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newsletter

EUROPEAN FUSION DEVELOPEMENT AGREEMENT

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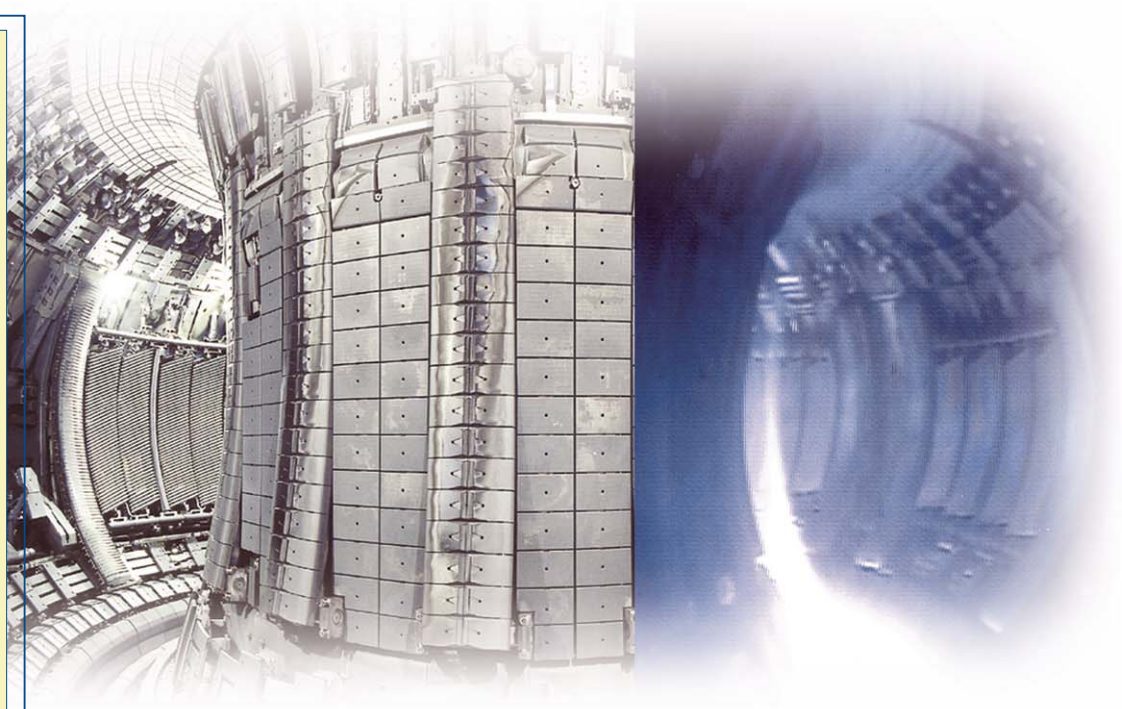
Contents

http://www.efda.org

News

Reinforcing JET capability to prepare ITER operation

After the most demanding operation period in the JET history with 3717 pulses and a Trace Tritium Experiment in 2003, a 12 months maintenance period started on 6th March 2004, aiming at reinforcing to the capability of JET to prepare ITER operation. The heating power will approach 40 MW, in particular with the installation of an ITER-like ICRH antenna. The geometry of the divertor will be modified to allow greater flexibility in plasma configurations, in particular in producing high-triangularity ITER-like scenarios at higher plasma current, i.e. closer to ITER plasma regimes. Finally, a new set of diagnostics will come into operation designed to address a number of crucial phenomena for ITER operation, from the physics of the power handling to the tritium retention.



ITER Competitiveness Council

At the press conference after the Council of Ministers meeting on the March 11, 2004, Commissioner Philippe Busquin commented that “Europe is the world leader on fusion; our candidature is the best,” when asked about the progress on the ITER negotiations. His statement was supported by the Irish government, who currently holds the rotating EU presidency, and the French research minister Claudie Haigneré who underlined the importance of ITER for maintaining the competences of the European fusion scientific community. ITER in Europe will contribute to the drive of establishing Europe as a knowledge based economy providing the best environment for young researchers.

