



DE LA RECHERCHE À L'INDUSTRIE

cea



Decay spectroscopy of ^{225}Pa : Toward laser spectroscopy of neutron-deficient actinides

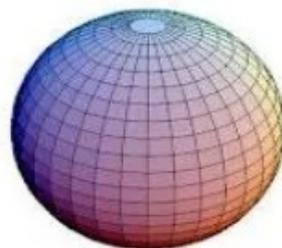
Emmanuel Rey-herme CEA/Irfu/DphN

Supervised by M. Vandebrouck (CEA/Irfu/DPhN)

In collaboration with I. Moore, I. Pohjalainen and A. Raggio (University of Jyväskylä)

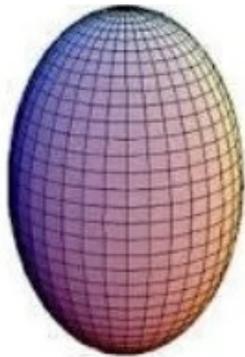


**Pheniics Fest
May 2022**

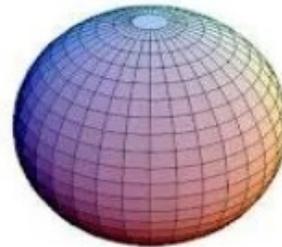


Spherical nuclei

Quadrupolar deformation :

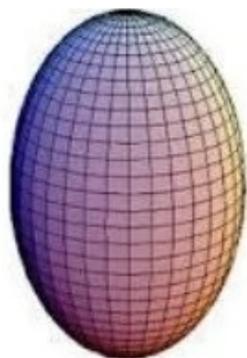


Prolate
($\beta_2 > 0$)

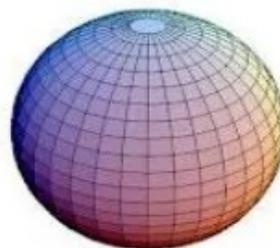


Spherical nuclei
($\beta_2 = 0$)

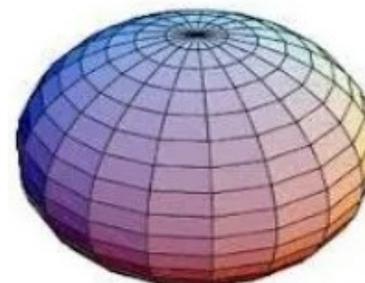
Quadrupolar deformation :



Prolate
($\beta_2 > 0$)

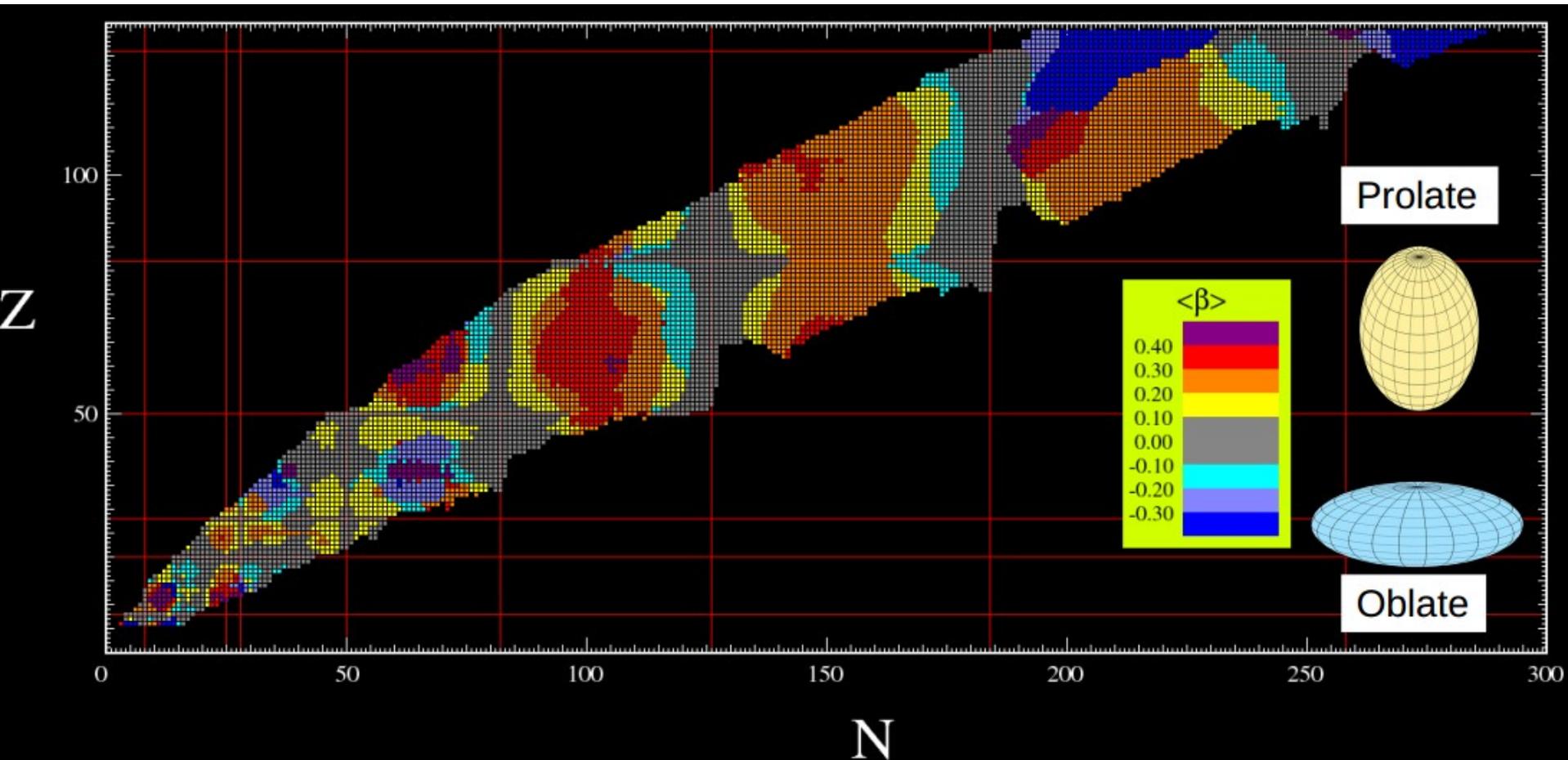


Spherical nuclei
($\beta_2 = 0$)



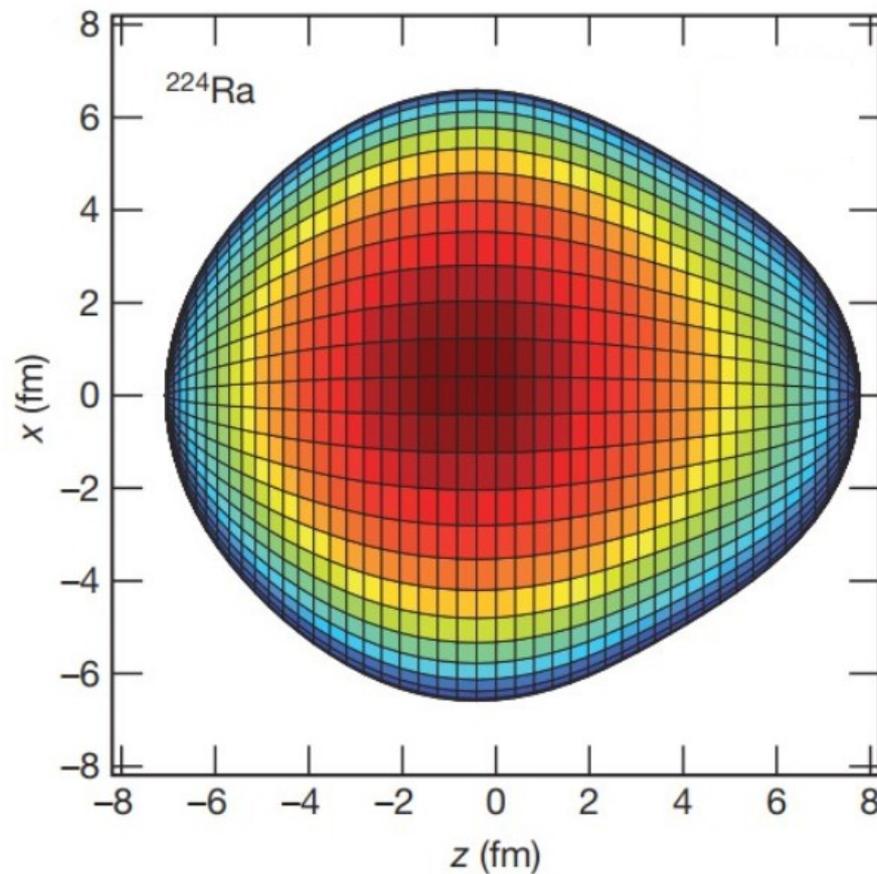
Oblate
($\beta_2 < 0$)

Quadrupolar deformation :



http://www-phynu.cea.fr/science_en_ligne/carte_potentiels_microscopiques/carte_potentiel_nucleaire.htm

