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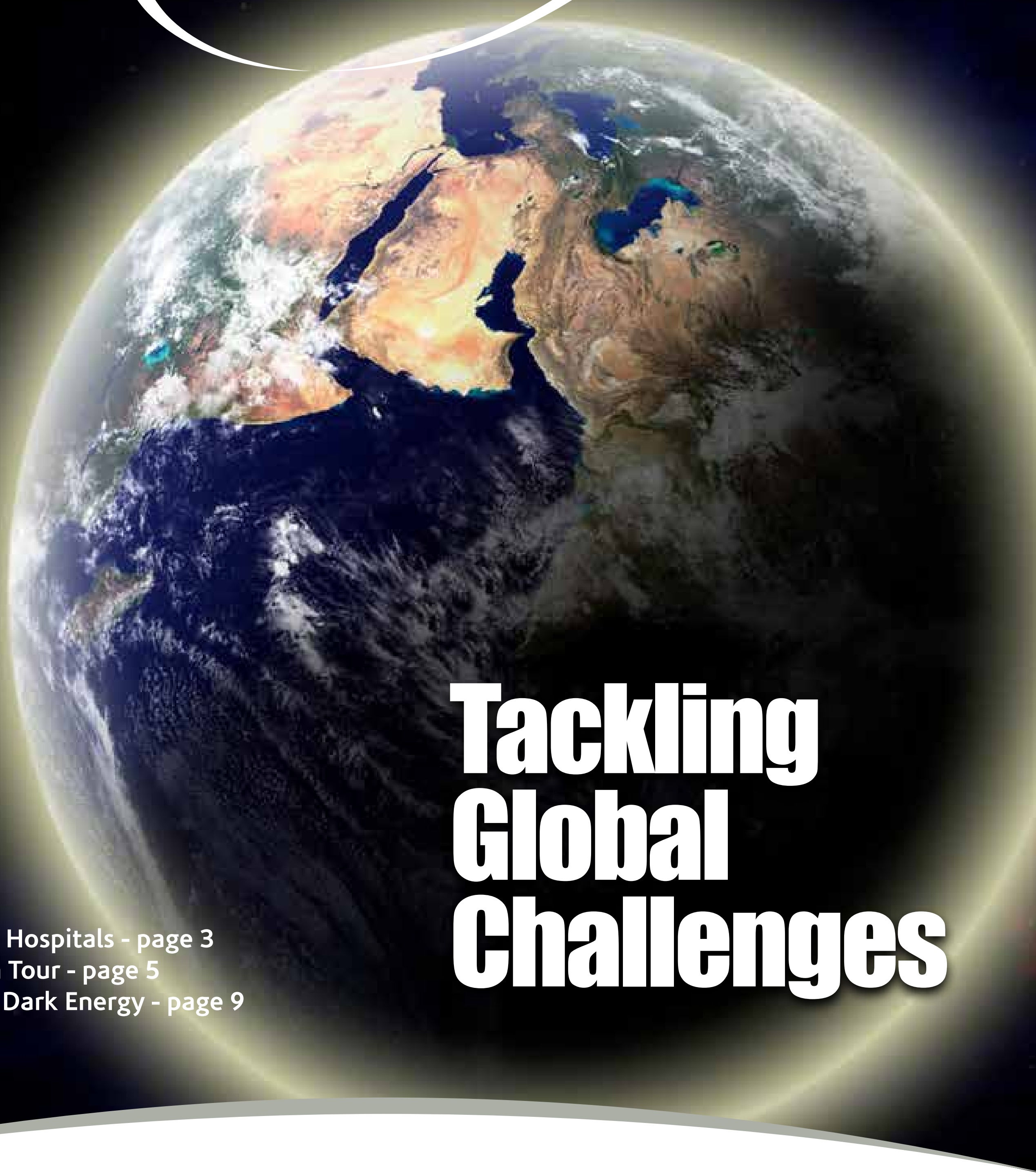
ISSUE 13 News from the Science and Technology Facilities Council

Exploring & Understanding Science

fascination



Tackling Global Challenges

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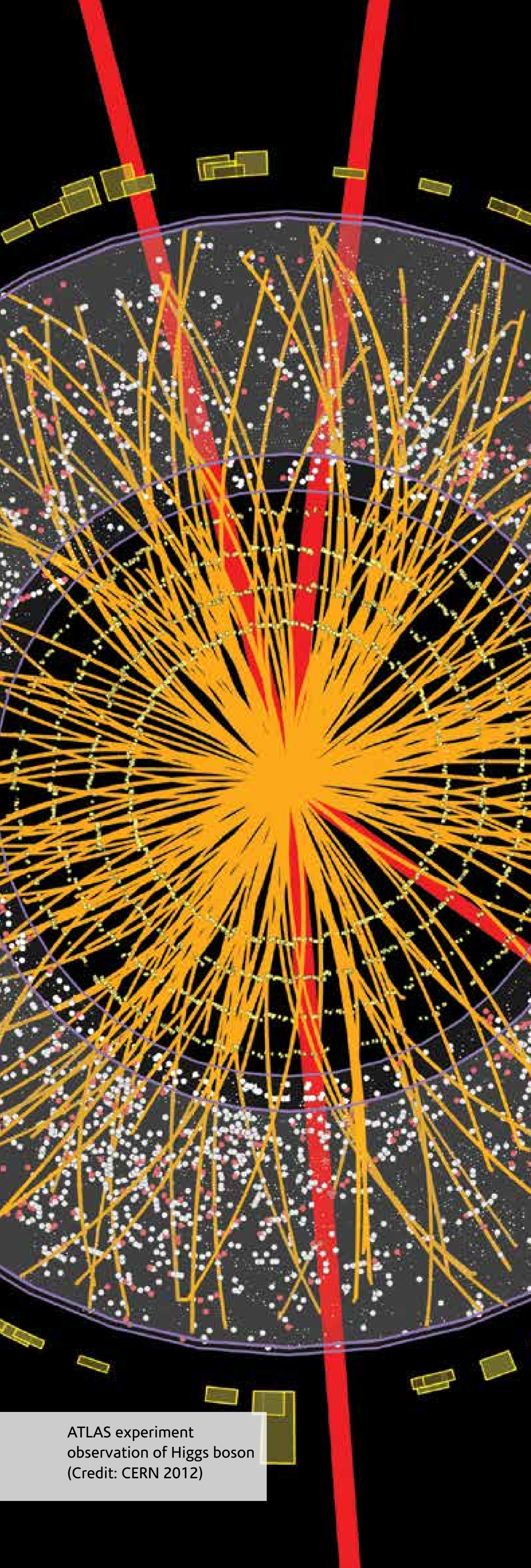


ATLAS experiment observation of Higgs boson (Credit: CERN 2012)

Welcome to our 13th edition of Fascination. This edition has a small round-up of some of the exciting projects STFC and its researchers have been involved in.

STFC creates direct impact by generating new knowledge from fundamental research through our programmes and at our facilities. That new knowledge can then create long-term impact and benefits for society and the economy via the development of enabling technologies. This edition of Fascination looks at some of our facilities that are finding solutions to new global challenges.

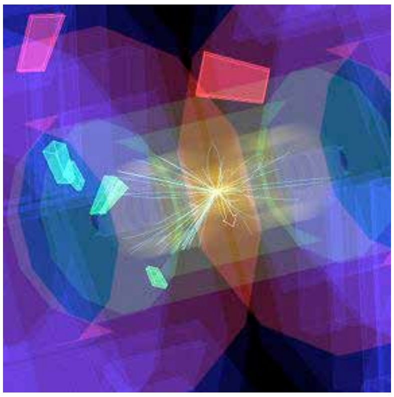
Nearly fifty years after it was first theorised and twenty years after the experiment that helped to find it was first sketched out on a napkin, the Higgs boson has helped win the UK its 120th Nobel Prize. The 2013 Nobel Prize for Physics has gone to Professor Peter Higgs and Professor François Englert for their prediction of the existence of the Higgs mechanism in the 1960s. The hugely sought-after particle was discovered in 2012 with the Large Hadron Collider, amidst a wave of public excitement.

Finding the Higgs boson marked a significant breakthrough in our understanding of the fundamental laws that govern the Universe. The knowledge gained in two decades of work at CERN on this has revolutionised our everyday lives.

