Photon induced γ-γ coincidence experiments at the γ³-setup at HIγS

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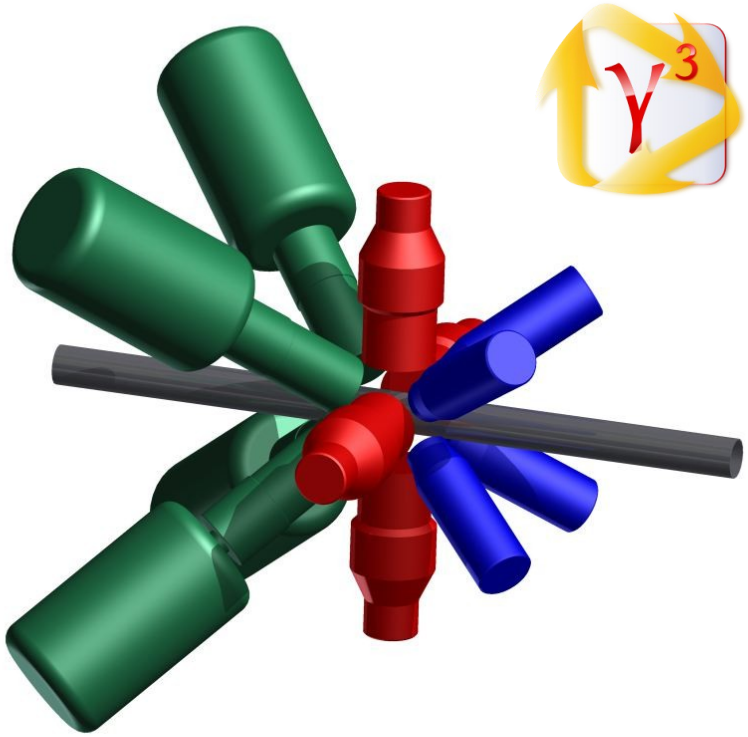

HGS-HIRe for FAIR
Helmholtz Graduate School for Hadron and Ion Research

FIAS Frankfurt Institute for Advanced Studies

Motivation

New experimental possibilities at γ^3 to study decay patterns

- Study of the Pygmy Dipole Resonance
- Deeper Investigation of the Scissors Mode
- Two phonon excitations in light and heavy nuclei

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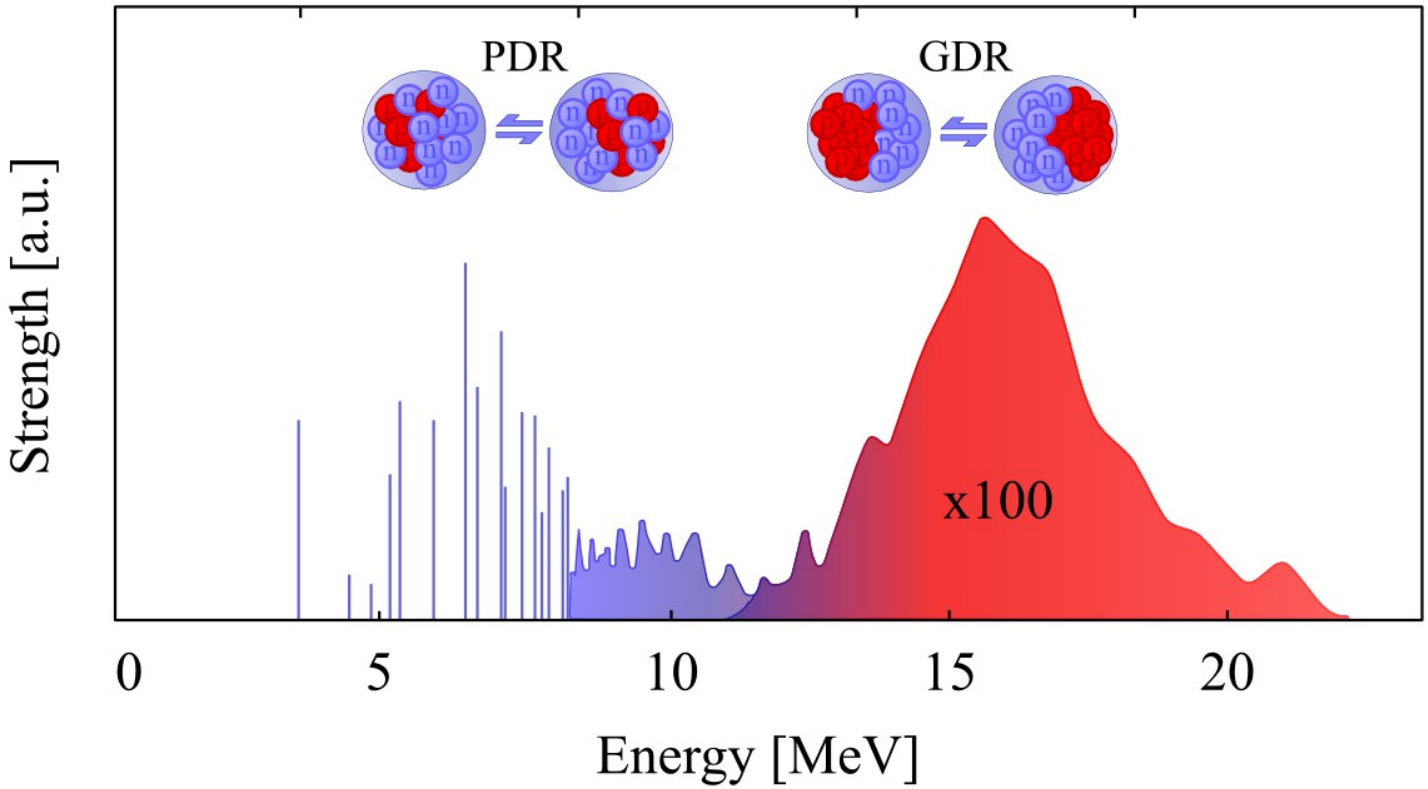
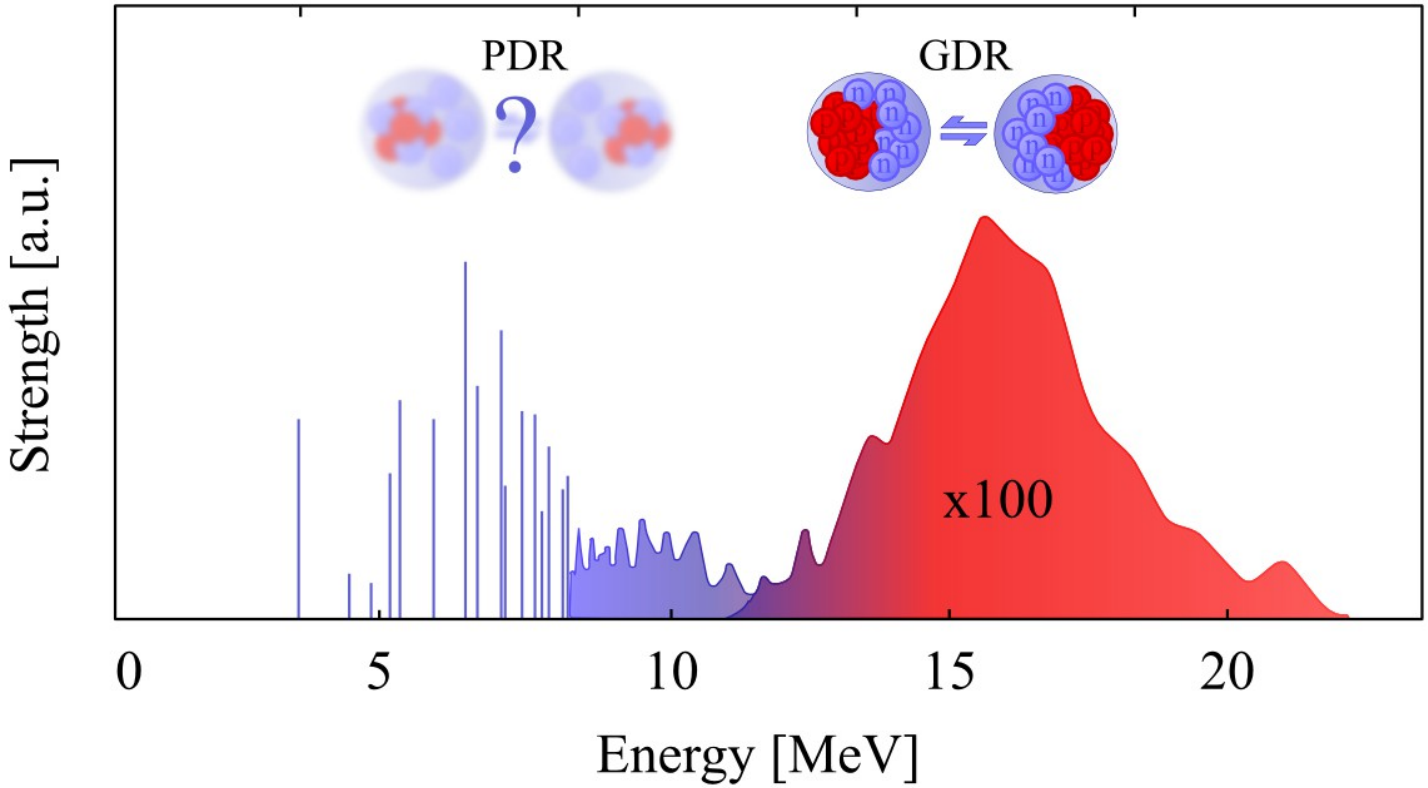


