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Characterization of liquid scintillator detectors for fast neutron detection up to 40 MeV

Fast neutron detection plays a critical role in nuclear science studies and in a range of nuclear technology applications, from hadron therapy in medicine to neutron monitoring in fusion and spallation technologies. Organic liquid scintillator detectors, such as those based on NE213, are widely used for neutron spectroscopy due to their excellent timing resolution and capability to discriminate neutrons from gamma rays via pulse shape analysis.

In this work, we present a comprehensive characterization of the light output response of two detector systems developed at CIEMAT —MONSTER [1,2] and sTED [3]—covering incident neutron energies from a few MeV up to 40 MeV. Measurements were performed at the NFS facility at GANIL [4] using a quasi-continuous neutron spectrum produced by a 40 MeV deuteron beam impinging on a beryllium target. The detectors were positioned at 30 meters from the source to enable neutron energy determination via the time-of-flight technique, with energy slices selected to extract pulse height distributions across the full energy range.

Special emphasis was placed on the contribution of secondary particles produced via $^{12}\text{C}(n, \alpha)$ and $^{12}\text{C}(n, n'3\alpha)$ reactions [5,6,7], as well as breakup reactions such as $^{12}\text{C}(n, p)$ and $^{12}\text{C}(n, d)$ above 20 MeV. Detailed comparisons with Geant4 [8] and PHITS [9] simulations incorporating recent reaction models and evaluated nuclear data were performed to extract the neutron light output functions.

The results provide key input for improving the accuracy of detector response modeling and will enhance the predictive power of simulation tools used in experimental design and data analysis in nuclear physics and technology applications [10,11].

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