Science and Technology Facilities Council

Review of the STFC-linked impact case studies submitted to REF 2021

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Executive summary

This report presents an analysis of the key themes arising from the Science and Technology Facilities Council (STFC)-related impact case studies submitted as part of the Research Excellence Framework 2021 (REF 2021) exercise. In addition, an illustrative example of an STFC-related impact case study is explored for each theme described in the report. The methodology used to identify the impact case studies attributable to STFC, and perform the analyses, is detailed in the appendix of this report.

The STFC-related impact case studies span a variety of disciplines and research programmes. These range from physics to history, and in many cases, the STFC-related impact case studies were jointly funded with another UK Research and Innovation (UKRI) council. The impact case studies also refer to STFC facilities, international facilities to which STFC subscribes, and campuses.

The impacts described in the impact case studies range from preserving King Henry VIII's 500-year-old ship, to tackling peat fires in Indonesia. The impacts were widely distributed geographically, with impact case studies submitted from across the UK, and impacts realised globally. Collaboration internationally and/or with industry was a key theme in the majority of impact case studies. The impacts themselves were also varied, including new technology, positive environmental impacts, and public engagement.

The analysis in this report provides a snapshot of some of the impacts realised as a result of STFC funding. The individual impact case studies available on the REF 2021 website could be used to inspire the public, support business cases, or to inform further analysis. However, it must be noted that the impact case studies presented represent a very small proportion of STFC's funding portfolio, and they have been specifically selected by higher education institutions (HEIs) as examples of their institution's best impacts. Therefore, the REF 2021 impact case studies should be considered alongside other analytical material when examining the impact of STFC's funding.

The identified STFC-related impact case studies comprised 225 (3.3%) of the 6,781[1] impact case studies submitted to REF 2021.

[1] The analyses in this document were undertaken on the 6,361 impact case studies that have been made available to the public.

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Introduction

The Research Excellence Framework (REF) is an exercise with the purpose of assessing the quality of research in higher education institutions (HEIs). Each submission to the REF contains a standard set of information on outputs, impact, and environment (REF, 2022). The REF was first undertaken in 2014, and again in 2021 (REF, 2022).

157 UK universities took part in REF 2021, submitting a total of 6,781 impact case studies. The impact case studies were required to demonstrate the impact of research beyond academia (REF, 2022).

As a funder of research, both via grants and infrastructure, STFC is in part responsible for some of the impacts reported via the REF. STFC staff worked on identifying impact case studies that describe impact attributable to STFC funding. This posed significant challenges, due to the complex nature of STFC's funding portfolio, and the structure of the REF impact case studies.

Once a positive link to STFC had been identified, the impact case studies were classified into three tiers, based on the strength of the link to STFC funding. In total, **225 STFC-linked impact case studies were identified**, all of which are included in the analyses presented in this report.

For example:

- 82 impact case studies mention an STFC-funded facility
- 73 impact case studies acknowledge STFC as a funder
- 56 impact case studies acknowledge an STFC grant, of which 27 acknowledge a grant in particle physics, nuclear physics, astronomy, space science or particle astrophysics

STFC and UKRI use a variety of methods and sources of information to capture and communicate the impact of research and innovation programmes. This report summarises the key messages from the STFC-related REF 2021 impact case studies, demonstrating the benefits to science, society, and the economy arising from STFC's long-term investment in research, facilities, and infrastructure. This report is designed to be viewed in the wider context of STFC's range of impact evidence and data that is regularly captured and communicated.

It should be noted that the information in this report has been taken from the published REF 2021 impact case studies and has not been independently verified by STFC.

Analysis

Disciplines

Each impact case study in the REF was submitted to one of 34 discipline-based units of assessment (UOA) (REF, 2022). STFC-linked impact case studies spanned 18 of the 34 units of assessment, covering a variety of disciplines ranging from physics to history.

As might be expected, a significant proportion of STFC-linked impact case studies belonged to the physics unit of assessment (over 43%). However, STFC-linked impact case studies also spanned many other units of assessment, including some perhaps unexpected disciplines. For example, a classics impact case study[2] on ancient manuscripts referenced an STFC grant-supported publication[3] about the imaging of subsurface text in mummy cartonnage.

It is worth noting that each impact case study is submitted to a single unit of assessment. Therefore, this label does not represent the multi-disciplinary nature of individual impact case studies. For example, the chemistry impact case study on creating environmentally friendly artificial snow for use in the film and TV industries[4] referenced one publication with two authors at STFC's ISIS Neutron and Muon Source (STFC, 2023), and one Diamond Light Source publication.

The spread of impact case studies across the units of assessment emphasises how STFC's facilities are used by researchers from numerous fields.

[2] 'The Circulation of Ancient Manuscripts on the Antiquities Market: Improving the Ethical and Regulatory Practices and Standards of Market Stakeholders'.
[3] 'An assessment of multimodal imaging of subsurface text in mummy cartonnage using surrogate papyrus phantoms'.
[4] 'Bristol and Snow Business co-create eco-friendly artificial snow and reduce environmental impact of film and TV industries'.

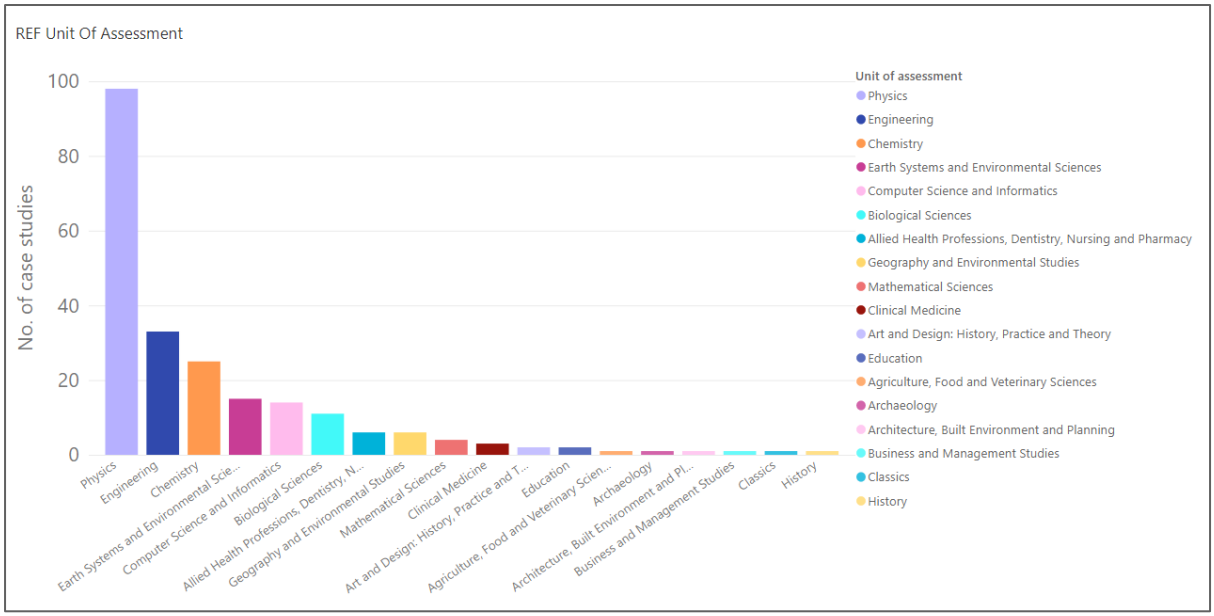

Figure 1 - STFC-linked impact case studies spanned 18 of the 34 units of assessment, covering a variety of disciplines ranging from physics to history.

Diamond Light Source helps protect historic artefacts

Diamond Light Source has played a vital role in the conservation of King Henry VIII's 500-year-old ship, the Mary Rose. The Mary Rose Museum in Portsmouth Historic Dockyard is one of the most important and visited heritage sites in the UK.

The Mary Rose sank in 1545, remaining buried on the seabed until 1982. Once raised from the seabed, signs of deterioration appeared. Scientists from the University of Kent have used Diamond Light Source to annually monitor samples from the Mary Rose's hull, enabling chemical changes in the ship to be measured in real time for the first time. Discoveries made during monitoring allowed the researchers to develop a pioneering treatment, which has prevented the ship from degrading. This treatment has also been used on artefacts from the ship which are now on display alongside it – without the treatment, these items could not have been exhibited.

The Mary Rose Museum is regarded as Portsmouth's top attraction, receiving on average 300 school visits and over 255,000 individual visitors annually between 2014 and 2019. Preservation of the Mary Rose and the thousands of artefacts has been central to the museum's popularity, providing cultural and educational benefits. The museum also plays a key role in generating income from tourism in Portsmouth, which is worth in excess of £610 million and supports around 12,700 jobs.

