NEWS*letter*

MIRROR

Issue 12

March 2019

Highlights

- High impact peer reviewed scientific article co-authored by AVA Fellow
- New paper published on physics opportunities at FAIR
- Antiproton-nucleus annihilation studies in the ASACUSA experiment
- Upcoming events
- Fellows activity

Happy birthday, world wide web!

30 years ago, the world wide web was invented at CERN. Thirty years ago, a young computer expert working at CERN named Tim Berners-Lee combined ideas about accessing information with a desire for broad connectivity and openness. His proposal became the World Wide Web – an invention for fundamental research that had one of the most profound impacts on society. The world celebrated the 30th anniversary of the web on 12 March – a fantastic reminder about the numerous (and most of the time unforeseeable!) benefits fundamental research offers for society. AVA targets very fundamental research questions in its core, however, I would not be surprised at all if several of our technical developments in novel sensor technologies and beam handling techniques will find application well outside of the low energy antimatter community in the future.

We successfully held our mid-term review meeting at GSI in February 2019. The mid-term meeting is an important milestone in our project as all aspects of our network are being reviewed: research progress, implementation of our training programme, events and communication – as well as most of all: how well we have managed to form a real network with close links between our Fellows and the numerous partner institutions. I was really happy and proud to see the excellent work of our Fellows on display and how well they presented their achievements to date. Initial feedback from our project officer on the day was extremely good and we are now awaiting a formal response. I would like to use this opportunity to thank all of our project partners and in particular our Fellows for the great work they have done so far and look forward to continuing our successful journey with the AVA project.

Prof. Carsten P. Welsch
AVA Coordinator

Research News

High impact peer-reviewed scientific article co-authored by AVA Fellow

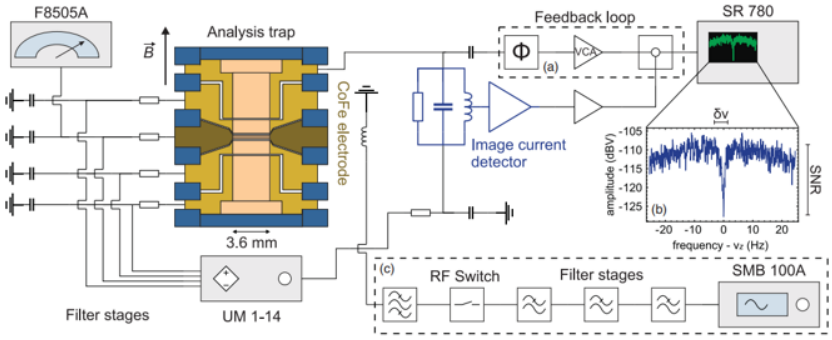


Illustration of the experimental setup, copyright PRL.

AVA Fellow Markus Wiesinger, who works at Max Planck Institute for Nuclear Physics in Heidelberg, Germany, was part of the team that invented novel ion multi-trap method enabling the *Measurement of Ultralow Heating Rates of a Single Antiproton in a Cryogenic Penning Trap*. This important achievement for the wider low energy antimatter and ion community was described in detail in an **article** just published in Physical Review Letters.

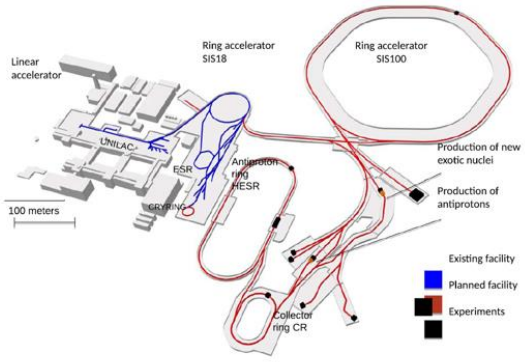
Antimatter is composed of antiprotons and positrons – the equivalents of protons and electrons in matter as we know it. Major advances have been made in characterizing positrons, one of the most important being very precise measurement of their mass and magnetic moment. However, the same measurements for antiprotons still remain very challenging because of the extreme experimental conditions that are required, reaching limits of even the most advanced technologies. The international team **BASE collaboration** has previously developed methods for measuring the properties of protons and antiprotons, including their magnetic moments. However, to reach even higher precision, the interfering noise had to be reduced beyond previously obtainable levels.

