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Networks Case Studies

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Introduction

21st Century Challenges are defined as the big and often complex social, environmental and economic challenges facing the UK and other countries. Examples of challenge areas include: energy, infrastructure, resources, health, development, defence, security and resilience. The 21st Century Challenges Networks were funded to support the creation of multidisciplinary research communities to bring together STFC researchers with challenge owners and provide solutions to these complex, multidisciplinary challenges.

The STFC 21st Century Challenge Programme has now been closed but a similar, refreshed programme was established in 2020. The STFC Horizons Programme aims to proactively build and support collaborations between STFC, UKRI, and external partners to enable our community to be an active partner in strategically selected, multi-disciplinary programmes. The programme addresses targeted priority areas, around which STFC's capabilities can be strategically applied, in partnership with UKRI and external partners. These priority areas are:

• Emerging/Transformative Technologies – underpinning technologies of the future

• Healthcare – technology and data for a healthy population

• Net Zero – future energy sources and supply and addressing the climate emergency

• Security – UK defence, security and resilience

STFC Horizons Programme funding is intended to provide pump-priming opportunities that support the STFC community's capacity to contribute in targeted priority areas, or proof-of-concept funds that allow focused development of promising concepts in these targeted priority areas.

STFC Air Quality Network (SAQN)

Air pollution is a major, global issue classified in 2014 by the United Nations Environment Programme as the 'world's worst environmental health risk'. Costs to the UK from deaths attributable to air pollution are estimated at £20 billion per year but this is only part of the overall impact.

The aim of the STFC Air Quality Network (SAQN) is to create a multidisciplinary community of experts, researchers, policy makers and businesses that can leverage Science and Technology Facilities Council (STFC) research, capabilities and facilities to address air quality challenges. The SAQN will facilitate the exploitation of the currently untapped potential of STFC capabilities to enhance and progress research into air pollution, particularly with relevance to impacts on human health and the environment.

The work of the SAQN cuts across all parts of the air quality system, including indoor and outdoor air pollution; activities that contribute to improving any aspect of that complex landscape with the involvement of STFC science, facilities or expertise can be supported.

The SAQN and the associated opportunities will enable its members to build the multidisciplinary collaborations necessary to propose genuinely integrated, challenge led research with pathways for real impact on industry, policy, society and the economy.

Case Study #1

In November 2020 SAQN ran an online Collaboration Building Workshop, facilitating over 25 researchers to develop innovative new research ideas, working collaboratively to apply STFC capabilities in societal air quality challenges.

During the workshop, project ideas were pitched to a funding panel and six new Scoping Studies worth up to £8,000 each were funded. The workshop fostered new interdisciplinary partnerships and supported Early Career Researchers to develop their own research ideas and to navigate funding processes.

The projects funded during the workshop made use of a wide range of STFC capabilities in the data and computing areas, including machine learning expertise and data and analysis platforms in STFC's Rutherford Appleton Laboratory (RAL) Centre for Environmental Data Analysis, RAL JASMIN and the Hartree Centre's High Performance Computing facilities. Applying unique STFC capabilities to air quality science has allowed researchers to generate models of indoor air quality using computational fluid dynamics (CFD) and to monitor volcanic plumes using unmanned aerial vehicles (UAVs).

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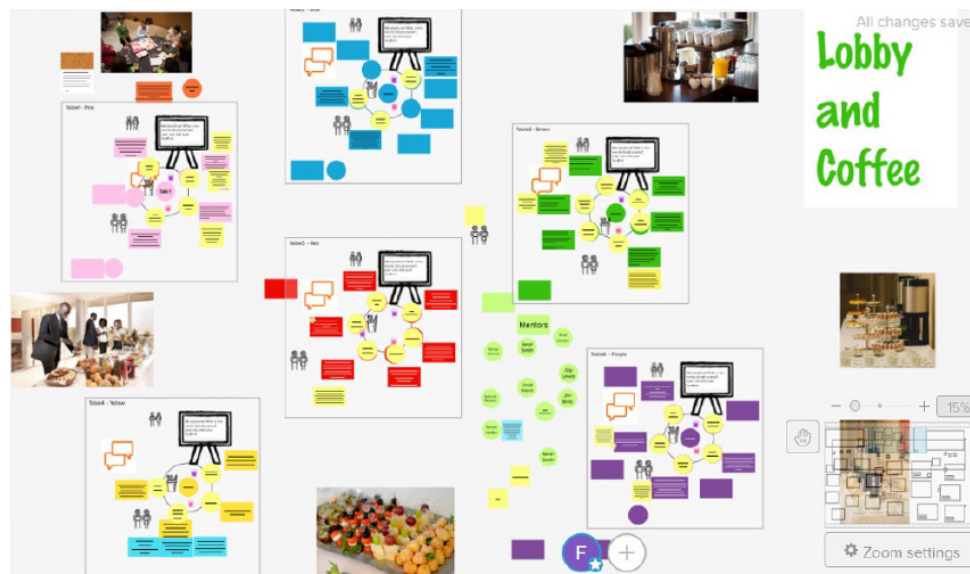
In June 2021, a second SAQN workshop was held, building on the success of the first. Four new scoping studies were funded in this round, one of which was built on successful outputs from a scoping study funded at the first workshop. This new research involves sensor technology designed by RAL Space Spectroscopy group, developing a new sensor product could ultimately have significant commercialisation potential.

> *"The format was brilliant, and in many ways actually better than an in-person workshop as it gave time for us to step away from the ideas and let them slowly develop."*

STFC Food Network (SFN)

The STFC Food Network+ (SFN) brings together STFC researchers and facilities with research and industry in the agri-food sector. SFN are focussed on highlighting and developing opportunities for the STFC community to make a meaningful contribution to the global food system – from sustainable intensification, through building resilience in supply chains to novel technologies to engage consumers and help change behaviour and improve nutrition.

Key features of the network are the strong links to policymakers and industry; the track record of large, collaborative follow-on projects that go on to achieve significant impact; and SFN's diverse use of STFC capabilities, covering robotics, AI, precision sensors, space science and astronomy, particle/nuclear physics, and data science.

