Nuclear structure beyond the proton drip line

- Introduction
- Experimental methods
- Recent results
  - Proton emission
  - Alpha emission
  - Beta emission

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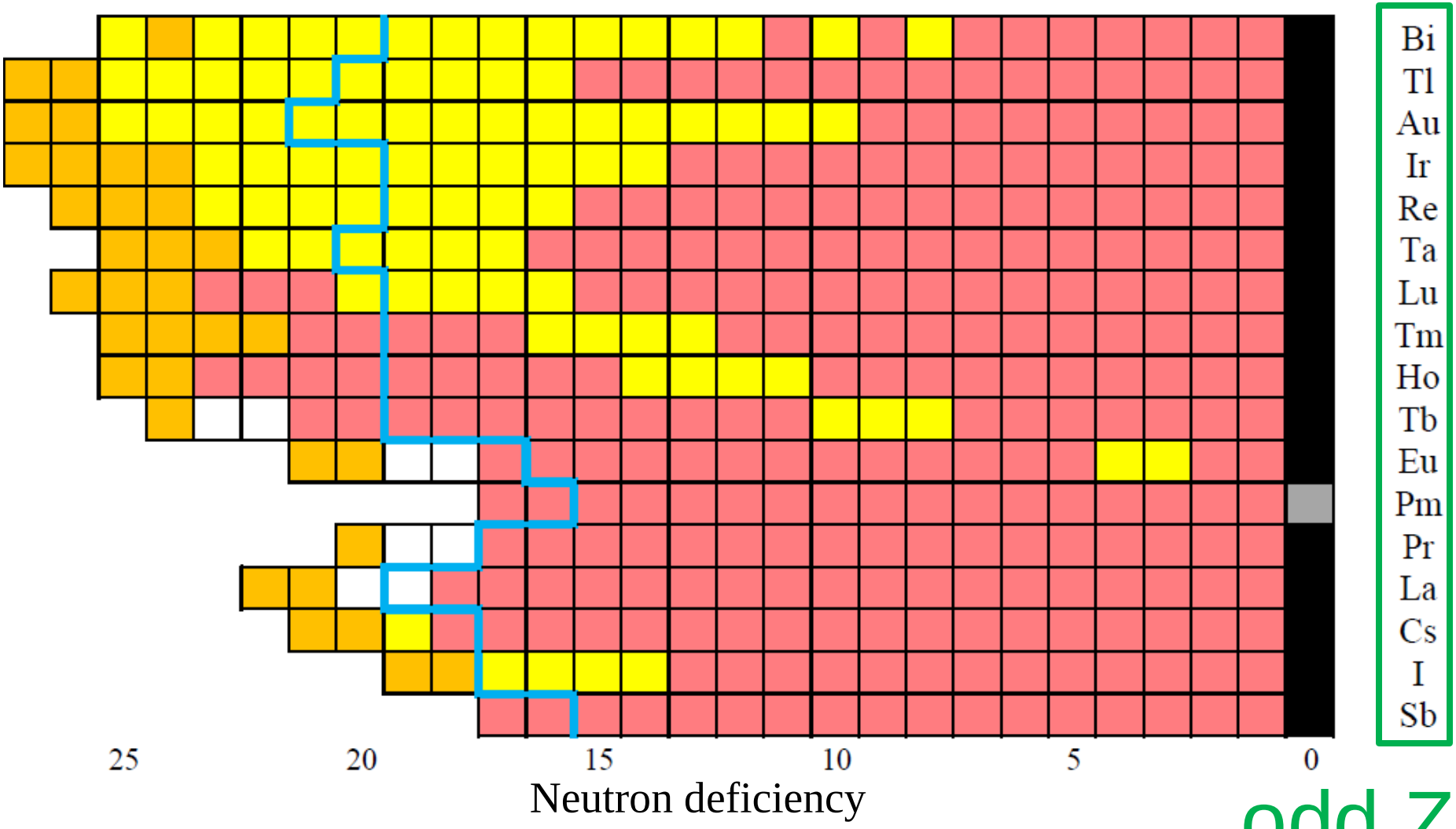
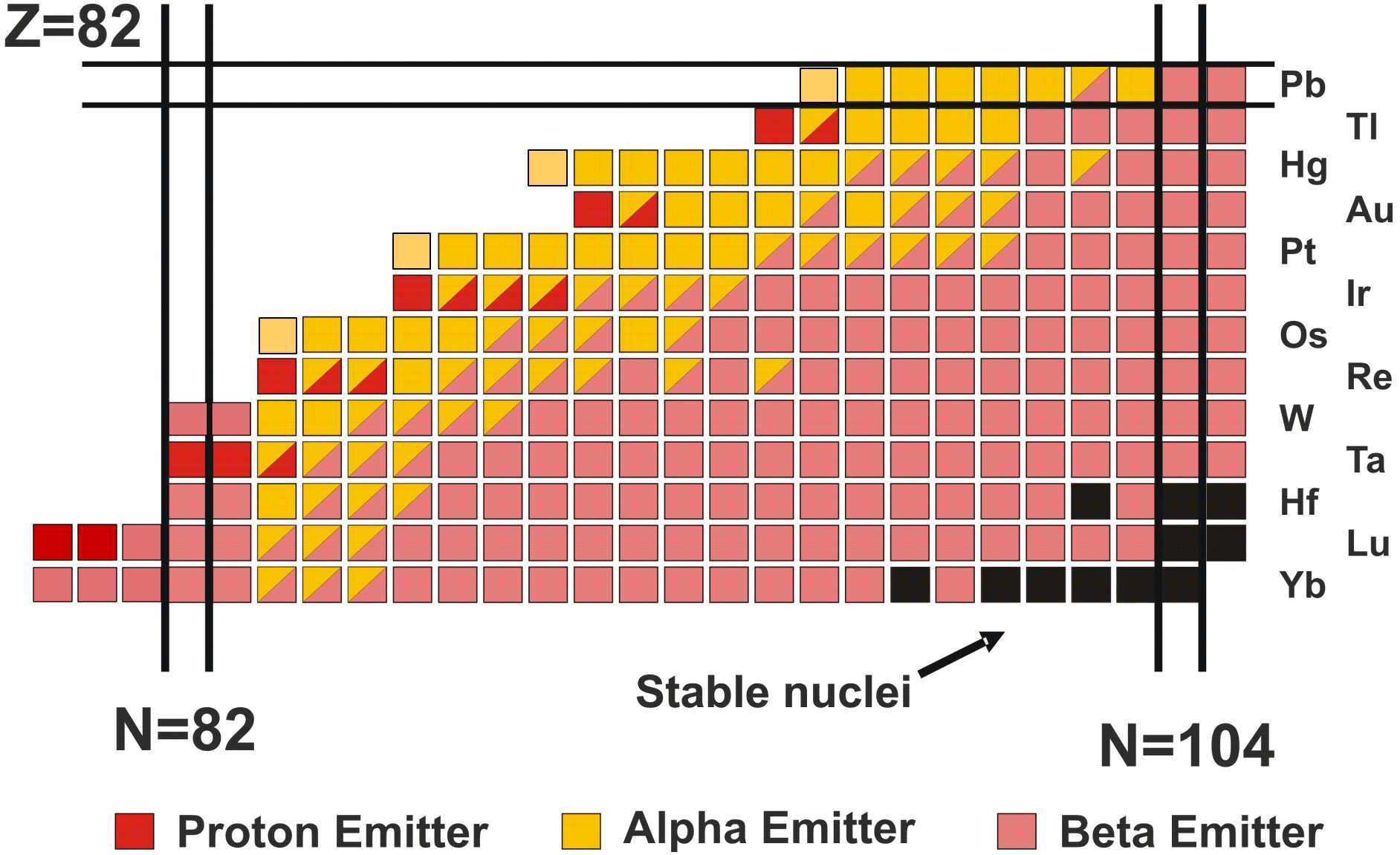
How exotic are these nuclei?