The paper reports on the characterization of the electric-field fluctuations in a cryogenic Penning trap by explicit measurements of cyclotron quantum transition rates of a single antiproton using the continuous SternGerlach effect. The observed electric-field spectral noise density was found to be more than 2 orders of magnitude lower than in room temperature Penning traps and more than 1,000 times smaller than observed in cryogenic Paul trap experiments. Based on heating rate measurements at various particle orbits the researchers managed to identify fluctuations in the trapping field caused by residual voltage noise as the dominant heating mechanism. Even lower heating rates that would enhance the sensitivity of their experiment further will now be the subject of additional experimental studies.

Further information:

M. J. Borchert, M. Wiesinger, et al., *Measurement of Ultralow Heating Rates of a Single Antiproton in a Cryogenic Penning Trap*, Phys. Rev. Lett. 122, 043201 (2019).
https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.122.043201

New paper published on physics opportunities at FAIR

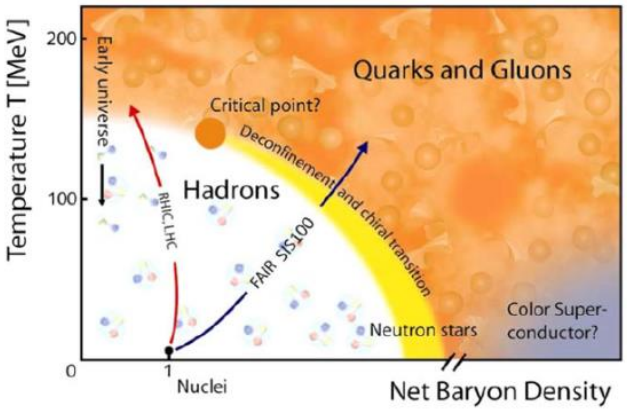


The FAIR accelerator complex. (Image copyright FAIR)

The Facility for Antiproton and Ion Research (FAIR) will open up unprecedented research opportunities in hadron and nuclear physics, atomic physics and nuclear astrophysics, as well as in applied sciences including materials research, plasma physics and radiation biophysics with applications towards novel medical treatments and space science. The facility drives an international R&D program into accelerator science, new detector technologies and advanced beam instrumentation for superior beam monitoring capabilities.

The facility is currently under construction as an international facility at the campus of the GSI Helmholtz Centre for Heavy-Ion Research in Darmstadt, Germany. While the full science potential of FAIR can only be harvested once the new suite of accelerators and storage rings will be completed and fully operational, some of the detectors and instrumentation are already available and have been used since summer 2018. They have already taken advance of the upgraded GSI accelerator complex.

In a paper just published in *Physica Scripta*, an overview of the exciting physics program at FAIR is given. This also includes prospects for R&D at a dedicated Facility for Low energy Antiproton and Ion Research (FLAIR) which will allow hitherto impossible experiments with ultra-low beams of ions and antiprotons.



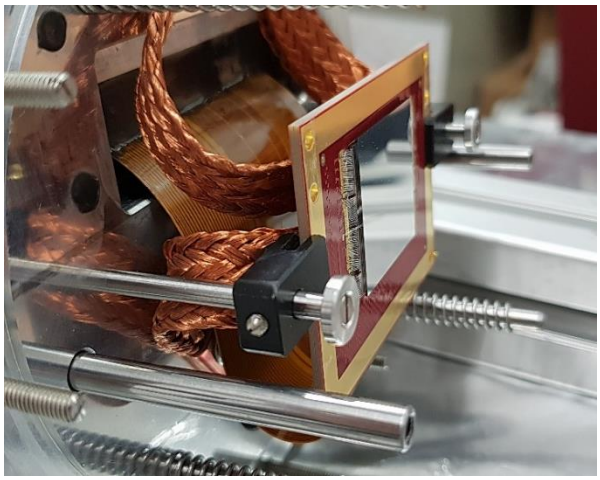
Sketch of the QCD phase diagram including a critical point and a first order co-existence region. Also shown are typical trajectories of heavy ion collisions at LHC, RHIC and FAIR.
(Image copyright FAIR)

Further information:

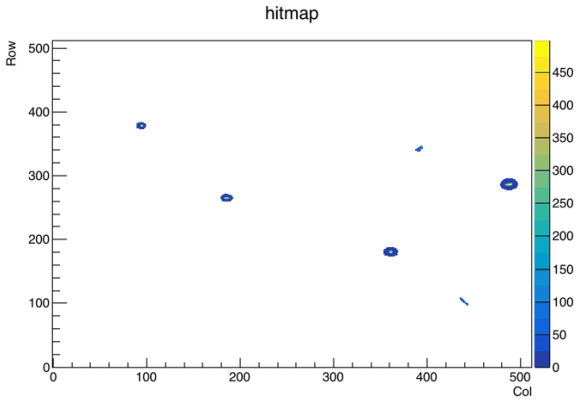
M Durante, et al., "All the fun of the FAIR: fundamental physics at the facility for antiproton and ion research", Physica Scripta, Volume 94, Number 3 (2019).
https://iopscience.iop.org/article/10.1088/1402-4896/aaf93f

Antiproton-nucleus annihilation studies in the ASACUSA experiment

In the last shifts of 2018, before the long shutdown (LS2), the ASACUSA experiment at the AD devoted its beam time to study the multiplicity and energy distribution of charged particles resulting from the antiprotons annihilating with nuclei at rest, which is not yet well known. The existing Monte Carlo data generators for such events are based on different physics models, such as FTFP in GEANT4, or FLUKA model. These models were initially developed for high energy hadronic interactions and were later extrapolated to the low energy regimes to simulate antiproton annihilations. In 2017, the AEgIS collaboration at the AD published its measurements of the products multiplicity of low energy (~100 keV) antiproton annihilations in three different materials (Copper, Silver and Gold) using emulsion detector [1]. It was found that the FLUKA model was in fair agreement with the data, yet not completely reproducing it.



The Timepix3 detector



An antiproton annihilation event with six annihilation prongs, recorded with the Timepix3 detector

In the measurement performed in ASACUSA were collected data for 150 eV antiprotons annihilating on thin foils (1-2 μm) of Carbon, Gold and Molybdenum. The antiprotons were extracted from the MUSASHI trap (the antiproton trap of ASACUSA) and focused on to the foils with an Einzel lens. The charged annihilation products such as charged pions, protons, alphas and other heavy fragments were detected using the Timepix3 quad array (silicon pixels) and the Hodoscope (scintillating bars and fibers) detectors. AVA Fellow Amit Nanda took part in the operation of the Hodoscope detector, including calibration and data acquisition. The measurement was led by his colleague Angela Gligorova from SMI, Vienna, and is supported by her Marie Curie IF project ANGRAM No. 748826.

The analysis of these data, which is in progress, will provide valuable information for the better tuning of the MC simulation models for antiproton annihilation at rest, which will heavily benefit the AD community, where especially the GEANT4 models are widely used.

[1] S. Aghion et al 2017 JINST 12 P04021

Network News

AVA collaboration welcomes new Project Manager

AVA Project Manager Dr Zuzana Oriou.

The new year started well for AVA as the network has now appointed a new Project Manager. Dr Zuzana Oriou has started on 2nd of January and met with all AVA researchers in February at the Mid Term Review meeting.

After graduating from the University of Chemistry and Technology in Prague, Zuzana obtained a PhD degree in Chemistry from the University of Strathclyde, Glasgow. After a postdoctoral Fellowship at the Max Planck Institute of Colloids and Interfaces near Berlin in Germany, she moved back to the UK to lead a commercial R&D project at the University of Lancaster. This helped her to shift her career focus towards academia-industry Knowledge Transfer and Research Project Management. Her enthusiasm for improving our environment then brought her into the Eco-Innovation project at University of Chester, where she supported postgraduate students and local SMEs to research and innovate in low carbon technologies.

Zuzana is experienced in managing collaborative cross-disciplinary research projects, communicating with variety of audiences and engaging with businesses. She joined the QUASAR Group at University of Liverpool in early January and is happy to help with any enquiries you might have regarding AVA (z.oriou@liverpool.ac.uk).

Welcome!

Accelerator designers met at GSI to discuss facility optimization

Photograph of the workshop participants.

The Antiproton Decelerator (AD) and the Extra Low ENergy Antiproton (ELENA) rings are unique facilities at CERN designed to trap, store and facilitate antimatter research. They help scientists understand fundamental properties of antimatter and to advance fundamental scientific knowledge. ELENA is currently being commissioned and will improve the conditions for antimatter experiments dramatically by lowering their energy - the less energy antiprotons have, the easier it is to study and manipulate them. ELENA is designed to reduce antiproton energies to below 0.1 MeV, which is lower than achievable anywhere in the world today.

