INSTITUTE OF PHYSICS

IOP PAB GROUP NEWSLETTER

IOP Institute of Physics
Particle Accelerators and Beams Group

Issue 22

December 2020

Editorial

Welcome to Issue 22 of our PAB Group Newsletter. As we welcome in a new year we also reflect on the year passed, and what a year 2020 was…. Every area of our lives was affected in some way both personally and professionally and there is no doubt that the loneliness, stress, anxiety and loss caused, will be in our minds for decades to come. It is not over yet, but thanks to the excellent work of scientists worldwide the end is now in sight. Despite all of the challenges we have faced this year the PAB community has remained as strong and vibrant as ever. Conferences such as Linac, IPAC and the PABG Annual Meeting moved online and were incredibly well attended; our national labs and facilities joined the fight against Coronavirus helping us to understand what the virus looks like, how it works and how it can be disrupted; we found new ways of working and teaching; and 2020 has given us a year which highlights the importance of science and innovation.

It is my great pleasure to be writing my first editorial as Chair of the PAB group. As is often said – I stand on the shoulders of giants and this is certainly true in my case, following our previous Chairs Mike Poole (2008 – 2012), Phil Burrows (2012 – 2016) and Brian McNeil (2016 – 2020). I would like to thank Brian in particular for his excellent work over the past four years, his dedication to the group, to diversity and inclusion and to challenging sexual harassment in the workplace.

Congratulations to our 2020 Prize Winners: Jake Flowerdew who won the PABG Student and Early Career Scientist Poster Prize and Susan Smith who was awarded the PAB Group Prize for Outstanding Professional Contributions and there is a nice article about her in the News from Daresbury section of this newsletter.

Our PAB Group's Annual Conference took place online this year in early October, with a slightly updated format. The conference opened with two panel discussions: first "How the IOP is Challenging Sexual Harassment in the Workplace" with IOP CEO Paul Hardaker and Director of Physics Programmes Phil Evans, then "Challenges and opportunities for the field of accelerators" with Mark Thomson, Peter Ratoff and Philip Burrows. We then had a series of excellent plenary talks, an online poster session and even an online drinks reception (which was a lot of fun and there were no complaints about the quality of drinks or nibbles as it was all BYO).

The PAB Group Annual Conference 2021 will also take place online on 9th April 2021 and I look forward to welcoming you all there and raising a glass with you afterwards.

In this issue of the newsletter we explore the work of the Cockcroft Institute to develop a unique laser driven solution to generate intense terahertz frequency pulses of light, and how researchers are using the CLARA electron accelerator at the Daresbury Laboratory to study the potential of very high-energy electrons for radiotherapy. We have an update on ISIS operations and how the ISIS operations team (one of few to remain on site at RAL) managed to navigate the pandemic and make a return to ISIS operations possible. We discuss: the use of AI to improve control of powerful plasma accelerators and the first UK series component production for HL-LHC.

(continued on the next page)

Inside this issue:

Editorial (continued)

We also take a look at: the Virtual Linac 2020 Conference which this year featured a completely new element in the scientific programme – a Women In Science and Engineering session focused on retention and advancement; and the VHEE2020 Workshop which attracted over 400 researchers this year.

Prof. Simon Hooker who has been awarded the Institute of Physics' Cecilia Payne-Gaposchkin Medal and Prize in recognition of his distinguished contributions to plasma physics. Congratulations to him and to all our prize winners and PAB group success stories included herein, which have all gone to show how our community has weathered this storm with aplomb.

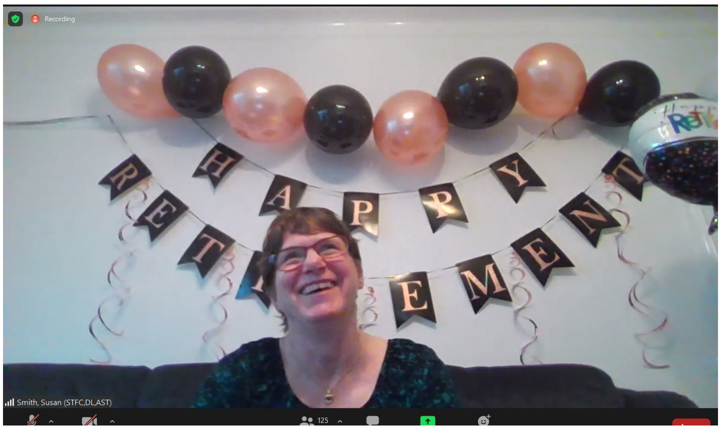
Finally, a big welcome to our new committee member Malik Salaam, who joins us from the Atomic Weapons Establishment (AWE) in Aldermaston UK.

Happy New Year to everyone in the IOP Particle Accelerator and Beams Group from all of us on the committee. We look forward to many more successes in the coming year!

If there is anything you think we could do better or should know of, please feel free to contact us at mauchida@hep.phy.cam.ac.uk and follow us on Twitter for updates of what is happening in our community @PartAccelBeams.

News from the Laboratories — Daresbury

Congratulations and Happy Retirement to Professor Susan Smith



Prof. Susan Smith at her socially distanced retirement party. (Credit: STFC)

It's been a time to celebrate the career of Professor Susan Smith, who received the 2020 Particle Accelerators and Beams Group prize in July before retiring from her roles as Head of Daresbury Laboratory and Director of ASTeC in recent weeks.

Susan was commended by the Group for her major contributions, innovation and leadership in accelerator and light source science, including in operations and upgrades of the SRS at Daresbury Laboratory, in leading the accelerator design for the Diamond facility at RAL, and leading the construction of the ERL ALICE, EMMA and CLARA facilities at Daresbury.

Upon hearing the good news, Susan said: "*I am truly honoured to receive this award. Having spent the whole of my working career in accelerator science I am very pleased for my contribution to the field to be recognised by the group through this prestigious prize.*

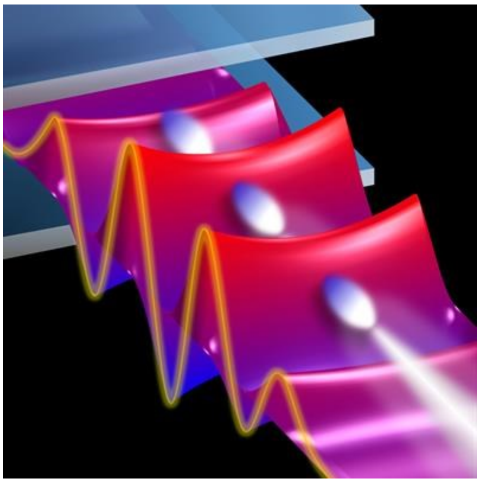
"In the 1980s, I could count the number of women in the accelerator field in this country on one finger, I hope being honoured through this award will give confidence and motivation to the many women who are entering this field in the 2020s."

