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Collaboration on A-ODD

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This talk: **Odd-Even Staggering**

Tool: ev8-odd

ev8 (Bonche, Flocard and Heenen, CPC 171 (2005) 49)

\+ **Blocking**

• **Goals:**

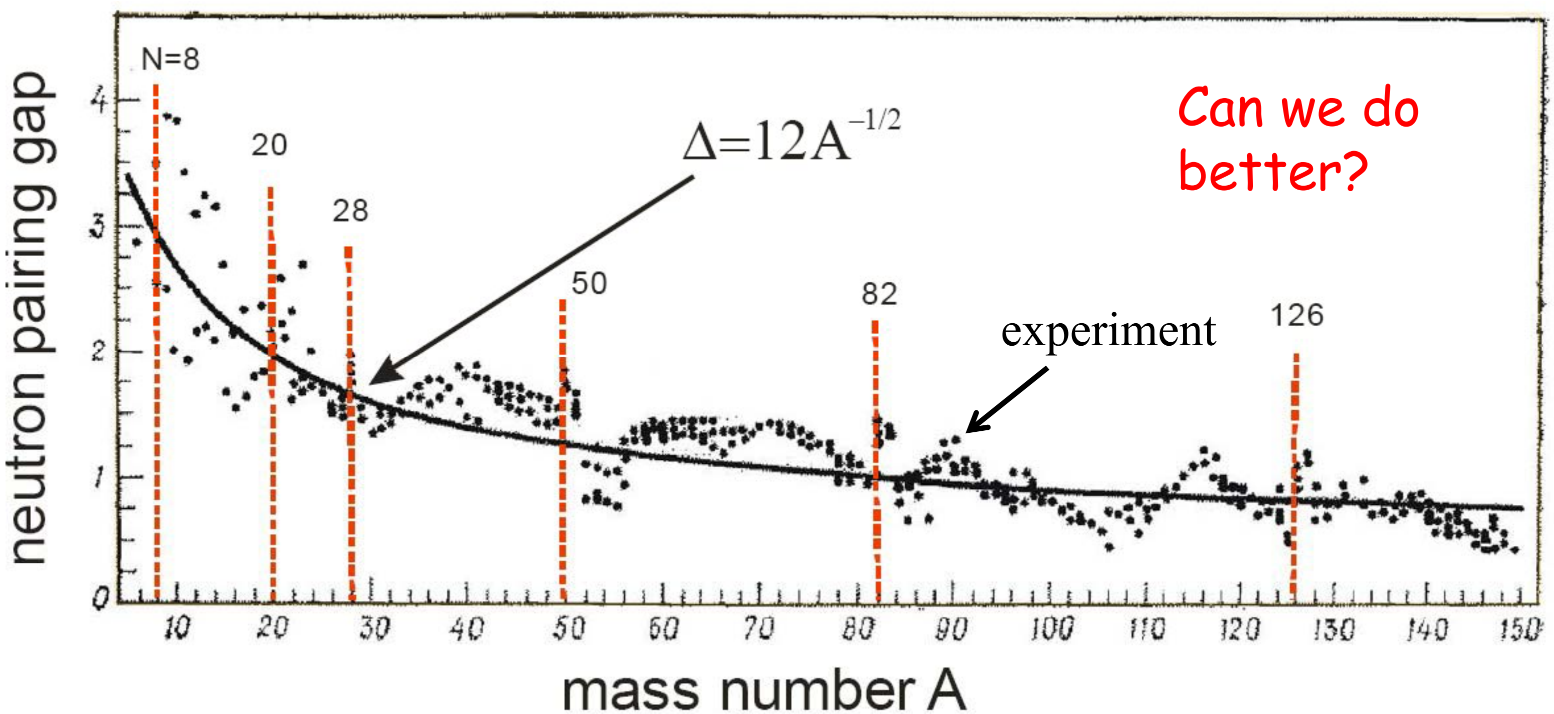
to benchmark existing theory of even-odd mass difference

•**T-odd effect neglected:**

but it should decrease as 1/A

• **Good observable**

3-point filter: $$\Delta = \frac{1}{2}(-1)^N \left[S(N,Z) - S(N-1,Z)\right]$$



Details: Binding energies

Example:

