NEWS letter MIRROR

Issue 23 July 2023

Highlights

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Dear friends of low energy antimatter and ion physics,

It is a great pleasure sharing this MIRROR with you. We are delighted to share a range of news about the various antimatter research collaborations at CERN, our (past) AVA Fellows and recent publications and events with you. The beams are currently ON at the Antiproton Decelerator and clearly we expect that many more news – and exciting research results – will be coming up very soon. So please continue to share these with us and we will be delighted to include them here in the MIRROR – the newsletter for all things antimatter.

The identification of the best possible training for future generations of scientists and engineers remains an international priority. Just last week I spoke with the Research Executive Agency (REA) about the benefits that come from cross-disciplinary collaboration between researcher training programs as we have experienced these first-hand in AVA: From our researcher skills school to our scientific symposium, we shared many aspects of our network with another major European training initiative, the OMA network, as well as the centre for doctoral training for data intensive science, LIV.DAT. This has led to more impactful events, significantly wider reach and impact of all communication, and also for unexpected career moves – in this newsletter, you will read that one of our AVA Fellows ended up now working on medical accelerators – a link established through the above events. Research is international and requires the best experts to work together across country and disciplinary boundaries. MSCA networks remain one of the driving forces to build bridges between communities and I am sure we will see more of the "AVA model" to researcher training in the future.

Prof Carsten P Welsch, AVA Coordinator

Research News

FAIR Booster accelerator operation demonstrated for the first time

Heavy-ion synchrotron SIS18 - exterior view. (Image credit: GSI)

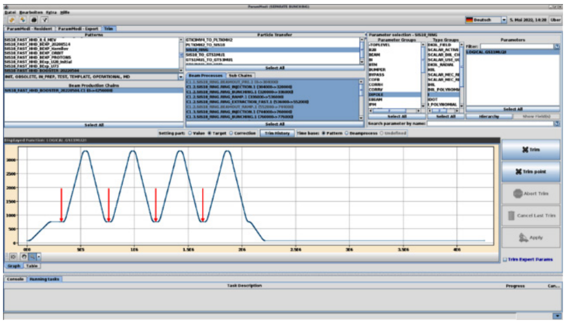
The ring accelerator SIS18 on campus at AVA partner institute GSI/FAIR in Darmstadt, Germany has been doing powerful work in accelerating ions for years.

It is being upgraded for the central task it will undertake for the future FAIR accelerator centre. The FAIR facility will provide beams of ions as well as antiprotons for scientific experiments.

SIS18 will serve as the injector for the large FAIR ring accelerator SIS100, the heart of the FAIR facility currently under construction at GSI. For the first time, booster operation has now been realized at SIS18, achieving the high repetition rate that will be needed in the future to reach the highest intensities at FAIR.

With the future requirements for FAIR, the operation of SIS18 will be fundamentally different from the current operation to supply experiments: To achieve the planned highest intensities in the five times longer SIS100, the SIS18 must accelerate and extract the ion beam four times per second. This results in a repetition rate of 2.7Hz, significantly higher than the maximum rate of 1Hz that has been common in experimental operation so far. Operation with heavy ions with low charge states, as intended for FAIR (the highest intensities can only be achieved with these), further increases demand on the devices.

To enable booster operation, which was not previously required to operate the current experimental program at GSI, various technical changes have been made over the past 15 years as part of an extensive upgrade program. In particular, the performance of the main power supplies and the high-frequency acceleration systems were improved to achieve the shortening of the acceleration cycle required for booster operation.



SIS18 machine cycle in booster mode (current curve of the deflecting magnets). The red arrows mark the times of injection from the UNILAC.

Realizing the high ramp rate of the magnetic field in the SIS18's deflecting magnets of ten tesla per second is very challenging. It requires the magnetic current to be brought up to a maximum current of 3500A at a rate of 19,000A/s. The current generated by the power supply must not deviate from the specified profile by more than 0.01 percent at any time. These requirements can only be met by special power supply units with outstanding control characteristics. The high-frequency facilities of SIS18 were extended by a group of broadband Magnetic Alloy cavities, which together provide an accelerating voltage of 40kV in the frequency range from 0.4 to 1.6 MHz. Only with these cavities can the energy of low charge state heavy ions be increased sufficiently per revolution to follow the fast magnetic ramp.

Taking all devices together, the SIS18 reaches pulse powers in the range of 50 MW in booster operation. A special characteristic of the SIS18 is that, unlike other very fast-pulsed synchrotrons, it is not constructed as part of an oscillating circuit and thus always delivers the same pulses at a fixed repetition frequency. Instead, it offers the flexibility to change the settings of all devices from cycle to cycle to supply the various experiments.

In addition to the technical demands on the SIS18 equipment, booster operation also brings new challenges for the timing control systems due to its high repetition rate. For example, it must be ensured that the four injections from the linear accelerator UNILAC take place exactly when the SIS18 is ready for injection, without having to wait at this point as they would in normal operation. In order to demonstrate the booster operation, the control systems were adapted in such a way that the injections could be performed with a known procedure, previously used for the "multi-multiturn injection". With this intermediate step, a U28+ beam could be accelerated and extracted at a repetition rate of 2.3Hz for the first time.

