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Shape coexistence and isomerism in neutron-deficient Hg isotopes

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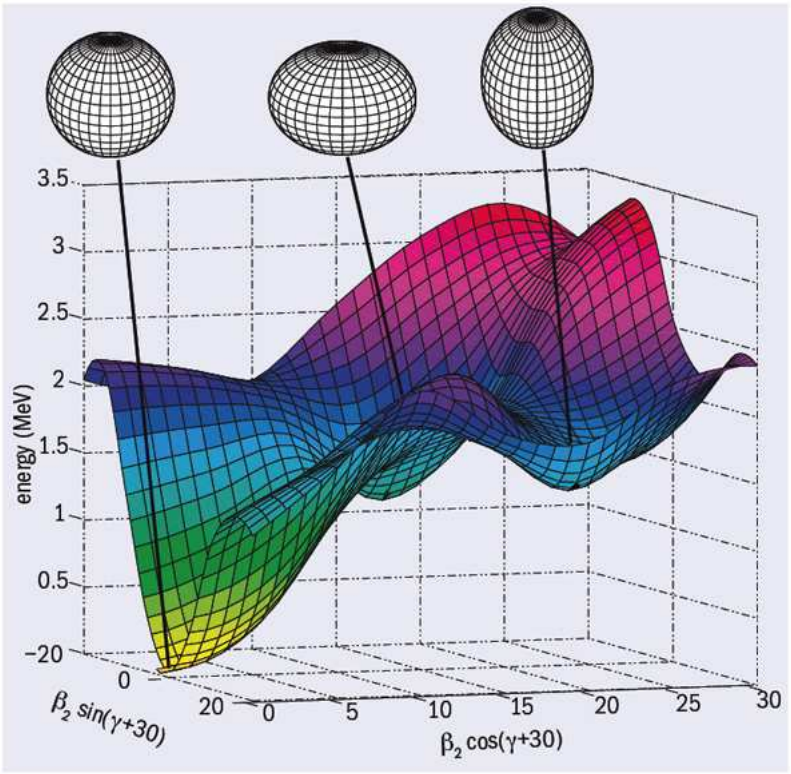
What is shape coexistence?

Competition between multiple shapes for the yrast sequence of a given nucleus

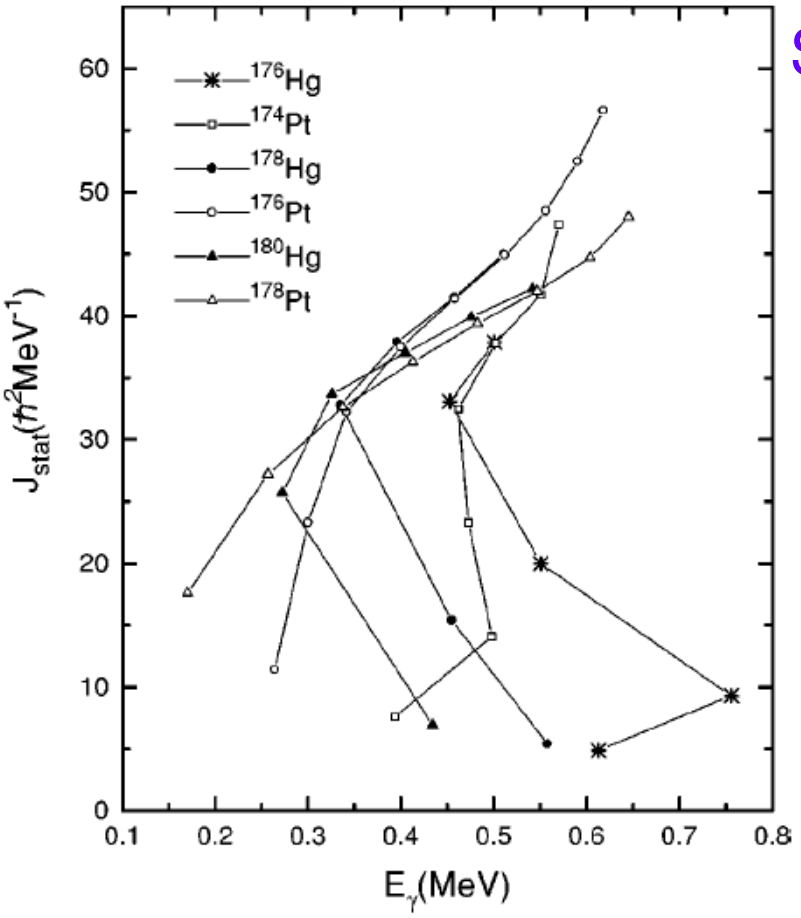
At different energies, particular shapes are preferred

Different shapes are driven by occupation of intruder orbitals or particle-hole excitations

Tends to occur around spherical shell gaps and mid-shell regions



Shape coexistence in neutron-deficient Hg isotopes



Static moment of inertia hints at deformation

Muikku *et al.* PRC **58** 3033(R) (1998)

