INSTITUTE OF PHYSICS

IOP Institute of Physics
Particle Accelerators and Beams Group

IOP PAB GROUP NEWSLETTER

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Editorial — 'Interesting Times'? by Phil Burrows

By now you may, like me, be weary of hearing speculation in the news about the possible consequences of the outcome of the recent UK referendum in which, of the 72% of electors who voted, 52% expressed a preference for the UK to quit the European Union (EU): the 'Brexit' option. But I cannot resist the opportunity afforded by this editorial to discuss possible ramifications of Brexit for our community.

The UK science community is engaged with a number of European accelerator facilities, in terms of both helping to provide technical capability and our use of the beams provided. In addition we operate and develop our flagship national facilities, Diamond and ISIS, which provide beam access to UK and overseas users, from Europe and beyond. The current political situation is complex and I don't wish to oversimplify matters, but it seems to me that since none of these facilities is 'owned' by the EU, Brexit ought not *a priori* to compromise our future successful participation in the network of European accelerator-based science facilities.

For example, the UK is a founder member of CERN, which is a separate international treaty organisation whose formation pre-dates the start of the EEC/EU by three years. So the UK's membership of, and collaboration with, CERN should be unaffected by Brexit. Interestingly, a number of EU states are not currently members of CERN, and several non-EU states are full CERN members. Long may CERN serve as the flagship of European (and increasingly, global) collaboration on accelerator-based particle physics, and long may the UK be a CERN member! And of course the UK also collaborates on accelerator-based particle physics with many countries outside Europe, notably the USA and Japan. There are corresponding UK formal relationships with organisations such as ESRF, ILL, and the European-XFEL, as well as with upcoming facilities such as ESS and FAIR, and UK participation in accelerator-based user facilities in a number of countries beyond Europe.

UK researchers have benefitted considerably from grants won competitively from the EU via the Framework and Horizon2020 R&D funding schemes as well as from the European Research Council. Estimates are that a nett £300M is currently received per annum by the UK research community. For example, my own research on electron-based linear colliders has benefitted from participation in the EU projects (which may be familiar to many readers) ELAN, EuroTeV, HiGRADE, EUCARD, TIARA, AIDA2020 and EJADE. I hope that other projects currently in the pipeline will be funded by the EU. However, it remains an open question whether, if Brexit goes ahead, the UK will be able to benefit from future EU research funding. Of course Brexit supporters argue that the UK Government could better use the money that it sends to the EU (currently a nett £8.5B annually) for direct investment at home. That is certainly a logical possibility, but governments are often tempted simply not to spend the money; and there are anyway many other proposals (e.g. healthcare) for how to use any 'savings'. However, non-EU states Norway and Switzerland have negotiated (and pay for) access to the EU research area, so if one is optimistic there is a sensible path forward for the UK also.

Trickier, perhaps, are negotiations ahead concerning mobility of UK and EU citizens in a post-Brexit Europe. Without doubt the UK has attracted many first-rate overseas scientists and engineers who make enormous contributions to our research programmes. They are valued and respected members of our community. Let us hope that the UK will continue to compete in the global market for scientific talent and continue to welcome highly-qualified researchers, from the EU and beyond, to our shores. Surely that is in our national interest?

So while there is no doubt that the UK research community is unlikely to be any better off with Brexit, we still have a vigorous, internationally collaborative UK accelerator programme that can, with good will and common sense, continue to thrive.

Inside this issue:

News from the Laboratories — Daresbury

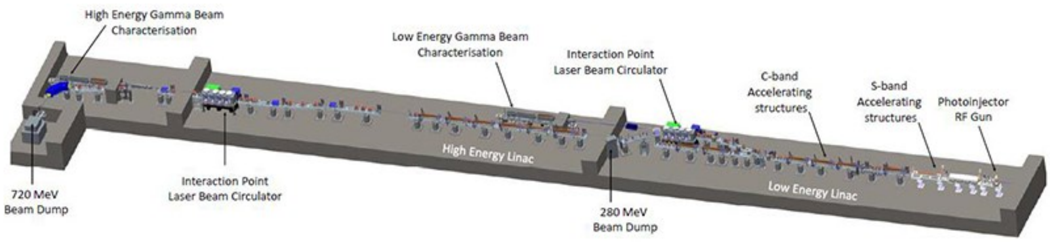
Daresbury Laboratory Delivers an Important Step Towards Nuclear Physics at ELI-NP

ASTeC and Technology Department staff at DL achieved a significant milestone on 05 November by supplying the first stage of STFC deliverables to the Extreme Light Infrastructure – Nuclear Physics project (ELI-NP). The delivery consists of the design, construction and integration of accelerator modules, power supplies, control and instrumentation that form an essential section of the Gamma Beam System (GBS) facility accelerator linac.

IFIN-HH, INFN and STFC Daresbury Laboratory staff during an inspection of hardware and documentation during a sign-off of the ELI-NP stage one deliverables
(Credit: ELI-NP)

The STFC contribution is part of a €68.8 million commercial contract awarded to the EuroGammaS by Horia Hulubei National Institute (IFIN-HH), Magurele, Romania, to design and construct the GBS. EuroGammaS is a European consortium of academic institutes and industrial partners with expertise in the field of electron accelerators and laser technology from eight European countries led by INFN, Italy.

The GBS generates very intense and brilliant gamma-ray beams with tuneable energy (0.2 – 19.5 MeV) based on incoherent inverse Compton back scattering of a high repetition pulsed laser beam on a high-intensity, low-emittance, relativistic electron beam. Compton back scattering has been previously demonstrated on the ALICE facility at Daresbury Laboratory and the accelerator technology to generate the high-repetition-rate, low-emittance electron beam is synergetic with developments required for the CLARA Free Electron Laser under construction at Daresbury Laboratory.



The Gamma Beam System accelerator
(Credit: ELI-NP)

ELI-NP is one of three pillars of the Extreme Light Infrastructure – a multi-million euro project being carried out in the Czech Republic, Hungary and Romania with the aim to implement the world's largest laser research infrastructure. It is expected to be producing intense laser light and gamma beams by 2018. Once constructed, the ELI-NP will be the most advanced laser and gamma beam facility in the world. The gamma beam will be used to map the isotope distributions of nuclear materials or radioactive waste remotely via Nuclear Resonance Fluorescence measurements. At lower energies the high resolution of the beam is very important for protein structural analysis. In addition it will produce intense neutron beams and intense positron beams, which opens new fields in material science and life sciences. The possibility to study the same target with these very different brilliant beams will be unique.

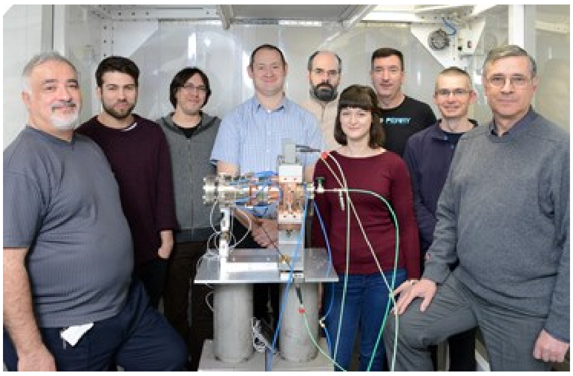
The ELI-NP Facility construction site, Magurele (near Bucharest), in August 2015
(Credit: ELI-NP)

Neil Bliss

First Prototype UK XFEL Injector Delivered by Daresbury Laboratory

Pushing beyond current UK photon facility capabilities to deliver short pulses of X-rays that can probe both structure and dynamics at the molecular level, demands light pulses over 1,000 times shorter than those in Diamond Light Source. Scientists and engineers at DL have been developing a high-brightness, high-repetition-rate electron injector to match the requirements of an envisaged candidate for a UK X-Ray Free Electron Laser (XFEL) facility.