Interview

Prof. **Nebojša Nakićenović** is project leader for Transitions to New Technologies (TNT) at the International Institute for Applied Systems Analysis (IIASA) in Laxenburg and Professor of Energy Economics at Vienna University of Technology (Austria).

Find a short CV of Prof. Nakićenović on our Website:

http://www.efda.org

Future energy perspectives - How to cope with the uncertainty?

EFDA Newsletter (EN): *Past warnings that the world will soon "run out of oil" have been compared with Æsop's* fable of the shepherd's boy who cried, "Wolf!". To date, the warnings – as in the fable - have proven to be unfounded. But in your opinion will technology advance rapidly enough to extend oil resources and facilitate a smooth transition to other energy sources?*

N. Nakićenović ***(NN):*** Definitely yes. One has to distinguish between reserves and resources. Most of the concern has been about reserves, which are usually defined as the amount of oil that can be extracted with the current knowledge, technology and costs. That amount lasts historically 40 to 50 years. The other concept, the resources, is where there is a lot of confusion. The resources are much larger but they have either not been discovered, just inferred, or too expensive to extract them or we simply don't have the technology. Over the years there has been a transfer from resources to reserves, this is why we have always had a limited amount of oil reserves. Indeed the current reserves will run out by the middle of the century, but they will be replenished with what we currently don't consider to be reserves, either conventional or unconventional resources. Another big future option is natural gas and other energy gases that might be produced from non-fossils. Gas is much more abundant than oil, and doesn't cause as many environmental problems.

EN: *The impression nowadays is that the problem of the limited resources is secondary to the environmental issue. Do you share this idea?*

NN: Absolutely. I think if the question was asked "what's the ultimate limitation to energy use?", my answer today is: generally of course technological change, but the ultimate limitation are the planetary processes. Humanity is already influencing planetary processes and energy is a big part of that equation – carbon dioxide emissions and climate change is the ultimate limit, not how much energy we can extract. Paul J. Crutzen, who won the Nobel prize in Chemistry in 1995, suggested to call this period in the evolution of earth "Anthropocene" to characterise this immense influence of humanity on the planet itself and on the planetary processes and systems. So the environment and the limitations of our planet are indeed the major obstacle to further increase the energy use as we have known it historically.

EN: *Do you think that a complete switch out of fossil fuels will happen before they run out?*

NN: Generally we switch to new technologies because they provide new opportunities, have characteristics that the society needs, not because they physically run out. Important reasons are climate and environment and the need for a very much larger concentration of energy.

EN: *These days, most "shepherd's boys" follow the principle "The best way to predict the future is to invent it". What can you predict for the world's future energy supply from the viewpoint of your TNT project?*

NN: We really cannot 'predict' future energy use, we 'invent' it through scientific scenario analysis. One of the major challenges in energy is that 2 billion people today do not have access to modern energy services and there will be more people in the world, so we have to at least double, triple or quadruple energy service, let's say over the next century. From my point of view a scenario that would be interesting is timely provision of adequate energy services and affordable ones, without adversely affecting human life and protecting the environment. I think there will be three sets of technologies for that. The most important one from current perspectives and economically most attractive is actually improving energy efficiency and rational use of energy. The second option is shifting to non-carbon energy sources, away from fossils. And the third set of options are to remove carbon from the fossil fuels and hydrocarbons, that means carbon separation, either prior to combustion or conversion, or post combustion. We already have technologies for that, for example separation of CO_2 from energy gases, such as natural gas or synthesis gas, that could be generated from coal through steam reforming and a shift reaction resulting in production of hydrogen as a clean energy xcarrier. Another option is to remove carbon after electricity is produced from power plants.

*Æsop: Greek writer, lived around 620 – 560 BC

Find the fable on:

http://www.pacificnet.net/~johnr/cgi/aesop1.cgi?sel&TheShepherdsBoyandtheWolf

In both cases you have to store carbon over geological times, for example in the deep underground saline aquifers or depleted oil and gas fields.

