LIV.DATA NEWS

Issue 07 | March 2026

Data-Intensive Science Through Collaboration

Recent work from our students and partners highlighted in this LIV.DATA NEWS demonstrates the growing role of advanced data analysis and machine learning across fields ranging from accelerator science to healthcare technologies and environmental applications.

From new approaches to remote beam imaging to advances in accessible metabolic monitoring using benchtop NMR, our projects show how combining physics, data science and industry partnerships can address real-world challenges.

I hope you enjoy reading about these exciting developments.

Prof Carsten P. Welsch
LIV.INNO Director

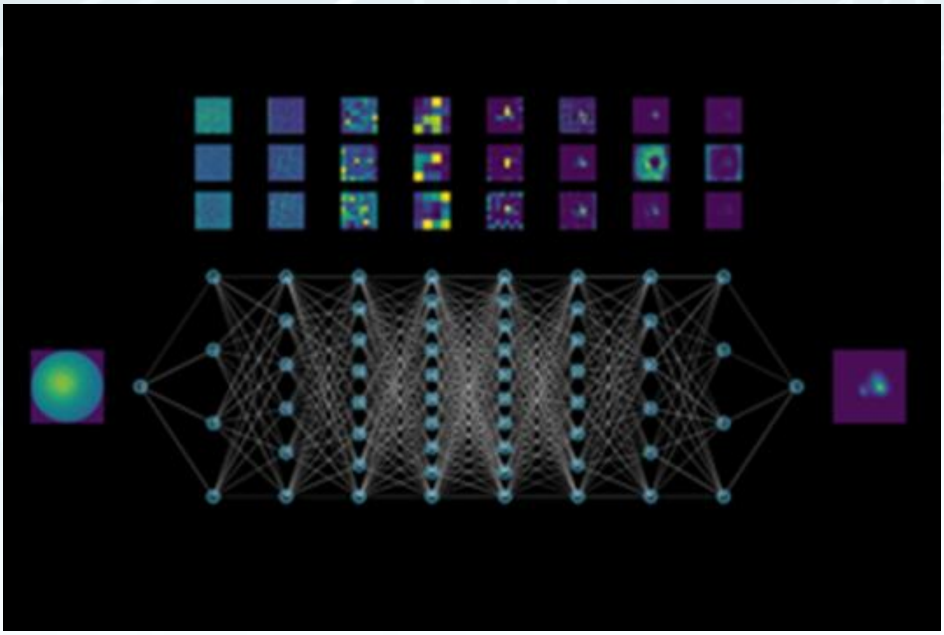
Machine Learning for Remote Beam Imaging

A new paper, led by LIV.INNO PhD student Qiyuan Xu, has just been published in Physical Review Accelerators and Beams. The paper presents a synthetic-data-driven machine-learning approach to beam imaging for radiation-constrained accelerator environments.

The paper explores how a standard camera can be moved away from a high-radiation area by relaying the optical signal through a multimode fibre, then reconstructing the original transverse beam distribution from the scrambled output pattern. The work addresses an important practical challenge in beam instrumentation: cameras and related electronics are likely to degrade in high-radiation areas and this makes reliable imaging in accelerator facilities difficult.

Qiyuan and collaborators from the University of Liverpool and CERN investigate how light from a beam-imaging screen is transported through a single large-core multimode fibre to a shielded location, where a conventional CMOS camera can operate safely. The difficulty in such a setup is that transmission through the fibre produces a complex speckle pattern rather than a directly usable image. Recovering the original beam image therefore becomes an inverse problem that is well-suited to machine learning. In practice, however, training such models requires large amounts of paired data, and this is difficult to obtain under real beam conditions as beam time is limited and experimental datasets often do not cover enough variation.

NEWS INSIDE



To address this, the team developed a training workflow based entirely on synthetic data generated using a Stochastic Gaussian Mixture model. This was used to create a large and diverse set of transverse beam distributions for training. The samples were displayed on a laser-illuminated digital micromirror device in a laboratory setup and transmitted through the same 5 m multimode fibre used in the optical tests. A custom convolutional autoencoder was then trained exclusively on the synthetic data, while real beam images from CERN's CLEAR facility, replayed through the same setup, were reserved for evaluation.

Qiyuan said: "Our results show that the method can successfully recover the main structure of real beam images transmitted through the fibre, including beams with different sizes, positions, and more complex shapes. We also found that the synthetic dataset helped reduce issues linked to imbalance in the real data, suggesting that carefully designed simulated data can provide a practical training route when experimental calibration data are limited."

This work is currently a proof-of-concept study, but it points toward a feasible route for more radiation-tolerant and remote beam imaging systems. Development will now focus on reducing the gap between laboratory light sources and real scintillation-screen emission. This will validate the approach further on real beam data and allow studying long-term stability under environmental perturbations such as temperature changes, vibration, and accumulated radiation dose. Together, these steps could help move the method closer to practical use on real beamlines.

More information:

Development of radiation-tolerant beam imaging via multimode fiber and synthetic data-driven machine learning

Q. Xu et al., Phys. Rev. Accel. Beams (2026) https://doi.org/10.1103/wddb-m37l

Detection Limits of Blood Metabolites at Physiological Concentrations Using Benchtop NMR

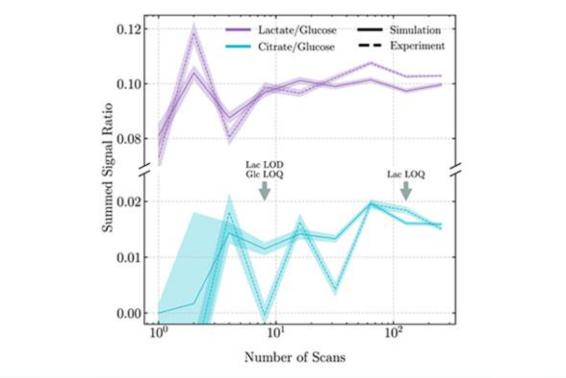
LIV.INNO Data Science Fellow Dr Alexander Hill, along with collaborators from ViBo Health, and the Universities of Liverpool and Leicester have recently published a paper sharing their work towards real-time, accessible metabolic tracking.

