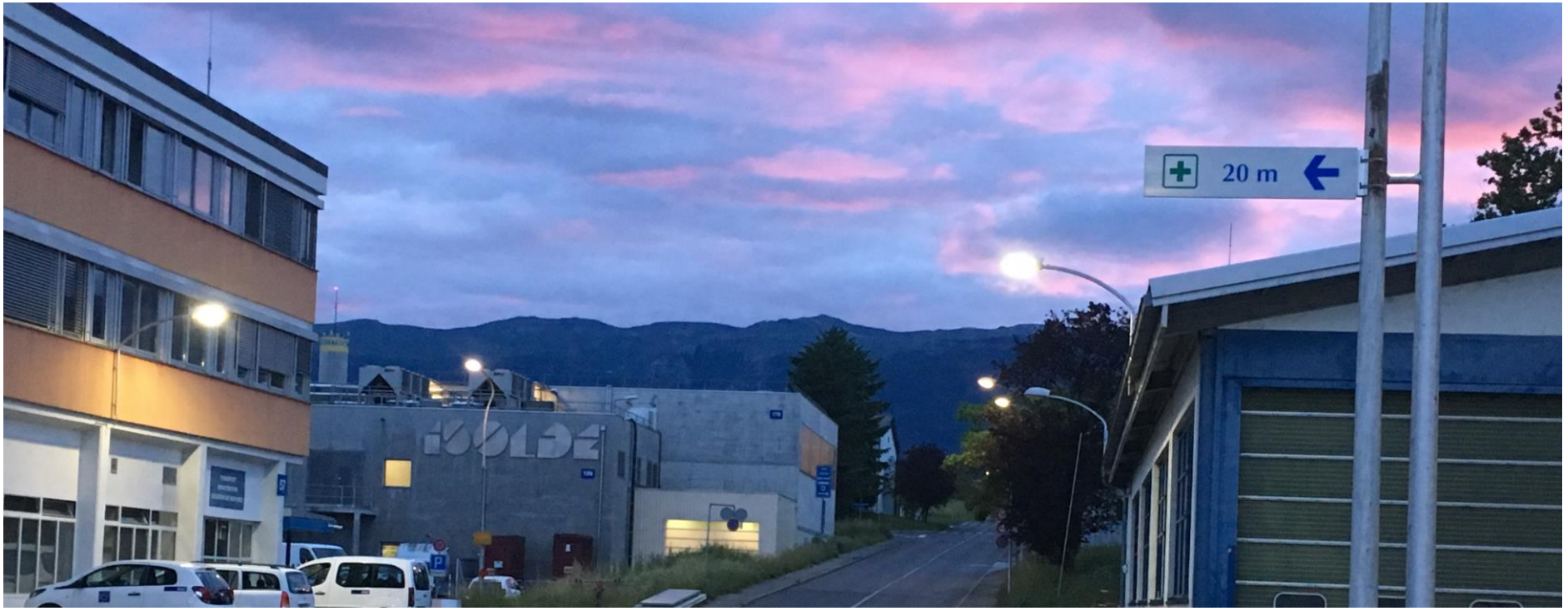

(Nuclear) Physics at ISOLDE-CERN
Q&A

Hanne Heylen
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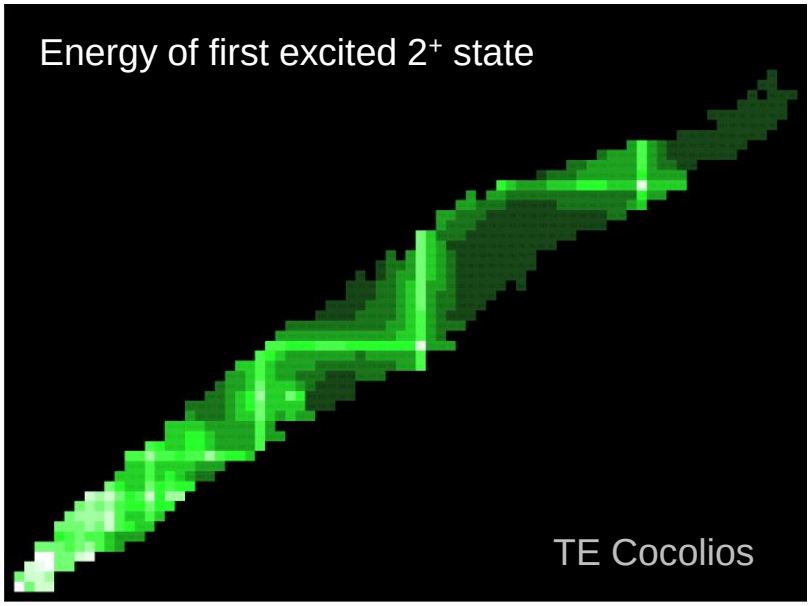
CERN, Experimental Physics department

