Isomers in even-Z nuclei below the $N = 82$ shell

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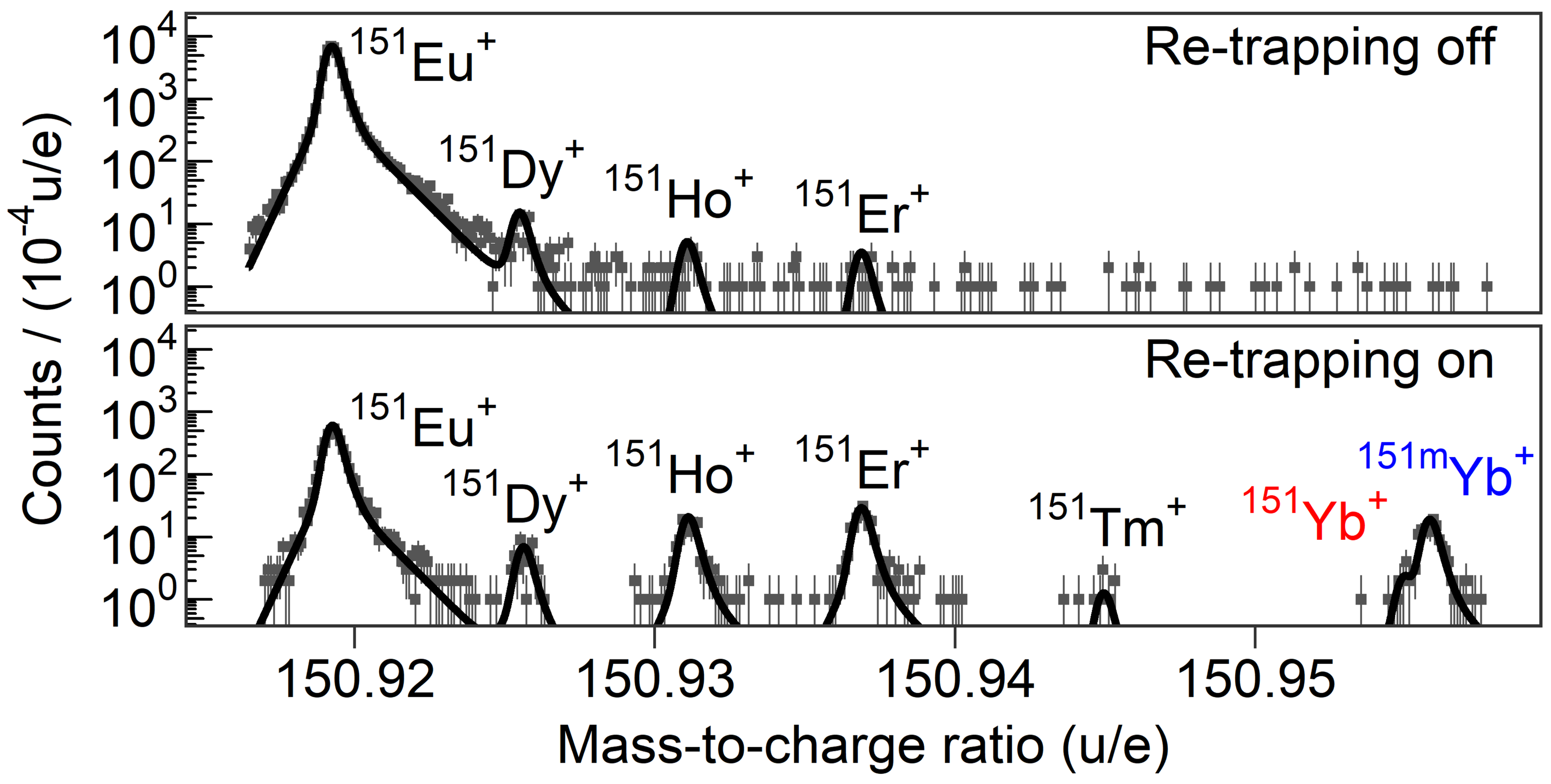
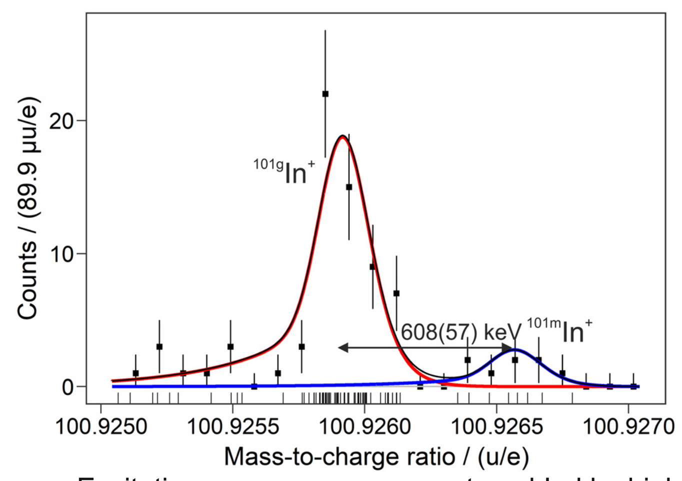
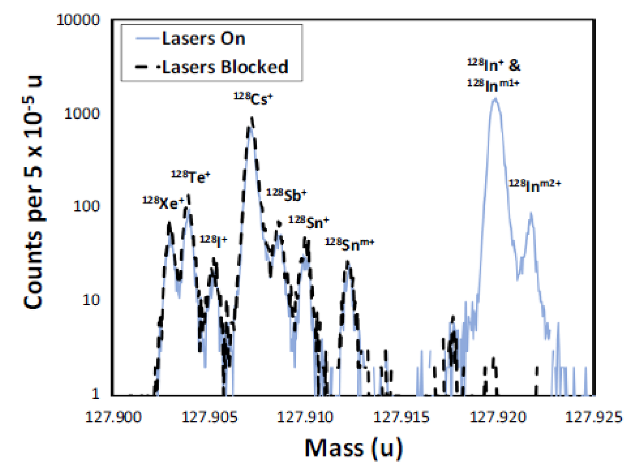
MR-TOF-MS for isomer studies

