Proton Emission Half-lives and Shape Coexistence for $71 \leq Z \leq 83$ Odd-Z Nuclei

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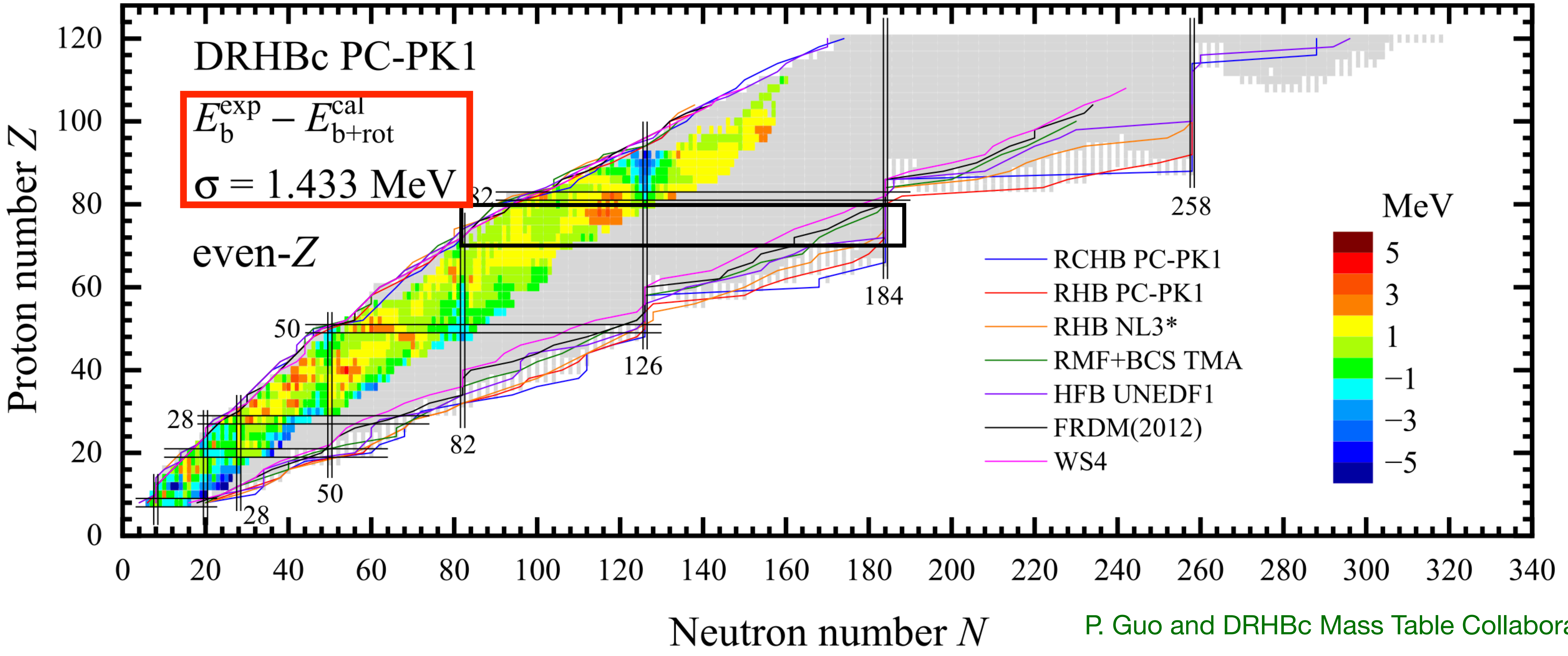
Motivation

Deformed **R**elativistic **H**artree-**B**ogoliubov theory in **c**ontinuum

DRHBc mass table project: to describe the ground states of nuclei with $Z \geq 8$



Model	DF	$\sigma(E_b)$
DRHBc$^{w/o}$ E_{rot}	PC-PK1	**2.562**
DRHBc$^{w/}$ E_{rot}	PC-PK1	**1.433**
RCHB	PC-PK1	8.082
RMF+BCS	TMA	2.063
HFB	SkM*	7.248
HFB	SLy4	5.275
HFB	SV-min	3.391
HFB	UNEDF1	1.934

P. Guo and DRHBc Mass Table Collaboration, Atomic Data and Nuclear Data Tables **158** 101661 (2024).

- DRHBc mass table project to describe ground states of nuclei with axial symmetry has begun in 2018 (Preliminary study RCHB was made in 2016).

