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# newsletter

EUROPEAN FUSION DEVELOPEMENT AGREEMENT

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## News

### ITER: Third Negotiation Meeting

Delegations from Canada, the European Union, Japan and the Russian Federation met in Moscow on April 7-12, 2002 to continue formal negotiations on the joint implementation of the ITER project. This was the third Negotiation meeting in a series that is expected to lead, by the end of 2002, to the text of an international agreement for the joint implementation of ITER.

The delegations discussed a number of technical issues such as the site selection process, approaches to the procurement allocation, and the structure of the eventual international organization of ITER.

The European Union Delegation reported that there has been a decision by the Spanish Government to offer a candidature for the European siting of ITER at Vandellós, near Barcelona. The licensing procedure concerning the possible siting of ITER in Cadarache has been launched. The European Delegation said that once it has a full negotiating mandate, the EU proposal(s) would be submitted to the other Delegations for consideration.

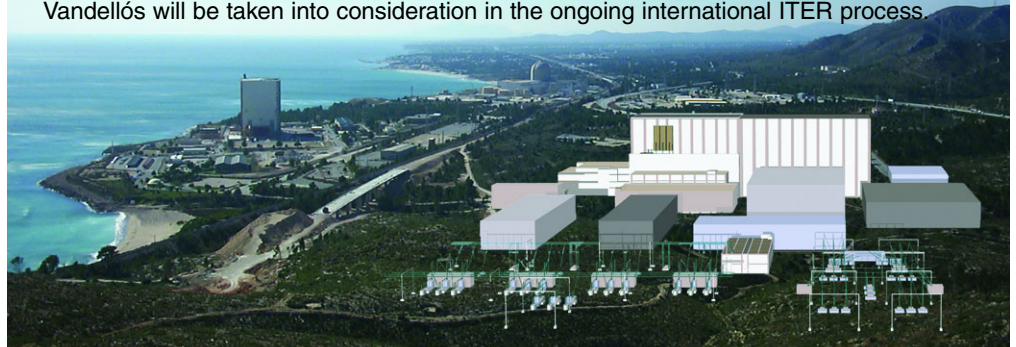
**The next meeting of the Negotiators will be held in Cadarache, France, on June 4-6, 2002.** For the full text of this press release see our web site!

### France confirms proposal of Cadarache to Host ITER

The former French Minister of Research, Roger-Gérard Schwartzberg, has written, on May 3rd, to Commissioner Busquin to thank him for his reply to the request formulated by France at the December Research Council. He also notes the Spanish declaration as a new manifestation of the strong support of the EU member states to fusion research as already expressed several times at the Council level. In this context and in view of the negotiation meeting to be held in Cadarache on June 4th, he does confirm his letter of December 7th, 2001 concerning the proposal of Cadarache as a possible European site for ITER. He stresses the strong support to the Cadarache candidacy from the regional authorities as well as from the French scientific community.

### Spanish government offers Vandellós as ITER site

On April 17th, the Government of Spain formally offered to the European Union its site at Vandellós to be evaluated as a possible European site for ITER. This proposal results from the technical and socio economic study co-ordinated by CIEMAT in collaboration with several institutions and industry. The Government also requested that Vandellós will be taken into consideration in the ongoing international ITER process.



<http://www.efda.org>

For more information see:

EFDA Newsletter  
Vol. 3/Dec. 2001 and

<http://hbksun17.fzk.de:8080/PKF/welcome.html>

**ITER SEVEN LARGE R&D PROJECTS**

- Central Solenoid Model Coil - L1
- **Toroidal Field Model Coil - L2**
- Vacuum Vessel Sector - L3
- Blanket Module - L4
- Divertor Cassette - L5
- Blanket Module Remote Handling - L6
- Divertor Remote Handling - L7

