Mass measurements of neutron-sabbb $N = Z$ nuclei with ZD-MRTOF-MS system

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Mass is a fundamental property of the atomic nucleus. High-precision mass measurements of exotic nuclei, which directly determine the nuclear binding energy, play a significant role in advancing our understanding of the nuclear structure and nucleosynthesis processes. In particular, the masses of neutron-deficient nuclei near ^{92}Pd with $N = Z$ are critically important for studying the rapid-proton capture process (rp-process).[1)] Furthermore, these nuclei, with equal numbers of neutrons and protons, exhibit enhanced correlations between neutrons and protons occupying the same orbitals, which would have a significant impact on the nuclear-level structure. In FY2024, we measured the masses of over 100 nuclei using the ZD MRTOF system.[2)] In this work, we focus on the masses of neutron-deficient nuclei in the vicinity of ^{92}Pd with $N = Z$, aiming to provide valuable data for nuclear astrophysics and nuclear structure studies.

Since beginning operation in 2020, the ZD-MRTOF system, combined with an RF gas catcher (RFGC), has precisely measured the masses of numerous nuclei. In this experiment, the radioactive isotopes (RIs) of interest were produced via the projectile fragmentation reaction of a 345 MeV/nucleon ^{124}Xe beam incident on a ^{9}Be target. The experiment was carried out in parallel with in-beam γ-ray spectroscopy experiments (NP2112-RIBF211). The reaction products and unreacted secondary beam after the secondary target were transported through the ZeroDegree spectrometer. These products were subsequently captured and thermalized by the gas catcher before being transported to the ZD MRTOF system for further high-precision mass measurement. Additionally, a newly developed β-TOF detector[3)] was employed to measure the TOF signals and the β decay events simultaneously, enabling unambiguous particle identification.

In Fig. 1, the masses measured in this work are marked with red squares, including those of ^{91}Rh, ^{92}Pd, and ^{96}Cd, which were measured for the first time. Figure 2 presents a typical example of the TOF spectrum obtained during the measurement. In this work, the mass resolving power of the ZD MRTOF system reached $R_m \approx 7.8 \times 10^5$. For nuclei with previously known mass values, our results show good agreement with the precise mass values reported in AME2020.[4)] However, data analysis is ongoing, and the final results will be updated in future publications.

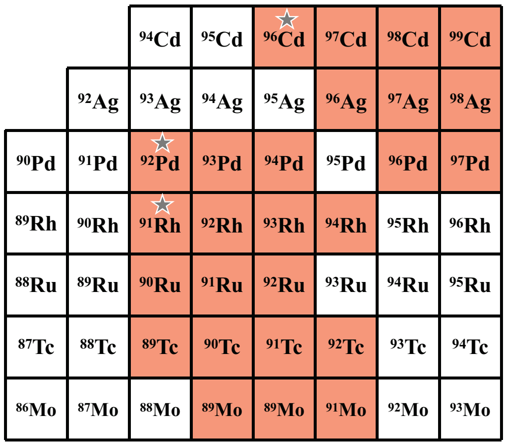

Fig. 1. The isotopes measured in this work are marked with red squares, and the new masses are marked with stars.

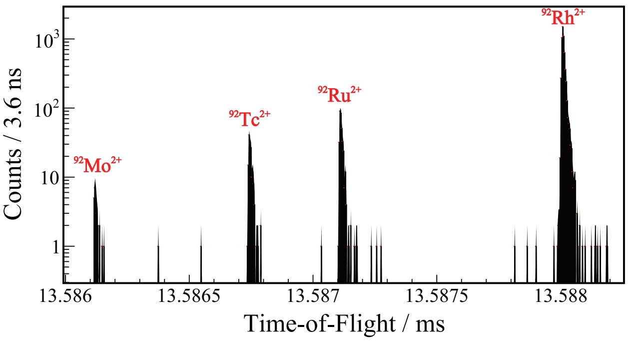

Fig. 2. TOF spectrum of ions with $A/q = 92/2 = 46$.

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References

1) E. Haettner *et al.*, Phys. Rev. Lett. **106**, 122501 (2011).
2) M. Rosenbusch *et al.*, Nucl. Instrum. Methods Phys. Res. A. **1047**, 167824 (2023).
3) T. Niwase *et al.*, Prog. Theor. Exp. Phys. **2023**, 031H01 (2023).
4) M. Wang *et al.*, Chin. Phys. C **45**, 030003 (2021).

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