Pairing around the neutron drip

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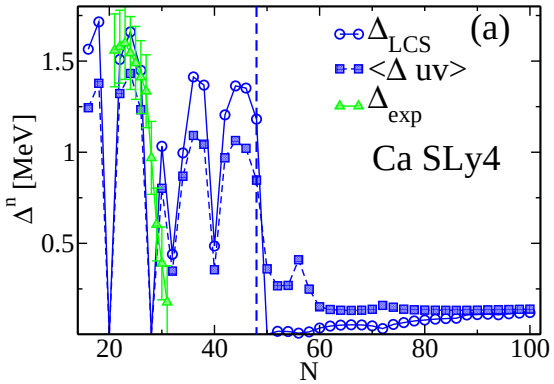
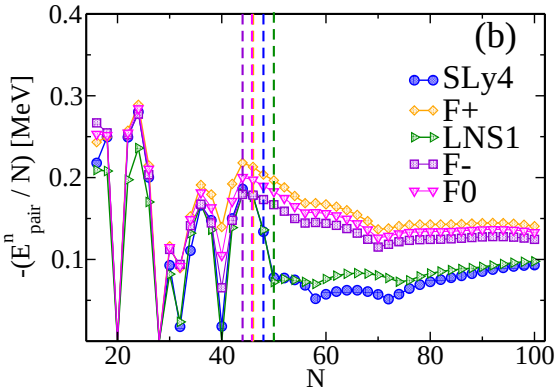
HFB results for nuclei around the neutron drip

Collaboration with Alessandro Pastore, Jerome Margueron, Xavier Viñas

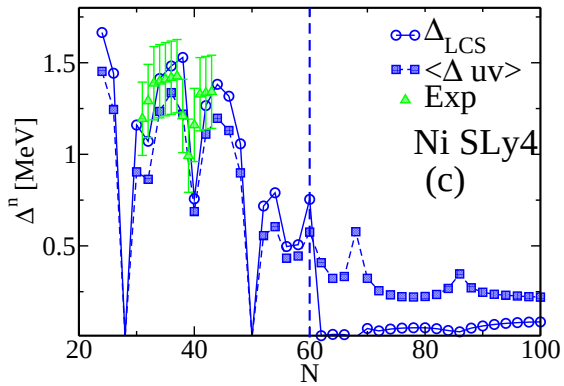
What about pairing around the drip with realistic HFB and BCS calculations?

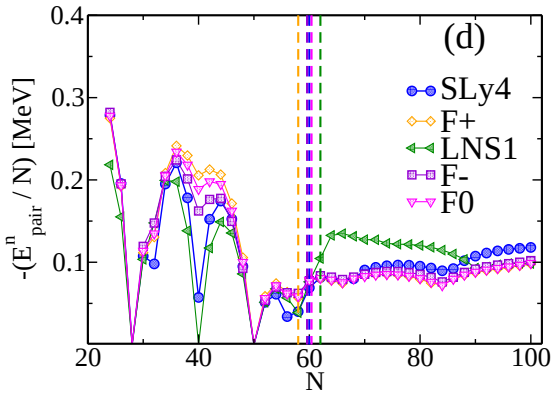
So far spherical nuclei, i.e. proton number closed shell or near closed shell



