INSTITUTE OF PHYSICS

IOP Institute of Physics
Particle Accelerators and Beams Group

IOP PAB GROUP NEWSLETTER

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Editorial

When reading through the draft of this Newsletter, I was struck by the wide range of activities, research and impact that flows from the field of Particle Accelerators and Beams. From adults given freedom to behave like children at the Accelerate! outreach event organised by the John Adams Institute, to Alisa Healy, an ASTeC and Lancaster University PhD student, winning a very competitive best student poster at the 3rd European Advanced Accelerator Concepts Workshop, to the new developments at the CLARA FEL test facility at Daresbury Laboratory and great progress at the MICE facility. A wide range of workshops, conferences and other developments with significant international impact is also reported. The UK is certainly at the forefront of our field internationally.

STFC are currently undertaking a Strategic Review of its Accelerator Programme. This will affect the research commitments and directions pursued by STFC for the next twenty years and is therefore of great importance to the work we do and will have long-lasting consequences. So, if you can, engage with STFC and let them know what you and the beneficiaries of your science think are the important strategic areas that should be developed.

This year our annual meeting will be hosted by Lancaster University on Wednesday 18 April, 2018. Please look out for the imminent announcement for registration and try to join us. It is a great way to hear of the latest developments, network, and have a bit of fun with long lost colleagues! As usual, there will be early career Poster-Prizes and the announcement of the winner of this year's Group Prize for Outstanding Professional Contributions – nominations can still be submitted (see also p.13 of this Newsletter).

The PABG Committee say goodbye to Phil Burrows who has served as Ordinary member, Treasurer, and Chair of the Committee. During this time we have greatly increased our membership and service to the community. So, thank you Phil for your sterling service! The committee also welcomes a new member, David Dunning of STFC, ASTeC, based at Daresbury Laboratory - details below. David, I am sure you will find the experience of serving our community very rewarding!

Brian McNeil

Group Chair

Dave Dunning is a senior physicist in the ASTeC department at STFC's Daresbury Laboratory. He specialises in free-electron laser (FEL) design and implementation. Dave graduated with a degree in physics from the University of Manchester in 2005 and received his PhD from the University of Strathclyde in 2016 for studies on generating ultra-short radiation pulses from FELs. He was part of the team which commissioned and operated the UK's first FEL, at Daresbury's ALICE facility. He has worked on several national and international projects to design FEL facilities for both scientific research and commercial applications.

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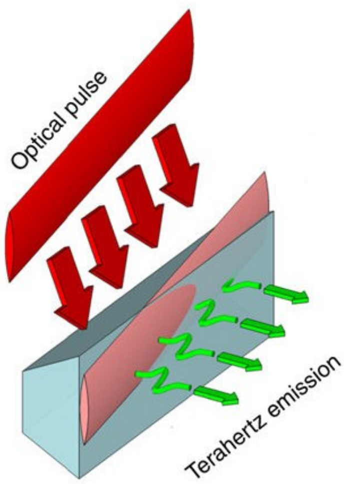
News from the Laboratories — Daresbury

Demonstration of Slow-Light for Particle Acceleration Published in Nature Communications



Modified configuration laser pulse-front tilt for THz generation in $LiNbO_3$ (Credit: Nature Communications)

The demonstration of the slowing of single-cycle terahertz frequency (10^{12} Hz) electromagnetic pulses to subluminal speeds has been published in Nature Communications. The work proves a new concept for velocity matching ultrashort, sub-picosecond, electromagnetic pulses with relativistic particle beams, opening up novel approaches for manipulating and accelerating femtosecond duration particle beams.

The ASTeC and the University of Manchester team involved, together with colleagues at Lancaster University, are now working to implement these concepts in experiments accelerating relativistic electron beams. Further information on THz driven acceleration is available on the ASTeC Laser and Optics Group webpage.

ASTeC and Lancaster University PhD Student Wins Best Student Prize

Alisa Healy, a 3rd year ASTeC and Lancaster University PhD student recently won one of three prizes for best student poster at the 3rd European Advanced Accelerator Concepts Workshop in Elba (EAAC 2017). The poster on using THz to accelerate electrons in dielectric lined waveguide was judged to be one of three best posters out of 92 entrants. Alisa gave a two minute talk about her research to the conference participants.

Alisa works on the dielectric and THz acceleration project to develop next-generation particle accelerators, together with students and staff from Lancaster and Manchester Universities and ASTeC.

Michelle Keeley

Alisa Healy wins the best student poster prize at EAAC 2017 (Credit: ASTeC)

Cryogenic Cluster Day 2017

Daresbury Laboratory proved to be the perfect host for the 8th Cryogenic Cluster Day on 20 September, which was attended by eleven Universities: Birmingham, Dresden, Liverpool, Lancaster, Loughborough, Manchester, Newcastle, Oxford, Sheffield, Sussex and Twente. Over twenty firms took part including Dearman Engine, Molecular Products, Kelvin, Cryogenic, Matrix Magnets, Polar, Scientific Magnetics, AVS, Statebourne, Carlton, Tamo, ASG, RUAG, Biomethane, IDT, Blackhall, Agilent, Springer and Stratox. A good number of institutions were also represented, including BCGA (British Compressed Gases Association), Diamond, RAL, ISIS, STFC, DL, CERN, ESS (European Spallation Source), NHS (National Health Service) and UK AEA (UK Atomic Energy Authority). Two of the session chairs were distinguished visitors from CERN and ESS: Dimitri Delikaris and John Weisend.

Participants at the 8th Cryogenic Cluster Day
(Credit: STFC)

Susan Smith, Head of the Laboratory and Director of ASTeC, opened the event, with the first presentation from Peter McIntosh, Technical Director of ASTeC. His review of Daresbury's contribution to superconducting accelerators revealed an awesome capability and perhaps the need - and opportunity - for UK industry to play a bigger part. The notion of the 'Northern Cryogenics Powerhouse' began to take hold with two subsequent talks from speakers from Lancaster and Manchester Universities. Professor Richard Haley at Lancaster works at temperatures as low as 1 mK, mentioning concepts like a 'superfluid speed limit' (using a dilution refrigerator the size of a house). Andrew May from Manchester, discussing applications in astronomy, memorably entertained the audience with a swift review of the History of the Universe, captured on one slide!

