EFDA EUROPEAN FUSION DEVELOPMENT AGREEMENT
JET

EFDA-JET Bulletin

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"In many respects the European Fusion programme is a model for the European Research Area. The experience the EU has gained in managing a highly complex scientific and technological programme such as JET gives us confidence to embark, in partnership with the leading fusion programmes throughout the world, on the next step towards the realisation of fusion".

Commissioner Potočnik at JET facilities, 3rd March 2005

The European Commissioner for Research Janez Potočnik made his first visit to the JET facilities on 3rd March together with Members of Cabinet, Mr Matjaž Malgaj, Mrs Charlotte Haentzel and his spokeswoman Antonia Mochan. The Commissioner was given presentations by Sir Chris Llewellyn Smith (Chairman of CCE-FU, the Consultative Committee for EURATOM-Fusion) on Fusion and the Fast Track, Prof Carlos Varandas (Chairman of the EFDA Steering Committee) gave a talk on EFDA and the role of the Associations in the fusion programme followed by a presentation on JET by Dr Jérôme Paméla (EFDA Associate Leader for JET).

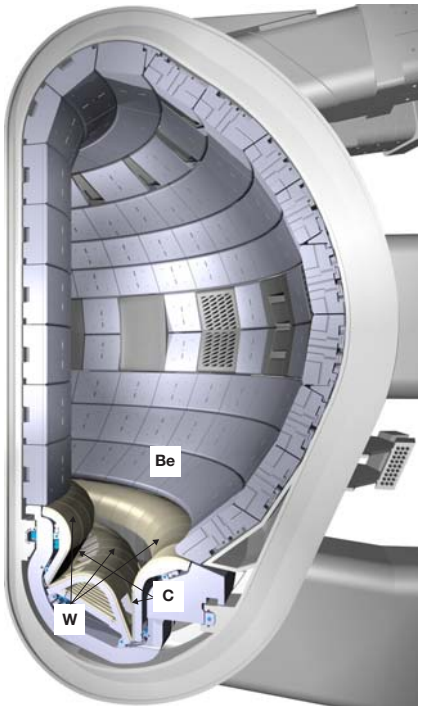
After a tour of the JET Facilities, which included a visit to the Torus Hall, Remote Handling and Tritium Storage facility, Dr Janez Potočnik addressed about 150 fusion Scientists working at Culham. The speech was also broadcasted to other EFDA partners including Cadarache and Garching through the JET computer network system and internet, and is available on the JET public webpage (http://www.jet.efda.org/ , section "What's new"). A meeting with all the chairmen of the fusion Committees, led by Dr Alex Bradshaw, and with EFDA Leadership concluded the afternoon visit.

JET Programme in Support of ITER

Launch of Enhancements for a possible use of JET beyond 2006 and issue of the Commission's proposal for FP7

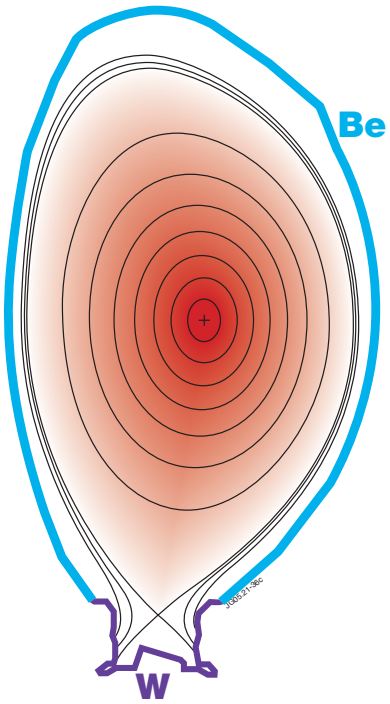
At its 27th meeting, held in Cascais, Portugal, on 4 April 2005, the EFDA Steering Committee approved the launch of three projects for upgrading JET, as part of a proposed "JET programme in support of ITER". This programme had received very positive support from the EFDA Scientific and Technical Advisory Committee (STAC) on 14 December 2004. The three projects are the "ITER-like wall", the "Neutral Beam Enhancement" and the "High Frequency Pellet Injector". The engineering design has started and the first calls for tender are being made. The implementation of the ITER-like wall and Neutral Beam Enhancement are foreseen for a shutdown in 2008 for exploitation in 2009 and 2010. In addition, proposals for diagnostics and plasma control are in preparation for presentation at EFDA Scientific and Technical Advisory Committee (STAC) in June 2005.