EN: *What can you say for the future energy supply for developing countries such as India or China, where 2/3 of world's population live?*

NN: I would call the challenge facing China and India "leapfrogging challenge", like when children jump over each other. Both will need to adopt most modern technologies, rather than repeat our development paths. So the type of technology I was talking about would be suitable also for China and India, but they will need large grids and networks to transport electric power in the order of 20 GW per year over the next decades. Infrastructure investment in large energy systems that would be based on clean fossils and renewables and nuclear – both fission and fusion – are the options for those countries as for the rest of the world.

EN: *In your book "Global Energy Perspectives" *, you identify six alternative long-term energy issues, which all require substantial early investments. In your opinion which of these should be developed with most urgency to avoid the "wolf" arriving at the door?*

NN: One of the urgent needs in the developing countries is – and I think we are not addressing this enough – to replace the traditional energy use like biomass, used in inefficient cooking stoves, by modern energy use, because this inhibits development and because women and children suffer from the resulting indoor air pollution. This usually doesn't require enormous investments, but quite a lot of capacity building, education and experience. Many of the renewable technologies can help in a decentralized manner. At the global level, also in the industrialized countries, I think number one priority is to increase investment in both research and deployment of new technologies and infrastructures, and also in reliability and security of the energy system.

Factors of Growth: The Last 200 Years

	1800	2000	factor
World population, billion	1	6	X 6
Life expectancy, years	35	75	X 2
Work hours per year	3,000	1,500	÷ 2
Free time over life	70,000	300,000	X 4
Mobility, km/day (excl. walk)	0.04	40	X 1000
World income, trillion $	0.5	36	X 70
Global energy use, Gtoe	0.3	10	X 35
Carbon, energy, GtC	0.3	6	X 22
Carbon, all sources, GtC	0.8	8	X 10

Source: IIASA 2001

EN: *In the fable, the wolf finally did appear, but townspeople, assumed yet another false alarm and failed to respond to the real danger leaving the sheep to be devoured. How will your TNT case studies help technology to transform society to stay sensitive to warnings, while responding to the needs of the developing countries?*

NN: Along these lines our interest in TNT is to get a slightly better grasp on both how much we can expect to increase widespread diffusion of new and advanced technologies in particular in developing countries, and also come to get to grips with the enormous uncertainty in technological change. We can't predict which of the technologies will be successful. But the question is: how to cope with uncertainty? We need to make sure that we have sufficient investment in new technologies that some of them, if successful, will actually be able to diffuse.

Interview: D. Lutz-Lanzinger

IIASA is a non-governmental research organization and conducts inter-disciplinary scientific studies on environmental, economic, technological and social issues in the context of human dimensions of global change.

Find more information on:
http://www.iiasa.ac.at/
and the TNT website on
http://www.iiasa.ac.at/Research/TNT/index.html?sb=1

You would like **more information** on energy? Visit the homepage of the Energy Economics Group of **Vienna University of Technology** on:

http://www.eeg.tuwien.ac.at/

* Global Energy Perspectives, edited by N. Nakićenović et. al., Cambridge University Press (1998)

Price: about $45.00
ISBN 0 521 64200 0 hardback
ISBN 0 521 64569 7 paperback

The main function of the **ITER divertor** is to exhaust the major part of the alpha particles power as well as helium and impurities from the plasma. The divertor must tolerate high heat loads and contribute in providing neutron shielding for the vacuum vessel and magnet coils. Most of the plasma-facing surface has tungsten armour whereas carbon fibre reinforced carbon is envisaged for the strike point area.

