NEWS*letter*

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In this Issue

MIRROR teams up with AVA

The brand-new European research and training network AVA (http://www.ava-project.eu) has started earlier this year. In focusing on antimatter R&D, training no less than 15 early stage researchers and building bridges between research on antimatter facilities design and optimization, novel beam diagnostics and detectors, as well as cutting edge antimatter experiments, AVA is build on the vision of our collaboration.

From this issue onwards, the MIRROR will feature the latest news and results from AVA, along with results from the wider antimatter research community. We will gradually introduce the background of all Fellows, present summaries of international events organised by the network and include research highlights. This will keep you informed about the latest developments and allow you to join us in future events and collaborative projects.

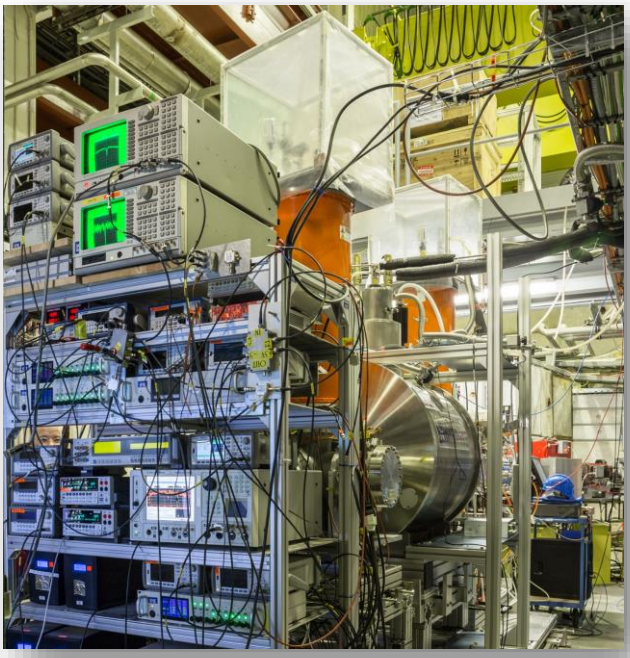
Carsten, Thomas and Jochen

News from FAIR

An important milestone: Groundbreaking ceremony for the FAIR accelerator facility. The construction of the international accelerator facility FAIR (Facility for Antiproton and Ion Research) has begun. The start of building construction and civil engineering work is a crucial moment for one of the largest construction projects for scientific research worldwide. On 4 July 4 2017 the ground breaking ceremony was held for the large ring accelerator SIS 100, which will be one of the key components of the future accelerator facility FAIR. The construction site is located to the northeast of GSI Helmholtzzentrum für Schwerionenforschung in Darmstadt.
At the ceremony, government officials and scientists from Germany and abroad extended greetings and symbolically broke the ground with a shovel. This crucial milestone was attended by representatives from all nine partner countries. **Congratulations!**

Antiproton magnetic moment measured with six-fold improved precision

Christian Smorra, RIKEN



Picture of the BASE experiment in the antiproton decelerator hall *(Image: Stefan Sellner/CERN)*.

The BASE collaboration, led by Dr Stefan Ulmer who is also part of the AVA network, published an article in Nature Communications. The collaboration reports the most precise measurement of the antiproton magnetic moment with a fractional precision of 0.8 parts per million. The result improves upon the last measurement by the ATRAP collaboration by a factor of 6.

The Standard Model of particle physics predicts that equal amounts of matter and antimatter have been created in the big bang, and it provides no satisfying answer to explain the disappearance of antimatter in the early universe. Inspired by this asymmetry, the reported measurement tests the most fundamental discrete symmetry of the Standard Model, the combined charge-parity-time (CPT) reversal symmetry. Any measured discrepancy in antiproton and proton magnetic moments would violate the equivalence of conjugate matter/antimatter pairs and indicate new physics beyond the Standard Model.

