

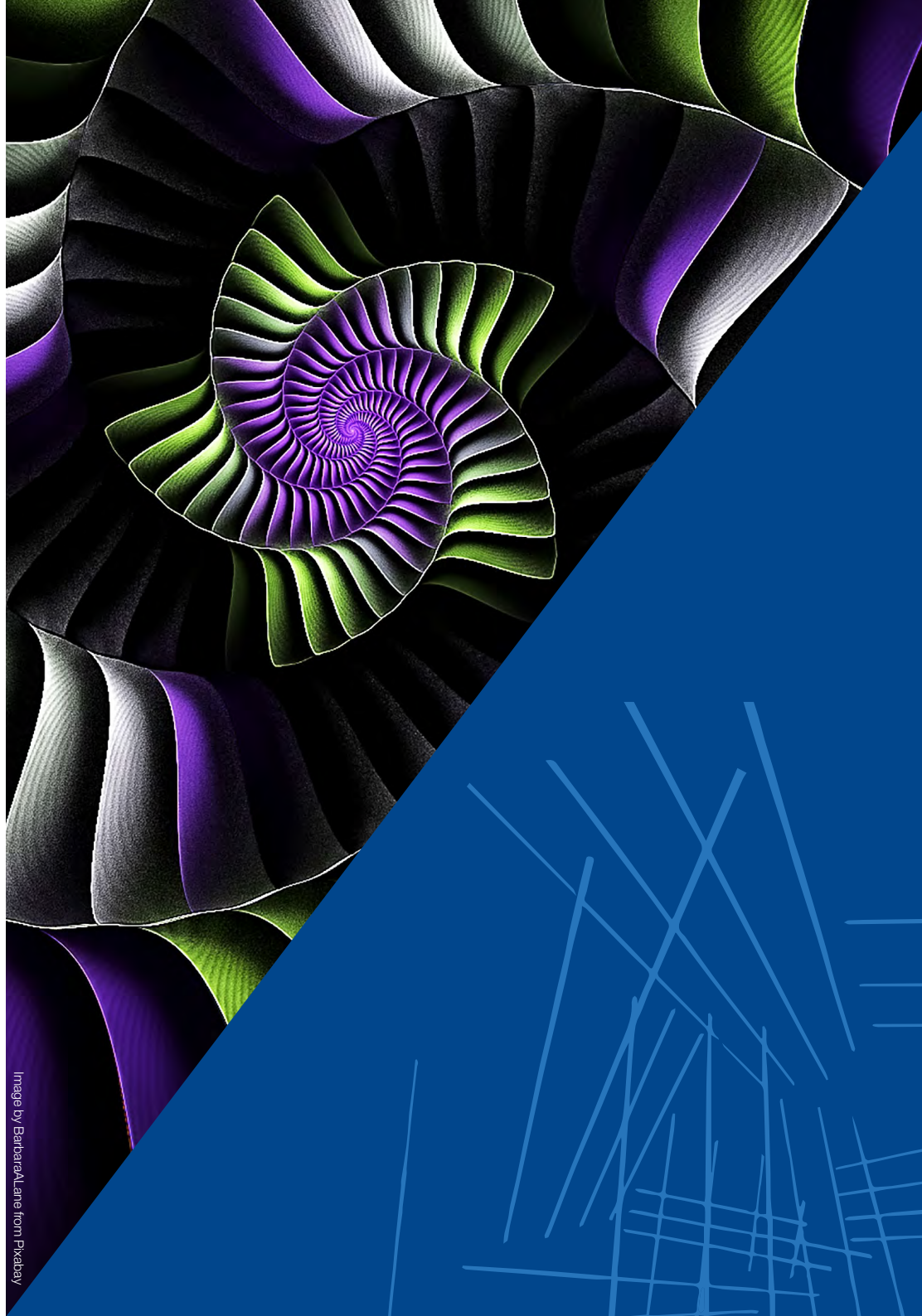


Science and
Technology
Facilities Council

From Knowledge to Impact: STFC Impact Acceleration Account

2021 edition

Image by Barbara Lane from Pixabay



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STFC Impact Acceleration Account

STFC's Impact Acceleration Account (IAA), first introduced in 2014, provides responsive funding, managed at the institutional level, for the promotion and practise of innovation activities at Universities receiving significant STFC core grant funding.

The scheme is designed to promote impact and develop opportunities originating from the core STFC research and technology programme. This includes leveraging extra investment, increased industry engagement and community building activities, maximising the impact from the STFC community.

The case studies in this document highlight some of exciting projects funding through the IAA. These studies showcase different approaches used by institutions and highlight the strengths and expertise of the STFC community.



"The important research carried out by STFC-funded scientists not only expands our understanding of the universe and the laws of nature, but it also drives profound innovation in technology and engineering. Through this agile scheme, we can quickly support exciting, impactful ideas born from fundamental research. In this way, STFC has supported a huge range of innovative projects, from using astronomy technology to better understand the growth of cancer, to creating 3D printed visors for the NHS during the pandemic, to making nuclear waste containers safer."

Professor Mark Thomson, Executive Chair of STFC

"Extensive feedback from researchers and scientists highlight that Impact Acceleration Awards (IAAs) funding helps deliver impact from fundamental research. As demonstrated by these fantastic case studies, STFC-funded IAAs provide critical funding that supports development of a wide-range of impacts including underpinning development of a wide range of new technologies and products, addressing important industrial and societal needs."

Dr Tony Soteriou, UKRI Director of Commercialisation

Delivering on Impact

Outputs from IAA recipients 2019/20

£2.5M STFC investment

£2.1M leveraged funding of which **£900K** from industrial partners

£3.3M continuation funding secured post IAA


4 spinouts

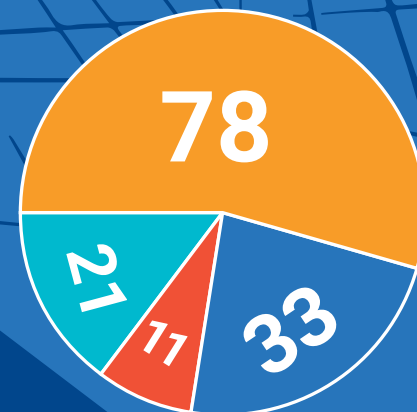

49 publications


14 new products


7 patents


80 follow on grants applied for

Funding Awarded



- proof of concepts
- collaboration events
- secondments
- *other

*Other includes: National and Local Government Engagement, Industry Engagement, Market Scoping and Analysis and Interdisciplinary Networking Events



Cardiff University
 Durham University
 Imperial College London
 Lancaster University
 Liverpool John Moores University
 Open University
 Queen Mary University of London
 Queen's University of Belfast
 Royal Holloway, University of London
 University of Bristol
 University of Cambridge
 University College London
 University of Edinburgh
 University of Glasgow
 University of Hertfordshire
 University of Leeds
 University of Leicester
 University of Liverpool
 University of Manchester
 University of Nottingham
 University of Oxford
 University of Portsmouth
 University of Sheffield
 University of Southampton
 University of St Andrews
 University of Surrey
 University of Sussex
 University of Warwick
 University of York

Cardiff University

From astronomy to security

Investigators: Simon Doyle and Peter Hargrave (Cardiff University)

Cardiff used IAA funding to contribute to the development of the next generation of real-world environment scanning for airport and border security.

Using state of the art technology originally developed for astronomy instrumentation, the technology allows for the real-time scanning of individuals or vehicles to identify potentially dangerous objects or contraband.

The team has secured additional funding of more than £1M, launched a spin-out company, Sequestim Limited, and filed a patent application.

The technology has been demonstrated at Cardiff Airport, and is designed to offer detailed screening of air travellers up to eight times more rapidly than is currently possible. This will deliver vast improvements in airport efficiency and the cost of security provision, as well as a transformation of the passenger experience and an enhancement of threat detection capability.

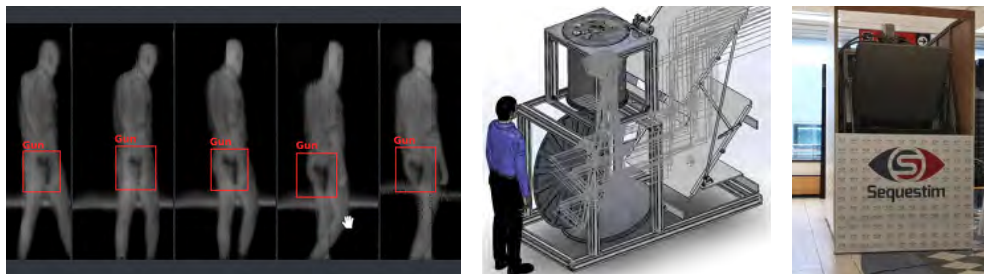


The Sequestim scanner uses 'kinetic inductance detectors' that can detect the equivalent of the heat of a 100-watt light bulb at a distance of half a million miles – twice the distance of the moon from Earth.

The Sequestim device acts like a video camera. It can reveal threat items hidden beneath clothing as a person walks by, and the presence of people concealed inside freight vehicles driving by, even at full motorway speed. The technology, pioneered by School of Physics and Astronomy researchers, could soon be installed at ferry ports.

The technology, pioneered by School of Physics and Astronomy researchers, could be installed at ferry ports globally, speeding up checks.

Further patents are planned, and certification by aviation authorities ECAC and TSA will be pursued qualifying the technology for use in airports all around the world.



Left: Demonstration of our system working at Cardiff Airport working at 5 frames/s. Here a mock gun has been concealed underneath a thick jacket. The system can clearly image the gun which has been identified by the AI as a threat. Centre: A CAD model of the early prototype demonstration system. Right: The demonstration system on temporary deployment at Cardiff Airport.



Sequestim CEO Ken Wood and Sequestim co-inventor Andreas Papageorgiou (background) conducting trials at Cardiff Airport

“The support provided by STFC for fundamental physics and device research is core to the success of this venture. The availability of specific funds like Innovation Partnership Scheme and IAA enabled us to explore and then exploit the commercial applications of technologies originally developed for astronomy applications. In particular, the availability of IAA funding has been invaluable to enable rapid implementation of ideas that have significantly improved the commercial offering of Sequestim Ltd.”

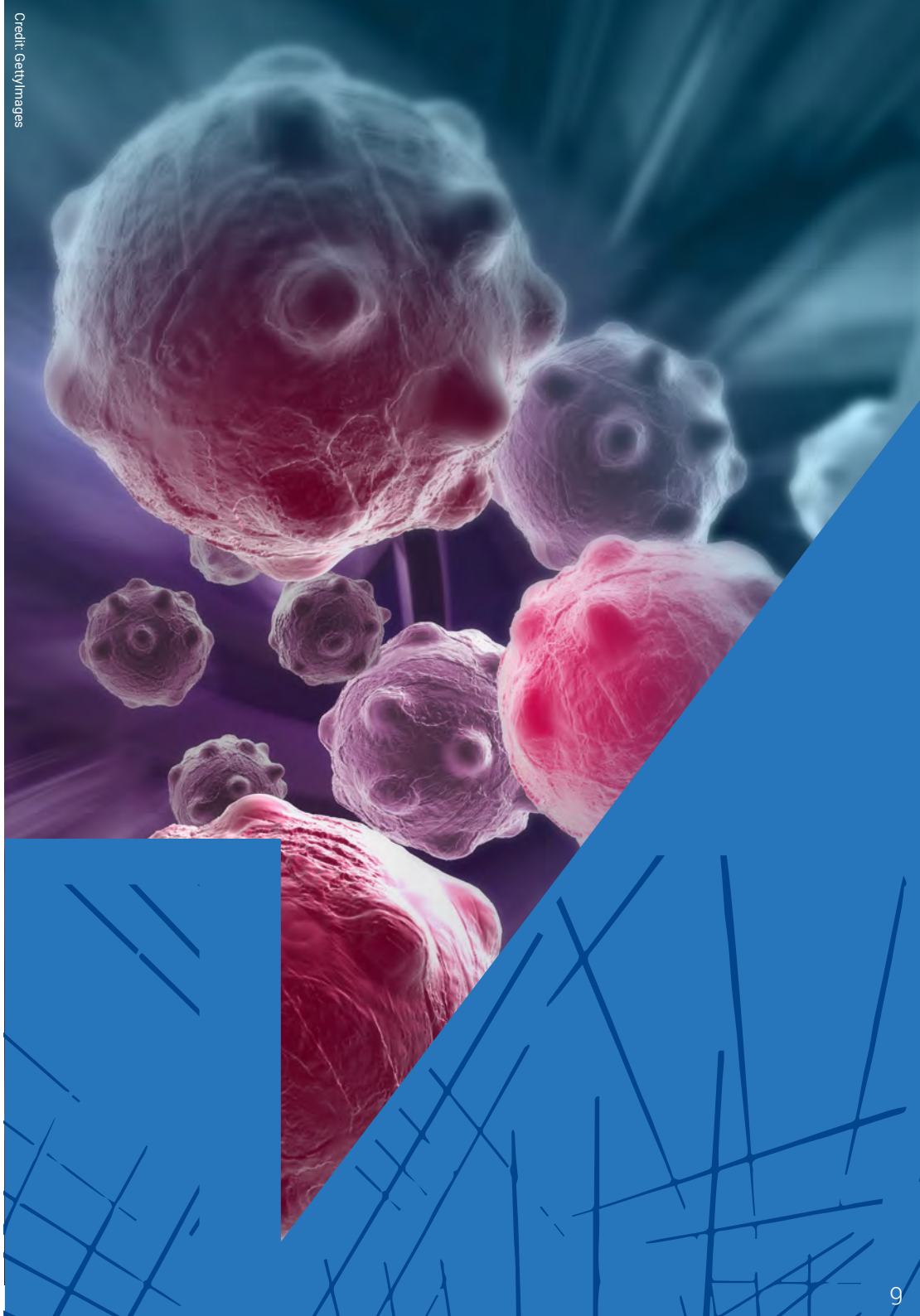
Peter Hargrave, Director of Innovation and Engagement,
School of Physics and Astronomy

Durham University

Personalised diagnosis of cancer growth, and treatment selection

Investigators: Richard Massey, James Nightingale

In his day job, Durham postdoctoral research associate James Nightingale investigates the nature of dark matter by modelling the shapes of gravitationally lensed galaxies. Because the shapes are complex, previous methods required labour-intensive human intervention. James automated the process of modelling new galaxy shapes, in preparation for the deluge of data from ESA's next space telescope. However, his automated model-fitting turned out to have applications in medical science too.