In order to share and discuss the latest research results, the AVA network organised a two-day **Topical Workshop** on *Low energy facility design and optimization through diagnostics* at GSI, Darmstadt, Germany between 6th - 7th of February 2019. Around 30 researchers from all across Europe came together to talk about ELENA and its challenges, the various AD experiments, as well as problems faced in other low energy ion storage rings.

Poster session.

The workshop kicked off by Dr Davide Gamba from CERN addressing operational aspects of ELENA commissioning. His presentation was followed by Dr Manfred Grieser from the Max Planck Institute

in Heidelberg and Dr Ansgar Simonsson from Stockholm University talking about the electrostatic cryogenic storage ring (CSR) and the Swedish low energy double ring DESIREE, respectively. Several AVA Fellows also gave talks on the first day exploring various techniques for beam quality optimization. Other participants prepared posters highlighting their research results which stimulated many interesting discussions.
The theme of the second morning was the mini-storage ring at Lyon and its application in molecular physics. Results were presented by Prof Jerome Bernard and Dr Abdulaziz Al Mogeeth, both from University of Lyon. After several other talks covering further optimisation towards experiments, talks highlighting R&D at GSI were presented by Dr Frank Herfurth, Dr Oleksii Gorda and Dr Zhexi Guo.

The workshop was concluded by Prof Carsten Welsch, AVA coordinator, who highlighted the importance of collaboration and knowledge sharing and pointed out that the workshop showed clearly that the various low energy storage rings and experiments covered during the two days faced may similar challenges. He added that a number of areas had now been identified which would require international collaboration to fully address them and that the workshop had now set an ideal basis for this.

GSI Tour by Wolfgang Quint

To finish off the event, the participants went on a tour of the GSI facilities which was kindly offered by Dr Wolfgang Quint and Dr Peter Forck. This included an overview of the FAIR construction site where a next-generation ion beam facility is being built.

All presentations are available via the event **indico page**. The AVA project will next organize a workshop at our partner COSYLAB, Slovenia in autumn 2019.

AVA Mid Term Review Meeting

The meeting kicked off with a welcome from the Project Coordinator, Prof Carsten Welsch, followed by an introduction by the EC representative from the Research Executive Agency (REA) and all Scientists-in-charge. Prof Welsch then presented an overview of progress made in research, training and networking, as well as aspects of the management of the contract. He spoke about the AVA training model, the events delivered so far, unique collaborations with other

Prof Welsch presenting his talk.

training initiatives and their impact on the Fellows' training. He also presented a summary of the project wide communication and significant outreach involvement, to conclude with plans for the remaining two years.

The Fellows' representative in the Steering Committee Milena Vujanovic delivered a presentation of the Fellows' perspective, which emphasized the exceptional opportunities that AVA network provides, the collaborative spirit the network supports and the friendships the Fellows created along the way. On behalf of all the Fellows Milena also expressed big thanks to all supervisors for their support so far and highlighted that they are all aware of the scale of the opportunity being AVA Fellow.

The individual presentations of the AVA Fellows were a central part of the meeting. Only one Fellow was missing due to a recent injury. All remaining 14 ESRs delivered talks on their project progress as well as communication, outreach and secondments activities. Remarkable achievements were presented by all Fellows only one year after the start of their individual projects. All Fellows then met with the EU's project officer to discuss their experiences and views on the project in more detail. Meanwhile the consortium representatives gathered for a Supervisory Board meeting to discuss project reporting and plan future events.
The meeting finished with a brief summary by the Project Officer, who recognized the very good progress made in the network and congratulated all Fellows on their results and achievements.

Photograph of AVA network members

New Fellowship approved – position vacancy

The AVA Network is currently recruiting an additional Fellow. An amendment to the grant agreement was requested so the project can use the person-months that could not be implemented due to late recruitment across the network and create one additional 13 months-long Fellowship at CIVIDEC. The European Commission has now approved this amendment and the recruitment process has started.

The Fellow will be working on a novel diamond-based detector for beam characterization.

We hope to welcome our new Fellow at the A*dvanced researcher skills training week* and *Accelerators for Science and Society Symposium* at the end of June 2019. Please encourage excellent candidates to apply. Usual MSCA Fellow mobility and eligibility rules and requirements apply.

