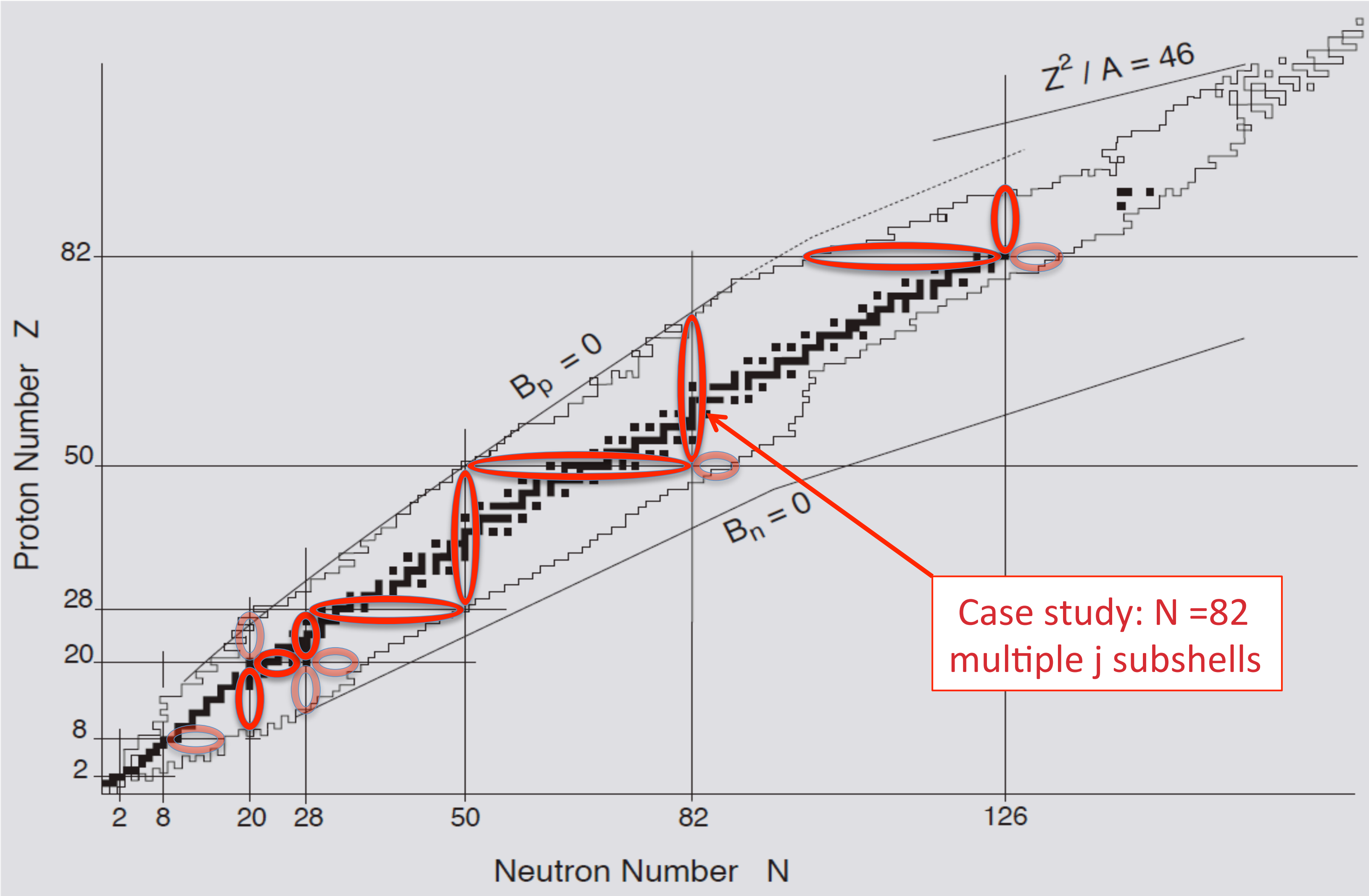
Singly closed shell nuclei:

