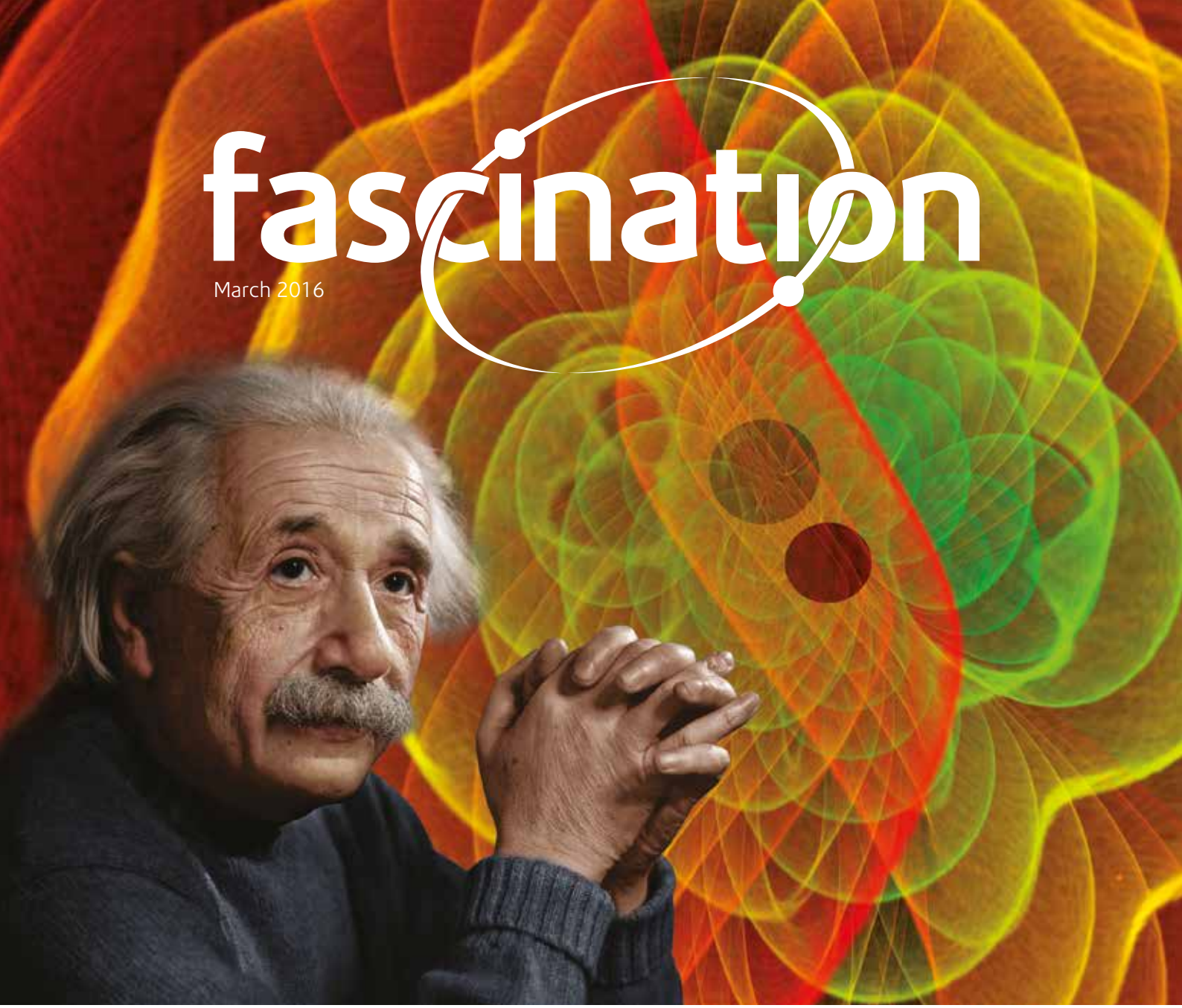
fascination

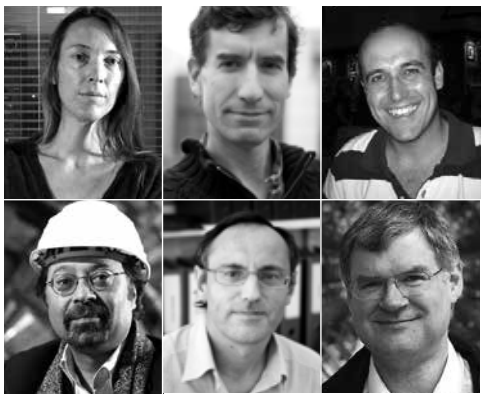
March 2016



Told you so!
Gravitational waves detected 100 years after Einstein's prediction

UK celebrates five years of bringing space technology to Earth for new start-ups

What will the Large Hadron Collider upgrade mean for physics?



Deep insights into carbon storage

Science & Technology Facilities Council

Welcome

Welcome to the March 2016 edition of ***Fascination*** magazine.

An international team of scientists has announced the first ever detection of gravitational waves. The discovery has been hailed as transformational, as it opens up a new way of observing the Universe. It also confirms the final key prediction of Einstein's theory of general relativity, published over a century ago. But why did it take 100 years for science to catch up with Einstein? Find out on page 20.

Have you ever considered a boring traffic jam on the M27 to be a place of inspiration for a globally-successful business idea? We hadn't – until we interviewed the founders of iGeolise, a travel time software company that has revolutionised mapping for the likes of VisitBritain, Zoopla and Jobsite. Turn to page 36 to discover how the ESA BIC helped put iGeolise on the map.

Remote caverns, subterranean passages, pioneering experiments – that's the heady cocktail of ingredients underpinning one of the most fascinating but least well-known science stories in the UK today. Turn to page 14 to learn more.

What exciting things does the upgrade of CERN's Large Hadron Collider, the machine that allowed us the discover of the Higgs boson, have in store for us? Turn to page 28 to discover what some of the country's leading particle physics experts predict the upgrade may mean for physics.

We hope you enjoy reading. As always, we'd love to know what you think of our magazine. Get in touch at fascination@stfc.ac.uk or contact us on Twitter @STFC_Matters.

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: Albert Einstein (left), S. Ossokine, A. Buonanno (Max Planck Institute for Gravitational Physics), W. Benger (Airborne Hydro Mapping GmbH) (background)

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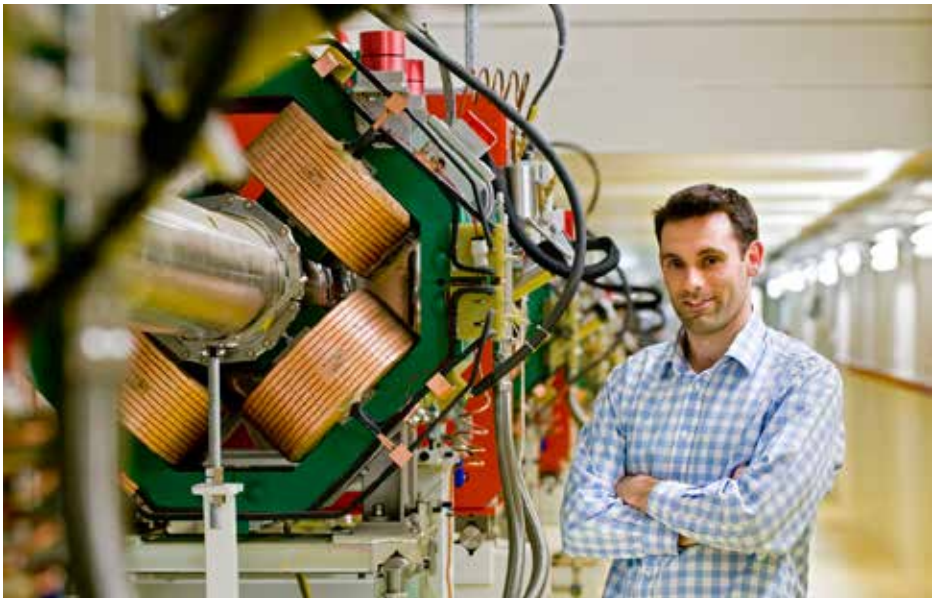
Major facility celebrates 31 years in operation



ISIS engineer Stephen Jago
Credit: STFC

ISIS neutron muon source, STFC's world-leading facility for research in the physical and life sciences, has been playing a key role in our understanding of materials science for 31 years.

Construction of ISIS began in 1978 when Nimrod, the existing accelerator on the site, was switched off and dismantled. In December 1984, the first neutrons were produced. Initially only 5000 pulses of protons were fed to the target, but this was sufficient for test experiments to confirm that our ISIS facility would be the world's leading spallation neutron source. It gave us a major step forward in carrying out research across a diverse range of scientific disciplines such as chemistry, physics, geology, engineering and biology.

The ISIS facility continues to shine as one of the UK's major scientific achievements. Dedicated to collaborating with external research partners from academia and industry, the facility supports a national and international community of more than 3000 scientists for research into subjects ranging from clean energy and the environment, pharmaceuticals and healthcare, through to nanotechnology and materials engineering, catalysis and polymers, and on to fundamental studies of materials. ■

For more information, visit
www.stfc.ac.uk/isis

Construction starts on Higgs Centre for Innovation

A celebration has been held to mark the official beginning of construction on the brand new Higgs Centre for Innovation at the Royal Observatory, Edinburgh.

Due to be completed in 2017, the Higgs Centre will focus on supporting start-up business, with the aim of creating new market opportunities both through incubation activities and access to facilities. It will link the world-class scientific and engineering expertise at our UK Astronomy Technology Centre with industry, connecting engineers, academics and PhD students directly with small and medium-sized entities.

