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A Novel Compton Camera Design featuring a Rear-panel Shield for Substantial Noise Reduction in Gamma-ray Images

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After the Japanese nuclear disaster in 2011, large amounts of radioactive isotopes were released and still remain a serious problem in Japan. Consequently, various gamma cameras are being developed to help identify radiation hotspots and ensure effective decontamination operation. The Compton camera utilizes the kinematics of Compton scattering to contract a source image without using a mechanical collimator, and features a wide field of view. For instance, we have developed a novel Compton camera that features a small size (13 x 14 x 15 cm^3) and light weight (1.9 kg), but which also achieves high sensitivity thanks to Ce:GAGG scintillators optically coupled with MPPC arrays. By definition, in such a Compton camera, gamma rays are expected to scatter in the "scatterer"and then be fully absorbed in the "absorber"(in what is called a forward-scattered event). However, high energy gamma rays often interact with the detector in the opposite direction—initially scattered in the absorber and then absorbed in the scatterer—in what is called a "back-scattered"event. Any contamination of such back-scattered events is known to substantially degrade the quality of gamma-ray images, but determining the order of gamma-ray interaction based solely on energy deposits in the scatterer and absorber is quite difficult. For this reason, we propose a novel yet simple Compton camera design that includes a rear-panel shield (a few mm thick) consisting of W and/or Sn, located just behind the scatterer. Since the energy of scattered gamma rays in back-scattered events is much lower than that in forward-scattered events, we can effectively discriminate and reduce back-scattered events to improve the signal-to-noise ratio in the images. This paper presents our detailed optimization of the rear-panel shield using Geant-4 simulation, and describes a demonstration test using our Compton camera.

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