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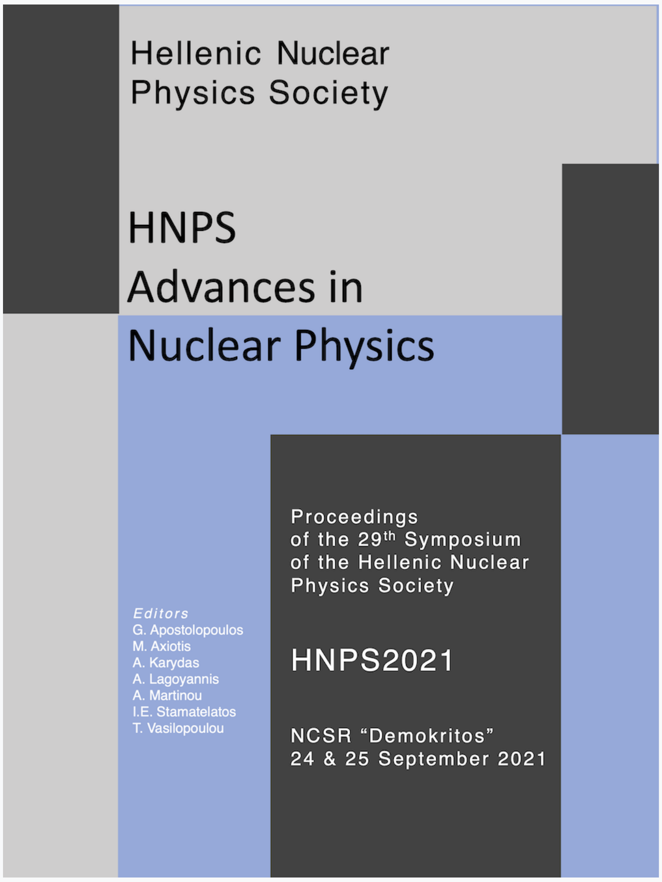

Characterisation of the new HPGe detectors at INPP/NCSR "Demokritos"... and future (n,2n) reactions to be studied

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Characterisation of the new HPGe detectors at INPP/NCSR "Demokritos" and future (n,2n) reactions to be studied

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Abstract Within the present work, the HPGe detectors of the Institute of Nuclear and Particle Physics at NCSR "Demokritos" were fully characterised in terms of their efficiency. The three n-type 80% relative efficiency HPGe were recently acquired in the framework of the CALIBRA project. All detectors are equipped with carbon epoxy windows that allow the detection of low energy γ-rays. Beside the efficiency characterisation, the three detectors were fully modeled by means of GEANT4. In all cases, the simulated detector geometries were fine-tuned, so as to fully reproduce the experimental efficiency data at different source-to-detector distances. Finally, as a demonstration of the new offered abilities, the efficiency characterisation and the GEANT4 modeling of the three HPGe detectors was used for a feasibility study of possible/future (n,2n) activation measurements on medium-weight nuclei.

Keywords HPGe detectors, efficiency characterisation, GEANT4

INTRODUCTION

The three n-type coaxial CANBERRA HPGe detectors (model: GR8023) are able to detect low energy photons due to their carbon epoxy windows and very small value of dead layer (0.5 mm). The first step in characterising the detectors, is the experimental determination of the peak efficiency for a variety of γ-ray energies and different source-to-detector distances. The next step, is the three dimensional modeling of the system using the GEANT4 simulation toolkit [1] and the successful reproduction of the experimental data.

EXPERIMENTAL SETUP

In order to experimentally determine the peak efficiency of the detectors (Fig. 1) in a wide range of energies, seven calibration sources of ^{22}Na, ^{54}Mn, ^{60}Co, ^{109}Cd, ^{133}Ba, ^{137}Cs and ^{152}Eu were used. Spectra were acquired at six different source-to-detector distances (2.7, 5, 7.1, 12, 17 and 21.8 cm). Specifically, ^{54}Mn and ^{152}Eu were measured at all the aforementioned distances, however, for the rest of the sources, the distances at which spectra were recorded, were selected according to the counting rate.

SIMULATION

The simulations of the HPGe detectors were performed by means of the GEANT4 detector simulation toolkit (Fig. 2). The geometrical characteristics of the detectors, as given by the manufacturer, were fine-tuned so as to achieve the best possible agreement between the experimentally obtained and the GEANT4 efficiency curves.