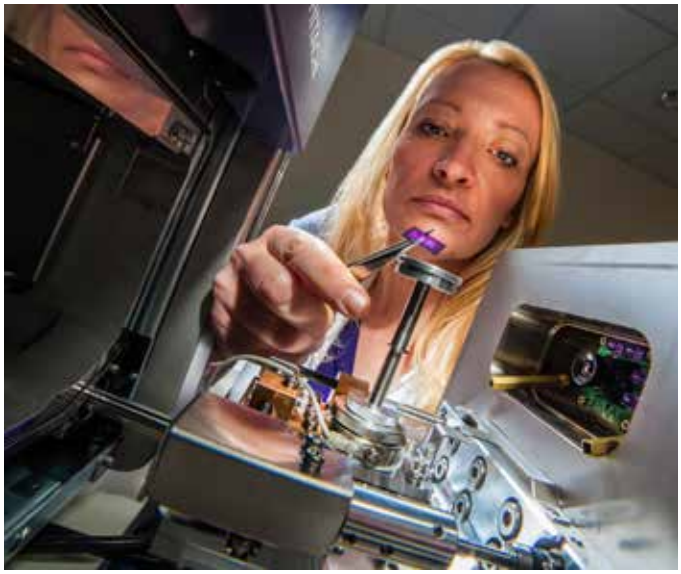
Final designs for the building were unveiled at the event on 27 January by jmarchitects, the company with responsibility for the implementation of the building.

Gillian Wright, Director of the UK Astronomy Technology Centre, said: "A huge amount of work has been put in by all partners over the past year to develop plans for the Higgs Centre for Innovation and now we begin the exciting phase of seeing it built before our eyes. We look forward to the completion of this important project and the benefits it will bring to both future generations of scientists and industry."

Named in honour of University of Edinburgh's Professor Peter Higgs, the centre is funded through a £10.7 million investment from the UK Government, along with a £2 million investment from STFC over five years, to operate the centre. ■

North Birdseye architectural drawing of the Higgs Centre for Innovation
Credit: jmarchitects

I-TAC challenge competition – fast-tracking SMEs to success



Technician working in an I-TAC laboratory
Credit: STFC

STFC's Innovations Technology Access Centre (I-TAC) is offering new small and medium-sized enterprises less than five years old undertaking research and development in life sciences/ healthcare, chemical, pharmaceutical, energy, environment, advanced materials and food industries the chance to win up to six months' free access to its laboratories, specialist facilities and equipment to accelerate their technology development.

Through ready access to an impressive array of shared lab facilities, including fume cupboards, de-ionised water, gases and analytical services, working with our I-TAC means up-front capital costs are reduced, allowing SMEs the time to concentrate on developing the business and focussing investment where it is needed. I-TAC allows companies to either lease their own exclusive self-contained lab or opt for access to a 'hot lab' and multi-user areas available on an hourly, daily, weekly or monthly basis to deliver a project.

For the opportunity to win six months' free access, businesses are invited to submit an application form outlining their requirements and how they believe I-TAC and STFC can support their business to develop. ■

For full details on how to apply and application criteria, visit www.stfc.ac.uk and search 'I-TAC Challenge Competition'.

That's not a sword. THIS is a sword!

Dr Antonella Scherillo places a sword into the INES beamline at ISIS, an instrument developed for the Italian scientific community
Credit: STFC

Over a thousand years ago, an unusual and very expensive kind of steel, known as crucible steel, was being produced in many areas of the Indian subcontinent, Iran and central Asia. The material was so strong, unequalled in Europe, that many people tried to replicate it and pass their swords off as the real thing.

The question is – out of the swords in the Wallace Collection, which ones are real and which ones aren't? Some of the swords lack the tell-tale 'watered-silk' pattern of crucible steel, known as 'Damascus', but this is almost certainly due to over-polishing by 19th century dealers. Others may be counterfeits, with the pattern falsely etched on the surface of cheaper metal.

Dr Alan Williams and Mr David Edge from the Wallace Collection are working with Dr Francesco Grazzi from the Italian National Research Council (CNR) to solve the mystery surrounding the swords. Using neutrons from the ISIS instrument known as INES, they are investigating the quality and type of steel used in a selection of sixteen Indo-Persian swords from the Wallace Oriental Armoury Collection. Due to its non-destructive nature, neutron scattering provides the perfect solution for studying ancient swords and detecting hidden patterns on the blades.

This is just one study made possible by a long-standing working relationship between STFC's ISIS neutron and muon source and the Italian National Research Council (the CNR).

"INES and the STFC-CNR collaboration, along with other collaborations with international facilities are crucial for the scientific Italian community as there are no neutron sources in Italy," said Dr Antonella Scherillo, ISIS instrument scientist for INES.

The ongoing research is expected to help accurately catalogue what amounts to over a thousand items of armoury.

Using our ISIS neutron and muon source, the UK's centre for studying the properties of materials on the atomic scale, scientists in the UK and Italy are helping conservationists as they try to establish whether material in a series of swords featured in the prestigious Wallace Collection in London are made from the crucible steel, or are replicas. ■

For more information, visit www.stfc.ac.uk/isis

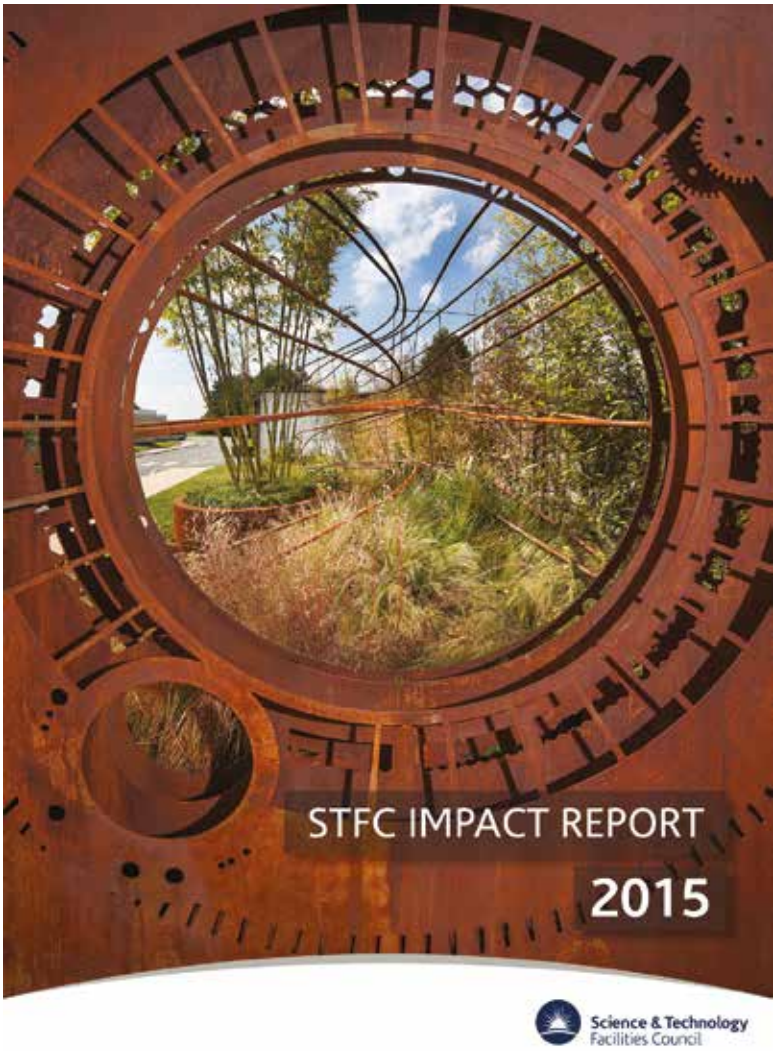
UK invests £72 million on cutting-edge particle physics research

LHCb collaboration in front of the LHCb detector
Credit: CERN

Cutting-edge particle physics research in the UK will receive £72 million over the next four years. This funding will enable researchers from 17 universities in the UK to focus on answering some of the big questions we still have in understanding the Universe - such as the mysteries of dark matter, the unseen 'stuff' that is believed to make up a big percentage of our Universe.

Professor John Womersley, particle physicist and Chief Executive of STFC, said of the funding announcement: "The UK's particle physicists are world leaders in expanding our understanding of some of the biggest and deepest questions in science. The support will enable this incredibly successful research community not only to analyse the new data coming from CERN, but also to work on developing new applications for particle physics technology and to continue to inspire future generations with the excitement of discovering how the Universe works". ■

New publications: STFC Impact Report 2015



Read our ***Impact Report 2015*** online:
www.stfc.ac.uk/files/impact-report-2015/

STFC's vision is to maximise the impact of our knowledge, skills, facilities and resources for the benefit of the United Kingdom and its people. The *Impact Report 2015* presents quantitative data and case study examples which illustrate the breadth and depth of our economic and societal impact over a year period.

In the 2015 edition, we showcase how long-term, fundamental research conducted at our ISIS neutron and muon source over the past 30 years has had a significant impact on UK society and the economy, amongst other achievements. ■

Reaching out

They got out of there – but where are they now?

Online outreach competition, 'I'm a Scientist, Get me out of here', has been funded by an STFC Large Award since 2013. Dozens of STFC scientists and engineers have taken part, talking to school students in different online 'zones' and competing for their votes at imascientist.org.uk.

The researchers voted the winners of each zone receive £500 to use for their own public engagement activities. Antony Poveda, Project Wrangler for I'm a Scientist, caught up with three previous winners to find out about the impact of their prize money and what they learnt from taking part in the online event…

Sam Connolly
Credit: STFC

"Until I went to University, I had never met a scientist, even though I wanted to be one."
- Sam Connolly

Sam Connolly, of the University of Southampton, set about changing this with the help of the I'm a Scientist prize money. "My favourite part of any outreach is always answering the questions people have" says Sam, "I love talking about science and like the challenge of questions whose answers can sometimes be very difficult to explain. I'm a Scientist was amazing because it was nothing but questions." Sam was runner-up to Roberto Trotta in the Astronomy Zone, but after securing funding for his own project through a STFC Engagement Fellowship, Roberto kindly donated the £500 to Sam.

Sam says that taking part in the competition brought home to him that researchers meeting children had to be key to his plans for the unexpected prize money. "I'm a Scientist is all about school students learning that scientists are just normal people who are really interested in science and meeting one in person teaches the same thing - anyone can be a scientist. This really encouraged me to use the prize money to talk to as many school students as possible in person."

