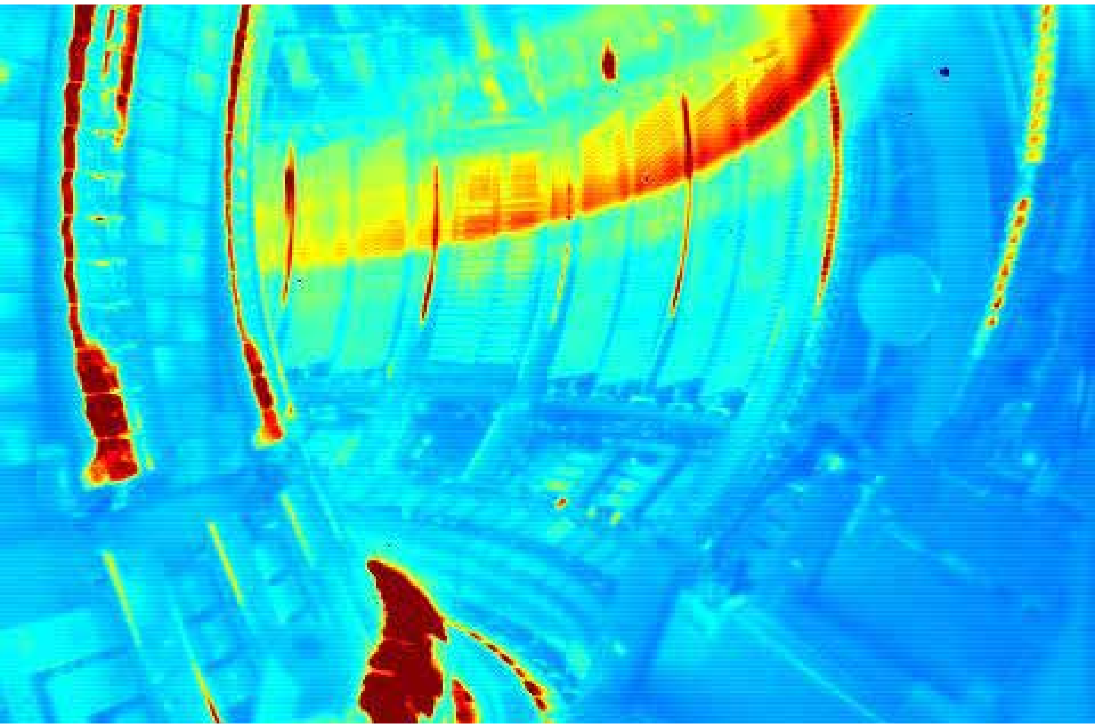
EFDA JET

JET Insight

Quarterly News & Views of Europe's largest Fusion Device

June 2009



A view into the JET vacuum chamber using an infrared viewing system developed and manufactured in close cooperation with industry. The image shows a plasma disruption event where strong interaction between the plasma and the wall components usually takes place. The red-yellow colour code indicates areas with increased surface temperature following this interaction. The new viewing system allows a more detailed characterisation of the location and the impact of power loads on the wall components during this type of events.

Mobilising fusion with industrial input

JET, like any research facility, must be continuously developed and upgraded in order to remain at the cutting edge in its field. JET, in particular, as the largest operating tokamak in the world is often called upon to test new concepts in conditions as close as possible to those foreseen for ITER, JET's international successor. Indeed, the presently running upgrade programme for JET, the so-called Enhancement Programme 2 or EP2, is specifically targeted at support of ITER. Such enhancement programmes necessarily involve industrial participation in manufacturing and, often, developing the necessary components. The budget for procurements for EP2, for example, is over 60 Million Euros, funded largely directly by the European Commission but also in part by the JET Joint Fund to which not only the Commission but also the European Fusion Associates contribute.

The largest activity in EP2 is the so-called ITER-Like Wall Project in which the plasma-facing components inside JET will be changed from carbon to the combination of beryllium and tungsten. This is the combination of materials that is foreseen for the wall in ITER. In order to accomplish this, more than 80,000 parts are being procured with the work divided between 19 different industrial contracts.

> "The benefits to industry in Europe of working with JET are more than simply the value of the contracts received."

