CCFE
CULHAM CENTRE FOR FUSION ENERGY

InFusion Issue 01 | Spring 2011

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Issue 01 | Spring 2011

All change for JET

How remote handling technology is transforming the world's largest fusion machine

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Welcome

This is the first issue of the new publication *InFusion* from the Culham Centre for Fusion Energy (CCFE). CCFE is the world's leading laboratory in fusion research. We host two experiments on our site, JET the European device and world's largest fusion machine and the UK's own machine MAST.

Now is an exciting time for fusion research at CCFE. JET is currently nearing completion of a major upgrade project to replace all its 4000 tiles with new ones made of materials more suitable for the next global fusion experiment ITER, currently being built in Cadarache, southern France.

The UK's fusion programme machine MAST will run experimental campaigns until 2013, after which it will undergo a major upgrade, ready to begin operating again in 2015 with significantly enhanced capabilities. Research on MAST Upgrade will then include the testing of potential systems for a fusion power plant, and examining the suitability of a MAST-like machine as a future component test facility.

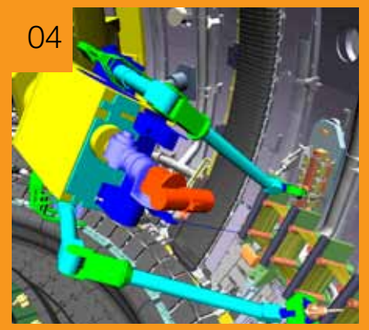
Our work at CCFE is also focused very strongly on contributing to the next fusion experiment, ITER. One crucial way in which we are doing this is by winning grants and contracts to design some of the complex systems for the machine which should begin operating in 2019.

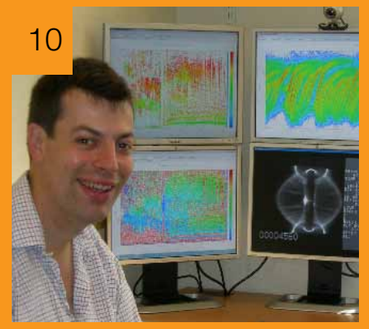
Details of these projects are explained in this first edition of *InFusion*, together with articles on the crucial role that university collaborations play in research at CCFE, an innovative global tokamak experiment initiated by a Durham University/CCFE PhD student and other news from the laboratory.

I hope you enjoy reading this first issue. If you would like to find out more about the fusion research at CCFE, all our contact details are on the inside back cover.

Professor Steve Cowley
CEO Culham Centre for Fusion Energy

In this issue





About CCFE

The Culham Centre for Fusion Energy (CCFE) is home to the UK's fusion research programme, centred on the MAST (Mega Amp Spherical Tokamak) experiment. It also hosts and operates the world's largest fusion facility, JET (Joint European Torus) under contract from the European Fusion Development Agreement (EFDA). Scientific research on the site is funded jointly by the UK Research Councils' Energy Programme through the Engineering and Physical Science Research Council (EPSRC) and EURATOM.

What is fusion?

Fusion is the process which powers the Sun. It occurs in the core of stars when light atomic nuclei are forced together to form heavier ones, resulting in the release of a large amount of energy. To utilise fusion as an energy source on Earth, gas is heated to extreme temperatures - 150 million ^{o}C, ten times hotter than centre of the Sun - when it becomes a plasma. At these temperatures, the nuclei are energetic enough to fuse together and release large amounts of energy that a future commercial power station will use to generate electricity.

Fusion will have major advantages as an energy source: no carbon emissions; abundant fuels (for potentially millions of years); no 'long-lived' radioactive waste (the radioactivity in the structure of a future fusion power station will decay in decades) and an inherently safe process.

Further information is available at www.ccfe.ac.uk and www.jet.efda.org.

All change for JET

Work is nearing completion on the upgrading of the JET vessel, a project which will test potential materials for the next fusion machine ITER; when finished over 100,000 components in the world's largest fusion machine will have been changed.

Fifty metres from the JET fusion machine, in a darkened control room lit by an array of computer screens, a pair of mechanical arms is expertly manoeuvred inside the vacuum vessel.

This scene is that of a typical shift by the CCFE Remote Handling team - the people working in the room are remote control operators and engineers. Some of the computers ahead of them display different camera views of the inside of the JET vessel, others show a real-time virtual reality simulator. The team are working on one of the longest shutdowns ever undertaken on JET, with the primary task of changing all the plasma facing tiles on the interior together with many other improvements to its future performance.

Work on this project began in October 2009 with the goal to remove all the 4,500 carbon fibre composite tiles which line the vessel, and replace them with new bespoke components of beryllium and tungsten. A giant jigsaw puzzle, which when complete will allow the testing of these future candidate 'first wall' materials for the interior tiles of the new global fusion experiment called ITER.

Other improvements carried out during the shutdown will increase the diagnostic and control capabilities of the JET machine. Following these changes the heating power will be increased by about 50%, bringing the neutral beam power available to 34 MegaWatts. This will allow the potential to access very high pressures in JET plasmas closer to those which will be achieved on ITER.

Work carried out during shutdown periods on the JET vessel is performed whenever possible by remote handling. This is because during its operating time the vacuum vessel becomes radioactive due to the bombardment of neutrons onto the inner wall and manned entries need to be kept to a minimum. Remote handling at JET combines advanced mechanical technology, sophisticated virtual reality and the problem solving skill and experience of human operators.

