Vol 2002 / 3
September 5, 2002

# newsletter

EUROPEAN FUSION DEVELOPEMENT AGREEMENT

Issued by the EFDA Close Support Unit Garching

## Content



http://www.efda.org

## News

### Fourth ITER Negotiations Meeting: New Site Offers by the EU and Japan

On June 6, delegations from Canada, the European Union (EU), Japan and the Russian Federation made significant progress towards the preparation of an agreement for the joint implementation of the ITER project at their Negotiations meeting hosted by the EU in Cadarache (France). Notable events at this fourth Negotiations meeting were the submission of official proposals to host the project by the European Union - at sites in Cadarache and Vandellós (Spain) - and by Japan at Rokkasho-mura in the Aomori Prefecture. These new site offers join an existing host proposal by Canada, presented in Moscow on June 7, 2001. At the conclusion of the meeting, the Delegations agreed that the site offers and the negotiating mandates of the EU and Japan represent substantial progress on issues critical to the successful implementation of the ITER project. The next meeting of the Negotiators will be held in Toronto (Canada) on September 17-18, 2002.

For the full text of this press release, please see our website: http://www.efda.org
For further information on Rokkasho-mura see: http://web.gat.com/iter-ga/images/pdfs/iter-japan.pdf

### Commissioner Busquin hopes to see ITER built in Europe

"It would be very good if ITER was built in Europe and I am glad to see that two Member States, France and Spain, have asked to host this facility. I hope the US will join the consortium again and help us to develop this promising technology."

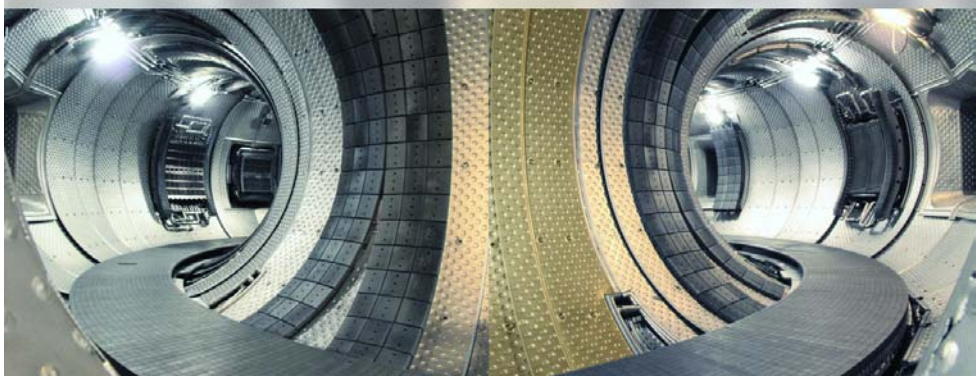
*Philippe Busquin, EU Commissioner for Research*

You can find the full speech on our website: http://www.efda.org

### World Record Plasma Discharge in TORE SUPRA

On July 30th 2002, the engineers and scientists of the Association Euratom-CEA in Cadarache (France) have achieved a three and a half minutes long plasma discharge on Tore Supra, sustained by 3MW of current drive power, thus requiring to exhaust more than 600MJ of thermal energy during the experiment. It establishes a new world record in this domain after the 280MJ discharges of 1996. Prior to the record discharge, a number of long pulse shots have been achieved, demonstrating the capability of Tore Supra to run long pulses on a regular basis.

You can find the full text of the Press Release on our website: http://www.efda.org



Tore Supra

**Tore Supra**

- High Magnetic field: 4T
- superconducting toroidal field coils cooled by super-fluid helium at a temperature of 1.8K
- 1988 to 1999: study of physics and technology of a hot core plasma in steady-state conditions - an essential item towards a reactor.
- Optimisation and sustainment of the plasma current and pressure distributions over long times are achieved by means of strong HF power at frequencies absorbed by the plasma: "lower hybrid resonance" at 3.7GHz. (6MW of microwave power) and "ion cyclotron resonance" at 42-63MHz (9MW of radio-frequency power).

