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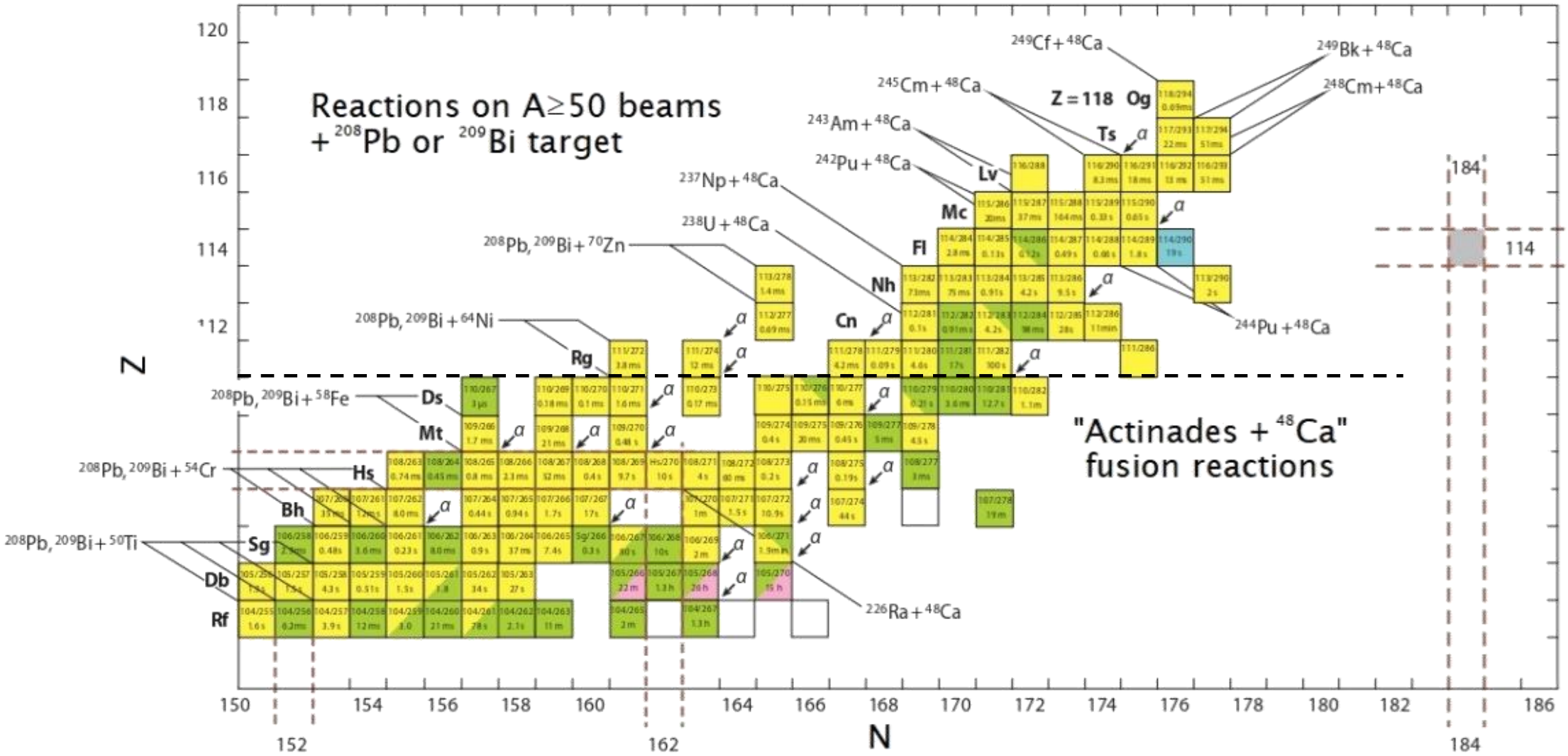
PREDICTION OF NUCLEAR PROPERTIES IN SHE REGION BASED ON LOCAL MASS RELATIONS

Ulianova V.S.[1], Bayramov D.F. [1], Sidorov S.V. [2], Stepanov M.E. [1], Stopani K.A.[1] ,Tretyakova T.Yu. [1,2]

[1] Faculty of Physics, Lomonosov Moscow State University, Moscow, Russia;

[2] Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Moscow, Russia





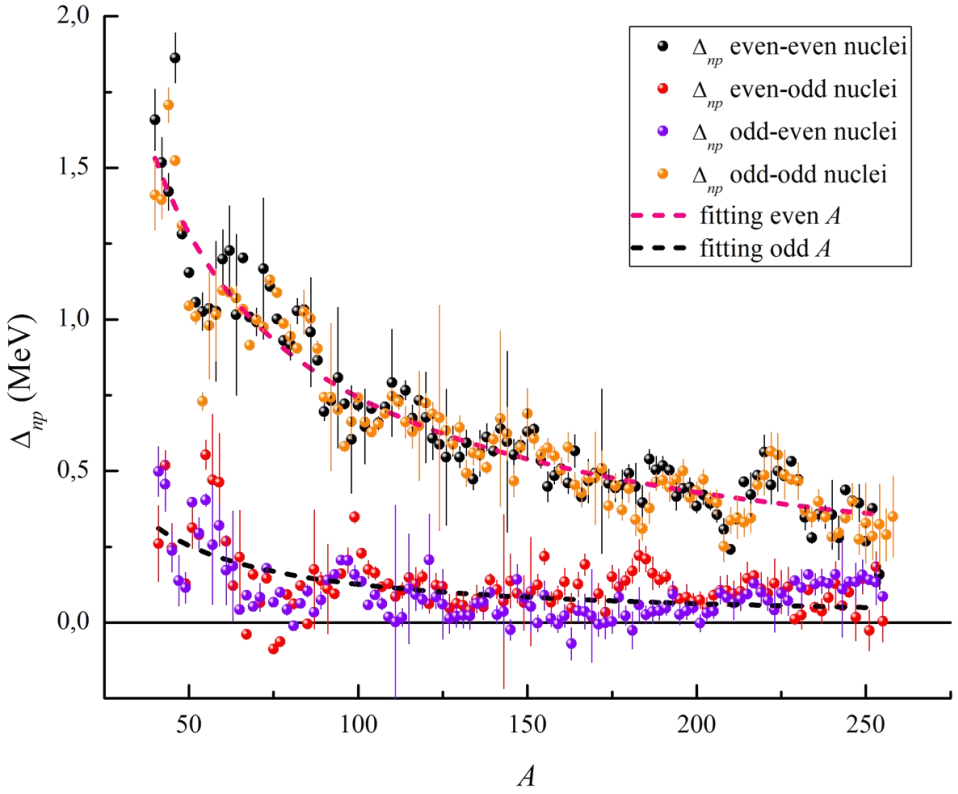
$$Q_{\alpha}(\mathrm{N},\mathrm{Z}) = M(N,Z) - M(N-2,Z-2) - M_{\alpha}(2,2)$$