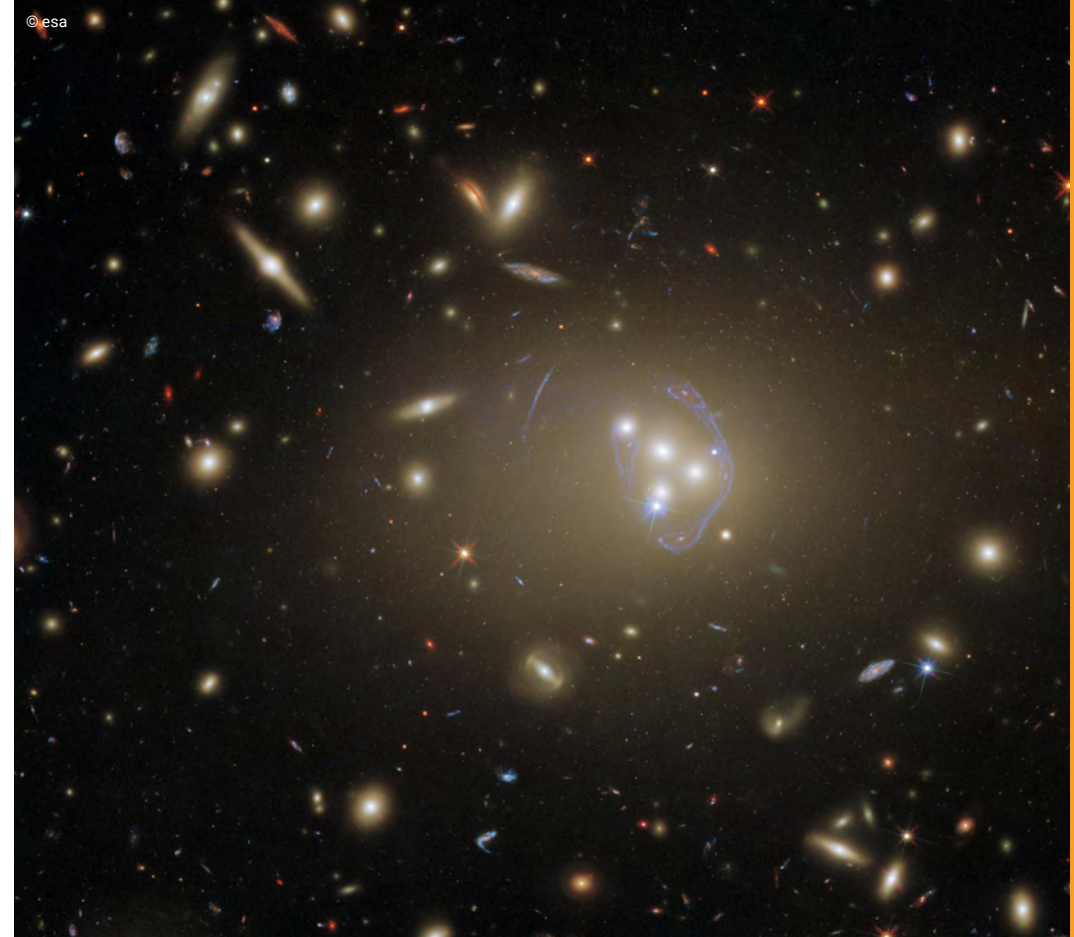
Credit: Getty/images

The key advance of the Durham team's approach was to separate a complex fitting procedure into a series of simple tasks that are linked together. They run initialization phases using an approximate model, followed by phases that gradually make it more complex.

Through this statistical tool, implemented in software, the team were introduced to ConcR, who had also found existing inference packages unable to scale up to a problem of their scope.

ConcR fit predictive models of pancreatic cancer growth to large samples of patient data and wanted to develop a tool for clinicians to rapidly identify when treatments are ineffective, then select treatments better tailored to a patient's genome. Through the work with Durham funded through the IAA, ConcR are now using Durham's Bayesian model fitting technique on large patient datasets. Extracting patterns in cancer progression, then matching new patients against those patterns can not only identify the best treatment to save lives, but also save the NHS hundreds of millions on ineffective treatment.

Following on from the success of the IAA project, Durham went on to partner with ConcR, Roche and The Christie NHS Foundation Trust. They were awarded an Innovate UK grant of almost £1m working to advance the diagnosis and treatment of Cancer of Unknown Primary (CUP)- which affects over 9000 people per year and is the 5th most common cause of cancer death. The 18-month grant will fund the 'CUP-COMP' study which will work with seven NHS sites across the UK.



“We are pleased that this new modelling of cancer progression can be used to improve individual treatment of patients to save lives, increase the cost effectiveness of the NHS, and accelerate the development of novel life-saving therapies.”

Dr Matthew Griffiths, Co-founder of ConcR

Imperial College London

Visualising Martian landscapes in 3D from Mars rovers

Investigators: Sanjeev Gupta and Robert Barnes (Imperial College London); Gerhard Paar (Joanneum Research, Austria); Chris Traxler and Thomas Ortner (VRVis, Austria); and Matt Gunn (Aberystwyth University)

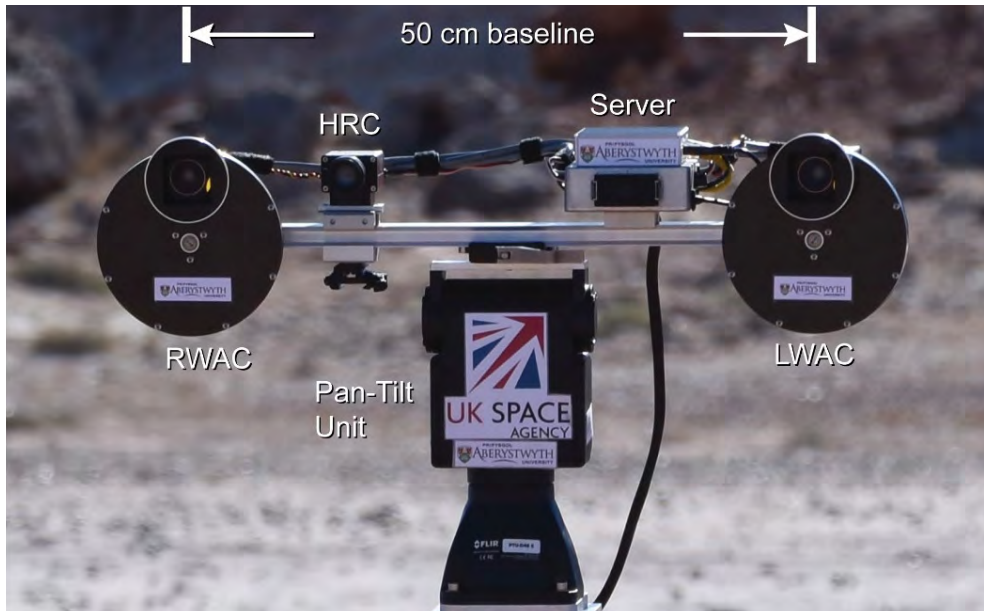
Imperial College London is involved in preparation for both the 2020 NASA Perseverance and the ESA/ROSCOSMOS ExoMars 2022 Rosalind Franklin rover missions to Mars.

The group had funding to test a terrestrial prototype of the camera system developed by Aberystwyth University and test 3D tools and visualisation techniques on terrestrial datasets building on ongoing funding from the UK Space Agency. With computer engineering colleagues from Austria they developed a novel 3D visualisation software tool, called PRo3D.

Working with a number of industrial partners, IAA funding was used for development, testing and validation of additional toolkits for PRo3D. A two-day workshop was hosted to demonstrate the tool, which was attended by academia, industry and funding bodies, enabling discussions on imaging requirements for the ExoMars mission, new technical capabilities and requirements and new opportunities to improve and apply the software.

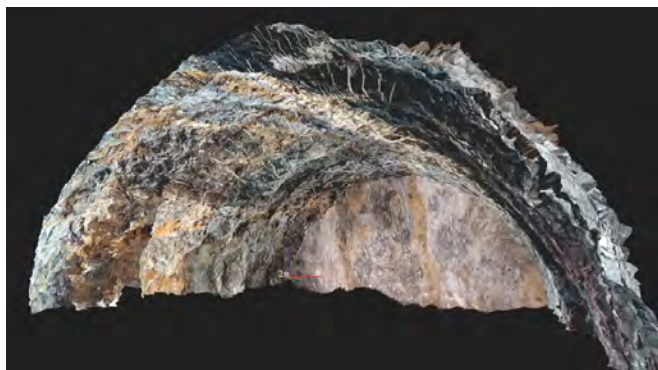


The team is now planning scoping work to applying this tool to engineering geology sectors in the UK and Europe. This follows interest from an Austrian tunnel company who have seen the potential for geological analysis during tunnelling using this technology.

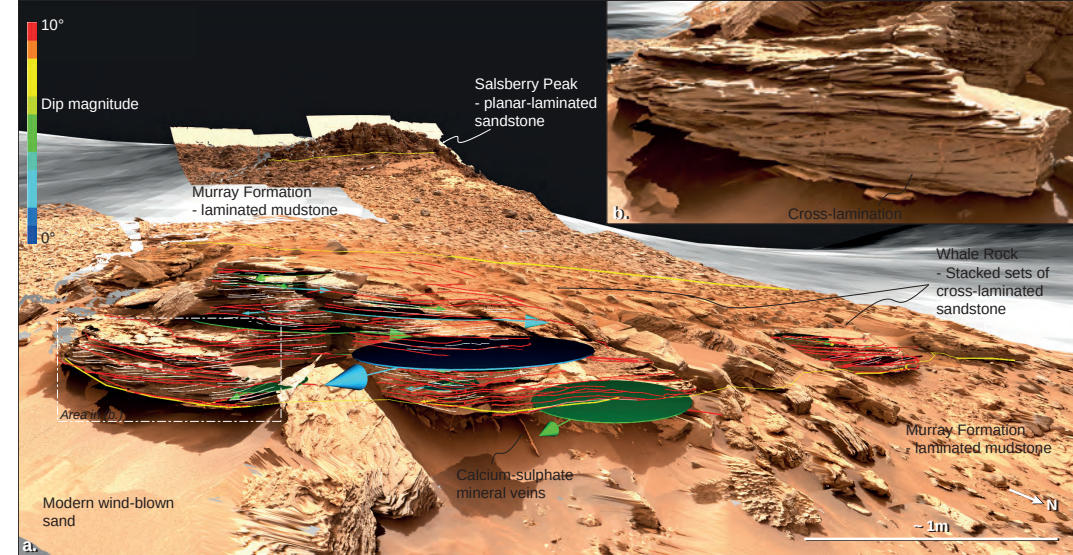


Aberystwyth University PanCam Emulator (AUPE) developed by Matt Gunn at Aberystwyth University for collection of stereo-images of rock outcrops, similar to that which will be collected by the ESA and ROSCOSMOS Rosalind Franklin ExoMars 2022 Rover PanCam at Oxia Planum on Mars.

3D View of a tunnel embrasure and face visualised with a tunnel monitoring viewer based on the same framework as PRo3D (Aardvark). Such 3D Digital Outcrop Models are collected every ~2.5 m during advance of tunnel drilling, and used for planning and assessment of rock properties, fracture styles and densities. Data courtesy of Dibit and Joanneum Research.



Credit: Dibit



Digital Outcrop Model (DOM) of Whale Rock at Pahrump Hills, Gale crater, Mars, visited by the NASA Mars Science Laboratory Rover Curiosity. It is a small lens of sandstone in a thick succession of lakebed mudstones. The complex layering was caused by migration and stacking of small dunes on an ancient riverbed, which can be analysed to understand the behaviour of the water which emplaced them. Credit NASA/JPL/MSSS/Joanneum Research/VRVis.

“With the help of STFC IAA funding, our group was able to significantly enhance the capabilities of visualisation software to analyse and interpret the geology of Mars to assist the search for evidence of ancient life on Mars. Now we are looking forward to applying our tools to engineering geology problems on Earth”

Sanjeev Gupta, Professor of Earth Science,
Department of Earth Science & Engineering, Imperial College London

Lancaster University

A New Process for Leather Tanning

Investigators: Robert Apsimon (Lancaster University); Rebecca Seviour (University of Huddersfield) and Will Wise (University of Northampton)

A team at Lancaster University in collaboration with the Universities of Huddersfield and Northampton are using particle accelerators to develop a new environmentally friendly method of leather tanning. This is a project that ties together research on accelerators, particle interactions with matter and leather tanning.

The RELIEF project is focused on the tanning of leather in a novel process using electron beams whilst drastically reducing the environmental impact of conventional processes by significantly reducing wastewater produced, which can have a long-term impact on the environment if improperly disposed of and incurs a large carbon footprint if properly treated.

Image right: Water contaminated by chrome salts near tanneries in Leon, Mexico.

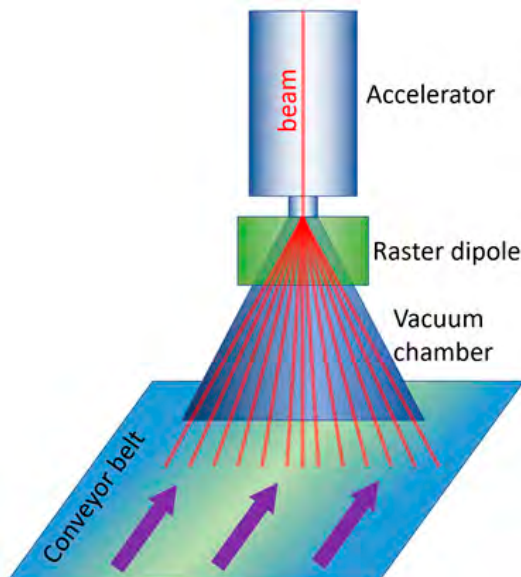


In conventional tanning, large drums are continuously turned to heat and mix large quantities of hide, water, and chemicals, after which the water and chemicals cannot be reused without treatment. With the RELIEF team's process, hides need only be soaked in tanning solutions and then irradiated on a conveyer system, essentially eliminating wastewater. By not needing to mechanically mix and heat large quantities of water, the process also has the potential to reduce water and energy consumption during the tanning, further reducing the cost and carbon footprint of the process.

The team are currently having meaningful conversations with global players in the leather market and there will be a significant impact potential both economic and environmental from this technology. As well as IAA funding the team has secured STFC funding directly and are currently approved for the ICURe programme, but have also received contributions in-kind to allow proof-of-concept testing in the near future, which will enable them to prepare bids for larger Innovate UK funding in the future.

As part of the ICURe programme, the team will explore the feasibility in creating a spinout or licensing business models. With the imminent beam tests planned, they intend to use this to bid for larger grants to allow the development of a prototype for industrial scale testing.

A conceptual layout of how the hides are irradiated on a conveyor system.



The RELIEF workshop, January 2019.

“Scottish Leather Group is the producer of the worlds lowest carbon leather and has over the past 20 years created novel approaches to increasingly efficient leather manufacture. Our innovation team is constantly sourcing new approaches to challenge established methodologies. One such is the application of ‘E Beam’ which seeks to eliminate the current highly water intensive drum stages of leather manufacture, by encouraging chemical stabilisation of the hide (known as tanning) without use of the drum or water bath. This is an exciting prospect, with potential application in both conventional production and could be applied to new tanning chemistry under development, in house. We are keen to support his work and to extend this work.”