The excitement of this award for the UK and its science community was recognised by the substantial interest and subsequent coverage in the media; over 25 million people in the UK either read this story in the press or saw it on television news. And on 8th and 9th October, the story was mentioned on over 430 UK television news bulletins.

Collider app available now

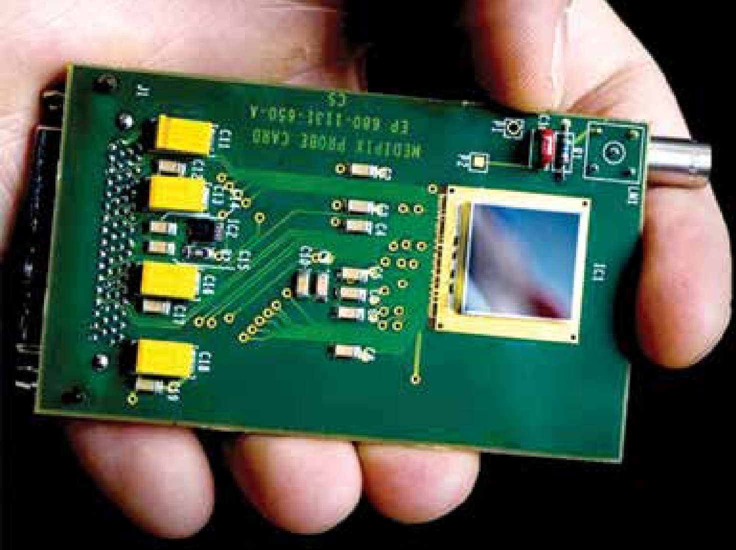
A new, free smart-phone app called 'Collider' is now available. The app allows you to watch high energy particle collisions streamed from the Large Hadron Collider, play games and hunt for the Higgs boson!



For more information about the Higgs boson visit:

- www.stfc.ac.uk/2892
- www.cern.ch

Screenshot of the app in action (Credit: University of Oxford



Medipix chip

Accelerator technology finds a home in hospitals and schools

Technology first developed at CERN for use in particle accelerators is proving useful in other areas – including hospitals and in space. Pixel detectors are finding their way into X-ray machines and onto satellites, but they were first suggested in the 1980s by CERN's Erik Heijine as a new kind of radiation detector.

He proposed putting all of the electronics needed to process the signals from a radiation sensor onto a square millimeter of silicon. He believed that a 2D array of these squares could be made, and that, combined with an array of sensors of the same dimensions, these hybrid pixel detectors could replace conventional strip detectors and wire chambers.

Even then it was clear that the existing detectors would not be able to deal with the huge particle fluxes foreseen at the heart of the detectors of the future Large Hadron Collider (LHC). Following early prototype work for the LAA project, in 1990, CERN launched a dedicated research and development programme for pixel detectors.

Michael Campbell, who was a recent recruit to CERN at the time, says: "Pixel detectors didn't exist, so we not only had to prove that they could be built, but also that they would work for particle physics." The team of engineers and physicists Michael was involved with rose to the challenge, and their early work on pixel detectors laid the foundations for the systems used in both the ATLAS and Compact Muon Solenoid (CMS) detectors that played an important role in the recent discovery of the Higgs boson at the LHC.

Pixel detectors can take images in a similar way to a digital camera, but are sensitive to high energy particles, or ionising radiation, instead of visible light. The pixel detectors needed for particle accelerators need to be very fast, taking millions of images every second, to make sure particle tracks from different time slots don't get mixed up.

Although developed for use in particle accelerators, pixel detectors have a wide range of applications outside of fundamental physics research. The early research at CERN had shown that pixel detectors could be used to detect X-rays, and could be used in medical settings. This led to the development of the Medipix1 chip in 1997, which demonstrated the power of single particle counting for a number of applications. However, its large pixel size and the small number of pixels it contained limited the quality of the images produced.

The Medipix2 Collaboration was formed in 1999 and the Medipix2 chip was unveiled in 2002. It had a larger number of pixels and could also detect the energy of the incident X-rays, meaning that colour images could be created. In 2005, the technology was picked up by the EUDet Collaboration, an international group working on gas detectors. They requested the ability to record the precise arrival time of each particle, leading to the Timepix chip.

In recent years, Michael Campbell and his team have been working on Medipix3 (in the context of the Collaboration of the same name), investigating how to identify and calculate the energy of a single X-ray particle when its detection is spread unevenly across several pixels. He believes that spectroscopic X-ray imaging based on the Medipix3 technology could ultimately lead to new medical applications, complementing the more expensive (but more sensitive) PET imaging.

Timepix-based pixel detectors are already in use as space dosimeters, with five devices the size of a memory stick in orbit on the International Space Station, to monitor the exposure of astronauts to ionising radiation. These devices were produced by teams at the Institute of Experimental and Applied Physics in Prague and the University of Houston, and have attracted interest from NASA and ESA, as they are smaller and lighter than conventional monitoring technology.

Five Timepix chips are being used by an instrument that will soon be launched into space on the TechdemoSat satellite, with the aim of studying cosmic radiation. Remarkably, the instrument was developed by a team of students from the Simon Langton Grammar School in Kent, and all of the data it captures will be made available to schools via CERN's computing grid. The CERN@school programme gives schools within CERN's member states the opportunity for students to design their own experiments with Medipix chips - inspiring the scientists of the future.

Revolutionary UK technologies wins US Department of Energy contract

Oak Ridge National Laboratory
(Credit: Oak Ridge National Laboratory, U.S. Dept. of Energy)

UK company Arvia has won a high-profile contract with the US Department of Energy (DOE) due to its innovative technology to deal with radioactive waste. Arvia researched and developed this technology at STFC's Innovations Technology Centre (I-TAC) at Sci-Tech Daresbury, and has partnered with US firms NuVision Engineering and Perma-Fix Environmental Services for the DOE contract.

Dr Martin Morlidge, Manager at I-TAC, said: "This high-profile contract with the US Department of Energy is superb news. Arvia is an excellent example of how innovation through access to STFC's I-TAC facilities and expertise, teamed with the wider benefits of locating at the Sci-Tech Daresbury Enterprise Zone, can help small, innovative companies achieve success in the global economy – in this case, with the US Department of Energy."

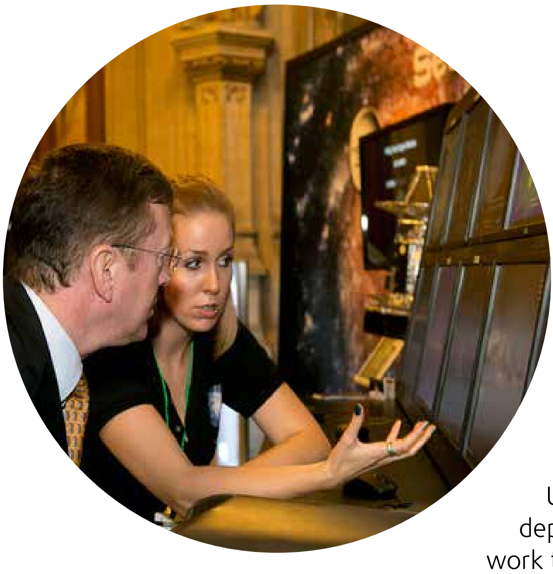
Arvia owns a patented, unique technology that destroys toxic and non-biodegradable organic wastes, using adsorption coupled with electrochemical regeneration. The technology has been developed for the treatment of low-level radioactive waste and intermediate level radioactive waste oils with Magnox Ltd.

Further development has taken place to treat plutonium-contaminated organic waste at Sellafield. Arvia is the only business in the world to have developed a way to treat radioactive oils for which there was previously no treatment - allowing the long-term storage of these oils without the risk that the storage drums will degrade and leak.

The first goal of the new collaboration is to demonstrate that the technology can efficiently treat radioactive wastes containing furans and dioxins, two related groups of toxic chemicals that are produced as by-products in a range of chemical, manufacturing and combustion processes. This work will be carried out at the Perma-Fix environmental facilities in Florida, but early in 2014, the team will move to the DOE Oak Ridge site to begin treatment of actual waste.