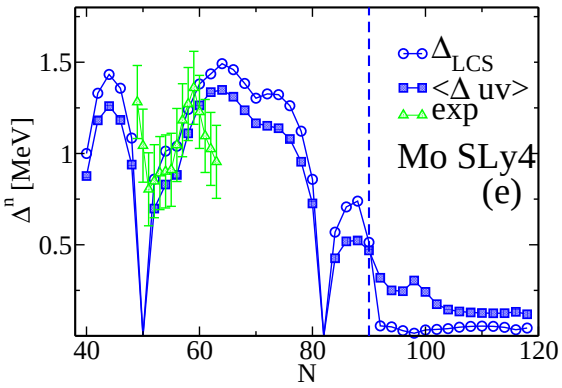


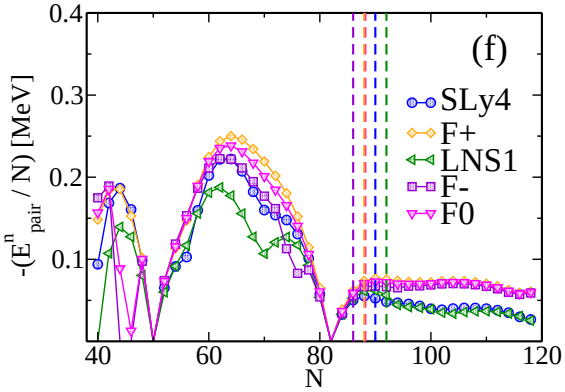
Calcium chain



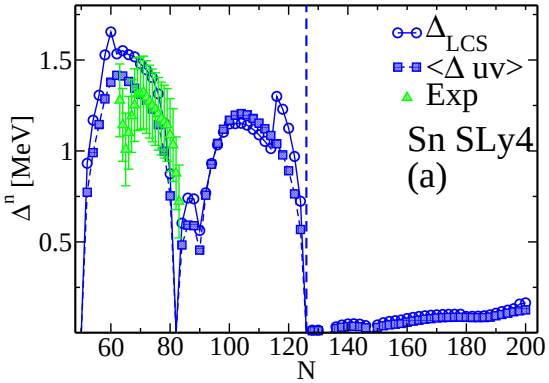


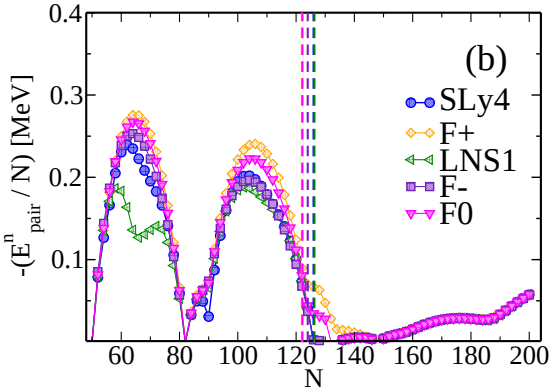
Nickel chain



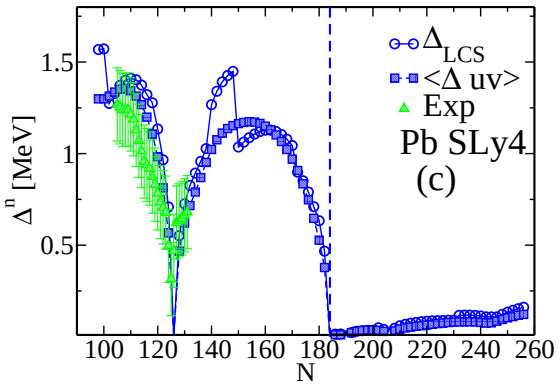


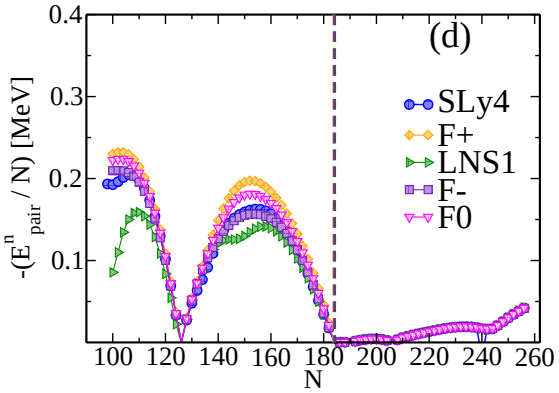
Molybdinum