odd Z

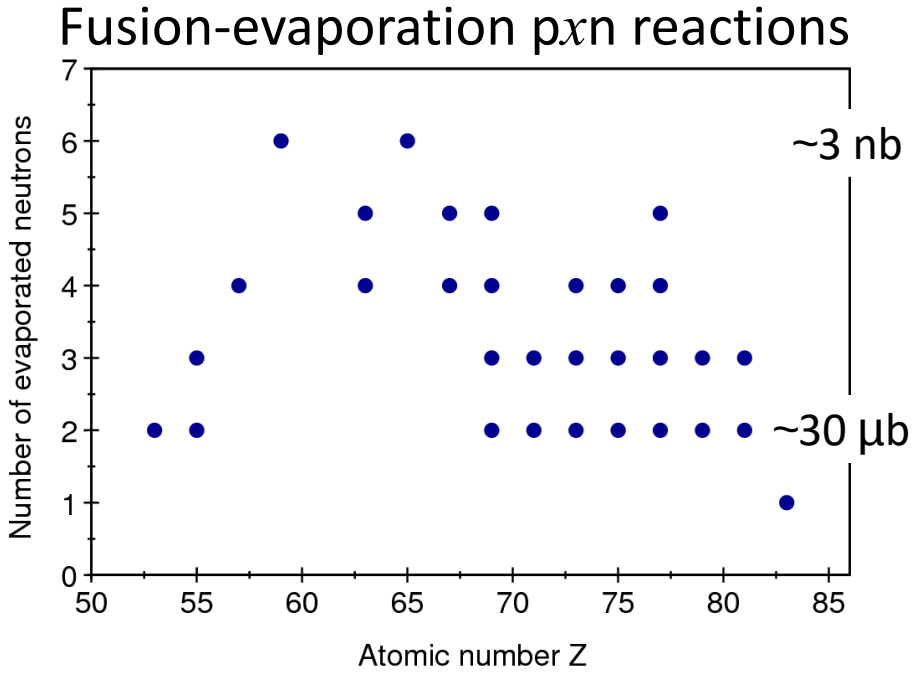
Properties of exotic nuclei test models far from stability

How exotic are these nuclei?

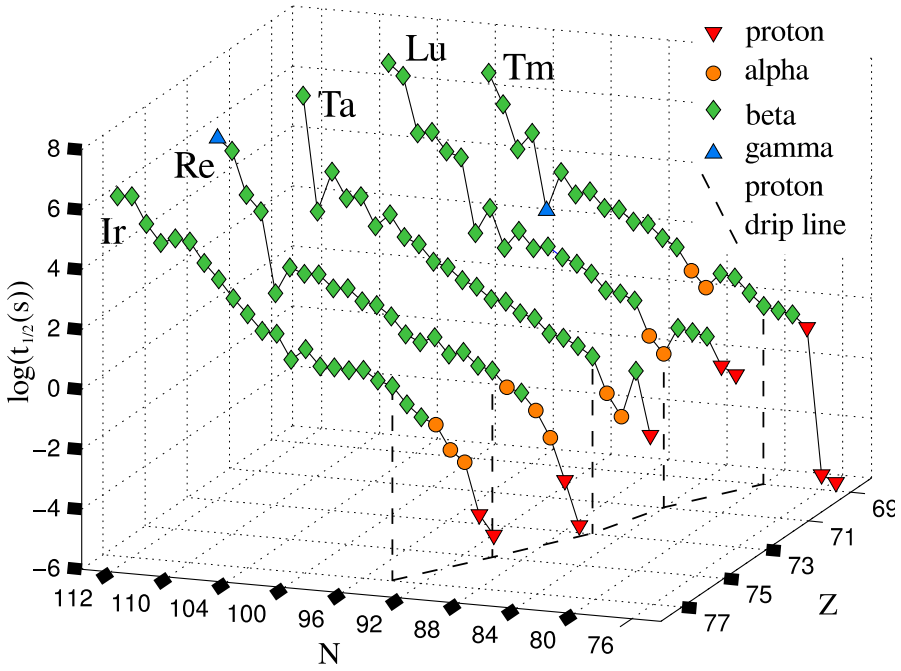


How hard are they to study?

Cross sections



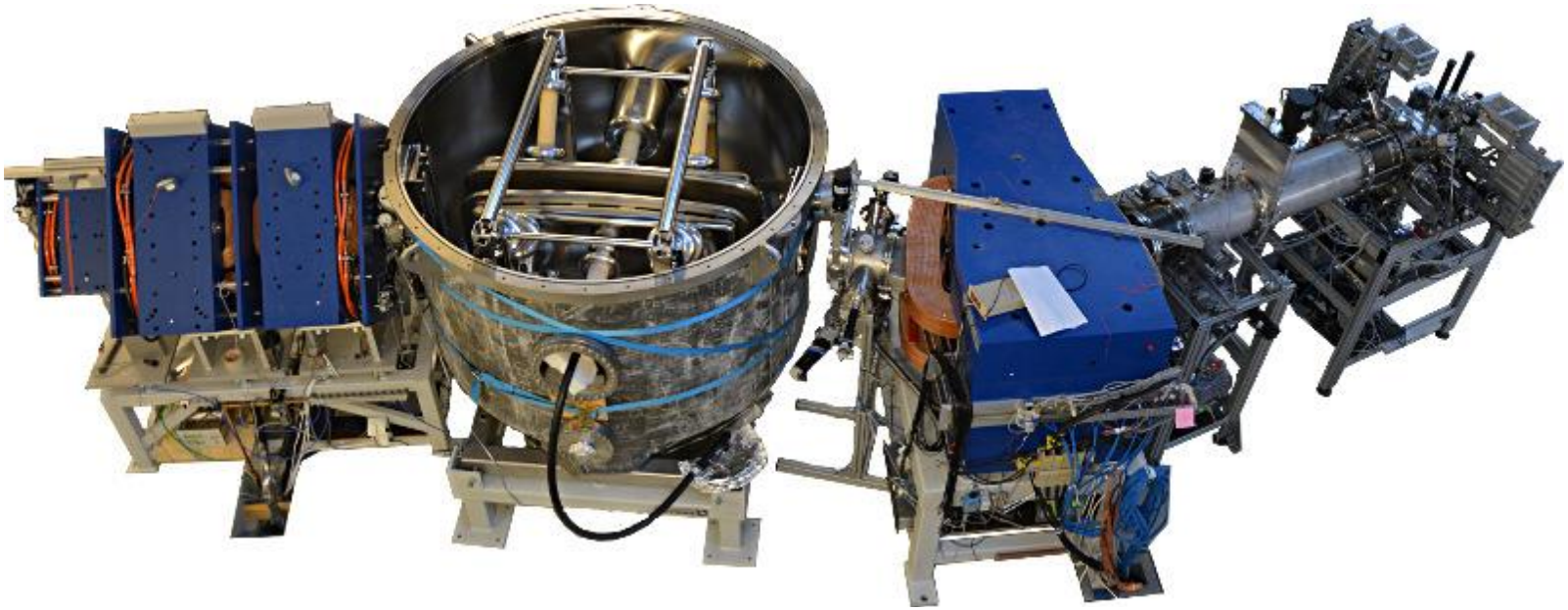
Half-lives



Low cross sections => selectivity & efficiency
Few events – beware of background!!
Short half-lives can help with selection

