Collectivity, shape coexistence and isomerism in lanthanides nuclei close to the proton drip line

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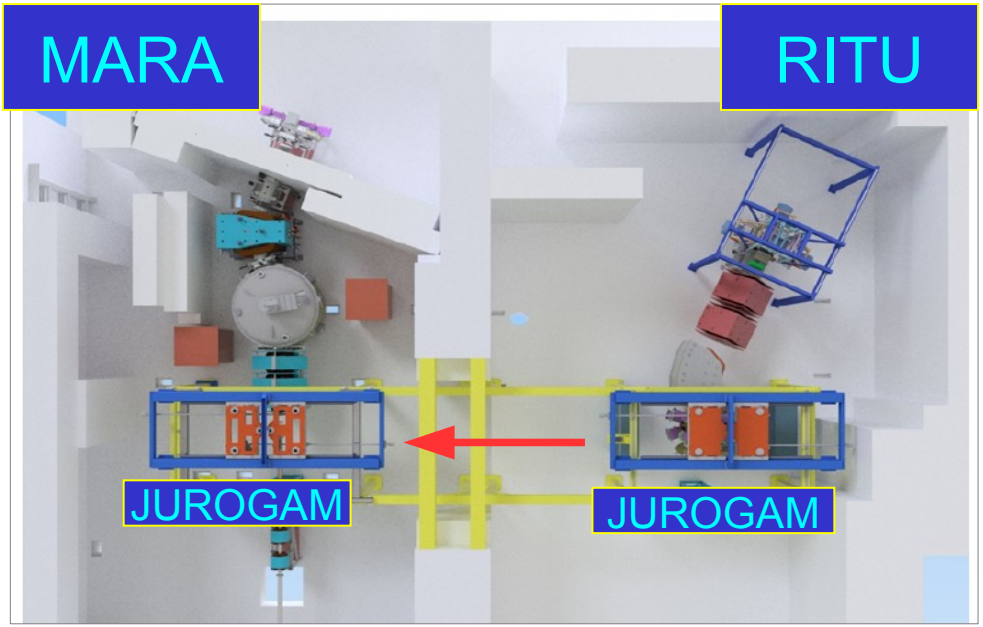
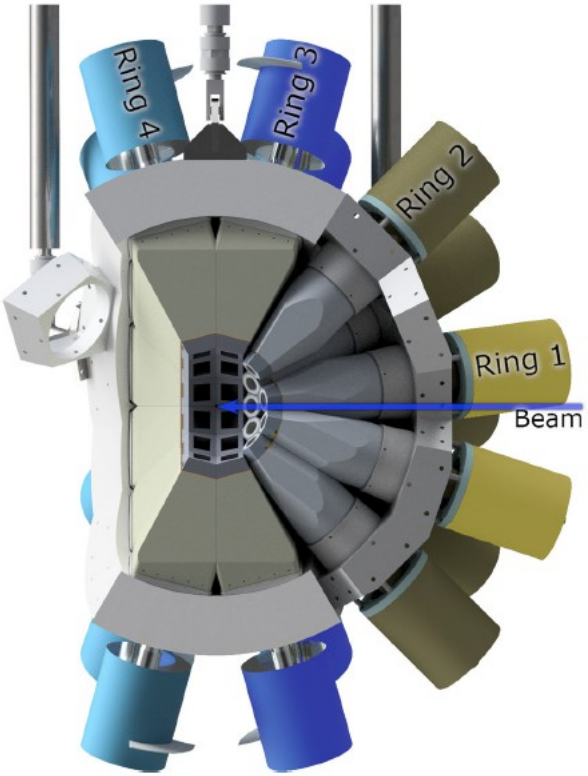
JUROGAM + MARA or RITU