**Status of the Development of the Toroidal Field Model Coil**

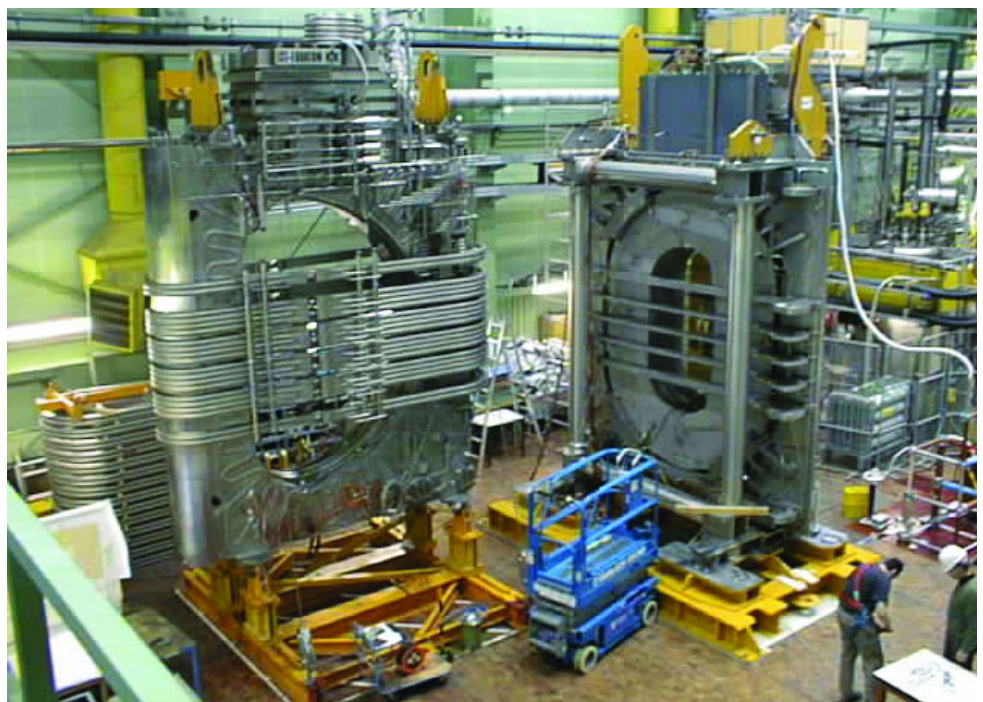
*The Toroidal Field Model Coil (TFMC) is one of the seven large ITER Research and Development (R&D) projects. Its objective is to develop and demonstrate the superconducting magnet technology to a level that will allow the ITER Nb<sub>3</sub>Sn toroidal field coils to be built with confidence. The current of 80 kA reached in this superconducting coil represents a world record.*

The TFMC was built by a European industrial consortium under the supervision of EFDA. The first tests were carried out by the joint European Research and Development Centre "Forschungszentrum Karlsruhe" (Fzk) in Germany. In this phase, the TFMC was installed as a single coil in the TOSKA facility and tested to its maximum current of 80 kA, which was reached for the first time on July 25, 2001. Up to the end of the year 2001, the TFMC was energized 19 times to its maximum current with eight safety discharges made (at this current level) and five following intentionally induced quenches. The maximum magnetic field of 7.8 T and the maximum temperature of 8.7 K were in agreement with the expected values, according to the previous tests of the superconductive strands used for the conductor.

Fifteen joints have been made in the path of the superconducting current between the positive and the negative warm end of the current leads. In the second test campaign, due to start in summer 2002, the already existing European Large Coil Task (LCT) coil will be used as a background field coil to test the mechanical performance of the TFMC. The two superconducting coils have been assembled back to back with a strong intercoil steel structure. At present the TFMC/LCT assembly is being installed in the cryostat of the TOSKA facility and the hydraulic and electrical connections are being finalised. During the second campaign, the maximum magnetic field will increase to about 9.6 T, although the maximum current in the TFMC will be reduced to 70 kA. EFDA Newsletter will follow the tests at the TOSKA facility and will report the results to you in forthcoming issues.