Sam, now nearing the end of his STFC-funded Astronomy PhD, used the money to take 'Astrodome', his group's inflatable planetarium, to local schools, including his very own secondary school, Bulmershe School in Reading. The prize money funded ten extra school visits on top of the dome's regular bookings, reaching over 1500 people.

"We spent a whole day at each school doing shows to explain what a modern astronomer does, some of the science behind objects you can see in the night sky, and our research at the University of Southampton" says Sam. "The dome fits around 35 people, so each group got an intimate, personal show by two Astronomy PhD students."

Sam is now doing more online science communication, organising the SETI Cipher Challenge, a competition for schools that took place over the summer of 2015. He intends to keep up outreach alongside his work. "The really great thing about talking to the public about your research is that there are always a huge number of people who are interested – talking to them reminds you why it's worthwhile."

Clara Nellist
Credit: Clara Nellist

"The reach of the project could be huge." – Dr Clara Nellist

CERN researcher, Dr Clara Nellist, also has high hopes for the impact of her prize money. Clara recently completed her STFC-funded PhD on improving the detectors of the ATLAS experiment. During this time she also emerged victorious from the Nuclear Zone in I'm a Scientist.

"Apart from it being a really enjoyable two weeks of sharing my research and love of science with enthusiastic young people, it also forced me to re-think how I answer questions to non-specialists." says Clara. "I learnt that it was possible to do good science communication online and I was able to develop my ability to describe complicated scientific concepts in a clear and understandable way. I also had to learn to think quickly, as the live chats could be intense, with many fantastic questions being asked in a very short space of time."

I'm a Scientist has been shown to act as a boost for researchers' public engagement with participants doing more outreach in the year after taking part* than they did previously. Clara is no different: "After seeing how much you can do online, I was motivated to find more ways I could use the nternet to communicate the research at CERN," she says, "and now I even manage all of the social media for my experiment, ATLAS."

Since her victory, Clara has joined the team of scientists working on the CosmicPi project, an initiative aiming to bring particle physics to the public by building cheap, open source cosmic ray detectors small enough to fit on a table top. Cosmic rays come down from the sky and surround us, passing through and around our bodies all the time. These can be monitored by detectors which, up to now, have been large and expensive. However ,the CosmicPi project aims to allow everyone who has an open source detector to join citizen scientists around the globe in collecting data.

Clara has used her winnings to further the CosmicPi project: "The prize money was put towards developing the next prototype and on materials to spread the message", says Clara. "The aim is to use materials which are as affordable as possible, such as the Raspberry Pi. This means schools around the world can take the design, start building their own and begin measuring cosmic rays coming from the sky and beyond!"

Thanks to Clara and the team behind the project, the public will soon be taking their first measurements. The runners up in CERN's Beam Lines for Schools Competition will receive a CosmicPi of their own.

Nick Wright
Credit: Gallomanor Communications Ltd

"We're providing the school students with a glimpse of what real scientific research is like" – Dr Nick Wright

Dr Nick Wright, Ernest Rutherford Fellow at Keele University ,was voted the winner of 2014's Extreme Size Zone by the students and he feels he gained more than just the prestige of winning: "It helped me understand how to speak to school children during public engagement, how to phrase answers to questions and what level to aim things at." he says, "That's always good experience."

This experience came in useful when Nick decided to adapt his ideas for the prize money to focus more on directly engaging students. I'm a Scientist winners are free to change their plans if they get new ideas during or after the two weeks of talking to students online. Nick took advantage of this freedom to do more than the posters for classrooms he'd originally planned: "I wanted to do something more proactive that would have a longer-term impact on school children across the country."

Nick decided to use the prize money to fund regular visits to help set up a STEM club at a local school and work with them to create resources for teachers. Over the last year he has used freely-available astronomy data to create pre-packaged projects that help school students complete space-themed CREST Awards. CREST is a UK STEM (science, technology, engineering and maths) award scheme for 11 – 19-year-olds that enhances curriculum learning by enabling students to build their skills and take ownership for personal achievement in project work. "My hope is that students will benefit from experimenting with the wealth of free data and beautiful astronomy imagery, and some might be inspired to pursue scientific subjects at A-level, and beyond," says Nick.

"I thought this would be a perfect opportunity not only to test my CREST projects, but also to work with a school in setting up a STEM club, and see the process through the teacher's eyes."

Nick's CREST projects will soon be available online and he is already looking at using his resource development skills again to create content for Keele University's STFC-sponsored portable planetarium. ■

Find out more about I'm a Scientist and apply to take part:
imascientist.org.uk/scientist-apply

* Figures available here: http://about.imascientist.org.uk/2014/does-im-a-scientist-enhance-the-participation-of-scientists-in-public-engagement

UK celebrates five years of bringing space technology to Earth for new start-ups

Since 2010, over 50 new space technology start-ups have launched in the UK, rocketing to become thriving, growing businesses thanks to the support of the European Space Agency's Business Incubation Centre (ESA BIC Harwell), now celebrating its fifth anniversary.

Managed and co-funded by STFC, the ESA BIC Harwell is the first business incubation centre supported by ESA in the UK. Its sole mission is to enable small, budding businesses and entrepreneurs to translate their brilliant ideas about how they can use space technology and develop the 'next big thing' in non-space fields. So far, these range from travel technology to regenerative healthcare, tracking resurfaced divers and surveying volcanic ash clouds, to protecting agriculture for farmers in Africa and even detecting bedbugs, just to name a few.

"For any start-up or entrepreneur, coming up with a great idea is just the first step in the innovation process, and turning an idea into a winning commercial offering is a massive challenge", says Michael Norris, our Head of Business Incubation. "The ESA BIC Harwell provides the ideal environment to do this and I am thrilled to say that, over the last five years, it has already played an invaluable role in the growth and success of over 50 early-stage companies. The ESA BIC Harwell plays a crucial role in maximising the potential of space for future economic growth, keeping the UK at the forefront of the global science race, creating jobs and profitable businesses."

As STFC provides the UK with access to world-leading, large-scale facilities and expertise across a diverse range of physical and life sciences, we are ideally placed to support small businesses develop their innovative ideas.

The Antarctic aurora,
Credit: ESA/NASA

The ESA BIC Harwell is one of a wider European network of 12 successful ESA BICs, as part of ESA's Technology Transfer Programme. Managed and co-funded by STFC, it provides up to ten companies a year with an impressive two-year support package that enables them to harness intellectual property, technologies and expertise generated by ESA research, alongside £41,500 funding, access to STFC's world-class research facilities and skills, and a dedicated STFC business champion.

"It is great to have STFC as our partner here in the UK. Working together on repurposing space technology and innovations for terrestrial purposes has really opened opportunities for a vast pool of engineers, researchers and competence," says Frank Salzgeber, Head of ESA's Technology Transfer Programme Office and responsible for the coordination of the ESA BIC programme, and the regional partners.

"We are very proud to work with STFC, and their involvement has been paramount to the success of our ESA BIC Harwell start-ups. It is wonderful to see how, after five years, the alumni and the current incubators are interacting together, exchanging ideas and inspiring each other. This is the foundation of more new businesses and employment opportunities. The 50 start-ups here at Harwell are already part of more than 300 we have supported so far in Europe with our incubation centre programme."

It is well-established that space technologies can be used to improve our lives and wellbeing. Here are just some of the current companies and recent alumni of the ESA BIC Harwell doing just that:

"It is very exciting to use satellite technologies for transforming baby products. We look forward to bringing more smart baby products to the market for helping baby care by using high-tech space technologies."

Oxford Space Structures

Oxford Space Structures is using technology that was developed for ESA's Alphasat mission to deploy satellites in space, to develop commercial baby-care products. The company will launch its first product, the SpaceCot in January 2016. The first UK premium baby travel cot on the market, it weighs less than five kilograms and can be assembled with one hand in three seconds.

Fujia Chen, CEO at Oxford Space Structures, said: "It is very exciting to use satellite technologies for transforming baby products. We look forward to bringing more smart baby products to the market for helping baby care by using high-tech space technologies."

Space Cot advertising
Credit: Space Cot

Clean room facilities at
The Electrospinning Company
Credit: The Electrospinning Company

The Electrospinning Company

The Electrospinning Company was the first company to join the ESA BIC Harwell when it opened in 2010. The company is using equipment designed for use in space programmes to develop and produce nanofibre materials for the biomedical research industry. It has since become a leading provider of materials for regenerative medicine and drug discovery. During its incubation period at ESA BIC Harwell, the company took part in the European Re-Liver project to improve the treatment of liver-associated diseases, and it is currently collaborating with the University of Sheffield in an international project to develop and test a new technique to address loss of vision caused by scarring of the cornea.

Ann Kramer, Chief Executive at The Electrospinning Company said: "Being at the ESA BIC Harwell was invaluable to us, giving us flexible access to state-of-the-art laboratories and networking opportunities. This meant that we could improve our own techniques and equipment and were able to turn our plans into actions and expand our team, whilst working and collaborating with people we might not have met otherwise."

Insect Research Systems Ltd

Insect Research Systems Ltd is developing a detector that enables the global hospitality industry to reproducibly, accurately and rapidly monitor for the presence of bed bug infestations. An infestation can prove expensive for hotels as a result of the costs associated with their effective elimination, the losses resulting from damage to the reputation of the hotel brand and the risk of litigation. The company is building upon the know-how and experience of developing instrumentation for solar system exploration, such as ESA's comet-chasing Rosetta mission, and subsequent translational projects at The Open University addressing a range of challenges back here on Earth.

Insect Research Systems Ltd Website
Credit: Insect Research Systems Ltd

RealTag

RealTag has developed technology that enables consumers to know that an item they are buying is authentic, and for brand owners to securely tag their goods, protecting their reputation and profits. RealTag uses technology to create a readable optical solution that will work across all smartphones – effectively turning any smartphone into a verification tool. ESA BIC has helped RealTag in developing the tech and introducing the company to valuable technology suppliers.