The paper, "Detection Limits of Blood Metabolites at Physiological Concentrations Using Benchtop ^{1}H NMR," is now out in NMR in Biomedicine. The study forms part of a long-term collaboration between the QUASAR Group and ViBo Health, focusing on translating low-field magnetic resonance into practical healthcare tools.

Monitoring the metabolism of a person rapidly and non-invasively would enable the tracking of individual trends, opening up major opportunities for screening, disease monitoring, treatment evaluation, and understanding responses to lifestyle change.

ViBo Health is developing DigiScan™, a benchtop finger-scanning device based on low-field magnetic resonance spectroscopy. The key questions in the design process are: which blood metabolites are realistically observable at physiological concentrations, by which methods is signal maximised, and how differentiable are variations in concentration?

The team have systematically evaluated a commercial benchtop spectrometer, operating at a field strength comparable to DigiScan, across key blood metabolites (glucose, lactate, and citrate) at concentrations from 0.05 to 10.0 mmol/L. By characterising the relationship between concentration, acquisition time, and signal-to-noise ratio across multiple pulse sequences, they established quantitative benchmarks for what is practically achievable.



Simulation-based fitting enhances the accuracy and stability of metabolite quantification at low signal-to-noise ratio (Image credit: A.D. Hill, et al., NMR in Biomedicine 39(2), (2026), CC by 4.0)

In order to improve quantification reliability under the low signal to noise conditions inherent to rapid, low-field measurements, they worked with a collaborative computational project for NMR (nuclear magnetic resonance) to develop a simulation-based template-fitting approach, eliminating reliance on large experimental libraries.

Millimolar metabolites such as glucose and lactate are detectable within around 20 seconds, with concentration differences readily distinguishable. The simulations stabilised quantification even under challenging signal to noise ratio conditions. In contrast, sub-millimolar metabolites like citrate required much longer acquisition times, helping define realistic boundaries for practical applications.

In an important next step, early results from biofluids are also presented, where glucose and lactate are again readily detectable at low field.

More information:

Detection Limits of Blood Metabolites at Physiological Concentrations Using Benchtop ^{1}H NMR

A.D. Hill, et al., NMR in Biomedicine 39(2), (2026) https://doi.org/10.1002/nbm.70215

LIV.INNO researchers visit Adaptix for OptiX project collaboration

Aquila Malavankar, Daliya Aflyatunova, Lauryn Eley, Alex Hill and Steve Wells (from left)..

Researchers from the University of Liverpool's QUASAR Group recently travelled to Begbroke Science Park in Oxford for a collaborative visit with Adaptix, their industry partner in the development of next-generation 3D X-ray imaging technology.

Dr Alex Hill and Dr Daliya Aflyatunova met with the wider team and advance their joint work on the OptiX project. The visit provided an opportunity for face-to-face discussions with key Adaptix personnel, including CTO Steve Wells, Principal Scientist Aquila Mavalankar, and Senior Imaging Scientist Ishbel Jamieson. LIV.INNO PhD student Lauryn Eley, currently on long-term attachment at Adaptix, joined the discussions.

A highlight of the visit was the chance to observe Adaptix's existing digital tomosynthesis (DT) devices firsthand. The Liverpool researchers were able to see both orthopaedic and non-destructive testing (NDT) setups in operation, providing valuable context for their computational modelling work.

"Seeing the devices in action gave us a much firmer understanding of what we're actually simulating," explained Dr Hill. "It's one thing to model X-ray beam interactions computationally, but quite another to witness the physical systems performing real imaging tasks. This kind of direct experience is invaluable for refining our approach."

The visit centred on discussions about how the Liverpool team's simulations are supporting Lauryn Eley's ongoing experimental campaign into the design and development of DT devices for both medical and industrial applications. The SCIMITAR framework, recently published by Dr Hill and colleagues in Biomedical Physics & Engineering Express, provides the computational foundation for virtually designing and optimising Flat-Panel Source (FPS) based imaging systems.

The teams also looked ahead to future research directions, exploring possibilities in feature detection within images and developing robust methods for image quality quantification. These discussions reflect the maturing nature of the collaboration as it moves from fundamental device optimisation toward clinical and practical deployment considerations.

The visit represents continued momentum for the OptiX project, a £400k initiative funded by the Science and Technology Facilities Council (STFC) under UKRI's Late-Stage Commercialisation Scheme. The project aims to deliver advanced 3D chest imaging directly at the patient's bedside using Adaptix's innovative FPS technology, which offers the potential for low-dose, portable imaging without the mechanical complexity and higher radiation exposure of conventional CT systems.

Dr Hill reflected on the visit: "This was a wonderful opportunity to see the fruits of our collaboration in action. The integration of our simulation work with Adaptix's cutting-edge hardware is progressing brilliantly, and it's clear we have much exciting work ahead of us. The partnership between academic research and industrial innovation is really driving this project forward."

The collaboration between the QUASAR Group and Adaptix, supported by the LIV.DAT and LIV.INNO Centres for Doctoral Training, continues to demonstrate the value of sustained, cross-sector partnerships in translating fundamental research into real-world medical technology.

With Lauryn's embedded presence at Adaptix and regular exchanges like this visit, the OptiX team is well positioned to deliver on its ambitious goal: a clinically deployable 3D X-ray imaging solution that is safer, faster, and more accessible than current alternatives.

