NEWSletter

MIRROR

Issue 24 December 2023

Highlights

- Breakthrough in understanding gravitational effects on antimatter
- Final sprint: Installation of the large FAIR ring accelerator SIS100 approaches
- Dr Ralph Aßmann heads accelerator operation and development at GSI/FAIR

Dear friends of low energy antimatter physics,

Despite a number of global challenges, 2023 has been a good year for the antimatter physics community. It was finally time again to take data at CERN's Antiproton Decelerator after some experiments had been in hibernation for a few years. This data will now form the basis for exciting new physics and first results are already available: This issue of the MIRROR features the latest news from ALPHA that Newton's "anti-apple" also falls down in the gravitational field of the earth. Whether or not this would be the case is a very fundamental question that until now had not been answered in an experiment. A recent *Nature* paper finally gave the long-anticipated answer; this measurement was recently identified as a Physicsworld Top 10 Breakthrough of the Year for 2023. **Congratulations!**

The AVA project targeted improved training standards for postgraduate researchers and produced many remarkable successes. I was delighted to receive an invitation from the EU to talk about best practice in researcher training, and in particular how synergies between large-scale training initiatives can be used to the benefit of project partners and Fellows. In AVA, we organized several training events jointly with other large-scale projects such as OMA and LIV.DAT, and these interdisciplinary events enriched the training of all Fellows, created many interesting links between projects, and – in some cases – even led to additional and exciting career opportunities.

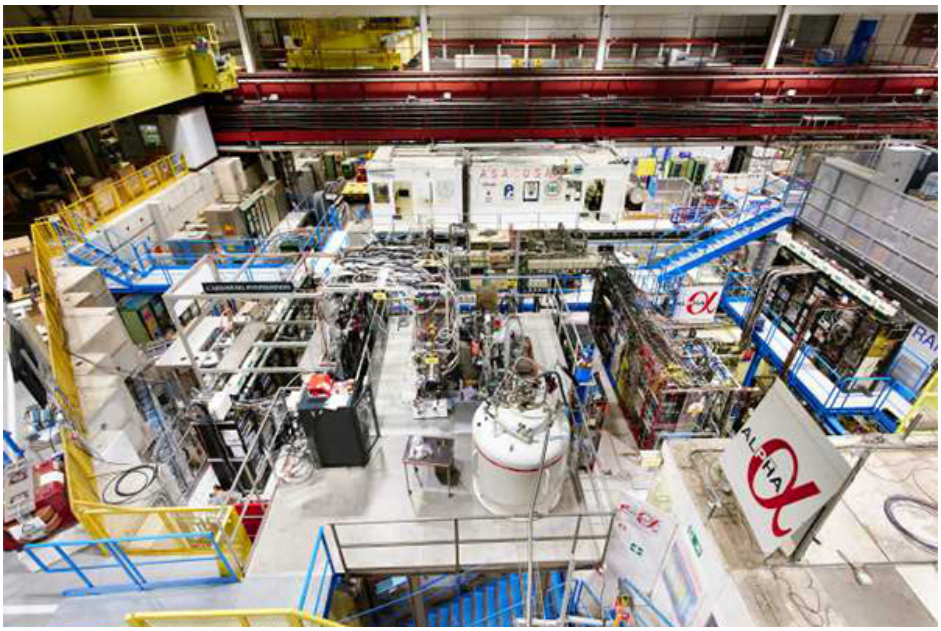
Another training element that AVA pioneered was the production of a short science video about the project. Produced by the network's Fellows in close collaboration with media experts, *"AVA – Nature (anti)matters"* became the most-viewed science video on the EU's official playlist and was highlighted as best practice in science communication a few years ago. The new EuPRAXIA Doctoral Network followed into AVA's footsteps and film production took place last month. The final cut has just been finished and the video will be released in early 2024. I can't wait!

Wishing all readers of the MIRROR a joyous Christmas season and a good start to the New Year!

