ASDEX Upgrade Letter

No. 9/April 2007

Foreword

With this Letter, we would like to take the opportunity to announce some important changes in the ASDEX Upgrade management structure, connected to the change of Department Head of the Experimental Plasma Physics Division 1, now also known as the 'Tokamak Scenario Development' Division. We have also rearranged the underlying group structure for line management. What has not been changed is our scientific structure of task forces which co-ordinate the programme and prepare, together with the project leader, the experimental campaigns.

At this point, I would like to express my sincerest thanks to Prof. Michael Kaufmann who will retire this summer. Under his leadership, ASDEX Upgrade has become what it is today, a successful fusion research facility of the highest standing in the international community. Due to his initiative, it has also become a project to which the EU Associations actively contribute.

The 2007 experimental campaign is about to start and we are all excited about the possibility to explore the behaviour of a machine with a fully tungsten-covered first wall. Despite last year's failure of one of three flywheel generators, we will be ready to document this important step towards the only wall material that seems presently acceptable for DEMO. In 2008, we plan to have the generator back in operation and explore the full range of long pulse, high power operation with the all-tungsten wall.

I wish you all, internal and external, a successful 2007 experimental campaign and look forward to the important results that will no doubt emerge from this new territory.

H. Zohm

Fig. 1: Damaged flywheel generator EZ4

The 2007 experimental campaign

On Thursday, 27th April 2006, an incident with the flywheel generator EZ4 led to serious damage of the generator and finally caused the cancellation of the 2006 campaign. EZ4 is one of three generators used on ASDEX Upgrade (AUG) to supply the ohmic transformer as well as poloidal field coils and additional heating systems. The cause of the malfunction has been clarified and the incident with EZ4 has given rise to a check of the safety concepts of all three generators. As a direct consequence of this check an improved brake for generator EZ2 which supplies all TF coils was built.

The repair of the generator EZ4 has been started, but will not be completed before summer 2008. Therefore, the operation of AUG in 2007 will rely on the two remaining generators, EZ2 and EZ3. All heating systems and poloidal field coils can be supplied by EZ3. This has been achieved by optimizing the thyristor configuration and especially by reducing the secondary voltage for the different poloidal field coil circuits. The new configuration was successfully tested in July 2006 and AUG will be able to operate in 2007 within a reduced operational window. For a plasma current of 1 MA a flattop length of 4s with up to 7,5 MW additional heating will be feasible. This will permit the study of tungsten compatibility of ITER-relevant scenarios without major restrictions. However, there will be restrictions for plasma shape and for operation at high densities or high plasma pressure. The 2007 planning foresees operation from April to July, a one-month break for maintenance in August, resumed operation in September to October and a short shutdown at the end of the year to improve the EZ3 break.

In the concluded 2006 shutdown the target plates of the lower divertor were completely covered with tungsten. Careful cleaning of all other tiles was performed to remove carbon and boron layers from their surfaces. In April 2007 the restart of AUG as a carbon-free machine will be attempted without boronization. Operation until June will be dominated by experiments which aim to assess the behaviour of the full tungsten machine without any low Z-radiators. After that, the experience gained from operating such a machine will build the basis for the planning of the remaining 2007 experimental campaign. At that time a decision also has to be made if a phase with frequent boronisations should be allowed. Only in such a phase will experiments at low collisionality, in particular improved H-mode studies, be possible.

Even under these difficult conditions, the involvement of European Associations in the AUG programme has been maintained at the high level of previous years. Altogether 80 scientists – 39 of them non-IPP scientists – responded to the call for participation in the 2007 AUG campaign.

Fig. 2: Wide-angle view of the AUG inner wall with tungsten coated tiles.

