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Configurations and decay hindrances of high-K states in ^{180}Hf

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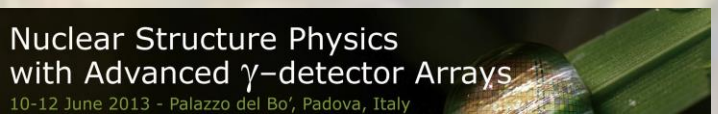

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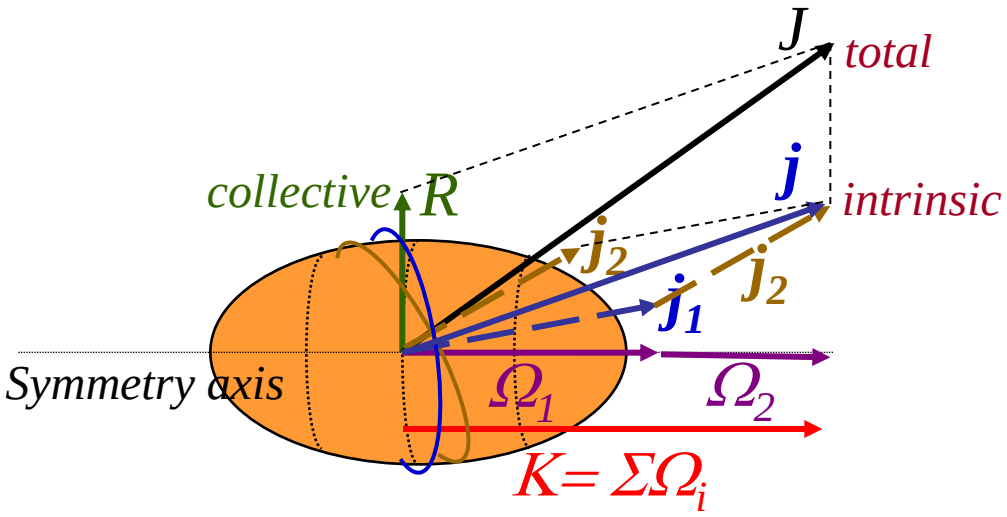
K isomers in the A~180 region



- Hf isotopes: prolate rigid rotors with high-Ω orbitals near proton and neutron Fermi levels
- Competition and distinct delineation between collective rotation and intrinsic excitations
- Decay of intrinsic high-K states provides insight into robustness of K quantum number
- Feeding of high-K states gives information about underlying nucleonic configurations

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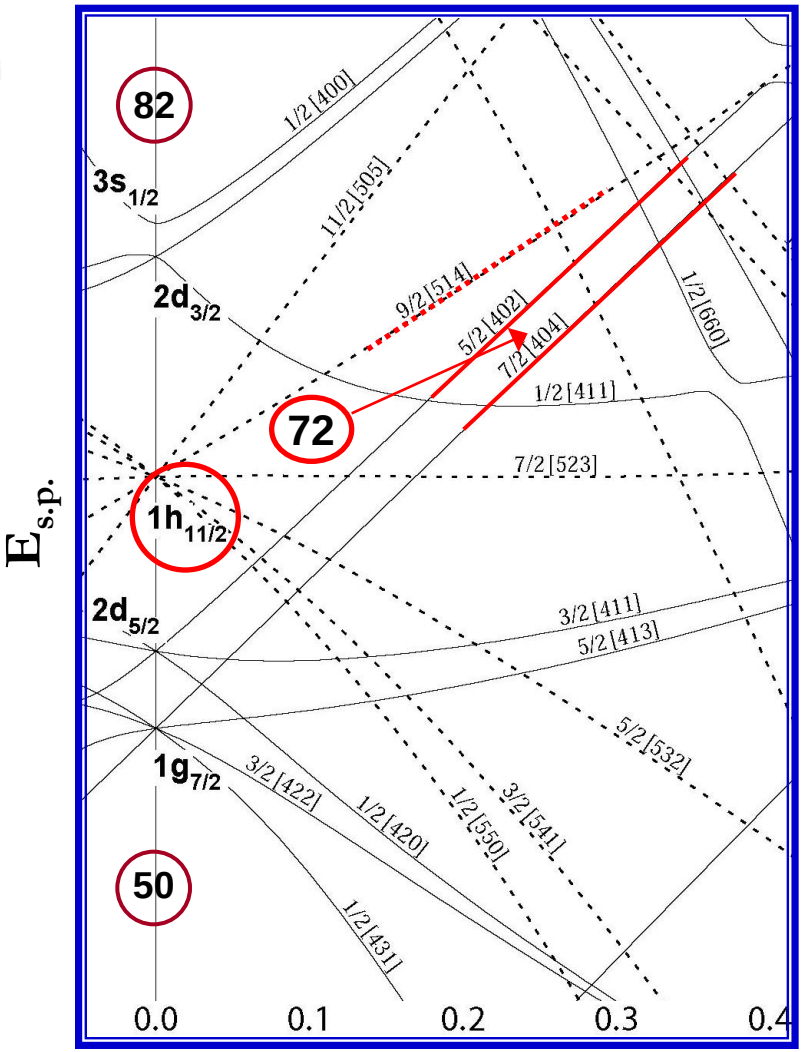
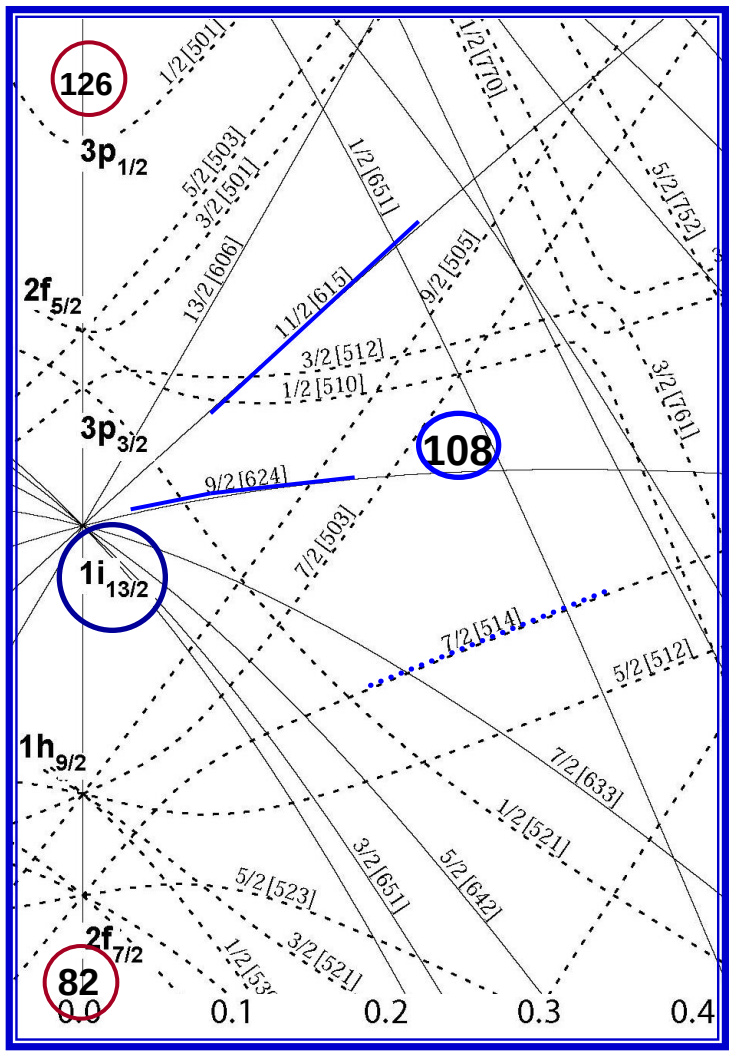
High-K orbitals in ^{180}Hf