Spherical nuclei and seniority-dominated coupling

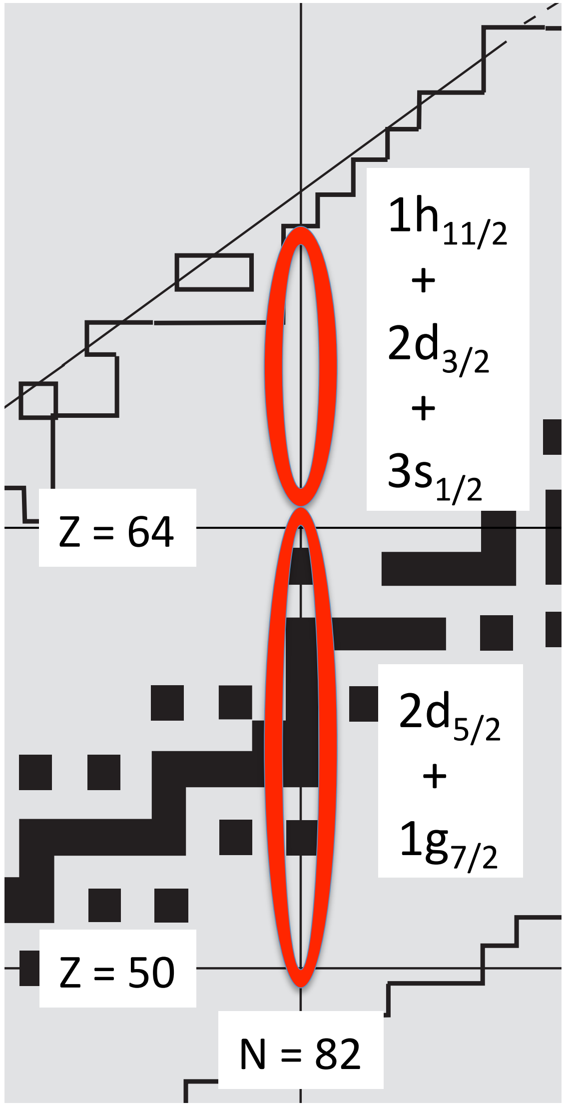
II. Multi-j shell seniority

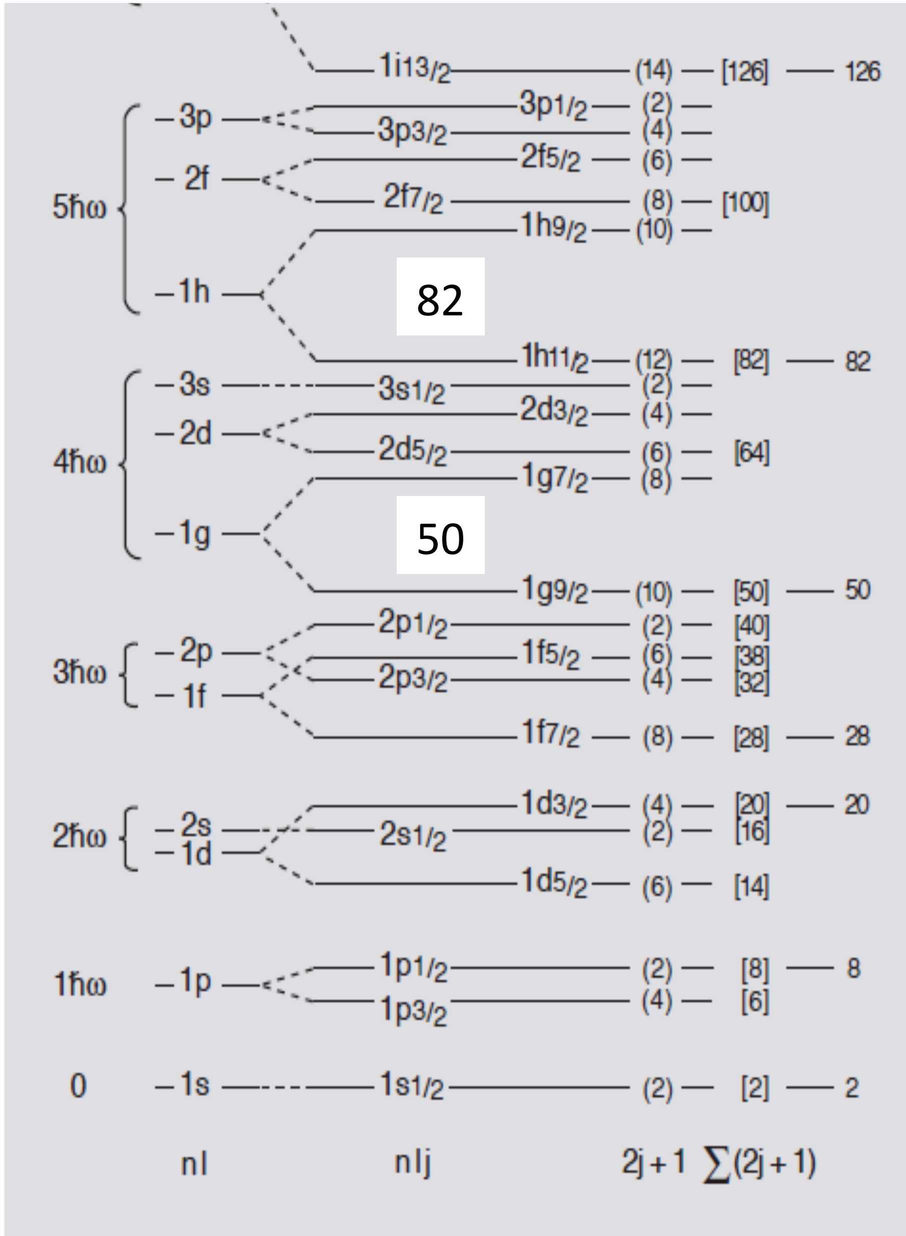
Singly closed shell nuclei



R&W Fig. 1.2

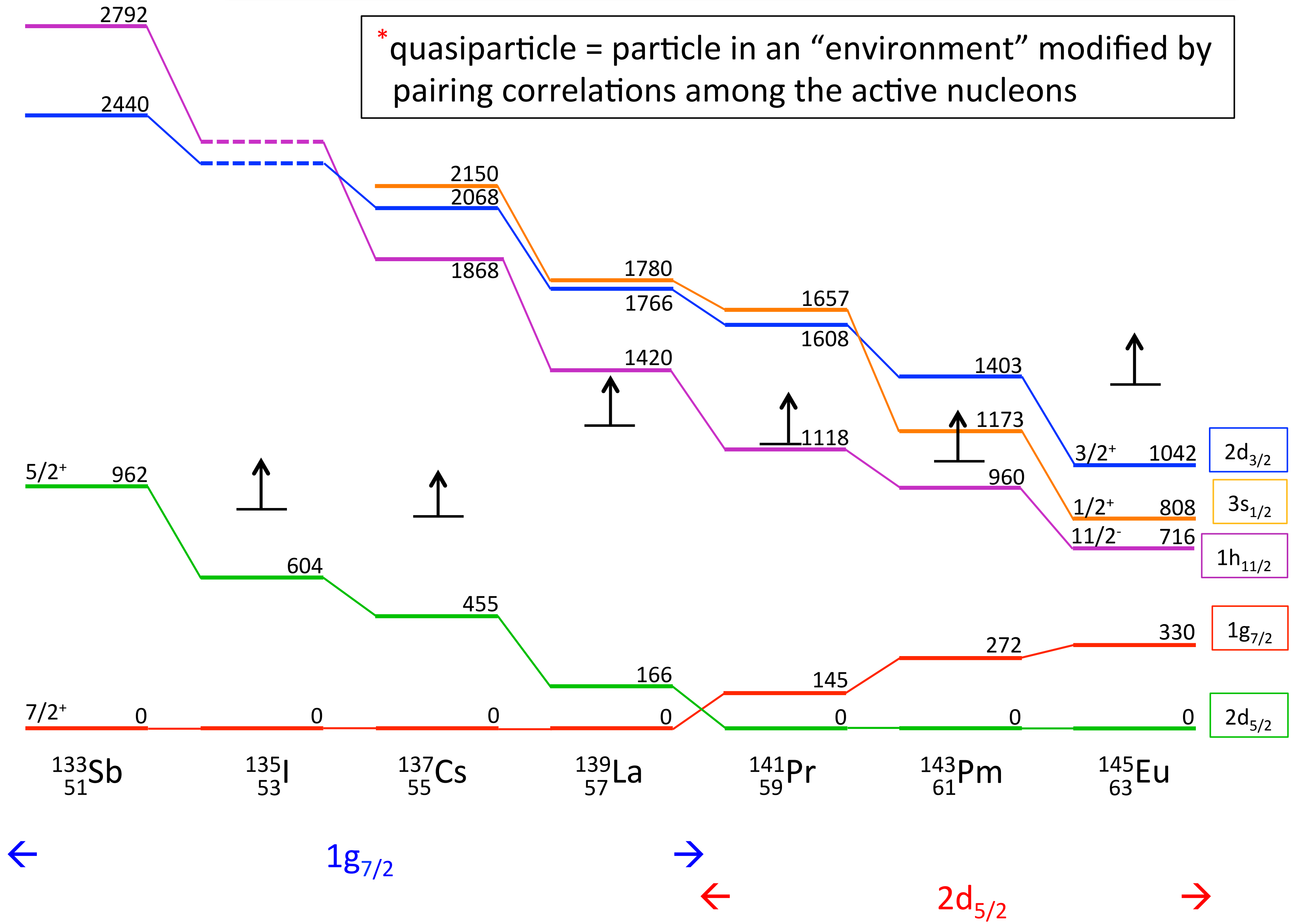
N = 82 singly closed shell nuclei: shell model





