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-1.043 (2008).

*Mattei, M., R. Albanese, A. Portone, G. Saibene, A. C. C. Sips, ASDEX Upgrade Team and JET EFDA Contributors:* ITER Plasma Scenarios scaled from ASDEX Upgrade and JET experimental data and their impact on ITER operational space. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-4.078 (2008).

*McMillan, B. F., S. Jolliet, T. M. Tran, A. Bottino, P. Angelino, L. Villard and JET EFDA Contributors:* Avalanche-like bursts in global gyrokinetic simulations. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-1.019 (2008).

*Mehlmann, F., C. Ionita, H. W. Müller, P. Balan, A. Herrmann, A. Kendl, M. Maraschek, V. Naulin, A. H. Nielsen, J. Juul Rasmussen, V. Rohde, R. Schrittwieser and ASDEX Upgrade Team:* Radial transport in the L- and H-mode SOL of ASDEX Upgrade. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.037 (2008).

*Meo, F., H. Bindslev, S. B. Korsholm, V. Furtula, F. Leuterer, F. Leipold, P. K. Michelsen, S. K. Nielsen, M. Salewski, J. Stober, D. Wagner, P. Woskov and ASDEX Upgrade Team:* First scattering results of the Collective Thomson Scattering (CTS) Diagnostic on ASDEX Upgrade. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-1.034 (2008).

*Müller, H. W., R. Neu, R. Pugno, V. Rohde, M. Wischmeier and ASDEX Upgrade Team:* From carbon to tungsten: divertor plasmas in ASDEX Upgrade. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.010 (2008).

*Neu, R., R. Dux, A. Kallenbach, B. Kurzan, C. F. Maggi, R. Pugno, T. Pütterich, G. Tardini and ASDEX Upgrade Team:* Influence of the $^4$He Concentration on H-Mode Confinement and Transport in ASDEX Upgrade. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-4.039 (2008).

*Nold, B., M. Maraschek, H. W. Müller, M. Ramisch, V. Rohde, U. Stroth and ASDEX Upgrade Team:* Comparison of Dimensionally Similar Turbulence in TJ-K and ASDEX Upgrade. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.019 (2008).

*Pautasso, G., D. Coster, X. Bonnin and ASDEX Upgrade Team:* Modelling of massive gas injection with SOLPS. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.007 (2008).

*Pereverzev, G. V.:* Properties of numeric schemes for stiff transport models. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-5.032 (2008).

*Podoba, Y., M. Otte, F. Wagner, I. Bondarenko, A. Chmyga, G. Deshko, A. Komarov, A. Kozachok, L. Krupnik, S. Khrebtov, A. Zhezhera, A. Melnikov, S. Perfilov and M. Schubert:* HIBP on WEGA Calibration and Measurements. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-1.088 (2008).

*Polevoi, A. R., A. S. Kukushkin, W. Houlberg, S. Maruyama, K. Gál, P. Lang, B. Pegourie, H. Nehme, M. Sugihara, A. Loarte, D. Campbell and V. A. Chuyanov:* Assessment of Pumping Requirements in ITER for Pellet Fuelling and ELM Pace Making. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-1.109 (2008).

*Pueschel, M. J., L. Laborde, F. Jenko and JET EFDA Contributors:* GENE simulations on the beta dependence of tokamak core turbulence. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-1.038 (2008).

*Pütterich, T., C. F. Maggi, L. D. Horton, R. Dux, B. Langer, E. Wolfrum and ASDEX Upgrade Team:* Fast CXRS-Measurements in the Edge Transport Barrier of ASDEX Upgrade. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.083 (2008).

*Pugno, R., R. Dux, A. Kallenbach, M. Mayer, R. Neu, T. Pütterich, C. Maggi and ASDEX Upgrade Team:* Evolution of carbon content in ASDEX Upgrade during the transition to a full W machine. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-4.011 (2008).

*Pusztai, I., T. Fülöp and P. Helander:* On the quasilinear transport fluxes driven by microinstabilities in tokamaks. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-1.032 (2008).

*Ribeiro, T. T. and B. Scott:* Drift wave vs. interchange turbulence: geometrical effects on the ballooning threshold. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-5.039 (2008).

*Schneider, W., M. R. Turnyanskiy, M. Kick, F. V. Chernyshev and T. Richert:* Neutral Particle Diagnostics at MAST with a Compact Energy Analyser and Comparison with Charge Exchange Recombination Spectroscopy. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-5.081 (2008).

*Scott, B.:* Fully Nonlinear Electromagnetic Gyrokinetic Computations. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-5.030 (2008).

*Scott, B. and R. Hatzky:* Rotation in the Presence of Turbulence in Large Tokamaks. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-5.031 (2008).

*Sempf, M., P. Merkel, E. Strumberger and S. Günter:* Robust control of resistive wall modes in ITER: comparing different feedback coil systems. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-1.077 (2008).

*Sengupta, A., A. Werner, M. Otte and J. Geiger:* Fast recovery of vacuum configuration of WEGA stellarator with error field effects. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.051 (2008).

*Sips, A. C. C., P. Lomas, O. Gruber, J. Hobirk, G. M. D. Hogeweij, L. D. Horton, F. Imbeaux, M. Mattei, F. Köchl, X. Litaudon, E. de la Luna, A. Lyssoivan, Y.-S. Na, I. Nunes, V. Parail, V. Plyusnin, J. Kim, J. Romero, G. Saibene, J. Seo, J. Stober, L. Zabeo, AUG Team and JET EFDA Contributors:* Current rise studies at ASDEX Upgrade and JET in preparation for ITER. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.003 (2008).

*Suttrop, W., M. Rott, T. Vierle, B. Streibl, A. Herrmann, V. Rohde, U. Seidel, D. Yadikin, O. Neubauer, B. Unterberg, E. Gaio, V. Toigo, P. Brunsell and ASDEX Upgrade Team:* Design of in-vessel saddle coils for MHD control in ASDEX Upgrade. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-4.075 (2008).

*Suzuki, Y., N. Nakajima, J. Geiger, S. Yamamoto, K. Y. Watanabe, S. Sakakibara, A. Weller, M. Drevlak, Y. Nakamura, W. Kernbichler, V. V. Nemov and J. Nührenberg:* Applications of HINT2 code to stellarator/helitron. Joint Conference of the 17th International Toki Conference on Physics of Flows and Turbulence in Plasmas and 16th International Stellarator/Heliotron Workshop. Proceedings (II) National Institute for Fusion Science (NIFS), Toki, P2-044, 664-667 (2008).

*Thomsen, H., P. J. Carvalho, S. Gori, U. von Toussaint, A. Weller, R. Coelho and H. Fernandes:* Application of neural networks for fast tomographic inversion on Wendelstein 7-X. 35th European Physical Society Conference on Plasma Physics and 10th International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-1.065 (2008).

*Throumoulopoulos, G. N. and H. Tasso:* A sufficient condition for the linear stability of magnetohydrodynamic equilibria with field aligned incompressible flows. 35$^{th}$ European Physical Society Conference on Plasma Physics and 10$^{th}$ International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.180 (2008).

*Urso, L., H. Zohm, R. Fischer, A. Isayama, Y. Kamada, ASDEX Upgrade Team and JT-60 Team:* Fitting of the Modified Rutherford Equation: a comparison between ASDEX Upgrade and JT-60 results. 35$^{th}$ European Physical Society Conference on Plasma Physics and 10$^{th}$ International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.068 (2008).

*Valeo, E. J., J. C. Wright, R. Bilato, P. T. Bonoli, M. Brambilla, R. W. Harvey, C. K. Phillips and J. R. Wilson:* Full-wave simulations of lower hybrid wave propagation in toroidal plasma with nonthermal electron distributions. 35$^{th}$ European Physical Society Conference on Plasma Physics and 10$^{th}$ International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.099 (2008).

*Weller, A., K. Y. Watanabe, S. Sakakibara, A. Dinklage, H. Funaba, J. Geiger, J. H. Harris, R. Preuss, Y. Suzuki, A. Werner, H. Yamada, W7-AS Team and LHD Team:* Extensions of the International Stellarator Database by High-b Data from W7-AS and LHD. Joint Conference of 17$^{th}$ International Toki Conference on Physics of Flows and Turbulence in Plasmas and 16$^{th}$ International Stellarator/Heliotron Workshop 2007. Proceedings (I) National Institute for Fusion Science (NIFS), Toki, P1-039, 325-328 (2008).

*Wolfrum, E., B. Langer, R. Fischer and ASDEX Upgrade Team:* Determination of the radial electric field from passive He II emission. 35$^{th}$ European Physical Society Conference on Plasma Physics and 10$^{th}$ International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, O-2.002 (2008).

*Wright, J. C., P. T. Bonoli, E. Valeo, C. K. Phillips, M. Brambilla and R. Bilato:* The importance of the effects of diffraction and focusing on current deposition of lower hybrid waves. 35$^{th}$ European Physical Society Conference on Plasma Physics and 10$^{th}$ International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-4.114 (2008).

*Wünderlich, D., R. Gutser, S. Christ-Koch, U. Fantz, M. Berger, P. Franzen, M. Fröschle, B. Heinemann, W. Kraus, C. Martens, P. McNeely, R. Riedl and E. Speth:* Modeling of Negative Ion RF Souces for ITER NBI: Current Status and Recent Achievements. 35$^{th}$ European Physical Society Conference on Plasma Physics and 10$^{th}$ International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-2.102 (2008).

*Yu, Q. and S. Günter:* Neoclassical tearing modes: its locking by error fields and stabilization by RF current. 35$^{th}$ European Physical Society Conference on Plasma Physics and 10$^{th}$ International Workshop on Fast Ignition of Fusion Targets. Contributed Papers, (Eds.) P. Lalousis, S. Moustaizis. ECA **32D**. European Physical Society, Geneva, P-1.078 (2008).

## Thesis

*Marsen, S.:* The Spatio-temporal Structure of Electrostatic Turbulence in the WEGA Stellarator. Universität Greifswald (2008).

*Nold, B.:* Comparison of Dimensionally Similar Turbulence in TJ-K and ASDEX Upgrade. Universität, Stuttgart (2008).

*Sauter, P.:* Development of a Monte Carlo code to understand the ASDEX pressure gauge performance. Ludwig-Maxmilian-Universität, München (2008).

*Schmidt, S.:* Numerical simulations of fast magnetic reconnection in low β plasmas. Technische Universität, München (2008).

*Stiehm, M.:* Untersuchung der Haltbarkeit von Aluminiumschweißnähten bei zyklischer Belastung. Fachhochschule Stralsund, University of Applied Science, Stralsund (2008).

## PhD-Thesis

*Adelhelm, C.:* Structure and Erosion Behavior of Metal-doped Carbon Films. Technische Universität München (2008).

*Christ-Koch, S.:* Profile der Plasmaparameter und Dichte negativer Wasserstoffionen mittels Laserdetachmentmessungen in HF-angeregten Ionenquellen. Universität Augsburg (2008).

*Kalentev, O.:* A Finite Difference Code for 3D Plasma Edge Modelling. Universität Greifswald (2008).

*Merz, F.:* Gyrokinetic Simulation of Multimode Plasma Turbulence. Universität Münster (2008).

*Nogales Tenorio, S.:* Numerical Simulation of the Thermal and Thermomechanical Behaviour of Metal Matrix Composites. Technische Universität Wien (2008).

*Rai, A.:* Dynamic Monte-Carlo modeling of hydrogen isotope reactive-diffusive transport in porous graphite. Universität Greifswald (2008).

*Reinelt, M.:* Untersuchungen zur Erosion ultradünner Kohlenstoffschichten und Wasserstoffrückhaltung in Beryllium. Technische Universität München (2008).

*Schlüter, M.:* Synergismen bei der Erosion von amorphen Kohlenwasserstoff-schichten mit niederenergetischen Teilchenstrahlen, eine In-Situ-Ellipsometriestudie. Universität Bayreuth (2008).

*Schmid, A.:* Characterization of Type-I ELM Induced filaments in the far scrape-off layer of ASDEX Upgrade. Technische Universität München (2008).

*Sharma, A. R.:* Atomistic Modelling Of Hydrocarbons in Plasma-Wall Interaction. Universität Greifswald (2008).

*Tröster, C.:* Development of a flexible reflectometry system and its application to turbulence characterization in the ASDEX Upgrade tokamak. Ludwig-Maximilians-Universität München (2008).

## Patents

*Brendel, A., T. Uihlein, W. Eichmann and F. Heutling*: Verschleißschutzbeschichtung mit Rissstopp-Funktion durch Rissumleitung. Erfindungsmeldung: 16.06.2008. Unbeschränkte Inanspruchnahme: 10.10.2008. Anmeldung erfolgt über MTU.

*Brockmann, R.:* Ultra Schnüffler: Ausgründung: 01.03.2008.

*Erckmann, V., G. Dammertz and M. Schmid:* Advanced collector sweeping with homogenous power desposition of electron beams in high-power rf vacuum tubes. Keine Nachanmeldung in den Nicht-PCT Staaten: 15.04.2008.

*Furmanek, A., A. Kallenbach, R. Tivey, H. Bolt and P. Lorenzetto:* Hitzeschild mit wendelförmiger Kühlung für thermisch und nuclear hochbelastete Komponenten. Erfindungsmeldung: 05.09.2008. Unbeschränkte Inanspruchnahme: 16.12.2008.

*Haas, G., A. Scarabosio, L. Giannone, J. Sachtleben and M. Marquardt:* ASDEX Pressure Gauges. Erfindungsmeldung: 30.05.2008. Inanspruchnahme als qualifiziertes Know-How: 09.09.2008.

*Mast, K.-F., G. Schramm and M. Münch:* Folienmanometer. Erteilung Japanisches Patent: 22.02.2008.

*Schauer, F.:* Abstandhalter. Freigabe des Deutschen Patents: 31.01.2008. Freigabe der Europäischen Anmeldung: 09.12.2008.

*Schauer, F.:* Stromzuführungseinrichtung. Freigabe der Deutschen Anmeldung: 09.12.2008.

*Schauer, F.:* Kaltleckprüfung. Freigabe der Deutschen Anmeldung: 09.12.2008.

*Sihler, C.:* Verfahren und Dämpfungsvorrichtung zur Dämpfung einer Torsionsschwingung in einem rotierenden Antriebsstrang. Benennung der Länder für die Europäische Anmeldung: 08.04.2008. Patenterteilung für Europäische Anmeldung 14.05.08.

## Laboratory Reports

### Internal IPP Reports

**IPP 4/287**
*Christ-Koch, S. and U. Fantz:* Profile der Plasmaparameter und Dichte negativer Wasserstoffionen mittels Laserdetachmentmessungen in HF-angeregten Ionenquellen. 145 p. (2008).

**IPP 4/288**
*König, S. and U. Fantz:* Untersuchungen der Eigenschaften cäsierter Oberflächen in Wasserstoffplasmen. 90 p. (2008).

**IPP 4/289**
*Manhard, A., U. Fantz, A. Stäbler, H. Greuner and B. Crowley:* Spectroscopic Studies on Positive Ion Based Neutral Beam Injection Systems. 125 p. (2008).

**IPP 5/120**
*Meyer-Spasche, R. and S. Huber:* Spektren und Pseudospektren – Theorie, Numerik und Anwendungen. 53 p. (2008).

**IPP 10/34**
*Nold, B.:* Comparison of Dimensionally Similar Turbulence in TJ-K and ASDEX Upgrade. 62 p. (2008).

**IPP 10/35**
*Schmid, A.:* Characterization of Type-I ELM Induced filaments in the far scrape-off layer of ASDEX Upgrade. 121 p. (2008).

**IPP 10/36**
*Whiteford, A. D., M. G. von Hellerman, L. D. Horton and K.-D. Zastrow:* CXSFIT User Manual. 62 p. (2008).

**IPP 10/37**
*Sauter, P.:* Development of a Monte Carlo code to understand the ASDEX pressure gauge performance. 86 p. (2008).

**IPP 13/9**
*Allen, F.:* Electron Capture by Highly Charged Ions from Surfaces and Gases. 135 p. (2008).

**IPP 13/10**
*Versteegh, A.:* Analysis of a Long Living Atomospheric Plasmoid. 120 p. (2008).

**IPP 13/11**
*Marsen, S.:* The Spatio-temporal Structure of Electrostatic Turbulence in the WEGA Stellarator. 140 p. (2008).

**IPP 13/12**
*Yuriy, P.:* Radio frequency heating on the WEGA stellarator. 113 p. (2008).

**IPP 16/18**
*Ulrich, V.:* Untersuchung von Autoionisationsprozessen in kleinen Molekülen und Clustern mittels hochauflösender Elektronenkoinzidenzspektroskopie. 132 p. (2008).

**IPP 17/5**
*Levchuk, S.:* Interface development for a EUROFER steel matrix composite with SiC-fibre reinforcement. 126 p. (2008).

**IPP 17/6**
*Köck, T.:* Herstellung und Charakterisierung eines SiC/Cu-Metall-Matrix-Verbundwerkstoffes mit angepasster Faser/Matrix-Grenzfläche. 135 p. (2008).

**IPP 17/7**
*Reinelt, M.:* Untersuchungen zur Erosion ultradünner Kohlenstoffschichten und Wasserstoffrückhaltung in Beryllium. 107 p. (2008).

**IPP 17/8**
*Schlüter, M.:* Synergismen bei der Erosion von amorphen Kohlenwasserstoffschichten mit niederenergetischen Teilchenstrahlen, eine In-Situ-Ellipsometriestudie. 83 p. (2008).

**IPP 17/9**
*Klages, K. U.:* Deuterium Retention in Carbon, Beryllium and Carbon Layers on Titanium and Beryllium. 106 p. (2008).

**IPP 17/10**
*Nogales Tenorio, S.:* Numerical Simulation of the Thermal and Thermomechanical Behaviour of Metal Matrix Composites. 166 p. (2008).

**IPP 17/11**
*Adelhelm, C.:* Structure and Erosion Behavior of Metal-doped Carbon Films. 126 p. (2008).

### External Reports

**EFDA-JET-CP(03)03-06**
*Lang, P. T., B. Alper, E. Belonohy, D. Frigione, K. Gal, G. Kocsis, K. Lackner, T. Loarer, M. Maraschek, F. M. Poli, G. Saibene, S. E. Sharapov, T. Szepesi, R. Wenninger, H. Zohm, ASDEX Upgrade Team and JET EFDA Contributors:* Pellet Investigations Related to ITER ELM Pacing and Particle Fuelling. JET-EFDA, Abingdon, 7 p. (2008).

# Lectures

*Adamek, J., V. Rohde, H. W. Müller, A. Herrmann, A. Kallenbach, R. Neu, J.-M. Noterdaeme, T. Pütterich and V.* Rohde: Direct measurements of the plasma potential in ELMy H-Mode plasma with ball-pen probes on ASDEX Upgrade tokamak. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Adelhelm, C., M. Balden, M. Rasinski, M. Rinke, M. Stüber and M. Sikora:* Impact of metal-doping and annealing on the structure and constitution of amorphous carbon films. (14th International Conference on Thin Films and Reactive Sputter Deposition 2008 (ICTF 14 & RSD 2008), 2008-11-17 to 2008-11-20, Ghent).

*Adelhelm, C., M. Balden, P. Sauter and P. Starke:* Deuterium plasma and ion beam erosion experiments on metal-doped amorphous carbon films. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Adelhelm, C., D. Levchuk, H. Maier, F. Koch and K. Ertl:* Ceramic Coatings as Tritium Permeation Barriers. (Fachbeirat, 2008-06-19, Garching).

*Albajar, F., M. Bornatici and F. Engelmann:* Recent progress in electron cyclotron radiative transport modelling of fusion plasmas in view of ITER and DEMO applications. (15th Joint Workshop on Electron Cyclotron Emission and Electron Cyclotron Resonance Heating (EC-15), 2008-03-10 to 2008-03-13, Yosemite National Park, CA).

*Albajar, F., M. Bornatici, F. Engelmann and A. B. Kukushkin:* Benchmarking of codes for calculating local net EC power losses in fusion plasmas. (15th Joint Workshop on Electron Cyclotron Emission and Electron Cyclotron Resonance Heating (EC-15), 2008-03-10 to 2008-03-13, Yosemite National Park, CA).

*Alimov, V., W. M. Shu, J. Roth, D. A. Komarov, S. Lindig, K. Isobe, H. Nakamura and T. Yamanishi:* Surface Modification and Deuterium Retention in Tungsten and Molybdenum Exposed to Low-Energy, High Flux Deuterium Plasmas. (1st International Conference on New Materials for Extreme Environments (ExtreMat), 2008-06-02 to 2008-06-04, San Sebastian).

*Andreeva, T., T. Bräuer, M. Endler, J. Kißlinger and U. von Toussaint:* Influence of construction errors on Wendelstein 7-X magnetic configuration. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Angioni, C., A. G. Peeters and G. V. Pereverzev:* Gyrokinetic simulations of alpha particle transport and consequences on ITER transport modelling. (13th EU-US TTF Workshop 2008 and 1st EFDA Transport Topical Group Meeting, 2008-09-01 to 2008-09-04, Copenhagen).

*Angioni, C., A. G. Peeters, G. V. Pereverzev, J. Candy, R. Dux, E. Fable, T. Hein and R. E. Waltz:* Gyrokinetic simulations of impurity, He ash and alpha particle transport and consequences on ITER transport modelling. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Antar, G. Y., S. Assas, V. Bobkov, J.-M. Noterdaeme, A. Herrmann, E. Wolfrum, R. Dux, R. Pugno, V. Rohde and ASDEX Upgrade Team:* Scrape-off Layer Turbulence L-mode, NBI-driven H-mode and ICRH H-mode. (Seminar CEA, 2008-09-11 to 2008-09-12, Cadarache).

*Assas, S. C.:* Investigation on possible spurious arc detections on the Tore Supra SHAD system due to plasma processes. (Seminar CEA, 2008-09-11 to 2008-09-12, Cadarache).

*Assas, S. C., L.-G. Eriksson, G. Tardini, T. Pütterich, C. F. Maggi, G. D. Conway, V. Bobkov, J. Schirmer, J.-M. Noterdaeme and ASDEX Upgrade Team:* Toroidal Rotation in ICRF only Heated ASDEX Upgrade Plasmas with Low Momentum Input. (13th EU-US TTF Workshop, 2008-09-01 to 2008-09-04, Copenhagen).

*Assas, S. C., L.-G. Eriksson, G. Tardini, T. Pütterich, C. F. Maggi, G. D. Conway, V. Bobkov, J. Schirmer, J.-M. Noterdaeme and ASDEX Upgrade Team:* Toroidal Rotation in ICRF only Heated ASDEX Upgrade Plasmas with Low Momentum Input. (ITPA-Confinement, Transport and Pedestal Physics Meeting, 2008-10-20 to 2008-10-22, Milan).

*Balden, M., C. Adelhelm, M. Rasinski, M. Sikora, E. Welter, M. Rinke and M. Stüber:* Structural investigation of amorphous metal-doped carbon films. (E-MRS 2008 Spring Meeting, 2008-05-26 to 2008-05-30, Strasbourg).

*Balden, M., V. Rohde and ASDEX Upgrade Team:* First investigation of the inner morphology of dust particles from ASDEX Upgrade. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Balden, M., P. Starke, I. Lopez-Galilea, C. Adelhelm, D. Filimonow, J. M. Ramos Fernandez, A. Martinez Escandell, A. Centeno, C. Blanco and C. Garcia-Rosales:* Erosion behavior of self-passivating metal-doped carbon materials under deuterium impact. (1st International Conference on New Materials for Extreme Environments (ExtreMat), 2008-06-02 to 2008-06-04, San Sebastian).

*Baudach, M., A. Cwiklinski, A. Markin, W. Bohmeyer and G. Fußmann:* Einfluss von Stickstoff auf Plasma-Wand-Wechselwirkungsprozesse. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Baylard, C., D. A. Hartmann, H. Greve and F. Herold:* Configuration space control for Wendelstein 7-X. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Behringer, K.:* Spectroscopy of fusion plasmas: Methods and atomic data requirements. (IAEA International Workshop on Challenges in Plasma Spectroscopy for Future Fusion Research Machines, 2008-02-20 to 2008-02-22, Jaipur).

*Behringer, K., U. Fantz and T. Hamacher:* Probleme der zukünftigen Energieversorgung. (WS 2007/2008. Seminar in Universität Augsburg).

*Behringer, K., U. Fantz and M. Schreck:* Anwendungen und Diagnostik von Niederdruckplasmen. (WS 2007/2008. Vorlesung, Universität Augsburg).

*Behringer, K., M. Stritzker, U. Fantz and M. Schreck:* Diagnostik von Niederdruckplasmen als industrielle Schlüsseltechnologie. (WS 2007/2008. Seminar, Universität Augsburg).