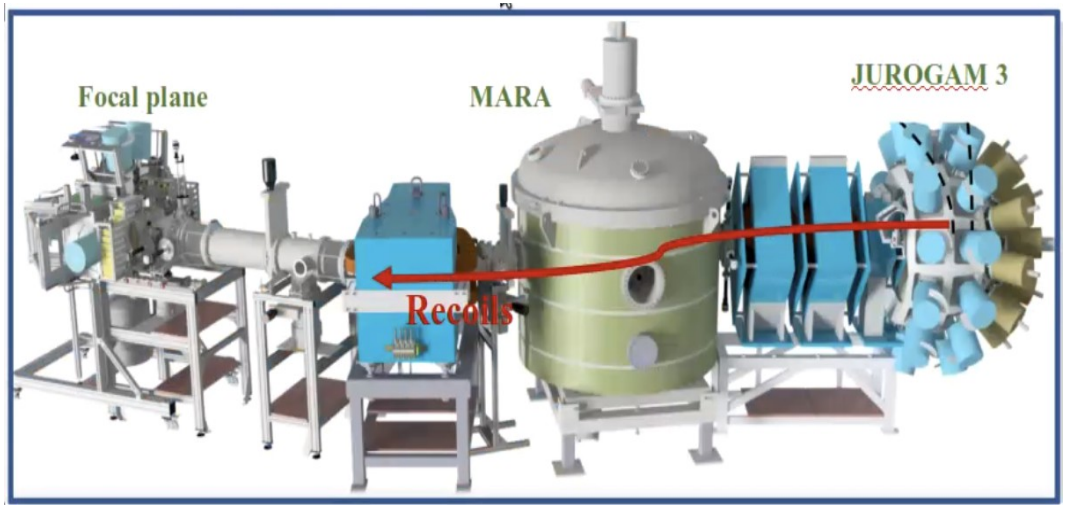
MARA

RITU

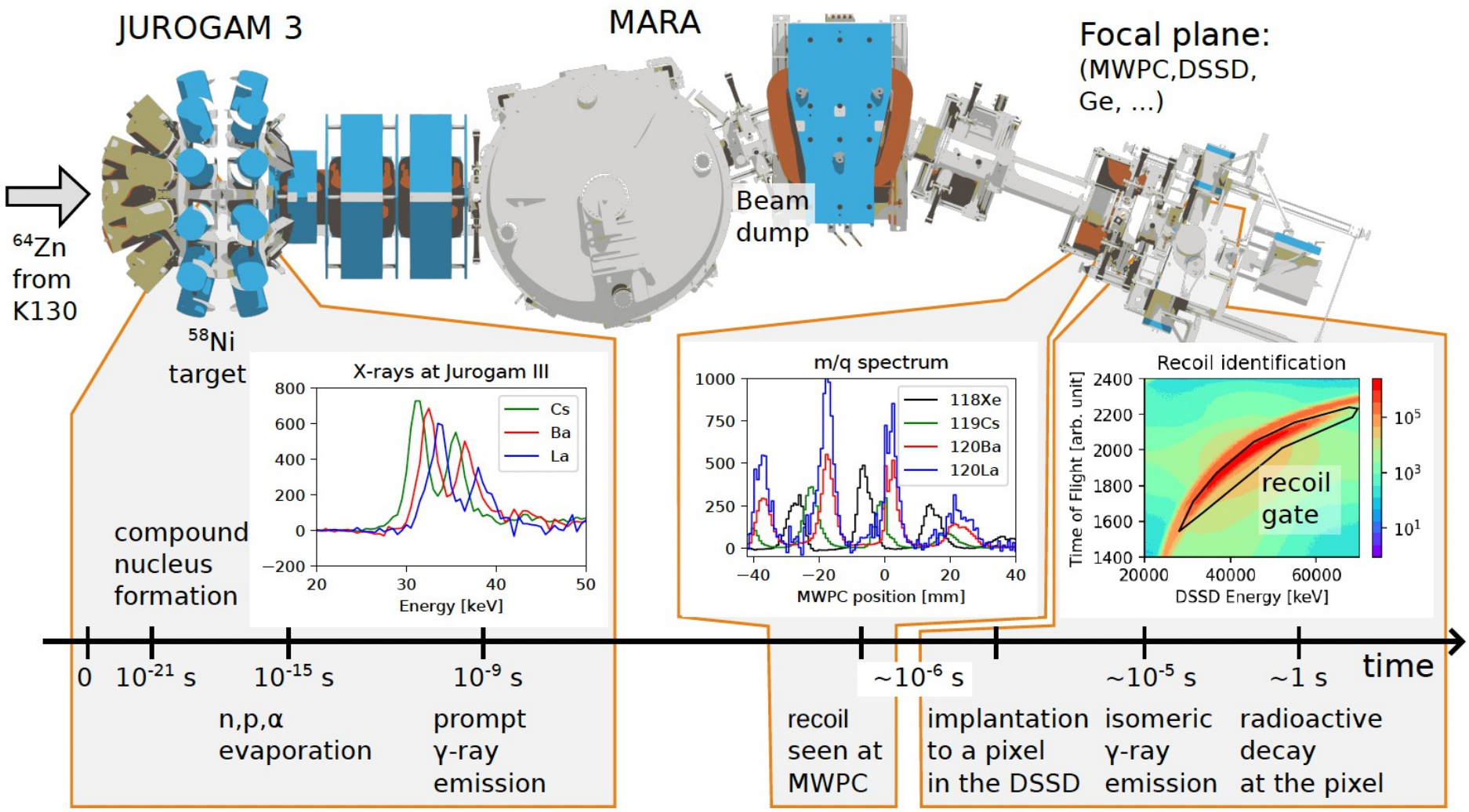


JUROGAM



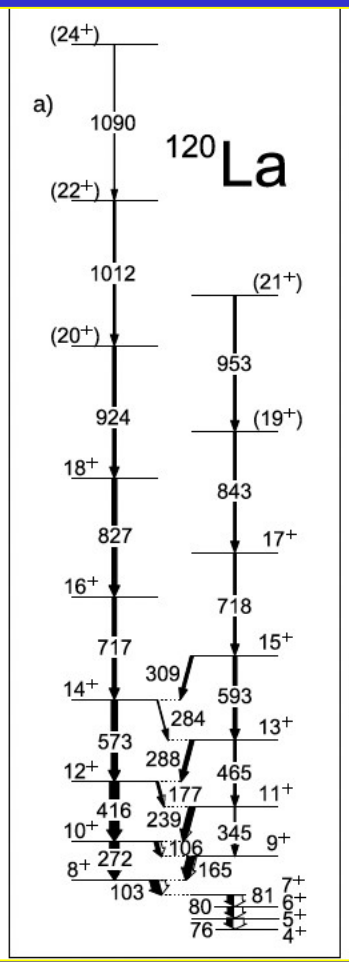


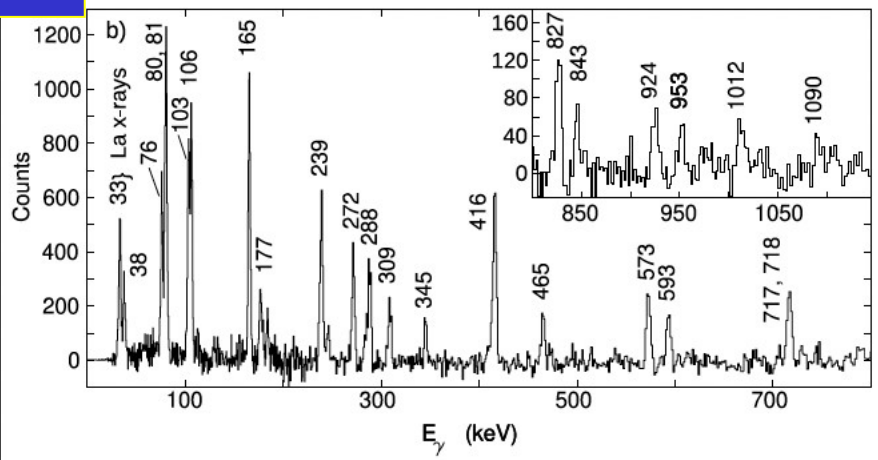
JUROGAM+MARA at Jyväskylä (^{64}Zn +^{58}Ni)

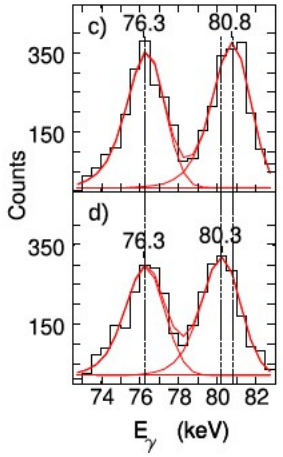


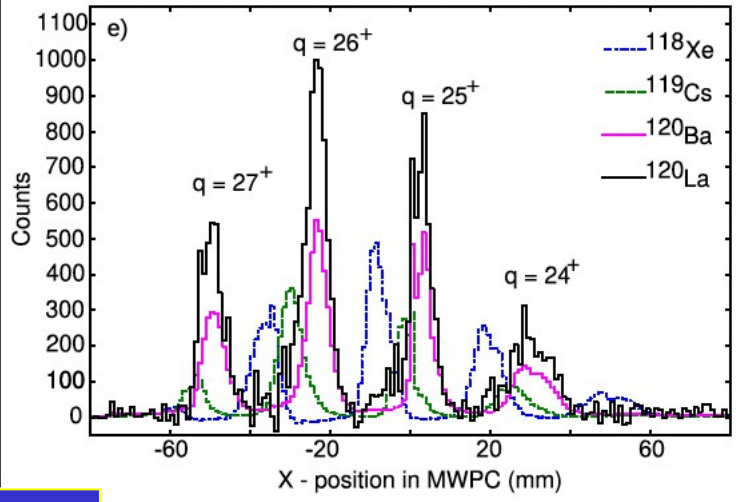
First observation of excited states in ^{120}La

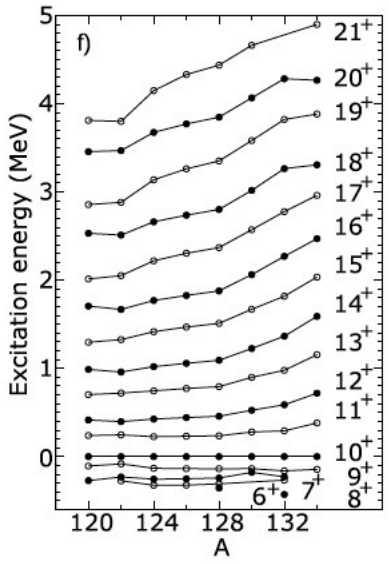
$\pi[550]1/2^{--} \otimes \nu[532]5/2^{--}$