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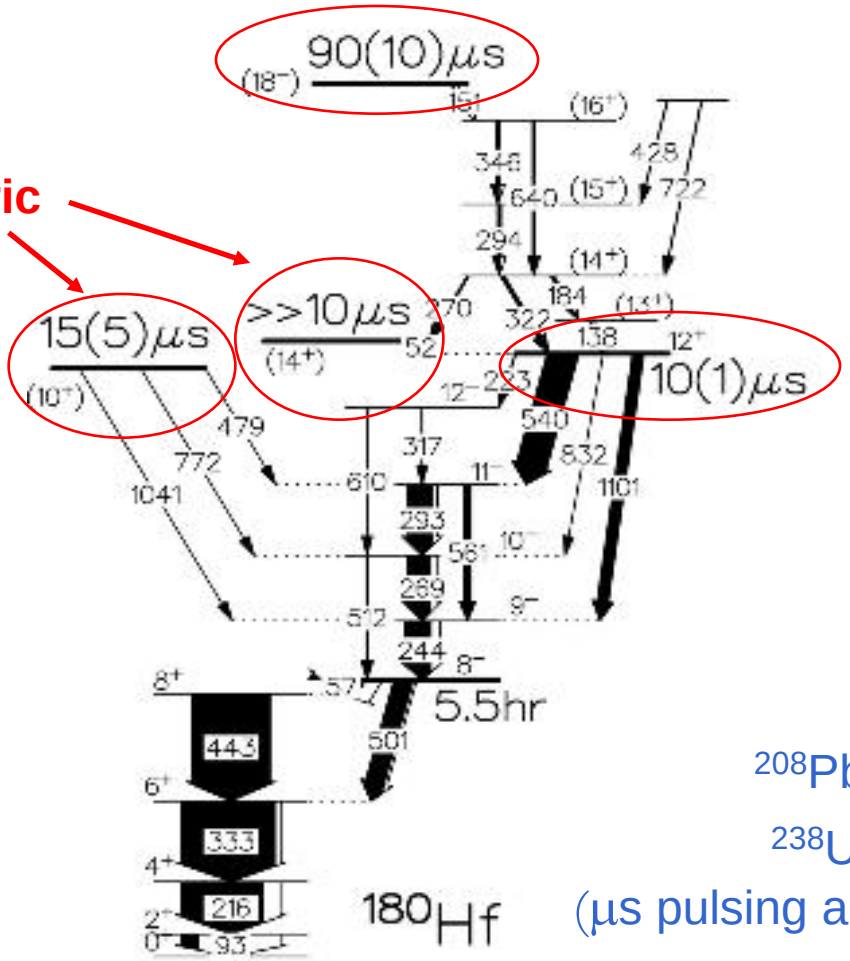
Previous work: K-isomers in ^{180}Hf



not isomeric

half life revised

^{208}Pb+^{180}Hf

^{238}U+^{180}Hf

(μs pulsing and out-of beam)

R. D'Alarcao *et al*, PRC59, R1227 (1999)

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High-K, 2-, 4- and 6-quasiparticle structures in ^{180}Hf

Deep-inelastic excitation:
1.4 GeV ^{207}Pb on 250 mg/cm^2 ^{180}Hf

Data taken in two regimes:
(i) prompt (ii) pulsed: 1 in 10 beam pulses from ATLAS

