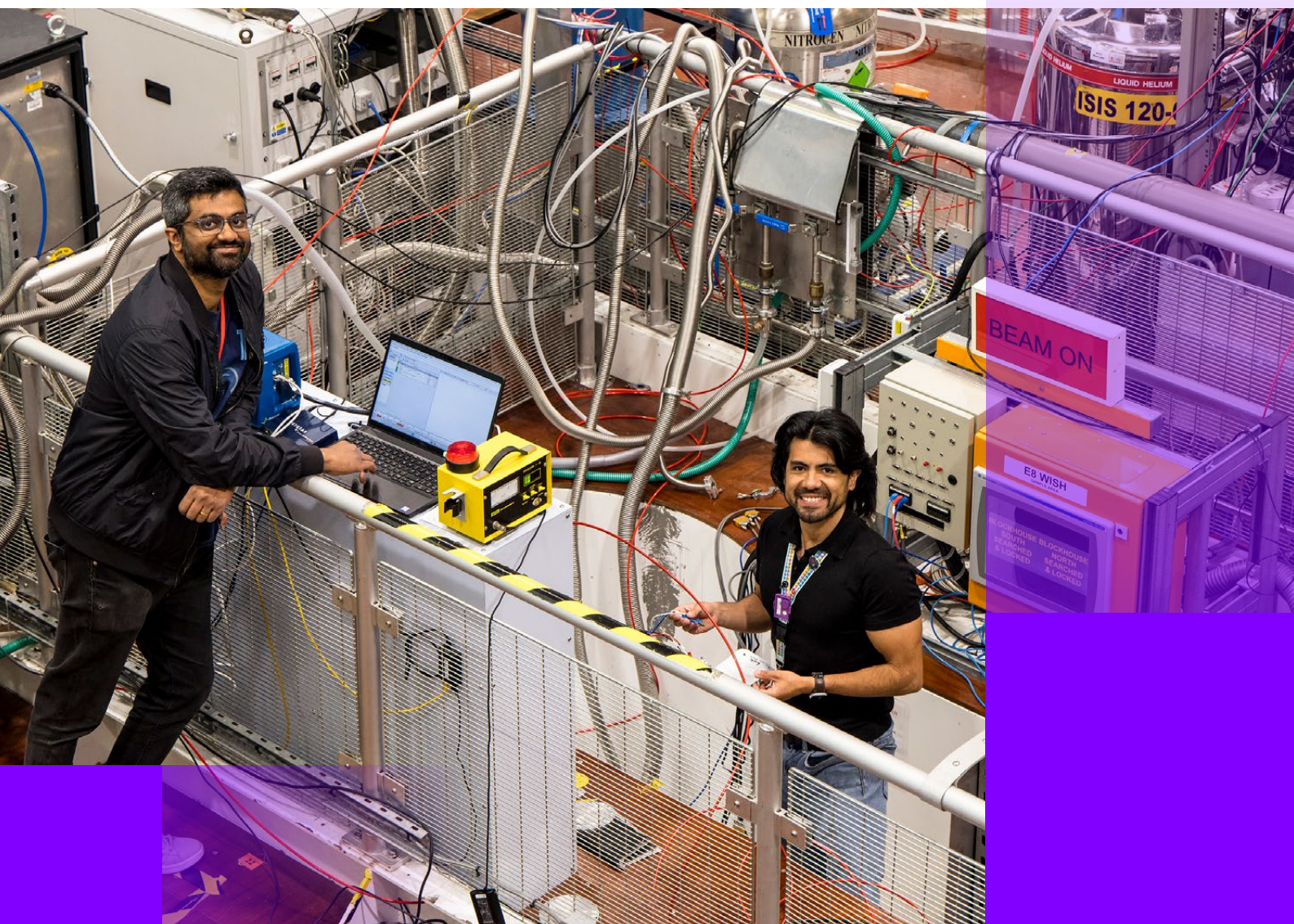




Science and  
Technology  
Facilities Council



# ISIS Neutron and Muon Source

Annual Review 2026

# Our mission

Our aim is to enable research that advances knowledge and improves lives.

We support a large and diverse user community that uses neutrons and muons to address global challenges and answer fundamental questions across a broad range of sciences. ISIS brings together national and international academics and industrialists to advance these challenges by taking advantage of the unique insights that neutrons and muons provide. The ability of our instruments to investigate the structure and dynamics of materials with unprecedented detail helps to ensure that the UK remains at the forefront of global materials research.

Cover image: Ashok Menon, University of Warwick, and Gabriel Perez, ISIS, studying lithium ion pouch cells on the WISH beamline.

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# Foreword

Every year, as we bring together contributions for this review, I'm reminded of the sheer scale and variety of what happens across ISIS.

Most of us see only part of the picture day to day. Whether supporting users, maintaining complex infrastructure, developing new capabilities or delivering world-class research, colleagues across ISIS contribute in many different ways to our shared success. Together with our users, they enable outstanding science and support UKRI's mission to advance knowledge, improve lives and drive economic growth.

The breadth of science carried out at ISIS continues to impress. Our users are tackling challenges in areas ranging from clean energy and advanced manufacturing to healthcare and digital technologies, supporting many of the priorities set out in the Government's Modern Industrial Strategy. Much of this work is led by UK researchers and strengthened by the wider UKRI ecosystem through the support of other research councils. Together, these partnerships help maximise the impact of the research undertaken at ISIS.

Alongside this scientific success, we continue to invest in the future of the facility. Our engineers, technicians and operations teams play a vital role in ensuring ISIS runs safely and reliably, while helping to enhance our capabilities for the years ahead. This includes the Endeavour programme, which continues to make excellent progress, with both SuperMuSR and HRPD-X moving through implementation.

We have also continued to strengthen collaborations across the UK and internationally, including with industry. I was pleased to take part in the first meeting of ISIS's Industrial Advisory Committee, which will help shape our engagement with businesses and ensure we continue to deliver value for the wider economy.

While current financial pressures require difficult decisions and careful prioritisation, they do not change the fundamental strengths of ISIS: our exceptional people, our world-class facilities, our outstanding user community and the unique insights that neutrons and muons provide.

The highlights in these pages represent only a snapshot of the past year, but together they reflect the expertise, dedication and teamwork that underpin everything we do. My thanks to everyone who has contributed to and supported ISIS over the past year.

**Sarah Rogers**

**Director of ISIS Neutron and Muon Source**



Sarah Rogers, the Director of ISIS.

# ISIS supporting UKRI's mission to advance knowledge, improve lives and drive growth



## How ISIS is helping deliver UKRI's research priorities

UKRI's strategic priorities set out how research and innovation can support the government's ambition for a thriving and resilient UK. These include backing discovery-led research, responding to national challenges and helping businesses grow.

ISIS contributes to this agenda as the UK's national neutron and muon facility. We provide access to specialist techniques and expertise beyond the reach of conventional laboratories, offering insights that other methods cannot easily provide. This supports research across fields including energy, health, engineering, environmental science and quantum technologies. This work is carried out in partnership with other UKRI research councils and the UK's academic and industrial research communities.

“As the UK's national neutron and muon facility, ISIS is an important part of our research and innovation landscape. Its unique capabilities enable researchers to make new discoveries, tackle real-world challenges and develop the products and technologies of the future, directly supporting UKRI's mission to advance knowledge, improve lives and drive growth.

**Professor Sir Ian Chapman,**  
UKRI Chief Executive



## Advancing knowledge: supporting discovery and curiosity-driven research

Researchers use ISIS to explore new ideas, test emerging theories and generate knowledge that can open unexpected routes to real-world impact.

Using neutrons, scientists uncovered a new mechanism by which DNA can fold without changing its genetic code, a finding that could improve understanding of how genetic information is organised. Researchers have also provided unambiguous evidence that particles and waves undergo a spatial Goos-Hänchen shift on reflection, confirming a long-contested prediction of quantum mechanics dating back to Newton. In quantum materials, teams have identified promising compounds that could support topological superconductivity, a rare property highly sought after for future computing technologies.

Discovery-led research at ISIS also connects unexpected areas of science. One project used Roman lead from an ancient shipwreck to test crystals being developed for supernova and dark matter detection, where extremely low-radioactivity materials are needed to detect faint signals from the universe.



## Improving lives: addressing strategic government and societal priorities

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Many of the UK's priorities depend on improving the materials, processes and technologies that underpin modern life. ISIS helps researchers understand how these systems work at the atomic and molecular scale, giving them the evidence they need to develop better solutions for society. As shown on pages 14–15, this work supports the themes of the UK Government's Modern Industrial Strategy.

In healthcare, neutron techniques have revealed how polymyxin B, a last-resort antibiotic, disrupts the protective outer membrane of Gram-negative bacteria, results that could help preserve existing antibiotics and inform new strategies against drug-resistant infections.

In energy storage, ISIS is helping researchers understand how batteries behave under real operating conditions, supporting the development of more reliable and efficient energy storage technologies.

ISIS is also helping researchers test the resilience of AI technologies. For example, exposing advanced image-processing systems to accelerated levels of atmospheric neutrons allows researchers to simulate years of real-world radiation exposure in a much shorter time. This provides insights to develop more reliable systems for applications such as self-driving cars, aircraft and unmanned vehicles.



## Driving growth: helping companies start, scale and stay in the UK

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ISIS supports UK businesses by giving them access to specialist techniques and expertise that can help solve technical problems, improve products and reduce development risk. Our capabilities are particularly valuable for companies that need to understand how materials behave and perform under real-world conditions. As shown on pages 10–11, and in other sections of this review, ISIS supports businesses at every stage of innovation, from early-stage research to product development and manufacturing.

For example, Rolls-Royce used ISIS to study residual stress in jet engine parts, helping them understand how manufacturing processes affect component lifetime. UK-based green packaging manufacturer Tensei used ISIS to support its development of sustainable papers and adhesives made from agricultural residues. In the pharmaceutical sector, researchers working with sustainable technologies company Johnson Matthey characterised a pharmaceutical cocrystal with the potential to improve drug delivery.

# This year at ISIS

## Operations



**4 cycles**

(80% operations due to finances)



**2808**

hours of beam on target



**554**

mAh of beam delivered



**86.1%**

accelerator availability (excluding offs < 1hr)

## Experiments



**1527**

proposals submitted



**3249**

instrument days delivered to the user programme



**80**

companies engaged with ISIS



**850**

unique principal investigators awarded time

of which **145** were new to ISIS



**1577**

unique researchers coming to ISIS for experiments

of which **41%** were students

View publications  
[bit.ly/3UbVVO0](https://bit.ly/3UbVVO0)



## Publications



**507**

journal publications



**7100**

authors



**77**

countries



**93%**

UK authors

## Training



**28**

ISIS staff on STFC  
graduate scheme



**14**

year-in-industry  
students



**58**

apprentice  
placements



**43**

summer work  
experience placements



**5300**

people reached through  
our engagement  
programme

## Public engagement

# Helping businesses solve real-world challenges

ISIS supports businesses at every stage of innovation, from early-stage research to product development and manufacturing. Through access to unique capabilities and scientific expertise, we help industry solve complex challenges, gain valuable insights and bring new technologies closer to application.

You can find out more about how we're working to support and develop the ISIS industry programme on page 42.

## Neutron scattering challenges long-held industry assumptions about bio-based additives in lead batteries

Lead batteries are still widely used because of their low cost, high recyclability, and safety. Although an established technology, they still have performance limitations, such as limited cycle life and modest discharge capacities. One way to improve battery cycling is to add organic additives such as lignosulfonates to control the formation of lead sulfate crystals during battery discharge. Although an established way to improve electrochemical performance, it was thought that lignosulfonate decomposition could then cause battery failure.

To understand what is really happening, and whether lignosulfonate decomposition was really a root cause of lead battery failure, the biorefinery company Borregaard turned to neutron scattering. Because neutron studies enable the study of the light elements present in lignosulfonates, even when surrounded by lead, they are an ideal tool to use.

Using the Tosca and Maps beamlines through the ISIS Collaborative Research and Development (ICRD) scheme, and VISION at ORNL, they studied lead battery electrodes using inelastic neutron spectroscopy (INS) after battery formation, performance testing and at the end of the battery's life, to track what was happening to the lignosulfonate during battery cycling.

If the degradation of lignosulfonates was causing battery failure, then their concentration would be expected to decrease throughout operations. However, their experiments showed that there was only a small loss of the additive, challenging this long-held assumption. Their approach provides proof-of-concept for the application of INS in lead battery research and opens new avenues for the study of organic additives under realistic operating conditions.

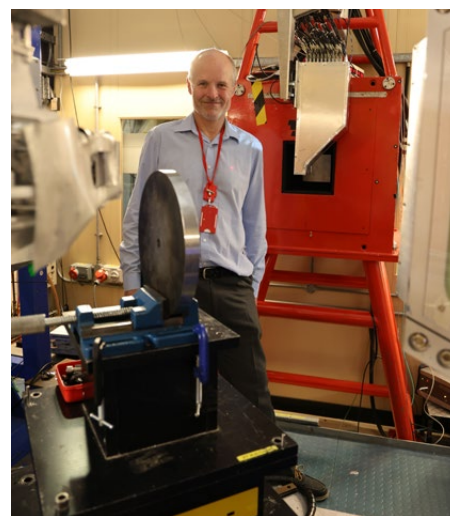


Sam Shafarik and Maria Gastony, Borregaard, preparing the battery electrodes for testing.

## Design problem averted for Levistor thanks to neutron diffraction measurements

Levistor has developed a low-cost kinetic energy storage system, which performs the function of a battery but has a cycle life two orders of magnitude higher than electrochemical batteries. Levistor's unique design reduces cost while guaranteeing safety, but they wanted to ensure residual stresses inside one component of the product were within allowable limits.

Thanks to the Industry Impact Fund (I2F), Levistor were able to access the Engin-X neutron diffractometer at ISIS to measure residual stress distributions within a specially manufactured prototype. They were able to accurately measure residual stresses inside the component in critical areas of importance and account for this in combination with results generated by finite element analysis modelling. The magnitude and position of residual stresses were unknown prior to these measurements.



Keith Pullen, Levistor, on Engin-X.

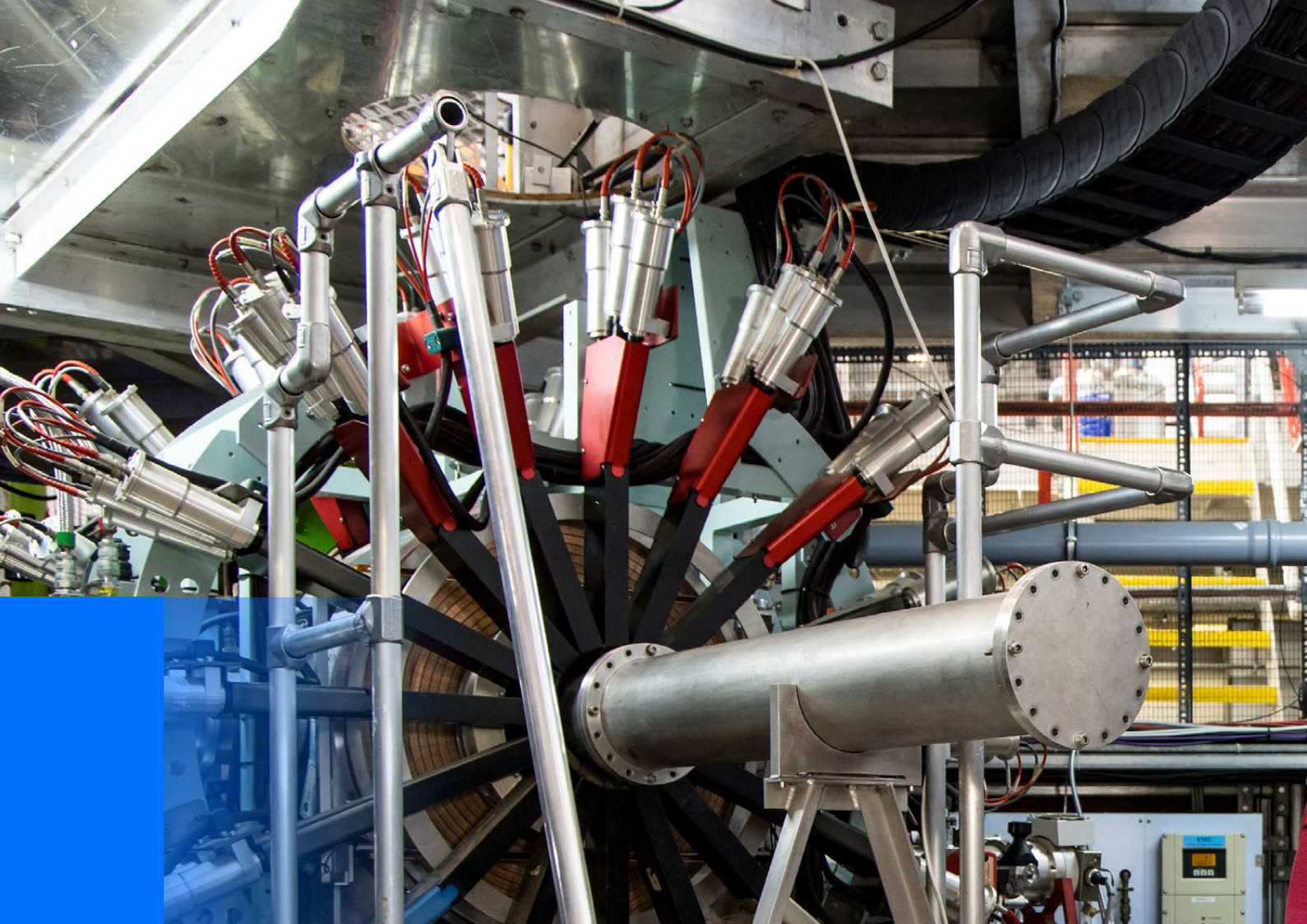
## New membrane technology could transform hydrocarbon processing by slashing energy use

A team of international researchers have developed a new class of ultrathin polymer membranes that can rapidly and selectively separate complex hydrocarbon mixtures, potentially transforming how crude oil is refined and refinery streams are processed, significantly reducing the energy required for one of the world's most energy intensive industrial processes.

The project was led by Exactmer, a spin-out company from Imperial College London developing cutting edge new membrane technology, in collaboration with Queen Mary University of London, the University of Edinburgh, UCL, and international collaborators, with support from UKRI, EPSRC, and KAUST.

