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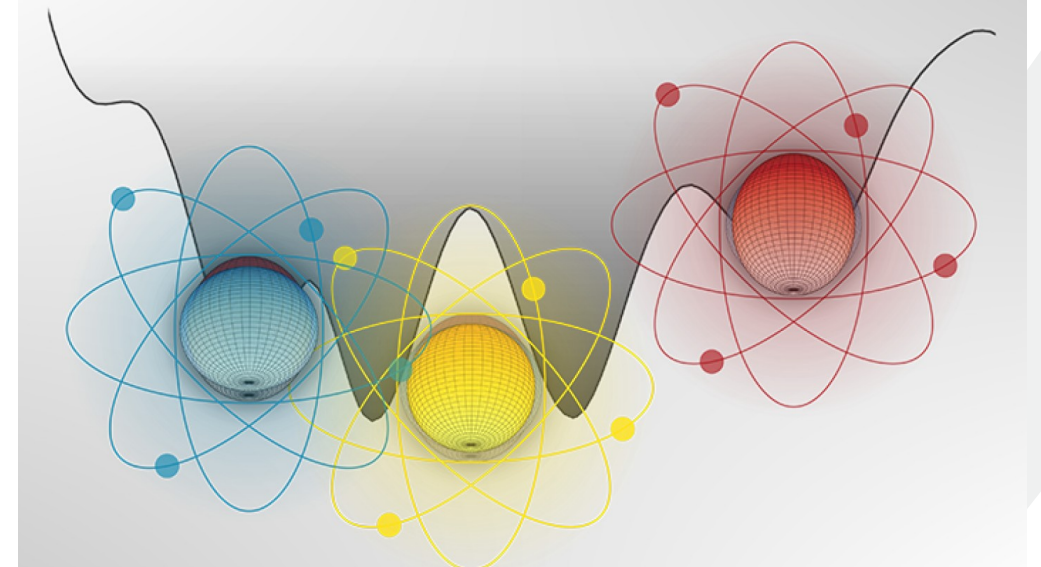
Shape coexistence in mid-shell of Pb isotopes and beyond

Presenter Joonas Ojala

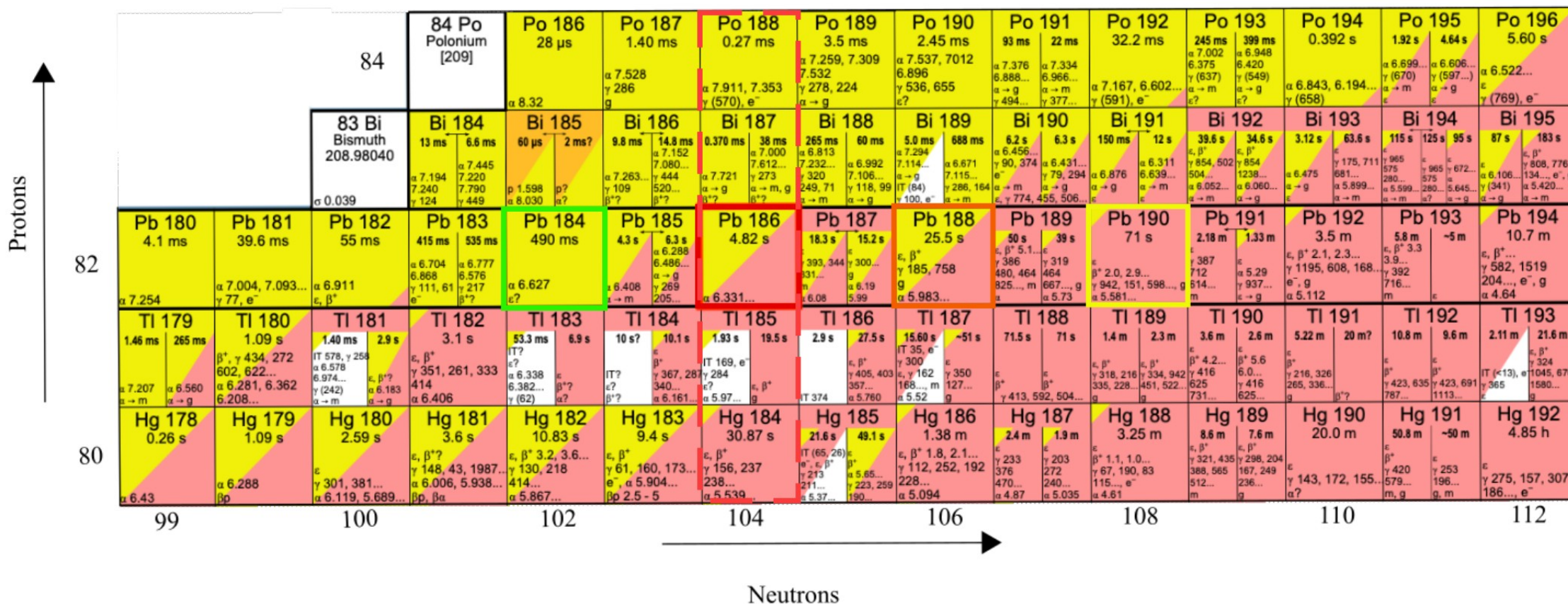
Shape coexistence in neutron-deficient Pb isotopes



- The shape coexistence phenomenon has been under study for several decades in Pb region
- Shape coexistence appears close to the neutron-midshell $N \approx 104$
- In addition to the spherical ground state, the intruder structures have been identified to be as following shapes, prolate $\pi(4p-4h)$ and oblate $\pi(2p-2h)$, in neutron-deficient Pb isotopes



Shape coexistence in neutron-deficient Pb isotopes





ARTICLE

<https://doi.org/10.1038/s42005-022-00990-4>

OPEN



2022

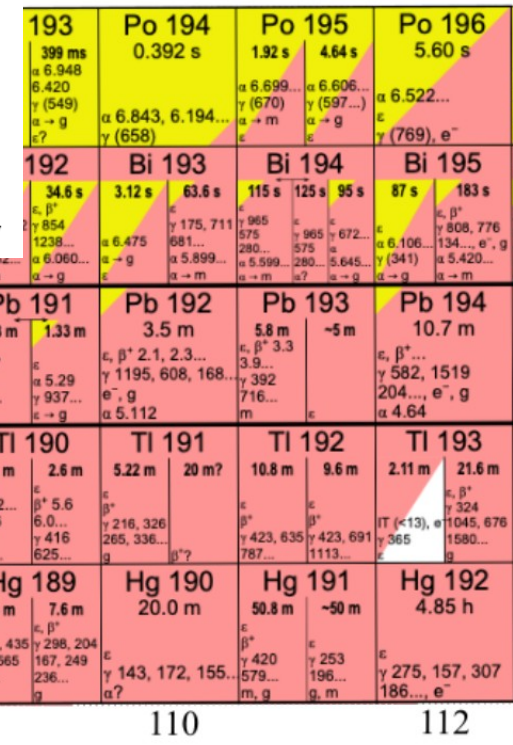
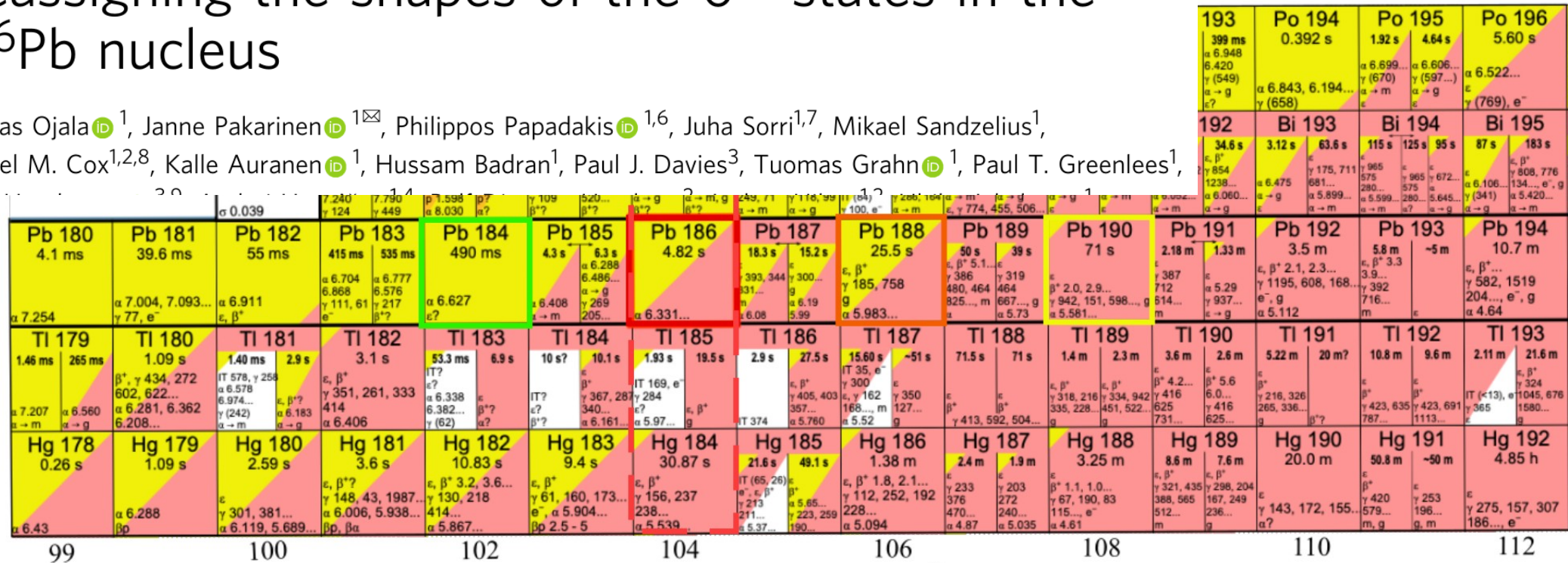
Reassigning the shapes of the 0^+ states in the ^{186}Pb nucleus

Joonas Ojala¹, Janne Pakarinen¹, Philippos Papadakis^{1,6}, Juha Sorri^{1,7}, Mikael Sandzelius¹, Daniel M. Cox^{1,2,8}, Kalle Auranen¹, Hussam Badran¹, Paul J. Davies³, Tuomas Grahn¹, Paul T. Greenlees¹,

Protons

82

80





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efficient Pb

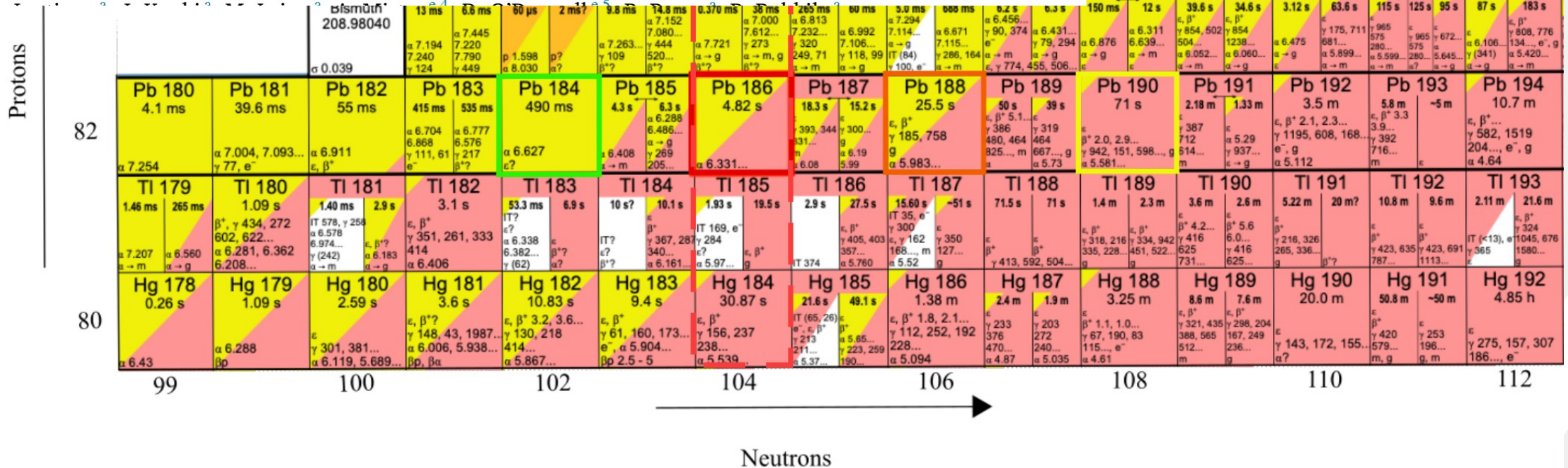
2024



Letter

Direct observation of $E0$ transitions in ^{188}Pb through in-beam spectroscopy

P. Papadakis ^{a,b,*,1}, J. Pakarinen ^{a,*,**}, A.D. Briscoe ^{a,2}, D.M. Cox ^a, R. Julin ^a, K. Auranen ^a, T. Grahn ^a, P.T. Greenlees ^a, K. Hadyńska-Klek ^c, A. Herzán ^{a,d}, R.-D. Herzberg ^c, U. Jakobsson ^{a,3}





