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Determination of the dead layer and full-energy peak efficiency of an HPGe detector using the MCNP code and experimental results

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Abstract

One important factor in using an High Purity Germanium (HPGe) detector is its efficiency that highly depends on the geometry and absorption factors, so that when the configuration of source-detector geometry is changed, the detector efficiency must be re-measured. The best way of determining the efficiency of a detector is measuring the efficiency of standard sources. But considering the fact that standard sources are hardly available and it is time consuming to find them, determining the efficiency by simulation which gives enough efficiency in less time, is important. In this study, the dead layer thickness and the full-energy peak efficiency of an HPGe detector was obtained by Monte Carlo simulation, using MCNPX code. For this, we first measured gamma-ray spectra for different sources placed at various distances from the detector and stored the measured spectra obtained. Then the obtained spectra were simulated under similar conditions in vitro. At first, the whole volume of germanium was regarded as active, and the obtained spectra from calculation were compared with the corresponding experimental spectra. Comparison of the calculated spectra with the measured spectra showed considerable differences. By making small variations in the dead layer thickness of the detector (about a few hundredths of a millimeter) in the simulation program, we tried to remove these differences and in this way a dead layer of 0.57 mm was obtained for the detector. By incorporating this value for the dead layer in the simulating program, the full-energy peak efficiency of the detector was then obtained both by experiment and by simulation, for various sources at various distances from the detector, and both methods showed good agreements. Then, using MCNP code and considering the exact measurement system, one can conclude that the efficiency of an HPGe detector for various source-detector geometries can be calculated with rather good accuracy by simulation method without any need for performing any experiment.

Keywords: HPGe detector, dead layer, MCNP code, full-energy peak efficiency

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