On 23rd January 2006, the EFDA Associate Leader for JET Dr Jérôme Paméla presented the JET 2005 report and future programme in a seminar at the JET site. In his talk, Dr Paméla outlined the most recent news regarding fusion, the 2005 JET main events and scientific highlights, the 2006 JET programme, and planning beyond 2006.

“2005 was a key year for fusion with the decision on siting ITER in Cadarache taken by the parties on 28 June 2005. India joined in November and ITER negotiations were completed in December 2005. The negotiation with Japan led to other projects being jointly prepared between the European Union and Japan, the so-called ‘Broader Approach’, a very good opportunity for faster development of fusion,” stressed Dr Paméla.

Some of the scientific results obtained at JET in 2005, which were outlined in the talk, are presented in this Bulletin. The current European fusion research strategy, reflected in the longer-term planning for JET, was also described in detail. In the upcoming campaigns significant enhancement of the JET facility, towards higher power with the ITER-like plasma shape will allow JET to perform important experiments in preparation of ITER. At the end of this year, an ITER-like ICRH Antenna is to be installed which will open new scope for reactor-relevant research at JET. These experiments shall be followed by the installation of an ITER-like first wall scheduled for 2008 (see the June 2005 JET Bulletin).

**JET in the Physics World**

The March issue of the Institute of Physics magazine, Physics World, carries an 8 page special feature on JET. The article describes, for a general physics audience, how the research programme now, and in the future, is concentrating on critical ITER issues. An interview with ITER’s new director general, Kaname Ikeda appears in the same edition. Fusion made it to the front cover of the magazine, which has a circulation of about 50,000 worldwide. The article was commissioned by Physics World and has been co-written by Richard Pitts, Richard Buttery and Simon Pinches, currently leaders of JET Task Forces E, S1 and M respectively. The authors would like to thank the JET EFDA contributors and in particular the following people for their assistance in preparing this article: Vasili Kiptily, Xavier Litaudon, Paola Mantica, Jan Mlynar, Olivier Sauter, Sergei Sharapov, Tuomas Tala and Mark Woollard.

**Edge plasma modelling workshop at JET**

During February, EFDA-JET hosted an intensive, month-long workshop dedicated to edge plasma modelling, which was co-ordinated by one to the JET scientific taskforces, Task Force E (Exhaust). As part of this activity, twenty physicists from across Europe and United States addressed a number of critical issues (power exhaust, material migration, fuel retention, etc.) related to the upcoming JET experiments and to the ITER project. These included fluid-kinetic modelling of: wall material erosion, deposition and transport; $^{13}$C injection experiments; Edge Localised Mode (ELM) power exhaust along magnetic field lines; ELM-limiter interaction; high density divertors and photon opacity; thermal quench phase of plasma disruptions; new ITER-like shaped JET plasmas; JET-ASDEX Upgrade comparison studies; drift wave edge plasma turbulence and edge-SOL (Scrape-Off Layer) plasma turbulence simulations of JET ohmic and L-mode discharges (see figure). Significant effort was also placed on code-code benchmarking, core-edge integrated modelling and improved formulations of guiding centre drifts within fluid codes.
**Plasma particle density profile versus collisionality in H-modes**
The JET database on density peaking has been expanded with discharges dominated by radio-frequency heating. Regression analysis was performed on the expanded database, which, among several other parameters, takes account of neutral beam fuelling as a particle source. The scaling obtained in this way confirms that collisionality is the most important scaling parameter and that density profile peaking increases with decreasing collisionality in H-modes. A significant level of density peaking is predicted for ITER. The theoretical interpretation of the observed dependence of density peaking on collisionality is still controversial and poses a challenge to gyrokinetic models.

**Poloidal rotation in discharges with ITB**
Figure on the left shows a strong Internal Transport Barrier (ITB) expanding outwards in major radius, in JET Pulse No: 61324. From t = 4.04s onwards, the ITB is within view of the poloidal charge exchange diagnostic, which can measure poloidal rotation of carbon impurities in the plasma.

