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ELI-Beamlines

Book of Abstracts

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(TBD) Statistical Properties of Atomic Nuclei

Oral contributions II / 20

Amplifying ultrashort high intensity laser pulses using Self Phase Modulation

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One of the fundamental goals of laser science is obtaining laser beams with larger and larger intensities. The most widely used methods for such are CPA (Chirped Pulse Amplification) and its derivatives, which are fundamentally limited due to LIDT (Laser Induced Damage Threshold) of components used. One of the solutions proposed is using SPM (Self Phase Modulation), which involves spectral broadening using non-linear materials, lowering the Fourier Transform Limit (FTL) duration of the pulse, enabling an increase in intensity after compression.
In this presentation, I will outline the principles and challenges of SPM, and present my work on LIDT data analysis, 1D SPM simulations and the experiment performed at CLPU.

Oral contributions IX / 24

Control of spatio-temporal correlations for experiments with synchronized laser pulses

This work explores the stabilization of key parameters in dual-arm femtosecond laser systems, focusing on improving spatio-temporal control and synchronization to achieve peak powers above 10 PW. In the High-Power Laser System (HPLS) at ELI-NP, pulse energy, spectrum, and temporal "jitter" were analyzed to identify sources of instability and improve overall performance. The ongoing upgrade of the Avesta laser system, with a second arm with parallel amplification and compression, provides a controlled setup for studying and addressing instabilities. This research demonstrates the potential for coherent pulse combination and the scalability of these systems to higher peak powers.

Oral contributions X / 30

Correlation of forward and backward acceleration at TNSA

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Laser-driven particle accelerators offer a wide range of applications, especially with the development of ultra-fast ultra-high-power lasers. Particle beams are produced on both sides of the Target during this process. Finding a correlation between both beams would allow us to use one of these for the actual application, while the other can be used for monitoring the spectrum.
Summer this year an experiment was done using a liquid leaf target at the JETI200 Laser at the Helmholz-Institut HI-Jena. In this experimental campaign, the acceleration was characterized regarding different parameters like laser energy, polarization, focus position, fluid, and others. Two Ion Spectrometers were installed, one in each acceleration direction. Furthermore, a Lithium Fluoride (LiF) converter was used to produce neutrons. Some of the preliminary results will be presented.

Oral contributions IV / 31

Cryogenic and Liquid Targets for High-Repetition-Rate, High-Intensity laser-matter interaction

Oral contributions X / 27

Exploring the Impact of Spatio-Temporal Couplings on Ultra-Intense Laser Pulses

The goal of this thesis is to explore the impact of Spatio-Temporal Couplings (STCs) on ultra-intense laser pulses and their role in relativistic particle acceleration. STCs, which link a pulse's spatial and temporal properties, can affect propagation and impact interactions with matter. The project implements advanced metrology methods and develops propagation simulations using real data from high-power laser systems to model and study STCs. By reconstructing laser beam propagation and analyzing spatio-temporal distortions, this work aims to apply the findings to particle acceleration experiments for improved performance in laser-driven particle acceleration and nuclear photonics.

Oral contributions IX / 16

Gradient based beam line optimization for laser-accelerated ions using surrogate models

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In recent decades, the development of high-power lasers has increased interest in the use and research of laser-accelerated ions. While offering excellent characteristics, such as high brightness, high energies, and very short pulse duration, laser-accelerated ions also pose significant challenges regarding their capture and transport due to high initial divergence and a wide energy spectrum. These challenges necessitate more accurate, high-fidelity simulations compared to reduced-physics models.

Leveraging the accuracy of high-fidelity simulations to train machine learning-based surrogate models offers the advantage of using gradient-based optimization methods, as neural networks are inherently backpropagable. This study demonstrates that such an optimization scheme provides accurate predictions for maximizing the transmission of a beam line handling laser-accelerated ion beams. Using transported particle distributions generated by a Runge-Kutta field tracking algorithm, a solenoid surrogate model was trained and incorporated into a toy model consisting of two solenoids and a radio frequency cavity. This toy model, a simulated counterpart of the LIGHT experiment at GSI Helmholtzzentrum für Schwerionenforschung, was subsequently optimized using the gradient-based optimizer Adam, which computed the optimal parameters such as solenoid currents and drift spaces to minimize the loss function. The resulting parameters were then implemented into the initial field tracking simulation to analyze the accuracy and robustness of the provided operating point with regard to transmission.

