IDENTIFICATION OF PARITY-DOUBLET BANDS IN ODD-Z ^{223}Pa

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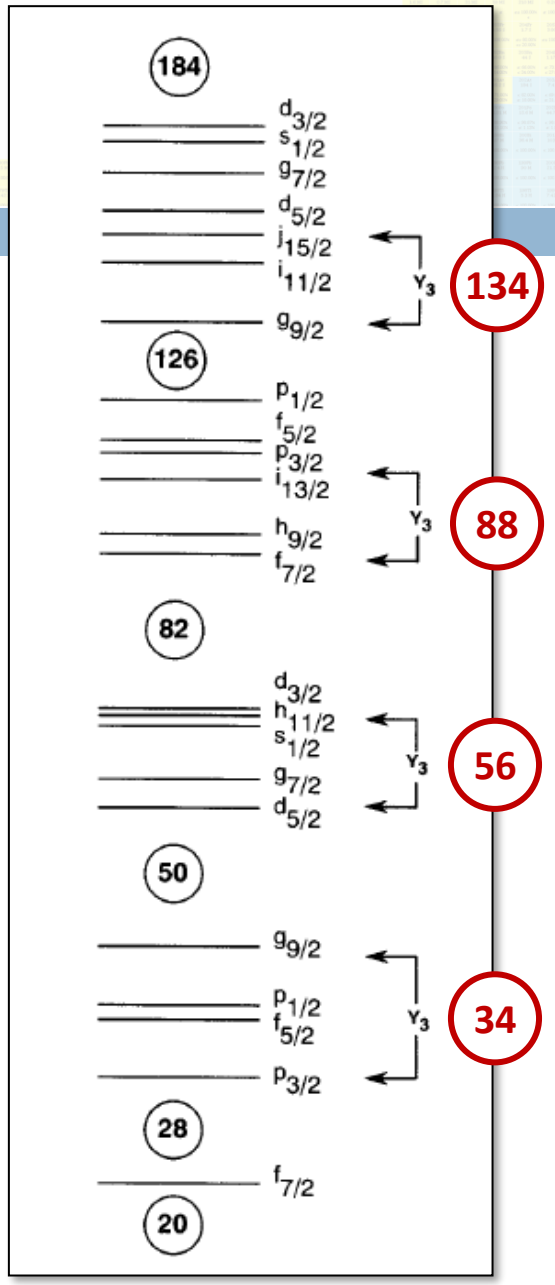
IOP Nuclear Physics Conference 2025
University of Manchester
24th April 2025

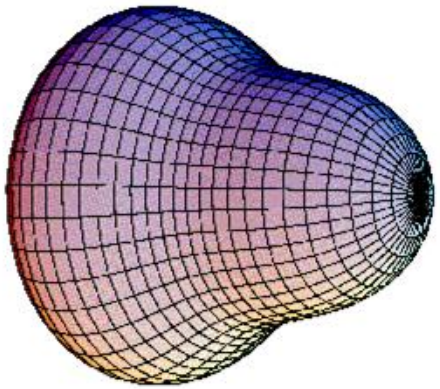
Octupole Deformation

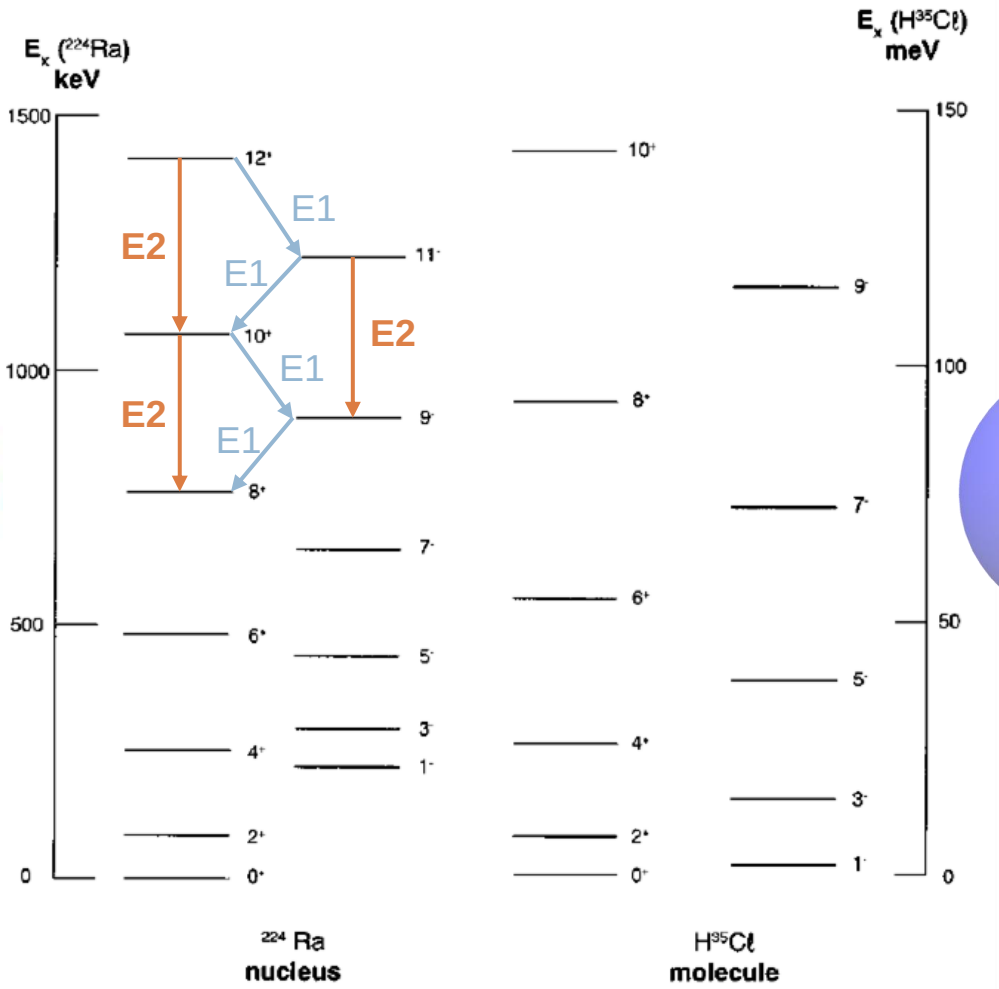
- Requires pairs of $\Delta l = \Delta j = 3$ shells near Fermi level.
- Octupole magic numbers:
  - 34 ($g_{9/2} \otimes p_{3/2}$)
  - 56 ($h_{11/2} \otimes d_{5/2}$)
  - 88 ($i_{13/2} \otimes f_{7/2}$)
  - 134 ($j_{15/2} \otimes g_{9/2}$)
- Regions centred around doubly magic nuclei:
  - ^{112}Ba (Z=56, N=56)
  - ^{144}Ba (Z=56, N=88)
  - ^{222}Ra (Z=88, N=134)

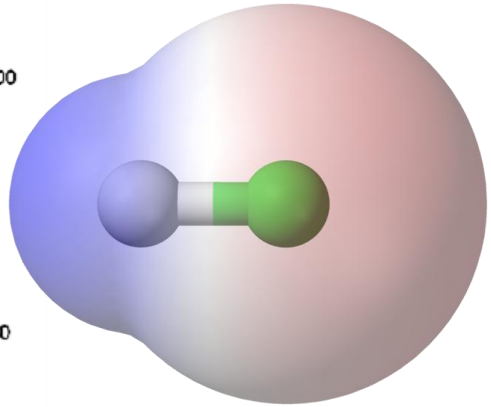


[1] P. A. Butler and W. Nazarewicz, Rev. Mod. Phys. **68**, 349 (1996).