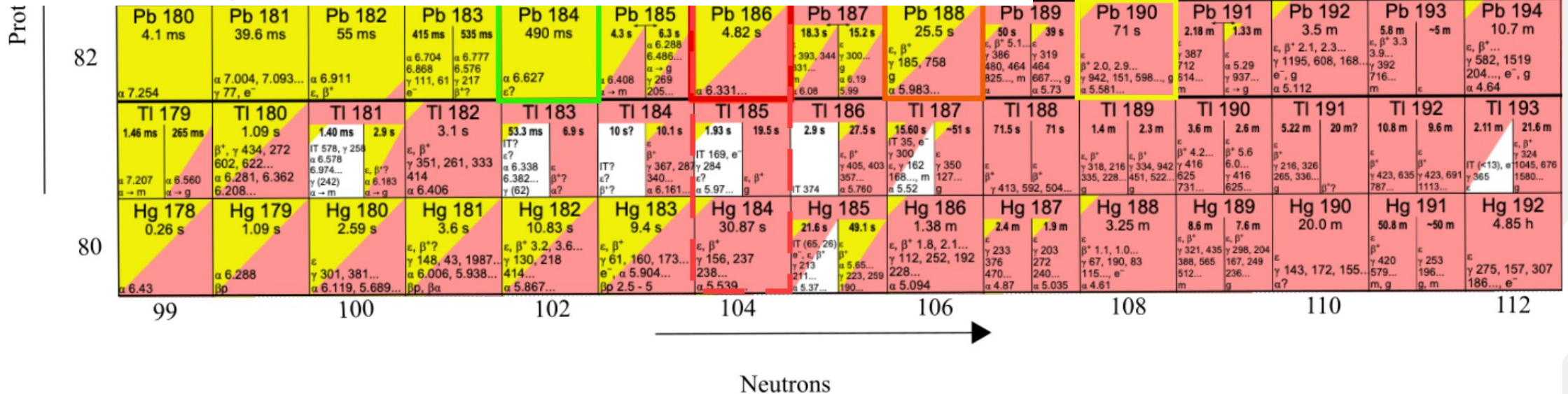
2025

<https://doi.org/10.1038/s42005-024-01928-8>

Direct measurement of three different deformations near the ground state in an atomic nucleus

Check for updates

Adrian Montes Plaza^{1,2}, Janne Pakarinen²✉, Philippos Papadakis³, Rolf-Dietmar Herzberg¹, Rauno Julin², Tomás R. Rodríguez⁴, Andrew D. Briscoe^{2,11}, Andrés Illana^{2,4}, Joonas Ojala²,



191 22 ms α 7.334 5.966... α → m γ 377...	Po 192 32.2 ms α 7.167, 6.602... α → m e ⁻	Po 193 245 ms 7.002 6.375 γ (637) α → m e ⁻	Po 194 399 ms 6.948 6.420 γ (549) α → g e ⁻	Po 195 0.392 s α 6.843, 6.194... α → m γ (658)	Po 196 1.92 s 4.64 s α 6.699... α 6.606... γ (597...) α → g e ⁻	Po 196 5.60 s α 6.522... γ (769), e ⁻								
90 6.3 s α 6.431... γ 79, 294 α → g 55, 506...	Bi 191 150 ms α 6.876 α → m e ⁻	Bi 192 12 s 39.6 s 34.6 s α 6.311 γ 854, 502 504... α → m α → g e ⁻	Bi 193 3.12 s 63.6 s α 6.475 α → g e ⁻	Bi 194 3.12 s 63.6 s α 6.475 α → g e ⁻	Bi 194 115 s 125 s 95 s γ 965 575 280... α 5.599... 280... 5.645... γ (341) α → m α → g e ⁻	Bi 195 87 s 183 s α 6.106... 134... e ⁻ , g α 5.420... α → m								
Pb 180 4.1 ms α 7.254	Pb 181 39.6 ms α 7.004, 7.093... γ 77, e ⁻	Pb 182 55 ms α 6.911 e, β ⁺	Pb 183 415 ms 535 ms α 6.704 6.868 γ 111, 61 e ⁻	Pb 184 490 ms α 6.627 e ⁻	Pb 185 4.3 s 6.3 s α 6.288 6.486... α → g e ⁻	Pb 186 4.82 s α 6.331... e, β ⁺	Pb 187 18.3 s 15.2 s α 6.331... 393, 344 331... α 6.19 γ 269 205... e, β ⁺	Pb 188 25.5 s α 5.983... γ 185, 758 g	Pb 189 50 s 39 s α 5.73 e, β ⁺ 5.1... γ 319 480, 464 464 825... 667... α 5.73	Pb 190 71 s α 5.581... β ⁺ 2.0, 2.9... γ 942, 151, 598... 514... m	Pb 191 2.18 m 1.33 m α 5.29 γ 937... e ⁻ , g α → g	Pb 192 3.5 m α 5.112 e, β ⁺ 2.1, 2.3... e, β ⁺ 3.3	Pb 193 5.8 m -5 m α 5.112 e, β ⁺ 3.3	Pb 194 10.7 m α 4.64 e, β ⁺ ... γ 582, 1519 204... e ⁻ , g
Tl 179 1.46 ms 265 ms α 7.207 α → m α → g	Tl 180 1.09 s β ⁺ , γ 434, 272 602, 622... α 6.281, 6.362 6.208... α → g	Tl 181 1.40 ms 2.9 s IT 578, γ 258 α 6.578 6.974... e, β ⁺ ? γ (242) α 6.183 α → m α → g	Tl 182 3.1 s e, β ⁺ γ 351, 261, 333 414 α 6.406	Tl 183 53.3 ms 6.9 s IT 17? e? e? α 6.338 6.382... β ⁺ ? e? γ (62) α?	Tl 184 10.1 s 10.1 s e, β ⁺ γ 367, 287 340... α 6.161... α 5.97... g	Tl 185 1.93 s 19.5 s IT 169, e ⁻ γ 284 e? e? e, β ⁺	Tl 186 2.9 s 27.5 s e, β ⁺ γ 405, 403 357... α 5.760 IT 374	Tl 187 15.60 s -51 s IT 35, e ⁻ γ 300 e, β ⁺ γ 162 γ 350 168... m 127... γ 413, 592, 504... g	Tl 188 71.5 s 71 s γ 413, 592, 504... g	Tl 189 1.4 m 2.3 m e, β ⁺ γ 318, 216 335, 228... g	Tl 190 3.6 m 2.6 m β ⁺ 4.2... β ⁺ 5.6 e, β ⁺ γ 216, 326 625 265, 336... β ⁺ ? 731... 625...	Tl 191 5.22 m 20 m? e, β ⁺ γ 216, 326 625 265, 336... β ⁺ ? 731... 625...	Tl 192 10.8 m 9.6 m β ⁺ γ 423, 635 787... 1113... β ⁺ ? 787... 1113...	Tl 193 2.11 m 21.6 m IT (<13), e ⁻ γ 1045, 676 1580... 365 1580...
Hg 178 0.26 s α 6.43	Hg 179 1.09 s α 6.288 βp	Hg 180 2.59 s γ 301, 381... α 6.119, 5.689... βp, βα	Hg 181 3.6 s e, β ⁺ ? γ 148, 43, 1987... α 6.006, 5.938... 414... βp, βα	Hg 182 10.83 s e, β ⁺ 3.2, 3.6... γ 130, 218 414... α 5.867...	Hg 183 9.4 s e, β ⁺ γ 61, 160, 173... e ⁻ , α 5.904... 238... α 5.539...	Hg 184 30.87 s e, β ⁺ γ 156, 237 238... α 5.539...	Hg 185 21.6 s 49.1 s IT (65, 26) e ⁻ , e, β ⁺ γ 213 211... α 5.65... 223, 259 190... α 5.094	Hg 186 1.38 m 2.4 m e, β ⁺ 1.8, 2.1... γ 112, 252, 192 228... 240... 470... α 4.87	Hg 187 1.9 m γ 203 376 272 240... 115... 512... g	Hg 188 3.25 m β ⁺ 1.1, 1.0... γ 67, 190, 83 240... 115... 512... g	Hg 189 8.6 m 7.6 m e, β ⁺ γ 321, 435 388, 565 167, 249 236... g	Hg 190 20.0 m e, β ⁺ γ 143, 172, 155... 579... 196... g, m	Hg 191 50.8 m -50 m e, β ⁺ γ 420 γ 253 196... g, m	Hg 192 4.85 h e, β ⁺ γ 275, 157, 307 186... e ⁻

Shape coexistence in neutron-deficient Pb isotc



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2025

Letter

Competing structures in the beyond neutron $N = 104$ midshell nucleus ^{184}Pb

J. Ojala^a, J. Pakarinen^{a,*,1}, R. Wadsworth^b, H. Badran^a, D.M. Cox^a, A.D. Briscoe^c, A. Brown^b, T. Calverley^{a,c}, T. Grahn^a, P.T. Greenlees^a, J. Hilton^{a,c}, R. Julin^a, J. Konki^a, R. Llewellyn^b, S. Juutinen^a, M. Leino^a, P. Papadakis^a, J. Partanen^{a,1}, P. Rakhila^a, M. Sandzelius^a, J. Sarén^a, C. Scholey^a, S. Stoltze^a, J. Uusitalo^a, B. Wallis^b

^a Accelerator Laboratory, Department of Physics, University of Jyväskylä, P.O. Box 35, FI-40014, University of Jyväskylä, Finland

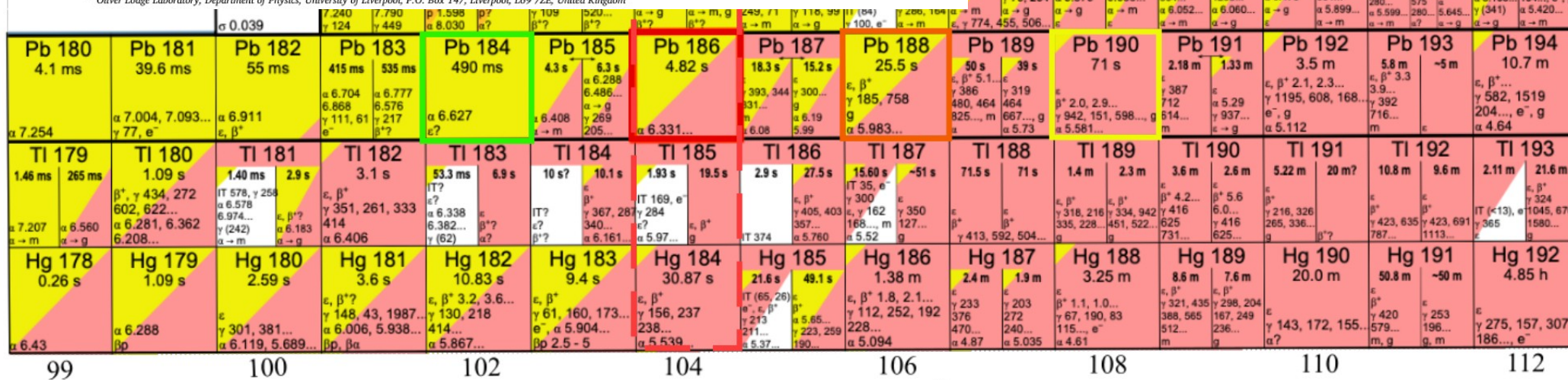
^b School of Physics, Engineering and Technology, University of York, Heslington, YO10 5DD, York, United Kingdom

^c Oliver Lodge Laboratory, Department of Physics, University of Liverpool, P.O. Box 147, Liverpool, L69 7ZE, United Kingdom