Oral contributions II / 25

High-brilliance gamma bursts by PW-class laser pulses interacting with a nanoblade target

Gamma radiation sources resulting from laser-plasma interactions take advantage of their small source size and ultrashort duration, therefore resulting in high brilliance. Different configurations based on laser-driven electron acceleration have been proposed in order to enhance laser-target energy coupling and obtain high energy and high photon flux sources, some of them involving structured targets. The setup presented here is inspired by the "peeler" scheme, originally suggested for the generation of monochromatic ion bunches. It consists of an intense laser pulse irradiating the narrow (submicron) side of a solid blade target, with length on the order of a few dozen microns, at normal incidence.
This scheme has been shown to work well for 100TW-class lasers, where the target tip remains reasonably intact and most of the photon generation is a result of electrons oscillating as they propagate along the target surface. By using 3D simulations performed with the fully relativistic particle-in-cell code SMILEI, we show that, at higher laser powers, a significant part of the photon generation events occur close to the target tip, where the plasma is pinched and electrons undergo accelerated motion in the laser electric field, thus emitting a large number of synchrotron photons. The resulting brilliance of this source exceeds 1023 second−1 mm−2 mrad−2 0.1% BW−1 at 10 MeV

Oral contributions VII / 32

Internal fluctuations of partial transition widths of 150Nd

Oral contributions VIII / 19

Microscopic description of collective inertias for fission

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The theoretical description of nuclear fission is a challenging quantum many body problem since it involves quantum tunneling of the nuclei through fission barriers. This tunneling is very sensitive to the collective inertia along the fission path. In most of the fission calculations, the collective inertia is evaluated using cranking approximation which neglects the dynamical residual effects. In this work, we are developing a scheme to compute collective inertias using finite amplitude method - quasiparticle random phase approximation (FAM-QRPA) method which also takes into account the consistent treatment of dynamical effects [1]. In this contribution, I will discuss the status of FAM-QRPA code that is being developed using the finite range Gogny energy density functionals and axial symmetry preserving Hartree-Fock-Bogoliubov framework [2]. The completed FAM-QRPA code will be then used to study the role of collective inertia in fission probabilities and the role of fission in r-process nucleosynthesis. Once the code is developed, it can also be used to study electromagnetic response of nuclei.

1. K. Washiyama, N. Hinohara, and T. Nakatsukasa, Phys. Rev. C 103, 014306 (2021).
2. L. M. Robledo, T. R. Rodríguez, and R. R. Rodríguez-Guzmán, J. Phys. G: Nucl. Part. Phys. 46, 013001 (2018).

Oral contributions VI / 26

Multispecies Targets for Spectral Control in Laser-Ion Acceleration

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Laser-accelerated ions typically feature an exponential energy spectrum with a characteristic cut-off energy, a signature of target normal sheath acceleration (TNSA) [1]. However, the broad energy distribution inherent to TNSA poses a significant limitation for applications demanding well-defined ion energies, such as proton therapy [2] and the fast ignition concept in inertial confinement fusion [3].

By introducing multiple ion species into the target material, modulations in the TNSA-driven ion spectrum can be achieved. During the acceleration, the differing charge-to-mass ratios of these species lead to a separation in space and energy [4]. This allows for enhanced control over the ion energy spectrum and particle number.

In my talk, I will introduce the concept of laser-ion acceleration using multi-species targets, discuss the potential advantages of such target compositions based on results from multidimensional particle-in-cell (PIC) simulations, and outline planned experiments to further investigate this approach.

[1] P. Mora, Phys. Rev. Lett. 90, 185002 (2003).
[2] V. Malka et al., Med. Phys., 31: 1587-1592 (2004).
[3] J.J. Honrubia et al., J. Phys.: Conf. Ser. 244 022038 (2010).
[4] V.T. Tikhonchuk et al., Plasma Phys. Control. Fusion 47 B869–B877 (2005).

