IOP | Institute of Physics

Instrument Science and Technology Group

NEWSLETTER JULY 2020

Welcome to the ISAT Newsletter. This has been a challenging year for the Group, as it has for all organisations, but we have continued to meet regularly and plan our future activities, as well as continuing our events, some of which are reported in this Newsletter.

We held a new meeting on *Fibre Optic Shape Deformation Sensing: An Emerging Technology* at the IOP on 7th May last year, organised by new committee member Thomas Kissinger. This attracted 35 delegates, an excellent turnout for such an event. On 15th March last year, a meeting was jointly organised by several of our committee members, led by Alex Boboc, for early career researchers, and held at UKAEA at Culham in Oxfordshire. The meeting was entitled *Instrumentation for World Leading Science*, and over 60 delegates attended this top quality event. A follow-up event is currently being planned for a similar time next year. The summer was rounded off with an event on *Instrumentation for Combustion and Environmental Sensing*, organised by Paul Wright, and held in Manchester, with an attendance of eight. We are currently heavily involved in contributing to *Photon 2020*, led by Thomas Kissinger on this. Our meetings this year have been a little thinner, partly due to a turnover of committee members, and partly due to the challenges brought on by Covid-19. I would like to thank our outgoing Honorary Secretary and Honorary Treasurer, Amir Sanjari and Andrew Tickle, for their service to the committee and the Group, and extend my thanks Paul Wright for taking on the role of Acting Honorary Secretary, and Sam Henry as Acting Honorary Treasurer (along with Newsletter Editor), until September 2020.

We do hope that you will support the Group by attending meetings and other events, either virtually or in person. If you feel that our future programme does not reflect your interests adequately, then please contact us: we will be happy to liaise with you, and arrange for a committee member to co-organise with you a meeting that more accurately reflects the interests of the ISAT community. Of course, the committee too always requires enthusiastic new members to maintain its vigour, and suggestions for new members are always welcome – please check the invitation to nominate committee that is circulated by the Institute.

Prof Andy Augousti. ISAT chair

Reports from past meetings

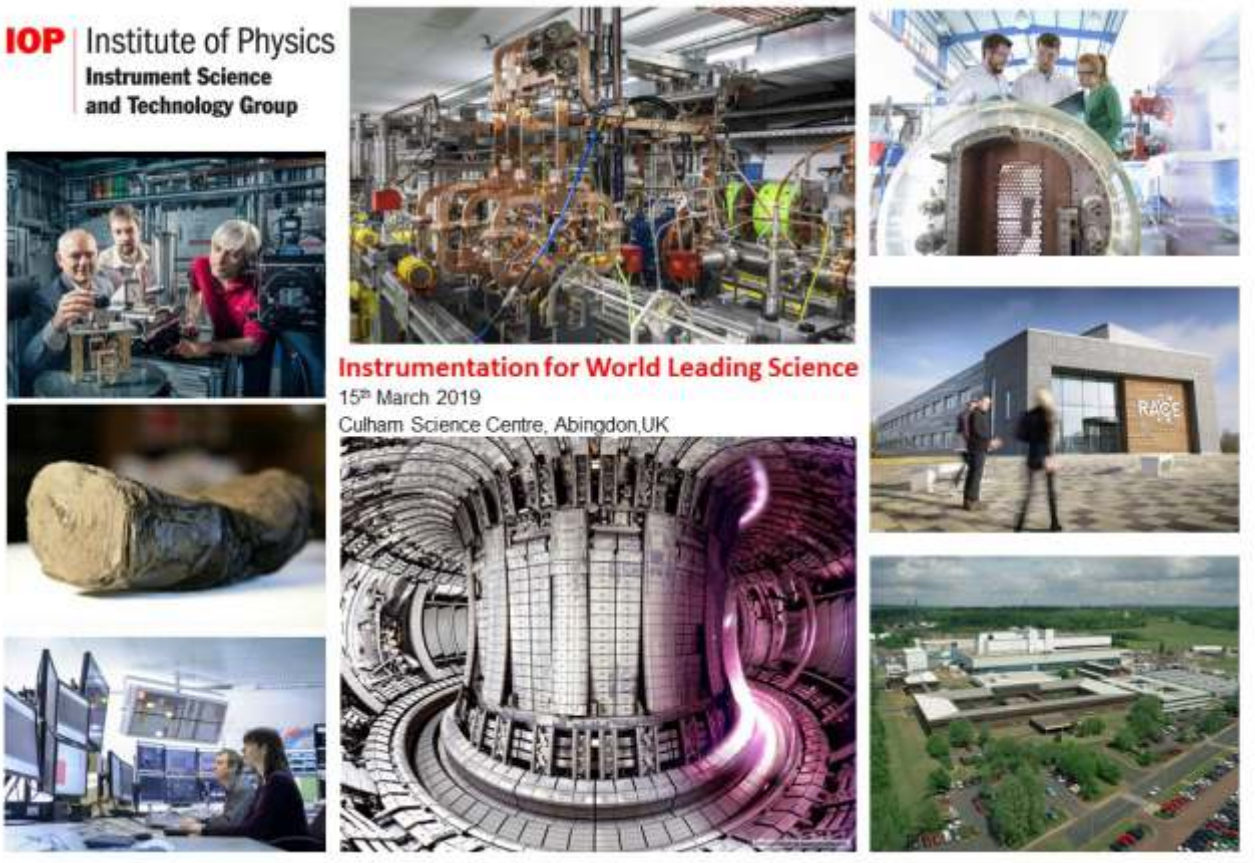
Instrumentation for World Leading Science

