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newsletter

EUROPEAN FUSION DEVELOPEMENT AGREEMENT

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Contents

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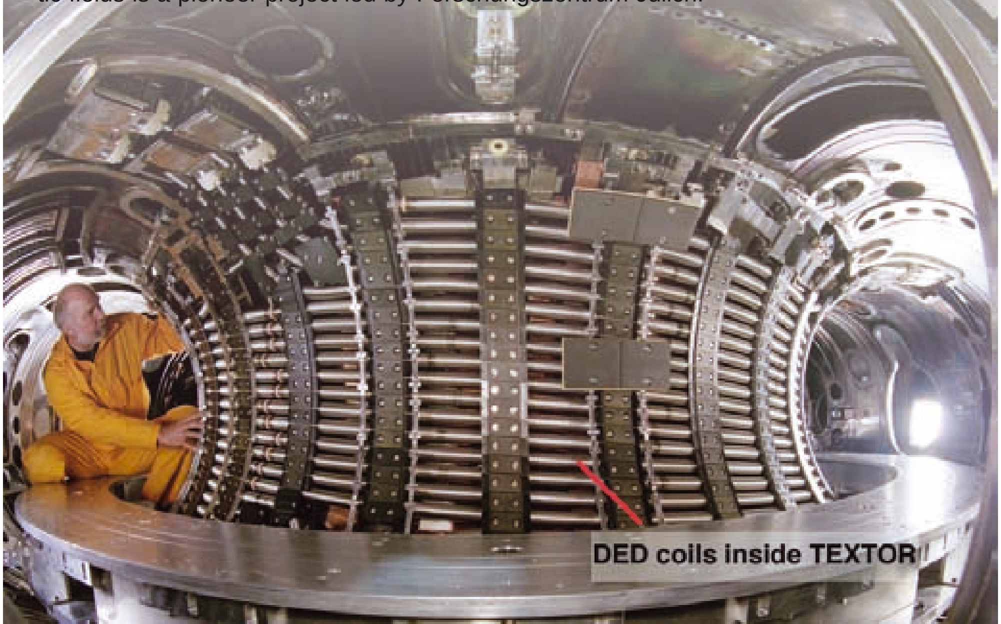
News

ITER Negotiations: Growing International Interest in Participating

At their seventh Negotiations Meeting on 2nd of December 2002 in Barcelona (Spain) the delegations from Canada, the European Union, Japan and the Russian Federation saw progress on a number of fronts towards the implementation of the ITER project. Josep Piqué, Spanish Minister of Science and Technology, emphasized the unconditional support of the Spanish Government, regional and local authorities for the proposal of Vandellòs as a European site for hosting ITER. The final report of the Project Board on the Co-ordinated Technical Acitivities for ITER was presented. As a very positive development the delegations welcomed expressions of interest in the ITER project from the People's Republic of China and the Republic of Korea. Discussions are underway with both countries regarding the possible steps to join the ITER Negotiations process. The eighth Negotiations Meeting will be held in St. Petersburg (Russian Federation) on February 18-19, 2003. (For News from China please see page 5)

TEXTOR Officially Re-opened after Dynamic Ergodic Divertor (DED) Installation

On 6th December 2002 Forschungszentrum Jülich (Germany) inaugurated a development which is unique within the worldwide fusion effort. The Dynamic Ergodic Divertor (DED) has been installed in the TEXTOR tokamak to improve the control of the fusion process, especially addressing the transport of energy, heat and particles in the plasma boundary. The DED consists of 18 single coils, which are fixed to the inner torus walls, exactly where the magnetic field lines hit the vessel. The heat fluxes are normally concentrated by the field lines, forming surface hot spots that may withstand damage only for a limited time before being overheated. The DED coils produce a rotating (dynamic) distortion of the magnetic field, and the closed magnetic field lines are broken up (ergodised) by vortices at the plasma edge. This helps to spread the heat from the plasma boundary over a larger surface. Moreover, it will allow for a better control of energy and particle transport in the plasma boundary. The principle of the ergodic divertor was experimentally proven for the first time on Tore Supra at the Association Euratom-CEA Cadarache (France) based on theoretical studies performed at Jülich and Cadarache in the 1980s. The addition of the dynamic concept of rotating magnetic fields is a pioneer project led by Forschungszentrum Jülich.