A presentation was held on 27th November to mark the occasion of Susan's retirement after 35 years of service. The well attended event was held virtually due to the present circumstances but at least that meant others from farther afield could take part to wish her well. Susan intends to spend more time on the golf course - we wish her well in the future and look forward to seeing her around the lab!

Prof. Susan Smith in the lab and on the golf course (Credit: STFC)

Dave Dunning

Terahertz accelerators scale up



Artistic impression of a linear relativistic electron accelerator powered by laser-generated, multicycle terahertz pulses. (Credit: CI - University of Manchester)

In new research published in Nature Photonics, a collaborative team of academics based at the Cockcroft Institute have developed a unique solution using lasers to generate intense terahertz frequency pulses of light.

Terahertz (THz) is a region of the electromagnetic spectrum between infrared (used in TV remotes) and microwave (used in microwave ovens). Intense sources of terahertz radiation can be created by exciting a nonlinear crystal with a high-power femtosecond laser. Laser-driven sources greater than 1 GV/m are now possible, which is more than an order of magnitude larger than capable in a 'traditional' RF accelerating cavity. This new technology allows particles to be excited to higher energies over shorter distances, therefore reducing both the footprint and cost of a particle accelerator facility.

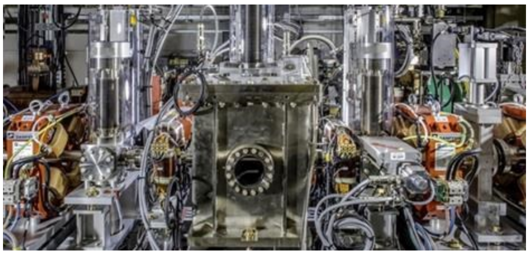
Professor Steven Jamison of Lancaster University who jointly leads the programme, explained: *"The controlled acceleration of relativistic beams with terahertz frequency laser-like pulses is a milestone in development of a new approach to particle accelerators. In using electromagnetic frequencies over one hundred times higher than in conventional particle accelerators, a revolutionary advance in the control of the particle beams at femtosecond time scales becomes possible."* More details and views from the Cockcroft Institute team are available here.

This research was part of an ongoing user access programme at CLARA accelerator at STFC Daresbury Laboratory and is a successful example of how the accelerator can generate impact for both UK and international collaborators. CLARA offers unique capability, providing access to FEL-quality electron beam combined with synchronized, high energy laser light. Experiments are currently operated at 35 MeV in CLARA Beam Area 1. In the future, CLARA will be upgraded to 250 MeV, and Beam Area 1 will be replaced with a new specialized user beam line titled FEBE (Full Energy Beam Exploitation). Funding for a new high energy laser system for FEBE is being pursued, which would allow CLARA to continue to support world-leading research in novel means of particle acceleration.

Ed Snedden

New treatment research using CLARA

Researchers are using the CLARA electron accelerator at the Daresbury Laboratory to study the potential of very high-energy electrons for radiotherapy. Louie Hancock, from the Cockcroft Institute, has reported his work at the recent Medical Physics & Engineering Conference with an article now appearing in Physics World.



A section of the CLARA facility. (Credit: STFC)

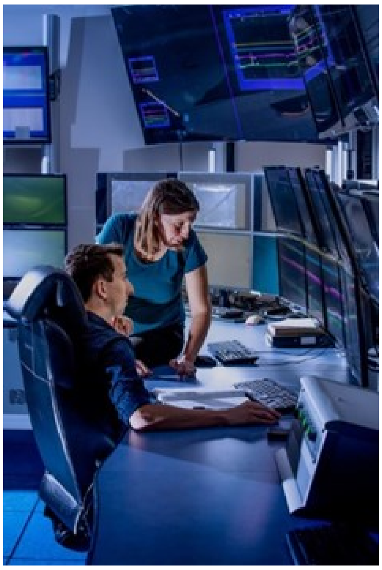
Read more at Physics World here:
https://physicsworld.com/a/very-high-energy-electrons-could-treat-tumours-deep-within-the-body/

Louie Hancock

News from the Laboratories — RAL

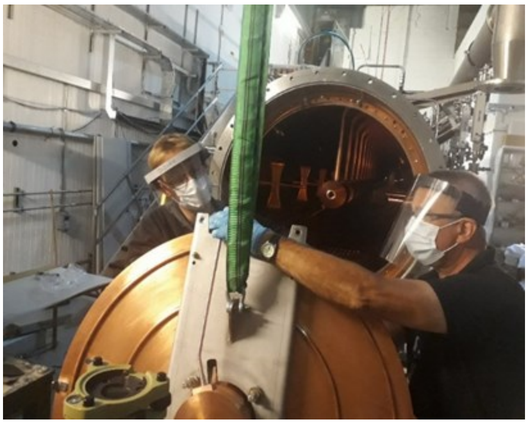
ISIS Returns to Operation – Learning to Live with Covid-19

On Sunday 16 February 2020 a new record was set for the integrated 24-hour beam current produced by the proton synchrotron at the ISIS Neutron and Muon Facility. This record was beaten again on 17, 20, 22 and 25 February, eventually reaching 5.84 mAh. This remarkable improvement was due to a number of long-term projects coming to fruition, in particular improved beam optimisation using high-sensitivity scintillator beam loss monitors (as reported by Bryan Jones in Issue 19 of this Newsletter) and development of a digital low-level RF feedback system. By Wednesday 18 March, overall accelerator and target availability for the user cycle was 95% – the second highest on record.



Peter Griffin-Hicks and Hayley Cavanagh optimising beams in the ISIS Main Control Room (picture taken in August 2019). (Credit: STFC)

And then Cycle 2019/04 came to an abrupt halt. As the global Covid-19 pandemic worsened ISIS management took the decision to curtail the user programme and it soon became evident that Cycle 2020/01, scheduled for April – June, would have to be cancelled. The initial plan was to re-schedule this time to advance project work for the forthcoming ISIS long shutdown – primarily focused on the replacement of the Target Station 1 neutron production target and of Linac Tank IV – but with the national lockdown imposed on 23 March and UKRI/STFC sites effectively closed this proved impossible.



Oliver Newell and Steve Cook installing the end plate for the replacement for Linac Tank IV. (Credit: STFC)

The ISIS Operational Crew were some of the few people to remain on the Rutherford Appleton Laboratory site throughout the closure (now termed ‘Level 4’ by UKRI/STFC), fulfilling their responsibilities for fire alarm response, doing regular checks of the ISIS premises and responding to phone requests from staff to check specific equipment. They were soon joined by a few other essential ISIS staff, primarily to maintain vacuum and ancillary plant equipment, and in some cases to ensure legal compliance.