Warren Bowden, Head of Innovation and Sustainability, Scottish Leather Group

The Open University

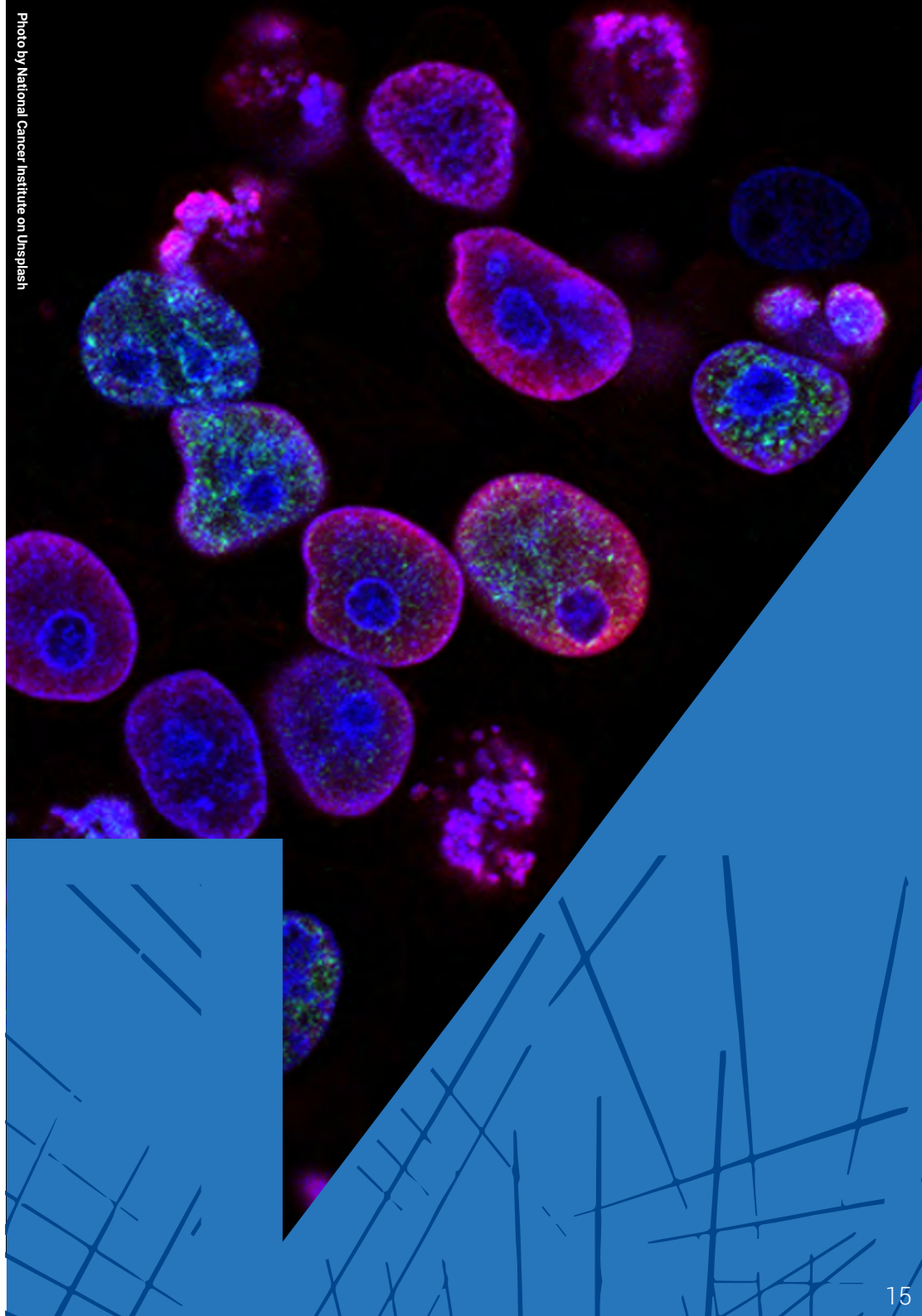
AstrobiologyOU: addressing scientific, governance, societal, ethical and commercial challenges

Investigators: Geraint Morgan, Karen Olsson-Francis, Victoria Pearson and Susanne Schwenzer (The Open University)

The Open University has a track-record of translating space know-how to solving terrestrial challenges, mainly led by Dr Geraint Morgan.

Recognising the potential for Innovation, IAA funding was used by Morgan and The Open University's Astrobiology research group to support its expansion. They brought STFC-funded and other researchers, together with an external consultant, to form a multi-disciplinary team to develop and visualise their future commercialisation and innovation objectives. These objectives and implementation plan were included in a bid to Research England's Expanding Excellence in England (E3) funding scheme.

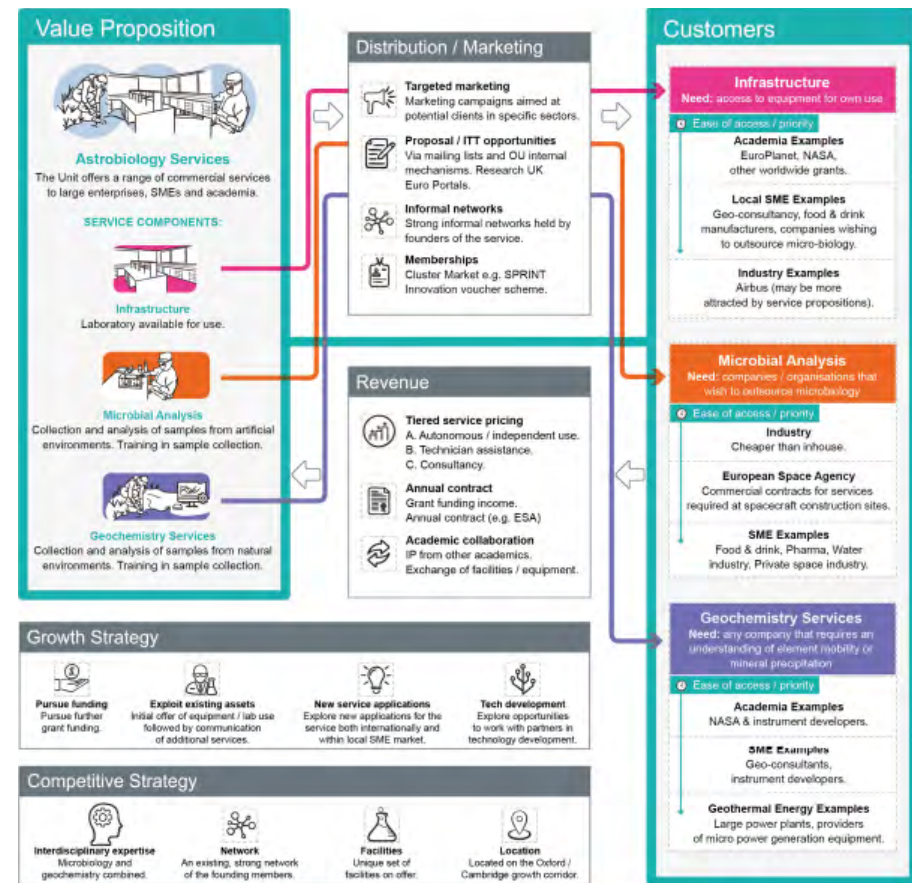
The Astrobiology group went on to secure £6.7M from this scheme with the aim to expand their capacity and capabilities; and make the UK a global leader in this area. The expansion has huge potential for industry engagement, and translational research, which will have significant economic and societal benefit.



The award of this prestigious E3 funding has already significantly raised the profile of (now) 'AstrobiologyOU's' research. It also provides a unique opportunity for STFC scientists to work closely with industry and other sectors of academia to develop new and innovative ideas in this space. After the successful bid, a dedicated Business Development Manager, Dr Yiannis Tsamis, was appointed for three years to develop the commercialisation strategy further. This has helped crystallise their ideas into a single, cohesive programme of work that can be easily articulated to other stakeholders, both internally and externally.



Dr Mario Toubes-Rodrigo from AstrobiologyOU presenting a poster about the group's activities and members at the Research England Expanding Excellence in England programme meeting



Visual Business Model created with Telford Consulting Ltd that illustrates AstrobiologyOU's commercialisation and knowledge exchange activities.

"This is an excellent opportunity to bring together several research strengths within The Open University, especially across disciplinary boundaries and with people we would not traditionally work with within science." Professor Karen Olsson-Francis, Director of AstrobiologyOU

Queen Mary University of London

Supporting the NHS during the Covid-19 pandemic

Investigators: Ildar Farkhatdinov with Kaspar Althoefer, and Shakeel Shahdad

Queen Mary University London researchers used Impact Acceleration Account (IAA) funding to produce newly designed 3D printed visors for the National Health Service (NHS) during the COVID-19 pandemic.

The project team, composed of computer scientists, engineers and clinicians, responded to the shortage of personal protective equipment (PPE) in the NHS by designing, clinically validating and producing 30,000 re-usable face visors. The face visors were manufactured using 3D printing and moulding technology and delivered to frontline NHS staff. The design of the face visors was optimised based on feedback from medical colleagues and regulators so that they were safe to disinfect, re-usable and quick to manufacture. The Queen Mary team also oversaw the organisation of the supply chain to Royal London Dental, Royal London and Nightingale hospitals, and Queen Mary University of London's School of Medicine and Dentistry.



Project co-ordinator Professor Shakeel Shahdad from Queen Mary's Institute of Dentistry said, *"The ingenuity of the combined team has allowed us to start immediate in-house production of 3D printed visors. Our aim is to equip all clinical staff with 3D printed visors and expand out into producing these with faster and higher volumes with injection moulded designs in the coming weeks."*

Reader in Bioengineering, Dr John Connelly, added, *"The original visor design has been successfully modified by our Robotics team in collaboration with the Queen Mary spinoff company, Keratify, to improve the printing efficiency and stability."*

The project promoted collaboration between Queen Mary computer scientists, engineers, medical colleagues, NHS staff, students and alumni to carry out novel research. It used IAA funds in an agile and responsive way to enable innovation and impact from physical sciences and engineering research by improving the working conditions and safety of frontline essential workers and mitigating the spread of the COVID-19 pandemic.

For more information please see the resulting publication: **'Innovation in the time of SARS-CoV-2: A collaborative journey between NHS clinicians, engineers, academics and industry'**.



All images: Beneficiaries of the newly-designed 3D printed visors



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Queen's University Belfast

A new era of solar science

Investigators: Mihalis Mathioudakis with Francis Keenan and David Jess

The Astrophysics Research Centre (ARC) at Queens University Belfast teamed-up with Oxford Instruments' Andor Technology and a UK university consortium to develop the Balor imaging sensor and synchronisation platform for the Daniel K Inouye Solar Telescope (DKIST).

The development of these sensors, which was overseen by the Astrophysics Research Centre, will provide a solution for imaging photometric and astrometric variability across a wide range of timescales.

The imaging capability provides a 16.9 Megapixel/70mm area suitable for large sky surveys; 54 fps full frame to enable the imaging of fast solar dynamic events or fast-moving objects; and low read noise for the detection of very weak signals. Dr Aaron Reid, one of the lead developers for the Balor cameras, suggested that they 'provide a unique solution to the complex problem of generating very high-resolution images providing a sufficiently fast readout speed to 'freeze' the turbulence generated within the Earth's atmosphere.

The Daniel K Inouye Solar Telescope



Experts believe that this will bring about a 'new era of solar science'. The large aperture of DKIST combined with the high frame rate of the Balor cameras will show the Sun's surface in greater detail allowing deeper understanding of the magnetic dynamics of 'Space Weather' that can damage human technology. They envisage that this will improve the prediction of eruptive events and help mitigate the effects of 'Space Weather'.

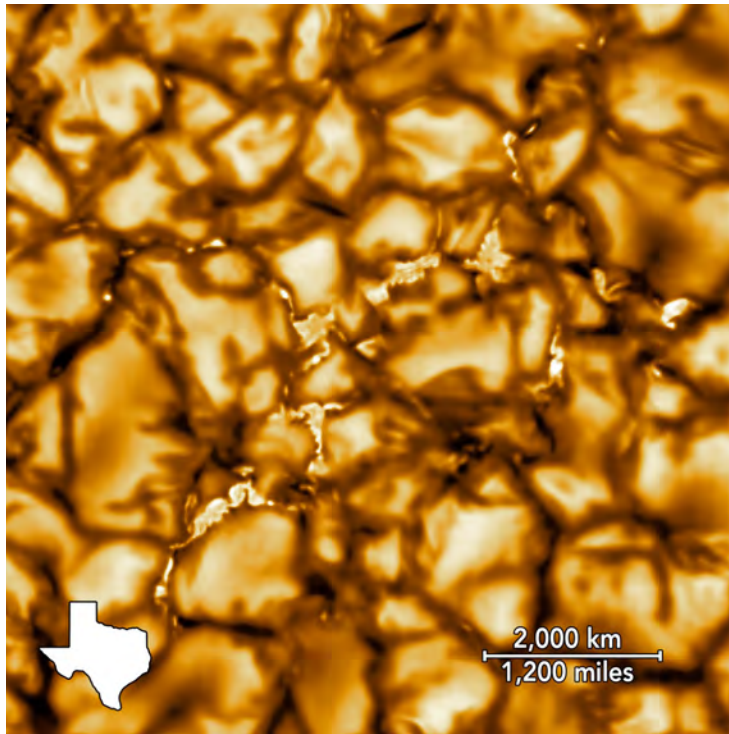
Furthermore, the unprecedented imaging produced by the first-light images has led to a lot of appreciation of solar physics and science in general by the public who have been able to see our star in greater detail than ever before.

The team believe that these developments will, in the coming years, contribute to both Andor's revenue and the UK economy.



Fig 2: The Balor camera

Note: Balor was initiated through the solar physics research programmes undertaken at Queen's University Belfast, and developed in collaboration with staff in the Queen's Astrophysics Research Centre, University College London, Armagh Observatory, Northumbria University, University of Glasgow, University of Sheffield, University of St Andrews, University of Warwick and the US National Solar Observatory, from funding provided by the Science and Technology Facilities Council, part of UK Research and Innovation.



The first-light image of the Sun obtained with DKIST equipped with the Balor camera. This is the highest resolution image of the solar surface and shows the fine structure of the bright granules and dark intergranular lanes produced by the currents of plasma that rise and fall from/into the solar convection zone. Image credit: NSO/AURA/NSF.

"The images produced by the Inouye Solar Telescope open new horizons in solar physics. Its imaging capability allows us to study the physical processes at work in the Sun's atmosphere at unprecedented levels of detail. We worked hard over the past few years with Belfast-based Andor Technology to develop the cameras that equip the Inouye Solar Telescope and it is highly rewarding to now see this fascinating imaging."

Professor Mihalis Mathioudakis, Queen's University Belfast

University of Bristol

New Approaches to Big-Data Analysis in Particle Physics

Investigators: Konstantinos Petridis and Jonas Rademacker

Researchers at the University of Bristol have used STFC IAA funding to test Graphcore's Intelligence Processing Unit™ use for large data analysis in particle physics research.

The Intelligence Processing Unit (IPU)™, developed by Bristol-based company Graphcore, is a new computer processor chip, designed from the bottom-up, for Artificial Intelligence applications. The IPU promises substantially better performance than traditional processors such as CPUs and GPUs, while being highly flexible and easily programmable.