RealTag homepage
Credit: RealTag

Soil Sampling GPS Hardware
Credit: IPF Africa

IPF Africa

IPF Africa is about to deliver space technology to farmers in southern Africa. The SeeCrop app will allow farmers to monitor their crops for damage using satellite imagery. By using their smartphone or tablet's GPS, farmers will be able to record the precise location and cause of crop damage while out in the field. Farmers cannot physically check every inch of their crops and therefore to rid a field of pests, weeds and diseases, they will typically spray the entire area with a crop protection chemical. However, by allowing farmers to record geo-referenced agronomic observations while out in the field, the technology will allow them to target treatments to specific areas, saving the farmer money and reducing the negative environmental impact of unnecessary applications.

Esplorio

Esplorio is a travel start-up, which, through mobile application technology, aims to provide an easy way for people to record, relive and share their travels. It lets users automatically record their travels with just a push of a button, aggregating GPS data from their mobile devices and social data to produce detailed interactive maps and timelines. The trips can easily be shared on social media and can also be used to understand a user's travel preferences, allowing Esplorio to make highly-personalised travel recommendations for the future to its users.

Esplorio software shown on devices
Credit: Esplorio

GigBug Homepage
Credit: Electronic Wonderland

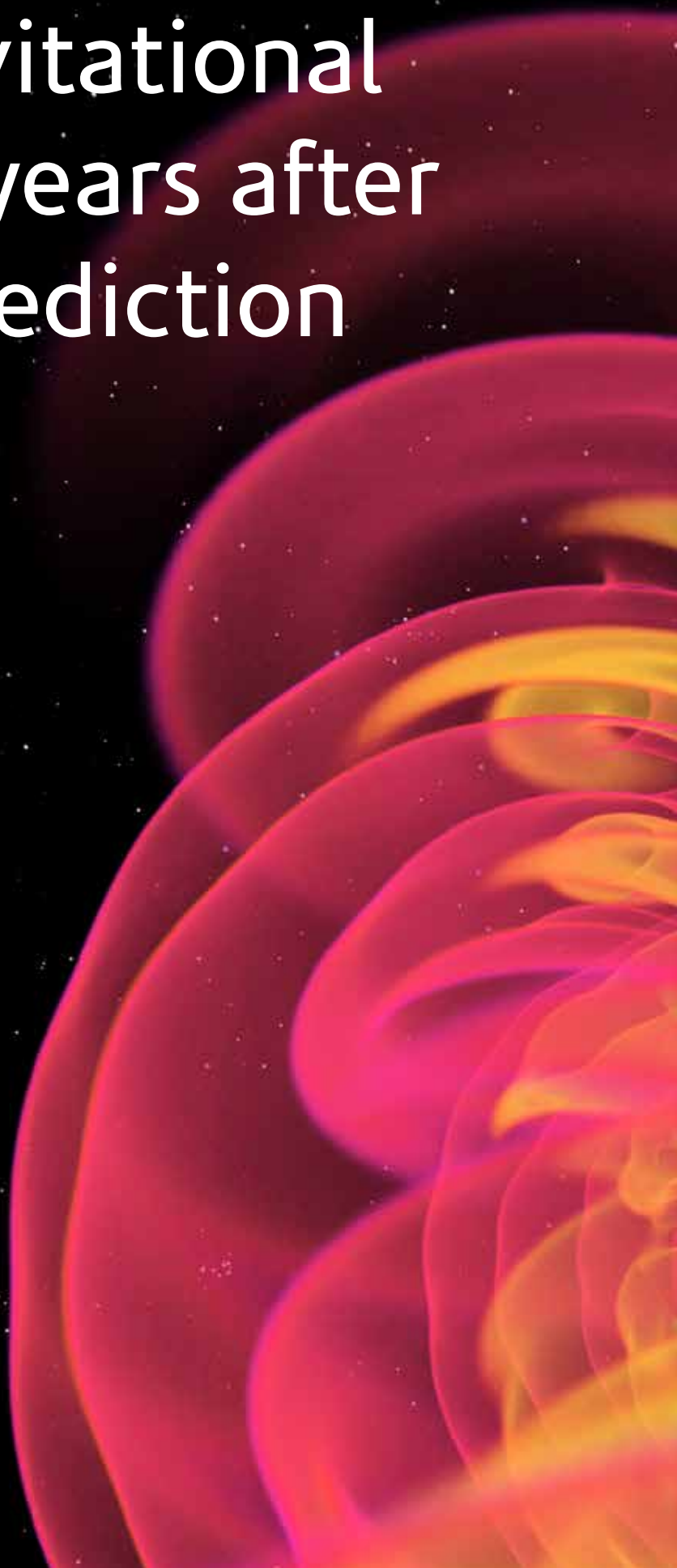
Electric Wonderland

Electric Wonderland is working on the creation of an innovative and comprehensive gig searching app known as Gigbug, which is due for launch within the next 12 months. Gigbug is a mobile application and an event guide that allows you to find gigs around you, providing users with a comprehensive local entertainment search.

For more information about the ESA BIC, visit:
www.esa-bic.org.uk
For ESA BIC updates on Twitter: @STFC_B2B

LIGO experiment detects gravitational waves 100 years after Einstein's prediction

An international team of scientists has announced the first ever detection of gravitational waves. The discovery has been hailed as transformational, as it opens up a new way of observing the Universe. It also confirms the final key prediction of Einstein's theory of general relativity, published over a century ago. But why did it take 100 years for science to catch up with Einstein?



Gravitational waves emitted during inspiral and merger of the black hole binary detected by LIGO.

Credit: S. Ossokine, A. Buonanno (Max Planck Institute for Gravitational Physics), W. Benger (Airborne Hydro Mapping GmbH)

Gravitational waves were detected by the Laser Interferometer Gravitational-Wave Observatory (LIGO) experiment on 14 September 2015, a matter of weeks after it had been upgraded to a higher sensitivity. The experiment is based at two sites in Louisiana and Washington, separated by around 3000 km. Instrumentation developed in the UK played a key role in the discovery, announced on 11 February in Washington D.C.

The waves were a by-product of the cataclysmic collision of two black holes, respectively 29 and 36 times the mass of the Sun, located 1.3 billion years from Earth. The objects orbited each other 30 times a second before accelerating to half the speed of light, slamming together and merging in a collision that lasted only 20 milliseconds.

Immense energy was emitted during the merger, equating to around three times the mass of the Sun. Dr Stuart Reid of the University of West Scotland noted that the "emitted energy in gravitational waves is comparable to the total light power being emitted by all the stars in the entire galaxy… staggering!"

Professor Alberto Vecchio of the University of Birmingham, stated that the observation is "truly incredible science and marks three milestones for physics: the direct detection of gravitational waves, the first observation of a binary black hole, and the most convincing evidence to-date that nature's black holes are the objects predicted by Einstein's theory."

The experiment

The LIGO experiment is the most precise measuring device ever built. It is a laser interferometer, which means it's a swanky ruler that uses lasers to measure length precisely… very precisely.

Each LIGO site comprises two arms, each four kilometres long, arranged in an L-shape. A laser beam is split in two and then shot down each arm. The constituent beams are reflected back and forth between damped mirrors, then recombined and directed to a photodetector.

Here's the clever bit: if the lengths of the arms are exactly the same, then the constituent parts of the beam will be in phase and register negligible signal on the detector. But gravitational waves passing through the experiment will stretch and squeeze space-time, changing the distance between the mirrors by a tiny amount. The beams will no longer be in phase when they recombine and so will interfere with each other. This interference will be detected by the photodetector.

A still from a computer simulation showing the merger of two black holes that caused the gravitational waves detected by LIGO on 14 September 2015. Credit: Simulating eXtreme Spacetimes (SXS) Project.)

Gravitational waves

Let's get the tricky bit out of the way. Einstein's theory of general relativity provided an entirely new way to think about gravity (sorry Newton!). He no longer distinguished between space and time but described them as a single entity – space-time – that makes up the fabric of our Universe.

Objects naturally follow straight lines through space-time but mass causes space-time to curve. So when objects pass near mass, their path is curved. This is what we perceive as gravity.

Now, when mass (such as a big black hole or teeny weeny human) accelerates, it generates changes in the curvature of space-time. These changes propagate outwards as concentric ripples – like tossing a pebble into a still pond. The ripples squeeze and stretch space-time, and travel at the speed of light. They are extremely subtle and difficult to detect.

LIGO can detect a change in the length of the arms of 10^{-19} metres – that's one-ten-thousandth the diameter of a proton! This level of precision is required to detect gravitational waves, and it has taken 1000 scientists from 16 countries over 50 years to achieve it.

The birth of gravitational astronomy

There's more to this discovery than first meets the eye. Professor Sheila Rowan, Director of the University of Glasgow's Institute for Gravitational Research, notes that "this detection marks the birth of gravitational astronomy. It expands hugely the way we can observe the cosmos and the kinds of physics and astrophysics we can do – with more discoveries to come!"

Astronomers currently observe the Universe using telescopes that detect light, X-rays and microwaves – all forms of electromagnetic radiation. Gravitational waves however provide an entirely new way of observing the Universe. Unlike electromagnetic waves, they travel unimpeded through matter and so provide information on objects that don't emit light, such as black holes. This is why gravitational astronomy is described as listening to the Universe.

Or as Dr Ik Siong Heng of the University of Glasgow eloquently puts it, "we can now listen to the symphony of the cosmic orchestra played to us from the darkest, densest regions of the Universe".

What will we hear?

This is where things get really interesting. Until now, astronomy has looked upon the cosmos as a calm sea but gravitational waves will allow astronomers to observe space-time during its most extreme storms. Professor B S Sathyaprakash of Cardiff University thinks that LIGO has "opened a new window to observe violent processes, such as merging neutron stars, supernovae, gamma ray bursts and other cosmic phenomena."

And while the early Universe was opaque to light, it was transparent to gravitational waves. So gravitational waves may contain information about the beginning of time.

We need more detectors!

Astronomers need more data. LIGO itself is currently operating at about one third of its designed sensitivity, so scientists expect to detect more gravitational waves with the instrument in 2016.

