Fission fragment angular distribution measurements for the ^{28}Si + ^{180}Hf reaction

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Introduction

In heavy ion reactions involving massive projectiles and targets the observed fission events is often seen as a mixture of two types of fission namely compound nucleus fission (CNF) and non compound nucleus fission (NCNF). Fast fission, quasifission and pre-equillibrium fission are examples of NCNF. Experimental signatures of NCNF includes ER cross section suppression, increase in the width of fission fragment mass distribution (FFMD), anomalous fission fragment angular anisotropy, fission fragment mass angle co-relation etc. Disentangling the non-compound nucleus fission from CN fission is a difficult task as the experimental observables overlap significantly. Fission fragment angular distribution is usually explained using transition state models. Any deviation from the transition state model predictions is generally attributed to the onset of NCNF processes. Here we report the fission fragment angular distribution measurement of ^{28}Si+^{180}Hf system.

Experimental details

The measurement was done at the Inter University accelerator center (IUAC), New Delhi. Pulsed beams of ^{28}Si with pulse seperation of 250 ns from 15-UD Pelletron + LINAC accelerator facility in the energy range 145-204 MeV were used to bombard the ^{180}Hf target of 150 μg/cm^2 thickness (on 40 μg/cm^2 thick carbon backing). The experiment was carried out in the scattering chamber of National Array of Neutron Detectors (NAND) [1] facility in the Beam Hall 2 of IUAC. The binary fission fragments were detected using 16 hybrid telescope detectors (HYTAR) [2, 3]. Hybrid telescopes, having combination of gas (ΔE) and silicon detectors (stopping), is used for heavy ion detection and particle identification. The ionization chamber (ΔE) measures the energy loss and the silicon detector (E) detects the residual energy. Fig.1 shows the two dimensional plot of residual energy (E) versus energy loss (ΔE) of the reaction products at lab angle 173^o for the ^{28}Si+^{180}Hf reaction at beam energy of 145 MeV. It can be seen that the fission fragments are well separated from other reaction products. Two passivated implanted planar silicon (PIPS) detectors of thickness 300 μm were positioned at 13^o with respect to beam direction to monitor the beam. The

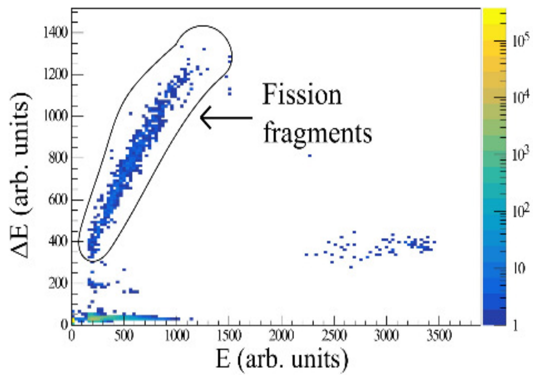

FIG. 1: Scatter plot of energy (E) versus energy loss (ΔE) of reaction products for the system ^{28}Si+^{180}Hf at 145 MeV beam energy with the hybrid telescope detector kept at 173^o lab angle.

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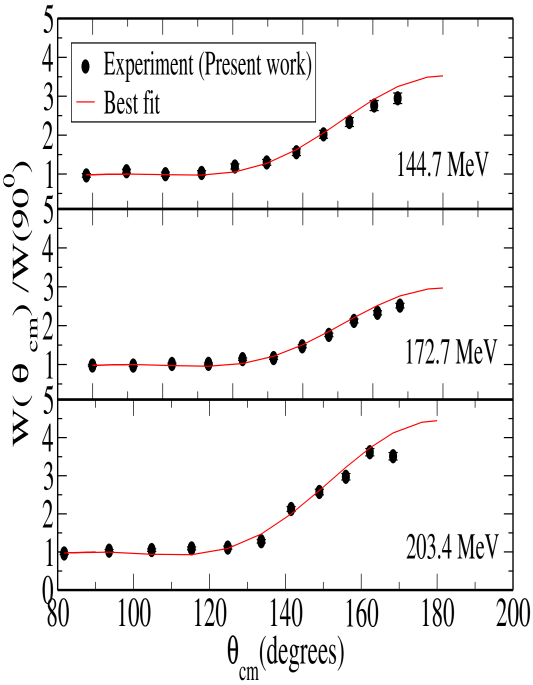

FIG. 2: Measured fission fragment angular distributions along with the best fit for the reaction ^{28}Si+ ^{180}Hf.

Rutherford events registered in these detectors were used for the absolute normalization of fission cross sections.

Data analysis

Fission fragments were distinguished from other reaction products based on the energy loss and residual energy. Differential fission cross sections in the laboratory frame $(d\sigma/d\Omega)_{\theta_{lab}}$ were transformed to center of mass frame by assuming symmetric mass division and using Viola systematics [4] for fission fragment kinetic energies. The fission fragment angular distribution in the center of mass frame $(d\sigma_{fis}/d\Omega)_{\theta_{cm}}$ is calculated by the equation

$$(\frac{d\sigma_{fis}}{d\Omega})_{\theta_{cm}} = \frac{1}{2}\frac{Y_{fis}}{Y_{mon}}(\frac{d\sigma}{d\Omega})_R\frac{\Omega_{mon}}{\Omega_{fis}}G \qquad (1)$$

where Y_{fis} and Y_{mon} are the yields of the fission fragments and Rutherford events respectively. $(d\sigma/d\Omega)_R$ is the differential Rutherford cross section in the laboratory frame of reference, Ω_{mon} and Ω_{fis} are the solid angles subtended by the monitor and fission detectors, respectively. G is the Jacobian which transforms the laboratory frame to center of mass frame. Total fission cross section σ_{fis} is calculated by integrating the differential cross sections.

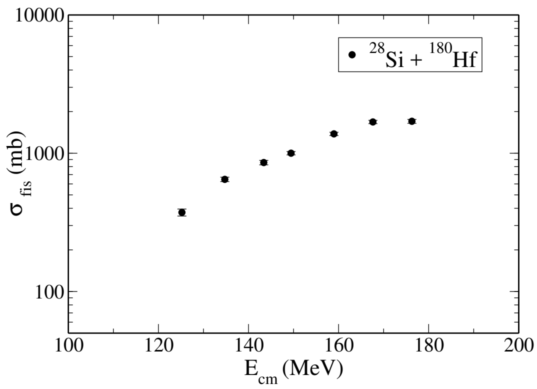

FIG. 3: Total fission cross section for the ^{28}Si+ ^{180}Hf reaction as a function of center of mass energy.

Result and conclusion

Fig.2 shows the fission fragment angular distribution for the system for three different energies along with the best fits. Total fission cross section is obtained by integrating the differential cross sections. Fig.3 shows the total fission cross section for this system. The experimental fission fragment anisotropy shows signatures of the onset of NCNF processes in this reaction.

Acknowledgments

We thank Pelletron and LINAC group of IUAC for providing good quality beam through out the experiment.Two of the authors (ACV) and (SM) acknowledges Kerala State Council for Science, Technology and Environment (KSCSTE) in the form of a fellowship.

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