ITER

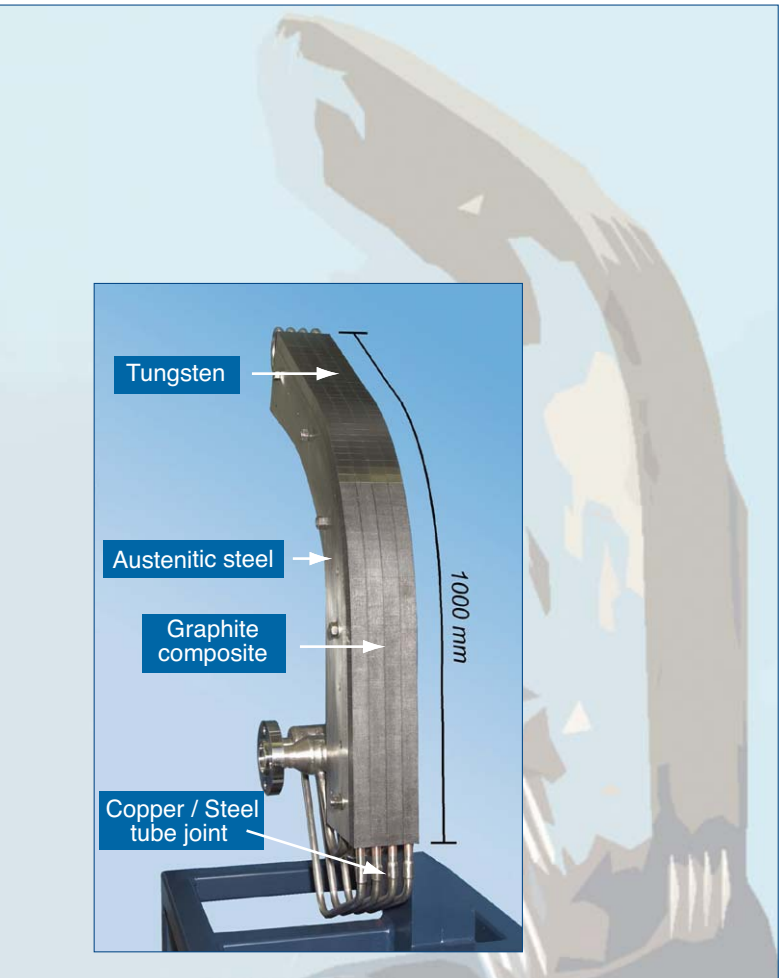
EU Vertical Target Full-Scale Prototype performs above ITER Requirements

A significant R&D effort was carried out by EU Associations and Industries during the ITER EDA (Engineering Design Activities) period to develop suitable technologies for high heat flux components. This joint effort culminated in the successful manufacturing and testing of a medium-scale vertical target prototype. On the basis of this experience, the manufacturing of a near full-scale prototype was then launched and completed during the ITER CTA (Coordinated Technical Activities) period. The high heat flux parts of this component were fabricated by the Austrian company Plansee and the steel supporting structure and the final integration of the high heat flux parts onto it were carried out by the Italian company Ansaldo Ricerche.

The prototype consists of four units having a full monoblock geometry, obtained by drilling a hole into each plasma facing tile (the “armour”). The cooling tube is then inserted and the parts are joined. The lower part of the prototype has a carbon fibre reinforced carbon (CFC) armour, grade NB31, supplied by the French company Snecma Propulsion Solide. This composite material is the outcome of an extensive R&D effort carried out by EFDA aimed at developing suitable CFC materials with a three-directional fibre structure, a high thermal conductivity, and an appropriate balance of the mechanical properties. The upper part of the prototype has a tungsten armour, as required by the ITER design. The main critical issues were:

- the large thermal expansion mismatch between the armour and the cooling tube made of copper alloy CuCrZr;
- the requirement for two different armour materials on the same component; and
- the preservation of the thermo-mechanical properties of the CuCrZr during the whole process.

The joint interface-stress between the armour and the heat sink was mitigated by the introduction of a thin (1-2 mm) pure copper (Cu) interlayer. The development of the CFC/Cu joint was one of the most challenging R&D efforts carried out within the divertor area. “Active Metal Casting”, developed by Plansee, which involves casting Cu onto the CFC surface, was used to obtain this joint. The CFC is first “structured” by a laser beam to improve the joint strength, and the surface is then “activated” to facilitate wetting. The Cu/CuCrZr joint was accomplished using a so-called “low temperature” hot isostatic pressing technique also developed by Plansee. Solution annealed, water quenched CuCrZr is used as a starting point for the manufacturing process. Both the joining of the CuCrZr onto the Cu and its required “ageing” is combined into one single step carried out at 550 °C.