Upcoming AVA Events

Advanced Researcher Skills and Technology Transfer Workshops

A declared goal of AVA is to guarantee international competitiveness of our Fellows on the global job market. We want to provide them with the necessary skills to succeed in their future career as researcher in either the academic sector or in industry. To this end, we will hold workshops on *'Advanced Researcher Skills'* and *'Technology Transfer'* in Liverpool this June. This will includes sessions on CV writing, assessment center training, commercialization, and career pathways

The training will be provided by project partners and external experts, supported by our Project TEAM.

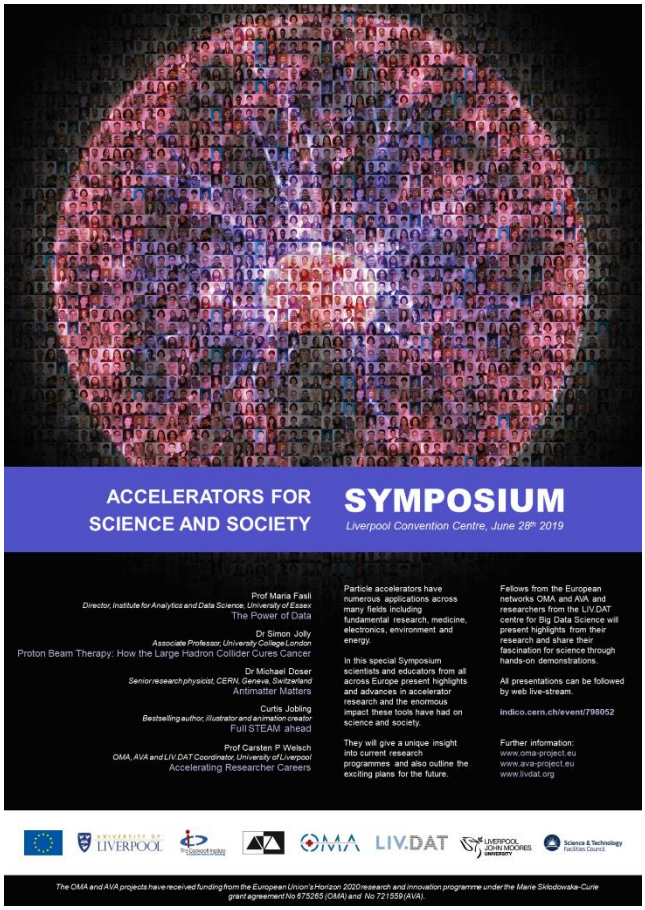
Symposium on Accelerators for Science and Society, 28 June 2019

Particle accelerators have numerous applications across many fields including fundamental research, medicine, electronics, environment and energy.
The AVA network, together with partners from the OMA and LIV.DAT projects, are delighted to host an International Symposium on *Accelerators for Science and Society* on 28th June 2019, at the Liverpool Arena and Convention Centre near the famous Albert Docks.

In this special event, scientists and educators from all across Europe present highlights and advances in accelerator research and the enormous impact these tools have had on science and society.

They will give a unique insight into current research programmes and also outline the exciting plans for the future. They will be joined by Fellows from the European networks OMA and AVA, as well as researchers from the LIV.DAT centre for Big Data Science who will all present results of their research and share their fascination for science through hands-on demonstrations.

All presentations can be followed by web live-stream. Project partners and Fellows have been invited to register as soon as possible.



Other Events

Symposium Particle Colliders - Accelerating Innovation, 22 March 2019

The University of Liverpool and CERN, together with partners from the FCC/EuroCirCol projects, will host a symposium to showcase the science and technology challenges related to the Future Circular Collider (FCC). The FCC study is a global collaboration, supported by the H2020 EuroCirCol project, to investigate options for a future higher energy particle collider.

The symposium "Particle Colliders - Accelerating Innovation" will take place in the Liverpool Arena and Convention Centre on 22nd March 2019. The aim of this special event is to explore the opportunities opened by the FCC for co-innovation with a variety of industries. The event will feature talks by keynote speakers, an industry exhibition, as well as hands-on activities for the general public.

The Symposium will be followed by an **Academia-Industry Co-Innovation Workshop** which will cover the technologies involved in the FCC study, but extend beyond the project and accelerator community, bringing together universities, research centres and companies from around the world. The aim is to explore opportunities for co-innovation between academia and industry.