*Beidler, C.:* ICNTS – Status of Benchmarking. (Kinetic Theory Workshop (KTW), 2008-10-23 to 2008-10-24, Madrid).

*Beidler, C., M. Isaev, S. Kasilov, W. Kernbichler, H. Maaßberg, D. Mikkelsen, S. Murakami, V. Nemov, M. Schmidt, D. Spong, V. Tribaldos and A. Wakasa:* Results From the International Collaboration on Neoclassical Transport in Stellarators (ICNTS). (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Beidler, C. and H. Maaßberg:* General Formulation of Taguchi´s Momentum Correction Approach. (Kinetic Theory Workshop (KTW), 2008-10-23 to 2008-10-24, Madrid).

*Berger, M., S. Christ-Koch, U. Fantz, P. Franzen and NNBI Team:* Characterization of the large-scale RF-driven negative ion source test facility RADI. (1st International Conference on Negative Ions, Beams and Sources (NIBS 2008), 2008-09-10 to 2008-09-12, Aix-en-Provence).

*Biedermann, C.:* Spectroscopy of highly-charged ions relevant to fusion plasmas. (6th International Conference on Atomic and Molecular Data and their Applications (ICAMDATA), 2008-10-28 to 2008-10-31, Beijing).

*Biedermann, C., R. Radtke, R. Seidel and E. Behar:* Dielectronic and Radiative Recombination of Si- to N-like Tungsten Ions. (14th International Conference on the Physics of Highly Charged Ions (HCI 2008), 2008-09-01 to 2008-09-05, Chofu, Tokio).

*Biel, W., R. Burhenn, E. Delabie, A. Greiche, M. v. Hellermann, R. Jaspers, J. Koning, R. König, F. Klinkhamer, H. G. Lee, O. Marchuk and TEXTOR Team:* Development of high-performance spectroscopic instrumentation for magnetic fusion plasma diagnostics. (IAEA International Workshop on Challenges in Plasma Spectroscopy for Future Fusion Research Machines, 2008-02-20 to 2008-02-22, Jaipur).

*Birus, D., M. Schneider, T. Rummel, M. Fricke, K. Petry and A. Ebersoldt:* Processing of the quench detection signals in W7-X. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Blackwell, B., D. Pretty, J. Howard, S. Kumar, D. Oliver, D. Byrne, J. Harris, C. Nührenberg, M. McGann, R. Dewar, F. Detering, M. Hegland, G. Potter and J. Read:* Configurational Effects on Stability and Confinement in the H-1NF Heliac. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Bluhm, T., P. Heimann, C. Hennig, G. Kühner, H. Kroiss, H. Laqua, M. Lewerentz, J. Maier, H. Riemann, J. Schacht, A. Spring, A. Werner and M. Zilker:* Common browsing and retrieval of technical and experimental data for steady state experiments. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Bobkov, V., F. Braun, R. Dux, A. Herrmann, L. Giannone, A. Kallenbach, H. W. Müller, R. Neu, J.-M. Noterdaeme, T. Pütterich, V. Rohde, A. Sips, A. Krivska, I. Zammuto and ASDEX Upgrade Team:* ICRF Antenna Operation with Full W-wall in ASDEX-Upgrade. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Bobkov, V., F. Braun, R. Dux, A. Herrmann, A. Kallenbach, R. Neu, J.-M. Noterdaeme, T. Pütterich and ASDEX Upgrade Team:* Operation of ICRF antennas in a full tungsten environment in ASDEX Upgrade. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Bohmeyer, W., F. L. Tabares, M. Baudach, A. Cwiklinski, T. Schwarz-Selinger, A. Markinc, J. A. Ferreiab, G. Fußmann and A. Loarte:* The Scavenger effect – does it work? (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Bolt, H.:* Oberflächentechnologie (OT). (SS 2008. Vorlesung, Technische Universität München).

*Bonicelli, T., A. Masiello, V. Antoni, A. De Lorenzi, M. Dremel, P. Franzen, R. Hemsworth, M. Liniers, D. Marcuzzi, D. Martin, R. Piovan, P. Sonato, L. Svensson, A. Tanga, V. Toigo and P. L. Zaccaria:* Programme towards the 1 MeV ITER NB injector. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Bonnin, X., A. Kukushkin and D. Coster:* Code Development for ITER Edge Modelling – SOLPS5.2. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Boscary, J., H. Greuner, T. Friedrich, H. Traxler, B. Mendelevitch, B. Böswirth, J. Schlosser, M. Smirnow and R. Stadler:* Pre-series and testing route for the serial fabrication of W7-X target elements. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Bosch, H.-S.:* Basics of Nuclear Fusion. (IPP Summer University for Plasma Physics, 2008-09-22 to 2008-09-26, Garching).

*Bosch, H.-S.:* Kernfusion – Was die Sterne mit unserer Energieversorgung zu tun haben. (MPG-Hauptversammlung, 2008-06-27, Marie-Curie-Gymnasium Dresden).

*Bosch, H.-S.:* Physics and Progress of the Wendelstein 7-X Stellarator. (20th NNV-Symposium on Plasma Physics and Radiation Technology, 2008-03-04 to 2008-03-05, Lunteren).

*Bosch, H.-S.:* Wendelstein 7-X – ein optimierter Stellarator. (Mitgliederversammlung Graduierten Kolleg 1203, 2008-10-27, Bad Breisig).

*Bosch, H.-S.:* Wendelstein 7-X – A technology step towards Demo. (18th International Toki Conference (ITC18), 2008-12-09 to 2008-12-12, Toki).

*Bosch, H. S. and W7-X Team:* Wendelstein 7-X Status and Technical Challenges. (Jahrestagung Kerntechnik 2008, 2008-05-27 to 2008-05-29, Hamburg).

*Bottino, A., P. Angelino, B. D. Scott, R. Hatzky, S. Jolliet, B. F. McMillan, A. G. Peeters and E. Poli:* Global nonlinear simulations of microinstabilities in tokamaks. (13th EU-US TTF Workshop 2008 and 1st EFDA Transport Topical Group Meeting, 2008-09-01 to 2008-09-04, Copenhagen).

*Bovshuk, V., W. Cooper, M. Mikhailov, J. Nührenberg and V. Shafranov:* Exploration of Configurational Space for Quasi-isodynamic Stellarators with Poloidally Closed Contours of the Magnetic Field Strength. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Bradshaw, A. M.:* Energy and Energy Research. (40th Anniversary of the European Physical Society, 2008-03-28, Mulhouse).

*Bradshaw, A. M.:* Our energy future. (IET Germany Network Annual National Meeting, 2008-10-04, Fulda).

*Bradshaw, A. M.:* Grundlagen und Perspektiven der Kernfusion – Was kommt nach dem Ölzeitalter? (Mitgliederversammlung der Gesellschaft Deutscher Naturforscher und Ärzte (GDNÄ), 2008-09-22, Tübingen).

*Bradshaw, A. M.:* ITER: the way to fusion energy. (Kolloquiumsvortrag, 2008-01-17, Universität Groningen).

*Bradshaw, A. M.:* ITER: Der Weg zur Fusionsenergie. (Physikalisches Kolloquium, 2008-02-06, Universität Duisburg-Essen).

*Bradshaw, A. M.:* Kernfusion: Klimaretter oder Utopie. (Institutskolloquium, 2008-10-21, Technische Universität Ilmenau).

*Bradshaw, A. M.:* Kernfusion: Klimaretter oder Utopie. (Klassensitzung der Berlin-Brandenburgischen Akademie der Wissenschaften, 2008-10-24, Berlin).

*Bradshaw, A. M.:* Kernfusion: Klimaretter oder Utopie. (ProcessNet-Jahrestagung, 2008-10-07, Karlsruhe).

*Bradshaw, A. M.:* Towards a nuclear fusion power plant. (Kolloquium. University of Warwick, 2008-11-19, Warwick).

*Bradshaw, A. M.:* Towards a nuclear fusion power plant. (The Royal Society; New Fellows Seminar, 2008-07-09, London).

*Brakel, R., P. van Eeten, D. A. Hartmann, K. Henkelmann, J. Knauer, K. Müller, A. Okkenga-Wolf and U. Wenzel:* Configuration management for Wendelstein 7-X. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Brandt, C., O. Grulke and T. Klinger:* Raumzeitliche Kontrolle von Driftwellenturbulenz. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Bräuer, T.:* High geometric prcision in the construction of the Wendelstein 7-X fusion experiment. (Coordinate Metrology Systems Conference, 2008-07-21 to 2008-07-25, Charlotte, NC).

*Bräuer, T., M. Endler, A. Junge and J. Müller:* Metrology at Half Module Assembly at Wendelstein 7-X. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Braun, F.:* Summary of IPP work on ICRH antenna shimming and grounding. (Topical Group on Heating and Current Drive, Coordinating Committee on ICRH (CCIC), 2008-04-09 to 2008-04-10, Culham).

*Braun, S.:* Collisional zonal-flow damping in an impure plasma. (Kolloquium, Department of Radio and Space Science, 2008-05-25 to 2008-06-06, Chalmers University Göteborg).

*Braun, S.:* Collisional zonal-flow damping in an impure plasma. (Theorie Seminar, 2008-11-17 to 2008-11-21, Schloss Ringberg, Tegernsee).

*Brendel, A. and D. Sporn:* Neuartige Kupfer-Komposite für extreme Belastungen im Fusionsreaktor. (Begutachtung des Projektes im Rahmes des Paktes für Forschung und Innovation der Max-Planck-Gesellschaft und der Fraunhofer Gesellschaft, 2008-06-16, Berlin).

*Brendel, A., V. Paffenholz and T. Köck:* SiC fibre reinforced copper as heat sink material – a comparison of SCS 6 and SCS 0 fibres. (New Congress "Materials Science and Engineering" (MSE 2008), 2008-09-01 to 2008-09-04, Nürnberg).

*Brendel, A., V. Paffenholz, T. Köck and A. Herrmann:* Faserverstärktes Kupfer für Bauteile in Fusionsreaktoren. (14. Nationales Symposium SAMPE Deutschland e.V. "Fasern und Matrix", 2008-02-27 to 2008-02-28, TU München, Garching).

*Brezinsek, S., A. G. Meigs, S. Jachmich, M. F. Stamp, J. Rapp, R. Felton, R. A. Pitts, V. Philipps, A. Huber, R. Pugno, G. Sergienko, A. Pospieszczyk and JET EFDA Contributors:* The impact of divertor detachment on carbon sources in JET L-mode discharges. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Briefi, S., U. Fantz, P. Starke, S. Dietrich and J. Griesbauer:* Untersuchungen an HF-angeregten Metallhologenidplasmen. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Briefi, S., U. Fantz and D. Wünderlich:* Emission and absorption spectra of InBr in low pressure discharges. (35th IEEE International Conference on Plasma Science (ICOPS 2008), 2008-06-15 to 2008-06-19, Karlsruhe).

*Burhenn, R., Y. Feng, K. Ida, D. Kalinina, H. Maassberg, K. J. McCarthy, S. Morita, Y. Nakamura, H. Nozato, S. Okamura, S. Sudo, C. Suzuki, N. Tamura, A. Weller, M. Yoshinuma and B. Zurro:* On impurity handling in high performance stellarator/heliotron plasmas. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Busse, A. and W. C. Müller:* Diffusion and dispersion of tracer particles in anisotropic MHD turbulence. (Frühjahrstagung der Deutschen Physikalischen Gesellschaft, 2008-03-03 to 2008-03-07, Freiburg).

*Bykov, V., K. Egorov and F. Schauer:* Structural analysis of W7-X: Overview. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Camenen, Y., A. G. Peeters, C. Angioni, F. J. Casson, W. A. Hornsby, A. P. Snodin and D. Strintzi:* Effect of the Coriolis drift on turbulent cross-field transport in tokamak plasmas. (13th EU-US TTF Workshop 2008 and 1st EFDA Transport Topical Group Meeting, 2008-09-01 to 2008-09-04, Copenhagen).

*Cantarini, J., J. P. Knauer and E. Pasch:* Design and study of the Wendelstein 7-X Thomsen scattering polychromators. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Cantarini, J., R. König, D. Hildebrandt, F. Klinkhamer, K. Moddemeijer, W. Vliegenthart and R. Wolf:* Optical Design Study of an Infrared Visible Viewing System for Wendelstein 7-X Divertor Observation and Control. (17th Topical Conference on High-Temperature Plasma Diagnostics, 2008-05-11 to 2008-05-15, Albuquerque, NM).

*Cavinato, M., G. Saibene, A. Portone, R. Sartori, P. R. Thomas, C. Kessel, M. Mattei, V. Parail, P. J. Lomas, F. Köchl, A. C. C. Sips, L. D. Horton, I. Nunes, G. Ambrosino and A. Loarte:* ITER operational space for full plasma current H-mode operation. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Chankin, A. V., D. P. Coster and ASDEX Upgrade Team:* Comparison of 2D Models for the Plasma Edge with Experimental Measurements and Assessment of Deficiencies. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Chauvin, D., T. Koppe, A. Cardella, B. Missal, D. Pilopp, J. Reich, G. Di Bartolo, R. Camin and L. Giordano:* Designing and manufacturing of the coil support structure of W7-X. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Chen, J., H. Kawashima, X. Gao, L. Hu, N. Asakura, K. Shimizu, H. Takenaga and D. P. Coster:* Edge Plasma Modelling for Transport Analysis on JT-60U Tokamak. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Chikada, T., A. Suzuki, T. Kobayashi, Z. Yao, D. Levchuk, H. Maier, T. Terai and T. Muroga:* Thermal Influence on Erbium Oxide Coating for Tritium Permeation Barrier. (18th Topical Meeting on the Technology of Fusion Energy (TOFE), 2008-09-28 to 2008-10-02, San Fancisco, CA).

*Chikada, T., A. Suzuki, Z. Yao, D. Levchuk, H. Maier, T. Terai and T. Muroga:* Deuterium permeation behavior of erbium oxide coating on austenitic, ferritic, and ferritic/martensitic steels. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Ciupinski, L., G. Krzesinski, K. Kurzydlowski, P. Marek, T. Zagrajek, V. Bykov, P. Czarkowski, W. Dänner, A. Dudek and F. Schauer:* Evaluation of the structural mechanical behaviour of W7-X central support connections by means of semi-automated FE analysis. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Coad, J. P., D. E. Hole, J. Likonen, S. Lindig, G. F. Matthews, M. Mayer, V. Philipps, V. Riccardo, E. Vainonen-Ahlgren, A. Widdowson and JET EFDA Contributors:* In-situ testing of Tungsten coatings in JET at critical areas for the ITER-like wall. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Conway, G. D. and ASDEX Upgrade Team:* Overview of fluctuation diagnostics on ASDEX Upgrade – Current and proposed. (EFDA Diagnostics Workprogramme Meeting, 2008-03-06, Garching).

*Conway, G. D. for the European Reflectometer Code Consortium:* Reflectometry for turbulence characterization – Interpretation and simulation. (EFDA Diagnostics Workprogramme Meeting, 2008-03-06, Garching).

*Conway, G. D., J. Schirmer, C. Tröster, S. Klenge, E. Holzhauer, W. Suttrop, H. Zohm and ASDEX Upgrade Team:* Edge Er and turbulence measurements using Doppler reflectometry. (16th European Fusion Physics Workshop, 2008-12-01 to 2008-12-03, Castlemartyr, Cork).

*Conway, G. D., C. Tröster, J. Schirmer, C. Angioni, E. Holzhauer, F. Jenko, F. Merz, E. Poli, B. Scott, W. Suttrop and ASDEX Upgrade Team:* Recent developments in Doppler reflectometry on ASDEX Upgrade and their relevance for ITER. (ITPA TGD European Progress Meeting, 2008-04-14, Lausanne).

*Conway, G. D., C. Tröster, J. Schirmer, W. Suttrop, C. Lechte, E. Holzhauer, B. Scott, E. Poli, H. Zohm and ASDEX Upgrade Team:* Turbulence and geodesic acoustic mode behavioural studies in ASDEX Upgrade using Doppler Reflectometry. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Coster, D. P.:* Whole Device ELM Simulations. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Coster, D. P., X. Bonnin, A. V. Chankin, C. Konz, G. Pautasso, M. Wischmeier, E. Wolfrum and ASDEX Upgrade Team:* Recent Results from Edge Modelling on ASDEX Upgrade. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Coster, D. P., X. Bonnin, D. Reiter, A. Kukushkin, S. Gori, P. Krstic, P. Strand, L.-G. Eriksson and Contributors to the EFDA-TF-ITM:* Simulations of the edge plasma: the role of atomic, molecular and surface physics. (6th International Conference on Atomic and Molecular Data and their Applications, 2008-10-28 to 2008-10-31, Beijing).

*Croari, G., H. Viebke, K. Hertel, J. Baldzuhn, L. Genini, B. Renard and L. Vieillard:* DC insulation tests of W7-X coils at CEA, Saclay. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Cwiklinski, A., M. Baudach, A. Markin, W. Bohmeyer and G. Fußmann:* Scavenger-Effekt: Lösung des T-Co-Depositionsproblems? (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Czarkowski, P., V. Bykov and A. Dudek:* Structural analysis of the central support elements for the Wendelstein 7-X magnet system. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*D'Inca, R., A. Onyshchenko, F. Braun, G. Siegl, V. Bobkov, H. Faugel and J.-M. Noterdaeme:* Characterization of arcs in ICRF transmission lines. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*De Temmermann, G., M. J. Baldwin, R. P. Doerner, D. Nishijima, R. Seraydarian and K. Schmid:* Insight into the codeposition of deuterium with beryllium: influence of the deposition conditions on deuterium retention and release. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Dey, R., M. Sertoli, R. Dux, A. Kallenbach, R. Neu, T. Pütterich and ASDEX Upgrade Team:* Modelling of Ar spectra using

STRAHL code in ASDEX Upgrade tokamak. (23rd National Symposium on Plasma Science and Technology (PLASMA 2008), 2008-12-10 to 2008-12-13, Trombay, Mumbai).

*Dhard, C., H. Bau, S. Pingel and F. Schauer:* Control Interface between W7-X Control Systems and Helium Refrigerator. (International Cryogenic Engineering Conference 22 and International Cryogenic Materials Conference 2008 (ICEC 22 – ICMC 2008), 2008-07-21 to 2008-07-25, Seoul).

*Dietrich, S., S. Christ-Koch and U. Fantz:* Plasmaparameterprofile in einer Quelle für negative Ionen. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Dinklage, A., B. Bruhn, H. Testrich and C. Wilke:* Experimentelle Untersuchung der rauschinduzierten Dynamik nahe Hopf-Hopf-Bifurkationen. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Dinklage, A., H. Dreier and R. Preuss:* Scaling law model comparison and impact of models on planning strategies. (5th Workshop on Fusion Data Processing, Validation and Analysis, 2008-01-14 to 2008-01-16, Culham).

*Dinklage, A., A. Kus, H. Maaßberg, R. Preuss, Y. A. Turkin, H. Yamada, E. Ascasibar, C. D. Beidler, H. Funaba, J. H. Harris, T. Mizuuchi, S. Murakami, S. Okamura, F. Sano, U. Stroth, Y. Suzuki, J. Talmadge, V. Tribaldos, K. Y. Watanabe, A. Weller, R. Wolf and M. Yokoyama:* Energy confinement scaling of stellarators/heliotrons towards reactor operation. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Dodt, D., A. Dinklage and R. Fischer:* Reconstruction of Electron Energy Distribution Functions from Optical Emission Spectroscopic Data. (5th Workshop on Fusion Data Processing, Validation and Analysis, 2008-01-14 to 2008-01-16, Culham).

*Dodt, D., A. Dinklage, R. Fischer, K. Bartschat and O. Zatsarinny:* Influence of uncertain atomic data on the reconstruction of EEDFs from optical emission spectroscopy. (28th Maximum Entropy and International Workshop on Bayesian Inference and Maximum Entropy Methods in Science and Engineering (MaxEnt 2008), 2008-07-06 to 2008-07-11, Sao Paulo).

*Dodt, D., A. Dinklage, R. Fischer, K. Bartschat and O. Zatsarinny:* Rekonstruktion von Elektronen Energie Verteilungsfunktionen aus emissionsspektroskopischen Daten. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Dreier, H., A. Dinklage, R. Fischer, M. Hirsch and P. Kornejew:* Bayesian Experimental Design of a multi-channel interferometer for Wendelstein 7-X. (17th Topical Conference on High-Temperature Plasma Diagnostics, 2008-05-11 to 2008-05-15, Albuquerque, NM).

*Drevlak, M., C. Nührenberg, A. Boozer, S. Hudson, L. Ku, D. Monticello and A. Reiman:* Computational Study of Magnetic Islands in the W7-X and NCSX Stellarators. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Dübner, A., D. Zacharias, M. Nagel, V. Bykov, F. Schauer and M. Ihrke:* Structural analysis of the W7-X cryogenic pipe system. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Dudek, A., V. Bykov, P. Czarkowski, D. Hathiramani, M. Nitz, F. Schauer, J. Klammer, C. Zauner and C. Damiani:* Verification tests of critical bolted connections of the W7-X coils. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Dux, R.:* Plasmaphysik und Fusionsforschung. (WS 2007/2008. Proseminar, Technische Universität München, Garching).

*Dux, R.:* Plasmaphysik und Fusionsforschung. (SS 2008. Vorlesung/Proseminar, Technische Universität München).

*Dux, R. and A. M. Bradshaw:* Plasmaphysik und Fusionsforschung. (SS 2008. Proseminar, Technische Universität München, Garching).

*Dux, R., V. Bobkov, A. Herrmann, A. Janzer, A. Kallenbach, R. Neu, M. Mayer, H. W. Müller, R. Pugno, T. Pütterich, V. Rohde and A. C. C. Sips:* Plasma-wall interaction and plasma behaviour in the non-boronised all tungsten ASDEX Upgrade. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Egorov, K., V. Bykov, F. Schauer and P. van Eeten:* Structural analysis of Wendelstein 7-X magnet weigth supports. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Ehrke, G.:* Transition of W7-X non planar coils from manufacturing to assembly. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Eich, T., W. Fundamenski, A. Kallenbach, A. Herrmann, J. C. Fuchs, S. Devaux, M. Beurskens, G. Arnoux, V. Naulin, ASDEX Upgrade Team and JET-EFDA Contributors:* Divertor heat loads due to edge localized modes in JET and ASDEX Upgrade. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Eich, T., A. Kallenbach, A. Herrmann, J. C. Fuchs, A. Loarte, G. Armoux, W. Fundamenski, S. Gerasimov, R. A. Pitts, D. Tshakaja and ASDEX Upgrade Team and JET EFDA Contributors:* Power balance and timescale of ELM divertor heat loads on ASDEX Upgrade and JET. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Endler, M.:* Observation of Turbulence in Wendelstein 7-AS and Status of the Wendelstein 7-X Project. (Hungarian Plasma Physics and Fusion Technology Workshop, 2008-03-26 to 2008-03-28, Györ).

*Endler, M., T. Bräuer, T. Kluck, J. Müller and L. Wegener:* Measurements investigating the embedding procedure of the Wendelstein 7-X non-planar coils. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Erckmann, V., P. Brand, H. Braune, G. Gantenbein, W. Kasparek, H. P. Laqua, N. B. Marushchenko, G. Michel, M. I. Petelin, D. Yu. Shchegolkov, M. Thumm, Y. Turkin, W7-X ECRH Team, FZK Karlsruhe Team and IPF Stuttgart Team:* Steady state ECRH for next step magnetic fusion devices. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Erckmann, V., H. Braune, H. P. Laqua, N. B. Marushchenko, G. Michel, Y. Turkin, M. Weissgerber, G. Gantenbein, M. Thumm, P. Brand, W. Kasparek, C. Lechte and W7-X ECRH Teams at IPP Greifswald, FZK Karlsruhe and IPF Stuttgart:* The 10 MW, CW, ECRH-Plant for W7-X: status and high power performance. (15th Joint Workshop on Electron Cyclotron Emission and Electron Cyclotron Resonance Heating (EC-15), 2008-03-10 to 2008-03-13, Yosemite National Park, CA).

*Erckmann, V., W. Kasparek, M. Petelin and D. Shchegolkov:* High-Power test of fast switch and combiner for millimetre wave beams. (15th Joint Workshop on Electron Cyclotron Emission and Electron Cyclotron Resonance Heating (EC-15), 2008-03-10 to 2008-03-13, Yosemite National Park, CA).