Their study created a new way to form the separating layers in polymer membranes for molecular separations. The breakthrough is the development of an in situ crosslinking approach that stabilises the polymer structure while the membrane is being formed. This process locks the pores in their optimal configuration, producing what the researchers call 'polymers of locked intrinsic microporosity'. To probe the molecular origins of locking, the UCL team used quasi-elastic neutron scattering on the LET instrument at ISIS.

This approach results in a scalable membrane technology capable of separating complex organic mixtures into valuable fractions with unprecedented efficiency. The membranes combine extremely high molecular selectivity with fast liquid transport. This combination has long eluded scientists and engineers working in this field.



# Delivering a world-leading science programme

The research conducted at ISIS in a year showcases the breadth, depth and quality of work delivered at the facility. That research plays a key role in delivering the UK Government's Modern Industrial Strategy, supporting many of the high-growth sectors it highlights. This year we have welcomed new and returning scientists and supported them to deliver outstanding research in areas such as green energy technology, quantum science, advanced materials and healthcare.



Jessie Isufaj, Max Fitzgerald, Jipeng Zhang of University College Dublin using the Emu instrument.

# ISIS Neutron and Muon Source and the UK's Modern Industrial Strategy

ISIS facilitates many activities which support the themes of the UK Government's Modern Industrial Strategy. The Government has identified eight sectors that have the greatest growth potential over the next decade and will play a critical role in supporting economic security and resilience, net zero and regional growth.

ISIS is a key part of research that supports many of these sectors, some examples of which are highlighted individually in this review. This double page spread provides an insight beyond those examples into the range of ISIS science from the last year that has relevance to the Industrial Strategy sectors.



## Clean Energy

As explained in the following pages, the use of the neutron's ability to study light elements in the presence of heavier ones has been exploited to study hydrogen storage materials, and the insight muon studies give to charge carrying materials has been used to investigate solar cell materials. Beyond this, our new NILE facility is a source of 14 MeV neutrons that can be used for testing materials such as superconductors under the conditions they would experience in a fusion reactor. We have also enabled studies into carbon capture and storage, enhanced oil recovery, industrial experiments on flywheels for electricity storage, and plastic waste recycling.



## Digital and Technologies

As the use of artificial intelligence grows, there is a greater need for reliable data on which to train these models. Facilities like ISIS are a reliable and valuable resource of these data, and our scientists are working with academics to develop new and improved machine learning models for predicting candidate materials.

Muonium, a bound state of a positively charged muon and an electron, is analogous to hydrogen, making it an important probe to understand the behaviour of hydrogen atoms in semiconductors. Neutron scattering has also been used for studying less environmentally damaging quantum dots: semiconductor crystals used in lighting and displays, as well as in medical imaging, photonics and as sensors. Superconducting Quantum Interference Devices (SQUIDs) are becoming increasingly popular in the commercial sector as scalable, fast and efficient manipulators of encoded information. Their resilience to atmospheric neutron exposure and mono-energetic neutrons has been tested using ISIS.



The Makepeace group from the University of Birmingham with Ron Smith from ISIS, studying catalysis materials for using ammonia for energy storage.



## Advanced Manufacturing

Battery research at ISIS continues to grow as sample environments and instrument capabilities develop. It is now possible to use both neutrons and muons to study battery cells whilst they are operating.

The breadth of ISIS research in this area reaches from the ground, and the study of fertilisers, to the skies with the testing of avionic electronics using Chiplr and Rolls-Royce investigating jet engines, and beyond – to space science and technologies for use in space flight.



## Life Sciences

This review features work studying antimicrobials, mRNA vaccines, pharmaceuticals and the effect of e-cigarette additives on the lungs. Researchers have also used ISIS this year to study the causes of cancer cell death, with implications for treatments, DNA damage, and the effect of pH on drug delivery.

One Harwell-based collaboration saw the UK Health and Security Agency (UK HSA) collaborate with ISIS and STFC's Central Laser Facility to investigate the effect of air pollution on brain health. Another research group have been studying pollutants, designing a new sample environment to replicate their behaviour in the atmosphere.



## Defence

Research into engineering components and electronics resilience has defence as well as civilian applications. ISIS has also enabled studies into rapid, small-scale and non-destructive screening of explosive safety.



Ozde Oztekiner of UCL in the ISIS Bio Lab.

# Energy and clean growth

## Neutrons provide a unique view of the synthesis of a potential hydrogen storage material

Zhongsheng Wei, a postdoctoral researcher whose fellowship is funded through the UK International Science Partnerships Fund, has used neutron diffraction to study the synthesis of a possible hydrogen storage material under industrially relevant conditions.

A key challenge in the implementation of a hydrogen economy is storage. An alternative to hydrogen gas is the use of metal hydrides, which form a framework into which the hydrogen atoms sit.

Using the Paris-Edinburgh press and the support of the Sample Environment group, the team used neutron diffraction to study the structure of the material as it formed, at pressures of over 6 GPa. The deuterated form was studied to avoid the incoherent scattering from hydrogen atoms. This enabled them to see the locations and occupancies of the deuterium atoms in the structure.

The large sample volume that the Paris-Edinburgh press can hold means that it is possible to follow the synthesis of a more industrially relevant volume and measure the bulk structure and not just the structure at the surface. Their work provides a deeper understanding into the practicalities of similar reactions for potential industrial applications.

“

Neutron scattering is particularly good for studying metal deuterides as the technique is highly sensitive to light elements such as deuterium, allowing for precise structural analysis even in the presence of heavier elements.

**Zhongsheng Wei, ISIS**

Zhongsheng presenting her work at the ISIS science day.



**Instruments:** Pearl

**Related publication:** Formation of Molybdenum Deuteride at High Pressure: A Neutron Diffraction Study, *Inorg. Chem.* 2026, 65, 1, 631–637, DOI: 10.1021/acs.inorgchem.5c04811

**Funding:** UKRI International Science Partnerships Fund (ISPF)

**Authors:** Z. Wei, N. P. Funnell, C. L. Bull (ISIS), C. J. Ridley (ISIS, now ORNL), S. Klotz (Sorbonne Université), C. R. Pulham (University of Edinburgh)

## ISIS's first Chilean co-investigator leads an investigation into the characterisation of a new series of battery electrolytes

An advanced characterisation of the  $\text{LiGaX}_4$  halides has uncovered their structures, transport properties, and the key differences between short- and long-range conduction.

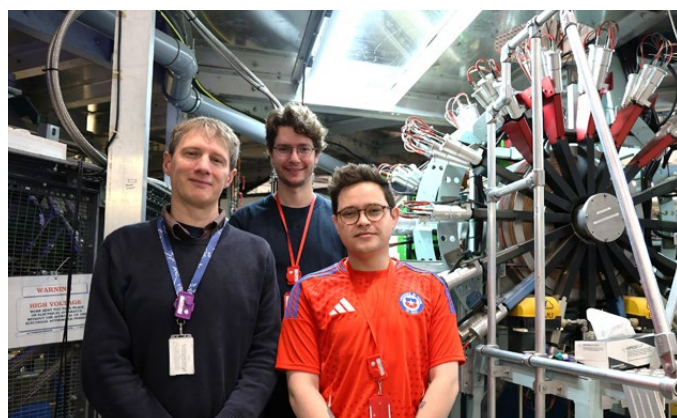
Halide solid-state electrolytes (HSEs) have promising properties when it comes to applications in batteries. These include good lithium conductivity at room temperature and compatibility with oxide cathode materials.

Initial synthesis and computational modelling have suggested that the family of compounds  $\text{LiGaX}_4$  ( $\text{X} = \text{Cl}, \text{Br}, \text{I}$ ) could have favourable properties, but they have scarcely been studied in terms of ionic conductivity.

In this study, researchers synthesised the full series and characterised their structure using

X-ray and neutron diffraction. They then studied the lithium conductivity using impedance and muon spectroscopy. The first author, Nico Flores-González was the first researcher affiliated with a Chilean university to visit ISIS for an experiment.

The compounds in the series had very different conductivities and, although rapid local lithium-ion hopping was seen in  $\text{LiGaCl}_4$ , it had the highest activation energy for long range diffusion, showing that the conductivity of these materials is more complicated than originally thought.



Peter Baker from ISIS, Wilgner Lima da Silva from University of Birmingham and Nico Flores-González from University of Concepción, Chile, on the Emu instrument.

“ Muon spectroscopy allows us to study diffusion at the atomic scale, unlike conventional laboratory techniques. This means we can understand our samples, and then use this understanding to make new, improved, battery materials. I hope this motivates more researchers from Chile to apply for access this world-class facility, and that together we continue tackling global challenges through science.

**Nico Flores-González,**  
**University of Concepción**

**Instruments:** Emu and Polaris

**Related publication:** Insight into the prospects and limitations of mechanochemically-synthesised lithium tetrahalogallates,  $\text{LiGaX}_4$  ( $\text{X} = \text{Cl}, \text{Br}, \text{I}$ ), as Li-ion conductors. *Chem. Sci.*, 2025,16, 23299–23309. DOI: 10.1039/D5SC03999A

**Funding:** Agencia Estatal de Investigación, Royal Society of Chemistry, Institutió Catalana de Recerca i Estudis Avançats, Generalitat de Catalunya, Comisión Nacional de Investigación Científica y Tecnológica, Universitat de Barcelona, Deutsche Forschungsgemeinschaft and EPSRC

**Authors:** N. Flores-González (University of Glasgow, University of Concepción), M. López, F. Viñes, F. Illas (Universitat de Barcelona), N. Minafra, W. G. Zeier (University of Münster), Jamie Jack, D. H. Gregory (University of Glasgow), J. Bohnenberger, I. Krossing (Universität Freiburg), A. Inoishi (Kyushu University) and N. Gupta, L. Liborio, R. I. Smith, P. J. Baker (ISIS).

## Pore size is crucial for effective hydrogen storage at low temperatures

Using neutron scattering, researchers from Estonia and ISIS have developed a better understanding of how hydrogen is adsorbed into a porous material, and how this could help increase the density of hydrogen stored at cryogenic temperatures.

Hydrogen storage is a significant barrier to the implementation of a hydrogen economy. Currently, compression or liquefaction is used, but both are energy-intensive and expensive. Another method is storing hydrogen in porous materials, which can be added to cryogenic storage containers to increase their capacity.

There is a lot to learn about the nature of the pores and the behaviour of the hydrogen within them, to then be able to develop improved materials with commercial relevance. At cryogenic temperatures, another factor needs to be considered, which is whether the hydrogen is present in its ortho or para form. If ortho

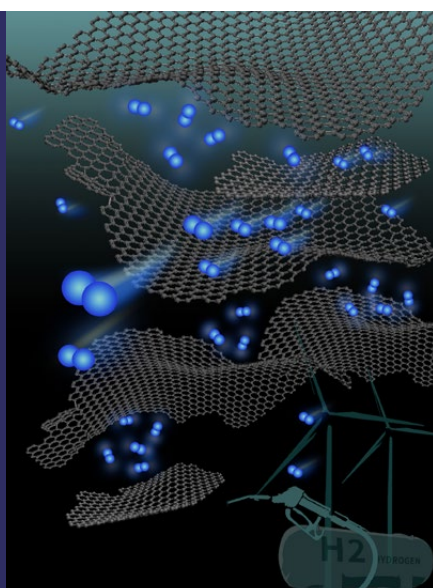
hydrogen is present, then it will convert to the para form and release heat, causing a need for continual cooling to keep the hydrogen liquid. In addition, the characteristics of the para-ortho transition yield information about the hydrogen confinement strength of the porous environment.

In this study, the authors used neutron scattering to study hydrogen inside a carbide-derived carbon absorbent, acting as a model porous material. They used quasi-elastic neutron scattering (QENS) to study the self-diffusion of hydrogen, and inelastic neutron scattering (INS) to investigate the immobile hydrogen in the system.

They found that, at all the hydrogen loading and temperature conditions they investigated, a fraction of solid-like, but free-to-rotate, adsorbed hydrogen was present. This was possible thanks to the presence of large ultramicropores, as well as small supermicropores.

The larger ultramicropores localised hydrogen in a high-density adsorbed phase but lacked the capability to preferentially adsorb hydrogen in its ortho form. However, narrower ultramicropores did restrict its conversion to the para form, making them essential for effective hydrogen storage in cryogenic applications.

Hydrogen molecules adsorbed in a carbon absorbent.



**Instruments:** Iris and Mari

**Related publication:** Restricted Dynamics and Para-Ortho Conversion of H<sub>2</sub> Adsorbed in Micro- and Mesoporous Carbide-Derived Carbon: A Quasi- and Inelastic Neutron Scattering Study. *J. Phys. Chem. C*, 129, 9, 4789–4799, 2025. DOI: 10.1021/acs.jpcc.4c08582

**Funding:** Estonian Research Council, the EU and the Estonian Research Agency

**Authors:** M. Koppel, R. Palm, R. Härmas, K. Tuul, M. Paalo, E. Lust (University of Tartu), M. T. F. Telling, M. D. Le and T. Guidi (ISIS).

## Distinguishing between bulk and surface behaviour in silicon using photo- $\mu$ SR

To understand charge carrier dynamics in semiconductors such as solar cell materials, which is key to their performance, researchers from Warwick and Birmingham have used photoexcited muon spin spectroscopy (photo- $\mu$ SR) to study both surface and bulk behaviour.

In photo- $\mu$ SR, excess charge carriers are generated in a material by a laser pulse, and spin-polarised positive muons are then implanted a short time later. Inside the material, the muons pick up electrons to form hydrogen-like ‘muonium’ atoms, and interactions with the surrounding charge carriers cause the muon spin to lose its alignment (depolarise) over time. The rate of this depolarisation depends on how many excess charge carriers are present. By varying the delay between the laser and muon pulses, researchers can directly determine the charge carrier lifetime.

Because muons can penetrate into samples, this lifetime can be measured at specific depths, and in completed devices such as silicon solar cells. In these materials, the lifetime of the charge carriers dictates their performance. The longer it takes for the charge carriers to recombine, the more efficient a device is.

Conventional photoconductance decay (PCD) measurements of carrier lifetimes are unable to separate surface and bulk effects unambiguously from a single sample. But, in this study, the researchers have found that photo- $\mu$ SR can do this.

The group used photo- $\mu$ SR to study silicon wafers produced by a broad range of treatment schemes, including state-of-the-art dielectric films. They also used PCD to measure the same samples so they could compare the techniques.

They were able to show that photo- $\mu$ SR can reliably distinguish bulk-limited from surface-limited recombination and distinguish between the quality of different treatment regimes. These findings establish photo- $\mu$ SR as a powerful tool for disentangling surface and bulk recombination in silicon solar cell materials and devices, with promise for future application to other semiconductors too.



Tim Niewelt, Sophie Pain, Koji Yokoyama and Anup Yadav at ISIS.

**Instruments:** HiFi

**Related publication:** Extracting surface and bulk recombination parameters for passivated silicon using photoexcited muon spin spectroscopy. *J. Appl. Phys.* 138, 135701, 2025.  
DOI: 10.1063/5.0288808

**Funding:** EPSRC, Leverhulme Trust, STFC and the Royal Academy of Engineering

**Authors:** A. Yadav, S. L. Pain, L. Wilkins, N. E. Grant, (University of Warwick) J. S. Lord, K. Yokoyama (ISIS) and J. D. Murphy (University of Warwick and University of Birmingham)

## Developing steels that are better able to cope inside a fusion reactor

Working with UKAEA, researchers from Manchester, Sheffield and Imperial universities have developed a new processing method that produces a steel that is very strong but also maintains flexibility: the properties required inside a fusion reactor.

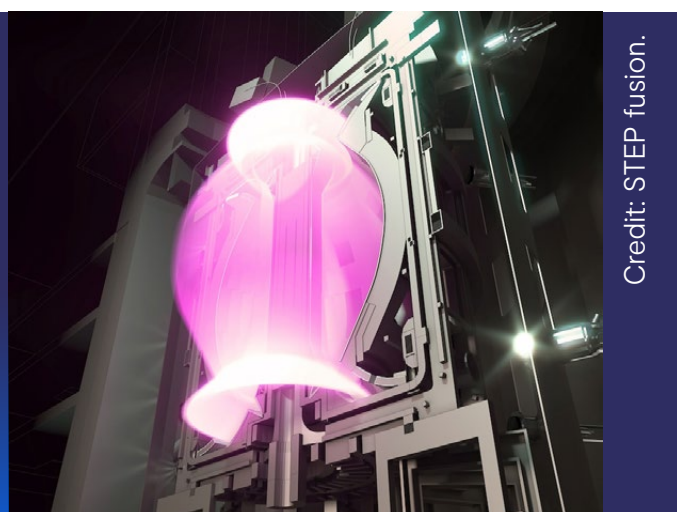
Future fusion power plants will require structural materials that can operate under intense neutron irradiation and elevated temperatures while retaining high strength, toughness and long-term stability. Reduced activation ferritic/martensitic (RAFM) steels are currently the leading candidate materials for fusion components, but existing alloys suffer from irradiation damage and limited operating temperatures.

In this study, researchers developed a new thermo-mechanical processing strategy that engineers a hierarchical multiscale microstructure in RAFM steel using conventional industrial processing. Rather than relying solely

on alloy chemistry, the approach combines controlled deformation, phase transformation and precipitation to generate heterogeneous ferrite/martensite structures together with a high density of nanoscale intragranular carbides. This unique microstructure overcomes the traditional strength–ductility trade-off, producing steels with substantially higher strength while simultaneously improving ductility compared with conventional Eurofer97 steel.

Small angle neutron scattering (SANS) played a crucial role in revealing the nanoscale precipitation responsible for the improved mechanical properties. Unlike conventional microscopy, SANS provided quantitative bulk measurements, which showed a significantly higher density of nanoscale carbides together with a reduced fraction of coarse precipitates. These observations confirmed the mechanisms responsible for strengthening and suggest that the refined carbide distribution may also enhance tolerance to neutron irradiation during service.

The work demonstrates how advanced neutron scattering can guide the design of next-generation structural materials for commercial fusion reactors, providing a scalable manufacturing route towards steels capable of operating under the demanding conditions expected in future fusion power plants.



Credit: STEP fusion.

Concept design of the STEP fusion reactor.