Designing and building a high-repetition-rate photo-injector for the CLARA FEL test facility at Daresbury has allowed scientists and engineers to research the challenges of creating extremely high quality electron beams with a combination of brightness and repetition rate, beyond those currently deployed on any normal conducting FEL facility in the world. The photo-injector cavity has been designed by ASTeC and Technology Department with the Cockcroft Institute (Lancaster University) and the Institute of Nuclear Research in Moscow.



The photo-injector team
(Credit: STFC)

Peter McIntosh, ASTeC Deputy Director said: ‘The project team has excelled in delivering a pivotal achievement for the CLARA project, in providing an innovative electron source which has been designed to overcome extensive technical challenges and which I know will demonstrate state-of-the-art performance capability.’

Having been manufactured by Research Instruments in Germany, the cavity has now been delivered to DL and initial radio frequency tests confirm it achieves the challenging specifications.

ASTeC Director Susan Smith said ‘This is a tremendous technical success, a major design challenge was delivering a ultra-high quality beam whilst pulsing the copper cavity 400 times a second with a big number of MW of RF power. A fraction of a mm change in dimensions through heating and it completely fails.’

First commissioning on CLARA will start later this year.

Deepa Angal-Kalinin

News from the Laboratories — RAL

Initial Experience with Carbon Stripping Foils at ISIS

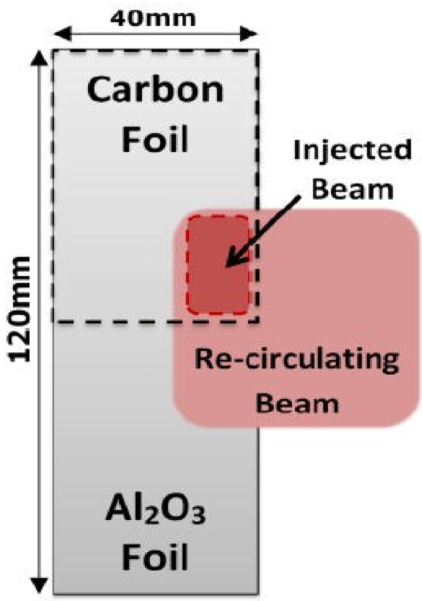
Al_2O_3 foil production
(Credit: ISIS)

Throughout its 30 years of operation ISIS has developed aluminium oxide (Al_2O_3) stripping foils in-house for H^- charge-exchange injection. The manufacturing and installation processes for these foils are time consuming, radiologically dose intensive and require a high degree of skill and experience. Commercially available carbon based foils have the potential to simplify foil preparation and installation, and following their successful operation at J-PARC in Japan and the Spallation Neutron Source in the USA, and planned use at the CERN Proton Synchrotron Booster and the Chinese Spallation Neutron Source (CSNS) ISIS has begun its own trials. Experimentation with carbon foils also provides valuable experience for any future upgrade to ISIS as it is likely that carbon foils would be required in order to handle probable increases in injection energy.

Diamond-Like Carbon (DLC) 100 μg/cm^2, 50×65 mm foils were purchased from Micromatter, a spin-out company from the TRIUMF laboratory. These foils give the same stripping efficiency (98-99%) as the current 40×120 mm Al_2O_3 foils. The DLC foils are about half the size of the current foils, but are sufficient to cover the injected beam area and reduce the number of foil traversals by recirculating protons. An aluminium support bracket was designed and manufactured to install the DLC foil in the existing mounting mechanism in the synchrotron.

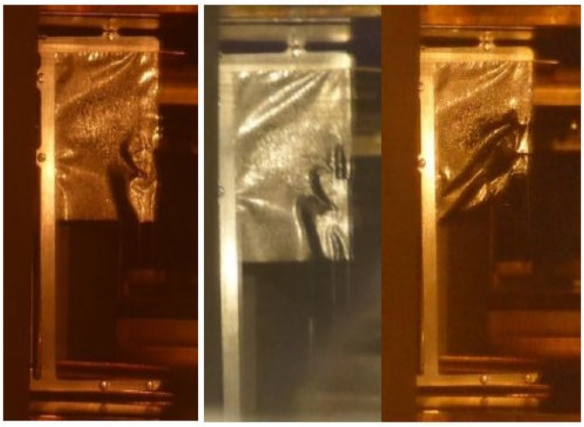
First tests with beam were carried out in July 2015, and after appropriate retuning of the synchrotron closed orbit good injection efficiency, vacuum level and beam loss were demonstrated. However, it was necessary to insert the foil a further 4 mm into the synchrotron injection aperture over the course of the experiment to maintain low loss levels: on inspection the foil had deformed and curled away from the injected beam after a total of 0.7 mAh exposure.

Subsequent experimentation has concentrated on using carbon fibres close to the foil edge to prevent curling and increase lifetimes. By February 2016 a DLC foil was able to survive the two-week start-up period for ISIS Cycle 2015/04 with no degradation in performance after receiving 29 mAh of beam, and it was decided to use the foil during the user run. This foil remained in operation for a further 15 days until, after 88 mAh of beam, a change to an Al_2O_3 foil was required on the mid-cycle maintenance day.



Stripping foils schematic
(Credit: ISIS)

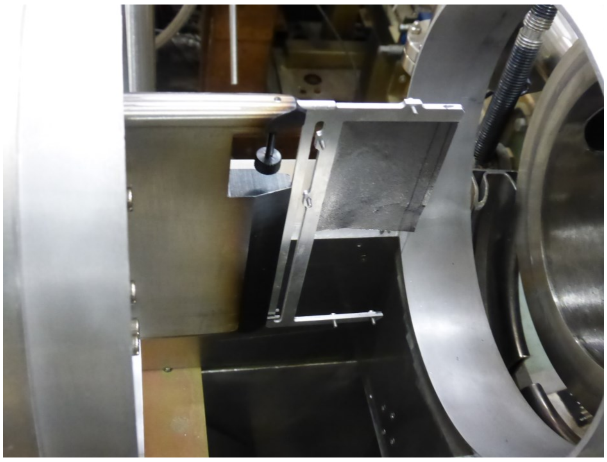
In April 2016, ISIS Cycle 2016/01 again started with a DLC foil, which operated for 117 mAh until the scheduled maintenance day. On inspection the foil was noticeably deformed, but was still held by the carbon fibres. Operation continued with this foil for a further few days, but a change was then required to another DLC foil, which lasted until the end of the user run — the first on ISIS to use only carbon foils.



DLC foil after 3, 15 and 117 mAh during Cycle 2016/01 (Credit: ISIS)

It is planned to continue to operate ISIS with carbon foils, experimenting with the fibre arrangements to establish reliable operation for at least a whole user cycle (up to 50 days or 250 mAh).

A redesign of the foil change mechanism is underway and a new camera system will be installed to allow remote foil inspection. It is also planned to investigate foil heating and deformation using an off-line electron gun test rig. The test rig has been developed by the ISIS diagnostics group and should produce an equivalent heat load on the foil compared to typical ISIS operation.