Prof Carsten P Welsch, Editor

Research Updates

Breakthrough in understanding gravitational effects on antimatter



Aerial view of the ALPHA experimental area in the AD hall. (credit: J.M.Ordan/CERN)

In a paper recently published in *Nature*, the ALPHA collaboration at CERN's Antimatter Factory shows that, within the precision of their experiment, atoms of antihydrogen – a positron orbiting an antiproton – fall to Earth in the same way as their matter equivalents.

Einstein's general theory of relativity described the effects of gravity in 1915 and has passed many experimental tests since then. A component of the theory called the weak equivalence principle states that all objects, regardless of their mass or composition, should experience exactly the same gravitational acceleration. Although the prevailing view is that antimatter should behave in the same way as matter in response to Earth's gravitational pull, it has been extremely difficult to test whether this is true because antimatter annihilates whenever it meets its opposite particle.

The ALPHA collaboration creates antihydrogen atoms by taking negatively charged antiprotons, produced and slowed down in the Antimatter Factory's AD and ELENA machines, and binding them with positively charged positrons accumulated from a sodium-22 source.

In 2018 the ALPHA collaboration from CERN constructed the ALPHA-g machine, a magnetic trap for antihydrogen atoms, designed to study the effects of gravitation. It confines the neutral – but slightly magnetic – antimatter atoms, which prevents them from coming into contact with matter and annihilating.

This machine makes it possible to measure the vertical positions at which the antihydrogen atoms annihilate with matter once the trap's magnetic field is switched off, allowing the atoms to escape.

In their investigations the ALPHA researchers slowly released antihydrogen atoms suspended within the ALPHA-g machine and tracked their subsequent motion. If more spill out of the bottom than the top it is likely that antimatter atoms behave in the same way as regular matter. With this experiment, Jeffrey Hangst and colleagues observed a tendency for magnetically trapped antihydrogen atoms released into ALPHA-g to fall from the bottom of the apparatus.

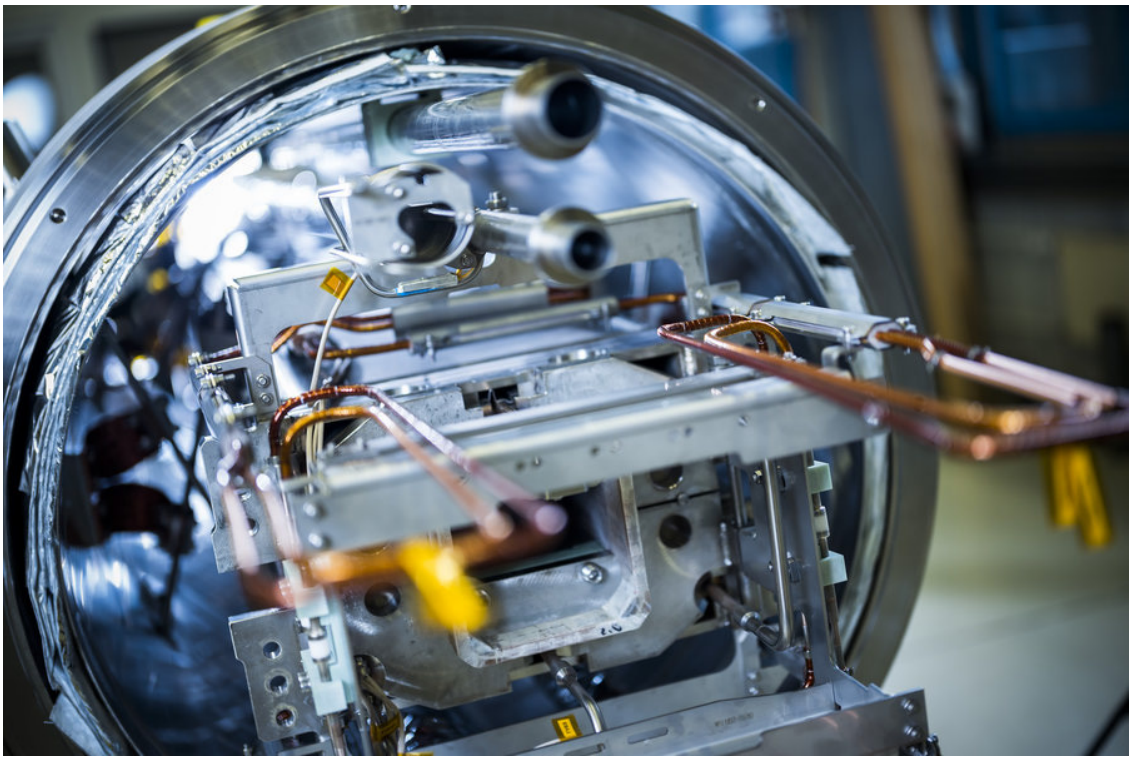
These findings confirm the prevailing view that antimatter should feel the effects of gravity the same way as for ordinary matter, in agreement with the predictions of general relativity. The work paves the way for future tests of the weak equivalence principle, which may improve our understanding of the gravitational nature of antimatter, the authors conclude.

