



## Matière nucléaire fortement couplée

### Thème scientifique P3

E. Khan



Merci à M. Guidal, F. Kunne, J.-Ph. Lansberg,  
O. Pène, D. Verney, ...

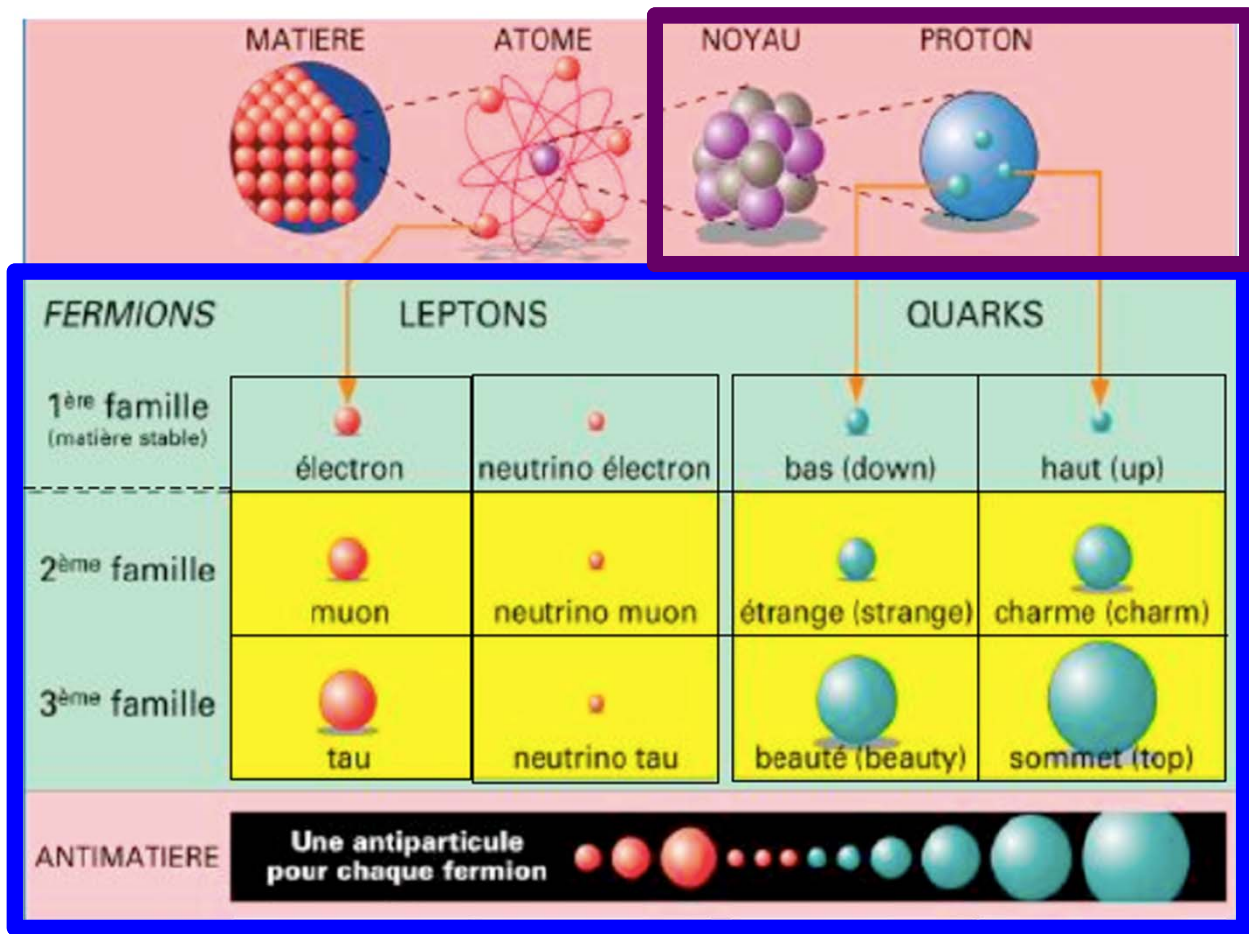
# **Matière nucléaire fortement couplée**

**Panorama**

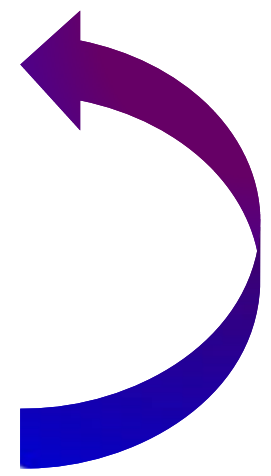
**Effectifs**

**Quelques projets**

# La structure primordiale de la matière

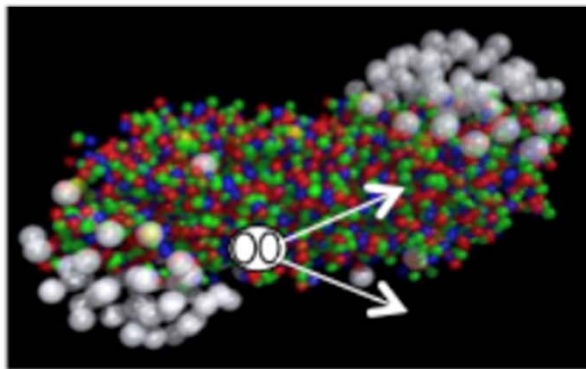
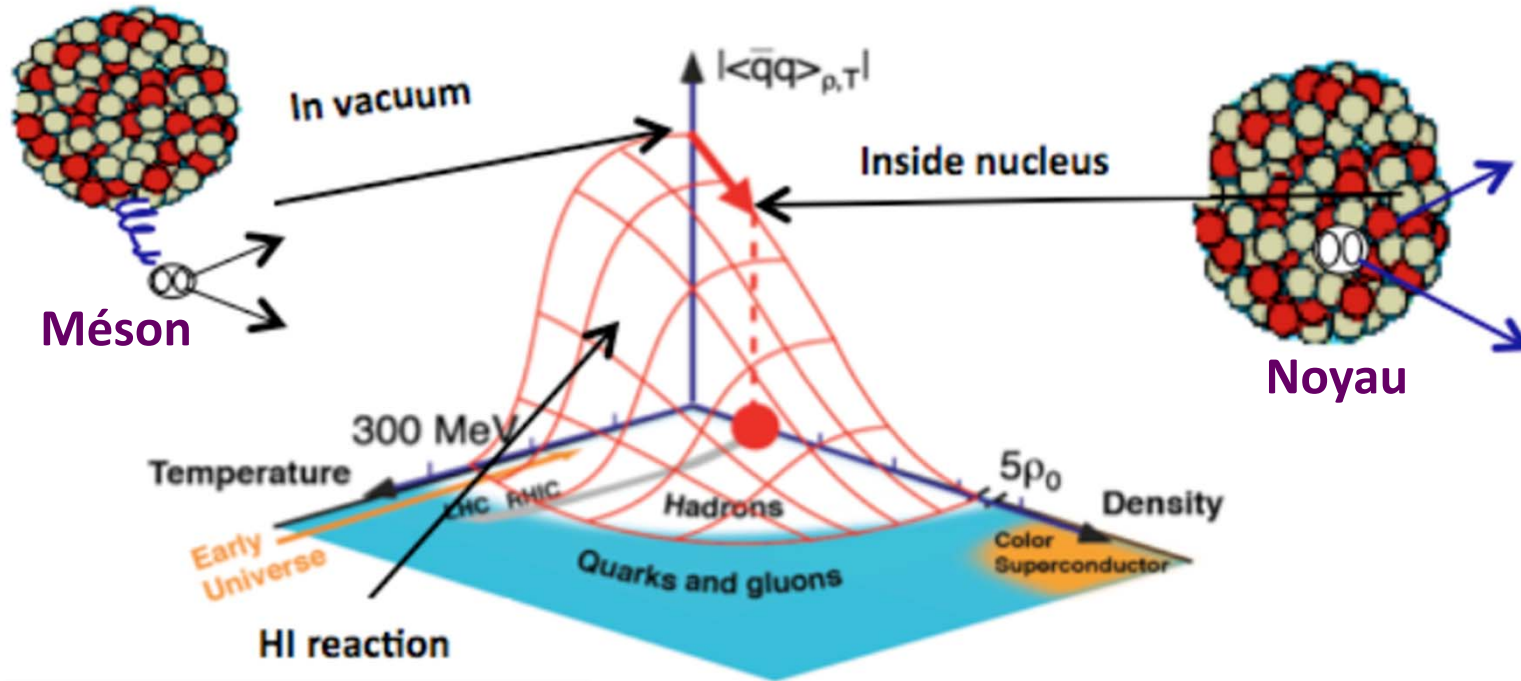


