Exploration of reaction mechanism at deep sub-barrier region for ^{28}Si+^{96}Zr system.

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Introduction

In the past decades, heavy ion fusion dynamics around the coulomb barrier was investigated in the framework of Coupled Channels (CC) calculations. The enhancement observed in fusion cross-sections at sub-barrier energies was quite well understood by including transfer channels along with inelastic excitations in CC calculations [1, 2]. In a recent study, an anomaly observed at far below the barrier (18% to 20%) has added curiosity to the fusion investigation [3, 4]. In this region, experimentally observed fusion cross-sections were somehow deviated with respect to the theoretically obtained cross-sections. This deviation was termed as a hindrance in fusion cross-sections [3]. Fusion hindrance at extreme sub-barrier energies is also important from astrophysical point of view [5]. Hence, it is interesting to investigate fusion reactions at these energies.

In the present paper, we are reporting the study of deep below barrier fusion dynamics for ^{28}Si + ^{96}Zr system. ^{96}Zr is a spherical nucleus and favours the transfer coupling due to its positive Q value upto six neutron transfer channels. Therefore, it is possible to observe the effect of multi-neutron transfer channels coupling on fusion cross-sections. The experimental details are discussed in the following section.

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Experimental Details

The fusion excitation function for ^{28}Si + ^{92,96}Zr was measured at Inter University Accelerator Centre (IUAC), New Delhi using ^{28}Si pulsed beam of 1-2 μs width (beam current of 1-4 pnA). It was used to bombard isotopically enriched ^{96}Zr (86.4%) oxide and ^{92}Zr (95.13%) targets. These targets of thickness $\sim$230 μg/cm^2 on $\sim$20 μg/cm^2 carbon backing were prepared by electron beam evaporation method at the Target lab of IUAC. Fusion cross-sections were measured from 120 MeV to 78 MeV (25% above barrier to 18% below barrier) in steps of 2 MeV to 4 MeV.

The experiment was performed using Heavy Ion Reaction Analyzer (HIRA) facility at IUAC [6]. The HIRA was kept at 0^0 with respect to the beam axis with 10 msr aperture at the entrance. A Multi-Wire Proportional Counter (MWPC) with dimensions 152.4 x 50.8 mm^2 was placed at the focal plane of HIRA to measure the forward focussed Evaporation Residues (ERs). MWPC was kept at a pressure of 3 mbar of isobutane gas. Two Silicon Surface Barrier Detectors (SSBD) of area 100 mm^2 and thickness 300 μm were placed in the target chamber at an angle of $\pm 25^0$ with respect to beam direction and at a distance of 10 cm from the target. These detectors were used to monitor the beam and for normalization. A carbon charge reset foil ($\sim$30μg/cm^2) was used at a distance of 10 cm from the target for equilibration of charge state of ERs having lifetime $\sim$ns. An inside view of target chamber is shown in FIG.1. A TOF was set up

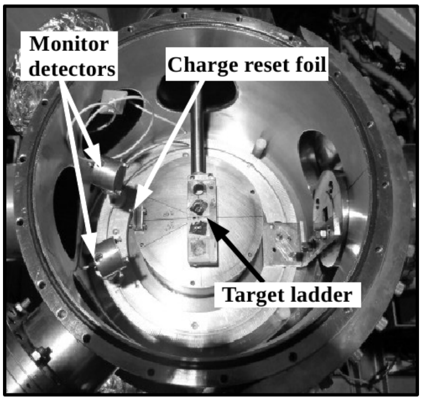

FIG. 1: Experimental arrangement inside the target chamber.

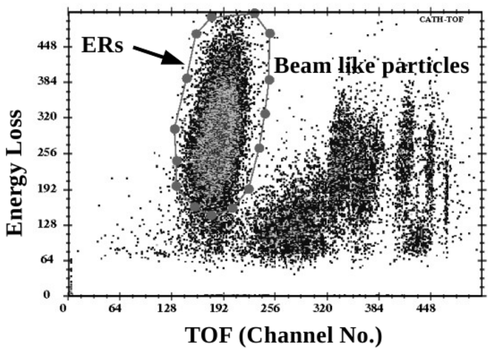

FIG. 2: Two-dimensional spectrum of Energy loss vs TOF for $^{28}Si+^{96}Zr$ at 96 MeV projectile energy.

between Anode of MWPC and RF signal from TWD (Travelling Wave Deflector) to separate beam like particles from ERs. Event by event data was recorded using online-offline software Freedom.

Results

The spectrum was constructed between energy loss in MWPC and TOF (FIG.2). This figure shows a clear separation of ERs from beam like particles. Further, mass/charge distribution was extracted by plotting energy loss in MWPC vs position gated by TOF (FIG.3). ER cross-sections have been extracted after normalizing with respect to the monitor yield. Further analysis is under progress.

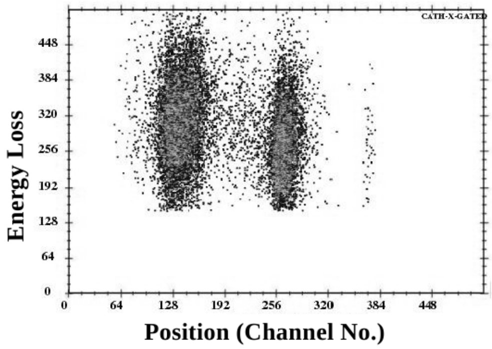

FIG. 3: Spectrum of Energy loss vs MWPC position gated by TOF at 96 MeV projectile energy.

Acknowledgments

We are extremely thankful to entire Accelerator (Pelletron) group for providing stable beam. We also want to thank Abhilash S. R. for the help during preparation of targets.

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