Mike Lodge, CEO at Arvia, said: "This is an extremely valuable opportunity for Arvia to showcase its revolutionary technology against some of the world's most challenging wastes and to demonstrate that these wastes can now be safely processed."

Seeing the Universe in All its Light



STFC's latest touring exhibition is encouraging everyone to see the Universe in all its light – showcasing the Big Telescopes family in all their glory and focusing on both the UK's scientific expertise and the economic benefits that astronomy can deliver.

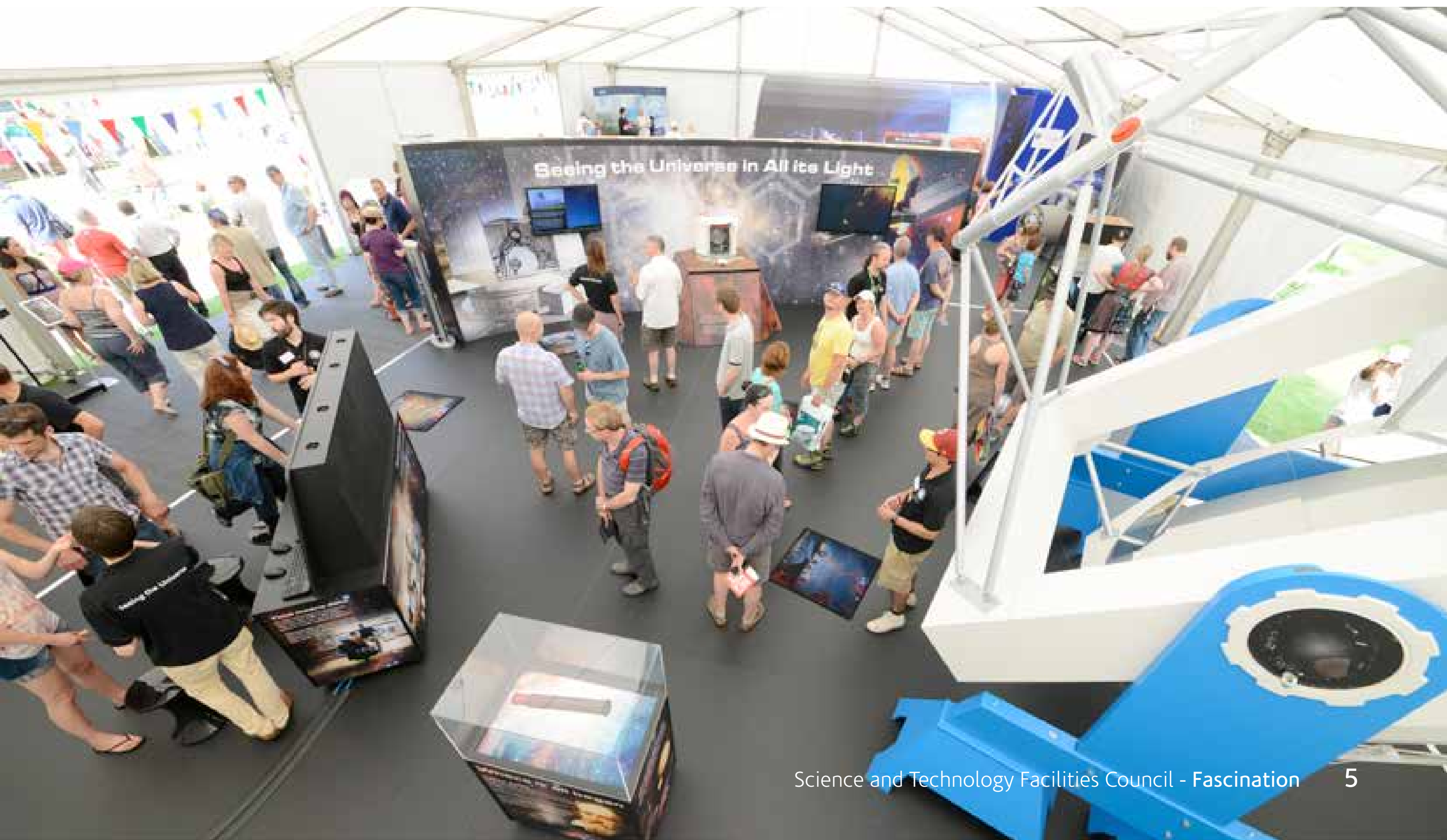
The roadshow features stunning science images alongside a range of interactive exhibits. Visitors will be able to experience a replica of English astronomer Thomas Harriot's first telescope, as well as a range of historical scientific papers from the Royal Astronomy Society and the Thomas Harriot Trust.

There will be young scientists on hand from UK university astronomy departments to enthuse about the work they do and answer questions on any aspect of astronomy. They'll be able to guide visitors around scale models of the Big Telescopes – ESO's Very Large Telescope, the Atacama Large Millimetre Array, the Herschel Space Observatory and the forthcoming James Webb Space Telescope.

Hands-on exhibits aim to explain the importance of building telescopes across the whole range of wavelengths, so that we really can see the Universe in all its light. An interactive control desk provides details on the full spectra of wavelengths used by astronomers, and visitors will be able to learn more about seeing the invisible, micro autonomous robots and the adaptive optics that are essential for telescopes but are also proving invaluable in more down-to-earth applications such as cancer screening.

The tour began in July 2013 at the Jodrell Bank music festival, and went on to be a big hit at the Houses of Parliament in October. It will visit the National Assembly for Wales in Cardiff in November, before moving to Glasgow in January 2014 for BBC Stargazing Live.

For a full list of locations on the tour, check the `Seeing the Universe in All its Light' webpage at: www.stfc.ac.uk/2740



Entries are open for the 2013 IOP-STFC Award for Physics Journalism

Every year, incredible work is done by broadcast and print journalists to bring science to the public – unravelling the complex details of physics, and revealing the pervasive effects it has on our lives: from optical fibres connecting continents together, to the particle accelerators used every day in cancer treatment.

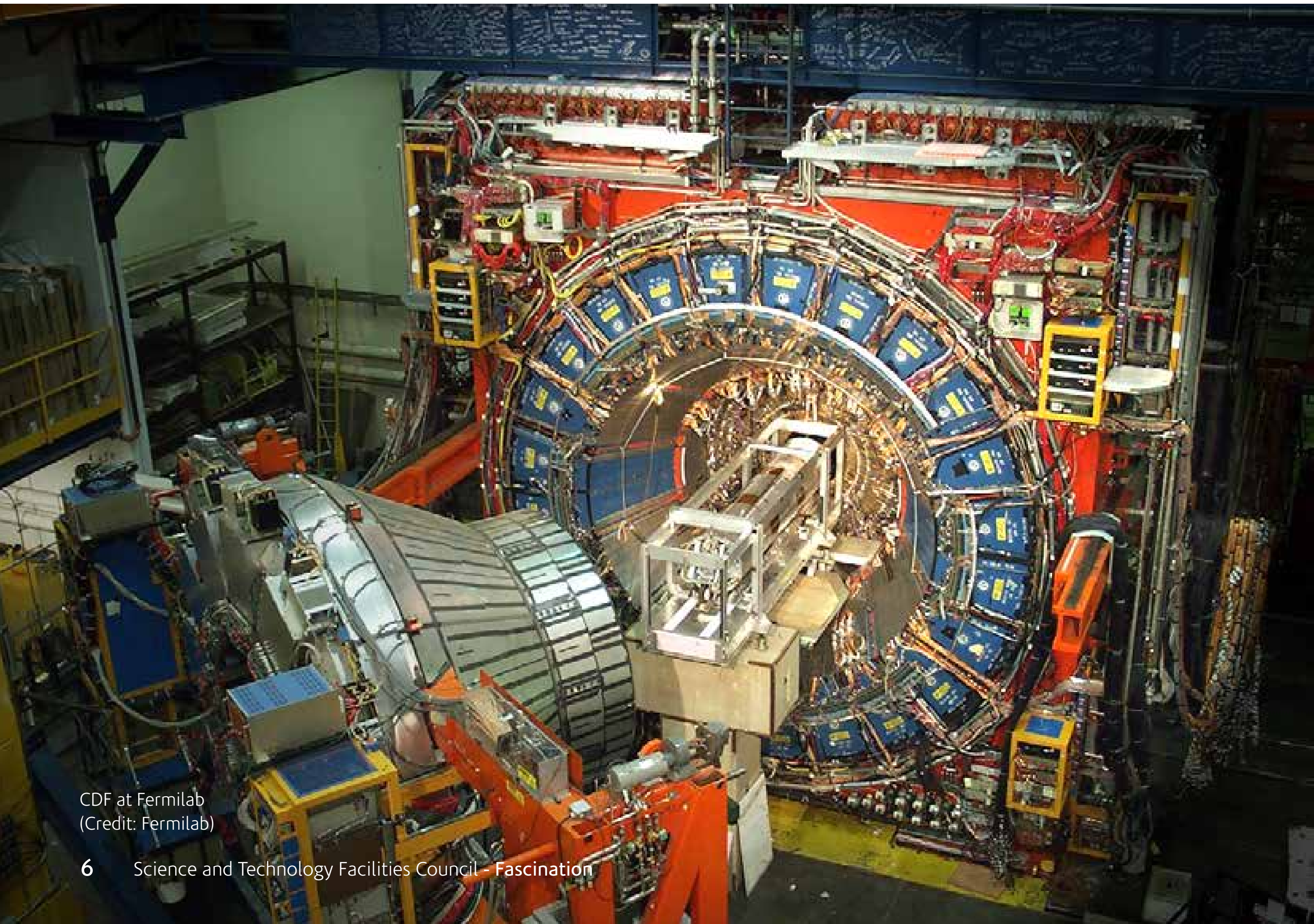
To highlight their achievements, STFC and the IOP (Institute of Physics) are running the Physics Journalism Prize 2013. The prize for the winning journalist is an expenses-paid trip to Chicago in February 2014, to visit the Fermi National Accelerator Laboratory and attend the 2014 meeting of the American Association for the Advancement of Science.

