22nd SPARC Topical Workshop

Reporte der Beiträge

Beitrag ID: **1** Typ: **Talk**

Polarization Transfer in the Inner-Shell Compton Scattering

Donnerstag, 18. September 2025 11:30 (20 Minuten)

We present a theoretical study of the Compton scattering of photons by K-shell electrons of a target atom. Special attention is paid to the polarization of the scattered photons for the case when the incident photons are themselves linearly polarized. In order to explore this polarization transfer we employ the S-matrix approach and the density matrix theory. Moreover, the S-matrix results are compared with the predictions of the well-known impulse approximation (IA), thus allowing to clarify the role of electron binding in polarization studies. Detailed IA and S-matrix calculations have been performed for hydrogen, xenon, and uranium targets, and for photon energies ranging from just above the K-shell ionization threshold to ten times above it. Based on these calculations, we conclude that the impulse approximation is suitable for describing the polarization of scattered photons only for their energies near the Compton peak. If the scattered photon is observed with higher or lower energy, electron binding can strongly affect the polarization transfer, which is clearly evident from the significant discrepancy between the S-matrix and impulse approximation predictions.

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Sitzung Einordnung: Session 10

Beitrag ID: **2** Typ: **Talk**

A Novel Compton Telescope for Polarimetry in the MeV Range

Dienstag, 16. September 2025 10:40 (20 Minuten)

For photon energies from several tens of keV up to a few MeV, Compton polarimetry is an indispensable tool to gain insight into subtle details of fundamental radiative processes in atomic physics. Within the SPARC collaboration [1] several segmented semiconductor detectors have been developed that are well suited for application as efficient Compton polarimeters. For photon emission processes in the hard x-ray regime these kind of detectors enable revealing photon polarization effects in great detail [2]. In our presentation, a novel Compton telescope detector that will enable us to extend to photon energies up to the MeV range will be presented. In particular, we will discuss new experimental possibilities in the higher energy range.

[1] Th. Stöhlker et al. *Nucl. Instrum. Methods Phys. Res. B* **365** (2015) 680.
[2] K.H. Blumenhagen et al. *New J. Phys.* **18** (2016) 119601.

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Sitzung Einordnung: Session 3

Beitrag ID: **3** Typ: **Poster**

Signature of Charge Equilibrium Process in L-Shell Auger-Meitner Electron Emission Spectra of Ar^{+q}-Ar Collisions

Montag, 15. September 2025 16:30 (1 h 30m)

The well-known Auger-Meitner (AM) effect has been used extensively to study electron correlations. In ion-atom collisions, the AM process occurs during hard collisions (small impact parameter). It is known that for ions, the energy of AM e^- shifts to the low-energy side, in contrast to X-ray energy, which shifts toward the high-energy side. For ion-atom collisions, understanding this process can be categorized into two regimes: (1) Coulomb ionization (for proton and bare-ion projectiles), and (2) excitation or ionization of a quasi-molecule. When the projectile moves very fast relative to the orbital electron or is lighter than the target, the process can be understood through Coulomb ionization. Excitation or ionization of a quasi-molecule has been studied for X^+–X collision systems. However, very few studies are available in the literature where the projectile undergoes inner-shell excitation.

In this talk, I shall discuss the double differential cross section (DDCS) for electron emission in Ar^{3+}–Ar and Ar^{6+}–Ar collisions. A significant shift exceeding 40 eV is observed in the characteristic Auger-Meitner (AM) electron energy peak for LMM transitions. For a neutral Ar target, this peak is expected near 197 eV; the shift occurs for both projectile and target after Doppler-shift correction. Although existing literature attributes this shift to binding-energy changes in ions versus neutral atoms, experimental peaks typically result from convolutions of multiple peaks. Here, simply knowing binding-energy changes is insufficient to quantify ionization. We adopt an approach where the probability of AM transitions is calculated using ground-state wave functions of ions. Using these probabilities as weight factors for the energy-peak function, the shift in convoluted peaks may quantify ionization. Comparing calculations with experiments, both target and projectile exhibit equilibrium charge states between 3+ and 4+ before AM emission. I shall also discuss experimental results for C^{q+} ($q = 1, 2$)–CH4 and N^{q+} ($q = 2, 3$)–CH4 collision systems.

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Sitzung Einordnung: Poster Session

Beitrag ID: **4** Typ: **Poster**

S-Matrix Calculations of Compton Scattering from Bound Electrons

Montag, 15. September 2025 16:30 (1 h 30m)

Compton scattering is one of the fundamental processes in light–matter interaction in which an incoming photon is inelastically scattered off an electron. In the energy range from a few keV to several MeV, Compton scattering makes a significant contribution to the light-atom coupling. It therefore has a wide range of important applications across various fields of modern science, from radiotherapy in medicine to X-ray polarimetry. The latter is of particular interest to the SPARC collaboration, where the development of Compton polarimeters is a key objective. In this context, we present theoretical studies of Compton scattering from bound electrons, with special emphasis on polarization effects. In particular, we discuss calculations within the framework of S-matrix theory and independent particle approximation (IPA). To perform these calculations, a program was developed to numerically solve the radial Dirac equation efficiently and accurately for a bound electron in the central potential of its nucleus, which is approximated by a Coulomb potential. Based on this, detailed calculations of the doubly differential cross section (DDCS) and the polarization behavior of the outgoing photon can be carried out across a wide range of energies and for arbitrary polarization states of the incoming photon beam.

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Sitzung Einordnung: Poster Session

Beitrag ID: **5** Typ: **Poster**

Experiments on Highly Charged Ions from S-EBIT II

Montag, 15. September 2025 16:30 (1 h 30m)

An Electron Beam Ion Trap (EBIT) provides highly charged ions (HCI) for spectroscopy and other experiments. To this end, a nearly monoenergetic electron beam is used. In interactions with the electrons from the beam, neutral atoms or positively charged ions can be stripped of bound electrons by means of electron impact ionisation. The electron beam originates at a so-called "electron gun", is accelerated towards the trap centre, and dumped at a so-called "collector". The electron beam is guided and compressed by a strong magnetic field. The positively charged ions are attracted and trapped radially by the negatively charged electron beam. Longitudinal trapping is achieved by electrostatic potentials applied to a set of cylindrical drift tubes around the beam axis. Once trapped, HCIs interact with the electron beam and emit X-rays, which can give insights into a wide range of atomic processes, of interest for plasma physics, astrophysics and fundamental research.
Facilities at GSI, such as CRYRING, ESR, and HITRAP [1] rely heavily on a steady supply of ions for a wide range of experiments. However, the dependence on the GSI accelerator limits operational flexibility, necessitating the development of independent, local ion sources. S-EBIT II emerged as a promising candidate to address this challenge, offering to be an alternative local ion source for HITRAP, supporting local experiments such as ARTEMIS [2]. It also offers stand-alone functionality for diverse experimental research into highly charged ion interactions, like dielectronic recombination (DR) pro-cesses by means of X-ray spectroscopy or using ions extracted from the trap.

Recent commissioning efforts include DR measurements with argon, alongside a new electron gun and preparing to attach S EBIT II to HITRAP. Further stand-alone experiments on isotopic shifts in the DR spectrum on few-electron krypton will be conducted in the future

References

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[2] M. Vogel et al., 2018, Annalen der Physik (Berlin), 531, 1800211.

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Sitzung Einordnung: Poster Session

Beitrag ID: **6** Typ: **Poster**

Testing Strong-Field QED to Second-Order in Highly Correlated Berylliumlike Pb^{78+} by Electron-Ion Collision Spectroscopy

Montag, 15. September 2025 16:30 (1 h 30m)

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Using the experimental technique of electron-ion collision spectroscopy at the electron cooler of the heavy-ion storage ring CRYRING@ESR [1] we have measured merged-beams rate coefficients for electron-ion recombination of berylliumlike Pb^{78+} ions. In the electron-ion collision energy range 12-16.5 eV, we have observed $2s2p\ (^3P_1)\ 19l_j$ dielectronic recombination (DR) resonances associated with a $2s^2\ ^1S_0 \to 2p2p\ ^3P_1$ core excitation and a simultaneous capture of the initially free electron into the $n = 19$ shell of the boronlike Pb^{77+} product ion. A careful analysis of the systematic experimental errors reveals that the uncertainty of the measured resonance positions amounts to $pm30$ meV. This uncertainty is lower than the theoretical uncertainty of the calculation of the $2s^2\ ^1S_0 \to 2p2p\ ^3P_1$ excitation energy by Malyshev et al. [2]. By considering second order QED effects and electron-electron correlation effects, which are particularly strong in berylliumlike ions, these authors obtained $E_{\mathrm{exci}} = 244.942(52)$ eV. Within the uncertainties this agrees with our experimental finding [3], which thus constrains second order strong-field QED.

