ASDEX Upgrade
Letter

No. 3/November 2002

Foreword

This issue of the ASDEX Upgrade letter appears just at the beginning of our new experimental campaign, which will start with plasma operation on November 26th. In preparation of this campaign we had asked all European associations for suggestions of experiments. By now proposals from ten associations have arrived. We would like to take this opportunity to thank all scientists involved for their great interest in the ASDEX Upgrade programme and we look forward to further fruitful collaboration with them.

All proposals received will be discussed in detail with the proponents at this year's annual Ringberg meeting (4.-11.11.2002). This meeting will be organised by the new task force leaders, who were recently appointed by our international programme committee. To make them known to the whole ASDEX Upgrade community we introduce them here in this letter. For the first time a non-IPP staff member is among them: Duarte Borba, from the Instituto Superior Téchnico Lisbon, Portugal, who will lead the MHD task force. Following the discussions in Ringberg, the task force leaders will recommend an experimental programme for the coming campaign, which is to be approved by the International Programme Committee of ASDEX Upgrade in December. As you may know, this programme committee is composed by 8 members of IPP and 9 members from other European Associations.

Besides discussing the preparation of the new campaign, we also describe in this letter a couple of highlights of the last one: the achievement of a current flattop duration of more than 10 s, and ion heating by ICRF using mode conversion. The latter result has been achieved in a close collaboration between IPP and CEA/Cadarache.

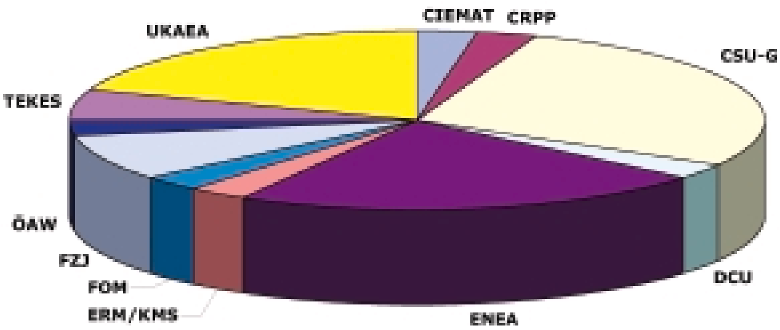
As the number of external proposals has considerably increased compared to last year's campaign we expect that these collaborations will produce many outstanding new physics results!

S. Günter

Preparation of 2003 Experimental Campaigns

On 15th August, a Call for Participation was sent to European Associates and collaborators asking for experimental proposals for the 2003 campaigns of ASDEX Upgrade. Thirty-six scientific proposals from 10 different Associates and the CSU Garching have been received. The number of received proposals demonstrates the large European interest in conducting their own experiments on ASDEX Upgrade.

In addition to this type of experimental collaboration many others will continue throughout 2003 including theory and modelling as well as development and improvement of hardware components and diagnostic systems. Taking into account all these activities, almost all European Associates are involved in the ASDEX Upgrade project.



Breakdown of received experimental proposals for 2003 campaigns by European Associates.

The ASDEX Upgrade tokamak has recently finished a shutdown phase which has been used to:

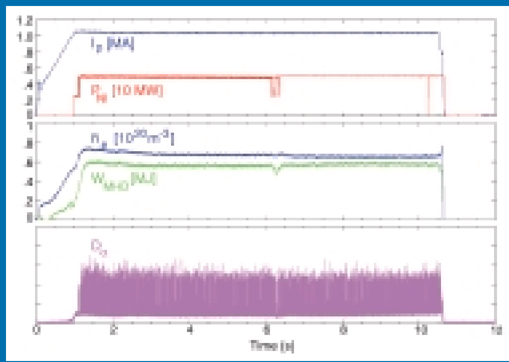
- harden the upper divertor against disruptions with VDE in the upper direction;
- complete the tungsten-coverage on the inner heat shield with larger tiles;
- cover the upper passive stabilising loop and the divertor baffle on the high field side with tungsten;
- extend the thermal capability of a vacuum switch in order to allow plasma operation at increased triangularity δ=0.45.