This allows JET to be adapted rapidly, efficiently and safely for each new experimental campaign, maximising the research work that can be achieved.

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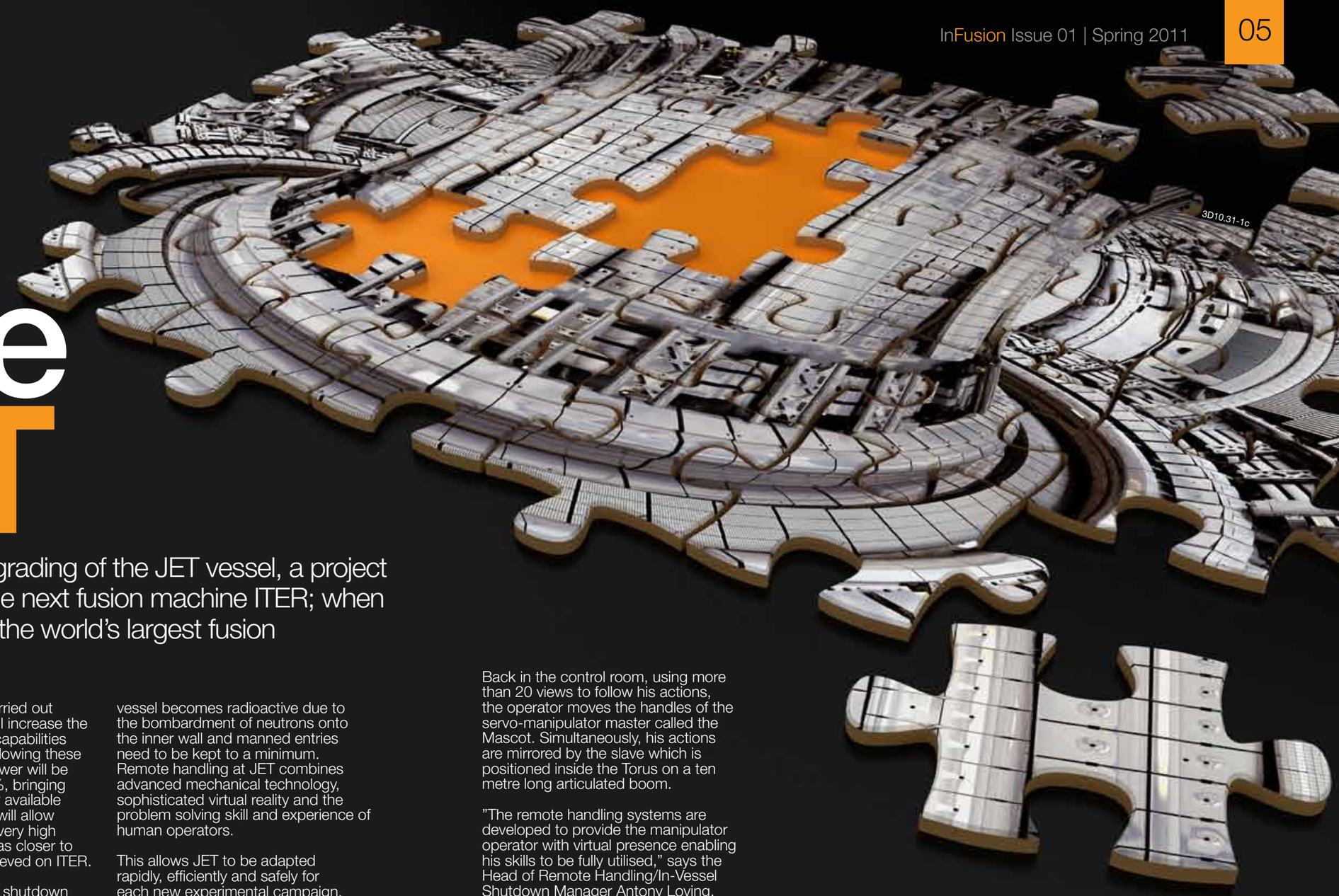
Engineers working in the Remote Handling Control room



A giant jigsaw puzzle, which when complete will allow the testing of these future candidate 'first wall' materials for the interior tiles of the new global fusion experiment called ITER.

Back in the control room, using more than 20 views to follow his actions, the operator moves the handles of the servo-manipulator master called the Mascot. Simultaneously, his actions are mirrored by the slave which is positioned inside the Torus on a ten metre long articulated boom.

"The remote handling systems are developed to provide the manipulator operator with virtual presence enabling his skills to be fully utilised," says the Head of Remote Handling/In-Vessel Shutdown Manager Antony Loving. "This allows tasks that require a high level of precision to be undertaken as if working at the bench."

Though he is not there in person, the operator feels the weight of each tile as he lifts it and he feels the tension of the screws as he tightens them. However, remote handling at JET isn't entirely a manual operation. A series of boom movements can be pre-programmed to get the mascot into position, but with the final dextrous work almost always performed by the operator.

"Remote handling requires a great deal of preparation," says Shutdown Project Leader, Phil Prior. "It is a very detailed process, the risks involved in vessel work are very significant"

But can the mechanical arms do it all? "The majority of the work is carried out using remote handling techniques," says Phil Prior. 'But we have had three manual phases of work involving manned entry into the vessel during this shutdown which account for about 7% of the total carried out."