In the figure on the right the poloidal rotation of carbon measured in this discharge is shown at two times, one (red) when the diagnostic is viewing outside the ITB, and the other (blue) when the diagnostic is viewing the plasma both outside and inside the ITB. These measurements indicate there is a significant difference between the poloidal rotation either side of the ITB, with rotation in the enclosed region (R<3.4m) reaching much higher levels.

Neoclassical theory predicts carbon poloidal rotation of a few km/s while the measured values are an order of magnitude larger within the ITB. Theoretical and modelling work is in progress to understand the cause of this rotation, and its link to ITBs. *(Published in Phys. Rev. Lett.)*

**Study of ion loss during Edge Localised Modes (ELMs)**
The JET Retarding Field Analyser (RFA) probe (photograph) provides the first direct measurement of ion energies convected outwards to the main chamber walls by Type I ELMs. The probe - inserted using a fast reciprocating drive into the scrape-off layer - is "bi-directional", with sensors aligned perpendicular to the magnetic field facing the inner and outer divertors (the "e-side" and "i-side" marked in the figure). During ELMs, the i-side current density (jsat) dominates, showing that the ELM ejects particles preferentially in the outboard midplane region. Picturing the ELM as made up of a series of current "filaments" expelled simultaneously at multiple toroidal locations then propagating radially whilst losing energy rapidly along the magnetic field (as observed on MAST, ASDEX Upgrade and DIII-D) provides an explanation for the structure seen in the probe detector currents. The ion current measured inside the RFA (i_coll) in the example shown here is due to ions which have been able to surmount a potential barrier of 400V. A new transient parallel loss model of ELM energy dissipation (published this January in Plasma Physics and Controlled Fusion journal) reproduces the measured i-side collector current (black line), showing that the ELM convects ions to the walls with energies characteristic of the H-mode pedestal region.
Heat wave damping by Internal Transport Barrier

In experiments with modulated Ion Cyclotron Resonant Frequency (ICRF) power is deposited at two locations, at the centre (R~3m) and off-axis (R~3.6m), in a plasma with an Internal Transport Barrier (ITB) around R~3.35m. Two heat waves are generated and propagate towards the ITB. The amplitude (red squares) and phase lag (blue circles) of the resulting heat wave across the plasma are shown. The amplitude is damped strongly when it meets the ITB from either side. The phase rise shows that the wave slows down. This demonstrates that the ITB is a narrow layer with reduced heat diffusivity and with transport properties consistent with turbulence suppression. *(Published in Phys. Rev. Lett.)*

Distribution of fast ions with off-axis heating

In experiments with off-axis Neutral Beam Injection, the radial distribution of fast injected tritium ions has been studied. This distribution is measured indirectly, by observing 14 MeV neutrons originating from fusion reactions between the fast tritium ions and the deuterium in the plasma. Plasmas with a high edge safety factor (q 95 ~ 8.5) show a radial distribution of fast tritium ions in good agreement with simulations using the transport code TRANSP, peaking off-axis where the beams are aimed. However, at more ITER-relevant, low q95 ~ 3.3, some fast ions appear to be transported to the plasma centre, in disagreement with simulations. This anomalous behaviour does not appear to be related to sawteeth or MHD. Efforts to develop an understanding are ongoing. The results of this study could be important to improve predictions relating to the off-axis neutral beam current drive on ITER.

Material migration in outer divertor

Previous experiments on JET (2001) showed that carbon injected at the top of the vacuum vessel was deposited mostly on the inner divertor. This was understood as a result of Scrape-Off Layer (SOL) flows from the outer divertor to the inner divertor, which carried the injected carbon with them. The observation suggested most material released from the first wall would be deposited on the inner divertor. More recent experiments with carbon (13C) injection in the outer divertor region rather than from the top of the vacuum vessel have shown that material migration is more complicated in this region. Part of the injected carbon is deposited locally onto the outer divertor tiles close to the injection point, and a significant amount is transported to the inner divertor. The injected carbon is also found on a deposition probe on top of the machine, indicating strongly that it migrated up to the X point, through the confined plasma, back into the SOL and then down to the inner divertor leg. Modelling is underway to understand how the observed migration arises, and to improve predictions for ITER, where tritium accumulation by co-deposition must be strictly controlled.

