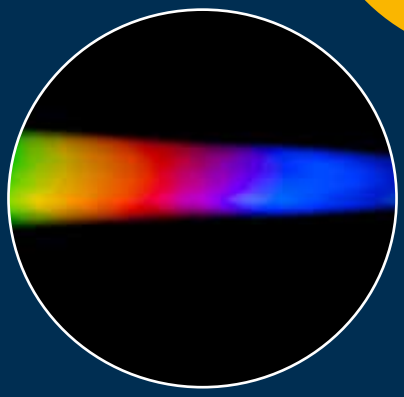
World-Class Skills:
Outputs from STFC Frontier Research

Skills



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Contents

This report has been written by Ian Fuller.

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Science and Technology Facilities Council
Polaris House, North Star Avenue
Swindon
SN2 1SZ
UK
T: +44 (0)1793 442000
F: +44 (0)1793 442002

www.stfc.ac.uk

Introduction

As a publicly funded research organisation, the Science and Technology Facilities Council (STFC) has the responsibility to report the outcomes of our research and demonstrate the value that the research base can add to our economy and society. Along with the other Research Councils, we collect information about our research funding in UK universities using an online system called Researchfish. The system allows our university partners to log a range of outputs from their research for at least five years after the end date of their award. The outputs range from publications and collaborations to commercialisation and public engagement.

A key part of STFC's remit is to fund frontier research in our partner universities; encompassing astronomy, space science research, particle physics and nuclear physics. UK research supported by us in these subjects is world class. In 2015-16 we committed over £100 million to support frontier research. This support also included funding for the on-going technology development necessary to support our experiments and facility upgrades. Equating to 18% of our total budget, this funding was used to support 60 universities and research organisations (ROs) across the UK in these areas.

The frontier science STFC supports is reliant on the strong skills base needed to deliver a world-class, international science programme. Ensuring the UK has the skilled staff required to deliver our research and underpinning technology is a key objective of the organisation. Our core mission is to support and train talented people – apprentices, graduates, doctoral students, postdoctoral researchers and research fellows – through research in universities, work and training at international facilities and at STFC's own national laboratories. We also aim to provide the 21st century science, technology, engineering and mathematics (STEM) skillsrequired by UK industry for the benefit of society and the economy.

The following report details how STFC supports PhD students in particle physics, astronomy and nuclear physics through the awards to our university partners. It also outlines how STFC-supported researchers engage with different audiences including the general public, teachers and school children. The report will show the number of people that they have reached and the channels used. Collaborations are key to building world-class skills, and this report also highlights the number and geographical reach of the collaborations our researchers have reported.

Dr Vardaki is using light to improve the detection of prostate cancer.

Credit: Dreamstime.com

Studentships

In 2015-16, STFC invested £23.4 million in postgraduate training and fellowships in particle physics, nuclear physics and astronomy, including 229 new PhD studentships, bringing the current cohort to 766[1]. We have also supported over 200 research fellows during the same period.

Working in our frontier science gives our students a range of transferrable skills applicable to both the research base and high-tech industries, for example in data-intensive science.

Those trained have been in a diverse range of areas including particle and nuclear physics, astronomy, planetary sciences, chemistry, supercomputing and instrumentation.

Towards the end of 2016 we collected information on the first destinations of 941 STFC-funded PhD students who had completed their doctorate in the previous four years (2012-2015)[2].The survey showed that nearly half (45%) of the graduates took up a postdoctoral position, 51% of which were at UK universities. Of those that took up postdoctoral positions, 15% were taken in EU countries. Other first destinations for STFC-funded PhD students were the private sector (28%), charity or other public sectors (5%), other roles in universities (5%), school teaching (4%), with the remaining minor percentages representing students still in further education, listed as other/unspecified or not in work or education.

For those students whose first destination was the private sector, a wide range of roles were taken up. These included software development, data analysis, engineering and finance (over 70% of students went into one of these areas).