Local mass relations

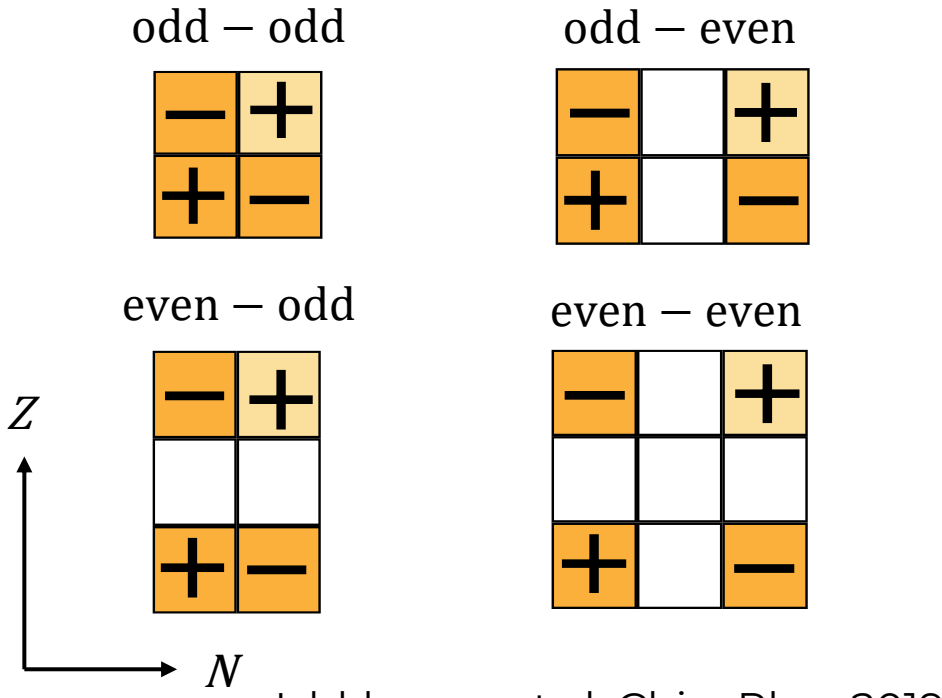
neutron-proton correlations

$$\Delta_{np}(N,Z) = B(N,Z) + B(N-1,Z-1) - B(N,Z-1) - B(N-1,Z)$$

$$\delta V_{np} = \begin{cases} B(N,Z) + B(N-1,Z-1) - B(N,Z-1) - B(N-1,Z), & \text{[oo]} \\ \frac{1}{4}\big(B(N,Z) + B(N-2,Z-2) - B(N,Z-2) - B(N-2,Z)\big), & \text{[ee]} \\ \frac{1}{2}(B(N,Z) + B(N-1,Z-2) - B(N,Z-2) - B(N-1,Z)), & \text{[oe]} \\ \frac{1}{2}(B(N,Z) + B(N-2,Z-1) - B(N,Z-1) - B(N-2,Z)), & \text{[eo]} \end{cases}$$



Dependence of np-correlations' energy on mass number



Ishkhanov et.al. Chin. Phys 2019

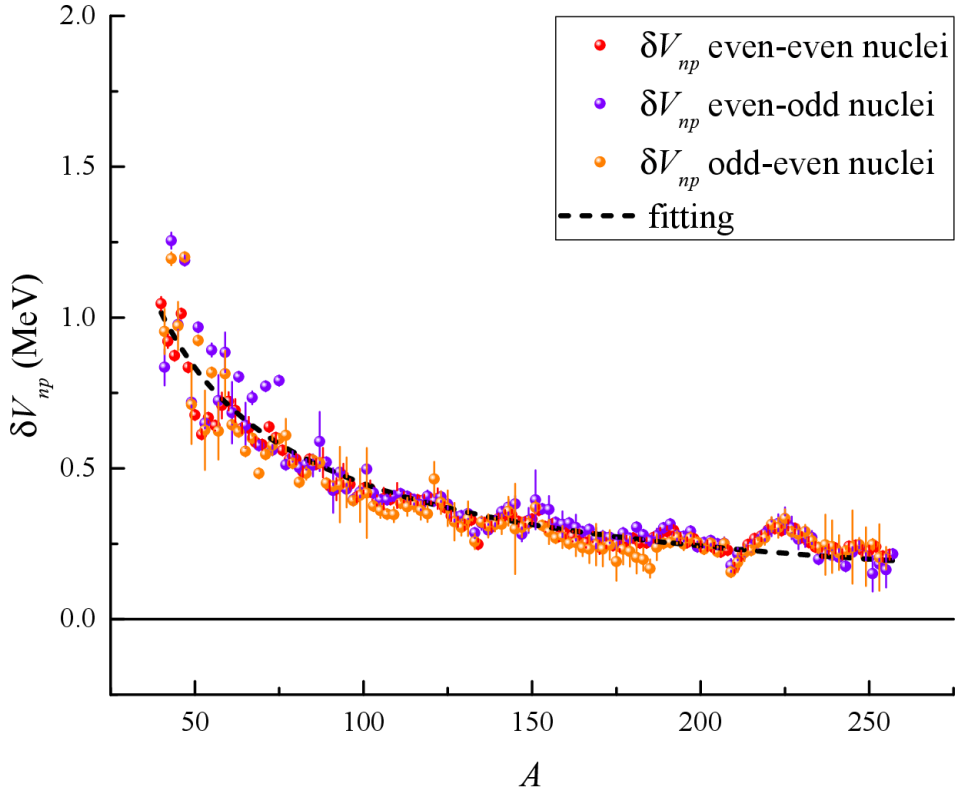
Calculation accuracy estimation for different formulas

$$\delta Q_{1n-1p}(N,Z) = Q_\alpha(N+1,Z) + Q_\alpha(N,Z+1) - Q_\alpha(N,Z) - Q_\alpha(N+1,Z+1) \sim \delta V_{np}^{oo}(N,Z) - \delta V_{np}^{oo}(N-2,Z-2) \approx 0 \quad \text{(A)}$$

$$\delta Q_{2n-1p}(N,Z) = Q_\alpha(N+2,Z) + Q_\alpha(N,Z+1) - Q_\alpha(N,Z) - Q_\alpha(N+2,Z+1) \sim \delta V_{np}^{oe}(N,Z) - \delta V_{np}^{oe}(N-2,Z-2) \approx 0 \quad \text{(B)}$$

$$\delta Q_{1n-2p}(N,Z) = Q_\alpha(N+1,Z) + Q_\alpha(N,Z+2) - Q_\alpha(N,Z) - Q_\alpha(N+1,Z+2) \sim \delta V_{np}^{eo}(N,Z) - \delta V_{np}^{eo}(N-2,Z-2) \approx 0 \quad \text{(C)}$$

$$\delta Q_{2n-2p}(N,Z) = Q_\alpha(N+2,Z) + Q_\alpha(N,Z+2) - Q_\alpha(N,Z) - Q_\alpha(N+2,Z+2) \sim \delta V_{np}^{ee}(N,Z) - \delta V_{np}^{ee}(N-2,Z-2) \approx 0 \quad \text{(D)}$$

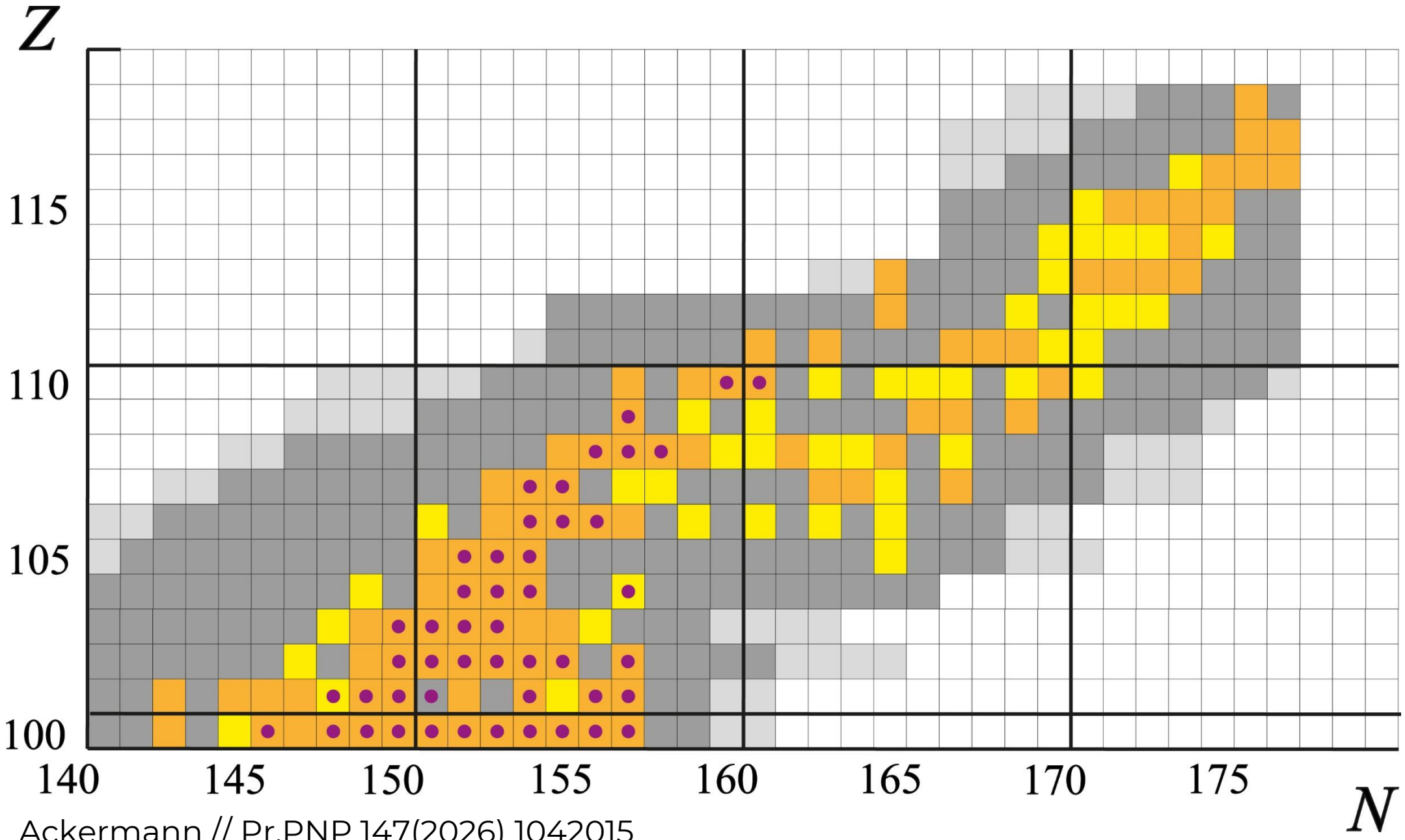


Mean deviations from zero for used data.

