# Long-lived isomers in neutron-rich hafnium isotopes: E109

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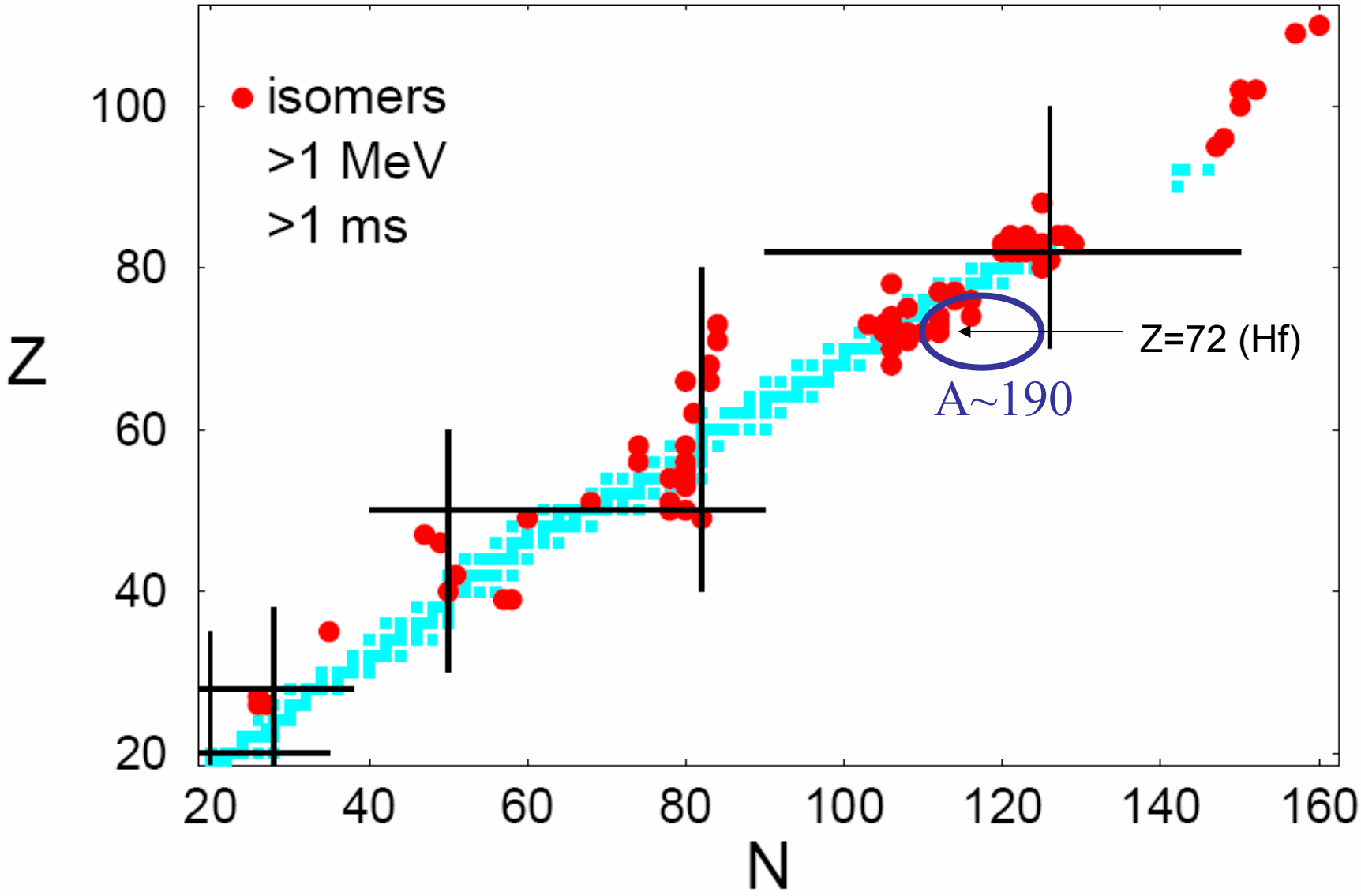
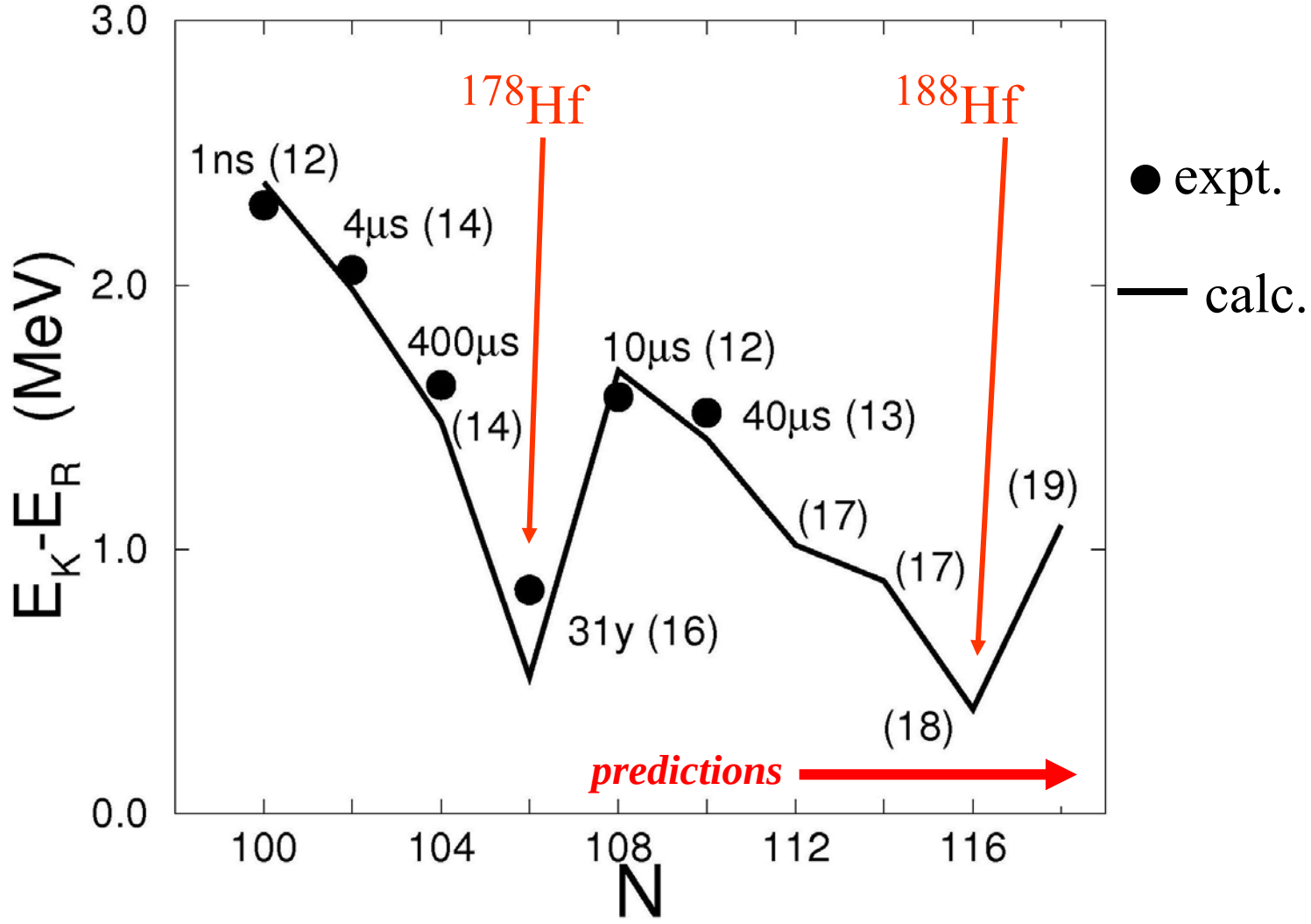
# Nuclear chart with isomers