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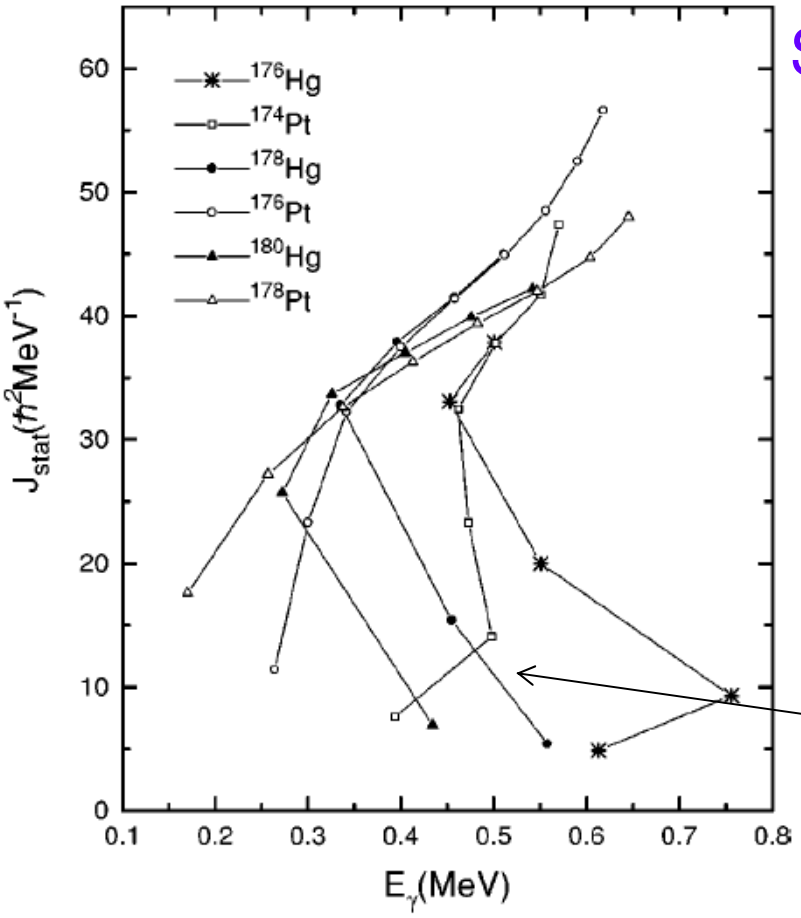
Shape coexistence in neutron-deficient Hg isotopes



Static moment of inertia hints at deformation

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-ve gradient associated with oblate shape

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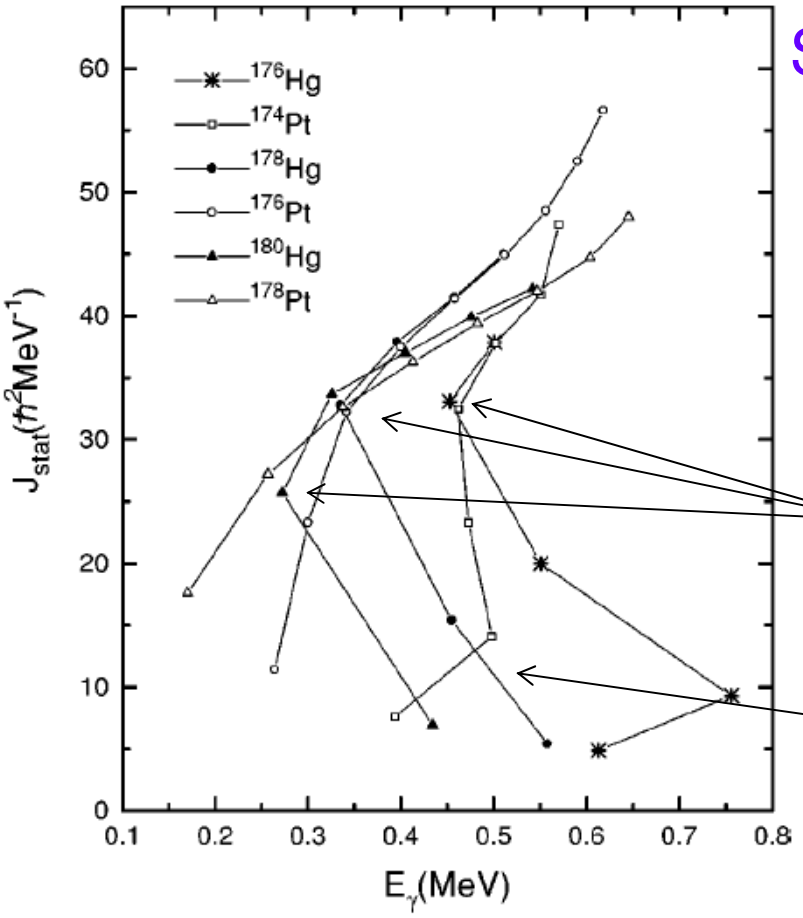

Static moment of inertia hints at deformation

Muikku *et al.* PRC **58** 3033(R) (1998)

Gradient changes –ve +ve indicating oblate prolate

-ve gradient associated with oblate shape

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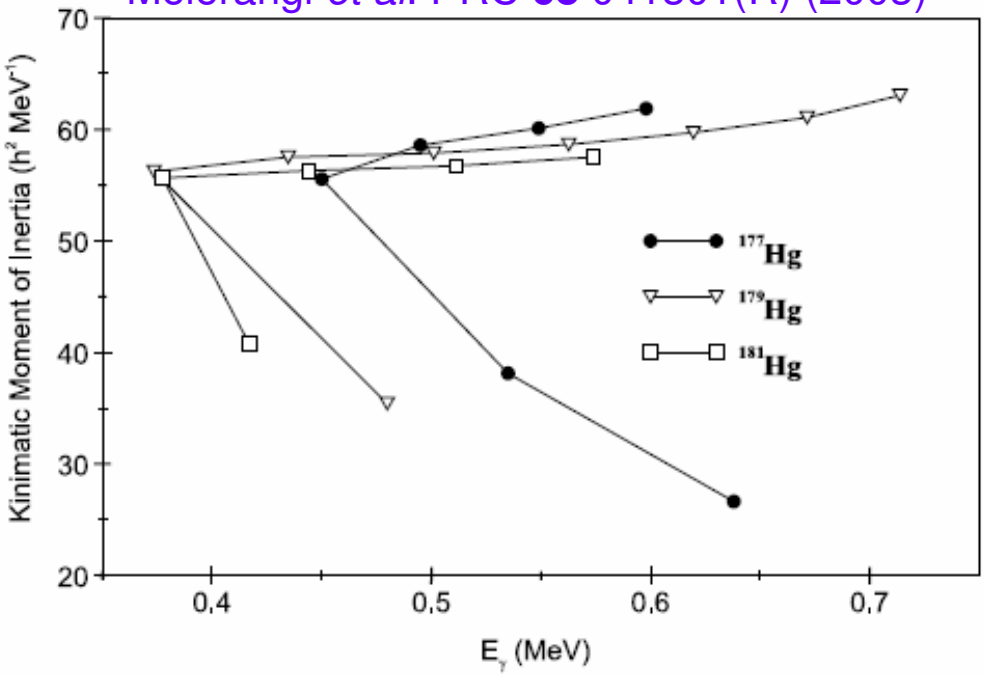
Shape coexistence in neutron-deficient Hg isotopes