Furthermore, in support of this change of wall material, the JET diagnostic suite is being significantly upgraded in order to be able to properly interpret the new results with the metal wall.
The benefits to industry in Europe of working with JET are more than simply the value of the contracts received. The technologies developed can have applications also in other fields. A recent example is a detector made of artificial diamond developed by the Italian Association ENEA for measuring the number and energy spectrum of neutrons emitted from the JET plasma. These detectors are being considered for application to high-energy physics research. For many firms, improvements in quality control necessary to meet JET standards are also qualifying them to bid for work on ITER. Moreover JET, as a high profile, high-tech research centre, provides a valuable reference for firms seeking to build a positive technical or scientific reputation.

Lorne Horton

Main article in this issue
"An all **metal** wall for JET"

It is not only changing of **carbon** for beryllium and tungsten tiles. ITER, in particular, and the whole fusion community in general look at JET's **ITER-Like Wall project**. With the **participation** of 19 industrial companies, the **contribution** of 9 European fusion Associations and a budget of over 30 Million Euros, replacing the wall and subsequently operating JET is going to be a learning exercise critical for the success of **ITER**.

An all **metal** wall for JET

It's impossible to give the exact number of people involved in this project, but I estimate that it is around one hundred", says Guy Matthews, Leader of the ITER-Like Wall project. First discussions about the scope started in 2004 and the Project Board held its first meeting in early 2005. "The challenge was not only that we had less than a year's time to go from the concept to a design that could be tended. On top of that we had to redesign everything in the machine".

The ITER-Like Wall Project is not the responsibility of any particular European Fusion Association but is administered within the same framework under which UKAEA acts as operator of the JET machine. Two reasons are responsible for this arrangement: The exchange of more than 4,500 plasma facing components requires detailed knowledge of the vessel interior and of the Remote Handling systems. Guy explains "You have got to use the existing support structures within the vessel and to understand exactly how Remote Handling works."

The project management is supported by the EFDA Close Support Unit (CSU) at Culham which supervises the contracts. David Fraboulet, Project Responsible Officer in the CSU explains his role as follows: "CSU has an interface role between the client, which is the European Commission, and the project".

The contribution of 9 European Fusion Associations has been essential to conduct in particular the research and development activities necessary to design and qualify the various components. The Romanian Fusion Association (MEdC) was given an EFDA task to develop a new process for coating carbon fibre tungsten composite tiles with tungsten. This has proven superior to the available industrial processes and essential for the success of the project.

Guy Matthews, Leader of the ITER-Like Wall project

Beryllium and tungsten replace carbon
During plasma operation the interaction between hot plasma particles and the vessel wall components leads to the wall components experiencing high thermal loads. Therefore a proper choice of materials forming the plasma facing components is needed in order to accommodate the heat loads. So far, JET has been operating with carbon tiles in its first wall. Carbon and hydrogenic species (hydrogen, deuterium, and tritium) form compact molecules that can be trapped in remote areas within the vessel. Guy explains:"The reason for the change of materials is to eliminate all this chemistry which produces very high erosion and migration rates of hydro carbon."The choice of materials for the ITER-Like Wall is, indeed, the one foreseen for the activated phase of ITER. The lightest metal beryllium was chosen for the main chamber. It is useful in engineering applications and well tolerated by the plasma. The twenty times heavier metal tungsten is one of the best in high temperatures and therefore the material of choice for the hottest parts on the bottom of the vessel, the divertor.
The variety of material combinations is quite impressive: bulk beryllium, beryllium-coated Inconel, beryllium-coated carbon fibre composite (CFC), bulk tungsten, tungsten-coated CFC.