Photoresponse of (spherical) nuclei

- GDR: Oscillation of Neutrons vs. Protons
- PDR: Oscillation of Neutron skin vs. Core

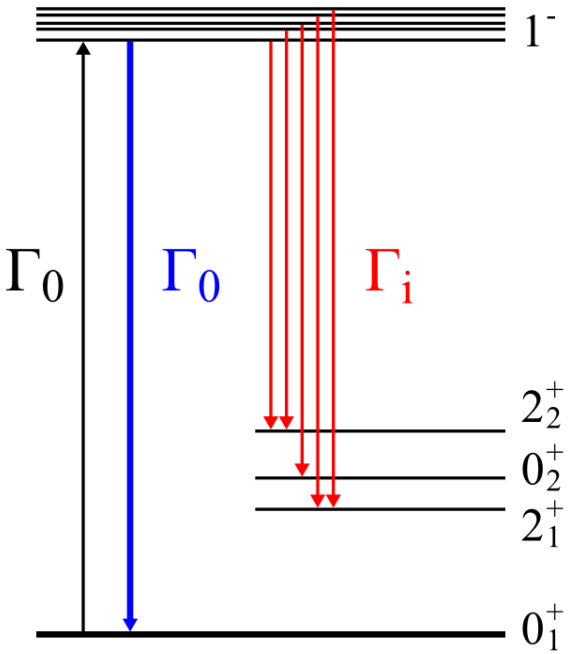
Motivation



Photoresponse of (spherical) nuclei

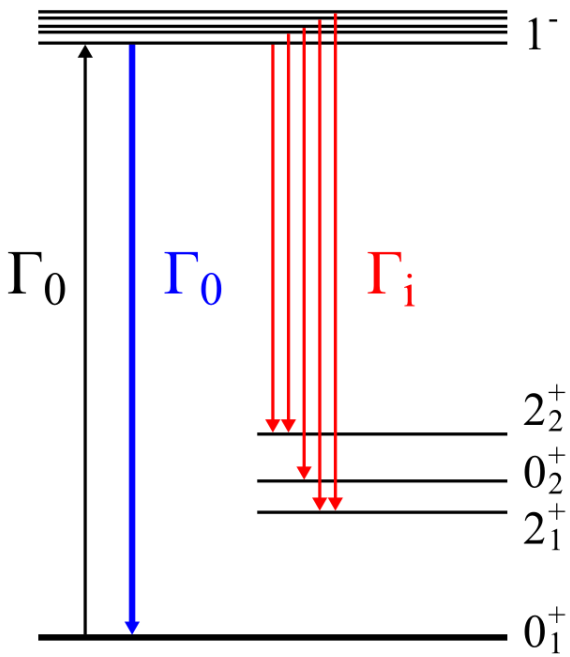
- GDR: Oscillation of Neutrons vs. Protons
- PDR: Oscillation of Neutron skin vs. Core
  → Investigate decay behavior

Experimental Method



- Decay „elastic“ (Γ_0) or „inelastic“ (Γ_i)
- Elastic channel dominant: ($\Gamma_0 \gg \Gamma_i$)

Experimental Method

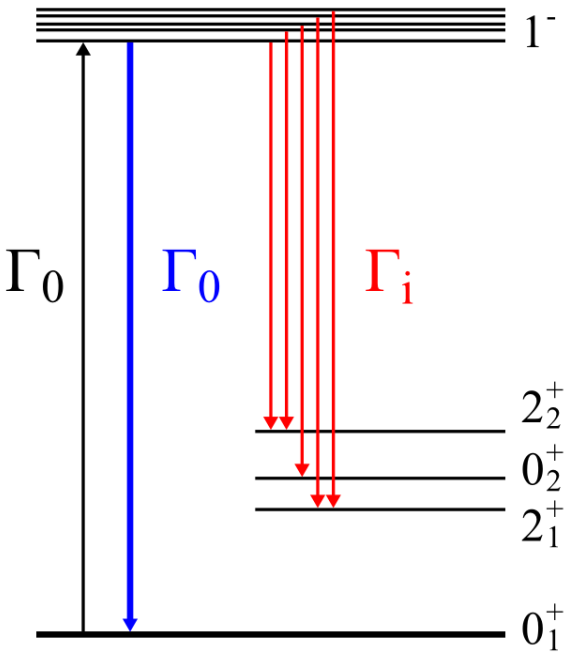


- Decay „elastic“ (Γ_0) or „inelastic“ (Γ_i)
- Elastic channel dominant: ($\Gamma_0 \gg \Gamma_i$)

Experimental challenge:

- Observe transitions with small branching (≈1%)

Experimental Method

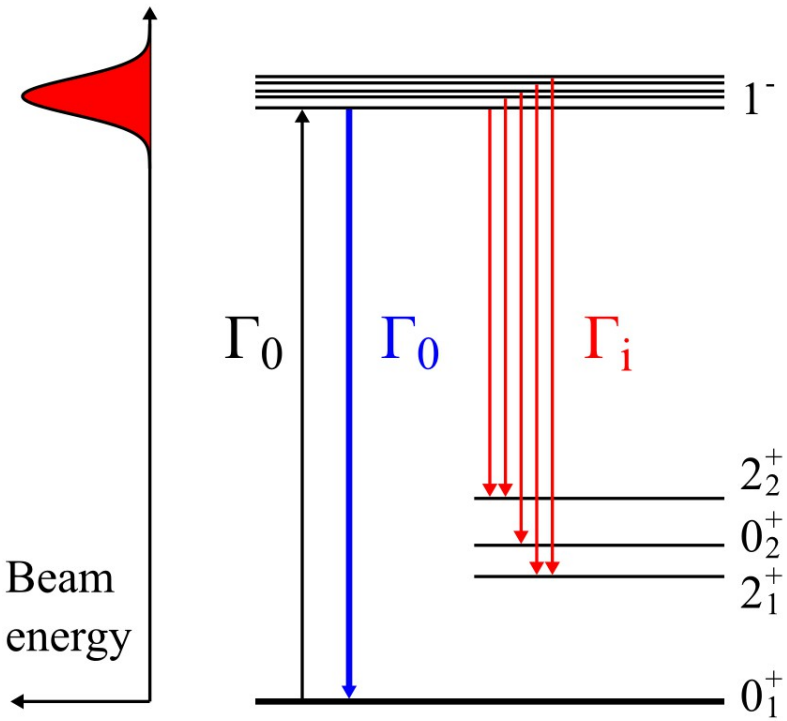


- Decay „elastic“ (Γ_0) or „inelastic“ (Γ_i)
- Elastic channel dominant: ($\Gamma_0 \gg \Gamma_i$)

