

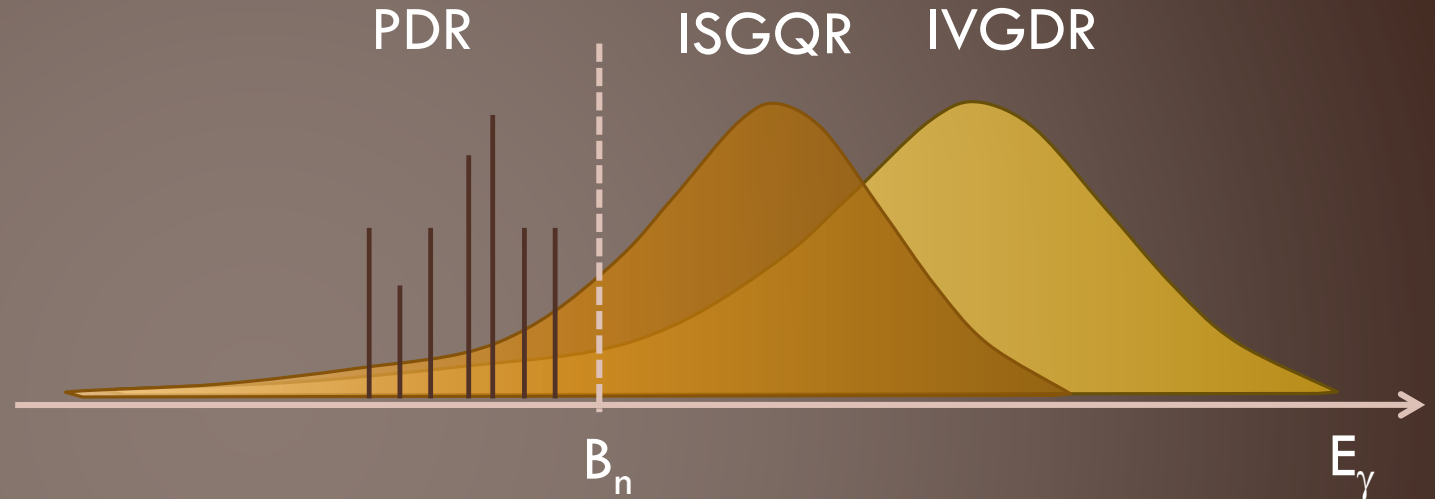
First measurements of collective excitations in ^{208}Pb induced by proton beam at CCB Krakow

B. Wasilewska¹, M. Kmiecik¹, M. Ciemała¹, A. Maj¹, J. Łukasik¹,
P. Pawłowski¹, M. Ziębliński¹, P. Lasko¹, J. Grębosz¹, F.C.L. Crespi^{2;3},
A. Bracco^{2;3}, S. Brambilla³, I. Ciepał¹, N. Cieplicka¹, B. Fornal¹, Ł. Iskra¹,
M. Matejska-Minda¹, K. Mazurek¹, P. Napiorkowski⁴, W. Parol¹, B. Sowicki¹,
A. Szperłak¹, M. Harakeh⁵, A. Tamii⁶, J. Isaak⁶, S. Bottoni^{2;3}

¹IFJ PAN Kraków; ²University of Milan; ³INFN Milan; ⁴SLCJ Warsaw; ⁵KVI Groningen,
⁶RCNP Osaka

Collective states

- Pygmy Dipole Resonance: E1 states below neutron threshold
- Isovector Giant Dipole Resonance – E1 collective state $\sim 10 - 20$ MeV
- Isoscalar Giant Quadrupole Resonance – E2 collective state below IVGDR