Full impact case study:
https://results2021.ref.ac.uk/impact/e08485b5-336d-4db8-a299-096112c45edc

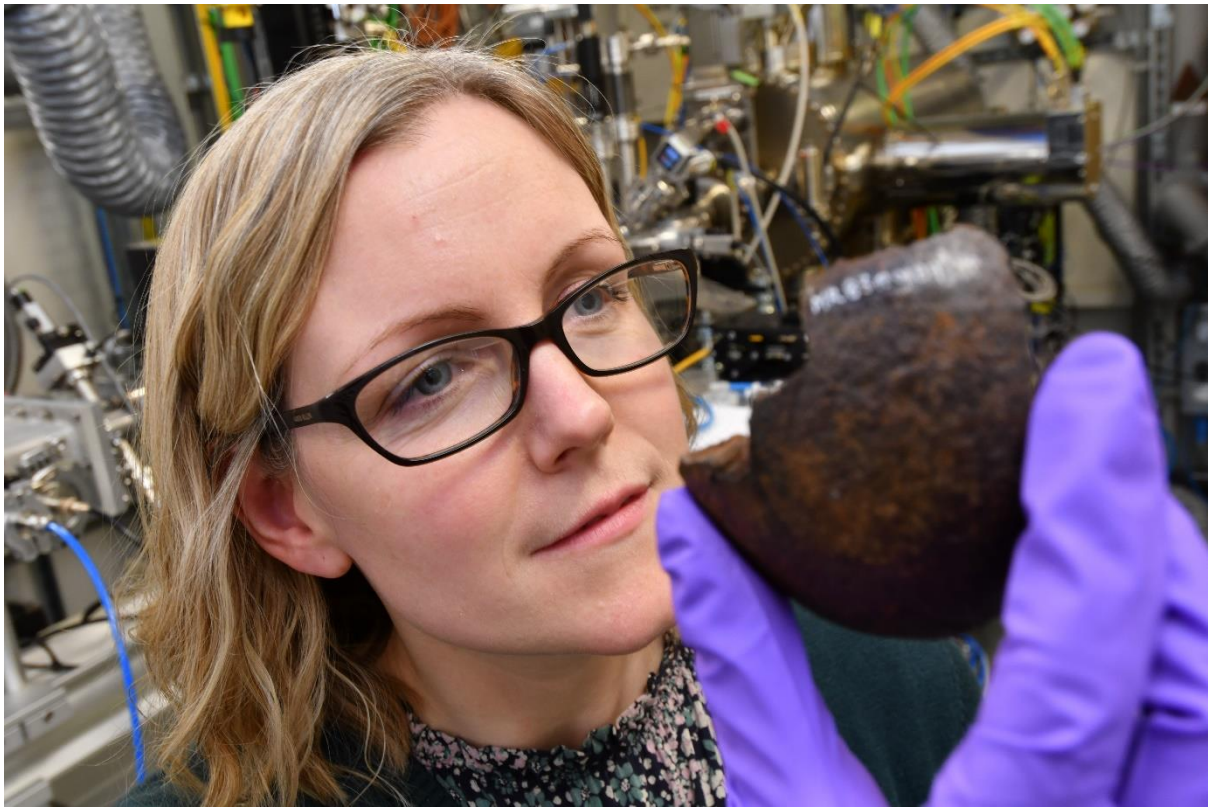

Image 1 - Dr Eleanor Schofield from the Mary Rose Trust with a cannon ball sample.

STFC funding programmes

STFC funds research through its grants programme in research areas including particle physics, nuclear physics, astronomy, space science and particle astrophysics, through a variety of calls and schemes.

In total, there were 244 STFC grant acknowledgements in the REF 2021 impact case studies. Some STFC-linked case studies acknowledge multiple STFC grants, whilst some do not acknowledge any. 56 of the 225 STFC-linked impact case studies (25%) acknowledge STFC grants, of which 27 of the these[5] were linked to grants for research into particle physics, nuclear physics, astronomy, space science or particle astrophysics.

STFC also funds a range of other schemes including schemes targeted at public engagement and knowledge exchange. 11 case studies acknowledge a public engagement grant, and four impact case studies acknowledge a knowledge exchange grant. Also, eight impact case studies were associated with the Global Challenges Research Fund and/or the Newton Fund, which were open to projects carried out in the Development Assistance Committee (DAC) list of countries eligible to receive official development assistance (ODA).

[5] Based on research outcomes data, which is held for 182 of the 244 grants.

Unsurprisingly, the different REF 2021 impact case study disciplines were associated with particular STFC grant calls. For example, the 'Earth Systems and Environmental Sciences' impact case study on conservation[6] was associated with grants from 'Exploration and Concepts' and the 'Global Challenges Research Fund'[7] (GCRF). Similarly, the 'Geography and Environmental Studies' impact case study on climate resilience in Africa[8] was also associated with a GCRF grant. Additionally, almost half of the grants associated with 'Engineering' impact case studies were knowledge exchange grants. This suggests that by offering a range of calls, STFC can target and diversify the areas of research that it funds.

Tackling peat fires with technology from astronomy

Thermal cameras used in astronomy have been employed on drones to detect peat fires in Indonesia, generating wide-ranging environmental and health benefits.

Using techniques from astronomy, researchers at Liverpool John Moores University have developed drones with thermal cameras and an automated fire-detection system to tackle the peat fires which occur annually in Indonesia. Working with Indonesian collaborators, they have used the system over two Indonesian peat-fire seasons.

Firefighters report that the system is over 10 times quicker at finding fires, 50% quicker at extinguishing fires, and over 10 times quicker at confirming fires are extinguished. The researchers estimate that this has:

- saved 78 tons of CO_2 from entering the atmosphere per drone system per month, equivalent to 156 trans-Atlantic flights
- saved firefighters 200 days of hazardous smoke inhalation and removed the risks associated with finding fires on foot in near-zero visibility
- reduced the toxic haze faced by the 15 million residents surrounding the fires

Peat forest fires in Indonesia are responsible for up to 15 – 20% of global CO_2 emissions from human activity. In severe years they release more CO_2 than the entire global transport sector, thus greatly contributing to climate change. They also lead to enormous economic losses for tens of millions of Indonesian people, and it is estimated that tens of millions of people suffer health problems from these annual fires.

£913,800 of research grants from STFC and a £574,039 award from EPSRC, funded through the Global Challenges Research Fund, helped facilitate this work.

[6] ICS5: Drones to improve conservation.
[7] The Global Challenges Research Fund (GCRF) supports cutting-edge research to address challenges faced by developing countries, addressing the UN sustainable development goals.
[8] 'Building climate resilience in Africa by enhancing anticipatory risk management'.

Full impact case studies:
https://results2021.ref.ac.uk/impact/c1fe5bc0-1268-45ac-a8c4-d33479a937a5
https://results2021.ref.ac.uk/impact/faa53480-3531-4971-8ae8-bc84fb307d9f