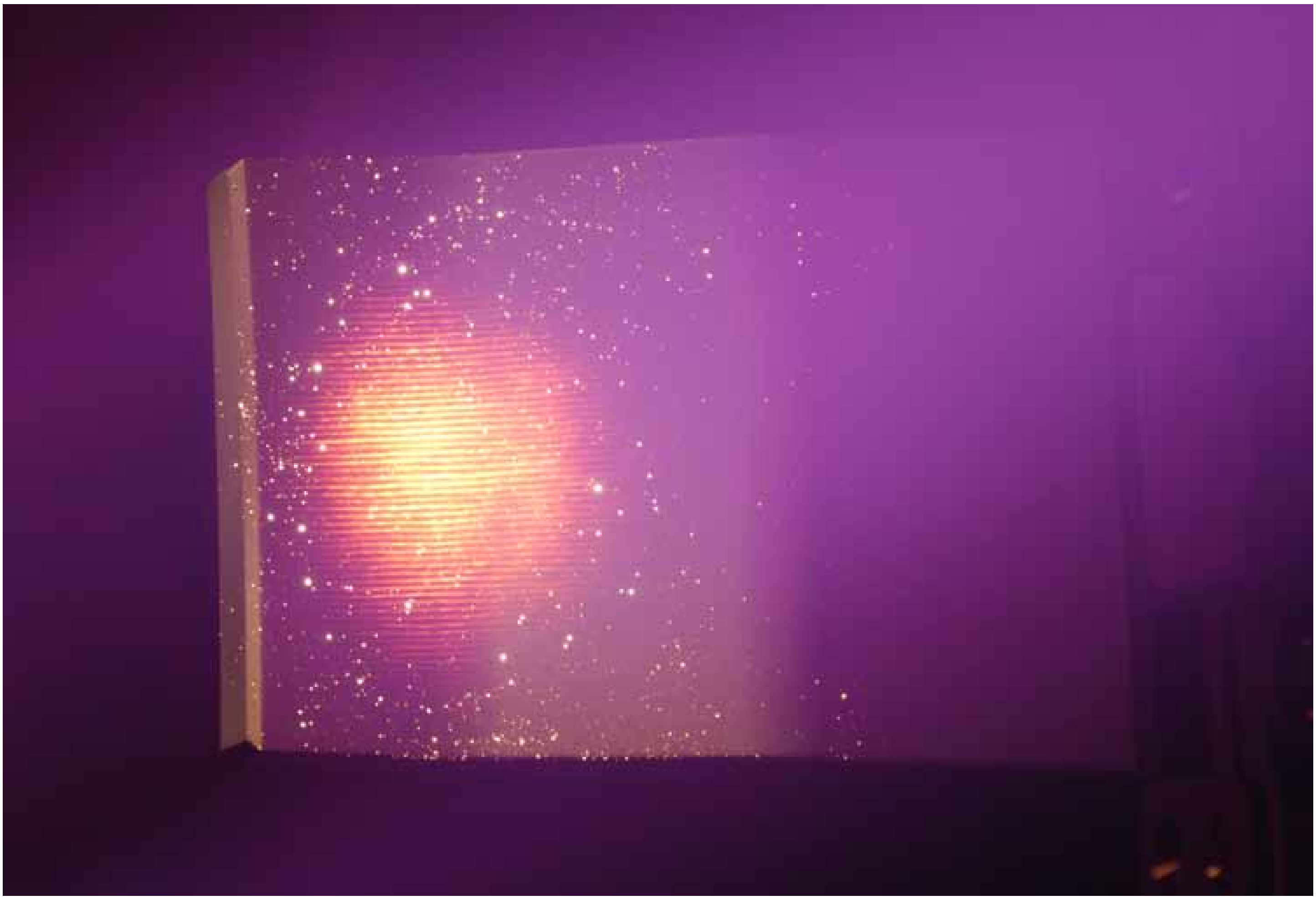
In spite of its advantages this solution bears some challenge for the engineers. They have to cope with lower electrical resistivity of beryllium leading to high forces on tile support structures. Engineering Design and Manufacture Team Leader Eric Villedieu explains:"We had to recover for acceptable forces and the only solution was, to split each beryllium or tungsten tile in up to twenty pieces or use thin coatings. A lot of work has had to be done adapting the new components to existing machine constraints, so we could mimic the planned material configuration of ITER." In order to keep the production of the tiles as simple as possible the project team opted for a casting process, which is "quite innovative for the fusion community", as Eric adds.

The new divertor will be made of tungsten. In the given temperature range for fusion experiments this metal shows excellent thermal properties comparable to those of carbon, and low erosion rates. Guy Matthews stresses that JET will operate after the refurbishment as a all metal machine:"Carbon is to all intended purposes indestructible. So, by putting a meltable wall plus an upgraded heating system in JET we have to develop control and protection procedures. With the metal wall, running JET is very much more like running ITER".

Precise answers for ITER
ITER will operate with long pulse duration and low core impurities in order to achieve its objectives. Carbon is no longer the material of choice for the first wall armour because it would trap a considerable amount of deuterium and tritium in the material of the inner wall. Making the right choice for the wall materials could be the difference between success and failure. Beside the scientific aspects Guy adds another one:"It is less expensive to make mistakes in JET rather than in ITER".