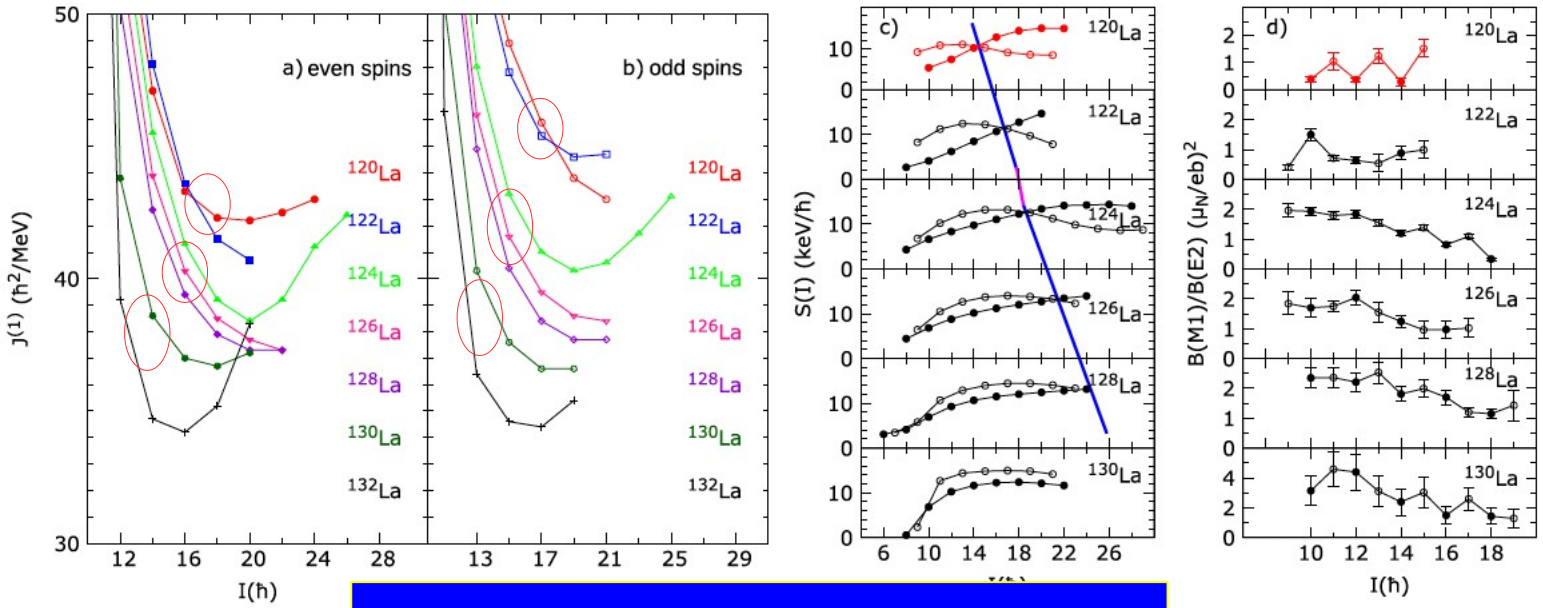




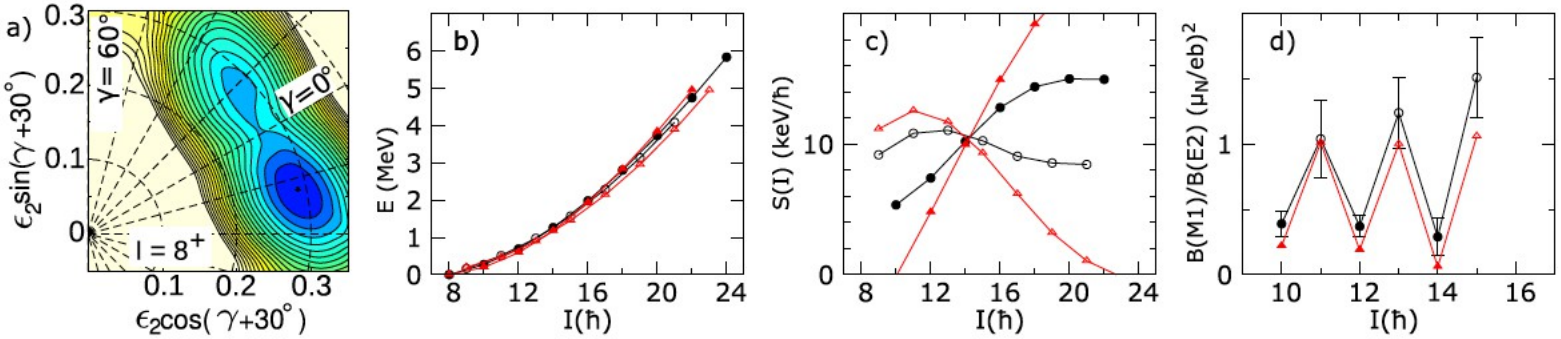
$\pi[422]3/2^{+} \otimes \nu[413]5/2^{+}$

P.Jodidar, C. Petrache, et al, PLB 855 (2024) 138806

First observation of excited states in ^{120}La



np interaction is important in reproducing the inversion point



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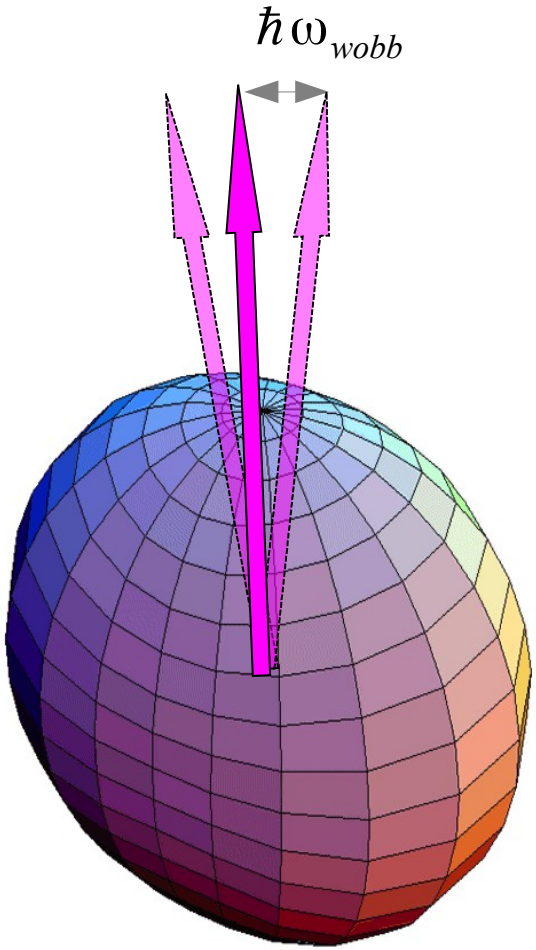
Wobbling mode



Approximation valide only when *I* >> *j*
and
fixed direction of *I*

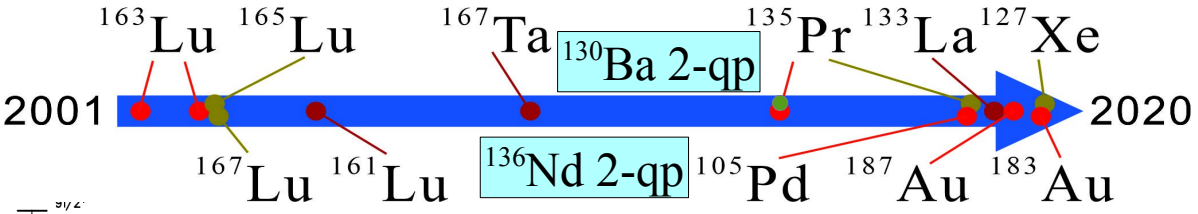
$$E(I, n_{\text{wobb}}) = \frac{I(I+1)}{2\mathcal{J}_x} + \hbar\omega_{\text{wobb}}\left(n_{\text{wobb}} + \frac{1}{2}\right)$$

$$\hbar\omega_{\text{wobb}} = \hbar\omega_{\text{rot}}\sqrt{\frac{(\mathcal{J}_x - \mathcal{J}_y)(\mathcal{J}_x - \mathcal{J}_z)}{\mathcal{J}_y\mathcal{J}_z}}$$

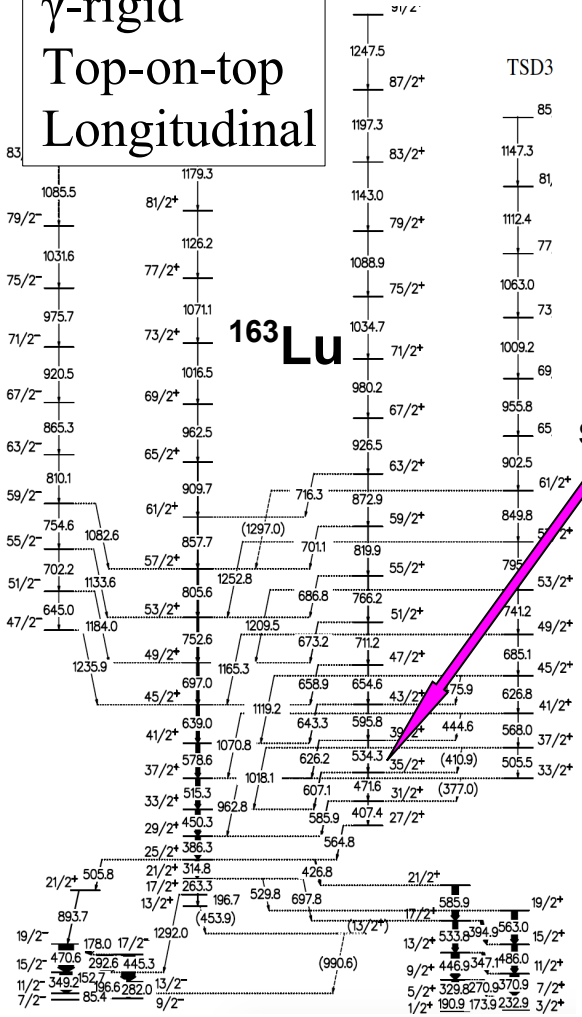
$$\hbar\omega_{\text{rot}} = \frac{I}{\mathcal{J}_x}$$