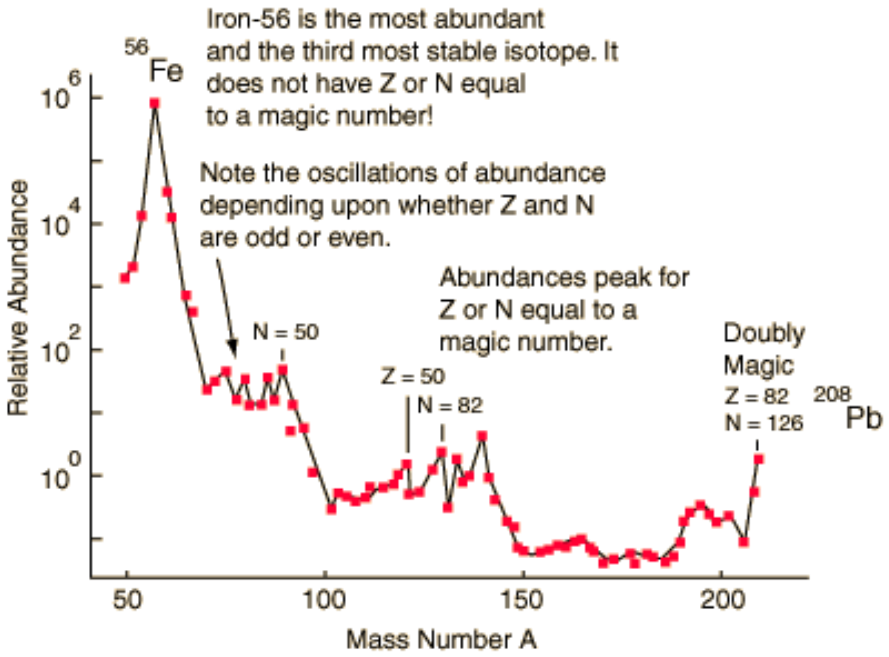
on behalf of the ISOLDE-CERN group

Question 1

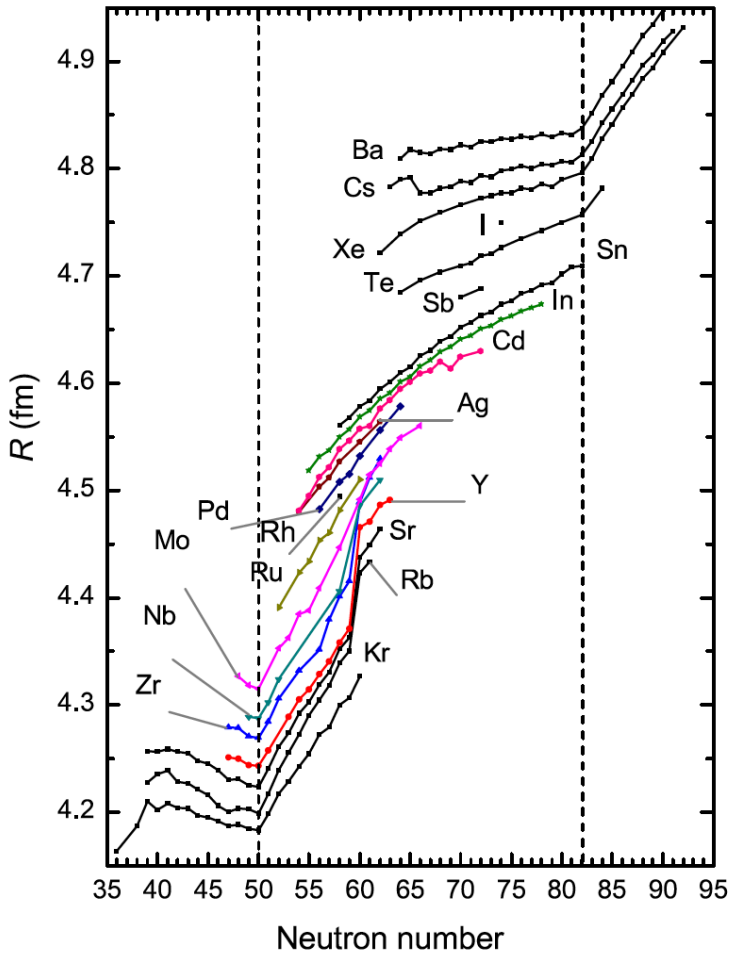
- Is the shell structure of the nucleus solely inferred from the existence of stable nuclei in analogy to stable atoms, or are there other reasons why this shell structure is inferred ?
- How are the values of the magic number obtained.

See RF Garcia Ruiz, A. Vernon:
“Emergence of simple patterns in many-body systems: from macroscopic objects to the atomic nucleus”, *The European Physical Journal A* **volume 56**, 136 (2020)





