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EFDA Fusion Newsletter
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European Fusion Development Agreement

http://europa.eu.int/comm/research/fusion1.html and http://efda.ipp.mpg.de

What's new?

A number of developments happened recently. The new ITER Outline Design has been presented for review by the Parties. JET is preparing operation with European Task Forces. Wendelstein 7-X Stellarator components are under industrial procurements. Record temperatures were achieved on FTU and TEXTOR with microwave heating. MAST started operation ...

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JET : Europe-wide Task Forces and Operator go into business

The JET Facilities are taking on a new life, following the closure of the JET Joint Undertaking at the end of 1999. When the decision was made that JET would continue operation as a large European facility, Europe-wide Task Forces were set up for the various tasks which JET will undertake. The scientific programme is now the responsibility of all Associations through EFDA.

Two Task Forces cover the comprehensive main area in the coming experimental JET campaigns which is the development of operating scenarios for fusion devices. Task Force 'S1' concentrates mainly on the 'Elmy H-mode' scenario which has been best developed to date and which is used as the baseline scenario for ITER. It also will investigate modes of operation with improved power exhaust such as the 'Radiative Improved Mode'. The Task Force, "S2", examines operating scenarios which also offer improved plasma performance but demand more effort in plasma control. Specialised Task Forces will look into areas such as heating, diagnostics, exhaust and, last but not least, in the technology aspects of fusion R&D, for which JET offers unique possibilities.

The EFDA Associate Leader for JET, responsible for the use of the JET facilities under EFDA, including the co-ordination of the work of the Task Forces, is Jerôme Paméla, former head of the French fusion Association Euratom-CEA. He says: "I am enthusiastic about the initiative shown by the Task Force Leaders, all of them key scientists from the Associations. They have brought experts from all the European labs into their Task Forces, and got the new system working at full speed very quickly."

JET in spring. Soon new research results should also be blossoming.

Frank Briscoe is the UKAEA manager responsible for JET operations. He adds: "There has been a big organisational change but things are going well. In particular we are now four weeks into restart and on target for the first campaign which is scheduled before summer. "

The New ITER takes shape and looks good

'On the shoulders of giants'. This could be the slogan for the new ITER design which builds on all the experience gained between 1992 and 1998 by designing the big ITER. The international ITER team has responded to the politician's view that 6 Billion Euro are too much. Within record time the team has conceived a new design.For about half the money the aim is a controlled burning plasma with 400-500 MW instead of the big ITER's 1500 MW. The design radius of the device is 6 instead of 8 metres. Robert Aymar, ITER director argues: " Of course, you cannot expect the same for half the money. But we have gained a lot from our previous work. We are convinced that ITER will meet its target of demonstrating feasibility of fusion. The new design will be easier to build and offers an improved cost-benefit ratio."

The present JET divertor MK II was installed using for the first time full remote techniques in a fusion device. Further modifications of the MK II divertor could be done with this technique as well.

Some like it hot: EFDA looks into JET

Brussels. EFDA has proposed options for improving the capabilities which the JET device is offering. For long it has been recognised that, by comparison with international devices such as JT-60 U (Japan) and the smaller ASDEX-Upgrade (Europe) or DIII-D (USA) the big JET plasma did not have adequate heating power.

The EFDA Steering Committee and its JET Sub-committee have now agreed to submit to scientific-technical assessment a proposal by the EFDA Leader and the JET Associate Leader with contains various options for enhancing JET.

Roger Weynants, Director of the fusion laboratory of the Belgian Royal Military School and Chairman of the ad-hoc evaluation says: "It is still too early to give a conclusive picture, but there is unanimity that the heating power of JET should be increased to about 50 MW and improved plasma shaping should be made possible. Neutral beam heating and wave heating systems are under consideration." Further examination will be devoted to the question how to modify the divertor in order to improve its power handling capability and to the possible adaptation of other in-vessel components. Tentative options to be kept open for the future have been identified, among them also a possible increase of the plasma volume and a high performance D-T campaign.