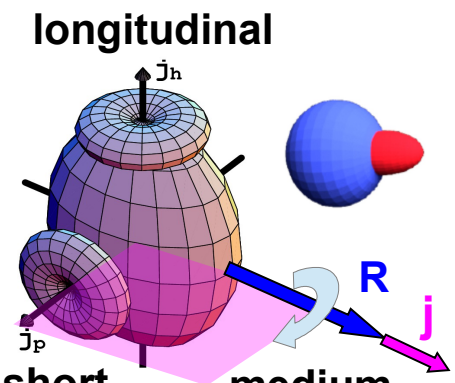
Reported wobbling bands

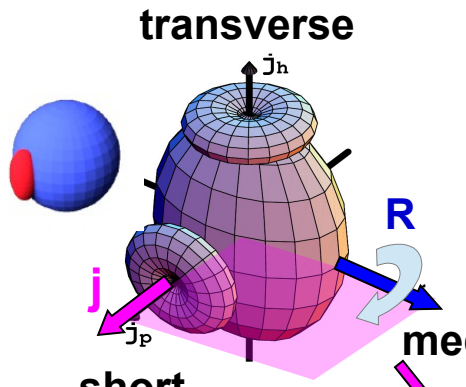
High spins
Large β_2
γ-rigid
Top-on-top
Longitudinal



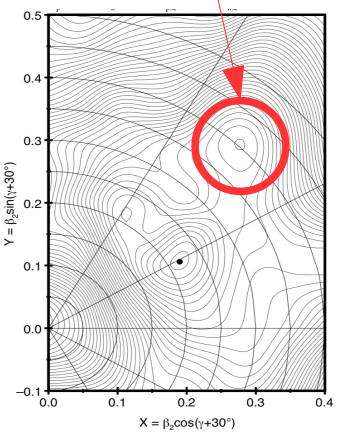
Low spins
Moderate β_2
γ-soft
Transverse or longitudinal