Octupole Deformation







[1] P. A. Butler and W. Nazarewicz, Rev. Mod. Phys. **68**, 349 (1996).

Region of Deformation

Volume 197, number 4 PHYSICS LETTERS B 5 November 1987

DEFINITION OF THE ACTINIDE REGION OF STATIC QUADRUPOLE–OCTUPOLE DEFORMATION

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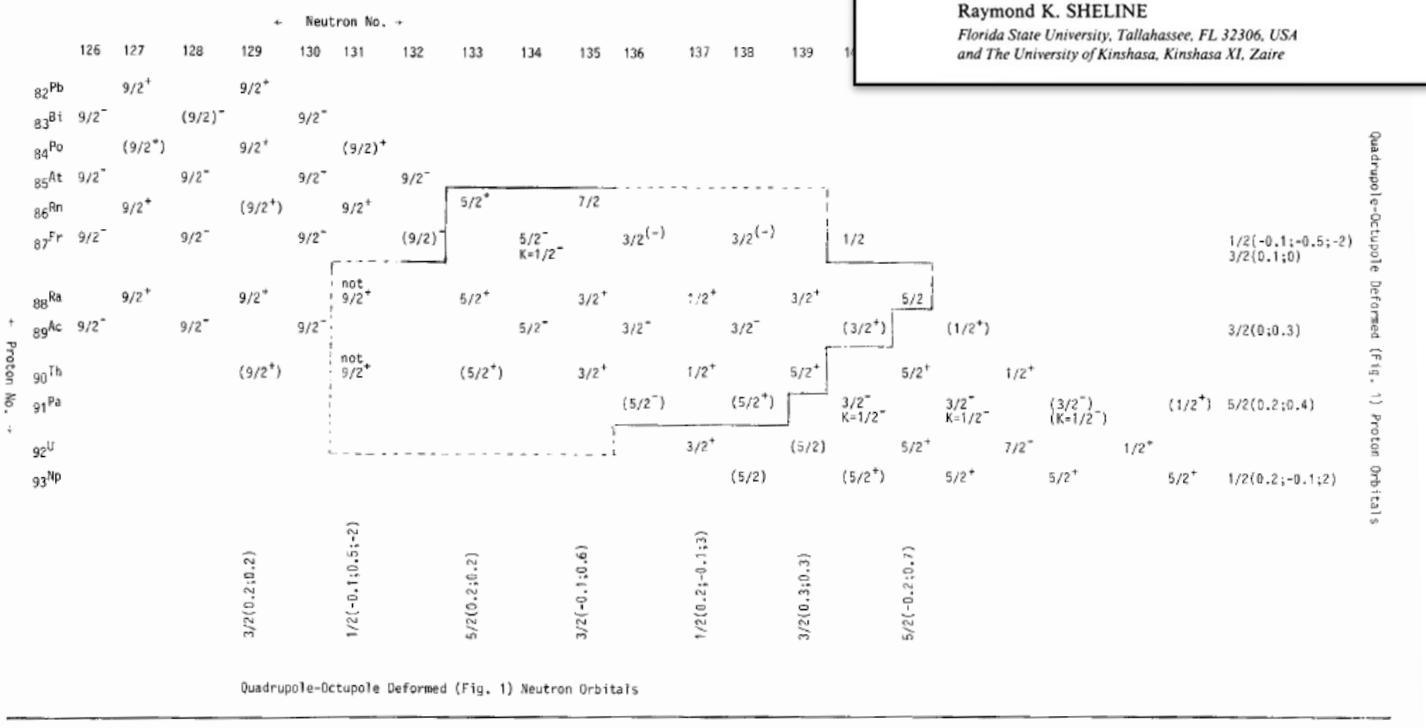
Table 1
Ground state spin and parities of the odd-A nuclei beyond ^{208}Pb. The appropriate parity mixed neutr
bottom and at the right of the table respectively. The region of the nuclear periodic table in which quadr
solid or dotted lines.



[2] R. Sheline, Phys. Lett. B. **197**, 500 (1987).

Region of Deformation

PHYSICAL REVIEW C **102**, 024311 (2020)

