Structural investigation of neutron deficient Pt isotopes: the case of ^{178}Pt

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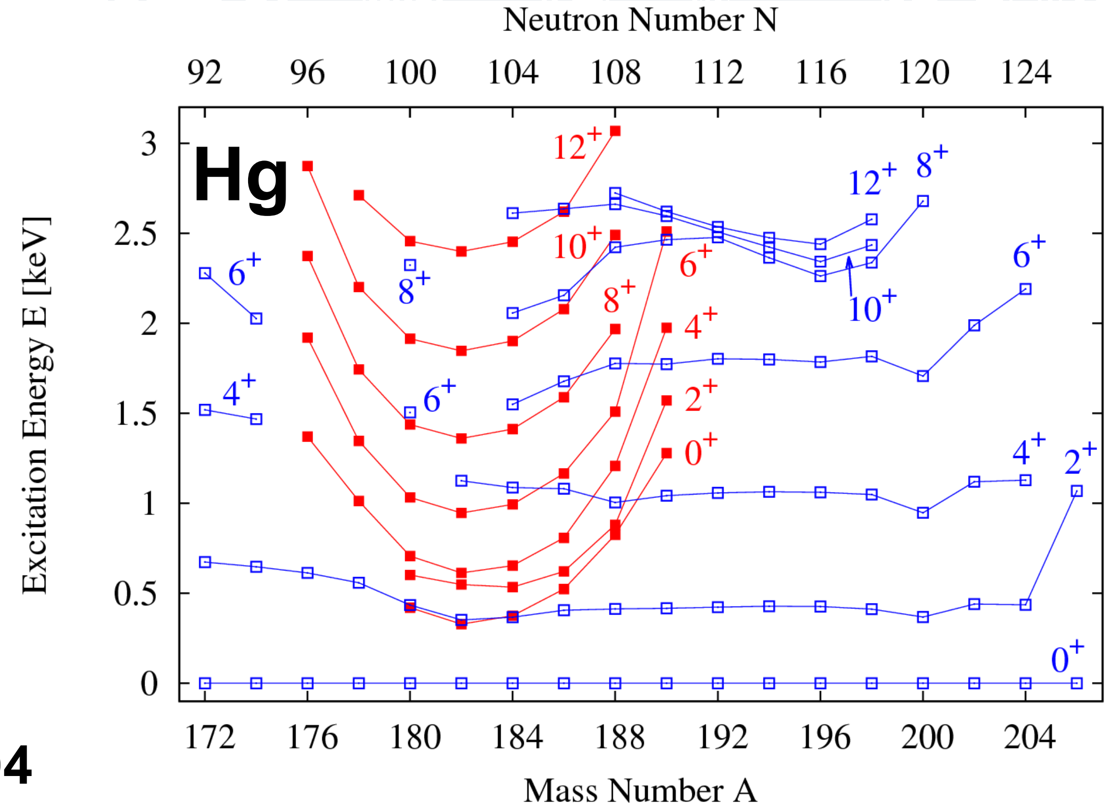
Motivation: rapid shape evolution in n-deficient nuclei in A=180 region

180Pb	181Pb	182Pb	183Pb	184Pb	185Pb	186Pb
179Tl	180Tl	181Tl	182Tl	183Tl	184Tl	185Tl
178Hg	179Hg	180Hg	181Hg	182Hg	183Hg	184Hg
177Au	178Au	179Au	180Au	181Au	182Au	183Au
176Pt	177Pt	178Pt	179Pt	180Pt	181Pt	182Pt
175Ir	176Ir	177Ir	178Ir	179Ir	180Ir	181Ir
174Os	175Os	176Os	177Os	178Os	179Os	180Os

178Pt

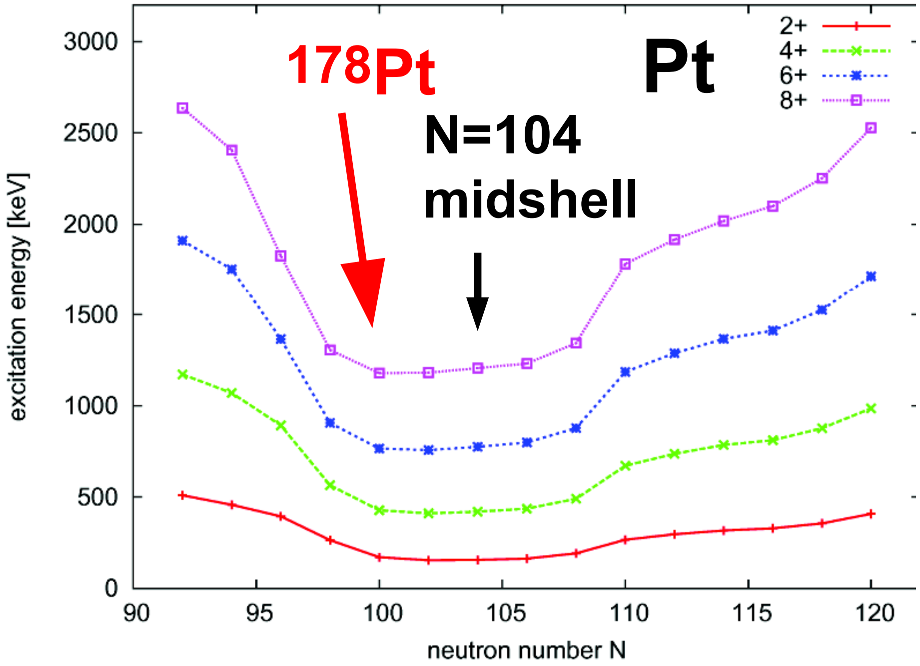
N=104
midshell

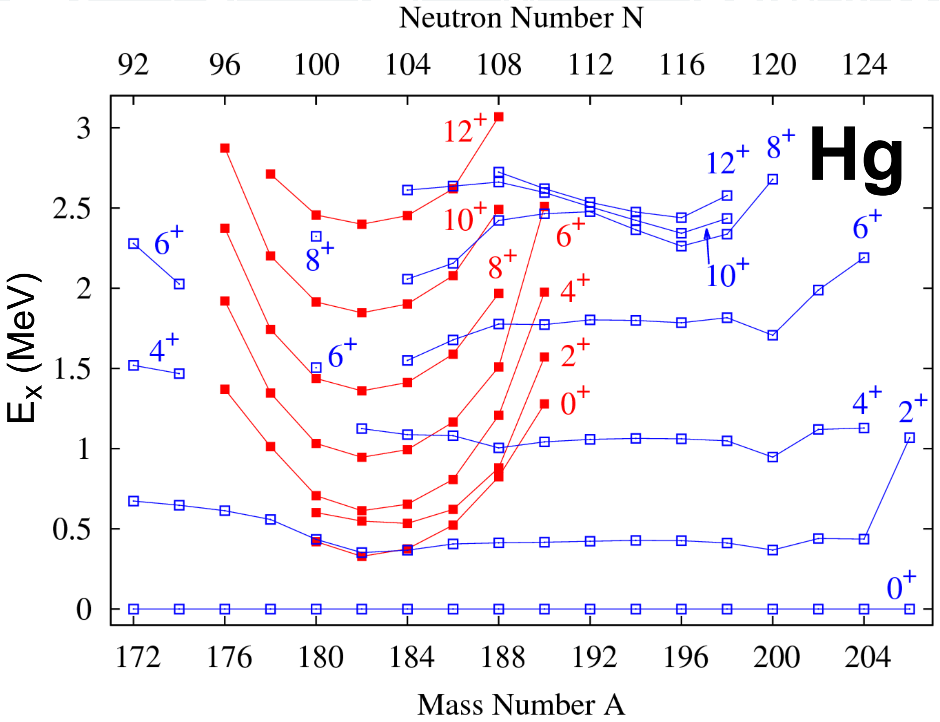
R4/2 1.6 2.6 3.3



Hg: prolate intruder,
oblate gs configuration

Evolution of the yrast bands in Pt and Hg isotopes





→ Level schemes of Pt isotopes: prolate gs conf. near midshell?

