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High-effective γ-ray spectrometer ELIADE for the nuclear resonance fluorescence studies at at ELI-NP.

The structure of a nucleus can be inferred from its decay patterns and the partial decay widths of excited states leading to the ground state. A standard method of in-beam γ-ray spectroscopy at charged particle accelerators relies on γ-γ coincidences, often correlated with the charged particles or neutrons produced in the same reaction. In charge-particle-induced reactions, J = 1 states are typically weakly populated, and the sensitivity of measurements may be insufficient to detect weakly branching transitions. This poses challenges in studying the decay behavior of excitation modes, such as the nuclear scissors mode and the Pygmy Dipole resonance. However, J = 1 states can be effectively populated through nuclear resonance fluorescence (NRF), a two-step process involving the resonant absorption of a γ-ray by a nucleus followed by the re-emission of γ-radiation [1]. Typically, a γ-ray beam is generated via bremsstrahlung, but specific nuclear levels can be uniquely excited using a mono-energetic photon beam, such as that produced by Compton laser back-scattering. At the Extreme Light Infrastructure Nuclear Physics (ELI-NP) in Romania, the combination of a mono-energetic γ-ray beam from the VEGA machine [2] and the highly effective ELIADE γ-ray spectrometer [3] enables access to weakly populated low-lying nuclear states and transitions with small branching ratios.
The VEGA system is expected to deliver a γ-ray beam with a continuous energy range up to approximately 19.5 MeV and a total flux of 10^11 /s. Its linear polarization of 95% and an average relative bandwidth of 0.5% will significantly enhance experimental capabilities for studies below the particle emission threshold in stable nuclei. The ELIADE γ-ray spectrometer consists of eight Compton-suppressed segmented clover detectors and four Compton-suppressed CeBr3 detectors. The custom-designed DELILA triggerless digital data acquisition system operates with commercially available CAEN digitizers.
In my presentation, I will briefly review the Day 1 experiments and then discuss the ELIADE γ-ray spectrometer. I will present results from implementing various add-back schemes, cross-talk corrections, and anti-Compton rejection techniques, using both standard γ-ray sources and a custom high-energy γ-ray source.

[1] A. Zilges, D.L. Balabanski, J. Isaak and N. Pietralla Prog. Part. Nucl. Phys. 122 (2022) 103903

[2] Variable Energy Gamma System at ELI-NP. 2021; https://www.eli- np.ro/rd2_second.php/

[3] D. A. Testov, A. Dhal, C. Petcu at al., Il Nuovo Cimento C 47 (2024) 60

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