Odd-*A* Hg isotopes also show oblate-prolate transition

Prolate bandhead energy increasing with decreasing neutron number

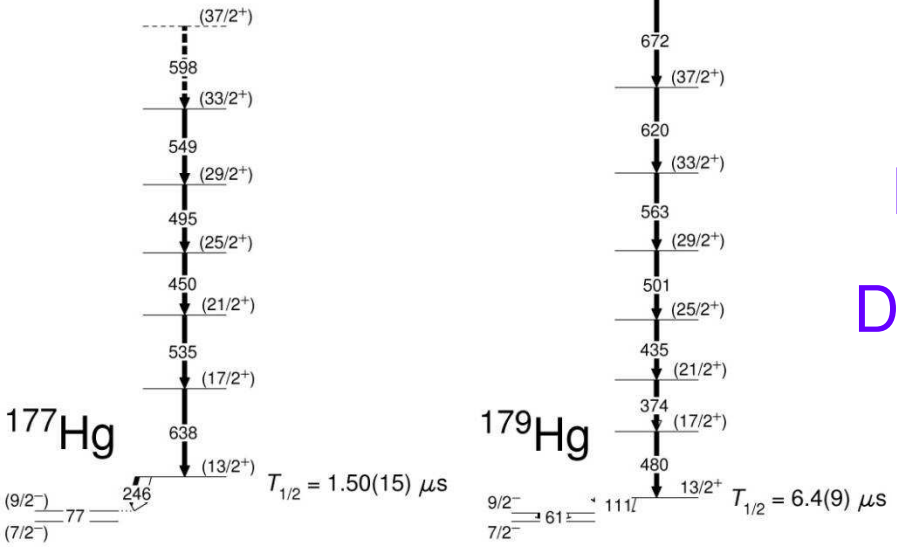
Do these trends continue to ^{175}Hg?

Melerangi *et al*. PRC **68** 041301(R) (2003)



Shape coexistence and isomerism in odd-*A* Hg isotopes

Kondev *et al*. PLB **528** 221 (2002)
Jenkins *et al*. PRC **66** 011301(R) (2002)
Melerangi *et al*. PRC **68** 041301(R) (2003)



Near-spherical ground states

$13/2^+$ isomers $\nu i13/2$ coupled to oblate core

Prolate band becomes yrast

Do these phenomena continue to lower neutron numbers?

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^{175}Hg: experimental details

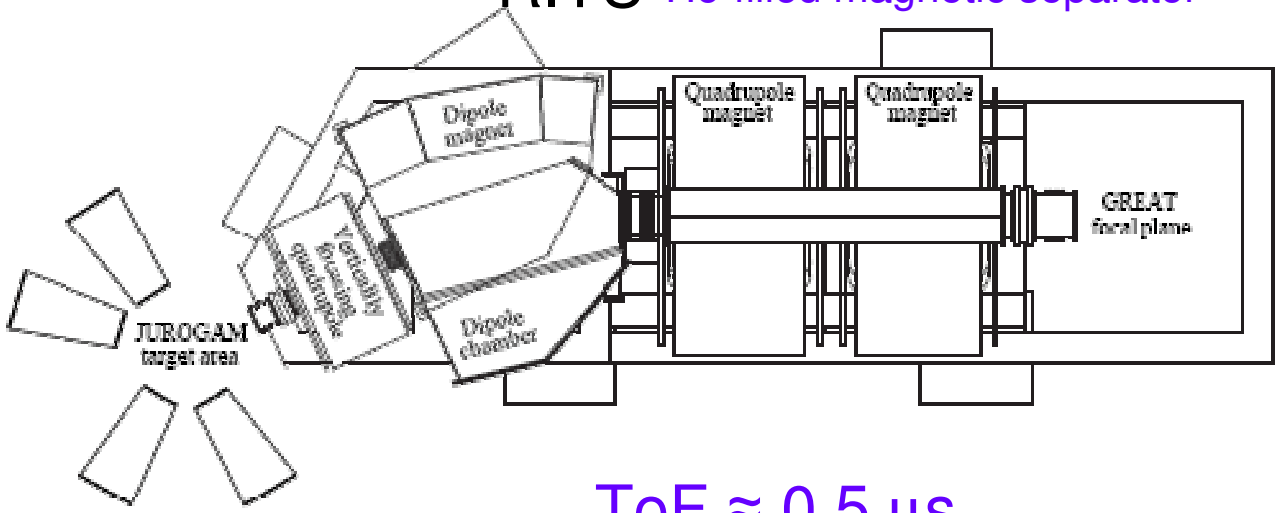
^{86}Sr (403 MeV) + ^{92}Mo $\rightarrow$ ^{175}Hg + 3*n*

