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A Novel Single-Plane Compton Gamma Camera: Design, Characterization, and Imaging Performance

In the rapidly evolving realm of radiation imaging, encompassing fields such as Astro-particle physics, medical imaging, and homeland security, the Compton gamma camera (CGC) emerges as a revolutionary technology. Recent strides in technological innovation and computational prowess have enabled the successful development and deployment of diverse radiation detectors. Among these, the Compton camera distinguishes itself with a wide field of view, three-dimensional image reconstruction without the need for tomography, and a portable, lightweight design owing to the absence of bulky collimation mechanisms.

The historical trajectory of gamma ray imaging, tracing back to the 1950s with the introduction of CGC utilizing mechanical collimators, has undergone remarkable evolution. Moving from semiconductors to scintillator detectors, the focus has shifted towards achieving comparable angular resolution at reduced costs and minimal maintenance requirements. A novel CGC concept has been devised, featuring segmented GAGG:Ce scintillators measuring 3 mm x 3 mm x 3 mm optically coupled with 20 mm plexiglass light guides and read out by silicon photomultipliers (SiPM) on a single side. Arranged in an 8x8 matrix with a 3.2 mm pitch and separated by ESR reflectors, the front layer acts as the scatterer while the back layer serves as the absorber. This design efficiently utilizes a SiPM array on the matrix's backside, connected to TOFPET2 DAQ, minimizing read-out channels for compactness. The 20 mm light guide length strikes a balance between detector efficiency and angular resolution, as validated through GEANT4 simulations. This innovative design ensures a minimal number of read-out channels, crucial for compactness.

The constructed CGC underwent rigorous laboratory testing using Cs-137 and Na-22 sources to characterize its energy resolution and performance. A preliminary imaging test conducted with a Cs-137 source positioned 50 mm in front of the module, utilizing a back-projection algorithm, was published in 2023. The detector was characterized using Cs-137 and Na-22 sources, achieving an energy resolution of 8.9 ± 1.9% (front layer) and 10.8 ± 1.6% (back layer) at 662 keV. Imaging tests with sources placed 100 mm in front of the module showed distinct angular resolution peaks of 13.6° (FWHM) for Cs-137 and 13.1° (FWHM) for Na-22, demonstrating its imaging capability. A comparative study between Simple Back Projection and MLEM algorithms highlights the camera's ability to reconstruct off-axis sources within the field of view. Additionally, GEANT4 simulations helped identify noise contributions, improving image reconstruction fidelity. This work underscores the potential of a single-plane readout CGC for environmental gamma-ray detection, homeland security, and portable radiation monitoring applications. Having previously submitted this research to IWORID and been accepted for a poster, I am eager to present the extended results this year.

Workshop topics

Detector systems

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