Study on Compton suppression system using HPGe and NaI(Tl) detectors

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1. Introduction

The Compton continuum formed below a peak in the γ-ray spectrum is produced by γ-rays which scatter one or more times and escape the active volume of γ-rays detector, and it obstructs resolving low energy γ-ray peaks from a background [1]. Many research labs develop Compton suppression systems to reduce the Compton continuum.

In this study, a feasibility test of Compton suppression system using suppression detectors was performed. The installed Compton suppression system and the result of the test are described.

2. Compton suppression system

The Compton suppression system consists of one HPGe and two NaI(Tl) detectors as shown in Fig. 1. The n-type HPGe detector is the main detector of the system, and it has an energy resolution of 1.88 keV (FWHM) at 1.33 MeV and a relative efficiency of 31.7% [2]. Two 3″× 3″ NaI(Tl) detectors are used as suppression detectors to detect Compton scattered γ-rays.

The energy signal of the HPGe detector goes to a spectroscopy amplifier, and the amplified signal goes to an analogue-to-digital converter combined with a multi channel buffer (ADC/MCB). The timing signal of the HPGe detector is shaped into a 5 ns width logic pulse by a timing filter amplifier (TFA) and a constant fraction discriminator (CFD), and the signal is sent to the start input of the time-to-amplitude converter/single channel analyzer (TAC/SCA). The signal of the NaI(Tl) detector is shaped similar to the timing signal of the HPGe detector and sent to the stop input of the TAC/SCA. The TAC/SCA generates a gate signal when a time interval between the start and stop signals is below 3 μsec.

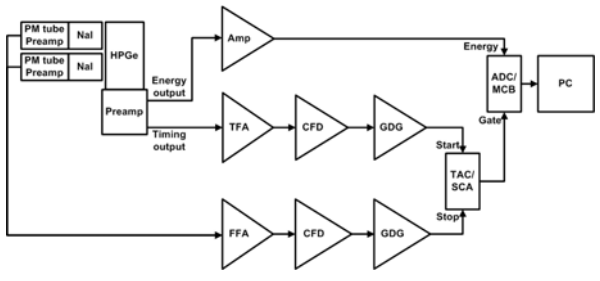

Fig. 1. Block diagram of the Compton suppression system using a HPGe and two NaI(Tl) detectors.

Two detection modes are set in the system. In the Single mode, all energy signals of HPGe detectors are recorded. In the Compton suppression mode, the energy signal of the HPGe detector is rejected when the gate signal comes to the ADC/MCB at the same time.

3. Compton suppression factor

The Compton suppression factor (CSF) which estimates the efficiency of the Compton suppression systems, is defined as the ratio of $PCR_{suppressed}$ / $PCR_{unsuppressed}$. The PCR(Peak-to-Compton Ratio) is defined as the ratio of the number of counts in the highest channel of the peak to the average number of counts per channel in the Compton continuum of 1040 to 1096 keV (1332.50 keV peak of ^{60}Co), or of 356 to 382 keV (661.66 keV peak of ^{137}Cs) [3].

4. Experimental Results

First, a single NaI(Tl) detector was used in the Compton suppression system as a suppression detector. The angle of the Compton Scattered 660 keV γ-ray is distributed around 60° mainly [4], so the suppression detector was installed at the side of the main detector as shown in Fig. 2(a). ^{137}Cs γ-ray spectra were collected in Single and Compton suppression modes. Then, ^{137}Cs and ^{60}Co γ-ray spectra were collected by using one more suppression detector as shown in Fig. 2(b). The results of measurements are presented in Table 1, and the spectra collected during 7200 sec by using two suppression detectors are shown in Fig. 3 and 4.

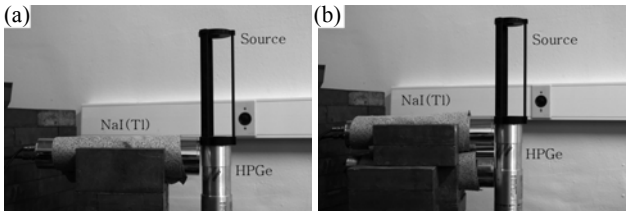

Fig. 2. Arrangement of Compton suppression system using one HPGe and one(a) or two(b) NaI(Tl) detectors.

