Surveying deep inelastic multi-nucleon transfer for creation of super- and hyper-heavy elements

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Recent advances in the super heavy element experimental reaction program have followed two tracks. The first approach has been to employ the current active catcher array, composed of fast plastics, to acquire a better data set. The second approach has been to develop a second generation active catcher array. The new array design is the product of carefully studying the most interesting results in the existing data and the previous detector shortcomings.

In the first active catcher experiment, the data suffered from three major issues. First, the time required for the silicon detectors to generate a trigger exceeded the waveform recorded for the active catcher detectors. Secondly, the fast plastic detectors proved to be incapable of differentiating alpha particles from fission fragments and degraded beam. Finally, the high beam rate necessary for accessing the low cross sections for production of heavy and super heavy elements exceeded the capability of the passive bases and resulted in unstable gain in the photomultiplier tubes.

A second fast plastic based active catcher experiment was conducted in the Fall. This experiment was able to correct some of the previous issues. The times in the active catcher and silicon detectors were calibrated. This required changes in the silicon triggering behavior, but resulted in a well-defined region where exit peaks should be found in the the active catcher waveforms. Additionally, the active catcher detectors were better gain matched throughout the array. Finally, both high and low beam intensity runs were taken.

Throughout the last year, we have studied alternate detector materials for the active catcher array. We determined that Yttrium aluminum perovskite (YAP) is the most suitable replacement material. YAP is radiation hard, has light decay constants in the ns range, and has two components to its light output. The two components of the light output make pulse shape discrimination (PSD) possible. We have confirmed the suitability of YAP during two test runs. Fig. 1 depicts the PSD available in the proposed YAP/PMT/active base configuration. Fig. 2 depicts the time correlation of events leaving the active catcher and being observed in the IC-Si modules (x-axis). When plotted against the Si energy (y-axis), a band emerges that is correlated to the flight times of alphas from the active catcher to the Si detector.

A second generation active catcher array is currently under construction. It will employ 40 YAP/PMT/active base modules. These modules will provide the PSD necessary to differentiate alpha decay from alphas emitted during fission or as the result of scattered beam reactions with the active catcher. The addition of newly constructed active bases will provide a factor of ~1,000 in increased beam intensity relative to the previous bases before gain shifting occurs.

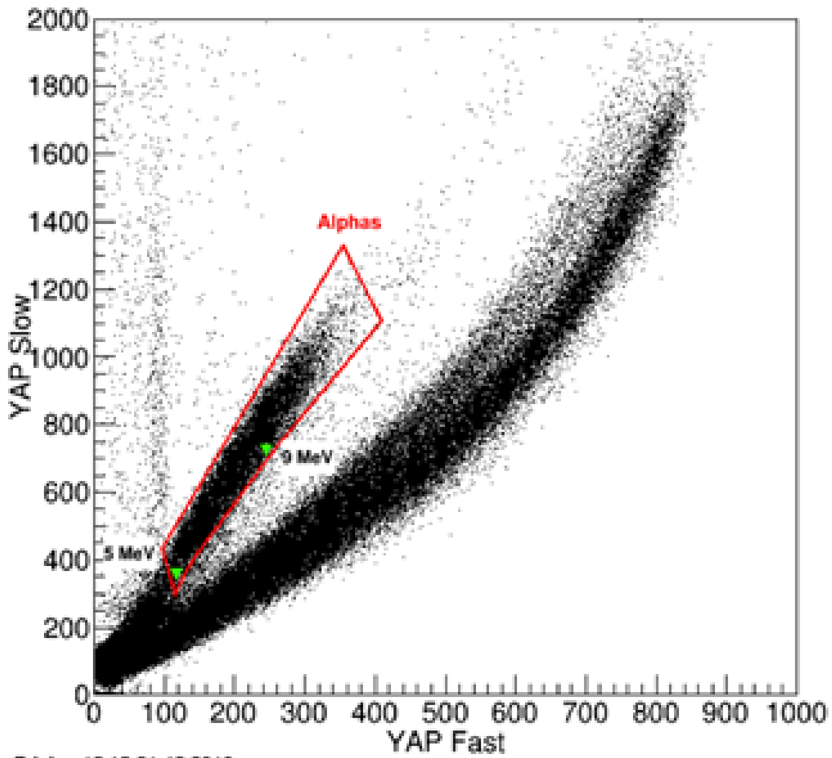

FIG. 1. YAP fast light output vs YAP slow light output. Approximate positions of Th228 alpha peaks are shown for reference.

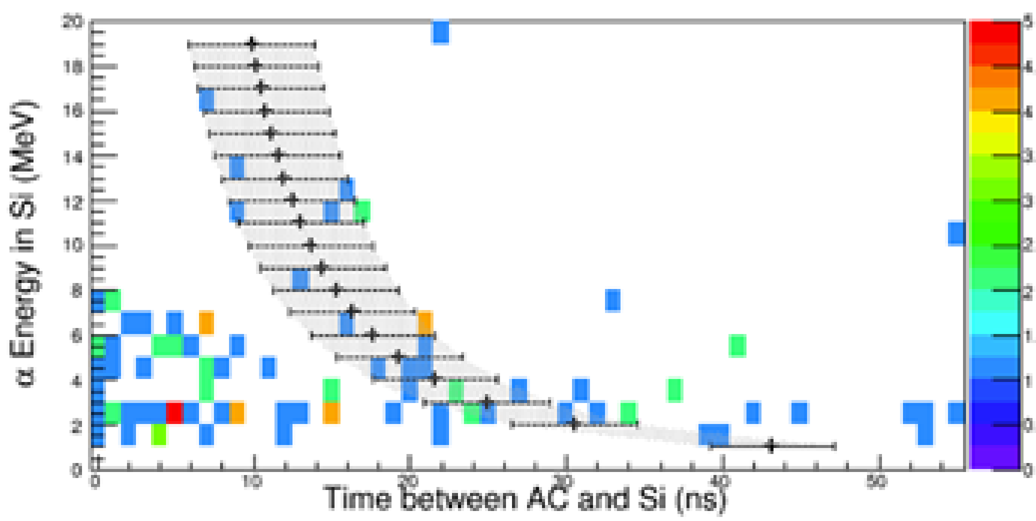

FIG. 2. The x-axis is the time difference between the signals observed in the active catcher module and the silicon module. The y-axis is the energy observed in the Si detector. The shaded region is the flight time (±4ns) for an alpha of a given energy.

Additionally, we have changed the waveform digitizers that will be used for the active catcher array. The new array will employ Struck SIS3316 digitizers (FADCs). These FADCs have a minimum 4ns bucket size but appropriate experimental conditions can reduce the the time resolution to ~1ns. These digitizers also offer new capabilities in triggering. The SIS3316 digitizers are capable of acquiring waveforms up to 32M samples long. This roughly translates to 1/8 s in wave form. Finally, the waveforms may be shifted to provide up to 64us of history prior to the trigger.