During these manned entry phases, the work undertaken involves specific tasks, and inspections that are not practical remotely including the removal of some tile assemblies, detailed inspections and some welding work. As with all the tasks carried out, significant preparation is crucial and the vessel can only be entered for short periods of time.

At the time of writing, over 600 man years of work have been successfully undertaken in this project. Attention will shortly turn to the restart of JET and how the newly fitted tiles will perform in the next experimental campaign.

The Super-X factor

With the testing of a Super-X divertor exhaust system a key goal of a future major upgrade of the UK fusion machine MAST, the multi-million pound project is set to become a user facility which attracts fusion scientists from around the world.

"The Mega Amp Spherical Tokamak (MAST) is the centrepiece of the UK's fusion research programme," says Professor Steve Cowley, CEO of CCFE. "It has led studies into the spherical tokamak, a compact fusion concept pioneered at Culham and since developed around the world."

Standing four metres high the MAST experiment is a grey cylindrical machine, with an abundance of wires and machinery covering its surface. Appearances may be deceptive, as this fusion device has created over 25,000 man-made 'stars' or plasmas at temperatures equal to the centre of the sun (15 million °C).

These experiments have provided data which have enabled many advances in key fusion research areas including plasma instabilities and start-up methods.

The first hot spherical tokamak START (Small Tight Aspect Ratio Tokamak) was developed at Culham in 1991. START, like the MAST machine, confined the plasma in a tighter magnetic configuration than the conventional torus shape of JET or the future ITER-style design.

This configuration results in the formation of a plasma inside the vessel which resembles more a cored apple than the usual doughnut shape.

Over ten years on MAST can boast significant contributions to fusion physics, particularly in understanding the instabilities that form at the edges of plasma and are often compared to the solar flares which burst out from the Sun's surface. During this time MAST has surged forward, notably 13 months ago, with the upgrading of its Thomson scattering system, installing the world's most advanced system for recording the temperature and density of the plasma inside the vessel.

At present, worldwide fusion research is focused on one goal, the ITER experiment in southern France, and ensuring its success in demonstrating the scientific and engineering viability of producing electricity from fusion power.

The MAST machine continues to be part of this globally directed effort with the approval of a £30 million major upgrade to MAST by the Engineering and Physical Sciences Research Council (the main funding body for UK fusion).

When completed in 2015 MAST Upgrade will be a worldwide user facility and perform several key roles in global tokamak development. It will provide important physics data which when scaled up will help predict performance on the much larger ITER fusion experiment.

MAST Upgrade will simulate ITER scenarios in the spherical tokamak configuration, assessing how the alternative 'tighter' shape affects plasma parameters and providing a different spectrum of results to be fed into the ITER knowledge base.

A further goal will be to test potential systems for use in a future fusion power station. MAST will be the first fusion device to incorporate an innovative plasma exhaust system, the 'Super-X' divertor.

Currently, tokamaks have a trench at the bottom of the vessel known as a divertor. This is used to exhaust heat and particles from the plasma core and is subject to high power loads. In the Super-X design, particles leaving the plasma will be steered along magnetic fields in such a way that they travel a much longer distance before interacting with the divertor plates – allowing the heat to spread over a much wider area. If Super-X performs well in MAST Upgrade, this divertor type could be included in the prototype power station (DEMO) that will be built after ITER.

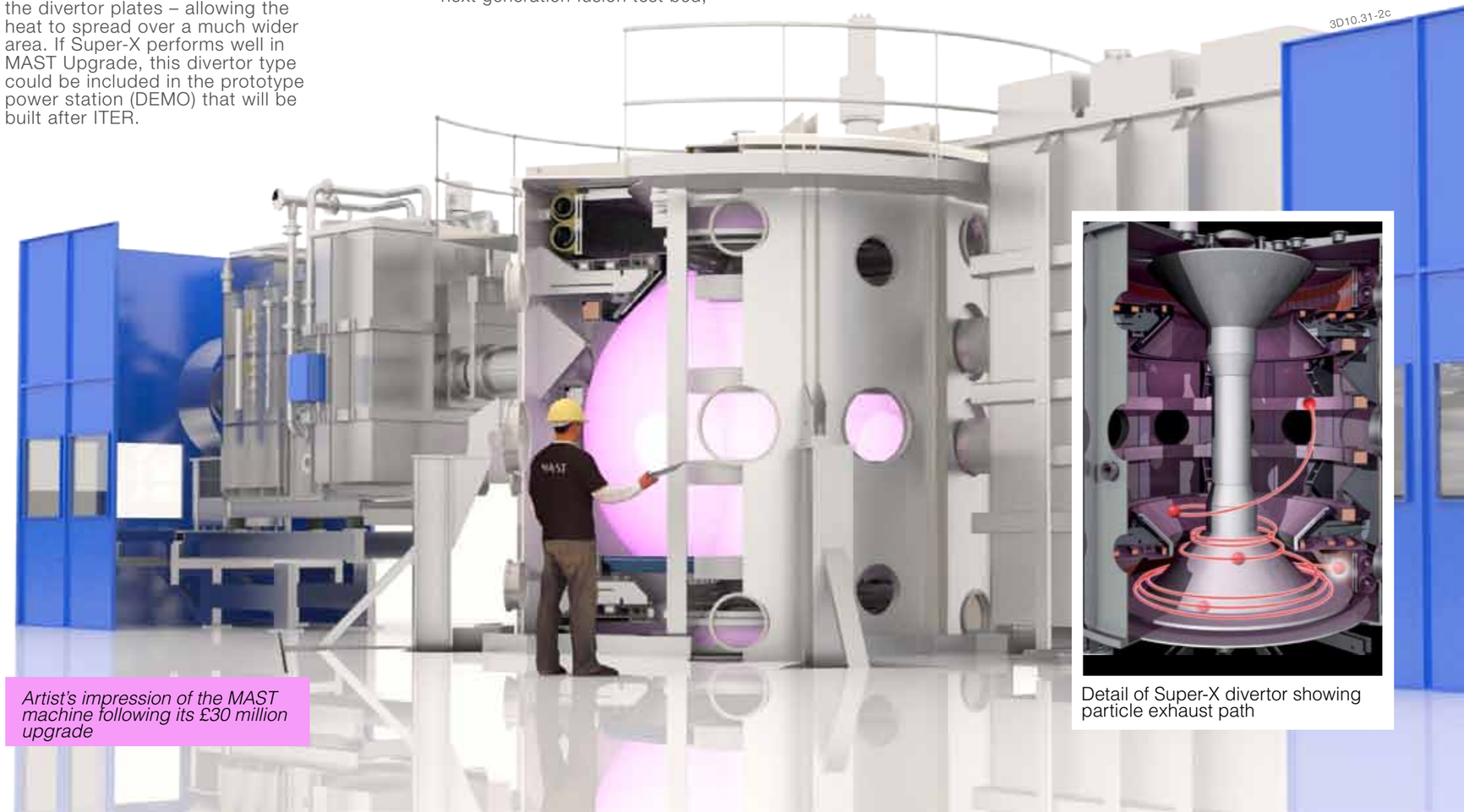
> "Here at CCFE we have a fantastic opportunity to develop a unique next generation fusion test bed."
>
> **Martin Townsend**
> MAST Upgrade Project Manager

