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newsletter

EUROPEAN FUSION DEVELOPEMENT AGREEMENT

Issued by the EFDA
Close Support Unit
Garching

Foreword

The preparation of ITER operating scenarios on JET and other European devices is proceeding vigorously: during the EFDA-JET 2000-2001 experimental programme the longest internal transport barriers to be produced in a tokamak so far were observed, and three promising H-mode operational scenarios have also been developed for application on ITER.

News from the European ITER Site Study Group and the Cadarache ITER siting team: in November 2001 the first step of their studies in Cadarache was completed, concluding that this site would fully satisfy the requirements of ITER. The team has now launched the second step, the preparation of a possible licensing process. The construction of ITER also got a ringing endorsement from a high level expert group, appointed by the EU Council of Ministers to examine the possibility for a fast track to fusion energy production.

Content

News

Fusion Budget in the 6th EU Research Framework Programme 2002-2006

On 10 December 2001 the EU Council of Ministers reached an agreement in Brussels on the budget for the 6th Research Framework Programme, allocating EURO 750 million to controlled thermonuclear fusion in the EURATOM Framework Programme. The final agreement is expected later this year.

For more details check the Website of the Council of the European Union: http://ue.eu.int/newsroom/main.cfm?LANG=1

Full Set of Divertor Prototypes made in Europe

During the ITER EDA (Engineering Design Activities) and CTA (Coordinated Technical Activities) Europe has developed an extensive R&D programme which included the manufacturing of a complete set of full-scale prototypes for each divertor component. To mark the occasion a special event was held on 16 January 2002, an "EU Divertor Celebration Day", which was organized at Plansee AG, Reutte, Austria. Full coverage of the event will be reported in the next EFDA Newsletter.

A fast Track for fusion

At the end of 2001, the EU Council of Ministers requested that a group of experts, chaired by Prof. David King, Chief Scientific Advisor to the UK Government, be set up to examine the possibility of a fast track towards fusion energy production. The conclusions of the panel were an endorsement of ITER, to be constructed as soon as possible, and at the same time, the start of IFMIF (International Fusion Material Irradiation Facility) engineering design activities.
For the full report see our EFDA website!

ITER

Find the complete press release on our website:

http://www.efda.org

News from Japan: Second Negotiation Meeting on ITER Site Selection

The second Negotiation Meeting to continue the formal negotiations on the Joint Implementation Agreement of the ITER project was held in Tokyo on 22 to 23 January 2002. The main subject of the meeting was a preliminary draft of the Agreement, which will govern the construction, operation and decommissioning on ITER. The participants – delegations from Canada, the European Union, Japan and the Russian Federation – also discussed the preparation of the basis for a site selection process, procurement allocation schemes and transitional arrangements towards the project implementation. The next Negotiation Meeting is scheduled for 19 to 20 March 2002 in Moscow.

You would like to learn more about Cadarache as ITER site?

