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Research and Development of a Large-Size CsI(Tl) Detector for Neutron Capture γ -ray Measurement at the Back-n White Neutron Source of CSNS

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Neutron capture reactions play a crucial role in nuclear physics research, as their cross-section measurements provide critical data for nuclear structure studies and nuclear databases, while also enabling the examination of symmetries and conservation laws in nuclear reactions. To meet the requirement for neutron capture cross-section measurements at the back-streaming neutron facility (Back-n) of China Spallation Neutron Source (CSNS), we have developed a large-size CsI(Tl) detector with a diameter of 10 cm and a length of 21 cm. The CsI(Tl) crystal is coupled to a photomultiplier tube (PMT) for signal readout. The PMT's performance, including single-photoelectron response and gain curve were characterized in the laboratory using an LED light source. The reflective layer material, energy response, and uniformity of the CsI(Tl) detector system were evaluated using gamma-ray radioactive sources. Preliminary results demonstrate that the detector achieves a uniformity better than 5% and an energy resolution of 2.5% at 662 keV. Beam experiments for neutron capture cross-section measurements were conducted using lead samples at the Back-n beamline to validate the detector's performance. Based on the preliminary results, an improved experimental protocol has been proposed. This work provides a detailed description of the design of the large-size CsI(Tl) detector system, the results of radioactive source tests, and the progress of beamline experiments.

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