Preparation of ITER site started

It’s now or never
EU politicians push for climate action

Fusion in the backyard

JET introduces Sun Dome

Fusion in Focus: Portugal
Interview with Carlos Varandas

EU and Japan sign Agreement on Broader Approach

On February 5 the EU and the Japanese government signed the “Broader Approach” agreement. The cooperation aims to complement the ITER Project and to accelerate the realisation of fusion energy as a clean and sustainable energy source, by carrying out R&D and developing some advanced technologies for a future demonstration fusion power reactor (DEMO). The agreement represents some 340 million Euro of European investment.

Together with the European Atomic Energy Community, known by its initials EURATOM, Japan will work on three projects over the next 10 years contributing to the development of nuclear power. The first project includes the development of Engineering Validation and Engineering Design Activities for the International Fusion Materials Irradiation Facility (IFMIF/EVEDA). The Deputy Director of the Agence ITER France and former leader of the European ITER Site Studies, Pascal Garin, has been nominated Leader of the IFMIF/EVEDA project.

The second project aims at building the International Fusion Energy Research Centre (IFERC). IFERC will focus on activities related to DEMO, the fusion device foreseen after ITER. These two projects will be established in Rokkasho.

Finally, the Japanese JT-60 tokamak will be upgraded to an advanced superconducting tokamak JT-60 SA, and be exploited under the framework of this agreement as a “satellite” facility to ITER. This project will be carried out in Naka, in the prefecture of Ibaraki near Tokyo.

“Today’s signature of the Broader Approach Agreement marks not only the successful end of our complex negotiations, but also the beginning of an ever-closer cooperation between the fusion communities of Japan and Europe to face the many challenges which we can best overcome when acting together”, Hugh Richardson, Ambassador of the Delegation of the European Commission to Japan, said. „The three projects that are to be undertaken under the Broader Approach Agreement carry great importance for the early realisation of fusion energy and will complement the global efforts on realising ITER.”
Preparation of ITER site started
The preparation of the ITER site started on January 29. By October 2007, part of an area of 180 hectares next to the Cadarache site will be prepared under the supervision of the Agence ITER France, for the construction of ITER. Great care has been taken to minimize the environmental impact of this work, including an environmental inventory of the flora and fauna and protective measures. Tree-felling on parts of the first 75 hectares will be carried out before the end of March 2007 when the bird nesting season starts. Work to enable the erection of a provisional fence should be completed in April 2007.

Prototype for ITER Cryopump
On the 13th of February, the EU launched a contract to build a full size prototype ITER cryogenic vacuum pump. After a competitive tendering process the Dutch company DeMaCo was awarded the contract. DeMaCo’s cooperation with EFDA and the German association in Karlsruhe (FZK) is based on its long-lasting experience in Cryo and Vacuum Technology.

The ITER machine will contain ten such cryo-pumps. They will produce the vacuum necessary to operate the torus and the cryostat. The ITER torus pumps are unique in that together they must function in a fast cyclic mode, continuously pumping the exhaust of the burning plasma, including the helium produced as a result of fusion. The pump will take 18 months to build and will undergo a period of vigorous testing. This prototype will hence enable validation of the design and fabrication methods prior to procuring the main batch of 10 pumps for ITER.

IBM to build new Supercomputer for Max Planck Society
One of Germany’s most prestigious science institutions, the Max Planck Society, has selected IBM to build a powerful new supercomputer devoted to solving the grand challenges of science. Scientists from the Max Planck Institute for Plasma Physics in Garching will use the new system for realistic simulations of turbulence in fusion devices, contributing to energy research in support of the world-wide ITER fusion project. The Max Planck Society’s new supercomputer will be designed to achieve a peak performance of over 100 Teraflops (100 trillion calculations per second), offering up to 20 times the application performance of the Society’s current supercomputer. The list of the Top 500 Supercomputers is led by IBM’s “BlueGene/L,” with a maximum capacity of 280,6 Teraflops, situated at the Lawrence Livermore National Laboratory, USA. Modern PCs can achieve up to a couple of Gigaflops or a couple of billion calculations per second.
It’s now or never

Following the recently published report of the Intergovernmental Panel on Climate Change (IPCC), temperatures are going to increase by 1.8-4°C by the end of the century. It also projected that sea levels were most likely to rise by 28-43cm, and global warming was likely to influence the intensity of tropical storms.