GAMMASPHERE

$K^\pi=(22^-)$

$K^\pi=14^+$

$K^\pi=(18^-)$

$K^\pi=(12^+)$

$K^\pi=(16^+)$

$K^\pi=12^+$

$K^\pi=(16^+)$

$K^\pi=(11^-)$

$K^\pi=10^+$

$K^\pi=8^-$

g-band

$K^\pi=4^-$

$K^\pi=6^+$

>>1 μs

2-qp

4-qp

6-qp

$t_{1/2}$=0.94 μs

$t_{1/2}$<2 ns

$t_{1/2}$=2.8 ns

$t_{1/2}$=0.57 μs

^{180}Hf

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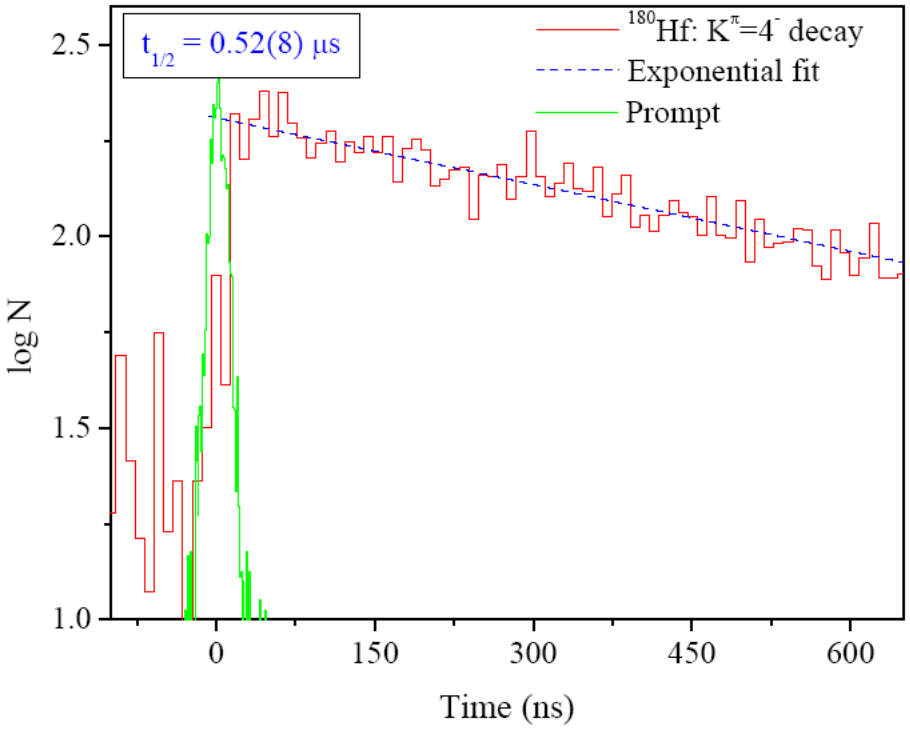
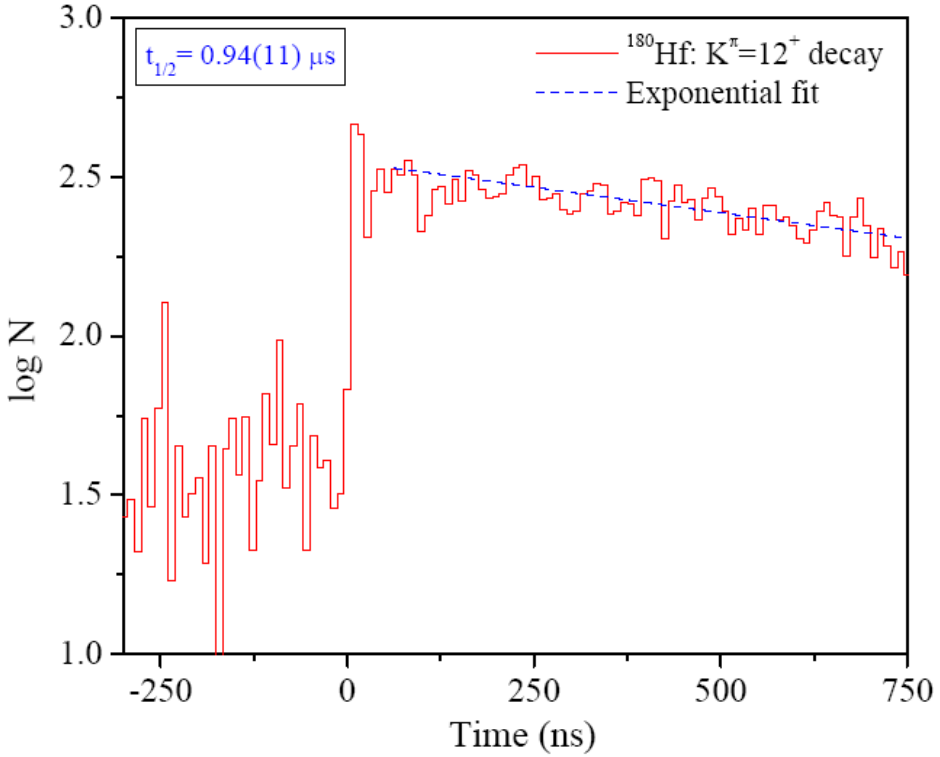
Sub-microsecond K-isomers in ^{180}Hf