Mass Analysing Recoil Apparatus

MARA – fusion-evaporation reactions

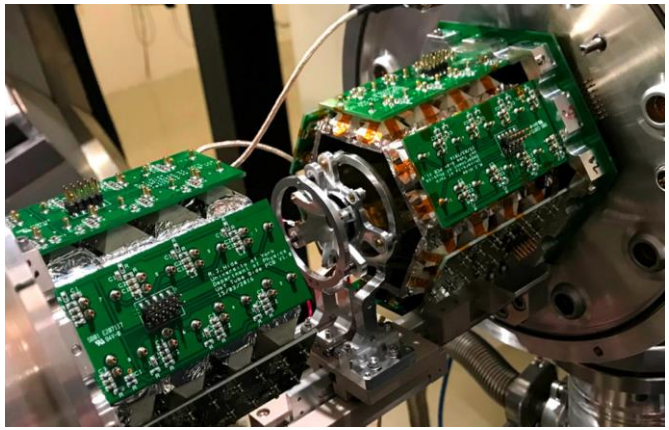


Efficiency ~40 % Flight time ~0.5 μs

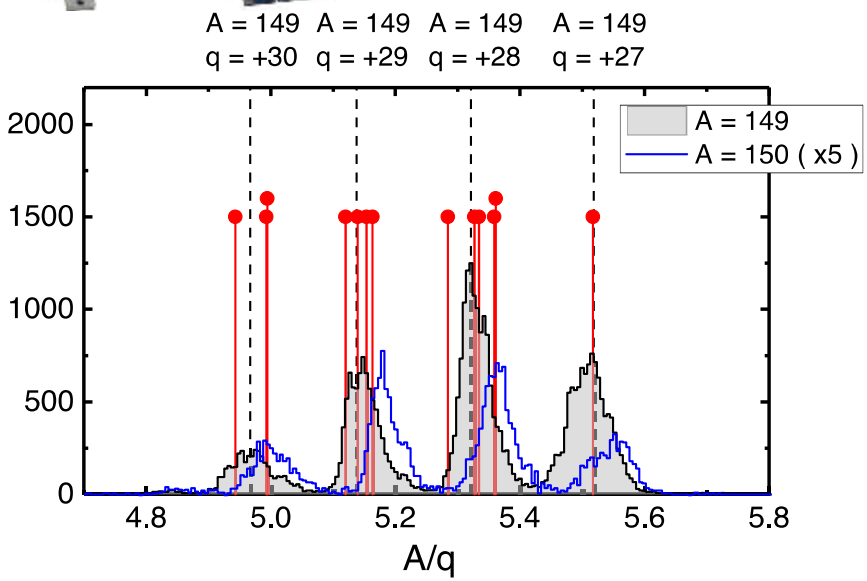
J. Uusitalo, et al., Acta Physica Polonica B50 (2019) 319

J. Sarén et al., NIMB 541 (2023) 33

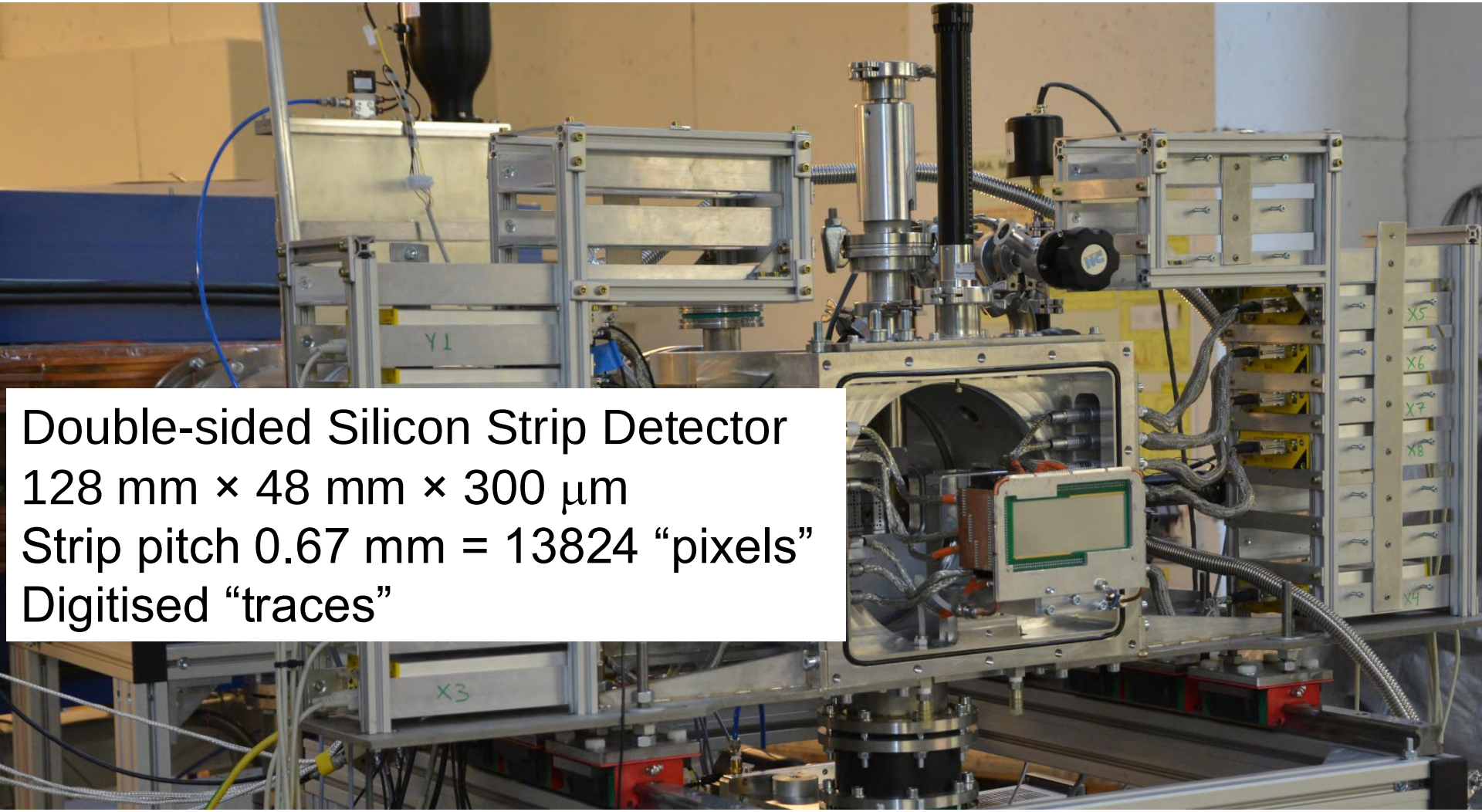
Maximising sensitivity



JYTube (with APPA)