Close up of installed DLC foil ready to be inserted into the synchrotron injection aperture. Two carbon fibres are visible at the right hand side of the foil (Credit: ISIS)

In addition to the DLC foils, a graphene foil has been purchased from Applied Nanotech in Austin, USA and this will be tested at ISIS later this year. The high thermal conductivity and tensile strength of these graphene foils make them an excellent candidate for charge-exchange injection stripping foil applications.

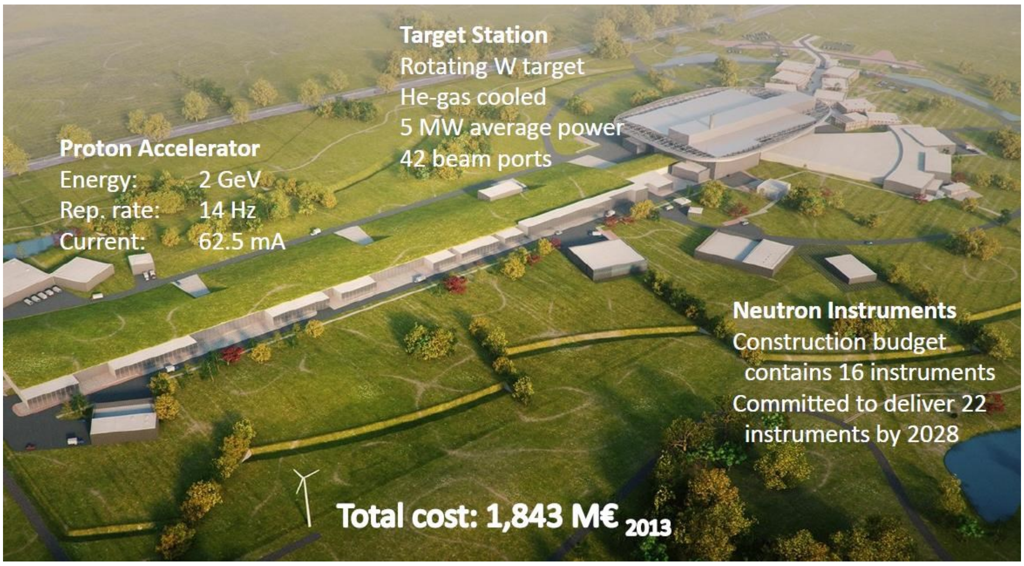
Members of the accelerator physics and engineering groups from CSNS visited ISIS in May 2016 to gain operational experience with carbon foils before they begin their own machine commissioning in 2017. During the visit there was a tour of the ISIS foil preparation lab and measurements of injected beam parameters were made during dedicated machine study time.

Bryan Jones
Hayley Smith

Science & Technology Facilities Council
ISIS

UK In-kind Contributions to the EUROPEAN SPALLATION SOURCE Linear Accelerator

The European Spallation Source (ESS) is a high intensity source of slow neutrons which is currently under construction in Sweden. ESS will deliver a peak neutron flux seven times more powerful than any existing accelerator based spallation source and a peak flux 30 times greater than any reactor based neutron source.



ESS overview
(Credit: ESS)

The €1.9 billion facility will use a mainly superconducting 600m linear accelerator to accelerate protons to an energy of 2.0 GeV and deliver an average power of 5MW (125MW peak) onto a helium-cooled, rotating tungsten target to spallate neutrons for 22 experimental stations. The linear accelerator will incorporate 146 superconducting cavities. Unusual features of the ESS linac design include the combination of long pulse time (2.86ms), the use of a proton beam and the absence of a subsequent ring accelerator. The UK is making a number of in-kind contributions to the linac. The three biggest are the high beta cavities, the RF distribution system and the Beam Transport Modules, the second and third of which are discussed in this article.

RF Distribution System (University of Huddersfield and STFC Daresbury Laboratory Technology Department)

The ESS requirement for 95% reliability (availability) has strongly influenced design choices including those for the distribution of radio-frequency (RF) power to the cavities. In particular the ESS reliability target requires that the accelerator should run, after re-tuning, even when multiple RF sources or cavities are inoperable. To achieve this each cavity will have a dedicated RF power source and a dedicated waveguide run. As a consequence there will be an aggregate waveguide length of over 3km.

Two types of cavity at two radio frequencies will be used: spoke cavities at 352.21MHz for proton energy up to 220MeV and elliptical cavities at 704.42 MHz for energies above 220 MeV. The waveguides will be aluminium and contain air at atmospheric pressure. The waveguide sections which traverse relatively enclosed spaces will be water cooled.

During filling of the cavities, RF power will be reflected back towards the relevant RF source. In order to protect the RF source from these reflections each waveguide run will incorporate a circulator which will divert any reflected power into a load, which will absorb it. Each waveguide run will also incorporate dual directional couplers and multiple arc detectors.

The directional couplers will measure the forward and reflected power. This information is used by the LLRF (Low Level RF) system, which regulates cavity tuning and sets the amplitude and phase for the RF sources, and for diagnostic purposes.


A prototype waveguide and a prototype circulator and load, at the FREIA Laboratory in Uppsala (Credit: ESS)

The function of the arc detectors is to trip RF power before an evolving arc can cause significant damage. The waveguides have been sized so that, in the absence of both field enhancement and significant heating, there should be no arcing. However, it is anticipated that during commissioning, loose particulate matter could cause local field enhancement and/or heating and thus lead to arcing. Waveguide 'processing' by limiting the arcs to short duration can be used to eliminate (vaporise) these loose particles and thereby improve the power handling capability.

The University of Huddersfield is acting with the UK's Science and Technology Facilities Council (STFC) in the selection, purchase, testing and commissioning of the equipment for this challenging in-kind contribution.

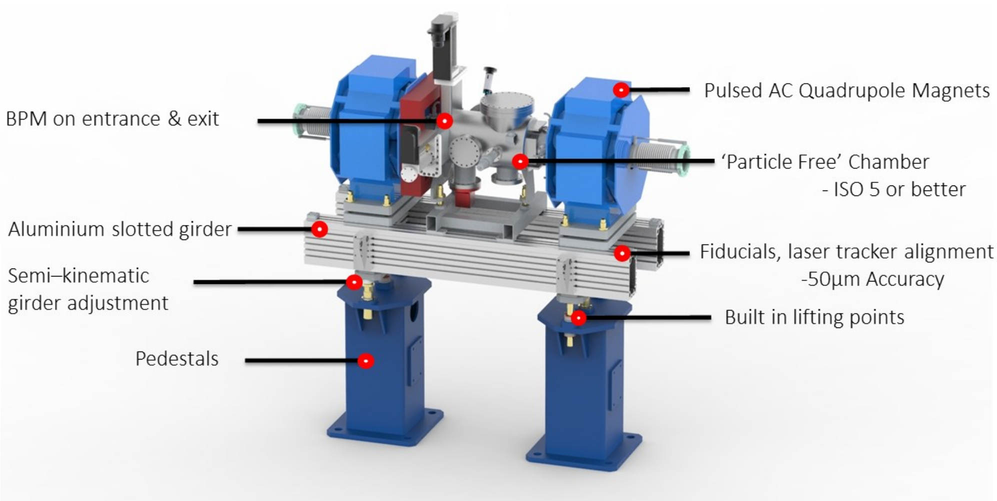
Norman Turner

Beam Transport Modules (STFC Daresbury Laboratory Technology Department)

One of the many projects being undertaken by Technology Department for the ESS is the Beam Transport Module (BTM) work package, a £10.5 million project to deliver 130 different beam transport modules — 50% of the entire length of the accelerator!

