

Highlights

- Lyman-Alpha Transition Observed in Antihydrogen
- Novel Look into Antimatter Beams
- How to characterize antimatter beams?
- Upcoming Events
- Fellows Activity
- Partner News
- Positions Vacancies

Dear friends of low energy antimatter and ion physics,

It was fantastic to meet all AVA Fellows at our [Workshop on Low Energy Beam Diagnostics and Sensor Technologies in Vienna last month](#). This event marked the start of a series of Topical Workshops that link between our three work packages and encourage dialogue between our Fellows and the international research community. The workshop was well attended with participants from all over the world and provided unique insight into latest technology developments.

Our next workshop is coming up soon and will focus on low energy [Facility Design and Optimization](#). Registration has just opened and I recommend to register soon to secure your place. Our formal mid-term review meeting with the EU will take place right after this workshop on 8 February 2019. All AVA partners are cordially invited to join and more details will follow by email.

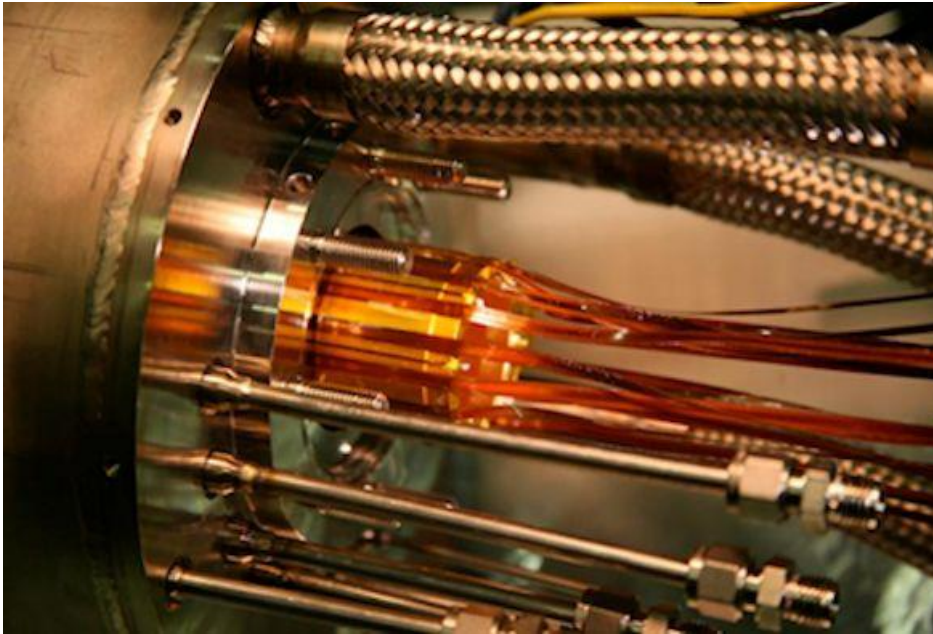
Bienvenue, Adélaïde! We are delighted to welcome AVA Fellow #15, Ms Adélaïde Grimaud in our network. Adélaïde has joined COSYLAB recently where she will be working on the *development of versatile control systems* – you can find more details in this MIRROR.

Save the date: On Friday, 28 June 2019 AVA will host a Symposium on *Accelerators for Science and Society* at the ACC in Liverpool, UK. This will mark the end of a week-long advanced skills training for our Fellows and will be organised along a Supervisory Board meeting to which all AVA partners are cordially invited. Talks from this international event will be available via web-stream and can be followed from all over the world.

A handwritten signature in black ink, appearing to read 'Carsten Welsch', is positioned above the printed name.

Prof. Carsten P. Welsch,
Coordinator

Lyman-Alpha Transition Observed in Antihydrogen



Inside the ALPHA apparatus, image courtesy of the ALPHA experiment.