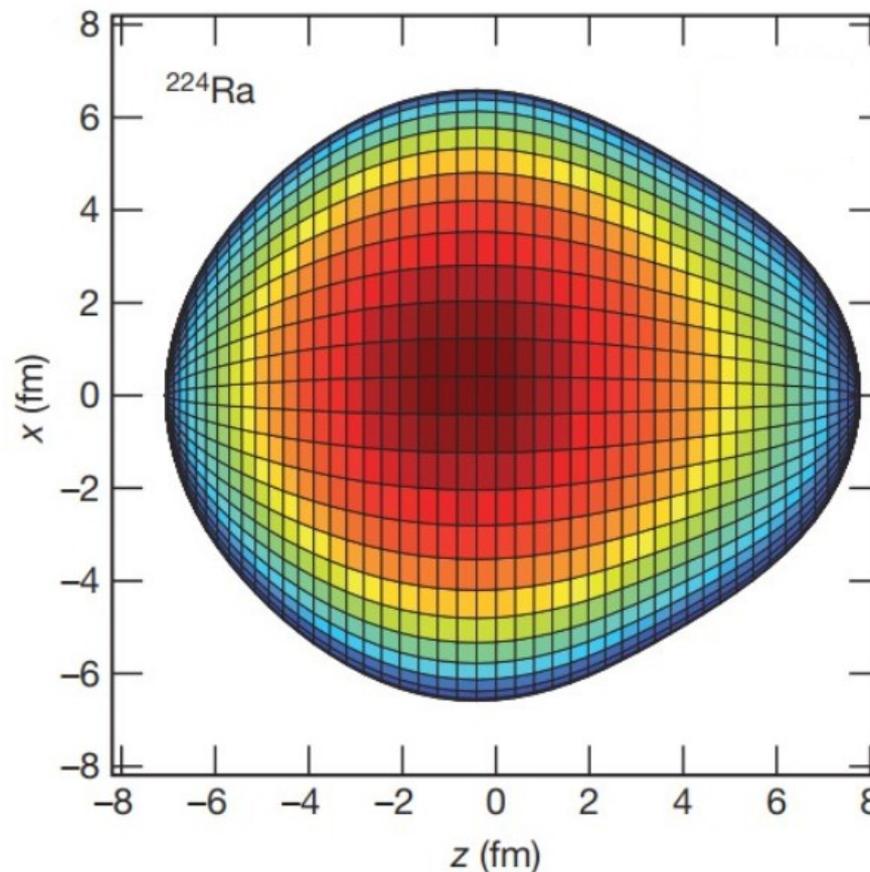
Octupolar deformation :



L. P. Gaffney et al. Nature 497 (2013)

Octupolar deformation :

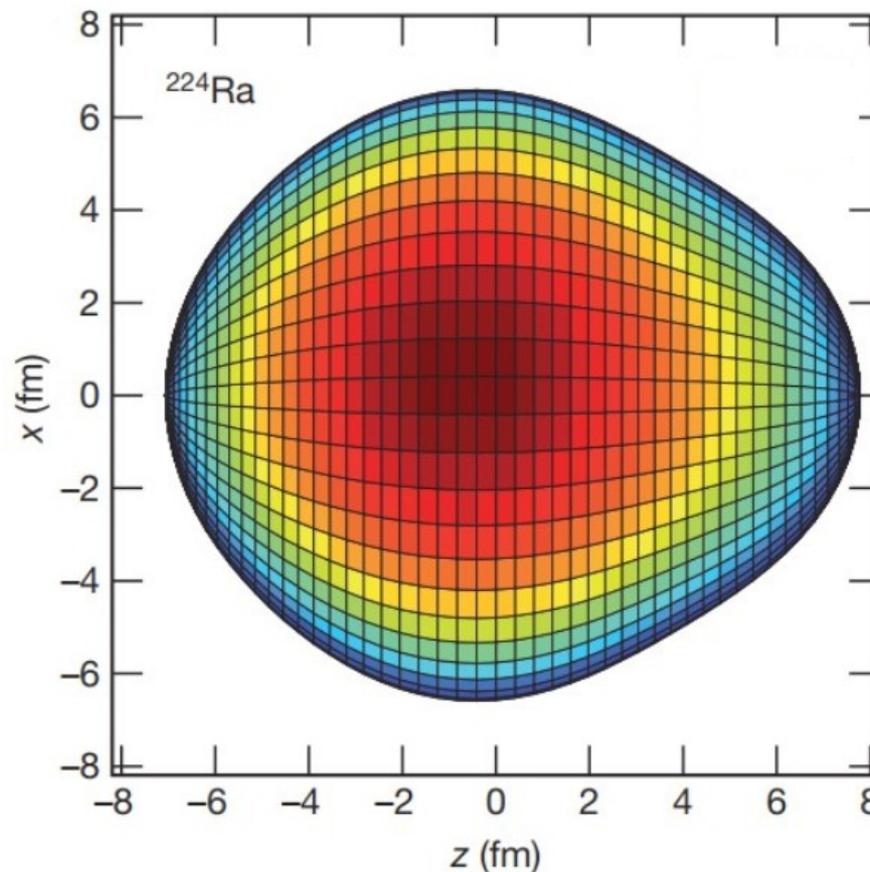
- Nuclear Structure



L. P. Gaffney et al. Nature 497 (2013)

Octupolar deformation :

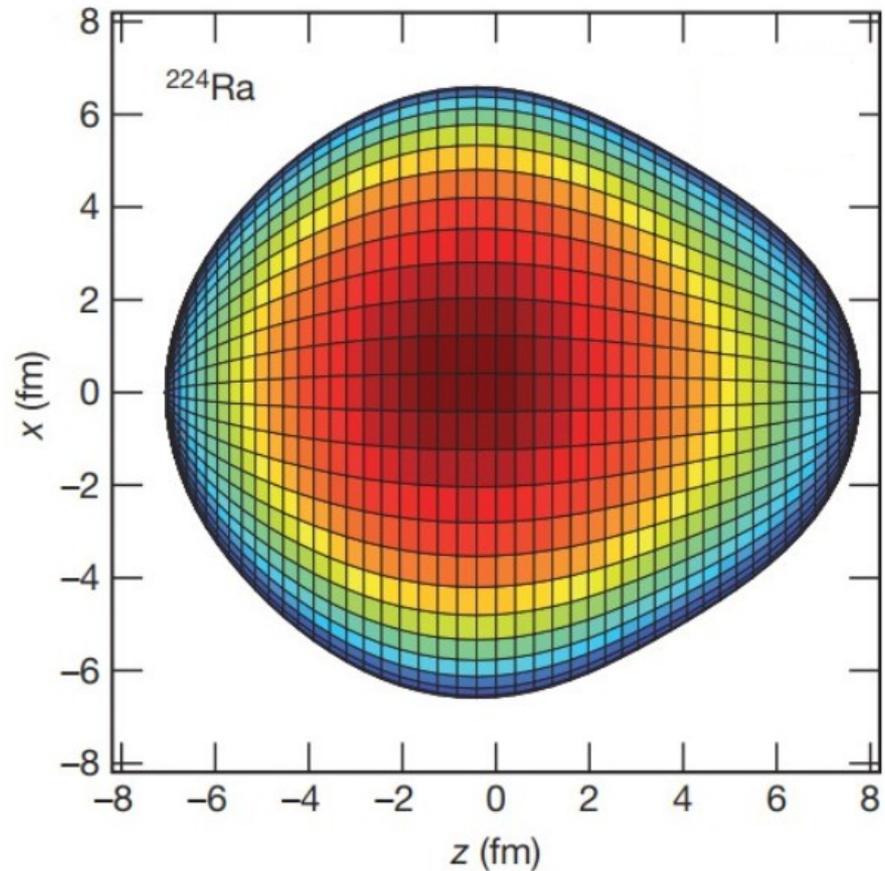
- Nuclear Structure
- Astrophysics (Nucleosynthesis)



L. P. Gaffney et al. Nature 497 (2013)

Octupolar deformation :

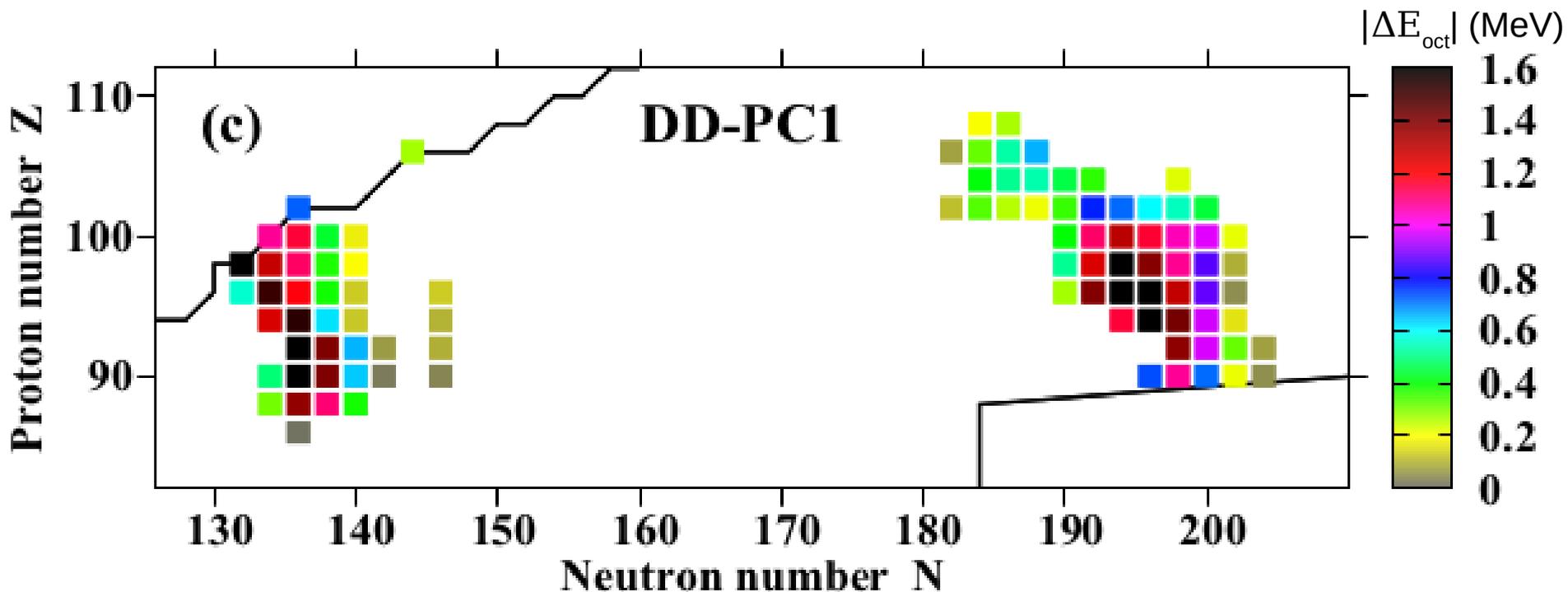
- Nuclear Structure
- Astrophysics (Nucleosynthesis)
- CP violation (Search for a nuclear electric dipole moment)