The results from the STFC survey are not dissimilar to the latest results from the Destination of Leavers from Higher Education (DLHE) data[3], compiled by the Higher Education Statistics Agency (HESA). The results of this can be found in our 2016 Impact Report[4].

For the 2016 submission period, research councils asked postgraduate students in their second year of study or later to provide details of outcomes they have realised as part of their studies via Researchfish. As well as encouraging the next generation of researchers to reflect on the impact of their work, it also allows the research councils to highlight the skills that have been acquired through our studentship programmes.

Shining a light on cancer detection

Improving the detection of prostate cancer using a novel, non-invasive technique

Prostate cancer is the most common cancer in British men, with around 46,700 cases diagnosed in 2014[5]. Since the late 1990s, prostate cancer incidence rates in males have increased by more than two-fifths (44%) in the UK, which is linked to changes in screening practices[5]. Identification of prostate cancer can be extremely challenging for doctors, with invasive biopsies often needed to provide a clear diagnosis[6]. Dr Martha Vardaki, from the University of Exeter, received support in the form of a studentship from STFC to develop a novel technique for non-invasive prostate cancer detection.

Dr Vardaki is using a technique called Transmission Raman Spectroscopy (TRS, a variant of Deep Raman Spectroscopy), developing its use for the specific function of studying prostate cancer. Deep Raman Spectroscopy consists of a group of emerging spectroscopic techniques being developed for biomedical, pharmaceutical and security applications[7]. This technique builds upon Spatially Offset Raman Spectroscopy (SORS), developed by Professor Pavel Matousek of STFC. In contrast with conventional Raman Spectroscopy, both SORS and TRS provide highly accurate chemical analyses of objects beneath obscuring surfaces, such as tissue.

This kind of spectroscopy has already shown potential in distinguishing between benign and malignant breast tissue, by detecting different types of calcifications associated with breast cancer[8]. The techniques have also been used to assess the surgical margins in excised breast cancer samples and to clinically diagnose bone diseases such as osteogenesis imperfecta[9].

Dr Vardaki along with Dr Benjamin Gardner (University of Exeter), Professor Nicholas Stone (University of Exeter) and Professor Pavel Matousek (STFC) have explored several aspects of the Deep Raman Spectroscopy techniques and have published the results[10]. The work helps the future design of instruments and paves the way towards the ultimate application of the technique to the non-invasive diagnosis of prostate cancer.

In recognition of her work, Dr Vardaki received a prize from her home university for the most innovative poster in the postgraduate research showcase. She also presented at a poster competition[11] at the Houses of Parliament raising awareness of STEM subjects to MPs.

1. www.stfc.ac.uk/files/impact-report-2015/
2. www.stfc.ac.uk/files/first-destinations/
3. www.hesa.ac.uk/news/30-06-2016/sfr237-destinations-of-leavers
4. www.stfc.ac.uk/about-us/our-impacts-achievements/annual-impact-reports/
5. www.cancerresearchuk.org/health-professional/cancer-statistics/statistics-by-cancer-type/prostate-cancer#heading-Zero
6. www.nhs.uk/Conditions/Cancer-of-the-prostate/Pages/Prevention.aspx
7. pubs.rsc.org/en/content/articlepdf/2015/an/c5an01118c
8. cancerres.aacrjournals.org/content/canres/68/11/4424.full.pdf
9. pubs.rsc.org/en/content/articlelanding/cs/2016/c5cs00466g#!divAbstract
10. pubs.rsc.org/en/Content/ArticleLanding/2015/AN/C5AN01118C#!divAbstract
11. www.setforbritain.org.uk/index.asp

New imaging and software could lead to more efficient treatment cancer treatment.

Credit: Dreamstime.com

Collaborations and partnerships

Much of the frontier science undertaken in astronomy, space science research, particle physics and nuclear physics takes place in conjunction with fellow scientists around the world. Working with their counterparts from various institutions and countries enables knowledge exchange to occur, allowing researchers to combine thinking not only on ideas but practical solutions to problems. This complements the skills attained by STFC-supported researchers.

