Applying QRPAdef

The “classical” approach

Work mainly by J. Terasaki

Reminders

Basic Procedure

- Do deformed HFB calculation in cylindrical box.
- Construct as basis (as large as possible) of two-proton-canonical-quasiparticle and two-neutron-canonical-quasiparticle states.
- Construct energy matrix between basis states — **many 2-d integrals (with splines)** — and diagonalize.

High-Performance Computing

- Task: Typically compute about 10^{10} matrix elements in each K^{π} and nucleus (using about 10^5 core-hours at desired level of accuracy for heavy nuclei).
- Info/Issues:
  - Code scales well up to 10,000 cores and beyond.
  - ADLB might help with larger numbers of cores

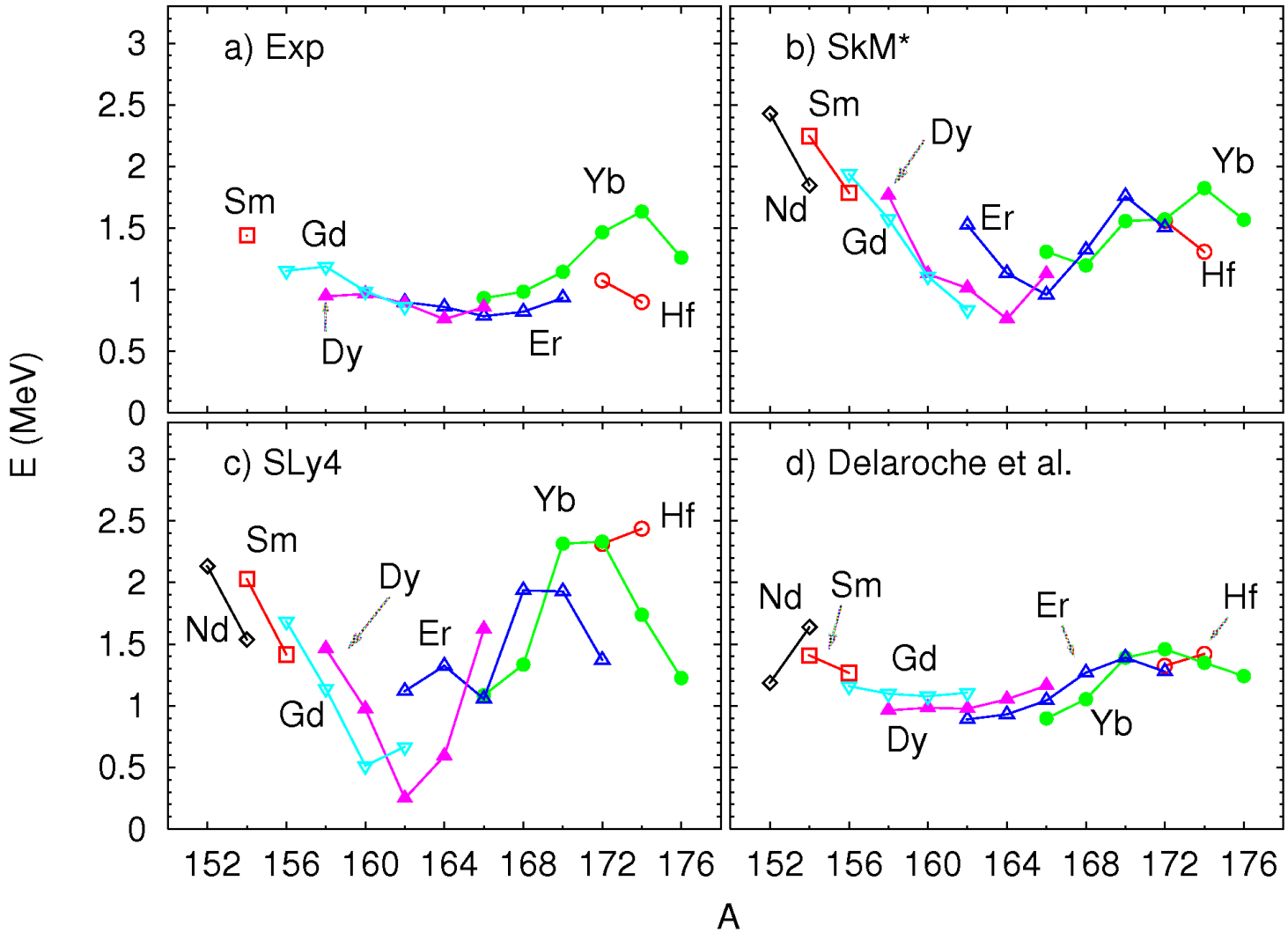
Beta and Gamma Vibrations in Rare Earths

With 10M core-hours:

Z\N	92	94	96	98	100	102	104	106	108	110
74										
72					^{172}Hf	^{174}Hf				
70			^{166}Yb	^{168}Yb	^{170}Yb	^{172}Yb	^{174}Yb	^{176}Yb		
68		^{162}Er	^{164}Er	^{166}Er	^{168}Er	^{170}Er	^{172}Er			
66	^{158}Dy	^{160}Dy	^{162}Dy	^{164}Dy	^{166}Dy					
64	^{156}Gd	^{158}Gd	^{160}Gd	^{162}Gd						
62	^{154}Sm	^{156}Sm								
60	^{152}Nd	^{154}Nd								
58										