Culham Science Centre, Abingdon, UK 15 March 2019

Alexandru Boboc CEng CPhys, UK Atomic Energy Authority

An event focusing on some of the cutting-edge science instruments being researched attracted a range of different delegates to Culham. The Instrumentation for World Leading Science took place in the Hans-Otto Wuster Conference Room at Culham Conference Centre. Geared specifically for graduates and early career scientists, it was a chance to find out more about instrumentation from nuclear fusion to ancient scrolls, as well as state-of-the-art accelerators and robots. Organised by the Instrument Science and Technology Group (Institute of Physics), UKAEA, STFC and Oxford University, the day introduced delegates to a range of fascinating subject areas.

Following a welcome by Alexandru Boboc, senior JET Researcher, UKAEA's Fernanda Rimini introduced guests to the range of measurements and control for tokamak fusion devices and gave a detailed interview on how to drive the JET machine. RACE Director Dr Rob Buckingham delivered a talk titled Towards Zero Manual Intervention. Acknowledging that designing a fusion power plant was difficult, he focused on remote maintenance being vital for refuelling, inspecting, maintaining, and upgrading a fusion machine.



Reports from past meetings

Dr Matthew Veale spoke about the development of X-Ray Imaging Technologies at STFC, while Professor of Accelerator Physics at the University of Oxford, Prof Philip Burrows, spoke about the changes which will be brought about from next generation particle accelerators. These would have applications in medicine, industry, security and energy generation, he said. Accelerators are machines that use electromagnetic fields to propel charged particles to a very high speed, which enables the protons to smash together. The collisions are then analysed and can tell physicists about the laws of nature.

Alex said: “Some of the science behind these various projects was fascinating.
“I had extremely positive feedback too from delegates, and in terms of both internal and external we had a great range of speakers. "I would like to thank the fantastic admin team, particularly Liz Towndrow and the IOP ISAT committee for organising this unique event.”

Fibre Optic Shape and Deformation Sensing: An Emerging Technology

Institute of Physics, London, 7 May 2019

Thomas Kissinger, Cranfield University

A free half-day meeting on the emerging topic of fibre-optic shape sensing (FOSS) organised by ISAT was held at the new IoP headquarters in London and over 30 participants attended the event. The measurement of shape and deformation using FOSS systems conveys information about a structure that is easily visualized and interpreted, and shape information is highly significant across applications as diverse as medicine (tracking of surgical instruments), healthcare (prosthetics), robotics (continuum robotics), wind turbines & aerospace (morphingwings/blades), civil engineering (structural health monitoring) and the sports and gaming industries (kinematic motion measurements). The aim of this meeting was to bring together researchers from across research spectrum to start forming a research community for this emerging technology.

