PostGraduate Institute
for measurement science

8th Annual PGI Conference

Measurement Science for a Better Future

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7 - 8 November 2024

Manchester Institute of Biotechnology

Contents

Foreword

On behalf of the PGI Conference Committee, we are delighted to welcome you to the 8th Annual PGI Conference, held at The University of Manchester on 7-8 November. In 2024, The University of Manchester is marking its bicentenary and our PGI conference will be joining in to celebrate 200 years of learning, innovation and research.
This year's programme is packed with presentations on science, engineering, and measurement, with a workshop focused on researcher development. This year our conference centres around the themes of curiosity-driven research, metrology at scale, cross-sector research and resource, refine and reuse, reflecting the broad and diverse research activities of our students.
The PGI has grown significantly over the past nine years, and to match this spirit of progression, we offer this fantastic opportunity for all our students to immerse themselves in the conference experience: attending, presenting, and networking. The opportunity for the PGI to forge and strengthen connections with both academia and industry has proven invaluable year after year, and we are confident this year will be no exception.
We are excited to officially welcome you to this year's conference and wish everyone an enjoyable and rewarding two days at The University of Manchester.

Christopher Hoole
PGI Conference Chair 2024

Conference Location

Venue: Manchester Institute of Biotechnology

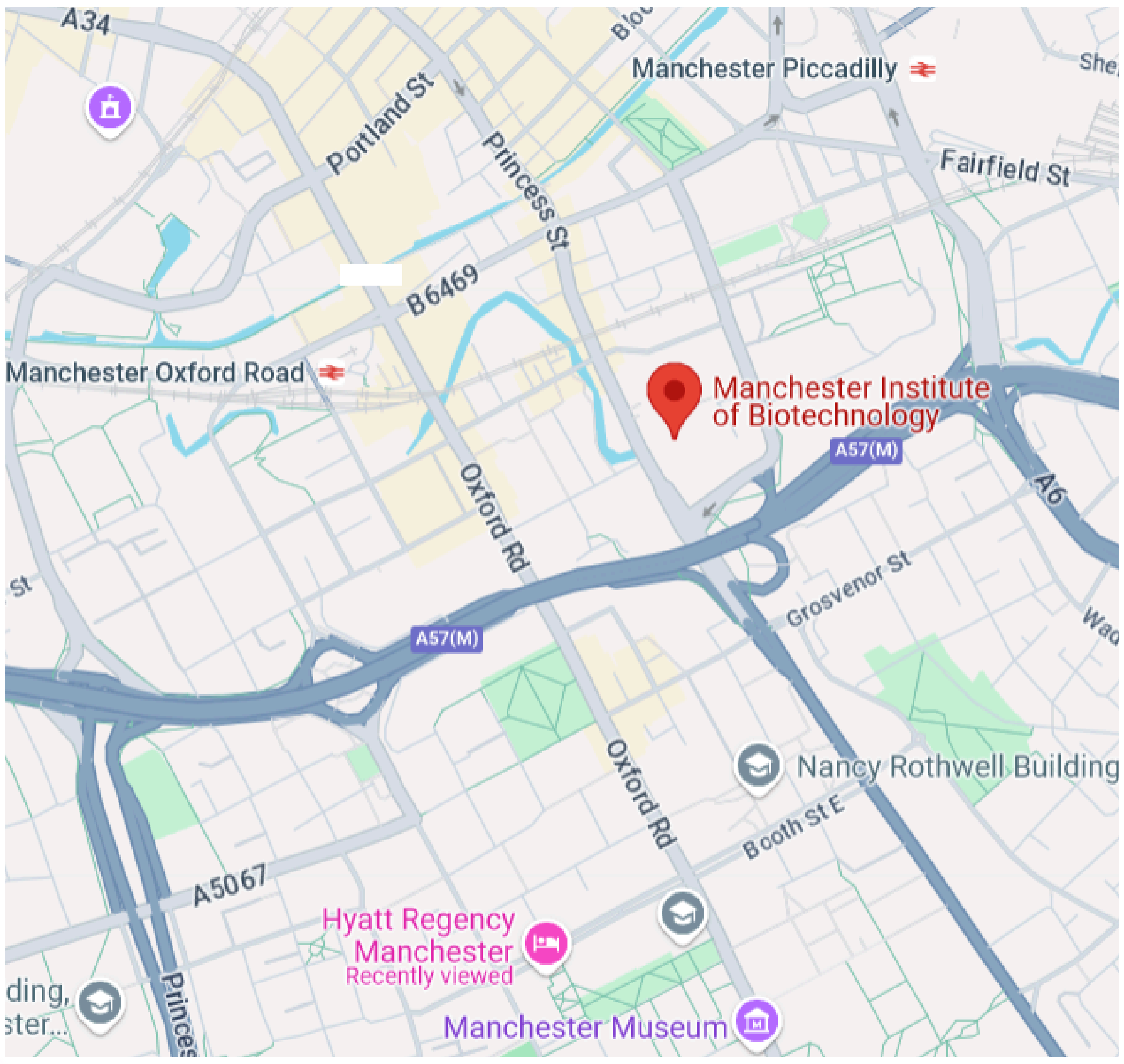
John Garside Building, The University of Manchester,
131 Princess Street, Manchester, M1 7DN
Please head to the Ground Floor Conference Room once you arrive


By Mjfsslb - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=22770759

Conference Dinner Location:

Hyatt Regency Manchester,
55 Booth St W, Manchester
M15 6PQ

On arrival, please make your way up to the 18th Floor Lounge. Pre-booking is necessary for the dinner.



