Technical and 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 detector (DSSD), 78 μm thick and 16×16 mm^2 in size. Each side is divided in 48 strips, 300 μm wide, oriented on perpendicular directions on the two faces. The detector comes mounted to a flange which will be 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 is currently mounted at 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 adapter piece has already been manufactured and is awaiting the shipment of the detector and its associated equipment. Everything should be in place by March 21, 2005.

There is only a slight modification to the TUDA data acquisition system that has to be made. Two scalers running from pulse generators 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 can be downloaded remotely by Vic Pucknell from Daresbury.

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 DSSD, 94 cm downstream. A scatter plot of the 48×48 = 2304 pixels of the DSSD will give the profile of the beam on the DSSD. 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 DSSD 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 DSSD 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 will be developed during the week of March 21-25, 2005. To ensure that the DSSD cannot be accidentally damaged by intense beam, the TUDA target ladder will have 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 DSSD. 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 DSSD, this procedure will most likely be somewhat difficult. Some thought should go into this procedure. The DSSD 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 Technical Assistance from TRIUMF

There is little technical development required from TRIUMF. Development time and tuning procedures for ^{16}O, ^{18}O, and ^{22}Ne beams have been requested and scheduled. A new defocussed beam tune has been requested, and such has been designed (see attached note by Marco Marchetto). Communications with the RIB target-source to turn on and shut off the beam will be required, but such a procedure has been available to experiments running in the ISAC Low Energy area, and should not represent a problem to extend it to TUDA. Beam diagnostics via the FCUP (EPICS, Keithly), beam rate(EPICS), and beam profile (Ethernet) will be provided by the experimenter over systems used before. There is no call on TRIUMF for DAQ resources or electronics except for 2 NIMBINS[1].

4 Safety

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 is 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 DSSD. The DSSD will just be measured for radiation, not swiped as that procedure will damage the detector.

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.

[1] there might be an unforeseen electronic module or 2