The search for super heavy elements using alternative mechanisms

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We reported a scheme of filtering events [1] in our search for Super Heavy Elements (SHEs) [2] to minimize the probability of identifying accidental events as super heavy element candidates. That analysis employed the profile of energy loss through successive segments of the ionization chamber (IC). We have continued the analysis of this data in an effort to assign an estimate of the charge and mass of the filtered SHEs. To accomplish this, we refined the filtering of the events to compare the IC energy loss profile of heavy elements to the predictions of an extrapolation based on the stopping power parameterization discussed in Ref. [3] which would lead to an estimate of the charge.

The comparison of the previously filtered heavy element candidates to the predictions of the extrapolated energy loss profile led us to the conclusion that the previously filtered events could not be real. We therefore used the extrapolated energy loss profile prediction as a filter in itself. This has the advantage that any SHE candidate that passes the filter will be consistent with the energy loss prediction of the particular assigned charge.

The complete unfiltered charge distribution of detected products that pass the hardware pileup filter is shown in Fig. 1. We note that there is a concentration of products in the region of the projectile. Above the target charge, we observe a small number of events. Even though the hardware pileup rejection has been applied, many of these events might result from pileup events that our hardware rejection missed. We therefore use all of the redundant measurements described in [1] to examine whether any of these higher charge events might be real.

The first check we make is to compare the measurement of the total energy obtained with the peak sensing ADC with that of the Flash ADC. That comparison is shown in Fig 2. The small scatter points represent the total event sample. The large solid points indicate the events that survived the filtering on charge as described above. The pileup rejection condition was not applied to these events. We note that only a few of the filtered events lie on or within a few percent of the diagonal line. The other events lie above the line. We speculate that these events result from accidental pileup in which the peak sensing ADC is integrating an event from a previous beam burst that occurred while the data acquisition was busy and then adding to it the triggered event that occurred a short moment later. We reject the events that do not line within a few percent of the diagonal line.

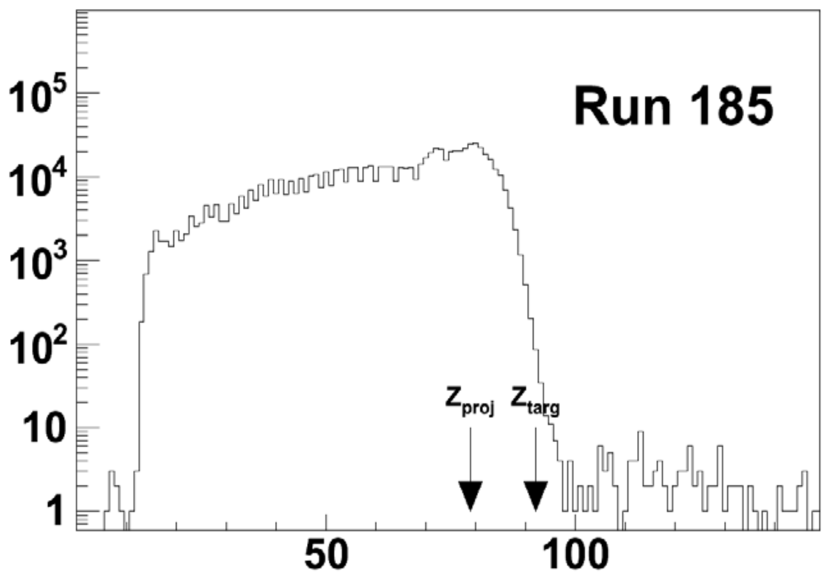

FIG. 1. Z distribution of all products that pass the hardware pileup rejection from a typical run.

We then further filter the accepted high charge events using the hardware pileup rejection.