Use:

- Selectivity of NRF reaction

Experimental Method

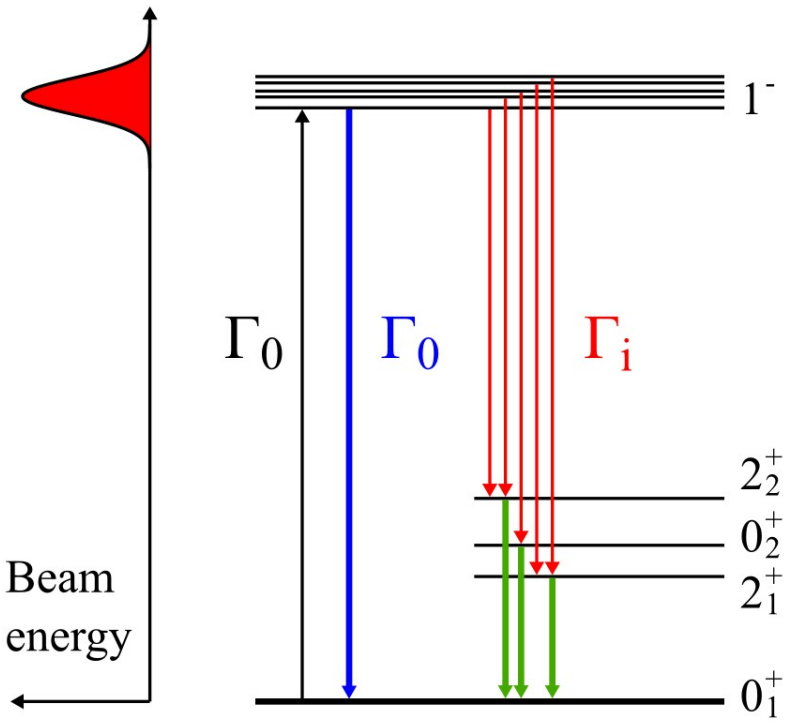


- Decay „elastic“ (Γ_0) or „inelastic“ (Γ_i)
- Elastic channel dominant: ($\Gamma_0 \gg \Gamma_i$)

Use:

- Selectivity of NRF reaction and mono-energetic beam

Experimental Method

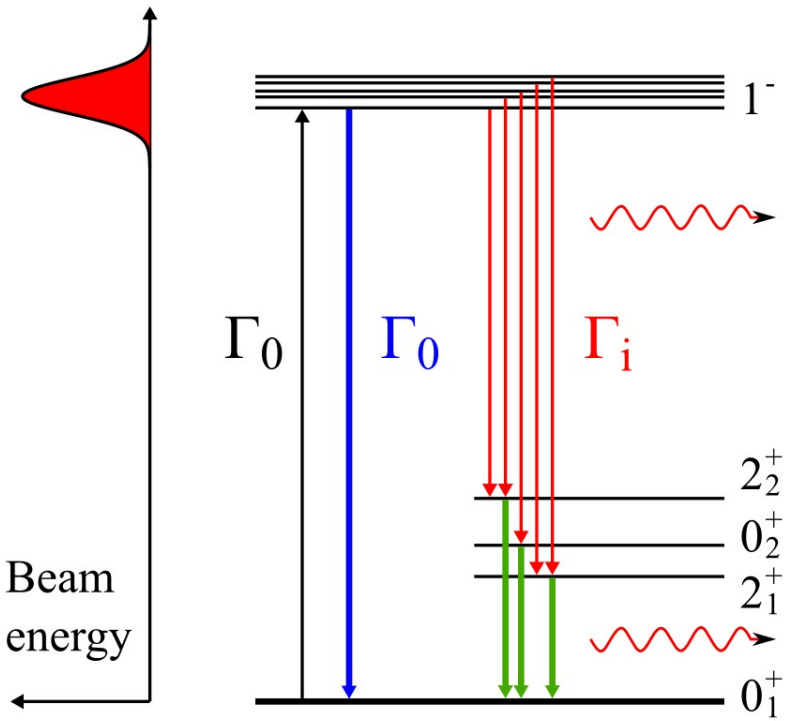


- Decay „elastic“ (Γ_0) or „inelastic“ (Γ_i)
- Elastic channel dominant: ($\Gamma_0 \gg \Gamma_i$)
- Select low energy decay

Combine:

- Selectivity of NRF reaction and mono-energetic beam
- Sensitivity of γ-γ coincidence method

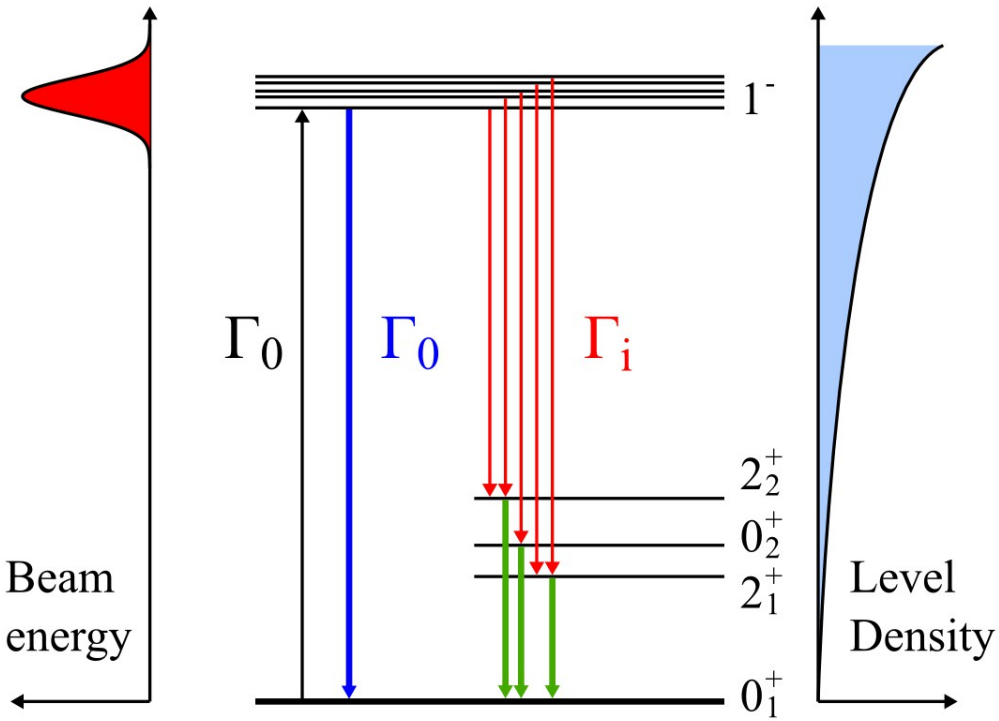
The γ^3 setup



- Decay „elastic“ (Γ_0) or „inelastic“ (Γ_i)
- Elastic channel dominant: ($\Gamma_0 \gg \Gamma_i$)
- Select low energy decay

