MEASUREMENTS OF TRANSITION AND SELF-INDICATION FUNCTIONS ON SAMPLES OF STRUCTURAL MATERIALS

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Abstract. Measurements of the transition functions on Ta, Au and Uranium metal samples thickness from 1 to 50 mm were held. Research carried out by the TOF method on 50 meter flight base of the pulsed neutron source RADEX, in the energy range from thermal neutrons to 30 keV. Measurements were performed using the 8-sectional liquid (n, gamma) detector and He-3 proportional high efficiency detector, during proton accelerator operation with parameters: energy of protons 209 MeV, repetition rate 50 Hz, pulse current 8 mA, pulse duration 1 microsecond. As spectrometric information accumulators, were used measurement module with an interactive program ROM, and a new single-channel high-speed system. Width of the time channel was 1 microsecond. Proportional He-3 counter was used as accelerator's proton beam intensity monitor. Sample of MnO_2 was used on neutron beam as a filter. Using experimental spectra, group total cross section, and group radiation capture cross sections were calculated.

1. Introduction

There is an increasing interest in the fast breeder reactors development, in connection with precise calculations of breeding ratio and transmutation of nuclear waste. Any successful development and implementation of these ideas depend strongly on accurate physics parameters, such as neutron reaction data.

In the present work, we have measured the group average capture and total cross sections of U^{238}, Ta^{181} and Au^{197} in the neutron energy range from 0.0253 eV to 30 keV by using the neutron time-of-flight method at the Russian Academy of Sciences 600-Mev proton linac of INR in Moscow. The gamma rays emitted from the capture sample inserted at a distance of 50 meters from the neutron source were detected by 8-sectional liquid scintillator consisting of 86% toluol and 14% trimethyl borate by volume. The neutron detector, 8-atmospheric He^3 counter, was placed in a 50-meter flight path to measure the neutron time-of-flight spectrum.

Experimental procedure

The experiment was carried out at the 50-meter flight path of 600-Mev INR proton linac in Moscow. The pulsed neutron source RADEX has water-cooled tungsten target with water neutron moderator. Accelerator was working with proton energy 209 MeV, repetition rate 50 Hz, pulsed current 8 mA and proton beam duration 1 mcs.

As experimental data accumulation system two systems were used. 'Old' type, made in Camac standard with minimum time channel 1 mcs, and 'new' fast system with time channel of 120 ns. Structure of count in the first channels is shown on figure 1.

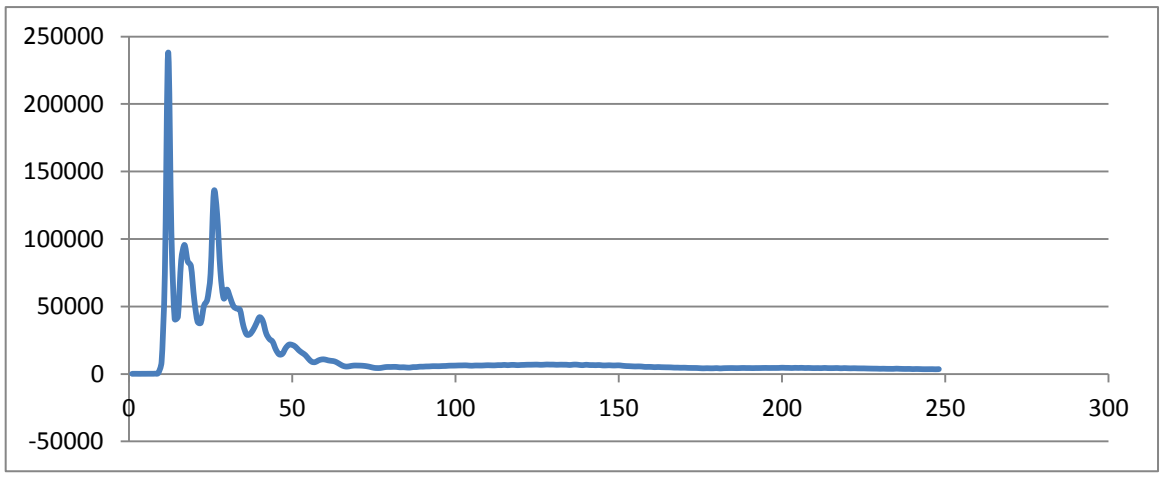

Fig. 1. ‘Beam’ structure.