Advancing plasma-based accelerators using nanostructured materials

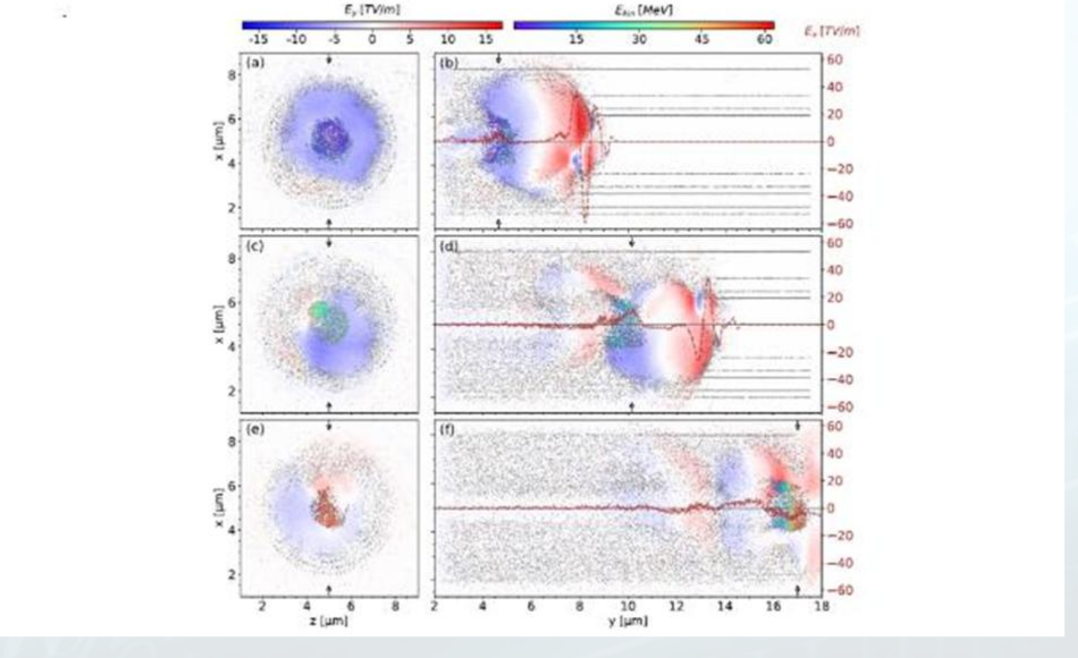
Over the past few decades, the field of plasma-based accelerators - such as laser wakefield acceleration (LWFA) and beam-driven plasma wakefield acceleration (PWFA) has made remarkable advances.

The long-predicted GeV/m accelerating gradients are now routinely achieved at multiple experimental facilities around the globe, paving the way for the design of future compact accelerators with applications that range from medical and industrial uses to high-energy physics research.

Current research suggests that laser wakefield acceleration may achieve TeV/m gradients using high-density solid-state plasmas as accelerating media. Attaining such high gradients would be a significant leap forward in accelerator technology.

However, achieving plasma-based acceleration at these high densities presents significant challenges. Studies indicate that driving wakefields in such dense materials requires attosecond laser pulses, such as X-ray lasers. Drivers with these characteristics are either not yet available or remain extremely limited in availability. In addition, the short wavelengths of solid-state plasmas constrain how far particles can be accelerated.

An alternative approach to overcome these challenges involves the use of nanostructured targets. By arranging bundles of nanomaterials - such as carbon nanotubes (CNTs) or graphene layers - in an alternating pattern with empty or low-density regions, the overall plasma density can be reduced effectively. This reduction enables the use of longer-wavelength lasers and extends the plasma wavelength and the acceleration length.

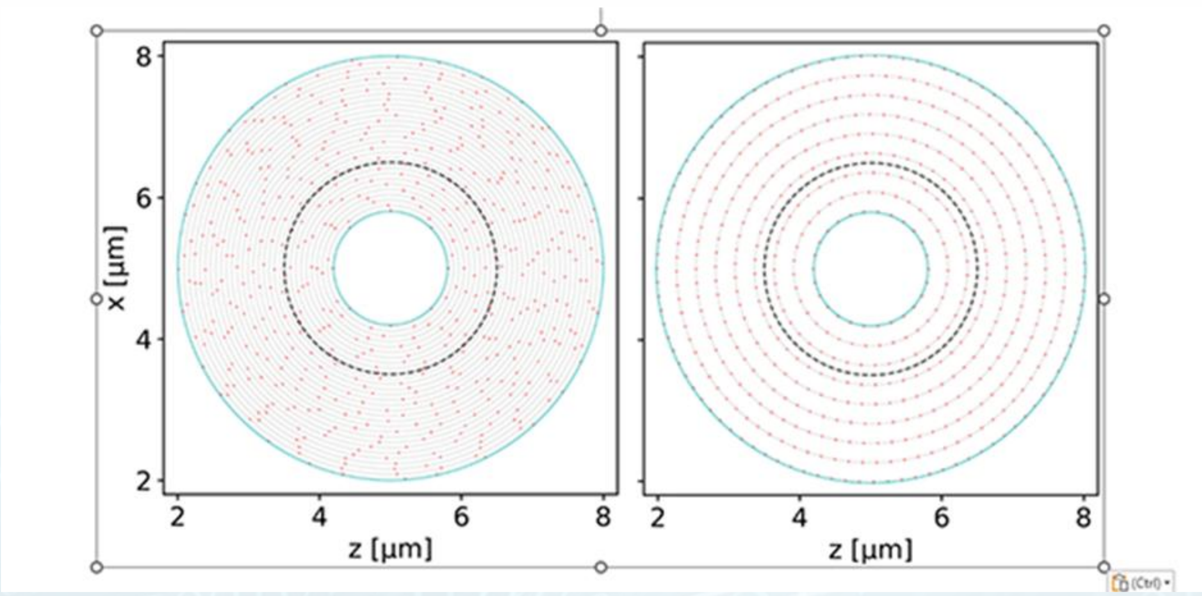


Electron macroparticles shown as grey dots and the longitudinal electric field shown as a colour density plot with the full pulse length 8 fs (3 cycles), peak intensity 1021 W/cm2: (a-b) at t/T = 11; (c-d) at t/T = 18; (e-f) at t/T = 25, where t is the simulation time and T is the laser period. The dashed-brown line shows the on-axis vertical electric field, which is due mostly to the laser pulse..