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

# hafnium (Z=72) 4-quasiparticle isomers

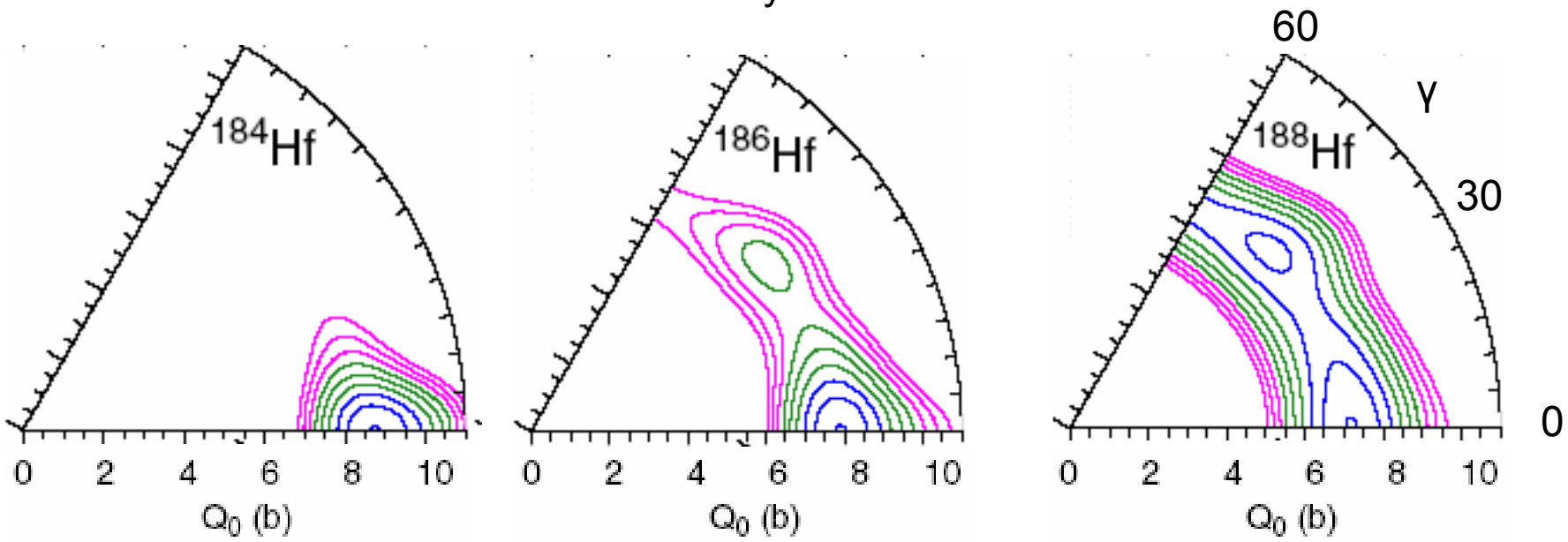



Walker and Dracoulis, Nature 399 (1999) 35; Hyp. Int. 135 (2001) 83