$V_{NN}^{\,eff}$ = Skyrme = SLy4

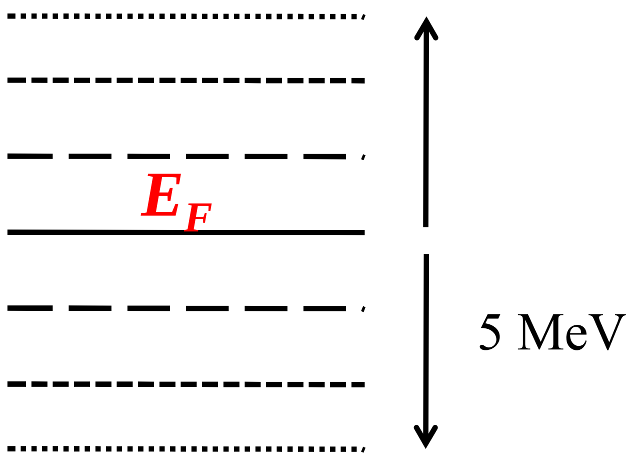
$$V_{pairing} = g\delta(\mathbf{r}_{12})\left[1 - \frac{\rho(\mathbf{r})}{\alpha}\right]$$

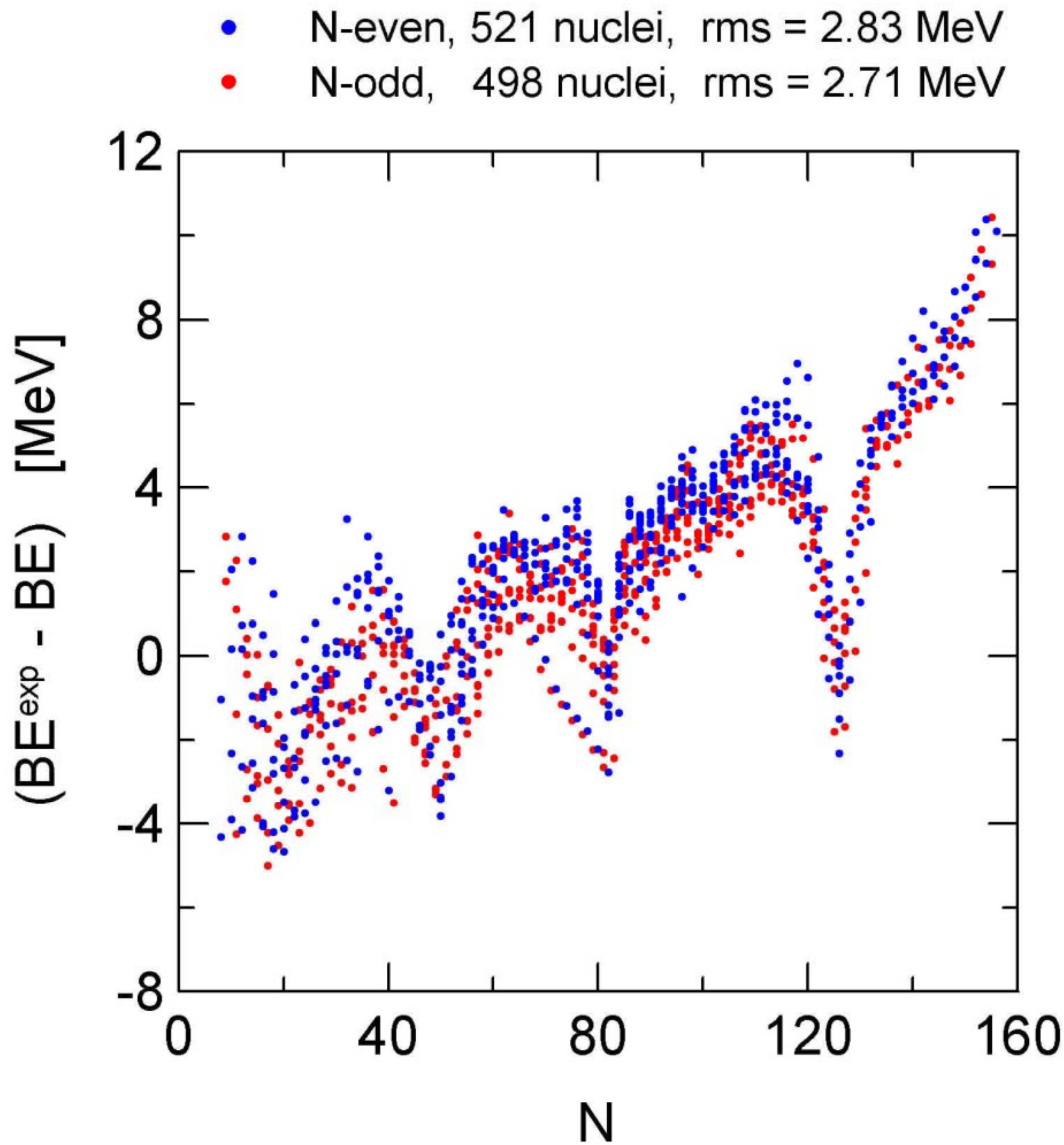
Surface pairing:

$g_n = g_p = 1000$ MeV fm^3

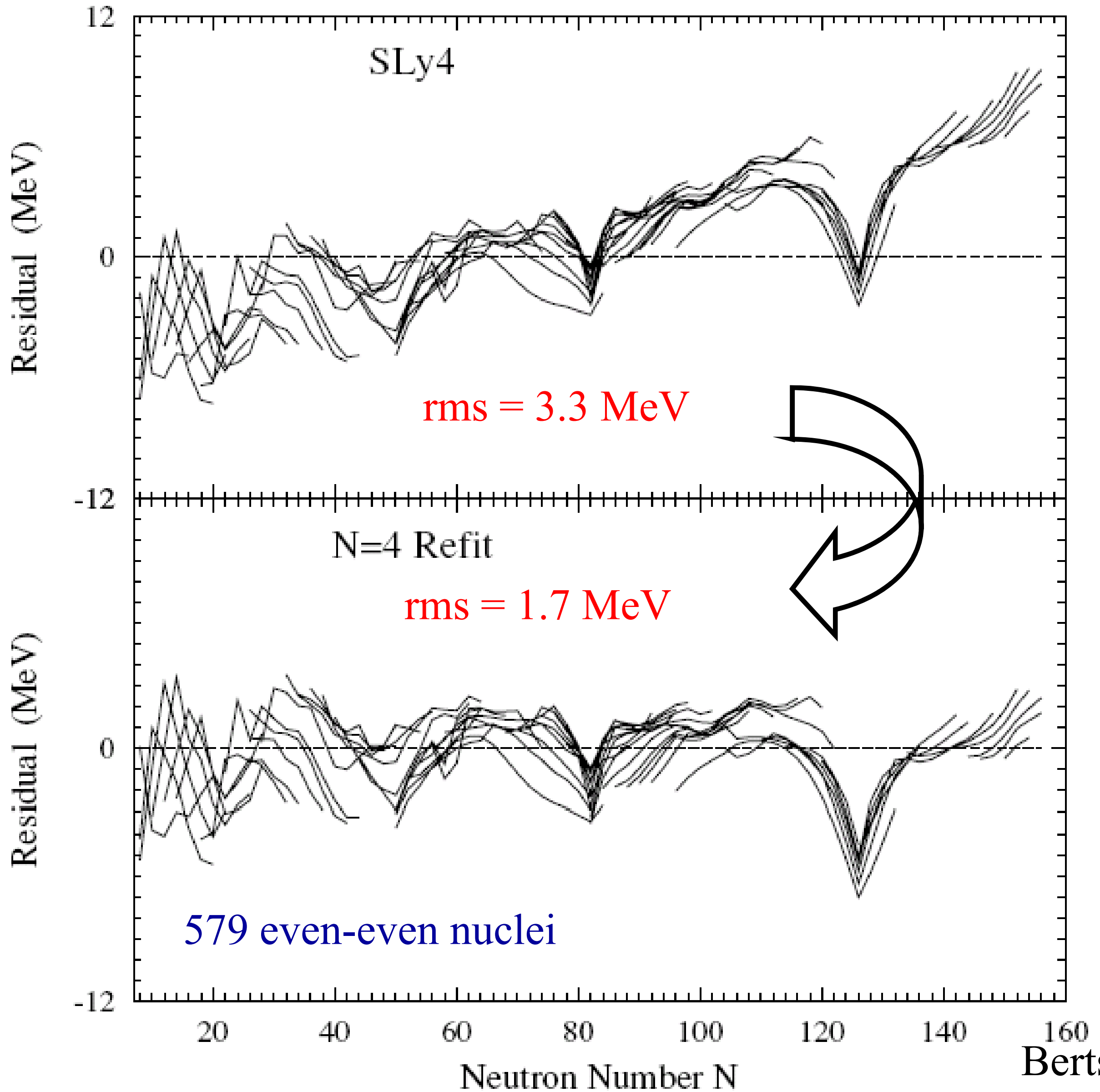
$\alpha = 0.16$ fm^{-3}

$$V_{pairing}(k)$$



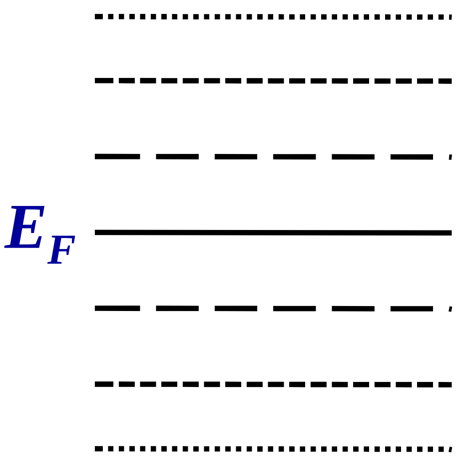


Reducing rms by refitting interactions



Bertsch, Sabbey, Uusnakki,
PRC **71**, 054311 (2005)