The MAST Upgrade project will also be able to explore the suitability of the spherical tokamak design as a candidate for a fusion Component Test Facility (CTF). This will allow the MAST machine to test fusion engineering and technology systems for DEMO. A CTF would also look at the viability of the spherical tokamak as a compact next generation design for a fusion power station beyond DEMO.

Here at CCFE we have a fantastic opportunity to develop a unique next generation fusion test bed," says Martin Townsend, the MAST Upgrade Project Manager. "Currently, the first phase of the technical review has been completed, project teams appointed and interest from industry for major procurements secured."

As the project continues to gather momentum, and with the next phase of the Engineering and Project Management review just around the corner in April, CEO Steve Cowley anticipates its completion in 2015:

"Collaborators will bring expertise and equipment to enhance MAST Upgrade," says Steve Cowley. "In return, we will provide a machine uniquely equipped to trial innovative diagnostics and to explore a wide range of key plasma physics areas."



Artist's impression of the MAST machine following its £30 million upgrade

Detail of Super-X divertor showing particle exhaust path

The heat is on

Dr Joe Milnes, Head of Engineering Design and Evaluation Group, who is leading the team designing one of the key heating systems for new fusion experiment ITER.

As the construction of the next stage international fusion experiment ITER gets underway,CCFE is winning contracts to design some key systems.

In Cadarache, southern France, an area the size of 60 football pitches has been cleared as the site for ITER. In 2010, building began on this ~ €10 billion international project, which will be twice the dimensions of JET, produce 500 MegaWatts of fusion power and is designed to demonstrate the viability of fusion power on the scale of a power station.

When recreating fusion on earth, less than 1 gram of fuel (deuterium and tritium) is used, while the temperatures required to generate the reaction are over 150 million degrees. Complex systems are needed to heat the fuel gases to these extreme temperatures and provide the confining magnet fields.

Developing these is the challenge for the seven ITER partners, China, Europe, India, Japan, Russia, South Korea, and USA. Before they can be built, further research and design is needed and CCFE is a leading player in this process. The European ITER Domestic Agency, Fusion for Energy (F4E) is allocating the research and development work to consortia of fusion laboratories.

When recreating fusion on earth, less than 1 gram of fuel (deuterium and tritium) is used, while the temperatures required to generate the reaction are over 150 million degrees.

"CCFE has successfully bid for grants to design ITER systems as part of consortia, some of which we are leading," says Technology Director, Derek Stork. "The systems we will be developing are, the LIDAR diagnostic which uses lasers to measure the plasma temperature, and the Ion Cyclotron Resonance and Neutral Beam heating systems, together with other key technology areas."

These areas include neutronics (the study of how fast fusion neutrons affect surrounding materials) and studies for magnetic diagnostics. In addition, CCFE is a third party to the French atomic energy agency for a detailed design of a representative port plug, and the diagnostic integration which is relevant to CCFE LIDAR work as the tool will use one of these ports to view the plasma.

Head of Engineering Design and Evaluation Group, Dr Joe Milnes is leading one of the teams designing the neutral beam heating system. This is the primary auxiliary heating system for ITER. As on JET, the supplementary heating system will allow temperatures ten times hotter than the sun's core to be reached in the centre of the plasma.