Landscape of pear-shaped even-even nuclei

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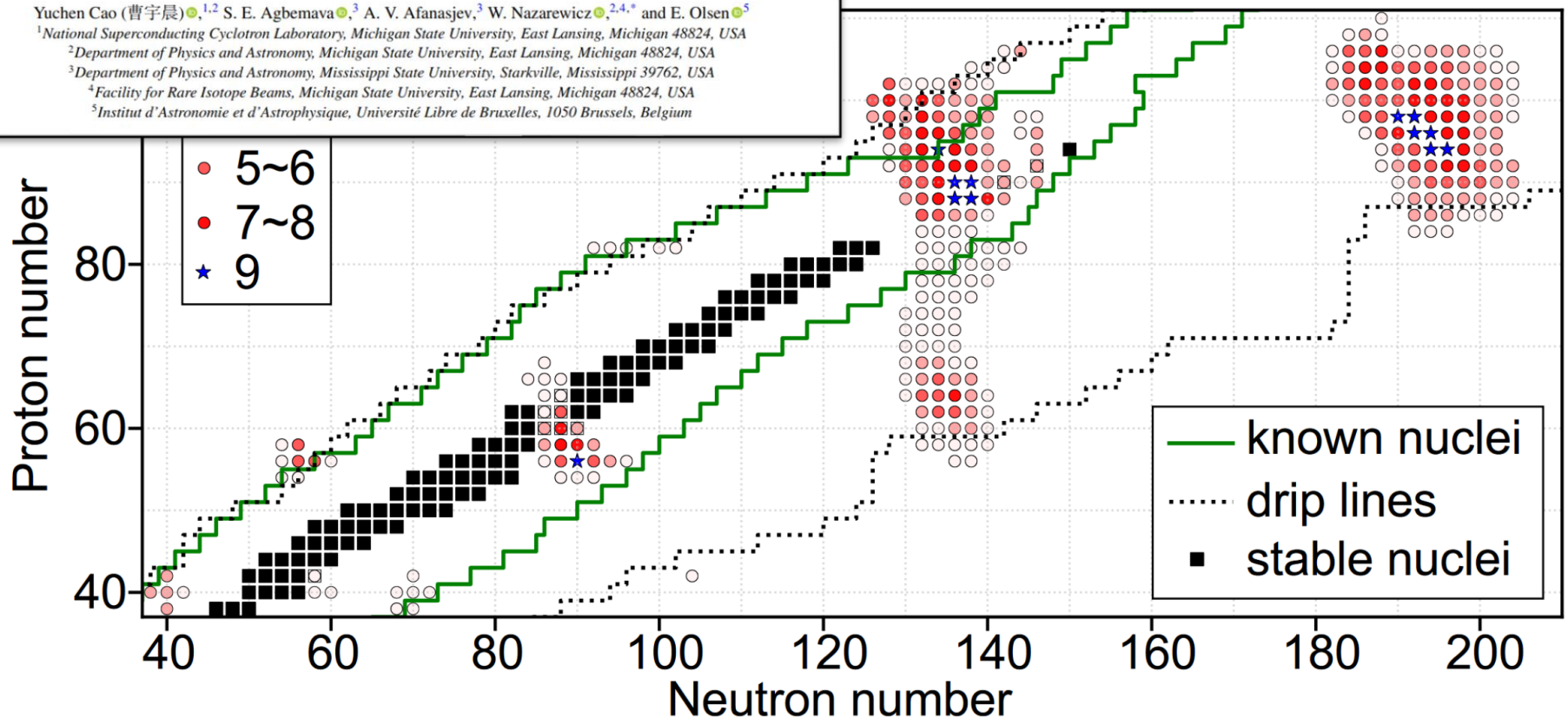
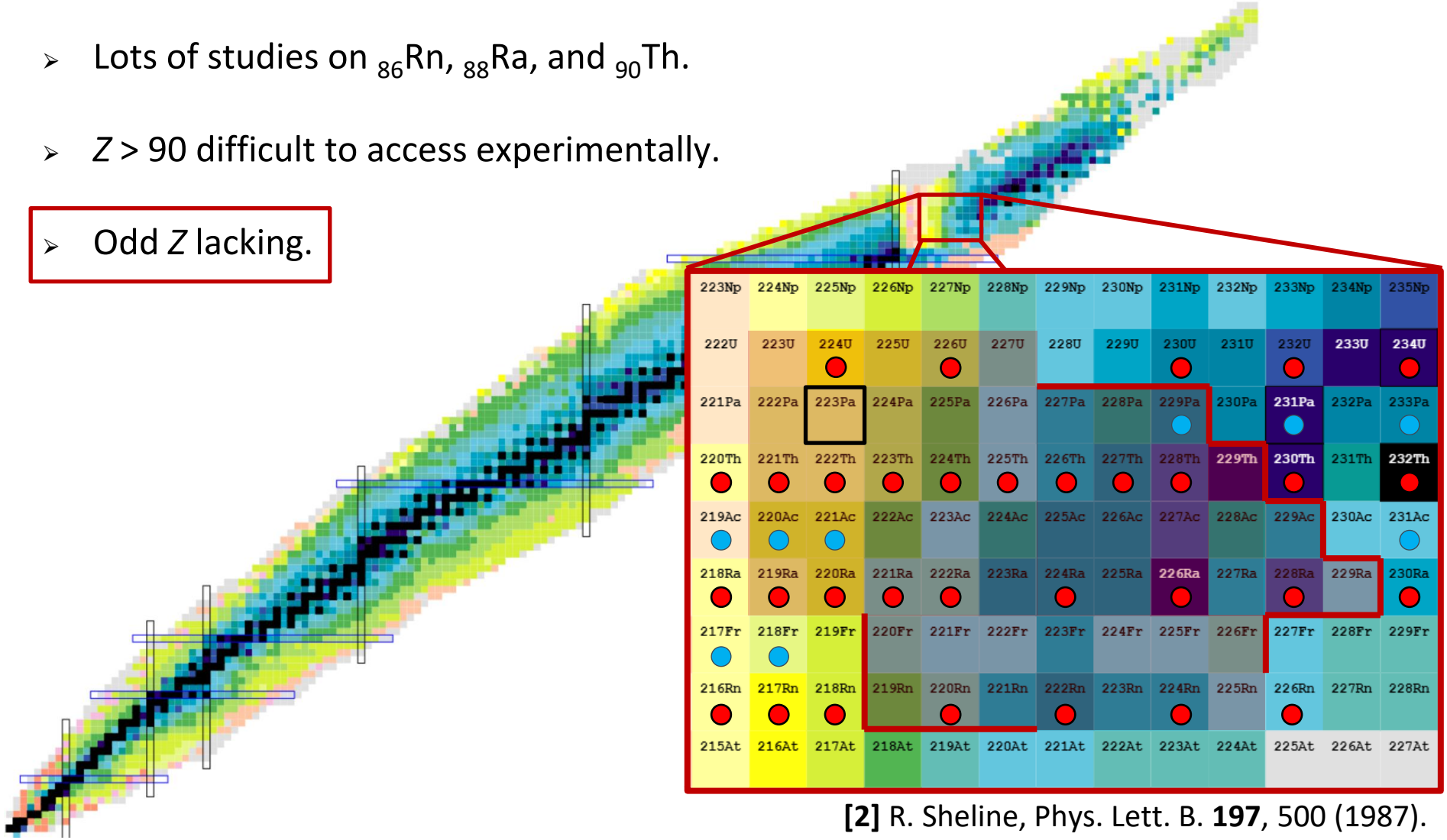


[3] Y. Cao *et al.*, Phys. Rev. C **102**, 024311 (2020).

Region of Interest

- Lots of studies on $_{86}$Rn, $_{88}$Ra, and $_{90}$Th.
- $Z > 90$ difficult to access experimentally.
- Odd Z lacking.



[2] R. Sheline, Phys. Lett. B. **197**, 500 (1987).

