Progress report for $71 \leq Z \leq 79$ odd-Z nuclei

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Contents

- Current progress for odd-Z nuclei (from $_{71}$Lu to $_{79}$Au)
- Comparison of the odd-Z nuclei with experimental data and RCHB
- Properties of odd-Z nuclei

Nuemrical conditions and progress of odd-Z nuclei

- Nuclei: Odd-Z $_{71}$Lu, $_{73}$Ta, $_{75}$Re, $_{77}$Ir, and $_{79}$Au isotopes
- Version: `Code_DRHBc_202112`
- Box size: $R_{\rm box} = 20$ fm
- Mesh size: $\Delta r = 0.1$ fm
- Energy cutoff: $E_{\rm cut} = 300$ MeV
- Angular momentum cutoff: $J_{\rm max} = 23/2\ \hbar$ (jmx=12 in paramet.for)
- Legendre expansion order: $\lambda_{\rm max} = 8$ (mlb=5 in paramet.for)
- Relativistic density functional: PC-PK1
- Pairing strength: -325.0 MeV $\cdot$ fm^3
- Initial deformations: $\beta = -0.4, -0.3, -0.2, -0.1, 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6$, and so on
- Blocking procedure: Automatic blocking procedure

- All the ground states of odd-Z nuclei have been determined by checking the potential energy curves of each nucleus.

Progress of odd-Z nuclei

Proton drip line ($71 \leq Z \leq 80$)

X. Xia *et al.*, ADNDT **121**, 1 (2024).
P. Guo *et al.*, ADNDT **158**, 101661 (2024).

	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg
DRHBc	83	81	86	83	88	87	92	91	98*	92
RCHB	84	81	86	83	88	85	90	88	91	90

Neutron drip line ($71 \leq Z \leq 80$): 184

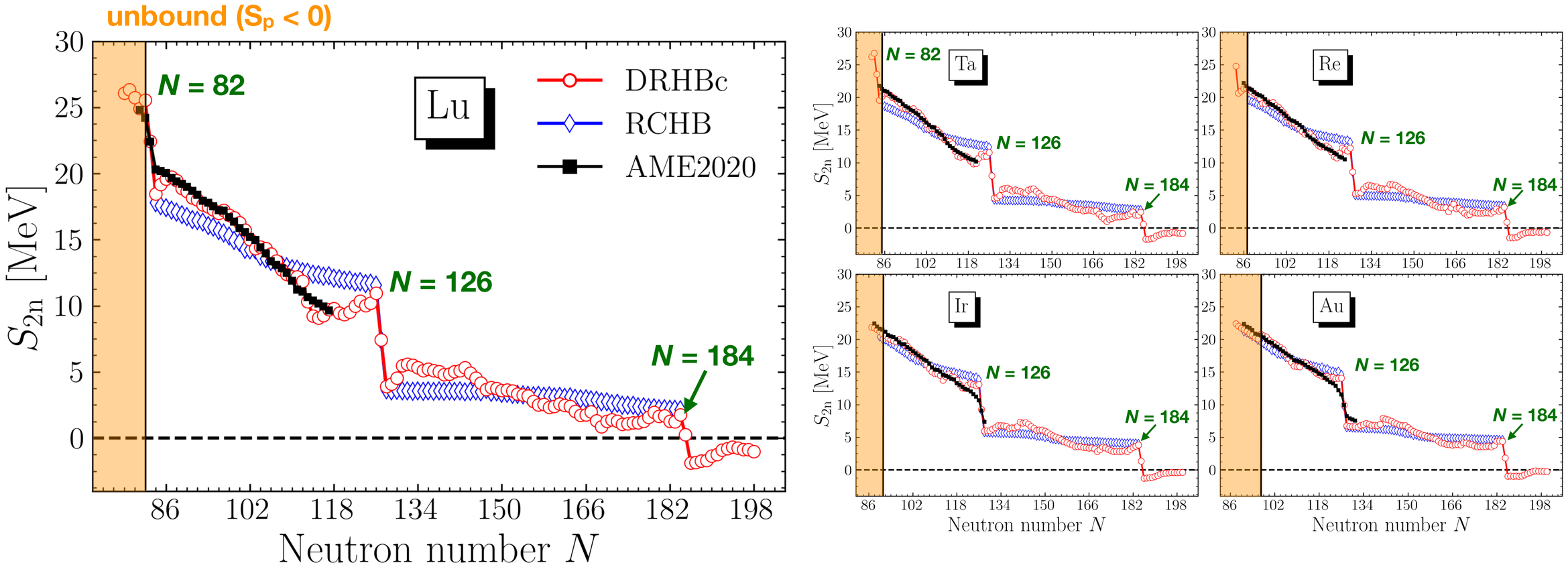
*Constrained by binding energies of Pt isotopes

Part of data table of Au isotopes

A	N	$E_{\mathrm{b}}^{\mathrm{Cal}}$ (MeV)	$E_{\mathrm{b+rot}}^{\mathrm{Cal}}$ (MeV)	E_B^{Exp} (MeV)	S_{2n} (MeV)	S_{2p} (MeV)	S_n (MeV)	S_p (MeV)	λ_{n} (MeV)	λ_{p} (MeV)	$m^{\pi}(N)$	$m^{\pi}(P)$
165	86	1258.70	1258.70			−1.29		−1.67	−11.287	0.74		1/2+
166	87	1269.12	1270.26			−1.15	10.42	−1.50	−11.303	0.15	5/2−	1/2−
167	88	1281.09	1282.19		22.39	−0.67	11.97	−1.20	−11.112	−0.088		1/2−
168	89	1291.13	1292.37	1291.584	22.02	−0.62	10.05	−1.21	−11.026	0.50	1/2−	11/2−
169	90	1302.82	1304.33	1304.004	21.73	−0.15	11.69	−0.90	−10.850	0.20		11/2−
170	91	1312.64	1314.10	1314.100	21.51	0.02	9.82	−0.76	−10.634	0.02	1/2−	11/2−
171	92	1324.06	1325.67	1325.952	21.24	0.48	11.41	−0.52	−10.558	−0.202		11/2−
172	93	1333.54	1335.00	1335.779	20.90	0.73	9.49	−0.36	−10.339	−0.366	3/2−	11/2−
173	94	1344.69	1346.47	1347.365	20.64	1.17	11.15	−0.16	−10.256	−0.616		11/2−
174	95	1353.79	1355.59	1356.678	20.25	1.22	9.10	−0.33	−10.150	−0.842	5/2−	11/2−
175	96	1364.77	1367.18	1368.079	20.07	1.63	10.97	−0.15	−10.116	−2.087		1/2+
176	97	1374.57	1376.26	1377.268	20.78	1.99	9.81	−0.05	−10.269	−0.588	5/2+	3/2−
177	98	1385.31	1387.42	1388.364	20.54	2.45	10.74	0.19	−10.160	−0.793		3/2−