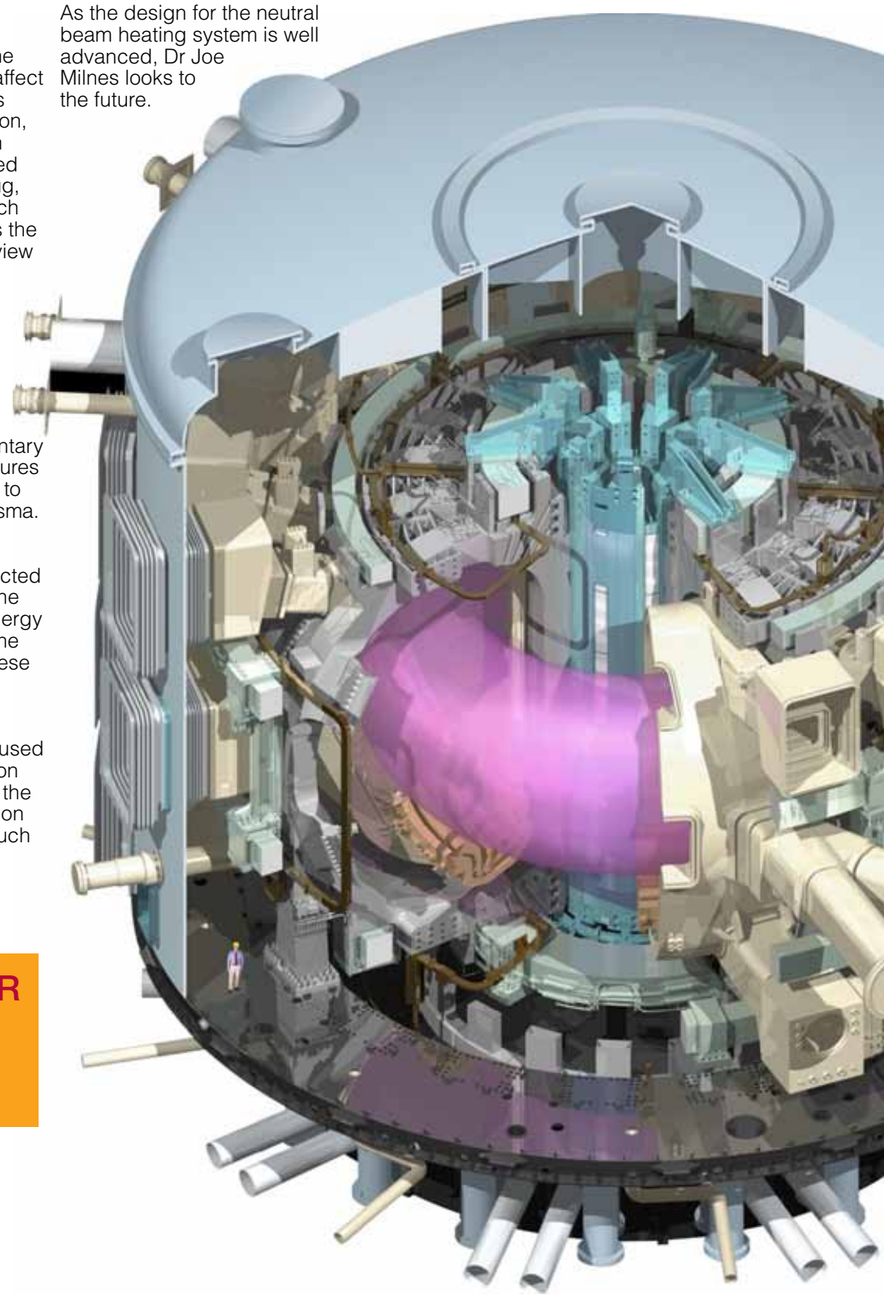
To achieve this, beams of highly energetic hydrogen atoms are injected through a port into the machine. The particles exchange their kinetic energy with those in the vessel, allowing the plasma to be heated and reach these high temperatures.

During experimental campaigns neutral beam injection is routinely used to reach these high temperatures on JET. But one year on from winning the contract, how is work progressing on a heating system for a machine much bigger than JET?

"We have successfully developed the functional specifications for most of the components and are well into the conceptual design phase," says Joe Milnes. "This is progressing well, we are getting good feedback from ITER and we hope to have finished the conceptual design review, a key milestone, by June this year."

As the design for the neutral beam heating system is well advanced, Dr Joe Milnes looks to the future.