Sponsors

Thank you to both the Henry Royce Institute and the Institute of Physics for their contributions to this year's conference.

Acknowledgements

We would like to extend our heartfelt gratitude to The University of Manchester for generously providing a venue for this year's PGI Conference.

Thank you also to our presenters, PGI members, stakeholders and all attendees of the 8th Annual PGI Conference for contributing and making this year's event a success!

The PGI was established through a Strategic Partnership between NPL, the Department of Science Innovation and Technology, the University of Strathclyde and the University of Surrey.

The PGI's

8th Annual Conference

Measurement Science for a Better Future

PostGraduate Institute for measurement science

Manchester Institute of Biotechnology
The University of Manchester
7-8 Nov 2024

A G E N D A

7 Nov	DAY ONE - Showcase Your Research
9:15	**Registration & coffee**
9:45	Opening remarks Richard Burguete (PGI Director), National Physical Laboratory
10:00	Welcome Prof Richard Jones, The University of Manchester
10:15	Keynote: What do Advances in Artificial Intelligence mean for Science? Prof Caroline Jay, The University of Manchester
Theme 1: Curiosity-driven research Chaired by Chris Hoole	
10:45	Depth profiling in microscope mode SIMS – is it possible? Anya Eyres, University of Oxford
11:00	Towards the development of a digital twin for selected sub-elements made of carbon fibre-reinforced composites for space applications Evangelos-Symeon Apostolopoulos, Coventry University
11:15	Analysis of tissue sections mounted on PEN membranes using 2 different mass spectrometry imaging sources for multi-modal applications Hugo Delattre, University of Surrey
11:30	**Break**
Theme 2: Metrology at scale Chaired by Chris Hoole	
11:45	A miniature 3D-printed Kibble balance for mass sensing applications Emily Edge, University of Southampton
12:00	Large volume 3D imaging of SSC crack in Nickel superalloy 600 using fs-laser serial sectioning technique Jacopo del Gaudio, The University of Manchester

12:15	Satellite-derived methane emission certification – a trusted source of climate information Kalyani Ramanan, The University of Edinburgh
12:30	**Lunch**
	Theme 3: Cross-sector research Chaired by Stefano Pretto
13:30	Deep Learning for Improving Photoacoustic Imaging for CAR-T Cell Cancer Immunotherapy Billy Vale, University of Surrey
13:45	Revealing 3D engineered cell-matrix interfaces by correlative imaging Camilla Dondi, UCL
14:00	Effect of Moisture and Temperature on the Insulating Performance of an EV Battery Thermal Fluid Reuben St John, The University of Manchester
14:15	Poster session
	Theme 4: Resource, refine and reuse Chaired by Stefano Pretto
15:15	Thermoelectric characterisation of nanomaterials with scanning probe microscopy Chris Hoole, University of Manchester
15:30	Designing, Building, and Testing a Mini-Fountain Cold Atom Clock Samuel Walby, University of Oxford
15:45	Validation of high temperature spectra of combustion gases for tomographic image reconstruction of gas turbine engine exhaust and combustor Stuart Clark, University of Strathclyde
16:00	**Break**
16:15	Keynote: Measuring at the extreme: why should I care and how will it affect me? Dr Jessica Boland, The University of Manchester
16:45	Awards and closing remarks
17:00	**Free time**
18:30	Dinner and drinks reception (Hyatt Regency Hotel)
22:00	**Guests depart**

8 Nov	DAY TWO - Careers Focus Chaired by Reuben St John
9:00	**Arrival and coffee**
9:30	Keynote: Adventures with Mass Spectrometry and Joy Milne Prof Perdita Barran, The University of Manchester
10:00	Talks from our sponsors
10:30	Workshop: The Resilient Researcher by Skillfluence
12:45	Closing remarks
13:00	**Lunch**
14:00	Manchester walking tour (optional)
16:00	**END**

HENRY ROYCE INSTITUTE

IOP Institute of Physics

Keynote Speakers

Prof. Richard A. L. Jones - The University of Manchester

Welcome Talk

Richard Jones is Vice-President for Regional Innovation and Civic Engagement at the University of Manchester. He is an experimental physicist, who was elected a Fellow of the Royal Society in 2006 for his work studying polymers at surfaces and interfaces, much of which is carried out in collaboration with industry.

He has written extensively about the role of science and innovation policy in supporting productivity growth and addressing regional economic disparities. His report "The Missing Four Billion: making research and development work for the whole UK" (with Tom Forth, NESTA 2020), made the case for the devolution of more R&D funding to cities and regions to support local economic and social priorities, including addressing health inequalities and supporting the transition to net zero.

In Greater Manchester, he is the Independent Science Advisor to Innovation GM, which brings together business, the GM Combined Authority and GM's universities. Its goal is to develop Greater Manchester's innovation ecosystem, to help level up communities, generate the solutions needed to achieve net zero, and create the conditions for more businesses in more places to benefit from global exporting and inward investment.

Richard is supporting the Atom Valley public-private partnership to capitalise on its proximity to an outstanding University research base, an evidence-based local industrial strategy, translational research centres such as the University of Manchester's Graphene Engineering Innovation Centre and a strong start-up/spin-out eco-system.

