fascination

Autumn 2015

Greater, greener ways to feed the world

Interview with palaeontologist Phil Manning

Big data predicts extreme weather blackspots for UK emergency services

Soapbox Science: from the Southbank to Down Under

Science & Technology Facilities Council

Welcome

Welcome to the autumn 2015 edition of *Fascination*.

As the world's population continues to grow, the future supply of sustainable and accessible food supplies is an issue affecting everyone. Turn to pg 24 to discover how we're using our science to help address this challenge.

Calling all natural history fans! Our interview subject for this edition is STFC Public Engagement Fellow, Professor Phil Manning, a palaeontologist and natural history expert who travels the world to uncover the secrets of prehistoric life. We find out about his interesting career, how he's using our science to aid his work and, of course, what his favourite dinosaur is, on pg 38.

In floods, time is of the essence. Delaying response to a water rescue by five to 10 minutes multiplies the risk of fatality by more than four times. On pg 20, find out how UK start-up company, KnowNow Information Ltd, is revolutionising how UK emergency services can plan for, and respond to, extreme weather conditions such as localised flooding, to help save lives and millions of pounds.

In the summer 2014 edition of *Fascination*, we featured an interview with the founders of the Soapbox Science project, Dr Seirian Sumner and Dr Nathalie Pettorelli. A year since the innovative project received an STFC Public Engagement Award, we caught up with them to see how the grant has helped them (pg 32).

Best wishes,
The *Fascination* editorial team

About Us

Our scientific research seeks to understand the Universe from the largest astronomical scales to the tiniest constituents of matter. Providing access to and managing a range of world-class research facilities, the Science and Technology Facilities Council delivers fundamental insight and scientific breakthroughs in areas ranging from particle and nuclear physics to space, laser and materials science. Through our UK operations and our involvement in major international collaborations, we generate outcomes that shape societies, strengthen economies, build industries, create jobs and transform lives.

Don't miss an issue

Fascination is STFC's quarterly in-house magazine. To receive an electronic version straight into your inbox for free, please visit: www.stfc.ac.uk/fascination and subscribe.

Cover images: ESA (top), Phil Manning (left), istock/Ralph125 (middle), L'Oreal Women in Science (right)

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One giant step closer to simulating the human brain

Breakthrough computer software used to model and simulate incredibly complex systems such as the human brain or global weather patterns is now being tested for use by computational scientists at Daresbury Laboratory.

Part of a major £960k project funded by the Engineering and Physical Sciences Research Council (EPSRC), researchers from Queen's University Belfast and the University of Manchester are creating ground-breaking computer software that will increase the ability of supercomputers to process masses of data at higher speeds than ever before.

Supercomputers are the key drivers of scientific advancement in every aspect of research. By simulating detailed models of natural phenomena such as ocean currents, the blood flow of a human body and global weather patterns using thousands of computer cores in parallel, scientists can use the information they produce to help address some of the big global challenges including sustainable energy, the rise in global temperatures, and worldwide epidemics.

The new software will be critical to the next generation of Exascale supercomputers, that could exist within the next five years, and will be capable of performing 1,000,000,000,000,000,000, or one billion, billion calculations per second. This is a thousand times more powerful than the Chinese Tianhe1A – the fastest supercomputer in operation today. But Exascale supercomputers will also rely on the development of equally as powerful, cutting-edge

Image Credit: iStock.com/Beholding Eye

software that will enable them to process masses of data at higher speeds than ever before. The new software will also contribute to increased energy efficiency, without which the supercomputers will be limited by the power they consume (read more about out plans to make supercomputing more energy efficient on page 22).

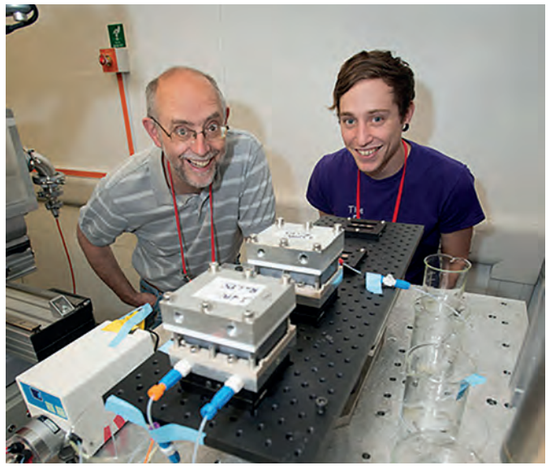
The Scalable, Energy-Efficient, Resilient and Transparent Software Adaptation (SERT) project is funded by the EPSRC under the Software for the Future II programme. ■

New tool for developing improved antibiotics produced by ISIS and Newcastle University

It is well known that all types of disease-causing bacteria are becoming resistant to antibiotics. Figures taken from the NHS website show that, in 2013, one in five infections involving E.coli (Escherichia coli) were resistant to a commonly-used antibiotic (ciproflaxin).

But now scientists have a brand new tool for developing new antibiotics and other drugs in the fight against infections like E.coli (Escherichia coli). Funded by the Wellcome Trust, researchers from Newcastle University and STFC have produced a working model of the outer membrane of E.coli, giving access to unprecedented information about the bacteria which is notoriously hard to study due to its size and exterior.

Single-celled Gram-negatives, the group of bacteria that E.coli belongs to, are of special concern because they have an extra wall around their cells which can protect them physically from our treatments. In evolutionary terms, they are believed to have descended from a common ancestor of cyanobacteria, which emerged 3.6 billion years ago. Understanding the outer membranes of Gram-negative bacteria is important for antibiotic development, but their structure and dynamics are poorly understood because of their small size and inaccurate lab, or in vitro, models. Scientists have used an instrument called POLREF at STFC's ISIS Neutron and Muon source to get information about the membrane's nanoscale structure needed to build their model.



Jeremy Lakey and Tim Robinson Credit: STFC

"Our model of the bacterial outer membrane can be used as a simulator to test how antibiotic molecules can be made to cross this critical barrier", Jeremy Lakey, Professor of Structural Biochemistry at Newcastle University who led the study explains. "A stable model is so important because the detailed structure of this wall is still not clear, largely because bacteria are very small and have a protective envelope that is only 20 nanometres thick. This model gives us unprecedented access to the structure and dynamics of the membrane."

Antimicrobial resistance has been named as the key challenge in the Longitude Prize, an initiative launched by the Prime Minister at G8 2014 with a £10 million prize fund to help solve one of the greatest issues of our time.

The results of this work have been published in the leading chemistry journal *Angewandte Chemie International Edition*, are featured as a 'Research Highlight' in *Nature Chemical Biology* (20 October 2015). ■

Space technology helps London commuters tackle strike


Image Credit: iStock.com/JohnnyGreig

Learn more about iGeolise: www.igeolise.com/
For more information about the ESA BIC Harwell, visit www.esa-bic.org.uk.

London commuters faced gridlocked traffic, packed-out public transport and much longer commute times in September, as the London Underground strikes left many people searching for alternative ways to get to work. Luckily, UK start-up company iGeolise has been busy using space technology to help commuters affected by the strikes.

The team at iGeolise launched a tube strike guide creating some specialised maps using software from its 'TravelTime' technology to help commuters get around. The maps, which were made available for free on the website, covered walk times and cycle times from several main London Underground stations, each showing where you could be within a 45 minute walk or cycle.

iGeolise developed its TravelTime platform at the UK's European Space Agency Business Incubation Centre in Oxfordshire (ESA BIC Harwell), which is managed by STFC. TravelTime uses satellite maps overlaid with public transport and road data to instantly identify, rank and sort potential routes by commute time, rather than miles. It is already popular with house hunters and job seekers, after all, a mile can take five or 50 minutes depending on traffic, the time of day or mode of transport.

Managed by STFC, the ESA BIC Harwell enables small companies with brilliant ideas using space technology, to transfer these ideas for use in non-space industries. ■

Super-fast lasers used to help improve cancer treatments

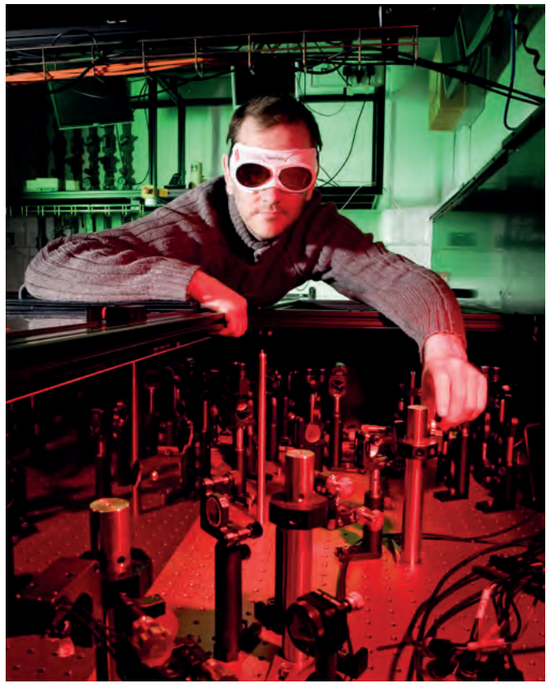

A member of the Ultra team and the Ultra laser facility
Credit: STFC

Photo-dynamic therapy is used to treat a number of conditions - including several cancers and psoriasis. It works by using light to activate a drug in a specific area of the body.