Previous Studies– ^{223}Pa

PHYSICAL REVIEW C, VOLUME 60, 057301

Electromagnetic transitions and α decay of the ^{223}Pa nucleus

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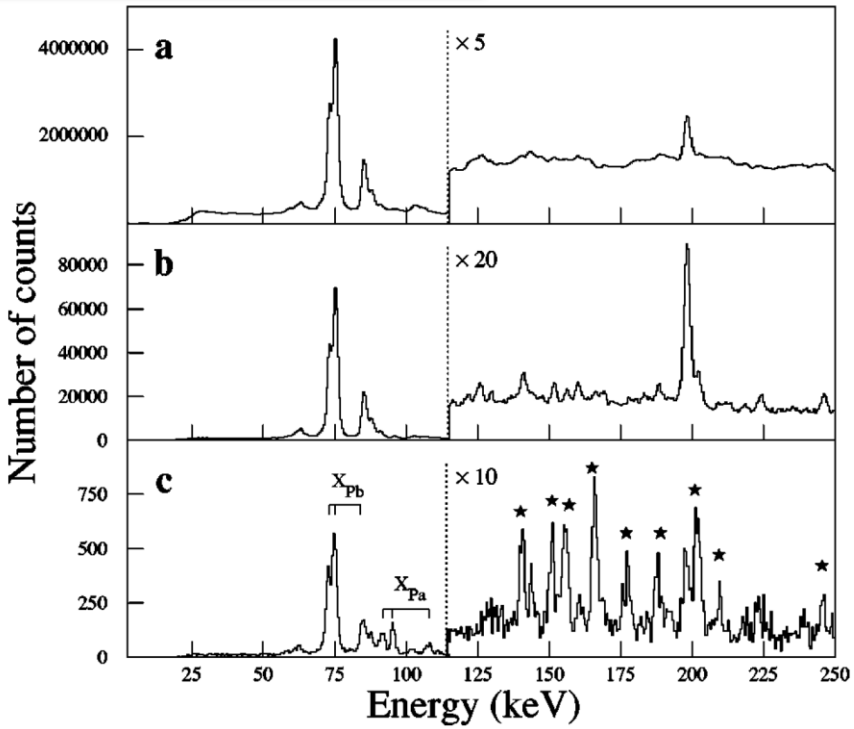
(Received 1 June 1999; published 4 October 1999)

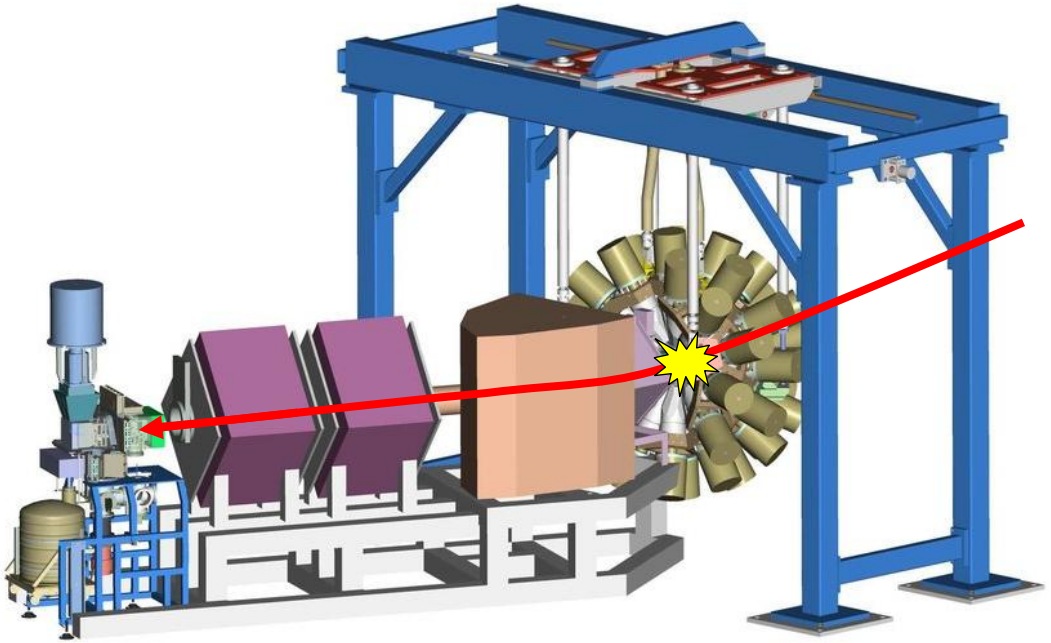
- Performed at JYFL with JUROSPHERE (13 EUROGAM & 10 TESSA) and RITU.
- Measuring RDT coincidences.
- ^{208}Pb(^{19}F,4n)^{223}Pa, E = 99 MeV.
- 500 µg/cm^2 target.
- 9 γ rays identified, but no level scheme possible.



[4] F. Hoellinger *et al.*, Phys. Rev. C **60**, 057301 (1999).

Experiment Details

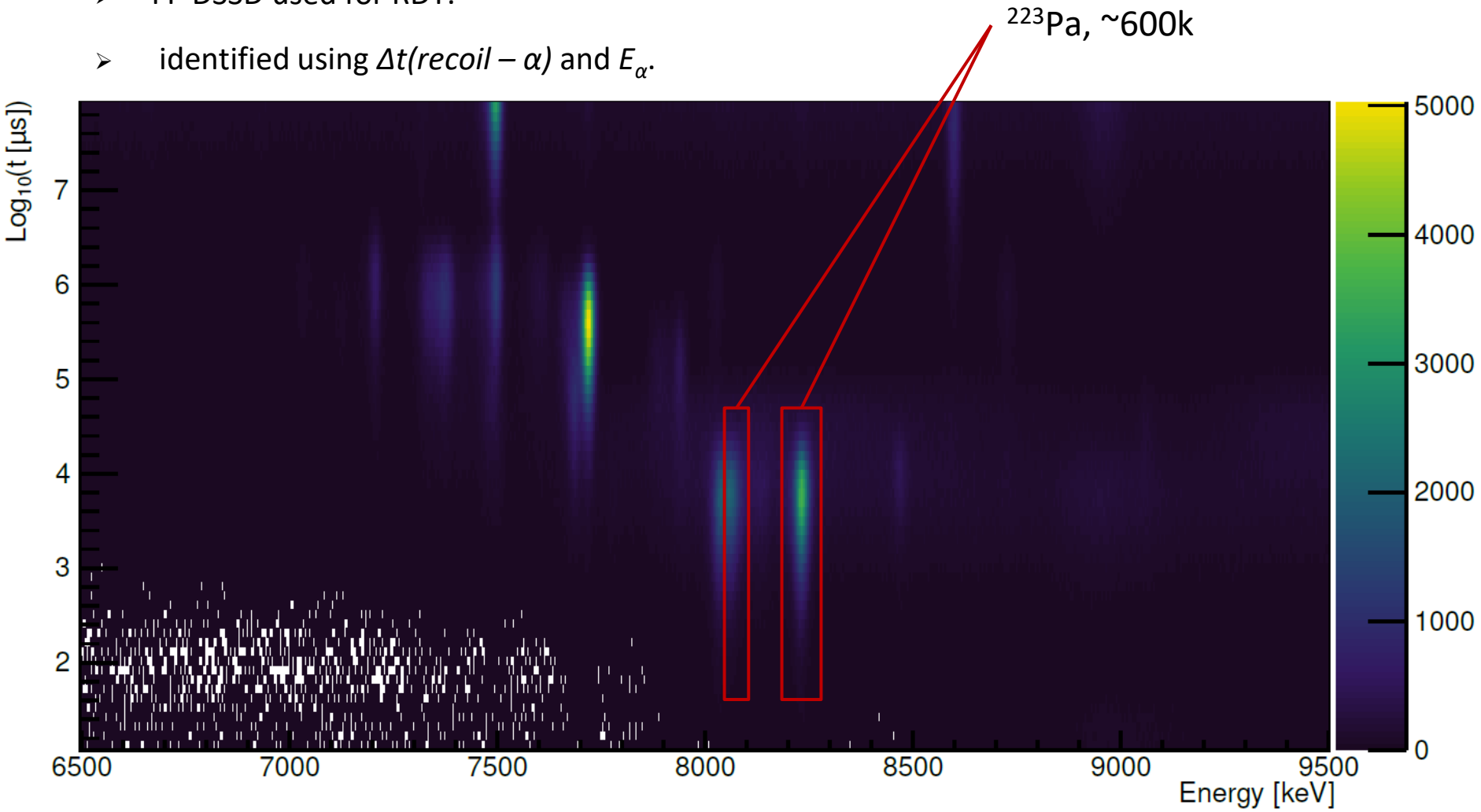
- JUROGAM-3, RITU, & FP array.
- ^{19}F beam, E = 99 MeV, 45 pnA.
- ~250 µg/cm^2 ^{208}Pb target, 40 µg/cm^2 C backing.
- 99% fission, ~100 µb.
- ^{223}Pa RDT γ-ray spectra.