DED coils inside TEXTOR

Pablo Fernandez Ruiz began his professional career in the projects office of Construcciones Aeronauticas (CASA) in Madrid (Spain) in the area of structural analysis. He has also worked in the area of nuclear fission fuel. In 1988 he joined the European Commission, Euratom as Head of Division. Now he is the director of Energy in the European Commission's Research Department.

For more information see:

http://europa.eu.int/comm/environment/wssd/index_en.html

and

http://europa.eu.int/comm/dgs/research/organisation_en.html

Interview

"The best image of a strong and efficient programme drives fusion ahead"

EFDA Newsletter (E.N.): *Your professional career started in the field of Aeronautics, which is – together with Energy – one of the 7 main themes of the European Commission's FP6. Which parallels do you see between these two fields?*

Pablo Fernandez Ruiz: Aeronautics and Energy are both fields of considerable importance in the economy of the EU. Aeronautics, since its beginning, and Energy, more recently, with their sophisticated forms of production, distribution and use, are highly dependent upon Research and Development for their future. The EU aerospace industry has gained its competitiveness at the world level by coordinating and integrating national activities. When it comes to fusion as a component of energy research, the EU is a world leader, thanks to a very well integrated research programme. So I can say that the integration aspect in both cases has been very positive for assuring that the EU can compete at the world level. But I also have a wide experience in the field of nuclear fission. This helps me greatly because the fission world, even though very specific, helps to understand the field of fusion in all of its complexity.

E.N.: *How do you see the respective roles of fusion and fission in the future energy market?*

Ruiz: At the moment it's not possible to achieve the Kyoto objectives without nuclear fission. But it's important for our future to develop new technologies for fission as well as for fusion, understanding that the two areas are on two different levels of development: fission being a reality in the generation of energy, and fusion being on the verge of scientific and technological demonstration of its feasibility. Beyond ITER, one further generation of demonstration and prototype devices will be needed before fusion will enter the market. In the end the objective of research is to offer options for society to choose when the right moment has come. And at that time we must be prepared in fusion. It's important to highlight the fact that fusion provides an enormous advantage in relation to security of supply of fuels. These are available within the European Union and could contribute to reduce the enormous dependence of the European Union on external supply of fuels.

E.N.: *In which way will you personally support fusion during the next few years?*

Ruiz: ITER is an initiative undertaken jointly by the Europeans and other international players, so it is important to recognize that we have to adapt the fusion programme to the new conditions. I will strongly support the fusion programme in implementing this process, so that it can reorganize itself to ensure that it is a coherent and well structured programme, remaining a good model of the European Research Area. This means I will help to find proper support to drive forward the ITER development in the coming 10 years and beyond. All parties must be involved and we need to present the fusion programme so as to reflect its true value, as a vital element of the Commission's energy research programme.

E.N.: *In the 2001 proposal by the Commission, fusion was allocated 700 Million Euro. Eventually, the EU parliament and the Council of Ministers have pushed it to 750 Million Euro. By "vital element", do you mean that fusion will get more financial support from the Commission during FP7 – without the "help" of the European Parliament and the Council of Ministers?*

Ruiz: It's difficult to say at this stage what will be the orientations for FP7 and beyond. But we should not apply for a large increase in budget without very solid arguments. The European Fusion Programme must be strong. In order to achieve this, there are clearly financial needs. But an effective response of the programme, in organisation and substance, to the forthcoming challenges is also essential. When preparing the fusion part of its proposal for FP7 it can be expected that the Commission will assess the coherence and the efficiency of the fusion programme and its relation with our possible international partners. But as you know, the decision will belong ultimately to the budgetary Authority, i.e. the European Parliament and the Council, and both Institutions will likely pay also great attention to how the programme is adapting itself to the realization of ITER.