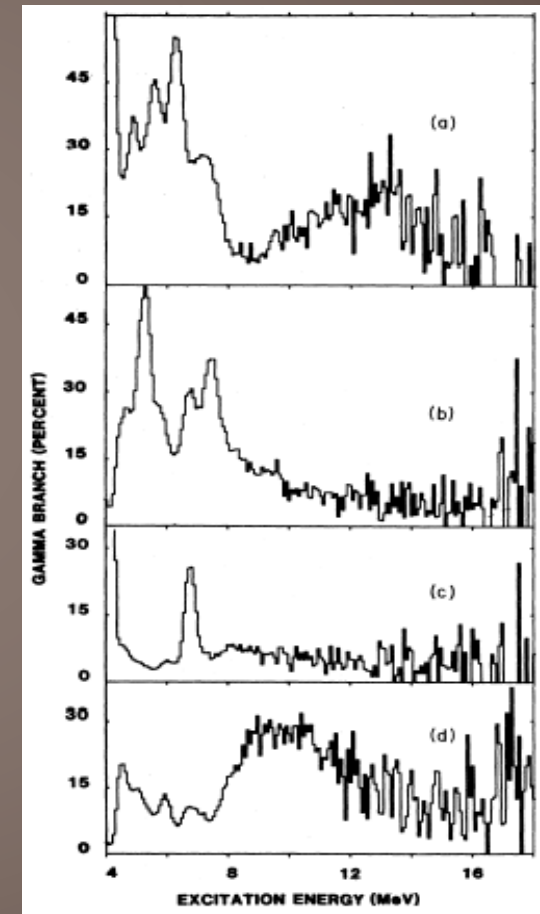


- Macroscopic interpretation: shape oscillations
- GR shape description: Lorentzian curve

Experimental motivations

$$E^* = \sum_{i=1}^m E_{\gamma i}$$

- Only one γ -decay of GQR results ever published
 - very challenging experiments
- PDR under intense studies worldwide
 - recently discovered
 - not fully understood
- Additional probe for models' verification
- Better understanding of the mechanisms of the collective excitations



