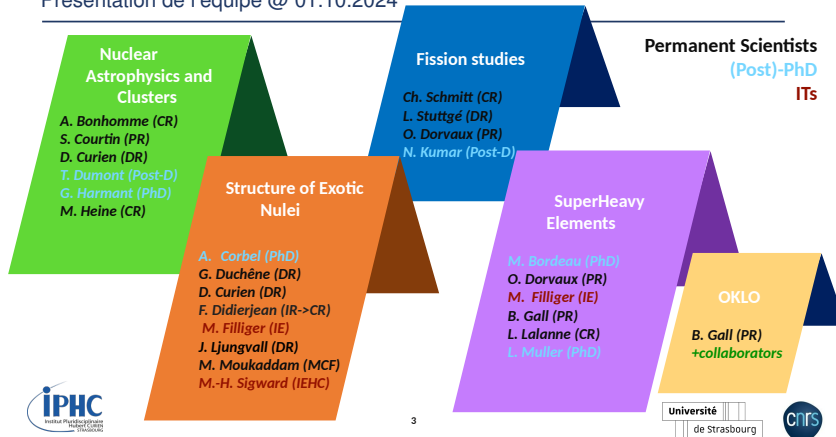# DNE - with focus on Nuclear Structure and in-beam γ-ray spectroscopy

J. Ljungvall

October 11, 2024

Some words about Du Noyau aux Étoiles
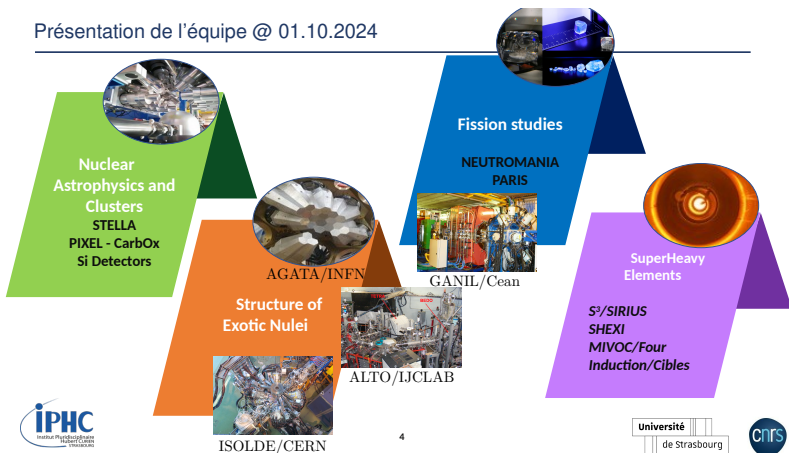
Présentation de l'équipe @ 01.10.2024

Permanent Scientists
(Post)-PhD
ITs

Nuclear Astrophysics and Clusters

A. Bonhomme (CR)
S. Courtin (PR)
D. Curien (DR)
T. Dumont (Post-D)
G. Harmant (PhD)
M. Heine (CR)

Fission studies

Ch. Schmitt (CR)
L. Stuttgé (DR)
O. Dorvaux (DR)
N. Kumar (Post-D)

Structure of Exotic Nulei

A. Corbel (PhD)
G. Duchêne (DR)
D. Curien (DR)
F. Didierjean (IR->CR)
M. Filliger (IE)
J. Ljungvall (DR)
M. Moukaddam (MCF)
M.-H. Sigward (IEHC)

SuperHeavy Elements

M. Bordeau (PhD)
O. Dorvaux (PR)
M. Filliger (IE)
B. Gall (PR)
L. Lalanne (CR)
L. Muller (PhD)

OKLO

B. Gall (PR)
+collaborators

IPHC
Institut Pluridisciplinaire Hubert Curien

3

Université de Strasbourg

cnrs

Slide from Olivier Dorvaux

Some words about Du Noyau aux Étoiles

Présentation de l'équipe @ 01.10.2024

Nuclear Astrophysics and Clusters
STELLA
PIXEL - CarbOx
Si Detectors

AGATA/INFN

Structure of Exotic Nulei

ALTO/IJCLAB

ISOLDE/CERN

Fission studies

NEUTROMANIA
PARIS

GANIL/Cean

SuperHeavy Elements

S³/SIRIUS
SHEXI
MIVOC/Four
Induction/Cibles

4

Slide from Olivier Dorvaux/modified JL

Some words about Du Noyau aux Étoiles

Présentation de l'équipe @ 01.10.2024

Slide from Olivier Dorvaux
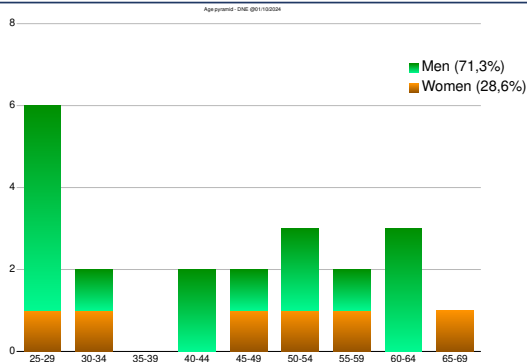
A very short ABC of Nuclear Structure

