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# newsletter

EUROPEAN FUSION DEVELOPEMENT AGREEMENT

Issued by the EFDA
Close Support Unit
Garching

## Contents



http://www.efda.org

## News

### China and the US as New Partners in the ITER Project

For the fusion community an historic milestone was achieved at the Eighth ITER Negotiations Meeting on February 18-19, 2003 in St. Petersburg (Russian Federation), when delegations from the People's Republic of China and the United States of America joined those from Canada, the European Union, Japan and the Russian Federation in their efforts to reach agreement on the implementation of the ITER project. The Head of the Chinese Delegation indicated that China, as the largest developing country in the world, has a great need to pursue alternative energy sources. China believes that ITER can potentially lead to new forms of energy and contribute to the peaceful and sustainable development of the world in the long-term. China expressed its strong wishes to be a valuable member of the ITER family, to make joint efforts with other partners to the successful exploitation of fusion energy.

At their St. Petersburg meeting the ITER Negotiators approved the Report on the Joint Assessment of Specific Sites (JASS). The JASS Report provided as a main conclusion and despite the differences between the candidate sites (Clarington in Canada, Cadarache in France, Vandellos in Spain and Rokkasho-mura in Japan) that the JASS assessment ascertained that all four sites are sound and fully capable to respond to all ITER Site Requirements and Design Assumptions, as approved by the ITER Council in its January 2000 meeting.

### European candidate sites for ITER confirmed

After the Spanish Government formally offered Vandellos as a possible ITER site on 17th April 2002 (see Newsletter Vol. 2002/2), the French Government confirmed its proposal for siting ITER in Cadarache at a meeting held in Paris on 30th January 2003 under the Presidency of Prime Minister Jean-Pierre Raffarin. Claudie Haigneré, French Minister for Research and New Technologies, declared that the decision of the French Government showed the importance to France of the work on controlled fusion, and of the maintenance of their position as one of the leading partners in this field. The French Government was pleased about the strong support that the local communities expressed by the pledging of financial support for this project.

### ITER: Important Topic at Competitiveness Councils

On March 3, 2003 Commissioner Busquin presented the state of play of the negotiations on the ITER project at the Competitiveness Council in Brussels (Belgium). A full progress report will be presented at the forthcoming Competitiveness Council on 12-13 May. Commissioner Busquin underlined two issues, which have still to be solved: the choice of the site where the ITER facility will be built, and cost sharing. A consensus on a draft international agreement, including the site and the cost-sharing scheme between ITER partners, is envisaged for the end of 2003.

**You would like to have more information on these topics? Please see the last page!**

Interview

**Dr. Joseph V. Minervini** is the Division Head for Technology and Engineering in the Plasma Science and Fusion Center at MIT (Massachusetts Institute of Technology, Cambridge, USA). His major project was as Principal Investigator for the US ITER Magnetics R&D Programme as a part of the ITER project. His present duties include spokesperson of the US Magnetics Programme organized under the Virtual Laboratory for Technology of the DOE Office of Fusion Energy Science (OFES).

For **more information** on MIT please see:

http://www.psfc.mit.edu/

## The US Fusion Community and Industry are ready for ITER

***EFDA Newsletter (E.N.):*** *The US withdrew from the ITER project in 1998, but has been still participating in the testing of the Central Solenoid Model Coil (CSMC), a pulsed superconducting magnet, through a bilateral agreement with Japan. Now as the US decides to rejoin the ITER project, what could be your main contributions in the field of superconductivity?*

***Joseph V. Minervini (J.M.):*** Personally I would prefer that we could come back with a strong role in the development of the superconducting magnets including delivery of substantial coils. We have a strong interest in MIT in the US magnetics programme in the CS coil area, but the US is right now in a sort of informal evaluation of the costs and what the contribution may be. We need to know that information to give it to anybody from the US side who would be negotiating the background information of what our potential contributions would be. The reinvigoration of the magnet technology programme in our country would be a big advantage for my team at MIT. After the US withdrew from ITER there was a major cut back in funding in general on the fusion programme. All technology areas were cut substantially and also our teams were reduced to a very low level, so there will be a new impetus to increase budgets and bring back a much stronger technology team.