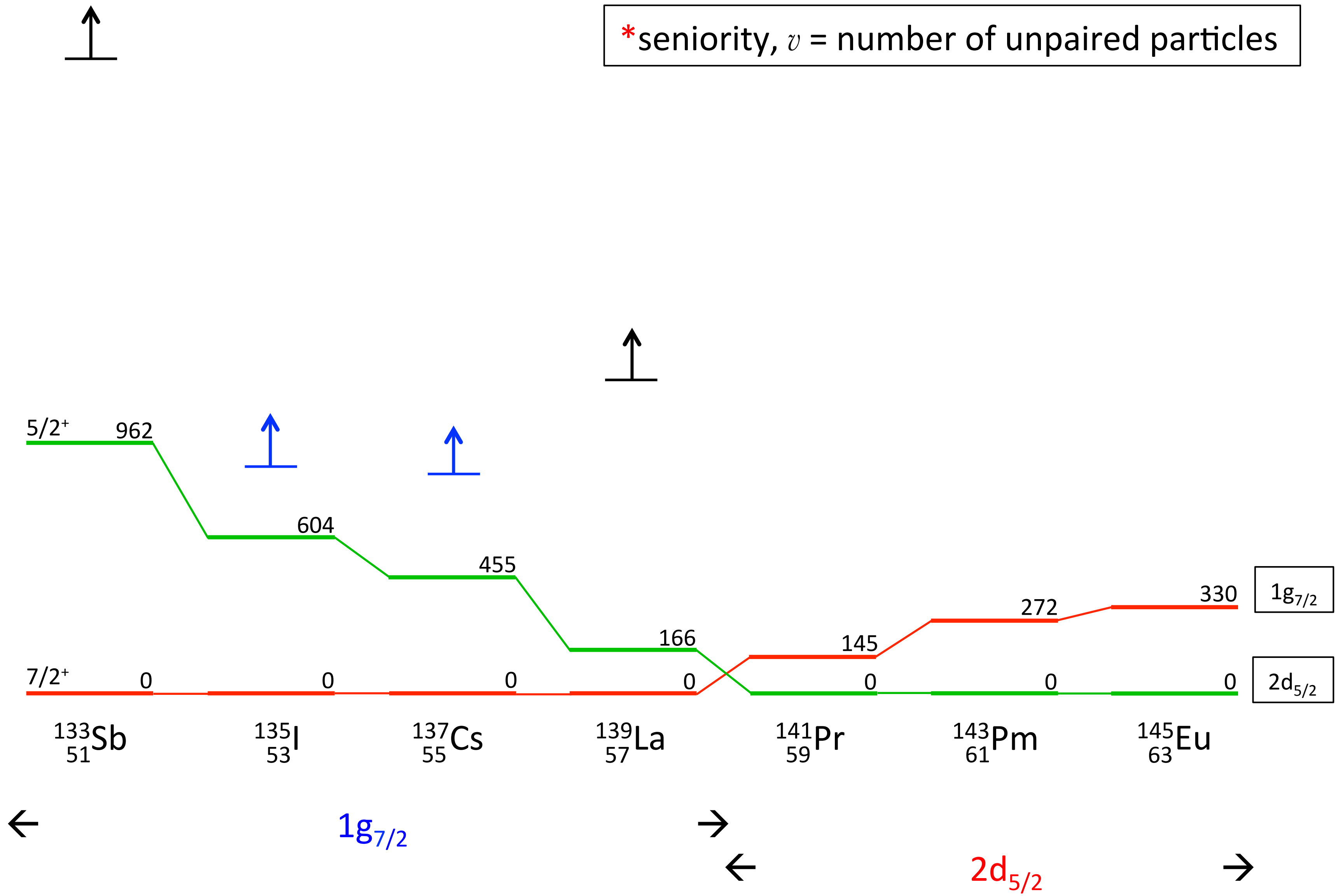
N = 82: proton single-quasiparticle* states, Z < 64

*quasiparticle = particle in an “environment” modified by pairing correlations among the active nucleons



N = 82: proton $1g_{7/2}$ and $2d_{5/2}$ seniority*, v = 1 structure

*seniority, v = number of unpaired particles



N = 82: proton $1g_{7/2}$ seniority*, v = 1, 3 structure

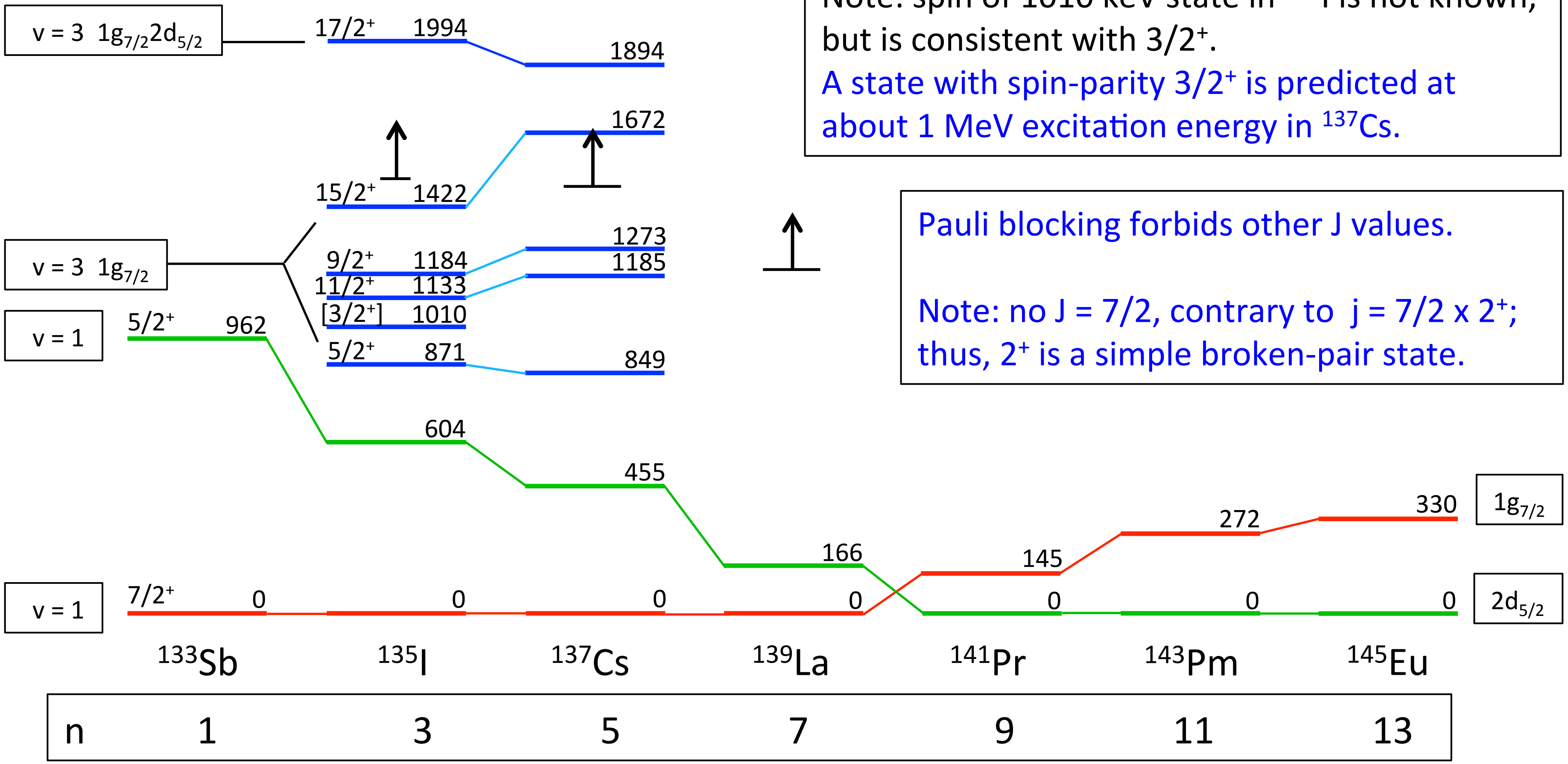
$1g_{7/2}^{3}$ v = 3, 2J* = 3, 5, 9, 11, 15;
$1g_{7/2}^{5} \cong 1g_{7/2}^{-3}$

