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Characterization of detector modules for a neutron detector array at fragment separator ACCULINNA-2

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A thorough investigation of neutron-halo nuclear systems such as 7H, which decay through neutron emission, requires the development of a sophisticated system of neutron detectors. At Flerov Laboratory of Nuclear Reactions, a neutron time-of-flight spectrometer of 110 BC-404 plastic-based scintillators was proposed. An individual detector module consists of a 75-mm thick, hexagon-shaped BC-404 scintillator, inscribed in a 100-mm diameter circle and an ET 9822B series PMT. Main characteristics of particular interest to our study are neutron detection efficiency and time resolution of the detector module. Additionally, cross-talk estimation is also of concern for the neutron spectrometer. To maximize neutron detection efficiency, we are required to set a minimal energy threshold, which must be expressed in energy units, typically in MeVee. Time resolution investigation demands amplitude comparison of different detectors in similar energy ranges. Both characterizations require thorough energy calibration. We suggest a semi-automatic procedure to calibrate Compton spectra. In which, the energy spectrum is first simulated with GEANT4 libraries. The optimal values of the Gaussian and calibration coefficients are found through the gradient descent algorithm and initial values are extracted through differentiation of a Fourier-filtered spectrum. A small sample of 15 detector module prototypes has been produced and characterized by time resolution and energy threshold value. To estimate the effect of cross-talk, a measurement was made at Frank Laboratory of Neutron Physics, where we use a 14.1 MeV tagged neutron generator to irradiate a detector module, positioned side-by-side with another module. The result for cross-talk is approximated by the signals detected from the module on the side.

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