Reaction mechanism and spectroscopy of superheavy nuclei

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Summary

Superheavy nuclei

Nuclei synthesis

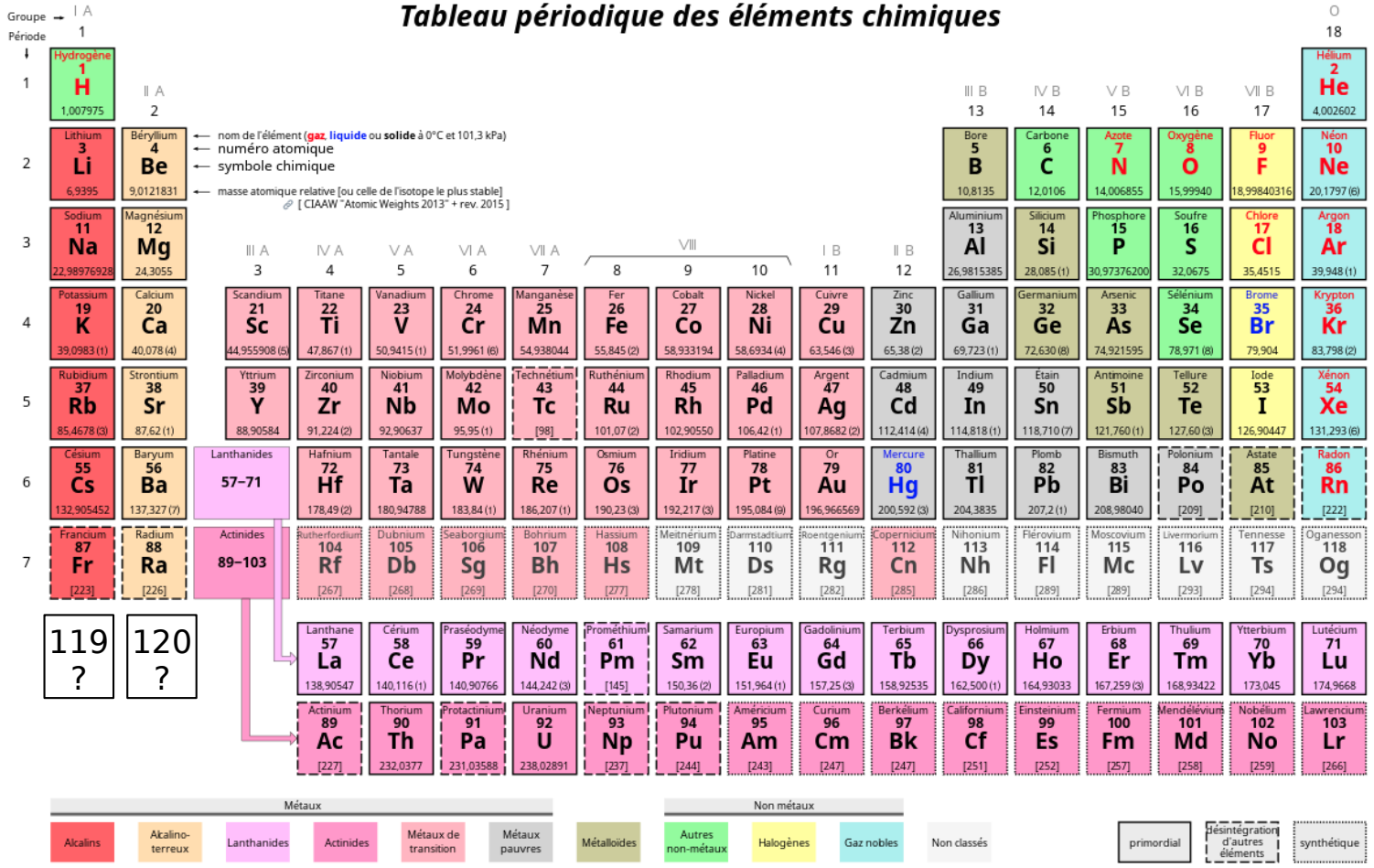
Fusion evaporation

Detection system

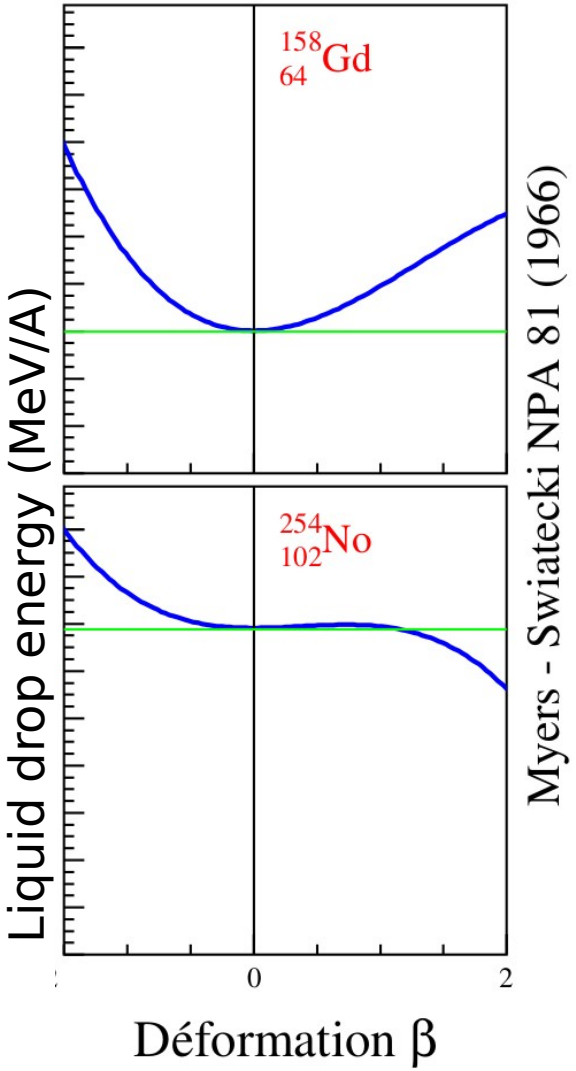
Gamma spectroscopy

Alpha spectroscopy

Superheavy nuclei



Wikipedia : Periodic table (28/11/2016)



