Study of Isospin simmetry using the PARIS detector

Alice Mentana

- The Isospin simmetry
- Isospin Mixing (breaking of Isospin simmetry)
- Experimental technique: γ-decay of GDR
- Experimental apparatus: the PARIS array (or GALILEO)
- Conclusion and future perspective

The Isospin simmetry

- ✓ The nuclear interaction is **charge independent**
- ✓ Neutrons (**n**) and protons (**p**) are different states of the same particle, the Nucleon (**N**)
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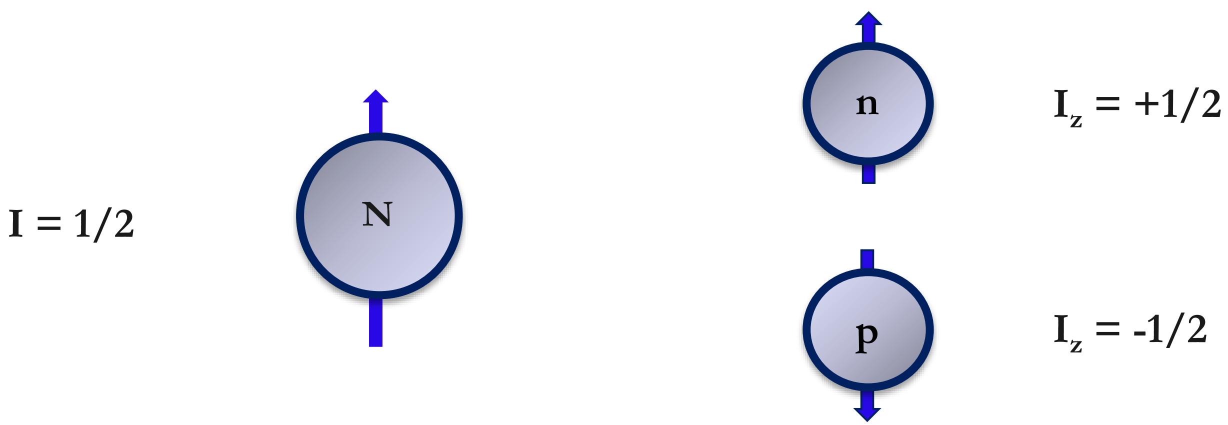
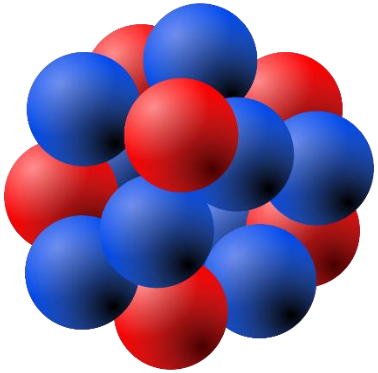


The Isospin simmetry

For a nucleus:



$I_z = (N - Z)/2$

$I_z \leq I \leq |I_z|$

nuclear ground state: minimum value of isospin $I = I_z$

N=Z nucleus → $I = I_z = 0$

Isospin Mixing

- ✓ Inside the nucleus, the presence of the **Coulomb interaction** induces a **mixing** between states with different isospin

- ✓ The mixing probability in the nuclear ground state is defined as:

$$\alpha^2 = \frac{|\langle I = 1|H_c|I = 0\rangle|^2}{\Delta E^2}$$

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How can we measure it?

In **N=Z** nuclei the **Electric Dipole transitions (E1)** in long-wavelength limit are forbidden in states with the same isospin:

Selection rule:

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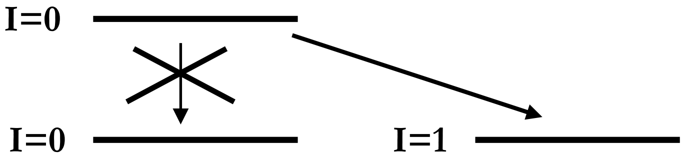

inhibition of γ-decay
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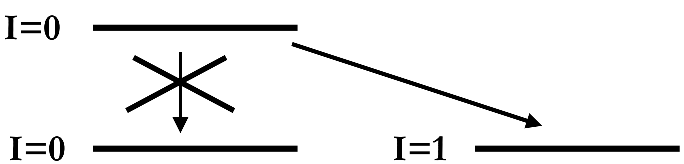