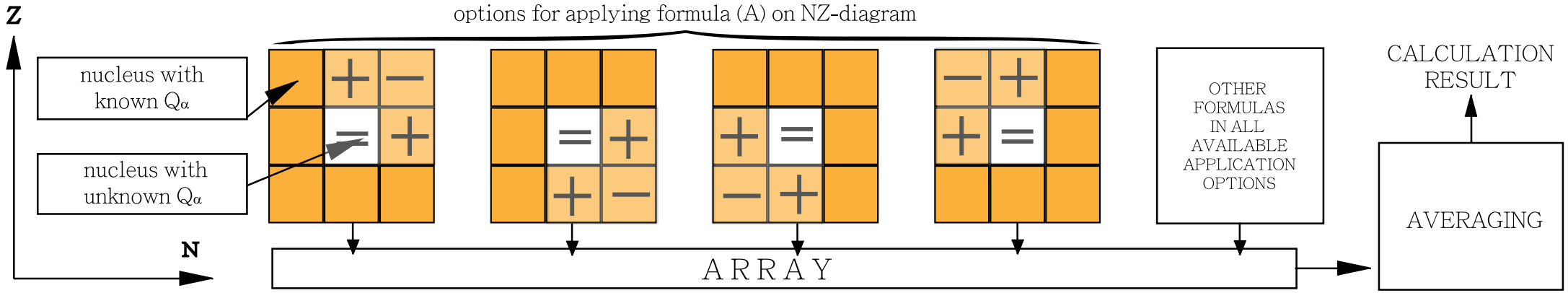
	σ_A, keV	σ_B, keV	σ_C, keV	σ_D, keV
A ≥ 280	71	156	151	285
A ≥ 250	78	152	92	183
A ≥ 240	88	149	94	168
A ≥ 220	106	126	128	145

$$\sigma = \sqrt{\frac{1}{N}\sum_{N,Z} \delta Q_{in\text{-}jp}(N,Z)^2}$$

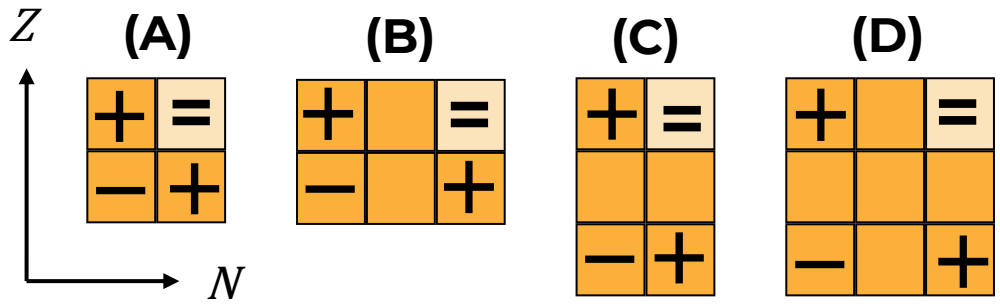
M. Bao [et al.] // PRC. 2014. Vol. 90, no. 2. P. 024314.



Ackermann // Pr.PNP 147(2026) 1042015



$$\bar{\sigma} = \sqrt{\frac{1}{N}\sum_{j=1}^{N}(Q_j^{exp} - < Q >_j^{th})^2}$$



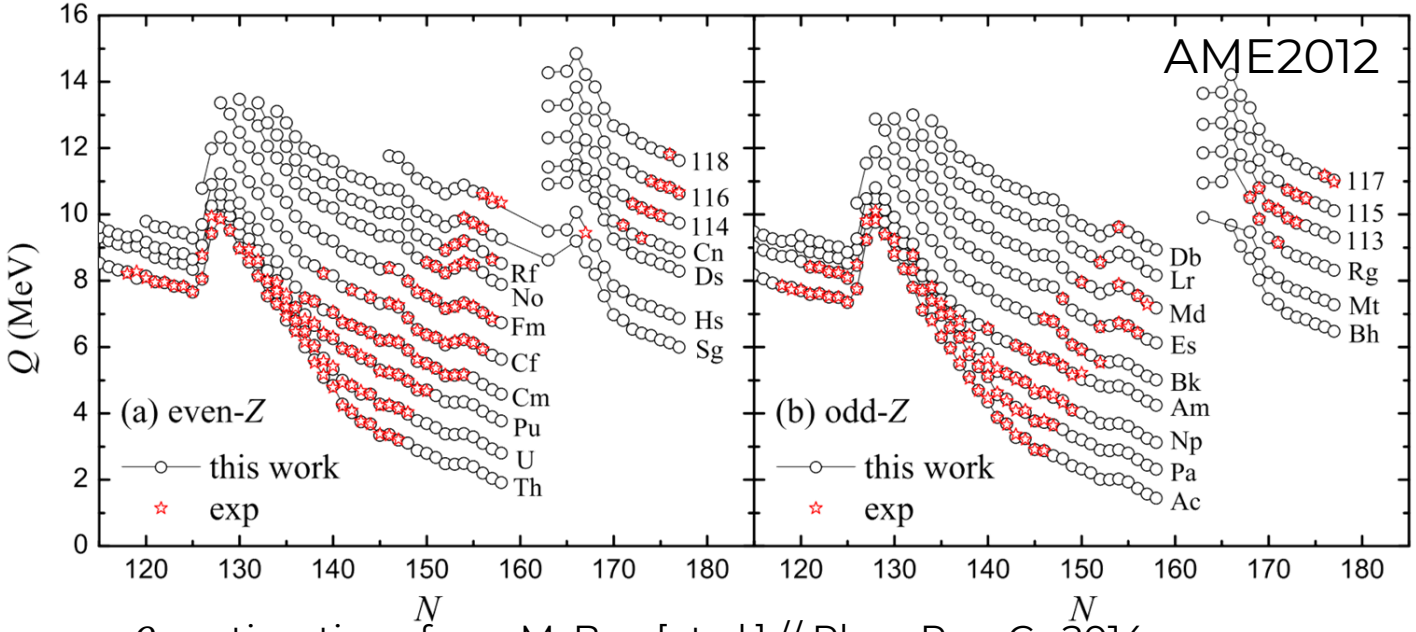
Total root mean square deviations from experimental data for AME2020. $\bar{\sigma}_i$ are obtained in keV

	$\bar{\sigma}_A$	$\bar{\sigma}_B$	$\bar{\sigma}_C$	$\bar{\sigma}_D$	$\bar{\sigma}_{A-D}$	$\bar{\sigma}_{A-C}$
A ≥ 280	45	54	70	80	56	41
A ≥ 250	60	105	64	113	97	80
A ≥ 240	68	95	73	126	89	75
A ≥ 220	88	88	116	112	92	88

