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Disclaimer

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Quarterly Progress Report

Near Field Detection

Project Title: Improving Fission Products at CARIBU

Quarter: Q1/FY22

Lab: Lawrence Livermore National Laboratory

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HQ Project Manager: Hank Zhu

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Programmatic Summary

Summary:

We worked with our collaborators at ANL to perform a measurement of the masses (and therefore energy difference) of the isomer and ground state for several fission products. The results of that measurement will have an impact on fission yields as well as on astrophysical calculations of r-process nucleosynthesis. We are currently analyzing the results of these measurements.

Notable Technical Highlights

Summary:

We worked closely with our collaborators at ANL to directly measure the masses of ground states and isomers of fission products from the CARIBU (^{252}Cf) source. These measurements were performed with the Canadian Penning Trap (CPT). The first step in these measurements is to identify the ions that have made it into the trap which relies on several filtering mechanisms. First there is a dipole magnet separator which filters out ions based on the charge to mass ratio. The resulting ions are further separated using a multireflection time-of-flight separator (MR-TOF), where the ions are allowed to travel back in forth between two electrostatic mirrors accruing a larger separation in travel time between the ions. Lastly, the ions are ejected from the MR-TOF and then tuned to be let through a Bradbury-Nielsen Gate, which is a set of wires that can be time to be quickly electrified and eject unwanted species. At this point the ions are injected into the CPT.

Figure 1 shows some representative spectra from the experiment. Figure 1(a) shows the result of ^{133}Cs ions injected in the CPT, trapped, and then measured after released. The ions are trapped by static magnetic and electric fields and process around the uniform magnetic field and along the electric-field gradients. With different trap times, the ions pick up different phases. When the ions are released, they are detected on a micro-channel plate (MCP) that provides x-y position information. Since the precession is largely circular, the ions will have a well-defined angle that is dependent on the ion mass. By using a known reference mass, such as ^{133}Cs, other ion masses can be identified by tracking their

resulting angles over different accumulation times. The main three clusters in Fig. 1(b) represent fission products from the A=154 mass region injected from CARIBU. By tuning the mass filters and observing the ions precessions they can be reliably identified. From this experiment we identified several fission products and their isomers including, ^{128,128m,132,132m}Sb, ^{154}Pm, and ^{154}Nd. We anticipate measuring the masses of these species to about 1 keV/c^2 precision.

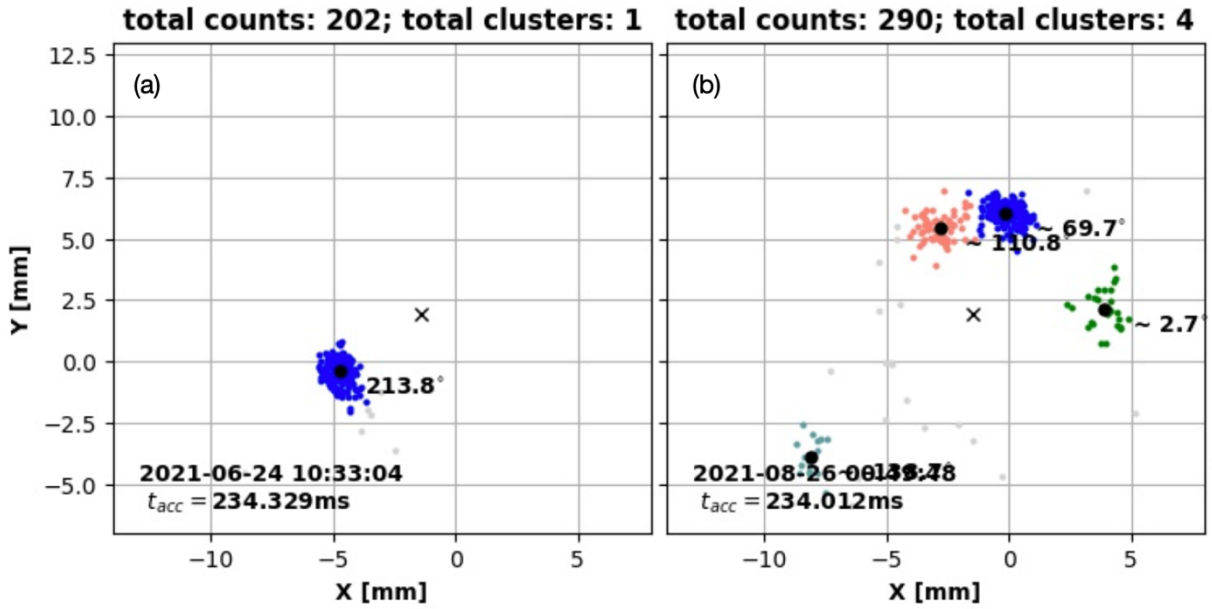

Figure 1: (a) A reference spectrum for ^{133}Cs, showing where the ion with a particular mass will appear on the MCP spectrum. (b) The resulting spectrum for mass 150 ions from the CARIBU fission product source. Disregarding the spot in the lower-left corner (from systematics) the other three clusters represent different mass ions. By looking at these with respect to the reference, their masses can be identified, and the mass differences can be determined.

Outlook

Summary:

- We plan to continue data analysis of isomer measurements including, ^{128,128m,132,132m}Sb, ^{154}Pm, and ^{154}Nd data collected in the recent experiment.
- We continue discussions with our collaborators at Texas A&M, as well as Argonne National Laboratory to plan for ^{161}Tb decay measurement.

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