Researchers from the particle physics group of the University of Bristol applied their understanding of big data analysis using AI to develop a suite of software tools to benchmark and stress-test Graphcore's IPU in the computationally demanding environment of particle physics experiments at the Large Hadron Collider. This was the first time that such a processor had been involved in these experiments.



The team found that the IPU's design offered significant advantages for algorithms such as those responsible for tracking the trajectories of particles that are found ubiquitously in a wide range of research fields. It highlighted that the novel design of the chip lends itself to superior performance over current processors for both AI and non-AI applications. It also allowed for the use of more complex algorithms that can process, select and analyse vast amounts of data at a fraction of the time taken by conventional computing architectures.

The STFC IAA played a crucial role in winning £212k of STFC-Projects Peer Review Panel (PPRP) funding as part of the LHCb UK upgrade-II project. Allowing researchers at Bristol University to further investigate modern computing architectures beyond CPU and GPU.

As the field of particle physics expands, with more sophisticated experiments generating vast quantities of data, there is pressure on CERN to seek new methods to deal with the ever-increasing computational demands of their experiments. With this in mind, and the promising results of the STFC IAA project, CERN are now looking at IPU's as a potential solution.

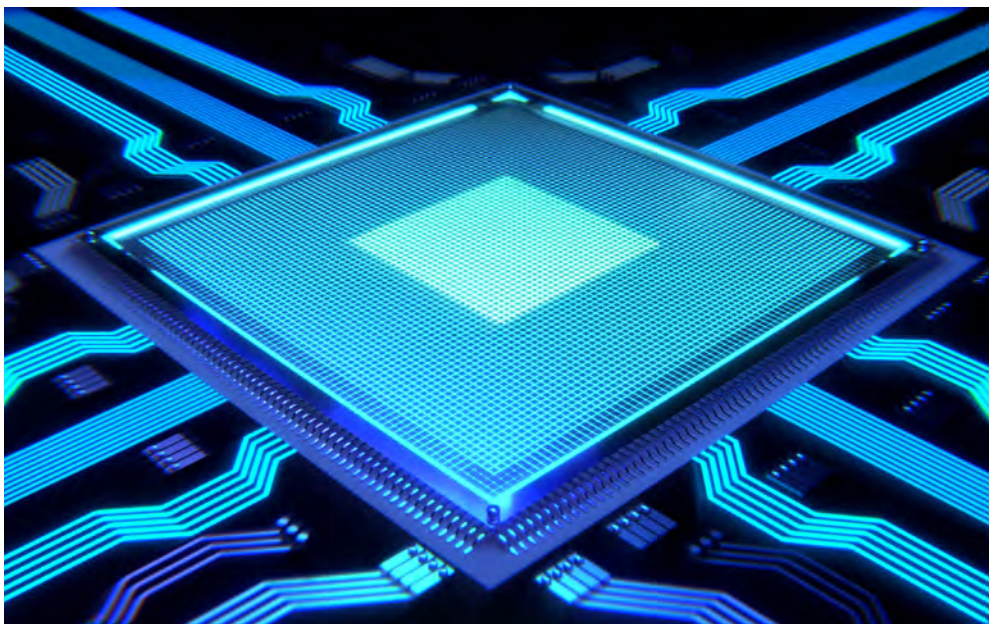
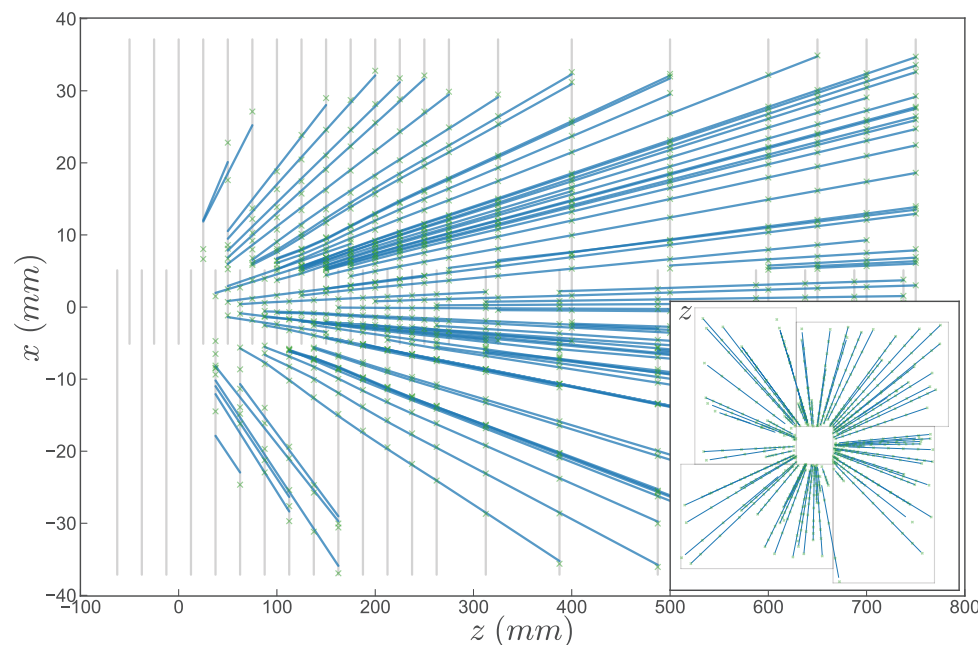


Image by Colin Behrens from Pixabay



A picture of part of the detector responsible for reconstructing the trajectories of particles. The vertical lines denote the detector sensors. The green dots represent where the particle went through the detector and the blue lines represent the reconstructed trajectories using an algorithm.

“For Graphcore, this demonstrated immediate impact, inspiring other researchers around the world to explore novel uses of IPU's in scientific computing.”

Graphcore Ltd, Industrial partner



University College London

Twinkle space mission to study exoplanet atmospheres

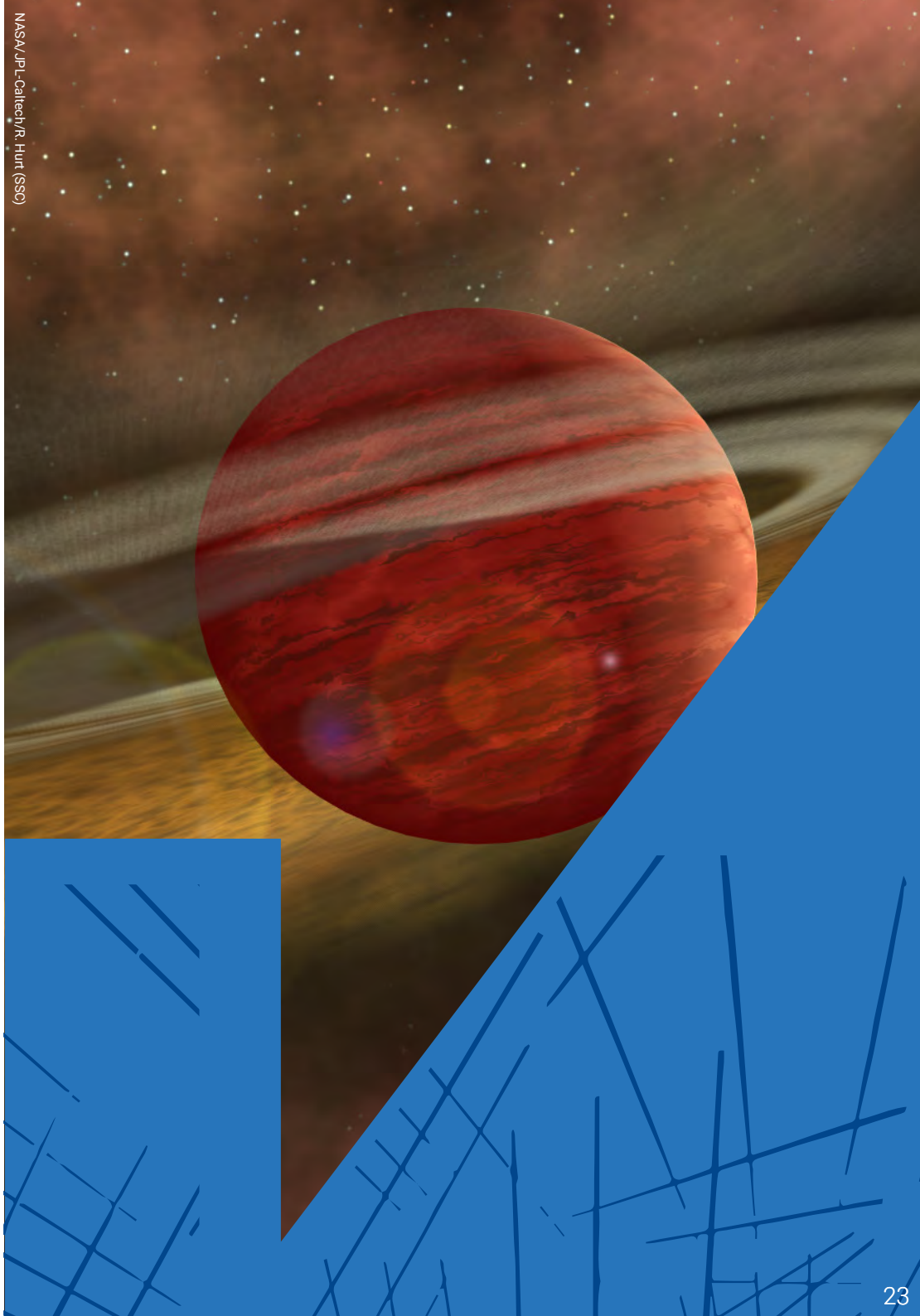
Investigators: Jonathan Tennyson, Giovanna Tinetti and Marcell Tessenyi (University College London)

The Twinkle mission grew from original research activities based at UCL which involved building a scientific space mission using off the shelf components for the spectroscopic analysis of exoplanet atmospheres.

Using IAA funding, UCL developed a business case to convert initial interest from scientists worldwide, with end user engagement, which led to the formation of a company called Blue Skies Space Ltd.

The impact of this work has allowed the company to engage users and develop new contacts. Since then, the company has generated >£569k in private capital and €250k co-funding from the European Space Agency and the backing of the UK Space Agency.

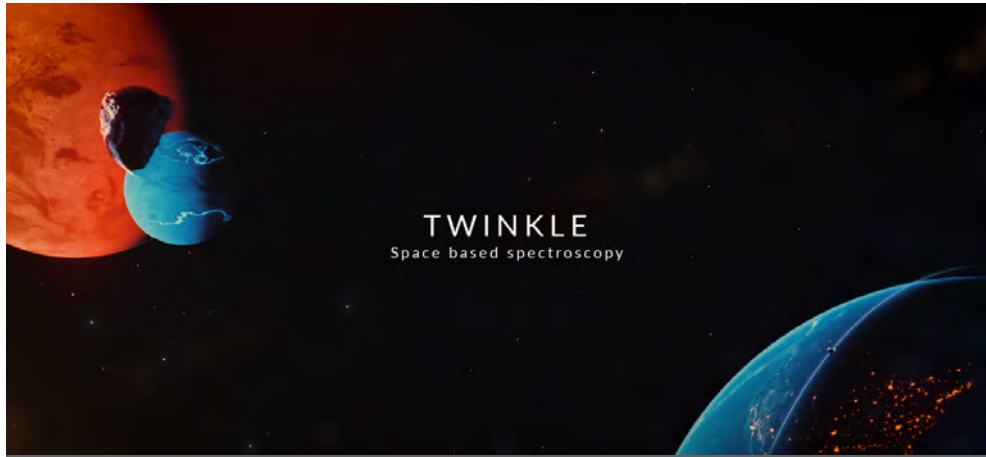
Image: In this artist's conception, a possible newfound planet spins through a clearing in a nearby star's dusty, planet-forming disc.



NASA/JPL-Caltech/R. Hurt (SSC)

The project has received interest from Airbus Defence and Space and ABB to progress the technical design of the Twinkle satellite ahead of construction which is due to begin late 2020.

For more information please visit: <http://www.twinkle-spacemission.co.uk/>



“We think Twinkle will be transformative on how space science data is collected and accessed globally. The service model we offer opens the door to a large number of institutions worldwide to partake in cutting edge research in a cost-effective manner. The success of Twinkle will lead to a series of scientific satellites delivered through this sustainable model.”

Dr Marcell Tessenyi, CEO of Blue Skies Space Ltd,
Senior Research Associate at UCL's Department of Physics & Astronomy



University
of Glasgow

University of Glasgow

Cosmic-ray imaging for nuclear decontamination

Investigators: Ralf Kaiser and David Ireland

Developed from underpinning research into nuclear physics on Quantum Chromodynamics, the team at Glasgow have developed a working full-scale prototype of a muon-tomography 3D imaging system for nuclear waste containers.

Working alongside the National Nuclear Laboratory, Nuclear Decommissioning Authority and Sellafield Ltd, the team developed muon imaging systems for deployment in the nuclear industry which is being commercialised via University of Glasgow spin-out Lynkeos Technology Ltd.

Cosmic-ray muon imaging is a non-destructive testing technology that makes use of naturally occurring, highly penetrating radiation. Nuclear waste containers must be shielded to contain radiation, so this technique can be used to monitor the inside of nuclear drums without penetrating the external shielding.

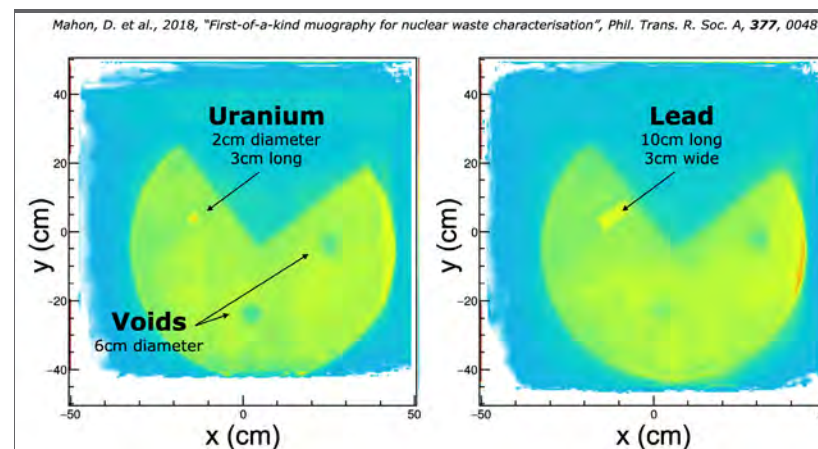


Image from PxHere

This system was a world-first in being able to reliably detect uranium inside shielded nuclear waste containers. From this, a spin-out company (Lynkeos Technology Ltd) was formed in 2016, which has since received £1.6M from Innovate UK. The system is now deployed at Sellafield to improve nuclear waste safety with an estimated savings of £100-200M over the next 20 years for UK taxpayers. Lynkeos has generated a total turnover of £2.5M over four years, while employing up to 6 staff.

Further investment is being utilised to develop a mobile system which is expanding this technology into civil engineering applications. Both STFC and EPSRC IAA funds have helped support this development, alongside funding from STFC's CLASP scheme and Innovate UK.

The images are two 5mm-thick horizontal slices through the drum at two different heights. One shows the presence of the uranium cylinder and the other a block of lead. Both show up as different colours - this represents the density of the material.