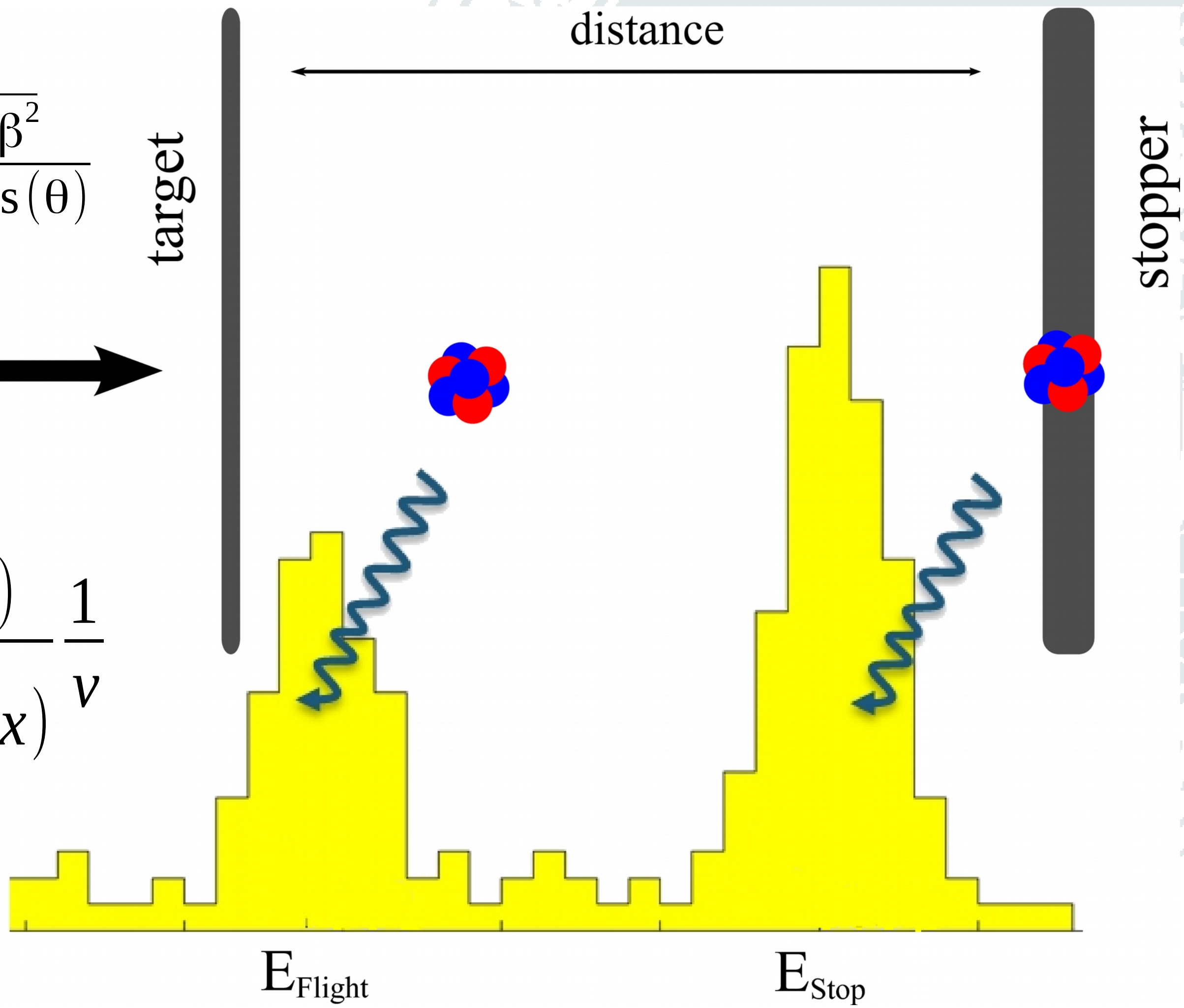
→ ^{176,178}Pt at the edge of a shape transition?

→ measure yrast B(E2) values!

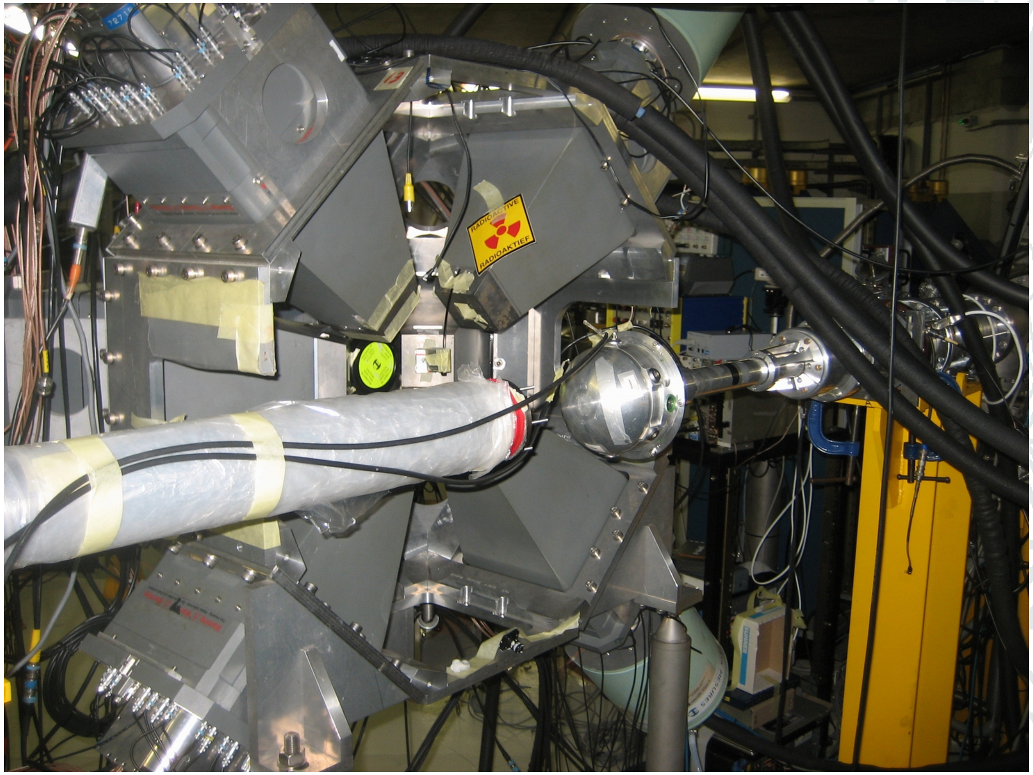
Lifetime determination with the recoil distance Doppler-shift technique

$$E_{sh} = E_{us} \frac{\sqrt{1-\beta^2}}{1-\beta\cos(\theta)}$$

$$\tau(x) = \frac{I_{us}(x)}{\frac{d}{dt} I_{sh}(x)} \frac{1}{v}$$



Experiment on ^{178}Pt @ AFRODITE, iThemba LABS, South Africa



Target: ^{98}Mo, 0.9 mg/cm^2
Stopper: Au, 15 mg/cm^2

Beam: ^{84}Kr, 375 MeV
Beam current: 2.0 – 2.5 pnA
Reaction: ^{98}Mo(^{84}Kr,4n)^{178}Pt