Keynote Speakers

Prof. Caroline Jay - The University of Manchester

Caroline Jay is a Professor of Computer Science and Head of Research in the School of Engineering at the University of Manchester. She is qualified as both a Psychologist (BA, CPsychol) and Computer Scientist (MSc, PhD), and undertakes research crossing these domains. She is Research Director of the Software Sustainability Institute, and a keen advocate for open and reproducible science. Caroline holds a Mercator Fellowship at Humboldt University of Berlin, where she is investigating the implications of new technologies, including generative AI, for the construction of scientific workflows. She was named as one of the Guardian's Top 50 Women in Engineering 2022: Inventors and Innovators, for her work advancing ECG interpretation.

What do Advances in Artificial Intelligence mean for Science?

Computation has transformed our ability to collect, process and analyse data, and it is becoming increasingly embedded in our research. Machine learning underpins the interpretation of large scale multi-dimensional data, and modelling and simulation allows us to make predictions prior to - or instead of - real-world experimentation. Large Language Models (LLMs), such as ChatGPT, now have the potential to transform our approach to research in many ways, by mining literature, generating hypotheses, designing experiments and vastly reducing the expertise required to perform complex computational analysis. With these opportunities also come risks, including increased bias within scientific communities, difficulties tracking provenance or spotting errors in analysis, and the significant carbon footprint of these technologies. This talk will outline the possibilities and challenges posed by AI, examine how we should navigate this new landscape, and describe the crucial role that early career researchers will play in building a scientific culture that will lead to its successful implementation.

Keynote Speakers

Dr Jessica Boland - The University of Manchester

Jessica Boland is a senior lecturer of functional materials and devices at the University of Manchester, where she leads the national cryogenic near-field microscopy (CUSTOM) facility. She is also a UKRI Future Leader Fellow and visiting researcher at the National Physical laboratory (NPL). Jessie graduated from University of Exeter with a masters in Physics with professional experience at Hewlett Packard Labs, before completing a DPhil in Condensed Matter Physics at Oxford under the supervision of Prof. Michael Johnston focused on terahertz spectroscopy. Her current research focuses on nanoscale optoelectronic characterisation of low-dimensional materials via ultrafast terahertz spectroscopy and near-field microscopy, as well as development of novel terahertz devices for ultrafast wireless communication applications.

Measuring at the extreme: why should I care and how will it affect me?

State-of-the-art measurement tools are always pushing extremes. From measuring at the fastest timescales, at the coldest temperatures possible or at the smallest length scales, we are always striving to push to new limits and measure our materials at this cutting edge. But is this really necessary? What can we learn from measurement at these extremes? In this talk, we look at why measurement science has a positive impact on society. By utilising examples of pushing optoelectronic characterisation down to nanometre length scales, we demonstrate new exotic material properties that could improve device performance and have applications in quantum technologies and photonic devices. We also demonstrate how inhomogeneity at these nanometre length scales can hinder device performance. Addressing this inhomogeneity can improve energy efficiency having a positive impact on society. We therefore hope to motivate the use of measurement science for direct feedback into future technological development.

Keynote Speakers

Prof. Perdita Barran - The University of Manchester

Professor Barran holds a Chair of Mass Spectrometry in the Department of Chemistry and is the Director of the Michael Barber Centre for Collaborative Mass Spectrometry and a member of Manchester Institute of Biotechnology. She is also the deputy chair of the Infrastructure and Capital Advisory Group for the Medical Research Council, UK.

Her research interests include: Biological mass spectrometry; Instrument and technique development; Protein structure and interactions; Dynamic and Disordered Systems; Parkinson's disease Diagnostics; HDX-MS; Proteomics; and Molecular modeling. She is a Fellow of the Royal Society of Chemistry and was awarded the Theophilus Redwood Award from the RSC in 2019, Researcher of the Year 2020 from the University of Manchester and the ACS Measurement Science Lectureship 2021. In 2020 she initiated the COVID-19 Mass Spectrometry Coalition and was appointed as Chief Advisor to the UK Government on Mass Spectrometry as part of their pandemic response. In 2021 Perdita founded the company Sebomix Ltd. to exploit sebum as a diagnostic biofluid with a focus on Parkinson's Disease.

Adventures with Mass Spectrometry and Joy Milne

The focus of this talk will be on Perdita's career pathway, how she has navigated her career and lessons learned along the way. The talk will emphasise the journey to discovery through a research program using mass spectrometry (MS) to find biomarkers for Parkinson's disease to enable diagnosis.

The unique research program was initiated by Mrs. Joy Milne, a retired nurse from Perth who noticed a change in her husband's body odour 11 years before his clinical diagnosis of Parkinson's disease (PD). Joy noticed the same distinctive odour was associated with other PD sufferers and hence linked it to onset of the disease.

She will emphasize how developing new instruments, being ignorant and being fundamentally optimistic have greatly aided her career.

Training Provider

Dr Jen Allanson - Skillfluence

Jen Allanson completed a PhD in Computer Science in 2000. She became a lecturer at Lancaster University, developing an international research profile based on pioneering work in the field of Physiological Computing.

In 2003 she moved to an academic post at Liverpool John Moores University. However in 2004 she quit and set about working for herself. Her first contract was for Manchester University where she served as Project Officer on a THE Award-winning "An Academic Career" online resource (now retired).

Over the last 20 years Jen has operated a successful, independent training and development business. She is a qualified End of Life Doula, trainee-clown and co-director of Liverpool Arts Lab.