After this first successful booster demonstration, extensive further developments in the control system for FAIR are required for the next step of the routine realization of booster operation. In particular, the timing system for the UNILAC must be renewed in order to combine the independent parallel operation of the UNILAC with those conditions that result from synchronization with the SIS18 in booster operation.

This article is based on an original article on the GSI website which can be found here.

ALICE estimates how transparent the Milky Way is to antimatter

The antimatter counterpart of a light atomic nucleus can travel a long distance in the Milky Way without being absorbed, shows the international ALICE collaboration based at AVA partner CERN, in an article published in Nature Physics. The finding, obtained by feeding data on anti-helium nuclei produced at the Large Hadron Collider (LHC) into models, will help space- and balloon-based searches for antimatter that may have originated from dark matter.

Artist's impression of the ALICE study of the transparency of the Milky Way to antimatter. (Image: ORIGINS Cluster, Technical University Munich)

Light antimatter nuclei such as anti-deuteron and anti-helium have been produced on Earth, at particle accelerators, but they have yet to be observed with certainty coming from outer space. In space, such anti-nuclei, as well as antiprotons, could be created in collisions between cosmic rays and the interstellar medium, but they could also be produced when hypothetical particles that may make up the dark matter that pervades the Universe annihilate each other.

Space-based experiments such as AMS, which was assembled at CERN and is installed on the International Space Station, are therefore looking for light antimatter nuclei in an effort to search for dark matter, as will the upcoming GAPS balloon mission.

To find out whether dark matter is the source behind any potential detections of light anti-nuclei from outer space, physicists need to determine the number, or more precisely the “flux”, of light anti-nuclei that is expected to reach the near-Earth location of these experiments. This flux depends on features such as the exact type of antimatter source in our Galaxy and the rate at which it produces anti-nuclei, but also on the rate at which the anti-nuclei should later disappear through annihilation or absorption when they encounter normal matter on their journey to Earth.

The latter is where the new study from the ALICE collaboration comes in. By investigating how anti-helium-3 nuclei produced in collisions of heavy ions and of protons at the LHC interact with the ALICE detector, the ALICE researchers were able to measure, for the first time, the rate at which anti-helium-3 nuclei disappear when they encounter normal matter. In this analysis, the ALICE detector’s material serves as the normal matter with which the anti-nuclei interact.

Next, the ALICE researchers incorporated the obtained disappearance rate into a publicly available computer programme called GALPROP, which simulates the propagation of cosmic particles, including anti-nuclei, in the Galaxy. They considered two models of the flux of anti-helium-3 nuclei expected near Earth after the nuclei’s journey from sources in the Milky Way. One model assumes that the sources are cosmic-ray collisions with the interstellar medium, and the other describes them as hypothetical dark-matter particles called weakly interacting massive particles (WIMPs). For each model, the ALICE team then estimated the transparency of the Milky Way to antihelium-3 nuclei, that is, the Galaxy's ability to let the nuclei through without being absorbed. They did so by dividing the flux obtained with and without anti-nuclei disappearance.

For the dark-matter model, the ALICE researchers obtained a transparency of about 50%, whereas for the cosmic-ray model the transparency ranged from 25% to 90% depending on the energy of the anti-nucleus. These transparency values show that anti-helium-3 nuclei originating from dark matter or cosmic-ray collisions can travel long distances – of several kiloparsecs – in the Milky Way without being absorbed.

"Our results show, for the first time on the basis of a direct absorption measurement, that anti-helium-3 nuclei coming from as far as the centre of our Galaxy can reach near-Earth locations," said ALICE physics coordinator Andrea Dainese.

"Our findings demonstrate that searches for light antimatter nuclei from outer space remain a powerful way to hunt for dark matter," said ALICE spokesperson Luciano Musa.

This article is based on an original article published on the CERN website which can be found here.

Fellows Activity

Bruno Galante successfully completes PhD

AVA Fellow Bruno Galante has successfully defended his PhD thesis on 'Characterization studies of carbon nanotubes as cold electron field emitters for electron cooling applications in the Extra Low ENergy Antiproton (ELENA) ring at CERN', with Dr David Martin (University of Liverpool) and Dr Jeremy Sloan (University of Warwick) as examiners.


Bruno Galante

Electron cooling of the antiproton beam is essential to reduce any emittance growth caused by the deceleration process. An antiproton beam with a small emittance will be needed for further deceleration and extraction to the trap experiments.

Different options for a cold electron source were investigated, including expected performance and limitations, to improve the understanding of cold electron beam generation.

Bruno's project involved simulations of the electron source performance, as well as experimental studies for a full characterization of the emitted electron beam. Carbon nanotubes, a novel material known for its ability to reach low field emissions, were optimized and investigated for durability to develop a suitable alternative source for cold electrons. Improved electron cooling will help to increase the number of available antiprotons for further studies and experiments.

Bruno's project was carried out within the AVA network and based at CERN; he was supervised by Dr Gerard Tranquille (CERN) and Prof Carsten P Welsch (University of Liverpool).