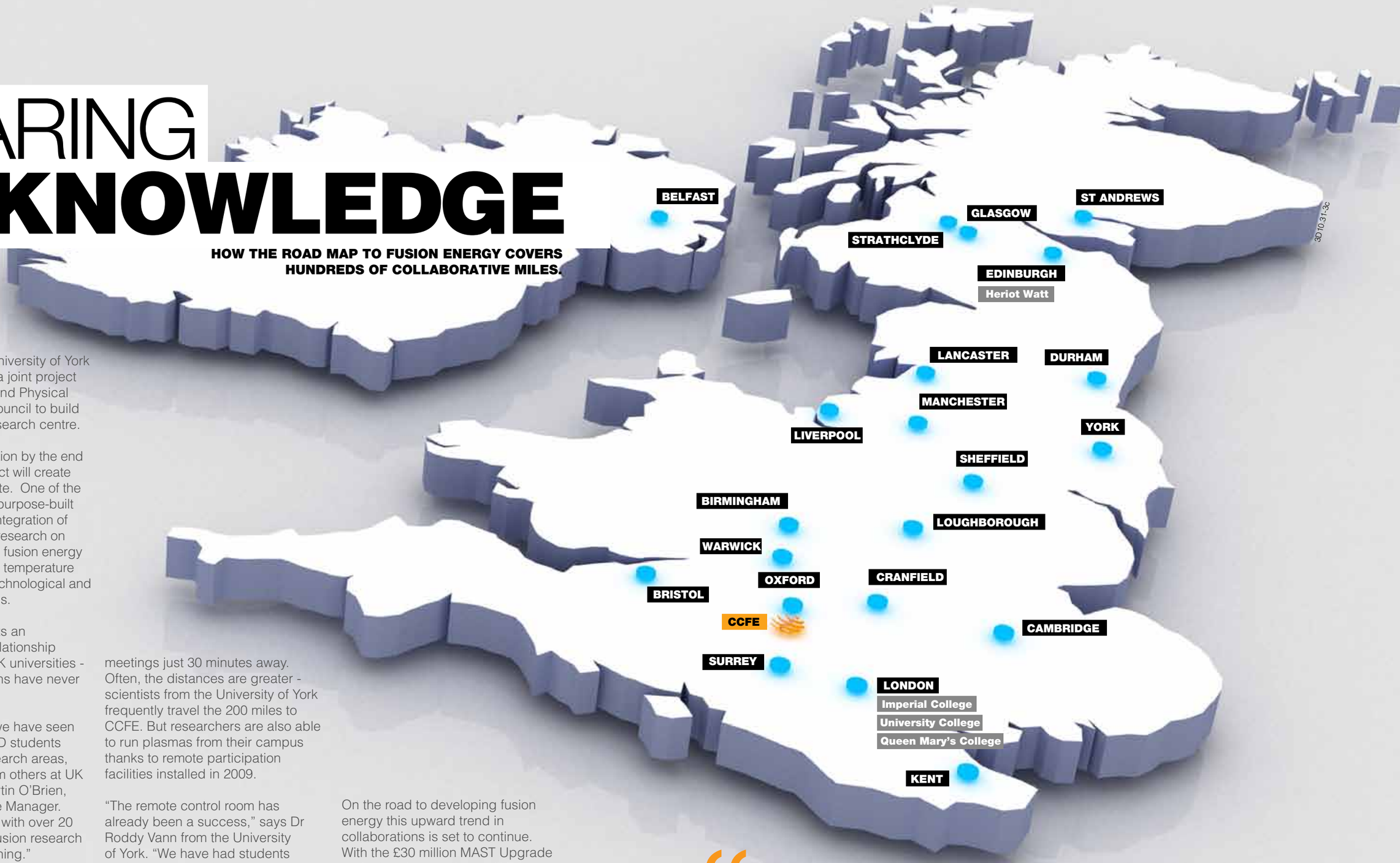
"I believe that it is vital for CCFE to be involved in the design grants for ITER, as it is the future of fusion. This is just the start; as the project develops in the next three to five years, I would hope there will be many more ITER design contracts that CCFE can compete for and win."



A cutaway of the ITER fusion machine, with the hot plasma visible in the centre

SHARING KNOWLEDGE

HOW THE ROAD MAP TO FUSION ENERGY COVERS HUNDREDS OF COLLABORATIVE MILES.



Last December, the University of York announced details of a joint project with the Engineering and Physical Sciences Research Council to build an interdisciplinary research centre.

Scheduled for completion by the end of 2011, the £3M project will create the York Plasma Institute. One of the main aims of this new purpose-built laboratory will be the integration of existing UK university research on hot plasma science for fusion energy applications with lower temperature plasma research for technological and for medical applications.

This investment reflects an expanding two-way relationship between CCFE and UK universities - and such collaborations have never been stronger.

"In the last ten years we have seen a large increase in PhD students working on fusion research areas, some based at Culham others at UK universities," says Martin O'Brien, UK Fusion Programme Manager. "We have forged links with over 20 universities, both for fusion research and postgraduate training."

Sometimes it's a local affair; long-term collaborations with Oxford University on materials work mean that CCFE scientists can attend weekly meetings just 30 minutes away. Often, the distances are greater - scientists from the University of York frequently travel the 200 miles to CCFE. But researchers are also able to run plasmas from their campus thanks to remote participation facilities installed in 2009.

"The remote control room has already been a success," says Dr Roddy Vann from the University of York. "We have had students working in here, who are not just from York but from the universities of Manchester, Durham and Liverpool, allowing them to access MAST more easily."

On the road to developing fusion energy this upward trend in collaborations is set to continue. With the £30 million MAST Upgrade project underway, there will be further opportunities as CCFE looks for knowledge sharing to develop diagnostics and other systems for the upgraded machine.

> **"We have forged links with over 20 universities, both for fusion research and postgraduate training."**
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> **Martin O'Brien**
> UK Fusion Programme Manager

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LAUNCH OF THE WORLD'S FIRST GLOBAL TOKAMAK EXPERIMENT

Durham University and CCFE PhD student Billy Huang set up a website for the world's first global tokamak experiment, which ran on 1 December 2010.

The project allowed anyone in the world with a physics background and internet access to apply to have a go at running experiments on the GOLEM Tokamak in Prague, a machine that has been made remotely operable by Tokamak Engineer Vojtech Svoboda and his team.

