

Dominique Guillemaud Mueller



**IN2P3**

Institut national de **physique nucléaire**  
et de **physique des particules**

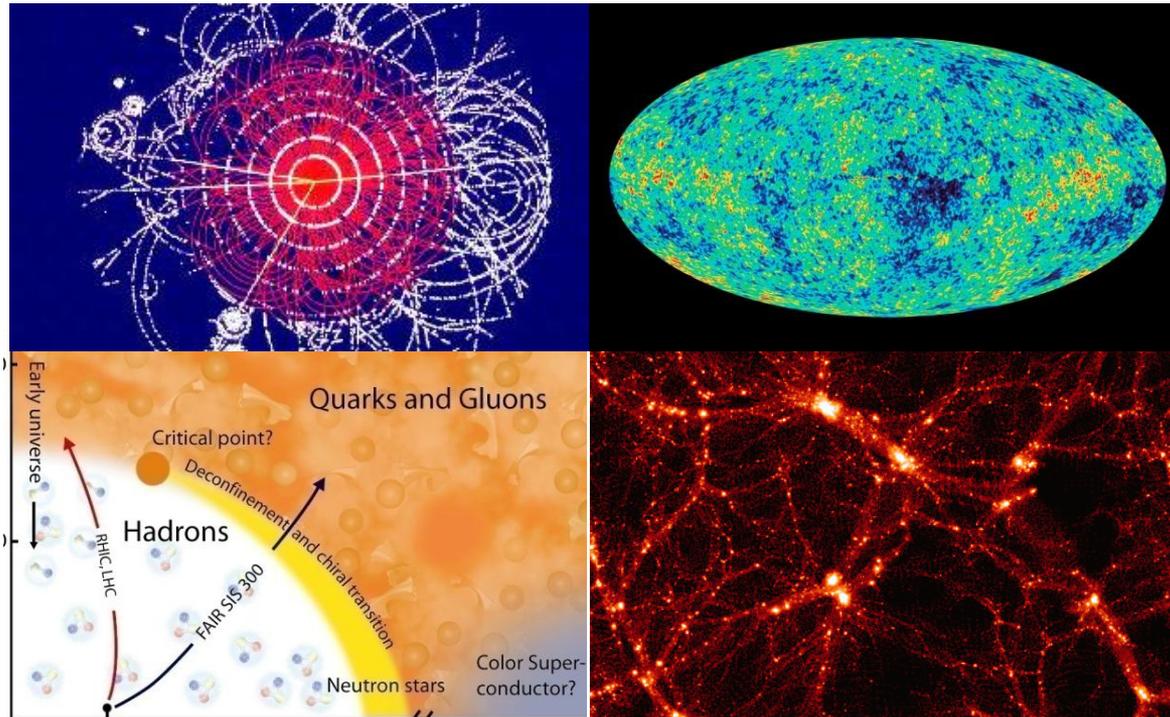
**Journées des entrants – 9 Nov 2011**

[www.in2p3.fr](http://www.in2p3.fr)

# Quatre questions fondamentales à l'IN2P3

What are the ultimate constituents of matter ?

What is the energy content of the Universe ?



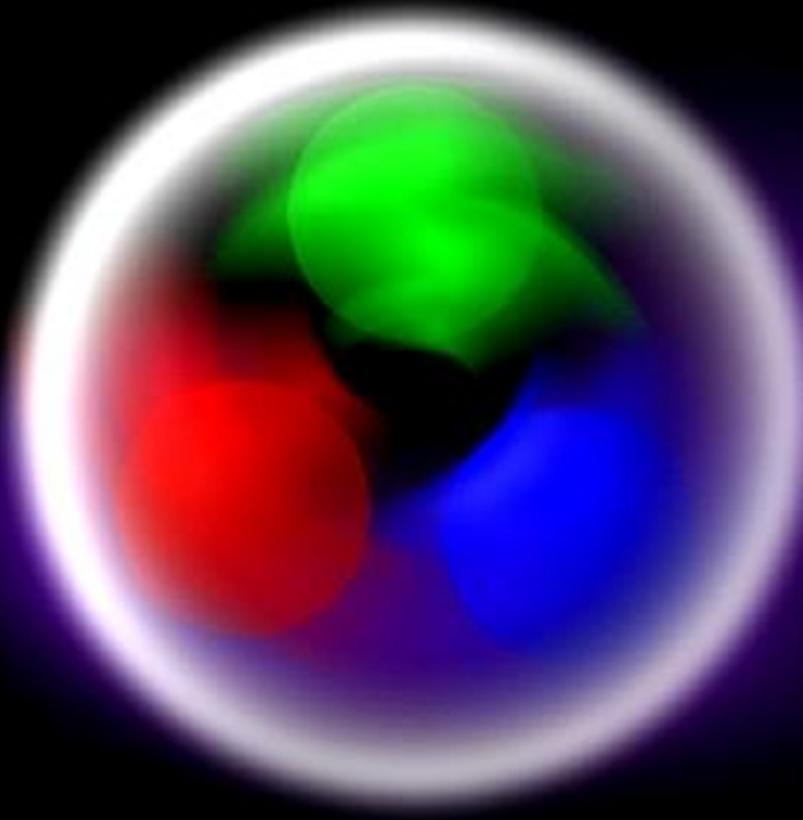
What are the origins of particles and nuclei ?

What are the origin and structure of Universe ?

# La structure de la matière à différentes échelles

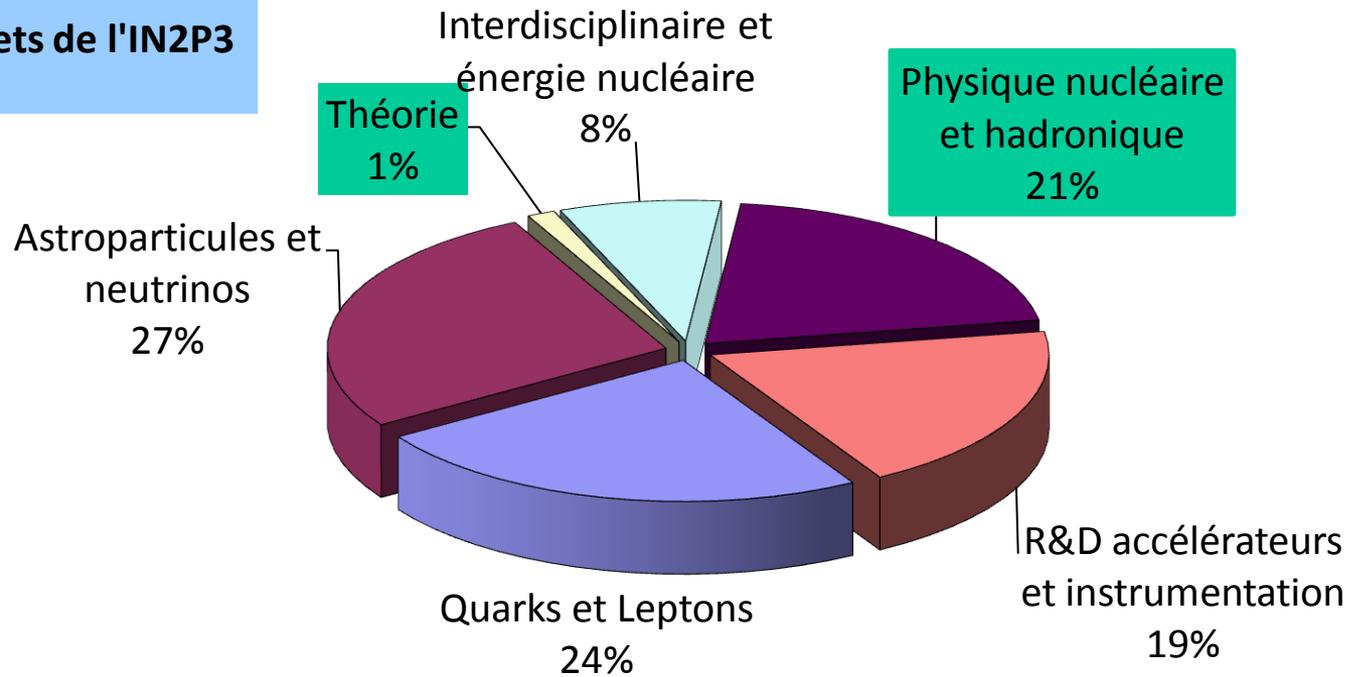
$10^{-15}$  m

nucléon : neutron ou proton

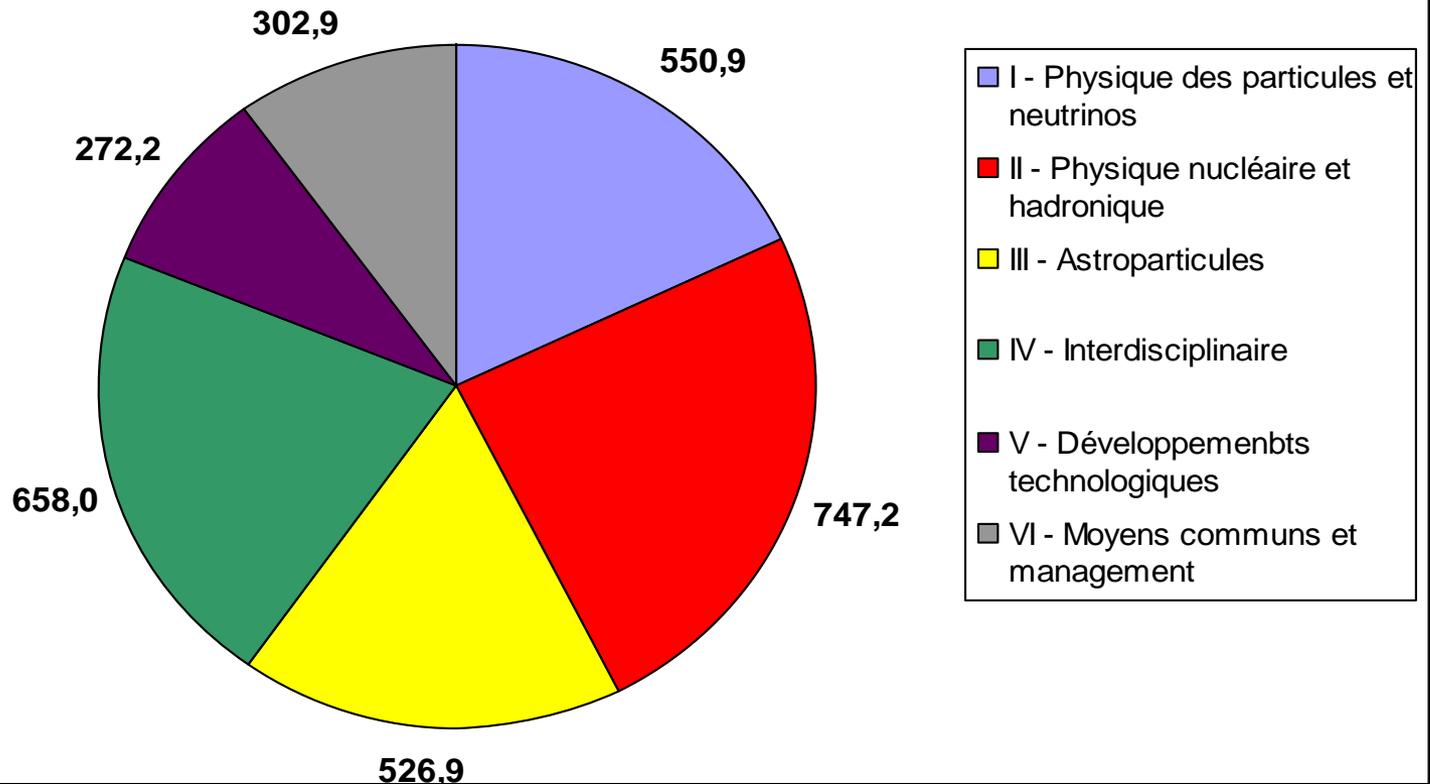


# Répartition des Projets

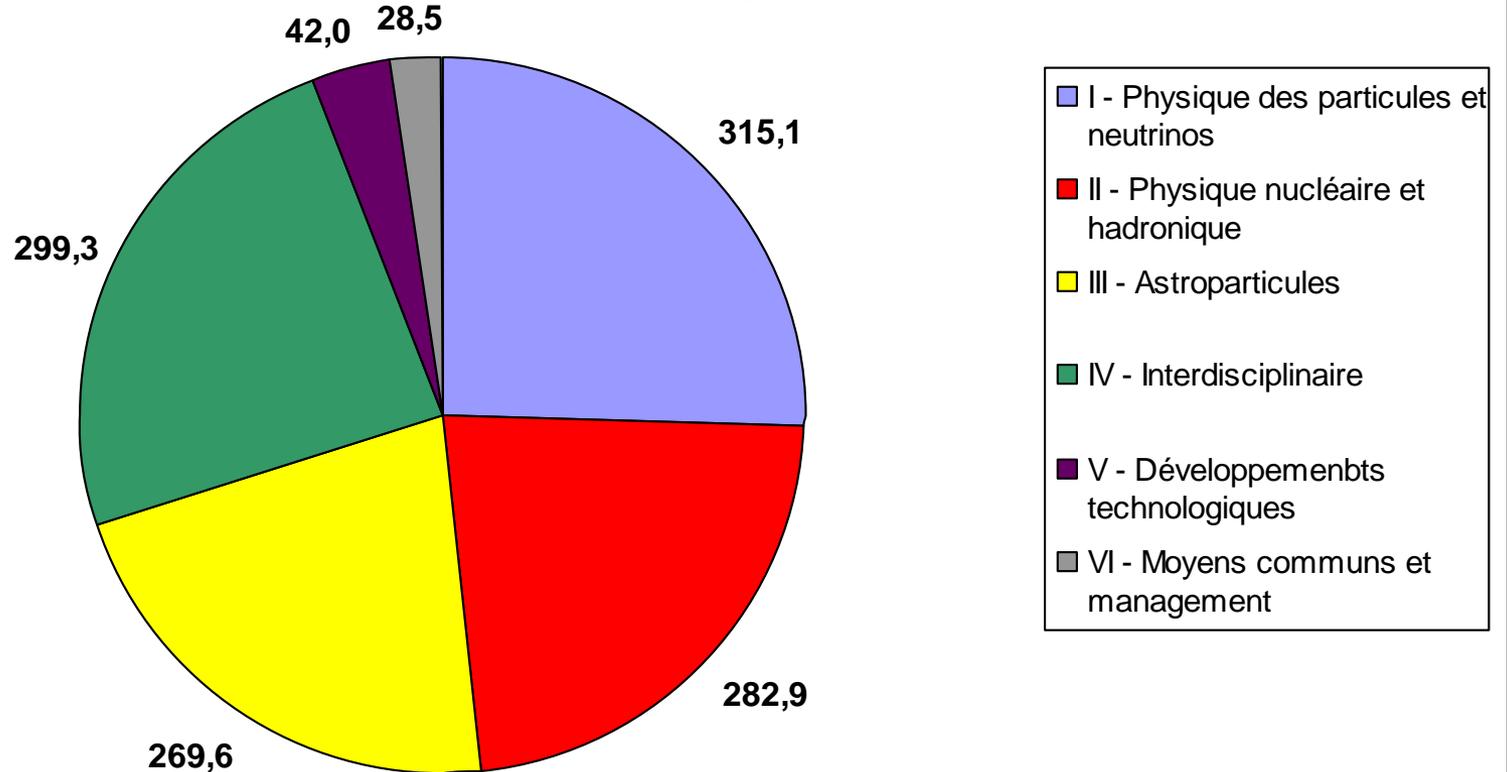
## Projets de l'IN2P3



Répartition des 3058,2 ETP de l'IN2P3



Répartition des 1237,3 ETP Chercheurs, Enseignants et Doctorants/Postdocs de l'IN2P3  
(source : ISIS 2009)