Nuclei synthesis

Neutron capture

U238 basis, and β- decay

Limited to Fermium (Z=100) who doesn't decay by β-

Fusion evaporation

Total fusion by collision above Bass barrier

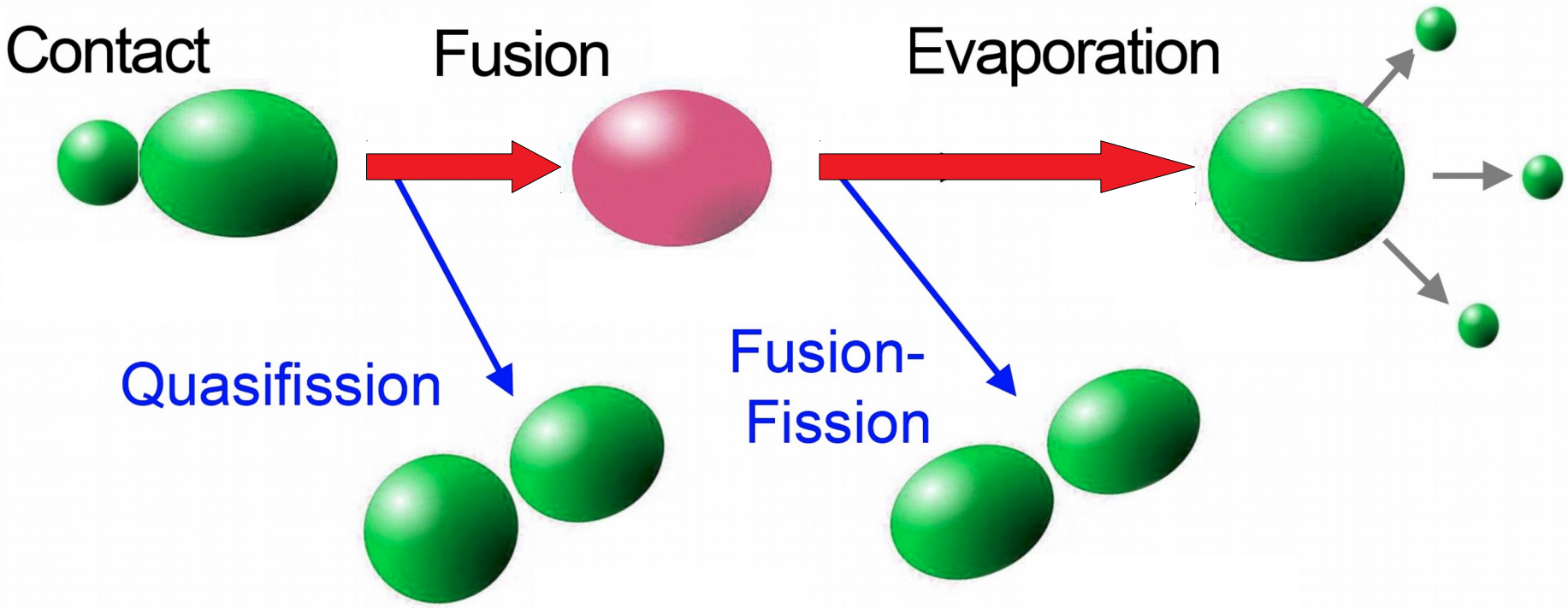
Multinucleon transfert

Collision below Bass barrier

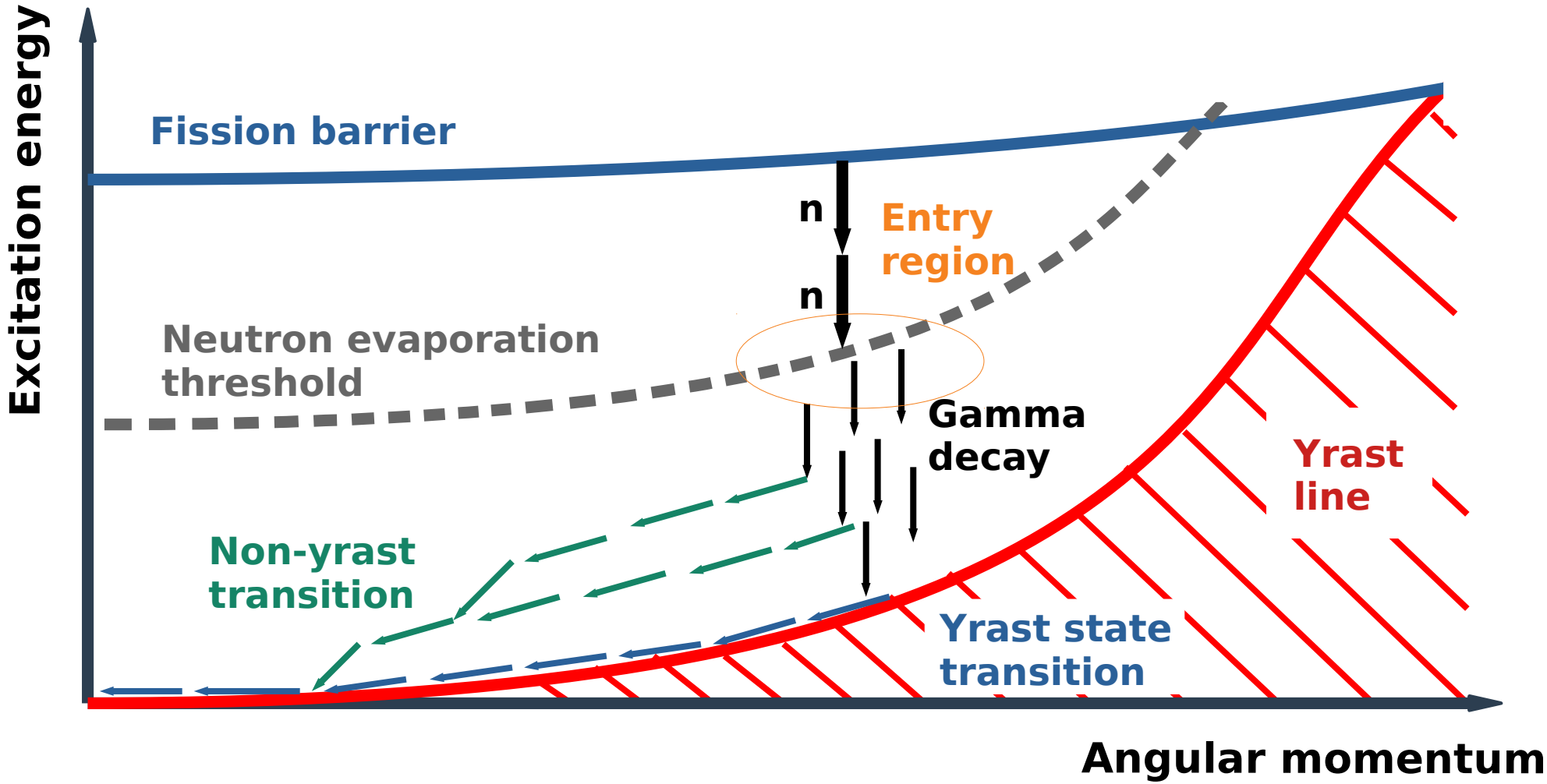
Low cross section, dificulty to separate reaction products