2-qp, $K^{\pi}=4^-$, $t_{1/2}$=0.52(8) μs

ν^2 [624]9/2 ⊗ [510]1/2





4-qp, $K^{\pi}=12^+$, $t_{1/2}$=0.94(11) μs

π^2 [404]7/2 ⊗ [514]9/2

ν^2 [624]9/2 ⊗ [510]1/2

Lifetime revised from previous reported value of 10(1) μs

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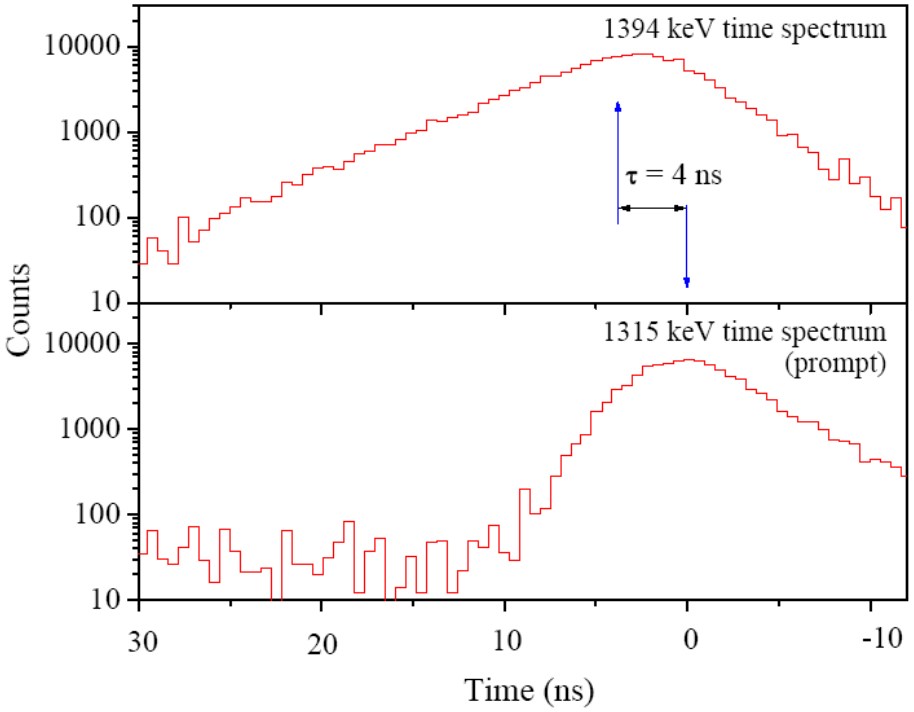
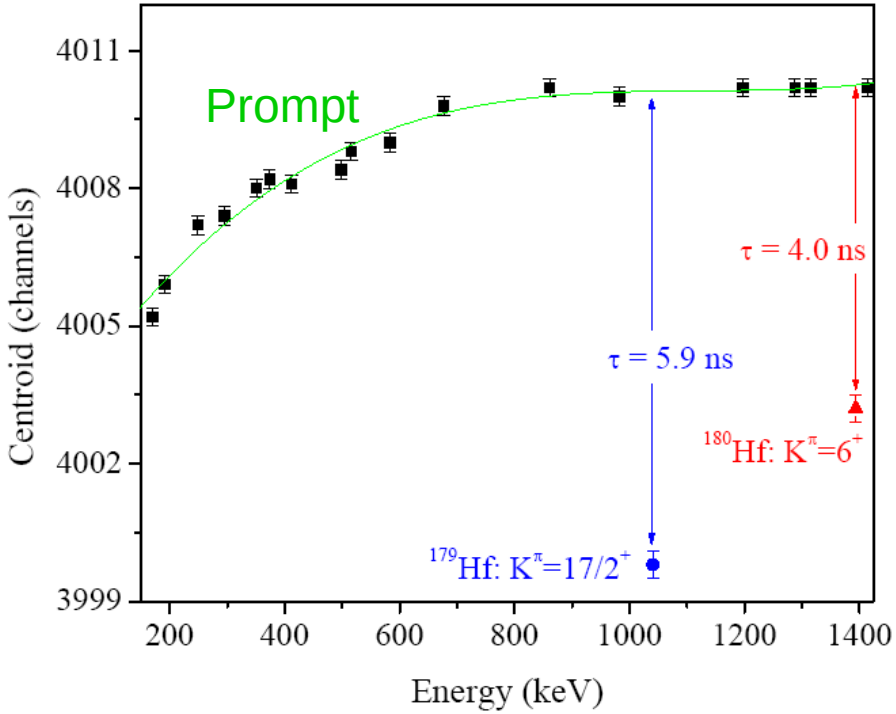
Centroid-shift method for lifetime of $K^{\pi}=6^{+}$ state





Lifetime of $K^{\pi}=6^{+}$ state within Ge time resolution, therefore centroid shift method

^{180}Hf - $K^{\pi}=6^{+}$ state: $\tau=4.0(4)$ ns $\rightarrow$ **$t_{1/2}=2.8(3)$ ns**

^{179}Hf - $K^{\pi} = 17/2^{+}$ state lifetime reproduced: $\tau=5.9(6)$ ns $\rightarrow$ **$t_{1/2} = 4.1(4)$** ns