### Activités en cours

GANIL et SPIRAL1 : Etude de la Structure nucléaire et des Réactions  
**EXOAM, VAMOS, MUST2, TRAPS, FISSION, TPC, ACTAR-MAYA, INDRA-AZ4p, LISE, ...**

AGATA@Legnaro (puis GSI et SPIRAL2)

ALTO-Tandem Physique et préparation SPIRAL2

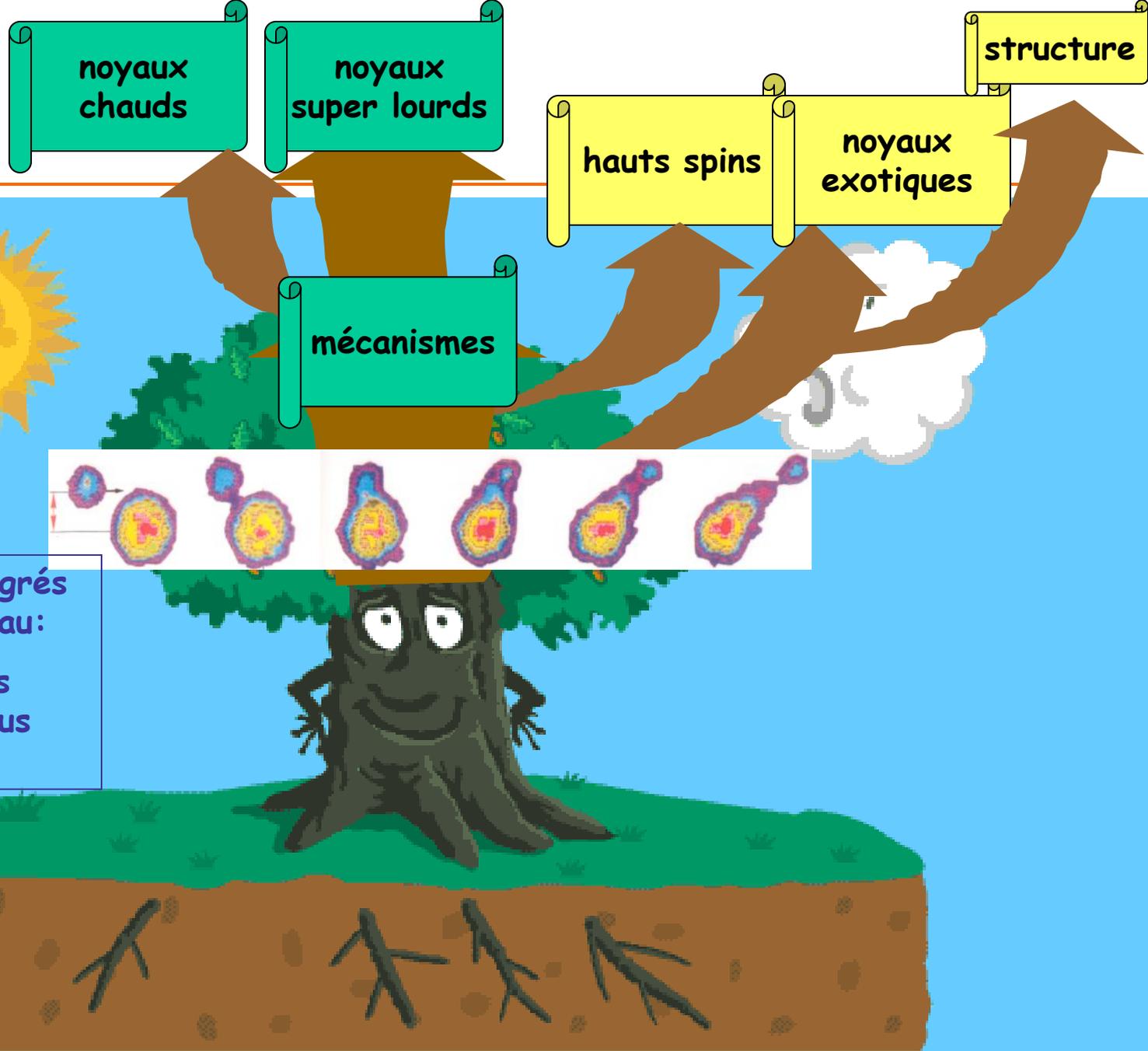
Structure et réactions auprès d'autres Installations : Europe-USA-Japon :  
*ISOLDE, GSI, MSU, RIKEN, LOHENGRIN, LEGNARO, JYVASKYLA,*

### Projet en construction

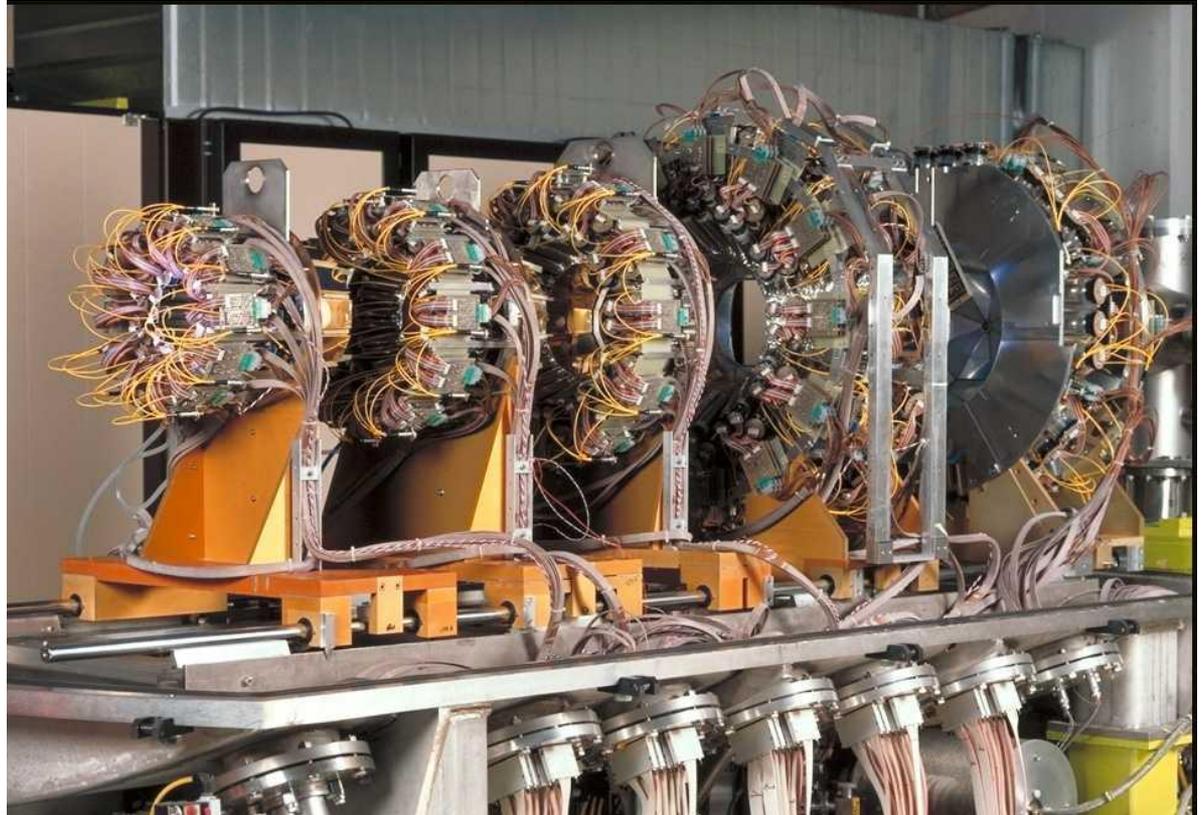
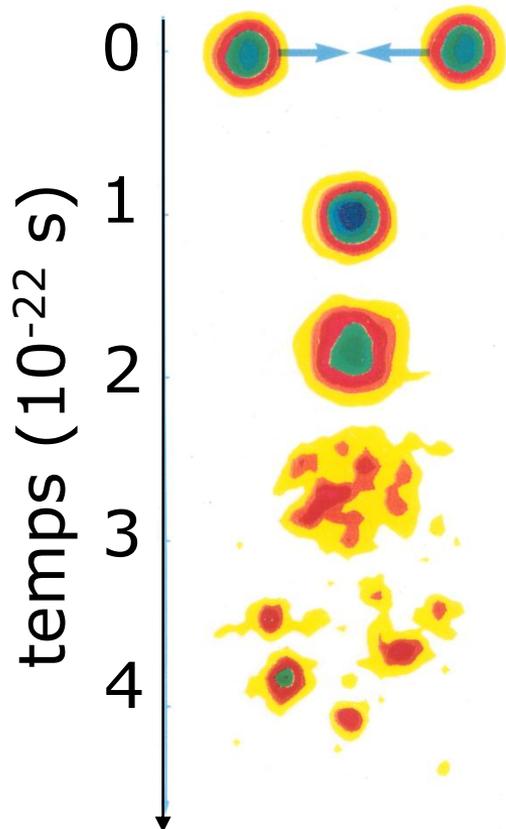
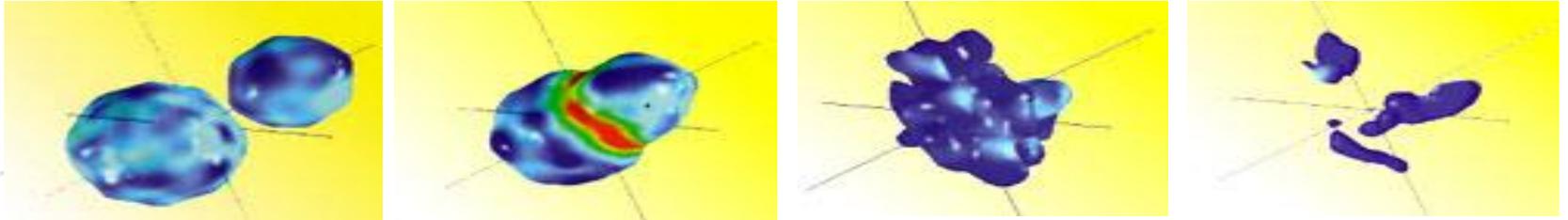
SPIRAL2 et Collaborations Internationales sur les Nouveaux Instruments  
**(S3, DESIR, PARIS, GASPARD, NFS, FAZIA, EXOGAM2, ACTAR)**