L. P. Gaffney et al. Nature 497 (2013)

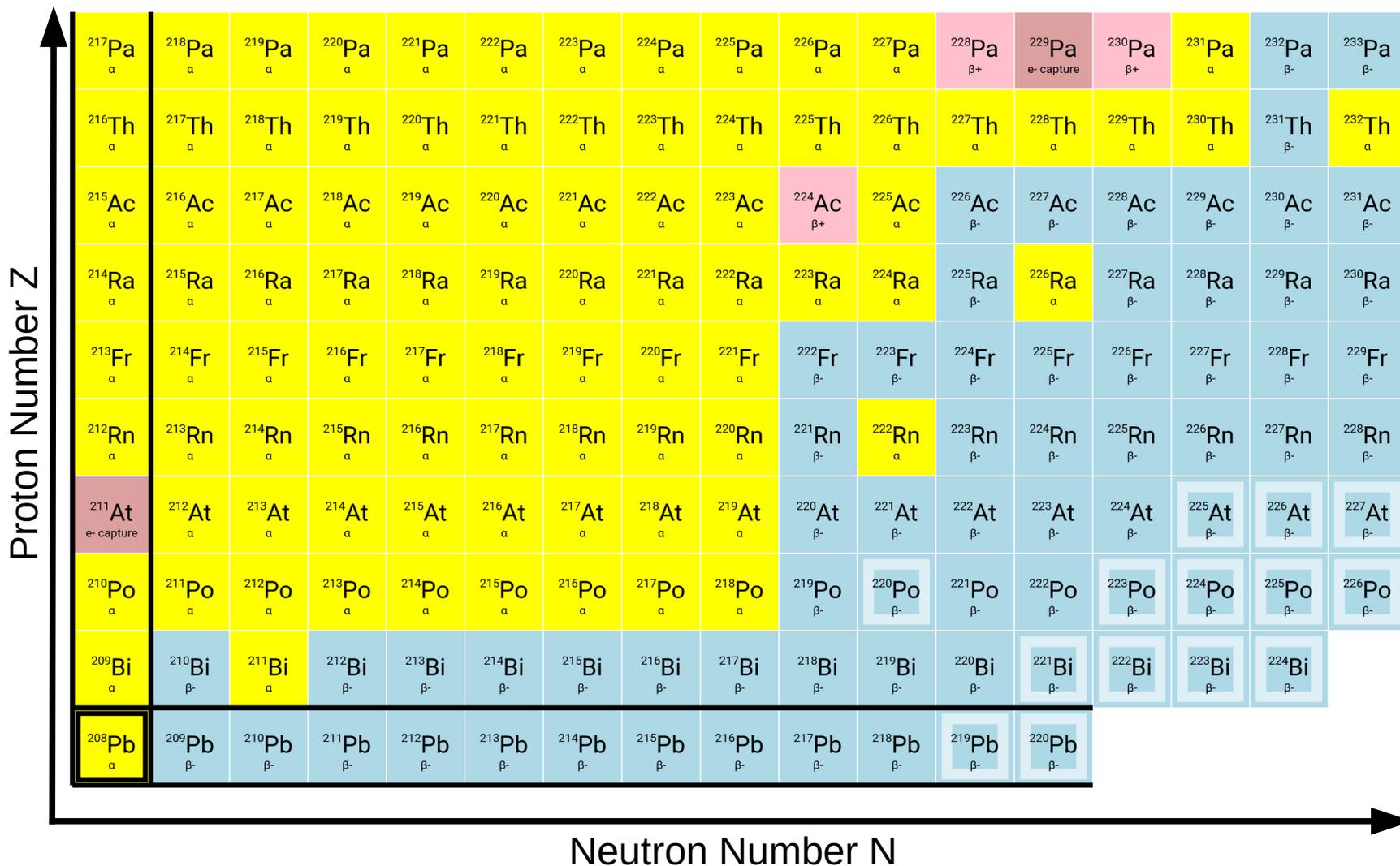
Octupolar deformation :

Prediction of strong octupolar deformations in the ground state of neutron-deficient actinides :