Interview: D. Lutz-Lanzinger

ITER

FZ Karlsruhe: Testing of the Toroidal Field Model Coil successfully completed

The ITER Toroidal Field Model Coil (TFMC) was built by European industry according to the conceptual design, which was elaborated by the European Associations under the coordination of EFDA. The objective of the project is to develop and demonstrate the superconducting magnet technology to a level that will allow the ITER toroidal field coils to be built with confidence. The construction and test of the TFMC is one of the seven large ITER R & D projects within the ITER activities.

After the first batch of tests in 2001, the TFMC was tested in the second half of 2002 in the background field of the existing Euratom Large Coil Task (LCT) coil in the TOSKA facility at Forschungszentrum Karlsruhe (Germany). The aim of the TFMC test phases was to verify the design concept and the industrial manufacturing procedures, as well as the achievable tolerances. To validate the design parameters, the mechanical strength of the structures and the current carrying capacity were tested at the rated values of 70 kA, 8.8 T and 4.5 K. Furthermore the operation limits of the "Cable-in-Conduit" conductor were to be checked.

The testing of the model coil was organized in two phases. During **Phase I**, which was carried out in **2001**, the TFMC was tested as a single coil:

- **June, 25:** The cool down started. The circuits of the coil were cooled by supercritical Helium, which maintains its cooling power by forced mass flow driven by pumps operating at 4.5 K.
- **July, 6:** The transition to the superconducting state was reached for the first time.
- **July, 23:** At the end of the ITER Engineering Design Activities (EDA), the TFMC operated as a single coil reached its maximum current of 80 kA.

The TFMC was intentionally quenched nine times, before and after being cycled, without counting safety discharges. There were no negative consequences arising from the quenches or from the cycling.
For preparing **Phase II** the ITER TFMC and the Euratom LCT coil were assembled as a single structure and re-installed in the TOSKA vacuum vessel. This was completed in the first half of **2002**.

- **August, 20:** the cool down started.
- **September, 3:** the superconducting state in TFMC was reached again
- **September, 26:** the coil testing of phase II started. The TFMC was energized alone up to 80 kA, which repeated the result of last year's test.

The Euratom LCT coil, providing the background field for the test of TFMC, was also tested alone: first at a winding temperature of 4.5 K to a maximum current of 11.3 kA, and later at a winding temperature of less than 3.1 K to a maximum current of 16 kA. Finally the coil assembly was energized to the rated values of 70 kA in TFMC and 16 kA in LCT. This corresponds to 8.78 T maximum field at the conductor of the TFMC and 282 MJ of stored energy in both coils.

In order to check the mechanical rigidity of both winding pack and coil case, the TFMC was cycled in the background field of the Euratom LCT coil, which was kept in steady state operation at 16 kA while the TFMC was ramped up and down to the maximum current in several steps, starting at 17.5 kA and ending at 70 kA. During this second phase the TFMC was intentionally quenched twice.

For the case of maximum currents (80kA in the TFMC and 16 kA in the Euratom LCT coil, 9.67T magnetic field at the conductor of TFMC) the design parameters of the conductor were confirmed. Phase II was successfully completed in December 2002. All tests have achieved the expected results and the operating conditions for ITER have been confirmed with a reasonable temperature margin.

The LCT project was undertaken in the framework of an international collaboration of Euratom, Japan, Switzerland and the US under the auspices of the "International Energy Agency" (IEA). The Euratom LCT coil was first tested in the TOSKA facility in 1984.

1995: The ITER TFMC project started

1997: Engineering design was completed

2000: The construction of the coil based on new design principles and manufacturing methods was completed

July, 23, 2001: The TFMC reached its maximum current of 80 kA.

Dec. 2002:
The Testing of the TFMC in the background field of the existing LCT coil was successfully completed.

