Safety Report
Experiment 1030
Charged-particle channels in the β-decay of ^{11}Li

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1 Introduction

This experiment has the aim of studying the charged-particle1 channels in the β-decay of the halo nucleus ^{11}Li. The experiment especially concerns the decay channels fed by the decay through a state at E* $\sim$18.1 MeV in ^{11}Be. One particular channel, ^{11}Li(β) $\rightarrow$^{9}Li + d, can also occur by direct decay into the ^{9}Li + d continuum and provides information about the spatial wave-function of the (halo-) ground state of ^{11}Li.

The total branching ratio to those channels is less than 1%. In order to compare with theoretical models, both the value of each branching ratio and the shape of the charged-particle spectra are of importance.

The experiment uses a novel technique by implanting the post-accelerated ^{11}Li nuclei directly into a finely segmented silicon detector and then observing the decay events via the detector. The high segmentation allows β particles to escape limiting the importance of their background. Further advantages with respect to previous techniques are the very large efficiency, a very reliable normalization for the measured branching ratios, and access to the history of each decay. Identification of the different modes will be possible via the observation of characteristic daughter decays (energy and half-life). In particular it will be possible to separate the ^{11}Li(β) $\rightarrow$^{9}Li + d decays from the ^{11}Li(β) $\rightarrow$^{8}Li + t decays through this separation in life time and decay energy spectrum.

The experiment is ideally suitable for running at TUDA. The detector is identical in manufacture (not geometrically identical) to the CD detectors used by TUDA, so that incorporation of the detector to the TUDA electronics is not a difficultly, and TUDA is part of the post-accelerated beamline at ISAC-I so that a ^{11}Li beam of the correct energy can be obtained for this implantation technique. For this purpose it is requested that a ^{11}Li beam at 16.5 MeV be developed for ISAC-I as well as beams of ^{8}Li and ^{9}Li at 12 MeV and 13.5 MeV respectively. The later two beams will be used for short calibration runs to quantify the ^{8}Li and ^{9}Li decay spectrum.

2 Description of the Experiment

The experimental apparatus is quite compact. It is a double-sided silicon strip detector (DSSSD), 78 μm thick and 16×16 mm^2 in size. Each side is divided into 48 strips, 300 μm wide, oriented on perpendicular directions on the two faces. The detector comes mounted to a flange which has been mounted onto an adapter piece which attaches onto the end of the TUDA chamber. The adapter takes the place of the TUDA Faraday cup which has been temporarily removed from this position. The mounting flange has vacuum feed throughs to which cables are attached connecting the detector to its preamplifiers. The preamplifiers are then connected to the TUDA electronics. The hardware of this experiment has been in place and working since March 21, 2005.

There is only a slight modification to the TUDA data acquisition system that has to be made. Two scalers running from the 11.67 MHz ISAC prebuncher signal provide time stamps for each event. These scalers will have to be read out for each event as part of the event buffer. This requires an update of the program currently running in the VME crate. This update has been downloaded remotely by Vic Pucknell from Daresbury and available since April 15, 2005.

A stable pilot beam will be initially tuned to a Faraday cup on the TUDA target ladder. This Faraday cup has been used before. A reading from this cup will be the indication that the beam has been tuned to TUDA. The beam will be then be defocussed and attenuated (by the pepperpots). The Faraday cup is then removed, and the beam passes through an open slot on the target ladder onto the DSSSD, 94 cm downstream. A scatter plot of the 48×48 = 2304 pixels of the DSSSD will give the profile of the beam on the DSSSD. The profile will be available to operations via logging onto the main DAQ computer, tuda0, via a MIDAS-UK session. The total beam rate will also be passed onto operations via EPICS from a scaler in the TUDA shack. With these diagnostics the beam on the DSSSD can be fined tuned. The beam rate will not exceed 10^4 pps. To ensure such a rate will not be exceeded, beam will not be allowed to pass unhindered to the DSSSD until it has first been through a succession of ever increasing collimators stacked up on the TUDA target ladder. The stable beams which will be used as pilot beams will be ^{16}O(4+), ^{18}O(4+), and ^{22}Ne(4+) for ^{8}Li(2+), ^{9}Li(2+), and ^{11}Li(2+) respectively. These beams and procedures have been developed during the week of March 21-25, 2005. To ensure that the DSSSD cannot be accidentally damaged by intense beam, the TUDA target ladder has had foils attached to it to block any beam from going over, under, to the side, or through it other than through the described apertures already mentioned.

Once the stable beam tune has been established RIB can be sent to the DSSSD. The rate of the RIB will be first checked at the YIELD station before being sent to the TUDA chamber. Since there will be no diagnostics of how well the RIB beam has been matched to the OLIS pilot beams until the beam illuminates the DSSSD, this procedure will most likely be somewhat difficult. Some thought should go into this procedure. The DSSSD will be protected in the usual manner by blanks and collimators on the target ladder. Three RIB species will be requested, ^{8}Li(2+), ^{9}Li(2+), and ^{11}Li(2+). ^{8}Li(2+) has been delivered to the TUDA station before, ^{9}Li(2+), and ^{11}Li(2+) will be new. Beam fluxes requested will range from 10^4 pps down to 200 pps.

Most of the run will occur at 200 pps with ^{11}Li.

During the ^{8}Li(2+) and ^{9}Li(2+) irradiations, the RIB species will first be implanted. Then beam will be shut off to observe the decays, $^{9}\text{Li}(\beta) \rightarrow 2\alpha$ + n (178.3 ms) and $^{8}\text{Li}(\beta) \rightarrow 2\alpha$ (838 ms). A signal from the TUDA shack will be provided to turn on and shut off the RIB beam.

3 Safety Concerns

Since the intension is not to run any RIB higher than 10^4 pps, and since none of the RIB species have long half-lives, the radiation hazard will be almost non-existent. When RIB is delivered, as a precaution, monitors will be used to note the radiation levels and areas tagged and roped off as required. However the necessity for the latter procedures is not expected. When the TUDA chamber is opened up after the experiment, face masks with air filters will be used until the inside of the chamber is checked out and swipe tests have been performed. It is expected that no traceable amounts of radiation will be found. The same procedure will be used on the adapter and flange holding the DSSSD. The DSSSD will just be measured for radiation, not swiped as that procedure will damage the detector.

TUDA has run RIB of ^{21}Na, ^{20}Na, and ^{8}Li in prior experiments at fluxes approaching 10^8 pps. The above procedures have proved adequate in these cases. The proposed beams should not require any special procedures or due concern. The only new variant could be neutron fluxes from ^{11}Li decay, but the beam flux to be used is the same as or below the ^{11}Li fluxes used in other ^{11}Li studies carried out in the low energy experimental area of the ISAC-I hall. I cannot think that the E1030 situation should merit special concern in this case.

In mentioning past TUDA beams, it should be pointed out that a recent development has been a decision to request ^{20}Na beam because it can decay into ^{16}O via a variety of α decays at various energies. As such it will provide an excellent tool to calibrate the DSSSD detector. Again this beam intensity will be less than 10^4 pps, and we have run ^{20}Na beam at TUDA at fluxes of 10^7 pps using the procedures described above.

There will be a 3kBq α source on the target ladder, an Am-Cm-Pu source. It has been used in several other TUDA experiments. A label will be placed on the TUDA chamber to notify others of its presence.

There are no other issues concerning safety relating specifically to the E1030 experiment that we are aware of.