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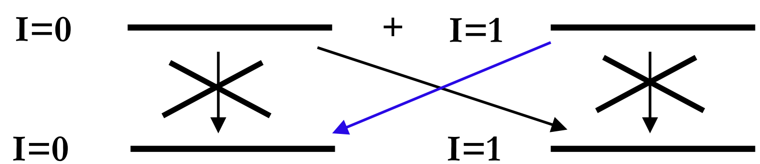
MIXING

$$|A\rangle = \beta|0\rangle + \alpha|1\rangle$$



The **mixing** increases the γ decay yield

↓

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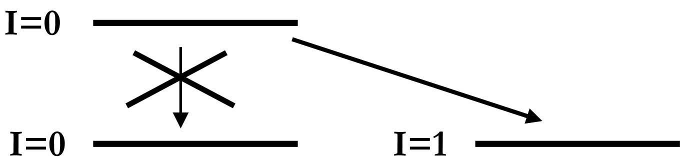

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E1 strength is concentrated in GDR

MIXING

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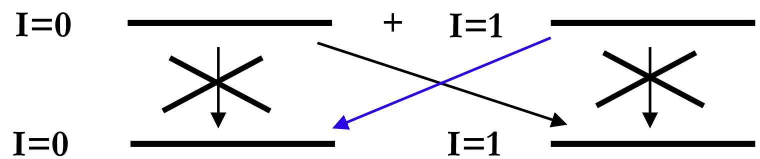

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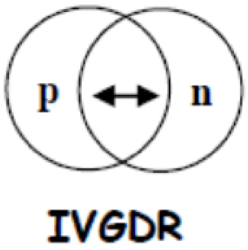
Giant Dipole Resonance (GDR)

- ✓ collective nuclear state
- ✓ macroscopic picture: protons and neutrons oscillate out of phase
- ✓ typical energy 15-18 MeV



De-excitation trough emission of high energy γ-rays or particles:

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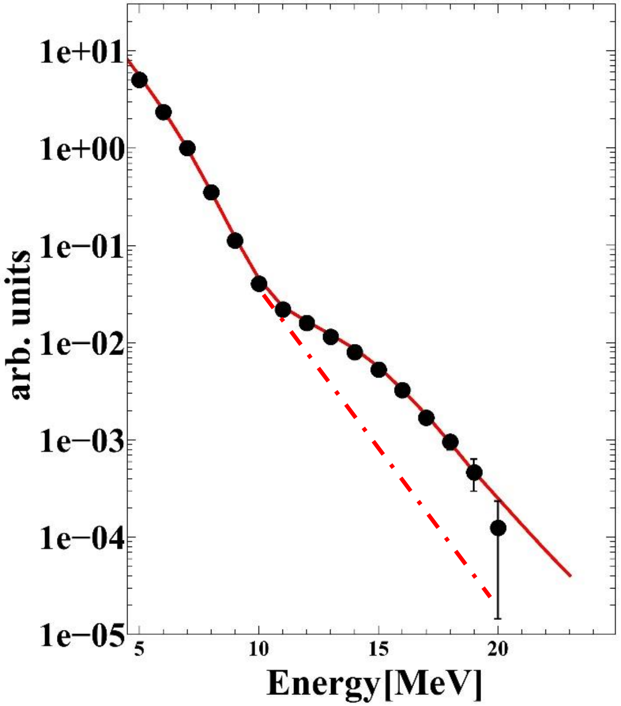
high detection efficiency



The fusion-evaporation Reaction

We form a I=0 Compound Nucleus with a heavy ion fusion reaction:

$$^{32}S + ^{28}Si \longrightarrow ^{60}Zn^{*}$$

(N=Z) (N=Z) (N=Z)

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We measure the γ-rays yield from the E1 decay of the GDR built on the CN (first step)

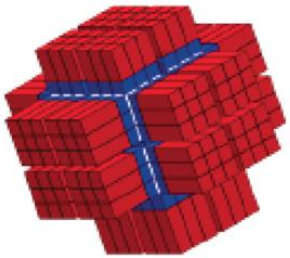
What do we need ?

