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Characterization of a LYSO Crystal and SiPM Array-Based Detector for Radiation Source Localization

Radiation source localization is a critical technology in fields such as emergency response and nuclear decommissioning, where identifying the position of radioactive materials is essential for safety and operational efficiency. In such scenarios, compact and deployable systems are particularly important to enable rapid and flexible detection in constrained or hazardous environments. While several systems have been developed in the past, most rely on bulky photomultiplier tube (PMT)-based detectors, limiting their field applicability. Furthermore, many of these studies focus only on the localization of one or two radioactive sources under controlled conditions. This highlights the need for compact, high-accuracy detection technologies capable of more versatile and scalable source localization..

The detection system consists of an 8×8 cerium-doped lutetium yttrium oxyorthosilicate (LYSO) crystal array directly coupled to an 8×8 silicon photomultiplier (SiPM) array, forming a compact 64-channel detector. Using this setup, 64 distinct spectra can be acquired through a multi-channel analyzer. Since the LYSO crystal serves both as a scintillation material and a radiation attenuator, each channel produces a unique spectral response influenced by the interaction between radiation and the scintillator. These spectral variations are affected by factors such as the scintillator properties, radioisotope types, and their spatial positions.

In this study, a performance evaluation was conducted to develop a position-sensing system based on an LYSO crystal array and a SiPM array. The system was composed of an 8×8 array of 3×3×20 mm^3 LYSO crystals coupled one-to-one with a 64-channel SiPM array (S14161-3050AS-08, Hamamatsu). Output signals were digitized using a DT5202 module (CAEN) and transmitted to a computer via Janus DAQ software (CAEN). To evaluate the system's capability, a 137Cs point source was measured at azimuthal and polar angles ranging from 0° to 180° and 0° to 90°, respectively, in 10° intervals. The acquired spectra from each channel were calibrated using a spectrum stabilization method, and the photopeak areas were extracted to form 8×8 feature maps. Centroid analysis of these feature maps was performed to estimate the source positions. The results demonstrated that the proposed detection system could accurately identify the location of the radiation source using relatively simple computational techniques.

Workshop topics

Applications

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