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The temperature of fission fragments from spontaneous fission of ^{252}Cf measured by time-of-flight spectrometer

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Our detection system MONA (Modular Neutron Array), consisting of eight large BC-501A liquid scintillators, described elsewhere [1,2] was applied to determine the temperature of fission fragments emitted in spontaneous fission of ^{252}Cf. The determination of the temperature was based on the measurement of the neutron spectra. The pulse shape discrimination (PSD) method was used to distinguish neutrons and gamma rays. For every detector we used the dual charge integration method, integrating the rising part of the anode pulse received from the scintillator and the slow component of it [3].

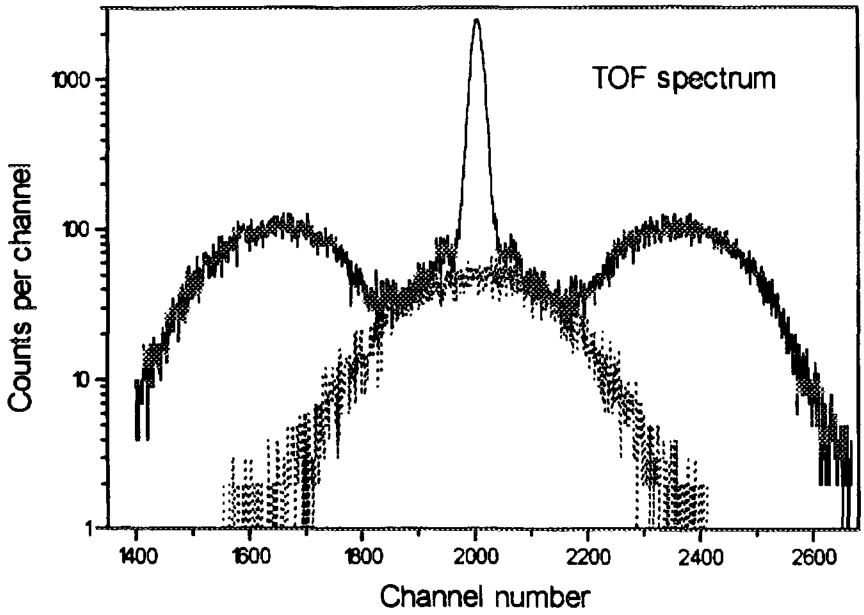

Fig. 1. Spectrum of time-of flight pseudoparameter taken for ^{252}Cf source. The pseudoparameter is defined as the difference of the registration times in two selected detectors.

In order to measure the neutron energy from spontaneous fission of ^{252}Cf the time-of-flight method was applied. The velocity of the neutron was determined by measuring the difference between flight time of a photon and neutron detected in coincidence event, as most of the γ-emission happens at the instant of fission process. A relation between detector thickness and flight path gives reasonable minimum distance of 40 cm from the source to the detector. The fast trigger was generated by multiplicity signal, M=2 produced in CFD unit. STOP signals were produced by CFD and sent to 8-channel TDC unit. The delay of ~80ns is necessary to shift STOP generated by the detection of a photon beyond START generated by the detection of a neutron. TDC and QDC outputs of all scintillators were stored in the computer by data acquisition system.

Some basic tests of our detectors were performed. We have optimized the neutron-gamma discrimination adjusting the widths of integration gates. The timing characteristics of the detector were also investigated. The response of the set-up to ^{252}Cf source is given in Fig.1. The eminent central peak is identified as γ - γ coincidence, the dashed broad bump represents n - n events, while the two side bumps are n - γ events. Neutron -γ coincidence events are seen to be well separated.

To obtain the neutron spectrum shape, the correction for detection efficiency is needed. For the present evaluation of the neutron detection efficiency, the energy dependence was calculated using the Monte Carlo code of Stanton improved by Cecil at al. [4]. This code calculates the absolute neutron detection efficiency for a given pulse-height threshold. The calculated detector efficiency is η=0.2 at the neutron energy of 2.0 MeV.

The neutron spectra from the ^{252}Cf source were measured by the detectors placed symmetrically around the source. Event by event spectra were collected and recorded on computer disc, neutron events were extracted in the off-line analysis. Fig. 2. displays the laboratory energy spectrum of neutrons integrated over all emitted fragments.

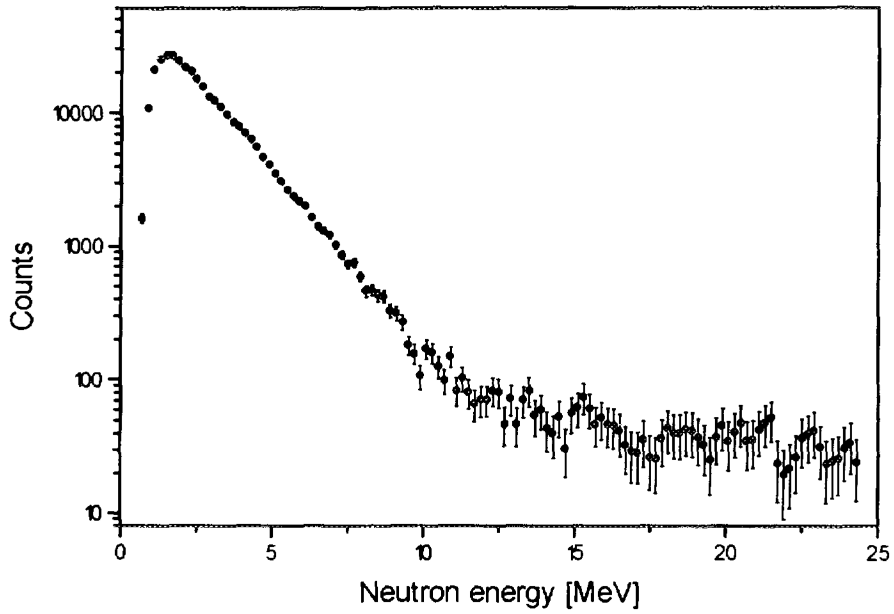

Fig.2. Fission neutron energy spectrum plotted versus laboratory neutron energy.

The extracted spectrum is confirmed by the measurements reported in the literature [5]. The simplest and most correct one-parameter representation of this spectrum is given by the Maxwellian distribution:

$$n(\varepsilon_\ell) = c\sqrt{\varepsilon_\ell/(\pi \cdot T^3)}\exp(-\varepsilon_\ell/T).$$

The obtained value of the parameter T=(1.36±0.04) MeV is consistent with other data taken at laboratory system. Good agreement between the previous measurement cited in literature [5] and the spectrum measured by us allows us to accept the calculated values of efficiency. The error of the value of the temperature is essentially determined by rather short flight path of 40 cm.

In fact the measurement of fission neutrons of ^{252}Cf is highly important as it is widely used for neutron detector calibration. Due to the fact that the energy distribution of neutrons emitted in the fission of ^{252}Cf is well known [5], the precise measurement of energy spectra can be used to determine the efficiency of the detector.

We intend to use the set-up described above as an autonomic detector for measurement of angular distributions and energy spectra of neutrons emitted in heavy ion collisions. It will also work as an suppplementing module for multiplicity filter from OSIRIS detector.

Acknowledgments

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