*from m scheme; M = +7/2 + 5/2 + 3/2 = 15/2

Note: spin of 1010 keV state in ^{135}I is not known, but is consistent with $3/2^+$.
A state with spin-parity $3/2^+$ is predicted at about 1 MeV excitation energy in ^{137}Cs.

Pauli blocking forbids other J values.

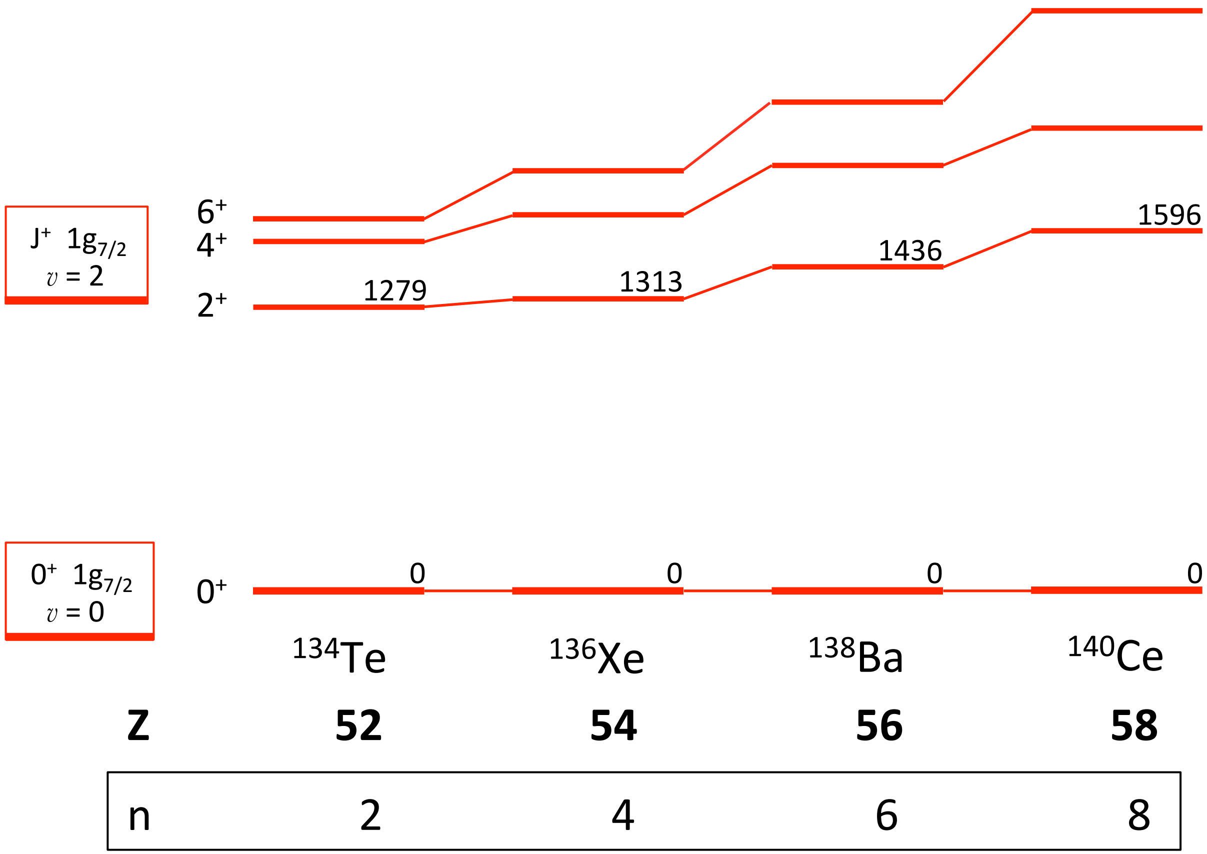
Note: no J = 7/2, contrary to j = 7/2 x 2^+; thus, 2^+ is a simple broken-pair state.



*seniority, v = number of unpaired particles

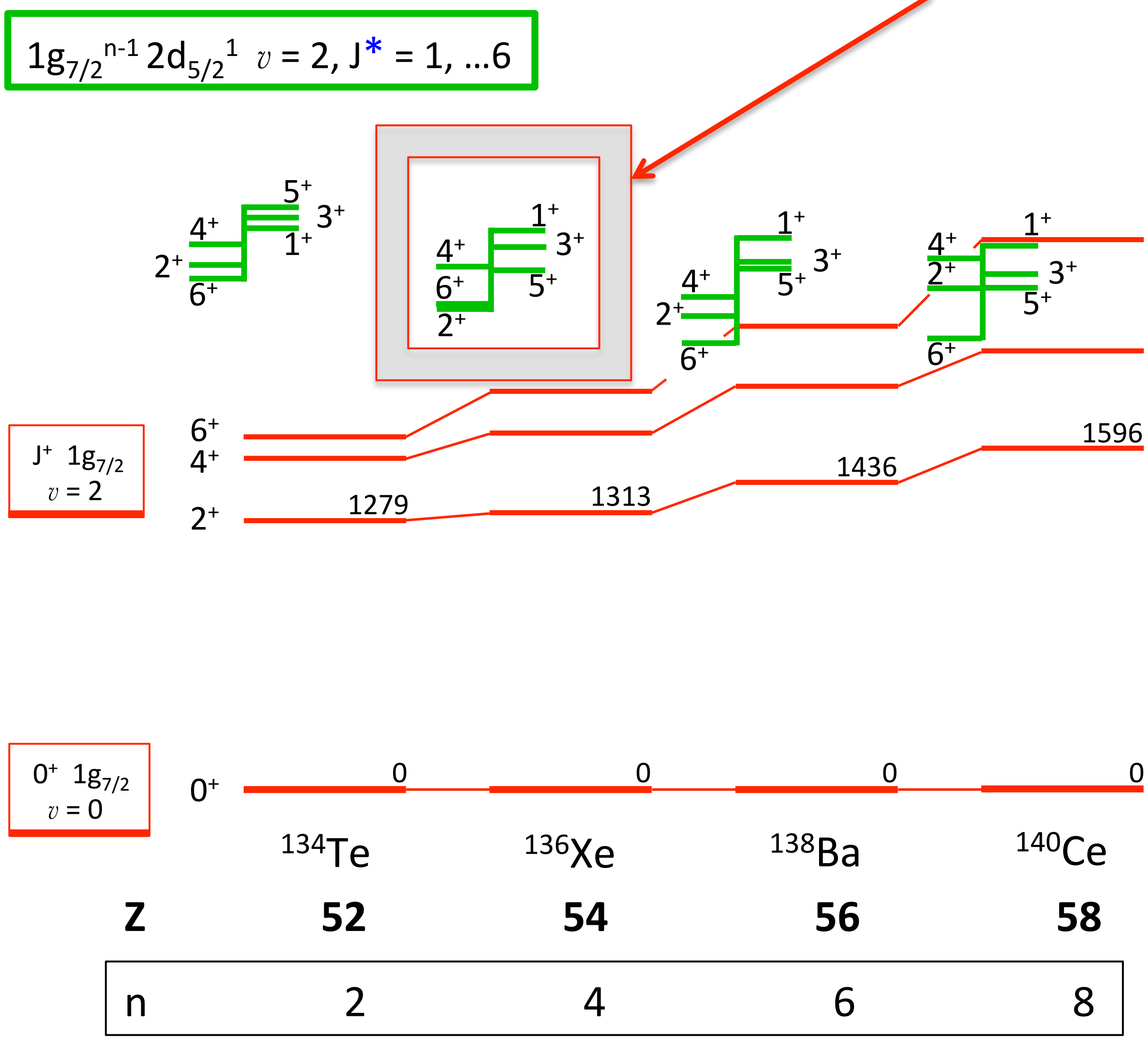
N = 82: proton $1g_{7/2}$ seniority, v = 0, 2 structure