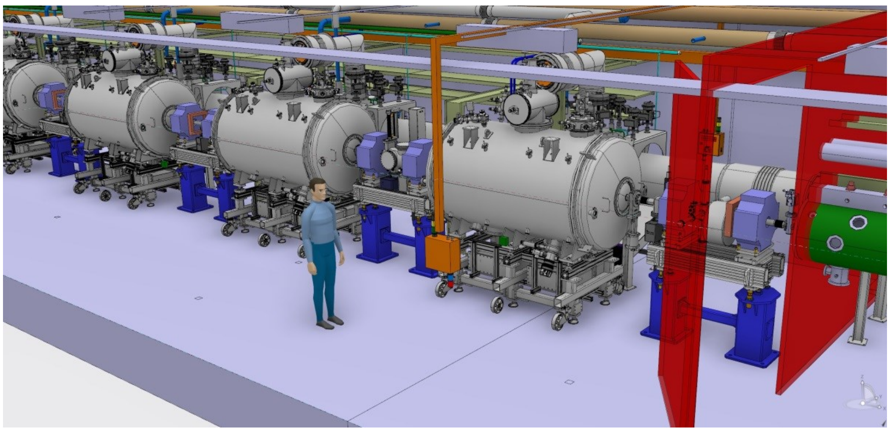
The BTMs themselves are situated in between the superconducting cryo-modules along the accelerating beam path and contain the steering quadruples, corrector coils, beam position monitors (BPMs) and various types of other beam diagnostic equipment.

Each module is being designed in-house and will be analysed for ground vibration, structural integrity and vacuum analysis before being put into production. The design of these modules will be based around many years designing accelerating modules for other accelerators, such as VELA, CLARA and ELI-NP. The build will require over 30 staff years of effort, will start in August 2016 and continue until October 2019, with the final delivery marking the end of the ESS stage I installation, meaning the accelerator can be turned on.



Beam Transport Module

The assembly, test and processing work will predominantly take place at the Engineering Technology Centre in Daresbury where the vacuum processing lab, cleanrooms, assembly area, and dedicated survey and alignment rooms are all situated within the same building. Having all of these facilities located closely within the same building is a great advantage to a project with such a large volume of components and allows for a more efficient production cycle as well as enabling the quality to be more closely managed. In order to deliver a high quality product to the ESS the project is being run under the ISO9001 quality management system but it also relies upon the experienced staff within Technology Department. With the majority of these beam transport modules being positioned next to superconducting cryogenic modules they must be processed to the same particle free, ISO 5 or better, standards so as not to contaminate the cryogenic sections. This means that each unit will be processed through the cleanroom. Previous experience on particle free processing, from ALICE, DICC, VTF *etc.* will be key to ensuring that these particulate levels can be achieved efficiently to a high standard without delay to the project.



Medium Beta cryo-modules and BTMs
(Credit: STFC Daresbury)

However, before anything can even be delivered to Daresbury it is important that there is good management of the many suppliers and other in-kind contributors (especially vacuum chamber manufacturers). Once delivery starts the chamber supplier will be required to produce, on average, one stainless steel vacuum chamber per week for two and a half years — this will be particularly demanding and will require close monitoring. With the ESS being built by many in-kind contributors across Europe, Technology Department will need to interface with the various partners supplying components for these modules, specifically BPMs and magnets. A close working relationship with these collaborators is needed to ensure that everything arrives on time, and that when it does it fits!

Once delivered each chamber must be been signed off by the vacuum lab and then processed through the cleanroom. It can then be assembled and aligned onto the girder. With each chamber containing the BPM it is necessary that each module is aligned to within 50μm accuracy and a custom transportation method is then required to ensure that they arrive without becoming misaligned. The work package is one of the more mature projects with a prototype now completed and under test at Daresbury. More recently the project underwent the scrutiny of a critical design review which reviewed and assessed every aspect of the project from staffing resources to technical design drawings. The outcome of this was extremely positive giving us the green light to start full procurement and production. The assessment panel consisted of external advisors as well as ESS work package leaders and as part of the close out report they included the following comments:

'The committee was very impressed with STFC Daresbury's project management planning and control, the sophistication of STFC Daresbury's quality management system and processes, and the resources and expertise applied. The knowledge and experience of STFC Daresbury in mechanical design and vacuum systems is exceptional. Impressive facilities exist at STFC Daresbury for vacuum cleaning & measurement as well as for assembly of the Linac Warm Units (LWUs).'

ESS site, January 2016
(Credit: ESS)

In total STFC at Daresbury will be handling over £60 million of in-kind contribution to the ESS, a substantial amount of the UK's £165 million investment. In short, the coming years will be extremely busy for the Technology Department.

Paul Aden

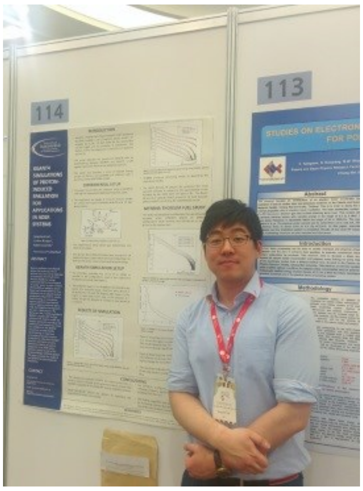
The 7th International Particle Accelerator Conference

Conference venue at BEXCO
(Credit: University of Huddersfield)

The 7th international particle accelerator conference was held in Busan, Republic of Korea (8-13 May 2016). The conference was intended to showcase the latest technology developments within the field of accelerator technology. The conference started with the opening statements from the Mayor of Busan City and an official from the Ministry of Science, ICT and Future Planning. The talk was followed by several speakers from the International Linear Collider in Japan, Pohang Accelerator Laboratory and Lawrence Berkeley National Laboratory (LBNL), *etc.* The most notable presentation was by W. P. Leemans (LBNL) who talked about the limits and possibilities of laser-driven plasma-wakefield accelerators. The presenter explained ideas proposed by LBNL for accelerator commissioning, such as the possibility of combining 100 units into one continuous accelerator. However, this idea was questioned by several audience members due to the beam loss being approximately 99% and not being feasible when there are many units combined.

The main hall for all major talks
(Credit: University of Huddersfield)

Many of the talks and posters in this conference either focused directly or related to Free Electron Lasers (FELs) or plasma-wakefield acceleration. Throughout the conference, industrial exhibitions were hosted along with the poster sessions showing advanced technologies related to particle accelerators, such as RF management systems and vacuum control systems, *etc.* It was interesting to see that there were a variety of different technologies involved in the advancement of accelerator development.



Presenting conference poster
(Credit: University of Huddersfield)

By attending this conference, I was able to engage with many scientists sharing their ideas and knowledge. I was also able to speak with several officials from the European Spallation Source (ESS), KEK Japan and the Chinese Academy of Science (CAS) regarding my research area. It was a valuable experience, and I would like to thank the Institute of Physics for its financial contribution towards my trip to attend this conference.

