ESR measurements of high-spin isomers in n-rich hafnium isotopes: E109

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1. Physics motivation
2. Results so far
3. Future plans

Physics motivation

- Upper part of shell (N=82-126, Z=50-82)
- Reinforcing proton and neutron effects
- Prolate-to-oblate phase transition (I=0)
- Prolate deformation-aligned vs.

  oblate rotation-aligned (I=10-20)

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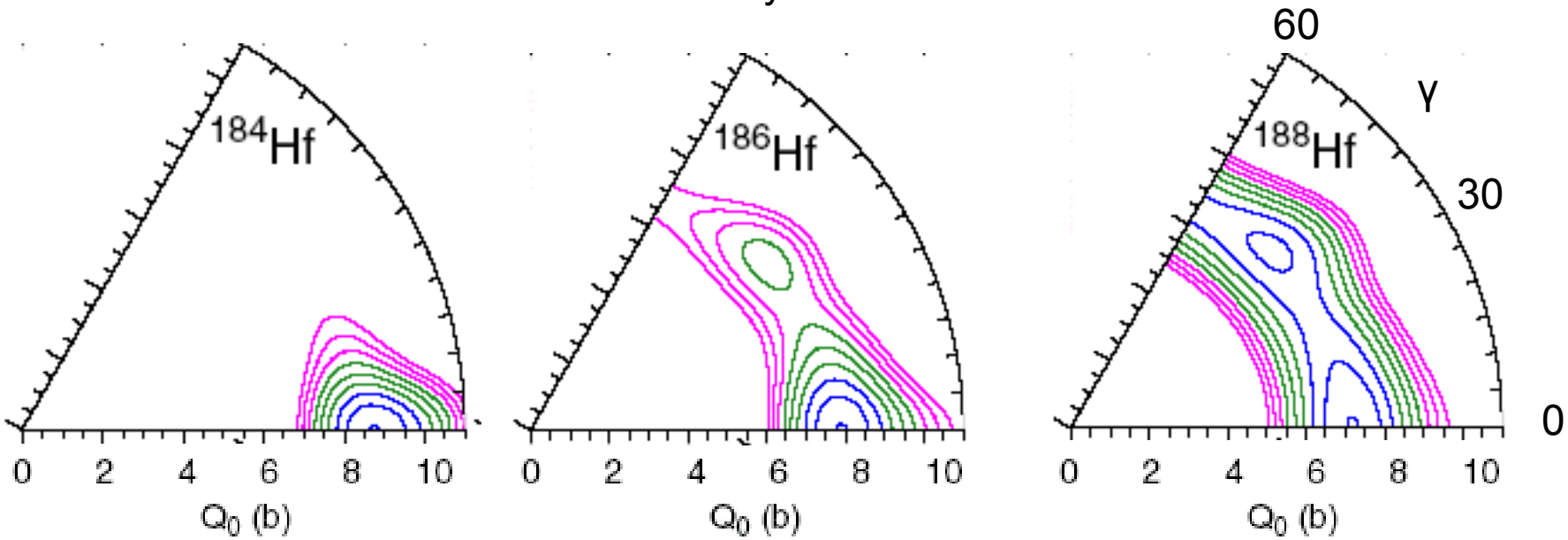
prolate-oblate shape transition

n-rich hafnium ground states

HFB + SLy4



Robledo et al., *J. Phys. G: Nucl. Part. Phys.* **36**, 115104 (2009).

