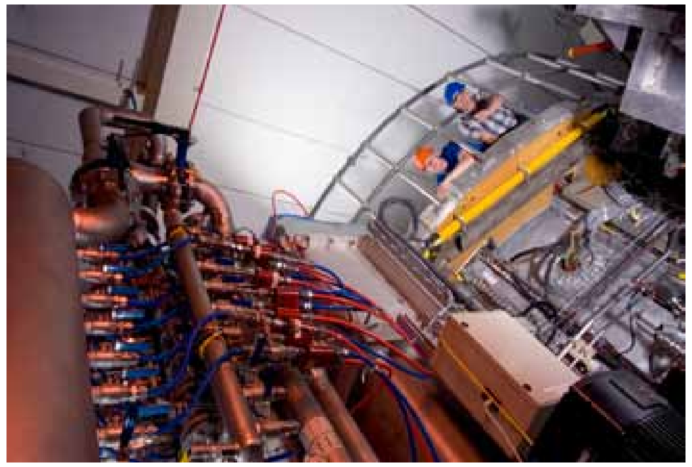

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CULHAM CENTRE FOR FUSION ENERGY

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PURE TRANSMISSION

Why this antenna is worth its weight in gold when it comes to fusion diagnostics

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Welcome

Welcome to the second issue of *InFusion*. Within these pages, I hope you will get a glimpse of the hugely diverse range of activities undertaken at CCFE – from innovative and collaborative ways of measuring the plasma in MAST, details of the new tiles installed on JET during the successful recent shutdown, CCFE's support for a new lease of life for COMPASS in Prague, to the extensive education outreach programme of activities we undertake for schools, colleagues and universities far and wide.

Highlighting this diverse range of activities brings to my mind the real need for CCFE to seek out new opportunities and areas of work – ensuring the laboratory has a bright future for decades to come. We are already pro-actively diversifying into:

- Areas of new commercial opportunity – where CCFE's expertise can be deployed to its greatest effect.
- Exploring the possibility of using our expertise in materials, neutronics etc. to help fission research in the UK.
- Seeking out ITER contract opportunities that tie in with our range of capabilities.
- Becoming a centre of work in the design of DEMO – the first demonstration fusion power station after ITER.

We also have a huge responsibility to help UK Industry benefit from ITER contracts – a massive opportunity over the coming years. I am delighted to report that CCFE's Industry Manager, Dan Mistry has been hugely successful in this area, leading the CCFE effort to secure over €170 million of business for UK companies – with the promise of more to come.

I am delighted to see CCFE spreading its wings into new areas and opportunities. This augers very well for a bright and prosperous future…

Professor Steve Cowley
CEO Culham Centre for Fusion Energy

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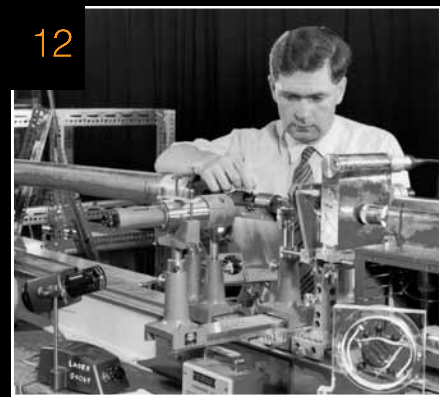

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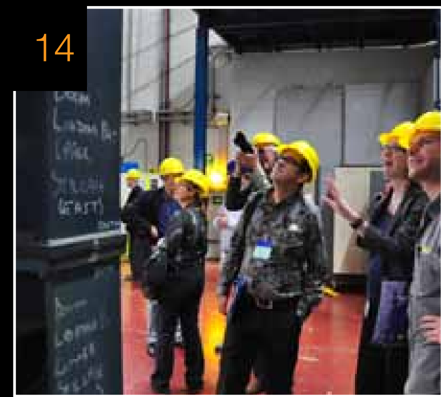


About CCFE

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 through 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 Sciences 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.

MEASURING the Plasma

From far left: PhD student Simon Freethy with his supervisors Vladimir Shevchenko (CCFE) and Roddy Vann (University of York) in front of the EBW imaging system

PhD student Billy Huang, who developed the FPGA board technology with Dr Roddy Vann for the EBW MAST diagnostic

CCFE's Dr Mikhail Turnyanskiy by the MAST neutron camera.

In the UK Fusion Programme experiment MAST, 'mini-stars' or plasmas of over 15 million °C are regularly created. For fusion research to reach its goal of commercial electricity generation, scientists need to be able to study what's happening inside the plasma.

Measurements of plasma properties such as temperature, density and plasma behaviour such as stability cannot be taken using conventional methods. Developing devices which will measure these properties involves designing complex and innovative diagnostic instruments, often achieved by the sharing of global expertise through long term collaborations with other fusion laboratories and university departments.

On the MAST experiment alone there are over 50 diagnostics, too many to detail here. In the last year, capabilities for studying the MAST plasma have been enhanced by installation of new diagnostics and upgrading of other equipment via collaborative projects. Three such recent projects are outlinedhere.

A deceptive white box

As you enter the MAST machine area through the south door, straight ahead to the right side of the tokamak is a large four ton white polythene structure. This is the recently upgraded MAST neutron camera, a collaboration between Dr Mikhail Turnyanskiy from CCFE, and Dr Marco Cecconello and a team of three scientists at Uppsala University, Sweden. The large opaque white box contains of a set of detectors that can 'look' at the plasma through collimated lines of sight and allow the neutron emissivity profile of the plasma to be studied from different angles.