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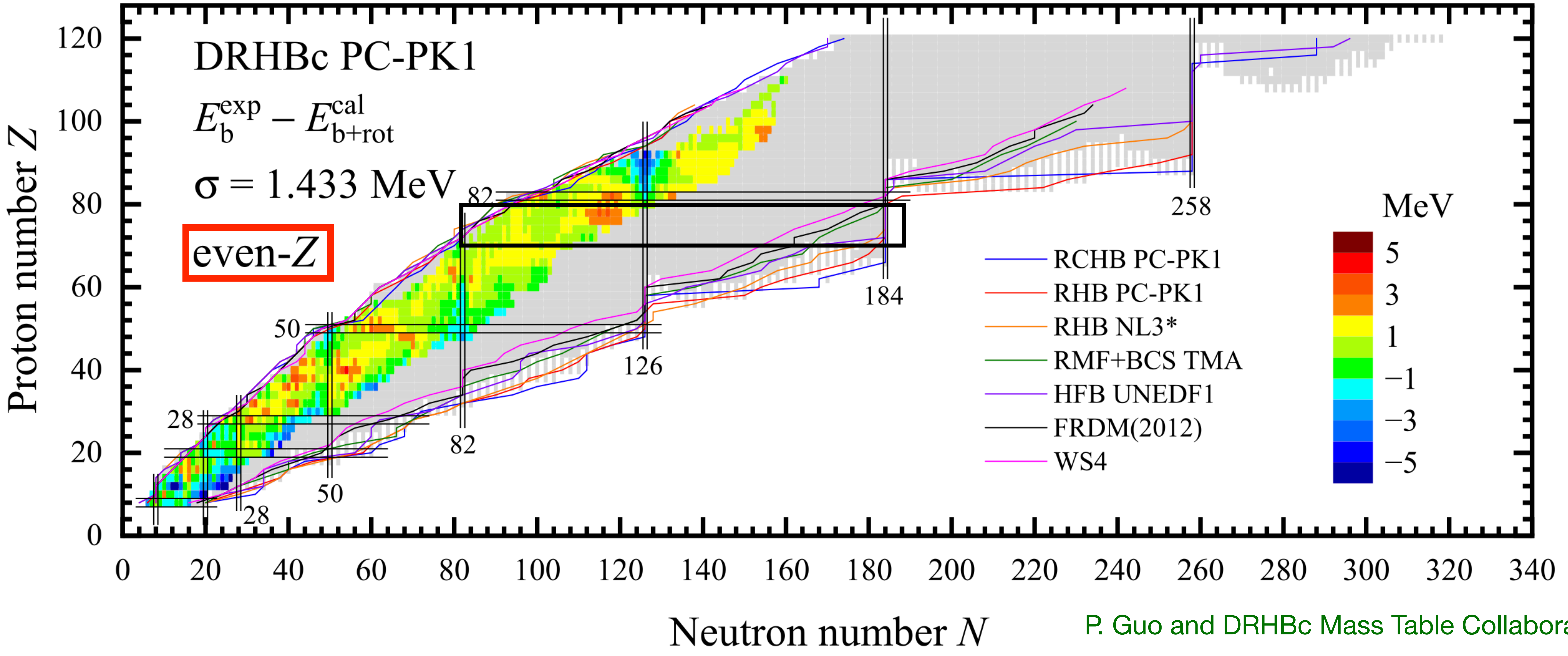