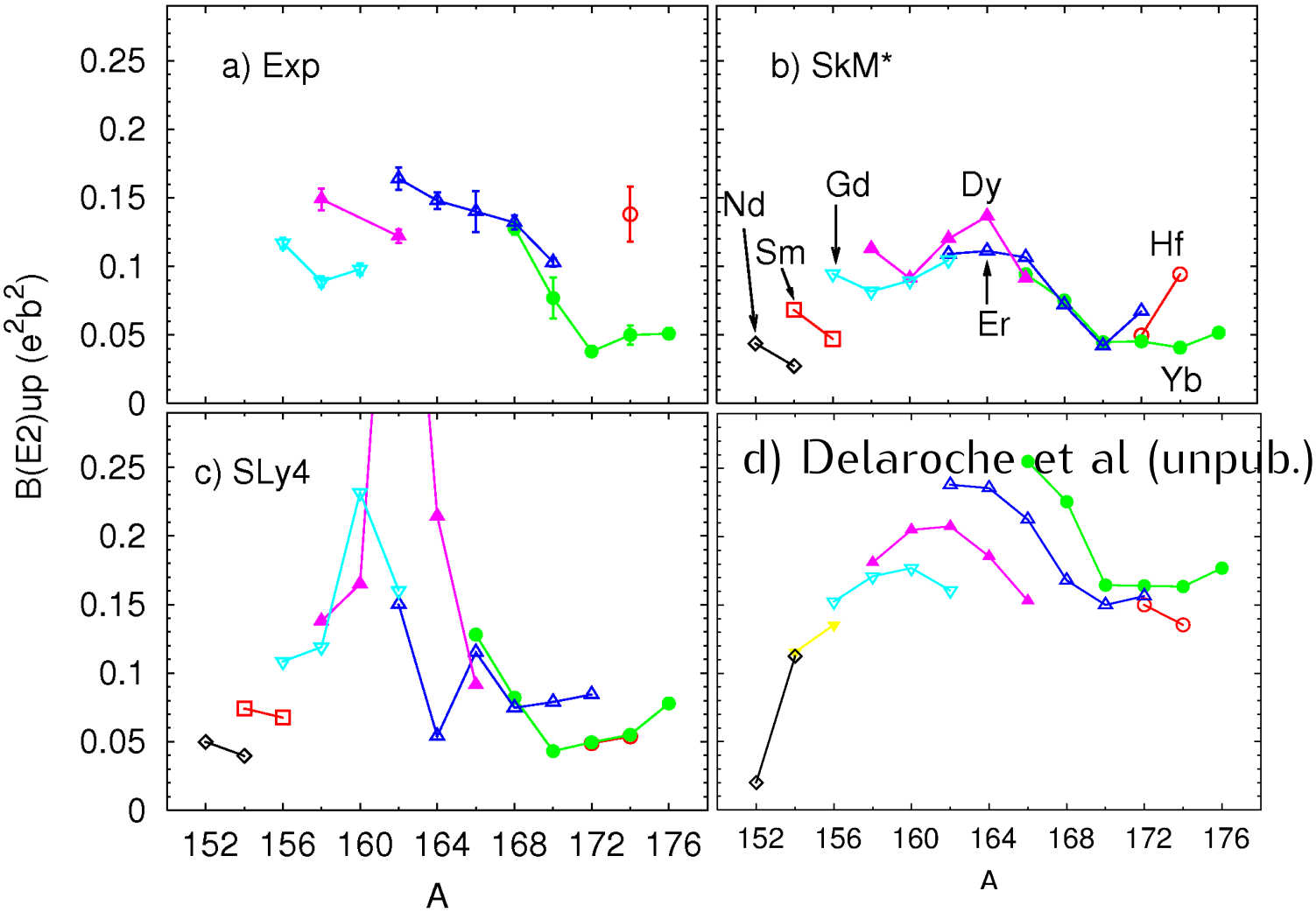
All have $\beta > 0.3$

Energies



Minimum is correct and SkM* does a very good job in Yb, but N dependence is too strong elsewhere and SLy4 $<$ SkM*.

Transition Strengths



Results seem a bit better than for energies, and Yb isotopes are good again.

Statistics

Deformed

	$\bar{R}_E$	σ_E	$\bar{R}_Q$	σ_Q
SkM*	0.28	0.18	−0.13	0.14
SLy4	0.20	0.50	−0.004	0.31

