Characterisation of the Canberra BE5030 Broad Energy High Purity Germanium detector by means of the GEANT4 simulation package

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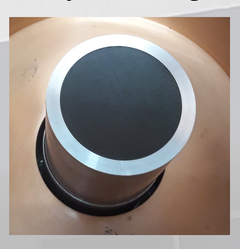
Introduction

Broad Energy (BE) High Purity Germanium (HPGe) detectors are an essential tool in γ-ray spectroscopy, since they cover a wide energy region, from 3 keV up to 3 MeV. This is achieved thanks to the detector window consisting of carbon fibres as well as to the low thickness of the front-contact crystal dead layer which minimises the low energy γ-ray attenuation, allowing for the detection of γ-rays with Eγ<100 keV. In the present work, the HPGe detector BE5030 by Canberra was characterised through the comparison of the experimental efficiency data with the simulation results for different geometrical characteristics of the detector. The experimental data were acquired using radioactive sources in different source-detector distances and the simulation was carried out using the Penelope GEANT4 Physics List. The BE5030 detector was used for the activity measurement of Ho-164, produced in the accelerator of the Institute of Nuclear and Particle Physics, N.C.S.R. "Demokritos".

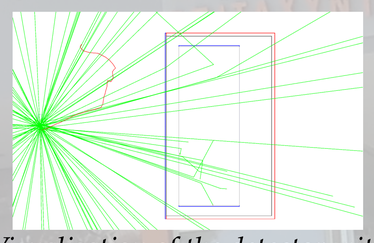
Methodology

1. Efficiency curve extracted from experimental data acquired for different calibration sources in different geometries.
2. Simulation with GEANT4 using the PENELOPE physics list performed.
3. Comparison and tuning of geometrical parameters until maximum agreement is achieved between experimental and simulated efficiency results:

Dead layer	⇨	affects the absorption of low energy γ-rays
Gap	⇨	affects the efficiency in all of the energy range
Crystal length	⇨	affects the absorption of the high energy γ-rays