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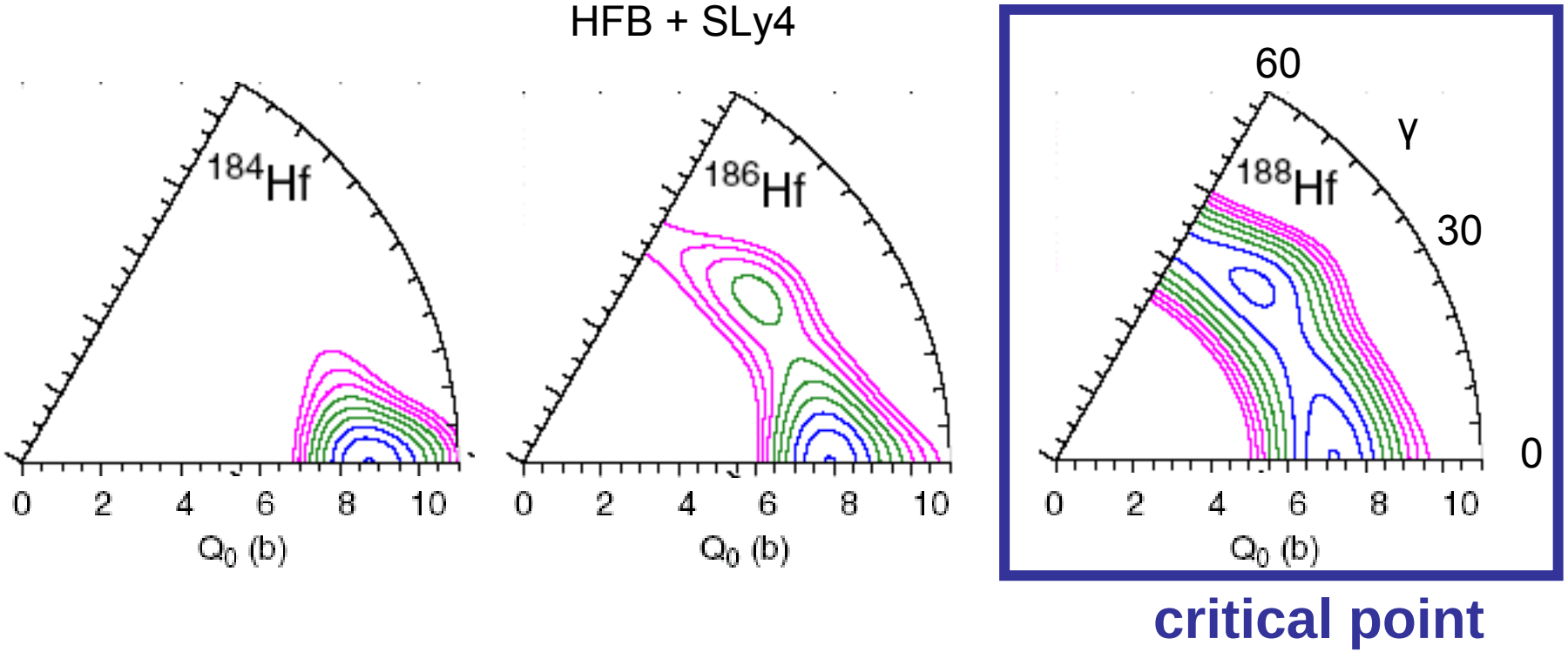
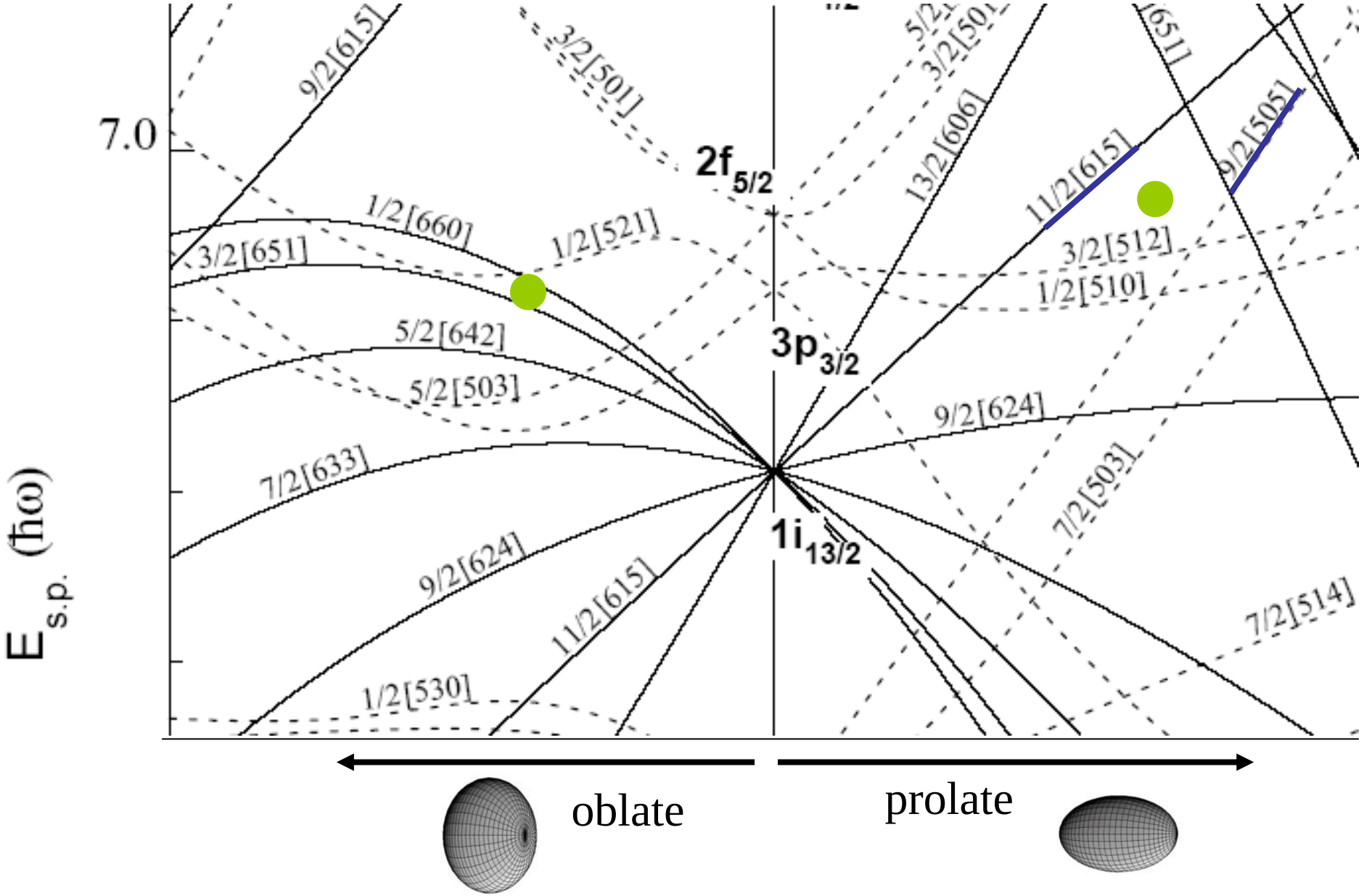


critical point

Robledo et al., *J. Phys. G: Nucl. Part. Phys.* **36**, 115104 (2009).

Nilsson single-particle diagram ● N = 116 Fermi level (^{188}Hf)



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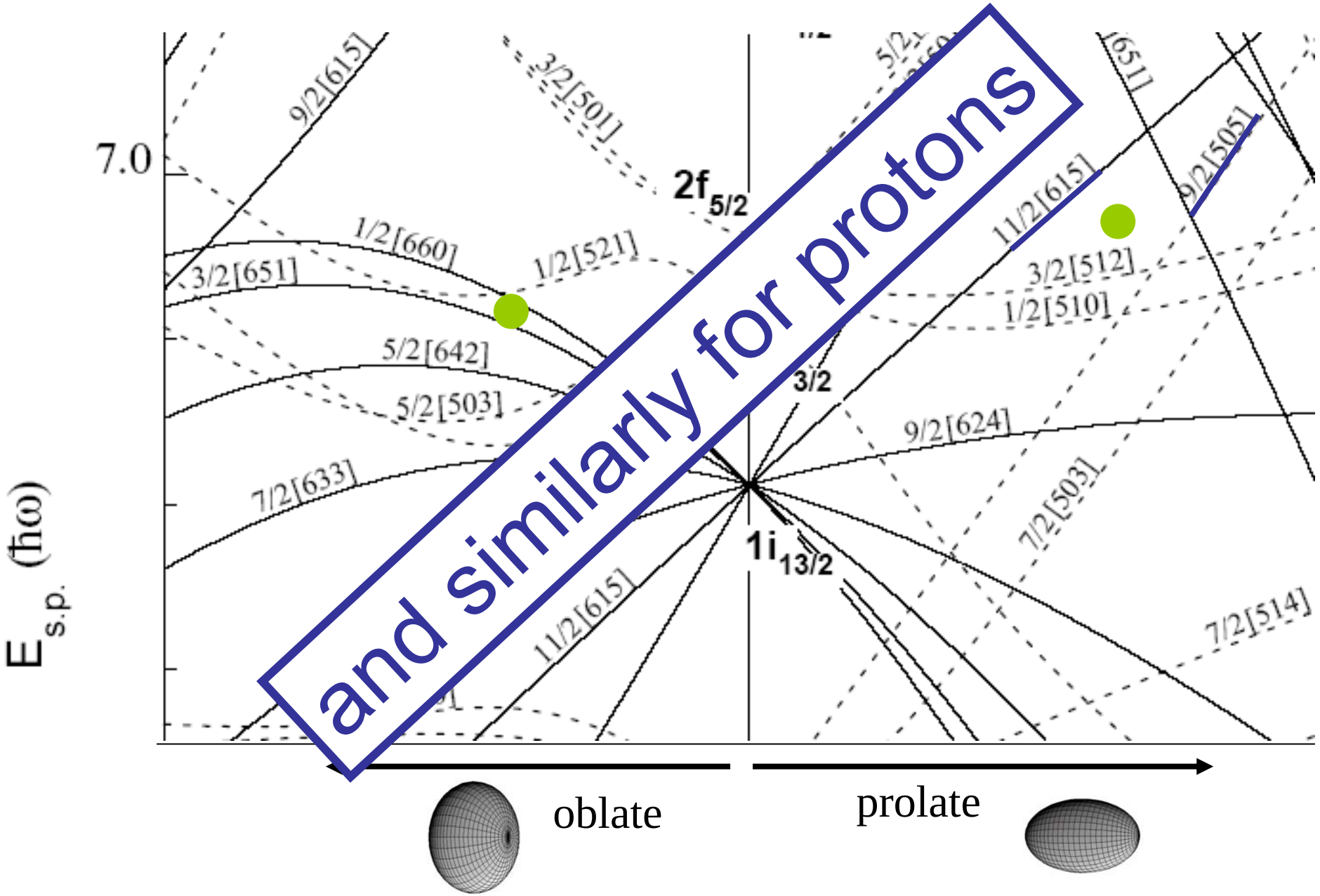