The second phase of the SFN (2020-2024) aims to further grow the SFN community whilst establishing an international multidisciplinary network of researchers focused on innovative ways to use the skills and facilities funded by the STFC. SFN have already funded projects that aim to tackle food sustainability challenges in 18 countries, such as India, Thailand, Indonesia, Nigeria, Malawi and Kenya, among others.

Case Study #1

In developing nations lacking such infrastructure, huge quantities of perishable food are lost between farmers and consumers. For these regions, simply producing more food won't help solve food insecurity unless these supply chain issues are fixed. Food loss occurs for many reasons, including lack of cold storage, poor road networks and challenging climates. Developing communities are also typically made up of isolated pockets of farmers that are poorly connected to the rest of the supply chain, making it difficult to match supply with demand.

TRAnsforming Cold Food Chains in INdia through Space ScIence and TechNologies (TRANSSITioN) uses a systems-wide approach and STFC advanced capabilities and facilities including space thermal engineering, cryogenics, infrared thermography, data science to provide solutions for digitising agriculture production, connecting farmers to supply chains, reducing food loss, and managing surplus. In addition, the project leverages capabilities and expertise in smart sensor technologies, big data analytics in combination with low-cost indigenous technology knowhow to achieve these objectives.

The SFN played a crucial role in the project's launch by funding the pilot phase through a Scoping Grant, involving a stakeholder workshop in India which brought together farmers, producers, distributors and retailers to discuss their key issues. Based on these discussions, the team successfully secured funding for a full-scale project proposal from the Global Challenge Research Fund.

TRANSSITioN has succeeded in developing a network of multidisciplinary stakeholders with a common vision towards solving food security challenges associated with cold chains in India, including successfully engaging with over 1000 in-country farmers.

Case Study #2

Air pollution has been described as one of the UK's most severe public health challenges. Ammonia is an atmospheric pollutant of international environmental concern, forming smog and particulate matter that can cause cardiovascular and respiratory disease and depositing excess nitrogen in habitats, which reduces biodiversity.

"It is really important that we are able to accurately measure ammonia emissions from agriculture" says Daniel Gerber, of STFC Rutherford Appleton Laboratory. "At the moment, most UK studies use wind tunnels to measure ammonia emissions—Although this does work, it is slow and requires significant person power." Daniel's work usually involves equipping space missions with highly sensitive instruments to detect radiation in outer space, rather than more 'down to earth problems'. Daniel's group leader, Brian Ellison (STFC RAL Space), attended a SFN Sandpit event in March 2018. Here he was introduced to Lizzie Sagoo from ADAS, an agricultural and environmental consultancy, who asked if his methods could be applied to measure ammonia emissions on the ground. Brian and Lizzie submitted a proposal for an SFN Scoping Grant, to fund a project investigate if ground-based remote measuring of ammonia emissions was practically feasible. The successful results from SFN funding enabled them to secure a STFC Proof-of-Concept grant to develop and specify an instrument concept that would meet the scientific requirements. Based on this concept, a significant amount of STFC Challenge Lead Applied Systems Programme (CLASP) funding has been won to build the prototype instrument and to test it out in the laboratory, as well as in a farm. If successful, then future projects – in collaboration with industry partners – will strive to develop a commercially viable, operational implementation of the instrument.

"Without SFN, we would not have realised the value of an instrument to measure ammonia on the ground" Daniel says. He also stresses how important it was to interact with experts in other disciplines to understand what was needed.

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Cancer Diagnosis Network (CDN)

The STFC Cancer Diagnosis Network+ (CDN) has established a multidisciplinary community with academic, clinical and industry stakeholders to address clinical challenges in the diagnosis of cancer. The management and treatment of patients with cancer is one of the most complex and important 21st century challenges. In addition to the devastating impact of this disease on patients and their families, the total annual global economic cost of cancer is estimated to be approximately £1 trillion. Reducing cancer mortality rates could be achieved by earlier diagnosis and more accurate staging of disease. The Network+ is built upon four challenge themes:

1. Early diagnosis

2. Precision and quantitative imaging

3. Multimodal techniques

4. Data science techniques applied to imaging and bioinformatics

The CDN ultimately seeks to enable researchers with expertise and knowledge developed through the STFC core science programmes and at STFC national facilities and laboratories to address these challenges. Relevant STFC expertise includes the development of high resolution and high sensitivity detectors, multispectral detectors, data mining techniques and algorithms for image analysis. The Network+ has hosted multidisciplinary challenge-led workshops to engage key stakeholders and has provided funding for scoping studies and proof of concept projects, which are aiming to translate STFC innovations into clinical impact. The research capacity of early career researchers (ECRs) is being developed through PhD funding, travel awards, placements and training.