Jen is hosting a workshop titled 'The Resilient Researcher' on Day Two of the conference. See page 22 for further information.

Skillfluence design and deliver impactful training experiences. They work with university managers and leadership to deliver outcome-focused training and skills development programmes for researchers, PhD students and university staff.

SKILLFLUENCE

Day One - Showcase Your Research

Abstracts PGI - Oral Presentations

Disclaimer: references for all abstracts have been redacted but are available upon request

Theme 1: Curiosity-driven research

Anya Eyres

University of Oxford

Depth profiling in microscope mode SIMS – is it possible?

Secondary Ion Mass Spectrometry (SIMS) is a well-established technique to create 3D spatial maps of molecules within a range of materials, from inorganic to biological. A sample surface is probed using a high energy primary ion beam causing emission of surface atoms and molecules. A small fraction of these are ionised and their mass determined using a variety of mass analysers, such as time-of-flight (ToF). In conventional microprobe SIMS, a finely focused (nanometre to micrometre) primary ion beam scans the sample surface, acquiring spectra on a pixel-by-pixel basis creating an image. A more focused beam gives better spatial resolution but requires more pixels and therefore more time to image a given area. Microscope mode SIMS partially decouples time and spatial resolution by combining a defocused primary ion beam with a stigmatic imaging ToF analyser and a fast-imaging camera. This enables imaging of a relatively large area (~2 mm diameter) simultaneously. The long-term aim is high throughput imaging of biological samples.

Additionally, SIMS is used to depth profile through a sample by sputtering through the material in layers, using either alternating analysis and sputtering primary ion beams, or a single primary ion beam. When combined with imaging a 3D chemical map is constructed. Efficient removal of material by sputtering requires a higher beam current than analysis. Using the same beam for simultaneous image acquisition and sputtering is therefore challenging.
Here we present preliminary work on the novel combination of depth profiling with microscope mode SIMS. We show proof-of-concept of single-beam sputtering using a semi-defocused (~ 200 µm diameter) beam combined with fast imaging. We use a well-characterised organic material, Irganox 1010, to estimate the sputtering yield of the defocused ion beam. Challenges of this novel technique are presented, including instrumentation development and the low sputtering rate of a defocused beam.

Evangelos-Symeon Apostolopoulos

Coventry University

Towards the development of a digital twin for selected sub-elements made of carbon fibre-reinforced composites for space applications

Digital twin modelling is a new technological field which has been proven to be able to increase the efficiency of design, production, inspection, and maintenance of components used in the aerospace and other industrial sectors. The aim of this PhD is to develop a digital twin model for two representative space structure elements under operational conditions.
The research has used both quasi-static load testing and vibration testing for composite struts and composite sandwich panels. Key findings are as follows:
For the struts under compression load, the predicted structural stiffness, strains at key locations, failure load and failure location show good agreement with the experimental test results. A sensitivity analysis was also conducted to identify the most critical parameter for failure along with how important uncertainty is for each parameter. A critical design parameter is identified.
For the sandwich panels, natural frequency test and analysis were conducted showing that it is viable to detect damage based on the velocity responses of signature points. A strong indication is that the homogeneity of the sandwich panel can be utilised as an indicator to delamination-type damage based on the differences in the homogeneity between the pristine and a defective panel. The finite element model has shown good agreement with the experimental results in terms of the first natural frequency and capturing of the peaks on the velocity response spectrum.

Hugo Delattre
University of Surrey
Analysis of tissue sections mounted on PEN membranes using 2 different mass spectrometry imaging sources for multi-modal applications

Mass spectrometry imaging (MSI) enables mapping of biomolecules in tissue samples, enabling the visualisation of their abundance and distributions. Integrating MSI with other orthogonal, chemically informative imaging methods can provide even richer data for a deeper comprehension of biological processes. Polyethylene naphthalate (PEN) membranes are compatible substrates to for ion beam analysis (IBA) and laser capture microdissection (LCM) and therefore are sensible candidates for a multi-modal workflow involving MSI. This study evaluated PEN membranes for matrix-assisted laser desorption/ionisation (MALDI) and for a custom-built ambient infrared laser-ablation desorption plasma post-ionisation (IR-LA-PPI) source.

Commercial MALDI instruments use an ultraviolet (UV) laser to ablate the matrix and sample, while the IR-LA-PPI source uses an IR laser. Since PEN membranes have a strong absorption band in the UV region, they are possibly less likely to be damaged by an IR laser. However, UV lasers, with shorter wavelengths, can be focused down to smaller sizes which aids the acquisition of images with smaller pixel sizes. The Bruker timsTOF Flex MALDI instrument used in this study functions under vacuum and accepts a more restricted range of sample geometries for effective analysis, compared to the atmospheric pressure IR-LA-PPI ion source, which can allow easier analysis of non-standard sample forms. Sample preparation is also significantly longer for MALDI analysis since a matrix compound must be coated on the surface, but this is not necessary for IR-LA-PPI.

The success of these preliminary experiments highlights the potential of both MALDI and IR-LA-PPI with PEN membranes in a multi-modal workflow. Each technique brings unique merits and drawbacks, making them interesting to compare. Additional work is required to fully assess the multi-modal compatibility of IBA and LCM with both techniques for optimal workflow selection.