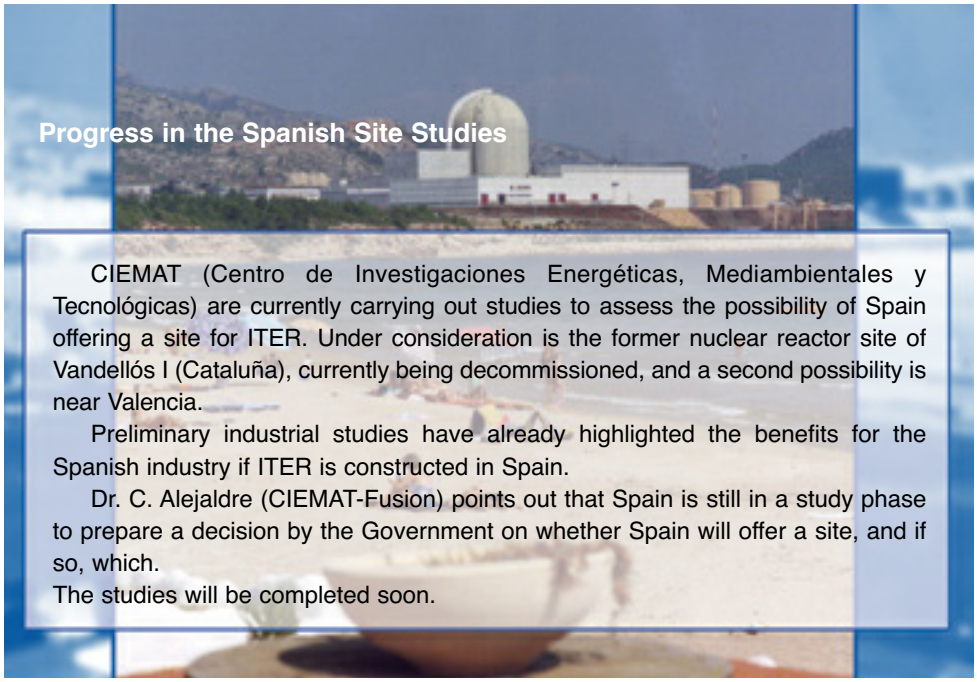
http://www-fusion-magnetique.cea.fr/

Progress in France: ITER Site Studies in Cadarache

Cadarache fulfills all ITER requirements. This is the conclusion of the first step of the ITER site studies that has now been completed and the documentation delivered to EFDA in November 2001. A Preliminary analysis of the safety and environmental impact around Cadarache ("Dossier d'Options de Sûreté") has been carried out.

The doses expected for the local population for both normal operation and accidental events are very low, in comparison with the recommendations issued by ICPR (International Committee for Radiologic Protection).

The second step of the European ITER Site Studies (EISS 2) will involve many Associations, and has now been launched. The main objective of this second step is to perform all activities that are on the critical path to the siting of ITER at Cadarache. This includes the writing of the "RPrS - Rapport Préliminaire de Sûreté" (preliminary safety report), a mandatory document for the licensing process. RPrS will describe the installation, present the safety objectives and propose the technical options and the scope of these objectives. Further steps will be the specification of the required site adaptations, and the realization of the "Débat Public", a key element of the public participation process.



Progress in the Spanish Site Studies

CIEMAT (Centro de Investigaciones Energéticas, Mediambientales y Tecnológicas) are currently carrying out studies to assess the possibility of Spain offering a site for ITER. Under consideration is the former nuclear reactor site of Vandellós I (Cataluña), currently being decommissioned, and a second possibility is near Valencia.

Preliminary industrial studies have already highlighted the benefits for the Spanish industry if ITER is constructed in Spain.

Dr. C. Alejaldre (CIEMAT-Fusion) points out that Spain is still in a study phase to prepare a decision by the Government on whether Spain will offer a site, and if so, which.

The studies will be completed soon.

More information in the article published by ABC (Spanish newspaper):

http://www.abc.es/Sociedad/noticia.asp?id=76482&dia=06022002

Interested in CIEMAT? See:

http://www.ciemat.es/eng

Highlights on JET

The present work on JET is directed primarily towards the preparation of ITER operation and is focused on the so-called ELMy H-mode which offers a well-established path to the ITER design target of a 10-fold amplification of the input power through fusion reactions (Q=10). Beyond this, however, ITER will also explore regimes of true steady state operation, which require the attainment of better confinement and higher plasma pressures at given plasma current and magnetic fields. The two largest task forces on JET, S1 and S2, address the scientific issues connected with the base-line and the steady-state operation of ITER.

Important results in advanced tokamak experiments

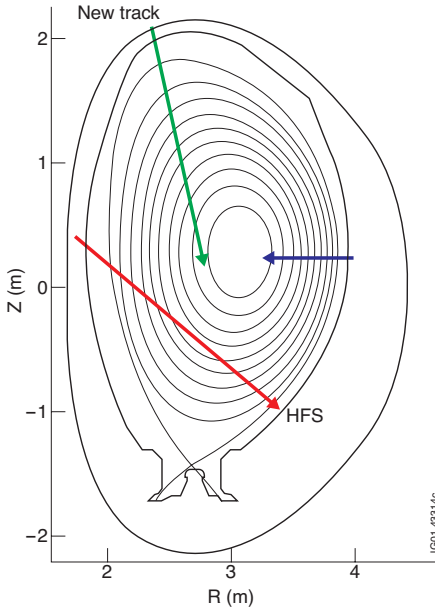
At the American Physical Society Plasma Physics Conference in Long Beach, California in October 2001, a paper on the progress made on internal transport barrier plasmas in JET was presented. The main goal of advanced tokamak experiments is to obtain plasmas with fully non-inductive current, as opposed to the more standard inductive current plasmas where operation is restricted to a pulsed mode. The advanced tokamak scenario relies on a combination of self-generated plasma current (bootstrap current) and external current drive provided by additional heating systems.