Cross-council

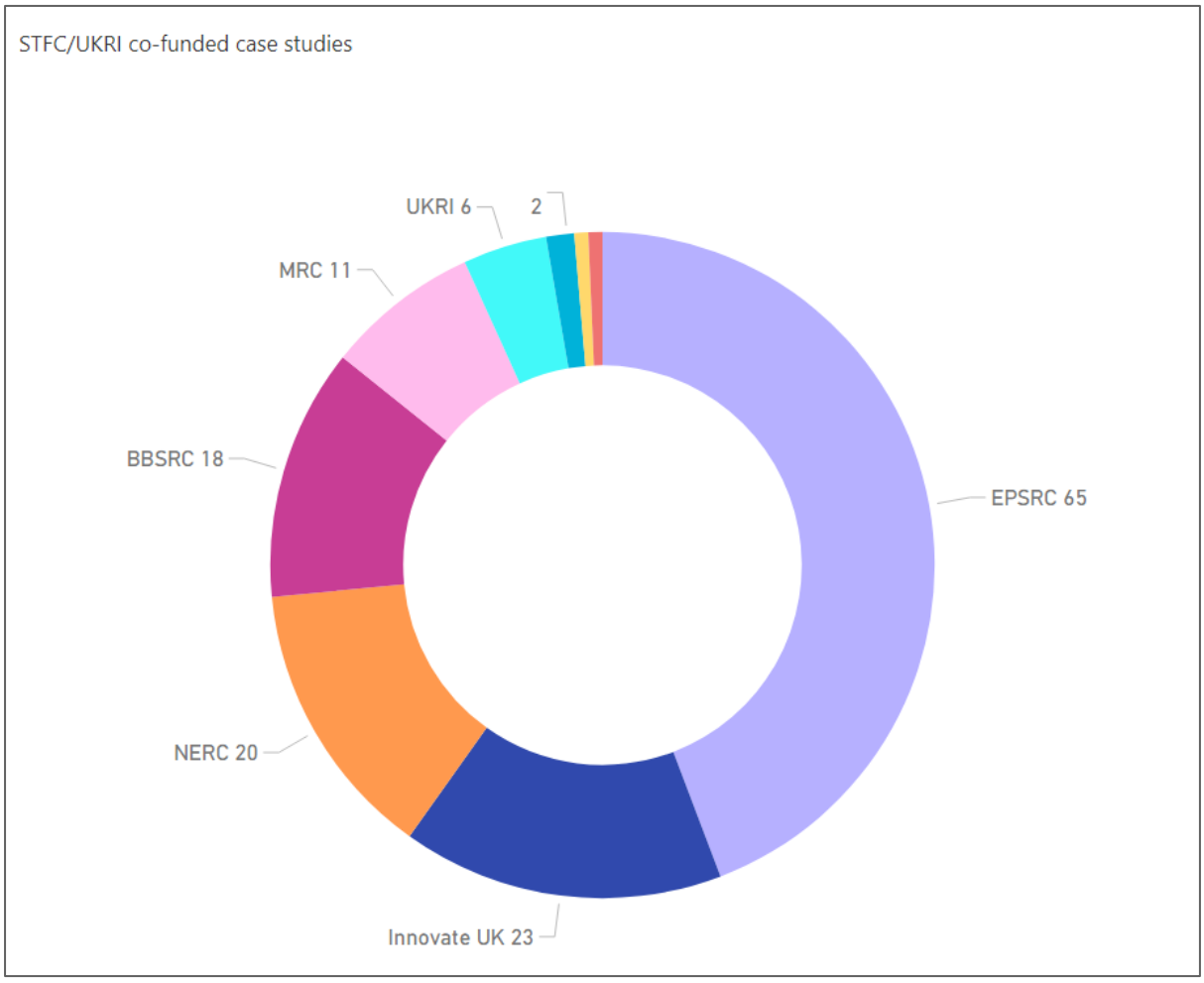

Figure 2 - 106 of the 225 STFC-linked impact case studies also reported receiving funding from another UKRI council.

STFC is part of UKRI, which comprises eight other research councils. Almost half of the 225 STFC-linked impact case studies reported receiving funding from another UKRI council, illustrating the way in which funding from different parts of UKRI combines to facilitate research in a broad range of disciplines and sectors. The council with which STFC shares the most impact case studies is EPSRC (65 impact case studies). This is as expected- many EPSRC funded projects use STFC's facilities to undertake research. Additionally, STFC's own researchers were principal investigators on over 50 EPSRC grants in the period between REF 2014 and REF 2021.

As might be expected, 42 of the 65 STFC/EPSRC impact case studies were in the physics and engineering units of assessment. Similarly, nine of the 18 STFC/BBSRC impact case studies were in the biological sciences unit of assessment. This emphasises the range of disciplines STFC is involved in through jointly supporting projects, either in the form of grants or facilities access, with other councils during the project's lifetime.

Accelerating the development of new pharmaceuticals

An idea conceived by researchers at STFC's Rutherford Appleton Laboratory and University College London (UCL) in 2007 has become a commercial product helping to improve the way medicines are manufactured, thanks to strategic funding from across UKRI.

Biopharmaceuticals – medicines synthesised from living sources – are increasingly used in nearly all branches of medicine, and the market for biopharmaceuticals is growing rapidly. To produce therapeutic proteins for use in biopharmaceuticals, they need to be purified to extract the desired molecules. The researchers developed a method of performing this purification using nanofibres (fibres with diameters one billionth of a metre), which is more efficient than previous techniques.

To commercialise and further develop this technology, spin-out company Puridify was created in 2013. Puridify was highly successful, receiving over £3 million in venture capital funding. As a result of its success, GE Healthcare bought Puridify in 2017.

The company's purification technology, Fibro PrismA, is now on sale and has been used by clients including AstraZeneca, resulting in a six-fold increase in efficiency of biopharmaceutical manufacture and an acceleration of the drug-discovery process.

The technology was initially developed through an EPSRC-funded PhD studentship, awarded to Oliver Hardick, who went on to become CEO of Puridify. Hardick was subsequently awarded a Royal Society of Edinburgh and STFC-funded Enterprise Fellowship to establish the feasibility of commercialising the technology. This was followed by a series of grants from BBSRC, EPSRC and Innovate UK, which allowed the researchers to progress the technology into a commercial product.

Full impact case study:
https://results2021.ref.ac.uk/impact/848fad3e-c3ba-4c33-9a83-900a2aa2153d

STFC-supported facilities

STFC's funding takes the form of not only grants, but also funding STFC's National Laboratories and International Subscriptions, providing UK academia and industry with access to world-class science facilities. For example, over 14,000 researchers from across life and physical sciences, from both academia and industry, use Diamond Light Source to conduct experiments, assisted by over 700 staff.

Impact case studies mentioning STFC-funded facilities were identified using text-based searches. In total, 36% of the STFC-related impact case studies were linked to an STFC-funded facility, demonstrating little change since REF 2014, in which 34% of STFC-related impact case studies mentioned the use of at least one STFC-supported facility.

Overall, 82 impact case studies were linked to STFC-supported facilities. 21 impact case studies were associated with a particle physics, nuclear physics, astronomy, space science or particle astrophysics facility[9], and 59 impact case studies were associated with other STFC-supported facilities[10]. A further two case studies were associated with both types of facility.

The STFC-linked REF 2021 impact case studies include:

- 43 impact case studies linked to Diamond Light Source
- 21 impact case studies linked to CERN (including impact case studies referring to the experiments LHC, ATLAS and CMS)
- 11 impact case studies linked to ISIS Neutron and Muon Source

(Note: some impact case studies appear more than once in figure 4, for example where the author has referenced both ISIS and CMS.)

[9] CERN (including ATLAS, CMS, LHC), ESO.
[10] Boulby, CLF, Diamond Light Source, ESRF, Hartree, ILL, ISIS, NQCC, VEC.

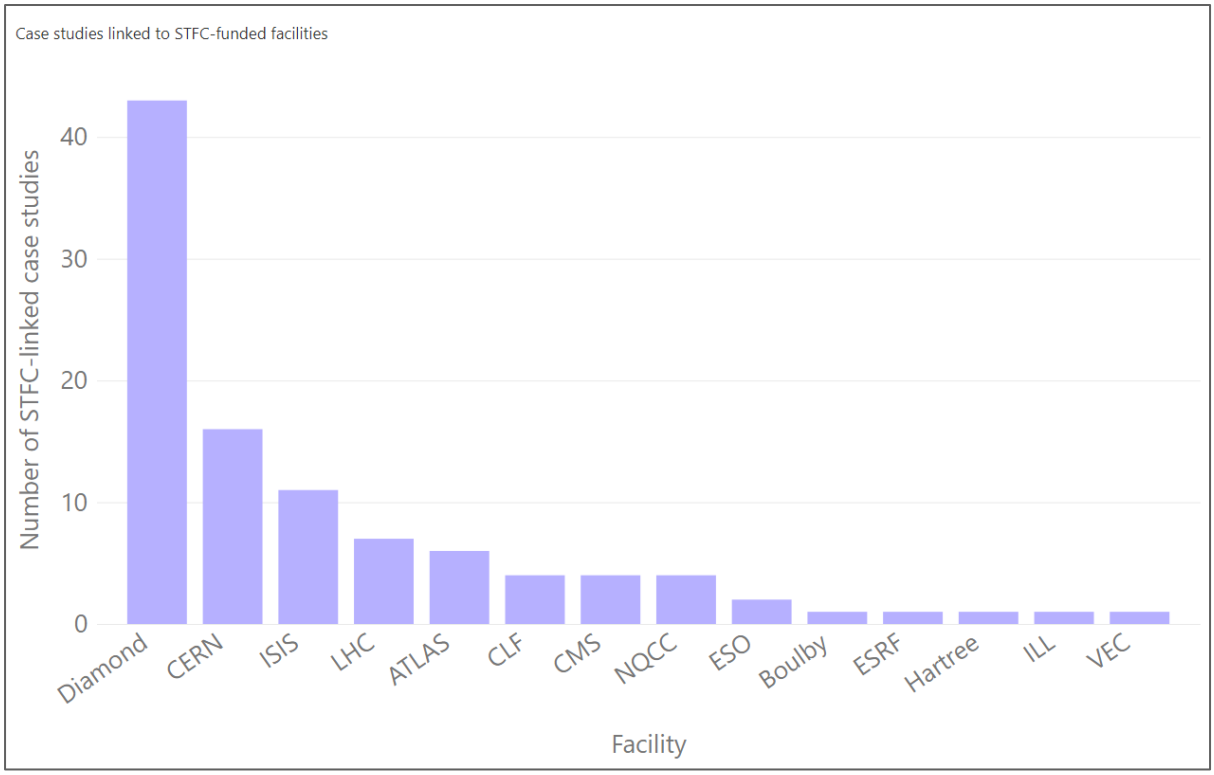

Figure 3 - Text-based searches were undertaken to identify impact case studies mentioning STFC-funded facilities.