Protons

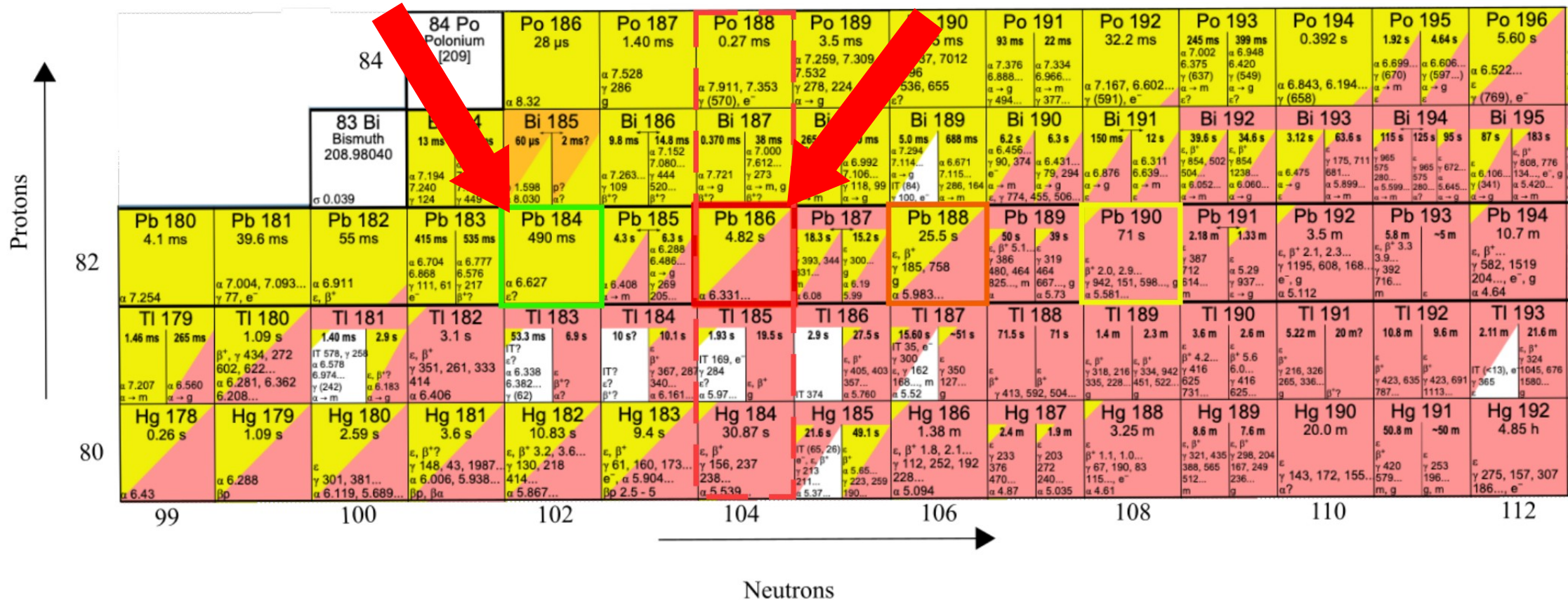
82

80



Neutrons

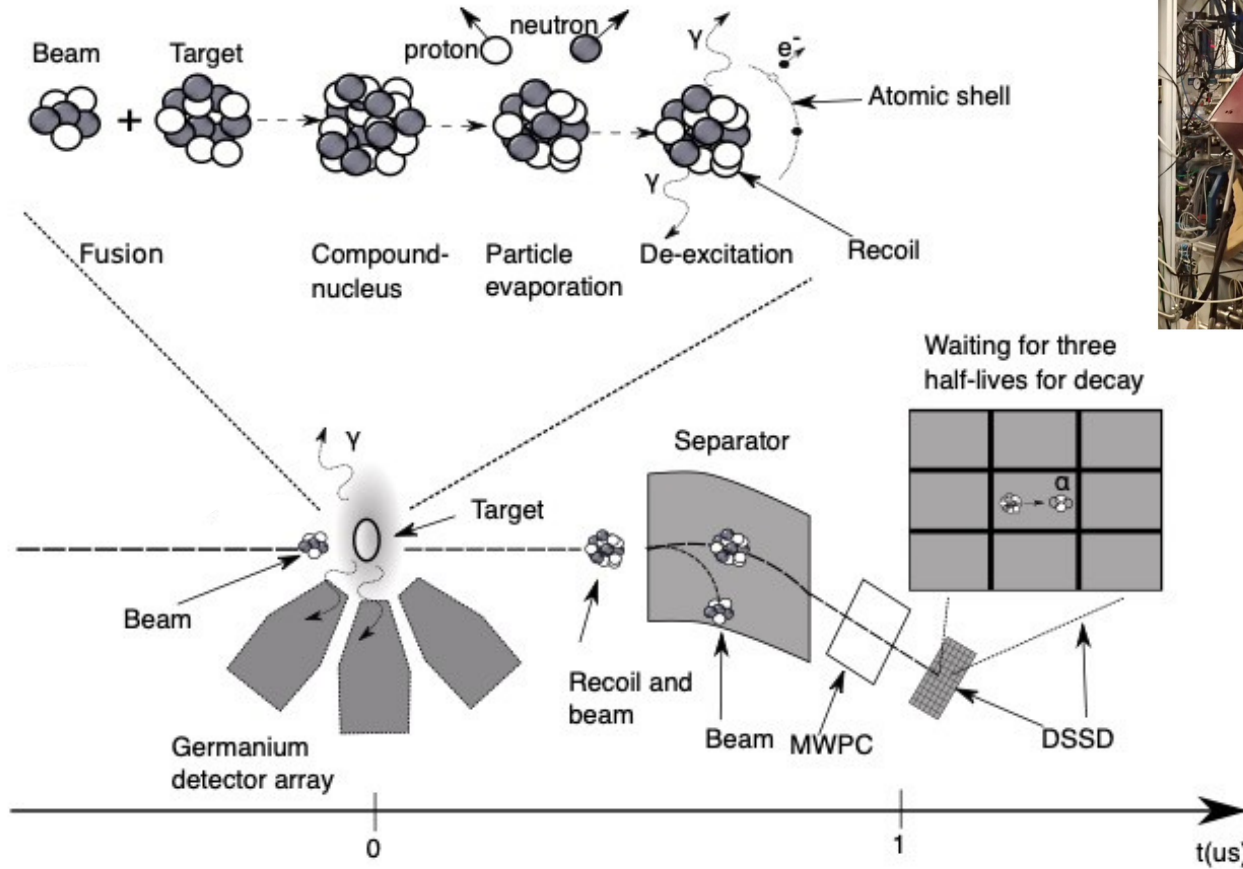
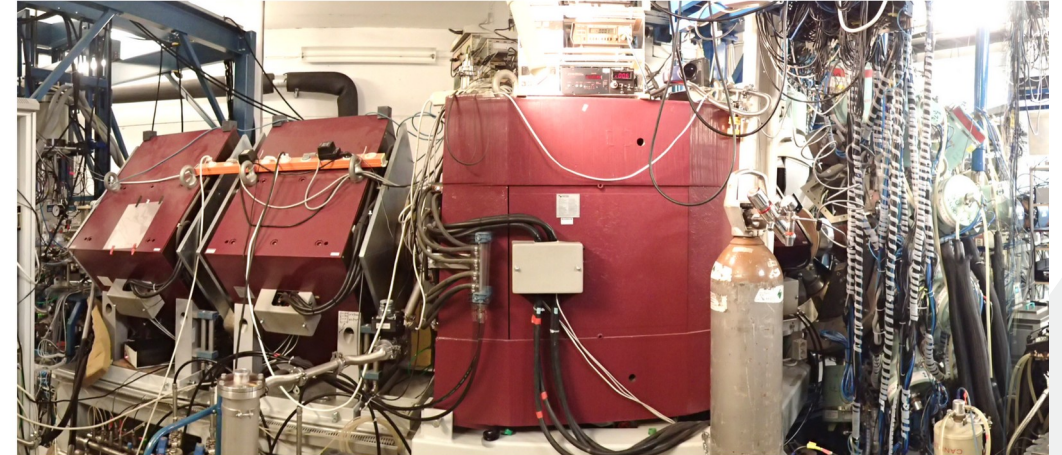
Shape coexistence in neutron-deficient Pb isotopes



Recoil-decay tagging(RDT)

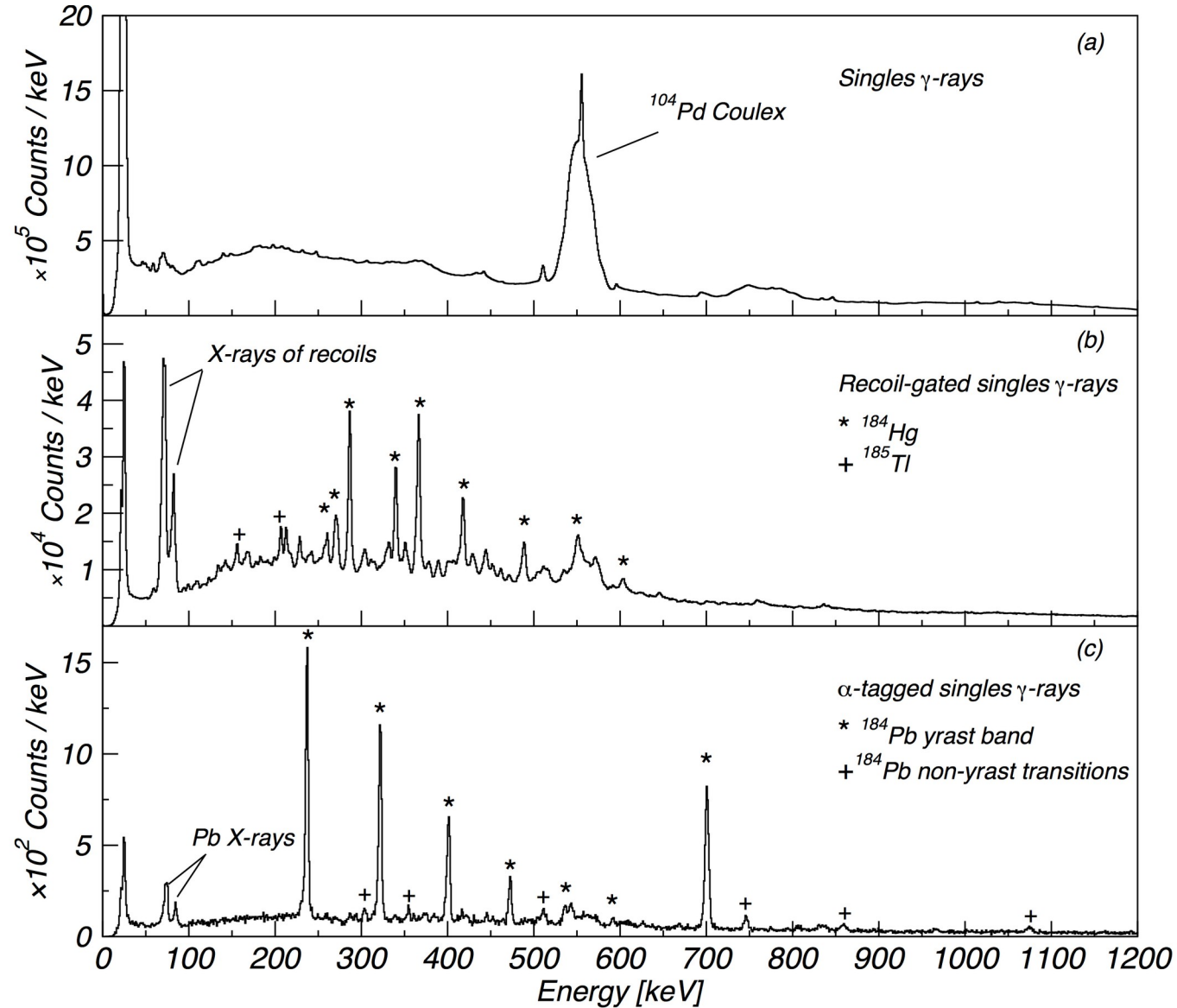


RITU



JUROGAM 3

Recoil-decay tagging(RDT)

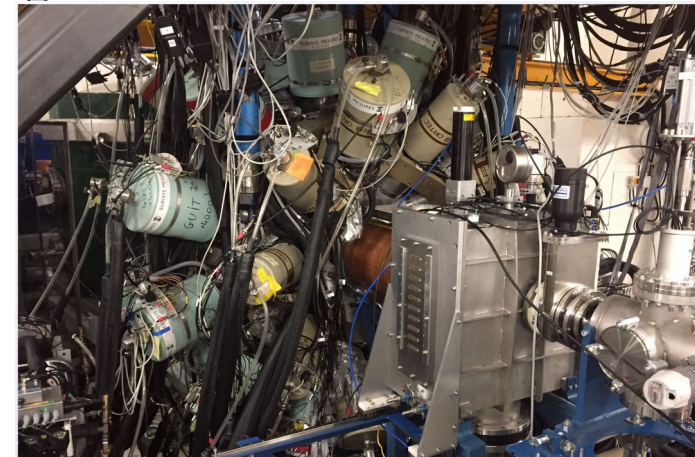
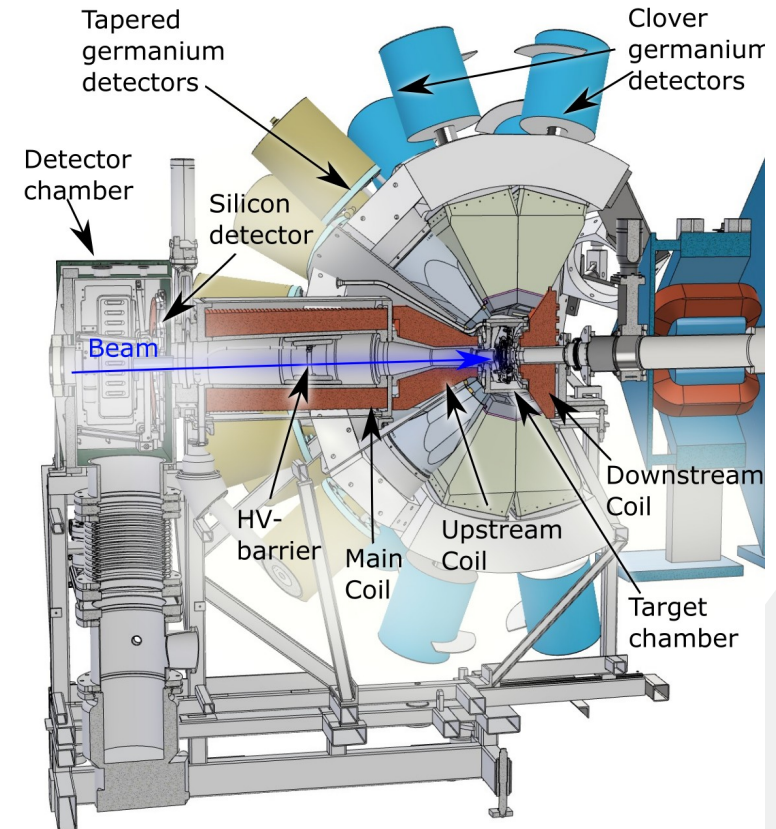