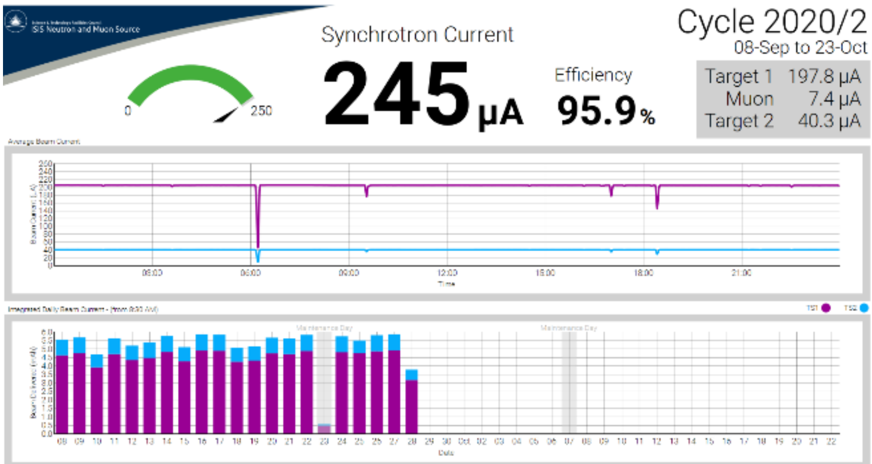
Then began the concerted effort to establish the ‘new normal’. The ISIS Business Continuity Team, in collaboration with UKRI/STFC, began to concentrate on enabling specific, high-priority pilot tasks, mostly associated with long shutdown preparation. Unsurprisingly this involved the development of appropriate Covid-secure processes, safety advice and training, backed up by a slew of risk assessments and method statements. Gradually, as buildings were made ready and re-opened for business, small numbers of staff were able to return to site under carefully supervised conditions. This activity was particularly aimed at those staff with ‘hands on’ roles, who had been unable to work effectively from home.

Over the next few months as the lockdown was eased and STFC sites eventually moved to ‘Level 3’, up to 30% of staff were able to come back on site. Where the first pilot tasks had all been undertaken with strict 2 metre social distancing in place it was now recognised that to progress further some tasks would require people to work closer together using suitable Personal Protective Equipment. One of the first of these tasks was assembly work for the replacement for Linac Tank IV.

By the end of July, with a number of tasks completed and having built up considerable experience of new, Covid-secure ways of working, a return to ISIS operations began to look possible. Key questions were whether the facility could be run effectively with only ~30% of staff on-site on any given day, if typical ‘large’ failures could be addressed in a Covid-secure manner and the timely provision of ‘on call’ cover during silent hours. Having analysed the risks the decision was made to prepare for a user cycle.

With the usual ups and downs along the way, and relying on the dedication, hard work and expertise of staff across the facility, ISIS resumed operation on 8 September. From a scientific perspective Cycle 2020/02 was very successful – although very few users were able to attend in person over 250 separate experiments were run by remote access.

As far as the accelerator goes, on Wednesday 16 September 2020 a new record was set for the integrated 24-hour beam current produced by the proton synchrotron at the ISIS Neutron and Muon Facility. This record was beaten again on 27 and 28 September, eventually reaching 5.87 mAh – which equates to running for 24 hours at the maximum current the neutron and muon production targets can take (245 µA) with only 2 minutes’ off time. That one may stand for a while!



ISIS record beam current. (Credit: STFC)

The overall availability for Cycle 2020/02 was just over 90%, and included an RF window change on the Linac, demonstrating that the Covid-secure procedures now in place for ‘large’ failures and ‘on call’ appear robust. The plan is now to run Cycle 2020/03 and Cycle 2020/04 before the long shutdown begins in April 2021.

John Thomason

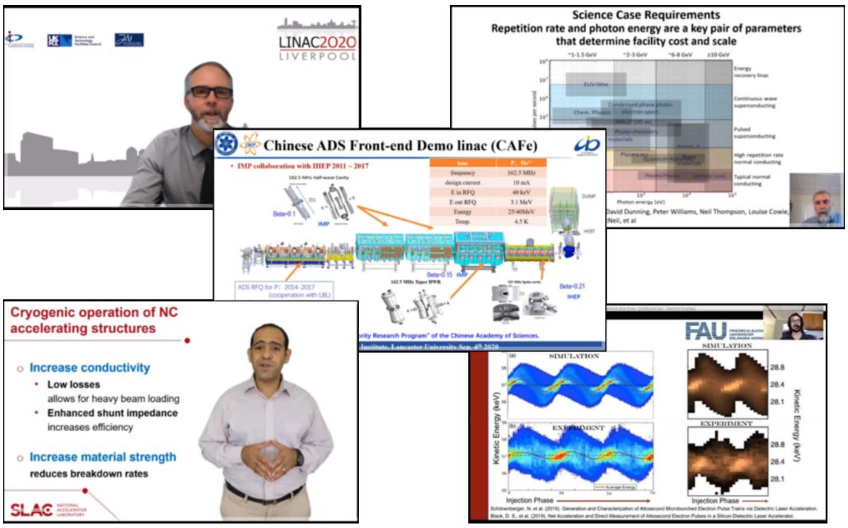
The Virtual International Linac2020 Conference

In the context of the current global Covid-19 pandemic, interfacing, interactions and collaborations are most certainly being challenged in terms of groups finding ways to maintain ongoing and effective engagements. Organisers for conferences, workshops and large meetings are having to look at alternative ways for ensuring appropriate communication and dissemination of topical information, such that associated discussion and debates can be optimally facilitated without having the opportunity to interact directly in person.

The International Linear Accelerator Conference (Linac2020), which is hosted bi-annually and typically attracts more than 400 linear accelerator specialists from all around the world, was originally scheduled to take place at the Liverpool Arena and Convention Centre in the UK during the week of 31st August 2020. As global travel and interaction restrictions of the pandemic were escalating, it became clear to the UK conference hosting organisations comprising STFC Daresbury Laboratory, the Cockcroft Institute (CI) and the John Adams Institute, that alternative solutions for the delivery of the Linac2020 conference had to be sought.

The Linac International Organising Committee concluded that delaying the original event by two years to 2022 was the best solution. At the same time, the IOC decided that the original Linac2020 scientific programme should be appropriately captured and disseminated in a smaller, virtual conference that could present the considerable linear accelerator R&D which has been undertaken since the last Linac2018 conference in Beijing.