"The Tokamak Global Experiment is an innovative project that gives participants the opportunity to change real parameters on a real machine, from anywhere in the world," said Billy Huang. "Our goal with this project is to get people participating and interested in fusion research around the globe."

GOLEM is one of the oldest tokamaks in the world, originating from Russia. Although not nearly as large as JET, GOLEM still produces small amounts of fusion energy and is used as an educational device.

Promotion of the initiative was in conjunction with the Institute of Plasma Physics of the Czech Republic and the Czech Technical University and targeted at university level physics students, although anyone was able to participate.

On the experiment day, the Tokamak Global Experiment brought together participants from ten countries around the world performing over 80 shots in four hours.

Billy Huang was delighted with the response to the project. "It's been a real challenge setting up the website, but to have so many people from countries across the world already participating in real live fusion experiments is great."

"The Tokamak Global Experiment is an innovative project that gives participants the opportunity to change real parameters on a real machine, from anywhere in the world."

For more details and to see the results visit:
www.tokamakglobal.com

Opportunity knocks for UK industry

CP08c-339-05

CCFE's Fusion and Industry Manager, Dan Mistry.

"The day was very useful," said John Watson, Director of Production at Davy Markham. "It's opened up avenues for many companies to understand the procurement procedures for both ITER and F4E. I think there will be more awareness among British industry of the opportunities from the ITER project."

As the next phase of ITER construction begins, so opportunities for UK industry to bid for contracts worth over €2 billion are becoming available. Keen to raise awareness of these opportunities and how to compete for contracts, UK Trade and Industry (UKTI) sponsored an event *Business Opportunities for UK plc for fusion and ITER,* which was hosted by CCFE in September.

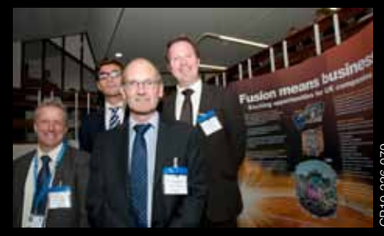
The event was attended by over 100 companies and also provided opportunities for industry managers to 'meet the buyer' and tour the European fusion experiment JET.

During the day, representatives from ITER, Fusion for Energy (F4E - Europe's procurement agency for ITER), UKTI, CCFE engineers and UK companies working on ITER projects, outlined the business opportunities and engineering challenges in the next phase of ITER construction, and described the procurement procedure and tendering process.

"The day was very useful," said John Watson, Director of Production at Davy Markham. "It's opened up avenues for many companies to understand the procurement procedures for both ITER and F4E. I think there will be more awareness among British industry of the opportunities from the ITER project."

"So far UK companies have secured a €150 million share of the ITER contracts available," said Fusion and Industry Manager, Dan Mistry. "To keep this momentum going, we need more businesses to participate in the bidding process and events like this help us to advise industry managers on submitting tenders."

Companies wishing to find out more about ITER and how to register with ITER and F4E should join CCFE's industry database at: www.fusion-industry.org.uk.



CP10-226-079

Industry visitors attending the UKTI sponsored business opportunity event at CCFE

Celebrating 20 years of collaboration

The annual Culham-Ioffe Symposium took place at Culham in late November, bringing together scientists from CCFE and the High Temperature Plasma Physics Laboratory in the Ioffe Institute, St Petersburg, Russia.

It was the 20th anniversary of the first symposium established by two former directors of the laboratories, Victor Golant and Derek Robinson, as a regular forum for exchanging information on fusion, alternating in venue between the Ioffe and Culham. Three of the 2010 Ioffe visitors were also at the first symposium in 1990.

The long-standing collaboration has proved extremely fruitful in providing engineer visits for design of MAST and the Ioffe's Globus-M tokamak, and interactions between both Thomson scattering and neutral particle analyser experts. More recently the symposium has generated numerous exchanges on Electron Bernstein Waves, experiment and theory, for the Component Test Facility, MAST Upgrade and, crucially, for the novel edge current measurements on MAST. Opportunities for young researchers have also arisen over the years, with Ioffe scientists working at CCFE and Culham PhD students visiting Russia.

"Culham has had a long and substantial relationship with the Ioffe, which is a very prestigious institute with many illustrious alumni across almost all areas of physics," said CCFE's Chief Scientist William Morris. "Since 1990, the topics covered by the symposia have been wide-ranging, and as ever the quality of presentations this year was excellent."

CP10c-314-06

The signing of the latest collaboration agreement between CCFE and Ioffe by directors Steve Cowley and Evgeniy Gusakov, with participants from the meeting.

CCFE in brief

CP10c-324-68

New appointees to UK Atomic Energy Authority board

Last November, the appointment of three new non-executive members of the board of the UK Atomic Energy Authority, which owns and operates CCFE, was announced by the Business Secretary, Vince Cable.

The Secretary of State appointed Keith Burnett, Stephen McQuillan and Peter Jones as non-executive members of the Authority's board for a three-year period from November 2010.

Keith Burnett is the Vice-Chancellor of the University of Sheffield. Previously he was Head of the Division of Mathematical, Physical and Life Sciences at the University of Oxford, having been a professor of Physics there for almost twenty years.

Stephen McQuillan is the CEO of a listed UK Engineering group – Avingtrans plc. His previous position was as Director/CEO of the National Physical Laboratory (working for Serco). Prior to joining NPL, he ran a division of Oxford Instruments.