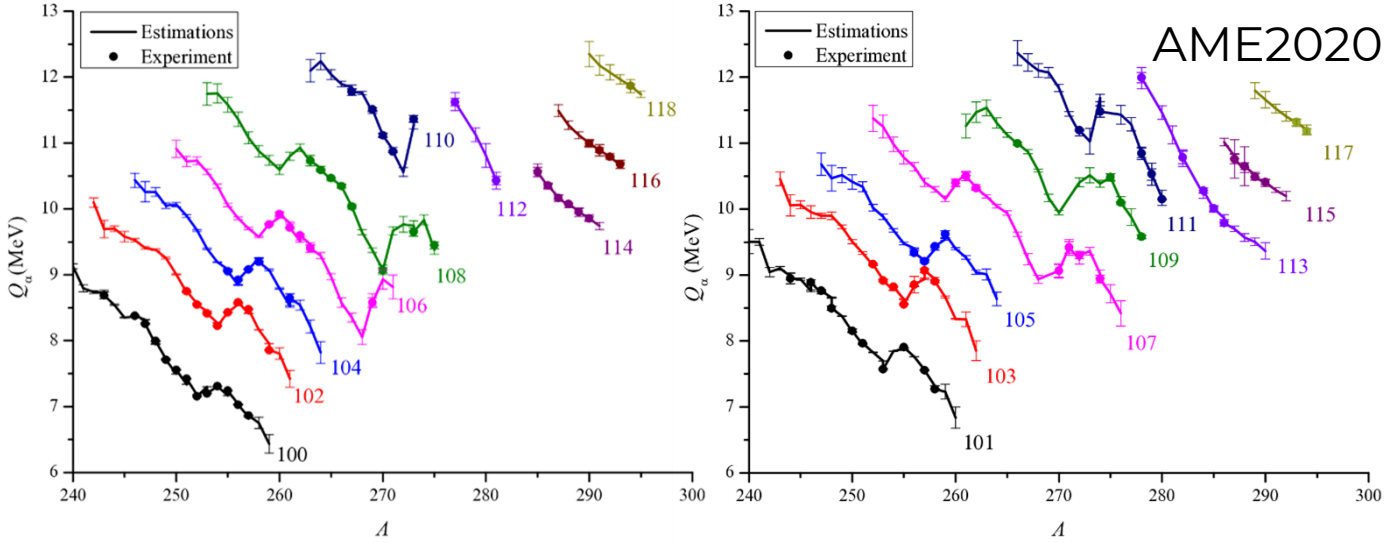
Total root mean square deviations from experimental data for AME2020 & additional data. $\bar{\sigma}_i$ are obtained in keV

	$\bar{\sigma}_A$	$\bar{\sigma}_B$	$\bar{\sigma}_C$	$\bar{\sigma}_D$	$\bar{\sigma}_{A-D}$	$\bar{\sigma}_{A-C}$
A ≥ 280	58	118	123	240	107	93
A ≥ 250	76	139	88	172	110	98
A ≥ 240	80	137	87	162	109	101
A ≥ 220	91	115	117	134	103	100