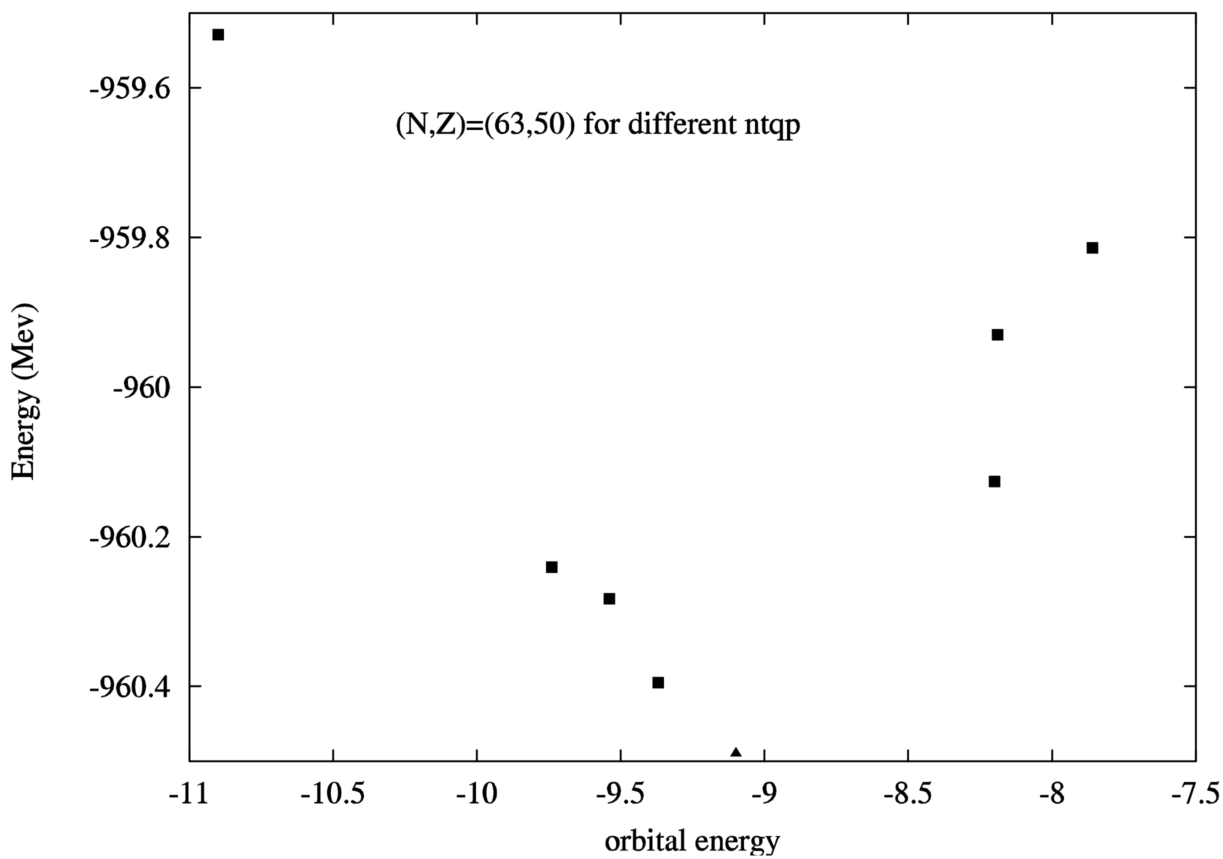
Blocking the levels



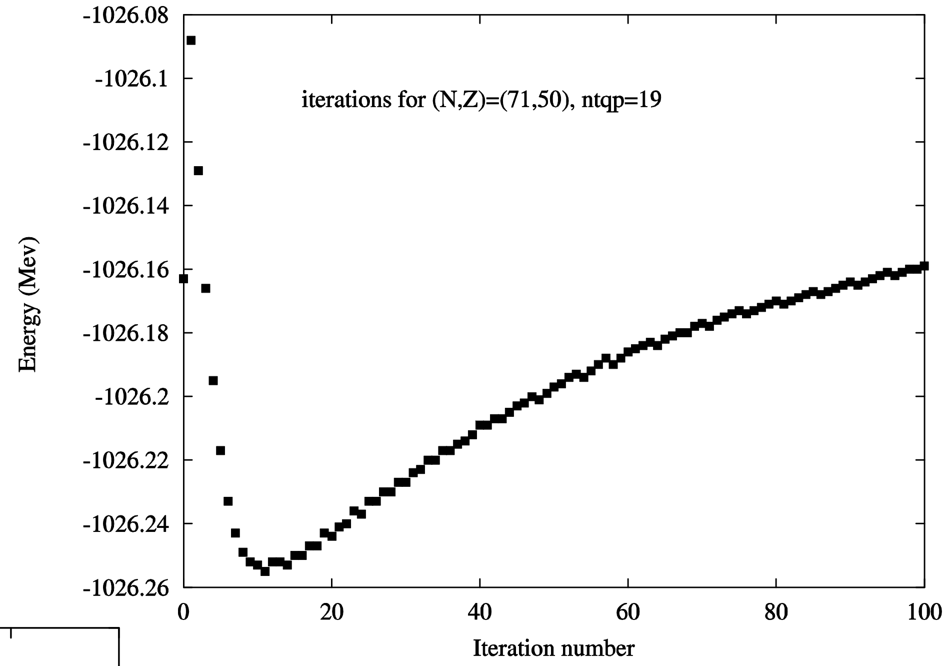
$v^2 \rightarrow \frac{1}{2}, \quad u \rightarrow 0$
for one orbit and its time-conjugate partner

