Gamma-ray inspection of a rotating object

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We are developing a method called gamma-ray inspection of a rotating object (GIRO) to image the spatial distribution of γ-ray sources. The setup employs two sets of collimated γ-ray detectors on the opposite sides of an object with RI sources that continuously rotates. The principle of the method and some results of test measurements have been reported.[1,2)]

We replaced the original detectors with four NaI(Tl) scintillation detectors (V51B102/2M-X from Scionix, 51 mm $\times$ 51 mm $\times$ 102 mm). Two detectors were stacked on either side of a turntable. The energy resolution of the new detectors was about 7.2 %-7.8 % full-width half maximum (fwhm) for 511-keV γ rays, which is better than the 17 %-18 % fwhm of the previous detectors.

The γ-ray collimator in the original setup was a 4-mm wide vertical aperture between two 3-cm thick lead blocks. The γ-ray photons that penetrated the edge of the block resulted in a dull collimation and caused a background near a strong source in the reconstructed image. To improve the collimation, we attached a parallel pair of wolfram plates (W-plates) to the lead blocks. The W-plates were 2-mm thick, 110-mm high, and 100-mm deep and separated by 4 mm, as shown in Fig. 1.

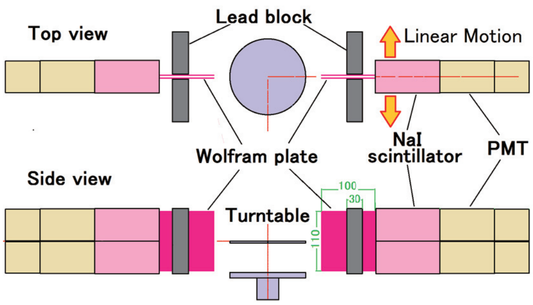

Fig. 1. GIRO detector setup with wolfram plates.

Figure 2 compares reconstructed images taken (a) without and (b) with the W-plates for three point-like ^{22}Na sources (309 kBq, 29 kBq, and 2.6 kBq) on the turntable. The turntable rotated at 150 rpm and the detectors moved by 2 mm/step and 1 step/10 s over a $\pm$74-mm range. The measurement time was about 10.3 h without the W-plates and 20.7 h with them.

The two-dimensional image shows three spots corresponding to the sources. In the image without the W-plates, a halo-like background surrounds the spot of 309 kBq, but it disappears in the image with the W-plates. The y-axis projections of the image on the right show that the W-plates reduced the background around the highest peak.

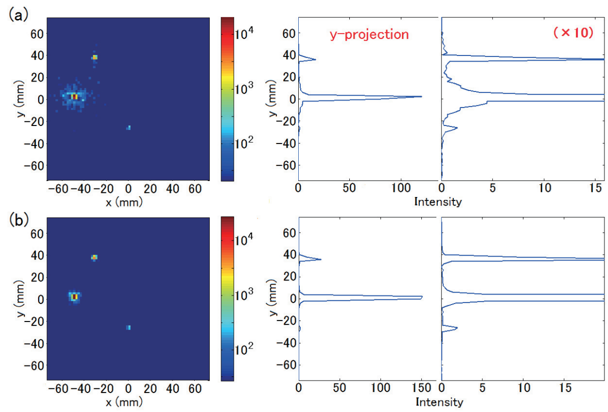

Fig. 2. Reconstructed image of three ^{22}Na sources with collimators (a) without and (b) with the W-plates. Left is the two-dimensional image, right is its projection to y-axis and its ten-fold magnification.

The measurements described above were performed in the PET mode with coincidence measurements of two 511-keV photons from the positron annihilation. GIRO also allows SPECT-mode measurements, where single γ-ray photons are detected by each detector. The SPECT mode has a lower spatial resolution for the RI distribution and higher background than the PET mode, but it is applicable to various γ-ray emitting nuclides and its measurement time is much shorter. Figure 3 shows SPECT-mode images of the same setup as shown in Fig. 2 taken by 511-keV photons. The measurement took about 27 min. The W-plates improve the resolution of the SPECT-mode image, which shows not only the 309 kBq source but also the 29 kBq source.

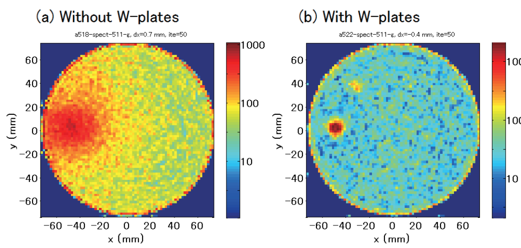

Fig. 3. SPECT-mode image of the same source shown in Fig. 2 (a) without and (b) with the W-plates.

References
1) T. Kambara, A. Yoshida, and H. Takeichi: Nucl. Instr. Meth. A **797**, 1 (2015).
2) T. Kambara: Nuclear Physics News **26**, No. 4, 26 (2016).

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