Metal complexes used in some drugs bind to DNA, and are now used in chemotherapies for cancer, or have potential activity against drug resistant bacteria. It's difficult to study how this extremely fast process, which takes place in half a billionth of a second, works in a living cell. But STFC scientists at our Central Laser Facility (CLF) have been working with colleagues from Dublin, Reading and the Diamond Light Source to study the process happening in detail, inside a DNA crystal.

When light is shone on the DNA crystal, the drug compound is activated, causing damage to the DNA. The team have been using the Ultra laser facility to examine how the drug compounds work at a fundamental level.

Discoveries made through these observations could lead to improved photo-dynamic therapy treatment. ■

25% growth for businesses collaborating with universities at Sci-Tech Daresbury

The latest tenant survey from STFC's joint venture project, Sci-Tech Daresbury, has uncovered that the total business value from businesses collaborating with universities at Sci-Tech Daresbury increased from £4 million to £5 million in the last year, a rise of 25%.

The latest tenant survey from STFC's joint venture project, Sci-Tech Daresbury, has revealed that companies operating from there are forming valuable collaborations with both STFC and universities at a higher rate than ever. The news is evidence that the Science and Innovation Campus is achieving its aim of accelerating growth for high-tech tenant businesses by driving collaboration.

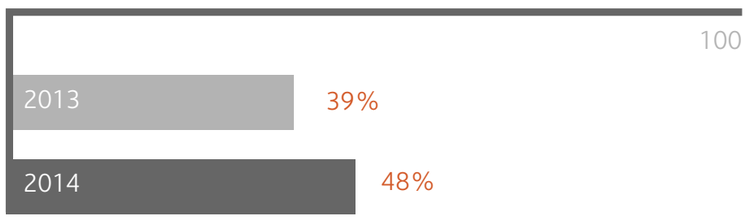
High-tech SME companies at Sci-Tech Daresbury are encouraged to form collaborative and mutually beneficial relationships with both STFC and regional universities.

The latest survey shows that interaction with STFC in the last year has increased with 48% of Daresbury companies now utilising services and/or expertise from STFC. This percentage is significantly up from 39% in 2013.

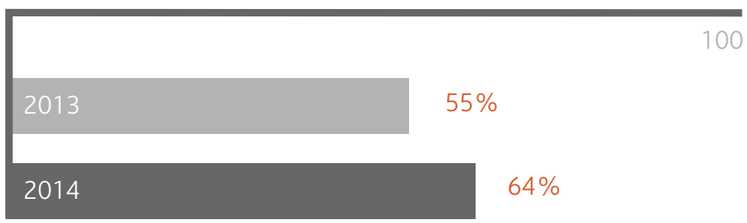
In addition, 64% of those companies surveyed were collaborating with a university, compared with 55% in 2013. This represents the highest level of university collaboration to-date.

An aeriel view of Sci-Tech Daresbury Credit: STFC

Sci-Tech Daresbury companies utilising STFC expertise



Sci-Tech Daresbury companies collaborating with a university



The increase in university collaboration was driven by a strong growth in collaborative research, student placements and recruitment; and sales activities to universities.

Professor John Womersley, Chief Executive of STFC, said, "We work hard to minimise business failure and accelerate growth for high-tech SME companies located on our campus.

"We do this partly by promoting interactions and collaborations with and between companies, the science base of STFC and the universities, and regional and national business support organisations.

"Collaboration between companies on site is very important. This grew by 16% last year: there are now more than 140 collaborations underway between campus companies. The value creation delivered through collaboration is impressive and we are determined to keep building on it year after year."

Overall, 77% of Daresbury companies reported that they had a collaboration with either STFC or a university, a big leap from 64% in 2013 and about one-third higher than the level reported in 2012.

The Universities of Liverpool and Manchester continue to be the most active with campus companies, followed by Lancaster, Cambridge and Oxford. ■

For more information about Sci-Tech Daresbury, visit: www.sci-techdaresbury.com

Could you help improve urban areas?

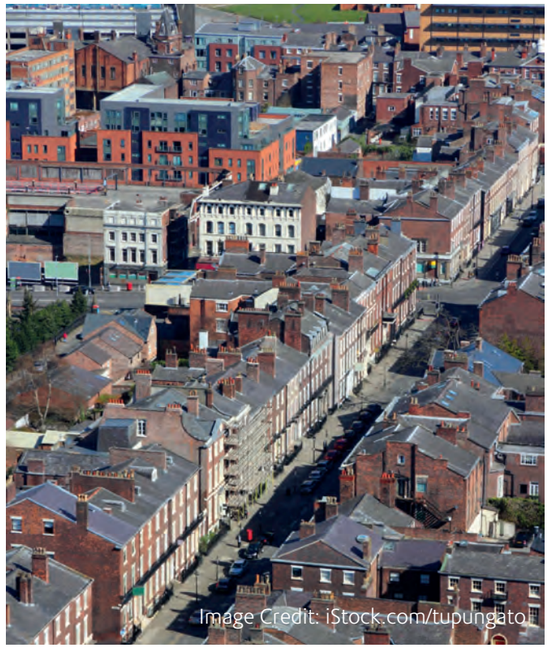


Image Credit: iStock.com/tupungato

The Urban Living Partnership is looking for proposals from expert consortia to help address the challenges faced by urban areas in the UK and to help these areas realise their visions for future urban living.

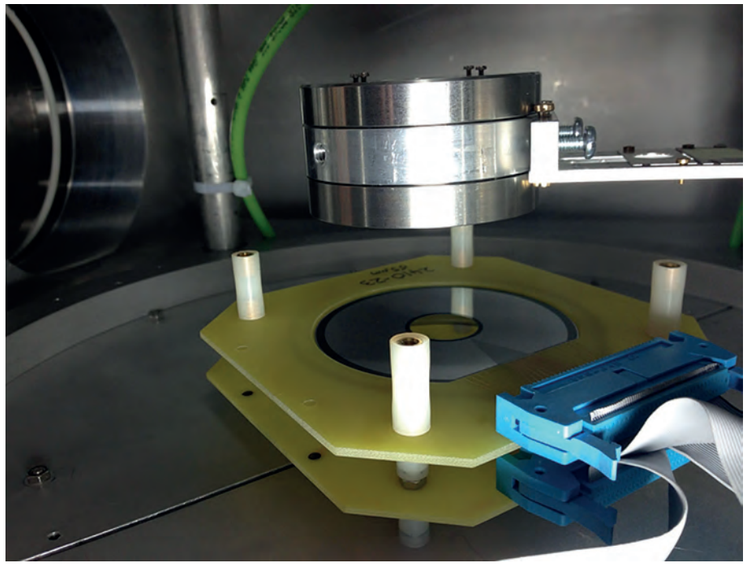
The Partnership seeks applications from consortia bringing together cross-disciplinary research expertise, city leaders, businesses, civic organisations and community groups, public, third sector and other urban innovators, who, in this initial diagnostic phase, will be expected to build a holistic understanding of the challenges, opportunities and future visions of a specific UK city/urban area and develop agendas for future research and innovation.

The Urban Living Partnership combines the strengths of all seven of the UK's Research Councils, together with Innovate UK, to understand key interconnected urban challenges, co-produce practical responses and exploit emerging market opportunities and capacity for social innovation. Taking a 'whole city' approach, the Partnership brings together the capabilities needed to address a wide range of challenges from infrastructure and environment to crime and social inclusion, from health and wellbeing to heritage and culture, from economy and employment to smart cities and big urban data, to give just a few examples.

Combined funding of £2 million is available for the pilot call, from RCUK and Innovate UK. This will be distributed between up to five projects, each focused on a different city/urban area. Funding of up to £400,000 will be awarded to support each pilot project to conduct a 'diagnostic' phase, commencing in April 2016 and running initially for up to 18 months. ■

Full applications must be submitted via JeS. The deadline for research organisations to submit full applications on behalf of consortia is 1600hrs on 21 January 2016, with a deadline for submitting initial expressions of interest on 26 November 2015. The Engineering and Physical Sciences Research Council is administering the pilot call on behalf of the partners. Further details, information about a Town Meeting on 20 October 2015 and the full call for proposals, can be found on its website: www.epsrc.ac.uk/funding/calls/ulppilotphase

York scientists unlock secrets of stars



The gas cell target and silicon detector array inside the TUDA scattering chamber at TRIUMF
Credit: Jessica Tomlinson

Physicists at the University of York have studied radioactive aluminium (Al26) to gain exciting new insights into the role massive stars play in the evolution of the Milky Way and the solar system.

Al26 is an element that emits gamma radiation as it decays, and this enables astronomers to image its location in our galaxy through the use of large gamma ray telescopes. It is known for its relatively short lifespan in astrophysical terms, decaying in around 1 million years, compared with the lifetime of massive stars of about 19 million years.