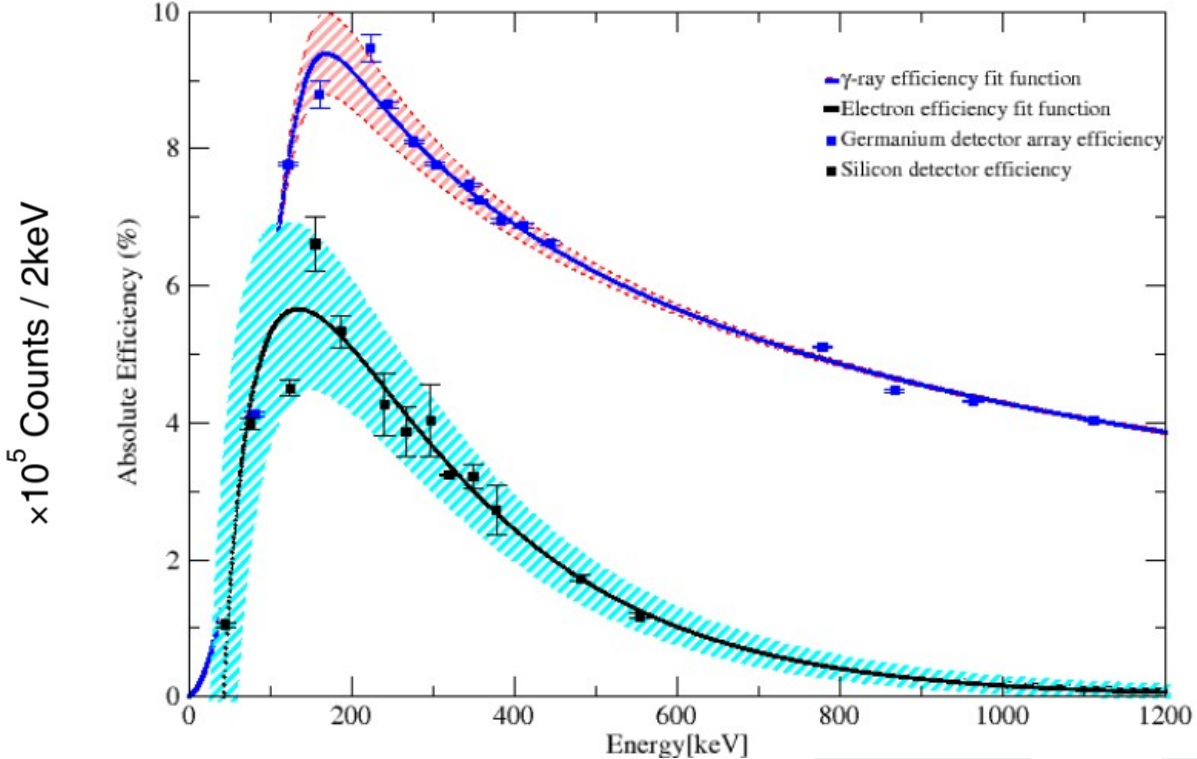
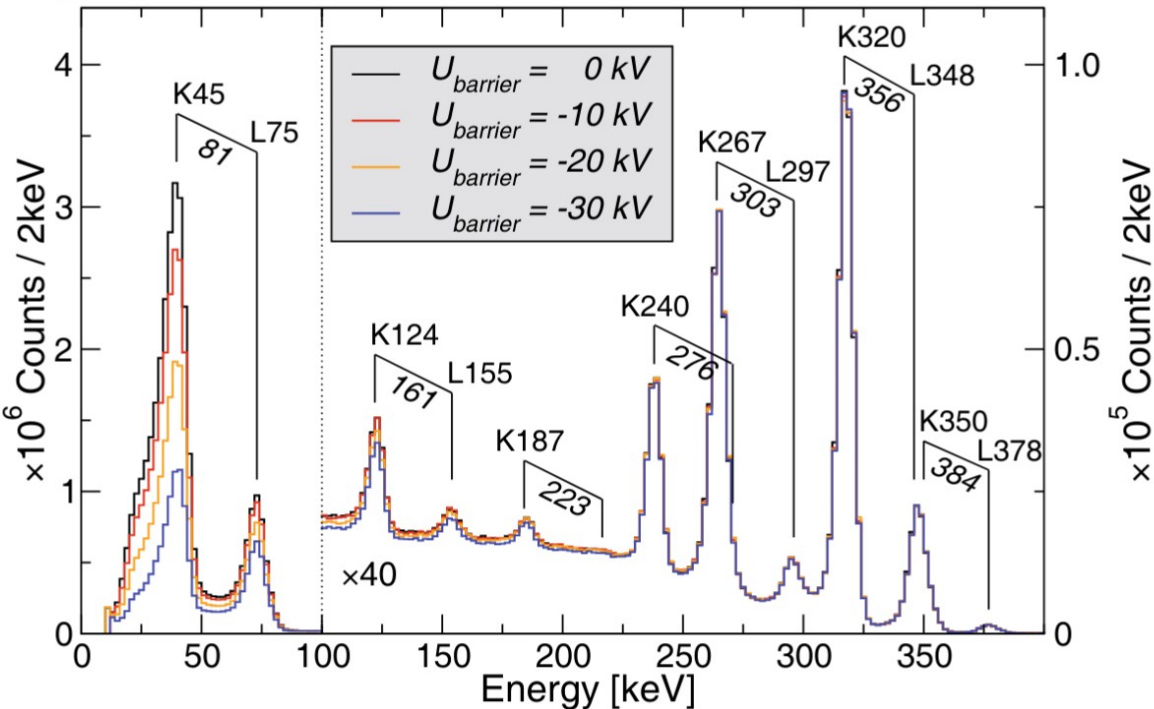
^{186}Pb

Simultaneous γ -ray and conversion-electron spectrometer SAGE

- 10 Tapered and 24 Clover type germanium detectors
- The SAGE silicon detector is positioned upstream of the target
- Conversion electrons are transported using the solenoid magnets from the target to the silicon detector (800A)
- HV-barrier inside solenoid is needed to prevent the low-energy delta-electrons reaching the silicon detector



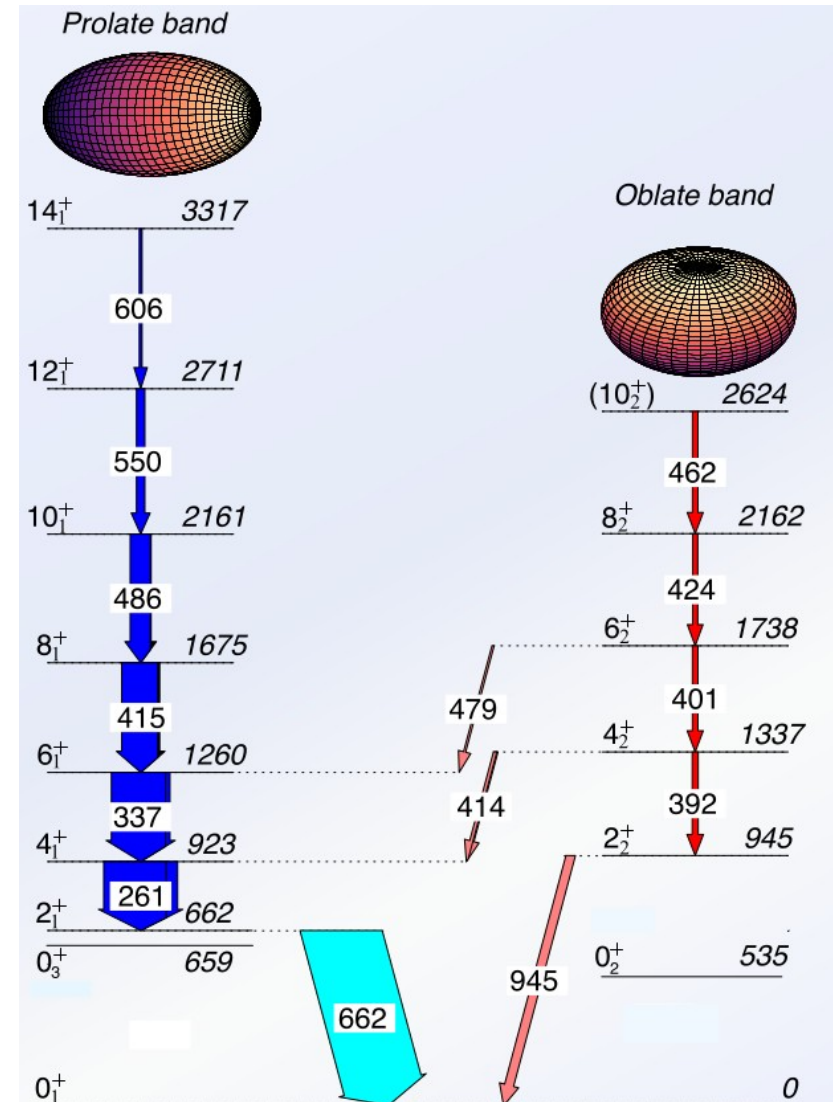
Simultaneous γ -ray and conversion-electron experiment SAGE



Previously known about ^{186}Pb



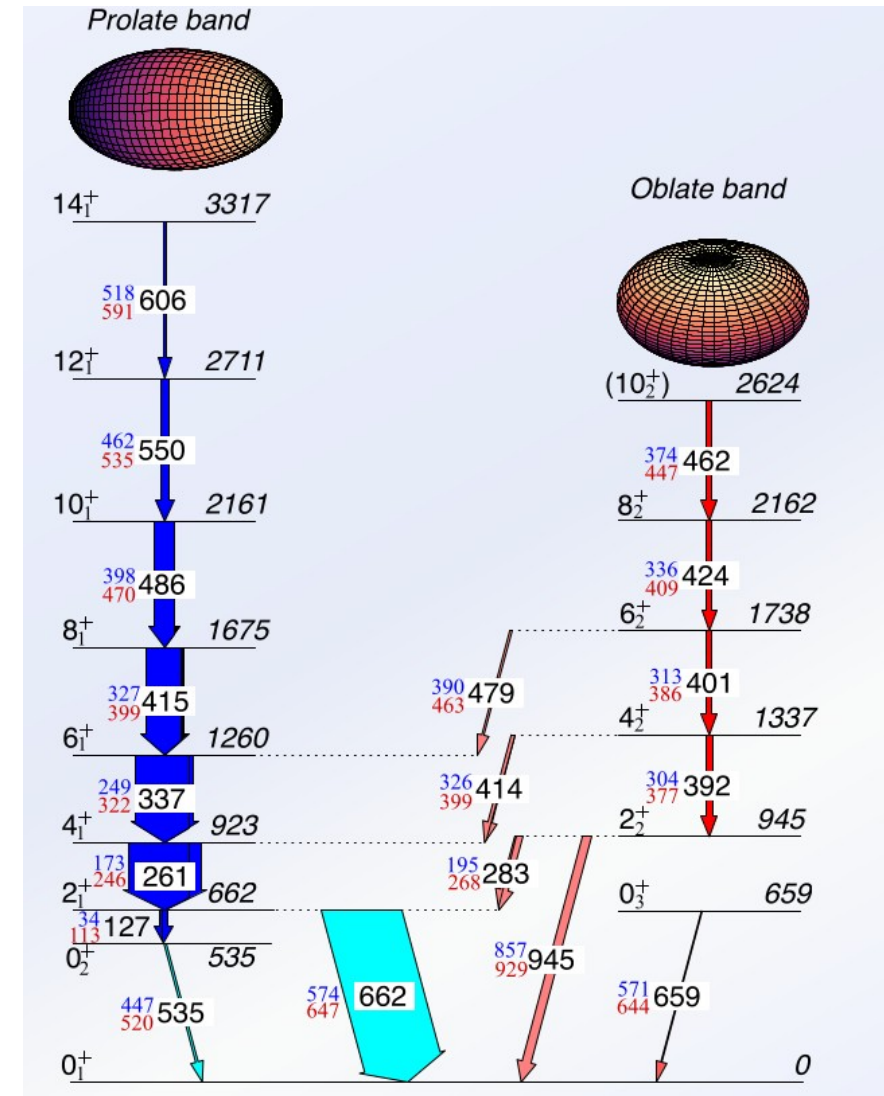
- The excited 0^+ states were observed for the first time at α -decay study of ^{190}Po
- The γ -ray spectroscopy study has shown rotational yrast and non-yrast band
- The lifetime measurement has been performed for the yrast band



