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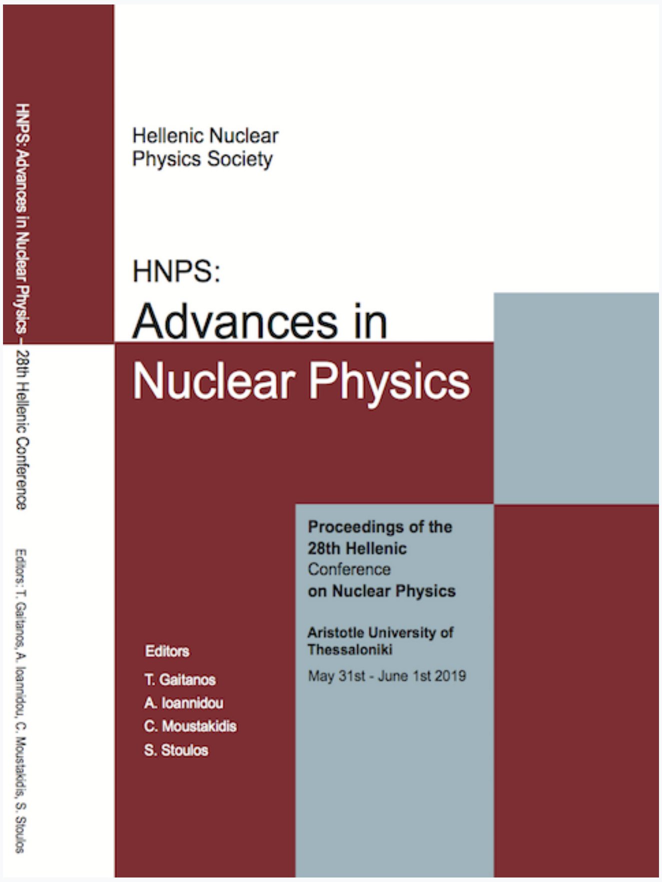

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Efstathia Georgali, ... et al.

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E. Georgali et al. HNPS2019 doi:10.12681/hnps.3002
Page 152

Characterization of the Canberra BE5030 Broad Energy High Purity Germanium Detector by means of the GEANT4 Monte Carlo simulation package

E. Georgali[1], M.E. Stamati[1], M. Peoviti[1], N. Patronis[1], C. Potiriadis[2], K. Karfopoulos[2], A. Anastasiadis[3], M. Axiotis[4], Z. Eleme[1], S. Harissopulos[4], A. Kalamara[5], M. Kokkoris[5], A. Lagoyannis[4], M.I. Savva[6], I. Stamatelatos[6], A. Stamatopoulos[5], T. Vasilopoulou[6], R. Vlastou[5]

[1] *Department of Physics, University of Ioannina, 45110 Ioannina, Greece*
[2] *Environmental Radioactivity Monitoring Department, Greek Atomic Energy Commission, Aghia Paraskevi, 15310 Athens, Greece*
[3] *Department of Physics and Astronomy, Uppsala University, SE-751 05, Sweden*
[4] *Tandem Accelerator Laboratory, Institute of Nuclear and Particle Physics, N.C.S.R. "Demokritos", Aghia Paraskevi, 15310 Athens, Greece*
[5] *Department of Physics, National Technical University of Athens, Zografou Campus, 15780 Athens, Greece*
[6] *Institute of Nuclear and Radiological Sciences, Technology, Energy and Safety, N.C.S.R. "Demokritos", Aghia Paraskevi, 15310 Athens, Greece*

Abstract *The accurate determination of the efficiency of HPGe detectors is a challenging procedure due to possible self-attenuation phenomena and/or coincidence summing effects. Both of these phenomena become important when close detection geometries and extended samples are considered. To deal with these features the simulation of HPGe detectors is used so as to calculate the corresponding correction factors, especially for those cases where low energy γ-ray are considered. Through the present work the Canberra BE5030 Broad Energy HPGe detector of the Environmental Radioactivity Monitoring Department of Greek Atomic Energy Commission was simulated through the GEANT4 toolkit. Experimental efficiency and counting rate data were compared with the simulation results for different geometries of the detector so as to identify the one for which the experimental data are better reproduced.*

Keywords *HPGe detectors, Broad Energy detectors, GEANT4 package*

Corresponding author: E. Georgali (e.georgali@uoi.gr) | *Published online:* **PROOF COPY**

INTRODUCTION

Broad Energy detectors provide the ability to perform activity measurements in a wide energy range. Especially, Canberra BE5030 Broad Energy HPGe detector [1], thanks to its carbon fibres window, and its tiny (a few μm) front-contact crystal dead layer, covers the energy region from 3 keV up to 3 MeV. In order to use this detector in experimental campaigns for the detection of low energy photons, its efficiency and the corresponding correction factors related to self-attenuation, coincidence summing effects and escape peaks phenomena must be known with high accuracy. Therefore, the BE5030 detector was fully characterised and simulated with the GEANT4 package [2]. The adopted detector geometry along with the modelling of the γ-ray transportation through matter were validated through the comparison of the simulation results with the experimentally deduced efficiency and counting rate data.