Richard Pitts, acts as Senior Scientific Officer at ITER and is in charge of Plasma Edge Physics and Plasma-Wall Interactions. He will be looking at JET's ITER-Like Wall project very carefully:"An experimental test with the materials mix foreseen for ITER, in a device large enough to approach some of the plasma edge conditions expected on ITER, will increase confidence that the ITER strategy is reasonable. JET should be able to establish that reliable tokamak operation at high power with acceptably low retention of hydrogenic species is indeed possible. The ITER-Like Wall project at JET truly is a defining experiment of unique importance to ITER."

Petra Nieckchen



*The German Association IPP has tested the tungsten-coated tiles with regard to their thermal mechanical behaviour. The photo shows one of the new designed JET divertor tiles during heat loading with a hydrogen beam in the **G**arching **LA**rge **DI**vertor **S**ample test facility (GLADIS).*

The ITER-like Wall Project is carried out under the European Fusion Development Agreement (EFDA) and by the following European Associations:

Commissariat a l'Energie Atomique (Cadarache, France)

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

Forschungszentrum Jülich (Jülich, Germany)

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

Institut de Fizica Atomica in Romanian (Bucharest, Romania)

Finnish Funding Agency for Technology and Innovation (Helsinki, Finland)

Belgian Nuclear Research Centre (Mol, Belgium)

United Kingdom Atomic Energy Authority (Culham, United Kingdom)

Swedish Research Council (Stockholm, Sweden)

A **collaborative** spirit

Although every high profile visit at the JET Facilities follows more or less the same format, each has its own character. When the Dutch Minister of Education, Culture and Science, Ronald Plasterk, visited the JET Facilities in mid-April the former molecular biologist left his individual mark on those accompanying him and his delegation by asking many detailed questions of both senior scientists as well as students.
The Netherlands Organisation (NWO) is the central Dutch institution in the field of fundamental and strategic scientific research. The Dutch EURATOM Association – the Foundation for Fundamental Research on Matter (FOM) – is funded predominantly by NWO. The FOM Institute of Plasma Physics in Rijnhuizen focuses its fusion research on superconductors, development and application of radiation sources and molecular physics. A partnership of Dutch organisations has agreed on developing a Master of Science in Fusion Technology which should encourage more graduates to study in this field.

"I have come to appreciate the work you are doing in fusion research in order to tackle one of the challenges of our time. I have taken note of the collaborative spirit which prevails here at JET and, in particular, of the enthusiasm which everybody demonstrated."

Ronald Plasterk
Minister of Education, Culture and Research in the Netherlands

"I was pleased to have met the Minister in person. He was very interested in my work experience in a research environment like JET and in my motivation to take my PhD studies abroad. As fellow scientists, we agreed that research environments like those present at JET are exciting learning grounds for motivated students. This would not be possible without the joint collaboration of many parties including FOM, the NWO and UKAEA.

With the newly formed Master of Science Course in Fusion Technology at the Eindhoven University of Technology, I even hope to see even more students participating in fusion research over the coming years."

Thijs Versloot
PhD Student from Institute of Physics, FOM

"Minister Plasterk asked very direct and penetrating questions concerning the feasibility and, in particular, the time schedule of fusion energy. In a lively exchange he found a homogeneous fusion community providing clear answers. The theme of the minister clearly was: can we afford not to develop fusion, and if we can't, can't we get it earlier! However, what really appeared to strike home with him was discussing science with a couple of young PhD-students and others in the JET control room. The dedication and enthusiasm of the researchers was inspirational!
My personal impression of the visit is most of all: our highest priority should lie with getting fusion energy as fast as possible. Identify future problems and start solving them. Work hard on reliability and reduction of complexity. Move towards the commercial plant along the fastest track. That is what politicians expect us to do, and rightly so.
I believe the visit was very important to broaden the support in the Netherlands for fusion research in European and international collaboration."

Nieck Lopez Cardozo
Head Fusion Research of the Dutch EURATOM-Asssociation FOM

"This visit showed that the Dutch are serious about fusion and their contribution to ITER."

Peter de Vries
Session Leader at JET

Imprint

JET Insight
is published by
EFDA JET Close Support Unit,
Culham Science Centre, Abingdon,
Oxfordshire, OX14 3DB
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2,500 copies of this issue have been printed.