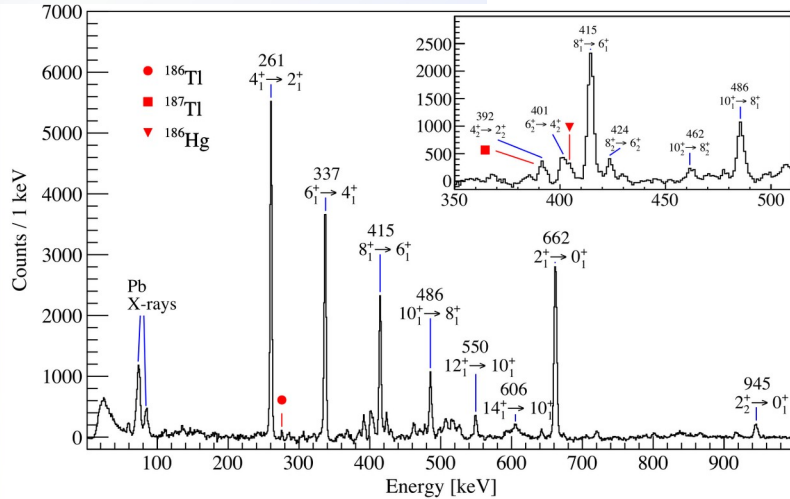
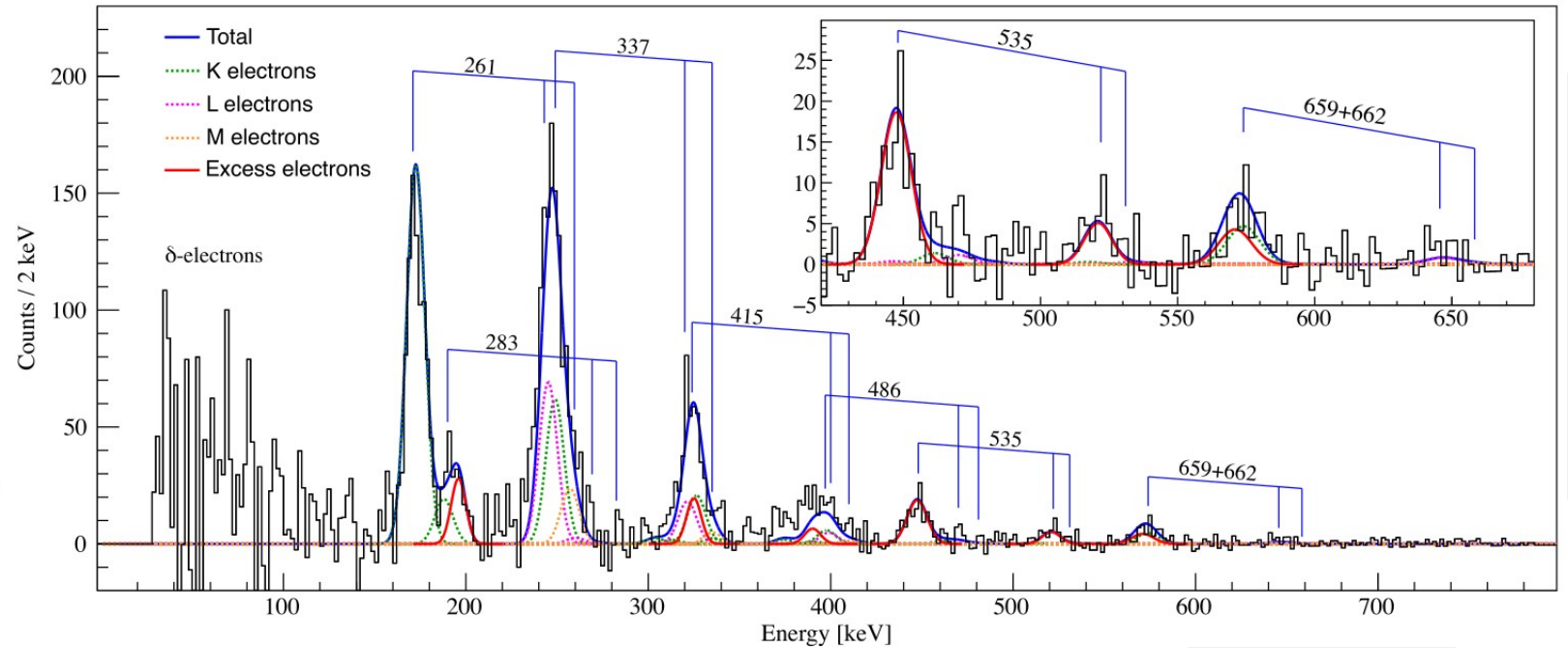
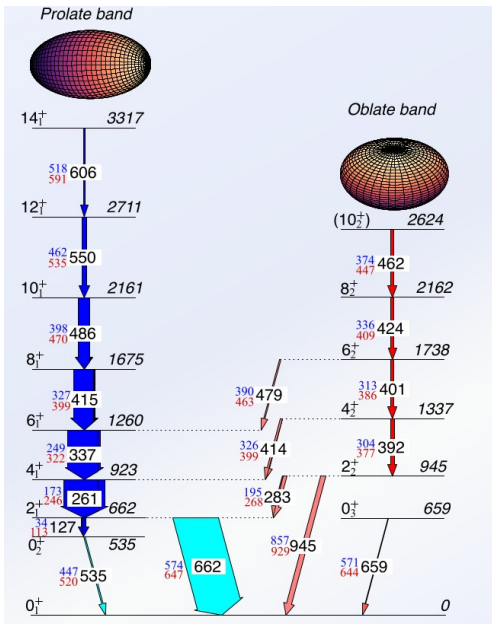
SAGE experiment for ^{186}Pb



- Performed in the Accelerator laboratory of Jyväskylä
- SAGE+RITU+GREAT+TDR
- $^{106}\text{Pd}(^{83}\text{Kr}, 3n)^{186}\text{Pb}$
- Recoil-decay tagging method
- Observed feeding of 0_2^+ state
- $0_2^+ \rightarrow 0_1^+$ and $0_3^+ \rightarrow 0_1^+$ transitions were observed
- $2_2^+ \rightarrow 2_1^+$ and $4_2^+ \rightarrow 4_1^+$ interband transitions' E0 component were identified

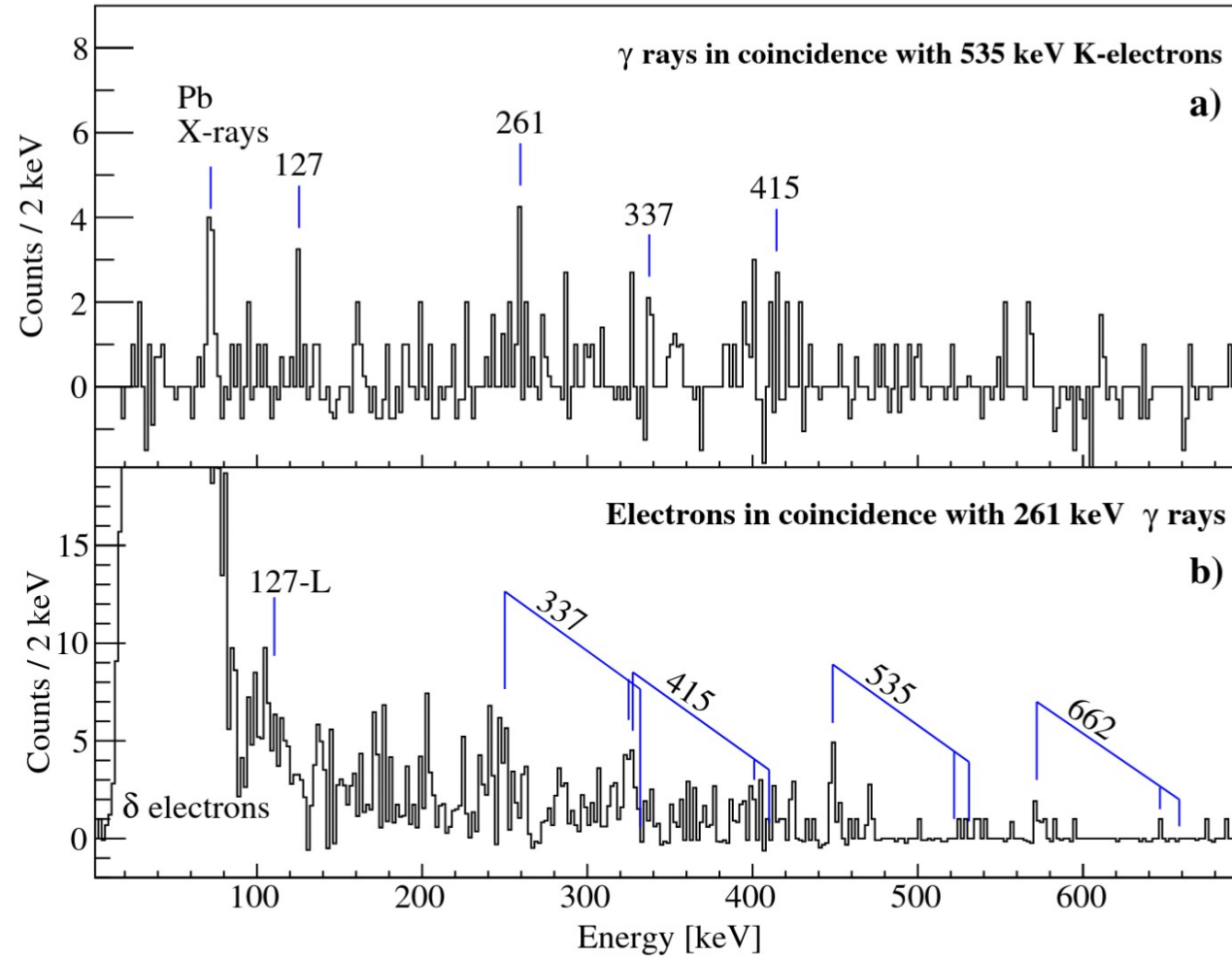
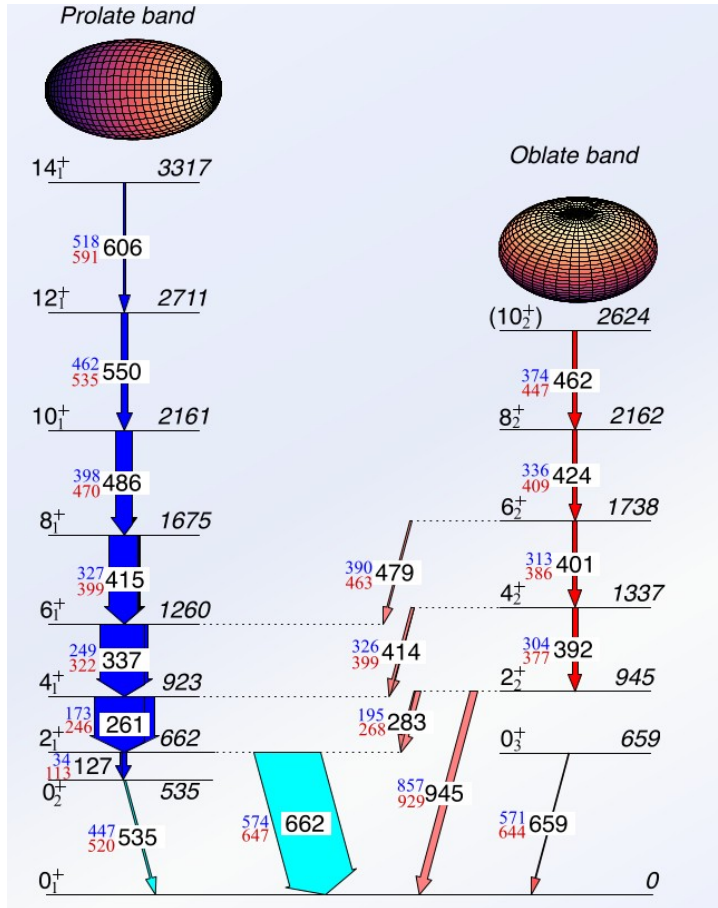