During a fusion experiment on MAST using deuterium gas, with significant neutral beam heating, some fusion neutrons (equivalent to around 100 Watts of power) are emitted and pass through the collimators in the polythene shielding to four detectors. The neutron detectors are able to measure where the neutrons are coming from inside the plasma and distinguish them from other emissions such as x-rays using their energy spectra.

In MAST, neutrons normally only originate from fusion reactions involving fast ions, which are often generated by the neutral beam system. Measurements from the neutrons gives us information on the fast ions that formed them. Studying fast ions is one of the main aims of MAST and its future Upgrade as their behaviour helps determine the attractiveness of the Spherical Tokamak concept in the areas of plasma stability, confinement and non inductive current drive. Understanding of the complex nature of interactions between the plasma instabilities and the beam ions requires further investigation and is important for predictions of future larger tokamak facilities such as ITER.

"This project has given Uppsala University a very good opportunity to participate in an international experiment like MAST," said Dr Cecconello. "We hope we can also collaborate in the future on the MAST Upgrade and by doing so put our expertise together and make the most of these fusion experiments."

A very sensitive camera

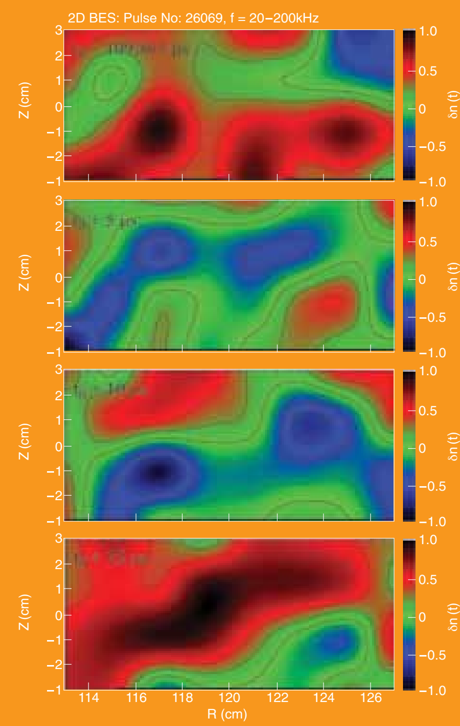
One of the factors which can degrade the energy confinement in plasmas is turbulence or irregular fluctuations. A new diagnostic, the Beam Emission Spectroscopy (BES) turbulence imaging system was installed on MAST in 2010 to measure such phenomena and the associated effect on energy confinement.

The BES system was developed under a collaboration between CCFE and RMKI of the Hungarian Academy of Sciences, Budapest. It detects the fluorescence of the energetic deuterium heating beam, taking two million measurements from each of its 32 spatial channels per second, thereby detecting fluctuations in the local plasma density with very high time and spatial resolution.

"Such images of turbulence in the core of the plasma are only available in a very few fusion experiments worldwide," said CCFE's Anthony Field, who designed the system. "Culham has been leading the way in theoretical work on turbulence, but we will now be able to compare our theoretical simulations directly with results from MAST for the first time."

Keeping the plasma stable within the magnetic field inside a tokamak will be essential for future fusion energy production. Turbulence can threaten this stability, creating irregular fluctuations in the movement of particles from the plasma's core to its edge, which cause unwanted energy losses. Getting a clear picture of the turbulence is therefore essential in understanding and mitigating it for future devices.

The 2D system measures turbulence in MAST by detecting the light emitted when beams of neutral atoms are injected into the plasma to heat it. The diagnostic's very high time resolution allows fusion researchers to map the evolution of turbulent structures at small scales. The four images pictured right demonstrate this – showing fluctuations in the density of the plasma at 5 microsecond intervals.



An array of gold antennas

The MAST Electron Bernstein Wave (EBW) emission imaging system consists of an array of 37 antennas, made of RT/Duroid® composite covered with gold, of which up to eight at any one time are used to detect microwaves from the plasma at frequencies not unlike those in a typical kitchen microwave oven. The system is designed to measure the position, intensity and shape of the microwave emissions which occur at the edge of the plasma. The data it collects will allow the calculation of how much electrical current is flowing near the edge of the plasma.

The device was constructed in collaboration between CCFE's Dr Vladimir Shevchenko the University of York's Dr Roddy Vann and PhD student, Simon freethy, whom they co-supervise. Further developments to the project were made through the expertise of PhD student Billy Huang from Durham University and his work on FPGA technology, as part of the Fusion Doctoral Training network.

Measuring currents in the plasma edge is particularly important because they are thought to determine the dynamics of so-called Edge Localised Modes (ELMs) – sudden eruptive instabilities during which substantial quantities of the total stored plasma energy are lost. Knowledge of such instabilities is crucial for the development of a commercial power plant in which ELMs must be controlled or their effects mitigated. While ELMs are tolerated in present day devices, they constitute a potentially serious heat-load problem for the ITER first wall.

"The aim of the current project is to demonstrate the feasibility of this new technique, which we have now achieved," said Dr Vann. "There are a lot of key physics questions to answer about ELMs and we are looking forward to using our new imaging system to probe them."

Accurate measurement of many plasma parameters is what sets apart a world leading tokamak from other devices around the world.

"MAST is renowned world-wide for the excellence of its measuring instruments," commented Brian Lloyd, MAST Experiments Department Manager. "These exciting new developments keep MAST at the forefront of fusion research and demonstrate the value of close collaboration with our international and UK university partners."

Susan Hayward
InFusion Editor

NOT JUST ANOTHER TILE IN THE WALL

The installation of thousands of new tiles on the inside of the JET vessel the 'ITER-Like Wall' heralds a new experimental campaign on the world's largest fusion machine. As scientists arrive from all over Europe eager to see how the machine will perform, InFusion gives an insight into what's behind the wall.