*Esposito, B., G. Granucci, S. Nowak, J. R. Martin-Solis, J. C. Gabellieri, S. Smeulders, M. Maraschek, G. Pautasso, J. Stober, W. Treutterer, L. Urso, F. Volpe, H. Zohm, FTU Team, ECRH Team and ASDEX Upgrade Team:* Disruption Control on FTU and ASDEX Upgrade with ECRH. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Evans, T. E., J. H. Yu, M. Jakubowski, O. Schmitz, J. G. Watkins and R. A. Moyer:* ELM Topology and Dynamics. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Fantz, U.:* Diagnostic and concept improvement of the RF-driven negative hydrogen ion source for ITER/DEMO NBI. (Coordinating Committee on Neutral Beams (CCNB) Meeting, 2008-11-24 to 2008-11-25, Padua).

*Fantz, U.:* Fundamental data of diatomic molecules relevant for fusion. (CRP (Co-ordinated Research Project on "Atomic and Molecular Data for Plasma Modelling"), 2008-11-17 to 2008-11-19, IAEA, Vienna).

*Fantz, U.:* Physikalisches Praktikum für Fortgeschrittene, Teil B. (WS 2007/2008, SS 2008. Universität Augsburg).

*Fantz, U.:* Plasma and beam homogeneity of the RF driven negative hydrogen ion source for ITER NBI. (1st International Conference on Negative Ions, Beams and Sources (NIBS 2008), 2008-09-10 to 2008-09-12, Aix-en-Provence).

*Fantz, U.:* Plasmaphysik und Fusionsforschung I. (WS 2007/2008. Vorlesung, Universität Augsburg).

*Fantz, U.:* Plasmaphysik und Fusionsforschung II. (SS 2008. Vorlesung, Universität Augsburg).

*Fantz, U., S. Christ-Koch, M. Berger, D. Wünderlich and NNBI Team:* Comparison of diagnostics methods for H densities in high power RF discharges. (19th Europhysics Conference on the Atomic and Molecular Physics of Ionized Gases (ESCAMPIG), 2008-07-15 to 2008-07-19, Granada).

*Fantz, U., P. Franzen, W. Kraus, M. Berger, S. Christ-Koch, H. Falter, M. Fröschle, R. Gutser, B. Heinemann, C. Martens, P. McNeely, R. Riedl, E. Speth and D. Wünderlich:* Physical Performance Analysis of the Negative Ion RF source for the ITER NBI System. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Fantz, U., P. Franzen, W. Kraus, D. Wünderlich, M. Berger and IPP NNBI Team:* Plasma and beam homogeneity of the RF-driven negative hydrogen ion source for ITER NBI. (1st International Conference on Negative Ions, Beams and Sources (NIBS 2008), 2008-09-10 to 2008-09-12, Aix-en-Provence).

*Fantz, U., R. Gutser and P. Franzen:* Plasma Heating: Neutral Beam Injection. (IPP Summer University for Plasma Physics, 2008-09-22 to 2008-09-26, Garching).

*Fellinger, J., A. Dudek, D. Zacharias, H. Dutz, K. Riße, D. Hathiramani, V. Bykov and F. Schauer:* Weld integrity of the superconducting cable aluminium jackets of W7-X. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Feng, Y. and M. Kobayashi:* Divertor-Transport Study for Helical Devices. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Feng, Y., M. Kobayashi, F. Sardei, S. Masuzaki, J. Kisslinger, T. Morisaki, P. Grigull, H. Yamada, K. McCormick, N. Ohyabu, R. König, I. Yamada, L. Giannone, K. Narihara, U. Wenzel, S. Morita, H. Thomsen, J. Miyazawa, N. Ramasubramanian, T. Watanabe, N. Ashikawa, K. Ida, A. Komori, O. Motojima, Y. Nakamura, B. Peterson, K. Sato, M. Shoji, N. Tamura, M. Tokitani and The LHD Experiment Group:* Comparative Divertor-Transport Study for Helical Devices. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Fischer, R.:* Integrated Data Analysis at ASDEX Upgrade. (Wendelstein Seminar, 2008-06-24 to 2008-06-25, Greifswald).

*Fischer, R. and A. Dinklage:* The concept of integrated data analysis of complementary experiments. (5th Workshop on Fusion Data Processing, Validation and Analysis, 2008-01-14 to 2008-01-16, Culham).

*Fischer, R., A. Dinklage and ASDEX Upgrade Team:* The concept of integrated data analysis of complementary experiments applied to nucelear fusion. (8th International FLINS Conference on Computational Intelligence in Decision and Control, 2008-09-21 to 2008-09-24, Madrid).

*Fischer, R., J. C. Fuchs, N. Hicks, B. Kurzan, J. Schweinzer, W. Suttrop, E. Wolfrum and ASDEX Upgrade Team:* Multidiagnostics data analysis. (16th European Fusion Physics Workshop, 2008-12-01 to 2008-12-03, Castlemartyr, Cork).

*Fischer, R., J. C. Fuchs, N. Hicks, B. Kurzan, J. Schweinzer, W. Suttrop, E. Wolfrum and ASDEX Upgrade Team:* Multidiagnostic profile reconstruction. (AUG Programme Seminar, 2008-10-27 to 2008-10-31, Schloss Ringberg, Tegernsee).

*Fischer, R., E. Wolfrum and J. Schweinzer:* IDA: Combination of Li-beam and Interferometry. (5th Workshop on Fusion Data Processing, Validation and Analysis, 2008-01-14 to 2008-01-16, Culham).

*Franzen, P., U. Fantz, W. Kraus, M. Berger, S. Christ-Koch, H. Falter, M. Fröschle, R. Gutser, B. Heinemann, C. Martens, P. McNeely, R. Riedl, E. Speth and D. Wünderlich:* Physical and experimental background of the design of the ELISE test facility. (1st International Conference on Negative Ions, Beams and Sources (NIBS 2008), 2008-09-10 to 2008-09-12, Aix-en-Provence).

*Franzen, P., U. Fantz, W. Kraus, M. Berger, S. Christ-Koch, H. Falter, M. Fröschle, R. Gutser, B. Heinemann, C. Martens, P. McNeely, R. Riedl, E. Speth and D. Wünderlich:* Progress in the RF source development for the ITER NBI system. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Franzen, P. and NNBI-Team:* The ELISE Test Facility. (CCNB Meeting, 2008-11-24 to 2008-11-25, Padua).

*Fröschle, M., R. Riedl, H. Falter, R. Gutser, U. Fantz and IPP NNBI Team:* Evaporation and control of cesium in negative ion sources. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Fülöp, T., I. Pusztai and P. Helander:* Quasilinear Transport Fluxes Driven by Electrostatic Microinstabilities in Tokamaks. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Furmanek, A., P. Lorenzetto and C. Damiani:* A proposal for modified manifold system for ITER. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Furubayashi, M., K. Hoshino, M. Toma, A. Hatayama, D. Coster, R. Schneider, X. Bonnin, H. Kawashima, N. Asakura and Y. Suzuki:* Benchmarking Kinetic and Fluid Neutral Models for Attached and Detached State. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Fußmann, G.:* Einführung in die Plasmaphysik. (WS 2007/2008. Vorlesung, Humboldt-Universität Berlin).

*Gantenbein, G., G. Dammertz, S. Illy, S. Kern, W. Leonhardt, B. Pioscyk, M. Schmid, M. Thumm, H. Braune, V. Erckmann, H. P. Laqua, G. Michel, W. Kasparek, C. Lechte, F. Legrand, C. Lievin and O. Prinz:* The 140 GHZ, 1 MW Gyrotron – status and recent results. (15th Joint Workshop on Electron Cyclotron Emission and Electron Cyclotron Resonance Heating (EC-15), 2008-03-10 to 2008-03-13, Yosemite National Park, CA).

*Garcia-Munoz, M., H.-U. Fahrbach, V. Bobkov, M. Brüdgam, M. Gobbin, S. Günter, V. Igochine, P. Lauber, M. J. Mantsinen, M. Maraschek, L. Marelli, P. Martin, S. D. Pinches, P. Piovesan, E. Poli, K. Sassenberg, H. Zohm and ASDEX Upgrade Team:* MHD induced Fast-Ion Losses on ASDEX Upgrade. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Garcia-Rosales, C., I. Lopez-Galilea, N. Ordas, C. Adelhelm, M. Balden, P. Starke, G. Pintsuk, M. Grattarola and C. Gualco:* Testing of TiC-doped isotropic graphite under ITER-relevant divertor conditions. (1st International Conference on New Materials for Extreme Environments (ExtreMat), 2008-06-02 to 2008-06-04, San Sebastian).

*Gasparyan, Y. M., A. V. Golubeva, M. Mayer, A. A. Pisarev and J. Roth:* Ion-driven permeation of deuterium through tungsten. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Gasparyan, Y. M., S. Stepanov, A. Rusinov, S. Yarko, A. Pisarev, M. Mayer, J. Roth, A. Golubeva and A. Spitsyn:* Comparison of Deuterium Permeation and Retention in Polycrytalline Tungsten. (9th International Workshop on Hydrogen Isotopes in Fusion Reactor Materials, 2008-06-02 to 2008-06-03, Salamanca).

*Geiger, J.:* Configuration studies for W7-X. (Theorie Seminar, 2008-11-17 to 2008-11-21, Schloss Ringberg, Tegernsee).

*Geiger, J.:* A new quasi-isodynamic configuration. (International Collaboration on Neoclassical Transport in Stellarators, 2008-10-23 to 2008-10-29, Madrid).

*Geiger, J.:* Shafranov-shift in a toroidally averaged helical system with and without shear. (4th Coordinated Working Group Meeting (CWGM) for Stellarator Studies, 2008-10-20 to 2008-10-22, Madrid).

*Geiger, J.:* Storing Magnetic Configuration Data. (4th Coordinated Working Group Meeting (CWGM) for Stellarator Studies, 2008-10-20 to 2008-10-22, Madrid).

*Geiger, J., Y. Suzuki, C. Wiegmann, D. Reiter and R. Wolf:* Applications of HINT2 to Wendelstein 7-AS & TEXTOR. (NIFS, 2008-03-01 to 2008-03-15, Toki).

*Gemisic Adamov, M., B. Kurzan and H. Murmann:* Thomson scattering diagnostic on ASDEX Upgrade tokamaks. (1st National Conference on Electronic, Atomic, Molecular and Photonic Physics, 2008-05-15 to 2008-05-18, Zajecar).

*Genoese, F.:* Charakterisierung amorpher Kohlenwasserstoffe mithilfe thermischer Effusionsspektroskopie. (XV. Erfahrungsaustausch Oberflächentechnologie mit Plasma- und Ionenstrahlprozessen, 2008-03-04 to 2008-03-06, Mühlleithen).

*Genoese, F., T. Dürbeck, U. von Toussaint, T. Schwarz-Selinger and W. Jacob:* Hydrogen and hydrocarbon release during thermal decomposition of hydrocarbon layers under vacuum. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Giannone, L., W. Schneider, P. J. McCarthy, A. C. C. Sips, W. Treutterer, K. Behler, T. Eich, J. C. Fuchs, N. Hicks, A. Kallenbach, M. Maraschek, A. Mlynek, G. Neu, G. Pautasso, G. Raupp, M. Reich, K. H. Schuhbeck, J. Stober, F. Volpe, T. Zehetbauer and ASDEX Upgrade Team:* Real time magnetic probe and flux loop measurements for tokamak control with a multi-core PCIe system. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Giannone, L., W. Schneider, P. J. McCarthy, A. C. C. Sips, W. Treutterer, T. Eich, J. C. Fuchs, A. Kallenbach, M. Maraschek, A. Mylnek, G. Pautasso, M. Reich, K. H. Schuhbeck, J. Stober, F. Volpe, ASDEX Upgrade Team, M. Cerna, T. Debelle, B. Marker and L. Wenzel:* Real time plasma diagnostics for tokamak control with FPGA and multicore PCIe systems. (13. Anwender- und Technologiekongress VIP 2008 "Virtuelle Instrumente in der Praxis", 2008-10-08 to 2008-10-09, München).

*Golczewski, A., K. Dobes, K. Schmid, M. Schmid, T. Schwarz-Selinger, J. Roth and F. Aumayr:* Ion – Induced Erosion of Fusion Relevant Surfaces. (17th International Workshop on Inelastic Ion-Surface Collisions (IISC-17), 2008-09-21 to 2008-09-26, Porquerolles).

*Goncharov, V. L., Y. V. Lakhotkin, V. P. Kuzmin, V. Alimov and J. Roth:* Chemical Vapor Crystallization of Hard Nanocomposite Tungsten Carbide Layers for Extreme Applications. (1st International Conference on New Materials for Extreme Environments (ExtreMat), 2008-06-02 to 2008-06-04, San Sebastian).

*Görler, T. and F. Jenko:* Nonlinear gyrokinetic simulations of coupled ITG/TEM and ETG turbulence. (13th EU-US TTF Workshop 2008 and 1st EFDA Transport Topical Group Meeting, 2008-09-01 to 2008-09-04, Copenhagen).

*Gradt, T., T. Schneider, J. Lingertat, D. Hathiramani, P. Junghanns, K. Aßmus and F. Schauer:* Cryogenic vacuum tests of scaled down narrow support elements (NSE) for the W7-X coil system. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Greuner, H.:* High Heat Flux Facility GLADIS – Introduction and Operational Characteristics. (ESA Workshop on Facilities, ESTEC, 2008-03-28, Noordwijk).

*Greuner, H. and B. Böswirth:* GLADIS: Cyclic Heat Load Testing of Improved CFC/Cu Bonding for the W7-X Targets. (Fachbeirat, 2008-06-19, Garching).

*Greuner, H. and B. Böswirth:* Heat Flux Facility GLADIS – Introduction and Operational Parameters. (Fachbeirat, 2008-06-19, Garching).

*Greuner, H., B. Böswirth, J. Boscary, T. Friedrich, C. Lavergne, C. Linsmeier, J. Schlosser and A. Wiltner:* Review of the high heat flux testing as an integrated part of W7-X divertor development. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Grisolia, C., P. Sharpe, A. Loarte, S. Rosanvallon, J. Roth, B. Lipschultz, V. Rohde and D. Whyte:* From eroded material to dust: an experimental evaluation of the mobilised dust production. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Groth, M., M. Wischmeier, N. H. Brooks, D. P. Coster, J. Harhausen, A. Kallenbach, C. J. Lasnier, A. W. Leonard, H. W. Müller, T. H. Osborne, G. D. Porter, J. G. Watkins, ASDEX Upgrade Team and DIII-D Team:* Comparison and SOL Modeling of Ohmic Plasmas in ASDEX Upgrade and DIII-D. (35th EPS Conference on Plasma Physics, 2008-06-09 to 2008-06-13, Hersonissos, Crete).

*Gruber, O. and ASDEX Upgrade Team:* ASDEX Upgrade enhancements in view of ITER application. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Gruber, O. and ASDEX Upgrade Team:* ASDEX Upgrade: Status 2008. (ASDEX Upgrade Programme Committee Meeting, 2008-07-17, Garching).

*Gruber, O. and ASDEX Upgrade Team:* Compatibility of ITER Scenarios with an all-W Wall. (35th EPS Conference on Plasma Physics, 2008-06-09 to 2008-06-13, Hersonissos, Crete).

*Gruber, O. and ASDEX Upgrade Team:* Full tungsten wall experiments and new developments. (Southwestern Institute of Physics (SWIP), 2008-11-13, Chengdu).

*Gruber, O. and ASDEX Upgrade Team:* Input to FacRevPanel: ASDEX Upgrade (AUG). (3rd Workshop on the Preparation of the Input to the Facilities Review Panel, 2008-01-29, Frascati).

*Gruber, O., A. C. C. Sips, R. Dux, T. Eich, J. C. Fuchs, A. Herrmann, A. Kallenbach, C. F. Maggi, R. Neu, G. Pautasso, T. Pütterich, A. J. Schweinzer, J. Stober and ASDEX Upgrade Team:* Compatibility of ITER Scenarios with full Tungsten Wall in ASDEX Upgrade. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Grulke, O., C. Brandt and T. Klinger:* Nonlinear control of transport in drift wave turbulence. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Grulke, O., T. Klinger, K. Rahbarnia, N. Sydorenko and S. Ullrich:* Dynamical response in magnetized negative ion plasmas. (International Colloquium SFB, 2008-11-07 to 2008-11-08, Greifswald).

*Gulejova, B., R. A. Pitts, D. Coster, X. Bonnin, M. Beurskens, S. Jachmich, A. Kallenbach and J. Marki:* SOLPS5 simulations of Type I ELMy H-mode discharges on JET. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Günter, S.:* Plasmaphysik und Fusionsforschung. (SS 2008. Vorlesung in Technische Universität München).

*Günter, S.:* On the way towards ITER: recent topics in high-temperature plasma physics. (Physik-Kolloquium, 2008-04-15, Universität Innsbruck).

*Günter, S.:* Wie gut verstehen wir den Tokamak? (Kolloquium Physikalisch-Technische Bundesanstalt, 2008-04-29, Berlin).

*Günter, S., M. Garcia-Munoz, K. Lackner, P. Lauber, P. Merkel, M. Sempf, E. Strumberger, D. Tekle and ASDEX Upgrade Team:* Three Dimensional Effects in Tokamaks – How Tokamaks can Benefit from Stellarator Research. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Günter, S., Ph. Lauber, E. Strumberger, M. Garcia-Munoz and ASDEX Upgrade Team:* Fast ion redistribution by MHD modes – ASDEX Upgrade experimental and modeling results. (Energetic Particle Topical Group Meeting CRPP, 2008-10-20 to 2008-10-22, Lausanne).

*Gustke, D. and W7-X Team:* Electrical tests on superconducting coils for Wendelstein 7-X. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Gutser, R., D. Wünderlich, U. Fantz, P. Franzen, B. Heinemann and NNBI Team:* Simulations for the generation and extraction of negative hydrogen ions in RF-driven ion sources. (1st International Conference on Negative Ions, Beams and Sources (NIBS 2008), 2008-09-10 to 2008-09-12, Aix-en-Provence).

*Gutser, R., D. Wünderlich, U. Fantz and NNBI-Team:* Simulation zur Entstehung und Extraktion negativer Wasserstoffionen an HF-Ionenquellen für ITER. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Hallatschek, K.:* Diamagnetic GAM Drive Mechanism. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Hamacher, T., K. Behringer and U. Fantz:* Physikalische Grundlagen der Energiewandlung und Verteilung. (SS 2008. Vorlesung/Seminar, Universität Augsburg).

*Hartfuß, H.-J.:* Introduction to Plasma Diagnostics. (IPP Summer University for Plasma Physics, 2008-09-22 to 2008-09-26, Garching).

*Hartmann, D.:* Stellarators. (Stellarators, 2008-02-05, Universität Gent).

*Hasinger, G.:* Cosmological Evolution of Active Black Holes. (JET EFDA Seminar, 2008-12-04, Culham).

*Hasinger, G.:* Cosmological Evolution of Active Galactic Nuclei. (Institute for Advanced Studies, 2008-11-25, Princeton, NJ).

*Hasinger, G.:* Der Kalender des Universums. Zeit wahrnehmen, erleben, verstehen. (Evangelische Akademie, 2008-12-05, Tutzing).

*Hasinger, G.:* Kernfusion: ein nachhaltiger Beitrag zum Energiemix des 21. Jahrhunderts? (Energiepolitisches Frühstück der SPD-Fraktion im Bundestag, 2008-11-27, Berlin).

*Hasinger, G.:* Das Schicksal des Universums. (Physikalisches Kolloquium, 2008-11-18, Universität Bayreuth).

*Hasinger, G.:* Schicksal des Universums. Der Kosmos im Wandel. (Alfried Krupp Wissenschaftskolleg, 2008-12-01, Greifswald).

*Hasinger, G.:* Von den Sternen zur Fusion. (Physikalisches Kolloquium, 2008-10-15, Technische Universität Chemnitz).

*Hasinger, G.:* Sternstunden. (Caravanserai, 2008-12-09, München).

*Hasinger, G.:* Der Weg zu einem Fusionskraftwerk. (Ringvorlesung Energie 2020, 2008-11-27, Technische Universität Hamburg-Harburg).

*Hathiramani, D., P. van Eeten, M. Sochor, M. Laux, V. Bykov, F. Schauer, B. Heinemann, P. Junghanns, A. Brenner, C. Zauner and H. Langer:* Full scale friction test on tilted sliding bearings for Wendelstein 7-X coils. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Hauff, T. and F. Jenko:* Mechanisms of turbulent fast particle transport in 3D tokamak microturbulence. (13th EU-US TTF Workshop 2008 and 1st EFDA Transport Topical Group Meeting, 2008-09-01 to 2008-09-04, Copenhagen).

*Hayashi, T., K. Sugiyama, M. Mayer, K. Krieger, K. Masaki, T. Tanabe and M. Sato:* Deuterium depth profiling in graphite tiles not exposed to hydrogen discharges before air ventilation of JT-60U. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Heidinger, R., R. Bertizzolo, A. Bruschi, R. Chavan, S. Cirant, A. Collazos, M. de Baar, B. Elzendoorn, D. Farina, U. Fischer, J. Gafert, G. Gantenbein, A. Goede, T. Goodman, G. Hailfinger, M. Henderson, W. Kasparek, K. Kleefeldt, J.-D. Landis, A. Meier, A. Moro, E. Poli, G. Ramponi, G. Saibene, F. Sanchez, T. Scherer, A. Serikov, C. Sozzi, P. Späh, D. Strauss, V. Udintsev, A. Vaccaro and H. Zohm:* Conceptual design of the ECH upper launcher system for ITER. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Heinemann, B., H. Falter, U. Fantz, P. Franzen, M. Fröschle, W. Kraus, R. Nocentini, R. Riedl, E. Speth, P. Agostinetti and T. Jiang:* Design of the "half-size" ITER neutral beam source test facility ELISE. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Helander, P.:* Intrinsic ambipolarity and rotation in stellarators. (Theorie Seminar, 2008-11-17 to 2008-11-21, Schloss Ringberg, Tegernsee).

*Helander, P.:* Magnetic field and transport in 3D configurations. (Workshop on the Theory of Magnetic Confinement for Fusion, 2008-09-22, Oxford).

*Helander, P.:* Magnetohydrodynamic. (Culham Plasma Physics Summer School, 2008-07-08 to 2008-07-09, Culham).

*Helander, P.:* Review of neoclassical transport theory. (Hungarian Plasma Physics and Fusion Technical Workshop, 2008-03-26 to 2008-03-27, Raab).

*Helander, P.:* Rotation in tokamaks and stellarators. (Workshop "Kinetic Equations, Numerical Approaches and Fluid Models for Plasma Turbulence", 2008-09-15 to 2008-09-19, Wien).

*Helander, P.:* Runaway acceleration of electrons in tokamaks. (Vortrag, 2008-06-24, Max-Planck-Institut für Sonnensystemforschung, Lindau).

*Hennig, C., T. Bluhm, P. Heimann, H. Kroiss, G. Kühner, H. Laqua, M. Lewerentz, J. Maier, C. Meyer, I. Müller, S. Pingel, H. Riemann, J. Schacht, A. Spring, A. Werner, A. Wölk and M. Zilker:* Wendelstein 7-X CoDaC system description. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Hergenhahn, U.:* Elektronische Struktur, Elektronenspektroskopie und Synchrotronstrahlung. (SS 2008. Vorlesung/Übung, Freie Universität Berlin).

*Hergenhahn, U.:* Photoionization of small molecules and clusters with synchrotron radiation. (Jaroslav Heyrovsky Institute of Physical Chemistry, Academy of Sciences of the Czech Republic, 2008-10-13, Prague).

*Hergenhahn, U.:* Recent experiments on cluster photoionization and autoionization. (Max-Planck-Institut für Physik komplexer Systeme, 2008-09-29, Dresden).

*Herrmann, A., M. Balden, C. Boswell, K. Schmid and H. Bolt:* Coating and microstructuring of tungsten fibers for enhanced interfacial adhesion in copper. (E-MRS 2008 Spring Meeting, Symposium N: Nuclear Materials, 2008-05-26 to 2008-05-30, Strasbourg).

*Herrmann, A., M. Balden, M. Laux, H. W. Müller, V. Rohde and ASDEX Upgrade Team:* Arcing in ASDEX Upgrade with a tungsten first wall. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Herrmann, A., C. Linsmeier and H. Bolt:* ExtreMat – Challenges in Materials Research and Integrated Solutions at European Level. (European Training Network for Plasma Fusion Materials (ETN-PFM) meeting, 2008-06-09 to 2008-06-11, Cadarache).

*Herrmann, A., M. Rasinski, M. Balden and H. Bolt:* Adhesion, stress state and phase analysis of thin graded W/Cu coatings on tungsten and their thermal behaviour in fusion application. (1st International Conference on New Materials for Extreme Environments (ExtreMat), 2008-06-02 to 2008-06-04, San Sebastian).