David Sangcheol Lee
International Institute for Accelerator Applications (IIAA),
University of Huddersfield

IPAC16

Cockcroft Institute at Big Bang 2016

The Cockcroft Institute public engagement team, comprising representatives from STFC, ASTeC and Lancaster, Liverpool and Manchester Universities, attended the Big Bang Science Fair at Birmingham NEC (16-19 March 2016). This is the largest public science and technology fair in the UK, and annually receives something in the region of 65,000 to 70,000 visitors over the four day event, and it certainly felt as if most of them visited the Cockcroft Institute stand!

'Hair raising' with a Van der Graff generator and delight and fascination at seeing the Meisner effect demonstrated with a superconductor
(Credit: Cockcroft Institute)

The stand focused on showcasing the key under-pinning principles and technologies common to all particle accelerators, and featured some real accelerator hardware with magnets from the EMMA accelerator and a superconducting linac module proving to be major talking points.

Many of the Institute's Ph.D. students manned the stand and talked with passion and eloquence about their work, the work of the Cockcroft Institute and the STFC as a whole – the impact was clear from the expressions on the faces of visitors as they listened, though it left everyone with sore feet after standing-up for most of the week, and sore throats from talking endlessly to the constant stream of visitors to the stand.

The event was also a great opportunity to prepare the Cockcroft Institute 'outreach machine' for the next big event which is the Daresbury Open Week in July. Having experienced the Big Bang Fair, our Ph.D. students are keen for more and look forward to their next chance to share their passion for science with the Great British public and have that rare opportunity to influence someone's career choices.

Busy times on the Cockcroft Institute stand
(Credit: Cockcroft Institute)

Lee Jones

The Cockcroft Institute
of Accelerator Science and Technology

The Big Bang
UK Young Scientists & Engineers Fair

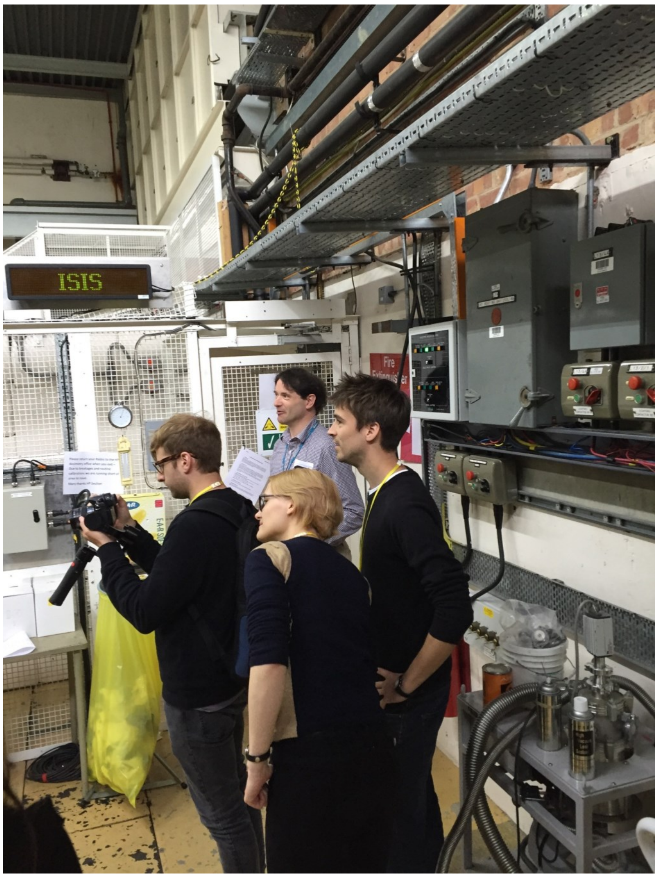
Accelerators for Humanity

Particle accelerators have many varied applications and their uses in medicine and industry are transforming lives. In recent years, the discovery of the Higgs Boson and CERN's Large Hadron Collider have captured the public imagination like few other recent scientific developments. Yet, the public remain largely unaware that accelerators have any uses apart from particle physics research.

In a recent survey, one participant said of accelerators: 'They have no practical use other than research into high energy physics. There's no practical use to high energy physics either'. In fact, around three-quarters of respondents were unaware that accelerators had any application outside particle physics research.

Those of us who work with particle accelerators already know how useful they are in medicine and industry, and we also know that it takes a huge range of people, skills and personalities to realise the incredible science and engineering that is the bedrock of our field. It is this human element of accelerator science that the project aims to communicate to the wider public, alongside a more detailed look at how we create and control beams of particles.

The project is led by the Royal Institution (Ri), who have 200 years of expertise in communicating in-depth science to the public and are best known for the annual Christmas Lectures on TV. Enabled by an STFC Large Award for Public Engagement, the Ri Channel production team have joined up with Dr. Suzie Sheehy (JAI/Oxford and STFC/ASTeC/RAL) to help tell the story of how particle accelerators work and the people behind them.



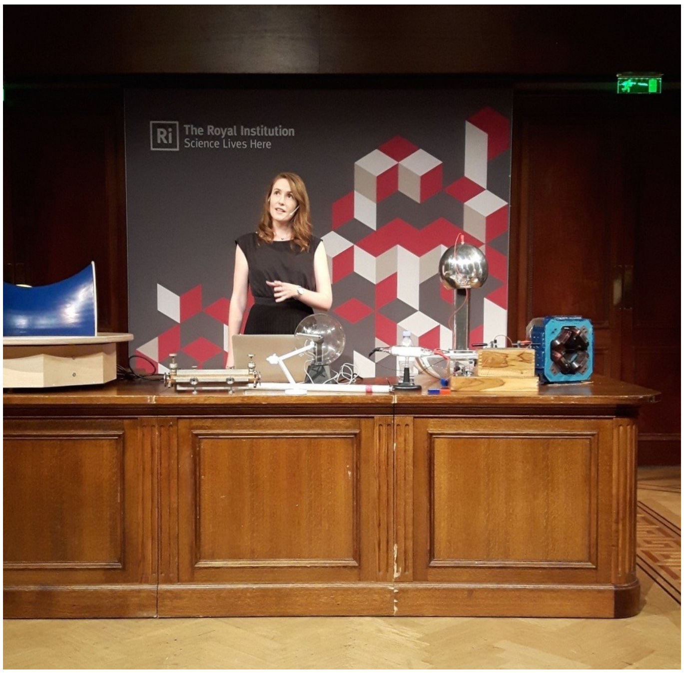
Dr John Thomason giving the Ri Channel production team a tour around the ISIS neutron and muon facility (Credit: Ri)

'Accelerators for Humanity' started in June 2016 and will run to September 2016, creating a programme of live events and a suite of digital video resources to help communicate accelerator science. The project will capture the dedication of particle accelerator researchers in accelerator laboratories and facilities and highlight the varied ways in which their work is impacting on our lives in areas such as medicine, food safety and nuclear power. All the video resources will be made available under creative commons licence through the Ri Channel and YouTube and we positively encourage the accelerator and beams community to make use of them.

The first live event was a Friday Evening Discourse (FED) called ‘Accelerators Reimagined’ delivered by Suzie in the Ri Faraday Theatre on 24th June. This series of historical lectures is famous for its quirks, such as the formal dress code, precision timing to the bell and the presenter being locked in a room for ten minutes before the lecture starts so they can’t run away. Apparently this has been a problem in the past.