"Lynkeos is working with key stakeholders in the global nuclear industry to provide a unique passive inspection and monitoring capability that will underpin the safety of waste storage for decades to come and deliver significant savings to the taxpayer in the process. Our muon imaging technologies are now being applied to applications in civil engineering to identify structural defects in ageing civil infrastructure. Groundbreaking initial investigations in this area have highlighted the key role that muon imaging in the Non-Destructive Testing toolkit."

David Mahon, Lynkeos Business Development Manager



UNIVERSITY OF LEEDS

University of Leeds

LowCat™ synthesis

Investigators: Alexander (Sandy) James, John Plane, Hu Li and John Blacker (PI on the IAA project linked to this)

Previous STFC funding resulted in the identification of the novel catalyst, LowCat™. This was found to have beneficial properties in the conversion of carbon monoxide to Carbon Dioxide (CO₂), following a STFC funded study of the atmospheric chemistry of Venus. It was also discovered that it was able to catalyse the conversion of nitrogen oxides (NO_x) to nitrogen and oxygen at significantly lower temperatures than current state of the art catalysts. This suggested that it would be an ideal candidate for use in diesel engine exhaust remediation, which was confirmed by a recently completed PoC project.

However, the original reaction procedure used to synthesise LowCat™ was inefficient and required optimisation, taking several weeks to prepare the small amounts of catalyst necessary to prove the process in laboratory trials. To make the catalyst



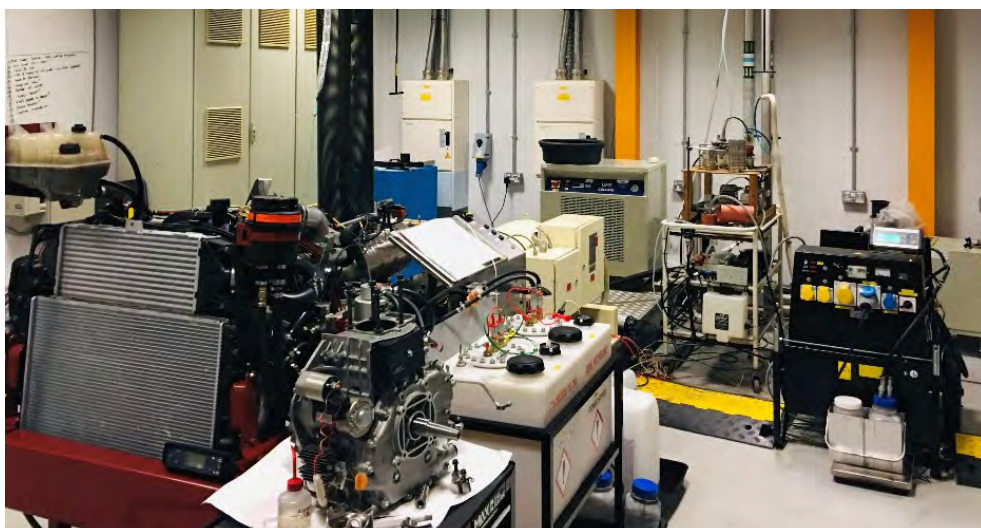
attractive to industry, it was important to reduce preparation time to a few days at most and develop a scalable route to produce up to 1 kg initially.

In a short project between the School of Chemistry and the School of Chemical and Process Engineering, funded by an STFC IAA award, Dr Alexander (Sandy) James and Professor John Blacker were able to carry out a series of experiments, initially at 1 litre scale, to learn more about the limiting factors in the synthesis and to test ways of speeding up the reaction trials to confirm that the catalytic activity of the material was retained.

The final stage was synthesis at larger scale to produce batches up to 1 kg of catalyst.

The outcome of this project was vital to the future commercialisation programme for LowCat™. It also played a significant part in the recent award of an IPS grant from the STFC, which will allow us to build and test a full-scale catalytic converter and carry out vehicle trials with our project partner, Cats & Pipes, a leading after-market supplier of catalytic converters for exhaust remediation.

Exhaust emissions contribute to poor air quality in urban areas, which in turn is linked to chronic ill health and death. A report from Public Health England in 2019 estimated that between 28,000 and 36,000 people a year die from long-term exposure to air pollution.



The Engine Lab at the University of Leeds



Credit: Gettyimages

While it is true that the use of diesel engines will start to decline by the introduction, for example, of the UK Government ban on the sale of new petrol and diesel cars and vans in 2030, most of these vehicles are likely to remain in use for many years after this, and the ban does not apply to heavy vehicles, such as lorries and buses, and to trains and ships, which extensively use diesel propulsion. In other parts of the world, where power transmission is less well developed, microgrid diesel generators are widely employed.

Traffic fumes in urban areas often come from vehicles operating at lower temperatures because they are either idling or moving at low speed. As a result, conventional catalytic converters under urban road conditions may be operating with less than 50% efficiency. LowCat™ is able to convert nitrogen dioxide at ambient temperature and has the potential to improve air quality significantly, thus offering societal and health benefits, particularly to poorer areas of the world, often with high population density.

“LowCat remains an exciting technology with good commercial potential, but more importantly, it now offers a real opportunity to make a significant difference to reducing global air pollution, particularly in urban areas. This is very timely, following the recent recommendation by the WHO of new Global Air Quality Guidelines that include a 75% reduction in NO₂ levels. We are extremely grateful for the continued support offered to us by the Science and Technology Facilities Council and we are looking forward to scale-up and prototype trials, with our industrial partner, Cats & Pipes.”

Simon Clarke, Commercialisation Manager at the University of Leeds.

University of Leicester

Astronomy cameras for societal applications

Investigators: John Lees and Sarah Bugby (research associate)

Building on expertise from the space program at Leicester on new technology for X-ray astronomy, researchers have developed a portable hybrid CCD-scintillator and co-aligned optical camera for the detection of gamma rays used in clinical nuclear imaging. The patented hybrid gamma camera (HGC) has undergone early-stage evaluation for non-surgical clinical use at Nottingham University Hospitals NHS Trust.

The technology is currently being licensed to the medical imaging field and has generated £30,000 in royalties. The device is planned to be launched onto the market in 2023/24.

In addition to medical applications, the system has been assessed for environmental imaging and showed the potential of the hybrid imaging approach for detecting radioisotopes in the environment. This has expanded the breadth of applications for

The hybrid gamma being used during a clinical imaging evaluation.

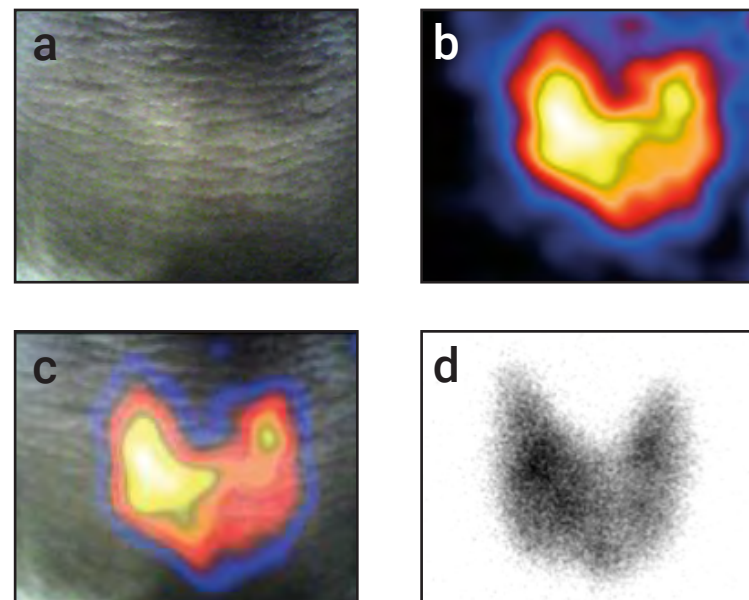


the camera into the field of nuclear security and received funding from both STFC and the National Nuclear Laboratory.

Decommissioning nuclear sites is a global concern, so potential environmental and economic drivers in this area will lead to significant commercial opportunities for the team. The cost to decommission Sellafield is expected to reach £85 billion – and Sellafield is one of 18 sites in the UK where decommissioning is underway. Plans to extend the licence for nuclear decommissioning applications were agreed in 2021, and work is still on going here to make a marketable product. The nuclear decommissioning market is set to projected to be £119 billion in the UK alone.



The hybrid gamma camera mounted on an articulated arm during clinical use.



Thyroid imaging. a) Optical, (b) gamma and (c) hybrid image of thyroid scan in patient administrated with ^{123}I acquired using the hybrid gamma camera and compared with (d) a large field of view planar gamma image.

“We believe the HGC to be a truly innovative and potentially disruptive technology which has the potential to increase access to and reduce the cost of molecular imaging and help deliver personalised medicine to more patients resulting in improved outcomes, better quality of life and more effective use of healthcare resources. We are also now very excited by the way in which it’s unique combination of benefits gives the HGC potential to make a major contribution in the Nuclear Decommissioning Industry”

David Hail, CEO, Serac Imaging Systems Ltd
<https://www.seraclifesciences.com/>

University of Liverpool

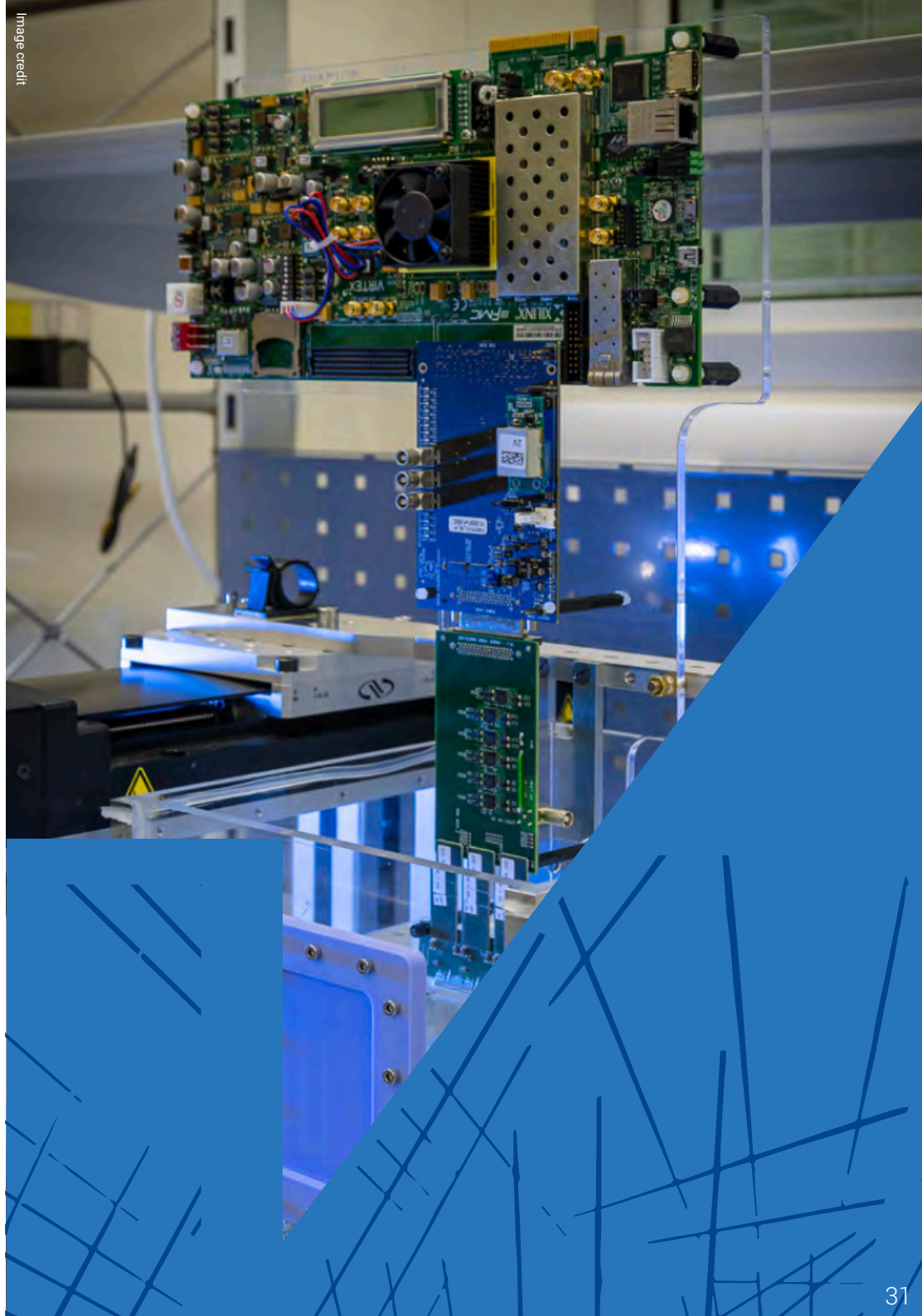
Water Phantoms for particle therapy using technology from CERN

Investigators: Gianluigi Casse and Jon Taylor

Imaging Phantoms are used as stand-in for human tissue in medical physics to ensure that imaging equipment is working correctly and to undertake quality control. Funding provided by the Impact Acceleration Account (IAA) to the Department of Physics at the University of Liverpool enabled the development of further enhancements to the water phantom that was originally developed in collaboration with Rutherford Cancer Centres and Rutherford Diagnostics.

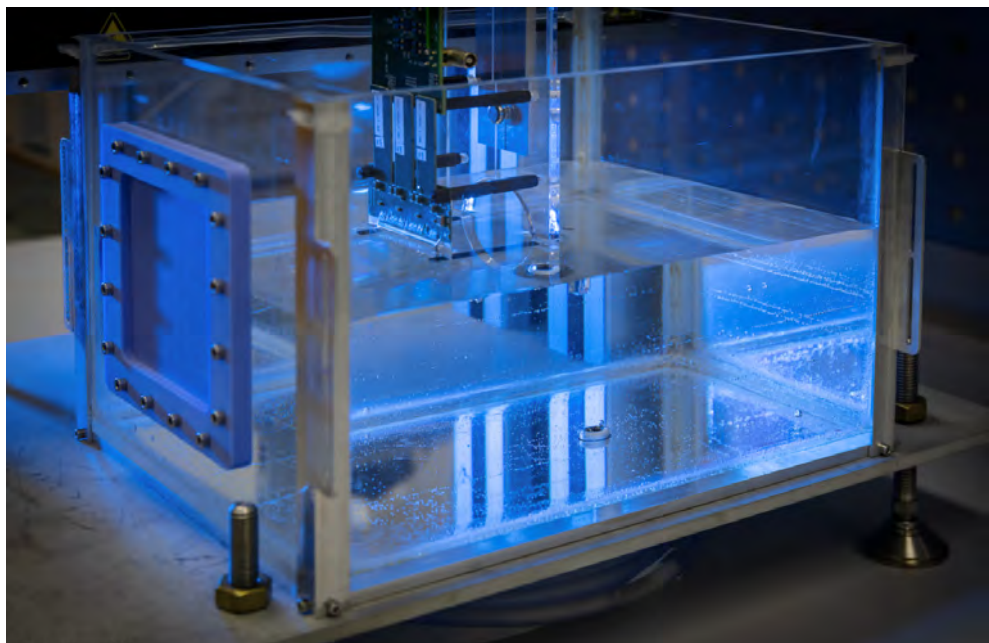
The project brings together technology developed for High Energy Physics (Timepix3) and sensors designed at Liverpool for the LHCb experiment at CERN. These sensors were manufactured by Micron Semiconductor Ltd. The project connects to a number of R&D studies in the department and capitalises on existing national and international networks coordinated by Liverpool experts.

