Response Function of "Romasha" Gamma-Ray Spectrometer

A. Gandhi[1],* D.N. Grozdanov[2,3],† N.A. Fedorov[2,4], F.A. Aliyev[2,5], D. Wang[6], Yu.N. Kopatch[2], V.R. Skoy[2], V.M. Byrtritsky[2], I.N. Ruskov[3], T.Yu. Tretyakova[7], C. Hramco[2,8], P.K. Prajapati[1], N.K. Rai[1], A. Sharma[1], N.L. Singh[9], S. Mukherjee[9], and A. Kumar[1]

[1]*Department of Physics, Banaras Hindu University, Varanasi, India*
[2]*Joint Institute for Nuclear Research (JINR), Dubna, Russia*
[3]*Institute for Nuclear Research and Nuclear Energy (INRNE), BAS, Sofia, Bulgaria*
[4]*Faculty of Physics, Lomonosov Moscow State University (MSU), Moscow, Russia*
[5]*Institute of Geology and Geophysics (IGG), ANAS, Baku, Azerbaijan*
[6]*School of Energy and Power Engineering, Xi'an Jaotong University, China*
[7]*Skobeltsyn Institute of Nuclear Physics (SINP), MSU, Moscow, Russia*
[8]*Institute of Chemistry, Academy of Science of Moldova, Chisinau, Republic of Moldova and*
[9]*Department of Physics, Maharaja Sayajirao University of Baroda, Vadodara, India*

Introduction

Bismuth Germanate Oxide ($B_4Ge_3O_{12}$) detector (BGO) is a type of scintillation detector, which has been widely used for γ-ray spectroscopy. These detectors have good time and energy response, and high γ-ray detecting efficiency, which is important for the measurement of high-energetic γ-rays. "Romasha" is an array, which consists of 18 BGO γ-ray detectors, built at the Frank laboratory of Neutron Physics (FLNP) of the Joint Institute for Nuclear Research (JINR), in Dubna (Russia), in the frame of the TANGRA (TAgged Neutron & GAmma Ray) project [1]. This array system is used for investigation of neutron induced inelastic scattering, capture and fission reactions with a number of nuclei, important for fundamental physics and nuclear industry. In this paper, we report the results on the response function of "Romasha" setup at different energies of γ-rays, starting from 350 keV up to 4438 keV.

Experimental setup

The measurements were carried out at FLNP (JINR, Dubna, Russia), using 18 cylindrical shape scintillation detectors based on BGO crystals, having a diameter of 76 mm and a thickness of 65 mm, coupled with-Hamamatsu R1307 PMT, which operate at ∼1000-1200V DC. The detectors are located in a horizontal plane circumferentially with radius of ∼750 mm in steps of ∼14 degree around the target, as shown in Fig.1. Different standard radioactive point-like sources ^{137}Cs,

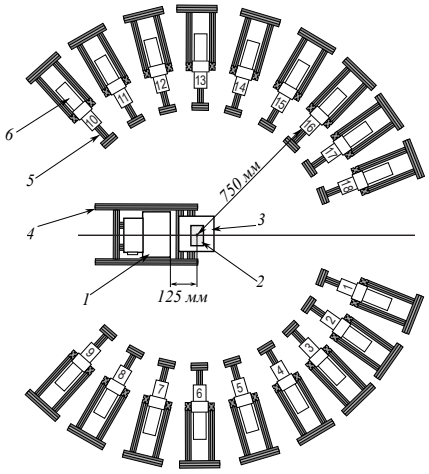

FIG. 1: TANGRA experimental setup: 1-neutron generator ING-27, 2-target, 3-holder for target, 4-holder for ING-27, 5-holder for detectors and 6-BGO detectors

*Electronic address: gandhiaman653@gmail.com
†Electronic address: dgrozdanov@mail.ru

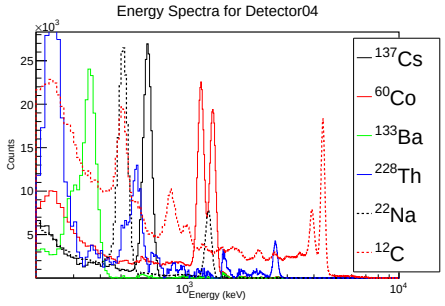

FIG. 2: γ-ray energy response function of BGO detector up to ∼4438 KeV, using radioactive point sources

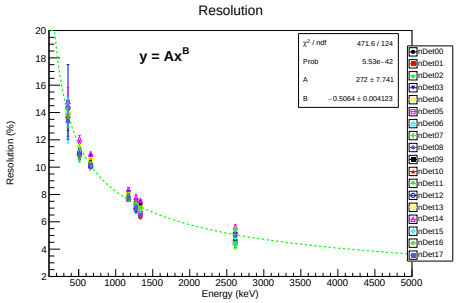

FIG. 3: Resolution(%) of all 18 BGO detectors for different γ-ray energy

^{60}Co, ^{133}Ba, ^{22}Na, ^{228}Th and ^{239}Pu-Be were used for energy-calibration and for determination of γ-ray detecting efficiency of the system.

Experimental results

A 32-channel computerized digital data acquisition (DAQ) system, utilizing two ADCM16-LTC 16-channel, 14-bit, 100 MHz, ADC boards [2], is used for the signals processing and data acquisition. In Fig. 2, we show the γ-ray energy spectra of ^{137}Cs (661 keV), ^{60}Co (1173, 1332 keV), ^{133}Ba (356 KeV), ^{22}Na (511, 1274 keV), ^{228}Th (583, 2614 keV) and ^{239}Pu-Be (^{12}C, 4438 keV) radioactive sources. The trend of resolution of BGO detectors for each γ-ray energy is shown in Fig. 3. The resolution for high energy (^{228}Th, 2614 keV) γ-rays of BGO detectors is about 5%. Fig. 4 represents the efficiency of BGO

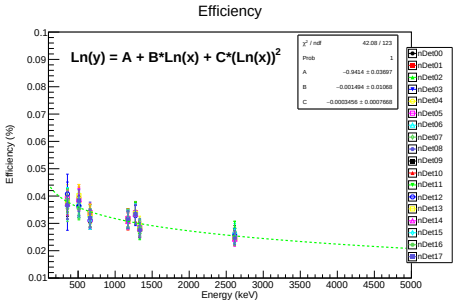

FIG. 4: Efficiency(%) of BGO detectors with respect to the γ-ray energy

detectors over a wide range of gamma-rays energies and it is approximately ∼0.03% for the high-energy γ-rays.

Conclusions

The BGO detectors have a good efficiency for the high-energy gamma rays, which is ideal for measuring the gamma-rays excited by the neutron inelastic scattering. This BGO detector system that was built under the TANGRA project has been named "Romasha". It is proposed to use these detectors for measurement of the angular distribution of gamma rays produced from the interaction of 14.1 MeV tagged neutrons with light nuclei.

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References

[1] Kopatch Yu.N., Bystritsky V.M., Grozdanov D.N et.al., Angular Correlation of Gamma-Rays in the Inelastic Scattering of 14.1 MeV Neutrons on Carbon. ISINN-23 proceedings, Dubna, 2016. p. 361.

[2] A digital pulse processing system for nuclear physics experiments ADCM16-LTC, http://afi.jinr.ru/ADCM.