Prof. Graeme Burt from Lancaster University and the CI, who chaired the Linac2020 Scientific Programme Committee (SPC), said: *"We agreed a suitable approach for a single, globally-focused virtual transmission. Working with the STFC Media Services team at Daresbury Laboratory, an effective Zoom-based webinar approach was adapted, all speakers kindly agreed to pre-record their talks, as well as being available for a live interaction with participants through an associated Q&A session. The decision to use this hybrid approach was critical to the success of Linac2020, to give talks free from issues whilst also having a live feel."*



Presentations from the Linac2020 Programme. (Credit: STFC)

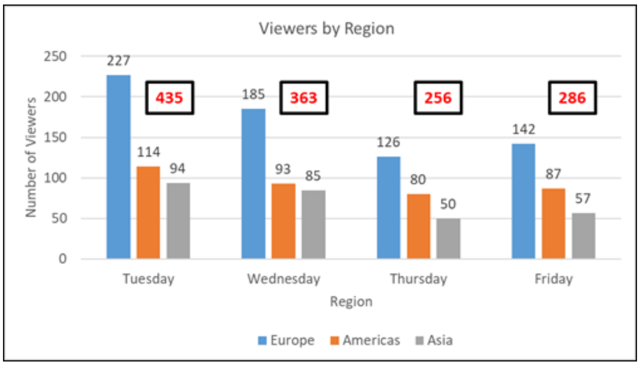
Working with the invited speakers to generate the talk videos, the STFC Media Services team set up the webinar site and coordinated the SPC convenors to be able to host the event, whilst also changing all of the existing website and SPMS communication and registration processes, which was a considerable undertaking to have everything ready within a 10-week period. Such an endeavour had never been undertaken by the STFC Daresbury Laboratory teams before.

Over the period, 1 - 4 September, the Virtual Linac2020 was hosted and interfaced with the international accelerator community as a non-physical conference, for the very first time in its almost 60-year history.

The chair of the Local Organizing Committee (LOC), Prof Carsten P Welsch from the University of Liverpool and the CI, added: *"Astonishingly, the virtual event attracted 710 live international participants from all around the world and almost 800 registered to access the offline videos. The timing of the afternoon sessions was tailored to ensure that speakers from all regions could be appropriately available for their scheduled talks at a reasonable time with respect to their location."*

Those participants who remotely connected into the virtual programme would not likely be able to connect to the entire session, owing to the regional time differences across the America's and Asia. That being said, participant connections to the sessions were impressive, with colleagues based in 30 countries around the world reached.

As expected, regional access for the event was predominantly from European participants, who most closely matched the hosting time-zone in the UK. It was also apparent that participants from Asia would most optimally connect earlier in the sessions and connections from the America's would consistently increase during the latter part of each session. The fact that the total participant numbers for each day were consistently high was testament to the attractiveness of the event.



Live viewers by region for each day during Linac2020. (Credit: STFC)

A completely new element in the scientific programme was a Women In Science and Engineering session focused on retention and advancement. This was conducted live comprising a number of distinguished panellists, who reviewed the challenges that they faced in being attracted to science and engineering, maintaining motivation to stay within the field and providing insightful and thought provoking personal career experiences, as well as answering questions from the online audience (see the following article for more details).

It is not straightforward to understand the full impact, benefits and challenges of virtual events. However, it is clear that IT solutions are now available to simultaneously be able to accommodate many hundreds of participants and to disseminate impactful information in a highly effective and robust manner. Future conferences will have to look seriously at utilizing modern communication mechanisms, in addition to long-established formats.

All talks from this year's conference will remain accessible via the Linac2020 website for registered participants. The UK partners are now looking forward to hosting the International Linear Accelerator Conference 2022 in Liverpool. More information will be made available via the event homepage in due time.

Peter McIntosh

Women in Science and Engineering at the LINAC 2020 conference

2020 has been a year of new experiences for many of us; it may be the first time you've been unable to leave the house, the first time you've worn a mask to go shopping or the first time you've worked from home. The accelerator community has also adapted to new ways of working with meetings and lectures moving online and reduced travel opportunities. Fortunately, there have also been some positive firsts: this year was the first time the LINAC 2020 conference, one of the oldest accelerator science conferences (celebrating its 60th year) went virtual, allowing participants from across the world to enjoy the conference talks with more flexibility. It was also the first time that LINAC has included a diversity event; this year with a focus on the retention and advancement of Women In Science and Engineering (WISE).

The LINAC WISE event took place on Wednesday 2nd September 2020 online at 3.30 pm (GMT) and was attended by an impressive 180 delegates from across the world. The event was the brain-child of Anna Shabalina (Jefferson Lab.) who noted the proportion of women working in Dept. of Energy laboratories in the USA dipped in the mid-career stages. This sparked many questions: what is the cause, is this problem universal, and what can we do about it? At the event, a panel of notable women scientists from around the world came together to share insights based on their personal stories and discuss ways to address the issues surrounding the retention and advancement of women working in the field of particle accelerators.

The event was chaired by Fulvia Pilat (Oak Ridge National Lab.). The session began with introductions and personal stories from each of the six panellists and ended with a discussion of questions from the audience. The panellists included Claire David (York University, Canada), Ling-an Wu (Chinese Academy of Sciences, China), Mihoko Nojiri (National Lab. of High Energy Physics, Japan), Manjit Dosanjh (CERN, Switzerland), Camille Ginsburg (Jefferson Lab., USA) and Susan Smith (Daresbury Lab., UK). The panellists' personal journeys were diverse and included a wide range of experiences; from motivational summer camps to poor provision at school, from supportive parents and partners to witnessing a workplace culture of sexual harassment toward female summer students. One panellist even had a career break enforced by a cultural revolution.

(Credit: Perimeter Institute)

Some common themes and messages emerged from the stories. The panellists encouraged women to keep curious and follow their interests; "If you like physics keep on at it!" They agreed that both men and women should act as allies and play a supportive role toward women and minorities starting their careers in STEM. Some panellists noted the positive role of their mothers; who believed in their abilities, encouraged them to study and supported them with childcare. The extra work of housekeeping and childcare often fall disproportionately to women; such tasks seem to have been exacerbated by the COVID 19 situation this year. There was hope that some of the flexible and remote-working practises implemented because of the pandemic may have a positive effect on women's ability to access science and engineering roles in the future.