The technical part of the evaluation is expected to continue into mid-summer 2000.

Looking sharper: There is a lot to learn

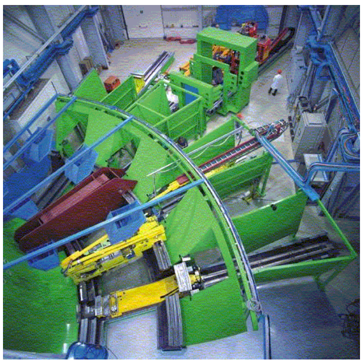
A programme cannot be justified by fringe benefits. But an effort which is as vigorous and complex as the Fusion Programme generates a lot of spin-offs.

How would you design a method for getting better pictures in such diverse fields as computer tomography in medicine, from galaxies in astrophysics or earth satellite pictures in climate control?

Such tasks can now be done faster and cheaper with a novel method which has been developed by fusion physicists at the Association Euratom-IPP /Max Planck Institute for Plasma Physics in Garching .

The title of their paper which appeared in the New Journal of Physics gives to the layman no clue of this wide applicaton : "Depth profile determination with confidence intervals from Rutherford backscattering data". But the mathematical techniques which were developed for studying material erosion of heat protection tiles in a fusion device are of rather general applicability. "The method lets a computer work like an artist paints a picture: using thick brushes for background and coarse areas while switching to a fine brush when details shall be pictured." says Karl Krieger, one of the authors of the invention.

The new method allows the derivation of the so far most extensive and reliable information from experimental data .



Not only the design of the new ITER, also prototypes and tests are nearing completion. (Test of ITER divertor maintenance at ENEA Brasimone.)

ITER – where to build?

One of the most frequent question asked on ITER is not how much it will cost but where it will be built. A few years ago several European countries looked into the technical qualities of potential sites. Italy stated in 1997 some preparedness to look, when necessary, closer into the question of offering a site.

There has always been a strong understanding that Japan is determined to develop a site proposal. The present ITER EDA site in Japan is NAKA, the site offer for the ITER machine construction would rather be thought to be in the north of Japan, if proposed by Japan and agreed by the other Parties.

Recently, Canada has made a declaration of interest naming two potential sites where ITER could be built: Bruce and Darlington. Canada, which is acting through the European Party in the ITER EDA, would be its own Party in a site offer.

With the new ITER design being completed by mid-2001, the site issue becomes interesting to everybody.

Welcome to the new EFDA Newsletter!

EFDA is a new player in the fusion scene in Europe. Its role of co-ordinating fusion activities make it the ideal source of information about everything that is going on in the fusion business. So, the EFDA Newsletter will present news about not just EFDA itself, but also about new developments in all the European laboratories, industrial involvement in fusion, spin offs from fusion R&D, and highlights of what is happening in fusion world wide.

What is EFDA ?

EFDA is the European Fusion Development Agreement. A long name for a simple idea: an agreement between all the active players in fusion in Europe to strengthen co-ordination and collaboration. Its activities include fusion technology R&D, contributions to international collaborations such as ITER, and the exploitation of the JET Facilities.

The parties to the Agreement are Euratom (represented by the European Commission) on the one hand and all the fusion Associations on the other. There is already a long standing collaborative relationship between these parties, and EFDA aims to provide an improved framework for the physics and technology research which will be needed in the run up to the possible construction of a Next Step machine.