Full article:
Anderson, E.K., Baker, C.J., Bertsche, W. et al. Observation of the effect of gravity on the motion of antimatter. Nature 621, 716–722 (2023). https://doi.org/10.1038/s41586-023-06527-1

Further information:
https://home.cern/news/news/physics/alpha-experiment-cern-observes-influence-gravity-antimatter
https://www.nature.com/articles/d41586-023-03043-0

Video release:
https://videos.cern.ch/record/2298631

Final sprint: Installation of the large FAIR ring accelerator SIS100 approaches



SIS100 dipole magnet -view inside the magnet (Credit GSI/FAIR)

While the structural works on the construction site is progressing and the development and production of the high-tech components for the future FAIR accelerator center is underway, the next decisive steps are being taken for the large FAIR ring accelerator SIS100: The assembly of the accelerator machine in the newly constructed buildings is being prepared, and the final sprint towards the installation start of the SIS100 has begun. The people responsible for the relevant subprojects recently met for a closed meeting focusing on this topic. The installation start is scheduled for the first quarter of the coming year.

A plan has already been drawn up so that the installations can be carried out precisely and accurately, step by step. Numerous different aspects, such as delivery windows and the type of magnets, must be exactly coordinated and logistically mastered so that the accelerator components fit together precisely in the shell like a gigantic jigsaw puzzle.

The start of the SIS100 installation will be in the straight of the western sector 4. From there, the installation will continue clockwise toward the sector 3 arc. While the straight line in sector 4 is dominated by high-frequency acceleration systems, the arc consists largely of superconducting magnet modules. Due to the supply situation of the quadrupole modules required for beam focusing, the superconducting dipole pairs are first set up in the arc and interconnected. They guide the beam onto the hexagonal "circular path" of the SIS100.

The installation begins in the straight section with the positioning of the superconducting bypass lines, which were manufactured as a Polish in-kind contribution. The bypass lines transport the liquid helium required for magnet cooling and the superconducting main bus bar system passing the room temperature components of the straight sections. The bypass lines are first moved to a parking position, from which they are then moved and connected to the quadrupole modules after delivery is complete. Gaps are left in the first assembly cycle for the quadrupole modules to be integrated in the second cycle.

Since the tunnel is still in settlement motion, the later integration of the quadrupole modules also leaves freedom of movement for fine adjustment. The extraction straight in sector 5 will initially be kept open for equipping the high-energy beam transport system, including heavy magnet systems. The expansion of the SIS100 tunnel with the technical building equipment, double floors and routes is in full swing. In the second half of 2023, cable pulling work will be carried out with a focus on sector 4.