Highlight
from a recent ASDEX Upgrade experiment

Optimised stabilization of NTMs with modulated ECCD

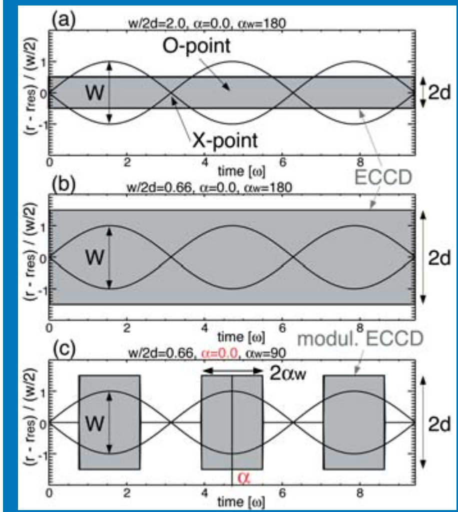


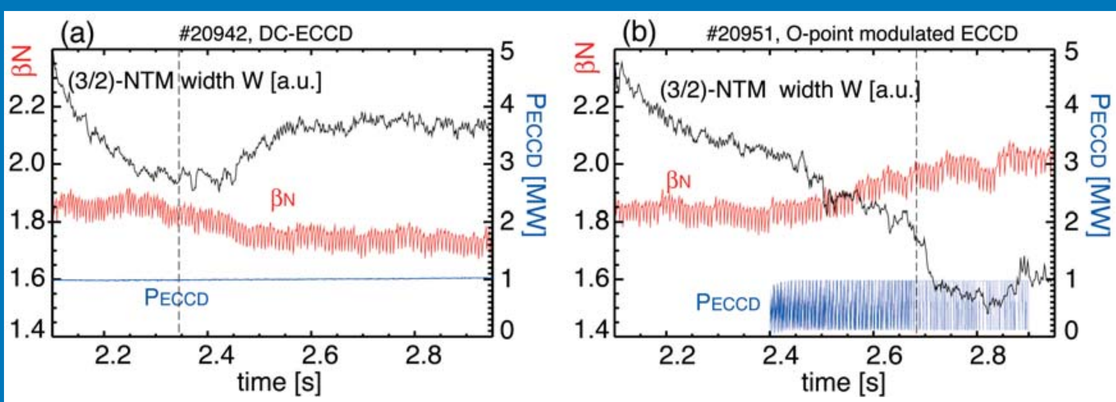
Fig. 3: Sketch of the different deposition patterns of ECCD for NTM stabilization.

Neoclassical tearing modes (NTMs) are driven by a lack of bootstrap current within the island, which can be replaced by localised externally driven current. NTMs are a major concern for ITER or any tokamak reactor, since they spoil confinement and may cause disruptions. ASDEX Upgrade has pioneered the field of NTM stabilisation and has shown the possibility to stabilise (3/2) and (2/1)- NTMs with radially very localised Electron Cyclotron Current Drive (ECCD). Figure 3 shows the distributions of the local EC current drive within an NTM. The X-axis represents the time lag of a complete rotation of the mode, the Y-axis the minor radius centred around the island position r_{res} and normalised to the island width W $((r_{res})/(W/2))$ together with the deposition width 2d of the ECCD (grey shaded area). Present experiments (fig. 3a) have a narrow deposition d smaller than the island width (2d < W), so that for optimal deposition ($r_{deposition} = r_{res}$) almost the entire current is driven within the islands O-point for constant ECCD. Thereby, complete stabilization of the NTM can be achieved with a moderate amount of power.

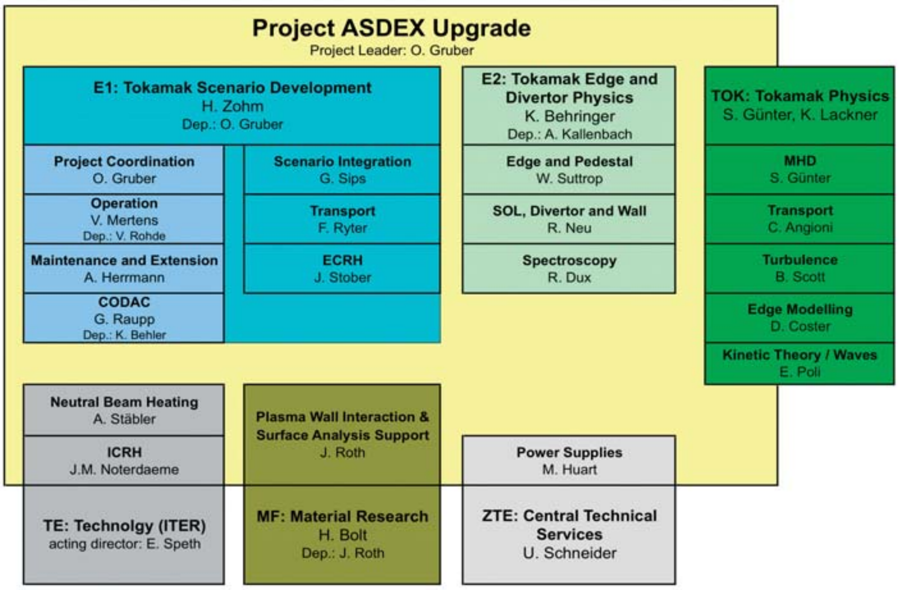
In ITER the ECCD deposition width d will be larger and the island width will become smaller due to the dependence on local plasma parameters in a hotter plasma. This leads to a broader deposition compared to the island width (2d > W) (fig. 3b). In this situation, a large fraction of current would be driven outside the islands O-point which is not only lost for the stabilization, but is also destabilizing for the island and a larger amount of ECCD power would be required. To compensate the reduced efficiency, ECCD modulation is predicted to recover this loss. In order to deposit ECCD power only in the O-point, the phase of the ECCD deposition has to be feedback controlled by the phase of the island (fig. 3c). On ASDEX Upgrade it has been shown for the first time that with such a feedback controlled modulation the stabilization capability could be recovered for broad ECCD deposition. In identical discharges the mode could not be stabilised with broad deposition (fig. 4a), but could be fully stabilised with modulated ECCD with the same peak power of 1MW in the O-point (fig. 4b) and β_N significantly recovers.