In the EFDA-JET 2000-2001 experimental programme, one of the most interesting results was to observe the longest internal transport barriers, which have been produced in a tokamak so far. They went on for nearly 8s and corresponded to 27 times the energy confinement time, which is the time required for energy to leave the plasma. These discharges had more than 80% non-inductive current.
Plasmas with full non-inductive current (1.8 MA) were maintained for a few seconds.

Real-time control experiments in this scenario have demonstrated that the local electron temperature gradient can be controlled with Ion Cyclotron Resonance Heating.

These new experiments allow the study of steady-state ITB plasmas in preparation of ITER operation.

Progress in developing ITER scenarios in JET



During the past two years at JET under EFDA three promising H-mode operational scenarios have been further developed. The results were the simultaneous realization of high density and confinement as required for ITER.

A first method showed that by increasing the plasma triangularity, strong gas puffing does not deteriorate confinement in these plasmas, provided sufficient heating is applied. Thus, high density values can be obtained without confinement loss, resulting in addition to plasmas with very low dilution. The additional 7.5 MW of Neutral Beam power, available in campaign C7, will allow to extend the studies to ELMs mitigation effects to plasmas at higher absolute densities.

Another means of increasing the density without confinement deterioration is high field side pellet fuelling with a well chosen repetition rate, as demonstrated in C4. A new high field side pellet track (fig. left) , due to be available in

Break-even (Q):
The fusion performance of a power plant is denoted by Q, which is the ratio of the power in the fusion products to that used to heat the plasma. Break-even corresponds to Q = 1, ignition corresponds to infinite Q. A burning plasma has Q > 5.

Task force S1:
Consolidation of ITER database and reference scenarios

Task force S2:
ITER Advanced Scenarios

Bootstrap current:
Self-generated current flowing in the plasma

Ion Cyclotron Resonance Heating (ICRH):
Additional heating method using radio-frequency waves at frequencies matching the frequency at which the ions gyrate around the magnetic field lines. The ICRH range of frequencies is 25–55 MHz.

Internal transport barriers (ITB):
These barriers are insulating layers created in the plasma core that decreases the transport of particles and/or energy outside the plasma and gives rise to large pressure gradients.

For more information see the EFDA-JET Bulletin in the JET website:

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

H-mode:
High confinement regime, observed in tokamak plasmas

Neutral Beam power:
Injection of a beam of fast neutral particles which become ionised in the plasma and heat it as they slow down

PINI:
Plugged In Neutral Injector

ELM:
Edge Localised Mode is an instability which appears when the plasma is in the high-confinement H-mode configuration as it depends on the pressure profile at the plasma edge

JET - C(ampaign)1:
31 March - 28 July 2000

C2:
4 Sept. - 27 Oct. 2000

C3:
6 Nov. - 8 Dec. 2000

C4:
8 Jan. - 30 March 2001

C5:
18 March - 31 May 2002

C6:
16 Sept. - 11 Oct. 2002

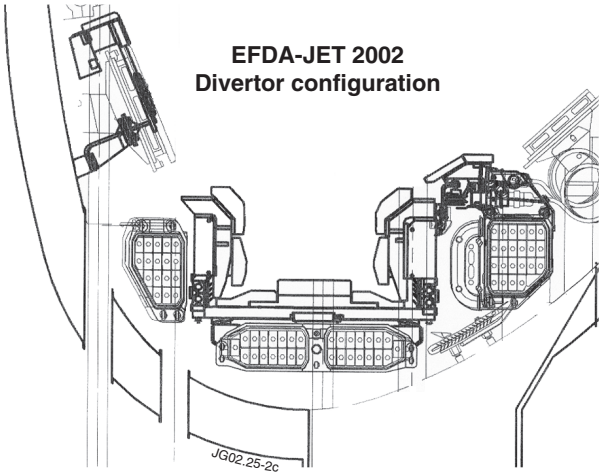
C7:
21 Oct. - 13 Dec. 2002

FOM:
Foundation for Fundamental Research and Matter.
http://www.rijnh.nl

Risø is a national Danish laboratory in Roskilde (Denmark) under the Ministry for Science, Technology and Innovation.
http://www.risoe.dk/