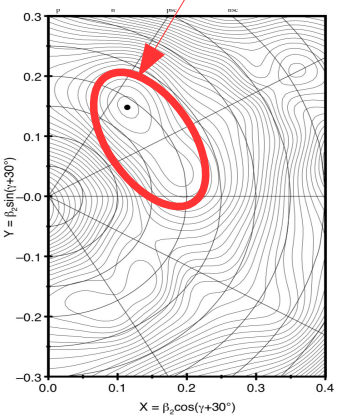


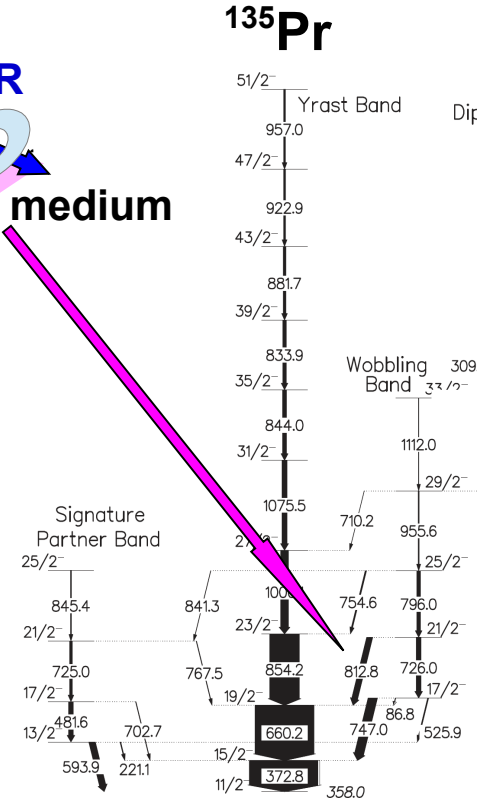


$\beta_2 \sim 0.4$



$\beta_2 \sim 0.2$

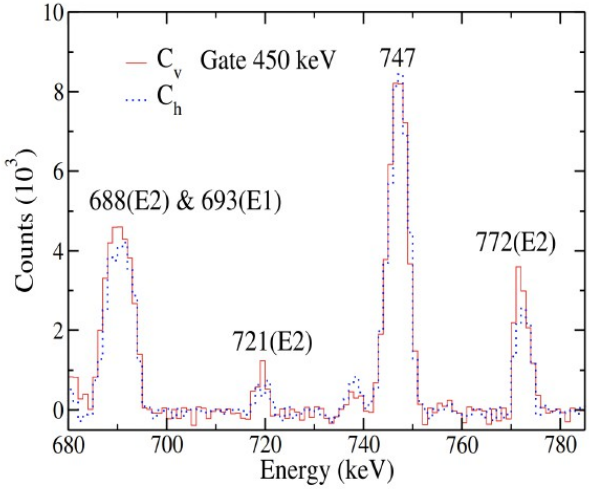


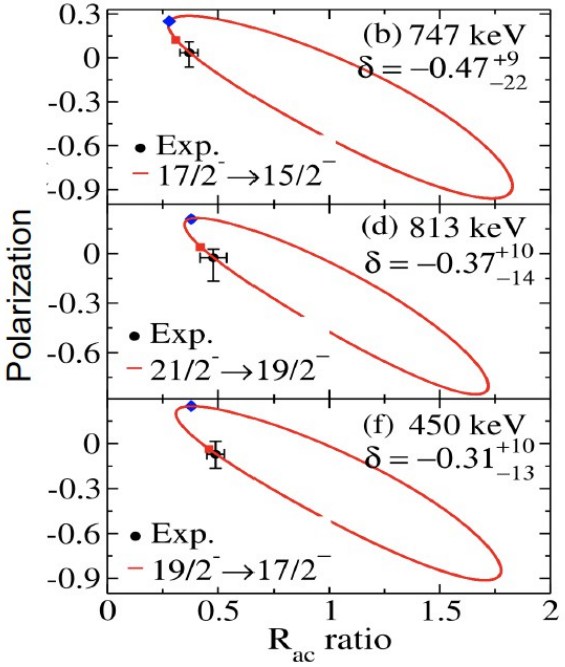


Frauendorf & Donau, PRC 89 (2014) 014322

Experimental evidence against wobbling interpretation

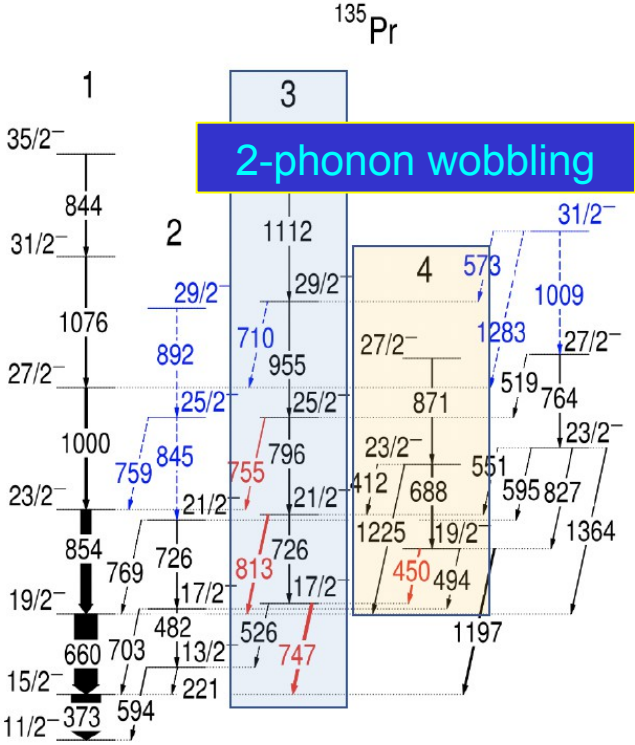
Experimental results





1-phonon wobbling

2-phonon wobbling



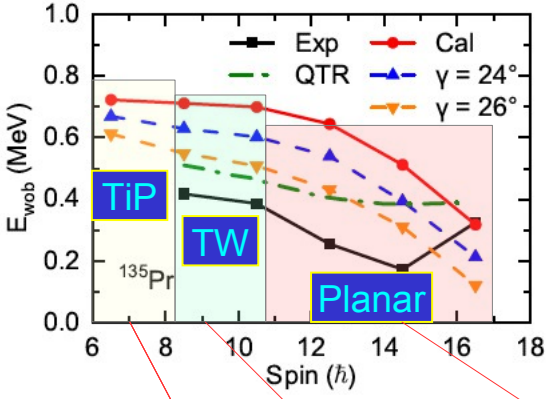
E_γ (keV)	P	R_{ac}	δ	$\frac{B(M1)_{out}}{B(E2)_{in}}$	$\frac{B(E2)_{out}}{B(E2)_{in}}$
747.3	0.04^{+8}_{-13}	0.37(4)	-0.47^{+9}_{-22}		
813.2	-0.03^{+5}_{-12}	0.48(6)	-0.37^{+10}_{-14}	0.4(3)	0.12(8)
755.1		0.50(6)			
450.2	-0.07^{+9}_{-10}	0.49(4)	-0.31^{+10}_{-13}		

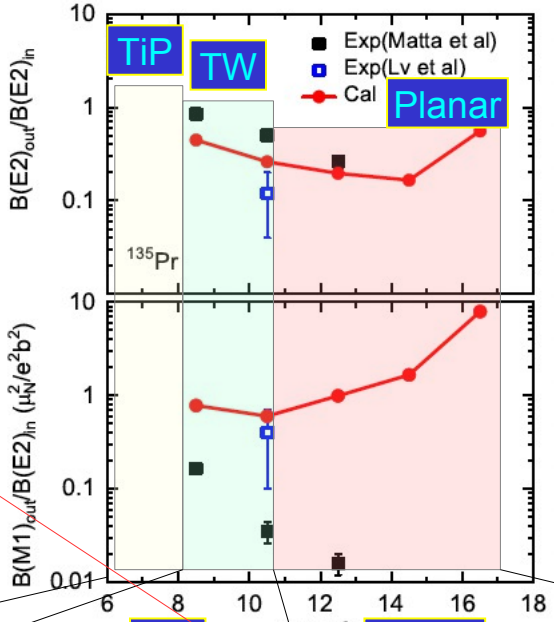
Experimental results do not support the wobbling nature of the bands!

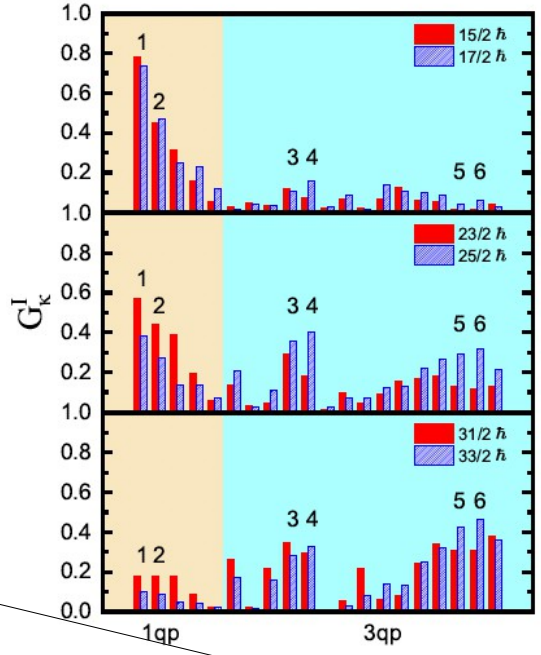
J. T. Matta, U. Garg, W. Li, et al., Phys. Rev. Lett. 114, 082501 (2015).
Sensharma, U. Garg, S. Zhu et al., Phys. Lett. B 792, 170 (2019).

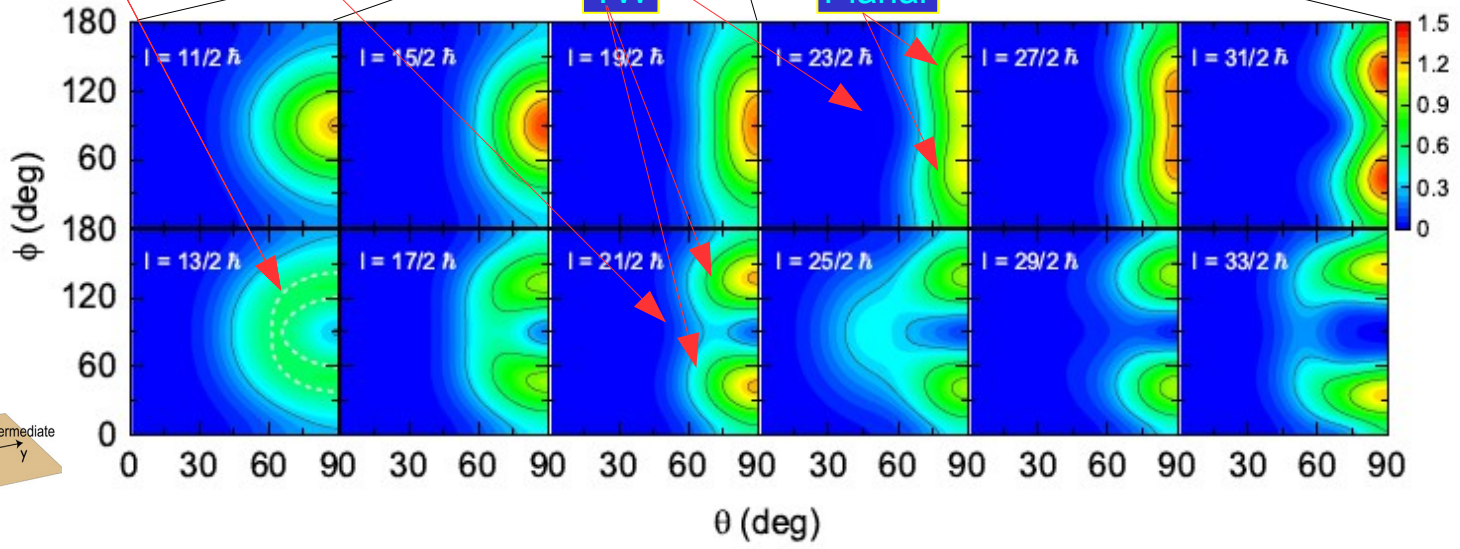
B.F. Lv, C. M. Petrache, et al., PLB 824 (2022)136840