The full-scale prototype was tested in the high heat-flux FE200 electron beam facility at Le Creusot in France. The CFC part was successfully tested up to 1000 cycles at 20 MWm^{-2} followed by an additional 1000 cycles at 23 MWm^{-2}. This is well beyond the ITER design target of 300 cycles at 20 MWm^{-2}. The W monoblock section endured up to 1000 cycles at 10 MWm^{-2} of absorbed heat flux (that is about half of the actual incident heat flux). This value is one order of magnitude higher than the ITER design target for the upper part of the ITER vertical target.

“The manufacturing of this worldwide unique component and the achieved results are the reward for several years of dedicated effort by EU Associations and Industries.”, said Mario Merola, Responsible Officer for divertor technology at EFDA-CSU Garching (Germany). “It clearly demonstrates that the EU already possesses the technologies to contribute to

the most critical components of the ITER divertor." However, these results, while certainly encouraging, cannot represent the end of the story. Work still needs to be done to bridge the gap between the demonstrated capabilities at the prototypical level and the required series production for ITER. Important issues needs to be addressed, such as the definition of practical "acceptance criteria" for the manufacturing of these plasma-facing components, the development of suitable repairing procedures in order not to have to scrap all flawed components during manufacture, the integration of diagnostics into these delicate parts, as well as their final assembly onto the cassette body. "We at EFDA are eagerly awaiting the day ITER becomes a reality and we can put into practice all the knowledge and experience that we have gained in the past years", said Merola.

FE200 is a high heat flux testing facility located at Le Creusot (France) and is operated by AREVA - Framatome ANP and Association Euratom-CEA Cadarache. It is used to simulate the cyclic thermal loads, which act on the plasma-facing components of a fusion reactor. The heat flux is obtained by a 200 kW electron beam gun and can be varied over a wide range of pulse durations and power densities.

Associations

Re-opening of the RFX facility

On 6 November 2003 the ceremony for the re-opening of the RFX facility took place in Padova (Italy), upon conclusion of its reconstruction.

The opening was attended by the Major of Padova City, Mrs. G. Destro, the President of Confindustria Veneto (the regional industrial federation) Dr. L. Rossi Luciani, as well as by cultural and industrial representatives.

Introductory remarks were given by the partners of Consorzio RFX (CNR, ENEA and Università di Padova), represented by the Commissioner of CNR, Prof. A. De Maio, the Rector of the Padova University, Prof. V. Milanesi, and by the Director of ENEA UTS Fusion, Dr. M. Samuelli. Euratom was represented by the EFDA Associate Leader for Technology, Dr. R. Andreani.

Prof. F. Gnesotto, Head of the Padova Research Unit and Director of Consorzio RFX, presented the most significant technological aspects of the new facility and the modified machine, together with the key elements of the scientific programme to be performed on RFX.

Prof. G. Rostagni, President of Consorzio RFX, described the reconstruction with its difficulties and successes and in particular stressed the dedicated commitment of the whole research team and the industries involved. Thanks to their effort, the future for RFX now offers more operational flexibility.

