ASDEX Upgrade Letter

No. 1/March 2002

Foreword

For a very good reason the Max Planck Institute for Plasma Physics (IPP) is actively encouraging the more intensive use of its tokamak experiment ASDEX Upgrade by the other European fusion research centres (or „Associations"). The chances for ITER have improved dramatically in the last eighteen months: the Canadian site offer, French and Spanish proposals to provide a European site, the start of negotiations on the legal entity and the re-awakening of American interest. Our attention now turns necessarily to the European fusion programme which must be rationalised and restructured in preparation for ITER construction. Resources, in particular funding, in the Associations will become scarcer.

A plausible scenario can be envisaged in which only very few fusion experiments remain in the Associations but there are exploited on a fully European basis. ASDEX Upgrade with its ITER-relevant geometry as well as its state-of-the-art plasma heating and diagnostics can play an important role. A necessary pre-requisite, however, is that other Associations are formally involved in the decision-making processes, in particular on the scientific programme and its execution. This epitomises the philosophy of the European fusion programme. We recall a conclusion from its last major external evaluation („Airaghi Panel"): „The fusion programme is probably the best example of European Added Value. The good co-ordination and co-operation between the Community and national research programmes has enabled far greater achievements to be made than would be possible at a national level."

In future, IPP will be informing the whole ASDEX Upgrade community about recent developments and latest results with the help of a regular Newsletter.

A. M. Bradshaw

ASDEX UPGRADE on the way to a European Fusion Facility

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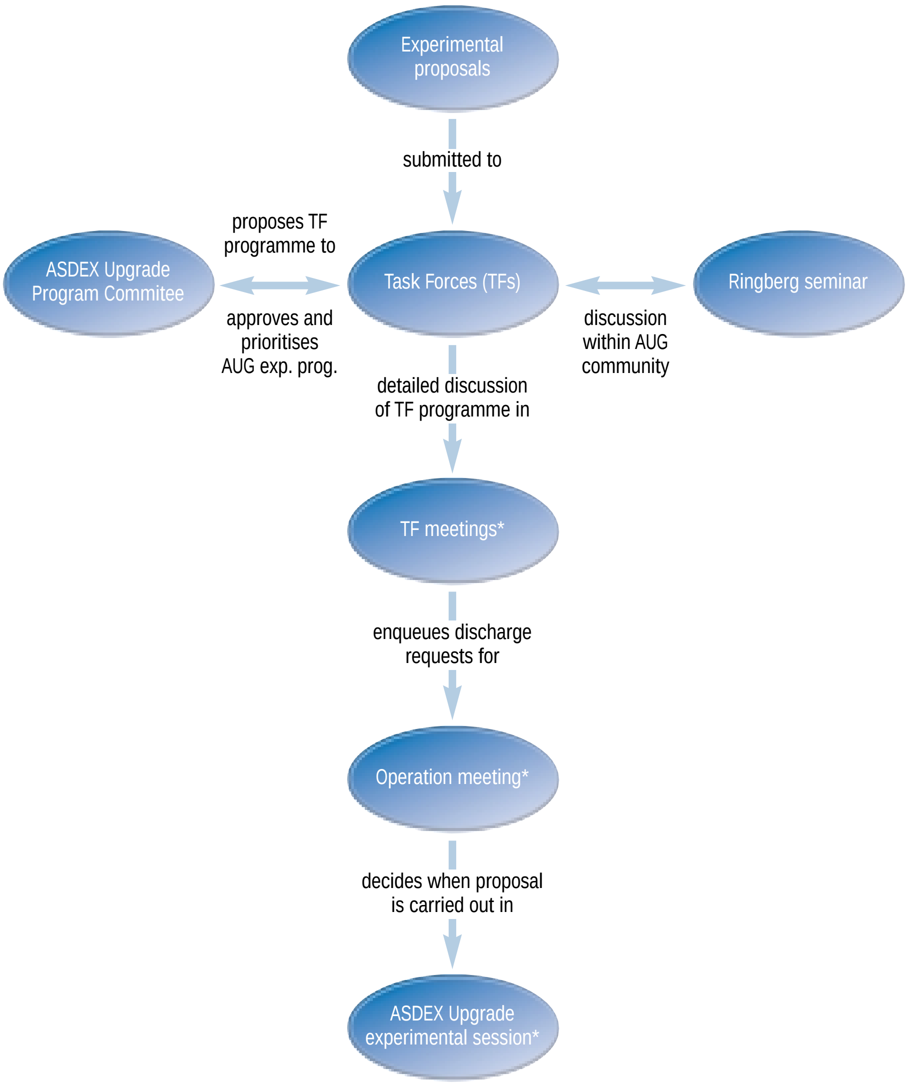
The ASDEX Upgrade programme has always had strong international links, especially within the EURATOM Associations. However, with the increasing number of experiments proposed by collaborators, also a formal structure was needed in which the Associations could take responsibility for the ASDEX Upgrade programme.