- Fast, sensitive, non-scanning and broadband mass measurements
- Measuring ground and isomeric states simultaneously
- One neutron farther from stability compared to PI-ICR.
- Decay-independant, thus powerful for discovering long-lived isomers [1,2] and study their properties [3]
- Mass-selective re-trapping enables measurements two more neutrons farther from stability [4,2].

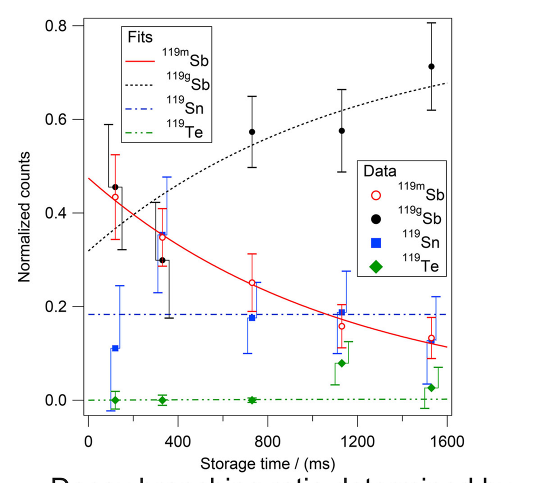




Excitation energy measurement enabled by high sensitivity and non-scanning measurement with ~30nbarn i.s. production cross section [1].