The operation of JET beyond 2006, as part of the ITER Accompanying Programme, remains subject to the approval of appropriate funding for the next Framework Programme (FP7). The Commission's proposals for FP7 published on 6 April 2006 contain promising news in this respect, including a substantial increase of the fusion funding under Euratom. Dr Pablo Fernandez Ruiz, Director in charge of energy research in the Commission, commented that "the proposed budget for fusion, if adopted by the Council, would enable realising ITER and permit at the same time a vigorous Accompanying Programme."



Reference design for ITER first wall (Courtesy of ITER)

The ITER-like Wall Project



JET ITER-like wall project, the reference design

Guy Matthews Project Leader

One of the main challenges for fusion reactors is the compatibility between a reactor-grade plasma and the first wall. To suppress carbon migration which co-deposits tritium in the divertor region, the ITER design comprises a beryllium-clad first wall in the main chamber, while use of carbon (CFC) tiles is limited to the divertor strike points only, and tungsten is to be applied for the rest of the divertor. However, such a combination of materials has never been tested in a tokamak, let alone in one with ITER-relevant geometry and plasma parameters. That is why recently JET succeeded in obtaining approval for installation of an ITER-like wall in 2008. Two designs are under consideration. The reference design consists of a beryllium wall in the main chamber and an all-tungsten divertor (see figure) which matches ITER back-up/second stage design. Another option is to use CFC tiles at the divertor strike points, which would make the material choices identical to those in the ITER reference design. A final choice between these two options will be made in 2006.

Preparations for installation of the new wall have been progressing rapidly. For tungsten plasma facing components, a research programme is currently underway to determine whether tungsten-coated CFC is suitable, and what coating thickness will be required. Should coated CFC not be deemed suitable, the alternative would be to use solid tungsten tiles.Tungsten will also be used for neutral beam shine-through protection tiles. During the one year installation period, extensive use of remote handling technology will be made to implement the new first wall and divertor in 2008. Following installation, the JET experimental programme will focus on optimising operating scenarios compatible with the ITER-like wall. The level of retained tritium and its dependence on plasma scenarios will be determined, and detritiation techniques will be validated. Plasma performance will be tested to show that the level of tungsten reaching the core is acceptably low.

The lifetime of the wall will be studied with ITER-relevant power loading provided by increased neutral beam heating power. This level of heating power is expected to produce ELMs and disruptions which could cause melt damage to the first wall. The performance and life of the wall will be studied in the presence of such events, and mitigation techniques for ITER will be demonstrated and optimised. The ITER-like wall programme on JET will benefit from expertise gained at ASDEX Upgrade on tungsten coating of carbon tiles. There is also a synergy between the objectives of the two programmes: ASDEX Upgrade is exploring the viability of a tungsten first wall (tungsten is considered the long-term front runner as a material for fusion reactors), while JET will be looking at more immediate ITER needs.

High Frequency Pellet Injector Project

Alain Géraud Project Leader

Another key component of the JET enhancement in support of ITER is a new High Frequency (50-60 Hz) deuterium ice Pellet Injector (HFPI) for mitigation of Edge Localised Modes (ELM) and for deep fuelling experiments. As the ELM mitigation is the main objective of this injector, the technical requirements are based on the results of recent ASDEX Upgrade experiments devoted to the study of ELM control. It has been demonstrated that the ELM frequency can be imposed by the pellet injection frequency, which leads to a significant reduction of the energy ejected during each ELM.