Thomson Scattering diagnostic:
To measure temperature and density by detecting laser light scattered and Doppler shifted by the plasma electrons.

campaign C6, enabling to launch pellets into the plasma with up to three times higher velocities, will allow a further optimization of the promising results of C4. A third method consists in seeding the plasma with impurities. Those plasmas not only show high confinement and densities as needed for ITER. Promising indications have been found that the enhanced radiation from the seeded impurity also results in a reduced heat load to the divertor. The studies started in campaigns C1-C4 will be further extended this year in all three regimes. The removal of the septum in the divertor (fig. left) will allow an assessment of its contribution in establishing the excellent results of the 2000-2001 campaigns. The final aim is to obtain an integrated operational scenario combining the necessary conditions for use on ITER : high confinement, high density and an acceptable power and particle exhaust.

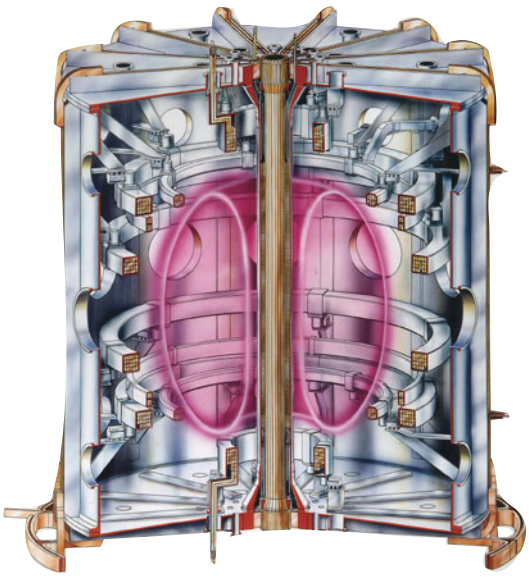


EFDA-JET 2002
Divertor configuration

Associations

MAST: Experimental campaign successfully completed

The 2001 experimental campaign on the MAST (Mega Amp Spherical Tokamak) at Culham was completed on 16th November. An important achievement during the campaign was the first injection of Deuterium Neutral Beam power into the plasma (up to 1.5 MW) with neutron emissions consistent with predictions.



The multiple pellet injector (dona- ted by the Association EURA- TOM-FOM and installed with the assistance of the Association EURA- TOM-Risø) inject- ted Deuterium pellets into the plasma and successfully fuel- led the plasma core for the first time. Furthermore the access to H- mode regimes with higher energy confi- nement times was improved. The results from these experiments helped to distinguish bet- ween different H- mode threshold scaling laws.

A new Thomson Scattering diagnostic was commissioned which provided measurements of accurate the electron densi- ty and temperature over 300 spatial points.

The next experimental campaign will start in February 2002 and will feature experiments directly relevant to ITER and the improved understanding of Spherical Tokamak Physics.

Austrian Association Day on Fusion: Technology at the cutting edge

The fifth annual "Association Day on Fusion Technology" of the Association EURATOM-ÖAW took place on 7 December 2001 and was for the second time hosted by Plansee AG in Reutte, Tyrol (Austria). In co-operation with the Erich Schmid Institut für Materialwissenschaft of the Austrian Academy of Sciences in Leoben, Plansee AG is participating in the development and testing of chromium alloys with a view to their possible use in future fusion power plants.

Guests were welcomed from EFDA Garching and the IAEA physics division in Vienna. An on-site presentation was made to participants on the production of Plansee High Performance Materials.

Junior and senior scientists currently active in these areas presented and discussed contributions to the EFDA Technology Programme in the fields "Nuclear data", "Magnetic structure and integration", "Materials development" and "Physics integration". Guests from Garching were M. Gasparotto and C. Sborchia, who made valuable recommendations especially for the Materials Programme (reduced-activation ferritic-martensitic steel, SiCSiC ceramic materials, chromium alloys). This programme is one of the declared areas of interest and expertise of the Austrian Association.