Peter Jones became a non-executive director of the National Nuclear Laboratory and Chairman of its Audit Committee in August 2009. He is also a qualified Chartered Accountant and has experience in a variety of sectors varying from financial services to electricity production.

"It's exciting to be working with such highly qualified and eminent physicists and engineers, who all believe, like me, in a great future for nuclear energy – in particular fusion," said the Authority's Chairman Roger Cashmore. "With the experience and skills of the new board members, I'm confident that we can provide the leadership that the Authority deserves as it tackles matters of huge importance to the UK and the future energy needs of the world."

Pictured above are board members visiting JET: Eric Hollis (Chief Financial Officer), Martin Cox (Operations Director), Derek Stork (Director of Technology), Stephen McQuillan (Non-executive Director), Steve Cowley (Chief Executive Officer), and Peter Jones (Non-executive Director)

Sun Dome clocks up 500 shows

CCFE's education outreach project, the Sun Dome, passed a notable landmark in January 2011.

During a visit to the European School at Culham, presenters Joana Silva and Chris Warrick, from the CCFE's Communications Group, gave the 500th Sun Dome show since the project was launched in January 2008. In that time, more than 11,000 children have been to the Dome – taking a 'virtual' trip to the Sun without leaving the school hall.

Primarily for Year 5 and 6 children at Oxfordshire primary schools, the Sun Dome has travelled to science festivals in the UK and abroad. Students from the University of York have also presented shows to local pupils. The activity, funded by the Engineering and Physical Sciences Research Council, consists of educational films about the Sun, fusion and energy, and role-play activities. It has been a big hit with kids, as Joana (CCFE's Outreach Manager) explains:

"The reaction we get from the children is great – often they send in drawings and posters based on what they have learnt – and the feedback from teachers is good too. It is a memorable experience for the kids, as it is so different from their normal lessons. We hope the Dome inspires them to study science and some may become future fusion scientists and engineers!"

Media update

What problem do you hope scientists will have solved by the end of century?
Who are the UK's top 100 scientists?
What is one degree?

These are some of the questions asked in the media in the last few months which have put fusion research at CCFE in the spotlight.

CP06j-298-06

Head of CCFE Steve Cowley with Professor Brian Cox during the filming of a BBC Horizon programme on fusion (2009)

- In September 2010, Professors Stephen Hawking and Brian Cox, two of Britain's pre-eminent scientists, named fusion as the century's top scientific challenge in an interview with *The Guardian* newspaper. They both agreed that fusion is an important priority in the search to meet increasing energy demands without endangering the planet.

  The full article is available at *The Guardian's* website.

- A month later, *The Times* newspaper named Head of CCFE Professor Steve Cowley as one of the UK's most influential scientists. He joined Stephen Hawking, David Attenborough and Richard Dawkins on the *The Times' Eureka 100 Science List*, in a respectable 58th position. This list aimed to 'identify the most important and interesting people in British science [who are] pushing back the boundaries of scientific understanding, transforming our lives through innovation and changing our attitudes to science, each other and the world.'

- Early in 2011, comedian and former physicist Dr Ben Miller asked *What is one degree?* during his exploration of temperature, for a BBC2 *Horizon* programme shown on 10 January. The documentary saw him filming in many locations, including CCFE where he interviewed Diagnostic Physicist, Joanne Flanagan about measuring the extreme temperatures reached on JET.

CP10c-202-42

David Willetts MP talks to apprentice Tom West in the Torus Hall where the JET machine is housed.

Science Minister visits Culham

David Willetts MP, Minister of State for Universities and Science, visited CCFE on 2 September 2010 for a briefing on the status of UK and European fusion research.

During his visit, Mr Willetts toured the European JET facilities and the UK's own MAST research device. He heard how the research at Culham is feeding into ITER, and how UK scientists are playing a key part in ITER preparations.

"David Willetts expressed his determination to keep the UK in the lead in fusion research and to develop the commercial potential of fusion," said Professor Steve Cowley, Head of CCFE.

Mr Willetts also discussed the business opportunities open to British companies from ITER construction and met representatives of firms which have already won contracts.

A revolution starting in Manchester …

A new multi-million pound gallery at the Museum of Science & Industry (MOSI) in Manchester recently installed an exhibition on the landmark ZETA fusion device, which operated at Harwell in the 1950s and 1960s.

The new Revolution Manchester gallery, part of a £9 million redevelopment of MOSI, was opened by Professor Brian Cox at the end of January. Divided into six themed areas, the gallery tells the story of how Manchester changed the world. The energy area includes a display on the construction of the ZETA vacuum vessel and some of its electrical components by Metropolitan Vickers in the Trafford area of the city.

The gallery contains a model of the vacuum vessel and an interactive game in which visitors can create a fusion reaction.

CCFE assisted by providing the gallery designers with information on ZETA and putting them in touch with former employees who worked on the project, as MOSI plans to incorporate interviews with them later in the exhibition.

More information is available at: www.mosi.org.uk

The replica model of the ZETA vacuum vessel on display at MOSI

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Visit us

We have free Open Evenings throughout the year (usually one per month) which give members of the public the chance to see the JET and MAST experiments on guided tours by scientists and engineers who work in fusion research.

For further details please visit our website: www.ccfe.ac.uk

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