Decay to g.s.,
 $m = 1$

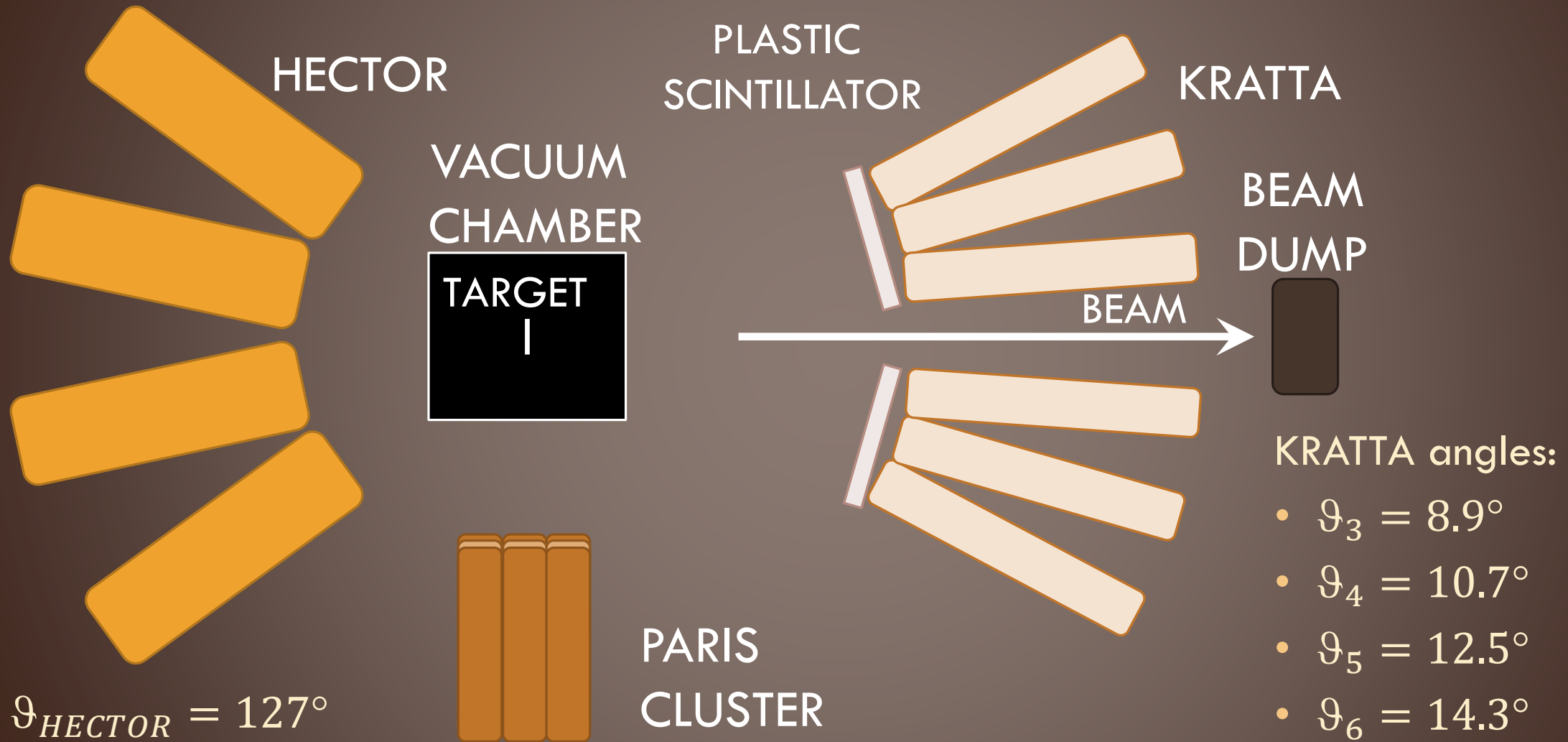
Decay via 3_1^- ,
 $m = 2$

Decay via 2_1^+ ,
