EFDA JET

JET Insight

Quarterly News & Views of Europe's largest Fusion Device

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The French ambassador to the UK, His Excellency Mr Maurice Gourdault-Montagne (left) meets the French community on site and has an intense discussion about fusion related topics.

Ambassador for Fusion

Francesco Romanelli, EFDA Associate Leader for JET, is always pleased to welcome high profile visitors to the JET Facilities. In the recent years, ambassadors from several European countries found their way to JET. They took back to their Embassies the impression of the scientific scope and scale of a large fusion experiment conducted in an international environment.

Early in September Francesco offered a warm welcome to the French Ambassador to the UK, His Excellency Mr Maurice Gourdault-Montagne. Michel Chatelier, Head of the EURATOM-CEA Association also participated in the event. In 2008 France contributes 70 scientists to the JET programme, second only to the UK, followed by Germany with more than 50 Physicists and Engineers. In addition, the French Embassy funds Internship Schemes for about eight French students per year to perform scientific work at JET.

The reason for the high interest of Mr Gourdault-Montagne is given by a particular event in his career: In his previous appointments as Ambassador of France to Japan and Senior Diplomatic Adviser to the then French President Jacques Chirac he played a key role in the negotiations leading to the ITER siting in Cadarache, France.

> *"In 2008 France contributes 70 scientists to the JET programme, second only to the UK."*

In meeting the French community on site Mr Gourdault-Montagne was pleased to note the large contribution of France to the JET project and was mostly interested in receiving feedback on what French scientists thought governments should be doing in order to speed up the development and implementation of fusion as an energy source.

In concluding his visit the Ambassador said that throughout his career he had learnt "two things are important to successfully run a country on the international scene, one of these is investment in research and development". He believes fusion must be further boosted due to its high energy and economic potential together with its safety and environmentally friendliness. Francesco Romanelli looks forward to introducing Ambassadors from other European countries to the unique atmosphere and the European character of JET as a world class leading experiment.

Richard Kamendje

Main article in this issue
"A step forward in **heating technology**"

ITER and **future fusion power plants** will need plasma heating systems with much higher power density than the present fusion devices are working with. To match this and other required values the **ITER-like Antenna** was designed, manufactured and installed in the **JET fusion device**. The knowledge gained by **JET engineers and physicists** will serve as a basis for developments on **future** devices such as **ITER**.

A step forward in **heating technology**

To produce fusion power efficiently in ITER and in a power plant it is necessary to raise the fuel temperature to more than 100 million degrees Celsius. To reach these extreme temperatures there are different systems available to heat the fuel. One of them is Ion Cyclotron Resonance Heating (ICRH).

JET has tested several antenna systems to couple ICRH power to the plasma. In 2000, a specific Enhancement Project was started at JET in order to test a prototype for ITER, the ITER-like Antenna.

ICRH works like a microwave oven: the plasma ions are heated by the absorption of radio frequency waves at the characteristic frequency of the ion motion around magnetic field lines. The devices which are necessary to build up the system are a generator, transmission lines and an antenna. A generator produces high-power radio frequency waves that are carried along a transmission line to an antenna, located in the reaction chamber that couples the waves to the plasma. The ITER-like Antenna consists of eight paired conductors, with each pair fed by a separate generator.

While generators and transmission lines are used in radio technology and therefore are commercially available, the antenna needs to be specially designed in order to couple the required power to the plasma because of a phenomenon called Edge Localised Mode (ELM). ELMs produce abrupt variations in the density in the edge of tokamak plasmas, leading to a change of the antenna characteristics such that it reflects a significant amount of power back into the generator. The result: on average the radio frequency power coupled into the plasma is much lower than the power produced by the generator. In view of the use of ICRH in ITER and in future fusion power plants, it is mandatory to develop antennas which are resilient to these disturbances.

Since JET is the machine closest to ITER in terms of edge plasma conditions, in 2000 it was decided to design, built, install and test an ITER-like ICRH Antenna at JET. The ITER-like Antenna project is carried out under the European Fusion Development Agreement (EFDA) and by leading fusion laboratories in Europe and the United States. The implementation of such a new piece of sophisticated technology presented many challenges.

An example is the undesirable interference between conductors: a major feature of the ITER-like Antenna developed is its ability to work at high power density. The antenna therefore had to be built in a more compact way. To achieve this, the antenna conductors were built much shorter and located very close together.

Without practical experience of the new system the engineers and designers couldn't be sure about the level of undesirable interference between the different conductors. Mark Nightingale, one of the two project leaders and Head of the Wave Heating & Current Drive Systems Group at the UKAEA, comments: "Initially, there was some concern as to whether this antenna control system could operate in the presence interference, but we were successful in overcoming this problem by demonstrating that we could fire power into the plasma. It wasn't easy, but it has been possible".

> *"It has been an essential learning exercise for the European ICRH fusion community."*

The European industry was deeply involved in the manufacturing process. In general, the components of a fusion device need a very high degree of accuracy. In most cases – such as for the ITER-like Antenna – the first task is to develop prototypes. The involvement of industry at this stage helps establish the technical feasibility of the entire project. Mark says "We have learnt that industry should be involved in the design phase".