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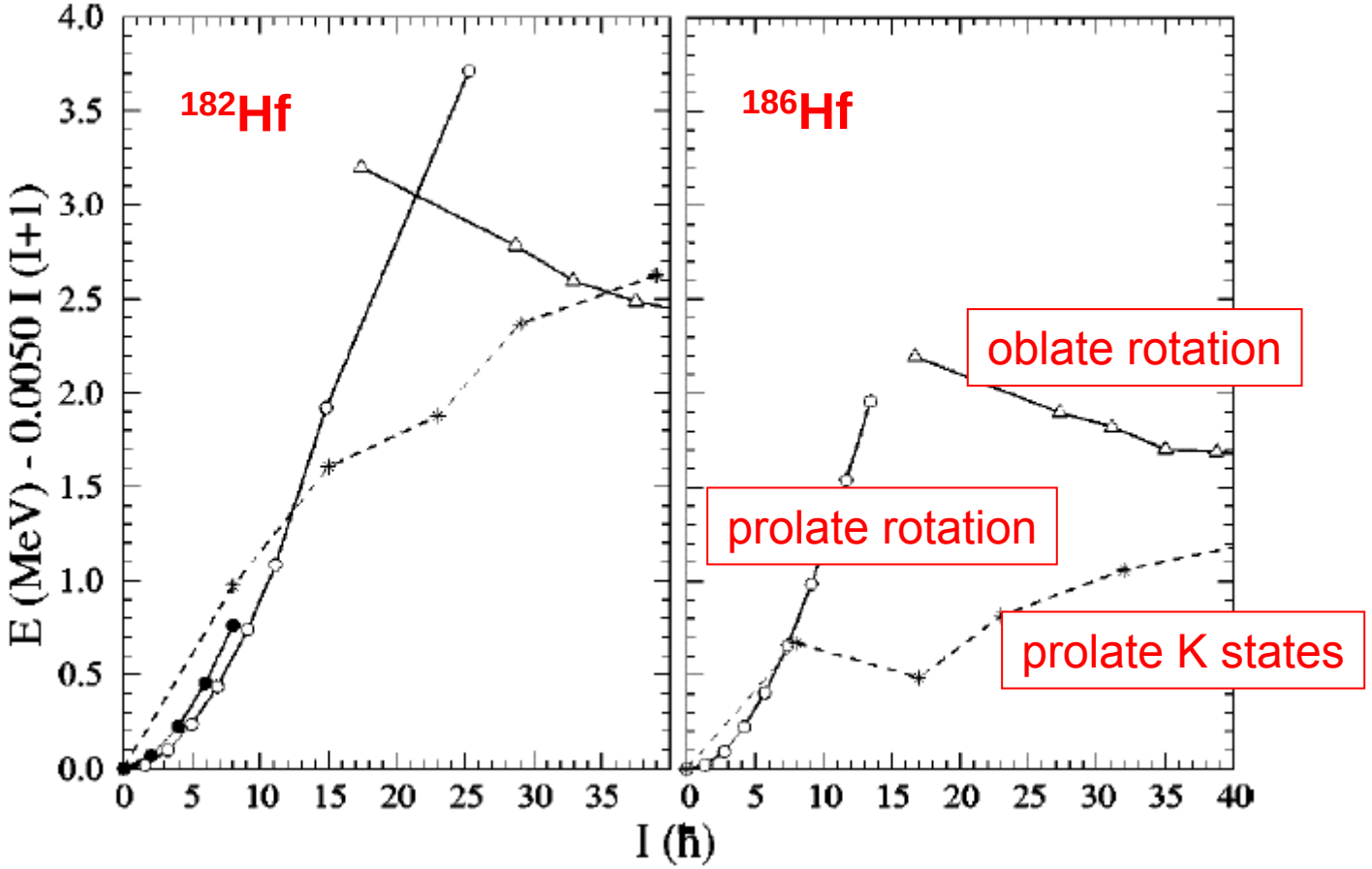
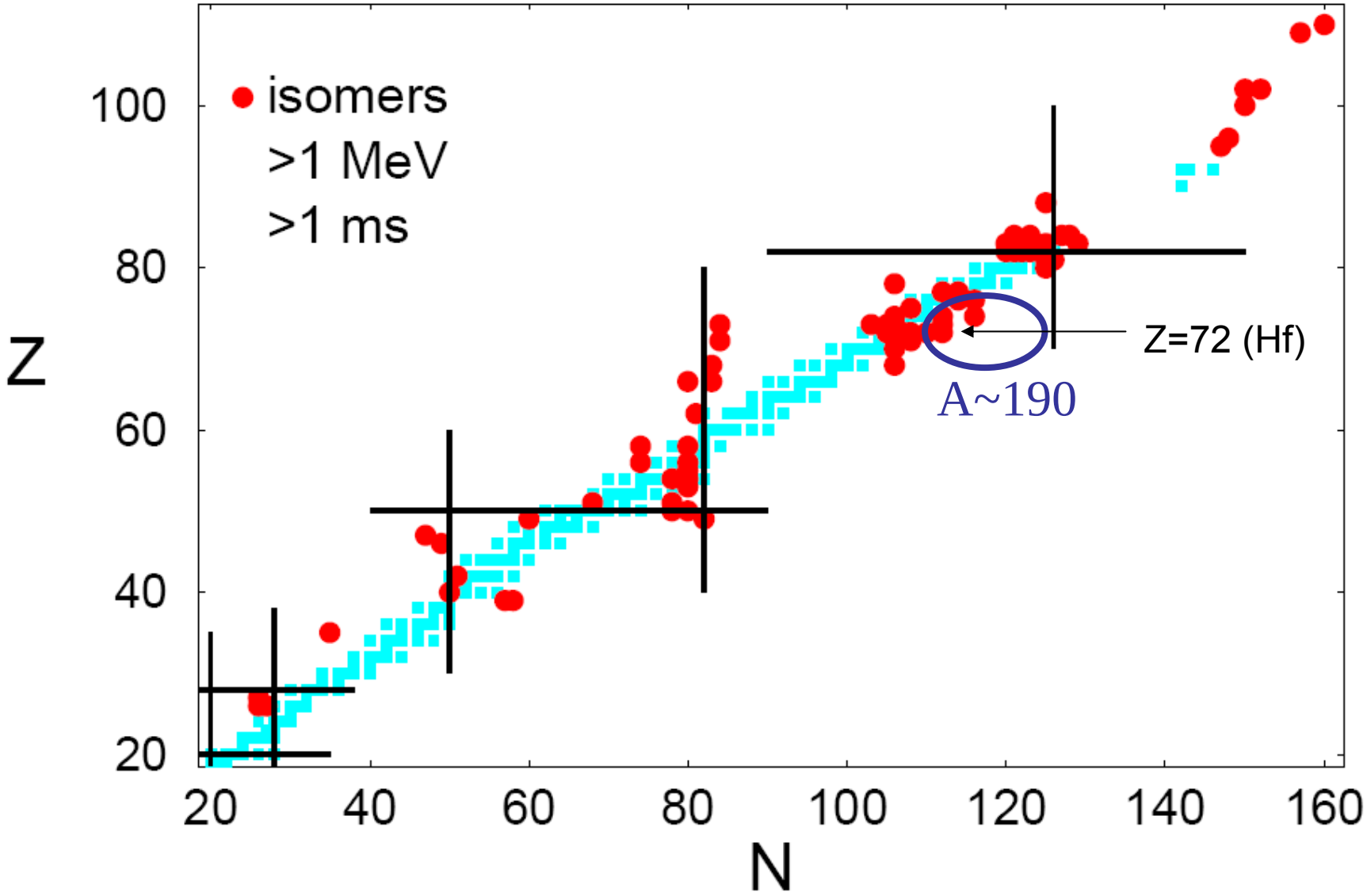