- ✓ Detection of high energy γ-rays → **high efficiency detector**
- ✓ γ-rays multiplicity (CN spin distribution) → **multiplicity filter**

⇩

PARIS **Array (*"Photon Array for studies with Radioactive Ion and Stable beams"*)**

final configuration:
256 detectors
(4πgeometry)



now: we are **testing the first cluster**
"PARIS Prototype"

PARIS array

large array of phoswich detector expected to measure gamma-rays over a wide range of energy

phoswich ("*phos*phor sand*wich*") = scintillation detection system consisting of two or more different scintillators, optically coupled to each other and to a common photomultiplier tube.

PARIS array

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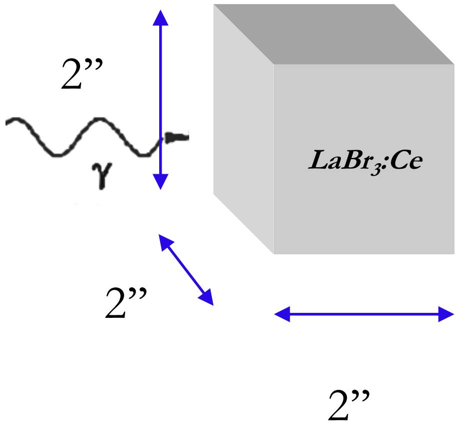

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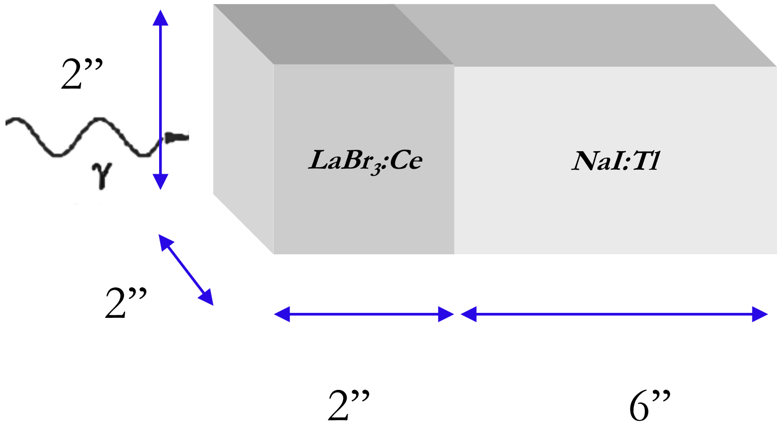

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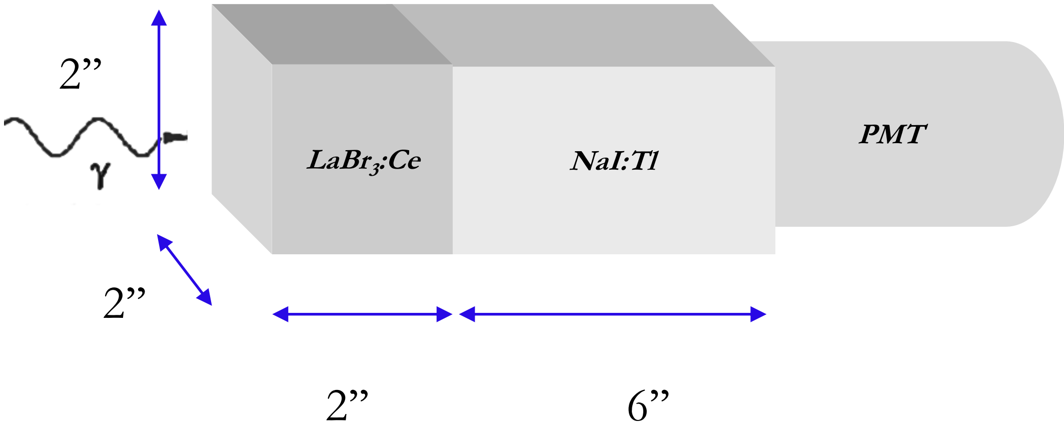