**Instruments:** SANS2D and Zoom

**Related publication:** A multi-scale microstructure to address the strength–ductility trade off in high strength steel for fusion reactors. *Nature Communications*, 16, 2746. 2025.  
DOI: 10.1038/s41467-025-58042-8

**Funding:** EPSRC

**Authors:** P. Gong (University of Manchester), R. Goodall, W. M. Rainforth (University of Sheffield), T.W.J. Kwok (Singapore Institute of Manufacturing Technology, Imperial College London), Y. Wang, H. Dawson (UKAEA) and D. Dye (Imperial College London)

## Using a ‘memory reactor’ to improve industrial chemical processes, and studying them during operation on the beamline

A team from Newcastle and Durham have been able to study a new type of chemical reactor during operation using neutrons, by developing a novel experimental setup.

Increasing the efficiency of key chemical processes will be key in the UK and globally when working towards net-zero targets. One example is the water–gas shift reaction (WGS) ( $\text{CO} + \text{H}_2\text{O} \rightleftharpoons \text{CO}_2 + \text{H}_2$ ), which is a critical step in hydrogen production. The WGS reaction is reversible, and so being able to drive it past its equilibrium point would improve efficiencies and reduce costs.

This study looked at the concept of a ‘memory reactor’, where the reagents ( $\text{CO}$  and  $\text{H}_2\text{O}$ ) are fed into opposite ends of a reactor containing perovskite oxygen–carrier materials (OCMs). A chemical potential is formed along the reactor, and the  $\text{H}_2$  and  $\text{CO}_2$  products leave in two separate product streams. The researchers found that this method could achieve close-to 100% conversion; significantly higher than the normal 50%.

As part of his facility development studentship, Daniel Telford worked with staff from across ISIS to design a split-bed reactor that could use neutron diffraction to measure the oxygen content along the bed during operation. This provided direct evidence for how the reactor functions. Neutrons are particularly useful thanks to their high sensitivity to the oxygen atom content of the OCM and their ability to



Harry Yan, Matthew Guy, Jose Fabian, John Evans and Daniel Telford at ISIS for their experiment.

penetrate bulk samples inside an industrially relevant reactor vessel.

The team were then able to use this reactor to collect real-time atomic-level information on a working reactor bed at a time resolution of less than 30 seconds, allowing the direct observation of the changing composition of a reactor bed during its operation.

They were also able to extend the reactor’s use to study the steam methane reforming reaction. Their new technique acts as a fast method of optimising these chemical processes, on a scale relevant to industry.

**Instruments:** Polaris

**Related publication:** Probing dynamic oxygen exchange for hydrogen production with operando neutron diffraction. *Nature Chemical Engineering*, 2, 447–455 (2025).  
DOI: 10.1038/s44286-025-00231-9

**Funding:** EPSRC, STFC and the Royal Academy of Engineering

**Authors:** D. M. Telford, A. Martínez Martín, M. D. Guy, W. Hu, I. S. Metcalfe (Newcastle University), P. F. Henry, M. O. Jones (ISIS) and J. S. O. Evans (Durham University)

# Quantum science

## Studying the mechanisms of skyrmion formation

Researchers from Warwick, Oxford, the US and Japan have used inelastic neutron scattering to study the magnetic behaviour of a material with an unusual magnetic ground state.

Because of their nanoscale size and high topological stability, skyrmions are actively being researched for use in next-generation electronics, such as spintronic memory devices and high-density data storage. Understanding how they could form under ambient conditions is a key challenge in the drive to discover materials with technological applications.

In this study, the researchers looked at  $\text{GdRu}_2\text{Si}_2$ , which has an unusual magnetic ground state at zero-field that features complex spin structures. States like these frequently host topological textures, such as skyrmions, and so understanding how the ground state of  $\text{GdRu}_2\text{Si}_2$  forms may provide evidence as to how zero-field skyrmions may be realised.

Using inelastic neutron scattering on a rare isotopically enriched crystal, the team were able to study how the spin waves in the material

behave in the field-polarised phase of  $\text{GdRu}_2\text{Si}_2$ . New analytical and computational techniques were developed to isolate and measure the interactions governing the magnetic behaviour of the system.

They found that the dominant force governing the magnetic behaviour is a long-range interaction called RKKY exchange, which operates across many neighbouring atoms. They did not find direct evidence for higher-order or anisotropic exchange interactions, which would drive topological magnetism. However, their findings narrow down the energy scales at which these interactions may occur.

The team also identified dipolar interactions, which would introduce anisotropic exchange, as a secondary energy scale to the system. Their results inform the search for similar materials with useful properties for future technology.

**Instruments:** LET

**Related publication:** A magnon band analysis of  $\text{GdRu}_2\text{Si}_2$  in the field-polarized state, *npj Quantum Mater.*, 10, 39, 2025, DOI: 10.1038/s41535-025-00755-6

**Funding:** US Department of Energy and EPSRC

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## Sliding neutrons: from contested to confirmed

Scientists have used ISIS to finally prove the connection between the reflection of particles and waves as required by quantum mechanics.

The Goos–Hänchen effect is an optical phenomenon where a beam of light appears to shift slightly along a surface when it's reflected. Instead of the light bouncing off exactly where you'd expect it to, it seems to travel a tiny distance along the surface before being reflected. This effect is very small but is important in various applications, particularly in fibre optics and some types of sensors.

The first reported observation of Goos–Hänchen for particles was of neutrons using the OffSpec instrument at ISIS in 2010. The theory predicts a spatial shift on reflection, and a corresponding change in polarisation, but neither had been observed experimentally. The team reflected a beam of polarised neutrons onto a film of magnetic material and observed a minuscule change in polarisation.

However, for some in the community, these changes were considered too small, and not conclusive enough. Now, a team that included some of the original researchers, have developed a specially designed multilayered magnetic sample and repeated the experiment on the newer Larmor instrument. They were able to measure a much larger change in polarisation after reflection.

This work proves that when particles are reflected, they behave the same way as light,



The Larmor instrument

“

As well as the polarisation change, in this experiment we were also able to observe the spatial shift directly. These two results verify both aspects and provide unambiguous evidence of the Goos–Hänchen shift.

**Roger Pynn, Indiana University**

as predicted from quantum theory. Their results provide insights for the design of neutron waveguides – important components in neutron optics that are used to channel neutrons along a specific path.

**Instruments:** Larmor

**Related publication:** Observation of a Giant Goos–Hänchen Shift for Matter Waves. *Phys. Rev. Lett.* 134, 093803, 2025. DOI: 10.1103/PhysRevLett.134.093803

**Funding:** IU Quantum Science and Engineering Center and Department of Commerce

**Authors:** S. McKay, Q. Le Thien, D.V. Baxter (Indiana University), V.O. de Haan (BonPhysics Research and Investigations BV), J. Leiner (Oak Ridge National Laboratory), S.R. Parnell, R.M. Dalgliesh (ISIS), P. Boeni, (Technical University of Munich, SwissNeutronics AG), L.J. Bannenberg (Delft University of Technology) G. Ortiz (Indiana University, Institute for Advanced Study, University of Waterloo) and R. Pynn (Indiana University, ORNL)

## Unusual material properties herald the future of quantum computing

An international team of researchers have used muon-spin rotation/relaxation ( $\mu$ SR) and other techniques to show that two new compounds are promising candidates to host topological superconductivity, which is highly sought after for quantum technologies.

They found that the compounds combined conventional bulk type-II superconductivity with unusual surface states that could give rise to topological superconductivity.

In this study, the researchers were interested in ternary germanides of either Ti or Hf. Using a combination of resistivity, magnetisation, and specific heat measurements they found that the compounds show conventional bulk type-II superconductivity with higher than usual transition temperatures. Zero field  $\mu$ SR revealed no magnetic field beneath the transition temperatures, indicating that the superconducting state preserves time reversal symmetry, and transverse field- $\mu$ SR revealed an isotropic s-wave superconducting gap structure.

First-principles calculations and symmetry analysis showed that the materials exhibited symmetry-protected hourglass topology and helical spin-textured surface states, leading to the potential for topological superconductivity at the surface.

Topological superconductors allow researchers to encode information in these materials as quasiparticles that are a feature of the material's topological order. That means they are more

stable and less error-prone than typical quantum computers that rely on trapped ions or photons.



“

The interesting thing is that these materials show conventional bulk superconducting behaviour, but in combination with a topological band structure. That's very exciting because it indicates the possibility for topological superconductivity at the surface of the materials, which is very rare.

Rhea Stewart, ISIS

**Instruments:** MuSR

**Related publication:** Superconductivity in Hourglass Dirac Chain Metals (Ti, Hf)IrGe. *Adv. Sci.* 2025. 12, e12434. DOI:10.1002/advs.202512434

**Funding:** Council of Scientific and Industrial Research, Government of India. Science and Engineering Research Board (SERB), Government of India. IIT Kanpur.

**Authors:** P. K. Meena, S. Jangid, R. K. Kushwaha, R. P. Singh. (Indian Institute of Science Education and Research Bhopal). R. Stewart, A. D. Hillier (ISIS), D. Samanta, S. K. Ghosh (Indian Institute of Technology Kanpur)

## Investigating the mechanisms behind unconventional superconductivity

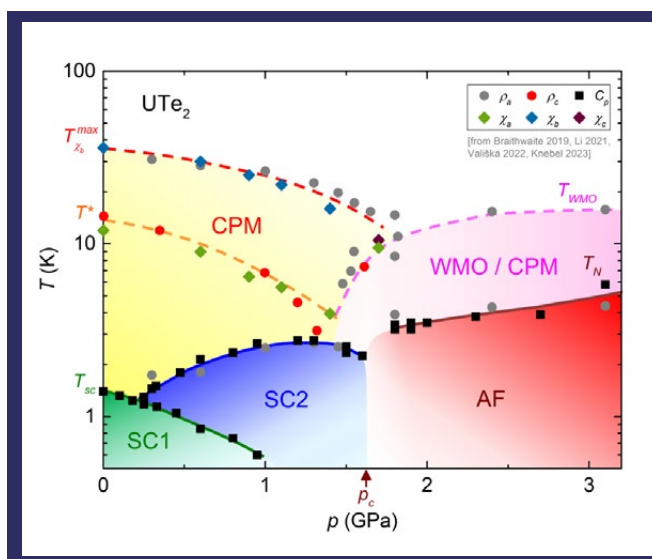
Using neutron diffraction under pressure, researchers have uncovered a novel long-range ordered magnetic phase in  $\text{UTe}_2$ , which reveals the key role of antiferromagnetic fluctuations in the unconventional superconductivity of this material at ambient pressure.

The compound  $\text{UTe}_2$  has been identified as a candidate for triplet and chiral superconductivity at ambient pressure and sparked further interest when multiple unconventional phases induced by pressure and magnetic field were recently observed. In this study, researchers from France, ISIS and Japan set out to explore which mechanisms lead to these different superconducting phases, and how they relate to its magnetic properties.

They studied the magnetic state of  $\text{UTe}_2$  under pressure using neutron diffraction, finding incommensurate antiferromagnetic order in

the high-pressure phase. The periodicity of the ordered phase is close to the wave vector where antiferromagnetic fluctuations were previously observed at ambient pressure. This finding rules out one of the initially proposed scenarios of superconductivity being driven by the proximity of the system to a ferromagnetic quantum state.

Their work offers a new direction for understanding the mechanisms behind the unconventional superconductivity in  $\text{UTe}_2$ , highlighting the key role played by antiferromagnetic interactions.



Pressure-temperature phase diagram of  $\text{UTe}_2$ ; the data collected on WISH was essential in understanding the AFM phase (in red).

**Instruments:** WISH

**Related publication:** Incommensurate Antiferromagnetism in  $\text{UTe}_2$  under Pressure. *Phys. Rev. X*, 15, 021075, 2025. DOI: 10.1103/PhysRevX.15.021075

**Funding:** French Research Agency ANR, Fédération Française de Diffusion Neutronique, JPSJ and the Programme Investissements d'Avenir.

**Authors:** W. Knafo, T. Thebault (Laboratoire National des Champs Magnétiques Intenses-EMFL), S. Raymond, E. Ressouche, K. Beauvois, G. Lapertot, D. Braithwaite, G. Knebel (CEA, Interdisciplinary Research Institute of Grenoble), P. Manuel, D.D. Khalyavin, F. Orlandi (ISIS), K. Kaneko (Japan Atomic Energy Agency) and D. Aoki (Tohoku University)

# Advanced materials, manufacturing and testing

## Neutrons reveal unexpected modes in magnetostrictive material

By combining neutron, X-ray and computational techniques, researchers from Manchester, Edinburgh, Japan and the US have fully characterised a magnetostrictive material, and the results were not as they expected.

Magnetostriction is the change in the dimensions of a material in response to an applied magnetic field. It's a property that is extremely useful for a wide variety of technical applications such as sensors, actuators and transducers. This study focussed on the material  $\text{CoFe}_2\text{O}_4$ , which is of particular interest because of its stability and because it is made of abundant transition metal ions.

Previous studies have been on nanoparticle and thin film samples, used in devices. However, to understand the physics that underpins their performance these researchers instead studied bulk  $\text{CoFe}_2\text{O}_4$ . They used X-ray diffraction and neutron diffraction at the Paul Scherrer Institut to study the structure, and neutron spectroscopy at ISIS for the dynamics. Their aim was to find out what influence the structural and magnetic properties had on the material's magnetostrictive behaviour.

Their inelastic neutron scattering measurements were not what they expected, showing the presence of two strongly dispersive spin wave modes with a large inter-mode gap. The fine details of the spectra also revealed a significant anisotropy, where the magnetic moments favour pointing along particular directions. From their results, the group were able to model the system, leading to a comprehensive characterisation.

The strong interactions demonstrated in this study are important for two reasons. Firstly, they give rise to a high ordering temperature, which means the devices work at room temperature and above. Then the anisotropy means that, rather than the system evolving gradually in response to an externally applied field, it jumps to a completely different direction, greatly amplifying the magnetostrictive response.

**Instruments:** Merlin and Maps

**Related publication:** Anisotropic Band-Split Magnetism in Magnetostrictive  $\text{CoFe}_2\text{O}_4$ . *Adv. Funct. Mater.*, 36, 17, e16830. DOI: 10.1002/adfm.202516830

**Funding:** Royal Commission for the Exhibition of 1851, EPSRC, STFC and the Royal Society of Edinburgh.

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## Testing the robustness of new AI technology for image processing

Using Chiplr to provide the equivalent of 250 million years of atmospheric neutrons, a research team from Italy and Brazil has tested the resilience of vision transformers run on Google Coral processing units.

Processing visual information is a key task in applications such as self-driving cars, aircraft and unmanned aerial vehicles, where reliable computing is also crucial. Until recently, convolutional neural networks (CNNs) were the main approach to detect or classify objects in an image or video.

Now, a new model has been developed to improve on CNNs that uses ‘transformers’, which outperform CNNs when it comes to detection accuracy. Transformers were originally developed for natural language processing. They became famous through ChatGPT, as the T stands for Transformer.

In this investigation, a group came to the Chiplr beamline at ISIS to see how well these Vision Transformers (ViTs) hold up under radiation testing when run on Google’s small, power-efficient Coral tensor processing unit (TPU) chips.

Their study is the first to investigate the impact of atmospheric neutrons on the reliability of transformers running on TPUs. They found that the probability of radiation-induced errors affecting the output of a model increases with the model size. The error rate is also significantly affected by the complexity of the model, with



Paolo Rech, University of Trento, at Chiplr.

more complex ones being more susceptible to radiation effects.

As well as studying different ViTs on the Coral Edge TPU, they also broke down the ViTs to see which parts fail most often and act as the critical component. They found that radiation-induced errors on the patch embedding layer of the transformer model are more likely to lead to misclassifications than errors on other layers of the model.

They were able to develop methods to improve the resilience of this layer of the ViT model. These insights can help designers create more reliable ViTs by strengthening the critical parts of the system while keeping the additional computing costs low.

**Instruments:** Chiplr

**Related publication:** Vision Transformer Reliability Evaluation on the Coral Edge TPU. *IEEE Transactions on Nuclear Science*, 72, 4, 2025. DOI: 10.1109/TNS.2024.3513774

**Authors:** B. Loureiro Coelho (University of Trento), P. R. Bodmann (Universidade Federal do Rio Grande do Sul), N. Cavagnero (Politecnico di Torino), C. Frost (ISIS), P. Rech (University of Trento)

## Safer screening of explosive material reactivity by vibrational spectroscopy

With the aim to make the development of energetic materials such as explosives, propellants and pyrotechnics safer, researchers from the Universities of Birmingham and Edinburgh are pioneering a spectroscopic approach for the rapid, small-scale and non-destructive screening of explosive safety.

Energetic materials such as explosives and propellants are critically important for technologies ranging from mining and entertainment to defence. Currently, to determine how easy it is to make an energetic material explode, scientists need to synthesise the material in gram-scale quantities and then a drop hammer is used in a trial-and-error approach. Not only is this current approach costly and time consuming, but it poses significant risk to the people doing the testing.

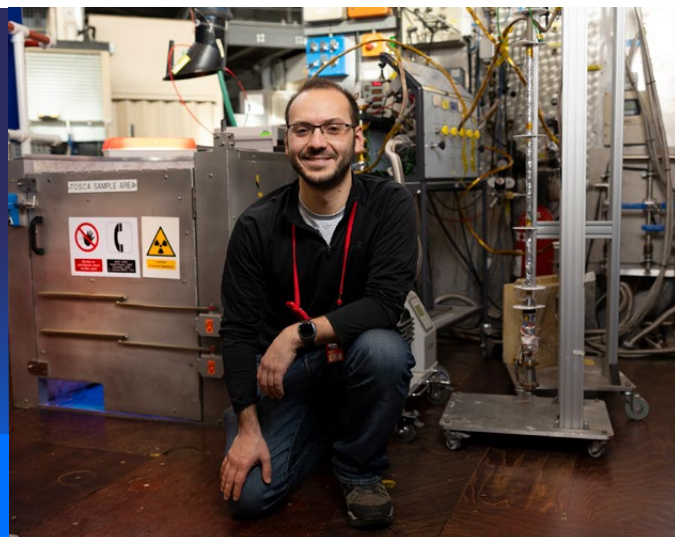
In their latest paper, the group have developed a safer screening approach using inelastic neutron scattering spectroscopy (INS). Unlike

laboratory spectroscopies, INS provides a complete fingerprint of the vibrational spectrum of a material, free from quantum mechanical selection rules. More importantly, INS spectroscopy provides access to the low-frequency lattice vibrations, which govern how mechanical energy from a mechanical impact is absorbed by the material and ultimately triggers the explosive reaction.

By feeding these INS spectra into a computational model, the research team can determine how much energy is absorbed by the explosive after a mechanical impact. This provides a key predictive metric for the reactivity (and hence safety) of energetic materials.