The Award is for a work of journalism covering physics research and related areas of technology, and/or the work and related lifestyles of physicists, engineers or other people working in physics. Articles on the application of physics in industry, or on interdisciplinary research including physics and other scientific disciplines, are encouraged. Eligible articles will have been published or broadcast in English, anywhere in the world, between 1st January and 13th December 2013.

The judges will include senior representatives from STFC, IOP, the Association of British Science Writers and the British Science Association.

Anil Ananthaswarmy won the inaugural Physics Journalism Prize, awarded in February 2013. His article for New Scientist magazine, `Hip Hip Array', brought to life the international project to design and build the largest radio telescope ever conceived, the Square Kilometre Array. His prize was an expenses-paid trip to Japan to visit world-leading facilities carrying out research at the frontiers of physics.

The deadline for entries is Friday 13th December 2013 at 17:00. For more details on how to enter, visit: www.iop.org/about/awards



CDF at Fermilab
(Credit: Fermilab)

New element discovered

The Gamma detection setup TASISpec at GSI used to fingerprint element 115 (Credit: GSI)

An international team of researchers led by Sweden's Lund University, and including nuclear physicists from the University of Liverpool (funded by STFC), have confirmed the existence of a new, 'superheavy' element.

First proposed by Russian researchers in 2004, this element was discovered during an experiment at the GSI Helmholtz Centre for Heavy Ion Research in Germany, which has previously discovered six other elements.

Superheavy elements have an atomic number above 104. As they normally only exist on the surface of exploding stars, here on Earth they have to be produced in an accelerator laboratory. They then decay very rapidly – the new element 115 exists for just a fraction of a second.

The experiment conducted involved bombarding a thin layer of americium (itself a rare element) with calcium ions. The team created a brand new, highly specialised and unique detection system, to measure photons released during the decay process. The energies of the photons detected correspond to the X-rays expected from these products, meaning that – for the first time – it is possible to obtain a reliable 'fingerprint' of an element, and this will help identify other rare elements in the future.

Element 115 sits on the periodic table between flerovium (114) and livermorium (116), which were both discovered in 2012. Once its discovery has been acknowledged by the International Union of Applied Chemistry, the process of choosing an official name for this new element can begin.

This Hubble image is of the Red Spider Nebula
(Credit: ESA & Garrelt Mellema (Leiden University, the Netherlands))

Galactic mystery emerges from butterfly line-up

Why do planetary nebulae that have formed in different places, have different characteristics, and have never had the opportunity to interact with each other, share a preference for a particular alignment in space? Astronomers don't yet know the answer to this question, which has arisen from research carried out by a team from the University of Manchester.

Researchers at the University used ESO's New Technology Telescope and the NASA/ESA Hubble Space Telescope to investigate 130 planetary nebulae (clouds of dust and gas ejected by dying stars) in the central bulge of the Milky Way. Sorting the nebulae into three different types, and looking closely at their characteristics, the scientists made a surprising discovery – one that could highlight a gap in our understanding of the Galaxy.

Although two types of planetary nebulae were randomly oriented in the sky, as expected, most of the third type – bipolar nebulae – line up in the same direction.

Our current understanding of planetary nebulae is that their shapes are sculpted by the rotation of the star system in which they form. In turn, this is dependent on the properties of the system, such as whether it has one star or two, or a number of planets. Some of the most extreme shapes are seen in bipolar nebulae, whose butterfly shapes are probably caused by jets blowing material out from a binary system, perpendicular to the orbit.

Bryan Rees, of the University of Manchester, explains: "The alignment we're seeing for these bipolar nebulae indicates something bizarre about stars within the central bulge. For them to line up the way we see, the star systems that formed these nebulae would have to preferentially rotate perpendicular to the Galaxy in which they formed, which is very strange."

This new finding suggests that strong magnetic fields that were present when the central bulge of the Milky Way was formed effectively played a role in the (recent) shaping of these nebulae.

Cosmic detectives begin five year quest

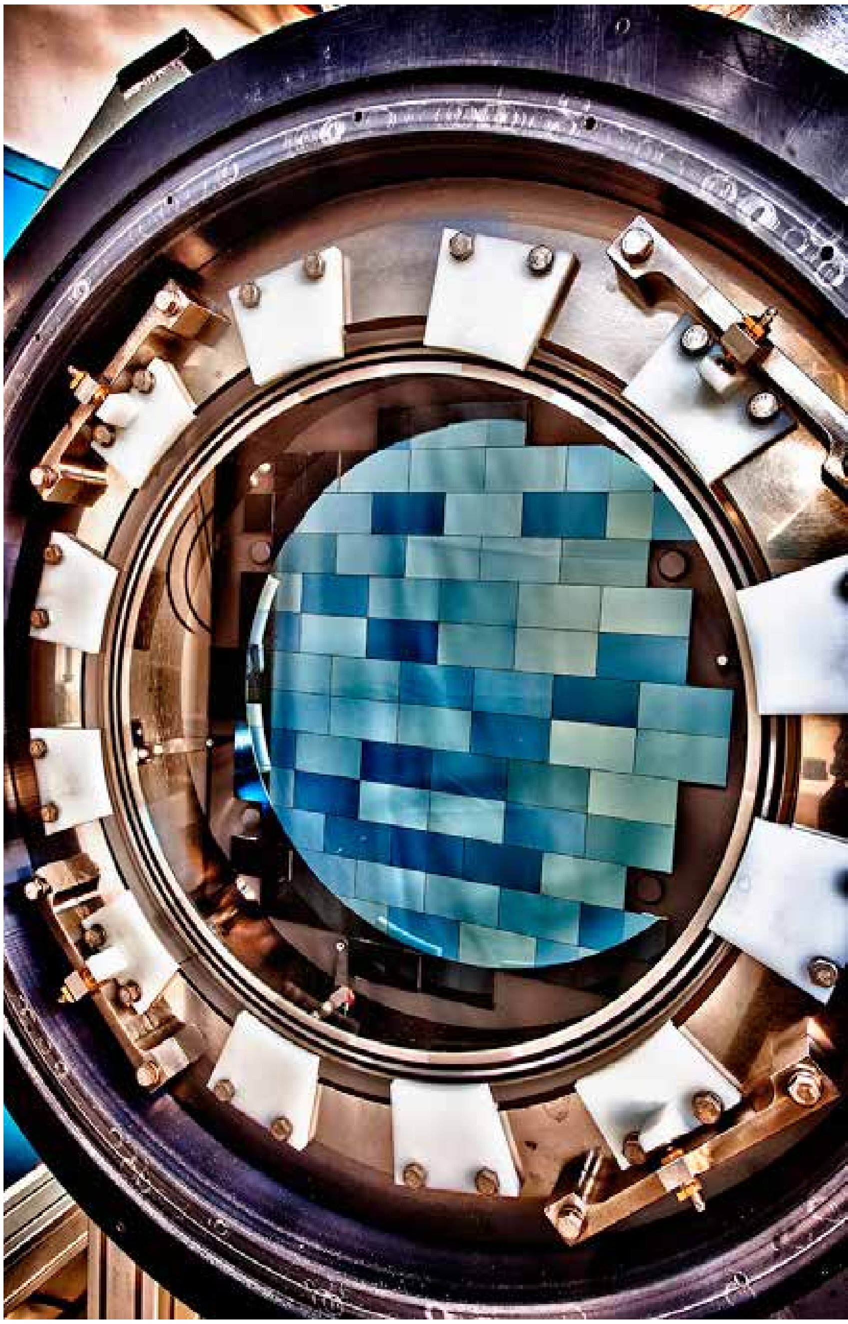
Why is the expansion of the Universe speeding up? We don't know, but a team of UK physicists and astronomers are teaming up with colleagues from around the world to use the Dark Energy Camera and try to answer some of the most fundamental questions about the Universe.