**Features of TFMC**

Height	3.79 m
Width	2.83 m
Diameter	0.78 m
Joint resistances	1.1 nΩ - 1.9 nΩ
Total weight	35 t



LTC coil (left) and TFMC with steel structure (right)

## EFDA at Plansee AG

### European Industry celebrates Full Set of ITER Divertor

On 16 January 2002, an "EU Divertor Celebration Day" with 30 participants was organized at Plansee AG (Reutte, Austria) to mark the end of the successful manufacturing activities (undertaken by EFDA) for the ITER large R&D project on the divertor. Both Plansee AG and Ansaldo Ricerche (Genoa, Italy) contributed to the manufacturing activities.

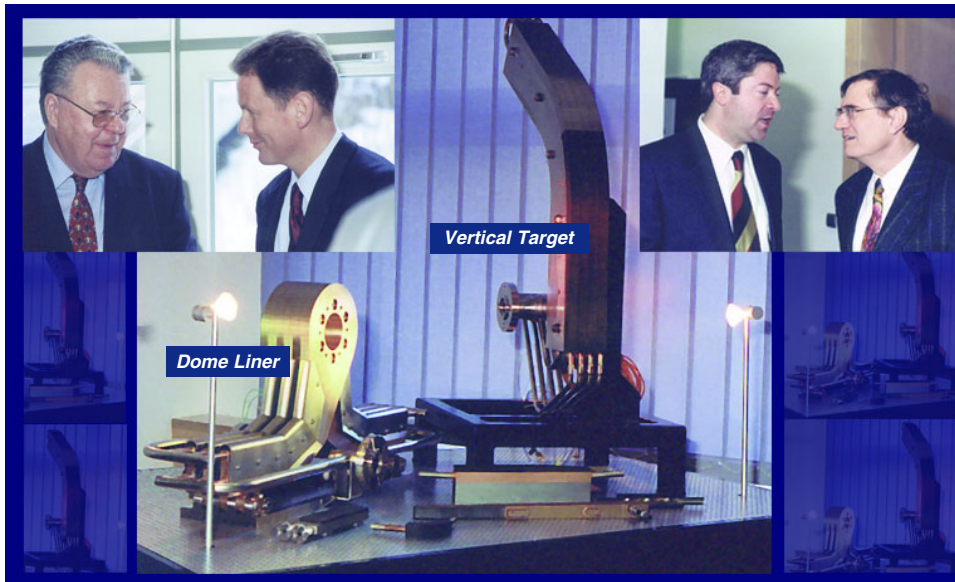
During the ITER Engineering Design Activities (EDA) and the Coordinated Technical Activities (CTA), the EU Party has developed technologies for high heat flux applications, which meet and even exceed the design requirements. The result of this extensive R&D programme was the manufacturing of a complete set of prototypes for each divertor component, namely the vertical target, the dome liner and the cassette body.

*Dr. Robert Aymar*  
(ITER)

*Dr. Michael Schwarzkopf*  
(Chief Executive Officer of Plansee)

*Dr. Mario Merola*  
(EFDA)

*Jacques Schlosser*  
(CEA Cadarache)



Among the participants in the event were Dr. M. Schwarzkopf (Chief Executive Officer of Plansee AG), Prof. A. Airaghi (President of Ansaldo Ricerche), Prof. K. Lackner (EFDA Leader), Dr. R. Aymar (ITER Director), who presented an overview of the ITER project and Dr. R. Andreani (EFDA Associate Leader for Technology), who outlined the activities envisaged on fusion technology during the 6th EU Research Framework Programme. Dr. R. Tivey (ITER Divertor Group Leader) showed the design of the different divertor components and summarized the impressive achievements obtained by the R&D activities carried out within this project. Dr. M. Merola, the EFDA Responsible Officer for Divertor Technology, remarked that the EU has shown a systematic capability to manufacture high heat flux components together with mastering the required non-destructive examination techniques and quality assurance procedures. Prof. Chung Wu, EFDA Responsible Officer for Plasma/Wall Interaction, summarized the EU development work on the carbon composites (reinforced with three-dimensional carbon fibres with high thermal conductivity) required for use in the vertical target.

The results of the event demonstrated, on the prototypical scale, that the ITER divertor can be manufactured. This allows the European Union to start the related procurement as soon as the decision on ITER construction is taken. The time period remaining until then will be used to optimize the fabrication processes and to develop more cost-effective alternatives.