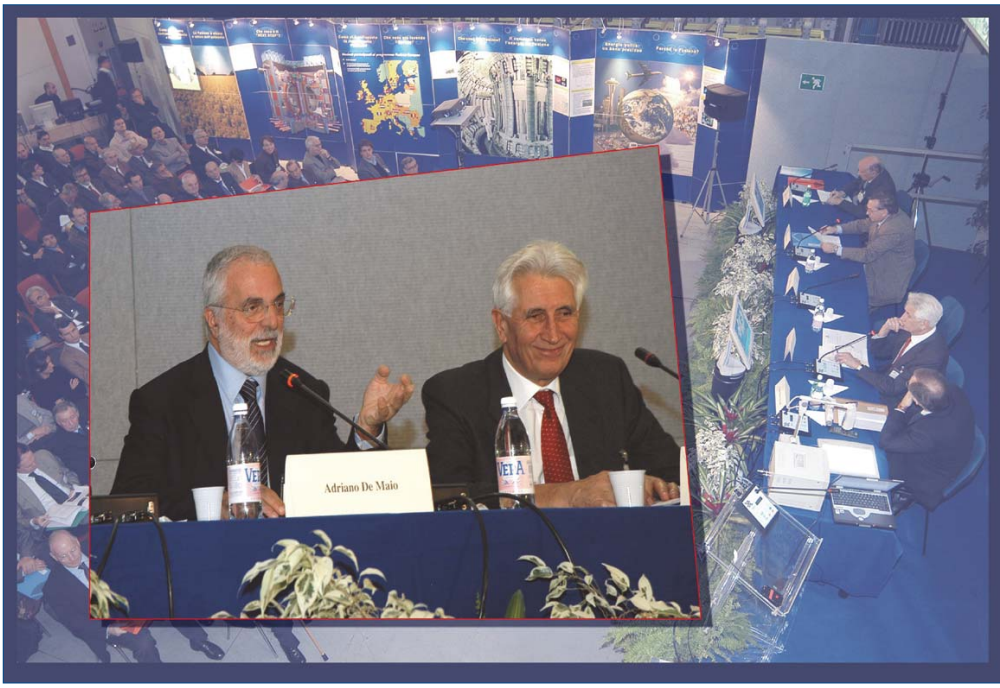
Collaboration between industry and research was the theme of the presentations that followed; in particular the importance of a strategy towards a greater synergy among research, industry and economy was emphasised by Prof. De Maio.

On visiting the new facility, the participants to the event could appreciate the results of the activity undertaken by the RFX team who, after the fire of December 1999, promptly reacted with strong determination.

The event was an opportunity to thank those who gave their contribution to the success of the reconstruction and improvement of the RFX device.

For **more information** see:

http://www.igi.cnr.it



Re-opening of the RFX facility: Prof. A. De Maio and Prof. G. Rostagni

JET

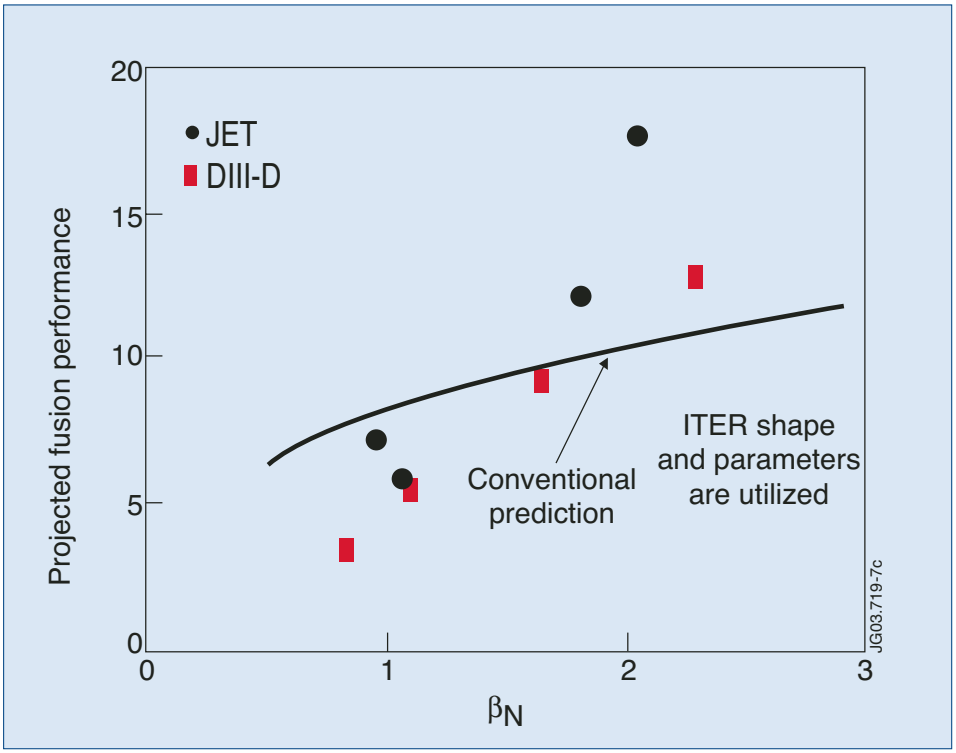
In 2003 collaborations were established between EFDA-JET and two new international partners, the Russian Federation and the People's Republic of China while collaboration with long-standing international partners US and Japan continued in full swing.