The dramatic outcome of the IPCC report has finally stirred up the political landscape. Environmental representatives of the European Parliament, lead by David Miliband, Christina Narbona and Janez Potocnik, are now pushing for action: “The window of opportunity is closing rapidly and a strong EU voice is necessary to provide the catalyst for UN discussions on taking effective action to cut emissions.”

In contrast to earlier reports in which it was “likely” that human activities lay behind the trends observed at various parts of the planet with “likely” meaning between 66% and 90% probability, the message this time is unequivocal: The panel concluded that it was at least 90% certain that human emissions of greenhouse gases rather than natural variations are warming the planet’s surface.

Fusion meets Economy

Fusion research and economy? How do these two fit together? Well, they do! At least since the publication of the “Stern Review”, a report on the “Economies of Climate Change” published by the former head of the World Bank, Sir Nicolas Stern. Since then, the link between world economy and the urgent need for new energy technologies is an undisputed fact. Therefore, to hear that fusion was on the agenda at this year’s World Economic Forum in Davos might not come as a surprise.

Once a year, the world’s leading politicians, economic and social representatives meet in the – still – snow covered Swiss village, to discuss the world’s economy. Among them was Alexander Bradshaw, Director of the Max-Planck-Institut für Plasmaphysik in Garching/Greifswald presenting “Fusion as a source for future energy”. Introduced by Nobel-Prize Winner Steven Chu, Bradshaw talked about the basics of fusion research, the ITER project and the correlation between R&D money and the timescale to develop a fusion power plant.

Pascal Garin nominated IFMIF-EVEDA Project Leader

The Deputy Director of the Agence ITER France and former leader of the European ITER Site Studies, Pascal Garin, has been nominated Leader of the IFMIF-EVEDA project. The Engineering Validation and Engineering design Activities (EVEDA) of the International Fusion Materials Irradiation Facility (IFMIF) is part of the Broader Approach Agreement between the EU and Japan. IFMIF will be an accelerator-based neutron irradiation facility focussing on developing fusion reactor materials.

The EVEDA phase of IFMIF will be jointly conducted by Europe and Japan, the location of the Joint Team being Rokkasho, Japan. The validation process consists of the design, manufacturing and test of three prototypes: the low energy part of one of the two accelerators, the lithium target and the test facilities, in particular to simulate in realistic conditions the future materials. The budget for the project amounts to 150 million Euro for the EVEDA programme and one billion Euro for the construction of IFMIF. 16 professionals and 14 support staff will help Garin in getting the project started.

By May this year, the new project leader plans to move. Even though this means a big change to his life, he is glad to return to science. “Even though I am going away, it is like coming back.” Until he leaves sunny Provence, Pascal Garin is eagerly learning Japanese. The language — one of the many challenges he has to face.
On the test-stand for ITER
Duarte Borba

On 25 September 2006, experiments resumed on JET, with the start of Experimental Campaign C16 of the EFDA-JET 2006 Work programme. After successful completion of this Campaign on 13 October 2006, Campaign C17 began on 23 October 2006, and was completed on 15 December 2006.

These experimental campaigns took advantage of the recent upgrades to the JET facilities. These included a new configuration of the lower part of the machine’s first wall - the area designed to exhaust most of the heat from the plasma with a null in the magnetic configuration (divertor configuration) - heating system upgrades, and several new and enhanced diagnostics. A strong focus was maintained on the preparation of the ITER detailed design and ITER exploitation. These include the preparation for the planned replacement of the carbon based protection tiles with beryllium and tungsten tiles, foreseen for installation on JET in 2008 and 2009.