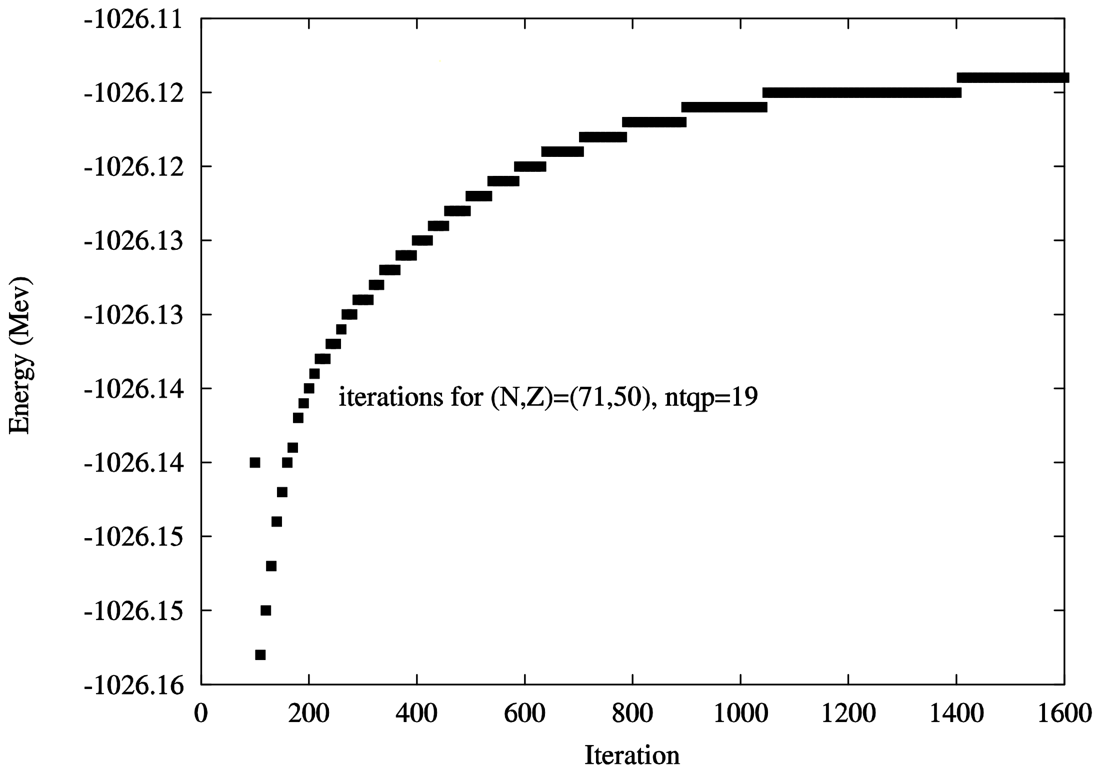
Starting N=even,Z=even wavefunctions from
http://gene.phys.washington.edu/ev8
Blocking added to BCS and Lipkin-Nogami
→ "ev8-odd"

See
http://gene.phys.washington.edu/~bertsch/pedlist.html
for justification.



Dependence on # iterations





We've used 50 iterations for the mass tables, corresponding to 100 keV error.

Using 100-150 iterations, we will expect To reduce this even further to 50 keV.