***E.N.:*** *Do you believe you will get those people back now into your project, especially those who went to industry?*

***J.M.:*** I think that we still retained a core of people and activities. Even within the team that we have now, only about 50 to 60 % of its effort is in fusion magnets, the rest is in other areas of applied superconductivity. Some of our former team's people are older and actually retired. But there are still enough people that we identify in other areas of different industries who have the right background and I think they could be brought into our project again from industry. But this is also a chance for some younger people from universities. I'm optimistic that now, as there is a substantial effort to really build ITER, it will have a strong influence on people deciding to come back into this project and making it a career commitment.

***E.N.:*** *After the US withdrew most of the industrial teams involved in ITER were dismantled. Do you believe they will be able to immediately participate in the ITER magnets construction?*

***J.M.:*** We have already been discussing with industry in the background, seeing who and what are available for industrial teams and capabilities. I can foresee that there is enough of a basis left there to come back in a strong fashion, including people who had participated in large scale industrial activities during the EDA phase and particularly during the construction of the CS model coil. We always have continued the activity with US industry for superconducting magnet development, so I don't see any big problem for them to reorganize now on a large scale.

***E.N.:*** *Superconductivity is one of the most advanced technologies in the ITER project. After 15 years of research, what are the main lessons learned for ITER?*

***J.M.:*** There is still a lot that we need to learn, but I think experiments like Tore Supra have certainly demonstrated that you can introduce superconductivity to a fusion application and have it work reliably. This has also been demonstrated in Japan with the Large Helical Device. The results of CSMC and the Toroidal Field Model Coil (TFMC) give the magnet technology community worldwide the confidence that the coils of the scale of ITER can be designed and fabricated in industry, using existing and new technology that was developed over the last five to ten years. Implementing and operating those coils in the appropriate operating conditions demonstrated that you can go ahead with confidence to build a machine like ITER and it will work.

Both interviews: D. Lutz-Lanzinger

## Interview

### Better collaboration, better support, a better future – the Chinese fusion community is looking forward to joining ITER

***EFDA Newsletter (E.N.):*** *In 1250 the Venetian Marco Polo travelled to China and thus opened the trade between China and the West. Do you think that, in the same way, ITER could be the way to start a high-tech collaboration between China and the West?*

***Huo Yuping (H.Y.):*** Yes, I think this is the start of close collaborations, because until now we have not really joined such a big scientific programme as ITER. We have already contributed to the High Energy Physics programme, but this simply involved sending scientists who took part in the experiments and were trained. So at present ITER is the first big project which China really wants to join. I hope this will also promote further collaboration in high tech and other areas.

***E.N.:*** *China started its studies on nuclear fusion in the mid-1980s. What has now made ITER so attractive for your country that your government is showing interest in joining shortly before the site selection?*

***H.Y.:*** The Chinese fusion community has already been interested in the ITER programme for a long time, but we knew that we would have to invest some money. The Chinese Government, especially the Minister of Science and Technology has supported the efforts to join the ITER project, but we also needed to convince the other members of China's scientific community. For example, some believed that if we paid 10% of the ITER cost, those funds could be lost for the other projects. But more and more people recognize that fusion research should have comparatively high priority in China because we urgently need clean sustainable energy sources for the next half of this century. We have established many projects mainly for cheap solar energy, and we also have kept a steady fusion energy programme over the last two decades.

***E.N.:*** *In which way will your country contribute to the ITER project as a major partner?*

***H.Y.:*** According to our evaluation group, we could deliver some conventional products, such as part of the power supply systems, mechanical structure manufacturing, blanket modules, superconducting conductors etc., but this depends on the negotiations.

***E.N.:*** *As you know, the US are going to rejoin the ITER project. Have you already made contact with them with regard to future cooperation in this field?*

***H.Y.:*** I believe within the ITER project we could develop a much stronger relationship with the US. During the last decade the US fusion programme has mainly emphasized studies of basic plasma physics. The Chinese fusion programme has mainly concentrated on reactor relevant problems. So there are some discrepancies between our goals of research, but in the end we work for the same project.