The BASE experiment is located at the Antiproton Decelerator (AD) of CERN. Antiprotons from the AD are injected into an advanced multi Penning trap system, where they are initially captured and cooled in a reservoir trap. A cloud of antiparticles can be stored in this trap for more than one year without annihilation loss. BASE developed methods to extract single antiprotons from this reservoir, and to provide them for single particle spectroscopic measurements, which are carried-out in the other traps of the experiment. This allows for highly economic use of the stored antiprotons: Using a single AD-shot trapped in November 2015, antiproton-experiments were conducted for in total 405 days, until December 2016. This enabled the operation of the experiment even during machine-shutdown periods.

The magnetic moment of the antiproton is determined by measuring the ratio of the spin precession frequency ν_L and the cyclotron frequency ν_c in a Penning trap. To this end a strong magnetic bottle (300000 T/m^2) is imposed on the measurement trap, which allows to detect the spin state of the antiproton, since the magnetic inhomogeneity couples the magnetic moment of the particle to its axial oscillation frequency. This axial oscillation is non-destructively read-out by a sensitive superconducting image-current detector connected to one of the trap electrodes. Measurements of axial frequency fluctuations induced by resonant radio-frequency drives enable the measurement of ν_L and ν_c, and thus the determination of the magnetic moment of the trapped particle.

From six measured spin-flip resonance curves interleaved by cyclotron frequency measurements, the BASE collaboration obtained the magnetic moment of the antiproton as 2.7928465(23) μ_N, where μ_N is the nuclear magneton. This value is in agreement with BASE's independent double-trap based proton magnetic moment measurement 2.792847350(9) μ_N and supports CPT invariance.

Future efforts of BASE target the application of the much more challenging double trap method to measure the antiproton magnetic moment, to further increase the precision in this value down to the parts per billion level.

Further information:
H. Nagahama, C. Smorra, et al., Sixfold improved single particle measurement of the magnetic moment of the antiproton, Nature Communications 8, Article number 14084 (2017) http://dx.doi.org/10.1038/ncomms14084

Non-invasive Beam Profile Monitor – An Accelerator Physicists' Dream

Beam profile measurement is very important for any particle accelerator to monitor how the beam moves and optimise the experimental output. Measuring the beam profile with high precision without affecting the primary beam's motion has always been the dream of beam diagnostics experts from around the world. This concerns both very high energy beams, such as the one found in the Large Hadron Collider, as well as low energy beams, such as the one found in the AD and FLAIR facilities.

Researchers from the QUASAR Group have now experimentally demonstrated a new type of monitor that can provide a universal solution to this problem. Compared with traditional beam profile measurements using scintillating screens such as phosphor or YAG, this monitor uses a supersonic gas jet curtain which on the one hand will not be fragile, because it can be reproduced many times. On the other hand, this monitor will not interfere with the projectile beam very much as the interaction rate can be controlled via the gas jet density and thickness.

The detection system of this diagnostic shares some basic ideas with commonly used ionisation beam profile monitors, as well as with gas jet target setups used in atomic physics experiments. The former use the residual gas inside a vacuum chamber to monitor the primary beam. Both methods are essentially non-invasive and rely on the detection of ions that are produced by the primary beam to be measured, however, the properties of the supersonic gas jet such as its density, low internal temperature and high directional speed give access to a better detection efficiency and resolution while maintaining much better vacuum conditions than what can be realised with an IPM.

An open access paper just published in the APS journal Physical Review Accelerators and Beams describes the detailed monitor design, underlying diagnostic principle and also presents first experimental results.

Further information:
V. Tzoganis, et al., Design and first operation of a supersonic gas jet based beam profile monitor, Phys. Rev. Accel. Beams 20, 062801 (2017) https://doi.org/10.1103/PhysRevAccelBeams.20.062801