NOTE: excitation patterns are not strongly dependent on particle number, only on Pauli principle



N = 82: proton $1g_{7/2}$ and $1g_{7/2}$ + $2d_{5/2}$ seniority, v = 0, 2 structure

NEW RESULT: ^{136}Xe n,n'γ, Erin Peters, Univ. Kentucky 2018, Phys Rev **C98** 034302 (2018)



NOTE: excitation patterns are not strongly dependent on particle number, only on Pauli principle

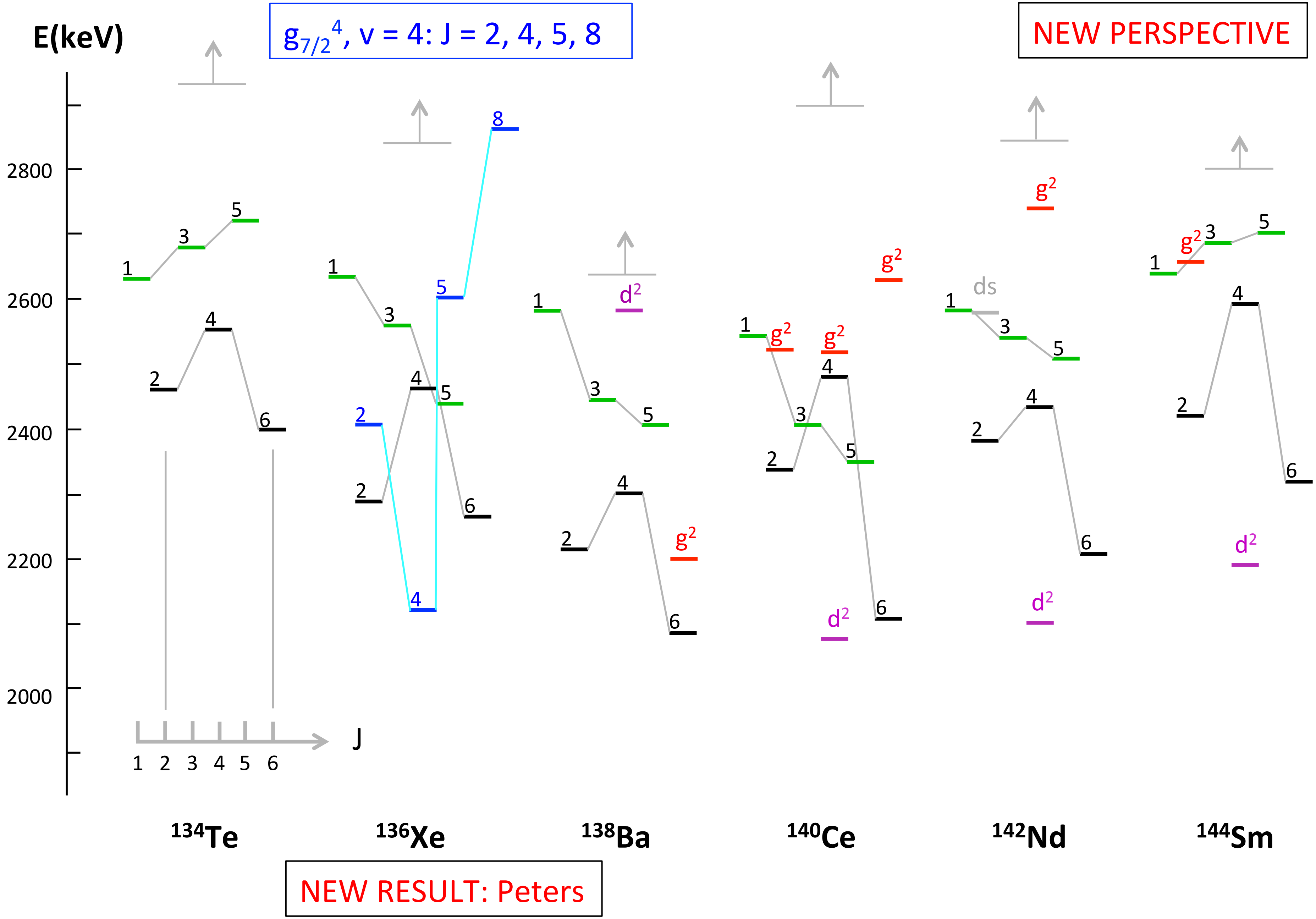
*from m scheme; but classical vector coupling can be used for $j_1 \neq j_2$:

J = 7/2 – 5/2 = 1

.....