*Herrmann, A., A. Schmid, H. W. Müller, M. Maraschek, J. Neuhauser, A. Kirk and ASDEX Upgrade Team:* Filament dynamics and transport in the Scrape-Off-Layer of ASDEX Upgrade. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Hertel, K., H. Viebke, J. Baldzuhn, G. Croari, H. Ehmler, L. Genini, B. Renard and L. Vieillard:* Documentation and first data-analysis on acceptance tests of W7-X coils. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Hicks, N.:* Upgrades and real time NTM control application of the ECE radiometeron ASDEX Upgrade. (15th Joint Workshop on Electron Cyclotron Emission and Electron Cyclotron Resonance Heating (EC-15), 2008-03-10 to 2008-03-13, Yosemite National Park, CA).

*Hildebrandt, D., A. Dübner, H. Greuner and A. Wiltner:* Thermal response of the W7-AS divertor surface to heat pulses. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Hinterland, F. and U. Schwenn:* Status, Standards & Future for EFDA Telecommunication & Solutions. (RFX, 2008-06-23, Padua).

*Hinterland, F. and U. Schwenn:* Videokonferenzen heute. (VIKTAS Tag 2008, 2008-04-03, Berlin, Hamburg, Garching, Zürich).

*Hong, S.-H., C. Grisolia, V. Rohde, P. Monier-Gabet and Tore Supra Team:* Temporal evolution and spatial distribution of dust creation events in Tore Supra and in ASDEX Upgrade studied by CCD image analysis. (25th Symposium on Fusion Technology (SOFT), 2008-09-15 to 2008-09-19, Rostock).

*Hopf, C., W. Jacob, M. Schlüter, U. von Toussaint and P. N. Maya:* Chemical Sputtering of Carbon with Atomic Hydrogen: Synergistic Effects. (Workshop on Elementary Mechanisms of Hydrogen/Carbon Interaction, 2008-10-27 to 2008-10-28, Marseille).

*Hopf, C., V. Rohde and W. Jacob:* $O_2$/He glow discharge cleaning: Experience at IPP. (SEWG-Meeting "Fuel Removal", 2008-07-21 to 2008-07-23, JET Culham).

*Hopf, C., M. Schlüter, W. Jacob and T. Schwarz-Selinger:* The ion-induced reaction of thermal molecular oxygen with carbon films as an important mechanism in oxygen-glow-discharge-based codeposit removal. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Huber, A., R. A. Pitts, A. Loarte, V. Philipps, P. Andrew, S. Brezinsek, P. Coad, T. Eich, J. C. Fuchs, W. Fundamenski, S. Jachmich, G. F. Matthews, K. McCormick, P. Mertens, J. Rapp, G. Sergienko, M. Stamp and JET EFDA Contributors:* Plasma radiation distribution and radiation loads onto the vessel during transient events in JET. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Igochine, V., O. Dumbrajs, H. Zohm, G. Papp, G. Por, G. Pokol and ASDEX Upgrade Team:* The role of stochastization in fast MHD phenomena on ASDEX Upgrade. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Ikkurthi, V. R., K. Matyash, R. Schneider, J. Meichsner and A. Melzer:* Particle-in-Cell Simulation of RF discharges in Ar/$CH_4$ Gas Mixture. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Ikkurthi, V. R., K. Matyash, R. Schneider and A. Melzer:* Computation of ion drag force on a static spherical dust grain in an RF plasma. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Ionata, C., F. Mehlmann, P. C. Balan, R. W. Schrittwieser, C. Lupu, H. W. Müller, M. Maraschek, V. Rohde, ASDEX Upgrade Team, R. Cavazzana, N. Vianello, M. Zuin, J. J. Rasmussen and V. Naulin:* Simultaneous measurements of electro-static and magnetic fluctuations in ASDEX Upgrade edge plasma. (14th International Congress on Plasma Physics (ICCP 2008), 2008-09-08 to 2008-09-12, Fukoka).

*Jachmich, S., Y. Liang, G. Arnoux, T. Eich, W. Fundamenski, R. Koslowski, R. A. Pitts and P. Thomas:* Effect of external perturbation fields on divertor particle and heat loads during ELMs at JET. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Jacob, W.:* Plasma Technology. (IPP Summer University for Plasma Physics, 2008-09-22 to 2008-09-26, Garching).

*Jacob, W., C. Hopf, M. Schlüter and T. Schwarz-Selinger:* Chemische Zerstäubung mit reaktiven Ionen. (XV. Erfahrungsaustausch Oberflächentechnologie mit Plasma- und Ionenstrahlprozessen, 2008-03-04 to 2008-03-06, Mühlleithen).

*Jacob, W., C. Hopf, M. Schlüter and T. Schwarz-Selinger:* Impact of $N_2$ on the Chemical Sputtering Yields. (SEWG-Meeting "Chemical Erosion/Material Migration", 2008-07-22, JET Culham).

*Jacob, W., M. Schlüter, C. Hopf and T. Schwarz-Selinger:* Chemical Sputtering of Carbon by Bombardment with Nitrogen Ions and Cobombardment with Nitrogen Ions and Atomic Hydrogen. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Jakubowski, M. W., W. Fundamenski, P. Andrew, G. Arnoux, T. Eich, R. A. Pitts and R. C. Wolf:* ELM filament interactions with the JET main chamber. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Jakubowski, M. W., C. Lasnier, O. Schmitz, T. Eich, M. Lehnen, B. Unterberg, R. C. Wolf, T. Evans, M. Fenstermacher, R. Moyer, J. Watkins, L. Baylor, J. Boedo, K. Burrell, J. deGrassie, P. Gohil, I. Joseph, A. Leonard, C. Petty, R. Pinsker, T. Rhodes, P. B. Snyder and W. West:* Divertor heat loads in RMP ELM controlled H-mode plasmas on DIII-D. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneve).

*Jenko, F.:* Computational Plasma Physics. (IPP Summer University for Plasma Physics, 2008-09-22 to 2008-09-26, Garching).

*Jenko, F.:* Theory and simulation of plasma turbulence: Recent advances and future challenges. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Jolliet, S., B. F. McMillan, T. M. Tran, X. Lapillonne, L. Villard, A. Bottino and P. Angelino:* Global Nonlinear Simulations Ion and Electron Turbulence Using a Particle-In-Cell Approach. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Kallenbach, A.:* Diagnostik von Nichtgleichgewichtsplasmen. (SS 2008. Vorlesung, Universität Augsburg).

*Kallenbach, A.:* Divertor protection and performance improvement with nitrogen seeding in ASDEX Upgrade. (JET Science Meeting, 2008-11-24, Abingdon, Culham).

*Kallenbach, A.:* Einführung in die Plasmaspektroskopie. (WS 2007/2008, SS 2008. Vorlesung, Universität Augsburg).

*Kallenbach, A.:* Kernfusion als zukünftige Energieform – Stand und Perspektiven. (Vortragsreihe zum Jahr der Mathematik, 2008-04-26, Leibniz Universität Hannover).

*Kallenbach, A.:* Wolfram als Wandmaterial im Fusionsreaktor? Plasma-Wand-Experimente im Tokamak ASDEX Upgrade. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Kallenbach, A., R. Dux, T. Eich, R. Fischer, A. Herrmann, B. Kurzan, H. W. Müller, R. Neu, R. Pugno, M. Wischmeier, E. Wolfrum and ASDEX Upgrade Team:* Pressure balance between midplane and inner and outer divertor in ASDEX Upgrade H-mode discharges. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Kallenbach, A., R. Dux, M. Mayer, R. Neu, T. Pütterich, V. Bobkov, J. C. Fuchs, T. Eich, O. Gruber, A. Herrmann, L. D. Horton, C. F. Maggi, H. Meister, R. Pugno, V. Rohde, A. Sips, A. Stäbler, J. Stober and ASDEX Upgrade Team:* Non-boronized operation of ASDEX Upgrade with full-tungsten plasma facing components. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Käsemann, C.-P., L. van Lieshout, M. Huart and M. Rott:* 10 MVA thyristor converters for the active damping of generator shaft oscillations at ASDEX Upgrade. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Kasparek, W., M. I. Petelin, V. Erckmann, A. Bruschi, F. Noke, F. Purps, F. Hollmann, Yu. Koshurinov, L. Lubyakov, D. Yu. Shchegolkov, B. Plaum, W. Wubiw, IPP Greifswald ECRH Group, FZK Karlsruhe ECRH Group, IFP Milano ECRH Group, IAP Nizhny Novgorod ECRH Group and IPF Stuttgart ECRH Group:* Power combiners, fast switches and filters for advanced ECRH systems. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Kauffmann, K.:* Collisions in EUTERPE Gyrokinetic Code. (Theorie Seminar, 2008-11-17 to 2008-11-21, Schloss Ringberg, Tegernsee).

*Kick, M., J. Sielanko, R. Riedl, B. Heinemann, A. Stäbler and E. Speth:* Shielding of the NBI boxes against W7-X magnetic stray fields. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Kim, B.-Y. and J.-H. You:* Three-dimensional shakedown analysis of fiber-reinforced metal matrix composite (FRMMC) layered plasma facing component for high heat flux loading. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Kirk, A., S. Lisgo, E. Nardon, T. Eich, A. Herrmann and A. Kallenbach:* Physics of ELM power fluxes to plasma facing components and implications for ITER. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Kirschner, A., D. Borodin, V. Philipps, U. Samm, K. Schmid, J. Roth, A. Kukushkin, G. Federici and A. Loarte:* Estimations of erosion fluxes, material deposition and tritium retention in the divertor of ITER. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Kleiber, R.:* Introduction to Stellarator Theory. (IPP Summer University for Plasma Physics, 2008-09-22 to 2008-09-26, Garching).

*Klinger, T.:* The construction of the Wendelstein 7-X stellarator. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Klinger, T. and W7-X Team:* Progress and Physics of the Wendelstein 7-X Project. (International Conference and School on Plasma Physics and Controlled Fusion and 3rd Alushta International Workshop on the Role of Electric Fields in Plasma Confinement in Stellarators and Tokamaks, 2008-09-22 to 2008-09-27, Alushta).

*Kobayashi, M., Y. Feng, S. Morita, K. Sato, M. B. Chowdhuri, N. Tamura, S. Masuzaki, M. Goto, Y. Nakamura, I. Yamada, K. Narihara, T. Morisaki, N. Ohyabu, H. Yamada, A. Komori, O. Motojima and LHD Experimental Group:* Impurity retention in the ergodic layer of LHD. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Koch, F. and H. Bolt:* Self passivating ternary and quaternary W-alloys as plasma-facing materials for fusion reactors. (1st International Conference on New Materials for Extreme Environments (ExtreMat), 2008-06-02 to 2008-06-04, San Sebastian).

*Köck, T., A. Brendel and H. Bolt:* Influence of different deposition parameters on the performance of a Ti-Ta-C interface layer in silicon carbide-copper metal-matrix composites. (1st International Conference on New Materials for Extreme Environments (ExtreMat), 2008-06-02 to 2008-06-04, San Sebastian).

*Kolesnichenko, Y. I., V. V. Lutsenko, A. Weller, H. Thomsen, Y. V. Yakovenko, J. Geiger and A. Werner:* Sub-GAM modes in stellarators and tokamaks. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Kolesnichenko, Y. I., V. V. Lutsenko, Y. V. Yakovenko, A. Weller, H. Thomsen, A. Werner and J. Geiger:* Theory of sub-GAM modes in toroidal plasmas and modelling of their observations in Wendelstein 7-AS. (International Conference and School on Plasma Physics and Controlled Fusion and 3rd Alushta International Workshop on the Role of Electric Fields in Plasma Confinement in Stellarators and Tokamaks, 2008-09-22 to 2008-09-27, Alushta).

*Kolesnichenko, Y. I., V. V. Lutsenko, Y. V. Yakovenko, A. Weller, H. Thomsen, A. Werner and J. Geiger:* Two-fluid description of alfven-drift and sound-drift modes in toroidal plasmas. (International Conference and School on Plasma Physics and Controlled Fusion and 3rd Alushta International Workshop on the Role of Electric Fields in Plasma Confinement in Stellarators and Tokamaks, 2008-09-22 to 2008-09-27, Alushta).

*Könies, A., A. Mishchenko and R. Hatzky:* From kinetic MHD in stellarators to a fully kinetic description of wave particle interaction. (Joint Varenna-Lausanne International Workshop on Theory of Fusion Plasmas, 2008-08-25 to 2008-08-29, Varenna).

*König, R., R. Burhenn, J. Cantarini, K. Grosser, H.-J. Hartfuß, D. Hildebrandt, M. Hirsch, G. Kocsis, P. Kornejew, M. Laux, E. Pasch, S. Recsei, J. Sarközi, W. Schneider, V. Szabo, H. Thomsen, A. Weller, A. Werner, R. Wolf, M. Y. Ye, D. Zhang and S. Zoletnik:* Diagnostic developments for quasi steady-state operation of the Wendelstein 7-X stellarator. (Vortrag. CEA, 2008-12-05, Cadarache).

*König, R., J. Cantarini, K. Grosser, D. Hildebrandt, M. Hirsch, G. Kocsis, P. Kornejew, M. Laux, E. Pasch, S. Recsei, V. Szabo, H. Thomsen, A. Weller, R. Wolf, M. Ye and S. Zoletnik:* Diagnostic Developments for Quasi-Continuous Operation of the Wendelstein 7-X Stellarator. (17th Topical Conference on High-Temperature Plasma Diagnostics, 2008-05-11 to 2008-05-15, Albuquerque, NM).

*König, S., U. Fantz, R. Merkle and M. Balden:* Verdampfung und Schichtwachstum von Cäsium auf verschiedenen Oberflächen in Wasserstoffplasmen. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Koppe, T., A. Cardella, J. Reich, B. Missal, B. Hein, R. Krause, H. Jenzsch, D. Hermann, D. Pilopp, G. DiBartolo, F. Leher, A. Binni, J. Segl, R. Camin, L. Giordano and B. Egloff:* Manufacturing and assembly status of main components of the Wendelstein 7-X cryostat. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Köppen, M., J. Kißlinger, T. Rummel, T. Mönnich, F. Schauer and V. Bykov:* Simulations of W7-X magnet system fault scenarios involving short circiuts. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Kornejew, P., L. Estebian, M. Hirsch, M. Sanchez and R. König:* Optimization of components of the infrared two-colour interferometer for Wendelstein 7-X. (17th Topical Conference on High-Temperature Plasma Diagnostics, 2008-05-11 to 2008-05-15, Albuquerque, NM).

*Kost, F. and C. Linsmeier:* Laboratory studies on the ternary Be-C-W system. (SEWG Meeting Mixed Materials, 2008-10-09, Garching).

*Kost, F. and C. Linsmeier:* Studies on the ternary Be-C-W system. (Institut für Materialphysik im Weltraum (DLR), 2008-11-22, Köln).

*Kost, F., C. Linsmeier, M. Oberkofler, M. Reinelt, M. Balden, A. Herrmann and S. Lindig:* Investigation of the ternary system beryllium, carbon and tungsten with depth-resolved photoemission spectroscopy. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Kraus, W., M. Berger, U. Fantz, P. Franzen, M. Fröschle, B. Heinemann, R. Riedl, E. Speth, A. Stäbler and D. Wünderlich:* Long pulse $H^-$ beam extraction with a RF driven ion source with low fraction of co-extracted electrons. (1st International Conference on Negative Ions, Beams and Sources (NIBS 2008), 2008-09-10 to 2008-09-12, Aix-en-Provence).

*Krause, R., J. Reich, T. Koppe, B. Missal and D. Pilopp:* Designing and manufacturing of the inter-coil support of W7-X. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Krieger, K.:* Plasma Wall Interaction in Nuclear Fusion Devices. (IPP Summer University for Plasma Physics, 2008-09-22 to 2008-09-26, Garching).

*Krieger, K., S. Brezinsek, H. G. Esser, A. Meigs, P. Mertens, G. van Rooij, M. F. Stamp and A. Widdowson:* Beryllium migration-ILW reference values for Be erosion. (JET TFE Meeting, 2008-07-01, Culham).

*Krieger, K., M. Stamp, S. Brezinsek, H. G. Esser, A. Kreter, S. Menmuir, P. Mertens and V. Philipps:* Be wall sources and migration after Be evaporation in the JET tokamak. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Krychowiak, M., D. Dodt, H. Dreier, R. König and R. Wolf:* Development of a virtual $Z_{eff}$ diagnostic for the W7-X stellarator. (17th Topical Conference on High-Temperature Plasma Diagnostics, 2008-05-11 to 2008-05-15, Albuquerque, NM).

*Kudyakov, T., K. H. Finken, M. Jakubowski, M. Lehnen, B. Schweer, T. Toncian, Y. Xu, G. Van Wassenhove and O. Willi:* Spatially and temporally resolved measurements of runaway electrons in the TEXTOR tokamak. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Kündig, A., C. P. Dhard, S. Raatz and H. Bau:* Progress Report of the Cryo-Plants for Wendelstein 7-X. (International Cryogenic Engineering Conference 22 and International Cryogenic Material Conference (ICEC22 – ICMC 2008), 2008-07-21 to 2008-07-25, Seoul).

*Kühner, G., T. Bluhm, P. Heimann, C. Hennig, H. Kroiss, A. Krüger, H. Laqua, M. Lewerentz, J. Maier, H. Riemann, J. Schacht, A. Spring, A. Werner and M. Zilker:* Employing industrial standards in software engineering for W7-X. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Lackner, K.:* 50 Jahre weltweite Fusionsforschung für den Frieden. (Festkolloquium, 2008-12-05, Universität Innsbruck).

*Lackner, K.:* Thermonuclear fusion as an energy source. (Conference on Strategies towards Affordable, Safe and Sustainable Energy Supply, 2008-11-11, Frankfurt).

*Lang, P. T.:* Investigation on pellet fuelling and ELM pacing on the AUG-JET-ITER step ladder. (4th Hungarian Plasma Physics and Fusion Technology Workshop, 2008-03-26 to 2008-03-28, Györ).

*Lang, P. T.:* JET pedestal plans. (14th ITPA Pedestal and Edge Physical Topical Group Meeting, 2008-04-30 to 2008-05-02, San Diego, CA).

*Lang, P. T.:* Status of pellet ELM control on AUG and JET and conclusions for ITER. (14th ITPA Pedestal and Edge Physical Topical Group Meeting, 2008-04-30 to 2008-05-02, San Diego, CA).

*Langer, B., E. Wolfrum, R. Fischer and ASDEX Upgrade Team:* Spektroskopische Bestimmung des radialen elektrischen Feldes am Plasmarand. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Laqua, H. P., D. Andruczyk, S. Marsen, M. Otte, Y. Y. Podoba, J. Preinhaelter and J. Urban:* Fundamental investigation of electron bernstein wave heating and current drive at the WEGA stellarator. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Laqua, H. P., D. Andruczyk, S. Marsen, M. Otte, Y. Y. Podoba, G. Warr, J. Preinhealter and J. Urban:* Experiments with electron Bernstein waves at the WEGA stellarator. (15th Joint Workshop on Electron Cyclotron Emission and Electron Cyclotron Resonance Heating (EC-15), 2008-03-10 to 2008-03-13, Yosemite National Park, CA).

*Laqua, H. P., D. Andruczyk, S. Marsen, M. Otte, J. Preinhealter, J. Urban, G. B. Warr and D. Zhang:* Fully electron bernstein wave sustained overdense plasma operation with 28 GHz ECRH at the WEGA Stellarator. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Lechte, C., G. Conway and U. Stroth:* Winkelabhängigkeit der reflektierten Leistung bei Doppler-Reflektometrie in turbulenten Plasmen. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Lederer, H.:* DEISA2 engaging for a European HPC Ecosystem. (Scientific Discovery through Advanced Computing (SciDAC), 2008-07-13 to 2008-07-17, Seattle, WA).

*Lee, H. T. and K. Krieger:* Simultaneous irradiation of tungsten with deuterium and carbon at elevated temperatures. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Lee, H. T., O. V. Ogorodnikova and Y. Gasparyan:* Sputtering, hydrogen retention and permeation in tungsten. (Fachbeirat, 2008-06-19, Garching).

*Lehnen, M., S. Bozhenkov, M. W. Jakubowski, R. Jaspers, V. V. Plyusnin, V. Riccardo, JET EFDA Contributors and TEXTOR Team:* Runaway generation during disruptions in JET and TEXTOR. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Leuterer, F. and AUG ECRH Team:* ECRH experiments in ASDEX Upgrade. (Seminar, Southwestern Institute of Physics, 2008-11-07, Chengdu).

*Leuterer, F. and AUG ECRH Team:* The new ECRH system of ASDEX Upgrade. (Seminar, Southwestern Institute of Physics, 2008-11-11, Chengdu).

*Leuterer, F. and AUG ECRH Team:* Operation experience with the ASDEX Upgrade ECRH system. (7th International Workshop “Strong Microwaves: Sources and Applications”, 2008-07-27 to 2008-08-02, Nizhny Novgorod).

*Leuterer, F. and AUG ECRH Team:* Operation experience with the ASDEX Upgrade ECRH system. (Seminar, Southwestern Institute of Physics, 2008-11-11, Chengdu).

*Leuterer, F. and AUG ECRH Team:* Planning, construction and operation experience of the ASDEX Upgrade. (15th Joint Workshop on Electron Cyclotron Emission and Electron Cyclotron Resonance Heating (EC-15), 2008-03-09 to 2008-03-14, Yosemite National Park, CA).

*Lewerentz, M., D. Aßmus, T. Bluhm, S. Heinrich, C. Hennig, U. Herbst, C. Meyer, E. Köster, I. Müller, H. Laqua, M. Otte, S. Pingel, J. Sachtleben, J. Schacht, A. Spring and A. Wölk:* First experiences with the new W7-X like control system at the WEGA stellarator. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Liang, Y., H. R. Koslowski, P. R. Thomas, E. Nardon, S. Jachmich, A. Alfier, G. Arnoux, Y. Baranov, M. Becoulet, M. Beurskens, T. Eich, E. De La Luna, W. Fundamenski, S. Gerasimov, C. Giroud, M. P. Gryaznevich, A. Huber, V. Kiptily, A. Kreter, L. Moreira, V. Parail, S. D. Pinches, S. Saarelma, O. Schmitz, O. Zimmermann and JET EFDA Contributors:*

Active Control of Edge Localized Modes with a low n external perturbation fields in the JET Tokamak. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Lindig, S., A. Zivelonghi and J. H. You:* Thermal Diffusitivity of Plasma Sprayed Tungsten: LFA-analysis and first FE-simulations. (1st International Conference on New Materials for Extreme Environments (ExtreMat), 2008-06-02 to 2008-06-04, San Sebastian).

*Lingertat, J., T. Gradt, D. Hathiramani, P. Junghanns, M. Laux, K. Meine, F. Schauer and T. Schneider:* Tribological performance of MoS2 coatings at T=4K and high loads. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Lingertat, J., D. Hathiramani, P. Junghanns and M. Laux:* Test of narrow support elements of the W7-X coil system at liquid helium temperatures. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Linsmeier, C.:* Das EU-Forschungsprojekt ExtreMat. (2. Bayerischer Werkstoffabend, 2008-10-16, Garching).

*Linsmeier, C.:* ExtreMat – Challenges in Materials Research and Integrated Solutions at European Level. (tech transfer, Hannover Messe, 2008-04-23, Hannover).

*Linsmeier, C.:* ExtreMat – Materialien für Anwendung unter extremen Bedingungen. (Pressegespräch zur Hannover Messe, 2008-03-05, Garching).

*Linsmeier, C.:* ExtreMat SiC-based materials activities. (EFDA Fusion Materials Science – SiCSiC Materials Development, 2008-04-02, Garching).

*Linsmeier, C.:* ExtreMat Tungsten and Tungsten alloy activities. (EFDA Fusion Materials Science – W and W-alloy Development, 2008-01-21, Garching).

*Linsmeier, C.:* Oberflächenchemie an Materialien für die Erste Wand von Fusionsanlagen. (Kolloquium für Physikalische und Theoretische Chemie, 2008-02-08, Technische Universität München, Garching).

*Linsmeier, C.:* Surface Chemistry of Fusion First Wall Materials. (Kolloqium Physikalische Chemie, 2008-02-07, Technische Universität München, Garching).

*Linsmeier, C.:* X-ray Photoelectron Spectroscopy. (Lecture Series: "Modern Methods in Heterogeneous Catalysis Research", 2008-01-25, Fritz-Haber-Institut der MPG, Berlin).

*Linsmeier, C., C. Adelhelm, M. Balden, F. Kost, F. Koch, H. Maier, D. Levchuk, K. Ertl, A. Brendel, A. Herrmann, V. Pfaffenholz, H. Bolt and A. M. Bradshaw:* Materialforschung in der Fusion. (Max-Planck-Gesellschaft Workshop: Materialforschung, 2008-04-21 to 2008-04-23, Schloss Reisensburg, Ulm).