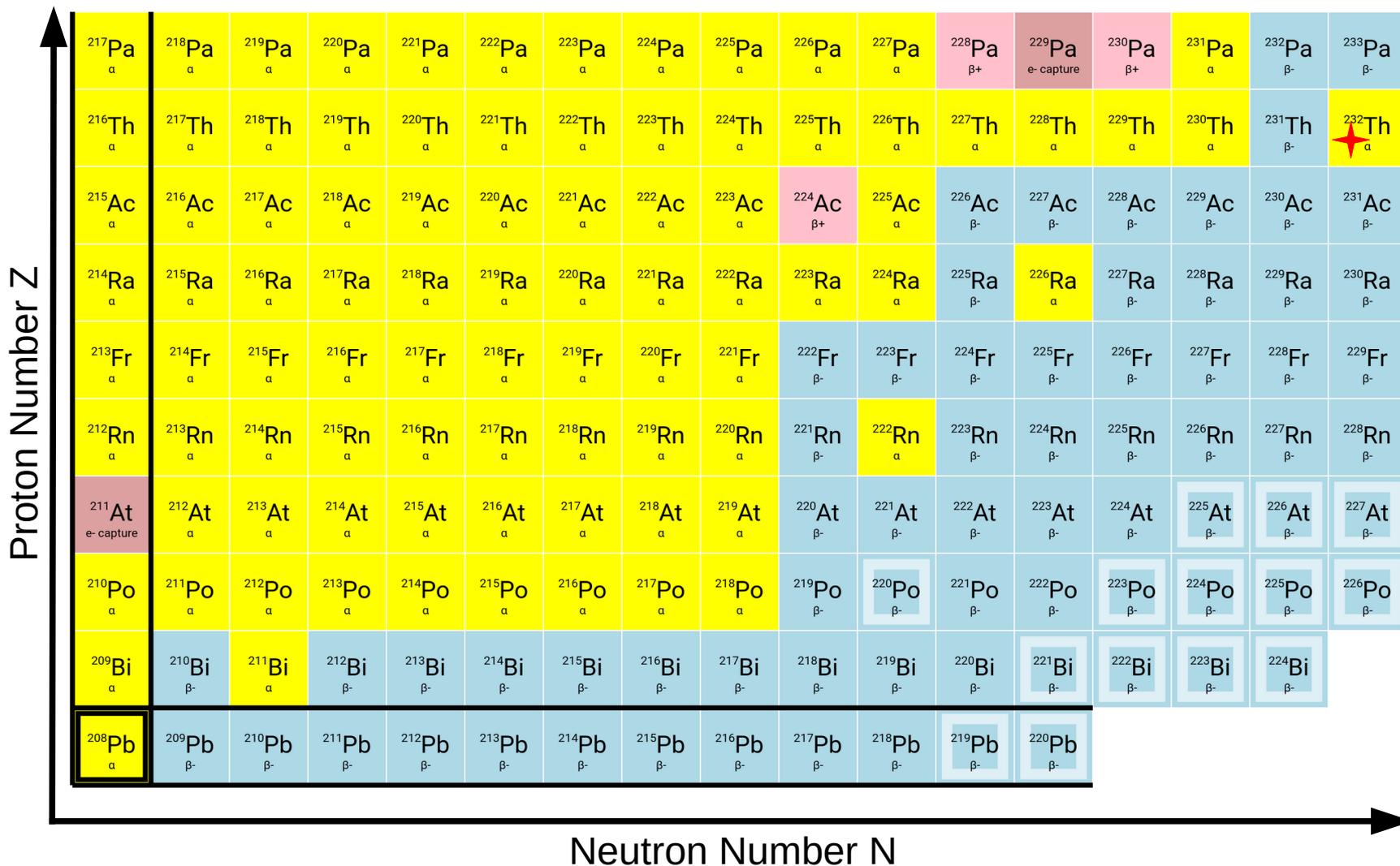


S. E. Agbemava et al. PRC 96 (2017)

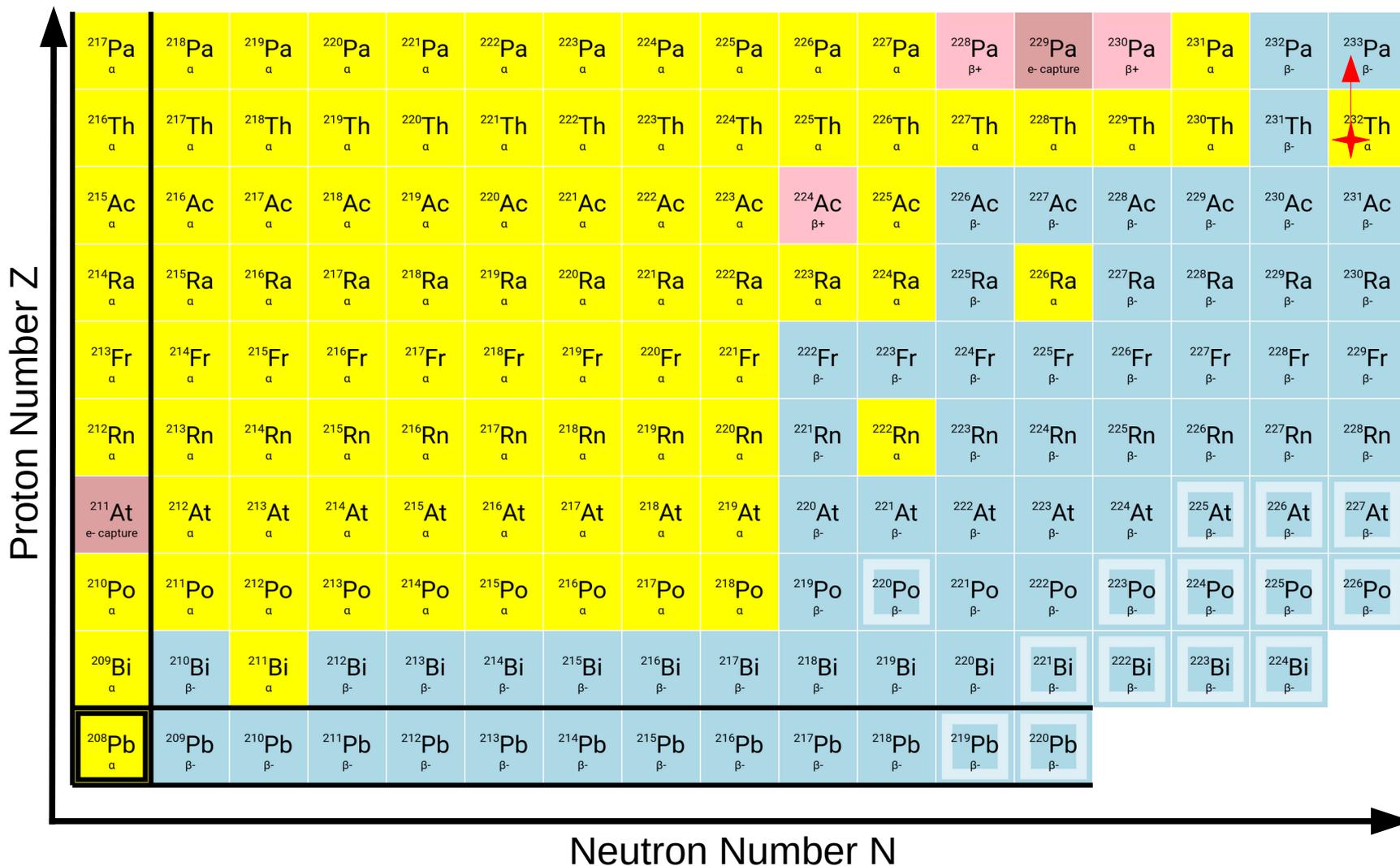
Proton induced fusion-evaporation reaction



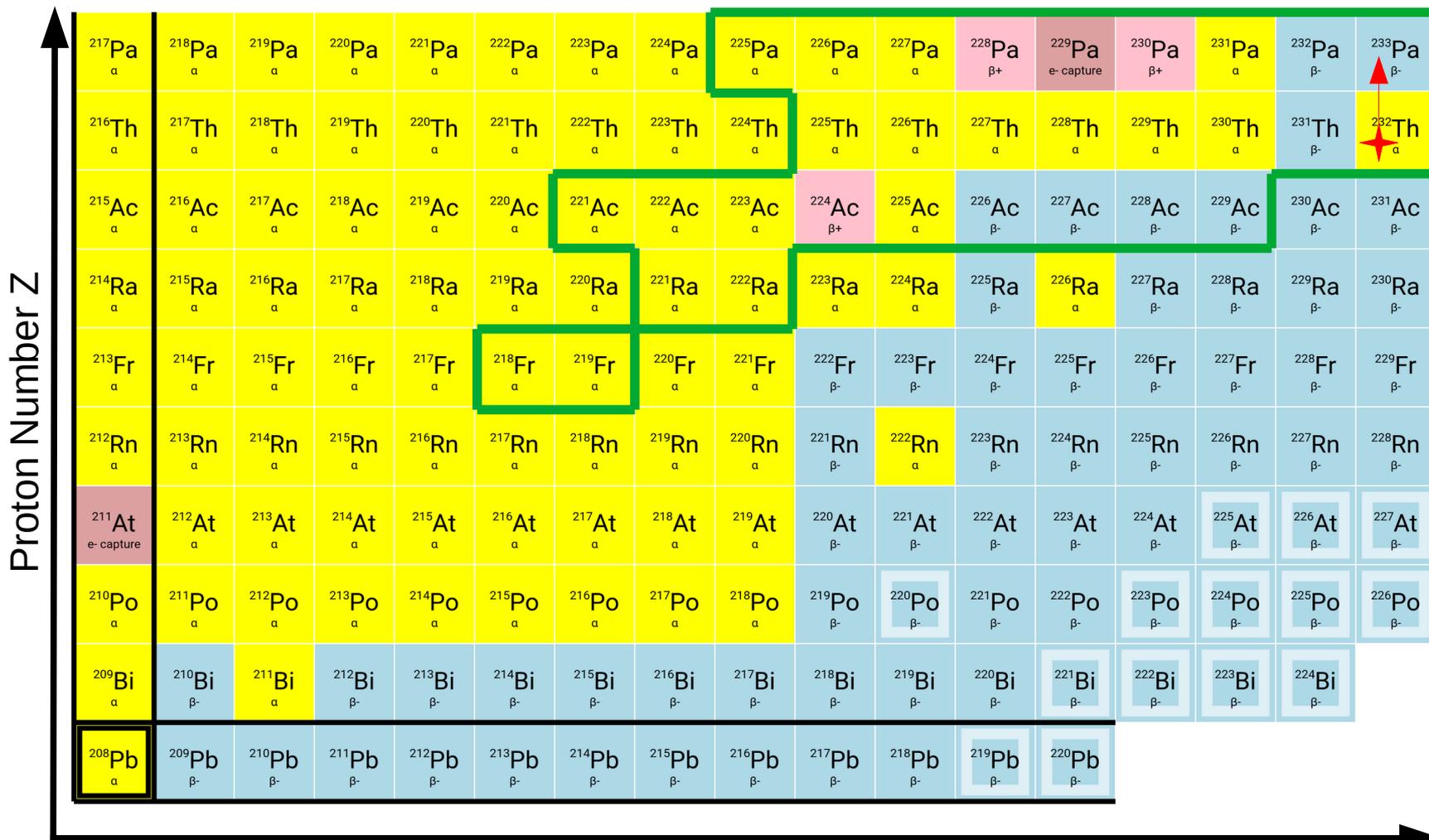
Proton induced fusion-evaporation reaction



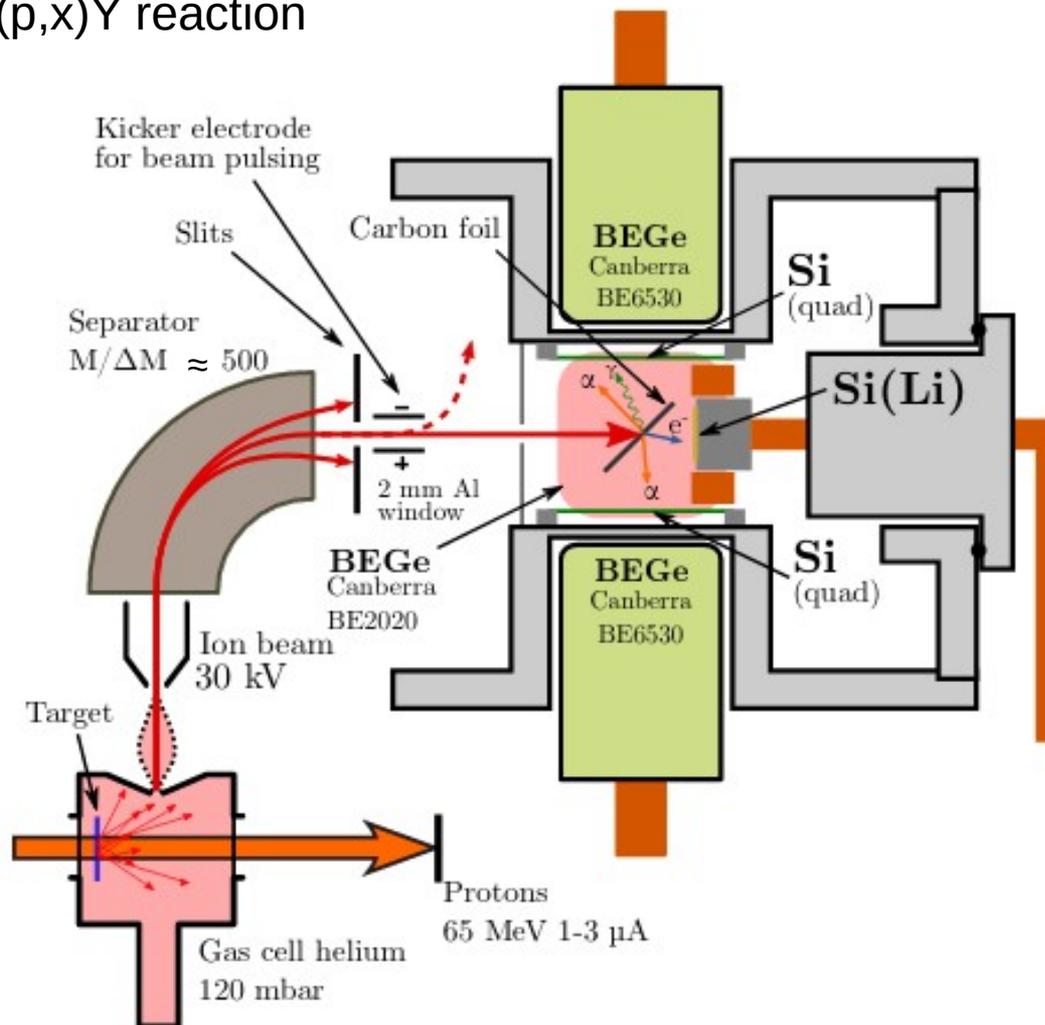
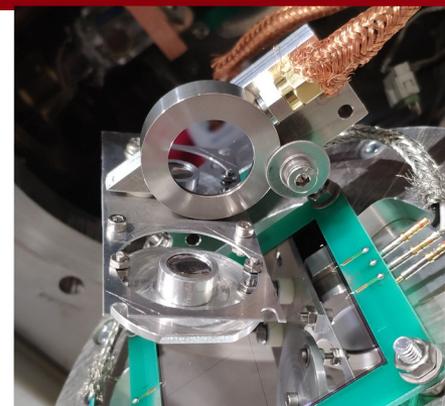
Proton induced fusion-evaporation reaction