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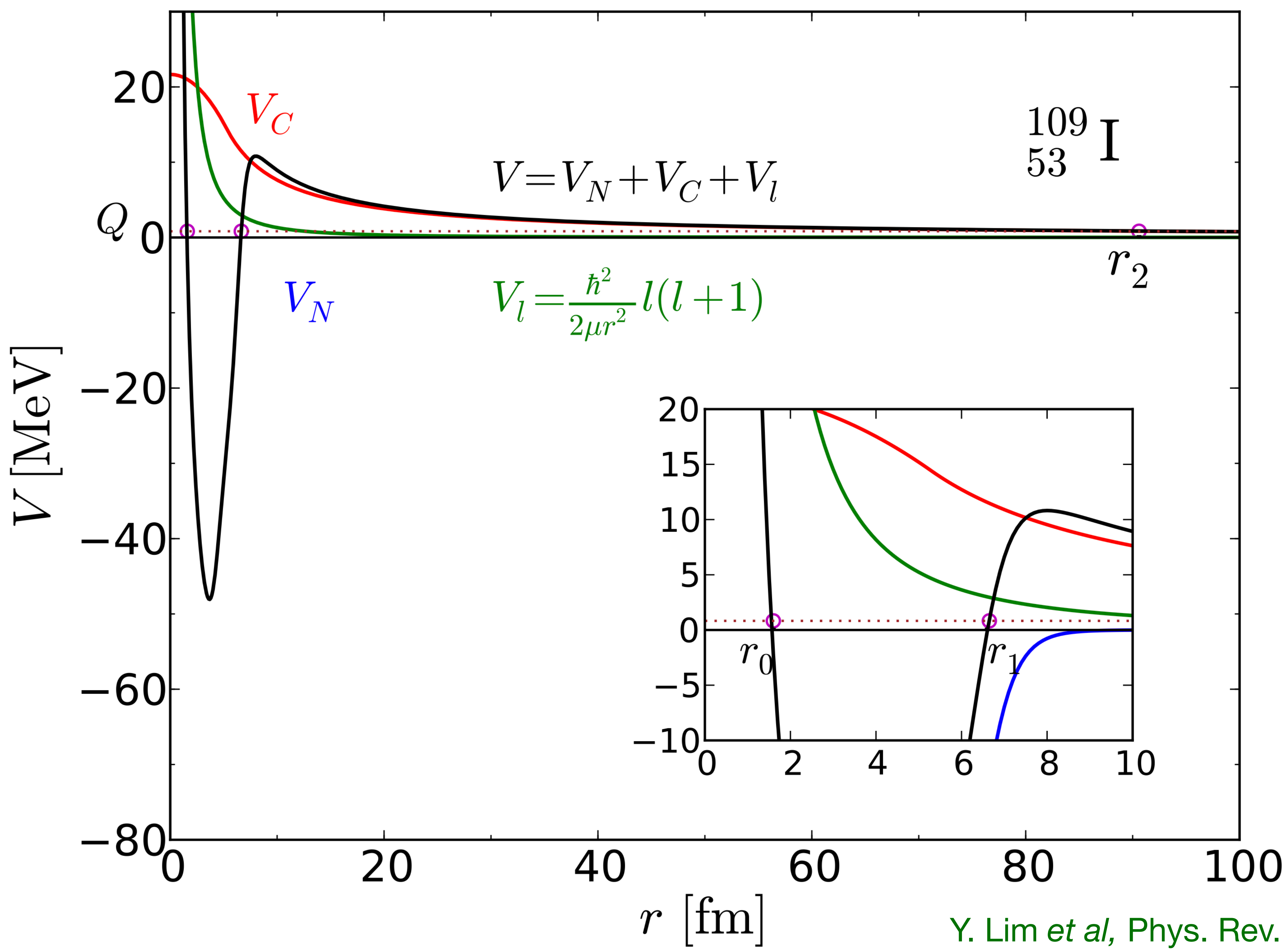
- To better understand nuclear structure of exotic nuclei, further investigation is necessary.
- The main motivation is to study how nuclear deformation and shape coexistence affect proton emission half-lives.

Method: WKB approximation



Y. Lim *et al,* Phys. Rev. C **93**, 014314 (2016).

$$T_{1/2} = \hbar \ln 2/(S_{\mathrm{p}}\Gamma)$$

$$S_{\mathrm{p}} \simeq 1 - \langle \Psi_{\mathrm{d}} | \hat{N}_{nlj} | \Psi_{\mathrm{d}} \rangle$$

X.-X. Sun and S.-G. Zhou, Sci. Bull. 66, 2072 (2021).