Between Richard and Andrew there was an excellent, well-illustrated talk by Ofelia Capatina from CERN, featuring CERN's collaboration with DL on cryomodule development. She began with an entertaining CERN anecdote from a review of Tim Berners-Lee's proposal for the world wide web by his boss at the time: 'vague but exciting...'. In a swerve to a different application, Jason Hill from Newcastle made a very convincing case for needing electric aircraft in the future to meet emission standards and enable new aircraft architectures - superconducting technology being the only electric option able to meet the requirements of aircraft propulsion.

DL Catering earned compliments for a fine lunch, taken in the exhibition area, with signs of many earnest conversations and new connections being made, and with the opportunity to examine a strong display of posters. A series of lab visits then took delegates on a guided tour of the SuRF Lab, the Cryolab and the Vacuum Lab, showcasing a hive of activity on cryomodules and other work with CERN and ESS which featured in the talks.

The Cluster Day industrial exhibition and poster session (Credit: STFC)

In the afternoon talks, Michael Ellis discussed the superconducting RF high-beta cavities being developed at Daresbury for ESS, and David Klaus from ASG gave an insight into the technology cluster in Genoa developing superconducting technology in wires, magnets and scanners. The impending arrival of revision five of the BCC Safety Manual was announced, and poster prizes were awarded by Peter Ratoff, Director of the Cockcroft Institute to Iryna Mikheenko from the University of Birmingham, Koen Ledeboer from the University of Twente and Nik Templeton from STFC.

Thanks go to Shrikant Pattalwar and his colleagues for organising a very successfully event that deserves repetition.

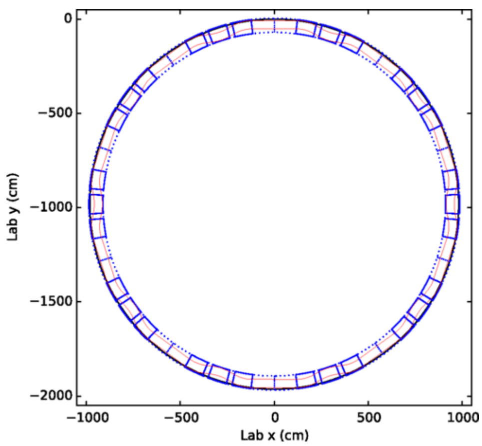
Michelle Keeley

Magnets For Cancer Therapy

Scientists from the Magnetics and Radiation Sources (MaRS) Group of ASTeC together with colleagues from Manchester University have recently completed a study on the feasibility of a normal conducting, fixed-field alternating gradient (FFAG) accelerator (NORMA) for cancer therapy.

FFAGs are machines that were first introduced in the 1950s. However, they require complex magnetic fields that are difficult to produce and for this reason they were largely abandoned. In recent times, the availability of advanced CAD simulation tools combined with considerable desktop computing power, have stimulated the re-emergence of FFAGs.

The main outcome of this work is a novel approach to complex accelerator designs. Traditionally lattice designers complete a preliminary investigation relying on simplified (e.g. formula-based) magnetic field models. This process results in a relatively quick design of the lattice and a magnet specification, which is then passed on to magnet designers who try to achieve the required magnet performance with more realistic CAD magnet models. This approach works well for relatively simple, conventional magnets, such as quadrupoles and dipoles. However, the complex magnetic fields required by NORMA combined with the limited information available at the early stages of the work make the traditional (linear) design approach unreliable.

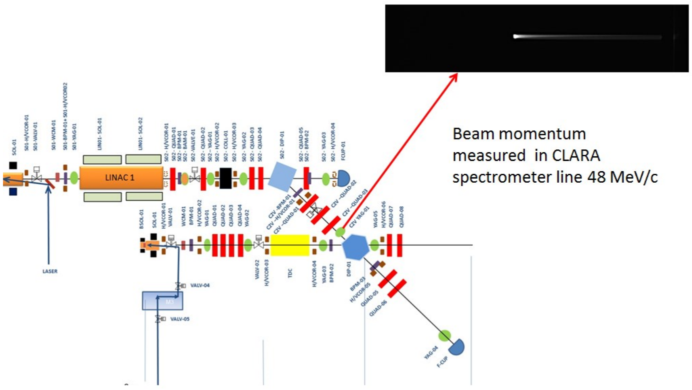


NORMA round lattice, with minimum and maximum closed orbits shown in red (Credit: ASTeC)

Instead, an iterative design process, in which lattice and magnet design steps are performed in sequence, with each completed stage of the work feeding information into the next one, has been adopted. The process is repeated until the required performance level has been achieved. In this way, lattice designers work from the start with realistic magnetic fields obtained from rigorous finite-element analysis and this allows the elimination of simplifications inherent to the traditional (linear) approach. The result is an accelerator design free from assumptions and uncertainties.

First Accelerated Beam Through Linac 1

On 16 November CLARA reached another significant milestone – accelerating electron beam with Linac 1 for the first time. At the first attempt, a beam energy of 48 MeV was reached, far exceeding the minimum facility requirement of 40 MeV. Before attempting acceleration the electron gun and linac both had to go through an intense period of RF conditioning which involved carefully feeding increasingly higher RF powers into each cavity to ensure they were capable of withstanding the very large electric fields required for acceleration. This process went particularly smoothly for the linac which was a testament to the high-quality engineering of the system as it had not previously been subjected to high power RF.



CLARA front end and first accelerated beam through linac 1
(Credit: ASTeC)

Before the beam attempt was made a number of other systems had to be optimised, most notably the photoinjector laser and associated laser optical transport and the new water cooling systems which must keep the linac and gun cavities at a fixed operating temperature within very small margin in order to sustain the correct RF frequency. Additionally, a large team of ASTeC, Cockcroft, and Technology Department staff have worked hard behind the scenes to ensure all of the other systems were operational on the day – these include the magnets, diagnostic screens, control system, vacuum system, power supplies, *etc.*

The focus of the commissioning has now shifted to proving the performance of the other technical systems, including the Faraday Cups, Wall Current Monitor, and the Beam Position Monitors before detailed beam characterisation begins. The new high energy beam will also now be transported through the VELA beam line towards Beam Areas 1 and 2 in preparation for exploitation later in 2018. The team is also looking forward to commissioning the new 400Hz photoinjector during 2018. It is installed and ready to be tested at an opportune moment.

