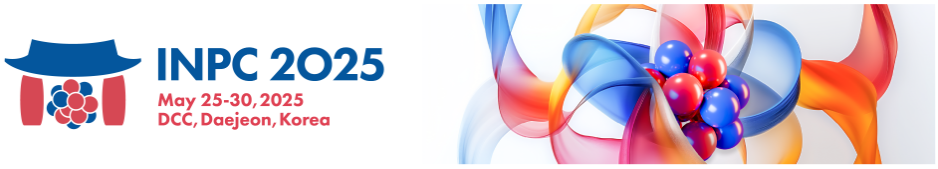

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Nuclear Photonics at ELI-NP

Thursday, 29 May 2025 12:10 (25 minutes)

Extreme Light Infrastructure - Nuclear Physics (ELI-NP) represents a novel research infrastructure that has been implemented in Romania as part of the pan-European Extreme Light Infrastructure project. The primary focus of ELI-NP is research in the field of nuclear photonics which involves the use of extreme electromagnetic fields for nuclear physics studies and related topics. To this end, two state-of-the-art sources of extreme light are being implemented at ELI-NP: a high-power laser system and an intense gamma beam system. These systems facilitate research in a broad range of topics, with the objective of pushing scientific and technological knowledge beyond its current boundaries.

Presently, ELI-NP is the host of the most powerful laser system in operation worldwide of 2 x 10 PW power. The fundamental physics research conducted presently at ELI-NP with high-power lasers is focused on two main objectives: the understanding of the nature of the laser–matter interaction and the development of novel particle acceleration schemes that are complementary to the present classical accelerators. The extreme electrical fields produced by the high-power lasers, reaching peak values of the order of 10^{15} V/m, and the very high pressure to which matter is compressed, of the order of Tbars, have been shown to accelerate electrons to energies of 10's of GeV on cm's scale. This development opens new opportunities for QED studies, e.g. study of Breit-Wheeler pair production process. Furthermore, protons and ions can be accelerated to 100's of MeV/amu on microns scale with extremely high beam densities.
The prospect of studying nuclear reactions in plasmas that replicate the conditions of stellar environment is being made possible by the use of high-power lasers. This approach enables the determination of cross sections for astrophysically relevant reactions or the investigation of nuclear states lifetimes as a function of the plasma temperature. Production of laser-driven brilliant neutron beams have the potential to provide new opportunities for the study of neutron physics and applications.

The applications of laser-based secondary beams are naturally emerging from the basic research conducted at ELI-NP. Two main application fields with significant societal benefits are in particular being pursued at ELI-NP: medical applications and energy. The medical applications of high-power lasers are focused on: hadron-therapy with C ion, high-accuracy low-dose X-ray interferometric imaging, and production of radioisotopes, in an integrated approach where the same lasers can be used for more applications in a hospital environment at a later stage. Fusion ignition with short pulsed high-power lasers is a subject of interest at ELI-NP. Other potential applications include the study of material aging and cell behavior in extraterrestrial mixed radiation fields.

The ELI-NP is evolving into a multipurpose unique research center where nuclear physics research and related applications introduce novel approaches, such as laser-driven particle acceleration, that complement classical accelerators. This overview is intended to provide a comprehensive introduction to this state-of-the-art facility which is user facility since 2022. It will also discuss the facility's recent achievements and how they align with the original scientific case.

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