 $m = 2$

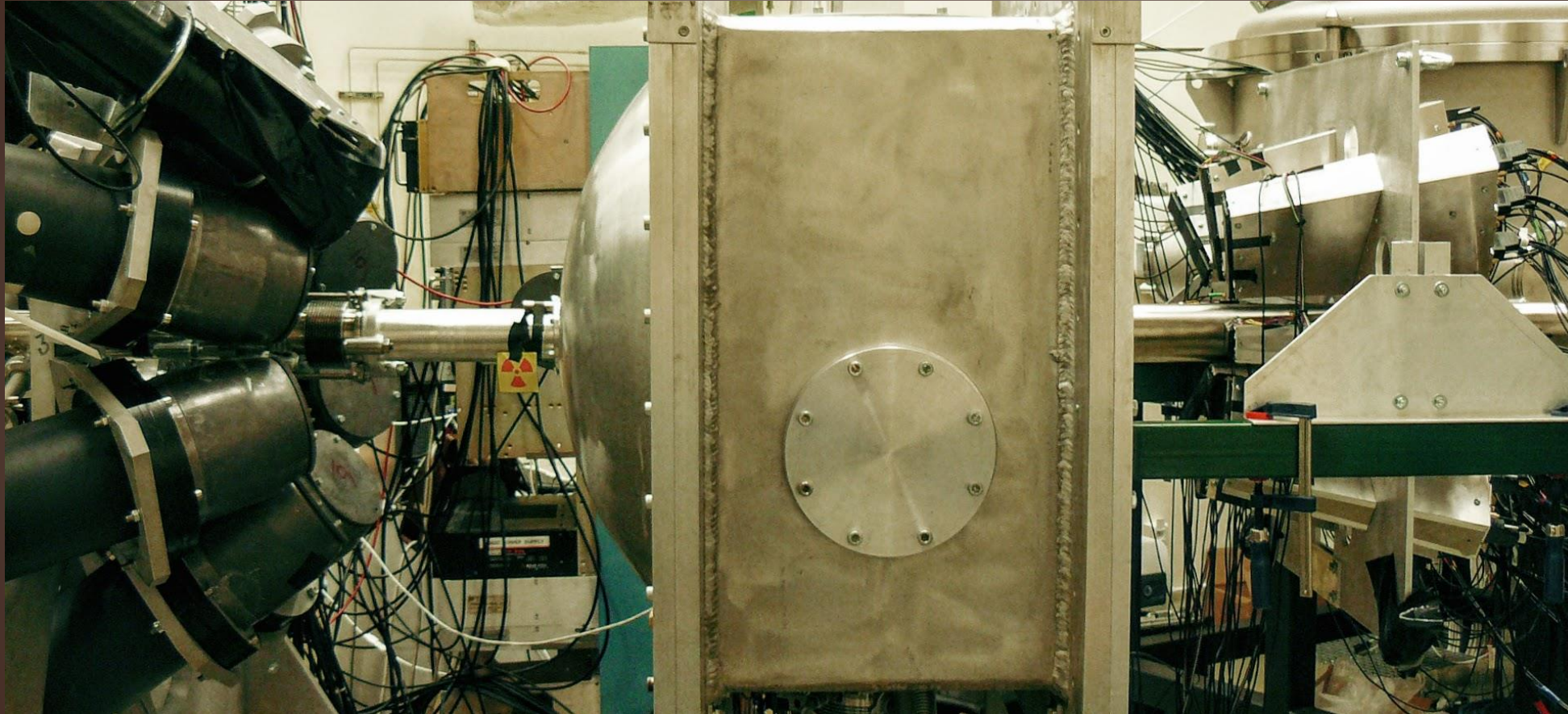
Decay via 3_2^- ,
 $m = 3, 4$

J.Beene et al PRC39(1989)1307

