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Test of Effective Solid Angle code for the efficiency calculation of volume source

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1. Introduction

It is hard to determine a full energy (FE) absorption peak efficiency curve for an arbitrary volume source by experiment. That's why the simulation and semi-empirical methods have been preferred so far, and many works have progressed in various ways [1, 2, 3]. Moens et al. determined the concept of effective solid angle by considering an attenuation effect of γ-rays in source, media and detector. This concept is based on a semi-empirical method.

An Effective Solid Angle code (ESA code) has been developed for years by the Applied Nuclear Physics Group in Seoul National University. ESA code converts an experimental FE efficiency curve determined by using a standard point source to that for a volume source.

To test the performance of ESA Code, we measured the point standard sources and voluminous certified reference material (CRM) sources of γ-ray, and compared with efficiency curves obtained in this study.

2. Method

The procedures to determine the FE efficiency for arbitrary volume source are as follow.

1) Determine the absolute FE efficiency of the standard IAEA point source at 25cm distance from the detector and counted on the end cap. And measure a voluminous CRM source at the same circumstance.

2) Calculate the effective solid angle ($\bar{\Omega}$) for the volume and point sources, and convert the FE efficiency for a point source (ε_{pt}) to that for a volume source (ε_{vol}) using the ratio of effective solid angles. The methodology is given in previous studies [2,3]. ESA code is written in Matlab language and the attenuation coefficients were obtained from NIST X-ray mass attenuation coefficient [4].

3) Compare the calculated FE efficiency for a volume source and the experimental one for the voluminous CRM source.

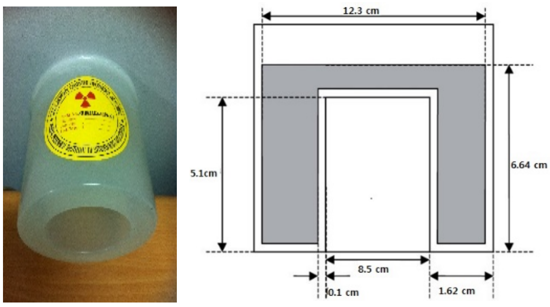

Fig.1. 450mL Marinelli beaker and dimension..

3. Experiment

3.1. Sources

Certified and traceable voluminous γ-ray sources were manufactured and certified by Korea Research Institute of Standards and Science (KRISS). Radionuclides are dissolved with a diluted HCl solution and solid medium in polyethylene containers. Certified IAEA point sources were also used to provide point efficiencies by measurement in coincidence-free geometries. The sample container and dimension is shown in Fig.1 and the list of source is shown in Table 1.

Table1. List of source used in this study

Nuclide	Type	Volume	Media
Am-241, Cd-109, Co-57, Ce-139, Cr-51, Sn-113, Sr-85, Cs-137, Co-60, Y-88	Marinelli	450ml	Solid
Am-241, Eu-152, Co-60, Cs-137	Point	-	-

3.2. Measurement

An Ortec HPGe detector (31.7%) was used and every source was measured 7200 seconds in the Pb cage, respectively. The distance of source-to-detector was 0 cm. Fig.2 shows the detector with source placed on the mount.

Fig.2. Set of volume source and detector.

4. Result

HyperGam[5] was used to determine the peak area.The FE efficiency curve fitted by 4^{th} polynomial.

$$\log(\epsilon) = \sum_{n=1}^{5} a_n \log^{n-1}(E) \quad \textbf{(1)}$$

The screen of ESA code is shown in Fig.3. Fig.4 shows the comparison of the measured efficiency curve of the marinelli beaker, and the curve calculated from the efficiency of point sources.

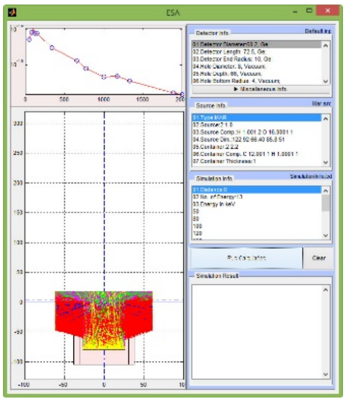

Fig.3. ESA running display of 450ml volume source.

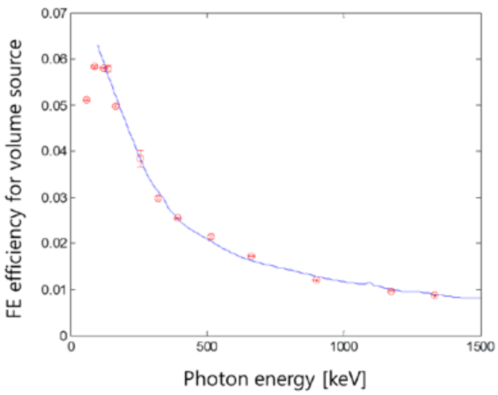

Fig.4. The measured (red circle) and calculated (blue line) result of FE efficiencies.

5. Conclusion and Further Work

200~1500 KeV energy region is fitted well. NIST X-ray mass attenuation coefficient data is used currently to check for the effect of linear attenuation only. We will use the interaction cross-section data obtained from XCOM code to check the each contributing factor like photoelectric effect, incoherent scattering and coherent scattering in the future. In order to minimize the calculation time and code simplification, optimization of algorithm is needed.

Acknowledgements

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