Fusion evaporation

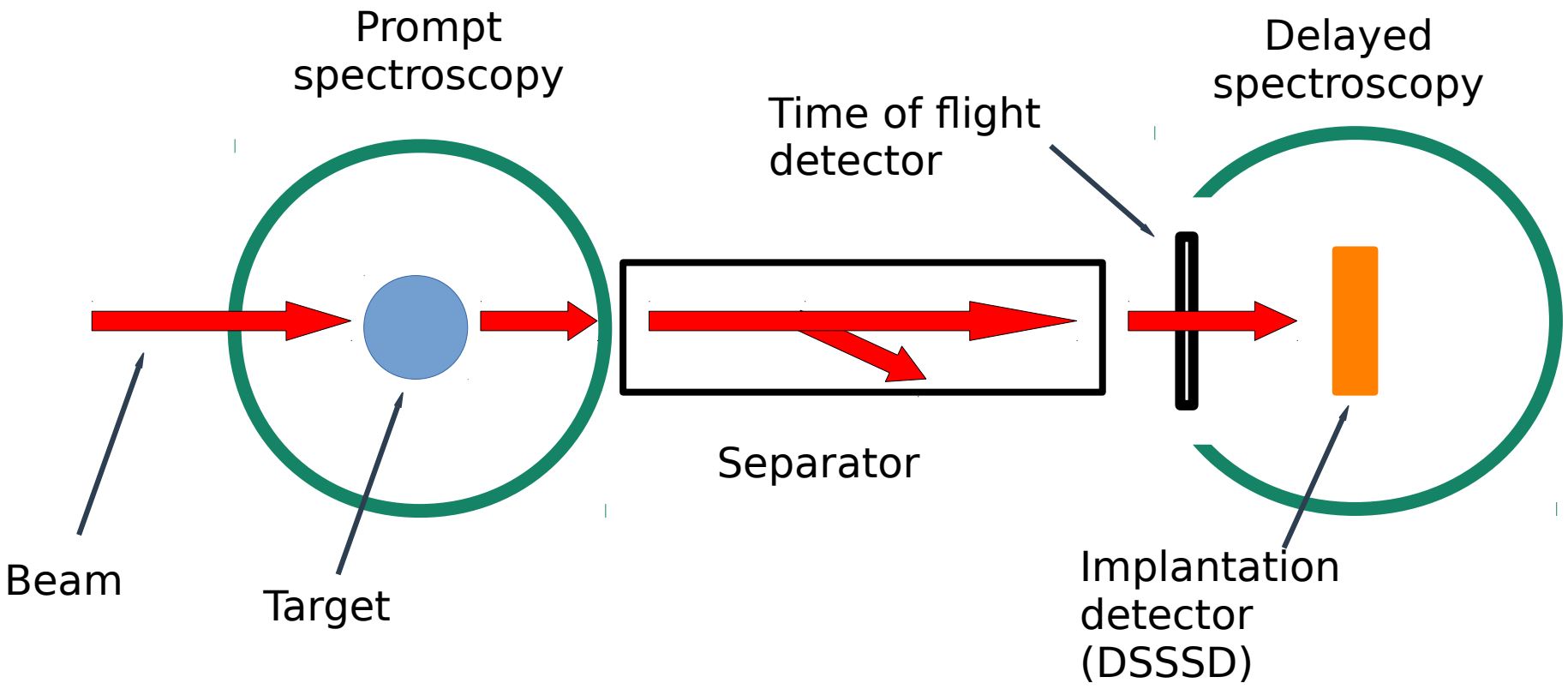
$$^{48}_{20}Ca + ^{249}_{98}Cf \rightarrow ^{297}_{118}Og^{*} \rightarrow ^{294}_{118}Og + 3\,^{1}_{0}n$$