JET Restart Status

Since the start of Neutral Beam injection into plasma in January, operation of the upper half of the Neutral Beam system on Octant 4 has been strongly affected by the presence of an obstruction in the vicinity of the Neutral Beam Duct and High Vacuum Rotary Valve. After an intervention to remove the foreign body from the Octant 4 Neutral Beam Duct and to repair a water leak in an Octant 8 neutraliser, JET resumed plasma operation on 3 March. The vessel conditions are good, as shown by the fact that an H-mode was demonstrated already on 8 March with auxiliary heating power in the range of 8 ~ 10 MW, obtained during 5-6 second neutral beam pulses from Octant 4. Vessel conditioning and commissioning of all systems -including Ion Cyclotron Resonant Heating, Lower Hybrid Current Drive and diagnostics- is under way. The Experimental Campaigns are foreseen to start after Easter 2006.
**Stavros Chatzipanagiotou gave a presentation on Joint European Undertaking for ITER**
Mr Stavros Chatzipanagiotou, Head of the European Commission Unit for Implementation of the European Legal Entity for ITER, and colleagues Mr R Monk and Mr T Bousios visited the JET facilities on Wednesday 15 February 2006. Mr Stavros Chatzipanagiotou outlined the Joint European Undertaking for ITER and the Development of Fusion Energy in a presentation to staff. Related personnel needs were also discussed during his presentation, which was broadcast via the Internet to over 20 different sites around Europe.

**MEP Umberto Guidoni**
Dr Umberto Guidoni MEP visited the JET facilities on Monday 6th February 2006. Dr Guidoni, a former astronaut in two space shuttle missions, had the opportunity of exchanging views on the European fusion programme with Dr Jérôme Paméla (Associate Leader for JET) and Prof Sir Chris Llewellyn-Smith (Director of UKAEA Culham Division). During the visit to the Torus Hall, Dr Umberto Guidoni gave an interview to Ms Emma Jane Kirby (BBC World Service) and was able to try for himself some of the remote handling tools.

**MEP Jan Christian Ehler**
Dr Jan Christian Ehler MEP and three colleagues visited the JET facilities on Thursday 8 December 2005. With a background as a managing director of Biotech GmbH - the biotechnology centre Hennigsdorf, Dr Ehler was well informed about European science policy and was particularly interested in energy research and fusion.

**Didcot Power Station staff tour JET**
On 31st January 2006 JET hosted a visit for staff from the nearby Didcot Power Stations, owned by RWE npower. Didcot A Power Station is a dual-fired (coal and gas) power station, capable of generating 2000 MW of electricity. The site also includes Didcot B, which is a combined cycle gas turbine (CCGT) power station that can generate up to 1360 MW of electricity. Together the power stations can supply enough electricity to some 3 million people, three times the size of Oxfordshire. The stations are approximately 5km from the JET site and were one of the positive factors deciding its location in Culham. Among other facts, our guests learned in detail about the JET remote handling system (photo) and JET power supply units. Emma East, Community Relations Co-ordinator from the power station said: “It was very popular with our staff. Engineers are always hungry for new information and ideas to expand their minds. We had such a good response for the visit from our staff that we’re hoping to organise another visit in the near future.”

**New staff join EFDA JET Close Support Unit**
Christina Mrozek from IPP Garching joined CSU in February as the new Head of Administration following the return of Catherine Soltane to Cadarache to work for the CEA ITER administration. Remi Reiss from CEA joined the Enhancement Department in January, and Daniela Püttermann-Kneupner from FZJ reinforced the Contract Service in March. The CSU also welcomed Helen Dawson as a new part-time finance administrator. Two students from the Netherlands, Jeroen Klijns and Joost Simkens, are currently attached to CSU Publications to finalise their theses in fusion policy - their study focuses on the secondary benefits of fusion research.