Mass gated Neutron Multiplicity in the $^{12}C + ^{238}U$ system at an excitation energy of 45.6 MeV

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Introduction

Nuclear fission is a subject of great interest even after eight decades of its discovery because of its applications in nuclear energy, synthesis of superheavy elements and understanding the anomaly in reactor antineutrino spectrum. The parameters such as Businaro-Gallone mass asymmetry (α_{BG}), fissility (χ), and fission barrier to temperature (B_f/T) ratio of the fissioning nucleus have played a crucial role in deciding the fusion-fission time scales [1, 2]. It has been observed that prescission neutrons are relatively higher compared to the statistical model predictions indicating the dynamical effect of the nuclear process. In other words, more the number of pre-scission neutrons, more slower is the fission process. In more recent work the excess pre-scission neutrons in comparison to the statistical model predictions have been converted into total fission time (τ_{tot}) [1]. In this work, authors have also shown that observed fission time in the heavy ion induced reactions can be quantitatively understood by considering the different formation time (τ_{fr}) predicted by the dynamical model code. In view of these exciting results, we are motivated to explore the fusion-fission dynamics in the $^{12}C + ^{238}U$ system as a function of neutron multiplicity at 73 MeV of bombarding energy. The objective of the present experiment is to extract pre- and post-scission neutron multiplicities and understand their dependence over mass as well as total kinetic energy (TKE) of fission fragments (ff).

Experimental Details

The present experiment was carried out at the BARC-TIFR Pelletron LINAC Facility located at TIFR, Mumbai. Pulsed beam of ^{12}C with 73 MeV beam energy (E_{beam}) with a pulse separation of 107 ns was bombarded on the ^{238}U target of thickness 100 μg cm^{-2} sandwiched between two carbon targets of thickness 15 μg cm^{-2} to populate the compound nucleus ^{250}Cf. The ^{238}U target was mounted at the centre of a general purpose scattering chamber (GPSC) of 1.25 cm wall thickness and 150 cm diameter. Multi Wire Proportional Counter (MWPC) detectors were used to detect the complementary fission fragments simultaneously [3]. One of the MWPC detectors was kept at an angle of 60° with respect to beam direction whereas the second MWPC detector was kept at an angle of 105° with respect to beam. Both these detectors were 42.5 cm away from the target position on movable arms on either side of the beam axis. Three liquid scintillators [4] placed at 0°, 65° and 90° with respect to one of the fission fragments which were situated at a distance of 85 cm from the target are used to detect the neutrons in coincidence with the binary fission fragments.

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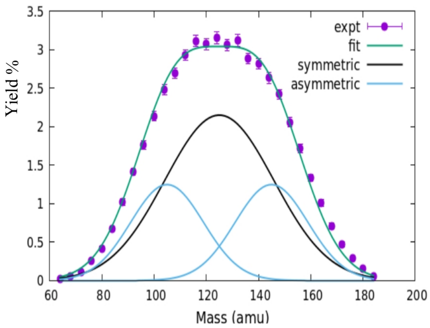

FIG. 1: Fission fragments mass distribution at E_{lab}= 73 MeV.

Data Analysis and Results

Using the measured velocities of the fission fragments and simple two-body kinematics, the masses and kinetic energies of the fragments have been determined event by event assuming that the sum of the projectile and target masses equals the compound-nuclear mass (A_{CN} = A_P+A_T)[5]. The mass distribution of fission fragments produced from ^{250}Cf nucleus for E_{beam} = 73 MeV is shown in Fig. 1. The best fit is achieved with three Gaussian distributions. Contributions from asymmetric fission is mainly coming from multichance fission. By following the method described in Ref. [1], mass gated pre- and post-scission neutron multiplicities have been deduced and are mentioned in table I. Deduced neutron multiplicities show higher pre-scission multiplicity for asymmetric mass region in comparison to symmetric mass region. From Fig. 2 it is noticed that as TKE increases the pre-scission neutron multiplicity decreases and post-scission neutron multiplicity remains more or less the same. The detailed study will be discussed during the presentation.

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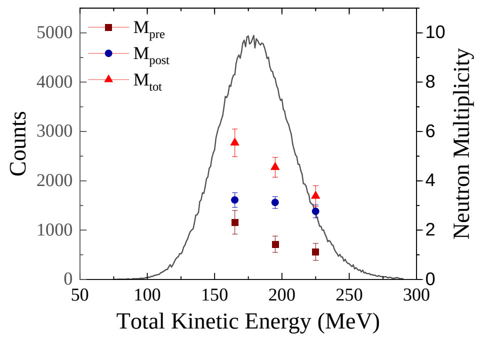

FIG. 2: Total projection of TKE in the selected mass range (64-186 μ) together with the deduced pre-scission (squares), single-fragment post-scission (circles), and total (triangles) neutron multiplicities.

TABLE I: Deduced mass dependent neutron multiplicities.

NM[a]	Mpre	Mpost	Tpre	Tpost
Avg[b]	1.98±0.34	1.58±0.12	1.27±0.21	1.04±0.10
Sym[c]	1.70±0.48	1.70±0.20	1.23±0.29	1.07±0.12
Asym[d]	2.30±0.58	1.48±0.13	1.07±0.22	0.95±0.12

[a]Neutron Multiplicity.
[b]Neutron Multiplicity corresponding to full ff mass distribution.
[c]Neutron Multiplicity corresponding to symmetric mass cut.
[d]Neutron Multiplicity corresponding to asymmetric mass cut.

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