Michelle Keeley

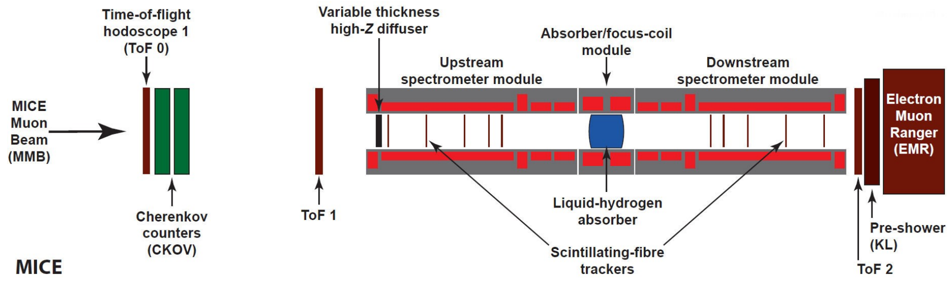
News from the Laboratories — RAL

An Update on the Muon Ionization Cooling Experiment

The Muon Ionization Cooling Experiment or MICE, as it is known, is a collaboration of over 100 scientists from 10 countries and 30 institutes around the world. It is based at the Rutherford Appleton Laboratory in Didcot, UK and the current stage of MICE, known as 'Step IV', has been taking data since December 2015.

It has been my pleasure to work on the experiment for the last five years and indeed to present the latest results at the IOP Particle Accelerator and Beams Group Annual Conference earlier this year. A lot has happened since then, so here is an update on MICE, its purpose, goals and progress.

Muon colliders and neutrino factories are attractive options for future facilities aimed at achieving the highest lepton-antilepton collision energies (imagine a collider of only 2 km in diameter that could provide 4 TeV collision energy!) and precision measurements of parameters of the Higgs boson and the neutrino mixing matrix. However, we have some hurdles still to overcome first. Unlike electrons and protons the short lifetime of the muon (~ 2.2 μs) and the large emittance of muon beams (as muons are tertiary particles) means that traditional beam cooling techniques which reduce emittance cannot be used for such beams and ionization cooling is the only practical solution to prepare high intensity muon beams.

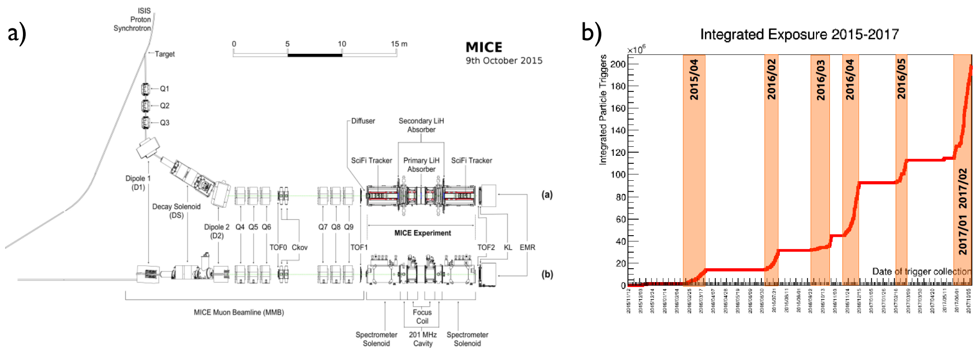


Schematic of the MICE Step IV experimental layout (without RF). A muon beam passes through a low-Z material (absorber), where the muons lose both longitudinal and transverse momentum through ionization energy loss.
(Credit: MICE)

MICE is designed to reduce the muon beam emittance through energy loss in ionization as particles cross an absorber material. This can be combined with restoration of the longitudinal momentum of the beam through re-acceleration (using RF cavities), thereby making sustainable cooling. This demonstration will be an important step in establishing the feasibility of muon accelerators for particle physics.

The muons produced in the MICE Muon Beam are passed through a series of detectors before and after the absorber or cooling cell. These detectors enable us to have a measure of the beam emittance before and after the cooling cell.

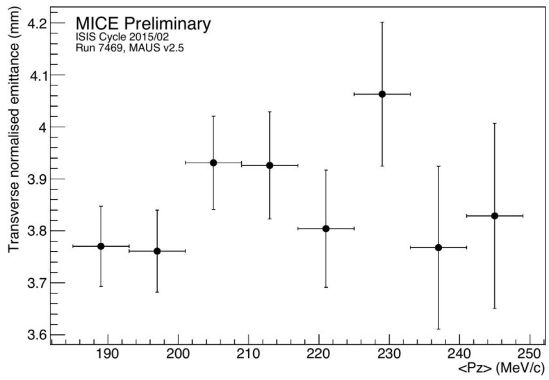
It all sounds easy enough. The muons pass through the cooling cell and lose energy/momentum through ionization. However, in reality there is also a heating effect produced as a result of multiple scattering on absorber nuclei and the net cooling is a balance between these two effects. MICE will therefore study both multiple scattering and cooling in detail for a variety of input beams, magnetic lattices and absorbers to demonstrate the feasibility of ionization cooling, making it of interest to many branches of physics.



a) Schematic of the ISIS proton synchrotron and the MICE beam extraction magnets. MICE uses a decay solenoid to enhance the initial pion to muon decay process, dipole magnets for momentum selection and quadrupole magnets for beam focusing. b) The MICE integrated particle triggers collected as a function of time. ISIS user cycles in which data were taken are highlighted in orange.
(Credit: MICE)

