High-precision mass measurements of proton-rich lanthanum and cerium isotopes with the ZD MRTOF-MS

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While the mass of an atomic nucleus is a crucial indicator of its underlying structure, few precise measurements have been carried out for proton-rich, medium-heavy nuclei. To fill this gap, we used the ZD MRTOF-MS (ZeroDegree-Multi-Reflection Time-of-Flight Mass Spectrograph)[1)] during the parasitic beam time PE24-03 to measure the masses of selected isotopes. Our proton-rich nuclei of interest were produced through the projectile fragmentation of a 345 MeV/nucleon uranium primary beam impinging on a beryllium target. The resulting cocktail beam was then separated and delivered to the experimental area by the BigRIPS-ZeroDegree spectrometer.

To ensure effective ion stopping in a helium-filled gas cell (RFGC), we placed a monochromatic wedge and a thickness-adjustable aluminum degrader at the final two focal planes of the ZeroDegree spectrometer. After thermalization via radio-frequency (RF) ion surfing and trapping techniques, the ions were injected into the MRTOF-MS for time-of-flight measurements, from which their nuclear masses were deduced.

Upgrading the conventional β-TOF detector to a system composed of a microchannel plate (MCP) and a MIRION PIPS silicon detector (MCP-Si)[2)] enabled a mass resolving power of approximately 500,000, although further optimization remains necessary. This new setup achieves low noise and high-resolution measurement and enables the detection of β-decay events occurring after ion implantation into the silicon detector. Consequently, β-decaying species can now be identified through the simultaneous acquisition of TOF data and silicon-detector signals.

Figure 1(a) presents the 12 nuclides measured in this work. Among them, the masses of six La and Ce isotopes (red circles) were determined for the first time; three isotopes (blue circles) were measured with improved precision, while the remaining isotopes (black circles) served as valuable reference masses. A preliminary TOF spectrum for the $A = 122$ isobars is shown in Fig. 1(b).

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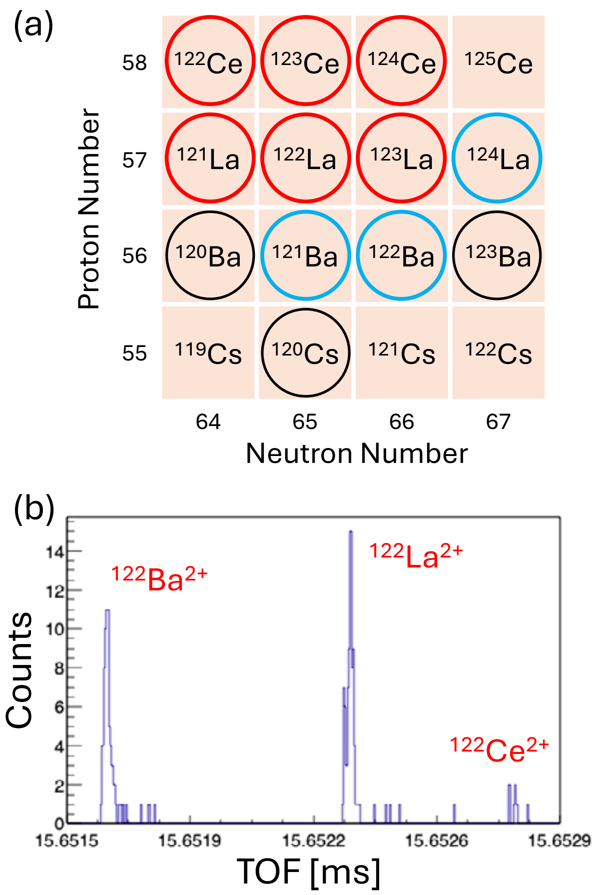

Fig. 1. (a) Nuclear chart around $A = 123$, showing the nuclides whose masses were measured with the ZD MRTOF setup (colored circles; see text for details). (b) TOF spectrum of ions with $A/q = 122/2$.

We are currently conducting detailed analyses to further refine the newly acquired masses and β-decay-correlated spectra, testing various degrader conditions, mass filters, and MRTOF configurations. These efforts are expected to enhance both the precision and accuracy of our measurements and deepen our understanding of the nuclear properties of the studied isotopes.

References
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