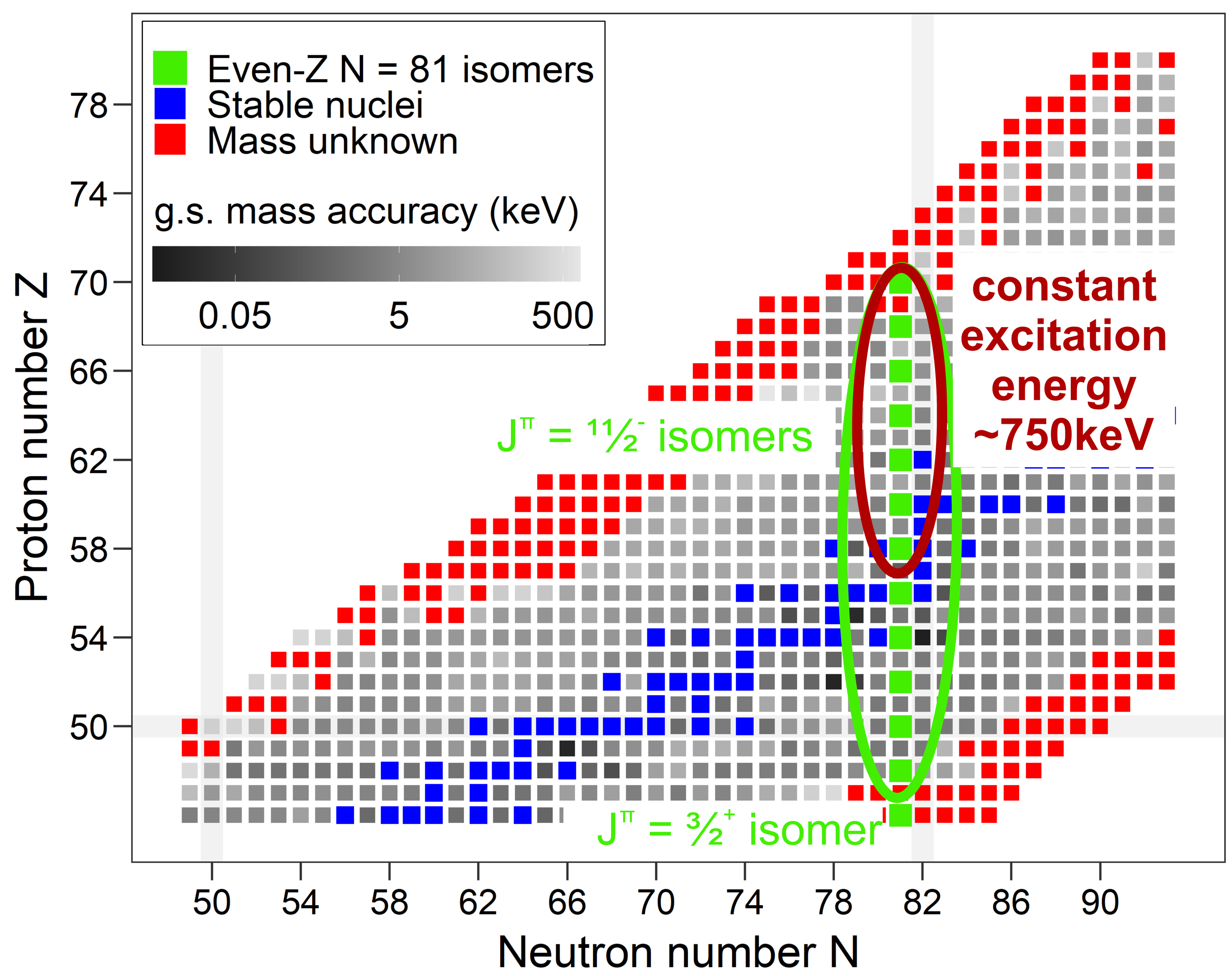
Isomer discovery enabled by non-scanning measurement [2].



Decay branching ratio determined by simultaneous measurement of the isomer and possible daughters after storage in an ion trap [3].

