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Development and Initial Testing of a Silicon-Based Compton Camera Prototype for Radiotracer Imaging

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Compton cameras (CCs) are promising imaging devices for nuclear medicine applications, as they can produce 3D images over a broad range of gamma-ray energies. Their flexible geometry suits compact and unconventional imaging setups. High energy resolution also improves background rejection and supports multi-isotope imaging, crucial in clinical contexts. Silicon detectors, due to their superior energy resolution are well-suited as scatterers in Compton camera systems.

The IRIS group at IFIC (Valencia), after developing several scintillator-based CCs under the MACACO project, is now working on a new prototype using silicon detectors, with the aim of improving the performance for radionuclides emitting photons with energies below 300 keV such as ^{177}Lu. The system combines a silicon pad detector as the scatterer and a scintillator crystal coupled to a SiPM array as the absorber. This design aims to enhance spatial resolution over previous setups, while preserving compactness and high detection efficiency. To evaluate its performance, experimental tests at the laboratory have been conducted using a ^{133}Ba source, focusing on the 356 keV gamma-ray line.

The dimensions of the silicon detector are 46.4 x 11.6 x 0.5 mm^3 and 1 mm x 1 mm pads manufactured by SINTEF for the MADEIRA project. The second detector of the CC consists of a Lanthanum (III) Bromide scintillator crystal from Saint Gobain of size 25.8 x 25.8 x 5 mm^3 coupled to a SiPM array S13360-3025CS with a pixel size of 3 mm^2. Data acquisition is handled by two time-synchronized AliVATA readout boards, each tailored to operate the ASIC for its respective detector: the VATA64HDR16 collects charge from the SiPM signals, while the VATAGP7.2 interfaces with the silicon detector, both developed by IDEAS.

Functional verification was performed by acquiring data in singles and coincidence mode using a point-like source of ^{133}Ba with an activity of 683 kBq. Energy spectra from both detectors were analyzed, and correlations between energy deposits are being evaluated to identify valid Compton events. System optimization is ongoing.

To complement the experimental work, Monte Carlo simulations using GATE v8.2 were performed, replicating the physical system. Two radionuclides (^{133}Ba and ^{131}I) were studied using a point-like source and a simplified Derenzo-like phantom to assess the spatial resolution. Simulations indicate that the silicon–scintillator configuration achieves superior performance at low energies relative to earlier MACACO prototypes.

Current efforts focus on comprehensive characterization of the silicon detector, expanded simulations for radionuclides emitting photons near 200 keV, and ongoing imaging experiments.

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