There are a number outputs that can arise from collaborations, the most common being the publication of a paper, the design and creation of new technologies, outreach events undertaken and awards and recognitions received. Arguably the most important impact of any collaboration is the sharing of knowledge and skills between researchers, with the aim advancing our understanding of the world around us.

STFC principle investigators (PIs) have informed us of over 1,500 unique collaborations involving more than 1,000 organisations from nearly 50 different countries. The collaborations and partnerships created have been with organisations from various sectors, including the academic, public, private, medical and non-profit-making sector.

The most frequently reported collaborating organisations were CERN, based in Switzerland, and the Max Plank Society in Germany. More collaborations were reported with these institutes than with any one UK university, demonstrating the significance STFC-supported researchers place on international partnerships.

Of the collaborations reported to STFC, 54% involved five or more partners, highlighting that international collaboration with multiple partners is common, and reflecting the international nature of our science.

Accelerating the targeting and treatment of cancer

Reducing the bottlenecks in cancer treatment with a virtual oncologist

Radiotherapy is an essential aspect of cancer treatment. Over 300,000 new cases of cancer are diagnosed every year[1], with almost half of these patients receiving radiotherapy as part of their treatment plan[2]. For those who have been treated and survived cancer, radiotherapy has been used in 40% of cases[3]. Recent developments in cancer treatment have seen improvements in the delivery of precision doses of radiotherapy targetting only the cancerous cells. This has major benefits in terms of both survival and quality of life. However, there is a cost involved with this approach, as treatment planning is a manual, labour-intensive process.

Before treatment can begin, several imaging techniques are used – including CT scans, X-rays, MRI scans and PET (Positron Emission Tomography) imaging – allowing for precise delivery of treatment to be planned. With patients undergoing regular imaging, often on a daily basis, the volume of data relating to cancer location and treatment delivery becomes too unwieldy for hospital computer systems to handle. A facility treating around 600 patients per year would require computational power that vastly exceeds what is currently available to them via standard PCs. All these factors introduce a bottleneck in the clinical delivery workflow that can cause delays to treatment, impacting on survivability rates[4].

STFC provided support to Professor Andy Parker from the University of Cambridge in the form of an Innovation Partnership Scheme (IPS) for the Accel-RT project. The aim was to deliver a high performance, service-based computing solution, ready for use with existing treatment platforms to reduce the bottlenecks that can delay treatment. A multidisciplinary collaboration involving clinical radiotherapists, computer scientists, engineers and particle physicists was formed. They achieved their objectives by using the partners' experience with grid computing, and implementing software tools and new processes that will speed up the procedure of planning for radiotherapy treatment.

The software tools created operate as a 'virtual oncologist', observing what the oncologist is treating and using novel search algorithms to recall similar cases. This allows the oncologist to draw on others' experience to develop the best treatment plan for their patients.

The developments all contribute to reducing the time taken by oncologists to create a treatment plan – including providing precise location images and a strategy for dose delivery. The tools produced by Accel-RT will be available as working open-source software, free for use by radiation oncologists and therapy radiographers across the UK, to complement existing radiotherapy treatment-planning and delivery tools. This will serve as a major benefit to the sector as oncologists are able to undertake the planning process with more patients, and treat them more quickly than before.

The collaboration was led by Professor Parker and included fellow researchers from the universities of Cambridge and Oxford and engineers from the University of Cambridge's School of Technology. Clinicians from Addenbrooke's Hospital in Cambridge provided the medical expertise.

Accel-RT is now being developed to support the infrastructure for clinical trials of radiation therapy in the UK. It is hoped that the knowledge management tools developed in the project will speed up the process of setting up new radiotherapy trials across the country, and provide a means for quality assurance of radiotherapy treatment in centres that are active in research.

1. www.cancerresearchuk.org/health-professional/cancer-statistics/incidence#heading-Zero
2. www.nhs.uk/conditions/Radiotherapy/Pages/Introduction.aspx
3. www.hep.phy.cam.ac.uk/accel-rt/
4. www.comprt.org/research/accelrt

IET Open House Family Day, Daresbury Laboratory.