CP11j-215-015

Anthony Loving (Head of Remote Handling), Guy Matthews (ILW Project Leader), Malcolm Kear (Planning and Management System) and Valeria Riccardo (Leader of the Engineering Design and Manufacture Strand).

1. A new beginning

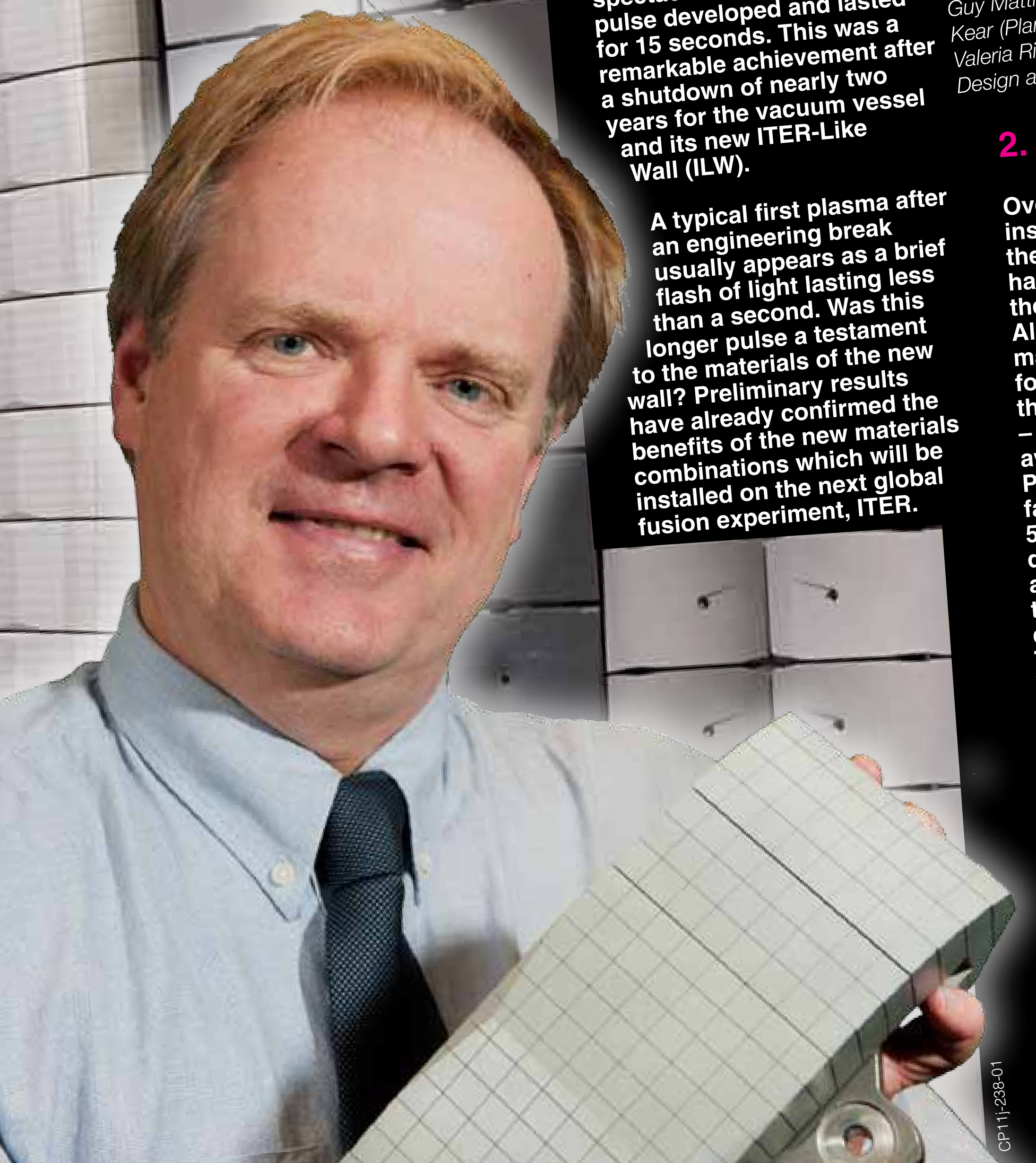
On 24 August 2011, a crowded JET control room, with an expectant air of excitement, witnessed the first plasma created on the machine for 22 months - a spectacular 1 Mega Amp pulse developed and lasted for 15 seconds. This was a remarkable achievement after a shutdown of nearly two years for the vacuum vessel and its new ITER-Like Wall (ILW).

A typical first plasma after an engineering break usually appears as a brief flash of light lasting less than a second. Was this longer pulse a testament to the materials of the new wall? Preliminary results have already confirmed the benefits of the new materials combinations which will be installed on the next global fusion experiment, ITER.

2. Focus on... the tiles

Over 2000 bespoke tiles were installed during the shutdown, the vast majority using remote handling techniques. Some of the tiles were made in Huntsville, Alabama by Axsys Technologies, manufacturers of the mirrors for the planned successor to the Hubble space telescope – others came from 350 miles away, made by Atmostat in Paris. Each tile on the plasma facing wall weighs between 5-10 kg. The prominent tiles in direct contact with the plasma are made of pure beryllium and those recessed are inconel alloy coated with this light element. These were produced by Casting Technology International in Rotherham and coated with berylium in Romania.

In the bottom of the vessel, where the exhaust system (divertor) is located the tile assemblies are faced with solid tungsten or tungsten coatings. These are crafted from pure tungsten on inconel carriers or from carbon fibre reinforced carbon coated with this hard, rare metal. Project Leader for the ILW, Dr Guy Matthews praised the feat of all those involved in creating this new wall: 'I hope they are all as proud as I am to have given JET a great experimental facility for the future.'



