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## ELENA Commissioning, FAIR Future and AVA

**The summer 2016 could hardly be more exciting for the antimatter research community.** With ELENA commissioning making very good progress, an exciting new facility will soon benefit all experiments at the AD. In this edition of the MIRROR we have asked PhD candidate James Hunt, who is currently spending 4 months at CERN to contribute to the commissioning, to present his views on this exciting phase of ELENA. Furthermore, FAIR council has made an important announcement in July which is outlined below and which was also commented on recently in an article in [Science](#). This is very good news and we all hope that the project can now advance according to the (new) plans. Finally, a brand-new European project on low energy antimatter research, AVA, has just been approved by the EU. This Innovative Training Network will be supported with 4 M€ of funding from the H2020 programme. We are optimistic that this will further boost enthusiasm for what is already one of the most exciting research areas.

With our very best wishes

*Carsten, Thomas and Jochen*

## News from FAIR

**International support for FAIR accelerator – Shareholders meet in Darmstadt and approve developments** Members of the international council of the future accelerator facility FAIR and the supervisory board of GSI have responded very positively to current developments at FAIR and GSI. At their most recent meeting in Darmstadt, delegates of the nine partner countries who are realising the new large-scale research institution alongside Germany welcomed FAIR's organisational restructuring and the further development of the strategy for the facility's construction.

**Following the FAIR Council's decision** in late September 2015 on the overall scope of the FAIR facility, the management team in Darmstadt was able to begin intensive work on defining the orientation and framework conditions of the FAIR project. The result is a new overall structure that merges the GSI Helmholtz Centre for Heavy Ion Research and FAIR GmbH at organisational level.

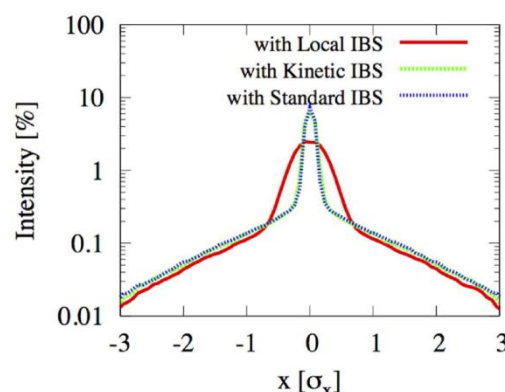


## A Cool Investigation into Antiproton Beam Dynamics

A paper that has just been published in *Nuclear Instruments and Methods in Physics A* will help scientists provide higher quality antiproton beams to experiments at CERN and antimatter facilities across the world.

“Non-Gaussian beam dynamics in low energy antiproton storage rings” by J. Resta-López, et. Al presents simulation studies undertaken to investigate the effects of beam heating phenomena present in antimatter decelerators.

Currently most, if not all, antimatter experiments rely on low energy antiproton beams as a means to study the fundamental properties of antimatter. As a result, particle “accelerators” are used in a more unusual way to reduce the energy of, and slow down anti-particles. Once such “decelerator” is currently undergoing construction at the Antimatter Factory at CERN and is due for completion later this year. The Extra Low Energy Antiproton Decelerator (ELENA) ring will provide several experiments with higher intensity and lower energy beams than they have had before – speeding up the process of obtaining answers to fundamental questions about the universe. However, during the deceleration and storage process the beam experiences heating effects, causing the beam to “blow up” in phase space and if unmonitored and ignored, become unusable.



ELENA's deceleration cycle, which includes breaks where electron cooling is applied to counteract undesirable heating effects.

**Using ELENA as a case study**, the paper investigates how cooling instruments such as the electron cooler can counteract these negative effects, and what this will mean for the shape and characteristics of the beam when it reaches the experiments. The paper presents several methods for simulating the beam evolution under these conflicting forces, eventually suggesting the best model and showing the distribution of the beam after the deceleration and cooling process. The paper marks an important step towards understanding how to best control and manipulate some of the more mysterious matter in the universe.

### Further information:

J. Resta-López, J.R. Hunt, C.P. Welsch, “Non-Gaussian beam dynamics in low energy antiproton storage rings,” *Nucl. Instr. Meth. A* **834** (2016), p. 123-131.

