Investigations on the geometrical origin of spectral structure in gamma backscattering

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Numerical simulation of γ-ray spectra and its comparison to experimental data is a tool customarily used to study the response function of both scintillators and HPGe detectors. The focus of the simulation, and its comparison to the experiment are typically limited to the photopeak shape trying to account for both the area under the gaussian and for its FWHM. The usual disagreement between experiment and simulation in the spectral shape in the backscattering region is not considered as a failure since no especial consideration of the environment around the source and the detector is made, paying attention only, to the formation of the photopeak. This state of matters is justifiably so since the spectral shape in the backscatter region, $E_\gamma \lesssim 300$ keV, is dependent in a very complex way not only on the material and geometry of the surroundigs close to both source and detector but also on the material, size, geometry of the active part of the detector (the crystal in the scintillators and Ge cases) and on their encapsulation material. There is however a case in which the geometry, materials and relative distances to both source and detector are well known. That is the case when using an industrially manufactured lead shield, which is, precisely used with that purpose, to insulate the experiment active parts from their surroundings. It turns out that a rather simple semi-analytical approximation predicts astonishingly well the main features of the spectral distribution of the backscattering peak in those conditions. We present comparisons of this semi-analytical result with Geant4 simulations and experimental results for BGO $2'' \times 2''$, HPGe $3'' \times 3''$ and CsI $0.5'' \times 2''$. A probable application of these successful results is the proper subtraction of reference spectra, sometimes called background spectra.