Neutron multiplicity measurement for α+^{232}Th reaction

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Introduction

The changing deformation of CN, which leads to the formation of fission fragments (FF), is a dynamic process, with neutron emission being one of the primary decay channels during this process. ν_{pre} is defined as the number of neutrons emitted during the transition of the CN from its initial shape to the scission point. The pre-scission neutron multiplicity (ν_{pre}) serves as a valuable probe to understand how a compound nucleus (CN) evolves towards fission [1]. It has been observed that the experimental ν_{pre} values are typically higher than the theoretical values predicted by the Bohr-Wheeler fission width within the statistical model, a discrepancy arising due to fission delay. This in turn is considered as dissipation in the fission dynamics. Nuclear dissipation is an area of intense study, as its exact nature and magnitude are still not fully understood. To determine the dissipative strength β, ν_{pre} data are usually fitted to the model calculations. Recent work has shown that while the statistical model can simultaneously reproduce measured fission and evaporation residue cross sections, it fails to match ν_{pre} values for a range of nuclei in the mass region 158 < A_{CN} < 225 [2]. Most of the previous measurements have been done with heavy ion beams, where contribution of non-compound process in the ν_{pre} value can not be ignored [3]. Consequently, we conducted measurements using α beams to determine the dissipation coefficients in a fissile system, where contributions from non-compound process is negligible. For this study, ^{4}He + ^{232}Th reaction was chosen, where ^{236}U was populated in the excitation energy E^*_{CN} range 20.98 MeV to 38.68 MeV. It is anticipated that the emitted neutrons will solely originate from compound nuclear fission, allowing the extracted β values to accurately reflect the true strength of nuclear dissipation.

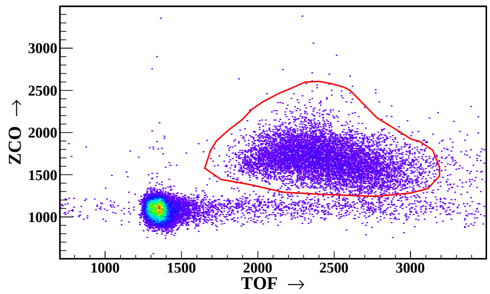

FIG. 1: ZCO-TOF spectrum from one of the neutron detectors.

Experimental Details

The experiment was conducted at the VECC K-130 cyclotron facility using a ^{4}He beam with energies ranging from 26 to 44 MeV, directed at a self-supporting ^{232}Th target with a thickness of 2 mg/cm^2. Two Parallel Plate Avalanche Counters (PPACs) were positioned at a distance of 9.5 cm from the tar-

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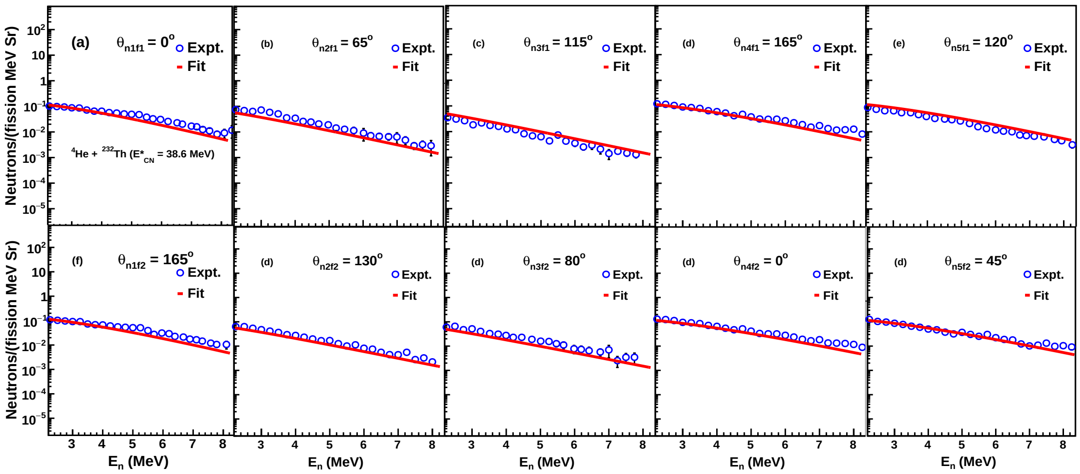

FIG. 2: The measured neutron energy spectrum gated with the fission event of PPAC detector for E^{*}_{CN}=38.6 MeV. The fission neutron correlation angle are shown in each panel.

get center, at laboratory angles of 90° and 75° on either side of the beam direction, to detect the fission fragments. Five liquid scintillator (BC501A) detectors were set up outside the scattering chamber, 1.25 meters from the target center, to measure the emitted neutrons.

The data acquisition was carried out using the VME based data acquisition system. The neutron energies were determined using the Time of Flight (TOF) technique, with the start time triggered by the coincidence of the RF signal from the cyclotron and a signal from one of the PPACs [4].

Data Analysis and Results

Neutron detectors are capable of detecting two types of events; neutrons and γ-rays. To differentiate between these, Pulse Shape Discrimination (PSD) based on zero-crossing and the Time of Flight (TOF) technique were employed. Figure 1 illustrates the ZCO-TOF spectrum from one of the neutron detectors. The efficiency of the neutron detectors was precisely measured using the ^{252}Cf source. To extract the neutron events from γ events, a two-dimensional neutron gate was applied to the calibrated neutron TOF spectra. The neutron energy spectra were then generated from the gated TOF spectra. Figure 2 displays the fission-gated neutron energy spectra for various angles at E_{lab}= 44 MeV respectively.

The pre- and post-scission components of neutron multiplicity were derived from the measured neutron energy spectra using a multiple-source least squares fitting procedure based on Watt's expression [5]. The preliminary fitting parameters obtained are: T_{pre}=1.49±0.015, T$_{post}$=0.97±0.009, ν_{pre}=2.7±0.04, ν_{post}=1.5±0.009 at E_{lab}=44 MeV, and T_{pre}=1.27 (fixed), T_{post}=1.09±0.017, ν_{pre}=1.99±0.066, ν_{post}=1.48±0.015 at E_{lab}=40 MeV. Detailed data analysis for all energy points and theoretical calculations will be presented at the symposium.

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