<http://dx.doi.org/10.1016/j.nima.2016.08.003>

## Antimatter research boosted by almost 4 M€ funding from the EU

*The AVA project will promote collaboration and train 15 Fellows in low energy antimatter research*



**Innovative Training Networks are funded within the H2020 programme as part of the Marie Skłodowska-Curie actions.**

They are awarded on a highly competitive basis with success rates ranging between 5-7% only, making them one of the most competitive funding schemes in Europe. They bring together universities, research centres and companies from different countries to train a new generation of researchers. The funding boosts scientific excellence and business innovation, and enhances researchers' career prospects through developing their skills in entrepreneurship, creativity and innovation.

**The project AVA** (*Accelerators Validating Antimatter physics*) has just been selected for funding. It joins no less than 4 universities, 8 national and international research centres, as well as 13 partners from industry at project start.

Within AVA, the project partners will pursue a closely connected R&D program across three scientific work packages. The first one focuses on facility design and optimization, addressing beam life time and stability issues in lowest energy storage rings, as well as beam cooling, deceleration and extraction processes.

Work package 2 addresses the design, development and testing of novel beam diagnostics and in particular the establishment of a dedicated test stand, to fully determine the characteristics of an antiproton beam. Finally, novel low energy antimatter experiments will be enabled through R&D into beyond state-of-the-art beam handling, storing and analysis techniques.

A total of 15 Fellows will be recruited and all will carry out their respective research project, as well as follow a structured combination of local and network-wide trainings. This will include hands-on training on accelerator facilities, as well as international Schools, Topical Workshops and Conferences that will all be organized by the AVA consortium.

Prof. Welsch, Head of the Physics Department at the University of Liverpool and coordinator of AVA said: *"AVA is a fantastic opportunity for the low energy antimatter research community. It will attract a lot of new talent into an exciting field of science and, through numerous events, will allow us to enhance communication and knowledge transfer. With research targeting both, the AD and ELENA facilities at CERN, as well as the future FLAIR facility at FAIR, the network is ideal for addressing both current and future research challenges."*

**The network will recruit its Fellows for start in spring/summer 2017. The deadline for applications is 31<sup>st</sup> January 2017** and the project kick-off meeting, gathering all project partners will be held in Liverpool on 12<sup>th</sup> -13<sup>th</sup> January 2017. More information about AVA can be found on the project home page: [www.ava-project.eu](http://www.ava-project.eu).



*This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 721559.*

## ELENA Shaping Up to Change the Future

*By James Hunt, PhD student at the University of Liverpool/Cockcroft Institute who is currently on a 4-month secondment at CERN to take part in the ELENA commissioning.*

**The Extra Low Energy Antiproton (ELENA) ring at CERN will enable experiments to receive lower energy and higher intensity antiproton beams – leading to a 10-100 fold increase in trapping efficiency.** It will also allow extra beam for an additional experiment, Gbar, which will investigate the effects of gravity on antimatter.

ELENA is currently undergoing construction and is foreseen to begin commissioning mid to late October this year. The machine is beginning to take shape with most of the bending and focusing magnets in place, a majority of beam diagnostics

installed and the vacuum system undergoing the “bake-out” process to ensure the best vacuum possible. A dedicated source has been introduced to the area in order to commission the machine with protons before connecting ELENA to the Antimatter Decelerator and the experiments using a new system of electrostatic transfer lines.

Many world firsts and ground-breaking achievements have been realised at CERN’s “antimatter factory” already, and ELENA is almost ready to ensure there are many more in the months and years to come!



Overview of the ELENA ring



## Mirror Symmetry under the Microscope

By Ralf Lehnert



M. Doser updating the audience on AEgIS (photo by A. Kostelecký).

**Mirror symmetry—known as CPT invariance—is guaranteed in the present-day physics by the famous CPT Theorem.** It implies that nature's mirror is perfect: matter and antimatter behave identically. But many experts anticipate CPT symmetry could be broken in an underlying unified theory, producing tiny observable differences between matter and antimatter at presently accessible energy scales.

To discuss prospective violations of CPT invariance and its accompanying Lorentz symmetry, about 120 experts from five continents gathered at Indiana University Bloomington June 20<sup>th</sup> – 24<sup>th</sup>, 2016 for the 7<sup>th</sup> Meeting on CPT and Lorentz Symmetry. Their primary mission: to scrutinize nature's mirror for possible microscopic imperfections.



From left to right: W. Bertsche, E. Widmann, and A. Kostelecký (photo by N. Russell).