configuration constrained TRS calculations

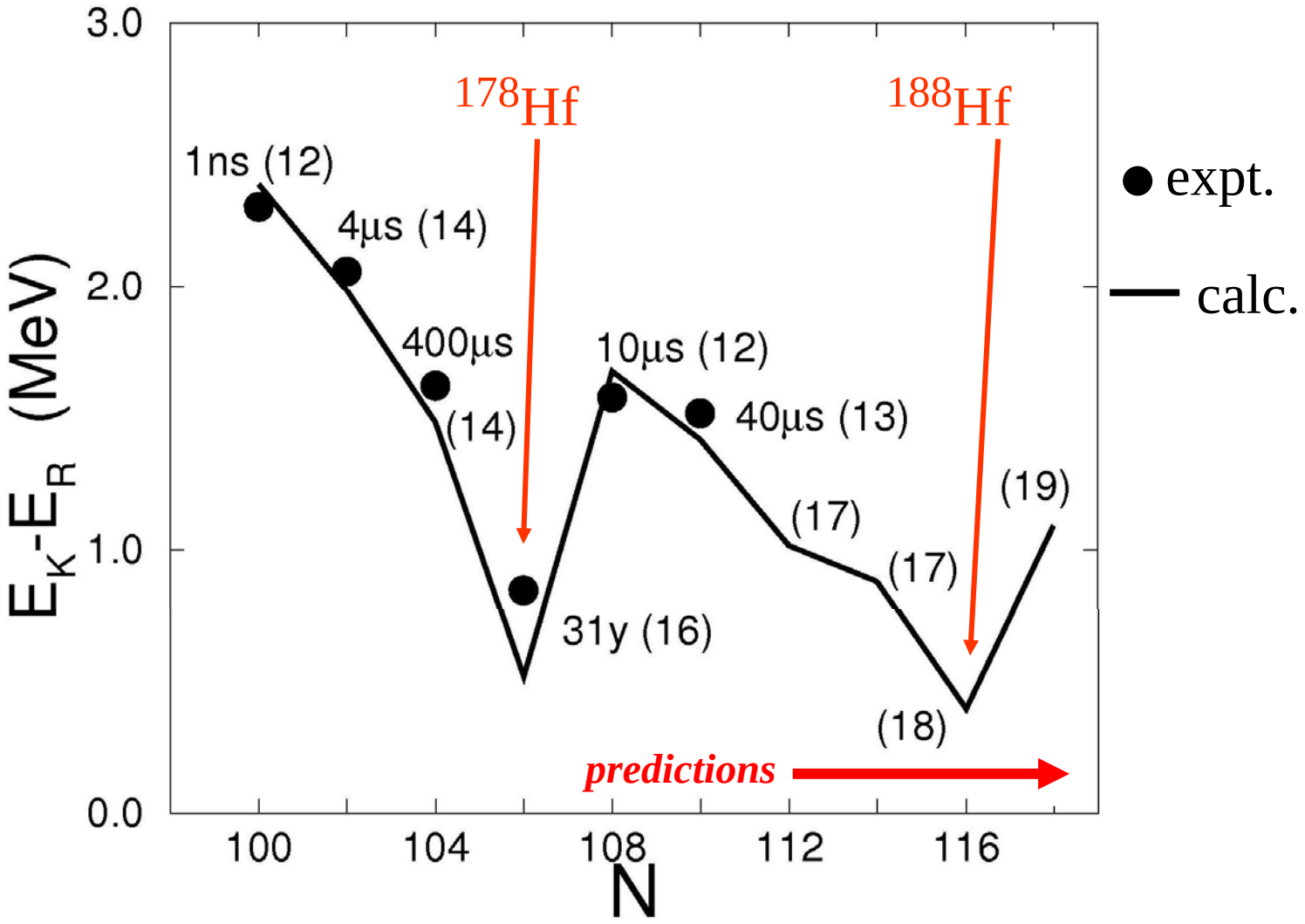
Xu, Walker and Wyss, Phys. Rev. C62 (2000) 014301

