Charged-particle channels in the β-decay of ^{11}Li

R. Raabe[1], A. Andreyev[2], L. Buchmann[2], P. Capel[2], H. Fynbo[5], M. Huyse[1,2], R. Kanungo[2], T. Kirchner[2], C. Mattoon[4], A. C. Morton[2], I. Mukha[1], J. Pearson[2], J. Ponsaers[1], J. J. Ressler[2,3], K. Riisager[5], C. Ruiz[2,3], P. G. Ruprecht[2], F. Sarazin[4], P. Van Duppen[1], P. Walden[2]

[1] *Instituut voor Kern- en Stralingsfysica, K.U.Leuven, Celestijnenlaan 200D, B-3001 Leuven*
[2] *TRIUMF, 4004 Wesbrook Mall, Vancouver, British Columbia, Canada V6T 2A3*
[3] *Department of Chemistry, Simon Fraser University, 8888 University Drive, Burnaby, B.C. Canada V5A-1S6*
[4] *Department of Physics, Colorado School of Mines, Golden, Colorado 80401, USA*
[5] *Department of Physics and Astronomy, University of Aarhus, DK-8000 Aarhus C, Denmark*

The ground state of the ^{11}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 β-decay has the advantage of being a well-understood process. The Q-value of the β decay of ^{11}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 $^{11}\text{Li} \xrightarrow{\beta} {}^{9}\text{Li+d}$ and triton emission $^{11}\text{Li} \xrightarrow{\beta} {}^{8}\text{Li+t}$. 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 β-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}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}Li nucleus and its daughters took place. Given the high segmentation of the detector ($\sim$2300 pixels on 16×16 mm^2) and the long half-life of some daughters (for ^{11}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 β background and a very accurate normalization.

We identified the channels of interest via the daughter-decays of ^{9}Li and ^{8}Li. The α 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}Li and ^{8}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}Li shown in Fig. 2. We will discuss the implications of these results for the halo structure of the ground state of ^{11}Li.

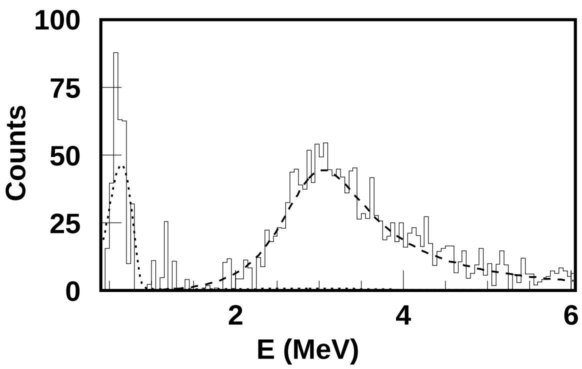

Figure 1: *Energy spectrum of the particles emitted in daughter-decays, following the implantation and decay of ^{11}Li, after background subtraction. The two curves are the spectra of ^{8}Li (dashed line) and ^{9}Li (dotted line) measured directly and scaled to fit the data.*

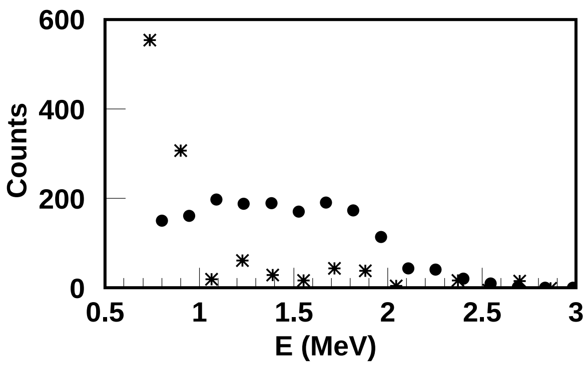

Figure 2: (PRELIMINARY) *Energy spectra from the decay of ^{11}Li: circles are tritons from ^{8}Li+t, stars are deuterons from ^{9}Li+d.*

[1] I. Mukha et al., Phys. Lett. B 367, 65 (1996).
[2] D. Smirnov et al., Nucl. Instr. and Meth. A 547, 480 (2005).