1963 Nobel prize: Maria Goeppert Mayer and Hans Jensen
https://www.nobelprize.org/prizes/physics/1963/summary/



I. Angeli, K.P. Marinova / Atomic Data and Nuclear Data Tables 99 (2013) 69–95

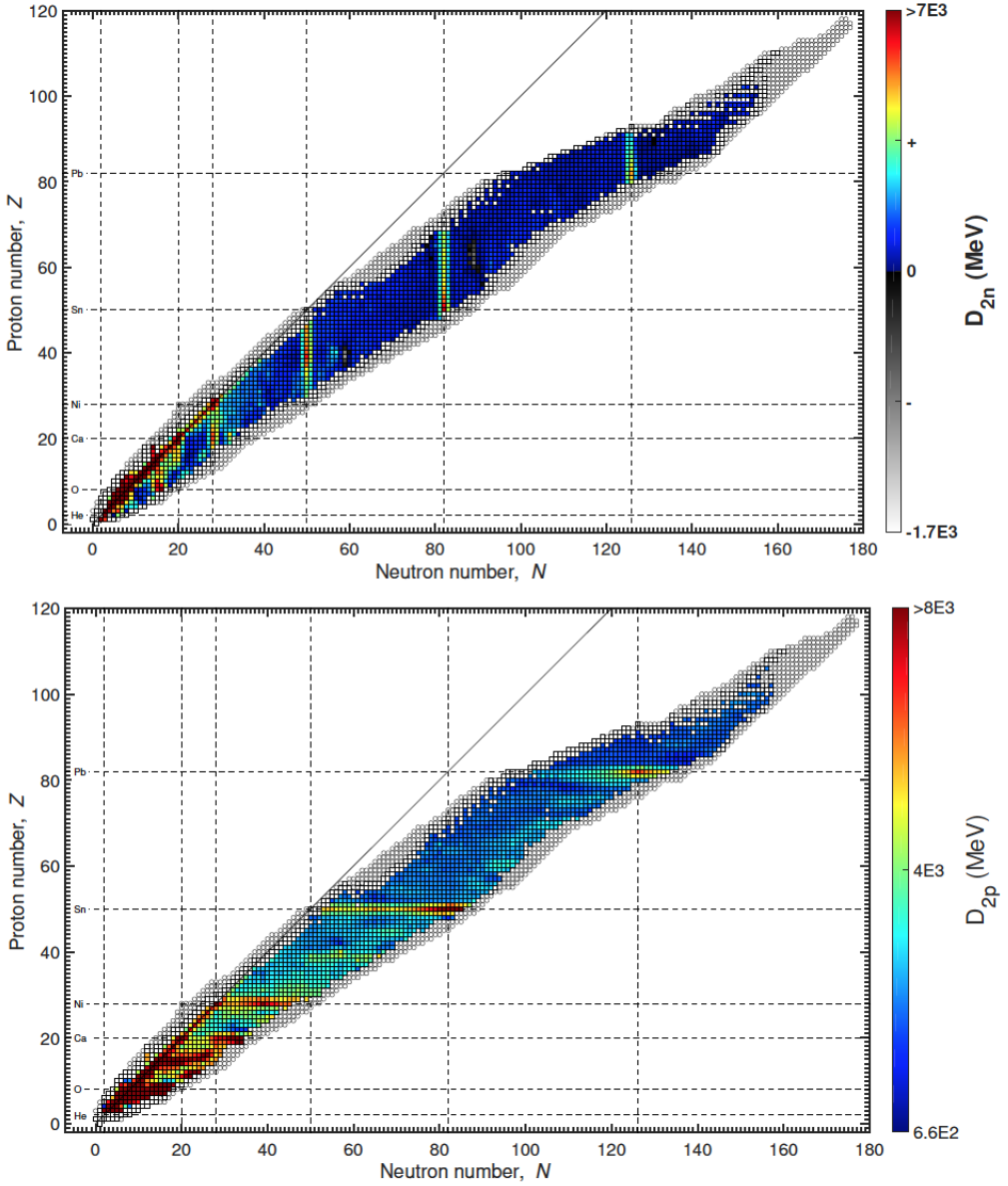
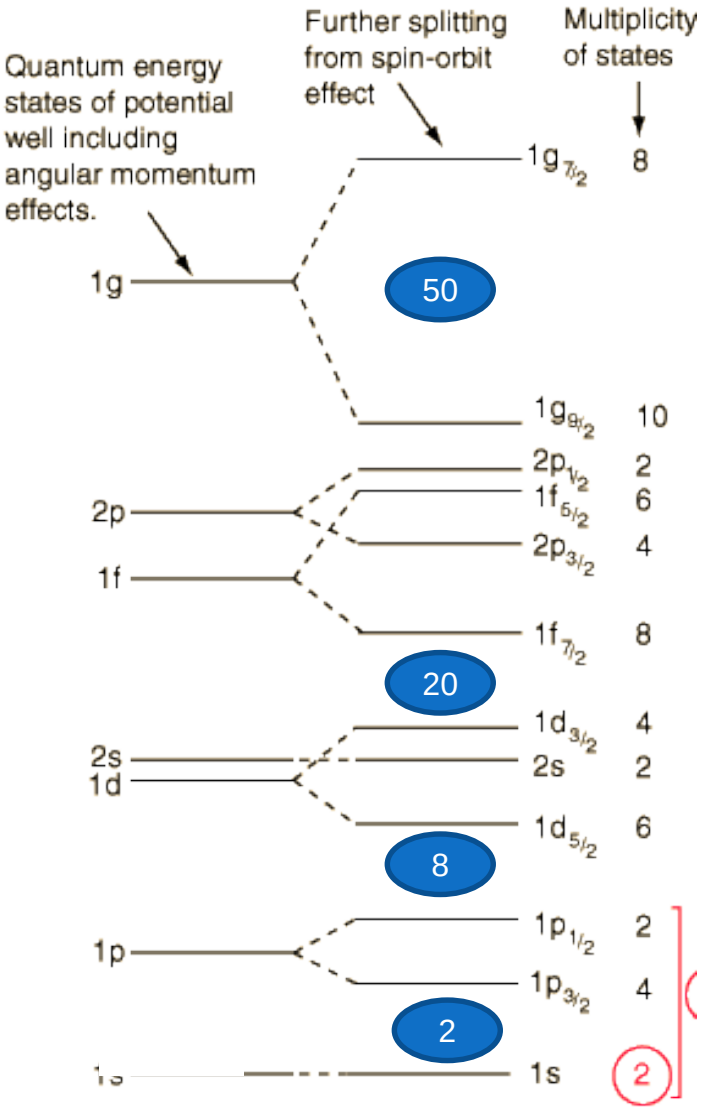