### Futur plus lointain

EURISOL Seconde génération de RIB

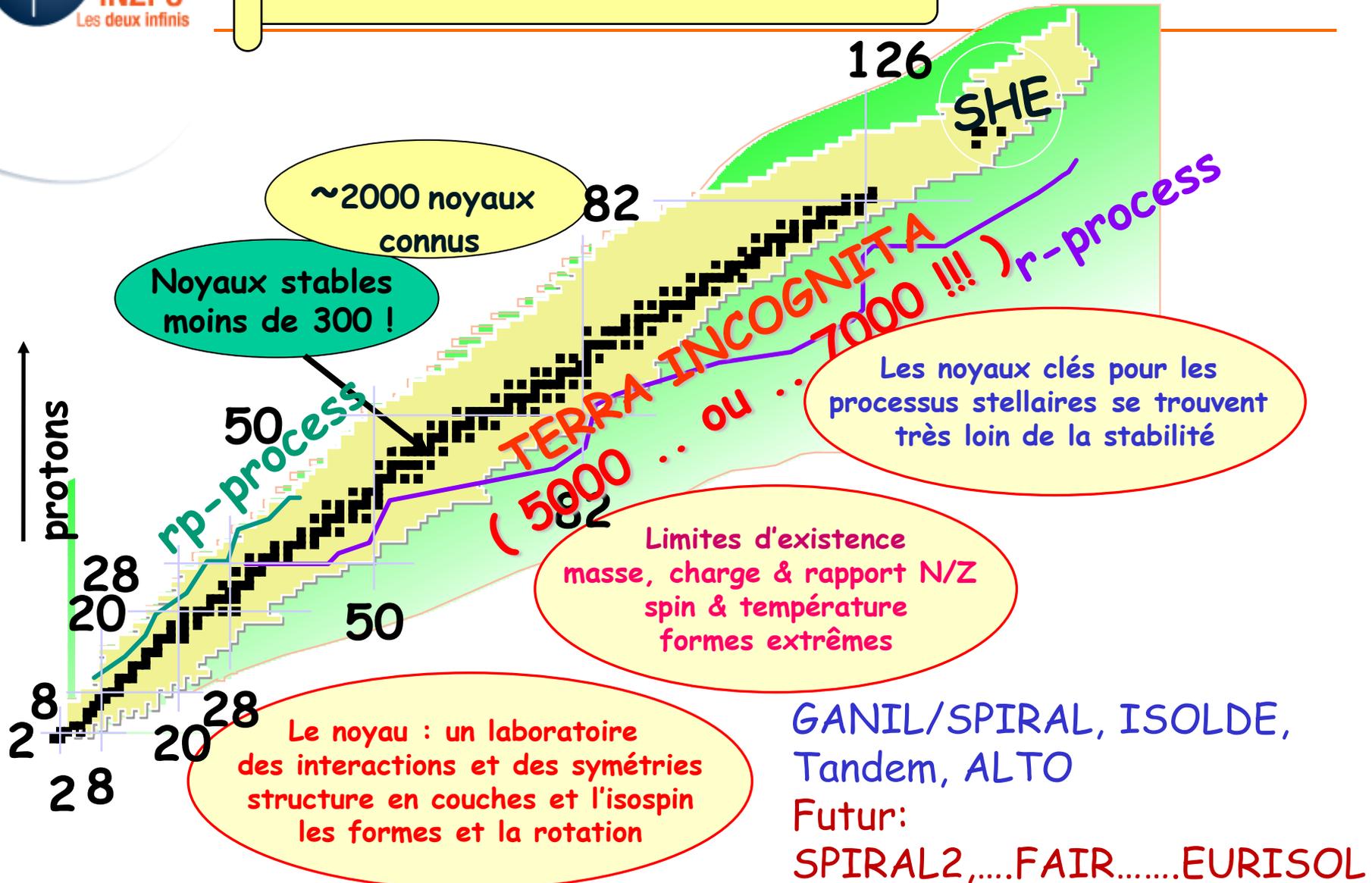


# Les noyaux chauds : A la recherche de l'équation d'état de la matière nucléaire

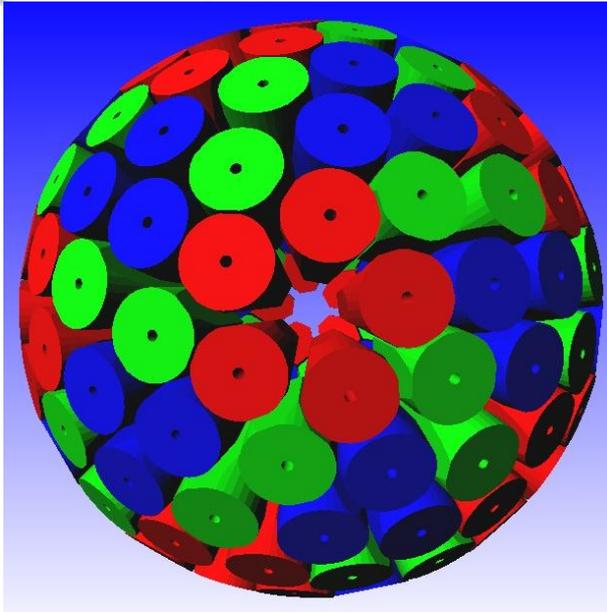


le détecteur INDRA au GANIL

# A la quête des extrêmes



# AGATA : le détecteur de rayonnement $\gamma$ ultime (photons)

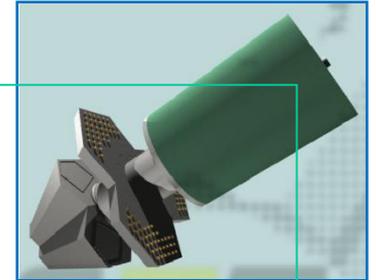


Détecteur  $4\pi$  Germanium

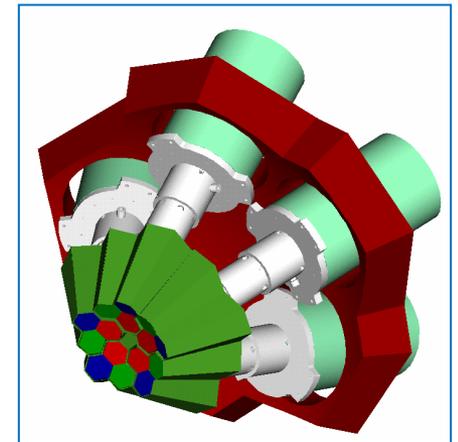
180 cristaux  
(60 Triple Clusters)

36 segments par cristal

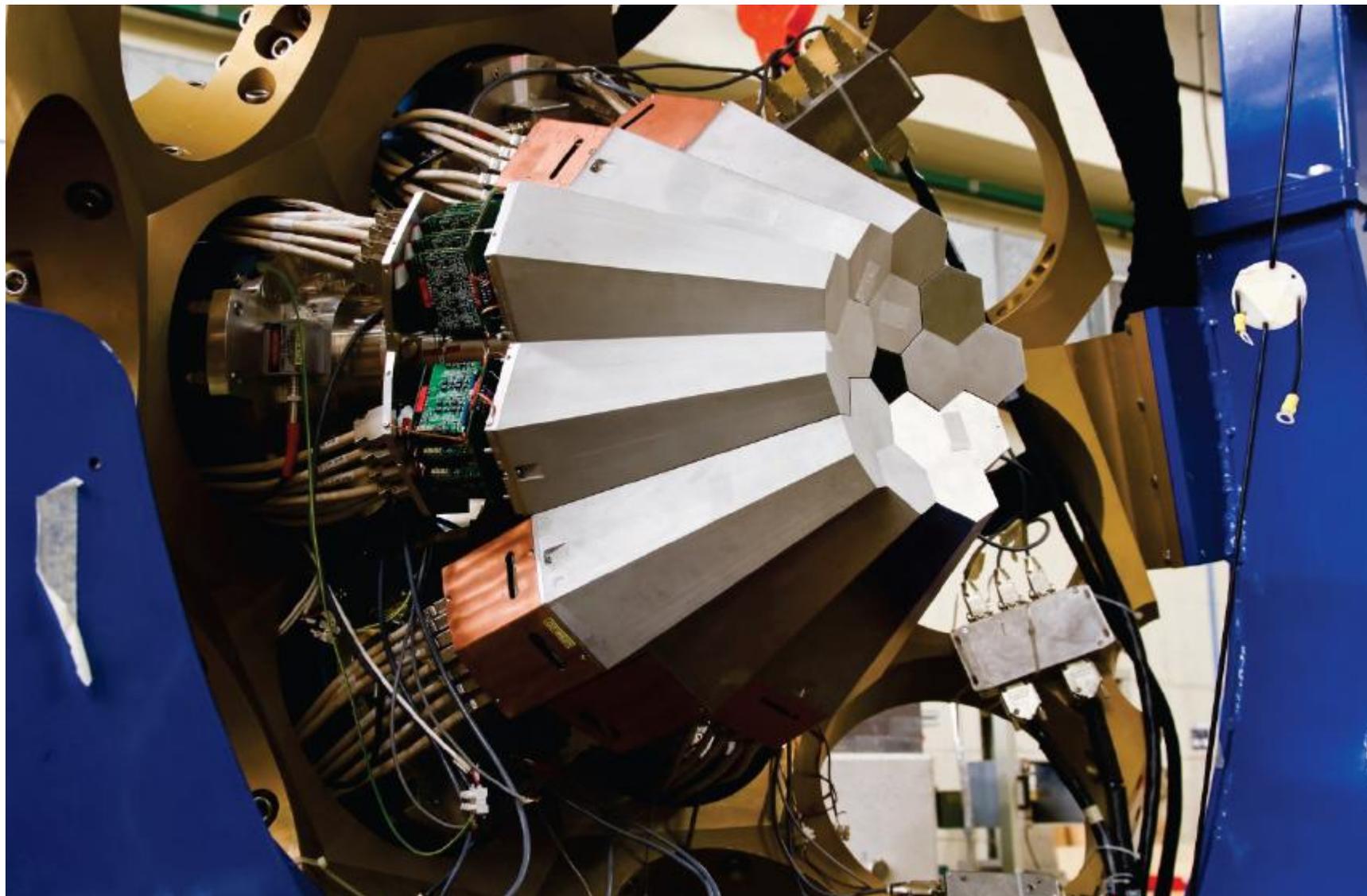
Electronique digitale (100 Mhz 14 bits)



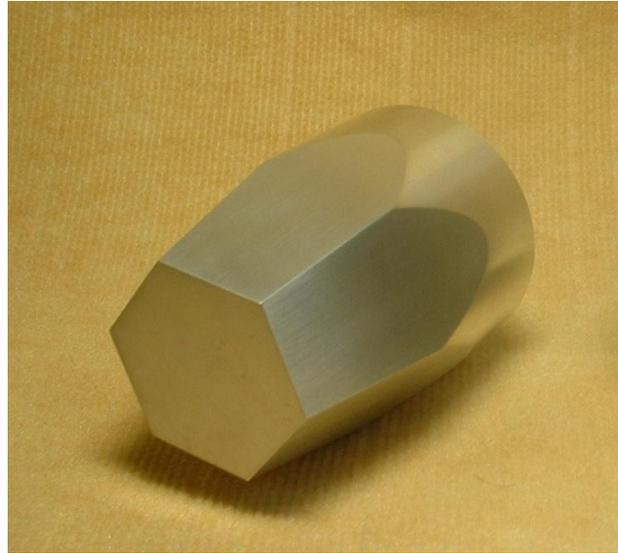
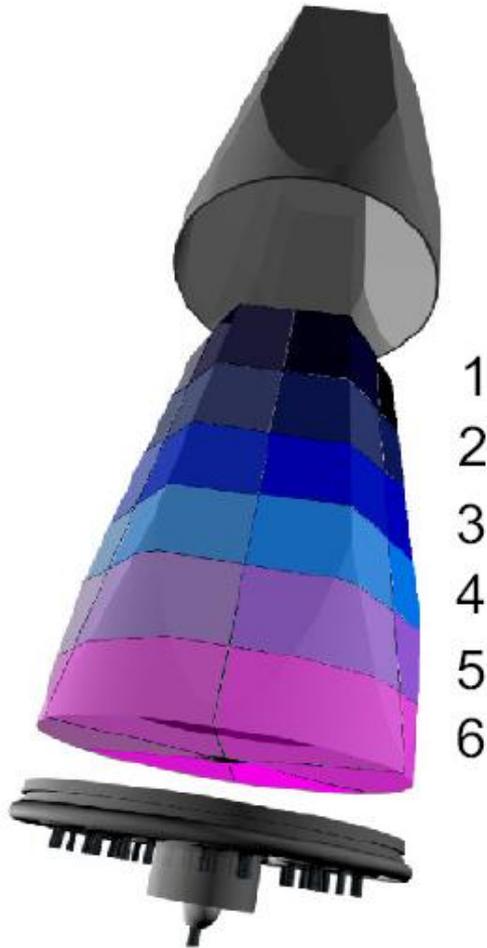
Réalisation d'un « Démonstrateur » de 5 TC  
à LEGNARO (Italie) en 2010-2011  
à GSI (Allemagne) en 2012  
au GANIL Caen en 2014



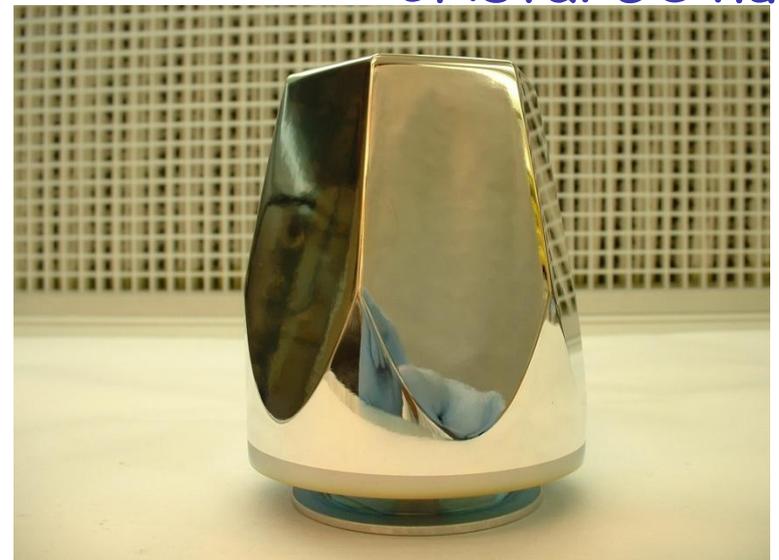
# Le démonstrateur d'AGATA ( 5 triples Clusters)