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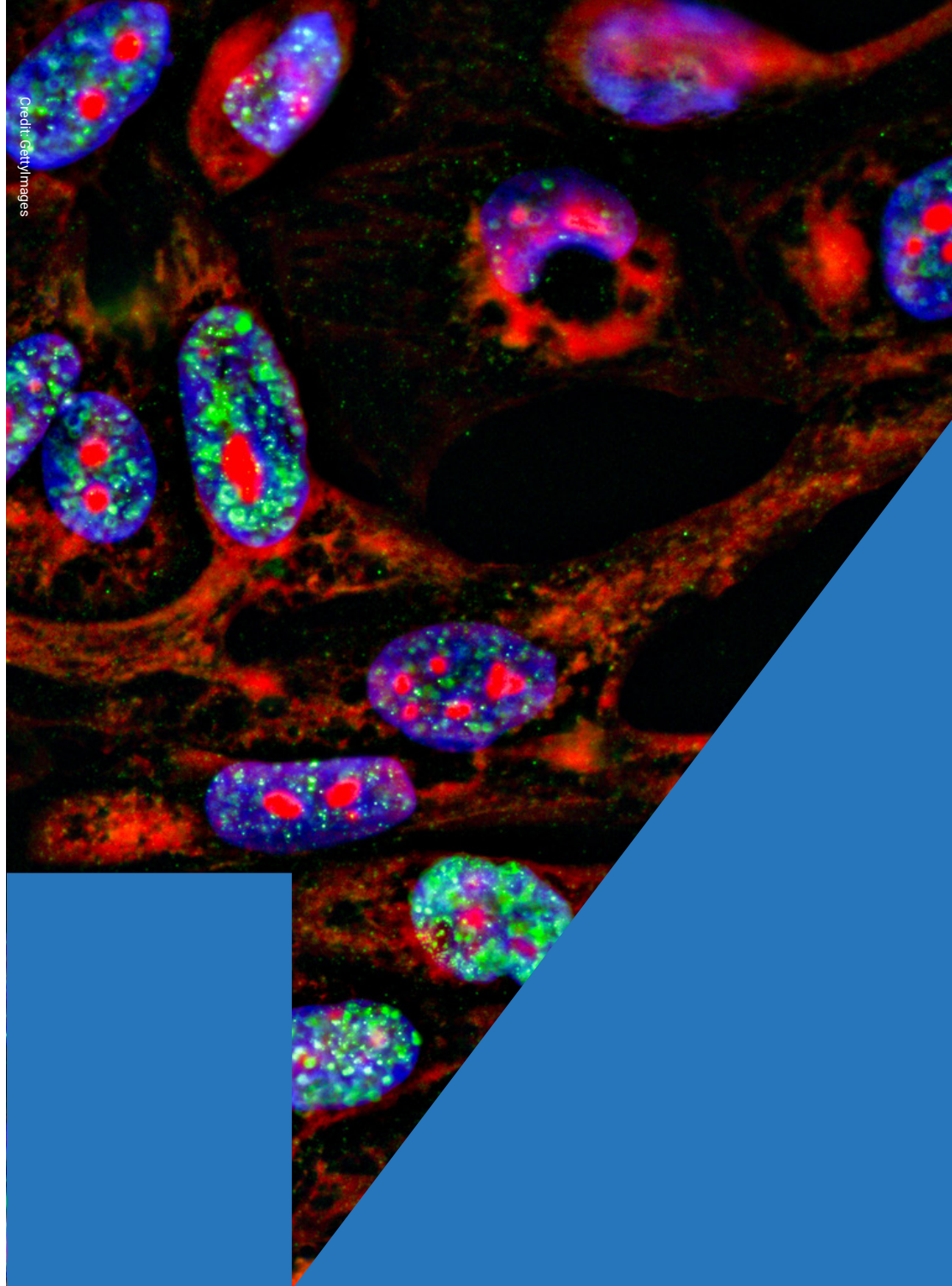
Case Study #1

Oakley Clark is a PhD student supervised by Dr Silvia Pani at the University of Surrey. His research project is partially funded by STFC's Cancer Diagnosis Network, aimed at using the STFC-developed pixellated spectroscopic HEXITEC technology to develop a method for estimating breast density, which is known to be an indicator of breast cancer risk. Women with dense breasts can be up to 6 times more likely to develop breast cancer in their lifetime.

Developing a reliable method to measure breast density would provide the option of a personalised screening schedule, with high-risk women being screened more often than low-risk women. This would optimise breast screening, reducing its associated cost, and ensure that women are not unnecessarily exposed to potentially harmful X-ray doses.

The project has fostered a new collaboration between STFC, the University of Surrey and Institute of Cancer Research (ICR). The collaboration with ICR is going to enable translation of this technology into the clinical environment.
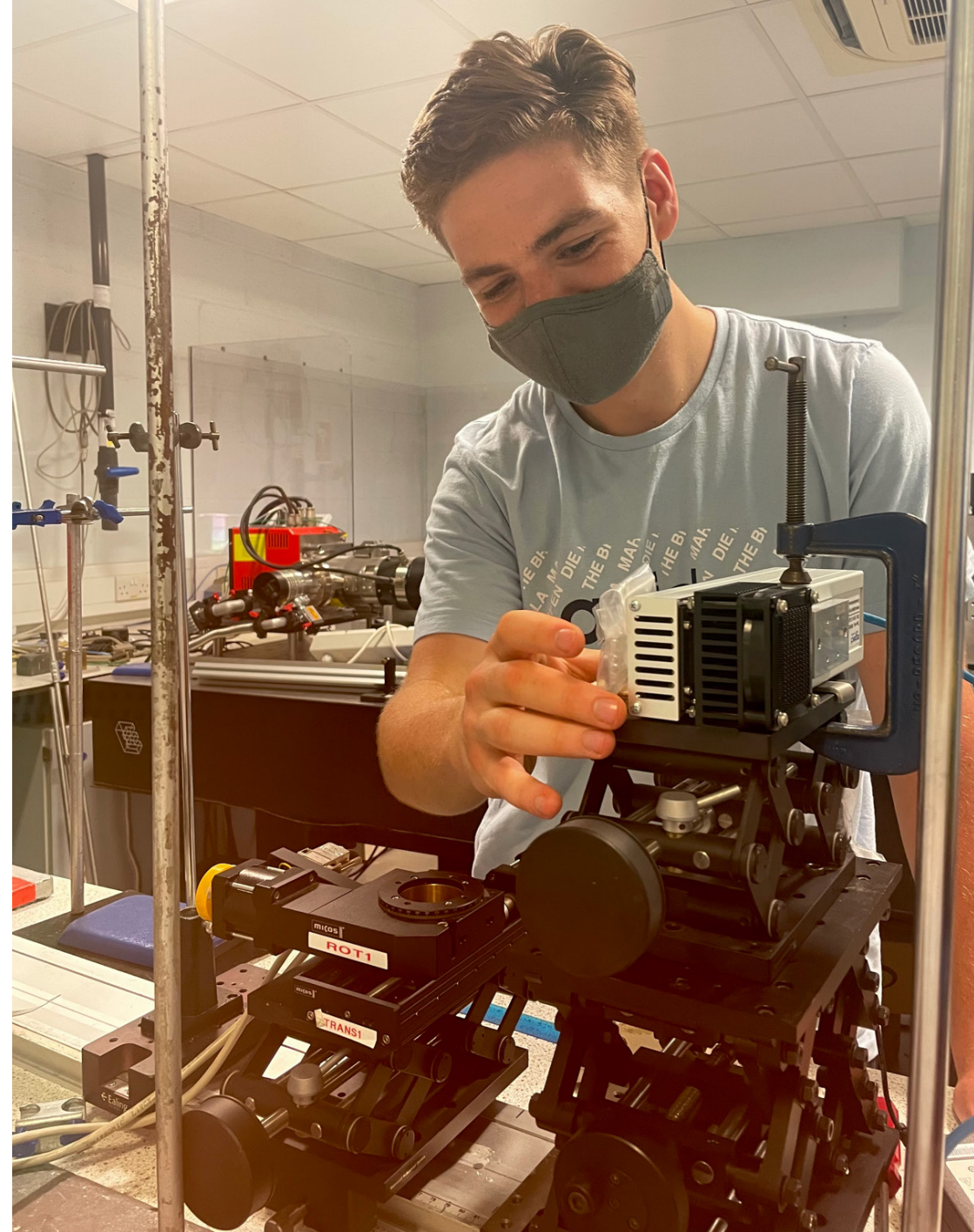
Case Study #2