AVA Fellow Interviews – Spotlight on Miha Červ

Miha Cerv (right)

Now the formal period of the project has come to an end, this is a good moment to look back at the Fellows' time with AVA. We have asked the Fellows a few questions as part of the AVA Spotlight Interview series; this will give you a more personal insight into their motivation, achievements and outlook.

For this interview we have spoken with Miha Červ who joined the AVA network at CIVIDEC in April 2018. During his Fellowship he was working on diamond detectors for beam characterization. His project focussed on the use of Ultra-thin Diamond Detectors as beam position and profile monitors in low energy antiproton beam lines.

What did attract you to the AVA network? Has it fulfilled your expectations?

"What attracted me to the AVA network the most was the topic itself. Working in the scientific field and especially with antimatter sounded cool. Another interesting point was the possibility of collaborating with an international group of people. Moving to another country, although a bit daunting, sounded exciting. In the end it turned out to be a very good decision to apply..“

Why did you choose to go to CIVIDEC?

“Most of the positions were meant for physicists, but CIVIDEC was one of the few meant for engineers. The background I had in electronics, especially experience with FPGA and a bit with detectors, this was a good fit for me. The relative proximity of Vienna to my hometown was also a plus.

Can you explain in a few words what your project was about and what have you achieved?

“Diamond detectors are the main product of CIVIDEC and they were also the main focus of my project. During AVA, I was testing and characterizing diamond detectors with laboratory radiation sources. I was developing FPGA implementations for real-time data signal analysis, such as rate measurements, spectroscopy and particle identification. A major achievement was a measuring campaign at the Grace beamline of the AeGIS experiment at CERN, where I measured the antiprotons with a diamond detector. .”

What has AVA provided you professionally?

“This was my first real employment, so AVA has given me a kickstart in my career. It has provided me with a lot of detailed knowledge and experience. Most importantly, I learned that complex issues that seem overwhelming at first, can be tackled if you really put your mind to it. And also that there are always people who know more about a certain topic, so you can rely on them for help..”

Can you say something about your next career move?

“My current employment is at MedAustron in Wiener Neustadt. It is an ion treatment facility with a synchrotron accelerator. My work is related to FPGA development, so I can say that what I learned during AVA is very useful for my current

work. I liked working in the field of particle physics already during AVA, but seeing the same principles being used for actual, non-academic applications is on a whole other level."

What will be your most cherished memory from AVA?

"The best memories will of course be of the group events. The one that immediately comes to mind is the Liverpool outreach symposium in 2019. After the official program, there was a nice dinner and after that we were dancing. I really enjoyed that everybody was in a good mood and we partied together."

AVA Fellows at the Liverpool Symposium.

David Haider successfully passed his PhD viva

David Haider

AVA Fellow David Haider, based at the Beam Instrumentation group at GSI, Darmstadt, successfully completed his PhD thesis on 'Ultra-sensitive Beam Intensity Measurements'.

During his project, David helped develop a Cryogenic Current Comparator (CCC) which allows non-destructive intensity monitoring of (anti)particles in storage rings and transfer lines with great precision, which benefits a wide range of areas from an improved control during antimatter production to a new level of online dose monitoring in radiation therapy.

As part of this work David introduced an absolute DC beam current measurement for beam intensities below 100 nA that are stored at the low energy storage ring CRYRING. At the end of his project he helped install the CCC at CRYRING which was followed by a successful first beam time.

This system now acts as the prototype for several installations in the upcoming Facility for Antiproton and Ion Research (FAIR).

David's project was carried out within the AVA network, supervised by Dr Thomas Sieber (GSI) and Dr Peter Forck (GSI).

Partner News

New look for AEgIS collaboration

The new AEgIS homepage. (credit: CERN)

A new look for the AEgIS collaboration website has been created including a new AEgIS logo. A group of American students who were in Switzerland as part of the SIT program were tasked with creating a modern and professional looking framework for the web appearance of the AEgIS collaboration. In just six weeks, the group of students designed the web pages you now see.

The SIT students were also asked to develop some new visuals for use on guided tours of the AEgIS facility at CERN (which currently attracts 150,000 visitors annually) and to develop strategies to raise funding for both Outreach and Scientific Equipment. The students explored the possibilities of fundraising at CERN, wrote a handbook about the fundamentals and started to use the pitch talk they created to contact local industry.

Part of the new look is a brand new logo for the collaboration. A local designer in Geneva designed this logo. The logo reflects the different aspects of the experiment with antimatter, gravity, interferometry and spectroscopy all represented in the rainbow coloured logo.

The AEgIS team plan to provide timely news updates on this new website as well as keeping publications, reports, teams and contacts section up to date. They are also planning to produce t-shirts for the team and some 3-D animations of the experiment to help people better understand what they are doing.

The AEgIS website can be found at https://aegis.web.cern.ch/index.php

The new AEgIS logo. (credit: CERN)

GBAR joins the anticlub

The GBAR experiment at CERN has just joined the very select club of experiments that have succeeded in synthesising antihydrogen atoms.