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Dr Lorne Horton, Head of EFDA's JET Department, with an aluminium prototype tile from the plasma facing wall.

3. Choosing the materials

The new ILW is the first test of the material combination selected for the full performance phase of ITER. So why have beryllium and tungsten been chosen as the new plasma facing materials for fusion research replacing the previous Carbon Fibre Composite tiles? Not surprisingly, it's all about their properties. Beryllium is a very light metal which does not absorb tritium, which together with deuterium is one of the valuable fusion fuels. Light elements also have the least impact on the plasma temperature if they are eroded from the wall and this was another important consideration for ITER. Wall materials such as carbon are not as suitable as they absorb too much tritium and become too radioactive.

Being heat resistant up to 1287°C means that berylium can be used in areas of the vessel where interactions with the plasma are significant but not the most intense. Tungsten has a higher melting point than its new counterpart on the ILW of 3422°C making it an ideal choice to line the divertor where parts of the plasma do actually touch the wall. Here, the plasma is 'diverted' down to a special area where temperatures of 1000°C are a routine occurrence. As a heavy metal tungsten has a high atomic number and is also chosen for this area due its exceptional resistance to erosion from the hot plasma when contact occurs.

This combination of beryllium and tungsten being tested on JET is the same configuration planned for the lining of the ITER vacuum vessel under construction in Provence, Southern France.

4. The experimental campaign is underway

Scientists from throughout Europe will be participating in the new experimental campaign on JET, keen to learn how to operate the machine with its new wall. In addition to the ILW, during the recent JET shutdown other upgrades were made to the heating systems to provide more power and additional diagnostic devices were installed.

The research programme is co-ordinated by EFDA, whose leader Dr Francesco Romanelli commented: "This is probably the largest effort that has been put into JET apart from the construction of the machine itself. With the expertise and contribution of many fusion laboratories, the JET team has succeeded in building a small ITER." It is on this new 'small ITER' that a promising start has already been achieved with the creation of high purity plasmas established in ITER relevant conditions – an encouraging sign for the use of these wall materials in ITER.

Studies so far have focused on the migration of Be from the plasma facing wall and the amount of fuel retained in the tiles. Other experiments have been examining the spectrum of light emitted by the plasma to learn about the role of impurities entering from the new tiles.

5. And so to the future…

The current ten month experimental campaign will aim to verify that the wall materials chosen for ITER will behave as expected. This is crucial for its development as the ITER vessel will be ten times larger in volume and eventually run pulses for up to ten minutes for which the old carbon fibre composite tiles would not be suitable. The ILW will allow experiments to take place with ITER-relevant edge conditions, thus speeding up the early phases of ITER.

To date the recent pulses run on JET have used Ohmic heating – which involves heating the plasma solely by running an electric current through it. Other auxiliary heating methods, such as neutral beams will soon be used. In this way JET will progressively be brought up to higher power levels during the length of the campaign to allow a detailed investigation of the wall materials under conditions approaching those of ITER.

"The first experimental results look very promising although there is a long way to go, "said Dr Lorne Horton, Head of EFDA's JET Department. "Options for a further extension of JET's capabilities are being considered, in the context of strengthening the participation of other ITER parties in JET."

Susan Hayward
InFusion Editor

COMPASS points in a new direction

Four years ago many staff at Culham witnessed the unforgettable sight of the fusion machine COMPASS dangling by cables above the D1 building at the start of its journey to a new life in the Czech Republic.

Here, InFusion editor Susan Hayward finds out about the feat of moving the multi ton machine to Prague and its reinstallation in a new laboratory, as she interviews CCFE's Project Manager, Andy Cullen and Jan Mlynar, Research Scientist from the Czech Institute of Plasma Physics (IPP).

Andy Cullen

Tell me about the fusion machine COMPASS when it was operating at Culham.
COMPASS (Compact Assembly) operated at Culham for over ten years at Culham from 1989-2001 when it formed the backbone of CCFE's domestic fusion programme. Despite its relatively small size, COMPASS ran at high magnetic fields (2.1T) and its results were crucial, along with those of other experiments in scaling key parameters through JET to ITER.

Can you take me back to the autumn day four years ago that COMPASS prepared to leave Culham for Prague?
Yes, it was an amazing day – although a small tokamak, COMPASS weighed 22 tons when it left Culham. We were faced with a very complex problem - how to lift something of that weight with a crane located 34 metres away. In the end it took a huge crane with a lifting capacity of over 500 tons to move the machine. With all this planning and preparation we all watched in anticipation as the machine was lifted high into the air and lowered successfully onto its transport cradle.

So what happened next?
COMPASS was packed up ready for the 700 mile road and sea journey to Prague. On the day of departure three scientists from IPP came over and we had a farewell presentation to say good-bye to COMPASS. It arrived safely four days later and was officially unveiled in its new home after six months. Then in February 2009, less than two years after it left Culham the first plasma 'shots' were carried out.

What were your thoughts as COMPASS was driven off the Culham site?
At Culham we work with many scientists and engineers from around the world. There are many collaborations in the fusion community involving the sharing of specialist equipment, and on this occasion it was great that we were giving IPP a fusion machine to enhance their contribution to international research.

Have you had the chance to visit COMPASS in its new home?
Yes, I have been to Prague several times to give help and advice with making COMPASS operational. The rebirth of COMPASS in Prague has provided numerous opportunities for young scientists and engineers to get involved in the fusion research at IPP.