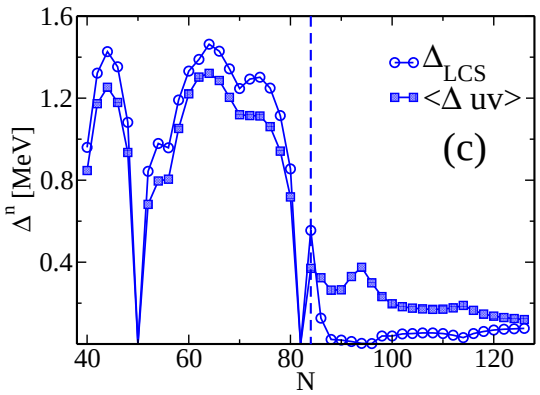


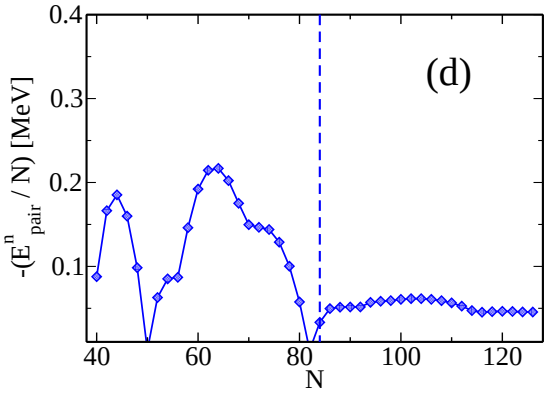
Tin



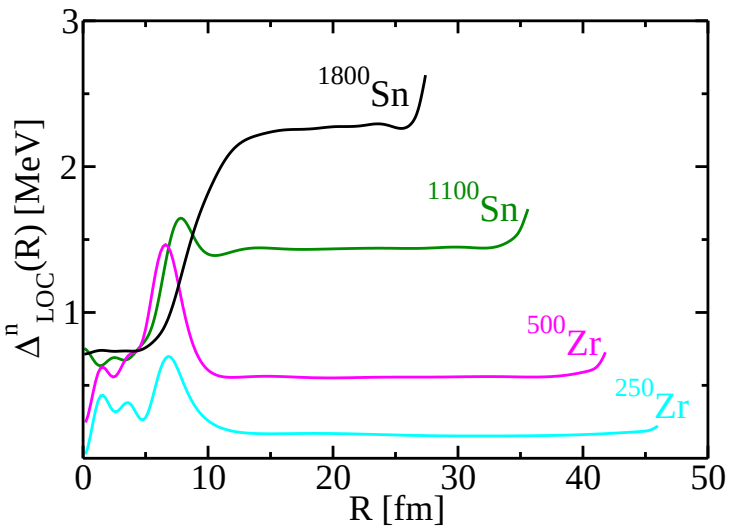


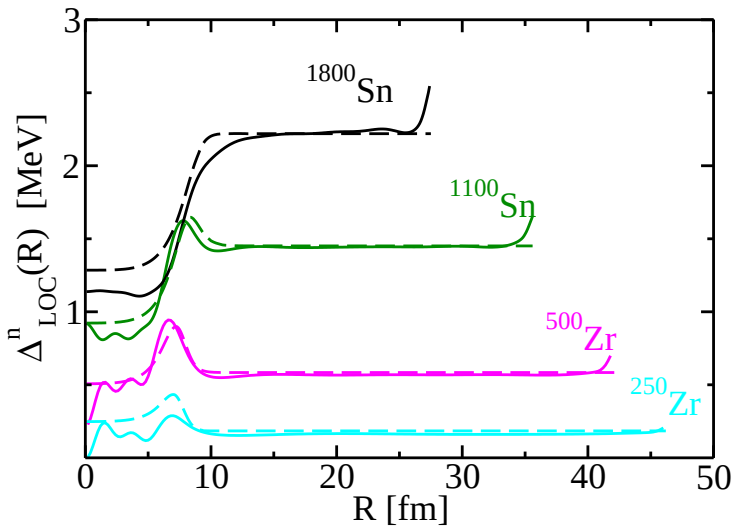
Lead





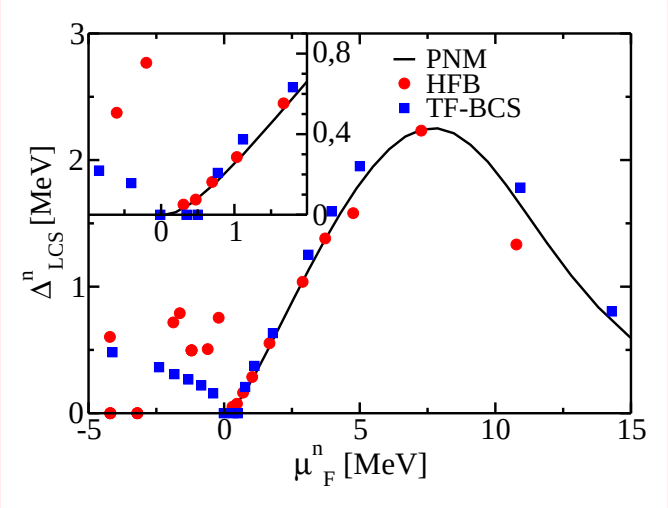
Zirkonium

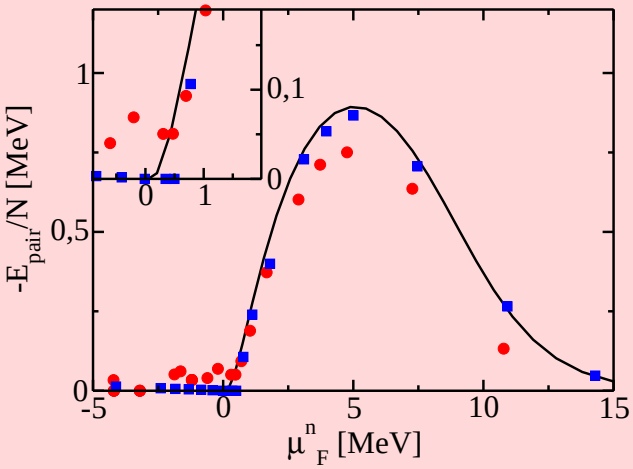




R-dependence of gap in WS cells; HFB and BCS (BCS-TF)

