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Welcome to the 2018 ISAT group newsletter. In this issue you can read reports on meetings the group has organised or supported over the last year. These include the Particle Detectors and Instrumentation meeting in September last year at the Institute of Physics in London, the 2nd Thermocouple Users and Manufacturers Workshop held at NPL in November, the 47th Intelligent Sensing Program held in Manchester in March, and the 2nd EMPRESS Workshop at NPL in April.

The big event planned this year is IMEKO: The XXII World Congress of the International Measurement Confederation. This will incorporate the group's Sensors and their Applications Conference, and will launch the nine-month *Festival of Measurement*. The event will be held on 3-6 September in Belfast.

This issue also contains a report from the PSD11 conference by Brett Thomas, and an article by Peter Clive on the impact of lidar on wind energy assessment.

Reports from past meetings

Particle Detectors and Instrumentation

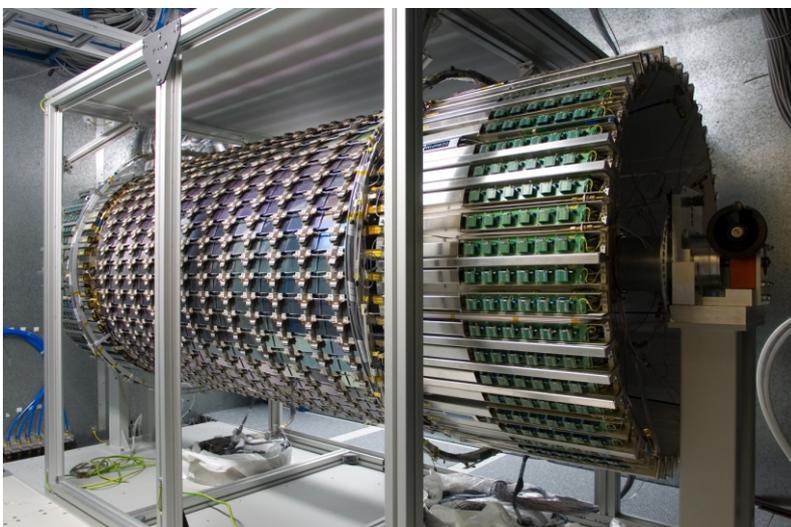
Institute of Physics, London, 25 September 2017

Sam Henry, University of Oxford

On 25 September 2017 the Instrument Science and Technology (ISAT) Group held its first half-day meeting on Particle Detectors and Instrumentation at the Institute of Physics in London. This was also supported by the High Energy Physics Group. The aim of the event was to bring together particle physicists, those developing detectors for other applications, and the wider sensors and instrumentation community. There were a total of eight engaging talks on the state-of-the-art of particle detector technology. It also provided an opportunity for many to make new contacts over lunch and coffee. The meeting was attended by 30 people.

The meeting began with a talk by Andreas Korn from UCL about the upgrade plans for the LHC detectors. The upgraded LHC will collide protons at a rate over ten times the current design, leading to intense radiation levels, and putting greater demands on the detectors. This was followed by talks on some of the new silicon technologies under development to meet these challenges including: depleted CMOS sensors (Daniela Bortoletto), 3D silicon detectors (Cinzia da Via), and MAPS (Laura Gonella). Nigel Allinson and Simon Jolly gave talks on the application of particle detector technology to medicine through monitoring radiation levels for proton therapy. There are further applications in astroparticle physics. Jon Lapington described silicon cameras for the Cherenkov Telescope Array (CTA). Peter Hobson gave a talk on high temperature diamond detector, explaining how this detector material is of interest for industrial applications in extreme environments.

The presentations are available at: <https://indico.cern.ch/event/654712/>



The inner silicon detector of the ATLAS experiment at CERN

Reports from past meetings

2nd Thermocouple Users and Manufacturers Workshop

National Physical Laboratory, 6 December 2017

Jonathan Pearce, NPL

Thermocouples are by far the most widely used temperature sensor, and are used in a broad range of process control applications. On 6 December 2017, 64 delegates, mainly technical leaders and decision makers, came to NPL for the 2nd Thermocouple Users and Manufacturers Workshop (the first was held 12 months ago). The aim of the meeting was to provide neutral territory for stakeholders to discuss contemporary challenges, as well as solutions, and to find out about the state-of-the-art in thermocouple measurement.

Discussions were punctuated by eleven presentations on a wide range of manufacturing sectors by delegates from NPL, Johnson Matthey, Isothermal Technology, University of Cambridge, Esterline, TC Limited, CCPI Europe, Ellab, Resonate Testing. Discussions centred on challenges in instrumentation, precious metal manufacturing, jet engine manufacture and operation, and aircraft fire testing. As well as providing helpful guidance on formulation of future research topics, a key outcome from the workshop was the progression of a 'thermocouple user group' overseen by NPL.