A paper recently published in Nature Scientific Reports led by Cristian Bonţoiu, during his time as a member of the LIV.DAT CDT, presents, for the first time, particle-in-cell (PIC) numerical results which demonstrate that it is theoretically possible to achieve laser wakefield acceleration in structured CNT targets with an 800 nm (infrared) laser pulse. Upon a suitable match of the laser pulse length and wavelength to the effective plasma density at complete ionization, electrons are self-injected and accelerated at TeV/m gradients with a total charge as high as 1 nC, contained within a bunch length as short as 5 fs.

It was found that due to the collective behaviour of the laser-target interaction, self-injection and acceleration does not depend on the exact arrangement of the CNT bundles and thus multiple choices can be made as long as the overall effective plasma density remains constant (~1020 cm-3). Moreover, a certain degree of misalignment and variation of the bundle diameter can be accepted while manufacturing the target.

If confirmed experimentally, the concept may have an impact on fundamental femtosecond research by delivering the shortest electron bunches ever produced in the laboratory with excellent potential to advance ultra-fast electron diffraction techniques beyond current limits. With further development, required to reduce the energy spread and divergence of the extracted electron bunches, it may also become a medium for compact light sources such as FELs or Compton γ-ray sources with promising implications across fields such as cell biology, surface chemistry, and condensed matter.



Transverse view of two targets built with 25 nm-thick CNT bundles: (Left) 535 CNT bundles are distributed more uniformly in 30 shells; (Right) 546 CNT bundles distributed less uniformly in 9 shells. The black dashed line indicates the laser spot size.

More information:

'Numerical study of self-injected electron acceleration in CNT structured targets driven by an 800 nm laser

Cristian Bonţoiu, et al., Nature Sci Rep (2025) https://doi.org/10.1038/s41598-025-29386-4

LIV.INNO students enhance their studies spending extended periods at CERN

Many LIV.INNO students have the opportunity to spend a significant amount of time working in another location besides their home university as part of their PhD studies. In some cases, this is spending time working with an industrial partner who co-funds their PhD and in other cases it is working at other international laboratories around the world including CERN in Switzerland, FBK in Italy and Fermilab in the USA.

Several of the LIV.INNO students are spending an extended period at CERN. In some cases, their PhDs are co-funded by CERN and so they spend two of their four years there. Others spend a year there as part of a long-term attachment (LTA). There yet more who do not get to live there permanently but who are regular visitors!

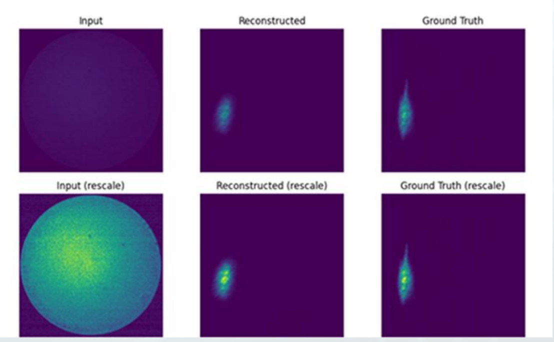
In the University of Liverpool's QUASAR Group there are several students who are working on projects co-funded by CERN and so the students spend two of their four years at the laboratory on the French Swiss border. These students are all working on projects where there are also experts in their field at CERN so they can benefit from working alongside these people for two full years.

One of these students is Qiyuan Xu, whose PhD project is titled "Reconstruction of Transverse Beam Distribution using Machine Learning". His work focuses on transporting light from a scintillating screen through a long, large-core multimode optical fibre to a camera placed in a low-radiation area. As the light propagates along the fibre, the original beam image is scrambled into a complex speckle pattern by mode coupling and other optical effects.

In the past, transverse beam distributions at CERN were often observed using radiation-hard Vidicon tube cameras installed directly in the beam line. However, production of these Vidicon tubes has now ceased, so different alternative diagnostics are being investigated. Qiyuan's fibre-based, machine-learning approach is one of these possible replacements.

As can be seen in the image below, the pattern at the fibre exit looks very different from the original transverse beam distribution at the screen. Qiyuan is developing machine-learning models to reconstruct the in-situ beam distribution from this speckle pattern, using large synthetic datasets together with experimental measurements and his understanding of fibre propagation.

Before going to CERN, Qiyuan tested an early version of the setup in the DITA Lab at the Cockcroft Institute. At CERN he now has an optics lab with an optical table to develop and characterise the system. He has also had a dedicated beam time at the CLEAR facility to validate the method with real electron beam data. In the future, he plans to use the CHARM facility to study how radiation affects the fibre and associated components, so that these effects can be included in his models.



Beam images as seen at end of optical fibre (left), reconstructed (centre) and in situ (right).

In the University of Liverpool Particle Physics and Nuclear Physics groups students often spend a one-year LTA at CERN. Matthew Ockleton who is studying in the Nuclear Physics group is one such student. Matthew is studying 'Developing Machine Learning methods to constrain the properties of the Quark-Gluon Plasma'.

Matthew's studies involve using the ALICE detector on the LHC and being based CERN means he has been able to take shifts on the ALICE detector during the LHC proton-proton data taking period as well as being able to work more closely with colleagues working on similar projects. He has also gained the opportunity to work with the ALICE Jet Working Group convenor on his data analysis which would not have happened if he were based permanently in Liverpool. During his time at CERN Matthew hopes to complete the proton-proton measurements he requires using the ALICE detector and contribute to the development of the new ALICE Inner Tracking System, ITS3. At the same time, he will continue to work with JETSCAPE to constrain QGP properties using data-intensive Bayesian methods.