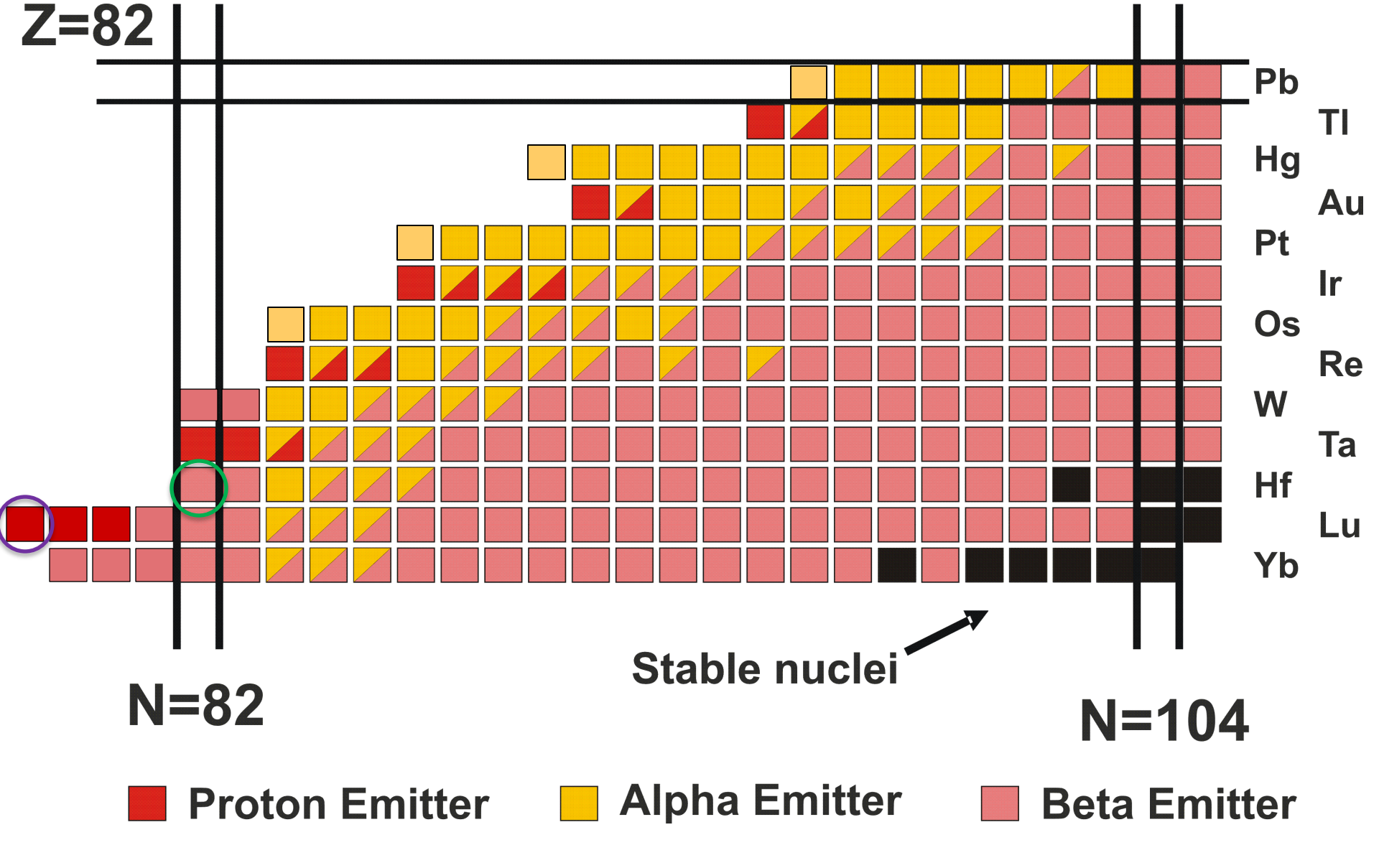


MARA Focal Plane Detectors



Double-sided Silicon Strip Detector
128 mm × 48 mm × 300 μm
Strip pitch 0.67 mm = 13824 “pixels”
Digitised “traces”

Proton emission from ^{149}Lu



Proton emission from ^{149}Lu

PHYSICAL REVIEW LETTERS **128,** 112501 (2022)

Editors' Suggestion

Nanosecond-Scale Proton Emission from Strongly Oblate-Deformed ^{149}Lu

K. Auranen,[1,*] A. D. Briscoe,[1] L. S. Ferreira,[2] T. Grahn,[1] P. T. Greenlees,[1] A. Herzáň,[3] A. Illana,[1] D. T. Joss,[4] H. Joukainen,[1] R. Julin,[1] H. Jutila,[1] M. Leino,[1] J. Louko,[1] M. Luoma,[1] E. Maglione,[2] J. Ojala,[1] R. D. Page,[4] J. Pakarinen,[1] P. Rahkila,[1] J. Romero,[1,4] P. Ruotsalainen,[1] M. Sandzelius,[1] J. Sarén,[1] A. Tolosa-Delgado,[1] J. Uusitalo,[1] and G. Zimba[1]

[1]*Accelerator Laboratory, Department of Physics, University of Jyväskylä, FI-40014 Jyväskylä, Finland*

[2]*Centro de Física e Engenharia de Materiais Avançados CeFEMA, Instituto Superior Técnico, Universidade de Lisboa, Avenida Rovisco Pais, P1049-001 Lisbon, Portugal*

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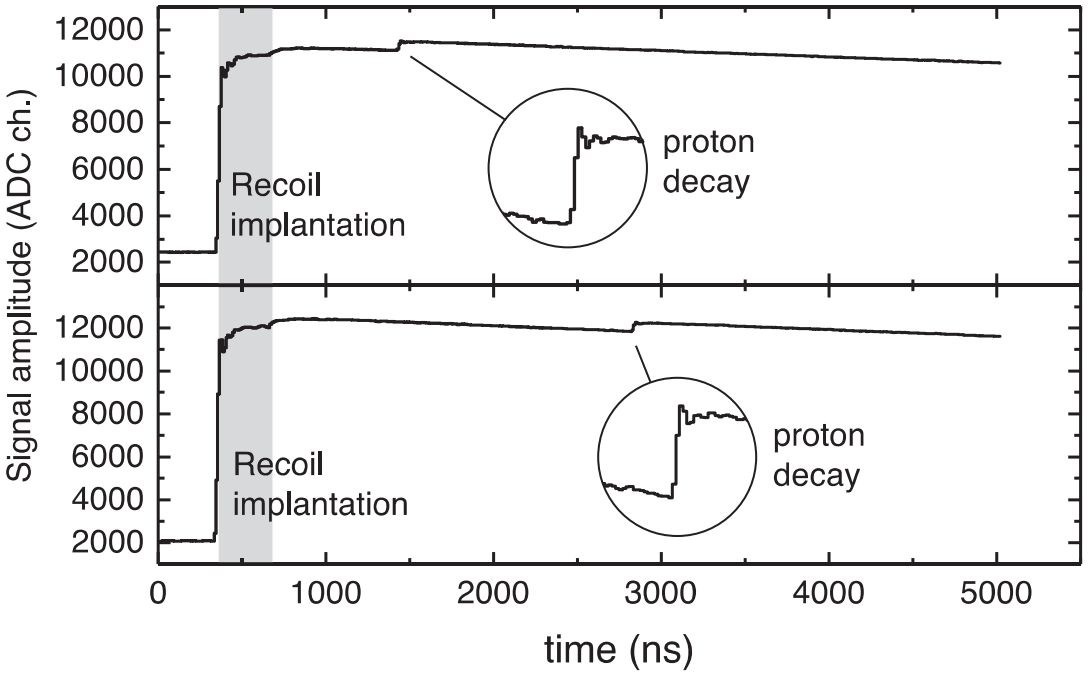
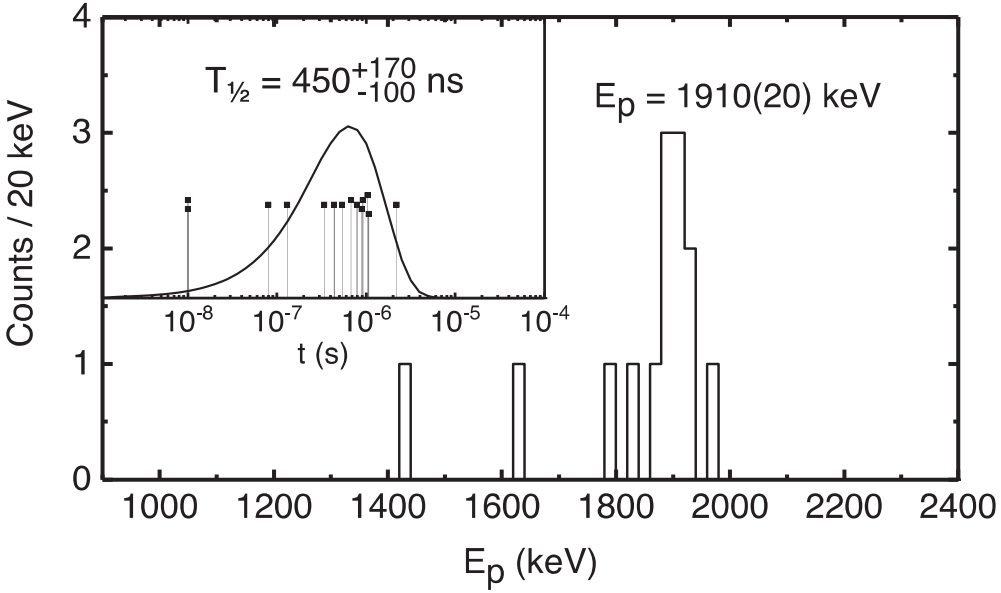
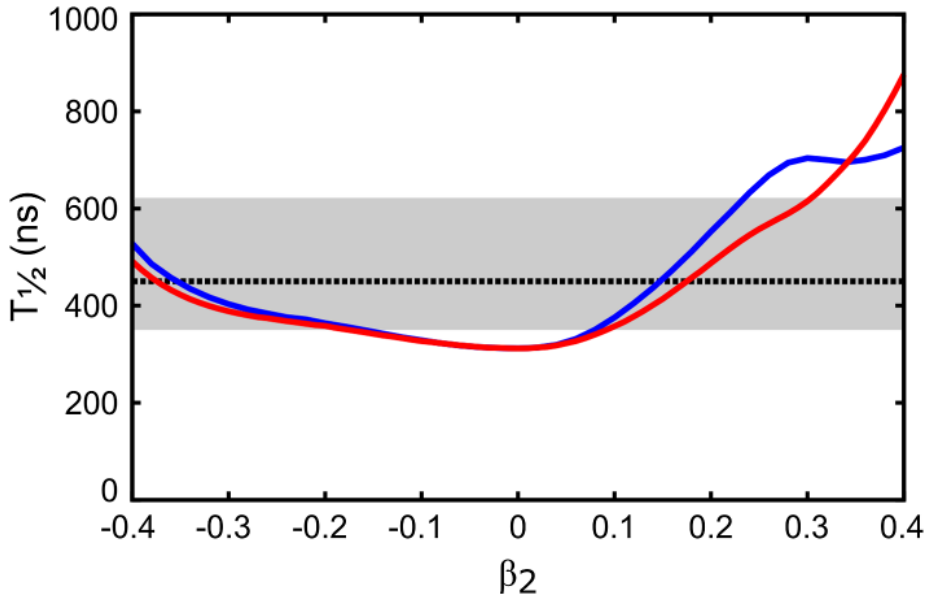
[4]*Department of Physics, Oliver Lodge Laboratory, University of Liverpool, Liverpool L69 7ZE, United Kingdom*



