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A benchmark for Monte Carlo simulations in gamma-ray spectrometry

M.-C. Lépy¹, C. Thiam¹, M. Anagnostakis², C. Cosar³, A. De Blas del Oyo⁴, H. Dikmen⁵, M.A. Duch⁴, R. Galea⁶, M.L. Ganea³, M. Hult⁷, S. Hurtado⁸, K. Karfopoulos⁹, A. Luca³, G. Lutter⁷, I. Mitsios², H. Persson⁹, C. Potiriadis¹⁰, S. Röttger¹¹, N. Salpadimos¹⁰, M.I. Savva¹², O. Sima^{3,13}, T.T. Thanh¹⁴, R. Townson⁶, A. Vargas⁴, T. Vasilopoulou¹², L. Verheyen¹⁵, T. Vidmar¹⁵

(1) *Université Paris-Saclay, CEA, LIST, Laboratoire National Henri Becquerel (LNE-LNHB), F-91120 Palaiseau, France,*

(2) *NTUA, Greece, (3) IFIN-HH, Romania, (4) UPC, Spain,*

(5) *TENMAK, Turkey, (6) NRC, Canada, (7) JRC-Geel, Belgium,*

(8) *U-Sevilla, Spain, (9) Mirion Technologies, Inc, USA,*

(10) *EEEA, Greece, (11) PTB, Germany, (12) NCSR "Demokritos", Greece,*

(13) *U. Bucharest, Romania, (14) VNUHCM, Vietnam, (15) SCK-CEN, Belgium*

Monte Carlo simulations are now widely used in gamma-ray spectrometry either to optimize measurement conditions or to calculate detection efficiencies or true coincidence summing correction factors. However, running the calculations is not always easy for new users, and errors in the definition of the input geometry files, as well as misinterpretations of their outputs, can lead to incorrect results. Within the Gamma-ray Spectrometry Working Group (GSWG) of the International Committee for Radionuclide Metrology (ICRM) an effort has been made to provide references for new users of the widely distributed Monte Carlo software. The case studies are based on simple geometries, two types of germanium detectors (P and N) and four kinds of sources, to reproduce eight typical measurements conditions. The first part of this work is devoted to the calculation of detection efficiencies for these geometrical conditions [1]. The second step focuses on the coincidence summing correction factors for the eight simulated configurations and for radionuclides with characteristic decay schemes: ⁶⁰Co and ¹³⁴Cs are beta minus emitters, ¹³³Ba decays by electron capture accompanied by intense X-ray emission, while ²²Na decays by both electron capture and beta plus emission, the latter leading to the emission of annihilation photons. Several Monte Carlo codes (EGSnrc, EGS4, GEANT4, MCNP and PENELOPE) were considered in this exercise and more than twenty series of results were collected from the participants and analysed. Initial discrepancies between the calculated results were discussed: for example the calculation of the coincidence corrective factors in the case of ¹³³Ba for the N-type detector emphasized the importance of appropriate processing of X-rays; the role of peak area determination procedures (e.g., background subtraction) was also highlighted. Further calculations with harmonized simulation conditions led to a better agreement between the results of the participants. The results of this collaborative work provide practical recommendations for training new users to avoid typical simulation errors. The practical benchmark material, including input files, efficiencies and correction factors as well as recommendations for each Monte Carlo code, is being distributed on the ICRM GSWG webpage [2].

[1] Applied Radiation and Isotopes, Volume 154, December 2019, 108850

[2] http://www.lnhb.fr/icrm_gs_wg/icrm_gs_wg_benchmarks/