***E.N.:*** *With which one of the ITER partners do you have the closest relationship?*

***H.Y.:*** We have a very close relationship with the European fusion community. Our two main institutions, the Chengdu Southwestern Institute of Plasma Physics and the Bejing Chinese Academy of Sciences received a lot of support from the European Fusion Community. Many of our researchers were sent to European fusion laboratories. We also collaborate very well with the Japanese fusion community, especially JAERI and Nagoya. But according to Chinese philosophy we would like to expand our collaboration and relationships with old friends and also new friends.

**Prof. Huo Yuping,** Academcian from the Chinese Academy of Sciences and Professor at ZhengZhuo University, visited the EFDA and ITER sites at Garching (Germany) and presented the Chinese fusion programme and its plans to join ITER.

For **more information** on the **Chinese Academy of Sciences**, please see:

http://english.cas.ac.cn/english/page/home.asp

The **ZhengZhou University** is represented on:

http://www.zzu.edu.cn/edefault.htm

**Chinese Guests at EFDA / ITER / IPP-Garching (Germany):**

From left to right:

***Prof. A. Bradshaw*** (Director of Association Euratom-IPP, Garching, Germany),

***Prof. Weng Peide*** (Institute of Plasmaphysics, Chinese Academy of Sciences and Deputy Director of HT-7U Project),

***Dr. R. Aymar*** (ITER director),

***Prof. Huo Yuping,***

***Prof. K. Lackner*** (former EFDA leader).

ITER

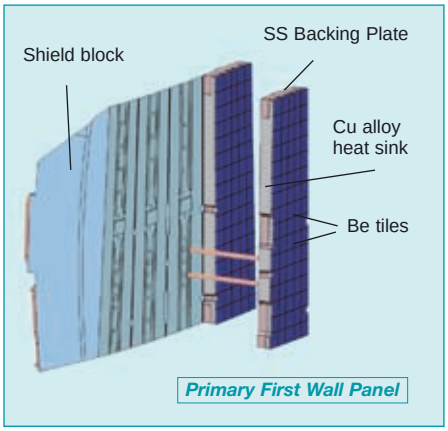
**ITER shield blanket:**
comprises 421 modules (404 regular modules, 17 Neutral Beam Injector modules)

**Shield module:**
consists of one shield block (316L Stainless Steel) and 4-8 separable Primary First Wall (PFW) panels.

**PFW panel:**
is a bi-metallic structure with a 316L Stainless Steel backing plate and a Copper alloy heat sink layer (CuCrZr or CuAl25 alloy).
Beryllium (Be) armor tiles are joined to the Cu alloy heat sink.

## First Full Scale EU Prototype Primary First Wall Panels for ITER

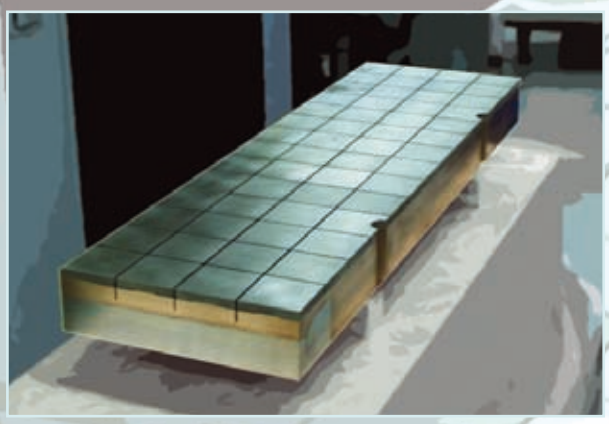
The ITER project is considering two shield module design options (A and B) for the shield blanket, as described in the Final Design Report issued in July 2001. The outer dimensions of the modules and the interfaces to the rest of the machine are the same for both options. The difference arises from the type of panel-to-shield attachment system used, which has implications for the detailed design of the components. For option A, studied in detail by the EU and shown in the figure below, the Primary First Wall (PFW) panels are attached to the shield block by a poloidal row of studs made from a high strength nickel-based alloy. These are located on a central poloidal key, which is also used as the electrical contact with the shield to minimise the current flowing through the studs. This central location for the electrical contact reduces the electromagnetic loads on the attachment system.