Nuclear chart with isomers



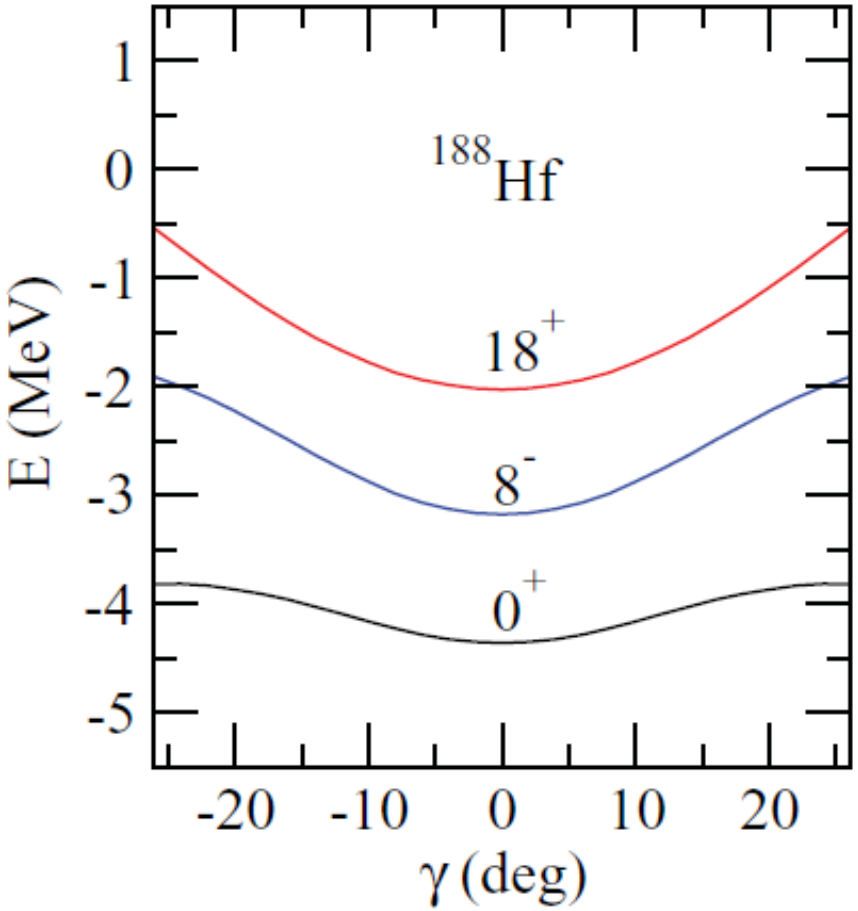
[Walker and Dracoulis, Nature 399 (1999) 35, updated]

hafnium (Z=72) 4-quasiparticle isomers



Walker and Dracoulis, Nature 399 (1999) 35; Hyp. Int. 135 (2001) 83

^{188}Hf high=K states from configuration-constrained TRS calculations



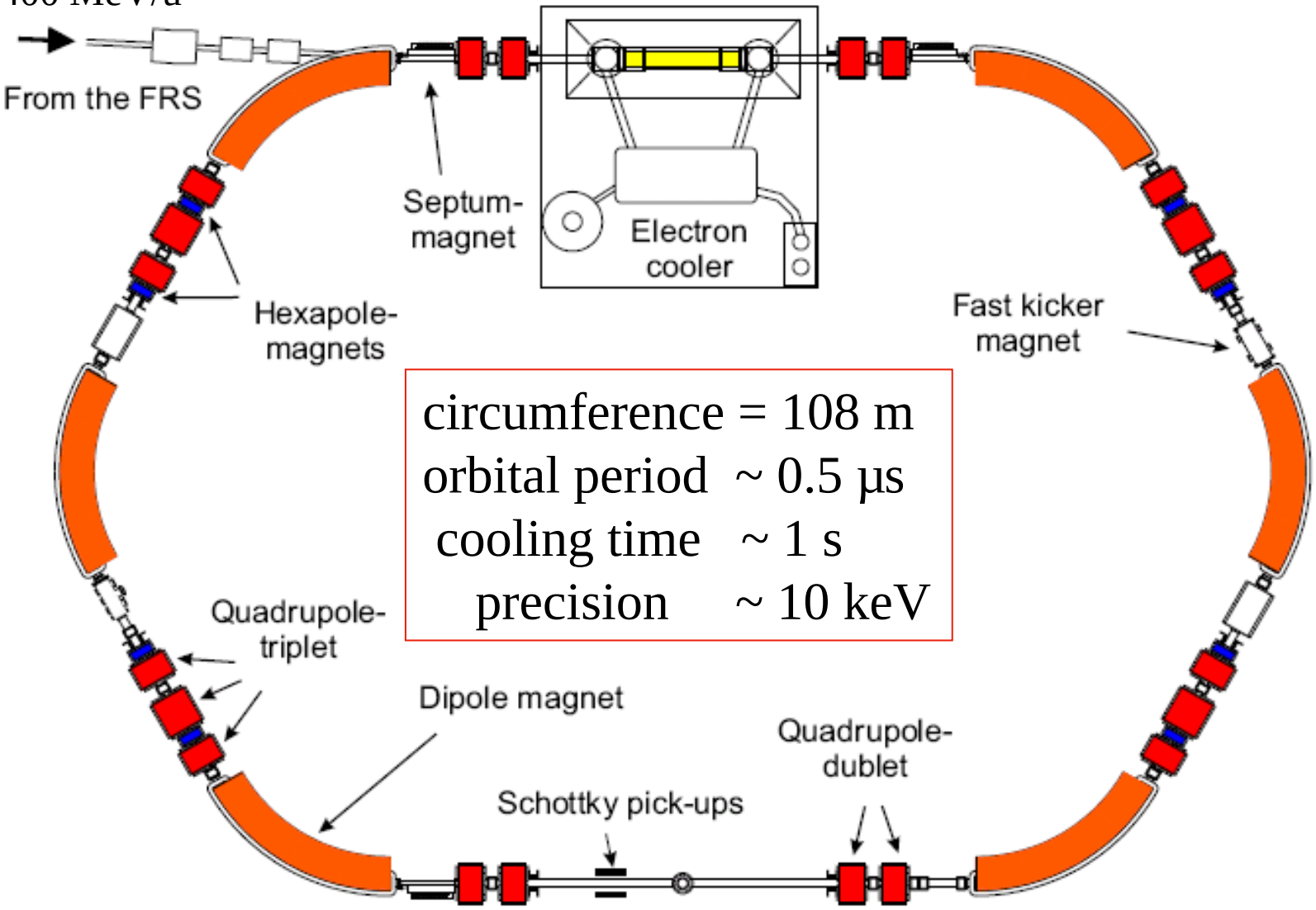
Liu et al., Phys. Rev. C83 (2011) 067303

Isomer measurements

- RISING: $T_{1/2} \leq 1$ s, rate ≥ 1 ion per second
- ESR: $T_{1/2} \geq 1$ s, rate ≥ 1 ion per experiment

Experimental Storage Ring

ions ~ 400 MeV/u



circumference = 108 m
orbital period ~ 0.5 μs
cooling time ~ 1 s
precision ~ 10 keV