Difference HFB $\leftrightarrow$ BCS quite important





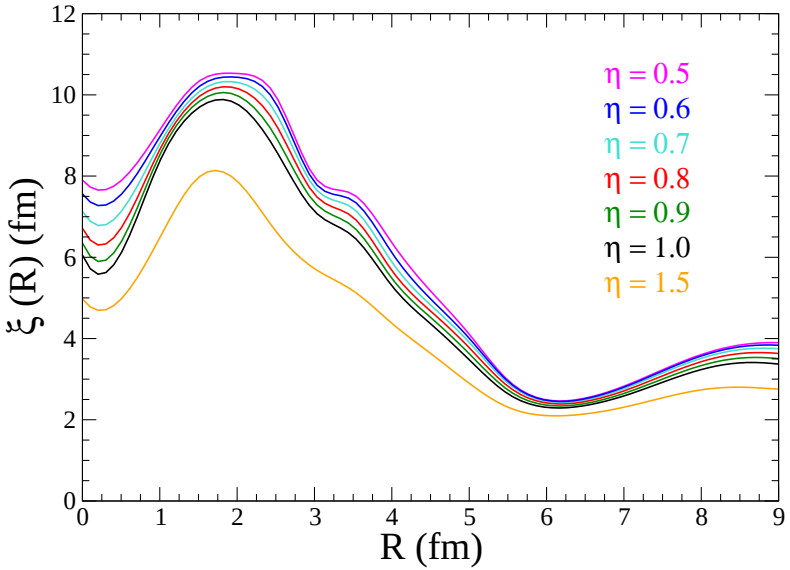
Pairing in Wigner Seitz cells

Conclusion

On average–for spherical nuclei– gaps and, thus, pairing diminish toward the drip line. Prediction of Hamamoto essentially correct.
Nevertheless local fluctuations due to resonances in the continuum under the centrifugal barrier can give quite sizable gaps also close to the drip point.
Situation in deformed nuclei? Task for the future: deformed HFB with continuum.
Also HFB-TF.

