An Anti-Compton Gamma-Ray Spectrometer of Axial Type Using BGO Crystals

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Anti-Compton gamma-ray spectrometers have been constructed for suppressing the background continuum due to the Compton scattering process in the Ge detector. We also have constructed an anti-Compton gamma-ray spectrometer using BGO crystals for detecting the gamma-rays with reduced Compton background, and measured the performance using standard sources. Monte-Carlo calculations were also made and compared with the measured performance. The details are described in ref. 1. Adopting an axial geometry on the basis of a high-purity Duet detector of n-type Ge from ORTEC, we succeeded in making a very compact assembly of ACS (Anti-Compton Spectrometer) as shown in Fig. 1.

The performance of the ACS was measured using ^{60}Co, ^{137}Cs and ^{137}Cs standard sources. We indicate the performance by the suppression, factor (SF) defined as a ratio of the intensity of Compton continuum around 500∿800 keV for the ordinary spectrum, i.e., the one without suppression, divided by the corresponding quantity for the Compton-suppressed spectrum. For the source of ^{60}Co we obtained a measured result of

$$(SF)_{exp} \fallingdotseq 6 \text{ (see Fig. 2).}$$

On the other hand we calculated the gamma-ray spectra with and without Compton suppression on the basis of a Monte-Carlo simulation program. The results are shown in Fig. 3. The results of simulation are different from the experimental ones in two respects; in the first place

$$(SF)_{simul.} \fallingdotseq 15,$$

in comparison with $(SF)_{exp} \fallingdotseq 6$ given above. Secondly, the slope of the Compton continuum is different; the slope of the simulated spectra is larger than that of the measured spectra as seen by a scrutiny of Figs. 2 and 3.

We interpret the difference between the measured and the simulated spectra as due to some effects of the response of the Ge detector, i.e., the Ge detector is considered to show a response consisting of a "photopeak" and a "low-energy tailing" even if the energy deposit to the detector is mono-energetic. Assuming that this tailing is composed of a constant plateau plus an exponential tail, both depending on the value of mono-energetic energy dependence of this assumed tailing, we succeeded in obtaining the corrected spectra which closely coincided with the measured spectra, as shown in Fig. 4. It is worth noting that not only the suppression factor,

$$(SF)^{corr.}_{simul.} \fallingdotseq 6,$$

is equal to the experimental value of $(SF)_{exp} \fallingdotseq 6$, but also the slope of the Compton continuum of the corrected simulation is nearly the same as that of the measured spectra.

The experimentally attained value of $(SF)_{exp} \fallingdotseq 6$ corresponds to a rather good performance as an ACS. Comparison with the corrected Monte-Carlo simulation indicates that the response of the Ge detector is vitally important as well as the performance of the veto crystals, in the present case the BGO crystals. The present ACS will be utilized in gamma-ray measurements in the study of short-lived nuclei as well as in in-beam spectroscopy.

Reference

1) Kamiya T., Master's Thesis, March 1986, Tohoku University.

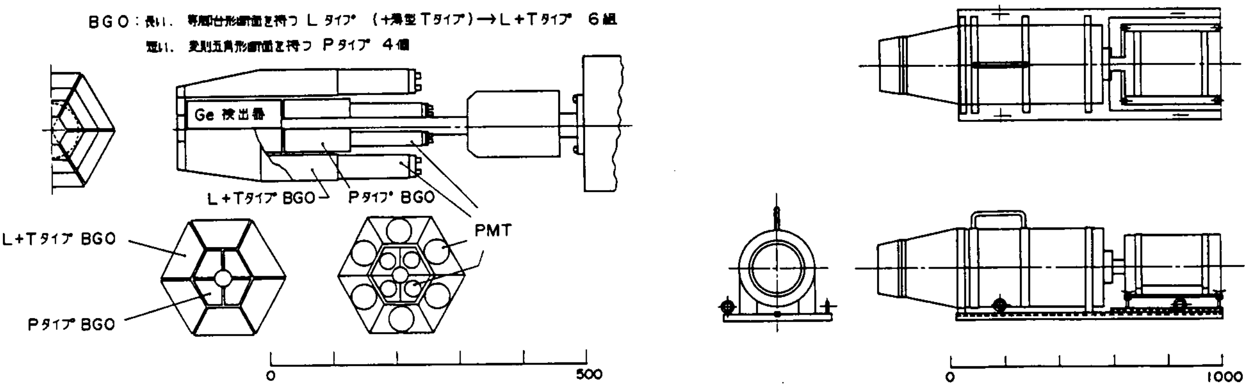

Fig. 1. Cross sections and external views of the Anti-Compton Spectrometer. Use of an axial geometry and BGO crystals made the instrument very compact.