By funding large science facilities, STFC facilitates research across a wide variety of disciplines. The impact case studies that referred to research carried out at an STFC facility spanned nine units of assessment, with 67% belonging to a UOA other than physics, compared to 56% for all STFC-linked impact case studies.

Sustainable artificial snow reduces environmental impact of film and TV industries

Fundamental insights into material structures gained at STFC's ISIS Neutron and Muon Source guided the development of sustainable artificial snow (ISIS Neutron and Muon Source, 2022), which has been widely used in the film and television industries.

A collaboration between researchers at the University of Bristol and Gloucestershire-based company Snow Business has led to the development of two new eco-friendly artificial snow products, EcoFlake and ProFlake™. They are the most environmentally friendly snow fluids currently on the market, and the only certified sustainable falling snow products endorsed by the British Academy of Film and Television Arts (BAFTA).

Previously, the company's most effective snow fluid was based on petrochemical ingredients. Consequently, the snow effect it generated could cause respiratory

discomfort for cast and crew on film sets and left behind residues that could be harmful to the surroundings and to sensitive plant and animal life.

The new, world-leading products have been used in over 1,200 events since 2017, including dozens of blockbuster Hollywood films, leading TV series and major festivals.

These products, with their world-leading certification of sustainability, have provided Snow Business with a competitive advantage, increasing the company's turnover by 80%. They account for 90% of the world market for environmentally friendly falling snow effects, and have generated a step change in the environmental impact of the UK's rapidly growing film production sector.

Research to develop the new products was co-funded by an EPSRC Impact Acceleration Award and Snow Business, and built on fundamental knowledge of material structures obtained at ISIS.

Full impact case study:
https://results2021.ref.ac.uk/impact/efaf6f00-83e2-45bd-bfc0-2948ddd55195

Campuses

Campuses are a key component of STFC's strategic objective, world-class places. The Harwell and Sci-Tech Daresbury campuses are hubs of research and innovation. They promote collaboration between researchers and industry, bringing great economic benefits locally, and to the UK.

There are:

- 7 impact case studies linked to Harwell Campus
  - spanning six UOAs including physics and clinical medicine
  - four of which cited some form of knowledge transfer
  - all seven had a summary impact type of 'technological'
- 4 impact case studies linked to Sci-Tech Daresbury
  - three in the physics UOA
  - one in the business and management studies UOA, which described 'Growth Catalyst' - a programme supporting learning and behavioural change in small firms in the Liverpool City-Region

DNA sequencing company at Harwell fights world-wide disease outbreaks

New DNA and RNA sequencing technology, which is undergoing development on the Harwell Campus, has played an important role in monitoring disease outbreaks around the world, including the coronavirus pandemic.

Oxford Nanopore Technology (ONT) was spun out of the University of Oxford in 2005 to commercialise low-cost, rapid, portable devices for DNA and RNA sequencing, based on a new technology. ONT's pioneering technology is revolutionising DNA sequencing and the emerging fields of RNA sequencing and epigenetic sequencing, and has impacted many disciplines, from zoology and microbiology to human genetics and cancer research.

ONT's devices have been used to sequence viruses in public health emergencies including Ebola and Nigerian Lassa fever in Africa and Zika in Brazil, and more recently the global COVID-19 pandemic. They have also been employed for real-time sequencing of polar ocean microbes in the Arctic, and the first ever DNA sequencing in microgravity on board the International Space Station.

By December 2020, ONT had raised £613.6 million and employed 600 people. In January 2020, the company was valued at approximately £1.7 billion, and its revenue for 2019 was £52.1 million.

STFC have supported ONT on the Harwell Campus by providing high-tech, world-leading, bespoke facilities and a unique ecosystem of people dedicated to science and innovation. The research which led to the formation of ONT was funded by BBSRC, MRC and EPSRC.

Full impact case study:
https://results2021.ref.ac.uk/impact/262D0804-6378-48CA-93C8-5F47F0D7BD2B

Image 2 - Harwell Campus.

Geographical spread

STFC-linked impact case studies were submitted by 64 of the 157 UK HEIs which took part in REF 2021, including 22 of the 24 Russell Group universities[11]. These institutions are located across the UK, reflecting the diverse geographical spread of STFC's funding. In the period between REF 2014 and REF 2021, STFC awarded grants to 133 research organisations.

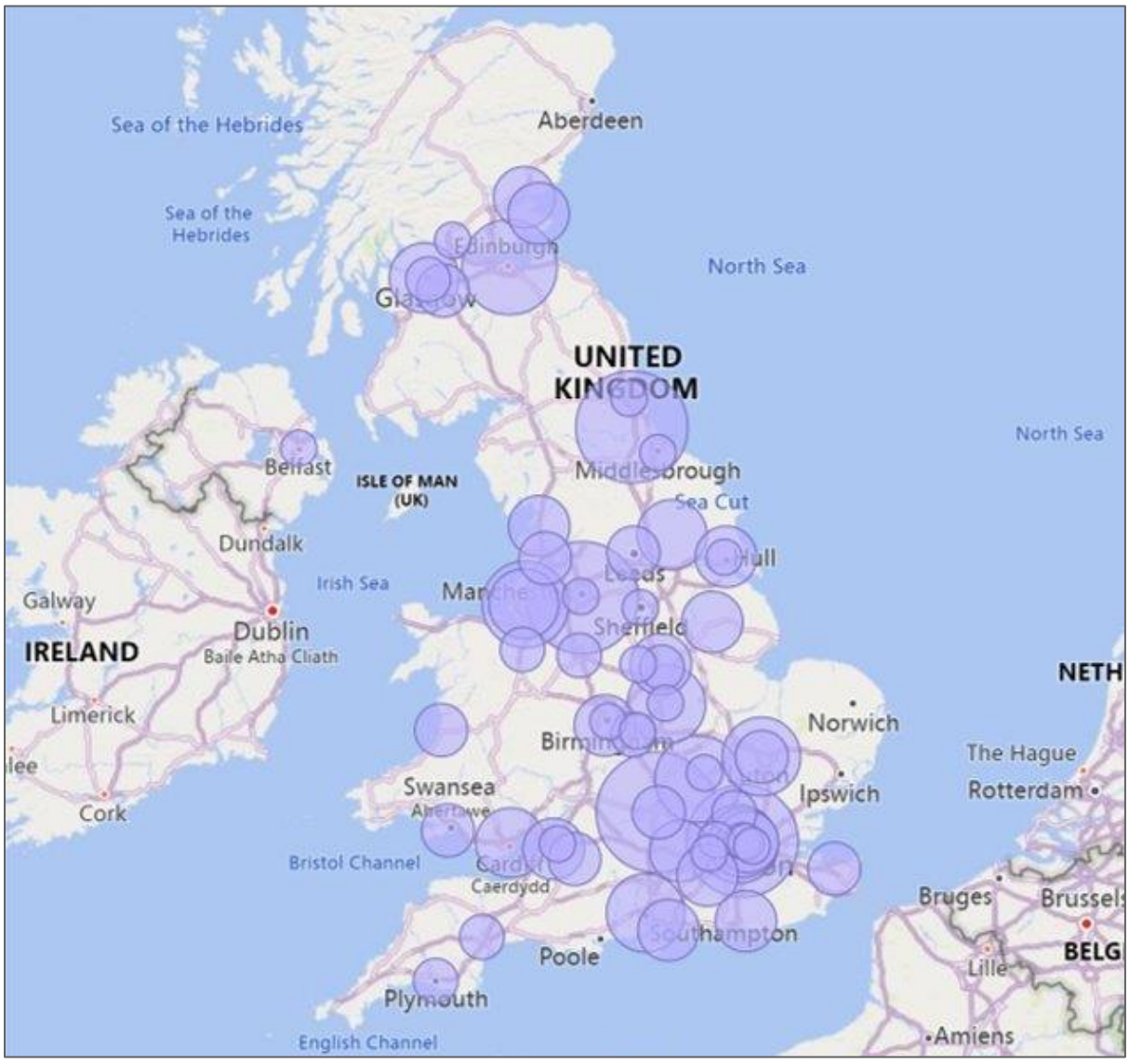

Figure 4 - STFC-linked impact case studies were submitted by 64 higher education institutions from across the UK.