On the home stretch until the end of the year, extensive work still needs to be completed in preparation for assembly. For example, various smaller subassemblies for closing the UHV (ultra-high vacuum) system have to be procured, pre-integration work completed and comprehensive documentation prepared for each subassembly. Then the installation itself can begin, another crucial milestone and a sign of the steady progress being made in the construction of FAIR.

In parallel, science is also taking major steps towards future research at FAIR. The FAIR experimental program is currently being defined more and more precisely, for example during research stays of high-ranking scientists on site at GSI and FAIR or in the collaborations of the large experiment pillars. Already today, "FAIR-Phase 0" offers outstanding experimental opportunities. In the future, the FAIR accelerator facility will deliver high-energy ion beams of highest intensities. In combination with the Super-Fragment-Separator, storage rings and cutting-edge instrumentation, it will provide worldwide outstanding research opportunities.

This article is based on an original article published on the FAIR website

News from the Antimatter Community

Liverpool expert invited by EU to share best practice in PGR training

Each year the European Commission organizes a briefing day for coordinators of new networks funded within the Marie Skłodowska-Curie Actions (MSCA). The main objective of these events is to provide a briefing on the key management and procedural aspects of the project life cycle, on how to comply with the MSCA rules under Horizon Europe, and to share and discuss best practice.

This year's event took place on 8 and 9 November in Brussels and was streamed to more than 1,000 project coordinators, managers and researchers. For the first time, it included a session to raise awareness on networking opportunities and potential synergies between projects.

AVA Coordinator Professor Carsten P Welsch, who has initiated and coordinated no less than six MSCA networks across physics, engineering and life sciences over the past decade, was invited to talk about his experience in fostering networking and synergies, the additional opportunities for project partners and Fellows that have arisen from these collaborations, and examples of some of his highly successful initiatives.

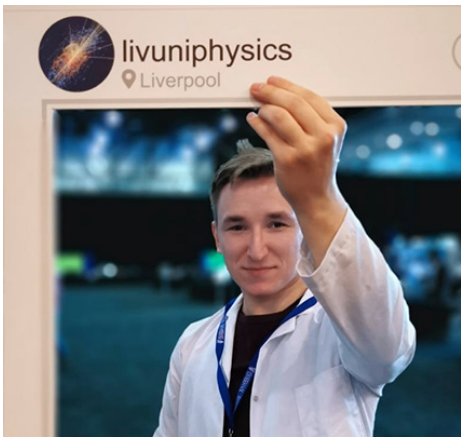
Professor Welsch said: *"We have seen enormous advantages from working across large scale postgraduate training programmes: Firstly, international and cross-sector collaboration has helped us boost interdisciplinary R&D, and this has driven cutting-edge science and innovation. In addition, by jointly hosting researcher skills trainings between several networks and doctoral training centers, we have successfully developed new skills of early-stage researchers, helped them establish new contacts and maximized their employability. Finally, we have seen that collaboration in the areas of communication and outreach was key to maximizing both, reach and impact. It was a great pleasure sharing the experiences we have made over several framework programs and in particular also in the AVA project with the leaders of new networks."*

'MSCA DN 2022 - Raising awareness on networking opportunities and synergies':

https://www.youtube.com/watch?v=5veoJf09L_s

Panel conversation during the 2023 MSCA Info Day.

AVA Fellow Volodymyr Rodin completes his PhD



Volodymyr Rodin

AVA Fellow Volodymyr Rodin has recently completed his PhD in the QUASAR Group at the University of Liverpool/Cockcroft Institute.

In his PhD project, Volodymyr investigated 6D beam dynamics in low energy ion and antiproton storage rings and beamlines. His goal was the realistic description of an experimental setup under consideration of all the real-world effects ranging from fringe fields, stray fields, space charge, etc. to give an accurate representation of the beam transport and handling in simulation. This required advanced simulations of stored beams, targets, as well as of all magnetic and electrostatic extraction, guiding and imaging fields that are part of each setup. Such a comprehensive simulation suite did not exist before the start of his studies but is now available and will serve as a template for low energy beam transport studies for years to come.