Complexe  
Elémentaire

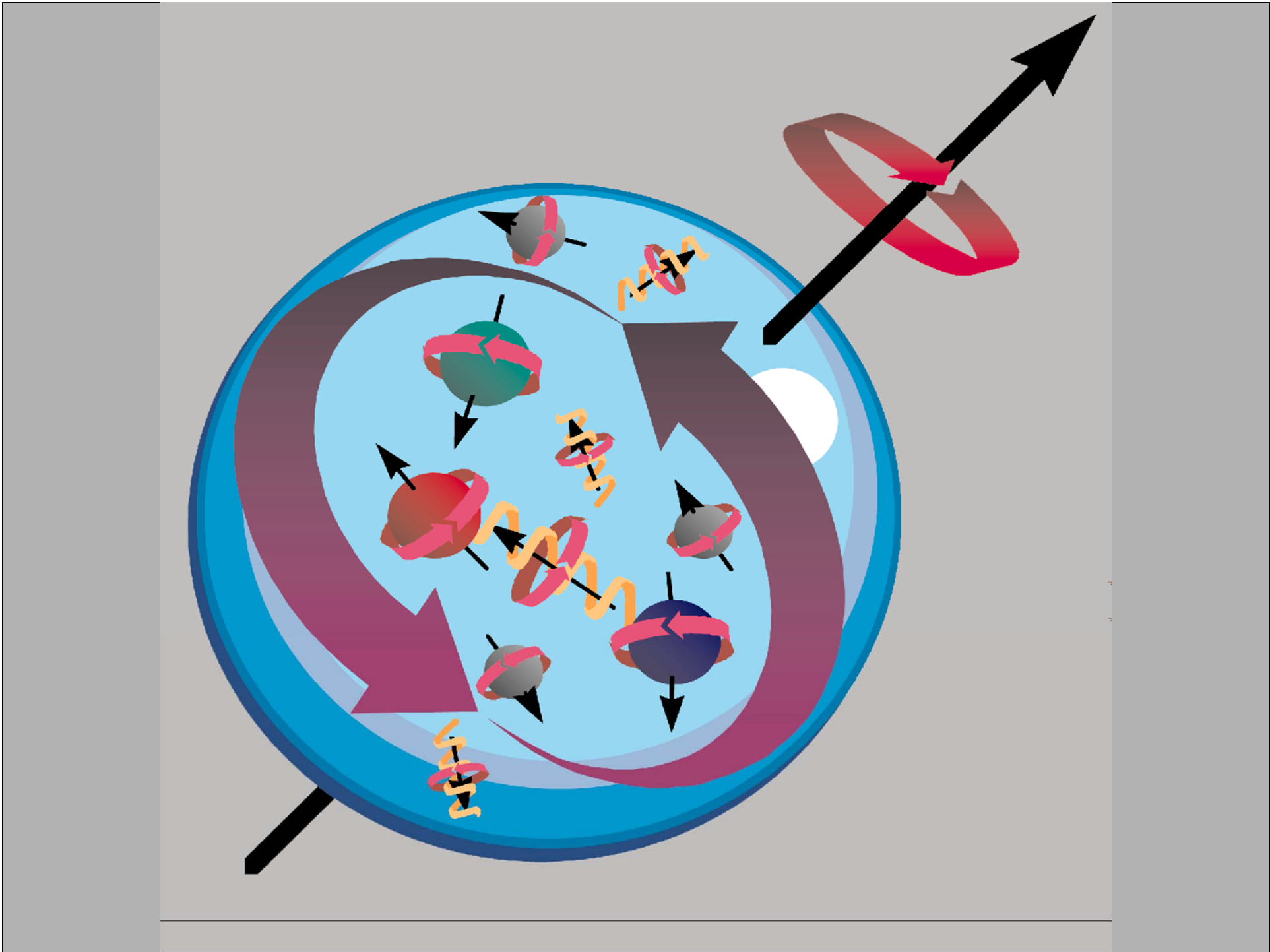


<b>FORCE</b>  Gauge Bosons Higgs Boson?	$Q/e = -1$	$Q/e = 0$	$Q/e = -1/3$	$Q/e = +2/3$
	faible, emgt		faible	
			faible, emgt et forte	

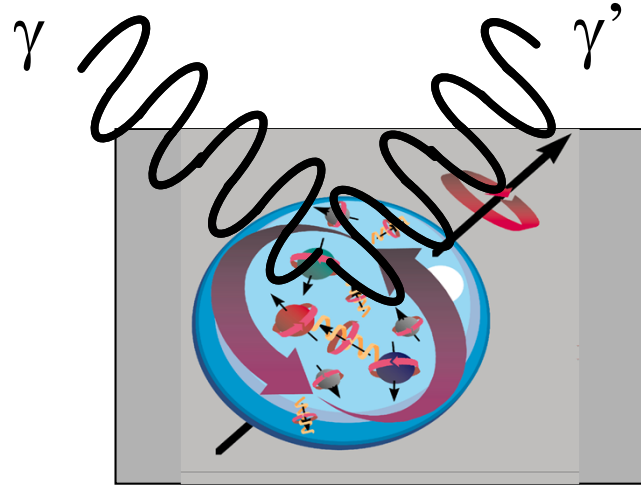
# La masse de la matière : 2% de Higgs et 98% de QCD



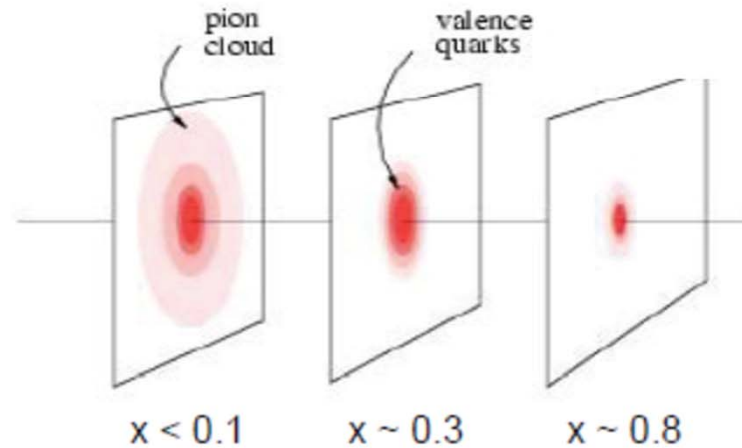
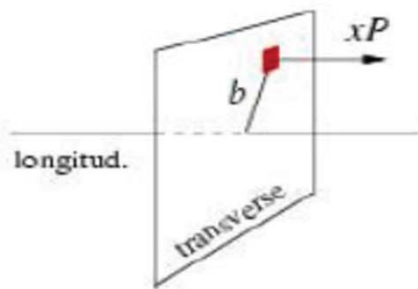
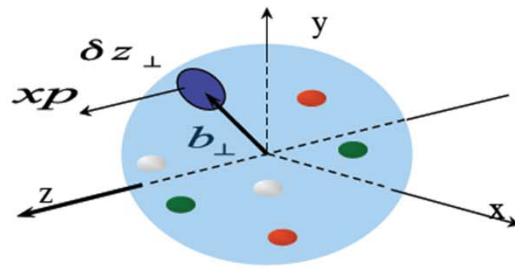
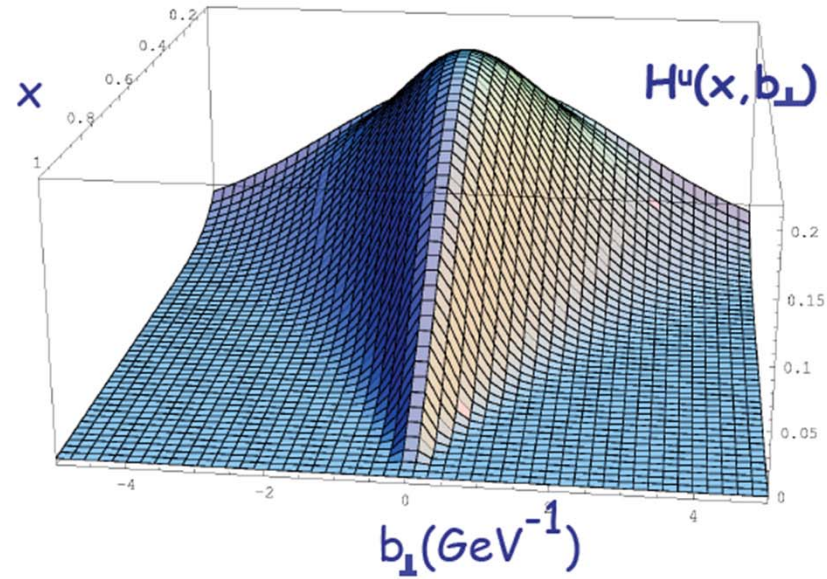
Matière nucléaire chaude et dense  
Plasma de quark et de gluons