Proton induced fusion-evaporation reaction



$^{232}\text{Th}(p,x)\text{Y}$ reaction



On going analysis :
 $^{225}\text{Pa} \rightarrow ^{221}\text{Ac} \rightarrow ^{217}\text{Fr}$

Existing literature :

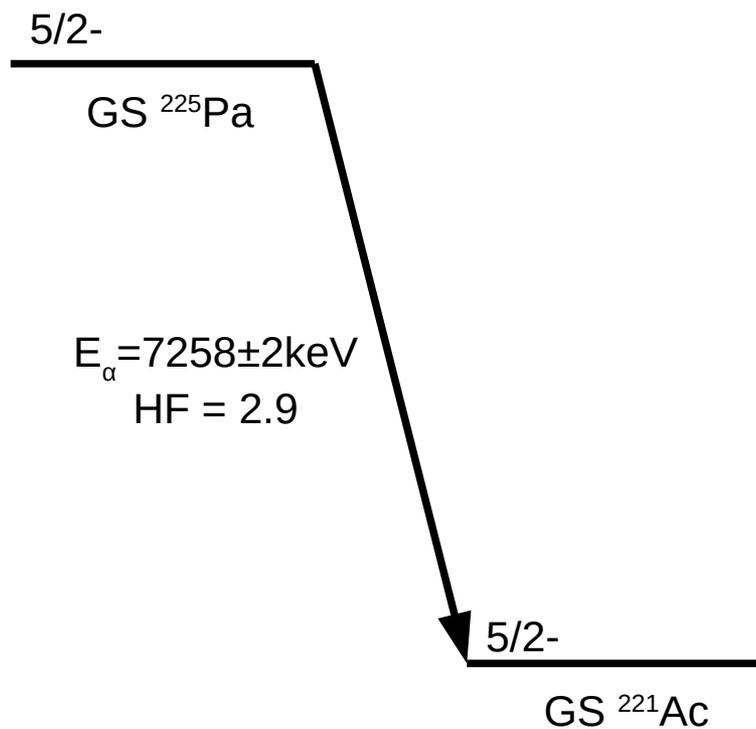
^{225}Pa decay data

Element	Our work	
	$E_\alpha(\text{keV})$	$I(\%)$
^{225}Pa	7170(5)	17(1)
	7235(5)	30(2)
	7261(5)	53(2)
^{221}Ac	7373(5)	6(1)
	7437(5)	20(2)
	7641(5)	74(3)
^{217}Fr	8312(5)	
^{213}At	9080(5)	

(1988) *Nuclear Inst. and Methods in Physics Research, B*, 31 (3), pp. 483-486



$5/2^-$
GS ^{225}Pa

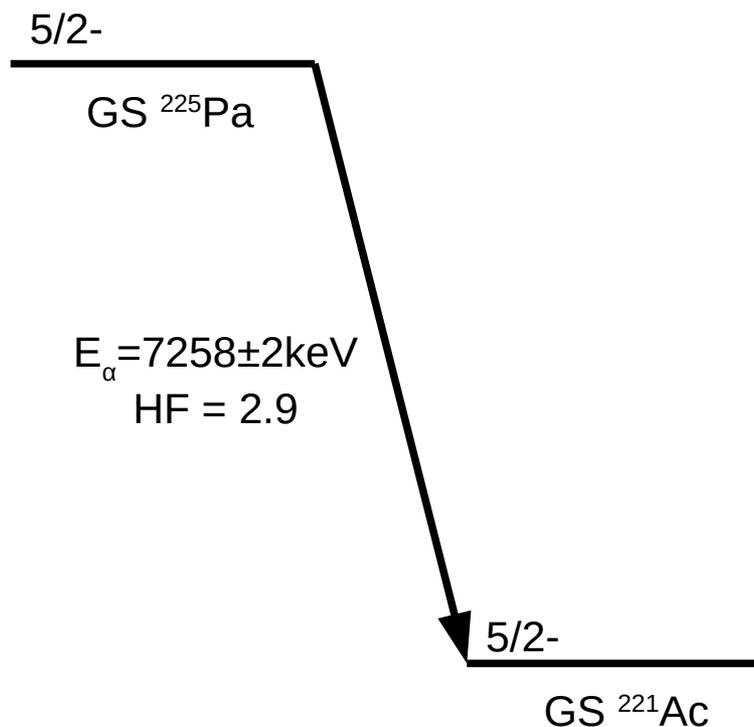


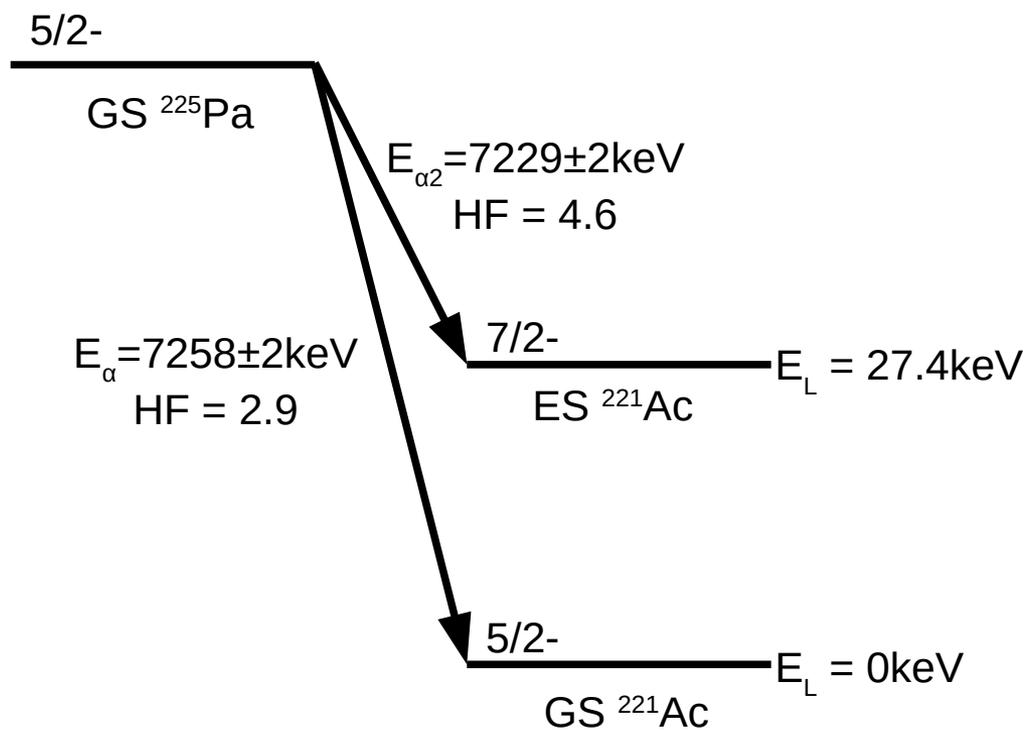
Hindrance factor :

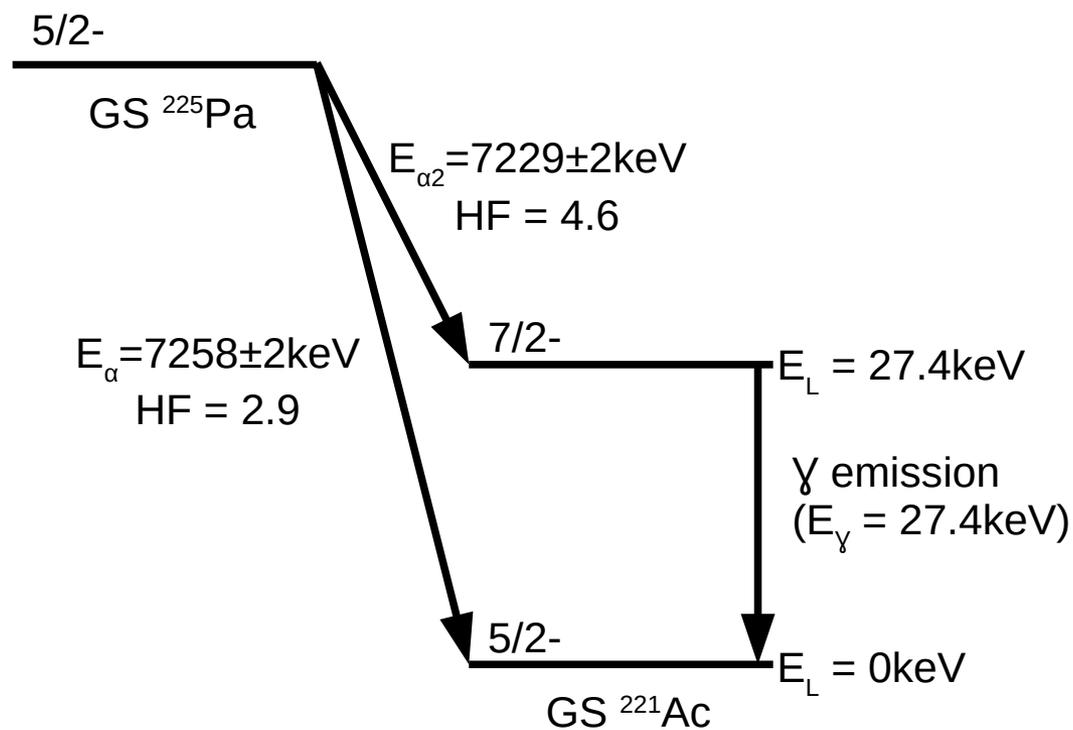
$$HF = \frac{T_{1/2, \text{exp}}}{T_{1/2, \text{th}}}$$