Studies in the ITER baseline scenario (ELMy H-mode) included the exploration of different techniques to minimize the sudden heat loss induced by edge plasma instabilities known as Edge Localized Modes (ELMs). These instabilities cause temporary loss of confinement in the plasma edge, leading to significant heat fluxes to the plasma facing components. Enhanced heat loads increases the erosion of the plasma facing materials, limiting the lifetime of such components in ITER. The new bolometer diagnostic was able to resolve radiation patterns between and during ELMs and filamentary power deposition was detected with the new wide angle infrared camera. One approach to reduce the impact of ELMs, further studied in these experiments, is to explore configurations with plasmas shapes, density and plasma current profiles that minimize the energy lost during these edge instabilities. Another approach is to use active techniques such as externally applied magnetic perturbations. This technique was shown to be effective in experiments carried out in the DIII-D tokamak (San Diego, USA), when a resonant magnetic perturbation with three wave periods in the toroidal direction was applied. On JET the Error Field Correction Coils, capable of producing a magnetic perturbation with longer wave lengths such as one and two wave periods in the toroidal direction, were used in these studies. In addition, the application of vertical kicks to the plasma, to control the ELMs was investigated, employing similar techniques to the experiments carried out in the TCV (Switzerland) and AS-DEX Upgrade (Germany) tokamaks. Both techniques proved successful in controlling the frequency and amplitude of ELMs, showing their potential as mitigation tools for these instabilities.

A complementary approach to avoid high heat loads on the plasma facing components on ITER, is to surround the plasma by a radiating zone, which can be produced by impurity injection. The production of such a radiating zone has been studied with nitrogen injection in plasma currents of up to 3 MA. To preserve high fusion performance, it is important that the impurities injected for this purpose do not accumulate to high levels in the plasma core and degrade plasma core confinement. To understand impurity transport, systematic studies were conducted with injection of low to high Z impurities. These experiments will also be useful to understand transport of ITER eroded first-wall materials into the plasma.

Indeed material erosion from the plasma facing components is another important issue for ITER. It relates to the study of migration and retention of impurities in Tokamaks. Recent results highlighted the importance of the magnetic field configuration in determining the location and thickness of the deposited layers, and the fact that a few large ELMs lead to a much stronger erosion and subsequent deposition than small ELMs.

Bringing the Sun into School

That’s what it says on the flyers: “We bring the sun down to earth.” Now we bring it directly into the classroom. “Sun Dome” is the name of a new device that has been developed by the Public Relations Department at the EURATOM/UKAEA Fusion Association at Culham, England.

The Sun Dome is an inflatable movie theatre measuring 6 metres in diameter and 3 metres high. Thanks to a special wide angle projector, the young visitors, mainly primary school children, get a wide angle view of the sun and the process that powers it: fusion. To reinforce the message, the pupils are then led through an interactive role play game in which they become atoms. They are taught about the dynamics of atoms as they heat up and how they ultimately fuse! At the end of the show, a movie on the work at Culham (MAST and JET), ITER and the future energy challenges wraps up the 30-minute show.

UKAEA Culham Division’s Education Outreach Manager, Chris Warrick, is confident about the Sun Dome’s potential: “I hope that the Sun Dome will foster the excitement and thrill of scientific discovery amongst primary school children,” he said. “We also hope it makes them more aware of energy and climate change issues – and how fusion might help in the future”.

Footnote: The Sun Dome was funded directly by public engagement funds from the UK Engineering and Physical Sciences Research Council (EPSRC) and EURATOM.
Fusion in the backyard

“At 9 pm the fusor was run at around 30 kV with deuterium flow. Nuclear fusion occurred!” In its issue from January 26, the Financial Times Magazine published an article about Thiago Olson, a 17 year old schoolboy from Michigan, USA, claiming to have produced fusion in his father’s garage. Although Thiago’s experiment, which he describes in every detail, reproduces a number of features which have been pioneered in laboratories during the 1960s and abandoned for more promising concepts, all the physicists reading the article must have been much impressed by this young man’s exceptional abilities both as a scientist and entrepreneur. The FT gives many details on how he conceived his experimental device, managed to acquire his equipment at very low costs and put it together successfully.

http://search.ft.com/ftArticle?queryText=Olsen&id=070126006711

In his documentation titled “Neutron Activation Analysis using an inertial electrostatic confinement fusion device” Thiago concludes: “My apparatus does not produce more energy than I put in – that’s never been done, and if someone can figure it out, they’ll be set. My research with the fusor has just started.” And this boy seems to aim for more indeed. In a letter to the EFDA editors he announces that he is currently working on adding multiple magnetron ion sources to the reactor to increase neutron counts. “The neutron rate is now up to 290,000 neutrons/sec, and I have activated indium and manganese metals.”