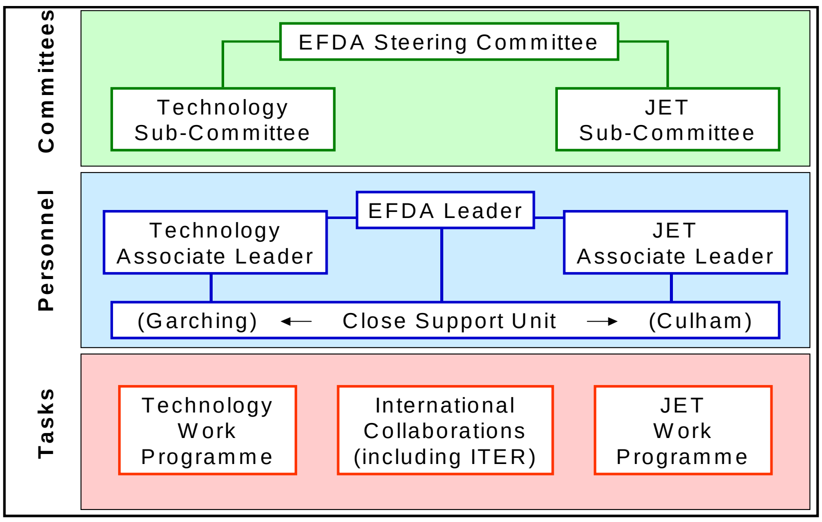
Umberto Finzi, the Director co-ordinating environmental and energy research, including fusion, in the Research Directorate General of the Commission, says "EFDA will reinforce the integration of European fusion research which has existed for many years, and will put us in a strong position to play a major role in the next step along the path to a fusion power plant".

The core of EFDA is a small number of staff in two "Close Support Units", one at IPP-Garching in Germany which co-ordinates work on ITER and fusion technology, and another at UKAEA-Culham in the UK which is responsible for the scientific programme of JET. These two small teams ensure that the collaborative work undertaken by the much larger number of workers from the Association laboratories - whether experiments on JET, technology R&D or design tasks for ITER - are fully integrated into the overall programme.

EFDA is managed by a Steering Committee (with separate sub-committees for JET and Technology) which has representatives from all the parties. It approves the EFDA Workplan which identifies the objectives, the schedules of the activities and the overall resources required for the duration of the Agreement, and any updating to it. It ensures the relevance of the Workplan to the aim of the Agreement as well as collaboration among the Parties in its execution.

An EFDA Leader (Prof R Toschi until 30 June 2000, then followed by Prof K Lackner), plus Associate Leaders for JET (Dr J Paméla) and technology (Dr R Andreani from 1 July 2000), are responsible for the execution of the work programmes. The EFDA Leader plays a leading role in implementing the European contributions to international collaborations within the scope of EFDA. In particular he acts as the Euratom ITER Home Team Leader.

Organisation of activities under EFDA



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Steady state comes closer: new results from TCV

One of the intrinsic limitations of the Tokamak is its large plasma current which is driven by transformer action. Since we learn at school that a transformer does not work with d.c. current, it is believed that a Tokamak cannot be operated in steady state.

Wrongly so, because years ago JET and Tore Supra demonstrated that the entire plasma current can be driven by injecting radio-frequency waves into the plasma. The so-called lower hybrid wave current drive has been demonstrated for minutes on the large JET and Tore Supra and even for hours on the small Japanese Triam-1M Tokamak.

Now the scientists from the Association Euratom-Suisse which is based at Lausanne's CRPP have demonstrated on their Tokamak TCV (Tokamak à configuration variable) that also much higher frequency waves can do the same, using electron cyclotron current drive (ECCD). With three 0.5 MW gyrotrons at 83 GHz they succeeded in producing 2-second long periods of continuous plasma current. The plasma is stable and attains high temperature and density. The duration is presently limited by the microwave sources but longer pulse tubes will become available in the future.

US scientists congratulated the Swiss-European Team: "It is the best demonstration so far" for ECCD, says Tony Taylor from General Atomics in San Diego according to *Physical Review Focus.* Others call it significant because it is the first proof that ECCD could work under realistic conditions. The results will appear in Vol. 84 of Physical Review Letters.

ECCD has the particular advantage that the current drive can be targeted to specific locations which allows its use also for the control of plasma instabilities.

An important step has been made in the TCV Tokamak towards steady state operation of a Tokamak. (picture: the plasma vessel of TCV)

Soon Mega-Amp Spherical Tokamak plasmas: Mast starts physics operation

A rapid start-up has been achieved on MAST, the spherical Tokamak at the Association Euratom-UKAEA. MAST, which carries the research done on the START device forward to higher temperature plasmas, has recovered from the manufacturing problems of the central solenoid. The first months of operation show excellent confirmation of the expectations.