The meeting started with a keynote lecture by Nick van de Berg from TU Delft on the topic of 'Data-driven design of steerable needles'. Six further talks on the use of FOSS for respiratory monitoring (Tom Allsop), polymer fibre sensing grids for human motion characterisation (Patricia Scully), hydrodynamic flow measurement using fibre-optic bend sensing (William N MacPherson), FOSS for aerospace structures (Steve James), the need for FOSS in civil engineering infrastructure (Raul Fuentes) as well as an overview talk on FOSS technology (Thomas Kissinger) followed. Two posters on distributed FOSS (Angeliki Zafeiropoulou) and on specialty fibres for FOSS (Andy Gillooly) complemented the talks.

Reports from past meetings

Instrumentation for Combustion and Environmental Sensing

Manchester, 25 June 2019

Paul Wright, University of Manchester

In June 2019 the University of Manchester hosted the inaugural IOP Instrumentation for Combustion and Environmental Sensing workshop (ICES). This full-day workshop brought together users and developers of instrumentation for combustion and environmental monitoring, with an emphasis on networking and seeding new and interdisciplinary collaborations.

Eight talks were presented, on topics ranging from sample line effects in extractive analysis of combustion exhaust to a fascinating account of a recent attempt to design and test an instrument capable of detecting sub-surface meteorites in Antarctica. Adil Shah described the challenges and opportunities of using UAVs to track greenhouse gas emissions and Leigh Stanger reported on how the smartphone technology might be used in monitoring the activity of volcanoes.

All of the talks were well received, sparking diverse and challenging questions from the audience. The networking opportunities were highly valued by all in attendance - two of the attendees will soon be collaborating on an EPSRC-funded pollutant imaging project.

Upcoming meetings

Photon 2020

1-4 September 2020

ISAT is one of seven Institute of Physics groups (together with Environmental Physics, Optical, Quantum Electronics and Photonics, Quantum Optics, Quantum Information and Quantum Control and Medical Physics groups) that organise the Photon 2020 conference, held this year in Nottingham, UK.

Photon 2020 is the major Optics and Photonics conference organised by the Institute of Physics in the UK and the tenth in the biennial series that started in 2002. Over four days, Photon participants will have the opportunity to visit exhibitions on the latest in optics and photonics technology, attend lectures from experts in the field, and get up to date with cutting-edge research. The programme will consist of plenary and invited talks, as well as contributed presentations and posters.

Due to the coronavirus outbreak Photon 2020 will now be held as a virtual event on the same dates. Attendance will be free for IoP members.

Dynamic Energy Yield Assessment in Wind Power Projects: Unlocking Actionable Insights Using Lidar

Peter Clive, Wood plc

We have a relatively well-established approach to developing a wind energy project, with associated sets of data and analysis requirements that must be fulfilled at each stage, from:

- Pre-feasibility assessments that dip a toe in the water to give some go / no-go indication about further investment in proper data that allows a firmer evaluation of potential, through
- Design and execution of the measurement and analysis campaigns that acquire those data and support those evaluations, ultimately producing
- Bank grade estimates of AEP (Annual Energy Production) that might attract equity investors and calculations of percentiles of the AEP distribution (e.g. P90) that will support debt finance, to
- Power performance testing and monitoring against baselines, condition monitoring, asset management and optimisation, predictive analytics, life extension, and so on.

Data requirements arise at every step of this process. Indeed, investor confidence is based on the consistency with which these requirements are applied.

Initially our approach to data acquisition to fulfil these requirements was based on the capabilities of met masts. For over ten years now, though, we have become increasingly reliant on lidar, which has gone from being a research tool to become a routine and indispensable part of the wind analyst's toolkit. We've used lidar in a vertically profiling role that emulates the capabilities (and limitations) of met masts. We've used it in other roles that go (well) beyond those capabilities, including fixed and scanning deployments on transition pieces and nacelles of wind turbines. We have floating lidars. We can use them to measure in offshore locations from an onshore position. We can used them in synchronised, co-ordinated multi-lidar configurations. We can even install them on drones.

