"Romashka" and "Romasha" gamma-ray spectrometers

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Introduction

An investigation of the angular and energy distributions of gamma rays from the inelastic scattering (INS) of 14.1 MeV neutrons on a number of light nuclei was performed in the frame of the project TANGRA (TAgged Neutron and Gamma RAys) at JINR Frank Laboratory of Neutron Physics [1]. The 14 MeV neutrons were produced in d(t,α)n reaction by a VNIIA ING-27[2] portable neutron generator, which contain a 64-pixel Si charge particle detector, incorporated in its vacuum chamber. By registering the alpha particles, we "tag" the corresponding neutrons, which according to the reaction kinematics are irradiated in directions nearly opposite to those of the neutrons.

"TANGRA" setup gamma-ray spectrometers

We used two types of the γ-detector systems. The first type called "Romashka" is an array of 22 hexagonal NaI(Tl) crystals placed around the irradiated sample for spectrometry of the coincided with α-particles characteristic γ-rays following the INS-reaction.

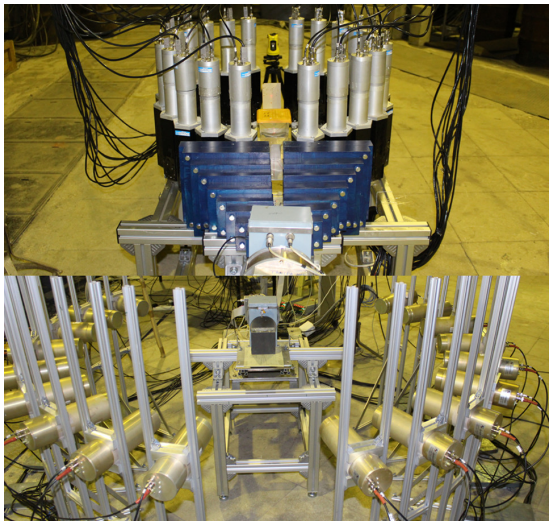

FIG. 1: "TANGRA" setup g-ray spectrometers: "Romashka" (up) and "Romasha" (down)

The outputs of NaI(Tl) probes were fed to a computerized 32-channel data acquisition system from JINR AFI electronics, which was used for digitizing the analog signals from the detectors and storing the waveforms on the computer hard-drive for further off-line analysis. Firstly, we measured the angular distributions of gamma rays from the INS of 14.1 MeV neutrons on ^{12}C, ^{16}O and other light elements. The final results obtained will be pub-

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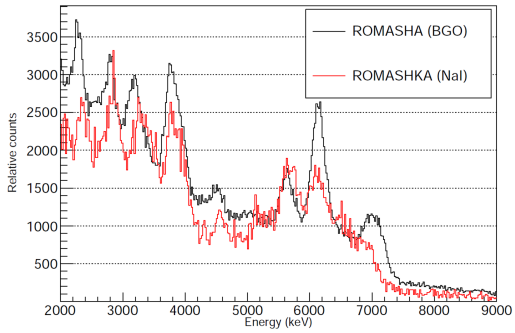

FIG. 2: Energy spectra of gamma-rays from INS of 14.1 MeV neutrons on Oxygen nuclei, obtained with "Romashka" (red) and "Romasha" (black) multi-detector systems

lished elsewhere. The second multi-detector system named "Romasha" consists of 18 cylindrical BGO gamma-detectors mounted in special mobile holders. Photos of the both detector systems are shown at Fig.1

The "TANGRA" setup with "Romashka" was used to study the INS on Carbon and Oxygen nuclei [3, 4]. But, because the efficiency and energy resolution of NaI(Tl) detectors are decreasing with increasing the energy of gamma-rays, it was not possible to register gamma-quanta with energy more than 7 MeV, as seen in Fig.2.

That is why we used Romasha for registering the E1 gamma transitions from 6917.10 keV and 7116.85 keV levels of Oxygen nucleus to its ground state. In addition to this, because of the system geometry used, the n-gamma separation was improved.

The angular distributions of gamma-rays with energy of 6.13 MeV, measured with NaI(Tl) and BGO detector systems are shown in Fig.3. It can be seen that, as it was expected, the error-bars of the data obtained with Romasha are smaller than those with Romashka.

Conclusion

The comparison between the two multi-detector systems shows that "Romasha", which is based on BGO gamma-ray detectors, provides more reliable information about

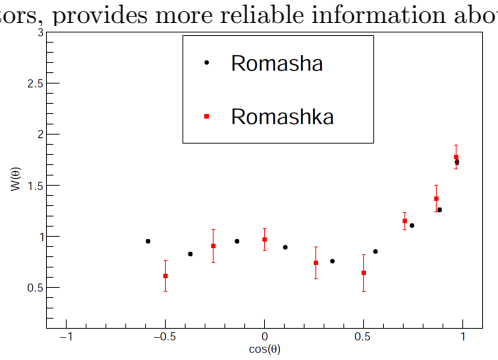

FIG. 3: Angular distribution of gamma-rays emmited by transition of Oxygen nuclei (6.13 MeV(3^+)$\rightarrow g.s$) and measured using "Romashka" (red) and "Romasha" (black)

the angular distribution of the gamma-rays from INS of 14.1 MeV neutrons on ^{16}O nuclei, than "Romashka", which is composed from NaI(Tl). It allows us to study high-energy gamma transitions in exited by INS nuclei.

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] http://www.vniia.ru/ng/element.html

[3] V. M. Bystritsky, D. N. Grozdanov, A. O. Zontikov et al. Angular distribution of 4.43-MeV γ-rays produced in inelastic scattering of 14.1-MeV neutrons by ^{12}C nuclei. Phys. Part. Nuclei Lett., 13, (2016) 54.

[4] Angular distribution of gamma rays from the inelastic scattering of 14 MeV neutrons on light nuclei. ISINN-25 proceedings, Dubna, 2017.