Now, in two independent experiments funded by STFC and carried out at accelerators in Canada and Denmark, the team of researchers have observed and measured, with unprecedented accuracy, the rate at which Al26 is produced through the fusion of helium and sodium, effectively simulating in the laboratory how stars work.

The research, published in Physical Review Letters, provides the most in-depth understanding yet of where and how aluminium is produced within stars and paves the way for more detailed research into how massive stars affect our galaxy and the origins of the solar system. ■

Reaching out

Doors Open at the Royal Observatory Edinburgh

On Saturday 26 and Sunday 27 September, STFC's UK Astronomy Technology Centre (UK ATC), along with our partners the Royal Observatory Edinburgh and The Institute for Astronomy became a hive of activity as we invited the public behind the scenes of our science, as part of Edinburgh Doors Open Day.

More than 3000 people visited over the weekend, and it was a great opportunity for us to explain and raise awareness of the various activities that take place on site and inspire the next generation of scientists with the magic of astronomy.

Visitors explored the cosmos via multimedia experience, Lost In Space, and were taken on a whistle-stop tour of the stars inside the Starlab Planetarium dome, before coming back down to Earth to visit the working laboratories on site, build a Lego version of the European Extremely Large Telescope (E-ELT) in an educational workshop, hold some real meteorites, talk to working astronomers and find out more about this fascinating area of science.

The Royal Observatory Edinburgh proved still to be one of the top destinations for Edinburgh Doors Open Day and it was fantastic to see so many people enjoying the work of the UK Astronomy Technology Centre and our partners. ■

Visitor using the telescopes on the Victorian balcony during Doors Open (below). Credit: STFC

Boy waiting for his turn on the telescope when STFC's Royal Observatory Edinburgh site was opened to the public in September 2015 (right). Credit: STFC

Neil Cuthbert
@cuthbertneil
Follow

Thanks @Royalobs for brilliant #doorsopen day #ROEopen.
5:00 PM - 27 Sep 2015 · Edinburgh, Scotland, United Kingdom

Alex Amon
@astroalexamon

Had such a fun day telling eager beavers about dark energy and space-face painting at #ROEopen !

Visitor tweets from the last Doors Open at the Royal Observatory (above).

UK scientists seal deal on European Extremely Large Telescope's first-light spectrograph

Artist's impression of the European Extremely Large Telescope (E-ELT) at night whilst observations are in progress.

Researchers from the UK have now signed an agreement to lead one of the first instruments for what will become the world's largest visible and infrared telescope, the European Extremely Large Telescope (E-ELT).

The spectrograph, called HARMONI, will provide the European Southern Observatory (ESO)'s telescope with a sensitivity that is up to hundreds of times better than any current telescope of its kind. It will be led by scientists from University of Oxford and STFC's UK Astronomy Technology Centre. The agreement was signed at a ceremony in Oxford.

Perched on top of Cerro Armazones in the Atacama Desert of northern Chile, the E-ELT will have a giant main mirror 39 metres in diameter. It is one of the biggest global science collaborations in history and includes an £88 million investment by the UK government. UK industry has already won over £10 million worth of contracts from the E-ELT in advance of HARMONI and that figure is expected to at least match the UK government's investment by the time construction is complete.

The telescope will enable scientists to see more distant objects than previously possible, allowing them to understand younger structures in our night sky than ever before - helping improve our understanding of the Universe, the effects of dark matter and energy, and planets outside of our solar system.

In its early days, the E-ELT will be equipped with three scientific instruments; two first light instruments, a camera (MICADO) and a spectrograph (HARMONI), followed soon after by the mid-infrared instrument (METIS).

Professor Niranjan Thatte part of the leading team from the University of Oxford, said: "By studying the light from galaxies, distant and nearby, in great detail, we hope to unravel the physical processes that have shaped the cosmos throughout its history."

The spectrograph splits the light from the object in the sky into its component wavelengths or colours. Astronomers can use these 'spectra' to determine far more than images alone ever can: they reveal the motion, temperature and chemical composition of structures imaged using the telescope.

The HARMONI instrument will be especially powerful in that it combines imaging and spectroscopy using a technique called 'integral field spectroscopy'. This enables spectra of many positions in a galaxy (for instance) to be measured simultaneously, producing a galaxy map in 3D including spatial information in two dimensions and wavelength in the third. The wavelength dimension tells astronomers the distribution of velocities within the image.

"HARMONI has been designed to be a workhorse instrument," explains Professor Thatte. "It will be utilised by all the early science being carried out at the E-ELT. That's why we designed it to be easy to calibrate and operate, providing the E-ELT with a 'point and shoot' spectroscopic capability."

The device will be used across all of the E-ELT's experiments in early years, from imaging planets to probing black holes. It will be used to directly observe planets and stars, providing early spectral analysis of exoplanets; to resolve individual stars, quantify the different types, their properties and their place in galaxy formation.

As well as project leadership, the UK will also deliver significant sub-systems. The University of Oxford will deliver the crucial user interface software and simulation tools and, with help from STFC's RAL Space, the four spectrographs. The UK ATC will host the system integration and test and deliver the main support structure and cryostat as well as wavefront sensing subsystems for the adaptive optics, in conjunction with Durham University.

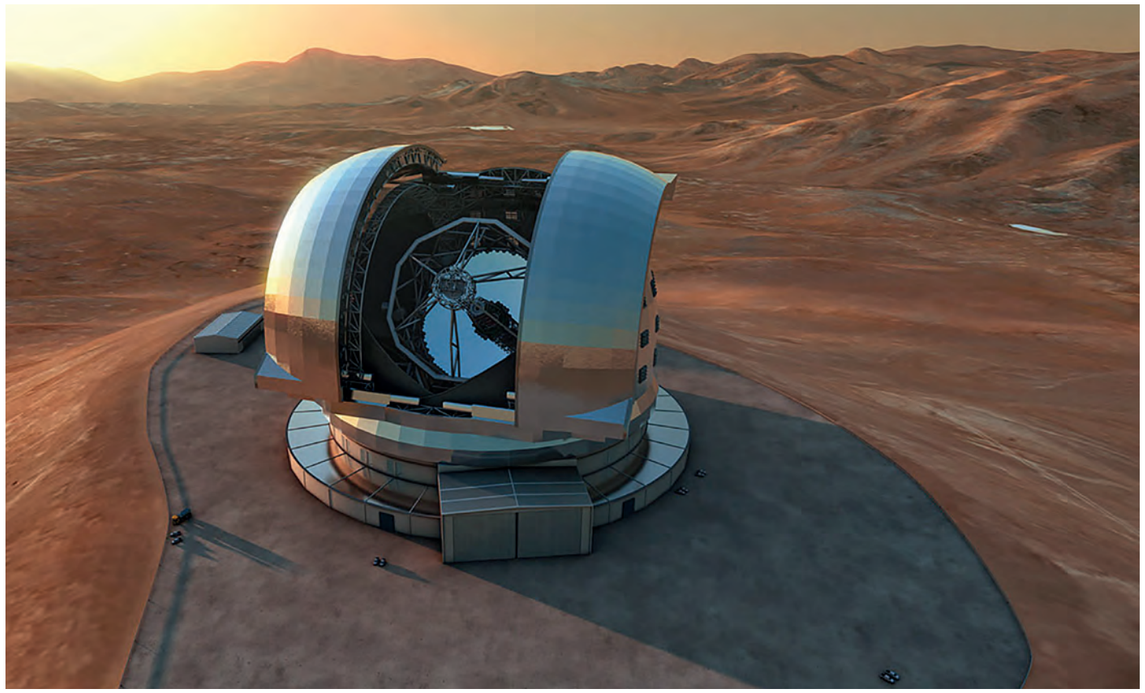
"The instrument is not just about high precision optics – all engineering disciplines are equally critical and we are fortunate in having a highly skilled team from across the consortium with the ingenuity, expertise and enthusiasm to make HARMONI a success."

Under the contract, the UK will receive just less than 20 million Euros from ESO to cover the purchase of components by the consortium and STFC will contribute around £7 million to support the required staff effort at Oxford and Edinburgh in the first four years.

Project manager for HARMONI, UK ATC's Ian Bryson, said: "To enable HARMONI to deliver great science, for the next nine years the combined engineering and science team face a daunting challenge to produce this unique state of the art capability. The instrument is not just about high precision optics – all engineering disciplines are equally critical and we are fortunate in having a highly skilled team from across the consortium with the ingenuity, expertise and enthusiasm to make HARMONI a success."

The project includes contributions from Centre de Recherche Astrophysique de Lyon and Laboratoire d'Astrophysique de Marseille, both in France, along with Instituto de Astrofísica de Canarias and Centro de Astrobiologia, Instituto Nacional de Tecnica Aeroespacial, both in Spain. ■

For further information about the UK's involvement in the E-ELT, please visit: www.eelt.org.uk



Artist's impression of the E-ELT on its future location atop Cerro Armazones, in the Chilean Andes (top).

Part of the 3000-metre peak of Cerro Armazones being blasted away in preparation for the construction of the E-ELT (above).
Credit: ESO (all images)

High-res laser X-rays could spot tiny fractures in bones

A new method of taking highly detailed X-ray images of bone using powerful laser beams has been developed by researchers at Imperial College London, in collaboration with STFC's lasers team.