International collaboration brings a taste of ITER to JET

As many as 12 Russian scientists visited EFDA-JET during the last quarter of 2003.They installed hardware on the JET machine, worked on software development and participated in experiments. One of the areas they concentrated on was the detection of neutrons, which are born in fusion reactions, and then escape from the plasma, carrying valuable information about conditions inside the plasma. JET is already equipped with several neutron detection systems, and the goal of the collaboration with the Russian Federation in this area was twofold: to make faster measurements so that the effect of various fast events in the plasma on the fusion reaction rate could be studied, and to test a compact neutron detection system. Other aspects addressed in the collaboration included improvement of a system to measure tritium concentration with improved sensitivity, and to study plasma flows and energy transport. The success of this work has led to proposals for further collaboration which will be reviewed in May 2004.

In the first collaboration with the People's Republic of China, a Chinese scientist visited JET for 3 months during September 2003 – February 2004 bringing expertise on mechanisms for electron heat transport in JET plasmas dominated by electron heating. Further visits by Chinese scientists to EFDA-JET are under discussion.

Collaboration with the US and Japan in 2003 focussed on 'joint experiments' which have the potential to uncover new physics via co-ordinated studies spanning the combined operating space of participating tokamaks. 28 such experiments have been selected by leaders of large fusion facilities for execution in 2004. 50% of personnel assignments between the EU, US and Japan under a major collaboration agreement are now associated with such experiments. The scientific areas covered correspond to those identified as having high priority for research because the results could refine the ITER design. In the area of confinement physics, one such joint experiment shows that plasma performance (proportional to fusion gain) increases faster with increasing β (proportional to plasma pressure) than predicted by the scaling law used in the ITER design (see figure). The experiments were performed using the ITER plasma shape in the two participating tokamaks, DIII-D and JET, which differ in linear dimensions by almost a factor of 2. Both machines confirmed the more favourable dependence on β, leading to high confidence in the validity of the result.



Results from joint experiments on JET and DIII-D showing that fusion performance (proportional to fusion gain) increases with β (proportional to plasma pressure) more rapidly than the conventional prediction used for the design of ITER. This will be studied in more detail in 2005.

The US is also collaborating in four important activities under a bilateral agreement between EURATOM and the USDoE. These include three of the 16 diagnostic enhancements which

will be installed on JET this year and used in the Experimental Campaigns of 2005. These three diagnostics are: a system to detect and characterise the loss of fast particles from the plasma (including fusion-born α-particles) and particles accelerated to high energy by ion cyclotron resonance heating; an upgraded system for improved measurements of the ion temperature profile, plasma rotation and plasma purity, with higher sensitivity , and a high-resolution system with broad coverage for improved electron temperature and density measurements to study barriers to energy transport in the core and the edge. The US contribution includes hardware design and procurement, and system commissioning. The fourth activity involves tests of a high-power prototype radio-frequency antenna, aiming at long-pulse operation at high voltage. This test is providing extremely valuable input to the development of an antenna based on the ITER design, which will be tested on JET.

Events

23rd SOFT: from Helsinki to Venice

The traditional appointment with the biennial Symposium on Fusion Technology conference comes this year to Italy.