EXPERIMENTAL SET-UP

Experimental spectra have been recorded using point sources of ^{60}Co, ^{137}Cs, ^{133}Ba and ^{241}Am at 20 and 11.4 cm distance with respect to the BE5030 detector window. In this way experimental efficiency curves have been resulted for these distances. The same sources have been used at close geometry, at 0.4 cm. Additionally, a filter (diameter=4.5 cm, thickness on the order of μm) with evaporated metallic salts of ^{60}Co, ^{137}Cs, ^{241}Am and ^{210}Pb was placed at 0.8 cm distance from the detector window. These measurements did not provide information about the efficiency of the detector due to the coincidence summing effect which dominates at close detection geometries. Instead of this, for the small distances the corresponding counting rates of the sources were deduced.

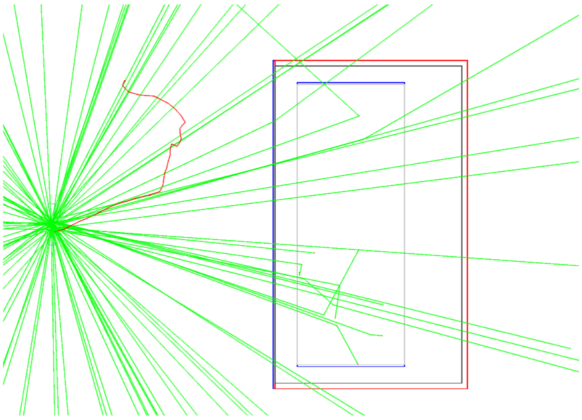

Figure 1. *GEANT4 model of the BE5030 HPGe detector*

Figure 2. *Depiction of the BE5030 HPGe detector*

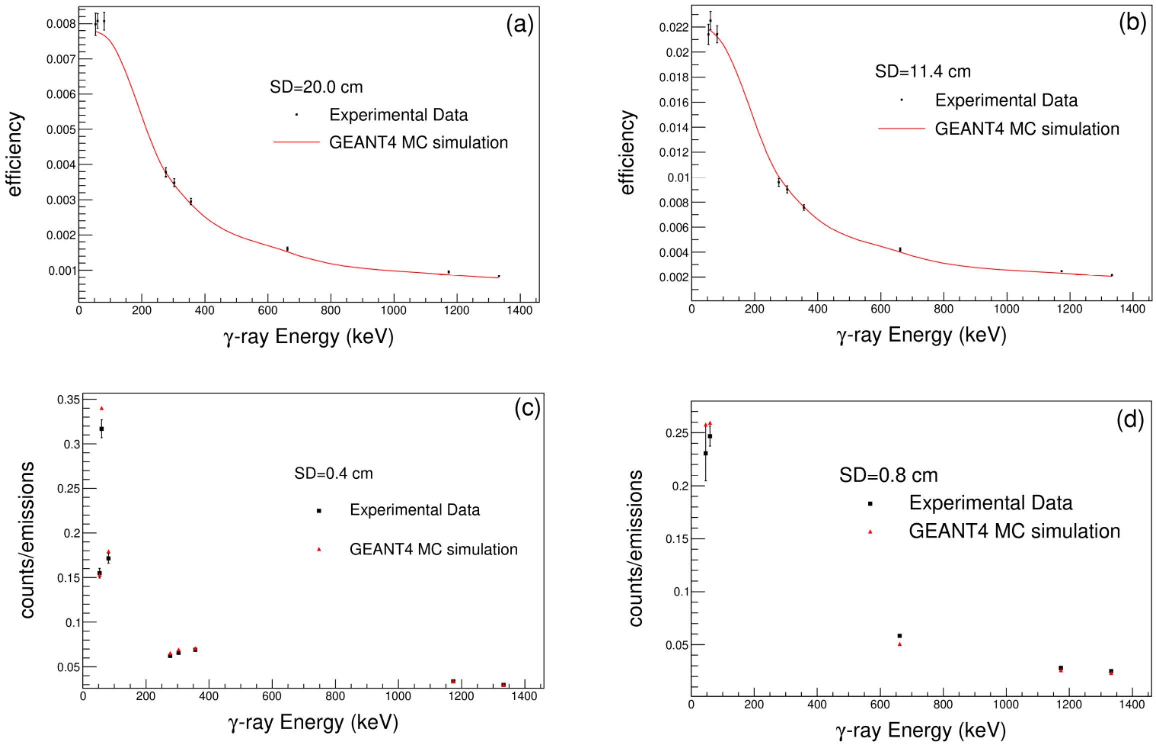

Figure 3. *Comparison of the experimental efficiency and counting rate data of the BE5030 HPGe detector with the GEANT4 MC simulations for the distances of (a) 20 cm (b) 11.4 cm (c) 0.4 cm (d) 0.8 cm.*

SIMULATIONS

BE5030 detector has been simulated through GEANT4 toolkit (Fig. 1). The nominal dimensions provided by the manufacturer were adjusted so that the simulations reproduce the experimental efficiency and counting rate measurements. The photons transportation and interactions through matter were simulated by the Penelope physics list of the code [2]. Furthermore, in order to reproduce escape peaks phenomena the particles tracking cuts were reduced to 1 nm [2]. For the simulation of the counting rates the full decay schemes of the sources, as they are defined in GEANT4, were utilized in order to take into account coincidence summing effects.