A general and model-independent description of possible CPT and Lorentz violation in nature is provided by the Standard-Model Extension (SME), developed by Alan Kostelecký and coworkers at Indiana University about two decades ago. The SME is nowadays the framework of choice for analyzing tests of spacetime symmetries, including matter–antimatter comparisons. Conference delegates discussed the most recent theoretical SME developments, including new signals predicted for the CPT-violation phenomenology of antihydrogen, trapped particles and antiparticles, and various hydrogenic systems.

**Recent significant strides in antiproton physics** featured prominently at the conference with at least one presentation per day by AEgIS, ALPHA, ASACUSA, ATRAP, BASE, and GBAR, all of which have excellent SME reach. Key topics involved testing the gravitational interaction of antimatter (P. Crivelli, M. Doser), the charge of antihydrogen (W. Bertsche), results and efforts to measure the antiproton magnetic moment (G. Gabrielse, C. Ospelkaus), and the in-flight spectroscopy of antihydrogen (E. Widmann).

Important SME predictions for CPT violation extend also to other antimatter systems. In particular, a number of plenary talks covered the latest advances and exciting future prospects in neutral-meson interferometry (A. Di Domenico, K. Schubert, J. van Tilburg, R. Van Kooten,) and antimuon physics (K. Ishida, K. Kirch, K. Shimomura).

Signals from violations of CPT and Lorentz symmetry could also appear in a broad range of other physical systems, as reflected in the wide variety of cutting-edge topics presented at the conference. These included atomic and nuclear spectroscopy, matter-wave interferometry, cosmic radiation, neutrino oscillations, lunar laser ranging, gravity-wave interferometers, short-range gravity measurements, and microwave cavities, and they stimulated numerous cross-disciplinary discussions.

## Upcoming Events

### SPARC Topical Workshop

**The preliminary program of the 13<sup>th</sup> SPARC Topical Workshop is now available on the [conference web-page](#).**

The abstract submission deadline has now passed by and poster sessions are being finalized on the basis of the received contributions.

### Novel Accelerators Workshop

**Lasers will play a key role in the development of future particle accelerators by increasing the achievable acceleration gradient significantly, thereby reducing the size and costs of the facility.**



After twenty years of experimental and theoretical efforts in antihydrogen physics, the community is now within striking distance of probing nature's mirror symmetry with Planck-scale sensitivity. The field of CPT and Lorentz tests has been advancing at a rapid pace during this same period as well, bearing testament to its vitality. The potential is excellent for future discovery in this exciting area of physics.

Further information:

<http://www.indiana.edu/~lorentz/cpt16/>

The conference will be held 16<sup>th</sup> - 20<sup>th</sup> September, 2016 at Marian Smoluchowski Institute of Physics of the Jagiellonian University in Kraków, Poland.

A dedicated workshop which will cover the science and technology of novel acceleration schemes for ion and electron beams including:

- Laser-driven wakefield acceleration
- Dielectric laser acceleration
- Beam-driven wakefield acceleration
- Scientific, medical and industrial applications

The Workshop will take place 24<sup>th</sup> - 26<sup>th</sup> October in Paris, France. Each area will consist of invited and contributed talks of 30 minutes duration. There will also be a dedicated session to discuss future funding opportunities in view of joining all the above areas.

You will find further information on the workshop home page: <https://indico.cern.ch/event/527727/>

## Conference on "Precision Physics, Quantum Electrodynamics and Fundamental Interactions"

**This conference will be held from April 30<sup>th</sup> to May 5<sup>th</sup> 2017 in Cargese, France.** It will bring together scientists in both experimental and theoretical physics from the fields of precision physics, particle trapping, the physics of simple atomic systems, strong-field physics, quantum electrodynamics and fundamental constants, interactions and symmetries.

Oral contributions of up to 40 minutes in lengths will be distributed over the 5-day long event. In addition, research results can also be presented through posters. Early career researchers are particularly encourage to participate.