# Cristal Ge et capsule

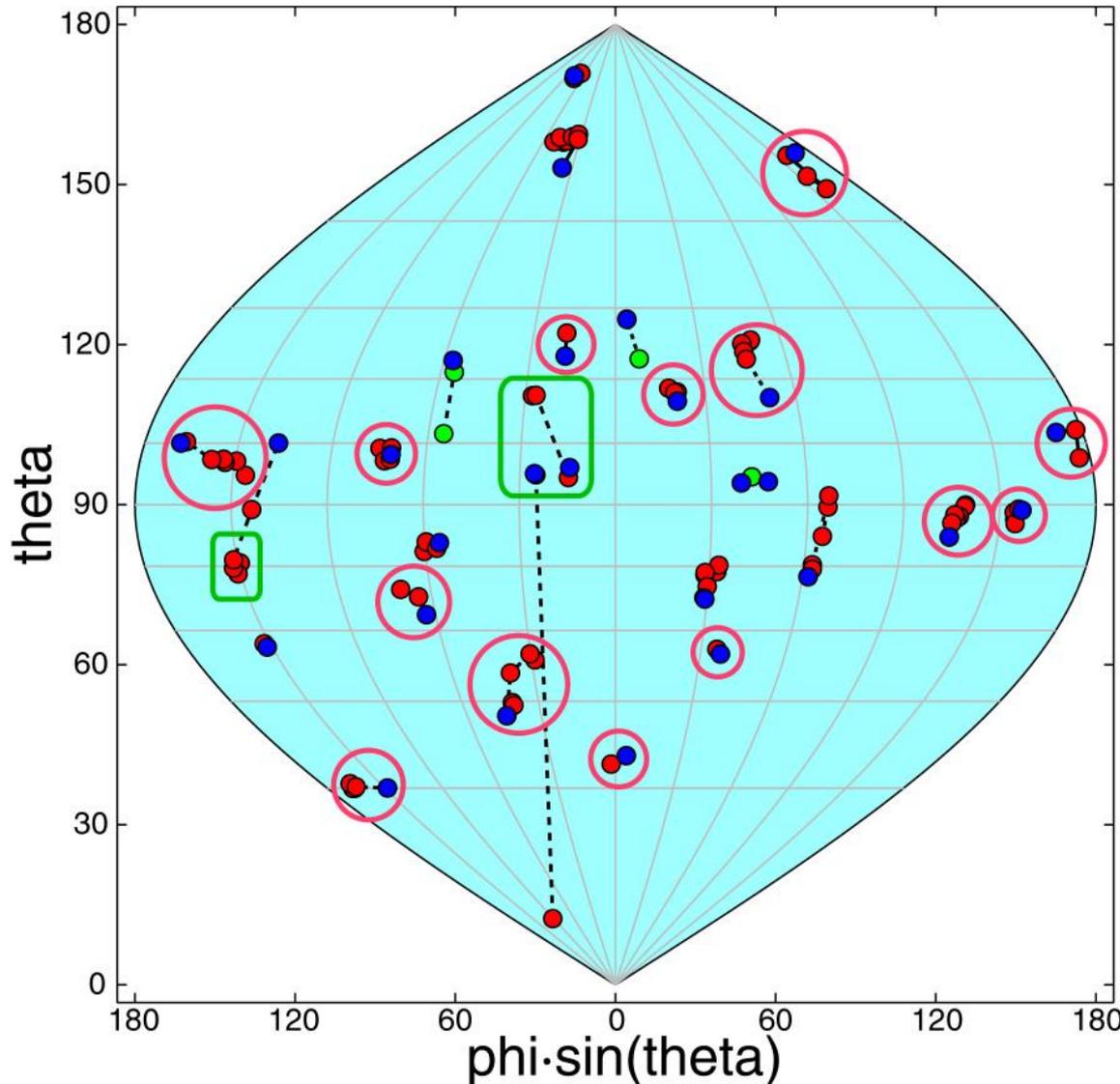


Cristal encapsulé



Cristal Ge nu

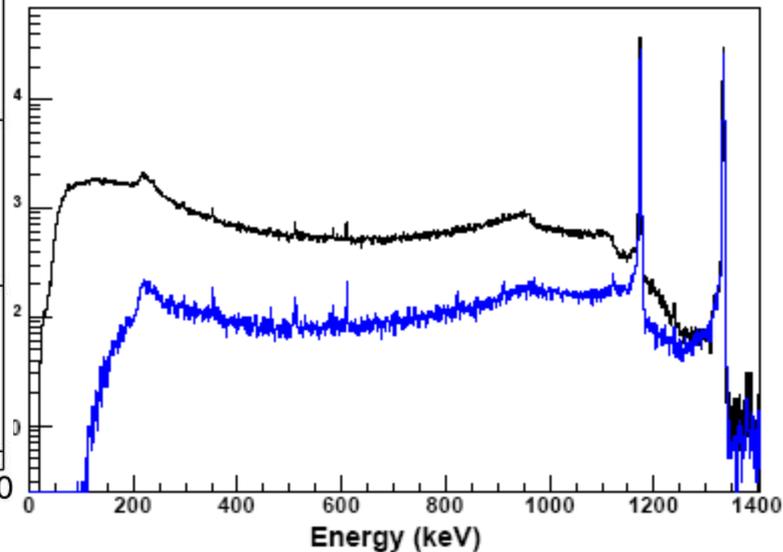
# Tracking gamma



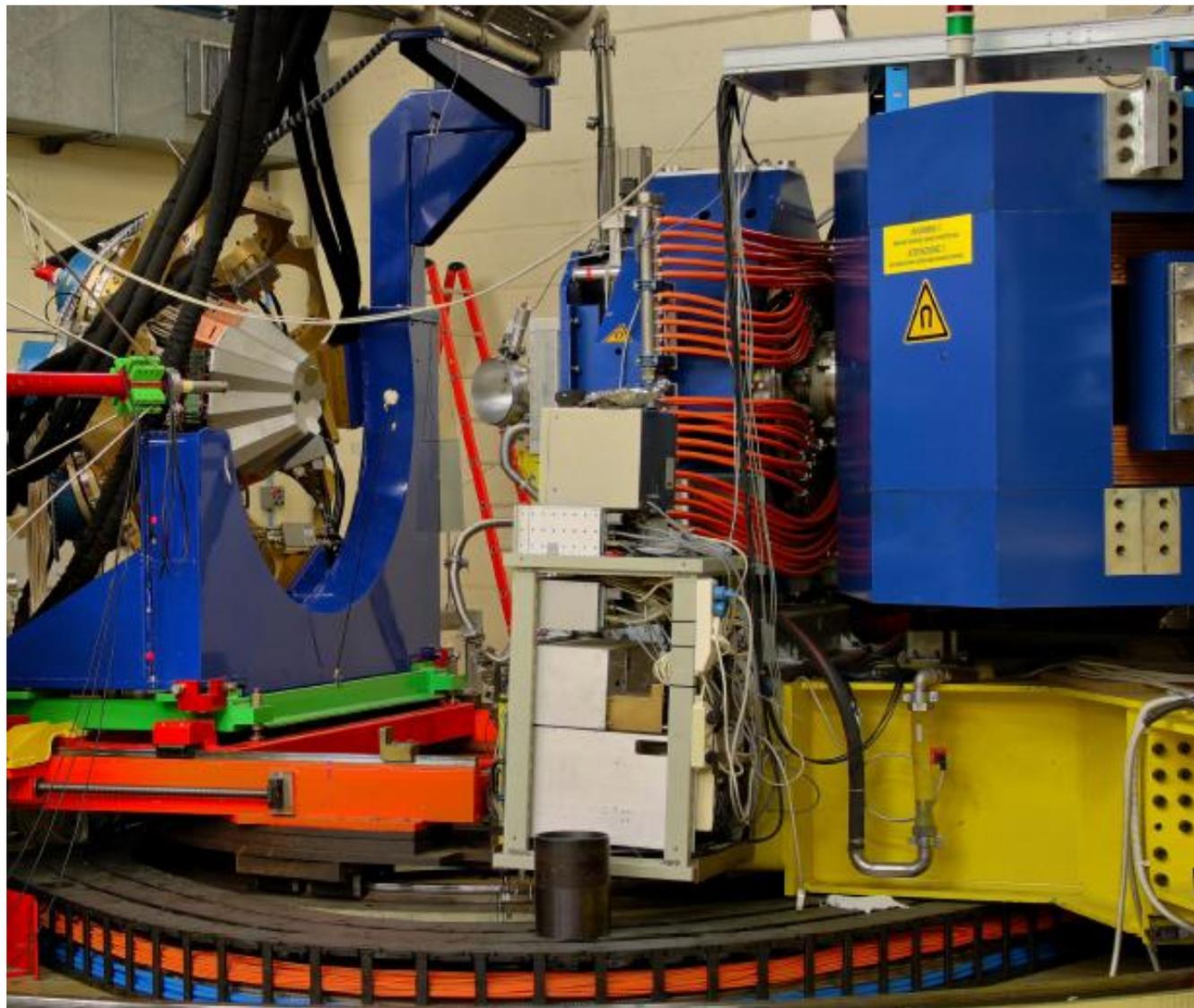
Chaque gamma fait plusieurs interactions (points de couleur dans le Ge (bleu))

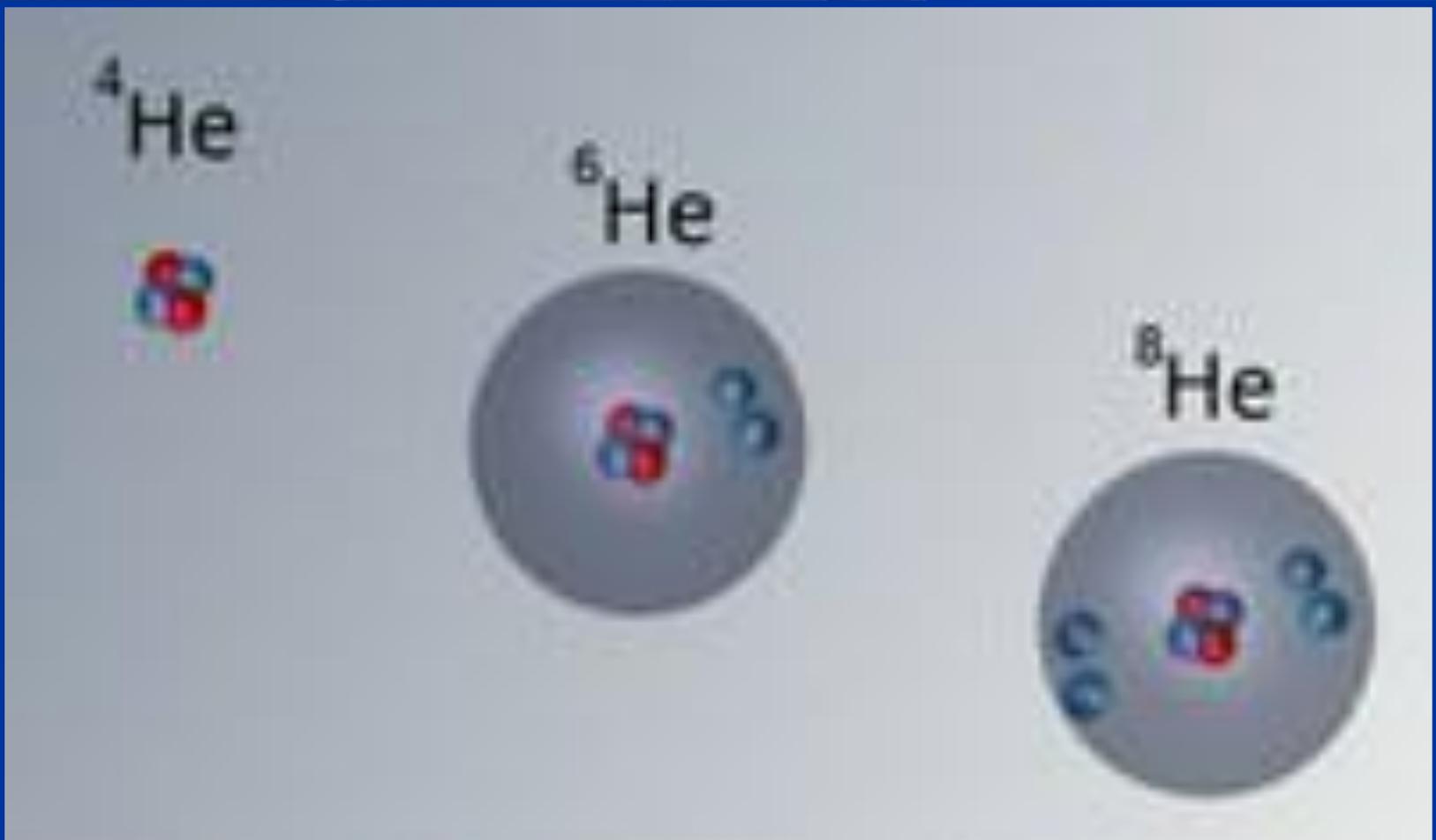
Les ronds rouges pour les gamma bien reconstruits

Spectre  $\gamma$  après tracking obtenu avec trois TC



# Démonstrateur d'AGATA à Legnaro (Italie)

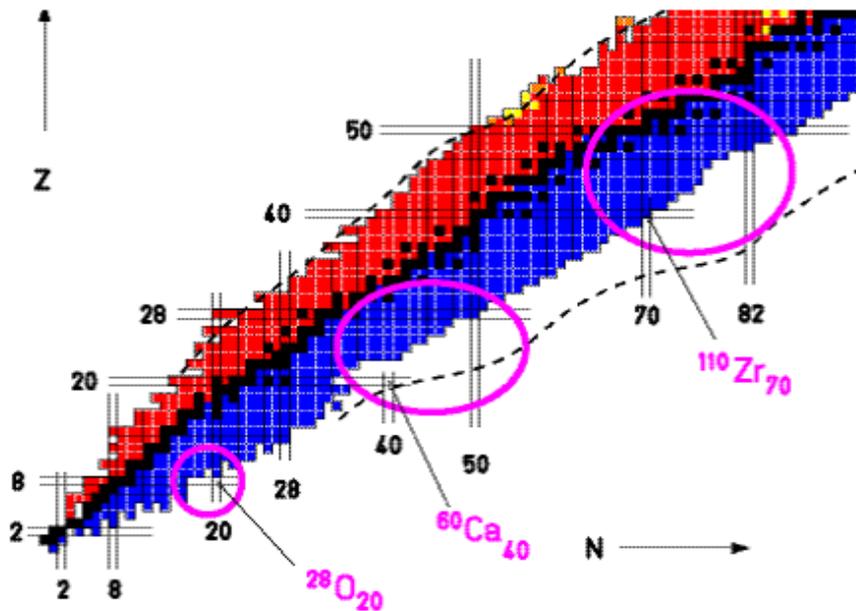




Ensemble de détection  
MUST2

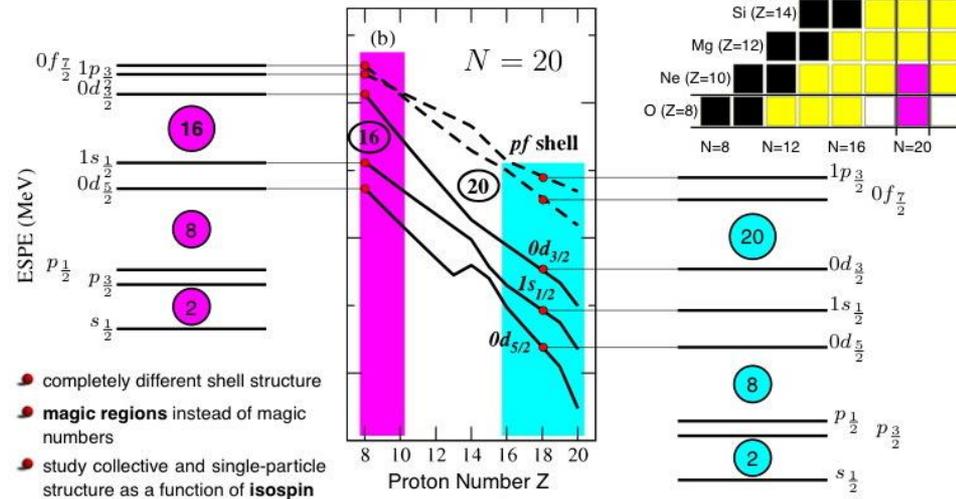


# Régions où l'on attend de nouveaux nombres magiques pour des rapports N/Z très grands



## Frontiers and challenges of nuclear shell model

T. Otsuka *et al.*, Euro. Phys. Journal A **15**, 151 (2002)



**Ganil existant**

2006-2014 200M€  
Complexe Accélérateur Unique  
au monde  
5 expts en Parallèle  
>1000 utilisateurs