The optics design resulted in the `starship' chamber which allows injection from two ion sources, as well as antiprotons from ELENA, into the AEgIS experiment. The addition of the ion sources was an exciting development that opened new areas of research for the AEgIS collaboration.

During his time as a PhD student Volodymyr won the first prize at the Cockcroft Institute Postgraduate Conference in 2019 for presenting his work on beam tracking studies in ELENA transfer lines. He also won the prize for the Best Sustained Contribution in the 2021 Cockcroft Institute Early Career Excellence Awards.

Volodymyr said that the highlights of his time as a PhD student were winning the awards and forming two productive collaborations during his project working on AEgIS and working with staff from TU Vienna.

Since finishing his PhD studies Volodymyr has moved onto a new project as a CERN Senior Fellow, and this is a giant leap in terms of particle beam energy. From working on the 100 keV low-energy ELENA machine he has switched to working on the 7 TeV High Luminosity LHC Project. His role in this project is to perform simulations into "beam cleaning", using enhanced collimation systems and channelling in bent crystals.

Congratulations, Volodymyr!

Dr Ralph Aßmann heads accelerator operation and development at GSI/FAIR

GSI/FAIR's business area "Accelerator Operations & Development (ACC)" has a new head: Dr Ralph Aßmann took over the position on September 1, 2023, and will in future manage GSI's existing accelerator facilities and plan the integration and commissioning of FAIR.

"GSI and FAIR have world-leading accelerator facilities in operation and, with the construction of FAIR, a new international flagship project in the pipeline. After eleven years of working with electron beams, it is therefore a fascinating task for me to return to the world of hadron accelerators, of which there are very few large facilities worldwide," Aßmann comments. "It is my goal to serve the planned user experiments with the existing accelerators in the best possible way, to make the present facilities fit for the future step by step, and, last but not least, to successfully commission the entire GSI/FAIR accelerator complex with the GSI accelerator team. Bringing these tasks together involves various challenges but also new opportunities that I, as head of the business area, will be happy to tackle with the departments and their heads."

In his work, Aßmann aims to preserve and cultivate what has been tried and tested, while integrating new and innovative approaches. He plans to foster a strengthened collaboration with regional universities to advance accelerator physics and technology and to solve challenges at GSI/FAIR. Examples include the use of advanced methods such as artificial intelligence in accelerator theory and operation, new optimization methods for particle beams, and the development of innovative accelerator structures or instrumentation. Aßmann also plans to collaborate closely on these and other topics within the Helmholtz Association and with other German, European and international partners. "With the observation of neutron star collisions in gravitational wave detectors, which is only now possible, and with innovative approaches in tumor therapy, research with ion accelerators is gaining additional momentum and new potential for discovery, both in basic research and its applications. That's where I'd like to be involved as a scientist."

About Dr Ralph Aßmann

Dr Ralph Aßmann

Ralph Aßmann has obtained his doctorate in physics from the Ludwig-Maximilians-University in Munich. His PhD research was performed at the Max Planck Institute for Physics in Munich and at CERN in the ALEPH experiment on the mass of the Z boson, spin polarized particle beams and precise energy calibration. He then spent almost four years as research associate and staff at Stanford University and SLAC, where he worked on operation, modelling and design of the colliders.

For the next 15 years he worked at CERN in leading roles on the LEP and LHC colliders. He was an LHC machine coordinator in run I of the LHC operation, that led to the discovery of the Higgs boson in 2012. In this role he helped to commission and to optimize the world-leading proton and heavy ion beams of the LHC.

In Summer 2012 he moved as Leading Scientist for Accelerator R&D to DESY, where he researched new, compact accelerators. He was awarded an ERC synergy grant together with three colleagues in 2014. Until a replacement has been identified, Dr. Assmann is the founding coordinator of the EuPRAXIA ESFRI project, a 569 M€ project on building the world-wide first user facility based on plasma-based accelerators that is supported by more than 50 institutes.