All morning talks can be watched via live stream:
https://indico.cern.ch/event/747618
Join in!

10th International Particle Accelerator Conference, May 2019

IPAC is the main international event for the worldwide accelerator community and industry. Attendees will be presented with cutting-edge accelerator research and development results and gain the latest insights into accelerator facilities across the globe. With over 1,000 delegates and 70 industry exhibits this is a unique opportunity to network with, learn from and meet a wide range of decision makers, opinion leaders, buyers and new kids on the block.

Fellows and partners from AVA will be at IPAC'19 presenting talks and posters and we look forward to meeting you all at **Booth D13** in the main exhibition hall.

Other Events

Eighth Meeting on CPT and Lorentz Symmetry (CPT'19), May

The Eighth Meeting on CPT and Lorentz Symmetry will be held in Bloomington, Indiana, on May 12-16, 2019. The meeting will focus on tests of these fundamental symmetries and on related theoretical issues, including scenarios for possible violations.

Topics which will covered include:

- searches for CPT and Lorentz violation involving accelerators and colliders
- atomic and molecular spectroscopy
- cavities, oscillators, resonators
- decays of atoms, nuclei, and particles
- gravitational waves
- matter-wave interferometry
- particle-antiparticle comparison
- trapped particles, ions, and atoms
- General Relativity, and beyond

Information about the meeting and online registration, including instructions on requesting a talk or poster, are available on the event web site:

http://www.indiana.edu/~lorentz/cpt19

Indiana University campus.
Copyright: Indiana university.

Workshop on antiproton-nucleus interactions and related phenomena, June

Low energy antiprotons as a probe for nuclear structure remains unexploited despite past pioneer works at Brookhaven and CERN.

The advent of new facilities, namely the ELENA low energy antiproton ring at CERN and the European Facility of Antiproton and Ion Research (FAIR) in Germany open a wide range of perspectives.
Nuclear structure studies with antiprotons require microscopic potentials and approaches to describe the interaction of low energy antiprotons with nuclei. The formation and decay processes of antiprotonic atoms is important to address the sensitivity of antiprotons to the nuclear density radial distribution.
In this workshop, past work with low energy antiprotons for nuclear physics will be reviewed in a critical way. New perspectives opened by the recent developments in the theory of nuclear interactions and in the treatment of the nuclear many-body problem, as well as the new facilities ELENA at CERN and FAIR will be discussed.

Main Topics

- physics with antiprotons
- antiprotonic atoms and nuclear structure
- antiproton-nucleon and antiproton-nucleus potentials
- antinucleon-nucleon annihilation mechanism and cross sections
- New facilities and projects

More information:
https://indico.ectstar.eu/event/41/

Fellows activity

Indrajeet Prasad collaborated with ELI Beamlines

Indrajeet working at ELI beamlines

FOTON s.r.o. worked on installation and commissioning of L3 High intensity laser lab at ELI Beamlines in Nov-Dec 2018.
It was a successful collaboration between both research centers. Indrajeet Prasad along with 2 of his colleague from FOTON had worked on installation, wiring and commissioning at L3 lab and its control center.

He gained experience of working on industrial diagram of laser lab design. He also gained experience in working on high intensity laser lab installation. Working in ELI Beamline's High intensity laser lab, he also learned the industrial protocol for highest LEVEL-4 safety instructions and it's working conditions. Overall, it was a great experience for Indrajeet to use his knowledge and apply it in real life scenarios.

ELI Beamlines is part of the Extreme Light Infrastructure (ELI) project, a new Research Infrastructure of pan-European interest and part of the European Strategy Forum on Research (ESFRI) Roadmap .

The ELI Beamlines research center aspires to install and run the world's most intense laser system. With ultra-high peak powers of 10 PW (Petawatt) and focused intensities up to 10^{24} W/cm^2 we will offer unique sources of radiation and particle beams to our users. These beamlines will enable ground-breaking research - not only in the fields of physics and material science, but also in biomedical research and laboratory astrophysics.

The Nobel prize for Physics in 2018 was awarded to Gerard Mourou, the father of the idea of ELI beamlines research center for groundbreaking inventions in the field of laser physics, jointly with Arthur Ashkin and Donna Strickland.

Milena Vujanovic started a blog to help students with CERN placements

One of our AVA Fellows, Milena Vujanovic, started a CERN related blog Tau Bytes (https://taubytes.com/). In this blog Milena's main focus is to help students with their applications for Summer Student program at CERN.