Osteoporosis is a condition that weakens bones, making them fragile and more likely to break. According to the NHS, more than 300,000 people receive hospital treatment every year for fragility fractures (fractures that occur from standing height or less) as a result of osteoporosis.

The new technology being developed by Imperial College London and STFC is at an early stage, but the researchers believe that with further development, it could ultimately enable doctors to make an early diagnosis of bone problems such as osteoporosis, without needing to take a biopsy.

For the first time, the researchers identified and tested a medical application for this type of accelerator by demonstrating that X-rays, produced as the electrons accelerate, can be used to create high-resolution images of dense material such as bones. The X-rays were produced using a laser wakefield accelerator – a compact type of particle accelerator developed at Imperial.

Their results, published in Scientific Reports, show that it is possible to use the X-ray source to produce three-dimensional images of bone samples at resolutions of around 50 microns. This would allow clinicians to spot features within the bone that were finer than a human hair – at around 100 microns thick.

The scientists are now working on refining their technique and exploring how the technology could be adapted for use in a hospital. In particular, work is underway to also miniaturise the laser system that underpins this work so that the whole system can be made to fit into a hospital imaging department.

"Wakefield accelerators have been developed with the idea that they could make the accelerators used in high-energy physics experiments, such as at CERN, much more compact and thus cheaper. However, those same benefits could see wakefield accelerators being used in other applications of accelerators, such as in generating high quality beams of X-rays," said research team leader Professor Zulfikar Najmudin, of the John Adams Institute for Accelerator Science in the Imperial physics department.

The team have been developing their technique at STFC's Central Laser Facility, based at the Rutherford Appleton Laboratory in Oxfordshire.

In a laser wakefield accelerator, the laser is fired into a helium gas cell to create a plasma. This means that electrons in the gas are shaken free from their parent atoms to make a 'soup' of charged particles – the plasma. The intense pressure of the high power laser then generates a cavity in the plasma that can accelerate some of these electrons almost to the speed of light in distances of a centimetre or less. A focused beam of energetic electrons exits the plasma which can then be used for physics experiments, such as the generation of beams of anti-matter.

Another consequence of this process, however, is that the electrons naturally oscillate in the cavity in which they are accelerated and as they do so, they emit a beam of high-energy X-ray particles. Since the cavity from which the X-rays are emitted is also compact, the size of the X-ray source is also remarkably small, about the order of one micron. This enables high-resolution imaging simply by propagating the X-rays through a sample.

"In this study, we've shown that the laser technology has the potential to be adapted so that we can create X-rays that reveal unprecedented detail," explained Jason Cole, lead author of the study, also from Imperial. "This kind of high-resolution X-ray would be extremely useful for identifying conditions such as osteoporosis. Conventional X-ray scanning cannot get the full picture, as early-stage bone cracks can be too fine to be picked up."

BoneCube - 3D reconstruction of a sample of human hip bone created using a laser wakefield accelerator. The research was funded by the Engineering and Physical Sciences Research Council and STFC. Credit: STFC

The team used this beam to produce pictures of a small sample from the leg bone taken from an elderly patient who had had a hip replacement. By rotating the bone slightly after each picture, a full three-dimensional reconstruction of the sample was produced showing fine detail of the bone's internal structure.

To be able to produce this kind of detailed study of bones presently requires expensive equipment and the technology is not yet sufficiently refined to detect microfractures in bone, which can be an early indication of osteoporosis. Microfractures can be just 10 microns thick and currently can only be detected by taking a biopsy of the bone and sending the sample for specialist analysis by microtomography machines – a time consuming and expensive process.

"The internal structure of bone is surprisingly complicated – you need powerful X-rays to penetrate the material deeply enough to get a detailed image," said Cole. "Our method was able to produce really detailed pictures that could be transformed into a 3D model of the sample."

The team expects that, with refinement, their system could provide a practical alternative to microtomography.

"In the next few years we envisage lasers like Gemini increasing in repetition rate and enabling microtomography at the cellular level to be carried out in a matter of minutes", said STFC's Dr Dan Symes. "Such an advance would allow a wider range of users access to cutting edge techniques currently only available on synchrotron beamlines."

"There is currently a lot of research being carried out into detecting microfractures," Cole said. "This method could match microtomography machines in terms of the resolution that could be achieved – and because laser technology is developing so rapidly, this could, eventually, become a viable technique for bone analysis in hospitals." ■

Big data predicts extreme weather blackspots for UK emergency services

UK start-up company, KnowNow Information Ltd, is revolutionising how UK emergency services can plan for, and respond to, extreme weather conditions, to help save lives and millions of pounds.

Using big data and the UK's most powerful supercomputers dedicated to industry, KnowNow has developed a capability that can accurately predict the probability of certain types of emergency occurring, based on location and weather conditions.

Torrential rain, overflowing rivers and heavy snowfall – these are just some of the factors that can bring danger and disruption through flooding to households, businesses, road users and those relying on public transport during extreme weather. They also put extra pressure on emergency service response time, meaning crucial time is lost in getting to those in need.

KnowNow are using the world-leading big data analysis capabilities of STFC's Hartree Centre to develop a flood event model that combines existing open data generated by the UK's emergency services, UK Met Office, Ordnance Survey, the British Geological Survey and the Environment Agency, to name a few, into a single, insightful repository of knowledge that makes such predictions possible.

The company won access to the Hartree Centre as part of a competition run in conjunction with the Open Data Institute. Located at our Daresbury Laboratory, the Hartree Centre recently announced major Government investment towards its £313 million partnership with IBM to help businesses, such as KnowNow, make the best use of big data and reduce the time and cost of developing new and better products and services (read more about this in the summer 2015 edition of *Fascination*).

KnowNow's predictive capability will enable emergency services, highways authorities, rail operators, local communities and businesses to improve their decision making and resource planning when there is a potential for flooding. A public facing 'app' will allow local residents to see the risks within their area and insurance companies will also be able to base prices, policies and products on more accurate assessments.

Through an advanced algorithm developed on the Hartree Centre's high performance supercomputers, KnowNow's 'Flood Event Model' combines information such as monthly rainfall data, daily river flow, terrain and bedrock classification and emergency call out histories to accurately predict when and where road accidents caused by flooding are likely to occur. Rather than predicting just where flooding will occur, or when, it also predicts a specific kind of incident, such as a car getting stuck in an overflowing river.

David Patterson, Co-Founder and Director, KnowNow Information Ltd, said: "Responding to weather-related emergencies is complex and resource-hungry, and the ability to predict accurately where and when they will occur has huge potential to protect lives, livelihoods and cut costs. Using the supercomputers and expertise at the Hartree Centre, we were able to 'mash up' and time-sort all the data which we then overlayed onto Ordnance Survey information, pinpointing the location of key infrastructure, buildings and other assets. The result was a robust platform of evidence highlighting trends and triggers that determine the probability of specific types of emergency occurring in specific places under specific weather conditions.

We are already in talks with local councils and Fire and Rescue Services who are interested to see how they can use our Flood Event Model."

KnowNow is initially focussing its Flood Event Model on the geographical area of Hampshire and it is intended that the project will be rolled out nationally in the near future." ■

Find out more about KnowNow on their website:
www.kn-i.com

Read about STFC's Hartree Centre online:
www.stfc.ac.uk/hartree

Heavy snow fall disrupting commuter lines (below, left).

Extreme weather affecting tides at Dawlish In Devon (below).

Image Credit: iStock.com/Ralph125

Image Credit: iStock.com/monkeybusinessimages

Supercomputing, the energy-efficient way

Our science writer, Emma Cooper, discovers how at STFC's Hartree Centre, we're exploring ways to make supercomputing greener and more energy-efficient.

In an otherwise unassuming room in the STFC Hartree Centre, there's a supercomputer dunked in a vat of water. At least… that's what it looks like, but the crystal-clear fluid is actually mineral oil. The ClusterVision (IBM) x86 oil-cooled supercomputer is just one of a number of systems being investigated for its potential in reducing the energy requirement of our ever-increasing computing needs. The sight of racks of individual component computers hanging in the oil is oddly mesmerising, but the installation is entirely practical. The tanks are connected to a special system that both filters the oil and removes the generated heat. The whole thing sits on a platform that contains an expandable membrane. In the unlikely event that the tanks spring a leak, this membrane can comfortably contain the oil, preventing it from spilling out and contaminating the environment.

In a nearby cabinet is a second supercomputer, looking misleadingly conventional. Its racks are filled with units based on the ARM64 architecture – chips more normally used in mobile phones and devices. In 2013, 10 billion ARM chips were produced, and if you were to look you may well find one within arm's reach. They are popular for mobile devices due to their low power consumption, and it is this feature that has warranted their inclusion in the Energy Efficient Computing (EEC) programme, which is developing the skills and knowledge vital to designing and optimising the next generation of high performance computers.

'Big science' projects such as the Square Kilometre Array (SKA) - which will be the world's largest and most sensitive radio telescope - and Gaia, which is creating an extraordinarily precise 3D map of the Milky Way, are one of the factors pushing us towards the exascale era of computing. Exascale computers will be capable of performing at least a billion billion calculations per second (making them a thousand times more powerful than any in the UK today) – a necessity to crunch all the data these big science projects will produce, but also essential for things like modelling and visualisation.

