Investigation of ^{27}P with the AstroBox prototype detector

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An experimental program to measure β-delayed proton decay has been done using the MARS beam line at TAMU and a configuration of silicon detectors, where the fragment of interest is implanted in a thin double sided strip detector and the subsequent decay is measured (for an example see [1]). In an attempt to reduce the β response while retaining high resolution at low energies for the protons of interest (10-15 keV FWHM at 200 keV), a new type of gas-filled detector utilizing a Micro Pattern Gas Amplifier Detector (MPGAD), called the AstroBox, has been developed [2-3]. Fig. 1 below shows the raw results from both the silicon configuration and the first AstroBox test run.

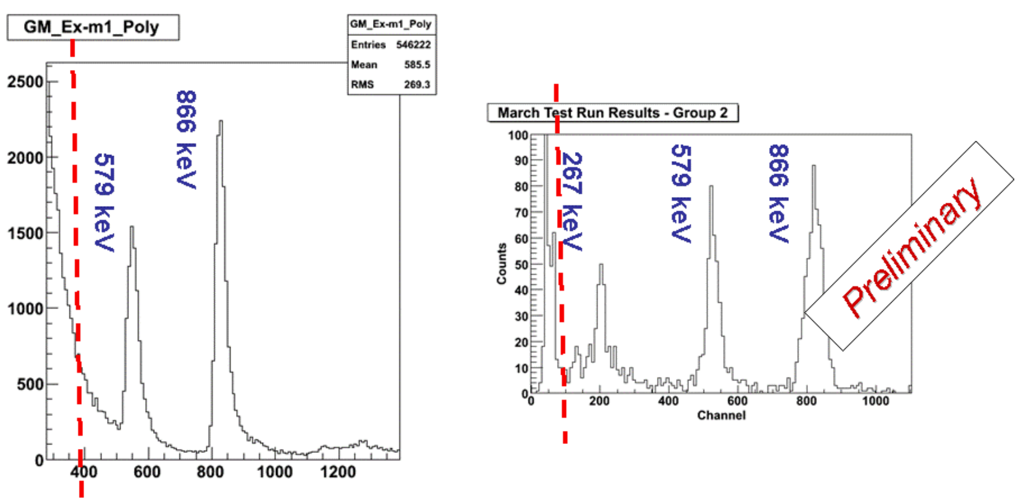

FIG. 1. The left-hand side shows the preliminary results with the silicon detector setup for the study of the β-delayed proton decay of ^{23}Al. The right-hand side shows the preliminary results achieved with the AstroBox prototype detector for the same nucleus.

As with the experiment performed with the silicon detectors in Nov. 2010 [3], a beam of $^{28}Si^{+10}$ at 40 MeV/u was obtained from the K500 superconducting cyclotron and impinged on a hydrogen gas target kept at LN_2 temperatures and a pressure of 2 atm in the MARS beam line. The ^{27}P nuclei were slowed down and implanted in the center of the P05 filled AstroBox detector with the use of a 10 mil aluminum degrader foil. It was decided to start with the known β-delayed proton emitter of ^{25}Si, which has a total proton branching ratio of 35%, in order to optimize the detector. Ideally, ^{28}P was the desired nucleus for this task due to the fact it has several low energy protons, however, its total proton branching ratio (0.0013 %) was much lower than even ^{27}P (estimated at 0.07 %). With the beam time of this experiment reduced to 7 days due to some trouble with the K500 at higher beam energies for the nuclei of interest and other demands on the beam time, ^{25}Si was chosen over that of ^{28}P. Once the detector had been optimized ^{27}P was to be implanted in the center region.

Several improvements to the setup were applied coming directly from the experience of the previous two test runs. Namely, in order to include the heavy ion signals, a second ADC with a different acquisition trigger was needed, which was achieved by utilizing the interrupt request (IRQ) feature in the VM-USB VME controller to access different readout lists for different event types (heavy ion implant vs. decay). Additionally, a low cost in-house beam pulsing NIM module was created. This new unit has the advantage of having NIM logic outputs for beam on, "move", beam off, and gating grid on, as well as an optically isolated TTL output for the beam off signal that can be patched to the phase shifter on the K500 RF console. Additionally, this new unit is easily set up (in terms of beam on, beam off etc.) via a GUI. Scalar units were also included in the electronics to monitor all 3 active detector pads of the AstroBox, for both beam-on (heavy-ions) and beam-off (proton) signals.

The production rate for ^{25}Si was about 65 pps with the coffin (momentum) slits open at ± 1.0 cm. With the momentum slits closed to the ± 0.4 cm needed for implantation, the rate dropped to about 19 pps. Later, when switching to ^{27}P, there was only about 13 pps of the desired nucleus with the momentum slits at ± 0.4 cm. Due to a problem within the detector itself, one that began midway through the experiment and grew considerably worse, along with the limited primary beam intensity and beam time, we were unable to observe protons. However, in the beginning, we did successfully see the correct heavy ions associated with ^{25}Si during the beam-off part of the decay measurement. The problem with the AstroBox detector was found after the run and corrected. Analysis of the data is ongoing in the hopes of aiding future endeavors.

[1] A. Saastamoinen *et al*., Phys. Rev. C **83** 045808 (2011).

[2] L. Trache *et al*., in *Progress in Research*, Cyclotron Institute, Texas A&M University (20101– 2012), p. V-52

[3] E. Pollacco *et al.* Nucl. Instrum. Methods Phys. Res. A (submitted)

[4] E. Simmons *et al*., in *Progress in Research*, Cyclotron Institute, Texas A&M University (2011 – 2012), p. I-27