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Simulation of well type HPGe detector for samples both in the hole and on the top of the endcap

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Content

High sensitivity of gamma ray spectrometry for a small amount of sample is advantage of a well type HPGe detector over a coaxial type one. Application of both small samples in the hole of the endcap of the detector and large samples on the top of the endcap extend usefulness in practical use. For the samples in the hole, correction factors of the self-absorption and the coincidence summing effect were previously estimated by numerical analysis and Monte Carlo simulation. Peculiar structure of germanium crystal and component object complex a model used in the Monte Carlo simulation especially for the samples on the top of the endcap. This study shows a model that was assembled on the bases of three types of calibration with a cross-sectional drawing supplied by the implementer. Simulation of the model was conducted using EGS5 code, and the results were compared with the calibrations. The model can be utilized for estimation of correction factors and uncertainties in the cases of both the hole and the top samples. The calibrations for a well type HPGe detector (GWL-150-50-S, ORTEC) were conducted by using 1) point sources at 25 cm from the top surface of the endcap, 2) 100 cm3 volume sources on the top of the endcap, and 3) 5 cm3 small volume sources in the hole of the endcap. Counting efficiencies of full energy peak were obtained from point sources between 60 keV from Am-241 and 1.8 MeV from Y-88. The efficiency characteristics to gamma ray energy were applied to determination of a sensitive area in the germanium crystal and the components which absorbed gamma rays at the place between the point source and the crystal. The crystal had a thick dead layer on the lateral side and the bottom. A 1.63 mm thick copper plate was placed between the endcap and the top surface of the crystal. In addition to these principal components for the energy characteristics, we assumed that additional dead area existed at the surface and outer edge of the crystal. As a result, calculated counting efficiencies agreed with the experimental efficiencies in 4 % in the whole gamma ray energy region. Counting efficiencies for the 100 cm3 on the top and 5 cm3 volume sources in the hole was obtained by calibration using Cs-134 and Cs-137 standard solutions. The model of germanium crystal created in the point source was applied to these volume source calibrations. The coincidence summing effect was considered in the simulation using the technique which was developed in previous study. A position of the crystal model in the endcap was adjusted by comparison of the counting efficiencies of the 100 cm3 source. A diameter of well at the center of the crystal was adjusted in 0.1 mm intervals from the calibration of the 5 cm3 source at last. The deviations between the calibration and the simulation were less than 5 % with variation in amount of the standard solution except for the Cs-134 sample in the hole. In this study, the model of well type germanium crystal which was applicable for estimating sensitivities of both the top and the hole samples was proposed. The comparison between the results of calibration and simulation indicated acceptable agreement for actual measurement. The results were demonstrated in the whole energy region of gamma ray spectrometry. Variation in sensitivity of any type of sample in material and volume can be complemented by simulation employing the model.

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