J = 7/2 + 5/2 = 6

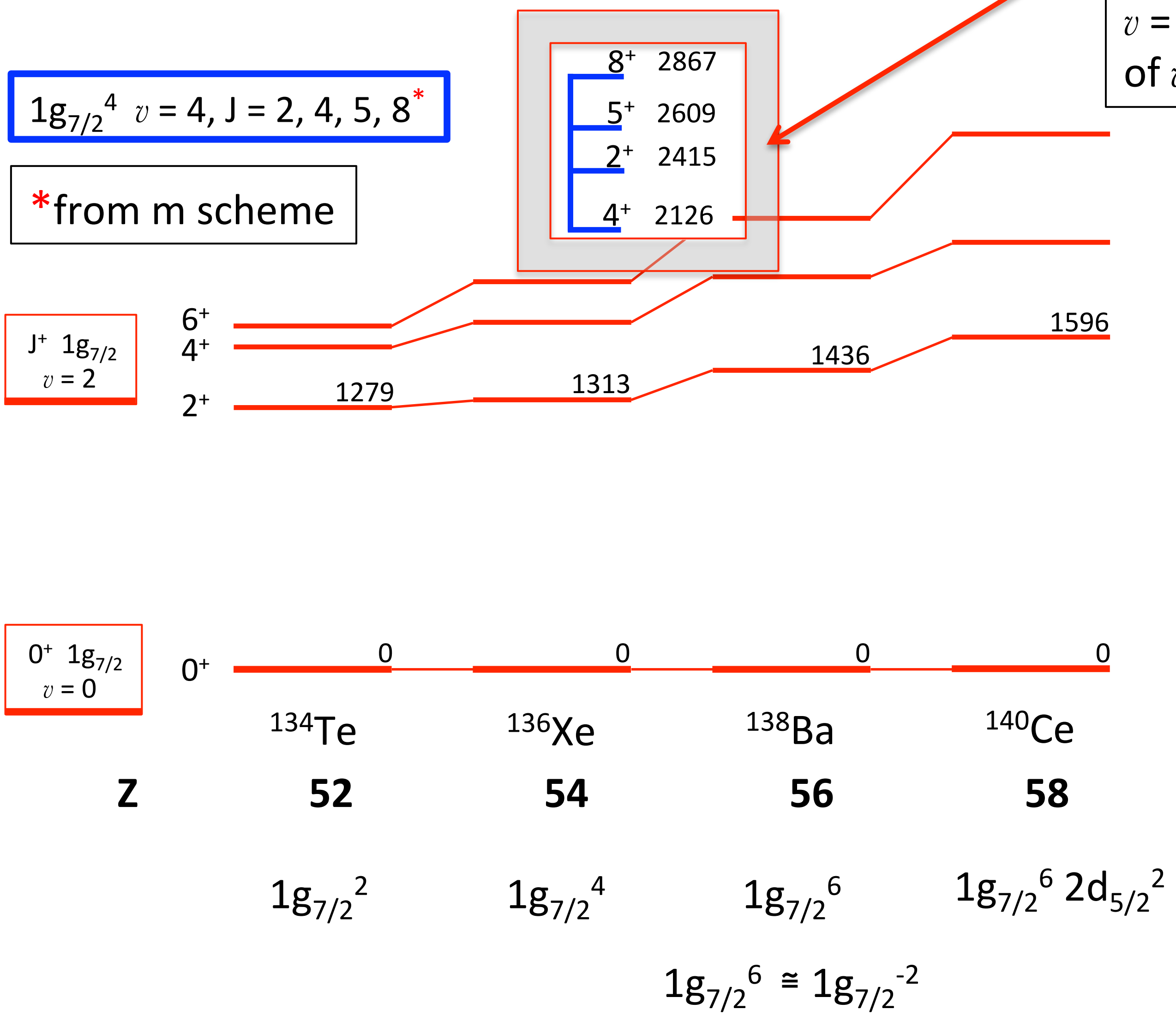
$1g_{7/2}$-$2d_{5/2}$ v = 2 multiplet in the N = 82 isotones



N = 82: proton $1g_{7/2}$ seniority, v = 0, 2, 4 structure

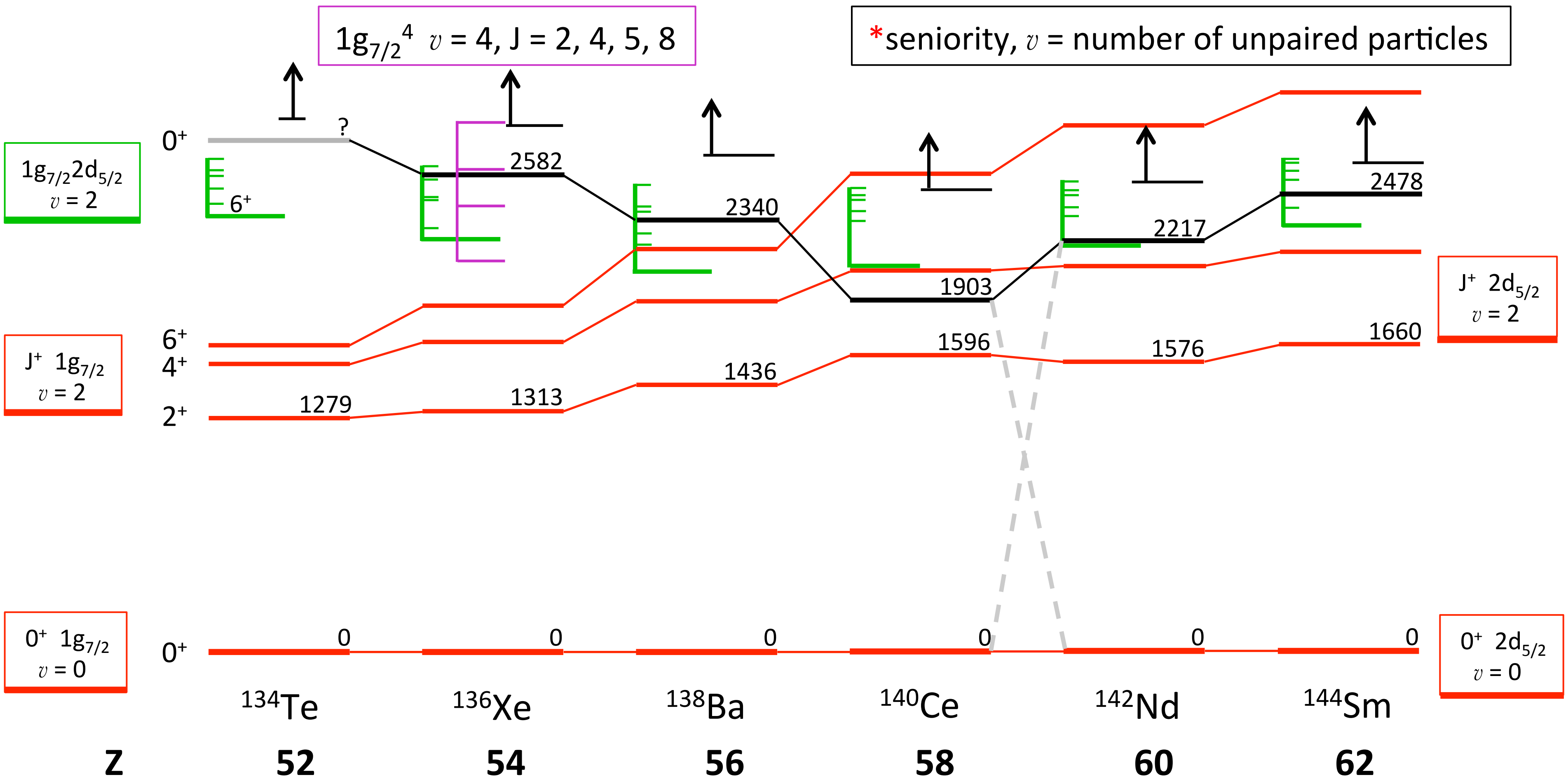
NEW RESULT: ^{136}Xe n,n’γ, Erin Peters, Univ. Kentucky 2018, Phys Rev **C98** 034302 (2018)

v = 4 not at twice the excitation of v = 2 because of Pauli blocking.