Fusion evaporation



Detection system



Gamma spectroscopy

$$R = \frac{E(4^+)}{E(2^+)}$$

R ~ 1 : closed shell nucleus

Nuclear pairing lowing 0+ state and bring the others

R = 2 : purely vibrational nucleus

The nuclei oscillate between different forms

R = 10/3 : purely rotationnal even-even nucleus

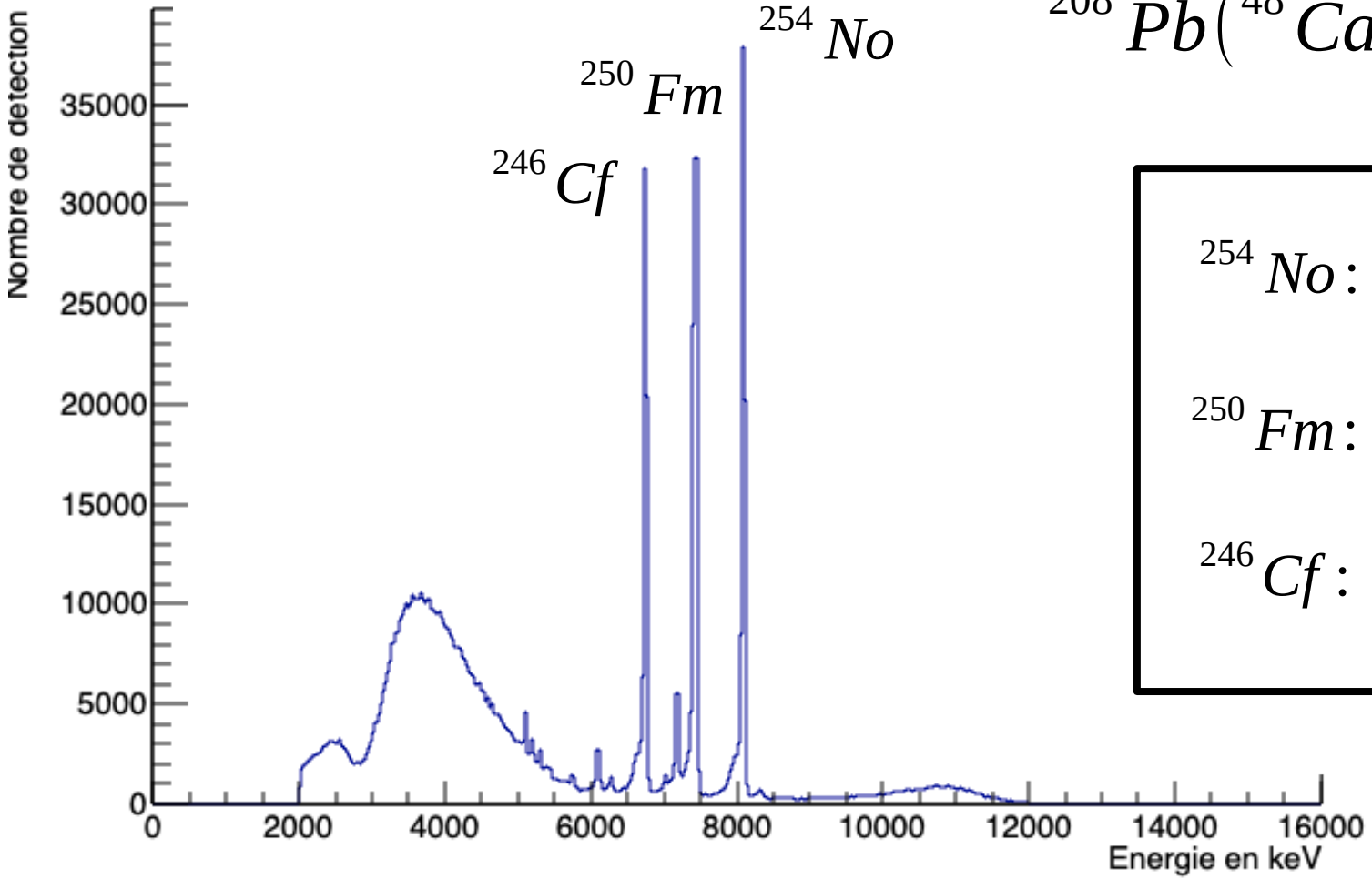
$$E_{rot} = \frac{\hbar^2}{2\zeta}(j(j+1))$$

j : azimuthal quantum number

ζ : inertial momentum

Ref : Noyaux et particules, modèles et symétries (Luc Valentin)

Alpha spectroscopy



$$^{208}Pb(^{48}Ca,2n)^{254}No$$

^{254}No :	T = 51s E ~ 8091 keV
^{250}Fm :	T = 30 min E = 7435 keV
^{246}Cf :	T = 35,7h E = 6750 keV