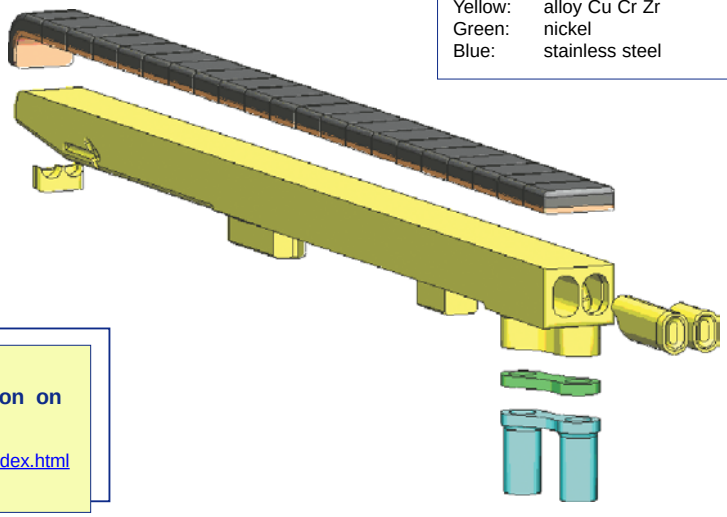
## The New CIEL Plasma Facing Components: a Major Step towards Steady-State, High Power Operation

*The main magnetic fusion research activities of the French-Euratom Association take place in the "Department of Controlled Fusion Research" (DRFC), at the CEA Cadarache site in Provence. The flagship of the DRFC programme is the Tore Supra tokamak. Its main role is the investigation of steady-state operation and the associated consequences in maintaining a continuous magnetic field.*

Power leaving the plasma must be extracted continuously, which means tackling the problem of plasma facing surfaces subject to a permanent bombardement of particles and radiation. For continuous power exhaust, it is necessary to simultaneously control the convective power deposition on the components facing the plasma and the flow of radiated power to all the internal components in direct line of sight of the plasma. Studies of long duration plasma discharges between 1988 and 1999 showed that the power exhaust capacity of the first generation of actively cooled plasma facing components was marginal for attaining steady-state operation. Therefore, all the internal components in Tore Supra were upgraded, within the framework of the CIEL (acronym in French for "Internal Components And Limiter") project, with the objective of giving Tore Supra the capacity to control, in steady state, the injected power (up to 15MW of convected power with a maximum flux of 10MW/m$^2$, and 10MW of radiated power with a flux of 1MW/m$^2$, continuously). The design, done in 1992, was aimed at simplifying the manufacturing processes and a series of mock-ups were realised and tested before the elements could be ordered in 1997, after the project obtained preferential support by the EU Commission in 1996.

### TPL - main component of the CIEL project

The TPL (Toroidal Pump Limiter) has the form of a flat ring of 5m diameter and 0.5m width. In order to extract the particles escaping the plasma, twelve throat-shaped "neutralisers" are located at one of the edges of the ring, under the limiter, each of which is connected to a turbo-molecular pump. The TPL consists of 576 "fingers" ("aiguilles" in French), each clad with carbon fibre tiles bonded to a copper structure that is actively cooled by pressurised water (30 bars) at high temperature (150°C), one centimetre away from the plasma surface. The fabrication by industry of these "fingers" was particularly complex (see exploded view, presented below); especially the bonding of the carbon composite fibre to the water-cooled copper base. It incorporates a proprietary process patented by our supplier, the Austrian company Plansee. The process is based on the engraving of tiny cavities into carbon using a laser, and subsequently impregnating the surface with liquid copper. The solidified 2mm layer of copper is then welded, using an electron beam, to the hardened copper-alloy base (copper-chromium-zirconium).



| | |
|---|---|
| Black: | carbon composite fibres |
| Orange: | copper |
| Yellow: | alloy Cu Cr Zr |
| Green: | nickel |
| Blue: | stainless steel |

**For more information on Tore Supra see:**

http://www-rfc.cea.fr/index.html

### Acceptance criteria reached

This assembly requires a very high degree of quality control to achieve perfect cohesion. The quality of thermal transfer between the surface of the plasma-facing composite and cooling water circulating in the finger is a major criterion of acceptance, for which a dedicated test station was developed at the DRFC. The first batch of fingers received in France had excellent quality (a little more than 10% rejection). However this performance did not last, with a rejection rate jumping up to 50% in the following batches. The cause of this high rejection rate, which is not yet completely understood, seems to be related to the sensitivity of the manufacturing procedures to slight modifications during production of successive series. The carbon-carbon composite, a complex production from the SNECMA company, proved to exhibit variations of its mechanical characteristics from one batch to the other. Fortunately, the development of a reliable repair process of the fingers made it possible to reach the acceptance criteria, at the price of many peregrinations (equally for the fingers as for the engineers) between France, Austria and Germany!