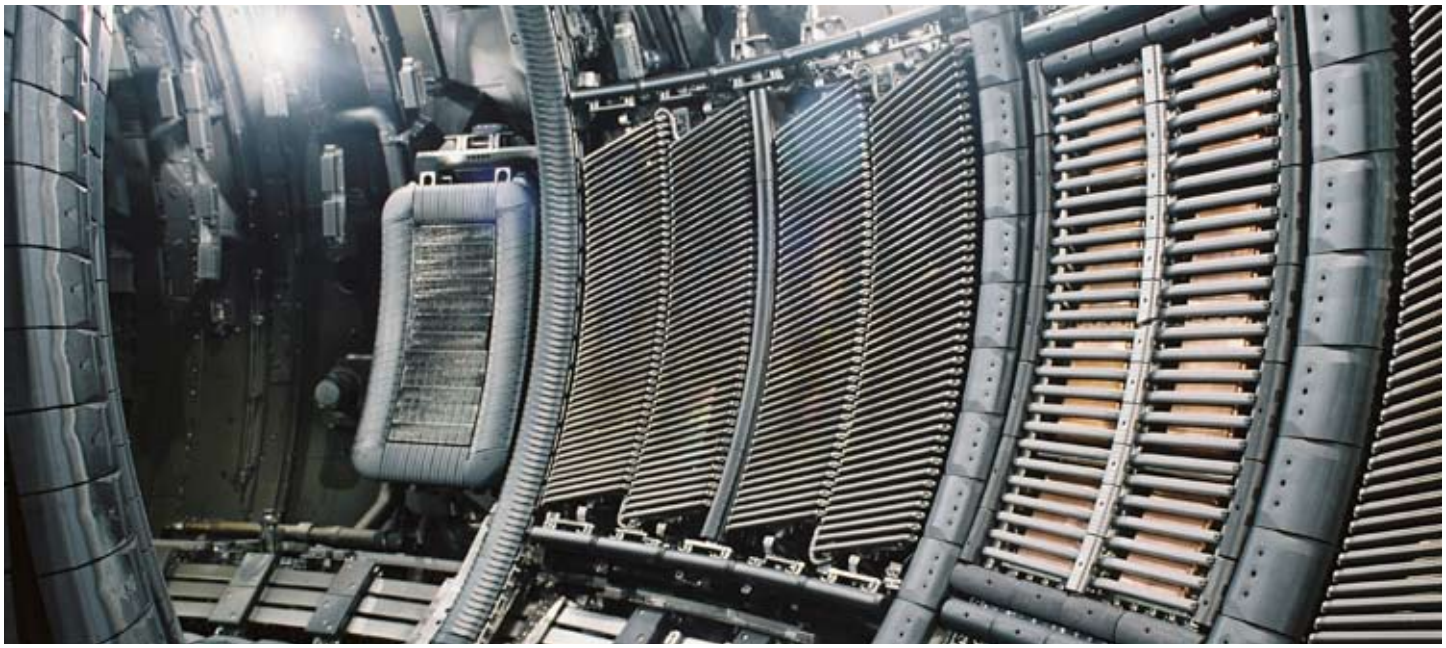
He summarises in his own words the development of the ITER-like Antenna: "It has been an essential learning exercise for the European ICRH fusion community. The antenna has been quite complex to test. It took quite some time to learn how to fully use it, but in the end we have been successful".

Frederic Durodie, Co-Leader of the project, recalls his experiences: "This has been a very challenging project for me where we have been able, for the first time, to use and validate new design tools. The complexity of the technical and managerial issues was fully recognised only as the project evolved." He remembers in a very positive manner the cooperation during the project: "It has been an honour to work closely with the colleagues on site and the many, many others across Europe and the USA."

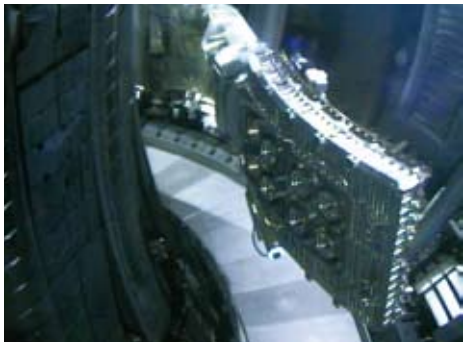
The commissioning of the ITER-like Antenna started in May. The knowledge gained by JET engineers and physicists will provide a firm basis for developments for future devices such as ITER.

Petra Nieckchen

Mark Nightingale, one of the two project leaders and Head of the Wave Heating & Current Drive Systems Group at the UKAEA.

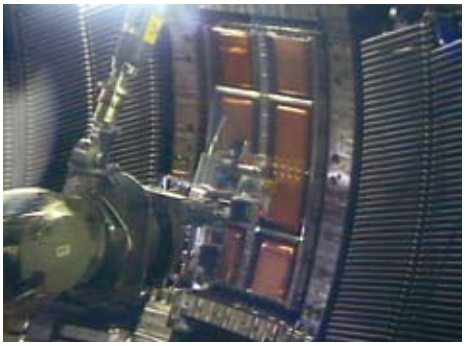


A look inside the vessel: The three rectangular elements are antennas for heating systems available at JET; (from left) the Lower Hybrid, the ICRH and the ITER-like ICRH.