The ALICE experiment is dedicated to the study of heavy ion collisions in which the Quark-Gluon Plasma (QGP) is created. In QGP, quarks and gluons are deconfined from their hadrons like what is believed to have occurred in the universe a split second after the big bang. However, the LHC program is dominated by proton-proton (pp) collisions. As a result, there is an abundance of pp data. This alongside well understood QCD theory allows the proton-proton collision system to act as a "vacuum" reference to lead-lead (Pb-Pb) collisions. Analyses construct the same observables in both pp and Pb-Pb collision systems, allowing modifications to be assigned to the presence of the QGP. Comparisons to Monte Carlo simulations based on different models allow the validity of different theories to be scrutinised.

One challenge in heavy-ion collision measurements is to identify signals within extremely large backgrounds. Modern data science techniques make signal identification possible with remarkable precision. Machine learning techniques are an essential tool for this process. Matthew has already used a boosted decision tree algorithm to identify candidates from background processes whilst also separating prompt (mesons made directly in the collision) from non-prompt (produced indirectly though other B-hadron after the initial collision). In the future, Matthew will explore using neural networks to distinguish between jets that form initially from a quark to jets that formed from a gluon.

JETSCAPE, a multi-institutional effort to design and use the next generation of event generators to simulate the physics of ultra-relativistic heavy-ion collisions, has recently been allocated approximately 13 million core hours on the Cambridge CSD3 supercomputer. Matthew's benchmarking tests on the performance of the JETSCAPE software on this facility directly led to this large allocation, which he is now using to constrain properties of the QGP using advanced Bayesian modelling.

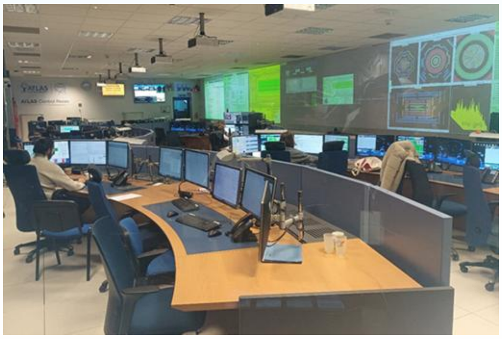
The ALICE detector on the LHC at CERN. Photo credit: CERN

Mehul Depala who is studying in the particle physics group is another student who is currently on an LTA at CERN. Mehul is using the ATLAS detector to see if any evidence of the theorised leptoquark particles can be found for his project 'Leptoquarks at ATLAS Run III'.

Mehul has also taken advantage of being physically present at CERN by completing over 30 shifts on the ATLAS detector during his time there. In particular, he has worked on the Run Control/Trigger and Muon shifts, which are responsible for data acquisition and the operation of the muon sub-detector, respectively. Mehul has also taken on responsibilities as a CERN guide, an important outreach role that allows him to share the exciting scientific prospects explored at CERN with the public. His time at CERN has also enabled him to get to know many people within the ATLAS collaboration and the wider CERN community.

Leptoquarks are a hypothetical particle motivated, in part, by the similarity between family structure of leptons and quarks. More recently, a significant focus has been given to leptoquark searches due to anomalies detected by the BaBar, Belle and LHCb collaborations in rare decays of B-mesons which can be explained by the existence of leptoquarks.

There are three production mechanisms for leptoquarks: single resonant, non-resonant, and pair production. Mehul's search focuses on pair production, as this involves production via QCD processes only and is therefore model-independent, with the cross-section depending solely on the mass of the leptoquark. The analysis aims to exploit the larger Run III dataset, the higher centre-of-mass energy (CoM), and the improved flavour and tau tagging algorithms, along with a dedicated phase-space search strategy, to enhance sensitivity and extend the current exclusion limits or find evidence of the particle. Mehul says that even finding evidence of one such particle would be valuable, as it would point the particle physics community toward physics beyond the Standard Model.



The ATLAS control room where Mehul Depala has completed over 30 shifts.

Qiyuan, Matthew and Mehul are just three of over ten students who will spend extended periods at CERN or other international laboratories as part of their LIV.INNO PhD studies. The benefits of spending the extended time in these places are numerous and the experience will be valuable to the students for their future careers.

LIV.INNO student undertakes placement at AllGreen Energy

LIV.INNO student Katie Ferraby completed her six-month industry placement with George Huang at AllGreen Energy, and it proved to be an extremely valuable and rewarding experience.

AllGreen Energy is a UK-based social enterprise focused on reducing energy costs with green energy solutions; the business wants to increase the amount of sustainable and renewable energy but also stop energy loss and help people achieve net zero targets. General mismanagement of current resources is a large part of energy waste and pollution and so if AllGreen Energy can help with this, many people could benefit without needing to make massive changes to their lives or pay for large unnecessary systems.

Throughout the placement, Katie regularly travelled between Sci-Tech Daresbury, near Warrington, and Liverpool Science Park. These locations were particularly interesting as they were largely co-working environments, with many innovative companies operating in close proximity. This created frequent opportunities for collaboration, and we held a number of productive meetings with neighbouring organisations to explore how our respective expertise, technologies, and designs could be integrated to deliver more effective solutions.

During her time at AllGreen Energy, Katie worked on a wide range of projects that varied significantly in scope, application, and workflow. One such project involved working with farmers in Wales to install large-scale solar panel systems on land traditionally used for agriculture. This project was a valuable learning experience, particularly in terms of communication, as it required addressing long-held views around farming practices and energy generation. Engaging with stakeholders in this way significantly strengthened my interpersonal and professional communication skills.

Another major project Katie contributed to was a scheme in collaboration with Liverpool City Council, aimed at improving the energy efficiency of housing across different regions of Liverpool. The pilot phase focused on the Newsham Park area, where she explored how existing houses could be upgraded. A subsequent phase was planned for the Festival Gardens area, a new development where energy-efficient design principles could be incorporated before construction began.

For this project, Katie undertook several responsibilities. She learned to use a geographic information system software, ArcGIS, which was completely new to her, and worked closely with local authorities, housing providers, and heat network companies. The project followed a “fabric first” approach, requiring careful consideration of how to balance commercial viability, homeowner engagement, and maximise energy savings. I was tasked with identifying and mapping electrical transformers across the region and converting a map of Liverpool into a detailed and informative database representing every individual house in the city.

