Proposal of an action of GSWG

Simple exercise on self-consistency of the methods applied for the evaluation of coincidence-summing corrections in the case of volume sources

Purpose of the test

The computation of coincidence-summing correction factors for volume sources is more difficult than for point sources. To make the problem less difficult, approximations are applied in some practical methods for the evaluation of the coincidence-summing effects. The quality of the results obtained using various methods was investigated in previous actions of the GSWG, either by comparison with experimental data or by intercomparison of the results provided by various computations methods, without reference to experimental data.

The present action has a more limited purpose, namely to test the internal self-consistency of the methods. While internal consistency does not guarantee the correctness of the method, if it is not satisfied, it points out that the method has some shortcomings and its validity has specific limitations. The proposed self-consistency test is based on exact relations that should be fulfilled in the case of specific ideal measurement configurations. More precisely, the results obtained using any computation method for one such configuration should be related by exact equations to the results given by the same method for other configurations. Thus, this test does not require experimental data (avoiding the problem of experimental uncertainties) or comparisons of a method with other methods (avoiding the debate concerning the selection of a particular reference method).

Proposed test configurations

Coincidence-summing correction factors should be computed for a simplified model of an n-type HPGe detector (Fig. 1). The detector has a radius RD=3 cm, a length LD=6 cm, the inner hole is of cylindrical shape with radius RH=0.5 cm and length LH=4 cm, the deadlayer has a negligible thickness. The endcap is made from Al with thickness TE=1 mm and has a radius RE=4 cm. The distance from the crystal to the endcap is DCE=0.5 cm. The distance from the bottom of the crystal to the inner surface of the bottom part of the endcap is also equal to 0.5 cm.

Three sources S1, S2, S3 should be considered. The sources S1 and S2 are identical, with the active volume of radius R=2 cm and height H_1=H_2=2.5 cm, while the third source, S3, has the same radius R=2 cm, and the height equal to the sum of the heights of S1 and S2, H_3=5 cm. The sources are filled with air (or vacuum) containing uniformly distributed radionuclides. The containers of the sources have walls with negligible thickness.

Three measurement configurations (a, b and c) should be considered, as shown in Fig. 2. In configuration (a) the first source is placed on the detector. In configuration (b) the second source is displaced upwards with exactly H_1 from the detector. In configuration (c) the third source is placed on the detector. Thus, configuration (c) corresponds to mounting the first two sources one upon the other on the detector. Each configuration is placed in vacuum (or in air) and there are no other materials in the vicinity of the detector and sources.