[1] C. Brandau et al., Chin. Phys. C **49**, 064001 (2025),
https://doi.org/10.1088/1674-1137/adbf81

[2] A. Malyshev et al., Phys. Rev. A **110**, 062824 (2024),
https://doi.org/10.1103/PhysRevA.110.062824

[3] All authors of this abstract, Phys. Rev. Lett. (submitted),
https://arxiv.org/abs/2502.15433

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Sitzung Einordnung: Poster Session

Beitrag ID: **7** Typ: **Poster**

Commissioning of the Transverse Free-Electron Target at the Heavy-Ion Storage Ring CRYRING@ESR

Montag, 15. September 2025 16:30 (1 h 30m)

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Electron-ion collision experiments in a merged beams geometry (electron cooler) are well established at ion storage rings. A complete new range of experiments is possible if the geometry is changed to a crossed-beams setup in 90° angle between the electron and ion beams employing a dedicated free-electron target. The target bridges the gap between low-collision-energy experiments in electron coolers and those employing quasi-free electrons of gas-jet targets. Compared to the latter, the absence of a target nucleus enables unambiguous studies of processes, which are otherwise masked by competing reactions with the target nucleus. As compared to an electron cooler, the interaction region of a transverse target is spatially well localized. This facilitates X-ray and electron spectroscopy with relatively large solid angles. Over the last years, a specially tailored electron-target for heavy-ion storage rings was developed and built at the University of Giessen in cooperation with GSI. Its scientific prospects have been outlined in the CRYRING@ESR Physics Book [1]. The project benefits from decades-long experience of single-pass electron-ion-collision experiments [2–4]. The target is equipped with a versatile electron gun that is optimized for an operation in storage rings. The electron gun can be fully retracted from the storage ring to a position behind a gate valve. One of the specific design criteria was a rather large opening for the ion beam in order to accommodate ion injection into the storage ring on different orbits. First electron-ion beam experiments showed that in total only up to 20% of ions are lost due to the electron target which is a great success. The electron target creates a ribbon-shaped high-intensity electron beam with energies up to 12.5 keV (lab system). The multi-electrode assembly offers a decoupling of electron energy and electron density, which is beneficial for the ultrahigh vacuum conditions in the ring. It also offers a quasi-constant electron density over large energy ranges. We report on the latest achievements during the commissioning beamtimes of the electron target at the CRYRING@ESR. The evaluation of the performance and operation behaviour is ongoing.

[1] M. Lestinsky et al., Eur. Phys. J Spec. Top. 225, 797 (2016).
[2] B. Ebinger et al., Nucl. Instrum. Methods B 408, 317 (2017).
[3] F. Jin et al., Eur. Phys. J. D 78, 68 (2024).
[4] B. M. Döhring et al., Atoms 13, 14 (2025)

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Sitzung Einordnung: Poster Session

Beitrag ID: **8** Typ: **Poster**

High-Resolution Dielectronic Recombination of Berylliumlike Gold Ions at the CRYRING@ESR Storage Ring

Montag, 15. September 2025 16:30 (1 h 30m)

Electron-ion collision spectroscopy is a very successful approach for studying the properties of highly-charged ions [1], in particular if low-energy dielectronic recombination (DR) resonances are scrutinized. The heavy-ion storage ring CRYRING@ESR at the international FAIR facility in Darmstadt, Germany, is especially attractive for dielectronic recombination studies, since it is equipped with an electron cooler that provides an ultra-cold electron beam promising highest experimental resolving power and precision [2–4]. Thanks to its high precision, DR spectroscopy of excitation energies at the CRYRING@ESR will allow us to sensitively probe higher order contributions to state-of-the-art quantum-electrodynamical (QED) calculations in strong fields [5, 6].
We will report on some preliminary DR results of berylliumlike gold ions, which were injected into the CRYRING (~ $5 \cdot 10^6$ ions/cycle, with an energy of 12 MeV/u) from the full chain of GSI accelerators consisting of the linear accelerator UNILAC, the heavy-ion synchrotron SIS18, and the high-energy storage ring ESR. The recorded DR spectra in the collision-energy range 0-300 eV exhibit a number of Rydberg resonances which are associated with different excitations of the Be-like ion core. Preliminary analysis of a few partial energy intervals will be presented in form of a poster during the SPARC workshop.

References:

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[4] Brandau C et al. 2025 Chin. Phys. C 49 064001
[5] Malyshev A et al. 2025 Phys. Rev. A 110 062824
[6] Schippers S et al. submitted (see also https://arxiv.org/abs/2502.15433)

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Sitzung Einordnung: Poster Session

Beitrag ID: **9** Typ: **Talk**

Electron Spectra obtained at Zero Degrees in Collisions of B(3,4)+ Beams with Methane Molecules

Mittwoch, 17. September 2025 11:55 (25 Minuten)

The interaction of fast ions with molecules of biological interest is a topic of unceasing research interest due to its inherent application to radiation damage of biological tissue [1]. Additionally, such collision systems provide stringent tests for advanced distorted-wave collision theories [2]. Here we report measurements of electron DDCS spectra obtained at zero-degree emission angle with respect to the ion beam from collisions of 11 MeV H-like and He-like boron ions with CH4 molecules. Theoretical DDCS spectra resulting from CDW and CDW-EIS theories along with their respective variants are critically compared to the measurements. While both theories show good overall agreement, specific differences and features observed in the cusp and BEe peak regions provide a basis for further discussion regarding the theories considered.

References

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[2] S. Nanos et al, Phys. Rev. A 107, 062815 (2023).

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Sitzung Einordnung: Session 7

Beitrag ID: **10** Typ: **Talk**

Relativistic Electron beams driven by ultra intense Laser-Plasma Electron Accelerator

Montag, 15. September 2025 15:05 (25 Minuten)

It has been more than two decades since the first experimental demonstrations of the generation of relativistic electron beams produced by the interaction of ultra intense laser pulses with plasma [1]. Ever since, several research groups worldwide invested considerable effort towards detailing the Physics behind the mechanism of Laser Wakefield Acceleration (LWFA), that drives the formation and dynamics of the relativistic electron beams [2]. Additional efforts were directed towards improving the electron beam quality characteristics (brightness, maximum energy, quasi-monochromaticity, divergence and stability) to harness it as a reliable secondary high energy electron source. Here, we will review our recent work on the generation of relativistic electron beams using multi-10-TW laser pulses [3]. The experiments were performed at the Institute of Plasma Physics and Lasers (IPPL) of the Hellenic Mediterranean University using the 45 TW fs laser system "Zeus"[4]. The optimization of the electron beam characteristics as well as its current application in radiation dosimetry will be detailed. Aspects of its potential applications in electron-atom collisions, electron diffraction, generation of anti-matter will also be discussed.

References

[1] S. P. Mangles et al. Nature 431, 535–538 (2004); C. Geddes et al. Nature 431, 538–541 (2004); J. Faure et al. Nature 431, 541–544, (2004).
[2] W. P. Leemans et al. Nat. Phys. 2, 696–699 (2006).
[3] A. Grigoriadis et al. Sci. Rep. 13, 2918 (2023).
[4] E. L. Clark et al. High Power Laser Sci. Eng. 9, e53 (2021).

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Sitzung Einordnung: Session 2

Beitrag ID: **11** Typ: **Talk**

Resonant Photon Scattering off Highly Charged Ions in External Electromagnetic Fields

Donnerstag, 18. September 2025 11:50 (20 Minuten)

Resonant scattering of laser photons off relativistic ion beams can serve as an effective approach for the generation of high-energy photons, as the relativistic Doppler effect leads to a substantial frequency boost of the scattered photons. This idea is expected to be realized by the Gamma Factory project, supported by CERN's Physics Beyond Colliders programme. The concept involves the interaction of laser photons with counter-propagating relativistic ion beams at the LHC, enabling the generation of high-intensity, narrow-band photons with energies of up to 400 MeV. Such a gamma-ray source would offer a broad range of applications in fundamental physics [1,2].
In this theoretical contribution, we investigate resonant photon scattering in the presence of external electromagnetic fields, which are strongly enhanced in a storage ring setup due to the high velocities of the ions. Using He-like calcium ions as a case study, our calculations show that realistic magnetic field strengths can substantially modify the total cross section, angular emission pattern, and polarization of the scattered photons. These findings point to potential applications within the Gamma Factory framework, such as the determination and calibration of the ion beam's Lorentz factor [3].

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[3] J. Richter, M. W. Krasny et al., Resonant photon scattering in the presence of external fields and its applications for the CERN Gamma Factory, Phys. Rev. A 111, 062820 (2025)

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Sitzung Einordnung: Session 10

Beitrag ID: **12** Typ: **Poster**

A Project Towards Ion-Ion Collision Electron Spectroscopy Studies

Montag, 15. September 2025 16:30 (1 h 30m)

Electron spectroscopy has long been a cornerstone for studying the dynamics of ion-atom/molecule collisions [1], offering detailed insight into fundamental processes such as electron capture, ionization, and excitation [2-4]. Extending electron spectroscopy to ion-ion collisions —where both collision partners are charged —is an emerging and largely unexplored frontier. Such studies enable the determination of ionization cross sections in pure three-body systems, allowing for a systematic investigation of the role of additional electrons by controllably varying the electrons carried from the colliding ions, and providing a testing ground for theories. In this context, we present the concept of developing a novel electron spectrometer designed to inaugurate Ion-ion COllisioN Electron Spectroscopy (ICONES). This setup will be implemented within the FISIC platform, which aims to explore ion-ion collisions in the hitherto unexplored intermediate energy regime [5]. The ICONES project is supported by the European Union under a Marie Skłodowska-Curie Postdoctoral Fellowship and provides an upgrade to the FISIC setup, which is currently being commissioned at the Institute of NanoSciences of Paris (INSP), Sorbonne University.

*We acknowledge support of this work from the European Union's Horizon Europe research and innovation programme under the Marie Skłodowska-Curie Postdoctoral Fellowship grant agreement No. 101204956 –ICONES.

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Sitzung Einordnung: Poster Session

Beitrag ID: **13** Typ: **Talk**

ESR Machine Performance During Beam Time 2025

Dienstag, 16. September 2025 09:30 (20 Minuten)

During the user run 2025 essentially all operation modes of the ESR were used and highlights will be presented: electron cooling, stochastic cooling, stacking, internal experiments and extracted beam experiments with beam delivery to CryRing and HITRAP. The new LSA control system is consolidated in the sense that it offers practically all operation modes covered by the decommissioned legacy system, and in addition offers with its large flexibility many options to improve and optimize ESR operation in future machine development periods. During 2025 several machine studies were executed making use of the improved features of the control system and results will be presented. The main goal is to improve the understanding of the machine optics, which will allow a more efficient setup and operation of the ESR for the users in the coming years. The presentation will conclude with an outlook to the 2026 user beamtime.