He has been the Chair of the Accelerator Group in the European Physical Society from 2020 - 2023, the proposer and initial coordinating PI of the 30 M€ Helmholtz ATHENA project, the leader of several European funding grants and coordinator of the European Network for Novel Accelerators.

This article is based on an original article published on the FAIR website

Prof Welsch contributes to THE Campus Live UK & IE

Times Higher Education (THE) Campus Live UK&IE 2023 brought together higher education leaders, industry partners and policy experts in Liverpool on 6 – 7 December 2023 to discuss, debate and plan how to achieve institutional success. One of the key areas that were discussed was equality, diversity and inclusion (EDI).

Despite significant efforts to diversify the fields of science, technology, engineering and mathematics (STEM), including Athena Swan and IOP Juno, women in these fields face persistent challenges.

AVA Coordinator Professor Carsten P Welsch was invited to join a roundtable discussion hosted by THE in partnership with City University of Hong Kong to explore how institutions can support and retain diverse talent in STEM fields. Amongst the many questions that were addressed by the high-profile panel were how the experiences of women in STEM have evolved over time, what challenges they continue to face today, and how one can inspire more women to enter STEM professions.

Professor Welsch brought his experience as Head of a physics Department and UK ambassador at the International Conference on Women in Physics into the discussion. He highlighted how the number of female Professors and research leaders in Liverpool physics was significantly increased in recent years, and also how initiatives such as the Marie Curie Day 2017 and targeted outreach events for girls' schools helped making physics more attractive.

Professor Welsch said “Boosting the visibility for women in STEM is very important for challenging stereotypes, and to inspire more women to pursue these subjects with greater confidence. This requires the careful development of talent, strategic planning of leadership roles and targeted communication and outreach campaigns.”

More information about the event including the full agenda can be found here.

Further information can be found in the following articles:

S Jordan, et al., “Women in physics in the United Kingdom: Successes, challenges, and wider diversity “, AIP Conf. 3040, 050041 (2023), https://doi.org/10.1063/5.0175698

C Andreopoulos, et al., “Liverpool women in physics: Initiatives and progress”, AIP Conf. 3040, 060007 (2023) https://doi.org/10.1063/5.0175667

Mourning Bikash Sinha

Bikash Sinha (credit GSI/FAIR)

FAIR and AVA-partner GSI mourn the loss of an outstanding scientist and one of the pioneers for the FAIR project. The Indian physicist Bikash Sinha passed away on 11 August at the age of 78.

Bikash Sinha was one of the key players and leaders in India's successful partnership with FAIR. He not only pioneered India's entry as a shareholder in FAIR but played a leading role in the conception of the FAIR scientific program. Furthermore, he was India's representative in the FAIR Council, FAIR's highest supervisory body, from its beginning in 2010 to 2021. It is largely thanks to his dedication that some 25 scientific institutions and 15 industrial partners in India are now involved in the FAIR project.

Prior to the establishment of FAIR, Bikash Sinha already had many years of successful collaborations with GSI. GSI is happy and proud for having been at the beginning of his great project of Indian international collaboration in the field of relativistic heavy ion physics.

Bikash Sinha was a world-renowned scientist and one of the outstanding personalities in science management in India. He was the director of the Saha Institute of Nuclear Physics and Variable Energy Cyclotron Centre, among others. He received numerous awards for his scientific work, including the prestigious Padma Shri and Padma Bhushan awards given by the Government of India. FAIR and GSI will have enduring memories of Bikash Sinha as an outstanding scientist, science policy maker, but most of all as a great person and a great friend. To his colleagues and friends Bikash Sinha with his attractive personality was always a source of positive energy and inspiration.

This article is based on an original article published on the FAIR website

AEgIS collaboration meeting takes place at CERN

The AEgIS collaboration convened at CERN in Geneva from 11 – 13 December 2023, for a comprehensive meeting to assess the accomplishments and advancements made in the past six months and to plan for the future of the experiment after the winter shutdown.