Usage of ‘new’ fast data storage system allowed to observe detailed structure of the first microseconds. The first peak is caused by gamma quanta, which are distributing with speed of light. The second peak appears, when spectrometer base is flown by cascade neutrons which energies are in interval from 14 to 209 MeV. And third peak is produced by spallation neutrons with average energies 3 MeV, few bigger then fission neutrons those have average energy 2 MeV. Structure below 1 MeV is caused by inelastic scattering in thick tungsten target, and also by capture resonances of tungsten and other construction materials available in RADEX target.

Data analysis and results

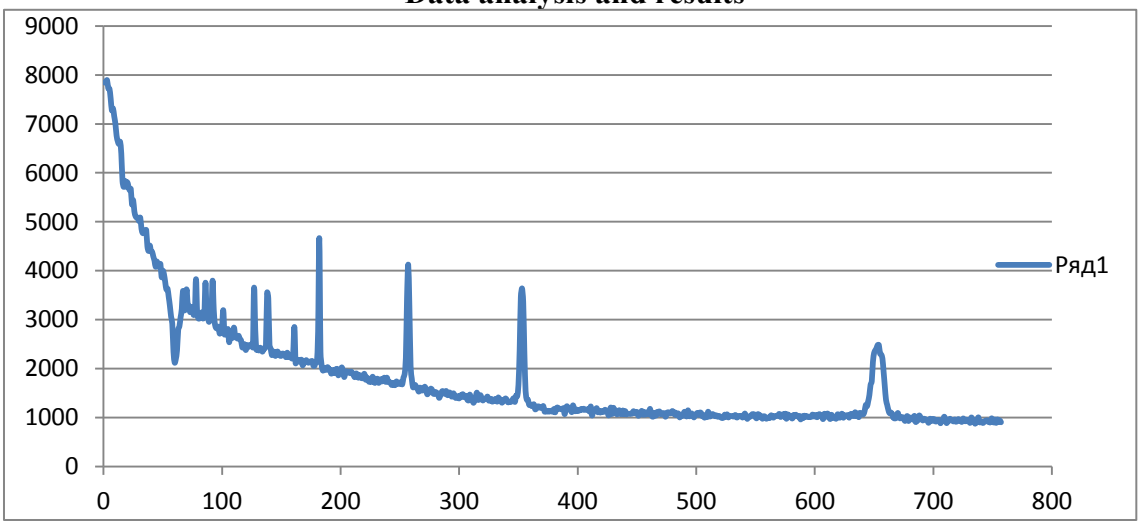

Fig. 2. U^{238} measured by ROM system (part of spectrum).

Measurement of U^{238} target using ‘old’ measurement system, with beam pulse length 1 mcs and channel width 1 mcs, is shown in figure 2. Flight base is 50 meters, spectrometer resolution is 28 ns/m. Marker in 70^{th} channel is caused by capture resonance of Mn, which was used as a filter in neutron guide.

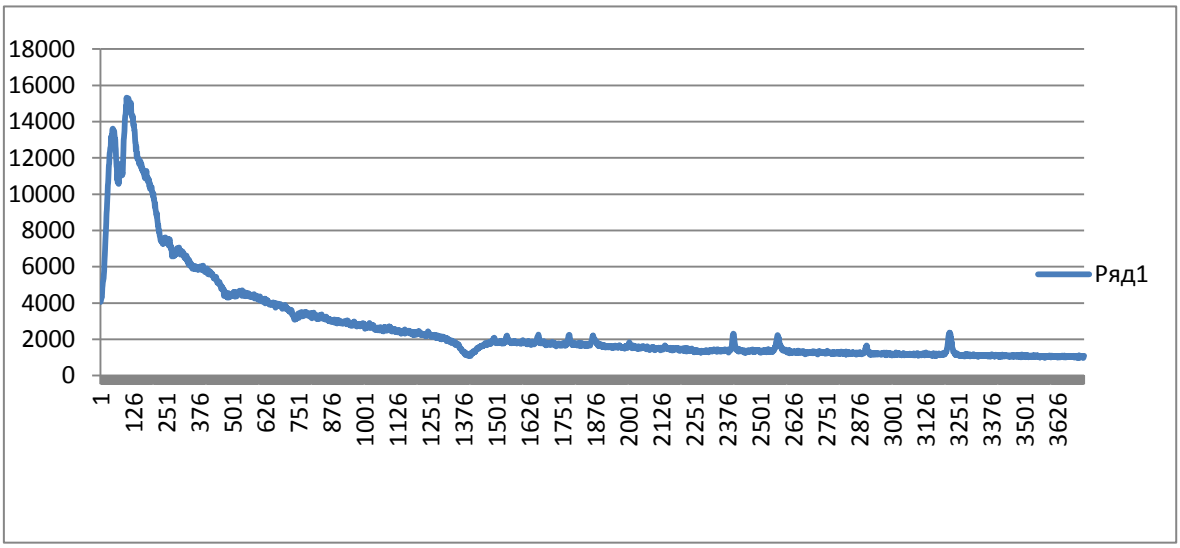

Fig. 3. U^{238} with Mn^{55} filter measured by new fast data accumulation system.

