Neutron multiplicity measurements for ^{48}Ti+^{144,154}Sm systems

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Introduction

The study of heavy ion induced fusion-fission (FF) reactions has become a topic of considerable interest in recent years. For nuclear reactions with heavy systems, along with pure FF process there is significant contribution from non-compound nuclear processes such as quasi-fission (QF) [1]. Several experimental as well as theoretical approaches have been adopted to understand the dynamics of FF process in heavy nuclei. For understanding the reaction mechanism of heavy ion induced FF reactions, our aim is to measure mass-gated neutron multiplicity, mass-energy correlation and fission cross-section for three systems: (i) ^{48}Ti+^{144}Sm→^{192}Po (ii) ^{48}Ti+^{154}Sm→^{202}Po and (iii) ^{16}O+^{186}Os→^{202}Po. For the system ^{18}O+^{192}Os→^{210}Po experimental data exists for neutron multiplicity, evaporation residue (ER) cross-section and fission excitation function [2, 3]. The chosen systems span the neutron deficient ^{192}Po (N=108) to neutron rich ^{210}Po (N=126) nuclei. For systems with heavier projectile, sizeable contribution from QF process is expected. Also, ^{144}Sm is nearly spherical (β = 0.088) and ^{154}Sm is deformed (β = 0.27). We planned to do consistent analysis of neutron multiplicity, fission and ER cross-sections for Po (N=108 to 126) nuclei to study the role of shell effects in fission dynamics. With this motivation, we have measured mass-gated neutron multiplicity for ^{48}Ti+^{144,154}Sm systems at 70 MeV of excitation energy using National Array of Neutron Detectors (NAND) at IUAC, New Delhi. In the present paper, we are reporting some of the preliminary results of this experiment.

Experimental Arrangement

The experiment was performed using 15 UD Pelletron + LINAC facility of IUAC, New Delhi. Pulsed beam of ^{48}Ti (beam current= 0.7 pnA) having repitition rate of 250 ns, with incident laboratory energy of 260 and 230 MeV was bombarded on sandwiched targets of ^{144,154}Sm of thickness 270 and 250 μg/cm^2 respectively. Targets were placed at center of a thin-walled spherical scattering chamber of 1 m diameter. Fission fragments were detected by a pair of multi-wire proportional counters (MWPCs) (6.4" × 4.4") kept at fission fragment folding angle of ±60° on both sides w.r.t beam direction at distance of 30 cm from target position. Two silicon PIPS detectors were also placed inside the chamber at ±13.5° w.r.t to beam direction for monitoring the beam. The neutrons emitted were detected by an array of 100 organic liquid scintillators (BC501 A) of dimension 5"×5" mounted on geodesic dome structure with both in-plane and out-of-plane positions having a flight path of 175 cm [4]. Hardware thresholds were adjusted to 0.5 MeV neutron energy using ^{137}Cs and ^{60}Co sources. The trigger for data acquisition was generated by setting up a coincidence between

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RF of the beam pulse and any one of the fission detectors. VME based data acquisition using LAMPS software was used to acquire event mode data.

Data Analysis and Results

Since, neutron detectors are sensitive to both γs and neutrons, the discrimination was done by pulse shape discrimination (PSD) based on zero-cross over and the time of flight technique (TOF) using IUAC made PSD modules [5]. TOF spectra recorded (Fig. 1) are calibrated using a precision TAC calibrator and the prompt γ peak as reference. To distinguish the neutrons and γ, a two-dimensional neutron gate (PSD vs TOF) is applied on the calibrated TOF spectra. The fission fragments were identified by TOF technique using MWPCs. The calibrated and gated TOF spectra are converted into the neutron energy (E_n) spectra. The efficiency correction for neutron detector was performed using statistical model code MODEFF [6]. Fig. 2 shows double differential neutron multiplicity spectra of two detectors placed at θ_n=54° and 126° for ^{48}Ti+^{144,154}Sm at 260 and 230 MeV respectively.

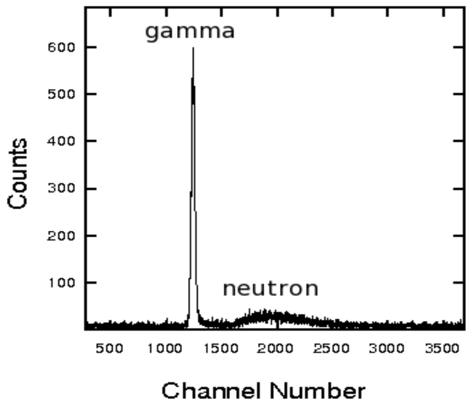

FIG. 1: TOF spectrum for ^{48}Ti+^{154}Sm reaction at 230 MeV.

The energy spectra in Fig. 2 correspond to fission fragments in the central region of the MWPC and we are also extracting spectra for the other regions. Further analysis to extract pre and post-scission components of neutron multiplicities (M_{pre} and M_{post}) from the neutron energy spectra using the Watt expression [7] is in progress.

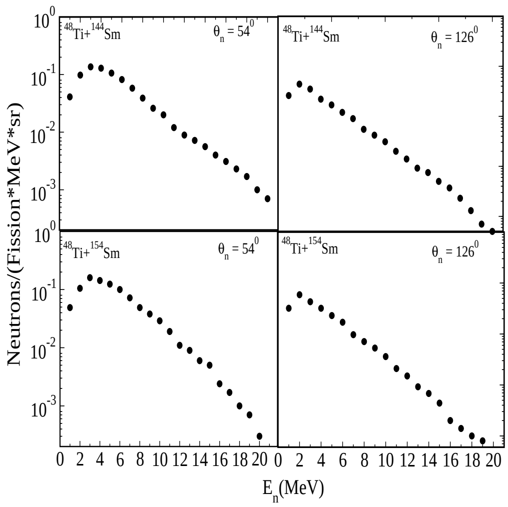

FIG. 2: Double differential neutron multiplicity spectra of two detectors for ^{48}Ti+^{144,154}Sm systems at 260 and 230 MeV respectively.

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