Study of complex fragment emission for ^{14}N + ^{58}Ni reaction at E/A ~18 MeV

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Introduction

The study of complex fragment (or IMF: $2<Z_{IMF}<A/2$) emission has been a standard probing tool to decipher the reaction mechanisms involved in heavy ion collisions for a vast energy range starting from Coulomb barrier to relativistic energies. The origin of IMFs is associated to different processes viz. complete equilibrium processes like fusion evaporation (FE) or fusion-fission (FF) and / or non-equilibrium processes like quasi-elastic (QE), deep-inelastic (DI), incomplete fusion, and deep-inelastic orbiting processes [1]. With the increase in beam energy, the production mechanism of the fragments shifts from equilibrium to non-equilibrium processes and the nature of the energy distribution as well as angular distribution get transformed. It has been observed that this process of transformation is a continuous one and there is no sharp boundary in the incident energy which segregates different components. Therefore, more and more data are required at different energies to properly understand the dynamics of evolution of the nucleus. However, at intermediate energies, most of the studies have so far been done for heavier systems [projectile mass (A_p) + target mass (A_t) >100] and data for lower mass is scarce. Therefore, an experiment has been designed to study the mechanisms involved in complex fragment emission for the reaction ^{14}N + ^{58}Ni at E/A ~18 MeV.

Experimental details & Results

The experiment has been performed with ^{14}N ion beam of energy 252 MeV from K-500 super conducting cyclotron (SCC) at VECC, Kolkata on ^{58}Ni target of thickness ~800μg/cm^2. To date, this is the highest heavy-ion beam energy (~18 MeV/u) available for experiments in the country.

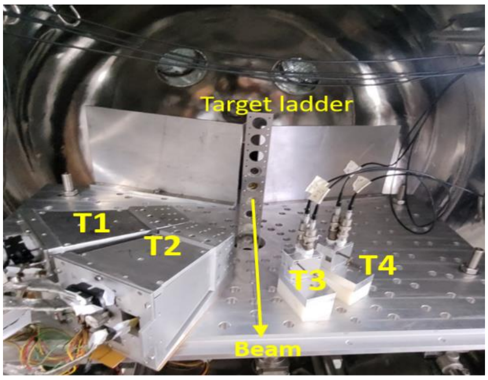

Fig. 1 Actual experimental setup inside SHARC (Segmented, Horizontal Axis, Reaction Chamber) [2]

The reaction products have been detected using four ΔE-E telescopes comprised of different charged particle detectors. The detailed description of the telescopes is given in Table 1.

Table 1: Telescope configuration

Telescope	Description
T1	Si strip (SSD ~50 μm + DSSD ~1000μm) + 4 CsI (Tl) (6 cm)
T2	Si strip (SSD ~50 μm + DSSD ~500μm) + 4 CsI (Tl) (6 cm)
T3	Si surface barrier (~100 μm + ~500 μm)
T4	Si surface barrier (~50 μm + ~500 μm)

The typical ΔE-E particle identification spectrum obtained from T1 is shown in Fig. 2. The fragments up to Z = 6 are isotopically well separated. From this, the isotopes of Li and Be have been extracted for further analysis.

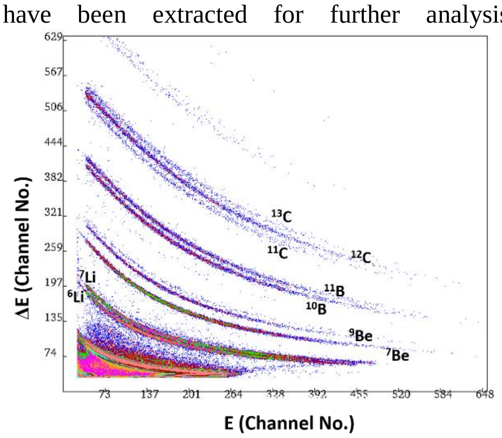

Fig. 2 2-D plot of particle identification from T1

The energy calibration of the detector has been performed using ^{229}Th 5-α source and a high precision pulse generator. The energy spectra of ^{6,7}Li and ^{7,9}Be obtained at two different laboratory angles (θ_{lab} ~52^o and ~58^o) are shown in Fig. 3 and Fig. 4, respectively.

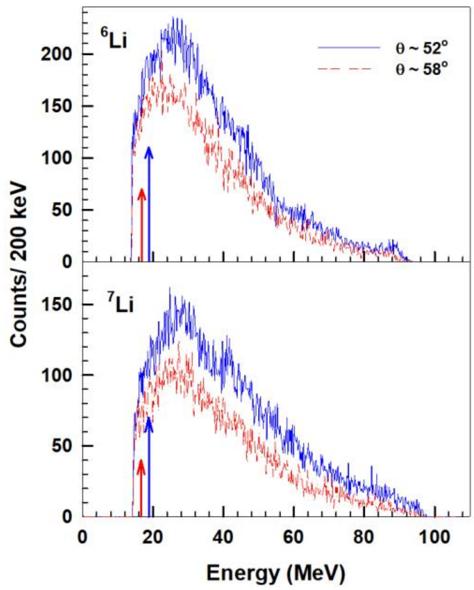

Fig. 3 Energy spectra (line) of ^{6,7}Li with Viola peak positions (arrows) at θ_{lab} ~52^o (solid, long) and ~58^o (dashed, short).

The arrows indicate the peak positions obtained from Viola systematic [3], corrected by asymmetry factors, for the respective fragments.

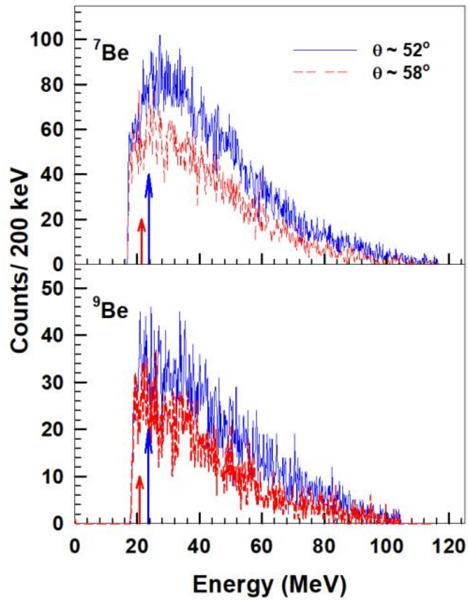

Fig. 4 Same as Fig. 3 for ^{7,9}Be.

Discussion & Summary

Complex fragment emission mechanism has been studied for the reaction ^{14}N + ^{58}Ni at intermediate energy (E/A~18MeV). Preliminary analyses show that the energy distributions of the fragments ^{6,7}Li and ^{7,9}Be peak at energies higher than the prediction of Viola systematic which indicates non-equilibrium nature of the reaction. Further analysis is in progress to extract more details about the origin of these fragments.

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References

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