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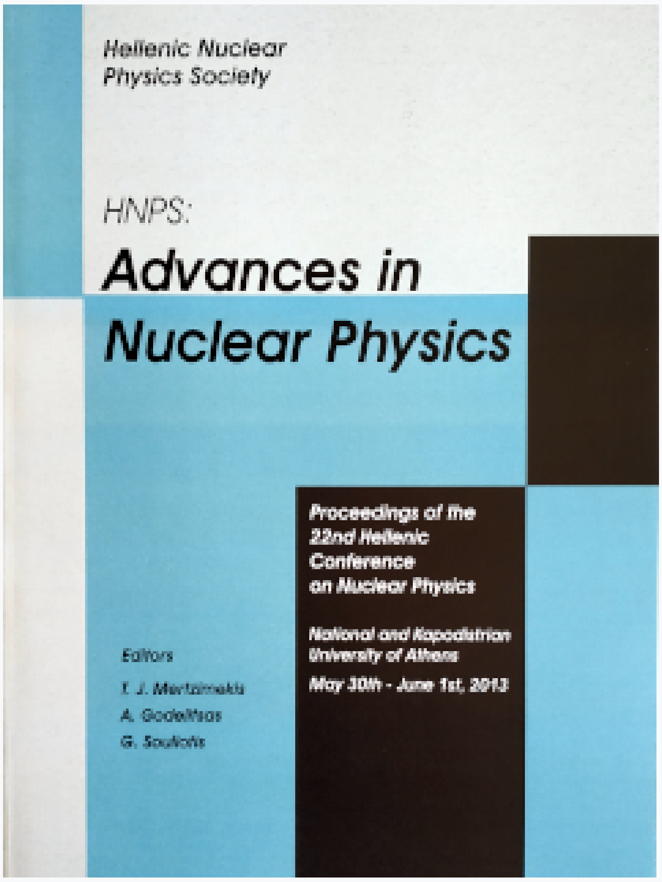

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Characterization of Canberra BE3825 Broad Energy High Purity Germanium Detector by means of GEANT4 Monte Carlo calculations

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Abstract

The Canberra BE3825 Broad Energy High Purity Germanium Detector facilitates the detection of γ-rays from a few keV up to the MeV energy region. Phenomena like self-attenuation and/or coincidence summing effects are hindering the detection of low energy gamma-rays in those cases where extended sources, particularly high volume sources are considered. In order to make corrections accordingly, the full characterisation of the HPGe detector is needed. In the present work the Geant4 modeling of the University of Ioannina BE3825 HPGe γ-ray measuring station is described. The Monte Carlo simulation results are compared with the experimental efficiency curves at two different source to detector distances. In both cases excellent agreement with the experimental results was obtained.

1. Introduction

In the last years a new series of Broad Energy (BE) High Purity Germanium (HPGe) detectors became available, extending significantly the applicability of γ-spectroscopy, especially in the low energy region. The minimal detector window thickness combined with the tiny dimensions of the front-contact crystal dead-layer facilitate the detection of γ-rays from a few keV up to the MeV energy region. The determination of the HPGe detector efficiency by means of calibrated point sources is not always precise enough, especially if we have to deduce the detector efficiency curve in the keV energy region. To take into account the self-attenuation of low energy γ-rays within the sample material and the specific geometry of the measurement set up, the full characterisation of the detector by means of Monte Carlo calculations is absolutely necessary. Accordingly, the Canberra BE3825 HPGe in the Physics Department of the University of Ioannina (UoI) has been characterised by means of extensive Geant4 Monte-Carlo (MC) calculations. In the present work the results of the MC calculations are discussed and compared with experimentally deduced efficiency curves.

Table 1: The nominal and the GEANT4 tuned values of the UoI BE3825 HPGe detector.

Component	Nominal (mm)	GEANT4 tuning (mm)
Ge crystal diameter	71	70
Ge crystal length	26.0	26.0
Aluminum endcap thickness	0.85	0.85
Detector window thickness	0.5	0.5
Top dead layer	4×10^{-4}	4×10^{-4}
Side dead layer	0.6	0.6
Crystal to det. window distance	5.0	6.2

2. Experimental Setup

In the present work, the Broad Energy (BE3825) HPGe and associated electronics provided by Canberra were used [1]. The relative efficiency of the BE3825 detector is 28% with nominal crystal dimensions as given in Table 1. The detector is shielded against background γ-ray radiation by means of the 747-Canberra lead shield [2], which consists of 10.1 cm low background lead internally covered by 1 mm tin and 1.6 mm copper. To fully characterise the UoI Canberra BE3825 HPGe detector, two calibrated γ-ray sources were used. Data were collected for both sources at two different distances. A specially designed sample holder was used for the precise sample/source positioning. The two experimentally deduced efficiency curves (Fig. 1) correspond to the 63 mm and 93 mm distances from the detector window.

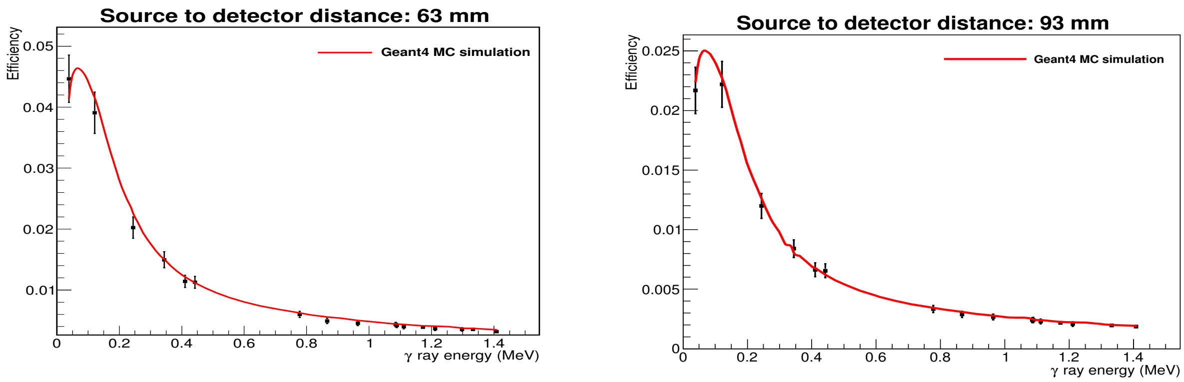

Figure 1: The experimental efficiency data together with the GEANT4 simulated efficiency curve for the two detector to source diatances considered in the present work.

3. Geant4 simulations

The simulations have been carried out using the GEANT4 Monte Carlo toolkit developed at CERN (version 9.6) [3]. The starting geometry for the Geant4 simulations was the one described in the first column of Table 1, which provides the nominal crystal dimensions. Only small deviations from the experimental curve were observed that were minimised by using the adjusted parameters given in the second column of Table 1. As it can be seen full agreement between the experimental efficiency data-points and the simulated curve resulted by slightly changing the crystal diameter by 1 mm and by increasing the crystal distance from the detector window by 1.2 mm.

4. Conclusions

In the present work the UoI BE3825 HPGe detector was fully characterised by means of Geant4 Monte Carlo simulations. By slightly decreasing the Ge crystal diameter and by increasing the crystal to detector window distance excellent agreement between experimental efficiency data and simulation results was achieved. This result is very important since the same detector model can now be used to obtain the detector response when complex geometries and extended volume sources are considered. In this way, self attenuation as well as coincidence summing corrections can be accurately determined.

Acknowledgements

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[2] http://www.canberra.com/products/detectors/detector-shields.asp
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