Measurement of fission fragment mass distribution in ^{19}F + ^{169}Tm reaction

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Unexpected observation of asymmetric mass split of ^{180}Hg in β-delayed fission [1] has initiated intense experimental and theoretical investigations in neutron deficient pre-actinide nuclei [2]. It has, for the first time, opened-up the possibility to investigate the delicate interplay between the macroscopic liquid drop and the microscopic single particle aspects to test the fission models outside the region, namely actinide, where they are developed. While the state of the art five-dimensional (5D) macroscopic-microscopic model calculations [1, 3] attributed these observations to a relatively small microscopic effects that make the fission saddle point and the nearby valley mass-asymmetric, the deformation dependent shell effects in the final fragments were found to be crucial in deciding the mass distribution in the improved scision point model [4, 5]. and prdiced Recently, self-consistent microscopic models are also being employed in order to get deeper insight [2]. In general, these theoretical models predict a new island of mass-asymmetric fission in the sub-Pb region with a strong persistence of these single particle effects even at higher excitation energies.

β-delayed and electromagnetically induced fission, due to low excitation energy, are most sensitive to single particle correction. However, these studies are so far limited to only few cases and poor in statistics due to extremely challenging experimental conditions. Heavy-ion induced fusion-fission route has also been exploited to study the mass-asymmetric fission and its evolution with excitation energy in neutron deficient sub-lead nuclei using beams of ^{35}Cl, ^{36}Ar and ^{40}Ca. The deviations in the measured mass distributions from single Gaussian shapes at excitation energy $\approx$ 25 MeV above the fission barrier were associated to the observed mass asymmetry in β-delayed fission at very low excitation energy. In a recent study [6], the presence of quasi-fission in neutron deficient sub-lead region was observed by populating the same compound nucleus via two different entrance channel. More measurements are required to investigate the predicted generic nature of mass-asymmetric fission and role of quasi-fission in the neutron deficient sub-lead region. With this motivation, we have carried out a measurement of mass and kinetic energy distribution for ^{19}F+^{169}Tm system at low excitation energies.

The experiment was carried out at BARC-Pelletron LINAC Facility, Mumbai. The pulsed beam of ^{19}F with energies 80, 85, 92, 99, and 103 MeV respectively was bombarded on self-supporting ^{169}Tm target having thickness of about 210μg/cm^2. Two (large area) multiwire proportional counters (MWPCs) [7] were used for fission fragment detection in coincidence. The detectors were kept at distance of 24 cm from the target at 45° and -105° with respect to the beam axis. Both the detectors were filled with isobutane gas at about 3 torr operating pressure. Time-of-flight (TOF) with respect to the arrival of the beam pulse, position (x,y) and energy loss information were recorded event-by-event mode.

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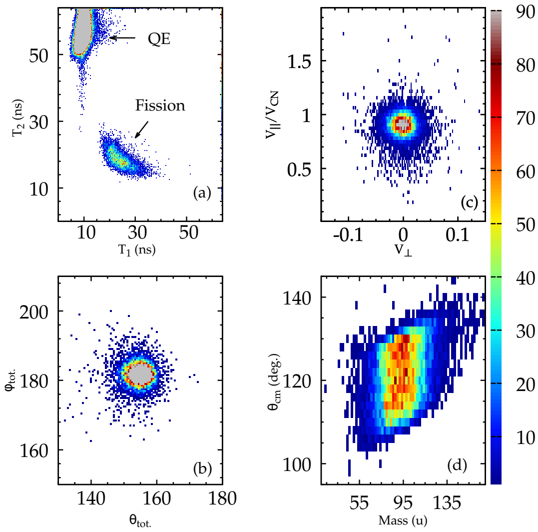

FIG. 1: (a) Time-of-flight (TOF) spectra to separate fission from quasi-elastic events. Correlation of (b) folding angle and azimuthal angle, (c) perpendicular and parallel component of velocity and (d) mass and angle corresponding to fission for ^{19}F+^{169}Tm at E_{lab}=85 MeV.

Velocity vectors of the detected fragments were determined using the TOF and position information. As shown in Fig. 1(a), T_1 vs. T_2 plot separates fission from quasi-elastic events very well and have been used to select fission events. Correlation plots of (Fig. 1(b)) folding angle ($\theta_{tot.}$) vs. azimuthal angle ($\phi_{tot.}$) and (Fig. 1(c)) parallel vs. perpendicular component of velocity were constructed to confirm the binary nature of the reaction. Linear momenta were calculated using the emission angle determined from the position information.

Finally, fragment mass were calculaed using the time-of-flight difference and linear momenta as well as velocities. Observation of no significant mass-angle correlation confirms the absence of fast quasi-fission. Typical experimental mass distribution is shown in Fig. 2 along with single Gaussian fit. Though the overall distribution could be fitted well with a single Gaussian function,

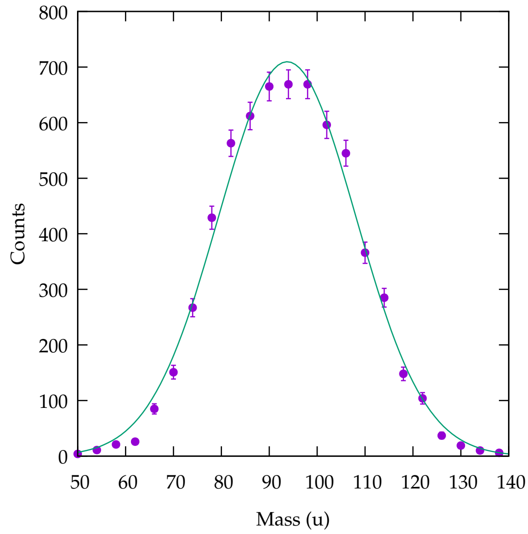

FIG. 2: The experimental mass distribution along with single Gaussian fit for ^{19}F+^{169}Tm at E_{lab}=85 MeV

small deviation has been observed around the middle of the distribution, similar to the observation made in Ref. [6]. Comparison of the experimental mass distributions with the prediction of statistical relation and GEF code, to investigate the role of microscopic single particle energy and quasi-fission, will be presented .

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