The panellists had many practical suggestions on tackling the issue of retention and advancement of women in accelerator science:

- Support young people in their work. Encourage others to go for that job they are considering.
- Retention: it is never too late to come back to STEM, no matter how long the break.
- Create an inclusive environment by listening to people on an individual level. Treat women the way you would any other staff; include them in group meetings and outings for coffee.
- Provide onsite childcare where possible.
- Have transparent processes for hiring and advancement in the workplace. This is an important way for women and minorities to see how they can succeed.
- Introduce part-time work and flexible working. These are common features of some science careers with higher proportions of women e.g. medicine.
- The problem we are facing is multifaceted; it needs multifaceted solutions. First acknowledge there is a problem, have open discussions and try to find strategies to overcome it. Change is a long process, so follow up and review what works.
- The decision-makers high up in a company (often men) can make the most positive change in terms of implementing systems and changing the workplace culture. If the inclusivity message comes from those who are not in the minority, it is more likely to be accepted and followed through.

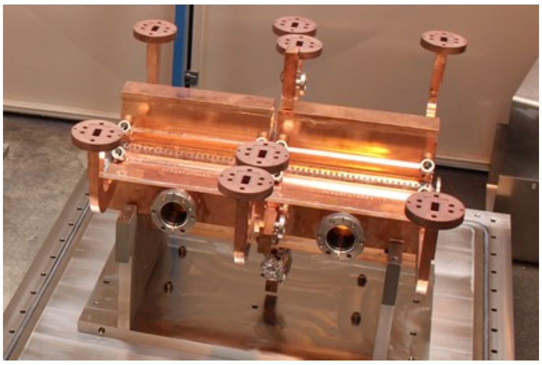
Overall the outlook from the event was very positive. It seems that things have already changed for the better since some of the senior speakers were in their early careers. I hope similar diversity events will continue to be a part of the LINAC conferences in the future and that these discussions continue to inspire us to make real and positive changes. If you were registered for the LINAC conference, you can watch the WISE event again (as well as all the other conference talks) by visiting http://linac2020.org/presentations/ and entering the password you received by email in September.

Kay Dewhurst

VHEE2020 Workshop Attracts Over 400 Researchers

Establishing innovative treatment modalities for cancer is a major 21st century health challenge since cancer will become the leading cause of death worldwide by 2040. Radiotherapy (RT) is a fundamental component of our current ability to effectively treat tumours and control their growth. Currently the most common form of RT involves the use of x-rays to treat the tumour. In addition to this, proton and ion beams have been used to treat deep-seated tumours whilst reducing the damage to surrounding healthy tissue. Although accelerated electrons are widely used to generate X-rays for radiotherapy, electrons are less frequently used directly because low energy electrons have limited penetration range and are mostly for the treatment of superficial tumours, thus limiting their clinical applicability.

Recently, studies involving **ultra-high dose rate** (mean dose rate above 100 Gy/s) delivery of ionizing radiation, termed **FLASH radiotherapy** (FLASH-RT), have uncovered some unexpected but possible therapeutic benefits that have caused tremendous excitement in the radio-oncology field. Data appear to show that FLASH-RT affords significant normal tissue sparing without compromising tumour control.



CLIC RF X-band cavity prototype (12 GHz, 100 MV/m)
(Credit: CERN)

In addition, the idea of investigating the use of **very high-energy** (50-250 MeV) **electron (VHEE)** beams for RT has gained interest, since electrons with higher energies can travel deeper into the patient. The advantages of VHEE are that the depth–dose profile from the electrons is flatter than the quasi-exponential dose given by X-rays, and in addition – in principle – the delivered electrons may be focused and steered in ways that are not possible for X-rays. One other potential benefit is that VHEE can operate at very high dose rates, possibly compatible with the generation of the FLASH effect. The challenge until recently has been the difficulty in obtaining high-energy electrons using compact accelerators. However, the development of high-gradient cavities for linear colliders, such as the Compact Linear Collider (CLIC), has meant that using VHEE beams for RT has become a feasible possibility.

Due to this increase in interest, the production of VHEE beams for RT was the subject of the VHEE2020 International Workshop, which took place 5-7 October 2020, organized by CERN. More than 400 scientists with diverse backgrounds, from clinicians to biologists and accelerator physicists to dosimetry experts, gathered virtually to evaluate and discuss the perspectives of this novel technique. This workshop followed a similar one organized in 2017 in Daresbury and the large increase in attendance demonstrates the increasing interest in the field.

Topics covered by the leaders in the field ranged from state-of-the-art, technological advances, biological and clinical aspects, to what is needed to exploit VHEE for RT and FLASH clinically, as well the future industrial perspective for the field.

VHEE Poster [https://indico.cern.ch/event/939012/]

Many challenges, both technological and biological, have to be addressed for the ultimate goal of using VHEE and VHEE-FLASH as an innovative modality for effective cancer treatment with minimal damage to healthy tissues. All of these topics were thoroughly discussed in the different sessions of VHEE2020. Talks given in the workshop outlined the current state of research in the VHEE field, what successful studies had been undertaken into VHEE and FLASH RT, what challenges have been faced by researchers in recent years and what the future outlook is for the field.

It was clear from the discussion that VHEE has the potential to provide a major input in our quest to fight cancer globally, but that many challenges have to be overcome first.

For example, current preclinical trials into the efficacy of FLASH-RT, on both animal subjects and humans, have shown exciting results, with potentially significant advantages in the treatment of tumours compared to conventional RT. However, it was noted that these results must be taken with caution as they only involved low-energy electron beams, which would not allow the treatment of deep seated tumours. One of the key aims set out for the future was to extend these experimental studies into the VHEE regime.

From the accelerator technology point of view, an important aim is to assess the possibility of focusing and transversely scanning the beam, thereby overcoming the disadvantages associated in the past with low energy electron and photon beam irradiation. In particular for VHEE-FLASH it will be necessary to ensure that the biological effect is maintained. Another major challenge for VHEE-FLASH is the delivery of a very high dose-rate, possibly over a large area, providing a uniform dose distribution throughout the target. The stability, reliability and repeatability are other mandatory ingredients for accelerators to be operated in a medical environment and so must be studied further. Of particular importance is the development of reliable on-line dosimetry for very high dose rates, a regime not adapted to the standard dosimetry techniques currently used in RT.

From a more general viewpoint, the parameter window in which the FLASH effect takes place has still to be thoroughly defined, as well as its effectiveness as a function of the physical parameters of the electron beam. Finally, a clear understanding of the underlying biological processes will likely prove to be essential in order to fully optimize the FLASH RT technique.

Luke Dyks working on CLEAR (Credit: CERN)

For these challenges to be met, a lot of future work must go into using test beam facilities in order to experimentally characterise and assess properties of VHEE beams and the ability to produce the FLASH effect. It is also important to demonstrate that the properties of the electron beams are independent of the way they are produced, (RF linac or LPA technologies). A number of experimental test facilities are already available to perform these ambitious objectives: the CERN Linear Electron Accelerator for Research (CLEAR), so far unique in being able to provide both high-energy (50-250 MeV) and high-charge beams. VELA-CLARA at Daresbury, PITZ at DESY and ELBE-HZDR using the SC RF technology at Dresden are becoming available.