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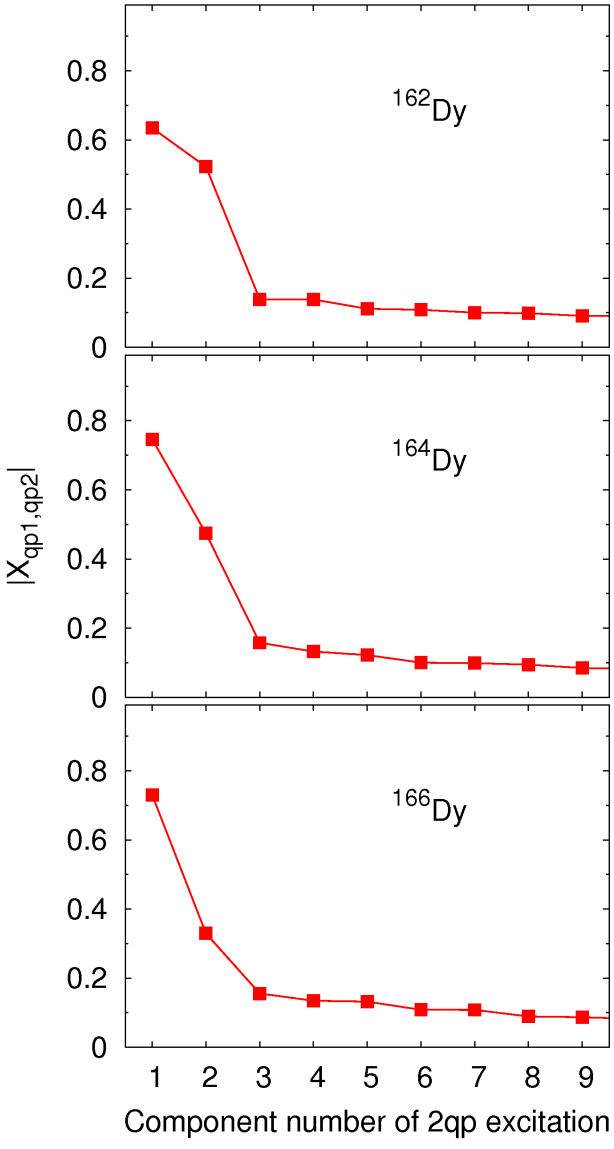
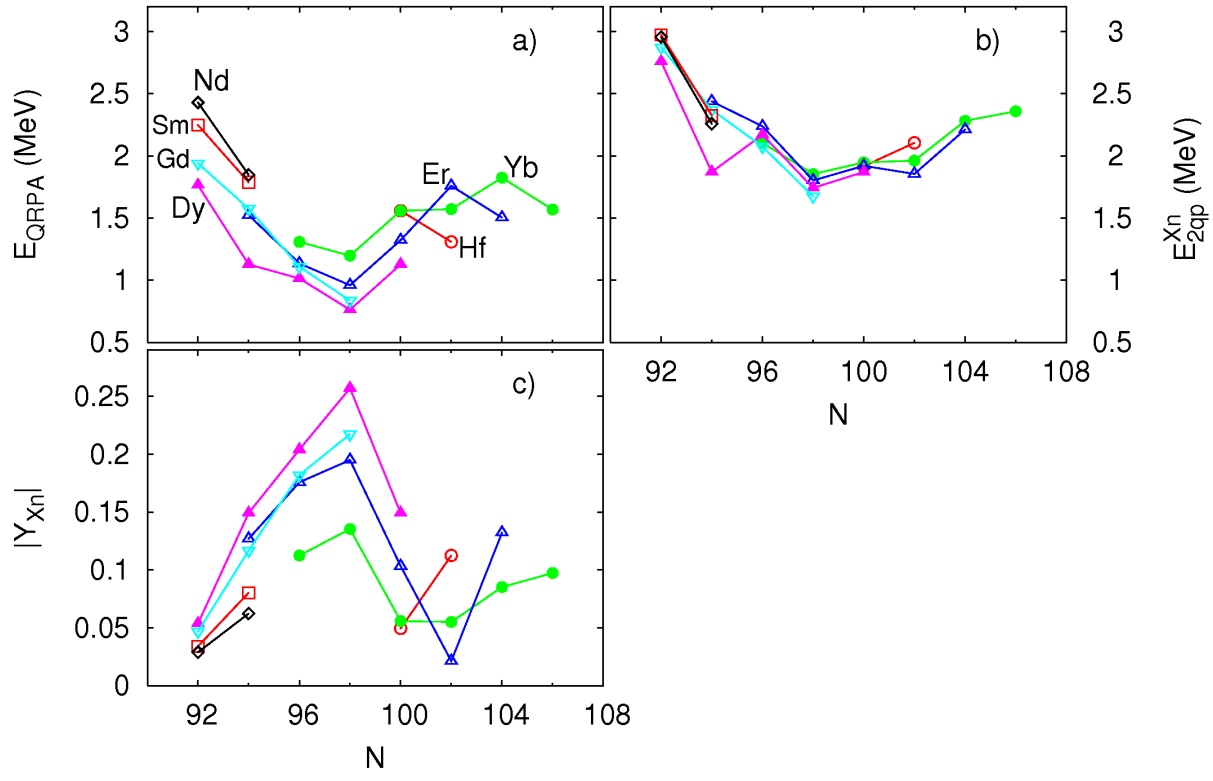
Spherical

	$\bar{R}_E$	σ_E	$\bar{R}_Q$	σ_Q
SkM*	0.11	0.44	-0.29	0.53
SLy4	0.33	0.51	-0.32	0.42