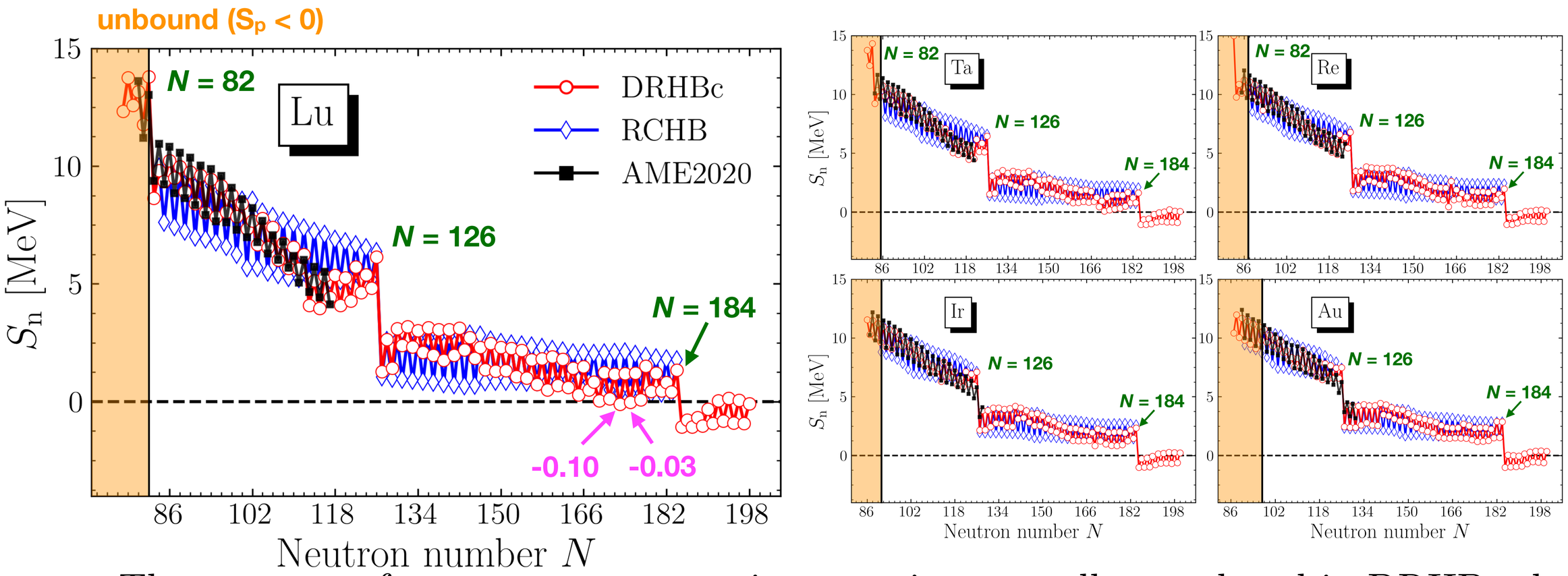
- The proton drip line for $71 \leq Z \leq 79$ odd-Z nuclei is determined by the one-proton separation energies.

Comparisons of odd-Z nuclei



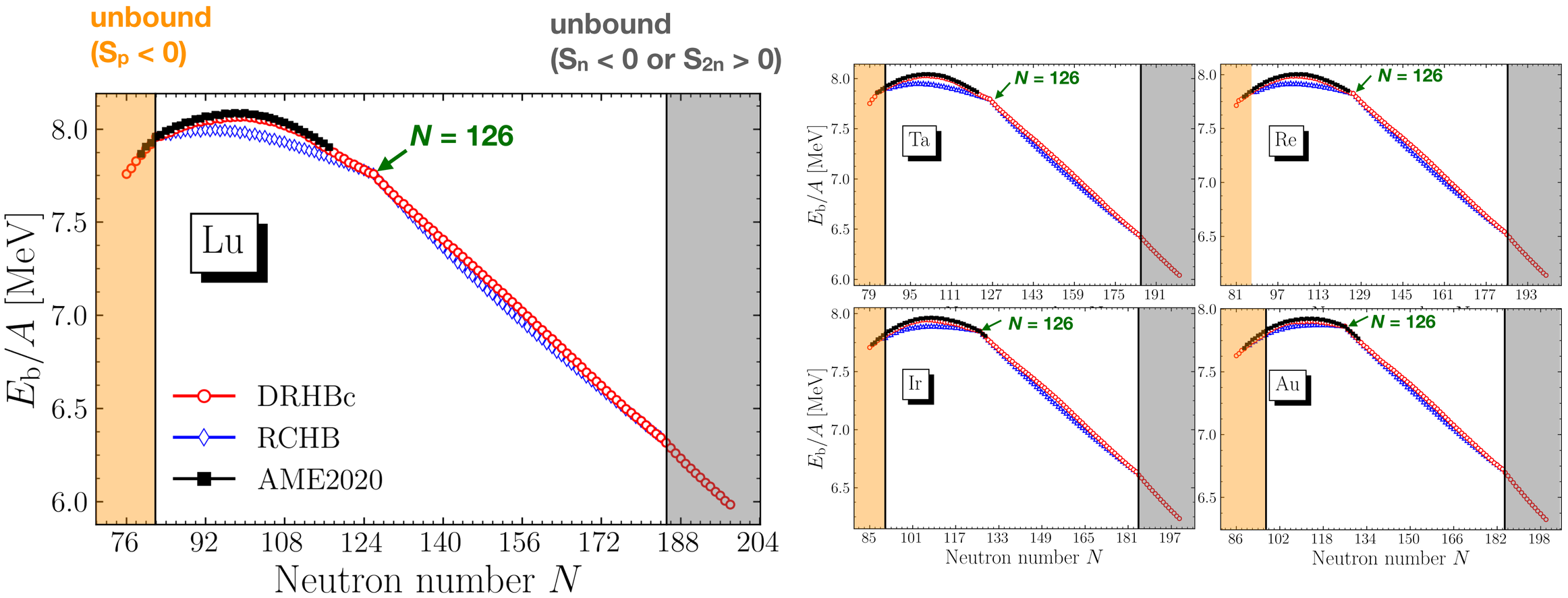
- Two-neutron separation energies with DRHBc theory well predict experimental data.