The meeting was co-sponsored by the Institute of Measurement and Control and the Institute of Physics.

Contact: Jonathan Pearce jonathan.pearce@npl.co.uk



Reports from past meetings

47th Intelligent Sensing Program - Sensing in Manufacturing Manchester, 27 March 2018

Liqun Yang, Knowledge Transfer Network

In manufacturing processes, sensing technologies are key to ensure the quality of the product and the efficiency of the manufacturing processes. Following the movement of manufacturing towards digital and intelligent manufacturing, sensing technology is becoming increasingly important in enabling process data and quality data to be generated in time, and ensuring the manufacturing process is intelligent, integrated, efficient and effective.

The emergence of the new manufacturing technologies such as Additive Manufacturing, and progressing of manufacturing towards Industry4 in recent years, are also raising new challenges and needs for novel sensing solutions to provide appropriate process monitoring and product QA&QC requirements.

This one-day event brought together manufacturers, sensing technology providers, new technology developers, and other relevant stakeholders including innovation funders, to network, share knowledge, stimulate new ideas, develop collaborations and partnerships, and promote innovation development in manufacturing sensing technologies in the UK.

A number of key expert speakers were invited to give talks covering the areas of:

- Market challenges and needs
- State of the art commercial sensing technologies
- Novel emerging sensor technologies
- Funding opportunities.

Further details are available at: <https://ktnuk.co.uk/t/2VFU-NHQA-1KI0A5-CO3BT-1/c.aspx>

Reports from past meetings

2nd EMPRESS Workshop

Enhanced temperature measurement techniques for improved process control

National Physical Laboratory, 18 April 2018
Organised by AFRC and NPL

EMPRESS is a European project with the goal of enhancing process efficiency through improved temperature measurement. This workshop is an excellent opportunity to bring together scientists and engineers from academia, research institutes and industrial establishments to present and discuss both the latest developments in the field of traceable temperature measurement for process control, and end-users' requirements and challenges.

The 2nd EMPRESS Workshop was held at the National Physical Laboratory on 18 April 2018.

2nd EMPRESS Workshop
Enhanced process efficiency through improved temperature measurement

18 April 2018
National Physical Laboratory, UK
www.npl.co.uk/events

Confirmed speakers from BAE Systems, Danish Technical Institute, National Nuclear Laboratory, NPL, Resonate Testing, RSCC Wire and Cable, TW Wire & Cable, Technical University of Denmark, University of Sheffield

Technologies

- Thermocouples
- Phosphor thermometry
- Surface temperature probes
- Combustion & flame thermometer

Application areas

- Furnace control
- Heat treatment
- Casting
- Forming
- Welding
- Forging
- Gas turbines
- Internal combustion engines

EMPRESS is a European project with the goal of enhancing process efficiency through improved temperature measurement. The consortium comprises 18 partners across government, industry and academia.

This workshop is an excellent opportunity to bring together scientists and engineers from academia, research institutes and industrial establishments to present and discuss both

- The latest developments in the field of traceable temperature measurement for process control
- End-users' requirements and challenges

NPL National Physical Laboratory

AFRC ADVANCED FORMING RESEARCH CENTRE UNIVERSITY OF STRATHCLYDE

Co-sponsored by
IOP Institute of Physics

EMPRESS TEMPERATURE METROLOGY FOR PROCESS EFFICIENCY

Upcoming meetings

Towards the THz imaging of cancer

Institute of Physics, London, 12 July 2018

The Instrument Science and Technology and Medical Physics Groups of the Institute of Physics invite you to this meeting of THz imaging technology. This meeting aims to pull together the THz imaging community and the medical imaging community in a joint conference which is of interest to both parties. The meeting shall focus on presenting the latest THz imaging technology to the medical physicists and exploring the potential requirements of what it would take to make THz imaging of cancer a clinical tool and ultimately join the panoply of standard diagnostics in a complementary role. We shall provide opportunities for one-to-one discussion and panel discussion in the meeting with the aim to foster collaborations between the two communities.

See the conference website: <http://www.iopconferences.org/iop/1238> for more details.

Upcoming meetings

IMEKO: The XXII World Congress of the International Measurement Confederation Belfast, 3-6 September 2018

This year Belfast in Northern Ireland will welcome experts in instrumentation and measurement from around the world for the XVII World Congress of the International Measurement Confederation. With the theme of 'Knowledge Through Measurement', the event is hosted by the Institute of Measurement and Control, with the involvement of the Institute of Physics, and others such as the National Physical Laboratory.

The congress will bring together world leaders in the field of sensors and instrumentation and allow companies from across the world to present their products and services. The event will incorporate the ISAT group's *Sensors and their Applications* conference for this year. It will cover a broad scope of topics including photonics, measurement science, and measurements of many different quantities in different fields.

