

Development of Neutron and Gamma-ray Localization System using Rotational Modulation Collimator Coupled to a CLYC Scintillation Detector

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To monitor the flow of radioactive materials, extensive research has been conducted on various types of suitable detectors and localization systems. Among those localization systems, neutron and gamma-ray dual-particle imaging systems have the advantage of being able to locate a radiation source in complex background environment. As radiation localization system, a rotational modulation collimator (RMC)-based imaging is considered as a promising imaging method with little complexity in the system composition. Recently, we have suggested an RMC system combined with the pulse shape discrimination capable Cs₂LiYCl₆:Ce (CLYC) scintillation detector as a dual-particle imager. Batches of Monte Carlo simulations were performed using Monte Carlo N-Particle version 6.1 (MCNP6.1) code to investigate the feasibility of developing CLYC-based RMC system, and the imaging reconstruction methodology developed implementing maximum-likelihood expectation-maximization method. We also optimized the collimator mask design parameters for dual-particle purpose and proposed a new asymmetric mask design to remove the ambiguous artifact without compromising the imaging capability. In the present study, measurement experiments were conducted in the mid-range field (source-to-front mask distance 100 cm) using gamma-ray and neutron sources. The fabricated CLYC-based RMC was tested with single and double source distribution and verified our imager performance in mixed neutron/gamma-ray environment. The reconstructed images of the source distributions were evaluated quantitatively with signal-to-noise ratio and structural similarity index. Measured modulation patterns showed good reproducibility and well matched MCNP6.1 simulation results. Reconstructed images also made good estimations on the radiation source location. In this study, it was shown that both gamma rays and neutrons can be visualized to estimate the source location of radioactive materials utilizing a CLYC-based RMC system. The experiments gave promising results on utilizing CLYC-based RMC for radioactive material monitoring and detection.