Odd-even staggering vs pairing strength

3-point filter:

Satula, Dobaczewski, Nazarewicz, PRL 81,3599 (1998).

$$\Delta = \frac{1}{2}(-1)^N \left[S(N,Z) - S(N-1,Z) \right]$$

$$\cong \frac{1}{2}(-1)^N \frac{\partial^2 B}{\partial N^2},$$

N = even (e), odd (o)

Rutz, Bender, Reinhard, Maruhn, PL B 468, 1 (1999).

$$B = E_{sp} - \widetilde{E}_{sp} + E_{macro},$$

$$E_{sp} = \sum_k e_k, \qquad \Delta^{(o)}{}_{sp} \approx 0, \qquad \Delta^{(e)}{}_{sp} \approx \frac{e_n - e_{n-1}}{2}$$

Mechanism	$\Delta_o^{(3)}$	$\Delta_e^{(3)}$
Single-particle	0	$(e_i - e_{i-1})/2$
BCS correlation	Δ_{BCS}	Δ_{BCS}
T-odd pp	$-v_{i\bar{i},i\bar{i}}/2$	$\overline{v} - v_{i\bar{i},i\bar{i}}/2$
T-odd DFT		
T-even polarization	$-e_{cp}$	0

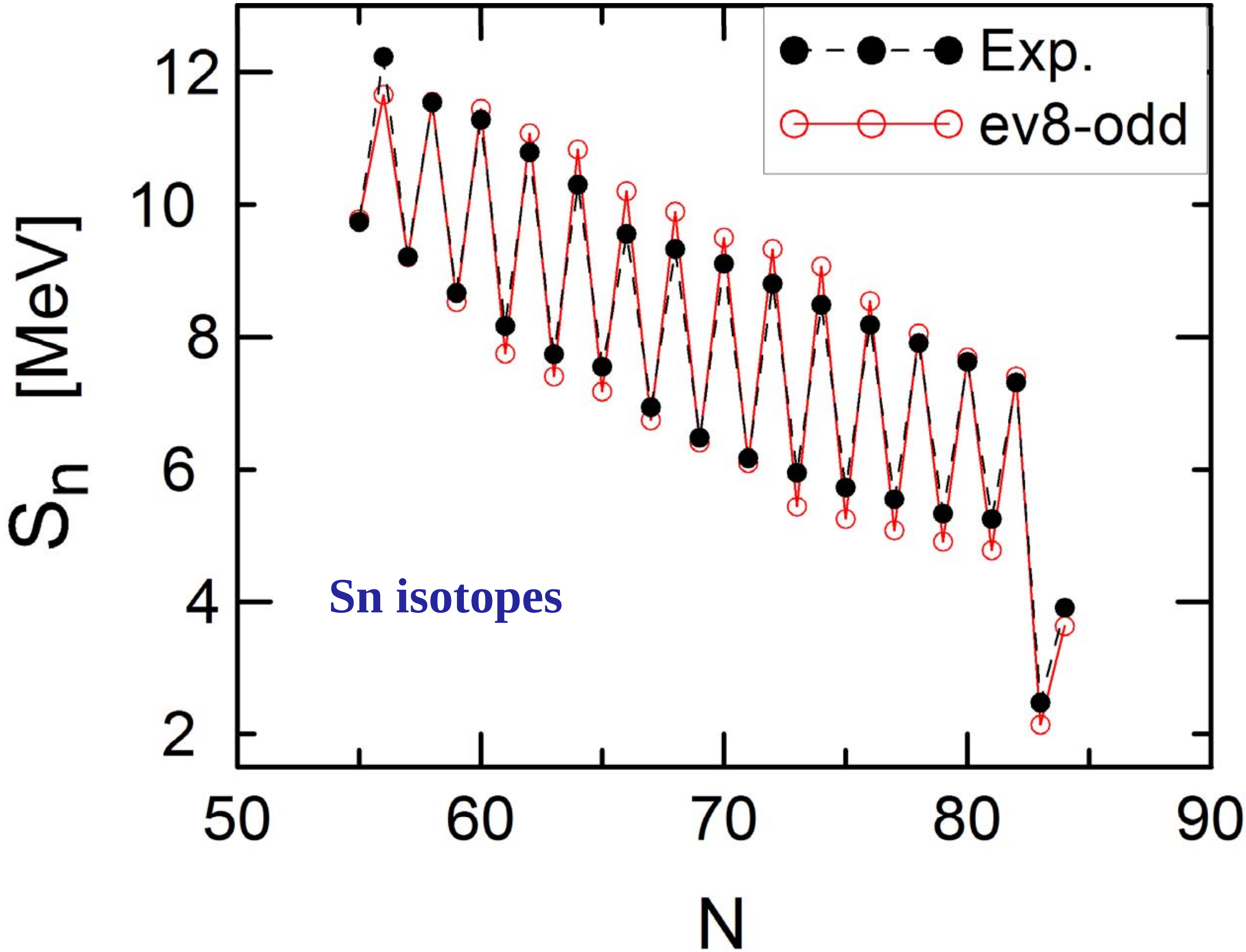
$$\partial^2 B_{\widetilde{E}_{sp}} / \partial N^2$$