nonoccupation probability for the corresponding orbital of the daughter nucleus

$$\Gamma = N_{\mathrm{f}} \frac{\hbar^2}{4\mu} P_{\mathrm{total}}$$

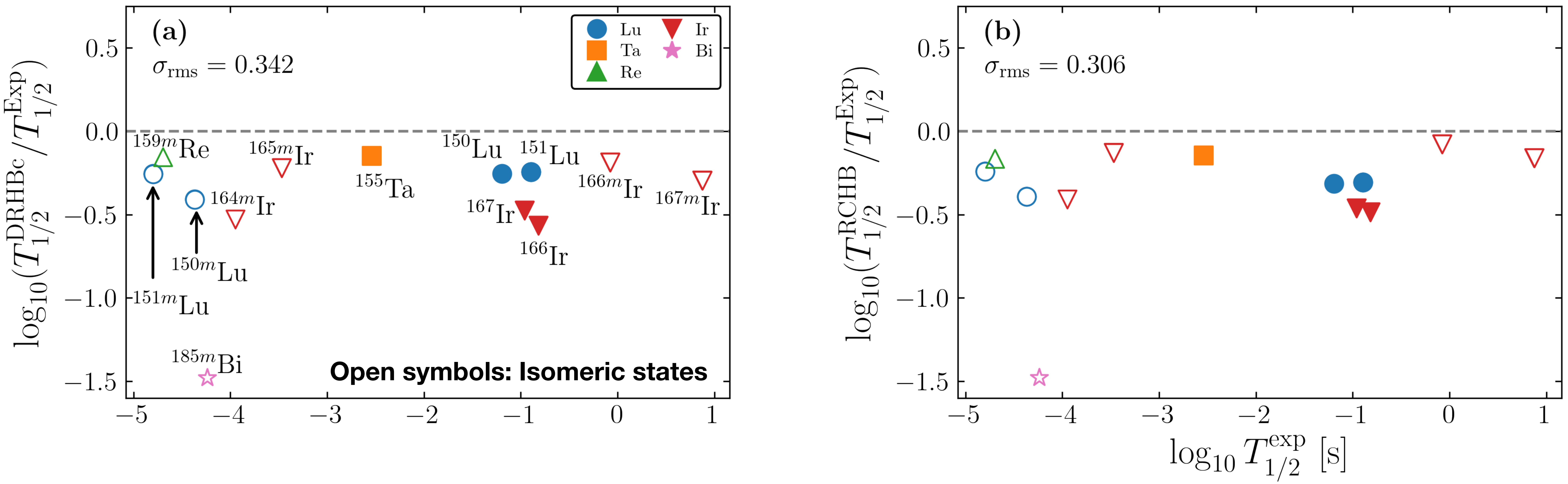
$$k(r,\beta) = \sqrt{\frac{2\mu}{\hbar^2}|Q - V(r,\beta)|}$$

- Calculating the half-lives takes into account the probability that a proton penetrates the Coulomb barrier.
- The isomeric state is assumed to have the same potential as the ground state

Y. Lim *et al,* Phys. Rev. C **93**, 014314 (2016).

Result

$T_{1/2} \propto 1/(S_\mathrm{p}\Gamma)$



- Calculated half-lives are systematically shorter than experimental data.

B. Blank and M. Borge, Prog. Part. Nucl. Phys. **60**, 403 (2008).

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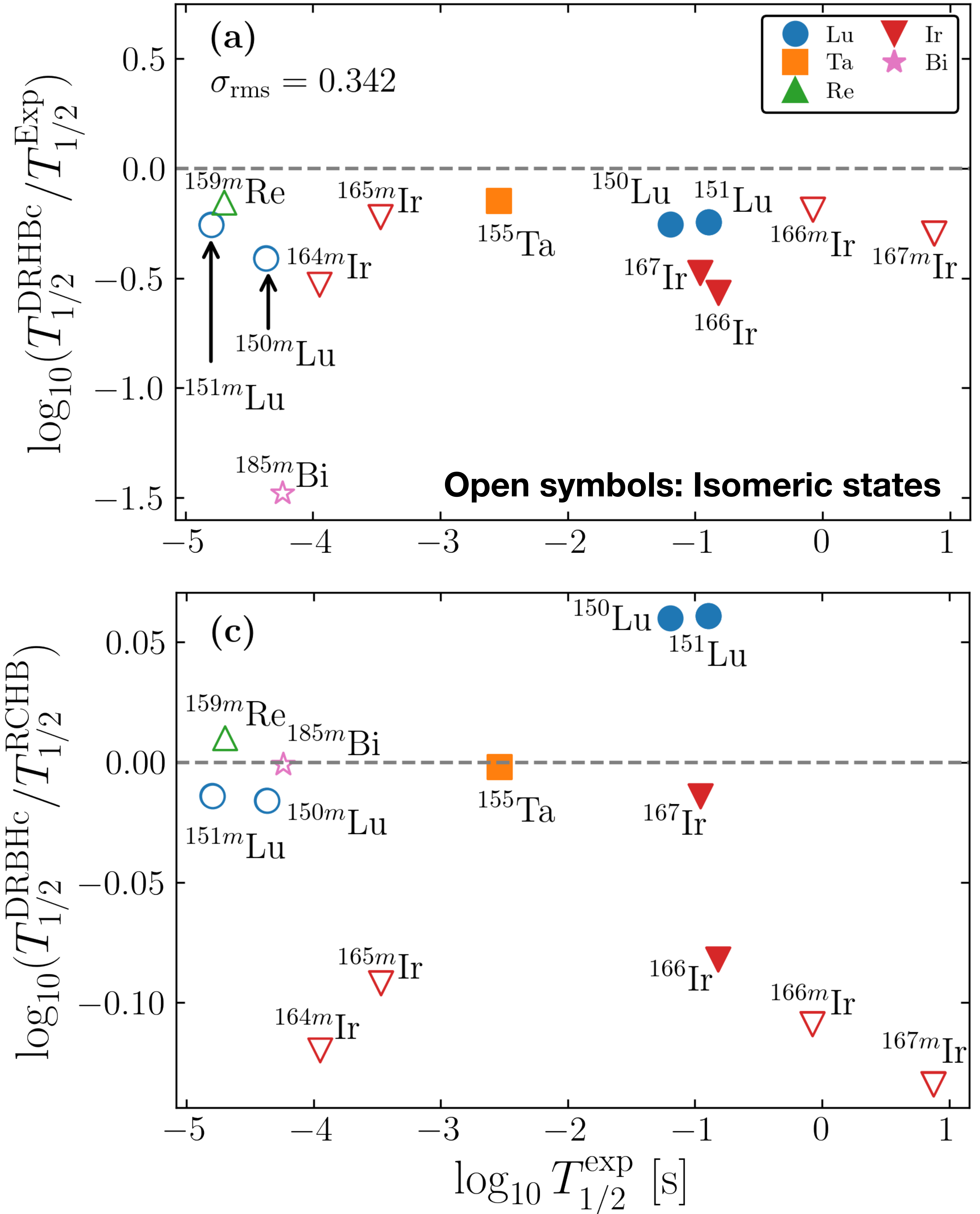