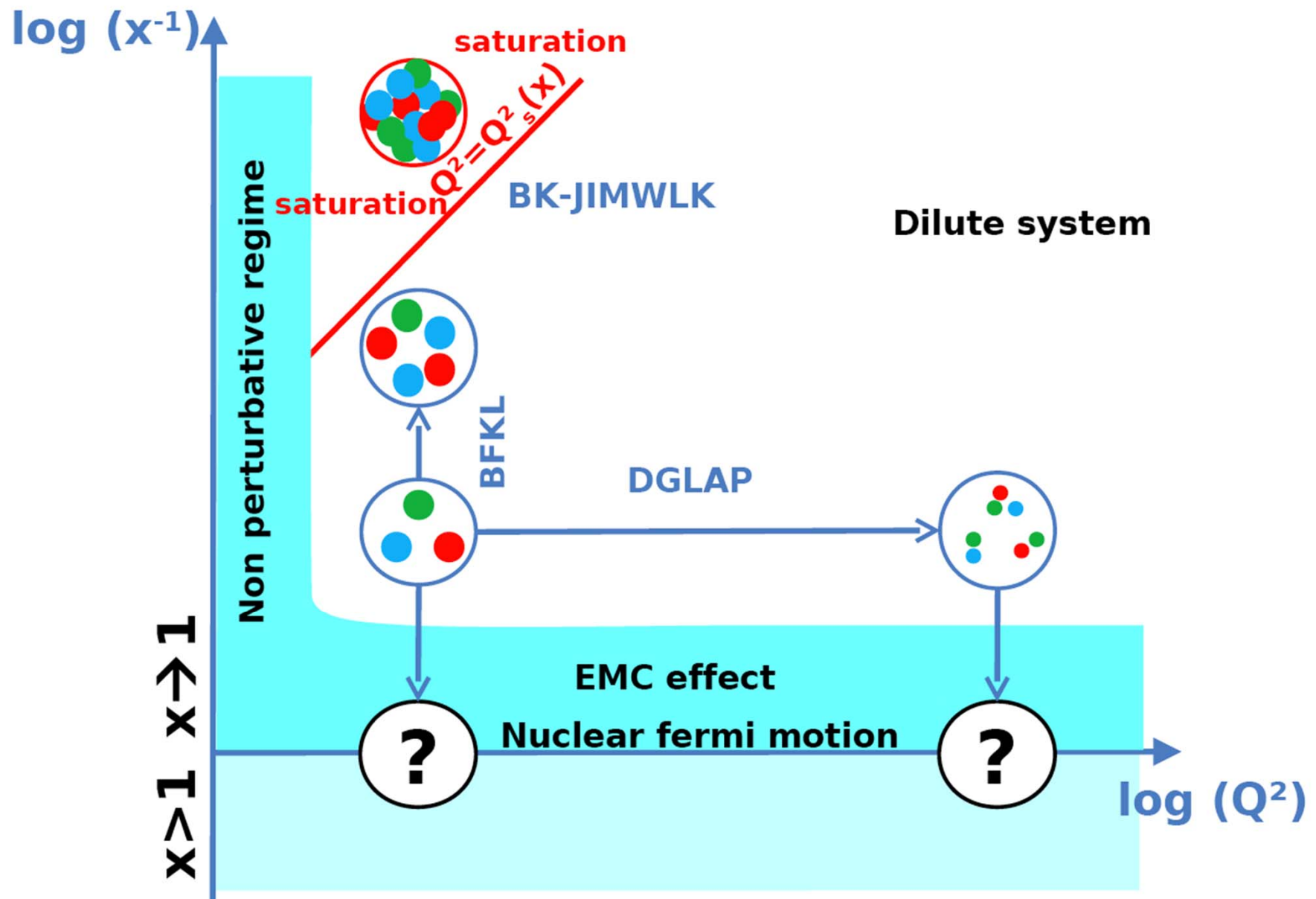


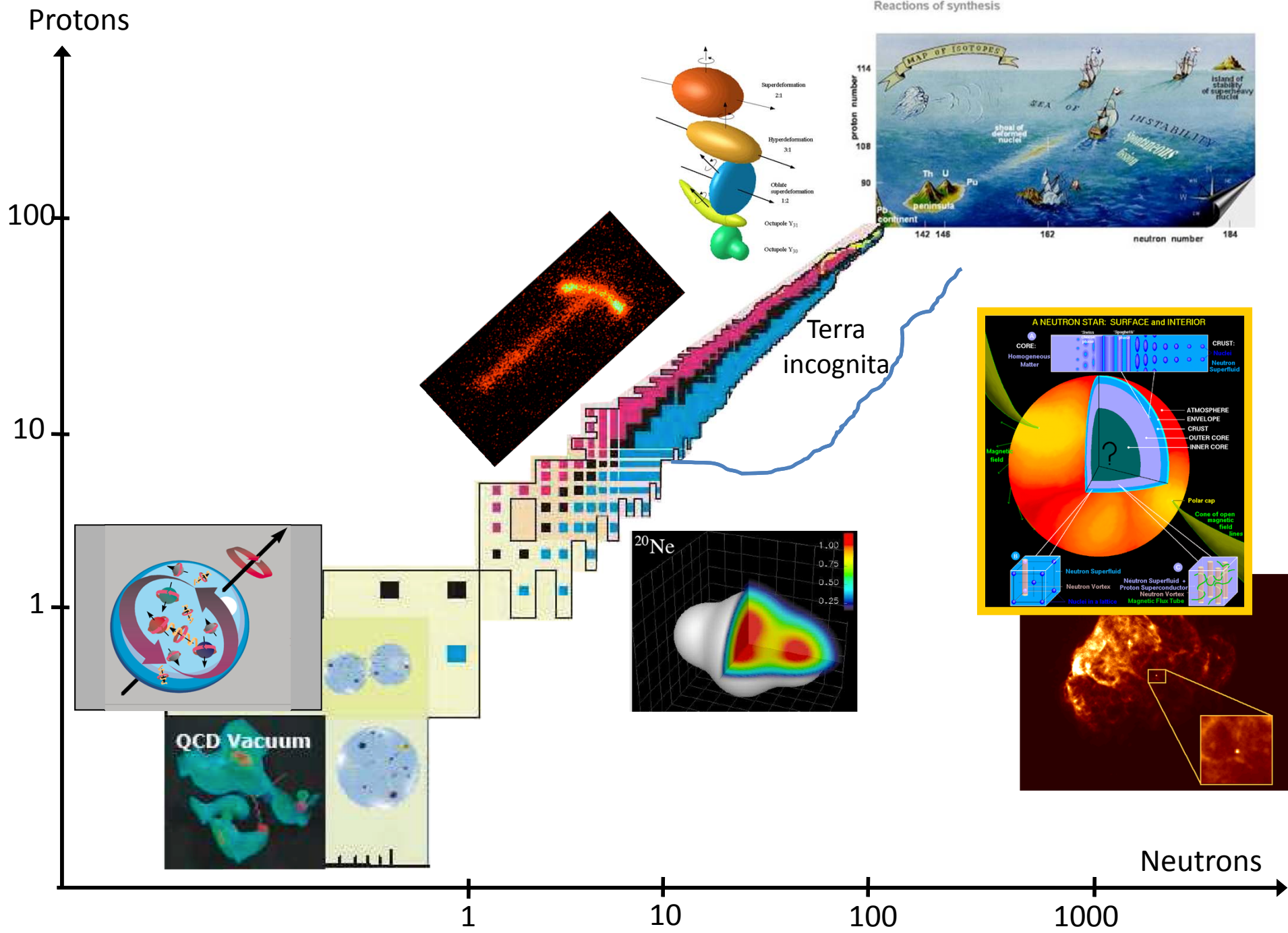
# Diffusion Compton à l'intérieur d'un proton