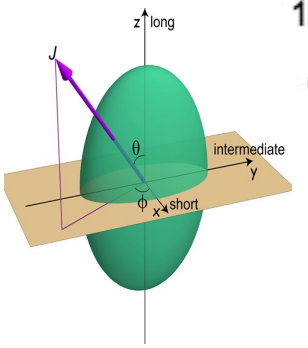
ReCD for ^{135}Pr: TiP → TW → Planar





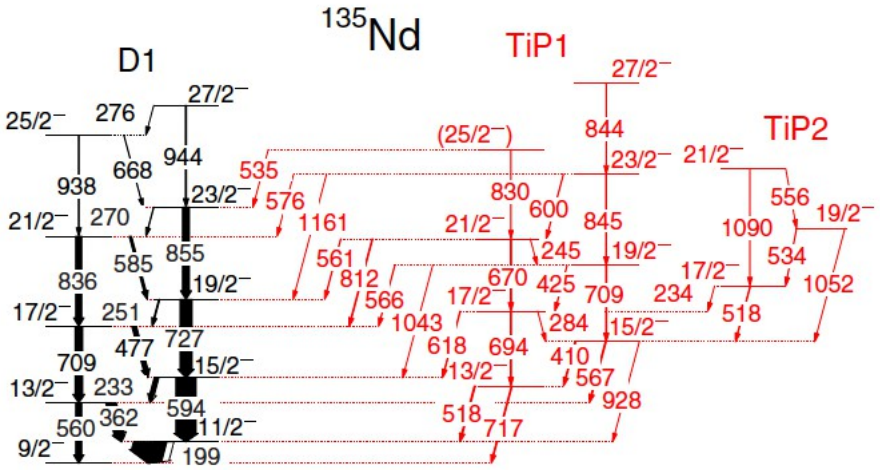


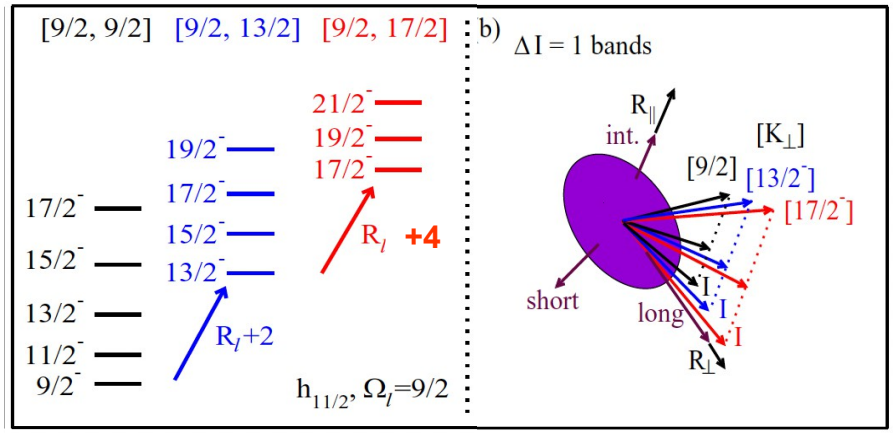


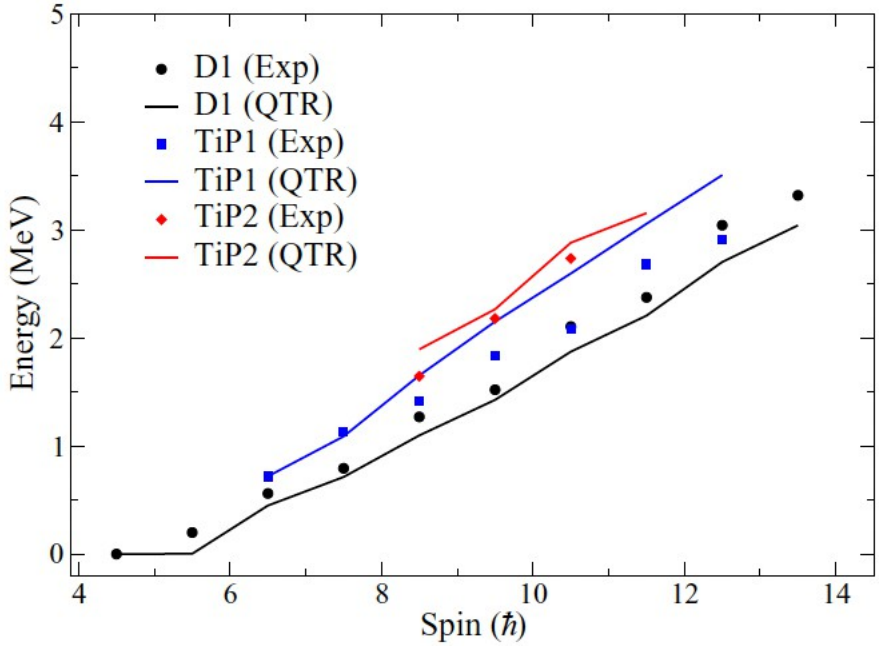


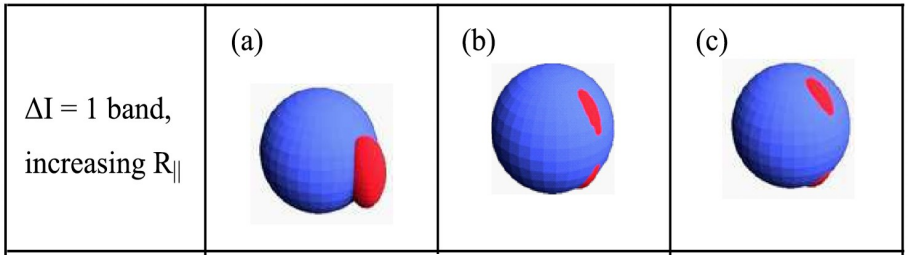
Courtesy of T. Qu, Y. K. Wang, P.W. Zhao