Nuclei are complex

- two fermion (neutrons and protons) systems.
- systems weakly bound by the non-central and 3(N)-body residual colour force.
- many-body systems showing both quantum and classical like behaviour.

  systems understood mainly within two paradigms.

A very short ABC of Nuclear Structure

The Nuclear Shell Model

https://arxiv.org/abs/1805.06501
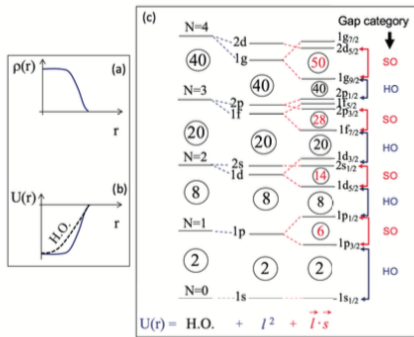
- The magic numbers
- Valid close to stability
- Modified for "exotic" nuclei

Final states given by diagonalisation with residual interaction taken form nucleon-nucleon scattering.

A very short ABC of Nuclear Structure

The nucleus as a macroscopic object with a shape

Spherical   Prolate   Triaxial   Oblate
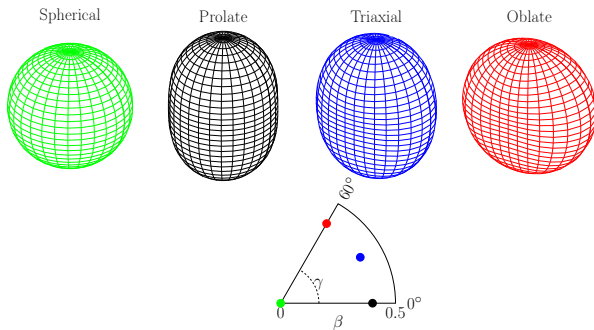
Here limited to quadrupole deformation.

A very short ABC of Nuclear Structure

"Shell-Model" like nucleus
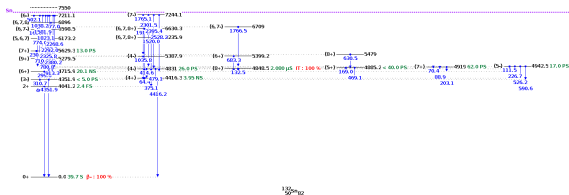
"Geometric nucleus"
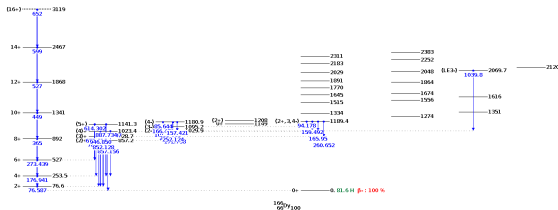
A very short ABC of Nuclear Structure

The need of high-resolution spectroscopy

- Binding energy $\approx$8 MeV/nucleon$\rightarrow$GeV
- Excited states keV to MeV

It is in these 1‰ variation all "physics" is!

Gamma-ray spectroscopy to our rescue

- Electromagnetic force weak, does not perturb the nuclear part
- High-Purity Germanium detectors offer resolution of keV!

Gamma-ray spectroscopy excellent tool to study properties of excited states in nuclei

- Excitation energy from E_γ
- Spin from angular distributions and correlations
- Parity from photon polarisation

  And in less direct ways

- Transition strengths
- Electromagnetic moments

I_i^π $\qquad\qquad\qquad E_i$

E_γ, L

I_f^π $\qquad\qquad\qquad E_f$
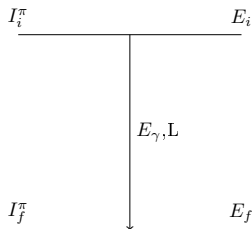
- $E_\gamma = E_i - E_f$
- $|I_i - I_f| < L < |I_i + I_f|$
- $\Delta\pi = -1^L$ for E
- $\Delta\pi = -1^{L+1}$ for M

A HPGe detector

Detector of n-type Ge diodes cooled to 77° K.