# prolate-oblate shape transition

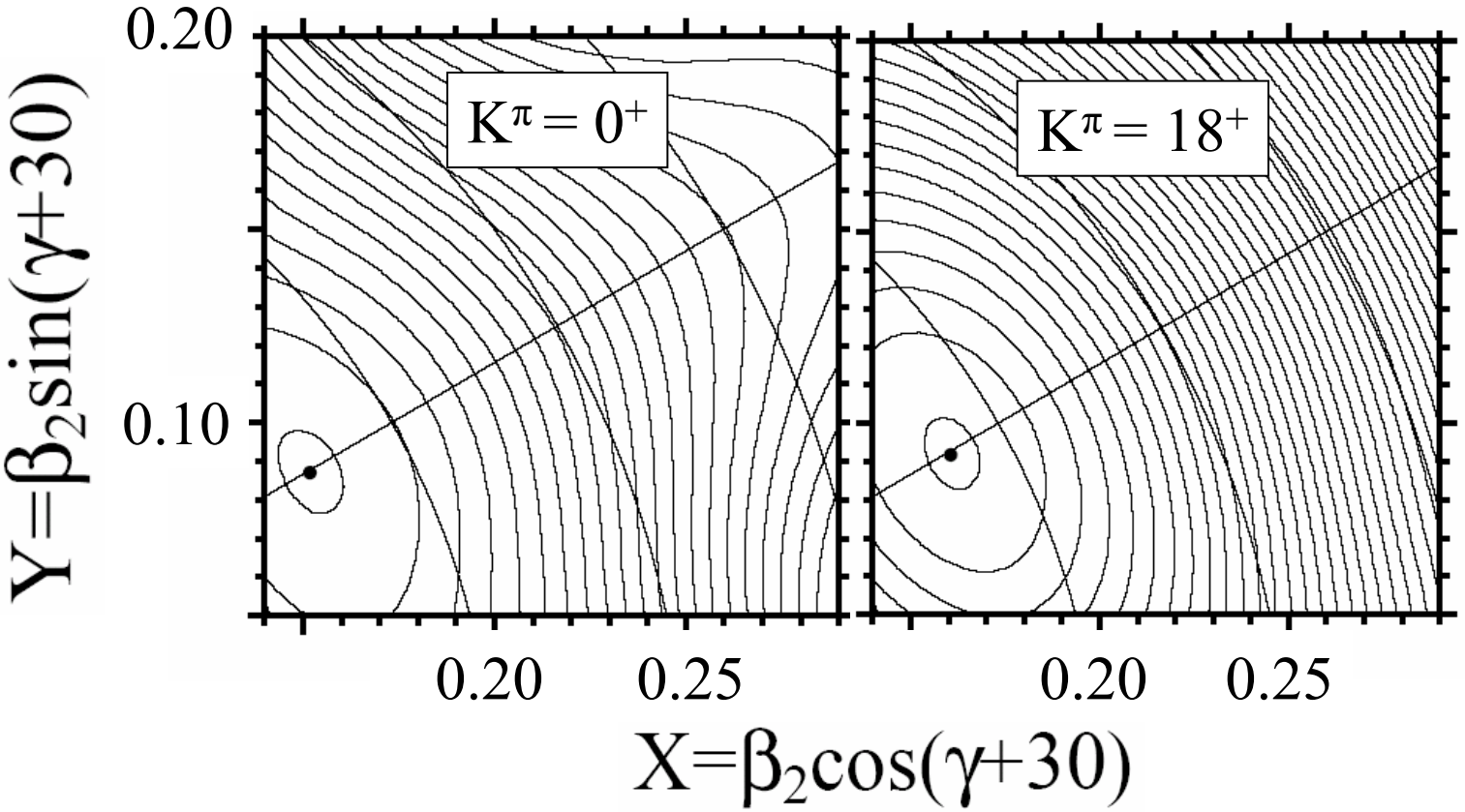
## n-rich hafnium ground states

HFB + SLy4



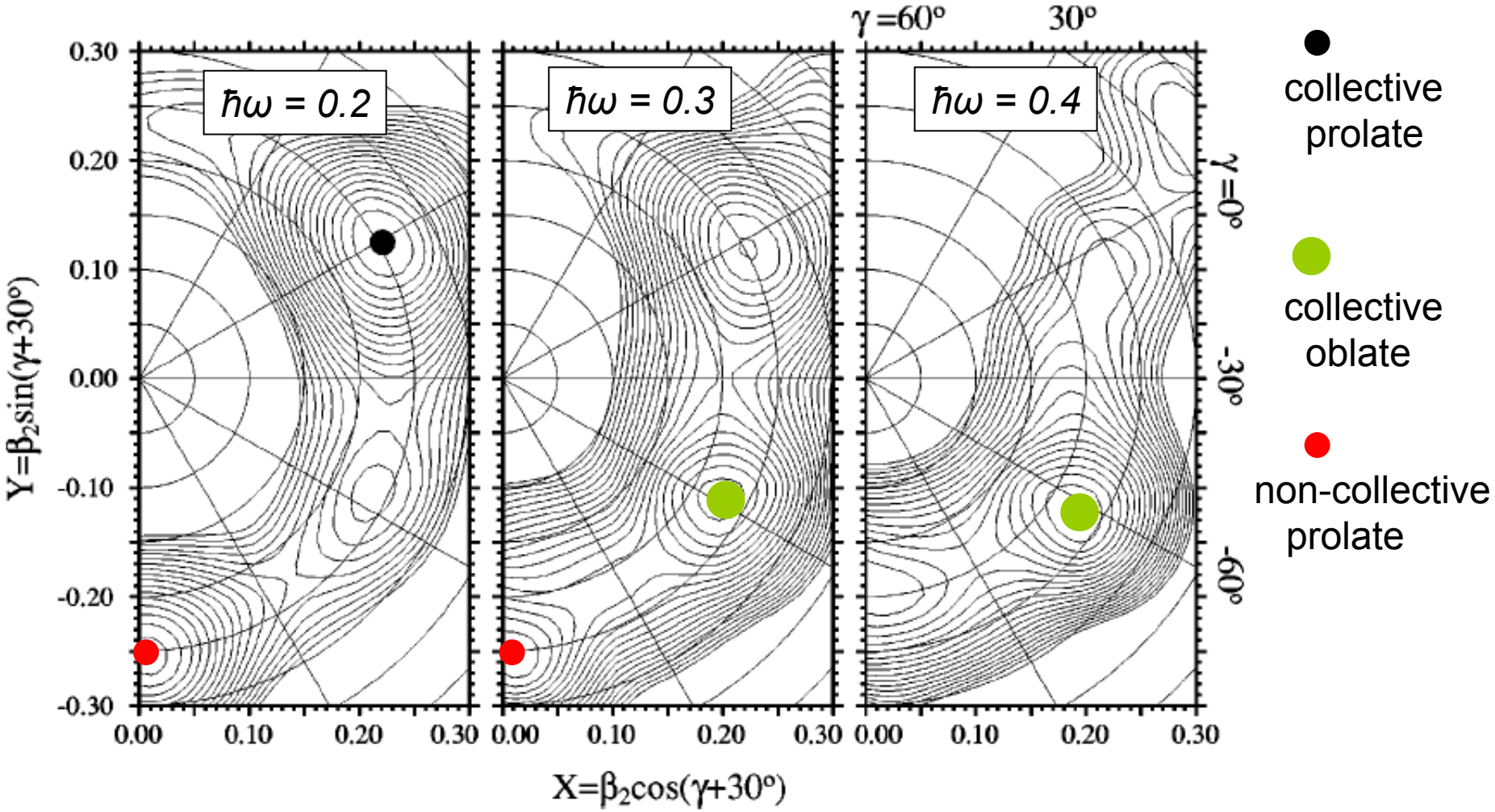

Robledo et al., *J. Phys. G: Nucl. Part. Phys.* **36**, 115104 (2009).