The 23rd SOFT will be held in Venice, from 20 to 24 September 2004, in the Giorgio Cini Foundation, on San Giorgio island, just in front of San Marco square. A truly wonderful venue for this event.

Responsible for the conference organization is Consorzio RFX, the Padova Research unit of the Euratom-ENEA Association.

Scientists and engineers will meet to exchange information on design, construction and operation of fusion experiments and on the technology for present fusion machines, the next step and power plants. Industry will participate as well through an industrial exhibition, to present the issues and results of their collaboration to fusion research. An R&D exhibition will be devoted to the presentation of the activities in the European Associations.

The very special venue shall help focusing the media attention to fusion as an important and eco-compatible energy source compatible with a sustainable development, specially with the expected decision on ITER construction.

23rd SOFT information:
http://soft2004.igi.cnr.it
E-mail: soft2004@igi.cnr.it

Conference Guide 2004

May 24 - 28	16th International Conference on Plasma Surface Interactions (PSI)	**Portland, MA (US)**
June 28 – July 2	31st EPS Conference on Controlled Fusion and Plasma Physics	**London (UK)** http://www.mpq.mpg.de/BPIF/London-and-beyond.html http://groups.iop.org/PP/EPS.html
September 20 - 24	23rd Symposium on Fusion Technology (SOFT)	**Venice (Italy)** http://soft2004.igi.cnr.it/Registration.html
November 1 - 6	20th IAEA Fusion Energy Conference	**Vilamoura (Portugal)** http://www.cfn.ist.utl.pt/20IAEAConf/Announcement.htm

EIROforum

Serving European Science

When seven leading European Intergovernmental Research Organizations (EIRO) decide to merge their forces for strengthening European science, it is indeed a major positive event for Europe. Their expertise in running world leading facilities in the fields of space, astronomy, biology, energy, particles physics, neutronics and radiation supports Europe's competitiveness in research.

The seven EIROs are world leaders within their respective field of science and their names are well known all around the world: the European Organization for Nuclear Research (CERN), the European Fusion Development Agreement (EFDA), the European Molecular Biology Laboratory (EMBL), the European Space Agency (ESA), the European Southern Observatory (ESO), the European Synchrotron Radiation Facility (ESRF), the Institut Laue-Langevin (ILL).

These seven member organisations constitute the vanguard of European science, enabling European scientists to engage in truly cutting-edge research and be competitive on a global scale.

Physics demonstration at the Physics on Stage 3 festival

A primary goal of EIROforum is to play an active and constructive role in promoting the quality and impact of European research. In particular the group mobilises its substantial combined expertise in basic research and in the management of large international infrastructures, facilities and programmes, for the benefit of European research and development. Furthermore EIROforum has developed a suite of educational programmes and public outreach activities, often in collaboration with the European Commission, and carried out by the Communication and Education departments of the partner organisations. Working in close dialogue both with the European Commission and national institutions, the EIROforum member organisations play a vital role in forging collaborations on a continental scale.

EIROforum is the main engine behind important initiatives such as Physics on Stage, a festival gathering each year about 400 teachers from 23 European countries. In such events the member organizations promote the exchange of information among educators, new teaching methods and tools and give a direct access to the cutting-edge research which is carried out daily in their laboratories. The words of EU Commissioner P. Busquin properly summarise the aims of EIROforum and its role in the European society: "EIROforum, in collaboration with the European Commission, will play a decisive role in promoting the quality and consistency of European research."

Find **more information** on:

http://www.eiroforum.org

http://www.physicsonstage.net

http://www.cern.ch

http://www.embl.de

http://www.esa.int

http://www.eso.org

http://www.esrf.fr

http://www.ill.fr

The 2005 World Year of Physics:

http://www.wyp2005.org

Meet EIROforum at the following forthcoming events:

- EuroScience Open Forum (Stockholm, August 2004)
- European Science and Technology Week (November 2004)
- Science on Stage (Spring 2005)

and all throughout 2005 for the World Year of Physics.

For more information see our EFDA website:

http://www.efda.org

and additionally

http://www.jet.efda.org
http://www.iter.org

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