> **"It took a huge crane with a lifting capacity of over 500 tons to move COMPASS."**

CCFE's (left) Andy Cullen with Czech scientists from IPP Prague ahead of the machine's journey to the laboratory.

Jan Mlynar

Tell me about yourself Jan and your role at the IPP, Prague.
I am a research scientist at the IPP. I am involved in fusion research (in particular in data analysis) and also fusion education – both at university level and for the general public.

When COMPASS arrived in Prague after its 700 mile land and sea journey in 2007.What were the challenges in getting the machine operating?
COMPASS was a miracle machine for fusion research in the Czech Republic. The challenges began even before the machine arrived with ensuring the financial viability of the project as we would need to build a new lab to house the machine. We also had to be sure that we had enough scientists and engineers to run the machine.

Building a new lab, that sounds like a big project.
Yes, it was. The new building was finished in nine months but we also had the challenge of finding a new power supply, control systems and diagnostics for the machine.

What were the challenges you faced to get the machine up and running?
When COMPASS arrived we couldn't get the power we needed to operate the machine from the grid as it would require about 50 MegaWatts. What we needed were flywheel generators to store the necessary power which were built by a company in Prague called CKD and so today we have two installed in the new laboratory.

So tell me a bit more about COMPASS as it is today.
As you see here [Jan points out features of the tokamak on the photo opposite during our interview.] the machine is three metres high, a tenth of the size of ITER. If you look here [pointing bottom right] you can see the neutral beam heating source from Novosibirsk in Russia which has just been commissioned. Using the neutral beam system makes the machine very relevant for studies relating to ITER.

You can also see [pointing top and bottom left] a diagnostic system known as Thomson Scattering which is completely new. It's the first time this system, developed at Culham, has been used in my country to measure the temperature in the plasma, quite precisely and locally.

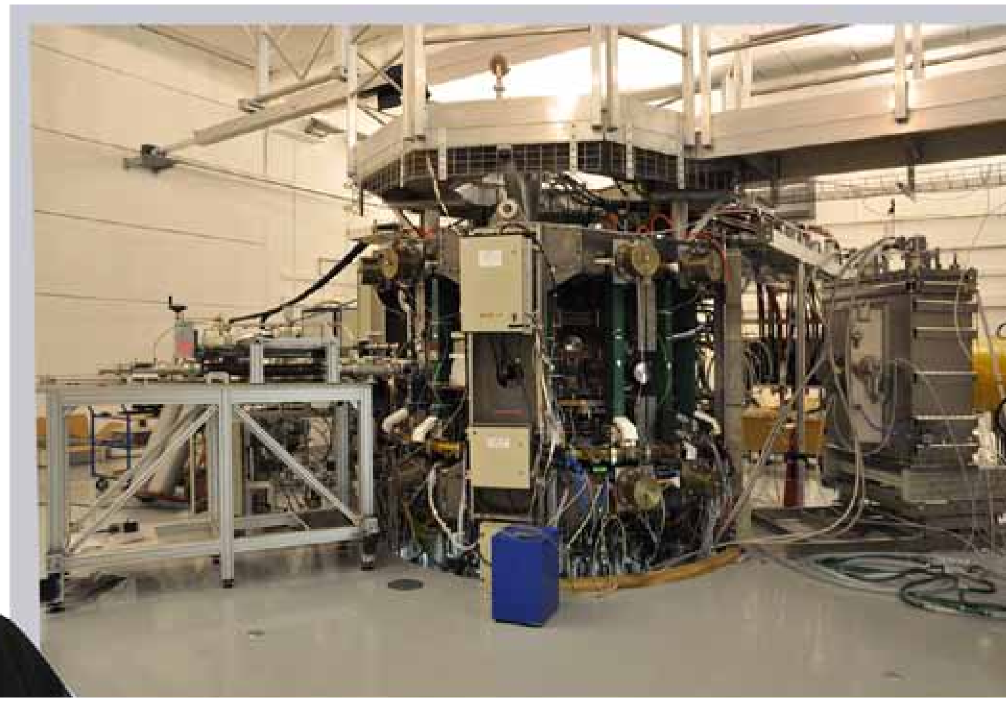
What has the impact been of COMPASS on the Czech fusion programme?
Its impact is massive, it is like a domino effect, once it was decided to build ITER in Europe we got COMPASS, and with COMPASS we got universities interested in our research and experts asking to collaborate with us. We have more staff working on fusion on site than ever before. So its arrival has made the fusion programme in Prague very buoyant.

> **"…this year we had a visit from your Prime Minister, David Cameron which was a really impressive experience. He visited the tokamak department at IPP with our Prime Minister, Petr Nečas."**

I also understand that the machine had a big unveiling and has recently attracted some very high profile visitors.
Yes, indeed, there was a big ceremony when COMPASS was properly installed in 2008 and this year we had a visit from your Prime Minister, David Cameron which was a really impressive experience. He visited the tokamak department at IPP with our Prime Minister, Petr Nečas. David Cameron showed a keen interest in fusion research and he was well informed about the ITER project and he asked our head of tokamak research several questions.

So what are the future plans for COMPASS?
Now we are living in this very exciting period of going from a technical reinstallation of COMPASS into doing research using all the integrated systems that have been commissioned. So we are very much looking forward to the first scientific results.

The newly refurbished COMPASS machine.



> **"COMPASS was a miracle machine for fusion research in the Czech Republic."**

scientists in the making

Where do you think we will find the physicists of the future? In a classroom? Maybe. Visiting Culham during an educational trip? Most definitely. Jo Silva, Education Outreach Manager at CCFE, outlines their extensive outreach programme.