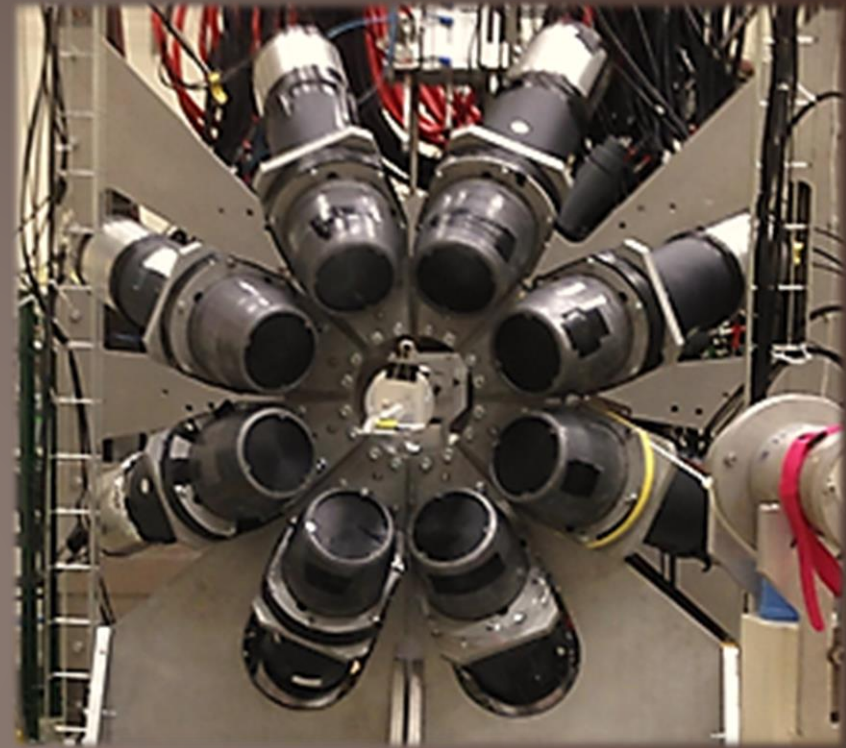
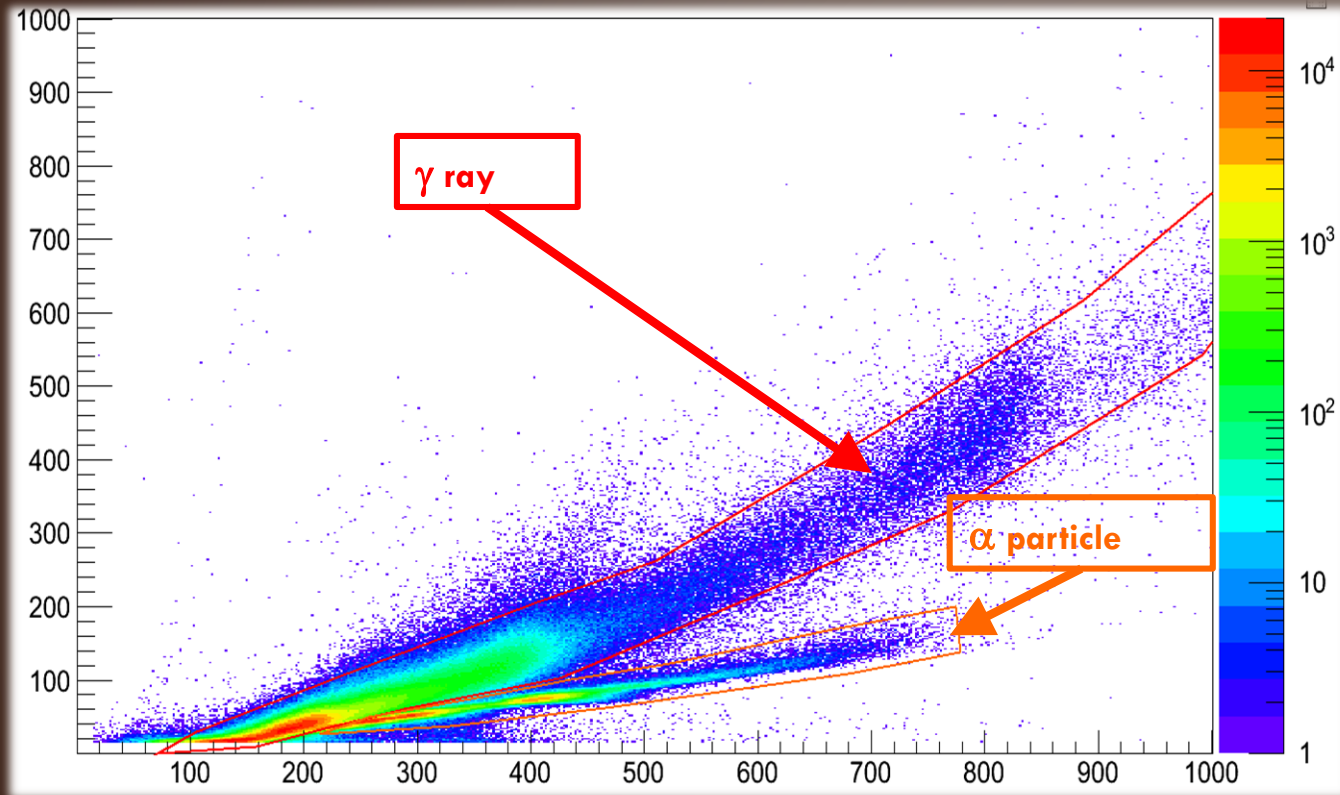
Experimental set-up