Credit: STFC

Engagement activities

At STFC we want to share the curiosity, excitement and ambition that drive us to discover and understand new things, inspiring the next generation to study and work in science and technology for the benefit of the UK. STFC have a dedicated public engagement programme[1], with a clearly defined strategy[2]. Dedicated funding for public engagement is available from STFC, including our new grant awards and leadership fellows.

STFC has committed over £3 million in funding for our Public Engagement awards over the past five years. In addition to this, a large amount of public engagement also takes place as part of research funding in our partner universities; this is also captured in Researchfish.

1. www.stfc.ac.uk/public-engagement/
2. www.stfc.ac.uk/public-engagement/strategy-and-evaluation/our-strategy-for-engagement/

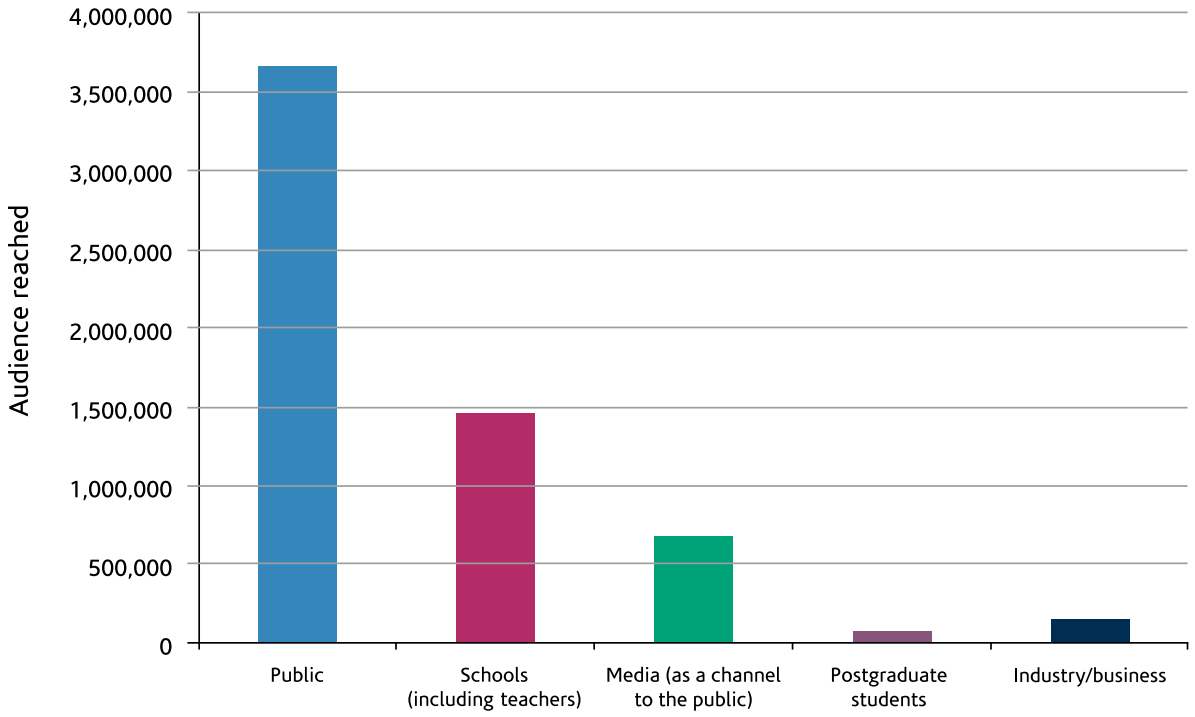
As part of the Researchfish submissions, we ask PIs to tell us about engagement activities they have undertaken as part of their award, the audience type and size that was involved and the geographical reach of the activity. We have analysed the engagement activity outcomes submitted across our past three submission periods. STFC PIs across our research and specific public engagement awards engaged with over five million people. This included members of the public, school children and teachers, media, postgraduate and undergraduate students, industry, business and a range of other audience types. The figures include audience numbers reported in the 'Engagement Activities' and STFC-specific 'Public Engagement' sections in Reseachfish, which are assigned only to STFC Public Engagement awards. Only unique activities were included in the analysis, which covered engagements undertaken between 2006-2016. PIs were able to report activities retrospectively.

