Artist impression of Rosetta, Philae lander and photograph of comet (Credit: ESA)
## Contents

1 Executive Summary ......................................................................................................................2
2 Introduction .................................................................................................................................5
3 World-Class Research ..................................................................................................................6
4 World-Class Innovation ...............................................................................................................14
5 World-Class Skills ......................................................................................................................24
6 Methodological developments and future challenges ........................................................29
7 Appendices ..................................................................................................................................32
   Appendix 1 STFC cross-council output metrics ........................................................................32
   Appendix 2 STFC-specific output metrics ..................................................................................33
   Appendix 3 Researchfish data ....................................................................................................34
   Appendix 4 Additional Global Challenge case studies ..............................................................35
   Appendix 5 Glossary ....................................................................................................................36
   Appendix 6 References ...............................................................................................................37

Note: All images are courtesy of STFC unless otherwise stated.
© Copyright Science and Technology Facilities Council 2014
1. Executive Summary

The Science and Technology Facilities Council (STFC) is one of seven UK Research Councils. Our research seeks to understand the Universe from the largest astronomical scale to the tiniest constituents of matter, yet creates impact on a very tangible, human level. From drug discovery to airport security, hydrogen-powered cars to accident-scene emergency care - our impact is felt across many aspects of daily life.

We achieve this extraordinary breadth of impact in three ways. Firstly, we invest in cutting-edge science that is world-leading in research quality and a rich source of innovation through the technical developments that it stimulates. Secondly, by providing access to large-scale scientific facilities we support interdisciplinary research that spans a range of physical and life sciences, enabling research, innovation and skills training in these areas. Thirdly, we are providing increasingly strong connections to business through our Science and Innovation Campuses, offering access to the UK’s premier supercomputing facilities, promoting academic and industrial collaboration, encouraging translation of our research to market applications, and helping to support the Government’s Industrial Strategy. This makes us uniquely equipped to play an important part in supporting the UK’s knowledge economy, creating jobs and generating growth.

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. In 2010, we set out our ten-year strategy1 to deliver this vision, through our three strategic goals of delivering world-class research, world-class innovation and world-class skills. By monitoring and evaluating our impact, we track our progress towards realising our vision. In this, our fourth Impact Report, we present quantitative data and case study examples which illustrate the breadth and depth of our economic and societal impact. In particular, we showcase how STFC has played a key role in delivering impact from CERN (European Laboratory for Particle Physics), as the facility celebrates its 60th anniversary. Highlights from this years’ report include:

World-Class Research
• Our research remains amongst the best in the world as measured by citation impact in astronomy, nuclear physics and particle physics. We also consistently outperform the other areas of physical sciences in the UK in terms of research quality.
• An independent international review assessed the scientific excellence and leadership of ISIS, praising it as being innovative and world-leading. ISIS researchers have developed a new cost-effective way to run hydrogen vehicles, thereby contributing to the hydrogen car market which is predicted to be worth £161 billion by 2050.
• With significant UK academic and industrial involvement, the Rosetta spacecraft has manoeuvred beside a comet and landed a probe on the surface of the comet. The spacecraft has delivered several firsts in space exploration, making it one of the most complex and ambitious missions ever undertaken.
• Using cameras built by STFC, the first-ever live images of Earth were taken from on-board the International Space Station this year. Applications of this technology include detecting deforestation, reducing congestion and monitoring conflict zones.
• Our research has been applied to detect the earliest stages of eye disease, made a breakthrough in the race to solve antibiotic resistance and is supporting carbon capture and storage to help the UK meet its greenhouse gas emissions target.

World-Class Innovation
• Our Campuses host over 230 enterprises and support more than 5,000 jobs. This year our tenant companies at Sci-Tech Daresbury created over 100 jobs, delivered £52 million in sales, attracted £97 million of investment and developed 97 new products.
• We continue to work with Innovate UK at our Campuses. In 2013, seven SMEs from Sci-Tech Daresbury won a share of £1.6 million in investment and are benefiting from STFC’s business support package.
• Between 2010 and 2013, £80 million has been invested into I-TAC companies from investors across the globe. 36% of companies receiving investment in the past year attributed this to being a direct result of being located on an STFC Campus.
• The Rainbow Seed Fund, in which STFC is the lead partner, has invested £14 million in this early-stage
venture capital fund. Co-investment levels from private investors of £127 million have been leveraged from just over £6 million of RSF investment.

- A new incubation facility, commemorating Peter Higgs, will exploit the UK ATC’s capabilities in instrumentation for space and big data. The £10.7 million Higgs Centre for Innovation will host 12 small businesses, bridging the gap between research and industry.

- Unilever, Syngenta and Infineum can now remotely access the Hartree Centre’s advanced computer modelling capabilities using an ‘app’ that can shave years from product development times, saving the companies significant costs.

World-Class Skills

- We play a key role in attracting young people to follow STEM careers. In 2013, applications to study physics at university increased a further 7% from the year before. There has been an increase in applications of 64% between 2008 and 2013.

- STFC research inspires future generations to study STEM subjects. This year we reached 18,000 teachers, 91,000 primary students, 243,000 secondary students and 1.1 million members of the general public through our public engagement programmes.

- Between 2009 and 2014, we reached 84 million members of the public through four STFC mass media initiatives.

- We have invested £22.4 million in postgraduate training and fellowships in particle physics, nuclear physics and astronomy. Our current cohort of 766 PhD students are trained in the high-end scientific, analytical and technical skills which drive the knowledge economy.

- STFC provided 14,200 training days to students from a variety of disciplines, across our facilities and departments, an increase of 30% from last year.

- Work experience placements for 14 to 18 year olds at our National Laboratories benefit more than 400 young people per annum, with over 50% of students saying that their placement at STFC has influenced their career path decision.
World-Class Research
World-Class Innovation
World-Class Skills

The Polref instrument in ISIS Target Station 2. National winner of the STFC photography competition. (Credit: STFC).
2. Introduction

STFC delivers impact in research, innovation and skills through three distinct but interrelated functions:

• **University partnership programmes**: supporting fundamental research in particle physics, astronomy, nuclear physics and space science through UK universities.

• **Multidisciplinary research facilities**: providing UK university and industrial researchers with access to a range of world-leading, large-scale facilities and organisations, both within the UK and abroad.
  - The facilities provided by STFC in the UK include Diamond Light Source (DLS), ISIS and the Central Laser Facility (CLF). These are the national synchrotron, neutron and laser facilities.
  - STFC’s Hartree Centre provides supercomputing facilities to support UK industry and academia develop better products and research outcomes.
  - STFC manages the UK’s participation as a partner in the European Synchrotron Radiation Facility (ESRF) and the Institut Laue-Langevin (ILL) neutron source in France.
  - STFC oversees the UK’s membership of the European Southern Observatory (ESO), an intergovernmental astronomical research organisation, and the UK’s subscription to CERN, the world’s largest particle physics laboratory.

• **Campuses**: building the Science and Innovation Campuses, Sci-Tech Daresbury and Harwell Oxford, to provide an environment where innovation flourishes to stimulate jobs and growth.

Our role within the Research Councils is thus uniquely broad: we commission and deliver our own scientific programme and, through our facilities and Campuses, we enable our strategic partners to deliver their programmes. Strong relationships are core to our role and many of our impacts are generated in collaboration with others, especially the other Research Councils and Innovate UK.

As would be expected from such an organisation, we deliver impacts of varying types, magnitudes and timescales:

• **Direct** – relatively easy to quantify, attribute and predict, these outputs are short- to medium-term in nature.

• **Indirect** – may only be predictable in general terms. These impacts often occur when original research is used in a novel manner and normally materialise over the medium-term.

• **Global** – significant international impact which has an effect on people’s daily lives. This kind of impact arises infrequently and generally happens over the longer-term.

This report is structured around our three strategic goals of **research, innovation and skills** and illustrates how our different delivery functions generate a range of impacts on varying timescales. By its nature, relatively short-term performance monitoring cannot be expected to provide a full picture of the broader economic and societal benefits of STFC research, facilities and Campuses. Therefore, we present a range of metrics and impact case studies of varying timescales in this report. We also review the improvements we are making in our impact evaluation activities. Cross-council output metrics are presented in Appendix 1. Additional STFC-specific output metrics are presented in Appendix 2.
3. World-Class Research

3.1 Introduction
Our ambition is to sustain the UK’s position as one of the world’s leading research nations and support the growth of a high-tech UK economy. This section demonstrates our progress towards this goal, starting with research statistics to give the scale and context of our research. STFC creates direct impact by generating new knowledge and technology from fundamental research through our grant-funded programmes and at our facilities. That new knowledge and technology can then create long-term impact and benefits for society and the economy through research exploitation and the further development of technologies. In addition, our Futures Programme harnesses our strengths and capabilities to find solutions for global challenges.

3.2 Research statistics
University partnership programmes
- STFC is the UK steward of research in astronomy, particle physics and nuclear physics, supporting a community of 700 academics in 75 universities in 2013/14.
- Our latest bibliometric publication data shows that we published over 4,000 papers across our university programmes in 2011/12.
- In 2013/14 we invested a total of £157 million across all of our university programmes: £22 million for fellowship and training awards and £135 million related to research, of which £82 million was for grants.
- In 2013, 614 UK particle physicists carried out research at CERN and 189 astronomers from the UK carried out research using telescopes operated by ESO. In 2013/14 we invested £123 million in the UK’s subscriptions to CERN and ESO.
We measure the strength of our university research base by research volume and citation impact, striving to maintain world-class research and leadership. Our latest analysis of the UK’s performance in physics research in 2011, as measured by citation impact, shows STFC-funded researchers are first in the world in particle physics, second in the world in nuclear physics and third in the world in astronomy, following extremely closely behind the USA and Germany.

Our third data collection of outputs from our university partnership programmes using the on-line data collection system, Researchfish, has been completed this year. We will release this information early in 2015 after it has been validated. More detail on our current Researchfish data is given in Appendix 3.

**Large-scale scientific facilities**

- In 2013/14, Diamond Light Source, ISIS and the Central Laser Facility were used by over 5,276 unique users to carry out 2,688 experiments, which produced over 1,000 papers in peer-reviewed journals. The user satisfaction rate exceeded 90% for each facility.
- The ESRF and ILL were accessed by over 580 unique UK users who made 819 visits to the facilities in 2013.
- The Protein Data Bank is the most significant world-wide archive for protein structure and nucleic acid data, receiving data by biologists and biochemists. In 2013, Diamond Light Source recorded 637 new depositions, bringing the total number to 2,062 between 2007-2013, and the ESRF recorded 837, totalling 10,239 over 18 years. This contribution equals nearly 13% of world-wide Protein Data Bank depositions, thereby benefiting biomedical research, for example, by helping to improve the treatment of many infectious diseases.

**New facilities and centres**

This year the Government has invested £265 million of new science funding for the UK to be part of two new major international science facilities. STFC will manage the UK role in these projects, ensuring the UK will be at the forefront of these research areas in the coming decade. These are:

- The Square Kilometre Array will be the world’s largest radio telescope and is designed to improve our understanding of the Universe. MeerKAT, the first of the telescope’s 64 antennas, became operational this year in South Africa. As well as involvement from UK astronomers, there are significant opportunities for UK industry in this project. For example, UK company Oxford Cryosystems are providing 1,000 specialist coolers for the first phase of the telescope. The entire project requires 12,000 coolers, putting the company in a good position to bid for these contracts.
- The European Spallation Source will be world’s most powerful neutron source. Complementing the existing ISIS neutron source at the Rutherford Appleton Laboratory, it will provide new opportunities for UK scientists to work at the cutting-edge of material science.