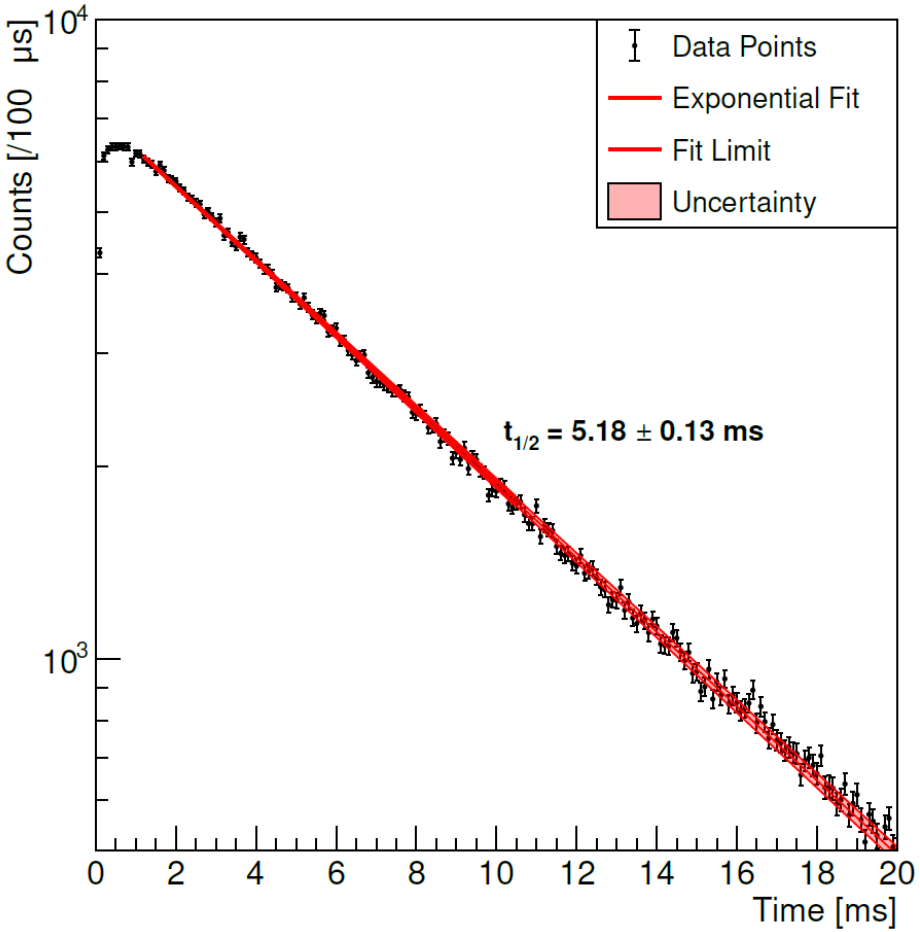
[5] J. Pakarinen *et al.*, Eur. Phys. J. A **56**, 149 (2020).
[6] J. Uusitalo *et al.*, NIM B **204**, 638 (2003).

Recoil Decay Tagging

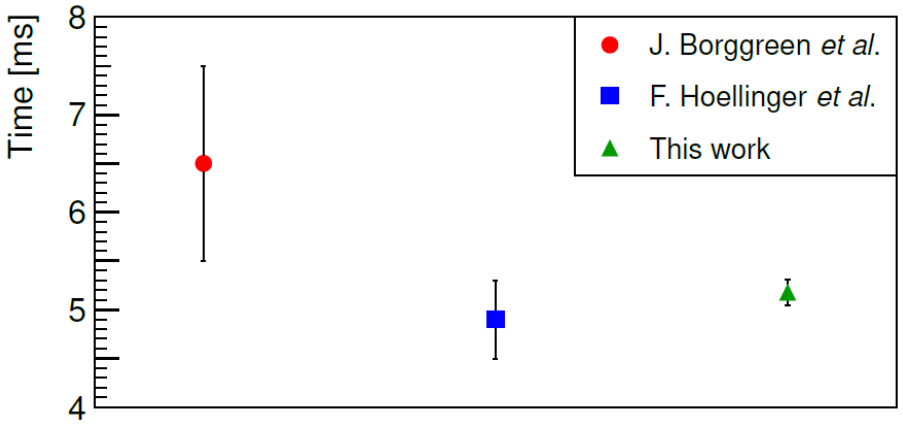
- FP DSSD used for RDT.
- identified using $\Delta t(recoil - \alpha)$ and E_α.