This work highlights how neutron spectroscopy can do more than reveal fundamental material properties: by screening sensitivity early, researchers can design explosives that meet performance needs while minimising risk, paving the way for safer technologies in critical sectors.

Adam Michalchuk, University of Birmingham, by the Tosca instrument



**Instruments:** Tosca

**Related publication:** Evaluating the impact sensitivity of energetic materials using inelastic neutron scattering and low frequency THz-Raman spectroscopies. *Phys. Chem. Chem. Phys.*, 2025, 27, 25276–2528. DOI: 10.1039/D5CP03040D

**Funding:** UK's Materials and Molecular Modelling Hub, partially funded by EPSRC

**Authors:** A. A. L. Michalchuk (University of Birmingham), C. A. Morrison, C. R. Pulham (University of Edinburgh) and S. Rudić (ISIS).

## Using neutrons and nanotubes to challenge assumptions about solvent behaviour

Thanks to the unique capability of the NIMROD beamline at ISIS, researchers from Oxford, UCL, Imperial, Queen Mary, University of London, have been able to investigate the behaviour of a solvent near a charged surface, discovering there is a lot more complexity than was previously assumed.

Charged surfaces and solvents are present in many different systems, from paints and dyes to batteries and supercapacitors. In trying to understand these systems, it is common for scientists to ignore the effects of molecular shape and arrangement of the solvent, which have been notoriously hard to measure. In this study, a team were able to interrogate solvent ordering at charged surfaces in unprecedented detail, finding far more complex picture than previously assumed.

There is a common simplification that assumes that the 3D structure of solvent molecules can be greatly simplified when considering solutions of ions and larger dissolved entities, and how these species approach surfaces. While sometimes this approximation can be useful, in many cases it gives a poor description of the system, especially when these surfaces approach the size of the molecules. The researchers focussed on this regime by investigating solvent ordering in a concentrated solution of charged carbon nanotubes.

The NIMROD beamline is uniquely optimised for this type of study as it's possible to look at both the length scale of the nanotubes themselves and that of the solvent molecules around them.



Camilla Di Mino, University of Oxford, and Tom Headen, ISIS, on the NIMROD instrument

Because of the distinct interaction between neutrons and hydrogen, the team could determine the position of hydrogen atoms, essential for the hydrogen-rich organic solvents commonly employed in batteries and supercapacitors.

They found that the 3D shape of the solvent molecule is very important. At the interface, these bulky molecules compete with the ions by hindering the accessible space and dramatically reordering. The effects reached far out into the bulk, as if the surface is acting as a template for the solvent. Their results show that solvent ordering is far more complex than previously thought. The understanding gained from this research paves the way for rationally informing the design of next-generation devices.

**Instruments:** NIMROD

**Related publication:** Intermediate-range solvent templating and counterion behaviour at charged carbon nanotube surfaces. *Nature Nanotechnology*, 20, 639–645 (2025).

DOI: 10.1038/s41565-025-01865-9

**Funding:** The Royal Society, EPSRC, European Research Council

**Authors:** C. Di Mino (UCL, now University of Oxford), N. S. Basma, D. J. Buckley, N. T. Skipper, C. A. Howard, A. J. Clancy (UCL), T. F. Headen (ISIS), M. S. P. Shaffer (Imperial College London), P. L. Cullen (QMUL), M. C. Wilding (UK Catalysis Hub).

## A cutting-edge experiment that's good for business

The Swedish multinational engineering company Sandvik, in collaboration with the spin-out company Scatterin, used ISIS to characterise the materials used in their cutting tools, providing information they can use to improve them.

Hard metal, composed of tungsten carbide (WC) particles bound together by a cobalt-rich binder, is the material choice for tools for metal cutting and rock drilling. During operation, the tools can reach temperatures exceeding 900°C and, since they are subject to significant mechanical stress, residual stresses become an important parameter affecting performance and tool failure. Cutting tool life can be made up to three times longer by adding chromium (Cr) to cemented carbides. The mechanistic understanding of the improved properties by Cr-doping is critical for accelerating innovations and reducing the lead-time for product development.

Sandvik took their engineering challenge to Scatterin, and they came to ISIS through the Industrial Collaborative R&D programme to gain understanding of the high-temperature deformation mechanisms in Cr-doped hard metals using in-situ neutron scattering.

Neutron scattering was the most suitable technique for them to use, due to the penetration depth compared to X-rays, and the large sample size that can be studied compared to lab-scale analyses.

In situ SANS experiments provided Sandvik with previously unattainable information on the evolution of the microstructure associated

with the formation, dissolution, and growth of interfacial layers and larger carbides. Their neutron diffraction measurements revealed the influence of dopants on the residual stresses; whilst the addition of Cr was found to increase residual stress in the WC particles, the addition of Ti resulted in reduced residual stress.

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Bulk measurements of material properties in situ using neutron scattering under simulated operating conditions will help us to further understand and develop our materials and tools.

**Fredrik Lindberg,**  
**Sandvik Coromant**



The cutting tools being analysed on the Engin-X instrument.

**Instruments:** Larmor and Engin-X

**Related publication:** Residual stresses and microstructure in fine grained cemented carbides doped with Cr and Ti. *International Journal of Refractory Metals and Hard Materials*, 128, 2025, 107005. DOI: 0.1016/j.ijrmhm.2024.107005

**Funding:** Sweden's Innovation Agency, Vinnova

**Authors:** J. Weidow, G. Olsson, V. Lilja, D. Mayweg, M. Thuvander (Chalmers University of Technology), A.B. Yildiz (Scatterin AB), S. Sten, I. Borgh (Sandvik Mining and Rock Solutions), P. Hedström (KTH Royal Institute of Technology), M. Kritikos, F. Lindberg, E. Coronel (AB Sandvik Coromant), J. Kelleher (ISIS), S. Norgren (Sandvik and Lund University)

# Life science and healthcare

## Neutrons reveal the workings of a last-resort antibiotic

With the unique insight from neutron reflectometry, researchers from Newcastle University and ISIS have discovered how the last-resort antibiotic polymyxin B breaks down bacterial membranes.

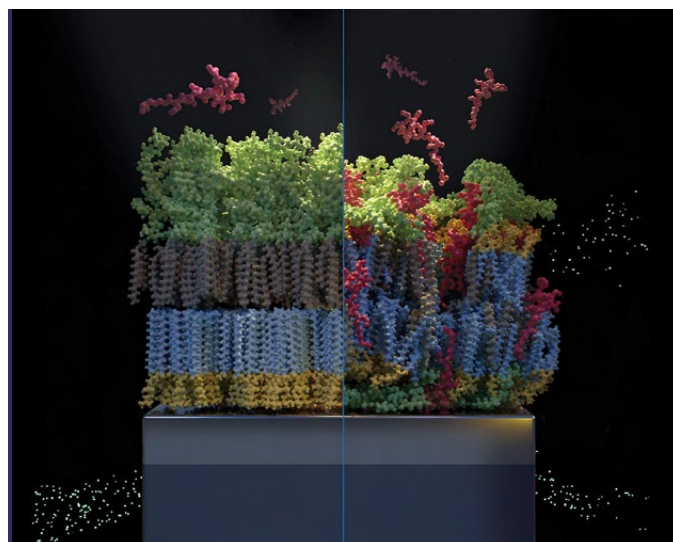
Bacteria fall into two main categories: Gram-positive and Gram-negative. Gram-negative bacteria have an additional impermeable membrane. This outer membrane differs from typical phospholipid bilayers and consists instead of phospholipids on its inner layer and lipopolysaccharides (LPS) on its outer surface. These LPS molecules form an impermeable barrier for many antibiotics, but polymyxin B stands out as a last-resort drug, as it can breach it by destabilising the LPS interactions in the membrane. This leads to the irreparable damage and the cell death that's needed to beat the infection.

Bacterial cell membranes consist of lipid bilayers approximately five nanometres thick, which makes detailed atomic-scale investigation extremely challenging. Neutron reflectometry offers a solution by measuring the structure of these ultra-thin layers at the molecular level without damaging the membrane during measurement.

Their results revealed that polymyxin B only damages bacterial membranes at 37°C but had no effect at room temperature. This dramatic all-or-nothing response demonstrates how the temperature-induced phase transition of LPS molecules, from gel to fluid state, enables antibiotic penetration.

The group were also able to make the most of the sensitivity of neutrons to different isotopes of hydrogen. They used deuterated LPS and lipids to precisely map the antibiotic's distribution across the membrane and found that it accumulates in the LPS hydrophobic region.

While the fight against antibiotic resistance continues, understanding the physical mechanisms of antimicrobial action helps us develop more effective strategies against bacterial resistance. This knowledge proves crucial for preserving our remaining antibiotic options and developing new ones.



The model bacterial membrane with (right) and without (left) disruption from polymyxin B.

**Instruments:** OffSpec

**Related publication:** Related publication: Depth-Resolved Temperature-Dependent Penetration of Polymyxin B in Phospholipids/Lipopolysaccharide Asymmetric Bilayers. *ACS Omega*, 2025, 10, 3, 2616–2627. DOI: 10.1021/acsomega.4c07648

**Funding:** STFC, Newcastle University and OJ Bio Ltd

**Authors:** N. Paracini (ILL, now ESS), J. H. Lakey (Newcastle University) and L. A. Clifton (ISIS)

## BioNTech and the European Molecular Biology Laboratory (EMBL) use neutrons to progress mRNA vaccine research

Their collaborative approach aimed to improve nanoparticle formulations for the pharmaceutical application of mRNA molecules.

mRNA is a natural information-carrying molecule that cells read to make a specific protein. An mRNA vaccine contains information for making a key protein of a pathogen. However, the mRNA molecule is too unstable to be used for pharmaceutical application without protection. In saRNAs (self-amplifying RNAs), a format of

mRNAs that could be developed in potential new RNA vaccines, polymer-based systems have been identified to be particularly effective for the delivery.

One of these polymer systems is polyethylenimine (PEI), a clinically established gene delivery vehicle. It forms polyplex nanoparticles when mixed with RNA, where the polymer to RNA ratio (N/P) and the size of the nanoparticles formed are important for determining their biological performance.

Using hydrogen/deuterium contrast experiments at ISIS, the group studied the formation of polyplexes from PEI and saRNA at a range of N/P ratios. By combining these results with other characterisation techniques and testing the samples' biological activity, they aimed to investigate how the way that the nanoparticles are assembled affects their behaviour.

They found that, unexpectedly, the saRNA molecules could be stabilised in the form of very small nanoparticles in solution. They are much smaller than the lipid nanoparticles, comprise mostly only one saRNA molecule, and performed well in experiments against influenza. These formulations are easy to manufacture and are low cost, which indicates they could be a good choice for developing into clinical products.

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Combining experiments at X-ray and neutron scattering facilities can create new insights with practical impact for development of future pharmaceuticals.

Heinrich Haas, BioNTech SE  
and now Neovac Ltd



**Instruments:** Zoom and SANS2D

**Related publication:** Compact polyethylenimine-complexed mRNA vaccines. *Nature Nanotechnology*, 20, 1323–1331, 2025. DOI: 10.1038/s41565-025-01961-w

**Authors:** Jorge Moreno Herrero, Theo B. Stahl, Stephanie Erbar, Konrad Maxeiner, Anne Schlegel, Tijana Bacic, Jens Schumacher, Ugur Sahin & Heinrich Haas (BioNTech SE), L. P. Cavalcanti (ISIS), M. A. Schroer and D. I. Svergun (European Molecular Biology Laboratory)

## Neutrons pave the way for new cancer therapies

Researchers from Jagiellonian University in Krakow, the Polish Academy of Sciences and ISIS have shown how neutron techniques can be used to characterise candidate boron-containing substances for use in boron neutron capture therapy (BNCT) to treat some cancers.

BNCT has been used since the 1950s to treat some types of cancer. The therapy works by introducing a boron compound containing boron isotope  $^{10}\text{B}$  to tumour cells. Exposing those cells to a neutron beam produces alpha and lithium-7 particles and gamma rays, damaging DNA in the tumour cell.

In this study, the researchers were interested in how local quantum dynamics of different isotopic species in different functional groups affects the absorption and scattering of thermal and epithermal neutrons in solid boric acid. They used the Vesuvio beamline at ISIS, which provides a unique combination of techniques at thermal-to-epithermal neutron energies.

Modelling in BNCT and other neutron cancer therapies previously assumed that neutrons interact with tissues and other materials composed of mixtures of non-interacting atoms. The main finding was that one has to take into account the local quantum rotations and vibrations of isotopes in functional groups at a finite temperature to correctly model the neutron transport in tissues.

The researchers also used prompt-gamma detection to identify different boron isotopes BNCT relies on  $^{10}\text{B}$  isotope only, so understanding which isotopes are present is vital for the design of new BNCT therapeutics.

**Instruments:** Vesuvio

**Related publication:** Nuclear quantum dynamics of boric acid as probed by a thermal-to-epithermal neutron station. *Sci. Rep.*, 15, 45447 (2025). DOI: 10.1038/s41598-025-29342-2

**Funding:** EU Horizon 2020, Jagiellonian University, Ministry of Education and Science, Foundation for Polish Science, Interreg South Baltic Region.

**Authors:** K. Dziejcz-Kocurek, M. Silarski, P. Grabowski (Jagiellonian University), L. Druzbicki (Polish Academy of Sciences), M. Krzystyniak (ISIS)

## Neutrons prove critical for cocrystal characterisation

Researchers from the University of Glasgow, Johnson Matthey and ISIS have comprehensively characterised a pharmaceutical cocrystal, with neutron experiments providing key insights.

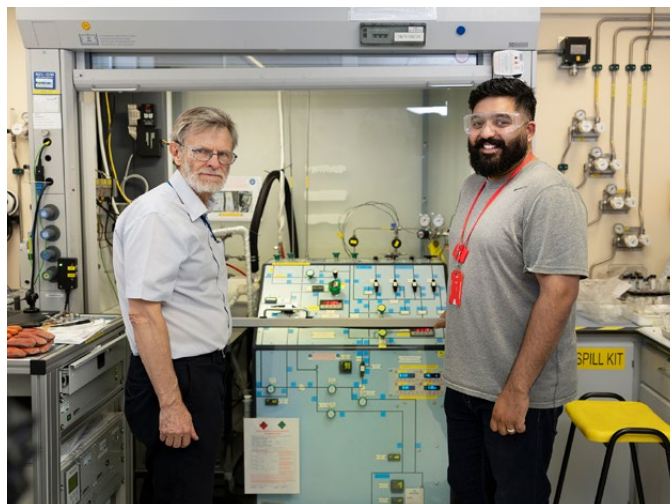
One method to improve the solubility, stability, and bioavailability of a poorly soluble drug is to combine it with another molecule to form a cocrystal. When in a cocrystal, the physicochemical properties of the drug are dependent on the overall structure, including the hydrogen bonding between the molecules.

In this study, the researchers used multiple analytical techniques, including neutron scattering, to characterise the structure of a cocrystal of the fungicide pyrimethanil, a proxy for new drug delivery vectors that are currently under development.

Their aim was to determine whether Fourier transform infrared spectroscopy in attenuated total reflection mode (FTIR-ATR), could be used for studying the hydrogen bonding in the crystal structure of a representative cocrystal.

First, they needed to fully characterise the cocrystal by doing single crystal diffraction studies using X-rays and then neutrons. Their X-ray studies provided useful geometric parameters, but to resolve the positional ambiguities of the hydrogen atoms they needed to use neutrons.

The team used their diffraction data as a basis on which to carry out computational modelling to predict the vibrational properties of the



Stewart Parker and Ramandeep Dosanjh in the ISIS preparation laboratory.

cocrystal. They were then able to measure the vibrational modes experimentally using inelastic neutron spectroscopy. Again, the inherent sensitivity of neutrons to the hydrogen atoms in the system was extremely useful. It enabled the team to assign the hydrogen-bonding deformation modes and use these as a basis for the analysis of the FTIR-ATR and Raman spectroscopy.

They found that Raman spectroscopy would not be a useful tool, but that there was greater diagnostic capability afforded by the FTIR-ATR.

**Instruments:** SXD and Tosca

**Related publication:** Spectroscopic investigations of a pharmaceutical solid form analogue: pyrimethanil l-tartaric acid hemi-cocrystal. *Phys. Chem. Chem. Phys.*, 2025, 27, 24766–24776. DOI: 10.1039/D5CP02802G

**Funding:** EPSRC and Johnson Matthey

**Authors:** R. S. Dosanjh, C. Wilson, D. Lennon (University of Glasgow), A. Patterson (Veranova), J. Harris (GlaxoSmithKline), M. J. Gutmann, S. F. Parker (ISIS), P. Collier, T. Johnson, T. Hyde, A. P. E. York (Johnson Matthey)

## A new way of folding DNA

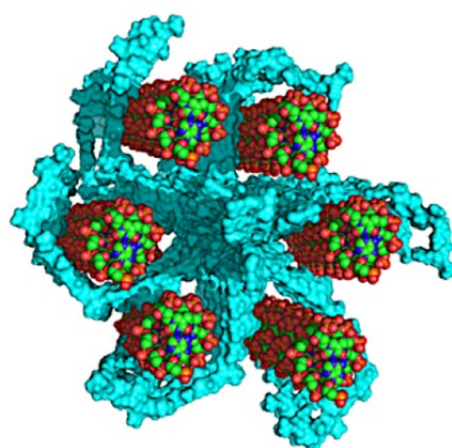
Using a combination of experimental techniques, an international research team has been able to, for the first time, characterise the structure and mechanism of a DNA bridging protein with an amyloid structure.

In all organisms, DNA is folded to fit inside the cell, and this folding is done by specific proteins in the cell. In this study, the researchers focused on the bacterial protein *E. coli* Hfq (Host factor Q-beta). Hfq is best known for its role in RNA-related processes, but it can also act as a DNA-bridging protein. It uses an amyloid-like region in its structure for the bridging, but the structure of the Hfq C-terminal region responsible for DNA bridging is not well characterised and therefore its mechanism is not fully understood.

To investigate this bridging mechanism in more detail, the team used a range of characterisation techniques, including neutron scattering. By using contrast variation, their small angle neutron scattering experiment at the ILL enabled them to highlight one component in the system at a time. Inelastic neutron scattering at ISIS allowed them to directly investigate the conformational changes of the protein. When combined, their results from all these techniques enabled the team to propose a model for the complex formed by the amyloid portion of Hfq and DNA.