On figure 3 can be seen the same spectrum, measured by new data accumulation system. Beam pulse width is 1 mcs, channel width was chosen 120 ns, energy resolution of spectrometer is 20 ns/m. In the channels around number 1400, the same 336 eV Mn capture resonance can be observed.

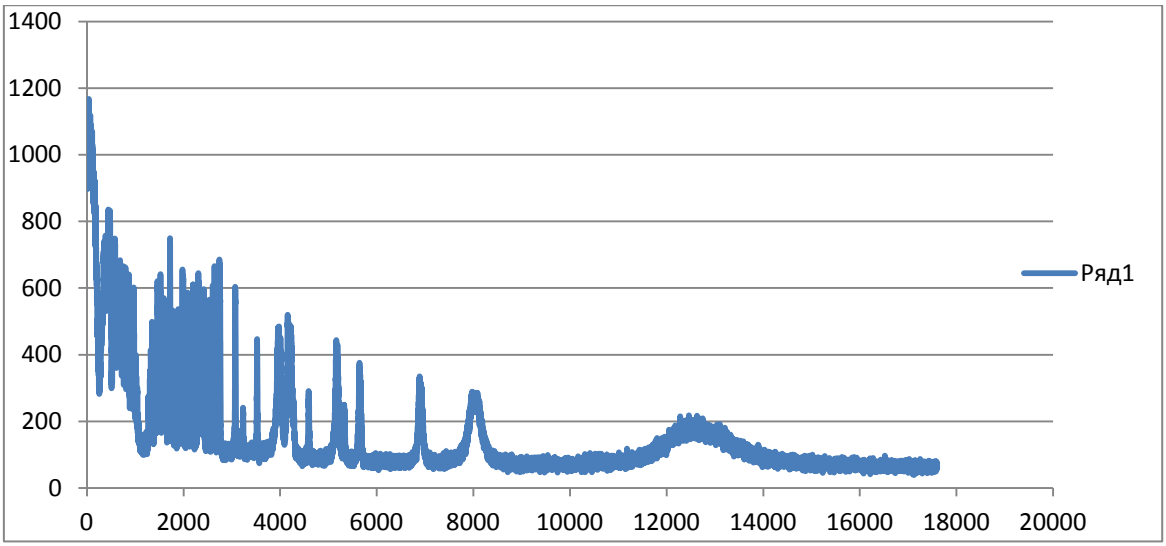

Fig. 4. Tantalum-181 measured at 50 meters.

Spectrum on figure 4 was acquired using thick tantalum sample. Structure above the second Mn resonance, whose energy is 2327 eV, is also observed. Beam pulse width is 1 mcs, channels are 120 ns.