Tilted precession in ^{135}Nd







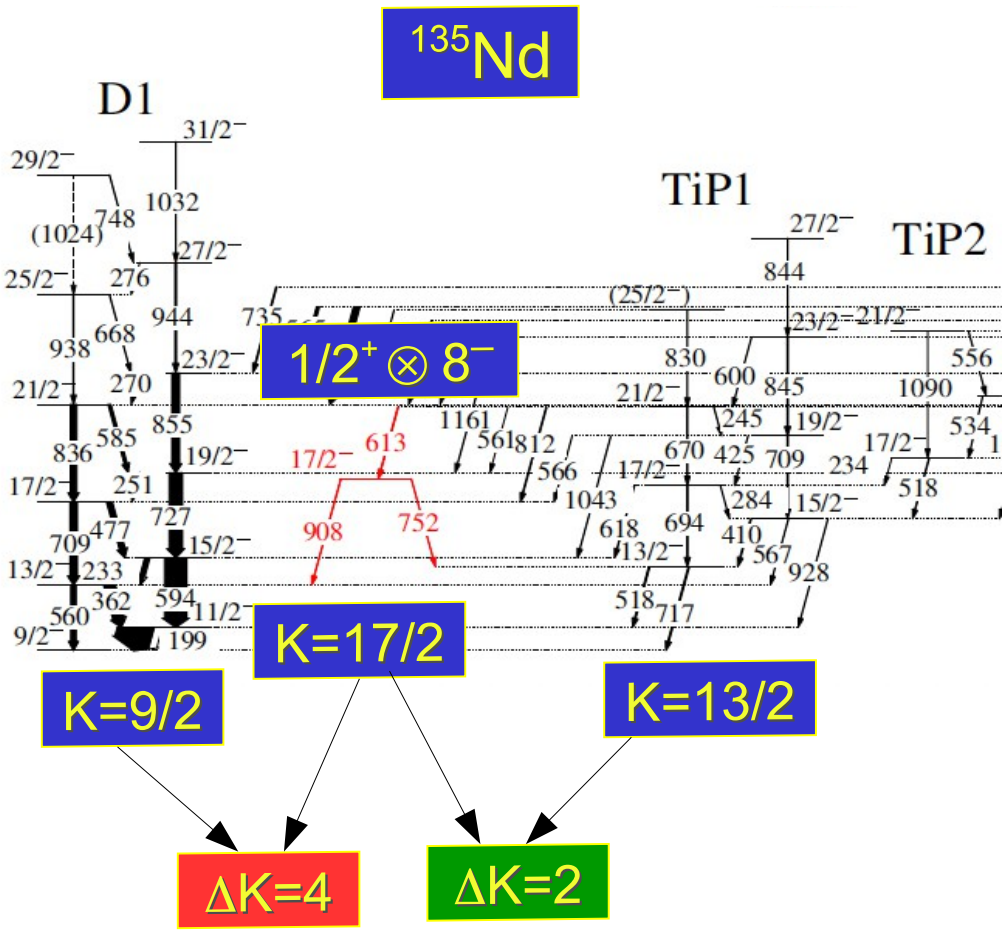


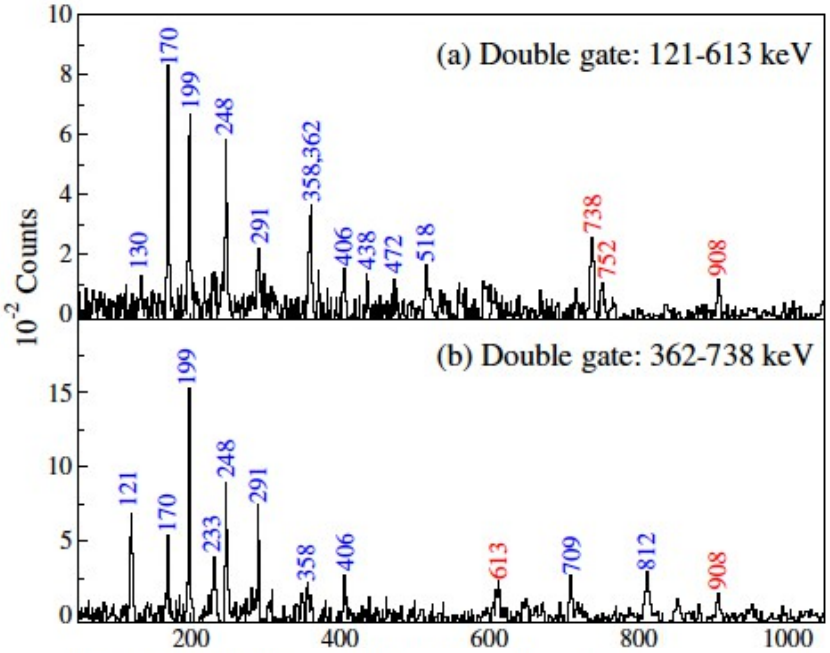
$$I^2 = I_1^2 + I_2^2 + I_3^2$$

$$E = A_1 I_1^2 + A_2 I_2^2 + A_3 I_3^2$$

B.F. Lv, C.M. Petrache, E. Lawrie, et al., PRC 103 (2021) 044308

Tilted precession in ^{135}Nd



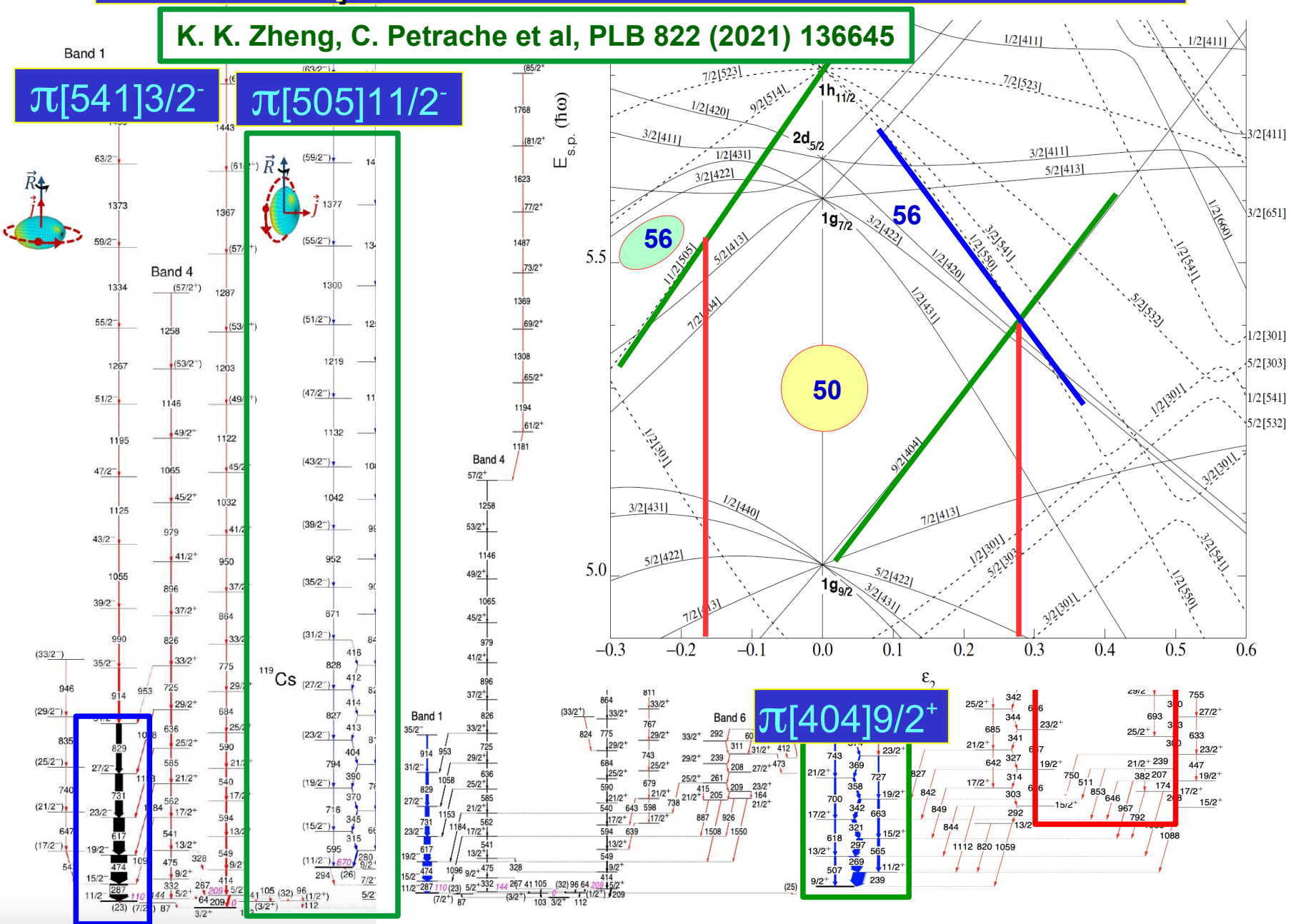


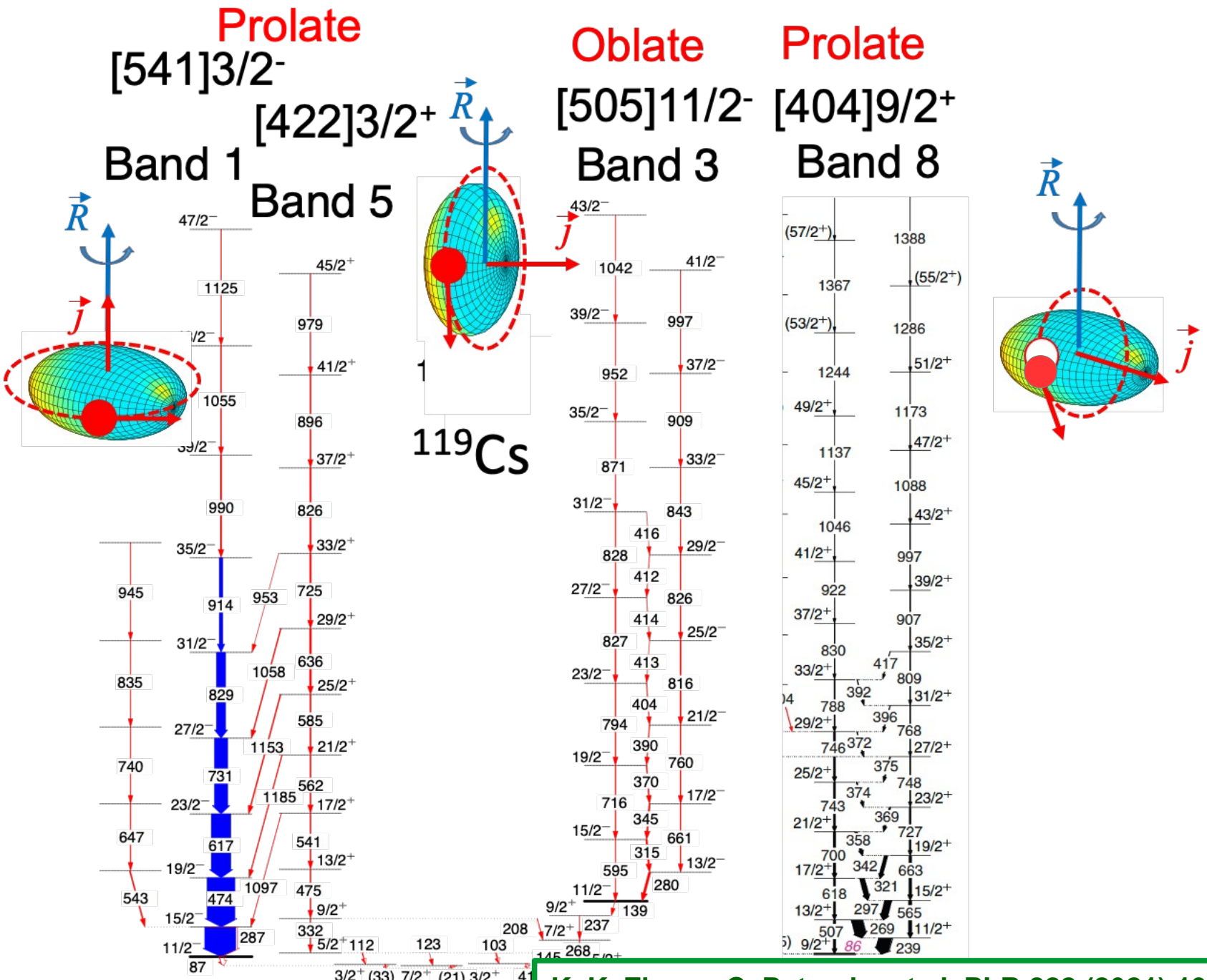
in Ref. [46]. The $13/2_1^-$ state of band D1 corresponds to a rotation around the intermediate axis, in which the rotational angular momentum is aligned along the intermediate axis, having $\approx 50\%$ contribution from the basis function with $K_l = 9/2$ and $\approx 30\%$ from the basis function with $K = 11/2$ (K_l is the projection of the total angular momentum on the long axis). The $13/2_2^-$ band head of band TiP1 corresponds to a rotation around a tilted axis, in which the rotational angular momentum R is aligned along the long axis, leading to $K = \Omega + R_l = 9/2 + 2 = 13/2$, and having $\approx 80\%$ contribution from the basis function with $K_l = 13/2$ (Ω is the projection of the single-particle angular momentum on the long axis).