Plasma Operation will restart on 26 November 2002.

Highl

from recent ASDEX U

ASDEX Upgrade pulse with 10 s flattop of plasma current



A new record in plasma current flattop of more than 10 s has been achieved at the end of the last experimental campaign by improving the tokamak power supplies. This value of 10 s exceeds the redistribution time of the plasma current significantly even at high central T_e of 10 keV and will therefore allow to study steady-state issues on this timescale in future campaigns.

ICRF ion heating with mode conversion (Collaboration with EURATOM Associate CEA/Cadarache)

In a fusion reactor, it is important to avoid decoupling of electron and ion temperatures. Thus one has to heat both electrons and ions. In general additional heating methods, as well as fast alpha particles produced in a DT plasma, heat electrons, either directly or via collisions. For ion heating fewer methods exist. An alternative to the well known approach of Ion Cyclotron Resonance Heating (ICRH), which produces an electron-heating tail of energetic ions, is nonlinear ion heating with an Ion Bernstein Wave (IBW) created by mode conversion (MC) from the fast magnetosonic wave in the plasma. In particular, the non linear damping of the IBW at the 3/2 cyclotron harmonic of an ion species can be used. A self interaction of the wave occurs, making a beat wave that resonates with the bulk ions of the plasma.

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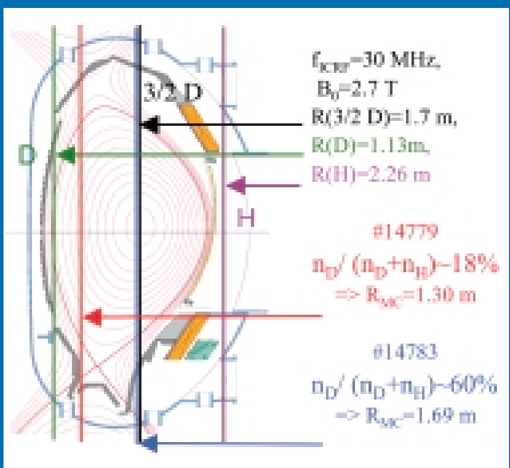
Upgrade experiments

The heating scenario developed for ASDEX Upgrade in collaboration with CEA/Cadarache relies on the fast magnetosonic wave launched from the low field side of the tokamak. An IBW is created at the centre in a two ion species (hydrogen and deuterium) plasma by MC. In such a scenario (see figure) the ion cyclotron resonance layers on the high field side at R(D)=1.13 m and on the low field side at R(H)=2.26 m are outside the plasma and damping of the Fast Wave through these channels is avoided. Electron heating from the Fast Wave and the IBW competes with ion heating caused by non linear damping of the IBW at the 3/2 deuterium cyclotron harmonic.

A series of discharges were performed during a transition from pure hydrogen to deuterium plasmas, allowing a large scan in isotopic ratio which determines the position RMC of the mode conversion layer (see figure). The closeness of this mode conversion layer to the location of the resonance at the 3/2 deuterium cyclotron harmonic determines how the heating power is divided between electrons and ions (deuterium in this case).



Power deposition on electrons has been measured by power modulation, and the location of the maximum of the damping varies accordingly with the position of the MC layer. Indications for direct ion heating have been deduced from the energy spectrum of neutral deuterium escaping from the plasma and from observed modifications of the power fraction deposited on electrons. All these data indicate that ion heating takes place when the MC layer lies close to the 3/2 D cyclotron harmonic layer. Thus the effectiveness of a nonlinear damping mechanism involving a IBW has been demonstrated. No tail of very fast (above 100 keV) D ions was measured, even in combined heating (ICRH + Neutral Beam Injection of D atoms) which is beneficial for ion heating.