The congress will launch the *Festival of Measurement* – a nine-month period of public engagement to promote the importance of measurement to the wider world, leading up to World Metrology Day (20 May 2019) and the redefinition of the Kilogram.

See the conference website: <http://www.imeko2018.org/> for more details.



Belfast Waterfront Hall

Research Student Conference Fund

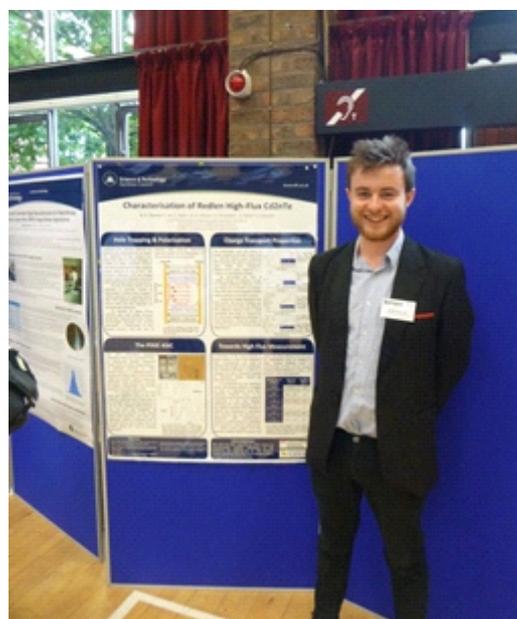
Financial support is available from the Institute of Physics to let research students attend international meetings. Research student members of the group are encouraged to apply.

See: http://www.iop.org/about/grants/travel-bursaries/research_student/page_38808.html for more details.

Position Sensitive Detectors (PSD) 11 The Open University, Milton Keynes: 3rd – 8th September

Brett Thomas, University of Surrey

From January 2017 – January 2018, as part of my MPhys Physics course at the University of Surrey, I completed a research placement with the Detector Development group at STFC's Rutherford Appleton Laboratory. Thanks to a bursary awarded by the IOP Instrument Science and Technology group, I was able to attend PSD-11 between the 3rd and 8th September at the Open University in Milton Keynes. During the conference, I presented my research in the form of a poster. The research I presented was on the charge transport characterisation of a novel compound semiconductor material, cadmium zinc telluride (CdZnTe), which had been optimised for use in imaging applications with very high fluxes of X-rays need to be detected.



I found attending PSD-11 a very beneficial experience. The majority of talks were multi-disciplinary and covered a wide variety of detector systems and applications. The use of detectors in orbital and ground-based telescopes, synchrotrons, FELs and for medical imaging; this highlighted the communities need for advanced detectors and really motivated me to continue my work and identified its importance. My personal highlights were the talks on space-based and medical imaging detectors, as these had very tight specifications and their development fostered strong innovation.

The comparison of different detector systems, e.g. silicon vs CdZnTe, pixels vs strips, CCD vs CMOS, gave me an idea of the options available for radiation detectors and the relative merits of each detector type. The overall context I now have, both in industrial terms (e.g. what can and can't be bought) and academic (what has and hasn't been done) is invaluable to my progress in ensuring my research has a wider impact on the detector community. For example, the research I presented suggests reduced trapping of holes in the high flux CdZnTe material – thanks to some very informative talks on radiation hardness in CCD's for astronomy, I now know methods to identify these traps and how to discover what causes them. As this was my first conference, witnessing the format through which collaborations are formed was very informative. This was demonstrated through the poster

session, in which other academics' interest in my own work highlighted possible areas of collaboration and I was able to make contact after the conference with an academic interested in my work. In fact, I was quite proud that respected experts in the field were interested in what I've been doing over the past seven months. I was also able to contribute to the work of others, even if only in a slight way. During one talk, a PhD student suggested use of GaAs for future research in order to measure higher energy events. I simply asked why he would use GaAs, as opposed to CdZnTe and was shocked when he told me he hadn't thought of it and thanked me!

Beyond detectors, my highlight of PSD-11 was a visit to Bletchley Park and the National Computing Museum, which were really inspirational. I was able to see rebuilds of the machines used to break Enigma / Lorenz (German encryptions) as well as some of the earliest computers. It was very indicative of my age when I asked about certain computers to the shock of older colleagues, who had begun their research working with these machines! Perhaps one of the finest testaments of the brilliance of these men was Colossus, the first ever computer, which used a form of optical read-out. After the end of WWII, the machines were destroyed for political reasons and it would be decades before this technology was reinvented for civilian purposes.

Overall, I consider the conference a success and a really great experience for me personally. It seemed to foster a healthy environment of competition and collaboration, drawing in the best people from both the UK and abroad, and was especially supportive of early-career researchers who were well represented. It was a great learning experience and I hope first of many!