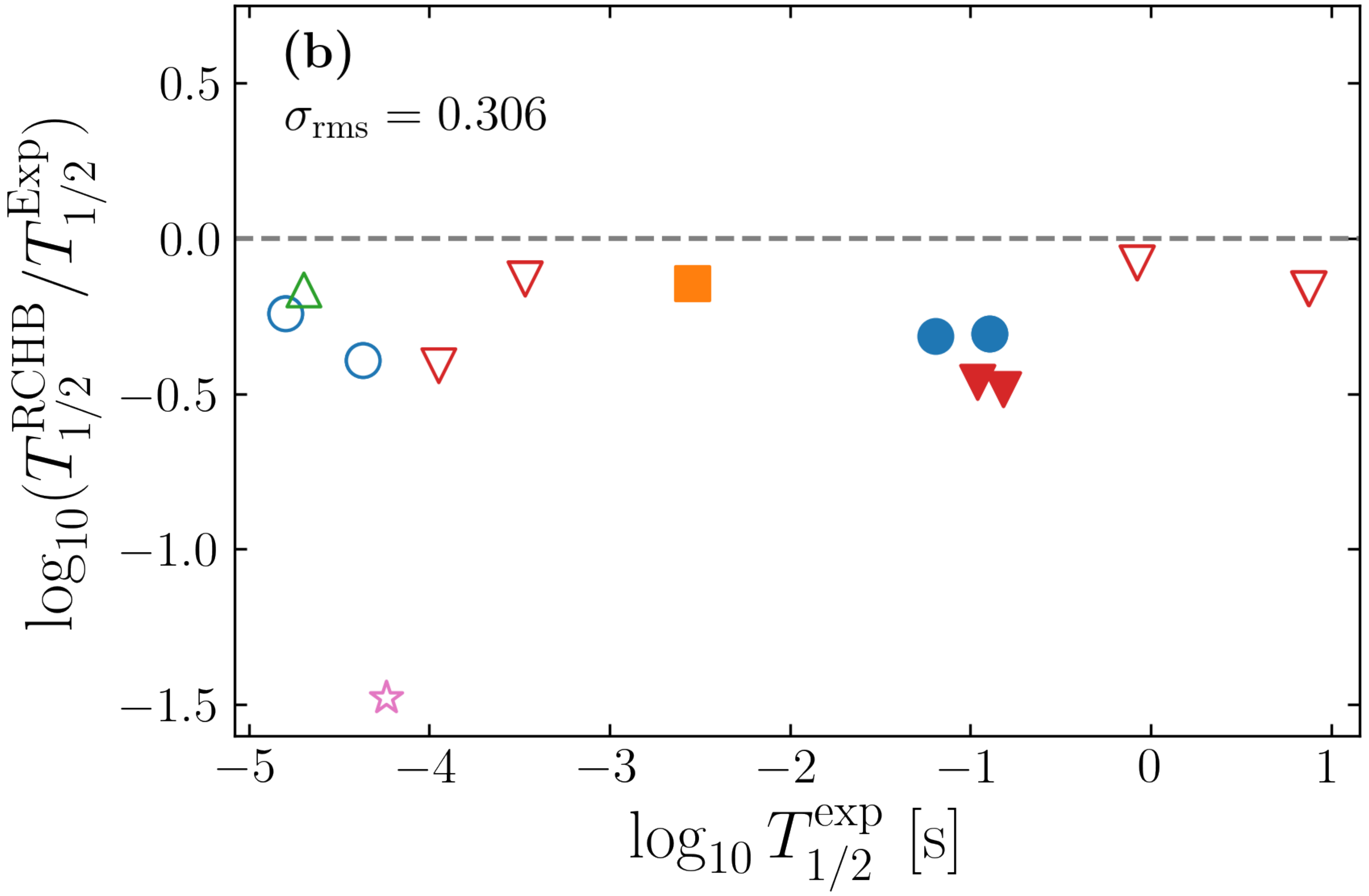

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- Two models show only