14 target – stopper distances
from 8 μm – 7200 μm,
each for 10 h

Recoil velocity:
v = 4.24% * c = 12.7 μm/ps

Level lifetimes: Recoil distance Doppler-shift method

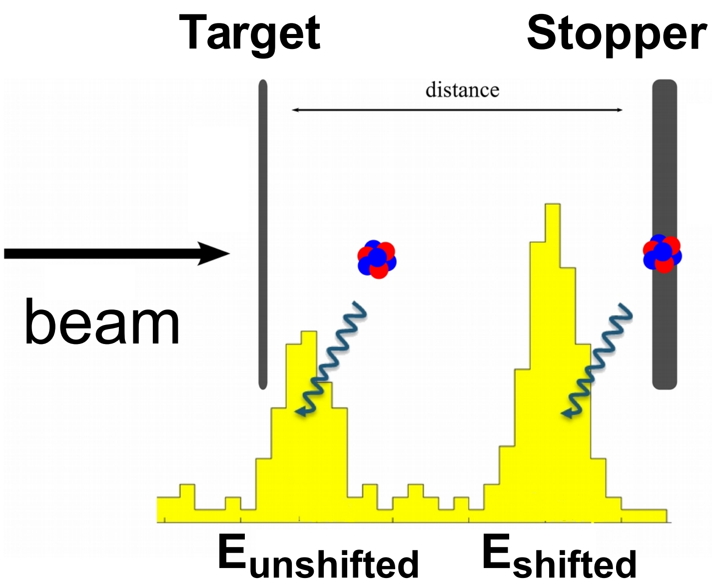
Cologne plunger at AFRODITE

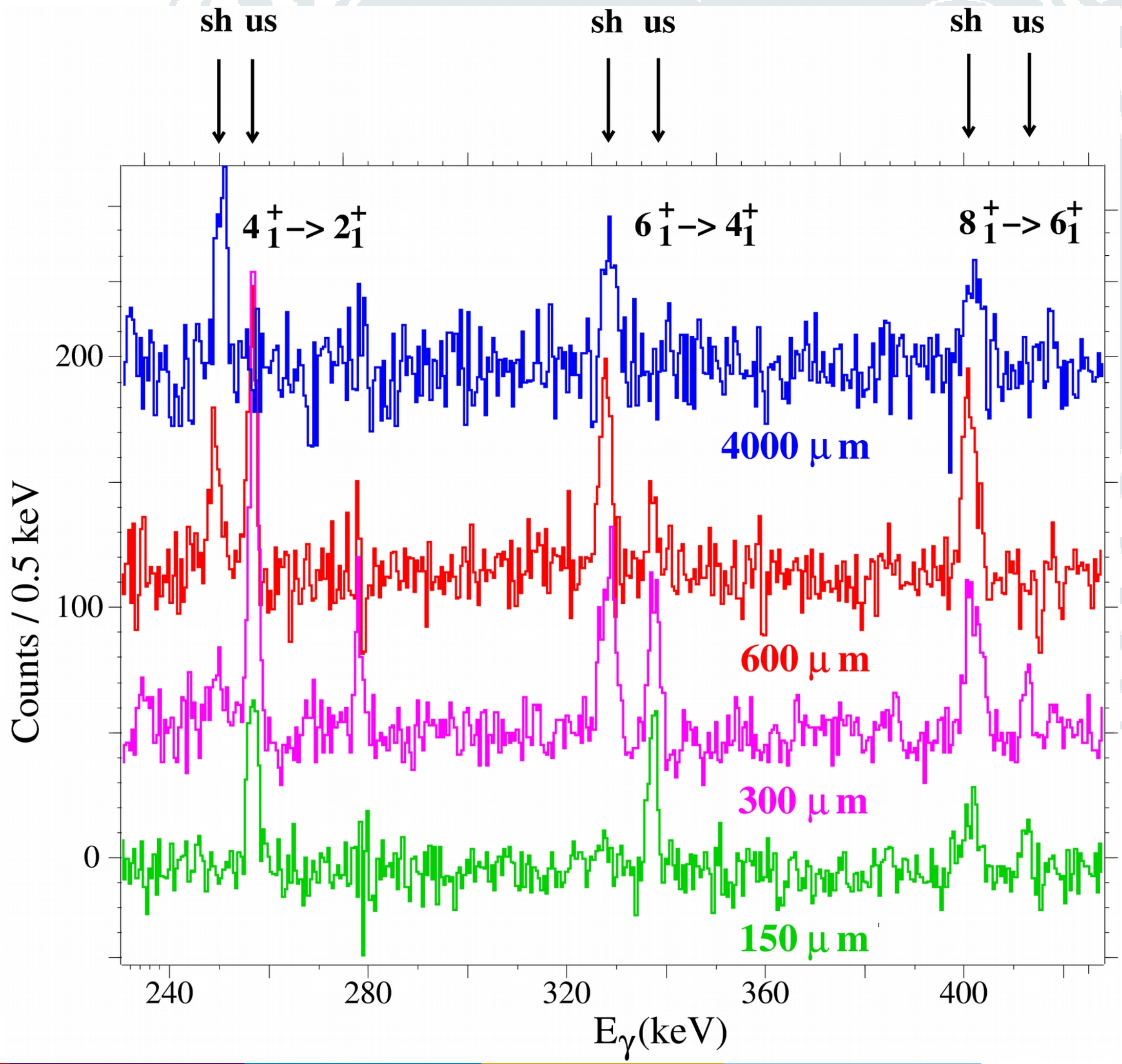
4 HPGe Clover detectors at 45^o and 135^o each

Experiment on ^{178}Pt @ AFRODITE, iThemba LABS, South Africa

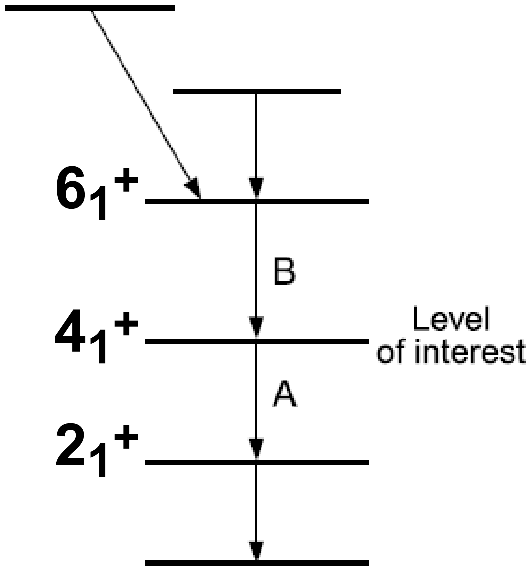
γ-ray spectra ^{178}Pt gated on $2_1^+ \rightarrow 0_1^+$