*Primary First Wall Panel*

Two Hot Isostatic Pressing (HIPping) methods are being considered for the fabrication of the bi-metallic structure of the PFW panels. With solid HIPping, the stainless steel (SS) backing plate, the copper alloy plates and the SS tubes are joined together with one single HIP cycle at 1040 °C. With powder HIPping, a first HIP cycle at 1100 °C is used to consolidate the SS powder with embedded SS tubes. A second HIP cycle at 1040 °C is then performed for consolidating and joining the Cu alloy powder. Beryllium (Be) tiles are finally joined by HIPping or brazing as shown in the table below.

| PFW panel | Cu alloy | Cu/SS joining | Be/Cu joining | Manufacturer |
|---|---|---|---|---|
| 1 | CuAl25 | Solid HIP | Furnace brazing (780 °C) | Framatome ANP |
| 2 | CuCrZr | Solid HIP | Solid HIP (580 °C) | CEA |
| 3 | CuAl25 | Solid HIP | Solid HIP (730 °C) | Framatome ANP |
| 4 | CuCrZr | Powder HIP | Solid HIP (low temperature) | Metso Powdermet & NNC Ltd |
| 5 | CuCrZr | Solid HIP | Inductive brazing | Framatome ANP |


*PFW Panel 1 fabricated by Framatome*

An R & D programme is in progress to demonstrate the manufacturing feasibility of these panels and to select the best fabrication method for the ITER Blanket procurement. Three full scale panel prototypes have already been completed (panels 1 to 3 in the table). Two more are under fabrication. All of these panels will be thermal fatigue tested to confirm the good results already obtained with PFW mock-ups. The fabrication method to be used for the series production will be selected after analysis of the thermal fatigue test results and after a comparative and detailed fabrication cost assessment.

JET

## Improved measurements of current density and electric field on JET

The active control of plasma profiles, such as pressure and current density, is key to the realisation of steady state operation on ITER and is an important area of research on JET. Control requires accurate measurements and, recently, the measurement of the plasma current density on JET has been improved significantly. The Motional Stark Effect (MSE) diagnostic provides a local measurement of the pitch of the magnetic field and thus the safety factor (q). This is used as a constraint on the calculation of the magnetic geometry and the determination of the current profile. The diagnostic (fig. 1) is based on the Stark splitting of the Dα line excited by collisions between the fast neutral particles injected by the Neutral Beams used for heating the plasma, and thermal plasma ions. In the presence of a magnetic field B the Lorentz field E = v x B produces a separation of the Dα line into components polarised parallel (ρ) and perpendicular (ς) to the E field. By measuring the polarisation angle of one of these components, together with information from magnetic sensors, it is possible to determine the safety factor q.

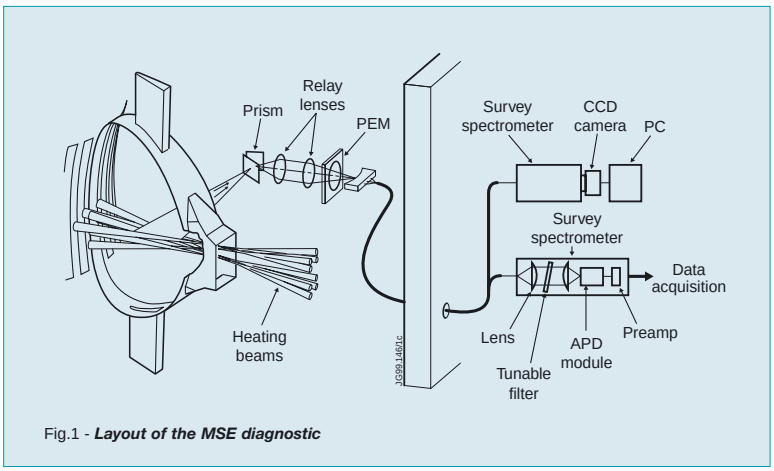



Fig.1 - ***Layout of the MSE diagnostic***

During the Shutdown of 2001 the Neutral Beam source (PINI #1) used by MSE was upgraded in energy from 80 kV to 130 kV. As a result there is an increased Doppler shift of the Stark emission, which is thus spectrally resolved from that due to the other sources whose neutral beams intersect the detection line-of-sight at different angles. Another beneficial effect is the separation from interfering CII spectral lines in the outer edge of the plasma.