Comparisons of odd-Z nuclei



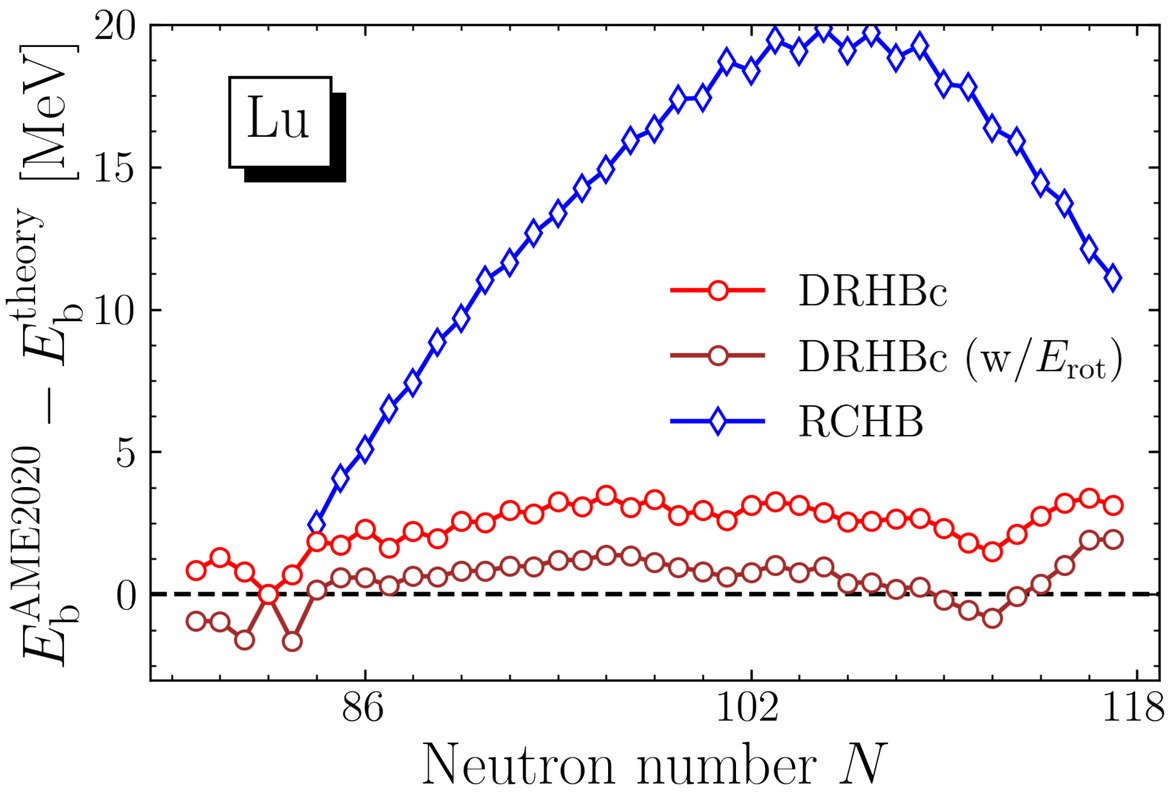
- The patterns of one-neutron separation energies are well reproduced in DRHBc theory.
- The one-neutron separation energies of ^{244}Lu and ^{246}Lu are less than 0.
- The nuclei with $N > 184$ are unbound (even-Z nuclei also).

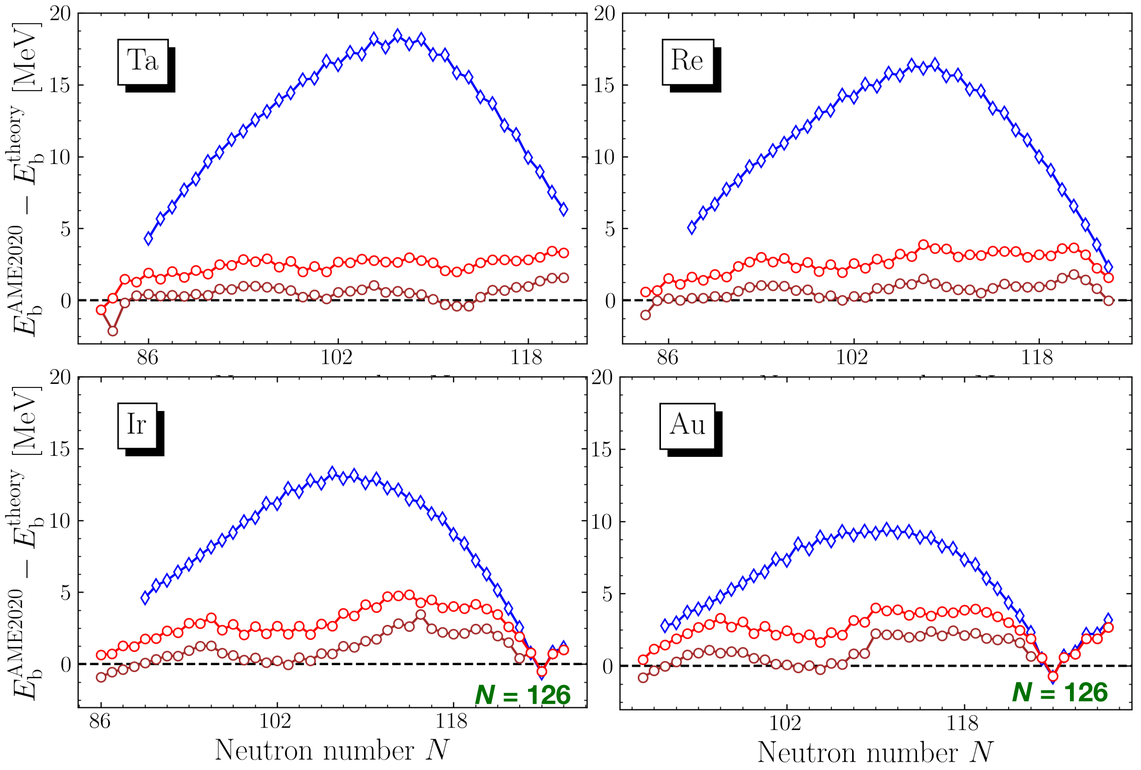
Comparisons of odd-Z nuclei



- The binding energies described by DRHBc show less discrepancy with the experimental data than those by RCHB.