Elsewhere in the Hartree Centre, the MPC-X Maxeler Dataflow supercomputer is a collaboration between STFC and Maxeler Technologies, looking into ways of speeding up dataflow computing and reducing the energy costs for the scientific and data computing workloads of our industrial and academic partners. This is one of the projects being funded by the UK Department of Business Innovation and Skills and helping to establish the UK as a global leader in energy-efficient computing. It enables UK industry and academia to develop a broad range products and services for a massive scope of applications, ranging from medical imaging and healthcare data analytics, to manufacturing, industrial microscopy, large scale simulations, security, real-time operations risk, and media and entertainment.

The visualisation facilities at Hartree Credit: STFC

Energy-efficient supercomputing isn't just about the hardware – there are software solutions as well. The Hartree Centre is busy rewriting computer code so that it will run on energy-efficient computers, and they're taking lots of baseline measurements that investigate how much energy scientific applications take to run. Any energy-intensive 'hotspots' can then be identified, and lower-energy versions developed.

With our software and hardware solutions, we're on the way to meeting the challenges of data-intensive supercomputing, and contributing to a more sustainable future. ■

Discover how our supercomputing capabilities and expertise are helping the GOcean project investigate next generation ocean modelling software: www.stfc.ac.uk/about-us/our-impacts-achievements/case-studies/developing-next-generation-ocean-modelling-techniques/

Greater, greener ways to feed the world

Global food security is a big issue, making it one of the government's eight great global challenges. So what are STFC and our partners doing to help tackle it?

Sustainable food supplies

In 2014, the UN warned that a 60% rise in global food production would be needed by 2050, in order to avoid social unrest and civil wars caused by serious food shortages. Rising food demand is being caused by increasing wealth, as well as a rising population that is expected to reach 9.7 billion by the middle of the 21st century.

Climate change is also having an effect on food security, and the UK-US Taskforce on Extreme Weather and Global Food System Resilience predicts that, by 2040, major food 'shocks' caused by extreme weather will occur at least once every 30 years.

The challenge of agri-science is to find greater, greener ways to feed the world. The case studies that follow are just a sample of the significant social and economic impacts of STFC's agri-science, but showcase the strength of UK expertise in this area.

Wiping out foot and mouth disease

Foot and mouth disease (FMD) is one of the most contagious animal diseases and has an estimated global impact of £4 - 13 billion per year. The 2001 outbreak cost the UK alone around £8 billion, with agricultural producers, the food industry and tourism all affected. Research carried out at our Synchrotron Radiation Source determined the 3D structure of the virus, which allowed the first vaccines to be developed.

In 2013 researchers used the Diamond Light Source to develop a new way to produce an FMD vaccine that does not require the use of live viruses. The new synthetic vaccine is therefore much safer to produce, and is also less fragile and easier to transport. There's still a long way to go before the vaccine reaches the market, but the signs from early clinical trials are very promising.

Unlike current vaccines, this new vaccine allows inoculated animals to be differentiated from infected animals, protecting UK exports. What's more, this approach to making and stabilising vaccine could also impact on how similar viruses from the same family are fought, including the virus that causes polio in humans.

Image Credit: iStock.com/dusanpetkovic

Livestock undergoing inspection (right).

Photograph of Earth from Europe's Sentinel-2A satellite (previous page). Credit: ESA

Monitoring our environment

Accurate measurements of sea surface temperature are an essential input for climate models. The Sea and Land Surface Temperature Radiometer (SLSTR) is scheduled to launch Sentinel 3a in late 2015, and is capable of making highly accurate measurements of global surface temperatures. RAL Space played a key role in the design process for the SLSTR, building a dedicated facility for pre-flight calibration activities.

Sentinel 3a will be the third satellite in the EU Copernicus programme, which aims to build the most efficient and comprehensive Earth-observation system in the world, using a constellation of satellites closely monitoring the planet.

The first satellite, Sentinel 1a, was launched in April 2014. Its task is radar mapping, and its key role is to provide rapid damage maps to help the emergency services deal with disasters such as earthquakes and severe floods. Sentinel 1a will also be able to monitor coastal waters for oil spills (or icebergs) and investigate subsidence. Airbus developed the radar instrument for Sentinel 1a in Germany, and the associated electronics in the UK.

Sentinel 1a is expected to produce 600 gigabytes of data per orbit, which is about 2.5 terabytes per day. When it has been joined by a full complement of Sentinel satellites, that figure is expected to rise to 8 terabytes per day.

Satellite observation of coastlines and sea temperature (below).

Image Credit: iStock.com/naiyyer

Dealing with this amount of data has required considerable investment in computer processing power and storage on the ground, but the aim of Sentinel is that it will be able to return data to Earth much faster than existing satellites, which store data to be sent down when they pass over a ground station. The European Data Relay System will use lasers to transmit data within minutes, rather than hours, meaning that Sentinel 1a could be used for flood prediction as well as flood monitoring.

Sentinel 2a, launched in June 2015, takes pictures of the planet's surface in visible and infrared light. It can also be tasked to view the extent of natural disasters, but has been designed to keep an eye on the world's food crops, with a camera sensor that detects wavelengths of light that show the health of plants. Its data will give us advanced warning of poor harvests and potential famines.

With six satellites in orbit by 2019, Copernicus will have many uses, including climate studies and monitoring fish stocks, air quality and waste disposal. All of Copernicus' data will be open, and freely available. Research has shown that allowing unfettered access is likely to stimulate novel uses of the data, resulting in the emergence of many new companies selling new services. It is anticipated that the Copernicus programme will give rise to around 48,000 jobs, and a boost to the EU's GDP of €30 billion, by 2030. The vision is for Copernicus to be an open-ended programme, with satellites being replaced as they reach the end of their lifespan and more Sentinel series to come.

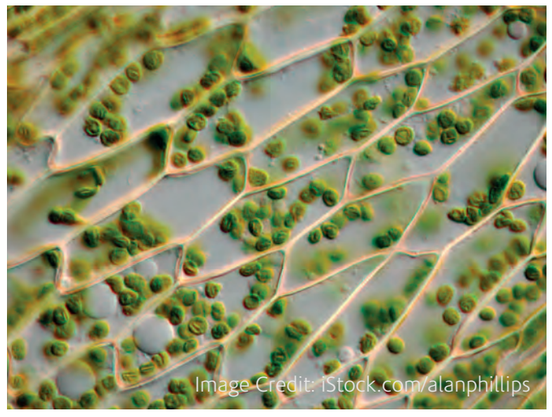


Image Credit: iStock.com/alanphillips

Close-up of plant cells during trials (right).

Monitoring world food crops from above (below).

Image Credit: iStock.com/harmatoslabu

Making plants more resilient

Last year, the Biotechnology and Biological Sciences Research Council (BBSRC) invested in a new super-resolution Stimulated Emission Depletion (STED) microscope, which will let scientists study almost any organelle (a sub-unit within living cell) in real time, to see how it is functioning.

Researchers will also be able to use STED to monitor the behaviour of receptor molecules in plants as they respond to bacteria attacks, which will help us to develop plant varieties that are more resistant, and so reduce the need for pesticides.

STFC's Central Laser Facility (CLF) has already been involved in a discovery about how plants defend themselves in the face of pathogen attacks, which could hold the key to making crops more disease-resistant. For a BBSRC-funded project led by Oxford Brookes University, CLF has developed a unique technique that has answered a question that has puzzled scientists for many years. Why do certain proteins in plant cells move around less than their counterparts in animal cells?

By showing the movement of individual molecules in living plant cells in real time for the first time, the new technique has revealed that the cell wall plays a crucial role in limiting the movement of proteins produced when a plant comes under attack.

The cell wall allows these proteins to stabilise in the plasma membrane (a 'skin' covering the inside of the cell wall). This restricts their ability to move around and fight invading pathogens and so increases the plant's vulnerability.

Increasing our understanding in this area could help to boost food production and improve global food security. ■

Scientists observing the differences in plants under varied conditions (right).