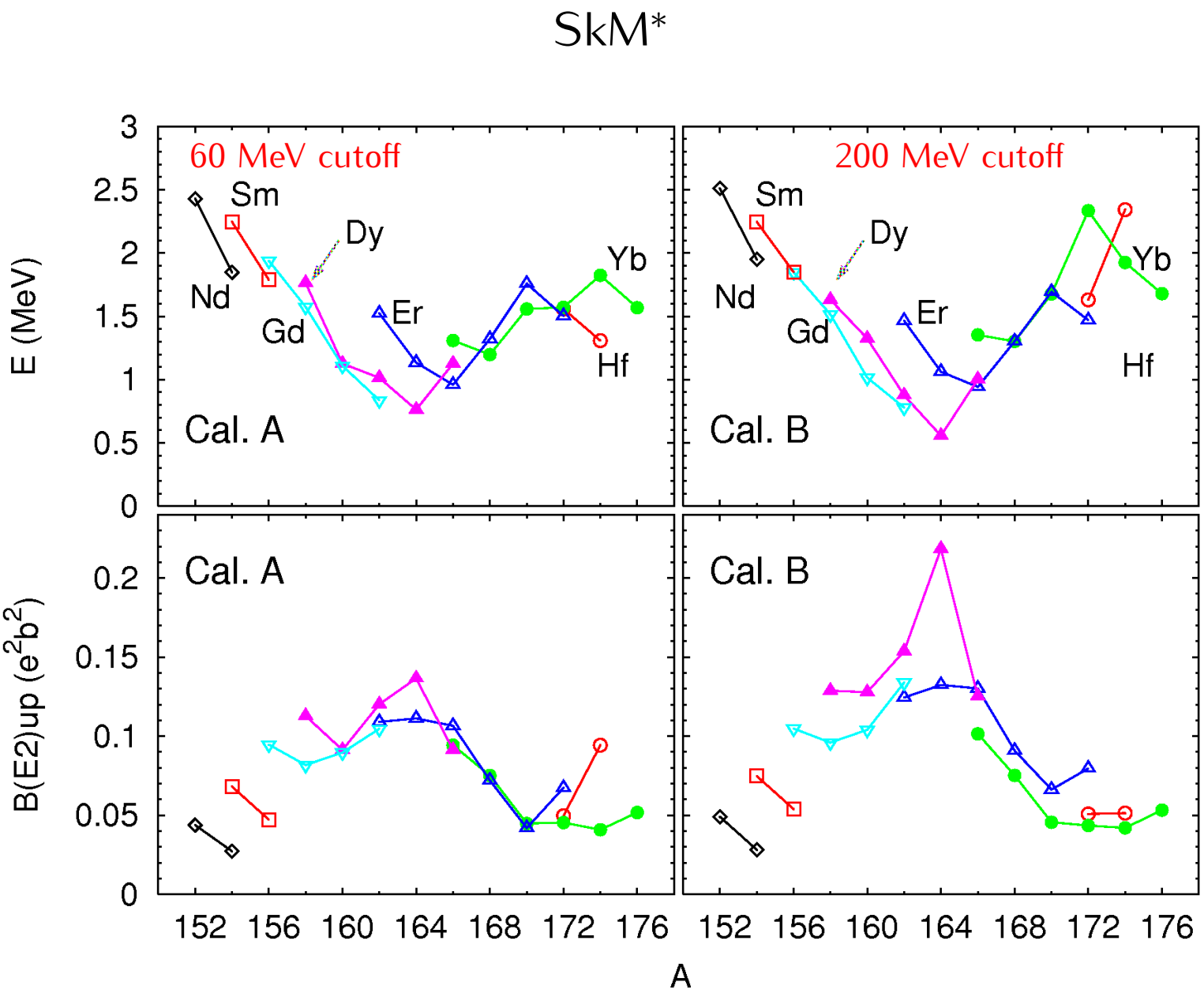
Dominance by a Few Two-qp States



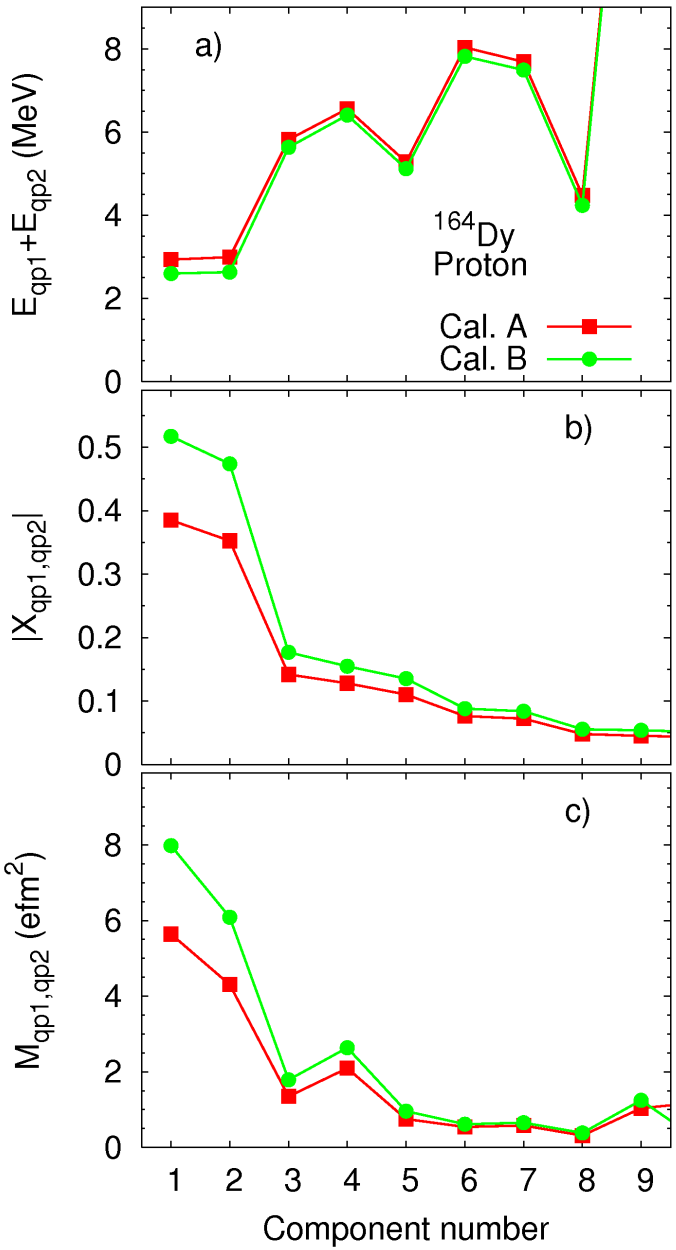


Not enough configuration mixing?

Varying Pairing Cutoff Energy



Effects of Cutoff Variation on Two-qp Makeup



60 MeV

200 MeV

Beta Vibrations

Meh...

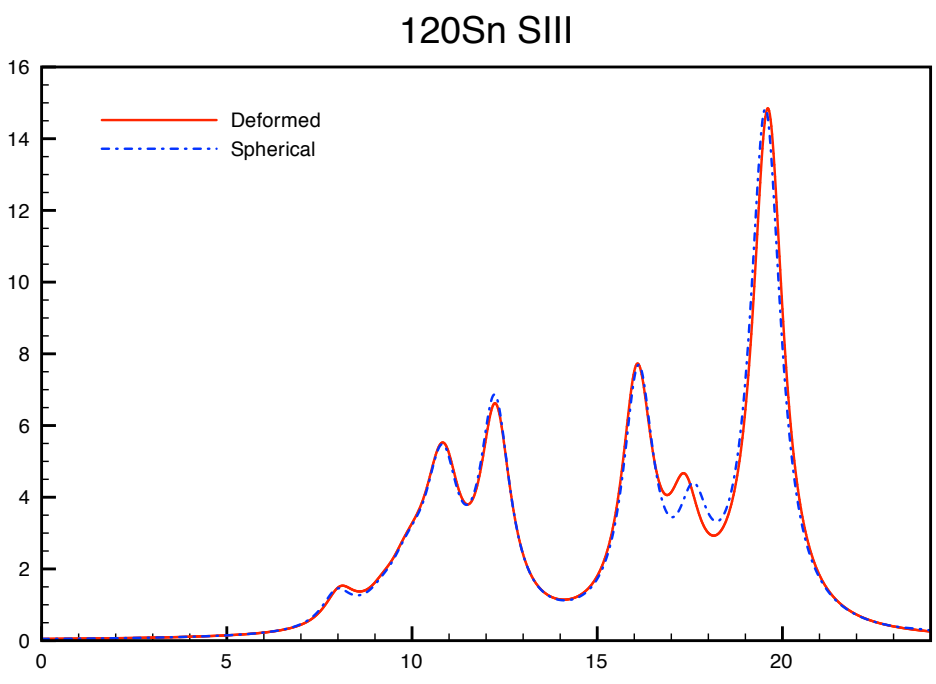
Need much larger basis — about 70,000 two-qp states. Even then, only a few nuclei have states that are uncontaminated by spurious number nonconservation.