Conclusion

Find island of stability

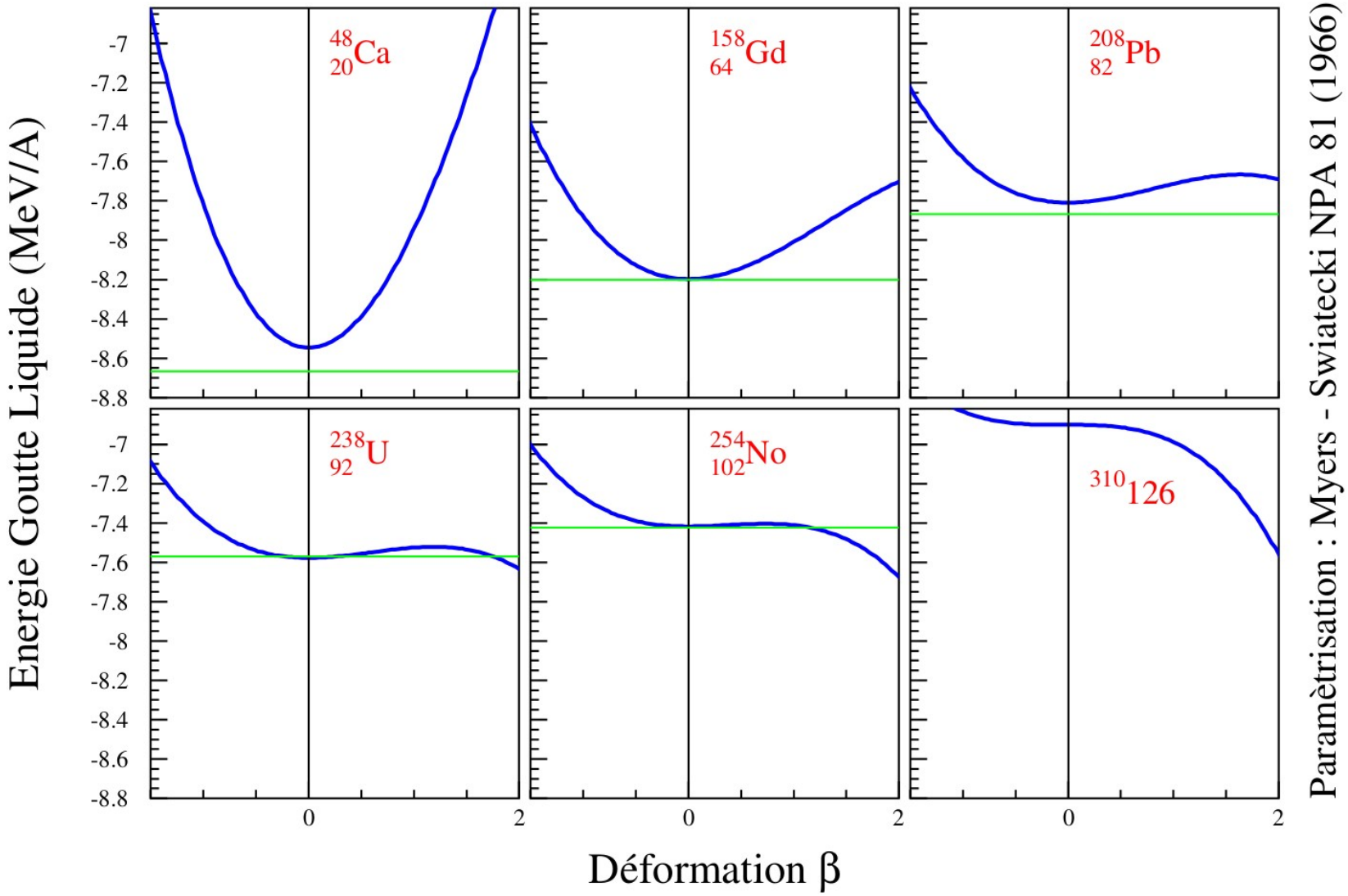
Study the nuclear structure

Constrain the models

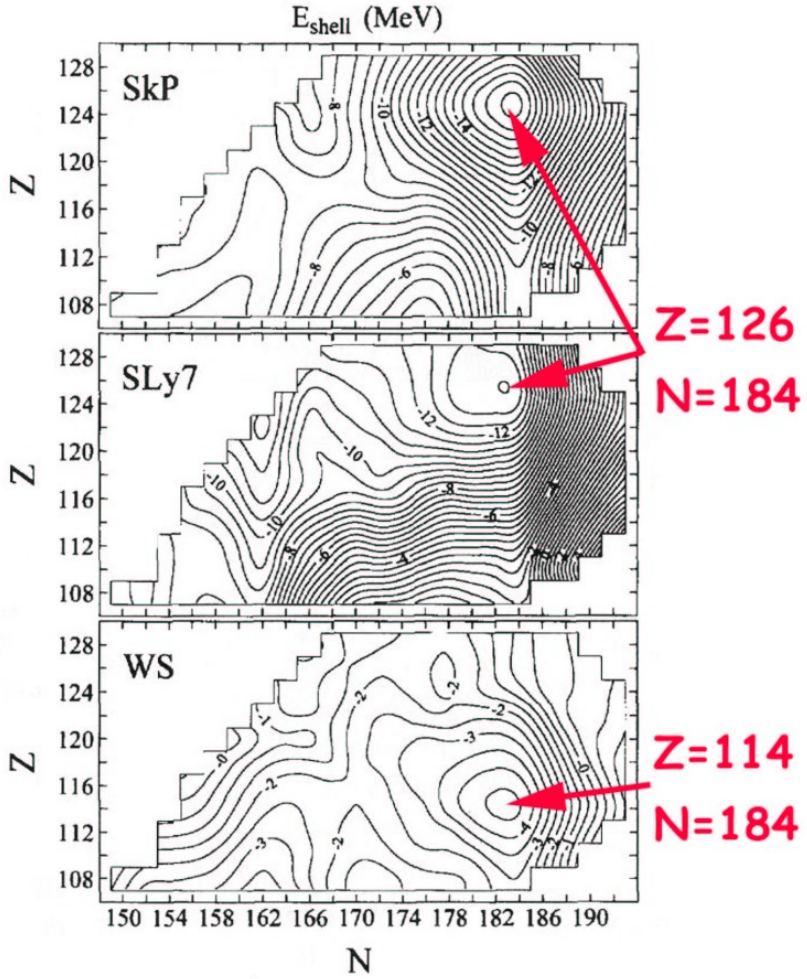
Study of strong interaction

Chemical property

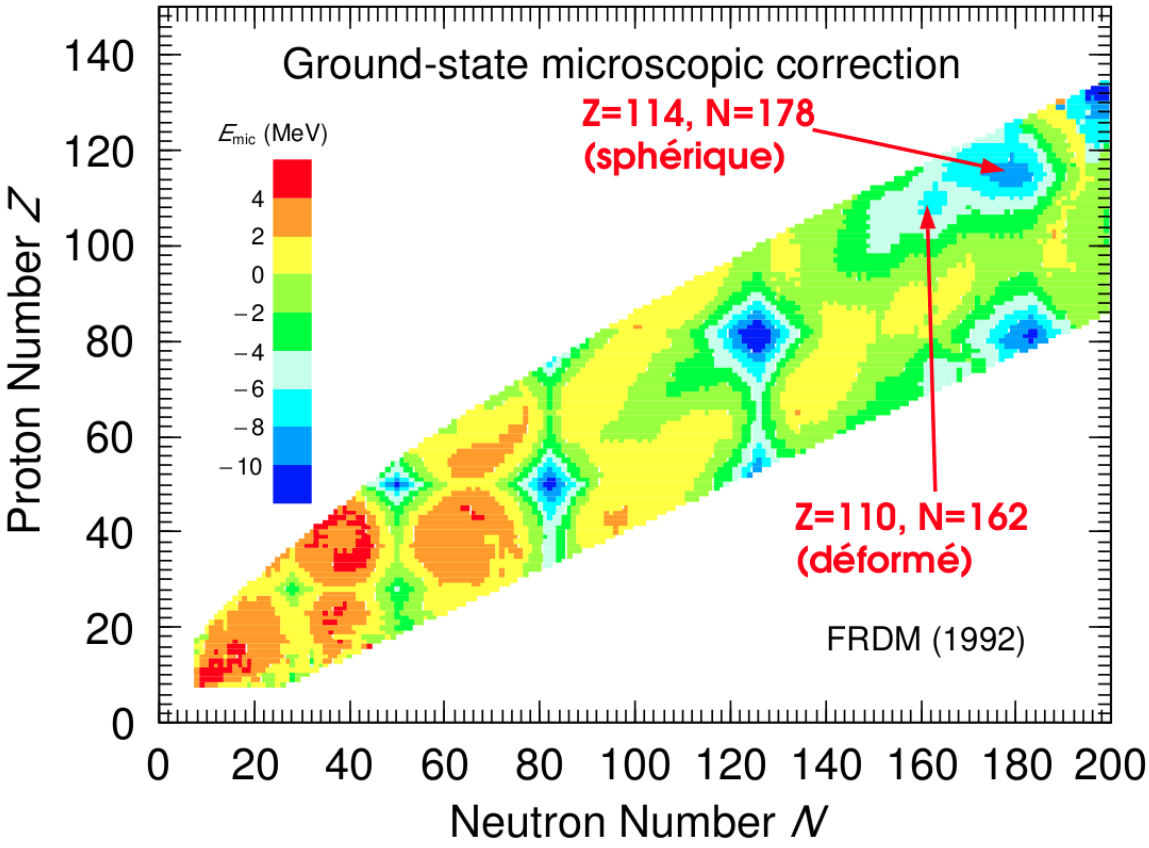
Liquid drop model