At least three detectors are required to triangulate wave signals and pinpoint the location of sources being observed. As luck would have it, the Advanced Virgo detector will go on line in Pisa, Italy later this year. Construction of a gravitational wave detector called KAGRA is underway in Japan, while there are plans to build a further LIGO detector in India in the coming years. Germany also hosts a ground-based gravitational wave detector called GEO600. And with space-based interferometers such as LISA Pathfinder also under development, it seems like we are on the cusp of a new era of astronomy.

Vindication

LIGO's detection of gravitational waves is momentous for several reasons. It is a phenomenal feat of precision engineering, provides the best evidence yet of the existence of black holes and their coalescence, and opens the door to a whole new kind of astronomy. But perhaps the most striking aspect is that 100 years ago – in midst of World War I – Einstein predicted how the Universe works. And he's been proved overwhelmingly correct.

As STFC's Chief Executive, Professor John Womersley, puts it:

"It has taken 100 years and the combined work of many hundreds of the cleverest scientists, engineers and mathematicians on Earth to prove that this key prediction of Albert Einstein is correct, and show that gravitational waves exist. Of course Einstein was always the smartest guy in the room." ■

Mirror Mirror on the Wall

The UK played a key role in the development of LIGO, investing over £7.8 million and designing the suspension systems for maintaining the stability of the mirrors used to reflect the laser beam.

Dr Giles Hammond of the University of Glasgow notes that the "suspensions are built from fused silica and support the 40 kg interferometer mirrors. Their goal is to reduce noise sources due to ground motion and thermal fluctuations, essential to produce the quiet reference frame necessary to detect gravitational waves."

The discovery of gravitational waves could not have been made without the UK helping to make LIGO's mirrors very, very still.

A technician inspects optics (mirrors) at LIGO. Credit: Matt Heintze/Caltech/MIT/LIGO Lab

Anthrax toxin: a new tool in the fight against cancer?

Famed for being a deadly disease, discoveries have now been made about how we can use the bacterium behind anthrax to treat other illnesses.

Conceptualisation of Anthrax bacteria.
Credit: Promotive | Dreamstime.com

What is anthrax and why are we researching it?

Anthrax is an acute disease caused by a bacterium that spreads via spores, which can become fatal when activated.

Its ability to spread through the body so 'effectively' makes anthrax attractive to scientists as a potential tool for drug delivery. By exploiting the anthrax toxin's natural ability to navigate cells' defences, the toxin components can be used to access specific compartments within a cell.

What has the research shown?

A team led by Dr Simon Richardson at the University of Greenwich has shown that by disarming the 'warhead' within anthrax, the toxin can be converted into a positive tool for delivering 'heavy' drugs, or those with a large mass, to where they are most needed within the cell.

"This is the first time a disarmed toxin has been used to deliver gene-modulating drugs directly to a specific compartment within the cell. We've achieved this without the use of so-called helper molecules, such as large positively-charged molecules like poly(L-lysine).

"This is important, as while these positively-charged molecules, known as 'polycations', can condense DNA and protect it from attack by enzymes before it reaches the target, they are also known to be toxic, break cell membranes and are sent quickly to the liver to be removed from the body. In this study, we demonstrate that using disarmed toxins without a polycation is effective, at a cellular level," said Dr Richardson.

Scientists used STFC's ISIS neutron and muon source to visualise the system they'd built at the molecular level. Neutron measurements enabled the scientists to see that the drug delivery molecules they had designed were behaving as they had predicted.

How did the team stop anthrax from causing lethal damage?

Using genetic engineering, the team showed that the anthrax toxin's 'warhead' can be replaced with a gene therapy drug. The toxin's 'rocket motor' is left in place and can be used to transport the drug

to the inside (the cytosol) of a cell, preventing it from being digested in the cell's stomach (or endolysosome). Rather than making a hole in a cell to get inside, which is harmful, this delivery system uses anthrax's natural ability to get to specific compartments within a cell through an 'airlock'- like system, leaving the cell membranes unharmed.

What does the breakthrough mean?

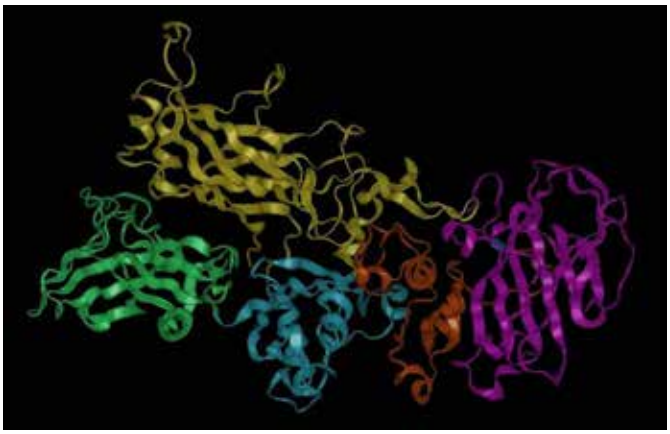
This new breakthrough builds upon years of research that has shown that synthetic, man-made materials (that have many well-known limitations) are not the only tools that can be used to deliver gene therapy drugs. This technology has been developed in relation to a gene therapy known as antisense (or siRNA) therapy, which effectively 'turns off' the expression of a gene causing problems.

How could the new delivery system improve cancer treatment?

Antisense therapy, a type of gene therapy, is being considered as one of the potential options for treating cancer. Without the delivery system, the therapy looks promising, but lacks the ability to effectively reach the correct compartment inside the cell. Consequently, the team are investigating whether the modified anthrax toxin will provide a solution; giving the drug the extra boost they need to get to the right part of the cell to produce an effect.

To test the delivery system, experiments were done on cancerous human cells (both HeLa (cervical cancer) and THP-1 (leukemia) cells) that were grown in the laboratory at the University of Greenwich. Scientists were able to deliver these drugs to their end destination with high efficiency and low toxicity, showing that their proposed method is effective thus far.

This novel approach towards treating disease could also have anti-viral and food security applications.



Anthrax toxin is composed of a cell-binding protein, known as protective antigen. This ribbon diagram shows the structure of the PA83 monomer.

Credit: STFC

What happens next?

Now that the team have demonstrated that anthrax can be used to deliver the gene therapy drug to the target cell, their focus turns to trying to find out exactly how the drug gets into the cell and if this system can be used in a more complex environment that is more like a patient than cells growing in a dish.

Dr Paul Dyer, lead scientist of the neutron study from the University of Greenwich, will return to the ISIS neutron and muon source to lead further neutron experiments, hoping to discover how the 'gate keeper', a doughnut-shaped protein which lodges in the cell's defence, opens the gate for the drug to pass through into the cell. Results from this project may not only impact on the use of gene therapies in the fight against cancer, but may also apply to food security and preventing the release of anthrax both accidentally and deliberately. ■

Deep insights into secure carbon storage

In the battle against climate change, capturing carbon dioxide (CO_2) before it escapes into the atmosphere could become one of our most effective weapons. But once captured, can it be stored securely? The unique environment and expertise at STFC's Boulby Underground Laboratory are being harnessed to develop cost-cutting technology that could help establish the UK as a global leader in this fast-emerging field.

Digging for the truth

Remote caverns, subterranean passages, pioneering experiments – that's the heady cocktail of ingredients underpinning one of the most fascinating but least well-known science stories in the UK today. Buried over a kilometre beneath Boulby Cliff in North Yorkshire, in a working potash and rock salt mine (operated by ICL-UK) boasting over 1000 kilometres of excavated tunnels, is a remarkable facility renowned globally for its increasingly wide-ranging and influential scientific work.

Boulby Underground Laboratory opened for business back in the early 1990s. It rapidly established itself as a specialist in the search for dark matter – the 'missing mass' thought to account for around 85% of total matter in the universe. In this quiet corner of the cosmos, shielded by rock from the cosmic rays that rip in from space and would otherwise interfere with experiments, this search has continued rigorously and relentlessly for over a decade.

But with scientists from a variety of disciplines recognising that 'going underground' can offer an excellent route to new insights and fresh perspectives, Boulby soon evolved into the UK's official deep underground science facility, offering an impressive breadth and depth of capabilities and possibilities for a wide range of science research. Geology, geophysics, astrobiology, robotics and space exploration technology development: these are just a few of the fields where Boulby's unique characteristics are now routinely exploited. To take one specific example, key similarities to the subsurface environment found on Mars have made it an ideal place to test techniques for extracting samples and data from Martian soils – techniques that could help resolve the burning question of whether there is (or ever was) microbial life on the Red Planet.

STFC scientist Chris Toth, inside Boulby mine.

Credit: Ian Forsyth / ICL-UK / Getty Images

Among the cascade of projects currently making good use of Boulby is an initiative whose focus is much closer to home. Project Deep Carbon has seen geoscientists, engineers and particle physicists join forces to develop detectors for monitoring liquefied CO_2 injected into saltwater aquifers or depleted oil and gas reservoirs under the sea. Funded by the Department of Energy and Climate Change and Premier Oil plc, the £1.4 million phase currently coming to a conclusion has involved Durham, Sheffield, Bath and Reading Universities working alongside NASA's Jet Propulsion Laboratory and Boulby Underground Laboratory itself. So what exactly has the project achieved so far, why is it needed – and what's next?

But once the CO_2 has been injected into an undersea repository, will it stay there? Or will it be a question of 'leak' rather than 'lock'? Monitoring represents a vital tool for checking stability and providing the data needed to take remedial measures if necessary. Currently, though, the only practical monitoring method is to carry out ultrasound-like seismic surveys – and at over £5 million for a typical survey, this is a costly option that would inevitably make CCS even less economically attractive than is currently the case. Add in the fact that surveys would only provide a snapshot and not a continuous picture of what's happening inside storage sites and there's clearly a market for a more cost-effective, 24/7 monitoring solution.

"Boulby Mine's labyrinth of tunnels are at a depth of 750 metres to 1.3 kilometres and extend six kilometres out from the shore."