News from AVA

First AVA Steering Committee Meeting held in Vienna

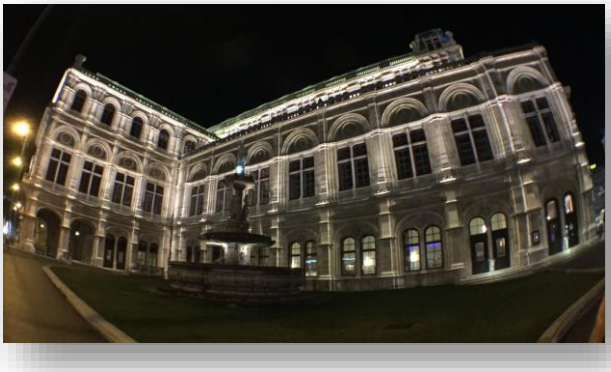
The Steering Committee of the new European network AVA is a small body of senior scientists chaired by the project coordinator and supported by Liverpool's project T.E.A.M. It is responsible for the overall network strategy and makes decisions on the running of AVA.

The Steering Committee has now met for the first time in Vienna, Austria to discuss work progress. Discussions initially focused on a review of the network's international recruitment campaign. No less than 15 highly skilled researchers had to be recruited. Following advertisements, mail shots, video and poster campaigns, hundreds of applications were reviewed and all but one position (COSYLAB, see vacancies sections) have now already been filled. Some of the Fellows have already started their projects and all will join before the end of this year. The wider project communication was also reviewed, including the AVA leaflet which provides an overview of the project's goals and R&D.

An important part of the network's wider strategy is the establishment of links to other major training initiatives. To this end, four AVA Fellows joined a researcher skills training in Liverpool, held in April 2017 which was organised for all 15 Fellows within the OMA project. The week-long course was found ideal to link both training initiatives and share best practice.

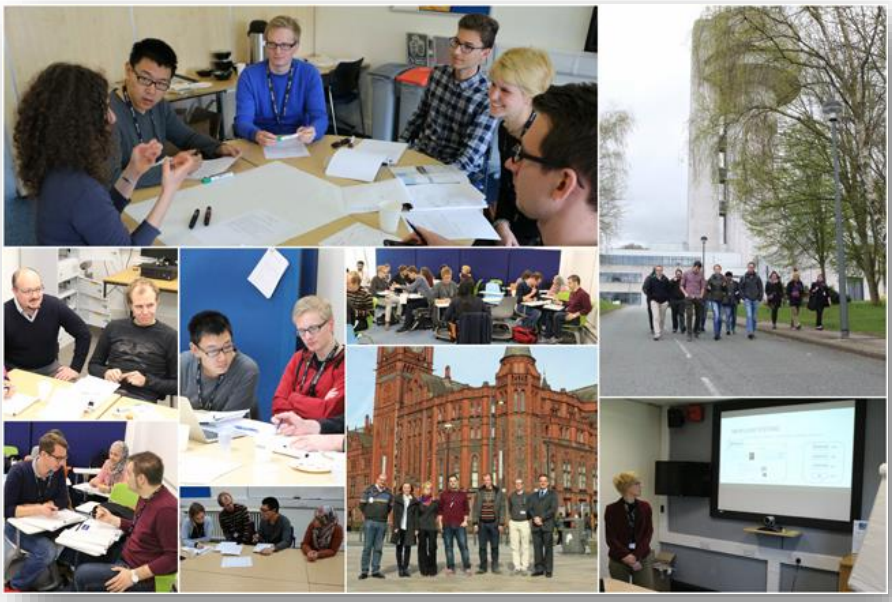
Future events were next on the busy agenda and the Steering Committee decided dates and locations for an international School on Antimatter Physics (summer 2018), as well as several internal trainings for all Fellows on detector physics, beam diagnostics and high performance computing. All events will be announced via the AVA website and the MIRROR in the future.

Vienna was found to be an ideal location for the meeting and the local organisation by Luisa Griesmayer was fabulous.



Complementary Skills School kicks off series of AVA training events

3rd-7th April 2017, Liverpool, UK



The newly recruited AVA Fellows gathered for their first training event organized at the University of Liverpool. They joined the OMA Fellows, to start collaborations between the two networks coordinated by Prof Carsten Welsch. The intense training programme was focused on complementary skills.