10+ years of lidar wind measurements have taught us:

- Wind is not a primitive data type. It is an object that integrates sophisticated measurements & models. The simplicity of the instruments we have used historically fooled us into thinking the wind itself was simple. It's not. Lidar is how we digitise the wind in a manner compatible with its object-oriented representation.
- Representing wind as an object is compatible with our object-oriented energy system architectures, systems in which we must embed it to codify its interactions with other objects such as turbines (real or digital), and systems to which we apply MDAO (multidisciplinary design analysis and optimisation).
- Our uncertainty budgets are incomplete: both fundamentally, as you cannot evaluate the likelihood of an unforeseeable event, and to an unnecessary extent, since the way our project life-cycles are siloed results in things that are, in fact, perfectly foreseeable, being unforeseen. Too often we discover real-world load cases through component failure rather than anticipate them due to pre-construction measurements. We fix this by de-siloing our approach to the project life-cycle and adopting fully

aligned and unified data requirements throughout, based on the project outcomes we want to achieve rather than the limitations of obsolete tools and techniques which we have already overcome, but which remain represented in our procedures like fossils.

- Historic limitations in measurement opportunities resulted in methods determined by constraints rather than outcomes: we thought about "what can I measure" rather than "what do I want to measure". This created silos, corresponding to the different answers we arrived at for the first of these questions at each stage in project delivery. However, these limits no longer exist, and so neither should the silos. We can acquire more data more often in more situations than our established procedures anticipate or require, and we don't exploit these possibilities as a result of the silos within which we operate.
- Concepts like "pre-construction" and "simple terrain" are artefacts of these limitations rather than descriptions of reality. The wind conditions that determine project performance don't exist until after the project exists, because (as phenomena like "blockage" show) the project modifies the wind. The project is part of the terrain. Treating wind as a primitive data type is incompatible with methods that can be applied consistently through all phases of project delivery that recognise this.
- There is an opportunity to adopt a dynamic approach in energy yield assessment (by analogy with risk assessment) that continuously improves our estimates on the basis of the best information as this becomes available, making it a living document rather than a series of loosely connected snapshots. Risk assessment accepts our information is always incomplete and puts in place procedures to dynamically assimilate new information as it comes to light, to protect life and limb. We should adopt a similar approach to protect our investments.
- This dynamic approach provides the most realistic understanding of the project at any given time and provides the best possible support for investor confidence.

In a wider context, this means that wind exemplifies developments in sustainable infrastructure more broadly, where improved realism supports sustainability and protects investment from climate-change related threats.

We are moving from an era dominated by a consumerist narrative exemplified by the phrase "Internet of Things" to one driven by an environmentalist narrative and what we might call the "Internet of Impacts". We are moving from an emphasis on connectedness to one on consequences, as we fully digitise and characterise our infrastructure and the ecosystems in which we embed it, to assimilate what was previously neglected as externalities into our sustainable costings and business models.

It turns out

- Representing wind as an object, rather than a primitive data type, that interacts with other objects in our systems architecture,
- Accepting we are always working on the basis of incomplete information, and using a database that is constantly improving,
- Adopting a dynamic approach to assessment that makes the best possible use of the available information as it becomes available to make our assessments living documents rather than limited, loosely connected snapshots, and
- Using unified data requirements based on an outcome-driven rather than constraint-driven approach that allows us to propagate our ultimate objectives back through the full (and fully de-siloed) project life-cycle to inform each phase of project delivery, so that insights are unlocked and made actionable at the earliest possible opportun puts the wind industry in the vanguard of this wider effort to represent as comprehensively and as realistically as possible the costs that accrue and the benefits that can be realised in the deployment of sustainable infrastructure. All of this is made possible by laser based remote sensing of wind conditions.