Brett has now completed his placement and has returned to the University of Surrey to complete his undergraduate degree. The work he presented at the PSD conference resulted in a peer reviewed publication in the IoP Journal of Instrumentation:
<https://doi.org/10.1088/1748-0221/12/12/C12045>

Convergence: the transformational impact of lidar on wind energy assessment technique

Peter Clive, Wood plc

Optical remote sensing of the environment using coherent heterodyne Doppler lidar is having a transformational impact on wind energy assessment procedures. Remote sensing of wind using back-scatter from aerosols entrained in the atmosphere is supporting the acquisition of datasets that were not previously available. Methods for assessing wind resource and characteristics relevant for wind turbine mechanical fatigue loads are gradually evolving to exploit these extended measurement capabilities.

Established wind measurement techniques, on which historic energy and load assessment procedures are based, rely on cup anemometry mounted on temporary meteorological masts (met masts). These allow acquisition of data at a single location, and wind conditions are extrapolated across the wind power project site to individual wind turbine locations using flow models of varying degrees of sophistication. In relatively simple circumstances linearized models are considered sufficient, with more sophisticated models being deployed in more challenging terrain.

The limitations of these instruments have imposed a number of approximations and rules of thumb that have become embedded in industry standards and guidelines. This has created a barrier to the adoption of new methods that exploit the far more extensive capabilities of lidar. Investor confidence depends on the use of consistent methodology which introduces a degree of conservatism and inertia in relation to the adoption of new techniques.

However, as the benefits of lidar, in terms of wind velocity vector field characterisation that at last provides a robust test for the physics parameterised and encoded in flow models, become apparent, these barriers are being overcome. Standards and guidelines are being written or revised to accommodate new methods. For example, the normative guidance published by the International Electrotechnical Commission now provides for lidar, with the publication in 2017 of the 2nd edition of IEC 61400-12-1. The International Energy Agency supports a wind energy annex for identifying and overcoming barriers to the adoption of lidar, IEA Wind Task 32.

A roadmap for future wind sensor development can be tentatively outlined, in relation to whether wind conditions are derived from a process of extrapolation, inference (or interpolation) or direct observation.

The capabilities of met masts (and vertically profiling remote sensing devices that effectively replicate their capabilities) can be identified as 1st generation systems. These acquire complete information in one location, and conditions across the site are obtained by a process of extrapolation from that location.

Scanning lidars, that acquire lidar returns across the project site, are 2nd generation systems. The information is incomplete (line of sight radial velocities rather than fully resolved wind velocity vectors are acquired) so wind conditions are inferred on the basis of assumptions. In addition, there is a trade off between time- and space-resolution, as higher space resolution requires the line of sight to dwell in more beam orientations, incurring a higher time overhead for each iteration of the scan geometry.

3rd generation systems directly observe fully resolved wind vectors in all locations and at all times of interest. The current state-of-the-art could be characterised as generation 2.5, in that some, but not all, aspects of this can be achieved currently. For example, in very restricted domains, where wind conditions are highly constrained, rapidly solved models can be integrated with measurements on the same timescale as the measurement process allowing the full resolution of wind conditions without incurring the resolution trade-off. Alternatively, lines of sight converging on a measurement point from multiple devices can fully resolve unconstrained wind velocity vectors, and this point of intersection can be relocated within the volume of interest. However, this method incurs the resolution trade-off.

Nevertheless, it is now becoming possible to fully digitise wind energy assessment using optical sensors: where fibre Bragg gratings are used as strain gauges to validate wind turbine load models based on aeroelastic and finite element calculations, the wind flow models themselves can now be validated using lidar measurements, closing the loop. This allows a common and comprehensive understanding of wind project performance to develop and be shared by all stakeholders, overcoming friction that has hitherto existed at the interfaces between phases of project delivery due to different perspectives on incomplete information.

A process of digital convergence is underway, where improved knowledge of underlying interconnected processes supports a set of shared long-term objectives and aligned data requirements. Simulations finally find their counterpart in data, and approximations that previously proved necessary can be discarded. Collaboration between stakeholders can be more easily co-ordinated and less fragmented with reference to the common perspective made possible by the acquisition of detailed field data using lidar.

Instrument Science and Technology (ISAT) Group Committee

Chair

Dr Sillas Hadjiloucas CPhys MInstP
University of Reading
s.hadjiloucas@reading.ac.uk

Secretary

Dr Paul Wright MInstP

Treasurer

Dr Andrew Tickle CPhys MInstP
Coventry University

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Culham Centre for Fusion Energy

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Knowledge Transfer Network

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Wood Group

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National Instruments

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National Physical Laboratory