This was recently started by opening the ASDEX Upgrade Programme Committee (AUG-PC) to the Associations. This body defines the Task Forces responsible for the different elements of the ASDEX Upgrade programme and nominates the Task Force Leaders. It also approves the experimental programme proposed by the Task Force Leaders. By definition, every Association involved in the ADEX Upgrade Programme has the right to nominate a member. In addition, the IPP Department Heads involved in the ASDEX Upgrade programme as well as the ASDEX Upgrade Project Leader and a representative of the IPP stellarator programme are part of the AUG-PC. At present, it comprises 9 members from the Associations and 8 from IPP (see box left). The first meeting took place in Garching on January 31st, 2002. The experimental programme for the 2002 campaign was discussed and finally approved.



Furthermore, the bodies that work out the programme proposals, namely the yearly 'Programme Seminar', the 'Task Force Meetings' as well as the weekly 'Operations Meeting' are now open for external participants. In parallel, an initiative has been started to ease remote participation in these meetings. Finally, the ASDEX Upgrade Intranet and the means for data access are constantly being improved. With this structure, a clear route from an experimental proposal to the final discharge exists (see figure). We aim at a compromise between the increased international participation and the flexibility that has so far been typical for the ASDEX Upgrade programme. We expect significant added value and exciting new results.

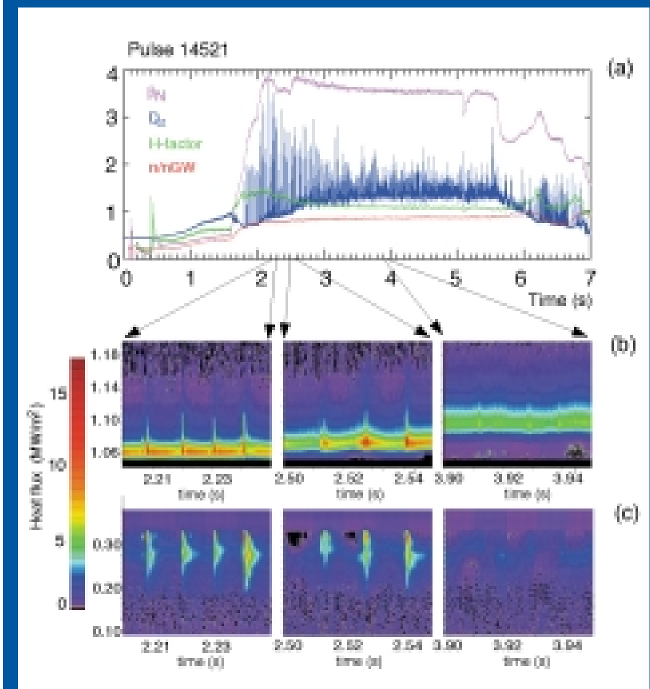
ASDEX Upgrade Collaborations

The ASDEX Upgrade programme enjoys fruitful collaborations with many other research institutes, both nationally and internationally. Amongst these are 8 German universities, laboratories from all EURATOM Associations, as well as a number of institutions world-wide, including the big fusion experiments in Japan and the US, various research institutes in Russia and also the tokamak programmes of China, India and Korea.

Highlights from recent ASDEX Upgrade experiments

Progress towards an Integrated Advanced Scenario

At ASDEX Upgrade, significant progress was made in 2001 towards achieving steady state H-mode discharges with improved confinement and weak magnetic shear. Recent experiments have concentrated on simultaneously increasing confinement, density and normalised beta (β_N) by using pressure and current profile control. In highly shaped, nearly double null plasma configurations, H-mode discharges with high β_N (>3.5) and good confinement (H_{98}-P≤1.3) have been obtained. Values of the figure of merit $\beta_N H_{98}$=8.0 are observed for 20 energy confinement times at q_{95}≈3.6-4. In these reactor relevant conditions the total non-inductively driven current exceeds 50% of the plasma current. Line averaged densities of up to $9 \cdot 10^{19}$ m^{-3} (80-90 %) of the Greenwald density n_{GW} are achieved by the combination of NBI and gas fuelling, while maintaining the good confinement. At the highest densities a transition from Type I to Type II ELMs is observed, providing a strong reduction of the peak heat load on the divertor which becomes steady in the range of 6 MW/m^2, despite the high input power used (10 MW).