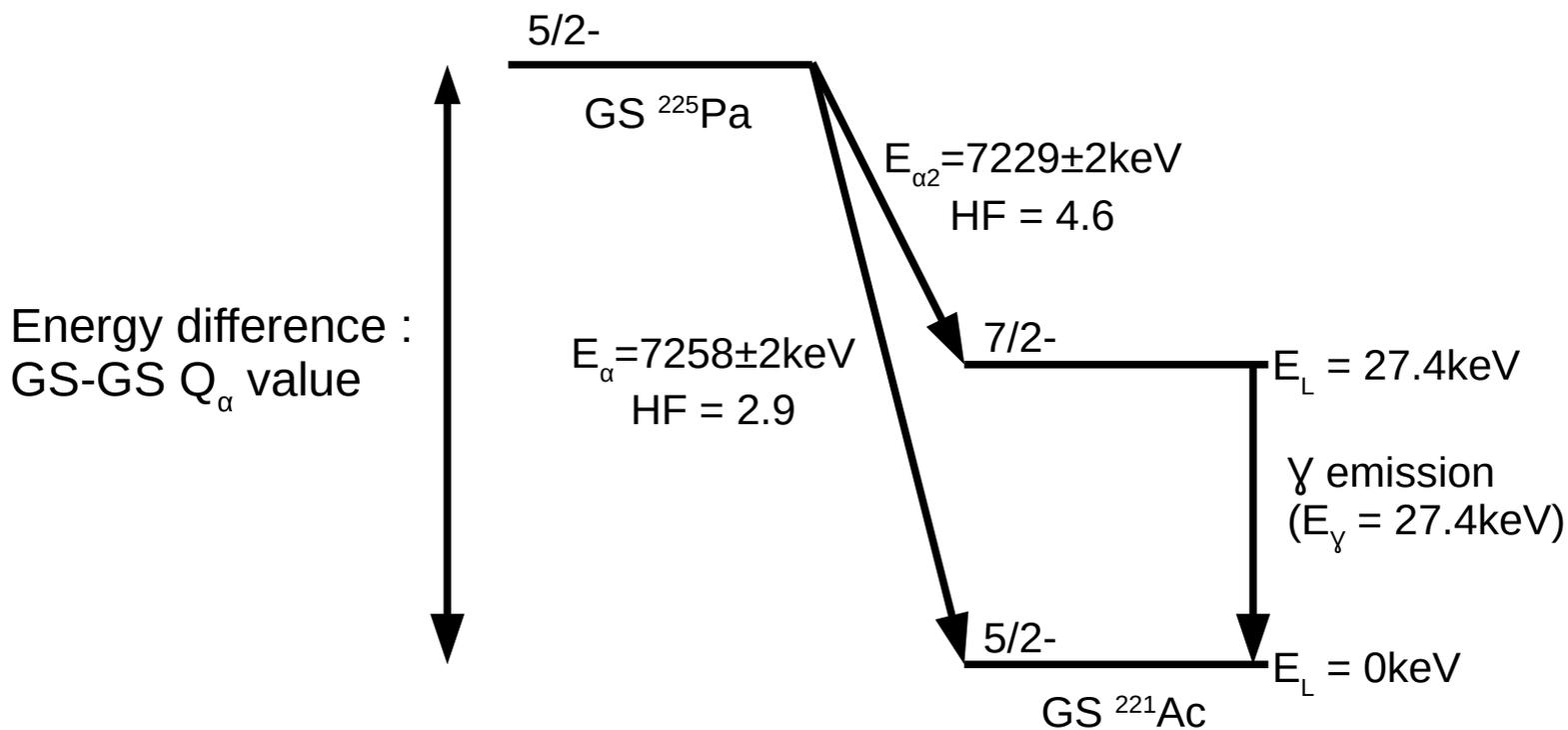
Measure how likely a given transition is with respect to a simple theoretical model

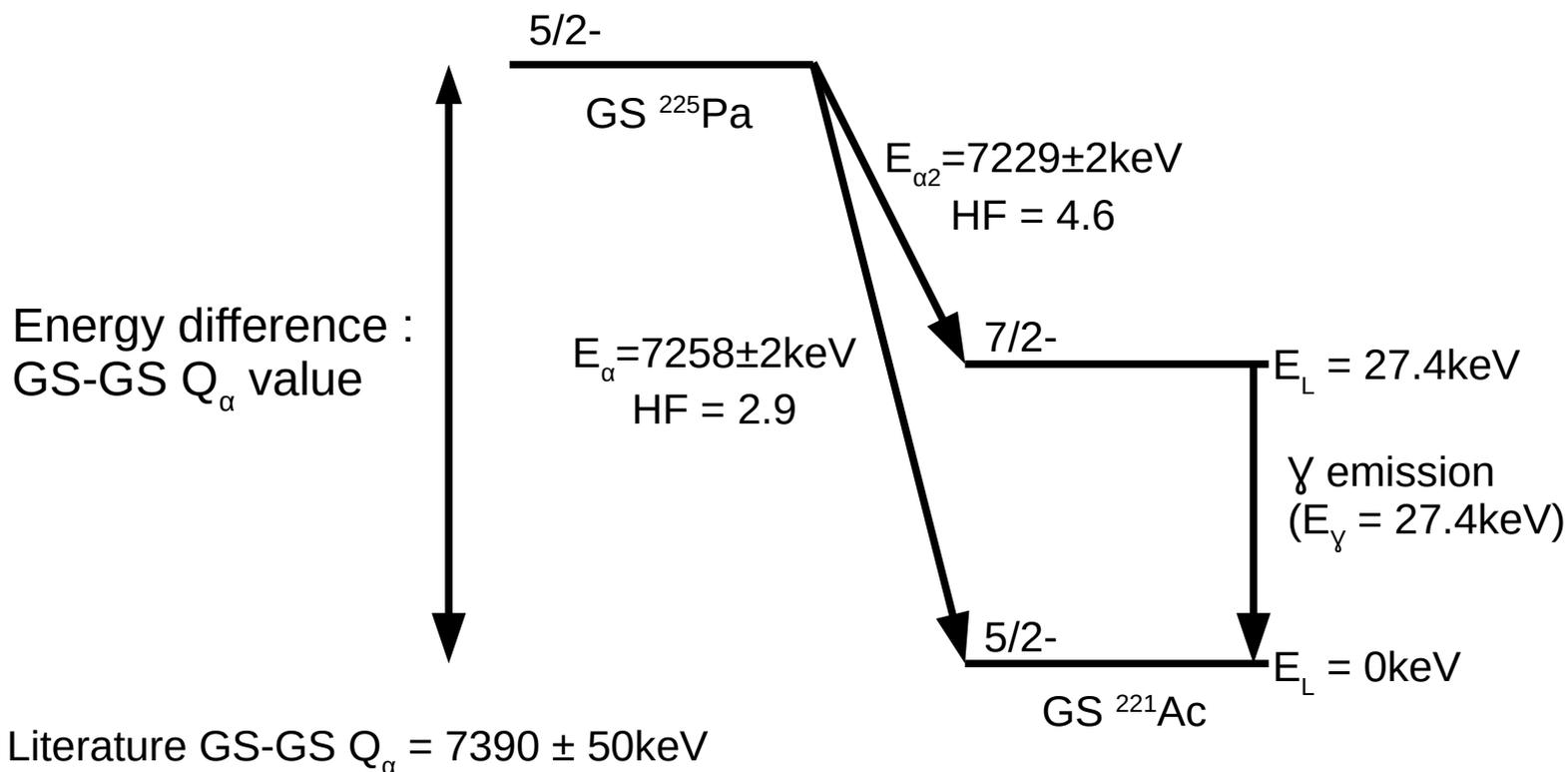
Typical low HF are between 1 and 10.
High HF can be above 1000.