→shifted and unshifted components of yrast transitions in ^{178}Pt





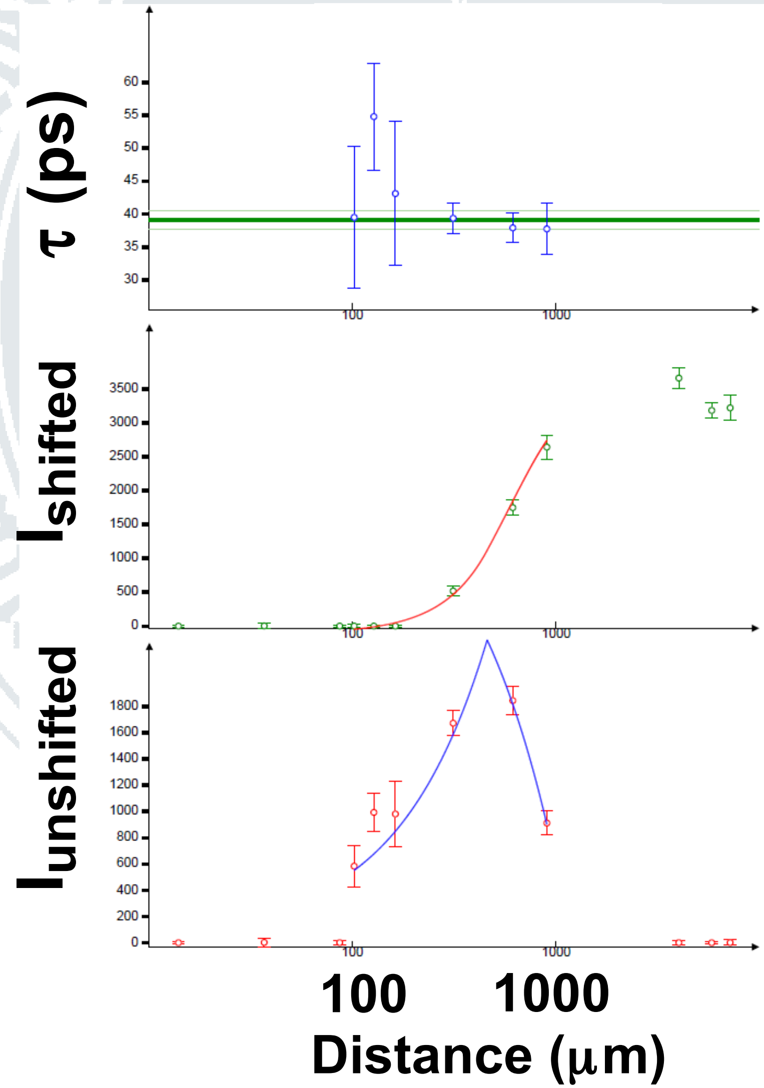
Lifetime determination: 4_1^+ in ^{178}Pt



Gate on shifted component
of populating transition „direct gate“

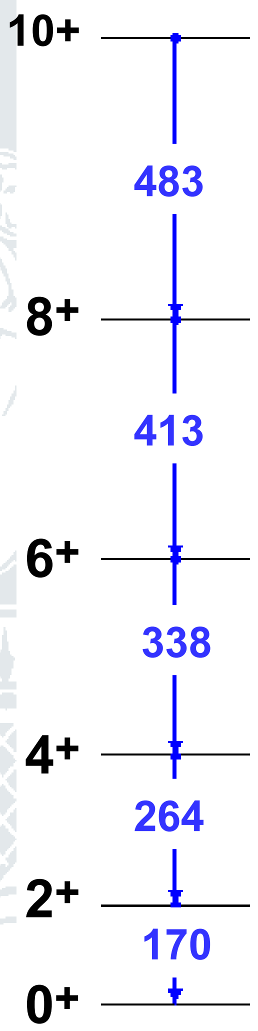
DDCM:

$$\tau_i = \frac{\{B_s, A_u\}_{ob}}{\frac{d}{dt}\{B_s, A_s\}_{ob}}$$



Experimental results ^{178}Pt

Level	E_γ [keV]	τ [ps]	B(E2) [W.u.]	Q_t [eb]
2+	170.3	412±30	143^{+11}_{-10}	$6.53^{+0.26}_{-0.22}$
4+	257.1	40.8±2.4	259^{+16}_{-14}	$7.36^{+0.23}_{-0.21}$
6+	337.7	11.9±1.1	245^{+25}_{-21}	$6.81^{+0.35}_{-0.29}$
8+	413.2	3.79±0.50	289^{+44}_{-34}	$7.24^{+0.55}_{-0.42}$
10+	483.0	1.84±0.82	276^{+222}_{-85}	$6.99^{+2.81}_{-1.08}$



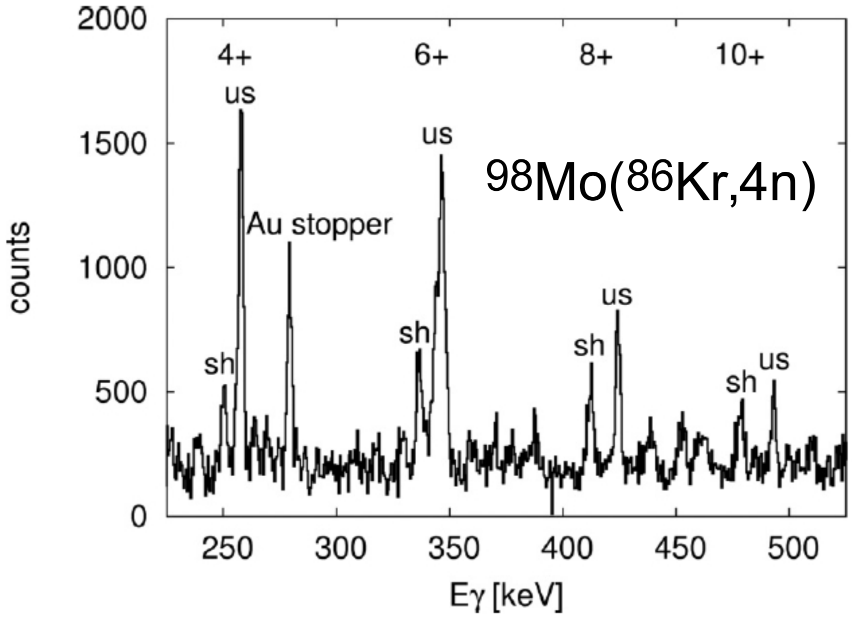
$\tau(2_1^+)$ from fast timing: Li et al., PRC 90, 047302 (14)

$\tau(12_1^+)$ not measurable: unshifted comp. $12_1^+ \rightarrow 10_1^+$ doublet with ^{197}Au Coulex γ-ray line from stopper.

Dracoulis et al., JPG 12, L97 (86): $\tau(4+)=54.1(46)$ ps
$\tau(6+)=15.7(12)$ ps

→ **only 1 HPGe detector + NaI as multiplicity filters**

Experimental details ^{180}Pt



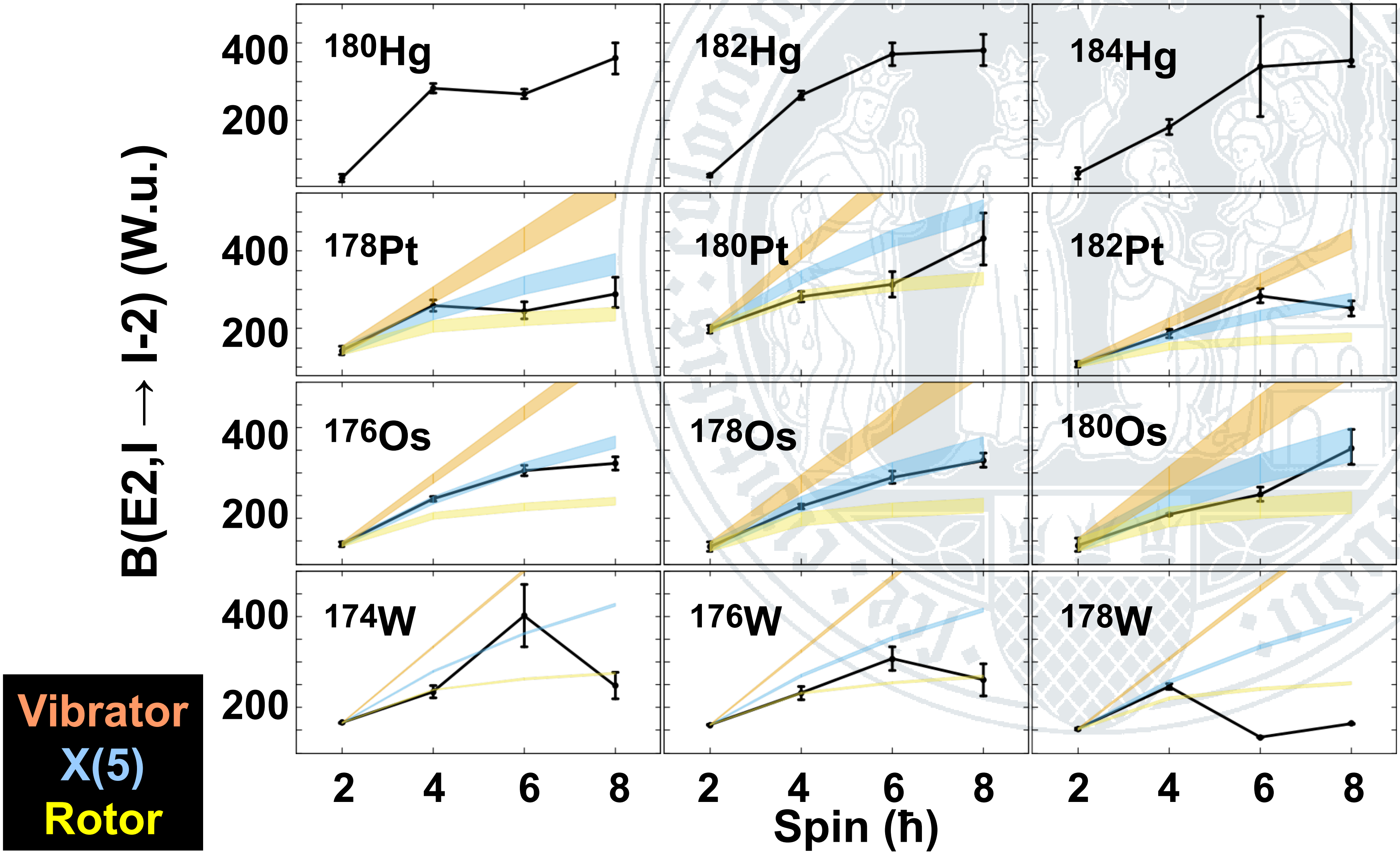
$\tau(2_1^+) = 420\ (20)$ ps
$\tau(4_1^+) = 37\ (2)$ ps
$\tau(6_1^+) = 7.7\ (9)$ ps
$\tau(8_1^+) = 3.1\ (1)$ ps