Experimental evidence of the enhanced performance especially at high power when all neutral beam sources are used is shown in fig. 2.a/b. Prior to the upgrade all detection channels were perturbed by about 7 degrees (fig. 2a) when one of the sources (PINI#7, not used for MSE) was also operated. Now, this effect is reduced to less than half a degree (fig. 2b) with smaller interference at higher toroidal magnetic field, compared with a statistical error of 0.1 degree.

A further use of this diagnostic is for the measurement of the radial electric field $E_r$ in the plasma. The influence of $E_r$ can become significant when plasma rotation is large and pressure gradients are steep, as in high performance discharges. A measurement of $E_r$ is also important for testing theories of improved plasma confinement mechanisms. On the other hand, the measurement of $E_r$ in the core of a hot (100 Million degrees), large (100 $m^3$) plasma is extremely challenging. Recently, an estimate of $E_r$ has been obtained in JET by measuring the change in the polarisation angle of the MSE emission when two different sources are operated sequentially at different energies. The first profile measurements have been made and further experiments planned for 2003 aim at improving the technique.

**Safety factor q**

Number of turns the helical magnetic field lines in a tokamak make round the major circumference for each turn round the minor circumference, denoted by q. The use of the term safety factor refers to magnetic plasma stability and not to the safe operation of a tokamak.

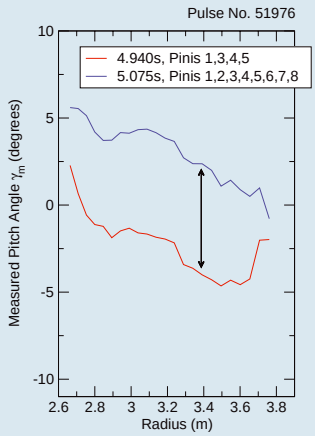



Fig. 2a

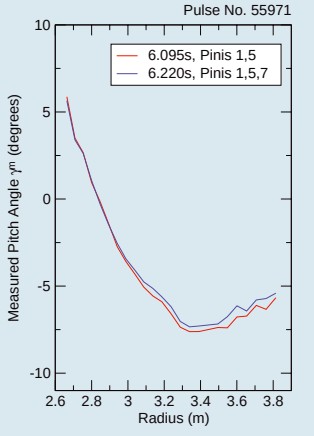



Fig. 2b

**Bulgaria:**
Sofia University St. Kliment Ohridski,
http://www.uni-sofia.bg/

Bulgarian Academy of Science,
http://www.bas.bg/index-en.html

Institute for Nuclear Research and Nuclear Energy – IRNE, Sofia,
http://www.inrne.bas.bg/

**Association Euratom-IPP.CR (Czech Republic):**
Institute of Plasma Physics,
http://www.ipp.cas.cz/WWW/

**Association Euratom-HAS (Hungary):**
KFKI-RMKI Dept of Plasma Physics,
http://www.rmki.kfki.hu/plasma/

Budapest University of Technology and Economics,
http://www.bme.hu/en/index.html

**Association Euratom-Univ. of Latvia (Latvia):**
Institute of Solid State Physics, University of Latvia, Riga,
http://www.cfi.lu.lv

Institute of Latvian Academy of Sciences, Salaspils,
http://www.lza.lv/EN/INST/in01.htm

**Association Euratom-MEC (Romania):**
Institute of Atomic Physics
http://alpha1.infim.ro/ifa

**Slovak Republic:**
Comenius University Bratislava, Faculty of Mathematics, Physics and Informatics
http://www.uniba.sk/mffuk/e/

Slovak University of technology
http://www.stuba.sk/eng1/

Slovak academy of Sciences, Institute of Elecrical Engineering
http://www.elu.sav.sk/

**Slovenia:**
Jozef Stefan Institute, Ljublijana,
http://www.ijs.si/ijs.html



## Candidate Countries: New Impetus in Fusion

Next year, the EU is set to expand from 15 to 25 member states, with further countries joining a few years later. As part of their preparations for membership, the candidate countries are already participating in many EU activities. In the field of research, the enlargement is already a reality. The strong scientific traditions in the candidate countries enrich and strengthen our research community.