The STFC Cancer Diagnosis Network provided scoping study funding to Prof Jeff Hartnell, University of Sussex, supporting a project aimed at exploiting novel detector technology to scale-up to total-body PET scanners in a cost-effective manner, thus making higher performance scanners substantially less expensive. This could have potentially huge impacts on cancer diagnosis and staging both in the UK and internationally. The NHS would be a major beneficiary since the cost of PET scans would be reduced, meaning more lives could be saved through better access to imaging.

As a result of Network funding, new software is now available which uses an extensive set of simulations that map out the position and timing resolution of an opaque scintillator. The research team have also received STFC Follow on Fund funding that will pay for the hardware development and allow researchers to actually build the scintillator prototype designed in the Network project.

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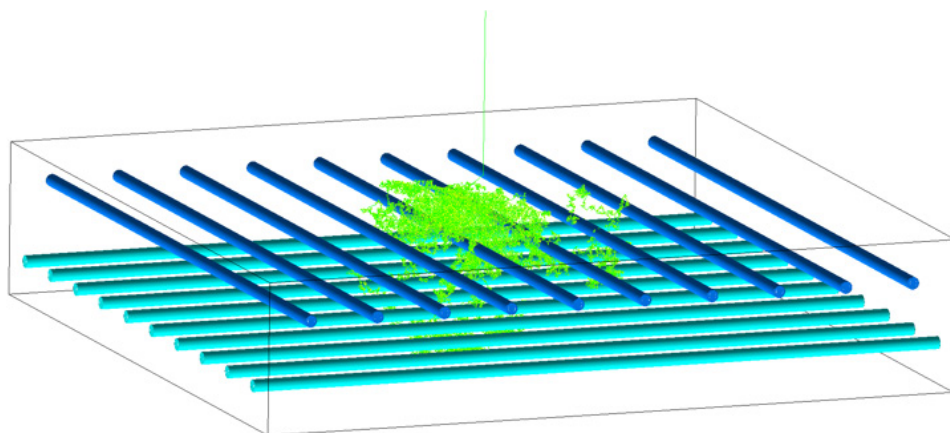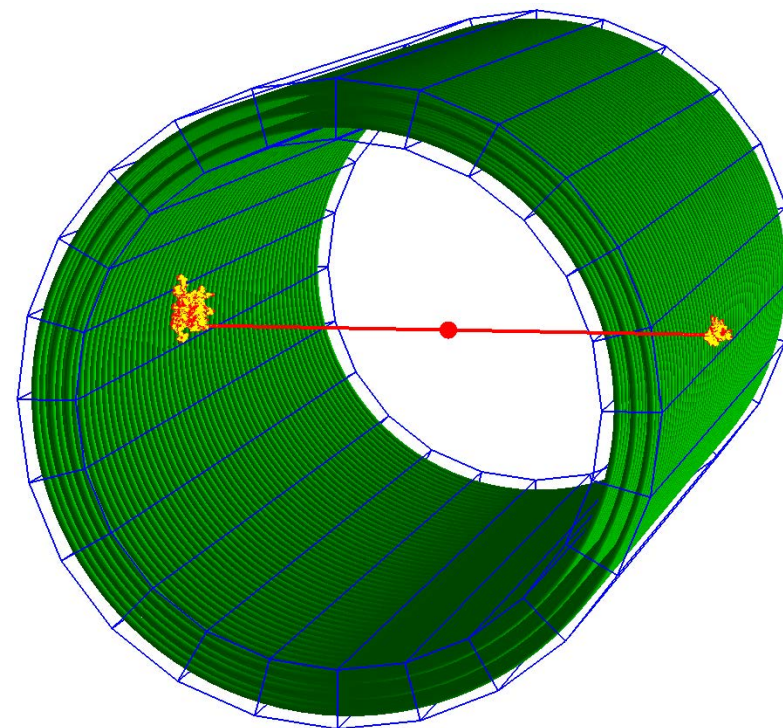
Advanced Radiotherapy Network (ARN)

In recent years radiotherapy (RT) has developed rapidly with the development of new machines and treatment methodologies. These in turn, have resulted in better outcomes for patients as the dose is more accurately delivered and conformed to the tumour and the dose to the surrounding normal tissue reduced, resulting in fewer side effects. If radiotherapy is to continue to advance and deliver a range of new challenges and issues need to be addressed all of which require innovation and solutions.

This is exactly where the STFC community can make an enormous impact, working in partnership with the clinical community, as they together they have exactly the skill set which is needed to effectively tackle these new challenges as they arise. If the UK is to remain competitive and deliver even better treatment for patients and produce income and impact for the UK economy, it can no longer rely on serendipitous partnerships. This is what this Global Challenge Network+ in Advanced Radiotherapy seeks to address.