Spherical Tokamaks help understanding the physics involved in all Tokamaks and have an interesting perspective as concept improvement of the Tokamak.

Stimulated by Spheromak research, experiments started with small university devices in the mid-eighties, pointed to the high pressure and stability of these plasmas. START, at the end-eighties and in the nineties confirmed expectations and achieved record values in plasma pressure.

MAST and TCV show that Tokamaks have attractive physics perspectives.

DIII-D confirms higher-density operation than so far thought possible

Fusion power goes up with the square of the plasma density if other parameters are held constant. Therefore the maximum plasma density is a crucial parameter for the future economic optimisation of fusion power plants. Researchers at DIII-D in San Diego (General Atomics) have now confirmed plasma operation with densities well above the Greenwald density. Sofar this was an empirically observed limitation to high density operation in standard Tokamak scenarios although a German-Dutch-Belgian team on TEXTOR, the Tokamak in Jülich, had already earlier achieved similar results though on a device without a divertor. The clue to the success is in both cases to control the hydrogen gas density at the plasma boundary. This is done at DIII-D with a novel method of pumping.

This is excellent news for ITER since it confirms that the density projections used in the design are realistic.

The Greenwald density has proven not to be a limit. US researchers on DIII-D (San Diego) confirmed operation at higher plasma densities. The key to success is: to control the boundary. (Photo: Courtesy General Atomics)

EFDA

European Fusion Development Agreement

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EFDA parties are the European Commission and the Associates of the European fusion programme which is co-ordinated and managed by the Commission.

http://EFDA.ipp.mpg.de

Within the context of the long-term objectives of the fusion activities set out in the fifth framework programme, the aim of the key action fusion is to further develop the necessary basis for the possible construction of an experimental reactor (the "Next Step"), with the objective of demonstrating the scientific and technological feasibility of fusion power production as well as its potential safety and environmental benefits. In the longer term, the programme will prepare for the development of a demonstration reactor (DEMO). This activity will be accompanied by relevant physics and technology R&D activities, also involving European industry.

EFDA is organised as an agreement between Euratom (represented by the European Commission) and the Associates of the European fusion programme. EFDA:

- *Co-ordinates international collaborations and Interfaces the European contribution to the ITER Engineering Design Activities (Close Support Unit at Garching);*
- *Manages the scientific exploitation of the JET facilities (Close Support Unit at Culham);*
- *Co-ordinates the European fusion technology activities (Close Support Unit at Garching).*

Fusion: A European Research Area in a specific domain

Fostering the integration of European Research and thereby setting free synergy and strengthening the European position in world-wide research and development is a key objective. Europe must not scatter its strengths and must develop a first class research infrastructure including high-speed networking, create centres of excellence and enhance the joint European spirit of all its researchers and research organisations.

Fusion, driven by the sheer impossibility for any of the European Member States to attack this complex domain individually, has for decades developed a fully European approach where the European Fusion Programme speaks world-wide with a single voice. By combining its strengths, the Member States with the Community were able to build JET and a series of powerful specialised devices and facilities which support the fusion development in particular physics and technology areas and stimulate the education and training in an integral European fashion.

Fusion has for a long time, with its clusters around large facilities and in particular with JET, created centres of excellence. As a consequence of this dedicated, fully European approach the European Fusion Programme is recognised world-wide as a leader in the development of fusion which aims ultimately at a new, attractive and environmentally benign energy system. The European collaboration in fusion has maintained its strength over the past decades driven by its own success and by the increasing conviction of the need of fusion as an environmentally friendly and societally acceptable energy system. With the approach towards the scientific and technological demonstration of the feasibility of fusion and the challenge to succeed in building the next Step, the European Fusion Programme, with EFDA, is further increasing its tight collaboration among all its partners and improving its infrastructures.

Thus, Fusion, in a specific R&D domain, demonstrates what could be achieved in a much wider range through a European Research Area.