Charged-particle channels in the $\beta$-decay of $^{11}\text{Li}$

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The ground state of the $^{11}\text{Li}$ nucleus is one of the best examples of a two-neutron halo state. Among the various probes that have been used for the investigation of its properties, the $\beta$-decay has the advantage of being a well-understood process. The $Q$-value of the $\beta$ decay of $^{11}\text{Li}$ is large, therefore most of the open channels are characterized by the emission of charged particles. We investigated these channels, with particular attention to the deuteron emission $^{11}\text{Li} \to ^9\text{Li} + \text{d}$ and triton emission $^{11}\text{Li} \to ^8\text{Li} + \text{t}$. The deuteron channel is especially of interest, since its branching ratio and the deuteron spectrum give direct information about the two-neutron halo wave function of the mother state. This decay mode has been identified in the past, but has not been disentangled from the triton channel [1].

We refined a calorimetric technique for the detection of $\beta$-delayed charged particles [2], by implantation of the nuclei of interest directly in a finely segmented silicon detector. To achieve the required implantation depth, a pure beam of the extremely neutron-rich $^{11}\text{Li}$ nuclei was produced and post-accelerated for the first time at the ISAC facility in TRIUMF. The energy of the beam was the highest provided by ISAC (1.5 MeV/nucleon). The beam intensity was kept deliberately low in order to avoid the overlap of two implantation signals before the decay of the $^{11}\text{Li}$ nucleus and its daughters took place. Given the high segmentation of the detector ($\sim 2300$ pixels on $16 \times 16$ mm$^2$) and the long half-life of some daughters (for $^{11}\text{Be}$ it is $T_{1/2} = 13.81$ s), an implantation rate of a few hundred particles per second was used to preserve the time correlation between decays. The method also provides a strong suppression of the $\beta$ background and a very accurate normalization.

We identified the channels of interest via the daughter-decays of $^9\text{Li}$ and $^8\text{Li}$. The $\alpha$ particles emitted in the two cases can be separated based on their half-life and energy spectra (shown in Fig. 1). To help with the identification, beams of $^9\text{Li}$ and $^8\text{Li}$ were also employed to measure the spectra directly. The correlation with the parent decay was used to obtain the deuteron and triton spectra from $^{11}\text{Li}$ shown in Fig. 2. We will discuss the implications of these results for the halo structure of the ground state of $^{11}\text{Li}$.

![Figure 1](energy_spectrum.png)

**Figure 1:** Energy spectrum of the particles emitted in daughter-decays, following the implantation and decay of $^{11}\text{Li}$, after background subtraction. The two curves are the spectra of $^8\text{Li}$ (dashed line) and $^9\text{Li}$ (dotted line) measured directly and scaled to fit the data.

![Figure 2](energy_spectrum2.png)

**Figure 2:** (PRELIMINARY) Energy spectra from the decay of $^{11}\text{Li}$: circles are tritons from $^8\text{Li} + \text{t}$, stars are deuterons from $^9\text{Li} + \text{d}$.