Image left: Silicon pixel sensor and timepix3 (copyright: University of Liverpool, McCoy Wynne)

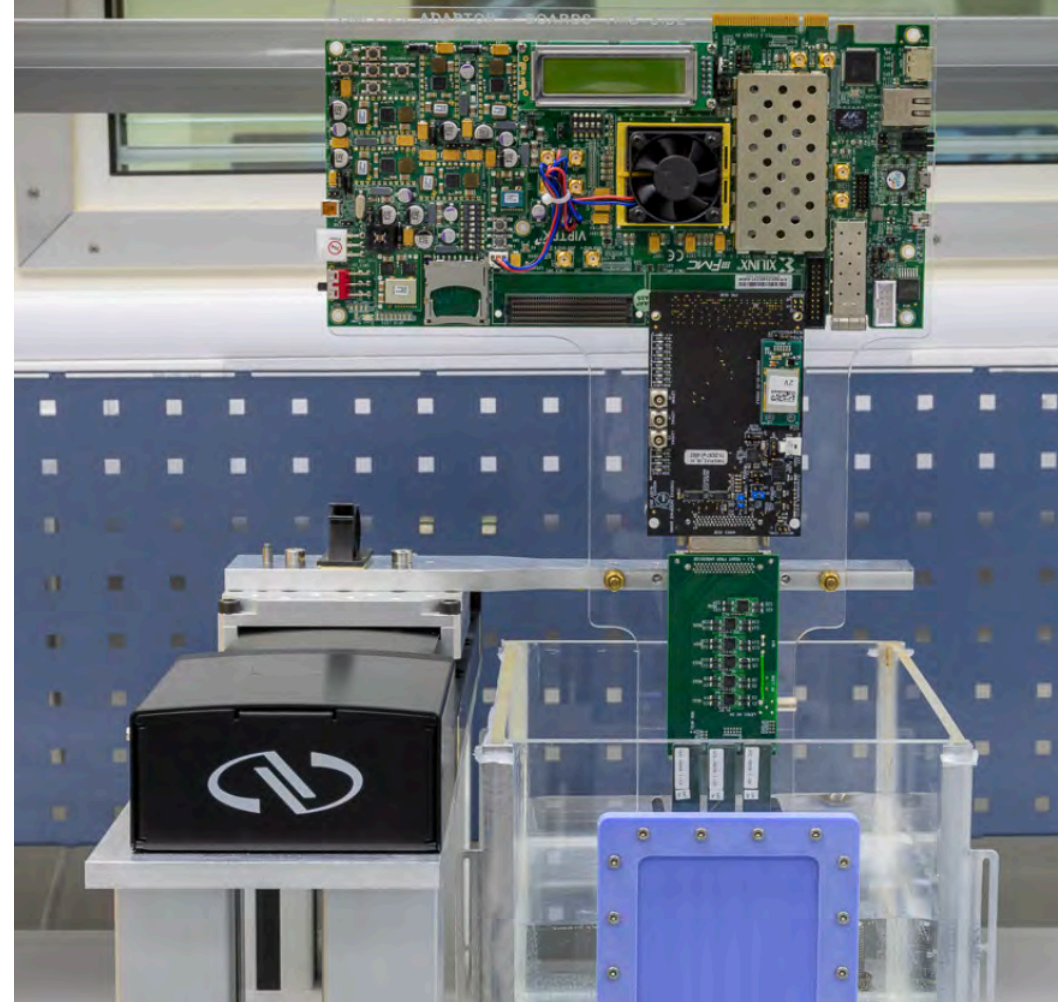


These enhancements allowed additional detectors to be added that provide accurate calibration of dose to water for clinical beams, allowing realistic clinical fluences to be used with the device during measurements. Additional parts for sensing of neutrons in clinical environments were also added to measure the neutron flux generated by clinical beams with greater precision that is currently available. These measurements can be correlated with measurements made in the Timepix phantom.

IAA funding has been instrumental in enabling the research team to develop a proof of concept water phantom with pixel detectors that can be applied in medical devices and diagnostics, bringing it closer to full commercialisation. The project forms part of a wider portfolio of initiatives and projects within the department to develop innovative healthcare instrumentation through its coordination of the EU Optimization of Medical Accelerators (OMA) network and the STFC Cancer Diagnostics Network.



Timepix3 readout immersed in water for measurements in clinical proton beams
(copyright: University of Liverpool, McCoy Wynne)



Silicon pixel sensor (copyright: University of Liverpool, McCoy Wynne)

“The support provided by STFC has opened up new opportunities for future developments in the design and fabrication of a new HV-CMOS detector with features that are optimised for data taking in a clinical proton beam. We aim to undertake further tests of the new detector in collaboration with industry partners in FLASH radiotherapy and carbon ion therapy.”

Professor Carsten Welsch,
Head of the Department of Physics, University of Liverpool

University of Oxford

From particle colliders to high value manufacturing...Absolute distance measurements

Investigators: Armin Reichold

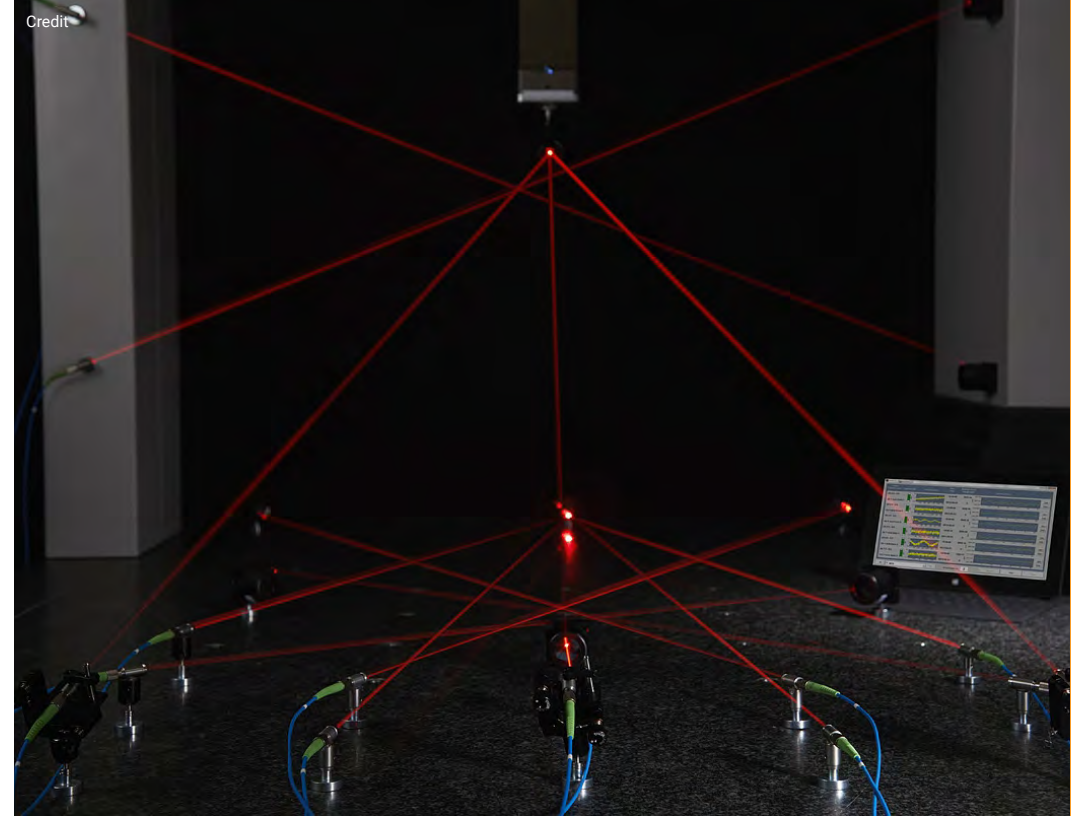
For operation of the ATLAS detector at CERN's Large Hadron Collider the components need to be positioned to an incredibly high level of accuracy, or they will not work. Misaligned components would result in erroneous measurements of particle properties or particles missing detection altogether. This is particularly critical in the Silicon tracking detector (SCT). To this end, researchers at the University of Oxford devised a sophisticated laser-based measurement system. Using frequency scanning interferometry (FSI) technology the technique is capable of simultaneously measuring large absolute distances very accurately, with a tolerated error of only half a micron per metre (roughly the width of a human hair over a kilometre).



Collaborating with Hexagon AICON ETALON GmbH, a German high-tech company specialising in laser tracers for measuring distances, the project team worked on developing this technology for multiple commercial problems. The technique was patented and licensed to Hexagon who manufacture and sell the technology under the brand name Absolute Multiline™, which can now measure many absolute distances simultaneously. The technology has brought in revenue in excess of £3.3M.

The technology is now employed in numerous areas including power production plants, precision mirror manufacturing, telescope alignment and material research laboratories. It is also on its way into space simulators, aircraft manufacturing, national metrology institutes and many other applications. The team is currently working on adapting the technology to be able to measure distances to fast-moving targets, which will open up yet another market: control of high-precision Computer Numerically Controlled (CNC) machine tools.

As the research continues, ideas are continuously exchanged to further improve the technology for commercial applications, through Etalon and also through a new industrial collaboration with VadaTech UK. The European National Metrology Institutes have identified FSI as one of the most important themes for Europe's future Large Volume Metrology, because of its ability to measure the size, location, orientation and shape of large objects, assemblies or machine tools.



Several measurement lines of an Absolute Multiline™ system for calibration of a Coordinate Measurement Machine. Note: the red laser lines from the alignment laser are digitally enhanced to make them more visible.

“The Absolute Multiline Technology provides the foundation for machines and structures that are self-monitoring. Therefore, it can become a building block in the future concept of intelligent production.”

Dr.-Ing. Heinrich Schwenke, CEO Etalon AG,



The
University
Of
Sheffield.

University of Sheffield

Muon imaging for international border security

Investigators: Vitaly Kudryavtsev

The University of Sheffield received IAA funding to generate preliminary data for the development of a new muon tomography system, which is designed to be used to determine different materials in cargo – supporting the detection of illegal goods crossing borders. The preliminary data supported Sheffield University's membership of the Horizon 2020 consortium, which has now been backed by a €7.5 million grant through the European Commission's Horizon2020 programme.

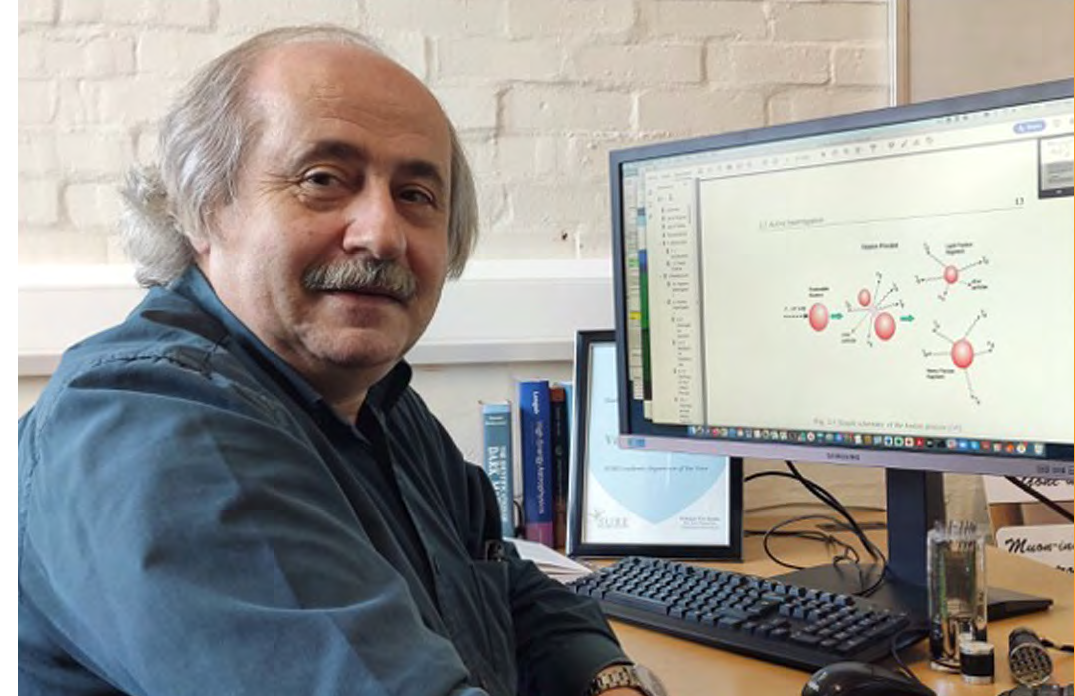
The European Consortium includes several universities, research centres and businesses including: the University of Sheffield (UK), the University of Tartu (Estonia), GScan OU (Estonia), German Aerospace Centre (DLR, Germany), Catholic University of Louvain (Belgium), CAEN (Italy), SGS (Switzerland), supported by border agencies in Estonia, Finland and Turkey.



The Consortium will design, build and characterise the first prototype muon tomography system to identify different materials in cargo. The project aims at testing the prototype in laboratory conditions, as well as at several border crossing points. Adding muon detectors to already existing scanning devices at border crossing points, will improve the efficiency of detection of illegal goods in lorries and sea containers.

Professor Vitaly Kudryavtsev, the lead researcher from the University of Sheffield's in thi project stated that *"Adding muon detectors to already existing scanning devices at border crossing points, will improve the efficiency of detection of illegal goods in lorries and sea containers."*

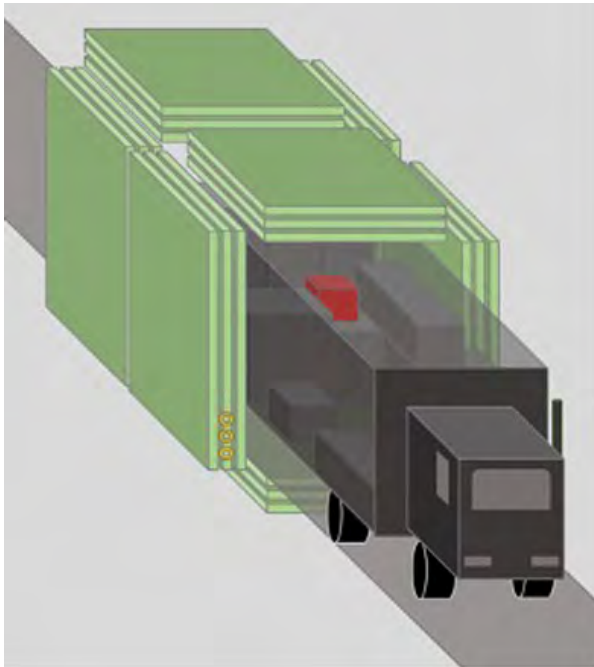
The applications of muon tomography have potential in diverse industries. Previous IAA funding supported the muon tomography start-up, Geoptic, to survey the structural integrity of key infrastructure, allowing for improved public safety. This is led by Professor Lee Thompson at the University of Sheffield, who is now the Technical Director of Geoptic, a spin-out that also includes academics from the University of Durham and St Mary's University, Twickenham.