### Difficult manufacturing process

The complicated manufacture of the fingers involved many other "delicate" procedures; such as the drilling of the water conduits through forty centimetres, for the welding of the "stoppers", or the "heterogeneous" joint between the copper-alloy and the stainless-steel pipe-work. The result was that the original fabrication and delivery targets of 630 fingers in two years slipped to complete delivery in 4 years. However this delay was not all bad. It resulted in a much better understanding of the mechanisms and procedures of industrial production of such a component which will be invaluable in the development of the next step fusion device. Today the TPL of Tore Supra is the only example in the world of a several square-metre structure allowing continuous power extraction in the range of a reactor heat load. Other less critical components around the plasma first wall are also actively cooled but made with a less complex technology: stainless panels to collect the radiation of plasma and guard-limiters for transient heat loads or localised particle losses.

### Towards steady-state high power plasma discharge

The inconvenience of using the temporary assembly in 2001 (compromising only three sectors of TPL) was largely compensated for by the satisfaction of developing very powerful techniques for testing and qualification of the components and to have been able to preserve a contact with the industrialist which was more of a partnership than that of the conventional customer-supplier relationship. It is of considerable significance that high heat flux components remain one of the major challenges for the success of thermonuclear controlled fusion and in particular of ITER. In 2002, after the completion of all the CIEL components, the main priority of the Tore Supra experimental programme will be the realisation of a steady-state, high power plasma discharge with an injected/extracted energy in the gigajoule range by injecting, for example, 3MW of RF power for more than 300 seconds. A new world record of 210 seconds with more than 600MJ of thermal energy was already achieved at the end of July.

In addition to the installation of the CIEL components, the **2000-2002 Tore Supra shut-down** provided the opportunity for a substantial upgrade of the plasma diagnostics. The installation of the CIEL components had consequences, not only on the position of these diagnostics, of which some were obscured by the new CIEL components, but also on their own heat capacities.

After a planned shut-down of 21 months, **Tore Supra restarted in September 2001** with a reduced set of three LPT sectors (out of twelve) installed. The first results were not long in coming, in spite of the reduced set of limiter sectors. A power of 5 MW (2.5 MW/m$^2$ on the LPT) could be injected with a surface temperature of the tiles lower than 400°C (value envisaged by the codes), without difficulty. **Today the interior "face-lift" of Tore Supra** is complete. As it can be seen in the figure, all the components of the CIEL project are now installed. The vessel was pumped-down in mid-April 2002. The first plasma has been achieved at the beginning of June.
The new record was

Women in Science II

The percentage of women in Europe tenured as full professors is very low, ranging in 2000 from 5% in the Netherlands to 18% in Finland. In natural sciences, technology and engineering these percentages are even lower. For example, in engineering the figures vary in the year 2000 from 4.6% in Italy to 2.1% in the UK. According to several studies most women are lost to science at the postdoctoral level, where the career path begins, because they feel discriminated against by their male colleagues or because of family responsibilities.

## Growing Influence on High Level: Women between Career and Family

***EFDA Newsletter (E.N.):***
Congratulations! You are one of only on average 10% of women in top positions in Europe's scientific system. Did you have any problems to get your C3-position in 1998 because of being female?

***Sibylle Günter (S.G.):***
Concerning the job, I had no problems at all. The main difference between a man and me in research is that I'm a mother. I had to do childcare and I was glad to have the support of my parents, who helped me to solve this problem. But it was a nice problem indeed …

***E.N.:*** Starting in 2000 then you were the youngest director and scientific member ever at the Max-Planck-Institute. Were you treated equally by your colleagues when you got this position?

***S.G.:*** Yes, of course. I think that things wouldn't be necessarily easier with a lot of women here. We are four young directors - aged close to forty - and the other directors are aged above 55, but we got along well with each other. When you start, you have to learn a lot anyway - there was nothing special about me being a woman.

***E.N.:*** So, up to now, you have never experienced a strange situation concerning gender equality?

***S.G.:*** Ok, there was one scene at the very beginning of my career when I applied for a permanent position and was clearly rejected because I was a woman. But fortunately there are just a few male professors, who clearly tell you: 'In my opinion women are not able to do science.'