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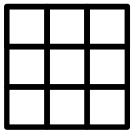
1 PARIS cluster: 9 detectors

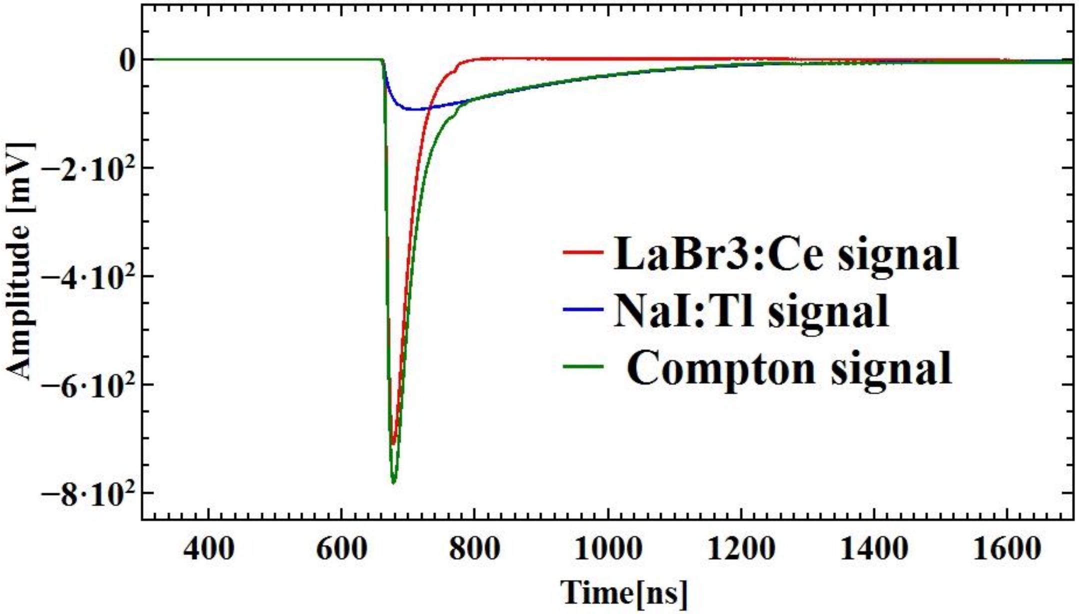


- ✓ LaBr$_3$:Ce crystals for multiplicity filter
- ✓ NaI:Tl crystals for high efficiency

PARIS array

Phoswich detector:

The crucial point is to be able to where the interaction occurs



PARIS array

Phoswich detector:

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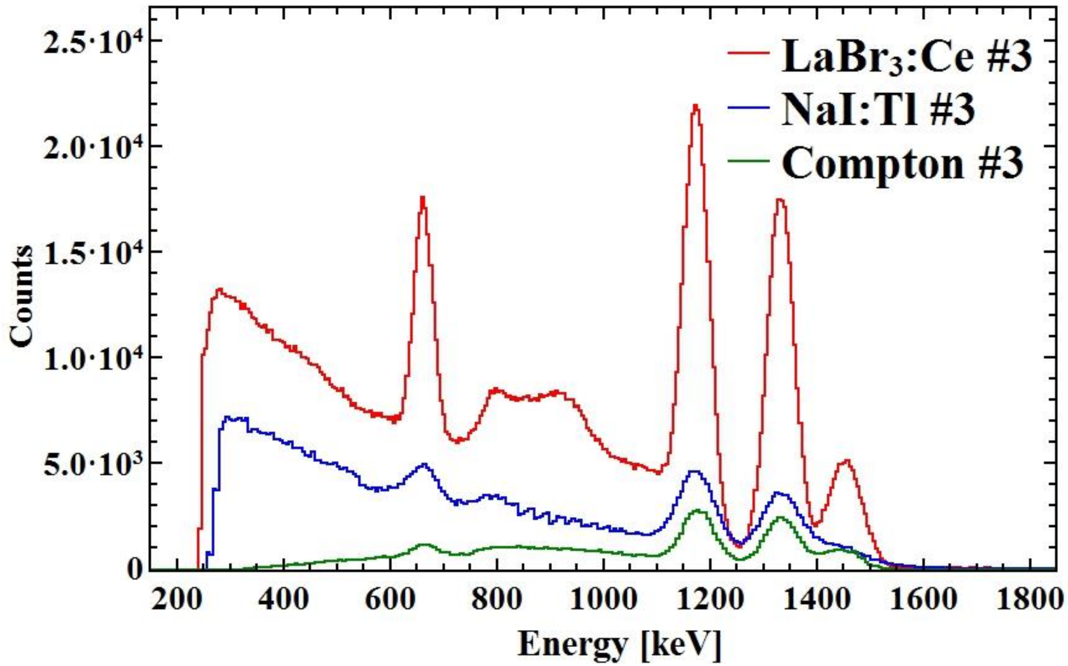
Multiplicity Filter:

⇩

only $LaBr_3$:Ce



High efficiency:

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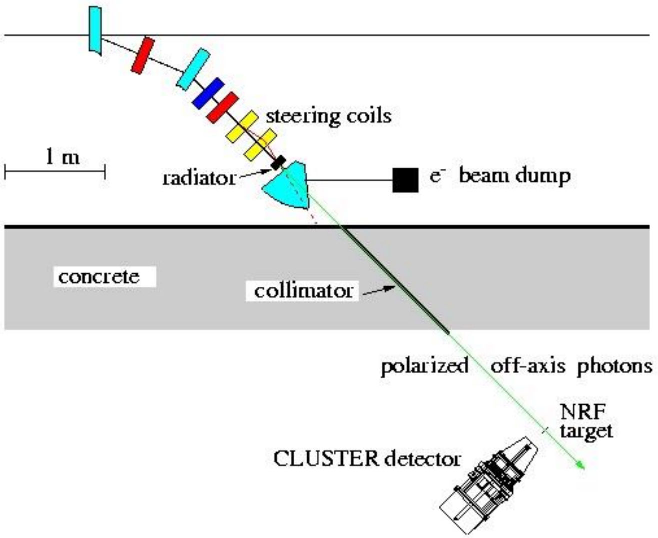
detector as a whole

PARIS cluster test

in beam (Dresden) with sources (Milan)



⇨ GOALS:

- ✓ Fix a poswich calibration method (based on signals separation)
- ✓ Analyze the cluster response to high energy γ rays

Conclusion

- ✓ The study of **Isospin simmetry** in atomic nucleus is an interesting topic for nuclear structure

- ✓ We want to study the Isospin Mixing probability ($\boldsymbol{\alpha}^2$) in N=Z nuclei using the GDR γ-decay as a probe.

- ✓ **PARIS** is a suitable array for this measurement: high efficiency and high granularity.

  Need of:
  - ✓ complete characterization of the array (**…work in progress…**)
  - ✓ more than 1 cluster: ~ 4 clusters = 36 phoswhiches

Future perspectives

- ✓ To conclude the characterization of the PARIS array
- ✓ Isospin Mixing experiment using the PARIS array:
  as soon as 4 clusters will be available
- ✓ We **propose** to measure the Isospin Mixing using another array:
  GALILEO (HPGe detectors) + $LaBr_3$:Ce detectors **@ LNL in 2016**

Thanks for your attention!