Whilst the world moves towards a so-called technological society, the number of graduates in physics and engineering in the UK is dwindling. In 2010, only 7% of all university applicants were accepted for physics and engineering degrees. In 2011, this figure went up 17% but this increase needs to be considered in a broader context. These low numbers are already having an impact in the make-up of the scientific workforce.

Dr Neil Bentley, deputy director-general of the Confederation of British Industry, says we are looking at an emergent skills gap in the scientific area, with over 40% of companies having difficulty recruiting people with these skills. Although the increase in the number of students taking up science, technology and engineering subjects is encouraging, it is essential to keep the momentum up.

The education outreach programme at CCFE has two main objectives: to encourage students to pursue a career in science and engineering, and to promote a positive image of fusion to future generations and the wider community.

With this in mind, the Communications Group runs educational visits to site for A-level, undergraduate, postgraduate, physics and engineering students. The groups are typically given a broad introductory talk on fusion followed by tours of the MAST and JET experiments.

At CCFE, there is an awareness of the power of inspiration when choosing a career path. This outreach programme relies on working scientists and engineers to lead tours of the facilities and provide the students with a flavour of their own unique perspective on a future in science and their commitment to fusion research. Our visits are enriched by the incredible diversity found at Culham, from backgrounds to nationalities; visitors are also welcomed to a true European endeavour in the form of JET.

Students are shown MAST by Dr Neil Conway.

Those visiting leave feeling inspired and motivated, as one recent student told us "I will be changing my UCAS application to engineering now; thank you for the visit, it has been really useful and fascinating."

Chris Warrick, Head of Communications, says that CCFE has always maximised education outreach as much as it possibly can, adding that "we recognise the duty a laboratory like ours has to inspire today's students."

Measuring the impact of our programme is difficult, but not always impossible. Roddy Vann, now a respected fusion physicist at the University of York who collaborates regulary with CCFE (see *Measuring the Plasma* page 4) visited Culham when he was an A-level student in 1993/1994, following it with a work experience placement that summer. Roddy says: "Being able to visit Culham on a school trip was the key first step in my career in fusion - the obvious 'big science' is very exciting."

By the ITER-like wall photo.

All the photos feature 'A' Level students from Peter Symonds College, Winchester.

Left: Students are shown JET by Dr Barry Alper.

MIKE'S LASER QUEST RECALLED IN NEW BOOK

A dramatic Cold War mission to Moscow, a close encounter with Colonel Gaddafi, and the quest to build a man-made Sun…it was all in a day's work for retired Culham scientist Dr Mike Forrest.

All of this and more are described in Mike's memoirs, *Lasers Across the Cherry Orchards*, which have been recently published and tell the story of his 50-year career in nuclear fusion.

The book has the backing of Tony Benn, the former Labour MP who was Energy Secretary in the 1970s. Mr Benn telephoned Mike to discuss his work and later sent him a note: "your book about international cooperation with the Russians on nuclear fusion is of great interest – I hope it attracts a wide readership."

"My life as a scientist started in 1957 on one of the world's first fusion experiments, ZETA at Harwell, progressing through to the European JET machine which is still taking the science forward today at Culham," said Mike Forrest. "Along the way I worked with the Libyans, Italians, Portuguese and Swedes on their fusion programmes. I was also part of a groundbreaking trip to Moscow to work with my Soviet counterparts at the height of the Cold War. A long way from the Welsh valley I grew up in."

It was the 1969 Moscow expedition that Mike – an expert in laser measurements – singles out as a highlight. A team from Culham went to validate the results of a new machine developed by the Russians, the 'tokamak', which was to revolutionise the fusion field. Mike's laser diagnostic system accurately measured temperatures of over 10 million degrees Celsius inside the T3 tokamak. This confirmed that a giant step forward had been made in achieving the conditions needed for fusion energy, opening the way for larger tokamaks such as JET to be built and the path to fusion power stations to be mapped out.

The trip – highly unusual at the time – was specially sanctioned by the UK Government because of the importance of the work.

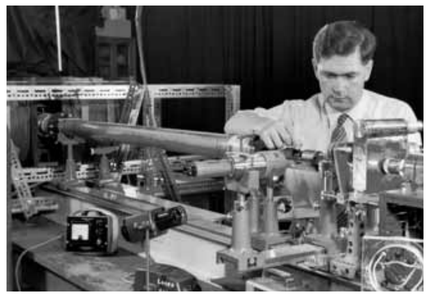
"It was a fascinating glimpse behind the Iron Curtain," Mike remembers. "The local Communist Party treated us to trips to the Moscow State Circus, the Bolshoi Ballet and the Kremlin – but the KGB were always there in the background. However, the overall memory was the general kindness of the Russian people."

Mike is still in demand even in retirement, and is currently acting as an adviser to ITER. His memoirs have attracted the interest of the British Library, which is conducting a series of interviews with him for its Oral History of British Science. An archive containing recordings with around 200 UK scientists, it aims to increase the public's understanding of science and the people behind the technological advances that shape our world.

Dr Thomas Lean from the British Library (pictured above with Mike) who has been interviewing Mike Forrest for the archive project, said: "Mike has an amazing story. I was lucky enough to join him for a visit to Culham, which gave me an insight into the work he's been describing. Seeing the JET and MAST experiments there really brought it alive and will help us to convey the atmosphere in the archive recordings."

Nick Holloway
CCFE Communications Group

Lasers Across the Cherry Orchards is published by Tandem Press and can be ordered at: www.mjforrest.co.uk.