[11] All the Russell Group universities except the London School of Economics & Political Science, which STFC did not provide grant funding to during this period, and the University of Sheffield.

Impact case study HEI distribution:

- 97 from the South of England[12]
- 52 from the North of England[13]
- 28 from the Midlands[14]
- 27 from Scotland
- 20 from Wales
- 1 from Northern Ireland

This shows that whilst upon first look at figure 5 the spread of HEIs submitting STFC-linked impact case studies across the UK seems fairly even, in fact, over 43% of STFC-linked impact case studies were submitted by HEIs in the South of England.

International observatory headquarters benefits North West economy

Siting the global headquarters of the Square Kilometre Array (SKA) radio telescope at Jodrell Bank in Cheshire has delivered significant economic benefits for the region and the UK more widely.

The SKA, which began construction at the end of 2022, will be one of the world's key large-scale scientific instruments, delivering a massive step change in radio astronomy. It will discover the evolution of the early Universe, exploring some the earliest processes in fashioning galaxies such as our own Milky Way.

The SKA will comprise 197 radio telescope dishes in South Africa and more than 130,000 antennas in Western Australia, which together will have a collecting area greater than one square kilometre, simulating a single giant radio telescope. The UK is one of three host countries, with the headquarters based at Jodrell Bank, part of the University of Manchester.

€121.9 million in construction contracts for SKA has been awarded to UK organisations. In addition, SKA staff contributed an estimated £6.2 million to the Cheshire East economy between 2018 and 2021 and invested an estimated £6 million in the local property market.

The decision to host the SKA global headquarters at Jodrell Bank was due, in part, to its long and significant history of world-leading research in radio astronomy, which STFC funding has helped to facilitate. STFC co-funded construction of the headquarters, and STFC researchers at its laboratories in Oxfordshire, the Liverpool City Region and Edinburgh are involved in the telescope's design.

Full impact case study:
https://results2021.ref.ac.uk/impact/ecb11bc0-801c-4e4e-906c-60c7fe1637b6

[12] East of England, London, South East and South West.
[13] North East, North West, Yorkshire and the Humber.
[14] East Midland, West Midlands.

International impact and collaboration

The 225 STFC-linked impact case studies reported impact in 80 countries across the globe, particularly in Europe, the USA, and in countries on the Development Assistance Committee (DAC) list of countries eligible to receive official development assistance (ODA) (OECD, 2023). In the period between REF 2014 and REF 2021, the DAC ODA list included countries such as China, Mexico, India and Madagascar. Projects carried out in these countries were eligible for UKRI Global Challenges Research Fund grant funding (UKRI, 2022), and the Newton Fund, which ran from 2014-2022, with a budget of £735 million (UKRI, 2022).

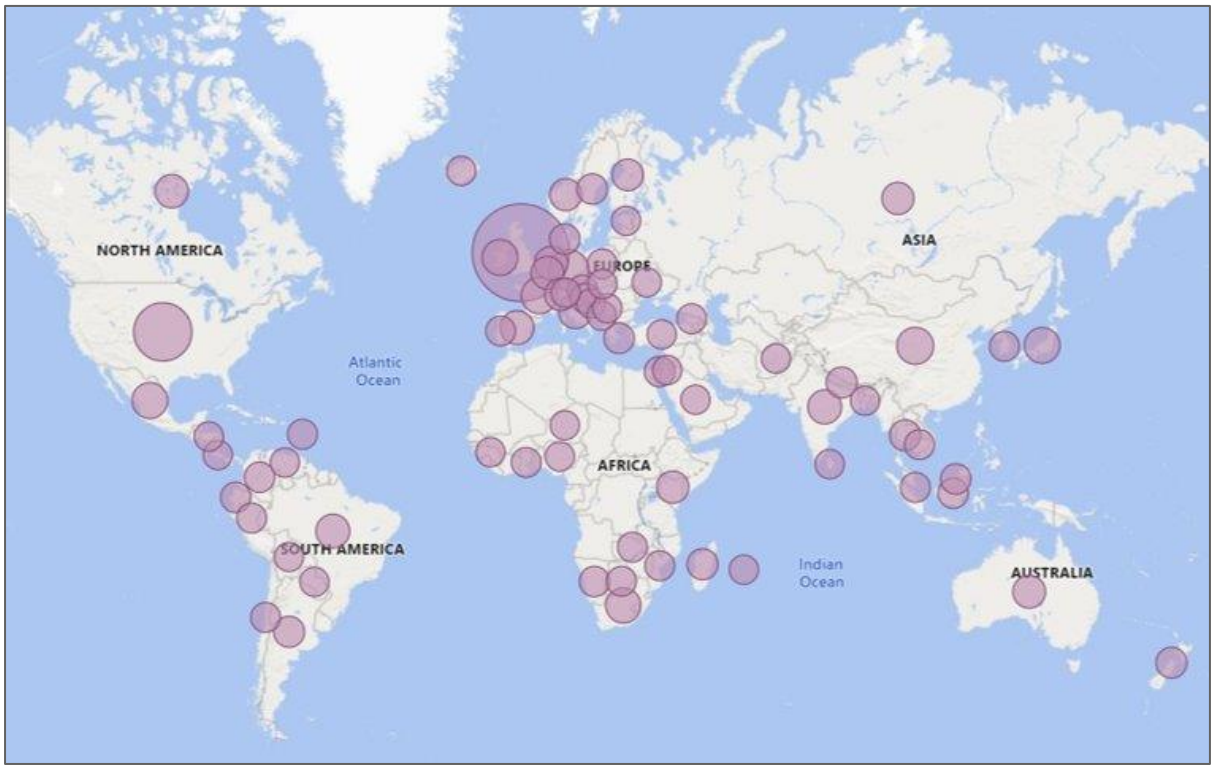

Figure 5 - STFC-linked impact case studies reported 80 countries in which impact occurred.

Although it is not recorded as a specific section in the REF, many impact case studies mentioned international collaboration, and the use of international facilities that STFC subscribes to such as CERN, the European Synchrotron Radiation Facility (ESRF), and the Institut Laue-Langevin (ILL) in France. Of the STFC publications that were listed in REF 2021 impact case studies and are recorded in SciVal, over 70% involved international collaboration.

Image 3 - The ALICE experiment at CERN.

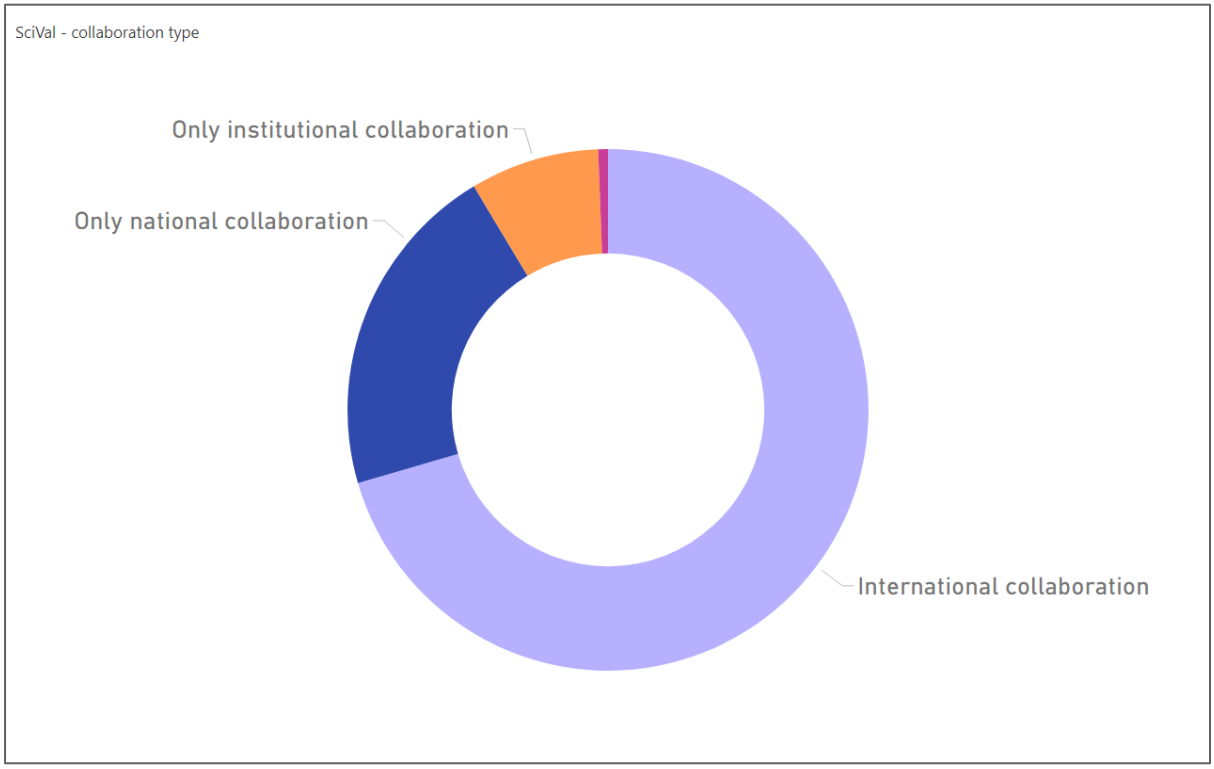

Figure 6 - Of the STFC publications that were listed in REF 2021 impact case studies and are recorded in SciVal, over 70% involved international collaboration.