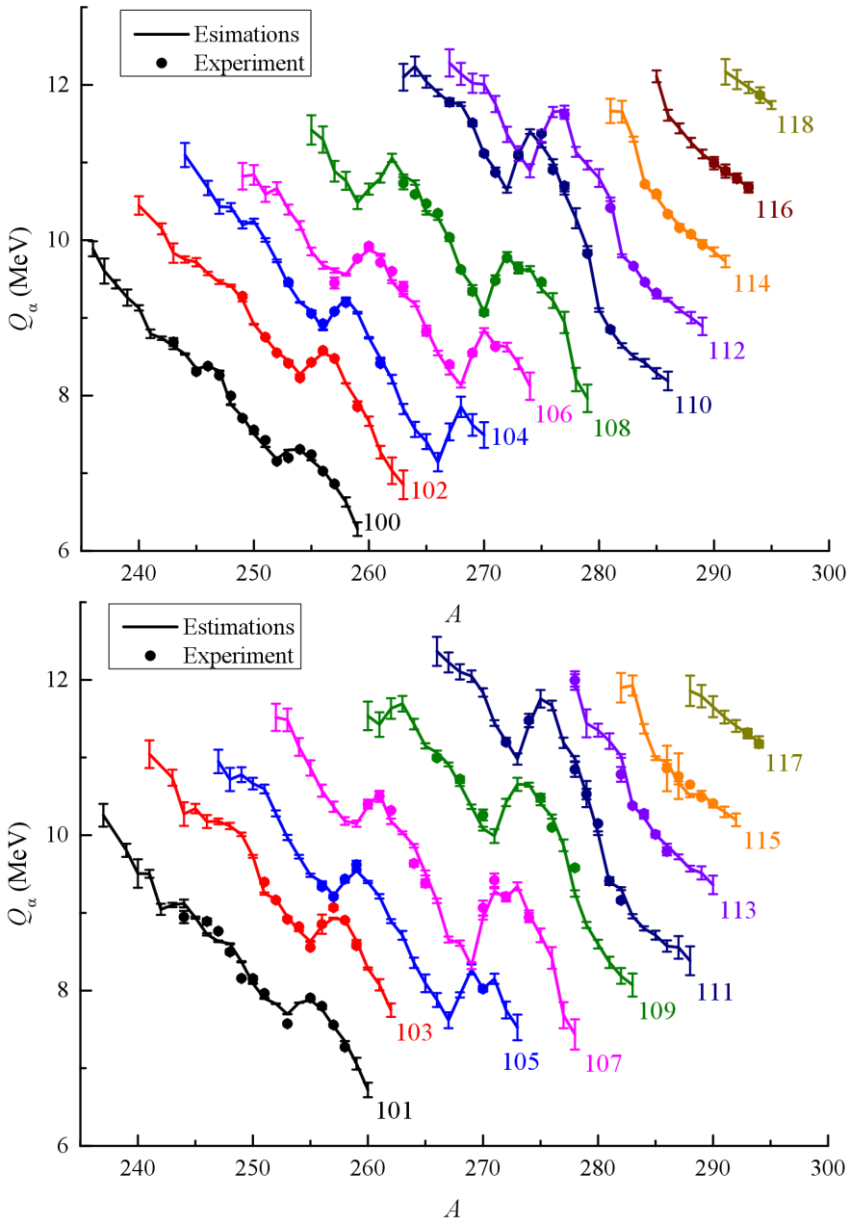
Results for Q_α



Q_α estimations from M. Bao [et al.] // Phys. Rev. C. 2014



AME2020+additional data



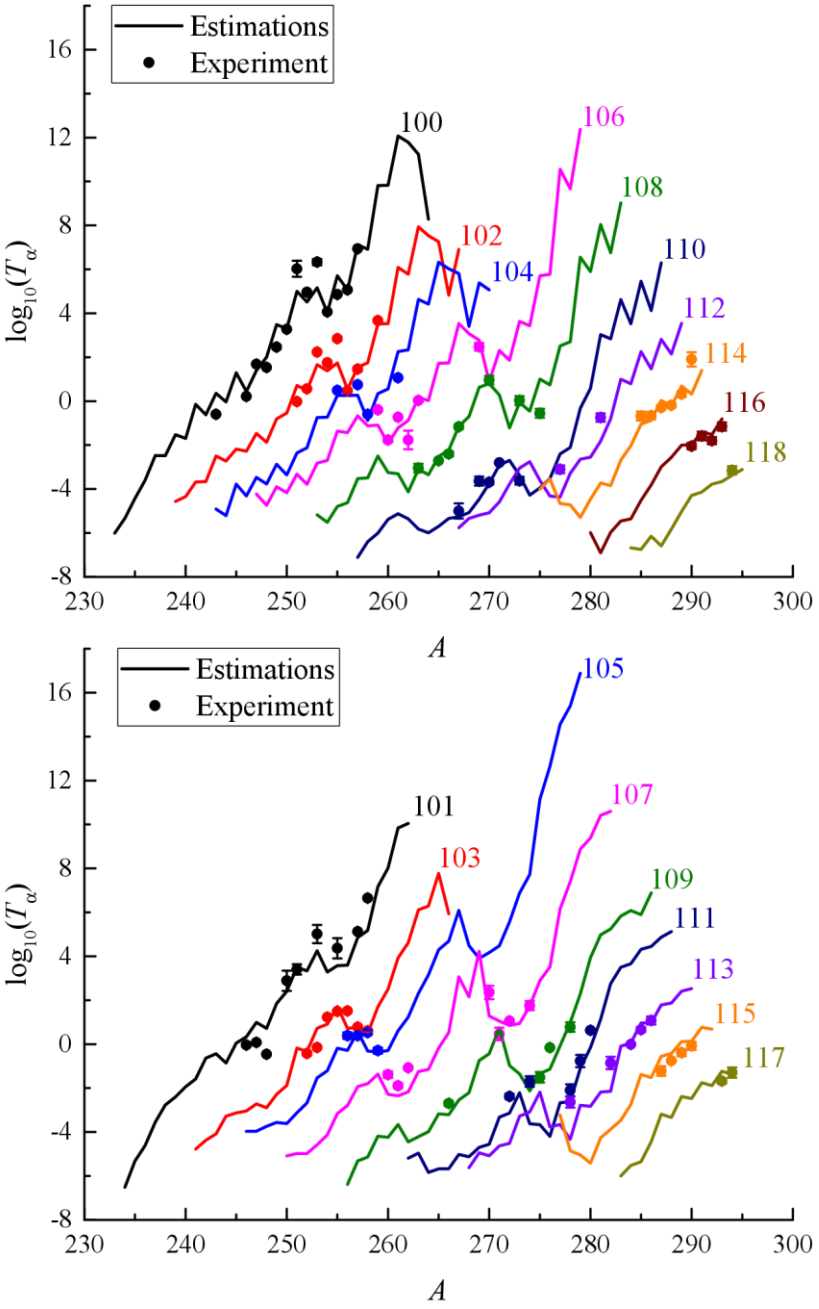
Half-lifes for α-decay

Viola-Seaborg formula

$$lgT_{1/2}^{\alpha} = \frac{aZ+b}{\sqrt{Q_\alpha}} + cZ + d + h_i$$

$\bar{\sigma}$	
original	refined
0.844	**0.747**

$$\bar{\sigma} = \sqrt{\frac{\sum \sigma_i^2 (\mathrm{N}_i - 1)}{\sum (\mathrm{N}_i - 1)}}$$



Viola V.E., Seaborg G.T. // J. Inorg. Nucl. Chem. 28, 3, 741 (1966).

Comparison with new experimental data

	Experiment				Calculations		AME2020	Bao et.al
	$Q_{\alpha,}$ MeV	$T_{1/2}$	$T^{\alpha}_{1/2}$		$Q_{\alpha,}$ MeV	$T^{\alpha}_{1/2}$	$Q_{\alpha,}$ MeV	$Q_{\alpha,}$ MeV
$^{288}_{116}$Lv	11,240(15)	$2{,}0^{+2,3}_{-0,7}$ ms	—	[16]	11,26(6)	2,8 ms	—	11,13(13)
$^{289}_{116}$Lv	11,059(13)	$2{,}4^{+4,4}_{-0,9}$ ms	—	[16,17]	11,11(6)	9,9 ms	11,10(30)	11,29(16)
$^{275}_{110}$Ds	11,37(2)	$0{,}43^{+0,29}_{-0,12}$ ms	0,22 ms	[15]	11,22(3)	113 μs	11,55(20)	10,96(19)
$^{271}_{108}$Hs	9,18(2)	$7{,}1^{+8.4}_{-2.5}$ s	5,1 s	[15]	9,52(3)	60 ms	9,46(9)	9,54(15)
$^{269}_{108}$Hs	9,22(15)	$2.8^{+13.6}_{-1.3}$ s	3 s	[15]	9,40(2)	4,238 s	9,27(17)	—
$^{267}_{106}$Sg	8,40(2)	$9{,}8^{+11,3}_{-4,5}$ min	6 min	[15]	8,31(4)	57,21 min	8,63(21)	—
$^{265}_{106}$Sg	8,82(5)	$14{,}4^{+3,7}_{-2,5}$ s	12 s	[15]	8,86(4)	53 ms	9,05(12)	—

[15]	Oganessian Yu.Ts. [et al.] // Phys. Rev. C. 109, 054307 (2024).
[16]	Oganessian Yu.Ts. [et al.] // Phys. Rev. C. 112, 014603 (2025)
[17]	Oganessian Yu.Ts. [et al.] // Phys. Rev.C. 113, 014614 (2026)

CONCLUSION

α-decay energies for Z≥100 region were predicted using local relations for Q_α on AME2020 and contemporary experimental data. The dependence Q_α (A) may indicate the presence of neutron magic numbers N=152,162.

Using the contemporary data new Viola-Seaborg formula parametrization was obtained. Then T_α were calculated on Q_α from the previous step.

The comparison with last experimental data showed accuracy of local relations method.

Thank you for your attention!

[1] M. Bao [et al.] // Phys. Rev. C. 2014. Vol. 90, no. 2. P. 024314.
[2] Yu. Ts. Oganessian et al., Phys. Rev. C 69, 021601(R) (2004); ,70, 064609 (2004); ,72, 034611 (2005); ,74, 044602
[3] M. Wang, G. Audi, A. H. Wapstra, and F. G. Kondev et al., Chin. Phys. C 36, 1603 (2012); http://iopscience.iop.org/1674- 1137/36/12/003/. <- AME2012
[4] Wang M., Huang W.J., Kondev F.G. et al // Chin. Phys. C. 45, 3, 030003 (2021). <- AME2020

Additional data

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[14] Yu. Ts. Oganessian // Phys. Rev. C 108, 024611 (2023)
[15] Yu. Ts. Oganessian // Phys. Rev. C 109, 054307 (2024)
[16] Yu. Ts. Oganessian // Phys. Rev. C 112, 014603 (2025)
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[19] J. Khuyagbaatar // Phys. Rev. L 112, 172501 (2014)
[20] A. Såmark-Roth // Phys. Rev. L 126, 032503 (2021)
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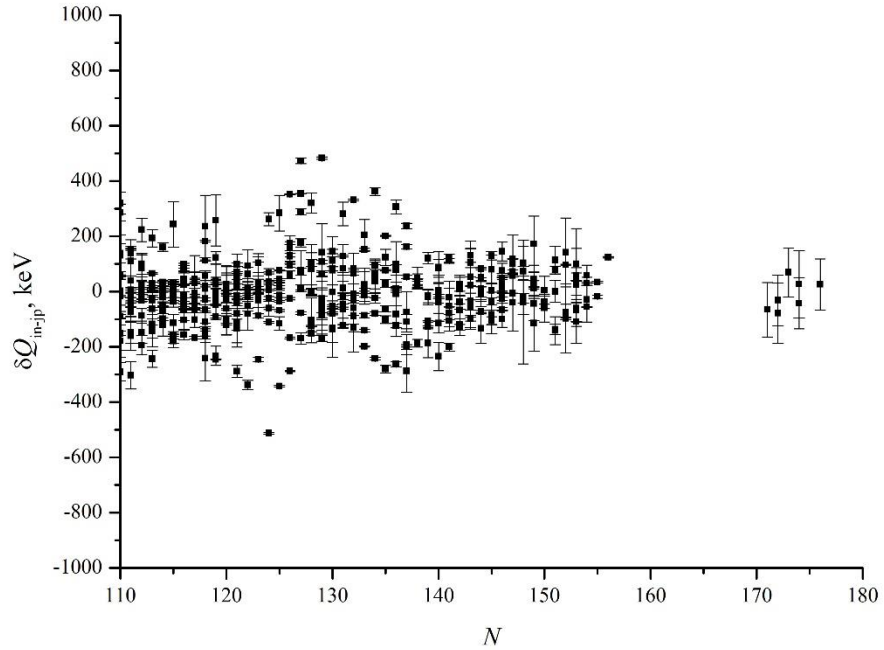
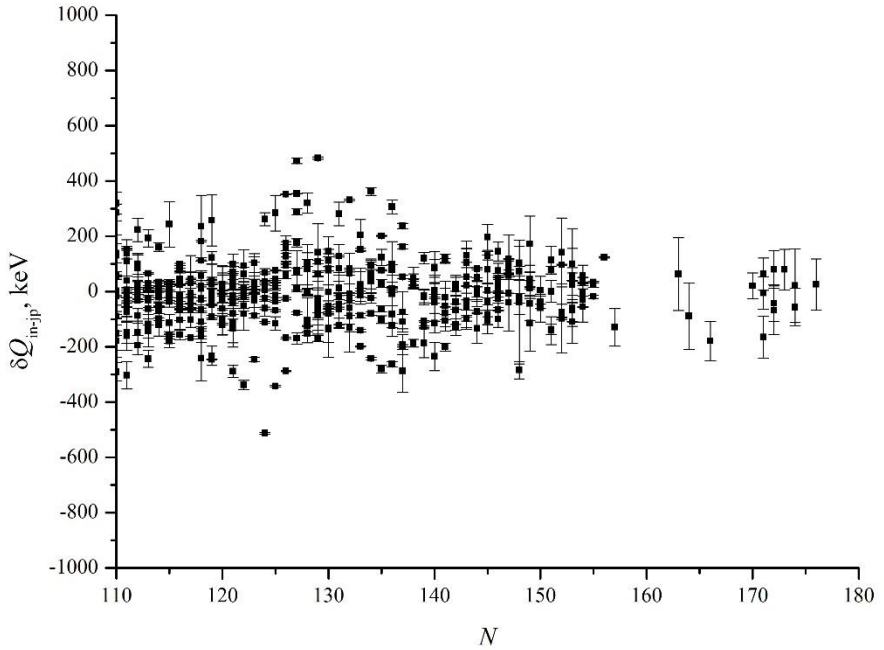
[22] K. Nishio // Phys. Rev. C 82, 024611 (2010)
[23] J. Khuyagbaatar // PRL 112(2014)172501
[24] Yu. Ts. Oganessian // Phys. Scr. 92 (2017) 023003