TOSKA vessel:
4.45 m Ø, 6.6 m high

TFMC:
2.73 m wide, 0.77 m thick, 3.8 m high, weight 34 t

Intercoil structure (ICS):
4.03 m wide, 0.70 m thick, 4.67 m high, weight 24 t

LCT coil:
3.5 m wide, 0.82 m thick, 4.6 m high, weight 59 t

For more information see:

http://hbksun17.fzk.de:8080/PKF/e_index.html

JET

JET:
Joint European Torus

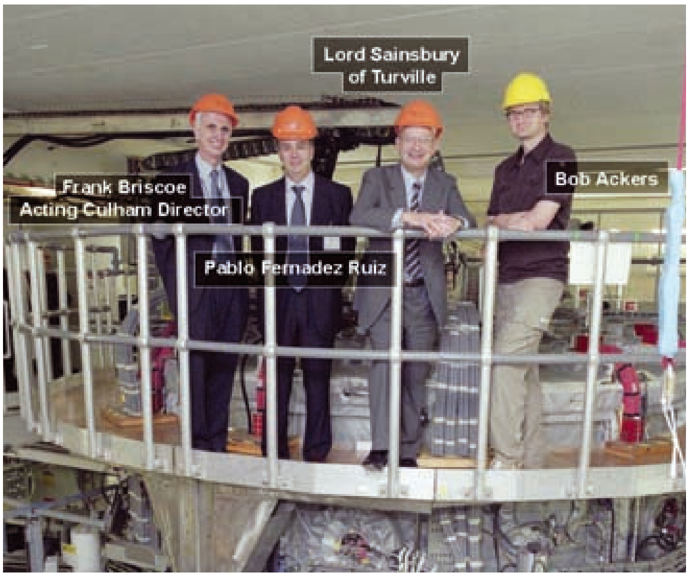
MAST:
Mega Amp Spherical Tokamak

For more information on JET and MAST see:

http://www.jet.efda.org/
and
http://www.fusion.org.uk/mast/

Lord Sainsbury visits the Culham Science Center (UK)

The UKAEA and JET facilities at Culham (UK) welcomed a prominent visitor on 29th November. Lord Sainsbury of Turville, Her Majesty's Parliamentary Under Secretary, was briefed on current developments in fusion research, including the status of planning for the ITER and the 'Fast Track' proposed by the European Expert Group led by Professors Sir David King, the UK Government Chief Scientific Advisor. He toured JET, MAST and the Culham Innovation Centre, showing keen interest in all areas of work.



A significant Step in the Coordination of Tokamak Experiments at World Level

A unique and successful meeting was held at MIT in Cambrige (USA) on 18/19 November 2002 to consider the coordinated implementation of high priority burning tokamak plasma research on the major world tokamaks. The leaders of these facilities (JET and ASDEX Upgrade from Europe; JT-60U from Japan; and DIII-D, C-Mod and NSTX from the U.S.) met with representatives of the Coordinating Committee of the International Tokamak Physics Activity (ITPA) and the Executive Committees of the International Energy Agency Implementing Agreements (IEA-IAs) on Cooperation Among the Large Tokamak Facilities between the EU, Japan and the US, and on the Poloidal Divertor Agreement between the EU and the US.

The ITPA Topical Physics Groups involve about 150 scientists from the EU, Japan, the Russian Federation and the US and during their meetings in October 2002 developed outline proposals for experiments on open physics issues which should be pursued in order to enhance understanding of tokamak burning plasma science for ITER. These proposals addressed issues related to plasma confinement, internal and edge transport barriers, divertor and scrape-off layer physics, MHD instabilities, disruptions and control, steady state operation, fast particles and diagnostic developments. The meeting at MIT discussed the implementation of those outline proposals which would benefit from coordinated joint experiments on the major world tokamaks and would lead to an improved predictive capability.

Significant advances are expected from conducting identity, and dimensionally similar, discharges on machines with different sizes and capabilities, from identifying the data needs for better conditioned data bases, from confirming that similar effects on different machines have the same physics basis, from establishing, characterising and determining the limitations of key operating scenarios, and from developing and transferring operational, control and analysis techniques.