#### For more information see:

<http://www.ansaldo.it/>  
<http://www.plansee.com/english/index.html>

#### Other EURATOM Associations participating to the meeting:

CEA: Commissariat à l'Energie Atomique  
<http://www.cea.fr/>

ENEA: Ente per le Nuove Tecnologie, l'Energia e l'Ambiente  
<http://www.enea.it/>

IPP: Max-Planck-Institut für Plasmaphysik  
<http://www.ipp.mpg.de/>

ÖAW: Österreichische Akademie der Wissenschaften  
<http://www.oew.ac.at/>

#### 1998

The fabrication of the first vertical target prototype, on a medium scale, was completed. It contained all the main features of the corresponding ITER divertor design, and was high heat flux tested up to 20 MWm<sup>-2</sup> for 2000 cycles without failure.

A full-scale section of the outboard divertor cassette body was also completed. This demonstrated the possibility of manufacturing this component by welded forged plates, rather than by casting with a corresponding drastic reduction in costs.

#### 2001

Near full-scale vertical target and dome liner prototypes were delivered.

**50ies:**

The history of ANSALDO Superconduttori S.p.A. starts with the construction of yokes for dipole magnets of the PS at CERN; at that time the name of the Company was ANSALDO San Giorgio.

**70ies:**

The so-called "Magnet Unit" became one of the first European Companies able to design and produce large size superconducting magnets;

**80ies:**

The "Magnet Unit" was organized with independent design and manufacturing teams, in coincidence of important contracts in High Energy Physics & Fusion research.

**90ies:**

Some other products were developed inside the "Unit" with involvement of new important technologies.

**At present:**

ANSALDO Superconduttori is a company of about 80 people, having orders in the research field, where fusion represents about 50% of the total production, starting from 1983 on.

For more information on Forschungszentrum Karlsruhe see:

<http://www.fzk.de/FZK2/english/welcome.html>

**Magnets Made in Italy: The Role of Ansaldo**

Ansaldo (Genoa, Italy) has been involved in the European Fusion Programme since the Eighties, in particular the Magnet Department which is now a separate company named Ansaldo Superconduttori. They manufactured the resistive and superconducting coils for most of the European experiments on fusion, such as ASDEX Upgrade, Tore Supra, Frascati Tokamak Upgrade (FTU) and COMPASS. In the past, Ansaldo was also involved in design and assessment work related to magnet coils for future fusion devices (NET, ALCATOR C, TJ-2). It currently also works as a subcontractor for EFET (European Fusion Engineering and Technology), which is a consortium of nuclear systems companies from seven European countries working on the design, R&D and feasibility assessment of ITER.

The most recent major project for fusion research was the design of the ITER prototype TFMC (Toroidal Field Model Coil), which was issued in 1995. The order for the manufacturing of the coil was awarded to the AGAN consortium (Ansaldo, GEC Alstom, ACCEL, Noell) in 1996. During the AGAN internal discussion, Ansaldo was chosen to undertake the winding react, transfer and impregnation of the TFMC double pancakes. This was one of the more critical jobs in the commissioning schedule, and took into consideration Ansaldo's previous experience in the construction of such toroidal field coils.

Ansaldo started with a series of tests to check the fabrication technology. Several problems had to be solved after the first winding test and during the construction of the dummy pancake and the full scale joint sample. The last of the five double pancakes was delivered to Alstom in May 1999. The final assessment of the design and construction method could only be made some years later with the cold test at FzK (Forschungszentrum Karlsruhe, Germany) where the first cryogenic tests were successfully performed in 2001. During this time, Ansaldo Superconduttori has continued to gain experience in the construction and impregnation of very large superconducting coils (up to 25 m), a very important expertise for the future manufacturing of the ITER coils.



*Ansaldo - DP1; lower pancake inserted, transfer of upper pancake on going. Genoa, 6 April 98.*



*Ansaldo - Insulating DP1.2; Genoa, 6 April 98.*

The company is now involved in the jacketing of 60 m of a NbTi Conductor for the construction of the PF conductor insert coil and in the construction of the non-planar coils for Wendelstein 7-X, again in co-operation with Noell.

