Mass-gated neutron multiplicity for ^{48}Ti+^{144,154}Sm systems

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Introduction

The mass-distribution (MD) and mass-energy distribution (MED) of fission fragments have contribution from fully equilibrated compound nuclear events and non-compound nuclear reactions, such as, quasi-fission (QF), fast-fission and pre-equilibrium fission, etc [1]. These processes have different reaction trajectories while a composite system evolves from the contact point to scission point. This results in different timescales of the fusion-fission and QF processes from the contact point to the scission point [2]. As fusion-fission reactions have longer timescale as compared to QF, there is considerable difference in the neutron multiplicities associated with these processes. Therefore, in order to have more precise picture of fusion-fission and QF processes, neutron multiplicity data has to be analyzed for different mass cuts of the fission fragments. The mass dependence of neutron multiplicities have been recently studied for the system ^{48}Ti+^{208}Pb systems forming ^{256}Rf CN after gating on the different regions (symmetric and asymmetric) of fragment MD and MED [3]. Very recently, the results for average neutron multiplicity have been reported for the ^{48}Ti+^{144,154}Sm [4]. In order to have better insight to the fission dynamics of Po compound nuclei, we have measured mass-gated neutron multiplicity for ^{48}Ti+^{144,154}Sm forming ^{192,202}Po compound nuclei at 72 MeV of excitation energy. This experiment was performed using the National Array of Neutron Detectors (NAND) at Inter University Accelerator Centre (IUAC), New Delhi. For more details on the experimental set up reader is refered to ref [4].

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Data Analysis and Results

We have analyzed the neutron energy spectra for different mass cuts for ^{48}Ti+^{144,154}Sm at 260 and 230 MeV respectively as mentioned in Table 1. The, pre- and post-scission components of the neutron multiplicity were derived from the measured neutron energy spectra using multiple source least square fitting procedure based on Watt's expression [4]. The experimentally measured folding angles and the energy per nucleon corresponding to each mass cut are found to be consistent with the Viola systematics and kinematical calculations [5]. Neutron multiplicities corresponding to full array obtained from fitting of the decay of ^{192,202}Po are given in Table 1 and the fitting plots corresponding to symmetric and asymmetric mass region for one of the neutron detectors for ^{48}Ti+^{144}Sm is shown in Fig. 1 a) and b) respectively.

The pre-scission neutrons are experimentally distinguished from post-scission neutrons by measuring the angular correlation between the fission fragment and the emitted neutron. For extracting the neutron-angular correla-

TABLE I: Fitted values of M_{pre}, M_{post}, T_{pre}, T_{post} and χ^2/NDF for ^{192}Po corrresponding to different mass cuts.

Mass cut (^{192}Po)	M_{pre}	$2M_{post}$	M_{total}	T_{pre}	T_{post}	χ^2/NDF
$36 \leq A_{FF} \leq 51$	0.65±0.04	0.94±0.04	1.59±0.04	1.70±0.08	1.25±0.08	2.6
$51 \leq A_{FF} \leq 81$	1.22±0.08	2.92±0.09	4.14±0.08	1.76±0.10	1.33±0.11	2.1
$81 \leq A_{CN/2} \leq 111$	1.49±0.06	3.60±0.07	5.09±0.07	1.80±0.08	1.36±0.08	1.8
Mass cut (^{202}Po)	M_{pre}	$2M_{post}$	M_{total}	T_{pre}	T_{post}	χ^2/NDF
$41 \leq A_{FF} \leq 56$	0.67±0.04	1.06±0.05	1.73±0.04	1.76±0.08	1.25±0.06	2.0
$56 \leq A_{FF} \leq 86$	1.77±0.10	3.92±0.14	5.69 ±0.0.15	1.77±0.09	1.30±0.08	2.8
$86 \leq A_{CN/2} \leq 116$	2.22±0.18	4.82±0.22	7.04±0.22	1.84±0.08	1.40±0.09	3.1

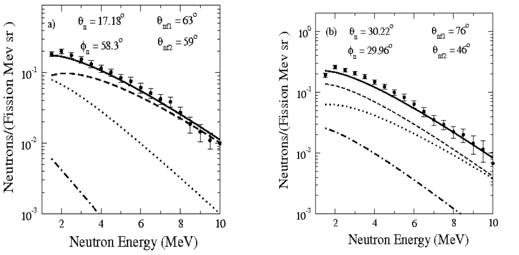

FIG. 1: Neutron multiplicity spectra for ^{48}Ti+^{144}Sm system at 72 MeV of excitation energy for some of the neutron detectors corresponding to a) symmetric and, b) asymmetric mass cut.

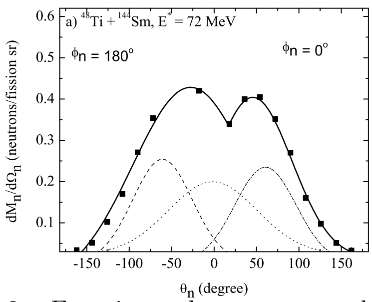

FIG. 2: Experimental neutron angular distribution (solid square) along with the angular distribution obtained from multiple-source fitting (solid line). The angular distribution of different sources; CN (dotted line), fragment1 (dashed line), fragment2 (dashed dotted line) for ^{48}Ti+^{154}Sm system at 72 MeV of excitation energy for different ϕ_n corresponding to symmetric mass cut.

tions, the differential neutron energy spectra is integrated over the neutron energy from 0-6 MeV in order to obtain the differential neutron yield. Fig. 2 shows the angular distribution of neutrons for in plane neutron detectors corresponding to symmetric mass cut for ^{48}Ti+^{144}Sm systems respectively, at 72 MeV of excitation energy.

Conclusion

The variation of neutron multiplicities on the fission fragment masses were studied for ^{48}Ti+^{144,154}Sm system at 72 MeV of excitation energy. It is noticed that M_{total} increases from 1.59±0.04 to 5.09±0.07 for ^{48}Ti+^{144}Sm and 1.73±0.04 to 7.04±0.22 for ^{48}Ti+^{154}Sm while transition from projectile like mass cut to symmetric mass cut. Similarly, M_{pre} is also found to increase from 0.65±0.04 to 1.49±0.06 for ^{48}Ti+^{144}Sm and 0.67±0.04 to 2.22±0.18 for ^{48}Ti+^{154}Sm while moving from projectile like mass cut to symmetric mass cut which can be justified on the basis of expected increase in the available excitation energy if one moves from projectile like mass cut to symmetric mass cut. It is inferred from the neutron angular distribution that the contribution for different sources depends significantly on the correlation angle between the fission fragment and the direction of emitted neutron.

References

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