compared to **3(1) ns**: *S.M. Mullins et al, Phys. Rev. C61, 044315 (2000)*

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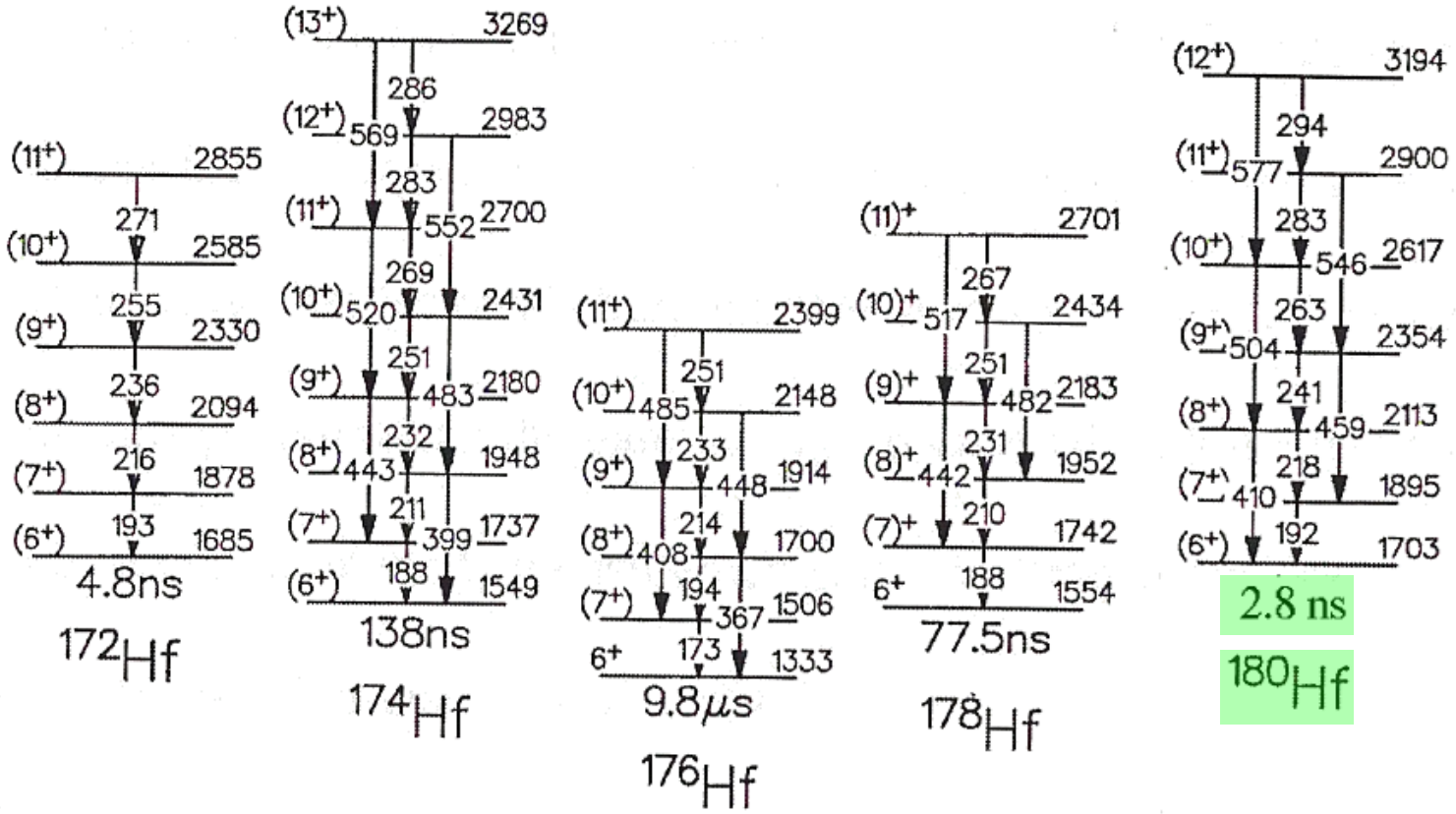
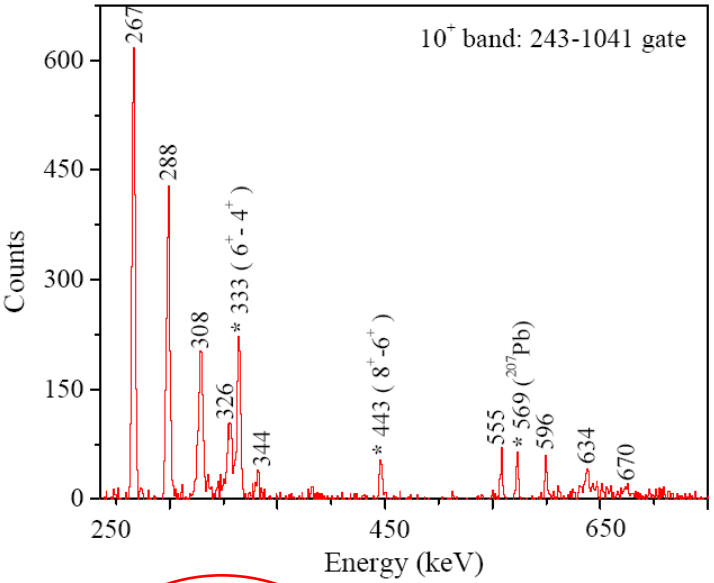
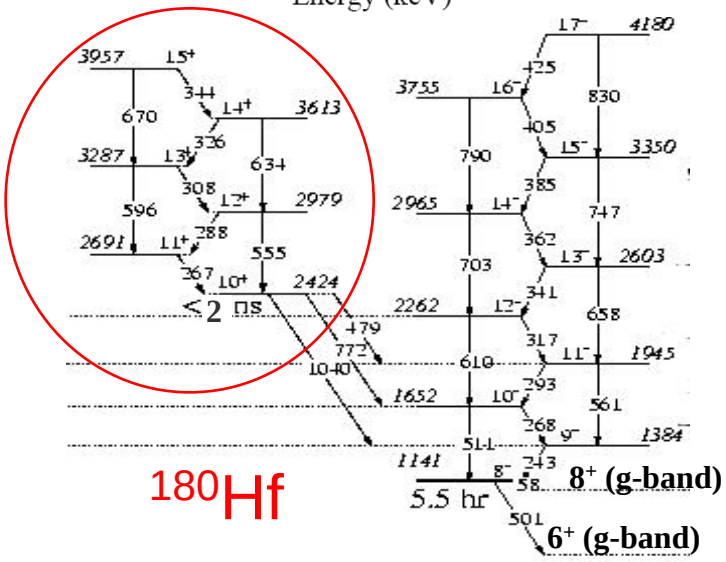
Systematics of $K^{\pi}=6^{+}$ bands in Hf isotopes