Comparisons of odd-Z nuclei

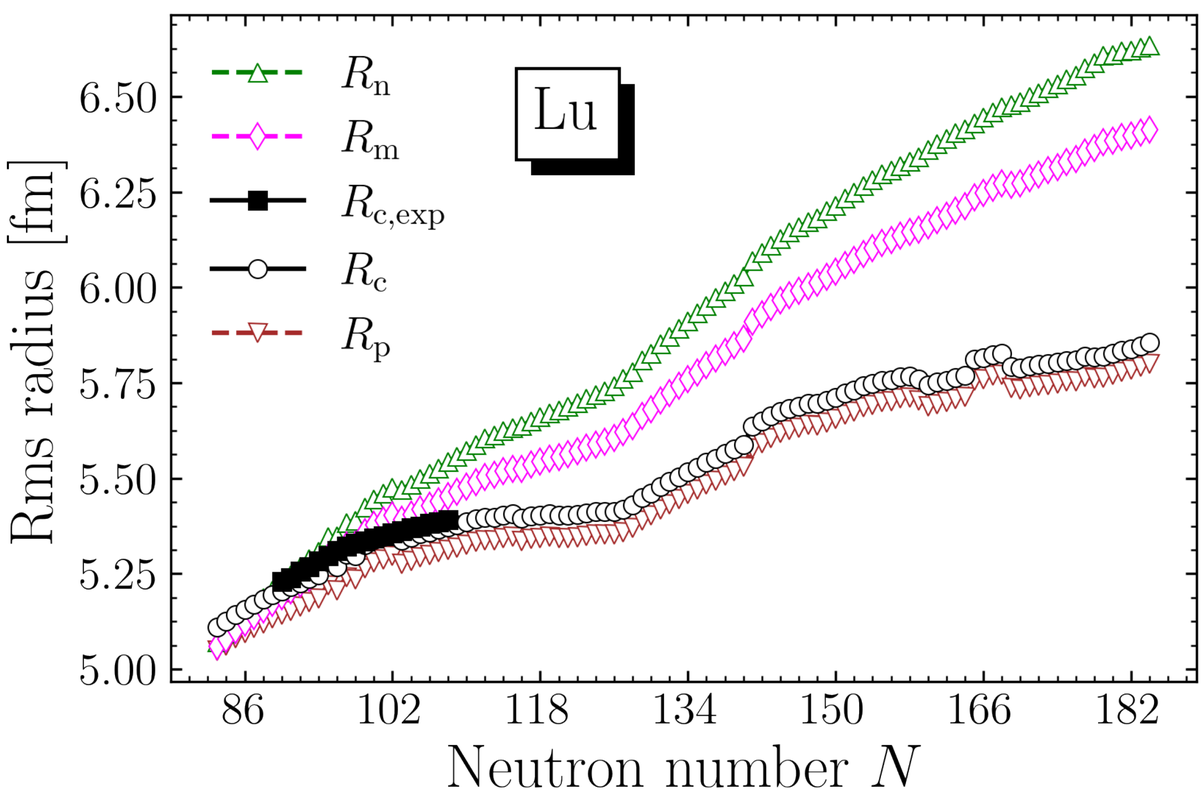


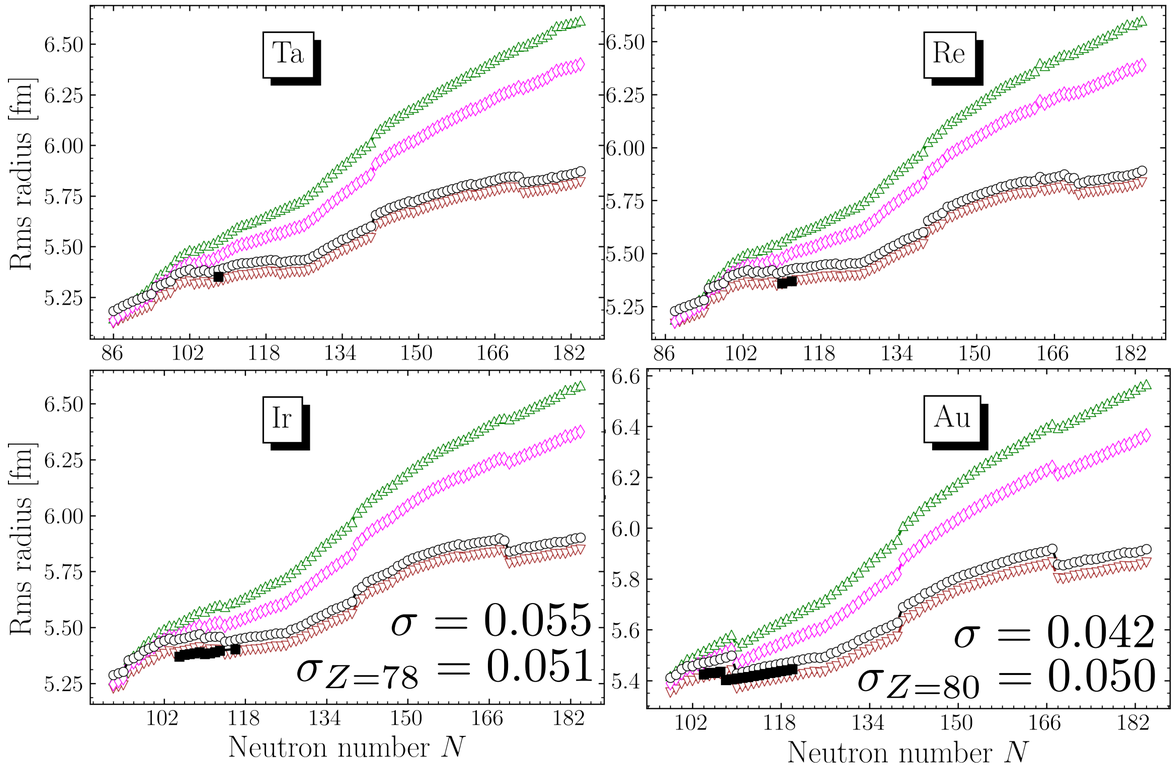


rms deviation

σ [MeV]	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Pt
$E_{\rm b}$	2.55	2.90	2.44	3.00	2.72	3.51	2.98	3.53	2.74	2.96
$E_{\rm b+rot}$	0.95	0.85	0.790	0.89	0.87	1.47	1.45	1.71	1.42	1.22