SAGE experiment for ^{186}Pb

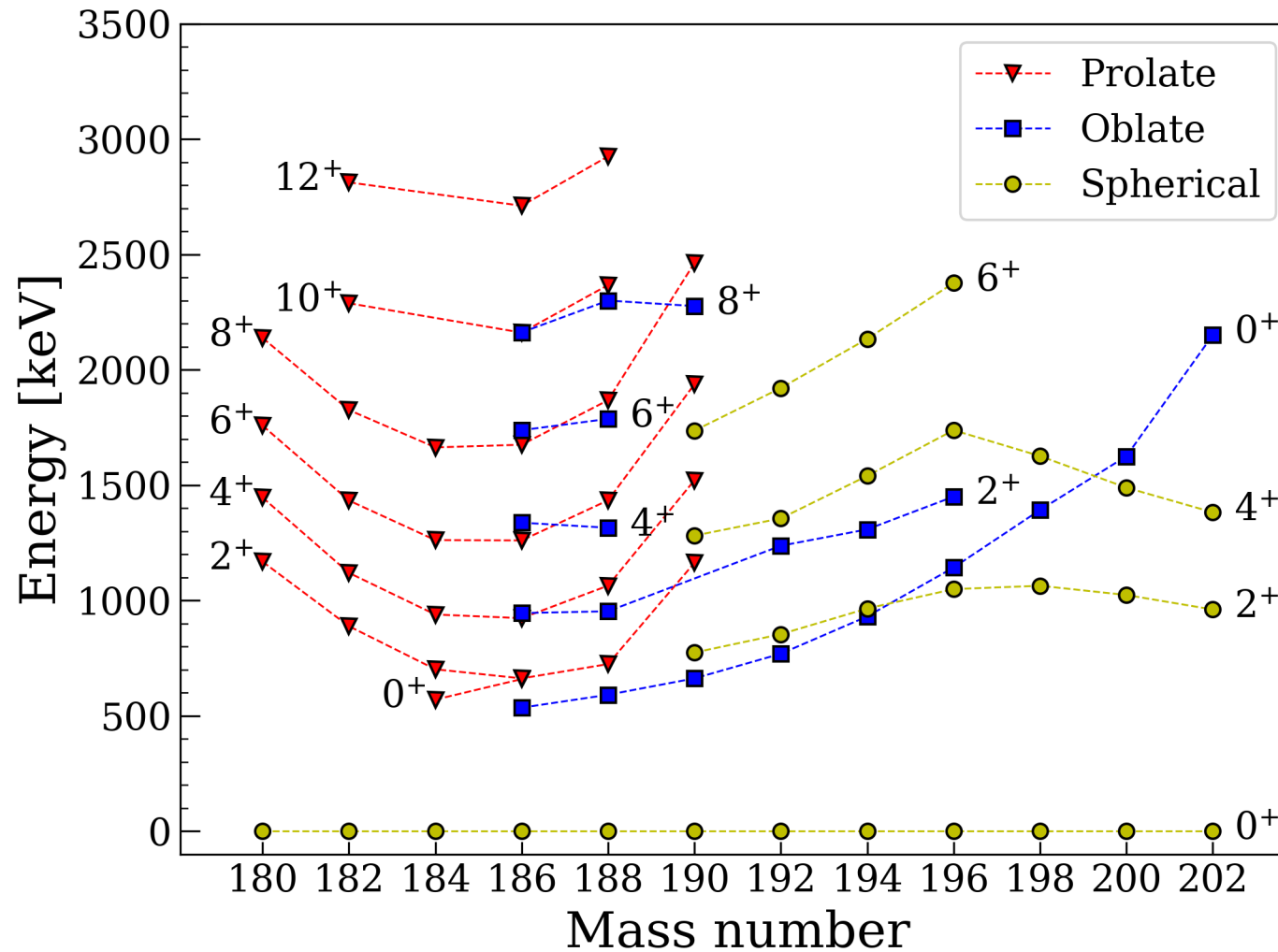


Ojala, J., et al., *Comm. Phys.*, 5(1). (2022).

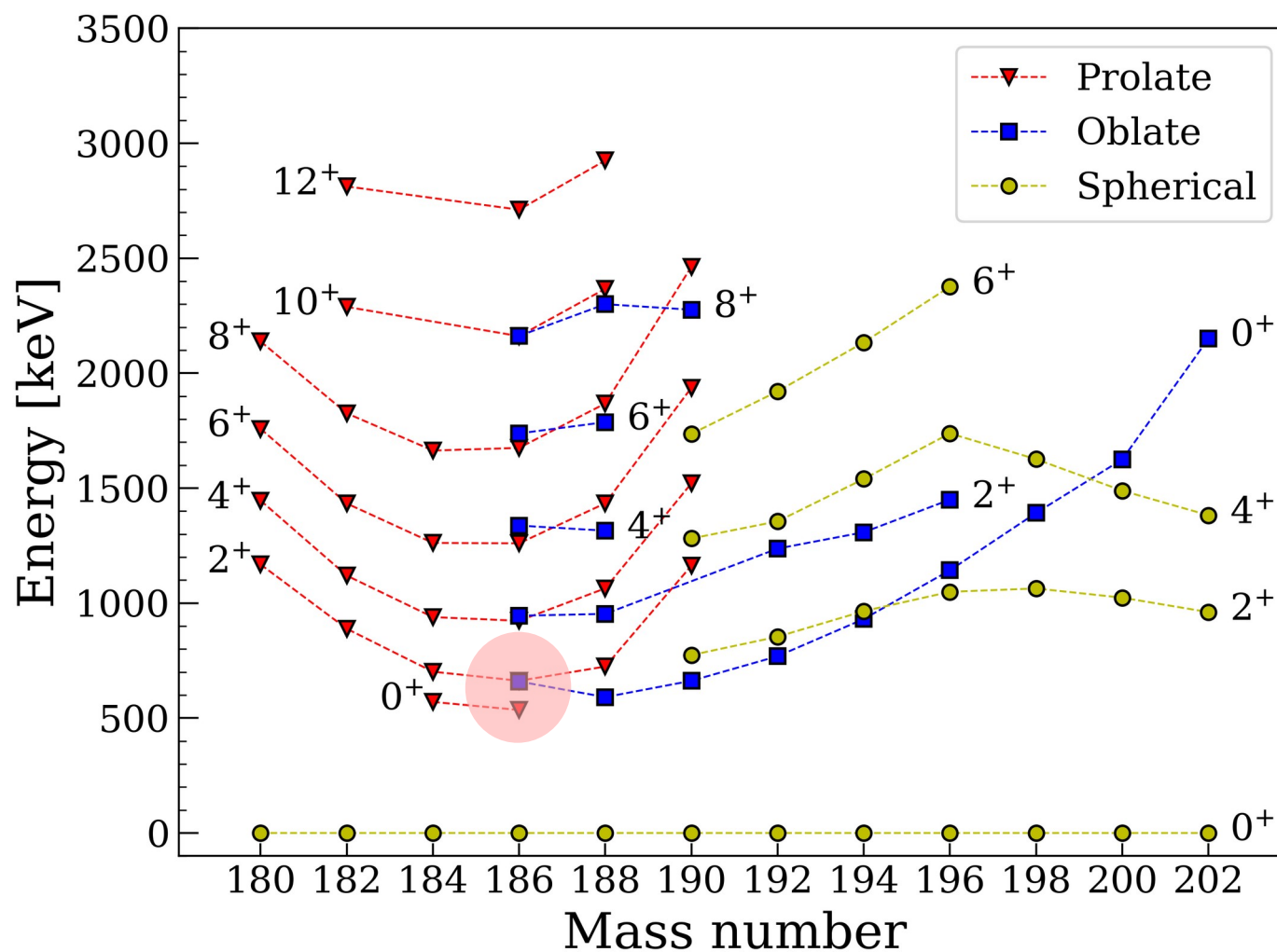
SAGE experiment for ^{186}Pb



The interpretation of level energy systematics of Pb isotopes before 2021



SAGE experiment: Pb-186



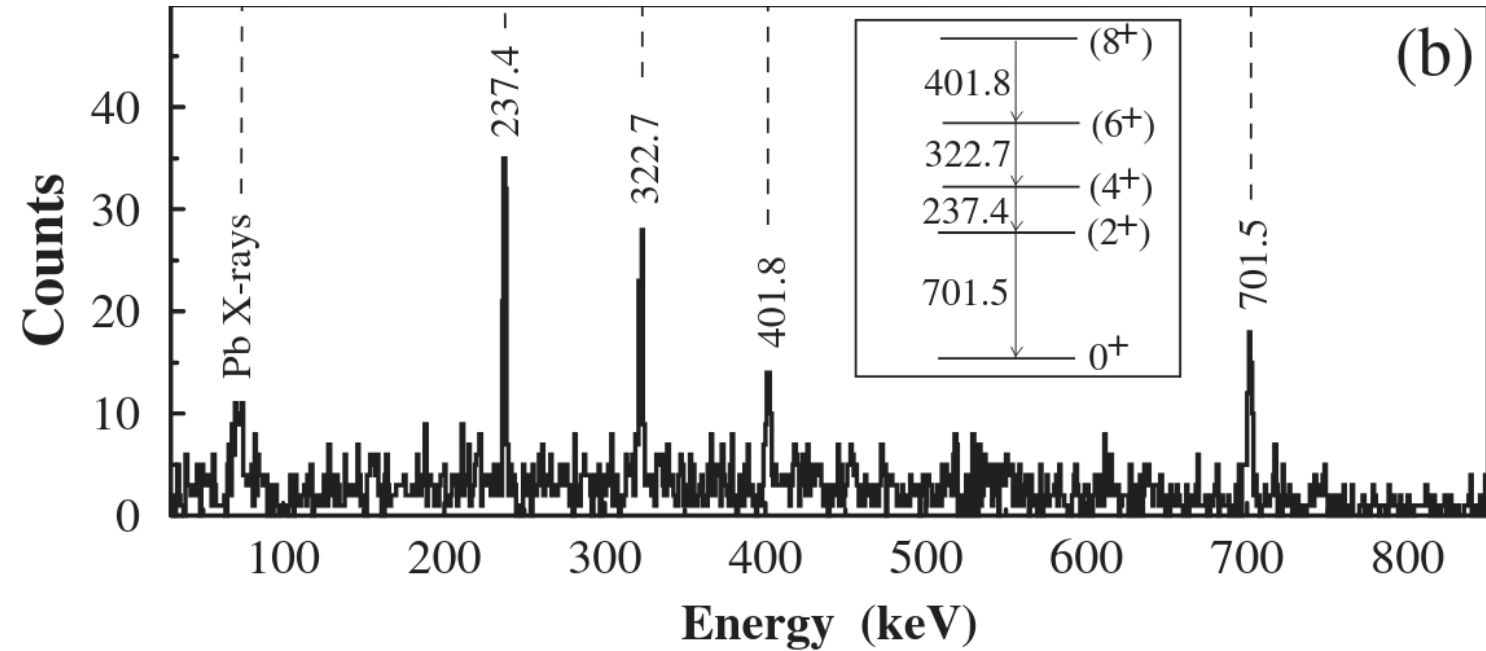


^{184}Pb

Previously known about ^{184}Pb



- The excited 0^+ state at 570(30) keV were observed for the first time at α -decay study of ^{188}Po
- The γ -ray spectroscopy study has shown yrast states up to 8^+ state.