Figure 2.3: Chart of nuclides of two-neutron shell gap (top) and two-proton shell gap (bottom). Data as in Fig. 2.1

F. Wientholtz, PhD thesis, 2019, Greifswald university

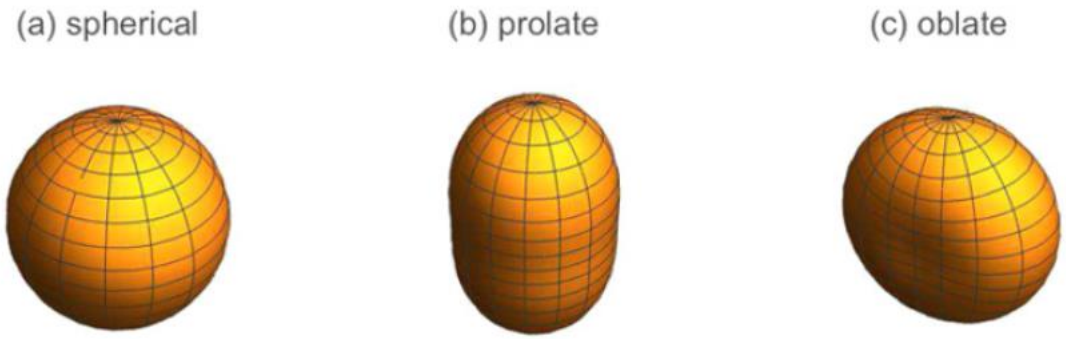
Question 1

- How are the values of the magic number obtained.



Question 2

What parameters give medium sized nuclei such as Mg, a quadrupole moment with all three axis different? What makes this distinction?



Near shell closures: spherical
Most common: axially symmetric deformation (prolate, oblate)

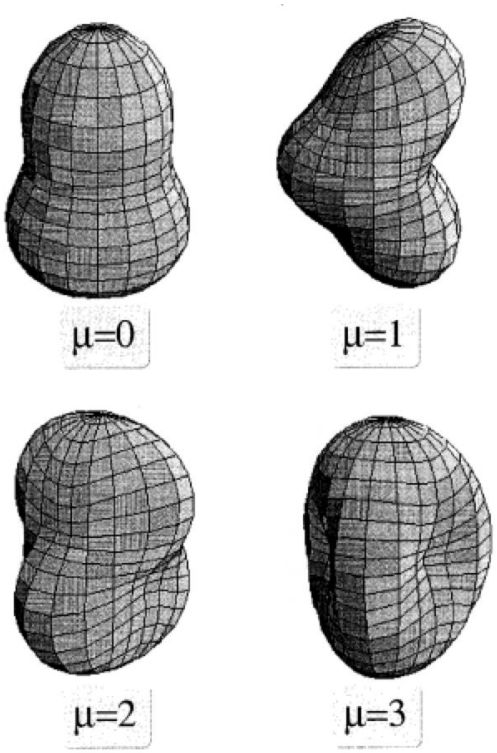
Quadrupole moment: measure for non-sphericity of a nucleus

