Fission fragment mass distribution in ^{19}F+^{238}U reaction

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Introduction

There has been a lot of interest in the study of fusion -fission dynamics at near barrier energies in the actinide region because of its importance in synthesizing super-heavy elements. Due to the presence of non-compound fission processes such as quasi-fission, the formation of super heavy elements gets hindered. Therefore, it is very much important to observe the presence or absence of quasi-fission processes in a reaction involving actinide targets and heavy projectiles.

In the recent past, contradictory results have been reported in the literature on the presence of the quasi-fission process even in the same reaction by different groups. Ghosh *et al.* [1, 2] have reported the presence of quasi-fission for ^{16}O+^{232}Th and ^{19}F+^{232}Th systems on the basis of sudden increase of mass width of fission fragment mass distribution (FFMD) at below barrier energies. Later on the above result for ^{19}F+^{232}Th system was contradicted by Yanez *et al.*[3], who also additionally reported on the absence of quasi-fission for other two ^{16}O+^{235,238}U reactions from the same FFMD measurement. Further Banerjee *et al.*[4] have reported the presence of quasi-fission in ^{16}O+^{238}U reaction at sub-barrier energies. In this scenario, we try to look for the presence of quasi-fission on another system ^{19}F + ^{238}U by measuring fission fragment mass distribution and aim to solve the above controversy.

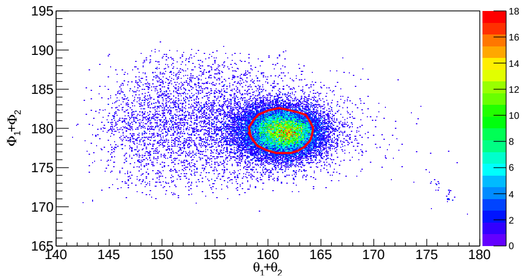

FIG. 1: (Color online) A typical $\theta_1+\theta_2$ vs. $\phi_1+\phi_2$ plot obtained at 96.3 MeV beam energy. The red contour indicates the events corresponding to full momentum transfer.

The experiment

The experiment on ^{19}F + ^{238}U reaction was carried out at 14-UD BARC-TIFR Pelletron-Linac facility, Mumbai using pulsed beam with energies ranging from 93.9 MeV to 142 MeV. A ^{238}U target of thickness ∼ 100 $\mu g/cm^2$, sandwiched between two layers of ^{12}C of thickness ∼ 15 $\mu g/cm^2$ each, was used in the experiment. Two position sensitive multi-wire proportional counter (MWPC) detectors having active area of 12.5 cm × 7.5 cm were placed at folding angles to detect coincident fission fragments [5]. From the timing correlation spectra of two fission fragments, they were separated from other events. Position spectra were calibrated using a mask and

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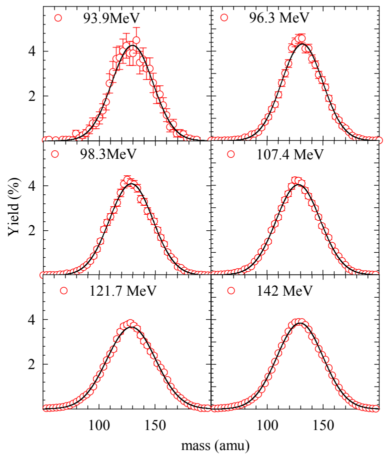

FIG. 2: (Color online) Mass distribution obtained in ^{19}F + ^{238}U reaction at different projectile energies.

timing calibration was done using a timing calibrator. From the known positions θ and ϕ information were obtained for each event. A typical $(\theta_1 + \theta_2)$ vs. $(\phi_1 + \phi_2)$ plot obtained at 96.3 MeV beam energy has been shown in Fig. 1, which shows a clear distinction between full momentum (mainly complete fusion-fission) and partial momentum transfer events (transfer induced fission). The events corresponding to full momentum transfer events as shown by a red contour in Fig. 1 were analyzed to obtain the fission fragment mass distributions (FFMD). Now applying the timing difference method the FFMD were obtained for the projectile energies ranging from 93.9 MeV to 142 MeV (excitation energy range $\sim$ 46 to 92 MeV) as shown in Fig. 2.

As shown in Fig. 3, each of the distributions were fitted using single gaussian function (solid line) and width of the distributions was obtained as a function of beam energy normalized to Coulomb barrier . Now the measured mass widths are compared with the ones reported in literature in the same Fig. 3. It can be observed that present mass width compares well with the ones measured by Yanez *et al.* for ^{16}O + ^{235}U (hollow triangle), ^{16}O + ^{238}U (hollow square) and ^{19}F + ^{232}Th (hollow star) system, where mass widths are either constant

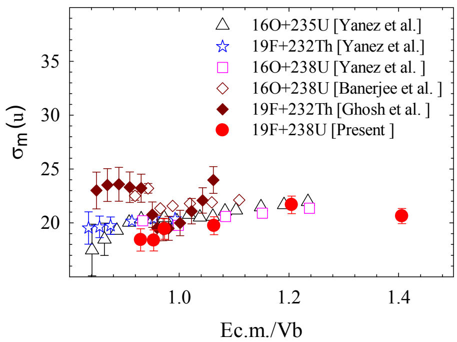

FIG. 3: (Color online) Mass widths of the FFMD (red filled circle) in ^{19}F + ^{238}U reaction are compared with the literature data for different reactions.

or monotonically increasing with the increasing beam energy. The present mass width does not show any unexpected enhancement at below barrier energies as observed in Ref. [4] for ^{16}O + ^{238}U system (hollow rhombus) and in Ref. [1] for ^{19}F + ^{232}Th system (filled rhombus). Therefore our observation supports the observation made by Yanez *et al.* up to the lowest measured energy.

Conclusion

Fission fragment mass distribution was measured in ^{19}F + ^{238}U reaction. Mass-width was found to be consistent with the observation by Yanez *et al.*, where no anomalous increase in the width was observed. Therefore, absence of quasi-fission for ^{19}F + ^{238}U reaction was concluded up to the lowest measured energy.

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