In preparing for the FED lecture Suzie was given access to a list of previous speakers that included the likes of Faraday, Thomson, Rutherford, Cockcroft and Oliphant, among many others who have been instrumental in our field. No pressure then…

Suzie’s lecture described some key applications of accelerators, outlined her research in the design of fixed field accelerators and delved into the challenges of reaching higher beam powers in hadron accelerators.



Dr Suzie Sheehy presenting a Friday Evening Discourse in the Ri Faraday Theatre (Credit: Ri)

The next upcoming event is focused on the future of accelerators for particle physics. ‘Colliding the Future: Where Next?’ will be held at the Ri on Friday 23rd September. This panel event will bring together representatives of four possible future collider projects who will discuss how and why these machines are being considered, where the major challenges lie and present their long-term vision.

The team would also like to extend a warm invitation to all IoP PAB group members to the final event of the project. The ‘Accelerators for Humanity’ reception event will be held in Oxford on the evening of Wednesday, September 28th to bring together accelerator scientists, science communicators and public engagement professionals to disseminate the resources from the project and share ideas and initiatives in communicating accelerator physics. Please mark the date in your diary: registration will be circulated via email lists closer to the date. For more information or if you have a project you’d like featured, please contact Suzie.

Suzie Sheehy

Accelerator Training Experiments

Research in the UK accelerator institutes, the John Adams Institute (JAI) and the Cockcroft Institute (CI), is to a large extent based on graduate training, centred around active engagement in forefront projects and work on accelerator facilities.

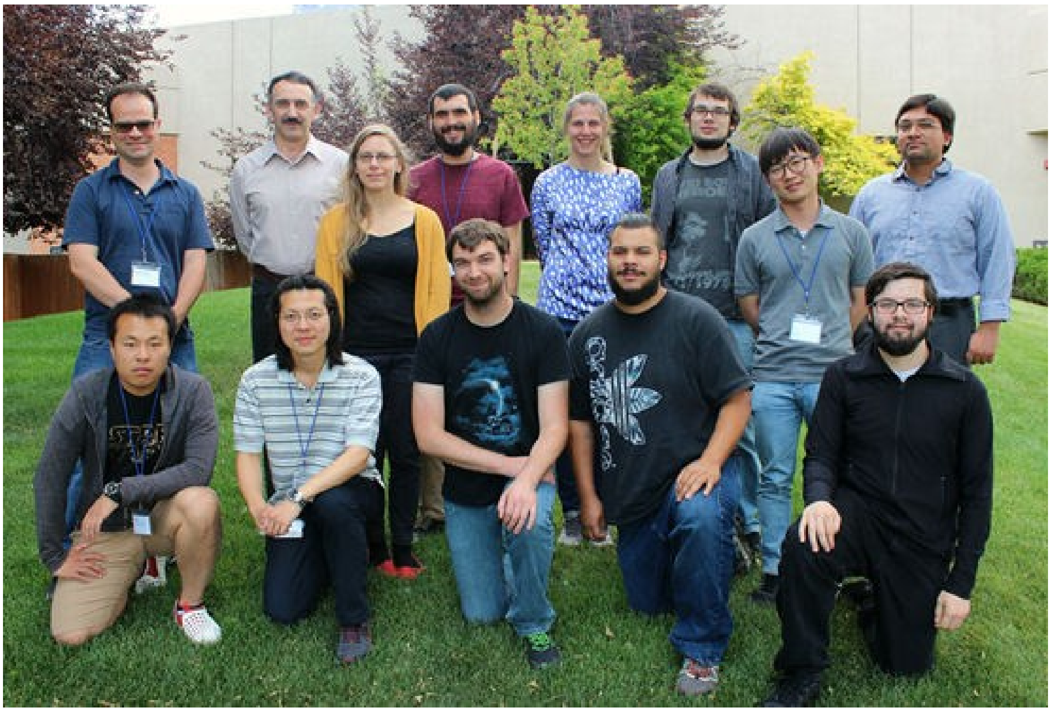
The institutes keep developing and expanding their training programmes and approaches, and the first such training experiment we would like to mention is the advanced graduate course, which was jointly organised by JAI and CI and ran early this summer as a pilot project. The course 'Imaging and Detectors in Medical Physics', was hosted by JAI and was delivered by Dr Barbara Camanzi (STFC). CI and JAI students attended in person and also remotely from their universities via video link and web-cast. We will continue this series of advanced courses in September, when the course on RF linear accelerators will be delivered by Dr Graeme Burt. More information about the joint CI-JAI course is available.

Another training experiment we would like to highlight is the short option course on accelerators for undergraduates, which was delivered in Oxford by Prof Riccardo Bartolini and Prof Andrei Seryi. A novelty of this course was a video bridge to the CERN Control Room during one of the lectures. Prof Emmanuel Tsesmelis and Prof Ted Wilson gave this lecture and were able to comment on how the LHC works and what was on the monitors in the control room from the very heart of the world's biggest operating collider. This training experiment proved to be very stimulating for students and we should consider expanding it to other courses (provided we do not cause too much of a distraction for our colleagues in CERN Control Room).

A shapshot of the display showing the CERN and Oxford sites connected (Credit: John Adams Institute)

Finally, we would like to mention the US Particle Accelerator School (USPAS) held in June 2016, where JAI colleagues Prof Andrei Seryi and Dr Aakash Sahai (Imperial College/JAI) taught the class 'Unifying Physics of Accelerators, Lasers and Plasma'. In this class, we introduced something novel for USPAS (although standard for JAI): mini-projects, where students focus on one particular design, trying to study it in detail.

At JAI such student projects usually run for 8 weeks, by the end of which the first-year graduate students have detailed optics, magnets, and RF design of *e.g.* the LHeC ring or linac options (the topic of the design projects changes every year). For USPAS everything needed to be compressed into one week and therefore we were primarily focused on approximate estimations of the key parameters of the machine we were designing. In this instance the machine the students were tasked to design was an X-ray source based on a compact electron beam storage ring with on-orbit and on-energy injection by a laser plasma acceleration system. One more challenge, as well as an additional strong motivation for students, was the aim to submit an abstract for a paper at the North American Particle Accelerator Conference (NA-PAC), based on the work in USPAS class.



USPAS class of 2016 'Unifying Physics of Accelerators, Lasers and Plasma'
(Credit: USPAS)

This ambitious goal was successfully achieved: the machine was designed in sufficient detail, an abstract for the NA-PAC paper was submitted, and students are now working, in truly collaborative spirit, on the paper that will be presented at NA-PAC in October. We plan to make such a mini-project approach standard for the USPAS classes we will deliver in the future, and also hope that this positive experience will be used by our colleagues for other USPAS classes.