Theme 2: Metrology at scale

Emily Edge
University of Southampton
A miniature 3D-printed Kibble balance for mass sensing applications

Mass measurements are an essential part of everyday life. Many transactions and tasks, from paying a fair price for groceries to receiving a safe and effective dose of medicine, rely upon accurate and traceable mass metrology. The redefinition of the International System of units (SI) kilogram in terms of the Planck constant in 2019 provided the opportunity for the implementation of directly traceable mass measurement at the point of need without the use of standard artefacts. This opened the possibility of miniaturisation for improved measurement capability at small scales, particularly for sub-milligram applications, such as gene therapy, where traceability is limited by high relative uncertainty due to the process of sub-division of the kilogram.

One of the routes to realising SI mass is via a Kibble Balance which compares a mechanical force (the weight of a mass) with an electrically generated force. 3D printing of micro-electromechanical system (MEMS) devices is an emerging technology with significant cost and flexibility benefits over traditional MEMS fabrication. The main aim of this work was to create a ‘low cost’ 3D printed Kibble balance at the gram-level as proof-of-concept for miniaturisation to 3D printed MEMS at the sub-milligram-level.

A prototype system was designed based upon a single ring magnet with co-wound tare and bifilar main coils, 3D printed mechanical parts, commercially available components, and National Physical Laboratory (NPL) produced hardware and software. The initial performance of this system was determined using glass marbles between 3.5g and 6.0g. The calculated uncertainty was 0.2% (at k=1).

These results were compared with a traditional mass calibration performed at NPL which revealed a +3.6% systematic error in the prototype system. Once identified, the source of this error can be eliminated to allow the device to be scaled to the micro-gram level within a target uncertainty of 0.5% (at k=1).

Jacopo del Gaudio
The University of Manchester

Large volume 3D imaging of SSC crack in Nickel superalloy 600 using fs-laser serial sectioning technique

Stress corrosion cracking (SCC) occurs when a susceptible material is subjected to stress in a corrosive environment. SCC is a major failure mechanism in the primary circuit of pressurized water reactors and a significant threat to the performance of nuclear power plants with significant economic impact. In this work, we aim to measure the crack path in three dimensions (3D) in space in relation to the microstructure of the material, which will help to design alloys to inhibit crack initiation and growth. The aim is to measure the crack propagation across hundreds of microns with sufficient accuracy to a precision of about 1 μm to measure the microstructural properties that may affect crack development on a large scale.
We use X-ray computed tomography (XCT) and fs-laser serial sectioning (fs-laser SST) to image the entire crack developed in on a nickel 600 specimen after the SSC test under primary water conditions, occupying a volume of approximately 450μm x 500μm x 250μm, with a spatial resolution close to 1μm. The images of the slices from the fs-laser SST must be accurately aligned to provide a true representation of the 3D volume. To address the metrology challenges of fs-laser SST, we developed a guideline for minimizing and quantifying the misalignment of the slices by milling a set of reference marks of known position and orientation on the sample surfaces. This can be reconstructed during the post-processing rendering process to estimate the bias due to the slice shape and position. The errors and uncertainties in lengths and angles will be calculated to measure the crack path and microstructure properties with sufficient confidences to reliably describe the significant parameters that determine the material performance under SSC.

Kalyani Ramanan
The University of Edinburgh

Satellite-derived methane emission certification – a trusted source of climate information

In response to the Paris Agreement, there has been a progressive shift towards using satellite observations to locate and estimate emissions of the potent greenhouse gas methane, particularly large plumes originating from fossil fuel extraction sites. This shift is driven by technological advancements, including the advent of private satellite constellations, and new regulations in the energy sector implemented by international bodies in response to the Global Methane Pledge.

Despite these advances, the methods for estimating methane emissions and their associated uncertainties—stemming from factors like wind, surface features, and sensor characteristics—often lack transparency. This hinders the perceived reliability of the emissions data products and therefore independent validation is needed to improve their credibility.

To address this challenge, I have begun to investigate the sources of uncertainty in satellite-derived methane emission estimates. By applying principles of metrology to the satellite retrieval of greenhouse gas data, I aim to ensure that all uncertainties are accurately reflected in the final emissions products. This validation process is crucial for certifying that the data products are fit for purpose. Reliable emissions data are essential for informed decision-making and evaluating the effectiveness of climate mitigation strategies, ultimately supporting global efforts to combat climate change.

Theme 3: Cross-sector research

Billy Vale

University of Surrey

Deep Learning for Improving Photoacoustic Imaging for CAR-T Cell Cancer Immunotherapy

CAR-T cell immunotherapy is an emerging powerful technique for cancer treatment. While it is effective in treating haematological cancers, methods for quantifying the time-varying spatial concentration of CAR-T cells in vivo are necessary to better understand and improve its efficacy for solid tumours. One approach involves inserting a reporter gene into the CAR-T cells, causing them to express photochromic proteins that provide strong near-infrared (NIR) optical contrast. NIR photoacoustic (PA) imaging is then used to image these proteins which in turn causes a variation in the contrast between successive images. Thus, the resulting temporal PA signal, distinguishable from the time-invariant background tissue signal embeds information about CAR-T cell distribution.

In this study, we explore the application of deep learning to quantify the spatial concentration of CAR-T cells from time-series PA images. To address the shortage of training data for deep learning approaches, we developed and validated a novel 3D simulation framework, which generates accurately labelled PA images of CAR-T cells expressing the reporter gene. This allowed us to create a large and inexpensive dataset for machine learning experiments. Then, we investigated the performance of various deep learning models and have shown that fine-tuned convolutional neural networks and transformers can accurately predict the spatial concentration of the photochromic proteins, even when significant noise is present in the training data.