Besides this section, which she called CERN, there are two other section PEOPLE and CAREER.
"The whole idea was not actually mine. My friend, after hearing how many students come to me with questions regarding CERN, got the idea of this blog. He suggested that many more people could benefit this way; simply by turning my answers into a few posts. That is exactly what I did and so far responses have been amazing! On his original idea I added two more section: CAREER where readers can find interviews/articles with people who worked at CERN but left academia. The goal of this sections is to share experience and different job opportunities outside fundamental research and academia. (First article "From Higgs boson discovery to data science"); and PEOPLE - this is probably my favourite part of the blog and it was inspired by my friend, CERN physicists who wrote an incredible sci fi book. This section is all about amazing, inspiring CERN scientist whose brilliance goes way beyond their research (First article "I create worlds"). "

Tau Bytes have received great support on social media, many students reached out saying that this blog is just what they needed and Ministry of science of Montenegro endorsed the blog on their Facebook page by advising their students to use it during the application process.

Partner News

AEgIS makes positronium for antimatter gravity experiments

The AEgIS collaboration at AVA Partner CERN has found a new way of making long-lived positronium atoms for antimatter gravity experiments.

Our Fellow Mattia Fani was co-author of the article describing the innovation which was published in published on Physical Review A – high Impact Peer Reviewed Journal.

Congrats!

For more details please visit:

https://home.cern/news/news/physics/aegis-makes-positronium-antimatter-gravity-experiments

Position Vacancies

Open positions at University of Liverpool/The Cockcroft Institute:

PhD position on *Ultra-high Gradient Acceleration using Carbon Nanotube Arrays*. To find out more about the project and how to apply, please visit: http://www.cockcroft.ac.uk/join-us

PhD position on *Performance optimisation of accelerators using machine learning techniques*. To find out more about the project and how to apply, please visit: https://www.liverpool.ac.uk/study/postgraduate-research/how-to-apply/

Open positions at CERN:

Computing Technical Engineer (IT-ST-FDO-2019-18-LD), Grade 4-5.

Mechanical Engineer (TE-ABT-EDS-2019-16-LD), Grade 6-7

Full-Stack Software Engineer (IT-CDA-DR-2019-17-LD), Grade 6-7.

Computer Security Expert (IT-DI-CSO-2019-19-LD), Grade 6-7.

News from FAIR

Since the ground-breaking in July 2017 a lot has been going on at the FAIR construction site. With a new filming technique, a unique drone time lapse video has been produced that shows the progress made ever since.

An aerial time-lapse video was shot showing the development over a complete year: For this so-called *long term drone lapse* the same routes across the construction site were flown with a drone in regular intervals. The recorded motion time lapse videos were then combined into one single video.

To this end, several videos that were taken over this time frame were super-imposed using GPS coordinates of all footage to highlight progress in construction.

You can now watch the video on YouTube.

AVA Events

24th - 27th June 2019	Advanced Researcher Skills and Technology Transfer Workshops, Liverpool, UK
28th June 2019	Symposium: Accelerators for Science and Society, ACC Liverpool, UK
9th – 10th October 2019	3rd Topical Workshop entitled Machine-Experiment Interface, Cosylab, Slovenia

Other Events

22nd March 2019	Symposium: Particle Colliders – Accelerating Innovation, ACC Liverpool, UK
1st – 5th April 2019	Advanced School on Medical Accelerators and Particle Therapy, Vienna, Austria
12th – 16th May 2019	Eighth Meeting on CPT and Lorentz Symmetry, Indiana University, Bloomington, US
19th – 24th May 2019	IPAC'19, Melbourne Convention & Exhibition Centre, Australia
10th – 15th June 2019	PTCOG58, Manchester, UK
17h – 21st June 2019	Antiproton-nucleus interactions and related phenomena, ECT*, Trento, Italy
28th June 2019	Symposium: Accelerators for Science and Society, ACC Liverpool, UK
1st – 3rd July 2019	ENLIGHT Annual Meeting and Training, Caen, France

Notice Board

This newsletter will be published on a quarterly basis. Help us keep it interesting by providing your news and updates.

DEADLINE FOR THE NEXT NEWSLETTER CONTRIBUTIONS: 15th June 2019

www.ava-project.eu

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