About 40 such proposals were discussed. The tokamak leaders indicated their interest in considering for 2003 eleven proposals which were well-developed for two or more tokamaks and another sixteen if they could be developed sufficiently for the programme

ITPA:
International Tokamak Physics Activity
You can find more information on ITPA on
http://itpa.ipp.mpg.de

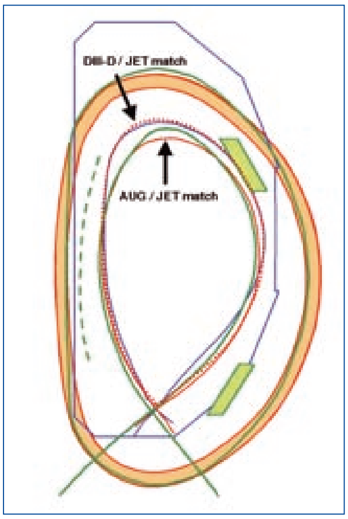
IEA:
International Energy Agency, represented on
http://www.iea.org/index.html

MIT:
Massachusetts Institute of Technology at Cambridge (USA). Learn more about MIT on
http://www.psfc.mit.edu/

MHD (Magnetohydrodynamic) instabilities:
Unstable distortions of the shape of the plasma/magnetic field system.

planning meetings which the major tokamaks were holding in December 2002. The remaining proposals were considered to be on-going programmatic activities that did not yet require joint experiments. The consolidated set of coordinated experiments on the major tokamaks during 2003 should be finalised in the middle of January 2003. The implementation of these proposals will require personnel and some hardware exchanges and these will be carried out under the legal framework provided by the existing IEA-IAs on tokamaks.

The meeting proved to be a very productive opportunity for enhanced communication among the leaders of the major world tokamaks, the leaders of the ITPA, and members of the Executive Committees of the IEA-IAs. The discussions and implementation of coordinated joint experiments will add significant value to the experiments on the individual facilities, enhance progress on tokamak burning plasma physics issues and contribute to the success of future burning plasma experiments such as ITER.



Scaled Superposition of Magnetic Configurations for Comparative Studies on ASDEX-Upgrade (AUG), DIII-D and JET.

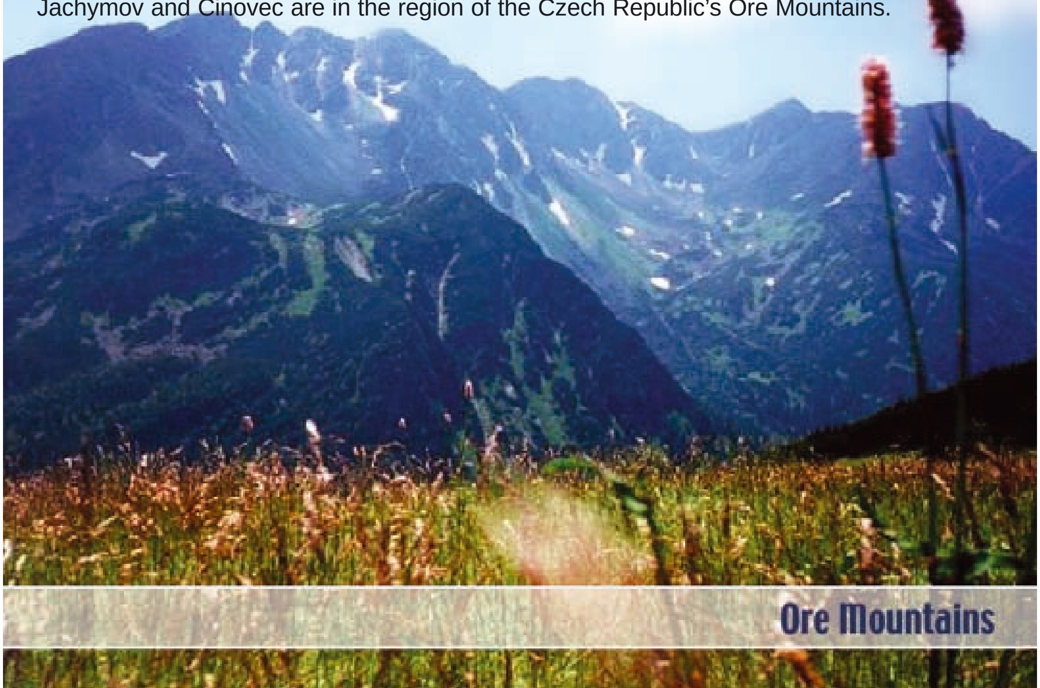
Fusion in Europe

Lithium - Czech Republic can help to provide the fuel of the future

Lithium is the lightest of all metals, with a density only about half that of water. It does not occur in the metallic form, but is found as chemical compounds in small amounts in nearly all ingeous rock and in the waters of many mineral springs, so that there are satisfactory deposits in the earth's crust and oceans to meet society's current demand for lithium.