The impact of STFC's funding is far-reaching and varied, ranging from large international projects such as CERN, to projects realising positive impacts for local people in developing countries.

Physics training increases representation of Africans in physics

STFC-funded researchers have helped to increase the representation of Africans in physics, through creating a graduate training programme for physicists from across Africa.

Researchers at King's College London, with prominent roles in research at CERN, created the African School of Fundamental Physics and Applications (ASP) in 2008. The ASP is a 3-week physics graduate summer school, held biennially in an African country. By the summer of 2018, it had trained over 300 qualified African physicists from approximately 30 different African countries.

The ASP plays a leading role in addressing underrepresentation of Africans in physics, and has directly contributed to keeping African physicists in the field and providing them with enhanced career opportunities. Former students have used the knowledge and experience they gained to obtain new positions in universities or other STEM-related roles, boost their career opportunities in the field of physics, and improve their teaching skills.

The ASP has directly contributed to closing the gender gap in STEM subjects in sub-Saharan Africa, which exhibits some of the world's worst rates of gender parity in STEM subjects. Since its inception, the percentage of female students participating has increased to around 40%, a higher percentage than in comparable graduate schools in Europe or the US. The ASP was also instrumental in establishment of the Rwandan Association for Women in Science and Engineering (RAWISE) in 2016, which actively engages and inspires young Rwandan women to study STEM subjects.

Full impact case study:
https://results2021.ref.ac.uk/impact/93f3c3af-c657-482d-8350-f3a6bc24e2eb

Collaboration with industry

Of the STFC-attributable publications that were listed in REF 2021 impact case studies and are recorded in SciVal, 13.5% involved corporate collaboration. Although this may seem less than expected in comparison to the examples given in impact case studies, it should be noted that whilst initial research and thus publications may not involve academic-corporate collaboration, subsequent knowledge exchange often does.

The word 'company' appeared 67 times in the 'summary of the impact' section of the impact case studies. Overall, 49% of the STFC-linked impact case studies included

at least one industry-related term[15] in this section. In the REF 2014 exercise, just 30% of STFC-related impact case studies mentioned collaboration with industry.

Removing mercury contaminants from natural gas

A new technology to more efficiently remove mercury contaminants from natural gas has been developed through a joint collaboration between researchers at Queen's University Belfast and PETRONAS, the national oil and gas company of Malaysia.

A major challenge in oil and gas production is the removal of impurities that pose significant health and safety issues, as well as contaminating the products. Mercury contamination is a particular problem in natural gas. In addition to its well-known problematic health and environmental effects, mercury also damages industrial facilities, causing them to corrode and become brittle, and can prevent catalysts from working properly.

The collaboration between Queen's University Belfast researchers and PETRONAS has created a new product for removal of mercury contaminants, HycaPure™. This was licensed for global commercialisation in 2014, and by 2017 thirteen systems had been built and deployed at several Malaysian processing plants.

HycaPure™ is four times more efficient at removing mercury than previous alternatives, can remove different chemical forms of mercury at different concentration levels, and has a lifetime three times that of the alternatives. The latter has commercial benefits, as replacing it costs approximately $180,000.

STFC's ISIS Neutron and Muon Source and Diamond Light Source were used to study the materials on which the new technology is based. The researchers also received funding from EPSRC.

Full impact case study:
https://results2021.ref.ac.uk/impact/885b8065-06c8-4e62-8ae3-2533c5375c86

[15] Terms included 'company', 'industry', 'commercial', 'industrial', 'business', and 'market'.

Knowledge transfer

In total, one third of the STFC-linked impact case studies mentioned a spin-out (9%), patent (28%), and/or licence (9%). This illustrates how science funded by STFC brings benefits to the UK economy and society, through the transfer of technology to industry.

20 new spin-outs were identified through REF 2021, representing a significant increase on the seven new spin-outs identified via REF 2014.

Prior to REF 2021, STFC was aware of 40 STFC-supported spin-outs. 29 of these were identified via the annual UKRI research outcomes collection process (Researchfish), eight via STFC Laboratories, and 3 via both Researchfish and STFC Laboratories (Cambridge Policy Consultants, 2021).

Two of the 20 spin-outs mentioned in the STFC-linked REF impact case studies had already been reported to STFC via Researchfish; the additional 18 were brought to the attention of STFC for the first time via REF 2021. 17 of the impact case studies relating to the additional 18 spin-outs did not acknowledge an STFC grant, and therefore could not have been identified via the annual UKRI research outcomes collection process. This will be considered as UKRI reviews how best to collect such data moving forwards.

Technology from astronomy yields faster medical image analysis

STFC-funded researchers at the University of Edinburgh have used data processing techniques developed for astronomy to improve and speed up medical image analysis.

Spin-out company Blackford Analysis was created in 2010 to market a new data compression algorithm. This has sped up analysis of radiology images by 10-50%, equivalent to treating more than 200,000 extra patients per year. As of December 2020, over 2 million medical scans per year had been analysed using the company's algorithms, at over 750 sites worldwide, primarily in the USA.

Assessing the changes between two medical scans taken at different times is a fundamental aspect of many medical diagnoses and can sometimes be very challenging for large or complicated images. The systems provided by Blackford Analysis make this process significantly faster and more certain, leading to more confident diagnosis, and enabling greater treatment confidence and better overall patient health outcomes.

The new data processing algorithm has also brought economic benefits. By December 2020, Blackford Analysis employed 42 staff in the UK and the USA, and the company generated more than £1 million in revenue in the financial year 2019-2020. Working with Blackford Analysis has allowed 20 companies to access the medical imaging sector, enabling further technology transfer to industry.

An STFC Follow-on Fund Award in 2008 supported the researchers to transfer image processing techniques from astronomy into medical imaging, which led to the formation of Blackford Analysis.

Full impact case study:
https://results2021.ref.ac.uk/impact/18998470-002e-4ab1-9828-40b5bb7d1ecc

Technology development

Each impact case study in REF 2021 was assigned a single 'Summary Impact Type' based on text analysis of the 'Summary of the Impact' and 'Details of the impact' sections of the impact case study (REF, 2022). STFC impact case studies spanned five of the eight Summary Impact Types. Identically to REF 2014, 60% of STFC's REF 2021 impact case studies were classified as having a Summary Impact Type of 'technological', reflecting STFC's mission, 'to develop advanced technologies'.

Furthermore, in the 'Summary of the Impact' section of the impact case studies, the word 'technology' appeared 90 times, and 'technologies' 41 times, in comparison to 'physics' which appeared 74 times. This emphasises that many of the impacts of STFC-supported research are technological as well as scientific.