They identified a unique mechanism in which the nucleoid-associated protein Hfq binds DNA edge-on and oligomerises into amyloid filaments, rather than wrapping DNA around its surface like in eukaryotic nucleosomes.

This novel mechanism of DNA bridging is important for genome organisation and the regulation of gene expression in simple cells and is also likely to be important for more complex cells. It will also shed light on the possible expanding role of amyloids, which are implicated in neurodegenerative diseases.



3D structural model of a transverse cross section of the fibre.

**Instruments:** Tosca

**Related publication:** Amyloid-like DNA bridging: a new mode of DNA shaping. *Nucleic Acids Research*, 53, 5, 2025. DOI: 10.1093/nar/gkaf169

**Funding:** EU Horizon 2020

**Authors:** F. Wien (Synchrotron SOLEIL), M. Gragera, M. T. Bueno-Carrasco, R. Arranz (Centro Nacional de Biotecnología), T. Matsuo (ILL, Hiroshima International University), G. Moroy (Université Paris Cité), A. Cossa (Laboratoire Léon Brillouin), A. Martel (ILL), H. N. Bordallo (University of Copenhagen), S. Rudić (ISIS), M. Velez (Instituto de Catálisis y Petroleoquímica), J. R.C. van der Maarel (National University of Singapore), J. Peters (Univ. Grenoble Alpes, ILL, Institut Universitaire de France), V. Arluison (Laboratoire Léon Brillouin, Université Paris Cité)

## Revealing the molecular origins of e-cigarette/vaping-associated lung injury

A group of researchers have found that vitamin E acetate, a common additive in illegal vaping, softens phospholipid model membranes, explaining its link to lung injury.

E-cigarette and vaping associated lung injury (EVALI) emerged in 2019. Since then, researchers have been investigating the biophysical impact of the additives used in these devices. In this study, the group exclusively focused on vitamin E acetate (VEA), which has been linked to lung damage in cannabis-based vape users.

Although VEA has since largely been banned for consumption by inhalation, it may still be present in the inhaled vapours after being used to dilute other ingredients.

The group used neutron techniques to study the interaction between VEA and a model pulmonary surfactant membrane, like those found in the lungs. They found that the VEA does not significantly disrupt the monolayer structure of the membrane, leading them to determine that the mechanism of action lies in the mechanical/dynamic properties of the pulmonary surfactant.

The group's findings provide a foundation for the respiratory toxicity of VEA but also show the significance of the composition of the lipids in the membrane on the fundamental biophysics of breathing. Their results can be used to understand other respiratory irritants and illnesses in the future.

“

Neutron reflectometry is one of the few techniques that is able to probe soft matter monolayers at sub-molecular resolutions. The Inter reflectometer provided us with a world-class instrument to measure these monolayer structures across a broad length scale with high-resolution, all under biologically relevant conditions.

Drew Marquardt,  
University of Windsor

**Instruments:** Inter

**Related publication:** Vitamin E Acetate Causes Softening of Pulmonary Surfactant Membrane Models. *Chem. Res. Toxicol.* 2025, 38, 3, 400–414. DOI: 10.1021/acs.chemrestox.4c00425

**Funding:** Natural Sciences and Engineering Research Council of Canada (NSERC)

**Authors:** M. DiPasquale, M. Dziura, O. Gbadamosi, S. R. Castillo, A. Fahim, J. Roberto, P. C. Chandrasekera, D. Marquardt (University of Windsor), J. Atkinson, N. Boccalon (Brock University), M. Campana (ISIS), S. V. Pingali, P. A. Zolnierczuk (Oak Ridge National Laboratory), M. Nagao (National Institute of Standards and Technology, University of Maryland, University of Delaware), E. G. Kelley (National Institute of Standards and Technology)

## Learning from the Dengue virus to develop new antimicrobials

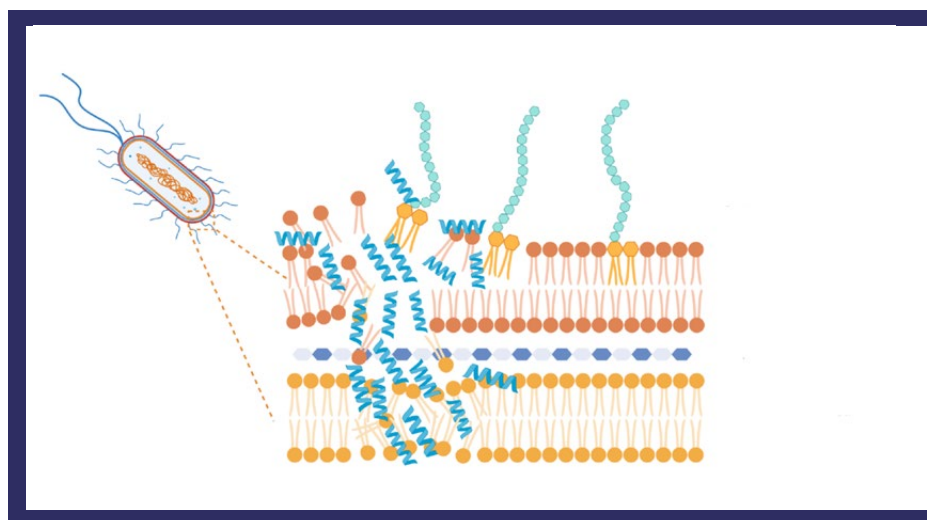
Inspired by a membrane-interacting region of the Dengue virus capsid protein, researchers from the University of Manchester have developed a series of new antimicrobial peptides (AMPs) that have improved bactericidal effects compared to natural AMPs.

AMPs can cause fast disruptions to the structure of bacterial membranes and kill pathogens by causing the leakage of their internal contents. This mechanism makes it less likely for pathogens to develop resistance. However, current AMPs still suffer from various drawbacks such as low efficacy and side effects.

In this study, the group aimed to address the challenges associated with natural peptides by designing synthetic peptides based on the  $\alpha 2$  region of the Dengue virus serotype-2 capsid protein. They hoped to mimic the membrane-disrupting properties while overcoming their limitations.

Their peptides were able to break through both real and model bacterial membranes more effectively than the previously studied AMP, G3. To understand the mechanism behind this, the group used neutron reflectometry and found that their peptide caused greater structural disruption in an LPS-containing model of the Gram-negative bacterial outer membrane than in a phospholipid model of the inner membrane.

Their work offers new insights into how these newly designed AMPs destabilise bacterial membranes and gives further insight into how we can work to develop medicines with improved antimicrobial performance.



The inner and outer membranes of a Gram-negative bacterium being disrupted to different extents by the AMPs.

**Instruments:** Inter

**Related publication:** Rational Design of Broad-Spectrum Antimicrobial Peptides Derived from the Dengue Virus Capsid Alpha2 Sequence. *ACS Appl. Mater. Interfaces*, 17, 34, 47894–47905, 2025. DOI: 10.1021/acsami.5c07879

**Funding:** The University of Manchester and BBSRC

**Authors:** Y. Wang, M. Liao, T. Ge, K. Ding, J. R. Lu (The University of Manchester), A. Hughes and P. Li (ISIS).

## Studying novel fertilisers using large-scale facilities

A scientific collaboration between Cranfield University, ISIS, Diamond Light Source, and the Central Laser Facility focused on developing more sustainable fertiliser solutions.

The manufacture of mineral fertilisers such as ammonium nitrate or urea produces almost two percent of global greenhouse gas emissions. Organo-mineral fertilisers use much less of these mineral ingredients, combining them with organic material such as manure or straw.

However, the organic materials are naturally varied, unlike the standard mineral ingredients. For farmers, reliability between batches is important, and the industry needs a way of assessing variability and ensuring the new fertiliser will be suitable for widespread application.

In this research, the scientific team developed a correlative study on a novel fertiliser. This fertiliser was produced by combining organic material with a small amount of mineral ingredients and carbon dioxide captured from carbon emissions.

Neutron imaging on IMAT at ISIS was used alongside synchrotron X-ray imaging on I12-JEEP at Diamond Light Source and Raman spectroscopy at CLF. Their paper is the first one to use large-scale facilities to evaluate the physical and chemical properties of these fertiliser pellets.

The correlative experiments showed the internal structure of the pellets, proving that

the manufacturing process produces intact pellets that could be applied successfully using a spreader. These spreaders propel the pellets up to 36 metres across a field, and it's important that the pellet remains intact during this process, giving an even distribution of fertiliser and therefore crop growth.

The results of these experiments will give farmers confidence when using this novel fertiliser.

“

Organo-mineral fertiliser pellets offer new opportunities in agriculture to utilise more organic amendments to improve soil health. Neutron imaging and synchrotron X-ray imaging offer a valuable technique for investigating the pellets, as they are non-destructive to assess their physical integrity and uniformity of packing.

**Ruben Sakrabani,**  
**Cranfield University**

**Instruments:** IMAT, I12-JEEP (Diamond Light Source), CLF

**Related publication:** Feasibility study on using combined tomography and spectroscopy techniques to evaluate the physical and chemical characteristics of organo-mineral fertilisers. *Front. Sustain. Food Syst.*, 9, 2025. DOI: 10.3389/fsufs.2025.1570461

**Funding:** STFC Food Network +

**Authors:** R. Sakrabani (Cranfield University), S. Mosca (CLF), A. Liptak (Diamond Light Source), G. Burca (ISIS and Diamond Light Source)

## Revealing the structure of cow and goat milk proteins

For the first time, researchers have used spin-echo small-angle neutron scattering (SESANS) to examine the structure of the protein casein in heated and unheated milk from cows and goats.

Casein forms most of the protein found in cow and goat milk, where it combines with calcium phosphate to form self-assembled proteins structures called casein micelles. The larger-scale aggregation of these micelles causes gelation, which is required for cheese and yoghurt production. To induce gelation, manufacturers can use acid or enzyme treatments, which alter the structure of the casein micelles in different ways, to form dairy products with different properties.

Milk also undergoes various other processes, such as heat treatment, before it can be used in food. In milk, casein micelles react with heat-denatured whey proteins at high temperatures. This causes structural changes in the casein micelles, which can alter their gelation behaviour.

The researchers treated cow and goat milk, then used SESANS on the Larmor instrument at ISIS, together with complementary confocal microscopy and rheological studies, to investigate the structure of the casein micelles and the gels. They found that goat milk forms larger, less hydrated, micelles than cow milk. After heat treatment, the casein micelles in both cow and goat milk increase in size, due to aggregation with whey proteins in the milk.

The results also showed that the effects of heat treatment were greater in cow milk gels than in

goat milk gels. Heat treatment also had different effects on gel structure depending on whether the milk was acid or enzyme treated. The findings will help manufacturers better control and optimise food production.

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Not many techniques allow us to study both the effects of processing on casein micelle structure and their gel structures in such detail.

**Swantje Breunig, Wageningen University & Research**



Zekun Fan, Wageningen University, Rafael V.M. Freire, Eindhoven University of Technology, Swantje Breunig, Wageningen University.

**Instruments:** Larmor

**Related publication:** Effect of heat treatment on casein micelle structure and acid and rennet gel properties in goat and cow milk – a SESANS approach. *Food Hydrocolloids*, 173, 2026, 112242. DOI: 10.1016/j.foodhyd.2025.112242

**Funding:** Ausnutria B.V., Dutch Research Council and China Scholarship Council

**Authors:** S. Breunig (Wageningen University and Research, Ausnutria B.V.), Z. Fan, R. Bouma, K. Hettinga, E. Bijl (Wageningen University and Research), G. N. Smith (ISIS), R. V.M. Freire, I. K. Voets (Eindhoven University of Technology) and Steven R. Parnell (ISIS, TU Delft)

# Discovery science

## Correlative imaging aids conservation of archaeological bones

Neutron tomography has enabled researchers to see the distribution of organic material within bones found at archaeological sites in the UK. Combined with synchrotron X-ray tomography, the researchers were able to reveal hidden details in the bones, including the distribution of organic material and previously invisible damage, which will help inform future analysis and conservation work.

Archaeological animal bones are an important source of information about how people lived and their relationships with the wider environment. Researchers use various techniques to examine archaeological bones to understand their preservation, but they all require damaging the bones to some degree. Neutrons and X-rays offer the potential for non-destructive testing. Neutrons are particularly sensitive to elements found in organic material, so neutron imaging can be used to non-invasively identify patterns of organic preservation in archaeological bone.

The interdisciplinary research team examined seven animal bones from four sites across the UK. Neutron imaging found organic matter along the outermost surface of the bones, although

there was substantial variation in how organic materials were preserved throughout the bones and between samples.

The findings demonstrate that neutron imaging could be a useful screening technique to identify target areas on samples for other analysis methods, including histology or Fourier transform infrared spectroscopy (FTIR). These methods often rely on spot sampling, so selecting the right sampling location is crucial if the results are to provide an accurate description of the bone's condition.

The first author, Chloe Pearce, completed the work during her PhD, which was funded by AHRC in collaboration with English Heritage and Birkbeck, University of London.

This study demonstrates that combining neutron and X-ray tomography provides a powerful, non-invasive toolkit for assessing archaeological bone preservation. It calls into question the reliability of traditional spot-sampling methods and highlights the need for context-aware, whole-object analysis in heritage science, adds Genoveva Burca from Diamond Light Source.



One of the cattle bones studied in the experiment.

**Instruments:** IMAT (ISIS), I12-JEEP (Diamond Light Source)

**Related publication:** Non-Invasive Preservation Assessment of Archaeological Animal Bones by Complementary Imaging Techniques. *Heritage* 2025, 8(9), 347. DOI: 10.3390/heritage8090347

**Funding:** AHRC

**Authors:** C. Pearce, M. Odlyha (University of London, Birkbeck) F. Léonard (ESRF, Diamond light Source), O. V. Magdysyuk (Diamond Light Source, University of St Andrews), D. Thickett (English heritage Trust) and Genoveva Burca (Diamond Light Source, ISIS, The University of Manchester)

## Neutron scattering reveals the unexpected structure of space ice

Zac Amato and his colleagues from The Open University and ISIS used neutron scattering to gain an insight into the structure of ice relevant to planet- and star-forming regions.

Within the enormous clouds where planets and stars form, temperatures are incredibly cold, allowing gases to condense onto dust grains to form ice. These complex multi-component interstellar ices are mainly made of Amorphous Solid Water (ASW) in which water molecules are disordered, unlike the crystalline ice you would find in your freezer. The structure of ASW, such as its porosity, determines the chemistry that it supports. However, most astrochemistry studies rely on indirect measures of porosity, which can be either unreliable or limited.

To shed light on this issue, the team used a complex experimental setup to grow space ice in situ at ISIS. That allowed them to use neutron scattering to understand how the ASW structure and porosity is impacted by the temperature of its formation, or deposition, as this varies depending on the region of space in which the ice forms.

Their results have led to a new picture of the overall ASW structure, which involves microporous islands with voids between them. This differs significantly from prior models visualising ASW to date.

“

Overall, these neutron scattering studies have drastically changed our picture of the structure of interstellar ice and the role this plays in processes that lead to planet- and star-formation.

**Zac Amato,**  
The Open University and ISIS

These complex experiments relied upon the support of the Pressure and Furnace, Cryogenics, Electronics and Soft Matter groups at the ISIS, who helped the group set up the dedicated deposition setup and were on hand to help solve any problems.

**Instruments:** NIMROD and SANS2D

**Related publication:** Using neutrons to ascertain the impact of deposition temperature on amorphous solid water. *Phys. Chem. Chem. Phys.*, 2025,27, 6616–6627. DOI: 10.1039/D5CP00270B

**Funding:** STFC, UK Space Agency

**Authors:** Z. Amato, S. Gärtner (ISIS and the Open University), T. F. Headen, T. G. A. Youngs, D. T. Bowron, L. Cavalcanti, S. E. Rogers (ISIS), P. Ghesquière, N. Pascual, O. Auriacombe, E. Daly, R. E. Hamp, C. R. Hill, R. Kumar and H. J. Fraser (The Open University)

# Working with industry

## Helping industry develop more resilient technologies for critical applications

From internet routers and data centres to electric vehicles, aeroplanes, satellites and artificial intelligence – modern society relies on electronic devices and systems. However, environmental radiation from cosmic rays has become a serious problem for technology, particularly in critical safety and infrastructure applications. Over the last decade, the ChipIrr instrument has provided an almost unique capability helping industry understand and mitigate these risks.

ChipIrr is Europe's only dedicated fast-neutron irradiation facility of its kind and one of only a handful worldwide. It reproduces the effects of atmospheric neutrons generated by cosmic rays and solar activity, enabling organisations to assess how electronic devices and systems perform under real-world radiation exposure. This capability is essential for testing technologies used in sectors including aerospace, communications, automotive and high-performance computing.

As a result, ISIS has become a major international centre for radiation-effects testing, supporting many of the world's leading technology companies including Infineon, NVIDIA, Broadcom and CISCO. ChipIrr's user base is almost entirely commercial, generating about £1 million in income for ISIS, with users from 14 countries benefiting from its expertise and infrastructure.

The instrument also supports strategically important national and international programmes, contributing to initiatives in space weather resilience, nuclear robotics and European irradiation testing networks.

As a unique national capability and globally recognised centre of expertise, ChipIrr is playing a vital role in strengthening UK research, innovation and industrial competitiveness in our increasingly technology-dependent world.

## Industrial Advisory Committee established

In August, the ISIS Industrial Advisory Committee (IIAC) met for the first time, bringing together representatives from a range of sectors with experience of using large-scale research facilities.

The committee will meet annually to provide strategic advice on industrial engagement, helping ISIS identify opportunities to strengthen support for commercial users and inform the development of our industrial strategy. The inaugural meeting covered topics including access mechanisms, strengthening engagement with industry and opportunities to develop ISIS's offer to industry.



Members of the newly formed Industrial Advisory Committee met with ISIS colleagues for the committee's inaugural meeting at ISIS.

## Katie Hughes

Katie joined ISIS in February 2026 as the Business Development Manager. Her role is to understand where ISIS can best help with industry problems and then reach out to businesses and build those collaborations.

Katie studied biochemical engineering at UCL, before completing her PhD at the University of Sheffield in stem cell research; developing bone grafts for cleft palate patients. She then moved to Keele University as a postdoctoral researcher in a similar field before leaving academia for industry and joining Adaptimmune: a clinical-stage biopharmaceutical company focused on the development of novel cancer immunotherapy products for cancer patients.

While at Adaptimmune, Katie initially worked in the laboratory as part of the Allogeneic group, but then the programme required additional investment to continue and so she transitioned into more of a business development role.