The website
http://www.oeaw.ac.at/euratom
presents an overview of the activities of the Association EURATOM-ÖAW.
Activities of Plansee AG in the field of thermonuclear fusion are shown at:
http://www.plansee.com/index.

Energy for the future: IPP celebrates multiple anniversary

On 30 October 2001 the Max-Planck-Institute for Plasma Physics (Association EURATOM-IPP) at Garching celebrated four anniversaries at one go. Approximately 800 employees and guests celebrated the 40th anniversary of the founding of the institute, the 30th anniversary of its becoming member of the Max-Planck-Society, the world's first demonstration of "real" stellarator operation 20 years ago and 10 years of successful operation of ASDEX Upgrade.

In his welcoming address **Prof. Alex Bradshaw** reminded that "already in the sixties it was clear that the way towards the utilisation of nuclear fusion as source of energy would be long and laborious." Now, the proposed experimental reactor ITER is to find out whether fusion can be used in power plants.

Dr. Hermann Schunck of the Federal Research Ministry pointed out that it is important for the federal government to see that fusion research is part of a long term energy strategy which includes reasonable promotion of renewable energies as well.

Prof. Hubert Markl, president of the Max-Planck-Society reminded of the enormous challenges connected with the founding of the IPP division at Berlin in 1992 and the establishment of the branch institute at Greifswald in 1994.

In his address **Dr. Edmund Stoiber**, Prime Minister of Bavaria, was not only looking back. He stated that the question of what role fusion could play in a future mix of energies is important, too: "Nuclear fusion is one of the most interesting options for future energy supply."

Prof. Fritz Varenholt, former SPD Minister of Environment at Hamburg and today executive chairman of the wind power company Repower Systems concluded in his address: "However, the presently used mix of energies cannot be preserved. Fusion research, inherently safe nuclear power stations and renewable energies - these are the directions to go."

Do you speak German and like to read the address of Prof. Varenholt?

See:
http://www.ipp.mpg.de/de/presse/pi/13_01_pi.html

Associations

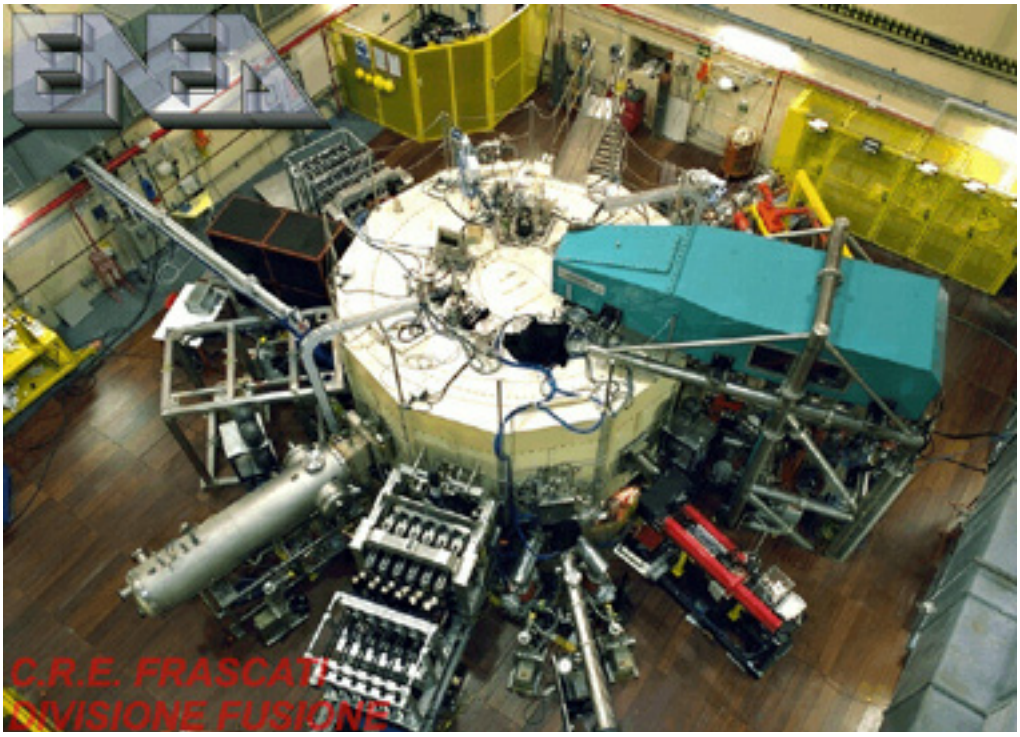
For more information:

http://www.frascati.enea.it/FTU

Lower Hybrid Current Drive (LHCD) Experiments in FTU

At present, FTU at the Centro Ricerche Energia (Association EURATOM-ENEA) in Frascati is the only high magnetic toroidal field tokamak operating in Europe (up to 8 Tesla, 1.6 MA) extending the database on confinement and heating necessary for ITER to high magnetic field and high-density regimes.

The FTU (Frascati Tokamak Upgrade) 8 GHz LHCD system has recently been operated close to its design value. This means: 6 gyrotrons feeding 6 independent wave guides launchers with a total launched power of 2.4 MW (about 4.4 MW at source) for 0.5 sec. At this power level, current drive experiments can be performed in conditions similar to the one foreseen for ITER advanced steady state scenarios. In effect, the LHCD system has been operated up to 2.2 MW for a time duration lasting several times the energy confinement time (typically 10 times) at density and magnetic field high enough to be relevant for ITER.



A substantial increase of the neutron yield, typically by a factor of five, is observed. This indicates that a good collisional transfer between the bulk ions of the plasma and the Lower Hybrid accelerated fast electrons is taking place.

Off-axis LHCD has also been used to produce electron internal transport barriers (ITB) at relatively high densities. ITBs are sought to be an important feature of the advanced scenarios foreseen for ITER allowing steady state operation to be achieved. By broadening the plasma current profile with off-axis ECRH (Electron Cyclotron Resonance Heating) during the plasma current ramp-up phase, ITBs were subsequently produced with 1.7 MW of LHCD leading to high central temperature for several energy confinement times.

Further development is taking place, in particular in combining ECRH (140 GHz) and LHCD systems at the highest possible densities in order to prepare ITER advanced scenarios.

LHCD:
The Lower Hybrid Current Drive is a non-inductive current drive using lower hybrid waves. The Lower Hybrid range of frequencies is 1- 8 GHz and it is between the one of the Electron Cyclotron Resonance Heating and the one of the Ion Cyclotron Resonance Heating.

ECRH:
Electron Cyclotron Resonance Heating uses radio-frequency waves resonating with electrons gyrating in the magnetic field, corresponding to frequencies in the range of 30 to 170 GHz.

Women in Science

Gender equality: A lot done, a lot still to do

EFDA Newsletter (E.N.):
You are working in a men's world – why did you choose a technical subject to study?

Gabriella Saibene (G.S.):
Well, I liked it and I was very lucky in my scientific high school in Italy. I had very good teachers, in particular in maths and physics. It was very exciting. So when I finished high school I thought that physics would be a very interesting thing to study.

E.N.: Did your parents have an influence on your decision?

G.S.: No, my parents are working in commerce, so they didn't know anything about physics. But they supported me all the time in this choice.

E.N.: Do you have an idea why women are under-represented in nearly all areas of research?

G.S.: The fraction of people who go into research is not very high anyhow – no matter if they are women or men – most of my student colleagues went into industry because of the money. But probably there are just a few women who go into research.

E.N.: So, what could be done in your opinion to get more women into research?

G.S.: First, good teachers have to get the attention of the girls at school, so they think that science is great, cool, something that you want to do. To get them into research is a matter of making the environment there possible for women and their families. After university it's common that one goes abroad for a period of one or two years. And this is more difficult for women: the husband that follows his wife around is really a very rare figure...

E.N.: What do you feel about quotas like the Commission's 40% target or other kinds of "positive discrimination"?

G.S.: Sure, there must be some effort in promoting women – role modelling is important. But in science the first criterion has to be competence and professionalism. So instead of quotas I'd prefer to call it gender equality. When people are equivalent and in that case women are preferred, that's ok to rise their number in research.

E.N.: … and there is also still an academic level above which very few women advance!

G.S.: This is a question of critical mass. If we manage to get more women in higher positions in research, the more there are the more acceptable will be a woman at a high level. Women need some structure when they are, say, between 25 and 35, to solve the problem between family life and a professional career in science. These women will stay in their career and will have the opportunity to progress and then later on when they would be mature for a manager position they will be there to take it - and not have disappeared because of family responsibilities.