Thiago Olson, 17 year old schoolboy from Michigan, claims to have produced fusion in his father’s garage.

Summer University for Plasma Physics and Fusion Research

A Summer University for Plasma Physics and Fusion Research is organized by the Max Planck Institute für Plasmaphysik in Greifswald, Germany, from September 24-28, 2007. The course will cover the main aspects of plasma physics with emphasis on nuclear fusion. The following lectures will be offered:

- basics of plasma physics and of nuclear fusion
- kinetic and magneto-hydrodynamic description of a plasma
- concepts, experimental results and optimization of tokamaks and stellarators
- heating and diagnostics of a fusion device
- plasma wall interaction and wall material research
- safety and environmental aspects of fusion
- inertial fusion
- ITER and the next steps towards a reactor

The course will include a tour to the assembly of the superconducting stellarator experiment Wendelstein 7-X and its periphery under construction at IPP. One goal of the Summer University is to promote an exchange of views among the coming generation of European scientists.

An opportunity for discussions with lecturers and students will be provided between the sessions, in the evening downtown Greifswald and during an excursion to the Island of Ruegen.

Deadline for applications is 31 May 2007.

Infos: stahlberg@ipp.mpg.de or matthias.hirsch@ipp.mpg.de
Divertor Test Platform being built in Tampere

In 2004, a Remote Operation and Virtual Reality Centre (ROViR) was established in Tampere Finland, following an agreement with EFDA and EURATOM-TEKES to host the Divertor Test Platform 2 (DTP2) at the premises of the Technical Research Centre of Finland (VTT) in Tampere. During the year 2005 the ROViR Centre was put in action and now the basic construction for DTP2 is done and ready to receive the remote handling tools.

Remote handling devices will play a key role in the ITER project, as the divertor system will have to undergo regular maintenance operations. The divertor system comprises a set of 54 cassettes supported on the inner and outer vacuum vessel walls by a pair of toroidal rails. Each cassette is expected to weigh eight to nine tonnes, their size will be approximately 3.5 x 0.8 metres. The cassettes will be sequentially removed from the machine in batches covering one sixth of the divertor region through 3 equi-spaced maintenance ports using remotely operated devices known as “cassette movers”.

There are already industrial projects running in parallel to the DTP2 platform for ITER. The Finnish company TP-Konepajat Oy won the contract to construct and deliver the steel structures for the platform. The cassette mock up is being constructed in Luxemburg, the Cassette Multifunction Mover (CMM) comes from Spain as well as the control system hardware. The software is developed in Finland.

All components are expected to be on site by spring 2007. In the next phase the CMM and the control system will be assembled.

Italian ITER Industry Workshop

This January, one hundred and eighty participants, representing industrial companies from all over Italy, gathered in Villa Tuscolana in Frascati to attend the “Presentation of ITER Project to Italian Industry”. The event was organized by ENEA with the objective of informing Italian industry on the present status of ITER and about the opportunities of participation in its construction. Working in the fusion program, Italian companies have gained valuable experience in providing large and complex components and meeting performance challenges. They are now looking forward to participate in the realization of the device.

PREFIT Kick-off Meeting

The ITER project and future fusion devices will require highly skilled people. To face these needs, a programme called PREFIT has been created, with its kick-off meeting held in Tampere, Finland, last December.

The PREFIT research projects have been chosen to deliver results which are of relevance to ITER and to the wider remote handling community. The areas covered include: virtual/augmented reality, integration of humans and computers for remote handling, high quality remote joining of pipes, control system standards for remote handling, real time condition monitoring and sensors for remote inspection inside the ITER torus. For more information see http://www.prefit.eu/index.htm
50 Years of Fusion Research at KFA Jülich

**Author: Ralph P. Schorn**

In November 2006 it was 50 years ago that work on high temperature plasma physics and nuclear fusion first started at the Rheinisch-Westfälische Technische Hochschule (Technical University) of Aachen. Inspired by first results abroad, a group lead by Prof. Dr. Wilhelm Fucks and Dr. Hermann L. Jordan first focussed on z- and theta-pinch experiments. After the foundation of the Nuclear Research Establishment (KFA), the group joined immediately and moved to a new campus near Jülich in 1960 adopting the name “Institute for Plasma Physics” (IPP). In 1962, Jülich became an EURATOM Association.

