TANGRA: Tagged Neutrons and Gamma Rays

A. Gandhi[1],* D. N. Grozdanov[2, 3], F. A. Aliyev[2, 4], W. Dongming[2, 8], N. A. Fedorov[2, 5], Yu. N. Kopatch[2], V.R. Skoy[2], V.M. Bystritsky[2], I. N. Ruskov[2, 3], C. Hramco[2, 6], E. P. Bogolyubov[7], Yu. N. Barmakov[7], V. Kumar[1], V. Mishra[1], N. K. Rai[1], and A. Kumar[1]

[1]*Department of Physics, Banaras Hindu University, Varanasi – 221005, INDIA*
[2]*Joint Institute for Nuclear Research (JINR), Dubna, Russia*
[3]*Institute for Nuclear Research and Nuclear Energy (INRNE), BAS, Sofia, Bulgaria*
[4]*Institute of Geology and Geophysics (IGG), AAS, Baku, Azerbaijan*
[5]*Faculty of Physics, Lomonosov Moscow State University (MSU), Moscow, Russia*
[6]*Institute of Chemistry (IC), Academy of Science of Moldova, Chisinau, Republic of Moldova*
[7]*All-Russia Research Institute of Automatics (VNIIA), Moscow, Russia*
[8]*School of Energy and Power Engineering, Xi'an Jiaotong University, Xi'an, China.*
* *email: gandhiaman653@gmail.com*

Introduction

Nuclear data are of fundamental importance in nuclear technologies studies for the design of fusion and fission reactors, in medical analysis and in basic science. To fulfill this application, we need a precise and reliable nuclear data. The tagged neutron method is used to measure the neutron induced reaction cross section with highest precision and less uncertainty. This tagged method is also used for elemental analysis and nuclear reactions studies [1-2].

Experimental Setup

The new TANGRA (Tagged Neutrons and Gamma Rays) setup consists of: a portable ING-27 neutron generator with in-build position sensitive detector for alpha-particles (Fig. 1) [3], an array of BGO detectors of gamma rays, 2 Stilbene detectors for neutron spectroscopy and PC based 32 channels ADC for signal processing [5].

ING-27 is an intense neutron generator (~$5*10^7 c^{-1}$) of neutrons with energy of 14.1 MeV through a reaction in which deuterium ions, accelerated to energy less than 100 keV (CMS), hit a thin (10mm) TiT-target (Eq. 1.) This (d-t) fusion-fission reaction has a low Coulomb barrier and a highest cross section to occur; it is used as a source of high energy neutrons for experimental research, for example, in fast neutron induced reaction cross section data measurements.

$$^{2}_{1}D + ^{3}_{1}T \rightarrow ^{4}_{2}He + ^{1}_{0}n, Q=17.589 \text{ MeV} \quad (1)$$

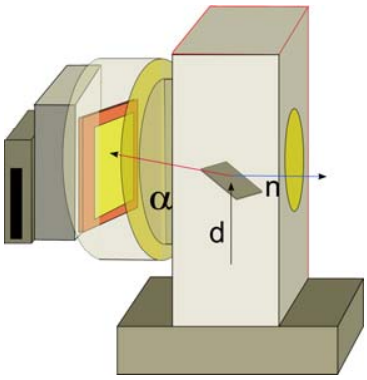

Fig.1 ING-27 Neutron Generator

Since the alpha-particle is associated with the neutron in the outgoing channel via the nuclear reaction kinematics, the both particles are emitted nearly in opposite direction in the CMS. In this way, by measuring the emission angle of the alpha-particle we can "tag" the emission angle of the neutron. The alpha-particle is detected by 64-pixel silicon detectors incorporated in the neutron generator vacuum chamber. Registering the neutrons one can determine the number of neutrons hitting the sample; as each neutron is "tagged" by the alpha-detector. From the pixel alpha-detector, we have information about the place and time of the interaction of the "tagged" neutron with the sample, where X and Y co-ordinates are given by the pixel of the alpha- detector and Z (t-co-

ordinates) are determined by the time-of-flight (TOF).

The BGO detectors have been widely used for high energy gamma rays spectroscopy due to the high atomic number of Bismuth (83) and its high density; it is most efficient gamma-absorber. At these gamma-ray energies they have a higher efficiency, comparing to NaI(Tl), and good energy resolution (Fig. 2).

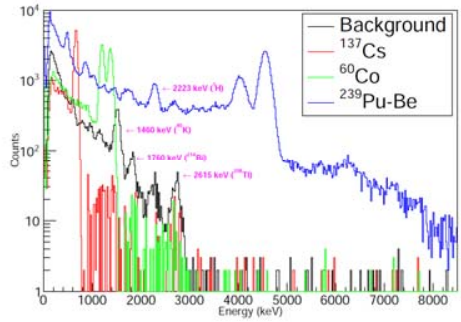

Fig.2 The response functions of a BGO detector to gamma-rays of different energy

For detection of reaction products like scattering neutron (n, xn'), gamma rays from INS (n, n'γ) or capture gamma rays (n, γ), a multi-detector system "Romasha" formed of 18 BGO detectors was constructed and tested (Fig. 3.) The tagging of alpha-detector (X, Y co-ordinates) with γ – rays detector (triple coincidences) helps to decrease the unwanted background γ-rays signals by almost 100%.

Fig.3 TANGRA setup with gamma detector array

Future Outlook

Investigation of energy distribution and angular correlation of characteristics gamma rays and neutrons from the inelastic scattering of 14.1 MeV neutrons on a number of elements important for nuclear science isotopes.

Acknowledgement

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References

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[3] Kopatch, Yu N. "Angular correlation of gamma-rays in the inelastic scattering of 14 MeV neutrons on carbon." http://isinn.jinr.ru/proceedings/isinn-23/pdf/Kopatch.pdf

[4] FSUE VNIIA ING-27 neutron generator based on a gas filled neutron tube, http://www.vniia.ru/ng/element.html

[5] AFI ADCM, a digital pulse processing system for nuclear physics experiments; ADCM16- LTC, a 16-channel/14 bit/100MHz ADC board with signal processing core, http://afi.jinr.ru/ADCM16-LTC.