This mapping work became a central focus of Katie’s placement. She gained extensive experience using geometric tools to manipulate spatial data, including splitting complex shapes into a specified number of segments along defined axes. In practice, this meant taking street-level polygon data and dividing it into segments corresponding to individual house UPRNs, aligned with the orientation of the properties. Using this data, she applied solar power calculations based on environmental data across Liverpool to estimate the average annual solar energy potential for each house. This analysis directly informed a business case outlining project delivery and how investors could recover their investment.

In addition, Katie worked on a project with Liverpool Science Park, where AllGreen Energy’s energy management system was installed within the building. This involved monitoring energy usage over a defined period and then implementing controlled changes to assess whether energy losses could be reduced. Katie contributed to the development of the management system itself and helped design the framework for monitoring and analysing building energy performance.

Throughout the placement, Katie worked with a diverse range of professionals, including engineers, software developers, local authorities, investors, and end users. This exposure gave her valuable insight into how multidisciplinary teams operate within the energy sector and how technical solutions must align with economic, regulatory, and social considerations. Overall, this placement allowed Katie to develop a broad set of technical and professional skills. She gained hands-on experience with GIS software, data analysis, and energy modelling, while also improving her understanding of sustainable energy systems and project feasibility. Equally importantly, she strengthened her communication, stakeholder engagement, and problem-solving skills by working with a wide range of partners and real-world constraints. The experience gave her a much clearer understanding of how engineering, data analysis, and business considerations intersect in industry, and it has significantly increased her confidence in applying her academic knowledge to practical, impactful projects.

LIV.INNO student collaborates with Mirion Technologies on gamma ray spectroscopy and detector diagnostics

Research and Technology track participants at the Mirion Connect conference including Thomas Wonderley (front row, second from right).

Thomas Wonderley, a fourth-year LIV.INNO Centre for Doctoral Training (CDT) student, is conducting advanced research in collaboration with Mirion Technologies, a global leader in radiation measurement and monitoring solutions. The project brings together academic research and industrial expertise to advance the field of gamma ray spectroscopy and detector diagnostics, with a particular focus on high-purity germanium (HPGe) detectors.

Through this collaboration, Thomas has contributed to several key areas of development within Mirion's detector systems and analytical processes. His early work focused on improving the ISOCS characterisation process, using data-mining techniques to identify trends and extract insights from large detector characterisation datasets. This analysis has provided valuable guidance for refining calibration methodologies and improving the overall efficiency of the characterisation workflow.

Building on this, Thomas explored the use of machine learning for spectral analysis, applying advanced algorithms to automatically detect and classify detector issues visible in gamma-ray spectra. This work demonstrated how computational models can support diagnostic processes, allowing for faster and more consistent identification of detector performance issues across a range of operating conditions.

Over the past two years, Thomas' main research focus has been the development of machine learning models for pulse shape analysis in HPGe detector signals. These models are designed for state-of-health monitoring, detecting subtle variations in signal characteristics that may indicate degradation, noise, or evolving detector faults. This approach contributes to the broader goal of predictive maintenance and long-term reliability monitoring within Mirion's range of radiation detection systems.

Thomas has also worked as a remote member of Mirion's Research and Development team in Meriden, Connecticut, engaging closely with engineers and scientists on ongoing projects. This involvement has included participation in project meetings and technical discussions, as well as the delivery of periodic research readouts to senior management and R&D leadership teams. The collaboration has provided valuable insight into how academic research integrates with industrial innovation pipelines and commercial product development.

In 2025, Thomas attended the Mirion Connect conference as part of the Research and Technology track, where he had the opportunity to network with R&D teams from multiple Mirion locations around the world. This experience facilitated closer collaboration with experts across diverse areas of detector design, signal processing, and system development, further broadening the technical perspective of his research.

Access to Mirion's advanced hardware platforms and professional expertise has allowed Thomas to conduct high-quality experimental and computational studies, bridging the gap between theoretical research and practical application. Working alongside Mirion's technical teams has provided an appreciation of product development lifecycles, system testing methodologies, and the challenges involved in maintaining performance consistency across global product lines.

Through the LIV.INNO CDT, Thomas has also benefited from an interdisciplinary training environment that encourages collaboration between academia and industry. This structure has supported the development of a versatile skill set encompassing experimental physics, data science, and software engineering — all critical to advancing next-generation detector technologies.

Collectively, this partnership between the LIV.INNO CDT, Mirion Technologies, and the University of Liverpool highlights the value of collaborative doctoral training in driving innovation. By combining advanced data analysis with detector physics, Thomas' work contributes to the evolution of radiation detection systems and the continued enhancement of precision measurement capabilities for scientific and industrial applications.

University of Liverpool Senior Leadership visits CERN

The University of Liverpool delegation at CERN, including LIV.INNO Director Prof Carsten P Welsch (second from right).

Liverpool’s department of physics welcomed senior University representatives Professor Anthony Hollander, Pro-Vice-Chancellor for Research and Impact, and Professor Tariq Ali, Pro-Vice-Chancellor for Global Engagement and Partnerships, to CERN last month, where a number of LIV.INNO students are playing important roles in major international experiments.

The visit provided an opportunity to showcase the breadth, scale and impact of the University of Liverpool’s research across particle physics, nuclear physics and accelerator science. All these research areas have several LIV.INNO students working within them. The visit highlighted the contributions of staff, postdoctoral researchers and students working at CERN.

A series of site visits and meetings took place which included a visit of the ALICE detector on the LHC. LIV.INNO student Matthew Ockleton was present at this visit to speak to the visiting delegation about his work on ‘Developing Machine Learning methods to constrain the properties of the Quark-Gluon Plasma’ which uses the ALICE detector as well as talking about the work of the wider collaboration.