STFC also became an associate member of the Facility for Antiproton and Ion Research under construction in Germany. STFC’s Nuclear Physics Group, along with a consortium of eight UK Universities, are constructing components for this facility.

---

**ISIS world-leading science and innovation**

As part of our Strategic Theme of “sustaining research excellence and leadership”, STFC has started a series of independent international reviews to assess the global standing of our science. The first of these was carried out this year on our ISIS facility to provide advice on the scientific excellence and leadership of ISIS. The international panel praised ISIS as being innovative and world-leading:

> "ISIS operations are providing an excellent capability to the user community, and are certainly world-class. ISIS has, since its creation, been able to create a culture of innovation that has had profound impact on, and will continue to change, the way neutron scattering is performed world-wide. Very few research institutions have demonstrated similar drives toward innovation and spread of the resulting technological development."

We will be extending this assessment methodology to our other large-scale facilities in the near future.

ISIS continues to collaborate internationally, this year signing Memoranda of Understanding with the European Spallation Source and the National Physical Laboratory to promote closer links with both organisations. In addition, ISIS also signed a six-year agreement worth €15 million with the Italian National Research Council to develop further collaboration between the two countries in the field of neutron scattering, building on nearly 30 years of collaboration.

---

1 Data presented in STFC’s 2013 Impact Report
3.3 Generating new knowledge and technology

Highlights from the new advances we have been at the forefront of this year include:

**Europe makes history with first-ever comet landing**

This year, the Rosetta spacecraft manoeuvred alongside comet 67P Churyumov-Gerasimenko and successfully deployed a lander on its surface. The spacecraft has delivered several firsts in space exploration, making it one of the most complex and ambitious missions ever undertaken. It is the first-ever spacecraft to orbit and land on a comet and scientists had to plan a ten-year, 6.4 billion kilometre trip through the Solar System in advance. With funding from the UK Space Agency and STFC, Rosetta is a mission with significant involvement from UK industry. Nine companies took part, including Airbus, e2v, SSTL and Sci-Sys UK. One of the main challenges in designing instruments for Rosetta was to ensure the components remained intact for ten years and then worked perfectly on arrival.

Rosetta’s main objective is to help understand the origin and evolution of the Solar System. The spacecraft will investigate the existence of organic chemicals inside the comet which may have been the building blocks for life on Earth. The probe that has landed on the surface of the comet is carrying a number of instruments. One of these instruments, Ptolemy, was built by STFC’s RAL Space Department together with STFC-funded researchers at the Open University. This instrument will examine the composition of ice on the comet to try and reinforce the theory that impacts of comets delivered water to Earth in its early history.

Universities, Science and Cities Minister Greg Clark said:

“This truly is a momentous day. The Rosetta mission is once again making history, this time by deploying a lander on the surface of the comet. We cannot underestimate just how much of a challenge and technical feat this has been to achieve. UK scientists, engineers and industry have played a central role in its success and will inspire a generation of children to become involved in science.”

**Using ammonia as fuel**

Researchers from ISIS have developed a new cost-effective way to run hydrogen fuel-cell vehicles by filling the cells with ammonia. Major car manufacturers including Toyota, Honda and General Motors have committed to launch hydrogen cars by 2015 and have already invested over £3.7 billion in their development. The hydrogen car market is predicted to be worth £1.61 billion by 2050. However, there are high manufacturing costs and safety concerns with the storage of hydrogen gas. Ammonia can be transported and stored easily, and can be manufactured cheaply. This new research at ISIS offers a solution to some of the major challenges in harnessing the power of hydrogen as a fuel source, and could address some of today’s transportation issues.

**Nuclear physics goes pear-shaped**

Existing theories on the shape and structure of atomic nuclei have been put to the test as an international team of nuclear physicists have discovered that some can be “pear” shaped instead of shaped like a rugby ball. This research, co-funded by STFC at the ISOLDE radioactive beam facility at CERN, has recently been published on the front cover of Nature.

The experimental observation of nuclear pear shapes is not only important for understanding the theory of nuclear structure and how nuclei behave, but also in answering the broader questions about the fundamental interactions that govern the structure of the universe. Over the past decade, studies of the nucleus have led to many major developments that have transformed our lives: for example, in cancer treatments, medical imaging and environmental monitoring.

**The search for Earth-like planets**

Earth-like planets outside our solar system which may support life are called exoplanets. However, they are extremely difficult to detect because they cannot be observed directly. Researchers first discovered an exoplanet in 1995, and were only able to image one ten years later using the world’s most advanced optical instrument, the STFC-funded Very Large Telescope. Now the study of exoplanets has become one of the most exciting and rapidly progressing fields in astronomy. For example, in 2013 alone, the UK’s WASP programme found 11 new exoplanets and discovered Kepler-78b, the first Earth-sized exoplanet with an Earth-like density. A number of UK astronomers played a role in this observation and Kepler’s discovery relied on HARPS, a detector partly built by STFC’s UK Astronomy Technology Centre.

**New techniques for early diagnosis of cancer**

Research led by the University of Liverpool, involving NHS Trusts and funded by EPSRC, will use a state-of-the-art tissue culture centre at STFC’s ALICE accelerator, to understand the effects of a particular type of radiation on human cells. The aim is to improve significantly the diagnosis and treatment of the three most common forms of cancer - prostate, cervical and oesophageal. Oesophageal cancer has the fastest rise in incidence, affecting more than half a million people annually worldwide. These cancers can be treated much more successfully if diagnosed early and this project aims to develop a new generation of portable, accurate low-cost instruments to improve diagnosis.
World’s first live video feed of Earth from space

Using cameras designed and built by STFC, the first-ever live image of Earth was taken from the International Space Station this year. Developed for Canadian company UrtheCast, these cameras are capturing images and video with a degree of resolution never seen before. This high-resolution earth-imaging can be used for a number of applications such as detecting deforestation, measuring crop yield, reducing congestion, predicting natural disasters and monitoring conflict zones.

A rare superheavy element is discovered

A newly discovered rare element will soon be added to the periodic table. An international team of researchers including nuclear physicists from the University of Liverpool, funded by STFC, has confirmed the existence of an extremely rare “superheavy” element named Element 115. Superheavy elements do not occur naturally on Earth; often they exist only on the surface of exploding stars. Therefore, in order to study them, they must be reproduced in the laboratory. The technique developed for this experiment can now be used to identify new rare elements in the future. The instruments and techniques developed in nuclear physics research are often applied to other areas including the diagnosis and treatment of cancers.
3.4 Creating long-term impact

Science and innovation are central to the delivery of economic growth. STFC plays a crucial role in this ecosystem by supporting fundamental research and technology which can have long-term impacts, often bringing unforeseen but significant improvements to our lives. Along with other key players in these fields, previous investment in STFC research helps support the following long-term impacts:

• **Technology for research saves lives:** STFC played a major role in enabling today’s high-resolution MRI scanners, which have a key role in medical diagnosis, through the development of superconducting magnet technology for particle physics experiments in the 1970s. The MRI industry contributed £111 million\(^24\) to UK GDP in 2010 and provides a multi-million pound market for UK companies such as Oxford Instruments.

• **A new generation of drug treatments:** Supporting a £7.4\(^{25}\) billion UK pharmaceutical industry, our large facilities provide an essential stage in drug development programmes. Fifteen of the world’s current 75 best-selling drugs were developed in the UK using techniques pioneered at STFC.

• **Foundations for laser eye surgery:** Knowledge gained from STFC’s Central Laser Facility was used to develop early laser techniques for eye surgery, providing a key building block for the world-wide industry which exists today. Over 100,000 annual procedures are carried out in the UK, worth more than £100 million per year for the economy\(^26\).

• **Fifty years of the UK in space:** STFC and its predecessors have been a part of key space projects for the past 50 years, since the launch of the UK’s first satellite. Not only have we delivered world-leading space missions, we also support the UK’s 464 space companies which had an annual turnover of £11.3 billion in 2012/13\(^27\).

• **STFC’s role in satellite navigation:** STFC capabilities support our daily weather forecasts, helping to determine the impact of weather on existing satellite navigation systems. We have also played a key role in developing Galileo, the European global navigation system. GPS-related benefits in just five key industries - delivery services, utilities, banking and finance, agriculture and communications - are worth 7% of UK GDP\(^28\).

• **Pioneering digital animation:** In the early 1960s, STFC’s predecessors developed ground-breaking computer graphics and animation technologies to help researchers visualise complex mathematical datasets. We led the UK’s CGI field through the next two decades and helped develop a new business sector, the UK computer animation industry, which has annual revenues of £300 million. It also directly supports other UK industries including the post-production industry, worth £1.4 billion, and the gaming sector, worth £1 billion\(^29\).

• **The foundations of the WWW:** Twenty-five years ago the web was established at CERN and is now a fundamental part of our lives – 33 million adults access the internet every day in the UK and it is worth over £121 billion\(^30\) to the UK economy annually. STFC manages the UK participation in CERN and underpinned the internet’s development at our Rutherford Appleton Laboratory.

• **Supporting power supply integrity:** Research at STFC’s ISIS facility supported five-year life extensions to two UK nuclear power stations, enabling uninterrupted energy generation, and deferring the need for decommissioning and replacement at a cost of around £3 billion.

• **Combating foot-and-mouth disease:** Working in collaboration with BBSRC-funded experts, researchers have developed a new vaccine against foot-and-mouth disease using STFC-funded synchrotron radiation facilities. The new vaccine could reduce the incidence of the disease in endemic regions and help stabilise the economies of those areas. The cost of the last outbreak of FMD in the UK is estimated at £8 billion\(^31\).

• **Supporting the microelectronics industry:** For over 25 years, STFC has provided training software for all UK microelectronics graduates, providing over 650 universities across Europe with training and expertise vital to the microelectronics industry worth £23 billion per annum to the UK economy\(^32\).

• **The physics-based manufacturing sector:** This sector provides 3.9 million jobs, 4% of the total UK workforce, and is worth £220 billion to the UK economy – which is more than the finance sector\(^33\). We provide skilled people, develop technology and support many companies based in this sector including the aerospace, automotive, life sciences and agri-tech industries.
Celebrating 60 years of CERN impact

Significant long-term impact has been generated through major research programmes funded by STFC and our predecessor organisations. In 2014 CERN is celebrating 60 years of excellence in scientific endeavour at the heart of some crucial technological revolutions of the 20th and 21st century. The last 60 years have seen the researchers at CERN advance our knowledge of the basic building blocks of matter and hugely improve our understanding of how the Universe works and how it began.

As a founding member of CERN, the UK has been a part of this facility through 60 years of partnership and today benefits from the global scientific, economic and social impacts that CERN has created. In this our fourth Impact Report, we highlight the areas of communications, big data, and medicine and health, areas in which the UK has gained direct benefit from CERN.

Communications

World Wide Web born at CERN 25 years ago

A notable technology originating from CERN is the World Wide Web, the cornerstone of the internet. The web was established at CERN 25 years ago and is now a fundamental part of our lives. There are three billion internet users globally in 2014, which is 40% of world’s population. The sector is worth over £120 billion to the UK economy, 8.3% of GDP, and is growing by 11% annually.