$\tau(2_1^+)$: fast timing, IKP Cologne
$^{168}Yb(^{16}O,4n)^{180}Pt$ @ 88 MeV

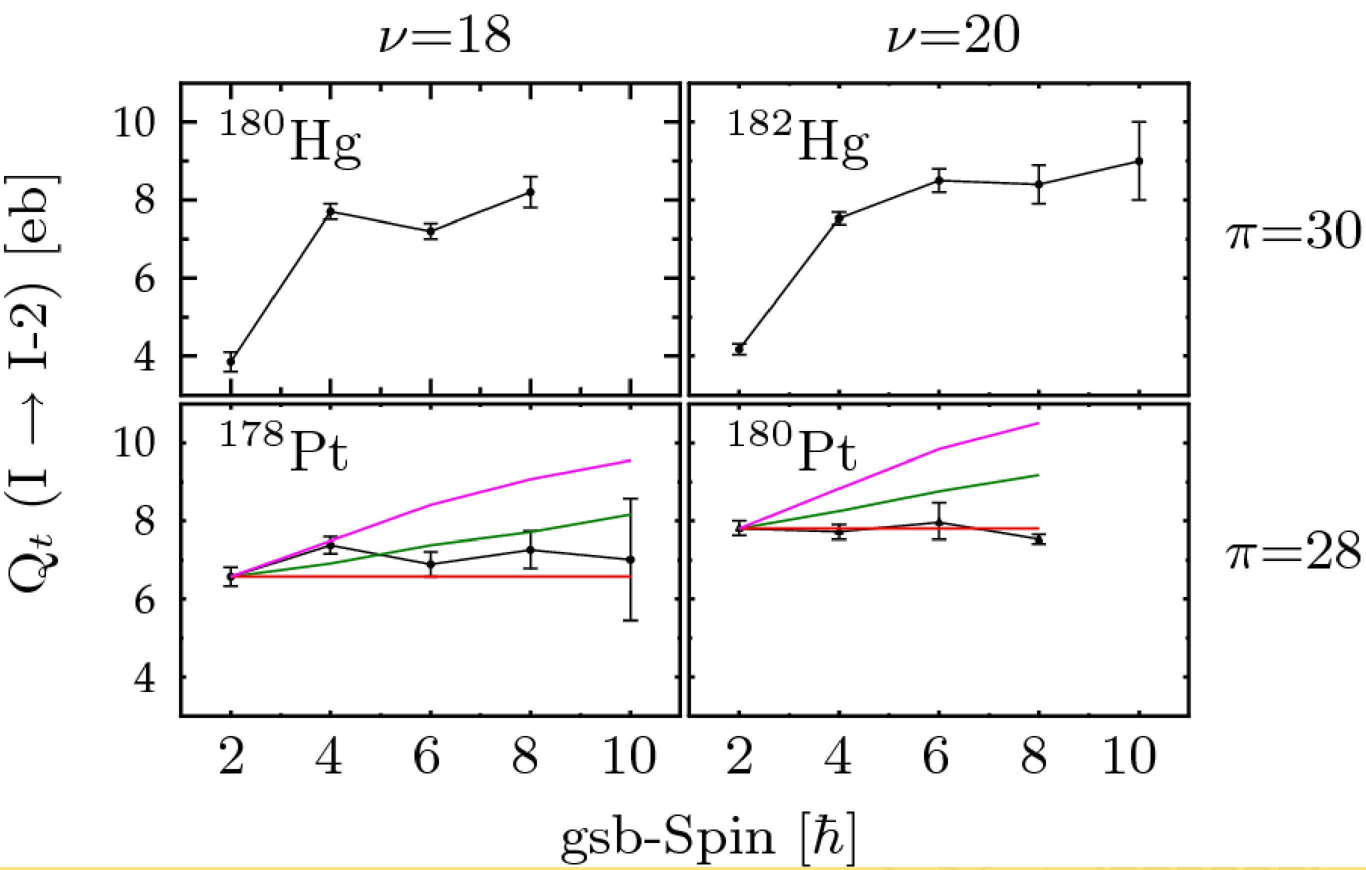
$\tau(4_1^+) - \tau(8_1^+)$: JYFL Jyväskylä
$^{98}Mo(^{86}Kr,4n)^{180}Pt$ @ 380 MeV
C. Müller-Gatermann et al., PRC 97, 024336 (18)

$\tau(8_1^+)$: LNL Legnaro
$^{154}Sm(^{32}S,6n)^{180}Pt$ @ 183 MeV
C. Müller-Gatermann et al., NIM A 920, 95 (19)