Back in 1906, Theodore Lyman discovered a series of transitions in the extreme-UV region of the atomic hydrogen spectrum, now named after him. These patterns were an important part towards the development of quantum mechanics, which we now know governs the world at a microscopic scale.

Studies involving the Lyman- α line, i.e. the 1S–2P transition at a wavelength of 121.6 nm, have played an important part in physics and astronomy experiments ever since, as one of the most fundamental atomic transitions in the Universe. In particular, they could shine some light on potential difference in this transition between matter and antimatter particles.

This summer, the [ALPHA](#) collaboration has for the

first time observed single-photon excitation of antihydrogen atoms from the ground (1S) state to the 2P state using 121nm pulsed laser light.

These exciting results were published in [Nature](#) on August 22nd 2018 and demonstrate how pulsed laser-light can be used to measure the temperature of antihydrogen atoms.

The single-photon Lyman-alpha transition takes ALPHA one step closer to laser-cooling of antihydrogen, a feat that would dramatically improve the potential for more precise measurements of the also recently detailed 1S-2S transition as well as measurements of the gravitational influence on antihydrogen. The ALPHA experiment is undergoing upgrades that will allow to cover these interesting areas in the future.

Novel Look into Antimatter Beams

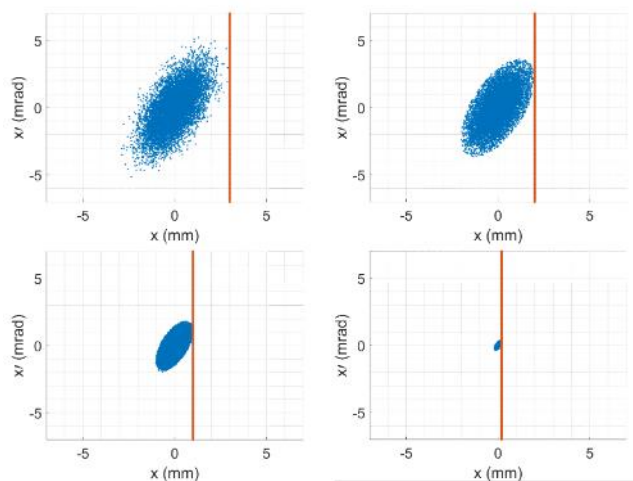
The development of the next generation of ultra-low energy antiproton and ion facilities requires precise information about the beam emittance to guarantee optimum performance.

In the Extra-Low ENergy Antiproton storage ring (ELENA) the transverse emittances will be measured by scraping. However, this diagnostic measurement faces several challenges: non-zero dispersion, non-Gaussian beam distributions due to effects of the electron cooler and various systematic errors such as closed orbit offsets and inaccurate rms momentum spread estimation. In addition, diffusion processes, such as intra-beam scattering might lead to emittance overestimates.

The paper “Emittance measurements in low energy ion storage rings” published in the journal [Nuclear Instruments and Methods in Physics Research A](#) provides an in-depth description of this method for measuring the emittance of particle beams in the presence of several complicating factors, and is supported with detailed beam simulations.



Photograph of the ELENA scraper system.



Horizontal phase space at different scraper measurement stages for an on-momentum Gaussian beam. The red line indicates the position of the scraper blade.

Although this technique is already in use in accelerator facilities all over the world, a new approach of combining pairs of measurements and analysing them simultaneously will allow scientists to obtain more detailed information on the beam. This will help to understand the complicated beam dynamics processes at work within particle beams.

Additionally, several previously problematic factors such as beam dispersion and unusual beam profile distributions may be dealt with by employing the new algorithm. Measurements at ELENA are currently underway that shall demonstrate the full potential of this method.

Network News

How to characterize antimatter beams?



Photograph of the workshop participants.

Around 30 experts from all over the world came together for a three-day Topical Workshop on Diagnostics and Detectors for Low energy Ion and Antimatter Beams in Vienna, Austria between 15-17 October 2018.