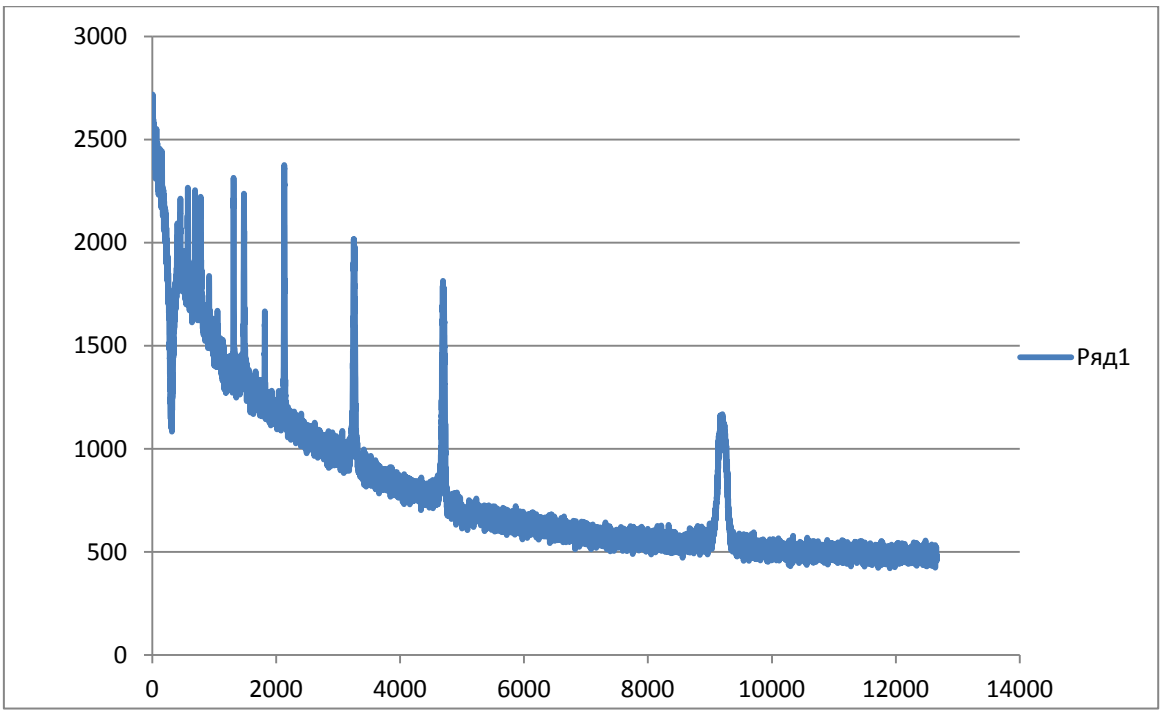

Fig. 5. Natural uranium at 50 meters, channel is 121 ns.

In figure 5 spectrum of U^{238} is shown below 337 eV resonance of Mn^{55}, which was used on neutron guide as a filter.

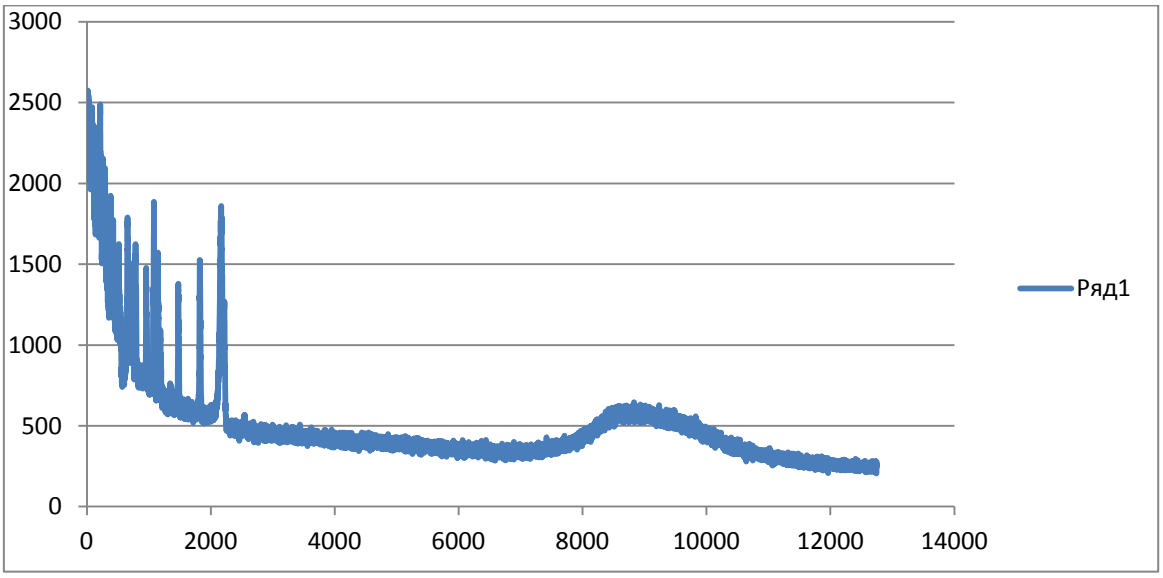

Fig. 6. Capture spectrum of Au^{197}.

On figure 7 spectrum of Au^{197} is shown measured at 50 meter TOF spectrometer base of pulsed source RADEX during April 2016. Lower resonance has large value of block-effect, due to big thickness of Au sample. Channel width is 120 ns.

Conclusion

As we can note, spectrometer flight path 50 meters and accelerator pulse 1 microsecond allows to distinguish 3 peaks: gamma-rays, cascade neutrons and spallation neutrons. Time channel width 120 ns founded experimentally was enough for this purpose.

Transition and self-indication functions were measured for samples of tantalum, Au^{197} and U^{238}. The group average capture and total cross sections have been calculated in the neutron energy region from thermal neutrons to 30 keV by using experimental spectra, measured on 50 meter TOF spectrometer RADEX. The present measurements were compared with the calculated data based on ENDF/B-VII data files. A satisfactory agreement was found between the results of the present work and ENDF/B-VII data.

The authors would like to express their sincere thanks to the staff of INR proton linac for the excellent operation of the RADEX pulsed spallation neutron source.