The meeting started with a welcome from AEgIS spokesperson Ruggero Caravita (Universita degli Studi di Trento and INFN) who also provided an overview of the agenda. The talks started with a presentation about the outreach initiatives undertaken by the collaboration. Subsequently detailed presentations on the main apparatus and the positron system were heard including discussion about performance and upgrades, and outlining plans for maintenance. An update on the current status of the Iodine source was provided, which will be integrated into the AEgIS experimental system. Insights into the performance, upgrades, and maintenance of the AEgIS antiproton trap system as well as the Data Acquisition (DAQ) and control system were also given. At the end of the first day, delegates heard updates on the performance and maintenance of the laser and of the injection/extraction line.

The second day commenced with a presentation focusing on the efficient capturing and cooling of antiprotons from ELENA, along with the trap development for physics experiments. Following this, a talk about positronium excitation to Rydberg levels in a collinear geometry was given and then trap preparations for antihydrogen production were discussed. Talks on the formation of an antihydrogen beam, emphasizing ESDA analysis, MCP analysis, and detector development respectively as well as a presentation on the formation of highly charged ions followed. Finally presentations on simulations related to the capture process of antiprotons and antiproton counting were given.

At the end of the second day a collaboration board meeting took place to discuss future experimental plans. Tomasz Sowinski (Polish Academy of Sciences) was appointed as the coordinator for financing and bookkeeping for the AEgIS experiment, while Benjamin Rienacker (University of Liverpool) assumed a new role as the physics coordinator at AEgIS.

Participants at the AEgIS collaboration meeting.

The final day of the collaboration meeting started with a presentation focusing on the visualization and dashboard for ALPACA after which micro-services for processes were discussed. A captivating talk on portable antiproton traps was heard after which anion spectroscopy was discussed. Later, talks were presented on the redesign of the new 1T region and the assembly of the new 1T MCP. Subsequently, the topic of external scintillators for antihydrogen annihilation timing was covered and then there was a talk on Doppler Shift Spectroscopy as a tool for non-invasive beam diagnostics. In the afternoon different design aspects of image plane detectors were discussed, followed by a presentation on 1s-

3s and 1s-2s Ps spectroscopy in AEgIS. An intriguing talk on the physics of positronium and its charged ions from a theoretical perspective was delivered plans for the winter shutdown and upgrade schedule were presented which was followed by a discussion on the possibilities for Ps physics during the winter shutdown.

The AEgIS collaboration meeting proved to be a dynamic and insightful event. Over the course of three days, participants engaged in comprehensive discussions and presentations, showcasing the significant progress made in the past six months.

From the efficient catching and cooling of antiprotons to the development of traps for physics experiments, and from positronium excitation to the formation of highly charged ions, the diverse range of topics addressed underscored the collaborative efforts and expertise within the AEgIS community.

United Kingdom joins Horizon Europe

As of 1 January 2024, the United Kingdom becomes an associated country to Horizon Europe, including the Marie Skłodowska-Curie Actions (MSCA).

Organisations based in the UK will be able to participate as beneficiaries in the same terms as those based in the European Union and countries already associated to Horizon Europe. This includes Doctoral Networks and Staff Exchange programmes among other coordination and support actions.

Researchers from the UK will continue to be able to participate in the programme, which is open to top researchers from all over the world. Under the previous EU framework programme for research and innovation, Horizon 2020, the United Kingdom was one of the best performing countries in the MSCA.

The University of Liverpool's QUASAR Group has played a leading role in no less than six Marie Skłodowska-Curie Networks, including DITANET, oPAC, LA³NET, OMA, AVA, and the brand-new EuPRAXIA-DN, as well as participated in many other EU projects such as EuroCirCol and EuPRAXIA.

