Population of *n*-unbound states of ^{65}Ni via one neutron transfer reaction ^{64}Ni(^{9}Be, ^{8}Be)

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Introduction

Transfer reaction is an indirect experimental technique to obtain the relevant quantities required to estimate the rate of astrophysical capture reaction [1]

In the present experimental investigation we explored the 1n transfer reaction (^{9}Be, ^{8}Be) on ^{64}Ni nucleus as an indirect probe for ^{64}Ni(n,γ) capture reaction. In (^{9}Be, ^{8}Be) reaction, the produced ^{8}Be quickly breaks up into two α-particles that can be detected as a clear signature of neutron transfer. The reaction ^{64}Ni(^{9}Be, ^{8}Be)^{65}Ni has a Q-value of 4.43 MeV. Being a positive Q-value reaction, the population probability of states above the n-threshold (S_n= 6.098 MeV) is high. We attempted the detection of γ-rays in coincidence with reaction α-particle for a high resolution determination of level energies and γ-branching factor of residual ^{65}Ni nucleus.

The branching factor will be used subsequently in ^{64}Ni(n, γ) capture reaction. The capture reaction ^{64}Ni(n, γ) has smallest Maxwellian Averaged Cross Section (MACS) among the even-even Ni-isotops[2] and may act as a bottleneck in the formation of ^{65}Cu and other heavier nuclei in the s-process nucleo-synthesis chain.

Experimental details and analysis

The experiment was performed using ^{9}Be (30 MeV) beam (current∼5 nA) from Pelletron Linac Facility (PLF) in Mumbai. A self-supporting foil of ^{64}Ni (~500 μg/cm^2) was used as the target. To detect outgoing ^{8}Be from 1n-transfer reaction, we used CsI(Tl) detector for charged particle detection. The detector were put on both sides of the beam line covering an angular region from 22° to 67° in the reaction plane. CsI(Tl) detectors, each of size 15x15 mm^2, were placed approximately 5cm away from the target center on each side of the beam axis. Tantalum absorbers of thickness 30mg/cm^2 were used before the scintillator detectors to stop the elastically scattered particles from entering the detectors. De-exciting γ-rays of residual nuclei were detected using the γ-detector setup consisting of 14 Compton-suppressed Clover detectors placed at 40°, 90°, 140°, 115° and 157° with respect to the beam direction. Data were recorded in list mode in a digital data acquisition system (DDAQ) based on Pixie-16 modules of XIA-LLC, which provides both energy and timing information. The γ-ray data were sorted using Multiparameter time stamped based Coincidence Search (MARCOS) [3] program to generate one dimensional histograms, γ-γ matrix, and γ-γ-γ cube for offline analysis. RADWARE software package [4] were used for subsequent analysis.

Results and Discussions

In **Fig. 1**, two representative γ-spectra of residual ^{65}Ni nucleus produced in the 1n-transfer channel have been shown. Some of known γ-lines like 310.4 keV, 382.5 keV and 1610.4 keV are marked. Decay γ-lines from resonance states in ^{65}Ni beyond the n-threshold are shown in **Fig. 2**. The direct transitions to the ground state of ^{65}Ni are marked in the figure. However, the final confirmation of these states will be established by gating with the α-spectrum from CsI(Tl) detector data. A representative 2D particle spectrum is shown in **Fig. 3**. Attempt will be made to identify the 2α or ^{8}Be band in single CsI(Tl) detector spectrum [5] to distinctly identify the γ-lines of ^{65}Ni nucleus through gating on . A detailed analysis is in progress and the results will be presented in the symposium.

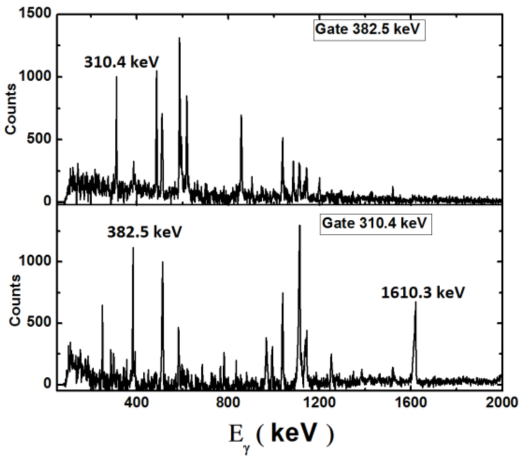

Fig. 1 Gamma spectrum obtained by gating on 382.4 keV (top) and 310.4 keV (bottom) γ-rays of residual ^{65}Ni nucleus.

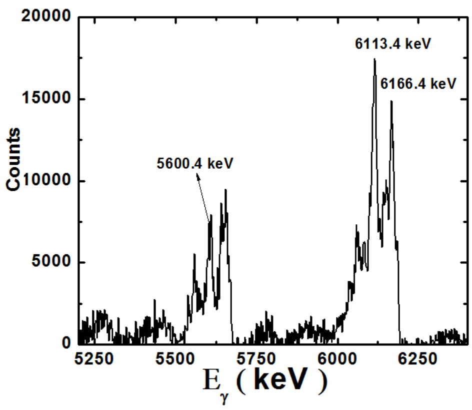

Fig. 2 Observed γ-rays of direct transitions from resonance states to ground state of ^{65}Ni.

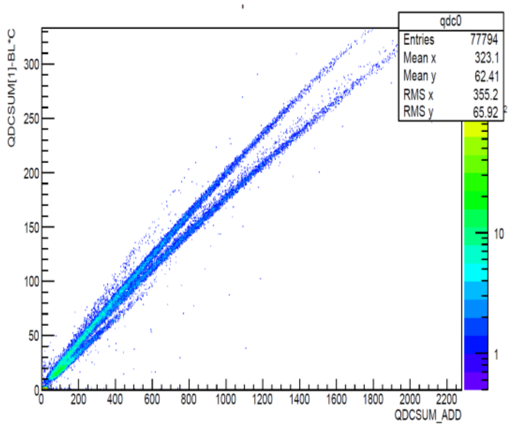

Fig. 3 CsI(Tl) - QDC spectrum.

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