In 1989 Tim Berners-Lee, a British scientist working at CERN, proposed a novel way of sharing information over the internet; this was the birth of the web.

“CERN was an early adopter of internet protocols, and their support for a royalty-free web has been a key to its widespread adoption today.” Tim Berners-Lee

STFC’s predecessor organisations also underpinned the internet’s development in the UK through early computer networking deployments, hosting the first UK website, developing web standards and protocols, supporting the evolution of the Grid, and spinning out some notable organisations.

Invention of the touch screen

CERN was also responsible for the invention of the touchscreen which can be found in many modern communication devices. The very first capacitive touchscreen was created by physicists at CERN in 1973 as a part of a control interface for a particle accelerator. Touchscreens have now advanced dramatically but the technique is still at the core of this technology.

Today mobile devices have redefined our mode of work, free time and social interaction. With smartphones outselling PCs for the first time at the end of 2010, the global smartphone market is growing rapidly and the total global smartphone market is set to be worth over £85 billion by the end of 2014.

Big data

Grid computing

In the 1990s, the Large Hadron Collider was the first project to require processing of petabyte-scale datasets and this led to the development of grid computing. The LHC Grid makes use of computer resources distributed world-wide to process the huge volumes of data produced by the experiment.
Grids are ideal tools for a wide range of applications, from screening of drug candidates to image analysis. The same approach is now widely used by academia and business as part of the cloud computing revolution.

**Axomic Ltd**

Several CERN IT projects have led to the establishment of spin-off companies. For example, Axomic Ltd is a UK company set up in 2002 by two CERN scientists. Their software allows architects, civil engineers and construction companies to store and search for images and 3D plans on the web. With staff numbers currently at 30, the company operates in global markets, with a client base comprising 500 of the world’s leading architectural practices.

**Medicine and Health**

For 60 years accelerators have been used in medical research and clinical practice and there are now 10,000 operating in these areas world-wide. Innovation in this technology has been primarily driven by the needs of particle physics.

**Diagnosis**

Twenty million people undergo medical diagnosis using radio-pharmaceuticals every year, many by means of Positron Emission Tomography. The detectors used in these scanners were initially developed as particle detectors for experiments at CERN. Additionally, powerful superconducting magnets developed for particle accelerators at CERN are now the basis of another common type of diagnostic equipment, the Magnetic Resonance Imaging scanner. Much of this research was carried out at STFC’s Rutherford Appleton Laboratory and then transferred to UK industry, which now produces the majority of superconducting magnets used in these scanners world-wide. Oxford Instruments have worked on a series of projects with CERN, particularly in the field of superconducting magnets.

Medipix is a small particle detector chip developed at CERN in collaboration with a number of different organisations including several in the UK. Developed to interpret results from the Large Hadron Collider, it has since been applied to a range of applications. In the field of medical imaging it has been used to produce clearer and more accurate pictures in order to improve diagnosis.

**Treatment**

Around one in six of the UK population will receive radiotherapy at some point in their lives. Next-generation treatments have been developed which offer advantages over radiotherapy. Hadron and proton therapies are advanced techniques of radiotherapy which offer improved success rates. This treatment has made remarkable steps forward in the last two decades and CERN projects have led to significant advances in this area. There are now 40 hadron therapy centres around the world but the accelerators are large and costly, at around £120 million per machine. Advanced Oncotherapy, a UK company, recently acquired a CERN spin-off in order to further develop this technology.

“It is an extraordinary privilege to work with expert scientists at CERN. We look forward to deploying globally affordable proton therapy machines.” Mike Sinclair, CEO of Advanced Oncotherapy

Other medical spin-offs from CERN include WISDOM, a molecular modelling programme which has been used to develop new malaria medication. In addition, Geant4, a software package originally developed for particle physics, is now being used to assess radiation doses to the healthy tissue around cancer tumours. This capability has fed into VoxTox, a project funded by Cancer Research UK, with significant involvement of STFC funded-researchers, that focuses on reducing toxicity from radiotherapy.
3.5 Solutions for Global Challenges

STFC science, technology and expertise are vital in tackling global challenges such as energy, the environment, healthcare and security. STFC facilities enable research and innovation aimed at providing solutions to these challenges across a range of disciplines. Researchers from the wider STFC community in universities, national facilities and laboratories contribute their expertise to interdisciplinary projects.

Underpinning this, STFC has several funding schemes which fund multidisciplinary, challenge-led activities to focus research and technology on solutions to the global challenges. Examples of STFC’s work in this area are given below and in Section 4.3.1.

Cosmic rays and carbon storage
Carbon storage could play a major part of UK and global environmental policies to tackle global warming but would still allow us to generate clean, affordable energy. With funding from an STFC Global Challenge Concepts award, a team from the universities of Sheffield and Durham and STFC’s Boulby Underground Laboratory have demonstrated that cosmic ray detectors, originally developed for physics research, are suitable for monitoring underground carbon capture and storage chambers. Further development of these detectors is being funded by the Department of Energy and Climate Change and Premier Oil plc.

Increasing UK capability in battery research
The global market for batteries is valued at over £31 billion. Applications for batteries are becoming increasingly diverse, with applications in sensors, biomedicine and grid storage. In the last 10 years, STFC’s large-scale facilities have made seminal contributions to our fundamental understanding of batteries through the use of X-ray and neutron diffraction.

An STFC Global Challenge Network is fostering new collaborations across academia, national facilities and industry to develop new instrumentation and methodologies in this key industry.

Early diagnosis of eye disease
A condition known as Age-related Macular Degeneration is the leading cause of visual impairment in the developed world. In the UK alone, there are 500,000 sufferers, who account for around 57% of all cases of blindness, costing the UK economy an estimated £3.7 billion per annum. STFC’s UK Astronomy Technology Centre is using expertise developed from astronomy technology to develop a unique instrument, a “retinal densitometer”, which can detect the crucial, earliest stages of this condition by measuring how the eye responds to light. In collaboration with Cardiff University’s School of Optometry and Vision Sciences, University College London and Bristol Eye Hospital, the aim is to develop a diagnostic test that can be offered for sale to healthcare providers.

Preventing antibiotic resistance
A group from the University of East Anglia, the University of St Andrews and Diamond Light Source has made a breakthrough in the race to solve antibiotic resistance. Funded by the Wellcome Trust and using Diamond, they studied bacteria in extreme detail to identify an innovative method of disabling the bacteria and preventing antibiotic resistance. The World Health Organization has warned that antibiotic resistance in bacteria is spreading globally and even common infections, which have been treatable for decades, can once again kill. Published in Nature, this breakthrough is a giant leap forward in the fight against superbugs.

Further examples from our Global Challenge Programme are given in Appendix 5.

© Docer | Dreamstime.com - Cosmic Sky Photo
4. World-Class Innovation

4.1 Introduction
Our ambition is to realise the innovative capacity of STFC’s science and research facilities to support the growth of the UK economy. We deliver considerable impact through our National Science and Innovation Campuses which offer a dynamic environment for innovation to flourish. We also support commercialisation from our grant-funded programmes through a range of schemes, the commercialisation of STFC intellectual property, and we support UK business to win contracts from our facilities and subscriptions.

4.2 Delivering impact through the National Science and Innovation Campuses
Harwell Oxford and Sci-Tech Daresbury are the UK’s foremost Science and Innovation Campuses and are both designated as Enterprise Zones. STFC is a major partner in the Campuses; they are built around STFC research laboratories and the cluster of technical expertise which they contain. These Campuses host over 230 enterprises and support more than 5,000 jobs. Campus tenant companies experience low failure rates, strong growth, high-value job creation and high levels of commercial innovation. Our Science and Innovation Campuses are developing as new high-tech clusters and growing as locations of international prominence. The unique combination of world-class scientific capabilities and a business ecosystem provides a compelling proposition that continues to attract start-ups, SMEs and large blue chip companies, leveraging £40 million in inward investment in 2013 alone. We are committed to growing this contribution to the regional and national economy.

4.2.1 Sci-Tech Daresbury
Sci-Tech Daresbury is an internationally-recognised national centre, home to around 100 high-tech companies. Growth on site continues, with the CERN Business Incubation Centre opening last year and the addition of £3.6 million from the Enterprise Zone Capital Grant fund for a new Techspace building. This award is part of an investment package of £30 million for Sci-Tech Daresbury in 2014.
A new Campus Technology Hub offering a purpose-built engineering facility is also under construction. It aims to provide an affordable mechanism for entrepreneurs to access engineering R&D equipment and expertise, and will play a vital role in training apprentices.

The annual tenant survey carried out with 77 companies located in the Daresbury Innovation Centre highlights significant improvement in business growth, and the support package has meant no business has failed in the past year.

In 2013, Campus companies:

- Employed 565 people (494 FTE), up from 448 last year, of which 76% are educated to bachelor degree or above (the UK average for science and engineering subjects is 10%)
- Created 105 jobs in the 77 companies surveyed, with 70% of companies forecasting recruitment of 179 jobs in 2014. A total of 318 additional FTE jobs have been created since 2010.
- Attracted investment of £97 million, now totalling £139 million since 2010.
- Delivered £52.4 million sales, up from £34.8 million, an increase in sales growth of 51%.
- Exported £13.6 million or 26% of their sales, an increase from £10.1 million last year.
- Developed 97 new products, with 34% of companies filing patents (up from 22%), 60% of which were granted.

**Hartree Centre**

A research collaboratory in association with IBM and underpinned by more than £70 million of investment to date, the Hartree Centre uses modelling, simulation and visualisation facilities to enable business growth and competitiveness. The Hartree Centre is now an “Intel® Parallel Computing Center”. This enables collaboration on the design of software for the world’s most advanced microprocessors, as well as providing a key focus to support UK industry requirements. Government investment of £19 million this year has helped establish the UK as the world-leader in energy efficient supercomputer software development to meet big data challenges.

The Hartree Centre is also leading in the area of big data analytics, the analysis of large data sets, having installed one of the most sophisticated data analytics clusters in Europe. The Centre’s future plans include development of data analytics, cloud and cognitive computing, and enabling new HPC collaborations that promote UK economic growth. Some recent highlights from the Hartree Centre include:

- Unilever, Syngenta and Infineum are part of a joint initiative to develop a range of new software tools that can shave months or years off product development time, saving significant costs. A week’s worth of experimentation on a new product formulation can now be done in just 40 minutes through advanced computer modelling, simulation and 3D visualisation. All that is needed is a simple “app” that is linked to the Hartree Centre and clients can remotely access one of the most powerful supercomputers in the UK.

- A virtual prototype project at the Hartree Centre’s visualisation suite has enabled Bentley Motors to integrate virtual models into their new product design and development process. This has enabled Bentley to speed up product development times, reducing the number of physical prototypes required and hence costs, and eliminating the need for late-stage modification.

- Recent work with Hartree has helped company Tech-X to increase the accuracy of models to design higher quality accelerator beams, potentially facilitating the next-generation of “table-top” accelerators. For businesses in the medical and security industries, this would add value by breaking down the size and cost barriers of accelerator-based R&D.

Other work and associated case studies include: ACAL Energy, FlowHD, HR Wallingford, Jaguar Land Rover, NPL, Sun Chemical, Unilever, and work with several universities.
4.2.2 Harwell Oxford Campus

The Harwell Oxford Campus is part of the Science Vale UK Enterprise Zone and a thriving environment for innovation and business with clusters in space, cryogenics, healthcare, digital/ICT and energy/environment technologies. It is home to over 4,500 staff within 150 high-tech research organisations and companies based on Campus.