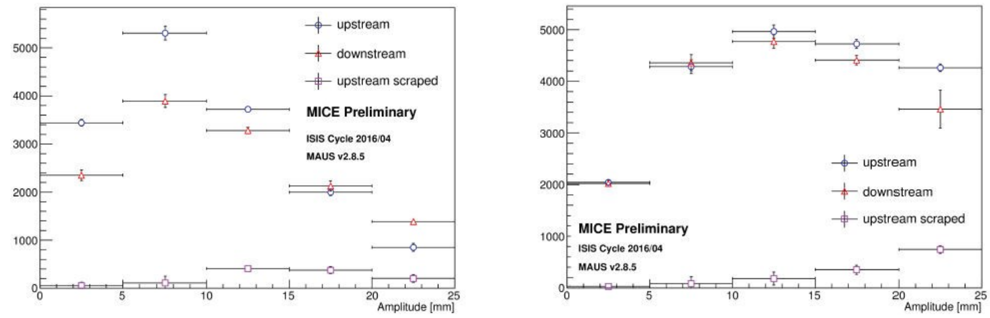
The MICE Muon Beam is produced by dipping a titanium target into the ISIS 800 MeV proton beam. This produces pions which then decay into muons. The beam can be prepared as a $\pi^{\pm}$ beam or $\mu^{\pm}$ beam with momentum between 140 – 450 MeV/c. This is a high-purity beam with less than 1.4% pion contamination in the muon beam. To date, over 200 million integrated triggers have been collected over six ISIS user cycles with negligible down time.

The first important milestone was to ensure that we could measure and understand the emittance before any cooling has taken place, using the MICE detector suite – the first time such an elaborate measurement has been made. The first direct measurement of the MICE Muon Beam momentum-binned transverse normalised emittance has now been made. The horizontal error bars represent the limits of each momentum slice, while the vertical error bars are purely statistical errors on the measurements. A full study of the contribution from systematic errors is underway and preliminary results indicate that that they are small in comparison to the errors shown. The binned emittance values are consistent across the range of studied momenta.



Transverse-normalised emittance of 8 MeV/c longitudinal momentum bins.
(Credit: MICE)

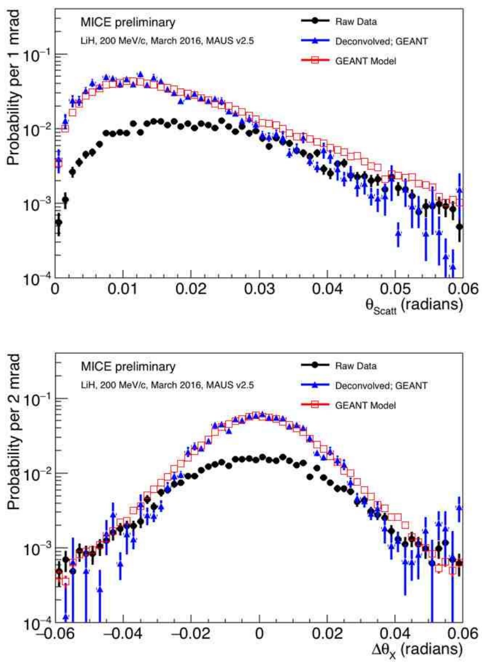
The next step for MICE is to measure the emittance change across the absorber. Muon beams of 140 MeV/c momentum with initial beam emittances of 3 mm and 6 mm nominal emittance have been analysed so far with the resulting amplitude distributions shown overleaf. In this data set (with fixed optics, lithium hydride absorber and a 140 MeV/c muon beam), we expect the heating due to multiple scattering to dominate for a beam with input emittance of 3 mm and for the heating and cooling (due to ionization) effects to be equal for a 6 mm input emittance beam. The first bin is at the beam centre and is one of the cleanest ways to look at emittance change, since the muons here sit in the centre of the fiducial volume and have no chance to scrape on or traverse the edges of the experimental apparatus. The 3 mm nominal emittance beam shows a clear reduction in the number of reconstructed muons downstream to upstream within the first bin, significantly above any scraping effects, which is characteristic of an emittance growth, or heating.



Change in amplitude distribution for the 3 mm 140 MeV/c configuration (left) and for the 6 mm 140 MeV/c configuration (right). Transmission is ~90% and 80% respectively. Blue circles show the amplitude of upstream events, red triangles show the amplitude of downstream events and magenta squares show the amplitude of upstream events that are not observed downstream.
(Credit: MICE)

Likewise muons with low amplitude upstream of the absorber are observed to move to higher amplitude when measured downstream, as the sample emittance is below equilibrium. Muons sampled from the 6 mm input emittance beam show negligible change between the upstream and downstream reconstruction, which is consistent with equilibrium emittance. The 10 mm data set is currently being analysed. Watch this space... a full description of emittance evolution in MICE will be published soon.

Multiple Coulomb scattering is a well-known electromagnetic phenomenon experienced by charged particles traversing materials, and in MICE is a major cause of heating or emittance growth in the beam. It is therefore essential that MICE measures multiple scattering in the absorber materials it uses – lithium hydride (LiH) and liquid hydrogen – and validates this multiple scattering against known simulations.

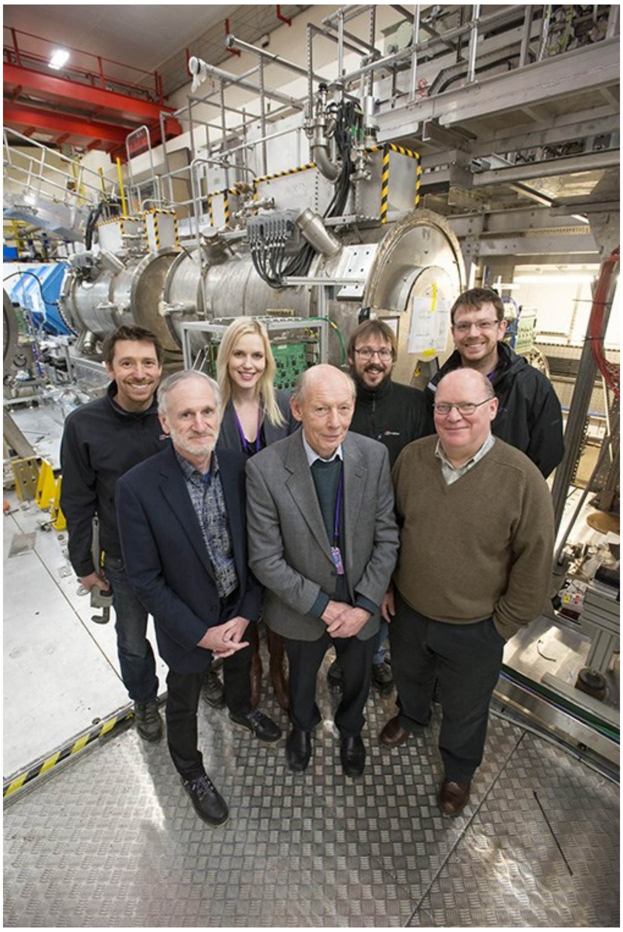


3D (top) and projected (bottom) scattering angle distributions of 200 MeV/c muons passing through the LiH absorber.
(Credit: MICE)