**GANIL-SPIRAL1**

**DESIR**

**« Exotic » Phase2 2014**

**S3**

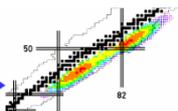
**Phase1 end 2012**

**NFS**

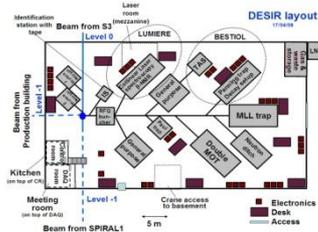
# 74 Letters of Intent

## for the Day 1 experiments at SPIRAL2

*Spiral2*



DESIR - 20

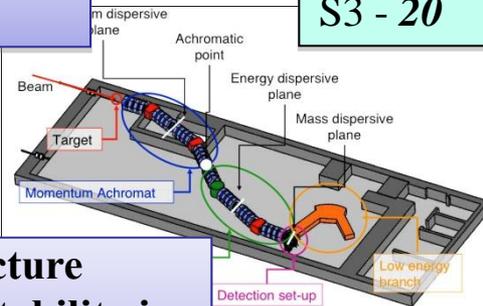


Shell structure  
very far from stability in  
p-rich nuclei  
13 LoIs

Heavy and Super  
Heavy Elements  
3 LoIs

*Atomic physics 1*  
*LoI*

S3 - 20



p, 2p,  $\alpha$   
decay  
3 LoIs

Shell structure  
very far from stability in  
n-rich nuclei  
22 LoIs

PARIS  $\geq 10$   
GASPARD - 13  
FAZIA - 2  
ACTAR - 4

Equation of State,  
Role of Isospin in  
nuclear reaction

4 LoIs

N=Z  
11 LoIs

Astrophysics  
CNO, rp-process  
9 LoIs

Astrophysics  
r-process path  
2 LoIs

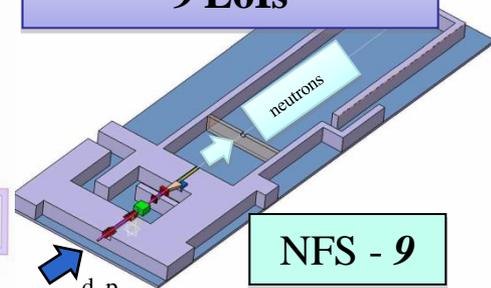
AGATA/  
EXOAM2  $\geq 20$

GANIL DETECTORS

Neutrons for science  
9 LoIs

Spins & Shapes, Collective  
modes, SD, HD  
8 LoIs

VAMOS - 12  
Other Exp. Halls  $\leq 20$



NFS - 9

Haloes & Structures in the Continuum  
0 LoIs

Fundamental Interactions - 2 LoIs

# Physique Hadronique

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## Collisions d'Ions Lourds

LHC ALICE,  
CMS Ions Lourds

*RHIC* *STAR*  
*PHENIX*

## Structure du nucléon

JLAB et JLAB 12 GeV

FAIR PANDA,

*GSI* *HADES (effets du milieu)*

# Phases de la matière nucléaire



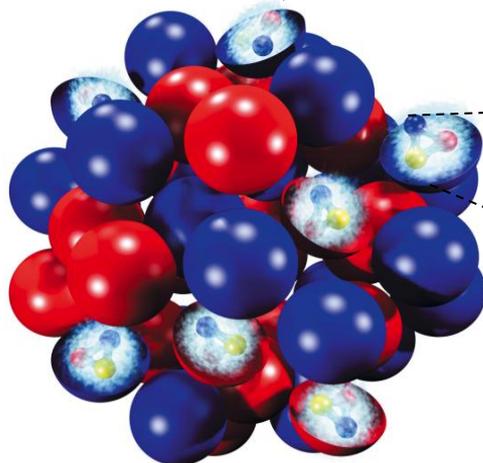
$T_c \sim 0,2 \text{ GeV}$

Temperature

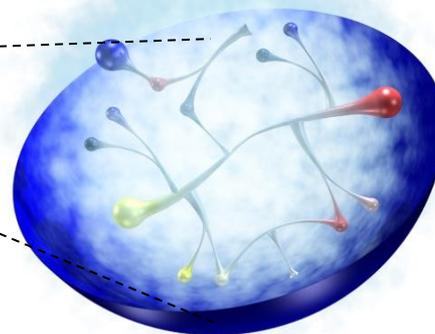


Net Baryon Density

Nuclei



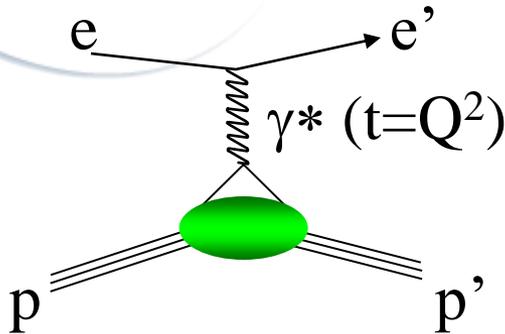
Nucleon





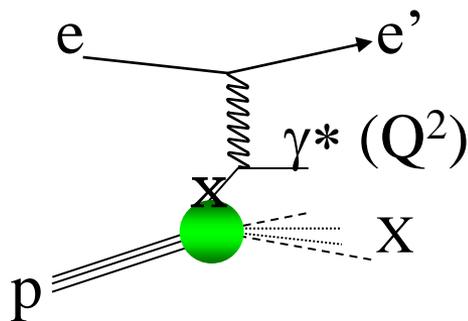
# Diffusion d'électrons sur le proton : hier

➤ 1950: Diffusion **élastique** :  $ep \rightarrow e'p'$  (Hofstadter, prix Nobel, 1961)

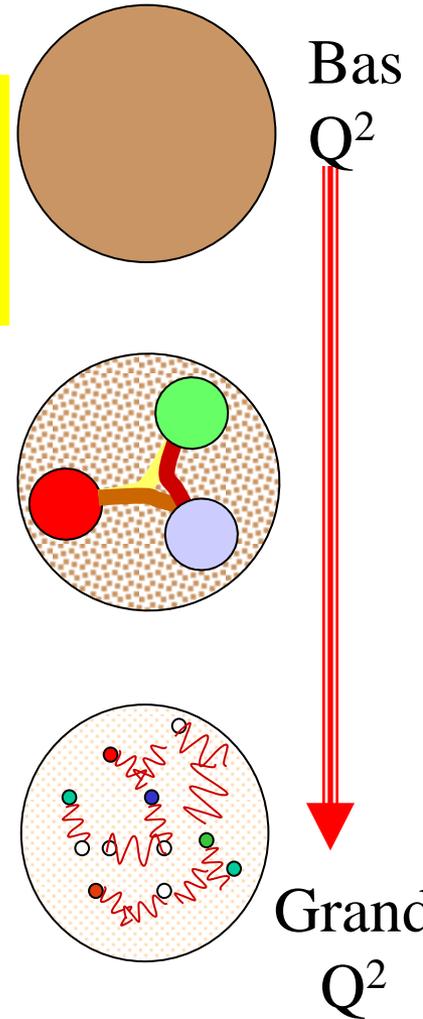


- Le proton n'est pas ponctuel
- Mesure des distributions de charge et courant du proton: facteurs de forme ( $F_1(t)$ ,  $F_2(t)$ )

➤ 1967: Diffusion **profondément inélastique** (DIS) :  $ep \rightarrow e'X$  (Friedman, Kendall, Taylor, prix Nobel, 1990)



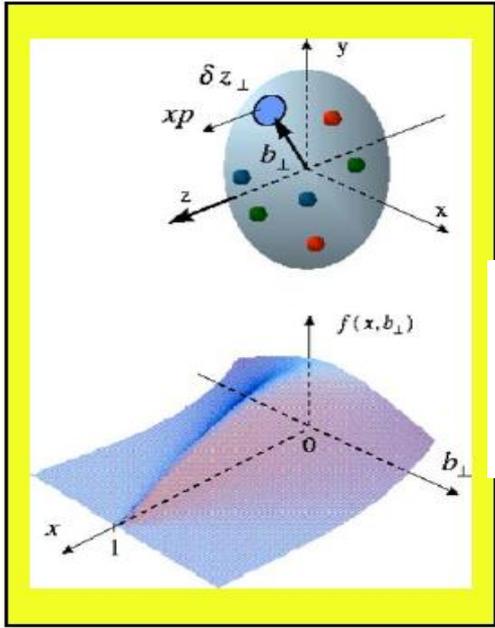
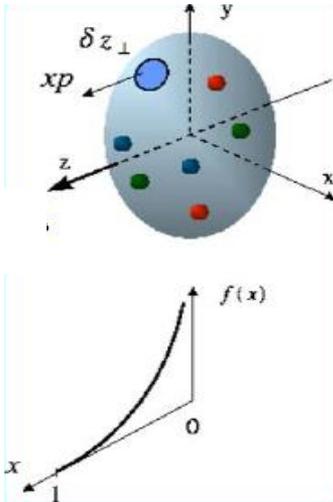
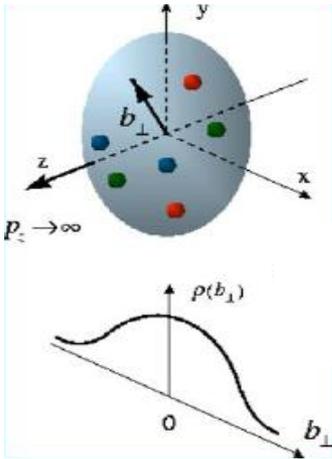
- Découverte des quarks (ou "partons")
- Mesure des distributions d'impulsion et spin des partons:  $q(x)$ ,  $Dq(x)$



# Diffusion d'électrons sur le proton : aujourd'hui

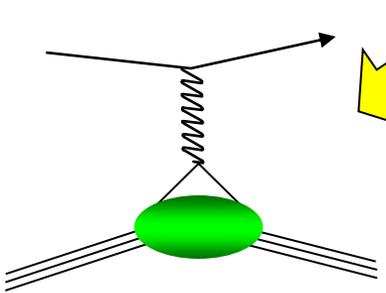


GPDs:  $H, E, \tilde{H}, \tilde{E}$   
 corrélation entre  
 les distributions spatiales  
 et les distributions d'impulsion

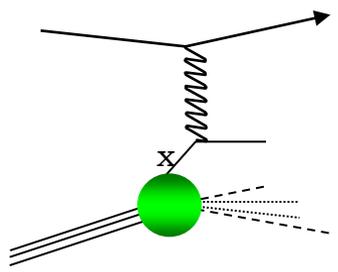


Facteurs de forme:  
 distributions **spatiales**  
**transverses**

Distributions des partons:  
 impulsion **longitudinale**  
 et **spin** des quarks



**Processus exclusifs « durs »**



# Jefferson Laboratory Newport News, USA

Cycle utile ~ 100%  
Pol. faisceau ~ 80%

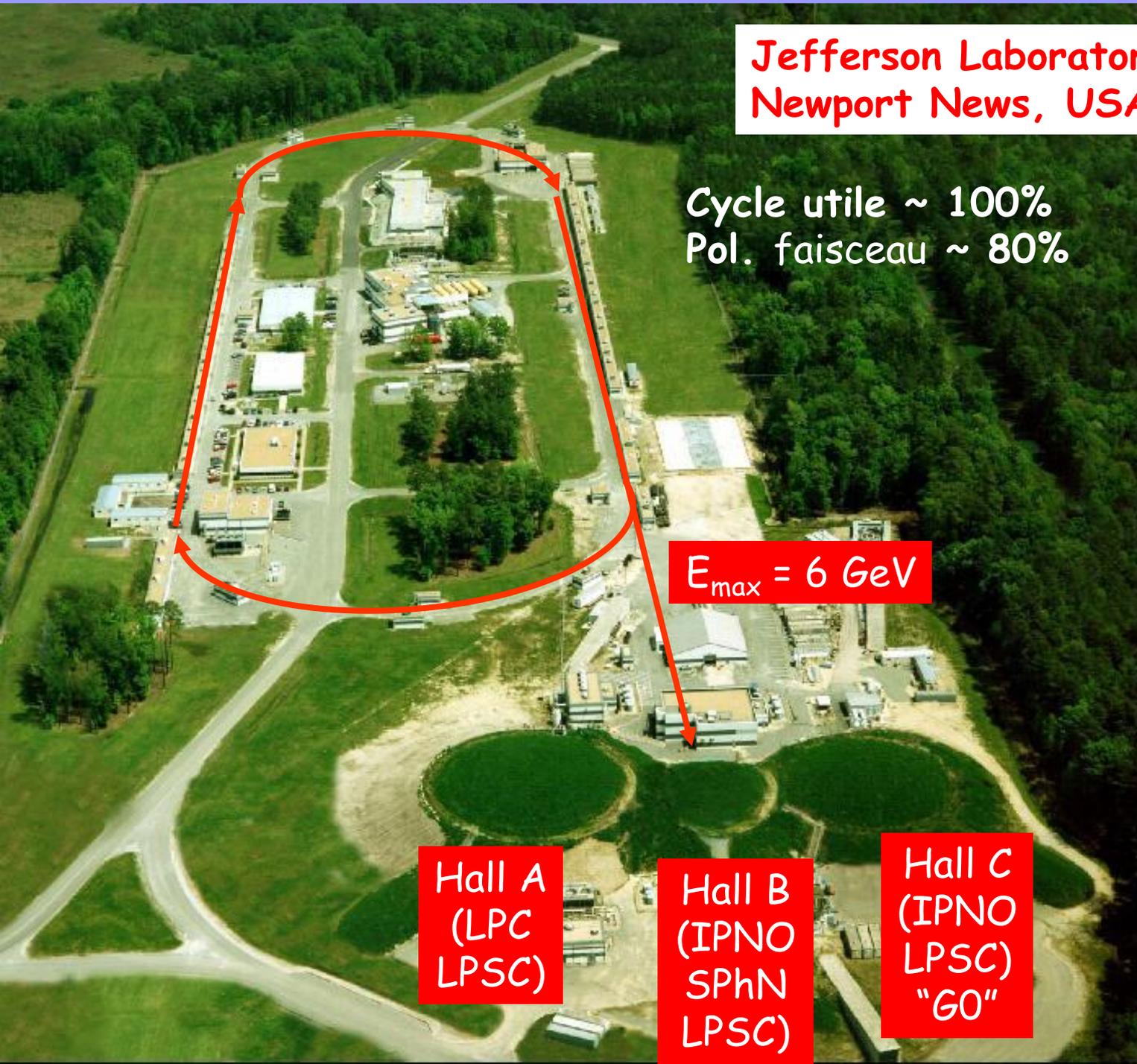
Continuous  
Electron  
Beam  
Accelerator  
Facility

$E_{\max} = 6 \text{ GeV}$

Hall A  
(LPC  
LPSC)

Hall B  
(IPNO  
SPhN  
LPSC)

Hall C  
(IPNO  
LPSC)  
"GO"