Professor Vitaly Kudryavtsev

"Adding muon detectors to already existing scanning devices at border crossing points, will improve the efficiency of detection of illegal goods in lorries and sea containers"

Professor Vitaly Kudryavtsev, University of Sheffield



Schematic of 'drive through' muon detector. Hidden illicit nuclear material is red and muon detectors are green. Credit Sorefan.

University of Southampton

Molegazer: Early detection of melanoma using astrophysical techniques

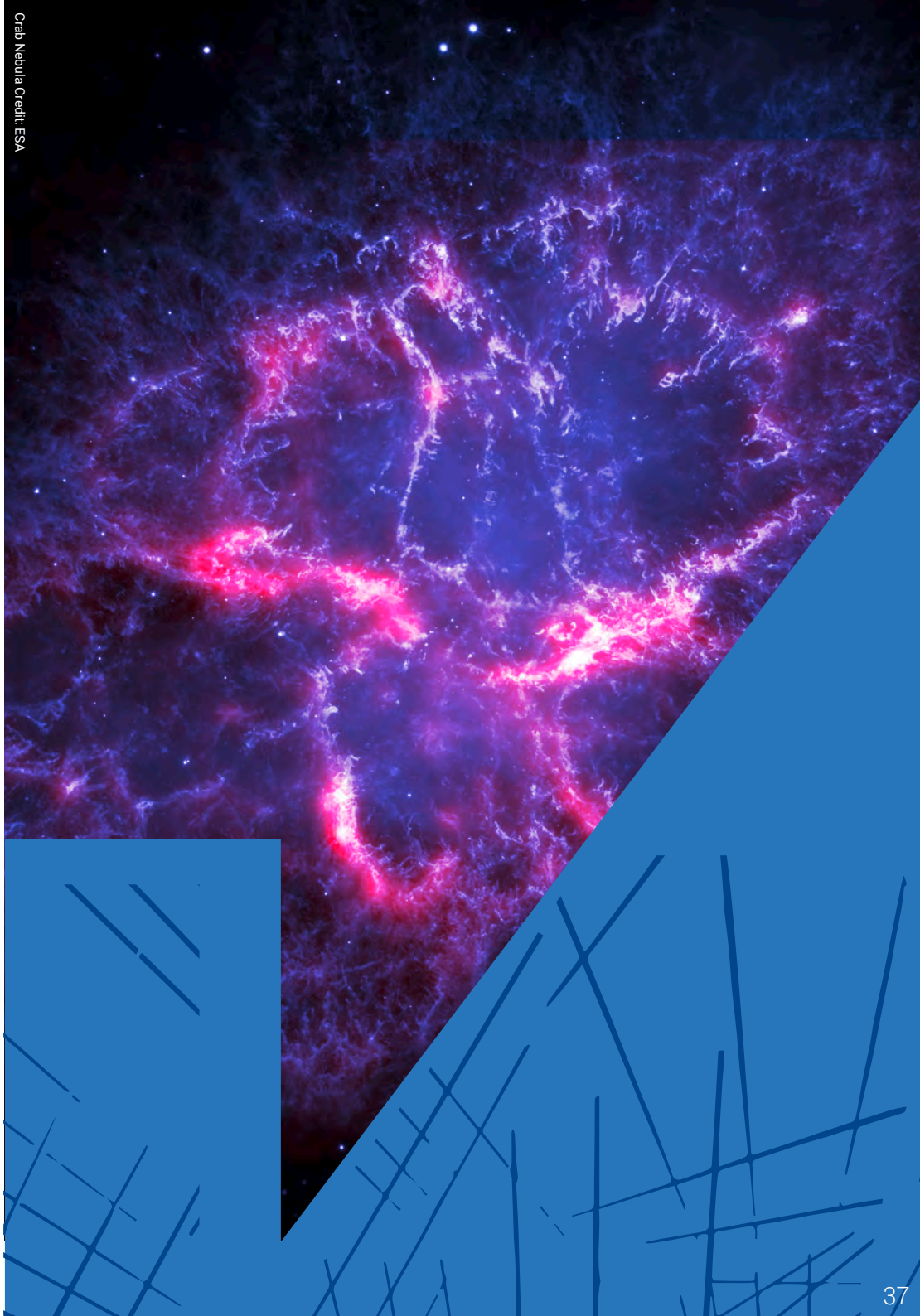
Investigators: Mathew Smith and Peter Boorman (University of Southampton); Rubeta Matin (Oxford University Hospitals NHS Foundation Trust)

Astronomical sky surveys routinely observe the sky every night, comparing each new image with a historical baseline to detect new cosmic explosions.

Images are taken over a period of time and compared to detect supernovae. In order to do this, Artificial Intelligence algorithms were developed to track changes in images. Tens of thousands of these images are taken and the supernova signature is very subtle – so it is impossible for humans to analyse them all.

Coincidentally, as part of routine care in the NHS, images covering the entire body (TBP) are regularly obtained for all patients with a high risk of developing melanoma. These are used to provide a baseline for clinicians who then visually inspect moles to determine if they have evolved into melanoma.

With similar challenges facing both astronomers and dermatologists, STFC funded researchers used IAA funding to set up the project 'MoleGazer'.

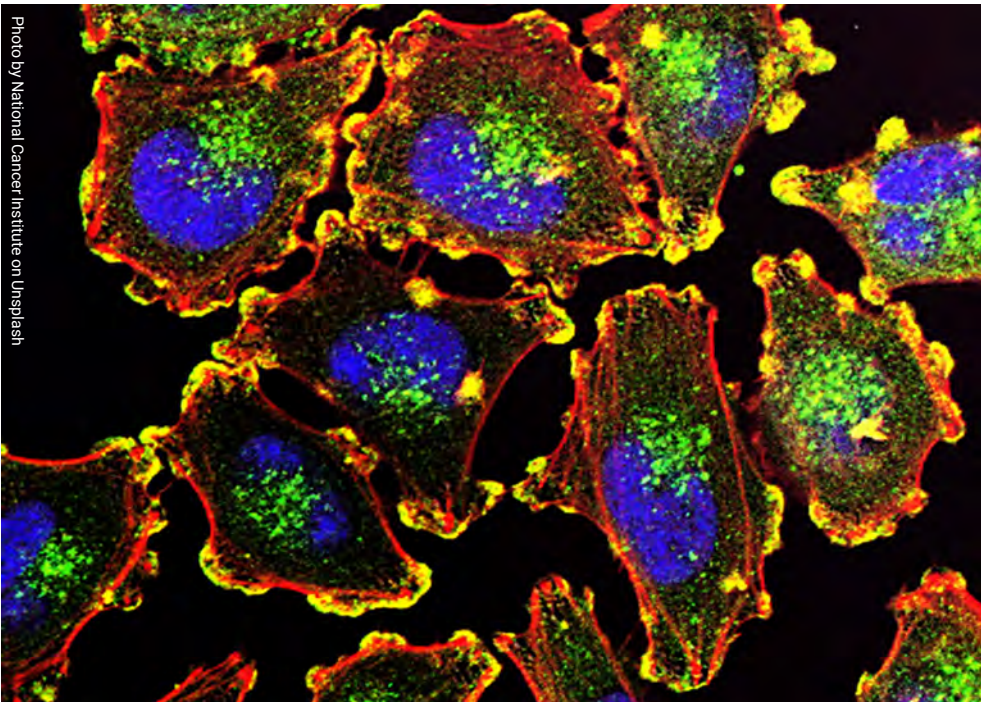
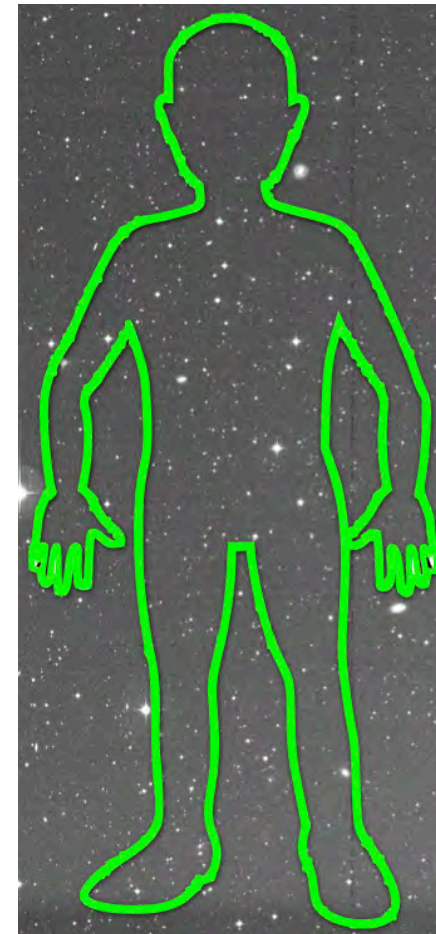


Crab Nebula Credit: ESA

Partnering with the Oxford University NHS trust, the team tested whether these algorithms could be transposed from studying the night's sky to routinely detecting skin cancer.

This successful project showed that astronomical techniques can be used to detect, classify and track the evolution moles from routine NHS imaging. With the development of an end-to-end automated pipeline, MoleGazer has laid the foundations for AI techniques, developed in astronomy, to be used as a clinical aid in the real-time detection of skin cancer.

Using the results from this study, the project was awarded an ERC Proof-of-Concept grant of €150,000 to extend this study towards a clinical setting. Over the next 24 months, the project will routinely image 50 patients, each with a high risk of developing melanoma, every three months, to characterise and predict how moles and skin lesions evolve into melanoma.



Metastatic Melanoma Cells

"We have developed a truly interdisciplinary approach with IAA funds at Southampton. This is a great example of where an astrophysicist and medical staff have worked together, taking non-medical related research, developing this for the greater good and contributing to better health outcomes." Ruth Saw, Impact Funding Manager

University of St Andrews

Software solutions to understanding our Sun

Investigators: Ineke De Moortel and Paolo Pagano

Researchers at the University of St Andrews have been using IAA funds to create a software tool to compare artificial observations and satellite observations to improve the observational data from the Sun.

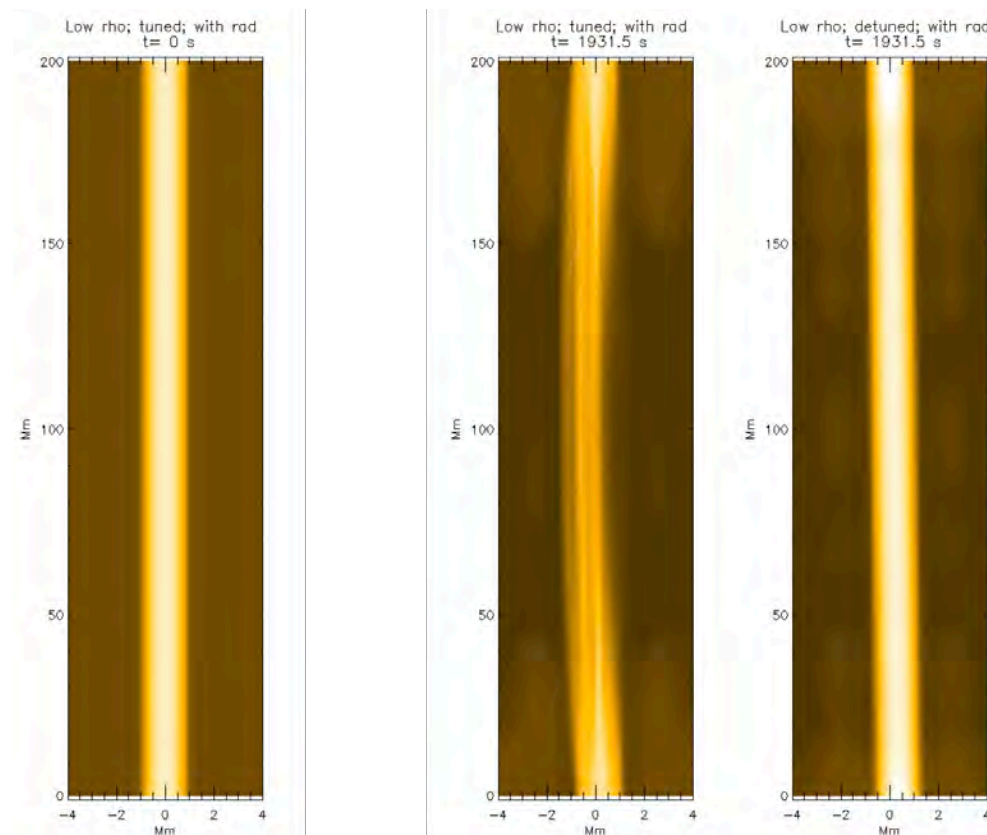
The team at the University of St Andrews recognised the difficulty with comparing computational models and actual observations of the Sun. Whereas the models calculate variables such as velocity, density and temperature of the plasma, these parameters cannot be measured directly by remote sensing observations. Instead, observations mostly show intensities and Doppler velocities, which result from non-trivial combinations of the basic plasma (model) parameters.

With this information, the team, received IAA funding to create a software tool as an intermediate step to enable them to compare models and observations in a detailed way, whereby the model parameters are converted into artificial observations.

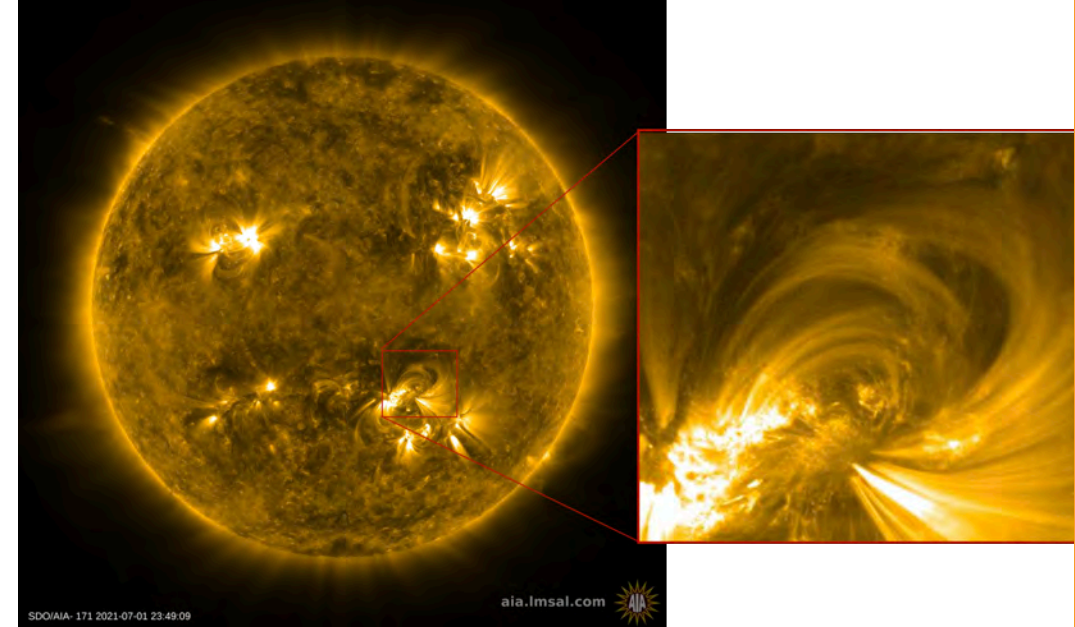


The artificial observations created with this project (e.g. observables such as intensity) can be used to test specific theoretical models with optimised observational campaigns and in collaboration with existing observational facilities.