To make the scattering measurements, MICE takes data over a range of beam momenta: 172 MeV/c (in order to compare with MuScat), 200 MeV/c and 240 MeV/c, and with the absorber in place and empty (to ensure scattering in the windows of the absorber module is accounted for). A strict track selection is imposed to ensure a pure, well-understood muon sample. Bayesian deconvolution is applied to the selected data in order to extract the scattering distribution within the absorber material and subsequent comparisons to GEANT4 are made, as well as to a standalone scattering model developed by the collaboration.

Data were taken with the 200 MeV/c beam, with and without the lithium hydride absorber (thickness of 65 mm, X_0 = 79.62 gcm^{-2}) and deconvolved using the GEANT model. All contributions to the systematic uncertainty were considered including sensitivity to the thickness of the absorber, the time of flight cuts used in the momentum selection, detector alignment and the choice of fiducial volume cuts. The time of flight systematics are found to dominate.

The scattering widths taken from the scattering distributions projected in the *X–Z* and *Y–Z* planes are θ = 20.3±0.2 mrad at 172 MeV/c, θ = 17.1±0.2 mrad at 200 MeV/c and θ = 13.8±0.1 mrad at 240 MeV/c. This preliminary analysis indicates that GEANT4 underestimates the scattering width. A full description of multiple scattering in MICE will be published soon.



Members of the MICE Tracker Detector Team in the MICE experimental hall at RAL.
(Credit: MICE)

A lot has happened in MICE over the past year. The liquid hydrogen system has been installed and commissioned, data has been taken and analysis is underway. The first measurement of emittance in an ionization cooling experiment has been made. The multiple scattering data program is nearing completion and the emittance change analysis is underway. MICE is now working to finalise this work and to make the first measurement of muon beam emittance reduction through ionization cooling – a huge step forward in creating a muon machine of the future.

Who knows, perhaps a muon collider is closer than we think...

Melissa Uchida

Accelerators for Security, Healthcare and Environment

Graeme Burt and Peter Ratoff at the ASHE kick-off
(Credit: Cockcroft Institute)

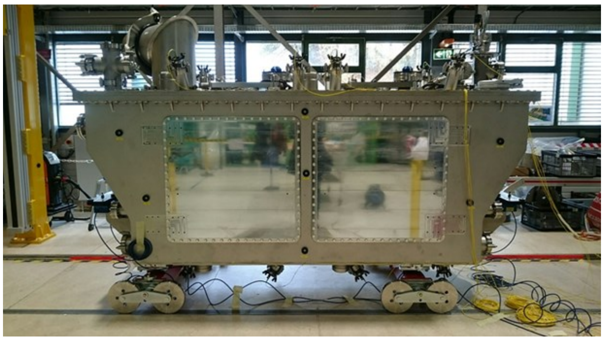
The Cockcroft Institute has recently been awarded funding for a new doctoral training centre from STFC which had its kick-off meeting on 8 November. The Accelerators for Security, Healthcare and Environment (ASHE) project has a number of PhD students in 2017 who will undertake research projects on the application of particle accelerators to these three vital areas. The first cohort will look into projects on radiotherapy, X-ray imaging and cargo screening.

The project has strong backing from industrial partners and each project is linked to at least one UK company. Each student will take a 3 - 6 month industrial placement in that company. Industrial partners include Elekta, TMD, Antaya, Adaptix, Rapiscan and the NHS through Christie and Clatterbridge. The students will also receive training in technical skills relevant for industry and industrially relevant skills in innovation, management and business.

The head of the ASHE project Dr Graeme Burt at the Cockcroft Institute and Lancaster University said 'The Cockcroft has long had a world leading education programme in the training of PhD students, and this new project aligns this with our strength in accelerators aimed towards the UK's industrial strategy'.

HL-LHC Prototype Cryomodule Completed

The HL-LHC project to increase the luminosity of the LHC met a key milestone this week when the first prototype crab cavity cryomodule for the Super Proton Synchrotron (SPS) was completed. The cavity included HOM couplers, thermal shields, supports and a magnetic shield designed with Cockcroft Institute engineers, and a cold magnetic shield manufactured by the Cockcroft Institute. Cockcroft engineers were also involved in measurements of the cavity from trim tuning to high gradient testing of the dressed cavities.



The first HL-LHC prototype crab cavity
cryomudule for SPS
(Credit: Cockcroft Institute)

The cryomodule will now undergo conditioning and cold testing in the SM18 test facility at CERN before being installed for testing with protons in the SPS at CERN. This is the first measurement of crab cavities with hadrons in the world and will mark a significant milestone in the HL-LHC project.

Graeme Burt

'Accelerate!' Show at the Curiosity Carnival

On 29 September the John Adams Institute's Lucy Martin (JAI, Oxford) and Sophie Bashforth (JAI, RHUL) performed the 'Accelerate!' show for the Curiosity Carnival, Oxford's version of 'European Researchers Night'. Lucy and Sophie report on their experience:

'The Curiosity Carnival was a fantastic event to be part of, and performing the Accelerate! show in the Museum of Natural History was a lot of fun, even if manoeuvering beach balls and hydrogen balloons past the queues of people waiting to get inside wasn't easy!

Oxford Museum of Natural History
(Credit: John Adams Institute)

The show aims to convey the basic recipe behind a particle accelerator: Particles, Acceleration, Control, Collision and Detection. The basic concepts are illustrated using a range of demonstrations, from liquid nitrogen to demonstrate superconductors to plasma balls lighting fluorescent bulbs to show wave based acceleration. The aim is to get as many members of the audience involved as possible and to leave the audience with the idea that accelerators aren't only used for particle physics.

