Mass measurement of $A = 184$ isobars near stability

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We present mass measurements of $A = 184$ isobars near stability, including the first direct measurement of ^{184}Ta and ^{184}Ir. A six-day online study of multi-quasiparticle isomers in neutron-rich ^{183,184}Hf isotopes was performed by measuring the β and γ-decays of high-K isomers. Neutron-rich $Z \sim 74$ nuclides and their isomeric states were produced at the KEK Isotope Separation System (KISS) facility[1)] via multi-nucleon transfer (MNT) reactions from a stable 50-particle nA ^{136}Xe beam impinging on a 5-μm thick tungsten ($Z = 74$) target. The MNT reaction products were thermalized in a high-pressure argon-gas filled stopping cell.[2)] The captured ions were then transferred to a two-step two-color resonant laser ionization setup to select nuclei with proton number, Z, of interest. The selected ions were then extracted and transported to a β-γ decay measurement station comprising a 32-element gas counter for β-decay and internal-conversion measurement and four Super Clover germanium γ-ray detectors. During the "beam-off" counting periods at the decay measurement station, an electrostatic switchyard was used to transport the extracted ions from the gas cell to a multi-reflection time-of-flight mass spectrograph (MRTOF) for precise mass measurement and isomer identification. The masses of several $A = 184$ isobars were directly measured with and without laser ionization.

Figure 1 shows a single measurement run of doubly-charged ^{184}W, Os, Ta and Ir isobars without laser ionization. By tracking the drift of the reference ion TOF peak over time, drift correction was performed on the $A = 184$ isobars. With a total flight time of $t \approx 9.9$ ms and FWHM ≈ 16 ns, yielding a mass resolving power, $m/\Delta m = 300\ 000$. Thus, the MRTOF can clearly separate the isobars. Four hyper-EMG[3)] functions were fitted onto all peaks with the same peak shape parameters and varying amplitudes, producing a well-fitted spectrum for the $A = 184$ isobars. The 2nd peak is tentatively assigned as ^{184}Os, as its expected that the TOF is closer to the peak compared to that for ^{184}Re, which has a 30-keV difference in mass excess based on AME2020.[4)]

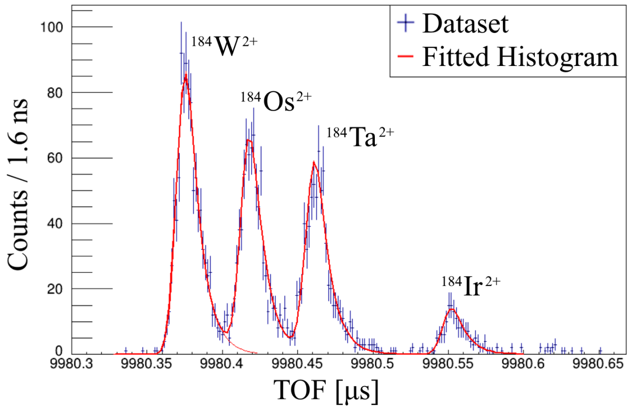

Fig. 1. TOF histogram of $A = 184$ isobars measured in MRTOF after drift correction. Four peaks are fitted (red) using the hyper-EMG function.

In comparison with literature, ^{184}Ta and ^{184}Ir masses were previously measured via β-decay end-point energies.[5,6)] Data analysis is ongoing, but we expect improved uncertainties from the MRTOF measurement. A preliminary evaluation by the atomic mass evaluation group also suggests that the new ^{184}Ta mass value leads to a significant shift in the evaluated mass of ^{184}Hf. In addition, the analysis of off-lap mass measurement of isobars at mass numbers $A = 182$ and 183 is currently underway. As the isotopes measured lie in the region of stability, we are also currently investigating the impact of the new measurements on the s and i-processes. Further efforts to survey isotopes in this region will also be undertaken in FY2024, to be conducted offline via ablation of metallic sources ranging from Hf to Pt at the KISS facility.

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