Oral contributions VI / 28

Nanostructured targets for improved interaction in the high intensity laser experiments

Nanostructured targets have a bigger surface area compared to flat targets, which are the usually employed materials in high intensity, high power laser-matter interaction experiments. This allows to improve the interaction by enabling a stronger coupling of the laser with the targets, leading to a volumetric heating and an enhanced particle acceleration. Nickel nanowires and nanotubes were prepared by electrochemical methods, with diameters of hundreds of nanometers and lengths of several micrometers. When interacting with a high intensity, femtosecond laser pulse, an enhancement in accelerated proton energy and signal of electrons and X-ray was measured experimentally, from the structured targets compared with the flat foils.

Oral contributions III / 11

Nuclear resonance fluorescence of ^{242}Pu

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The electromagnetic dipole response of ^{242}Pu was studied for the first time using the nuclear resonance fluorescence (NRF) method, hence with real photons. The experiment was performed at TU Darmstadt, where monoenergetic electrons are provided by the superconducting Darmstadt linear electron accelerator S-DALINAC to produce bremsstrahlung by impinging on a gold radiator target. A sample of PuO_2 with a total mass of about 1 g was irradiated by a bremsstrahlung beam, having a continuous energy distribution up to 3.7 MeV. Resonantly scattered photons were detected with two high-purity Germanium detectors at angles of $90°$ and $130°$ relative to the direction of the incident photon beam, which allows us to distinguish between dipole and quadrupole transitions based on their different angular distributions. The highly-enriched ^{242}Pu target was placed in a special container taking into account the sample's total radioactivity of about 370 MBq. To identify the NRF signals originating from the target, NRF spectra of an empty target container, γ-ray spectra of the sample's radioactivity, and background measurements were compared. Evidence for decays of photo-excited states of ^{242}Pu was found – making ^{242}Pu the heaviest nuclide for which NRF data is available for the moment. Details of the experiment, γ-ray spectra, and preliminary results will be presented.

We thank the Institute of Resource Ecology of HZDR for providing the ^{242}Pu sample. This work was supported by the State of Hesse within the LOEWE program and by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under project-ID 499256822 – GRK 2891 "Nuclear Photonics".

Oral contributions I / 10

Online diagnostics for high-intensity laser-plasma radiation characterization

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High-intensity laser-plasma interactions are pivotal in advanced scientific research, with applications spanning fundamental physics to medicine. The ELIMAIA (ELI Multidisciplinary Applications of laser-Ion Acceleration) [1-3] beamline at the ELI Beamlines facility, part of the Extreme Light Infrastructure ERIC, offers a cutting-edge platform for studying laser-driven ion acceleration at high repetition rates. For such a beamline, real-time measurements and analysis of the laser-produced radiation are essential characterizing the laser-plasma interaction.
We describe a comprehensive set of online diagnostics developed at the ELIMAIA beamline, enabling immediate and precise analysis of radiation and secondary sources generated from high-intensity laser-plasma interactions. The key diagnostic tools include ion detectors such as online Thomson parabola and semiconductor detectors operating in the Time-of-Flight regime, laser beam diagnostics, and X-ray spectrometers. These tools are integrated with a real-time data acquisition and analysis system.
The diagnostic set was successfully tested in multiple internal and user experiments at ELIMAIA including high repetition rate tests. It has proven invaluable for optimizing ion acceleration and monitoring the quality of laser-target interactions.
Our results highlight the importance of integrating advanced diagnostics in high-intensity laser-plasma research, driving forward the capabilities of next-generation laser facilities.

[1] D. Margarone, "ELIMAIA: A laser-driven ion accelerator for multidisciplinary applications." Quantum Beam Science 2.2 (2018): 8.
[2] F. Schillaci, "The ELIMAIA laser–plasma ion accelerator: Technological commissioning and perspectives." Quantum Beam Science 6.4 (2022): 30.
[3] L. Giuffrida, et al "The ELIMAIA laser-plasma Ion Accelerator: a user platform of high-repetition-rate, ultrahigh intensity, and high stability", in preparation.