Recoil-decay tagging experiment performed at JYFL in Jyvaskyla, Finland

JUROGAM-RITU-GREAT apparatus

RDT@JYFL: experimental apparatus

RITU He-filled magnetic separator



GREAT
MWPC
2 DSSDs
Si PIN diodes
Planar Ge
Clover Ge

ToF ≈ 0.5 μs

JUROGAM
43 Compton-suppressed HP Ge detectors

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Results: α-decay

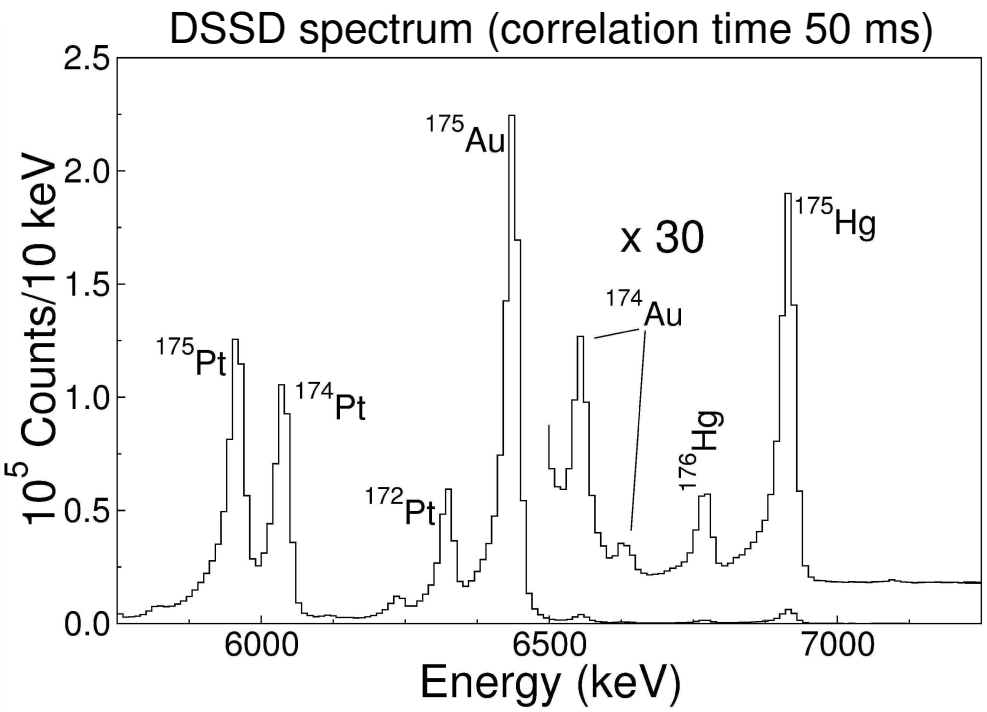
Approximately 25,000 recoil-α(^{175}Hg) events

$\sigma(^{175}Hg) \approx 1.5$ μb

$E_\alpha = 6913(5)$ keV

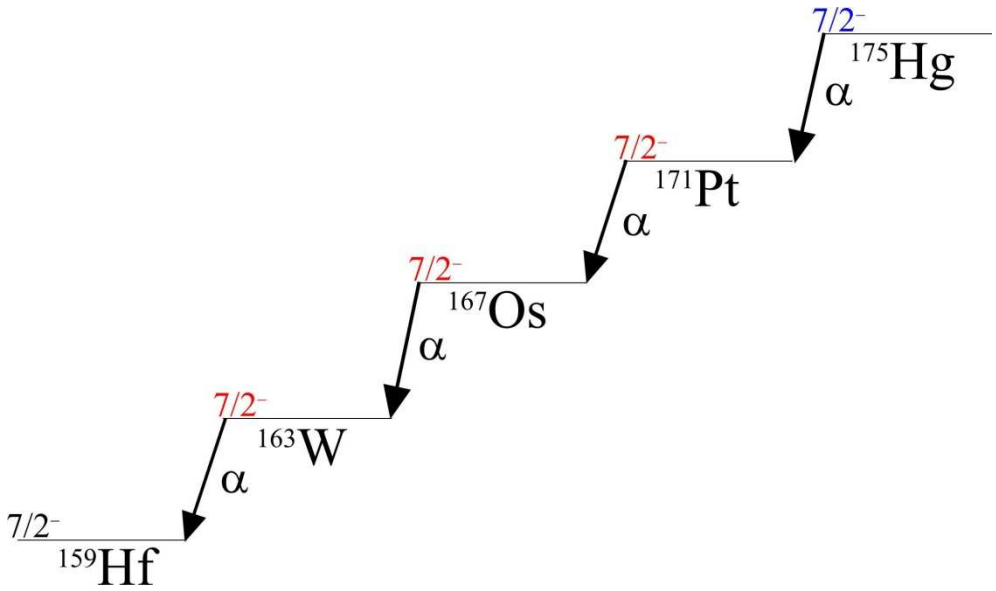
$T_{1/2} = 10(1)$ ms

$\delta^2 = 54(5)$ keV (assuming B.R. = 100% and $\Delta I = 0$)



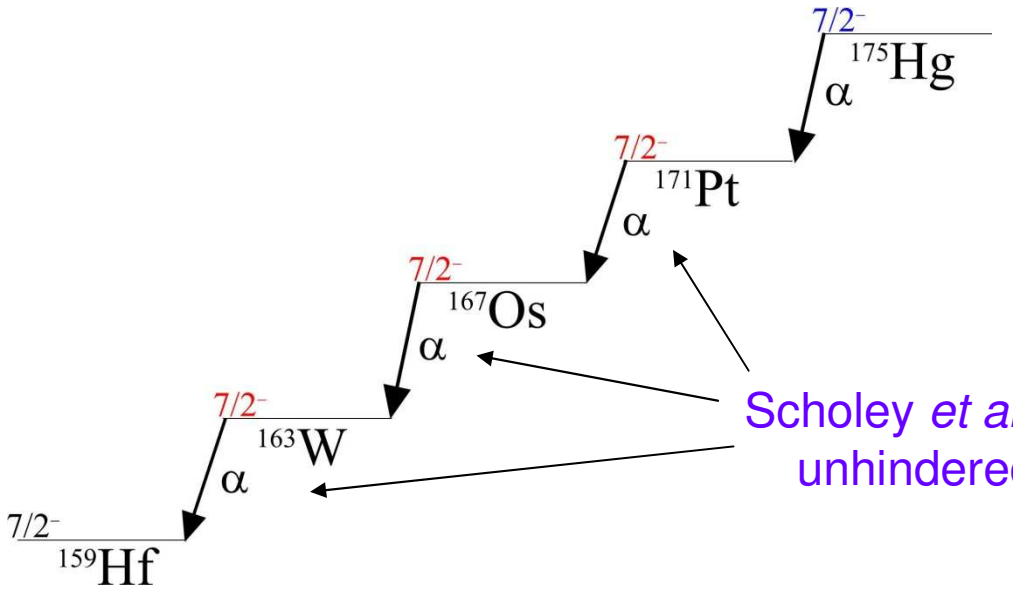
J.O. Rasmussen, Phys. Rev. **113** 1593 (1959)