***E.N.:*** In spite of caring for your daughter, you spend as much time on your job as a man now. If you think about your salary statement, would you prefer to be a man?

***S.G.:*** No - I get the same salary as a man. This might be different in industry, but in the Max-Planck-Society there is simply a kind of ranking and once you have achieved a C3-position you get a fixed salary.

***E.N.:*** Children and family responsibilities have very often a negative impact on a woman's career in academic science. What is your experience as a mother?

***S.G.:*** My boss was happy for me when he heard that I was pregnant. But a child needs care and you don't have this time for your career. When my daughter was born, I stayed at home for about one year and then started again with science. I went home early in the afternoon and went back to work late at night. In 1994 I had to go to the US for five months and I left my daughter behind with her father and my parents. This was certainly hard and I would never do it again.

***E.N.:*** What kind of support did you get from your colleagues?

***S.G.:*** Well, for example, when I was staying at home with my little daughter, my supervisor came to my home and we worked together in the evenings. This helped me to stay in the scientific process. But nowadays, also men start to take over much more responsibilities for their children. So the problem of reconsidering family and job will become important for both - men and women - and therefore will be handled much more straightforwardly in future. But generally any kind of support should be in such a way that you are able to fulfill the same requirements as a man, not just get a higher position because of being a woman.

***E.N.:*** What would be the most important advice that you would give to your daughter Stefanie if she wants to become a researcher in a leading position like you?

***S.G.:*** To think carefully about if she really wants to do both - a good job at home and at work. She should be aware of the fact that the time that you have for your family is limited. But I would certainly support her in the same way my parents supported me.

Interview: DL

In our interview **Prof. Dr. Sibylle Günter** (38), who is the Head of the Tokamak Physics Division and a member of the board of directors at Max-Planck-Institute for Plasma Physics in Garching (Germany), encourages young women to withstand the pressure on career and family - it's worth it.

Find a short CV of Sibylle Günter and more information on our website:
http://www.efda.org

## Fusion & Publications

### Fusion Research and Scientific Publications in the Internet Era

A commentary from Dr. Alberto Loarte (EFDA Garching, Germany, Divertor Physics Division)

*Publication of results is a key activity in scientific research. The publication record of a scientist or institution is frequently used to evaluate their contributions to their field both by other scientists and, more importantly, by the governmental and private institutions, which fund their research.*

Many aspects of the publication of research papers have been greatly improved by the easier access to fast internet connections and the adoption of widespread standards for electronic documents. However, other aspects of this activity seem to be suffering from these changes. Scientific journals are under pressure to publish quickly, to bring the newest results to the attention of the widest research audience and that can easily lead to a deterioration of standards in the refereeing process. So nowadays, reputable journals often accept relatively mediocre or incorrect articles, which would not have survived the refereeing process just a decade ago.

Due to the link between number of published papers and research funding or career development, the results of a research project are frequently divided and published in subsequent separate papers. This over-abundance of reporting very similar results should be, of course, controlled by the peer-review system. Pressure from the editors, in order to maintain a reasonable turn-around time in the refereeing process, and the increasing numbers of references to be checked by the referees, whose work is not publicly acknowledged due to the obvious anonymity requirements, makes this a very difficult task.

Scientific publishing seems to be at a stage now where changes should be considered to take advantage of the possibilities offered by the internet. At the same time, the high levels of scientific standards which have been (and usually still are) the norm in the scientific publications on fusion research need to be preserved. The way forward could well be a similar scheme to that followed by other groups of scientists who are involved in activities with worldwide collaborations, such as high-energy physics. The path followed by them has been the use of a publicly accessible database of electronic pre-prints (e.g. http://www.lanl.gov, maintained by the Los Álamos National Laboratory in the USA) which serves as a central archive of all research publications in their field. This archive has several sub-sections, with one already on plasma physics (dominated by non-fusion orientated plasma physics). An improved system along those lines could be set up (it is already partially set-up with the JET pin-board web-page system) for worldwide fusion research activities or, at least, for the European ones. The basic system would be a web-page where papers can be submitted (after clearance by the fusion research institutes) in a standard format (pdf) to various subsections of the fusion research pre-print archive. A discussion board could be allocated to every submitted pre-print so that other researchers can express their opinion/questions about the results contained in the paper. Obviously, such a discussion board system can easily be subject to abuse and it may be necessary to control it, if too many users do not behave in a civilized manner. If copyright with particular journals becomes an issue once the paper is published, the link in the archive to the pre-print and the pre-print discussion board would be replaced by the link to the corresponding journal article. This would only be accessible to the institutions, which subscribe to the journal in question.