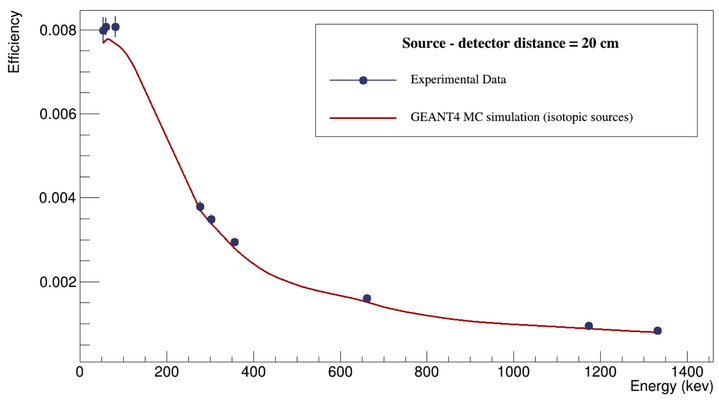


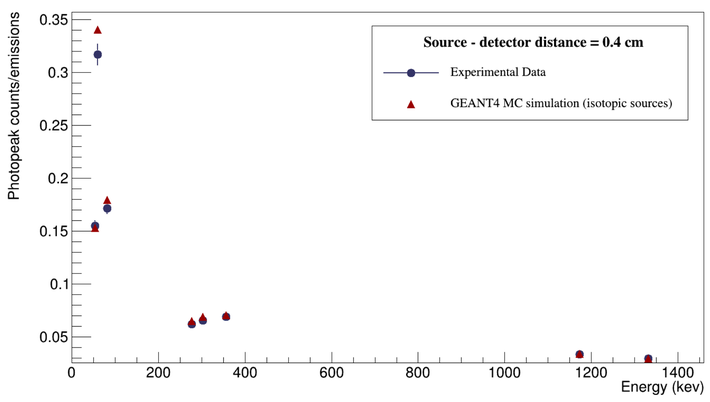
Photograph of the detector



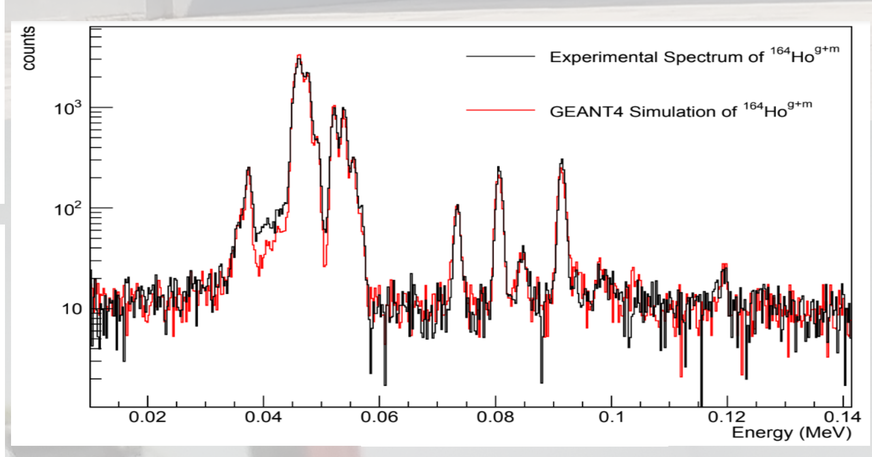
Visualisation of the detector with the GEANT4 toolkit

Results

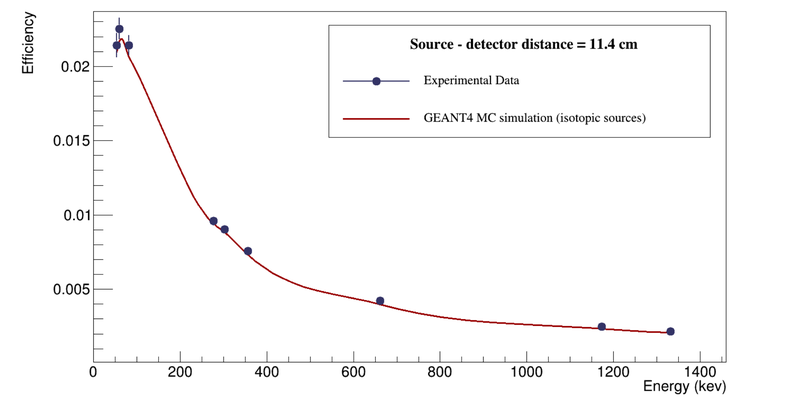


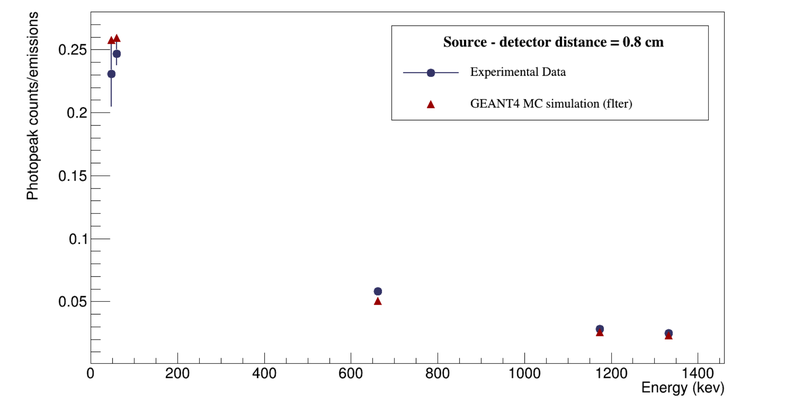


Comparison between simulation and experimental efficiency for the final geometrical values



Experimental spectrum vs simulation





Comparison between simulation and experimental efficiency for the final geometrical values

	Nominal Values (mm)	Geant4 tuned values (mm)
Ge crystal diameter	80	76
Ge crystal length	30	29
Al endcap thickness	1.5	1.5
Detector windows thickness	0.5	0.5
front dead layer	0.0004	0.0004
side dead layer	0.5	0.5
Crystal to detector window distance (gap)	5	6
* the gap is measured from the inside of the window		

Detector geometry: Manufacturer's geometrical parameters vs GEANT4 optimum configuration

Conclusions

In the present work, the characterisation of the BE5030 HPGe detector by Canberra was carried out by means of numerous Monte Carlo simulations using the GEANT4 simulation toolkit. The geometrical characteristics of the detector were changed for each trial and the simulation results were compared with experimental data acquired for different radioactive sources. The configuration which lead to the best agreement between the data points and the simulations could then be used to calculate the efficiency of the detector in the actual measurement geometry for the γ-rays emitted by Ho-164.

References

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