In 2013, notable developments included the appointment of new joint venture partners, UK real estate developer Development Securities Plc and Prorsus – now known as Harwell Developments Ltd. The first phase of the Campus development Masterplan comprises one million square feet of commercial and R&D space. Future plans include two new office blocks for high-tech start-up companies and a new £14 million Harwell Innovation Hub in 2015.

This year, the Deputy Prime Minister and Minister of State for Universities, Science and Cities, Greg Clark MP, visited the Harwell Oxford Campus to sign the Oxford and Oxfordshire City deal. Oxfordshire, an internationally recognised hub of research and innovation, will benefit from £67 million of investment for four business “incubator” centres, including one based at Harwell Oxford by 2020.

Harwell’s UK Space Gateway

The space cluster at Harwell Oxford, also known as the UK Space Gateway, is supporting the growing UK space industry, which is expected to be worth £40 billion by 2030, creating 100,000 UK jobs. Working with Innovate UK’s Satellite Applications Catapult, we are attracting an increasing number of international space organisations such as Aero Sekur, Magellium, VEGA and MDA Space and Robotics to the Harwell Oxford Campus. Facilities include ESA’s new Centre for Space Applications and Telecommunications, the ESA Business Incubation Centre and a £26.4 million commitment for a new 7,000m² RAL Space Technology building ready for occupation in 2015. In addition, Lockheed Martin Space Systems business has secured a presence on Campus, to enable a pipeline of joint projects with STFC.

“Harwell’s open innovation environment, combined with the breadth and depth of the research and innovation undertaken on Campus lends itself to the Lockheed Martin collaborative approach.” Paul Davey, Business Development Director, Lockheed Martin Space Systems
4.2.3 Business incubation

STFC business incubation activities are well recognised for our offering to high-tech businesses within a dynamic multi-sector campus environment. Our unique Innovation Technology Access Centre (I-TAC) facility, ESA Business Incubation Centre and the STFC CERN Business Incubation Centre have enabled companies to create jobs, gain investment and develop new products. This has been recognised by four awards, including the UK Science Park Association’s award for having the best track record in developing and supporting start-up and high-growth businesses.

Between 2010 and 2013, over £80 million was invested into I-TAC companies from investors world-wide. 36% of companies receiving investment in the past year attributed this to being located on an STFC Campus. In this period, 128 new jobs were created and companies generated 46 new products, 33 patent applications and two licences, firmly indicating the success of this unique incubation model.

Improving portable X-ray systems

Since 2011, the ESA Business Incubation Centre has supported pioneering companies like Radius Healthcare who are incorporating cutting-edge technology originally developed by STFC for ESA satellites. Their aim is to commercialise an innovative X-ray system which is 20 times lighter than existing portable X-ray systems, and hence more easily operated at the bedside or an accident site.

Helping house hunters

A revolutionary app developed by UK company iGeolise Ltd, will help house hunters to search online for new homes by commuting time. Adapted to be commercially applicable, iGeolise’s Travel Time is being used by leading property website, Zoopla. At least 40% of all web searches rely on geographical information and Travel Time uses satellite maps overlaid with public transport and road data to identify accurate journey times to properties.

Higgs Centre for Innovation

The successful business incubation model pioneered by STFC and its partners at Harwell Oxford and Sci-Tech Daresbury is now set to be extended. A new Centre for Innovation, commemorating Nobel Prize winner Peter Higgs, in partnership with the University of Edinburgh, is set to exploit the UK Astronomy Technology Centre’s capabilities in space instrumentation and big data. The £10.7 million Higgs Centre for Innovation will incubate 12 small start-up businesses, bridging the gap between research and industry, and will allow PhD students to gain entrepreneurial experience. This new partnership will support businesses to tap in to the UK’s £11.3 billion space sector.
Partnering with Innovate UK

Innovate UK and STFC partnerships continue to be a success this year. STFC is working with Innovate UK on two Launchpads which are concentrated around STFC’s Campuses: the materials and manufacturing cluster at Sci-Tech Daresbury and space cluster at Harwell Oxford.

In 2013, 19 SMEs including seven from Sci-Tech Daresbury have been awarded a share of £1.6 million in funding. These businesses are the winners of the Materials and Manufacturing Launchpad, run by Innovate UK. All 19 SMEs will benefit from STFC’s business support package, to enable them to expand and develop innovative new products. Some of the winning companies are based in the I-TAC at Sci-Tech Daresbury and include NanoFlex Ltd, a company which has produced the first high performance electrode. This technology will be applied to many processes including the production of bleach and powering the flash in a digital camera.

New technology reduces cost of cancer treatment

Researchers at the University of Leicester have adapted gamma-ray technology originally used for astronomy in order to improve the detection and treatment of cancer. In collaboration with researchers at the University of Nottingham, the Leicester scientists developed a hybrid gamma-optical camera and went on to form a spin-out company, Gamma Technologies Ltd. The portable, high-resolution camera extends the use of nuclear medicine procedures to the bedside and operating theatre; it also reduces the cost of detecting and treating cancer. The device is currently undergoing trials at Queen’s Medical Centre, Nottingham.

4.3 Knowledge Exchange and Commercialisation

4.3.1 Commercialisation of STFC research

Our External Innovations team actively engage with our communities to maximise the benefits of our science and technology portfolio to the UK economy and society through commercialisation and exploitation activities. Working with academia, industry and knowledge exchange professionals, we develop innovation projects and support the development of skills that facilitate commercialisation skills and enable best practice.

STFC runs an active programme of engagement events and funding programmes. For example, the Challenge-Led Applied Systems Programme is designed to focus innovative research towards solutions to global challenges in energy, the environment, healthcare and security. The challenges are set by experts from industry, Government and the third-sector organisations which use STFC science. In addition, our Innovation Partnership Scheme supports researchers to collaborate with business. This scheme currently funds 50 projects and started 12 new projects in 2013 worth £2.4 million, which leveraged a further £1.2 million from industrial partners. Examples from these schemes include:

Gamma Technologies Ltd has a range of products with the potential to broaden the scope of clinical investigation. (Credit Gamma Technologies Ltd)

University-business collaboration in the nuclear industry

Experts at the University of Liverpool are working with CANBERRA UK Ltd to improve the radiation-detection technology used in the safety and security products that the company supplies to the nuclear industry. CANBERRA contributed 35% of the cost of the project and now predicts a 15% growth in sales of detectors and a 7% increase in market share.
“The STFC-funded department at the University of Liverpool is recognised as a world leader in detector research and has access to great facilities, so we are moving in a common direction which will deliver enormous benefits to both organisations and the measurement community as a whole.” Dr James Cocks, Vice President for Research and Development at CANBERRA

Spin-out successes
We support growing spin-out companies by helping them to form collaborative partnerships to continue the development of innovative technologies. With our support, Durham University Physics Department’s spin-out, Kromek, has worked on collaborative projects with Glasgow, Liverpool and Oxford universities for the past five years. These projects have enabled STFC-funded expertise to be used in the development of Kromek’s radiation-detection technologies, made available to the medical imaging, nuclear detection and security screening markets. Incorporated in 2003, Kromek now employs more than 100 staff over five sites; the company has also acquired two businesses in the USA, and made a successful initial public offering in 2013 which raised £15 million.

Another spin-out, the University of Southampton’s Symetrica, was created with the support of the STFC/Royal Society of Edinburgh Enterprise Fellowships programme, and has since continued its collaboration with the university with our support. The company now has facilities in the UK and the USA, and supplies the gamma and neutron detection subsystems included in the Smiths Detection product, Radseeker. The US Department for Homeland Security has this year awarded a £6 million contract for the devices.

4.3.2 Commercialisation of STFC Intellectual Property
Our Innovation team are responsible for the protection and exploitation of STFC’s intellectual property portfolio. Since 2002, 16 spin-out companies have been set up, raising more than £59 million of third-party investment and creating over 164 jobs. Many of our spin-outs have been successful in winning funding from Innovate UK as part of their early-stage development. Key statistics from 2013/14 include:

- Despite the recent downturn in the economy, 12 spin-out companies are trading and currently employ more than 108 people, with seven companies actively recruiting.
- Five new patent applications were filed, bringing the total number of patent families to 63. In addition, two new royalty-bearing licences were created, bringing the total to 12.
- We also awarded 13 new Proof of Concept awards totalling £900k.

Some recent highlights from our spin-out companies include:

- **Oxsensis** is a successful STFC spin-out formed in 2003. This year the company developed two new high-accuracy sensors, both through collaborative development programmes part-funded by Innovate UK. One sensor was developed for commercial oil and gas applications with UK company GE Measurement and Control systems.
- **Teratech Components** designs and fabricates components for a wide range of commercial products in areas including space science research, security and medical instrumentation. The company is currently part of a £3.8 million European consortium which seeks to improve the efficiency and security of border checks.

Innovation Partnership Scheme Fellows
These Fellowships provide a dedicated knowledge exchange and commercialisation resource in STFC-funded departments in UK universities. Eight Fellowships have been awarded since 2008, the first three of which generated investment back into their respective universities valued at 15 times the initial STFC contribution:

- The Scottish Universities Physics Alliance Fellow has so far helped to secure over £6 million in knowledge exchange funding for Alliance partners and facilitated seven new commercial ventures.
- The University of Leicester Fellow has generated grant income to the Space Research Centre in excess of £4.5 million for space-related knowledge exchange activities.
- The University of Cambridge Fellow has been instrumental in setting up VoxTox, a research programme with over £1.2 million in external funding which focuses on reducing toxicity from radiotherapy. This Fellow has also facilitated a new R&D strand in computational radiotherapy, translating technologies from CERN to cancer treatments.

*A patent family is a set of patents taken in various countries to protect a single invention. It can take a number of years from first filing to the patent being granted.*
Cobalt Light Systems

Cobalt Light Systems was established in 2006 to commercialise Spatially Offset Raman Spectroscopy, a laser technique that was developed at STFC’s Central Laser Facility. Cobalt Light Systems is the UK’s 10th fastest growing tech company\textsuperscript{104}, having grown sales from £0.8 million to £12 million in the past two years. In 2014 they employ 40 people and their three-year average sales growth is 125% per annum.

The company have developed a number of applications using this technique including an instrument used by pharmaceutical companies to verify the contents and quality of medicines. Their airport scanners identify the contents of opaque bottles and have been introduced into 65 airports across Europe. Other applications including real-time diagnostic tools for cancer and bone disease.

In 2014, the company won the UK’s most prestigious prize for engineering innovation, the Royal Academy of Engineering MacRobert Award—given for proven commercial promise and tangible societal benefit.

Rainbow Seed Fund

The Rainbow Seed Fund\textsuperscript{105}, of which STFC is a core member, is an £14 million early-stage venture capital fund dedicated to generating investment in companies started from publically funded research. Started in 2002, its focus is to help translate promising technologies into useful products, tools and services. STFC is a lead partner in this fund, along with BBSRC, NERC and the Defence Science & Technology Laboratory, which is run by private sector fund manager Midven Ltd\textsuperscript{106} and has former Science Minister Ian Taylor, as the Chair of its Advisory Board. In 2013 they commissioned an economic analysis of 25 companies\textsuperscript{107} that have been supported through the fund. Highlights from this report include:

• Over £10 million of UK exports have been generated from these companies to date, and this is expected to rise to over £90 million by 2018.
• Co-investment from private investors of £127 million was leveraged from just over £6 million of fund investment.
• 73% of the companies would not have been created without this fund, highlighting its importance to early stage business development.