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Sitzung Einordnung: Session 3

Beitrag ID: **14** Typ: **Talk**

Precision Spectroscopy of Highly-Charged Heavy Ions: Towards a Quantum Logic Clock Based on a Cryogenic Monolithic Paul Trap

Mittwoch, 17. September 2025 15:30 (20 Minuten)

Quantum logic spectroscopy (QLS) enables optical clocks based on atomic and molecular ions that lack direct laser cooling or state detection transitions [1]. QLS therefore serves as a key technique driving significant advances in optical frequency metrology [2-5]. Heavy hydrogen-like or lithium-like ions offer optical transitions that feature both strong suppression of systematic shifts and enhanced sensitivity to physics beyond the Standard Model [3,6,7]. While substantial progress has been demonstrated using medium-mass highly charged ions (HCIs) such as Ar^{13+} [4,5] or Ca^{14+} [8], extending QLS to the heaviest HCIs remains an open challenge while promising unprecedented tests of fundamental physics.

In this contribution, we present the current status of our experimental setup for QLS of heavy HCIs, specifically targeting the optical hyperfine-structure transition in $^{207}Pb^{81+}$ at 1019.7 nm [9], serving as a proof of principle. The experiment is set up downstream of the HITRAP decelerator at the GSI Helmholtz Center for Heavy Ion Research in Darmstadt. It will provide cryogenic trapping conditions for accelerator-produced heavy HCIs, enabling long storage times for high-resolution spectroscopy. Furthermore, it involves various laser systems for in-situ production of the logic ion Be^{+}, laser cooling to the quantum-mechanical ground state of motion, and coherent manipulation of qubit and HCI clock transitions. Based on these ingredients, quantum logic-assisted state preparation and clock state detection will be implemented. An advanced monolithic linear Paul trap is currently under development. Its design aims to minimize detrimental excess micromotion and thus plays a central role in the suppression of leading systematics.

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Sitzung Einordnung: Session 8

Beitrag ID: **15** Typ: **Talk**

Electron Cooling at CRYRING@ESR

Dienstag, 16. September 2025 14:55 (20 Minuten)

Electron cooling is a central beam preparation technique at CRYRING@ESR, and has been employed in all beamtimes since re-commissioning of the storage ring at GSI/FAIR in 2020. With the large variety of ion species available from the UNILAC/SIS18/ESR injector chain and from the local ion source, the electron cooler is required to operate at a wide range of beam parameters. Over the years, beam cooling could be applied successfully for ion energies ranging from $\sim 12\ \mathrm{MeV/u}$ down to $\sim 90\ \mathrm{keV/u}$. The FAIR control system allows for multi-flattop operation, enabling the cooler to assist with efficient synchrotron acceleration or deceleration of ions in CRYRING@ESR.
In addition to the beam cooling application, the cooler doubles as low-energy internal electron target in some experiments. The latter take advantage of the particularly cold electron beam, created by strong magnetic expansion by factors up to 100. This results in a transverse electron temperature in the order of $1\ \mathrm{meV}/k_\mathrm{B}$ and correspondingly high spectroscopic resolution, as recently demonstrated in an experiment on dielectronic recombination of F^{6+}.
Since re-installation at GSI/FAIR, several aspects of the cooler hardware have been upgraded and consolidated, including vacuum and high-voltage systems. Further reliability and performance improvements are planned for the upcoming years of CRYRING@ESR operation.

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Sitzung Einordnung: Session 5

Beitrag ID: **16** Typ: **Talk**

The ARTEMIS Experiment for Precision Measurements of Electron Magnetic Moments in Heavy Highly Charged Ions

Mittwoch, 17. September 2025 14:50 (20 Minuten)

The ARTEMIS experiment at the HITRAP facility situated at GSI, Darmstadt, focuses on precision spectroscopy of highly charged ions as a benchmark of QED in extreme fields. Electron magnetic moments (g-factor) will be determined using the laser-microwave double-resonance spectroscopy on the desired few-electron ions stored in the trap. Laser-microwave double-resonance spectroscopy enables microwave probing of the Larmor frequency through laser spectroscopy of fine/hyper-fine structure of the ions. The induced Zeeman transition is determined through a difference in intensity of the fluorescence produced in a closed optical cycle. Ions are currently produced within the cryogenic Penning trap[1] and are stored, prepared and cooled using electronic, non-destructive techniques[2].
The experimental setup is connected to the low energy HITRAP beamline thereby facilitating online/offline beam delivery, dynamic capture and injection into the trap. Upgrades are ongoing to perform g-factor measurements on hydrogen-like heavy species such as Bi82+ and other lighter species such as S11+. We present an overview along with the current status of the experiment.

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Sitzung Einordnung: Session 8

Beitrag ID: **17** Typ: **Talk**

Vacuum Polarization in Heavy Electronic and Exotic Atoms

Donnerstag, 18. September 2025 12:10 (20 Minuten)

In exotic atoms, one or more electrons have been replaced by a heavier exotic particle like a muon or antiproton. These systems are ideal candidates to test strong-field QED since the particle orbits much closer to the nucleus due to its higher mass, thus experiencing stronger fields. Many upcoming experiments will use this fact to improve QED tests in high-Z systems. However, to effectively use the measurements that will be produced by such experiments, matching theoretical predictions are necessary. We present improved calculations of the Lamb shift in heavy electronic, muonic, and antiprotonic atoms that are non-perturbative in the coupling parameter αZ. In particular, we will focus on the all-order one- and two-loop vacuum polarization as it is strongly enhanced compared to the self-energy in exotic systems.

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Sitzung Einordnung: Session 10

Beitrag ID: **18** Typ: **Talk**

Enhanced Antihydrogen Accumulation With Laser-Cooled Be+

Mittwoch, 17. September 2025 12:20 (20 Minuten)

The study of cold antihydrogen for CPT symmetry tests began in 2010 with the first successful demonstration of trapping individual antihydrogen atoms [1]. In the ALPHA experiment, antihydrogen is produced via a three-body recombination process involving one antiproton and two positrons [2]. Antihydrogen is formed by combining cold plasmas of positrons and antiprotons in a specialized Penning-Malmberg trap, which spatially overlaps with a magnetic minimum trap designed to confine antihydrogen atoms [3]. Due to the shallow depth of the magnetic potential - capable of trapping only atoms with kinetic energies corresponding to temperatures below 0.5 K - early experiments typically confined ~20 antihydrogen atoms per production cycle. In 2017 the technique was advanced to allow continuous synthesis and accumulation of antihydrogen [4, 5], enabling key milestones such as the first high-precision measurement of the 1S–2S transition [6] and the first observation of gravity's influence on antimatter [7].
Antihydrogen production through the three-body recombination process depends on the thermal energy of the positrons; both the production and trapping rates increase as the positron temperature decreases. So far the temperature of positron plasma in ALPHA-2 trap was limited to around 20K, which was achieved via the cyclotron cooling mechanism in the high magnetic field. To reduce the temperature of the positron plasma even further, an active cooling mechanism is required.
Inspired by pioneering work at NIST [8], a sympathetic cooling of positrons with laser-cooled beryllium ions (Be+) was proposed [9]. The Be+ ions are generated via laser ablation of a solid beryllium target [10], then confined within a Penning-Malmberg trap and Doppler cooled using a 313 nm laser. Upon merging with the positron plasma, the laser-cooled Be+ ions carry away thermal energy from the positrons through Coulomb interactions. Sympathetic cooling technique allowed to achieve ~2.5 times lower temperatures of positron plasma than before [11].
Early development of Be+ laser-cooling technique suffered from irreproducibility of the number of ablated beryllium ions and inefficient laser-cooling scheme. Several laser system upgrades were performed, most importantly to allow for simultaneous laser-cooling and Be+ cloud compression using Rotating Wall technique [12]. This improved
laser-cooling technique was successfully integrated into the standard antihydrogen synthesis cycle. An eight-fold enhancement in antihydrogen trapping efficiency per synthesis cycle has been demonstrated, enabling the accumulation of over 15,000 antihydrogen atoms in less than seven hours.
The implementation of sympathetic cooling of positrons method into antihydrogen production cycle has not only accelerated the experimental timeline but also opened new opportunities for detailed investigations of fundamental symmetries. These include potential searches for sidereal variations and other precision tests of antimatter and its
interactions, which were previously inaccessible due to limited sample sizes and extended accumulation times.

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Vortragende(r): PESZKA, Joanna

Sitzung Einordnung: Session 7

Beitrag ID: **19** Typ: **Talk**

Electron-Ion Recombination at the Cryogenic Storage Ring

Montag, 15. September 2025 15:30 (30 Minuten)

The electrostatic Cryogenic Storage Ring (CSR) at the Max Planck Institute for Nuclear Physics in Heidelberg offers unique possibilities to study electron recombination of internally cold molecular ions as well as low-charged heavy atomic ions. The CSR provides a cryogenic environment with vacuum chamber temperatures < 10 K, resulting in a low residual gas density. This enables storage of ion beams for up to several thousand seconds, which in turn allows many molecular ion species to radiatively relax to their lowest electronic, vibrational, and rotational states in the weak blackbody radiation field of the CSR. In one section of the storage ring, a nearly mono-energetic electron beam is collinearly overlapped with the stored ion beam. This setup enables the investigation of electron-ion collisions at tunable center-of-mass collision energies ranging from several tens of eV down to the meV range. Due to the low ion beam energies of 300 keV per charge state, the merged electron beam has to be operated at low lab frame energies of only a few eV to reach the low collision energies. Here, recent electron-ion recombination experiments conducted at the CSR will be reviewed, including dissociative recombination of astrophysically relevant molecular ions and dielectronic recombination of low-charged heavy atomic ions. Special emphasis will be placed on electron collisions with fullerene ions, which exhibit significantly different reaction dynamics compared to small molecular ions. Additionally, recent advances in low-energy electron beam operation and electron cooling will be highlighted.