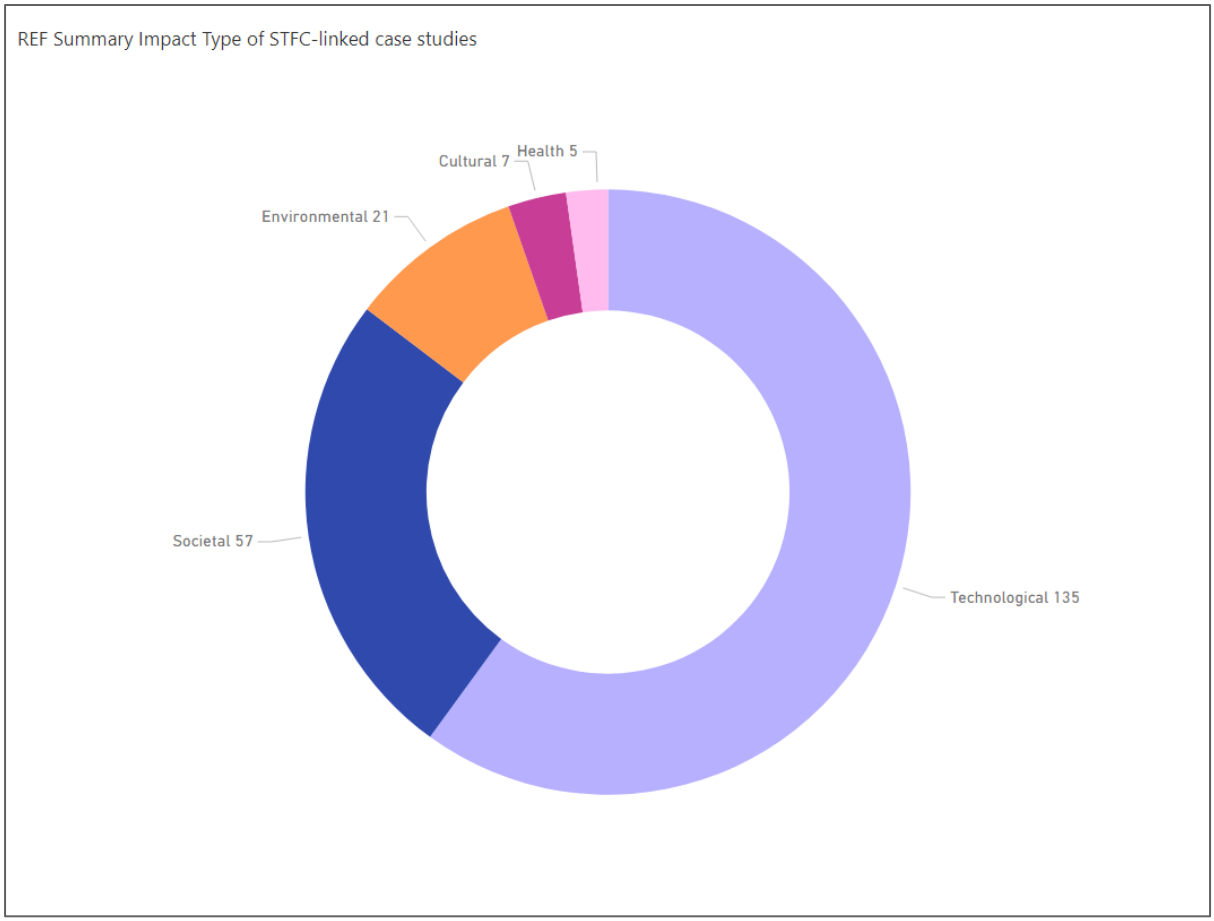

Figure 7 - Each impact case study in REF 2021 was assigned a single 'Summary Impact Type'. STFC impact case studies spanned five of the eight Summary Impact Types. There were no links identified between STFC and any Political, Economic, or Legal REF 2021 impact case studies.

CERN technology helps protect astronauts

Particle detector chips developed for use at CERN have been employed by NASA to better understand crew protection needs, and integrated into electron microscopes.

MediPix and TimePix are particle detectors which have found applications beyond the detection of fundamental particles at CERN.

Since 2009, NASA has been assessing the use of TimePix-based radiation detectors to monitor the levels of high-speed ionising radiation on the International Space Station. These radiation detectors are key to monitor and protect both astronauts and vital equipment during solar storms. TimePix detectors have enabled NASA to develop lighter radiation detectors, which were deployed on the Space Station in 2012 and continually send data to the Mission Control Center, providing information on the location, dose, and speed of radiation.

MediPix chips are being adopted by transmission electron microscope (TEM) manufacturers. TEMS are widely used by research institutions and multinational companies in life sciences, electrical engineering and material sciences. MediPix chips can improve the performance of TEMs by counting each individual electron reaching the detector.

Quantum Detectors Ltd, a spin-out company from Diamond Light Source and STFC, licensed the MediPix technology from the University of Glasgow in 2017, enabling the company to develop four new products and gain access to the global TEM market. By the end of 2020, sales of more than 20 detector systems had generated £2.6 million in revenue for the company.

Funding from STFC and EPSRC facilitated the development of this technology and its transfer to industry.

Full impact case study:
https://results2021.ref.ac.uk/impact/126AC8A8-48BE-472C-95D0-AF5DC066D37D

Public engagement

Research funded by STFC into some of the biggest questions at the cutting edge of science is used to inspire the public and young people across the UK and worldwide, fostering an appreciation of and interest in science. In line with STFC's goal of world-class skills, STFC's public engagement schemes inspire the next generation of scientists, engineers, and technicians.

STFC's public engagement grant funding programme reached hundreds of thousands of members of the public during the REF 2021 time period, engaging with more than 500 schools each year[16]. 3.8%[17] of STFC's grants were public engagement grants in the period between REF 2014 and REF 2021. However, this only accounted for 0.4% of the funding value, as public engagement grants are generally relatively low in value. Yet, several STFC-linked impact case studies mentioned public engagement. The 'award schemes' pie chart includes 19 public engagement grants which were acknowledged in the STFC-related REF impact case studies. However, examples of public engagement are not limited to impact case studies supported by public engagement grants. In total, 32% of the STFC-related impact case studies mentioned the words "public", "school" or "schools", indicating some form of public engagement.

[16] These figures varied over the course of the REF 2021 reporting period due to the impact of the COVID-19 pandemic.
[17] 3.8% of the number of grants awarded (as opposed to the value of grants awarded).

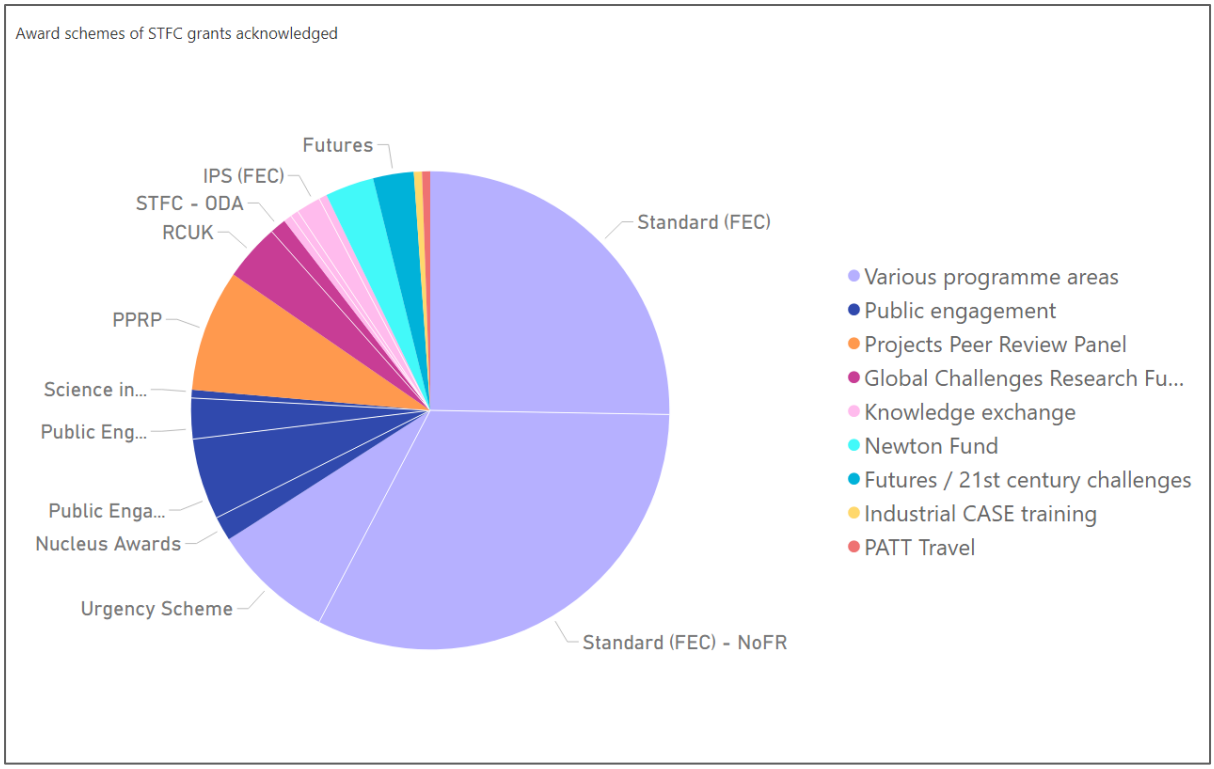

Figure 8 - STFC grants identified in REF impact case studies were associated with a variety of grant schemes.