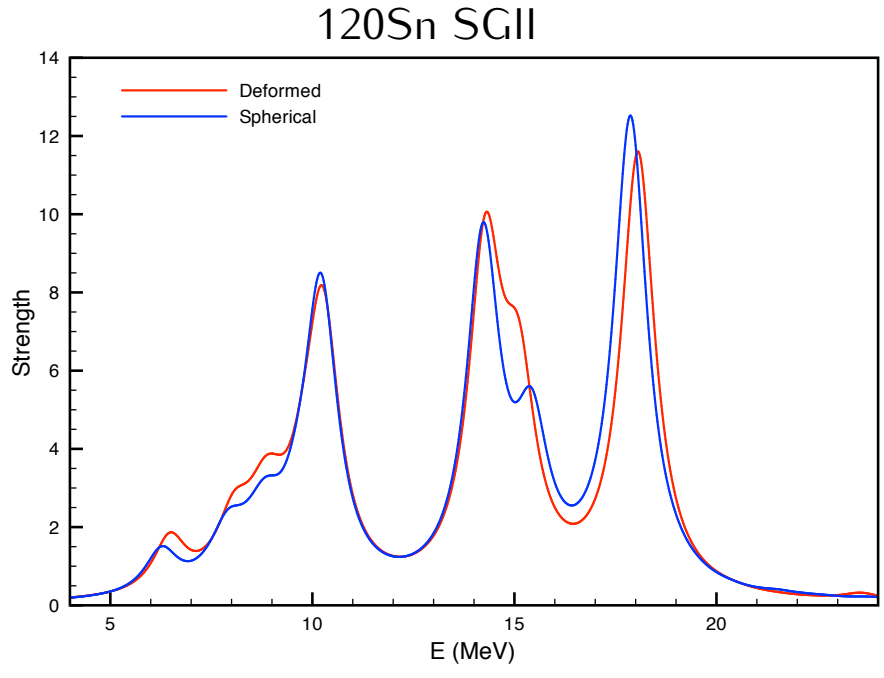
	E^{β}_{cal} (MeV)	E^{β}_{exp} (MeV)	$B(E2)\uparrow^{\beta}_{\text{cal}}$ $(e^2\text{b}^2)$	$B(E2)\uparrow^{\beta}_{\text{exp}}$ $(e^2\text{b}^2)$	$S_N/S_N^{\text{spurious}}$
^{166}Yb	1.802	1.043	0.0398		0.004
^{168}Yb	2.039	1.155	0.0343		0.012
^{172}Yb	1.605	1.117	0.0049	0.0081(17)	0.054
^{170}Er	1.596	0.960	0.0030	0.0079(9)	0.054