Proton emission from ^{149}Lu





Proton emission from ^{149}Lu

Physics Letters B 845 (2023) 138160

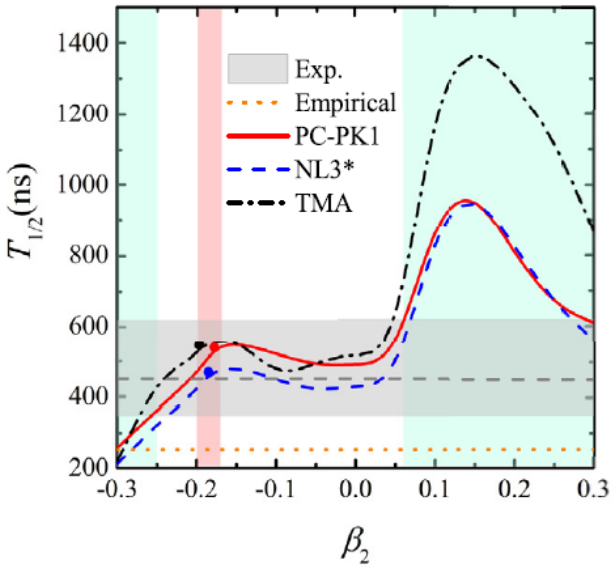
Contents lists available at ScienceDirect

Physics Letters B

journal homepage: www.elsevier.com/locate/physletb

One-proton emission from $^{148-151}$Lu in the DRHBc+WKB approach

Yang Xiao [a,b], Si-Zhe Xu [b], Ru-You Zheng [b], Xiang-Xiang Sun [c,d], Li-Sheng Geng [b,e,f,g,*], Shi-Sheng Zhang [b,*]



Phys. Lett. B 856 (2024) 138922

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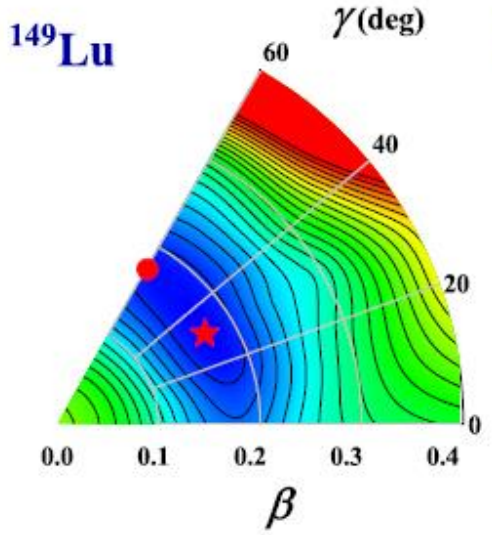
Physics Letters B

journal homepage: www.elsevier.com/locate/physletb

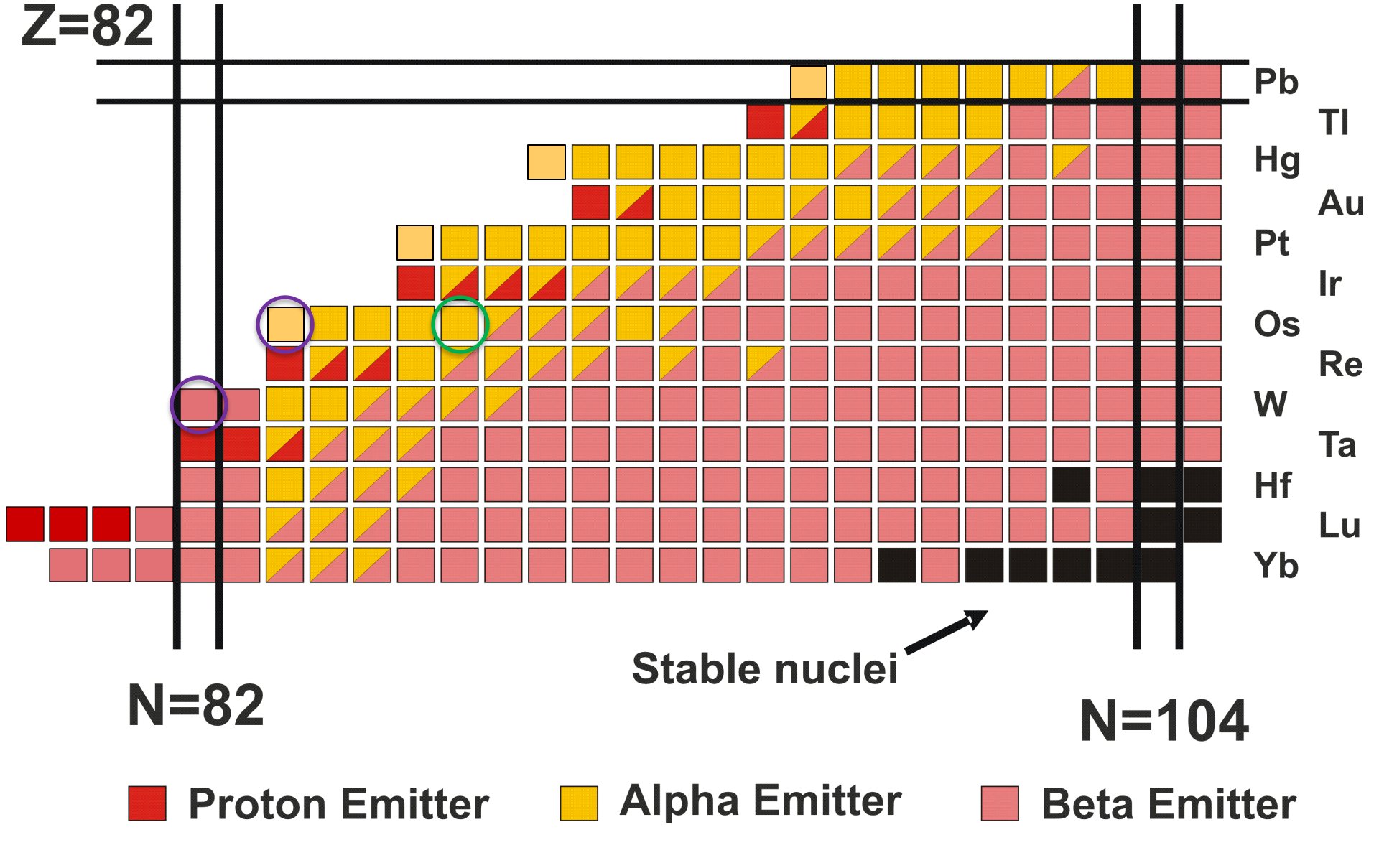
Letter

Triaxial shape of the one-proton emitter ^{149}Lu

Qi Lu [a], Kai-Yuan Zhang [b,*], Shi-Sheng Zhang [a,*]