The boom transports the antenna within the vessel to its final location.

After installation the operator backs the boom out of the vessel.



Attaching the antenna housing to the support box.

Remote Handling

The ITER-like ICRH Antenna was fully installed during August 2007. With the remote-handling facilities developed at JET the 250 kilogram load was moved into exactly the right position inside the plasma vessel without causing any damage. The required accuracy was less than one millimetre.

JET was built as a nuclear device and remote-handling was incorporated from the beginning of the design. Special manipulators were developed at JET to extend the operators' own arms. These manipulators provide the operator with a sense of touch and feel and, together with the associated Closed Circuit TV system, create a sense of being inside the Torus.

The ITER-like Antenna project is carried out under the European Fusion Development Agreement (EFDA) and by the following leading fusion laboratories:

LPP ERM - KMS
Ecole Royale Militaire
(ERM, Brussels, Belgium)

ENEA
Ente per le Nuove tecnologie, l'Energia e l'Ambiente
(ENEA, Frascati, Italy)

UKAEA
United Kingdom Atomic Energy Authority
(UKAEA, Culham, United Kingdom)

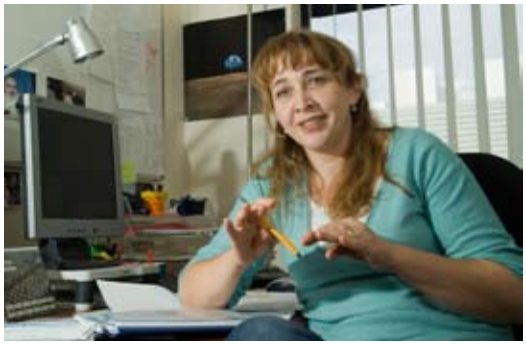
IPP
Max-Planck-Institut für Plasmaphysik
(IPP Garching, Germany)

CEA
Commissariat a l'Energie Atomique
(CEA, Cadarache, France)

OAK RIDGE National Laboratory
Oak Ridge National Laboratory
(ORNL, United States)

French colleagues in leading positions

From an outsider's point of view it is difficult to imagine how a joint European experiment might work. Because of the wide range of different tasks associated with the scientific exploitation of JET, nine Task Forces have been established. The scientific areas covered by each Task Force integrate into a "large puzzle" that make up JET experiments. The Task Force leaders and deputy leaders have to meet the challenge of balancing the ideas and interests of creative, expert physicists from all over Europe to a mutual purpose. The visit of the Ambassador of France to the United Kingdom, which is mentioned in this issue, underlined once more the strong involvement of the French association to this European experiment. JET Insight interviewed two of five French colleagues in leading positions. How do they manage to work efficiently? What have their experiences been of an internationally staffed science centre?



Task Force H Leader
Marie-Line Mayoral

Deputy Leader for Task Force S1
Thierry Loarer

"What is the contribution of your Task Force to the JET programme?"

"Task Force Heating is in charge of organising all the experiments which are related to heating the plasma which means experiments to develop a reliable heating scheme for ITER, and also experiments that give useful input to the design of the heating systems for ITER."

"The aim of Task Force S1 is to develop and validate plasma scenarios on JET which will also be used as references for ITER. That means that you need simultaneously a good confinement of the energy in the core plasma and a good control of the plasma edge."

"Most of your Task Force members are not always on site. How do you manage to get the work organised and done?"

"Basically it's a lot of email exchange. We also make use of the Task Force H website on which we put a lot of helpful information. Last but not least we have regular Task Force H meetings. For those members who can't be on site for the meeting we use remote participation, which means we can hear each other and we are able to present slides to each other. This now works well, for example: We've got an experiment next Wednesday and the person in charge will arrive on Monday as the experiment is already well prepared, because of the interactions I described before."

"Normally, the experiments are known well in advance. Therefore we organise Task Force meetings to discuss the experimental programme. Many people join these meetings from outside. The Scientific Coordinator is in charge of building a team, preparing the experiments and prioritising the experiments. He is also in charge of post-planning and making some intermediate reports before, during and after the experiments. Obviously, a part of the preparation is carried out remotely, but one week before an experiment and one week after an experiment people should be on site. That is sometimes a little difficult, because Task Force members have other duties at their home laboratories, but in general we cannot complain. People always make a good effort to be on site."

"What have you learned so far from working with people from so many different backgrounds?"

"I've got experience working with people in Europe and in the US. Yes, indeed we come from different nationalities, but if we start talking about science we are on the same ground. The people who come to JET are very open-minded. So, we all have more or less the same backgrounds and we want the same thing. We are not so different."

"I think it is not only the difference in background. You have not only to listen to all the people, you have also to understand the way a Spanish, English, German or Portuguese scientist approaches technical and or scientific issues which sometimes can show significant differences. This is not always as obvious as it could appear from outside, but it leads to additional ideas and the more ideas we have the better it is. However, summaries and decisions have to result, this is not always easy"

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