Analysis of Background γ-Ray Measured with Shielded HPGe Detector

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1. Introduction

The background γ-ray was measured with shielded HPGe detector. Lead bricks with 10 cm thickness and copper plates with 3 mm thickness were used for the shield. The shield dimension was 1000×1400×1150 mm^3. The background was measured with and without the shield as well as with the copper plates inside of the shield. Also, the X-rays and γ-rays spectra for standard sources, ^{241}Am, ^{133}Ba, ^{137}Cs, ^{60}Co, ^{152}Eu, were measured. The γ-ray spectroscopy systems was composed of closed-ended coaxial type HPGe detector, Linear AMP, ADC, and AIM. The relative detection efficiency of the HPGe detector is 18% and the energy resolution is 1.8 keV for the 1.3 MeV γ-ray peak from ^{60}Co.

2. Comparison of background spectra under various shield conditions

The measured background spectra are shown in figure 1. Analysis of the background peak areas was performed by HYPERMET code[1].

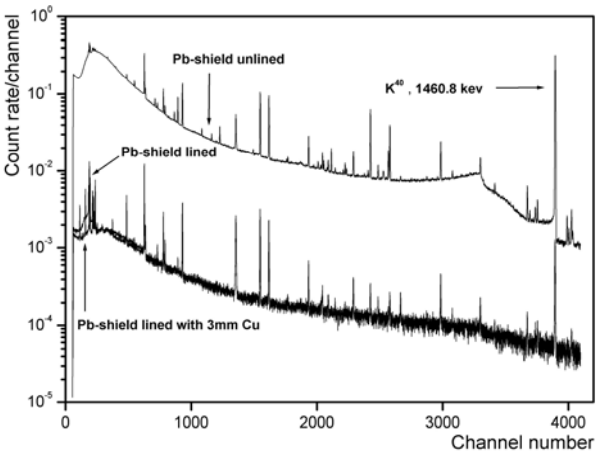

Figure 1. Background spectra under various shield conditions.

Total count rate of the background was drastically reduced by shield from 187.2 cps to 1.7 cps. Some of the background γ-rays and X-rays peaks is listed in table 1. As for ^{40}K, one of the most representative background γ-ray peaks[2], it has decreased by a factor of 200 from $1753.6(3)\times10^{-3}$ cps to $6.3(1)\times10^{-3}$ cps. Count rate of γ-rays from any other background sources such as ^{214}Bi, ^{228}Ac and ^{208}Tl[2,3] has also decreased by a factor of 100. In the case of 238.6 keV γ-ray emitted from ^{212}Pb, the count rate has decreased by a factor of 20 from $779(7)\times10^{-3}$ cps to $33.4(3)\times10^{-3}$ cps. Some peaks that were from ^{212}Pb and ^{235}U showed a similar tendency. It is determined that this tendency was shown because of the decreased Compton continuum and lead shield .

Table 1. Major background γ-rays and X-rays.

Nuclide	Energy (keV)	Count rate(10^{-3}cps)		
		Not shielded	Pb-shielded	Pb, Cu-shielded
Pb	74.8*)	394.3(76)	27.8(2)	6.9(2)
Bi	77.1*)	258.6(64)	15.1(2)	8.9(3)
^{226}Ra	186.0	90.4(31)	10.8(2)	7.7(2)
^{212}Pb	238.6	778.8(67)	33.4(3)	22.4(3)
^{214}Pb	351.9	345.6(20)	6.9(2)	11.5(2)
^{208}Tl	583.1	350.7(16)	10.9(2)	7.8(2)
^{228}Ac	911.1	255.3(14)	1.1(1)	0.9(1)
^{228}Ac	968.9	151.5(11)	0.6(1)	0.6(1)
^{214}Bi	1120.3	83.2(9)	1.1(1)	1.7(1)
^{214}Bi	1238.1	38.3(12)	0.4(0)	0.7(1)
^{40}K	1460.8	1753.6(3)	6.3(1)	5.9(1)

*) Characteristic X-rays

In addition, below 95 keV characteristic X-ray emitted from Pb and Bi was shown apparently after shield[2,3]. In order to reduce these characteristic X-rays, 3 mm copper plates were added inside of the shield. As a result, the X-ray peaks have decreased. In the case of the characteristic X-rays of 74.8 keV emitted from ^{214}Pb, its count rate has decreased by a factor of 4 from $27.8(2)\times10^{-3}$ cps to $6.9(2)\times10^{-3}$ cps.

3. Comparison of spectra of standard sources

Standard sources, ^{241}Am, ^{133}Ba, ^{137}Cs, ^{60}Co, ^{152}Eu, were measured with and without the shield as well as with the copper plates inside of the shield for 36,000 s in each case. Figure 2 shows the spectra of ^{137}Cs.

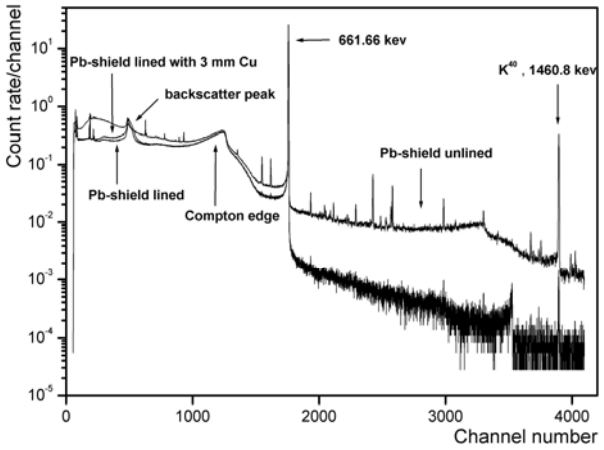

Figure 2. Spectra of Cs-137 under various shield conditions.

It was noticeable that backscatter peak and Compton edge were shown because of the decreased background. After adding the copper plates, the count rates of characteristic X-rays have decreased by a factor 5 whereas backscatter peak has increased. It is thought that the γ-ray emitted from ^{137}Cs is backscattered on the surface of the copper plates and detected[4].

4. Conclusion

Analyses on the background and standard source spectra both with and without the shield were performed. Under adding the shield, most of the count rates of the background γ-rays have decreased by a factor of 100. In order to reduce the characteristic X-rays, copper plates with 3 mm thickness were added inside the lead bricks, which resulted in X-rays reduction effect. On the measurement of the standard sources, Compton edge and backscatter peak were observed due to the reduced background by shield. When the copper plates were added, the X-ray counts have decreased while the backscatter peak has increased.

REFERENCES

[1] G.W. Phillips and K.W. Marlow, Nucl. Instr. and Meth. 137 (1976) 525.
[2] G. F. Knoll, “Radiation Detection and Measurenent”,3rd ed., pp.757~770, John Wiley & Sons, New York, 1999.
[3] K. Debertin and R. G. Helmer, “Gamma- and X-ray Spectrometry with semiconductor Detectors”, pp.133~147, Elsevier Science Publishers, 1988.
[4] G. Gilmore and J. D. Hemingway, “Practical Gamma-Ray Spectrometry”, pp.32~33, John Wiley & Sons, 1995.