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Design and development of gamma camera based on LaBr3 (Ce) crystal coupled SiPM array

The location of radioactive material is critical for the radiation protection of workers in the field of nuclear industry. During the overhaul of the nuclear power plant or the decommissioning detection of the nuclear facility, since the distribution of the radioactive material in the pipeline is not known in advance, it is necessary to use the detection technology for determining the location information of the radioactive source. Radiographic imaging technology is a new technology in the field of nuclear radiation detection. It can detect radioactive substances in the field of view from a long distance and give a two-dimensional distribution image that cooperate with an optical camera to intuitively indicate the location of hot spots. In radiographic imaging technology, coded aperture imaging technology are the current mainstream imaging technologies, which have been successfully applied in the fields of nuclear security, nuclear industry, and nuclear medicine. Because of its good angular resolution, strong anti-interference ability, and high efficiency, the coded aperture imaging system has advantages in applications with high dose rates such as the nuclear industry. In order to meet the needs of the nuclear industry for imaging systems with high dose rate, high energy resolution, miniaturization, and strong anti-interference capability, a coded aperture imaging (CAI) system based on LaBr3(Ce) crystal-coupled SiPM arrays is proposed in this paper.

The CAI system includes four parts: the coded aperture collimator, the position sensitive detector, the data acquisition system,and the terminal display. The modified uniformly redundant array (MURA) aperture was selected due to its significant improvements to SNR of the reconstructed images compared with randomly distributed arrays. tungsten-nickel-copper alloy with 99% tungsten content was selected to make the aperture with an 7×7 loop nesting MURA pattern to modulate the incident particles. the size of a single pixel is 7mm×7mm×7mm. The detector part is composed of 8×8 LaBr3(Ce) crystal strips which the size of a single pixel is 6.4mm×6.4mm×20mm. The photoelectric conversion device uses ARRAYC-60035-64P array SiPM produced by Onsemi Company, which is composed of 8×8 C-60035 pixel SiPM. The LaBr3(Ce) crystal array is coupled with the SiPM array through silicone grease to form a detector module. The data acquisition system uses IDEAL's ROSMAP-MP, which can simultaneously acquire 64-channel analog signals. After completing the entire coded aperture imaging system, we performed a series of tests of detector performance and imaging performance. The average energy resolution of 64 crystal strip pixels is 4.96%, of which the best and worst energy resolution is 3.92% and 5.91%, respectively. The projection map of (Am-241, Cs-137, Co-60) detectors was decoded and reconstructed using the direct convolution algorithm, and the results were all accurately reconstructed the position of the radioactive source. The test results show that the coded aperture gamma imaging system can clearly image radioactive sources and has the ability to image radioactive substances on site.

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