Characterisation of an array of large square bars of $LaBr_3$:Ce detectors up to 22.5 MeV.

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The advent of Lanthanum Halide scintillator detectors, namely, Lanthanum Bromide and Lanthanum Chloride has been a very important development in the field of scintillator detectors. The much superior properties of these scintillators, compared to other existing scintillators, have resulted in increasing demand of these crystals and their in-depts characterizations. At ~ 3% energy resolution for 662 keV γ-rays the Lanthanum Bromide detector ($LaBr_3$:Ce) has the best energy resolution of all known scintillator detectors. The timing resolution of few hundred pico seconds is also as good as Barium Fluoride (BaF_2) detectors. In addition the $LaBr_3$:Ce crystals have very high efficiency and stability of performance with change in temperature. We have previously carried out and reported detailed studies of small volume $LaBr_3$:Ce detectors [1]. We have also reported the performance of a large volume cylindrical crystal [2] and the performance of a $LaBr_3$:Ce+NaI(Tl) phoswich for the first time [3]. Here we report about our complete characterization of the large volume square bars of $LaBr_3$:Ce detectors, individually, and in a compact array of four bars. The square bars have dimensions of 2"X2" in cross section and length of 8" and are manufactured and supplied by St. Gobain Inc. The crystals are encapsulated in 2mm thick Al casings with a glass window on one of the sides along the length for coupling to PMT. We have studied the performance of the crystals individually with a variety of PMTs to select the best possible tube to give optimum performance for both energy and timing resolutions. The energy resolution, timing resolution, linearity of response, uniformity of the crystal, internal activity and efficiencies of detection have been measured using different radioactive g-ray sources and also using in-beam reactions. We have carried out detailed realistic simulations using GEANT4 package to reproduce the measured spectra. The main purpose of procuring and characterizing these large volume detectors is to set up an array of large volume $LaBr_3$:Ce detectors for measurement of high energy g-rays efficiently up to 40-50 MeV. Such an array will be highly useful for GDR decay studies and nuclear Bremsstrahlung measurements. It is absolutely imperative to have a clear idea about the linearity, energy resolution and response of the detector to high energy γ-rays. We have carried out the measurement of γ-rays up to 4.43 MeV using Am-Be radioactive source. However, for higher energies one has to take recourse to in-beam measurements. We have carried out an experiment at the TIFR-BARC Pelletron machine using low energy proton beam. A 7.2 MeV proton beam was used to bombard natural Boron target of around 1 mg/cm^2. The target was evaporated on a thick Ta backing. The bean current was about 10-15 pna. The p(^{11}B,γ)^{12}C reaction produced monochromatic g-rays of 22.5 MeV. The γ-rays were measured in a compact array of four square bars (mentioned above) kept at around 15 cm from the target position. The energy signals from the four detectors were added and recorded in event mode. Figure1. shows a comparison of an energy spectrum of 4.43 MeV photons from the ^{241}Am–^{9}Be source measured in the an array of large square bars of $LaBr_3$:Ce detectors as well as with single square bar LaBr3:Ce detector. The 22.5MeV γ-ray spectrum measured is shown in Figure2. The array of the sq. bar detector was placed 16 cm away from the target.

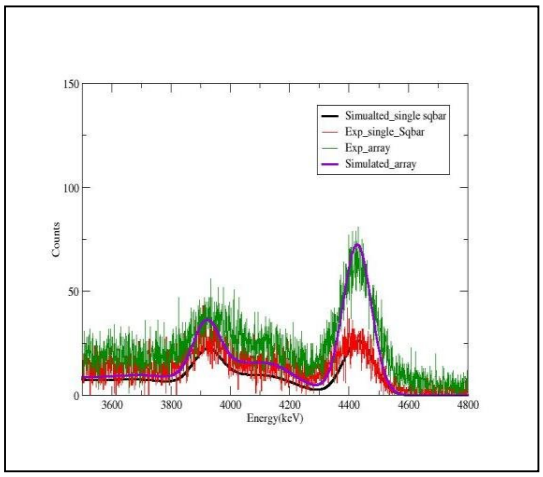

Figure1. Measured energy spectrum of 4.43MeV γ-rays from the ^{241}Am–^{9}Be source in the $LaBr_3$:Cedetector.The solid line is the GEANT4 simulation of the spectrum.

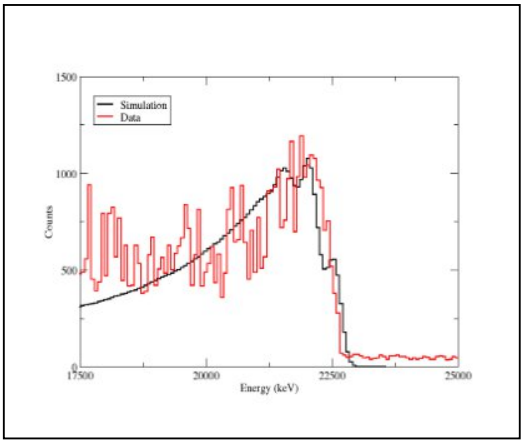

Figure2. The measured energy spectrum for 22.5MeV γ-rays produced in the p(^{11}B,γ)^{12}C reraction. The solid line is the GEANT4 simulation of the spectrum.

The γ-ray spectra from the sources and also for the22.5MeV photons were reproduced using realistic GEANT4 simulations. The experimental results are in very good agreement with simulated results

References

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