This multi-disciplinary research integrating physics and artificial intelligence is part of the effort to advance non-invasive high-accuracy quantitative in vivo imaging of CAR-T cells in general, and to accelerate pre-clinical research in cancer immunotherapy for solid tumours.

Camilla Dondi

University College London

Revealing 3D engineered cell-matrix interfaces by correlative imaging

Much of our understanding of cell and tissue biology has been elucidated in flat receptacles two-dimensional (2D) cell cultures. The limitations of these have become clear with the development of three-dimensional (3D) cultures, which more reliably mirror features and complexities of cells and tissues. Particularly striking was the discovery of the amoeba-like migration behaviour of cancer cells, a phenomenon unseen in 2D environments which fail to consider the reliance of cells' adhesion and migration on extracellular matrices (ECMs), 3D environments for cells to reside and grow in. To promote metastasis, cancer cells detach from their scaffold and swim like amoeba to other body locations. This discovery changed drug development approaches, bridging the gaps between research and clinic.

3D cultures advanced tissue regeneration studies, generating interest in synthetic protein matrices with tailorable properties and controllable chemistry. Developed as hydrogels, such matrices can mimic composition and fibrillar structures and meshes of the native ECMs. Despite many designs, much remains unknown about matrices interactions with cells, how they influence cell survival and proliferation, and how cell responses can be controlled through matrix design. Individual analytical techniques fall short of providing structural, chemical, and functional properties of scaffolds and cells cultured within. Correlative approaches with different, but complementary, spatiotemporal resolutions can in turn support the development of more reliable and consistent 3D scaffolds.
To unravel interfacial events between cells and rationally designed synthetic matrices, we use a correlative imaging strategy comprising atomic force microscopy, fluorescence, Raman, electron microscopy and secondary ion mass spectrometry imaging. Our multi-component self-assembling protein matrix forms a fibrous network shown to support human cell growth in a responsive manner. We aim to develop well defined and characterised cellular models, through matrix properties, to use as models for more accurate drug delivery studies.

Reuben St John
The University of Manchester
Effect of Moisture and Temperature on the Insulating Performance of an EV Battery Thermal Fluid

As electric vehicles become increasingly popular, there is a growing emphasis on innovating their technology, evidenced by the interest surrounding novel thermal management techniques like immersion cooling. Unlike conventional thermal management methods, immersion cooling involves submerging active components directly into a thermal fluid, necessitating an insulating fluid. It offers improved thermal management, which can enable faster charging and extended battery life. The insulating performance of such a fluid depends on various factors, including temperature and moisture content. Therefore, it is crucial to quantify these factors to provide a comprehensive understanding of their impact on fluid properties. While quantifying temperature is straightforward, moisture content in a fluid can be expressed in different ways, namely absolute water content and relative saturation. The relative saturation value is derived from the absolute and the maximum water content at a specific temperature, proving more representative than the absolute value, as the maximum water content can vary significantly with temperature and among different fluid chemistries. With these parameters quantified, a closer examination of insulating performance is possible, in this case focusing specifically on DC resistivity. Following the IEC 60247 standard, the DC resistivity of an EV battery fluid at different temperatures and moisture levels are measured. The results showed that the DC resistivity of the fluid decreases with the increase of temperature or moisture level.

Theme 4: Resource, refine and reuse

Chris Hoole
University of Manchester
Thermoelectric characterisation of nanomaterials with scanning probe microscopy

Photocurrent nanoscopy is a powerful tool for investigating the thermoelectric and optoelectronic behaviour of 2D materials. Combining an electric current measurement capability with a scanning near field infra-red nanoscopy system allows these properties to be probed with nm-resolution. Previous studies have focussed on graphene because its electronic characteristics make it an ideal medium for studying optoelectronic and thermoelectric behaviour in 2D. This has revealed the impact of grain boundaries, flake edges and moiré superlattice on these properties. However, the impact of graphene folds on thermoelectric behaviour has not been studied in great detail, and the effects of adjacent ferroelectric materials has only just begun to be explored. In this study we demonstrate a nano-photocurrent measurement system capable of probing the optoelectronic and thermoelectric properties of 2D materials with nm-resolution and present the findings from two different experiments. The first is an investigation on the impact of folds on the thermoelectric properties of graphene. The second is a first-time study into the ability of a ferroelectric twisted hBN bilayer to modulate the carrier density of an adjacent graphene layer. Our work aims to demonstrate the capabilities of the photocurrent nanoscopy technique and its ability to investigate the thermoelectric properties of 2D materials in a range of different systems.

Samuel Walby

University of Oxford

Designing, Building, and Testing a Mini-Fountain Cold Atom Clock

Atomic fountain clocks are currently the best microwave-based clocks available to humankind: they laser-cool atoms down to the single microkelvin regime to define the SI second with 16 digits of accuracy and precision. However, they are large, expensive apparatus whose use is limited to well-funded research laboratories. As the ultimate source of the long-term stability of national timescales, wider access to accurate, drift-free clocks would improve society's resilience to loss of GNSS coverage, which is currently the workhorse of precise time distribution.