Results: α-decay



^{159}Hf spin & parity determined Ding *et* al. PRC **62** 034316 (2000)

Results: α-decay



Scholey *et al.* PRC **81** 014306 (2010) measured unhindered decays of ^{163}W, ^{167}Os and ^{171}Pt

^{159}Hf spin/parity determined Ding *et* al. PRC **62** 034316 (2000)

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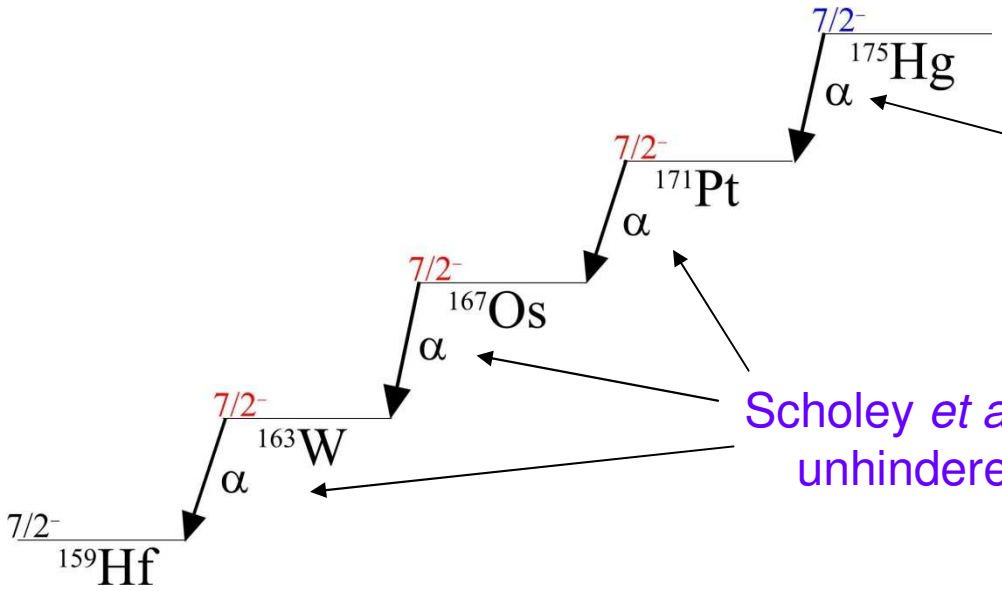
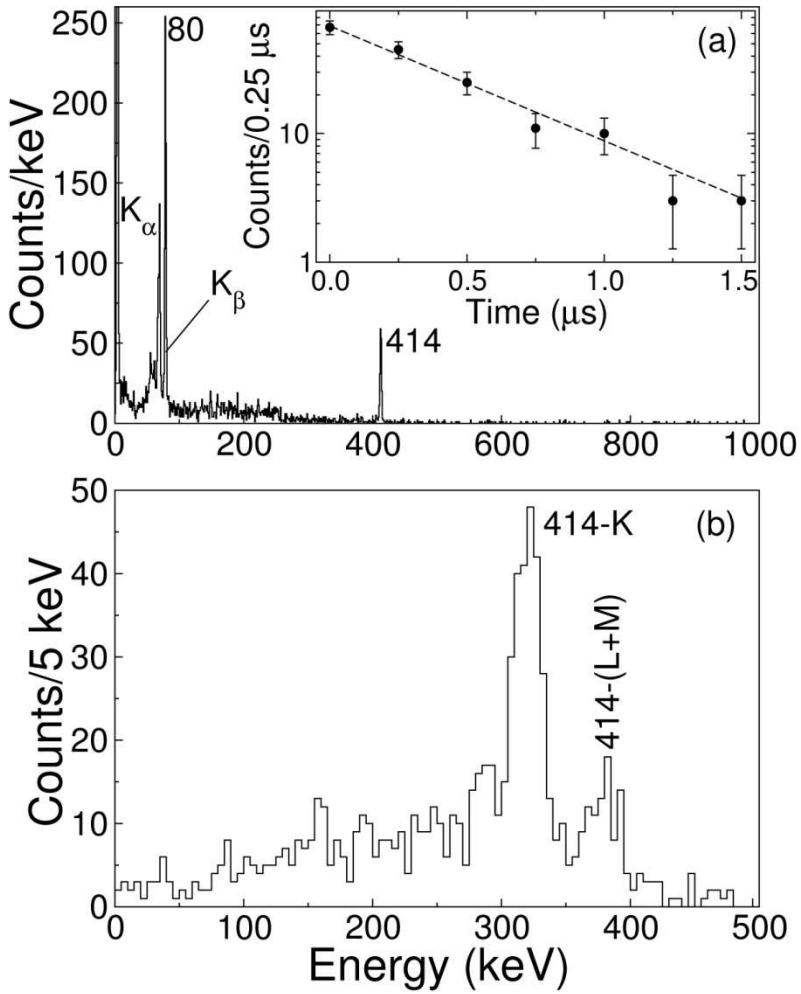


δ^2 = 54(5) keV indicates unhindered decay establishing GS $J^\pi = 7/2^-$

Scholey *et al.* PRC **81** 014306 (2010) measured unhindered decays of ^{163}W, ^{167}Os and ^{171}Pt

^{159}Hf spin/parity determined Ding *et al*. PRC **62** 034316 (2000)