Lithium is applied as a component of a light and firm alloy, in electronics and electrical technology and in the glass and ceramic industry. Because it has the highest specific heat of any solid element, it has found use in heat transfer applications. Lithium will also be the feedstock for the production of one component of fusion power station fuel – tritium. In a fusion reactor neutrons will transform the lithium contained in a "blanket" surrounding the plasma into tritium and helium.

Even if the total world energy production was to be covered by fusion power stations with a lithium blanket, approximately 3800 kg/GWy, lithium demand would still be only 25 % above the current pure lithium world production (6kt/y), which represents a very small fraction of world resources. Therefore, the progressive start-up of fusion power stations would not require significant adaptation for the lithium production and a wide scale use of lithium for fusion based electricity production is not expected to meet any resource limitations. One percent of global lithium resources can be found in the area of Cinovec, Krupka and Krasno in Czech Republic. This amount would be sufficient to supply the whole European Union. Jachymov and Cinovec are in the region of the Czech Republic's Ore Mountains.



Name: Lithium

Symbol: Li

Atomic number: 3

Atomic weight: 6.94

Density @ 293 K:
0.53 g/cm^3

Atomic vol.:
13.10 cm^3/mol

Group: Alkali Metals

Discovered: 1817

For more information on the Institute of Plasma Physics at the Academy of Sciences of the Czech Republic please see:

http://www.ipp.cas.cz

Fusion in Europe

In order to further progress in the integration of the fusion programme, in view of the forthcoming ITER activities, the Association Euratom-IPP Garching (Germany) has recently announced the opening up of the ASDEX-Upgrade experimental programme to the EU Associations.

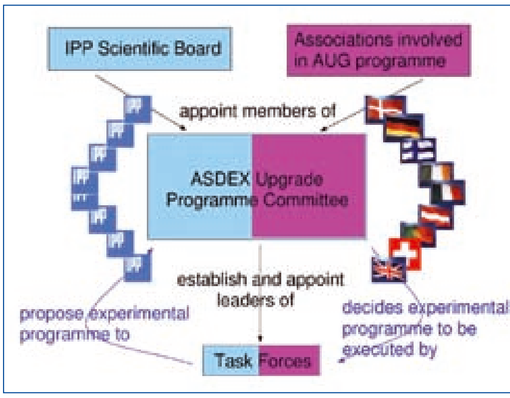
TEC:
Euregional cooperation of Euratom Associations: IPP Jülich (Germany), Ecole Royale Militaire Brussels (Belgium), FOM Institute for Plasmaphysics Rijnhuizen (Netherlands).

For more information see:

http://www.ipp.mpg.de

ASDEX-Upgrade: Experimental Programme: stronger Role of Associations

Strong links to the EU and world wide tokamak programmes already existed on ASDEX Upgrade (Garching, Germany), but the present initiative greatly improves both the rights and the responsibilities of the collaborating EU Associations. The experimental programme is now decided by the ASDEX Upgrade Programme Committee, which consists at present of 8 members of IPP and 9 members from the collaborating Associations. The Task Force leadership is also open to the Associations. For the period 2003-2004, one of the five task forces (MHD stability) is actually led by an associate representative, Duarte Borba from IST Lisbon. In addition, the meetings in which the programme is discussed are now open to remote access via a videoconferencing system. The ASDEX Upgrade intranet has also been substantially revised to give all the necessary information on planning, execution and analysis of the ASDEX Upgrade experiments. This initiative also includes access to the machine experimental data via the standardised MDSplus system also used on TCV, RFX, JET and other devices. First experiments under this structure have already shown the benefit of close collaboration and the first results in the field of transient transport, radio frequency heating and sawtooth tailoring have been obtained in cooperation with the Istituto Fisica Plasma-Milano (Italy), the Association Euratom-CEA Cadarache (France) and the Trilateral Euregio Cluster (TEC), producing a range of exciting findings. As a result, at the 2002 EPS conference in Montreux, 18 out of 32 ASDEX Upgrade papers had contributors from the Associations, with 10 having an external first author.