The event covered the challenges in the design and operation of advanced detectors and beam instrumentation to optimize the performance of the antimatter facilities AD and ELENA at CERN, as well as the future FLAIR facility at FAIR in Germany.

AVA Coordinator Professor Carsten Welsch started the meeting by explaining the project background, as well as challenges in low energy beam diagnostics. He was followed by Professor Paolo Crivelli from ETH Zurich who gave a comprehensive overview of Instrumentation for Antimatter Beams, triggering many interesting questions. Presentations by other workshop participants, including a number of AVA Fellows then explored various detectors in more detail.

Particular challenges arise when very long lifetimes are targeted in experiments and this typically requires a cryogenic environment. Dr Stefan Strahl, CEO of Stahl Electronics in Germany, presented the state-of-the-art in Cryo Detector Technology.

The second day of the workshop was started by Dr Angela Gligorova from SMI in Vienna with a presentation about *Solid State Detectors for Antimatter Experiments*. She presented technologies used across the different AD experiments, including Silicon pixel and strip detectors, how they are used in the respective experiment and what their limitations are. Presentations about a number of novel diagnostic techniques, including liquid target-based detectors and gas jet-based techniques followed in this session. The final session on Wednesday afternoon was started by Dr Gunn Khatri who focused on *Sensors and Instrumentation for Trap Experiments*.

The specific geometrical constraints of traps make

the detailed diagnostics of stored particles particularly challenging and despite more than 30 years of studies into storing and analysing antiparticles, technological advances are still required to measure the properties of these elusive particles in better detail. Presentations about specific experiments and their respective diagnostics challenges completed the interesting workshop program.

All presentations are available via the event [indico page](#). The AVA project will next organize a workshop on *Low energy facility design and optimization*. This event will take place on 6/7 February 2019 and registration will open this month and be announced via the [AVA homepage](#).

Upcoming AVA Event

Topical Workshop on Low energy facility design and optimization through diagnostics, February 2019

We are delighted to announce a two-day workshop on the design and optimization of low energy ion and antiproton facilities with a focus on how cutting edge diagnostics help improve machine and experiment performance. The event will be hosted by GSI near Darmstadt, Germany on 6th - 7th February 2019. We will discuss the performance limits of the latest low energy diagnostics, as well as how their readout can be used for beam dynamics simulation purposes, as well as for an efficient control of the accelerator and experiments.

This event will combine talks by research leaders, with opportunities for early stage researchers to present their work and panel discussions. The standard fee of £250 will include accommodation, coffee breaks, lunch, welcome reception, and the workshop dinner.

Registration and further details can be found here: <https://indico.cern.ch/event/770063/>

**ACCELERATORS
VALIDATING
ANTIMATTER
PHYSICS**

Topical Workshop
Low energy facility design and optimization through diagnostics

Antimatter experiments are at the cutting edge of science. They are, however, very difficult to realise. The AVA project aims at enabling new antimatter experiments, probing the fundamental laws of nature.

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www.ava-project.eu

Contact and further details: Prof. Dr. Carsten Wespel, Head of Experiment, European Centre of Physics, University of Liverpool, L69 7GE, Liverpool, UK. c.wespel@liverpool.ac.uk



Other Events

Symposium Particle Colliders - Accelerating Innovation, 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.

Companies, academics, researchers and students can now register for free via the following website:

<https://indico.cern.ch/event/747618>

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 1000 delegates and 70 industry exhibits IPAC 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.



Meet our AVA Fellows (cont.)

We are delighted to welcome AVA Fellow #15, Ms Adélaïde Grimaud in our network.



Adélaïde Grimaud studied Mechanical engineering at Arts et Métiers, France. She obtained her Master of engineering concurrently with a master of research in Digital engineering - interactive 3D technologies in 2017.

After finishing her master thesis on exploration and annotation of data in virtual reality at the Brigham and Women Hospital in Boston, USA, she extended her stay in the laboratory to work on the development of SPINE, a medical research web platform.