*Linsmeier, C. and H. Bolt:* Materials issues for ITER, DEMO and the European coordination action FEMaS-CA. (29th Risø International Symposium on Materials Science, 2008-09-01 to 2008-09-05, Roskilde/Denmark).

*Linsmeier, C., M. Oberkofler, M. Reinelt and S. Lindig:* Effects of ion energy on the retention of hydrogen isotopes in beryllium. (17th International Workshop on Inelastic Ion-Surface Collisons (IISC-17), 2008-09-21 to 2008-09-26, Porquerolles).

*Linsmeier, C. and M. Reinelt:* Retention mechanisms of hydrogen implanted into beryllium. (Seminaire Physique des Interactions Ioniques et Moleculaires, 2008-03-21, Universite de Provence, Marseille).

*Lischtschenko, O., R. König, M. Otte and F. Wagner:* Plasmapolarisation mit Graphit-Sonden am WEGA Stellarator. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Litnovsky, A., V. Philipps, P. Wienhold, K. Krieger, A. Kirschner, D. Borodin, G. Sergienko, O. Schmitz, A. Kreter, U. Samm, S. Richter, U. Breuer, J. P. Gunn, M. Komm and Z. Pekarek:* Investigations of castellated structures for ITER: the effect of castellation shaping and alignment on fuel retention and impurity deposition in gaps. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Liu, R.:* Gesteuerte Kernfusion und der Forschungsstand. (Vorlesung, 2008-10-24, Shandong Jiaotong University).

*Liu, R.:* Gesteuerte Kernfusion und der Forschungszustand. (Vorlesung, 2008-10-22, Shandong University).

*Liu, R.:* Gesteuerte Kernfusion und der Forschungsstand. (Vorlesung, 2008-10-23, Shandong University of Technology).

*Liu, R.:* Gesteuerte Kernfusion und der Forschungsstand. (Vorlesung, 2008-10-28, Yuxi University).

*Lizunov, A., P. Bagryansky, W. Biel, H. Dreier, H. T. Lambertz, Y. Khilchenko, Y. Krasikov, M. Mitri, B. Schweer, A. Solomakhin and TEXTOR Team:* Development of a multi-channel dispersion interferometer at TEXTOR. (17th Topical Conference on High-Temperature Plasma Diagnostics, 2008-05-11 to 2008-05-15, Albuquerque, NM).

*Lopez-Galilea, I., C. Garcia-Rosales, C. Adelhelm, P. Sauter, M. Balden and P. Starke:* Chemical erosion behaviour of Ti-doped isotropic graphite for plasma facing components. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Lyssoivan, A., G. Sergienko, V. Rohde, V. Philipps, G. Van Wassenhove, M. Vervier, V. Bobkov, J. Harhausen, R. Koch, J.-M. Noterdaeme, D. Van Eester, M. Freisinger, H.-U. Fahrbach, H. Reimer, A. Kreter, D. Hartmann, J. Hu, R. Weynants, O. Gruber, A. Herrmann, D. Doual, Y. D. Bae, H. G. Esser, J. G. Kwak, E. Lerche, O. Marchuk, V. Mertens, R. Neu, U. Samm, A. Scarabosio, C. Schulz, S. J. Wang, TEXTOR Team and ASDEX Upgrade Team:* Influence of toroidal and vertical magnetic fields on Ion Cyclotron wall conditioning in tokamaks. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Maaßberg, H.:* Momentum correction techniques for bootstrap current. (Theorie Seminar, 2008-11-17 to 2008-11-21, Schloss Ringberg, Tegernsee).

*Maaßberg, H. and C. Beidler:* Momentum Correction Techniques (2) and Benchmarking. (Kinetic Theory Workshop (KTW), 2008-10-23 to 2008-10-24, Madrid).

*Maaßberg, H., C. Beidler and V. Trialdos:* Compressible E×B Flow – analytic tokamak modelling in plateau regime. (Kinetic Theory Workshop (KTW), 2008-10-23 to 2008-10-24, Madrid).

*Maier, H.:* Discoloration analysis results. (ITER-like Wall Project Board Satellite Meeting, 2008-10-01, JET, Culham).

*Maier, H.:* Material Aspects of Plasma-Wall Interaction. (Basic Aspects of Plasma-Wall Interaction, 2008-11-19 to 2008-11-20, Französische Akademie der Wissenschaften, Paris).

*Maier, H.:* Overview of test results. (ITER-like Wall Review Meeting on Tungsten Coatings, 2008-06-25, JET, Culham).

*Maier, H.:* Technical overview of divertor coating options. (ITER-like Wall Project Board Satellite Meeting, 2008-03-06, JET, Culham).

*Maier, H., H. Greuner and C. Linsmeier:* Thermal fatigue comparative tests under H & He beam loading of different W alloys in GLADIS. (EFDA Tungsten Alloy Development and Characterisation Coordination Meeting, 2008-09-08, EFDA, Garching).

*Maier, H. and R. Neu:* Development of Tungsten Coatings for the JET ITER-like Wall Project. (Special Expert Working Group Meeting High-Z Materials of EU Task Force Plasma-Wall Interaction, 2008-06-25, JET, Culham).

*Manhard, A., U. Fantz, A. Stäbler, ASDEX Upgrade NBI Team, H. Greuner and GLADIS Team:* Spektroskopische Untersuchungen an HF-Quellen für positive Wasserstoffionen. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Mantica, P., F. Ryter, D. Strintzi, T. Tala, C. Giroud, T. Johnson, E. Lerche, T. Loarer, A. G. Peeters, A. Salmi, S. Sharapov, D. Van Eester, P. C. de Vries, L. Zabeo, K.-D. Zastrow and JET-EFDA Contributors:* Experimental Study of the Ion Critical Gradient Length and Stiffness Level and the Impact of Rotational Shear in JET. (13th EU-US TTF Workshop 2008 and 1st EFDA Transport Topical Group Meeting, 2008-09-01 to 2008-09-04, Copenhagen).

*Marcuzzi, D., M. Dalla Palma, M. Pavei, B. Heinemann, W. Kraus and R. Riedl:* Detailed design of the RF source for the 1 MV neutral beam test facility. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Markelj, S., I. Cadez and T. Schwarz-Selinger:* Chemical Erosion of Carbon by Vibrationally Hot Hydrogen Molecules. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Markins, A., W. Bohmeyer, A. Loarte and G. Fußmann:* Sticking and Erosion of Hydrocarbons in Gaps. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Martins, J.-P., L. Doceul, S. Marol, E. Delchié, J.-J. Cordier, B. Levesy, A. Tesini, E. Ciattaglia, R. Tivey, R. Gillier and C. Abbes:* Study of ITER equatorial port plug handling system and vacuum sealing interface. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Marushchenko, N.:* Calculations of ECCD with momentum conservation and arbitrary collisionalities. (Theorie Seminar, 2008-11-17 to 2008-11-21, Schloss Ringberg, Tegernsee).

*Marushchenko, N.:* Summary of the theory presentations at EC-15. (15th Joint Workshop on Electron Cyclotron Emission and Electron Cyclotron Resonance Heating, 2008-03-10 to 2008-03-13, Yosemite National Park, CA).

*Marushchenko, N., C. Beidler and H. Maaßberg:* Current Drive Calculations with an Advanced Adjoint Approach. (15th Joint Workshop on Electron Cyclotron Emission and Electron Cyclotron Resonance Heating, 2008-03-10 to 2008-03-13, Yosemite National Park, CA).

*Marushchenko, N., H. Maaßberg and C. Beidler:* ECCD Calculations with parallel momentum conservation. (Kinetic Theory Workshop (KTW), 2008-10-23 to 2008-10-24, Madrid).

*Marushchenko, N., H. Maaßberg, C. Beidler and M. Romé:* Current drive calculations with parallel momentum conservation. (Ringberg Theory Meeting, 2008-11-17 to 2008-11-21, Schloss Ringberg, Tegernsee).

*Marushchenko, N., H. Maaßberg, Y. Turkin, C. Beidler, V Erckmann, J. Geiger, H. Laqua and W7-X Team:* IECRH/ECCD Scenarios on W7-X Stellarator. (4th Coordinated Working Group Meeting (CWGM) for Stellarator/Heliotron Studies, 2008-10-20 to 2008-10-22, Madrid).

*Marushchenko, N., H. Maaßberg, Y. Turkin, C. Beidler, V. Erckmann, J. Geiger, H. Laqua and W7-X Team:* IECRH/ECCD Scenarios on W7-X Stellarator. (7th International Workshop "Strong Microwaves: Sources and Applications", 2008-07-27 to 2008-08-02, Nizhny Novgorod).

*Masuzaki, S., M. Kobayashi, Y. Feng, T. Morisaki, N. Ohyabu, A. Komori and LHD Experimental Group:* Investigation of particle and heat flux profiles on divertor plates in the Large Helical Device. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Matthews, G. F., P. Coad, H. Greuner, M. Hill, T. Hirai, J. Likonen, H. Maier, M. Mayer, R. Neu, V. Philipps, R. Pitts, V. Riccardo and ITER-like Wall Team:* Choice of Tungsten Coating Thickness for the JET ITER-like Wall Project Divertor. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Matyash, K., R. Schneider, V. R. Ikkurthi and A. Melzer:* Ion drag force on dust grain in the magnetized edge plasma. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Mayer, M.:* The SIMNRA package. (2nd Workshop on Ion Beam Analysis (IBAF 2008), 2008-10-13 to 2008-10-15, Carcans).

*Mayer, M., V. Alimov, M. Balden, K. Krieger, S. Lindig, O. Ogorodnikova, V. Rohde, J. Roth, K. Sugiyama and ASDEX Upgrade Team:* Deuterium retention in tungsten. (SEWG Meeting "High-Z Plasma Facing Components", 2008-06-25 to 2008-06-26, JET, Culham).

*Mayer, M., M. Balden, K. Krieger, S. Lindig, O. Ogorodnikova, V. Rohde, K. Sugiyama and ASDEX Upgrade Team:* Fuel retention in ASDEX Upgrade tungsten coatings. (SEWG-Meeting "Gas Balance and Fuel Retention", 2008-07-22 to 2008-07-23, JET, Culham).

*Mayer, M., M. Balden, S. Lindig, J. Roth, R. Neu and ASDEX Upgrade Team:* Surface modifications and blistering of tungsten exposed in ASDEX Upgrade. (10th ITPA Meeting on SOL/Divertor Physics, 2008-01-07 to 2008-01-10, Avila).

*Mayer, M., V. Rohde, K. Sugiyama, C. L. Chen, X. Gong, C. Hopf, J. Likonen, S. Lindig, R. Neu, G. Ramos, E. Vainonen-Ahlgren, A. Wiltner and ASDEX Upgrade Team:* Carbon balance and deuterium inventory from a carbon dominated to a full tungsten ASDEX Upgrade. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Mayer, M., V. Rohde, K. Sugiyama, A. Herrmann, C. Hopf, J. Likonen, S. Lindig, R. Neu, R. Pugno, G. Ramos, E. Vainonen-Ahlgren, A. Wiltner and ADEX Upgrade Team:* Carbon sources in ASDEX Upgrade with carbon and tungsten walls. (SEWG Meeting "Material Migration", 2008-07-21 to 2008-07-22, JET, Culham).

*Mayer, M., V. Rohde, K. Sugiyama, G. Ramos, E. Vainonen-Ahlgren, J. Likonen, R. Neu and ASDEX Upgrade Team:* First results on C deposition and D inventory in a fully-tungsten ASDEX Upgrade. (10th ITPA Meeting on SOL/Divertor Physics, 2008-01-07 to 2008-01-10, Avila).

*McCormick, K., R. Dux, R. Fischer, A. Scarabosio and ASDEX Upgrade Team:* Main chamber high recycling on ASDEX Upgrade. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*McNeely, P., S. Christ-Koch, M. Kammerloher and P. Turba:* Langmuir Probe Measurements on High Power RF Negative Ion Sources. (1st International Conference on Negative Ions, Beams and Sources (NIBS 2008), 2008-09-10 to 2008-09-12, Aix-en-Provence).

*Mehlmann, F., C. Ionita, H. W. Müller, P. Balan, A. Herrmann, A. Kendl, M. Maraschek, V. Naulin, A. H. Nielsen, J. J. Rasmussen, V. Rohde, R. Schrittwieser and ASDEX Upgrade Team:* Radial transport in the L- and H-mode SOL of ASDEX Upgrade. (13th EU-US TTF Workshop 2008 and 1st EFDA Transport Topical Group Meeting, 2008-09-01 to 2008-09-04, Copenhagen).

*Meister, H.:* Technical progress of the ITER bolometry and pressure gauge diagnostic. (ITPA Meeting, 2008-04-14 to 2008-04-16, Lausanne).

*Meo, F., H. Bindslev, S. B. Korsholm, V. Furtula, F. Leuterer, F. Leipold, P. K. Michelsen, S. K. Nielsen, M. Salewski, J. Stober, D. Wagner and P. Woskov:* Commissioning activities and first results from the collective Thomson scattering diagnostic on ASDEX Upgrade. (17th Topical Conference on High-Temperature Plasma Diagnostics, 2008-05-11 to 2008-05-15, Albuquerque, NM).

*Meyer-Spasche, R.:* Mathematische Probleme in Fluiddynamik und Plasmaphysik. (SS 2008. Vorlesung, Technische Universität München).

*Meyer-Spasche, R.:* Nichtlineare Eigenwertprobleme. (WS 2007/2008. Vorlesung, Technische Universität München).

*Meyer-Spasche, R. and K. Dimova:* On a moving boundary model of anomalous heat transport in a tokamak plasma. (GAMM Meeting, 2008-03-31 to 2008-04-04, Bremen).

*Michel, G. and W. Kasparek:* Numerical analysis of complex mirror transmission lines. (33rd International Conference on Infrared, Millimeter, and Terahertz Waves (IRMMW-THz 2008), 2008-09-15 to 2008-09-19, Pasadena, CA).

*Michel, G. and W. Kasparek:* Numerical Analysis of the W7-X ECRH Transmission Line. (7th International Workshop "Strong Microwaves: Sources and Applications", 2008-07-27 to 2008-08-02, Nizhny Novgorod).

*Michel, G., W. Kasparek, H. Laqua, M. Weissgerber and V. Erckmann:* ECRH-Antennas and In-Vessel Components for the W7-X Stellarator. (33rd International Conference on Infrared, Millimeter, and Terahertz Waves (IRMMW-THz 2008), 2008-09-15 to 2008-09-19, Pasadena, CA).

*Milch, I.:* PR für die Forschung. Ein Praxisbericht. (Koordinatorentreffen des Elitenetzwerks Bayern, 2008-11-12, München).

*Mishchenko, A.:* Global PIC simulations of Alfvenic modes. (Theorie Seminar, 2008-11-17 to 2008-11-21, Schloss Ringberg, Tegernsee).

*Mishchenko, A., R. Hatzky and A. Könies:* Global particle-in-cell simulations of Alfvenic modes. (Joint Varenna-Lausanne International Workshop on Theory of Fusion Plasmas, 2008-08-25 to 2008-08-29, Varenna).

*Mishchenko, A., P. Helander and A. Könies:* Collisionless dynamics of zonal flows in stellarators. (Joint Varenna-Lausanne International Workshop on Theory of Fusion Plasmas, 2008-08-25 to 2008-08-29, Varenna).

*Missal, B., A. Cardella, T. Koppe, B. Hein, J. Reich, R. Krause and H. Jenzsch:* Current Status of some Main-Components of Cryostat Wendelstein 7-X. (18th Topical Meeting on the Technology of Fusion Energy (TOFE), 2008-09-28 to 2008-10-02, San Francisco, CA).

*Missirlian, M., J. Boscary, R. Guigon, J. Schlosser, H. Greuner and A. Durocher:* Upgraded acceptance criteria from transient thermography control for the W7-X target elements. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Mlynek, A., K. McCormick, G. Sips, J. Eheberg, G. Schramm, M. Zilker and ASDEX Upgrade Team:* Echtzeitkorrektur von 'fringe sumps' am DCN-Laserinterferometer von ASDEX Upgrade. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Mordijck, S., X. Bonnin, J. Canik, D. Coster, T. E. Evans, M. Groth, R. Maingi, R. A. Moyer, T. H. Osborne, L. W. Owen, T. W. Petrie, D. Reiter, G. R. Tynan, E. A. Unterberg and J. G. Watkins:* Fluid Modeling of an ELMing H-mode and a RMP H-mode. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Mühlich, P., T. Hamacher, T. Hartmann, Y. Lechon, H. Cabal, M. Labriet, F. Gravecca, U. Ciorba, M. Biberacher, P. E. Gronheit, D. J. Ward, W. E. Han, A. Lehtilae and C. Eherer:* Global energy scenarios in the multi-regional EFDA-TIMES energy system model. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Müller, J.:* Aufbaubegleitende Vermessung beim Wendelstein 7-X. (Norddeutsche Fachtage, 2008-04-11 to 2008-04-12, Neubrandenburg).

*Muller, S. H., C. Holland, G. R. Tynan, M. Xu, Z. Yan, J. H. Yu, C. Brandt, O. Grulke, K. Rahbarnia, A. Stark, S. Ullrich, T. Windisch and V. Naulin:* Fast-camera imaging on linear devices for the validation of numerical simulations. (13th EU-US TTF Workshop 2008 and 1st EFDA Transport Topical Group Meeting, 2008-09-01 to 2008-09-04, Copenhagen).

*Müller, W. C.:* The inverse cascade of magnetic helicity. (AGU Fall Meeting, 2008-12-15 to 2008-12-19, San Francisco, CA).

*Müller, W. C.:* The role of cross-helicity in two-dimensional magneto-convection. (14th International Congress on Plasma Physics (ICPP 2008), 2008-09-08 to 2008-09-12, Fukuoka).

*Murari, A., J. Vega, A. Alonso, J. Farthing, C. Hidalgo, G. A. Rattá, J. Svensson and G. Vagliasindi:* New methods of data mining and soft computing for JET with a view on ITER. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Naujoks, D.:* Plasmaphysik II. (SS 2008. Vorlesung, Humboldt-Universität Berlin).

*Neu, R.:* Fifth Report of the SEWG on Hig-Z PFCs. (Meeting of EU TF on PWI, 2008-10-27 to 2008-10-29, Frascati).

*Neu, R.:* Plasmaphysik und Fusionsforschung II. (WS 2007/2008, SS 2008. Vorlesung, Universität Tübingen).

*Neu, R.:* Recent Experience on PMI in Tokamaks. (International Workshop on High Heat Flux Components, 2008-12-10 to 2008-12-12, San Diego, CA).

*Neu, R., R. Dux, O. Gruber, A. Kallenbach, M. Mayer, T. Pütterich, V. Rohde, A. C. C. Sips, V. Bobkov, T. Eich, J. C. Fuchs, A. Herrmann, C. F. Maggi, J. Schweinzer, J. Stober, H. Zohm and ASDEX Upgrade Team:* Non-boronized operation of ASDEX Upgrade with full-tungsten plasma facing components. (DIII-D Seminar, General Atomics, 2008-12-12, San Diego, CA).

*Neu, R., R. Dux, R. Pugno, T. Pütterich and ASDEX Upgrade Team:* ELM resolved measurements of W sputtering. (ITPA SOL/DIV Meeting, 2008-01-08 to 2008-01-09, Avila).

*Neu, R., T. Pütterich, R. Dux and ASDEX Upgrade Team:* W Spektroskopie für ASDEX Upgrade, JET und ITER. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Neubauer, O., A. Charl, G. Czymek, B. Giesen, M. Sauer, L. Scheibl, R. Schick, A. Panin, A. John, S. Jung, K. Rummel and L. Wegener:* The busbar system for Wendelstein 7-X prepared for assembly and operational loads. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Nightingale, M., G. Agarici, A. Argouarch, B. Beaumont, A. Becoulet, A. Borthwick, F. Braun, P. Dumortier, F. Durodie, J. Fanthome, C. Hamlyn-Harris, D. Hancock, R. Koch, P. Lamalle, F. Louche, R. Maggiora, R. Merrit, A. Messiaen, D. Milanesio, I. Monakhov, J.-M. Noterdaeme, R. Sartori, D. Stork, M. Vrancken, K. Vulliez and D. Wilson:* RF and Mechanical Design of the ITER Ion Cyclotron Resonance Frequency Antenna. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Nocentini, R., R. Gutser, B. Heinemann, M. Fröschle and R. Riedl:* Plasma grid design for optimized magnetic filter field configuration for the NBI test facility ELISE. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Nold, B., H. W. Müller, M. Ramisch, V. Rohde, U. Stroth and ASDEX Upgrade Team:* Turbulence investigation in TJ-K and ASDEX Upgrade. (11th Workshop on Electric Fields, Turbulence and Self-Organisation in Magnetized Plasmas (EFTSOMP2008). Satellite Meeting of the 35th EPS Conference on Controlled Fusion and Plasma Physics, 2008-06-16 to 2008-06-17, Hersonissos, Crete).

*Nold, B., M. Ramisch, V. Rohde, H. W. Müller, ASDEX Upgrade Team and U. Stroth:* Vergleich dimensional ähnlicher Turbulenz in TJ-K und ASDEX Upgrade. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Noterdaeme, J.-M.:* The 7th BNEN academic year. (Belgian Interuniversity Programme BNEN "Master in Nuclear Engineering", 2008-09-29, Mol).

*Noterdaeme, J.-M.:* Ion cyclotron frequency range (ICRF) power on the way to DEMO. (18th International Toki Conference (ITC18), 2008-12-09 to 2008-12-12, Ceratopia Toki, Toki Gifu).

*Noterdaeme, J.-M.:* Kernreactortheorie. (WS 2007/2008. Vorlesung, Universiteit Gent).

*Noterdaeme, J.-M.:* Nuclear Reactor Theory and Experiments. (SS 2008. Vorlesung – Interuniversity Program Master in Nuclear Engineering in SCK/CEN (Studiencentrum voor Kernenergie/Centre pour Energie Nucleaire), Mol).

*Nührenberg, J.:* The Computational Stellarator. (3rd International Congress: Large Scale Simulations of Complex Systems, Condensed Matter and Fusion Plasma (BIFI 2008), 2008-02-06 to 2008-02-08, Zaragoza).

*Numssen, K., I. Zammuto, G. Friedsam, C. Hollwich and P. Mayer:* Thermal limitation of the mean power rating of coaxial transmission lines for ICRH. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Oehrlein, G. S., T. Schwarz-Selinger, K. Schmid, M. Schlüter and W. Jacob:* Interaction of Deuterium Atoms with Hard a-C:H Films: Isotope Exchange, Softlayer Formation and Steady-state Erosion. (9th International Workshop on Hydrogen Isotopes in Fusion Reactor Materials, 2008-06-02 to 2008-06-03, Salamanca).

*Ogorodnikova, O. V.:* Assessment of tritium inventory in all-W machine. (9th International Workshop on Hydrogen Isotopes in Fusion Reactor Materials, 2008-06-02 to 2008-06-04, Salamanca).

*Ogorodnikova, O. V.:* Ion-driven deuterium retention in high-Z metals. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Ogorodnikova, O. V.:* Modelling of hydrogen retention and permeation in tungsten. (9th International Workshop on Hydrogen Isotopes in Fusion Reactor Materials, 2008-06-02 to 2008-06-04, Salamanca).

*Pacher, H. D., A. S. Kukushkin, G. W. Pacher, V. Kotov, D. Reiter, D. P. Coster and G. Janeschitz:* Impurity seeding and scaling of edge parameters in ITER. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Paffenholz, V. and A. Brendel:* SiC-Fibre reinforced Copper as Heat Sink Material for Fusion Applications. (Fachbeirat, 2008-06-19, Garching).

*Paffenholz, V., A. Brendel, S. Lindig and H. Bolt:* Synthesis and analysis of the thermal behavior of SiC-fibre reinforced copper matrix composites as heat sink material. (1st International Conference on New Materials for Extreme Environments (ExtreMat), 2008-06-02 to 2008-06-04, San Sebastian).

*Panin, A., B. Giesen, V. Bykov, A. Charl, G. Czymek, F. Hurd, A. John, S. Jung, O. Neubauer, K. Rummel, M. Sauer, L. Scheibl, R. Schick and L. Wegener:* Study of structural behavior of busbar system for ready-to-assembly module no. 5 of Wendelstein 7-X stellarator. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Pautasso, G., D. Coster, X. Bonnin, T. Eich, J. C. Fuchs, B. Kurzan, K. McCormick, B. Reiter, V. Rohde and ASDEX Upgrade Team:* Disruption mitigation in ASDEX Upgrade with the in-vessel fast valve. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Peacock, A., H. Greuner, F. Hurd, R. König, B. Mendelevitch, R. Stadler, F. Schauer, R. Tivey, J. Tretter and C. von Sehren:* Design and development of a test divertor (TDU) for the start of W7-X operation. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Peeters, A. G., C. Angioni and D. Strintzi:* The toroidal momentum pinch velocity and turbulent equipartition. (35th EPS Conference on Plasma Physics, 2008-06-09 to 2008-06-13, Hersonissos, Crete).

