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Monte Carlo Study of a Compton Camera: Quantification of Detector Parameters Affecting Image Quality

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This study quantifies various parameters which affect the image quality (i.e., spatial resolution, signal-to-noise ratio, etc.) of a Compton camera by using the GEANT4 Monte Carlo particle simulation toolkits. This study considers F-18 radioisotope, which is popular in PET imaging and produces 511-keV annihilation photons. The Compton camera modeled in this study is composed of a scatterer (a double-sided silicon strip detector, 5 x 5 x 0.15 cm3) and an absorber (a 25-segmented germanium detector, 5 x 5 x 2 cm3) and these detectors are separated by 5 cm. The F-18 radioisotope (point source) is assumed to be located at 6 cm in front of the scatterer. This study modeled the Compton camera realistically including all the details of the Compton camera. The PENELOPE physics model was used to include the effects of atomic binding and Doppler energy broadening in Compton scattering. The discrimination level of the Compton camera was also modeled for the scatterer and absorber (i.e., 15 keV and 50 keV, respectively). This study modeled the resolution of the detectors by assuming the Gaussian distribution of the energy peak. Our result shows that the segmentation of the absorber, which is a 25-segmenterd germanium detector (5 x 5 x 2 cm3), significantly degrades the resolution of the Compton camera (FWHM = 1.6 cm). The Doppler broadening and detector energy resolution slightly lower the resolution of the Compton camera (i.e., FWHM of 0.328 cm and 0.130 cm, respectively). The image quality is also slightly affected by the detector discrimination level.

Keywords : Monte Carlo, Compton Camera, GEANT4