$$\hat{Q} = \sum_{i}^{A} e_i (3z_i^2 - r_i^2)$$

Question 2

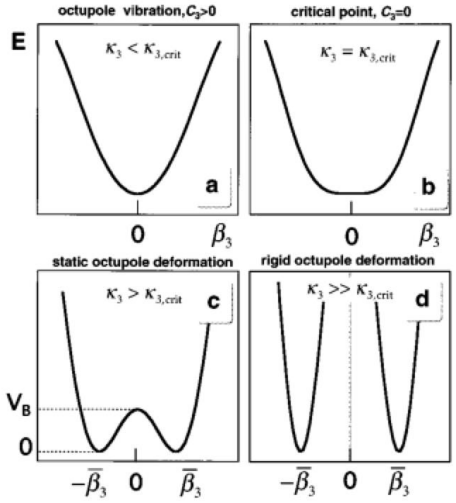
What parameters give medium sized nuclei such as Mg, a quadrupole moment with all three axis different? What makes this distinction?

Some nuclei: reflection symmetry is lost!
Octupole deformation ("Pear shaped")



Intrinsic reflection asymmetry in atomic nuclei

P. A. Butler and W. Nazarewicz
Rev. Mod. Phys. **68**, 349 – Published 1 April 1996



Direct measurement of the intrinsic electric dipole moment in pear-shaped thorium-228

M. M. R. Chishti, D. O'Donnell, G. Battaglia, M. Bowry, D. A. Jaroszynski, B. S. Nara Singh, M. Scheck, P. Spagnoletti & J. F. Smith

Nature Physics (2020) | Cite this article

Article | Open Access | Published: 06 June 2019

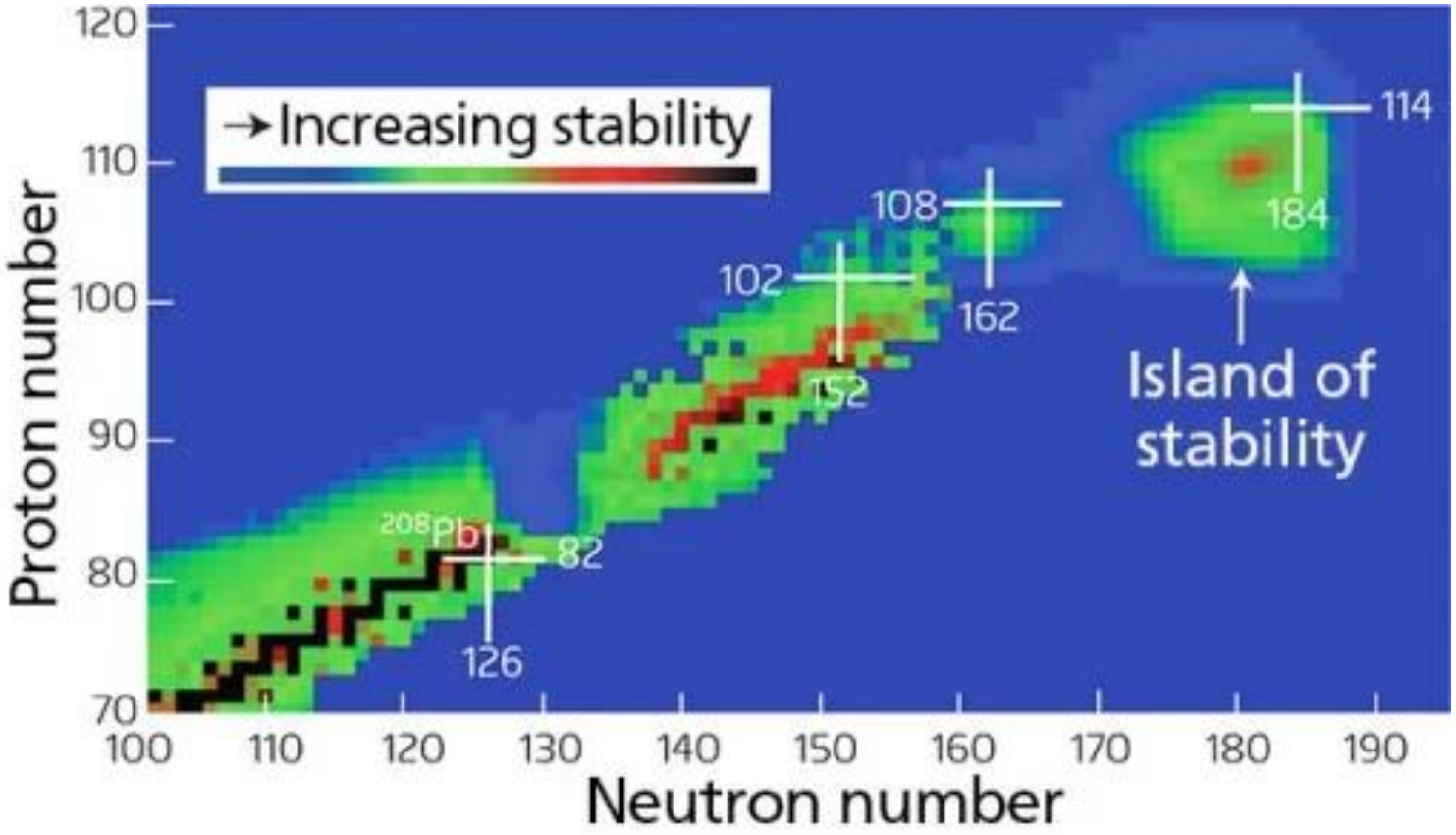
The observation of vibrating pear-shapes in radon nuclei