The software can also be used to customise instrument design for future satellites: it allows the modelling of the expected observations for certain spatial, temporal and/or spectral resolution and hence, can help to make decisions about the most effective trade-off between these aspects in the design phase of the detectors and instrumentation. The aspiration is to use this system to increase engagement between the St Andrews Solar Group and instrumental groups such as the Lockheed Martin Solar and Astrophysics Lab.



Synthetic intensity of a model of a coronal loop. The initial, stationary state of the loop (left-hand side image) is the same. The footpoint of the loop is then moved with different frequencies. The two images on the right clearly show that the loop evolves differently depending on the period of the oscillation. These synthetic observations allow the team to decide what should be the temporal, spatial and spectral resolution of a new instrument to be able to distinguish between these two models.



An example of an intensity observation of coronal loops (SDO/AIA 171 A- corresponding to plasma at about 1 MK). Credit: NASA/LMSAL/SDO.

The work has contributed to the design of a proposal for a new satellite mission to observe the Sun. If the mission is selected, it will help to improve our understanding of the Sun and its effects on Earth. The effects of the solar wind and solar storms ('Space Weather') is increasingly important as we rely ever more on space-based assets such as satellites. A severe solar storm can corrupt communications or even destroy a satellite. Improving our understanding of the solar atmosphere will help us to build more accurate predictions of severe, potentially disrupting, Space Weather events.

“Creating synthetic observations of theoretical models is allowing us to help optimise instrument design and improve space-based satellite observations of the Sun”

Professor Ineke De Moortel, Principal Investigator

University of Sussex

Data science for mitigation of drought in Lower-middle income Countries

Investigators: Seb Oliver, Peter Hurley, Steven Duivenvoorden, Edward Salakpi, Pedram Rowhani and Adam Barrett

Research at the University of Sussex has improved the reliability of drought forecast information is produced and used in Africa by creating a new forecasting tool that is now included in early warning systems (EWS).

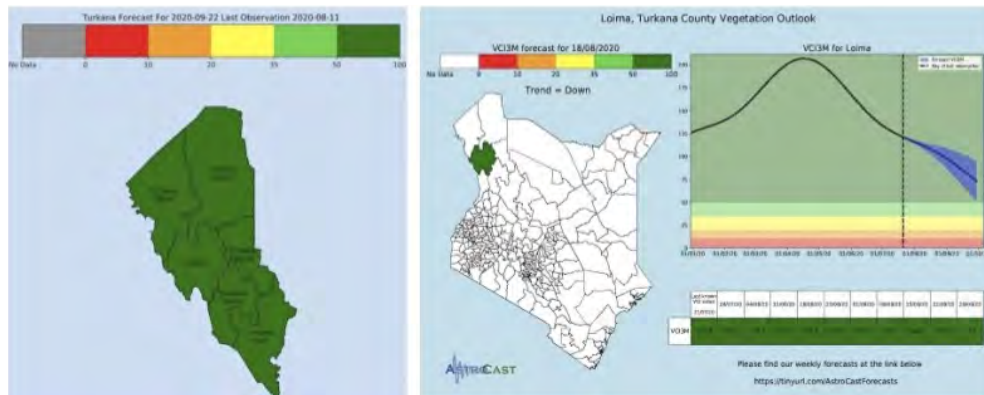
Droughts are a recurring hazard in sub-Saharan Africa that can wreak huge socioeconomic costs. Acting promptly through an EWS can provide substantial mitigation. However, often the salience, credibility, and legitimacy of climate and weather information are insufficiently reliable to signal the right actions needed.

AstroCast, an STFC-GCRF project directly linked to ForPAC (funded by SHEAR), developed and implemented a novel satellite earth observation data analysis that originated in investigations of galaxies. Coproduced with Kenya's NDMA, a team of astronomers and geographers from the University of Sussex developed a new, highly accurate, short-term forecast of vegetation condition which is now produced by the RCMRD. Once implement in the country's EWS, this information will allow disaster risk managers trigger anticipatory action to mitigate the impacts of droughts.



Image by Julian Hacker from Pixabay

This research, produced by a collaboration of astrophysicists, geographers with Kenya's National Drought Management Authority, has produced new, highly accurate, short-term forecasts which are now included in EWS. This information will be used by government agencies, national and international NGOs and populations at risk, to trigger earlier and more appropriate action.



An example report produced by AstroCast and included in Kenya's National Drought Management Authority's Turkana County Drought Early Warning Bulletin for August 2020.



African children carrying water from the well, Kenya, East Africa



Row of young cattle, Isiolo, Kenya

"It was really great to see this project grow. It started with a conversation between excellent data scientists in my astronomy team with geographers, facilitated through the Data Intensive Science Centre at University of Sussex (DISCUS) who then funded a hack-day to generate a proof-of-concept. This provided the justification that STFC needed to support the underlying forecasting research with GCRF funding. We then obtained STFC IAA funds to support the development and training in Kenya to help the implementation into their Early Warning Systems. It is really fantastic to see that the skills and techniques we developed for understanding star formation in distant galaxies with ESA's Herschel Space Observatory allowed us to help enhance the vital systems that can mitigate the devastating impacts of drought."

Seb Oliver Professor of Astrophysics, University of Sussex

University of Warwick

Modelling the impact of space weather events on the National Grid network

Investigators: Sandra Chapman, Lauren Orr, and Nick Watkins (University of Warwick); Ciarán Beggan (British Geological Survey); and Jesper Gjerloev (Johns Hopkins University, USA)

Space weather is driven by solar flares and coronal mass ejections that propagate to Earth in the solar wind. Such events can cause a variety of problems, from damaging satellites that we use for communication and navigation to disruption of flights and railway networks.

One key impact of space weather is that it can cause the magnetic field at ground level to change rapidly, inducing a surface electric field. This rapidly changing electric field causes Geomagnetically-Induced Currents (GICs) to flow through the ground through the soil, water and rocks of the Earth. These currents find their way into earthed metal networks such as power grids, pipelines, railways and undersea cables, essentially short-circuiting through the path of least resistance. GICs pose a risk to the continuous, safe and efficient operation of high voltage power transformers, which may suffer permanent or cumulative damage. UK power grid companies typically only monitor at a few fixed sites in the grid, yet there are many hundreds of expensive transformers grounded to the earth.

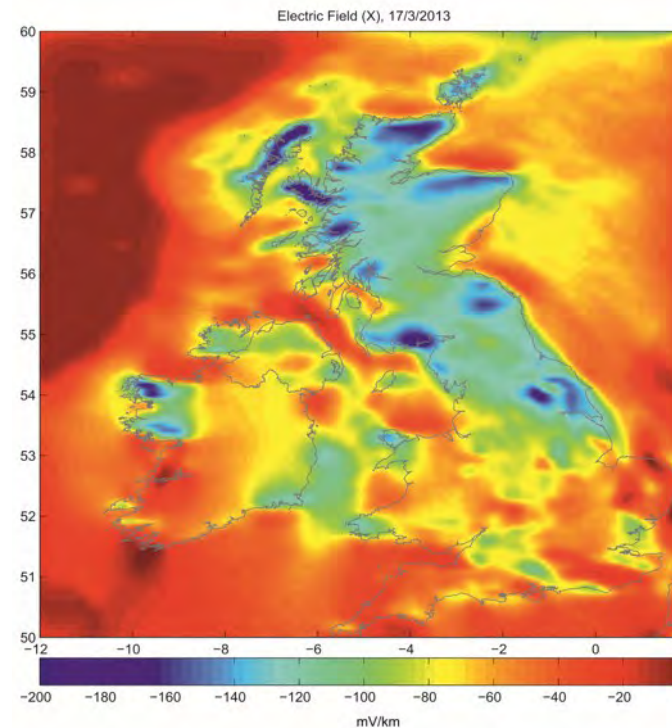


Researchers at Warwick, in collaboration with Johns Hopkins University, USA have recently developed a novel methodology based on directed networks which takes data from a multi-station magnetometer system and characterizes its response to space weather events. This work has come to the attention of the British Geological Survey (BGS), which provides space weather monitoring services, including forecasts of geomagnetic activity and near-real-time GIC simulations of its effects.

Working with the British Geological Survey (BGS), and with support from STFC (IAA fund) the team have applied this new methodology to perform a network analysis of the UK High Voltage grid. This could offer a tool where monitoring one section of the network could reliably predict the impact of space weather in other sections. These advances could help the UK Space Weather-proof existing infrastructure and potentially save billions in lost economic activity.

“This research will be useful as an operational aid and for understanding which substations are at risk.”

Dr Ciarán Beggan (Geophysicist, British Geological Survey)



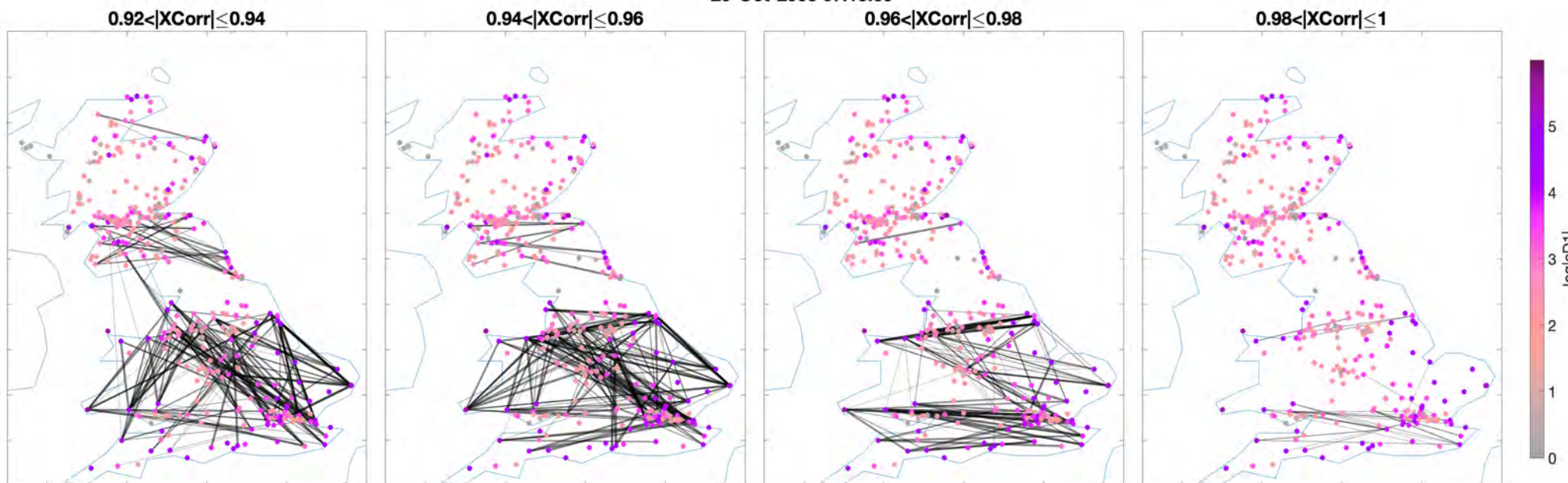
Estimated surface electric field that drove GIC through the power grid during the peak of the geomagnetic storm of March 2013 [BGS]. Network response to substorm onset. We can extract basic parameters to quantify ground-based response to geomagnetic activity.

Publications

L. Orr, S. C. Chapman, C. Beggan, Wavelet and network analysis of magnetic field variation and geomagnetically induced currents during large storms, Space Weather (2021) see [here](#)

R. Calel, S. C. Chapman, D. A. Stainforth, N. W. Watkins, Temperature variability implies greater economic damages from climate change, Nature Communications, 11, 5028 (2020). see [here](#)

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Network of GIC model output of the UK High Voltage grid during the Halloween storms 2003.

University of York

Gamma-ray imaging detectors for medical applications

Investigator: Stefanos Paschalis and Dan Watts (University of York)

Using state-of-the-art Gamma-ray detector technology, researchers at the University of York are working on new medical imaging equipment.

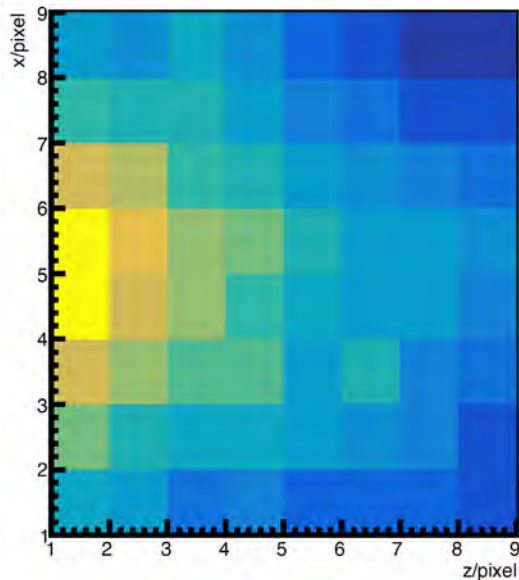
York receives funding to understand exotic nuclei and how they can be used to study the strong nuclear force predicted by the standard model. Using this same technology, the team have developed position sensitive scintillator detectors for medical imaging applications. The team's new detectors for positron emission tomography (PET) scanning and for imaging during proton radiotherapy, will address a number of challenges currently facing the medical imaging community.

PET scans are a type of test that create 3 dimensional (3D) pictures of the inside of your body. The PET scan uses a mildly radioactive drug to show up areas of your body where cells are more active than normal. It's used to help diagnose some conditions including cancer.



On the other hand, proton radiotherapy is one of the faster-growing cancer treatment modalities in which fast moving proton beams are used to kill cancer cells located deep inside human tissues. Advancing gamma-ray imaging technology increases the sensitivity and effectiveness of diagnostic tools and cancer treatment methods.

Using IAA funding, the group at York demonstrated that the technology could be adapted to the medical imaging sector and have subsequently been awarded £88k from STFC's Follow on fund, developed novel publications, and are working alongside the University of Manchester and Christie's hospital to further develop the technique.



A reconstructed gamma-ray beam that is entering the detector volume from the left.



Patient receiving radiotherapy treatment

“The IAA has helped us transform our technology for fundamental research into solutions for societal applications, and transition from pump-priming ideas to functional demonstrators.”

Stefanos Paschalis, Principle Investigator and Lecturer in Nuclear Technology



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Image by BarbaraAlane from Pixabay