Generalised Parton Distributions



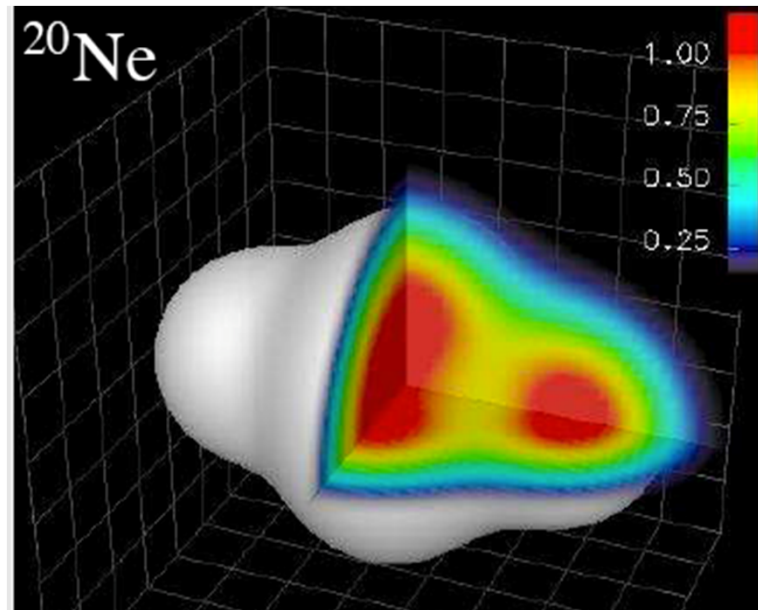




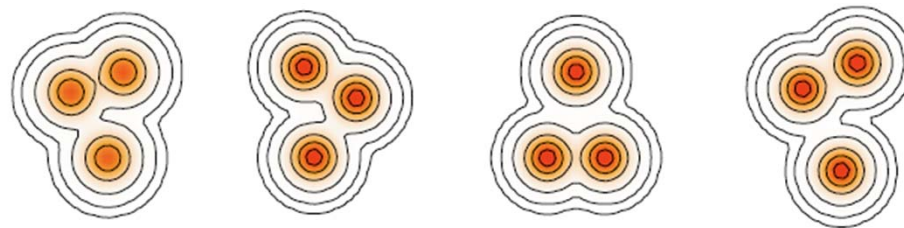


# Les noyaux légers

Molécules nucléaires



La synthèse du carbone

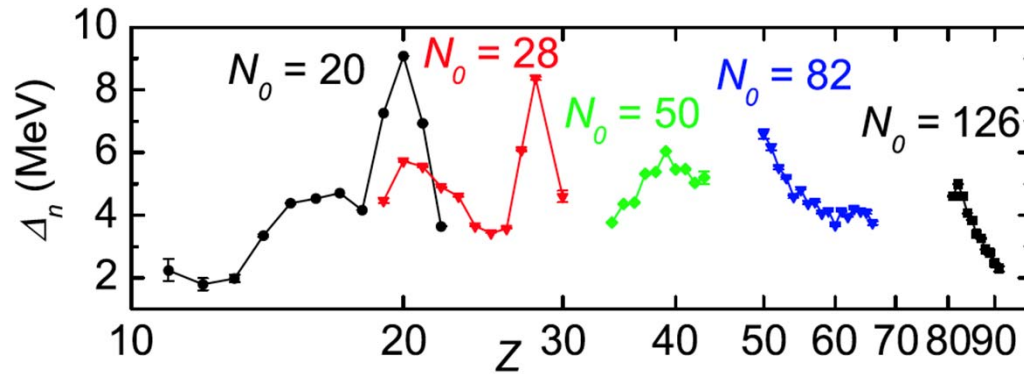


Condensation de bosons dans le noyau

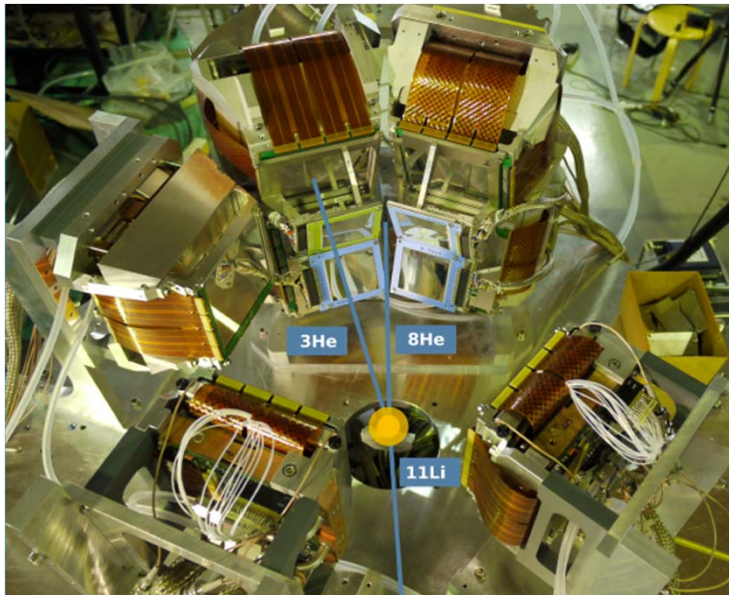
CSNSM, IPN, SPhN



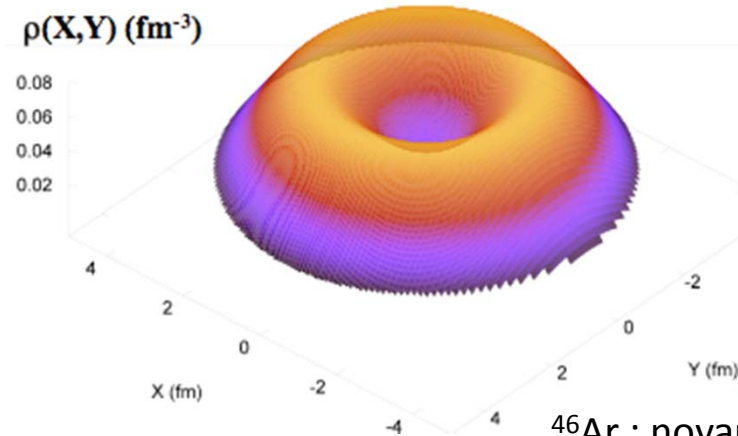
# Les états nucléaires exotiques



Evolution de la magicité par piègeage du  $^{132}\text{Sn}$  : tenseur, 3 corps



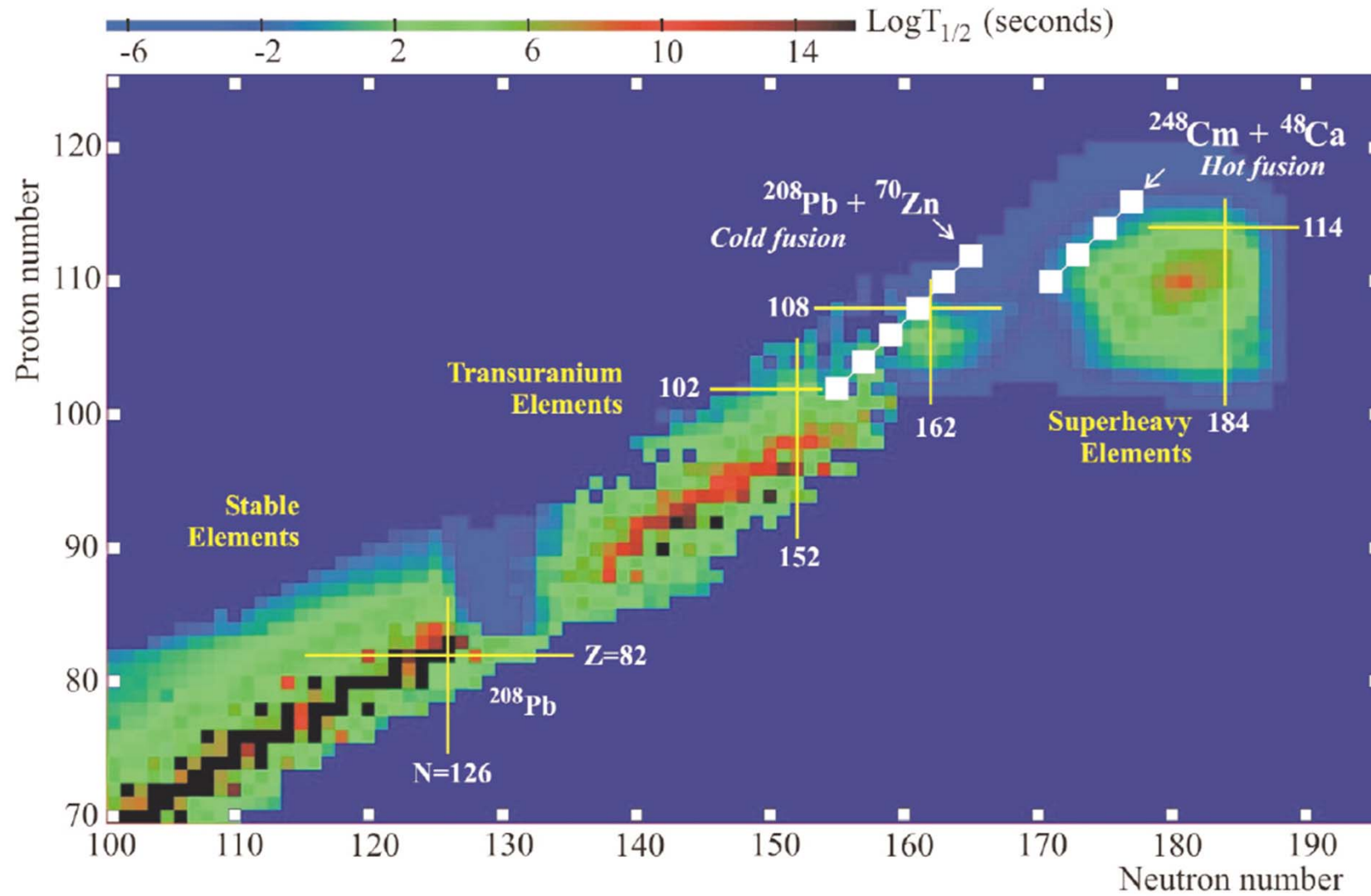
Etude du  $^{10}\text{He}$  à Riken (Japon)