Charge-Changing Code

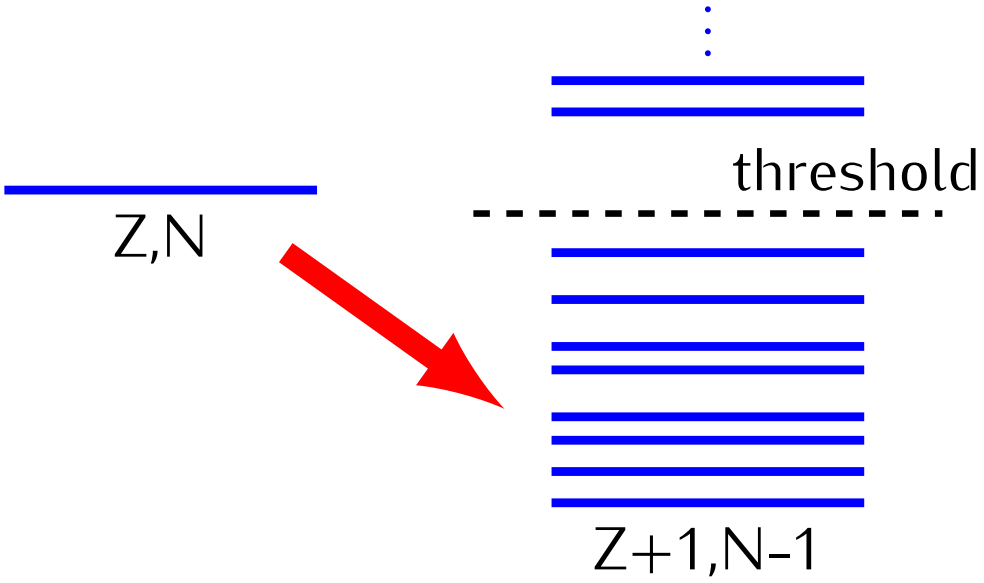
Two-qp basis states now contain one neutron qp and one proton qp.