Yrast B(E2) values n-deficient W – Os – Pt – Hg region



Yrast Q_t values ^{178,180}Pt, ^{180,182}Hg

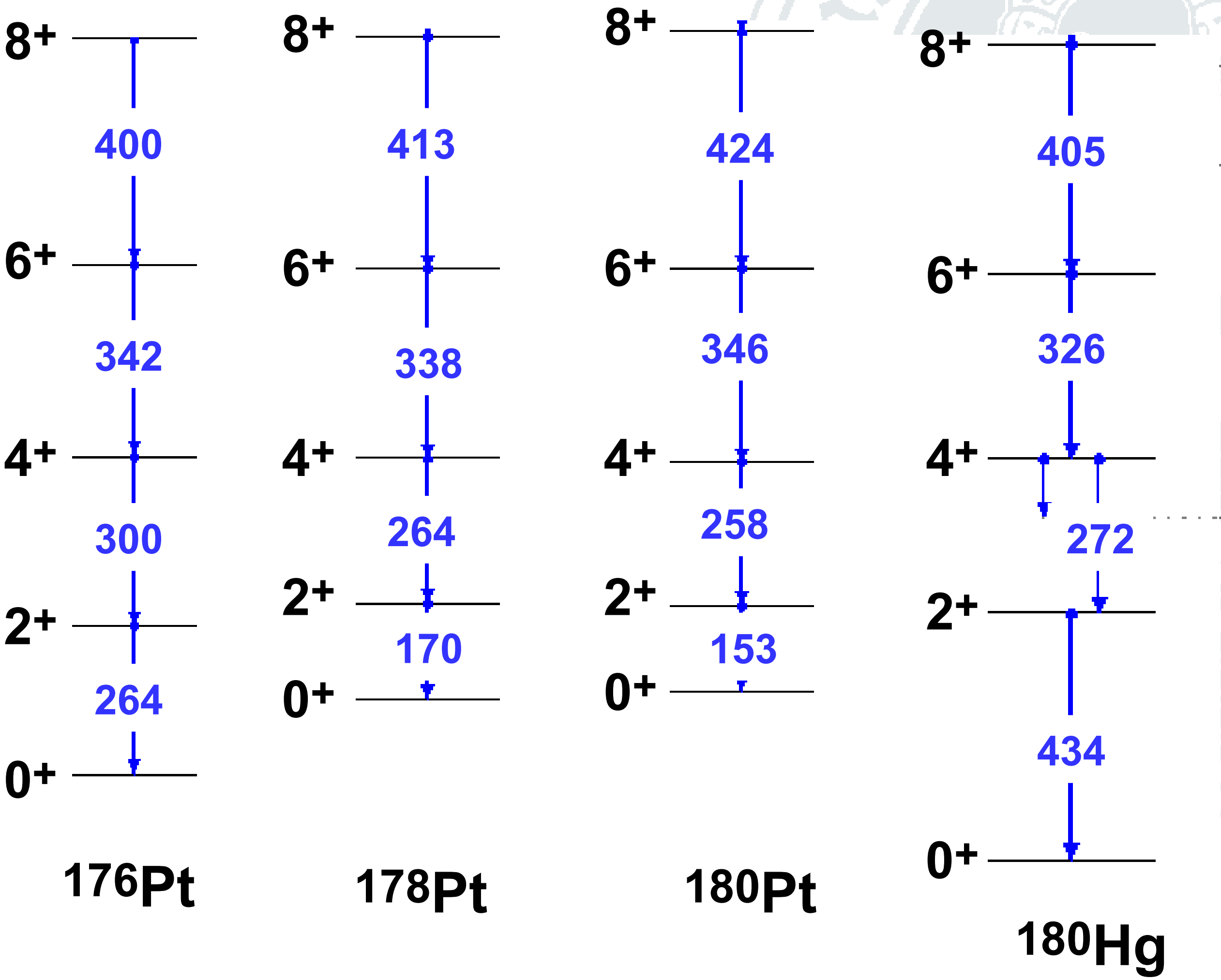


Vibrator
X(5)
Rotor

^{180,182}Hg: Prolate intruder, weakly oblate deformed gs conf.

Prolate structure evolves into gs configuration in ^{178,180}Pt similar collectivity than intruder in ^{180,182}Hg

Structural evolution $^{176-180}Pt$, ^{180}Hg: level schemes



→ $^{178,180}Pt$: prolate

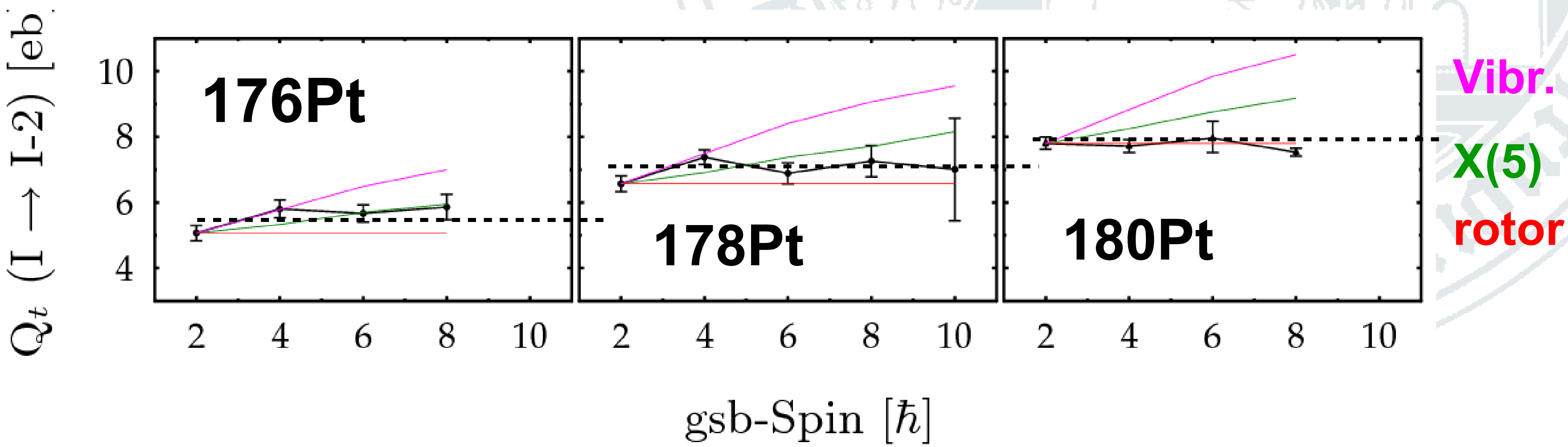
→ ^{176}Pt: 0_1^+, 2_1^+ weakly deformed? prolate intruder band above 4_1^+, similar to ^{180}Hg?

Structural evolution $^{176-180}$Pt: yrast Q_t values

→ ^{178,180}Pt: prolate gs config.,
^{178}Pt: Q_t ~ 7 eb, ^{180}Pt: Q_t ~ 8 eb

→ ^{176}Pt: prolate config. of states above 4_1^+ from level scheme,
0_1^+, 2_1^+ weakly deformed?

→ not supported by Q_t ~ 5 eb from Dracoulis et al., JP G 12, L97 (86),
γ „singles“ experiment: unknown feeding?



Structure of ^{180}Pt

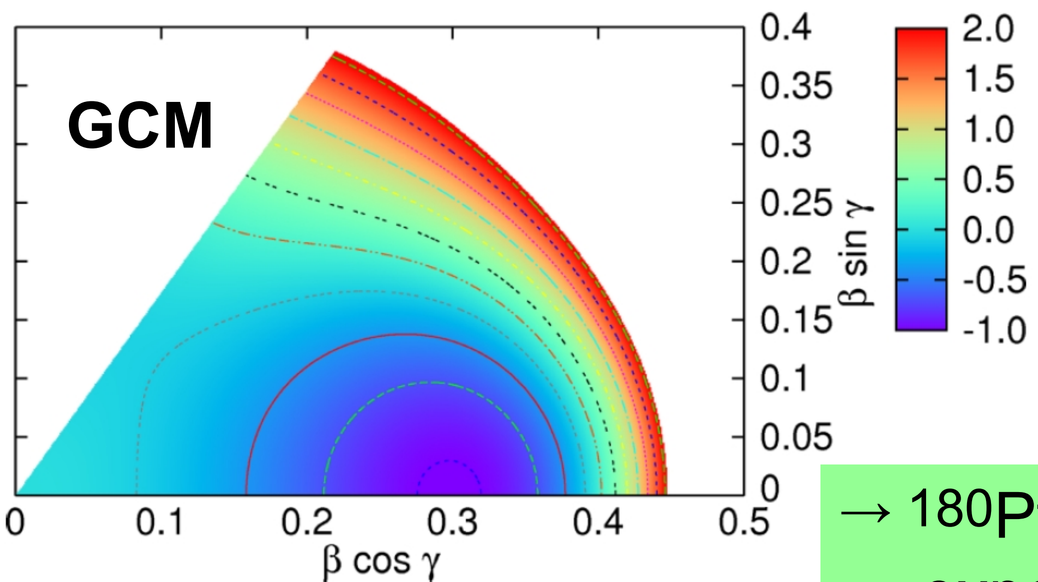
Calculations ^{180}Pt (C. Müller-Gatermann et al., PRC 024336 (18))