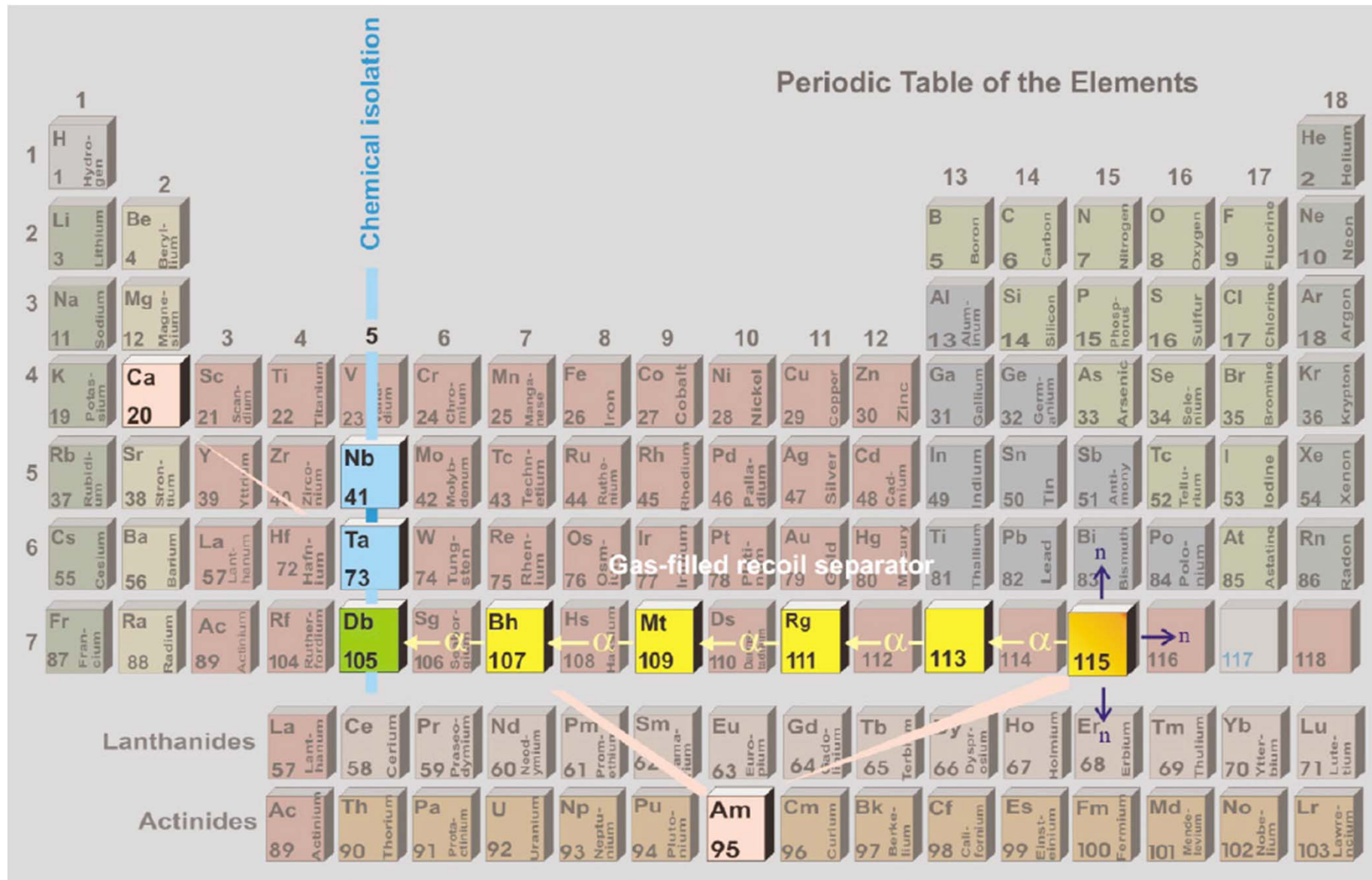


$^{46}\text{Ar}$  : noyau bulle ?



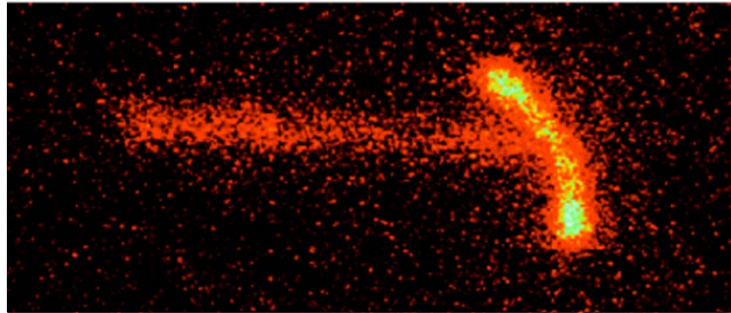
# Les nouveaux éléments





Crédits: Y. Oganessian

# Une dizaine de radioactivités



Radioactivité 2 protons  
du  $^{45}\text{Fe}$

Interaction	Nom de la radioactivité (date de découverte)	Particule(s) émise(s) par le noyau
Electromagnétique	$\gamma$ (1900)	photon
	Electron de conversion (1938)	$e^-$
Faible	$\beta^-$ (1898)	$e^-, \bar{\nu}_e$
	$\beta^+$ (1933)	$e^+, \nu_e$
	Capture électronique (1937)	$\nu_e$
	Double $\beta$ (1980)	$2e^-, 2\bar{\nu}_e$
Forte (+ELM)	$\alpha$ (1896)	${}^4_2\text{He}$
	n, p (1982), 2p (2000)	n ou p ou 2p
	Clusters (1984)	${}^{14}\text{C}$ ou ${}^{24}\text{Ne}$ ou ${}^{32}\text{Si}$ , ...
	Fission (1939)	n, noyau lourd ( ${}^{90}\text{Zr}$ , ${}^{132}\text{Sn}$ , ...)