Her general background and curiosity for physics then led her to join Cosylab, Slovenia, in September 2018 to work on the development of a versatile control system for the AVA project.



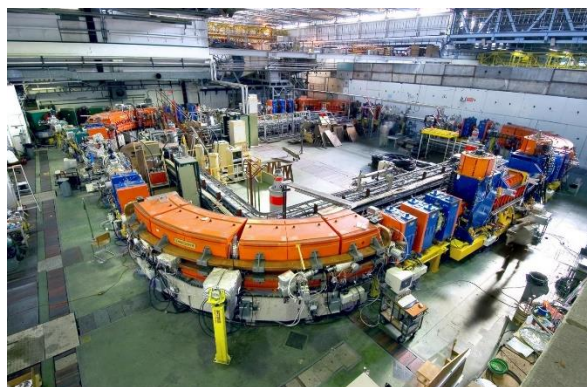
Welcome to AVA!

Fellows Activity

How to make antiproton beams cool(er)?

In September and November, AVA Fellow Bianca Veglia spent a very productive time at CERN, working with Bruno Galante and colleagues from the AD. The initial purpose of the trip was to take data of the effect of the ELENA electron cooler on the antiproton beam evolution so that these could be compared with the simulation results.

Unfortunately, measurements in ELENA were not possible as a technical issue with the AD electron cooler meant that no antiprotons were injected into ELENA for many weeks. However, this didn't stop the research. The initial visit helped establish close contacts with the wider ELENA group and allowed collaboration on cooling-related questions in both, ELENA and LEIR (Low Energy Ion Ring). This joint effort currently focuses on benchmarking simulation tools and investigating electron cooling at low energies. LEIR works with 'regular' matter (even if it is a conversion of the old Low Energy Antiproton



Low Energy Ion Ring (image copyright CERN)

Ring), accelerating pulses of lead ions. It is equipped, as ELENA, with an electron cooler. The availability of a large amount of data of the LEIR electron cooler performance enables a reliable benchmarking for different simulation tools.

Open Day at the MPIK

On the occasion of its 60th birthday, the Max-Planck-Institut für Kernphysik (MPIK) in Heidelberg, Germany opened its doors for visitors on Sunday, September 16th.

The general public was invited to take a look at the diverse research at the institute. The MPIK carries out basic experimental and theoretical research in the fields of astroparticle physics and quantum dynamics. It is recognized for its work on cosmic accelerators, the inner workings of atoms and molecules, search for the mysterious dark matter, how space can be brought to the lab, how scales work for atoms, and what is possible with super-strong and ultra-short laser flashes.

An exciting program awaited the visitors at the MPIK: This included numerous demonstrations, hands-on experiments, laboratory visits, exhibits, posters and lectures. Among many other PhD students at the institute, AVA Fellow Markus Wiesinger contributed by presenting a Paul trap experiment that showed trapped Coulomb crystals of lycopodium spores, see image. The connection to real experiments was made via guided tours of the ion trap experiments at the institute as well as exhibits of traps in the institute laboratories.

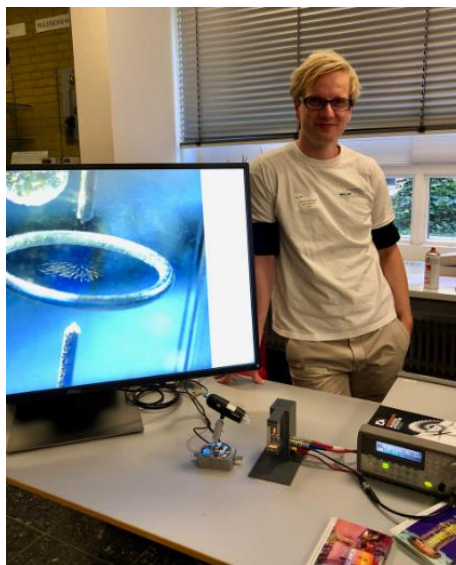
More than 3,000 guests enjoyed a warm and sunny Sunday at the institute and were able to dive into the world of atoms, molecules, nuclei and particles.