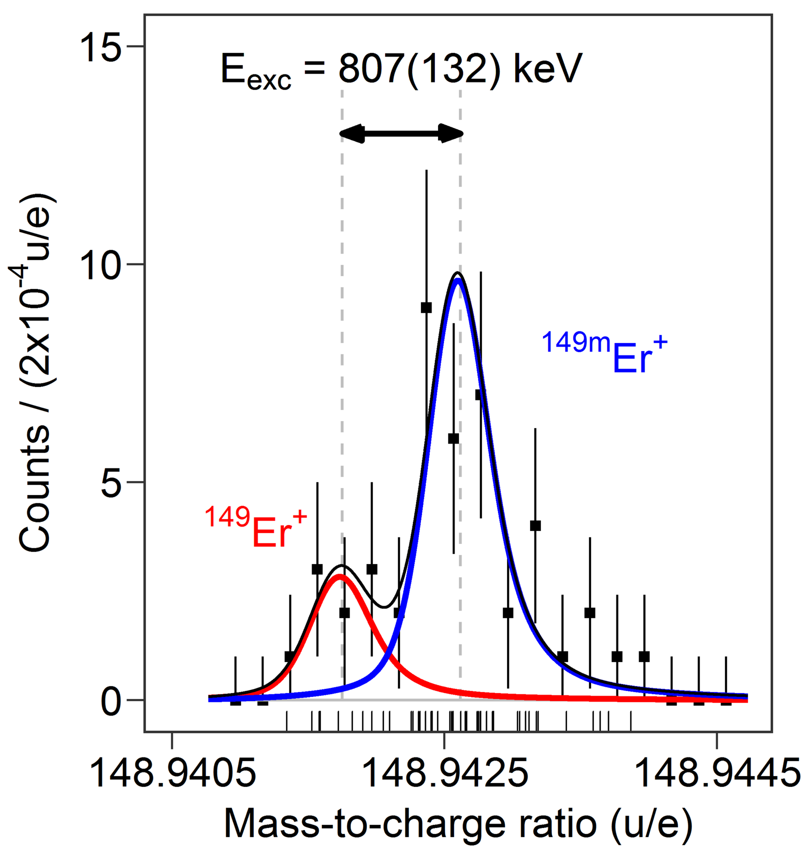
Even-Z $N = 81$ isomers

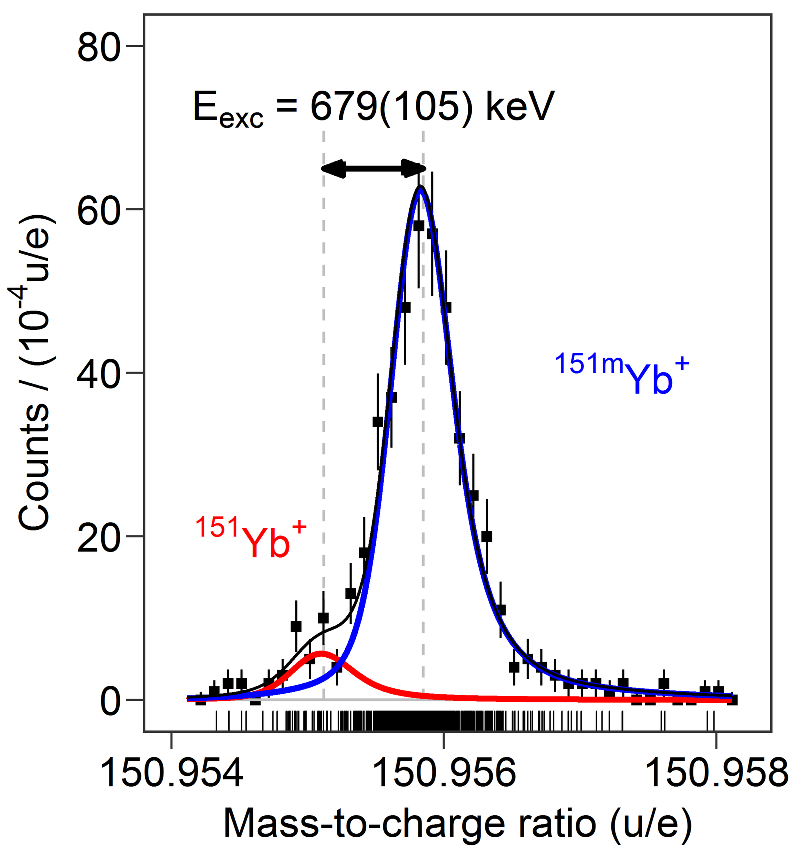
Neutron-hole states below the closed shell. The $J^\pi = 1/2^+$, $3/2^+$ and $11/2^-$ states are associated with $s_{1/2}$, $d_{3/2}$ and $h_{11/2}$ orbitals, respectively.



Experimental results

Measured $J^\pi = 11/2^-$ isomer excitation energies and isomer-to-ground state ratios for ^{149}Er and ^{151}Yb, the latter excitation energy measured for the first time, which requiring mass-selective re-trapping [4].





