A New Virtual Point Detector Concept for a HPGe detector

Jong In Byun[1] · Ju Yong Yun[1,2]

[1]University of Science & Technology · [2]Korea Institute of Nuclear Safety
E-mail: komuzul@hotmail.com

keyword : HPGe detector, Virtual point detector

Introduction

For last several decades, the radiation measurement and radioactivity analysis techniques using gamma detectors have been well established. Especially, the study about the detection efficiency has been done as an important part of gamma spectrometry. The detection efficiency depends strongly on source-to-detector distance. The detection efficiency with source-to-detector distance can be expressed by a complex function of geometry and physical characteristics of gamma detectors. In order to simplify the relation, a virtual point detector concept was introduced by Notea[1]. Recently, further studies concerning the virtual point detector have been performed. In previous other works the virtual point detector has been considered as a fictitious point existing behind the detector end cap. However the virtual point detector position for the front and side of voluminous detectors might be different due to different effective central axis of them. In order to more accurately define the relation, therefore, we should consider the virtual point detector for the front as well as side and off-center of the detector.

The aim of this study is to accurately define the relation between the detection efficiency and source-to-detector distance with the virtual point detector. This paper demonstrates the method to situate the virtual point detectors for a HPGe detector.

Materials and Methods

The methodology

In this study we suggested that the virtual point detector concept should be explained for three areas; the front, side and off-center of the HPGe detector. Firstly, the virtual point detector for the front and side of the detector can be determined on each effective symmetry axis. The effective symmetry axis can be determined by scanning using radioactive point sources. The relation between the counting efficiency(ε_i) and the distance d_i can be expressed as

$$\frac{\varepsilon_2(E,d_2)}{(d_1+d_e)^2}=\frac{\varepsilon_1(E,d_1)}{(d_2+d_e)^2} \qquad (1)$$

where d_e is the distance between d_i and the virtual point detector. Secondly, the virtual point detector for the off-center of the detector can be calculated by three different counting efficiencies on the area.

$$d_1 : d_2 : d_3 \cong \sqrt{\varepsilon_3(E,d_3)} : \sqrt{\varepsilon_2(E,d_2)} : \sqrt{\varepsilon_1(E,d_1)} \quad (2)$$

We can derive three circle's equations from Eq. (2). And the virtual point detector position can be determined as the point which the circles cross.

Monte Carlo Simulation

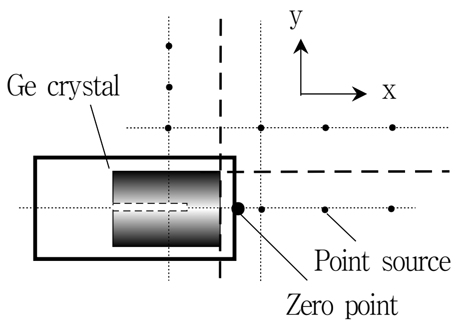

Fig. 1. The geometry of the HPGe detector and point sources located at the each area.

For this study we simplified the HPGe detector geometry with point sources using MCNPX code. The detector model used in this study was a portable p-type HPGe detector with 30 % of relative efficiency. As shown in Fig. 1, in the modeling for the front and side area the point source was situated on each effective central axis. In the case of off-center area it was done at arbitrary three positions on the area. The point source was modelled as a mono energy source with energies of 59.54 and 661.66 keV.

Results and Discussion

The full-photo peak counts were obtained by Monte Carlo Simulation and the virtual point detector positions were calculated by using Eqs. (1) and (2).

Table 1. The relative positions of the virtual point detector to the front end cap center.

Energy (keV)	The virtual point detector position (cm)		
	Front	Side (x, y)	Off-center (x, y)
59.54	-2.10	-2.45, 0.69	1.09, -2.12
661.66	-2.86	-2.48, 0.63	-2.06, -0.56

Table 1 shows that the virtual point detector was situated at different positions for each area defined in this study. Especially, the virtual point detector for off-center did not exist at the inner part of the detector. In order to validate the positions for each area, we compared the simulation and numerical calculation results for the detection efficiency at different positions on the areas. The results showed a good agreement.

Conclusions

The new virtual point detector concept was introduced for three area of the detector and its characteristics also were demonstrated by using Monte Carlo Simulation method. We found that the detector has three virtual point detectors except for its rear area. This shows that we should consider the virtual point detectors for each area when applying the concept to radiation measurement. This concept can be applied to the accurate geometric simplification for the detector and radioactive sources

REFERENCES

1. Notea, A., Nucl. Instrum. & Methods 91(1970) 513.
2. Debertin, K., Helmer, R.G., Gamma- and X-ray spectrometry with semiconductor detectors,(1988).