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Sitzung Einordnung: Session 2

Beitrag ID: **20** Typ: **Poster**

Polarization Effects in the Compton Scattering from Atomically Bound Electrons

Montag, 15. September 2025 16:30 (1 h 30m)

Precise studies of the linear polarization for Compton scattered photons open the unique opportunity for a detailed test of the impulse approximation for energetic photon matter interaction. Compton scattering is the inelastic scattering of a photon off an electron, in which the scattered photon carries a lower energy than the incident photon. For scattering off bound electrons, the resulting Compton scattering peak is broadened due to the momentum distribution of the electrons. Additionally, the electron momentum distribution is expected to influence the polarization transfer from incident to scattered photon beam such that the linear polarization will vary across the Compton peak.
In an experiment, in which a highly linearly polarized hard x-ray beam was scattered off a gold target, the scattered radiation was analyzed with a special interest in its linear polarization. The result of the analysis of the Compton scattered radiation is presented and compared to a simulation developed in the framework of the impulse approximation.

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Sitzung Einordnung: Poster Session

Beitrag ID: **21** Typ: **Poster**

Absolute Rate Coefficients for Dielectronic Recombination of the Astrophysically Relevant Ne3+ Ion at CRYRING@ESR

Montag, 15. September 2025 16:30 (1 h 30m)

Neon, one of the most abundant elements in the universe, is frequently observed in the spectroscopic data of many astrophysical objects. Dielectronic recombination (DR) is a key process for the charge state distribution in astrophysical plasma environments. It is initiated by the resonant capture of a free electron with simultaneous excitation of a bound electron and completed by the emission of photons, which stabilizes the charge state of the recombined ion. We report on the preliminary results from our DR experiment with nitrogen-like Ne ions.
At CRYRING@ESR in Darmstadt, beams of specific elements and charge states are stored, cooled, and exposed to an almost monoenergetic electron beam for DR measurements [1]. The ultra-cold electron beam provided by the CRYRING electron cooler enables high-resolution DR rate coefficient measurements [2], particularly at low electron-ion collision energies, which are essential for understanding recombination rates in cold photoionized plasmas [3].
The ions were injected from an ECRIS at the local injector, accelerated to an energy of 2.23 MeV/u, stored and electron cooled with an average of 5.5×106 ions per cycle. The merged-beams DR spectrum was measured across several overlapping energy ranges, covering a total range of -0.5 to 25 eV in the center-of-mass frame, where the dominant resonances arise from Δn=0 transitions through 2s⟶2p core excitation into 2s2p4 4P levels. Notably, we observed strong DR resonances at energies below 0.5 eV, with the associated merged beam recombination rate coefficient nearly as strong as at the 2s2p4 4P1/2 series limit at 22.91 eV.
Additionally, the level population fractions as a function of storage time was modelled to compare theoretical DR of a mixed ion beam with the experimental data [4].

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Sitzung Einordnung: Poster Session

Beitrag ID: **22** Typ: **Poster**

COLSPEC_MMC –a Setup of Magnetic Metallic Microcalorimeters for the CRYRING Transverse Tlectron Target

Montag, 15. September 2025 16:30 (1 h 30m)

The transverse electron target at the CRYRING has recently been commissioned successfully. It will allow investigating interactions between heavy ions and a collimated beam of monoenergetic electrons, including the emission of X-rays from radiative electron capture. For ions of low and medium nuclear charges, the X-ray transitions lie in the energy range of $1–50\,\mathrm{keV}$. To determine the transition energies with high precision, a detector array of magnetic metallic microcalorimeters (MMCs), which was developed at the Rupprecht-Karls-University Heidelberg, is prepared for the application at the transverse electron target. For this purpose, an existing $^3\mathrm{He}/^4\mathrm{He}$ dilution refrigerator is prepared at the TH~University of Applied Sciences in cooperation with the Justus-Liebig-University Giessen in the framework of the APPA FSP. In addition, a special very small electron trap, a socalled MaMFIT, is set up at the TH Mittelhessen for complementary investigations which can be performed independently of the ion beams at CRYRING. The poster will present the status of the project and future perspectives.

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Vortragende(r): Prof. KRAFT-BERMUTH, Saskia (TH Mittelhessen University of Applied Sciences)

Sitzung Einordnung: Poster Session

Beitrag ID: **23** Typ: **Poster**

Setting Up the Ion Source Test Bench for the Commissioning of a New 14.5 GHz ECR Source

Montag, 15. September 2025 16:30 (1 h 30m)

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The Giessen ion source test bench is an apparatus designed to facilitate an easy adaption to a variety of different ion sources and to provide straightforward control and operation. Therefore, reliable and easy operation was the main focus, so the number of ion-optical components is reduced to the minimum. The test bench consists of an extraction and einzel-lens system, which is adaptable to the dedicated ion source. A pair of two double-plate capacitors permits the ion beam shift in vertical and horizontal direction. A double-focusing mass analyzing bending magnet with four-jaw slits at both focal points follows.
For recording mass spectra with an accuracy for isotope isolation, the ion current is measured in two Faraday cups: one in front and one behind the magnet. The ion current measurement is realized with an in-house developed amperemeter capable of measuring currents between 1 pA and 100 μA.
The test bench is currently under modification to be able to perform performance tests of a new 14.5 GHz ECR ion source as a preparation for commissioning the source at PIPE@P04 at DESY, Hamburg. To achieve this, we have set up the in-house ion current measurement system and established the control of the magnet power supply to record mass spectra. Since the new ECR provides mass-flow controllers as the gas-inlet system, we will be able to determine the ionisation efficiency and find the optimal settings for the new source.
We will report on the experimental setup of the ion source test bench and the steps taken to adapt it to our new ECR source.

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Sitzung Einordnung: Poster Session

Beitrag ID: **24** Typ: **Talk**

Cryogenic Current Comparators: Status and Challenges

Mittwoch, 17. September 2025 10:15 (20 Minuten)

DC operation, non-destructive measurement, high sensitivity and direct traceability to the unit ampere are the advantages of CCCs. SQUIDs, superconducting shielding currents and low-temperature flux concentrators made of soft magnetic nanocrystalline alloys allow single cur-rent pulses resolution below 1 nApp and frequency bandwidth from DC of up to 2 MHz De-pending on the application, the DC value can be defined by a time constant (ranging from days to minutes) through analog filters in front of the SQUIDs. Similarly, the upper cutoff fre-quency (commonly between 1 to 100 kHz) can be limited, which supports system stability. A breakthrough in magnetic shielding was achieved through the transition from massive Nb to thin Pb foils. The use of two pickup coils and up to 3 SQUIDs per CCC sensor further im-proved the interference resistance and dynamic range. The revision of the FAIR cryostat now allows more than six months service life of the CCC system. Based on comparative meas-urements in the beam, the Pb-DualcoreCCC-xD was qualified as the standard for the FAIR installations. Currently, the beam pipe of the first FAIR prototype cryostat is being upgraded from 125 mm to 150 mm for permanent installation in the HEBT tunnel. The manufacturing of a second FAIR cryostat has started. In parallel, the manufacturing of a second Pb-DCCC-xD is taking place in Jena. For special experiments at a beamline diameter of 40 mm, a complete DCCC system without a re-liquefier is now also available in Jena, with a service life time of up to 10 days.
As part of a BMFTR project started in 2024, dedicated to digital signal processing, the three data channels generated at the DCCC are optimized and filtered for application of the device in a spill optimization feedback system. Particularly challenging is the development of a very short CCC system specifically for the CRYRING@ESR as part of another BMFTR project that started this year. The second CCC installation planned at CERN, now in the North Area at TT20 from the Super Proton Synchrotron, will also explore new approaches regarding cryogenics.

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Sitzung Einordnung: Session 6

Beitrag ID: **25** Typ: **Talk**

Precision Low-Energy X-Ray Spectroscopy With an Asymmetric von Hamos Spectrometer at CRYRING@ESR

Mittwoch, 17. September 2025 10:35 (25 Minuten)

We present recent advancements in the development and simulation studies of a high-resolution asymmetric von Hamos (AvH) spectrometer designed for low-energy X-ray spectroscopy (5–10 keV) at the CRYRING@ESR electron cooler [1]. The spectrometer exploits the unique features of a long linear X-ray source formed by the overlap of cold electron and highly charged ion beams, combined with an electron temperature in the meV range, enabling high energy resolution.

The experimental setup will consist of two identical AvH spectrometers installed symmetrically at 0° and 180° with respect to the ion beam direction. This configuration enables simultaneous detection of red- and blue-shifted radiative recombination (RR) photons, ensuring full cancellation of Doppler-induced energy shifts. Each spectrometer uses a 100 × 100 mm^2 cylindrically bent Si(111) crystal with a 1 m radius and a position-sensitive Timepix3-based detector featuring 25 × 25 μm^2 pixels and 1.6 ns time resolution. The system is optimized for operation in photon-ion coincidence mode, allowing effective background suppression and high-purity spectroscopy.