The new injector will be designed on the basis of the injector recently installed on Tore Supra at CEA Cadarache and installed in the Torus Hall close to the existing centrifuge pellet injector, which will be kept in place to allow a maximum of flexibility. In particular simultaneous fuelling (centrifuge) and ELM control (new injector) experiments should be possible. The new pellet injector will be connected to the vacuum vessel through an appropriate pumping line followed by a selector and by the existing pellet guide tubes. The selector system will allow selection of either the new injector or the existing one and also the track to be used to convey the pellets to the plasma (the three tracks already used with the centrifuge are still in place). The new pellet injector will be able to produce both small pellets at high frequency for ELM control (1 – 2 mm^3 , up to 60 per second, 50 – 200 m/s) and large pellets at lower frequency for deep fuelling (35 – 70 mm^3, up to 15 per second, 100 – 500 m/s)

Neutral Beam Enhancement Project

Tim Jones Project Leader

An upgrade of the neutral beam system on JET is planned to be installed in 2008 and subsequently deliver up to 35 MW of power for up to 20 seconds, and half this power for up to 40 seconds. This will allow exciting advances in extending ITER scenarios. With the higher power, the ELMy H-mode and Improved H-mode will be taken to higher normalised pressure β_N, where Neo-classical Tearing Mode and Resistive Wall Mode control techniques will be refined under conditions closer to ITER. Furthermore, the long pulse capability of the upgraded neutral beam system will be crucial to progress advanced scenarios with full current drive sustained for an entire current diffusion time at ITER-relevant normalised pressure. In addition, greater demands will be placed on techniques for mitigation against large ELMs and disruptions. This is of particular importance in view of their potential to cause melt damage to the ITER-like first wall.

The goals of NBE project will be accomplished by changing the magnetic configuration of the ion sources from present "supercusp" configuration to pure "chequerboard" configuration, replacing eight of the existing 80kV/60A High Voltage Power Supply (HVPS) units used for beam acceleration with four new 130kV/130A/20s units, and replacing critical components of each beamline, which presently rely on inter-pulse cooling (first stage neutralisers, beam duct protection etc.), with actively cooled components.
The main increase in neutral beam power will come from the conversion of the ion sources that generate the positive ions that are accelerated to form the neutral beams. This process takes place in a combined ion-source/accelerator module called a Positive Ion Neutral Injector (PINI). Chequerboard ion-sources produce larger fractions of molecular ions (D_2^+ and D_3^+) leading to an increase of neutral beam power as a consequence of better neutralisation efficiency for the heavier (hence slower) molecular ions. The names "chequerboard" and "supercusp" derive from the arrangement of permanent magnets and the resulting magnetic field used to confine the plasma in the PINI ion-source. In order to convert it to a pure "chequerboard", the rows of uni-directional magnets will be changed over to an alternating pattern like all the others. The plasma in the extraction region of the chequerboard ion sources is highly uniform, resulting in better optical properties of the beam and higher geometrical transmission, which will also contribute to higher power delivered to the plasma.

All 16 PINI accelerators will be modified to allow the maximum beam current to be raised from the present 60A to 65A (optimum beam optics condition at 125kV beam energy). This will further contribute to the power increase. This change requires replacement of the first grid in the accelerator structure (see figure) with a slightly modified design incorporating enlarged beam extraction apertures.

The present "supercusp" ion-source was originally developed to maximise the production of atomic ions (D^+). The higher yield of slower molecular ions from the chequerboard ion-source will result in an increase of fractional (half and third) energy components in the neutral beam. In terms of the central plasma heating efficiency, normalised to total neutral beam power, the effect of the higher fractional energy components will be compensated for by the increase in acceleration voltage from 80kV to 125kV on the PINIs presently fitted to the Octant 4 injector box. This voltage increase (at 65A beam current) is only made possible by the new power supplies, which will also improve the reliability and availability of the NB system. In combination with the two similar 130kV/130A HVPS units commissioned on the Octant 8 neutral injector box in 2003, 75% of the JET PINI accelerators will be fed by new HVPS units when the enhancement is completed and brought into full operation in 2009.

Accelerator grid undergoing alignment checks during PINI assembly. New grids with enlarged beam extraction apertures will be manufactured for the Neutral Beam Enhancement Project.

Planning New Diagnostics Enhancements

A significant upgrade of the present JET diagnostics is also needed for an effective scientific programme in support of ITER. The upgrade will include diagnostics for ITER scenario development and systems required to fully exploit the JET new projects, such as ITER-like Wall and the High Frequency Pellet Injector. Final validation of diagnostic concepts for ITER, even if not indispensable for JET operation, could also be tested at JET before being installed on ITER.