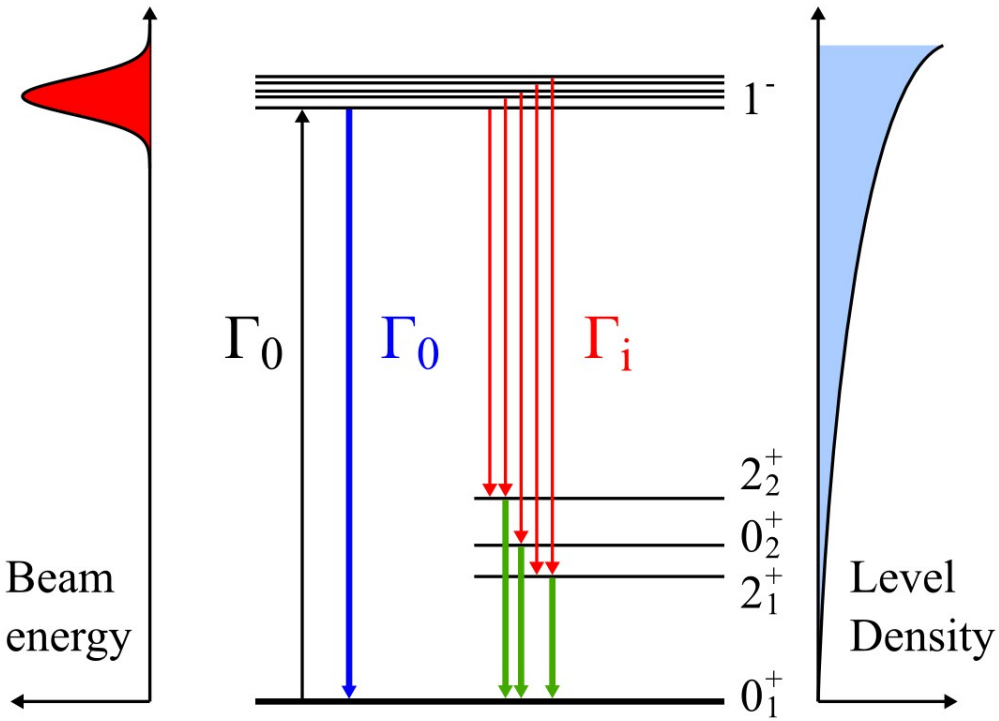
- Detect two photons in coincidence
  → **High photo peak efficiency** needed

The γ^3 setup



High level density
→ Use high resolution HPGe

The γ^3 setup

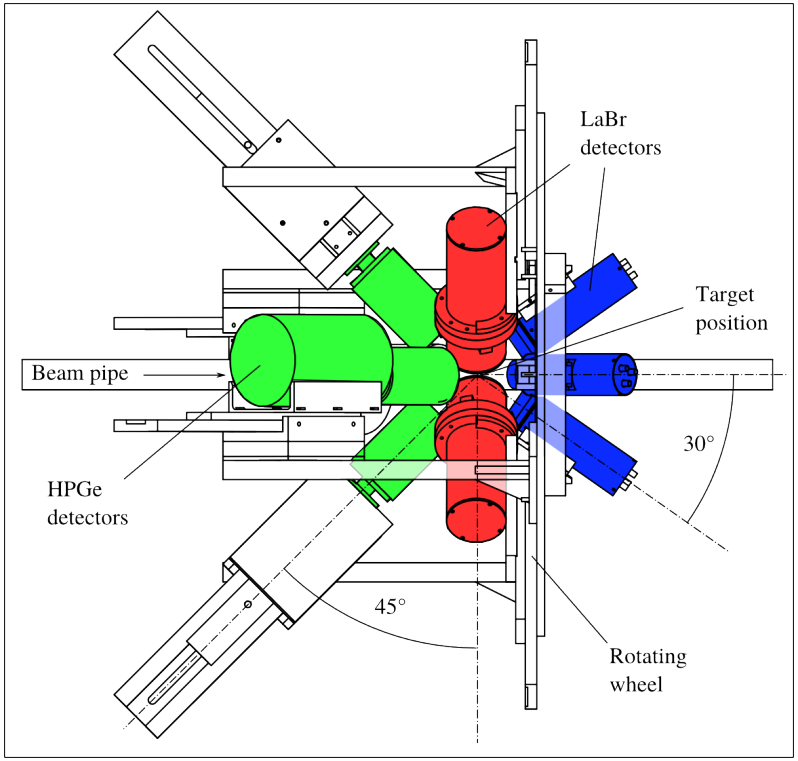


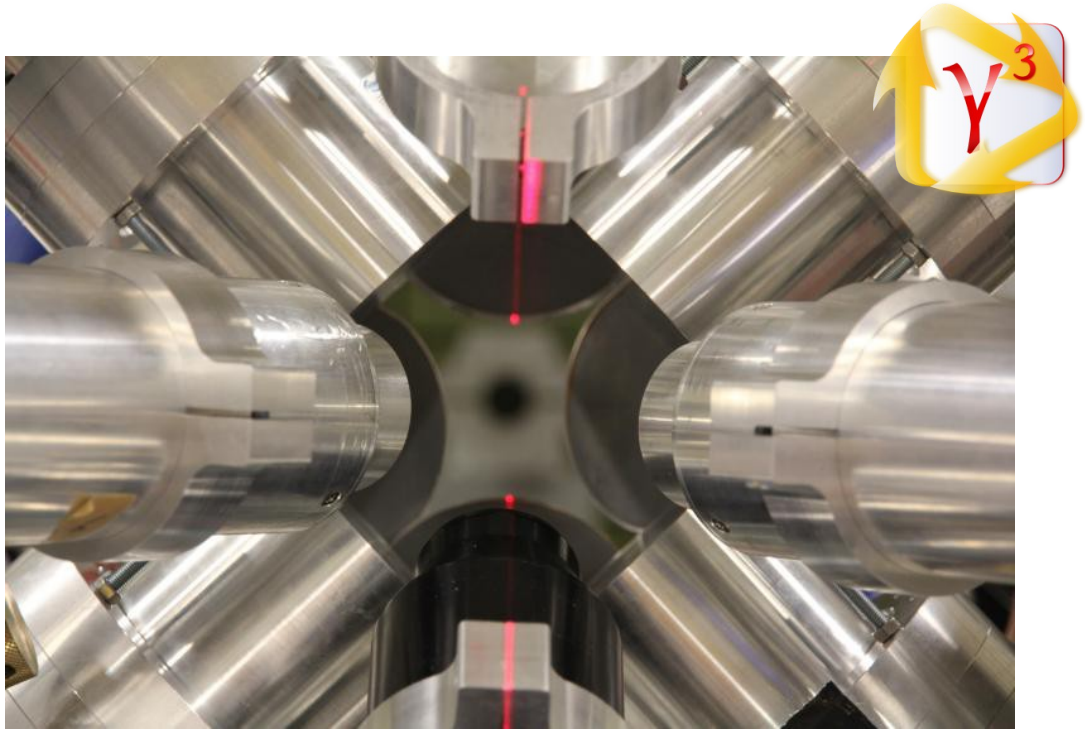
High level density
→ Use high resolution HPGe