# $^{188}$Hf shape from configuration-constrained TRS calculations



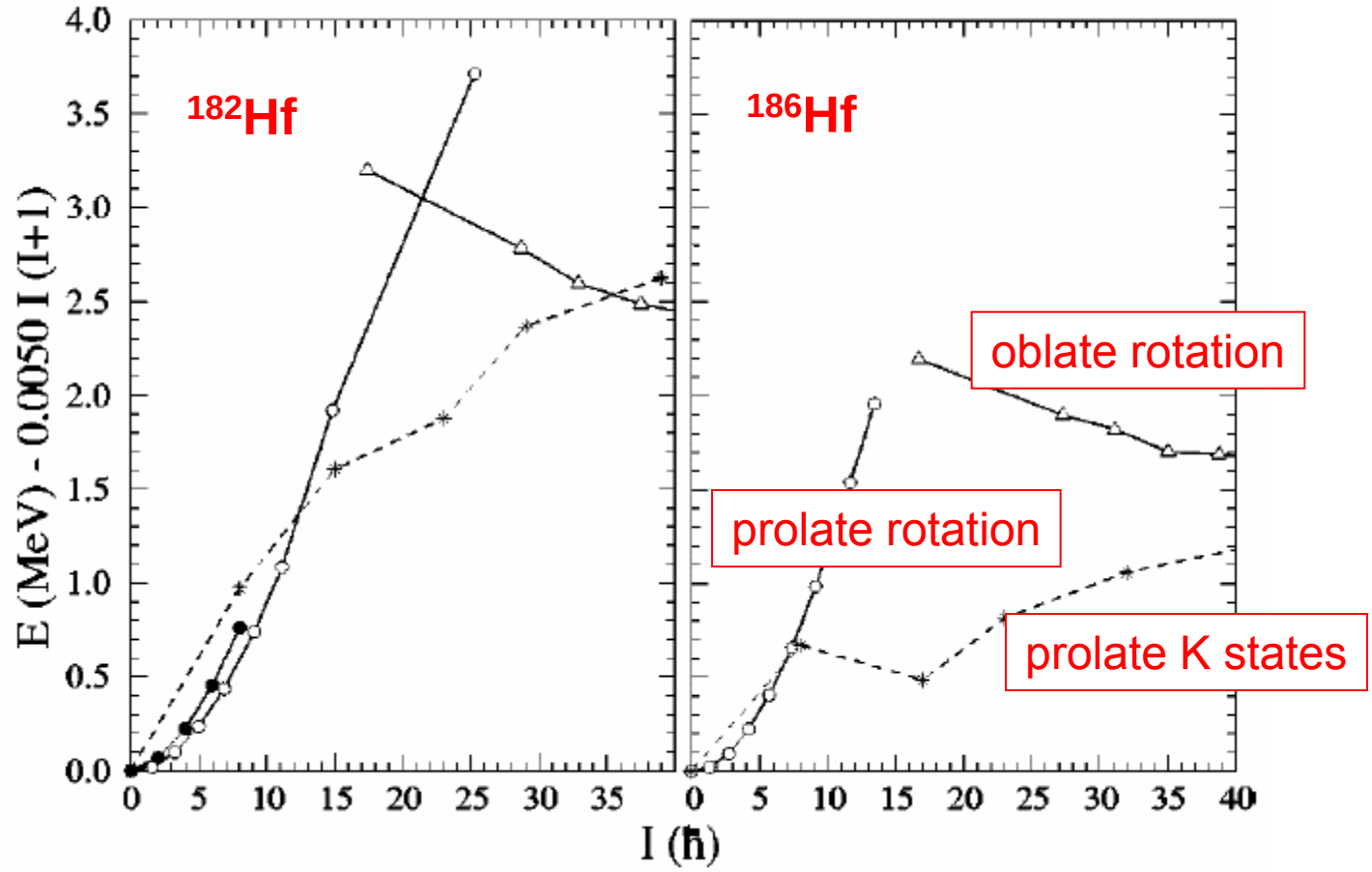

Xu, Walker and Wyss, Phys. Rev. C62 (2000) 014301

# cranked n-rich hafnium: 3 well-deformed minima



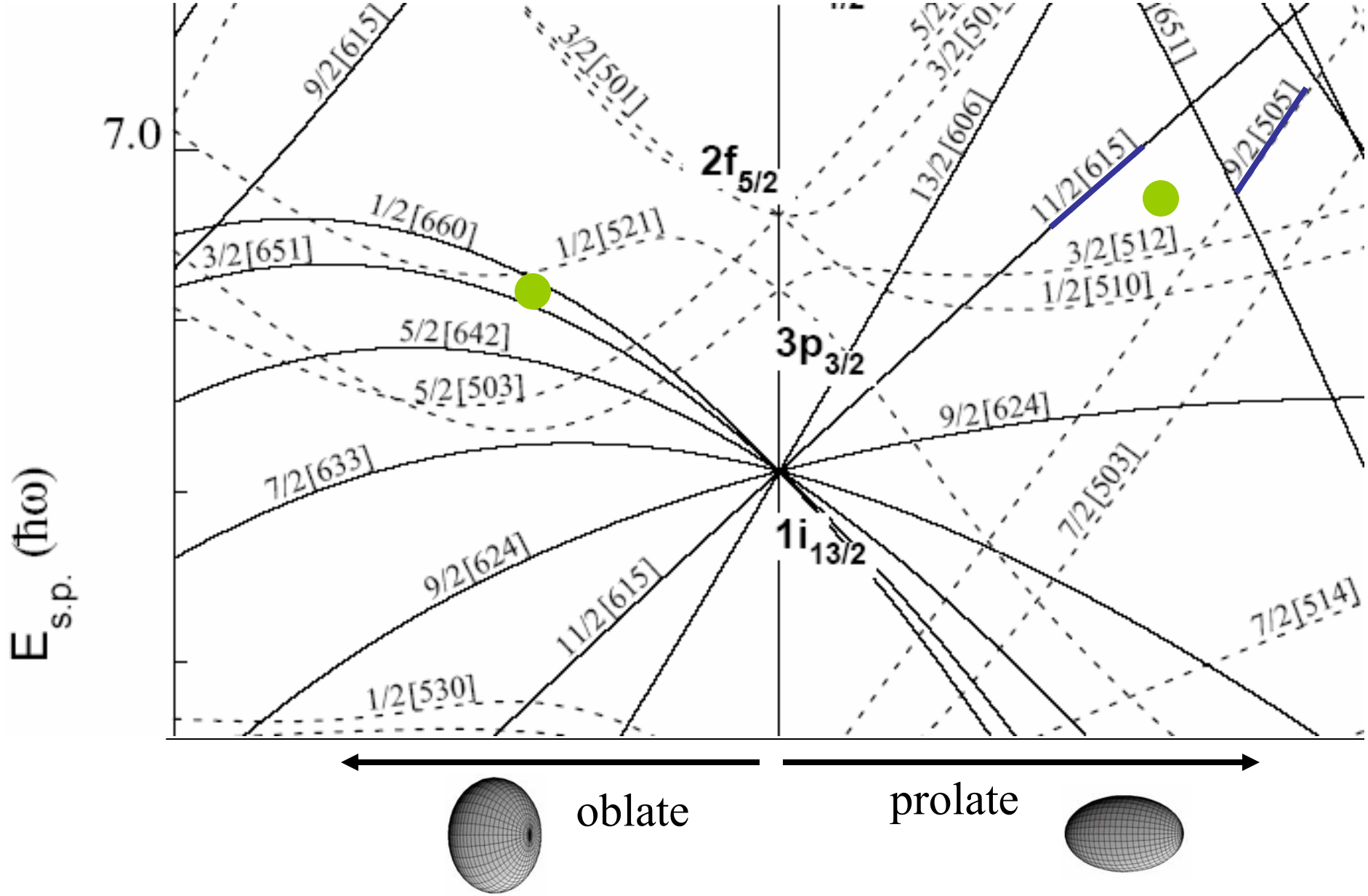