Prof Carsten Welsch, QUASAR Group leader and AVA Coordinator, says, *“This is wonderful news! The best science and innovation comes from international collaboration as we have seen over the many projects, we have been involved in over the years. Horizon Europe is the world’s flagship science program, and it is great that UK experts can now play a leading role once again.”*

Prof Carsten Welsch to co-chair EIC Accelerator Collaboration

The Electron-Ion Collider (EIC) partner host labs, Brookhaven National Laboratory and Jefferson Lab, have announced Professor Carsten P Welsch, Head of Liverpool's Accelerator Science cluster based at the Cockcroft Institute, as co-chair of the EIC Accelerator Collaboration.

AVA Coordinator Professor Welsch has a broad experience in accelerator physics and technology, and in establishing collaborative environments with international participation. His research covers the development of advanced instrumentation, medical applications, data intensive science, antimatter physics, and novel high gradient accelerators. He has led numerous large scale international projects and is a member of a large number of advisory panels.

Professor Welsch will share his duties with Prof Andrei Seryi (Jefferson Lab and Old Dominion University). This leadership team will establish a formal international collaboration, rooted in the 2020 and 2021 EIC accelerator workshops, which attracted hundreds of participants from more than 20 countries, as well as numerous technical meetings with representatives from national and international institutions.

The construction of the EIC at Brookhaven National Laboratory marks the establishment of a world-leading facility for nuclear physics. The design, construction, and future upgrades of the EIC will have many exciting scientific and technical challenges, creating opportunities for a worldwide accelerator collaboration to become part of this exciting venture.

The EIC will be a particle accelerator that collides electrons with protons and nuclei to produce snapshots of those particles' internal structure—like a CT scanner for atoms. The electron beam will reveal the arrangement of the quarks and gluons that make up the protons and neutrons of nuclei. The force that holds quarks together, carried by the gluons, is the strongest force in Nature. The EIC will allow us to study this "strong nuclear force" and the role of gluons in the matter within and all around us. What we learn from the EIC could power the technologies of tomorrow.

Professor Welsch has a broad experience in accelerator physics and technology.

The EIC Accelerator Collaboration will benefit the EIC project, its collaborating partners, and the wider community of accelerator experts. Furthermore, it will play an important role in enhancing the developments of the evolution, upgrades, and the ultimate performance of the EIC facility.

The collaboration kick-off meeting will be held as a satellite meeting at the IPAC2024 conference in May 2024 in Nashville, TN, USA.

Further information about the EIC: https://www.bnl.gov/eic/

Position Vacancies

Open positions at the University of Liverpool/The Cockcroft Institute:

Postdoc position *Novel Gas Jet Monitors*
A Postdoc position focusing on R&D into gas jet-based beam diagnostics is available in the QUASAR Group at Liverpool University for an initial duration of 2 years. The post will be based at the Cockcroft Institute on Daresbury Science and Innovation Campus.

Application deadline 7 January 2024. More info

Postdoc position *Sustainable technologies for accelerators*
A Postdoc position focusing on R&D into sustainable technologies for particle accelerators is available in the QUASAR Group at Liverpool University for an initial duration of 2 years.

Application deadline 7 January 2024. More info

Furthermore, the QUASAR Group offers several ***PhD positions*** over a range of projects. Find out more

Events

18th – 24th May 2024	15th International Particle Accelerator Conference (IPAC24), Nashville, USA
25th – 30th August 2024	LINAC24, Chicago, USA
7th – 12th July 2024	Early Career Conference on Trapped Ions
26th – 30th August 2024	ECA/LEAP 2024, Vienna, Austria
9th - 30th September 2024	13th International Beam Instrumentation Conference (IBIC), Bejing, China
27th Oct – 1st Nov 2024	International Workshop on Positron and Positronium Chemistry
7th - 11th September 2025	14th International Beam Instrumentation Conference (IBIC), Liverpool, UK

Notice Board

Help us communicate interesting events, updates and latest R&D in antimatter physics and send us your news and updates.

MIRROR – A newsletter for friends of antimatter physics

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