Low level density
→ Use high efficiency LaBr

- Combine HPGe with LaBr detectors

The γ^3 setup

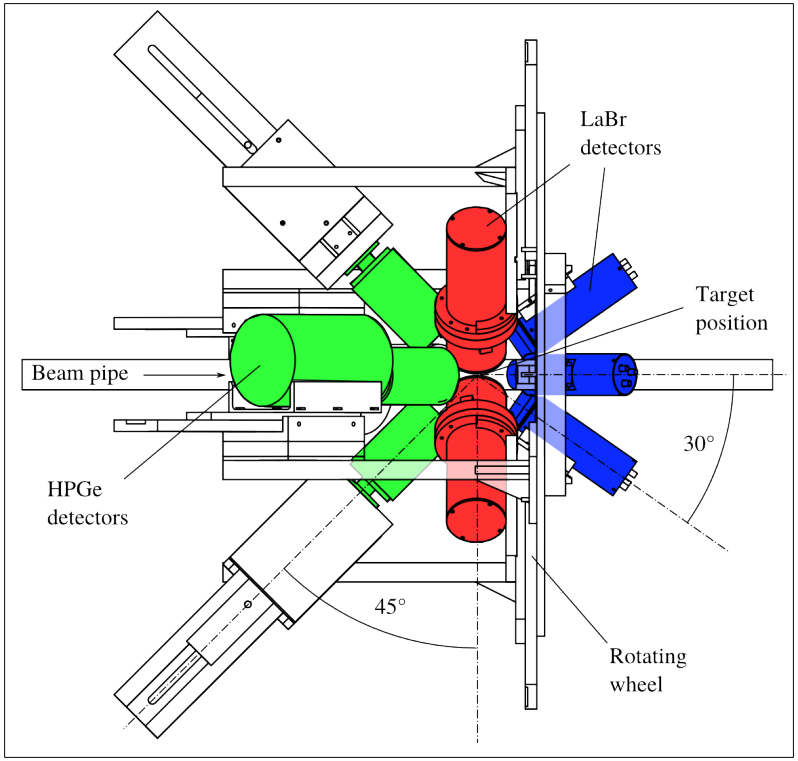


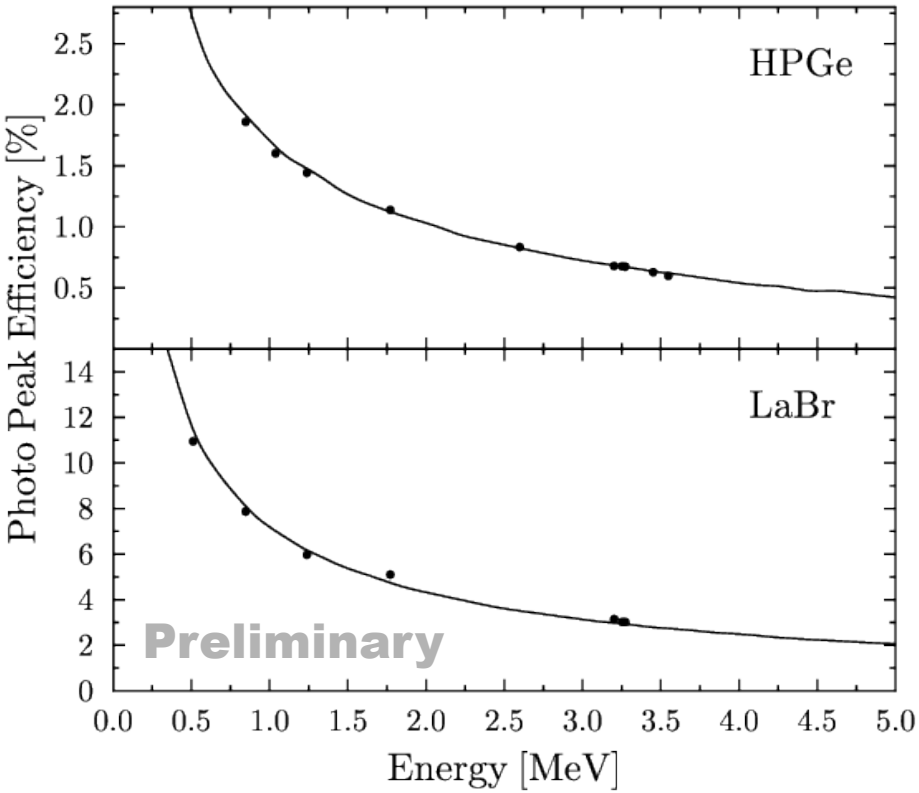


New detector array at HIγS

- 4 high resolution HPGe detectors
- 7 high efficiency LaBr detectors

The γ^3 setup

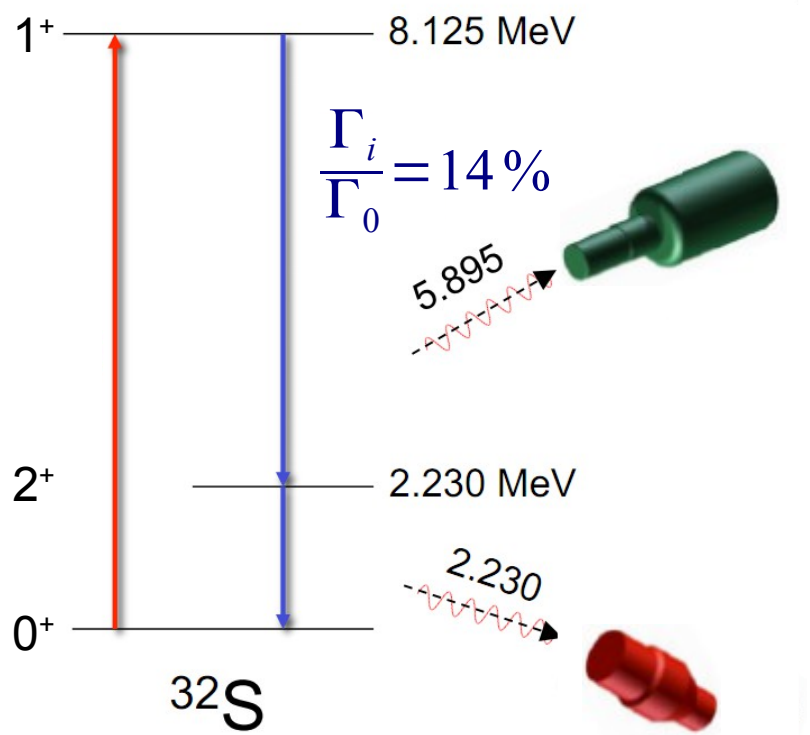




New detector array at HIγS

- Total efficiency: 2-11%

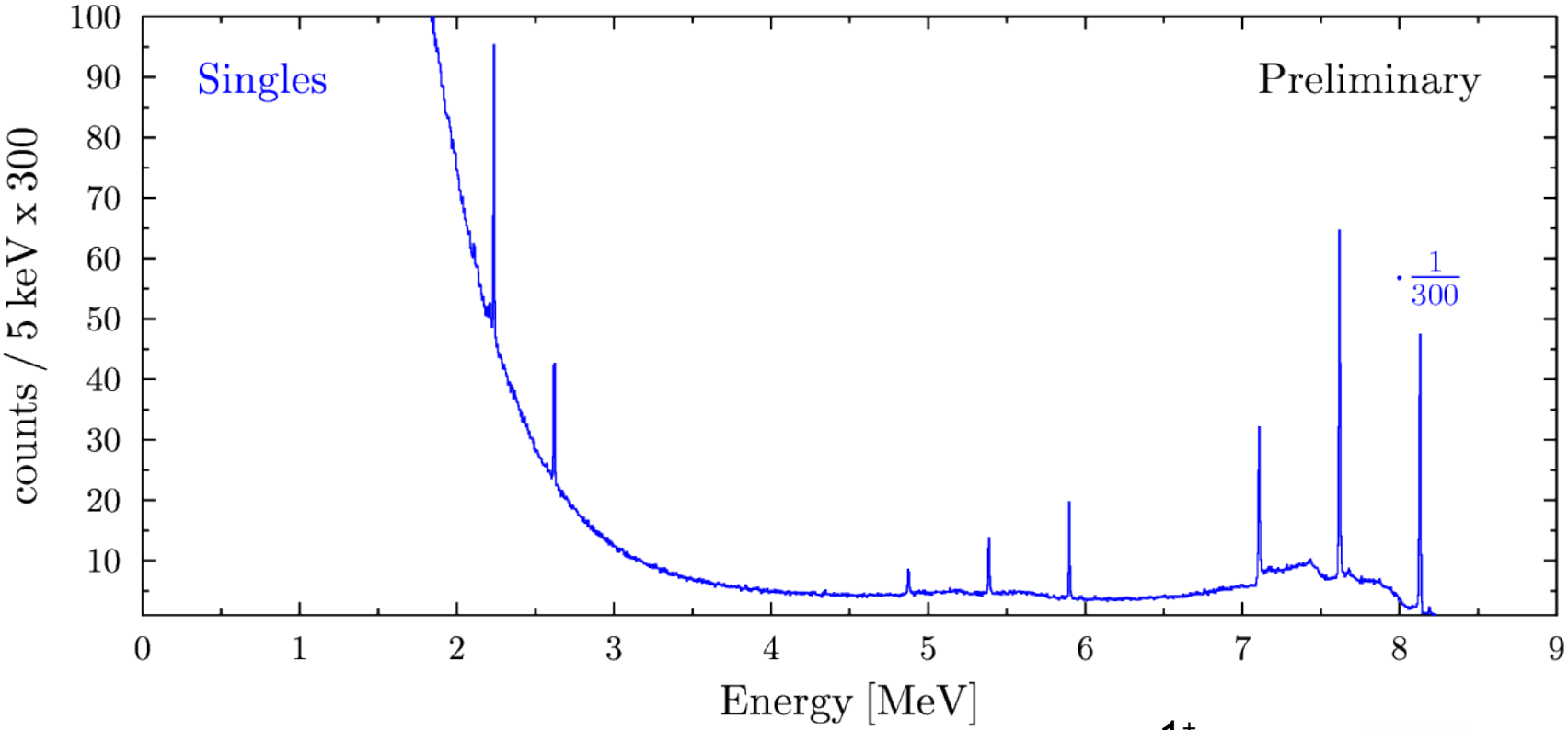
Setup Commissioning