New Task Force Structure for Experimental Campaigns 2003/4

On 5th July 2002 the international ASDEX Upgrade Programme Committee has approved a new Task Force structure for the years 2003/4. The preparation and execution of the experimental campaigns and the subsequent analysis of results will be organised under five Task Forces (I - V). For the first time a scientist from outside IPP, D. Borba (IST Portugal), will act as a Task Force Leader (TFL). In the following the new TFs are characterised by their scientific objectives in more detail.

TASK I
– Improvement of H-mode including tolerable ELMs

Task Force Leader: A. Stäbler

- Performance optimisation of steady state H-mode scenarios with weak central shear.
  - „Improved H-mode“: high confinement at moderate densities
  - „High β_N plasmas“: scenario to optimise $\beta_N{\cdot}H$ at densities close to n_{GW} including reactor relevant edge conditions (e.g.: Type-II ELMs)
- Study of core transport in non-ITB plasmas, i.e. plasmas with stiff temperature profiles. This includes heat conduction by ions and electrons as well as transport of impurities and particles.
- Integration of low amplitude ELMs into H-mode scenarios with improved performance.
- Pellet fuelling in non-ITB plasmas.
- Characterisation and development of heating scenarios (ICRH, ECRH, NBI).
- Core similarity experiments: comparison of ASDEX Upgrade with other tokamaks.

TASK II
– ITB scenarios & current drive

Task Force Leader: J. Hobirk

- Creation of ITBs, e.g. variation of current ramp rate, or heating scenario.
- Development of ITBs, e.g. performance optimisation, change in barrier foot by heating power.
- Sustaining of ITBs, e.g. optimum current profile shape, ELM mitigation.

- Transport studies in ITBs, e.g. measurements by reflectometer to study turbulent transport, laser blow off, ECRH modulation.
- Current diffusion studies, e.g. current holes, effect of MHD activity.
- Current drive studies, e.g. ECCD preheat, NBCD current profile shaping.
- Studies of current profile control, e.g. measurement of NBCD efficiency or ICCD efficiency

TASK III
– Pedestal and SOL physics including ELM physics

Task Force Leader: L. Horton

- L-H transition physics
  - dependence on local parameters at the transition
  - specific scaling issues, e.g. reversed field direction, upper divertor configurations
- ELM physics and mitigation
  - scaling of ELM size and width
  - tests of specific ELM models
  - access conditions and physics of Type II ELMs
- Pedestal and SOL perpendicular transport
  - qualify (diffusive / streamers) and quantify edge transport between & during ELMs
  - influence of wall recycling on plasma parameters
- Pedestal stability
  - tests of ideal and resistive MHD as the ELM trigger mechanism
- Density limit scaling
  - comparison of divertor detachment and pedestal confinement degradation in high density H-mode plasma

TASK IV
– Divertor physics and first wall materials

Task Force Leader: R. Dux

- Behaviour of Tungsten plasma facing components
  - new complete Tungsten heat shield
  - Tungsten on upper part of passive stabilization loop (PSL)
  - Tungsten on inner divertor baffle
- Erosion and deposition of carbon
  - C sources in main chamber and divertor
  - fluxes from chemical erosion (D/XB values)
  - erosion and deposition probe measurements
- Divertor characterization
  - influence of geometry (Div I, II, IIb)
  - in/out- and up/down-asymmetries during and in-between ELMs
  - importance of drifts
  - divertor versus main chamber radiation
  - heat flux from thermography and Langmuir probes
  - code calculations
- Radiative divertor
  - documentation of Carbon as radiating species
  - feed back tools for control of divertor radiation

TASK V
– MHD stability and active control

Task Force Leader: D. Borba

- Neoclassical Tearing Modes (NTM)
  - empirical scaling of critical pressure and comparison with model predictions
  - stabilisation with localised ECCD and ECRH
- Sawtooth
  - sawtooth behaviour and control
  - conditions for triggering NTMs
- Disruptions
  - mitigation by injection of gas and pellets
  - real time detection and avoidance
- Resistive Wall Modes (RWM)
- Fast Particle driven instabilities(Fishbones & Alfvén Eigenmodes)
  - conditions for destabilisation
  - effect of these instabilities on particle confinement

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