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Development of Compton-PET hybrid imaging system with CeBr3-SiPM arrays

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Positron emission tomography (PET) and single photon emission computed tomography (SPECT) has played an important role in nuclear medicine. While PET can only visualize a positron emitter by detecting annihilation gamma-rays, SPECT is used for low energy gamma-ray imaging (50-400 keV) by using a Pb-based collimator. It is difficult to integrate these modalities because SPECT requires collimators to determine the direction of incoming gamma-rays. Against this backdrop, we proposed a Compton-PET hybrid camera, which can provide images of PET and SPECT nuclides simultaneously by PET imaging and Compton imaging without any collimators. Recently, we succeeded the simultaneous in vivo imaging of ^{18}F-FDG and ^{111}In antibody with a GAGG- silicon photomultipliers (SiPM) based camera. In this study, we have developed a $CeBr_3$-SiPM based Compton-PET hybrid camera to improve time resolution potentially for time-of-flight PET imaging and evaluated the performance of PET imaging and Compton imaging.

The $CeBr_3$ scintillator has first decay time (20 ns), excellent light output (˜70000 photons/MeV), and great energy resolution (˜4%@662 keV when coupled with APD). The 8×8 arrays of $CeBr_3$ scintillator were fabricated by C&A corporation. The pixel size is 2.5 mm × 2.5 mm, and the pitch size is 3.2 mm. Each pixel was separated with the BaSO4 powder reflector. The arrays were hermetically sealed in an aluminum package with a quartz window and were coupled to 8×8 arrays of SiPMs (Hamamatsu MPPC S13361-3050). The charge signals from SiPMs were processed through time-over-threshold (ToT)-based application specific integrated circuits with the intrinsic time resolution of 50 ps. The time resolution of 198.7 ps was achieved with 1 mm thick $CeBr_3$ array detectors by using a digital oscilloscope. In addition, the angle resolution of a $CeBr_3$ Compton camera with the dynamic ToT method was 5.5° at 662 keV. In the presentation, we will report the evaluation in detail.

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