Oral contributions IX / 33

Optimizing High-Energy Photon Generation via Nonlinear Inverse Compton Scattering in Structured Targets Using 3D PIC Simulations

Authors: Dragana Dreghici[None] ; Vojtech Horny[None] ; Paolo Tomassini[None] ; Domenico Doria[None]

The generation of high-energy synchrotron-like radiation through Nonlinear Inverse Compton Scattering (NICS) and bremsstrahlung radiation during the interaction of ultra-intense laser pulses with structured targets is a critical area of research. This study, conducted using 3D particle-in-cell simulations with the fully relativistic simulation code Smilei, investigates the parameters that influence radiation yield, focusing on photon density, energy, and angular distribution.

We demonstrate the benefits of using high-intensity pulses ($a_0 > 150$) with laser parameters from previous experimental campaigns at ELI-NP. The target configuration consists of a dual-layered assembly: a fully ionized, low-density carbon plasma layer, followed by a high-density plasma acting

as a plasma mirror. The low-density plasma focuses the laser pulse, enhancing compression and serving as a source of high charge and energy. The high-density layer reflects the laser pulse toward the high-energy electrons generated in the first phase.

Using 3D simulations with the Smilei code, we studied the behavior of the laser pulse inside the low-density layer, highlighting the self-focusing effect and the enhancement of pulse intensity. We comprehensively evaluate the impact of target configuration and geometry, as well as laser characteristics, on the production efficiency of NICS photons. By analyzing the complex dynamics of laser-target interactions, we identify optimal target parameters for NICS production, improving our understanding of the resultant radiation characteristics.

The insights gained from this study are pivotal for guiding experimental setups and interpreting experimental results, particularly in discerning the contributions of various mechanisms involved. Our findings have significant implications for developing next-generation photon sources and advancing fundamental research in high-energy-density physics using multi-petawatt laser systems, such as the 10 PW laser infrastructure of ELI-NP.

To save computational resources, we propose a novel scheme for simulating the reflective solid layer by replacing it with a reflecting boundary on one side of the simulation box. This allows for more resources to be utilized for more realistic modeling of the target and the physical processes involved in photon generation while reducing the overall cost of the simulation by up to a factor of 8 (for 2D geometries). This work not only advances theoretical knowledge but also lays the groundwork for practical applications in high-energy laser-plasma interactions, aiming to optimize radiation sources for various scientific and technological applications.

References:
[1] Galbiati M, Formenti A, Grech M, and Passoni M. (2023). Numerical investigation of non-linear inverse Compton scattering in double-layer targets. Front. Phys. 11.

[2] Formenti A, Galbiati M, and Passoni M. (2024). Three-dimensional particle-in-cell simulations of laser-driven multiradiation sources based on double-layer targets. Phys. Rev. E 109, 035206.

[3] Günther MM, Rosmej ON, Tavana P, Gyrdymov M, Skobliakov A, Kantsyrev A, Zähter S, Borisenko NG, Pukhov A, and Andreev NE. (2022). Forward-looking insights in laser-generated ultra-intense γ-ray and neutron sources for nuclear application and science. Nat. Commun. 13, 170.

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P3 platform at ELI Beamlines for High Energy Density Physics and Ultrahigh Intensity Interactions

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The plasma physics platform (P3) in the E3 experimental hall is a state-of-the-art facility designed for advanced research in laser-plasma and laser-matter interactions. P3, dedicated to plasma physics, offers access to multiple beams, for experiments in the field of High Energy Density Physics (HEDP) and Ultrahigh-Intensity Interactions. The P3 facility has been available to users since 2023, with the non-compressed L4-ATON laser (L4n) delivering pulses up to 500 J (1 to 10 ns) at an unprecedented rate of one shot every three minutes. The L4 system will achieve 10 PW power (L4f: 1.5 kJ, 150 fs) by early 2025. Additionally, the L3-HAPLS laser, currently operating at 0.5 PW (12 J, 27 fs, 3.3 Hz), will be upgraded to 1 PW.
Whether used individually or in combination, these two lasers significantly enhance data collection speed and efficiency for plasma physics research, particularly in ns-kJ HEDP experiments, which typically rely on low-repetition facilities (often one shot per hour).

The presentation will provide a comprehensive overview of the experimental infrastructure, highlighting both current capabilities and future opportunities for user operations.