Microvisk Technologies

Spun-out from STFC in 2004, Microvisk\textsuperscript{108} is a medical device company which has developed a unique handheld device which monitors blood clotting in patients. Seven million patients world-wide take Warfarin, which help stops clots forming in the blood and is used to prevent heart attacks and strokes. Due to launch in 2015, this home testing device will revolutionise the blood testing market, saving the NHS millions of pounds a year. STFC and the Rainbow Seed Fund have played a critical role in Microvisk’s development, providing technical support, access to facilities and investment funding throughout the company’s development\textsuperscript{109}.

Transferring knowledge and technology to industry

STFC supports new product development through its licensing activities and funds STFC’s own researchers to transfer technology to industry. Examples include:

• Former ESA Business Incubation Centre company, SubTeraNDT, has designed a product to non-destructively inspect insulation and coatings in oil and gas plants for corrosion. A recent corrosion problem on the Statoil Troll rig resulted in a three-day shutdown of the rig and a multi-million pound loss of revenue\textsuperscript{110}. With the technology licensed from STFC and ESA, and funding support from Innovate UK, the company has launched a camera to carry out these inspections\textsuperscript{111}.

• Oxford Instruments signed a contract with CERN to carry out work on the upgrade of the Large Hadron Collider at CERN. This upgrade requires the deployment of specialist superconducting magnets licenced from STFC\textsuperscript{112}.

\textsuperscript{104}GVA measures the contribution to the economy of each individual producer, industry or sector in the UK. Office for National Statistics.

\textsuperscript{105}All GVA, ROI and employment figures stated include indirect effects in addition to direct numbers.

\textsuperscript{106}CMOS is a technology for constructing integrated circuits.
4.4 Supporting UK business

Industry engages with STFC at many levels in addition to our commercialisation activities described in the preceding sections. We offer our skills, products, services and facilities to UK industry. This can include engaging with key STFC staff who act on a consultancy basis and the co-development of technology. Industries which benefit from our expertise include security, space, aerospace, automotive, healthcare, pharmaceuticals, oil and gas, environmental, software and manufacturing.

STFC collaborates extensively with industry and our top industrial collaborators include Astrium, e2v, Intel, Selex Galileo, Siemens, Oxford Instruments, Unilever and IBM. Our study on the relationship with e2v and Oxford Instruments showed that these two companies benefited by an estimated £500 - 700 million through collaboration with us.

Between 2012 and 2014, around 1,000 different organisations utilised STFC facilities and services, of which 440 were commercial companies. In 2013/14 STFC’s external income was £67 million, of which 22% was direct from industry and 37% was foreign direct investment from sources including the European Parliament, overseas government departments and universities.

Examples of contracts that STFC has won from external partners this year include:

- A £10 million Czech contract for HiLASE was won by the Central Laser Facility to develop new laser technologies. This project will develop the power and efficiency of current laser systems, opening up new applications across a wide range of industries.
- The Extreme Light Infrastructure project in Romania has awarded a £2.2 million contract to the Central Laser Facility for a cutting-edge laser amplifier and a £4.5 million contract to Daresbury Laboratory for accelerator modules.

4.4.1 Industrial use of large-scale facilities

Our synchrotron and neutron facilities form a critical part of research and development in industry for companies ranging in size from FTSE 100 multi-national organisations to SMEs. This year, our UK industrial customer base has increased from 89 to 96 proprietary commercial facility users, an increase of 36 in two years. In addition, 13 UK companies accessed the STFC-funded ILL and ESRF facilities and it is estimated that 10-15% of all proposals to these facilities have additional industrial involvement. Some highlights of industrial use of large-scale facilities include:

The Linde Group

The Linde Group, a gases and engineering company, used ISIS to gain vital information about a novel ink product they are developing with a wide range of applications including solar cells, touchscreens and sensors. Current technology has high processing costs and is unsuitable for flexible displays. It is hoped that this new product will revolutionise a large global market, with touchscreens and interactive displays alone estimated to be worth £2.5 billion by 2017.
Infineum
Companies such as Infineum, a UK manufacturer of petroleum additives, regularly depend on STFC facilities, including ISIS, Diamond Light Source and the ESRF to improve fuel efficiency. One area of research is the fuel injection system, where carbon deposits can increase emissions and fuel consumption. Only these facilities allow the systems to be examined without disassembly, giving companies an unparalleled understanding of the engine processes. This knowledge is essential to create the next generation of more environmentally friendly vehicles. Since the introduction of tight global emissions standards, the automotive industry is committed to reducing carbon emissions and invests over £66 billion in research and development every year.

4.4.2 Creating new business opportunities
STFC helps UK companies take advantage of on-going opportunities to supply products and services to our national and international facilities. One way STFC supports this is by showcasing the procurement opportunities available at our international facilities, explaining how to access contracts at these facilities and introducing companies to the UK liaisons for industry. The impact of winning contracts by UK companies from international facilities is often greater than anticipated, as it boosts a company's reputation, enables development of new products and allows business to be won elsewhere, leading to a bigger return on investment.

In 2013 UK industry won £28 million in contracts from our international subscriptions including CERN, ESO, ILL and ESRF, totalling £178 million since 2005. Like our partner facilities, STFC also has on-going procurement requirements and in 2013/14 we placed £143 million in contracts with UK companies, with just over 30% going to nearly 1,000 SMEs and the remainder was contracted to 212 large UK companies.

Contract successes for UK companies
- AS Scientific, a global supplier of low-temperature engineering equipment, won several contracts from CERN which led to an invitation to join a consortium for work at ITER on a €53 million project. The company expect to gain £2-3 million in sales from the project.
- F2 Chemicals have won a £2 million contract to supply CERN with chemical coolants for the Large Hadron Collider. F2 Chemicals reported that working with CERN led to a boost in their sales and market image.
- In 2003, SME HireServe provided CERN with their iCams software recruitment solution, which directly led to expansion of the company and its client base. For example, following endorsement by CERN, the University Hospital of Geneva implemented the software to manage their 10,000 job applications each year.
- SCISYS won a £50k contract with ESO for a software project to provide architectural design for the Telescope Control System of the E-ELT. This experience enabled them to win an initial £90K contract for the pre-construction of the Square Kilometre Array.

SKA-MID Africa Widefield computer generated image (Credit: SKA)
5. World-Class Skills

5.1 Introduction

STFC’s ambition is to deliver the scientific and technically skilled workforce that will sustain the UK as one of the world’s leading research nations, supporting the growth of a high-tech economy. Our skills activities are designed to meet a variety of different needs. We inspire and involve young people and the general public, capitalising on the inspiring nature of STFC’s science programmes to attract young people into STEM education and increase public awareness of the benefits of science. We provide highly-skilled people for the UK research base and the wider economy through post-graduate training, apprenticeships, by developing our own staff and by transferring skills into industry. This ensures we foster transferable skills for the benefit of the wider economy.

We are currently developing a skills strategy to support and enhance each of the skills offerings outlined above. This strategy will be supported by a new Skills and Engagement Advisory Board reporting directly to our Council, with complementary expertise from the sector.

5.2 Inspiring and involving

We continue to involve the wider public in STFC-supported research, with the aim of creating a culture in which scientific endeavour is highly valued by society, opportunities to engage are open to all, and young people from every type of background are encouraged to study science and technology and follow STEM careers. To ensure our public engagement in science and technology is as inclusive as possible, we are implementing a new strategy125 to reach audiences which do not traditionally engage with science and engineering activities.

STFC has a strong and internationally respected programme of communications and outreach that attracts young people into science and helps improve the scientific literacy of the general population. Between 2009 and 2014, we had around 84 million cumulative public contacts through four STFC mass media initiatives alone.

An important aspect of growing the UK’s knowledge economy is helping young people follow STEM careers, and we play a key role in enabling this to happen. Applications for physics degree courses saw a further 7%126 increase in 2013, meaning applications have increased by 64% since 2008. This is widely attributed to the high profile of physicists such as Professor Brian Cox127 and the prominence of CERN in the media, including the coverage of the Higgs boson discovery. The following infographic highlights some of our activities designed to engage the public in our programmes in 2014:
Key statistics from our public engagement programme in 2013 include:

- We reached an estimated 18,000 teachers, 91,000 primary students, 243,000 secondary students and 1.1 million members of the general public.
- We awarded 32 public engagement grants and fellowships valued in total at £626k.
- We organised 330 STFC events, which attracted 28,500 members of the public.
- We enabled visits to CERN by a total of 369 school groups (8,738 pupils).

Highlights from this programme include:

- A project led from the UK Astronomy Technology Centre, and part-funded by the Scottish Government, has enabled deaf scientists and linguists from Heriot Watt and Edinburgh universities to create more than 90 new British Sign Language signs related to astronomy. There are an estimated 150,000 users in the UK, and the newly created signs are now helping the deaf community, other learners and teachers to connect with cutting-edge research. Previously, users have had to rely on finger spelling.

  "It's brilliant to see especially created signs in BSL. They have created signs for each and every planet. It's fantastic to see it portrayed in a visual means." Gerry Hughes, the first deaf man to sail solo round the world

- In 2014 we upgraded our education-support materials for our loans scheme for lunar rock and meteorites. Valuable samples of 382 kilograms of lunar moon rock and soil were brought back to Earth by NASA's Apollo astronauts. STFC is the only authorised source for these samples in the UK. Overall, these popular resources have reached 683 borrowers, including schools, museums, universities, science centres and the National STEM Centre since the scheme started in 2009.

- One-day particle physics master-classes were held for GCSE and A-level students at 20 universities and laboratories across the UK. At STFC laboratories alone, more than 1,000 students took part. These events provide the opportunity for school students to learn about particle physics from the scientists who carry out the research, and to engage with this exciting area of STFC science.

- Explore Your Universe is a strategic national partnership between STFC and the Association for Science and Discovery Centres. Now in its second phase, the first phase was recently evaluated and the infographic below demonstrates key statistics from this phase of the project:

5.3 Developing skills for the UK research base

STFC's university groups are fundamental to delivering our skills training. Our research areas attract 90% of undergraduates who study physics, and our world-class researchers train our PhD students in high-end scientific, analytical and technical skills.

In addition to PhD studentships, we fund 12 Ernest Rutherford Fellowships and research grants per annum. We also fund Studentship Enhancement Programme awards which aim to help departments to retain the most promising researchers among completing PhD students in research. In addition, five new STFC CaSE studentships each year offer PhD students the opportunity to work with industry, enabling effective technology transfer. Industrial partners involved over the last 10 years include Surrey Satellite Technology Limited, Siemens, Micron Semiconductor Ltd. This year STFC has harmonised with AHRC, BBSRC, NERC and MRC on a common application process.
In 2013/14 STFC:

• Invested £22.4 million in postgraduate training and fellowships in particle physics, nuclear physics and astronomy, including 220 new PhD studentships, bringing the current cohort to 766.

• Provided over 14,200 training days to postgraduate students at our facilities and departments across a range of disciplines. Some 1,815 PhD students used our UK facilities, 34% of the total number of users.