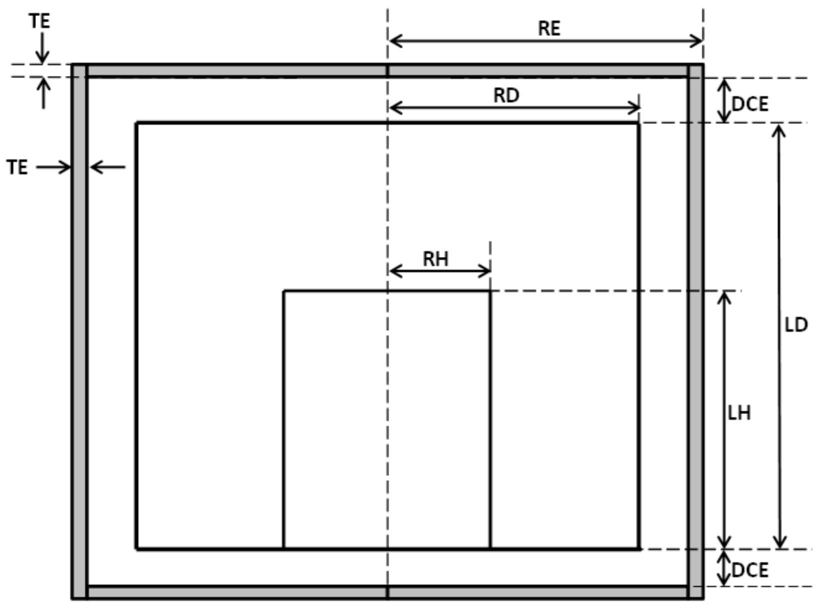

Fig. 1. Detector parameters

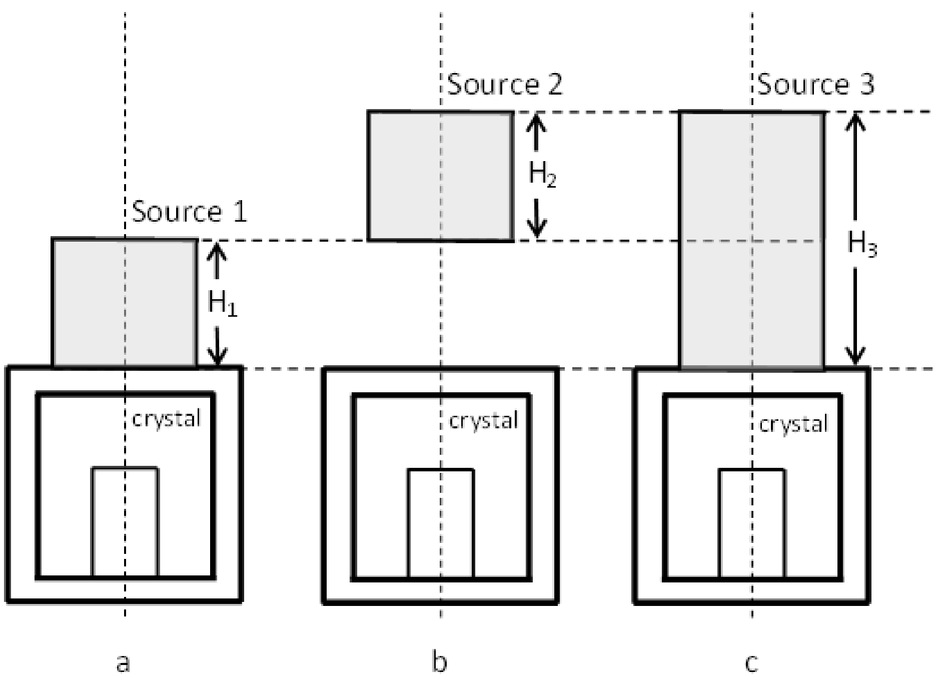

Fig. 2. Geometry configurations

Nuclear Decay Data

The participants are asked to use the decay data recommended by ICRM, that is the data published on the web page of Decay Data Evaluation Project, at the address: http://www.nucleide.org/DDEP_WG/DDEPdata.htm.

However, the test being based on the comparison of the values calculated with the same software for three configurations, the dependence on the decay data is weak, so the use of other sources of decay data is permitted, if it is not possible to use the recommended data.

Density of the materials

Please use the density ρ_{Ge}=5.323 g·cm^{-3} for Ge and ρ_{Al}=2.70 g·cm^{-3} for Al. In the case that you consider air as the matrix of the sources, use the density ρ_{Air}=1.20·10^{-3} g·cm^{-3}.

Proposed computations

The participants are required to compute the coincidence-summing correction factors *FC* for several peaks of Co-60, Cs-134, Ba-133 and Eu-152 (see the attached Excel file) for the three configurations. The uncertainty of the computed values of *FC* should be better than 1%. They should report also the values of the full energy peak efficiency for the energies of the same peaks.

In order to facilitate the analysis of the results, all participants should use the same definition of the coincidence-summing correction factors. We propose to adopt the definition of *FC* that is obtained from the following basic equation:

$$N(E;X) = I_\gamma(E;X) \cdot FC(E;X) \cdot \varepsilon(E) \cdot A(X) \qquad (1)$$

Here $N(E;X)$ is the expected count rate in the peak of energy E of nuclide X, $I_\gamma(E;X)$ is the emission probability of the photon of energy E, $\varepsilon(E)$ is the usual full energy peak efficiency at energy E and $A(X)$ is the activity of the nuclide. It should be stressed that $\varepsilon(E)$ is the efficiency in the absence of coincidence-summing effects. In the case of a pure sum peak, by convention $FC(E;X)$ is defined using the basic equation:

$$N(E;X) = FC(E;X) \cdot \varepsilon(E) \cdot A(X) \qquad (2)$$

Thus, the definition of *FC* is:

$$FC(E;X) = \frac{N(E;X)}{I_\gamma(E;X) \cdot \varepsilon(E) \cdot A(X)} = \frac{\varepsilon^{app}(E;X)}{\varepsilon(E)} \qquad (3)$$

Here $\varepsilon^{app}(E;X)$ is the apparent efficiency for the peak of energy E of nuclide X. The definition is valid also for pure sum peaks with the convention that $I_\gamma(E;X)$=1 in this case.

Besides reporting the values of *FC* and ε as required in the attached Excel file, the participants are asked to provide information on the method applied to compute the values:

- Name of the software applied and references
- Does the method apply the quasi-point-source approximation (i.e. *FC* is computed using the full energy peak and the total efficiencies evaluated for the complete source)? If not, what procedure is applied for the evaluation of the integrals of the products of efficiencies, taking into account the dependence of the efficiencies on the position of the emission point within the source?
- Does the method include the effect of coincidences due to the detection of three or more photons, or is it limited to pair coincidences?
- What decay data library is used?

Any additional information considered relevant by the participants should also be provided.

Proposed time schedule

The participants are kindly asked to send the results before the end of April 2018, in order to have time for the analysis of the data before the next GSWG meeting in Paris (June 14, 2018). We intend to discuss the results during the GSWG meeting and conclude on the opportunity of preparing a paper to be submitted to the next ICRM conference, which will be held in the last week of May, 2019, in Salamanca (Spain).

Future work

The proposed exercise is a simple test, not very powerful, because it is based only on the dependence of the detection probability on the position of the emission point within the source, i.e. the dependence on the solid angle. Depending on the results of this test, a more powerful test may be proposed, in which a real matrix of the sources (thus including photon interactions) will be considered.

On behalf of GSWG,

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