To effect wider adoption of atomic fountain clock technology, we have been working on designing, building, and testing a mini-fountain, which aims to achieve similar stability and accuracy to the full-sized Primary Frequency Standards, but at a fraction of the cost and with reduced complexity and size. By accepting even only a slight reduction in performance, many parts of the traditional apparatus become overkill, and can be replaced with more efficient solutions. Particular attention has been paid in the design to improving the temperature stability through the design of the microwave cavity used for interrogating the clock transition; improving the overall robustness of the laser system by using all-in-fibre optics for generating the light for laser cooling and detection; and reducing the size by carrying out state-selection and detection in the same chamber as the cooling.

The result is a clock that is less than half of the height, and approximately 20x smaller in volume, than the Primary Frequency Standards, while achieving the same linewidth on the clock transition. The aim now is to optimise the short-term stability via the compact detection method, and to integrate the magnetic shielding so that the accuracy and long-term frequency stability of the clock can be fully evaluated.

Stuart Clark

University of Strathclyde

Validation of high temperature spectra of combustion gases for tomographic image reconstruction of gas turbine engine exhaust and combustor

Air travel has a significant contribution to climate change, contributing 2.4% of all anthropogenic emissions of CO2. To reduce these emissions requires a better understanding of the combustion process for the ongoing development of gas turbine engines, and the performance assessment of alternative fuels, such as synthetic aviation fuel (SAF) or hydrogen. This can be achieved by measuring the stoichiometry of the carbon species during or after combustion. As tuneable diode laser spectroscopy is a non-intrusive and in-situ measurement technique it is ideally suited to this application, allowing for the measurement of concentration of the target gas species (water vapour and carbon dioxide), as well as system temperature and pressure and we have identified spectral features for water vapour around 1964 nm and 1999 nm for the recovery of temperature and water vapour concentration, and a CO2 spectral features at 1999 nm.

A major focus on measurement validity is the accurate physical knowledge of the spectral parameters for each of the target spectral features as a function of temperature and pressure. A high pressure and temperature near-infrared spectrometer has been built for the interrogation of the absorption features of these key species in a controlled environment to improve the confidence interval of the modelling of combustion gases. The identified spectral features have been recorded as a function of pressure and temperature and the key line parameters, temperature dependent line strength, pressure dependent broadening, and the shift in central wavelength were fitted.

This improved modelling approach, combined with the most accurate wavelength modulation characterisation methodology, will be applied to a multi-species tomographic imaging system for use in both exhaust and in-combustor applications. This tomographic imaging system will significantly improve understanding of combustion and the influence of fuel composition which will enable the development of more efficient and sustainable aviation.

PGI Poster Presentations

Please visit our poster presentations at 14:15 (day one). This is a summary of the posters on display.

Theme 1: Curiosity-Driven Research	
Matt Wray	Exploring differing hydrogen embrittlement mechanisms resulting from differences in electrochemical versus gaseous charging of hydrogen into stainless steels
Merljin Surtel	Predicting Wave Height through Wave Spectra Partitions and Machine Learning
Genevieve Jenking-Rees	Quantitative X-ray Phase Contrast Imaging
Robert John	AI for Automated Cancer Staging
Razan Abusam	The study of Resorcinol formaldehyde gels for CO_2 Capture
Laura Copeland	Bio-Medical Applications of Fourier Ptychographic Microscopy
Sean Demetre	Quantum transport measurements of Weyl semimetal WTe_2
Theme 2: Metrology at Scale	
Muhammad Osama	Health monitoring of CFRP integrated electrical power system
Sifa Poulton	What's the Ratio? Enhanced Safety Monitoring for Nuclear Fuel and Power Stations
Grace Amadi	Investigating the Impact of Pinhole Defects in Catalyst-Coated Membranes
Mahjabeen Fatima Yousafzai	Encapsulated Graphene as a sensor for practical Johnson Noise Thermometry
Lewis Walker	Low-Cost Fourier Ptychographic Microscopy for Cancer Margin Detection
Emily Cachia	Novel x-ray interferometers (XRI) for length metrology
Lucy Green	Assessment of 24-Hour Lung-Deposited Surface Area Exposure in Children

Theme 3: Cross-Sector Research	
Clea Dronne	Detecting abnormal radiotherapy organ at risk contours for head and neck patients
Purnank Aggarwal	Optogenetic control of MSC-mediated immunosuppression in 3D
Rebecca Habgood	Development of a Novel Radiation Research Platform for Future Cancer Therapy Research
Emma Wall	Analysis of TRIR data for vitamin B12-derivatives and the B12-dependent photoreceptor, CarH
John Buckingham	The resistance of polymers to degradation in a marine environment
Anthony Criscuolo	Analysis of breathing volumes and patterns for Radiotherapy in upright and supine positions
Maximillian Wells Peste	Demonstration of weighted graph optimization on a Rydberg atom array using local light-shifts
Josephine Hoare	Assessing new and emerging technologies using the Edinburgh Pipe Phantom
Theme 4: Resource, Refine and Reuse	
Maryana Baran	De novo design of Collagen-Like Peptides for cell-based technologies
Khadija Asif	Assessing MOFs in Direct Air CO_2 Capture: Forcefield Selection and Material Screening
Cameron Mein	Measurement of cattle emissions and their unprecedented impact on the climate crisis
Hugh Claridge	From theory to reality – practical data challenges in pancreatic cancer prediction
William Johnson	Hydrogen production from waste biomass conversion using polyoxometalates/metal salt redox mediators
Angelica D'Ottavi	Signal identification in timing and scintillation detectors for the Pu239 fission with STEFF, at the neutron time of flight facility (n_TOF)
Matthew Birch	Nuclear data measurements at CERN for applications in fusion technologies
Euan Parry	Characterizing superconducting microresonators for the interface of spin-qubits

Day Two - Careers Focus

This day will provide a workshop for PGI students, as well as another exciting keynote talk and an optional walking tour of Manchester.