The aim of the GBAR experiment at CERN is to measure the acceleration of an antihydrogen atom – the simplest form of atomic antimatter – in Earth's gravitational field, and to compare it with that of the normal hydrogen atom. Such a comparison is a crucial test of Einstein's equivalence principle, which states that the trajectory of a particle is independent of its composition and internal structure when it is only subject to gravitational forces.

However, producing and slowing down an antiatom enough to see it in free fall is no mean feat. GBAR's approach is to first produce an antihydrogen atom and then turn it into a positive ion (the antimatter equivalent of an H^- ion). The ion can then be slowed down using quantum-optical techniques. Finally, the ion is neutralised for free-fall measurement. In a new paper, the GBAR collaboration reports the successful production of its first antiatoms.

To achieve this, the team has developed a complex protocol in which antihydrogen atoms are assembled from antiprotons produced by the Antiproton Decelerator (AD) and positrons produced in GBAR. The AD's 5.3-MeV antiprotons are decelerated and cooled in the ELENA ring and a packet of a few million 100-keV antiprotons is sent to GBAR every two minutes. In GBAR, a device called a pulsed drift tube further decelerates this packet to an adjustable energy of a few keV. In parallel, in another part of GBAR, a linear particle accelerator sends 9-MeV electrons onto a tungsten target, producing positrons, which are accumulated in a series of electromagnetic traps. Just before the antiproton packet arrives, the positrons are sent to a layer of nanoporous silica, from which about one in five positrons emerges as a positronium atom (the bound state of a positron and an electron). When the antiproton packet crosses the resulting cloud of positronium atoms, a charge exchange can take place, with the positronium giving up its positron to the antiproton, forming antihydrogen.

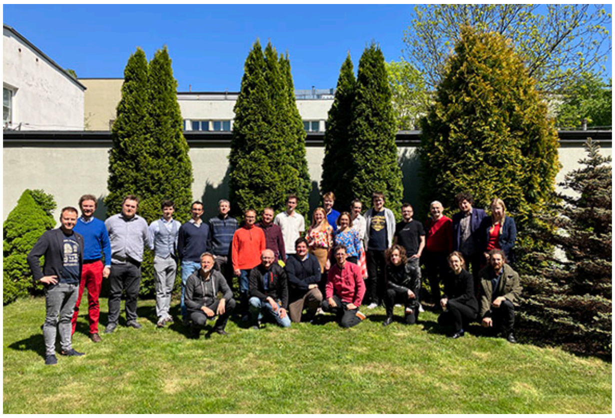
At the end of 2022, during an operation that lasted several days, the GBAR collaboration detected some 20 antihydrogen atoms produced in this way, validating this "in-flight" production method for the first time.

After this essential first step, the collaboration will now improve the production of antihydrogen atoms. This will enable precision measurements to be made on the antihydrogens themselves, in particular a measurement of an energy gap between two specific atomic levels, known as the Lamb shift. This measurement will give a more precise value of the radius of the antiproton. This will be followed by the production of positive antihydrogen ions, and finally by the implementation of the laser systems for cooling and neutralising these ions in order to finally observe the free fall of an antihydrogen atom.

GBAR is not alone in its aim of testing Einstein's equivalence principle with atomic antimatter. ALPHA and AEgIS (which includes AVA partners the University of Liverpool and INFN) are also working towards this goal using other approaches. ALPHA, a pioneer in the synthesis and trapping of neutral antihydrogen, is the most advanced. The AEgIS experiment produces antihydrogen using the same reaction as GBAR with positronium. It detects the downward trajectory of antiatoms using a sensitive interferometer.

This article is based on an article on the CERN website which can be found here and an original article (in French) on the CNRS website here.

AEgIS collaboration meeting takes place in Warsaw



Participants at the AEgIS collaboration meeting in Warsaw.

An AEgIS collaboration meeting has taken place in Warsaw, Poland from 9-11 May 2023 to review the current status and consider the future outlook of the AEgIS project. Many people attended the meeting in person and some others attended online. There were over 30 participants in total.

The meeting commenced with a comprehensive overview of the physics program and current analyses being conducted within the project. Talks followed on the detailed experimental set up including the apparatus, vacuum and cryogenics, the positron system and the EKSPLA laser system. There followed a session on the control system status and upgrades.

Later on the first day there was a session looking at working toward a Rydberg antihydrogen source including talks on plasma manipulations and an overview on Ps excitation to Rydberg states in a 1T field and ionization diagnostics. This talk proposed new ionization diagnostic methods. To check the impact on the positron beam, a unipolar and bipolar electrode configuration were proposed.

The second day started with a session on Gravity with Rydberg antihydrogen. Interferometry and deflectrometry were both discussed as was material gratings and a tentative design of the gravity module was presented.

The next session was on antiproton atoms physics. Experiments with anti-protonic atoms at LEAR were described before an update on the beamline was provided. The STARSHIP chamber has been successfully integrated with the beamline, and the electrodes have undergone Hi-pot tests under vacuum conditions, achieving the required vacuum levels. Pulsed production of negative ions were also discussed.