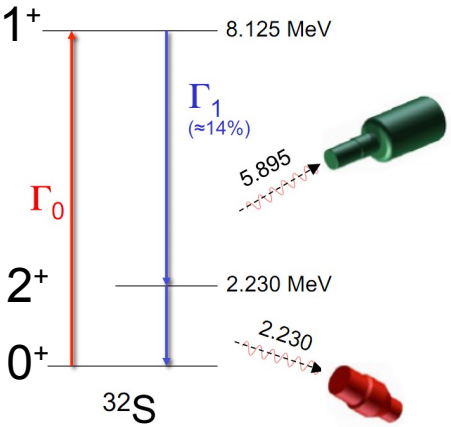


Full setup with 4x HPGe (60%) + 4x 3“x3“ LaBr

- Target: ^{32}S @ 8.125 MeV beam energy
- Duration: 4 h

Setup Commissioning





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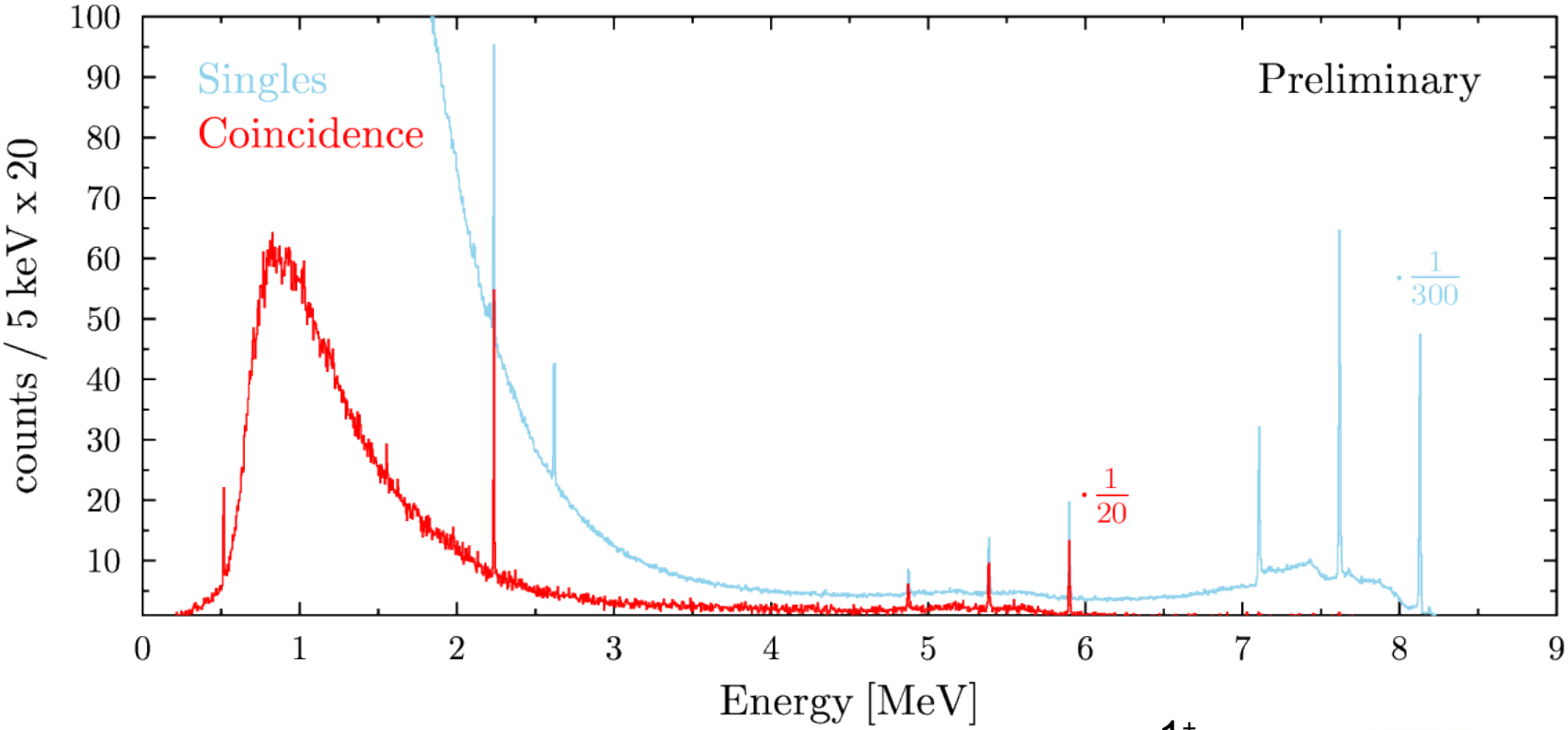

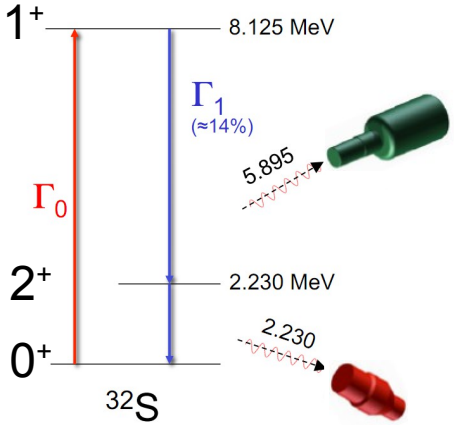

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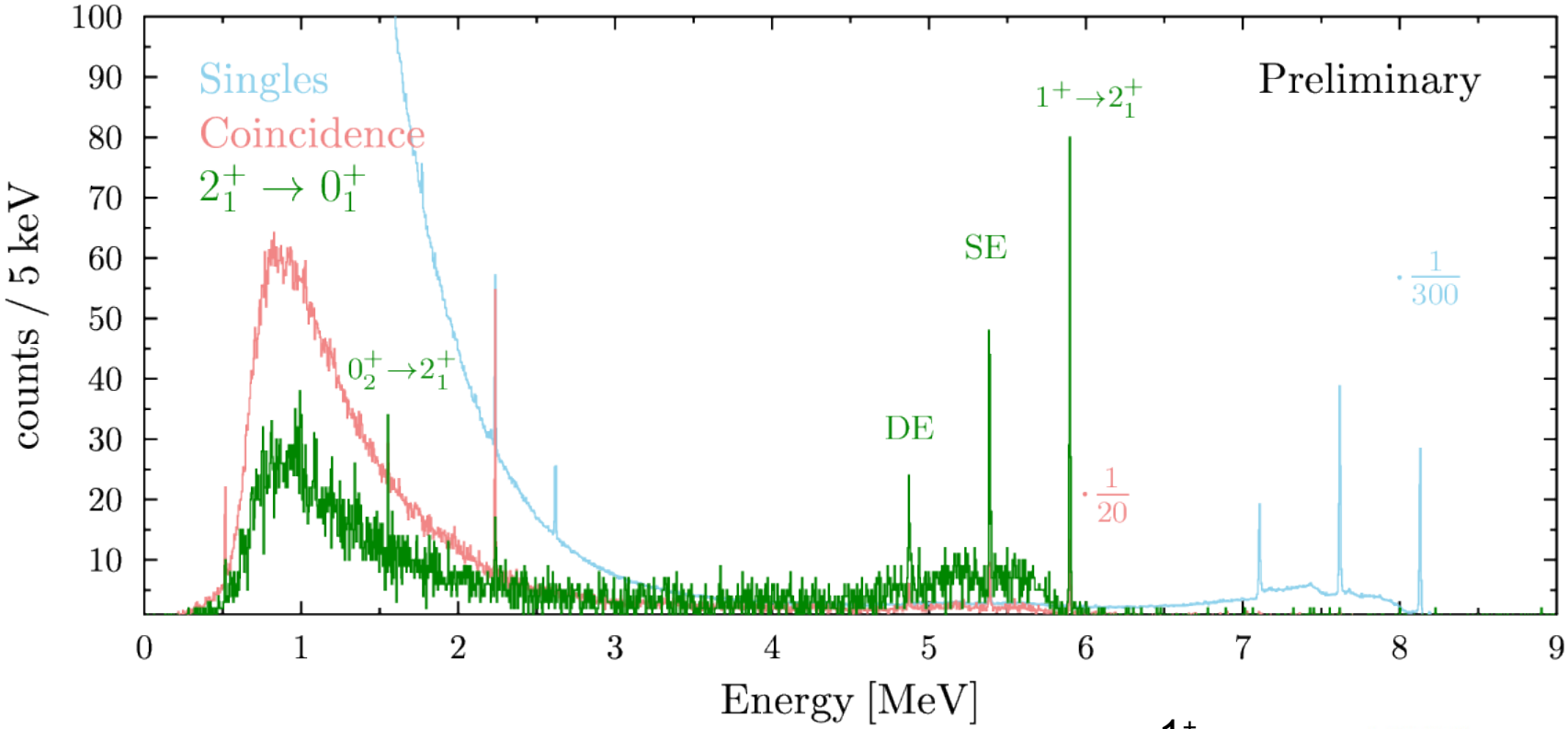
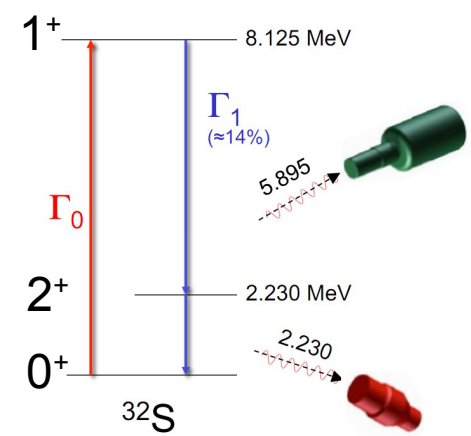


