Investigation of the entrance channel effect through neutron multiplicity measurement for ^{208}Rn

Neeraj Kumar[1],* Shashi Verma[1], Jhilam Sadhukhan[3,4], K. Rojeeta Devi[1], A. Banerjee[1], N. Saneesh[2], M. Kumar[2], Meenu Thakur[5], Ruchi Mahajan[5], Gurpreet Kaur[5], Anjali[1], Neelam[1], Abhishek Yadav[2], Kavita[6], Rakesh Kumar[6], Unnati[1], S. Mandal[1], Suresh Kumar[1], B. R. Behera[5], K. S. Golda[2], A. Jhingan[2], and P. Sugathan[2]
[1]*Department of Physics &Astrophysics,University of Delhi, Delhi-110007, INDIA*
[2]*Inter University Accelerator Centre, Aruna Asaf Ali Marg, New Delhi-110067, INDIA*
[3]*Variable Energy Cyclotron Centre, Kolkata, West Bengal-700064, INDIA*
[4]*Homi Bhabha National Institute, Training School Complex, Anushakti Nagar, Mumbai-400094, INDIA*
[5]*Department of Physics, Panjab University, Chandigarh-160014, INDIA and*
[6]*Department of Physics, Kurukshetra University, Kurukshetra-136119, INDIA*

Introduction

Study on heavy ion nuclear reactions involve many complex processes and have been under investigation for many decades through experimental as well as theoretical approaches. The deep understanding of such processes is still a matter of detailed studies, because of the complexities involved. During the dynamically evolving path of fusion-fission reaction, neutron emission is one of the dominant decay channel. Neutron multiplicity measurements have been used as an effective probe to study the details of such kind of dynamical evolution of nuclear system [1]. Entrance channel mass asymmetry affects dynamical evolution of Di-Nuclear System (DNS). The entrance channel dependence shows changes in reaction dynamics across the Businaro-Gallone critical mass asymmetry (α_{BG}) and the presence of pre-equilibrium fission events are also entrance channel dependent [2]. In the present study, neutron multiplicities for the Compound Nucleus (CN) ^{208}Rn, populated at same excitation energies through two different entrance channels, ^{30}Si+^{178}Hf and ^{48}Ti+^{160}Gd have been measured. These measurements were performed at Inter University Accelerator Centre (IUAC), New Delhi using the National Array of Neutron Detectors (NAND) facility [3]. The value of α_{BG} for the CN ^{208}Rn is 0.857 and the values of mass asymmetries for the entrance channels, ^{30}Si+^{178}Hf and ^{48}Ti+^{160}Gd are 0.711 and 0.538, respectively.

Experimental Details

Pulsed beams of ^{30}Si and ^{48}Ti with incident energies of 138-178 MeV and 211-249 MeV, respectively, were used for the experiments. The repetition rate of the beam was 250 ns with the beam width of ∼400-800 ps. The carbon-backed sandwiched target of ^{178}Hf was used for the reaction ^{30}Si+^{178}Hf, which have effective thickness of ∼350.0 μg/cm^2. The self-supporting target of

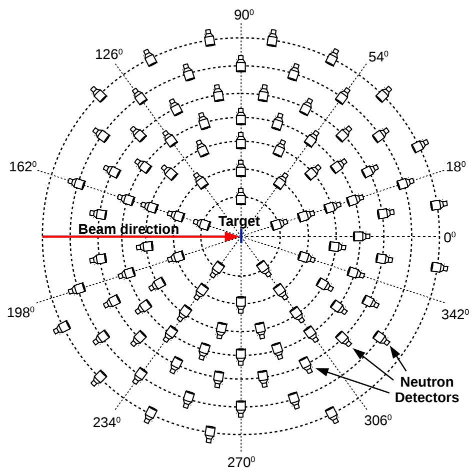

FIG. 1: Schematic diagram of NAND array, showing the angular orientation of the neutron detectors (top view).

*Electronic address: `neerajkumar.phys@gmail.com`

thickness ~1.00 mg/cm^2 was used for ^{48}Ti+^{160}Gd reaction. Two Multi-Wire Proportional Counters (MWPCs) with an active area of 11×16 cm^2 were symmetrically placed at the folding angles, at a distance of 16.5 cm from the center of the target. Two Silicon Surface Barrier Detectors (SSBD) were also placed inside the chamber at ±12.5^0 with respect to to beam direction to monitor the beam. The neutrons were detected by NAND array consisting of 100 organic liquid scintillator detectors (BC501A) of dimension 5"×5" mounted on geodesic dome structure. In this geometry, the flight path of neutrons is 175 cm [3]. For the data collection, VME based data acquisition system coupled with Linux Advanced MultiParameter System (LAMPS) software was used to acquire event mode data. The acquisition was set according to the trigger logic generated by coincidence between RF of the beam pulse and the fission detectors.

Data Analysis and Results

Neutron detectors can detect neutrons as well as gamma-rays. The discrimination of neutron and gamma was done by using in-house developed PSD modules [4], based on zero-cross over and the time of flight (TOF) technique. As a representative

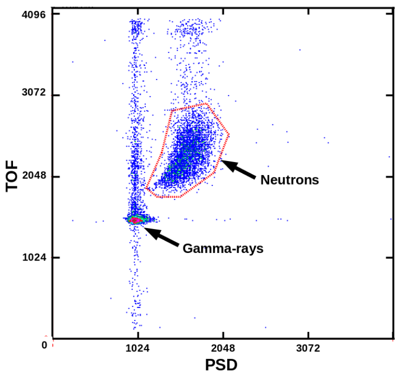

FIG. 2: PSD-TOF spectrum for ^{30}Si+^{178}Hf reaction at E*=70 MeV.

case, the PSD-TOF spectrum of one of the neutron detector is shown in the FIG. 2. To distinguish the neutrons and gamma events, a two-dimensional neutron gate (as marked by the dotted closed-loop in FIG. 2) is applied on the calibrated neutron TOF spectra. The neutron energy spectrum were gener-

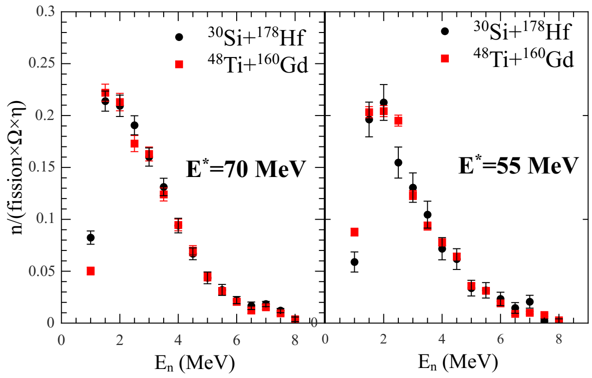

FIG. 3: Double differential neutron multiplicity spectras for ^{30}Si+^{178}Hf and ^{48}Ti+^{160}Gd.

ated from the calibrated and gated neutron TOF spectra. Double differential neutron multiplicity spectras are shown in the FIG.3 for the neutron detector placed at 72^o w.r.t. beam direction for both the entrance channels, ^{30}Si+^{178}Hf and ^{48}Ti+^{160}Gd at the excitation energy values of 70 MeV and 55 MeV, respectively. Further analyses to extract pre and post-scission neutron multiplicities (ν_{pre} and ν_{post}) and required theoretical calculations are in progress.

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