

Geant4 Simulation of VECC array for Nuclear Spectroscopy (VENUS) and HPGe detector of NDPCI

Md. A. Asgar^{1,*}, G. Mukherjee¹, T. Roy¹, Soumik Bhattacharya¹,
C. Bhattacharya¹, A. Dhal¹, D. Mahato², and S. Bhutani³

¹Variable Energy Cyclotron Centre, 1/AF Bidhan Nagar, Kolkata 700 064, INDIA

²Indian School of Mines, Dhanbad, Jharkhand 826004, INDIA and

³Vellore Institute of Technology, Tamil Nadu 632014, INDIA

Introduction

Geant4 simulation of a single-crystal HPGe detector of NDPCI (Nuclear Data Physics Centre of India) and the recently installed VENUS (VECC array for Nuclear Spectroscopy) facility at Variable Energy Cyclotron Centre (VECC), Kolkata has been performed in its experimental configuration. At present the array consists of 6 clover HPGe detectors [1] with BGO Anti-Compton shield (ACS) in the horizontal plane. The NDPCI detector is an n-type coaxial HPGe detector (Model No. EGNC-25-200-R of M/s. Canberra, France) with Be window for detecting low-energy γ - and X-rays but without ACS. The results of the simulation were compared with the available experimental data from the experiments done with VENUS array and from the measured values reported in [2, 3] for the single-crystal HPGe.

Geometry construction

For both the cases, the geometries of the cylindrical-shaped detectors were constructed first using the dimension provided by the supplier. VENUS: 4 HPGe crystals, each of size 50 mm (dia) x 70 mm (length), were placed on a copper plate of 10 mm thickness to constitute the clover detectors and placed inside an Al housing (3 mm). The geometry includes the ACS with the heavy-metal collimator, the beam line and the target chamber. The detectors are placed at 45° , 55° , $\pm 90^\circ$ and $\pm 150^\circ$ angles about the beam direction at a distance of 26 cm from the centre, as shown in Fig. 1.

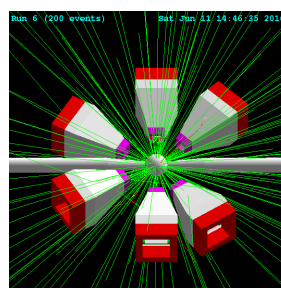


FIG. 1: Simulated geometry of VENUS array.

NDPCI detector: The dimension of the HPGe crystal is 53 mm (dia) x 60 mm (length) with a 0.5 mm dead layer. The Be window is 0.3 mm thick and is placed at 6 mm away from the front face of the crystal. The remaining part of the crystal is surrounded by 3 mm thick Al cover.

Physics processes

In this simulation, three particles γ , electron and positron were considered. The photoelectric effect, Compton scattering, pair production, electron ionization, multiple scattering, bremsstrahlung radiation and positron-annihilation processes were incorporated.

Results and discussion

Some of the simulated results of efficiencies in the crystal, sum and add-back modes for the clovers and of the array are shown in Fig. 2. Comparison of the measured efficiency (normalised with simulation) is also shown. The absolute efficiencies of the clover addback and of the VENUS array were obtained as $\sim 0.17\%$ and $\sim 1.0\%$, respectively, at 1 MeV in the simulation. The peak-to-total

*Electronic address: aliasgar@vecc.gov.in

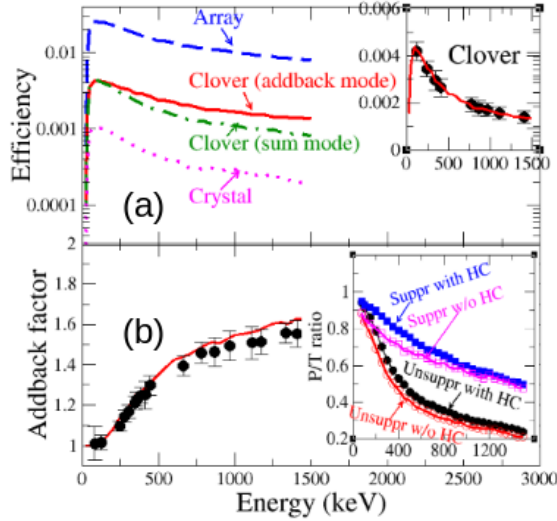


FIG. 2: (a): simulated efficiency in various modes (inset: addback efficiency compared with measured data) vs. E_γ . (b): measured and simulated addback factors (inset: simulated P/T ratios vs. E_γ) for the clovers in VENUS array.

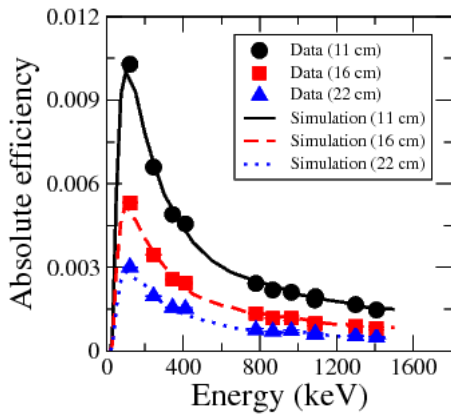


FIG. 3: Measured and simulated absolute efficiencies of the NDPCI detector vs. E_γ for 11 cm (circle), 16 cm (square) and 22 cm (triangle) distances from the source.

(P/T) ratios were also obtained as a function of E_γ and shown in Fig. 2 ((b), inset).

The absolute efficiencies for the NDPCI detector at various distances were simulated and their comparison with measured data are

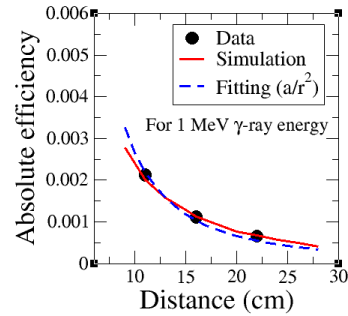


FIG. 4: Variation of measured and simulated absolute eff. with distance for 1 MeV γ -ray (NDPCI det). Data are fitted with a a/r^2 equation.

shown in Fig. 3 as a function of E_γ . Excellent agreement between data and simulation has been achieved. The absolute efficiency of the detector at 11 cm has been found to be 0.2% for $E_\gamma = 1$ MeV. Variation of the measured and simulated efficiencies of the detector with distance from the source are shown in Fig. 4 for 1 MeV γ -ray which is observed to follow the a/r^2 equation (fitted curve).

Summary

A complete simulation of the VENUS facility at VECC and the EGNC-25-200-R n-type HPGe detector procured by NDPCI has been performed in the Geant4 platform. Efficiency, addback factor and P/T ratio have been obtained and compared with measured data.

Acknowledgement

The efforts of all the persons from VECC who were involved in the setting up of the VENUS are gratefully acknowledged. We also acknowledge with thanks the cooperation, help and fruitful discussion with Prof. A. Goswami, Dr. R. Raut and Dr. S.S. Ghugre.

References

- [1] Soumik Bhattacharya, et al., Proc. DAE Symp. on Nucl. Phys. 58, 906 (2013)
- [2] D. Mahato, Report of Summer Training Project at VECC (2015).
- [3] S. Bhutani, Report of Summer Training Project at VECC (2015).