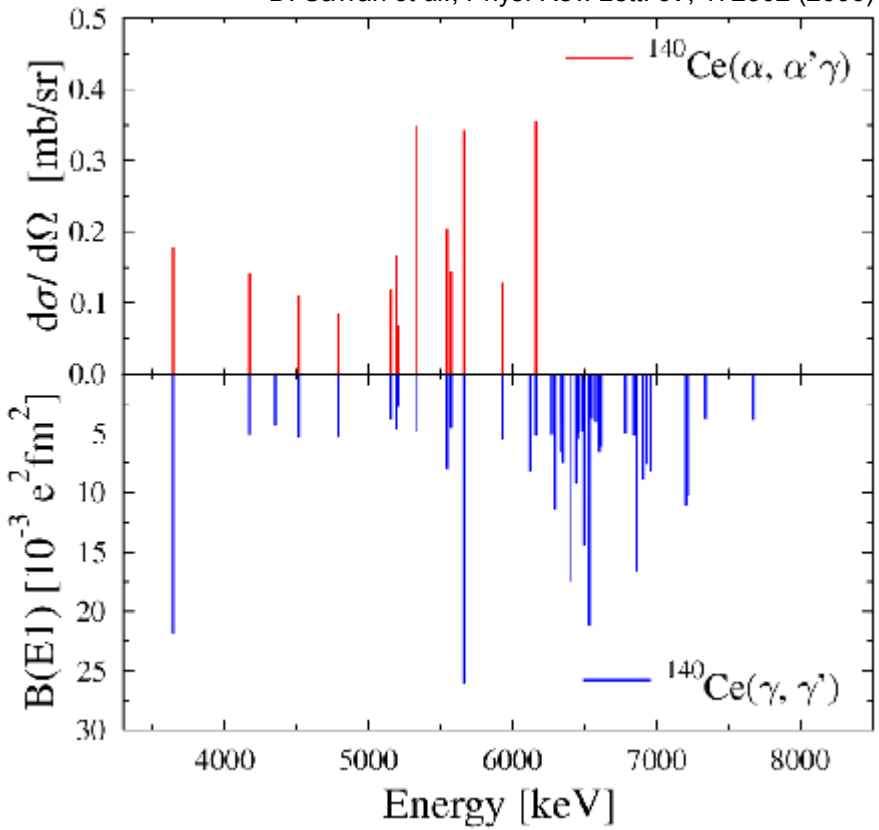
Peak to Background:

2230 keV	• Singles:	0.197(3)
	• Energy Cut:	9.6(15)
5894 keV	• Singles:	1.03(2)
	• Energy Cut:	11.7(13)



^{140}Ce (γ,γ')

D. Savran *et al.*, Phys. Rev. Lett. **97**, 172502 (2006)



Experiment at HIγS:

- 5 days of beamtime
- 11 Beam energies
- ~100 h beam on target
- Target: 2.35 g enriched $^{140}CeO_2$

^{140}Ce (γ,γ')

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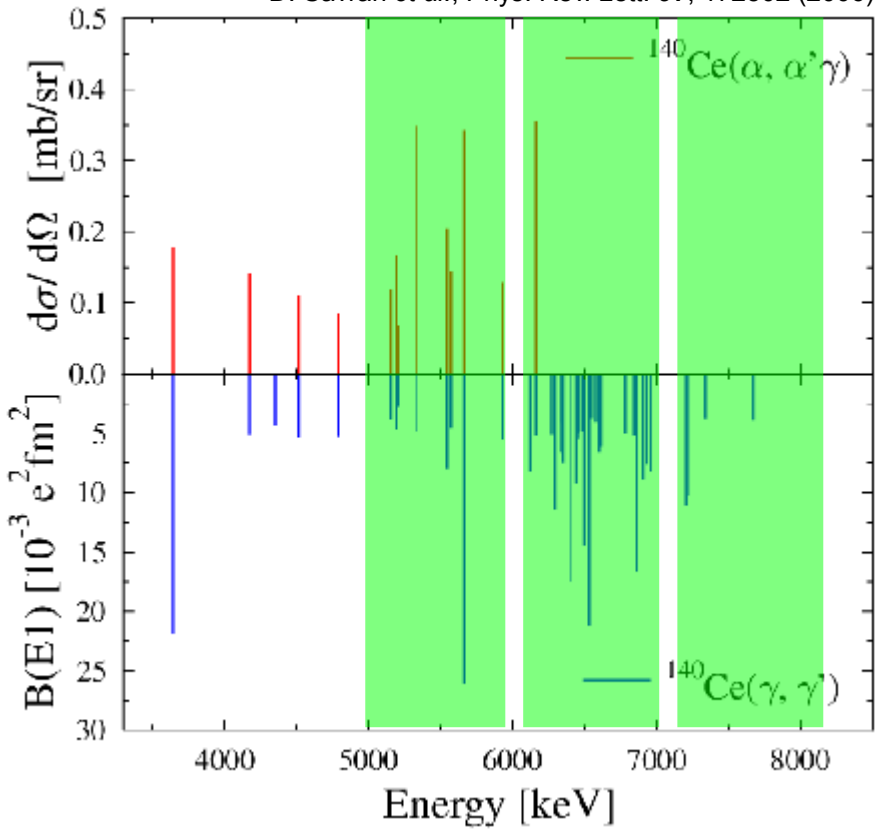