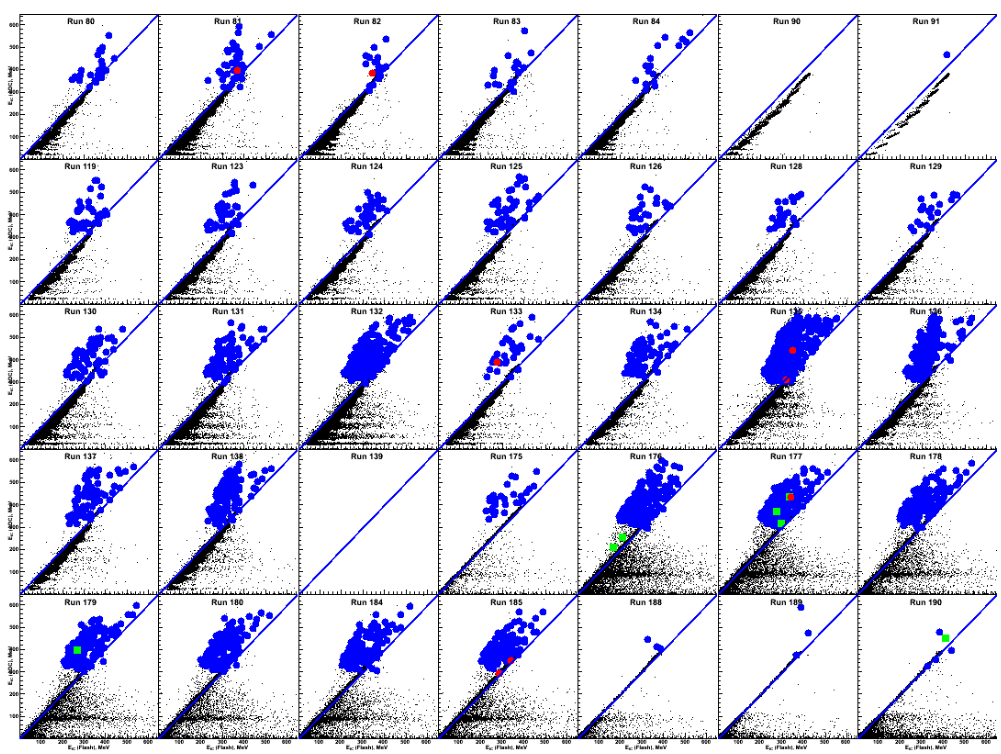

FIG. 2. Comparison of E measured from peak sensing ADC (y axis) with E measured from Flash ADC (x axis). A consistent measurement lies on the diagonal line.

Those points are shown in red in Fig. 2. That brings the total number of candidates to 5. We note that of those five, only 4 ie within 10% of the diagonal line, ie are a consistent measurement between the peak sensing ADC and the Flash ADC. One of the events fails one of the redundant time of flight tests and is therefore rejected as well.

The fit of the extrapolated stopping powers to the remaining events is shown in Fig. 3. We note that the

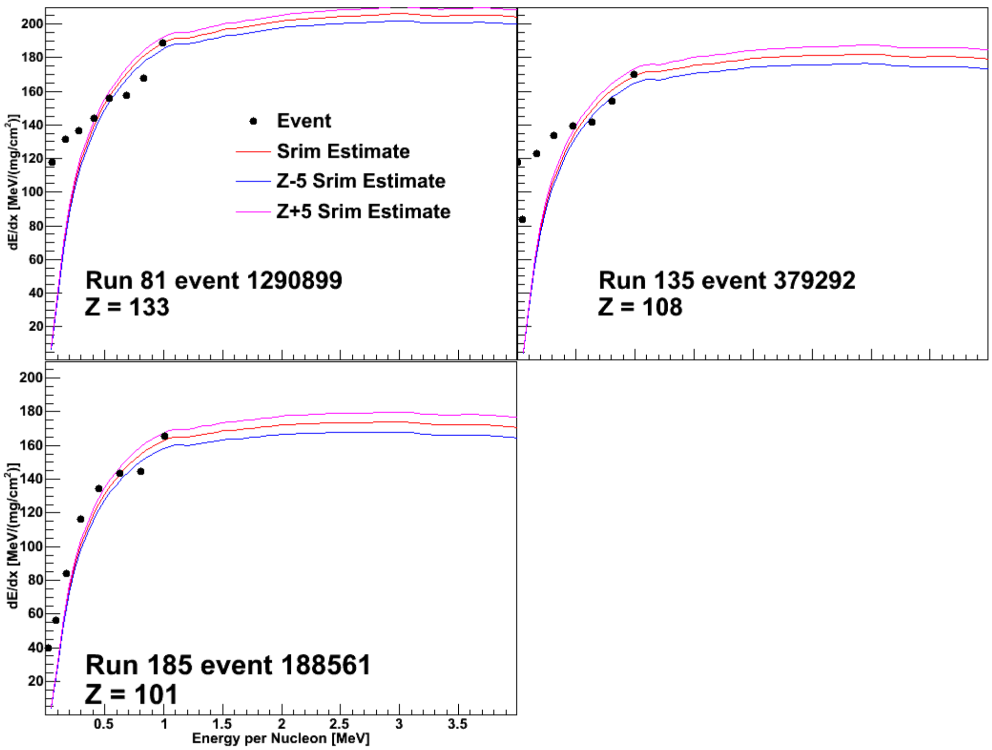

FIG. 3. Fits of the data to extrapolated SRIM. The calculated charge is shown.

data in the top two panels show a completely different characteristic as compared to the prediction of the extrapolated version of SRIM. We therefore reject those two events.

We are left with one event that has a charge near 100 that passes all of the tests. We have calculated based on an extension of what we reported previously [1] that we have a sensitivity of about 11nb per event.

That we have one event that passes all of the stringent tests gives us hope that we can use this technique in the search for super heavy elements. It is necessary, however, to build in several enhancements. We are planning an experiment to extend this study in which we hope to increase our sensitivity by a factor of 10-50. In addition, we plan to pulse the beam to eliminate the possibility of the spurious events in the peak sensing ADC. The plans also call for segmenting the IC in order to directly detect more of the events where more than one enter the IC at the same time.

[1] J.B. Natowitz *et al*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2008-2009) p. II-1.
[2] P. Sahu *et al*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2006-2007) p. II-1.
[3] M. Barbui *et al.*, Nucl. Instrum. Methods Phys. Res. **B** (in press), doi:10.1016/j.nimb.2010.04.018.