Two quasiproton: $\pi^2[404]7/2^+ \otimes [402]5/2^+$ configuration

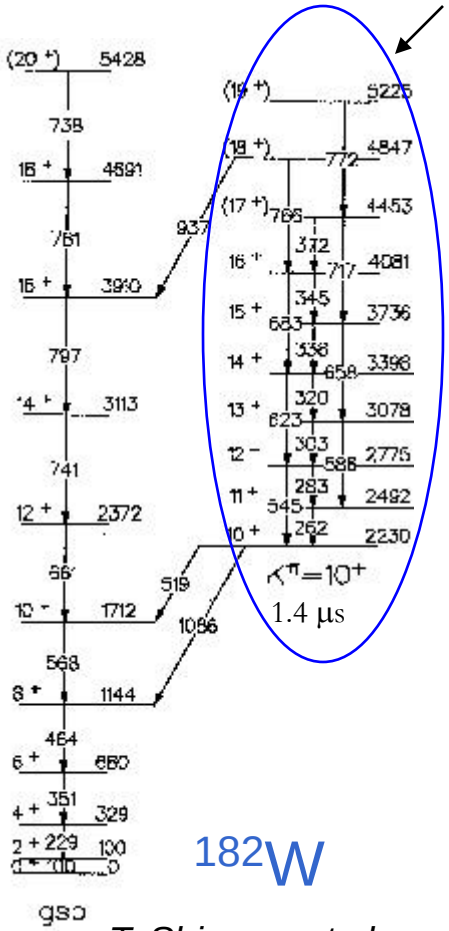
$K^{\pi}=10^{+}$ bands in N=108 isotones





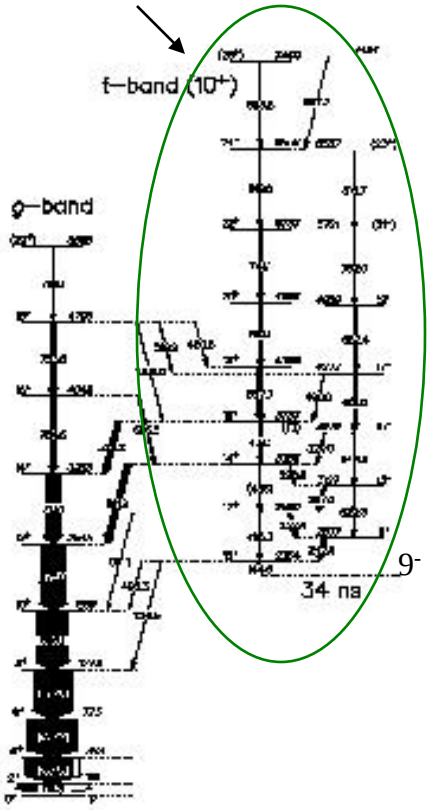
180Hf

Fermi-aligned
(t-band) structure



182W

T. Shizuma et al., Nucl. Phys. A593, 247 (1995)



184Os

C. Wheldon et al., Nucl. Phys. A699, 415 (2002)

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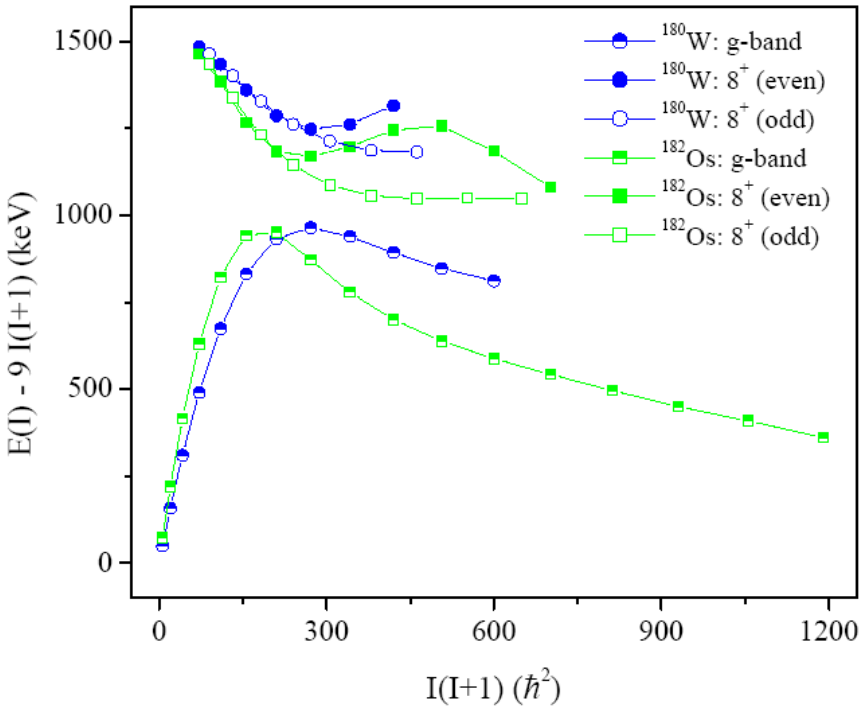
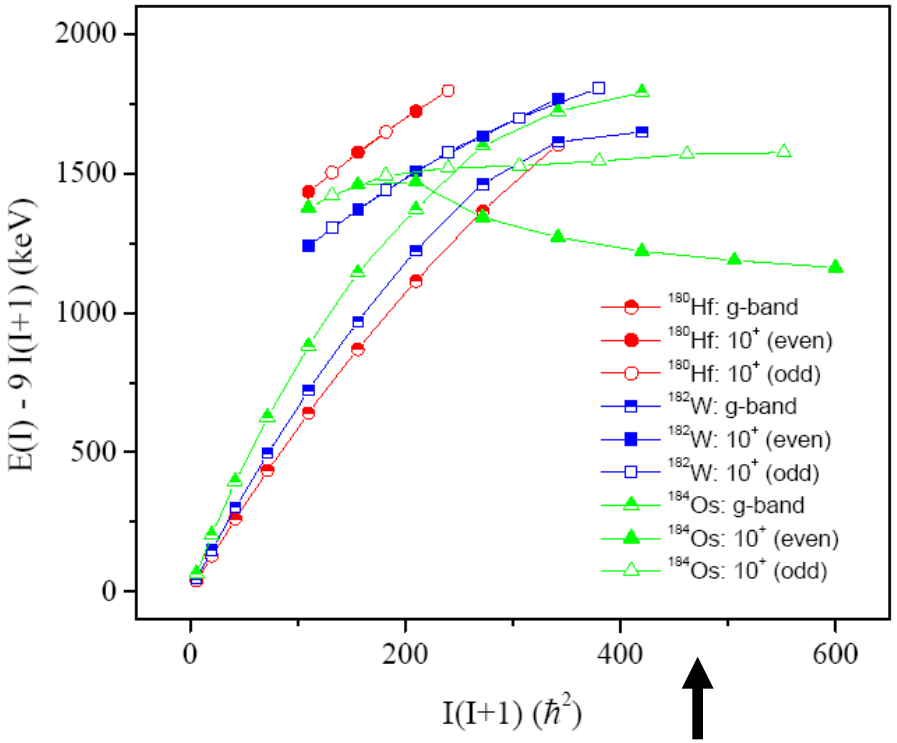
Fermi-aligned bands in N=106 and N=108 isotones

