Evaluating Coaxial HPGe Detector Efficiency in Beam Geometry Using LCS γ-ray Source

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Abstract

High-resolution γ-ray spectroscopy involving beam geometry may be measured with higher efficiency if γ-ray beam hits out of the axis of the coaxial HPGe detector. Hitting off-axis makes γ-rays avoid travelling through the contact hole, which is an inactive axial portion of the detector. We performed Monte Carlo simulations to study the effects of contact hole dimensions and off-axis distance on the coaxial HPGe detector efficiency. The simulation considered γ-ray energy up to 10 MeV. In general, the simulation results reveal that the off-axis efficiency is higher than on-axis efficiency for a wide range of γ-ray energies and beams sizes. Our simulations results are validated by experimental measurements of γ-ray beams generated from laser Compton scattering at UVSOR III facility.

Keywords: Coaxial HPGe detector, Efficiency, Monte Carlo simulation, Laser Compton scattering

1. Introduction

The emergence of high-brightness and energy-tunable γ-ray beams and their applications requires accurate methods of γ-ray beam measurements. It has been found that measuring γ-ray beams using a coaxial high purity germanium (HPGe) in an off-axis configuration may be of statistical and accurate merits [1]. Monte Carlo simulations are necessary for accurate estimation of the coaxial HPGe detector efficiency [1-2]. Here, we use Monte Carlo simulations to evaluate the off-axis efficiency of a coaxial HPGe measuring γ-rays produced by laser Compton scattering (LCS).

2. Materials and Methods

To study the off-axis efficiency of the coaxial HPGe detector, we measured LCS γ-ray beams directly by a 140% coaxial HPGe detector in the on-axis and off-axis configurations. LCS γ-ray with a maximum energy of 7.54 MeV were generated by collision of 746-MeV electrons with laser photons with a wavelength of 800 nm at an angle of 82 degrees. Efficiency calculations have been performed by the general Monte Carlo tool-kit of Geant4 [3].

3. Results and Discussion

Fig. 1 shows typical energy spectra of LCS γ-ray beams measured with the coaxial HPGe detector in the on-axis and off-axis at a distance of 2 cm from the center of the detector. The off-axis counting rate at approximately 7 MeV is 1.66 ± 0.2 times the counting rate of the on-axis measurement at the same energy. In addition, the efficiency calculations estimated from Monte Carlo simulation are also shown in Fig. 1. The ratio of the off-axis efficiency to the on-axis efficiency at 7 MeV as calculated by Monte Carlo simulation is 1.8. This value agrees, within the experimental uncertainty, with the measured value. However, the statistical uncertainties of the measured energy spectra are in the order of 10% and needs to be improved.

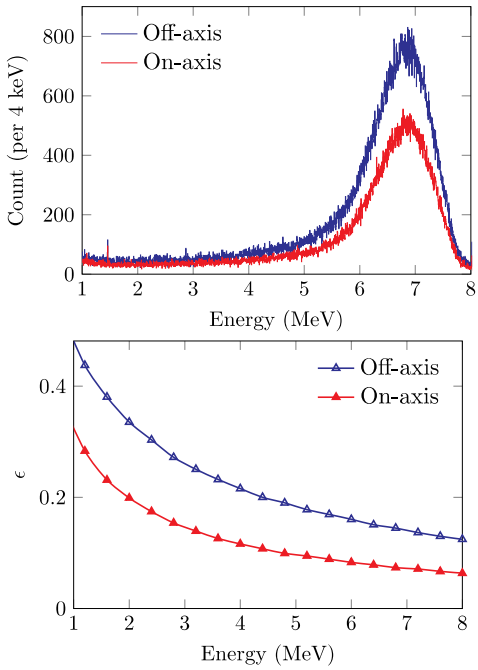

Fig. 1: LCS profiles measured on-axis and off-axis at 2 cm from the detector's center (top). Corresponding Monte Carlo calculations of the detector efficiency (bottom).

4. Summary

In summary, we demonstrate that off-axis configuration of a coaxial HPGe detector may be used in measuring the LCS γ-ray beams. Furthermore, the simulation results reveal that the off-axis efficiencies are sensitive to the contact hole dimensions and depth from the detector surface.

References

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