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Beryllium target for proton-induced neutron production: CoolGal

Compact accelerator-driven neutron sources (CANS) provide excellent opportunities for generating intense neutron beams. As research nuclear reactors close, CANS provide a cost-effective alternative, supporting communities that rely on advanced neutron instrumentation; in addition, their distributed nature allows for broader accessibility, including use as training centers. The potential impact of these compact facilities has driven strong international collaboration, uniting representatives from nearly all developed countries every two years through UCANS (worldwide) and ELENA (European network). Within this framework, CoolGal is an innovative target system designed to generate fast neutrons with a continuous energy (white) spectrum using the SPES cyclotron. Funded by the Ministry of Research for 2023-2025 (PRIN_2022JCS2CN - CUP I53D23001180006), CoolGal incorporates a beryllium target cooled by liquid Galinstan, aiming to advance neutron science by enabling high-intensity neutron beam production at Compact Accelerator-driven Neutron Sources. A separation window will divide the target volume from the accelerator vacuum, thus preventing contamination of the beamline. Using the SPES 35-70 MeV proton cyclotron, the proposed experiment aims to test a simplified CoolGal prototype, without the Galinstan liquid. The study will assess the fundamental performance of the separation window and the target structure under real beam-induced thermal stresses, as well as address operational and decommissioning concerns. A key goal of this study is to measure the double-differential neutron yield of the Be(p,n) reaction, a crucial process for copious production of fast neutrons. Despite the importance of the Be(p,n) reaction, the data present in the literature at proton energies of 35-70 MeV comes from JENDL libraries. The lack of data in this range itself is a strong motivation to measure it. The produced neutron spectrum (spanning thermal to 70 MeV) is highly relevant for studying atmospheric neutron-induced effects in electronics; 65% of the atmospheric neutron spectrum at sea level above 1 MeV falls within the 1-70 MeV energy range. Two independent methods will be employed to measure the neutron energy spectrum and validate simulation results: the standard stack-activation foil technique and a plastic scintillator-based neutron detector. The latter was developed at the University of Cape Town (UCT) and is characterized at a number of fast and high energy neutron facilities, including at the UCT and iThemba LABS. These measurements will be conducted in collaboration with iThemba LABS. The HBS (High Brilliance Neutron Source, Jülich, Germany) is also proposing the study of the Ta(p,n) reaction as an alternative neutron production method using a heavy target instead of beryllium. These complementary proposals create a valuable opportunity for collaboration, promoting the exchange of manpower, instrumentation, and expertise.

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