Measurement of the ^{7}Be(d,p)^{8}Be* reaction at 5 MeV/A at HIE−ISOLDE, CERN

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Introduction

The cosmological lithium problem [1] is a widely studied and yet unsolved problem in nuclear astrophysics. The problem delineates a serious discrepancy between the observed abundance of ^{7}Li and that predicted by the Big Bang Nucleosynthesis (BBN) theory [2]. The BBN calculations rely on nuclear physics inputs. So it is natural to study in details the nuclear reactions pertinent to the abundance anomaly of ^{7}Li. Sensitivity studies [3] involving the ^{7}Be(d,p)^{8}Be(2α) (Q_{gs} = 16.67 MeV) reaction has shown that the primordial lithium problem can be resolved if the reaction rate is a factor of 100 larger at the relevant Gamow energies. Recent experiments studying the destruction of ^{7}Be with deuterons could not find any significant enhancement in the reaction rate to resolve the anomaly [4]. However, these experiments did not measure the contributions of high lying excitations above 11.35 MeV in ^{8}Be, in particular the 16.6 MeV state.

Experiment

We carried out the experiment at the HIE-ISOLDE radioactive beam facility of CERN using a 5 MeV/A ^{7}Be beam. We measured the resonance excitations in the ^{7}Be(d,p)^{8}Be* reaction up to about 22 MeV for the first time.

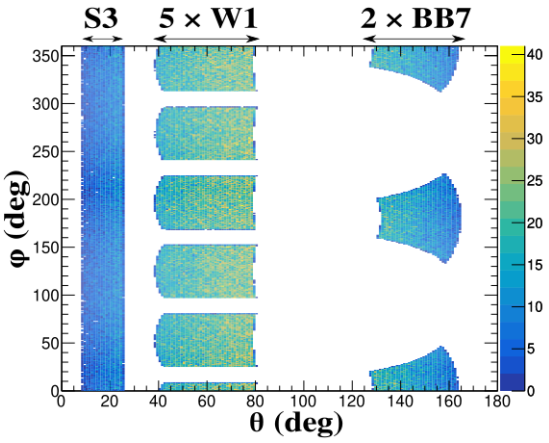

FIG. 1: The angular coverage θ (polar angle) and ϕ (azimuthal angle) of the detector array used in the experiment.

The ^{7}Be beam impinged on a CD_2 target of thickness 15 μm and the average beam intensity was $\sim 5 \times 10^{5}$ pps. An array of double sided silicon strip detectors (DSSD) covering $8^{\circ} - 165^{\circ}$ in lab was used inside the Scattering Experiment Chambers (SEC) [5] for detection of the charged particles. The forward angles from $8^{\circ} - 25^{\circ}$ were covered by a 1000 μm thick annular DSSD (Micron S3). Five DSSDs (Micron W1) of thickness 60 μm arranged in the shape of a pentagon around the target centre covered the angles $40^{\circ} - 80^{\circ}$. The back angles of $127^{\circ} - 165^{\circ}$ were covered by two sets

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of DSSDs (Micron BB7) of thickness 140 μm and 60 μm placed symmetrically to the left and right of the beam direction respectively. Each of these DSSDs, except S3, were backed by unsegmented silicon pads (Micron MSX25) of thickness 1500 μm in $\Delta E - E$ telescope configuration. The configuration resulted in a highly pixellated array (Fig. 1) appropriate for coincidence detection of the α particles and protons from the ^{7}Be(d,p)^{8}Be* transfer reaction.

Analysis and discussion

The light charged particles from the interaction of ^{7}Be on CD_2 were clearly identified from the $\Delta E - E$ spectra. After identification of the charged particles, we impose coincidence detection of α particles and protons. This results in the signatures of the higher excited states of ^{8}Be from the ^{7}Be(d,p)^{8}Be*(2α) reaction.

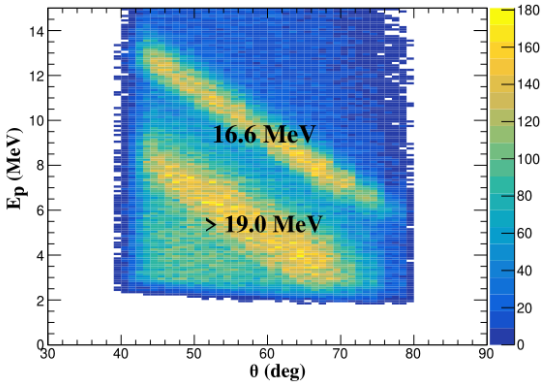

FIG. 2: Energy (E_p) vs scattering angle (θ) of the coincident protons. The bands highlight the higher excited states of ^{8}Be above 16 MeV.

From the plots of energy (E_p) vs scattering angle (θ) (Fig. 2) of the coincident protons and the energy correlations of the two coincident α particles, we observe clear signatures of the higher excited states of ^{8}Be, namely the 16.6 MeV and other high lying resonances around 19-22 MeV. The ground state (0^{+}), 3.03 MeV (2^{+}) and 11.35 MeV (4^{+}) states were identified from the background subtracted excitation energy spectrum of ^{8}Be as well as the energy vs scattering angle plot of protons detected at the BB7 DSSDs. The excitation energy spectrum is shown in Fig. 3. Work on the angular distribution of the excited states are in progress.

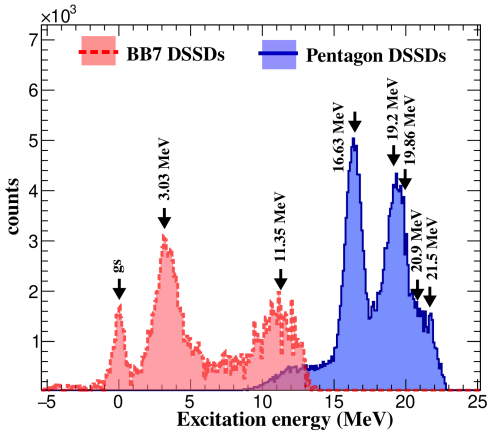

FIG. 3: The excitation energy spectrum of ^{8}Be obtained at the BB7 (red dashed) and pentagon W1 (blue solid) DSSDs.

Acknowledgement

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