Later during the visit LIV.INNO student Qiyuan Xu talked about how machine learning is now used as a tool for reconstructing the profile of some of the world's most demanding particle beams – an area that combines traditional accelerator science expertise in the QUASAR Group with a data-driven approach to analysis specific to our centre.

LIV.INNO student Matthew Ockleton (right) talking to the University of Liverpool delegation at the ALICE detector on the LHC.

The programme also included discussions on emerging strategic areas, including quantum technologies and artificial intelligence – an area that LIV.INNO is already strategically developing into, and where a planned future CDT shall focus on. Conversations with CERN colleagues explored potential synergies in quantum computing, sensing and AI-enabled data analysis, building on Liverpool's growing activity at the interface of fundamental physics and advanced technologies. It also allowed a discussion of the very successful partnership between CERN and Liverpool's CDTs LIV.DAT and LIV.INNO. For years, Liverpool PhD students have had the exciting opportunity to spend part of their PhD at CERN, and this has boosted their research and allowed them to work in a truly international setting.

A reception was held at the end of the first day for Liverpool postgraduate researchers, postdoctoral researchers and students currently based at CERN. The event was attended by CERN's Director-General Professor Mark Thomson and provided an opportunity to recognise the important achievements of early-career researchers and the central role they play in delivering world-leading science within large international collaborations.

Reflecting on the visit, Anthony Hollander said: "It was a real pleasure to spend time with colleagues at CERN and to see first-hand the extraordinary science being delivered by Liverpool researchers. My enthusiasm for particle physics, which was already very high, has gone through the rafters. The University is committed to supporting this work, and visits like this really bring home both its scientific importance and its international profile."

Tariq Ali added: "I very much enjoyed our discussions on science – it was much-needed food for the soul. It was no surprise, but still wonderful, to see how highly Liverpool and its researchers are regarded within the global particle physics community. We are already investing strongly in this area, and it is important that we continue to communicate the scale and excellence of these achievements more widely."

The visit reaffirmed the close connection between LIV.INNO and CERN and underlined the shared commitment to world-class research in data intensive science and to training the next generation of scientists and engineers.

Professor Welsch recognized on the MeetEngland 2025 Roll of Honour

Participants at the MeetEngland launch event. (credit: MeetEngland)

Prof Carsten P Welsch, Head of Accelerator Science at the University of Liverpool and LIV.INNO Director, was presented with a 2026 MeetEngland Impact Network Award in recognition of his outstanding achievements in bringing major scientific events to England.

In addition to dozens of scientific workshops, schools and symposia, Professor Welsch had a key role in bringing the flagship Linear Accelerator Conference (LINAC 2022), the International Beam Instrumentation Conference (IBIC 2025), and the International Particle Accelerator Conference (IPAC'29), the world's largest event in this scientific area, to Liverpool.

The event took place at Cutler's Hall in Sheffield on 12 February 2026, bringing together convention bureaus, conference ambassadors, and academics.

Professor Welsch has been an ambassador for Club Liverpool since the programme's launch ten years ago, supporting efforts to attract business events to the region and contributing millions of pounds to the local economy.

The MeetEngland event, held to officially launch the new national Impact Network, featured insightful success stories by academic and sector leaders which highlighted collaboration, innovation, and impact in international business events. It also included the presentation of the MeetEngland 2025 Roll of Honour, and panel discussions about collaboration in action and how conferences can effectively catalyse business activity.

The MeetEngland Impact Network brings together ambassadors, advocates, academic leaders, and sector specialists from across England, combining their individual contributions into a strong and visible national movement. By acting as a single strategic umbrella, it aims to strengthen the work of city ambassador programmes and city partnership networks, helping them connect with important academic and industry communities in their areas.

AI for Astronomy Summer School – Heidelberg

Group photograph of the participants at the 2025 IMPRS-HD Summer School

The 2025 IMPRS-HD Summer School, held in Heidelberg from 8-12 September, brought together students and researchers to explore the growing role of artificial intelligence in astronomy. Hosted by the International Max Planck Research School for Astronomy and Cosmic Physics (IMPRS-HD), the event aimed to equip students with the skills to integrate cutting-edge AI methods into their research. Teaching was delivered through a blend of lectures and hands-on sessions, provided by leading researchers working in the fields of AI and astronomy.

With the rapid growth of both deep observational surveys and large-scale cosmological simulations, astronomy has entered an era of big data. Developing and understanding tools capable of analysing these vast datasets has become essential. The summer school provided not only an introduction to a range of AI methods for interpreting such data today, but also a glimpse into ongoing efforts to prepare for the next generation of deep-sky surveys and simulations.

The lecture series covered a broad spectrum of AI topics, including simulation-based inference (Matthew Ho, Columbia University), differentiable programming (François Lanusse, CNRS), large-scale generative modelling (Carolina Cuesta-Lazaro, Harvard University), transformer models (Ioana Ciuca, KIPAC), and domain adaptation (Aleksandra Ciprijanovic, Fermilab). The applications of such methods to ongoing astrophysical problems were described in great depth over the course of the week.

Hands-on sessions complemented the lectures, giving students the chance to experiment directly with the techniques discussed. Delivered through interactive Google Colab notebooks, these sessions provided a practical setting to code and test AI models, reinforcing the theoretical material presented during the lectures. Some examples of hands-on programming include building and applying deep-learning models such as Convolutional Neural Networks, writing a transformer model from scratch, and utilising coding packages such as JAX for solving inverse problems.

Local researchers from Heidelberg also contributed, with postgraduate and postdoctoral speakers presenting their work on applying AI methods to a variety of astronomical challenges.

The school fostered a welcoming and collaborative atmosphere, encouraging discussion and networking among participants and invited speakers. A number of social events offered opportunities for informal conversations about science and research, including a visit to the Max Planck Institute for Astronomy and its research facilities and observatories.