Tests

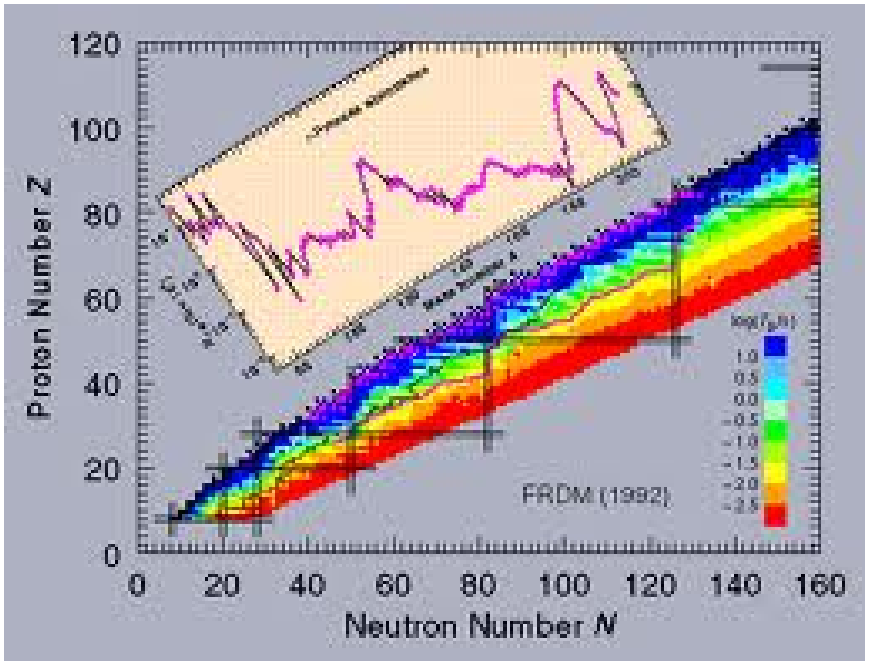




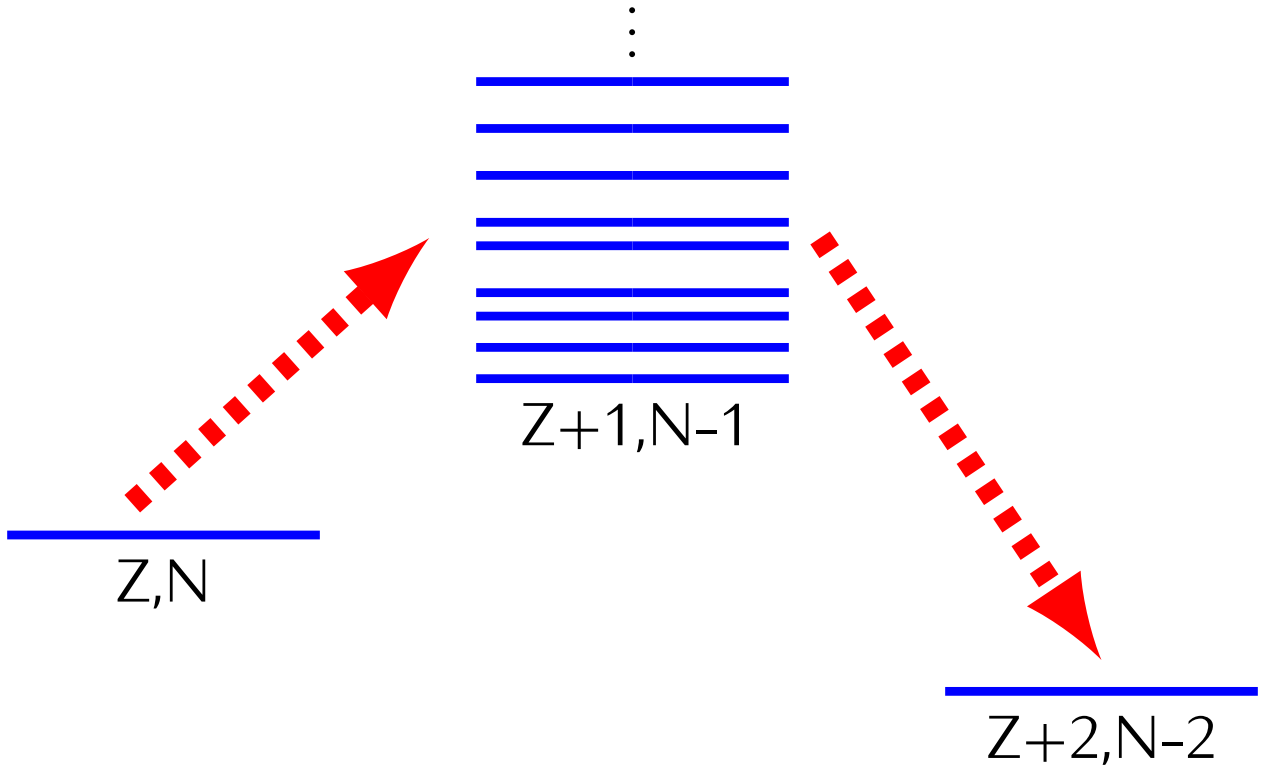
Initial Application: Light R-Process Elements



In *r*-process nuclei, significant fraction of GT strength is below threshold. Tom Shafer (topical-collaboration-supported student) applying first to nuclei important for formation of $A = 80$ r-procss peak.



Upcoming Application: Double-Beta Decay



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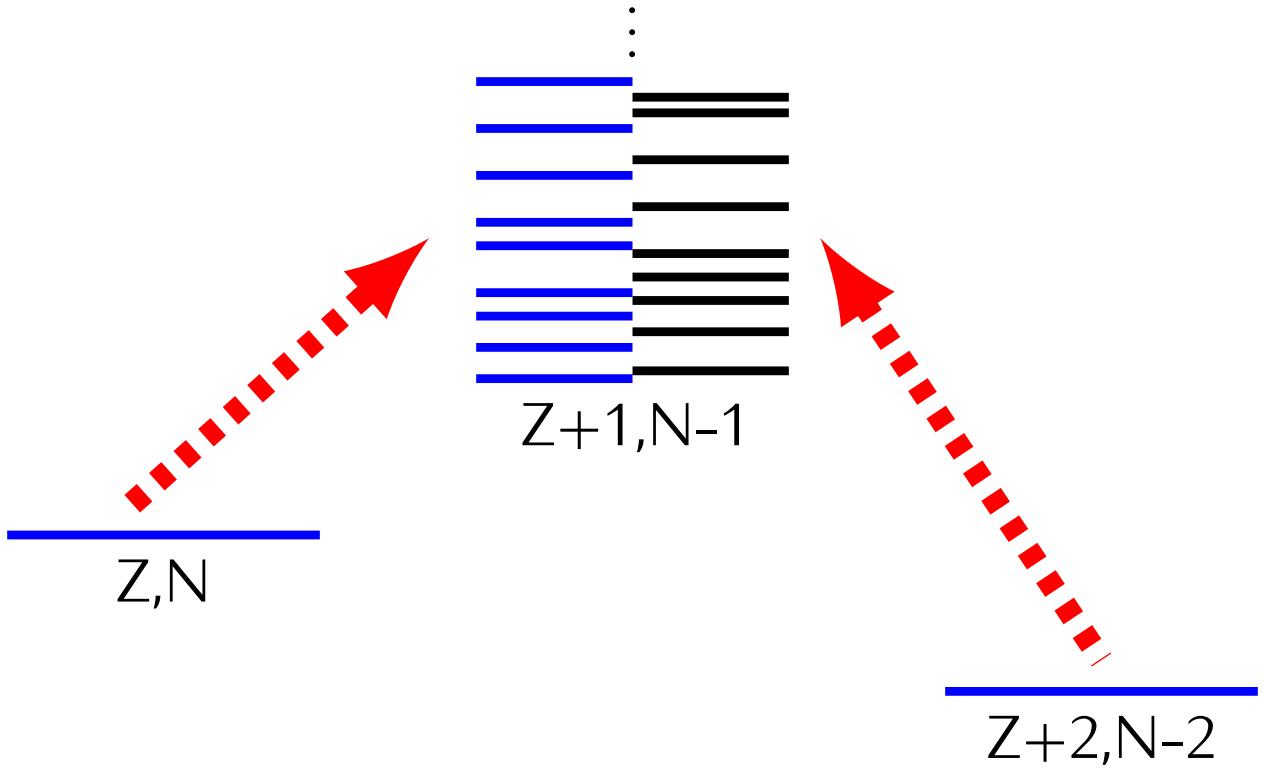