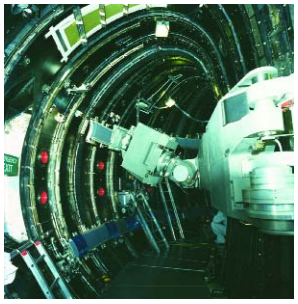
There are easy ways to publicly acknowledge the work of the referees, which can be implemented readily by the journals, and imply no risk to the anonymity of the refereeing process. A very simple option is to publish in the journal, at the end of every year, a list of all the referees that have provided advice to the journal and the number of papers that they have evaluated in the course of the year. This public recognition of the refereeing work is long overdue and, if implemented, could also form part of the researcher's record of scientific activities.

**Advantages** of an internet pre-print archive in conjunction with the traditional publication in scientific journals:

- standard pre-print number and submission date are available to authors, which serves as record of their contribution
- authors can obtain a pre-submission peer-review of their work if they wish
- scientists are provided with an up to date and centralized database of research advances in their field
- information (criticisms and answers) in the discussion board would be available to all the fusion researchers and also to the referees
- even if a paper is not finally published, its contents will be available to other fusion researchers, which can acknowledge the contributions of such a pre-print in their publications.

You would like to get **more information** on scientific publishing in the Internet? Please find interesting links to several scientific publishers on:

http://www.efda.org
> EFDA Forum



**Octant 8 Neutral Beam Injection (NBI) system:** The JET torus is divided into 8 sectors. Three of them are equipped with a NBI system injecting beams of fast neutral particles, which become ionised in the plasma and heat it as they slow down.

**S/T (Science and Technology) programme:** The experimental programme on the JET facilities since 1 January 2000 has been organised and conducted by S/T task forces comprising staff from the European fusion Associations.

JET

## 2002 JET Restart and Campaign 5: No Spurt but Hurdles

After the 2001 shutdown the restart activity commenced as planned on November 26th with the torus pump down. In January and February 2002 a series of problems with leaking vacuum windows, faults in the cryogenic plant, and a water leak from a window on the Lower Hybrid System delayed the restart activities by a total of two weeks.

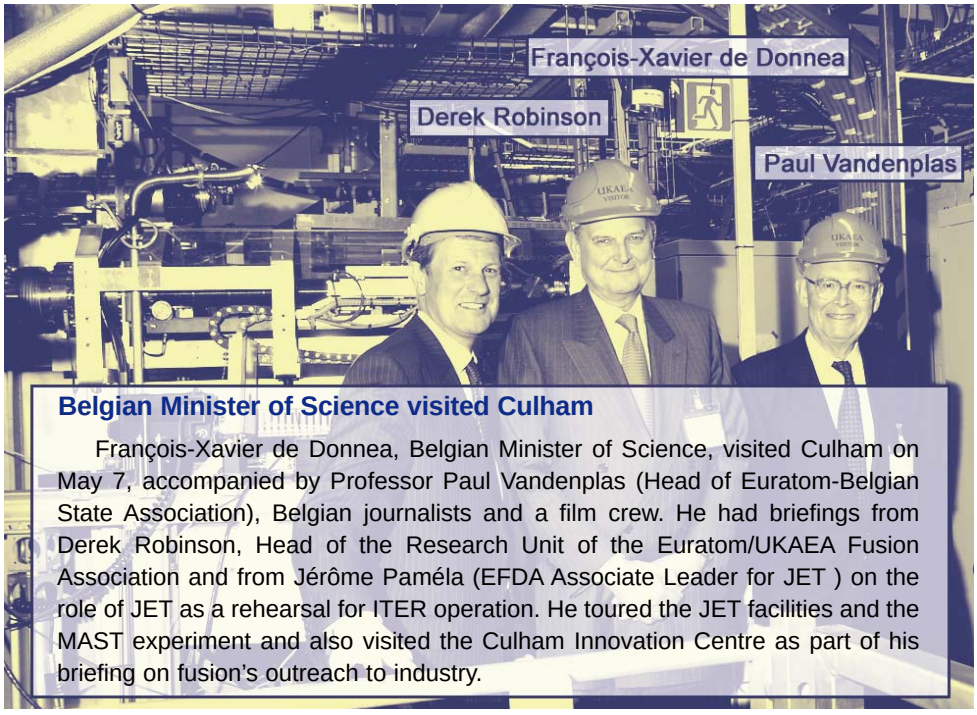
Following these delays, the start of EFDA experimental campaign C5 was moved to 18th March to allow the key systems to be commissioned. However, problems with the power supplies of Octant 8 Neutral Beam Injection (NBI) system delayed the availability of this system until the end of April.