Island of stability



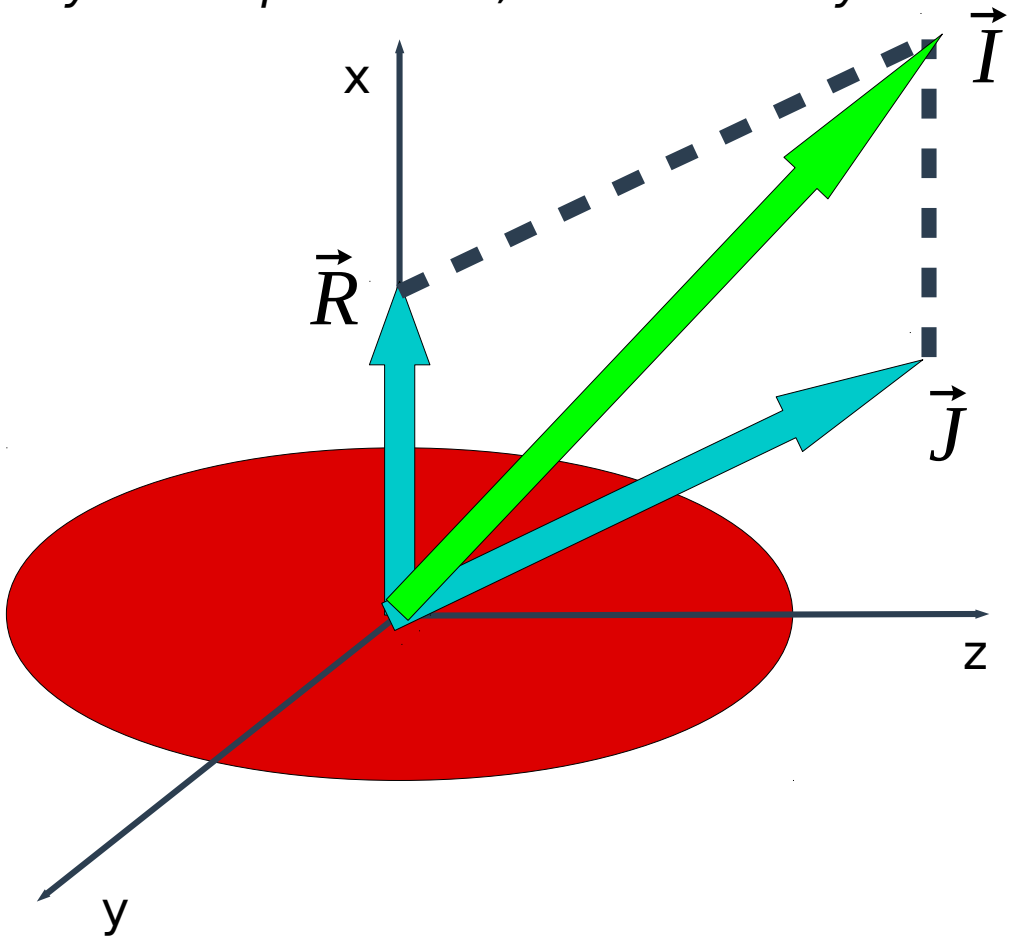
S. Cwiok et al. Nucl. Phys. A611 (1996) 246.



P.Möller et al. At. Data. Nucl. Data Tables 59 (1995) 185.

Collective rotation

Ref : Noyaux et particules, modèles et symétries (Luc Valentin)



$\vec{R}$ Rotational angular momentum

$\vec{J}$ Individual angular momentum

$\vec{I}$ Total angular momentum

ζ Moment of inertia

$$K = \vec{I} \cdot \vec{z}$$

$$E_{rot} = \frac{\hbar^2}{2\zeta}\left(j\left(j+1\right)-K\right)+\frac{\hbar^2 K}{2\zeta_z}$$

Even-even nucleus $J^{\pi} = 0^{+} \Leftrightarrow K = 0$