Comprehensive Monte Carlo simulations of X-ray diffraction predict an energy resolution ranging from approximately 160 meV at 5 keV to a few eV at 10 keV, with expected sub-meV precision in measuring X-ray transition energies [2]. The long, narrow photon source and asymmetric geometry enable high sensitivity to small energy shifts and allow flexible spectrometer alignment using Bragg angle tuning.

The Technical Design Report has been formally approved, and all technical specifications have been finalized. Project execution documentation is nearing completion, and major procurement and installation steps are scheduled between 2026 and 2028. Once operational, the AvH spectrometer will enable precision measurements of X-rays from radiative recombination and cascade transitions in mid-Z H- and He-like ions. These measurements will provide access to subtle quantum electrodynamics (QED) effects, including two-loop corrections and nuclear size contributions, with unprecedented experimental accuracy.

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Sitzung Einordnung: Session 6

Beitrag ID: **26** Typ: **Talk**

Dielectronic Recombination-Assisted Laser Spectroscopy: A new Tool to Investigate the Hyperfine-Puzzle in Bi80+,82+

Dienstag, 16. September 2025 09:50 (25 Minuten)

We briefly report on the first laser excitation of the ground-state hyperfine transition in lithium-like 208Bi80+. The experiment took place at the ESR during the beam-time block at GSI in May 2025 (GPAC-Experiment: G-22-00038). The detection of the transition became possible by combining the laser excitation with dielectronic recombination as (DR) a new detection scheme.

Therefore, the electron cooler is set to a voltage that allows the DR process from the upper hyperfine state, but not from the lower one. Resonantly driving the laser transition to the upper state will then lead to an appearance of the DR signal.

We have demonstrated this technique for the first time using the radioactive isotope 208Bi in the lithium charge state, which is by itself very challenging to be produced and stored at the required energy at the ESR. In summary, a beam time with ups and some downs and a happy end. Precision measurements are now envisaged for the next beam time, which has already been granted by the GPAC (Proposal: G-24-00290).

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Sitzung Einordnung: Session 3

Beitrag ID: **27** Typ: **Talk**

Nuclear Two-Photon Decay Investigation of 98Mo at the ESR Heavy Ion Storage Ring

Dienstag, 16. September 2025 12:15 (20 Minuten)

The nuclear two-photon or double gamma (2γ) decay is a rare
second-order electromagnetic process in which an excited nucleus emits two gamma rays simultaneously [1]. Its branching ratio is significantly lower than that of competing first-order processes such as internal conversion, pair creation, or single-photon emission, making its experimental observation extremely challenging. However, in the Experimental Storage Ring (ESR) at GSI, these competing decay modes can be suppressed by storing fully stripped ions and selecting a $0^+ \rightarrow 0^+$ transition with excitation energy below the electron-positron pair creation threshold (1022 keV) [2, 3]. Under these conditions, the two-photon decay becomes the only available decay channel.

In this talk, we will report on the current status of the analysis of an experiment investigating the 2γ decay of $^{98}\mathrm{Mo}$, which has a first excited 0^+ state at 734.75 keV. The experiment was performed at the GSI facility in Darmstadt, employing the unique conditions in the Experimental Storage Ring. Fully stripped $^{98}\mathrm{Mo}$ ions were produced using the projectile fragmentation of $^{100}\mathrm{Mo}$ primary beam on a ^{9}Be target in the transfer line to the ESR. These ions were then transported and stored in the ESR, which was operated in the isochronous mode. To monitor and detect the revolving ions, two non-destructive Schottky detectors [4] were used at different operation frequencies (245 and 410 Hz). These detectors allow for precision measurement of the ions'revolution frequencies, enabling extraction of both the nuclear half-life and mass. In addition, the revolution frequency provides particle identification via the ions'mass-to-charge ratios. The preliminary results indicate that the measured half-life of $^{98}\mathrm{Mo}$ is consistent with the expected theoretica estimates based on extrapolation from previously studied $0^+ \rightarrow 0^+$ nuclear transitions [1].

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Sitzung Einordnung: Session 4

Beitrag ID: **28** Typ: **Talk**

Depolarization of Radiation of High Energy Electron Bunch in a Strong Magnetic Field

Donnerstag, 18. September 2025 10:20 (20 Minuten)

Synchrotron radiation is widely used to generate intense beams of hard photons [1]. Of particular intrest is the case of electron propagation in a strong magnetic field comparable to the critical Schwinger field, $H_c \approx 4.41 \cdot 10^{13}$ G. In this regime, rapid radiative self-polarization, accompanied by intense emission, is expected to occur on a timescale of femtoseconds. Recently, the generation of a strong magnetic field of approximately $4 \cdot 10^9$ G has been proposed via the collision of a dense high-energy electron bunch with a solid target at a grazing angle [2,3].

In this contibution, we perform simulation of propagation of an bunch electron in a strong uniform magnetic field. Energy loss due to radiation and the consequent emission of multiple photons are taken into account. We numerically solve the balance equation to determine the time evolution of the spin-resolved energy distribution of the electron beam. This, in turn, allows us to evaluate the polarization of the emitted radiation as a function of time and photon energy.

We consider the dependence of radiation polarization on the dimensionless parameter $\varepsilon = (E/mc^2)(H/H_c)$, where E is the electron energy and H is the magnetic field strength. For $\varepsilon \ll 1$, we reproduce the well-known result that radiation is predominantly polarized perpendicular to the magnetic field [4]. However, when $\varepsilon \gg 1$, the spectral maximum shifts toward the emission of high-energy photons, resulting in a substantial decrease in radiation polarization. The most notable case arises for electrons with spins aligned parallel to the magnetic field. In this regime, significant or nearly complete depolarization of the synchrotron radiation is observed.

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Sitzung Einordnung: Session 9

Beitrag ID: **29** Typ: **Talk**

The Bound-State Beta Decay of 205Tl(81+) to Understand 205Pb in the Early Solar System

Montag, 15. September 2025 14:30 (35 Minuten)

Lead-205 initially looks like a very promising candidate to be used as a chronometer for the early Solar System due to its unique position among astrophysically short-lived radionuclides as an *s*-only isotope probing the termination of the *s* process [1]. Unfortunately, the 2.3 keV 1/2− first excited state in ^{205}Pb reduces the half-life in stellar environments by around 6 orders of magnitude, which could severely inhibit ^{205}Pb production. However, Yokoi *et. al.* [2] pointed out that the bound-state beta decay of ^{205}Tl could counter-balance this decay by producing ^{205}Pb. To clarify the complex production of 205Pb, we measured the bound-state beta decay of ^{205}Tl^{81+} at the Experimental Storage Ring in GSI, Darmstadt. From the measured half-life, we calculated new weak decay rates for a wide range of astrophysical conditions. AGB stellar nucleosynthesis models based on these new rates saw approximately a factor 2 increase in ^{205}Pb production (when legacy rates were controlled). With new production ratios, we predicted an updated steady-state interstellar medium (ISM) ^{205}Pb/^{204}Pb ratio. By comparing the ISM ratio to the ratio measured in the earliest meteorites, we derived, for the first time, a positive time interval for the isolation period of the solar material from enrichment. Our new results are also preliminarily consistent with other *s*-process chronometers. Looking forward, we now aim to investigate the ^{205}Pb(n, γ) cross-section, currently unmeasured at astrophysical energies, using surrogate reactions at the ESR with the NECTAR collaboration.

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Sitzung Einordnung: Session 2

Beitrag ID: **30** Typ: **Talk**

Surrogate Reaction in Inverse Kinematics at the ESR

Dienstag, 16. September 2025 11:30 (25 Minuten)

Neutron-induced reaction cross sections of short-lived nuclei are crucial for our understanding of nuclear astrophysics and for various applications in nuclear technology. However, direct measurements of these cross sections are extremely challenging or even impossible, due to the difficulty in producing and handling the required radioactive targets.

We are developing a novel approach that, for the first time, employs surrogate reactions in inverse kinematics at a heavy-ion storage ring [1][2]. This method enables us to measure all de-excitation probabilities as a function of the excitation energy of nuclei formed via surrogate reactions, with unprecedented precision, thereby allowing for the indirect determination of the desired neutron-induced cross sections.

In this talk, I will present our methodology and the results from our second successful surrogate-reaction experiment conducted at the ESR storage ring of the GSI/FAIR facility in Darmstadt, Germany. In this experiment, we investigated the (d,p) and (d,d') surrogate reactions on ^{238}U, achieving a major breakthrough: for the first time, we simultaneously measured fission, γ-ray, neutron, as well as two- and three-neutron emission probabilities.

Simultaneous measurement of all competing decay channels enables the precise determination of key nuclear properties such as fission barriers, particle transmission coefficients, γ-ray strength functions, and nuclear level densities, which in turn allow us to infer neutron-induced cross sections for (n,f), (n,γ), (n,n'), (n,2n), and (n,3n) reactions.

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Sitzung Einordnung: Session 4

Beitrag ID: **31** Typ: **Talk**

Interdisciplinary Research at GANIL: Status and Current Activities

Mittwoch, 17. September 2025 11:30 (25 Minuten)

The interdisciplinary research platform CIRIL at GANIL (Caen, France) provides a unique environment for cutting edge studies using a wide variety of ion beamlines. These beamlines cover a wide energy range and offer excellent stability, making it possible to run experiments with both light and heavy ions. As one of the few facilities worldwide offering simultaneous access to such a spectrum of beams, CIRIL hosts over a hundred projects annually, with several thousand hours of beam time delivered to a diverse user community.
Today, the topics explored at CIRIL are as varied as its users: from atomic physics to radiobiology and astrophysics, and from organic and hybrid materials to the study of metals and ceramics. Looking ahead, several new installations are planned at CIRIL@GANIL. The talk aims to give an overview of the current status and to discuss current challenges and future endeavours.

