Mass gated neutron multiplicity measurements in ^{19}F+^{208}Pb system

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Introduction

Study of heavy ion induced fusion-fission by measuring neutrons in coincidence with fragments can provide a comprehensive picture about different modes of fission process. The correlation of pre-scission neutrons, M_{pre} with fission observables such as fragment mass, kinetic energy, etc. have been studied in the past [1, 2] to identify the nature of fission. Mass Gated pre-scission Neutron multiplicity (MGN) measurements by Hinde *et al.* in ^{18}O+^{197}Au system exhibits a parabolic dependence of M_{pre} to fragment mass in fully equilibrated fusion-fission at higher excitation energies [1]. The mass distribution was found to be symmetric and M_{pre} increases with fragment mass up to symmetric split and decreases thereafter.

MGN measurements in actinide region by Itkis *et al.* in ^{18}O+^{208}Pb shows that the systems follow asymmetric mass distribution at lower excitation energy [2]. It was found that M_{pre} is lower in symmetric mass gate compared to asymmetric mass region. The increase in M_{pre} in asymmetric mass region was attributed to shell effects in the fissioning system.

Recently, Dubey *et al.* [3] have reported the evidence of shell influenced mass asymmetric fission in ^{19}F+^{208}Pb at excitation energies below 35 MeV. So, a study of MGN in this system at medium and higher excitation energies would reveal the presence of fragment shells at these energies.

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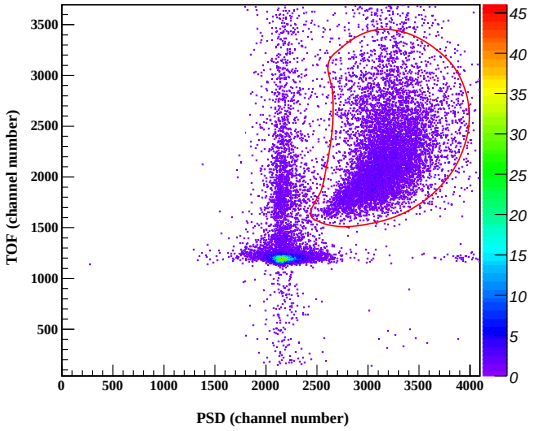

FIG. 1: Neutron gamma separation by PSD and TOF. The marked region shows neutron triggered events

In this article, we report the analysis and results of MGN measurements in ^{19}F+^{208}Pb system at 42 and 50 MeV excitation energies. The details of experiment set up and facility used are given in [4, 5]

Data analysis

Mass ratio distribution was derived by velocity reconstruction method. Fission fragments were identified from the flux of scattered beam by Time of Flight (TOF) and folding angle correlation. Proper software cuts were applied to separate full momentum transfered (FMT) events from transfer induced fission. Fission fragment velocities were estimated from TOF and finally, the mass ratio distribution was derived from the centre

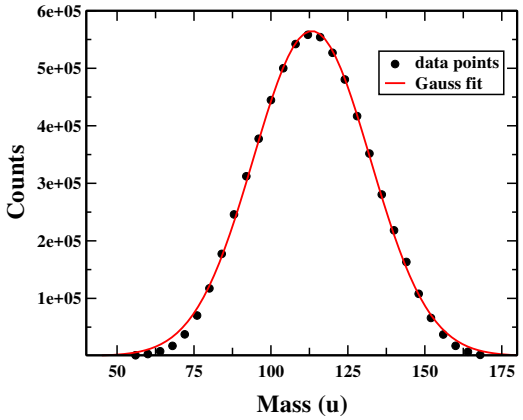

FIG. 2: Mass distribution of fission fragments at 100 MeV lab energy along with a Gaussian fit.

of mass velocities of fragments.

Neutrons were discriminated from gamma rays by pulse shape discrimination technique and TOF which is shown in the figure 1. The neutron TOF spectrum was converted to energy histogram considering prompt gamma peak as the time of reference and proper corrections were applied in terms of efficiency, solid angle, etc. Three sources of neutron are considered in heavy ion induced fusion fission reactions: the compound nucleus and two fission fragments. The energy and angular distribution of neutrons are dependent on neutron sources. M_{pre} was extracted by moving source fit based on the kinematics of neutron emission which is formulated in [6]. A global fit to neutron energy spectra at different angles was used to obtain the parameters by minimizing chi-square.

Obtained neutron multiplicity was further constrained by applying two mass gates to explore its mass dependency. The width of mass gates (symmetric and asymmetric) was chosen to have sufficient statistics for moving source fit.

Results and Discussion

The mass distribution at 42 MeV excitation energy is shown in the figure 2. The mass distribution at both 42 and 50 MeV excitation energies can be fitted well with a single Gaussian and it does not show any structure effects. Surprisingly, MGN measurements do not follow the parabolic dependence reported in [1]. Both 42 MeV and 50 MeV excitation data analysis show that M_{pre} is higher in asymmetric mass gate compared to symmetric mass gate. The observed correlation is similar to [2] reported in actinide region at lower excitation energy where evidence of fragment shells are present in mass distribution. A detailed analysis to understand the origin of shell like mass-M_{pre} interdependence is in progress.

Acknowledgments

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