Measurement of multiple isobar chains as a first step toward SHE identification via mass spectrometry†

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The SHE-mass project is a joint effort between KEK and RIKEN with a long-term goal of identifying new superheavy element (SHE) isotopes produced via hot fusion. It makes use of cryogenic-capable, high-purity helium gas cell to convert the energetic (5∼50 MeV) evaporation products of fusion reactions into thermal ions. The evaporation products are separated from projectile-like fragments by use of the GARIS-II[1)] gas-filled recoil ion separator. The thermalized ions are transferred to a multi-reflection time-of-flight mass spectrograph[2)] (MRTOF) which can analyze the ions with a mass resolving power of $R_{\mathrm{m}} > 100\,000$. The SHE-mass system is described in some detail in Ref. 3.

We previously reported[4)] initial results of the SHE-mass project, where MRTOF mass measurements were performed on ^{205,206}Fr, ^{205,206}Rn, ^{205,206}At, and ^{205}Po produced via ^{169}Tm(^{40}Ar, X) reactions at a bombarding energy of 193 MeV. In the interim, numerous upgrades were made to the apparatus, increasing the system efficiency and improving stability of operation.

In July, 2016, the ^{169}Tm(^{40}Ar, X) reaction was revisited at a bombarding energy of 207 MeV. At this higher energy, it was possible to simultaneous observe $4n$ and $5n$ evaporation channels (^{204,205}Fr$^+$), $p3n$ and $p4n$ evaporation channels (^{204,205}Rn$^+$) as well as higher-order evaporation channels (^{204,205}At$^+$, ^{204,205}Po$^+$, ^{205}Bi$^+$). The very small β-decay branching ratios of ^{204,205}Fr$^+$ (4(2)% and <1%, respectively) and the long half-lives of the lower-Z isotopes indicate that these are dominantly directly produced and not decay products.

Of particular interest for the long-term goals of the SHE-mass project, the very low-yield isotopes ^{205}Bi, ^{204,205}Po, and ^{206}Rn could be identified with very few detected ions, as shown in Figs. 1 & 2. The 3-σ deviation in the case of ^{205}Po is attributed to the admixture of a high-lying isomeric state[5)]. Based on this we can confidently claim that this technique can be applied to low-yield SHE for confirmation of their identity.

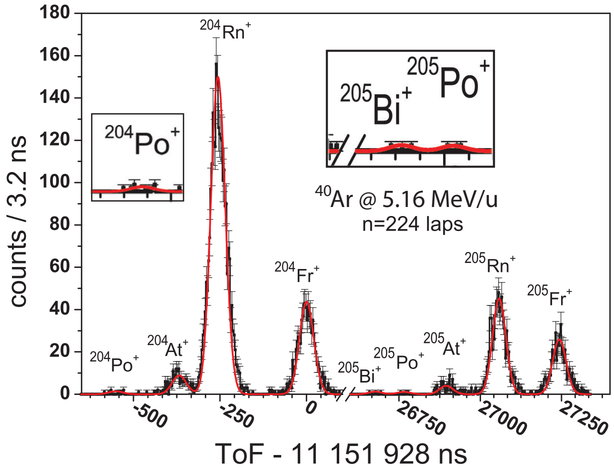

Fig. 1. Time-of-flight spectrum observed for A/q=204, 205 ions at n=224 laps.

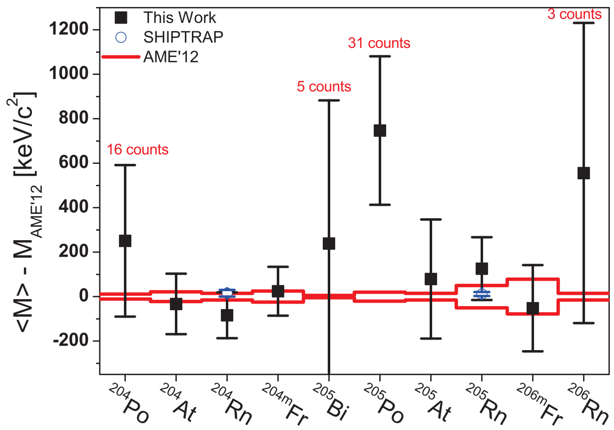

Fig. 2. Summary of the deviation of each isotopes measured mass from literature values.

References
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