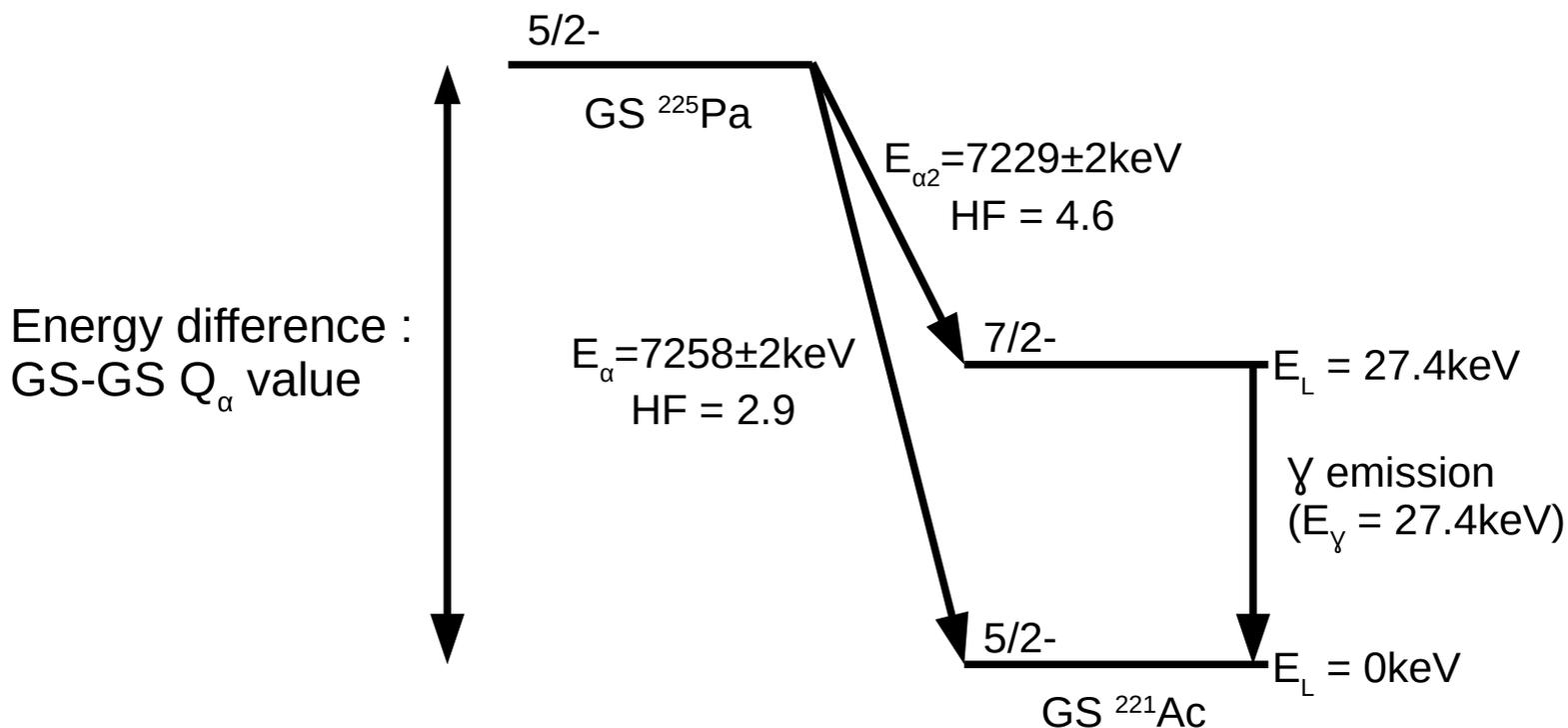






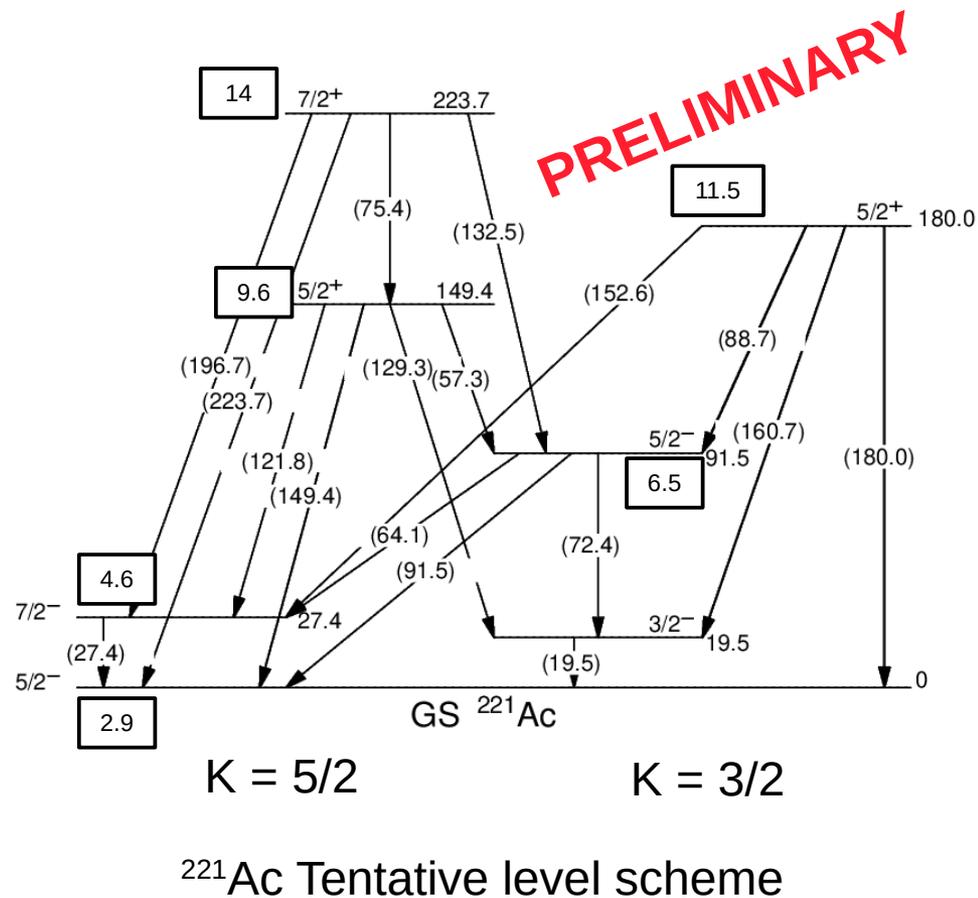






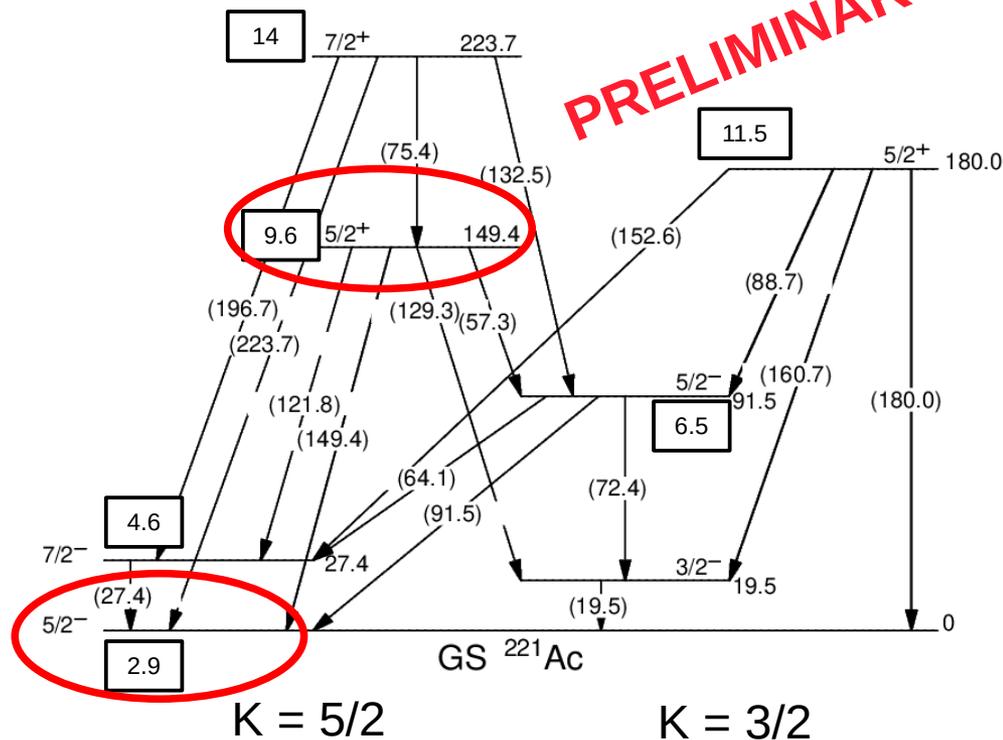
Literature GS-GS $Q_\alpha = 7390 \pm 50 \text{ keV}$

This work : $Q_\alpha = 7388 \pm 1 \text{ keV}$



PRELIMINARY

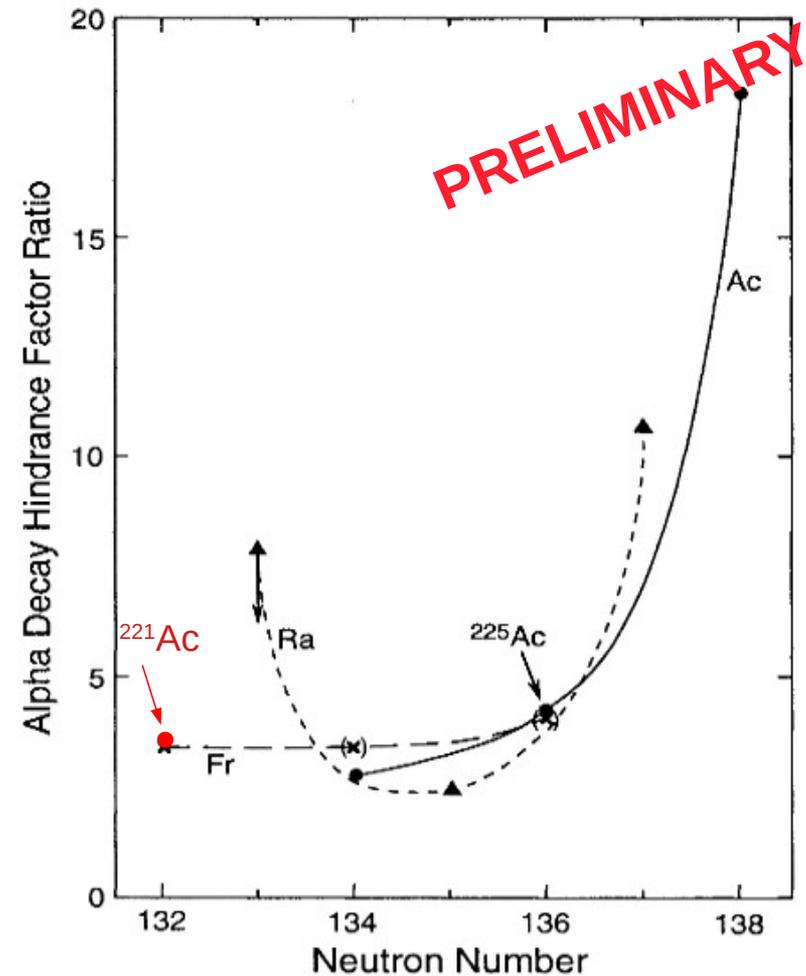
Presence of parity doublet :
Clear sign octupolar deformation in ^{221}Ac