Visit of Delegation from Finland in Garching

A delegation from Finland representing industry and contributors to Finnish Fusion Society visited the Association Euratom-IPP, the ITER International Team and the EFDA CSU on 2 December 2002 in Garching (Germany). Their goal was to find out how their companies and associations could contribute to the skills and technologies of fusion research with regard to ITER.

The Meeting started with a welcome by Prof. K. Lackner (EFDA Leader) and Prof. A. Bradshaw (Director of IPP) to put the Finnish guests in the right mood for a day rich in information. Prof. M. Kaufmann (IPP Directorate) gave an overview of the IPP Fusion programme, presented in more detail by Dr. M. Winkler (IPP), who explained how the experiences gained with Wendelstein 7-X have been benefitting industry. The involvement of European industry in the special research areas was presented by Dr. E. Salpietro (EFDA, Magnet Structures), Dr. P. Barabaschi (ITER design), Dr. R. Andreani (EFDA technology programme) and Dr. W. Dänner (EFDA, Vessel/In-Vessel). The delegates toured ASDEX Upgrade and during an open discussion showed avid interest on the perspectives towards ITER construction.

Finnish participants:

- Mikko Karvinen (Metso Paper Oy)
- Raimo Rantaanen, (Outokumpu Oy)
- Harri Tuomisto, (Fortum Nuclear Services Oy)
- Prof. Jorma Routti, (former DG Research, EC)
- Prof. Jouko Suokas (VTT)
- Dr. Mervi Sibakow (TEKES)
- Juha Lindén (TEKES)
- Iiro Andersson (Finnu Fusion/PrizzTech)
- Pertti Pale (FinnFusion/ PrizzTech)

Fusion & China

Fusion Research Activities in China

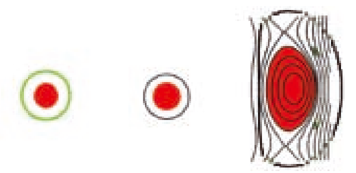
A contribution from Prof. Huo Yuping, ZhengZhou University (People's Republic of China)

China is the largest developing country with a projected population of 1.6 – 2 billion people and with an energy consumption growing from the current 1.3 Billion Tons Coal Equivalent (TCE) to more than 4 Billion TCE by 2050.

This large demand can only be accommodated in a sustainable way which would also allow energy generation in an environmentally-friendly way. Fusion is one of the most promising candidates to solve this important issue.

The history of fusion in China goes back to the 1950's, when Magnetic Confinement Fusion research was first started at the Institute of Atomic Energy in Beijing.

Confinement studies of high-temperature plasmas were carried out in several small-size machines. In the mid 1960's the South-Western Institute of Physics (SWIP) was founded by the Ministry of Nuclear Industry. With a manpower of up to 400 persons, including both scientists and technicians, over 20 experimental devices were built and operated, mainly following the tokamak concept. Among them, the HL-2A, derived from the German device ASDEX.



HL-1	HL-1M	HL-2A
1984-1992	1994-2000	2002-
R=1.02m,a=0.2m	R=1.02m,a=0.26m	R=1.62m,a=0.4m
Bt =3.5T, Ip=225kA	Bt =3.0T, Ip=320kA	Bt =2.8T, Ip=400kA
Mo Limiter	**Graphite Limiter**	**Divertor**

At the end of the 1960's, the Chinese Academy of Science founded the Plasma Physics Department (ASIPP) within the Institute of Physics in Beijing. A small tokamak, the CT-6 was built, followed by two air-core tokamaks, the HT-6B and the HT-6M. The ASIPP began its superconducting tokamak programme in 1990. The first success was the HT-7 machine, an improved version of the Russian T-7, which started operations in 1994. The next step was the design of the HT-7U, a divertor machine to study non-circular plasmas.