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Sitzung Einordnung: Session 7

Beitrag ID: **32** Typ: **Poster**

New Experimental Platform for Atomic Parity Violation Studies in Ytterbium

Montag, 15. September 2025 16:30 (1 h 30m)

Precision studies of the weak interaction in atomic systems offer sensitive tests of the Standard Model and open avenues for exploring physics beyond it. Although the landmark atomic parity violation (APV) measurements in cesium represent a key reference in the field [1], further studies are necessary. Currently, two complementary experimental approaches are being pursued: (1) large-scale efforts at accelerator facilities aim to measure APV in highly charged ions, such as He-like uranium or europium, via two-photon laser spectroscopy [2]. These systems feature simple electronic structures, allowing for accurate theoretical predictions. (2) In parallel, compact table-top experiments provide competitive sensitivity. At the University of Crete, we have developed a new experimental setup for APV studies across various isotopes of ytterbium [3]. The goal is to improve upon the sensitivity of previous Yb APV measurements [4], enabling the extraction of neutron-skin effects across isotopes and the observation of nuclear-spin-dependent (NSD) contributions such as the nuclear anapole moment. Here, we present an overview of the experimental apparatus, its operating principles, and preliminary results.

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Sitzung Einordnung: Poster Session

Beitrag ID: **33** Typ: **Poster**

A Pedestrian Approach to Modeling Atomic Processes and Behavior

Montag, 15. September 2025 16:30 (1 h 30m)

Synopsis While the interaction of atoms with particles and light has been extensively studied over the past decades, making precise and reliable predictions about the behavior and dynamics of atoms and ions remains a challenge. Serious difficulty arise not only from the complexity of most atomic processes but also from the intricate nature of inter-electronic interactions. In this work, we introduce, emonstrate, and advance computational tools designed for providing consistent and reliable atomic data.

Atomic data and information are essential in fields such as astrophysics, plasma physics or fusion research, where an accurate modeling of atomic interactions, radiation processes, and en-
ergy transfer is more or less urgently required, but also at many places elsewhere. Whereas, at least in principle, this information could be
obtained through (spectrocopic) measurements, computational methods need to be developed in order to solve the quantum many-electron
problem with sufficient accuracy. Despite recent progress, however, detailed predictions in atomic and plasma physics are challenging due
to the complex interplay of many-body interactions, relativistic effects as well as quantum corre-lations, which altogether often require sophis-
ticated models and extensive computational resources.To overcome these difficulties, powerful opensource codes are required to incorporate manybody interactions and relativistic contributions into the modeling of atoms, and especially into their coupling to the electron continuum. With JAC, the Jena Atomic calculator [1,2], we now supports atomic (structure) calculations of different kinds and complexities. Indeed, this toolbox can be readily applied also to model a good number of atomic excitation and decay processes within the same computational ramework. With the design and implementation of JAC, we aimed also to develop a "descriptive language"that is (i) user-friendly, (ii) emphasizes the underlying atomic physics, and (iii) avoids most technical jargon, as is common for other established codes.

All these goals are relevant in order to ensure a good (self-)consistency of the data generated for different atomic roperties, processes and cascade [3].

Figure 1. Features of the JAC toolbox [1,2].

In this talk, I shall explain how JAC can be utilized to model many, if not most, of the known processes. Explicit examples will include collec-
tive Auger processes [4], the decay dynamics of double core-hole states [5], or various types of hyperfine-induced transitions. In particular, I
shall demonstrate that such a collaborative approach is not only desirable but also feasible and highly beneficial for the atomic physics community.

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Sitzung Einordnung: Poster Session

Beitrag ID: **34** Typ: **Poster**

Atomic Cascade Computations for Astro and Plasma Physics

Montag, 15. September 2025 16:30 (1 h 30m)

Synopsis
Atomic cascades occur frequently in Nature and have therefore been tudied in different fields of physics and elsewhere, from precision measurements to the modeling of astrophysical spectra, and up to aterials research. We here discuss a classification of atomic cascades and shall demonstrate how such cascade processes can be readily modeled within the framework of JAC, the Jena Atomic Calculator.

Atomic cascades occur frequently in Nature owing to the interaction of matter with particles and light. They typically refer to a stepwise modification in the (electronic) structure of atoms and ions and are often "caused"by either the excitation of inner-shell electrons due to photon, electron, or proton impact, or by the capture of electron(s) into Rydberg orbitals. If, for instance, an atom or ion is initially excited into the continuum of the next higher (or even a several times higher) charge state, it will stabilize itself via various decay rocesses towards some ground configuration, a process that is typically
seen in the observed photon, electron or ion spectra. In astrophysics, for example, much of the information about distant stars originates from
the photon emission of particular atoms or ions at well-defined wavelengths, and may help reveal the temperature, density and chemical composition of these objects, Figure 1 displays selected needs for modeling atomic cascades in different field of physics [1,2]. In practice, most of these (atomic) cascades exhibit a rather high complexity, even if just the dominant decay pathes are to be taken into account. This complexity arises first of all from the large number of decay paths that a (manyparticle) quantum system may take. To systematically model such cascades, we have expanded JAC, the Jena Atomic Calculator [3,4], that supports the calculation of different atomic shell structures and processes. To model the excitation and subsequent decay of atoms and ions, we have classified and implemented a number of atomic cascade schemes within the framework of JAC. Moreover, this implementation is based on a clear distinction between (so-called) cascade computations, to first generate all of the necessary transition data, and subsequent simulations in order to properly combine these data and compare them with experiment.

Figure 1. Needs for modeling of atomic cascades in different field of physics.

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Sitzung Einordnung: Poster Session

Beitrag ID: **35** Typ: **Poster**

Energy Loss of an Antiproton in an Electron Plasma

Montag, 15. September 2025 16:30 (1 h 30m)

In modern charged particle collider research, increasing the number of investigated events requires beams with high-quality characteristics, particularly high brightness and low velocity spread. This can be achieved using beam cooling techniques. The most well-known among them is electron cooling, which involves colliding fast charged particles with a cold electron beam, resulting in a reduction in the velocity spread of the particles [1]. Despite its widespread use in accelerator technology, several theoretical issues related to this method remain unresolved. These include the dependence of energy loss on the particle's charge sign, the electron beam temperature, its velocity distribution, and other factors. These problems still lack a comprehensive theoretical description. For example, explaining the energy loss difference between protons and antiprotons within binary collision theory requires a phenomenological approach with additional adjustable parameters. Notably, the cooling difference between protons and antiprotons is relevant to the FAIR (Facility for Antiproton and Ion Research) project at GSI in Darmstadt, where advanced physics experiments with antiprotons and heavy ions will be conducted [2].

This work studies the deceleration of a charged particle in an electron plasma using a nonlinear dielectric model and one-dimensional Particle-In-Cell (1D PIC) simulations, taking into account close collisions between the external charged particle and electrons. The one-dimensional model is justified by the magnetization of electrons in electron cooling. The simulation parameters were as follows: the thermal velocity of electrons was taken as the unit of velocity, the inverse plasma frequency as the unit of time, and the Debye radius as the unit of length. The length of the simulation domain was L=1000, with 2000 cells, a time step of 0.1, and 10 particles per cell. Periodic boundary conditions were applied.

The simulations yielded time-dependent energy profiles for oppositely charged particles at various values of the velocity of the external particle. It was shown that for fast particles, the obtained dependencies agree well with analytical expressions. However, at five thermal velocities, a significant deviation was observed. A comparison of energy losses showed no significant deceleration difference at high velocities due to collective effects. However, for intermediate cases, a difference is observed, analogous to the Barkas effect. Close collisions between the external particle and plasma electrons were also taken into account using the Monte Carlo method. It was assumed that negatively charged ions reflect electrons forward and backward along the magnetic field if they are located at small impact parameters, while protons, on the contrary, attract electrons, causing them to accelerate and pass close to the proton without energy transfer. These simulations qualitatively demonstrate the possibility of energy loss differences between protons and antiprotons in an electron plasma.

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[2] B. Galnander et al., HESR Electron Cooler Design study. Technical report, The Svedberg Laboratory, Uppsala University, 2009.

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Vortragende(r): DIACHENKO, Mykhailo (The Institute of Applied Physics NAS of Ukraine)

Sitzung Einordnung: Poster Session

Beitrag ID: **36** Typ: **Talk**

Laser Cooling at the SIS100

Dienstag, 16. September 2025 12:35 (25 Minuten)

The heavy-ion synchrotron SIS100 at FAIR will be equipped with a truly unique laser cooling facility. A sophisticated combination of 3 newly developed UV (257 nm) and VIS (514 nm) laser systems and modest rf-bunching will allow for fast cooling of injected intense heavy-ion beams. There will be two powerful pulsed laser systems with MHz repetition rates and variable pulse duration and one powerful tunable cw laser system. The picosecond laser pulses are broad in frequency and will enable fast cooling of injected ion beams with a large initial longitudinal momentum spread. The cw laser can be quickly tuned over a large range and has high spectral power, forcing the ion beams to remain cold during storage. This combination of 3 laser beams should be up for the challenge of suppressing intra-beam scattering and space charge effects. I will give an update of the status of the SIS100 laser cooling facility and will show new results from our laser cooling simulations.