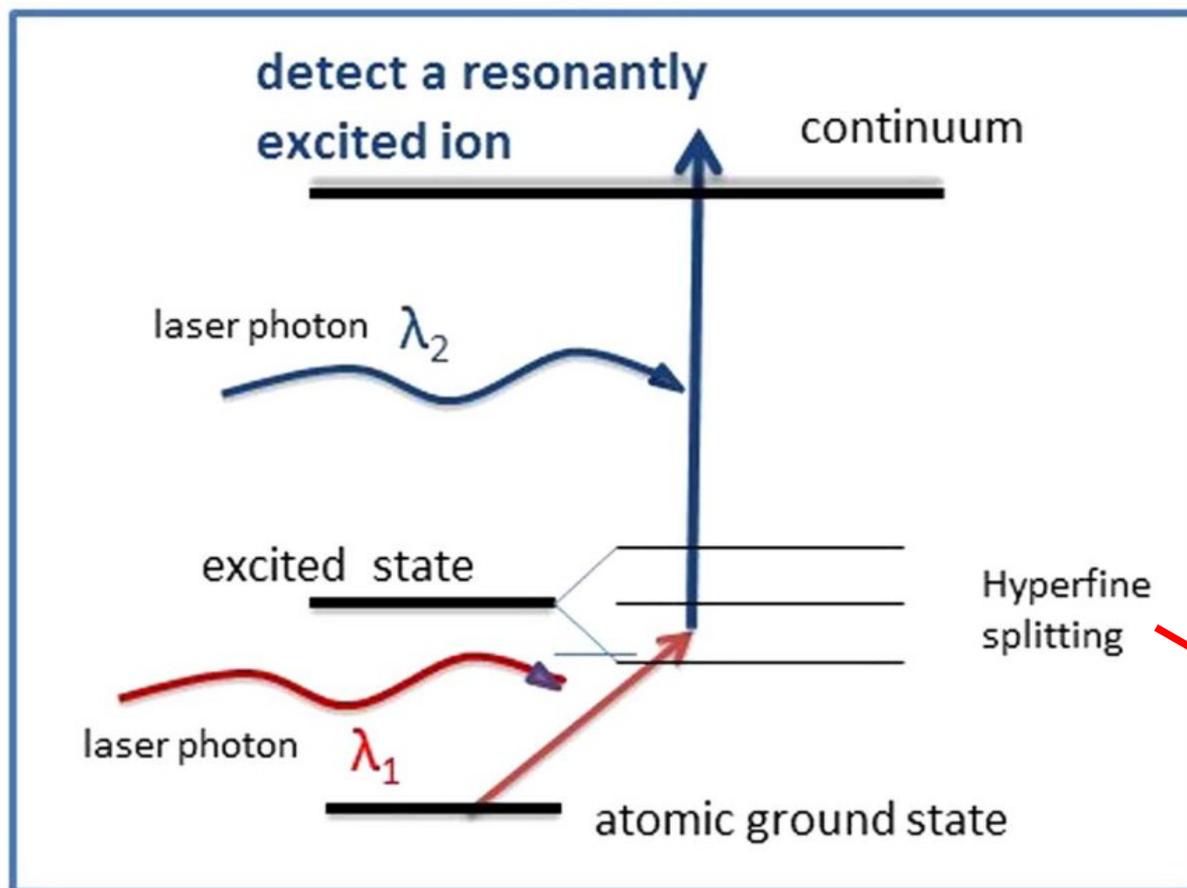
^{221}Ac Tentative level scheme

Presence of parity doublet :
Clear sign octupolar deformation in ^{221}Ac

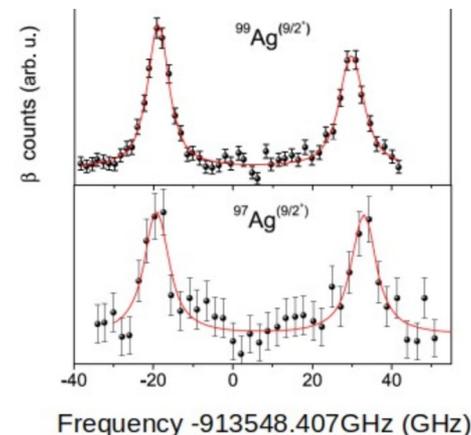
Low HF ratio in the parity doublet (~ 3.3):
Clear sign of octupolar deformation in
both ^{225}Pa and ^{221}Ac



R. K. Sheline PRC 48 (1993)



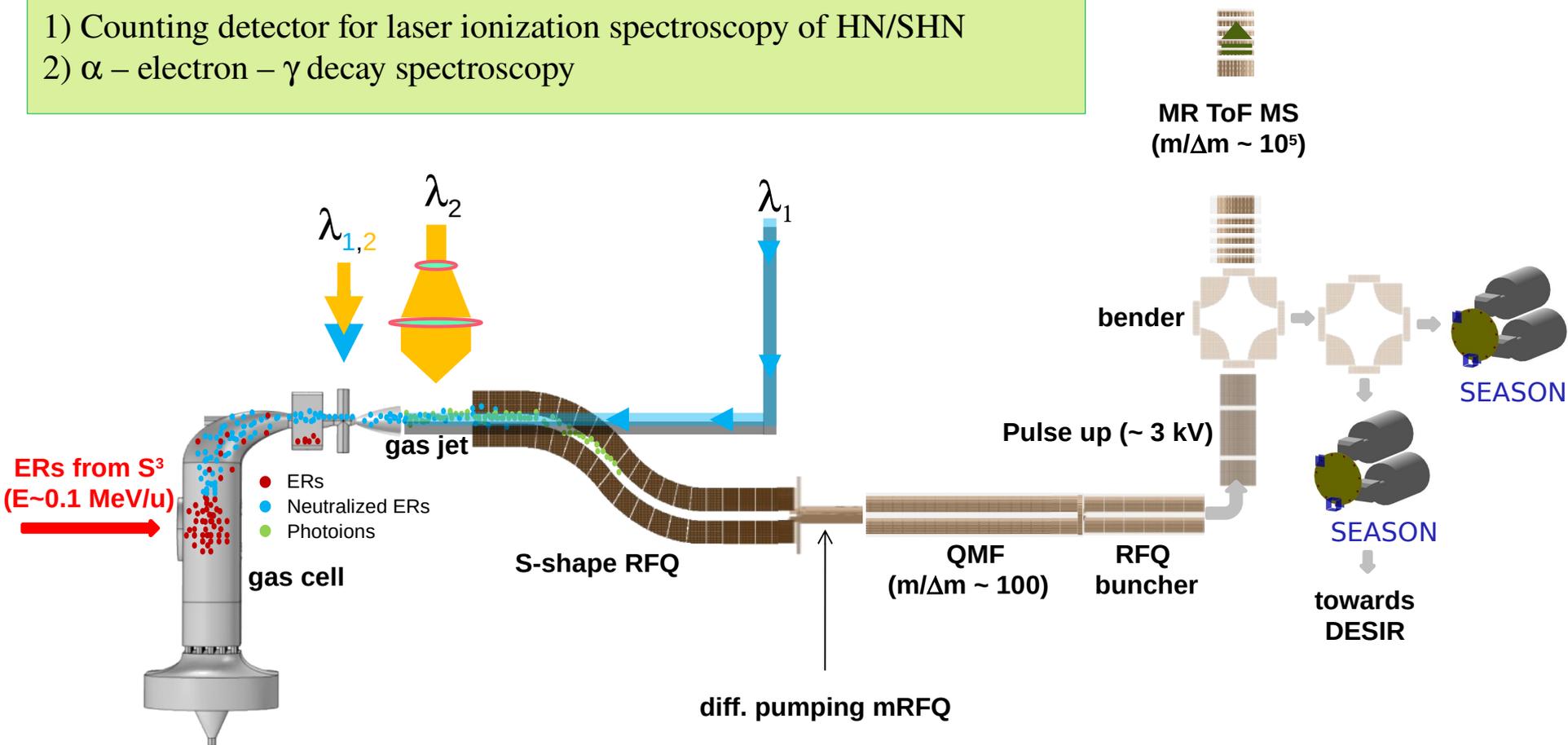
R. Neugart et al. *Journal of Physics G : NuclearPhysics* 44 (2017)



- Nuclear structure properties :
- Charge radii
 - Spin
 - Electric quadrupole moment
 - Magnetic dipole moment

SEASON (Spectroscopy Electron Alpha in Silicon bOx couNter)

- 1) Counting detector for laser ionization spectroscopy of HN/SHN
- 2) α – electron – γ decay spectroscopy



Thank you for your attention !