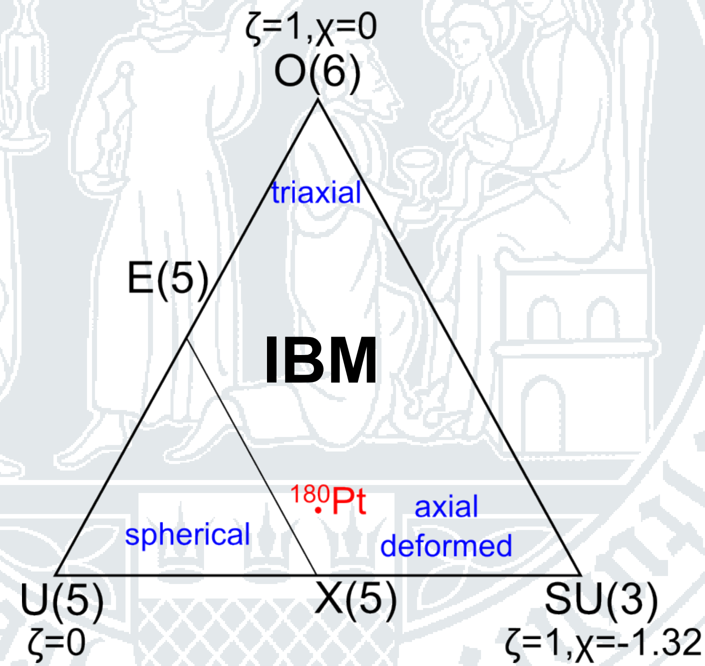
1. IBM, extended Q formalism

Warner, Casten, PRC 28, 1798 (83)

2. General collective model GCM

Gneuss, Greiner, NPA 171, 449 (71)

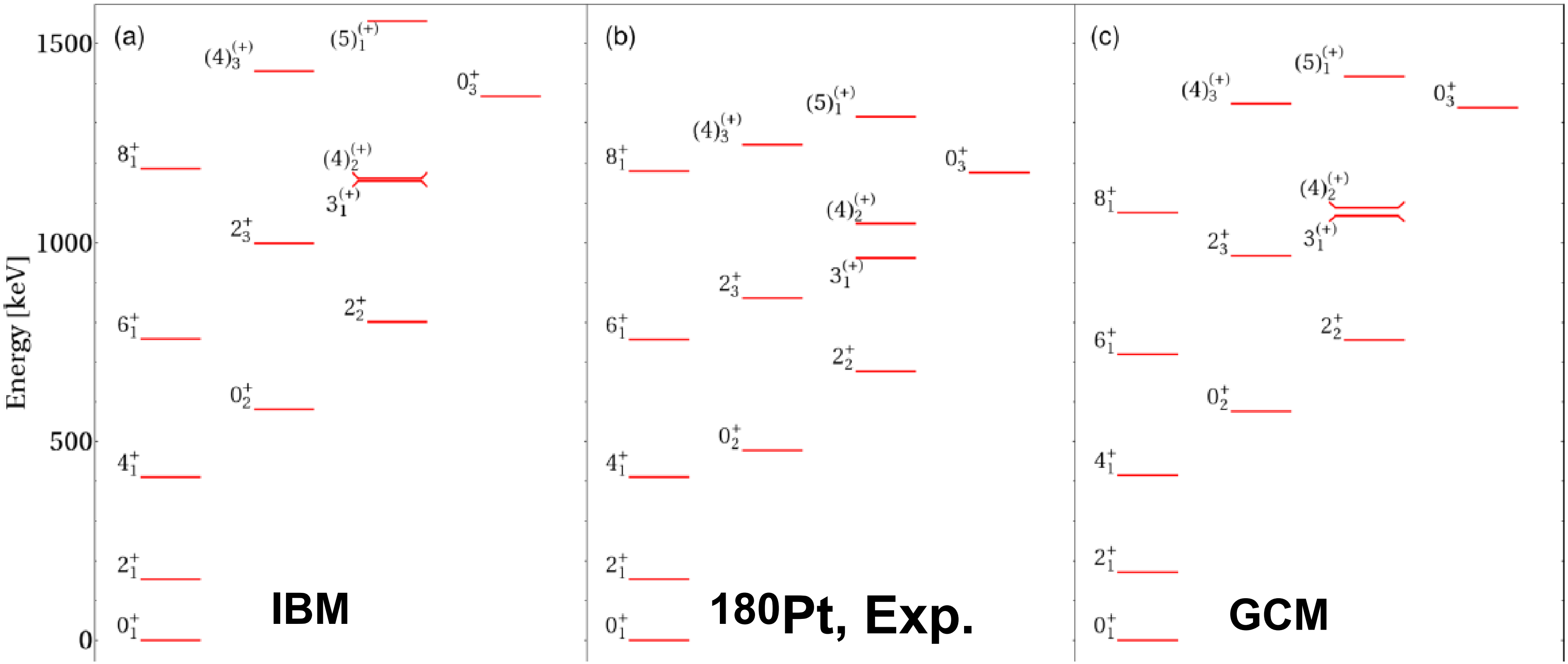




→ ^{180}Pt towards axial deformation

→ expect similar structure of ^{178}Pt

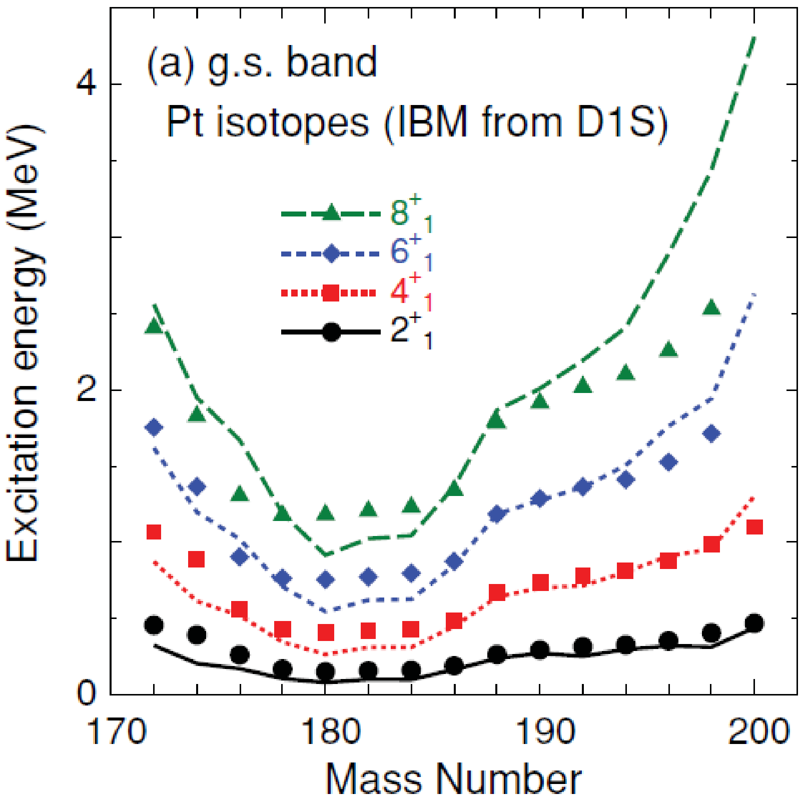
Level scheme ^{180}Pt: comparison with IBM, GCM