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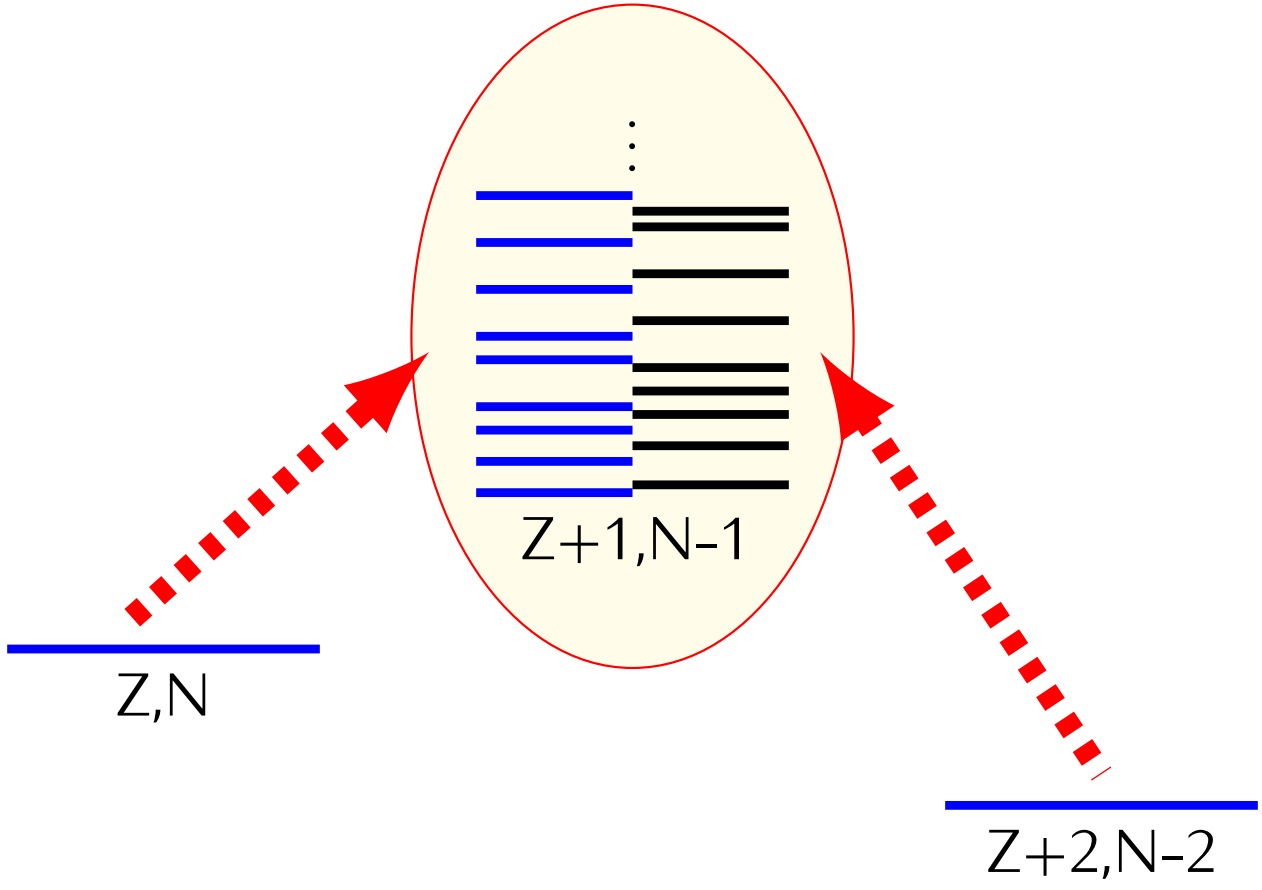

Need to "debosonize" QRPA to calculate overlaps of states based on different vacua, e.g, through representation of Jancovici and Schiff. Haven't found alternative to complicated expansion in Y's

Milestones, etc.

- Finish quadrupole vibrations ✓

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- Do beta decay Underway

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- Start beyond RPA Still working on this one