^{197}Au fragmentation

2009 experiment

beam

new isomers $T_{1/2}$ >10 s

Reed et al., Phys. Rev. Lett. 105 (2010) 172501

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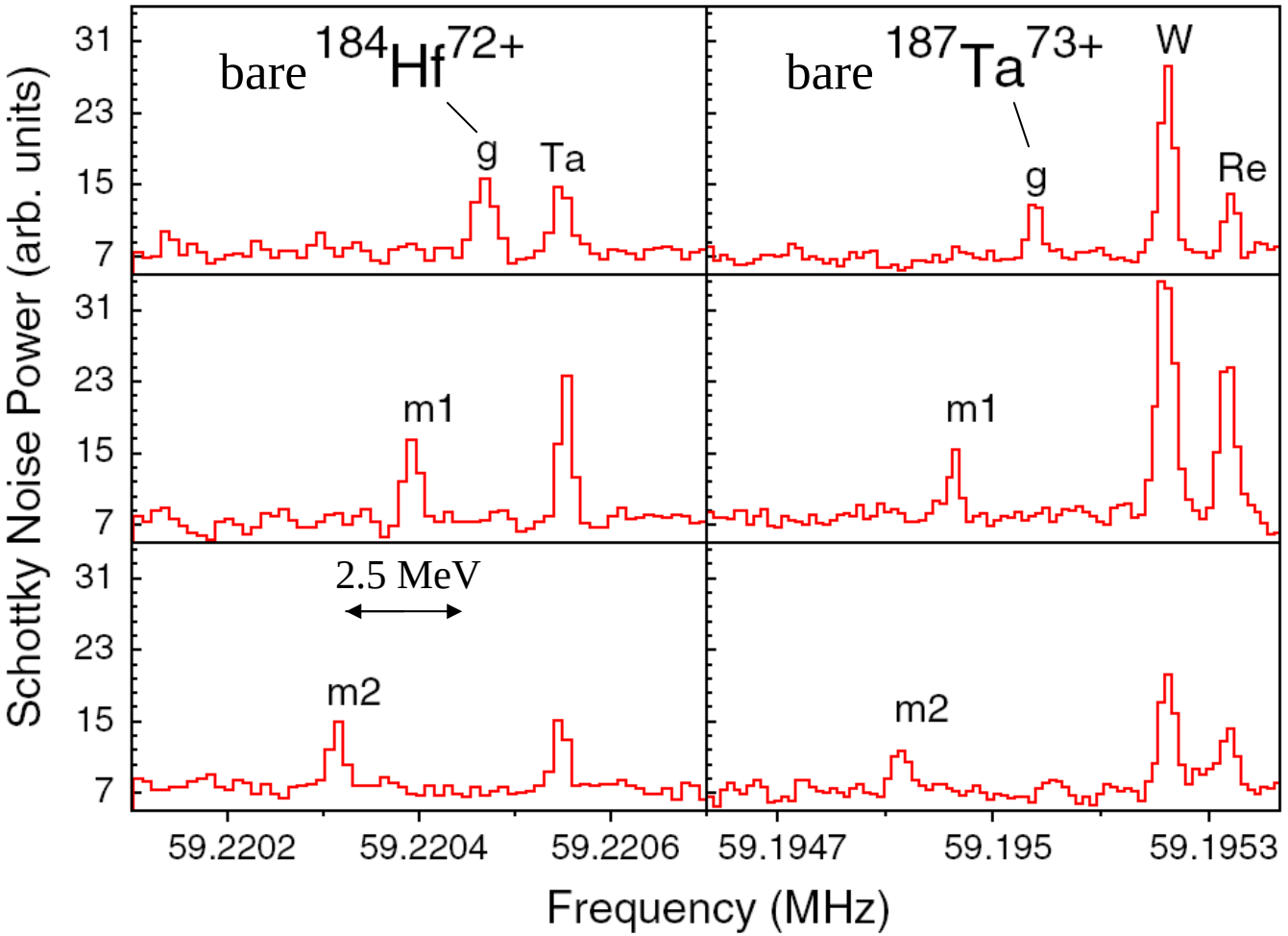
isomers in the ESR