On average, around 50% of STFC students move directly into university postdocs or fellowships, with two-thirds of them remaining in the UK. Around 10-20% secure permanent academic posts, helping to sustain a vibrant research base. Within seven years of completing their PhD, 30% of STFC students have typically entered the private sector, either in high-tech or financial services companies, and many more join the private sector after undertaking postdoctoral research. A physics PhD equips students for a range of careers requiring high-level skills, with 90% of the ex-students reporting that their PhD was important to their career development.

5.4 Developing skills for the wider economy

5.4.1 School leavers and undergraduates

We undertake several activities and schemes which support school leavers, those at college or those in their first degree. Activities at our national laboratories include apprenticeships, vacation students, sandwich students and graduate placements. STFC supports apprenticeships and traineeships at CERN and ESRF and also contributes to National Space Academy courses.

Work experience placements for 14-18 year-olds at our National Laboratories benefit more than 175 young people per annum, with over 50% of students saying that their placement at STFC has influenced their career path decision. STFC offer placements across a number of departments and facilities. For example, Diamond Light Source run a number of schemes for school leavers and students; the Student Summer Placement scheme provide 8-12 week paid positions undergraduate students each year.

We currently host 37 apprentices and our scheme has been running for 21 years. Each apprenticeship offers four years’ paid training and it is regarded as one of the best engineering apprenticeships in the country. Some 65% of the apprentices that have been taken on are still employed with us.

The National Space Academy

The National Space Academy, a non-profit organisation, began in 2008 and since then has developed into a world-renowned education programme. It was recognised by the Queen in 2014, when Anu Ojha, Director of the National Space Academy, was awarded an OBE for services to science education. The National Space Academy delivers STEM support to teachers and students up to BTEC level, with a programme of student masterclasses, teacher CPD and careers events across the UK, and these programmes have improved student attainment and teacher effectiveness in the UK. The programme is funded by STFC, the UK Space Agency, ESA and partners from the UK Space Sector.

Training to provide the best medicine

Nuclear medicine harnesses techniques originating in nuclear physics and transforms them into life-saving healthcare procedures. To maximise the benefits, it is essential to embed the right expertise in the healthcare sector – a goal underpinning the new Medical Teaching and Research Laboratory located at Sci-Tech Daresbury, involving the University of Liverpool, Royal Liverpool University Hospital and STFC. Targeted at MSc students...
specialising in medical physics and bioinformatics, this unique UK facility delivers hands-on training in specialise medical imaging. This imaging can show how well blood is flowing to the heart, helping to diagnose coronary artery disease and find out if a heart attack has occurred. It is also providing continuous professional development for those already working in the sector.

5.4.2 Developing our people
STFC employs 1,780 people, many of whom are highly-skilled scientists, technicians and engineers. STFC is a focal point for the UK's national capability in a number of areas, such as microelectronics, high performance computing and research techniques such as neutron and X-ray scattering. We provide training to develop the skills of our own staff, with each staff member receiving an average of five days' training per annum.

Having achieved Silver Investors in People accreditation in 2011, STFC is delighted to have achieved Gold accreditation following its latest Investors in People review in 2014. Investors in People provides a best practice people management standard, offering accreditation to organisations that adhere to the Investors in People framework.

This year STFC was voted the Best Graduate employer within Science, Research and Development by the JobCrowd website, the UK's leading graduate job review site. This was decided following graduate reviews of STFC, and followed on from STFC being nominated in 2012 and 2013 as one of the top 100 companies for graduates to work for. STFC also sponsored the WISE (Women in to Science and Engineering) awards 2013, which each year recognises UK women for their contribution to industry and innovation.

Amongst STFC’s staff and the academics we support in universities are many individuals considered to be world-leaders in their respective fields. Around 100 staff members hold honorary academic positions and joint appointments with universities or companies, both within the UK and internationally. Some 400 staff received significant awards or recognition in 2013, such as research prizes, representation on international scientific committees and membership of journal editorial boards.

STFC is also committed to the diversity and equality agenda and our organisation benefits from the wider range of skills, experience and attitudes provided by a truly diverse workforce. We aim to attract people from diverse backgrounds and closely monitor statistics in our studentships, grants and panel membership to ensure this happens.
5.4.3 Developing industrial skills

STFC works extensively with industry, both supplying skilled staff and university researchers who transfer into industry through our employment and training programmes, and transferring knowledge and skills to industry through collaboration activities. Our expenditure on activities that aim to improve knowledge transfer, business or industrial skills is approximately £2.5 million per year.

Our Campuses make substantial contributions to skills development activities, with various training activities offered. Working with Campus partners and organisations such as the Growth Accelerator\textsuperscript{141}, we deliver investment readiness programmes, mentoring and skills training on key business issues. This support forms a key part of the delivery of Innovate UK’s Launchpads in which STFC deliver technical and business support. We also offer a comprehensive technical support package to eligible Campus companies to provide access to the skills and technologies that will improve product or service development.

The following examples demonstrate the different ways in which we support industrial skills development:

Revolutionising medical diagnosis

Recognising the expertise of STFC’s engineers in accelerator design, Siemens have been working in collaboration with staff at our ISIS neutron source to build and develop a Siemens accelerator based at the facility\textsuperscript{142}. This accelerator will increase the provision of isotopes used for medical scans, lowering the costs and making advanced diagnostic techniques more available to patients. Dr Paul Beasley, Head of Strategic Development at Siemens said, “The Siemens ONIAC project is a great example of how industry can collaborate with national labs to develop new technologies that will benefit society.”

Training Entrepreneurs

STFC funds and helps manage the Enterprise Fellowship scheme, in collaboration with Royal Society of Edinburgh, Scottish Enterprise and BBSRC, to support the creation of new commercial ventures that have grown out of the STFC-funded science and technology. This scheme offers researchers the opportunity to acquire the skills to spin out a business from their academic institution. The objective of the Fellowship is the completion of an “investor ready” business plan, incorporation of a new spin-out company and seed funding. These new companies are able to target global market opportunities with innovative new technology. Enterprise Fellow Dr James MacFarlane, based at the University of Bristol, is now Managing Director of the spin-out, ImiTec\textsuperscript{143}, which has developed an advanced airborne radiation monitoring system that was deployed recently in the area around the Fukushima nuclear power plant in Japan.

Using lasers to develop anti-cancer drugs

STFC have funded a PhD studentship with industry partner Evotec, to test their cancer drug Gefitinib\textsuperscript{144} using STFC’s Central Laser Facility. Some drug-based cancer treatments work by inhibiting the signals that cause mutated cancer cells to multiply, but the efficiency of these drugs varies greatly. Treatments are often effective for a short while, but the disease can return because signals, initially blocked by the drugs, start finding alternative routes to multiply. This project aims to refine the design of inhibitor drugs, helping to prevent patients becoming unresponsive to treatment. It is hoped this work will contribute to the eventual development of patient-by-patient cancer treatment options.

Early development of laser eye surgery

More than 16 million laser eye surgery procedures are performed world-wide, generating sales of around £400 million a year and creating around 3,000 direct jobs. In the early 1980s Central Laser Facility staff worked with Excimer lasers to etch electrical components onto silicon chips. As a result, they developed rare expertise into how lasers interact with different substances, including organic material. The knowledge gained there was then applied to the emerging field of corneal reshaping. Through a unique collaboration between researchers at the Institute of Ophthalmology and a researcher, Tony Raven, from the Central Laser Facility, one of the first successful methods of laser eye surgery was developed. This researcher then formed Summit Technology with investors and the company went on to become one of the top global manufacturers of eye surgery lasers, and was acquired by the Alcon division of Nestle for £707 million in 2000. “The key step in those early days that enabled the development of the eye surgery technique came out of the know-how developed at RAL in the CLF.” Tony Raven, Chief Executive at Cambridge Enterprise
By its nature, short-term output metrics cannot provide a full picture of the broader economic and societal benefits of STFC research, facilities and Campuses. Our evaluation programme includes impact studies, case study evaluations and bibliometric studies. This year we have undertaken some substantial projects designed to explore different methodologies which will form part of our evidence base for the Comprehensive Spending Review 2015. We have also been trying to reach new audiences with our impact communications through a targeted mailer and updated case studies on our website.

Investment appraisal and evaluation approach

STFC is part of a joint approach to investment appraisal and evaluation developed across the Research Councils, which links into work that is being carried out from Recommendation One of the Triennial Review on performance monitoring. This approach matches appraisal and evaluation to investment decisions. As part of this work, STFC recently published its Impact Evaluation Strategy and Framework. Developed in 2011, recently refreshed and published, our framework articulates STFC’s impact across our strategic goals, delivery vehicles and differing timescales. The framework demonstrates the complex nature of STFC’s impact and guides evaluation priorities.

ISIS impact study

BIS gave recommendations on the evaluation of large research facilities in their Big Science and Innovation study last year. In response we have carried out a 30-year lifetime study on the impact of our ISIS neutron facility. The project has captured the impacts of our key strategic themes of world-class research, innovation and skills, measuring these benefits where possible, and contains both quantitative and qualitative evidence.

Impact study on Atlas Computer Laboratory

This year we have carried out a study on the impact of the Atlas Computer Laboratory at STFC’s Rutherford Appleton Laboratory. This early supercomputing facility, founded in 1962, was responsible for some of the key technology developments which underpin modern computing. We have utilised the expertise of an economist to assist in the valuation of STFC’s contribution to the modern computing industry.
Ben Green working on the last front end receiver for the Atacama Large Millimetre Array (ALMA), for which STFC is supplying the cryostats (Credit: STFC)
Cryogenics impact study
STFC specialises in underpinning technologies that are the foundation for many industries. We have a particular strength in cryogenic technology as many of our applications need to be cooled to cryogenic temperatures. This year we have carried out a study on the impact of our cryogenic technology and how this has underpinned the cryogenic industry in the UK. The study will be published in early 2015.

Sci-Tech Daresbury Campus study
This year we will also be kicking off a project to measure the impact of our Sci-Tech Daresbury Campus. We will develop a framework and series of metrics to baseline and measure the ongoing impact of the Campus. This report will be concluded in summer 2015 and we will report on the results in next year’s impact report.

Researchfish
Researchfish is the on-line data collection system that we use to collect metrics on our University partnership programmes. We completed our fourth data collection in late 2014. The data collection focuses on the following areas: publications, collaborations, further funding, staff development and next destinations, technology development, IP and licensing, spin-outs, measures of esteem, public engagement, and use of facilities. The level of reporting and quality of data will continue to improve as we gather more information in future years. Work continues to gather outputs arising from use of the large UK facilities, piloting the scheme for ISIS and the Central Laser Facility. Researchfish has now been adopted by all Research Councils, going live in late 2014. The harmonised approach will deliver robust evidence of all councils’ investments and improve reporting on all grant portfolios.

Gateway to Research
Gateway to Research is RCUK’s website which enables users to search and analyse information about publicly funded research through a single web-based portal funded by the Research Councils and Innovate UK. Launched in December 2013, the portal allows exploration of the entire breadth of research across all disciplines and industry sectors. The system contains information about the research the Research Councils fund, as well as details about the outcomes, outputs and impact captured through Researchfish, linking through to other available open access repositories and data catalogues.

Improved communications
This year we have updated our case study area on the STFC website and have a series of longer term case studies and shorter term success stories. We have also published a joint case study with colleagues in BBSRC on the impact of research on the foot and mouth disease virus. We introduced a quarterly impact mailer that we have been sending out to key stakeholders including Government, industry, science influencers and our research community. Containing information on our key impact publications, we have released two of these mail shots so far with open rates of 31% and 38% respectively.