The Biotechnology and Biological Sciences Research Council (BBSRC) has a website providing more information about food security. Visit: www.foodsecurity.ac.uk/issue

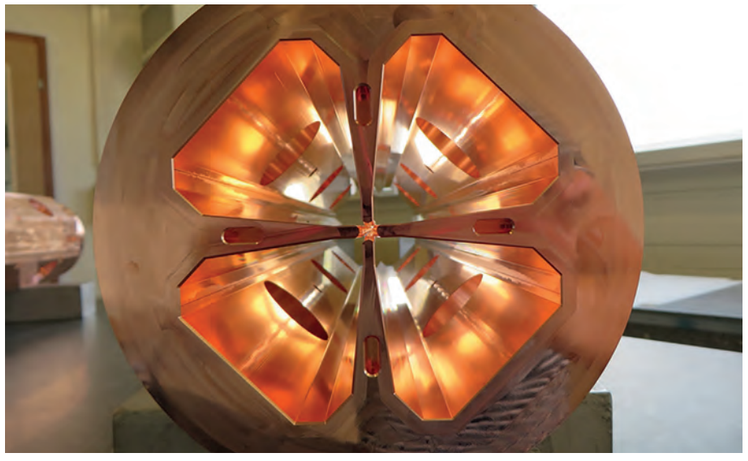
Image Credit: iStock.com/chinaface

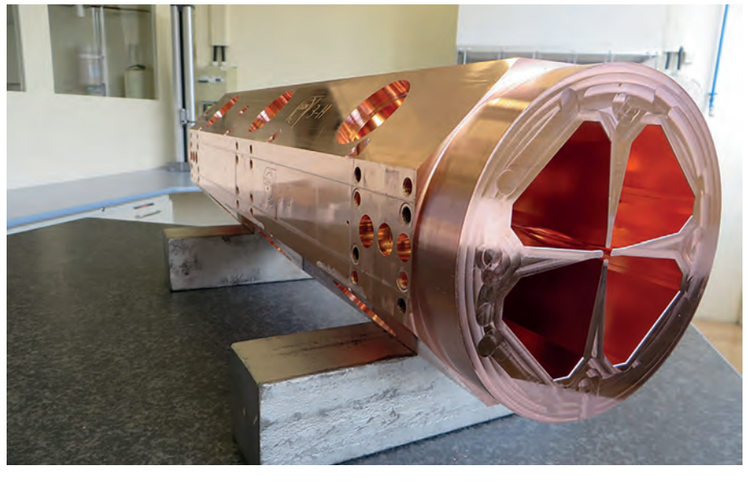
UK artists in residence at CERN

Two UK artists collaborating under the name Semiconductor are this year's recipients of the Collide@CERN Ars Electronica Award. In their art works, Ruth Jarman and Joe Gerhardt explore the material nature of our world, and how we experience it, through the lens of science and technology, questioning how they mediate our experiences.

During their two-month residency at CERN, they plan to create a digital artwork elaborating on the nature of the world and our perception of it, including consideration of how scientific instruments and particle physics discoveries influence our perception of nature.

CERN's art programme gives world-class artists the time and space to reflect, research and renew their artistic practice and career by encountering the multi-dimensional world of particle physics in carefully curated encounters with CERN scientists. ■





Kumquat or RFQ? (top).
Credit: S Hills

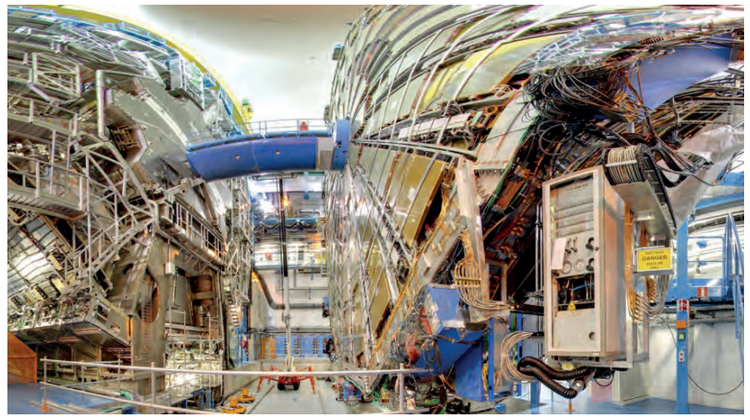
Precision machining for the mini RFQ (right).
Credit: S Hills

Street View of CERN

Virtual visitors can now explore many CERN sites directly from Google Maps via Google Street View.

Above ground you can click around the Meyrin campus and get a feel for daily life as well as visiting CERN's first experiment, the Proton Synchrotron.

But the real excitement takes place below ground and you can visit the LHC tunnel and all four LHC experiments through a dedicated CERN part of Google Street View. ■



CERN experiments as viewed in Google Maps (right).
Credit: Google Maps

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Soapbox Science: from the Southbank to Down Under

In the summer 2014 edition of Fascination, Lisa Davies interviewed Dr Seirian Sumner and Dr Nathalie Pettorelli, two inspirational female scientists with the mission to raise the profile of women in STEM by transforming public places into areas for scientific learning. She caught up with them again to find out how their £90,000 STFC Public Engagement Award has impacted the project.

Founded in 2011, when both Dr Sumner and Dr Pettorelli were working as research fellows in the Zoological Society of London, Soapbox Science was created in response to the low numbers of women in STEM subjects. Dr Sumner cited "the gradual disappearance of our female peers, the vast underrepresentation of female speakers in conferences and committees, and the lack of female role models at the top of the science career ladder" as their inspiration to give female scientists the platform (in this case, a soapbox) they needed to be heard. By getting on their soapboxes in parks, on commuter routes, and in tourist traps, the Soapbox Science speakers give everyone passing by the opportunity to question, interact with and be inspired by some of the country's leading female scientists. The Soapbox Science project has not only received support from STFC and the Zoological Society of London, but also NERC and L'Oreal Women In Science, where both Dr Sumner and Dr Pettorelli are also fellows.

Soapbox Science at the Southbank.
Credit: L'Oreal Women in Science (all images)

On the Southbank back in 2011, Soapbox Science was limited to the London area. It involved 12 speakers, including the likes of Dr Maggie Aderin-Pocock and Professor Georgina Mace FRS OBE, and got off to a fantastic start. But since receiving the STFC Public Engagement Award, the number of women becoming Soapbox Science speakers has grown dramatically: "Our STFC grant has allowed Soapbox Science to really spread its wings and reach most corners of the UK", says Dr Pettorelli. "This year, our award allowed us to employ a part-time event coordinator, while providing the funds to support the organisation of seven events in London, Newcastle, Glasgow, Exeter, Belfast, Bristol and Swansea. These events meant that Soapbox Science was able to showcase the work of over 100 women in science in 2015."

And the audiences keep on growing too, thanks to the project's expanded reach, with an estimated 30,000 people coming into contact with Soapbox Science speakers this year. "Footfall in Newcastle was estimated to reach over 19,000 people, which is an absolute record for us. This was all down to the location and settings: first sunny Saturday of the year; event set up at a tube's exit in the middle of the city centre", says Dr Pettorelli.

As well as raising the profile of female scientists, Soapbox Science was also designed to generally enthuse people about how amazing science is. The grass-roots, no-frills set up of the event means people who wouldn't normally seek out science events are unexpectedly exposed to exciting scientific topics in a non-intimidating way, with speakers favouring silly props and interactive experiments over stuffy PowerPoint presentations in lecture theatres. Speakers talk about everything from psychology, physics and medicine through to biology, computer science and conservation. As Dr Sumner says: "Soapbox Science is designed to engage with the whole spectrum of society. People who don't usually think about science get to hear about it first hand, from scientists who don't necessarily have shaggy beards and odd shoes, but who do know how to share their passion for experimentation, discovery and innovation… and we aim to make a difference!"

And make a difference they are, with the public providing some fantastic feedback. "Our favourite was one little girl's mum telling us she had never seen a real woman scientist before," says Dr Sumner. "Several people told us that our events had inspired them to learn more about a given scientific topic; others told us that they came to see our events as they were considering to study science for their A level. Altogether, the feedback we got was really positive with an overwhelming majority of respondents likely to attend one of our events again."

Since the expansion of Soapbox Science, Dr Sumner and Dr Pettorelli have had their individual volunteering efforts recognised by the Prime Minister, David Cameron: "Seirian and I received Point of Light awards from the Prime Minister for Soapbox Science this year", says Dr Pettorelli. "That definitely surprised us, especially so when we saw our names mentioned by our MPs in our local newspapers or tweeted by Number 10! We are delighted for our initiative to receive such attention on its fifth birthday."

Dr Sumner and Dr Pettorelli have big plans for the future of Soapbox Science. They are currently working towards bringing events to Oxford and Cambridge, Hull, Cardiff, Milton Keynes, Southampton and Edinburgh, and are even looking to go international in 2016, taking Soapbox Science Down Under to Australia. "We are very much looking forward to setting up new events in these locations, and developing relationships with local organisers there" says Dr Sumner. "2016 is going to be a busy year for us!"

Soapbox Science is always on the lookout for new speakers to join the movement. "We are really keen to showcase the fantastic work done by female scientists funded by STFC or using STFC facilities" says Dr Pettorelli. "If you are one of these women, please do respond to our call for speakers, which will occur in January and February 2016: we are pretty sure one of our local events will take place nearby you!"

Meet the Soapbox Science speakers ▸

Keep in touch and find out more about becoming a Soapbox Science 2016 speaker by following the Soapbox Science Twitter account: @SoapboxScience or visiting the website: www.soapboxscience.org.

Meet the speakers: find out more about three of Soapbox Science's speakers

Kathy Romer

Amy Edgington

Cristina Lazzeroni

Kathy Romer

Fascination: Where do you work?
KR: The University of Sussex Astronomy Centre.

F: Where have you got on your soapbox?
KR: Newcastle and London Bridge Live Arts Festival.

F: What do you talk about on your soapbox?
KR: Cosmology, particularly Dark Energy and the Dark Energy Survey (DES). Dark Energy is a weird phenomenon that is driving the expansion of the universe. DES is a major international experiment to study Dark Energy by making a multi-colour map of the Southern night sky.