ARN+ has been able to catalyse new multi-disciplinary partnerships between the clinical and STFC communities and through a series of Sandpit events and PhD projects, and is now providing innovative solutions to some of the most challenging problems in advanced RT.
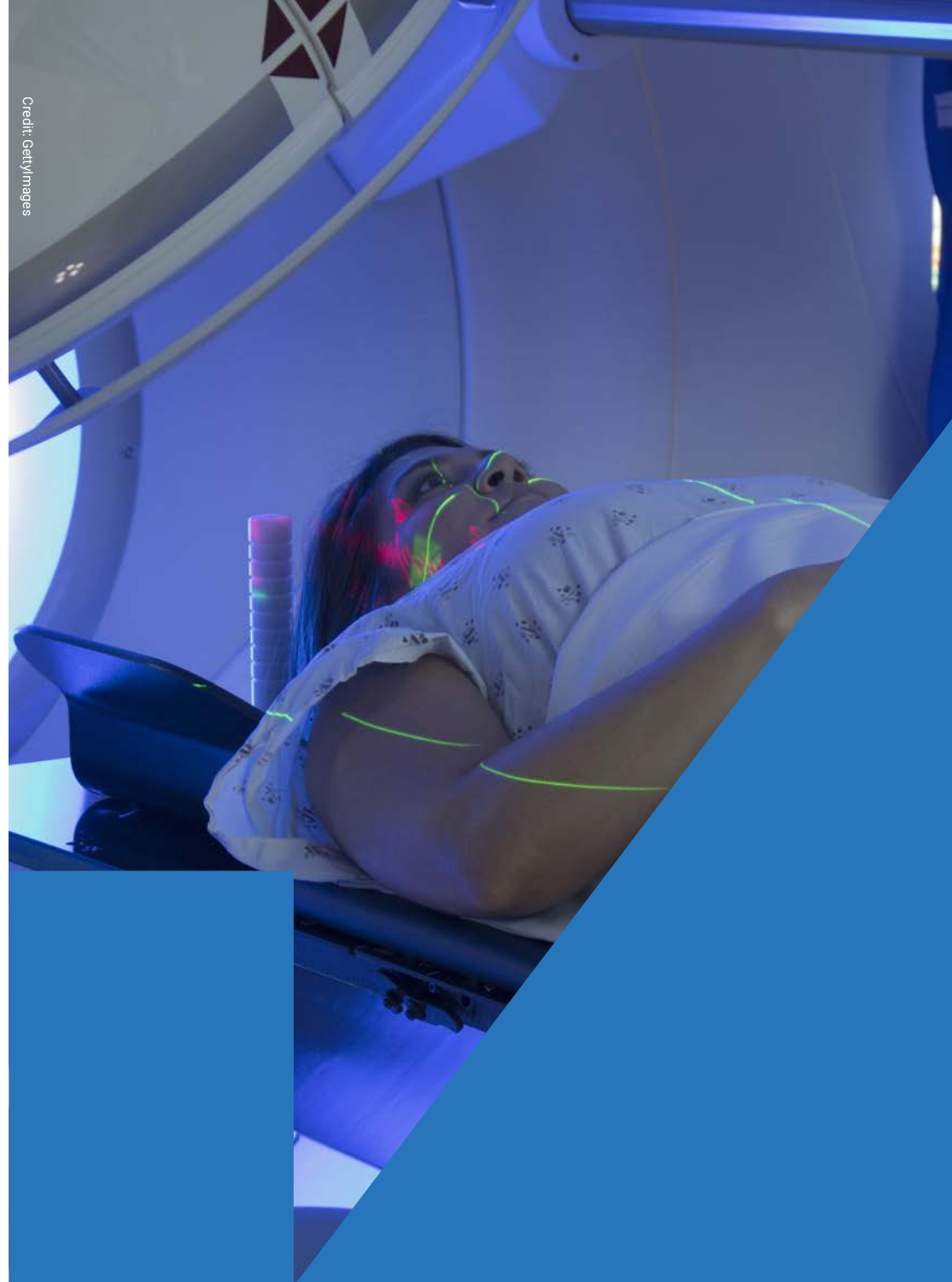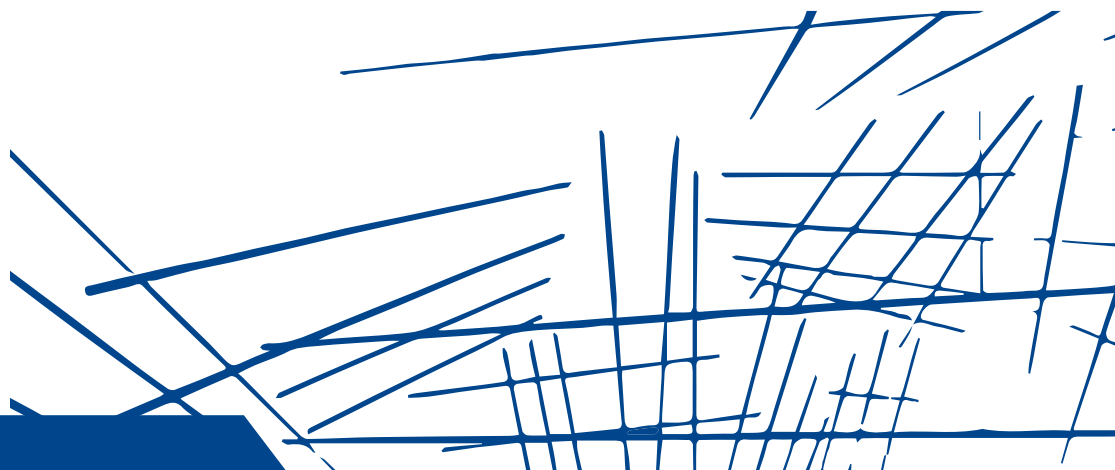
Case Study #1

Everyone is different and so the efficacy of radiotherapy treatment and the side effects experienced differ from patient to patient. If we want to personalise radiotherapy we need to understand not only how DNA is damaged and repaired during radiotherapy but also how these interactions differ between people and then exploit this knowledge to personalise their treatment.

ARN, through their Sandpit funding mechanism, have supported a series of workshops between the Universities of Exeter and Manchester and Queens University Belfast (QUB) with invited speakers from Stanford University and Massachusetts General Hospital/Harvard Medical School (MGH) in Boston, USA. The projects developed in the workshops have grown into a major international partnership with MGH and Stanford, enabling 2 PhD students from Manchester (Drs John-William Warmenhoven and Nick Henthorn) supervised by Dr Michael Merchant to visit MGH to put the research they were doing on DNA damage and repair, using Geant 4 DNA particle simulation software into the US model TOPASn-Bio funded by US NIH. The work done through this project looks at how particles (protons and heavier ions) damage the DNA and how it is subsequently repaired.