$^{182}$Hf example: Xu, Walker and Wyss, Phys. Rev. C62 (2000) 014301

# prolate-oblate shape transition



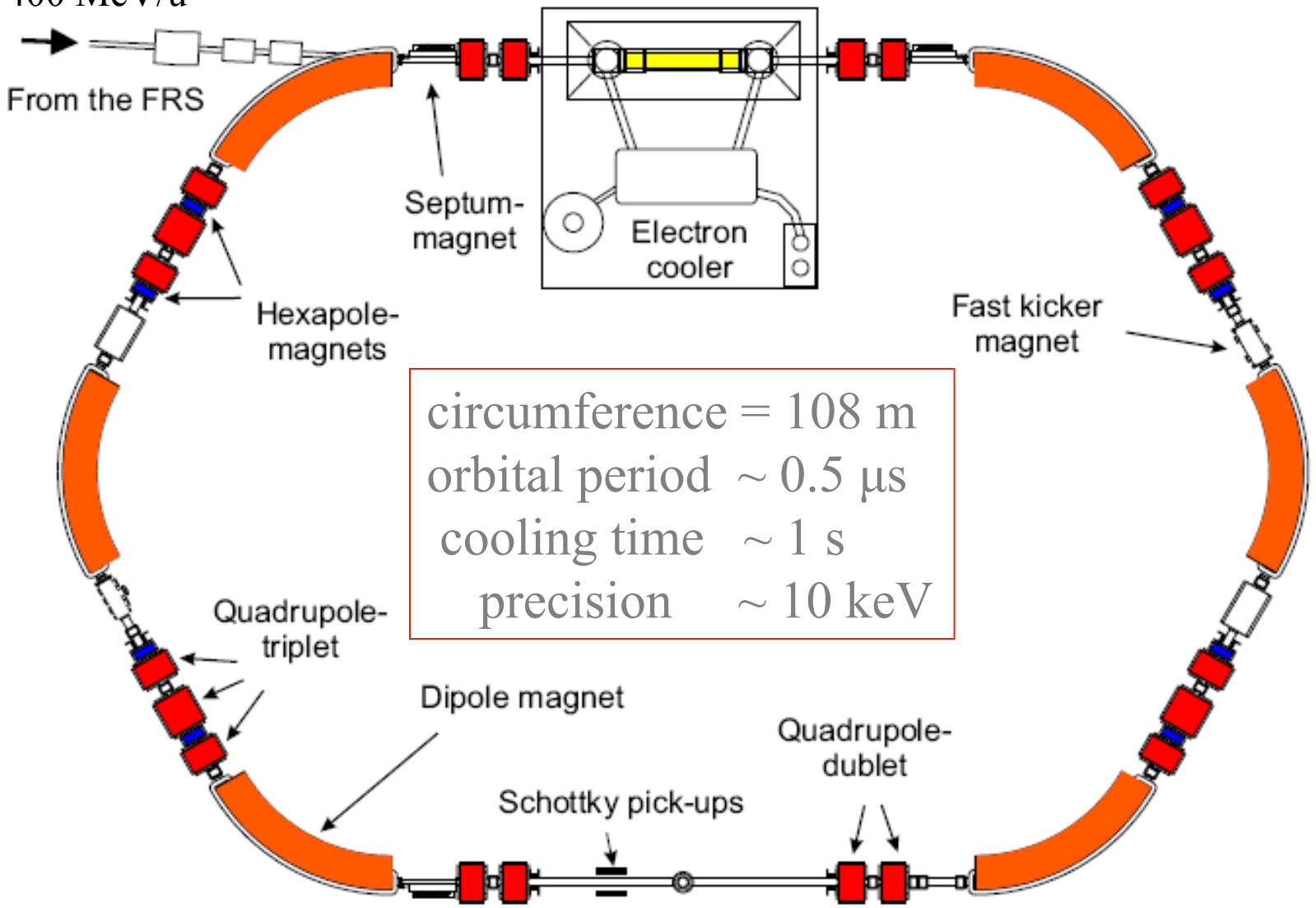

Xu, Walker and Wyss, Phys. Rev. C62 (2000) 014301

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