Keynote II / 22

P3 platform at ELI Beamlines for High Energy Density Physics and Ultrahigh Intensity Interactions

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Oral contributions VIII / 14

Probing the Giant Dipole Resonance Using Nuclear Resonance Fluorescence

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The giant dipole resonance (GDR) is one of the most fundamental nuclear excitations and it dominates the dipole response of all nuclei. Since its discovery in the early days of nuclear physics it has consistently attracted a great deal of attention. Its evolution from a single-humped structure in spherical nuclei to a double-humped one in deformed nuclei is considered one of the prime signatures of nuclear deformation. This phenomenon is commonly explained through the geometrical model, which depicts the GDR as an isovector oscillation of the proton against the neutron body. However, the geometrical model also makes strong predictions about the γ-decay behavior of the GDR. Yet, despite decades of research on the GDR, its γ decay, though a key property of the resonance, remains poorly characterized, leaving these predictions largely untested.

To address this long-standing issue, photonuclear experiments on the γ decay of the GDR of the well-deformed nuclide ^{154}Sm and the spherical ^{140}Ce were recently conducted at the High Intensity γ-ray source (HIγS). Individual regions of the GDR were selectively excited using intense, linearly-polarized and quasi-monochromatic γ-ray beams provided by HIγS. This enabled an excitation-energy-resolved determination of the GDR's elastic and 2^+_1 Raman γ-scattering cross sections.

The data obtained from these experiments allow for a novel close experimental assessment of the geometrical model of the GDR, in particular for ^{154}Sm with its double-humped GDR and respective K-quantum-number assignments. The findings establish γ decay of the GDR as an observable sensitive to both the structure of the resonance and the nuclear shape.

This research has been funded by the German state of Hesse's Ministry of Higher Education, Research and the Arts (HMWK) under grant No. LOEWE/2/11/519/03/04.001(0008)/62, by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – Project-ID 499256822 – GRK 2891, by the German Federal Ministry of Education and Research (BMBF) under grant No. 05P21RDEN9, and by the U.S. Department of Energy, Office of Nuclear Physics, under grant Nos. DE-FG02-97ER41041 (UNC) and DE-FG02-97ER41033 (TUNL/Duke).

Keynote I / 21

Science Offer at ELI Beamlines

Oral contributions V / 17

Simulating the focusing of laser-plasma accelerated particle beams

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The interest in laser-plasma accelerated particle beams with potential application in the biomedical field is rapidly growing [1, 2]. The future use of such beams greatly depends on the development of specially designed focusing and beam transport systems that can control the delivery of the beam with a predefined set of parameters [3]. Some of the main issues that need to be addressed, particularly for the case of ultra-short accelerated hadrons, are the broad energy spectrum and the high angular divergence.

Here we present simulation-based studies which aim to understand the focusing effects of various beam steering elements such as coils, dipoles, quadrupoles and their combinations on laser-plasma accelerated particle beams. The proposed beamline configurations are being analyzed in terms of collection efficiency by varying the position, dimension and geometry of the magnetic elements, as well as the mean focusing distance and profile of the beam.

Acknowledgement: This work was supported by Project ELI-RO/DFG/2023_001 ARNPhot funded by Institute of Atomic Physics Romania

[1] F. Romano, et al., The ELIMED transport and dosimetry beamline for laser-driven ion beams. Nuclear Instruments and Methods in Physics Research, A 829, (2016), 153-158
[2] F. Kroll, et al., Tumor irradiation in mice with a laser-accelerated proton beam. Nature Physics 18, (2022), 316-322
[3] M. Wu, et al., Collection and focusing of laser accelerated proton beam by an electromagnetic quadrupole triplet lens, Nuclear Instruments and Methods in Physics Research, A 955, (2020), 163249

Oral contributions VIII / 12

Simultaneous measurement of fragment mass, energy, and angular distributions from the 234U(γ,f) reaction

Authors: Vincent Wende[1] ; Ronald Malone[2] ; Dimiter Balabanski[3] ; Joachim Enders[1] ; Sean Finch[4] ; Forrest Friesen[4] ; Alf Göök[5] ; Calvin Howell[4] ; Maximilian Meier[1] ; Andreas Oberstedt[3] ; Stephan Oberstedt[6] ; Marius Peck[1] ; Norbert Pietralla[7] ; Anthony Ramirez[8] ; Jack Silano[8] ; Gerhart Steinhilber[1] ; Anton Tonchev[8] ; Werner Tornow[4]