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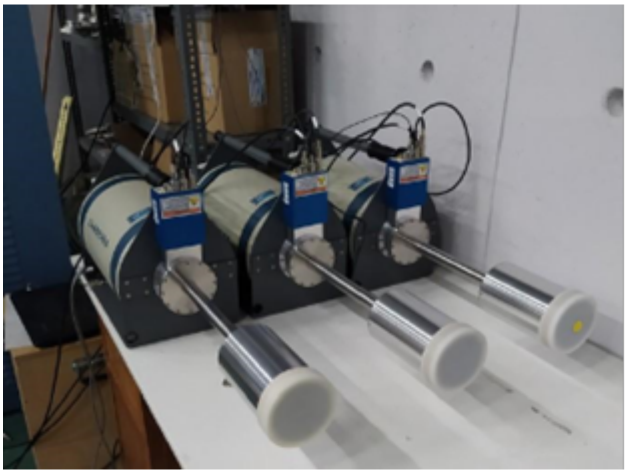

Fig. 1. *The three CANBERRA detectors*

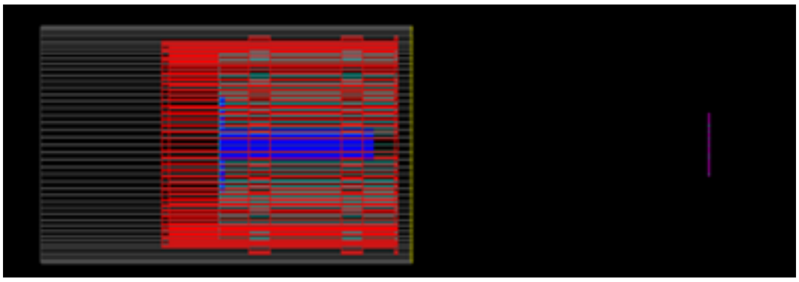

Fig. 2. *A visualization of the GEANT4 simulation of the detection system along with the source*

RESULTS AND DISCUSSION

In Figs 3 – 5 the results of the simulation, after tuning the geometrical features of the detection system, are compared to the experimental efficiency for the different energies and distances for the three detectors. In all three cases, the majority of the points lie within the experimental uncertainty (one σ).

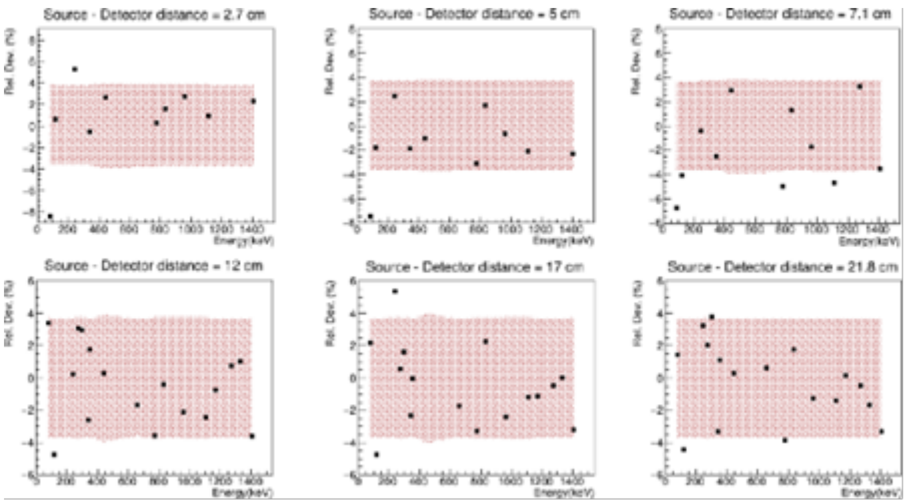

Fig. 3. *Relative deviation of the simulation (black points) and the relative experimental error (red band) for the first detector*