The final day started with a session on positronium physics. A status report on Ps laser cooling was given, further information on the gravity module was presented and near future physics with Ps was discussed.

The final session looked to the future with a discussion on a recently proposed theory: Can gravity induce mechanical resonances? This was followed by talks on the ongoing development of a room temperature antiproton trap and the ideas of BOREALIS setup which uses the sympathetic cooling of antiprotons to mK temperatures using C2 anions.

At the end of the meeting, a session was presented about outreach including the new logo and website design and then finally a planning session for the AEgIS experiments took place.

The full program for this workshop is on Indico and all presentations can be found here.

AEgIS researchers take part in 'I'm a scientist' outreach project

AEgIS, one of the antimatter research experiments at CERN, is not only pushing the boundaries of science but also making efforts to promote science education and awareness through its participation in a live-chat based outreach project called "I'm a Scientist". The project is hosted on a webpage that includes the CERN Zone section, which provides an exclusive behind-the-scenes look at modern science in motion and an opportunity for students and teachers to connect with the scientists working on the various projects.

AEgIS provides a team of six people, including AVA Co-ordinator Prof Carsten P Welsch, who take part in live-chats every two weeks with the aim of answering questions about science, their research, careers and goals. The questions are moderated before being published to ensure their appropriateness and relevance, and the answers come directly from the scientists themselves. The project has been running for half a year now and has attracted over 100 students who have been reading the profiles of the scientists, asking questions, and taking part in live chats.

The project was created in response to an STFC study that found that while 80% of young people believed that science was important and necessary for the future, only about 20% of the same group stated they wanted to become a scientist. The aim of the project is to inspire and encourage more young people to consider science as a career option by providing them with an opportunity to connect with scientists, ask questions and learn more about science.

One of the typical questions asked by students is "What is the point in trying to create antimatter?" The typical answer provided by scientists is that understanding the properties of antimatter could help us get closer to understanding the "matter-antimatter asymmetry problem". This is one of the big questions in physics that has baffled scientists for a long time, as we expect the Big Bang to have produced matter and antimatter in equal quantities, but we don't see that in the universe around us. Additionally, not all antimatter has to be made costly at CERN in collisions - in fact, anti-electrons or "positrons" are very likely being made in a hospital near you right now through radioactive decay, for use in Positron Emission Tomography (PET), which is a very important medical tool and a great example of an application of particle physics.

Through its participation in the "I'm a Scientist" project, AEgIS hopes to inspire more students to pursue careers in science and to promote a better understanding and appreciation of the importance of science in our world.

Council decides about progress of the FAIR project

Following a special meeting on 9-10 March 2023, the shareholders of FAIR GmbH have decided on the future of the FAIR project. Due to the excellent evaluation carried out in the scientific review of the FAIR project, the Federal Republic of Germany and the State of Hesse have decided they are willing to finance the first construction stage 'First Science' with a supplementary sum of approximately 518 million euros. This means that the predicted total budget available for the project will be approximately 3.3 billion euros.

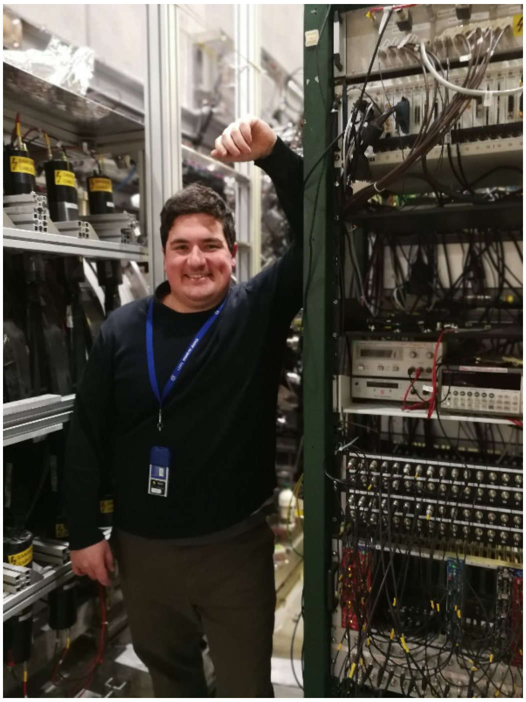
The Management of AVA partner GSI and FAIR are very happy about the commitment of the Federal Ministry of Research and the Hessian Ministry of Science and the Arts to provide the additional funding for FAIR and thus to secure "First Science" at FAIR. Despite the difficult global economic and geopolitical conditions, this represents a significant step forward for the FAIR project and for the excellent research that can be conducted at FAIR. FAIR's 'First Science' stage can, for example, provide completely new insights into the structure and behaviour of matter and open up new possibilities for tumour therapy with high-intensity charged particles for the benefit of society. The scientific review evaluated FAIR's scientific program as compelling and world-leading in many aspects.

The international project partners have also acknowledged the additional costs and want to make further commitments themselves in a timely manner. The most recent decisions are an outstanding opportunity for the site and its employees, but they are also an outstanding opportunity for science in Germany and Europe.