N=106 isotones: $K^{\pi}=8^{+}$ bands
ν^2 [624]9/2 ⊗ [514]7/2 configuration





N=108 isotones: $K^{\pi}=10^{+}$ bands
ν^2 [624]9/2 ⊗ [615]11/2 configuration

$K^{\pi}=10^{+}$ band in ^{180}Hf is not seen to interact with the g-band over the observed range of spins unlike Fermi aligned structures in isotones

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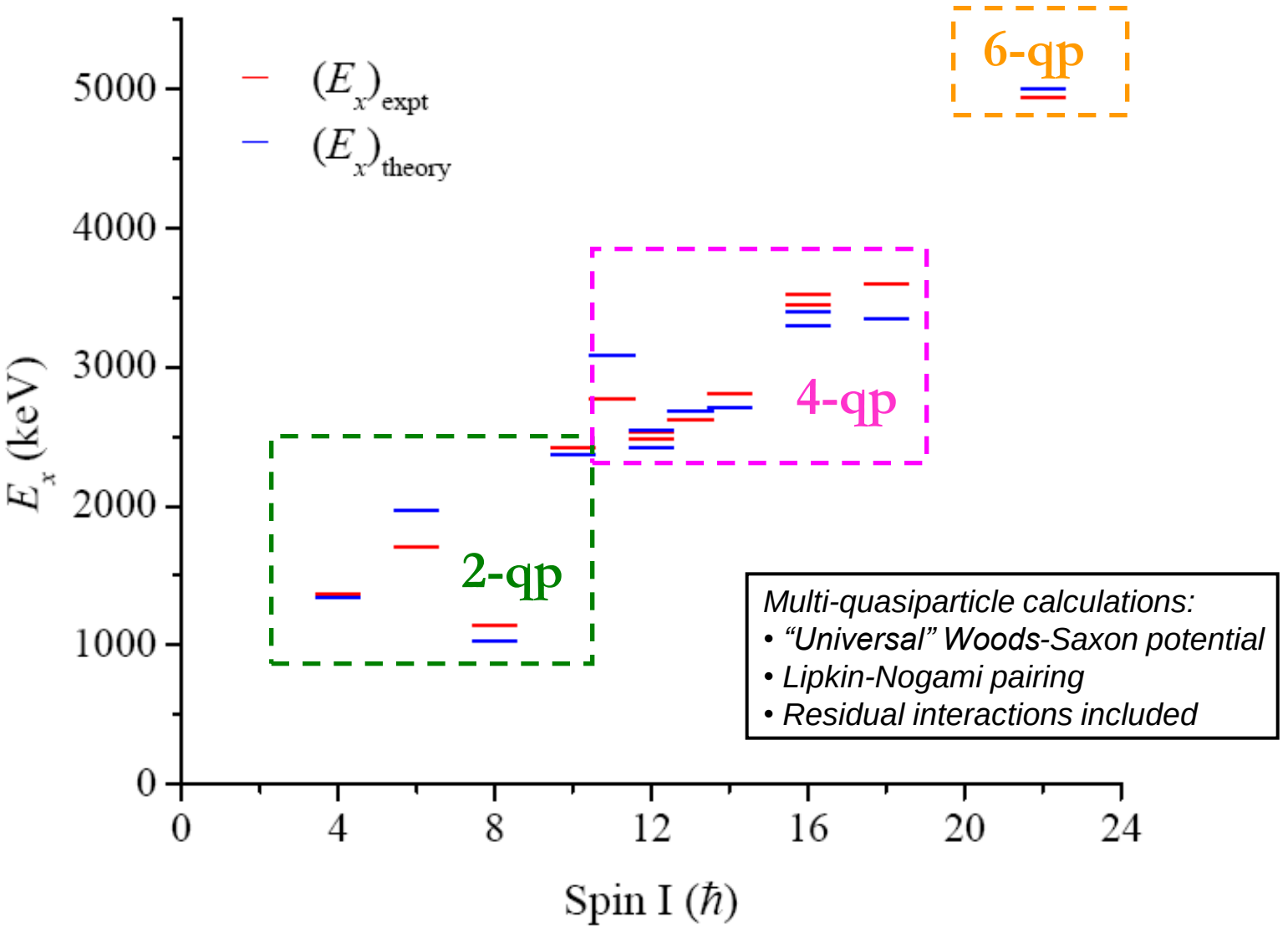
Observed high-K states and multi-quasiparticle calculations