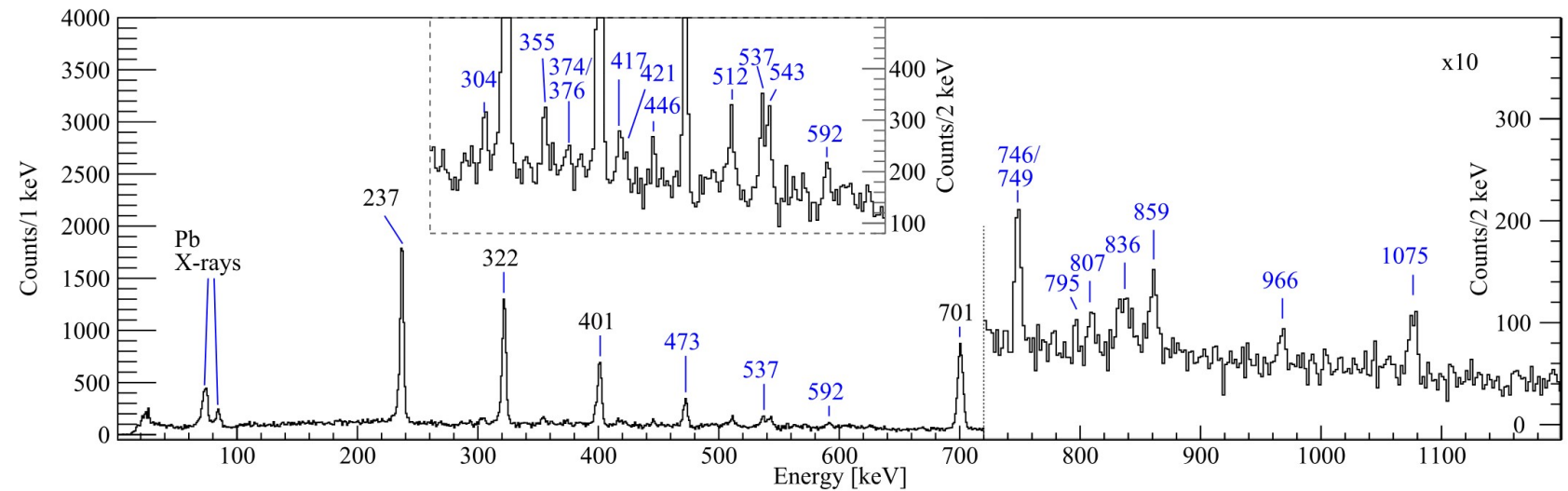


Cocks, J.F. C., et al., *EPJA* 3 17-20 (1998)

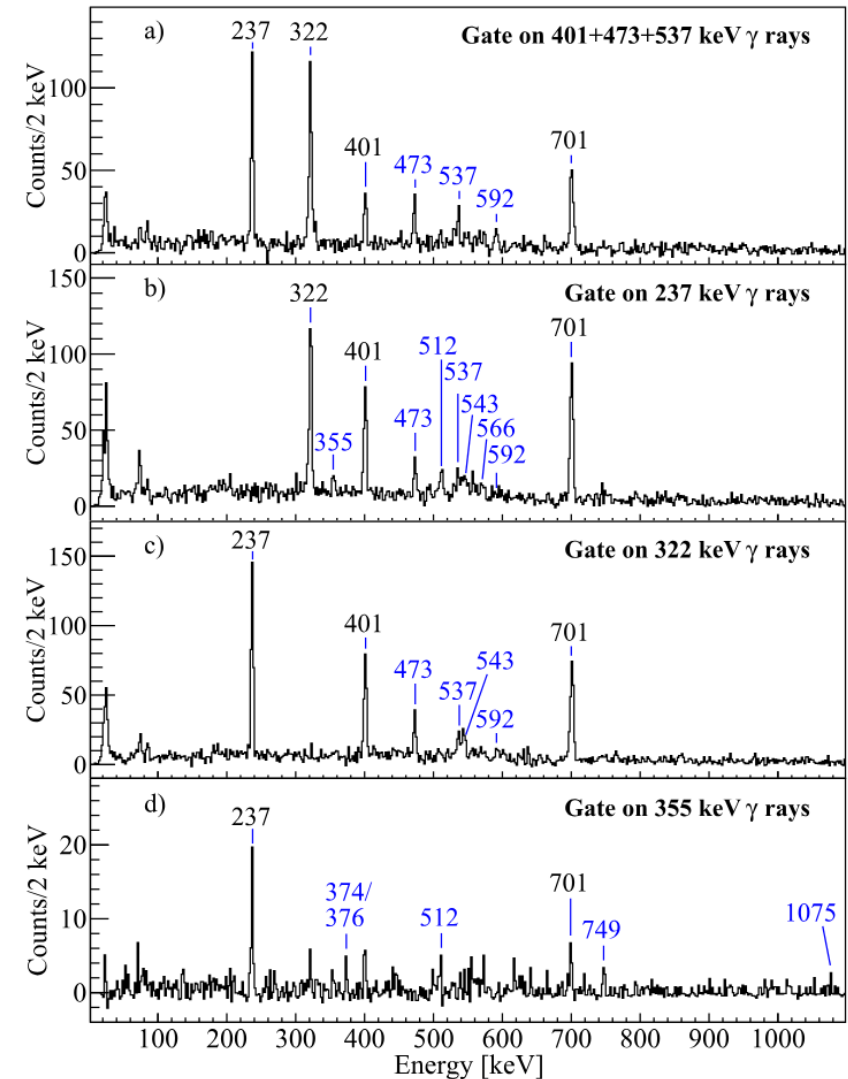
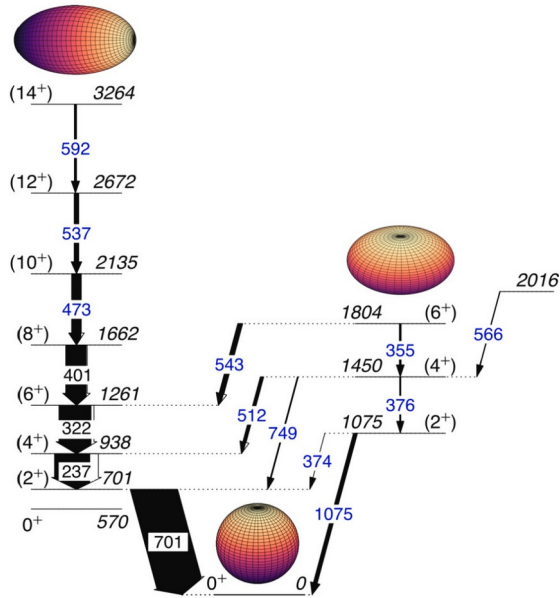
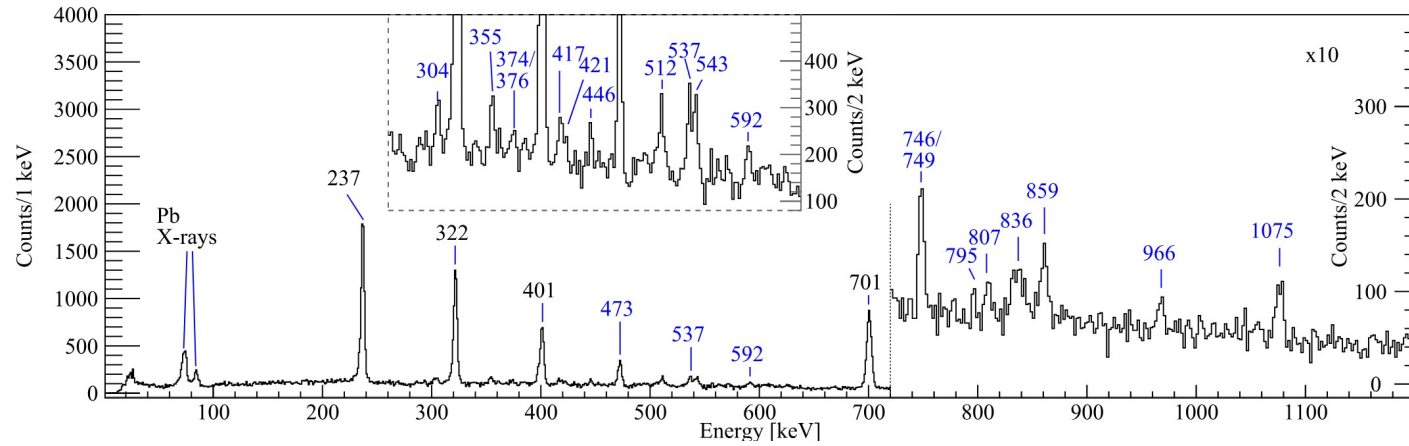
JUROGAM II experiment: ^{184}Pb



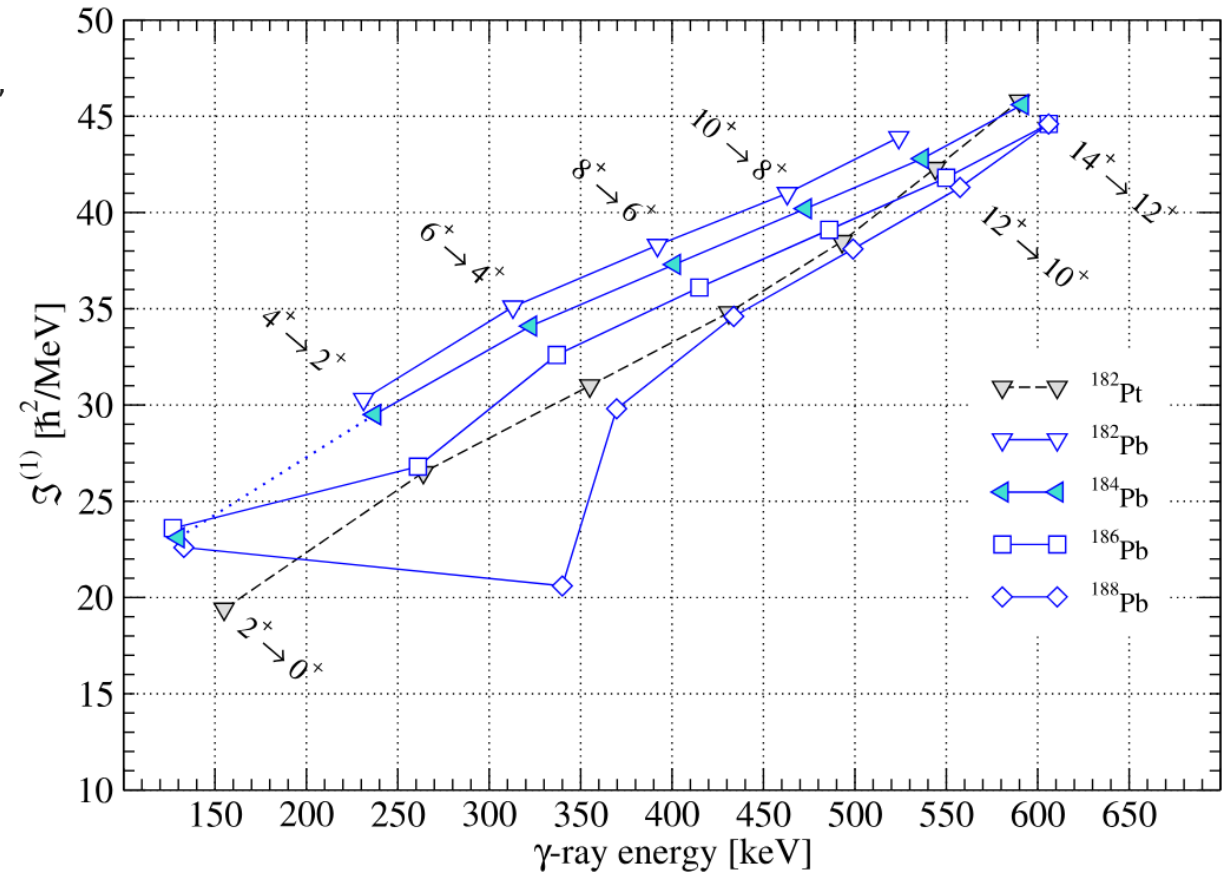
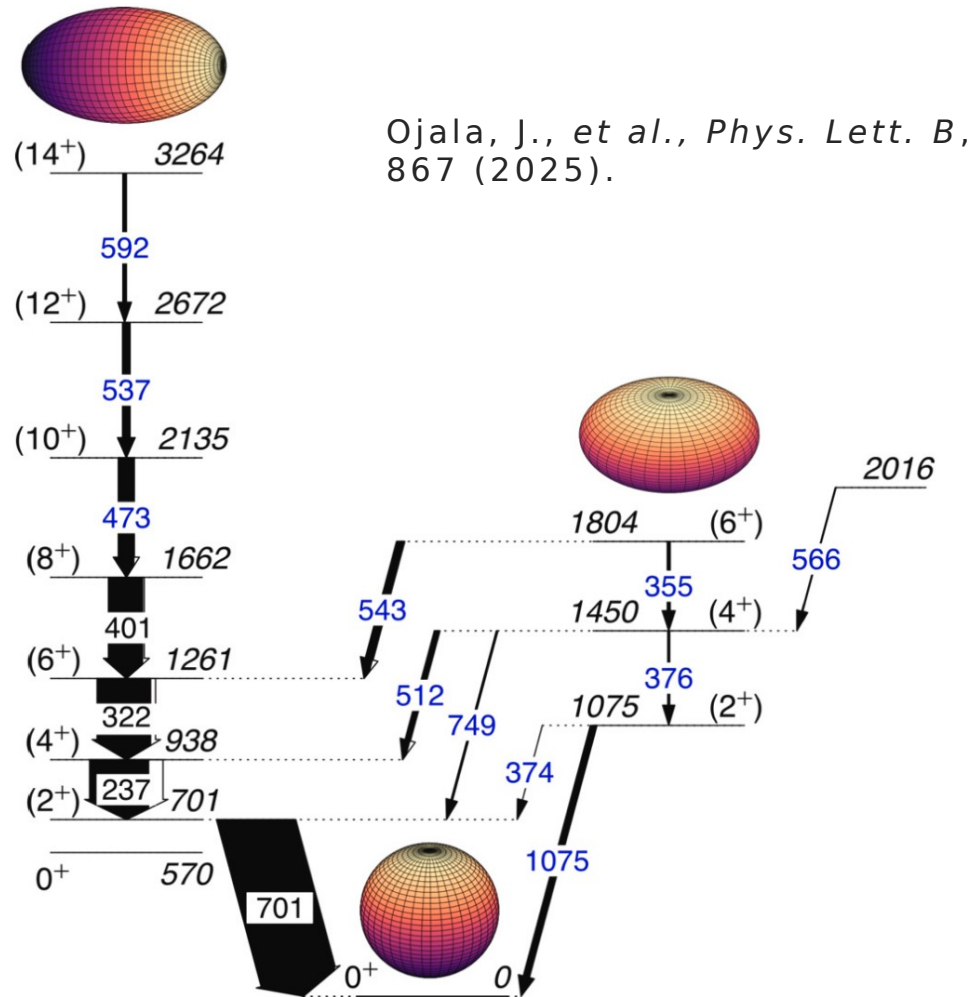
- JUROGAMII+RITU+GREAT +TDR
- $^{104}\text{Pd}(^{83}\text{Kr},3n)^{184}\text{Pb}$
- RDT-method was used
- Were able to identify candidates for non-yrast structure