Oxford DPhil student, Luke Dyks, attended the workshop, *"For me as a young researcher it's very exciting to be working in a field that is so dynamic. Some of the ideas discussed at the workshop have great promise and I feel privileged to have to opportunity to contribute to their development. I can't wait to get my teeth into them!"*

Despite the number of necessary developments highlighted at the meeting, there was an air of cautious optimism that with a well-directed, consistent effort to fully understand the physical processes underlying VHEE-RT and FLASH, the challenges could be overcome and operational medical VHEE facilities could be designed and built in the future.

Luke Dyks & Manjit Dosanjh

IOP recognises Professor Simon Hooker

Professor Simon Hooker from the University of Oxford's Department of Physics has been awarded the Institute of Physics' Cecilia Payne-Gaposchkin Medal and Prize in recognition of his distinguished contributions to plasma physics.

The award recognises in particular Simon's pioneering contributions to the development of high-power plasma waveguides and their application to laser-driven plasma accelerators.

Simon is internationally known for his world-leading research into novel waveguides capable of guiding relativistically-intense laser pulses. He invented the gas-filled capillary discharge waveguide and applied this novel waveguide to laser-driven plasma accelerators. In collaborative experiments with the group at Lawrence Berkeley National Laboratory, this approach was used to reach an electron energy of 1GeV for the first time in a laser-driven plasma accelerator. This widely recognised milestone was reported in The Economist as well as in scientific journals, and the paper describing this work has been cited well over 1,000 times. The discovery opens the way to the development of lab-scale GeV accelerators.

The capillary discharge waveguides developed by Simon and his group are now used by many groups around the world. The applications in science and technology are numerous, from hospital-based diagnostic imaging to opening novel research fronts in high-field QED science.

Professor Hooker and his research group have contributed to many other important developments in plasma accelerators, including identification of a mechanism for controlling electron injection by laser ionisation; the first generation of soft X-ray undulator radiation from laser-accelerated electrons; and all-optical steering of laser-accelerated electron beams.

His most recent work has shown that plasma accelerators can be driven by a train of lower energy optical pulses, potentially allowing plasma accelerators to be driven at multi-kilohertz pulse repetition rates by capitalising on state-of-the-art laser developments and new forms of all-optical plasma waveguides.

Simon responded to the good news by saying: *"I am absolutely delighted to receive this award on behalf of the very talented and hard-working group of graduate students, post-docs, and collaborators I have been fortunate to work with"*.

Find out more at: https://www.iop.org/about/awards/2020-cecilia-payne-gaposchkin-medal-and-prize

Phil Burrows

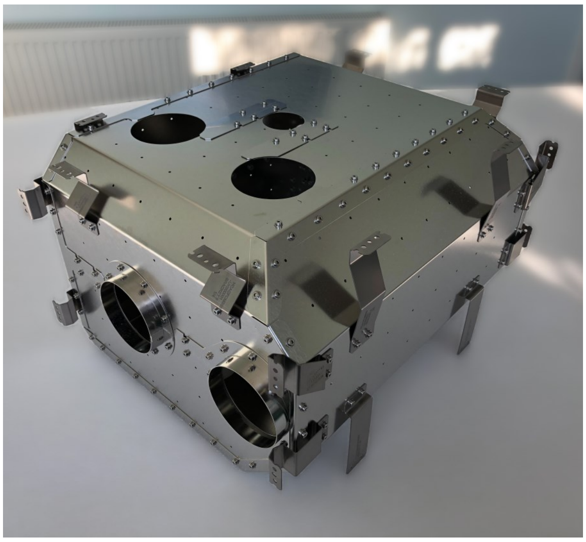
First UK series component production for HL-LHC

The first series production components for the LHC Luminosity upgrade (HL-LHC) from the UK has been produced by Magnetic Shields Ltd in collaboration with STFC and Lancaster University. The cold magnetic shields are designed to be installed inside the helium vessel of a superconducting RF cavity to shield the cavity from stray magnetic fields, which can increase RF surface resistance. A special material, known as Cryophy, is required to maintain the magnetic shielding properties at low temperatures of 2 K. In this case the RF cavity is a crab cavity, which rotates the bunches into alignment at collision.

The production units were delivered and successfully tested in July 2020. The work follows on from prototype shields that were produced three years ago, under the HL-LHC-UK project, and were installed in the first proton beam crab cavity tests in the SPS at CERN.

Graeme Burt, who is Technical Co-ordinator of HL-LHC-UK2 said: *"It's really important to see UK companies get a return on the UK's investment in CERN, and I am glad we can help deliver these critical components for HL-LHC".*

The UK team is now looking to manufacture components for the pre-series crab cryomodule including the warm magnetic shield, outer vacuum chamber, cryo-lines, and other vacuum components and tooling in 2021, before producing four series cryomodules for HL-LHC over the next 4 years.



Cold magnetic shield for HL-LHC
(Credit: STFC)

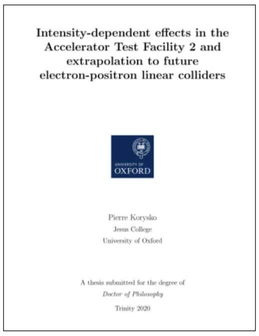
As well as crab cavities the UK team is also working on BPM, electro-optic BPM, & gas-jet diagnostics to measure beam profiles, cryomodules for cold powering, laser surface treatments and beam dynamics modelling for HL-LHC.

Graeme Burt

PhD Successes and CERN Fellowships

In a welcome break from the trials and tribulations of the current COVID-19 lockdown, Oxford DPhil students Pierre Korysko, Jan Paszkiewicz and Eugenio Senes have all successfully submitted and defended their DPhil theses. In further good news, Jan and Eugenio have also been offered CERN fellowships.

Pierre Korysko has spent the last three years working on intensity-dependent effects in future linear colliders. The feasibility of the technology needed for these colliders are studied at the Accelerator Test Facility (ATF2) at KEK in Japan. Pierre simulated the impact of wakefields in this machine and made measurements to confirm the theory. He implemented beam corrections such as Wakefield Free Steering and Wakefield knobs, which decrease the impact of the wakefields on the beam size. Pierre took his results on the test accelerator, ATF2, and applied the impact of wakefields on both the International Linear Collider, ILC, and the Compact Linear Collider, CLIC. He simulated the impact of static and dynamic imperfections on CLIC and ILC, evaluated the effectiveness of different mitigation techniques and quantified the impact of intensity-dependent effects.