We gave the show at 9pm and audience members made their way to the lecture theatre past stalls representing hundreds of different areas of research in Oxford. Our audience were mainly adults due to the time of the day, but although the show is more usually presented to children we didn't change the format and still included a large amount of audience participation. It was great to see the audience gradually become more involved, shouting out answers to questions, and 'accelerating' beach balls across the room seemed to go down just as well with adults as with children!'

Images from the event
(Credit: John Adams Institute)

Also helping out backstage were Mephare Atay (Oxford), Peter Tudor (Oxford) and Andrey Abramov (RHUL) together with Lena Shams (Oxford Physics Access) and Dr. Suzie Sheehy (who was also a member of the Oversight Committee for the Curiosity Carnival).

Andrei Seryi

JAI winners at the SEPnet Public Engagement Awards

The wide variety of Public Engagement activities, enthusiastically delivered by members of the John Adams Institute were recognised by multiple prizes at the SEPnet PE Awards in London, on Wednesday 29 November:

Suzie Sheehy (JAI-Oxford, Royal Society University Research Fellow) was Highly Commended for both the Communication Award and the Achievement Award, recognising her long standing contributions to Public Engagement over the last decade. These include live events reaching over 10,000 people per year, an online video series about accelerators with the Royal Institution and a wide range of media work.

Sophie Bashforth (JAI-RHUL, PhD student) was Highly Commented as a Newcomer in Public Engagement – an important distinction that recognises the wide range PE activities she has been involved in the past year, including RHUL's Big Bang Experience lectures, the Cheltenham Science Festival and most recently co-leading Accelerate! at the Curiosity Carnival. Sophie is now based at CERN where she continues to communicate her research with the public, taking part in initiatives like School Lab and FameLab.

Stephen Gibson accepts the SEPnet award
(Credit: Royal Holloway)

The SEPnet Research Group Award for best embedded culture of Public Engagement was won by the Royal Holloway Centre for Particle Physics (including JAI-RHUL) for the group's Public Engagement activities, coordinated by Stephen Gibson (JAI Deputy Director and Public Engagement and Outreach Coordinator). Stephen presented the group's nomination at the Awards, highlighting a range of activities including: RHUL's Physics popular evening lectures, CERN's BeamLine4Schools, FameLab, ImAnEngineerGetMeOutOfHere, RHUL and Cheltenham Science Festivals, the Big Bang Fair, *etc.* and concluded with an explosive video showcase.

Dr. Gibson said 'We're all thrilled to receive this prestigious SEPnet Award that recognises the whole team's exuberant dedication to inspiring the public with our research in Particle Physics, over many years, most recently aided by the amazing Anna Christodoulou, our enthusiastic SEPnet and Ogden Trust Public Engagement and Outreach Officer'.

Stephen Gibson

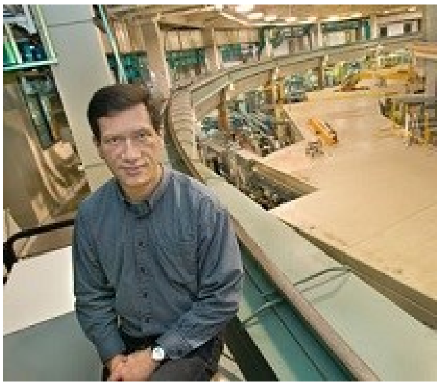
SEPnet
South East Physics Network

JAI
John Adams Institute
for Accelerator Science

IoP Particle Accelerators and Beams Group Prize

The Particle Accelerators and Beams Group of the IoP is seeking nominations for the 2018 Prize for Outstanding Professional Contributions. This will recognise the contribution made by an individual to the field of accelerator science and technology in the UK or Ireland whilst also enhancing the public profile of the subject.

Previous recipients of the prize are Andy Wolski (2017), Mike Poole (2016), Chris Prior (2014), Ian Gardner (2013) and Neil Marks (2012).



2017 prize recipient Andy Wolski

The Prize can be awarded to a person of any nationality although the nomination must be made by an IoP member. The identified personal contributions should be demonstrated to have had significant impact on major scientific or technological advancement, or alternatively to have promoted important educational or outreach activities.

Neil Marks, Ian Gardner, Chris Prior and Mike Poole are presented with their prizes

A maximum two page summary case must be submitted, together with a small amount of ancillary material, including major citation evidence (where relevant). Up to three letters of support for the candidate may also be included. The material must be submitted to the PAB Group Secretary, Aled Jones by the nomination deadline of 28 February 2018.

A Prize Committee has been appointed and will meet to determine the award winner. The recipient will be presented with a certificate at the PAB Group Annual Conference on 18 April 2018 at Lancaster University and will be invited to give the prize lecture at the PAB Group Annual Conference 2019.

Aled Jones

Very High Energy Electron (VHEE) Radiotherapy: Medical & Accelerator Physics Aspects Towards Machine Realisation

The VHEE'17 workshop was held at the Cockcroft Institute (at Daresbury Laboratory, UK) on 24–26 July. More than fifty delegates attended, with 38 from the UK, 7 from Europe, 3 Asia and 2 from the USA. This workshop explored fundamental issues associated with the development of a radiotherapy machine capable of delivering 250 MeV electrons at a high dose. Both the dose delivery aspects and the potential to realise a radiotherapy machine suitable for patient treatment were explored. In the former, Monte Carlo modelling of the dose distribution featured and entailed contrasting with extant therapy techniques – potential benefits and disadvantages. The accelerator physics part of the workshop addressed the practicalities of realising a medical radiotherapy machine equipped with multiple linacs surrounding the patient on a fixed gantry system. High gradient linac development featured, along with the application, with suitable modification, of X-band linacs already developed for linear colliders – the Compact Linear Collider (CLIC) and the Next Linear Collider/Japanese Linear Collider (NLC/JLC) were discussed by delegates.

Attendees at the VHEE'17 workshop
(Credit: Stuart Ayres, Daresbury Laboratory)

The workshop consisted of 20 plenary sessions which mixed issues on fundamental machine design with the practical implications of conformal dose delivery. Many exceptional talks were given during the two and a half day workshop. A particular highlight was the talk given by Prof. Steve Myers (ADAM Executive Chairman, former CERN Director of Accelerators and Technology, and in 2014, Head of CERN Medical Applications) who provided a detailed overview of the practicalities of operating and designing a VHEE machine suitable for patient treatment.