Over the next five years, the researchers will investigate why the Universe seems to be defying gravity and not only expanding, but expanding at an increasing rate. To identify why this acceleration is occurring, researchers will take part in what is called the Dark Energy Survey (DES), to probe the mystery of dark energy, which is thought to be the force behind this acceleration.

The team will systematically survey an eighth of the sky (5000 square degrees) in unprecedented detail. The start of the survey marks the culmination of ten years of planning, building and testing, by scientists from 25 institutions in six countries – including the universities of Cambridge, Edinburgh, Nottingham, Portsmouth, Sussex and University College London (UCL).

The Dark Energy Camera is a 570-megapixel digital camera, which includes five precisely-shaped lenses, the largest of which is nearly three metres across. Designed and built at UCL, the work was funded by STFC. The lenses allow the Dark Energy Camera to see light from more than 100,000 galaxies, up to eight billion light years away. The survey team will use the camera to take colour images of 300 million galaxies and 100,000 galaxy clusters, and hope to discover 4,000 new supernovae – many of which were formed when the Universe was only half the size it is now.

DES uses four complementary methods to probe dark energy: counting clusters of galaxies, measuring the distance to supernovae, examining the bending of light due to gravitational lensing, and using sound waves to study the patterns in the distribution of galaxies across the sky. We can't see dark energy directly, but by studying the expansion rate of the Universe, and how quickly structures grow, the survey team can infer the properties of dark energy more precisely than ever before. If the different measurements agree, that gives the team confidence in their results; if they don't, then that could be an indication that there is new physics involved that we don't yet understand.



Dark Energy Camera (Credit: Reidar Hahn,Fermilab)

Using cutting-edge science to address real world challenges

Airports all over the world are trialling a technique, developed at the CLF, that can be used to scan the contents of opaque bottles

Security

The world is on high alert for potential terrorist attacks and security is a top priority. Detecting explosives and biochemical hazards and investigating how space weather affects our electronic infrastructure are examples of the wide range of ways that research using the Central Laser Facility (CLF) and ISIS can help to keep us safe.

Improving airport scanners

CLF science has resulted in the emergence of novel security applications that benefit society across the globe.

Our spin-out company, Cobalt Light Systems, has developed equipment for the non-invasive analysis of materials. Based on a laser spectroscopy technique developed and patented in the CLF, this new technology has wide-ranging applications – particularly in the area of security. By rapidly and accurately measuring the chemical composition of a substance without touching it, liquid explosives can quickly be detected through opaque packaging. This could bring an end to the ban on liquids in hand luggage on flights.

Cobalt Light Systems Limited have announced they've won the contract to supply their Liquid Explosive Detection Systems (LEDS) to all five terminals at Heathrow, and to Glasgow, Aberdeen and Southampton Airports.

The CLF's Vulcan and Gemini lasers are also being used to develop compact, flexible and tuneable sources of high energy X-rays and gamma rays. The short bursts of radiation created by focusing a super high-powered laser onto a small target could, in future, be used to screen large, mobile containers at UK ports.

What is ISIS?

With 37 instruments optimised for a wide range of applications, **a multidisciplinary research facility – ISIS** – provides possible solutions to some of the greatest challenges facing humanity. The neutrons generated by ISIS are used to provide information on atomic structure and behaviour, the keys to understanding why materials have the properties they do, and how they can be improved.

What is the CLF?

Our Central Laser Facility (CLF), based at the Rutherford Appleton Laboratory, is one of the world's leading laser facilities, with an array of applications. It has a range of lasers with different uses. We can use it to accelerate subatomic particles to high energies, probe chemical reactions and study biochemical and biophysical processes. The CLF works at the cutting edge of science, and is constantly looking for new ways to address the issues we face in our everyday lives.

Protection from extreme space weather

STFC scientists are leading research to understand and mitigate the impact that space weather could have on UK infrastructure. We are constantly being bombarded by a shower of subatomic particles from space, the intensity of which is affected by space weather such as solar flares. Most particles pass safely through the Earth without us noticing, but our increasing reliance on microelectronic devices makes it a cause for concern.

In single event upsets, subatomic particles strike electronics and cause them to malfunction. The challenge is to understand how silicon chips respond to neutron bombardment, which is the first step in determining what mitigating action needs to be taken.

We're constructing a dedicated instrument, CHIPIR, for testing the effects of neutrons on microelectronics, which should be ready for use early next year. Chris Frost (CHIPIR's Instrument Scientist) says: "It's an exciting prospect to be working directly with industry to ensure the UK is as resilient as it can be to the problems of space weather as our understanding of these effects increases."

A group from Vanderbilt University have been using the muon facility at ISIS to investigate whether these more exotic particles could also cause problems, and the Space Weather Research Network (SEREN) is bringing together scientific research and applications from across the UK to build a virtual UK space weather centre. It will be looking into the impacts on:

- Power grids
- Aviation
- Satellite navigation
- Communications
- The tracking and navigation of space craft.

Healthcare

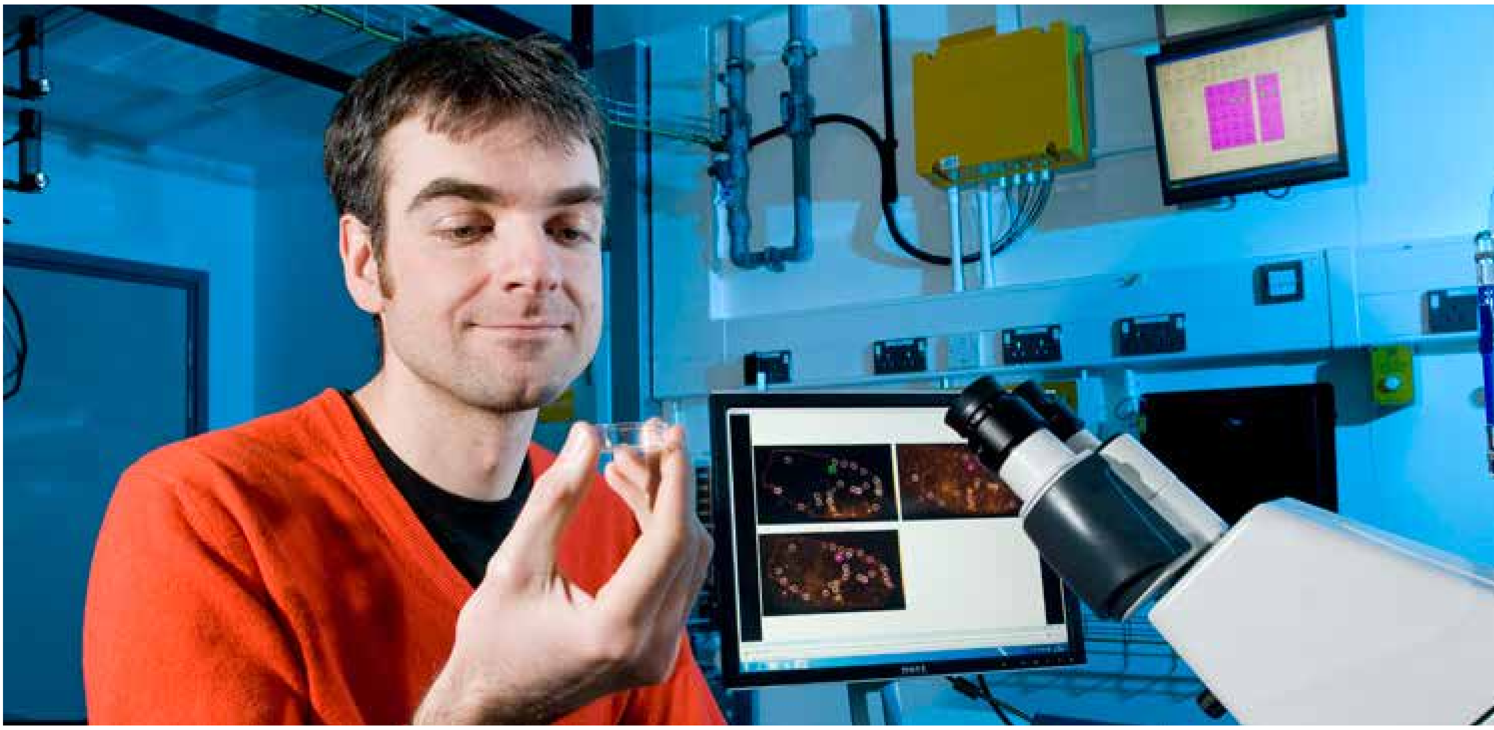
Lasers have wide-ranging roles in healthcare, from fundamental biomedical research investigating the processes underlying health and disease, to the use of lasers for disease diagnosis and treatment. Work at ISIS is helping people breathe more easily, as well as working towards improved radiotherapy treatments for cancer patients.