Results: delayed transitions



Recoil-α(^{175}Hg) tagged planar Ge and clover spectrum

$T_{1/2}$(414 keV) = 0.34(3) μs

I_γ(414 keV)/I_γ(80 keV) ~ 3

Recoil-α(^{175}Hg) tagged Si PIN-diode spectrum

$\alpha_K = 0.36(11)$; $\alpha_{(L+M)} = 0.10(3)$

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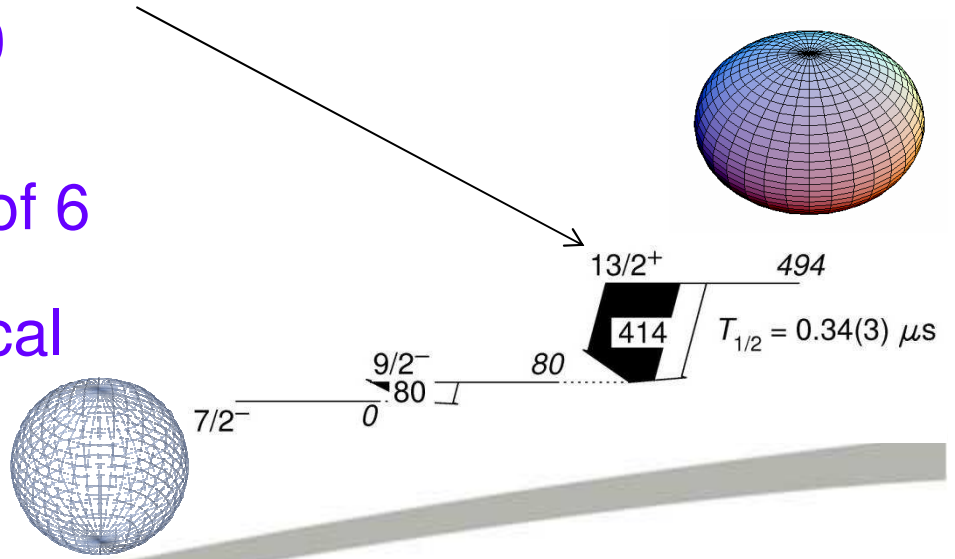
Evidence of shape coexistence?

Measured half-life indicates M2 transition

Supported by internal conversion coefficient measurements c.f.
$\alpha_K = 0.36(11)$; $\alpha_{(L+M)} = 0.10(3)$ and
BrIcc values 0.38 and 0.10
T. Kibedi *et al*. NIM A **589**, 202 (2008)

B(M2) = 0.16(1) hindrance of 6

^{179}Hg: oblate to near-spherical
hindrance ~ 5



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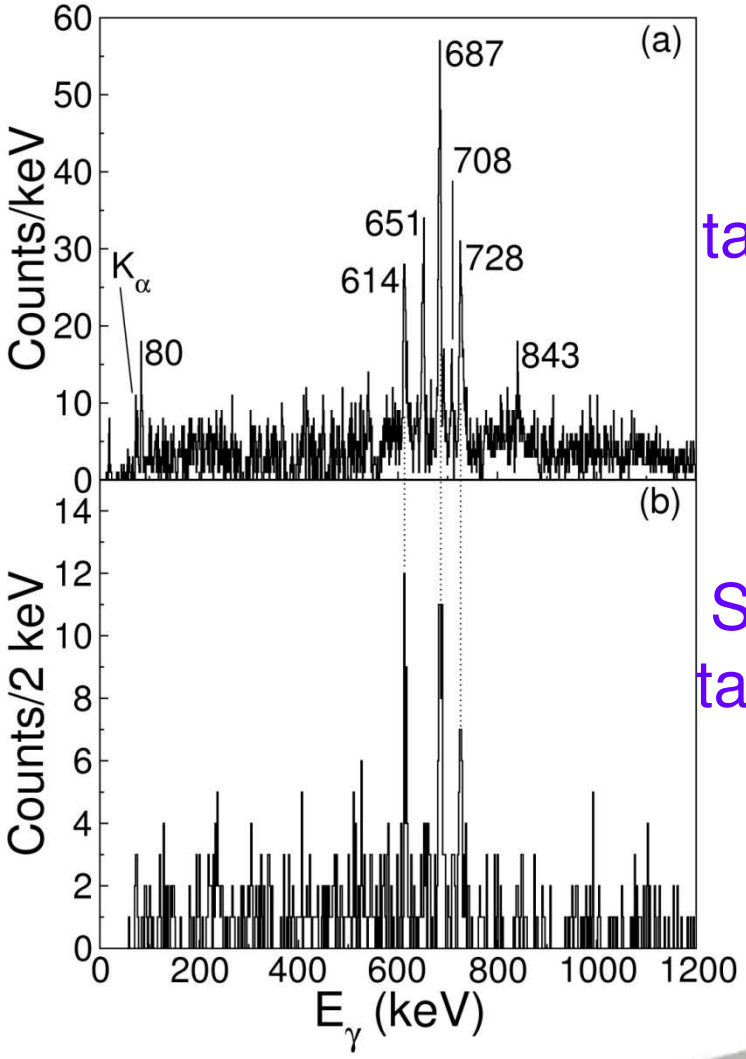
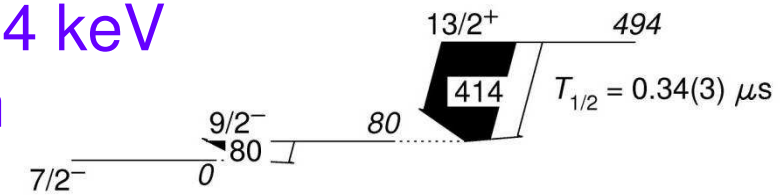
Results: prompt transitions



