Prompt fission neutrons and gamma-rays measurement in fast neutron induced fission of ^{237}Np

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Introduction

The investigation of prompt fission neutron and gamma ray (PFNG) emissions during fast neutron-induced fission offers exclusive insights into the allocation of excitation energy and the creation of angular momentum among fission fragments and their dependence on intermediate compound nucleus properties[1, 2]. Furthermore, it holds substantial promise for diverse nuclear applications and technological advancements such as detection of Special Nuclear Materials (SNM), research into nuclear transmutation, the progression of Accelerator-Driven Systems (ADS), and the evolution of Generation IV reactor technologies[3].

In the past measurements were carried out in fast neutron induced fission of ^{232}Th target [4, 5] utilizing the different proton beam energies from FOTIA facility, BARC. Given the limited availability of PFNG nuclear data for ^{237}Np isotope, a series of such measurement is planned for the fast neutron induced fission of ^{237}Np target as a function of incident neutron energies. In this work we present preliminary findings from our measurement from neutron induced fission carried at $\langle E_n \rangle$ ~3 MeV on ^{237}Np target.

Experimental Details

Measurement of prompt fission neutrons and gamma rays were carried out using fast neutron induced fission on ^{237}Np target at FOTIA facility, BARC(Mumbai). Proton beam of 5 MeV was used to generate fast neutrons of average energy $\langle E_n \rangle \sim 3$ MeV via ^{7}Li(p,n) reaction. Two cylindrical organic liquid scintillators (EJ301 with dimension ϕ 5" x 2") and two inorganic $CeBr_3$ (ϕ1.5" x 1.5") detectors were used for neutron and gamma measurements respectively. Both liquid scintillators (LS) were placed at sufficient distance of ∼ 80 cm from fission target to optimize the detection efficiency as well as making the neutron time of flight(TOF) measurement possible. The thin foils of ^{237}Np, with effective thickness of $\sim$ 200 $\mu g/cm^2$, was pasted on both sides of central cathode of the double sided fission trigger chamber. A positive voltage of 450 V was applied to the anodes. Photograph of the experimental setup is shown in Fig. 1.

FIG. 1: A photograph of experimental setup used.

Each $CeBr_3$ detector [6] was kept at electronic threshold of ∼65(±5)keV while the LS detectors were set at an electronic threshold of ∼52(±5)keV and ∼64(±5)keV respectively. The VME based data acquisition system LAMPS was used to acquire the processed signals data via an ADC and a TDC module. The trigger for the data acquisition system was obtained from the energy loss signal in the ionization chamber produced by the fis-

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sion fragments. Fission trigger was also used as the reference (start signal) for obtaining the timing signals of all the detectors used.

Analysis

The partial energy deposited by the fission fragments within the air volume of the ionization chamber is shown as a pulse height spectrum in Fig. 2. A clear distinction between alpha and fission like events is marked with a vertical dashed line. Fission gated coincidence neutron TOF and gamma rays spectrum were generated for each run and finally summed together to get the cumulative spectra from each detector. Fig. 3 shows the energy vs timing plot in one of the $CeBr_3$ detectors.

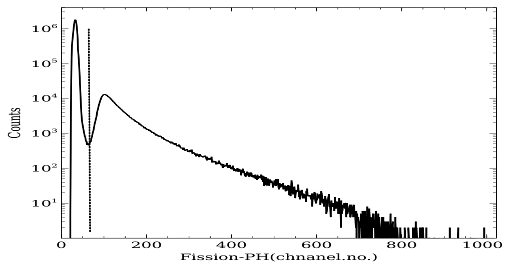

FIG. 2: Fission trigger chamber pulse height spectrum.

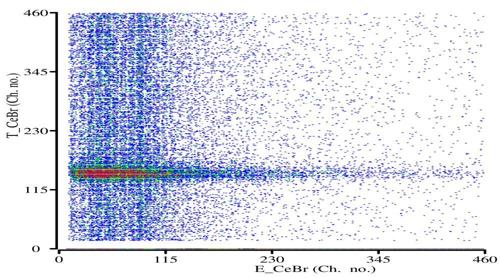

FIG. 3: Fission gated energy vs time spectrum in one of the $CeBr_3$ detector.

The projection of gamma energy spectrum from fig. 3, making use of the proper prompt time window, is shown in fig. 4. This spectrum is convoluted with the $CeBr_3$ detector response function which further needs to be corrected via unfolding to extract the true emission spectrum. In fig. 5, neutron TOF spectrum of one of the LS is depicted after applying a cut on the neutron pulse shape. A constant background mostly due to chance coincidences of primary neutrons from ^{7}Li(p,n) can also be seen in the TOF spectrum. Further analysis to extract the emission spectrum and characteristics for both prompt neutrons and gamma-rays is underway.

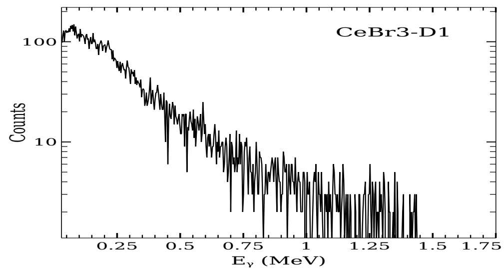

FIG. 4: Coincident gamma-rays spectrum in one of the $CeBr_3$ detectors.

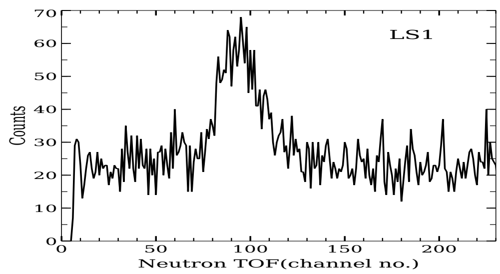

FIG. 5: Coincident neutron TOF spectrum in one of the LS detectors.

Acknowledgments

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