Multi-quasiparticle calculations:
- *"Universal" Woods-Saxon potential*
- *Lipkin-Nogami pairing*
- *Residual interactions included*

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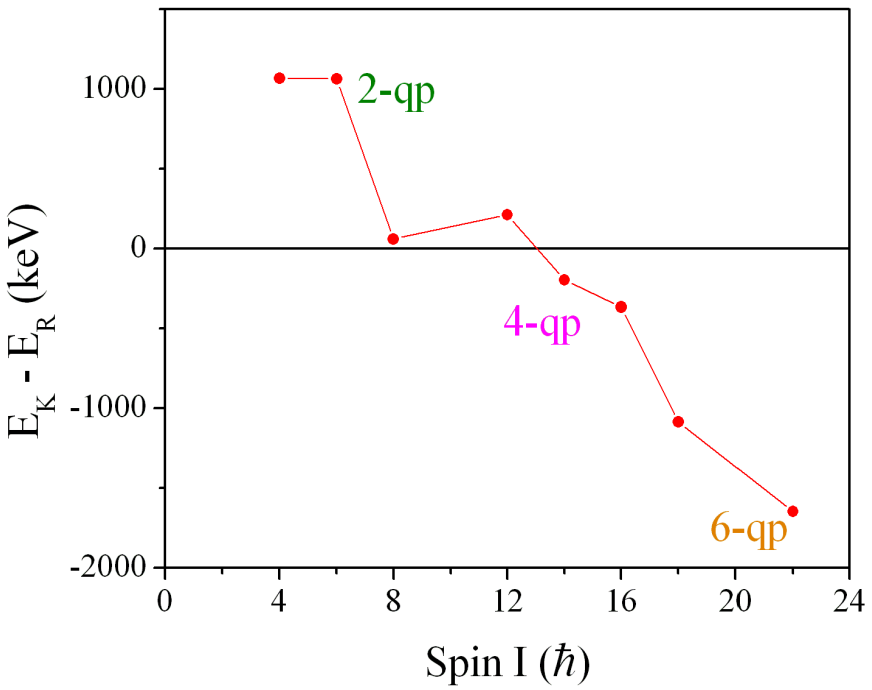
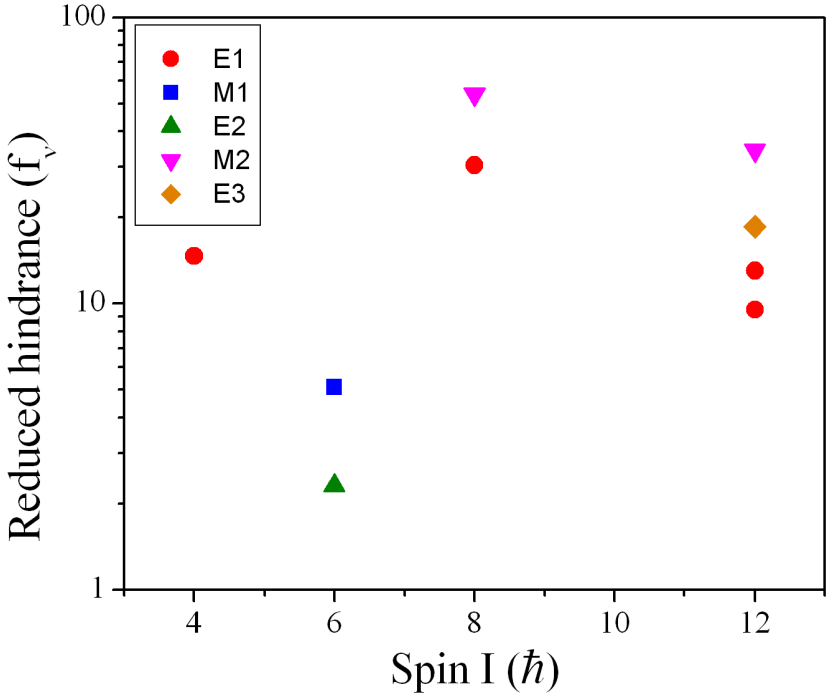
Energetics of high-K states and decay hindrances in ^{180}Hf





High-K excitations favored with increasing spin

Hindrances for 2- and 4-qp decays

S.K. Tandel et al., for publication in Physical Review C

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Summary

- Four new bands built upon 2- and 4-qp high-K states identified in ^{180}Hf. Two new intrinsic states observed, one of which has 6-qp character, at E_x~5 MeV
- New lifetime measurements for the $K^{\pi}=6^{+}$ and $K^{\pi}=12^{+}$ states; upper limit for the lifetime of the $K^{\pi}=10^{+}$ state
- Intrinsic excitations increasingly favored at higher spins; K-quantum number robust even at spin 22$\hbar$, with three broken pairs of nucleons
- Configuration assignments for high-K bands based on M1/E2 branching ratios
- $K^{\pi}=10^{+}$ band in ^{180}Hf does not interact with g-band in the observed region of spin, unlike Fermi-aligned bands in N=108 isotones
- Multi-quasiparticle calculations (including residual interactions) reproduce experimentally observed 2-, 4- and 6-qp excitation energies

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Collaboration

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