Working towards personalised treatments

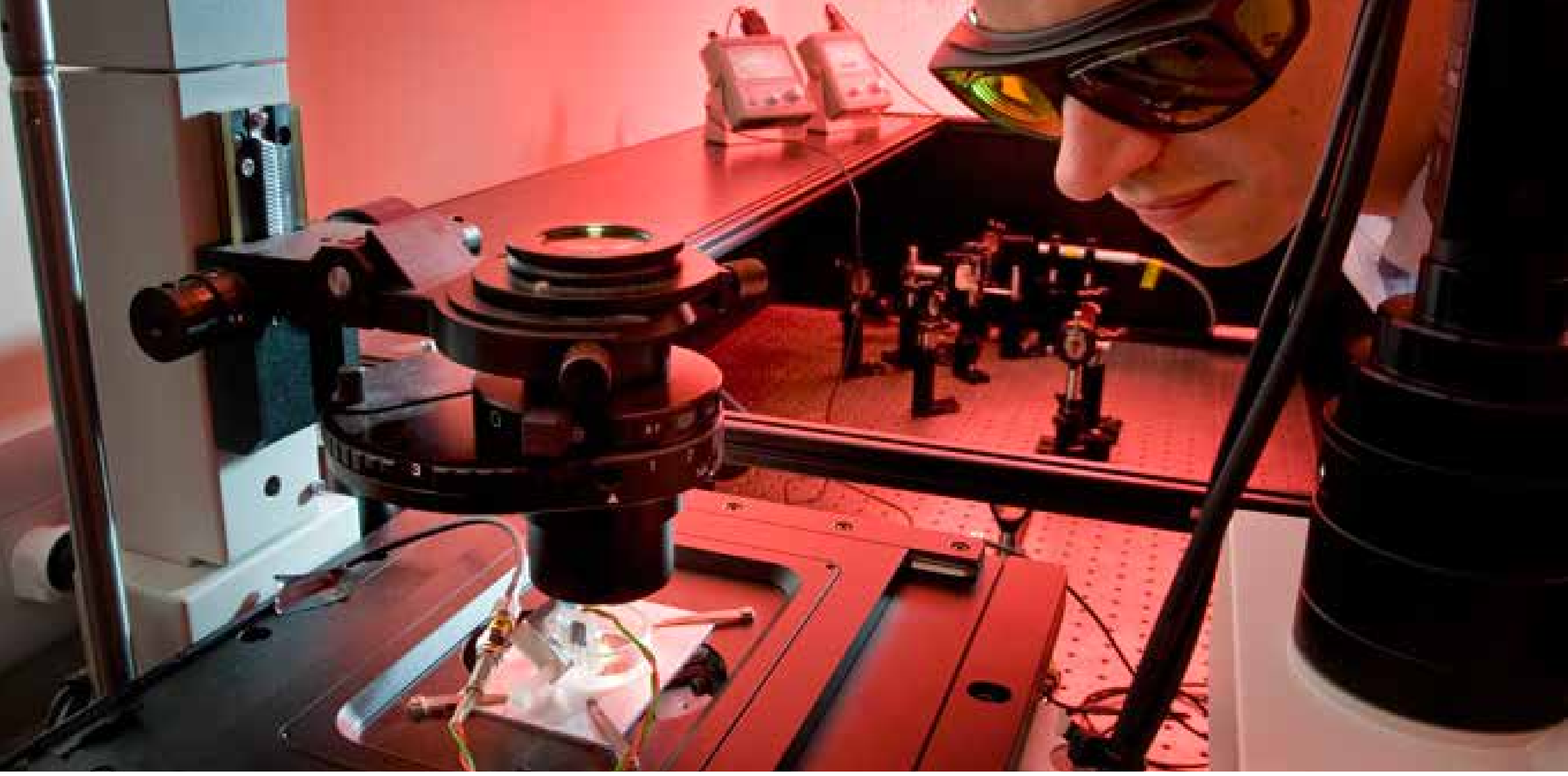
The Central Laser Facility (CLF) at the Rutherford Appleton Laboratory is home to the Octopus system, developed and built by STFC with funding from the BBSRC (the Biotechnology and Biological Sciences Research Council). Octopus combines multi-coloured lasers with advanced microscopy techniques to build up a unique picture of the proteins and molecules inside a patient's cells that are causing disease. By tagging these 'misbehaving' proteins and using lasers to illuminate them, scientists can see the molecular interactions behind the disease. This complex picture, which is unique to every patient, is being studied with the ultimate aim of developing tailored drug treatments that will increase the efficiency of therapies whilst reducing side-effects and preventing the development of drug resistance.

Developing new technologies for hospital use

Experiments using the CLF's Gemini laser are bringing us closer to ultra-compact, laser-driven particle accelerators small enough to be installed in hospitals, where they can be used for particle beam cancer therapy. We're also investigating laser-driven X-ray beams for diagnosis and in-situ imaging during treatment.



Combining lasers with advanced microscopy techniques enables new avenues of research in biological and medical sciences



Using lasers to levitate and manoeuvre cloud droplets, in order to investigate their surface chemistry

Neutrons could help us breathe more easily

Coughing, wheezing, and an uncomfortable tightening of the chest are some of the unpleasant symptoms asthma sufferers will recognise, which are often at their worst in cities during the summer. One of the causes of these symptoms is ozone. In the upper atmosphere, ozone protects us against harmful UV rays, but at ground level, it can be detrimental to health.

An increase in the morbidity rates associated with ozone concentration and respiratory problems has sparked interest in the scientific community. A team from Birkbeck College in London are using ISIS to look at how ozone attacks the lipid molecules in lung surfactant – the body's first line of defence.

Neutrons are the perfect tool for this research, as they allow visualisation of interfaces at the molecular level. Results from these studies could lead to a better understanding of how to help people who have problems with their lung surfactant - including premature babies - and to the development of new inhalers for asthma and cystic fibrosis sufferers.

ISIS is used by chemists, life scientists and material scientists to explore a range of scientific questions.

Environment

Climate change is one of our most immediate challenges, with deforestation and our use of fossil fuels raising the concentration of greenhouse gases in the Earth's atmosphere. Specialist laser techniques in use at the CLF allow us to see and capture microscopic objects, and to understand more about our environment. Neutrons from ISIS allow us to study chemical processes in the atmosphere and develop new carbon-storage techniques.