Recoil-α(^{175}Hg) tagged prompt γ-ray spectrum

Same as above but tagged with 414 keV transition



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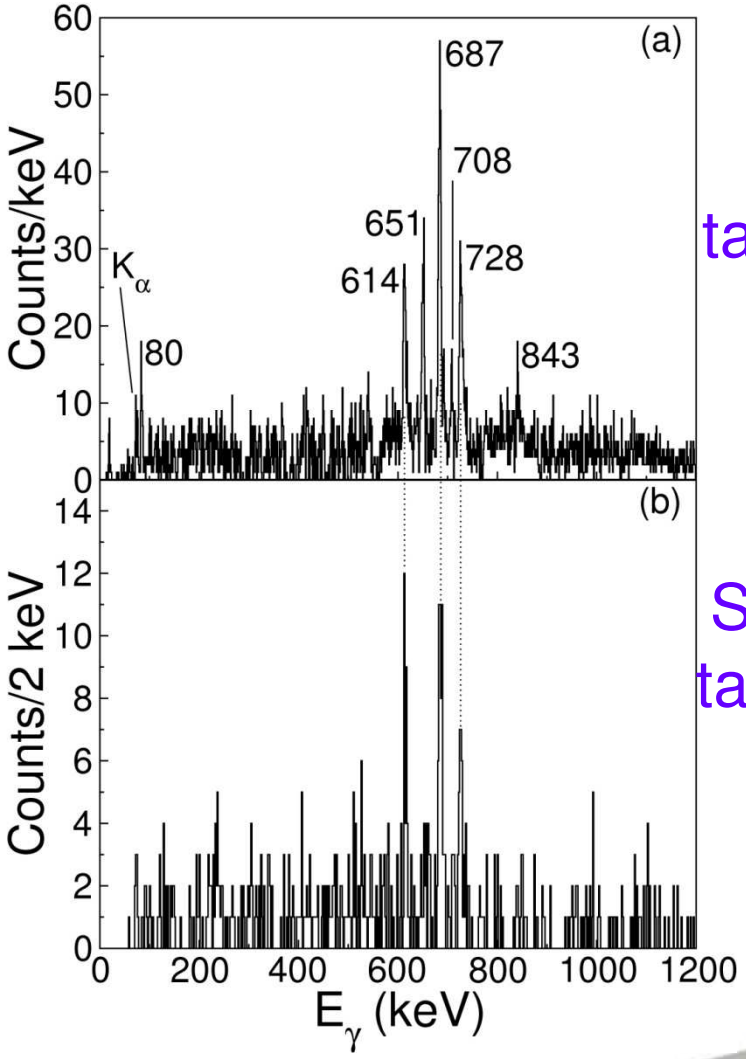

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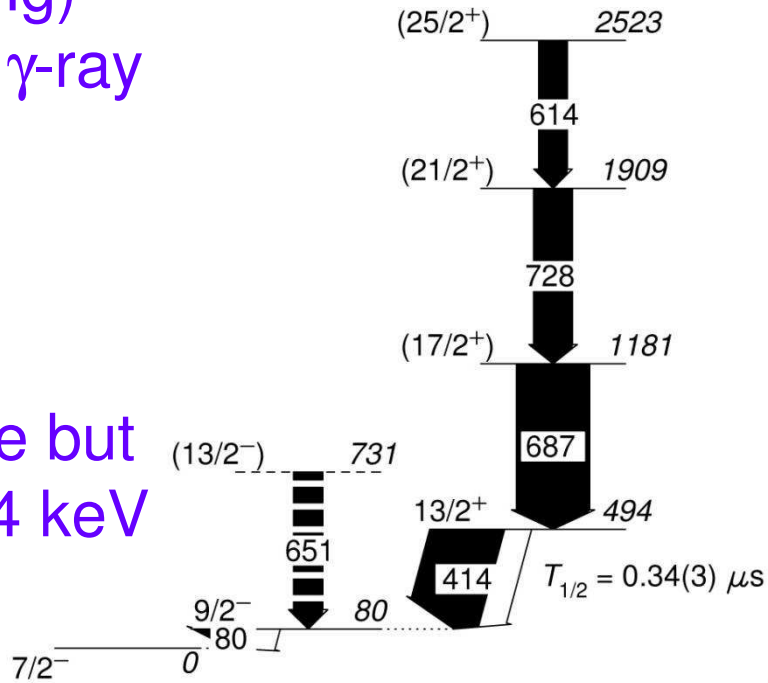