E.N.: What about your own situation as one of two women among 33 male researchers at EFDA Garching? Do you have to fight more for getting through your results than a man?

G.S.: Maybe there are some small problems with attitude. A man is defined to be "determined" while a woman is "aggressive" for the same kind of behavior. But by and large it's ok. I think that a supportive and unprejudiced direct management, as I was lucky to have in my career so far, is essential since it creates a working environment that is not conflictive and boosts self-confidence.

Interview: DL

The lack of women in nearly all areas of science was already a hot topic of discussion in Brussels during the 5th Framework Programme (FP5). But at the third Commission conference on gender and research in Brussels on 8 / 9 November 2001, a poll showed that 57.9 % of the audience of around 600 people (91.9 % of which were female) believed that the situation has improved in terms of policy, but not in practice, since 1998.

Dr. Gabriella Saibene (43), a scientist taking care of physics issues of ITER construction at EFDA Garching, outlines in our interview her experiences as a female researcher. Dr. Saibene is one of the only five people who have the license to lead JET operation at maximum performance level - and two of the other four are also women.

On 5 June 2002 the conference on "Mujeres y Ciencia", a Spanish edition of the Commission's conference mentioned above, will take place in Madrid.

For more information:

http://www.cordis.lu/spain/es/05062002.htm

For further information on women and science see:

http://www.cordis.lu/rtd2002/science-society/women.htm

http://www.ieee.org/organizations/committee/women/

http://www.iaea.or.at/women/safeguards/

Fusion & the Public

EFDA at AOG Expo 2001 in Buenos Aires

EFDA participated in the Argentina Oil & Gas (AOG) Expo 2001, which was organized together with the 18th World Energy Congress (WEC) and held in Buenos Aires (21 - 25 October 2001). The stand was sponsored by the Max-Planck-Institute for Plasma Physics (Association EURATOM-IPP) in Garching, Germany.

Through exhibiting at this event EFDA has established many new contacts with opinion formers and decision makers from different branches of energy research and energy planning. The aim of EFDA is to get fusion recognized as a key player in the debate over long term energy provision and climate change.

About 300 exhibitors came from different energy sectors including hydro, oil, gas, carbon, nuclear and wind. During the five days of the exhibition the EFDA stand received approx. 650-700 visitors, who were congress participants as well as external visitors – such as journalists, university professors, politicians, energy experts and energy advisers. The large majority of people who visited our stand were aware of fusion in general. All the visitors were impressed by the progress that has been made in fusion research and most of them considered fusion a serious candidate for the future energy supply.

The outcome of the participation was extremely positive. It gives us confidence in pursuing further the EFDA policy to be represented at this type of event. We have also been encouraged to do so by Alan Morrison, the Executive Director of the organization committee for the next WEC, to be held in Sydney in 2004.

For more information on 18th/19th WEC see:

http://www.18th-wec.com.ar/congress.html

http://www.tourhosts.com.au/energy2004/english/invit.asp

Mechanical Engineering, Vol. 123 / No. 12, December 2001, p. 51- 55

For this article see:

http://www.memagazine.org/backissues/dec01/features/basicdrv/basicdrv.htm

Some of the main exhibitors were:

EDF, Alstom, Babcock Borsig Power, GE Power, Mitsubishi, Toshiba, IHI, Hitachi, Repsol YPF, Siemens, Techint

Physics on Stage ...

is an educational outreach initiative of European Intergovernmental Research Organizations for European physics educators. It was set up by three leading organizations (ESA, ESO, CERN) in 2000 to give teachers from 22 European countries the opportunity to take part in national programmes and international festivals to exchange teaching ideas and materials.

The first year of events was so successful, that a continuation of the project was ensured, in the form of Physics on Stage 2. The next festival will take place between 2-6 April 2002 at ESTEC in Noordwijk, The Netherlands.

You would like to get involved with Physics on Stage?

For further information and contacts see:

http://www.estec.esa.nl/outreach/pos

For more information see our new EFDA website:

http://www.efda.org

and additionally

http://www.jet.efda.org

http://www.iter.org

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