P. A. Butler, L. P. Gaffney, [...] M. Zielinska

Nature Communications **10**, Article number: 2473 (2019) | Cite this article

Question 3

Has the predicted island of stability been found?
If the island of stability exists, would the relatively stable heavy nuclei have any readily apparent applications?

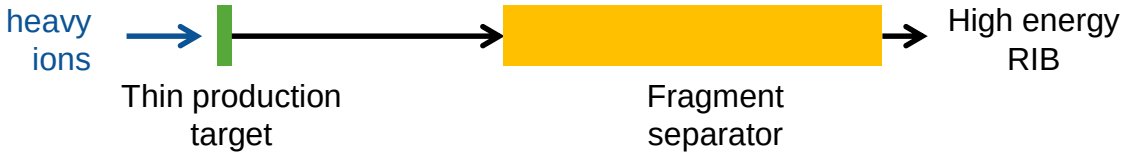


A beachhead on the island of stability
https://physicstoday.scitation.org/doi/full/10.1063/PT.3.2880

Question 3

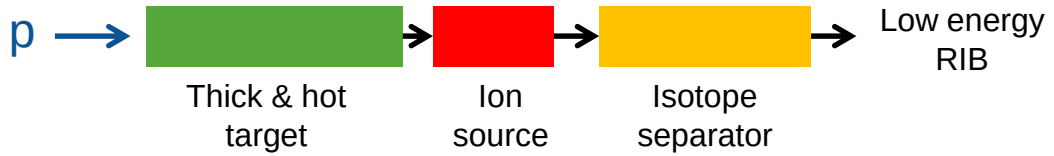
Has the predicted island of stability been found?
If the island of stability exists, would the relatively stable heavy nuclei have any readily apparent applications?

In-flight



- Chemistry independent
- Fast
- Poor beam quality
- Discovery of new isotopes

ISOL



- Chemistry dependent
- Slow release from target
- Good beam quality

Question 4

how can we harness nuclear fussion energy in a controlled form ?"

https://www.iter.org/sci/whatisfusion