New α emitter ^{160}Os & β emitter ^{156}W



MARA

Phys. Lett. B 847 (2023) 138310

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SHANS

PHYSICAL REVIEW LETTERS **132,** 072502 (2024)

Editors' Suggestion | Featured in Physics

Discovery of New Isotopes ^{160}Os and ^{156}W: Revealing Enhanced Stability of the $N = 82$ Shell Closure on the Neutron-Deficient Side

H. B. Yang (杨华彬),[1] Z. G. Gan (甘再国),[1,2,3,*] Y. J. Li (李英健),[4] M. L. Liu (刘梦兰),[5] S. Y. Xu (徐苏扬),[1,2] C. Liu (刘晨),[4] M. M. Zhang (张明明),[1] Z. Y. Zhang (张志远),[1,2] M. H. Huang (黄明辉),[1,2,3] C. X. Yuan (袁岑溪),[5,†] S. Y. Wang (王守宇),[4,‡] L. Ma (马龙),[1] J. G. Wang (王建国),[1] X. C. Han (韩星池),[4] A. Rohilla,[4] S. Q. Zuo (左思琪),[4] X. Xiao (肖骁),[4] X. B. Zhang (张鑫博),[4] L. Zhu (祝霖),[4] Z. F. Yue (岳志芳),[4] Y. L. Tian (田玉林),[1,2,3] Y. S. Wang (王永生),[1,3] C. L. Yang (杨春莉),[1,2] Z. Zhao (赵圳),[1,2] X. Y. Huang (黄鑫源),[1,2] Z. C. Li (李宗池),[1,2] L. C. Sun (孙路冲),[6] J. Y. Wang (王均英),[1,3] H. R. Yang (杨贺润),[1,2] Z. W. Lu (卢子伟),[1] W. Q. Yang (杨维青),[1] X. H. Zhou (周小红),[1,2] W. X. Huang (黄文学),[1,2,3] N. Wang (王宁),[6] S. G. Zhou (周善贵),[7,2] Z. Z. Ren (任中洲),[8] and H. S. Xu (徐瑚珊)[1,2,3]

Phys. Lett. B 847 (2023) 138310

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Letter

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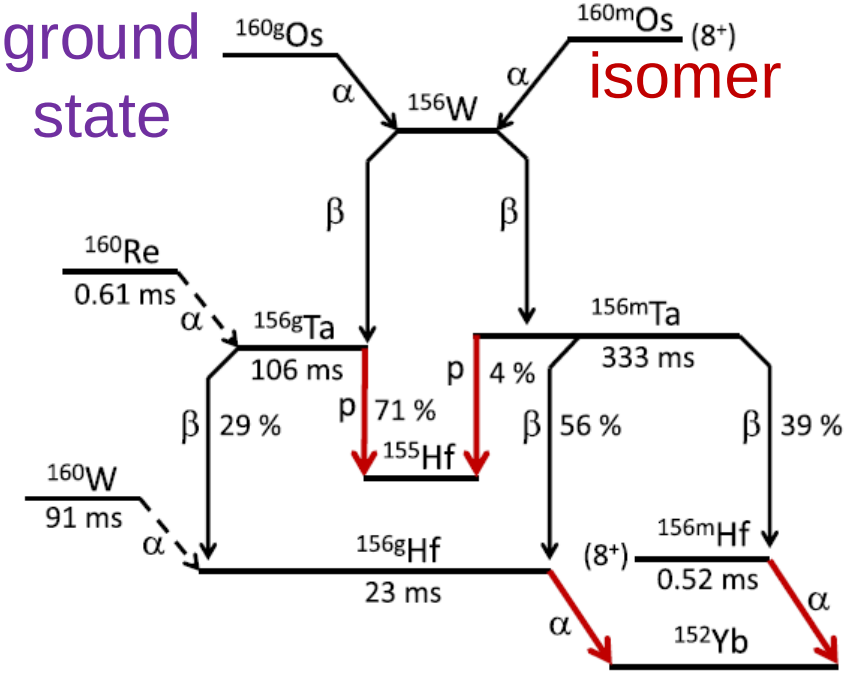

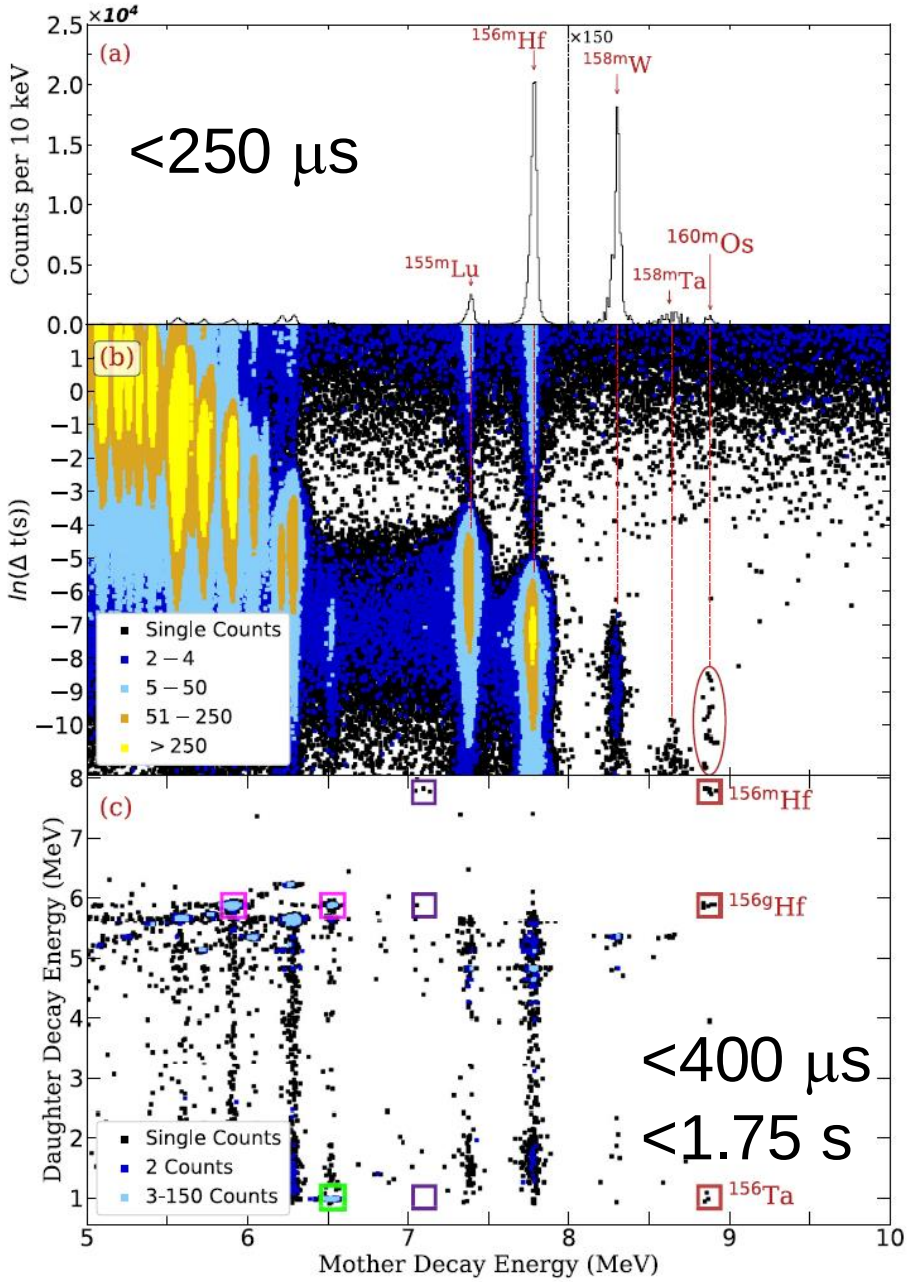

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Cleanly correlated decay chains