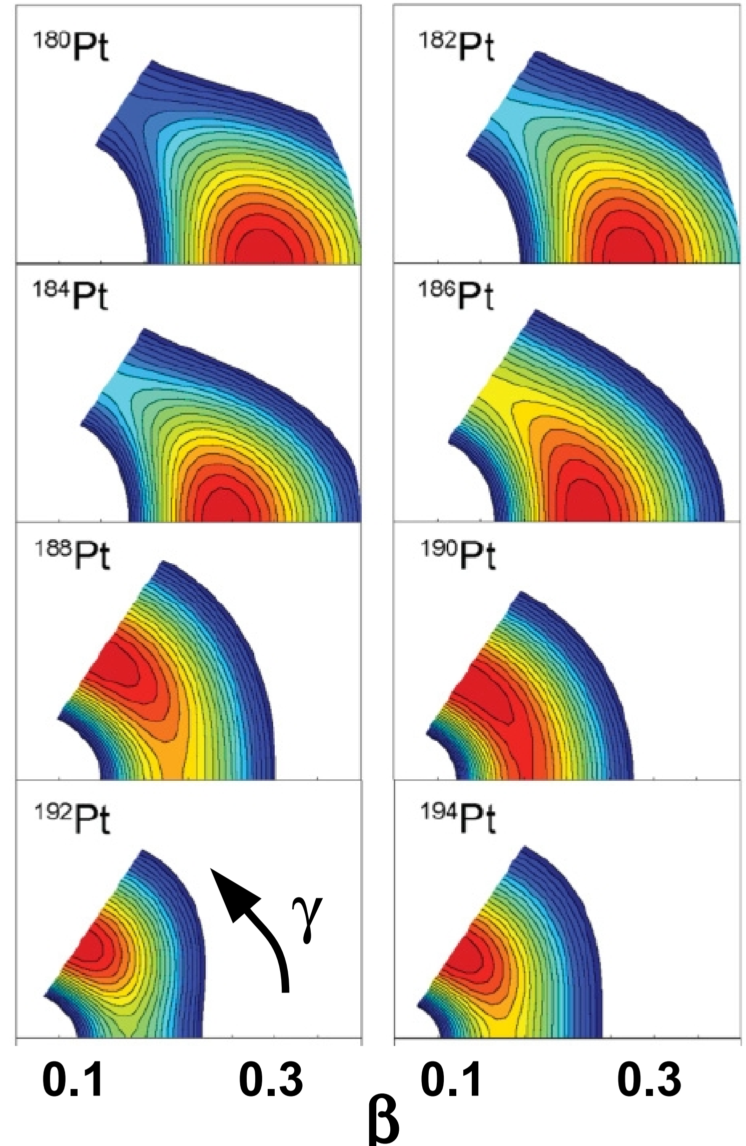


→ ^{180}Pt rotor like

C. Müller-Gatermann et al., PRC 97, 024336 (18)

Structural investigation $^{180-194}Pt$ (IBM, HFB)

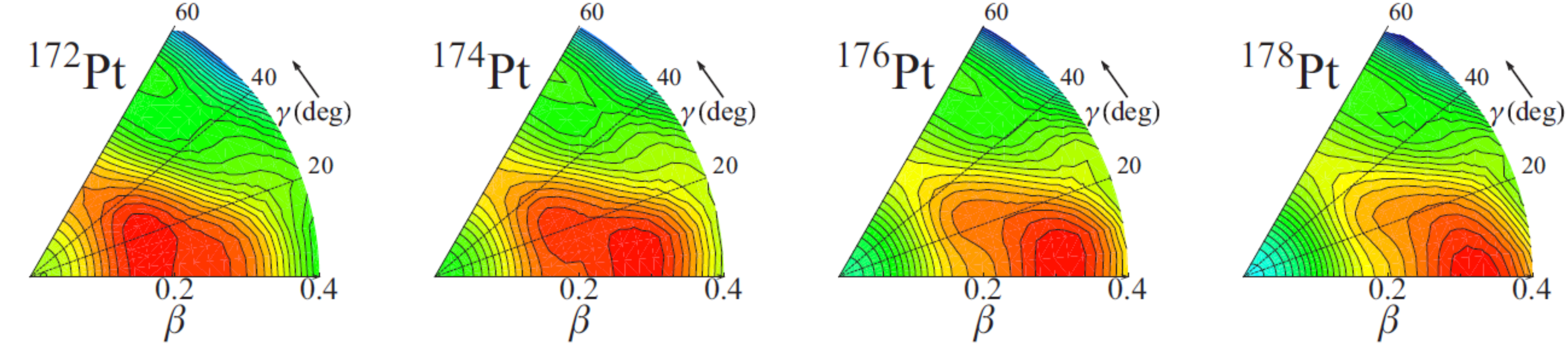




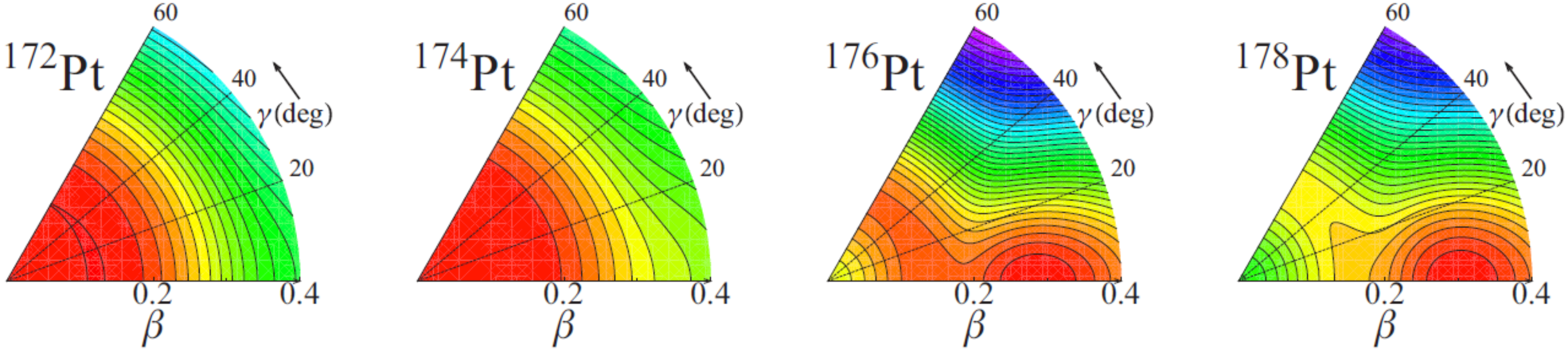
K. Nomura, et al., PRC 83, 014309 (11)
transition rotor-like to γ-soft
→ from IBM PES, similar: HFB PES

Structural evolution $^{172-178}Pt$

IBM with configuration mixing: smooth transition to weakly prolate deformation



Hartree-Fock Bogoliubov: sharp transition prolate (^{178}Pt) – spherical (^{174}Pt)



Exp.:

$^{178,180}Pt$ prolate (^{180}Pt: C. M.-G., PRC 97, 024336 (18))

^{176}Pt: Dracoulis et al., JP G 12, L97 (86)

„level scheme changes from quasi-vibrational to well deformed at low spins, similar to shape coexistence in light Hg.

IBM-CM, HFB calc.:
Garcia-Ramos et al., PRC 89, 034313 (14)

Conclusion

→ Determination of yrast B(E2) values from level lifetimes in $^{178,180}Pt$ in RDDS $\gamma\gamma$ coincidence experiments

→ ^{178}Pt: first plunger experiment at iThemba LABS, South Africa

→ $^{178,180}Pt$: similar rotor structure, but slightly decreasing collectivity in ^{178}Pt

→ hints for a structural change in ^{176}Pt:
weakly deformed gs configuration, prolate intruder:
Similar to n-deficient Hg isotopes

→ Contradicting predictions (IBM-CM, HFB) for structural change $^{178}Pt \rightarrow {}^{172}Pt$: measure yrast B(E2) values in $^{174,176}Pt$!