Fusion research, funded through the Euratom Framework Programme, is well along the road to bringing these countries into substantial, long-term collaborations. Contracts of Association with Euratom have been established in the Czech Republic, Hungary, Latvia and Romania, while Bulgaria, the Slovak Republic and Slovenia participate by means of Cost-Sharing contracts on specific projects. Since they contribute to the global pool of funds, researchers and organisations in these countries can apply for funding on equal terms with researchers in the Member States. The Associations in the candidate countries are also members of EFDA. In all countries, co-operation is promoted by the Agreement on Staff Mobility and a fellowship scheme supports the involvement of young scientists in fusion research. (http://fp6.cordis.lu/fp6/call_details.cfm?CALL_ID=46)

The integration of the fusion research activities of the new partners into the programme is proving successful. Not only are their researchers involved in the collective use of JET, in work on other large European fusion devices and facilities, as well as in technology activities under EFDA, which offer them world-class research opportunities, but the expertise of their laboratories also attracts the interest of researchers from all over Europe.

At the National Institute of Laser, Plasma and Radiation Physics (within the Romanian Association) a laboratory for micro-tomography has been established with Community support. Here it is possible to undertake non-destructive testing of materials with on-line three-dimensional interpretation during the exposure of samples. A further interesting example concerns the preparation, based on considerable experience in liquid metal magneto-hydrodynamics in the University of Latvia, of an experiment to study a liquid metal limiter (as a possible alternative to having solid materials in contact with the plasma) in collaboration with the Portuguese Association Euratom-IST. On the Castor tokamak of the Institute for Plasma Physics (Prague, Czech Republic) preparations are being made for edge plasma diagnostics and experiments on larger fusion devices in collaboration with scientists from a number of Associations. Building on its experience of implementing and operating diagnostics on a number of fusion devices, the Hungarian Association (HAS), in collaboration with others, is further developing the technique of beam emission spectroscopy with accelerated Lithium and Helium beams for plasma density and turbulence measurements. The HAS is also carrying out studies on the tomographic reconstruction of the radiation profile from bolometry measurements for ITER.

The expertise of these and other institutes and the established collaborations on fusion physics and technology are a good basis on which to build enhanced involvement of our new partners in the developments needed for the construction and future exploitation of ITER.

## Conference Report

### Energy Choices: "China wants to be the first nation to generate electricity from fusion."

This was the startling message from Professor J. Li at the "Energy Choices for Europe" conference, which was held in Brussels (Belgium), on March 5, 2003.The one day cross party conference was organised by Touchstone Europe and sponsored by European Industry with an interest in energy including EFET (European Fusion Engineering and Technology), CEA, BP, Centrica and Areva.

Under the Presidency of Dr. G. Adam MEP the conference debated European long-tem energy needs together with the role which the different energy sources could play in the future. Energy supply, liberalisation of the energy market, climate change, green-house gas emissions, R&D policies were the background topics which provided the boundary conditions to define a future strategy.

All these aspects were analysed during a very intense day with the help of international speakers, such as members of the EU Parliament, EU Commission officials, energy experts and advisors.

The topics discussed included oil, renewables, fission, gas, energy efficiency, fusion, coal and an overview was provided on the state of art and the future development in these areas.

It was recognised that the European Union, through the Commission, Parliament and the Council of Ministers, is taking very seriously these issues - energy will be an important topic for the future development of the Union. The Green Book on Energy, published by the Commission in 2000, and similar documents in other EU countries provide a good basis for a debate and urge measures to be taken swiftly.