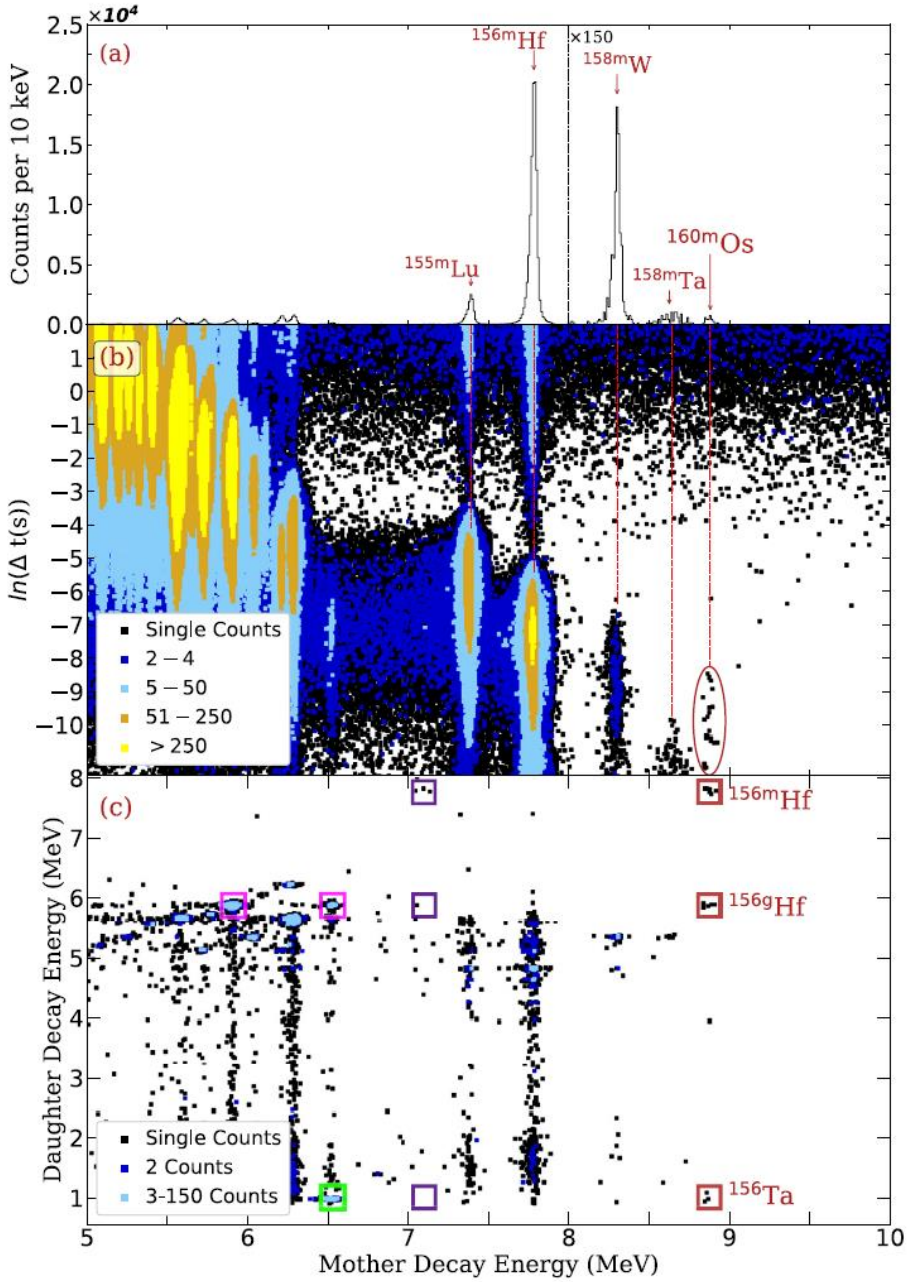
Chain #	E_1 (keV)	t_1 (μs)	E_2 (keV)	t_2 (ms)	E_3 (keV)	t_3 (ms)	E_4 (keV)	t_4 (ms)	E_5 (keV)	t_5 (ms)	JYTube Fold
1	8911	27	5886[a]	1285	-	-	-	-	-	-	0
2	8894	31	472[h]	43	165[i]	1498	5883[a]	55	4820[e]	1139	0
3	8868	31	180[i]	1605	7801[b]	1	-	-	-	-	0
4	8878	205	1016[c]	256	-	-	-	-	-	-	1
5	8850	15	341[h]	256	5904[a]	1285	-	-	-	-	0
6	8888	28	156[h]	28	7741[b]	923	-	-	-	-	0
7	8891	166	867[h]	314	7716[b]	48	-	-	-	-	0
8	8852	14	218[h]	108	7811[b]	662	-	-	-	-	0
9	8847	102	5839[a]	864	-	-	-	-	-	-	0
10	8888	181	204[h]	712	7791[b]	307	1345	314	-	-	0
11	8929	27	245[h]	48	7765[b]	578	-	-	-	-	0
12	8851	52	425[g]	312	974[c]	226	215	840	-	-	0
13	8871	57	5864[a]	800	-	-	-	-	-	-	0
14	8856	13	1131[d]	916	5577[f]	1096	-	-	-	-	1
15	7108	112	878[h]	88	7812[b]	70	-	-	-	-	0
16	7069	105	5879[a]	489	-	-	-	-	-	-	0
17	7144	13	7756[b]	82	1871	1414	4815[e]	4721	-	-	0
18	7049	364	7767[b]	481	-	-	-	-	-	-	1