Several aspects were considered, including design of high gradient machines (~100 MeV/m) based on the wealth of robust experience gained in linear colliders. Very high gradients (laser plasma, dielectric wakefield) were also investigated with talks and posters. Multi-linac systems and phase switching to linacs azimuthally surrounding patients were discussed. Dose conformity (VHEE versus photon and proton) was discussed by several delegates and plenary presentations in this area highlighted some of the potential advantages, such as relative range insensitivity. Imaging was also discussed in some detail with talks highlighting the need for rapid *in situ* imaging. Some of the latest results and the prospect for further work on ultra-high dose delivery with 'FLASH' radiotherapy proved to be particularly stimulating topics for discussion.

The scientific programme committee was chaired by Prof. R. M. Jones (Cockcroft Institute/ University of Manchester) and the local organising committee was chaired by Dr. D. Angal-Kalinin (STFC Daresbury Laboratory/Cockcroft Institute). There were also four working groups consisting of – WG1: Machine Design (Chaired by J. Allen and P. Goudket), WG2: Facilities (Chaired by P. McIntosh and A. Faus-Golfe), WG3: Radiophysics (Chaired by R. McKay and K. Kirkby), WG4: Imaging (Chaired by M. Van Herk and C. Baker). The output from these was combined into presentations in two joint sessions.

Prof. R. M. Jones presents prizes to Agnese Lagzda and Karolina Kokurewicz
(Credit: Stuart Ayres, Daresbury Laboratory)

Four student bursaries were provided to allow students with exceptional academic qualifications to attend the workshop. The dinner took place at Ruthin castle and here prizes were presented to the winners of the poster competition. Eight judges marked the very high quality poster presentations and awards were presented to the winner, Agnese Lagzda (Cockcroft Institute/ University of Manchester) and the runner up, Karolina Kokurewicz (Cockcroft Institute/University of Strathclyde).

This workshop brought together accelerator physicists, clinicians, radiologists and industrialists, allowing cross-fertilisation of ideas. The next VHEE workshop is planned to take place in 2019. The programme committee will decide on an appropriate location.

The workshop was sponsored by the Advanced Radiotherapy Network, IOP Particle Accelerators and Beams Group, The Cockcroft Institute, STFC ASTeC and ICFA.

Prof. R. M. Jones

Advanced Radiotherapy

The Cockcroft Institute of Accelerator Science and Technology

Science & Technology Facilities Council

ICFA

Successful CERN Accelerator School

Royal Holloway, the John Adams Institute hosted the CERN Accelerator School course in Advanced Accelerator Physics from 3 – 15 September 2017, which was attended by 20 instructors and 70 student accelerator physicists from around the world, including Canada, China, Japan, Germany and Turkey. The school was aimed at graduate students and post-doctoral research fellows and covered specialised concepts like transverse and longitudinal particle motion, non-linear dynamics and instabilities. These topics are critical for the smooth and successful operation of accelerators like the Large Hadron Collider (LHC) and a host of other accelerators such as the UK's Diamond Light Source at STFC's Harwell Campus.

Participants at the CERN Accelerator School
(Credit: Royal Holloway)

On Monday 4 September, Vice Principal Professor Paul Hogg gave an excellent welcome talk to the students. In addition to describing the relationship between the John Adams Institute, the Physics Department at Royal Holloway and CERN, he emphasized the importance of women in science, technology and engineering.

Professor Paul Hogg's welcome talk
(Credit: Royal Holloway)

Mornings at the school consisted of four hours of formal lectures, mainly in the Moore Lecture Theatre, whilst the afternoons were dedicated to hands-on specialist courses in accelerator optical simulation, beam instrumentation and radio frequency techniques. This concentration of expertise and experimental equipment is rarely found outside international high energy physics laboratories and students seized the opportunity to enhance their skills.

Morning lectures and afternoon experiments
(Credit: Royal Holloway)

Participant Sophie Basforth said of the school 'It was amazing to attend such a prestigious school, where advanced topics were explained by experts in the field and we had access to state-of-the-art technology in the labs.'

Andrey Abramov added 'The school was a great opportunity to network with researchers from around the world, some of whom may be future colleagues or collaborators. I was very proud to have them at my university.'

The square at Royal Holloway
(Credit: Royal Holloway)

This intensive program was peppered with social activities to help students deal with the impressive workload and form professional connections between fellow students and instructors alike. These activities included a welcome reception in the picture gallery, a movie night, a boat tour to Windsor and a formal dinner. All the visitors were complimentary about the hospitality and impressive surroundings of Royal Holloway, especially the library and square. The CERN organisers even commented that the Royal Holloway hosted event was 'one of the smoothest in 15 years'.

Academic staff members Stewart Boogert, Stephen Gibson and Pavel Karataev enjoyed welcoming the school participants and extend their thanks to Ian Murray and Charlotte Nedd (laboratory technicians), Sophie Bashforth and Andrey Abramov (physics PhD students), Siobhan Alden (master's student) William Shields (post doc) and Tracy Webster (SFA) for all the hard work behind the scenes which made the event possible.

Stewart Boogert

ROYAL HOLLOWAY UNIVERSITY OF LONDON

John Adams Institute for Accelerator Science

National Vacuum Electronics Conference

The National Vacuum Electronics Conference (NVEC) is the UK's national meeting for early career researchers and PhD students in the area of Vacuum Electronics. NVEC gives many researchers the key opportunity to network and the chance to discuss their research with other researchers and industrial experts from around the country.

This year NVEC 2017 took place at the University of Huddersfield on 26 September. Over 40 attendees from Industry, National Laboratories and Universities listened to a range of presentations from PhD students and junior researchers from Huddersfield, Lancaster, Oxford and STFC. The material presented covered a large and diverse range of areas, including talks on a compact Fabry-Perót interferometer for measurements of Smith-Purcell radiation in the terahertz region, an X-band system for phase space linearisation on CLARA, photonic-bandgap dielectric structures for laser-driven accelerators, DNA fabrication of nano-scale metallic/ dielectric EM structures, shutter switches for high power RF applications and multiple other areas.