Virtual reality exoplanet tour inspires millions

A unique and immersive virtual reality (VR) tour of exoplanets, based on STFC-funded astronomy research, has reached a worldwide audience and positively influenced millions of people around the world towards science.

Researchers at the University of Exeter worked with local SME Engine House VFX and Bristol-based science museum We The Curious to create the first fully-immersive VR experience of exoplanet environments.

This unique resource attracted over 12 million views and over 5,000 comments on YouTube between its launch in 2017 and the end of 2020, making it the most viewed science-based VR resource on the entire platform. During this period, it attracted over 3.5 million views per year, significantly more than videos on comparable popular physics channels which typically achieve a few hundred thousand views per year.

In 2018 the researchers set up the Exoplanet Outreach Programme, allowing school students to view the VR animation as part of wider engagement sessions. By the end of 2020 this programme had reached over 1,000 students in schools across the South West, covering several regions with very low rates of progression to higher education and areas with high Indices of Multiple Deprivation.

Following the outreach sessions, 97% of the students reported that their feelings towards STEM-based subjects had changed positively, and more than 50% stated they were inspired to work in a science or technology job in the future.

Full impact case study:
https://results2021.ref.ac.uk/impact/9a0d0a5c-8fb1-4595-a4f2-418a351d750f

Conclusion

The impact case studies submitted to REF 2021 clearly demonstrate how STFC funding contributes to a wide range of disciplines and impact types, with impact realised across the globe.

The 225 STFC-related impact case studies identified outline not only a wide range of scientific impacts, but also include impacts in technology, the environment, health, and public engagement. From biopharmaceuticals to technology used to protect NASA astronauts, the REF impact case studies provide a rich picture of impact examples from UKRI funding. The large number of cross-council impact case studies identified not only highlights the interdisciplinary nature of STFC-funded research, but also the significance of collaboration across the UKRI community.

Whilst the impact case studies highlight meaningful impacts, there are limitations to the data. For example, a considerable number of impact case studies mention STFC-funded facilities and projects, without referring to STFC. In addition, although the REF is a great source of reported impact resulting from STFC funding, due to the nature of the exercise, it is important to note that the impact case studies are not suitable for carrying out detailed analysis on the HEI research landscape. In particular, the selectivity of case studies mean that it would be unwise to extrapolate findings to the wider research system.

Understanding and supporting world-class impact is an important part the UKRI strategy. STFC, and UKRI more widely, are continuing to develop an approach to evaluating the impact of our funding. The REF impact case studies form part of this, and will be used in combination with other evidence such as the annual UKRI Research Outcomes collection, evaluation reports for major investments, and data collected by our facilities, on research outputs, facilities usage, and public engagement.

Appendix - Methodology

Identification of STFC-related impact case studies

The STFC Evidence and Impact team gained early access to the REF 2021 impact case studies in January 2022. Initial searches for STFC-related impact case studies were undertaken using the 'Name of funders' and 'Grant number' sections of the impact case studies, and by searching the impact case studies for keywords such as the names of STFC facilities and projects. The list of keywords was compiled in collaboration with colleagues from across STFC.

We also provided our colleagues in UKRI with a list of Digital Object Identifiers (DOIs) for STFC-attributable publications, collected from Researchfish, ePubs, and colleagues at STFC facilities. These were cross-referenced with the 'References to the research' section of the impact case studies, to identify further impact case studies related to STFC.

Identifying the impact case studies related to STFC funding posed significant challenges. Although there are specific sections in which impact case study authors have the opportunity to acknowledge funders and grants they have received, many authors mentioned STFC within the main body of the text, without acknowledging STFC as a funder. In addition to this, there is no section in the REF impact case study structure to specifically acknowledge facilities used, and therefore the main body of text had to be searched for these. We also searched the text for other links to STFC, such as project names. This challenge is unique to STFC: for example, grants comprised just 26% of STFC's total funding in 2016.

Upon finalising the longlist of potential STFC-related impact case studies, we read the impact case studies to confirm the link to STFC and classified the impact case studies into tiers, based on the strength of the link to STFC funding. It was important to confirm the link, as there were several false matches: for example, 'ESRF' stands for both 'European Synchrotron Radiation Facility' and 'end-stage renal failure'.

In total, **225 STFC-linked impact case studies were identified**, all of which are included in the analyses presented in this document. This amounts to a sizeable increase compared to the 170 STFC-linked impact case studies identified via REF 2014, although the threshold for attribution used in 2014 is unknown.

STFC impact case study tiers

Once we had identified a positive link to STFC, we classified the impact case studies into three tiers, as outlined in table 1. Tiers 1 and 2 were defined by the UKRI REF working group for analysis purposes, and tier 3 was defined by the STFC Evidence and Impact team. Due to the nature of STFC's varied funding portfolio and wide reach, several impact case studies have links to STFC, but did not directly receive STFC funding. Hence, tier 3 was created to acknowledge these impact case studies.

As the analysis presented in this document is not an analysis of the HEI landscape, but rather of a small selection of impact stories, impact case studies from all three tiers are included in the analyses presented in this document.

Table 1

Tier	Definition of tier	Attribution to STFC	Number of impact case studies
Tier one	STFC funding underpinned these impacts	STFC was identified as a funder by the impact case study author, through an STFC grant reference, or the impact case study is strongly linked to an STFC facility/project	105
Tier two	It is likely that STFC (UKRI) funding helped to enable these impacts	Linked to an STFC facility/project, or two or more publications listed have an STFC author	49
Tier three	STFC (UKRI) funding indirectly helped to enable these impacts	Weaker link to an STFC facility/project, or one or more publications listed have an STFC author	71

STFC impact case study tags

During the process of reading and identifying impact case studies, STFC-linked impact case studies were tagged[18] with the keywords that linked them to STFC[19]. Keywords included facility names, STFC departments, and project names. This has enabled analysis of fields of interest explored in this report. It has also enabled the impact case studies to be brought to the attention of relevant staff in STFC.

[18] 'Funder' = the impact case study author has identified STFC as a funder in the 'funders' section of the REF. 'STFC' = STFC was mentioned anywhere in the content of the impact case study (not including the 'funders' section).
[19] Impact case studies can be tagged with more than one keyword; therefore, an impact case study could be included in the totals more than once, for example Diamond Light Source and CERN.

For example, we identified:

- 43 impact case studies linked Diamond Light Source
- 16 impact case studies linked to CERN
- 3 impact case studies linked to the James Webb Space Telescope

STFC Impacts Library

The STFC Evidence and Impact team maintains an 'Impacts Library' of STFC-related impact case studies. All STFC tier one and two impact case studies were entered into this library. This will enable them to be easily identified as relevant for use in exercises such as spending reviews, evaluations, the development of impact case studies for STFC strategic delivery plans, and dissemination of STFC's impacts to external audiences.

STFC REF 2021 Power BI dashboard

The STFC REF 2021 Power BI Dashboard, created by the STFC Evidence and Impact team, is an interactive dashboard, interrogable by all STFC staff. The dashboard allows users to apply filters to the REF 2021 impact case study data in order to answer specific questions, and to search for impact case studies associated with particular disciplines, facilities, or HEIs, amongst other characteristics. Within the dashboard, the REF 2021 data is also linked to STFC Researchfish grants data and SciVal bibliometric data, to enhance the possibilities for analysis.

Glossary

Facilities

ATLAS - A Toroidal LHC Apparatus (CERN)
Boulby - Boulby Underground Laboratory
CERN - UK's national laboratory for particle physics
CLF - Central Laser Facility
CMS - Compact Muon Solenoid (CERN)
Diamond - Diamond Light Source
ESO - European Southern Observatory
ESRF - European Synchrotron Radiation Facility
Hartree - Hartree Centre
ILL - Institut Laue-Langevin
ISIS - ISIS Neutron and Muon Source
LHC - Large Hadron Collider
NQCC - National Quantum Computing Centre
VEC - Virtual Engineering Centre

Grant schemes

CLASP - Challenge Led Applied Systems Programme
FEC - Full Economic Cost
IPS - Innovation Partnerships Scheme
ODA - Official Development Assistance
PATT - Panel for the Allocation of Telescope Time
PPRP - Projects Peer Review Panel
RCUK - Research Councils UK

Image references

1. Dr Eleanor Schofield from the Mary Rose Trust with a cannon ball sample
   Credit: Copyright of Diamond Light Source Ltd

2. Harwell Campus
   Credit: Harwell Campus

3. The ALICE experiment at CERN
   Credit: STFC

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