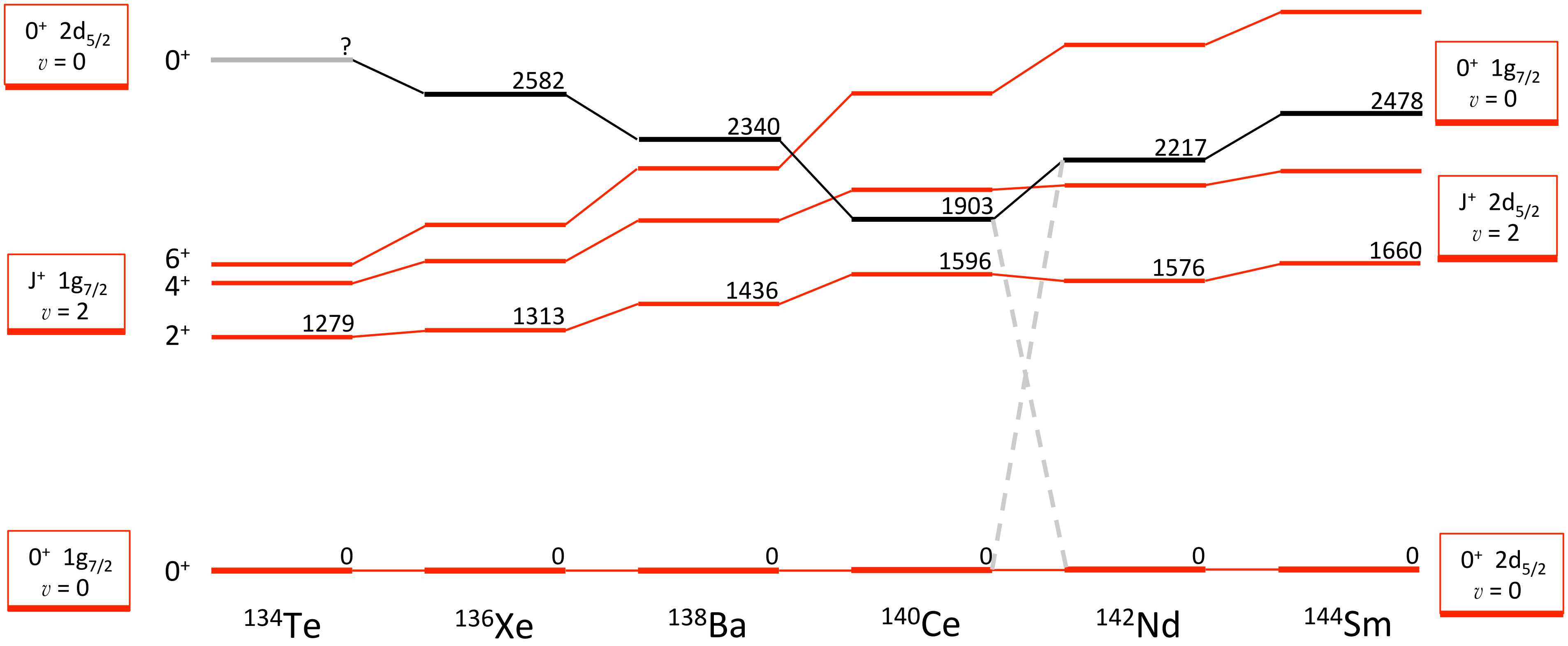
N = 82: proton seniority* structure, Z < 63, $1g_{7/2}2d_{5/2}$

NEW RESULT*: ^{136}Xe n,n'γ, Erin Peters, Univ. Kentucky 2018, Phys Rev **C98** 034302 (2018)



*Comprehensive (complete) spectroscopy up tp spin 6

N = 82 excited 0_2^+ states and B(E2; $2_1^+ \rightarrow 0_1^+$) strengths



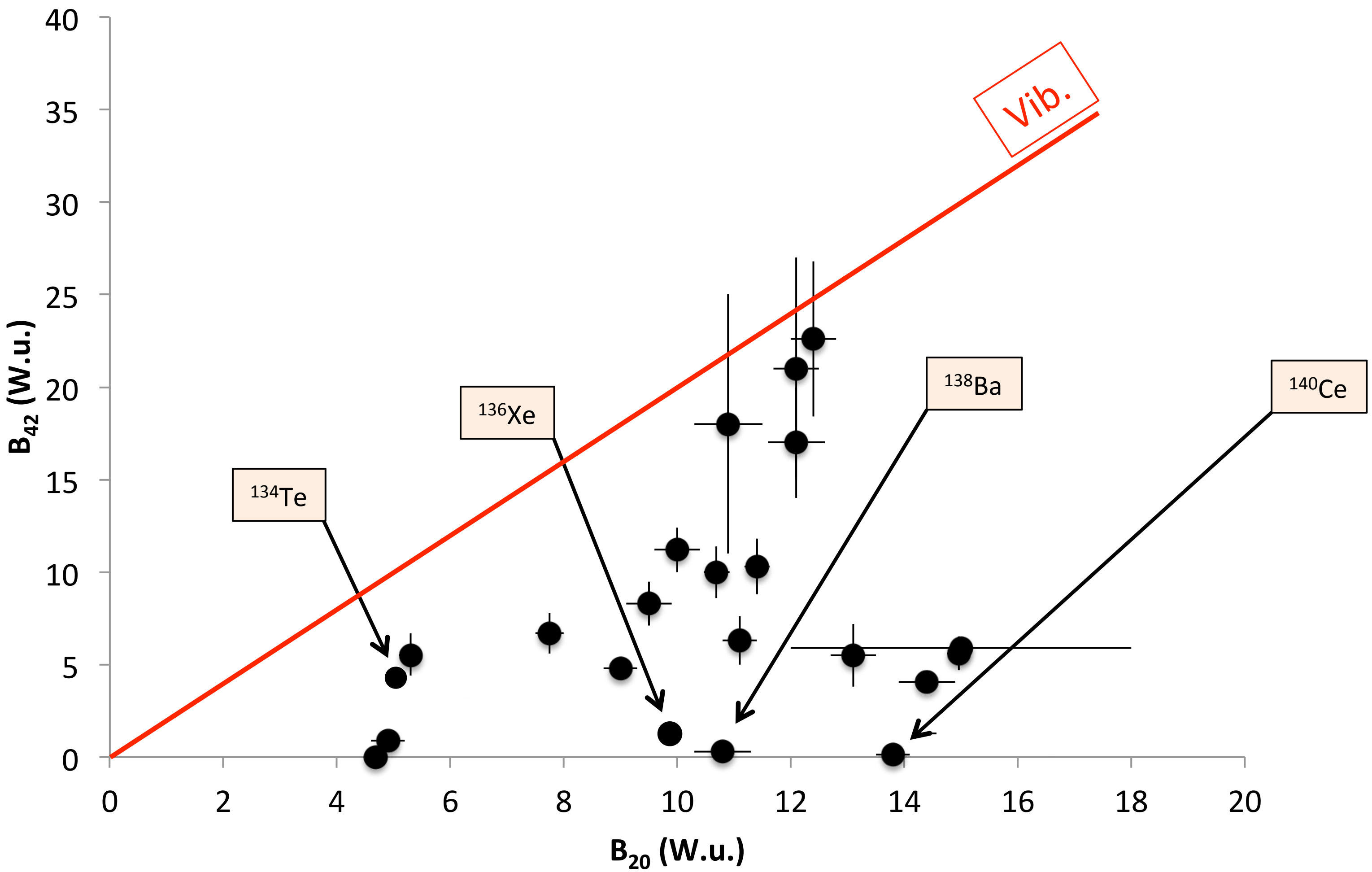
Z	52	54	56	58	60	62
B_{20}(W.u.)	5.12^{21}	16.6^{24}	10.8^{5}	13.8^{3}	12.0^{2}	11.9^{4}

