Nuclear AstroPhysics at ELI-NP: preliminary experiments with ELISSA detector

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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 accurate measurements of the cross sections of several reactions important for the astrophysical p-process, Big Bang Nucleosynthesis and supernova explosion. [1, 2].
For this purpose, a silicon strip detector array (named ELISSA) will be realized in a common effort by ELI-NP and Laboratori Nazionali del Sud (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 a very compact barrel configuration, leaving open the possibility in the future to pair a neutron detector with the array. The kinematical identification will allow to separate the reaction of interest from others thanks to the good expected angular and energy resolutions [3].
An experimental campaign is ongoing in order to test the feasibility of the future study at ELI-NP. With this aim, an experiment has been approved at INFN-LNS in order to measure the ^{19}F(p,α_π)^{16}O reaction at astrophysical energies using a prototype of the ELISSA array. Indeed, ^{19}F synthesis is believed to take place in the H-He intershell region of AGB stars but current models fail to explain the high F abundances found in the low-mass AGB stars [4]. Despite the ^{19}F(p,α)^{16}O is the main destruction channel and its reaction rate is determined by the sum over the rate for the (p,α_0), (p,α_π) and the (p,α_γ) channels, most of the existing measurements refer only to the ^{19}F(p,α_0)^{16}O channel, while very little experimental info is available for the (p,α_π) and (p,α_γ) rates at very low energies. Our simulations show that ELISSA will ensure the energy separation between the different channels and the kinematical identification of the outgoing reactions for which a good resolution is a crucial parameter.
Moreover, an exploratory experiment to measure the ^{7}Li(γ,^{3}H)^{4}He reaction has been performed at High Intensity Gamma Source (HIγS). The reaction is of interest for the longstanding "Cosmological Li problem" and for verifying several recent theoretical predictions. The preliminary results of the experiment will be presented.
The good preliminary results of our tests and simulations allows us to say that the ELISSA detector will be very suitable for nuclear astrophysics experiment with the upcoming gamma ray beam at the ELI-NP facility.

References

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