Characterization of Canberra BE3825 Broad Energy High Purity Germanium Detector by means of Geant4 Monte-Carlo calculations

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Introduction

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's material and the specific geometry of the measurement set up, the full characterization of the detector by means of Monte-Carlo calculations is absolutely necessary. Accordingly, the Canberra BE3825 HPGe at the Physics Department of the University of Ioannina has been characterized 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.

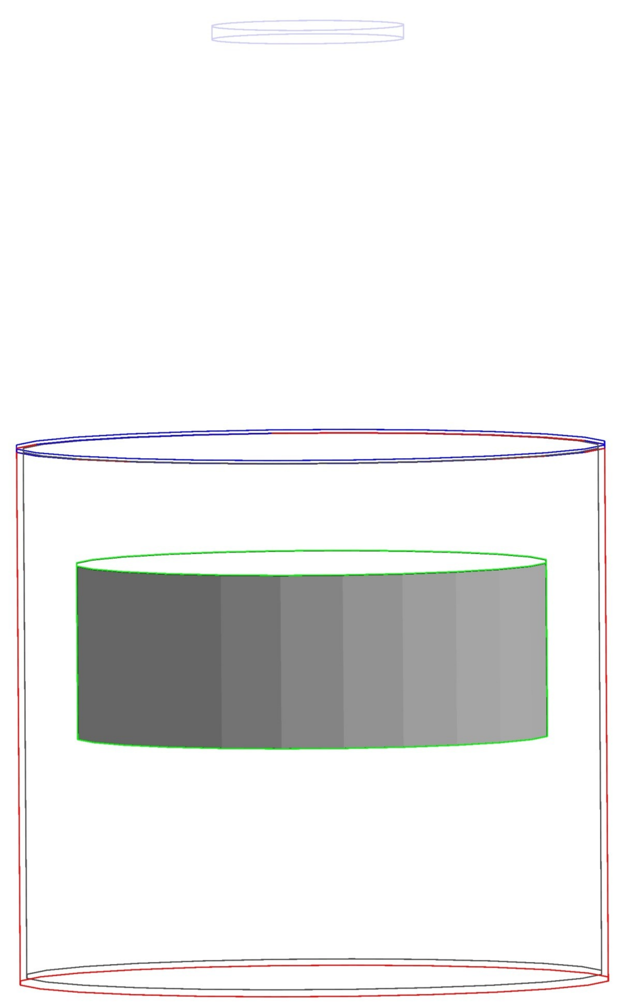
Method and setup

To fully characterize the Univ. of Ioannina Canberra BE 3825 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.

