First Measurement of High Energy 22.5 MeV Gamma rays in a Large $LaBr_3$:Ce Detector

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Introduction

The recent discovery of Lanthanum-halide (LaX_3:Ce) crystals is proving to be a major step forward in the continuing quest for an ideal scintillator for nuclear radiation detection. The production and marketing of the $LaCl_3$:Ce and $LaBr_3$:Ce crystals have resulted in a flurry of activities for their testing and characterisations. The very attractive and superior properties of $LaBr_3$:Ce, namely, energy and timing resolution, stability, high efficiency etc. over most of the other scintillators open up a very wide usage of these scintillators in nuclear spectroscopy, astronomy, medical imaging, geological applications etc. As far nuclear spectroscopy is concerned the $LaBr_3$:Ce and $LaCl_3$:Ce scintillators demonstrate the capabilities to be used for the detection of both low and high energy gamma rays.

Measurements with a large $LaBr_3$ crystal

We have carried out extensive measurements and realistic GEANT4 simulations to study the important properties of $LaBr_3$:Ce crystals of different sizes and also in phoswich configuration [1, 2]. In this paper we report about the detailed measurements of a large crystal using low to very high energy discrete gamma rays. The cylindrical crystal has 3.5" diameter and 6 length and is coupled with a 3.5 Hamamatsu photomultiplier tube. The integral assembly is manufactured by Saint Gobain Inc. and is currently one of the largest commercially available crystals for nuclear physics research. The performance of the crystal has been tested over a wide range of energy using radioactive sources of gamma rays and also in-beam reactions at the Pelletron accelerator facility at TIFR. A host of sources producing gamma rays from tens of keV to 4.433 MeV have been used for the measurements. The properties studied in-depth are, energy and timing resolutions, detection efficiencies (both photo-peak and total), uniformity of the crystal, internal radioactivity, neutron response, linearity, neutron-gamma separation in heavy-ion induced in-beam reactions etc. The uniformity of the large volume crystal has been tested over its entire surface using gamma ray sources of ^{137}Cs and ^{60}Co. The internal radioactivity of the large $LaBr_3$:Ce crystal has been extracted and the rate of activity estimated. The neutron response of the large crystal has been measured using radioactive source and also in in-beam measurements using heavy-ion fusion reactions. We have recently carried out p(^{11}B, ^{12}C)γ reaction to produce 22.5 MeV monochromatic gamma rays using 7.2 MeV proton beam from the Mumbai Pelletron. The performance of the crystal has been studied for signals drawn from the anode and different dynodes of the photomultiplier tube in order to obtain the optimum configuration for maintaining linearity over the entire range of energy. The measured efficiencies have been compared with the simulated results obtained from the GEANT4 package. The maximum dynamic range of detection of the detector has been measured. The primary role of this de-

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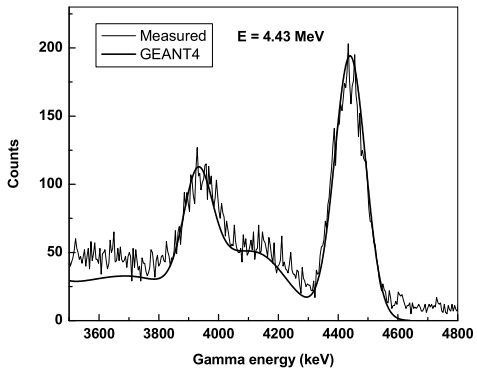

FIG. 1: .The 4.433 MeV gamma ray spectrum recorded in the 3.5" × 6" $LaBr_3$:Ce detector using an AmBe source. The solid line is the GEANT4 simulation of the response of the detector.

tector will be to measure high energy gamma rays up to a range of around 50 MeV. The cosmic ray rejection of this detector up to 50 MeV, when operated in conjunction with a large plastic anti-coincidence shield, has also been measured. Figure 1 shows the measured gamma ray spectrum for 4.433 MeV using AmBe source. The solid line is the GEANT4 simulation for the response of the detector. The 22.5 MeV gamma ray spectrum using p(^{11}B, ^{12}C)γ reaction has been analysed and fitted to extract the energy resolution. The spectrum has also been reproduced using realistic GEANT4 simulation. The detailed results will be presented in the meeting.

References

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