Cross-section measurements of (α,n) reactions in light nuclei

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Introduction

The investigation of (α, n) reactions is crucial due to their wide-ranging impact across several critical fields of nuclear physics. In nuclear power technologies, accurate neutron yield data from these reactions is necessary for designing and optimizing these systems, where controlling neutron production is the key to both efficiency and nuclear safety. In nuclear safeguards, these reactions play an essential role in monitoring and verifying nuclear materials to prevent proliferation [1]. In nuclear astrophysics, these reactions are involved in nucleosynthesis processes, contributing to our understanding of the origins of elements in the universe [2]. The (α, n) reactions are important in the production of medical isotopes, which are widely used in diagnostic imaging and cancer treatment [3]. In detector simulation, these reactions help to refine the models that predict the behavior of radiation detectors, improving their accuracy and reliability. In the field of fusion research, understanding these reactions aids in the development of fusion reactors, which promise a future source of nearly limitless, clean energy. Hence, the study of (α, n) reactions is essential not only for advancing the scientific knowledge but also for its applications in technology, medicine, and energy.

The reactions which involve the interaction of α particles with the nuclei of light elements such as Li, Be, B, C and others up to K, are of particular interest because they produce neutrons: a process that has significant practical and theoretical implications. Therefore, we performed experiments involving α-induced reactions on the light elements, such (^{19}F and ^{27}Al), using an array of ^{3}He counters, named ELI- Gamma Above Neutron Threshold for Thermal Neutrons (ELIGANT TN) [4].

Experimental Details

ELIGANT-TN, a high-and-flat efficiency moderated neutron detection array of 28 ^{3}He counters, as shown in Fig 1, has been developed for neutron cross section measurement at Extreme Light Infrastructure - Nuclear Physics (ELI-NP) [5]. It has three rings geometry of 28 counters with a 37% efficiency flat within 5% in the 10 keV to 5 MeV neutron energy interval [4]. This state-of-the-

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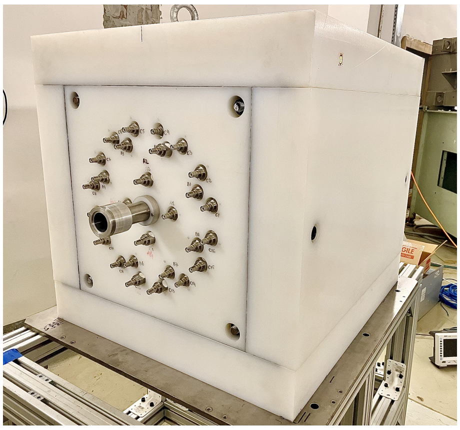

FIG. 1: The ELIGANT-TN neutron counter.

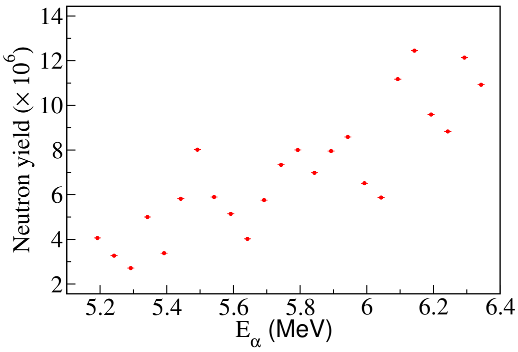

FIG. 2: Neutron yield from the ^{27}Al(α,n) reaction (per 10^{-7} C).

art detector is a very useful setup to measure the cross section of neutron-emitting reactions featuring almost full angular coverage, high efficiency, very low sensitivity to γ-rays, and negligibly small neutron energy threshold.

Using the ELIGANT-TN array, cross section measurements have been performed with a thin ^{19}F (20 $\mu g/cm^2$) and a thick ^{27}Al (65 $\mu g/cm^2$) target. The energy range for the measurements with the ^{19}F and ^{27}Al targets, were 3-6 MeV and 5.19-6.32 MeV, respectively. The α beam has been used having the intensity ranging from 50-100 nA. The beam current was read at the target position.

Results and Discussion

Fig. 2 shows the obtained neutron yield for ^{27}Al(α,n) in the energy range 5.19-6.32 MeV. The targets used in the experiments, has been analyzed and accumulation of ^{13}C contamination was found during the experiments. Details about the analysis and results will be presented presented during the symposium. The new results will contribute in understanding the cross section of ^{19}F(α,n) and ^{27}Al(α,n) in the desired energy range [6, 7], and the discrepancy in the earlier known data. The obtained data will also be an important input ingredient to serve the statistical model working in this energy region [8, 9].

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