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Vortragende(r): WINTERS, Danyal (GSI)

Sitzung Einordnung: Session 4

Beitrag ID: **37** Typ: **Poster**

Ionisation Phenomena in Stored Highly Charged Ions at Relativistic Laser Intensities

Montag, 15. September 2025 16:30 (1 h 30m)

Interaction of high-intensity lasers with highly charged atomic ions is
widely explored field in theory while there is still a lack in experimental data.
In the past, several experiments have analyzed high-intensity laser
ionization of gases. However, experiments of relativistic laser beams
targeting highly charged ions would allow for addressing only the
weakest bound electron in the target ion which can be described more
precisely by the elaborated theoretical models. Nevertheless, such experiments remain scarce due to the complexity of the needed setup
which calls for a combination of highly charged ions together with the
ability to trap, analyze and control the ions to pinpoint accuracy
while still being able to expose the ions to a high-intensity laser.
In our working HILITE setup, highly charged ions are created in an
electron beam ion trap, species selected by a Wien filter, and finally
stored, analyzed and confined a Penning trap for several seconds in a
defined position. We have connected this setup to the 200
Terawatt Femtosecond Laser system JETi200 and perform
ionization dynamics beyond 10^19 W/cm². We will present the experiment's purpose and preliminary results.

Autor: Dr. RINGLEB, Stefan (GSI Helmholtzzentrum für Schwerionenforschung)

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Vortragende(r): Dr. RINGLEB, Stefan (GSI Helmholtzzentrum für Schwerionenforschung)

Sitzung Einordnung: Poster Session

Beitrag ID: **38** Typ: **nicht angegeben**

Registration & Refreshments

Montag, 15. September 2025 10:00 (1 Stunde)

Beitrag ID: **39** Typ: **Invited Talk**

Beam Times 2026-2027

Dienstag, 16. September 2025 16:30 (15 Minuten)

Vortragende(r): VOGEL, Manuel (GSI Helmholtzzentrum für Schwerionenforschung GmbH(GSI))

Beitrag ID: **40** Typ: **Invited Talk**

SPARC Business

Dienstag, 16. September 2025 16:45 (45 Minuten)

Vortragende: HILLENBRAND, Pierre-Michel (GSI Helmholtzzentrum für Schwerionenforschung GmbH(GSI)); SCHUCH, Reinhold (Stockholm university); STÖHLKER, Thomas (GSI , HI Jena and Uni Jena)

Beitrag ID: **41** Typ: **nicht angegeben**

Visit to Labs

Mittwoch, 17. September 2025 15:50 (1 Stunde)

Beitrag ID: **42** Typ: **Invited Talk**

Concluding Remarks

Donnerstag, 18. September 2025 12:30 (15 Minuten)

Vortragende: BENIS, Emmanouil (University of Ioannina); SCHUCH, Reinhold (Stockholm university)

Beitrag ID: **43** Typ: **Talk**

The SpecTrap Experiment

Mittwoch, 17. September 2025 15:10 (20 Minuten)

On behalf of the SpecTrap collaboration, I will present the physics and status of the SpecTrap experiment located at the HITRAP facility at GSI, Germany. The aim of the experiment is optical and near-optical precision spectroscopy of highly charged ions that are confined and cooled in a dedicated Penning trap. Highly charged ions of interest comprise Bi82+ for further studies in the ARTEMIS project, and few-electron 229Th for studies within the HiThor project.

Autoren: VOGEL, Manuel (GSI Helmholtzzentrum für Schwerionenforschung GmbH(GSI)); SPECTRAP COLLABORATION

Vortragende: VOGEL, Manuel (GSI Helmholtzzentrum für Schwerionenforschung GmbH(GSI)); SPECTRAP COLLABORATION

Sitzung Einordnung: Session 8

Beitrag ID: **44** Typ: **Talk**

Recent Highlights from the Storage Rings at GSI/FAIR

Montag, 15. September 2025 12:15 (45 Minuten)

An overview of the experiments conducted at the ESR in the last beam time running periods will be given. The big number of proposals submitted to the G-PAC in 2024 illustrates an exiting future of the storage ring program at GSI. The presentation will be concluded by an outlook to the planned studies in 2026/2027.

Autor: LITVINOV, Yury (GSI Helmholtzzentrum für Schwerionenforschung GmbH(GSI))

Vortragende(r): LITVINOV, Yury (GSI Helmholtzzentrum für Schwerionenforschung GmbH(GSI))

Sitzung Einordnung: Session 1

Beitrag ID: **45** Typ: **Talk**

Development of a Liquid Jet Target to Probe Early Crystallization

Donnerstag, 18. September 2025 10:40 (20 Minuten)

The freezing of a liquid begins with the random formation of a tiny crystalline seed, often consisting of only a few atoms. For over a century, the theory describing this crystal nucleation process has been remarkably difficult to verify experimentally. In our earlier studies with krypton and argon, we observed striking discrepancies between theoretical predictions and measured nucleation rates [1]. Building on our long-standing expertise in target development at GSI—particularly in producing micrometer-scale liquid jets—we have now carried out a dedicated experiment focused solely on krypton. Using the European X-ray Free-Electron Laser Facility in Germany, we collected data that enables us to probe the early stages of crystallization. Looking ahead, we plan to refine our liquid jet techniques further to rigorously test key hypotheses of nucleation theory. These efforts will not only deepen our fundamental understanding of crystallization but also contribute to more accurate climate models, where such processes play a critical role.

[1] **Crystal nucleation in supercooled atomic liquids**; Phys. Rev. Lett. 132, 206102 (2024); Featured in Physics Magazine and Nature Physics
J. Möller, A. Schottelius, M. Caresana, U. Boesenberg, C. Kim, F. Dallari, T. A. Ezquerra, J. M. Fernández, L. Gelisio, A. Glaesener, C. Goy, J. Hallmann, A. Kalinin, R. P. Kurta, D. Lapkin, F. Lehmkühler, F. Mambretti, M. Scholz, R. Shayduk, F. Trinter, I. A.Vartaniants, A. Zozulya, D. E. Galli, G. Grübel, A. Madsen, F. Caupin, R. E. Grisenti

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Vortragende(r): BINISKOS, Andreas (Institut für Kernphysik, Goethe-Universität Frankfurt am Main, 60438 Frankfurt am Main, Germany)

Sitzung Einordnung: Session 9

Beitrag ID: **46** Typ: **Talk**

Atomic Physics –from Metrology to BSM Searches

Donnerstag, 18. September 2025 09:30 (25 Minuten)

Atomic physics has long been at the forefront of precision measurement, providing both the tools to define fundamental standards and the sensitivity to probe physics beyond the Standard Model (BSM). Recent advances have allowed us to address open questions in neutrino physics, test the limits of bound-state quantum electrodynamics (QED), and provide benchmark data for astrophysics and plasma modeling. In this talk, I will present a broad overview of these efforts, drawing from my work, co-workers and collaborations.
On the BSM frontier, I will discuss the BeEST experiment, which uses superconducting tunnel junction detectors to measure the recoil spectrum of ^{7}Li nuclei from electron-capture decay of ^{7}Be [1,2]. This approach enables direct searches for heavy sterile neutrinos and has recently provided the first constraints on the spatial extent of neutrino wavepackets [3]. I will also highlight the theoretical challenges in accurately modeling atomic relaxation processes, particularly shake-up and shake-off, using multiconfiguration Dirac–Fock methods [4], which are essential to disentangle potential new-physics signatures from standard atomic effects.
In parallel, high-precision x-ray spectroscopy of highly charged ions provides stringent tests of QED in multi-electron systems. Reference-free measurements of He-like transition energies [5-7] combined with Bayesian statistical analyses [8] allow us to benchmark theory at the ppm level and to evaluate possible deviations as potential signs of new interactions.
Finally, I will show how these precision tools feed into applications well beyond the laboratory, from accurate fluorescence yields and line-shape parameters [9–10] relevant for plasma modeling to laboratory measurements of astrophysically abundant ions [11-12], which are essential for interpreting modern x-ray observations of hot cosmic environments.
Together, these examples illustrate how atomic physics continues to connect precision metrology with fundamental physics searches, playing a key role in both testing the Standard Model and enabling discoveries in astrophysics.

Autor: MACHADO, Jorge (LIBPhys-UNL)

Vortragende(r): MACHADO, Jorge (LIBPhys-UNL)

Sitzung Einordnung: Session 9

Beitrag ID: **47** Typ: **Talk**

Precision X-Ray Spectroscopy of Helium-Like Uranium Using Metallic Magnetic Calorimeter Detectors (MMC)

Dienstag, 16. September 2025 15:15 (25 Minuten)

Metallic-magnetic microcalorimeter detectors for X-ray precision spectroscopy provide excellent energy
resolution combined with a broad bandwidth acceptance. This opens up new experimental possibilities, in
particular for bound-state QED studies in highly charged ions. Using a pair of such detector systems, we
recently conducted a landmark experiment, as presented in [P. Pfäfflein et al. Quantum electrodynamics
in strong electromagnetic fields: Substate resolved Kα transition energies in helium-like uranium, PRL
134, 153001 (2025)].
At CRYRING@ESR, we recorded the X-ray spectra for the electronic transitions into the ground- and
excited states for electron-cooled, helium-like uranium (U90+) ions. This provided us with an unmatched
spectral resolution close to 90 eV FWHM. That enables to resolve and to determine precisely the four
components of the Kα groundstate transitions. The results are in good agreement with state-of-the-art
bound-state QED calculations for the strong-field regime. In this contribution, we will present a summary
of this measurement as well as a first glance at data obtained in a follow-up experiment conducted this
summer.