# Experimental Storage Ring

ions ~ 400 MeV/u



# $^{197}$Au fragmentation

2009 experiment


**beam**

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

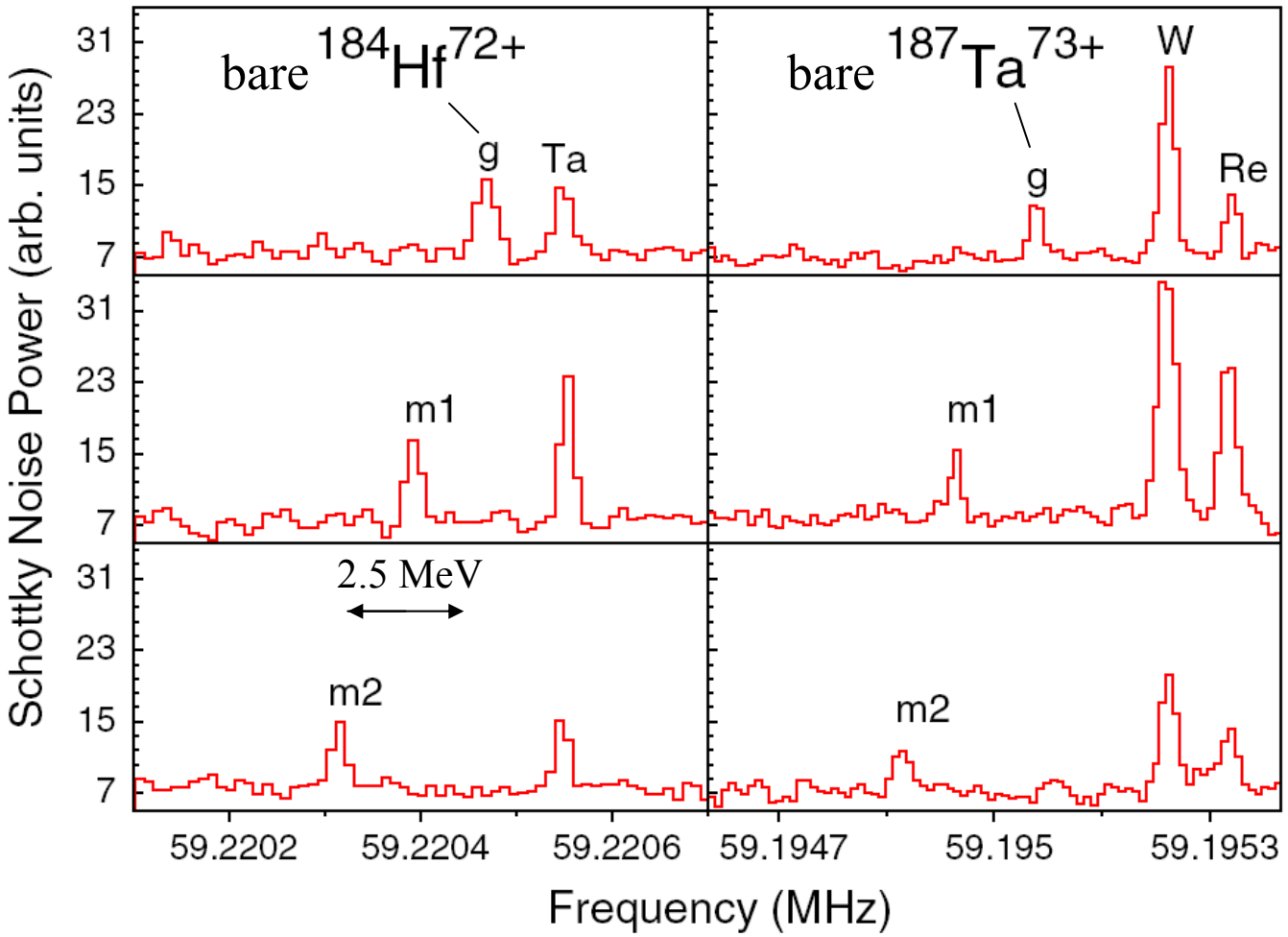
*Reed et al., Phys. Rev. Lett. 105 (2010) 172501*