Intensity-dependent effects in the Accelerator Test Facility 2 and extrapolation to future electron-positron linear colliders

Pierre Korysko
Jesus College
University of Oxford

A thesis submitted for the degree of
Doctor of Philosophy
Trinity 2020

(Credit: Pierre Korysko)

(Credit: Jan Paszkiewicz)

Jan Paszkiewicz's DPhil has focused on better understanding the process of vacuum breakdowns in normal-conducting high-gradient accelerating structures, such as the ones found in CLIC, with the aim of optimising their design. Jan's work has included the high-power testing of prototype CLIC accelerating structures at the high-gradient X-band test stands at CERN, as well as experiments in a specialised setup designed to study the physics of breakdown itself. One of two main results was the measurement of dislocation motion related to the nucleation of breakdowns. Potential breakdown sites are subject to strong tensile forces from the intense electric fields, and can deform suddenly and stochastically, possibly starting the runaway process of breakdown. He was able to measure small spikes in field emitted currents, which are consistent with fluctuations in the geometry due to this dislocation motion in surfaces subject to high electric fields. The other main result was the development of a numerical quantity that predicts the influence of the geometry of an accelerating structure or other high-field device with a high operating gradient. The new result is more generally applicable than previous cases, being able to explain results from diverse types of accelerating structures and also breakdowns in DC experiments. Jan's fellowship will focus on performing vital upgrades to the longitudinal beam dynamics feedback system for CERN's Proton Synchrotron, a key part of the upcoming high luminosity upgrade to the LHC.

Eugenio Senes has focused on the Advanced WAKefield Experiment (AWAKE) at CERN. AWAKE uses proton beams from the super proton synchrotron to generate plasma wakefields in a rubidium plasma. The plasma, which is created by shining a laser beam through rubidium vapour, is then used to accelerate an electron beam. Having three different beams in such close proximity creates a number of challenges for beam instrumentation, which is mostly saturated by the proton beam presence. In his thesis, Eugenio demonstrated that a measurement of the electron beam position with reduced bias from the proton beam is possible if the BPM system electronics work at a frequency between 20 and 30 GHz. Most conventional BPMs do not, however, work at such high frequencies, so a BPM was designed to work on the emission of Cherenkov Diffraction Radiation from dielectric inserts in the beam pipe. This innovative design allows the BPM to work at tens of GHz and also be selective on the bunch length. Experimental verification of the design was undertaken at the CERN Linear Electron Accelerator for Research. Eugenio recently defended his thesis via zoom and will continue to work on this system as part of his CERN fellowship, in order to transform this experimental device into an operational instrument for the AWAKE run 2.

(Credit: Eugenio Senes)

Phil Burrows

Atomic and Laser Physics Prize and Paper

Laser and beam driven wakefields promise orders of magnitude increases in electric field gradients for particle accelerators for future applications. Key areas to explore include the emittance properties of the generated beams and overcoming the dephasing limit in the plasma.

(Credit: Charles Sillett)

Charles Sillett, a final year Masters student on the Oxford Physics MPhys course won the Atomic and Laser Physics Prize for his contributions to this research this year.

The research contributed to a wider study published in Physical Review Accelerators and Beams 23, 093501 (2020) by Marko Mayr and colleagues. Marko, Charles and others in Peter Norreys' research group provided the first in-depth study of the self-injection mechanism into wakefield structures from nonhomogeneous cluster plasmas using high-resolution two dimensional particle-in-cell simulations.

(Credit: Marko Mayr)

They are very grateful to UKRI-EPSRC, the ARCHER National Supercomputer, the STFC SCARF Cluster at the Rutherford Appleton Laboratory and all the staff at the UKRI-STFC Central Laser Facility.

Peter Norreys

Particle Accelerator Engineering Network 2020 Poster Prize

Oxford JAI student Laurence Wroe has won the early-career poster competition at the annual IET Particle Accelerator Engineering Network (PAEN) meeting.

(Credit: Laurence Wroe)

PAEN 2020, held on the 9th - 10th September, was originally due to take place at CERN, but the ongoing pandemic meant the annual event was moved online. Topical talks on the COVID-19 response from the particle accelerator community took place on Day 1 before a series of talks on cutting edge accelerator research on Day 2.

Day 2 also included the PAEN 2020 Early-Career Poster Competition where entrants would be judged on poster quality, engineer's ability to answer questions, quality of the engineer's contribution to the work and relevance to particle accelerator engineering.

A member of the JAI for just one year, Laurence was encouraged by his supervisors, Rob Apsimon (Lancaster University and Daresbury Laboratory), Suzie Sheehy (University of Oxford and Melbourne University) and Manjit Dosanjh (University of Oxford and CERN) to enter the poster competition with his research. The poster, entitled Utilising Transverse Forces in Accelerating RF Cavities with an Azimuthally Modulated Design, can be viewed here.

Having spent a large proportion of the first year of his DPhil completing the JAI's graduate training course as well as working with my cohort to design a 3 TeV Muon Collider for acceleration in the SPS tunnel, this was the first event to publicise and get feedback on his research.

"Presenting the poster virtually behind my laptop was a new experience but I really enjoyed it and the engineers who visited my 'Zoom Room' engaged with the poster well and asked great questions that have also given me food for thought on taking my research forwards."

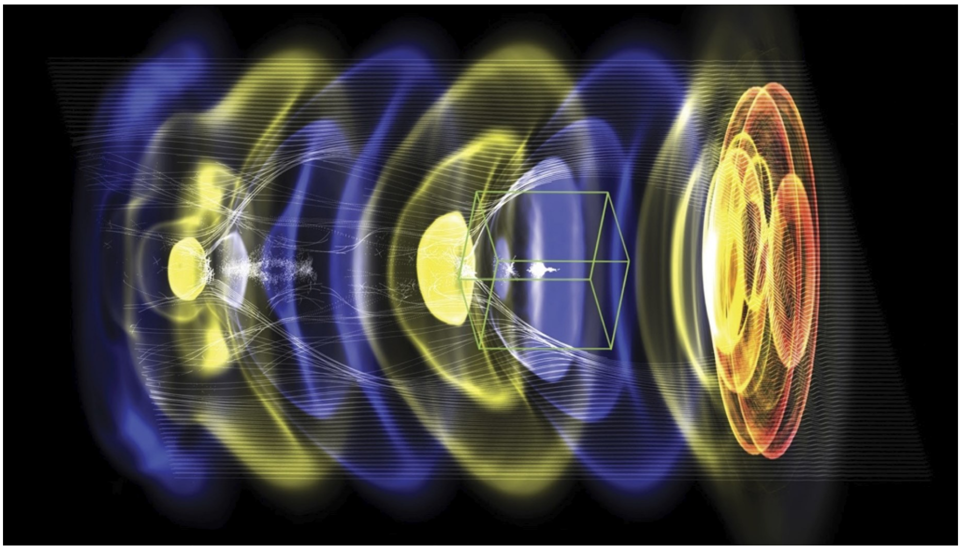
After 2 hours of presenting and discussing his poster, he was delighted to learn that he had won the poster prize and briefly joined the main video stream of the conference to accept the Prize.

