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Gamma ray beams for Nuclear Astrophysics: first results of tests and simulations of the ELISSA array

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The Extreme Light Infrastructure-Nuclear Physics (ELI-NP) facility, under construction in Magurele near Bucharest in Romania, will provide high-intensity and high-resolution gamma ray beams that can be used to address hotly debated problems in nuclear astrophysics, such as the measurement of controversial 12C(α,γ)16O cross section through the 16O(γ,α)12C reaction, the accurate measurements of the cross sections of the 24Mg(γ,α)20Ne reaction and other photo-dissociation processes relevant to stellar evolution and nucleosynthesis [1].
For this purpose, a silicon strip detector array (named ELISSA) will be realized in a common effort by ELI-NP and INFN-LNS (Catania, Italy), in order to measure excitation functions and angular distributions over a wide energy and angular range. We performed very accurate GEANT4 simulations in order to optimize resolution, detection efficiency, compactness, granularity, possibility of particle identification and costs. According to our simulations, the final design of ELISSA will be the barrel configuration. This results in a very compact design as the distance target - detector is about 10 cm, leaving open the possibility in the future to pair a neutron detector with the ELISSA. Because of the compact design of the detector, time-of-flight or standard ΔE-E approach cannot be used for particle ID. However, kinematical identification still making possible to separate the reaction of interest from others thanks to the good expected angular and energy resolutions.
A prototype of ELISSA was built and tested at Laboratori Nazionali del Sud (INFN-LNS) in Catania with the support of ELI-NP. In this occasion, we have carried out experiments with alpha sources and with a 11 MeV 7Li beam. We used X3 and QQQ3 silicon-strip position sensitive detectors manufactured by Micron Semiconductor ltd. Thanks to our approach, the first results of those tests show up a very good energy resolution (better than 1%) and very good position resolution, of the order of 1 mm. At very low energies, below 1 MeV, a worse position resolution is found, of the order of 5 mm, but still good enough for the measurement of angular distribution and the kinematical identification of the reactions induced on the target by gamma beams. Moreover, a threshold of 150 keV can be easily achieved with no cooling. We will discuss technical details of the detector and present results regarding Monte Carlo simulation, energy resolution and detection thresholds of ELISSA, the physical cases to be investigated.
To sum up, these tests allows us to say that the X3 detectors, as well the standard QQQ3 detectors, are perfectly suited for nuclear astrophysics studies with ELISSA.

1. D. Filipescu et al., Eur. Phys. J. A51, 185 (2015).
2. O. Tesileanu et al., Rom. Rep. Phys. 68, Suppl. S699-S734 (2016)

Primary author: LA COGNATA, MARCO SALVATORE (LNS)

Co-authors: TAFFARA, A. (INFN-LNS); ANZALONE, Antonino (LNS); MATEI, C. (ELI-NP/IFIN-HH); SPITALERI, Claudio (LNS); BALABANSLI, D. (ELI-NP/IFIN-HH); Dr LATTUADA, Dario (LNS); GUARDO, Giovanni Luca (LNS); TESILEANU, O. (ELI-NP/IFIN-HH); CRUCILLÀ, W- (INFN-LNS)

Presenter: LA COGNATA, MARCO SALVATORE (LNS)

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