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Vortragende(r): WALCH, Johanna H. (HI Jena, IOQ-FSU Jena)

Sitzung Einordnung: Session 5

Beitrag ID: **48** Typ: **Talk**

The Quest for a Dense Target at CRYRING

Mittwoch, 17. September 2025 09:30 (20 Minuten)

An internal target station featuring a novel design based on previous experiences gained at the ESR has been installed and commissioned in the CRYRING storage ring during 2022. Since then, numerous target experiments utilizing different gases, ranging from hydrogen to xenon, were performed at moderate target densities. However, a considerably higher area density for hydrogen and deuterium was requested for this years beamtime block.

It had been known from previous experimental campaigns that the limiting factor preventing higher densities was the gas load in the first differential pumping stage of the inlet chamber. Consequently, the target station has been enhanced by installing a larger pump. Moreover, a refined control system as well as a beam shutter has been introduced in order to improve target beam handling and monitoring. An unexpected issue nearly led to the cancellation of the beamtime, which could fortunately be prevented by an improvised emergency operation.

The necessary modifications and the intervention that eventually led to a successful campaign will be presented in detail and the current status as well as future plans regarding the target stations both at ESR and CRYRING will be discussed.

Autor: PETRIDIS, Nikolaos (GSI Helmholtzzentrum für Schwerionenforschung GmbH(GSI))

Vortragende(r): PETRIDIS, Nikolaos (GSI Helmholtzzentrum für Schwerionenforschung GmbH(GSI))

Sitzung Einordnung: Session 6

Beitrag ID: **49** Typ: **Talk**

HITHOR: Laser Spectroscopy of 229Th89+ at ESR

Dienstag, 16. September 2025 10:15 (25 Minuten)

The low-lying isomeric state of the ^{229}Th nucleus has been intensively discussed as a candidate for nuclear clocks. Different approaches are pursued worldwide, either based on Th-doped crystals or lowly charged Th ions. The HITHOR project follows a different approach by utilizing nuclear hyperfine mixing (NHM) in highly-charged hydrogen-like ^{229}Th^{89+}. GSI offers the unique possibility to produce Th in this charge state and it is planned to conduct a series of successive experiments at the ESR storage ring, the SPECTRAP Penning trap, and the quantum logic spectroscopy setup, which is currently build behind the HITRAP deceleration facility. The aim is to successively reduce the uncertainty of the nuclear transition, with the ultimate goal of establishing a new time standard based on a ^{229}Th nuclear clock.
The first step of this endeavor is the demonstration of NHM at the ESR by means of collinear laser spectroscopy. Due to hyperfine quenching of states with the same total angular momentum, the transition probability is significantly enhanced, making the transitions within the hyperfine structure of ^{229}Th^{89+} accessible to conventional laser spectroscopy. The production of ^{229}Th from a ^{229}U primary beam, as well as the preparation of an electron-cooled bunched ^{229}Th beam, has already been successfully demonstrated. Initial laser spectroscopy attempts were carried out at a beam energy of 189 MeV/u, which Doppler-shifts the 8.34 eV transition into the visibile regime.
In this talk, I will present the current status of the experiment as well as the associated experimental challenges.

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Vortragende(r): MOHR, Konstantin (GSI Helmholtzzentrum für Schwerionenforschung GmbH(GSI))

Sitzung Einordnung: Session 3

Beitrag ID: **50** Typ: **Talk**

Machine Learning Approaches for Metallic Magnetic Calorimeters

Dienstag, 16. September 2025 15:40 (20 Minuten)

Metallic magnetic calorimeters (MMCs) of the maXs-series, developed within the SPARC collaboration, offer exceptional energy resolving power (up to $E/\Delta E \approx 6000$ at 60 keV) [1] over a broad spectral range (1–100 keV) with high quantum efficiency and linearity [2], making them ideal for high-precision X-ray spectroscopy in fundamental atomic physics. Their operation, however, requires intricate per-pixel optimization of hardware parameters - such as SQUID array tuning - and extensive manual steps in the analysis of raw detector pulses [3]. These procedures, while manageable for current small-scale arrays, become infeasible for future MMC developments with orders of magnitude more pixels.
We present first results of applying machine learning (ML) methods to automate MMC signal classification and feature extraction, thereby improving scalability and robustness. Classical techniques such as principal component analysis combined with clustering were evaluated for reliable pulse shape classification. More advanced architectures, in particular convolutional variational auto-encoders (CVAEs) coupled with multilayer perceptrons (MLPs), were trained on synthetic MMC pulses to embed them into a low-dimensional latent space and reconstruct physical pulse parameters (e.g., amplitude, trigger time, decay time). Notably, neural networks trained solely on synthetic data successfully reconstructed calibration spectra from real measurements, surpassing traditional finite response filter performance.
These results demonstrate the feasibility of incorporating ML into MMC analysis pipelines, paving the way for automated operation. Future developments will explore fine-tuning with real data, improved artifact simulation for temperature drift correction, and reinforcement learning for autonomous hardware optimization.

References

[1] J. Geist, Ph.D. Thesis, RKU Heidelberg, Germany (2020)
[2] C. Pies et al., J. Low Temp. Phys. 167 (2012) 269–279
[3] M.O. Herdrich, Ph.D. Thesis, FSU Jena, Germany (2023)

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Vortragende(r): HERDRICH, Marc Oliver (GSI Helmholtzzentrum für Schwerionenforschung GmbH(GSI))

Sitzung Einordnung: Session 5

Beitrag ID: **51** Typ: **Talk**

Welcome

Montag, 15. September 2025 11:00 (15 Minuten)

Vortragende: BENIS, Emmanouil (University of Ioannina); KANTI, Panagiota

Sitzung Einordnung: Session 1

Beitrag ID: **52** Typ: **Talk**

Keynote from the Scientific Director of GSI & FAIR

Montag, 15. September 2025 11:15 (20 Minuten)

Vortragende(r): NILSSON, Thomas (GSI Helmholtzzentrum für Schwerionenforschung GmbH(GSI))

Sitzung Einordnung: Session 1

Beitrag ID: **53** Typ: **Talk**

Keynote from the President of CERN Council

Montag, 15. September 2025 11:35 (20 Minuten)

Vortragende(r): FOUDAS, Constantinos

Sitzung Einordnung: Session 1

Beitrag ID: **54** Typ: **Talk**

New Developments in SPARC

Montag, 15. September 2025 11:55 (20 Minuten)

Vortragende(r): STÖHLKER, Thomas (GSI , HI Jena and Uni Jena)

Sitzung Einordnung: Session 1

Beitrag ID: **55** Typ: **Talk**

Status & Future of Schottky Spectroscopy

Dienstag, 16. September 2025 11:55 (20 Minuten)

Vortragende(r): DMYTRIIEV, Dmytro (GSI Helmholtzzentrum für Schwerionenforschung GmbH(GSI))

Sitzung Einordnung: Session 4

Beitrag ID: **56** Typ: **Talk**

Status of CRYRING@ESR

Dienstag, 16. September 2025 14:30 (25 Minuten)

Vortragende(r): LESTINSKY, Michael (GSI Helmholtzzentrum für Schwerionenforschung GmbH)

Sitzung Einordnung: Session 5

Beitrag ID: **57** Typ: **nicht angegeben**

Progress Report: CARME

Mittwoch, 17. September 2025 09:50 (25 Minuten)

Vortragende(r): MARSH, Jordan (University of Edinburgh(UE))

Sitzung Einordnung: Session 6

Beitrag ID: **58** Typ: **nicht angegeben**

Status of the Commissioning of HITRAP

Mittwoch, 17. September 2025 14:30 (20 Minuten)

Vortragende(r): HERFURTH, Frank (GSI Helmholtzzentrum für Schwerionenforschung GmbH(GSI))

Sitzung Einordnung: Session 8

Beitrag ID: **59** Typ: **Talk**

New Concept of Testing Strong-Field QED Via X-Ray Spectroscopy of Antiprotonic Atoms at CERN

Donnerstag, 18. September 2025 09:55 (25 Minuten)

The advent of quantum sensing x-ray microcalorimeters such as Transition Edge Sensors (TESs) [1] has created exciting new opportunities to push the limits of precision physics in the hard x-ray domain. Thanks to the factor of 50 improvement in energy resolution offered by TESs over high-purity germanium [2, 3], and their high efficiency compared to crystal spectrometers [4], anti-protonic atom x-ray spectroscopy has entered a new era compared to the previous generation of experiments. The PAX project (anti-Protonic Atom X-ray spectroscopy) will employ a next-generation TES detector for spectroscopy of transitions between circular Rydberg states in antiprotonic atoms to establish new benchmarks for bound-state QED at field strengths well beyond the Schwinger limit with a precision of 10-5 in the few hundred keV regime [5]. Details of the PAX experiment at the CERN's ELENA facility [6,7] and preliminary results from the test beam conducted in 2025 including unique challenges for detector development related to annihilation and electromagnetic background will be discussed.

References

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Development of in-trap electron cooling of HCI

Montag, 15. September 2025 16:30 (1 h 30m)

The Highly charged Ions TRAP (HITRAP) located at the GSI, Darmstadt, is a facility for deceleration and cooling of ions that are produced at the accelerator complex thereby providing heavy, highly charged ions at low velocities and small energy distributions. Ion bunches consisting up to 10^8 ions are injected into HITRAP at energies of 4 Mev/u from the Experimental Storage Ring (ESR), which are then slowed down to 6 kev/u in the two-stages linear decelerator. The decelerated ions travel further down the beamline to a Penning trap that captures and cools the ions down to low temperatures, before they are ejected and transported to various precision experiments.

We present the current status of the cooling trap and the ongoing progress to demonstrate electron cooling of extended amounts of heavy HCI for the first time. During the last year, HCI coming from the accelerator complex were successfully trapped for the first time. Additional optimization is still required in order to cool online produced HCI down to low temperatures.

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