The audience reached figures are reliant on the PIs informing us of the audience size via their Researchfish submissions. Not all PIs have entered a specific number; therefore the best data available to us is likely an underestimation of the true activity.

STFC-supported PIs reported over 5,000 unique engagement activities undertaken over the past five years, 54% of which were classified as being on an international or national scale. The different activity types undertaken and channels used included talks and presentations, workshops, press releases and press conferences, broadcasts (including TV, radio, film, podcast etc.), participation in open days, and websites, amongst a host of others.

The graph below shows the total audience reached across all three submission periods according to the audience type. We can see that the general public have been the main audience for activities undertaken by STFC-supported PIs.

Figure 1. Audience reached by type between 2006-2016



Podcasting pioneers expose science to the world

The Naked Scientists was one of the first ever podcasts and has been a leader in public engagement for over 10 years

One of the pioneers of the podcast has, with support from STFC and other partners, created one of the most popular science broadcasts currently available to the public[1].

Dr Chris Smith from the University of Cambridge was the creator of the Naked Scientists, which began life as one of the first ever podcasts in 2001. Since then it has grown exponentially into a world renowned channel for science engagement. In total, the Naked Scientists full suite of podcasts has achieved over 50 million downloads and the website receives over 1.2 million unique visitors every month.

Further support from STFC has allowed Dr Smith to create the Naked Astronomy podcast. This is a spin-off podcast strand from the Naked Scientists, intended to enable the team to delve into space science, astronomy, cosmology and physics in more depth than time would permit in the main Naked Scientists show. The Naked Astronomy Podcast has since been downloaded millions of times by consumers all over the world, and each new episode receives 15-20,000 downloads within a month of publication.

The award from STFC also allowed the Naked Scientists team to overhaul the website, which now contains over 70,000 pages of content and includes over 1,000 podcasts all of which are freely available for the public to download. The team have received support from the Wellcome Trust, the Engineering and Physical Sciences Research Council (EPSRC), the Royal Society of Chemistry as well as STFC, demonstrating the interdisciplinary nature of the science featured.

The shows are broadcast in Australia, New Zealand and South Africa, allowing them to reach an international audience. They also have a weekly one-hour radio programme broadcast nationally across the UK by BBC Radio 5 live and also made available as a podcast. They have won eight national and international awards for science communication since 2006 including the Royal College of Pathologists Furness Prize for Science Communication 2010, the Society of Biology Science Communication Prize 2012[2] and the Royal Society's Kohn Medal for public understanding of science, 2008.

The Naked Scientists team have recently received additional funding from STFC to establish a programme of paid internships. PhD students from STFC-supported institutions and facilities will be recruited into the Naked Scientists team. Participants will receive hands-on training within a real-world media environment, including learning to write and broadcast about science for general audiences. Interns will contribute to the Naked Scientists flagship science radio programmes, as well as learning to produce and present their own podcasts and programmes.

1. www.telegraph.co.uk/culture/tvandradio/11668186/The-10-best-ever-podcasts.html
2. en.wikipedia.org/wiki/The_Naked_Scientists

The Naked Astronomy Podcast will take space science to listeners around the world.

Credit: ESO/M.-R. Cioni/VISTA Magellanic Cloud survey.
Acknowledgment: Cambridge Astronomical Survey Unit.

Establishments at Boulby Underground Science Facility, Cleveland; Chilbolton Observatory, Hampshire; Daresbury Laboratory, Cheshire; Polaris House (STFC headquarters), Swindon; Rutherford Appleton Laboratory, Oxfordshire; UK Astronomy Technology Centre, Edinburgh.

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