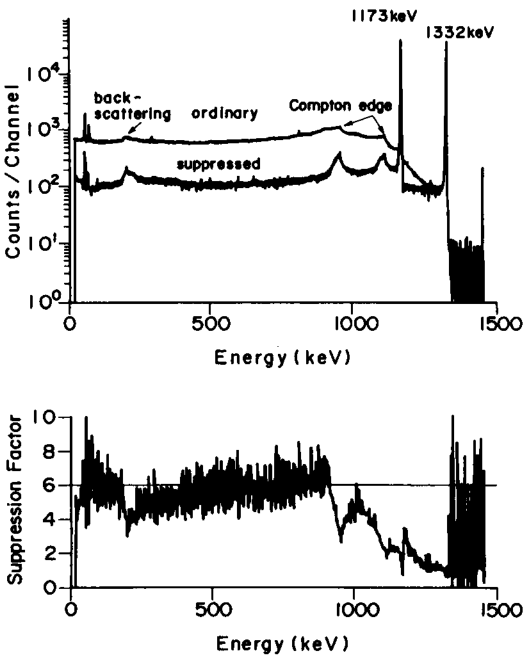

Fig. 2. Ordinary and Compton-suppressed spectra measured for a ^{60}Co source.

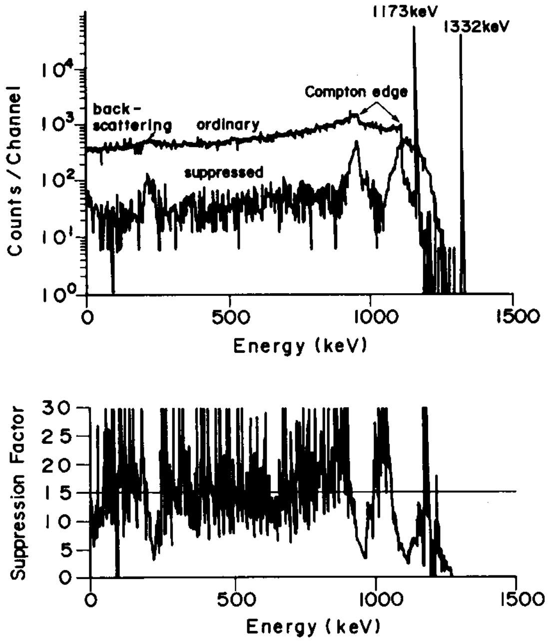

Fig. 3. Results of the Monte-Carlo simulation without correction. Note the differences in the spectrum shape and the suppression factor in comparison with the measurement (Fig. 2).

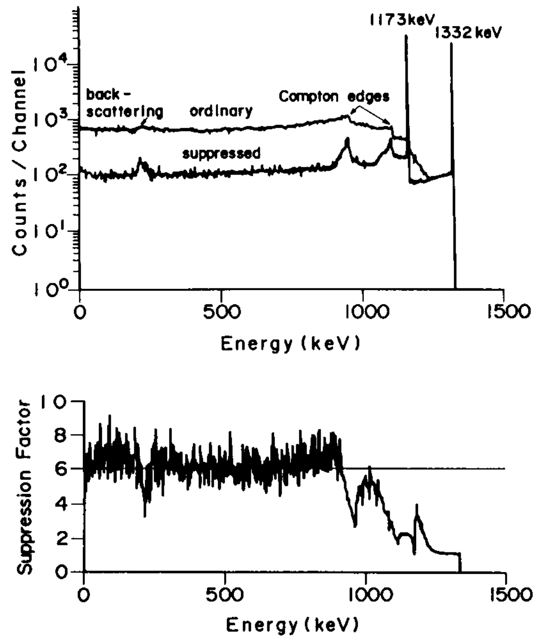

Fig. 4. Results of the Monte-Carlo simulation after correction, i.e., the Ge detector is assumed to have a response function consisting of a tailing as well as the peak. Note a good agreement with the measurement (Fig. 2).