Getting a grip on clouds

Scientists using laser beams as 'tweezers' can levitate and move individual micro-droplets of the kind that make up clouds, which allows us to study these delicate objects under a microscope or in an X-ray beamline. Scientists think that the ability of clouds to absorb and reflect heat has a substantial impact on climate change, and it is therefore essential for us to understand the complex chemistry that occurs within them.

Dr Martin King and his team from Royal Holloway, University of London, have been using the CLF and ISIS to look at the effect pollutants have on cloud droplets. With large numbers of people cooking in cities, the cooking oil that vaporises can cause an oily layer – a surfactant film – to form on cloud droplets. Surfactant films affect every aspect of cloud dynamics, from the size of the water droplets to whether or not rain falls from the cloud. But surfactant films oxidise in the atmosphere, and Dr King's team is interested in the rate of these reactions. By mimicking their behaviour under controlled laboratory conditions, we can reveal how these and other pollutants, such as those caused by burning fossil fuels, affect the formation and growth of droplets. Understanding this fundamental atmospheric chemistry will allow us to produce more accurate cloud models.

Capturing greenhouse gases

We've been using ISIS to study a new material with the potential to revolutionise the capture of greenhouse gases. The materials currently in use generate toxic by-products, and are energy intensive to produce. A group from the University of Nottingham has developed a porous material called NOTT-300 that captures carbon dioxide within a molecular cage, so that the gas can be safely removed from the environment.

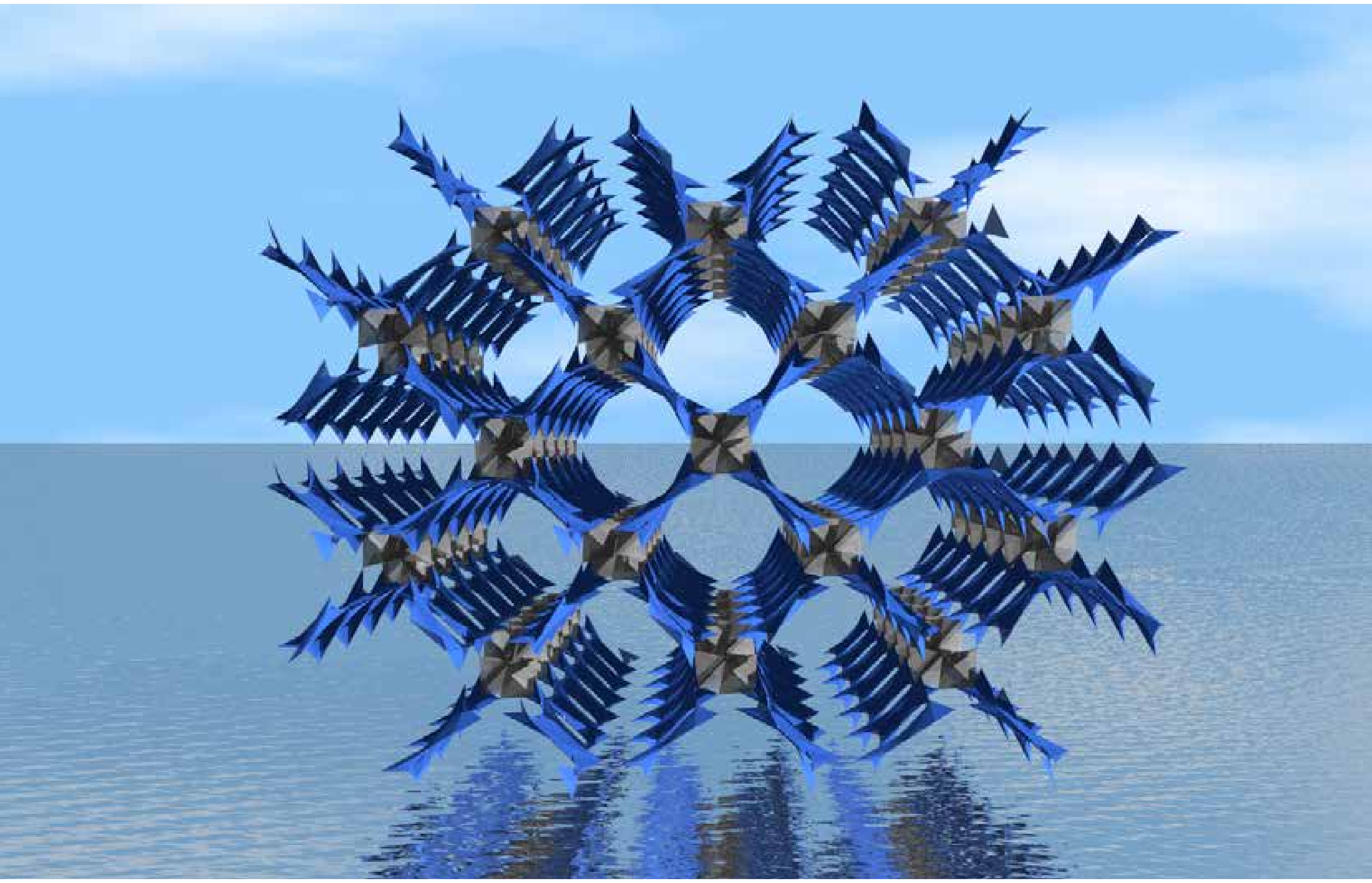
Energy

We're developing advanced solutions to the global energy challenge, including using lasers in the CLF to study fusion and solar energy. Another option is to use carbon dioxide and hydrogen to make a synthetic petrol substitute, and scientists at ISIS are working on ways to improve this process.

Harnessing the power of the Sun

We've known for a while now that nuclear fusion – the process that powers the Sun – could provide an inexhaustible supply of clean, safe energy. Scientists here on Earth are trying to replicate the fusion process by using lasers to fuse together the nuclei of hydrogen isotopes, which releases huge amounts of energy. Just one cubic kilometre of seawater contains enough of the hydrogen isotope deuterium to provide more energy than the world's oil reserves. With no greenhouse gas emissions, and a freely-available source of fuel, fusion could address our future energy needs. Understanding extremely high-temperature and high-density physics is key to fusion research, and we use high-powered lasers such as Vulcan to create these conditions.

Elsewhere in the CLF, we're using the Ultra system to investigate photoactive proteins – light-driven nanomachines designed to be robust or readily replaceable. We expect these nanomachines to form an important part of solar energy driven nanoscale devices, and this work underpins solar energy research.