Phil Burrows

2020 Roadmap on Plasma Accelerators

The New Journal of Physics 2020 Plasma Accelerator Roadmap presents perspectives from experts in the field to provide an overview of the topic and insights into the research needs and developments for an international audience of scientists, including graduate students and researchers entering the field.

The accepted version is already available at the following link, and the final published version is expected to be available soon. https://iopscience.iop.org/article/10.1088/1367-2630/abcc62



Snapshot from a WarpX 3D simulation of a laser-driven plasma accelerator, as featured in the paper. (Credit: Maxence Thévenet)

Stuart Mangles

New PABG Committee Member

(Credit: Malik Salaam)

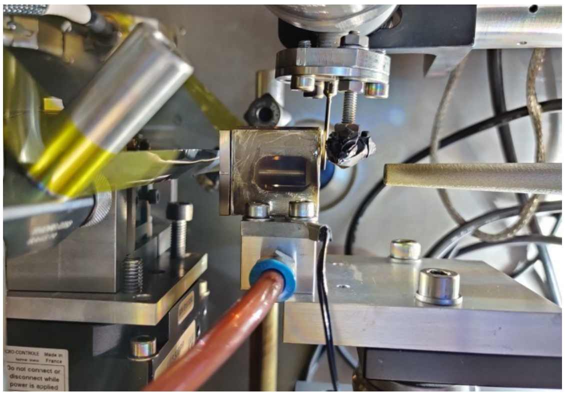
Welcome to Malik Salaam, who has recently joined the committee as an ordinary member.

Malik is an early career physicist at the Atomic Weapons Establishment (AWE) in Aldermaston UK. He is an alumnus of three Universities, having done a BSc. in astronomy involving particle detection at South Wales, a graduate diploma in physics involving materials research at York, and an MSc in applied physics involving molecular spectroscopy at Strathclyde.

After working in the photonics industry as a test engineer, he joined AWE where he worked on radiation detection and is currently working in computational physics. He also holds secretarial roles in internal groups and is involved with the IoP Nuclear physics committee.

Malik Salaam

Artificial intelligence improves control of plasma accelerators



The plasma source for the accelerator (Credit: Imperial)

Researchers have used AI to control beams for the next generation of smaller, cheaper accelerators for research, medical and industrial applications.

Experiments led by researchers at Imperial College London, using the Science and Technology Facilities Council's Central Laser Facility (CLF), showed that an algorithm was able to tune the complex parameters involved in controlling the next generation of plasma-based particle accelerators.

The algorithm was able to optimize the accelerator much more quickly than a human operator, and could even outperform experiments on similar laser systems.

Several facilities using these new accelerators are in various stages of planning and construction around the world, including the CLF's Extreme Photonics Applications Centre (EPAC) in the UK, and the new discovery could help them work at their best in the future. The results are published in Nature Communications.

First author Dr Rob Shalloo said: *"The techniques we have developed will be instrumental in getting the most out of a new generation of advanced plasma accelerator facilities under construction within the UK and worldwide.*

"Plasma accelerator technology provides uniquely short bursts of electrons and x-rays, which are already finding uses in many areas of scientific study. With our developments, we hope to broaden accessibility to these compact accelerators, allowing scientists in other disciplines and those wishing to use these machines for applications, to benefit from the technology without being an expert in plasma accelerators."

Because wakefield accelerators operate in the extreme conditions created when lasers are combined with plasma, they can be difficult to control and optimise to get the best performance. Both the laser and plasma have several parameters that can be tweaked to control the interaction, such as the shape and intensity of the laser pulse, or the density and length of the plasma.

While a human operator can tweak these parameters, it is difficult to know how to optimise so many parameters at once. Instead, the team turned to artificial intelligence, creating a machine learning algorithm to optimise the performance of the accelerator.

The algorithm set up to six parameters controlling the laser and plasma, fired the laser, analysed the data, and re-set the parameters, performing this loop many times in succession until the optimal parameter configuration was reached.

Lead researcher Dr Matthew Streeter said: *"Our work resulted in an autonomous plasma accelerator, the first of its kind. As well as allowing us to efficiently optimise the accelerator, it also simplifies their operation and allows us to spend more of our efforts on exploring the fundamental physics behind these extreme machines."*

The team demonstrated their technique using the Gemini laser system at the CLF, and have already begun to use it in further experiments to probe the atomic structure of materials in extreme conditions and in studying antimatter and quantum physics.

Hayley Dunning

International Calendar

Given the present circumstances, many events have been postponed or are being replaced by virtual events. The virtual events organised so far are listed below. Updates are available at: https://www.jacow.org/About/UpcomingEvents

12th International Particle Accelerator Conference, IPAC'21
May 24-28, 2021
https://www.ipac21.org/

2021 International Conference on Radio Frequency Superconductivity (SRF 2021)
28 June 2021 to 2 July 2021
https://indico.frib.msu.edu/event/38/

18th International Conference on Accelerator and Large Experimental Physics Control Systems, ICALEPCS 2021
16-22 October 2021
https://indico.ssrf.ac.cn/event/1/

Upcoming schools

Accelerator schools are similarly affected by the present situation. Information is available at: https://cas.web.cern.ch/ and https://uspas.fnal.gov/.

Useful Links

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

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

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

http://www.diamond.ac.uk

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

http://www.linearcollider.org/

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

http://www.jacow.org/

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IOP Institute of Physics
Particle Accelerators and Beams Group

IoP Particle Accelerators and Beams Group

IoP PAB Committee

***Chair*: Dr. Melissa Uchida (Cambridge)**

***Secretary*: Dr. Andrew Smith (Dalton Cumbrian Facility)**

***Treasurer*: Dr Glenn Christian (Diamond Light Source)**

Dr. Graeme Burt (CI Lancaster)

Dr. Tessa Charles (CI Liverpool)

Miss Kay Dewhurst (CI Manchester)

Dr. David Dunning (STFC Daresbury); *Newsletter*

Dr. Stephen Gibson (JAI RHUL); *Web Manager*

Dr. Ben Pine (Opera Software)

Mr Malik Salaam (AWE)

Dr. Jonathan Smith (STFC Hartree)

Dr. John Thomason (STFC RAL)

Deadline for submissions to the next newsletter is
31 May 2021