# Astronoyaux

## Nucleosynthesis in the r-process

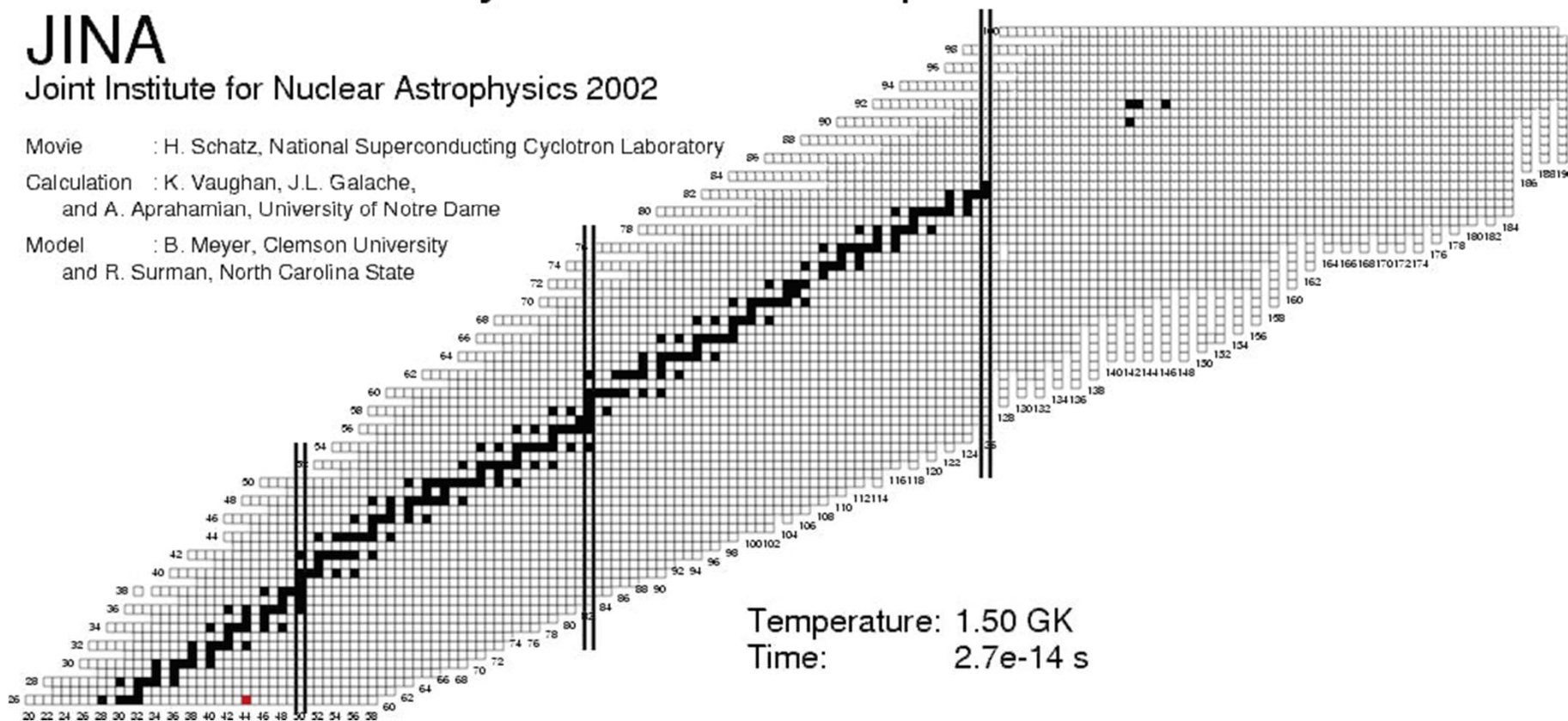
JINA

Joint Institute for Nuclear Astrophysics 2002

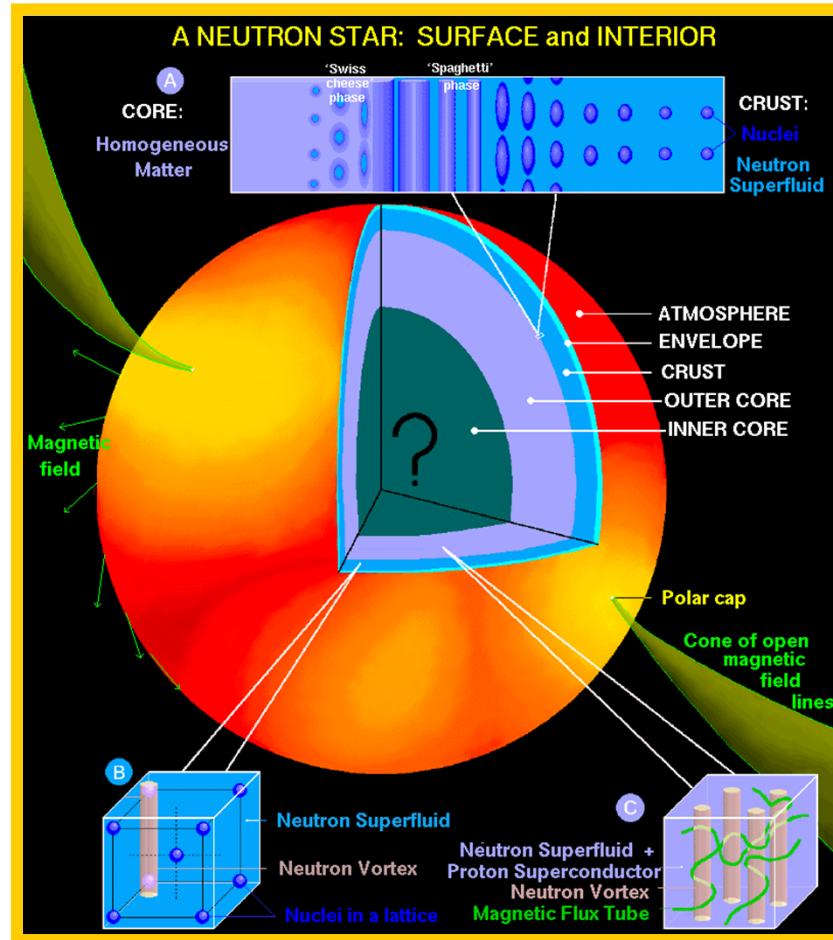
Movie : H. Schatz, National Superconducting Cyclotron Laboratory

Calculation : K. Vaughan, J.L. Galache,  
and A. Aprahamian, University of Notre Dame

Model : B. Meyer, Clemson University  
and R. Surman, North Carolina State



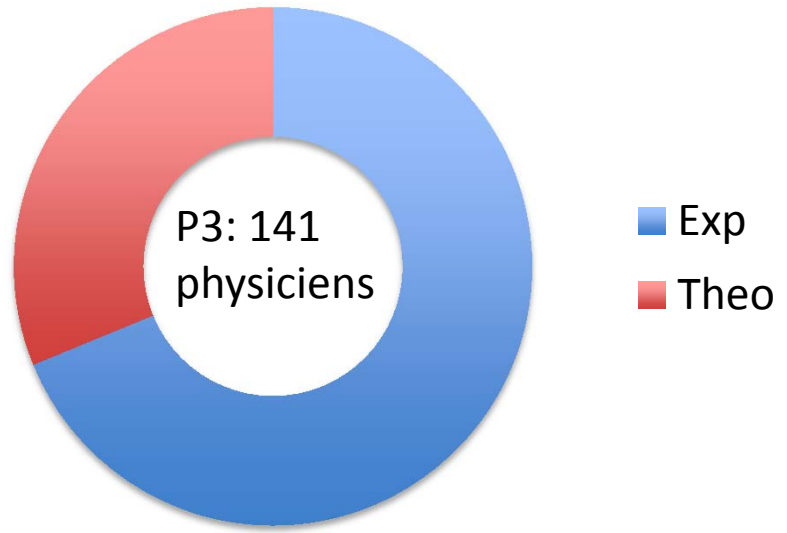
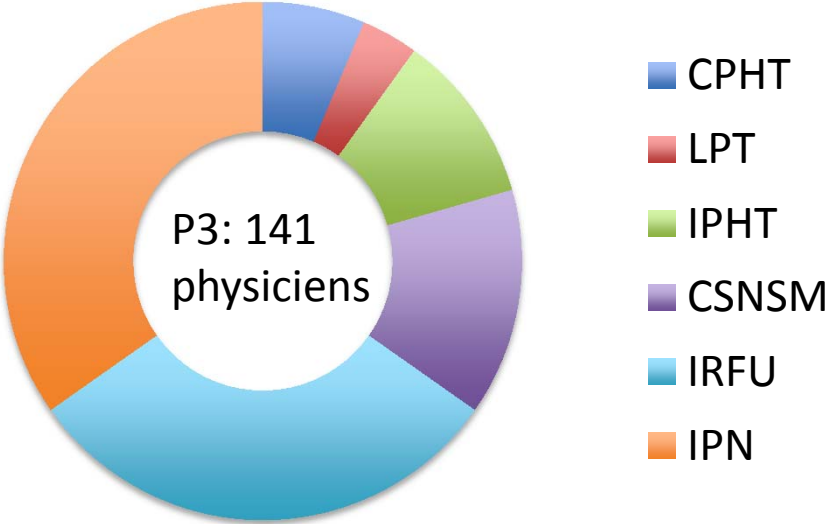
# Astronoyaux



Matière nucléaire riche en neutrons

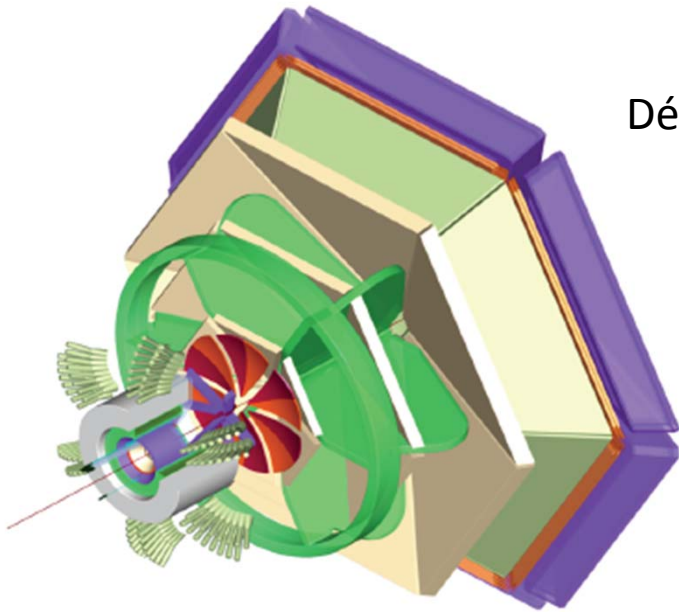
Composante nucléaire des rayons cosmiques

# Les effectifs P2IO



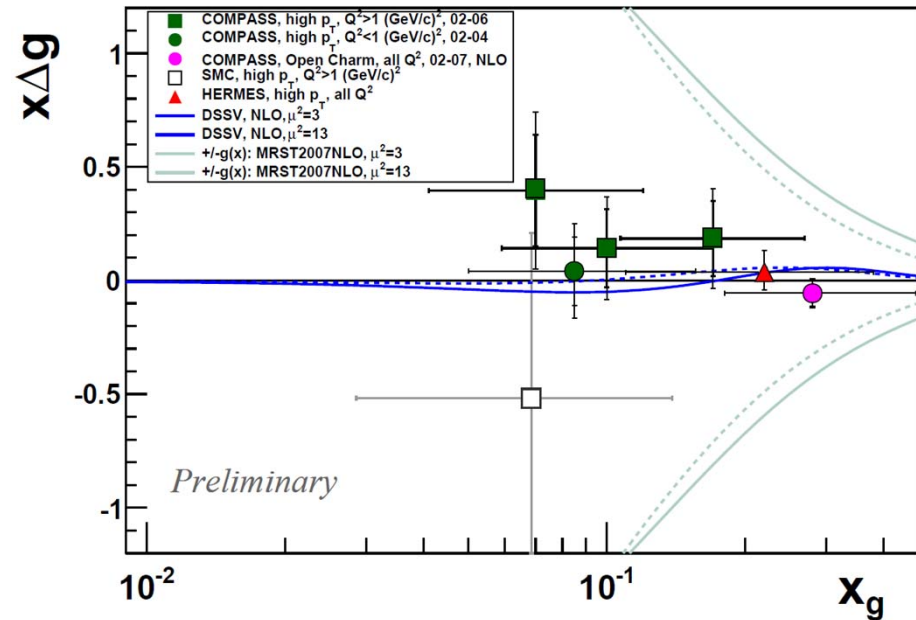


# Clas12 (GeV) au JLab

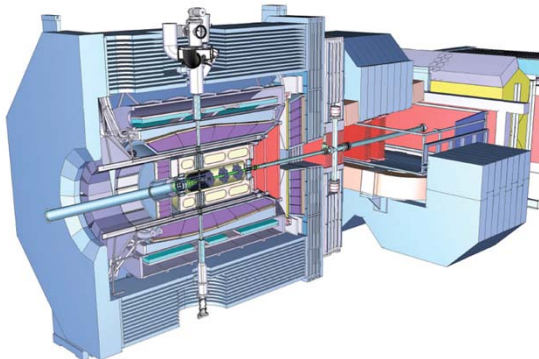


Détecteur central pour DVCS a 12 GeV (JLab)