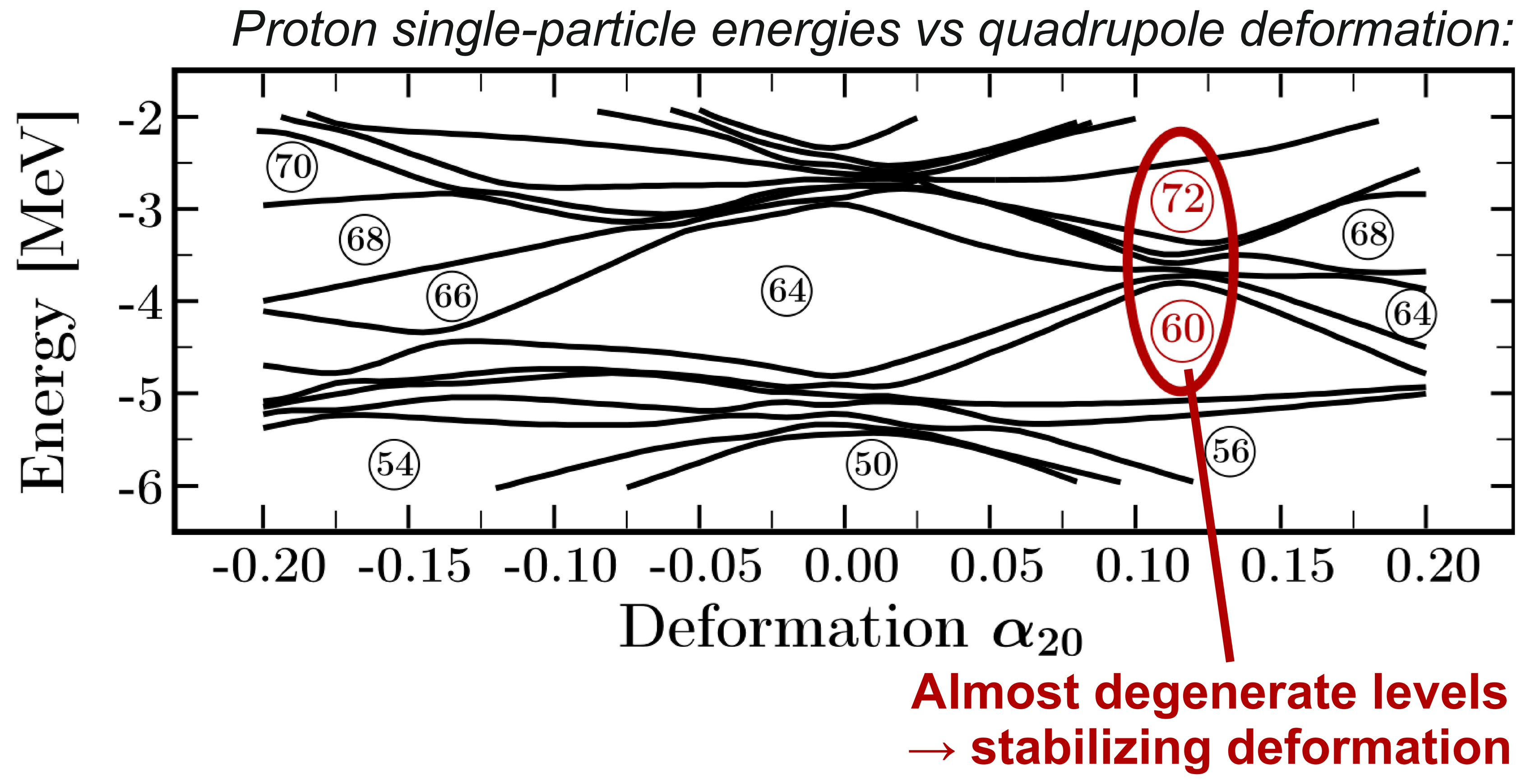
Theoretical results

Constant excitation energies of $J^\pi = 11/2^-$ isomeric states over half of the shell was not understood before.