B_{42} vs. B_{20} for singly closed-shell nuclei

N = 82

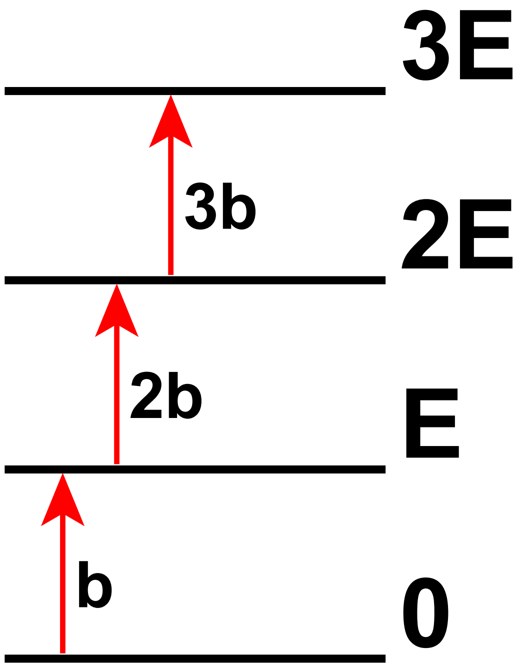
$B_{20} := B(E2;\, 2_1^+ \rightarrow 0_1^+)$

$B_{42} := B(E2;\, 4_1^+ \rightarrow 2_1^+)$



Vibrations: a schematic view

Transition probabilities between collective vibrational states should be proportional to the number of phonons.



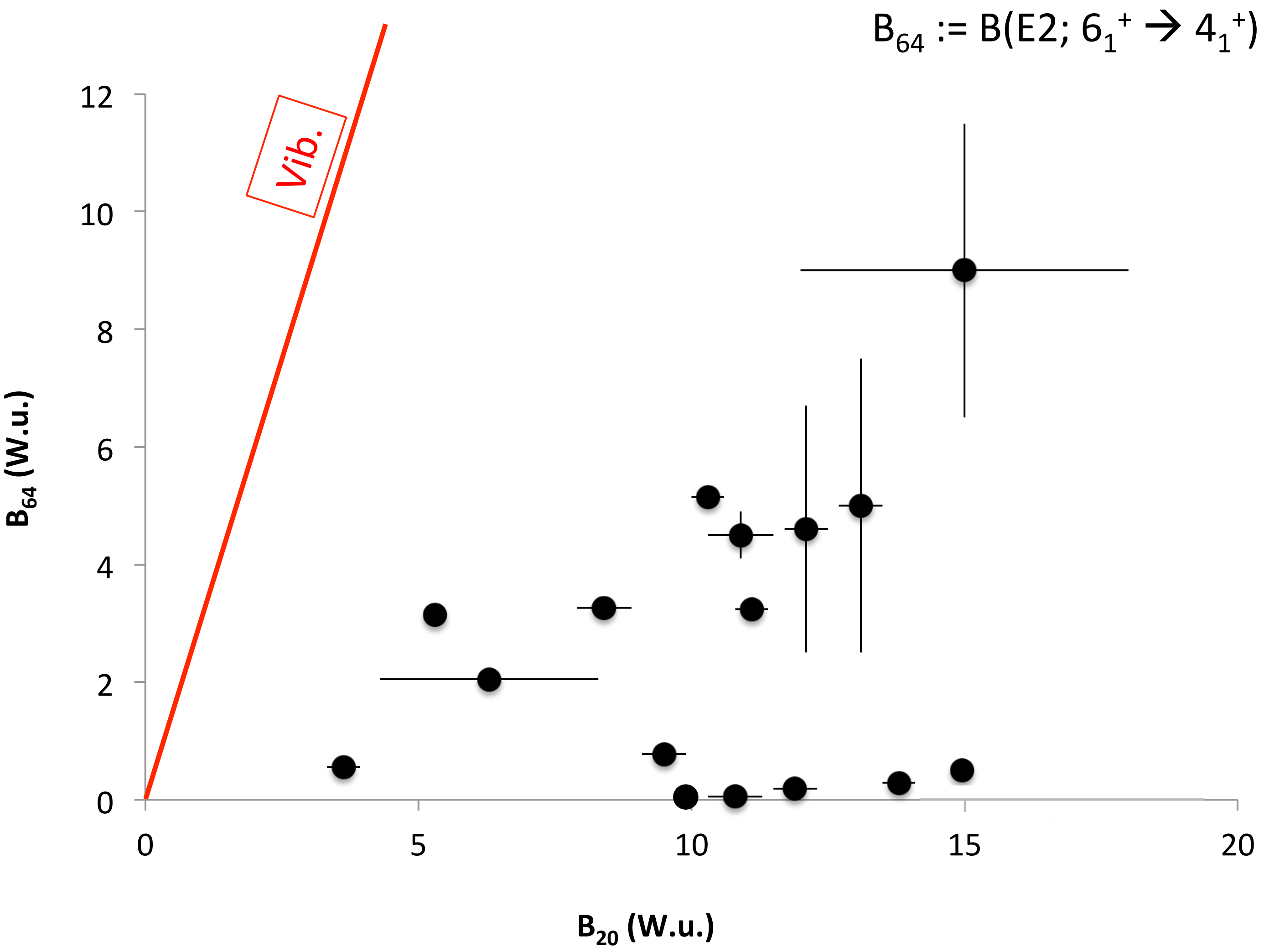
$$a^\dagger|0\rangle = |1\rangle$$

$$a^\dagger|n\rangle = \sqrt{n+1}|n+1\rangle$$

$$T(n \rightarrow n+1) = b\langle n+1|a^\dagger|n\rangle^2 = b(n+1)$$

B_{64} vs. B_{20} for singly closed shell nuclei

No multi-phonon quadrupole collective strength



CONCLUSIONS

- $N = 82$, singly closed shell nuclei with $Z < 65$ exhibit only seniority-dominated excitations at low energy
- This is for *two* j shells ($1g_{7/2}$, $2d_{5/2}$)—a "first"
- A comprehensive (complete) view up to ~ 2500 keV
  has been achieved
- No multi-phonon vibrational degrees of freedom are present

- This perspective suggests that simple, seniority-dominated multi-j excitations be explored in *all* singly closed shell nuclei