Pioneering work on the understanding of collisionless high-beta plasmas in theta pinch devices and the development of fusion related technologies – such as high voltage capacitors and switches – dominated the first twenty years: In 1971 an ion temperature of 100 million degrees was produced for the first time ever worldwide, using a new high voltage theta pinch experiment. In 1972, toroidal geometries, non-circular cross sections and the successful tokamak principle moved into the focus. Jülich too entered the field of tokamak physics and started the design and construction work for TEXTOR. From the beginning, TEXTOR was especially designed to provide flexible and easy access to wall components and diagnostic systems.

Since its inauguration in November 1982, TEXTOR stands for pioneering work in various fields: Carbonisation, boronisation, radiation cooling, toroidal pump lim- iters (ALT, helium exhaust), the RI mode, modelling and measurement of erosion and deposition processes, new diagnostic methods for edge plasma studies, material test and development and also the present Dynamic Ergodic Divertor (DED) and its ability to influence turbulence at the plasma edge.

Today Jülich fusion research is an integral part of the European strategy towards a fusion power plant, focussing on plasma-wall interaction studies. On December 19th, 2006, more than 250 guests, former colleagues and active staff – among them many former institute directors – came together to commemorate and - most of all - celebrate 50 successful years of fusion research – with a bright future ahead.

A detailed chronicle of IPP Jülich is available at http://www.fz-juelich.de/ipp/en/chronicle/

### New Avenues for European Fusion Research

In order to maintain the expertise that has placed the EU fusion programme at the forefront of international research on fusion energy, the European fusion research community, the FP7 Euratom Workprogramme 2007, has made provision for three Coordination and Support Actions (CSA) on fusion data management, material research and educational affairs respectively, with a total budget of five Million Euros.

The aim of this effort is to bring together a range of organisations active in this area, including newcomers on the periphery of the fusion community, to identify and provide access to key facilities and to promote joint initiatives. “By this we want to open up new avenues for cooperation to fulfill the objectives of the programme”, Yvan Capouet, Head of the Fusion Association Agreements Unit at the European Commission, said during an information workshop focussing on materials research, held at the EFDA Close Support Unit in Garching on March 2.

In particular, the CSA on materials research aims:

- to bring together a range of organisations in materials research
- to identify key facilities outside the program
- to provide conditions for mutual access for various research communities to these facilities
- to promote joint collaborative initiatives and the joint funding with other parts of the programme
- to enhance material development by cross field materials activities
- to support the mobility of materials researchers and their access to the fusion facilities

Similar objectives are defined for the other two actions. The three competitive calls for proposals for the funding mechanisms will be issued on the 22nd of May, with a deadline for proposal submission ending on October 23. These calls aim at strengthening the interfaces of the fusion community with related scientific communities. They are open to the Euratom Associations, universities, and other bodies involved in the field including newcomers.

In order to provide the relevant information involving the Associations, a third Workshop on educational affairs will be held in Brussels on March 29, 2007 while the first one on fusion data took place on February 23.

For further information please contact Alejandro Zurita, alejandro.zurita@ec.europa.eu
**I always liked to participate in challenging projects**

Carlos Varandas

Professor Carlos Varandas, 55 years old, is Director of the Centro de Fusão Nuclear and Chairman of the European Fusion Development Agreement Steering Committee. He started his professional career at the Instituto Superior Técnico (IST) in Lisbon as an electrotechnical engineer, later he focussed on Plasma Physics and Physics Engineering. After the adhesion of Portugal to the European Union in 1986 Carlos Varandas was one of six Portuguese researchers that decided to build a new fusion research unit. “I always liked to participate in challenging projects since the very beginning”, he explains his motivation.

Mr. Varandas, could you please describe the fusion landscape in Portugal?