F: Tell us an awesome fact from your soapbox talk.
KR: Because of Dark Energy, the universe is expanding faster now than it was before. If Dark Energy continues unchecked, the Universe will eventually rip apart. This might seem farfetched, but we have evidence for it from a variety of sources, including exploding stars and from clusters of galaxies.

F: What has been your best audience question?
KR: Q: "Really?! So where do all the other elements come from?" A: "Gosh, I didn't expect to be explaining baryogenesis today, but let's go for it! We are going to start 2 minutes after the Big Bang to a time before there were atoms…."

F: What does Soapbox Science mean to you?
KR: I loved taking part: seeing the light go on in the eyes of members of the public, being with other female scientists, and even wearing the white coat (I'd not worn one since A-level Chemistry lab back in the 80s!). I felt like a celebrity (albeit a nerdy one!).

Amy Edgington

F: Where do you work?
AE: I am currently a PhD student in the Earth Sciences Department at UCL, studying the deep interior of the planet Mercury.
F: Where have you got on your soapbox?
AE: Soapbox Science has not only improved my public speaking dramatically, but has opened doors to more public outreach opportunities including the London Bridge Live Arts Festival and Lambeth Libraries Fun Palaces.

F: What do you talk about on your soapbox?
AE: With the help of a large polystyrene/papier mâché model of Mercury and iron bolts, I spoke all about my PhD research so far, investigating the materials deep beneath Mercury's surface. My talk ranged from the structure of planets to condensed matter and in particular how we can use atomic scale models to calculate the properties of materials at the extreme conditions within the centre of terrestrial planets.

F: Tell us an awesome fact from your soapbox talk.
AE: My big reveal was that a 50g iron bolt contains approximately 500,000,000,000,000,000,000,000 atoms! It was amazing to see the expression on audience members' faces when they realised that they were holding that in their hands.

F: What has been your best audience question?
AE: The best questions were those that the audience were really excited to ask, which varied from how far away is Mercury, to how many calculations have I run in my PhD? It was wonderful to be able to share my enthusiasm for the subject with the audience, and them share theirs with me.

F: What does Soapbox Science mean to you?
AE: For me, Soapbox Science means learning. It gave me the opportunity to teach members of the public of all ages all about the planets, and the research that I do - and show them why it's really interesting! Plus it gave me the tools to become a more confident communicator, and the ability to explain complex scientific ideas simply and effectively.

Cristina Lazzeroni

F: Where do you work?
CL: School of Physics and Astronomy, University of Birmingham and CERN

F: Where have you got on your soapbox?
CL: Exeter

F: What do you talk about on your soapbox?
CL: The matter-anti-matter asymmetry in the Universe

F: Tell us an awesome fact from your soapbox talk.
CL: That without this asymmetry from the very beginning of the Universe creation, and something very mysterious called CP violation, the world would be nothing would be nothing like it is now..

F: What has been your best audience question?
CL: I was explaining what happens when a strange and anti-strange quark annihilate, and a little girl asked what happens if a strange and an anti-charm quark get together. Very good question! I often find that the best questions come from little ones.

F: What does Soapbox Science mean to you?
CL: It was really interesting and somehow extraordinary to see that people wondering around shops on a Saturday afternoon actually wants to stop and listen about science! At exhibitions, talks, etc, the public is self-selected, but not here. That was the amazing thing, to see that a large crowd stopped and listened. ■

Image Credits (left to right): Travis Hodges, L'Oreal Women in Science, Cristina Lazzeroni

An interview with Professor Phil Manning

Professor Phil Manning is a palaeontologist, Professor of Natural History and Director of the Interdisciplinary Centre for Ancient Life at the University of Manchester. He is also a Research Associate at the American Museum of Natural History (New York) and a Visiting Scholar at the University of Pennsylvania. On top of all that, Professor Manning is also an STFC Fellow, and is passionate about public engagement in science. Ever wondered what the life of a real-life dinosaur hunter is like? Read on to find out!

Fascination: Hi Phil, can you tell us a bit about yourself and what you do?
Phil Manning: I will do my best, as life has a habit of throwing new challenges into my path on a daily basis…this is always exciting, and keeps me on my toes!

F: Give us a window into the life of a palaeontologist - what is an average day like for you?
PM: An average day doesn't exist. Well… not in the past 15 years or so. Since moving back to the University of Manchester, where I studied in 1990, my colleagues and I have been kept busy with an avalanche of projects, from research and fieldwork to outreach in multiple places/forms. If variety is the spice of life, then I am totally infused with the said spice! However, when we head into the field each summer, the rise and fall of the Sun dictates our day. We always try and optimise that special time when we get to amble through Earth's history in the field. When we are working at a synchrotron, a day is a relative measure, as we tend to work longer hours than a 24-hour cycle. Even at the University, we tend to be pulled between pillar and post working on multiple fronts these days. I think in the last 14 years I have had two vacations, but that does suggest I love my work; which I do.

F: We know you work across so many research fronts in natural history. Can you tell us about one of the things you're researching at the moment?
PM: Our team is currently studying the chemistry of life itself. At the Diamond Light Source, as well as other synchrotron facilities around the globe, we are imaging the fossil remains of life. We have realised that if we want to truly unpick the chemistry of fossils, we have to start with studying the composition of living (extant) species. We're in the process of generating a 'bio-bank' of chemical standards for different tissue types (from bone to skin). Each can be explained through the distribution and concentration of elements from which they are made. We even look at how each element is 'bound' in relation to neighbouring chemistry, permitting us insight to the very biological pathways that led to the construction of the tissue. In many cases the tissue, such as bone, can also give information on an organism's diet…you are literally what you eat sometimes! As we increase our knowledge of the chemistry of life from the world in which we live today, we are able to shed new light on past worlds from millions of years ago.

Archaeopteryx lithographica, the Thermopolis Specimen. This beautiful fossil shows both reptilian and bird-like characters and marks one of the earliest examples of a bird in the fossil record, some 150 million years old. This same fossil has been studied using synchrotron light to better understand the chemistry and preservation of this remarkable fossil (below).

F: How do different areas of science come together in palaeontology?
PM: I have often considered myself an 'accidental scientist'. My original intention, some 25 years ago, was to simply explore the globe and dig-up dinosaurs…but once we started applying science to dinosaurs, that's when life really got interesting. Working at the University of Manchester opened-up my eyes to the potential that palaeontology had, if only we could get often-disparate disciplines to work together. ▸

Prof. Phil Manning and a rather unlucky alligator that ended-up on the dissection table. This gator was hit by a car and died, but was donated to a vet school in Philadelphia, where Phil got to dissect the animal to study its bones, muscles, skin and other tissues to compare with fossils (above).

My journey to discovering the value of interdisciplinary research began with the discovery of a remarkable dinosaur, one that was mummified. The 66-million-year-old fossil from North Dakota (which we nicknamed 'Dakota') was a treasure trove of information, but we had to learn how to unlock this wealth of data. To do this, I assembled a team of scientists from multiple disciplines. The team consisted of biologists, geochemists (both organic and inorganic), computer scientists, engineers, geologists, physicists, archaeologists…to name but a few! I suddenly found myself in the middle of a group of scientists who all used different language to communicate their science, and we all had to find common ground to explain what we each wanted to achieve with the project. We soon realised that by working together from multiple disciplines, we could cross-check and validate our science as we reviewed samples from this splendid fossil. This project ended-up identifying some of the first organic fragments original to dinosaur skin, still locked within the fossil remains. We only achieved this by working together.

"Palaeontology is making a major contribution to answering some pivotal questions that will impact on the future of our species and those with which we share the planet."

F: Aside from learning about dinosaurs and how these amazing creatures roamed the Earth, what are the other benefits to studying dinosaur bones?

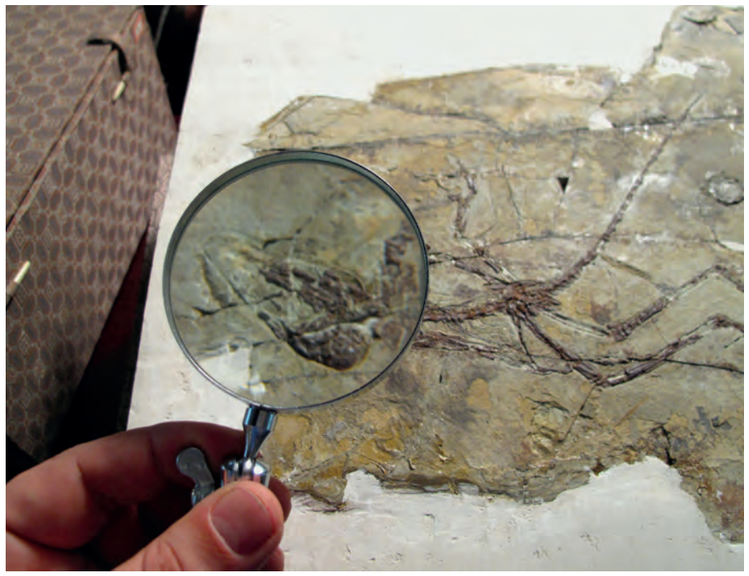
PM: Palaeontology is making a major contribution to answering some pivotal questions that will impact on the future of our species and those with which we share the planet. Many problems face humanity in the 21st century; from the long-term storage of our waste to our impact on the species that share the modern world with us.