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Photon-induced reactions provide unique data on nuclear fission due to their selectivity on excitations of low multipolarity and thereby contribute significantly towards a detailed microscopic description of the nuclear fission process. In particular, using quasi-monochromatic linearly-polarized photons to induce the fission process gives access to information about the nuclear energy landscape around the fission barrier and allows determining transition states and channels through which the fission process proceeds. A position-sensitive twin Frisch-grid ionization chamber is used in order to measure mass, total kinetic energy and polar as well as azimuthal angular distributions of the fission fragments simultaneously, enabling examination of correlations between these observables. This contribution will present an overview of our recent experimental campaigns at the High-Intensity γ-Ray Source (HIγS) at Triangle Universities Nuclear Laboratory (TUNL). Additionally early data currently under analysis from a $^{234}U(\gamma,f)$ experiment investigating multiple quasi-monochromatic excitation energies, including excitation energies near the fission barrier, will be presented.

Oral contributions V / 15

Status of the new Bunch Length Measurement System Downstream of the Injector of the S-DALINAC*

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Energy-recovery linacs provide high beam currents with lower RF power requirements compared to conventional machines while maintaining the high beam quality of a linac. The S-DALINAC is a thrice-recirculating accelerator operating at a frequency of 3 GHz, that is capable of being operated as a multi-turn superconducting energy-recovery linac. Its efficiency is currently limited by the bunch length, which by now is measured using the RF zero-crossing method. In order to improve both accuracy and measurement time a new setup using a streak camera is developed. Optical transition radiation from electron bunches passing an aluminum-coated Kapton screen is used to produce light pulses that can be measured with the streak camera. An imaging system consisting of multiple mirrors is used to maintain a high temporal resolution for the measurement and to support in shielding the streak camera from harmful radiation. First measurements with the setup were performed downstream of the injector. Preliminary results of the measurements and the design of the setup will be presented.

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Oral contributions III / 13

The electric dipole response of 106Pd nuclei

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This study aims at understanding the dependence of the E1 strength in the transition region from vibrational to rotational nuclei. The chosen method of study is the Nuclear Resonance Fluorescence method, a two-step photonuclear process which consists of the absorption of a photon and the subsequent resonant re-emission of gamma rays [1].

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The experimental data has been acquired using the DHIPS (Darmstadt High-Intensity Photon Source) sett
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  This first measurement in 106Pd uncovered new transitions in the 5-8 MeV energy range. The data t
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References:
[1] – A. Zilges, D.L. Balabanski, J. Isaak, and N. Pietralla, Prog. Part. Nucl. Phys., 122 (2022) 103903
[2] – C. Romig, "Investigation of Nuclear Structure with Relative Self-Absorption Measurements", PhD thesis, TU Darmstadt, 2014

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Oral contributions VIII / 29

The study of the ^{7}Li(γ,α)^{3}H reaction at energies below 6 MeV at HIγS

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The abundances of the light elements can be spectroscopically determined by observing the low-metallicity stars. Usually, those measurements are in agreement with the Big Bang Nucleosynthesis predictions. Particularly, the Li-7 measured abundance is 3-4 times lower than expected, discrepancy known as the "cosmological Li problem". The reaction $^{3}H(\alpha,\gamma)^{7}Li$ contributes to the production of Li-7 in Universe and can be studied through its inverse reaction, according to the reciprocity theorem. In consequence, the Li-7 photodisintegration has been measured by our team in 2017 at the High Intensity γ-ray Source (HIγS) Laboratory of Duke University (USA) using a silicon detector array (SIDAR) to observe the coincidences between the alpha particles and the tritons. The considered energies of the gamma beam have been between 4.4 and 10 MeV, but below 6 MeV the coincidences have been observed only in the thinner detectors. In 2023, a new similar experimental campaign, with an improved set-up, took place at HIγS for gamma-beam energies between 3.7 and 6 MeV. The coincidences have been clearly separated and the preliminary astrophysical S-factor of the direct $^{3}H(\alpha,\gamma)^{7}Li$ reaction has been successfully extracted.
The set-up and the preliminary results of the experimental campaign performed at HIγS in 2023 will be presented.