The need for stable storage

In the last few decades, incredible amounts of ingenuity have been directed at the problems posed by climate change. In terms of delivering big cuts in carbon emissions and helping to restrict increases in global temperatures, carbon capture and storage (CCS) looks like one of the most promising technologies. In principle, it sounds straightforward – capture at source the CO_2 produced by power stations and industrial facilities that burn fossil fuels, then transport liquefied CO_2 for safe, secure underground storage and so remove it from the carbon cycle altogether. It's estimated that CCS could theoretically deliver cuts in emissions of up to 90%. What's more, the UK is superbly placed to develop a vibrant, successful CCS industry, not least due to its outstanding research base and its array of potential storage sites under the North and Irish Seas.

Paradoxically, a potential answer to a problem below the Earth's surface originates in exploding stars hundreds and thousands of light years away. Supernovas produce cosmic rays that collide with the nuclei of oxygen and nitrogen atoms in the upper atmosphere to produce subatomic particles called muons. Crucially, in the same way as medical CT scans harness X-rays, muons can be used to generate 3D images of whatever they pass through – and it's this basic concept that underpins Project Deep Carbon.

Depths of success

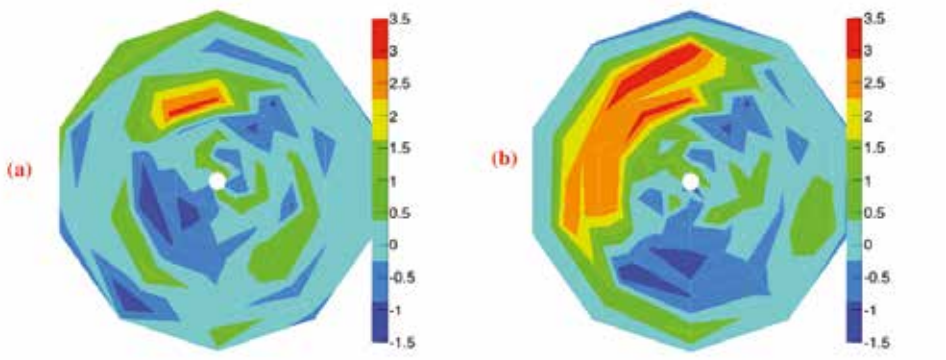
Boulby mine's labyrinth of tunnels are at a depth of 750m to 1.3km and extend six kilometres out from the shore. This makes Boulby an ideal location to develop and test technologies designed for insertion into subterranean CO_2 storage sites, while at the same time offering immediate access to the world-class science facilities and capabilities available at the Laboratory.

In a cavern below the North Sea, the project team is installing a muon detector to measure variations in the rate of muons coming from above due to daily tidal variations – demonstrating the fundamental sensitivity of the technique, even at this great depth, to small changes in the density of the overburden, be that from tidal oscillations or because CO_2 is present. Such sensitivity will be essential for applying the technique (known as Muon Tomography) to CCS sites to monitor the CO_2 injection process, plus any subsequent movements by the CO_2 and the integrity of the containment. A parallel study at Boulby has seen a demonstration borehole detector successfully tested in a horizontal borehole specially cut into a rock wall in Boulby mine. This closely replicates the conditions that muon detectors would experience in real CCS sites, where they would need to fit into boreholes around 20 centimetres in diameter and withstand temperatures exceeding 40°C.

Professor Sean Paling, Director and Senior Scientist at Boulby Underground Laboratory, says: "It's been a pleasure to support this exciting proof-of-principle work, which has laid the foundations for developing compact, robust, reliable detectors that can provide cost-effective, in-situ monitoring of CO_2 storage sites. The aim now is to secure further funding that enables the project team to build more detectors and evaluate their performance in an operating borehole at an oil extraction site as well as here at Boulby. We are lucky to have here in the UK one of the very best places to develop CCS monitoring technology in an environment that's safe and relatively easy to access, and simulates the depths and geology within which future storage sites will operate."

The Rt. Hon. Michael Fallon MP, then Minister of State for Energy, commended the project during a visit to Boulby back in summer 2014, saying: "It's fascinating to see how the innovative CO_2 monitoring technology being tested at Boulby could help to reduce the costs of CCS. The UK is ideally suited to the development of a CCS industry."

Certainly, the prize looks well worth pursuing. As well as cutting hundreds of millions of pounds a year from the cost of implementing CCS, muon detectors could open up a valuable market for 'UK plc' as interest in this important carbon abatement option ramps up worldwide – an excellent example of the benefits that can be delivered by today's era of deep-down discovery and unique subterranean science made possible by Boulby Underground Laboratory.



Results of simulations exploring differences in muon flux for two different CO_2 injection patterns assuming realistic detectors and deployment sites.

Computing Insight UK 2015: a super success

Over 200 delegates and 50 industry exhibitors joined us at the Ricoh Arena, Coventry, in December, for the UK's newest supercomputing conference and exhibition - Computing Insight CIUK - where, amongst many other things, we learned that the Hakskeen Pan desert has better 4G than London.

CIUK 2015 was organised by STFC's scientific computing department and the Hartree Centre, and gave delegates the unique chance to hear about the latest developments in high performance computing, cloud computing and big data analytics from the experts.

"I believe this is the only UK conference that's completely focused on high performance computing, big data analytics and cloud computing," said Dave Cable, one of the conference organisers.

"It brings together technology providers in these markets with a community of expert users and people responsible for the procurement and running of systems, in an environment where they can easily network and share information."

The conference evolved from an already-established technical workshop focused on academia, the Machine Evaluation Workshop, in which a small number of exhibitors would make their systems available for delegates to try out their own codes and see which system worked best for them. CIUK aims to build on the success of this but shift the focus.

"It was born out of a time when people were just starting to buy these systems and needed a forum to understand the technology," said Dave Cable. "Nowadays, the range of hardware is less diverse and people have more experience of using it - so the focus has shifted to looking at partnerships between institutions, between academia and the commercial world, and between academia and technology providers."

At CIUK 2015, there was a good mix of presentations from both academics and industry representatives, including:

- using data analytics to predict where archaeological sites and burial grounds are likely to be, saving on time and costly excavations for construction and civil engineering companies;
- the challenges of merging high-performance computing and cloud technologies to deliver a high-performance cloud computing service, and the impact that is now having on biomedical research; and
- how industries use high-performance computing in their innovation plans.

Colin Bridger from Mellanox Technologies, one of the event's sponsors, said, "The conference is a great opportunity to meet all of our end-users in one place, and continue building the relationships with our partners…it's been a tremendous success."

Richard Noble from the Bloodhound Project was our keynote speaker and enthused delegates with his account of the big data challenges involved in developing a supersonic car, and his vision of it reaching 1000 mph in 2016.

Richard and his team are working with the UK Government to inspire the next generation of engineers and scientists. They have set up an education programme that now involves 6000 schools in 220 countries. Interest in the Bloodhound Project in the UK has led to the demand for mechanical engineering courses to exceed places available at one university.

Data that can be accessed in real time is a proven stimulus for schools and enthusiasts, so the Bloodhound team has installed more than 300 sensors and three video streams that will transmit live through a single channel from the car. Richard said that the Hakskeen Pan desert track in South Africa, where the Bloodhound car will attempt the land speed record, is now one of the most connected regions on Earth. "It now has better 4G than we have in London!" he said.

CIUK attracted a solid base of clients from academia, with delegates from 26 UK universities attending. In future, the organisers would also like to see more commercial organisations at CIUK, taking advantage of the opportunity to explore the added value these technologies can bring to their business and encourage innovative collaborations.

Delegate at Insight CIUK 2015
Credit: STFC

Delegate at CIUK 2015
Credit: STFC

For more information about future CIUK events, please contact Damian Jones:
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@CompInsightUK

What will the LHC upgrade mean for physics?

An upgrade to the Large Hadron Collider (LHC) promises to increase its discovery potential from the year 2025. But what will the next generation of the machine have in store? Find out what leading UK physicists think the LHC upgrade will mean for physics.

Back in October 2015, more than 230 scientists and engineers worldwide, including from the UK, met at CERN to discuss the High-Luminosity (HL-LHC), a major upgrade to the machine that brought us the much-anticipated discovery of the Higgs boson in 2012.

The new High-Luminosity LHC will provide more accurate measurements of fundamental particles and enable physicists to observe rare processes that occur below the current sensitivity level of the LHC.

After a four-year-long design study, the project is now moving into its second phase, which will see the development of industrial prototypes for various parts of the accelerator. STFC has been actively involved in this initial design phase and has supported UK researchers in developing innovative solutions to a number of Hi-Lumi challenges.

With this upgrade, the LHC will continue to push the limits of human knowledge, enabling physicists to explore beyond the Standard Model and Brout-Englert-Higgs mechanism.

Model of quadrupole magnet for the High-Luminosity LHC.

Credit: CERN

So what do the experts think of the upgrade and what it will mean for physics?

Tara Shears, Professor of Experimental Particle Physics and University of Liverpool LHCb group lead:

"HL-LHC will let us turn the spotlight on the Universe to see it in really intimate detail. The huge amount of data we're going to gather will reveal the smallest patterns in matter, perhaps even the faintest traces that dark matter or new, exotic particles leave behind. It's our best hope for solving our biggest mysteries with our best particle physics machine."

Professor Tara Shears
Credit: Tara Shears

Professor Sir Tejinder (Jim) Virdee FRS, one of the leading lights behind the Compact Muon Solenoid (CMS) experiment at the LHC and part of the physics department at Imperial College London:

"With the HL-LHC we shall be entering a new phase, one that will enable the exploitation of the full potential of the LHC. The accelerator will be upgraded to provide an instantaneous proton-proton collision rate that is roughly ten times higher than originally foreseen.

"The higher instantaneous proton-proton collision rate also will require the experiments to be upgraded and some of their parts to be replaced. UK researchers are in the vanguard of vigorous research and development that is ongoing to select and then upgrade/construct new parts of the LHC experiments, to be ready for physics exploitation by the middle of the next decade. An exciting physics and technological advancement programme lies ahead in which UK scientists are positioned to play a major role, as is currently the case for the analysis of data from the ongoing higher energy run of the LHC."