For ITER, these and previous results define two major requirements for the launcher system. The deposition has to be as narrow as technically possible and a fast feedback controlled modulation capability in the expected frequency range of NTMs should be foreseen. This improved efficiency may also relax the power requirements for the ITER ECCD system.

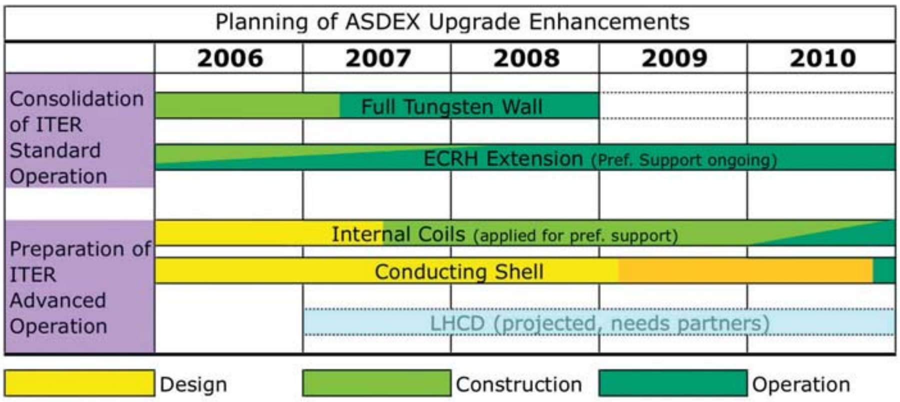
Fig. 4: Unmodulated (a) versus modulated ECCD with broad deposition (b) NTM stabilization. The mode amplitude from magnetics, β_N and the applied ECCD power are shown in black, red and blue, respectively.



New project structure of ASDEX Upgrade and planning of enhancements



In 2004 the Max-Plank-Gesellschaft set up a commission („Zukunftskommission“) on the future development of IPP with the aim of devising a plan for the scientific and organisational development of the institute. The commission recommended to have six departments in Garching, three tokamak-oriented experimental departments (two for AUG and one for ITER), two theory departments and one for plasma-wall interaction. The fact that two department heads, Prof. K. Behringer and Prof. M. Kaufmann will retire in 2007 was taken as an opportunity to rearrange the structure according to the recommendation of the „Zukunftskommission“. Thus, since January 2007 two departments, ‚Scenario Development‘ and ‚Edge & Divertor Physics‘ are the two main experimental units pursuing the AUG project. The overview shows not only their substructure, but also all other departments which contribute to the AUG project with some of their activities.



In order to achieve AUG’s programmatic goals and to maintain a leading position parallel to the ITER construction and the first operation phase, it will be necessary to continuously upgrade the device. The planning comprises, besides the present extension of the ECRF system, internal, active coils for MHD, ELM and rotation control, LHCD for current profile control, and a passive, conducting shell for wall stabilization. Considering the limited resources, however, the last three enhancements of AUG, in particular an LHCD system, will only be possible if other EU Associations take substantial responsibility for design, construction and operation. For the internal coil project, partnerships have been agreed with Consorzio RFX, Padova, the Swedish Associate VR and FZ Jülich. An application for preferential support was recently endorsed by STAC.

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