Half-Life Measurement



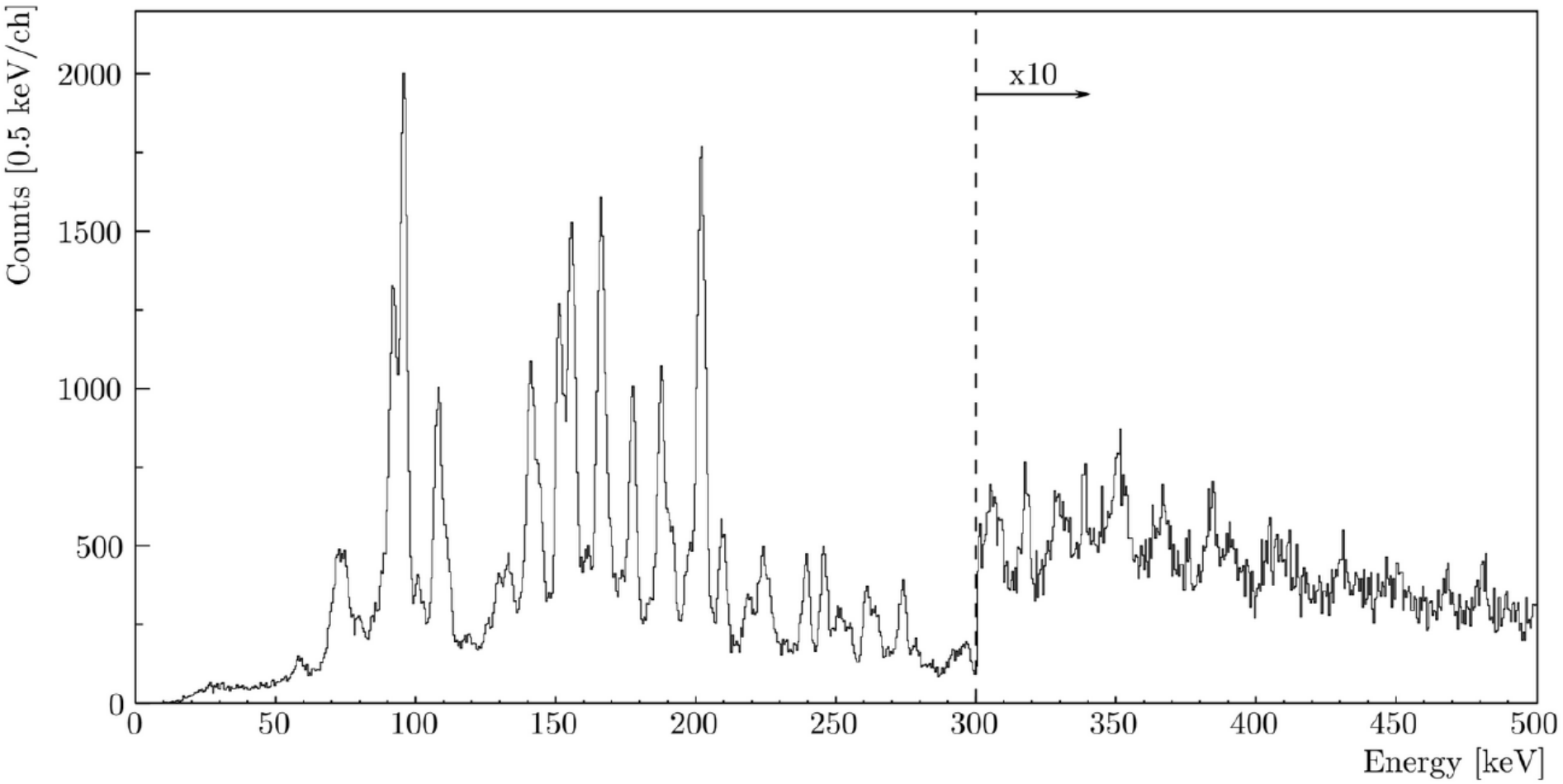
- Slightly disagreement with two previous measurements.
- Our new value consistent with F. Hoelinger *et al.*



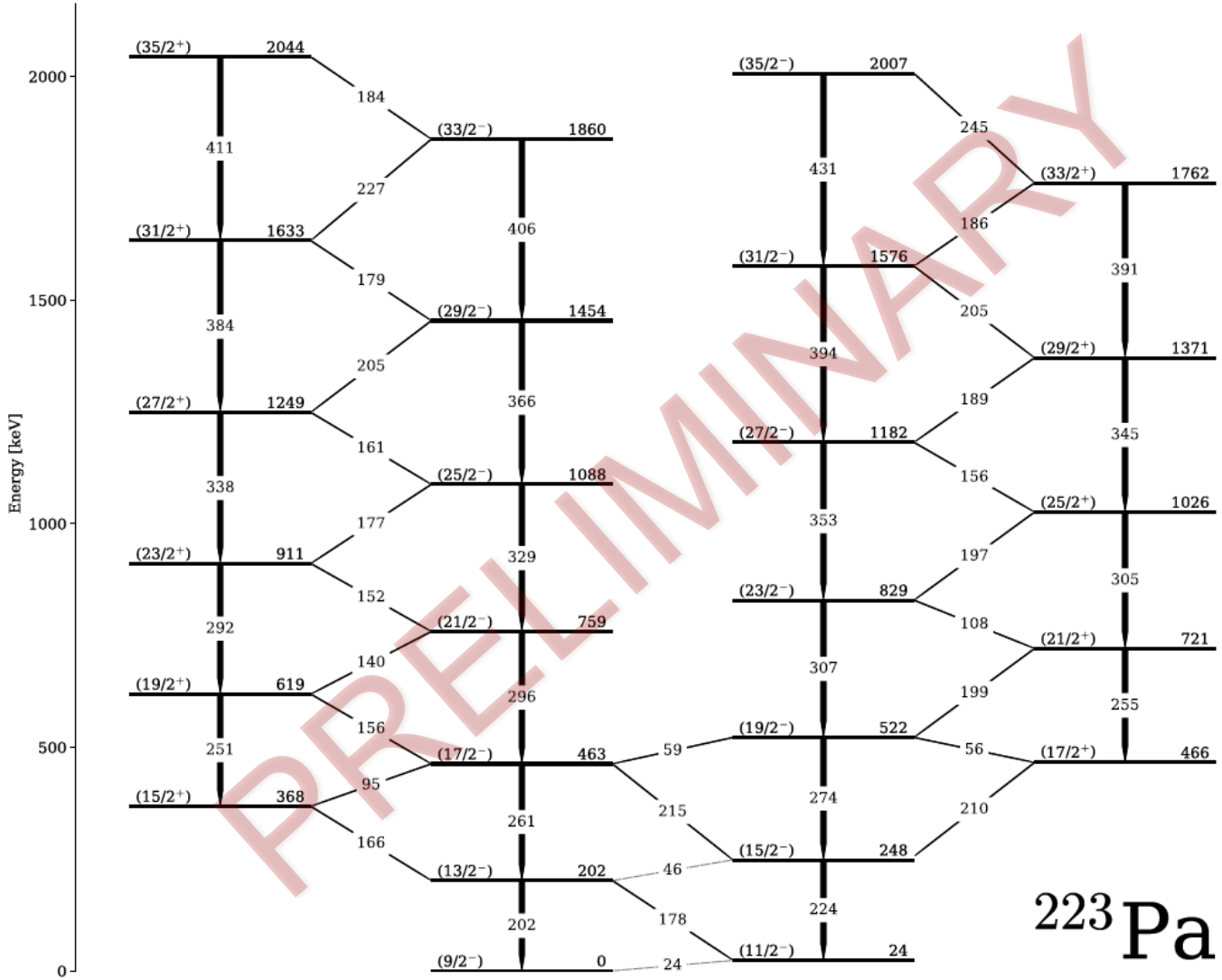
[7] J. Borggreen et al., Phys. Rev. C **2**, 1841 (1970).
[4] F. Hoellinger *et al.*, Phys. Rev. C **60**, 057301 (1999).