$$\approx \partial^2 B_{macro} / \partial N^2$$

Table by Bertsch

Odd-even staggering

$S(N,Z) = M(N\text{-}1,Z) + M_n - M(N, Z)$



Dependence on pairing strength

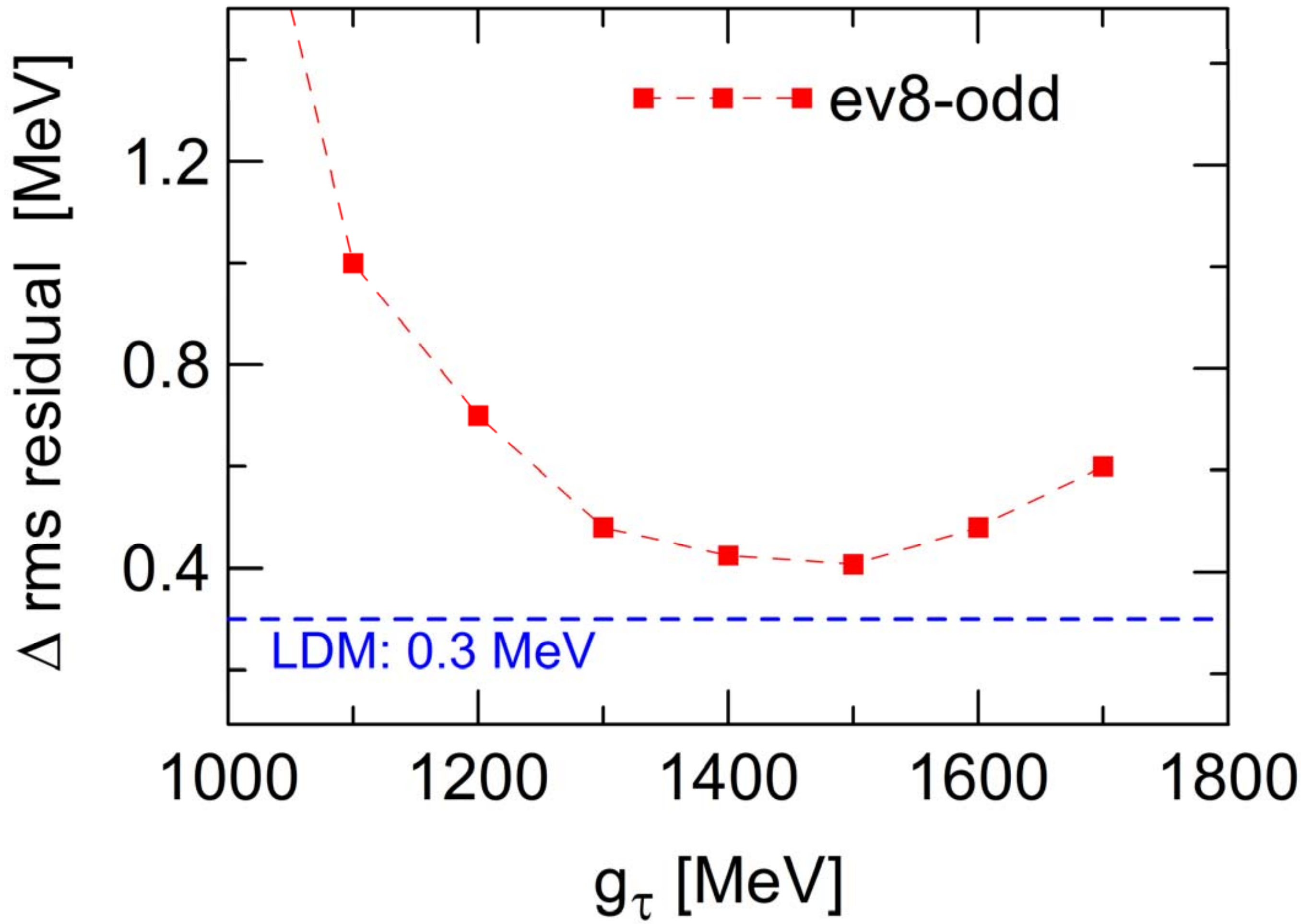
Skyrme = SLy4

$V_{pairing} = g \, . \, \delta(r_{12}) \, . \, [1- \rho(r)/\alpha]$

$\alpha = 0.16 \text{ fm}^{-3}$

search for $g_n = g_p$

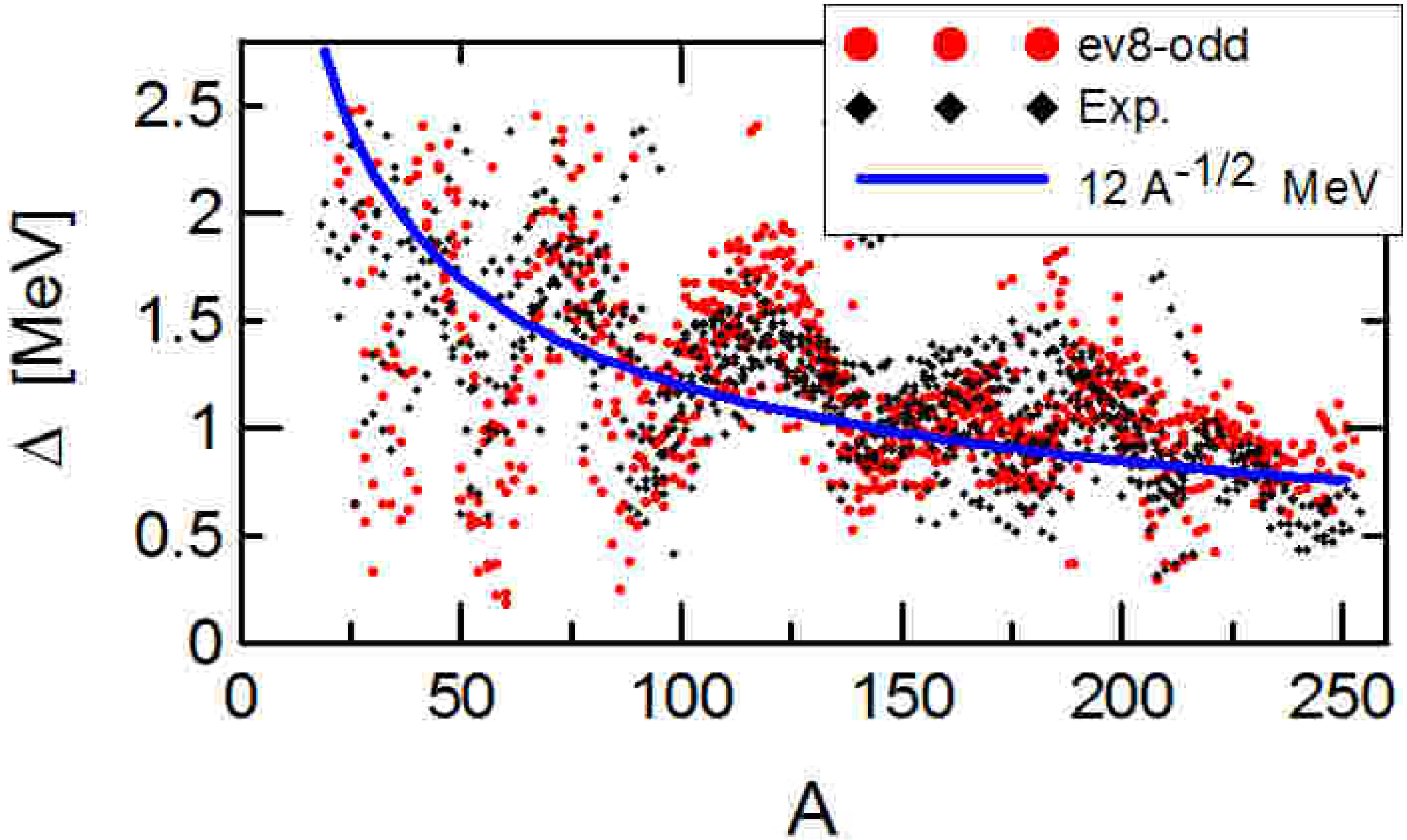
From even-even to even-odd and odd-odd (absolute value):



$$\Delta_{LDM} = \frac{12}{A^{1/2}} \text{ MeV}$$

rms residual for LDM with known exp. data = 0.3 MeV

Odd-even staggering with 967 masses!



Visually, HF-BCS looks like it does better!

True?

Conclusions:

Treatment	rms residual
Liquid Drop	0.28
HF-BCS surface	0.28
HF-BCS volume	0.34
Lipkin-Nogami	0.40
(426 nuclei)	

RMS residuals of $\Delta^{(3)}_o$ *. There are 443 in the data set. Energies are in* MeV.

Treatment	^{59}Ni	^{97}Zr
HF-BCS surface	.-1.09	0.86
HF-BCS volume	-0.69	1.02
Lipkin-Nogami	-.96	1.00

Two extreme cases. Energies are in MeV.

Note: ^{59}*Ni with a starting deformation point is better. But not substantial.*

- Fit to even-Z (to avoid np pairing)
- Require N > Z+1 to avoid Wigner energy
- Surface peaked pairing almost as good as LD
- Volume pairing poorer