Professor Tejinder Virdee
Credit: Imperial College London

Dr Robert Appleby, member of the University of Manchester High Energy Physics group and of the Cockcroft Institute, spokesperson of HL-LHC-UK at CERN:

"We are very excited to design and build an upgraded Large Hadron Collider to make proton-proton collisions at a much higher collision rate, to probe the fundamental structure of matter, measure the Higgs boson and other new particles to an unprecedented level of precision and search for undiscovered particles of nature"

Dr Robert Appleby
Credit: Robert Appleby

Dr Bill Murray is a member of the Particle Physics Group at STFC:

"The LHC found the Higgs boson, which we think means that apparently empty space is filled with an incredibly dense 'Higgs field'. This field is something new: not matter, not a force, but a different sort of constituent of nature. HL-LHC will look for a proof: pairs of Higgs bosons, because their interaction, can confirm or disprove the existence of the field."

Dr Bill Murray
Credit: STFC

Dr Stephen Haywood, from the Particle Physics Group at STFC:

"The LHC has made a fantastic start to its physics programme with the discovery of the Higgs boson. But many mysteries remain and these can only be revealed by a substantial increase in the amount of data we collect – reducing uncertainties and extending our reach to greater energies. Only then might we begin to understand of what our Universe is made and why it exists at all."

Dr Stephen Haywood
Credit: STFC

Professor Dave Charlton from the University of Birmingham and spokesperson of the ATLAS Collaboration:

"The High-Luminosity upgrade of the LHC and the large detectors, ATLAS and CMS, will extend the exciting physics programme of the LHC until the 2030s. The upgrades will enable physicists from the UK and around the world to study in much more depth the Higgs boson.

"What's more, the tenfold increase in data will help us search beyond where we have explored before, perhaps giving us glimpses into dark matter or other new physics. This upgrade ensures that the LHC will be at the cutting-edge for the next 20 years."

Professor Dave Charlton
Credit: The Royal Society

The youngest ever Grid user

Cal typing his password in at the local Grid authority
Credit: Cal Hewitt and SLGS

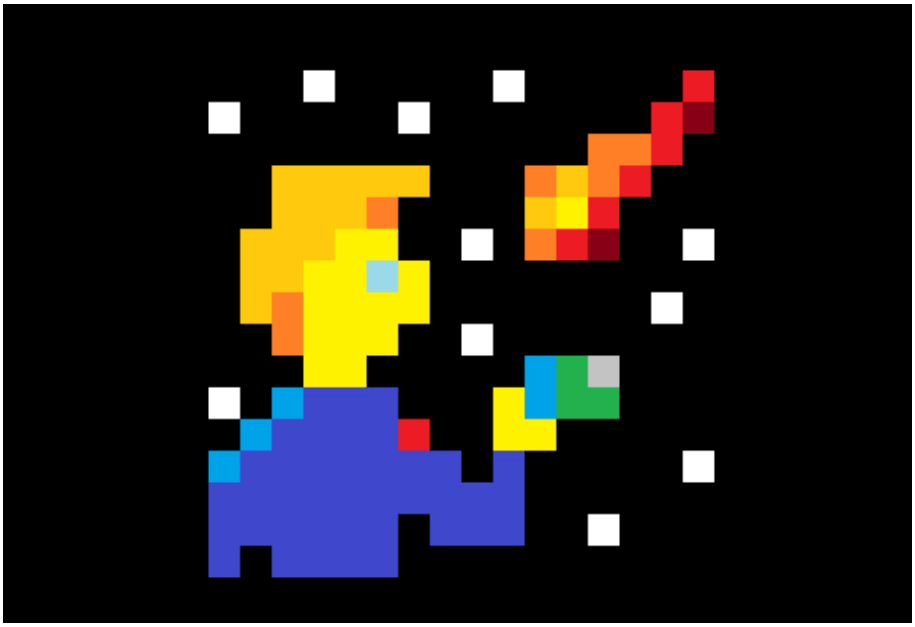
A UK school student has become the youngest person ever to be given access to computational power of the Grid.

Cal Hewitt, is the project leader for LUCID, the Langton Ultimate Cosmic Ray Intensity Detector, a satellite designed by the students at the Simon Langton Grammar School for Boys, as part of the CERN@School programme. Also a student at Simon Langton Grammar School, at the age of 16, Cal has become the youngest person ever to be given Grid access.

The certification, a 'passport' that allows Cal to access the global network of supercomputers, is essential to enable him to analyse data from LUCID. Since the launch of the satellite, Cal and his fellow students have been optimising the detector settings. With data starting to stream back to the school, being able to access the same computing resources that are available to Large Hadron Collider experiments will be essential for analysing cosmic ray and radiation measurements.

Read more about LUCID in Issue 44 of UK News from CERN:
https://www.stfc.ac.uk/files/uk-news-from-cern-issue-44/

Tim Peake's TimPix



The TimPix Project
Credit: CERN

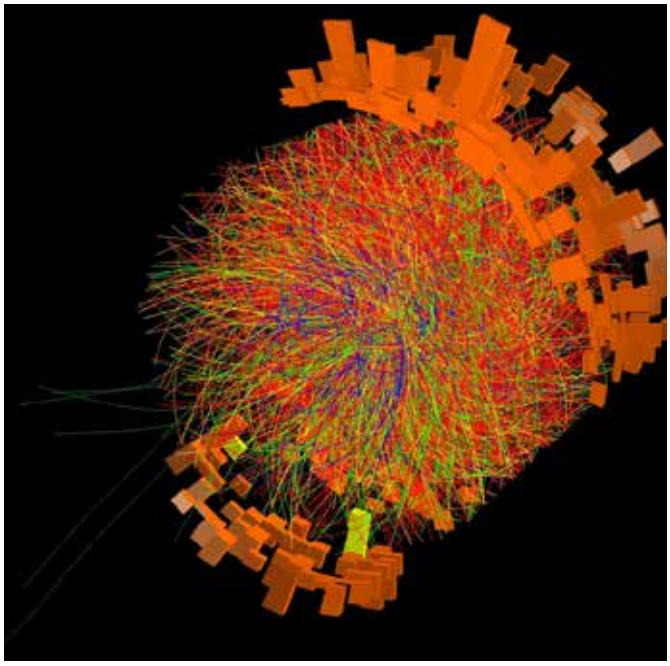
When British Astronaut Tim Peake blasted off for the International Space Station at the end of last year, CERN@School launched the TimPix project.

Whilst living on board the International Space Station (ISS), astronauts and cosmonauts come into contact with radiation from a variety of sources. This can be monitored using the Timepix hybrid silicon pixel detector, which measures the type (alpha, beta, gamma, minimum ionising particles, heavy ion fragments, etc), direction and energy of the radiation. Data from the Timepix detector is downloaded on the ground at regular intervals.

NASA has five TimePix detectors on board the ISS. The TimPix project, supported by the UK Space Agency via a Principia award, offers students the unique opportunity to access Timepix detector data from the ISS during Tim's stay. Where possible, schools were also able to host a Timepix detector to carry out their own experiments. The schools that took part in this project are directly contributing to research that will improve our understanding of radiation in space.

CERN@School is led by the Institute for Research in Schools.

Large Hadron Collider experiments get heavy



The first heavy ion event recorded by ALICE on 25 November 2015
Credit: CERN

When it comes to colliding heavy ions, the spotlight is very much on ALICE. But for the first time, all four of CERN's Large Hadron Collider experiments are taking data during the heavy ion run, including LHCb, which will record this kind of collision for the first time.

Results from Run 1 confirmed the perfect liquid nature of the quark-gluon plasma (the 'primordial soup' of particles that existed for a few millionths of a second in the early Universe), and the existence of 'jet quenching' in ion collisions, a phenomenon in which generated particles lose energy through the quark-gluon plasma. There's still much to discover about this strange state of matter, and the higher energy collisions is Run 2, coupled with advances in analytical techniques, should lead to a greater understanding.

"The heavy-ion run will provide a great complement to the proton-proton data we've taken this year," said ATLAS spokesperson, Dave Charlton (Birmingham). "We are looking forward to extending ATLAS' studies of how energetic objects such as jets and W and Z bosons behave in the quark gluon plasma."

For CMS, the relatively high numbers of heavy flavour particles that will be produced will open up unprecedented opportunities to study hadronic matter in extreme conditions. The detector is optimised to capture these rare probes, and to measure them with high precision.

"This is an exciting step into the unknown for LHCb, which has very precise particle identification capabilities," explains LHCb Spokesperson, Guy Wilkinson (Oxford). "Our detector will enable us to perform measurements that are highly complementary to those of our friends elsewhere around the ring." ■

Recreating the real CERN

Microcosm
Credit: CERN

There's no denying that particle physics is complicated, but that doesn't mean that it can't be made accessible. After a major refurbishment, CERN's permanent exhibition, Microcosm, is back and better than ever, thanks to a team of passionate science communicators, designers, animators, videographers and crane operators.

Microcosm contains exhibits that are designed to inspire and engage. Visitors can meet CERN physicists, follow the path of particles, discover how the experiments work and try their hand at the controls, amongst other hands-on activities.

"The combination of genuine components, realistic models, clever technology, real time LHC status screens and creative imagery is narrated by people who work in each of the areas. It feels right." says Emma Sanders, CERN, who masterminded the transformation of the exhibition space.

"We wanted to create real spaces where visitors can meet real CERN people and hear about the laboratory in their own words. The spaces need to feel authentic – CERN people should feel at home in the exhibition."

The exhibition is fun, simple and jargon-free, making it enjoyable for people of all levels of scientific understanding, and the passion and excitement of those involved in it flows as energetically as the protons.

For more information, visit:
http://microcosm.web.cern.ch/en

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How STFC's European Space Agency Business Incubation Centre (ESA BIC) helped put iGeolise on the map

iGeolise is an innovative software company whose travel time concept is making data more human for people all over the world. To mark five years of the ESA BIC Harwell, we caught up with them to find out how their time as ESA BIC incubatees got their business moving in the right direction.

F: Peter and Charlie, tell us a bit about iGeolise – what do you do?

P: iGeolise is a location-based software company that turns miles into minutes. We make locations searchable by time, rather than distance. For example, if you need to find a hotel, shop or restaurant nearby, most online search results are listed by miles and assume users can travel as the crow flies. Because customers can't do this, we came up with a platform that can make search results more relevant and contextual to the user.