Andrei Seryi

JAI John Adams Institute for Accelerator Science

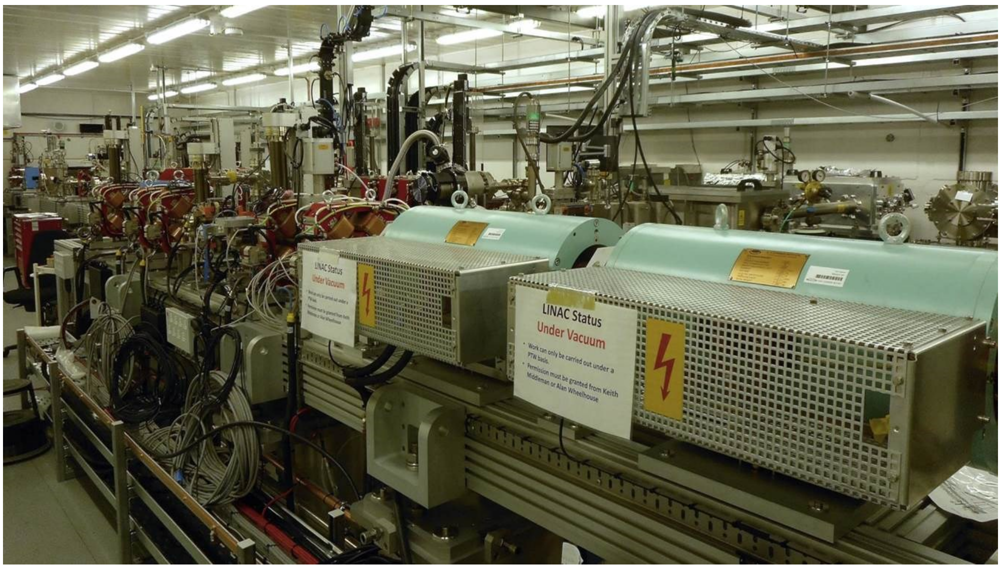
The Cockcroft Institute of Accelerator Science and Technology

U.S. Particle Accelerator School
Education in Beam Physics and Accelerator Technology

STFC/PABG Workshop — Towards a UK XFEL

On Tuesday 16 February 2016 the Science and Technology Facilities Council (STFC) hosted a joint workshop in conjunction with the Institute of Physics Particle Accelerators and Beams Group, to consider R&D goals for Free Electron Lasers (FELs) aiming towards a potential future UK X-ray FEL user facility. The workshop provided a high level overview of the work being carried out in the UK and overseas currently in this area and discussed the future steps the UK should take to address ongoing challenges for XFEL facilities.

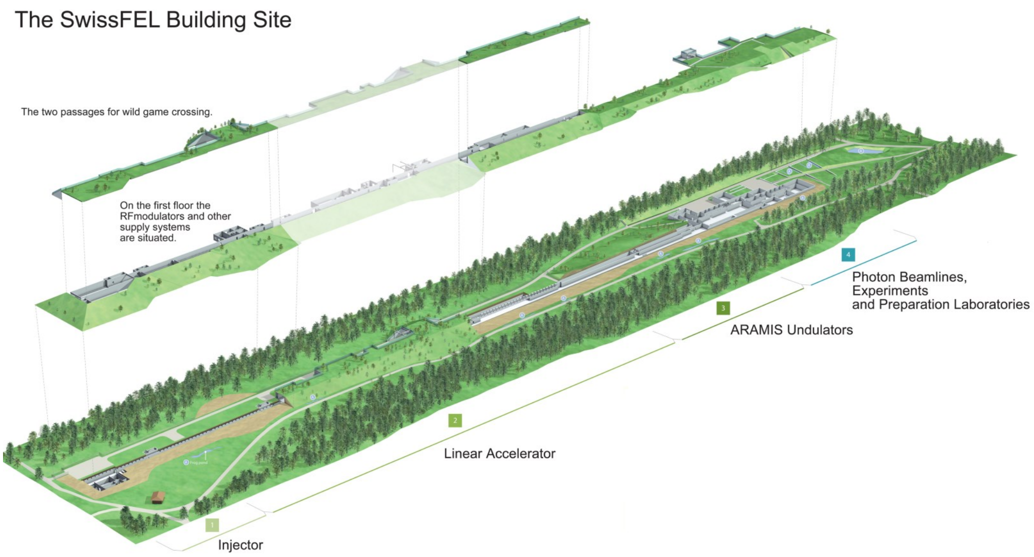
Following a welcome from Grahame Blair (STFC), an overview of existing and upcoming FEL facilities worldwide was provided by Neil Thompson (STFC). Neil also highlighted several of the techniques currently being investigated, both theoretically and experimentally, for improving the FEL output dramatically in terms of reducing the time-bandwidth product, reducing the photon pulse lengths (attoseconds), or increasing the power (Terawatts). This was followed by Jim Clarke (STFC) who discussed the UK context and plans specifically. Jim reported that the accelerator community, including representation from STFC, Cockcroft Institute (CI), Diamond Light Source (DLS) and John Adams Institute (JAI), had held a number of forum meetings to assess the priority FEL R&D topics for the UK. The community had converged on six R&D goals, covering important challenges across the accelerator and FEL, which would significantly improve the output performance of any UK XFEL and so give UK users a competitive advantage over existing facilities. The six goals covered areas such as the injector, RF system, beam dynamics, FEL techniques, diagnostics, and synchronisation of pulses. Jim went on to explain that the CLARA FEL test facility, currently being installed at Daresbury, would enable all of these goals to be addressed in an optimal manner and would therefore have an international impact for the community.



Phase one installation of the CLARA FEL test facility
(Credit: STFC)

This was followed by a series of talks from the four major accelerator centres within the UK, given by Riccardo Bartolini (DLS), Susan Smith (STFC), Andrei Seryi (JAI) and Brian McNeil (CI), with each of them covering their specific capabilities and interest in UK XFEL R&D. All of the speakers expressed a strong interest in contributing to work in this area and agreed that collaborating on the agreed set of six goals would be an optimal use of the available resources.

An overseas perspective was provided by Hans Braun (Paul Scherrer Institute) who looked back on the evolution of the SwissFEL project and commented on the current status (beam commissioning starts in 2016). He noted that the UK decision to build a FEL test facility (CLARA) and to work on critical R&D towards the UK XFEL was very similar to the Swiss approach. He stated that this requires more time and resources in the preparatory phase, but was more cost effective overall and would lead to a more advanced facility which would be far better integrated with the specific UK user needs. He urged STFC to pursue CLARA with a more aggressive schedule and in close coordination with the UK XFEL design team.



SwissFEL overview
(Credit: Paul Scherrer Institute)

Jon Marangos (Imperial College) provided a UK user perspective for the workshop. He explained that there are currently around 80 active FEL users in the UK, despite there being no national facility, based at 12 different institutions. These researchers have been using the facilities at LCLS, FLASH, SACLA, and FERMI to investigate protein structural dynamics, nanocrystal protein structures, matter at extreme conditions, fast modifications to metals and ultrafast electron dynamics in molecules. Jon reported a number of recent high impact FEL-based experiments across a diverse range of research areas. He strongly supported the development of a coordinated FEL R&D plan and pointed out that the inherent temporal and wavelength jitter in a FEL inhibited a number of experimental techniques. He noted that the UK R&D plan was aiming to overcome such jitter through novel techniques and he reinforced the message that this would enable high impact science across an even broader range of established photon science.

At the end of the day Grahame Blair chaired a lively discussion session focused on the next steps for UK FEL R&D and the role that STFC should play in bringing the UK XFEL closer to reality. All the workshop presentations are available.