First, there is the Centro de Fusão Nuclear (CFN), the research unit (RU) of the Contract of Association signed between EURATOM and IST in 1990. Since then, other Portuguese RUs have collaborated with CFN, such as the Centro de Física de Plasmas, the Instituto Tecnológico e Nuclear, the Centro de Electrónica e Instrumentação da Universidade de Coimbra, the Centro de Física Atómica da Faculdade de Ciências de Lisboa, the Instituto de Sistemas e Robótica, the Departamento de Física da Universidade da Beira Interior and the Departamento de Física da Faculdade de Engenharia do Porto. We are participating in the collective use of the JET facilities as well as in other projects like ASDEX-Upgrade, TJ-II, TCV, COMPASS-D, TORE SUPRA, TCA-Br, ETE and, of course, ITER. Our main areas of expertise are microwave reflectometry, control and data acquisition, real-time plasma control, heavy ion beam analysis, MHD, turbulence and transport, edge physics, lower hybrid physics and engineering, tokamak operation with AC discharges, interaction of liquid metals with plasmas, interaction of ultra-intense lasers with plasmas and materials characterization.

What will be the Portuguese contribution to the ITER project? How has the ITER project influenced your workplan?

Portugal would like to participate in the ITER project by leading the EU contribution on microwave reflectometry and digital instrumentation for control and data acquisition. Furthermore we hope to contribute to the European research teams and industrial consortia working on the fields listed above and hopefully provide staff for the International Team and ELE. An involvement in the ITER project would strongly influence our work plan for 2007-2011. It would mean important strategic changes to our scientific agenda, the construction of new laboratories, the implementation of quality assurance procedures, the increase of the number of engineers in our staff and technical assistance to the Portuguese firms that will participate in ITER.

Besides your manifold duties you are also a member of the International Organizing Committee of the Latin-American Workshop on Plasma Physics. Is it true that Brazil is interested in joining the ITER project?

Several Latin-American countries have theoretical and experimental activities on plasma physics. There are four tokamaks, three in Brazil (TCA-Br, ETE and NOVA) and one in Mexico (Novillo). So far, only Brazil has shown an interest in participating in the ITER project, as an Associate Party. Brazil has the largest fusion community of Latin-America and is currently implementing a national programme on nuclear fusion aiming at participating in the ITER project. Brazil is discussing an agreement on how to cooperate with EURATOM. In the meantime, the Brazilian fusion research units and CFN are carrying out joint works on microwave reflectometry, Alfvén waves, control and data acquisition, MHD, Thomson scattering and liquid metal limiters. This collaboration also includes the participation of Brazilian physicists in the JET and ASDEX-Upgrade programmes.

Coming back to Europe - you are the Chairman of the European Fusion Development Agreement Steering Committee. What is going to happen with EFDA once the European Legal Entity (ELE) is implemented?

“Fusion for Energy”, previously referred as ELE, will be responsible for the EU contributions to ITER and the Broader Approach (BA) as well as the project-oriented activities related to DEMO. ELE will be operational very soon.

Then, the present EFDA activities related to ITER and a large majority of the Fusion Technology Programme will be transferred to ELE while a new version of EFDA is under discussion.

The new scope of this agreement has already been approved by the EFDA Steering Committee and endorsed by the CCE-FU. A first version of the new EFDA and related instruments will be discussed in the forthcoming meeting of the EFDA Steering Committee in March in Aachen, Germany. The new EFDA will most probably be in force by September-October 2007. It will aim to reinforce the coherence within the EURATOM Fusion Programme by coordinating the physics activities within the Associations and by implementing a new scheme for preferential support.

**Fusion — Power for Future Generations**

The CD “Fusion — Power for Future Generations”, produced by EFDA, is now available in seven languages: English, German, French, Spanish, Italian, Dutch and Hungarian. The CD explains the basics of nuclear fusion and the principle of a fusion power plant. It also provides videos and photographs of the Joint European Torus (JET) as well as drawings of the ITER project. Also included is the famous “Star-maker” movie. The CD gives links to many fusion related sites and answers to the most frequent questions on fusion.

The CD is available through EFDA. Please contact aline.duermaier@efda.org.