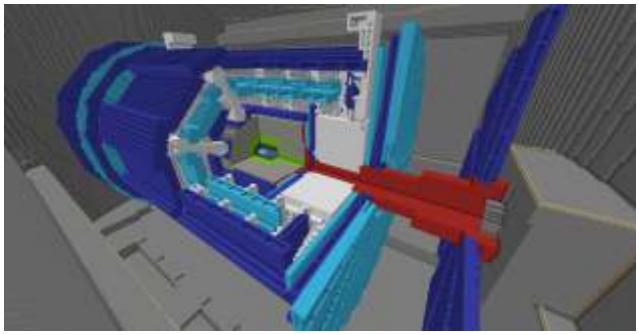
Exploring the World's Biggest Scientific Instrument in Minecraft

Sam Henry, University of Oxford

Need something to do while stuck at home? Enjoy playing the Minecraft computer game? If so, take a look at ATLAScraft – a Minecraft model of the ATLAS experiment at CERN. In this virtual world you can visit the control centre, take a lift underground and explore the tunnels and detector components. Take a train ride through a semiconductor tracker detector, and learn about the electromagnetic and hadronic calorimeters, the muon spectrometer, the magnet system, and other parts of this cathedral-sized instrument. You can also roam around the CERN campus and learn about the Large Hadron Collider and the big science questions particle physicists are addressing.

ATLAScraft was built by students from schools across the UK, directed by researchers from the University of Oxford and University of Birmingham. It includes many games and interactive features to illustrate how the parts of the detector work. It is available for anyone with Minecraft on their PC or Mac to download and play.

Download from: https://atlascraft.web.cern.ch/




Instrument Science and Technology (ISAT) Group Committee

Prof Andy Angousti (Group Chair)

Andy Augousti is a Professor of Applied Physics and Instrumentation at Kingston University London. His research interests are wide, and include optical and acoustic sensors for physical and biomedical measurements, as well as modelling of the eye, rocket engine development and communication in and around black holes. He has been Chair of the ISAT Group on three occasions now, in every decade since the 1990s.

Dr Paul Wright (Group Secretary)

Paul Wright is a Senior Lecturer in Sensing and Measurement Systems at the University of Manchester. Following a Ph.D. in medical instrumentation, Paul spent his early career in industry, as a development engineer working on radiation thermometry of low and variable emissivity surfaces for process control applications. He returned to academia in 2002, to work on in-cylinder imaging in internal combustion engines by laser absorption tomography. His current research interests include medical instrumentation and optical diagnostics for combustion systems.

Dr Matthew C Veale MinstP CPhys (Ordinary Committee Member)

Matthew Veale is the Principal Scientist of the Detector Development Group at the STFC Rutherford Appleton Laboratory. His current research interests are the development of high frame rate X-ray imaging detectors. He also acts as Head of Profession for Physics for the STFC Graduate Scheme and sits on the IOP Membership Committee.

Instrument Science and Technology (ISAT) Group Committee

Dr Thomas Kissinger (Ordinary Committee Member)

Thomas Kissinger is a Lecturer in Optical Instrumentation at Cranfield University, researching novel optical interferometry techniques and applying them to solve real-life engineering problems in areas as diverse as additive manufacturing, aerospace, precision dimensional metrology and environmental gas sensing.

Dr Sam Henry (Ordinary Committee Member, Acting Treasurer)

Sam Henry is a Detector Development Scientist at the University of Oxford. He is working on the upgrade of the ATLAS experiment at CERN.

Dr Alexandru Boboc CEng CPhys MInstP (Ordinary Committee Member)

Alexandru Boboc joined UKAEA in 2004 as the physicist responsible for the JET fusion experiment far infrared interferometer/polarimeter diagnostic. His current focus is on diagnostic preparation for the JET D-T campaign. His research interests include laser-based diagnostics design, implementation and operation in harsh nuclear environments, and real-time systems used for safety systems in a nuclear fusion plant. Alexandru is a Chartered Engineer and Chartered Physicist with Institute of Optics as well as member of Optical and ISAT groups within IOP.

Instrument Science and Technology (ISAT) Group Committee

Dr Declan Tucker (Ordinary Committee Member)

Declan Tucker is part of the Temperature & Humidity group at NPL. He is currently working in contact thermometry, specialising in the design and characterisation of novel thermocouples, as well as involved in temperature measurement consultancy work for UK industry. He also has experience of installing and commissioning high temperature fixed points and thermocouple calibration facilities.

Dr Amir Sanjari MInstP (Ordinary Committee Member)

Experimental Particle physicist with lectureship and research background at various UK and US universities and national laboratories with specialism in software analysis and simulation as well as radiation detector design. Currently involved in lectureship and consultancy in radiation physics.