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Study of fusion-fission dynamics in $^{19}F+^{238}U$ reaction

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Abstract

Mass angle distribution measurements for $^{19}F+^{238}U$ reaction were carried out around the sub barrier energies. Mass angle correlation has not been observed at above and below the fusion barrier in present reaction. This infer the minimal presence of non compound like events at these bombarding energies range.

1 Introduction

Over the years, a large number of experiments have been performed to study the dynamics of fusion-fission mechanism in heavy ion induced reactions. These studies are important for better understanding of the reaction dynamics involved in the formation of super heavy elements in laboratory [1]. Apart from pure fusion-fission, the existence of pre-equilibrium fission and

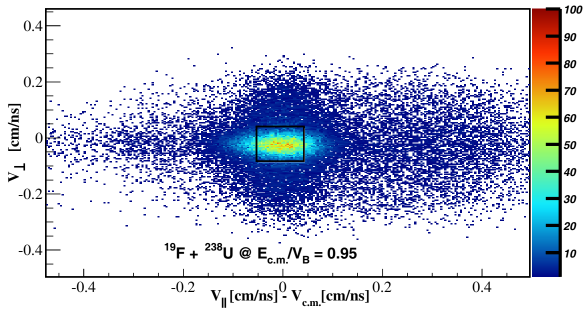

Figure 1: Measured distribution of FF velocity components at 5 % below the fusion barrier. Full momentum transfer fission events are shown inside black rectangular box.

quasi-fission add further complexity to the reaction dynamics [2–4] . They are found to be the competing reaction channels for light ion induced reactions with actinide targets. Though many studies have been performed in this mass region, there are still inconsistencies in the results of many of these reactions. For example, the angular anisotropies of fission fragments (FF) measured in reactions ^{19}F, ^{16}O, ^{12}C + ^{232}Th, ^{238}U have been found inconsistent with the statistical saddle point model (SSPM) predictions [5–7]. Hence for understanding the anomaly of this mass region, we performed the measurement of mass angle distribution (MAD) of FF in the reaction ^{19}F+^{238}U.

2 Experimental details

Measurements of fission fragments from reaction ^{19}F + ^{238}U were carried out at the 15UD Pelletron accelerator facility of Inter University Accelerator center (IUAC), New Delhi. ^{19}F pulsed beam with energy 96 MeV and 112 MeV was used to bombard the ^{238}U target. The thickness of enriched target ^{238}U was about $\sim$ 110 μg/cm^2. It was sandwiched between the carbon layers of thickness of thickness $\sim$ 20 μg/cm^2. The FF were detected in to large area multi-wire proportional counters (MWPCs) [8]. Front detector was placed at 35 cm from target centre covers the scattering angle from 25°-60°. The back detector was placed at a distance of 27 cm away from the target centre covers the scattering angle from 105°-135°. Two silicon detectors were placed at ±10° with respect to the beam axis to monitor the beam position on the target during the experiment.

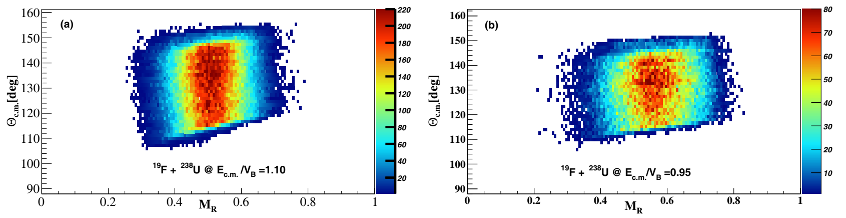

Figure 2: FFs mass angle correlations for reactions $^{19}F+^{238}U$ at a) above the fusion barrier ($E_{c.m.}/V_B$=1.1) and b) below the fusion barrier ($E_{c.m.}/V_B$=0.95) are shown. No mass angle correlation for $^{19}F+^{238}U$ are observed around this barrier energies.

The velocity component $V_\perp$, in the plane perpendicular to the beam axis was determined from the projection of the fragment velocities onto the azimuthal plane. FF velocities in laboratory frame were calculated by using polar angles and Viola systematics [9]. Parallel components of velocity ($V_\|$) were adjusted such that it became equal to velocity of compound nucleus in the centre of mass frame ($V_{c.m.}$) which is pre-condition for full momentum transfer in fission process, i.e, (($V_\|$ -$V_{c.m.}$, $V_\perp$)=(0, 0)) which has been as shown in inside the rectangular gate of Figure 1. Only the events within the black rectangle marked as FF were used to gate the mass spectrum (Fig 1).

3 Result

The dependence of mass ratio on emission angle in center of mass frame ($\theta_{c.m.}$), known as mass-angle-correlation, is a probe to disentangle the compound and non-compound nucleus fission processes. The mass ratio yield is independent of the emission angle of FFs coming from compound nucleus process, however, the yield for FF coming from non-compound processes exhibit the dependence on $\theta_{c.m.}$. In the present work, the mass-angle-correlation have been studied for $^{19}F+^{238}U$ at near and above barrier energies. As a representative case, the mass-angle-correlation for this reaction around barrier energies are shown in Fig. 2. Here, the correlation angles ($\theta_{c.m.}$) are lying $\approx 100°$ to $160°$. It is evident from figures that mass ratio yield is independent of emission angle. Thus the absence of correlation between mass ratio yield and $\theta_{c.m.}$ in present nuclei concluded the minimal presence of non compound nucleus processes around the barrier energies. Similar observations for $^{12}C+^{238}U$, $^{16}O+^{238}U$ [10, 11] have been observed.

4 Conclusion and summary

MAD for $^{19}F+^{238}U$ reaction were measured at the 5% below and 10% above the fusion barrier energies. The reaction products, mainly fission fragments were detected by two large area MWPCs. The absence of correlation between mass ratio yield and $\theta_{c.m.}$ has been observed for present reaction. The characteristics of mass angle correlation for $^{19}F+^{238}U$ exhibit similar to the $^{12}C+^{238}U$ and $^{16}O+^{238}U$ reactions. This infer the fission mechanism of ^{12}C, ^{16}O, ^{19}F $+^{238}U$ reactions indicate the minimal yield of non compound like events around sub barrier energies range.

Acknowledgments

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