## JET

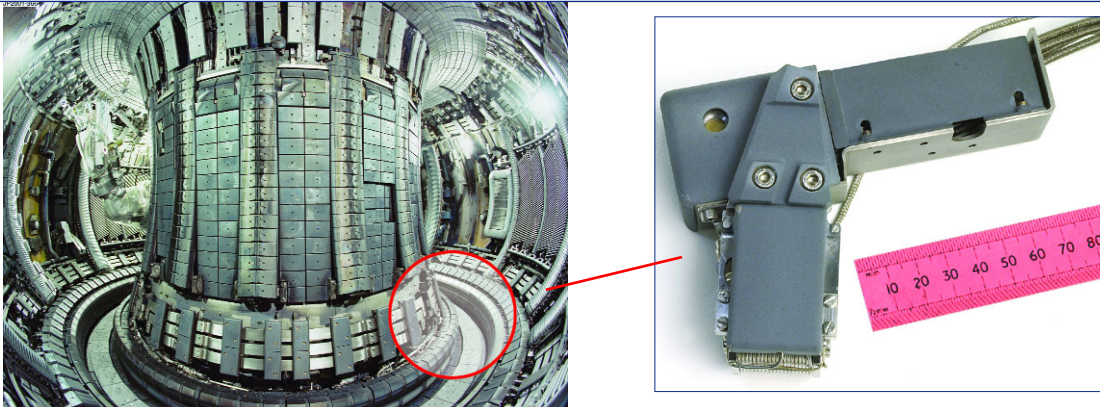
**New Quartz micro-balance device: Successful from shot to shot**

When hydrogen plasma interacts in JET with the carbon divertor target plates, amorphous hydrocarbon films are deposited, particularly in the pump duct region of the inner divertor. These films can trap large quantities of tritium and are therefore a key area of research in support of ITER, due to safety related restrictions on the quantities of tritium which can be retained in the ITER torus.

The traditional method for measuring film growth has been to analyze tiles removed from the JET torus during a major shutdown. Surface analysis provides valuable data on long term evolution and composition of surface layers but it is difficult to tell which type of discharges contribute most to the measured deposits.

The quartz micro-balance (QMB) device has been developed through an EFDA-JET enhancement project and preliminary results show that it can measure deposition on a shot to shot basis with a resolution of around one monolayer ( $\sim 10^{-10}\text{m}$ ). This novel device is based on a quartz crystal oscillator circuit originally developed to measure the pressure in oil wells. At its heart is a high temperature application-specific integrated circuit (ASIC) which is mounted close to the measuring crystal and must survive the harsh conditions inside the JET torus. The hardware was largely designed and assembled at JET by G. Neill and D. Wilson (UKAEA) and calibrated and tested at Forschungszentrum Jülich (Germany) by G. Esser. The system was successfully commissioned at the start of JET Campaign 5 (C5, 18 March – 31 May 2002) and is now being used as part of the physics programme by the Exhaust Physics Task Force.

The **QMB assembly** was mounted in JET during the last shutdown. The shutter, which normally protects the quartz crystal, is shown in the open position. Before a JET pulse the resonant frequency of the crystal is measured with respect to an internal reference. During the pulse the shutter is opened to expose the crystal during a specific part of the discharge and after the pulse the frequency is again measured. This resonant frequency decreases as the mass of the deposit increases.

**New spectrometer installed for the study of pellet ablation**

A new spectrometer, provided by the Plasma Physics Laboratory of Princeton University (New Jersey, USA), has been installed during the last shutdown at JET.

This new instrument provides a detailed spectrum of the pellet ablation light and allows improved studies of the processes involved in the ablation of injected pellets.