Formula A

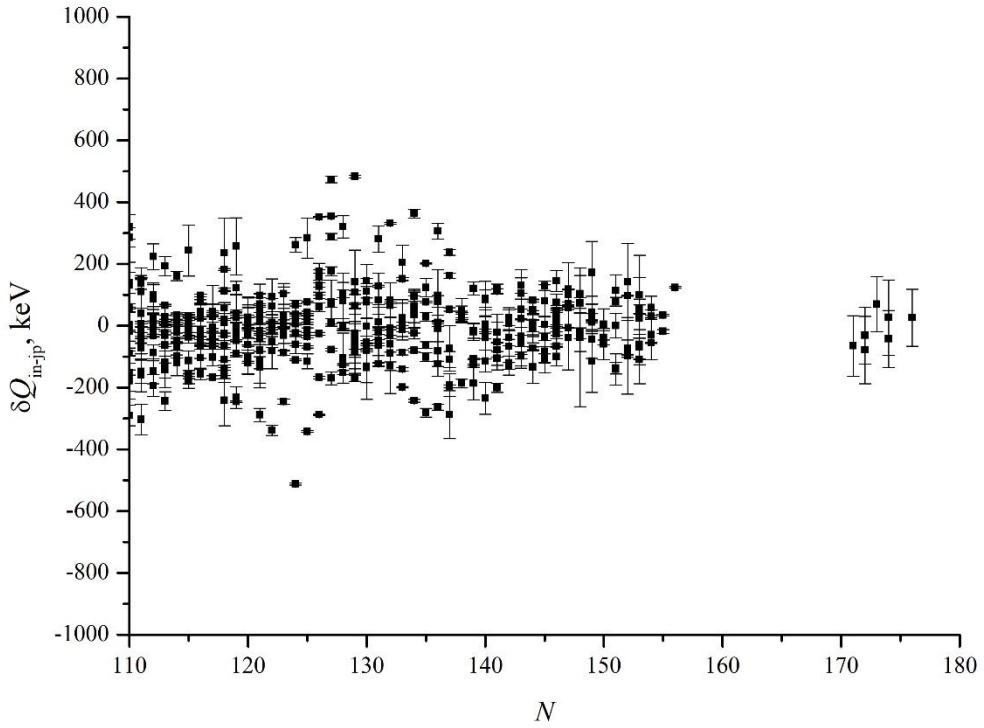


AME2020

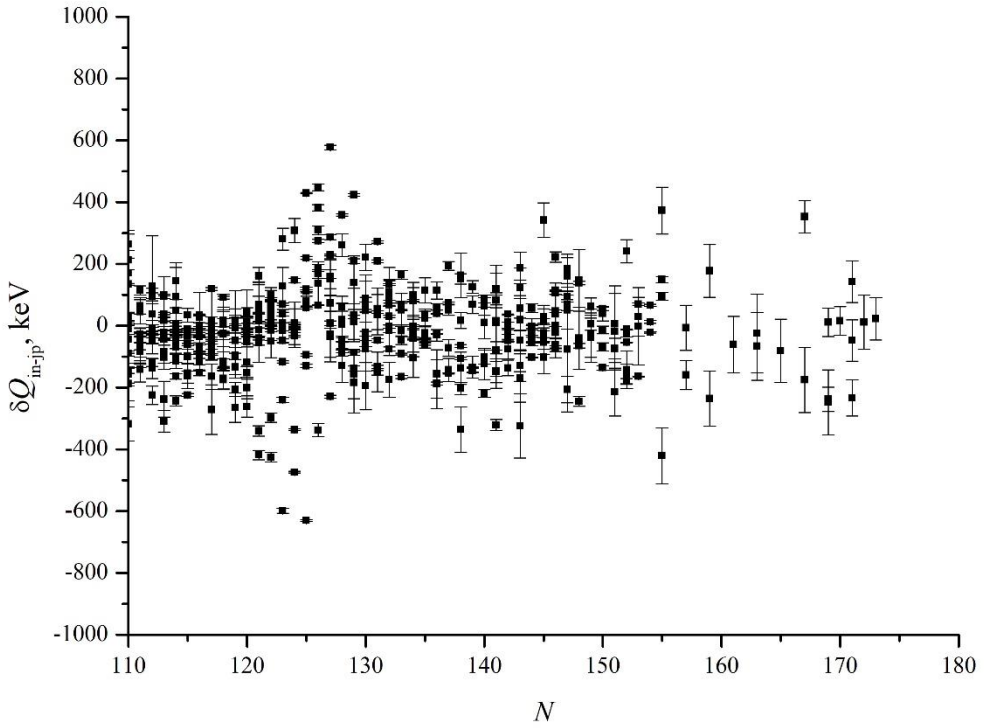


AME2020 + ADD

Formula B

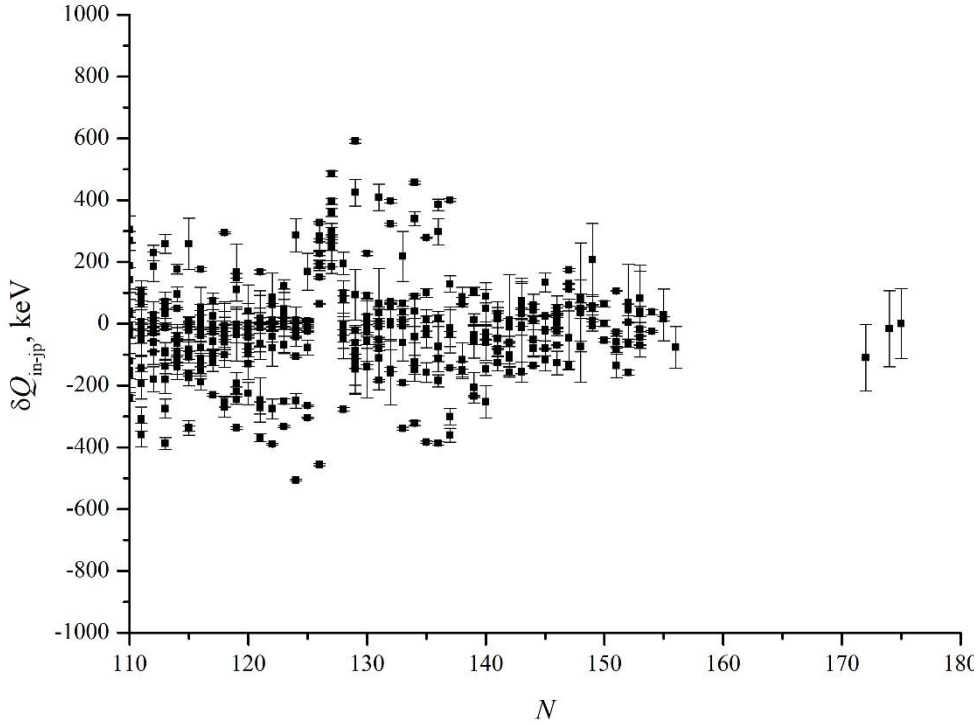


AME2020

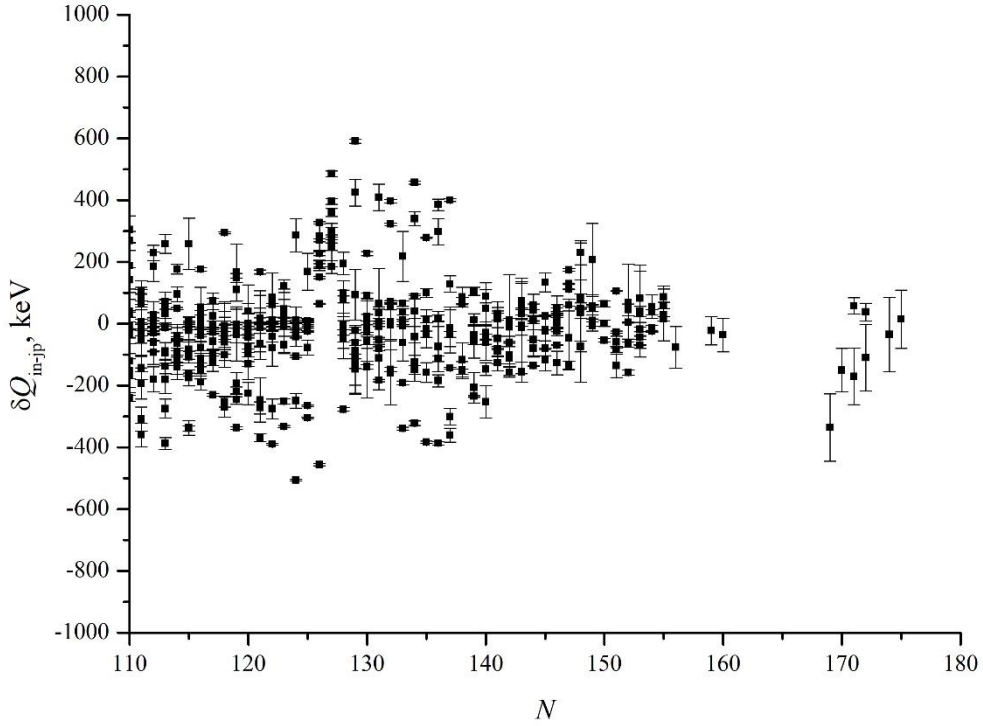


AME2020 + ADD

Formula C

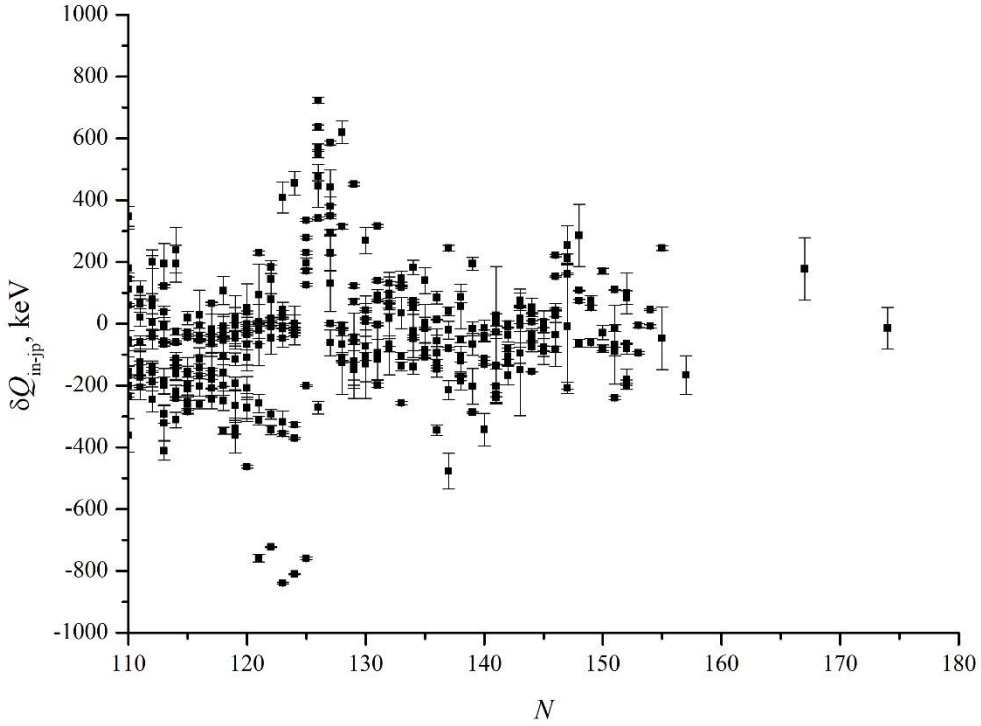


AME2020

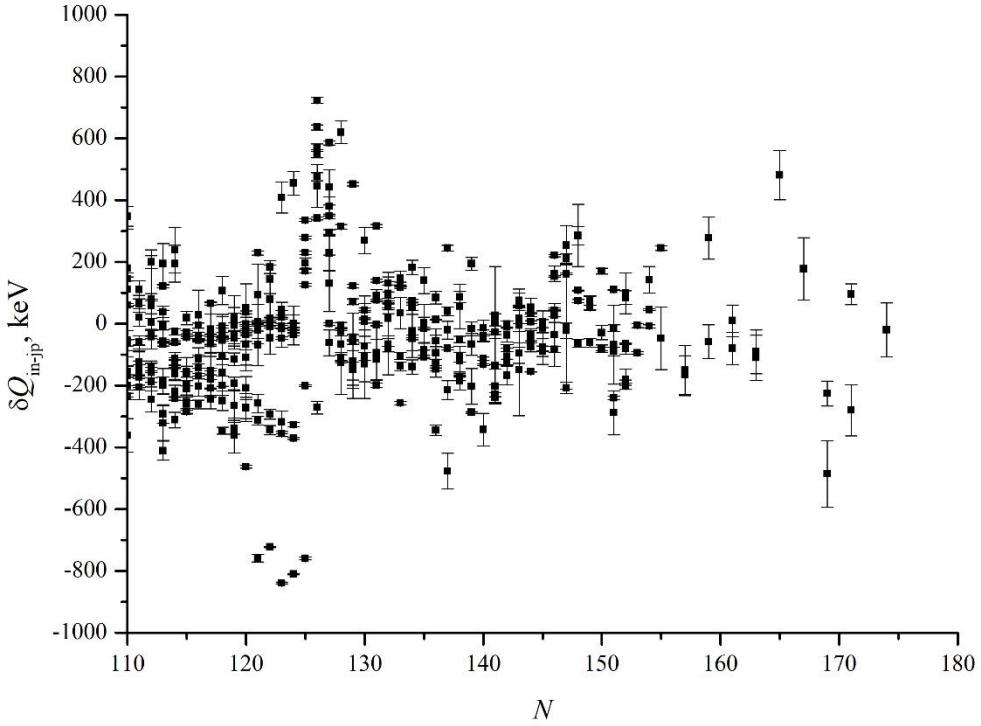


AME2020 + ADD

Formula D

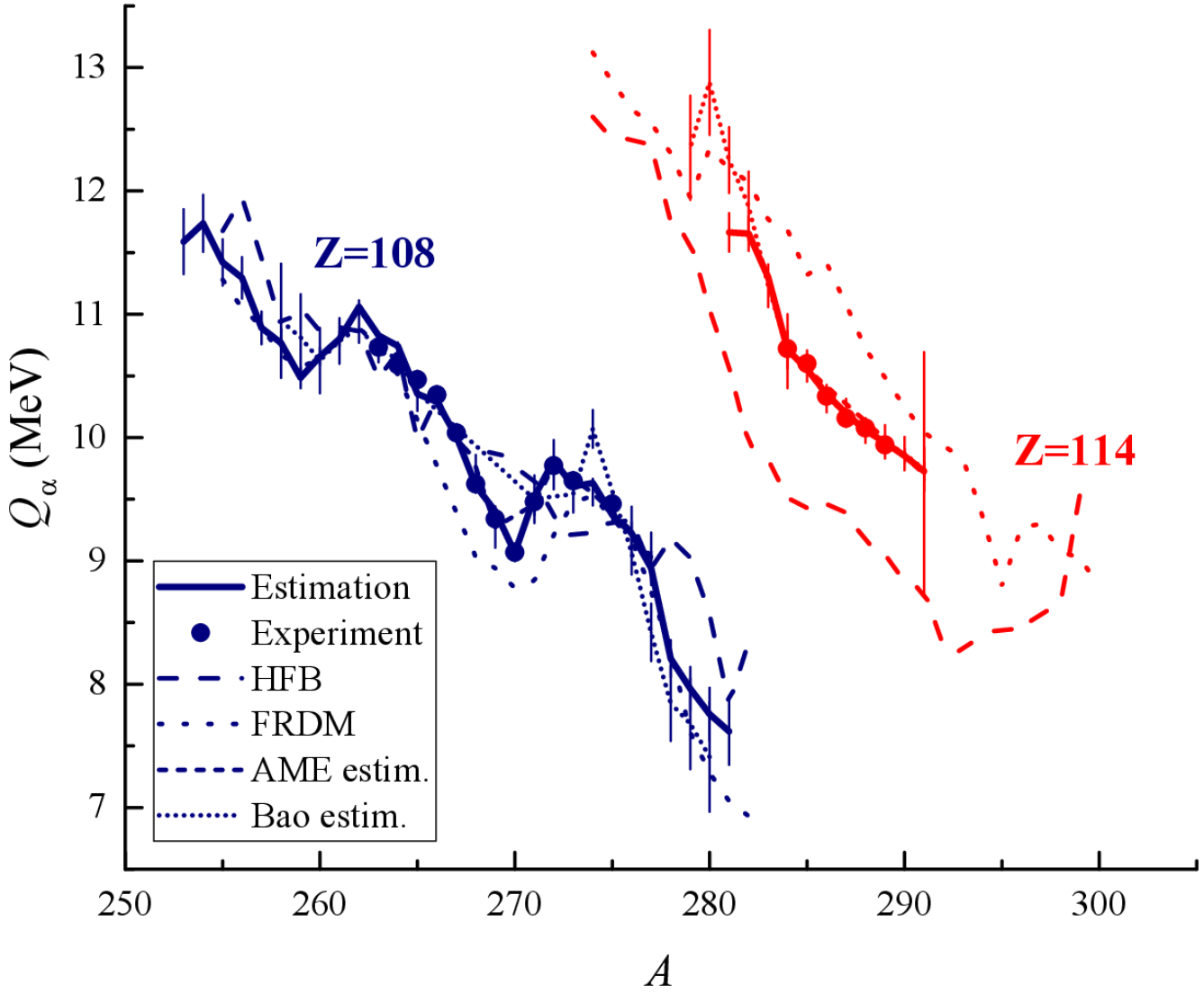


AME2020



AME2020 + ADD

Results for nuclei with $Z \geq 100$



data	references
AME, estim. AME	Wang M, (2021).
HFB	Goriely S (2013)
FRDM	P. Möller (2016)
Bao estim.	M. Bao (2014)

Half-lifes for α-decay

Geiger-Nuttal law for α-decay

$$lgT_{1/2}^{\alpha} = \frac{a}{\sqrt{Q_\alpha}} + b$$

type	a	b	c	D	σ
even-even	1.220	24.947	–0.115	–38.830	0.772
odd-even	1.733	–15.426	–0.228	–30.675	0.670
even-odd	2.092	–48.251	–0.370	–17.413	0.800
odd-odd	1.518	8.365	–0.157	–38.175	0.772

Viola-Seaborg formula

$$lgT_{1/2}^{\alpha} = \frac{aZ+b}{\sqrt{Q_\alpha}} + cZ + d + h_i$$