B p+ implantation

n-type

Li drifted n+ ~.5 mm

Passivation

n−p
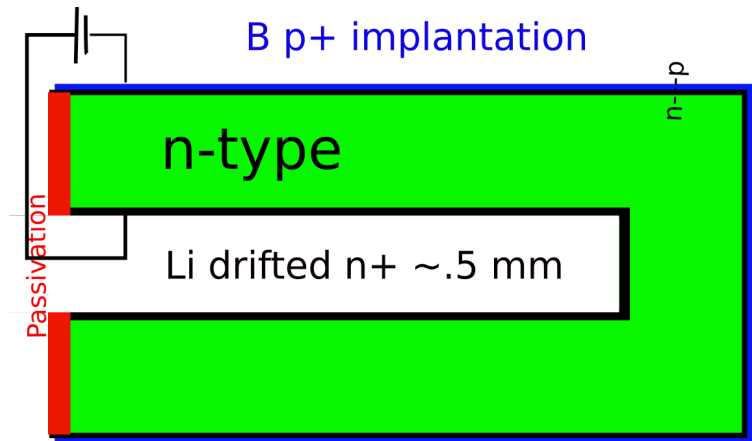
Gamma-ray spectrometers

A favorite example - AGATA
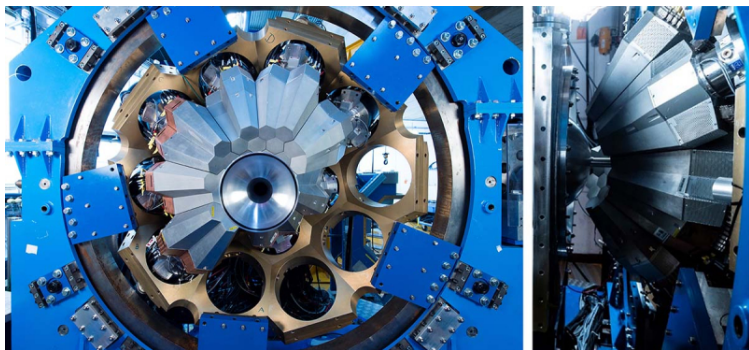
A travelling European project presently at INFN Legnaro, Italy

Gamma-ray spectrometers

A favorite example - AGATA
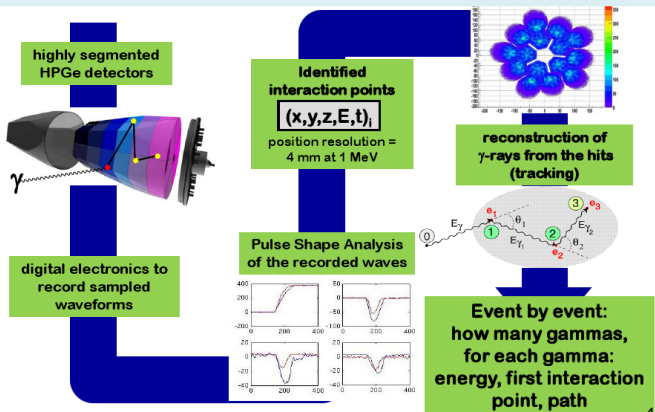
Gamma-ray spectrometers

A favorite example - AGATA

IPHC strongly involved

- "Scanning" of HPGe, response as function of position
- Mounting and testing AGATA Triple Clusters
- Detector modeling and pulse-shape analysis
- Primary investigators on experiments in each AGATA campaign

Gamma-ray spectrometers

A favorite example - AGATA

Lifetimes of excited states in ^{60}Fe - looking for competing shapes by measuring picosecond lifetimes
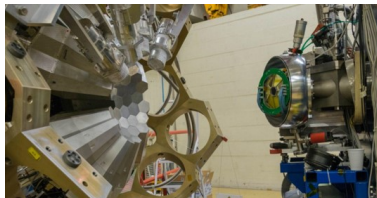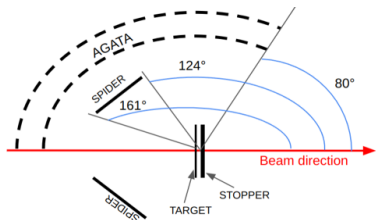
- ^{18}O beam on ^{58}Fe target
- Particle detector Spider to detect back-scattered ^{16}O ions
- Some 1000 channels of high-precision electronics

