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#09-170 A whole gamma imaging prototype with a two-layer depth-of-interaction GSO scatterer detector

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Whole gamma imaging (WGI) is our new imaging concept which combines PET and Compton imaging. By inserting a scatterer detector ring into a PET ring, two different modalities can be evaluated on the same platform. We developed a WGI prototype and demonstrated Compton imaging of 909 keV photons emitted from a ⁸⁹Zr-injected mouse. While Compton imaging can avoid theoretical limitation in PET resolution due to positron range and angular deviation, the quality of obtained Compton images was worse than that of PET images. Therefore, in this work, toward our final goal of achieving Compton imaging to outperform PET, sensitivity and energy resolution of the scatterer detector were improved.

Depth of interaction (DOI) detection was introduced for the scatterer to improve the sensitivity while suppressing the parallax error. GSO crystals sized at 2.85 × 2.85 × 7.5 mm³ each were used. The GSO crystals were arranged into a 7 × 7 array for the 1st layer and an 8 × 8 array for the 2nd layer, and these layers were stacked with the staggered arrangement. Each 2-layer GSO array was coupled to a multi-pixel photon counter (MPPC) array module (3 × 3 mm², 8 × 8 array, sub-pixel size of 50 × 50 μm², Hamamatsu, S13360-3050PE). The redesigned scatterer detector ring had four rings, and each ring had ten GSO detectors. The total axial length was 10.4 cm, which was twice as long as the previous WGI prototype. The newly developed scatterer detector ring was inserted into the PET ring, which was the same absorber ring used in the previous WGI prototype.

Energy resolution at several energies, angular resolution measure (ARM), and Compton imaging sensitivity at 662 keV gamma ray were investigated. In addition, imaging tests using a ⁸⁹Zr Derenzo phantom and a ⁸⁹Zr-injected mouse were conducted. The PET and Compton image were compared.

The new WGI prototype showed a better energy resolution (e.g., at 202 keV, 12.7% vs. 15.9%) than the previous WGI prototype. However, the improvement in the angular resolution was not so remarkable (6.4 deg. vs. 6.7 deg.). We think that the increased crystal size may have impacted on compromised improvement in the angular resolution. On the other hand, doubling the axial length of the scatterer in addition to the use of the thick crystals resulted in 1.5 times higher Compton imaging sensitivity. For the ⁸⁹Zr Derenzo phantom images, the PET image resolved the 2.4-mm rods while the Compton image resolved the 3.2-mm rods roughly. For the ⁸⁹Zr-injected mouse images, the Compton imaging result which was close to the PET image was obtained.

In conclusion, the new WGI prototype showed a promising basic performance. Further improvement of the WGI system will be performed toward the goal of achieving Compton imaging that outperforms PET.

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