*Pégourié, B., C. Brosset, E. Tsitrone, A. Beauté, S. Brémond, J. Bucalossi, S. Carpentier, Y. Corre, E. Delchambre, C. Desgranges, P. Devynck, D. Douai, G. Dunand, A. Ekedahl, A. Escarguel, E. Gauthier, J. P. Gunn, P. Hertout, S.-H. Hong, F. Kazarian, M. Kocan, F. Linez, Y. Marandet, A. Martinez, M. Mayer, O. Meyer, P. Monier-Garbet, P. Moreau, P. Oddon, J.-Y. Pascal, F. Rimini, J. Roth, F. Saint-Laurent, F. Samaille, S. Vartanian, C. Arnas, E. Aréou, C. Gil, J. Lasalle, L. Manenc, C. Martin, M. Richou, P. Roubin and R. Sabot:* Overview of the Deuterium Inventory campaign in Tore Supra: operational conditions and particle balance. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Pfannmöller, J., O. Grulke, T. Klinger and K. Sauer:* Experimentelle Untersuchungen über nicht-lineare Whistlerwellen Propagation. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Pintsuk, G., J. Blumm, W. Hohenauer, R. C. Hula, T. Koppitz, S. Lindig, D. Pitzer, M. Rohde, P. Schoderböck, T. Schubert, F. Tietz and O. Wouters:* Inter-Laboratory Test on Thermophysical Properties of the ITER Grade Heat Sink Material Copper-Chromium-Zirconium. (1st International Conference on New Materials for Extreme Environments (ExtreMat), 2008-06-02 to 2008-06-06, San Sebastian).

*Pintsuk, G., J. Compan, J. Linke, A. Peacock, D. Pitzer, M. Rödig and S. Wikman:* Mechanical and thermo-physical characterization of three-directional carbon fiber composites for W7-X and ITER. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Pitts, R. A., A. Alonso, G. Arnoux, S. Brezinsek, M. Beurskens, T. Eich, H. G. Esser, W. Fundamenski, A. Huber, B. Gulejova, S. Jachmich, A. Kreter, A. Loarte, E. De La Luna, J. Marki, G. F. Matthews, V. Philipps, E. Solano, M. F. Stamp, D. Tshakaya and JET EFDA Contributors:* The impact of large ELMs on JET. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Pokol, G., T. Fülöp, H. Smith and P. Helander:* Criteria for Runaway Electron Generation in Tokamak Disruptions. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Poli, E.:* Kinetic Theory. (IPP Summer University for Plasma Physics, 2008-09-22 to 2008-09-26, Garching).

*Poli, E.:* Magnetic islands in nuclear fusion experiments. (Physik-Kolloquium, 2008-11-03, Universität Ulm).

*Poli, E., A. Bottino and A. Peeters:* Behaviour of turbulent transport in the vicinity of a magnetic island. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Prechtl, M.:* Vakuum- und Kryotechnik. (WS 2007/2008. Vorlesung/Praktikum, Hochschule für angewandte Wissenschaften – Fachhochschule München).

*Prechtl, M., V. Bobkov, F. Braun, H. Faugel and J.-M. Noterdaeme:* Theory on dynamic matching with adjustable capacitors for ICRF at ASDEX Upgrade. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Pueschel, M. J., F. Jenko and M. Kammerer:* The beta dependence of tokamak core turbulence. (13th EU-US TTF Workshop, 2008-09-01 to 2008-09-04, Copenhagen).

*Pugno, R., K. Krieger, V. Rohde, M. Airila, D. Coster, A. Chankin, M. Wischmeier and ASDEX Upgrade Team:* Investigation of local carbon transport in the ASDEX Upgrade divertor using $^{13}CH_4$ puffing. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Rahbarnia, K., A. Stark, S. Ullrich, O. Grulke and T. Klinger:* Alfvénwellen in Mehrkomponentenplasmen. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Rahbarnia, K., S. Ullrich, A. Stark, O. Grulke and T. Klinger:* Alfvén waves in multi-component plasmas. (14th International Congress on Plasma Physics (ICPP 2008), 2008-09-08 to 2008-09-12, Fukuoka).

*Rahbarnia, K., S. Ullrich, A. Stark, O. Grulke and T. Klinger:* Driven Alfvén Waves. (Workshop on Plasma Waves, 2008-06-10 to 2008-06-12, Stettin).

*Rai, A., R. Schneider, M. Warrier, P. Roubin, C. Martin and M. Richou:* Dynamic Monte-Carlo modeling of hydrogen retention and chemical erosion from Tore-Supra deposits. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Rajna, T., F. Herold and C. Baylard:* Reverse engineering process of cryostat components of Wendelstein 7-X. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Ramm, J., D. Levchuk, H. Bolt, M. Döbeli, S. Eggenberger and B. Widrig:* Al-Cr-O Thin Films as an Efficient Hydrogen Permeation Barrier. (11th International Conference on Plasma Surface Engineering (PSE 2008), 2008-09-15 to 2008-09-19, Garmisch-Partenkirchen).

*Rasul, B., F. Zappa, N. Endstrasser, W. Schustereder, J. D. Skalny, Z. Herman, P. Scheier and T. D. Märk:* Ion surface collisions with surfaces relevant for fusion devices. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Raupp, G., K. Behler, A. Buhler, R. Drube, K. Engelhardt, A. Lohs, R. Merkel, G. Neu, H. Eixenberger, G. Schramm, W. Treutterer, D. Zasche and T. Zehetbauer:* ASDEX Upgrade CODAC overview. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Recchia, M., A. Zamengo, W. Kraus, M. Bigi, C. Martens and V. Toigo:* Electrical and thermal analyses for the radiofrequency circuit of ITER NBI ion source. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Reetz, J.:* DEISA – Towards a European HPC Infrastructure. (7th Annual Meeting on High Performance Computing and Infrastructure in Norway (NOTUR2008), 2008-06-03 to 2008-06-05, Tromsø).

*Reinelt, M. and C. Linsmeier:* Retention mechanisms of hydrogen implanted into beryllium. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Reinelt, M., M. Oberkofler and C. Linsmeier:* Deuterium retention in clean beryllium at the ARTOSS experiment. (Fachbeirat, 2008-06-19, Garching).

*Reinke, L.:* Preparation of components for mounting of Wendelstein 7-X. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Renard, B., L. Genini, H. Viebke and J.-L. Duchateau:* W7-X superconducting coils cooling in the CEA Saclay cryo-magnetic test facility. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Reuter, H.:* 20 Jahre Langzeitarchivierung am RZG. (Münchener AK Langzeitarchivierung, 2008-07-22, LRZ Garching).

*Ribeiro, T.:* Gyrofluid turbulence simulations near the X-point: drift wave vs. interchange turbulence. (13th EU-US TTF Workshop 2008 and 1st EFDA Transport Topical Group Meeting, 2008-09-01 to 2008-09-04, Copenhagen).

*Riccardo, V., G. Matthews, V. Thompson, E. Villedieu, P. Coad, P. Mertens, H. Maier, T. Hirai, R. Mitteau and A. Loving:* Engineering Challenges of the JET ITER-like Wall. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Riemann, H., T. Bluhm, P. Heimann, C. Hennig, G. Kühner, H. Kroiss, H. Laqua, M. Lewerentz, J. Maier, J. Schacht, A. Spring, A. Werner and M. Zilker:* From a physics discharge program to device control: Linking the scientific and technical world at Wendelstein 7-X. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Riemann, J.:* Kernfusion – eine Energieoption für die Zukunft. (Schulvortrag im Rahmen der Jahrestagung der MPG, 2008-06-25, Großröhrsdorf).

*Riemann, J.:* Kernfusion. (Europäische Akademie Mecklenburg-Vorpommern, 2008-09-04, Waren (Müritz)).

*Riemann, J., M. Borchardt, R. Schneider and A. Mutzke:* Coordinates for Global Modelling. (Theory Meeting, 2008-10-23 to 2008-10-24, Sellin).

*Riße, K. and W7-X Team:* Experiences from design and production of Wendelstein 7-X magnets. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Rohde, V.:* Gas balances in ASDEX Upgrade W-wall and retention. (SEWG-Meeting "Gas Balance and Fuel Retention", 2008-07-22 to 2008-07-23, JET, Culham).

*Rohde, V., M. Balden and A. Herrmann:* Dust investigations in ASDEX Upgrade. (IAEA CRP Dust in Fusion Devices, 2008-12-10 to 2008-12-12, Vienna).

*Rohde, V., M. Balden, A. Herrmann and ASDEX Upgrade Team:* Dust measurement in ASDEX Upgrade and ideas for JET. (EFDA Task: TW6-TPP-DUSMEAS, Demonstration of Diagnostic Techniques for Time Resolved Dust Measurement in Tokamaks, 2008-03-08, Garching).

*Rohde, V., M. Mayer, V. Mertens, R. Neu, A. Scarabosio, K. Sugiyama and ASDEX Upgrade Team:* Dynamic and static deuterium inventory in ASDEX Upgrade with tungsten first wall. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Rohde, V., V. Mertens, G. Haas, T. Loarer and ASDEX Upgrade Team:* Gasbalance in ASDEX Upgrade with tungsten first wall. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Roth, J.:* The EU Plasma Wall Interaction Task Force: Highlights 2007 and Programme 2009. (24th Meeting of the Science and Technology Advisory Committee (STAC), 2008-04-28, Culham).

*Roth, J.:* Medium Size Technology Facilities at IPP Garching: Integrated PWI facilitiy and GLADIS. (3rd EFDA Workshop, 2008-01-28, Frascati).

*Roth, J.:* New input data for W: Flux and temperature dependence of retention. (ITPA Meeting on ITER Fuel Retention, 2008-06-23, Boston, MA).

*Roth, J.:* Prediction of ITER T retention levels with W PFCs. (10th ITPA Meeting on SOL/Divertor Physics, 2008-01-07 to 2008-01-10, Avila).

*Roth, J.:* Programme of bilateral EU-Russia collaboration. (PWI TF Meeting, 2008-10-28, Frascati).

*Roth, J., J. Davis, R. Doerner, A. Haasz, A. Kallenbach, A. Kirschner, R. Kolasinski, B. Lipschultz, A. Loarte, O. Ogorodnikova, V. Philipps, K. Schmid, W. Wampler, G. Wright and D. Whyte:* A new look at the specification of ITER plasma wall interaction and tritium retention. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Roth, J., J. Davis, R. Doerner, A. Haasz, A. Kallenbach, A. Kirschner, R. Kolasinski, B. Lipschultz, A. Loarte, O. Ogorodnikova, V. Philipps, K. Schmid, W. Wampler, G. Wright and D. Whyte:* A new look at the specification of ITER plasma wall interaction and tritium retention. (PWI TF Meeting, 2008-10-28, Frascati).

*Roth, J., B. Lipschultz, A. Loarte, V. Philipps, A. Kallenbach, K. Schmid, R. Doerner, D. Whyte, G. Wright, A. Haasz, J. Davis, R. Kolasinski and B. Wampler:* Recent analysis of Tritium retention in ITER. (Meeting of Special Expert Working Group on Gas Balance and Fuel Retention, 2008-07-22, JET, Culham).

*Roth, J., E. Tsitrone, S. Brezinsek, P. Coad, G. Counsell, C. Grisolia, M. Lehnen, T. Loarer, A. Loarte, R. Neu, V. Philipps, V. Alimov, R. Causey, R. Doerner, A. Kallenbach, A. Kirschner, K. Krieger, B. Lipschultz, O. Ogorodnikova, K. Schmid, ITER PWI Team, EFDA PWI TF, F4E and ITPA SOL/DV:* Recent Analysis of Key Plasma Wall Interaction Issues for ITER. (18th Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI-18), 2008-05-26 to 2008-05-30, Toledo).

*Rott, M., U. Seidel, B. Streibl, W. Suttrop, T. Vierle and ASDEX Upgrade Team:* Electro-magnetic modeling of the planned active in-vessel coils at ASDEX Upgrade. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Rozhansky, V., E. Kaveeva, P. Molchanov, I. Veselova, S. Voskoboynikov, D. Coster, G. Counsell, A. Kirk and S. Lisgo:* Simulation of H-regimes of ASDEX-Upgrade and MAST. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Rummel, T., T. Mönnich, M. Köppen and E. Harmeyer:* Final tests of the power supply system for the W7-X superconducting magnet system. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Runov, A.:* 3D transport modelling at the tokamak edge with resonant magnetic field perturbations taking into account screening of perturbations by the plasma. (Theorie Seminar, 2008-11-17 to 2008-11-21, Schloss Ringberg, Tegernsee).

*Ruset, C., E. Grigore, H. Maier, H. Greuner, C. Hopf, V. Philipps, G. Matthews and JET-EFDA Contributors:* Industrial scale 10 microns W coating of CFC tiles for the ITER-like wall project. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Ryter, F., T. Pütterich, M. Reich, A. Scarabosio, E. Wolfrum, R. Fischer, M. Gemisic Adamov, N. Hicks, B. Kurzan, C. Maggi, R. Neu, V. Rohde, G. Tardini and ASDEX Upgrade Team:* H-Mode Threshold and Confinement in Helium, Deuterium and Hydrogen in ASDEX Upgrade. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Saarelma, S., M. Romanelli, C. M. Roach, A. G. Peeters, A. Bottino and MAST Team:* Global Turbulence Simulations of CYCLONE Base Case and MAST Plasmas. (Joint Varenna-Lausanne International Workshop on Theory of Fusion Plasmas, 2008-08-25 to 2008-08-29, Varenna).

*Sagara, A., S. Imagawa, Y. Kozaki, O. Mitarai, T. Tanaka, T. Watanabe, N. Yanagi, H. Tamura, K. Takahata, M. Shoji, S. Masuzaki, K. Nishimura, H. Chikaraishi, S. Yamada, T. Goto, T. Mito, T. Muroga, N. Nakajima, S. Fukada, H. Hashizume, A. Shishkin, Y. Igitkhanov, O. Motojima and FFHR Design Group:* FFHR – The LHD-type reactor design optimization toward Demo. (18th Topical Meeting on the Technology of Fusion Energy (TOFE), 2008-09-28 to 2008-10-02, San Francisco, CA).

*Sarasola, A., S. Wethekam, H. Winter, C. Linsmeier, V. M. Silkin and A. Arnau:* Auger neutralization rates and ion fractions for the $He^+$/Be(0001) system. (25th European Conference on Surface Science, 2008-07-28 to 2008-08-01, Liverpool).

*Scarabosio, A., G. Haas, H. W. Müller, R. Pugno, M. Wischmeier and ASDEX Upgrade Team:* Measurements of neutral gas flux under different plasma and divertor regimes in ASDEX Upgrade. (18th Internatinal Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Schacht, J., H. Laqua, M. Lewerentz and A. Spring:* Die Bedeutung des Timingsystems für die Steuerung und Datenerfassung des Fusionsexperiments Wendelstein 7-X. (5th Symposium on Automatic Control, 2008-09-18 to 2008-09-19, Wismar).

*Schacht, J. and Project Group "Prototype W7-X Central Control":* Overview and status of the prototype project for Wendelstein 7-X control system. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Schega, D., S. Abdullaev, K.-H. Finken, M. Jakubowski, M. Lehnen, D. Reiser, G. Sewell and R. Wolf:* MHD-simulations of the plasma response on the magnetic perturbations in the TEXTOR tokamak. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Schlüter, M., W. Jacob, C. Hopf and T. Schwarz-Selinger:* Energy, Temperature, and Flux Dependence of the Chemical Sputtering of Carbon Surfaces by Low-energy Ions in the Presence of Atomic Hydrogen. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Schmid, K.:* Beryllium flux distribution and layer deposition in the ITER divertor. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Schmuck, S., H.-J. Hartfuß, M. Hirsch and T. Stange:* Design of the ECE diagnostic at Wendelstein 7-X. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Schneider, R., A. Mutzke and I. Bizyukov:* SDTrimSP-2D studies of the influence of mutual flux arrangement on erosion and deposition. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Schöbel, M., H. P. Degischer, T. Buslaps, M. di Michiel, T. Poeste, R. Schneider, S. Kleiner, J. Hemptenmacher and A. Herrmann:* Residual stresses in metal matrix composites for heat sink applications during thermal cycling. (8th International Conference on Residual Stresses (ICRS-8), 2008-08-06 to 2008-08-08, Denver, CO).

*Schrader, M., T. Koppe, B. Missal, A. Cardella, A. Capriccioli and P. Friedrich:* Vertical supports of plasma vessel Wendelstein 7-X. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Schröder, M. and R. Vilbrandt:* Messung der Schraubenvorspannung mittels Ultraschall bei der Montage von W7-X. (DACH-Jahrestagung, 2008-04-28 to 2008-04-30, St. Gallen).

*Schröder, M., R. Vilbrandt and H. Allemann:* Messung der Schraubenvorspannung mittels Ultraschall bei der Montage von W7-X. (DACH Jahrestagung, 2008-04-28 to 2008-04-30, St. Gallen).

*Schustereder, W., A. Herrmann, K. Krieger, V. Rohde and ASDEX Upgrade Team:* Residual carbon and impurity fluxes in the scrape-off layer of ASDEX Upgrade in the full tungsten wall configuration. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Schwarz-Selinger, T., F. Genoese, C. Hopf and W. Jacob:* Carbon removal from tile-gap structures with oxygen glow discharges. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Schwarz-Selinger, T. and W. Jacob:* a-C:H film removal from tile gap structures with oxidising plasmas. (SEWG-Meeting "Fuel Removal", 2008-07-21 to 2008-07-23, JET Culham).

*Schwarz-Selinger, T. and W. Jacob:* Entfernung von Kohlenwasserstoffschichten mittels Sauerstoffplasmen: Das delikate Zusammenspiel von Physik und Chemie. (XV. Erfahrungsaustausch Oberflächentechnologie mit Plasma- und Ionenstrahlprozessen, 2008-03-04 to 2008-03-06, Mühlleithen).

*Schweinzer, J.:* Physics of high performance. (ASDEX Upgrade Programme Seminar, 2008-10-27 to 2008-10-31, Schloss Ringberg, Tegernsee).

*Schweinzer, J.:* Status of the ASDEX Upgrade Tungsten Programme. (IEA Executive Committee Meeting, 2008-06-03 to 2008-06-04, San Diego, CA).

*Schweinzer, J.:* Status of the Task Force I Programme. (ASDEX Upgrade Programme Committee Meeting, 2008-07-17, Garching).

*Schwenn, U.:* Psychologie und Akzeptanz moderner Videokommunikation. (MPG DV-Treffen 2008, 2008-11-18 to 2008-11-20, Göttingen).

*Schwenn, U.:* Psychology and Acceptance of Modern Videocommunication – 10 Years of Videoconferencing at IPP. (HPCM Symposium to Honour Ralf Gruber on his 65th Birthday, 2008-06-16 to 2008-06-17, EPFL, Lausanne).

*Schwenn, U.:* VC Integration – Needs & Solutions. (Ozeconf – Video Room Design Essentials, 2008-05-19).

*Scott, B. D.:* An Introduction to MHD, or Magnetic Fluid Dynamics. (IPP Summer University for Plasma Physics, 2008-09-22 to 2008-09-26, Garching).

*Scott, B. D.:* Ion Temperature Effects in Electromagnetic, Transcollisional Gyrokinetic Computations of Edge Turbulence. (13th EU-US TTF Workshop 2008 and 1st EFDA Transport Topical Group Meeting, 2008-09-01 to 2008-09-04, Copenhagen).

*Scott, B. D.:* Rotation in the presence of turbulence in large tokamaks. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Scott, B. D., A. Bottino, R. Hatzky, S. Jolliet, A. Kendl, B. F. Mcmillan, D. Reiser and T. Ribeiro:* Global electromagnetic gyrofluid/gyrokinetic computation of turbulence and self consistent rotation in large tokamaks. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Sertoli, M., R. Neu, T. Pütterich, R. Dux and ASDEX Upgrade Team:* Compact Soft X-Ray Spectrometer for Argon Measurements at ASDEX Upgrade. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Shimizu, S., T. Shimizu, W. Jacob, H. Thomas, N. Sato and G. E. Morfill:* Diamond fine particles growth on seed particles in the rf $CH_4/H_2$ plasma chamber equipped with a hot filament. (3rd International School of Advanced Plasma Technology, 2008-07-28 to 2008-07-31, Varenna).

*Sias, G, B. Cannas, A. Fanni, G. Pautasso, P. Sonato and ASDEX Upgrade Team:* Criteria and algorithms for constructing reliable data bases for statistical analysis of disruptions at ASDEX Upgrade. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Siccinio, M. and E. Poli:* Kinetic effects on slowly rotating magnetic islands in tokamaks. (Joint Varenna-Lausanne International Workshop on Theory of Fusion Plasmas, 2008-08-25 to 2008-08-29, Varenna).

*Sikora, M., C. Adelhelm, M. Balden, K. Schneider, C. Kapusta and P. Glatzel:* Nanocrystallization in vanadium doped carbon films studied by means of X-Ray emission spectroscopy. (9th International School and Symposium on Synchrotron Radiation in Natural Science (ISSRNS 2008), 2008-06-15 to 2008-06-20, Ameliowka).

*Silva, M., S. Alberti, J.-P. Ansermet, K. A. Avramides, G. Bodenhausen, J.-P. Hogge, I. Pagonakis and D. Wagner:* Design of a Low-Power High-Frequency Gyrotron for DNP-Enhanced NMR Spectroscopy. (35th IEEE International Conference on Plasma Science (ICOPS 2008), 2008-06-15 to 2008-06-19, Karlsruhe).

*Simon-Weidner, J.:* Anwendung der SFE-Methode für Schadenvoraussage. (INTES, 2008-11-07, Stuttgart).

*Sips, A. C. C., T. A. Casper, E. J. Doyle, G. Giruzzi, Y. Gribov, J. Hobirk, G. M. D. Hogeweij, L. D. Horton, A. E. Hubbard, I. Hutchinson, S. Ide, A. Isayama, F. Imbeaux, G. L. Jackson, Y. Kamada, C. Kessel, F. Kochl, P. Lomas, X. Litaudon, T. C. Luce, E. Marmar, M. Mattei, I. Nunes, N. Oyama, V. Parail, A. Portone, G. Saibene, R. Sartori, T. Suzuki, G. Tardini, S. M. Wolfe, C-Mod Team, ASDEX Upgrade Team, DIII-D Team and JET EFDA Contributors:* Experimental studies of ITER demonstration discharges. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Spitsyn, A. V., A. V. Golubeva, M. Mayer and A. A. Skovoroda:* Gas-driven hydrogen isotopes permeation through different carbon materials. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI-18), 2008-05-26 to 2008-05-30, Toledo).

*Stäbler, A., U. Fantz, P. Franzen, M. Berger, S. Christ-Koch, H. D. Falter, M. Fröschle, R. Gutser, B. Heinemann, W. Kraus, C. Martens, P. McNeely, R. Nocentini, R. Riedl, E. Speth and D. Wünderlich:* Development of a RF-driven ion source for the ITER NBI system. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Stadler, R., A. Vorköper, J. Boscary, A. Cardella, F. Hurd, C. Li, B. Mendelevitch, A. Peacock and H. Pirsch:* Steady-state in vessel components in Wendelstein 7-X stellarator. (18th International Toki Conference (ITC18), 2008-12-09 to 2008-12-12, Ceratopia Toki, Toki Gifu).

*Stadler, R., A. Vorköper, J. Boscary, A. Cardella, C. Li, B. Mendelevitch, A. Peacock and H. Pirsch:* Status of the in-vessel components of the experiment W7-X. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Stark, A., O. Grulke and T. Klinger:* Ionendynamik von nichtlinear angeregten Alfvénischen Wellen. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Starke, P., D. Filimonov, M. Balden, M. Martinez Escandell and J. M. Ramos Fernandez:* Erosion dotierter Kohlenstoffmaterialien in Deuterium-Niedertemperaturplasmen bei verschiedenen Oberflächentemperaturen. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Stober, J., T. Franke, G. Grünwald, F. Leuterer, A. Manini, F. Monaco, M. Münich, R. Neu, H. Schütz, D. Wagner, H. Zohm, G. Gantenbein, R. Heidinger, A. Meier, M. Thumm, W. Kasparek, C. Lechte, A. V. Chirkov, G. G. Denisov, A. Litvak, S. A. Malygin, V. E. Myasnikov, V. O. Nichiporenko, L. G. Popov, E. A. Solyanova, E. M. Tai, F. Meo and P. Woskov:* On the way to a multi-frequency ECRH system for ASDEX Upgrade. (15th Joint Workshop on Electron Cyclotron Emission and Electron Cyclotron Resonance Heating (EC-15), 2008-03-09 to 2008-03-13, Yosemite National Park, CA).