“

When I first started my career, I couldn't imagine myself away from the laboratory bench. But then when I experienced building other people's excitement in our research, I realised I couldn't go back!

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**Katie Hughes**



Without funding gained from outside investors, the stem cell research carried out by her group at Adaptimmune wouldn't have progressed as far as it did. "These kinds of projects, especially in start-ups or small/medium-sized companies, need external funding to keep them going, which is something the scientists can forget," she adds.

Since joining ISIS, Katie has focussed on understanding which techniques at ISIS are best placed for helping to solve problems for industry and then finding ways to reach businesses in those areas. "I needed a crash course in neutron science when I started," she says, "but everyone has been extremely helpful in explaining what they do, and its relevance to industry."



# World-class technology and infrastructure

Across ISIS, teams are continually developing the technology, infrastructure and expertise behind every experiment. Their work helps researchers ask more ambitious questions, push experiments further and open new areas of discovery. As we build future capability, we are also making sustainability a stronger part of how ISIS grows, operates and supports world-class science.



Grace Fenemore at the ISIS Target Manufacturing facility

# Sustainability

The ISIS Sustainability Strategy, launched in 2022, supports STFC's goal of reaching net zero by 2040. It focuses on developing the skills, knowledge and processes needed to reduce emissions while maximising scientific output.

## Reducing our carbon footprint

Since 2021, ISIS has been tracking its annual energy use, along with total CO<sub>2</sub> emissions and the amount of CO<sub>2</sub> emitted per unit of beam delivered. In the year to April 2026, ISIS recorded its lowest annual carbon emissions and most carbon-efficient beam delivery since monitoring began. While there is still much to do, things are heading in the right direction.

## Smart metering

ISIS's live energy consumption is now displayed in the Main Control Room, like a smart meter in your home. This gives teams real-time insight into the impact of their equipment, helping them identify opportunities to reduce energy use. During the Christmas 2025 shutdown, these actions, together with a targeted energy saving campaign, reduced the average instantaneous power demand from 2.1 MW to 1.7 MW compared with the same period the previous year.



## R80 adiabatic cooler project

In 2024, an adiabatic cooling system was installed in R80 to improve cooling efficiency and reduce the environmental impact, while maintaining reliable operation of key accelerator infrastructure. The first full year of operational data demonstrates significant savings, including:

**11,350 m<sup>3</sup> of water**

**18,800 kWh of electricity**

**36.8 tonnes of CO<sub>2</sub>**

**£49.9k operational costs**

## Laboratory lighting upgrade

The Support Laboratories group has led a project to replace laboratory lighting across ISIS with energy-efficient LED systems. The new lighting has improved safety and visibility, while reducing energy consumption by around 60%. The upgrade is expected to save 12,073 kWh of electricity annually.

ISIS's live energy consumption on display in the Main Control Room

## Recycling rate success

By necessity, ISIS operations generate between 100 – 200 tonnes of radioactive waste per year – mostly metals, like magnets and shielding. Last year, 90% of this waste was reused or recycled, up from 55% just a few years ago.

The Health Physics and Facility Safety Group worked with regulators to implement the UK Government's 2023 risk-based approach to radioactive waste management. This allows much of ISIS's radioactive waste to be treated, separated and stored safely until radiation levels fall sufficiently for the material to be recycled. Over the lifetime of ISIS, this is expected to save 51,600 tonnes of CO<sub>2</sub>e compared with using new metal.

The ISIS Health Physics and Facility Safety Group



## Recycling deuterated water

ISIS uses around 250 L of deuterated water (D<sub>2</sub>O) each year. Producing D<sub>2</sub>O is energy intensive, and inflation has driven costs up to around £2000 per kilogram. Long lead times also creates supply challenges. To address these issues, James Tellam and June McCorquodale from the ISIS Deuteration Facility, with colleagues the Support Laboratories Group, developed a new process to recover and reuse D<sub>2</sub>O. The approach reduces costs and supply pressures while supporting more sustainable science.



Rachel Pearce prepares the rotary evaporator in the Deuteration Laboratory

## All-electric forklifts

In support of STFC's sustainability goals, the Lifting Operations team has completed the transition to an all-electric forklift fleet, helping to reduce carbon emissions across the facility.

# Neutron and muon instrument projects

## Endeavour

Endeavour is ISIS's programme of large neutron and muon instrument development projects. It is funded mainly by the UKRI Infrastructure Fund.

Two of the nine projects being developed as part of the Endeavour programme are in implementation with component procurement well underway.

SuperMuSR is a new concept of muon instrument, designed to give greater time resolution as well as flux. Key components including the pulse slicer and spin rotator electrodes have been manufactured, and the pre-build has begun. Production of detectors for SuperMuSR began in summer 2025. The first 200 optical fibres have been bent into a tight U-shape, critical to building a gapless detector for muon spectrometers.

HRPD-X is a significant upgrade of the high-resolution powder diffractometer, which includes a rebuild of the instrument building. Following removal of the existing instrument, the HRPD building was demolished and the new, larger building is in final stages of construction ready for installation of the new instrument in 2027.



Spin rotator testing.

SuperMuSR and HRPD-X are currently planned to be ready for the user programme in the first half of 2028. Sandals-2 is now also in implementation with WISH-II and Mushroom about to move to implementation and Osiris+ and Tosca+ following over the next 18 months.

Photos of the HRPD building throughout 2025 and 2026.



April 2025



August 2025



April 2026



August 2026



## Alex Gouws and Will Rowland – from apprenticeships to Endeavour

Alex Gouws is just coming to the end of his apprenticeship and is beginning a full-time role in the design division at ISIS. He has been working on two projects that are part of the Endeavour programme. For SuperMuSR, he has been working on the design of the utilities interface, which is about to move to the build phase. He'll then be working with the assembly team on its installation and alignment.

He's also just started working with the detector group and instrument scientists on the collimator for WISH-II. This project is in its early stages, in the prototyping/feedback loop. "I have to understand the science and theory behind each component and then apply it in my work – this is what drew me into working in design. My team, and the others across ISIS that I work with, are always open to questions. ISIS offers a strong ecosystem of support to its early career staff," he explains.

"The size of these projects is initially overwhelming, but it's rewarding to know that even your small piece of work is contributing to such a large programme of work. The big end goal helps keep you motivated and driving forwards."

Will Rowland will be Alex's line manager and has been supporting him through the transition from apprentice to employee. He completed the STFC apprenticeship scheme himself four years

ago and since then has worked on a series of instrument projects across ISIS.

Over the last year, he has been working on SuperMuSR, but now Will's focus is on WISH-II, designing the secondary aspects such as the detector vessel, the beam in/out snouts and the blockhouse and sample environment interactions. The design is always science-led; with WISH-II they are using new detector technology, with the aim to create coverage that is as spherical and uninterrupted as possible.

“Working on something this novel is hard but enjoyable. It's exciting to be part of the fundamental design of a new instrument. It's a bit daunting to be working on a project that will take many years but rewarding to be part of the process the whole way through. Even though it will take a long time to design and build, you know it will be operational for even longer.”

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### Will Rowland

Alongside his work, Will has been continually supported to develop his skills and is currently studying for a degree in Mechanical Engineering.

## Doing more with less

New materials are often produced in tiny quantities, which can make it difficult to study their properties, particularly at the ultra-low temperatures where exotic quantum states can emerge. To address this challenge, a novel ‘fly-past’ setup has been developed on Emu for small samples mounted on a dilution refrigerator.

In this geometry, muons that miss the sample simply fly past it, eliminating background signals. The fly-past setup has been used with samples as small as 50 mg, though in principle 15 mg is possible. Compared with conventional mounting methods, it delivers an order-of-magnitude improvement in data quality and can be used at temperatures from 50 mK to around 1300 K.

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## WISH benefits from moderator developments

WISH is the only instrument in TS2 that uses the solid methane moderator, which provides a high flux of cold neutrons with the sharp time structure needed to achieve high resolution at long d-spacing.

Over the past year, the WISH Moderator Design and Target Operation teams have commissioned two new versions of the solid methane moderator, incorporating a gadolinium ‘poisoning foil’ and new heat exchanger geometries. The new moderator has delivered a clear improvement in d-spacing resolution while maintaining a similar signal-to-noise ratio.

The new solid methane moderator assembly showing the gadolinium foil and the new plate heat exchanger.

## Software for elemental analysis

EVA, the user-friendly software developed for visualising muon elemental analysis data, has received its second release. Features include quick identification of peaks (muonic X-rays or gammas), analysis of multiple peaks, muon stopping profile, simulated data and an interactive periodic table with muonic X-rays, gamma emission and X-rays.

## LET returns to full operation

LET has returned to full operation following the replacement and alignment of its neutron guide. The work has improved beam homogeneity and increased flux for the lowest-energy neutrons by around 30%. Parts of the high-speed chopper system have also been replaced to support the long-term sustainability of the instrument.



## New detector electronics for Merlin

Design and testing work has been completed on new detector electronics for Merlin. The upgrade is expected to improve consistency across the detector bank between cycles and reduce the time required for calibration.

## Osiris upgrade

A new silicon analyser and position-sensitive detector technology have been added to Osiris, extending the instrument's accessible timescales to around 400 ps and enabling the collection of four-dimensional datasets. The upgrade allows complementary datasets to be collected in a single experiment and will support new research in areas ranging from energy materials to quantum technologies. User operation is expected from autumn 2027.

## Growing impact for Chiplr

Chiplr is playing an increasingly critical role in helping industry ensure the reliability and resilience of modern electronics, with global leaders in internet infrastructure, power electronics and AI computing hardware among its users. Planned upgrades to the fast-neutron collimation system and front-end positioning table will further enhance the instrument's performance and flexibility for testing commercial electronics.

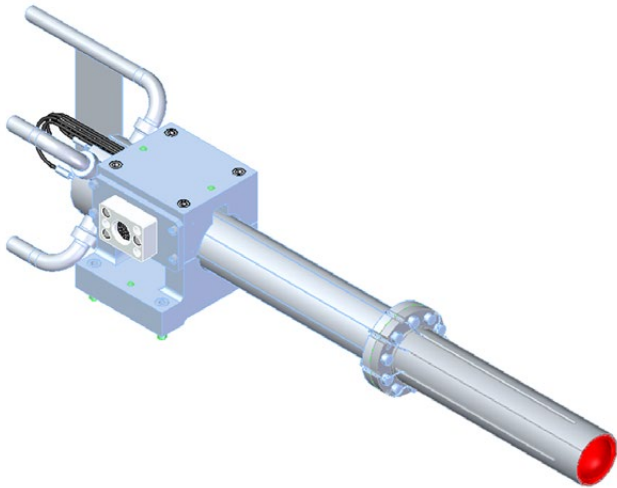
These capabilities also support academic research, including pioneering studies into the effects of neutron radiation on superconducting quantum interference devices (SQUIDs), a key technology for future quantum computers.

The fully assembled silicon analyser and the team involved in building it.



# Targets

## Target design sets new ISIS record



During cycle 2026/01, the Target Station 2 target exceeded the previous record for accumulated beam exposure. The achievement marks a major milestone in the target development programme and reflects the successful collaboration across ISIS and the Technology Department to extend target lifetimes. Longer-lasting targets reduce costs, resource use, operational effort and environmental impact.

A schematic showing the design of the TS2 target.

## New remote handling facility takes shape

Development is continuing across both target stations, with work on a new standalone remote handling facility moving from design into manufacturing and construction this year. Engineers and operators have been working closely with suppliers, carrying out site visits to inspect equipment and systems.

The new target remote handling facility under construction.



# Accelerator

## Diagnostics for the new MEBT

The Medium Energy Beam Transport (MEBT) system helps focus, steer and bunch  $H^-$  ions before they enter the linac. Ahead of the installation of a new MEBT line during the 2027 long shutdown, the ISIS Diagnostics team has installed and commissioned new diagnostic systems that provide data to optimise magnet, RF and ion source settings, supporting more efficient beam transport. The team has also developed the associated electronics, data acquisition systems and operator software.

## Beam physics collaboration with India

An ISPF project with the Indian Department of Atomic Energy has made great progress in understanding high-current low-energy beam transport processes by directly comparing  $H^+$  and  $H^-$  beams. The collaboration has also developed new technologies for plasma confinement that will provide very low emittance beams.

## Improving beam intensity

During the 2021 long shutdown, ISIS completed major accelerator and target upgrades. Beam returned in 2022, but increased proton losses in the synchrotron reduced the amount of beam delivered to the targets.

Teams from across the ISIS Accelerator Divisions undertook extensive inspections and

maintenance to identify and resolve a range of issues causing beam loss. Their efforts pinpointed the main issue as damaged RF screens within the magnet apertures. Since the RF screens were replaced at the end of 2025, beam losses have been significantly reduced and no longer restrict the beam current on target.



Members of the ISIS Accelerator groups at ISIS

## Re-engineering a critical cooling-water system

New high-power drive systems, a key part of the beam acceleration system, have improved the efficiency and reliability of the synchrotron RF system. However, part of their cooling-water system was not matched for actual flow requirements, causing unnecessary trips and interruptions to operation. Together, the Synchrotron RF and Ancillary Plant groups re-engineered the cooling-water system, replacing key control valves and flow instrumentation with a more robust system for a more reliable beam.

## Securing the future of the NINA choke

The NINA choke, an iconic part of the synchrotron magnet power system, has been operating for over 40 years. This year, the ageing oil-cooling system was upgraded with a modern water-cooled heat exchanger, alongside new environmental safeguards and refurbishment work to reduce oil leaks. The project brought together expertise from ISIS Plant Design, Ancillary Plant, Magnet Power Supplies, Electrical Design and Controls to ensure the continued reliability of this critical infrastructure.

## Leading international ion source events

The Low Energy Beams Group launched the first ever International Workshop for Ion Source Technicians at ISIS in April, with participants from ESS, CSNS and SNS. In

September, the group brought the International Conference on Ion Sources to the UK for the first time, hosting 200 delegates in Oxford for a week-long meeting.



Attendees of the 21st International Conference on Ion Sources held at St Catherine's College, Oxford.

## Preserving a piece of ISIS history

Tank IV, a former component of the ISIS linear accelerator dating back to 1976, has found a new home outside the RAL Visitor Centre. Replaced in 2021, the 6.4-tonne vessel was prepared for display by the Accelerator Engineering and Lifting Operations teams in a project championed by Mark Keelan, RF Group Leader. The exhibit is a lasting reminder of the engineering heritage behind nearly 50 years of ISIS science.



Tank IV on display outside the RAL Visitor Centre

## Jim Loughrey

After more than three decades at ISIS, Jim Loughrey has seen the facility evolve from a newly commissioned accelerator into one of the world's leading neutron and muon research facilities. Today, as Accelerator Engineering Group Leader, he leads a team responsible for maintaining and upgrading the mechanical systems that keep the accelerator running reliably for scientists from around the world.

Jim's passion for engineering started long before his career. "I always liked working with my hands, taking things apart as a kid and rebuilding them," he says.

Jim now manages a team of engineers responsible for the mechanical maintenance, installation, vacuum systems and survey work across the ISIS accelerator. One of the aspects Jim enjoys most is the variety of engineering challenges. "The scope of the work is huge. You never know what you're going to be dealing with from one day to the next."



Over the years he has worked on numerous major upgrades, from installing new accelerator equipment to replacing critical components that had never been changed before. He has also continued to develop professionally, studying for a Higher National Diploma while progressing through a series of technical and leadership roles.

After 36 years at ISIS, Jim believes the key to a successful engineering career is building a strong technical foundation and embracing the opportunities that come with an ever-evolving field. "Engineering is a great field to get into. Technology is always changing, so there will always be opportunities. Someone has to build these machines and keep them running."

# Detectors

The Detector Systems Group has continued to develop technology for the Endeavour programme, making significant progress with both gas and scintillator technologies. A key focus of the detector development programme is finding ways to reduce costs while improving detector performance. This approach has already generated savings of several hundred thousand pounds for the Mushroom and WISH-II projects, with further opportunities still being explored.

This year also marked a major milestone with the delivery of the detector system for the Osiris upgrade. These are the first gas detectors at ISIS to be connected in a 'sausage-link' style with unique readout electronics that enable the entire detector system to operate within a vacuum. The innovative design, developed through collaboration between the Detector Systems Group and the STFC Technology Department, incorporates previously unknown and high-risk components. Their successful implementation demonstrates both the quality of the design and the robustness of the development process.

Osiris is also the first neutron instrument at ISIS to adopt a new signal readout and processing methodology using the CAEN R5560 data streaming digitisers. These provide enhanced diagnostics and data handling capabilities, setting a new direction for gas detector readout and processing across the facility.



The upper portion of Osiris during installation and most members of the team responsible for the Osiris upgrade.

## Detector technologies for SANDALS-2

SANDALS-2, a major upgrade to the SANDALS instrument as part of the Endeavour programme, will include a new high-resolution detector bank that will give the capability of detecting minor crystalline components in complex materials and solutions. To inform the design of the high-resolution detector bank, SANDALS has been used to evaluate novel high-efficiency

position-sensitive scintillator detectors, confirming their suitability for SANDALS-2 and helping to optimise detector performance and manufacturability. Tests have also been carried out on different glass and scintillator combinations for the main detector array, helping to identify the best balance between performance and affordability.

# Support laboratories

## Ensuring safe science

In the past year, the Sample Safety Team approved more than 1,300 experimental risk assessments, supporting a wide range of research across ISIS. Part of the Support Laboratories Group, the team reviews experimental materials, assesses hazards and develops the controls needed to enable research to be carried out safely. The team works closely with researchers, instrument scientists and technical specialists across ISIS to understand risks and develop practical solutions.

This includes supporting complex projects such as an IMAT experiment investigating structural changes in peat during combustion, which required close collaboration between users, instrument scientists, and technical and safety teams to ensure the work could proceed safely and successfully.

The Sample Safety team are part of the Support Laboratories Group.



# Sample environment

## Cryogenic science

Over the past year, the Sample Environment Group has supported nearly 700 pieces of cryogenic equipment. More than 100 experiments used dilution refrigerators and high-field superconducting magnets, giving researchers access to temperatures below 1 K and magnetic fields exceeding 10 Tesla.

## High-temperature experiments

At the opposite end of the temperature scale, the team supported more than 60 experiments using high-temperature furnaces, enabling samples to be heated to up to 2000°C while in the beam.

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## Polarisation support

Operational support for polarisation is now provided by the Sample Environment Group, which supports  $^3\text{He}$  spin filters on several ISIS instruments. The final cycle of 2025 was a record-breaking one for the team, with more than 20 polarised  $^3\text{He}$  cells supplied for experiments.