More information can be found at:  
<http://indico.gsi.de/event/cargese2017>

## Selected Research Papers

G. Tranquille, et al, *The ELENA Electron Cooler*, Proc. IPAC (2016), [TUPMR006](#)

J. Jentsch, et al., *Beam Dynamics Studies of the ELENA Electrostatic Transfer Lines in the Presence of Magnetic Stray Fields*, Proc. IPAC (2016), [THPMB047](#)

C. Carli, et al, *ELENA: Installations and Preparations for Commissioning*, Proc. IPAC (2016), [MOPOY009](#)

G. Tranquille, J. Cenede, *Design and Optimisation of the ELENA Electron Cooler Gun and Collector*, Proc. IPAC (2016), [THPMB048](#)

J.R. Hunt, J. Resta-López, et al., *Emittance Measurements in Low Energy Storage Rings*, Proc. IPAC (2016), [WEPOR052](#)

K. Bozhkov, *Design of a support system for the vertical beam transfer lines of the ELENA project*, [CERN-STUDENTS-Note-2016-183](#)

## Position Vacancies

### PhD and Postdoc Vacancies

The Matter-Antimatter Asymmetry Section of the [Helmholtz Institute Mainz](#) has opening for outstanding candidates for post-doctoral and PhD positions to tackle some of the most important questions in fundamental physics using a variety of experimental techniques including those of atomic, molecular, and optical physics, magnetic resonance, etc.

Interested qualified candidates should contact Prof. Dmitry Budker at [budker@uni-mainz.de](mailto:budker@uni-mainz.de)

### Research Coordinator

There is a position vacancy for an experienced research coordinator in the QUASAR Group, based at the Cockcroft Institute on the campus of Daresbury Laboratory. The Group carries out a broad and interconnected research program into accelerator design and optimisation, as well as advanced diagnostics for charged particle beams. We are now looking for an outstanding researcher who can make important contributions to our wide-ranging research and training program. This includes frontier accelerators, novel accelerators and accelerator applications. The post will give ample opportunities to participate in, lead and grow our research activities, make contributions to teaching and student supervision, and help in the coordination of a number of major European projects.

To find out more and to apply, please visit:

<https://www.liverpool.ac.uk/working/jobvacancies/currentvacancies/research/001531/>

### PhD Position

#### Study of Filaments and Spokes in Magnetized Plasmas

There is a PhD position opening for start 1 October in the group of Prof. James Bradley at the University of Liverpool. The project involves a detailed plasma diagnostic study of fast rotating spoke and filament structures in magnetized (magnetron) plasma discharges and their relationship to the generation of energetic ions. The project will provide a close collaboration with the ASTEC group (Cockcroft) at Daresbury UK who are using these types of plasma discharges to deposit superconducting thin films for RF accelerating beam cavities and wish to characterize and understand how high-energy metal ions from the plasma can improve their deposition process. Opportunities to travel include to our collaborators in the Czech Republic.

Contact: [j.w.bradley@liv.ac.uk](mailto:j.w.bradley@liv.ac.uk)

*Please keep us informed about vacancies at your institution.*



## Selected Events

### International Beam Instrumentation Conference (IBIC16)

11<sup>th</sup> - 15<sup>th</sup> September 2016, Barcelona, Spain

### Sparc Topical Workshop

16<sup>th</sup> - 20<sup>th</sup> September 2016, Kraków, Poland

### LA<sup>3</sup>NET Laser Ion Source Workshop

24<sup>th</sup> - 25<sup>th</sup> October 2016, Paris, France

### LA<sup>3</sup>NET Novel Accelerators Workshop

24<sup>th</sup> - 26<sup>th</sup> October 2016, Paris, France

### Conference on "Precision Physics, Quantum Electrodynamics and Fundamental Interactions"

30<sup>th</sup> April - 5<sup>th</sup> May 2016, Paris, France

*The collaboration is often requested to present research highlights and suggest good speakers to various program committees. If you think you or your work should be highlighted, please do not hesitate to get in touch with us.*

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

[www.flairatfair.eu](http://www.flairatfair.eu)

Spokesperson  
Prof. Dr. Carsten P. Welsch  
University of Liverpool/Cockcroft Institute, UK  
[carsten.welsch@cockcroft.ac.uk](mailto:carsten.welsch@cockcroft.ac.uk)

**FLAIR**  
Facility for Low-energy Antiproton and Ion Research

Co-Spokesperson  
Prof. Dr. Thomas Stöhlker, GSI, Darmstadt, Germany  
[t.stoehlker@gsi.de](mailto:t.stoehlker@gsi.de)  
Prof. Dr. Jochen Walz, JG University Mainz, Germany  
[jochen.walz@uni-mainz.de](mailto:jochen.walz@uni-mainz.de)