minor differences.

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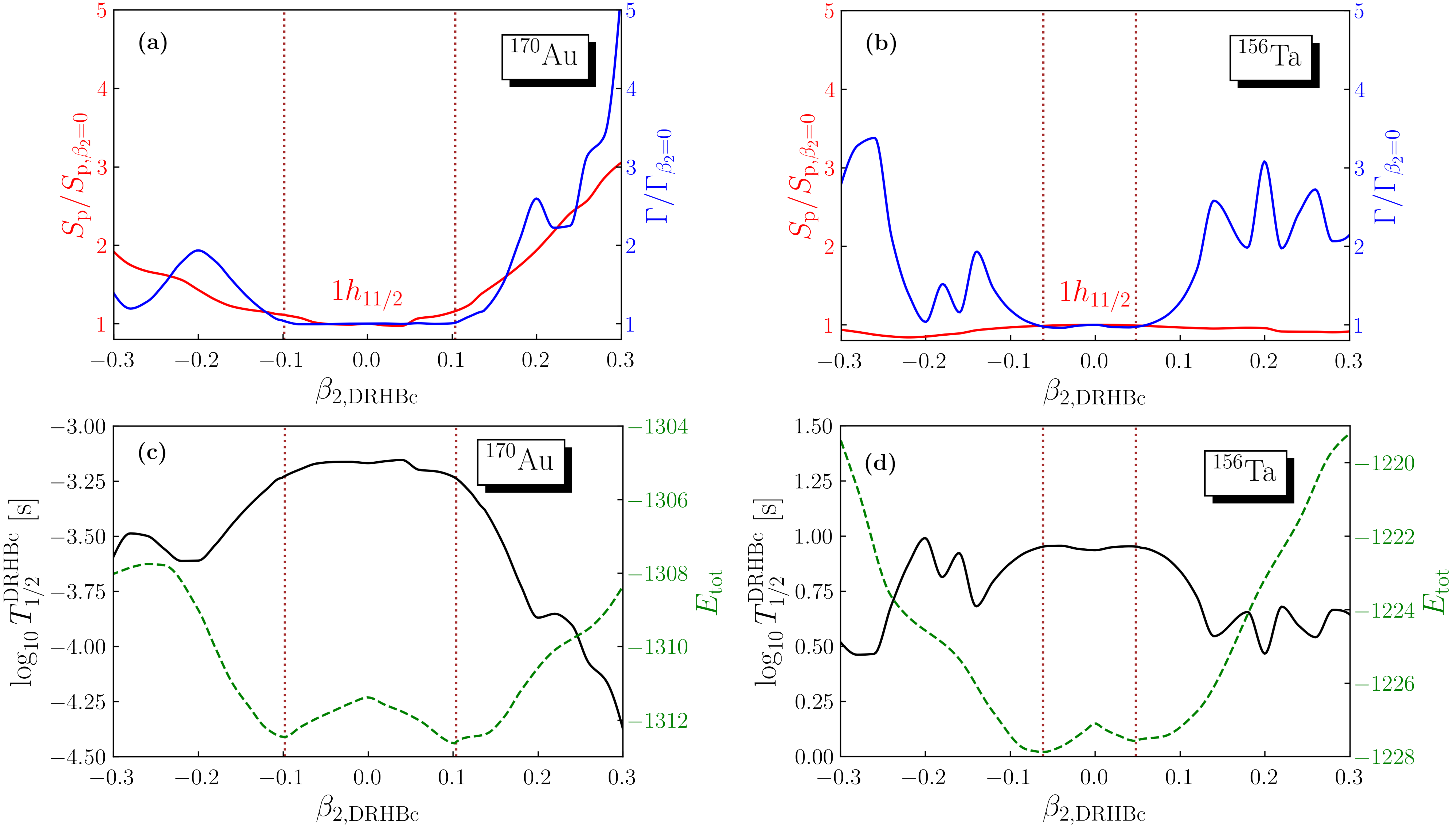