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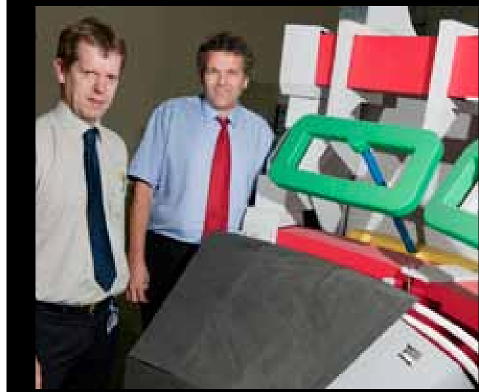
Mike Forrest at work on laser diagnostics at Culham in 1964.

MAST Upgrade procurement begins



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Martin Cox (Director, MAST Upgrade) with MAST Upgrade Project Manager Martin Townsend by the new MAST Upgrade model.

The first major tenders for MAST Upgrade have been issued, as the project moves from design to procurement. MAST Upgrade Project Director, Martin Cox gave details at a recent update meeting for those involved in the project.

"It is important to celebrate successes," said Martin Cox. "Big projects are a long and strenuous journey and it is all too easy not to appreciate the progress as it happens."

Two large tenders for MAST Upgrade – for the centre tube of the vacuum vessel and the divertor power supplies – have recently been published. By December 2011 most tenders for the components on the critical path will have been issued, with contracts to be placed by Spring 2012.

The meeting was also a chance for staff to see the changes being made to the building where the MAST machine is housed to prepare for the upgrade assembly. Attracting much interest was a full-scale cutaway model of a section of MAST Upgrade (pictured), which enables designers to see at first hand and full scale the interface constraints of the divertor and coils.

In demand: the unique capabilities of CCFE's Special Techniques Group

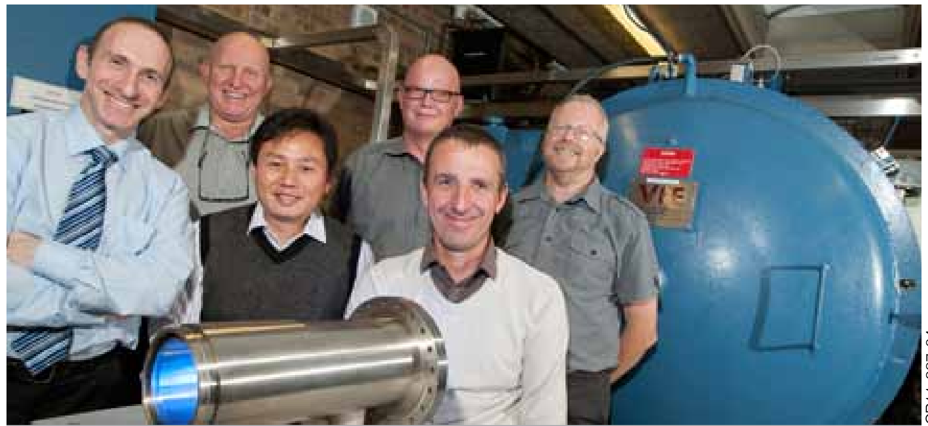
If you think that business with the Far East is all one-way traffic, you may want to think again. For Special Techniques Group (STG) – an expert material joining facility based within CCFE – has been bucking the trend by winning contracts in China and Singapore, as well as Australia.

Over 40 years of meeting the demanding requirements of fusion scientists and engineers has given STG a unique capability which is in global demand. The facility offers a 'one-stop shop', from advice and consultancy to the design and manufacture of a wide range of technical items using air and vacuum furnaces, brazing, welding and diffusion bonding equipment.
Its reputation has spread beyond the fusion sector and the group has worked with laboratories and companies in America, Japan, Russia, Canada and most of Europe – even providing material joining solutions for F1 motor racing teams.

Customers come to STG for services they literally cannot find anywhere else. The National University of Singapore recently contacted them for the manufacture of an atom chamber and optical viewports. It was a similar story for Peking University, which required bespoke windows for specialist magneto-optical traps and were put in touch with STG Manager Simon Hanks.

STG has also just completed a project for the Australian Synchotron in Melbourne to produce synchotron components that could not be sourced elsewhere. The team has since received another contract from the same facility to manufacture a diamond window assembly. The window's unusual geometry causes stresses that risk breaking the diamond while it is being bonded to the synchotron's beamline. "It is the first time such a job has been carried out, and joining something with high-stress regions without damaging expensive materials is a challenge," explained Simon Hanks. "But working on fusion projects at Culham has given us the ability to solve complex and unusual problems – finding novel approaches is what we thrive on."

Nick Holloway
CCFE Communications Group



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Simon Hanks (far left) with course delegates Patrick Vertongen, Ce Ye, Tommi Jokinen, Thierry Jourdan, and Chris Wilson of Special Techniques Group.

Setting the standard for ITER

Special Techniques Group trained engineers from ITER on material joining and vacuum QA issues at a workshop at Culham in November. ITER's Head of QA David Sands has used Special Techniques' services for many years and approached manager Simon Hanks to arrange the course as a way of tapping into their expertise. Delegate Ce Ye commented: "The training will be very helpful for us at ITER and is good experience to prepare future similar QA inspections."

CCFE in brief

Professor Steve Cowley appointed to Government Council for Science and Technology

Prime Minister David Cameron has appointed Professor Steve Cowley, Head of CCFE, as a member of the Council for Science and Technology.

The Council for Science and Technology is the UK Government's top-level advisory body on science and technology policy issues. It is made up of figures from senior levels in science and engineering fields from industry, business and academia, and reports directly to the Prime Minister.