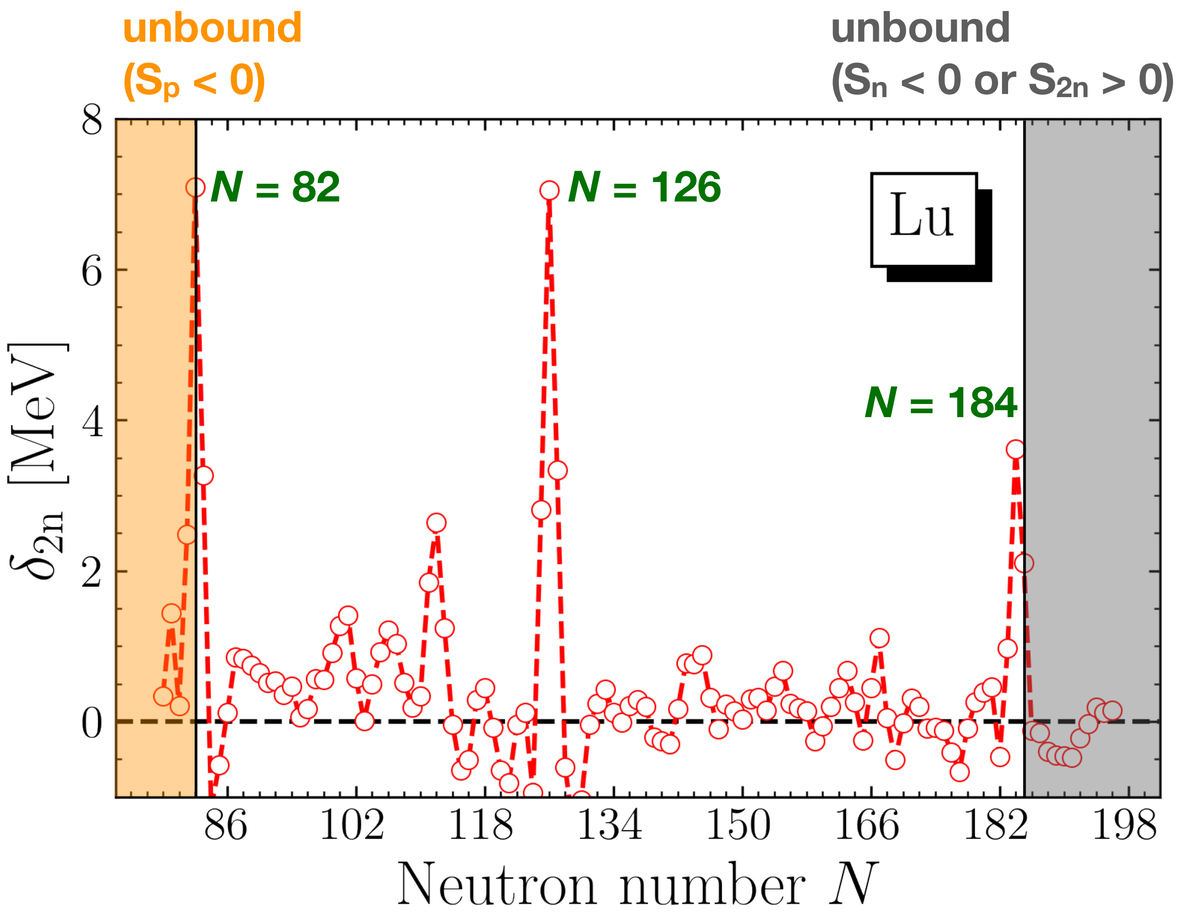
Properties of odd-Z nuclei

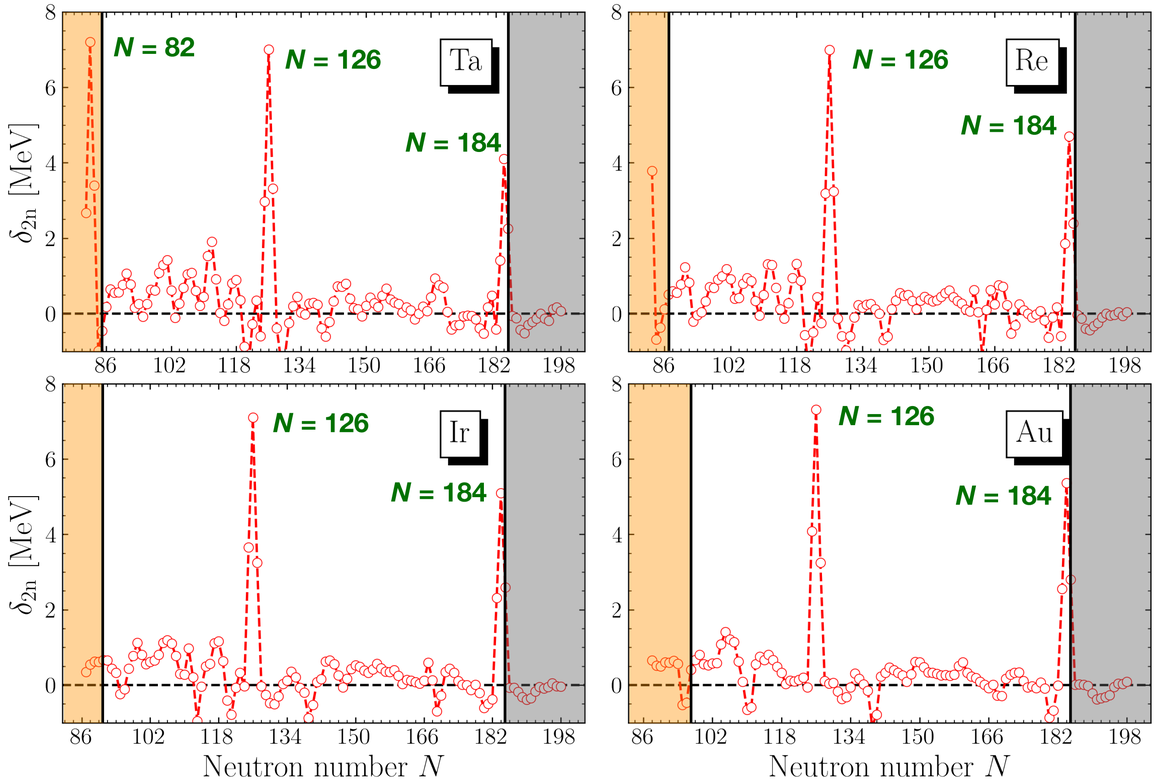




- For Lu isotopes, predicted R_c values are larger than experimental data.
- However, For Ir and Au isotopes, predicted R_c values are smaller than experimental data.