When we study the fossil remains of life on Earth, we are able to do multiple things that many areas of science find very difficult to do. Let me expand on this. The safe burial of nuclear waste is one problem that faces many governments across the globe - how we can make sure that when we place such waste in the ground, that it will safely stay put for millions of years? The mobility of radioactive waste has the potential to damage water supplies and much worse, so an understanding of what happens when you bury something in the ground is critical. To a chemist, the burial of anything in the ground enables us to measure the mass transfer from the object in question to its surrounding environment, and vice versa. Ideally, such experiments should run over thousands of years, something our own mortality makes very hard to conduct. However, the fossil record [the history of life as documented by fossils] provides us with a series of time-stepped samples in multiple burial regimes. It is through the study of fossils that we can better constrain the mass transfer of elements from life to environment and generate more robust models to help us understand the kinetics of such pathways. Palaeontologists have known for many years that dinosaur bones naturally 'mopped-up' chelated radionuclides, such as Uranium. However, it is only recently that we have begun to study the uptake of Uranium in dinosaur bone as a possible 'biological mop' for waste. It seems that fossil bone can offer great insight to the mobility and bioavailability of compounds in past environments, which can inform how we can better manage modern environments for the future.

F: Your work takes you to excavation sites all over the world. What's it like to work in the field?

PM: After my previous answer trying to drag palaeontology away from excavations in deserts to the high-tech of synchrotrons…we have to admit, we do thoroughly our enjoy my time in the field every year! To be quite honest, this is the reason we [Phil's team] originally became a palaeontologists; we simply loved working in the great outdoors. It is our work in the Badlands of the American Midwest that has driven much of our research these past few years, excavating the 'fossil fuel' that has so helped our work continue at Diamond and other laboratories. It is wonderful to walk into wilderness with a backpack, water and supplies, and vast quantities of optimism. Each year we discover new fossils that directly feed into our research programme at Manchester and Charleston. Also, each year every member of the field team has the potential to find something so new, that it might challenge an existing paradigm. The excitement is clear when we take those first steps, each year, into the Earth's past. It is the closest we can get to being time travellers. ▸

Phil Manning points to the fossil remains of a 50-million-year-old bird from the Green River Formation of Wyoming, USA. The team are taking their first look at a fossil before it gets placed in the beam hutch to be scanned using synchrotron light (below).



Anchiornis huxleyi under the magnifying glass from the Late Jurassic of China, some 160 million years old. While many beautiful fossils such as this have been studied using visible light, it is through the use of synchrotron-based imaging that robust evidence for pigment has been identified (left).

F: You have used the Diamond Light Source at our Harwell Campus to aid you on some of your studies. How do synchrotrons like Diamond help with your research?
PM: The Diamond Light Source is a world-class facility that enables us to image life on Earth in such fidelity, that few facilities elsewhere can deliver such stunning results. The micro-focus X-ray fluorescence beam line, i18, offers us the unique capacity to not only map the chemistry of past life, but also constrain how much of the chemistry present in the organism is original to that life form. We are now at a stage where we can image biological processes based upon the presence of discrete chemical signatures.

"The excitement is clear when we take those first steps, each year, into the Earth's past. It is the closest we can get to being time travellers."

The amazingly bright light that Diamond shines on our samples, some 10 billion times' brighter than the Sun, supplies the ultimate beam to interrogate the evolution of life on Earth.

F: As an STFC Fellow with experience of working to promote the benefits of science and technology, what do you think needs to happen to inspire more children and young adults to pursue careers in science?
PM: It is my duty as a scientist and communicator to enthuse all generations about science. We do not have to convince folks that science is cool, as it already is. My career has provided me a wealth of experience in people, places and ideas that continues to grow day after day. No day is the same when you are pushing at the frontiers of science. As a child I had wonderful BBC programmes with Sir David Attenborough to inspire me, but such programmes are simply not made any more, making the role of scientists in the community even more important. What really needs to happen is for scientists to work together and promote 'all' science and not just 'core' areas. We should be less divisive on how we are funded but more socially responsible in how we educate wider audiences about our work. Not only should we promote our science to the next generation of scientists, we need to be ambassadors for science to the policy makers who ultimately drive much of what we do.

F: What inspired you to become a palaeontologist?
PM: The ability to pick up a fossil in my own garden aged seven years old. I needed no books and no prior knowledge, simply being inquisitive was enough - something that all scientists, however young, all possess.

Can you recall your first dig?
PM: I recall slowly working my way through my parents' garden in Somerset. It was littered with large boulders that contained fossils from the Lower Jurassic. Very soon, the boulders were reduced to gravel and the fossils curated to my bedroom!

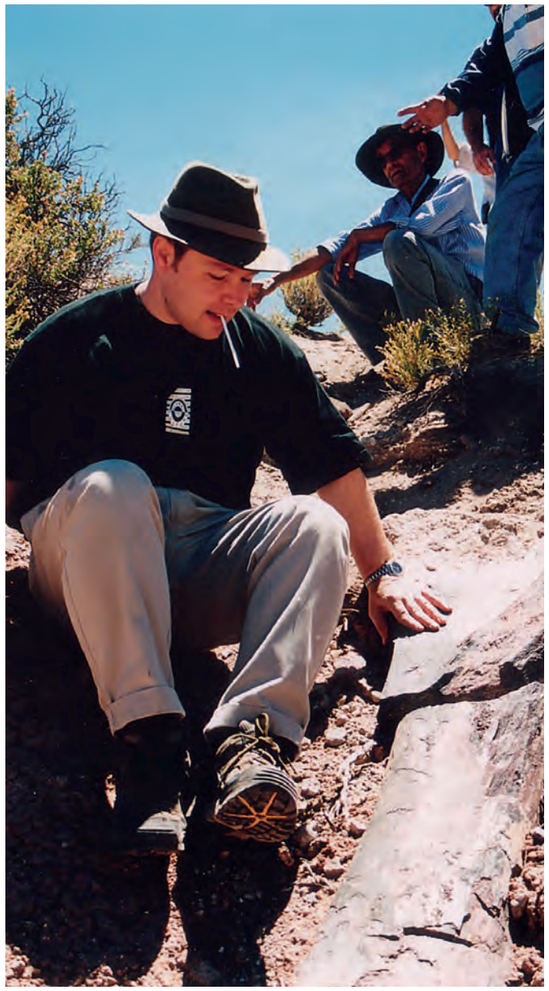
F: Twenty-five years into your career, what would you say has been your most awe-inspiring, 'wow' moment?
PM: There are too many 'wow' moments to choose one. It would be wrong of me to pick and choose, given I hope there will be many more. It is fair to say though, my first vertebrate find (a plesiosaur vertebra) in my home garden as a child still makes me smile!

F: What natural history question do you wish you could find the answer to the most?
PM: Simply to add more pieces to our understanding of the jigsaw puzzle that is the evolution of life on Earth. This story of life is a wonderful tapestry that mas many threads missing and is rather moth-eaten, making the mapping of life through time harder the further back in time we study. So, to sum-up, it would be wonderful to find the answer to 'the ultimate question of life, the Universe and everything'… to paraphrase the splendid Douglas Adams!

F: What advice would you give someone looking to become a palaeontologist?
PM: Advice is a minefield…very rarely is good advice applicable to all, given we all learn and approach our world in different ways. So, there is no 'one-size fits all' approach to becoming a palaeontologist. This said, almost all of us have skills that we can bring to palaeontology; given it is the ultimate interdisciplinary field. The hardest thing to teach is a passion for studying the evolution of life on Earth. Thankfully, many students bring this to the classroom in spades. Such enthusiasm is infectious and helps one and all access the greatest story every written, albeit in stone, the story of life on Earth.

F: What have you got planned for the remaining part of the year – will we be seeing you on our TV screens again anytime soon?
PM: My team and I often work with the media, as this is a useful way to reach many new folks and diverse audiences. Thankfully, dinosaurs and physics make for a fun area to cover by the media, so we are never far from a new show. In the new year we start filming an IMAX movie, 'In The Footsteps of Giants', with the Emmy-Award-winning team that we filmed 'Dinosaur-13'. In this new film we hope to show the wonders of life on Earth, with a liberal dose of the STFC-related science that really underpins the work my team and I are currently pursuing.

F: And finally, the obligatory question to ask any palaeontologist: what is your favourite dinosaur?
PM: This is akin to being asked to choose between your own children; an impossible thing to do. However, I have a great love of Archaeopteryx and Ankylosaurs…but to be honest, there is not a fossil on the planet that I would not stop to admire. ■



Giant bones of sauropod dinosaurs litter the ground in certain areas of the world. Here Phil Manning is looking at a large femur from one such sauropod dinosaur in Patagonia. Cut sections from dinosaur bones like this have been studied at the Diamond Light Source (right).
Credit: Phil Manning (all images).

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