This article is based on an original article published on the GSI/FAIR website and can be found here.

Arial view of the FAIR construction site.

New spokesperson elected for AEgIS antimatter experiment



AEgIS spokesperson Ruggero Caravita.

Ruggero Caravita, a physicist at the Trento Institute for Fundamental Physics and Applications of Istituto Nazionale di Fisica Nucleare, has been elected as the new spokesperson for the AEgIS antimatter experiment at AVA partner institution CERN. He studied for his PhD at the University of Genova and at CERN, and then worked at CERN as a Marie Curie Fellow. He has been involved in AEgIS activities for over 8 years, including serving as the Physics Coordinator in the years before the election.

The AEgIS experiment is one of several ongoing experiments at CERN that are investigating the properties of antimatter and the fundamental laws of physics. The results of these experiments could have important implications for our understanding of the universe and the nature of matter itself.

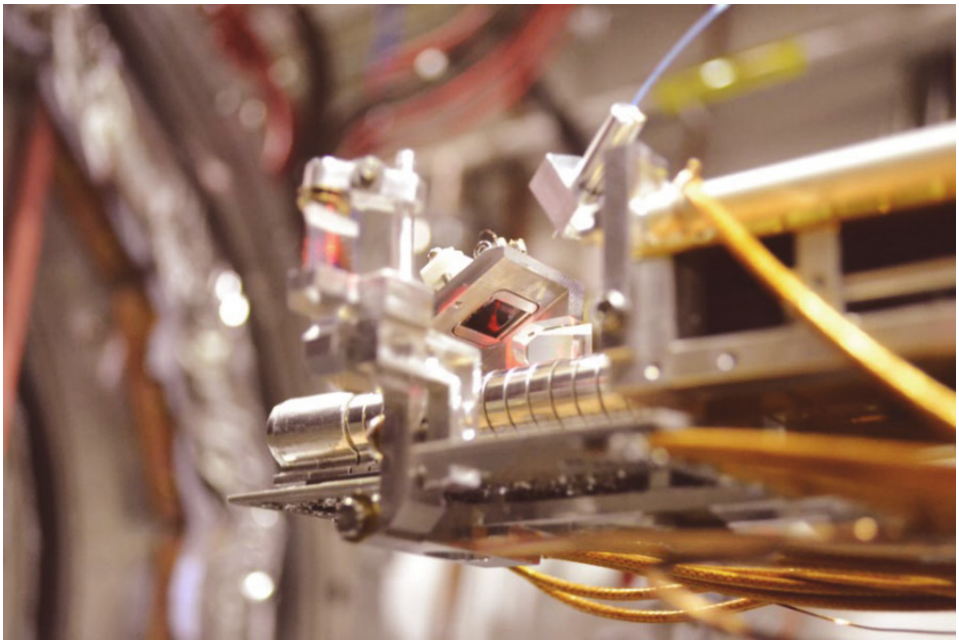
The aim of the AEgIS experiment is to measure the gravitational free-fall of antimatter atoms for the first time. This ground-breaking experiment will help scientists to better understand the behaviour of antimatter and could lead to new discoveries in fundamental physics

Ruggero is excited to lead the AEgIS team in this ambitious endeavour and is confident that the experiment will yield important results in the upcoming years.

The AEgIS experiment uses a beam of antihydrogen atoms, which are the antimatter counterpart of hydrogen atoms, to test the equivalence principle, one of the fundamental principles of Einstein's theory of general relativity.

The experiment will measure the gravitational acceleration of antihydrogen atoms to an unprecedented accuracy and thus test whether antimatter falls at the same rate as matter in a gravitational field.

University of Liverpool awarded £1M for antimatter research



AEgIS antihydrogen detection region. Photograph: Michael Doser, CERN.

Physicists at AVA partner the University of Liverpool are leading a £1M antimatter research project as part of the AEgIS experiment at CERN.

The project entitled `Slow Neutral Antimatter Atoms in Excited States for Inertial-type Precision Measurements' (SNAP) is funded by The Engineering and Physical Sciences Research Council (EPSRC).

The University of Liverpool was the first UK university to join the AEgIS (Antihydrogen Experiment: Gravity, Interferometry, Spectroscopy) antimatter experiment which aims to measure the gravitational fall of an antihydrogen pulsed beam. AVA partners CERN and INFN are also part of the AEgIS collaboration.

AEgIS will create nanostructured silicon membranes with a few micrometres thickness, a geometrically optimized positron-to-positronium converter that will be used to efficiently form a Positronium (Ps) beam in a cryogenic UHV environment.

Making use of AEgIS's two established laser systems for Ps excitation, Liverpool physicists, led by Professor Carsten P Welsch, aim to make important contributions to laser-cool this exotic system for the first time.

The goal will be to create the world-wide coldest Ps-beam and Professor Welsch's **QUASAR Group** is extremely well-positioned for this with group member, Dr Benjamin Rienaecker, already contributing substantially to the first successful production of pulsed antihydrogen from AEgIS in 2018.