# new isomers in the ESR

2009 experiment

10-second snapshots

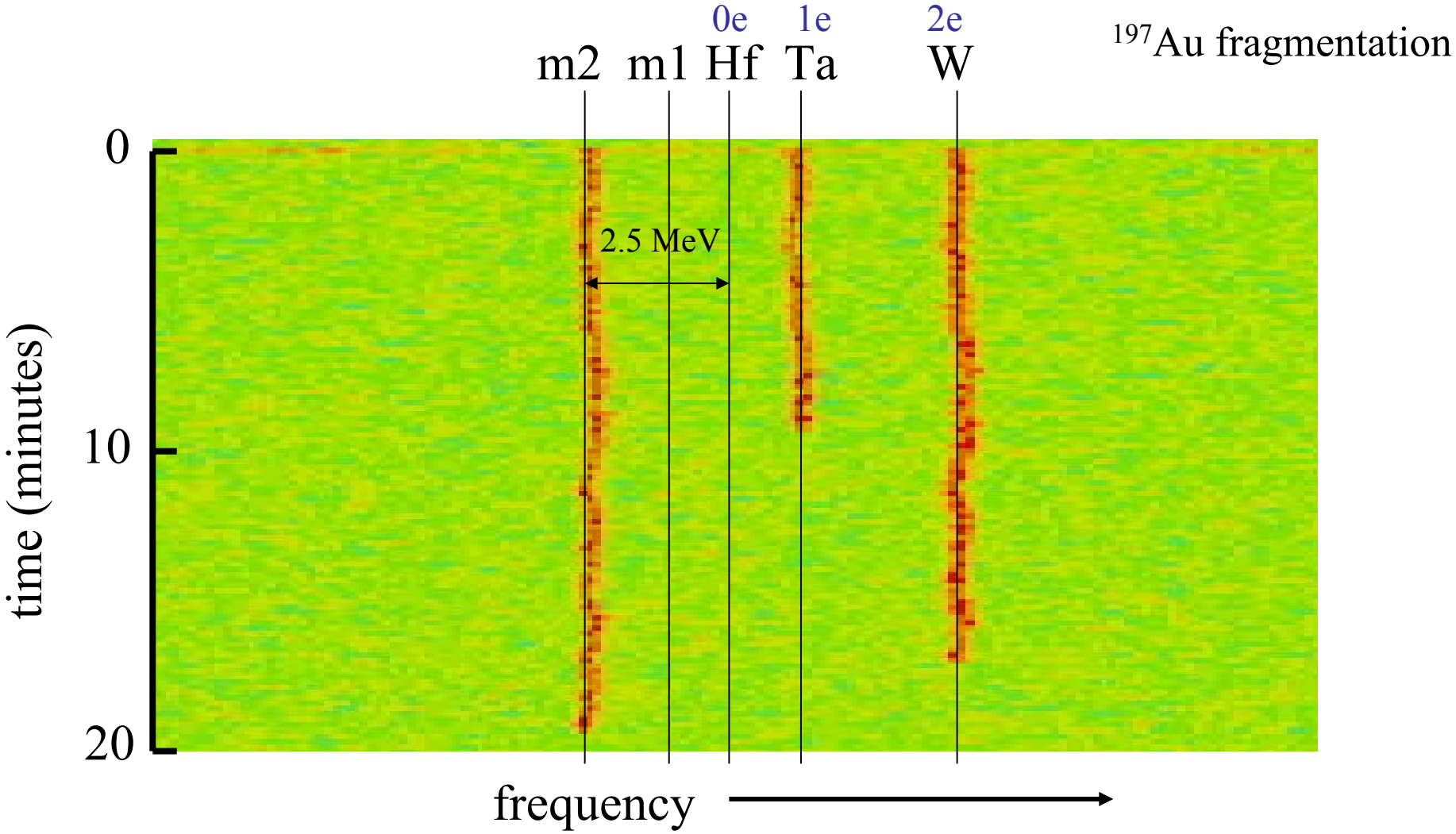
A = 184, q = 72+ A = 187, q = 73+ $^{197}$Au fragmentation