Bruno Galante participates in CAS

The CERN accelerator school (CAS) and the Extreme Light Infrastructure – Nuclear Physics (ELI-NP) in Bucharest hosted this year a training course on Introduction to Accelerator Physics in Constanta, Romania.

This course is considered as the core teaching course of all CAS courses. It attracts students and researchers from universities and laboratories all over the world who attend the multitude of lectures and activities offered by this school.

Over the course of 2 weeks, the school offered



Strong Fields: Markus with a demonstration of the working principle of a Paul trap using trapped lycopodium spores.

They visited some of the more than 60 demonstrations and exhibits, listened with interest to the more than 20 talks, including one of MPIK Director Professor Klaus Blaum on "Research with Antimatter". They also had the unique opportunity to take a close look at all the experiments carried out at the MPIK.

lectures about all aspects of accelerator physics, hands-on trainings, as well as many opportunities for discussions. Topics that were covered included beam dynamics, physics and engineer concepts behind different types of accelerator, as well as most of the components and devices found in accelerators, from the particle source, through the transport lines, to the beam instrumentation.

Different activities were also offered during the school including an excursion by boat on the Danube River and a visit to ELI-NP in Bucharest

where the students were shown the new facility under construction, as well as already the existing accelerator infrastructure on site.

At the end of the course feedback from students was very positive and underpinning the high

standard of the lectures and activities. Bruno said: “It was a fantastic experience. After two packed weeks full of accelerator physics, you can feel a bit overwhelmed, but for sure this has been an opportunity that is absolutely worth to be taken!”



Group photograph of CAS 2018.

Milena Vujanovic spreads the word about AVA

This summer, AVA Fellow Milena Vujanovic, based at the University of Liverpool, was invited to give an overview talk about her Marie Curie Fellowship and the MSCA ITNs in general at an event organized by the Ministry of Science in Montenegro.

Milena was asked to help organise an “Info day” as well as give a talk about Marie Curie ITNs to a group of students. She related her own experience as AVA Fellow with the wider targets of the MSCA ITN programme, and also explained how students can apply for early career stage positions at institutions across Europe.

STEM students coming from the Western Balkan countries currently face many problems during their studies. This includes the lack of research institutions, insufficient funding, sparse information about career opportunities abroad, and the feat that

they might not be good enough to work outside of the Balkan borders. Therefore, the Ministry of Science in Montenegro is investing significant effort to change this and make science careers more attractive.

Several female participants approached Milena after her talk and told her that they saw one of her recent interviews about women in science on TV. They thought it was important to send a strong message about the importance of science and communicate the opportunities for science careers. After delivering a well-received presentation, Milena was invited to a meeting on the organisation of future events by Dr Branka Zizic, Director General for Innovation and Technological Development. Milena also established a collaboration with the Serbian science promotion centre and she is hoping to work with them in the future.

Milena said: *“I am trying very hard to help students from Serbia and Montenegro to become aware of the opportunities they have. So far, I have had very positive feedback and I hope I will be able to help many more students in the future.”*

The event participants are now eager to see what Milena will achieve in the coming months. Asked about her thoughts regarding how attracting a prestigious AVA Fellowship has helped her reach so many people, Milena said:

“I am very grateful that I am given a platform which I can use to help students who are going through the same doubts, problems, and challenges I had to face in the past. I am very happy that I have so much support from my country and Ministry of Science.”



Busy summer at FZJ

With some projects finalized and a few new ideas born in the meantime, this summer turned out to be tense but fruitful for AVA Fellow Dominika Alfs at Forschungszentrum Jülich (FZJ). It would be a summer that defined the direction of work for the rest of the year.