IN2P3  
Les deux infinis

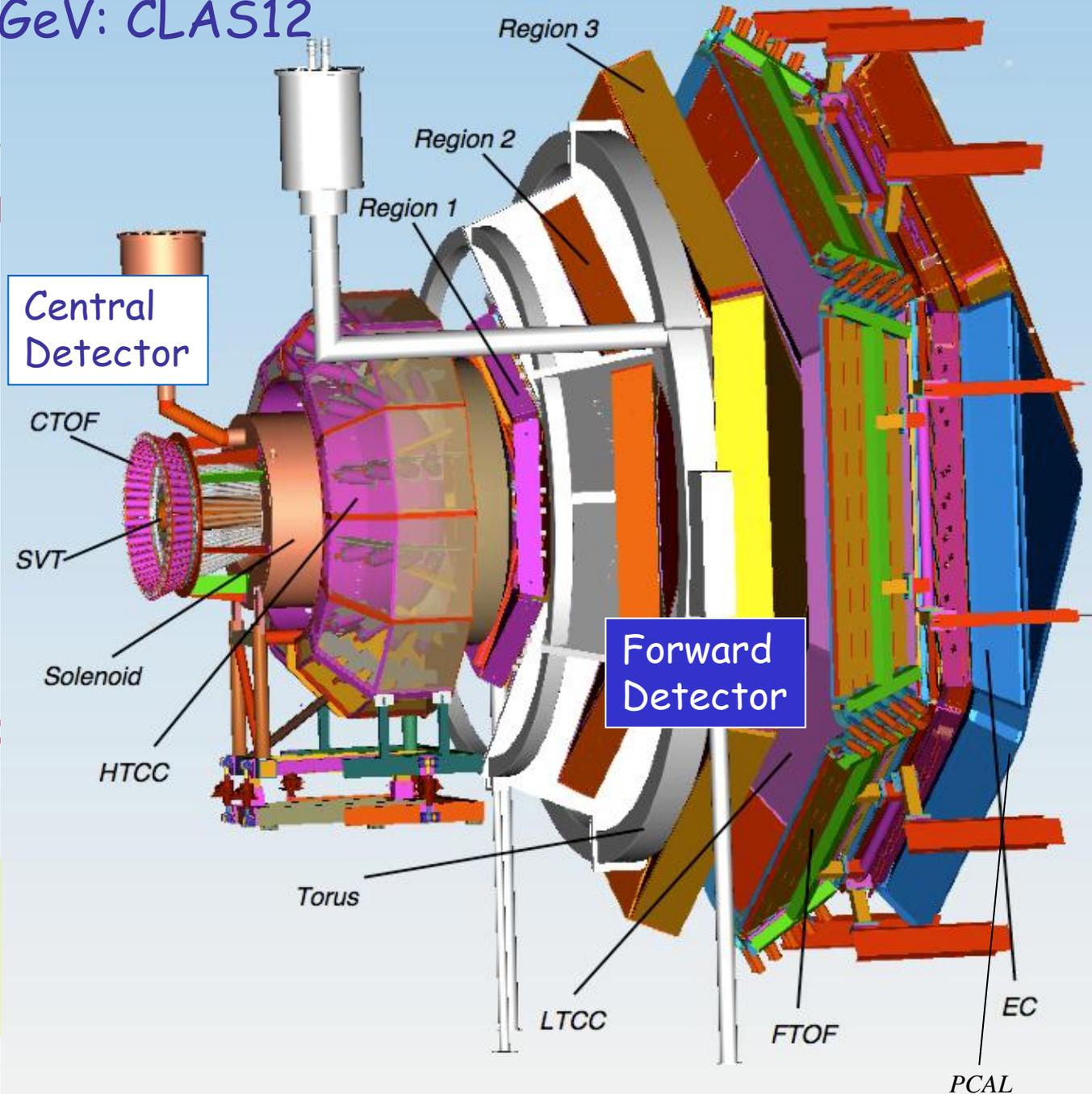
# Hall B@12 GeV: CLAS12

## Forward Detector

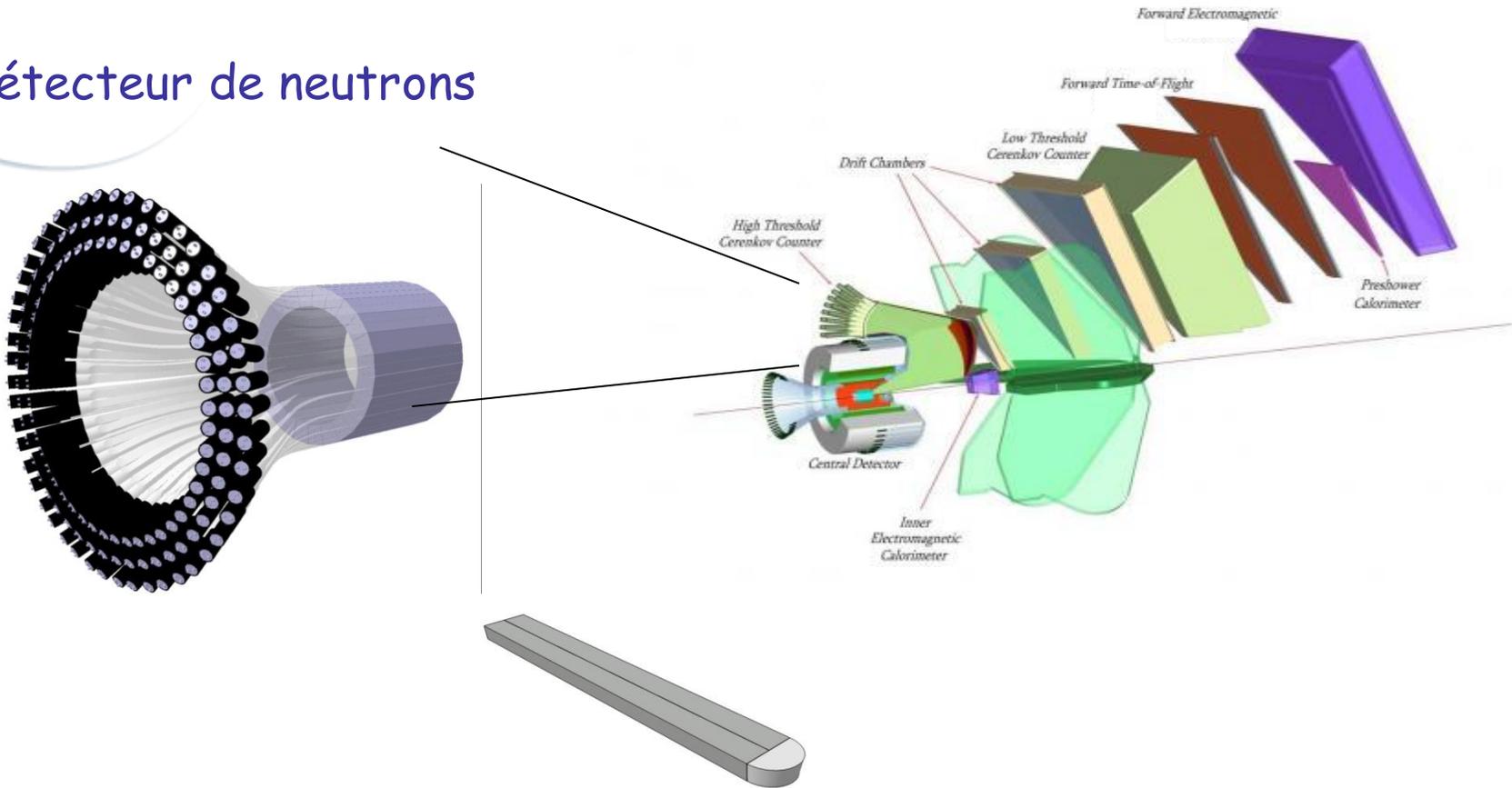
- TORUS magnet
- Forward tracker
- HT Cherenkov Counter
- Drift chambers (3 regions)
- LT Cherenkov Counter
- Forward ToF System
- Preshower calorimeter
- E.M. calorimeter (EC)
- Inner Calorimeter (IC, not shown)

## Central Detector

- SOLENOID magnet
- Barrel Silicon Tracker
- Central Time-of-Flight
- Micromegas (SPhN)
- Central Neutron Detector (IPNO)



## Détecteur de neutrons



Tonneau de scintillateurs pour détecter les neutrons de recul et signer l'exclusivité de la réaction en→eng

Challenge: intense champ magnetique (5T).  
Longs guides de lumière en forme de "U" pour collecter la lumière  
⇒ **Expérience approuvée en janvier 2011**

# Que devient la matière dans des conditions extrêmes de température et de pression? Recréer le Big Bang

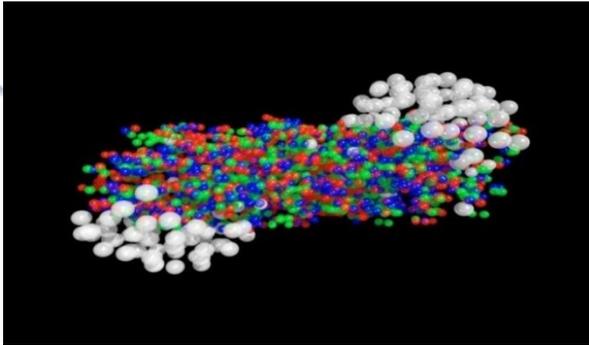


Schéma simplifié du big bang  
1: Big Bang  
2: Inflation  
3: Nucléosynthèse  
4: Formation des galaxies