*Stroth, U., F. Greiner, T. Happel, P. Manz, A. Köhn, H. W. Müller, B. Nold, M. Ramisch, V. Rohde, T. Ribero, B. D. Scott, G. Birkenmeier, S. Enge, E. Holzhauer, H. Höhnle, N. Mahdizadeh, R. Neu and ASDEX Upgrade Team:* Experimental Investigation of Turbulence at the Transition from Closed to Open Field Lines. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Strumberger, E., S. Günter, P. Merkel, M. Sempf and D. Tekle:* Three-dimensional effects in tokamaks. (50th Annual APS Division of Plasma Physics Meeting, 2008-11-17 to 2008-11-21, Dallas, TX).

*Subba, F., P. Boerner, X. Bonnin, D. Coster, A. Kukushkin, F. Loarte, D. Reiter and R. Zanino:* ASPOEL-SOLPS modeling of the ITER edge plasma up to the first wall. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Sugiyama, K., K. Krieger, C. P. Lungu and J. Roth:* Hydrogen retention in ITER relevant mixed material layers.

(18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Sugiyama, K., M. Mayer, V. Rohde, R. Neu, A. Wiltner, T. Dürbeck, S. Lindig, T. Höschen, M. Balden, H. W. Müller and ASDEX Upgrade Team:* Deuterium inventory in the full tungsten divertor of ASDEX Upgrade. (9th International Workshop on Hydrogen Isotopes in Fusion Reactor Materials, 2008-06-02 to 2008-06-03, Salamanca).

*Suttrop, W.:* Astrophysikalische Plasmen, Teil I. (WS 2007/2008. Vorlesung, Universität Bayreuth).

*Suttrop, W.:* Astrophysikalische Plasmen, Teil II. (SS 2008. Vorlesung, Universität Bayreuth).

*Suttrop, W.:* The challenge of edge localised modes and their mitigation. (International Board of Advices Meeting, 2008-03-31 to 2008-04-01, IPP-CR Czech Acadamy of Sciences, Prague).

*Suttrop, W.:* Experimental results from Tokamaks. (IPP Summer University for Plasma Physics, 2008-09-22 to 2008-09-26, Garching).

*Suttrop, W.:* Auf dem Weg zum Kernfusionsreaktor? (Kerntechnische Gesellschaft, 2008-12-09, Hannover).

*Suttrop, W., A. Herrmann, M. Rott, T. Vierle, U. Seidel, B. Streibl, D. Yadikin, O. Neubauer, B. Unterberg, E. Gaio, V. Toigo, P. Brunsell and ASDEX Upgrade Team:* In-vessel saddle coils for MHD control in ASDEX Upgrade. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Suttrop, W., M. Rott, T. Vierle, U. Seidel, B. Streibl, B. Unterberg, P. Brunsell, E. Gaio and V. Toigo:* Active in-vessel coils and conducting wall for MHD control in ASDEX Upgrade. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Suttrop, W. and H. Zohm:* Tokamaks: Equilibrium, Stability and Transport. (IPP Summer University for Plasma Physics, 2008-09-22 to 2008-09-26, Garching).

*Sydorenko, N., O. Grulke and T. Klinger:* Detection of the negative ion density in oxygen helicon discharges. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Sydorenko, N., O. Grulke, T. Klinger, R. Schneider and K. Matyash:* Electronegativity of low pressure high-density oxygen discharges. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Szepesi, T., S. Kalvin, G. Kocsis, P. T. Lang, T. Senichenkov and ASDEX Upgrade Team:* Increased pellet penetration depth by pellet acceleration in hot tokamak plasmas. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Taglauer, E., D. Primetzhofer, S. N. Markin and P. Bauer:* Matrix effects in the neutralization of $He^+$ ions in LEIS. (Symposium on Surface Science (3S'08), 2008-03-02 to 2008-03-08, St. Christoph am Arlberg).

*Tala, T., K.-D. Zastrow, J. Ferreira, P. Mantica, A. G. Peeters, G. Tardini, M. Brix, G. Corrigan, C. Giroud, D. Strintzi and JET EFDA Contributors:* Evidence of Inward Toroidal Momentum Convection in the JET Tokamak. (35th EPS Conference on Plasma Physics, 2008-06-09 to 2008-06-13, Hersonissos, Crete).

*Tardini, G., J. Ferreira, P. Mantica, A. G. Peeters, T. Tala, K. D. Zastrow and JET-EFDA Contributors:* Angular momentum studies with NBI modulation in JET. (13th EU-US TTF Workshop 2008 and 1st EFDA Transport Topical Group Meeting, 2008-09-01 to 2008-09-04, Copenhagen).

*Telesca, G., S. Brezinsek, E. Delabie, K. H. Finken, M. von Hellermann, M. Jakubowski, M. Lehnen, Y. Liang, A. Pospieszczyk, U. Samm, O. Schmitz, M. Tokar, B. Unterberg and TEXTOR Team:* Carbon transport in the stochastic magnetic boundary of TEXTOR. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Tereshchenko, A., V. Bykov, F. Schauer and M. Ye:* FE simulation of the W7-X cryostat system. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Terry, J. L., S. J. Zweben, B. LaBombard, I. Cziegler, O. Grulke, R. H. Cohen, D. D. Ryutov, M. Umansky, T. Stoltzfus-Dueck, J. Krommes and D. Stotler:* Observations and Interpretation of the Spatial Structure of Edge Turbulence at the Outboard Midplane and High-Shear Region of Alcator C-Mod. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Thomsen, H., P. Carvalho, S. Gori, U. von Toussaint, A. Weller, R. Coelho and H. Fernandes:* Fast tomographic methods: Online Soft X-Ray inversion for Wendelstein 7-X stellarator. (5th Workshop on Fusion Data Processing, Validation and Analysis, 2008-01-14 to 2008-01-16, Culham).

*Tichmann, K.:* Bestimmung des Haftkoeffizienten von niederenergetischen Kohlenwasserstoffionen. (XV. Erfahrungsaustausch Oberflächentechnologie mit Plasma- und Ionenstrahlprozessen, 2008-03-04 to 2008-03-06, Mühlleithen).

*Toebbicke, R., A. Maslennikov, L. Giammarino, R. Belloni and H. Reuter:* OpenAFS and Object Storage. (AFS & Kerberos 2008 Best Practice Workshop, 2008-05-19 to 2008-05-23, New Jersy's Science & Technology University, Newark, NJ).

*Toebbicke, R., A. Maslennikov, L. Giammarino, R. Belloni and H. Reuter:* OpenAFS and Object Storage. (European AFS Conference 2008, 2008-09-24 to 2008-09-26, Graz).

*Tomarchio, V., K. Riße and H. Viebke:* Data analysis of the strain gauges system of the W7-X superconducting coils. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Treutterer, W., K. Behler, L. Giannone, K. Lüddecke, G. Neu, G. Raupp, D. Zasche, T. Zehetbauer and ASDEX Upgrade Team:* Real-time diagnostic integration with the ASDEX Upgrade Control System. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Tsitrone, E., C. Brosset, B. Pegourie, J. Bucalossi, S. Carpentier, Y. Corre, E. Delchambre, L. Desgranges, D. Douai, A. Ekedhal, A. Escarguel, E. Gauthier, P. Ghendrih, C. Grisolia, A. Grosman, J. Gunn, S. H. Hong, W. Jacob, F. Kazarian, M. Kocan, H. Khodja, T. Loarer, Y. Marandet, A. Martinez, M. Mayer, O. Meyer, P. Monier Garbet, P. Moreau, B. Pasquet, F. Rimini, H. Roche, S. Rosanvallon, P. Roubin, J. Roth, F. Saint-Laurent and F. Samaille:* Deuterium Inventory in Tore Supra: reconciling particle balance and post mortem analysis. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Tsitrone, E., J. Roth, C. Brosset, E. Gauthier, H. Khodja, F. Linez, M. Mayer, B. Pasquet, B. Pegourie and I. Roure:* Plasma Wall Interactions in Tokamaks: Understanding Fuel Retention. (17th International Workshop on Inelastic Ion-Surface Collisions (IISC-17), 2008-09-21 to 2008-09-26, Porquerolles).

*Tskhakaya, D., R. A. Pitts, W. Fundamenski, T. Eich, S. Kuhn and JET EFDA Contributors:* Kinetic simulations of the parallel transport in the JET Scrape-of Layer. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Turkin, Y.:* Impact of momentum correction on bootstrap current and ECCD in W7-X. (Theorie Seminar, 2008-11-17 to 2008-11-21, Schloss Ringberg, Tegernsee).

*Turkin, Y., C. Beidler, H. Maaßberg and N. Marushchenko:* Modelling of bootstrap current and ECCD in W7-X using momentum correction techniques. (4th Coordinated Working Group Meeting (CWGM) for Stellarator/Heliotron Studies followed by the Kinetic Theory Workshop (KTW), 2008-10-20 to 2008-10-24, Madrid).

*Tyburska, B., K. Ertl and K. Schmid:* Deuterium retention and diffusion in carbon implanted and self implanted tungsten. (16th International Conference on Ion Beam Modification of Materials (IBMM 08), 2008-08-31 to 2008-09-05, Dresden).

*Tyburska, B., K. Ertl and K. Schmid:* Influence of C pre-implantation and pre-annealing on D inventory in W. (7th International Conference "Ion Implantation and other Applications of Ion and Electrons" (ION 2008), 2008-06-16 to 2008-06-19, Kazimierz Dolny).

*Tyburska, B. and M. Mayer:* Hydrogen isotopes inventory and diffusion in tungsten. (Seminarvortrag, 2008-07-30, Universität der Bundeswehr, Neubiberg).

*Ueda, Y., M. Fukumoto, A. Yamawaki, Y. Ohtsuka, S. Brezinsek, T. Hirai, A. Kirschner, A. Kreter, A. Litnovsky, V. Philipps, A. Pospieszczyk, B. Schweer, G. Sergienko, T. Tanabe, K. Sugiyama, K. Ohya, N. Ohno and TEXTOR Team:* Effects of tungsten surface conditions on carbon deposition. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Ullrich, S., O. Grulke and T. Klinger:* Nichtlineare Kopplung von Drift- und Alfvénwellen. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Unterberg, B., S. S. Abdullaev, J. W. Coenen, K. H. Finken, M. W. Jakubowski, D. Kalupin, M. Y. Kantor, H. R. Koslowski, A. Krämer-Flecken, Y. Liang, M. Lehnen, K. Löwenbrück, U. Sammm, O. Schmitz, G. Sergienko, S. Soldatov, H. Stoschus, M. Z. Tokar, G. W. Spakman, E. Uzgel, G. van Wassenhove, O. Zimmermann, Y. Xu and TEXTOR Team:* The Influence of Resonant Magnetic Perturbations on Edge Transport in Limiter H-mode Plasmas in TEXTOR. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Viebke, H., J. Baldzuhn, D. Gustke, K. Hertel, K. Riße, R. Schroeder, S. Bates, B. Leigh and M. van Leusen:* The Testing of the W7-X Planar Coils and its Reaction to the Manufacturing. (18th Topical Meeting on the Technology of Fusion Energy, 2008-09-28 to 2008-10-02, San Francisco, CA).

*Viebke, H., K. Hertel, J. Baldzuhn, G. Croari, L. Genini, B. Renard and L. Vieillard:* Acceptance tests of W7-X coils. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Vierle, T., B. Streibl, M. Rott, U. Seidel, A. Herrmann, O. Neubauer, W. Suttrop and ASDEX Upgrade Team:* Design and stress analysis of in-vessel saddle coils for MHD control in ASDEX Upgrade. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Vilbrandt, R., M. Schröder and H. Allemann:* Quality assurance measures during thightening of various bolts at Wendelstein 7-X. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Volpe, F.:* Plasma Waves and Heating. (IPP Summer University for Plasma Physics, 2008-09-22 to 2008-09-26, Garching).

*Von Toussaint, U.:* Bayesian Methods in Nuclear Fusion: Integrated Data Analysis and Bayesian Experimental Design. (University of Helsinki, 2008-06-26, Helsinki).

*Von Toussaint, U. and S. Gori:* Fast inversion methods: Bayesian Neural Networks for fast inversion. (5th Workshop on Fusion Data Processing, Validation and Analysis, 2008-01-14 to 2008-01-16, Culham).

*Von Toussaint, U., P. N. Maya and C. Hopf:* Chemical Erosion of Carbon Films: A Molecular Dynamics Study of Synergistic Co-Bombardment Effects. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Von Toussaint, U., T. Schwarz-Selinger and S. Gori:* Optimizing Nuclear Reaction Analysis (NRA) using Bayesian Experimental Design. (28th Maximum Entropy and International Workshop on Bayesian Inference and Maximum Entropy Methods in Science and Engineering (MaxEnt 2008), 2008-07-06 to 2008-07-11, Sao Paulo).

*Wagner, D., T. Franke, F. Leuterer, F. Monaco, M. Münich, H. Schütz, J. Stober, F. Volpe, H. Zohm, M. Thumm, R. Heidinger, A. Meier, G. Gantenbein, J. Flamm, W. Kasparek, C. Lechte, A. G. Litvak, G. G. Denisov, A. Cirkov, L. G. Popov, V. O. Nichiporenko, V. E. Myasnikov, E. M. Tai, E. A. Solyanova and S. A. Malygin:* Multi-frequency ECRH at ASDEX Upgrade. (7th International Workshop "Strong Microwaves: Sources and Applications", 2008-07-27 to 2008-08-02, Nizhny Novgorod).

*Wagner, D., F. Leuterer, J. Stober, A. Manini, F. Monaco, M. Münich, H. Schütz, H. Zohm, T. Franke, M. Thumm, R. Heidinger, A. Meier, G. Gantenbein, J. Flamm, W. Kasparek, A. G. Litvak, A. V. Cirkov, L. G. Popov, V. O. Nichiporenko, V. E. Myasnikov, G. G. Denisov, E. M. Tai, E. A. Solyanova and S. A. Malygin:* Progress with the new multi-frequency ECRH system for ASDEX Upgrade. (35th IEEE International Conference on Plasma Science (ICOPS 2008), 2008-06-15 to 2008-06-19, Karlsruhe).

*Wagner, F.:* Ausblick auf die Energieversorgung von übermorgen. (Technologiezentrum Vorpommern, 2008-02-28, Greifswald).

*Wagner, F.:* Fusion and the physics behind magnetic confinement. (Rutherford Appleton Lecture, 2008-01-31, Rutherford).

*Wagner, F.:* Introduction to High Temperature Plasma Physics Part I. (WS 2007/2008 Vorlesung, Universität Greifswald).

*Wagner, F.:* Sichere Energie und Klimaschutz – ein Widerspruch? (Siemens Wirtschaftsforum, 2008-03-13, Hohen Luckow).

*Waldmann, O. and W. Bohmeyer:* Multi-anode photomultiplier tube as a tool for spatio-temporal measurements in a plasma. (14th International Congress on Plasma Physics (ICPP 2008), 2008-09-08 to 2008-09-12, Fukuoka).

*Waldmann, O. and G. Fußmann:* Einfluß des Sondenschaftes auf die Bestimmung der Plasmaparameter. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Warrier, M., A. Rai and R. Schneider:* A time dependent model to study the effect of surface roughness on reactive-diffusive transport in porous media. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Watkins, J. G., T. E. Evans, I. Joseph, C. J. Lasnier, M. Jakubowski, O. Schmitz, R. A. Moyer, D. L. Rudakov, M. Groth and M. E. Fenstermacher:* Particle, Heat, and Sheath Power Trasnmission Factor Profiles During ELM Suppression Experiments on DIII-D. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Wegener, L. and W7-X Team:* Status of Wendelstein 7-X construction. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Weller, A.:* Operationsgrenzen von Stellaratoren – Chancen für eine attraktive Fusionsenergiequelle? (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Weller, A., K. Y. Watanabe, S. Sakakibara, A. Dinklage, H. Funaba, J. Geiger, J. H. Harris, S. Ohdachi, R. Preuss, Y. Suzuki, A. Werner, H. Yamada, M. C. Zarnstorff, W7-X Team and LHD Experimental Group:* International Stellarator/Heliotron Database Activities on High-Beta Confinement and Operational Boundaries. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Werner, A., M. Endler, J. Geiger and R. König:* W7-X Magnetic Diagnostics: Rogowski Coil Performance for very long pulses. (17th Topical Conference on High-Temperature Plasma Diagnostics, 2008-05-11 to 2008-05-15, Albuquerque, NM).

*Werner, A. and J. Svensson:* The service oriented fusion initiative and its future application to Wendelstein 7-X. (5th Workshop on Fusion Data Processing, Validation and Analysis, 2008-01-14 to 2008-01-16, Culham).

*Wiegmann, C., J. Geiger, Y. Suzuki, D. Reiter and R. Wolf:* 3D Equilibrium Calculations of TEXTOR like discharges with resonant magnetic perturbations. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Windisch, T., O. Grulke and T. Klinger:* Dekorrelation turbulenter Strukturen durch Scherströmungen. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Windisch, T., O. Grulke and T. Klinger:* Experimental investigations of decorrelation of turbulent structures by a radial velocity shear. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Wischmeier, M.:* Experimental results and modelling of ASDEX Upgrade partial detachment. (ITPA Meeting, 2008-01-07 to 2008-01-09, Madrid).

*Wischmeier, M., M. Groth, A. Kallenbach, A. V. Chankin, D. Coster, R. Dux, T. Eich, A. Herrmann, H. W. Müller, R. Pugno, D. Reiter, A. Scarabosio, J. G. Watkins and DIIID Team and ASDEX Upgrade Team:* Current understanding of divertor detachment: experiments and modelling. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Wolf, R. C.:* Nuclear Fusion – Hope for the Future or Costly Illusion? (5th International Summer Academy "Energy and the Environment", 2008-07-31, Greifswald).

*Wolf, R. C.:* Status des Projekts W7-X. (Kolloquium der Programmleitung Kernfusion, 2008-10-02, Karlsruhe).

*Wolf, R. C.:* Stellarator: Another Fusion Reactor. (13th European School "Low Temperature Plasma Physics: Basics and Applications" and the Master Class, 2008-10-10, Bad Honnef).

*Wolf, R. C.:* Wendelstein 7-X. (SEI-Herbsttagung (Studiengruppe für Elektronische Instrumentierung), 2008-09-22, Greifswald).

*Wolf, R. C.:* From Wendelstein 7-X to a Stellarator Reactor. (18th International Toki Conference (ITC18), 2008-12-09 to 2008-12-12, Ceratopia Toki, Toki Gifu).

*Wolfrum, E., R. Fischer, B. Langer, T. Pütterich, G. D. Conway, D. P. Coster, R. Dux, J. C. Fuchs, M. Gemisic Adamov, N. Hicks, L. D. Horton, C. Konz, B. Kurzan, K. Lackner, C. F. Maggi, P. J. McCarthy, M. Reich, J. Schweinzer, W. Suttrop, C. Tröster and ASDEX Upgrade Team:* Pedestal Studies at ASDEX Upgrade. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Wolfrum, E. and S. Schweinzer:* Grundlagen des Fusionsreaktors. (WS 2007/2008. Vorlesung, Universität Wien).

*Wolfrum, E., J. Schweinzer, D. Bridi, K. Igenbergs, J. Kamleitner, F. Aumayr and ASDEX Upgrade Team:* A sodium (Na) beam edge diagnostic. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Wolter, M., T. Schwarz-Selinger, W. Jacob and H. Kersten:* Energieeintrag durch Neutralteilchen in einem ECR Plasma. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Worbs, P., M. Grattarola, H. Maier and H. Bolt:* Wetting and fracture characteristics of TiCx coated C/Cu braze joints. (1st International Conference on New Materials for Extreme Environments (ExtreMat), 2008-06-02 to 2008-06-06, San Sebastian).

*Worbs, P., F. Koch, A. Herrmann, J. H. You and R. Piechoczek:* Measurement and control of internal stress of magnetron sputtered tungsten coatings. (11th International Conference on Plasma Surface Engineering (PSE 2008), 2008-09-15 to 2008-09-19, Garmisch-Partenkirchen).

*Wright, G. M., E. Alves, L. C. Alves, N. P. Barradas, M. Mayer, G. J. van Rooij, J. Westerhout, R. S. Al, M. J. von de Pol, H. J. van der Meiden, J. Rapp, N. J. Lopes Cardozo and A. W. Kleyn:* Hydrogenic retention of high-Z refractory metals exposed to ITER divertor relevant plasma conditions. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Wünderlich, D., U. Fantz and NNBI-Team:* Particle-in-Cell-Modell für Langmuirsondenmessungen in HF-Quellen zur Produktion negativer Wasserstoffionen. (DPG AMOP-Frühjahrstagung, 2008-03-10 to 2008-03-14, Darmstadt).

*Xanthopoulos, P.:* Verification and application of magnetic coordinate systems in gyrokinetics. (Theorie Seminar, 2008-11-17 to 2008-11-21, Schloss Ringberg, Tegernsee).

*Xu, Y., R. R. Weynants, M. Van Schoor, M. Vergote, S. Jachmich, M. W. Jakubowski, M. Mitri, D. Reiser, O. Schmitz, K. H. Finken, M. Lehnen, B. Unterberg, D. Reiter, U. Samm and TEXTOR Team:* Suppression of the Intermittent Blob-type Transport by the Resonant Magnetic Perturbation (RMP) in the TEXTOR Tokamak. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Yakovenko, Y. V., Y. I. Kolesnichenko, V. V. Lutsenko, A. Weller and A. Werner:* Effect of the toroidal asymmetry on the structure of TAE modes in stellarators. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Yakovenko, Y. V., Y. I. Kolesnichenko, V. V. Lutsenko, A. Weller, A. Werner and H. Thomsen:* Effect of the toroidal asymmetry of stellarator configurations on the structure of TAE modes. (International Conference and School on Plasma Physics and Controlled Fusion and 3rd Alushta International Workshop on the Role of Electric Fields in Plasma Confinement in Stellarators and Tokamaks, 2008-09-22 to 2008-09-27, Alushta).

*Ye, M., M. Hirsch, R. König, M. Laux, H. Thomsen, A. Weller and A. Werner:* Thermo-mechanical analysis of in-vessel diagnostic components in the Wendelstein 7-X stellarator. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*You, J. H.:* Failure risk assessment of a fusion reactor component with a tungsten-wire-reinforced copper matrix composite heat sink. (Fachbeirat, 2008-06-19, Garching).

*You, J. H.:* Failure risk assessment of a fusion reactor component with a tungsten-wire-reinforced copper matrix composite heat sink. (1st International Conference on New Materials for Extreme Environments (ExtreMat), 2008-06-02 to 2008-06-04, San Sebastian).

*Yu, Q.:* Interaction between resonant magnetic perturbations and plasma. (13th MHD Stability Control Workshop, 2008-11-23 to 2008-11-25, Austin, TX).

*Zagorski, R., G. Telesca, G. Arnoux, M. Beurskens, W. Fundamenski, C. Giroud, S. Glowacz, S. Jachmich, K. McCormick and JET EFDA Contributors:* Self-Consistent Modeling of Impurity Seeded JET Advanced Tokamak Scenarios. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Zammuto, I., A. Krivska, V. Bobkov, F. Braun, R. Bilato, J.-M. Noterdaeme and ASDEX Upgrade Team:* ICRF antennas optimized for operation with a metallic wall in ASDEX Upgrade. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Zauner, C., H. Langer, D. Hathiramani, J. Lingertat, P. van Eeten, V. Bykov, F. Schauer, B. Heinemann and P. Junghanns:* Acoustic monitoring of superconducting magnet component test and shock simulation of coils. (25th Symposium on Fusion Technology (SOFT 2008), 2008-09-15 to 2008-09-19, Rostock).

*Zha, X., F. Sardei, Y. Feng, M. Kobayashi, A. Loarte and G. Federici:* 3D analysis of impurity transport and radiation for ITER limiter start-up configurations. (18th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 18), 2008-05-26 to 2008-05-30, Toledo).

*Zohm, H.:* From ASDEX Upgrade to ITER – Preparing the next step in fusion research. (Kolloquium, 2008-01-25, Madison, WI).

*Zohm, H.:* ECRH and ECCD in next generation fusion devices. (15th Joint Workshop on Electron Cyclotron Emission and Electron Cyclotron Resonance Heating (EC-15), 2008-03-09 to 2008-03-13, Yosemite National Park, CA).