Gamma-Ray Spectra

- ~600k ^{223}Pa-γ events.
- ~225k ^{223}Pa-γ-γ events.
- ~60 γ rays observed.
- ~25x data as F. Hoelinger *et al*.

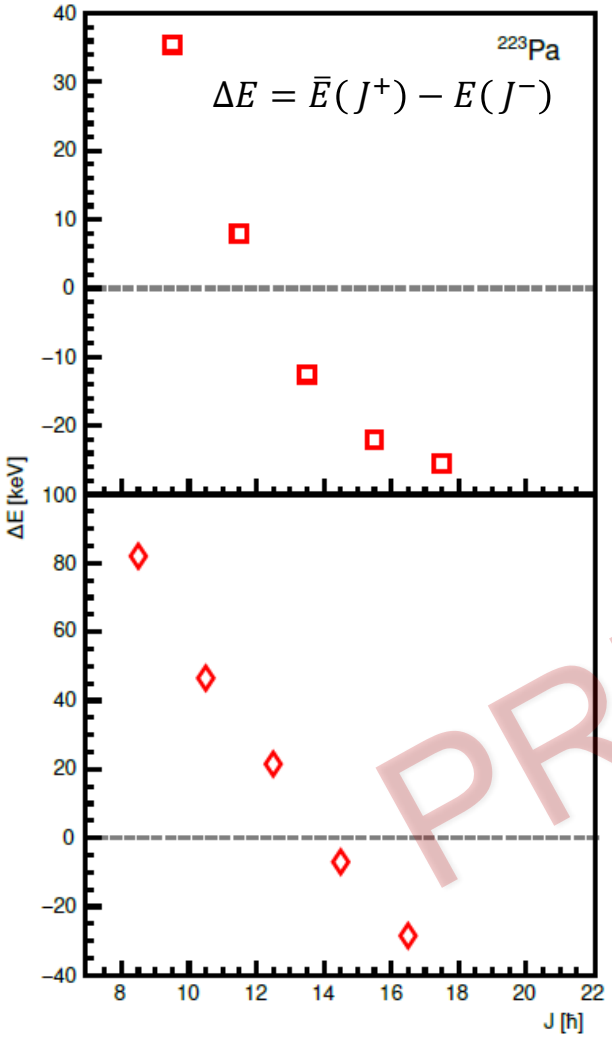


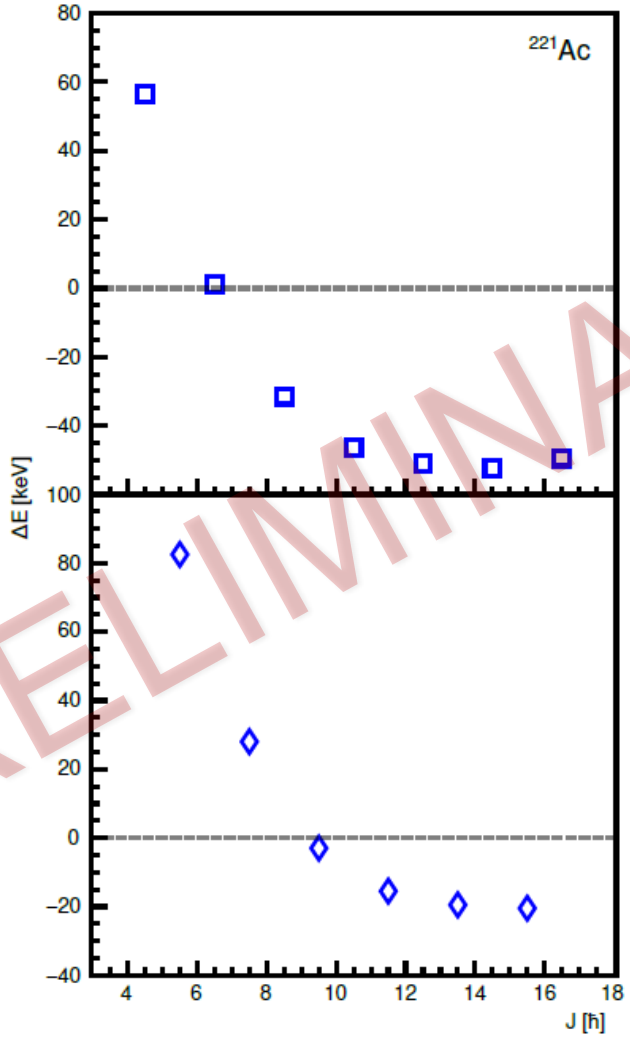
Level Scheme

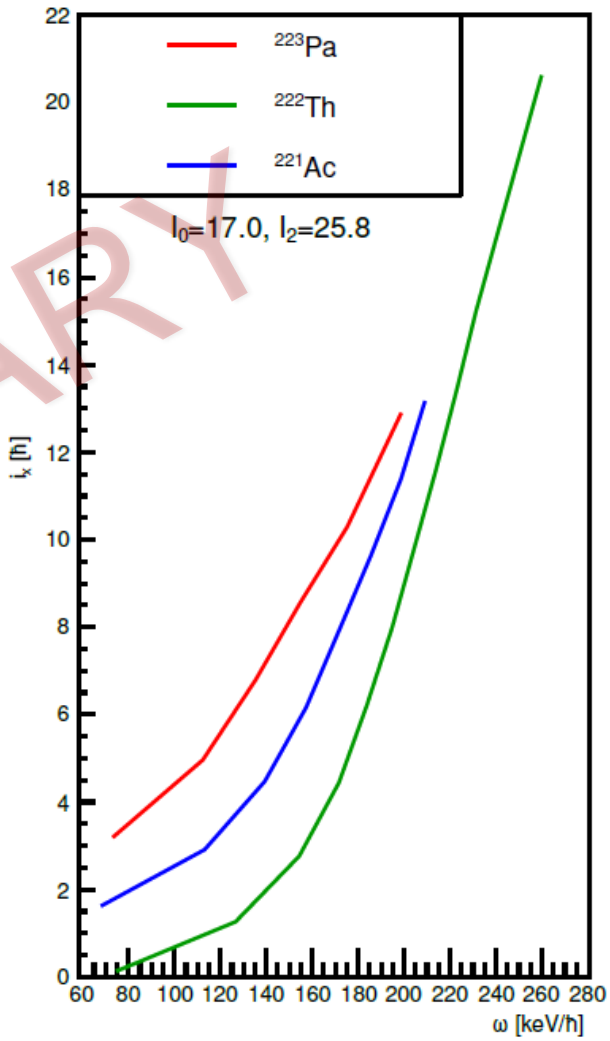


- First high-spin levels scheme for Pa in octupole region.
- Angular correlations not measured.
- J^{π} assignments (very) tentative.
- Parity doublet band structure.
- Work in progress.

Energy Splitting



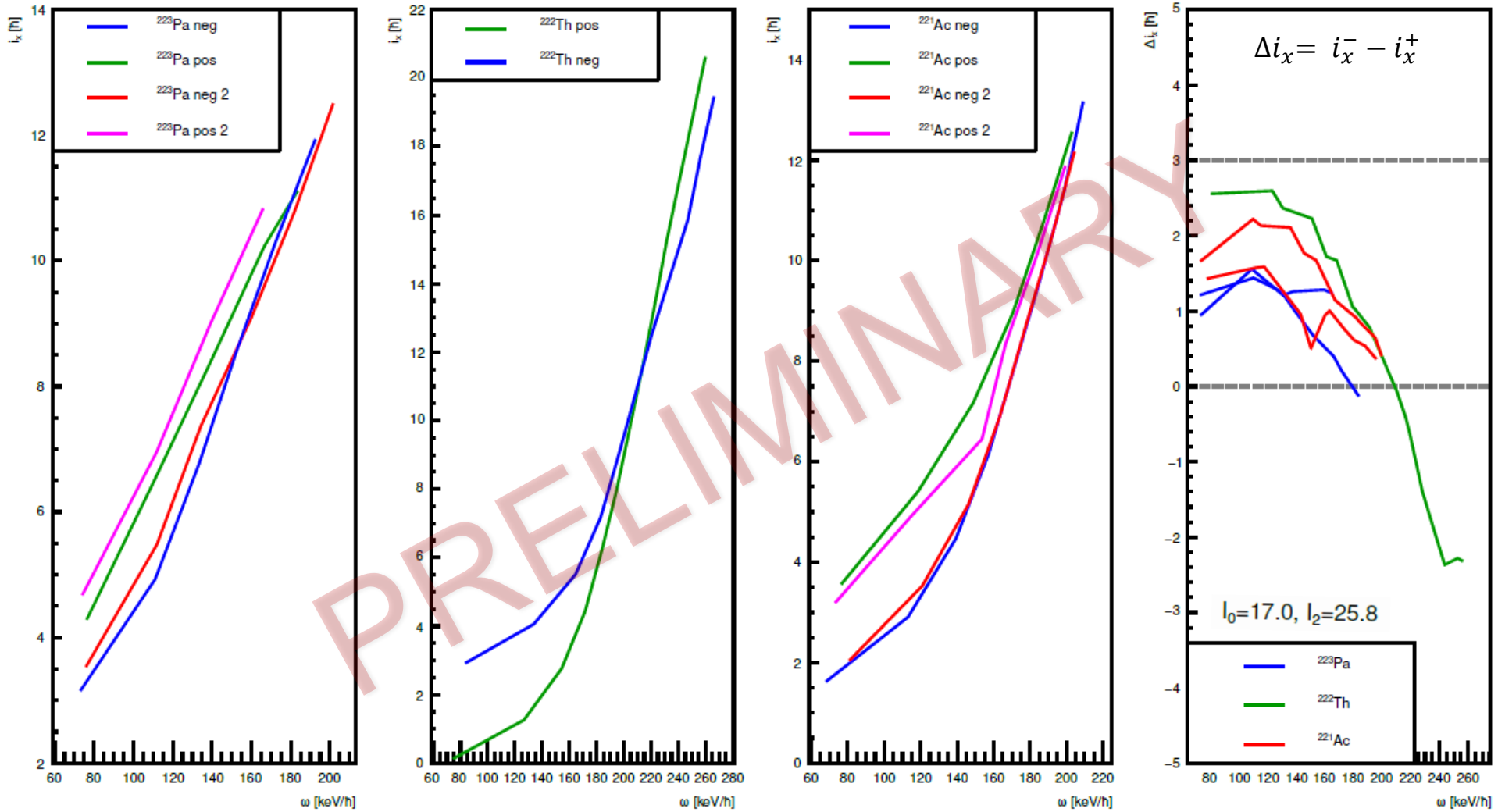




[8] M. Aïche *et al.*, Nucl. Phys. A **567**, 685 (1994).

[9] J. F. Smith *et al.*, Phys. Rev. Lett. **75**, 1050 (1995).

Alignment



[8] M. Aïche *et al.*, Nucl. Phys. A **567**, 685 (1994).

[9] J. F. Smith *et al.*, Phys. Rev. Lett. **75**, 1050 (1995).

Acknowledgements & Summary

Summary:

- There is a lack of experimental evidence for octupole deformation for Z>90.
- Performed ^{208}Pb(^{19}F,4n)^{223}Pa experiment at JYFL with JUROGAM3 & RITU.
- First excited states in ^{223}Pa observed, shows parity doublet octupole bands.
- Collectivity appears comparable to ^{222}Th, analysis is still ongoing.

Collaborators:

J. F. Smith[1], P.-A. Aden[3], N. Alwadie [2], K. Auranen[3], H. Ayatollahzadeh[1], M. Bowry[1], A. D. Briscoe[2], P. A. Butler[2], J. Chadderton[2], R. Chapman[1], L. P. Gaffney[2], P. T. Greenlees[3], T. Grahn[3], B. J. M. Hogg[1], D. T. Joss[2], H. Joukainen[3], R. Julin[3], H. Jutila[3], M. Leino[3], J. Louko[3], M. Luoma[3], A. McCarter[2], B. S. Nara Singh[1], D. O'Donnell[1], J. Ojala[2], R. D. Page[2], J. Pakarinen[3], P. Rahkila[3], P. Ruotsalainen[3], J. Sarén[3], M. Scheck[1], C.M. Sullivan[2], A. Tolosa[3], J. Uusitalo[3]

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