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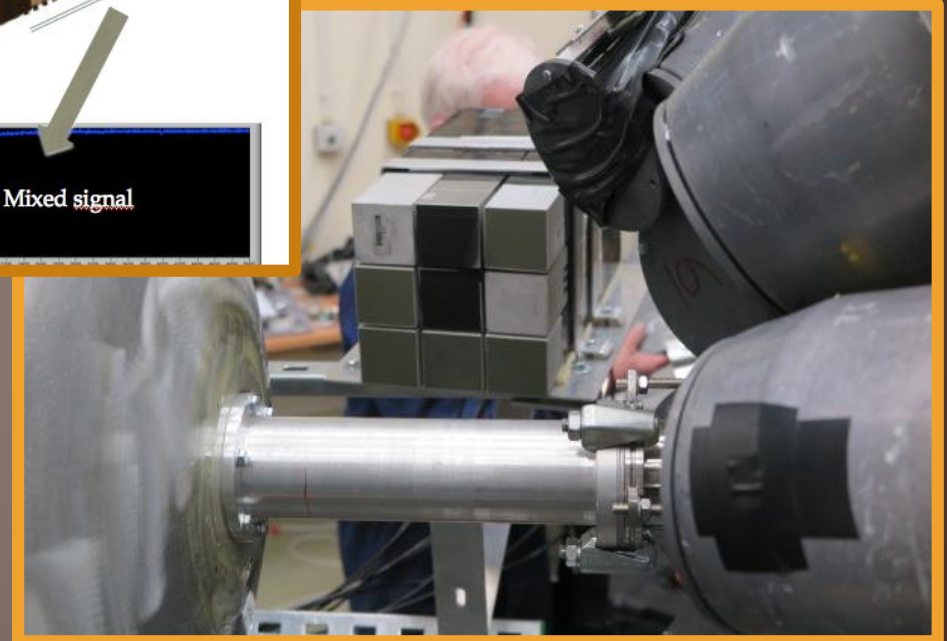
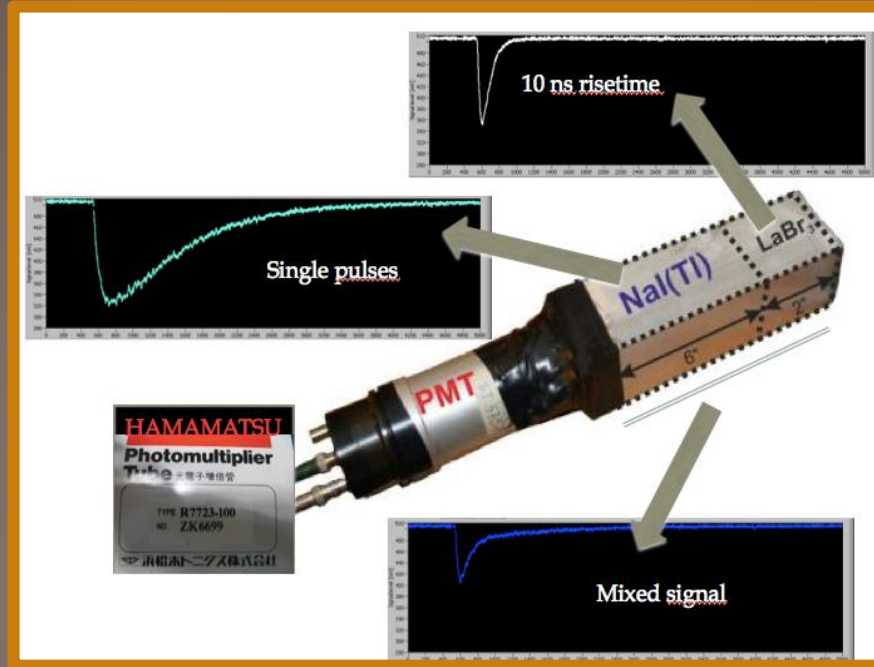
HECTOR