$$\bar{\sigma} = \sqrt{\frac{\sum \sigma_i^2 (\mathrm{N}_i - 1)}{\sum (\mathrm{N}_i - 1)}}$$

Decimal logarithm of α-decay half-life standard deviation

$$\sigma = \sqrt{\frac{1}{N-1} \sum_i \left(lg \frac{T_{1/2,i}^{th}}{T_{1/2,i}^{exp}} \right)^2}$$

$\bar{\sigma}$	
original	refined
0.844	0.747

Viola V.E., Seaborg G.T. // J. Inorg. Nucl. Chem. 28, 3, 741 (1966).

Local relations for Q_α

$$\delta Q_{1n-1p}(N,Z) = Q_\alpha(N+1,Z) + Q_\alpha(N,Z+1) - Q_\alpha(N,Z) - Q_\alpha(N+1,Z+1) = \delta V_{np}^{oo}(N,Z) - \delta V_{np}^{oo}(N+2,Z+2) \approx 0 \quad \text{(A)}$$

$$\delta Q_{2n-1p}(N,Z) = Q_\alpha(N+2,Z) + Q_\alpha(N,Z+1) - Q_\alpha(N,Z) - Q_\alpha(N+2,Z+1) = 2(\delta V_{np}^{oe}(N-1,Z) - \delta V_{np}^{oe}(N+1,Z+2)) \approx 0 \quad \text{(B)}$$

$$\delta Q_{1n-2p}(N,Z) = Q_\alpha(N+1,Z) + Q_\alpha(N,Z+2) - Q_\alpha(N,Z) - Q_\alpha(N+1,Z+2) = 2(\delta V_{np}^{eo}(N,Z-1) - \delta V_{np}^{eo}(N+2,Z+1)) \approx 0 \quad \text{(C)}$$