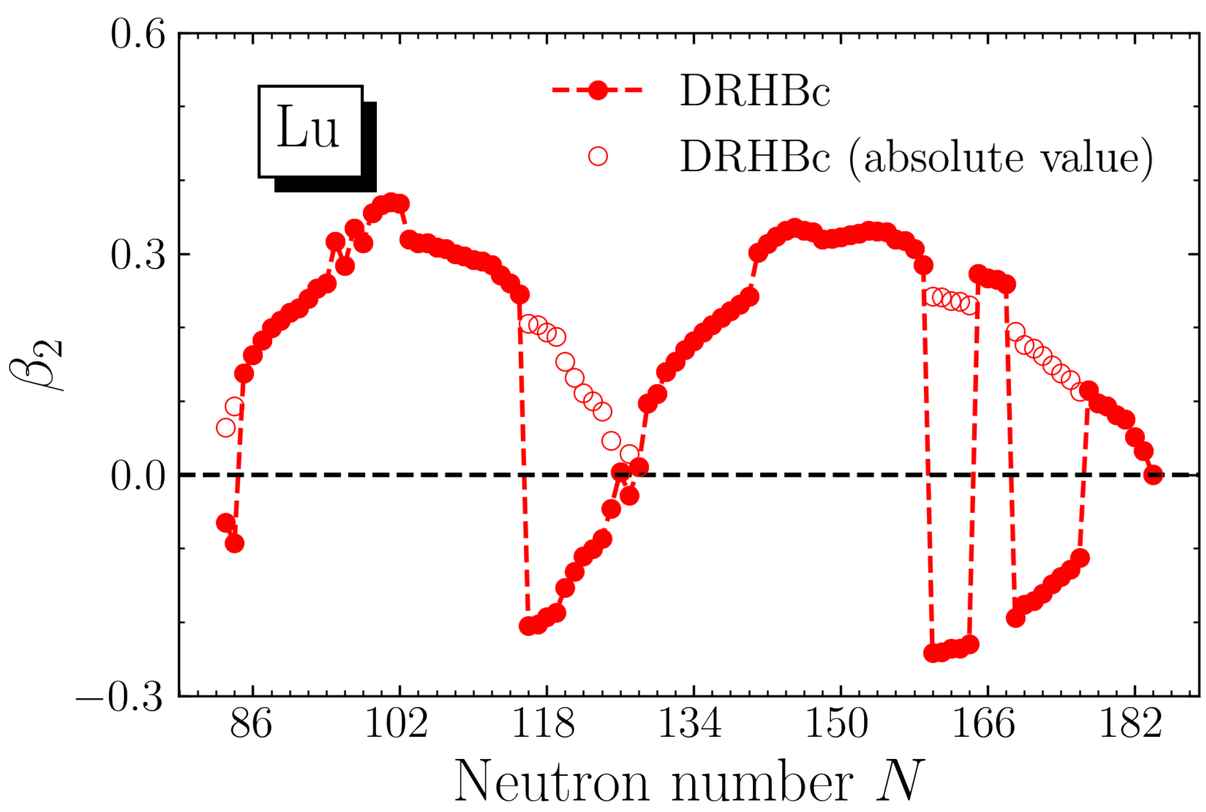
Properties of odd-Z nuclei

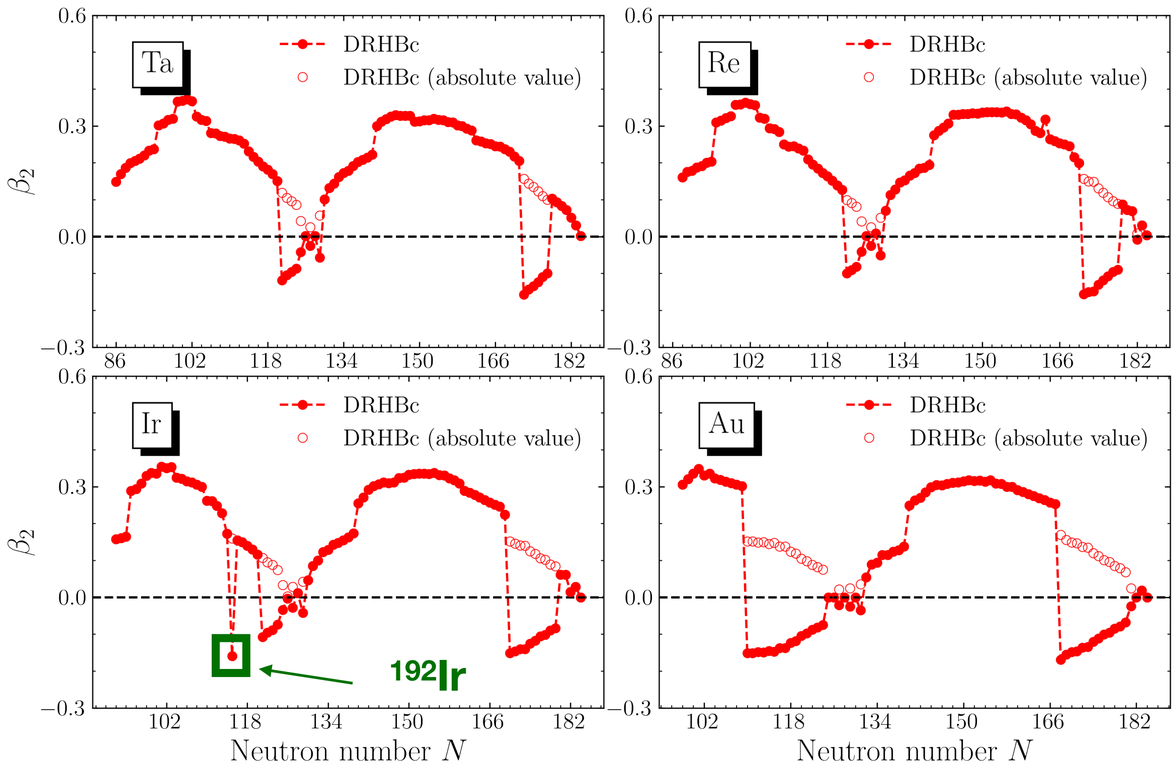




- The nuclei with neutron magic number are also stable in odd-Z nuclei.