Gamma-ray spectrometers

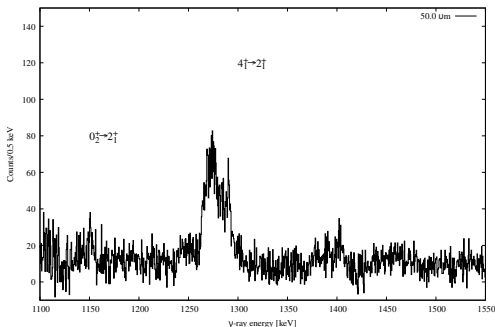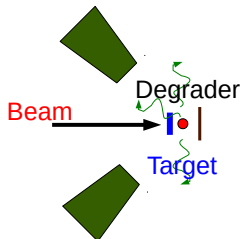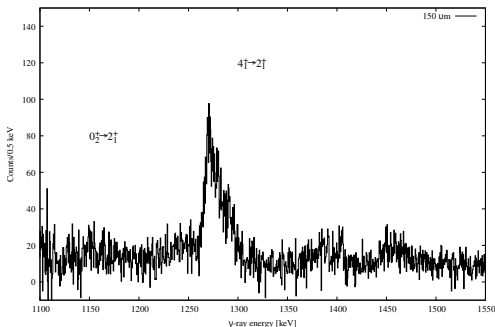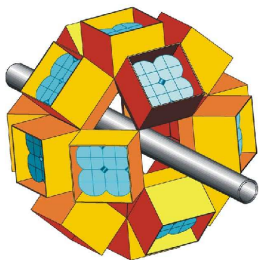## A favorite example - AGATA

Lifetimes of excited states in ^{60}Fe - looking for competing shapes by measuring picosecond lifetimes

Gamma-ray spectrometers

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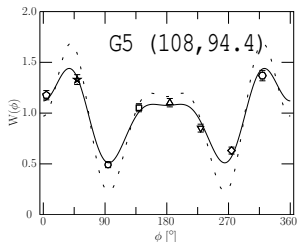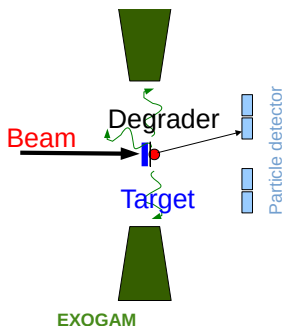
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Gamma-ray spectrometers

A second example - EXOGAM

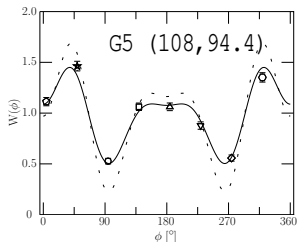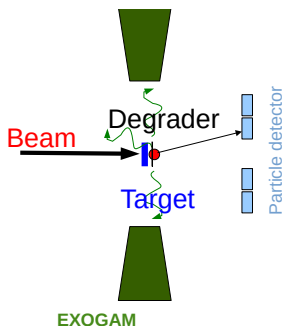Presently (and almost always) at GANIL, Caen, France

Gamma-ray spectrometers

A second example - EXOGAM

Recent experiment - measuring g-factor in ^{22}Ne

- g-factor is a property a single state
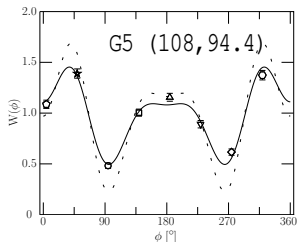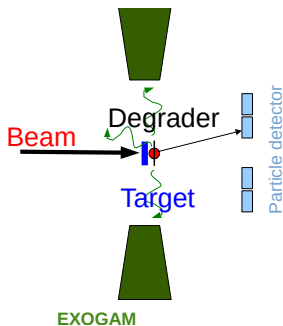- $\omega \propto \vec{J} \cdot g\vec{I}$, J electronic spin, I nuclear

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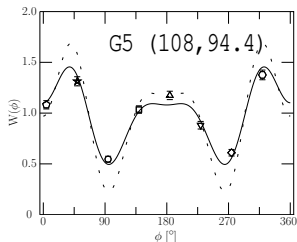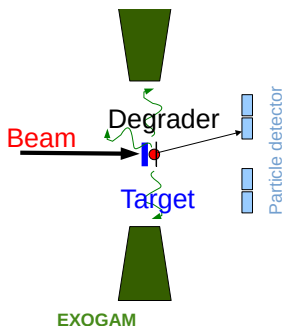
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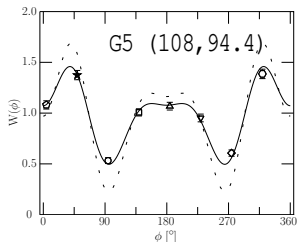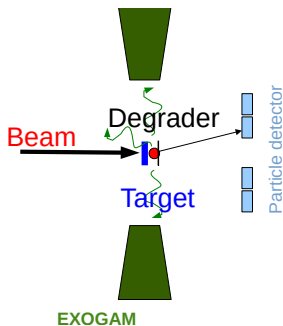- $\omega \propto \vec{J} \cdot g\vec{I}$, J electronic spin, I nuclear