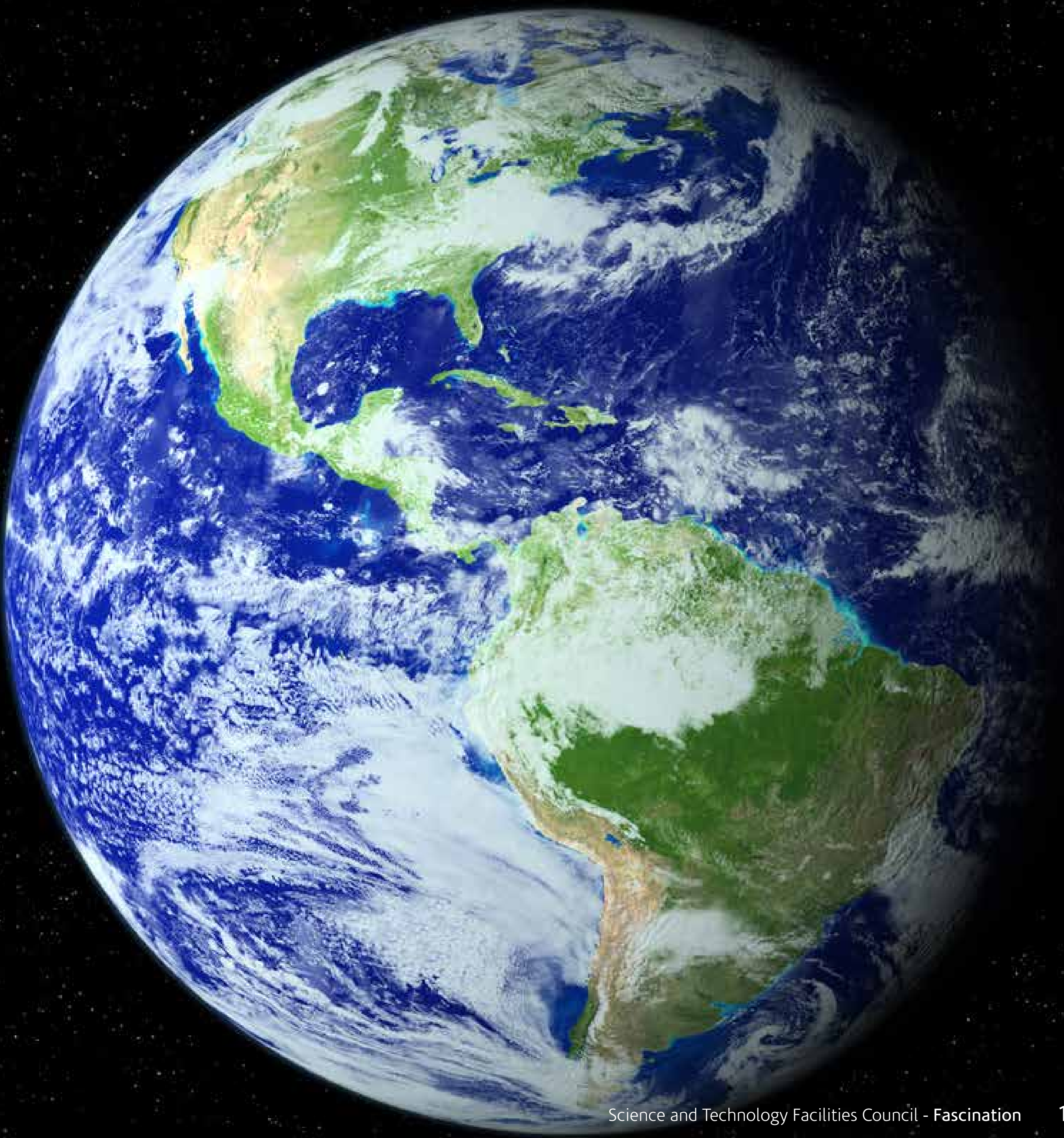


New materials like NOTT-300 can help capture carbon dioxide
CREDIT: University of Nottingham

Developing alternatives to oil

We know that supplies of fossil fuels will run out, but what if it was possible to make oil? Syngas (or synthesis gas) is a mixture of carbon dioxide and hydrogen, which can be converted into petrol and diesel via a process called Fischer-Tropsch catalysis. The carbon dioxide used can come from any source, including biomass, coal and methane – making the process very flexible.

The reaction relies on the use of catalysts, which are often iron-based as iron is readily available. Inside reactors, the transformation from the iron-based precursor to the active catalyst is highly complex, and scientists using the TOSCA instrument at ISIS studied samples from a working plant to investigate whether the composition of the catalyst can be influenced to improve the production process.



More CERN contracts awarded to the UK

Arcade Sam Williams, Projects Director at Arcade UK Limited, pictured at the Alice experiment at CERN
(Credit: Arcade)

LHC Tunnel
(Credit: CERN)

Arcade, a family-run UK company, has won contracts at CERN worth £1 million to update the ventilation systems that are essential to the day-to-day running of the experiments carried out there. The work will be carried out during the current long shutdown, which is also allowing important upgrades to take place.

Over the last three years, UK companies have been awarded £47 million in contracts from CERN, a benefit to the UK economy that is only possible due to STFC's membership of CERN. Arcade, based in Cambridgeshire, was introduced to CERN by STFC at a `Meet the Buyer' event in 2011. As a result of the event, Arcade were invited to tender for several contracts, and they have been steadily winning them ever since. They have been able to increase their work force, and their engineers are now trained to work in radiation environments; skills which are highly-transferable.

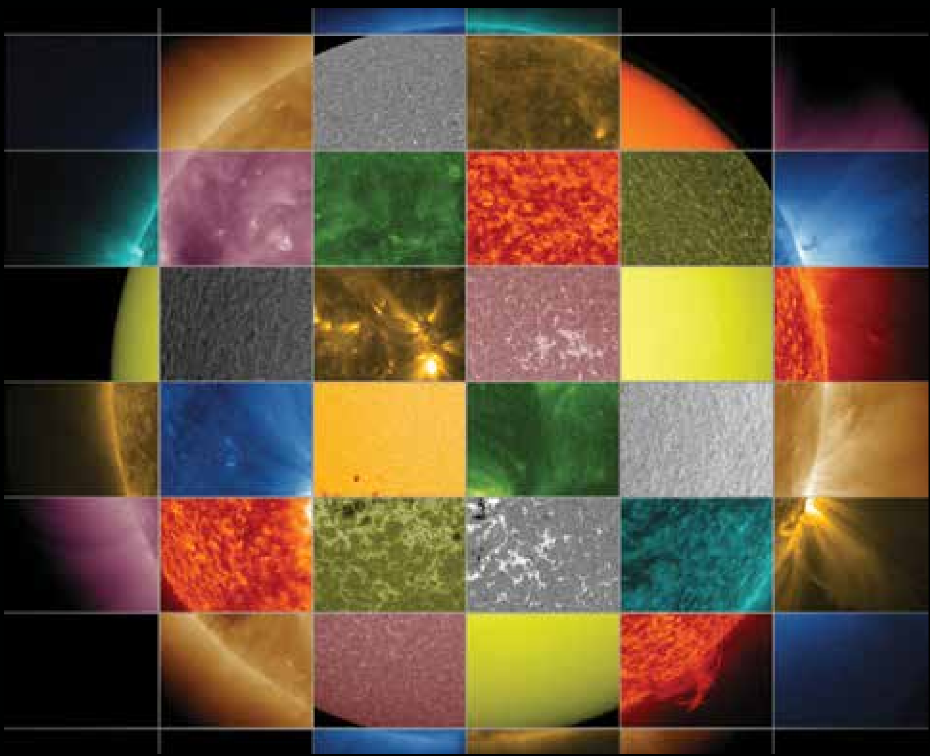
UK companies have won over £47M at CERN over the last three years

Mike West, Arcade's managing director, says: "We are pleased to have been able to establish such a strong working relationship with CERN and are grateful to the Science and Technology Facilities Council for making the initial introductions which enabled us to demonstrate our expertise in this industry sector. The projects that we have contributed to at CERN over the last year have had a significant impact on our business – our work there has led to an expansion in our engineering team and we have seen a positive increase in this year's turnover."

As Julie Bellingham, Head of Business Opportunities for International Facilities at STFC says: "When people imagine CERN they often think of complex scientific equipment but their requirements are not always for scientific needs. CERN requires everything from civil engineering to patent lawyers and as we've seen with Arcade, heating and ventilation. We're really pleased that they have gone on to win these contracts and develop such a good working relationship. At today's exchange rates, UK companies have won over £47 million at CERN over the last three years and there continues to be huge opportunities. The impact of winning contracts is often even greater as it boosts reputations and enables companies to win business elsewhere."

Big Telescopes: spanning the spectrum

The breathtaking big telescopes available today use every part of the electromagnetic spectrum to provide the fullest possible picture of objects both close to home (in cosmic terms) and billions of light years away.



Specialised telescopes are used on the ground and in space to observe light way beyond the ranges that are visible to the naked eye. This collage of solar images from NASA's Solar Dynamics Observatory (SDO) shows how observations of the sun from telescopes with different wavelengths can be used to learn about the various components of the sun's surface and atmosphere. This information allows scientists to paint a fuller picture of the sun and the rest of the Universe.

Credit: NASA/SDO/Goddard Space Flight Center

From radio waves through visible light right down to gamma rays, different types of telescope capture different types of electromagnetic radiation and so generate different types of insight:

- Optical telescopes generate 'conventional' images that reveal the dust bands, young blue stars and old red stars within the galaxy superbly.
- Radio telescopes reveal jets of phenomenally hot material, which has been spewed out from the galaxy's centre, suggesting the presence of a super-massive black hole there.
- X-ray telescopes have captured data backing up the black hole theory.
- Near infrared telescopes have enabled astronomers to penetrate dust clouds in the galaxy and see what's happening behind them.
- Far infrared telescopes show radiation being emitted as dust clouds are heated by stars inside them.

Telescopes operating at different wavelengths complement one another and the range of big telescopes available to astronomers enables them to build a comprehensive picture of our Universe, helping to unravel some of its deepest secrets.

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