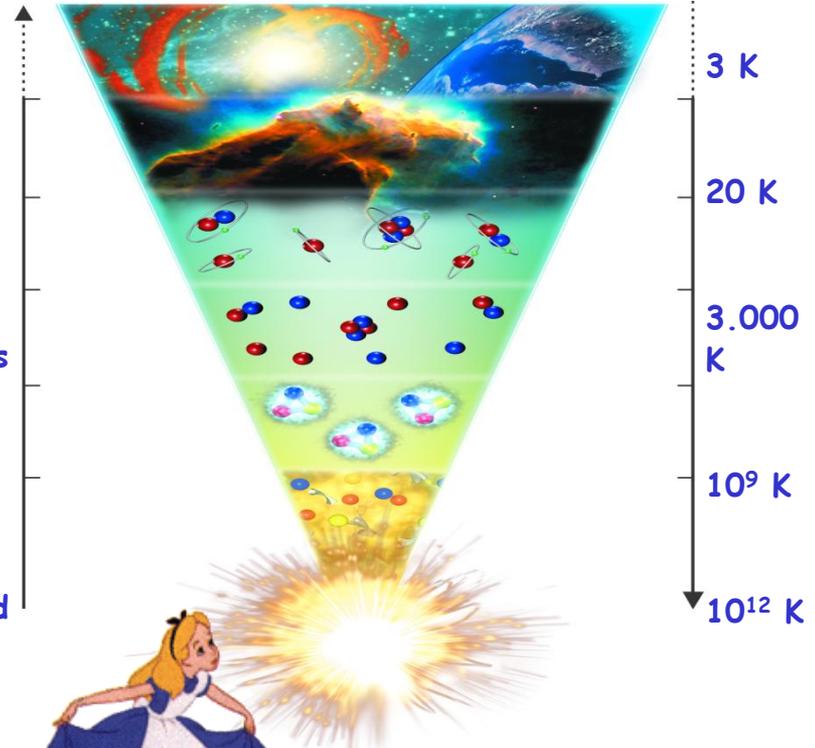
15 billion years

1 billion years

300.000 years

3 minutes

1/1000 second



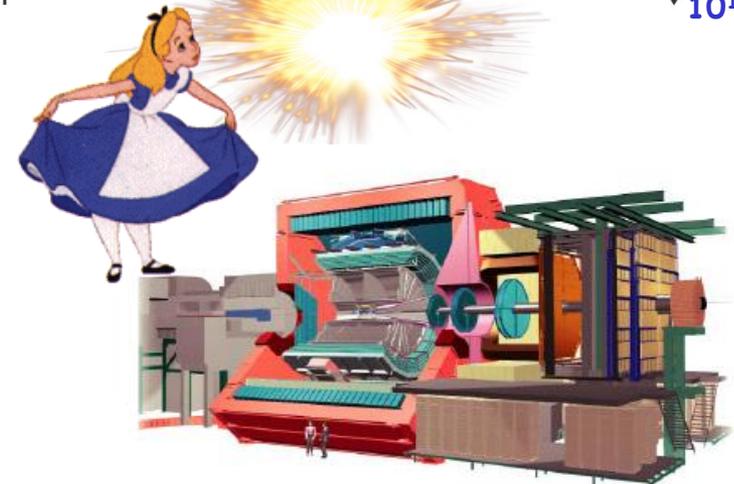
3 K

20 K

3.000 K

10<sup>9</sup> K

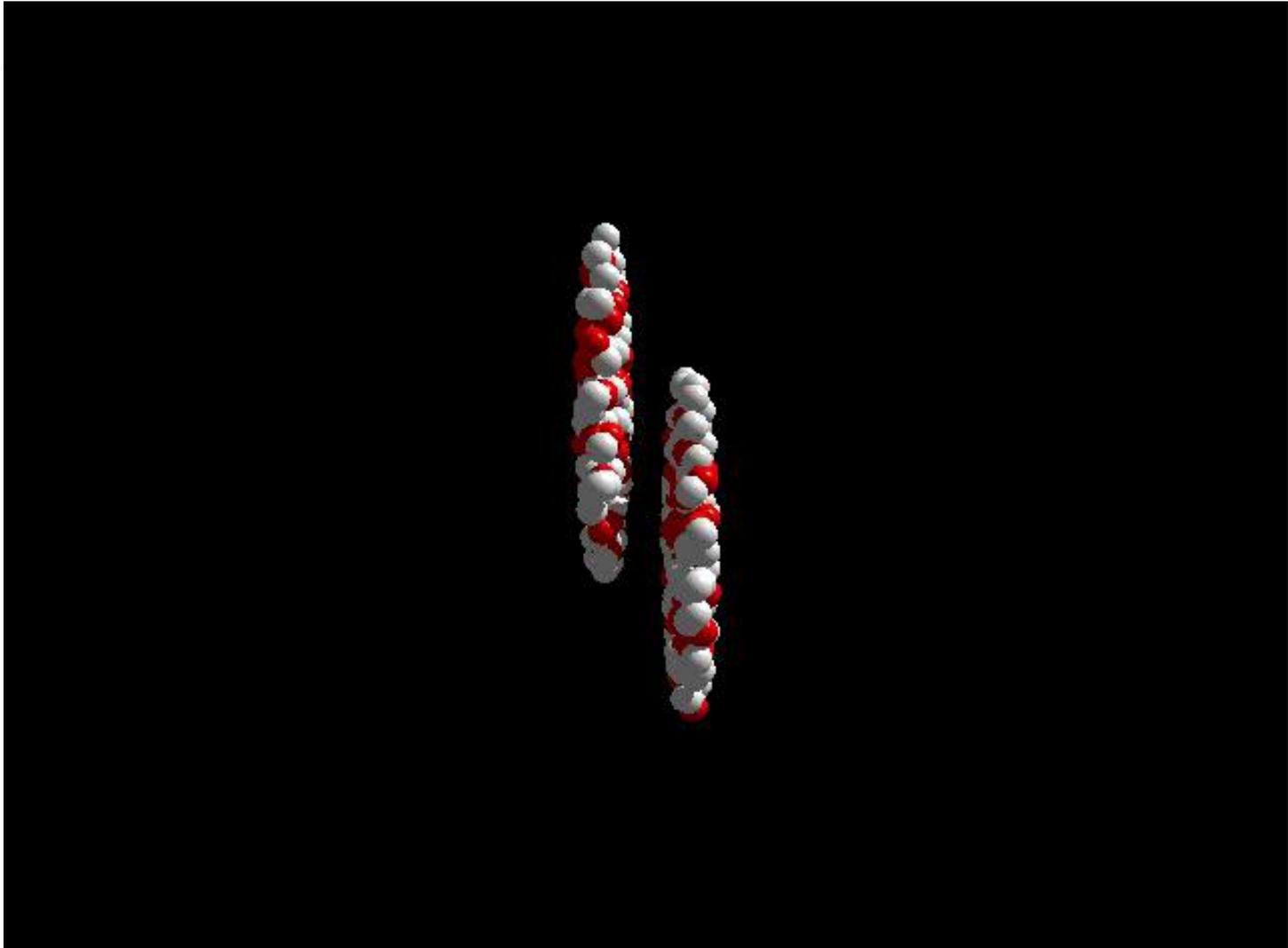
10<sup>12</sup> K



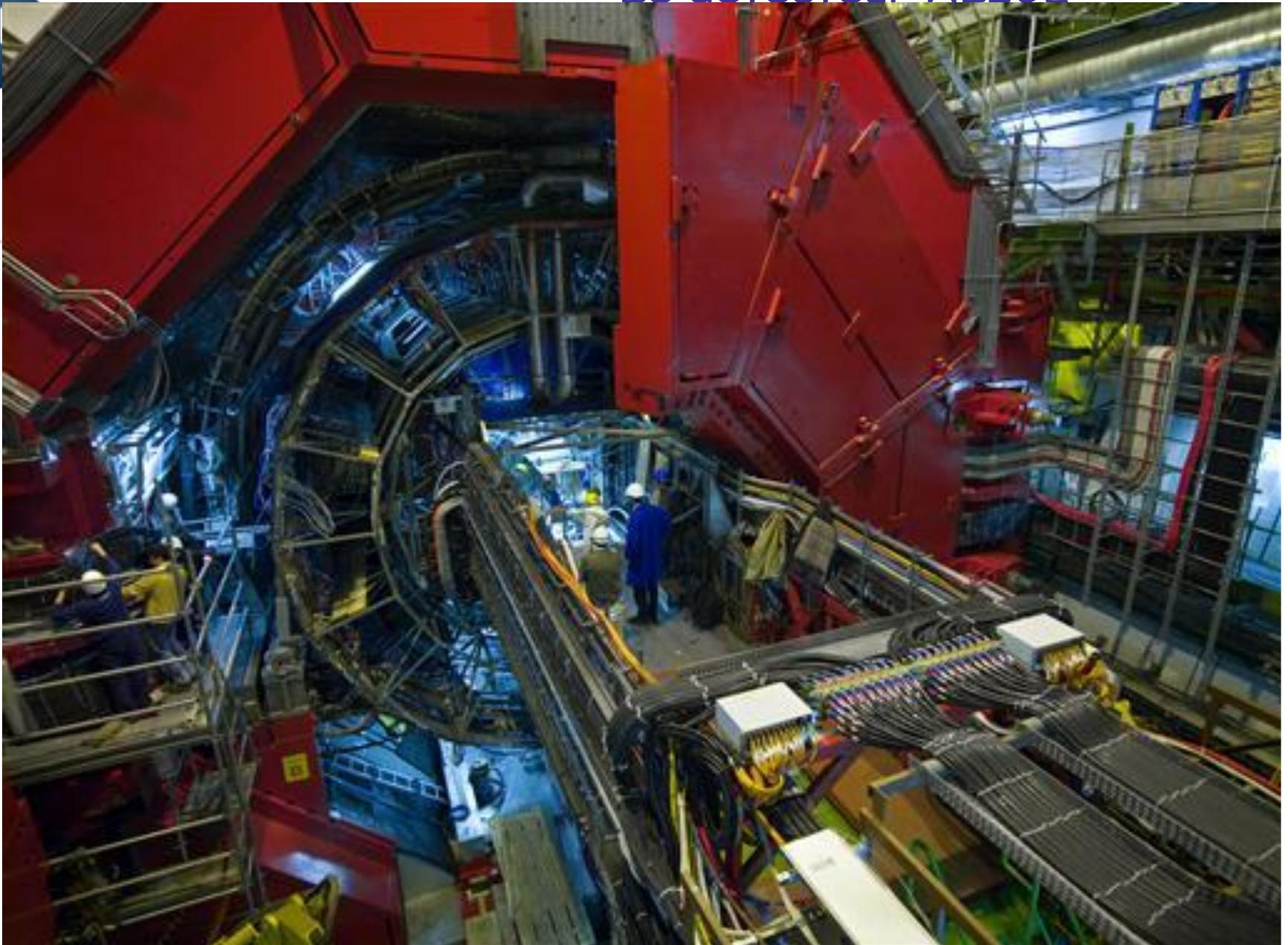
ALICE au CERN Recherche du Plasma de Quark et de Gluons

# Recréer les conditions du Big Bang c'est-à-dire la « soupe primordiale »

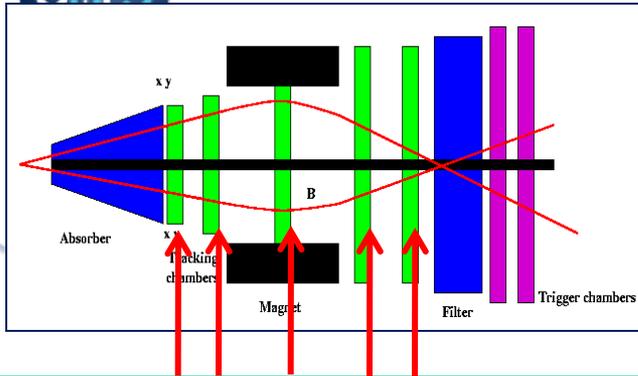
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# Le détecteur ALICE



# Le Bras Dimuon de ALICE

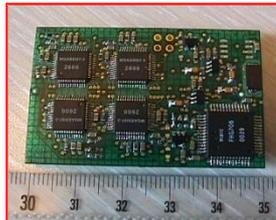


Electronique



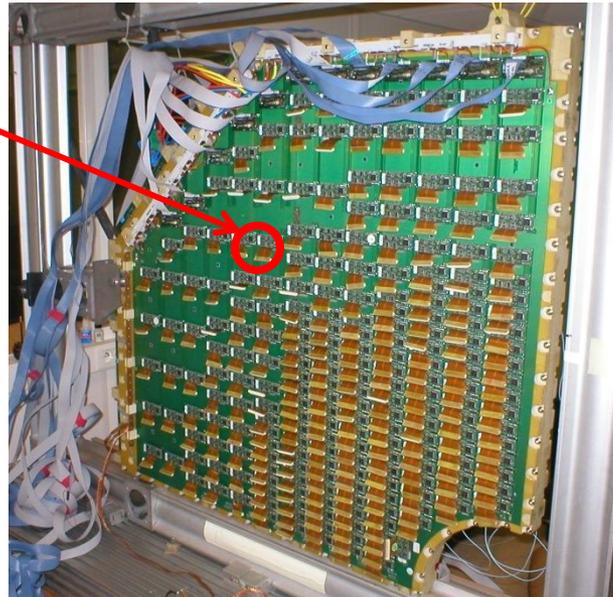
Etude et construction de l'électronique pour l'ensemble des chambres à fils

Cartes MANU  
(2 types)



64 voies  
Préamplificateurs Filtrés  
Multiplexage  
Conversion numérique  
Suppression de zéros

1 million de voies  
(20 000 cartes MANU)

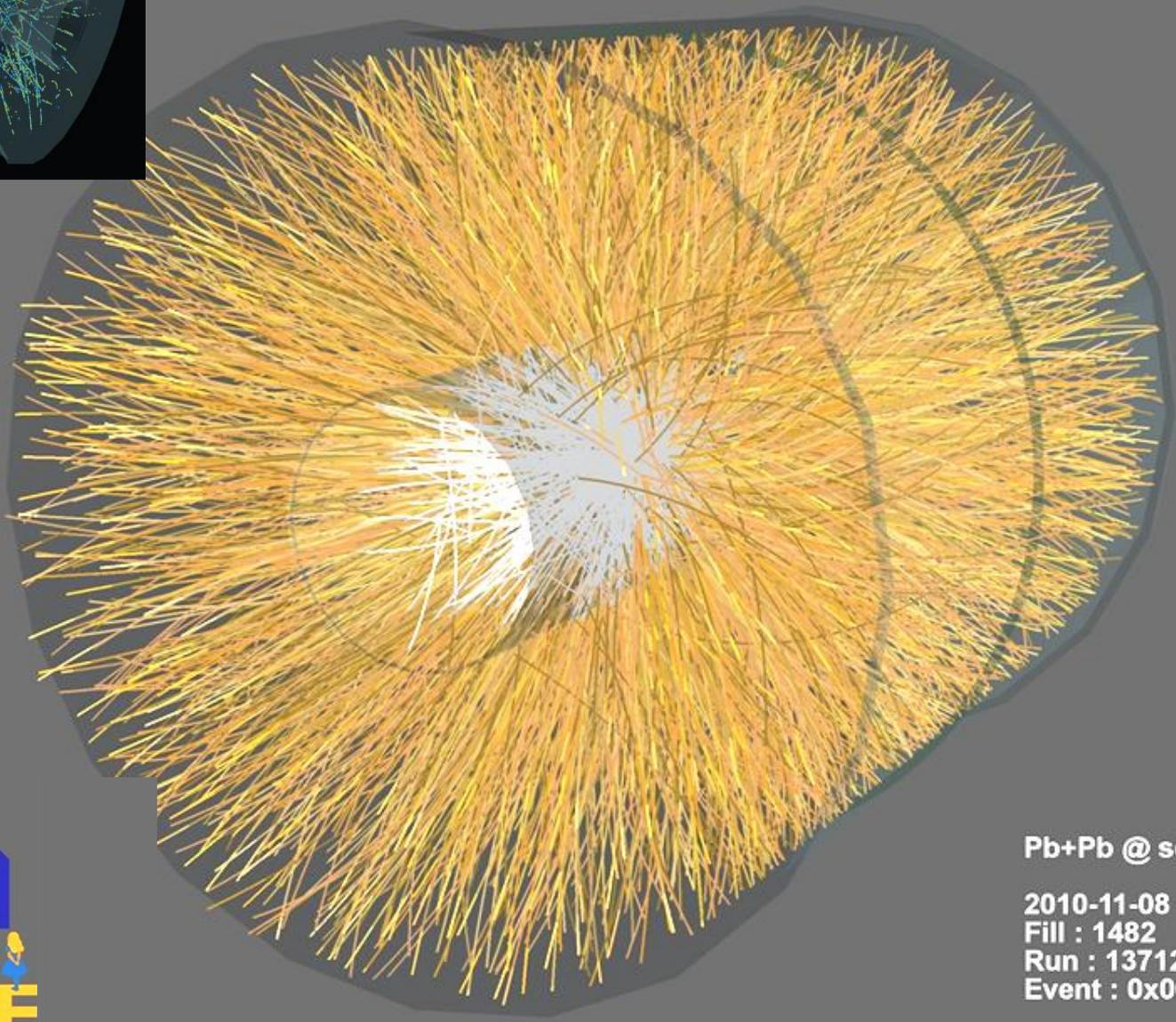
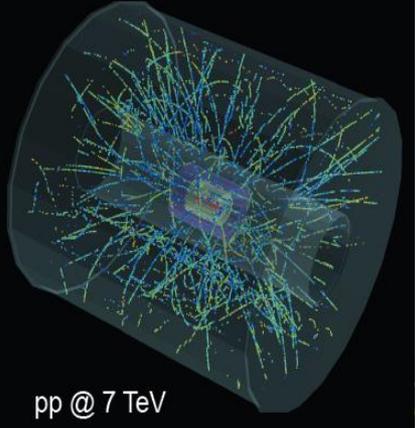


Lecture

Traitement numérique



Crocus



Pb+Pb @  $\sqrt{s} = 2.76$  ATeV

2010-11-08 11:30:46

Fill : 1482

Run : 137124

Event : 0x00000000D3BBE693



## ALICE à l'IN2P3

### 6 Laboratoires Principaux

LPC-Clermont<sup>1)</sup>, LPSC Grenoble<sup>2)</sup>,  
IPN-Lyon<sup>3)</sup>, IPHC-Strasbourg<sup>4)</sup>,  
IPN-Orsay<sup>5)</sup>, SUBATECH-Nantes<sup>6)</sup>

### Contributions majeures

Calorimétrie ECAL&DCAL<sup>2)6)</sup> + SSD<sup>4)6)</sup> + Muons trigger<sup>1)6)</sup> GMS<sup>5)</sup> tracker<sup>6)</sup>  
+ Logiciels et Calcul (CC IN2P3, T2's ...) etc.

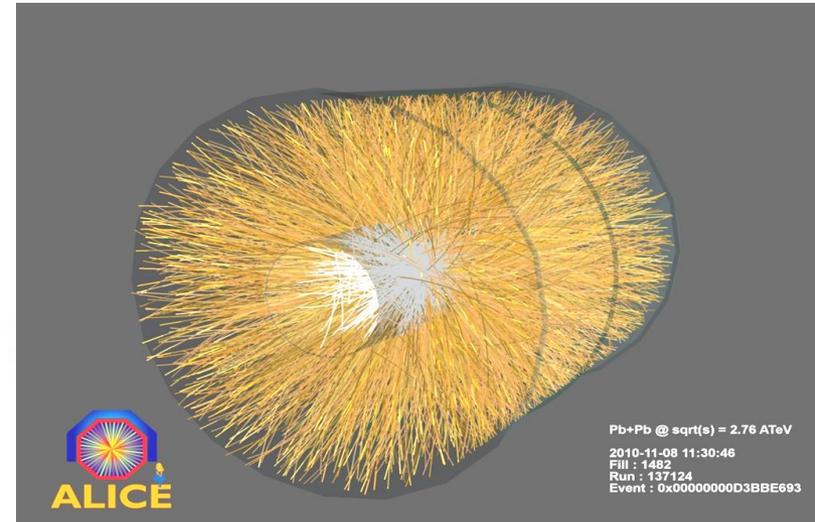
Contribution financière: 8.0% du "core" (i.e. 9.0/116 M€)

37 Permanents, 22 Post-doc & Doctorant(e)s

### Responsabilités majeures au sein de l'expérience ALICE:

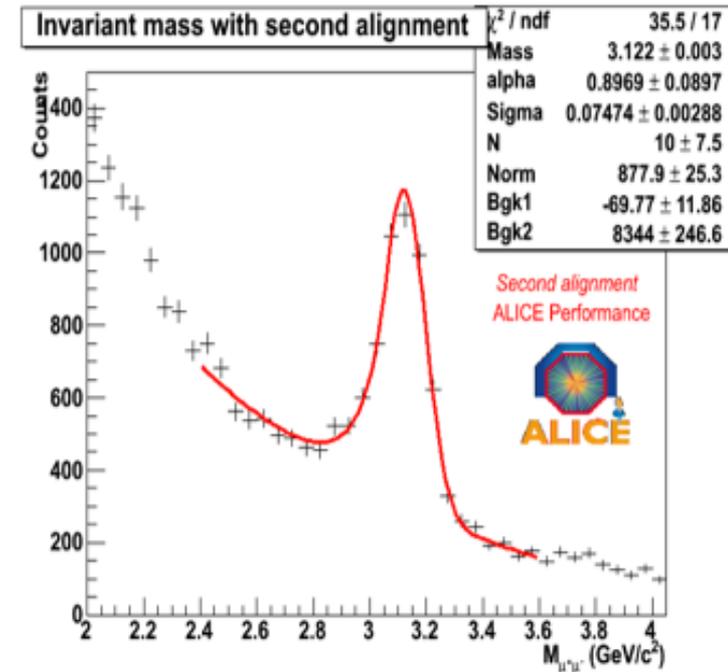
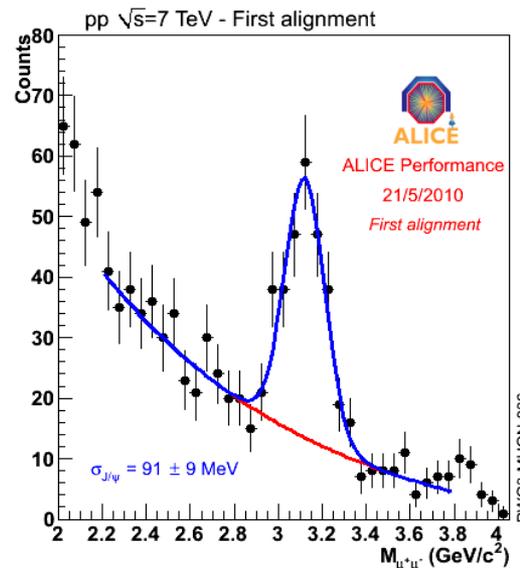
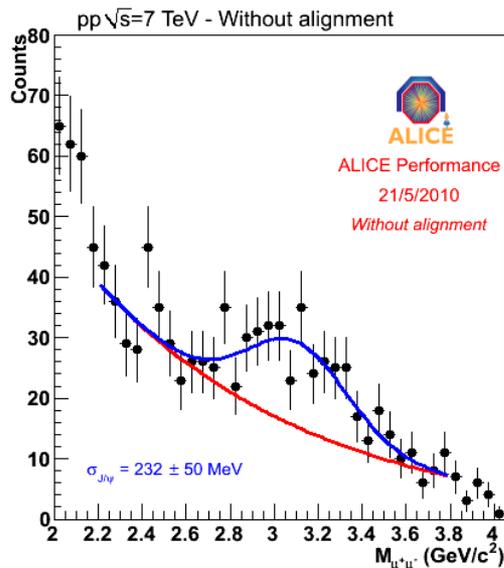
**A. Baldisseri**<sup>a</sup> (Project Leader MUON), **P. Dupieux** (Project leader MUON trigger),  
**J.-Y. Grossiord** (Project Leader V0), **Y. Schutz** (Porte Parole Adjoint)