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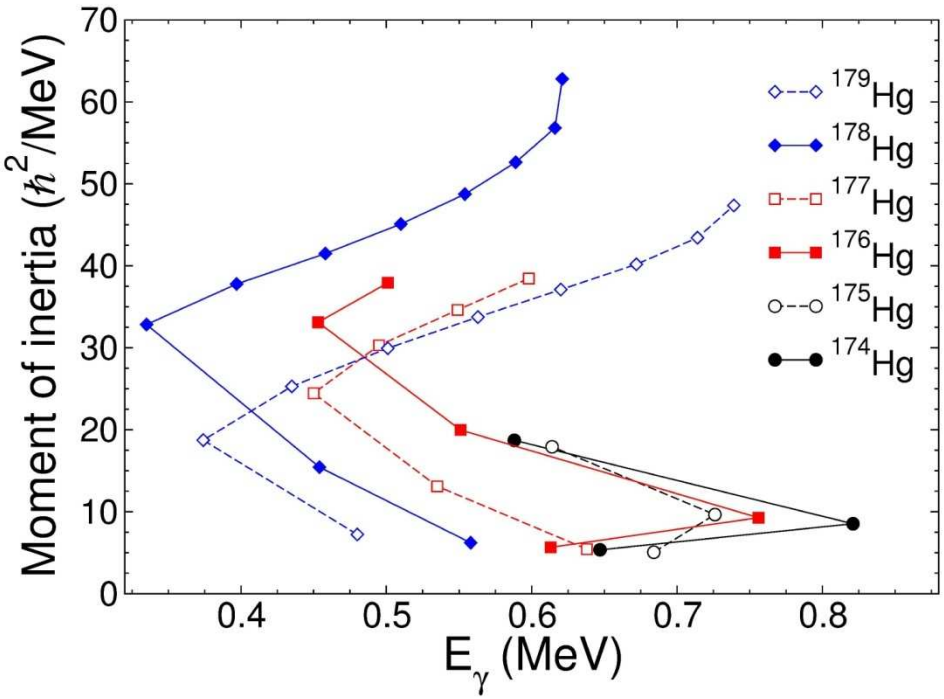
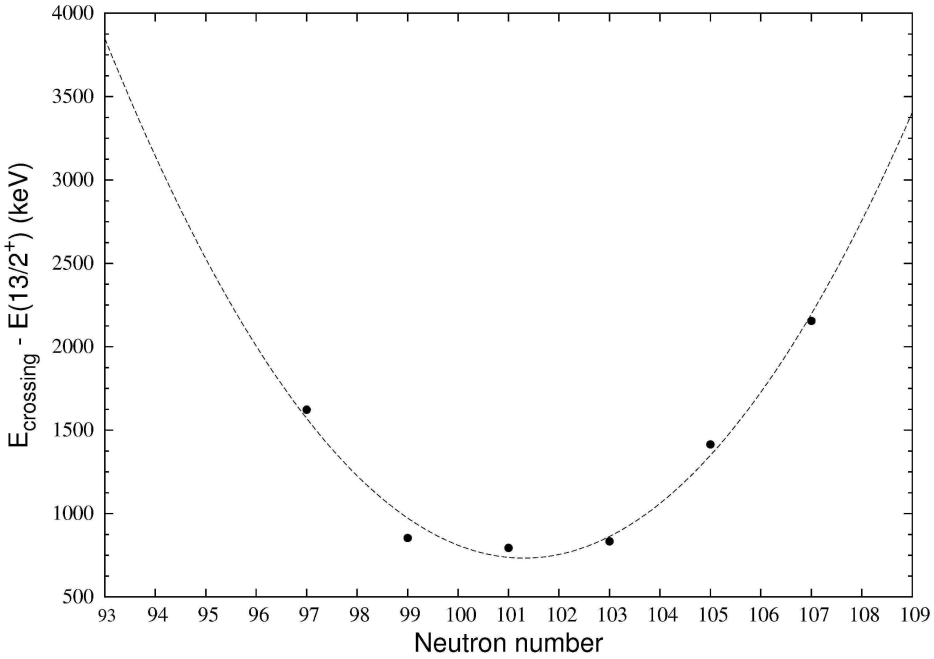
Conclusions





For ^{175}Hg, prolate crossing at ~2.5 MeV above isomer

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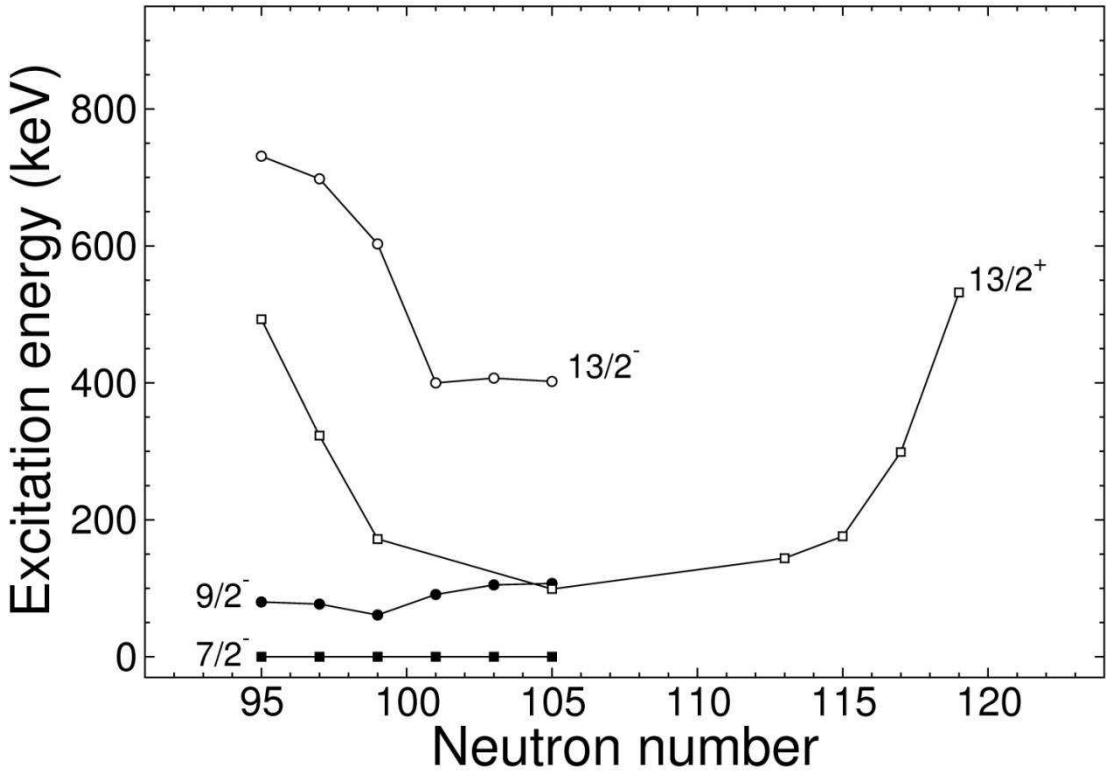
What next?



Plans to study ^{173}Hg (N = 93)

May not observe isomeric decay: E(13/2$^+$) ~ 800 keV

Single-particle $T_{1/2}$(M2) = 6 ns

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Collaborators

STFC Daresbury Laboratory – J. Simpson, M. Labiche

University of Liverpool – R.D. Page, D.T. Joss, D.S. Judson, L. Bianco, P. Sapple, J. Thomson, H.V. Watkins

University of Jyvaskyla – P.T. Greenlees, U. Jakobsson, P. Jones, R. Julin, S. Juutinen, S. Ketelhut, M. Leino, M. Nyman, P. Peura, P. Rahkila, P. Ruotsalainen, J. Saren, C. Scholey, J. Sorri, J. Uusitalo

KTH, Stockholm – T. Back, M. Sandzelius

O'Donnell *et al*. PRC **79** 051304(R) (2009)