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Establishment of the Compton Suppression System (CSS) for Gamma Screening of Environmental Samples

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1. Introduction

Environmental sampling has been a part of verification tool on North Korea nuclear activities since 2006. These swipe samples collected from the nuclear facilities are used for tracing the activity at the facilities [1]. Collected samples undergo gamma screening at the Korea Institute of Nuclear Nonproliferation and Control (KINAC) before detailed analysis is carried out.

Many nuclides in the environmental samples such as fission products, activation products and actinides emit gamma-ray. Some nuclides from the environmental samples emit gamma-ray of similar energy [2]. KINAC had established the Compton Suppression System (CSS) to distinguish the radiation of similar energy emitted from these nuclides and it is designed to reduce the background by means of passive and active shielding. The active shielding is implemented to suppress Compton scattered events in the HPGe detector [3]. The photons Compton scattered penetrate the HPGe and are detected by the secondary detector. The events counted in the secondary detector reject the registration of simultaneous events in the HPGe detector by means of fast electronic circuits.

This article showed the performance test result. The result is comparison of the suppression effect of Compton scattering in the measured gamma-spectrum.

2. The configuration of the Detection units

Two detectors compose the CSS; one is a High Purity Germanium (HPGe) detector as a primary detector for detecting all events, another is a NaI(Tl) detector as a secondary detector for rejecting events Compton scattered. As shown on the figures 1, the HPGe detector is surrounded by NaI(Tl) detectors.

N-type (0.3 μm ion implanted), coaxial HPGe with carbon fiber end cap is used. Its relative photo peak efficiency is 60% and its energy resolution at 1.33 MeV is 2.3 keV.

The NaI(Tl) detectors are arranged in three ways; annulus(4'×6'), plug(3'×3') and back-catcher(9'×9') detector are used to collect scattered photons from low-medium energy and high energy of incidence photons, respectively.

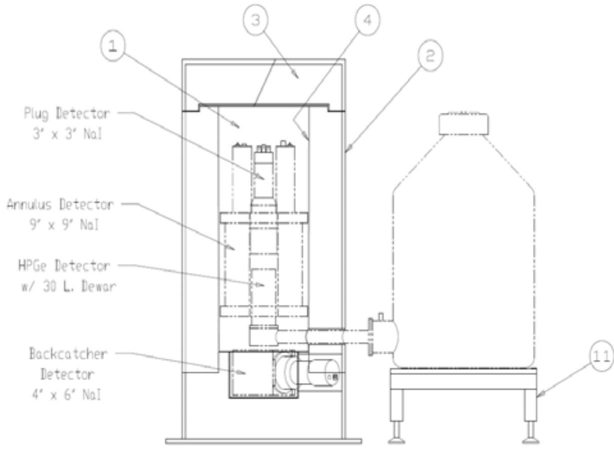

Fig. 1. The configuration of the CSS in the KINAC.

3. The electronics circuits of the CSS

The detector pulses are processed by both energy and fast electronic circuits. The circuits consists circuits processing energy and timing. Whole progress processing the signal is as below;

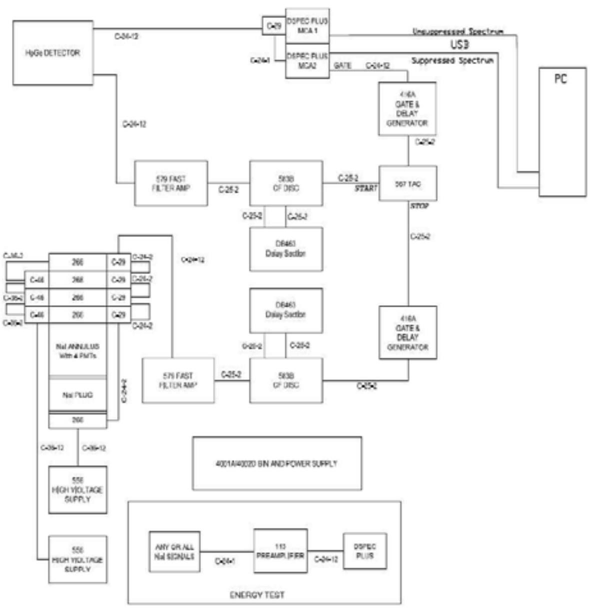

Fig. 2. The electronics of the CSS in the KINAC.

For using anti-coincidence mode, the fast timing circuits process the timing output pulses from the detectors. The outputs occurred from the NaI(Tl) detector summed together and processed by one timing chain. The timing chains consist of timing filter amplifiers (TFA) and Constant Fraction Discriminator (CFD).

A fast coincidence unit collects pulses from both timing chains and generates signal which gate the input of the two ADCs, one working in a coincidence and the other in an anti-coincidence mode. A delay line is included into the circuit to compensate for the difference in time between processing of energy and time pulses.

The Gamma Vision spectroscopy software provides data acquisition.

4. Performance Test Results

The background and the ^{137}Cs source were measured on the normal and anti-coincidence mode. And the data provides the performance of the CSS by the means of comparing each other.

As shown on table I, BKG counts on suppressed mode decrease in half of counts on the unsuppressed mode.

Table I: Comparison of the background counts between unsuppressed and suppressed mode

	Unsuppressed			Suppressed		
	Counts	Minutes	cpm	Counts	Minutes	cpm
1	588	180	3.27	330	180	1.83
2	596	180	3.31	351	180	1.95

P/C ratio evaluated from the measured ^{137}Cs source spectra indicates the performance of the CSS. P/C ratio is derived as [counts of full energy peak] divided by [average counts of Compton continuum]. For ^{137}Cs source, Compton continuum plateau energy is from 358 to 382 keV. As shown on table II, ^{137}Cs P/C ratio on suppressed mode was approximately seven-fold increase compared P/C ratio on the unsuppressed mode.

Table II: Comparison of the ^{137}Cs source counts between unsuppressed and suppressed mode

	Unsuppressed			Suppressed		
	Plateau AVG	Full energy Peak	P/C	Plateau AVG	Full energy Peak	P/C
1	160.5	20581	128.2	22.6	21068	934.2
2	162.6	20649	127.0	23.0	21194	923.6
3	163.5	20804	127.2	23.4	21248	909.5
4	163.4	20331	124.4	22.8	20970	920.7
5	163.5	20566	125.8	23.4	21271	910.9
6	163.0	20497	125.8	22.7	20887	920.1
7	164.3	20449	124.4	22.3	21102	947.7
8	161.6	20629	127.7	24.2	21174	875.7
9	162.5	20383	125.4	23.5	21329	909.3
10	163.1	20776	127.4	23.5	21281	903.9
AVG	162.8	20567	**126.3**	23.1	21152	**915.1**

5. Conclusion

The performance test result was satisfied its design objective. The CSS reduced the BKG counts significantly, and it directly connected with the improvement of detection limits. Also P/C ratio is up to 7 times better on suppressed mode. Therefore, this article expects this CSS is appropriate for screening of the environmental samples.

REFERENCES

[1] Mairov.V, Kuno.Y, Raab.W, Donhue.D, Jansta.V, Gamma screening of swipe samples at the IAEA, paper presented on the 22nd ESRADA seminar, 2000.

[2] V.Maiorov, Y.Kuno, W.Raab, V.Jansta, D.Donohue, Gamma Screening of Swipe Samples at the IAEA, IAEA.

[3] V.Maiorov, D.Donhue, W.Raab, Gamma screening of sipe samples with a Compton Suppression Sepctrometer, IAEA.