Antiproton polarization measurement at CERN/PS

The aim of the P349 antiproton polarization experiment is to test if the antiproton production process results in some polarization in view of the preparation of a polarized antiproton beam by means of the left-right asymmetry measurement in the Coulomb-nuclear interference region.

The ongoing analysis of the data collected in 2014 and 2015 at CERN/PS complex has clearly shown the way of improvements in the setup that would allow for collecting of a high quality data sample. With this in mind, over the last year a new setup

was designed and prepared at Forschungszentrum Jülich with a focus on precise tracking with a scintillating fiber detector and straw tube tracker and more efficient particle identification with Cherenkov detectors.

Finally, between July 18th and August 17th a beamtime took place at T11 beamline of the CERN/PS ending the time of preparations and shifting the focus back to the analysis. Very first results can hopefully be shown in the next MIRROR already!

Scintillating fiber-based antiproton beam monitoring device

The experience with 0.25 mm diameter scintillating fiber detectors used in the P349 experiment triggered the discussion about other possible applications. An idea of a simple antiproton beam monitoring device consisting of two double layers of

scintillating fibers readout with SiPM was proposed and will be in the near future in detail considered including simulation studies and test measurements.

RISE Germany internship

For 10 weeks the Institute for Nuclear Research (IKP) at Forschungszentrum Jülich hosted a summer student from the University of Birmingham, UK within the framework of the RISE Germany program. RISE Germany is a project of the German Academic Exchange Service (DAAD) which offers summer research internships in Germany for

undergraduate students from Great Britain, Ireland and North America in the field of natural sciences. In the recruitment process undergraduate students are matched with doctoral students whom they assist and who supervise their work. The task of being a supervisor at the IKP was taken by the AVA Fellow, Dominika Alf.

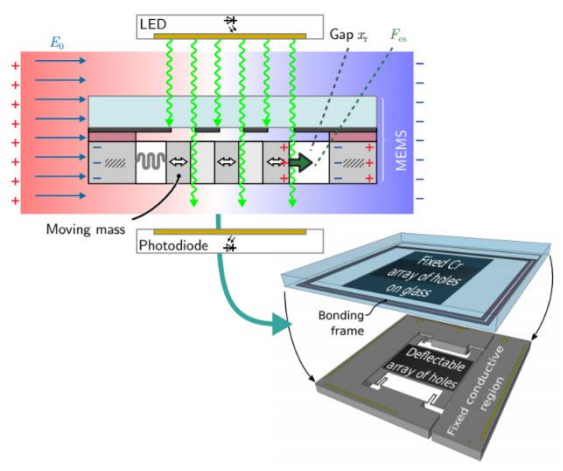
Furthering our understanding of low energy beam transport

This autumn was very productive for one of our AVA Fellows, Volodymyr Rodin based at the University of Liverpool/Cockcroft Institute who joined his co-worker James Hunt and Andreas Kainz from TU Wien, as well as Wilfried Hortshitz and Matthias Kahr from Danube University Krems to turn the idea of applying a novel MEMS sensor¹ for accurate field measurements into reality. Thus far, nobody has ever done detailed 3D-field measurements of electrostatic optics. This may seem surprising as these are widely used in low energy storage rings and beam transfer lines. In stark contrast, magnetic quadrupoles and dipoles are almost always tested in detail with appropriate Hall sensors, providing detailed insight into the real field distribution. An equivalent sensor for electrostatic optics would be a true game-changing technology.

In a nutshell, the device uses a very clever approach, converting field strength into a light signal. More details about the device and results from these measurements will be published soon. The original application of the sensor was oriented towards safety inspections in industry for high-voltage applications, electrical breakdown studies, as well as lightning-hit areas. However, this study may now open an entirely new range of applications.