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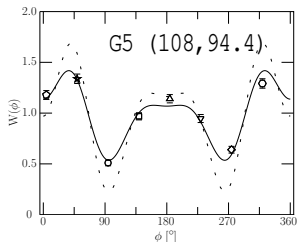- $\omega \propto \vec{J} \cdot g\vec{I}$, J electronic spin, I nuclear

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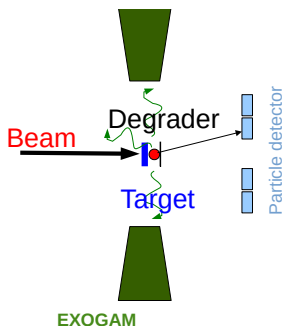
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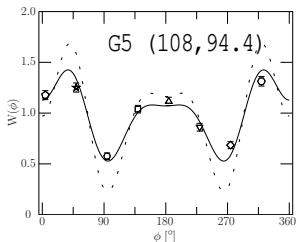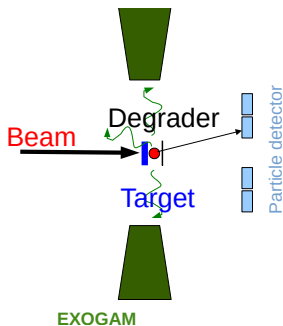
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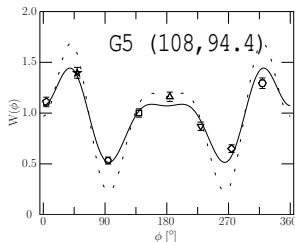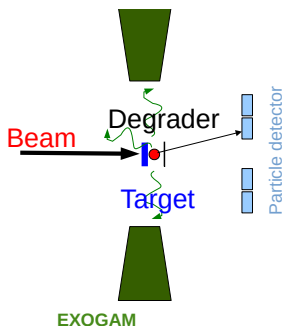- $\omega \propto \vec{J} \cdot g\vec{I}$, J electronic spin, I nuclear

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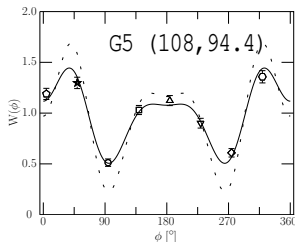- $\omega \propto \vec{J} \cdot g\vec{I}$, J electronic spin, I nuclear

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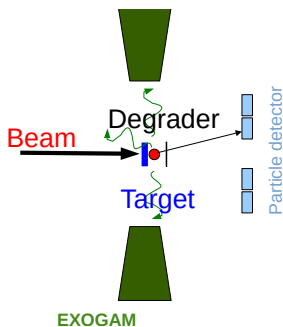
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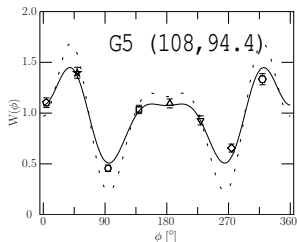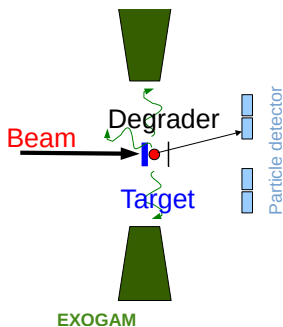
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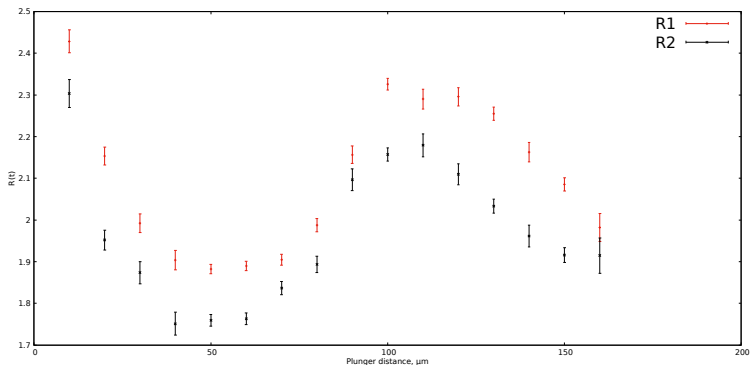- $\omega \propto \vec{J} \cdot g\vec{I}$, J electronic spin, I nuclear

Thank you