B.F. Lv, C. M. Petrache, et al., PRC 111 (2025) 044308

Oblate-prolate coexistence in ^{119}Cs

K. K. Zheng, C. Petrache et al, PLB 822 (2021) 136645





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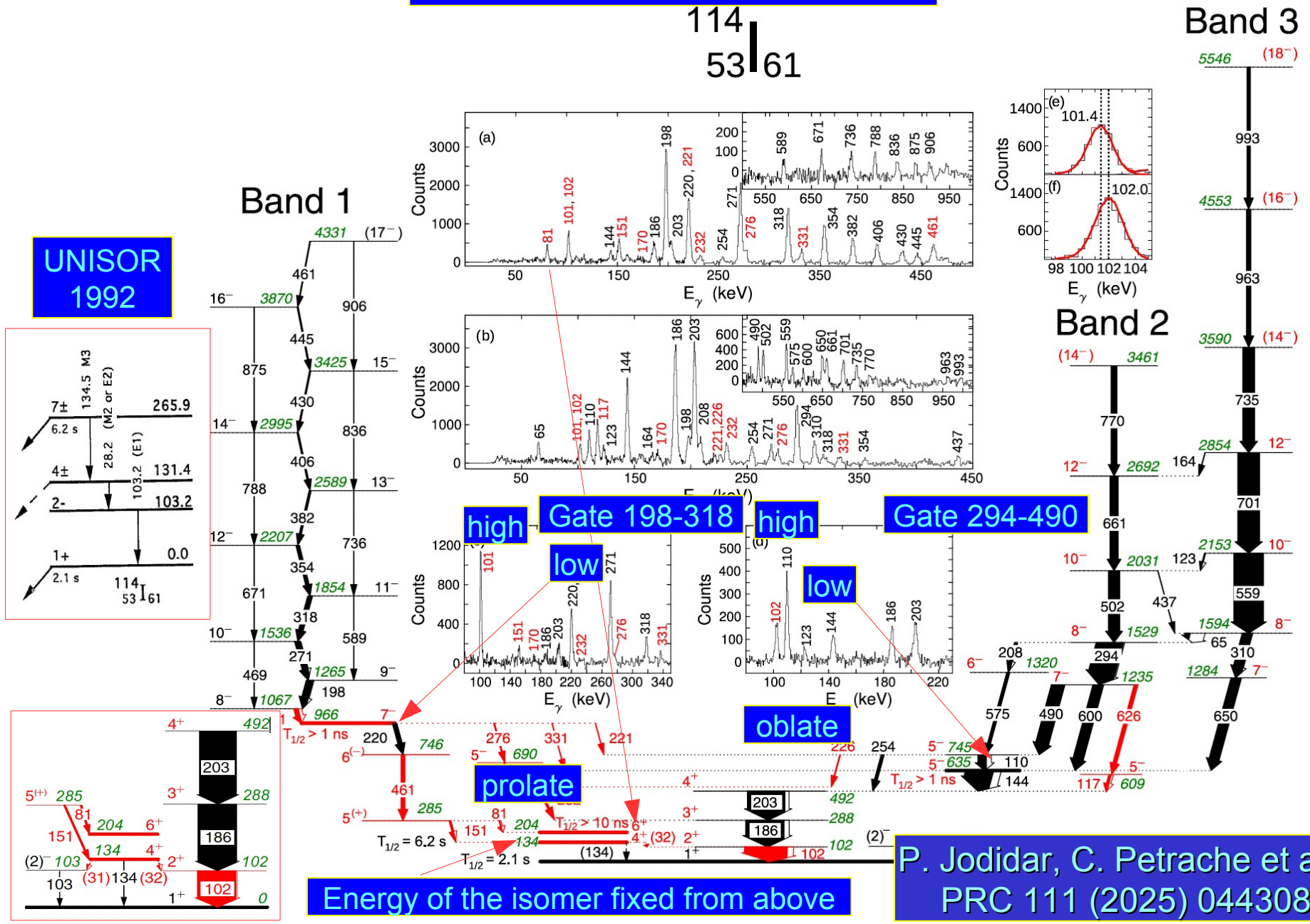
^{114}I conundrum



Collaboration

Experiment:

France: P.M. Jodidar
A. Astier, C.M. Petrache
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China: S. Guo, B.F. Lv, K.K. Zheng
South Africa: E. Lawrie
Canada: C. Andreoiu
Poland: J. Srebrny
Hungary: J. Timar
UK: R.D. Page

Theory:

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P.W. Zhao (Peking),
Z.H. Zhang (Peking),
Y.K. Wang (Pekin),
Q.B. Chen (Shanghai),
X.T. He (Nanjing),
Y. Liu (Huzhou),
F.Q. Chen (Lanzhou),
USA: S. Frauendorf
Sweden: I. Ragnarsson
Japan: K. Nomura
Italy: A. Gargano
Romania: A.A. Raduta
R. Budaca

Thank you !