+ diverses autres responsabilités centrales (sous-groupes de physique & coordination technique)

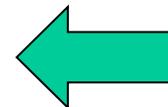


# Muon spectrometer alignment

No and 1<sup>st</sup> alignment      2<sup>nd</sup> alignment

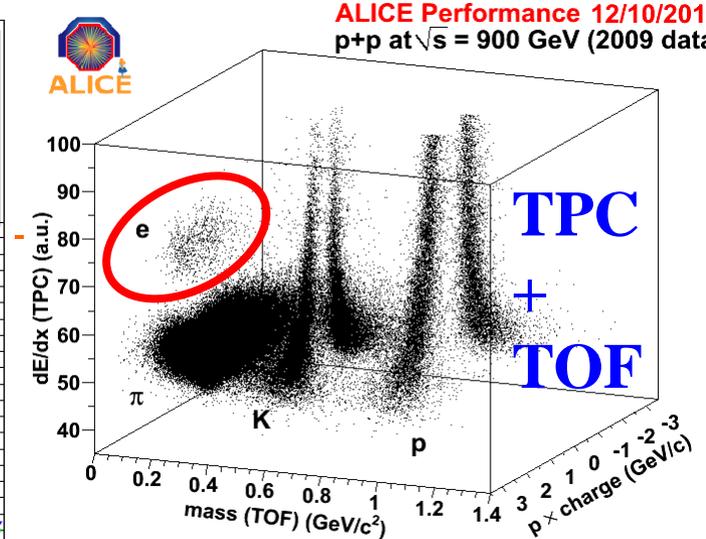
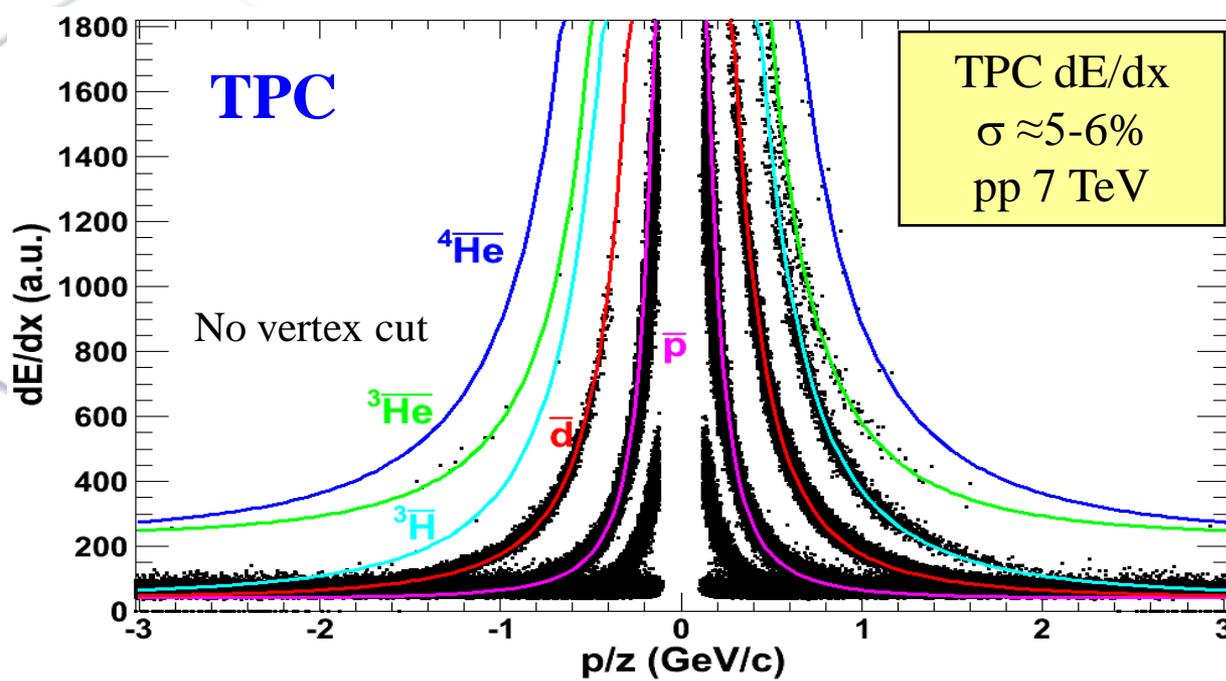


To be compared with expected performance with perfect alignment of 70 MeV

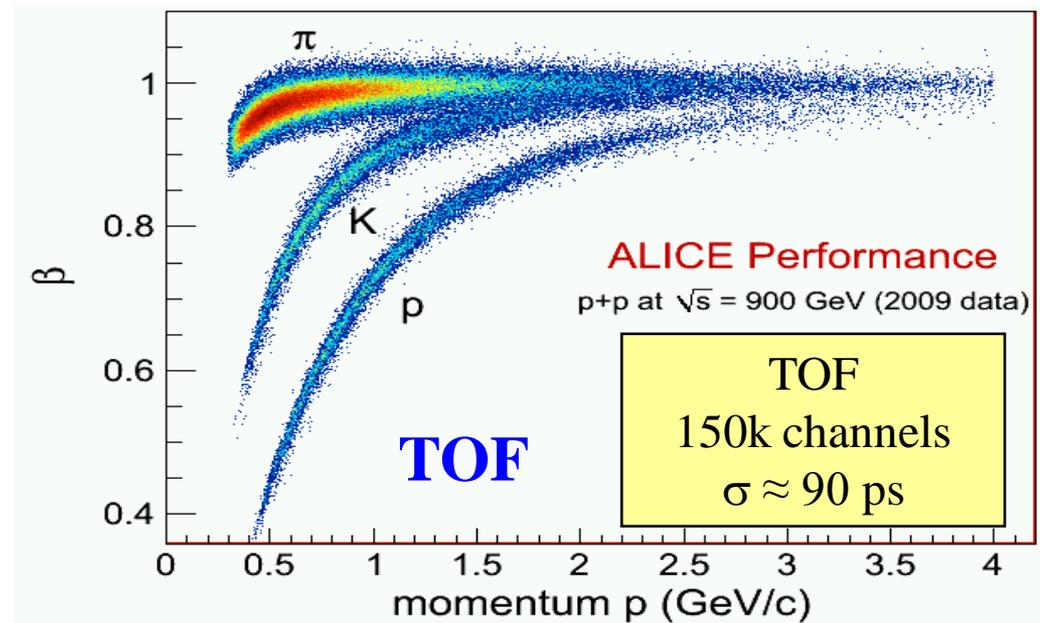
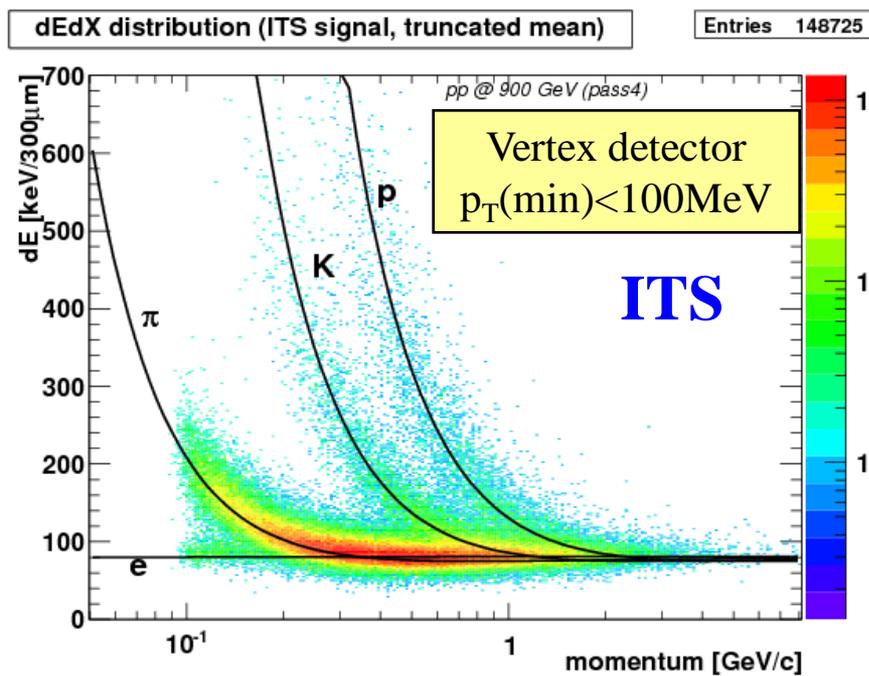


$$\sigma_{J/\psi} = (75 \pm 3) \text{ MeV/c}^2$$

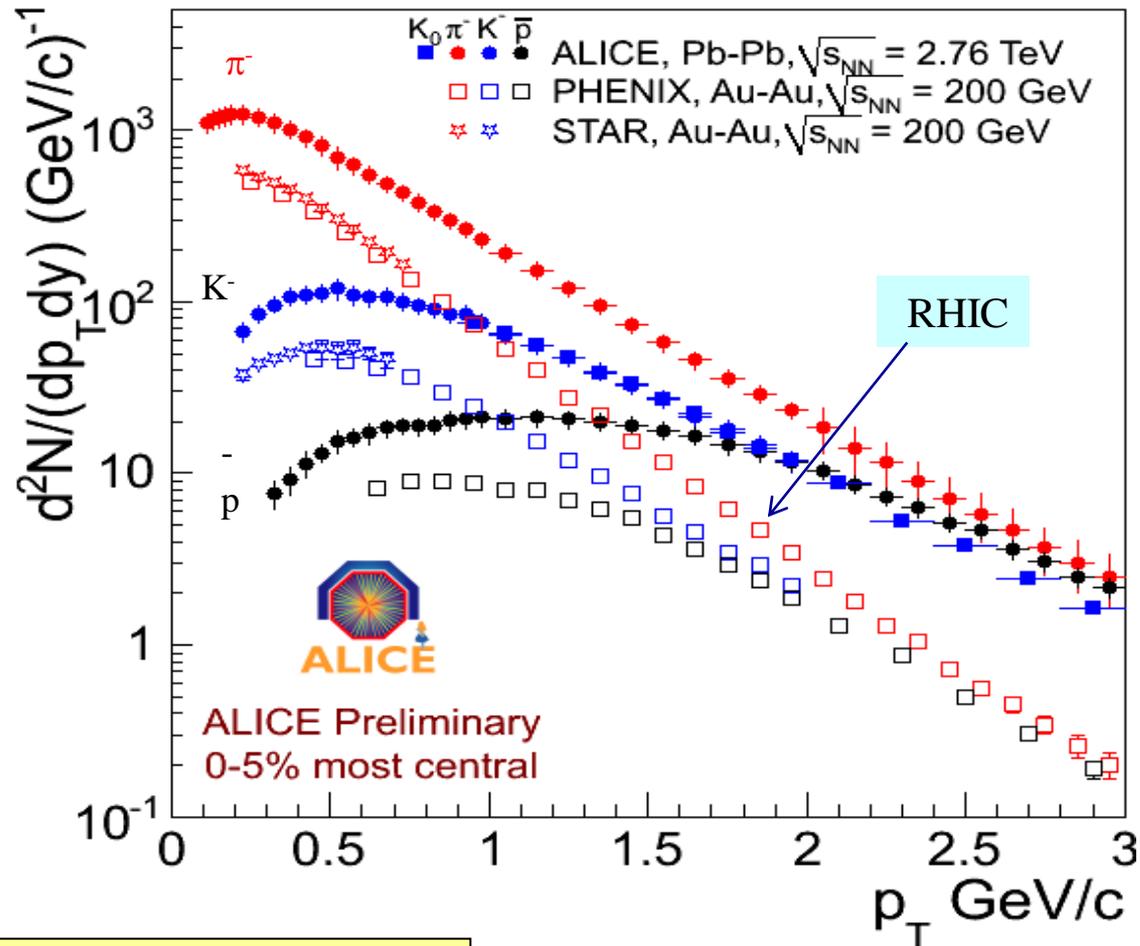
Courtesy of Paolo Giubellino



**PID**



# Identification de spectres de particules



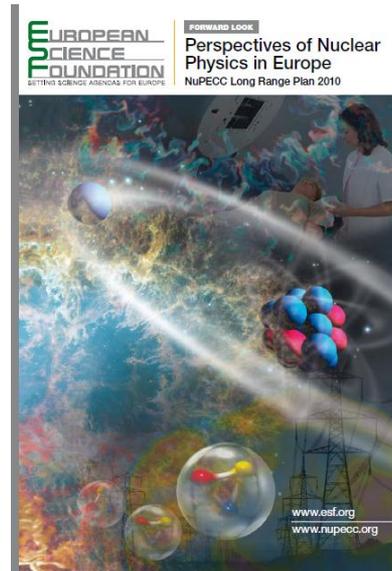
Changement très significatif des pentes par rapport aux résultats de RHIC  
 Encore plus dramatique pour les protons

# NuPECC LRP2010 Recommendations

- **Complete ESFRI Facilities**
  - FAIR with PANDA, CBM, NuSTAR and FLAIR
  - SPIRAL2 at GANIL including S3 and DESIR
- **Complete Major Upgrades**
  - HIE-ISOLDE at CERN
  - SPES at INFN-LNL
  - AGATA
- **Enhance potential of ALICE**
  - Fully develop nuclear beam programme
  - Upgrade to new kinematical regime



- **Support Theory**
  - Develop projects for advanced studies related to the experimental roadmap
  - ECT\* in Trento
- **Existing Facilities**
  - Fully exploit the currently existing large scale facilities
  - Fully exploit smaller scale national and University Nuclear Physics laboratories across Europe dedicated to nuclear structure and astrophysics experiments





**IN2P3**

Institut national de **physique nucléaire**  
et de **physique des particules**

**Merci**

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