2009 experiment

10-second snapshots

A = 184, q = 72+ A = 187, q = 73+ ^{197}Au fragmentation



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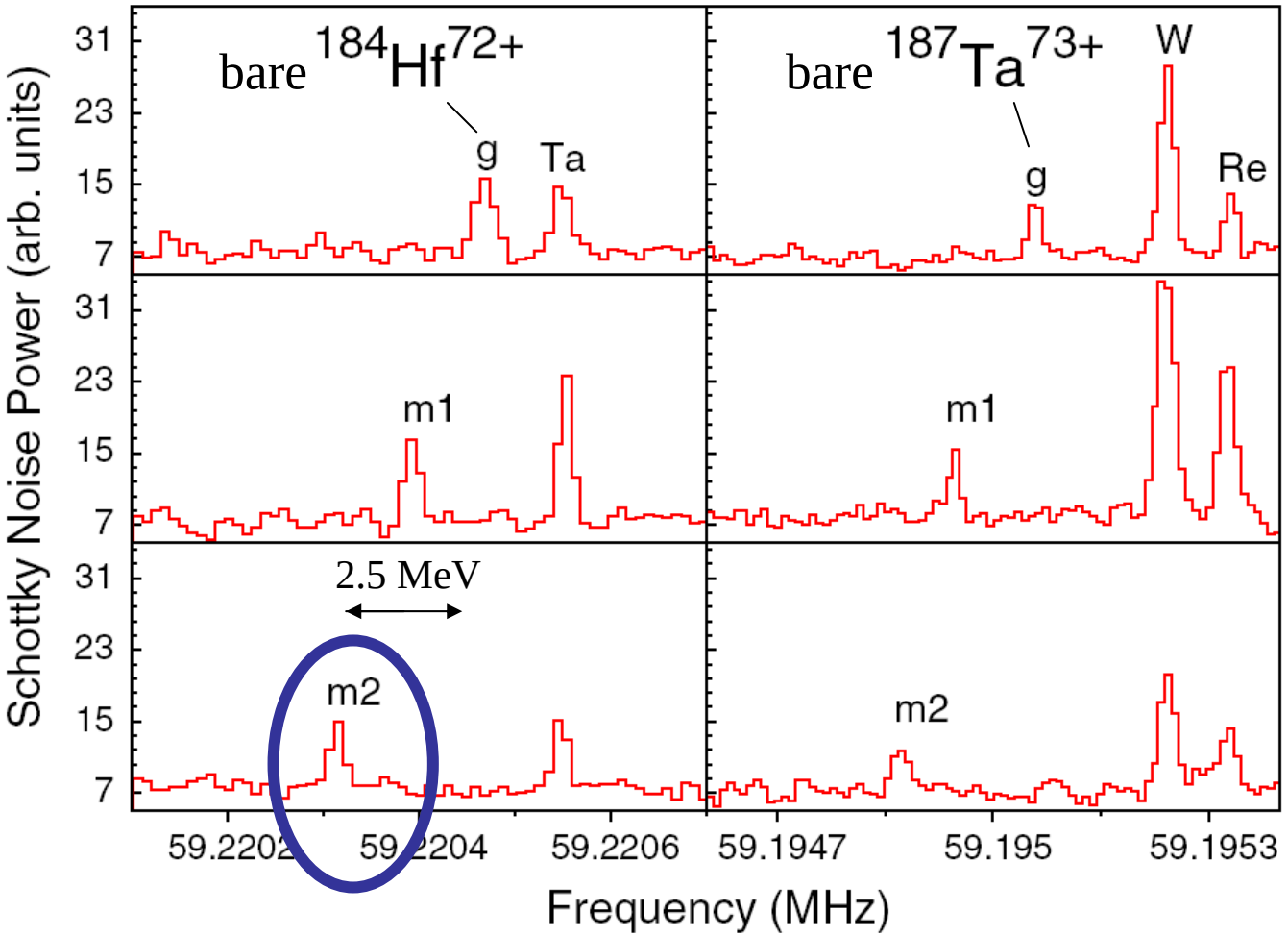
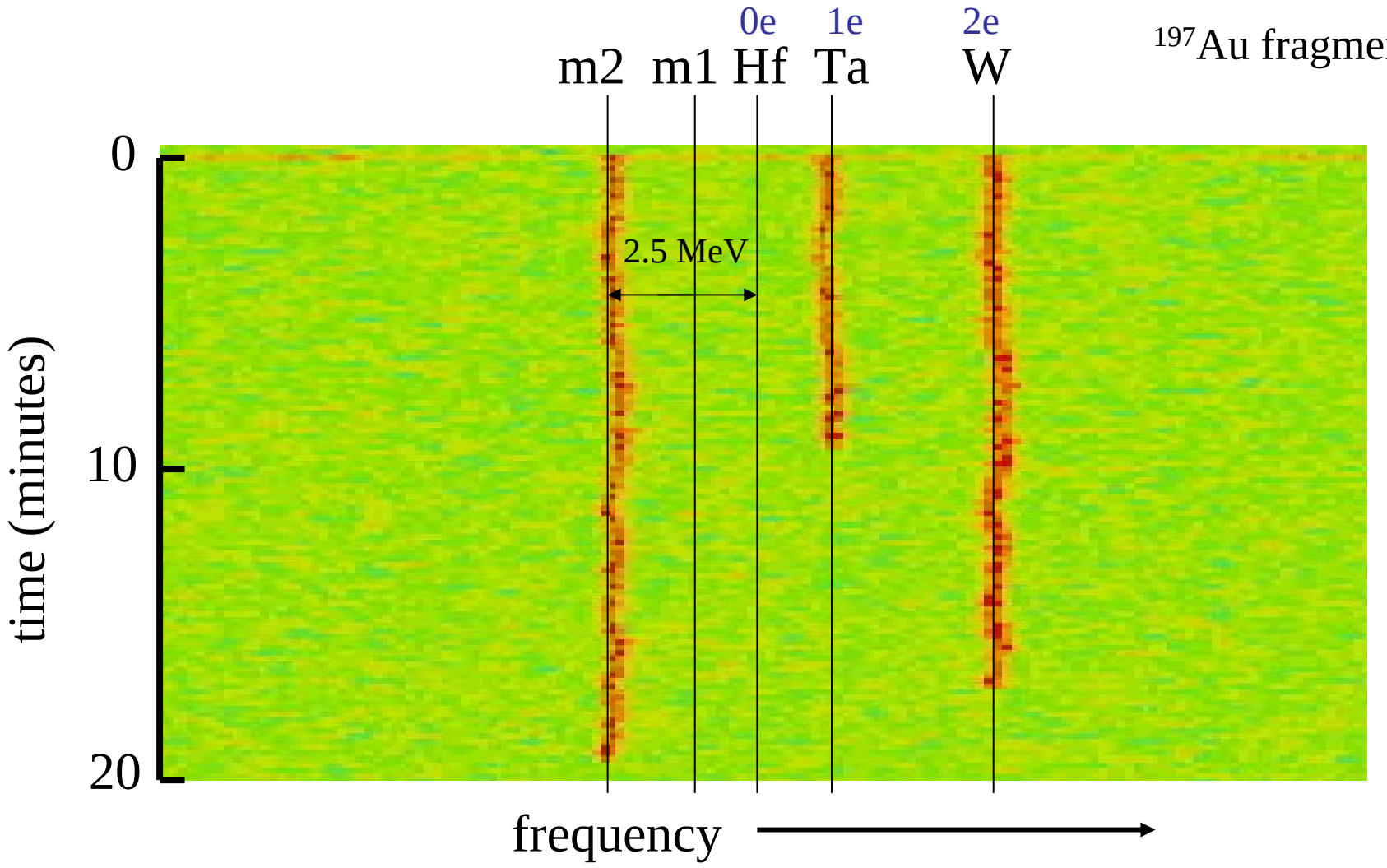