# Compass (~100 GeV au CERN)



# Panda (~10 GeV au GSI)

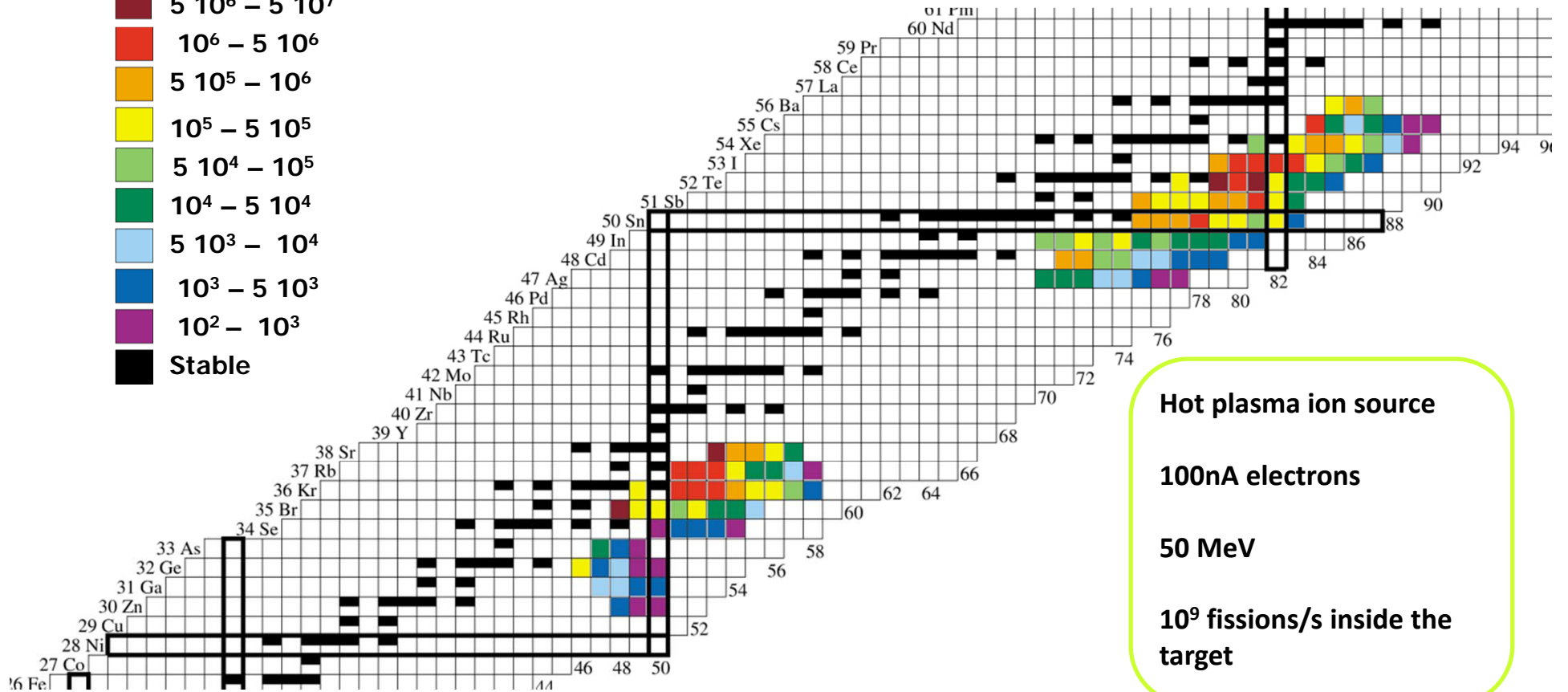
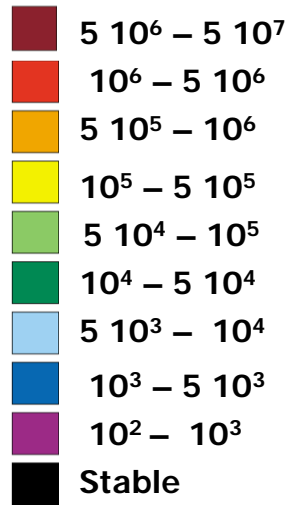


IPN, SPhN

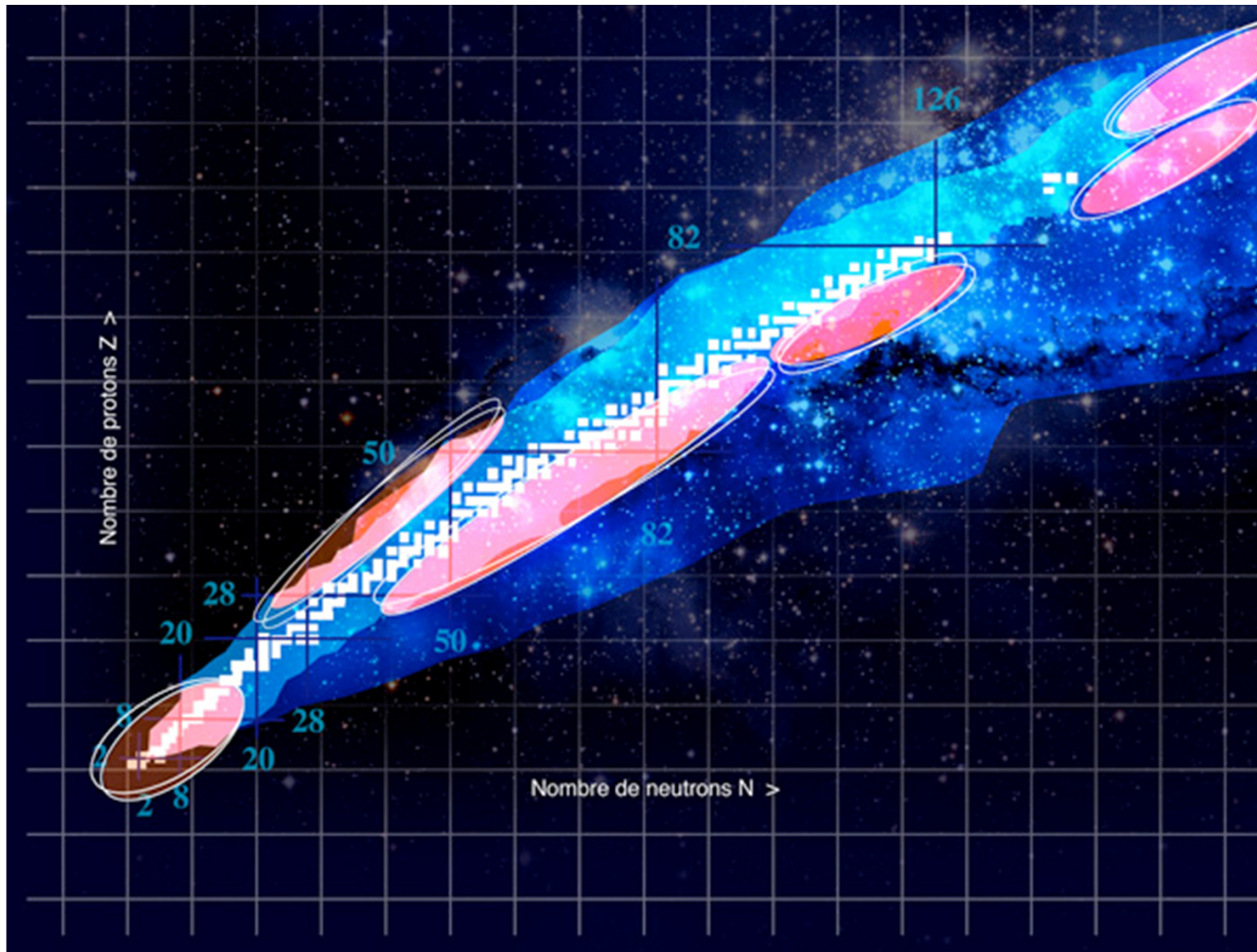
- Contribution des gluons de la soupe au spin du nucléon
- 2014: DVCS et plus