Future programme and challenges
In the next year we will complete the evaluations mentioned above. The main focus of our work next year will be compiling our evidence base for the spending review in 2015.
### 7. Appendices

#### Appendix 1 - STFC cross-council output metrics

All data is collected from STFC internal sources unless otherwise stated.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Funds Available</strong></td>
<td>£mil</td>
<td>691</td>
<td>705</td>
<td>639</td>
<td>601</td>
<td>571</td>
<td>580</td>
</tr>
<tr>
<td><strong>Budget Allocation</strong></td>
<td>£mil</td>
<td>603</td>
<td>607</td>
<td>583</td>
<td>536</td>
<td>508</td>
<td>513</td>
</tr>
<tr>
<td><strong>Total Leverage</strong></td>
<td>£mil</td>
<td>89</td>
<td>98</td>
<td>56</td>
<td>65</td>
<td>63</td>
<td>67</td>
</tr>
<tr>
<td>of which Private</td>
<td>£mil</td>
<td>9</td>
<td>35</td>
<td>32</td>
<td>39</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>of which from other Research Councils</td>
<td>£mil</td>
<td>14</td>
<td>19</td>
<td>14</td>
<td>14</td>
<td>11</td>
<td>18</td>
</tr>
<tr>
<td>of which from other source</td>
<td>£mil</td>
<td>66</td>
<td>44</td>
<td>10</td>
<td>12</td>
<td>37</td>
<td>37</td>
</tr>
<tr>
<td>of which Private %</td>
<td></td>
<td>1%</td>
<td>5%</td>
<td>6%</td>
<td>6%</td>
<td>3%</td>
<td>2%</td>
</tr>
<tr>
<td>of which Other Research Councils %</td>
<td></td>
<td>2%</td>
<td>3%</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>of which Other %</td>
<td></td>
<td>9%</td>
<td>7%</td>
<td>1%</td>
<td>1%</td>
<td>7%</td>
<td>6%</td>
</tr>
<tr>
<td><strong>Total Expenditure</strong></td>
<td>£mil</td>
<td>691</td>
<td>705</td>
<td>639</td>
<td>601</td>
<td>571</td>
<td>580</td>
</tr>
<tr>
<td>of which Responsive Mode Grant</td>
<td>£mil</td>
<td>116</td>
<td>120</td>
<td>90</td>
<td>99</td>
<td>79</td>
<td>82</td>
</tr>
<tr>
<td>of which Postgraduate Awards</td>
<td>£mil</td>
<td>23</td>
<td>25</td>
<td>26</td>
<td>24</td>
<td>23</td>
<td>22</td>
</tr>
<tr>
<td>of which Other components</td>
<td>£mil</td>
<td>552</td>
<td>530</td>
<td>523</td>
<td>478</td>
<td>469</td>
<td>476</td>
</tr>
<tr>
<td>of which Responsive Mode Grant %</td>
<td></td>
<td>17%</td>
<td>18%</td>
<td>14%</td>
<td>16%</td>
<td>14%</td>
<td>14%</td>
</tr>
<tr>
<td>of which Postgraduate Awards %</td>
<td></td>
<td>3%</td>
<td>4%</td>
<td>4%</td>
<td>4%</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>of which Other components %</td>
<td></td>
<td>80%</td>
<td>78%</td>
<td>82%</td>
<td>80%</td>
<td>82%</td>
<td>82%</td>
</tr>
</tbody>
</table>

#### Human Capital

<table>
<thead>
<tr>
<th></th>
<th>#</th>
<th>#</th>
<th>#</th>
<th>#</th>
<th>#</th>
<th>#</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Principal Investigators</strong></td>
<td></td>
<td>365</td>
<td>345</td>
<td>360</td>
<td>266</td>
<td>226</td>
<td>232</td>
</tr>
<tr>
<td><strong>Research Leaders in Sponsored Institutes</strong></td>
<td>#</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Research Fellows</strong></td>
<td>#</td>
<td>19</td>
<td>12</td>
<td>11</td>
<td>13</td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>

#### Knowledge Generation

<table>
<thead>
<tr>
<th></th>
<th>#</th>
<th>#</th>
<th>#</th>
<th>#</th>
<th>#</th>
<th>#</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of Grants assessed for reporting</strong></td>
<td>#</td>
<td>294</td>
<td>189</td>
<td>280</td>
<td>229</td>
<td>358</td>
<td>271</td>
</tr>
<tr>
<td><strong>Refereed Publications</strong></td>
<td>#</td>
<td>4281</td>
<td>4438</td>
<td>4654</td>
<td>4966</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

#### Human Capital

<table>
<thead>
<tr>
<th></th>
<th>#</th>
<th>#</th>
<th>#</th>
<th>#</th>
<th>#</th>
<th>#</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of PhD Students Supported</strong></td>
<td>#</td>
<td>258</td>
<td>235</td>
<td>235</td>
<td>220</td>
<td>220</td>
<td>220</td>
</tr>
<tr>
<td><strong>Finishing Rates</strong></td>
<td>%</td>
<td>95%</td>
<td>85%</td>
<td>91%</td>
<td>92%</td>
<td>93%</td>
<td>93%</td>
</tr>
<tr>
<td><strong>Rolling cohort of PhDs</strong></td>
<td>#</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>912</td>
<td>782</td>
<td>766</td>
</tr>
</tbody>
</table>

#### Commercialisation Activities

<table>
<thead>
<tr>
<th></th>
<th>#</th>
<th>#</th>
<th>#</th>
<th>#</th>
<th>#</th>
<th>#</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>New patent family applications filed</strong></td>
<td>#</td>
<td>7</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total number of patents granted worldwide</strong></td>
<td>#</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>26</td>
<td>23</td>
<td>7</td>
</tr>
<tr>
<td><strong>Spin-outs/new businesses created</strong></td>
<td>#</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><strong>Licences</strong></td>
<td>#</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Income from IP activity</strong></td>
<td>£mil</td>
<td>0.23</td>
<td>0.11</td>
<td>0.09</td>
<td>0.104</td>
<td>0.07</td>
<td>0.07</td>
</tr>
</tbody>
</table>

#### Human Capital

<table>
<thead>
<tr>
<th></th>
<th>%</th>
<th>%</th>
<th>%</th>
<th>%</th>
<th>%</th>
<th>%</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>First destination after PhD</strong></td>
<td></td>
<td>50%</td>
<td>52%</td>
<td>45%</td>
<td>47%</td>
<td>42%</td>
<td>39%</td>
</tr>
<tr>
<td><strong>Of which University</strong></td>
<td>%</td>
<td>15%</td>
<td>6%</td>
<td>7%</td>
<td>5%</td>
<td>8%</td>
<td>5%</td>
</tr>
<tr>
<td><strong>Of which Wider Public Sector</strong></td>
<td>%</td>
<td>9%</td>
<td>7%</td>
<td>13%</td>
<td>15%</td>
<td>17%</td>
<td>17%</td>
</tr>
<tr>
<td><strong>Of which Private Sector</strong></td>
<td>%</td>
<td>26%</td>
<td>35%</td>
<td>35%</td>
<td>33%</td>
<td>33%</td>
<td>39%</td>
</tr>
<tr>
<td><strong>Of which Unknown or Other</strong></td>
<td>%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Of which Unemployed</strong></td>
<td>%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

#### Facility usage

<table>
<thead>
<tr>
<th></th>
<th>#</th>
<th>#</th>
<th>#</th>
<th>#</th>
<th>#</th>
<th>#</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Station Days</strong></td>
<td>X</td>
<td>X</td>
<td>9297</td>
<td>11349</td>
<td>6724</td>
<td>7003</td>
<td></td>
</tr>
<tr>
<td><strong>Unique Users</strong></td>
<td>X</td>
<td>X</td>
<td>2803</td>
<td>3675</td>
<td>4254</td>
<td>5276</td>
<td></td>
</tr>
<tr>
<td><strong>Experiments</strong></td>
<td>X</td>
<td>X</td>
<td>1584</td>
<td>2072</td>
<td>2376</td>
<td>2688</td>
<td></td>
</tr>
</tbody>
</table>

---

* Bibliometric data for 2012/13 will be reported in next year’s report.
* A patent family is a set of patents taken in various countries to protect a single invention. It can take a number of years from first filing to the patent being granted.
* * * Patents can be awarded in different countries; this number does not represent the number of inventions, but the number of patents held across all countries and across all inventions.
* * * * Data collected from Higher Education Statistics Agency (HESA). http://www.hesa.ac.uk. Accessed Oct 2014
* Historical data unavailable due to changes in method of data collection.
Appendix 2 - STFC specific output metrics

All data is collected from STFC internal sources unless otherwise stated

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Principal Investigators supported by STFC grant funding</td>
<td>Number</td>
<td>439</td>
<td>226</td>
<td>256</td>
<td>232</td>
</tr>
<tr>
<td>Number of rolling cohort of STFC-supported PhD students</td>
<td>Number</td>
<td>830</td>
<td>912</td>
<td>782</td>
<td>766</td>
</tr>
<tr>
<td>Number of new PhD studentships supported by STFC</td>
<td>Number</td>
<td>235</td>
<td>220</td>
<td>220</td>
<td>220</td>
</tr>
<tr>
<td>New depositions in the Protein Databank from ESRF and DLS**</td>
<td>Number</td>
<td>X</td>
<td>1200</td>
<td>1394</td>
<td>1379</td>
</tr>
<tr>
<td>No. of UK researchers accessing CERN</td>
<td>Number</td>
<td>X</td>
<td>650</td>
<td>674</td>
<td>614</td>
</tr>
<tr>
<td>Number of unique users accessing STFC's large facilities</td>
<td>Number</td>
<td>Over 2000</td>
<td>Over 3600</td>
<td>4254</td>
<td>5276</td>
</tr>
<tr>
<td>Total number of experiments carried out at Diamond, CLF &amp; ISIS</td>
<td>Number</td>
<td>Over 1500</td>
<td>Over 2000</td>
<td>Over 2400</td>
<td>2688</td>
</tr>
<tr>
<td>Innovation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cumulative value of contracts placed with UK companies from CERN since 2008</td>
<td>£mil</td>
<td>19.5</td>
<td>38</td>
<td>60</td>
<td>74.9</td>
</tr>
<tr>
<td>Commercial organisations accessing STFC's UK facilities</td>
<td>Number</td>
<td>40</td>
<td>Over 60</td>
<td>89</td>
<td>96</td>
</tr>
<tr>
<td>Sci-tech Daresbury – total employees within companies on site</td>
<td>Number</td>
<td>337</td>
<td>437</td>
<td>448</td>
<td>474</td>
</tr>
<tr>
<td>Sci-tech Daresbury – external investment in companies in total*</td>
<td>£mil</td>
<td>54</td>
<td>75</td>
<td>63</td>
<td>97</td>
</tr>
<tr>
<td>ITAC, ESA BIC and STFC CERN BIC: No of new jobs created</td>
<td>Number</td>
<td>X</td>
<td>34</td>
<td>42</td>
<td>141</td>
</tr>
<tr>
<td>Number employed in STFC spin-outs</td>
<td>Number</td>
<td>88</td>
<td>121</td>
<td>120</td>
<td>73</td>
</tr>
<tr>
<td>Skills</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of STFC site based PE events</td>
<td>Number</td>
<td>X</td>
<td>X</td>
<td>200</td>
<td>330</td>
</tr>
<tr>
<td>The public audience reached by STFC (millions)</td>
<td>Number</td>
<td>1.4</td>
<td>X</td>
<td>2</td>
<td>1.1</td>
</tr>
<tr>
<td>The number of teachers involved with STFC PE per year</td>
<td>Number</td>
<td>X</td>
<td>X</td>
<td>17,500</td>
<td>18,000</td>
</tr>
<tr>
<td>Number of public engagement grants (awards and fellowships)</td>
<td>Number</td>
<td>51</td>
<td>50</td>
<td>27</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>(value £520,000)</td>
<td>(value £626,000)</td>
</tr>
<tr>
<td>Number of UK schools that visited CERN</td>
<td>Number</td>
<td>300</td>
<td>250</td>
<td>305</td>
<td>369</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(9500 pupils)</td>
<td>(8736 pupils)</td>
</tr>
<tr>
<td>Training days to postgraduate students at our facilities and departments across a range of disciplines</td>
<td>Number</td>
<td>7,000</td>
<td>12,000</td>
<td>16,800</td>
<td>14,280</td>
</tr>
<tr>
<td>STFC staff who received awards per year</td>
<td>Number</td>
<td>X</td>
<td>250</td>
<td>359</td>
<td>403</td>
</tr>
<tr>
<td>Number of apprenticeships</td>
<td>Number</td>
<td>X</td>
<td>X</td>
<td>24</td>
<td>37</td>
</tr>
</tbody>
</table>