According to these guidelines, new diagnostic systems were proposed for JET based on their scientific relevance at the end of 2004 by an expert working group, and is being considered by the EFDA Scientific and Technical Advisory Committee (STAC).

Meeting Portugese Secretary of State for Science and Innovation

On February 4th the Portuguese Secretary of State for Science and Innovation, Mr Sampaio Nunes and the Head of his Cabinet, Mr Pedro Cardoso e Cunha, visited the JET facility. Mr Sampaio Nunes was welcomed by the EFDA Associate Leader for JET Dr. Jérôme Paméla, the Chairman of the EFDA steering committee and Head of the EURATOM/Instituto Superior Tecnico (IST) Association Prof. Carlos. Varandas, the Senior Manager of the JET Operations Contract Dr Frank Briscoe and six members of the EURATOM/ IST Association currently on the JET site. Mr Sampaio Nunes was particularly interested in the microwave guides and data acquisition system developed in collaboration with IST, and highly appreciated the participation of IST staff in the JET campaigns and the dedication and enthusiasm showed by the IST scientists working at JET.

Close Support Unit in Culham

In January, Duarte Borba from IST joined us as the new Head of Office of EFDA Associated Leader for JET. In May, Marco de Baar from FOM was appointed the new Head of Operations, following the departure of Jürgen Rapp, who took with him the good wishes of his colleagues and a number of well deserved gifts for his motorcycle.

Brasilian delegation visits JET

On the 18th of April, Dr Odair Dias Gonçalves, President of the National Commission for Nuclear Energy of Brazil, Dr Paulo Wrobel, Adviser of Science and Technology, Embassy of Brazil and Minister Ana Maria Sampaio Fernandes, Head of Economic and Commercial Sector of the Embassy visited the JET facility. After introductory discussions, Sir Chris Llewellyn Smith presented Fusion and the Fast Track approach while M. Watkins explained the role of JET, emphasising its unique capabilities for the preparation of ITER. The following tour of the JET facility allowed the delegation to visit the control room, the remote handling and tritium storage facilities.

Dr Odair Dias Gonçalves showed a great interest in fusion research and on the possibilities for Brazil to co-operate on fusion with Euratom, in particular on possible participation in the EFDA JET Workprogramme and in ITER.

Visit at JET on the 18th April (from left to right): Dr Pascal Lallia from the European Commission (representing the Energy Research Director Pablo Fernandez Ruiz), Minister Ana Maria Sampaio Fernandes (Head of Economic and Commercial Sector of the Embassy of Brasil), Dr Michael Watkins (representing the EFDA Associate Leader for JET Dr Jérôme Paméla), Dr Odair Dias Gonçalves (President of the National Commission for Nuclear Energy of Brazil), Sir Chris Llewellyn Smith (Chairman of the Euratom Consultative Committee for Fusion), Dr Paulo Wrobel (Adviser of Science and Technology, Embassy of Brazil) and Dr Duarte Borba (Head of Office of EFDA Associate Leader for JET).

Week with an EUCYS Winner

Robin Mooney from the JET team (left) explains to François Tissot principles of the pellet injection

EFDA JET, as a member of EIROforum (see footnote), sponsored the latest European Contest for Young Scientists (EUCYS 2004) with a one week invitation to JET facilities for one of the EUCYS winners. Our special guest - Mr François Tissot, student from the Joseph Fourrier University in Grenoble – joined us in Culham in the week starting on 25th April. “It was a very nice prize. I am very happy to have had the chance to visit JET” he remarked after his return to France. We also asked François whether he can imagine a career in a large research centre : “Yes, that’s what I want to do now. I hope to work in a laboratory in fusion research, like JET or may be ITER. Before the visit, I knew only little about fusion, but now I know more and I enjoy it.” At JET, François made an excellent impression when he presented his EUCYS award-winning work on “Development of an atomic force microscope”.

EIROforum is a collaboration between seven European intergovernmental scientific research organisations (CERN, EFDA, ENBL, ESA, ESO, ESRF and ILL), see http://www.eiroforum.org

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