It has recently been commissioned successfully and the result of first measurements during pellet injection experiments in Campaign 5 (18 March – 31 May 2002) are promising. For example the line width of the spectrum, which is broadened by the Stark effect, delivers information on the density of the pellet ablation cloud. The spectrometer can also measure the ratio of the intensities of the  $D\alpha$  and  $D\beta$  lines, which reflects the electron temperature of the pellet ablation cloud. Thus simultaneous time resolved measurements of the electron density and temperature of the pellet cloud are now possible for the first time at JET. This will provide significant additional data for use in the modeling of the ablation of a pellet and of the drift of the ablated pellet mass in the plasma.

**Pellet Injection:**

Firing little cubes ('pellets') of frozen deuterium or deuterium-tritium mixtures into the plasma to increase its core density.

**More information about the Plasma Physics Laboratory of Princeton University:**

<http://www.pplpl.gov/>

**Features of the Error Field Correction Coils Project**

Area enclosed by the loop	6 m <sup>2</sup>
Toroidal angle (each)	70°
Number of turns	16
Cable area	150mm <sup>2</sup>

**Locked modes** are Magnethydrodynamic modes that cease rotating (though they can still grow).

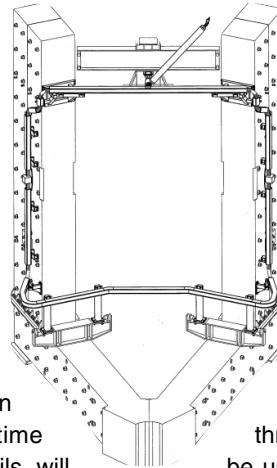
**Neo-classical tearing mode:** The magnetic island produced by a tearing mode perturbs the bootstrap current which further amplifies the island and degrades confinement or leads to a disruption.

**TAE** means Toroidal Alfvén Eigenmode, which is a fast particle driven instability.

**News from Error Field Correction Coils Project**

Non axi-symmetric magnetic fields can be responsible for the onset of large locked modes in tokamak discharges, which in turn often trigger disruptions.

The internal saddle coils on JET have been used to study the generation and correction of error fields. However, these internal coils had technical problems and therefore a new set of external correction coils were proposed as an EFDA enhancement project. The installation of the coils started and two coils have remaining two coils 2002 intervention.



The new set of 4 used to replace the AC (alternate current) saddle coils for the error fields, and the modes. The internal TAE studies, which frequency - this functional error field correction field penetration time

The correction coils will (which arises from machine asymmetries), to ameliorate its effect, and to control the level of the error field so that the threshold level can be studied as a function of plasma parameters. It is important to understand this process since the maximum tolerable error field decreases with the machine size and the permitted value on ITER is close to the value that is likely to be generated by anticipated machine asymmetries.

external, non-symmetric coils can be DC (direct current) and low frequency (alternating current) function of the existing internal generation and correction of static seeding of neo-classical tearing saddle coils are also currently used for involves their excitation at high frequency cannot be performed by the external coils due to the high inductance and the through the JET mechanical structure.

be used both to reduce the 'natural' error field (which arises from machine asymmetries), to ameliorate its effect, and to control the level of the error field so that the threshold level can be studied as a function of plasma parameters. It is important to understand this process since the maximum tolerable error field decreases with the machine size and the permitted value on ITER is close to the value that is likely to be generated by anticipated machine asymmetries.

**Fusion & Environment**

**INDIA: Energy Developments for a Growing Nation**

What role could fusion power plants play in the future energy supply of India as a country with one of the fastest growing populations? How will the energy needs of India develop in general up to 2100 and which technologies are therefore required? How do these facts influence the production of greenhouse gases such as CO<sub>2</sub>?

The new study "Long-term Energy Scenarios for India" tries to answer these questions. It was undertaken by the Indian Institute for Management (IIM) in Ahmedabad, together with Max-Planck-Institute for Plasmaphysics (Association EURATOM - IPP) in Garching (Germany) and the Netherlands Energy Research Foundation (ECN), in the framework of the "Socio-economic studies on Fusion" which were initiated by the European Fusion Programme.

If the development of the Indian energy economy is left to the unregulated market, coal, for which there are adequate resources, remains the most important energy source for electricity production (over 70%) up to the year 2100 – with dire consequences for the global climate. To replace the coal power plants, emission free technologies such as renewables and fusion could become more and more important. Depending on the limit set to CO<sub>2</sub> emissions, fusion could produce about 10% of India's electricity requirements in the second half of our century.