Drs Warmenhoven and Henthorn are now postdoctoral research assistants in Manchester and the work they did during their secondment at MGH was built into an EPSRC grant. This work along with the work of another of the STFC ARN+ Network funded PhDs, Dr Samuel Ingram, is also now built into the latest releases of Topas n-Bio, allowing structure modelling to be integrated with genome organisation and providing a link what really happens in the cell dish, tissue and the patient during radiotherapy and also providing a route to personalised radiotherapy.

Furthermore, through a collaboration with Varian and extra funding from STFC via ARN+, a treatment planning test bed has been created using the research version of a commercial treatment planning system (TPS) Eclipse, providing a route to biologically optimising and personalising proton therapy for patients. The application of this work and how it can be applied to patients is incorporated into the Advanced Radiotherapy theme of Manchester's NIHR Biomedical Research Centre.

The collaboration has overall led to 10 publications, with a further 5 in preparation, and has been presented at numerous major international conferences.

Case Study #2

Sharing of radiotherapy imaging and planning data is essential to enable multi-centre studies and advance radiotherapy research, but it is paramount that the data is shared in a safe and secure manner to protect patient privacy. This project developed a prototype system for sharing radiotherapy data for both clinical and academic research.

ARN supported a successful sandpit project on data sharing, awarded to Prof Jamie McClelland at UCL, looking at the need to easily share data between different clinical and academic centres in a safe way that ensured patient confidentiality. A prototype system was developed with funding from ARN+ to pseudonymise clinical data locally at the clinical site and then securely share the deidentified data with a central server, and was demonstrated by sharing test data between UCL and KCL. The prototype system developed with the ARN funding was sufficiently promising to help secure additional funding to develop the system for both academic research (as part of the CRUK ART-NET grant, worth a total of £4.5M) and clinical trials (from the UK Radiotherapy Trials Quality Assurance RTTQA group). With these additional funding sources the prototype system was further developed and its functionality expanded, resulting in the Data Anonymisation and Synchronisation in Healthcare Research (DASHER) platform, which has now been opensourced and is available to the wider research community. This platform has now been used to share data between clinical and academic centres extensively as part of ART-NET and will also soon be used for a number of projects funded by the CRUK RadNet research hub. RTTQA are intending to deploy DASHER into clinical sites over the coming year and will start to use it to facilitate the sharing of radiotherapy imaging and planning data for several upcoming clinical trials.

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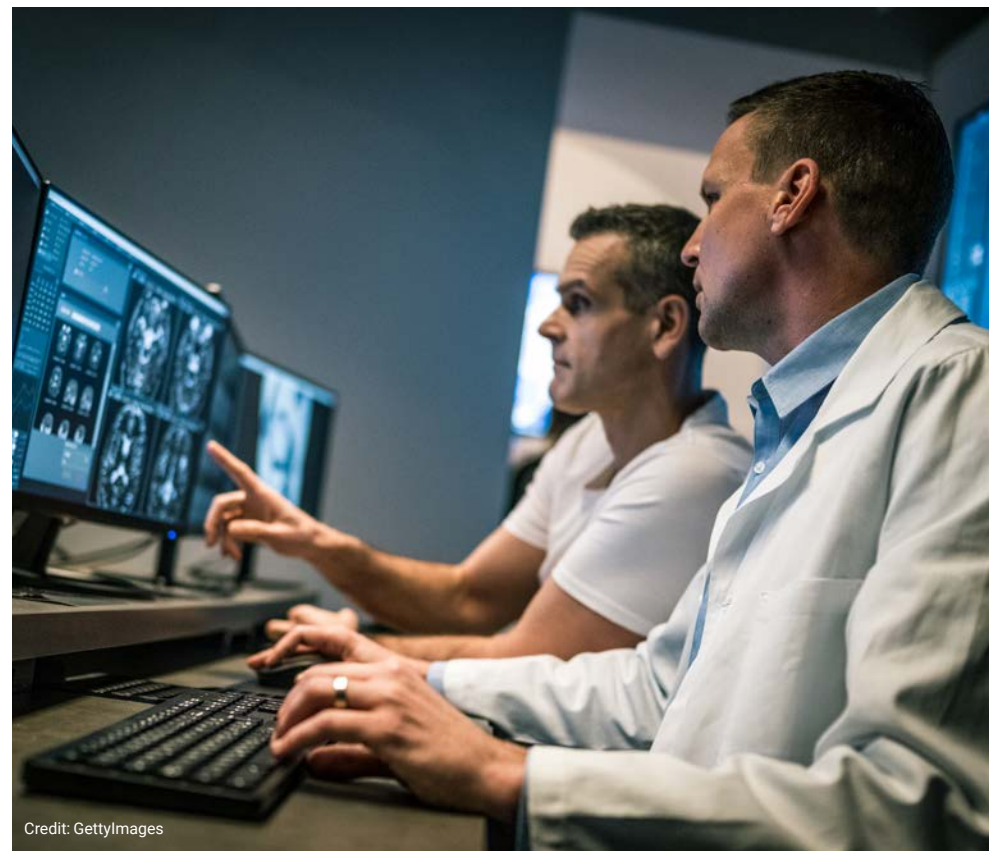
Global Network on Sustainability in Space (GNOSIS)

With the onset of the new era in space technology and applications the space environment surrounding Earth is becoming more congested. There is an increasing risk of collisions occurring, either between active space traffic or as a result of the growing population of space debris. At the same time, we are becoming increasingly dependent on satellite-based applications for so many aspects of our lives, including safety-critical systems, so the consequences of any damage to satellite operations can be far-reaching.

GNOSIS supports the STFC scientific community to address some of the fundamental problems associated with the sustainable use of space. Space debris is a problem only because we do not understand the positions and movements of these objects sufficiently well. Improved understanding of the space environment, with better observation, monitoring, tracking and characterisation of objects is needed in order to reduce the threat of collisions. The STFC community has all the skills needed to understand this material and its movement relative to the satellite population.