Prof. Sir D. King, Chief Scientific Advisor to the UK Government, outlined the UK recent White Paper on Energy and the concerns that he had over global warming. He highlighted the fact that 1.6 billion people have no access to electricity, 2.4 billion have to rely on wood burning for cooking and heating and it would only take a one metre rise in sea level to lose 50% of Bangladesh. With this in mind he went on to present the case for fusion. He defined ITER as a kind of international "man-on-the-moon project". G. Caudron MEP, who was the European Parliament's Repporteur on Fusion for FP6, reiterated the need to give fusion the necessary support during FP7 to construct ITER. Prof. J. Li explained how fusion is urgently needed in China, which has triggered the current commitment for ITER. Mr. A. Vallée, President of EFET, underlined the role of industry in ITER and gave examples of the spin off in employment and competitiveness.

The provisional dates for the "Energy Choices for Europe Conference 2004" are March 2/3.

**Participating Companies / Organizations:**

**OPEC:**
http://www.opec.org/homepage/frame.htm

**BP:**
http://www.bp.com/

**Centrica:**
http://www.centrica.com/framesets/frontfset.htm

**International Energy Agency (IEA):**
http://www.iea.org/index.html

**AREVA:**
http://www.arevagroup.com/servlet/ContentServer?pagename=arevagroup_fr/home

**World Nuclear Association:**
http://www.world-nuclear.org/

**Commissariat à l'Energie Atomique (CEA):**
http://www.cea.fr/default_gb.htm

**Gasunie:**
http://www.gasunie.nl/n_eng/index.htm

**Eurogas:**
http://www.eurogas.org/

**Wuppertal Institute:**
http://www.wupperinst.org/Sites/home1.html

**Energy Saving Trust:**
http://www.est.org.uk/

**Université de Liège:**
http://www.ulg.ac.be/foreign/

**Energy Charter:**
http://www.encharter.org/index.jsp

## ...more information

**For more information see our EFDA website:**
http://www.efda.org
and additionally
http://www.jet.efda.org
http://www.iter.org

### China and the US as New Partners in the ITER Project

For the **full text** of the press release please see our website: http://www.efda.org
The **JASS Report** can be found on: http://www.iter.org/jass

**Further information:**
http://www.energy.gov/HQPress/releases03/janpr/pr03026_v.htm

### European candidate sites for ITER confirmed

Find the **full text** on: http://www.recherche.gouv.fr/discours/2003/enprojetiter.htm
If you missed reading the opening speech of the Spanish Minister for Science and Technology, Josep Piqú, at the Seventh ITER Negotiations meeting in Barcelona, find it on our website: http://www. efda.org

### ITER: Important Topic at Competitiveness Councils

The **full text** of the document, please see:
http://ue.eu.int/newsroom/newmain.asp?lang=1 => Council => General Affairs and External Relations => 2487 th Council meeting => Page 22 on ITER

### Conference Guide 2003

| DATE / LOCATION | EVENT / WEBsite |
|---|---|
| **May 13 - 16** Hangzhou, China | 4th General Scientific Assembly of Asia Plasma and Fusion Association http://www.ipp.ac.cn/APFA2003/APFA.htm |
| **June 2 – 5** Seoul, Korea | 30th International Conference on Plasma Science http://www.ieee.org/icops2003 |
| **July 7 – 11** St. Petersburg, Russian Federation | 30th EPS Conference on controlled Fusion and Plasma Physics http://www.ioffe.ru/EPS2003 |
| **September 8 – 10** Helsinki, Finland | 10th European Fusion Theory Conference |
| **October 14 - 17** San Diego, USA | 20th Symposium on Fusion Engineering (SOFE 2003) |
| **October 20 – 24** Morioka, Japan | MT 18th Int. Conference on Magnet Technology |
| **October 27 - 31** Albuquerque, NM/USA | 45th Annual Meeting of the Division of Plasma Physics of the American Physical Society http://www.aps.org/meet/ |
| **December 7 – 12** Kyoto, Japan | 11th Int. Conference on Fusion Reactor Materials (ICFRM-11) http://icfrm.iae.kyoto-u.ac.jp |

**EFDA Close Support Unit - Garching**
**Boltzmannstr. 2**
**D-85748 Garching / Munich - Germany**

**phone: +49-89-3299-4237**
**fax: +49-89-3299-4197**
**e-mail: federico.casci@efda.org**
**editors: Federico Casci, Doris Lutz-Lanzinger**
**graphic design: Karen Jens**