Reed et al., Phys. Rev. Lett. 105 (2010) 172501

A=184 (72^+) isobars and isomers

2009 experiment

^{197}Au fragmentation



Reed et al., Phys. Rev. Lett. 105 (2010) 172501

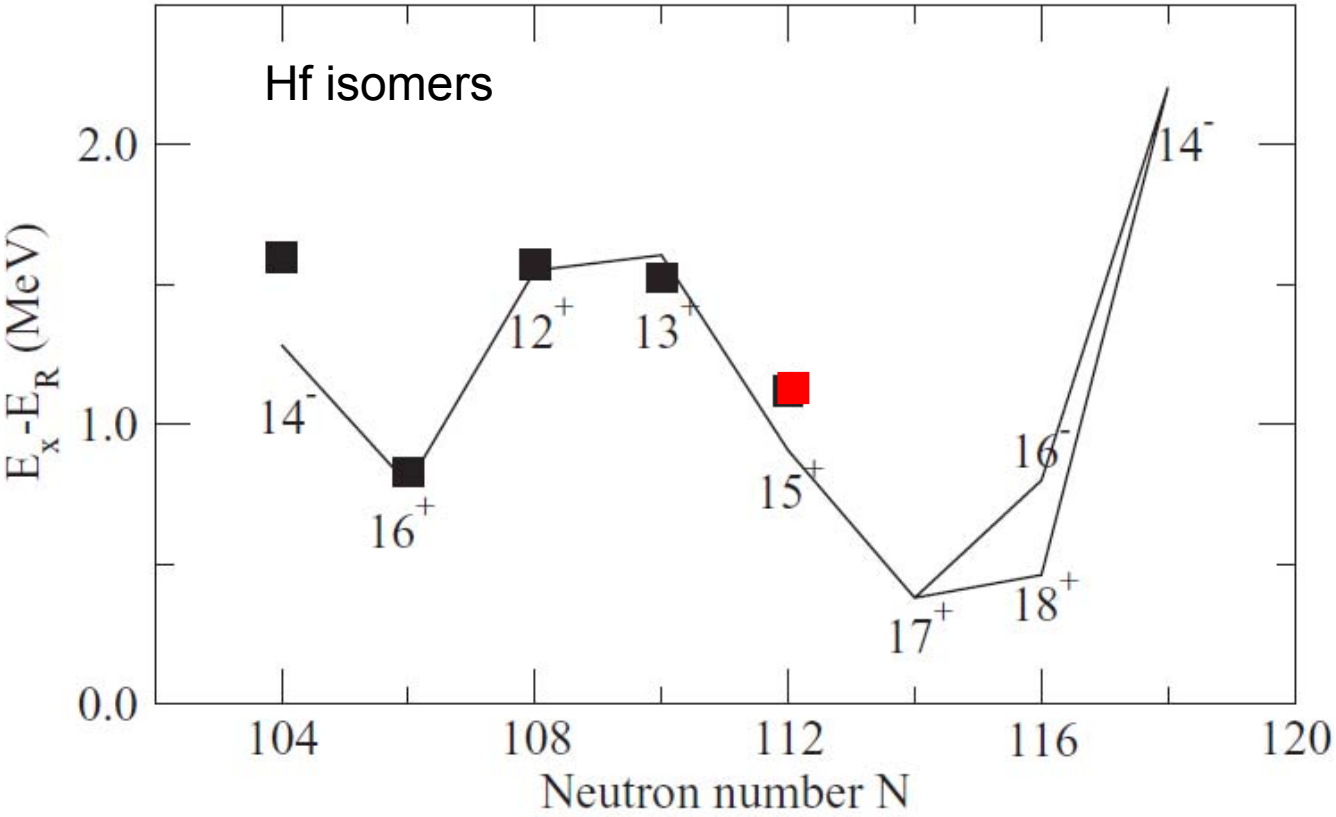
^{184}Hf isomers

	decay	$E^{keV}_{\gamma\text{-spec}}$	E^{keV}_{ESR}	$T_{1/2}$(exp)
ground state (0^+)	β			4 h
isomer 1 (8^-)	γ+β	1272(1)[a]	1264(10)	48 s
isomer 2 (15^+)	β		2477(10)	12 min

[a] Krumbholz et al., Z. Phys. A351 (1995) 11

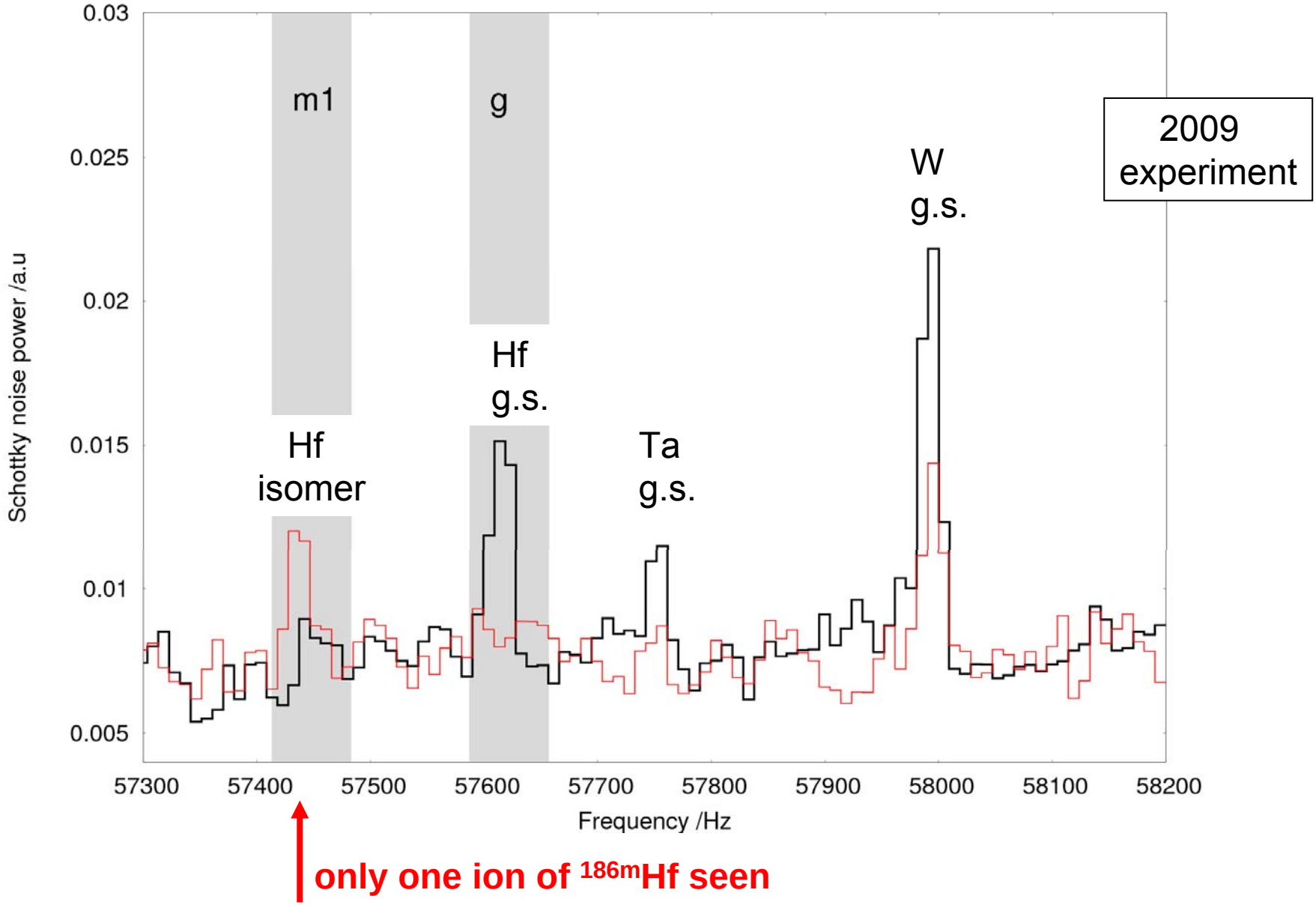
2009 ESR experiment

Reed et al. PRL105 (2010) 172501



Liu et al., Phys. Rev. C83 (2011) 067303

A=186 (72+) isobars and isomers



E109 experiment

^{208}Pb beam

^{188}Hf	100 nb	15 shifts
^{186}Hf	560 nb	3 shifts
Setting up FRS and ESR (two settings)		3 shifts
		Total beam time: 21 shifts

^{197}Au beam

Previous data:

^{184}Hf	550 nb	3 shifts
^{187}Ta	340 nb	
^{186}Hf	34 nb	(3 shifts)

2009 experiment