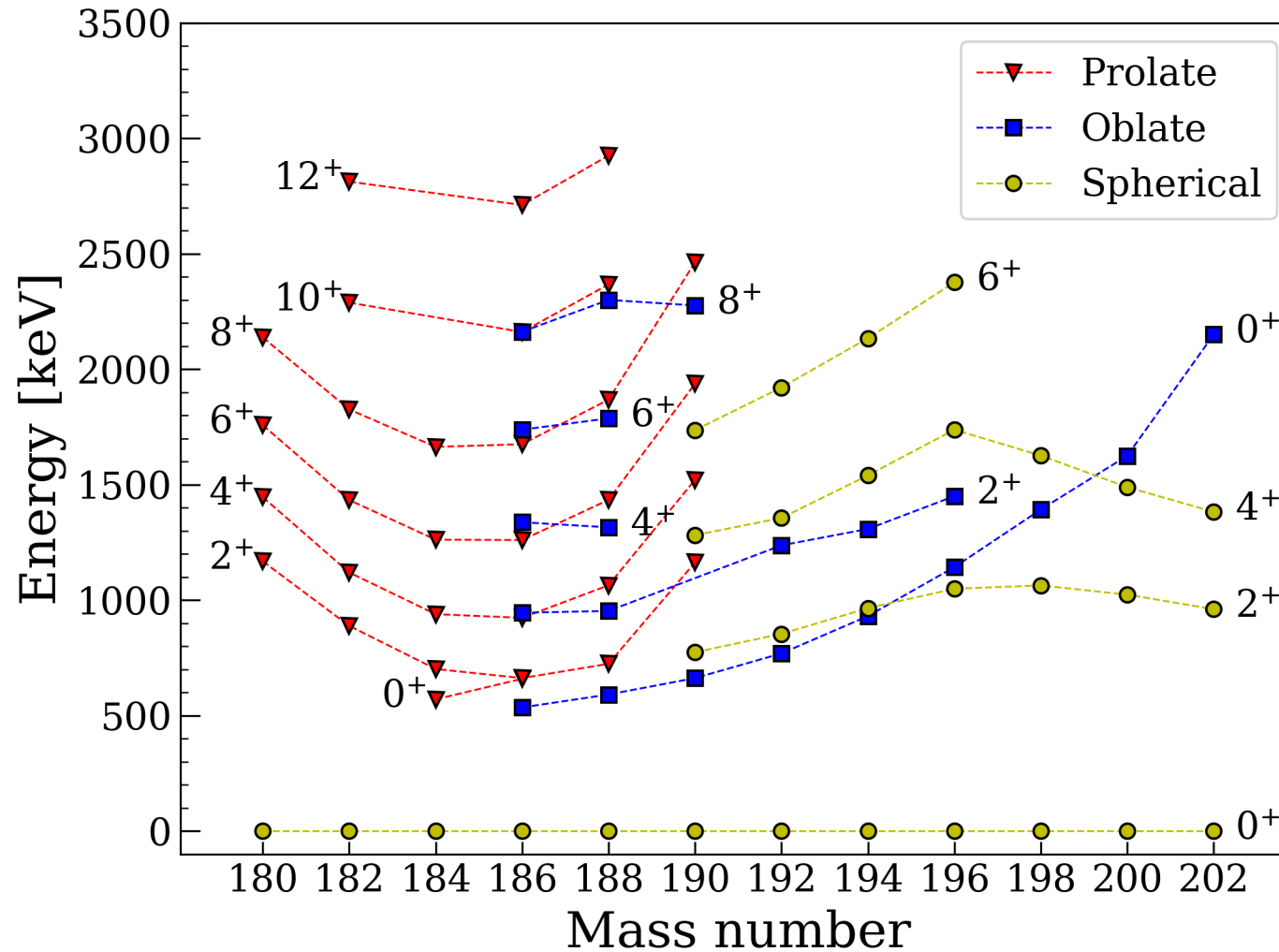
JUROGAM II experiment: ^{184}Pb



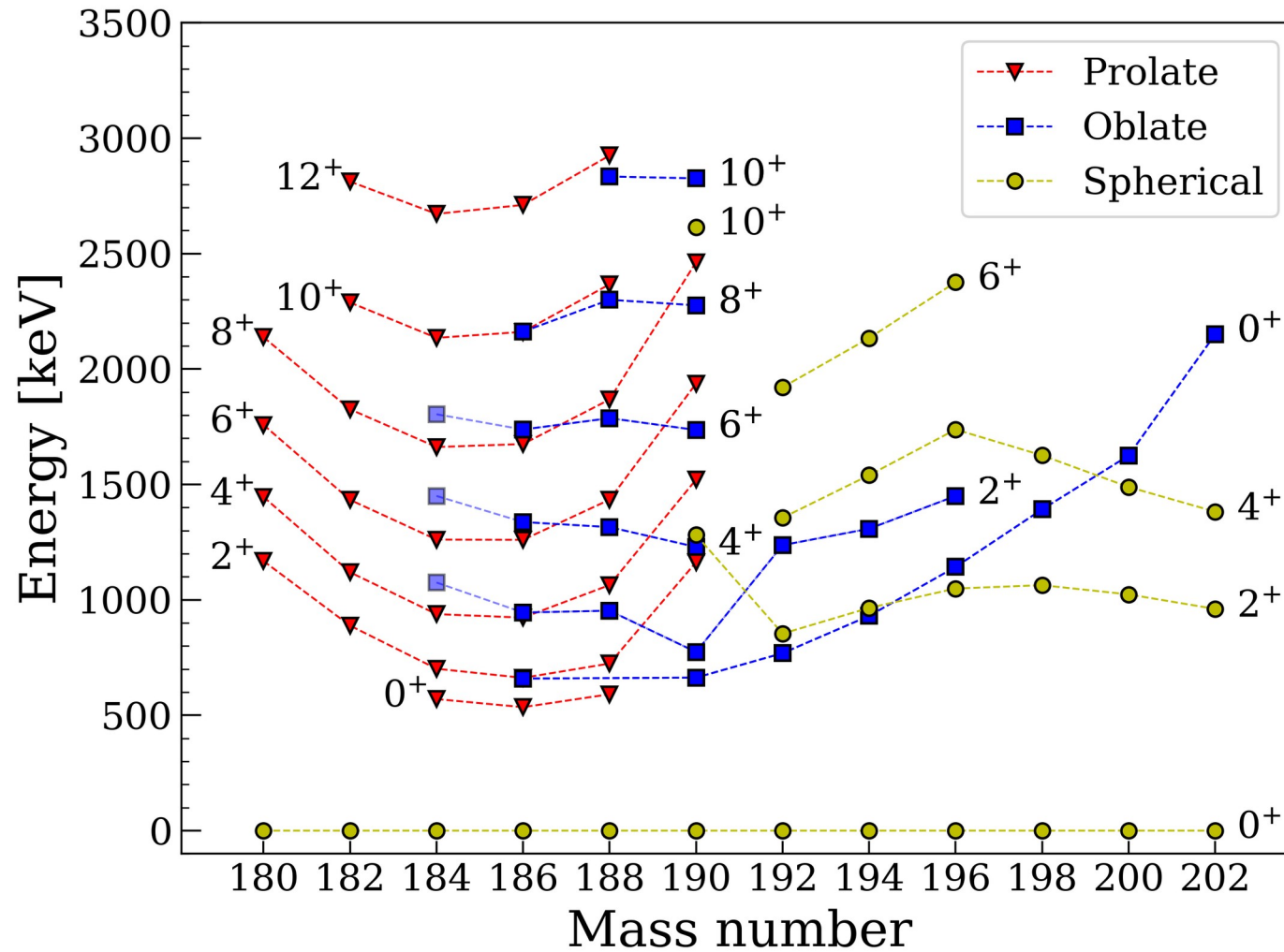
JUROGAM II experiment: ^{184}Pb



The interpretation of level energy systematics of Pb isotopes before 2021



After Pb-184 experiment

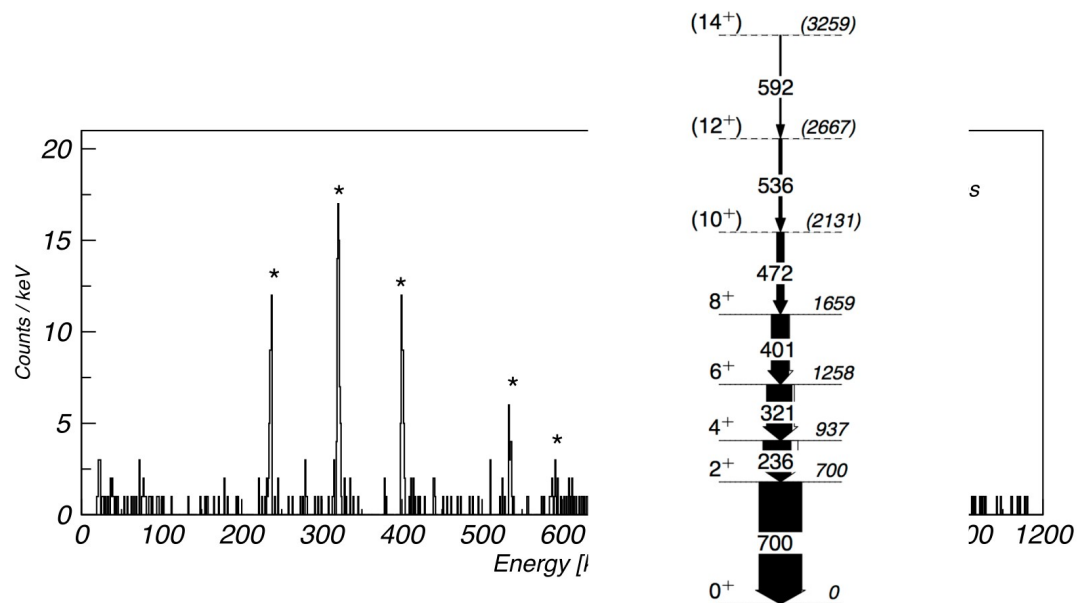


14th Nordic meeting



UNIVERSITY OF JYVÄSKYLÄ

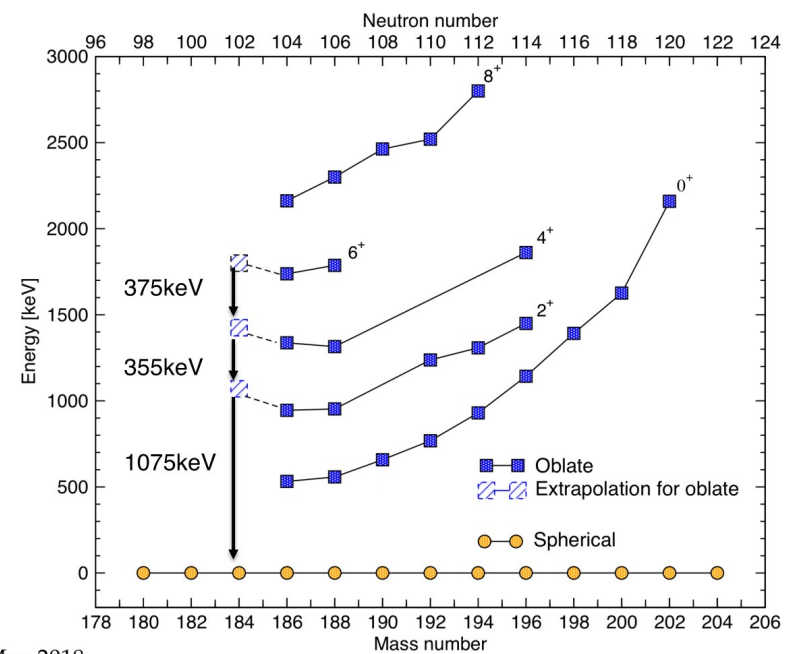
Yrast band



23 May 2018

UNIVERSITY OF JYVÄSKYLÄ

Possible oblate states?



23 May 2018

THANK YOU!