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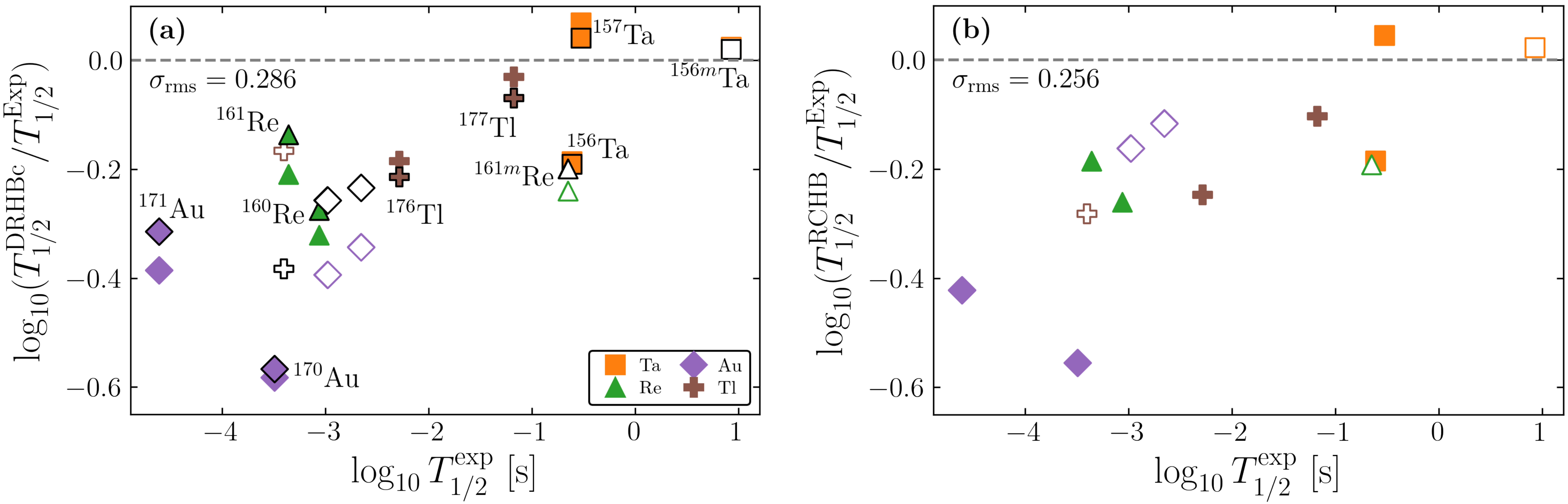
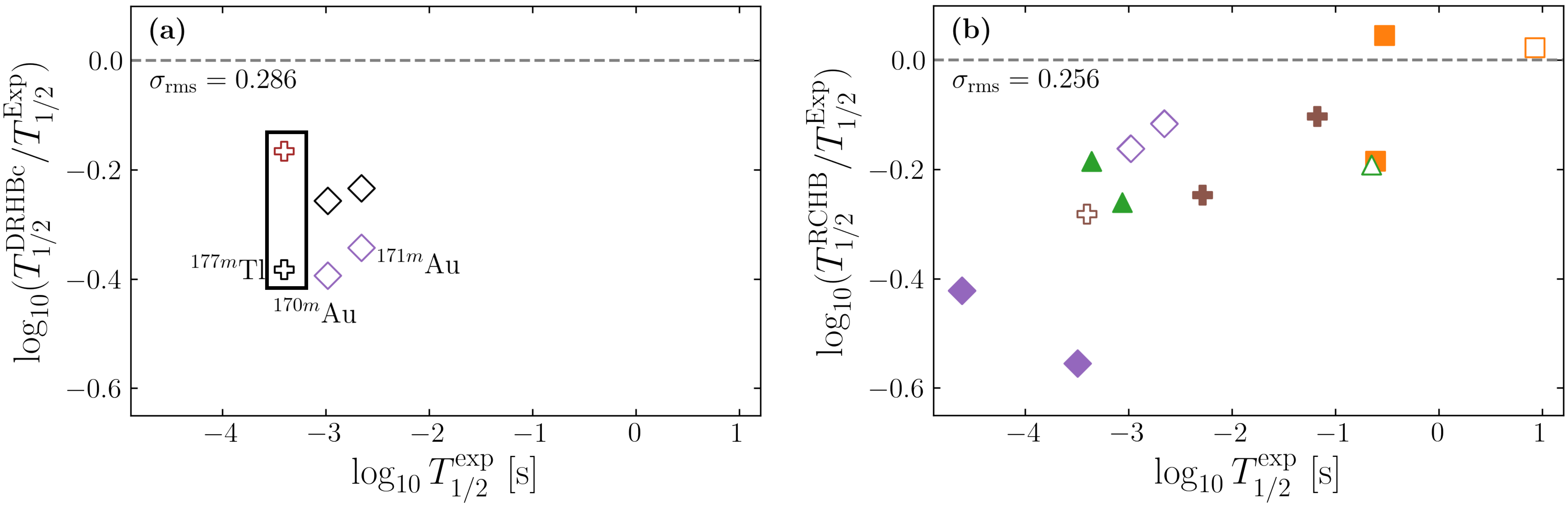


