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Semi-empirical Calculation of Detection Efficiency for Voluminous Source Based on Effective Solid Angle Concept

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1. Introduction

To calculate the full energy (FE) absorption peak efficiency for arbitrary volume sample, we developed and verified the Effective Solid Angle (ESA) Code. The procedure for semi-empirical determination of the FE efficiency for the arbitrary volume sources and the calculation principles and processes about ESA code is referred to, and the code was validated with a HPGe detector (relative efficiency 32%, n-type) in previous studies [1-5]. In this study, we use different type and efficiency of HPGe detectors, in order to verify the performance of the ESA code for the various detectors.

2. Experiment

2.1 Sources and detectors

The specification of sources and detectors used in this study is listed in table 1 and table 2 and its pictures are shown in figure 1.

Table 1. Specification of detector and γ-ray sources

	Contents		
HPGe Detector	Relative efficiency	32%	n-type (ORTEC)
		17%	p-type (CANBERRA)
Sources	IAEA standard Point source	Nuclides	^{60}Co, ^{137}Cs, ^{152}Eu, ^{133}Ba, ^{241}Am
	KRISS CRM Volume source	Nuclides	^{60}Co, ^{137}Cs, ^{113}Sn, ^{109}Cd, ^{241}Am, ^{51}Cr, ^{139}Ce, ^{85}Sr, ^{88}Y, ^{57}Co
		Volume	450ml
		Type	Marinelli
		Medium	0.1M HCl agar

Fig.1.The KRISS CRM volume source and IAEA standard point source

Table 2. Relative efficiency 17% and 32% detector's specifications as input data of ESA code

	32% detector [mm]	17% detector [mm]
Crystal Diameter	52.9	50.5
Crystal Length	79.5	36.5
Hole Diameter	9	7.5
Hole Depth	71.4	22
Outside Contact Layer	0.3-micon Ge/B	0.5 Ge/Li
Hole Contact Layer	0.7 Ge/Li	0.3-micon Ge/B
End Cap Window	0.5 Be	1 Al
Insulator /Shield	0.03 Al Mylar	0.008 Be Mylar

2.2 Device Configuration and measurement

In order to obtain sufficient statistics, the minimum area of the interest peak is acquired over 10,000 counts. The source-to-detector distance 0 cm and dead time was less than 2%. An experimental conditions are listed in table 3 and detection geometry and experimental instruments are shown in figure 2.

Table 3. Experimental condition

	Contents	
Detector Relative efficiency	32%	17%
Location	Pb+Cu Shield in SNU	Detection room
Acquisition Time	2 hours	
Source to detector distance	point source : 25 cm Marinelli volume source : 0 cm	

Fig.2.Experimental instruments and detection geometry

3. Result

Figure 3 shows the comparison of the efficiency curve for a voluminous source between the calculation value and the experimental data at efficiency 17% and 32% detector.

At mid-energy region, calculation value and experimental data fits well for both detectors, but high- and low-energy region results seems to be overestimated in the measurement by using the 17% HPGe detector. This problem arise as a consequence of the difference of the semiconductor detector's type. So efficiency 17% p-type HPGe detector needs an additional correction about effective dead layer [7].

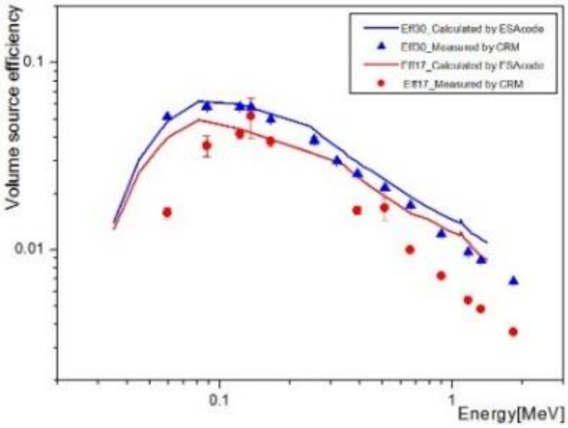

Fig.3.Comparison of efficiency curve between calculation and measurement

4. Conclusion and Further Work

We calculated the efficiency curve of voluminous source and compared with experimental data. We will carry out additional validation by measurement of various medium, volume and shape of CRM volume sources with detector of different efficiency and type. And we will reflect the effect of the dead layer of p-type HPGe detector and coincidence summing correction technique in near future.

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