The ASDEX Upgrade Scientific Programme

The ASDEX Upgrade Scientific Programme gives priority to experiments which could influence detailed aspects of ITER's operational scenarios: plasma shaping, mitigation and physics of ELMs, operation near boundaries, further characterisation of the edge/divertor plasma, effect and control of neoclassical tearing modes, optimisation of advanced tokamak scenarios and assessment of tungsten as a potential first wall material. It includes joint experiments with other tokamaks to obtain important scaling information in several areas. Especially comparisons with the JET tokamak are routinely done and facilitated by the strong involvement of ASDEX Upgrade scientists in EFDA-JET campaigns.

The hardware improvements of the 2000/2001 shutdown will also come to further exploitation. These changes comprise an optimised divertor geometry with enhanced flexibility for shaping, a re-direction of one neutral beam box to improve current drive efficiency, a further replacement of carbon by tungsten in the main chamber and a substantial increase of the pulse length to values beyond the current diffusion time. The latter improvement will allow to investigate the stationarity of scenarios and makes in this respect ASDEX Upgrade unique among all ITER-shaped tokamaks. Experiments on ASDEX Upgrade in 2002 will be performed throughout the year and are interrupted only by a shutdown of 12 weeks starting in August. This break will mainly be used to improve the mechanical stability of the upper divertor and to increase the area of tungsten coated tiles leading to a further reduction of carbon in the machine.

The scientific programme is organised in the form of Task Forces, with their Leaders being the main actors in the process of preparation and execution. Currently four Task Forces (TFs) exist. Their programme approved by the AUG-PC will be introduced in the following in more detail.

TASK FORCES

TASK A – Edge, Divertor and Wall Physics

Task Force Leader: R. Neu

In a stepwise manner ASDEX Upgrade will increase the tungsten covered area in the machine and document the effect of each step on plasma operation by advanced diagnostic methods and by dedicated pulses.

Characterisation of ELM properties and the ELM impact on the upper and lower divertor, especially in the favourable operation close to double null is a major goal.

The relation between parameters of the Scrape-Off Layer and the confinement of the core plasma will be further analysed with improved measurements. The origin of the scatter in edge and divertor data which exceeds in general the error bars of the measurements will be investigated.

Activities to improve the model for carbon impurity production and transport to the central plasma are on the way.

TASK B – Pedestal and Core Physics in Conventional Scenarios

Task Force Leader: J. Stober

Due to the temperature profile stiffness no separation of pedestal and core plasma investigations is done. Therefore almost all scientific issues of conventional, inductively driven scenarios are addressed in the frame of a single Task Force.

The exploration of an operational space with high confinement and high density with tolerable ELMs (Type II) is a major goal. The influence of ICRH on small ELMs and the comparison with the EDA mode of Alcator C-Mod is investigated.

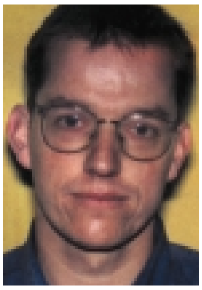
The physics of the L/H threshold will be investigated by varying plasma rotation, the ratio of T_i/T_e and the charge and mass of the ions (operation in H and He).
Experimental time will be devoted to improve radiation cooled scenarios on ASDEX Upgrade.

The investigations on temperature profile stiffness with ECRH will be extended to the ion channel.
Pellet injection will be used for particle fuelling and triggering ELMs in discharges with otherwise low ELM frequency.

The relation between particle and energy transport will be investigated. Disruption mitigation by fast gas puffs will be performed.
NTM stabilisation methods using ECCD will be optimised. NTM-onset experiments will be compared with JET.

TASK C – Advanced Tokamak Scenario Development

Task Force Leader: A. Sips



and TASK D – Physics of Advanced Tokamak Scenarios

Task Force Leader: A. Peeters

Improved H-mode discharges at low density with peaked profiles and zero magnetic shear: 2002 activities will focus on physics of density peaking, operation at q_{95}=3, ion temperature modulation experiments and strategies to control the impurity content by RF heating.

High β_N H-mode discharges at high density with low magnetic shear and a substantial fraction of non-inductively driven current: Further optimisation of this scenario, especially improved NTM stability and extended duration are the goals for the coming campaign. (see highlight).

Formation of Internal Transport Barriers (ITBs) in discharges with reversed q-profiles: Future studies will aim to combine electron and ion barrier formation, to explore ITB access conditions, to perform comparisons with JET and to prolong reversed shear phases with off-axis current drive.

Full non inductive current drive scenarios at low plasma current (400 kA): The MSE diagnostic system will be upgraded to access the efficiency of the neutral beam current drive.

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