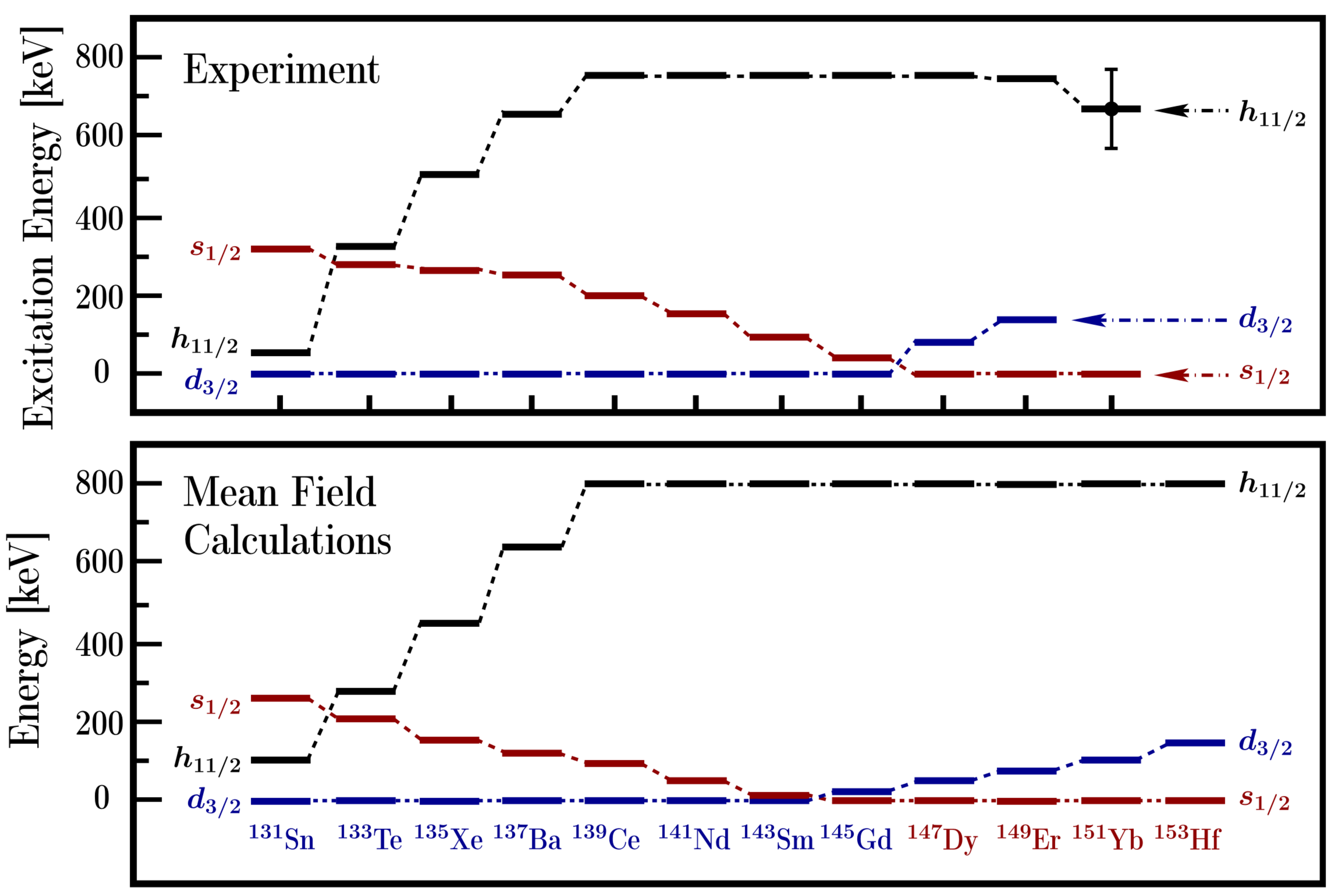
Microscopic-Macroscopic calculations with the phenomenological, deformed Woods-Saxon mean-field Hamiltonian with universal parametrization were performed.

- Ground state shapes predicted spherical up to $Z = 56$, then oblate; isomeric state shapes predicted prolate.

Proton single-particle energies vs quadrupole deformation:



- The highest occupied neutron level becomes dominantly an $h_{11/2}$ orbital with spin projection $m_j = 11/2$ for prolate deformations, consistent with the experimentally observed level crossing.
- Onset of constant excitation energies coincides with $\alpha_{20} \approx 0.1$ prolate shapes in the isomeric states.



- Trend predicted to persist in ^{153}Hf, the next isomer in the chain.

References

[1] C. Hornung *et al.*, Phys. Lett. B **802**, 135200 (2020)
[2] C. Izzo *et al.*, Phys. Rev. C **103**, 025811 (2021)
[3] I. Miskun *et al.*, Eur. Phys. J. A **55**, 148 (2021)
[4] S. Beck *et al.*, Phys. Rev. Lett. **127**, 092502 (2020)