C: The software is used in two different ways. The TravelTime platform is an application program interface that plugs into any website with a location-based search, to deliver results by travel time. It's used on Zoopla to find homes by travel time, and by other companies like Jobsite, VisitBritain and Local World.

P: MinuteMapr is used to analyse large volumes of transport data. Using time-based analysis, it can identify where the best retail store or office location is, or identify the best area for outdoor advertising and direct marketing.

F: So how did it all begin? What gave you your vision for iGeolise?

C: It all started on the M27. I was on my way back from a meeting when I got stuck in a traffic jam. I started thinking about how much more I cared about the passing time I was wasting while I was stuck, rather than the distance I should have been travelling. I took it a stage further and wondered why you couldn't search the web itself by travel time instead of 'within X miles search radials'. So that's where we started - we wanted to make locations (maps) searchable by travel time, because it's just so much more useful than distance.

P: Lots of people can tell you the travel time from A to B but we wanted to do the bit before that, the search. People could ask: 'What are all my possibilities if I have 30 minutes and no car?'

C: The vision? To replace every 'within X miles (or kilometres)' search filter. Globally.

F: Who were your first customers?

P: Bristol and Bath Science Park were out first clients, in 2011. A potential new tenant was considering relocating the office to the park, but they were unsure if the move would negatively impact their staff. Our software enabled

Bristol and Bath Science Park to calculate 200 staff commute times and compare their current commute to the proposed one.

The next step was to get Countrywide on board in 2013, listing properties by commute time on their online search site, Propertywide.

F: So far we have seen iGeolise's technology benefit house-hunters and people looking to recruit. Who else do you think could benefit from the technology?

C: Any company that currently requires distance-based analysis should change to travel time to ensure more accurate results.

P: Some key industries that would benefit would be travel, retail, online classified ad listings, and local authorities.

C: It would work well with holiday accommodation sites, such as finding a hotel within a 15-minute drive from Heathrow. The same applies to finding your nearest shop, picking up furniture from an ad listing or finding the most convenient local recycling centre. We already work with OpenTable, Visit England and Visit Britain.

F: We recently saw that you were using your technology to help commuters during the Tube strike – how did that work?

P: The Tube strike caused a lot of difficulties for a lot of Londoners. The congestion and lack of alternatives during a strike can be very stressful. We decided to show Londoners the distance they could travel on bike and by foot within 45 minutes, so that travellers could see if they could rely on their own modes of transport rather than take congested buses.

Charlie Davies, Co-founder and Peter Lilley, Co-founder and CEO of iGeolise
Credit: iGeolise

Peter Lilley, Co-founder and CEO of iGeolise
Credit: iGeolise

F: Are you doing business internationally?
C: Yes – we have our platform live across the UK and Republic of Ireland, as well as parts of the US, Switzerland, France, Australia and Thailand.

F: How did you become involved with the ESA BIC Harwell?
C: We were fortunate enough to win the UK leg of the European Satellite Navigation Competition in 2012 – and one of the judges happened to run the ESA BIC in Harwell. He suggested that we might like to apply for membership. We did, and we were accepted.

P: It was one of the best things that has happened to us.

F: How did joining our ESA BIC Harwell benefit the development of your product? What were the main benefits of being there?
P: ESA BIC did lots of things for us – and two things in particular.

Membership came with a grant that we could use for technical development and intellectual property protection. When we joined the ESA BIC, we had a good prototype, but that grant gave us the ability to add all public transport timetables to the platform and generate accurate public transport travel times. Having that feature was decisive in winning our first customer…

C: … and we couldn't have won clients two, three, four, etc, without first getting client number one!

P: Secondly, ESA BIC opened doors for us, all we had to do was walk through them. As a result of ESA BIC, we met Vince Cable when he was the minister for the Department for Business and Innovations, we met five MPs, presented to a Select Committee, and met two special advisors to David Cameron and Nick Clegg.

C: We also appeared on BBC South and Radio Oxford. All things we wouldn't have managed on our own.

F: How did winning Innovate UK's Future Cities competition impact iGeolise?
P: That competition enabled us to add four important features to the TravelTime platform; to measure the CO_2 emissions; to measure the financial cost - for any mode of transport; to include real-time updates; and to model public transport timetables and routes/road developments. The platform contains details of all transport routes/timetables and can model things like, 'if we added another bus route at X time from A to B, how would it interact with all existing timetables in terms of overall travel times within the city?'

"As a result of ESA BIC, we met Vince Cable when he was the minister for the Department for Business and Innovations, we met five MPs, presented to a Select Committee, and met two special advisors to David Cameron and Nick Clegg."

F: Can you tell us a little about your individual backgrounds?
C: I was born in Salisbury in 1986 and started my first business at 13, cycling around the New Forest fixing PCs. That led to me building my own technical consultancy business, called iForest. I studied Politics at Cardiff University and it was then that I began working for small web development business, The Local Channel, where I first met Peter and started iGeolise in 2009.

P: I have 37 years' experience in a huge range of companies – from large blue chip media companies like ITV and the Mirror to developing businesses from the ground level up. My experience throughout the years spans media

buying, advertising, marketing, sales, innovation and lots more. Now at iGeolise, I'm responsible for doing anything it takes to grow the business.

C: Peter is the reason iGeolise won the Digital Convergence grant from what's now known as Innovate UK, as well as other awards.

F: What advice would you give to anyone trying to start up a new business? What would you say are the major challenges and how did you overcome them?

C: We wouldn't normally be so presumptuous as to offer advice but since you ask, there are some things we learned the hard way. First, build a product as soon as you can.

P: Even if it's basic. Don't hang around waiting for someone to give you cash/investment before starting. Do stuff.

C: Secondly, sell something as soon as you can. Sales revenues are the best form of funding for a business (better than investors or grants).

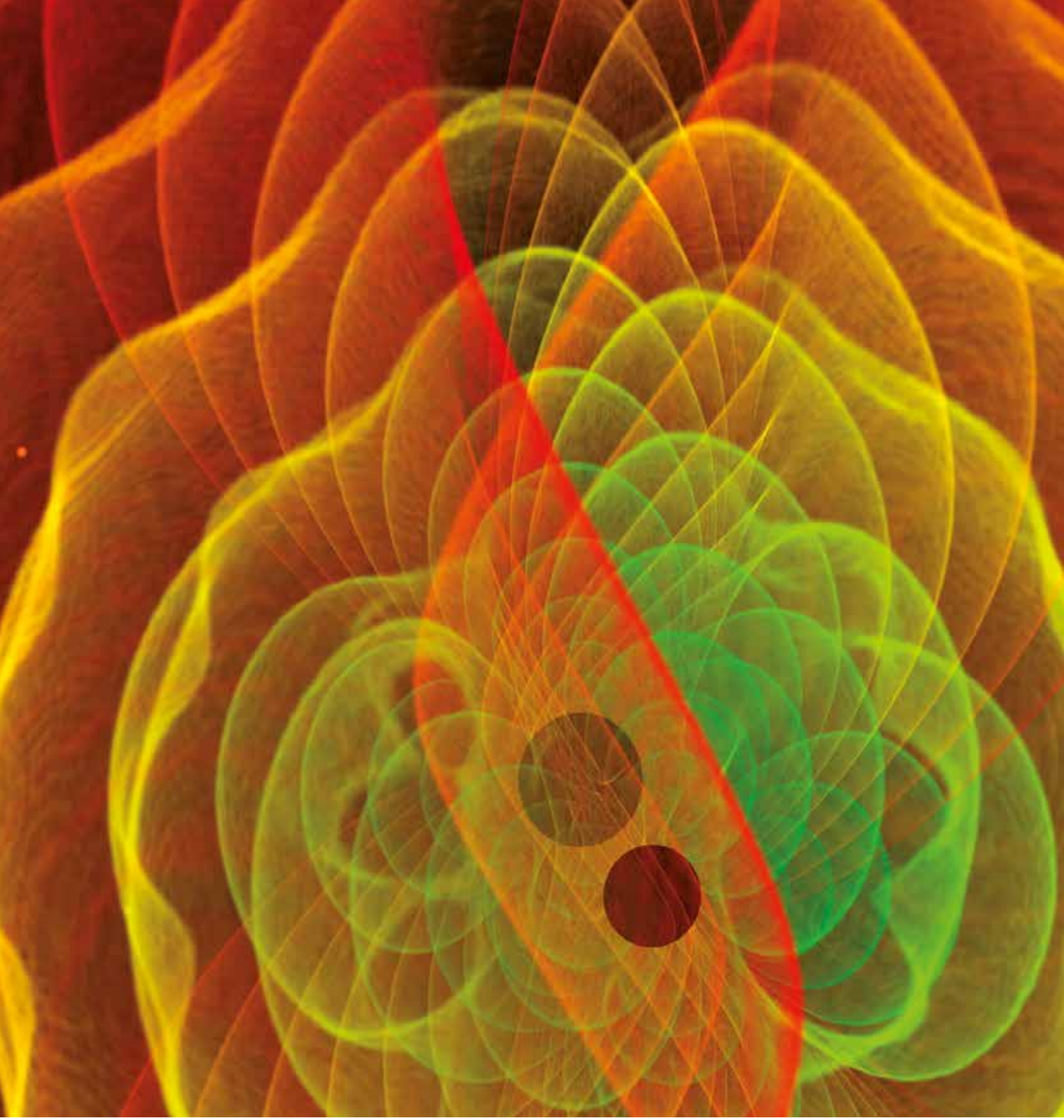
P: You'll seldom learn more about your business than when you have to win (and then support) a real, live client. Also, try and do a job yourself first, before employing people to do it. Then you know exactly what skills you're looking to hire. And when you do employ, you may find that good people often turn out to be expensive. ■

More about iGeolise:
www.igeolise.com
@igeolise

About the ESA BIC Harwell:
www.esa-bic.org.uk

Follow @STFC_B2B for ESA BIC updates.

Charlie Davies, co-founder of iGeolise.
Credit: iGeolise



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