LIV.INNO student Ryan Roberts, who attended the summer school, had this to say about the experience: “It was a fantastic opportunity to meet and learn from top experts in the field, as well as like-minded students. The fast pace of AI research can make it hard to keep up with new developments and applications, but this school provided the perfect environment to understand the state-of-the-art from both a big-picture and detailed perspective. I’m excited to apply the knowledge and experience I gained here to my own research.”

IPAC'26 Scientific Program Committee meets in Liverpool

Participants at the IPAC 2026 SPC meeting in Liverpool

The University of Liverpool's QUASAR Group hosted the third and final planning meeting for the IPAC'26 Scientific Program Committee (SPC) in Liverpool from 14 - 15 January.

The event was held at the Arena and Convention Centre (ACC), located on Liverpool's iconic waterfront and the host venue for IPAC'29. Professor Carsten P Welsch, Head of the QUASAR Group and Local Organizing Committee Chair of IPAC'29, had the pleasure of welcoming more than 20 committee members to the city.

Discussions focused on finalizing the scientific program for IPAC'26, as well as reviewing organizational provisions.

On the second day, the SPC members were offered a guided tour of the ACC and Exhibition Centre allowing them to experience the state-of-the-art event venue first hand.

The ACC Liverpool and Exhibition Centre is a purpose-built conference and exhibition complex designed to host international congresses, exhibitions, and large-scale plenary sessions. Its flexible meeting rooms, lecture theatres, and expansive exhibition halls enable organisers to run parallel scientific sessions, poster presentations, and industry exhibitions within a single integrated venue

Its prime waterfront location also places the venue within easy walking distance of hotels, restaurants, and Liverpool's major cultural attractions, offering an enhanced experience for international delegates.

"It was a real pleasure to welcome the committee members to Liverpool," said Professor Welsch. "The visit allowed finalizing the IPAC'26 scientific program and demonstrated Liverpool's excellent capability to host large-scale international scientific conferences. We are all already very much looking forward to welcoming the global particle accelerator community to Liverpool in 2029."

Meet the LIV.INNO students

In each edition of this newsletter, we will introduce some of the students who are studying as part of LIV.INNO CDT

Saransh Malhotra (2nd year LIV.INNO student)

Project title

Preparation and Characterisation of 'Green' Photocathodes for the Generation of High-Brightness Electron Beams

Where are you from?

I am from Mandi, Himachal Pradesh, India

What degree did you study?

I studied a Master's in Semiconductor Physics at Cardiff University, UK

What do you do in your free time?

I love mountain biking, recently did one track from Neath to Brecon Beacon National Park. Additionally, I like to cook and I read nonfiction, such as philosophy and history.

Shirsendu Roy (2nd year LIV.INNO student)

Project title

Searches for Axions in Ultra-Peripheral heavy ion collisions

Where are you from?

I am from Kolkata, India.

What degree did you study?

I am a postgraduate with an MSc in Physics from the Indian Institute of Technology (IIT) Madras.

What do you do in your free time?

In my free time, I like to read books, watch movies, listen to music, and play sports like badminton, football, and cricket

Jak Woodford (2nd year LIV.INNO student)

Project title

High volume data processing in real-time infrastructures for the Mu3e experiment

Where are you from?

I'm from Blackwood, South Wales, UK.

What degree did you study?

I did a Master's in Physics at the University of Liverpool

What do you do in your free time?

Outside of Physics, I enjoy going to Liverpool games.

Stephen Randles (2nd year LIV.INNO student)

Project title

Search for Higgs bosons decaying to dark matter using advanced artificial intelligence techniques and upgrade of the silicon tracker at ATLAS

Where are you from?

I'm from Blackpool, England, UK...

What degree did you study?

I studied a BSc in Physics at the University of Liverpool.

What do you do in your free time?

In my free time I eat biscuits, play football and lift weights.

Innovations for a sustainable tomorrow Symposium to be held in Liverpool

The Innovations for a sustainable tomorrow symposium will be held in Liverpool on Friday 10th July 2026. This symposium will bring together the LIV.INNO Centre for Doctoral Training and the EuPRAXIA community to explore how innovation and sustainability are reshaping fundamental research, medicine, electronics, the environment, and energy.

Scientists from across Europe will present highlights and advances in both the accelerator science and data intensive science fields and the enormous impact these have had on science and society. They will offer unique insight into current R&D programmes, technology roadmaps and outline exciting plans for the future.

LIV.INNO's focus on efficient data usage, computational optimisation, and experiment design aligns directly with EuPRAXIA's mission to create more energy-efficient, resource-responsible research infrastructures. Together, these programmes demonstrate how researchers can develop groundbreaking technologies, and access long-term career pathways across high-tech sectors. This event celebrates a shared commitment to training innovators who will shape the future of sustainable, high-impact science.

The symposium will also offer an opportunity for potential new partners to present their research and to network with current staff, fellows, and collaborators to start a dialogue for future partnerships and projects.

We welcome the whole data science community to this symposium which will be held at the Spine, a stunning building overlooking Liverpool city in the heart of the Knowledge Quarter. Following the daytime agenda a dinner will be held at Lutyens' Crypt Hall underneath the Metropolitan Cathedral, at which delegates are welcome.

To see the detailed agenda for the day and to register, please visit the symposium Indico page :

agenda.infn.it/event/49199/overview

Registration will close on 31st May 2026.

Dates for your Diary

10 March 2026	15:00 GMT	Technological Advancements and Opportunities with the Advanced Gamma Tracking Array (AGATA)	Fraser Holloway (University of Liverpool)
14 April 2026	15:00 BST	Describing the evolution of genomes through Bayesian models	Leonardo de Oliveira Martins (University of Liverpool)
10 July 2026	All day	Innovations for a Sustainable Tomorrow Symposium, Liverpool, UK	

Notice Board

Liverpool Virtual Seminar Series on Data Intensive Science

The seminars in this series cover R&D outside of the LIV.INNO centre's core research areas and give an insight into cutting edge research data intensive science.

To register to attend these seminars please visit https://indico.ph.liv.ac.uk/e/data_science_seminars

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