GNOSIS aims to strengthen and grow the Space Situational Awareness community, forming interactions between scientists and industry and policy makers in order to tackle the debris problem and safeguard spacecraft. Through a multidisciplinary approach, GNOSIS works with teams of scientists, exposing them to the problems faced by the space sector through workshops and sandpit events, and helping them to apply their knowledge to tackle these problems. In this way, GNOSIS is generating societal and economic impact through the application of expertise from the STFC-funded research community to the Space Situational Awareness/Space Traffic Management (SSA/STM) domain.

Case Study #1

Ever since the first human activity in space, in the 1950s, space debris has increased exponentially, especially with fragmentation debris, produced by the ever-increasing number of impacts, and by the natural deterioration of defunct satellites. Even particles as small as 1mm in size can cause fatal damage to spacecraft in an impact, due to the high impact speeds involved ~ 10 km s^{-1}. So much so that millimetre-sized debris pose the largest mission-ending threat to the majority of robotic spacecraft in Low Earth Orbit.

PhD research student Luke Cornwell is working on a project to help improve sensors to detect impacts in space arising from collisions with space debris. Luke's PhD work, co-funded by the STFC GNOSIS Network and the University of Kent, is intended to help tackle the growing problem of space debris in Low Earth Orbit.

Luke says, "It is vital that we improve sustainability in space, not just for the future of the near-Earth environment, but for its applications to the Earth environment as well. The accurate characterisation of the debris environment is an essential first step, hence the need for impact sensors deployed in space."
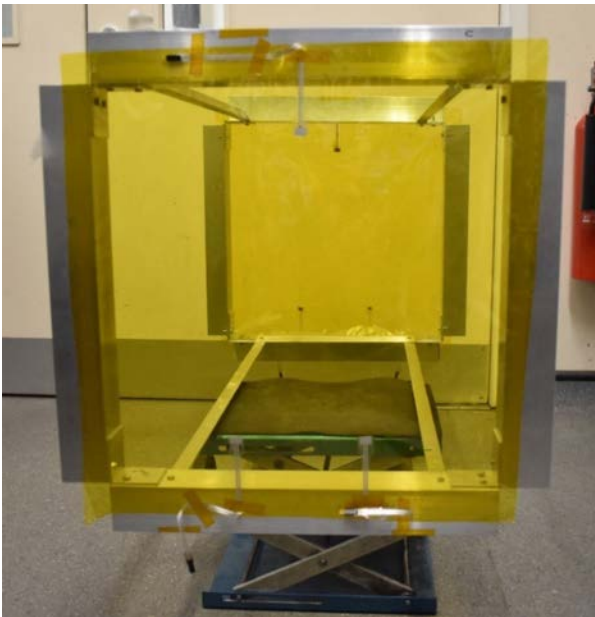
A prototype detector Luke produced to determine particle deceleration through thin films.
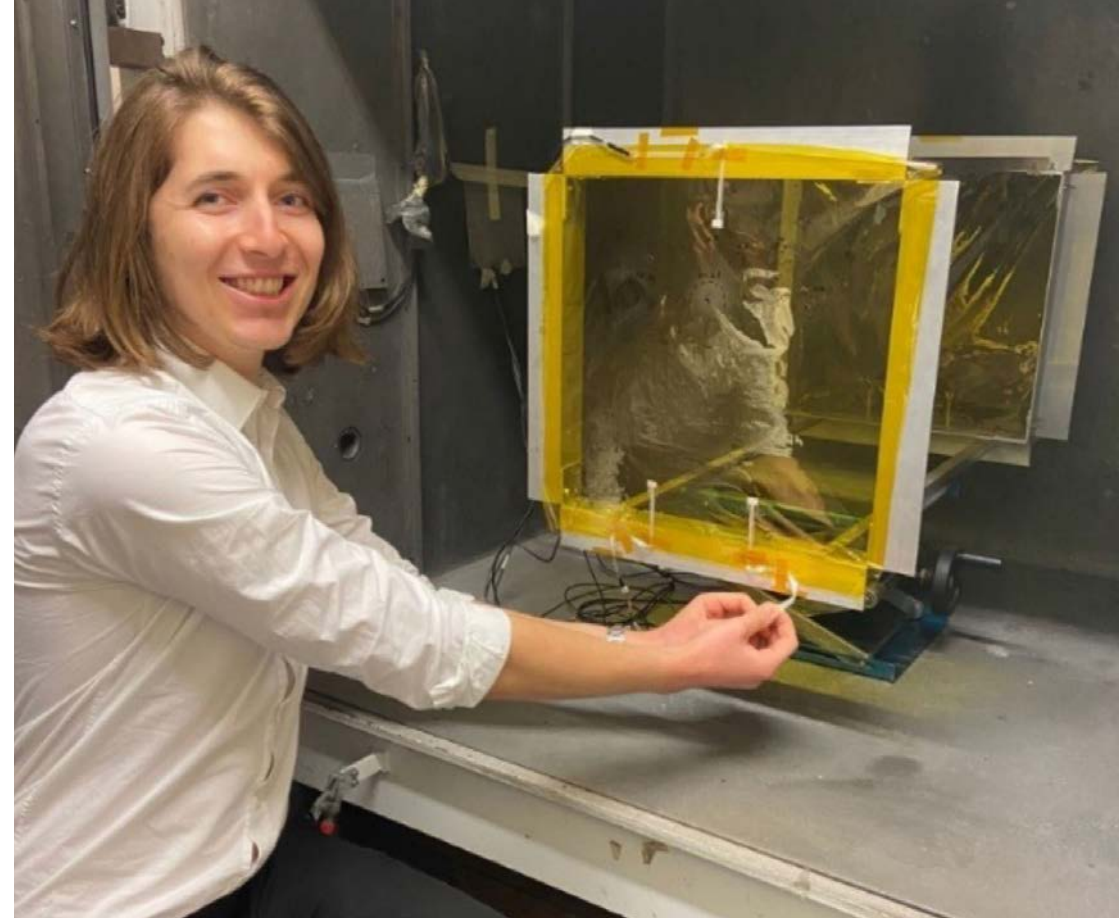
Luke using the prototype detector in the target chamber of the university's Impact Facility.