E_α 7092 keV

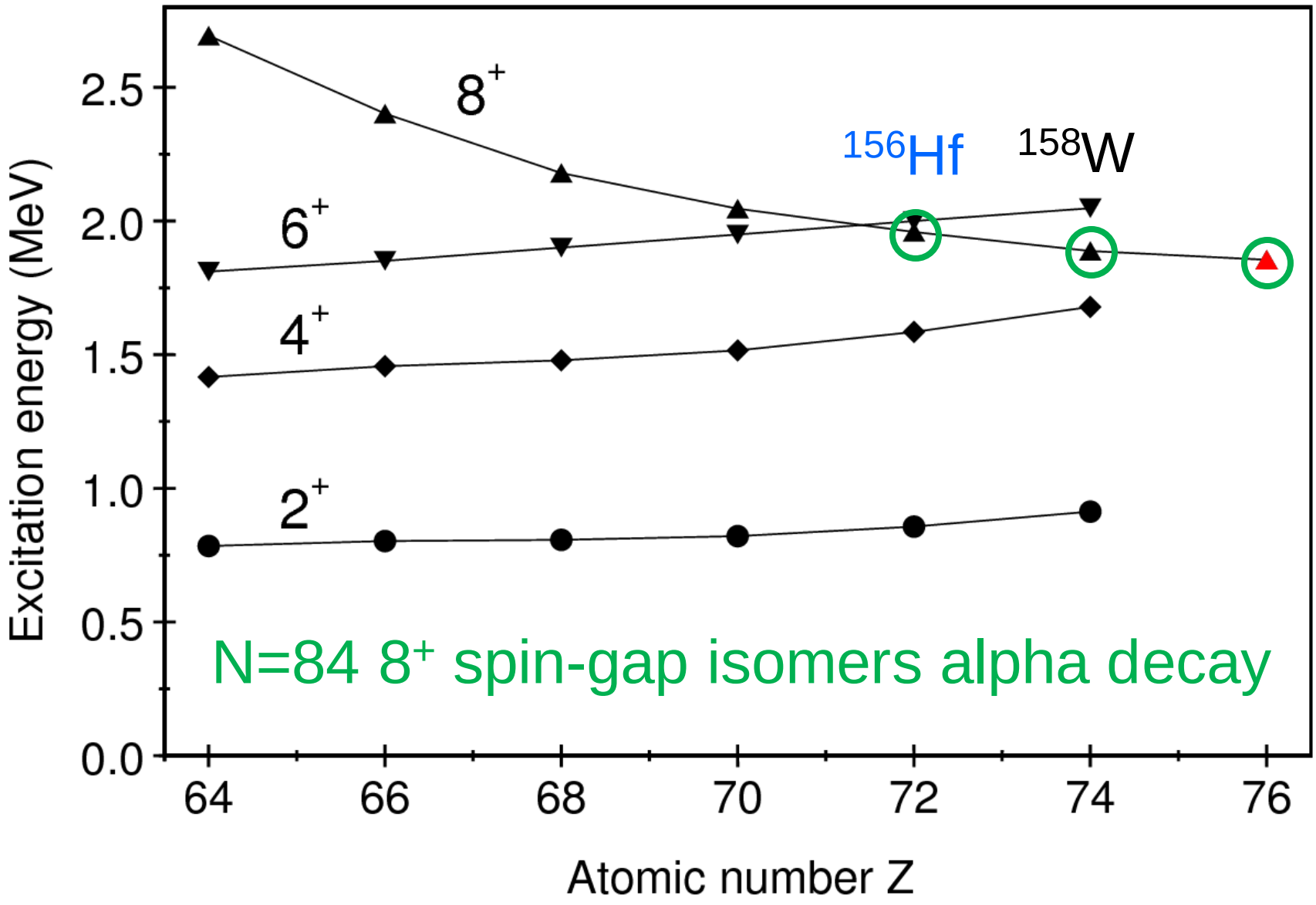
$t_{1/2}$ 97^{+97}_{-32} μs

8890 keV

41^{+15}_{-9} μs



N = 84 energy level systematics



PHYSICAL REVIEW LETTERS **132,** 072502 (2024)

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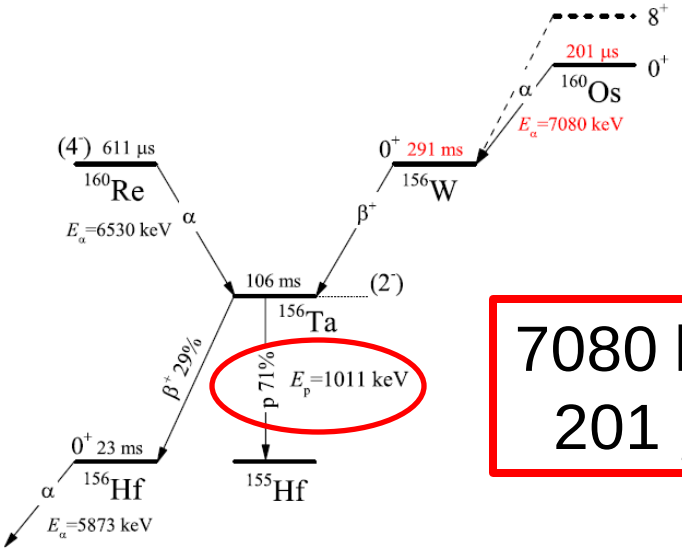
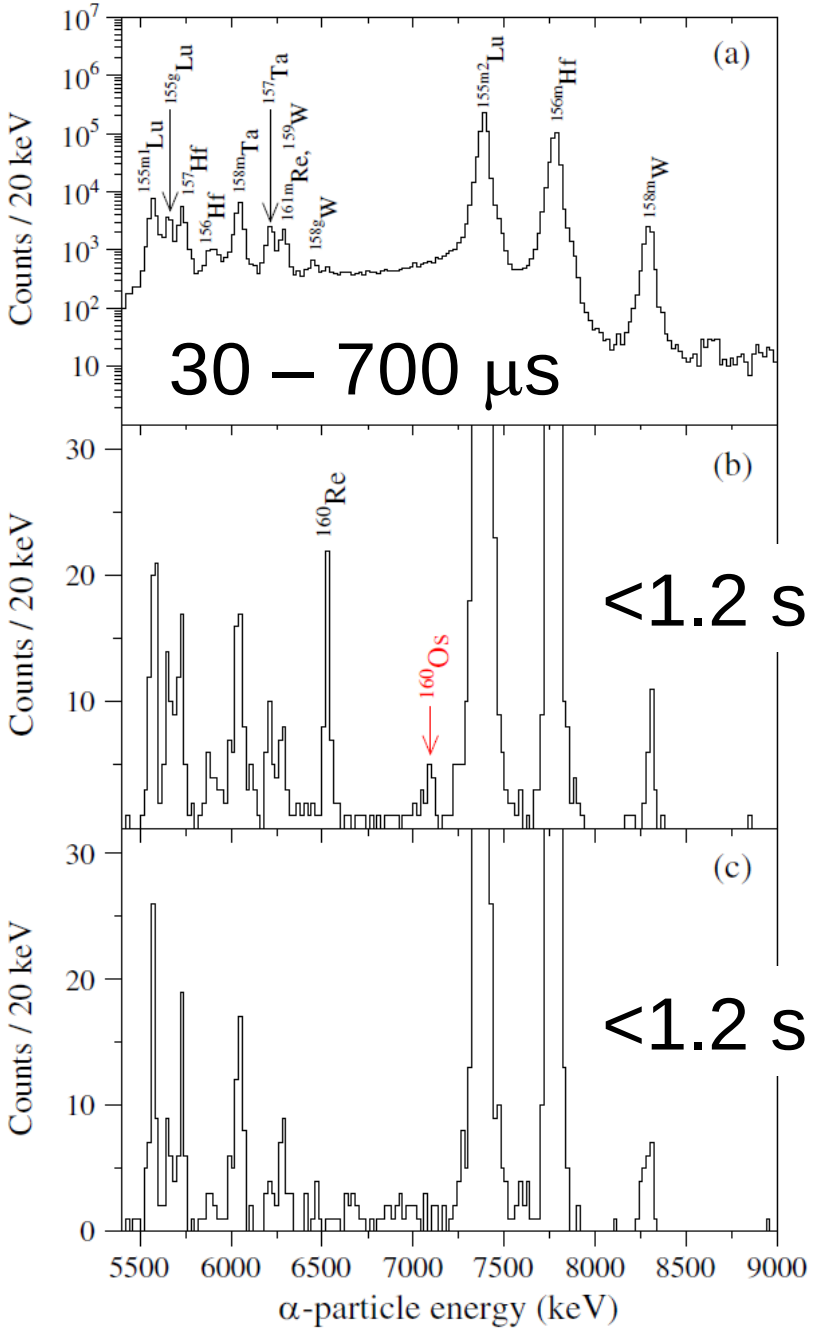


7080 keV
201 μs



Background in spectrum (c)

Summary

Proton emitter ^{149}Lu

New α emitter ^{160}Os

New β emitter ^{156}W

More new results to come!

UNIVERSITY OF LIVERPOOL

Robert Page

Extra acknowledgements

A. D. Briscoe,[1,2] R. D. Page,[1] J. Uusitalo,[2,1] D. T. Joss,[1] K. Auranen,[2] A. McCarter,[1] M. A. M. AlAqeel,[9,1] B. Alayed,[10,1] B. Andel,[3] S. Antalic,[3] H. Ayatollahzadeh,[4] V. Bogdanoff,[2] R. M. Clark,[5] J. G. Cubiss,[6] T. Grahn,[2] P. T. Greenlees,[2] A. Illana,[2,11] H. Joukainen,[2] D. S. Judson,[1] R. Julin,[2] H. Jutila,[2] J. M. Keatings,[4] M. Leino,[2] J. Louko,[2] P. Mosat,[3] J. Ojala,[2] C. A. A. Page,[6] A. M. Plaza,[2,1] J. Pakarinen,[2] P. Papadakis,[7] E. Parr,[1] P. Ruotsalainen,[2] J. Sarén,[2] J. Smallcombe,[1] J. Sorri,[8] C. M. Sullivan,[1] S. Szwec,[2] and G. Zimba[2,12]

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