The methods, which were applied in the study give an impression of the future economic development and the demand for energy in India, as well as information on the development of the energy resources, technologies and other factors which influence the energy market. The model also picks the combination of energy technologies with the lowest total system costs.

**You want to learn more about the Indian Institute for Management (IIM)? Please see:**

<http://www.iimahd.ernet.in/>

**More Information on the Max-Planck-Institute for Plasmaphysics (Association EURATOM - IPP):**

<http://www.ipp.mpg.de>

**For the Netherlands Energy Research Foundation (ECN) see:**

<http://www.ecn.nl/main.html>

## Fusion & the Public

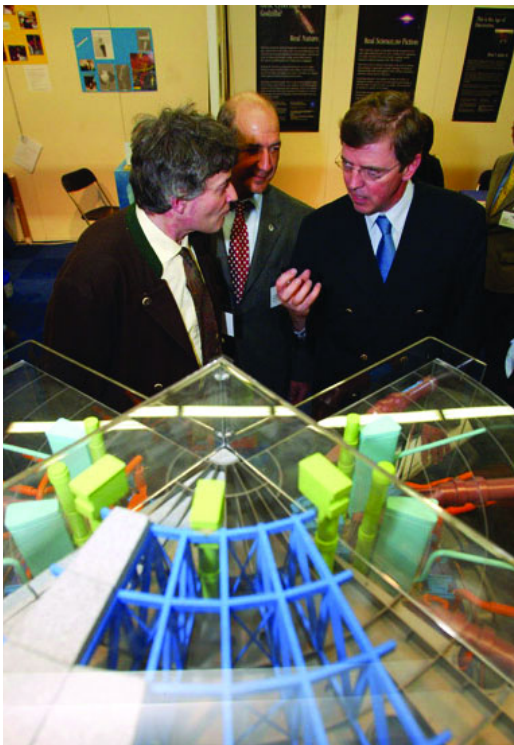
### EFDA at Physics on Stage 2

Physics on Stage 2 (PoS-2), an initiative for European physics educators, took place at ESTEC in Noordwijk (Netherlands) on April 2-6, 2002. CERN, ESO and ESA originally set up this annual event as part of the European Week for Science and Technology 2000. It is one of the milestones of the co-operation between the seven EIROFORUM partners (CERN, EFDA, EMBL, ESA, ESO, ESRF, ILL) on outreach and education activities.

The PoS project aims at motivating teachers and also provide them with information about current activities carried out in the leading European research organizations. This is very important as the tendency towards a lack of interest in physics by the younger generation nowadays mostly results from the lack of exciting lessons at school.

ESTEC welcomed at its headquarters 465 participants all involved with education, both teachers and members of national education programmes from 22 different European countries. The event consisted of a fair, live performances and workshops.

Chairman of PoS-2 was Prof. W. Ockels (ESA), ex-scientist/astronaut who flew aboard the US space shuttle Challenger in 1985 to conduct experiments in a multitude of disciplines in the German-organized Spacelab mission.



**Dr. F. Casci (left, EFDA Garching) presenting the EFDA stand to Prof. W. Ockels (center) and HE Mr. L. Hermans**

The hot site for cool science



"Couldn't be without it!" is the next initiative launched this year by the seven European Research Organizations.

**For more information, visit the site:**

<http://www.cern.ch/sci-tech>

During the week various VIPs visited the festival, such as Commissioner Busquin and His Excellency Mr. L. Hermans, Minister for Education, Culture and Science in the Netherlands.

The EFDA stand was equipped with posters on energy issues, EFDA and JET, but also with the ITER model. The visitors showed great interest in using fusion CD-Roms and information material on the ITER and JET projects at schools and universities.

As a general comment we can say that it was very useful to be among the participants in the event, as we could not only answer the visitors' questions on Fusion, but also offer to take the Fusion Expo to their premises and give talks on fusion at their schools or places of work. There was a pressing request for the research organizations to provide more support for the work of teachers. PoS-2 showed once more the necessity of informing the public and especially the schools and universities on what's going on in our research establishments.

