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Measurement of ^{27}Al(α,nγ)^{30}P thick-target yields and total ^{27}Al(α,n) yields by activation

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Reactions induced by alpha particles on stable elements play a relevant role in several scientific fields, from nuclear technologies and nuclear astrophysics, to dark matter searches and neutrino physics. Data on neutron yields from the interaction of α-particles with nuclei via (α,n) reactions are of particular interest in this context, both due to the inconsistency of the available experimental data in the literature and to the need for new measurements with higher precision [1].

In this work we focus on reactions induced by alpha particles on stable aluminium undertaken at the recently commissioned beam line at the CMAM laboratory in Madrid [2], Spain. The experiment was performed in the framework of a wider effort by the Spanish MANY collaboration, whose ultimate goal is the measurement of (α,xn) production yields, reaction cross-sections and neutron energy spectra.

The ^{27}Al(α,n) reaction has been proposed as a benchmark to inter-compare measurements and cross check experimental techniques. Firstly we present measurements of ^{27}Al(α n) reaction yields by activation and gamma counting for energy ranging from the reaction threshold to 15 MeV. Secondly, we address ^{27}Al(α,nγ) production yields. The experiment was carried out using an array of $LaBr_3$(Ce) FATIMA-type [3] detectors placed at selected angles in the laboratory frame. The gamma spectroscopy measurements allow to determine the total reaction yield from the decay of the activation products and the (α,nγ) yield from the de-excitation of the states in the target nuclei. The setup was complemented by a neutron monitoring unit based on a 3He-filled neutron proportional counter embedded high-density polyethylene, and a high-resolution HPGe detector to aid gamma- ray identification.

The activation results are in remarkable agreement with direct neutron measurements, and can be compared with the literature. This makes it possible to commission the of the detector system and the new experimental beam line via the previously measured ^{27}Al(α,n)^{30}P reaction. The (α,nγ) gamma measurements provide information for the first time on the thick-target production yields of γ rays from ^{30}P in the reaction and their angular distributions.

[1] S. Westerdale et al., Tech. Report INDC (2022) NDS-0836
[2] A. Redondo-Cubero et al., Eur. Phys. J. Plus 136 (2021) 175
[3] V. Vedia et al., Nucl. Instrum. Methods A 857 (2017) 98

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