Jim Clarke

PAB Group Annual Meeting

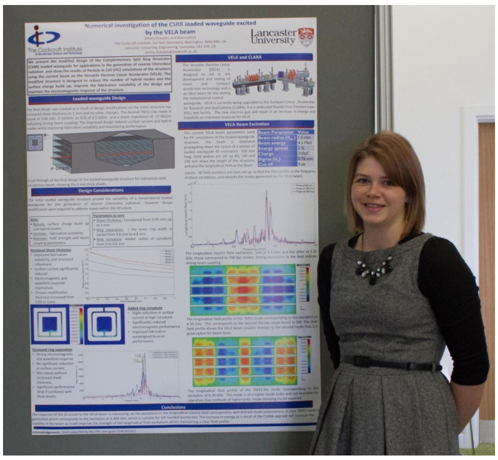
The group's Annual Meeting was held in Huddersfield on Friday 8 April 2016, and over 60 delegates gathered for a mixture of talks, discussion and posters covering the broad range of accelerator activities in and beyond the UK.

John Womersley was not available give his usual upbeat view of the STFC programme, but Susan Smith did an excellent job in his place, highlighting the opportunities offered by the 'Global Challenges' programme and the changes that the Nurse Review is liable to bring.

Richard Walker and Jim Clarke gave accounts of FELs present and future and Rob Appleby described the plans - recently funded - for UK involvement in the upgrades to increase the luminosity delivered by the LHC.

Delegates visiting the Medium Energy Ion Scattering Facility
(Credit: University of Huddersfield)

Over lunch many took the opportunity to tour the MEIS accelerator. This 200 keV Medium Energy Ion Scattering Facility was moved from Daresbury to Huddersfield and is now, thanks to the Huddersfield staff with help from Daresbury colleagues, operational and productive once more.



Poster prizewinner Emmy Sharples
(Credit: University of Huddersfield)

The Group AGM also took place at lunch time. The outgoing chair (Phil Burrows) and Treasurer (Brian McNeil) reported the activity and financial health of the group, and the members elected Brian McNeil as the new Chair and Jonny Smith as the new Treasurer; Susan Smith and Phil Burrows were re-elected to the committee, with Andy Rossall as a new member.

There were also many posters on display, over lunchtime and afterwards, and after due consideration prizes were awarded to Emmy Sharples (Lancaster University) for her poster on *Numerical Investigation of the CSRR Loaded Waveguide Excited by the VELA Beam* and to Tanjil Amin (University of Huddersfield) for *Proton Therapy Verification with PET Imaging.*

After lunch there were talks from Riccardo Bartolini on the Diamond upgrade, from Roman Walczak on plasma acceleration and the EUPRAXIA project, and from Ranald Mackay on particle therapy and the Christie and UCL proton centres. These familiar topics were complemented by presentations on lesser-known accelerators: John Thomason talked about the Chinese SNS project and Daria Sokhan described the JLAB electron-ion collider.

Mike Poole receives the Group Prize
from Phil Burrows
(Credit: University of Huddersfield)

A highlight of the meeting was - as always - the presentation of the annual Group Prize, which this year was awarded to Mike Poole for '*his world-class, internationally-recognised contributions to accelerator physics and the advancement of Free Electron Laser facilities worldwide; for his stewardship of the field of accelerator science in the UK, including his leadership of the Accelerator Science and Technology Centre; for his work for the Institute of Physics leading to the creation of the Particle Accelerators and Beams Group; and for his support and mentorship of his staff and colleagues.*' Everyone in the UK accelerator field today owes a lot to Mike and it was great to have the opportunity to acknowledge this in public.

The meeting concluded in the traditional way with drinks and nibbles, which ran on rather beyond the scheduled stopping time - though I don't think anyone missed their train.

Slides from the talks and photos are available.

Roger Barlow

Drinks and nibbles
(Credit: University of Huddersfield)

PAB Group & UK Events

4th Workshop on ADS and Thorium
University of Huddersfield, 31st August - 2nd September 2016
http://www.hud.ac.uk/research/researchcentres/iiaa/events/conferences/

Designing Future X-ray FELs
Daresbury Laboratory, 31st August - 2nd September 2016
http://www.xrayfels.co.uk/

Particle Accelerator Engineering Network Meeting
Rutherford Appleton Laboratory, 21st October 2016

National Particle Accelerators Open Day
Rutherford Appleton Laboratory, 26th October 2016

International Calendar

2nd International Workshop on ECR Ion Sources (ECRIS'16)
Busan, Korea, 28th August - 1st September 2016
http://www.ecris2016.org/

International Workshop on FFAG Accelerators (FFAG'16)
Imperial College, London, UK, 6th - 9th September 2016
https://indico.cern.ch/event/543264/

5th International Beam Instrumentation Conference (IBIC 2016)
Barcelona, Spain, 11th - 15th September 2016
http://www.ibic2016.org/welcome.html

21st International Conference on Cyclotrons and their Applications (CYC2016)
PSI, Switzerland, 11th - 16th September 2016
https://indico.psi.ch/conferenceDisplay.py?confId=3238

9th Mechanical Engineering Design of Synchrotron Radiation Equipment and Instrumentation Conference (MEDSI'16)
Barcelona, Spain, 11th - 16th September 2016
https://www.medsi2016.org/indico/event/42/

5th International Symposium on Negative Ions, Beams and Sources (NIBS'16)
St. Anne's College, Oxford, UK, 12th - 16th September 2016
http://nibs2016.org/

21st International Conference on High-Power Particle Beams
Cascais and the Estoril Coast, Portugal, 18th - 22nd September 2016
http://eappc-beams2016.org

Workshop on Accelerator Operations 2016
Shanghai, China, 18th - 23rd September 2016
http://wao2016.csp.escience.cn

28th Linear Accelerator Conference (LINAC2016)
East Lansing, MI, USA, 25th - 30th September 2016
https://indico.fnal.gov/conferenceDisplay.py?confId=10522

North American Particle Accelerator Conference (NA-PAC16)
Chicago, IL, USA, 9th - 14th October 2016
http://napac2016.aps.anl.gov/ComingSoon.html

The 11th International Workshop Personal Computers and Particle Accelerator Controls 2016 (PCaPAC)
Campinas, Brazil, 26th - 28th October 2016
http://pages.cnpem.br/pcapac2016/

8th International Particle Accelerator Conference (IPAC'17)
Copenhagen, Denmark, 14 - 19 May 2017
https://ipac17.org/

Upcoming schools

CERN Accelerator School — Introduction to Accelerator Physics
Budapest, Hungary, 2nd - 14th October 2016
http://cas.web.cern.ch/cas/Hungary2016/Hungary-advert.html

Useful Links

http://www.scitech.ac.uk/

http://www.cockcroft.ac.uk/

http://www.adams-institute.ac.uk/

www.diamond.ac.uk

http://www.desy.de/index_eng.html

http://www.linearcollider.org/newsline/

http://home.web.cern.ch/

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IoP Particle Accelerators and Beams Group

IoP PAB Committee

***Chair*: Prof. Phil Burrows (JAI Oxford)**

***Secretary*: Mr. Aled Jones (AWE)**

***Treasurer*: Dr. Brian McNeil (Strathclyde)**

Miss Talitha Bromwich (JAI Oxford); *Co-opted Student*

Dr. Graeme Burt (Lancaster)

Dr. Hywel Owen (Manchester); *Web Manager*

Dr. Jonathan Smith (Tech-X UK); *Industrial representative*

Prof. Susan Smith (Daresbury)

Dr. John Thomason (RAL); *Newsletter*

Dr. Melissa Uchida (Imperial)

Dr. Peter Williams (Daresbury)

Deadline for submissions to the next newsletter is
10 December 2016