This cold beam will then form the basis of a cutting-edge research programme, targeting the systematic study of excited neutral Positronium atoms passing through a matter grating to study the effect of van-der-Waals forces of the matter grating on neutral excited atoms.

Professor Welsch, who has been leading the AVA network, said: *"We will tackle some of the most fundamental questions about antimatter. We will develop new technologies and know-how, working within the wider AEgIS team at CERN. We have very ambitious plans and target a transformational science program. We are extremely grateful for this major funding award and cannot wait to start our project."*

"The announcement of this AEgIS award concludes an amazing year for the University of Liverpool's Department of Physics which has received millions of pounds in funding for the next-generation plasma accelerator EuPRAXIA, a prestigious Leverhulme Professorship grant, as well as £1.3 million for its new STFC Centre for Doctoral Training LIV.INNO to pioneer innovation in data-driven research."

Former AEgIS spokesperson and AVA Steering Committee member, Dr Michael Doser (CERN), said: *"Congratulations to the Liverpool team for this major award. The research field that is being pioneered in the framework of the AEgIS experiment will greatly benefit from the breakthrough advances that the obtained grant will target."*

The AEgIS experiment involves physicists from a number of countries in Europe as well as from India.

More information about AEgIS:
https://aegis.web.cern.ch/home.html

Magnets for FAIR ring accelerator: Commissioning of new test facility in Salerno, Italy

Commissioning ceremony for the test facility THOR.

The future FAIR ring accelerator SIS100 uses superconducting magnets for deflection, focusing and correction of the circulating ion beams. The FAIR facility is currently under construction at AVA partner GSI Darmstadt, Germany. While the complete series of dipole modules required for beam deflection has already been manufactured and tested, series production of the quadrupole modules required for focusing and correction is still in an earlier phase. In the meantime, an important step has been taken with the commissioning of the cryogenic test facility THOR (Test in Horizontal) for this magnet group in INFN Salerno, Italy.

The quadrupole modules for the FAIR ring accelerator are extremely complex. One of the key components are the superconducting quadrupole units. Each module contains two quadrupole units as well as other, technically highly sophisticated components. These include, for example, thin-walled magnetic chambers cooled with liquid helium, cryogenic ion catchers and cryogenic beam position monitors. The manufacturing stages of SIS100 quadrupole module production thus includes numerous suppliers and locations. After production, the superconducting quadrupole units are sent to Bilfinger Noell in Würzburg, where they are integrated with the superconducting quadrupole modules.

The integration of the quadrupole modules generates a complex system consisting of parallel hydraulic circuits for liquid and gaseous helium and a vacuum system whose walls have temperatures between four and ten Kelvin. Extreme demands are also made, for example, on the positional fidelity of the components when cooling from room temperature to the 4.5 Kelvin operating temperature of the magnets. Although the cold mass is built on a carrier consisting of two separate support structures, their position in the cold state may only deviate from the nominal value by a maximum of 0.1 millimetres. The properties of each integrated module must therefore be examined and confirmed in a separate cold test.

The cold testing of 81 of the 83 SIS100 quadrupole modules was made possible by a Memorandum of Understanding (MoU) between the German Federal Ministry of Education and Research and the Italian Ministry of Education, Universities and Research. The Salerno site offered ideal conditions for this because a cryogenic test facility for testing FAIR-SIS300 magnets had already been built within the campus of the University of Salerno.

Building on this existing infrastructure, the local INFN team led by Dr Umberto Gambardella has now developed, procured and built all the additional equipment necessary for testing the SIS100 quadrupole modules. In addition to the actual cryogenic system, measurement systems for the electrical circuits of the magnets and systems for monitoring superconductivity (quench detection) have also been developed and built.

Over the course of this year, the THOR cryogenic test facility has been cold run and commissioned for the first time. For this purpose, the first SIS100 quadrupole module (FoS, First of Series) were brought to Salerno and assembled at the test facility. The Italian team had previously been trained at GSI to test the modules, and a continuous exchange of information has been set between the GSI and INFN groups.

The Italian scientific community and GSI/FAIR are closely linked in many areas. The Scientific Managing Director of GSI and FAIR, Professor Paolo Giubellino says: “Our collaboration with Italy is of great importance. Italian researchers are represented in many fields and collaborations at GSI and FAIR and are making excellent contributions. Italy and INFN in particular have a very strong scientific and technological participation in FAIR, contributing to both the accelerators and the experiments. We hope this involvement will eventually become a full membership. I am delighted about this further deepening at the test facility THOR and the enhancement of our successful cooperation.”

This article is based on an original article on the GSI/FAIR website

Test facility Thor at the University of Salerno.

FAIR cryogenics facility receives its centrepiece

Delivery of the coldbox for the FAIR cryogenics facility.

A large heavy goods vehicle set off from Aschaffenburg to Darmstadt on November 30, 2022. Its destination was the international accelerator facility FAIR (Facility for Antiproton and Ion Research), which is currently being built at AVA partner GSI Helmholtzzentrum für Schwerionenforschung. On board was the so-called "coldbox", a steel tank with a length of 18 meters, a height of more than 4.5 meters and a weight of 85 tons. The coldbox is the heart of the cryogenics facility and has been produced and installed by Linde engineering. It is used to cool and liquefy helium for the FAIR accelerator. Following the construction of the shell and the installation of technical building services, the cryogenics plant is the first technical component to be brought into the FAIR buildings.