The first day began with Prof Welsch presenting the basics of the AVA and OMA (Optimization of Medical Accelerators) networks, as well as tips for scientific presentations, to be used later in the week. This was followed by fellows' creative introductions, letting them get to know each other. The afternoon session on science communication was delivered by Ms Rachel Holdsworth and Ms Elsa Loissel from Holdsworth Associates, who provided tips for targeted writing about science. In addition, on the first day the participants were divided into three sub-groups, to start working on the week challenge – outreach project proposal, based on their own outreach ideas.

Tuesday followed an intense training on project management, delivered by Dr Fraser Robertson from Fistral. The fellows learned how to apply project management methodology to their research projects and started to work on their outreach project ideas. This was followed by a workshop on research commercialisation by Ms Kate Lowes from Inventya and a talk by Dr Alexandra Alexandrova, former LA³NET fellow and owner of the company D-beam, who shared her own experience. The day concluded with a public talk by Dr Simon Jolly from University College London, presenting *Treating Cancer with Accelerators*.

Wednesday started early as the participants set off to the Cockcroft Institute in Daresbury. The morning was devoted to practical presentation skills training in sub-groups, which included video recording and feedback from supervisor and other fellows in the room. In the afternoon the group visited Daresbury accelerator labs, which was preceded by an overview talk by Dr Lee Jones from the Cockcroft Institute. After the busy day the group enjoyed a

social evening out at the go-karting track in Warrington, full of fun and friendly competition.

The following day, the fellows were introduced to Intellectual Property Rights by Mr Richard Bray, Patent Attorney from Appleyard Lees. Afterwards, OMA Project Manager Ms Magda Klimontowska gave a presentation on practical aspects of a European Training Network, and Prof Welsch presented important tips on international collaborations. The fellows spent most of the day working in sub-groups, finalizing their proposals and organizing their group work within a very challenging time frame.

The last day of the school was focused on presentations of the outreach projects by each group and a peer-review process. In the morning Dr Dave Joss from the University of Liverpool gave a talk about the rules of peer-review, which later helped to discuss and evaluate each project, as well as vote for the best outreach proposal.

The school was concluded by Prof Welsch, who summarized the fellows' achievements of the whole week. **The group is looking forward to the next AVA event.**

AVA welcomes first Fellows

Fourteen Fellows have already been recruited to the AVA project. Below we present the ones that have recently started work in their host institutions, with other Fellows to be introduced in the next issue.

Welcome to AVA!

Bianca Veglia studied Physics at the University of Turin. During Bianca's bachelors she had the opportunity to spend a year at the Rheinische Friedrich-Wilhelms-Universität in Bonn joining their Erasmus program.

She got her masters degree in Theoretical Physics in 2015 and subsequently started to work as a credit risk management analyst for a big consulting company.

Bianca joined the AVA project in 2017 and will be based at the Cockcroft Institute / University of Liverpool, where she will develop a project on *"Beam Stability and Life Time in Low Energy Storage Rings"*.

Mattia Fani joined the AVA project as a PhD student in physics from the University of Genova (Italy) in the discipline of experimental physics in fundamental interactions.

He earned his Master's Degree in physics at the Alma Mater Studiorum - University of Bologna with a specialisation in nuclear and subnuclear physics. During his thesis work he took part in the ALICE Collaboration at CERN. His work showed how the time-of-flight detector could acquire four times more data in proton-proton collisions without any additional cost by relying on electronics and a triggering system already available at that time. He also worked at LNGS in the realization of a high collection efficiency detector for applications in experiments on the direct detection of dark matter.

In April 2017 he was enrolled by CERN as a fellow working towards a measurement of the behaviour of antimatter in a gravitational field in the framework of the AEgIS experiment at the Antiproton Decelerator (AD).

Miha Cerv studied electrical engineering at the University of Ljubljana. He finished his bachelor's degree in 2012. When he started his master's studies, he also started working at the Institute of Josef Stefan as a student. There he designed a devices that were used at the insitute and at CERN. He turned one of the projects into his master thesis, which he completed in 2017.
During his studies, he did an internship at CERN, where he was working with FPGA chips and diamond detectors.

