Observation of ^{256}Db by MRTOF-MS

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In the final run of the LINAC07 superheavy nuclide mass measurement campaign we observed a handful of time-of-flight counts consistent with ^{256}Db^{2+}. A ≈304 MeV beam of ^{51}V^{18+} with an intensity of up to 2 particle μA was delivered by the RIKEN Ring Cycltron to the GARIS-II target in E6. The rotating target wheel was equipped with ^{nat}PbS targets; aluminum energy degraders were used to reduce the beam energy at target center to overlap with the excitation function of ^{208}Pb(^{51}V, $2n$)^{257}Db centered at ≈250 MeV.[1] The targets were produced via sputtering of the PbS material onto 2.9 μm-thick titanium support sheets. The typical areal density of the ^{nat}PbS was 650 μg/cm^2.

The gas-filled recoil separator GARIS-II removed the unreacted primary beam and delivered the fusion-evaporation products to the SHE-Mass gas cell.[2] After stopping in the gas cell, the ions were extracted via radio-frequency ion carpet and transferred to an ion trap suite where they were cooled in preparation for transfer to a multi-reflection time-of-flight mass spectrograph (MRTOF-MS).[3] After transfer to the MRTOF-MS, they were stored while undergoing several hundred reflections before being ejected and impact a combined ion implantation and decay detector.[4] In order to to preclude erroneous misidentification of ions with A/q far from the ions of interest—which would undergo a different number of reflections than, but have similar times-of-flight to the ions of interest—a pulsed deflector[5] located inside the MRTOF-MS's field-free central drift region removes ions of undesired isobar chains. In this measurement the MRTOF-MS achieved a mass resolving power of $m/\Delta m \sim 5 \times 10^5$.

In the course of 52 hours of beam on target, 12 time-of-flight (ToF) events consistent with ^{257}Db^{2+} and six ToF events consistent with ^{256}Db^{2+} were observed; no counts consistent with ^{258}Db^{2+} were observed. Three of the ^{256}Db^{2+} ToF events were quickly followed by a spontaneous fission event. While lacking any α-decay signals, we cannot absolutely confirm the identity of these ions as being ^{256}Db. The number of spontaneous fission events is consistent with the known fission branching ratio and the expected ≈100% detection efficiency for these events; the lack of detected α-decays from the other three events is slightly outside of statistical expectations.

To improve confidence in the identification of the these events as being ^{256}Db^{2+}, following 52 hours of target irradiation, after the end of the online measurement, a measurement was made under the exact same conditions but with a 10 MBq ^{252}Cf fission source inserted into the gas cell. The resulting spectra from online irradiation and fission source are shown in Fig. 1. The three identified molecular ions were significantly more intense in the case of the fission source, whereas the rate of ions in the ^{256}Db^{2+} span decreased; no spontaneous fission events were observed. In eventual future studies we hope to observe counts of ^{256}Db^{2+} with subsequent α-decays to unambiguously confirm the identification.

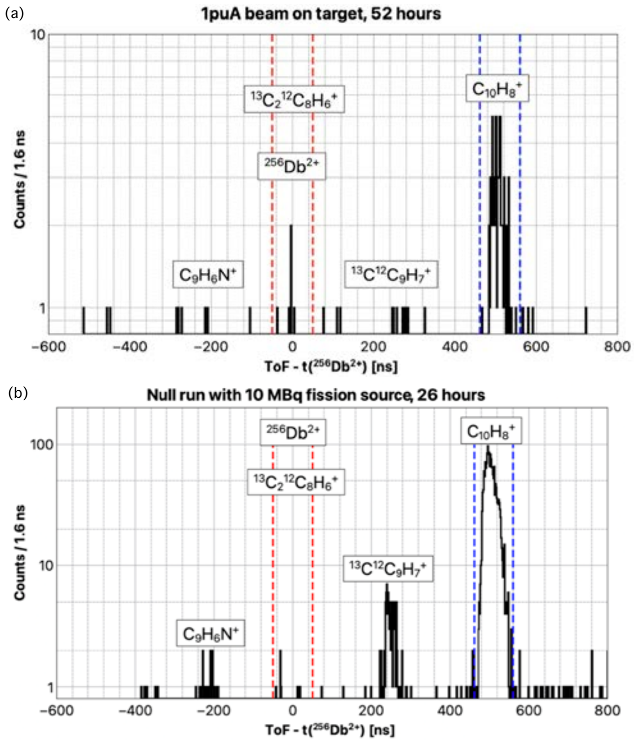

Fig. 1. (a) Observed ToF spectrum in the vicinity of ^{256}Db during target irradiation. (b) Observed spectrum in vicinity of ^{256}Db with intense fission source inserted immediately following the end of the online experiment.

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