RESULTS AND CONCLUSIONS

In the present work the modelling of the BE5030 detector was achieved through Monte Carlo simulations with GEANT4 code. Fig. 3 depicts the comparison of the experimental efficiency and counting rate data with the corresponding results of the GEANT4 simulations.

The GEANT4 simulation of the detector can be utilized for the determination of full-energy peak efficiencies and/or for efficiency corrections factors (relevant to self–attenuation, coincidence summing effects, escape peaks phenomena etc). An example of the applicability of the outcome of the present work is provided in Fig. 4, where the experimental spectrum of the decay of $^{164}Ho^{g+m}$ [3] has been successfully reproduced by the GEANT4 simulation of the detector.

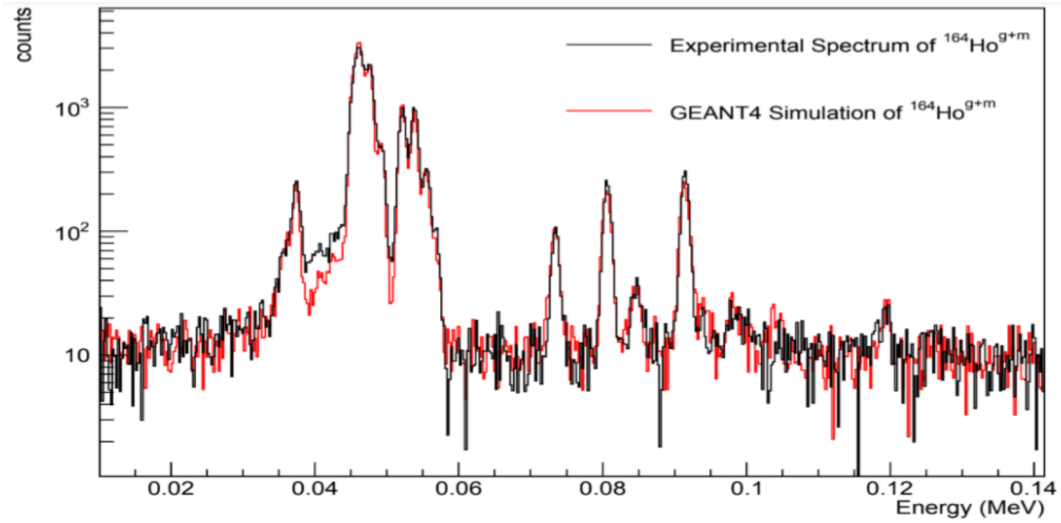

Figure 4. *The experimental spectrum of the $^{164}Ho^{g+m}$ decay as recorded in the detector under study relevant to the simulation with GEANT4.* The *$^{164}Ho^{g+m}$ was produced by the $^{165}Ho(n,2n)$ reaction in the 5.5 MV Tandem Van de Graaff accelerator of N.C.S.R. "Demokritos".*

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References

[1] https://www.mirion.com/products/standard-high-purity-germanium-detectors
[2] S. Agostinelli et al., NIM A 506, 250 (2003); IEEE Trans. Nucl. Sci. 53, 270 (2006); NIM A 835, 186 (2016)
[3] B. Singh and J. Chen, Nuclear Data Sheets 147, 1 (2018)