Table 1. Results of measurements of Compton suppression systems.

NaI(Tl)	Source	$PCR_{unsuppressed}$	$PCR_{suppressed}$	CSF
1 ea.	^{137}Cs	163	178	1.09
2 ea.	^{137}Cs	163	186	1.14
2 ea.	^{60}Co	58	61	1.06

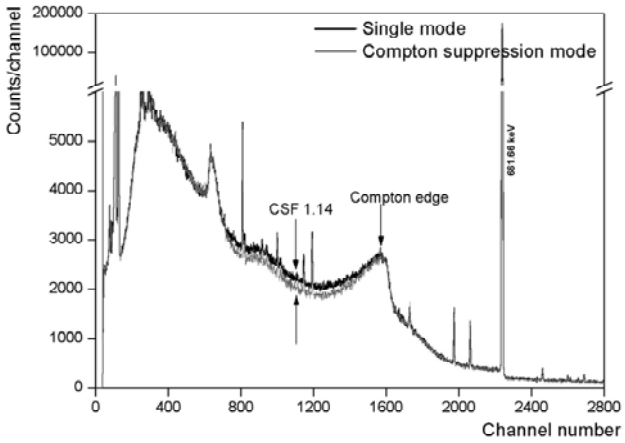

Fig. 3. Pulse height spectra from ^{137}Cs γ-ray source in Single and Compton suppression modes using two suppression detectors.

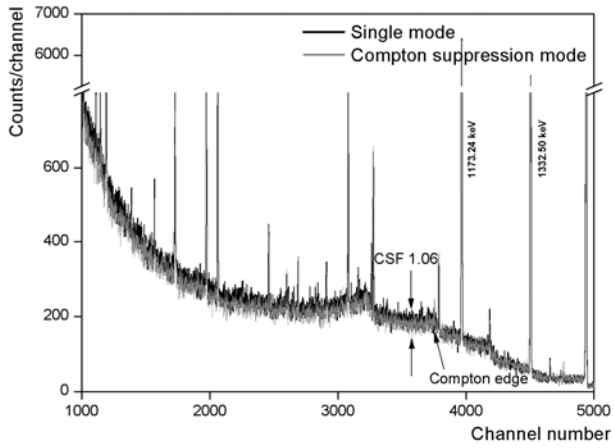

Fig. 4. Pulse height spectra from ^{60}Co γ-ray source in Single and Compton suppression modes using two suppression detectors.

5. Conclusion and further work

The Compton suppression system using one HPGe and two NaI(Tl) detectors was installed and tested. The CSF using one suppression detector is 1.09 at 661.66 keV peak position of ^{137}Cs, and those by using two suppression detectors are 1.14 at 661.66 keV, and 1.06 at 1332.50 keV.

To obtain better efficiency of the Compton suppression system, more suppression detectors are required because a Compton scattered γ-ray is deflected through any direction with respect to its original path. Hence, four more suppression detectors will be installed and tested in a symmetric structure around the main detector.

Acknowledgement

This research was supported by the Ministry of Education, Science & Technology (MEST) of Korea and also supported by Brain Korea 21 project.

REFERENCES

[1] G. F. Knoll, Radiation Detection and Measurement, John Wiley & Sons, New York, pp.308-317, 2000.
[2] C. S. Park, An Automatic Nuclide Identification for Ambient Gamma Radiation Monitoring by Radionuclide, PhD thesis, Seoul National University, p.70, 2009.
[3] K. Fukuda, J. Ohkuma, T. Asano and Y. Satoh, Performance of a Ge-BGO Compton-suppression spectrometer and its application to photon activation analysis, Nuclear Instrument and Method B, Vol 114 , p.379, 1996.
[4] K. H. Kim, Simulation for Compton Suppression System with EGS Code, graduate thesis, Seoul National University, pp.9-10, 2006.