#### ESTEC:

European Space Agency's Space Research and Technical Center

<http://www.estec.esa.nl/>

**EIROFORUM** is a co-ordination and collaboration group of the European Inter-governmental Research Organizations (CERN, EFDA, EMBL, ESA, ESO, ESRF, ILL). A primary goal is to play an active and constructive role in promoting quality and impact of European Research.

#### For more information see:

<http://www.eso.org/outreach/pr/ess-rel/pr-2001/pr-12-01.html>

[http://www.cerncourier.com/main/article/42/1/18/3/cernpeople10\\_1-02](http://www.cerncourier.com/main/article/42/1/18/3/cernpeople10_1-02)

#### CERN:

European Organization for Nuclear Research

<http://public.web.cern.ch/Public/>

#### ESO:

European Southern Observatory

<http://www.eso.org/>

#### ESA:

European Space Agency

<http://www.esa.int/>

#### EMBL:

European Molecular Biology Laboratory

<http://www.embl-heidelberg.de/>

#### ESRF:

European Synchrotron Radiation Facility

<http://www.esrf.fr/>

#### ILL:

Institut Laue-Langevin

<http://www.ill.fr/>

**For more information on Physics on Stage, visit the site:**

<http://www.physicsonstage.net>

## Questions & Answers

**"It is said that the US may reconsider its withdrawal from the ITER project. What is the status on this?"**

The US were partners in the ITER project until 1999. They then left the project for different reasons. While, at that time, the scientific and technical developments for the first (the "big") ITER project had been successfully concluded, the political and economic boundary conditions for the project had deteriorated. Moreover, none of the partner countries had presented a proposal for a site. In essence, the project appeared too costly for realization: Russia was experiencing a serious economic crisis, and Japan, also in the throes of economic problems, had decided on a moratorium on the construction of major research facilities. The US had re-oriented its research activities, and the provision of clean energy on a timescale of fifty years did not appear to be a top priority. A short-lived, but widely publicized, theoretical prediction that ITER might not satisfy its stated goals probably also played a part in the decision of the US to abandon the project. In the meantime, ITER has become a leaner project, focusing exclusively on objectives lying on the critical path to a fusion power plant. Three concrete site proposals have been made, or are expected to be made official, in the near future, and three years of targeted research have further verified the design assumptions forming the basis of the project. The fact that Europe, Japan and Russia forged ahead successfully with the project has evidently re-established the credibility of the project in the US and re-kindled their interest in participation. The scientific advisor of the US President has expressed his wish to follow closely the progress in the ITER negotiations and we already see the first steps taken by the US fusion community to re-enter ITER.

### United States engaged in serious consultations on ITER

"President Bush is particularly interested in the potential of the international effort know as ITER and has asked us to seriously consider American participation."

Secretary of Energy, Mr. S. Abraham at the Conference of G8 Energy Ministers, Detroit, May 2, 2002.

**For the full text see:**

<http://www.energy.gov/HQDocs/speeches/2002/mayss/PublicEnergyForumLunch.html>



IAEA (Vienna - 1998): The US DoE Secretary signs a one year extension of the US participation to ITER.

### Milestones of US Participation to ITER

#### November 1985

Geneva Summit Meeting: proposal by the then Soviet Union to build a next generation tokamak experiment

#### October 1986

The United States, Japan and the European Community proposed an activity under the auspices of the International Atomic Energy Agency (IAEA).

#### April 1988 – Dec. 1990

ITER Conceptual Design Activities (CDA)

#### July 1992

Agreement on the Engineering Design Activities (EDA) of ITER. Protocol 1

#### March 1994

The four Parties signed Protocol 2 to the ITER Agreement.

#### July 1998

ITER Final Design Report, Cost Review and Safety Analysis (FDR).

#### July 1998

Extension of EDA to July 2001

#### September 1999

The US left ITER project at the end of the US fiscal year.

#### More information:

<http://www.iter.org>:

- > What is ITER?
- > Background & Origins of ITER

#### 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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