In 2017 he joined the AVA project and is now located in Vienna, at CIVIDEC, where he works on diamond detectors for beam characterization.

Upcoming Events

2017 International Beam Instrumentation Conference (IBIC 17)

IBIC 17 takes place in Grand Rapids, Michigan, USA, on 20th - 24th August 2017.
IBIC is a gathering of the world's beam instrumentation community and is dedicated to exploring the physics and engineering challenges of beam diagnostic and measurement techniques for particle accelerators worldwide.

The University of Liverpool's Project T.E.A.M. will represent the AVA project at the conference and industrial exhibition.

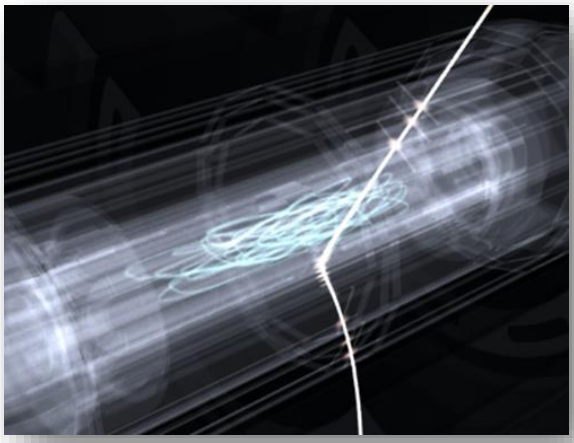
You can visit us at booth #107.

International Conference on Exotic Atoms and Related Topics – EXA2017

The EXA2017 is the 6th edition of the EXA conference series, and will take place in Vienna, Austria, from September 11th to 15th, 2017. It is organized by the Stefan-Meyer-Institute for Subatomic Physics of the Austrian Academy of Sciences.

More information can be found here

Antiproton physics in the ELENA Era – Scientific Meeting



The CERN Antiproton Decelerator supplies antiprotons to a lively scientific programme. The imminent addition of the ELENA machine will massively increase both the availability and the number of low energy antiprotons. The meeting gathers experts from all across antiproton science to discuss their vision of the new opportunities presented by this step change and how they will profit from and exploit them.
The meeting will take place in Newport Pagnell, Buckinghamshire, UK on 4th – 5th September 2017.

More information can be found here

Vacancies

AVA Project Manager – Full details and how to apply can be found here.

Early Stage Researcher Fellowship within the AVA project at Cosylab d.d.
More information can be found here: https://www.liverpool.ac.uk/ava/projects/cosylab/

Postdoc Opportunity
The High Luminosity (HL) upgrade of the Large Hadron Collider (LHC) at CERN requires advanced beam simulation studies to fully exploit the machine performance. There is currently a position vacancy at the University of Liverpool/Cockcroft Institute that will look into longitudinal and transverse beam motion in preparation of crab cavity tests at CERN. If you are interested in further details, please contact Prof Welsch.

Fellowship Opportunities
We invite expressions of interest for a number of prestigious Fellowships and grants, including ERC Starting and Consolidator Grants, Marie Curie Fellowships, and STFC Rutherford Fellowships all year around. These funding schemes offer outstanding supporting and developing opportunities for time frames between 2-5 years and are an ideal platform for those who have already demonstrated their potential as outstanding researchers. We can provide access to world-class research infrastructures and help you develop your proposal into a competitive bid. If you are interested in further details, please contact Prof Carsten P Welsch at c.p.welsch@liverpool.ac.uk

Selected Events

IBIC'17
20th - 24th August 2017, Grand Rapids, MI, USA

Antiproton physics in the ELENA Era
4th – 5th September 2017, Kavli Royal Society Centre, Newport Pagnell, UK

EXA2017
11th – 15th September 2017, Austrian Academy of Sciences, Vienna, Austria

2nd OMA School – Monte Carlo Simulations
6th - 10th November 2017, LMU Munich, Germany

Please email us your stories, news articles, events and position vacancies to share them with the antimatter community!

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