Plasma laboratories opened in the 1970's at the University of Science and Technology of China, at the Dalian University of Science and Technology and at the Tsinghua University with the aim of training graduate students in fusion science. SWIP and ASIPP have almost 100 graduate students in fusion science.

In the 1980's international relationships with other fusion institutions around the world gave the opportunity to a large number of Chinese physicists and engineers to spend some time abroad and gain experience in different fields.

Participation in the ITER project would now be an obvious path following from the steady, but growing, importance that fusion has gained in the country. After having completed a domestic evaluation of the project, China is now considering joining ITER as a full member.

Main topics of study in earlier tokamaks:

- Plasma confinement
- Plasma edge and wall-conditioning (successful use of new techniques such as RF boronisation, RF siliconisation and RF Li + Si).

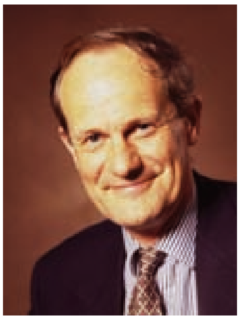
Superconducting Tokamaks:

Main focus on reactor-relevant issues: steady-state (or quasi-steady-state) operation, non-inductive plasma discharges, Heating & Current Drive operations.

HT-7U parameters:

Plasma current = 1.1 - 1.5 MA
Toroidal field on axis =3.5 T
Major Radius = 1.95 m
a=0.45m, b=0.9m,
t_{dis}=1000s

Obituary



† Dr. D. Robinson
1941 - 2002

UKAEA Culham mourns for Dr. Derek Robinson FRS

Dr. Derek C. Robinson, Director of the UKAEA Fusion Programme and Culham Science Centre, died on Monday 2 December 2002, in Oxford. After gaining a First Class Physics degree at the University of Manchester in 1962 he embarked upon his career in fusion research with a PhD which involved the study of plasma turbulence in ZETA. In 1968 he spent a year at the Kurchatov Institute in Moscow, at the height of the Cold War, in a historical Anglo-Soviet collaboration in which a team led by Dr Nichol Peacock made crucial measurements of the temperature in the T3 Tokamak. Robinson's contribution was seminal work on the theory of instabilities of plasmas. As a result of the team's measurements, confirming that the performance of T3 actually exceeded the Soviet claims, the tokamak became the main line for international fusion research, as it still is today. On returning to Culham he became the driving force behind COMPASS and ultimately the UK's pioneering spherical tokamaks, START and then MAST.

Robinson was for many years a member of the JET Scientific Council and JET Council, he was also a member of the ITER Technical Advisory Committee. He was as adept in fusion "politics" as in the actual science and an acknowledged international elder statesman. The many messages of condolence from colleagues across the world show the esteem in which he was held.

See Obituary written by Dr. R.S. Pease, published in "The Independent", 9th December 2002:

http://www.independent.co.uk/story.jsp?story=359899

and also Obituary from the Institute of Physics:

http://www.physicsweb.org/article/news/6/12/1

Personalities

Dr. Robert Aymar to be next Director General of CERN

The CERN Council, where the representatives of the 20 Member States of the Organization decide on scientific programmes and financial resources, elected Dr. Robert Aymar to succeed Prof. L. Maiani as CERN's Director General. Dr. Aymar, Director of the ITER International Team, is foreseen to take office on 1 January 2004. He will serve a five-year term and will oversee the start up of CERN's current major project, the Large Hadron Collider (LHC) in 2007.

For more information see our EFDA website:

http://www.efda.org

and additionally

http://www.jet.efda.org

http://www.iter.org

Outstanding Technical Accomplishment Award for Dr. Gianfranco Federici

The Outstanding Technical Accomplishment Award 2002 of the Fusion Energy Division of the American Nuclear Society (ANS) was presented to Dr. Gianfranco Federici (ITER International Team, Garching, Germany). This award was given in recognition of his contributions in the area of theoretical and computational research on plasma-wall materials interactions that led to the design of the ITER divertor. The award was presented at the 15th Topical Meeting on the Technology of Fusion Energy, held in Washington, DC, on November 17 to 21.

More information on the Honors and Awards Committee on

http://fed.ans.org/fed_awards.pdf

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