SKILLFLUENCE

The Resilient Researcher

Workshop hosted by Dr Jen Allanson

Challenges make life interesting. When challenges come all at once, are unexpected, or are huge it is natural to feel overwhelmed. The Resilient Researcher workshop by skillfluence is an experiential workshop full of ideas and strategies to help you to deal with life's challenges: from imposter syndrome, to failed lab experiments to isolation and maintaining a good work/life balance. Resilience is key to managing the twists and turns of life as a researcher. Strategies and approaches to overcome difficulties, maintain balance and keep motivated will be explored. Research pressures can be intense so this workshop will help you to recognise your strengths and apply them so you can bounce back from setbacks and become more resilient in your career.

The topics covered will be:

- Strategies to actively manage your interface with the world
- Tools and techniques to deal with destabilising events
- Routes to recovery and well-being
- Practical actions, knowledge and behaviours that strengthen your foundations
- Self-knowing to help you to make good, life-affirming choices

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Manchester Walking Tour

A guided walking tour around Manchester city centre will be held on the afternoon of day two. Immerse yourself in the city's rich culture, whilst stretching your legs and getting to know fellow PGI delegates!

Conference Committee 2024

PGI Students

Chris Hoole (Chair) 

Stefano Pretto (Co-Chair) 

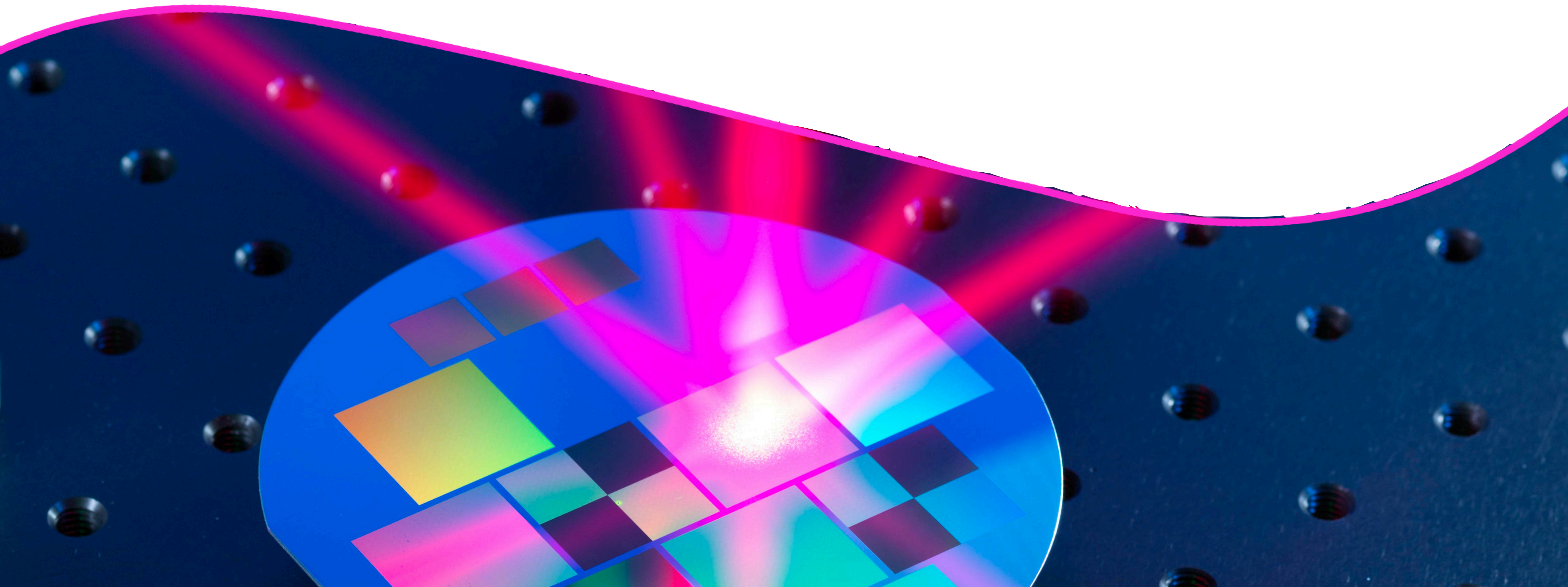
Emma Wall 

Reuben St John 

Jacopo Del Gaudio 

PGI Team

Richard Burguete (PGI Director)
Leah Chapman (PGI Operational Manager & University Liaison Manager - South of England)
Linden Fradet (PGI Operational Manager & University Liaison Manager - North of England and Scotland)
Helen Murugan (PGI Development Officer)
Maggie Mayer (PGI Administrator)



NPL

Department for Science, Innovation, & Technology

University of Strathclyde

UNIVERSITY OF SURREY

Would you like to get involved with organising our next conference in 2025? Please get in touch at pgi@npl.co.uk to register your interest.

Get in touch

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PGI PostGraduate Institute for measurement science