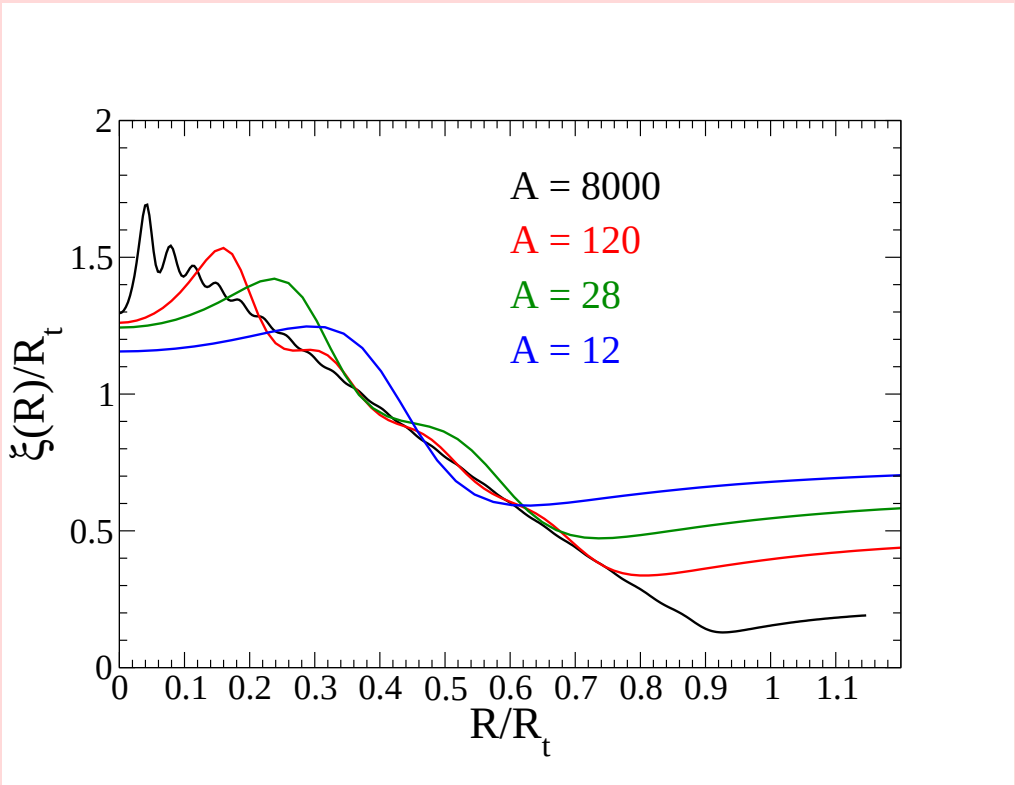
Miscellaneous

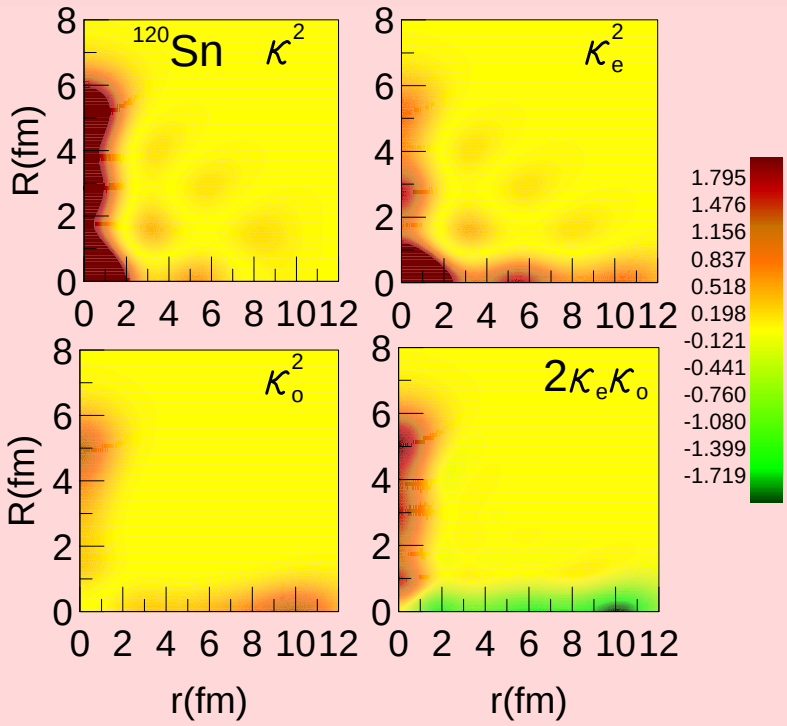
Coherence Length



For η = 0.5, gap is almost zero!

with N. Pillet and X. Viñas


A = 8000
A = 120
A = 28
A = 12
ξ(R)/R_t
R/R_t
0
0.5
1
1.5
2
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1



$$\kappa(\mathbf{r}_1 = \mathbf{R} + \mathbf{r}/2, \mathbf{r}_2 = \mathbf{R} - \mathbf{r}/2) = uv(\mathbf{R}, \mathbf{r})$$

Parity mixing very important for localisation!

with N.Pillet and N. Sandulescu

Self-Consistent particle-particle RPA

$$
\begin{aligned}
Q^+_\alpha &= \frac{1}{2}[\sum_{pp'} X^\alpha_{pp'} c^+_p c^+_{p'} - \sum_{hh'} Y^\alpha_{hh'} c^+_h c^+_{h'}] && (1)\\
|N+2,\alpha\rangle &= Q^+_\alpha |Z\rangle && (2)\\
Q_\alpha |Z\rangle &= 0 && (3)\\
|Z\rangle &= e^{\sum z_{p_1 p_2 h_1 h_2} c^+_{p_1} c^+_{p_2} c_{h_2} c_{h_1}} |\mathrm{HF}\rangle \qquad z = X/Y && (4)
\end{aligned}
$$

Coupled Cluster wave fct. $|Z\rangle \rightarrow |\mathrm{HF}\rangle$: standard RPA.

$$E_\alpha[X,Y] = \frac{\langle Z|[Q,[H,Q^+]]|Z\rangle}{\langle Z|[Q,Q^+]|Z\rangle}$$

Minimisation gives very good results for excited and ground state!
standard RPA: N=2: $E_\alpha \propto \sqrt{1-G}$
SCRPA: N=2: $E_\alpha \propto \sqrt{1+G}$
Screening has turned sign of G !! **Exact result!**
Single particle level density $\rightarrow$ **Pseudogap**
Ann.Physics 296(2002)187, J. Dukelsky, J. Hirsch et al.

Open problems

Finite nuclei: **particle number projection**
polarisation and screening effects
Three body force
severe problems because of extreme sensitivity of pairing to interaction
pp-superfluidity in two proton decay

THANK YOU!