The MIAMI-1 system
(Credit: University of Huddersfield)

The meeting also included a tour of the accelerator facilities at Huddersfield, which included the MIAMI, MEIS and RF-Laboratories. MIAMI-1 can irradiate samples *in situ* with inert gas ions in the energy range 20 - 100 keV. The MIAMI-2 facility is capable of irradiating samples *in situ* with up to 350 keV ions whilst simultaneously irradiating with up to 20 keV inert gas ions. The Medium Energy Ion Scattering facility (MEIS) generates positively charged light ions, typically hydrogen or helium accelerated up to 50 - 200 keV, used to analyse and modify the surfaces of materials. The RF laboratory offers a range of equipment for the fabrication and characterisation of RF devices and subwavelength geometries and the ability to study the interaction of these geometries with electron beams, from MHz to optical frequencies.

At this point it is important to mention and thank the supporters of NVEC - CST, TECH-X and of course the IOP Particle Accelerators and Beams groups. The support of these organisations is critical to enable NVEC to take place. As an attendance fee is not charged this maximises the ability for junior researchers and students to attend, network and in the end further their research and careers.

NVEC 2017 can be considered a great success and a valuable contribution to the vacuum electronics community of the UK, and we can all look forward to NVEC 2018 to be held at the University of Oxford, organised by Dr. Ivan Konoplev.

Rebecca Seviour

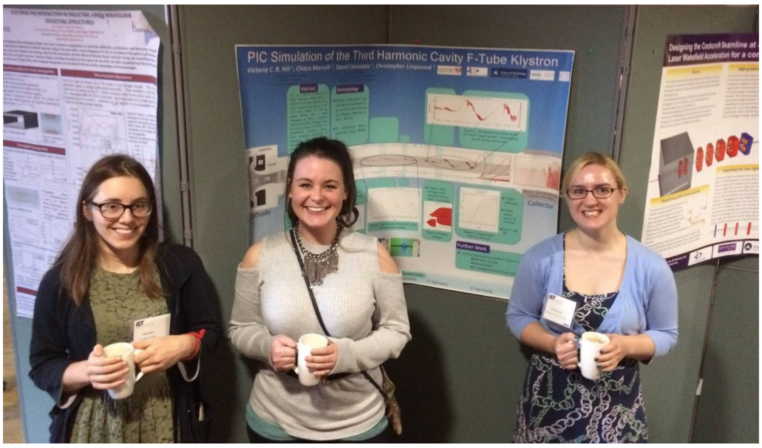
University of HUDDERSFIELD Inspiring tomorrow's professionals

CST

TECH-X

Particle Accelerator Engineering Network Meeting

The IET held its Particle Accelerator Engineering Network meeting in Birmingham on 27 October. This network brings together engineers working on particle accelerators in universities, national laboratories and industry. The day before the meeting Dr. Graeme Burt from Lancaster University ran a half day technician training event aimed at increasing the knowledge of accelerators for technicians employed to work on these systems.



Participants Alisa Healy, Victoria Hill and Kay Dewhurst
(Credit: Graeme Burt)

At the main event Prof. Susan Smith, Director of ASTeC, gave the keynote talk on free electron lasers in the UK followed by several other talks on particle accelerator engineering from industry, national laboratories and universities.

Susan Smith presents Victoria Hill with her prize
(Credit: IET)

At lunch there was a poster competition for early career engineers, covering PhD students, graduate engineers and apprentices. After careful consideration of all the posters the prize was awarded to Victoria Hill, a 4th year PhD student at Lancaster University.

Graeme Burt

International Calendar

60th ICFA Advanced Beam Dynamics Workshop on Future Light Sources (FLS2018)
Shanghai, China, 4 - 9 March 2018
http://indico.sinap.ac.cn/event/4/

9th International Particle Accelerator Conference (IPAC'18)
Vancouver, Canada, 29 April - 4 May 2018
https://ipac18.org/

61st ICFA Advanced Beam Dynamics Workshop on High-Intensity and High-Brightness Hadron Beams (HB2018)
Daejeon, South Korea, 17 - 22 June 2018

10th Mechanical Engineering Design of Synchrotron Radiation Equipment and Instrumentation Conference (MEDSI 2018)
Paris, France 25 - 29 June 2018
https://www.synchrotron-soleil.fr/en/events/medsi-2018

23rd International Conference on ECR Ion Sources (ECRIS 2018)
Catania, Italy, 10 - 14 September 2018
https://agenda.infn.it/conferenceDisplay.py?ovw=True&confId=13199

International Beam Instrumentation Conference (IBIC 2018)
Shanghai, China, 17 - 21 September 2018

29th Linear Accelerator Conference (LINAC2018)
Beijing, China, 17 - 21 September 2018

13th International Computational Accelerator Physics Conference (ICAP'18)
Key West, Florida, USA, 20 - 24 October 2018
http://www.icap18.org/

Upcoming schools

CERN Accelerator School — Beam Dynamics and Technologies for Future Colliders
Zurich, Switzerland, 21 February - 6 March 2018
http://cas.web.cern.ch/schools/zurich-2018

CERN Accelerator School — Beam Instrumentation
Tuusula, Finland, 2 - 15 June 2018
http://cas.web.cern.ch/schools/tuusula-2018

Summer 2018 USPAS Session
East Lansing, Michigan, USA, June 4 - 15 2018
http://uspas.fnal.gov/programs/2018/msu/index.shtml

PAB Group & UK Events

Intelligent Controls for Particle Accelerators
Daresbury Laboratory, 30 - 31 January 2018
https://www.cockcroft.ac.uk/events/ICPA/

Annual General Meeting of the PAB Group
Lancaster University, 18 April 2018

Attosecond and Free Electron Laser Science International Conference 2018
University College London, July 2 - 4 2018
https://eventbooking.stfc.ac.uk/news-events/afels-2018

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/

http://www.jacow.org/

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IoP Particle Accelerators and Beams Group

IoP PAB Committee

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

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

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Dr. Graeme Burt (CI Lancaster)

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Dr. Andrew Rossall (Huddersfield)

Prof. Susan Smith (STFC Daresbury)

Dr. John Thomason (STFC RAL); *Newsletter*

Dr. Melissa Uchida (Imperial)

Dr. Peter Williams (STFC Daresbury)

Deadline for submissions to the next newsletter is
15 June 2018