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Efficiency computation for gamma-ray spectrometry assessment of samples with intrinsic inhomogeneity

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Content

A Monte Carlo based tool for the evaluation of the efficiency and its uncertainty for the measurement of volume samples with activity and matrix inhomogeneity was developed. In this work we present the application of the tool to the evaluation of the efficiency for samples with an intrinsic inhomogeneity, such as various environmental samples. Usually environmental media are not homogeneous, comprising actually several elementary components, which may differ from each other in atomic composition, density and activity. The environmental samples extracted from these media inherit the inhomogeneity of the parent population. In the case of low activity samples, the particular distribution of activity may easily depart from a uniform distribution. The model of inhomogeneity implemented in the tool assumes that the medium is composed from a number of building blocks, all with the same dimensions; in each block the activity is uniformly distributed and the matrix is homogeneous; the probability of each building block to correspond to an elementary component (specific matrix and activity) is given. In order to evaluate the efficiency and to assess its uncertainty component due to the inhomogeneity-related sampling uncertainty, the following procedure is applied. Using the Monte Carlo method, a large set of samples simulating the probes to be measured is drawn from the parent population. The samples differ with respect to the number of blocks of each type, as well as to their spatial distribution. For each sample from the set the efficiency is evaluated using the GESPECOR code. After processing all the samples, the distribution of the efficiency values is obtained and summarized, the mean value and standard uncertainty being reported. As an example, the application of the tool in the case of a soil sample which includes grains of pitchblende (with higher specific activity and self-attenuation) is presented. It is assumed that the sample is measured with a n-type HPGe detector. The elementary components of the sample considered are common soil, pitchblende and air. Several dimensions of the building blocks are selected, as well as several values of the probability of each component. In each case a large set of sources, with activity and matrix distribution sampled from the corresponding population, are prepared. For each source the full energy peak efficiency for the energies E=46.539 keV, 92.59 keV, 186.211 keV and 1001.030 keV is evaluated and finally the distribution of the values of the efficiency for all the sources from a set is constructed. Generally, the distribution of the efficiency values is sensitive to the spatial distribution of the activity, thus to the distribution of pitchblende grains, which represent the highest activity blocks. Due to the much stronger self-attenuation of low energy photons in pitchblende grains than in soil grains, the distribution of the efficiency values at 46 keV depends significantly on the number of pitchblende grains from the source; as expected, it decreases with this number, thus with the total activity of the source. In addition, the distribution of the values of the efficiency is studied (a) as a function of the dimensions of the elementary blocks, for fixed values of the probability of each component; (b) as a function of the probability of pitchblende blocks, for blocks of fixed dimensions. Thus a detailed picture of the effects of source inhomogeneity on the uncertainty of the efficiency is obtained.

About the Presenter

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