Before joining CCFE, Steve Cowley was a professor at the University of California Los Angeles and led the Plasma Physics Group at Imperial College, London, where he remains a part-time professor. He has published over 140 papers and articles during his scientific career. Professor Keith Burnett, a Board member of the United Kingdom Atomic Energy Authority, has also been appointed to the Council for Science and Technology.

Professor Steven Cowley said: "The quality of the UK's science and technology is second to none and our future prosperity depends it. I am honoured to serve on a Council dedicated to enhancing UK science and technology."

Announcing the appointment of new Council members, David Cameron said: "We have some of the world's best scientists, leading technologies, cutting-edge facilities and the most innovative hi-tech companies, and it is our determination that we do all that we can to ensure the UK remains one of the world leaders in this field. That is why I am delighted that I can announce the appointment of such a high calibre team, with such a broad range of experience, to the Council for Science and Technology."

M V Kotwal visits JET


CP11j-167-02

M V Kotwal with colleague S Chakraborty (third and first from left) in the JET Assembly Hall, accompanied by Francesco Romanelli and Roger Cashmore (right).

M V Kotwal, Director and President of Heavy Engineering at the Indian multinational conglomerate Larsen and Toubro Limited, visited Culham on 14 September for discussions and tours of JET and MAST.

As a former representative on ITER's Technical Advisory Group, he was interested to learn more about the work at Culham and the opportunities in fusion. He met The Authority Chairman Professor Roger Cashmore, as well as EFDA Leader and EFDA JET Associate Leader Dr Francesco Romanelli and Head of CCFE Professor Steven Cowley.

Other organisations visiting Culham in 2011 include Rolls Royce, Forsmark Nuclear Power station, PA Consulting Group, BRE Ltd, Johnson Matthey, World Nuclear University, National Grid, AWE Aldermaston and BAE Systems.

Media update

During its long and distinguished record of scientific service, JET has never before been compared to a chilli pepper nor a 'Krispy Kreme' donut. But that is exactly how technology news website *Gizmodo* described the world's largest tokamak in an entertaining, offbeat look at fusion recently. Reporter Jamie Condliffe wrote that: "this beryllium and tungsten donut, which has a radius of three metres and a total volume of two hundred cubic metres, isn't filled using jam, but a stream of high-energy hydrogen isotopes...that ensures the contents are hotter than a jalapeño in a frying pan." You can find the full article on the *Gizmodo* website.

Science and engineering journalists from the Netherlands visiting JET.

A more conventional piece appeared in *The Guardian* newspaper in late August. Features journalist Leo Hickman reported on the restart of the newly-upgraded JET, and asked the question "Is fusion power getting any closer?" He interviewed EFDA JET Associate Leader Francesco Romanelli and Head of CCFE Steve Cowley in an extended analysis of fusion's prospects.

Now JET is operational, the progress of its restart and experimental campaign has been much in demand from journalists around the world. A party of Dutch science journalists travelled to Culham in early November in a visit co-organised with the FOM fusion institute in the Netherlands. Middle East news channel *Al Jazeera* filmed at JET for its *Earthrise* environmental programme.

Russia 24, the TV news arm of the Russian state broadcaster, spent a day recording footage for an in-depth documentary on fusion, broadcast in early December. Also, keen to update its viewers on JET's progress was the US business news channel CNBC who recorded footage for their *Energy Opportunity* series which is available to view on their website.

Steve Cowley speaking at the Royal Society.

The hottest talk in town this summer

Head of CCFE Professor Steve Cowley was one of the speakers at the '100 Years of Superconductivity' event at the Royal Society, London in July this year.

The event celebrated the advances made since Heike Kamerlingh Onnes' discovery of superconductivity in 1911. Organised by Oxford Instruments – one of the leading industrial exponents of this technology – and the Institute of Physics, it was attended by an audience of science and business leaders.

Steve Cowley described the importance of superconductivity in fusion, with particular reference to ITER, which will use superconducting magnets at extremely low temperatures to achieve maximum efficiency and limit energy consumption.

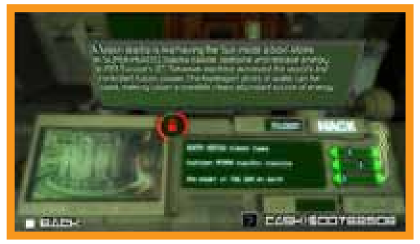
Other talks focused on the history and development of the technology and its medical applications, with speakers from Oxford University, the Centre for Advanced Biomedical Imaging and Oxford Instruments.

You can watch Steve Cowley's talk courtesy of Oxford Instruments' YouTube channel:

http://www.youtube.com/watch?v=0T0EptOWBmE

Winning the race for green energy

Fusion features in a new racing video game, with a little bit of help from EFDA-JET.



Just launched by Australian broadcaster ABC and Screen Australia, 'Alternator' is an action-packed game set in the year 2060. Contestants race across a futuristic Australian landscape in a car that uses alternative energy sources. The aim of the game is to win the races and defeat the forces of oil baron Slickrod, gaining support for green technology along the way.

A range of modifications for the car become unlocked during the game, one of which is a miniature tokamak which can be added for a power boost. Dean Tuttle, Alternator's Creative Producer, contacted EFDA for permission to illustrate the fusion upgrade with a picture of JET. Dean explains:

"The big twist with this game is that you are racing with 'new, clean, green' technologies. You have to win, make money and then invest it to build these inventions. As you win, you convert your world to supporting and using these technologies.

"At the same time, they learn about some very cool, real-world inventions of today. We are aiming to take these ideas to a wide audience. By playing the game, for example, they will find out that fusion is actually real science and that it is really being developed."

Find out more at: http://www.abc.net.au/abc3/games/alternator

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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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