The Determination of the Efficiency of a Compton Suppressed High Purity Germanium Detector using Monte Carlo Simulations

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Abstract

The low level radiochemistry laboratory at the Australian Nuclear Science and Technology Organisation (ANSTO) performs radioactivity measurements of various environmental samples for a broad range of low level radionuclides. The laboratory's low-level gamma-spectrometry facility contains two Compton suppressed high purity Germanium (HPGe) detector systems. A Compton suppressed HPGe detector is well suited to the analysis of small environmental samples, however the nature of these samples (range of different geometries, densities and compositions) can make it difficult to construct an efficiency curve for the instrument. Currently, efficiency calibrations are carried out using reference materials packed into a particular geometry, e.g. a petri-dish. This makes the analysis of samples with different geometries difficult and time-consuming. Monte Carlo simulations can be a powerful tool in estimating the efficiency of the detector, especially for complicated detector systems and unusual sample compositions and geometries, provided enough geometric information on the system is available. Monte Carlo radiation transport simulations can also be used to determine self absorption, random and coincidence summing corrections, cascade and background effects. We model the gamma-Compton suppressed system using the simulation toolkit Geant4 for the efficiency calibration and compare the calculated efficiencies with the measurement of standard radionuclides in the low energy region of ~ 40 to 1500 keV. The calculated efficiencies have the same dependence on energy as the measured values and the discrepancies between the two values can be attributed to incomplete knowledge of the detector geometry.