Mark Devonport and Kirill Nemkovskiy with two of the  $^3\text{He}$  cells.

## Automation

As part of ongoing efforts to improve the efficiency, reliability and capability of sample environment operations, the team is expanding its use of automation and digital tools. Recent developments include the development of an interim liquid nitrogen autofill system for the soft matter cryostats, and a prototype helium and nitrogen autofill system to support the cryogenics team and soft matter system.

The team has also created software tools to streamline the calibration and configuration of cryostat and dilution refrigerator controllers.

Lucy Bain and Alex Jones from the Sample Environment Group are working on process automation.



## High-pressure and gas handling

Gas handling and high-pressure capabilities have remained in high demand, with around 100 experiments supported this year. Many involved toxic or hazardous gases, which the team delivered safely and successfully.

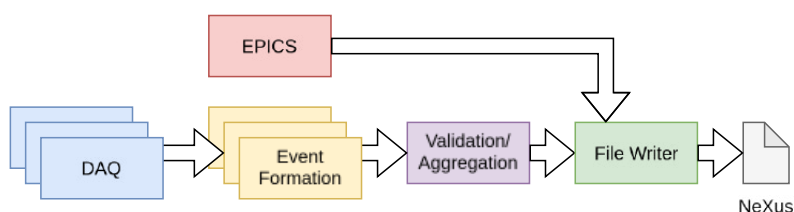
## Soft matter research

The Soft Matter Team provided more than 350 pieces of equipment to ISIS instruments, ranging from syringe pumps and sample changers to rheometers and Langmuir-Blodgett troughs.

# Computing

## SuperMuSR event streaming

SuperMuSR will be one of the first instruments to use event streaming for real-time software signal processing, helping to create a more flexible and modular approach to data collection. Building on concepts developed through collaboration with the ESS, the system has been adapted to meet the needs of a next-generation ISIS instrument. Testing is underway on the SuperMuSR hardware, while work continues on the graphical user interface.



A schematic showing high level system architecture

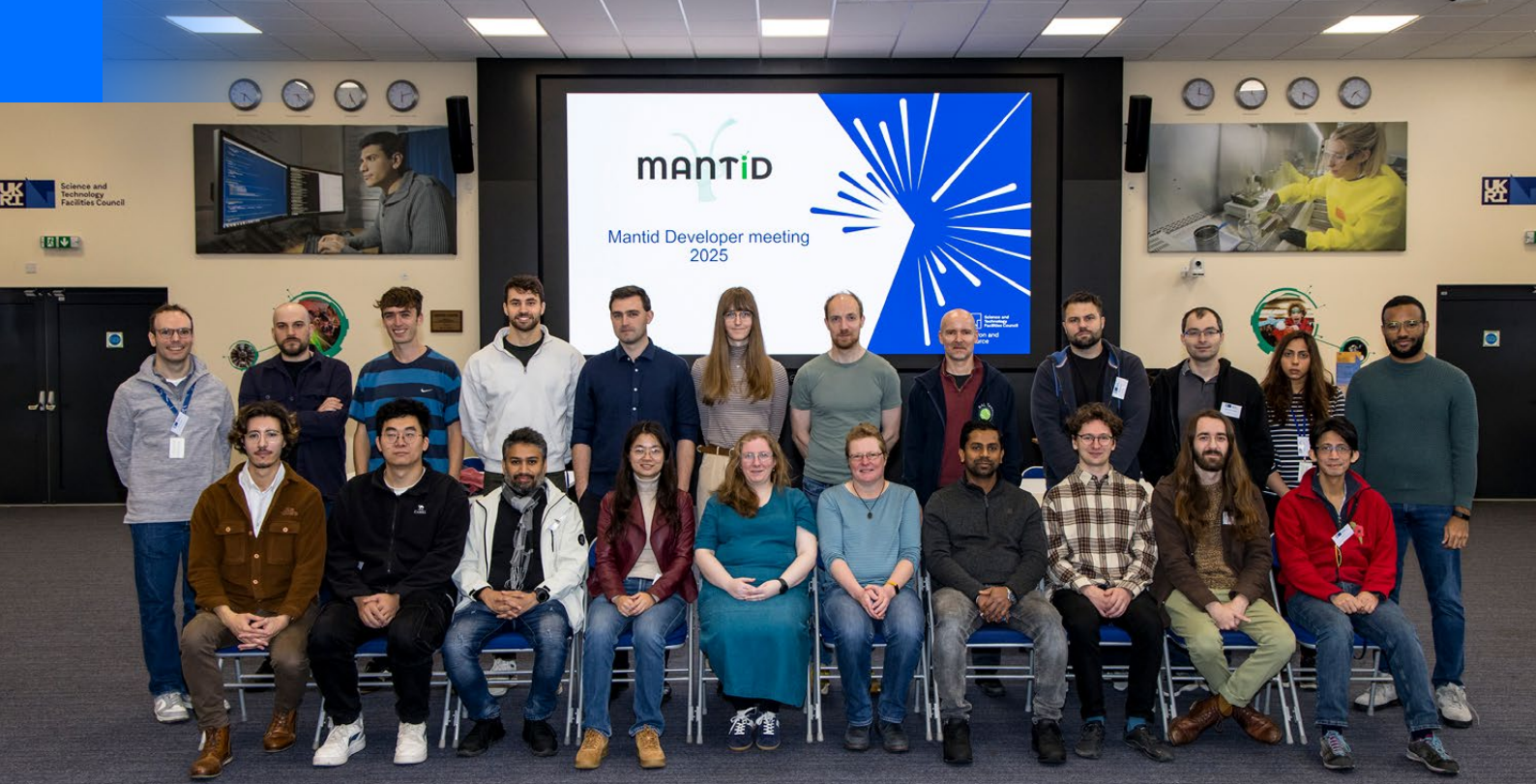
## Accelerator operations data pilot

A pilot data platform for accelerator operations is now in routine use, making it easier to monitor equipment downtime and identify performance trends. Previously, analysis relied on multiple manual processes and offered limited flexibility to respond to changing operational needs. The new platform imports entries from the

MCR Logbook, applies mapping to rationalise equipment types and supports flexible analysis to help identify trends. Live dashboards also provide operational insight during user cycles, and electricity consumption data can be incorporated into performance reports.



Accelerator operations being monitored in the Main Control Room.



Attendees of the Mantid developer meeting

## Software and systems

The past year has seen three stable Mantid releases, a Mantid Imaging release, and the general availability of MDANSE 2.0 and the Reflectometry Algorithm Toolbox. Updates have also been delivered to Dissolve, SasView, PySpinW and Horace.

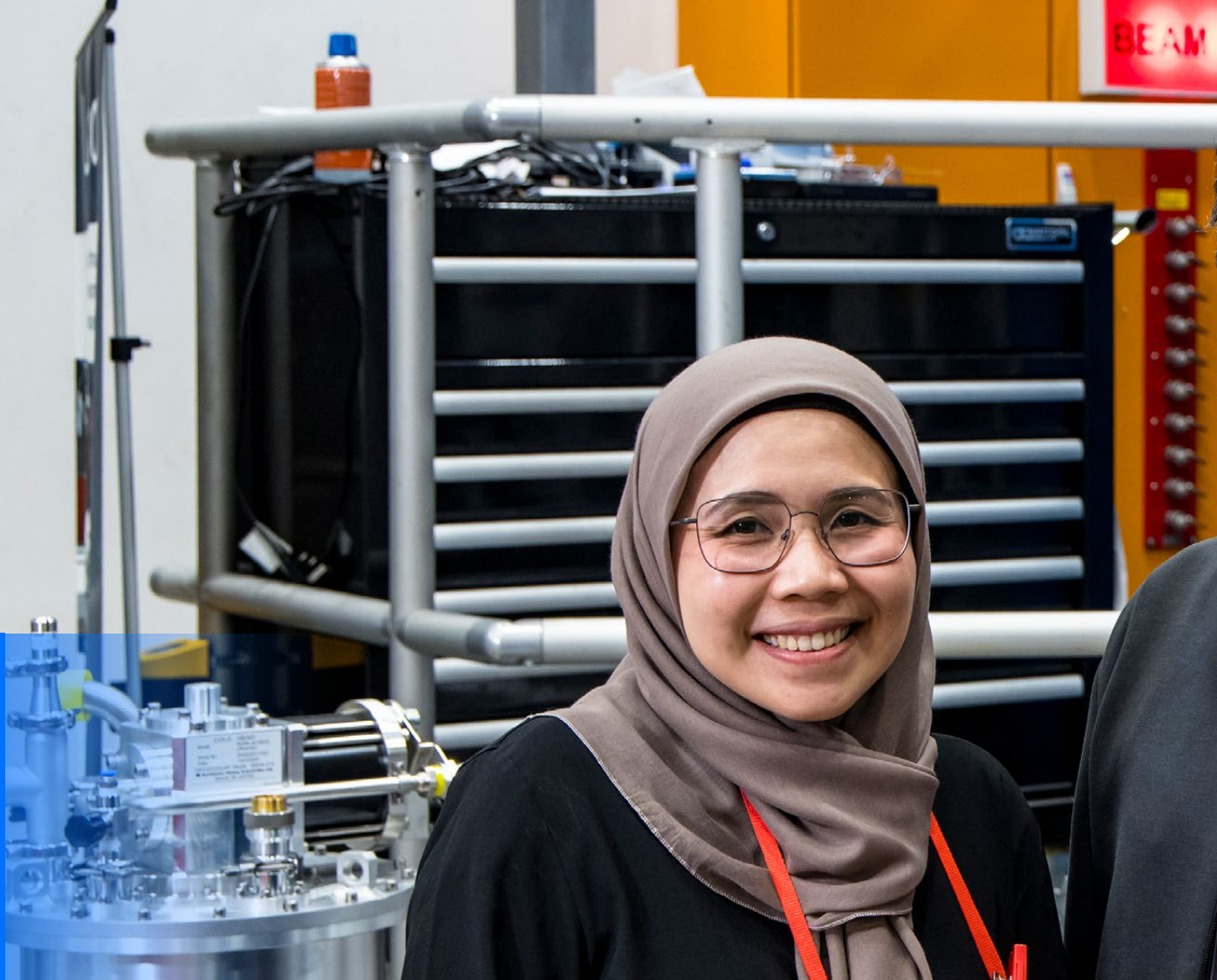
For users, a new user portal homepage has introduced a modern interface and laid the

foundations for future dashboard features. Improvements to the User Office software have streamlined the processing of claims and consumables and new proposal routes have been introduced. Work is also underway with Diamond Light Source, the ESS and ELI to co-develop further systems for management of the user programme.

## Automatic data reduction roll-out

Automatic and live data reduction has been extended to additional instruments and has new graphical interfaces. A working prototype has been developed to automate IMAT reconstructions, while live data processing for event-based instruments is being developed to provide researchers with faster feedback during experiments.

Automated processing and storage systems have also been introduced for the high-data-rate nGEM detector shared by Ines and IMAT, helping to improve efficiency and reliability. This work complements wider efforts to strengthen the infrastructure that underpins data reduction across ISIS.



# Partnerships and collaborations

Over the past year, ISIS has continued to strengthen partnerships across the UK and around the world, supporting and growing our user community, sharing scientific and technical expertise, and advancing neutron and muon science to enable discoveries that benefit society.



Fatimah Fatimah, Arry Yanuar and Khadijah Zharifah of the Faculty of Pharmacy, Universitas Indonesia, using the Larmor instrument.

# International partnerships

ISIS is the UK's national neutron and muon source, but it has significant international partnerships. These bring a variety of benefits to the facility and to STFC, including new science, new materials and samples, new collaborations and expertise – as well as additional funding for instrument projects and operations.

Over the past year, funding to support international use of ISIS has amounted to over £6M, both from partner countries and from the UK International Science Partnerships Fund (ISPF). ISIS welcomes proposals from researchers from any country, but proposals from the UK and partner countries are prioritised to ensure these countries' programmes are fulfilled.

## Sweden

ISIS renewed its partnership with Sweden (through the Swedish research council Vetenskapsrådet) in 2025. The Swedish programme at ISIS is broad but has a particular focus on biosciences and health studies, alongside applied materials.



Linn Jansson, KTH, Svea Schlag, Uppsala, Martin Mansson, KTH, and Elisabetta Nocerino, Stockholm, came to ISIS to study ion diffusion in perovskites.

## Italy

ISIS has had a partnership with Italy for over 40 years, supporting a very wide range of science as well as significant instrument developments.



Anna Marsicano, ISIS, Margherita Simoni, Rome Tor Vergata, Setareh Fatemi, Istituto Nazionale Di Fisica Nucleare, and Giovanni Romanelli, Rome Tor Vergata, using Vesuvio to investigate neutron transport within moderators for medical applications.

## Switzerland

The ISIS-Diamond-PSI (Paul Scherrer Institut) collaboration, supported by the ISPF, has produced a wide range of benefits for the facilities involved. As just one example, postdoctoral researcher Rafael Heeb and Joel Hodder from STFC's Technology department have built an extruder for producing filaments for a 3D-printer. The 3D printing technology was developed at PSI and then brought to RAL through the ISPF programme, and is now being used to produce neutron optical components for Endeavour Programme beamlines.



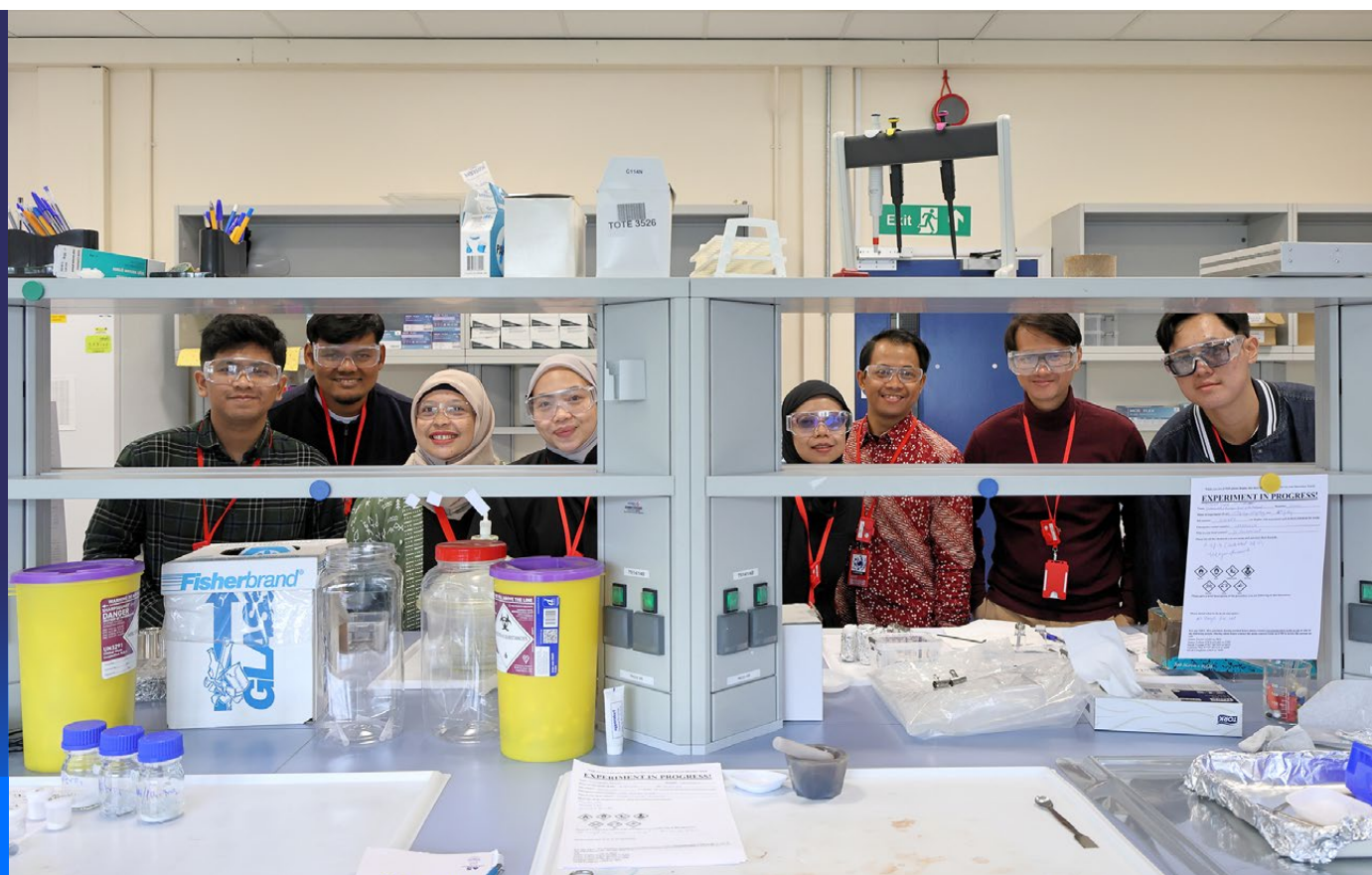
Joel Hodder and Rafael Heeb by the 3D printer filament extruder.

## Indonesia and Malaysia

User programmes with both countries have continued to grow through ISPF support. A BRIN-ISIS Neutron and Muon Workshop was held at BRIN in Indonesia in November 2025 and marked the launch of the Indonesian Community for Large Scale Research Facilities user group.



The BRIN-ISIS Neutron and Muon Workshop, Jakarta, November 2025.



Indonesian researchers at ISIS for experiments on Maps and Tosca, May 2026.

## Brazil

The ISPF award to ISIS to develop Brazilian use of the facility has resulted in over 40 proposals being allocated time with 31 new Brazilian principal investigators from 17 institutions across the country. The first Brazilian neutron user meeting was held in São Paulo in January 2026.

The first Brazilian Neutron User Meeting in São Paulo.



## New European users

The EU-funded NEPHEWS project has allowed European researchers who have not used neutron methods before to come to ISIS to experience a neutron experiment for the first time. Over 20 individuals have been supported to come to ISIS since the project began.

Ivan Voiteshenko and Tymofii Nikolaienko from Kyiv National University spent a week at ISIS, participating in reflectometry measurements at OffSpec, in November 2025 as part of the NEPHEWS programme.



## Advancing ion source technology in the UK and South Africa

The Low Energy Beams Group (LEBG) has delivered its world-leading plasma diagnostic technology to iThemba Labs, South Africa as part of an ISPF project, allowing continuous on-line monitoring and diagnostics of operational ion sources.



