Investigation of cluster structure of ^{9}B from triple coincidence α-α-p measurements

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The Borromean ^{9}B nucleus is mirror nuclei of another Borromean nucleus ^{9}Be. Understanding of the cluster structure along with decay modes of these nuclei is crucial for astrophysical interest [1–3]. There are very few studies on cluster structure of these nuclei. Recently, we have carried out the investigation on cluster structure of ^{9}Be by measuring 3-body decays of ^{9}Be (α-α-n) from low lying $\frac{1}{2}^{\pm}$ and $\frac{5}{2}^{\pm}$ states, which are unbound and strongly overlapping due to their large widths [4]. In the present investigation, it is aimed to understand the 3-body decay mechanism of ^{9}B nucleus, which is expected to have α-α-p predominant cluster structure. In a recent study, α-α-p coincident measurement has also been carried out using radioactive ion beam ^{7}Be on deuterium gas target [5]. Although in this method a direct population of ^{9}B was achieved but the breakup mode of ^{9}B to α-α-p can not be distinguishable from transfer-breakup reaction ^{7}Be(d,p)^{8}Be$\rightarrow$ α-α. As direct ^{9}B beam is not available, it is planned to investigate via ^{93}Nb(^{10}B,^{9}B$\rightarrow$ α-α-p) transfer-breakup measurements, which is expected to be cleaner root to measure ^{9}B$\rightarrow$ α-α-p three body breakup correlation.

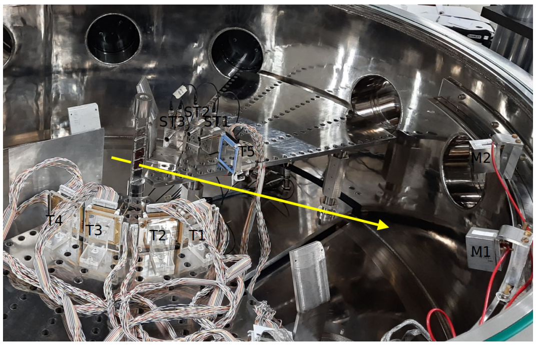

FIG. 1: The experimental setup consists of five ΔE-E Si-strip detector telescopes, three Si surface barrier telescopes and two monitor detectors.

An experiment, to measure α-α-p triple coincidence, was carried out for the ^{10}B+^{93}Nb system at the BARC-TIFR Pelletron-LINAC facility, Mumbai. The measurements were performed at beam energy of 54 MeV. Self supporting foil of ^{93}Nb of thickness $\sim$ 2 mg/cm^{2} was used as target. Five segmented large area Si-telescopes of active area 5 x 5 cm^{2} were used for the measurement of the energy and scattering angle of the outgoing proton and α particles. Three of the ΔE detectors were $\sim$50 μm thick, while other two were $\sim$30 μm thick. Both the thinner (30 μm) detectors were kept at backward angles to increase the dynamical energy range of α-particles. All the five E-detectors were of thickness 1.5 mm. The telescopes were mounted at angles 35°, 55°, 85°, 105° and -55° in a scattering chamber of diameter 1.5 m. All the five E-detectors were double sided with 16 strips allowing a maximum of 256 pixels. To avoid random coincidence due to high

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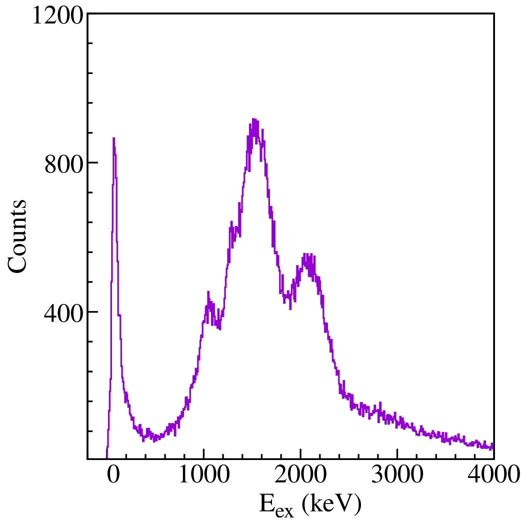

FIG. 2: The reconstructed excitation energy spectra of ^{9}B from α-α-p triple coincident measurement.

event rates from elastic scattering at forward angel, a tantalum foil of thickness $\sim$20μm was kept in front of the forward most telescope at 35°. Three Si surface barrier telescopes (thicknesses ΔE $\sim$ 20-50 μm, E $\sim$ 450-1000 μm) were also kept for the detection of elastic scattering and singles α-particles around the grazing angle. Two Si surface barrier detector of a thickness $\sim$ 300 μm was mounted at $\pm$20° to monitor Rutherford scattering for absolute normalization purposes. The data were collected in an event by event mode for three or higher fold coincidence in 120 ns time window from any strips out of all the E-detectors. The Si-detectors were calibrated using the known energies of α-particles from ^{229}Th source.

The energy loss information from ΔE and E detectors were used to identify the α-particles. A good charge and mass resolution has been achieved which allowed the separation of all the isotopes of Z = 1 and 2 nuclei. The measured energies (E^1_α, E^2_α, E_p) and scattering angles (θ^1_α, ϕ^1_α; θ^2_α, ϕ^2_α; θ_p, ϕ_p) were used to reconstruct the energy ($E_{^9\mathrm{B}}$) and angle ($\theta_{^9\mathrm{B}}$) of the scattered ^{9}B prior to breakup. The energy (E^*) of the excited states of ^{9}B were extracted using the energy conservation E^*=E^1_α+ E^2_α+E_p-$E_{^9\mathrm{B}}$. The reconstructed ^{9}B excitation energies are shown in the Fig.2. It can be seen from the excitation energy spectra, there are population of ^{9}B to discrete resonance states at energies 0.1, 1.0, 1.3, 1.6 and 2.2 MeV. The majority of the measured relative energy between two α-particles are found to peak at 92 keV indicates the dominance of sequential breakup mode of ^{9}B$\rightarrow$ p+^{8}Be$\rightarrow$ α+α. However, a good fraction of events with relative energy, between one of the α-particles and the proton detected in coincidence, of 1.97 MeV gives the signature of the sequential decay channel ^{9}B$\rightarrow$ α+^{5}Li$\rightarrow$ α + p. The details of investigation to study breakup mechanisms from different resonance states will be presented.

Acknowledgments

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