Measurement of pre-fission neutron multiplicity for ^{7}Li + ^{203}Tl at E* $\sim$ 43.8 MeV

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Introduction

Pre-fission neutron multiplicity has been widely used as a probe to study the fission dynamics at high energy (E* > 60 MeV) in heavy-ion induced reaction. The excess pre-fission neutron emission as compared to the statistical model prediction is ascribed due to dissipation, which results delay in the fission process. It is also well known that there are ambiguities in choosing statistical model parameters, namely fission barrier and level density parameter [1]. Generally, the statistical model parameters are fixed by fitting the fission excitation function and the pre-fission neutron multiplicity data at low energy (E* < 60 MeV), assuming that the pre-fission neutron emission is dominantly due to statistical competition.

In a recent analysis [2], the statistical model parameters have been constrained by simultaneously fitting the p, α, ^{12}C and ^{18}O induced fusion-fission excitation functions of ^{210}Po nucleus. The analysis predicted lower pre-fission neutron multiplicities as compared to the experimental pre-fission neutron multiplicities available for ^{12}C+^{198}Pt system [3] even at excitation energies as low as 50 MeV. This indicates that there are non-statistical emission even at these energies. These non-statistical emission might arise due to dynamical delay or due to emission from the neck region at the instant of neck rapture. Pre-fission neutron multiplicity measurement at low excitation energies are scarce. More measurements are required to understand the pre-fission neutron emission mechanism at lower energies. With this motivation an experiment has been performed to measure pre-fission neutron multiplicity for ^{7}Li+^{203}Tl system at E* = 43.8 MeV.

Experimental Details

The experiment was carried out by bombarding 40 MeV pulsed ^{7}Li ions on a 0.9 mg/cm^{2} thick ^{203}Tl target on carbon backing at the BARC-TIFR Pelletron-LINAC facility, Mumbai. Two 5 cm × 5 cm single sided silicon strip detectors, kept at ± 150°, have been used to detect fission fragments. Each of the detectors have 16 strips and covered an angular range of ∼ 35°. An array consisting of 15 liquid scintillator (5 inch dia and 2 inch thick) were used to determine neutron energy by measuring time-of-flight. The liquid scintillator detectors were kept at a distance of 70 cm from the target with angular separation of 16° between them, covering an angular range from 58.3° to 143.3°. Pulse shape discrimination (PSD) technique have been used for n-γ discrimination. In order to have better time resolution, the TOF spectra were recorded with respect to the RF filtered by fission. Data were collected in list mode using a VME based data acquisition system. For the neutron detectors, TOF, PSD and the pulse height information have been recorded. For one of the strip detector, having resistive strip capable of giving position information along the strip, 32 energy signals from front side along with one energy signal from the back side have been acquired. For the other strip detector, 16 energy signals from the front along with one signal

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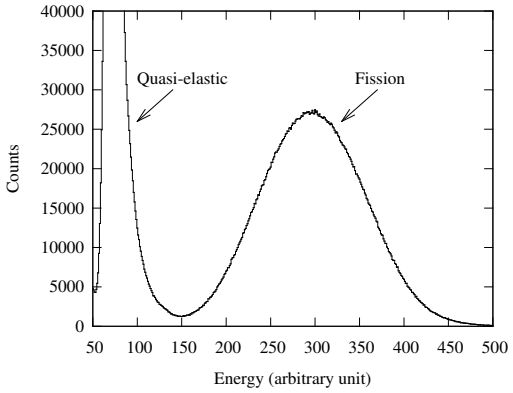

FIG. 1: Typical pulse height spectra of a strip detector used for detection of fission fragment.

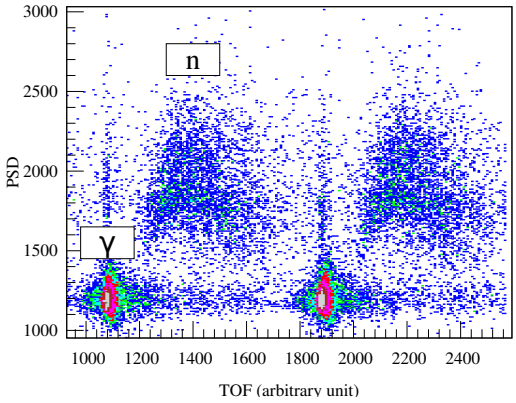

FIG. 2: TOF vs. PSD plot for n-γ discrimination. Two groups corresponds to two beam bunches for a RF pulse.

from back have been acquired.

In order to determine the efficiency of the neutron detectors as a function of neutron energy, neutron energy spectra of ^{252}Cf source have been also measured. The Cf-source was kept inside a small gas detector to have good efficiency for fission fragment detection. Signal from the gas detector was used to start the TOF measurement. In order to have better time/ energy resolution 4 BaF_2 detectors were also setup. The threshold of the BaF_2 detectors were kept at 300 keV to avoid triggering them with non-fission decay. Further, fission events were selected by requiring coincidence between two BaF_2 detectors or between one BaF_2 and gas detector. This can be also used to study dependence of the efficiency measurement on threshold of the gas detector.

Analysis and Results

A typical pulse height spectrum of the common output of one of the strip detector is shown in Fig. 1. As can be seen from the figure, the fission and quasi-elastic events are well separated. Fig. 2 shows the TOF vs. PSD plot gated with fission. Good separation between γ and neutron have been achieved. Neutron energy spectra have been obtained from the walk corrected TOF spectra. Neutron energy spectra of Cf-source obtained using trigger from coincidence of gas-BaF_2 detector and BaF_2-BaF_2 coincidence shows considerable difference. Further analysis is in progress.

Summary & Conclusion

To extract pre-fission neutron multiplicity, a measurement of neutron energy (TOF) spectra in coincidence with fission have been carried out for ^{7}Li+^{203}Tl system at E^{*} = 43.8 MeV . Neutron energy spectra of ^{252}Cf source have also been measured to determine the efficiency of the setup. Data analysis is in progress. Results will be compared with statistical model prediction to understand the mechanism of neutron emission during fission at low energies.

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