First reach of ^{100}Sn high-precision mass measurements

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The masses of atomic nuclei, including their ground states and isomers, are valuable observables to understand the underlying nuclear structure and nucleosynthesis networks. Nuclei in the region around ^{100}Sn are sought after, to locate a possible rp-process endpoint cycle and study the existence and relevance of proton-neutron pairing. The nucleus ^{100}Sn, having equal proton and neutron numbers $N = Z = 50$, is of particular interest due to its closed-shell structure and being self-conjugate. This configuration maximizes contributions of short-range interactions by *pn*-pairing. Furthermore, it is the heaviest known doubly-magic $N = Z$ nucleus, although new theoretical studies for ^{164}Pb are in progress.[1] Isotopes in the ^{100}Sn region are difficult to produce, and experimental knowledge is incomplete. However, in-beam γ-ray and β-γ spectroscopy could be performed, and an unconventional mass measurement of ^{100}Sn performed in the second cyclotron of GANIL at high kinetic particle energies was reported.[2] Recently, high-precision mass measurements with slow ions have reached ^{103}Sn; however, $A < 103$ Sn isotopes remain untouched.[3,4]

We have performed new mass measurements of proton-rich nuclei down to ^{100}Sn with high precision at low ion energies, using the ZD MRTOF system.[5] Proton-rich nuclei were produced via fragmentation reactions of a ^{124}Xe beam operated at 345 MeV/nucleon on a ^{9}Be target. The experiment was performed with in-beam γ-ray measurements at the focal-plane chamber F8, where ^{100}Sn was delivered upon direct production, and populated by $1n$ and $2n$ knock-out in ^{101,102}Sn, respectively. Residual ions were stopped in the SLOWRI cryogenic He-filled gas cell with a radiofrequency ion carpet (RFGC) downstream of the ZeroDegree spectrometer. The ions were thermalized and extracted from the RFGC, transported to a planar radiofrequency ion trap, and injected into the MRTOF device. A β-TOF detector, which enableds the simultaneous measurement of heavy-ion impact and β-decay signals, was used for ion-TOF detection. While performing multiple reflections, the ion ensemble was purified using an in-MRTOF deflector (IMD), where individually selected isobar chains with multiple chosen mass units were transmitted simultaneously.[6]

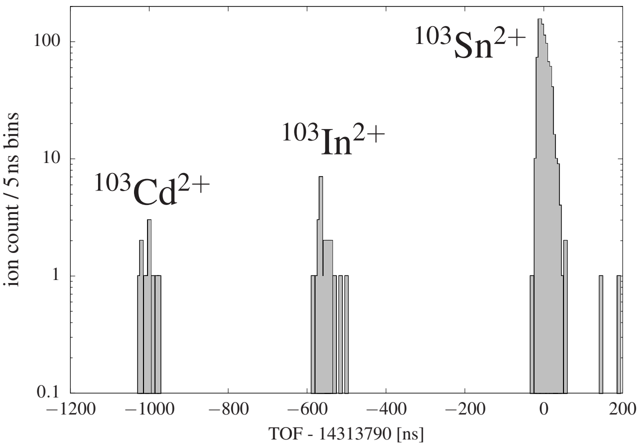

Fig. 1. TOF spectrum of the $A = 103$ isobaric chain.

The combined experiments were conducted over a period of 11 days, where the isotope masses of $^{101-104}$Sn were measured with high statistics (see ^{103}Sn example in Fig. 1), and β-decay correlated TOF spectroscopy was performed. Subsequently, a dedicated measurement for the desired ^{100}Sn^{2+} ions was commenced, with the IMD configured to exclusively transmit $A/q = 50$ ions. The beam-energy degrader was adjusted using the RFGC transmission-PID data and MRTOF data of other isotopes, followed by an extrapolation to ^{100}Sn. The TOF events at a low rate of a few counts per day could be detected in the expected TOF range, while the particle PID was continuously used to confirm the incoming rate of ^{100}Sn (10–20 cph). A challenge for the unambiguity of the ^{100}Sn measurement is the possibility of obtaining the intruder molecule $^{13}C^{37}Cl^{+}$, which would be detected with a TOF in the same proximity. The data is presently under review, where an event-by-event analysis is being performed.

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