- By considering shape coexistence, the half-lives can differ by up to a factor of ~1.26 (≃$10^{0.1}$).

Result



- By considering shape coexistence, the half-lives can differ by up to a factor of ~1.26 ($\simeq 10^{0.1}$).

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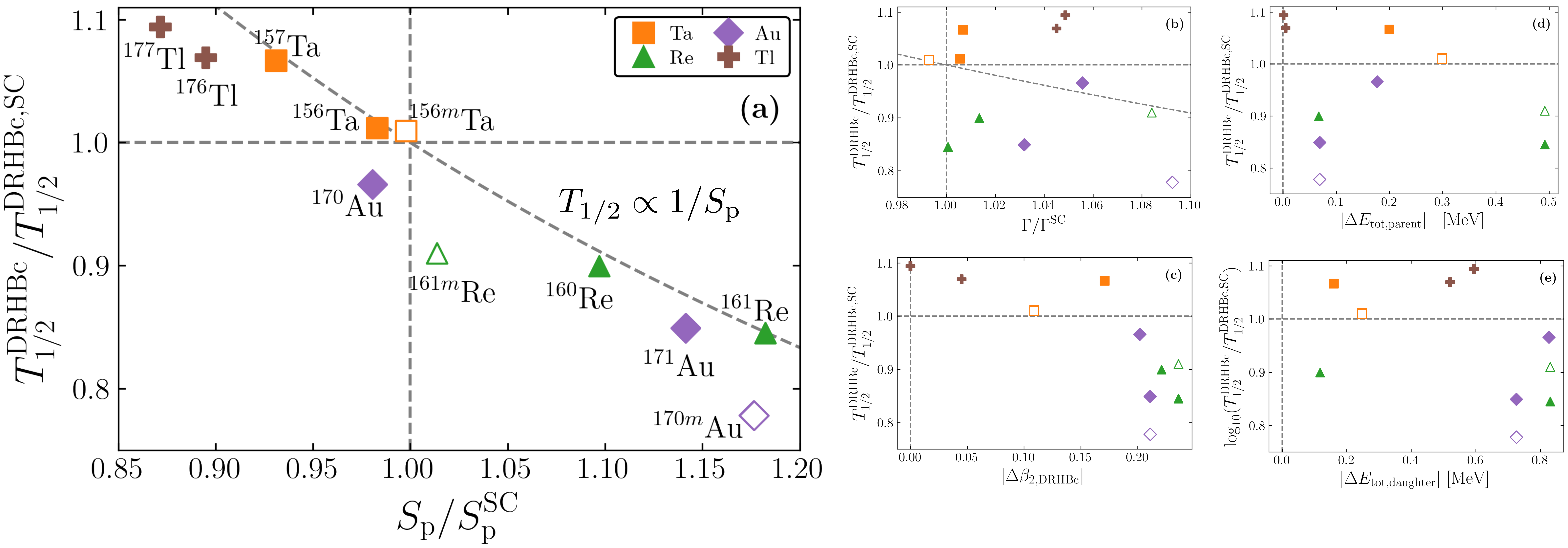

- The spectroscopic factor difference shows a possible correlation with the half-life difference between the two minima,
- Decay width, deformation, and energy differences show no clear trend.

Summary

✓ The half-lives of one-proton emitters ($71 \leq Z \leq 83$) were studied using the WKB approximation with potentials derived from DRHBc and RCHB.

✓ The calculated values are systematically shorter than experiment, implying that more sophisticated framework, such as those beyond the WKB approximation, may be required.

✓ Within $|\beta_2| \leq 0.14$, the spectroscopic factor plays a dominant role in determining the half-life.

✓ For nuclei exhibiting shape coexistence, the half-lives can vary by up to a factor of approximately 1.26 when the effect of shape coexistence is taken into account.

Thank you for your attention!