Luke is working in collaboration with the US based company Astroacoustics, who help NASA design new generation impact sensors. One such design of detector involves measuring the debris speed as it passes through two thin films. But what if it slows down when passing through the first film – will the detector then underestimate the true speed? This has been the focus of Luke's work during his first year at Kent, supervised by Dr. Penny Wozniakiewicz and Prof. Mark Burchell. Luke has constructed a prototype detector to answer this question and is in the process of testing it in the target chamber of the universities Impact Facility. The outputs of Luke's work will inform the development of the final design of the detector to be deployed in space.

Nuclear Security Network (NuSec)

The Nuclear Security Science Network 'NuSec' promotes research and technology in nuclear security, with an emphasis on radiological detection techniques and systems. The network is open to all academic, industrial and government scientists and engineers working in nuclear security, and acts as a forum to encourage collaboration, networking and capability for all stakeholders.

The network, funded by the Science and Technology Funding Council (STFC) and AWE, was established in 2016 initially as a three-year project and has secured extension funding up to 2023. It is led by the University of Surrey, with the operation and activities of the network managed by members of industry, academia and government. The network uses STFC funding to support collaborative research and training in nuclear security topics amongst the STFC community, including pilot research projects, technical meetings, career development grants and publications. The network also actively engages with key industry and government stakeholders.

In collaboration with the US National Nuclear Security Administration (NNSA), NuSec also manages a new UK-US Academic Network in Nuclear Skills that aims to connect UK and US university researchers working in the areas of nuclear security and non-proliferation. Financial support is provided for research, engagement, mobility and skills-based activities that involve both UK and US researchers.

Case Study #1

James Greer is a NuSec-funded PhD student based at the University of Sheffield, supervised by Professor Lee Thompson and working in collaboration with a UK company, LabLogic Systems Ltd. In January 2018 an STFC NuSec/AWE/BP sponsored workshop "ROADMAPPING WORKSHOP FOR IDENTIFYING ALTERNATIVE TECHNOLOGIES FOR RADIATION SOURCES IN THE ENERGY INDUSTRY" was held. The primary aim of the workshop was to identify suitable alternative technologies for well logging to reduce the risk of radionuclide threats through reducing the presence and availability of radionuclide materials. Prompted by the findings of the January 2018 workshop, James' project aims to test the feasibility of implementing low-cost, modular, plastic scintillation detectors for use in the Oil and Gas industry. High temperatures and pressures, along with the extreme vibrations in Logging-While-Drilling operations require highly robust sensitive detector volumes and instrumentation. The project aims to build and deploy a prototype detector for both neutron and gamma measurements. The detectors under development here are likely to have several other applications due to the unique physical properties of the liquid silicone rubber scintillators and the other materials being considering, which would allow for use in highly robust detectors.

Initial work has explored the plausibility of plastic scintillator prisms beyond standard operating temperatures. These materials, in an alternate "tile" format, were originally developed many years ago for an STFC schools outreach project. When thermally cycling these materials to 110 degrees over several cycles, effects including the formation of bubbles from off-gassing as well as warping of the prism shape, were observed. In principle, this would prevent their use in detectors for deeper, hotter oil wells however they are still a candidate detection medium for lower temperature applications. As a consequence of these observations, alternative plastic bases are now under consideration. The team are also currently exploring the use of liquid silicone rubber-based scintillators, which boast impressive physical qualities, including high temperature resistance and flexibility. A particular focus of this work, as educated by the NuSec/AWE/BP 2018 report, is to develop instrumentation that will change organisational culture and practices within the oil and gas industries. The translation of the project outputs into the nuclear security application space is also a possibility.
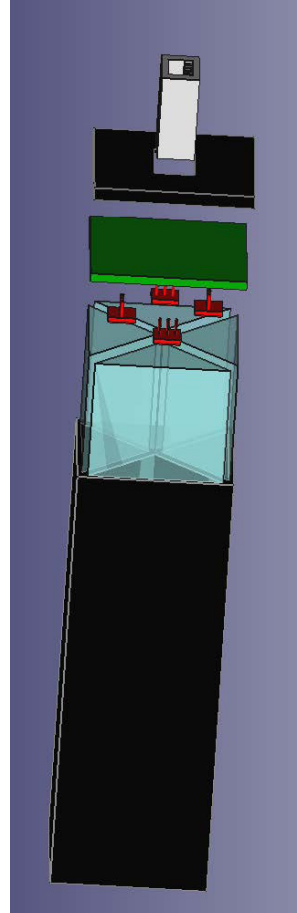
Prototype design for a 4-prism detector module coupled to KETEK SiPMs and transmitted via Ethernet

Room temperature vs 120 degree cycled polystyrene prism

Liquid Silicon Rubber sample doped with PPO/POPOP combination

Nuclear Data Network

The STFC-funded UK Nuclear Data Network (UKNDN) establishes a strong connection between academia, industrial partners, STFC national labs, regulators and UK representatives on international nuclear data committees (IAEA, NEA) in order to facilitate the measurement, analysis and dissemination of industrial nuclear data.

Industrial nuclear data are defined as those data that underpin the safety and economics of industrial nuclear operations and processes. The Network addresses the Energy Global Challenge by responding to the nuclear data needs of industry, particularly as new reactor technologies are developed. In so doing, UKNDN will help to foster links that meet the requirements identified in the Government's "Our Plan for Growth". UKNDN is mentioned as part of a recommendation to Government in the recent NIRAB report.

UKNDN funds applications for small research projects and research-related travel in the area of nuclear data as well as providing educational support through CPD training. Annual workshops are supported through the Network.

STFC Global Challenge Network in Batteries & Electrochemical Energy Devices

Large scale user facilities play a pivotal role in the development of new and improved electrochemical energy devices including batteries and fuel cells. The STFC Global Challenge Network brings together leading researchers in industry and academia with a shared interest in the application of large-scale user facilities to address key challenges in battery science and technology. The Network promotes collaboration between world-class users and developers of large-scale research facilities and provide a forum to draw together researchers from a range of disciplines.

The Network also encourages best-practice research – this is especially important for new techniques where protocols are not clearly established. In bringing together leading practitioners of synchrotron and neutron techniques, we will ensure that effort is not duplicated, thus enabling the most efficient use of beam-time resources.

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