- 8 BaF₂ detectors
- Good time resolution
- High efficiency
- BaFPro module

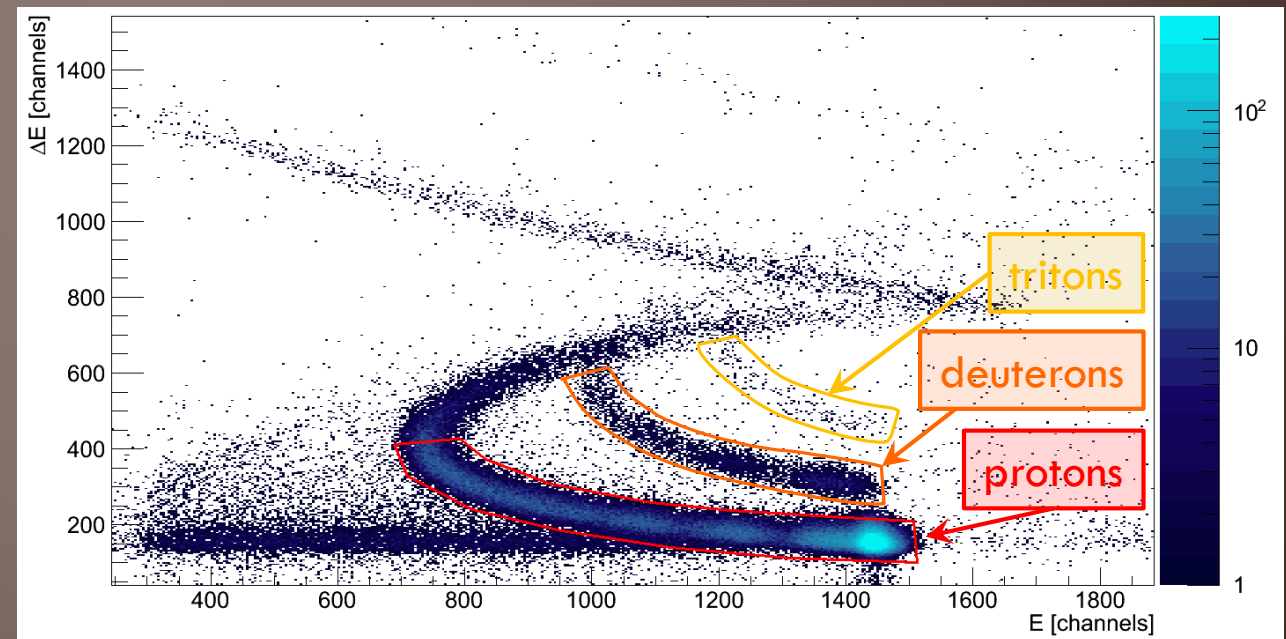
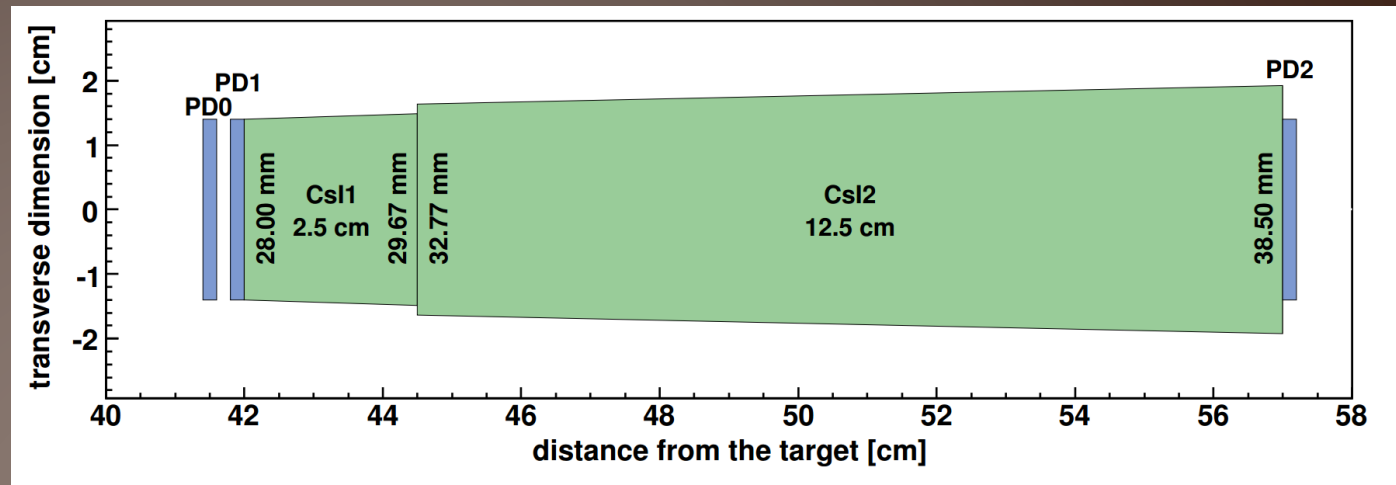