$$\delta Q_{2n-2p}(N,Z) = Q_\alpha(N+2,Z) + Q_\alpha(N,Z+2) - Q_\alpha(N,Z) - Q_\alpha(N+2,Z+2) = 4(\delta V_{np}^{ee}(N,Z) - \delta V_{np}^{ee}(N+2,Z+2)) \approx 0 \quad \text{(D)}$$

$$\delta V_{np}^{oo}(N,Z) - \delta V_{np}^{oo}(N-2,Z-2) =$$
$$= B(N,Z) - B(N,Z-1) - B(N-1,Z) + B(N-1,Z-1) - B(N-2,Z-2) + B(N-2,Z-3) +$$
$$+ B(N-3,Z-2) - B(N-3,Z-3) + 2B(\alpha) - 2B(\alpha) =$$
$$= -(B(\alpha) + B(N-2,Z-2) - B(N,Z)) + (B(N-2,Z-3) + B(\alpha) - B(N,Z-1)) + (B(\alpha) + B(N-3,Z-2) - B(N-1,Z)) -$$
$$- (B(\alpha) + B(N-3,Z-3) - B(N-1,Z-1)) = Q_\alpha(N,Z-1) + Q_\alpha(N-1,Z) - Q_\alpha(N,Z) - Q_\alpha(N-1,Z-1)$$

	σ_A, keV	σ_B, keV	σ_C, keV	σ_D, keV
A ≥ 280	71	156	151	285
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A ≥ 240	88	149	94	168
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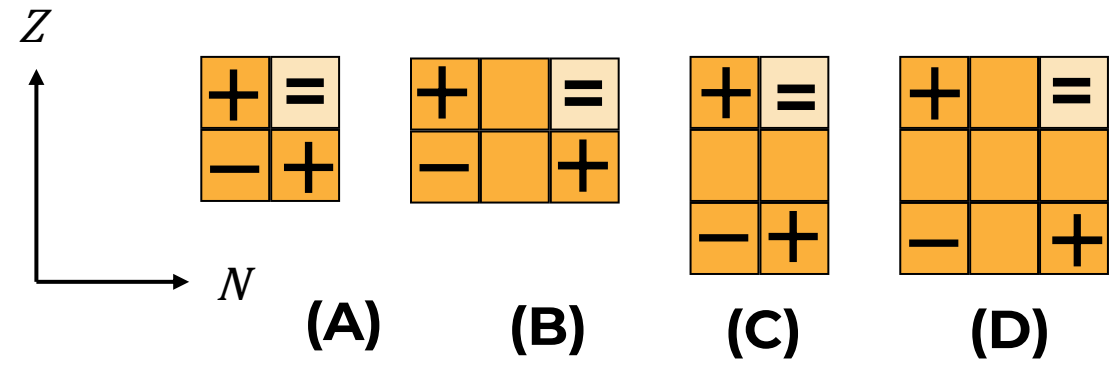
$$\sigma = \sqrt{\frac{1}{N}\Sigma_{N,Z}[\delta Q_{in_jp}(N,Z)]^2}$$



M. Bao [et al.] // PRC. 2014. Vol. 90, no. 2. P. 024314.