The study was supported by CERN colleagues who provided access to one of the ELENA beam transfer line quadrupoles, in particular by W. Bartmann and J. Borburgh. Even though the design work of all ELENA beam lines in the AD hall has already been completed, there is still an interest in an improved description of the optics as this can help optimize overall beam transport.

Without preempting the results from a detailed analysis which will be published soon, the campaign gave a wonderful insight into the field distribution and demonstrated the unique capability of the sensor. It also helped improve existing simulation models used for 3D field map generation and will now be the basis for detailed 6D beam dynamics studies.



Partner News

QUASARs participate in Claire House charity run in remembrance of Ava



Members of the QUASAR Group taking part in the Splash Dash event.

The 21st September 2018 marked the 5-year anniversary of the day little Ava Scott grew her angel wings.

Ava was diagnosed as having a Ewing's Sarcoma, a cancerous tumour in her leg in July 2012. She battled her illness without complaining and with so much dignity. She never moaned about the treatment and accepted what was necessary. Sadly, on 21st September 2013, Ava lost her battle - she was only 8 years old. The AVA project is named after her.

To remember the precious little girl who always had a smile on her face and happiness in her eyes, the QUASARs, including AVA Fellow Milena Vujanovic and AVA coordinator Professor Welsch, joined the team 'Ava Forever' and jogged, walked and danced through clouds of powdered paint at the 5k Claire House Splash Dash event at Sefton Park, Liverpool.

Claire House Children's Hospice helps seriously and terminally ill children live life to the full by creating wonderful experiences and bringing back a sense of normality to family life and provided amazing support to Ava and her family during their ordeal.

'Ava loved people and parties', said Janine Scott, Ava's mum, and despite the rainy weather team 'AVA Forever' has been in high spirits throughout that colourful day and had an amazing, fun-filled time, remembering beautiful Ava and keeping her lovely, precious memories alive. And we are sure, that a little angel looked down on us that day, smiling and dancing along...



Science knows no borders – new video

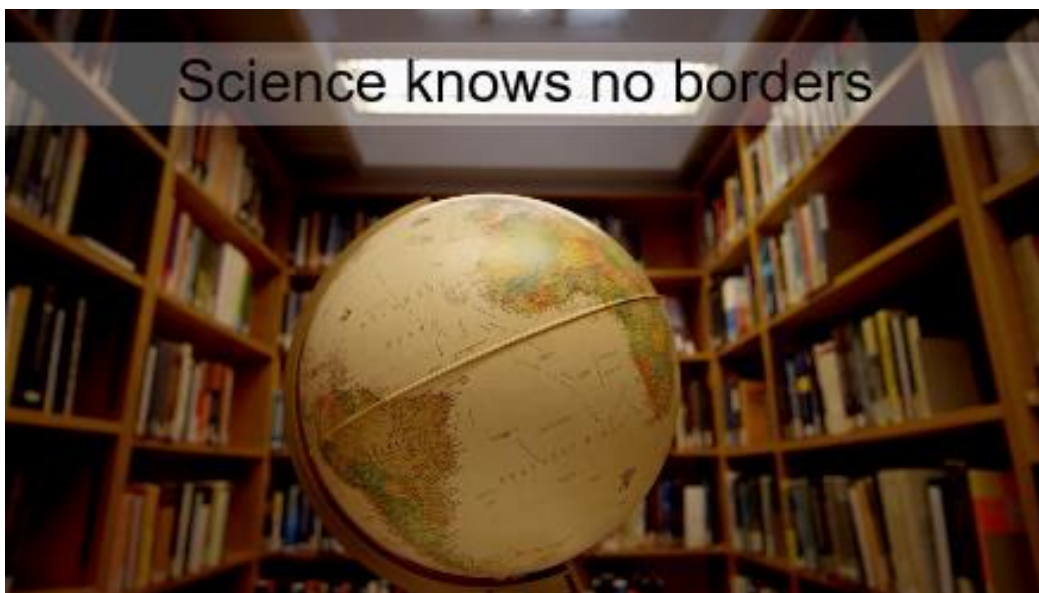
A new video featuring former CERN DG Prof Rolf Heuer highlights the importance of international research collaboration on the example of the Future Circular Collider (FCC) project. It was produced by the University of Liverpool in collaboration with CERN in the framework of the FCC and EuroCirCol projects.