Properties of odd-Z nuclei

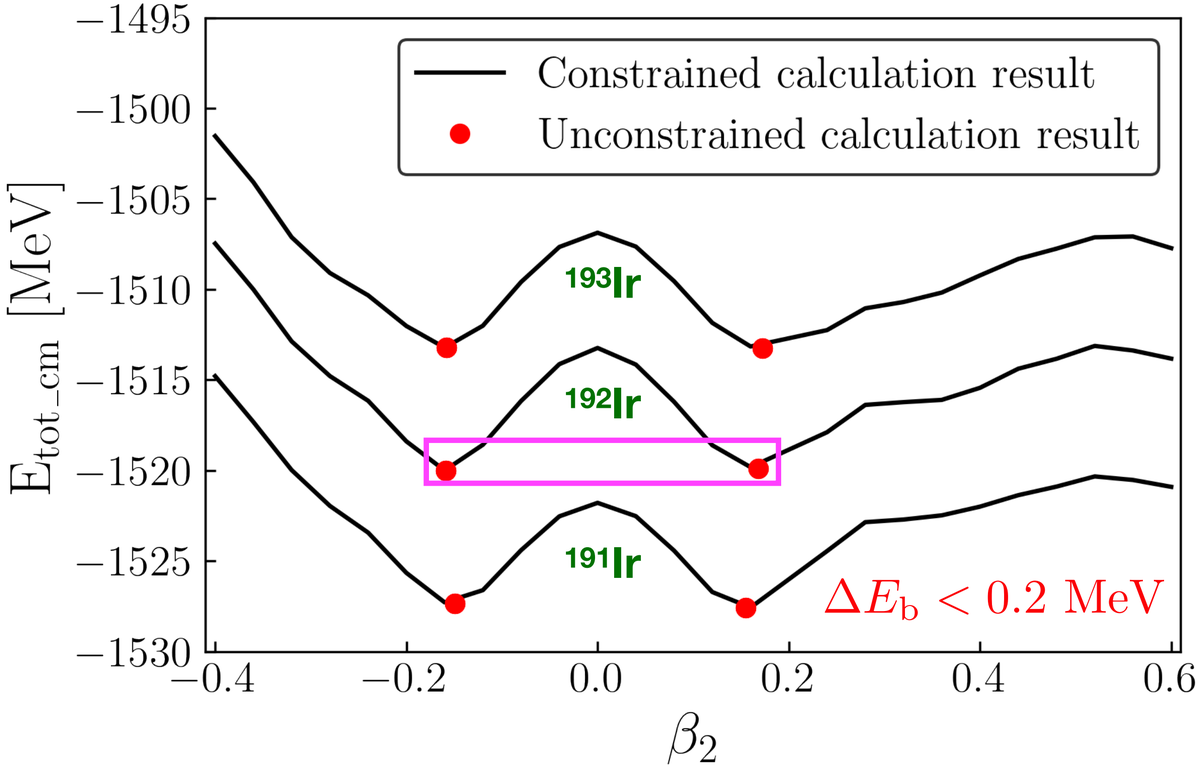


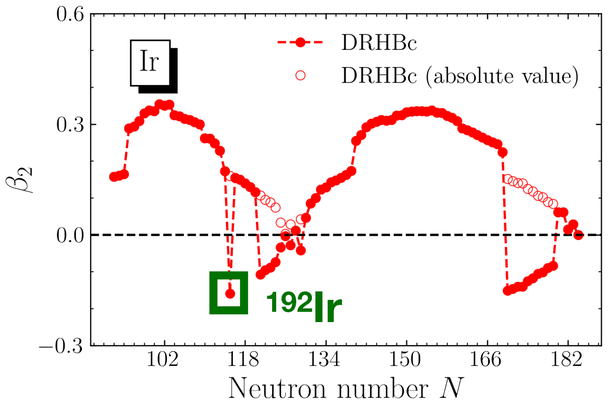


- Ubrupt Changes of nuclear shapes are related to shape coexistence.

Properties of odd-Z nuclei

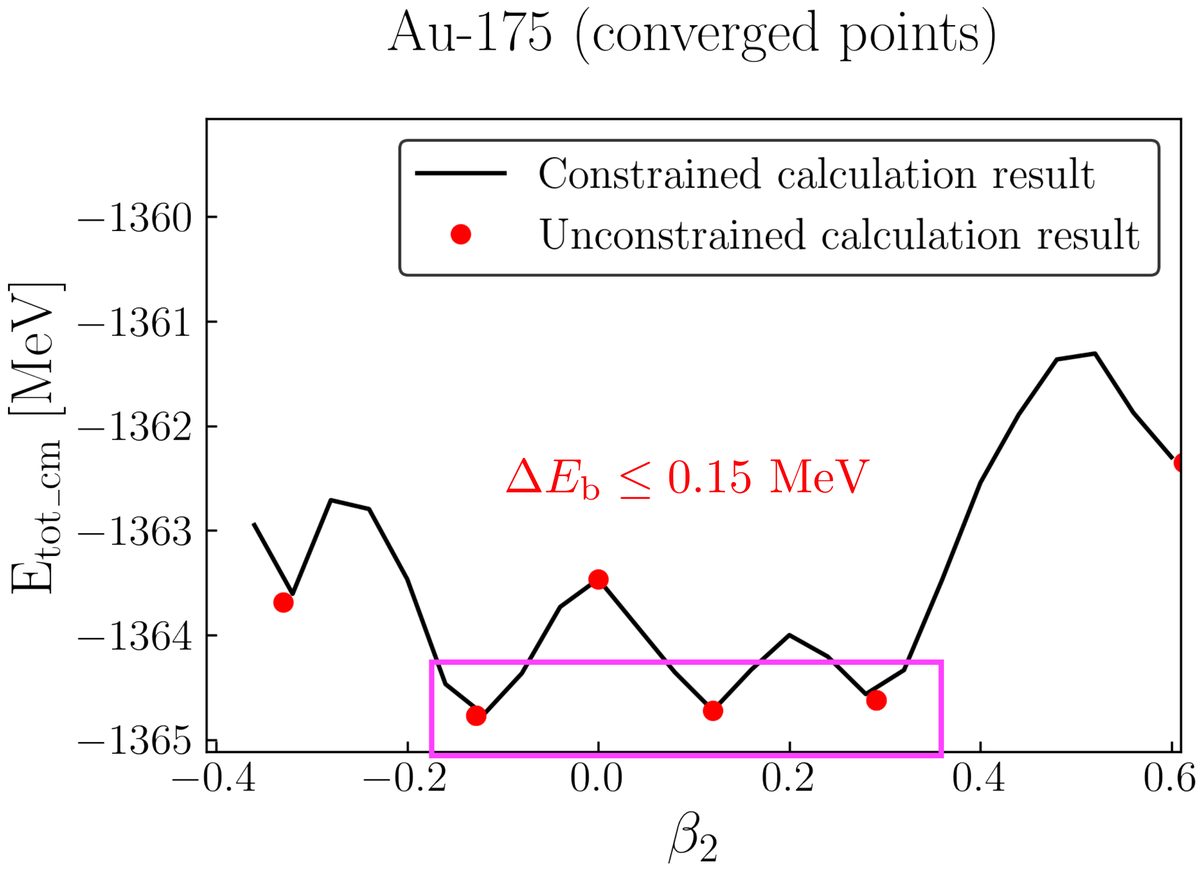
Potential energy curves

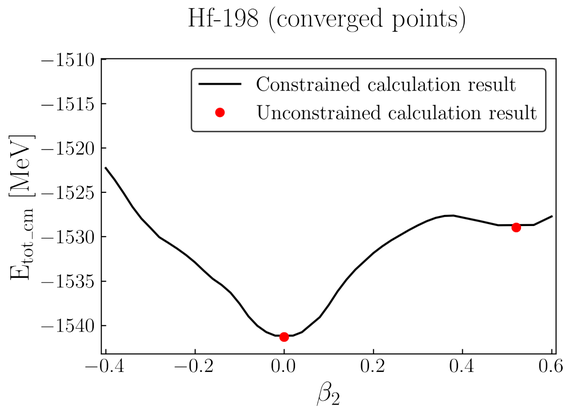


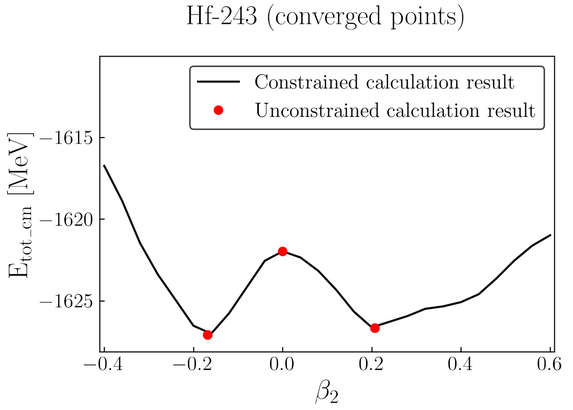


- The ^{192}Ir isotope exhibits the shape coexistence with $\Delta E_{\mathrm{b}} < 0.2$ MeV.