The huge cooling facility will supply liquid helium to two key FAIR building blocks, the FAIR ring accelerator SIS100 and also the Super Fragment Separator (Super-FRS). In the future, ions will travel around the curves of the SIS100 ring accelerator at up to 99% the speed of light, then collide with samples of other materials to produce nuclear reactions. The Super-FRS is a giant sorting machine for newly produced, exotic atomic nuclei which can tell us about processes in stars and other stellar events. With these and other large-scale devices, scientists at FAIR hope to bring the universe into the laboratory.

In order to guide the particles along their paths, strong magnetic fields are required, which can only be achieved using superconducting magnets: Extreme cryogenic temperatures can cause the electrical resistance in some materials to nearly disappear, allowing high electrical currents to flow in the electromagnets. To achieve this, the magnets must be cooled to a temperature of four kelvin (-269°C). To achieve this, the cryogenic system can deliver a maximum flow rate of over 21,000 litres of liquid helium per hour, with a total helium storage of nine tons, and a maximum cooling capacity of 14 kilowatts at four kelvin.

"The delivery of the coldbox to the FAIR construction site is a milestone and a sign of the steady progress being made in the construction of FAIR. The coldbox is the heart of the cryogenic facility, the first high-tech system to be installed in the newly constructed FAIR buildings on the construction site. This will bring us a big step closer to our goal of accelerating particles to almost the speed of light. Linde Engineering is an important partner in this process," says Jörg Blaurock, Technical Managing Director of FAIR and GSI.

"The FAIR cryogenic plant is one of the largest possible refrigeration plants that can still be built from one unit. For even higher cooling loads, several plants would have to be used in parallel," explains Dr Holger Kollmus, who as head of the Cryogenics Department at GSI/FAIR is responsible for the construction of the plant. "A special feature of the plant is the possibility to change the cooling capacity dynamically. Comparable plants, which are mainly used for the production of liquid helium, permanently run at full load. Since the required cooling capacity for the accelerator fluctuates depending on the operating condition, the plant is designed to adjust its pressures and mass flows accordingly to save energy and coolant. Efficient response to changing loads places high demands on the design and construction of the unit."

As a contract partner, Linde Engineering is responsible for the production and installation of the helium cooling facility on site. Two large buildings are available at FAIR to house the plant components and now the coldbox. Several large pieces of equipment, such as compressors, have already been delivered and integrated into the plant in the past weeks. The coldbox, the largest and central component of the system, was manufactured by Linde Engineering at its Schalchen plant. From there, the unit was driven by transporter to Passau, brought to Aschaffenburg by ship and reloaded onto the final heavy goods transport to GSI/FAIR. Mechanical completion of the entire plant is scheduled for mid-2023.

This article is based on an original article on the GSI/FAIR website and can be found here.

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Selected Publications

'Design and performance of a novel low energy multispecies beamline for an antihydrogen experiment', C.J. Baker, …, **S. Fabbri,** et al., Phys. Rev. Accel. Beams. 26, 040101 (2023).

https://journals.aps.org/prab/abstract/10.1103/PhysRevAccelBeams.26.040101

'GRASIAN: towards the first demonstration of gravitational quantum states of atoms with a cryogenic hydrogen beam', C. Killian, …, **A. Nanda**, et al., Eur. Phys. J. D 77, 50 (2023)

https://link.springer.com/article/10.1140/epjd/s10053-023-00634-4

'Influence of Mechanical Deformations on the Performance of a Coaxial Shield for a Cryogenic Current Comparator', N. Marsic, **D. Haider**, et al., IEEE Transactions on Applied Superconductivity, vol. 32, no. 9, pp. 1-9, Dec. 2022, Art no. 2500409

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https://www.nature.com/articles/s41598-023-28617-w

'Superconducting Curved Canted–Cosine–Theta (CCT) for the HIE-ISOLDE Recoil Separator Ring at CERN', G. Kirby, **V. Rodin**, C.P.Welsch., IEEE Transactions on Applied Superconductivity, vol. 32, no. 6, pp. 1-5, Sept. 2022, Art no. 4004105

https://ieeexplore.ieee.org/document/9735349

Events

10th – 14th Sep 2023	12th International Beam Instrumentation Conference (IBIC23), Saskatoon, Canada
8th – 13th Oct 2023	International Workshop on Beam Cooling and Related Topics (COOL23), Montreux, Switzerland
9th – 13th Oct 2023	68th ICFA Advanced Beam Dynamics Workshop on High-Intensity and High-Brightness Hadron Beams (HB2023), CERN, Geneva, Switzerland
18th – 24th May 2024	15th International Particle Accelerator Conference (IPAC24), Nashville, USA
7th – 11th September 2025	14th International Beam Instrumentation Conference (IBIC25), Liverpool, UK

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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.