* Companies that are no longer located at the Sci-Tech Daresbury Campus are not included in that year’s total investment figures
Our case for investment in science is underpinned by data on impacts arising from grants in our core university funded areas of astronomy, space science exploitation, nuclear physics and particle and nuclear physics. We record output data from these grants in our Researchfish outputs collection system. The data covers a wide cross-section of key areas of importance to demonstrate impact: publications, collaborations, further funding, staff development and next destinations, technology development, IP and licensing, spin-outs, measures of esteem, public engagement, and use of facilities.

We are encouraging a greater number of Principal Investigators to input into the collection system, and are pleased to report a year-on-year improvement in the number of submissions from 46% in 2010 to 51% in 2013. Due to this submission level however, it should be noted that the data presented here is an underestimate and not a full picture of impact from our university programmes. Given this strong caveat, existing data from our Researchfish system for grants that ended in December 2009 onwards, are shown in the table below.

<table>
<thead>
<tr>
<th>Year</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Publications</td>
<td>810</td>
<td>1160</td>
<td>1848</td>
<td>2534</td>
<td>2651</td>
<td>2942</td>
<td>3373</td>
<td>15318</td>
</tr>
<tr>
<td>Collaborations</td>
<td>64</td>
<td>76</td>
<td>103</td>
<td>146</td>
<td>124</td>
<td>78</td>
<td>59</td>
<td>650</td>
</tr>
<tr>
<td>Further Funding</td>
<td>35</td>
<td>23</td>
<td>56</td>
<td>110</td>
<td>87</td>
<td>85</td>
<td>59</td>
<td>455</td>
</tr>
<tr>
<td>Next Destination</td>
<td>6</td>
<td>14</td>
<td>29</td>
<td>57</td>
<td>48</td>
<td>78</td>
<td>120</td>
<td>352</td>
</tr>
<tr>
<td>Dissemination</td>
<td>146</td>
<td>188</td>
<td>320</td>
<td>471</td>
<td>577</td>
<td>474</td>
<td>713</td>
<td>2889</td>
</tr>
<tr>
<td>Technology Development</td>
<td>0</td>
<td>2</td>
<td>8</td>
<td>5</td>
<td>62</td>
<td>10</td>
<td>14</td>
<td>101</td>
</tr>
<tr>
<td>IP &amp; Licensing</td>
<td>0</td>
<td>13</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>Spin Out Companies</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Awards</td>
<td>209</td>
<td>237</td>
<td>357</td>
<td>571</td>
<td>706</td>
<td>437</td>
<td>374</td>
<td>2891</td>
</tr>
<tr>
<td>Total</td>
<td>1270</td>
<td>1713</td>
<td>2725</td>
<td>3898</td>
<td>4258</td>
<td>4105</td>
<td>4712</td>
<td>22681</td>
</tr>
</tbody>
</table>

The level of reporting and quality of data will continue to improve as we gather more information in future years. Our most recent data collection exercise, in late 2014, has a completion rate of 70%. This data will be presented in next year’s report. Furthermore, it has now been agreed across the Research Councils that it will be compulsory for Principal Investigators to input data into the system from 2015 onwards.
Appendix 4 – Additional Global Challenge case studies

**Early diagnosis of Alzheimer’s disease:** An estimated 800,000 people in the UK live with dementia, and numbers are expected to double within 30 years. Some 60% of cases of dementia are caused by Alzheimer’s disease. Early diagnosis is of crucial importance in improving quality of life for sufferers. A team from the Astronomy Centre and Medical Imaging Centre at the University of Sussex applied a machine learning technique used in astronomy to predict the probability of Alzheimer’s disease from functional MRI brain scans. The technique achieved 97% accuracy in distinguishing people with mild cognitive impairment from those with Alzheimer’s disease.

**Low-cost gas sampling:** Gas-sensing systems are used in a wide range of industrial, environmental and atmospheric applications: for example, for monitoring atmospheric pollution, testing of vehicle emissions, and detecting chemicals and explosives used in suspected terrorist activity. A low-cost, miniaturised, highly sensitive spectrometer, capable of analysing gaseous, solid or liquid samples, was developed by STFC and the University of Cambridge in conjunction with SenseAir Ltd. Additional funding was then secured through the STFC Challenge Led Applied Systems scheme in collaboration with the NERC Centre for Ecology & Hydrology to develop the spectrometer for environmental monitoring purposes, for the detection of dissolved organic carbon in water.

**Fukushima radiation monitoring:** Sensors developed at the University of Liverpool with funding from STFC and NERC can find the source of radiation with much greater accuracy and sensitivity than ever before. These sensors aim to see how radioactivity moves with changes in water flow or sediment movement, and how the radiation in contaminated soil gets into the food chain through plants and animals. The continued release of radioactive material from the earthquake-damaged Fukushima Dai-ichi nuclear power station in Japan, with risks to water, coastal environments, agricultural land, animals and human health, has drawn international concern. These sensors will help the recovery and regeneration of the post-disaster Fukushima region and pave the way for improved monitoring and control of radioactivity at nuclear sites world-wide.

**New applications for adaptive optics:** Supported by STFC, the European Extremely Large Telescope will be the largest optical and infrared telescope in the world, giving us a much more detailed and deeper view of the Universe from Earth. But the benefits of this telescope are much broader than astronomy. For example, sophisticated adaptive optics developed for this telescope at Durham University are now having far-reaching applications for research in other areas. In heart research, adaptive optics will be used to better understand the human heart and develop improved drugs and treatments for heart conditions by seeing beating hearts within Zebra fish. Similarly, scientists have also been using adaptive optics for ophthalmology; and have made a number of advances ranging from creating “true” 3D images of the eye and providing more detailed diagnostics for use at opticians.
### Appendix 5 - Glossary

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHRC</td>
<td>Arts and Humanities Research Council</td>
</tr>
<tr>
<td>ALMA</td>
<td>Atacama Large Millimeter/sub-millimeter Array</td>
</tr>
<tr>
<td>BBSRC</td>
<td>Biotechnology and Biological Sciences Research Council</td>
</tr>
<tr>
<td>BIC</td>
<td>Business Incubation Centre</td>
</tr>
<tr>
<td>E-ELT</td>
<td>European Extremely Large Telescope</td>
</tr>
<tr>
<td>EPSRC</td>
<td>Engineering and Physical Sciences Research Council</td>
</tr>
<tr>
<td>ESA</td>
<td>European Space Agency</td>
</tr>
<tr>
<td>ESO</td>
<td>European Southern Observatory</td>
</tr>
<tr>
<td>ESRF</td>
<td>European Synchrotron Radiation Facility</td>
</tr>
<tr>
<td>ILL</td>
<td>Institut Laue-Langevin</td>
</tr>
<tr>
<td>IoP</td>
<td>Institute of Physics</td>
</tr>
<tr>
<td>I-TAC</td>
<td>Innovation Technology Access Centre</td>
</tr>
<tr>
<td>JCMT</td>
<td>James Clerk Maxwell Telescope</td>
</tr>
<tr>
<td>KMOS</td>
<td>K-band Multi-Object Spectrograph</td>
</tr>
<tr>
<td>LHC</td>
<td>Large Hadron Collider</td>
</tr>
<tr>
<td>MIRI</td>
<td>Mid-Infrared Instrument</td>
</tr>
<tr>
<td>MRC</td>
<td>Medical Research Council</td>
</tr>
<tr>
<td>MRI</td>
<td>Magnetic Resonance Imaging</td>
</tr>
<tr>
<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
</tr>
<tr>
<td>NERC</td>
<td>Natural Environment Research Council</td>
</tr>
<tr>
<td>RAL</td>
<td>Rutherford Appleton Laboratory</td>
</tr>
<tr>
<td>SKA</td>
<td>Square Kilometre Array</td>
</tr>
<tr>
<td>STEM</td>
<td>Science, Technology, Engineering and Maths</td>
</tr>
<tr>
<td>STFC</td>
<td>Science and Technology Facilities Council</td>
</tr>
<tr>
<td>UK ATC</td>
<td>UK Astronomy Technology Centre</td>
</tr>
<tr>
<td>UKSA</td>
<td>UK Space Agency</td>
</tr>
<tr>
<td>VLT</td>
<td>Very Large Telescope</td>
</tr>
</tbody>
</table>
Appendix 6 - References

17. http://www.stfc.ac.uk/2920.aspx  Sep 2014
25. ‘ONS Annual Business Survey’ (provisional) 2012, Section C Manufacturing, 15 Nov 2012
34. Contributions for this section have been used from ‘CERN - Innovation for Impact’ a report written by Matjaz Vidmar for STFC as part of an MSc in Science and Technology in Society at the University of Edinburgh, 2013/14
49 http://www.youtube.com/watch?v=fHm4TV1hDCo Oct 2014
52 http://www.voxtox.org/ Oct 2014
54 http://openaccess.city.ac.uk/3770/1/Low-level%20night-time%20light%20therapy%20for%20age-related.pdf Oct 2014
69 http://www.stfc.ac.uk/3152.aspx Oct 2014
70 http://www.stfc.ac.uk/3166.aspx Oct 2014
71 http://www.stfc.ac.uk/3167.aspx Oct 2014
113 The economic and societal impact of STFC support: case studies on e2v and Oxford Instruments’, The Galbraith Muir Consultancy Ltd, 2012

114 http://www.stfc.ac.uk/2631.aspx Oct 2014
120 http://www.stfc.ac.uk/1449 Oct 2014
133 Review of UK Physics, RCUK (2008)
136 http://www.stfc.ac.uk/3391.aspx Nov 2014
142 http://www.imitec.co.uk/ Oct 2014
144 http://www.gtr.rcuk.ac.uk/ Oct 2014
145 http://www.gtr.rcuk.ac.uk/ Oct 2014
147 http://www.stfc.ac.uk/1846.aspx Oct 2014
149 http://www.stfc.ac.uk/3149.aspx Oct 2014