*Zohm, H.:* ECRH and ECCD in next generation fusion devices. (20th Russian German Workshop on ECRH and Gyrotrons, 2008-07-26, Nizhny Novgorod).

*Zohm, H.:* First Wall Materials in Nuclear Fusion Research. (UCSB-MPG Workshop on Inorganic Materials for Energy Conversion, Storage and Conservation, 2008-02-22, Lake Arrowhead, CA).

*Zohm, H.:* Standard and Advanced Tokamak Operation Scenarios for ITER. (Hungarian Plasma Physics and Fusion Technology Workshop, 2008-03-26 to 2008-03-28, Györ).

*Zohm, H.:* The W-Programme in ASDEX Upgrade: a Plasma Physicist's View. (Seminar, 2008-01-22, Princeton Plasma Physics Laboratory, NJ).

*Zohm, H. and ASDEX Upgrade Team:* Overview of ASDEX Upgrade results. (22nd IAEA Fusion Energy Conference, 2008-10-13 to 2008-10-18, Geneva).

*Zohm, H. and J. Stober:* Plasmaphysik I. (SS 2008. Vorlesung, Technische Universität München).

# Teams

## ASDEX Upgrade Team

J. Adamek*, C. Angioni, G. Antar*, C. V. Atanasiu*, M. Balden, W. Becker, K. Behler, K. Behringer, A. Bergmann, R. Bilato, V. Bobkov, J. Boom, A. Bottino, M. Brambilla, F. Braun, M. Brüdgam, A. Buhler, A. Chankin, I. Classen, G. Conway, D. P. Coster, P. de Marné, R. D'Inca, R. Drube, R. Dux, T. Eich, K. Engelhardt, B. Esposito*, H.-U. Fahrbach, L. Fattorini*, J. Fink, R. Fischer, A. Flaws, C. Forest*, J. C. Fuchs, K. Gál*, M. García Muñoz, M. Gemisic Adamov, L. Gianonne, T. Görler, S. Gori, S. da Graca*, G. Granucci*, H. Greuner, O. Gruber, A. Gude, S. Günter, G. Haas, T. Hauff, B. Heinemann, A. Herrmann, N. Hicks, J. Hobirk, H. Höhnle*, M. Hölzl, D. Holtum, C. Hopf, L. Horton, M. Huart, V. Igochine, C. Ionita*, S. Jämsä*, M. Janzer, F. Jenko, A. Kallenbach, S. Kálvin*, O. Kardaun, M. Kaufmann, M. Kick, A Kirk*, H.-J. Klingshirn, G. Kocsis*, H. Kollotzek, C. Konz, K. Krieger, T. Kurki-Suonio*, B. Kurzan, K. Lackner, P. T. Lang, B. Langer, P. Lauber, M. Laux, F. Leipold*, F. Leuterer, J. Likonen*, L. Liu, A. Lohs, T. Lunt, A. Lyssoivan*, C. Maggi, K. Mank, M.-E. Manso*, M. Mantsinen*, M. Maraschek, P. Martin*, M. Mayer, P. McCarthy*, K. McCormick, H. Meister, F. Meo*, P. Merkel, R. Merkel, V. Mertens, F. Merz, H. Meyer*, A. Mlynek, F. Monaco, H. W. Müller, M. Münich, H. Murmann, G. Neu, R. Neu, J. Neuhauser, B. Nold*, J.-M. Noterdaeme, G. Pautasso, G. Pereverzev, E. Poli, M. J. Püschel, T. Pütterich, R. Pugno, G. Raupp, M. Reich, B. Reiter, T. Ribeiro*, R. Riedl, V. Rohde, J. Roth, M. Rott, F. Ryter, W. Sandmann, J. Santos*, K. Sassenberg, A. Scarabosio, G. Schall, A. Schmid, K. Schmid, W. Schneider, G. Schramm, R. Schrittwieser*, J. Schweinzer, B. Scott, U. Seidel, M. Sempf, F. Serra*, M. Sertoli, M. Siccinio, A. Sigalov, A. Silva*, A. C. C. Sips, E. Speth, A. Stäbler, K.-H. Steuer, J. Stober, B. Streibl, E. Strumberger, W. Suttrop, G. Tardini, C. Tichmann, W. Treutterer, C. Tröster, L. Urso, P. Varela*, F. Volpe, D. Wagner, V. Weinzettl*, C. Wigger, M. Wischmeier, E. Wolfrum, E. Würsching, D. Yadikin, Q. Yu, D. Zasche, T. Zehetbauer, M. Zilker, H. Zohm.

## ECRH-Team

A. Arnold, K. Baumann, B. Berndt, P. Brand, H. Braune, G. Dammertz, V. Erckmann, J. Flamm, G. Gantenbein, R. Heidinger, H. Höhnle, F. Hollmann, M. Huber, H. Hunger, S. Illy, J. Jin, L. Jonitz, W. Kasparek, S. Kern, M. Krämer, H. Kumric, M. Kupper, R. Lang, H. P. Laqua, C. Lechte, W. Leonhardt, D. Mellein, G. Michel, S. Miksch, F. Müller, R. Munk, F. Noke, B. Piosczyk, B. Plaum, S. Prets, O. Prinz, F. Purps, T. Rzesnicki, P. Salzmann, A. Samartzev, K.-H. Schlüter, M. Schmid, T. Schulz, W. Spiess, U. Stroth, J. Szczesny, M. Thumm, P. Uhren, J. Weggen, M. Weissgerber, D. Wimmer.

## ICRF-Team

S. Assas, W. Becker, V. Bobkov, F. Braun, R. D'Incà, B. Eckert, M. El Khaldi**, R. Euteneier, H. Faugel, F. Fischer, C. Hamlyn-Harris**, A. Krivska**, L. Liu, J.-M. Noterdaeme, A. Onyshchenko*, M. Prechtl**, G. Siegl, H. Wehling, E. Würsching, I. Zammuto**.

## NBI-Team

M. Berger, S. Christ-Koch, H. Falter, U. Fantz, P. Franzen, M. Fröschle, R. Gutser, B. Heinemann, D. Holtum, C. Hopf, T. Jiang*, R. Kairys, M. Kick, W. Kraus, C. Martens, P. McNeely, R. Nocentini, S. Obermayer, R. Riedl, P. Rong, N. Rust, J. Schäffler, R. Schroeder, J. Sielanko*, E. Speth, A. Stäbler, P. Turba, D. Wünderlich.

## NNBI-Team

M. Berger, S. Christ-Koch, H. Falter, U. Fantz, P. Franzen, M. Fröschle, R. Gutser, B. Heinemann, D. Holtum, T. Jiang*, W. Kraus, C. Martens, P. McNeely, R. Nocentini, S. Obermayer, R. Riedl, E. Speth, P. Turba, D. Wünderlich.

## W7-X Team

G. Adam, J. Ahmels, T. Andreeva, M. Balden, K. Bald-Soliman, J. Baldzuhn, M. Banduch, H. Bau, Ch. Baylard*, W. Becker, M. Bednarek, K. Behler, D. Beiersdorf, A. Benndorf, A. Berg, N. Berger, A. Bergmann, Th. Bergmann, P. Biedunkiewicz, R. Binder, D. Birus, T. Bluhm, R. Blumenthal, J. Boscary, H.-S. Bosch, B. Böswirth, A. Braatz, R. Brakel, H.-J. Bramow, T. Bräuer, M. Braun, H. Braune, T. Broszat, B. Brucker, R. Brüderl, C. Brun*, R. Burhenn, V. Bykov, C. Caldwell-Nichols*, J. Cantarini*, A. Cardella, D. Chauvin*, P. Chen, W. Chen, P. G. Croari*, P. Czarkowski*, M. Czerwinski, W. Dänner*, J. Dedic, C. Dhard, A. Dinklage, A. Domscheidt, H. Dreier, A. Dübner, A. Dudek, H. Dutz, B. Eckert, P. v. Eeten, K. Egorov, G. Ehrke, H. Eixenberger, M. Endler, V. Erckmann, H. Faugel, W. Fay, J.-H. Feist, J. Fellinger, St. Freundt, A. Friedrich, F. Fischer, N. Fuchs, F. Füllenbach, K. Gallowski, L. Giannone, G. Gliege, S. Gojdka, M. Gottschewsky, H. Greuner, H. Greve, S. Gross, H. Grote, D. Grünberg, H. Grunwald, D. Gustke, M. Haas, M. Hagen, E. Hahnke, N. Hajnal, K.-H. Hanausch, A. Hansen, H.-J. Hartfuß*, T. Härtl, D. Hartmann, D. Hathiramani, D. Haus, P. Heimann, B. Hein, B. Heinemann, S. Heinrich, K. Henkelmann, C. Hennig, U. Herbst, D. Hermann, R. Herrmann, F. Herold, K. Hertel, D. Hildebrandt, M. Hirsch, A. Hölting, D. Holtum, A. Holtz, R. Holzthüm, M. Huart, A. Hübschmann, M. Ihrke, N. Jaksic, M. Jakubowski, D. Jassmann, H. Jenzsch, A. John, L. Jonitz, S. Jung, A. Junge, J. Kallmeyer, U. Kamionka, M. Kammerloher, M. Kick, J. Kißlinger, T. Kluck, C. Klug,

M. Kluger, J. Knauer, F. Koch, S. König, R. König, T. Koppe, M. Köppen, P. Kornejev, R. Krampitz, R. Krause, U. Krybus, M.Krychowiak, H. Kroiss, G. Kühner, F. Kunkel, B. Kursinski, B. Kurzan, A. Kus, H. Laqua, H. P. Laqua, R. Laube, M. Laux, H. Lentz, M. Lewerentz, G. Lex, C. Li, L. Liu, S. Lindig, J. Lingertat*, A. Lorenz, J. Maier, C. Martens, M. Marquardt, G. Matern, C. Martens, P. McNeely, B. Mendelevitch, G. Michel, B. Missal, H. Modrow, St. Mohr, T. Mönnich, A. Müller, E. Müller, I. Müller, J. Müller, K. Müller, S. Müller, H. Murmann, M. Nagel, D. Naujoks, G. Neu, U. Neumann, U. Neuner, U. Nielsen*, M. Nitz, F. Noke, J. M. Noterdaeme, S. Obermayer, A. Okkenga-Wolf, U. Ortner, E. Pasch, A. Peacock, B. Petersen-Zarling, B. Petzold, K. Pfefferle, M. Pietsch, D. Pilopp, S. Pingel, H. Pirsch, R. Pollner, B. Prieß, F. Purps, D. Rademann, T. Rajna *, G. Raupp, L. Reinke, S. Renard*, T. Richert, R. Riedl, H. Riemann, K. Riße, V. Rohde, M. Rott, K. Rummel, Th. Rummel, N. Rust, N. Rüter, F. Sabathier*, J. Sachtleben, A. Scarabosio, J. Schacht, F. Schauer, F. Scherwenke, D. Schinkel, R.-C. Schmidt, M. Schneider, W. Schneider, P. Scholz, M. Schrader, M. Schröder, R. Schroeder, U. Schultz, A. Schütz, E. Schwarzkopf, V. Schwuchow, Ch. von Sehren, K.-U. Seidler, G. Siegl, J. Simon-Weidner, B. Sitkowski, M. Smirnov, L. Sonnerup*, E. Speth, A. Spring, A. Stäbler, R. Stadler, F. Starke, M. Steffen, M. Stöcker, R. Stephan, B. Streibl, A. Tereshchenko, D. Theuerkauf, S. Thiel, H. Thomsen, H. Tittes, R. Tivey, W. Treutterer, P. Turba, P. Uhren, S. Valet, A. Vetterlein, H. Viebke, R. Vilbrandt, O. Volzke, S. Vorbrugg, A. Vorköper, S. Weber, L. Wegener, M. Weissgerber, A. Weller, J. Wendorf, U. Wenzel, A. Werner, K.-D. Wiegand, M. Winkler, R. Wolf, A. Wölk, E. Würsching, M. Ye, D. Zacharias, G. Zangl, F. Zeus, D. Zhang, M. Zilker, K. Zimmermann.

## W7-X NI-Staff

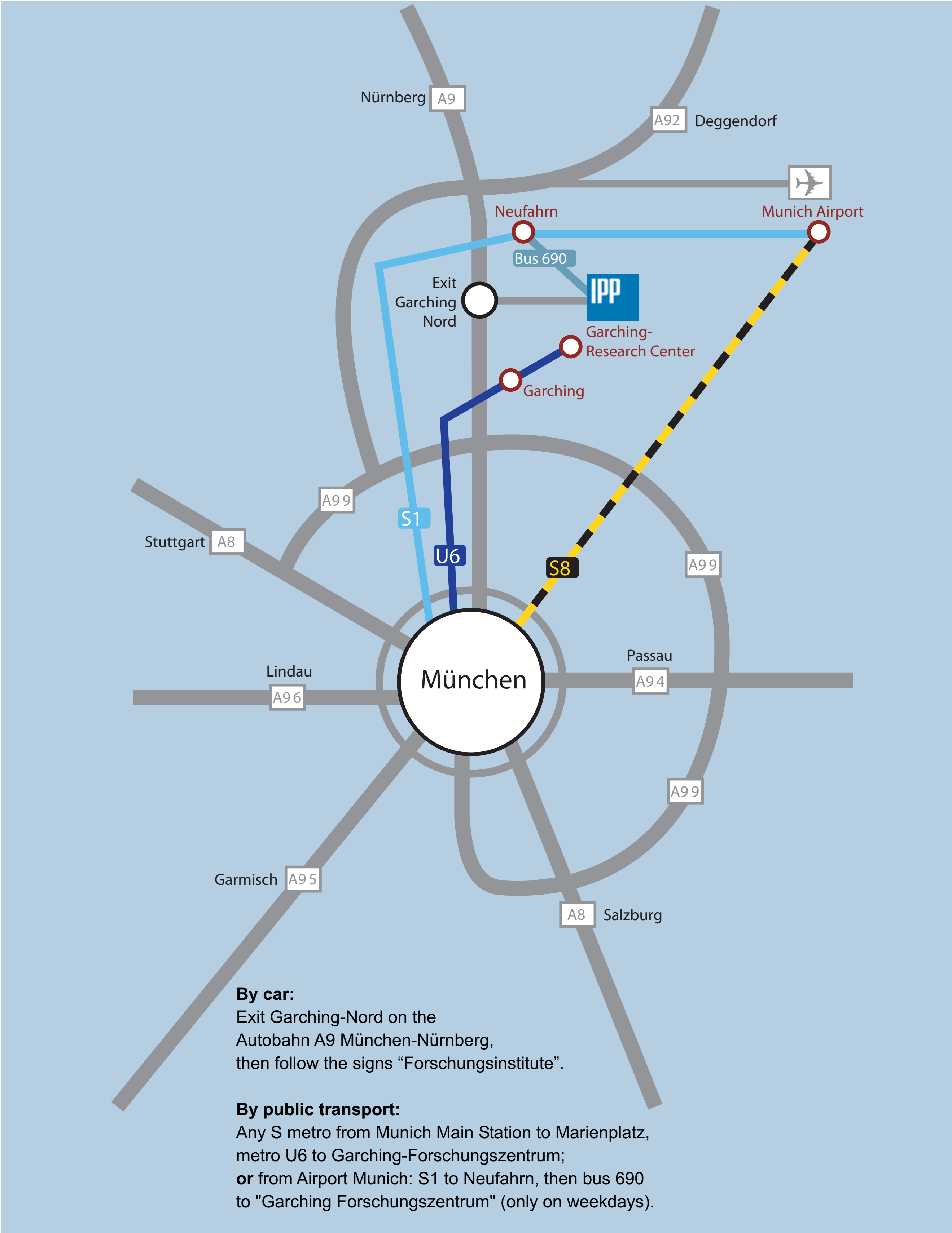
B. Heinemann, D. Holtum, R. Kairys, M. Kick, P. McNeely, R. Riedl, P. Rong, N. Rust, R. Schroeder, J. Sielanko*, E. Speth, A. Stäbler.

* *external authors*

** *EnTicE-Trainees*

# Appendix

# How to reach IPP in Garching




**By car:**
Exit Garching-Nord on the
Autobahn A9 München-Nürnberg,
then follow the signs “Forschungsinstitute”.

**By public transport:**
Any S metro from Munich Main Station to Marienplatz,
metro U6 to Garching-Forschungszentrum;
**or** from Airport Munich: S1 to Neufahrn, then bus 690
to "Garching Forschungszentrum" (only on weekdays).

# How to reach Greifswald Branch Institute of IPP


**By air and train:**
Via Berlin: from Berlin Tegel Airport by bus "JetExpressBus" to Hauptbahnhof (central station), by train to Greifswald.
Via Hamburg: from the airport to main Railway Station, by train to Greifswald main station.

**By bus:**
From Greifswald-Railway Station by bus No. 1 to the "Südbahnhof", then change to bus No. 5 to the "Elisenpark" stop.

**By car:**
Via Berlin, Neubrandenburg to Greifswald **or** via Hamburg, Lübeck, Stralsund to Greifswald, in Greifswald follow the signs "Max-Planck-Institut".

# IPP in Figures

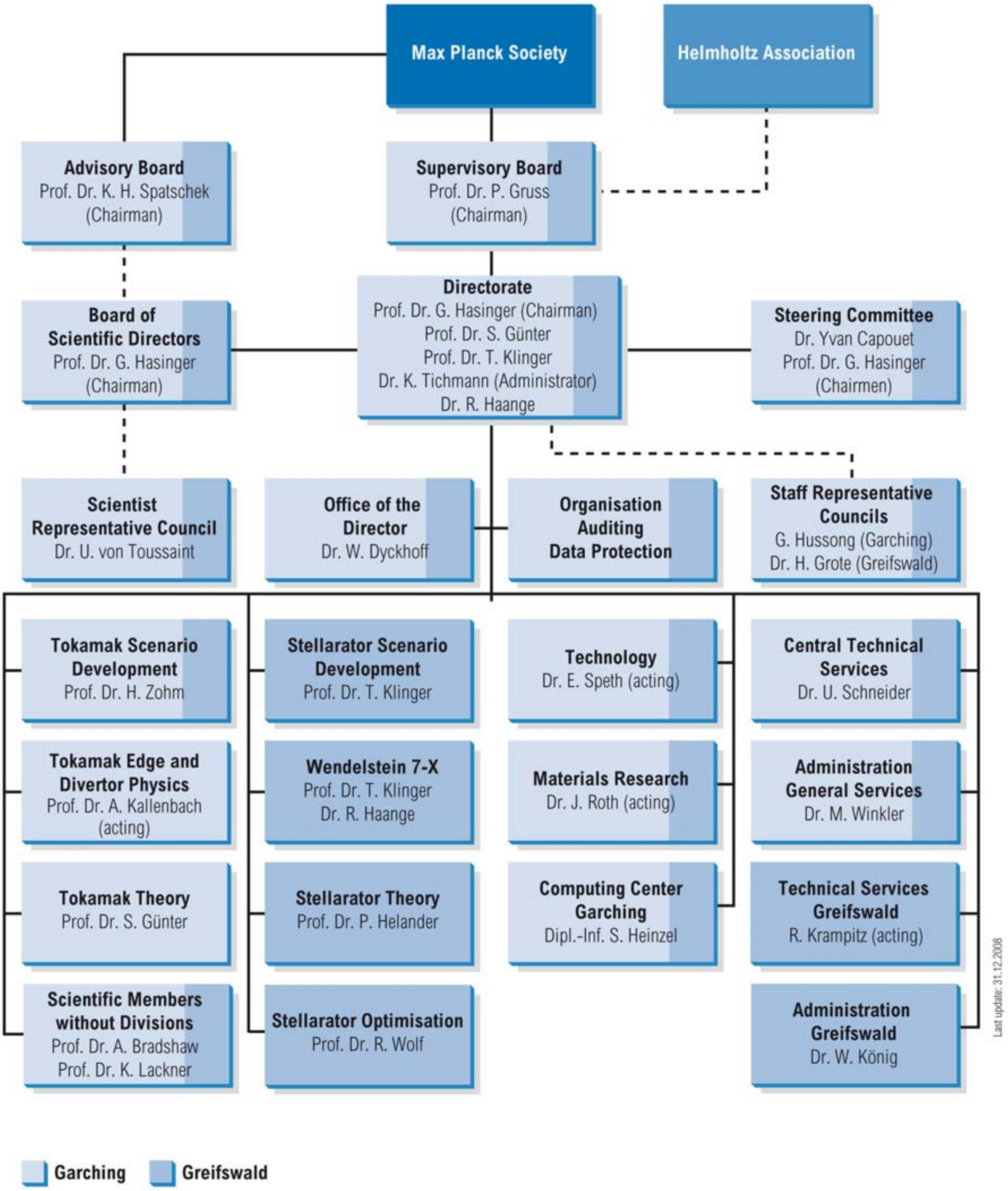
## Funding

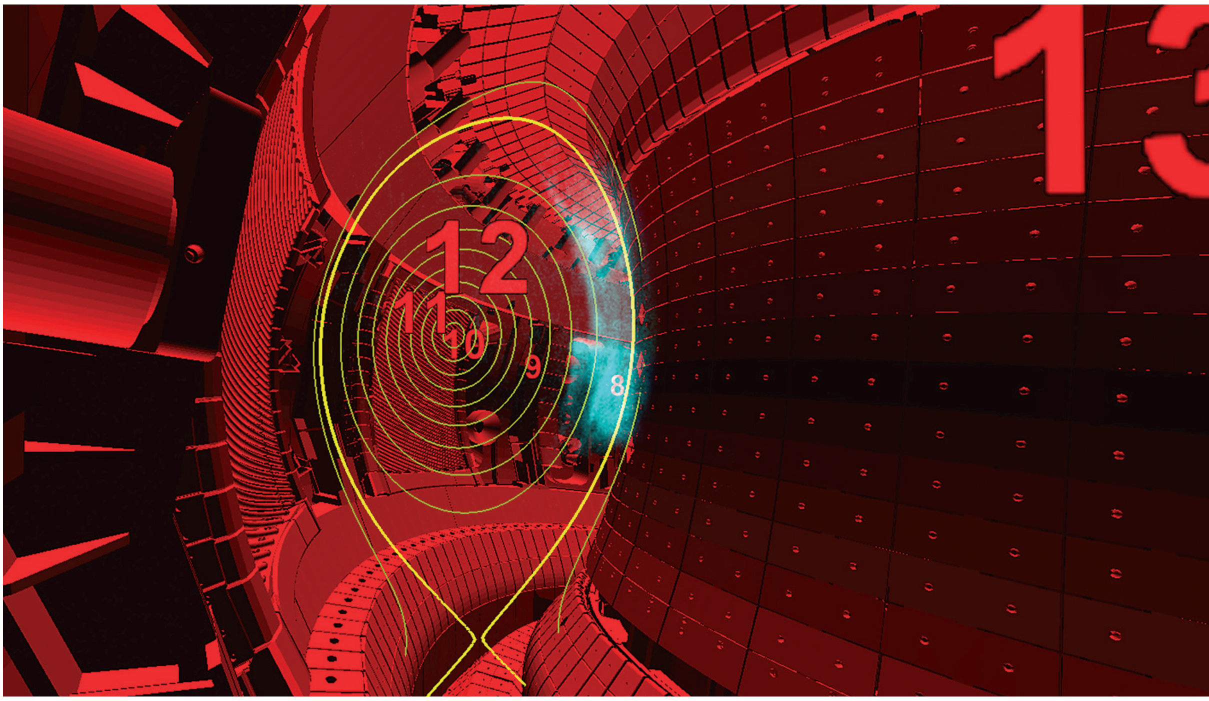
IPP is funded 62 % by the German federal government, 17 % by the European Union and 7 % by the state governments of Bavaria and Mecklenburg-Western Pomerania. The income from these sources and own proceeds in 2008 amounted to approx. 140 million Euro.

## Scientific Staff

At the end of the year total staff was 1156 employees, 450 of which worked at IPP's Greifswald site. The workforce comprised 283 researchers and scientists, 43 postgraduates and 31 postdocs. In addition 43 guest researchers used the research infrastructure.

## Organisational Structure






# Imprint

**Annual Report 2008**
Max-Planck-Institut für Plasmaphysik (IPP)
Boltzmannstraße 2, 85748 Garching bei München
phone (0 89) 32 99-01, fax (0 89) 32 99-22 00
http://www.ipp.mpg.de

**Editorial Team**
Julia Sieber
Andrea Henze

**Further Information**
This work was performed under the terms of the agreement between Max-Planck-Institut für Plasmaphysik (IPP) and the European Atomic Energy Community (EURATOM) to conduct joint research in the field of plasma physics.



**Printing**
Druckerei Behr, Scheyern-Fernhag

Printed in Germany
ISSN 0179-9347

Max-Planck-Institut
für Plasmaphysik