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

# A=184 ($72^{+}$) isobars and isomers

2009 experiment



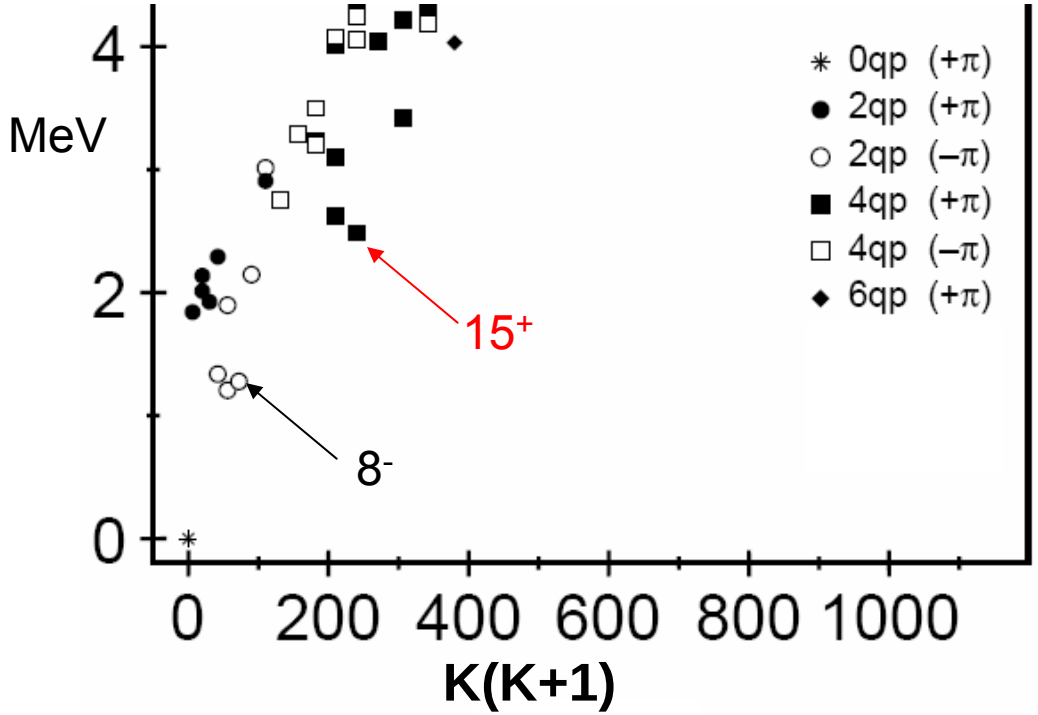

*Reed et al., Phys. Rev. Lett. 105 (2010) 172501*

# $^{184}$Hf isomers

2009 experiment

| | decay | $E_{\gamma\text{-spec}}$ (keV) | $E_{ESR}$ (keV) | $E_{calc}$ (keV) | $T_{1/2}$(exp) |
|---|---|---|---|---|---|
| ground state ($0^+$) | β | | | | 4 h |
| isomer 1 ($8^-$) | γ | 1272(1)[a] | 1264(10) | 1241 | 48 s |
| isomer 2 ($15^+$) | β | | 2477(10) | 2369 | 12 m |

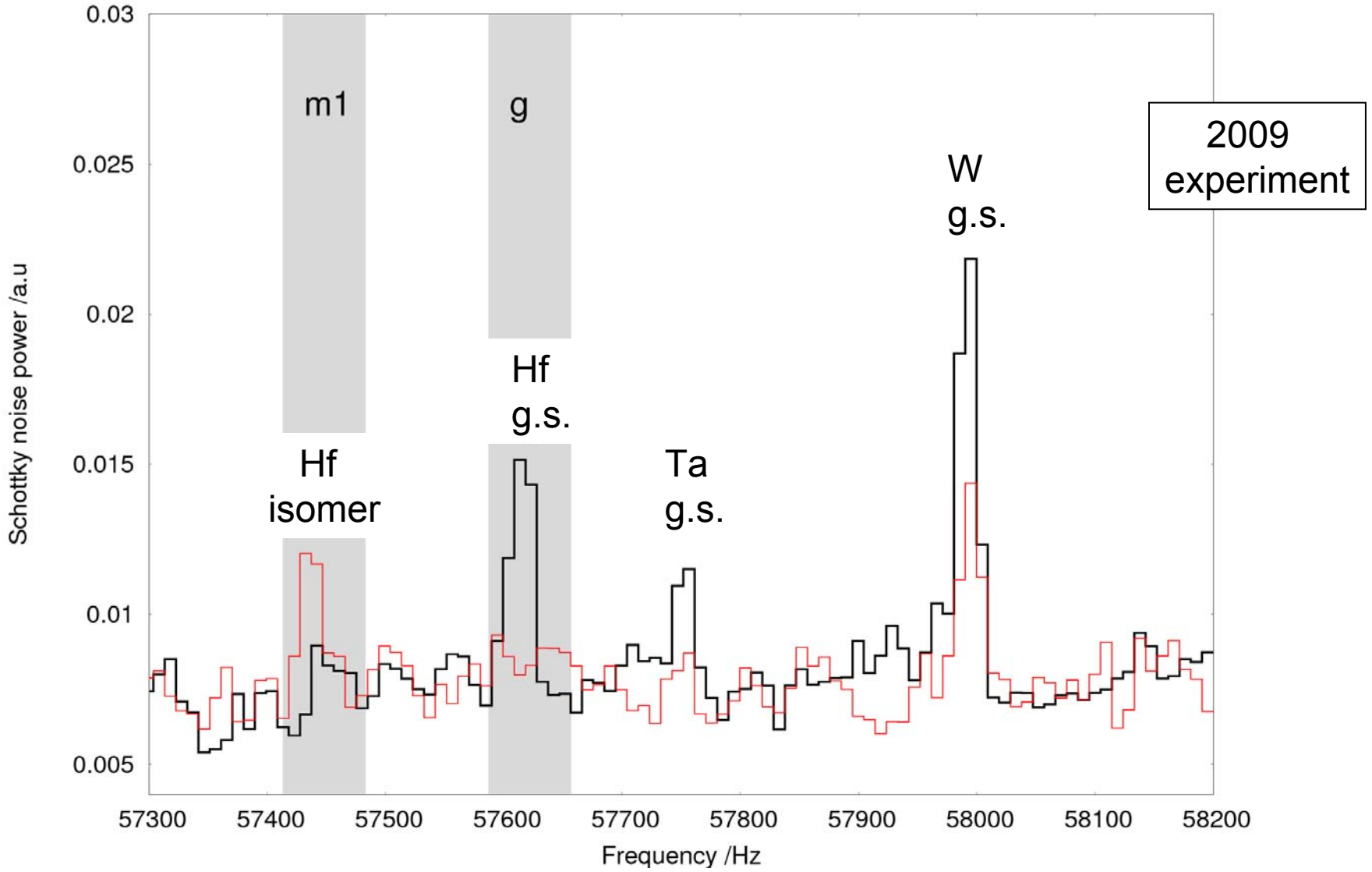
[a] Krumbholz et al., Z. Phys. A351 (1995) 11




multi-quasiparticle calculations
[method of Jain et al., Nucl. Phys. A591 (1995) 61]

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

# A=186 (72+) isobars and isomers



# E109 beam-time allocation

$^{208}$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** |

**Surrey PhD student is waiting for the data**

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$^{197}$Au beam

| | | | |
|---|---|---|---|
| Previous data: | $^{184}$Hf | 550 nb | 3 shifts |
| | $^{187}$Ta | 340 nb | |
| | $^{186}$Hf | 34 nb | (3 shifts) |

2009 experiment