Properties of odd-Z nuclei

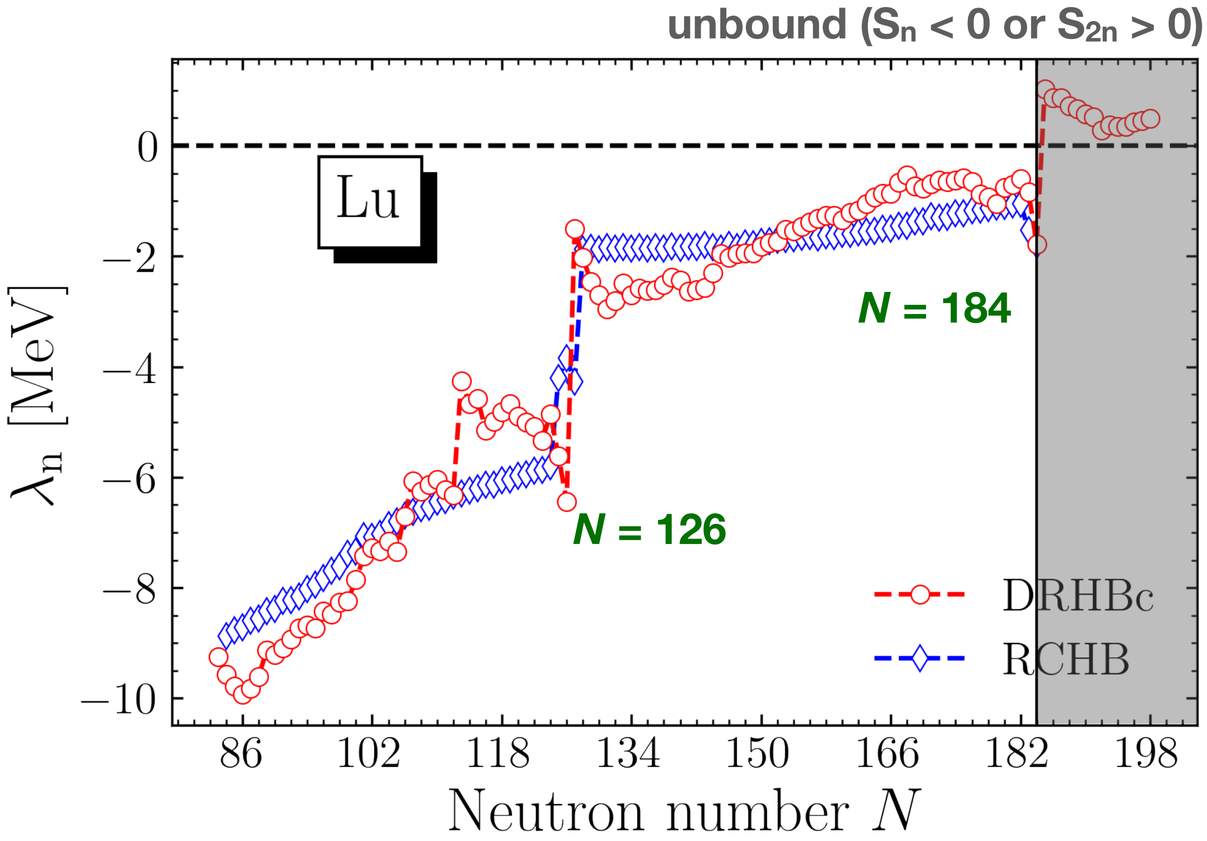


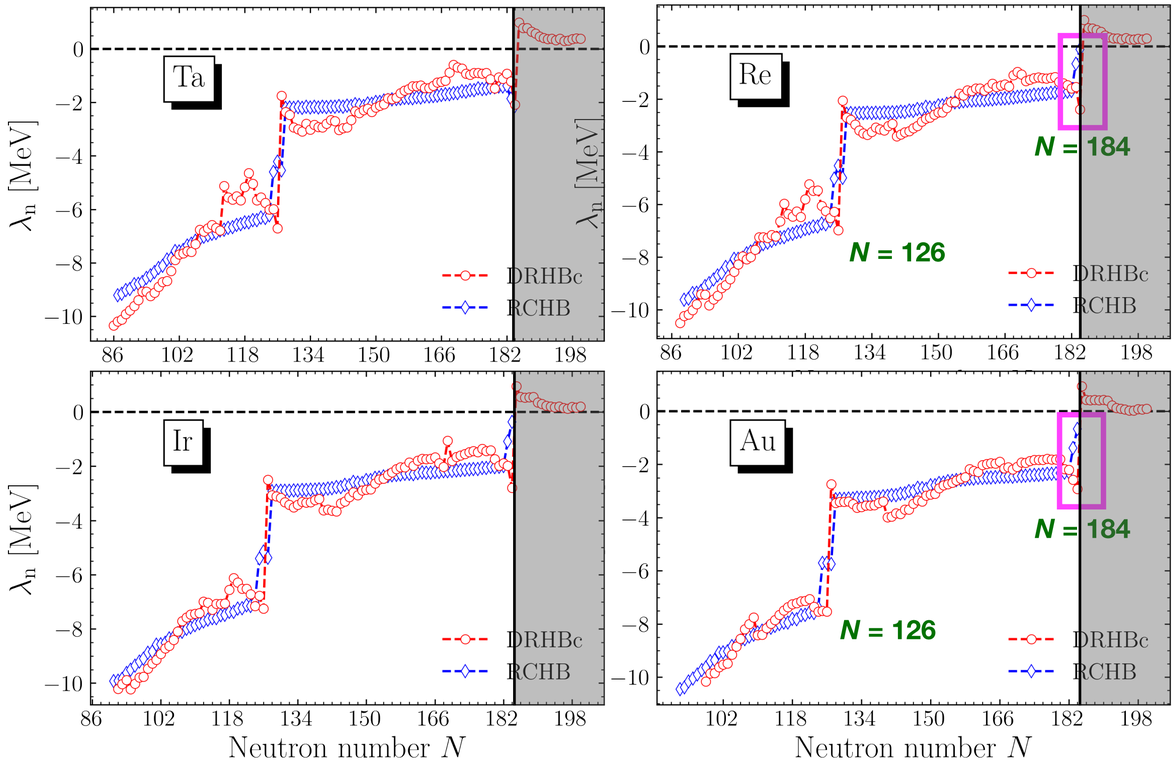




- There is new type of PEC in Au isotopes.

Properties of odd-Z nuclei





- At the magic number, neutron Fermi surface is low.
- The results from DRHBc show consistent in neutron drip line.

Summary

- The ground states of $71 \leq Z \leq 79$ odd-Z (about 500) bound nuclei have been determined.
- Some of the calculation results of odd-Z nuclei were compared with experimental data and RCHB.
- The results from DRHBc describe the experimental data qualitively well.

Thank you for your attention!