Mass measurements of neutron-deficient Yb isotopes and their impact on tracing the two-proton dripline

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Introduction

The masses of neutron-deficient Yb isotopes with mass numbers 150-157 were measured with the TITAN MR-ToF MS. Thanks to long alpha chains of known decay energies but of unknown masses, the measured Yb isotopes can be used as anchors for these alpha chains and the unknown masses can be therefore determined. With the newly calculated masses we derive the two-proton separation energies S_{2p} from which we determine the position of the two-proton dripline between Z=77-82.

Mass measurements of n-deficient Yb isotopes with the TITAN MR-ToF MS

- The TITAN MR-ToF MS (Fig. 2) is one of the 4 traps in the TITAN beamline (Fig. 1).
- Mass resolving power: $\frac{m}{\Delta m} \approx 200{,}000$
- Background handing $1:10^4$ partly due to mass selective re-trapping.
- Measured:
  - ^{150}Yb, ^{153}Yb for the first time.
  - ^{151g}Yb, ^{151m}Yb , ^{152}Yb directly for the first time.

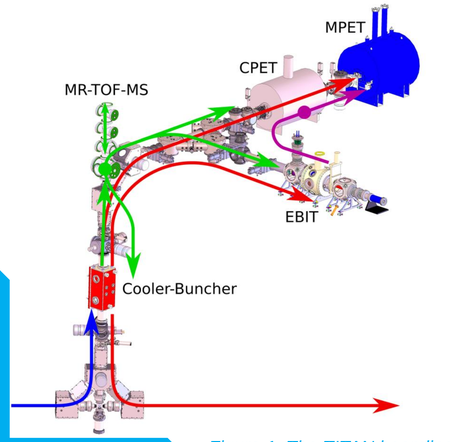

Figure 1. The TITAN beamline

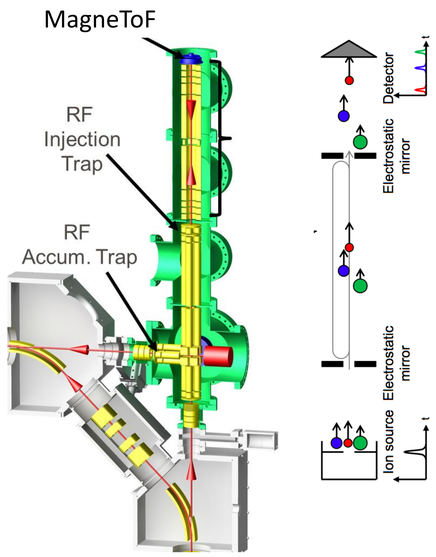

Figure 2. The TITAN MR-ToF MS (left) and the principle of MR-ToF mass spectrometry (right)

Decay chains

- Due to known α,β and p-decay energies, the masses of all connected isotopes in the region can be calculated.
- Due to the long alpha chains, we are able to reconstruct masses over the range of 18 elements (Fig. 3).

Results

- We collaborated with the Atomic Mass Evaluation (AME) group and used the AME algorithm to determine all the interlinked nuclei for which we could improve their mass uncertainties. The result can be seen in Fig. 3.
- More specifically, we were able to significantly improve (by about a factor of 2 or more) the precision of the masses of 10 isotopes and to calculate for the first time the mass of another 14 nuclei (See Fig. 4).
- From these masses, the two-proton separation energies were calculated as $S_{2p} = [m(Z,N) - m(Z-2,N) - 2m_p]c^2$. The result along with comparison with literature values can be seen in Fig. 5.
- Theoretical two-proton driplines for the even-Z nuclei are represented in Fig. 6 with solid red (Gogny CHFB+5DCH) and dashed blue (Skyrme UNEDF1) vertical lines.

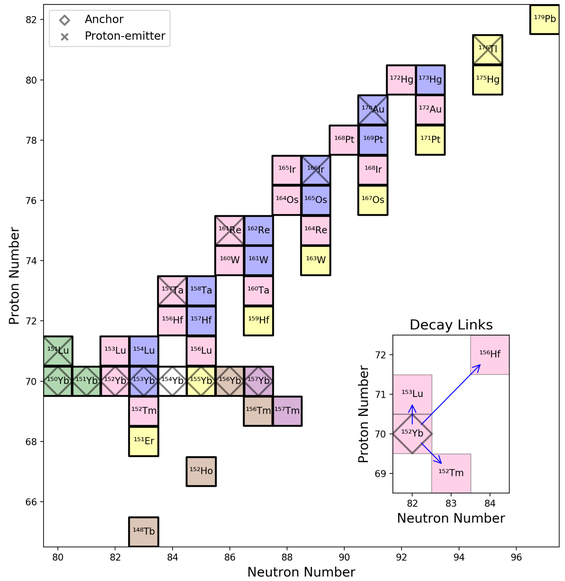

Figure 3. The decay chains used in this work. The anchors of the chains are indicated with diamond symbols..

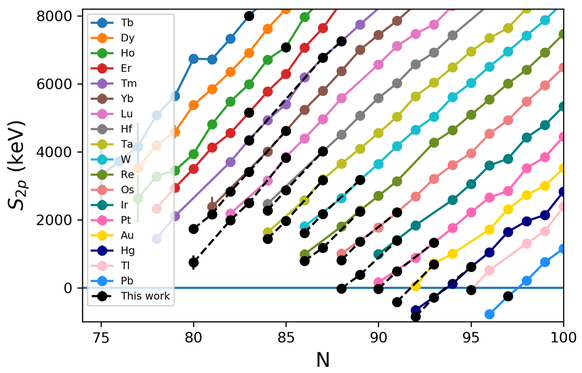

Figure 5. Comparison between the two-proton separation energies calculated in this work and those derived from literature mass values (AME2020).

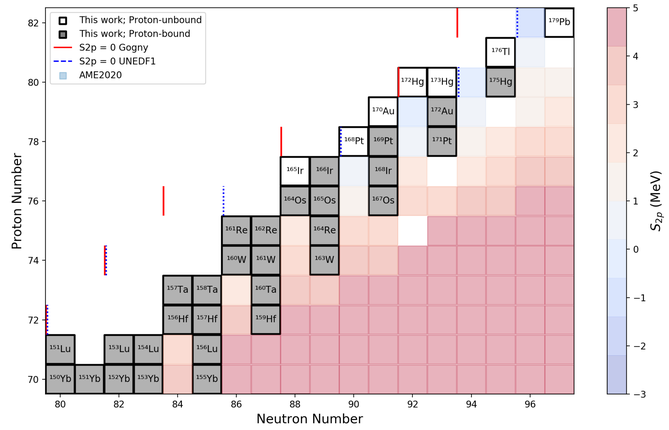

Figure 6. Two-proton bound and two-proton unbound species determined in this work. Red solid lines and blue dotted lines represent theory calculations.

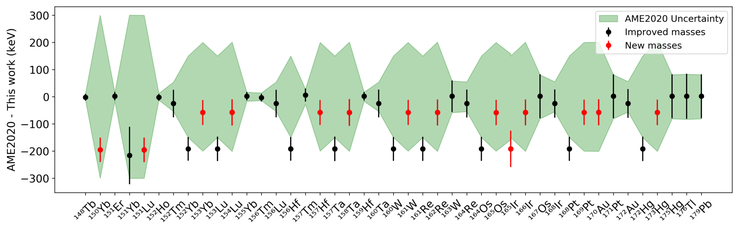

Figure 4. Deviation of improved (black) and new (red) mass values derived from this work from their AME2020 values. The green area indicates the AME2020 uncertainty of each mass. .

Acknowledgments

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Discovery, accelerated