# ALTO à Orsay

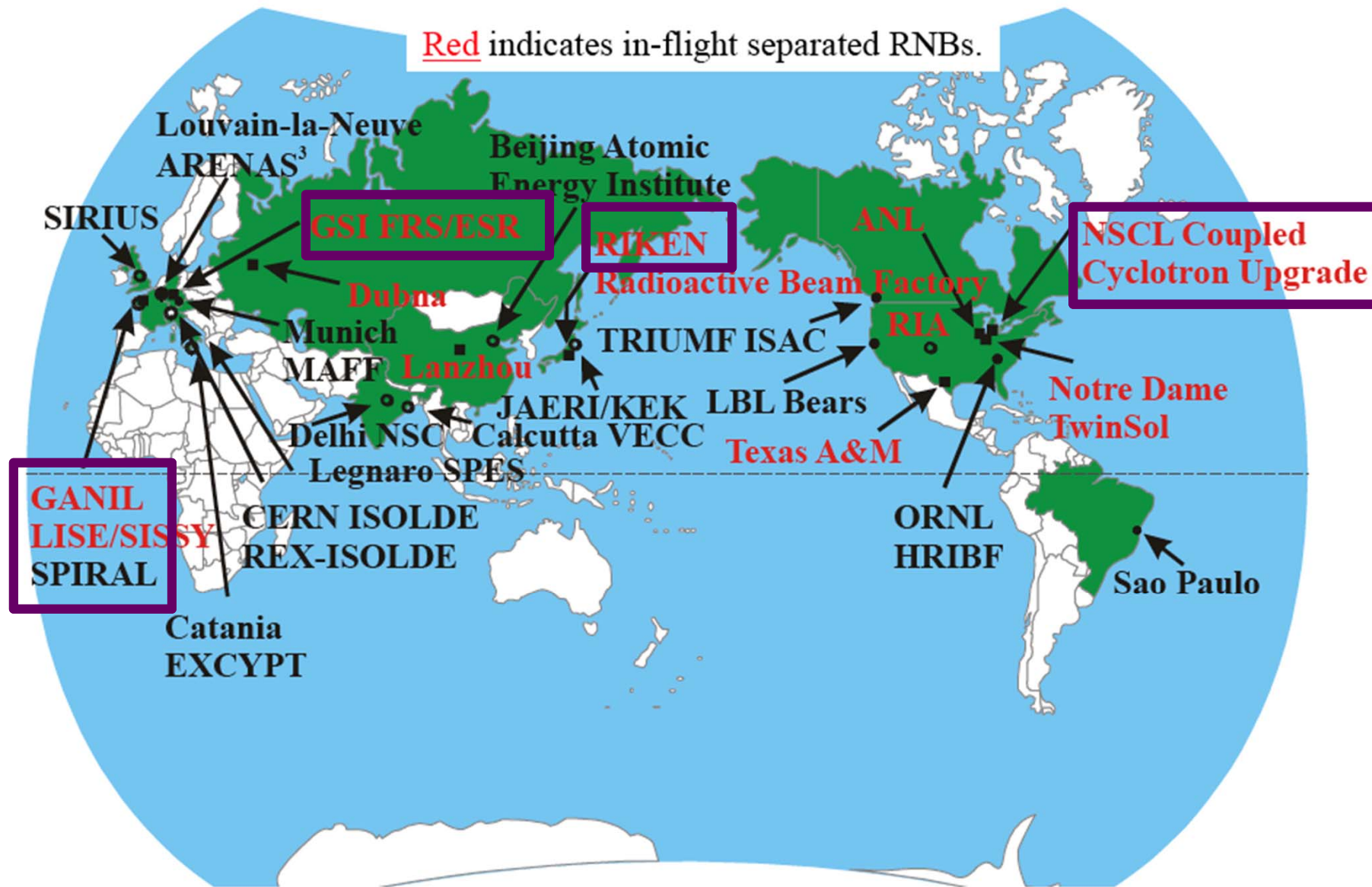
Production /s/100nA



# Spiral2 au GANIL

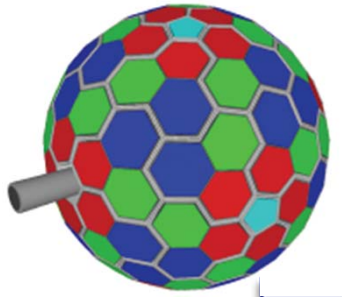


# Projets mondiaux

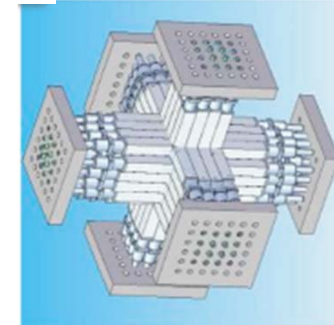


# Détecteurs de prochaine génération

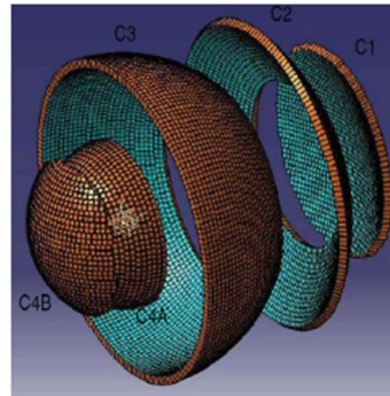
## AGATA



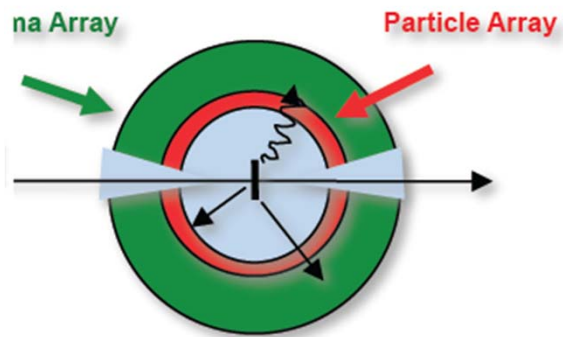
## PARIS



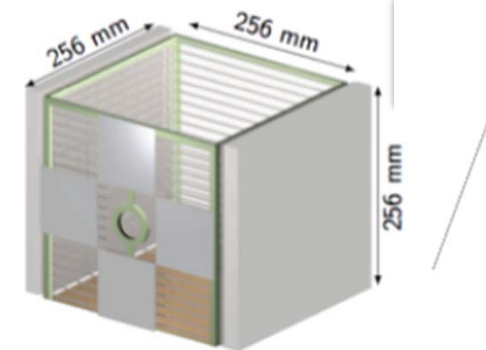
## FAZIA



## GASPARD



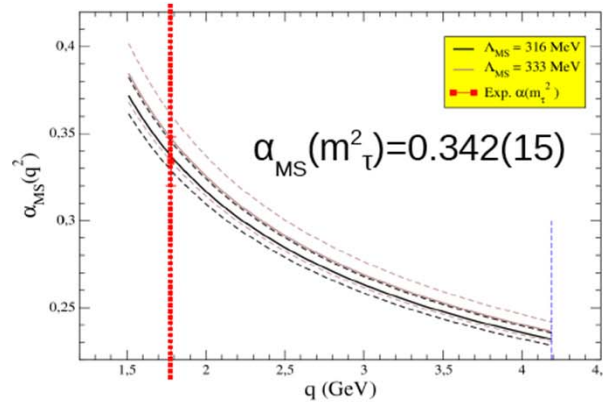
## ACTAR & GET



# Théorie

CPhT, IPhT, LPT, IPN, SPhN

Quarks



4-loops RGE QCD sur réseau



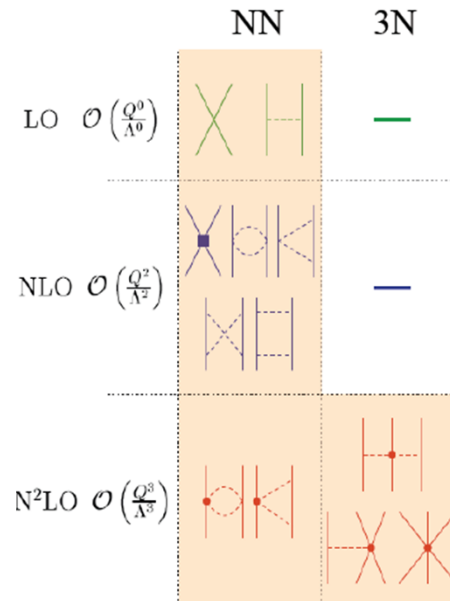
$$\alpha_{MS}(M_Z^2) = 0.1198(9)(5)_{-5}^{+0}$$



PDG[J.Phys.G37(2010)075021] :

$$\alpha_{MS}(M_Z^2) = 0.1184(7)$$

Nucléons

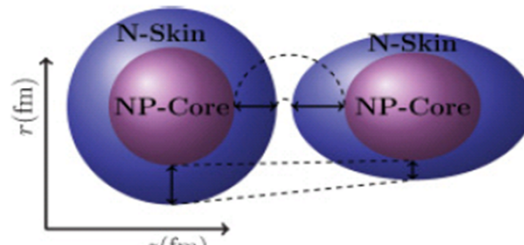


Théorie effective chirale

Weinberg 1990 et al.

Noyaux légers (A ~ < 10)

Noyaux



Fonctionnelle de la densité: excitations dans les noyaux superfluides, déformés dans un cadre relativiste

# Et après ?

