Optimization of characteristic of BGO gamma-ray detectors

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Introduction

One of the main experimental physics research problem to be solved in the frame of project TANGRA (TAgged Neutron & Gamma RAys) is to measure the angular distribution of gamma-rays from the inelastic scattering of 14.1 MeV neutrons on some important for nuclear sciences and engineering isotopes with a bigger accuracy and confidence [1].The first step that we did in this direction was to optimize the energy and time resolution of the gamma-detectors used in our TANGRA setup [2].

For this purpose, we investigated the time and energy characteristics of the BGO scintillators with 2 different types of photomultiplier tubes (PMT). The signals from the PMT were recorded with a computerized 32-channel digital data acquisition (DAQ) system, utilizing two 16-channel, 14-bit, 100 MHz, ADC boards ADCM16-LTC [3]. From the digitized analog signals, we obtained their amplitude and time characteristics simultaneously.

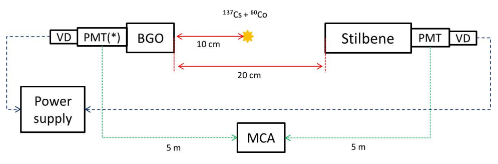

FIG. 1: Block-scheme of the experimental setup

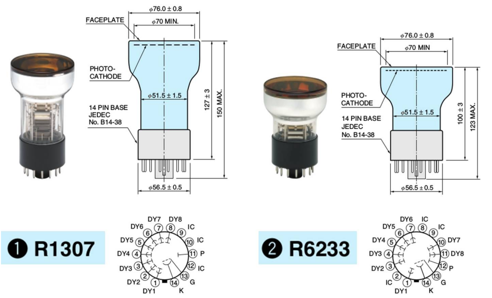

FIG. 2: Types of PMTs used in the experiments

Experimental setup

For determination of the energy and time resolution of BGO+PMT at different source-detector geometries and PMTs high-voltages, we used standard point-like ^{137}Cs and ^{60}Co γ-ray sources. The block-scheme of the experimental setup is shown in Fig. 1. For determination of the energy resolution, only one detector was used, which was set by ticking

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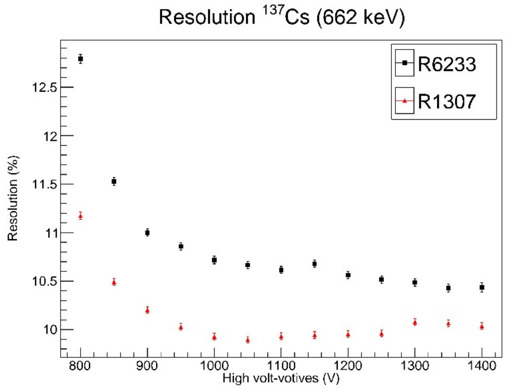

FIG. 3: The energy resolution at different PMT R1307 and R6233 high-voltages for ^{137}Cs and E_γ=662 keV

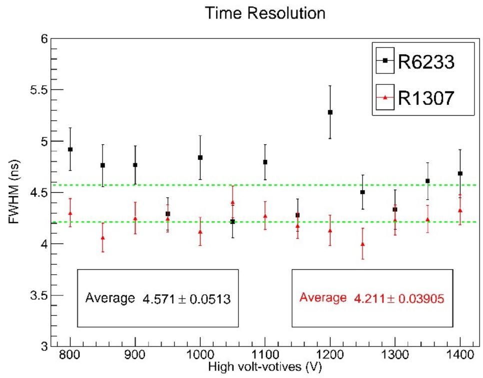

FIG. 4: The time resolution at different PMT R1307 and R6233 high-voltages

(γ-γ) for this detector, on the main panel of the ADCM software [3]. The determination of the time resolution with two detectors in coincidence was set by ticking (γ-γ) of the both detectors. This way one of them was conditionally accepted as a start signal and the second as a stop signal.

Fig. 2 shows the both types of Hamamatsu photomultiplier tubes that we tested: R1307 and R6233 [4], (76mm dia., Head-on type, Bialkali photocathode Effective area: 70mm dia./Spectral response: 300 to 650 nm)

Experimental results

Fig.3 shows the results from the measurements of the energy resolution of BGO with R1307 and R6233 PMTs for gammas with energy with E_γ=662 keV (^{137}Cs) at different high-voltages.

Fig.4 shows the results from the measurement of the time resolution of BGO with R1307 and R6233 and Stilbene (with R1307) for gammas with energy E_γ=1173 keV and 1332 keV ^{60}Co, at different high-voltages.

Conclusions

In the present work, we have compared the energy resolution for BGO detector, and observed that PMT R1307 show better results then PMT R6233 up to 1000 Volts. At higher voltages, both the detectors show similar results. Similarly, while comparing the time resolution of the two types of PMT, it was observed that R1307 gives better results with FWHM=4.2 ns.

Based on the results from this comparison, we are using Hamamatsu PMT R1307 in new multidetector system “Romasha” [5]

References

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