Large scale research infrastructures require the world to work together on the design, construction, operation and subsequent optimization of these facilities to fully exploit their discovery potential. Scientists and engineers are working together across country borders, research disciplines, building bridges also between cultures, genders

and generations. These are the cornerstones of the AVA project. CERN in Geneva has been an outstanding example of the successes made possible through open collaboration and this video presents a strong message why the world needs more of this.

The video is now available on [YouTube](#) with subtitles in eight languages and has also been added to the [EU Science & Innovation](#) playlist where it stands among the most watched videos, second only to our [AVA video!](#)

Enjoy!



[Watch the video!](#)



Position Vacancies

PhD position at ALBA on *Particle Beam Size Measurements in Accelerators Using Colloidal Suspensions* to carry out research on the new technique for particle beam size measurements in accelerators using the scattering of the x-rays from synchrotron radiation with colloidal suspensions. More information and how to apply can be found here <https://projects.icmab.es/docfam/> or contact Dr Ubaldo Iriso uiriso@cells.es

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>

Postdoctoral Research Associate in Accelerator Physics Grade 7. The post involves the design and optimisation of beam transport in the High Luminosity LHC. The post can be based either at CERN or in the UK. More information about the post and how to apply: <https://recruit.liverpool.ac.uk/>

Grade 7/8 Research Fellow based at the Cockcroft Institute specialised in beam diagnostics R&D for charged particle beams. You will contribute to/lead activities in cutting edge beam instrumentation and collaborate closely with staff and students in the QUASAR Group. An internationally excellent track record, demonstrated for example through publications or leadership roles, will be expected. The grade point will be determined on the basis of experience. For more details please contact c.p.welsch@liverpool.ac.uk

News from FAIR

During the visit of a delegation of representatives of the Budker Institute for Nuclear Physics (BINP) to FAIR in September 2018, the contract for the remaining part of the CR was signed with FAIR management.

The CR is designed for fast precooling of hot secondary ions coming from the antiproton separator and the Superconducting Fragment Separator (Super-FRS). Fast cooling will be done by means of RF debunching and stochastic cooling, which are both being developed at GSI. The CR is going to be used for mass measurements of short-lived secondary rare isotope beams from the Super-FRS in a special CR optical mode as well.

A large part of the CR is being developed under the direction of the Budker Institute as a Russian in-kind contribution to FAIR. The signed contracts foresee that BINP will manufacture dipole, quadrupole and sextupole magnets, vacuum system, power supplies for all magnets, beam diagnostic components, as well as the beam injection and extraction system.

More information can be found in this [full article](#).



From left to right: BINP deputy director Eugeniy Levichev, Administrative Managing Director of FAIR and GSI Ursula Weyrich, Technical Managing Director Jörg Blaurock and CR Subproject Leader Ivan Koop. Photo: G. Otto/GSI

Events

11 th – 12 th December 2018	OMA Topical Workshop - Accelerator Design and Diagnostics, GSI, Germany
6 th – 7 th February 2019	AVA Topical Workshop - Low energy facility design and optimization through diagnostics, GSI, Darmstadt, Germany
13 th - 26 th March 2019	2019 CERN Latin-American School of High-Energy Physics, Córdoba Province, Argentina
22 nd March 2019	Symposium: Particle Colliders – Accelerating Innovation, ACC Liverpool, UK
19 th – 24 th May 2019	IPAC'19, Melbourne Convention & Exhibition Centre, Australia
28 th June 2019	Symposium: Accelerators for Science and Society, ACC Liverpool, UK

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 January 2018



www.ava-project.eu

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