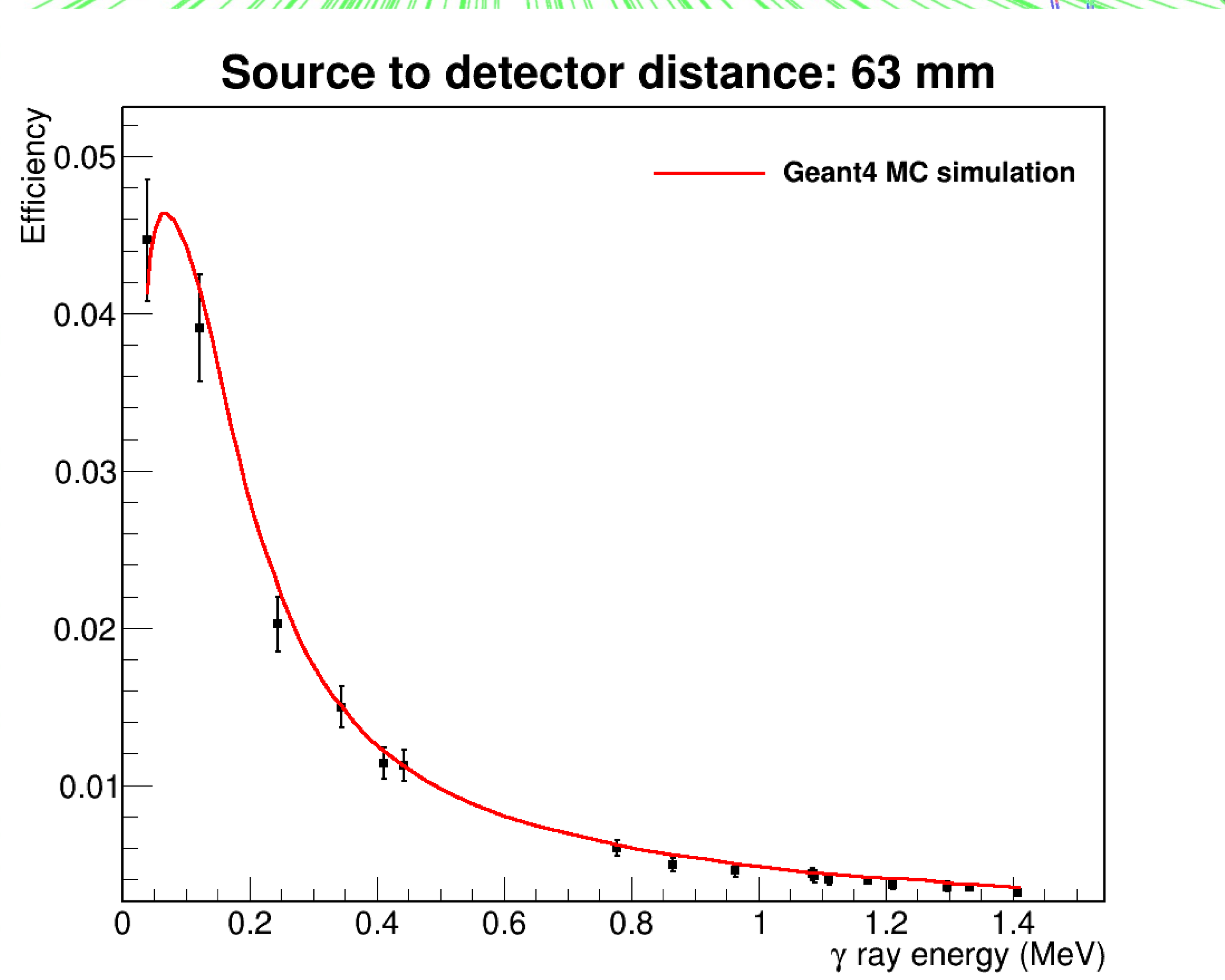
Detector: Canberra BE3825; 28% relative efficiency
Source to detector distance: 63 mm and 93 mm
γ-ray calibrated point sources: ^{152}Eu (11.5 ± 0.9)kBq; ^{60}Co (6.85 ± 0.14)kBq