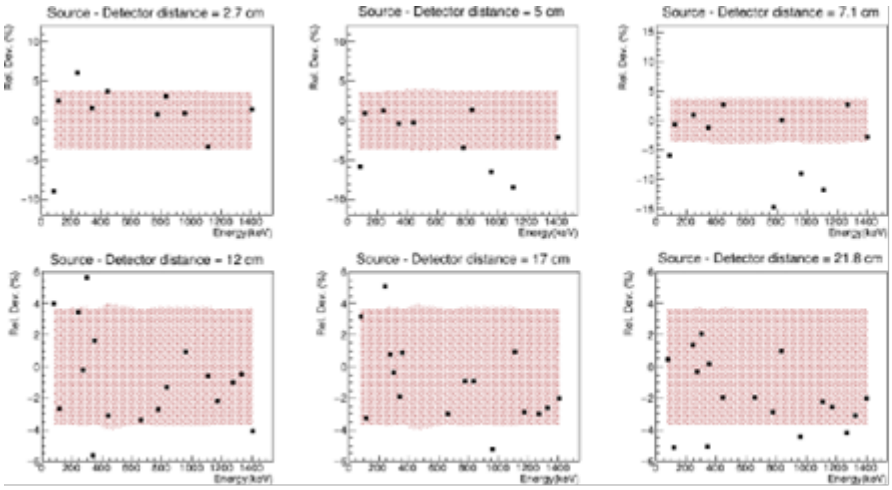

Fig. 4. *The results for the second detector*

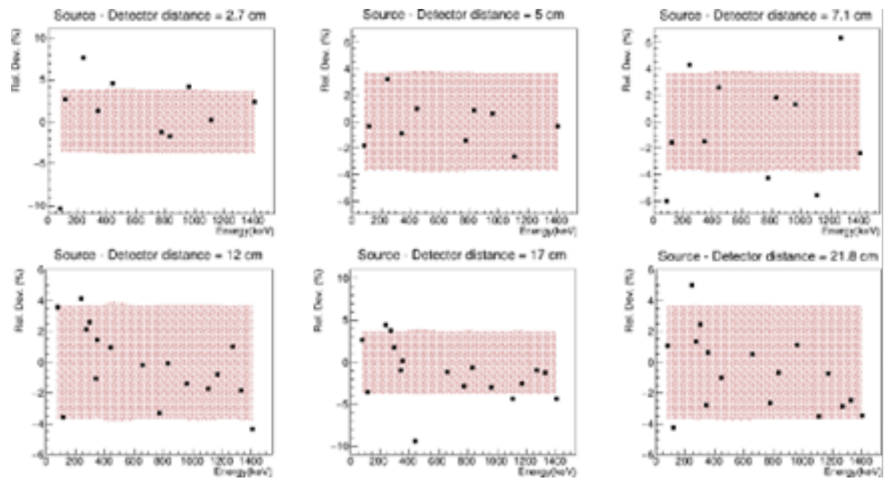

Fig. 5. *The results for the third detector*

Afterwards, the full modeling of the HPGe detectors was used for a preliminary study of three neutron induced activation measurements on medium weight nuclei. Table 1 contains some information on the three reactions.

Table 1. *Information on the three reactions under study [2]*

Reaction	**Abundance (%)**	**Half life**	**Eγ (keV)**	**Iγ (%)**
^{127}I(n,2n)^{126}I	100	12.93 d	388.6	35.6
^{133}Cs(n,2n)^{132}Cs	100	6.48 d	667.7	97.59
^{136}Ce(n,2n)^{135}Ce	0.185	17.7 h	265.6	41.8

Using the cross section formula from the activation technique and the efficiency of the detectors in the corresponding energies, the counting rate for each reaction was calculated for different irradiation and measuring times. The cross section is given by the equation:

$$\sigma = \frac{counts \cdot CF}{N_T \cdot \Phi \cdot \varepsilon \cdot \mathrm{I}_\gamma (1 - e^{-\lambda t_m}) e^{-\lambda t_w} f_B}$$

The results showed that all three reactions can be performed using the three new HPGe, even the reaction $^{136}Ce(n,2n)^{135}Ce$ where the isotope ^{136}Ce has a particularly low abundance.

CONCLUSIONS

In this work, the three new HPGe of the INPP/NCSR “Demokritos” were successfully characterised in terms of their efficiency, using the GEANT4 simulation toolkit. The characterisation of the detectors and the detailed modeling through the GEANT4 toolkit was used for the feasibility study of future (n,2n) activation measurements. The estimated counting rates showed that the proposed physics cases can be realized at INPP of NCSR "Demokritos" and high accuracy experimental information can be obtained.

Acknowledgements

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