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Measurements of neutron-induced light-ion production in Carbon at the energy range 1 - 40 MeV

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Experimental data on double-differential cross-sections (DDX) for neutron-induced production of light ions (*p*, *d*, *t*, ^{3}He, and α-particles) are important for nuclear theory and for a number of applications, such as e.g. neutron dosimetry in aerospace and medical applications, radiation effects in electronic devices [1] and in materials, in particular for fusion technologies [2], as well as development and application of diamond detectors [3] used as neutron sensors, *e.g.*, in fusion diagnostics [4] and in research at accelerator-driven neutron sources [5].

From the theoretical point of view, at moderately high incident neutron energies, e.g. at 14 MeV, light-ion emission spectra are known to have a pronounced structure in the high-energy end, that is gradually “washed out” at higher neutron energies as various distinct reaction channels open up. That structure is not present at incoming neutron energies of 60 MeV and above. Furthermore, the energy range under study is at the edge of the validity for traditional statistical models, e.g. those included in the TALYS code [6], for reactions involving light nuclei. Theoretical analysis of the obtained results, together with existing neutron- and proton-induced reaction data, will aim at an improved description of pre-equilibrium reactions, thus contributing to further development of the TALYS code and future versions of the TENDL evaluated nuclear data library [6,7].

With the aim of studying those effects, a series of light-ion production measurements in energy range from 1 to 40 MeV has been started at the recently commissioned Neutrons For Science (NFS) [8] at GANIL (France), which is capable of delivering unprecedentedly high spectral neutron flux and favorable temporal structure of the neutron beam. The experiments make use of the Medley setup [9], designed for detection and identification of charged particles over a wide energy range. The setup consists of eight three-element telescopes mounted at 20º intervals inside a vacuum chamber, thus covering emission angles from 20 to 160º simultaneously, as can be seen in Fig. 1. Using the measured DDX, integral cross sections for production of light ions will be deduced.

Figure 1: The inner view of the Medley chamber, showing the eight telescopes for detection of secondary light ions. The rectangular frame, attached to the lid of the chamber, is holding a circular CH_2 target, supported by thin wires.

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The energy of the incident neutron that induced the given reaction event is determined by time-of-flight (ToF) technique. The start signal in the ToF measurement is provided by a particle produced in the reaction and detected in a telescope. The signal from the linear accelerator associated to the arrival of the beam bunch to the neutron production target is employed as a stop. In this way we will be measuring the total ToF including the flight time of the detected charged particle from the studied target to the detector. Knowing the energy of the detected particle and the target-detector distance, that time can be determined, and then subtracted from the total ToF. This procedure allows us to measure the double-differential cross-sections for a continuous range of neutron energies, from 1 to 40 MeV, in a single experiment.

The measurements will make use of the elastic *np*-scattering cross section as the primary neutron standard. For that purpose, the measurement program includes exposures of a CH_2 target and detection of recoil protons from the H(*n*,*p*) reaction.

The first experiment of the series is dedicated to the study of light-ion production in ^{nat}C, and it is currently being performed at NFS (September-October 2021). In the full-scale contribution, the experimental setup and the preliminary results will be presented.

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