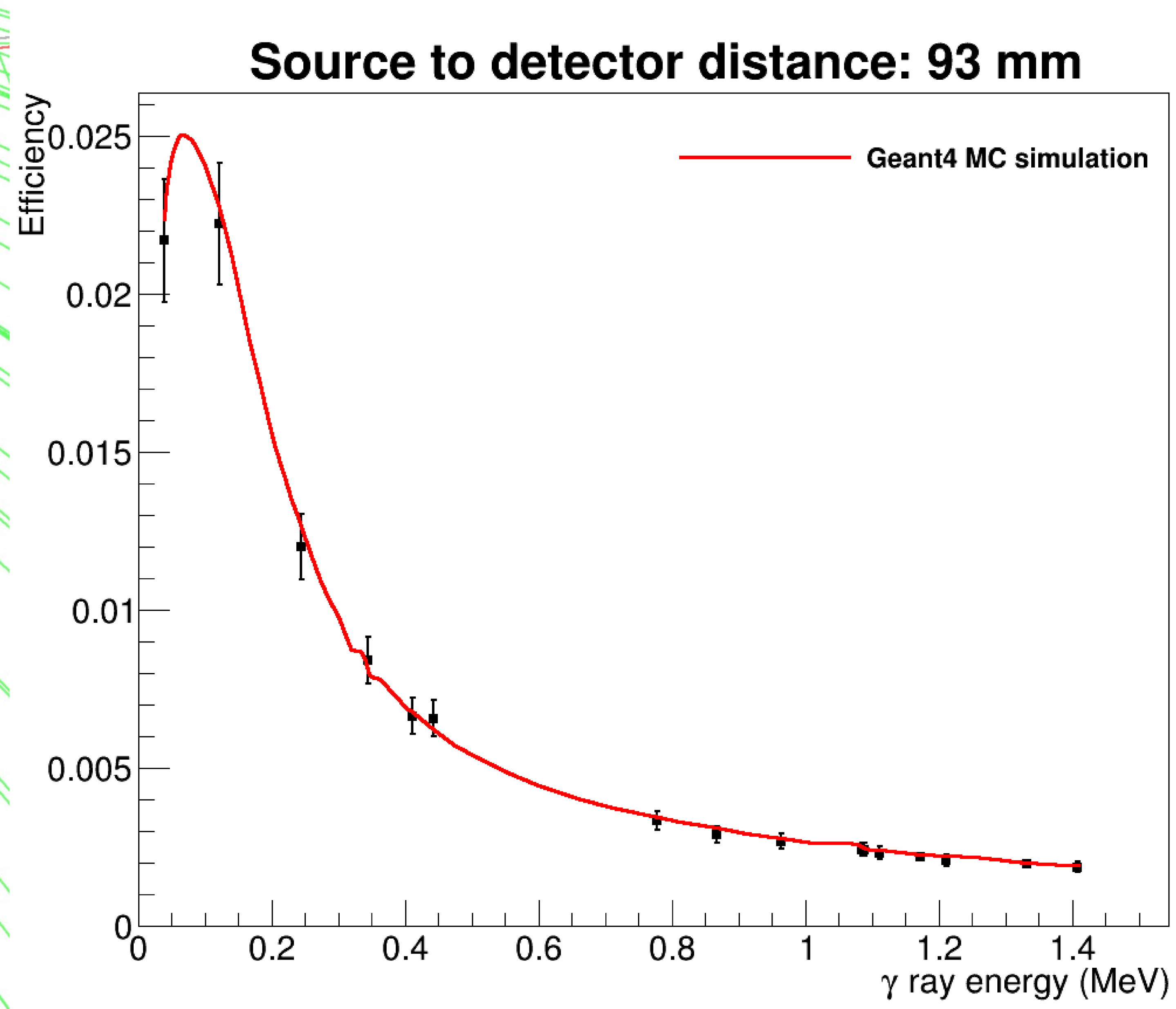
Summary of the BE3825 detector dimensions

Component	Nominal values (mm)	Geant 4 tuned values (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	0.0004	0.0004
Side dead layer	0.6	0.6
Crystal distance from the detector window	5.0	6.2



Results





Discussion and conclusions

The BE3825 Broad Energy HPGe detector was characterized by means of extensive Monte-Carlo calculations by using the latest version of the Geant4 detector simulation toolkit. As can be seen from the above figures the simulated peak efficiency is in excellent agreement with the experimental data at both source-to-detector distances. The absence of the crystal borehole in the new series of Canberra BE detectors provides a uniform detector response along the detector surface. Accordingly, the modeling of the detector response by means of MC simulation is more reliable since the number of the "free" parameters involved in the simulation is significantly lower. This was confirmed from the fact that almost all the manufacturer's parameters were finally adopted in the MC simulations with only exception slight modifications in the crystal diameter and in the crystal to window distance. The low Z material of the detector window (Carbon Epoxy) along with the minimal top dead-layer thickness allows for the efficient detection of γ-rays with energies down to the keV region. This was also confirmed by our Geant4 calculations. Having characterized the detector in detail, we are able to perform measurements with various samples, where the self-attenuation of the emitted γ-rays and/or the geometry can be taken into account in the most accurate way.