Campaign C5 started on 18th March and finished on 31st May with a total of 101 experimental sessions planned and the participation of 200 scientists from 15 Associations. There was good progress with many aspects of the S/T programme, but various technical problems occurred during the campaign. This resulted in 21 sessions lost due to problems with various systems: failure of the baking plant control system; investigation of a suspected air leak (which turned out to be a false alarm); investigation of a suspected in-vessel water leak arising from the connection of an un-pumped volume to the torus; failure of a fan on the Poloidal Field (PF) flywheel generator; and problems with the Toroidal Field (TF) cooling circuit.

There were also constraints on the S/T programmes arising from the delayed availability and reduced power from the Octant 8 NBI system. This required significant reshuffling of the programme. Consequently, some experiments originally planned for C5 will not be completed until C7.

An analysis of the events and the relevant causes has been done by the operator and Culham CSU. Corrective actions have been defined. The urgent actions are being addressed in the August restart and campaign C6. The implementation of the full corrective plan is under discussion.

Although C5 was a difficult campaign, a number of interesting experimental results were obtained. The removal of the septum has increased the flexibility in terms of plasma shape. In ELMy H-mode plasmas there is preliminary evidence of higher confinement in the preparation of high current discharges; of mixed Type I-II ELMs in near double null configuration; and of reduction of target plate temperatures with Ar seeding. Diagnostic optimised configurations have been developed, with resolved pedestal and edge gradients. Electron heat modulation experiments using ICRF mode conversion in L mode indicate stiffness of electron profiles. The existence of a Neutral Point for density limit disruptions in JET was demonstrated and modelled: this has useful applications for disruption amelioration. Active control of advanced tokamak scenarios has been demonstrated with real time control of the plasma current profile. ITBs were obtained with the ITER shape. Pellets injected after the prelude phase lead to high density ITBs, with Te~Ti. Promising high current experiments were started by producing ITBs with 3.5 MA and 3.45 T.




### Belgian Minister of Science visited Culham

François-Xavier de Donnea, Belgian Minister of Science, visited Culham on May 7, accompanied by Professor Paul Vandenplas (Head of Euratom-Belgian State Association), Belgian journalists and a film crew. He had briefings from Derek Robinson, Head of the Research Unit of the Euratom/UKAEA Fusion Association and from Jérôme Paméla (EFDA Associate Leader for JET ) on the role of JET as a rehearsal for ITER operation. He toured the JET facilities and the MAST experiment and also visited the Culham Innovation Centre as part of his briefing on fusion's outreach to industry.

## ITER


### Successful meeting of US Fusion Experts in Snowmass, Colorado

Grounded in continuous progress, the world is now at a major decision point how to go forward with the exploration of a burning plasma, dominated by the self-heating from the fusion reactions.

The ITER participating countries have already since a long time, chosen ITER as their preferred approach. The US instead has been debating since 1999 which way to go. Mid July, for two weeks, the US Fusion community gathered in Snowmass, Co., to take a major decision about which burning plasma experiment to support. This place has been traditionally used by scientists from other fields to recess for an in-depth discussion of long-term programmatic issues. The combination of healthy mountain air and seclusion has been observed to foster a spirit of togetherness and optimism, and this effect seems to have worked once again! The major conclusions, which were developed by the participants during the 2002 Fusion Summer meeting are summarized below.

The study of burning plasmas, in which self-heating from fusion reaction dominates plasma behavior, is at the frontier of magnetic fusion energy science. The next major step in magnetic fusion research should be a burning plasma programme, which is essential to the science focus and energy goal of fusion research.

The three experiments proposed to achieve burning plasma operation range from compact, high field, copper magnet devices to a reactor-scale superconducting-magnet device. These approaches address a spectrum of both physics and fusion technology issues, and vary widely in overall mission, schedule and cost.