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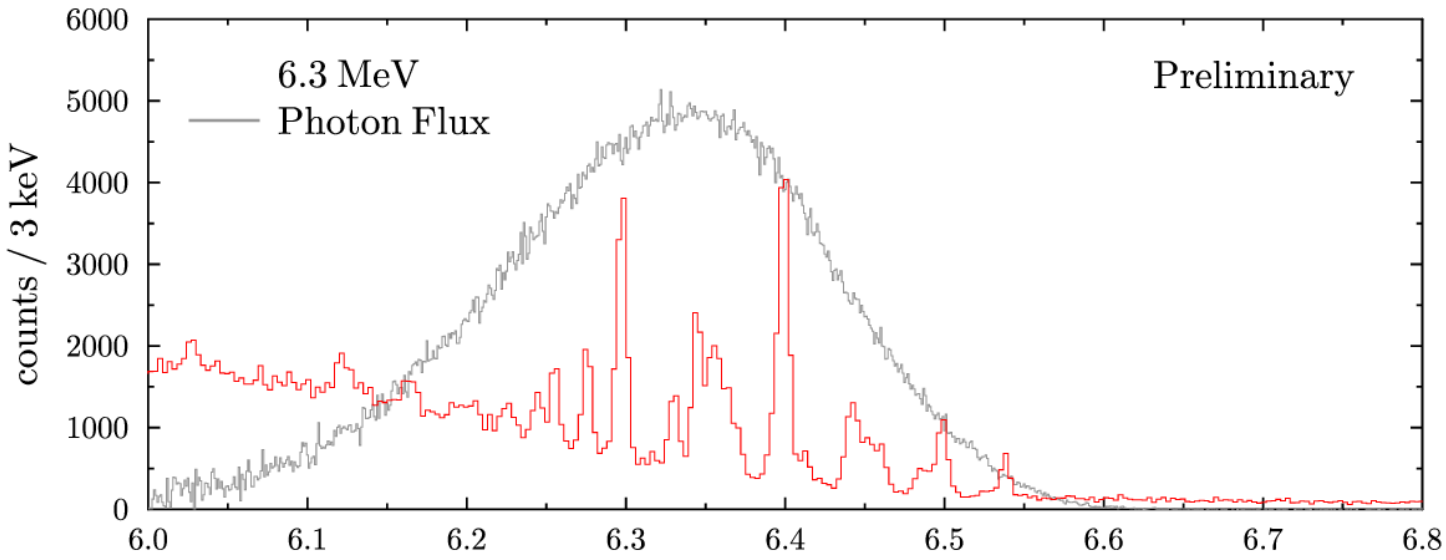
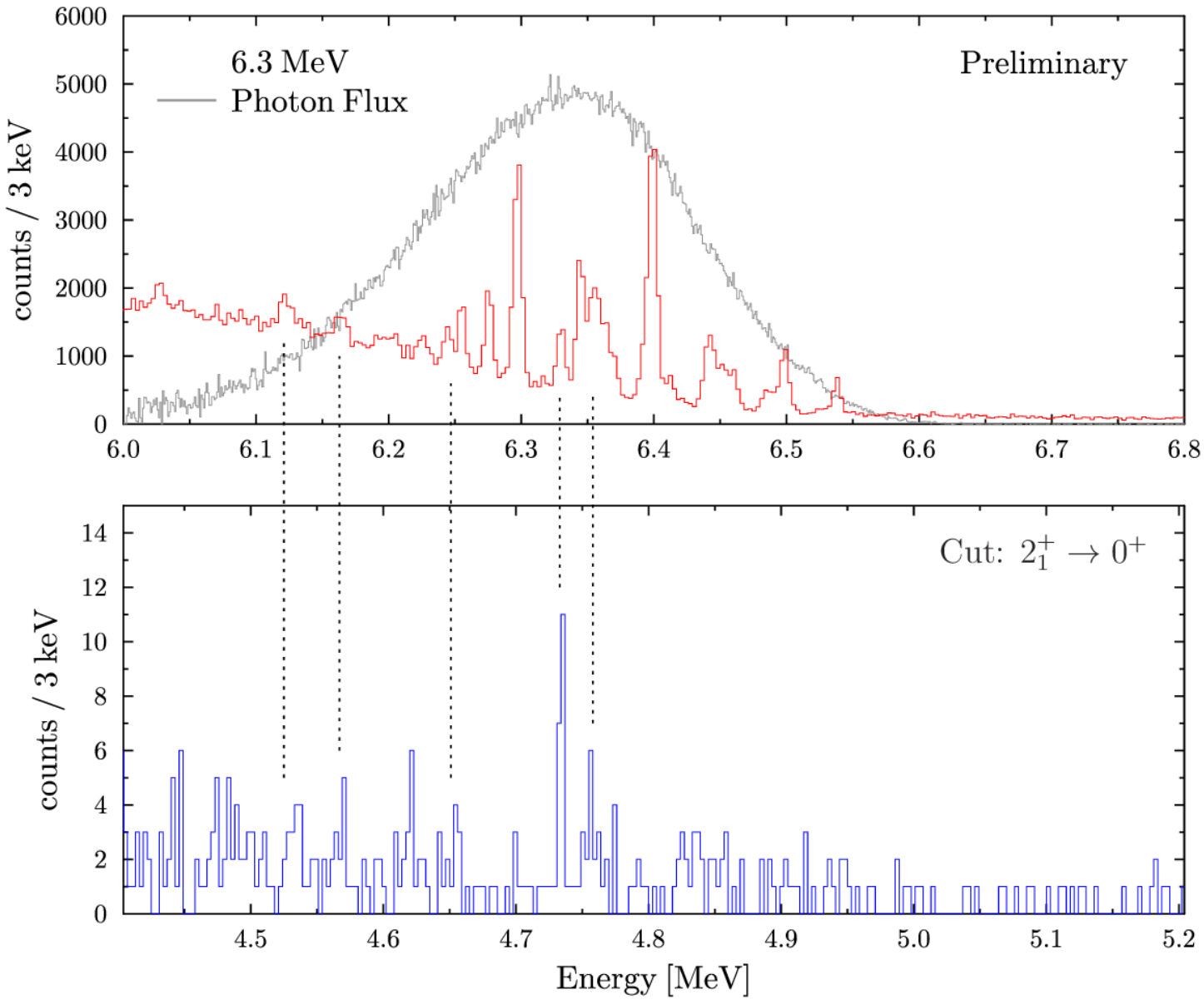
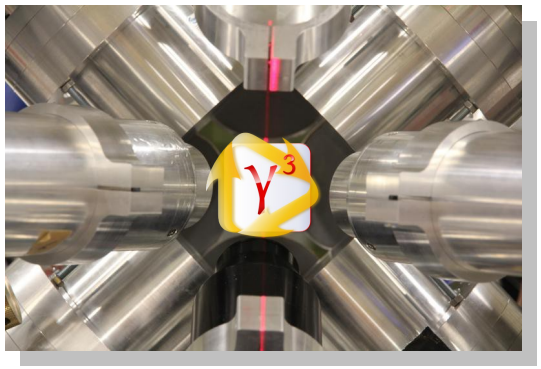
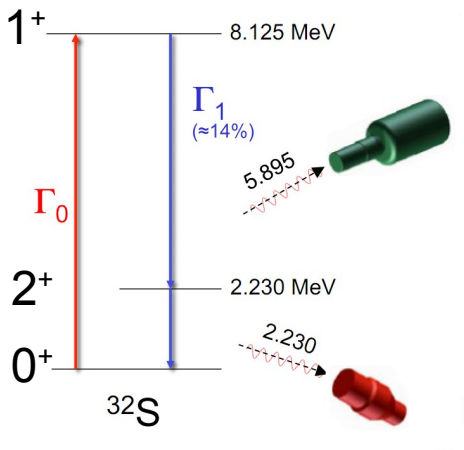

6.3 MeV
Photon Flux
Preliminary
counts / 3 keV
6000
5000
4000
3000
2000
1000
0
6.0
6.1
6.2
6.3
6.4
6.5
6.6
6.7
6.8

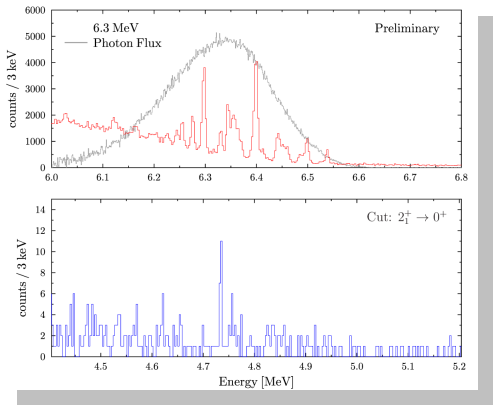
^{140}Ce (γ,γ')


6.3 MeV
Photon Flux
Preliminary
counts / 3 keV
Cut: $2_1^+ \rightarrow 0^+$
Energy [MeV]

γ³ Collaboration







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- **TU Darmstadt**
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- **Yale University**
  - N.Cooper, P.Humby, V.Werner