As part of the collaboration with iThemba LABS, the LEBG welcomed Muneer Sakildien to ISIS in July 2025. Pictured (left to right) are Muneer Sakildien with ISIS staff Olli Tarvainen, Erin Flannigan and Dean Morris.

# UK and the European Spallation Source

## Major progress for the ISIS instrument contributions to the ESS

This year has seen significant progress for the two instruments that ISIS is delivering on behalf of the UK to ESS.

LoKI is an advanced small-angle neutron scattering instrument for studying complex hierarchical nanoscale materials, such as those found in consumer products and advanced healthcare applications. LoKI has successfully completed its installation at the ESS and is awaiting first neutrons to start its scientific mission.

FREIA, an innovative reflectometer, has also progressed significantly in this period. All components for the reflectometer have been delivered to ESS and are being rapidly installed in the experimental hall.

These two beamline projects have illustrated the strength and professionalism of the UK-ESS collaboration, which has delivered these two significant projects. We eagerly await the first science and many new impactful discoveries that LoKI and FREIA will deliver.



The teams from across ISIS that delivered the LoKI instrument met to celebrate their achievements and share best practice for future projects.



Renee Helfert, ESS, Michael Lovell, Simon Cooper, Jacob Simms, Thomas Willoughby, ISIS, Kristina Jurisic, ESS.

## How the ISIS targets group are helping ESS to prepare for operations

As well as the close relationships built through the construction of the LoKI and FREIA beamlines, other ISIS groups are also working closely with their counterparts at the European Spallation Source. This includes target operations group leader Jeremy Moor, who has set up collaborations with their targets, remote handling and cryogenic systems teams.

The collaboration has involved multiple trips between the facilities, for the ISIS team to visit and share their experiences gained over many years of operations, and for the ESS teams to see how it works in reality.

This has included the basics, like the ISIS group size and structure, as well as ways of working, risk assessments and other safety procedures such as DSEAR and PSSR. “We are helping them to get prepared and have a head start for when the facility becomes operational,” explains Jeremy. “It may be small things that we discuss, but the conversations are very useful to both us and them.”

One example was a recent visit to ESS by Justin Miles from the targets group, who went over to help with the ESS cold box, showing their technicians how to change the circulator bearings, as it’s not something any of them had done before. He was able to explain in person as they went along, rather than them teaching themselves, or Justin trying to demonstrate remotely.



## Sharing experiences for safer experiments

As the ESS moves towards user operations, it is time to focus on the user program and therefore experiment safety.

“We need to be prepared for the usual, but also to the unexpected requests from the users,” explains Betina Pereira Ferreira, who is the Chemical Responsible for ESS.

Betina is leading the Experiment Safety Review Committee who, in addition to general advice on conventional safety, supports laser, magnet and pressurised system safety. The group is defining strategies and methods for a successful Experiment Risk Assessment. Betina and Nathalie came to ISIS learn about our experiment safety procedures and how they might be applied at ESS.

Pictured, above: Ludmila Mee, ISIS, Nathalie de Ruette, ESS, Betina Pereira Ferreira, ESS, and James Taylor, ISIS, during the visit.

“We had very valuable discussions about experiment safety involved in many different areas. We certainly learned from everyone we met and now have a large variety of information to use and implement in our own safety routines.

**Betina Pereira Ferreira**

# STFC and NDA sign a new Memorandum of Understanding

The Nuclear Decommissioning Authority (NDA) is responsible for decommissioning the UK's nuclear legacy, including managing radioactive waste and providing routes to interim storage and disposal across one of Europe's largest and most complex clean-up programmes.

Collaboration between STFC and the NDA has already supported the development of jointly agreed radioactive waste management plans, strengthening confidence in STFC's long term waste management strategies and enabling more effective financial and operational planning.

The scope of the MoU spans the complete lifecycle of ISIS and future facilities. It includes radioactive waste arising from current operations, planning for end-of-life decommissioning, and input into the design and development of a next-generation neutron source. Embedding waste management considerations from the outset will ensure sustainable, optimised solutions are in place for the future.

“

This MoU reflects the strong commitment of both the NDA and STFC to working closely together on sustainable, forward looking solutions, strengthening the long term strategic approach for how ISIS manages radioactive waste, both now and into the future.

**Matt North, Head of ISIS  
Instrumentation Division**



The ISIS Health Physics and  
Facility Safety Group



# People and teams

The research conducted at ISIS is supported by approximately 550 staff – from beamline scientists that run our instruments to engineers that keep the accelerator operational and the User Office that supports our visiting researchers – everyone at ISIS plays a key role in keeping the facility running.



Lauren Matthews and Ella Ho, ISIS, setting up an experiment on SANS2D

# Neutron training course and student conference

In Autumn 2025, we ran the Neutron Training Course (NTC) in a new format: combining three days of online lectures and tutorials in the style of the Oxford School of Neutron Scattering, and a week of practical training on the beamlines at ISIS.

In the middle of the practical week, we hosted the ISIS student meeting, open to both NTC attendees and other PhD and placement students who use ISIS for their research. We also held an induction event for incoming ISIS Facility Development Students.

To end the student meeting, there was careers panel, comprising of people who had been NTC attendees together on the course in 2016, returning to speak about their career journeys since then, and how the course helped them on their way.

Adam Michalchuk is now an Associate Professor of Physical Chemistry at the University of Birmingham. After his PhD, Adam moved to Berlin as a postdoctoral researcher at the

Federal Institute for Materials Research and Testing (BAM). In 2022, Adam moved to the University of Birmingham. His research focuses on making new energetic materials that are more reliable and sustainable (see page 28).

“During my PhD, the NTC proved to be absolutely pivotal to my career, introducing me to the breadth of research made possible by neutron scattering and helping me to build a network of friends and colleagues with whom I continue to work to this day. It was a real pleasure to return to the NTC 10 years on to speak with the next generation of neutron scatterers, and share my experiences of growing my career through the support of the neutron scattering community and the exciting ways that neutron scattering enables us to push scientific boundaries.”



The careers panel at the 2025 ISIS student meeting.



Attendees of the 2025 ISIS student meeting.

Gabriel Perez is an Instrument Scientist at ISIS, supporting the GEM and Polaris beamlines. His research focuses on using neutron and muon techniques for in situ and operando studies of battery materials, with particular emphasis on industry-relevant devices and applications. He initially joined ISIS after his PhD as a postdoctoral researcher joint with The Faraday Institution. “The NTC does a great job of showing students the value of neutrons for research to society. Beyond the technical knowledge, everyone leaves with different and unique insights into the work carried out at a facility like ISIS. In my case, learning about the role and day-to-day life of an instrument scientist inspired me to become one.”

Charlotte Kirk completed her PhD in energy materials at the University of Oxford, and since then has had a varied career path, including working in consultancy and as a venture capitalist. She has combined this with an athletic career, as a sponsored runner, recently completing the Pacific Crest Trail, and becoming the fastest woman to run the Camino de Santiago. “I found there was a gap for people who understand the technicalities and can translate complex science into something commercial.”

Stephanie Richardson was also in the NTC cohort of 2016 and is now leading the ISIS Communications and Impact group. After her PhD in catalysis, Stephanie moved into science communications at Instruct-ERIC before joining ISIS in 2021 to lead communications for the League of advanced European Neutron Sources (LENS Initiative).

“

When I started my PhD, I was a complete newcomer to neutron science. The training course gave me the grounding I needed to get the most from my experiments at ISIS, which went on to become a core part of my research project. Coming back to work at ISIS felt like a full-circle moment. My career may have taken me away from the lab, but it's shown me that the knowledge, skills and connections you gain can be valuable in ways you don't always expect!

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**Stephanie Richardson,**  
ISIS

# Public engagement

## Inspiring the next generation

It has been another successful year for public engagement at ISIS. We have delivered more than 60 events, engaging 5,300 school pupils, further education students, teachers and members of the public. Through these activities and partnerships, we have supported education, skills development and awareness of STEM careers.

At the beginning of 2026, ISIS launched its refreshed Public Engagement Strategy, setting out the priorities and mission that will guide our work in the years ahead:

**To use our world-class facility, research and expertise to create meaningful, high-quality STEM learning experiences for all, for the benefit of ISIS, the public and the future of STEM in the UK.**

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Through a broad programme of in-person and virtual activities, ISIS brings STEM to life beyond the classroom. Participants gain unique insights into our multidisciplinary research facility and engage directly with the scientists and engineers behind our world-leading science – interactions that are consistently highlighted as one of the most valuable aspects of the experience.



Students enjoy hands-on activities at the Science in your Future event.



Students showcase and celebrate the achievements of the Engineering Experience Program.

Engaging diverse and under-represented audiences remains a key priority. We continue to increase engagement with young people from disadvantaged backgrounds, helping to reduce barriers to participation. Alongside this, we deliver activities and resources that celebrate diversity in STEM, broaden awareness of STEM opportunities and support young people's aspirations.

We also continue to support the STEM skills pipeline. ISIS hosted 43 work experience students, mentored 24 A-level students through the RAL Engineering Experience programme, rated "Excellent" by all participating schools, and contributed to training days for 29 UK educators.

“

As ever, this was a fantastic opportunity for our students. They have learnt so much – both in terms of knowledge and skills – and this is something that will go with them into HE+.

**Teacher from King Alfred's Academy, participating in the Engineering Experience Programme.**



As part of Particle Physics Masterclass, participants had the opportunity to tour ISIS, including the chokes room and muon beamlines.

# Student placements

The last year saw 14 undergraduates complete year-long placements at ISIS, and a further nine join for placements over the summer. These students completed a range of projects that were hugely valuable to the facility, ranging from detector testing for the Endeavour programme to developing novel deuteration synthesis routes.



“

My favourite part of the placement has been meeting and learning from a variety of researchers, scientists, and staff. Working with people has genuinely been one of the best parts because I got to interact with so many passionate people. I really enjoyed taking their research and writing about it in a way that was easy to understand and engaging for a wider audience.

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**Rohini Gupta,**  
**Industrial Placement student**  
**in the Communications Team.**



“

I have really enjoyed being able to work in the lab and drive my own project. The placement has given me the ability to problem solve and look into the different ways I could move forward in my experiment to achieve a specific goal, and I think that has been really interesting.

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**Isha Rajadyhax,**  
**Industrial Placement student**  
**in the Bio Labs.**

# Technicians

ISIS continues to play a leading role in the delivery of the STFC Technician Commitment, which aims to improve the visibility, recognition, career development and sustainability of technical careers across the organisation. Members of ISIS staff chair both the Technician Commitment Steering Group and the associated Working Group, helping to shape and drive technician-focused activity across STFC.

STFC's work in this area was recognised nationally with a Technician Commitment Impact Award, highlighting the organisation's progress in embedding the values of the Technician Commitment.

## Darren Mitchard

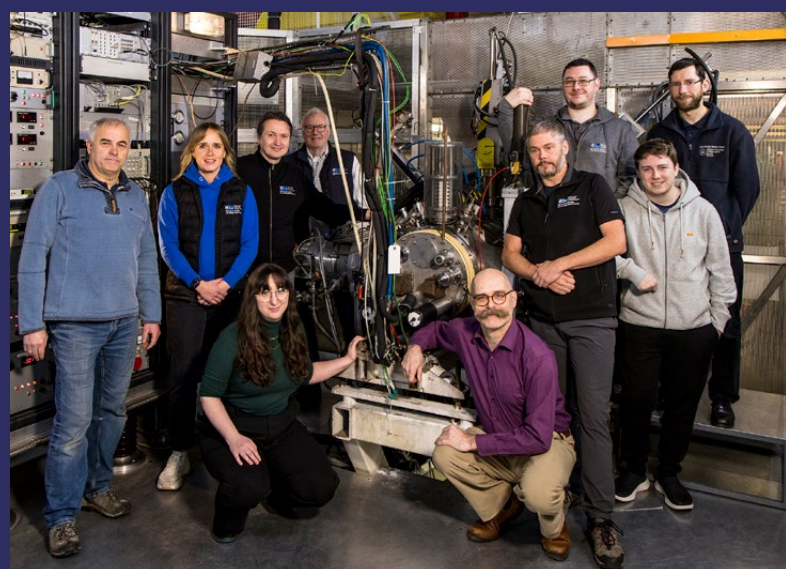
**ISIS Ion Source technician Darren Mitchard won the Early Career Excellence Award at the STFC Technician Commitment conference in 2025.**

Darren is part of a team of four technicians that manage the ion source, which is the first step towards producing neutrons and muons at ISIS. Darren joined ISIS in 2020 on a four-year apprenticeship. The move was a career change; before then, he worked as a chef. "There's lots of skills that are transferable," says Darren. "I'm working with my hands a lot and managing time pressures."

After his apprenticeship, Darren joined the ion source team in the Low Energy Beams Group, which is responsible for the early stages of the process by which ISIS generates neutrons.

"I've brought my set of skills to the team. I'm very systems and computer oriented," says Darren. "I also brought in 3D printing, which allows us to do rapid prototyping."

Currently, Darren is working on elements of an optical diagnostics system that will allow the team to monitor levels of hydrogen and caesium in the plasma. He's also working on a new RF ion source to replace the existing source. It will be more reliable and could become the ion source for a future facility that will one day replace ISIS.



Darren Mitchard (second from right in the back row) and the rest of the Low Energy Beams Group.

# Awards and prizes

## ISIS Springboard Award Winners

The ISIS Springboard Awards were launched in 2024 to support early-career researchers to use neutrons and muons in their research. Their awards last three years and provide recipients with funding to present ISIS research at conferences, a case study highlighting their research and the chance to spend an extended period at ISIS, amongst other benefits.

This year, ISIS appointed its second cohort of Springboard Award winners.

**Andrew McCluskey** from the University of Bristol uses mathematical and simulation approaches to improve the analysis of neutron scattering data and is exploring how classical and machine learning interatomic potential simulations can enhance the information obtained from quasi-elastic neutron scattering (QENS) measurements.

**Camilla Di Mino** from the University of Oxford focuses on understanding intermolecular interactions and solvation patterns in liquids. Using total and inelastic neutron scattering alongside classical modelling, she investigates the molecular mechanisms that govern the behaviour of complex liquid systems.

**Daniel Mayoh** from the University of Warwick researches quantum materials, growing and studying single crystals that exhibit a wide range of phenomena, from unconventional superconductivity and frustrated magnetism to exotic states of matter such as skyrmion lattices and topological magnetism.



**ISIS Springboard Awards**  
Supporting UK early-career researchers

UKRI Science and Technology Facilities Council  
ISIS Neutron and Muon Source

**Congratulations to our three award winners:**

- Andrew McCluskey**  
University of Bristol
- Camilla Di Mino**  
University of Oxford
- Daniel Mayoh**  
University of Warwick

## Awards success for ISIS apprentice Connie Butler

ISIS Health Physics Surveyor Connie Butler won the Impact award at STFC's Apprentice Awards 2025 and was highly commended in the Apprentice of the Year and Public Engagement categories.

Connie, who has just finished a two-year apprenticeship with the Health Physics and Facility Safety Group, won the award for her support of the MuSR upgrade project at ISIS. "It was the first time I did a project on my own. I learned a lot from it," Connie says.

Since completing her apprenticeship, Connie has been working as a Health Physics Surveyor in the same team. "I have more independence now, more responsibility," says Connie. "I'm also helping the new apprentice learn the job, passing on the things I know now that I wish I'd known when I started."



Connie Butler receiving her award from Helen Johnson, head of the STFC Skills Centre

## George Green recognised in the University of Oxford's Vice-Chancellor's Awards shortlist

George Green, who is an Associate Professor in Classical and Scientific Archaeology, was shortlisted for the Breakthrough Researcher Award in the University of Oxford's Vice-Chancellor's Awards. He holds a newly created post between the ISIS Neutron and Muon Source, and Archaeology, Classics and the Ashmolean Museum at the University of Oxford.

His research uses muon-based elemental analysis on the MuX instrument to investigate the composition of artefacts deep beneath their surface without causing damage. This approach is particularly suited to his work on the movement and manufacture of gold across ancient Africa, Asia and Europe.

George's inclusion on the awards shortlist recognises the significant impact the partnership he leads between ISIS and the University of Oxford is having. As well as his research, the partnership is also creating new teaching and training opportunities for students across multiple disciplines, alongside research projects based on the Ashmolean's collections.

“

So many of the things recognised in the nomination were only possible due to the partnership we've built between ISIS and Oxford.

---

**George Green,**  
University of Oxford and ISIS

# Looking ahead

There is a lot in store for ISIS in 2027, not least the start of our next long shutdown.

Roughly every five years, ISIS undertakes an extended shutdown to deliver major upgrade and maintenance projects that are too complex or extensive to complete during routine shutdown periods. The 2027 long shutdown will begin on 30 March, with the first user run following the shutdown expected to start on 16 November 2027.

This will be a significant programme of work, focused on enhancing the facility's performance, reliability and scientific capability, while also delivering essential infrastructure, safety and sustainability improvements.

Key projects include upgrading the pre-injector, the first part of the accelerator, to reduce beam loss, improve beam availability and prepare for the installation of a more modern, reliable, long-life ion source. A new generation of high-power amplifiers will also be installed to provide the radio-frequency power needed to accelerate the particle beam through the linear accelerator.

Alongside these accelerator upgrades, Target Station 2's target and instrument cooling systems will be modernised through the installation of new chillers that use greener refrigerants and consume less energy, helping to reduce environmental impact while supporting compliance with future regulations.

The long shutdown will also be a busy and exciting time for the Endeavour programme, as installation of the HRPD-X and SuperMuSR instruments progresses, bringing them closer to their first user experiments in 2028.

While SuperMuSR represents a major investment in the future of muon science at ISIS, 2027 provides an opportunity to celebrate the progress made over the past four decades. Since the first muon experiments in 1987, ISIS has established itself as one of the world's leading centres for materials research using muons, enabling discoveries across fields including superconductivity, magnetism, energy materials, chemistry and cultural heritage. The 40th anniversary will be a chance to recognise scientific discovery, technical innovation and the many users and staff who have contributed to this success, as well as to look ahead to future opportunities, including SuperMuSR.

Undoubtedly, there will be challenges ahead. The financial situation facing STFC will require difficult decisions, careful prioritisation and a continued focus on delivering maximum value from our investments. However, ISIS has a strong track record of adapting to change. By continuing to invest in our infrastructure and capabilities through the long shutdown and the Endeavour programme, we will remain well positioned to support the research community in delivering excellent science.

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