The contribution from IGNITOR, FIRE and ITER , the three candidate machines would differ considerably.

There is confidence that both ITER and FIRE will achieve burning plasma performance in H-mode based on an extensive experimental data base. The capabilities of IGNITOR, instead, remain an unresolved issue between the assessors and the IGNITOR team.

The results of the meeting, as analysed from a European point of view, were very positive. At the end of the meeting there was great enthusiasm among the community present to re-join the ITER process as a full partner. The output of this meeting will be the basis for a proposal to the US President to be prepared by FESAC (Fusion Energy Science Advisory Committee) at its meeting on September, 11.

**Snow what?**

The participants of the 2002 Fusion Summer Study in Snowmass (Colorado) reached major conclusions regarding the approach that the US should pursue to explore in the field of burning plasmas. These conclusions were based on analysis led by over 40 convenors working with hundreds of members of the fusion community extending over 8 months. This effort culminated in two weeks of intense discussion by over 250 US and 30 foreign fusion physicists and engineers present at the 2002 Fusion Summer Study.

**For more information please see:**

http://web.gat.com/snowmass/

The next FESAC Burning Plasma Strategy Panel Meeting has taken place on August 6-8, 2002 in Austin, Texas.

### New Websites on ITER

The EFDA Technical Working Group (European ITER Site Study group: EISS Group) has been established to prepare the technical basis for European ITER site proposals. Now you can find the EISS studies on our website:
http:///www.efda.org > Europe for ITER > EISS

New information on Cadarache as a candidate ITER Site is available by the end of August on http://www.itercad.org

On http://www-fusion.ciemat.es/fusion/iter/ITER-eng.html Euratom-Association CIEMAT presents Vandellós, the European Site proposed by Spain to host ITER.

## IPP & EPS

### First "Advanced Stellarator" at Garching (Germany) closed

On July 31, 2002, at 6.25 p.m. the last experiment was run in the Wendelstein 7-AS stellarator at the Max Planck Institute for Plasmaphysics in Garching (IPP), Germany. The device was closed after 14 years of successful work as the first machine of the"Advanced stellarator" generation. The resources and personnel are now transferred

You can find **more information** on Wendelstein 7-AS in EFDA-Newsletter Vol.3 / December 2001 on our EFDA website:

http://www.efda.org

For **more information** on IPP Greifswald and Wendelstein 7-X see:

http://www.ipp.mpg.de/eng/pr/institut/pr_inst_standort.html

### Fusion goes Switzerland: 29th European Physical Society Conference in Montreux

The 29th European Physical Conference on Plasma Physics and Controlled Fusion was held at the Centre de Congrès in Montreux, Switzerland from 17 to 21 June 2002. It was organized by the Centre de Recherches en Physique des Plasmas of the Ecole Polytechnique Fédérale de Lausanne, under the chairmanship of Dr. J. Lister, and held under the auspices of the Plasma Physics Division of the European Physical Society (EPS). The scientific programme was the responsibility of the International Programme Committee under the chairmanship of Prof. C. Varandas of Instituto Superior Tecnico (IST), Lisbon.

In alternate years the conference encompasses virtually the entire spectrum of activities in plasma physics topics in addition to controlled fusion research. The breadth of the main conference programme and the additional specialist sessions reflects the intention of the board of the Plasma Physics Division of the EPS to enlarge the scope of the conference with the aim of integrating all fields of plasma physics.


*Prof. M. Rosenbluth (left) and Prof. C. Varandas (right)*

Within the main conference programme, the delegates listened to 30 plenary invited talks and 36 contributed oral presentations and had the opportunity, stamina permitting, to see almost 500 poster presentations during the week. A particular highlight of the meeting was the award of the Hannes Alfvén Prize to Prof. Marshall Rosenbluth of University of California at San Diego in recognition of his distinguished achievements in plasma physics. In addition to the scientific programme a comprehensive social programme allowed the participants' partners to enjoy the many attractions in Montreux and in the surrounding Alps. An evening cruise on Lake Geneva also allowed the participants and their partners the opportunity to enjoy the beautiful countryside encircling the lake, to meet many old friends and to mix with colleagues from the many fields of plasma physics represented at the meeting.

**Topics of the Conference:**

- Basic plasma physics
- Astrophysical / geophysical plasmas
- Plasma applications
- Magnetic and inertial confinement fusion

**For more information see:**

**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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