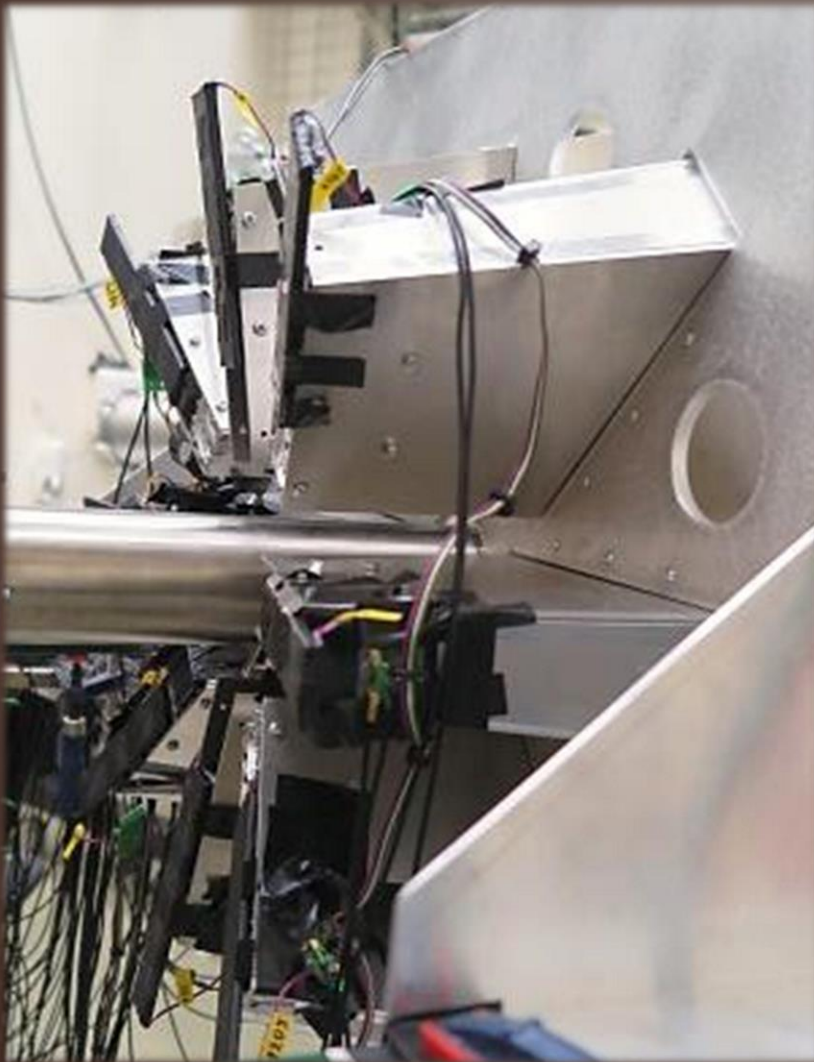
PARIS

- Phoswich configuration
- Cluster of 9
- Good energy resolution
- Good time resolution
- High efficiency
- PARISpro module



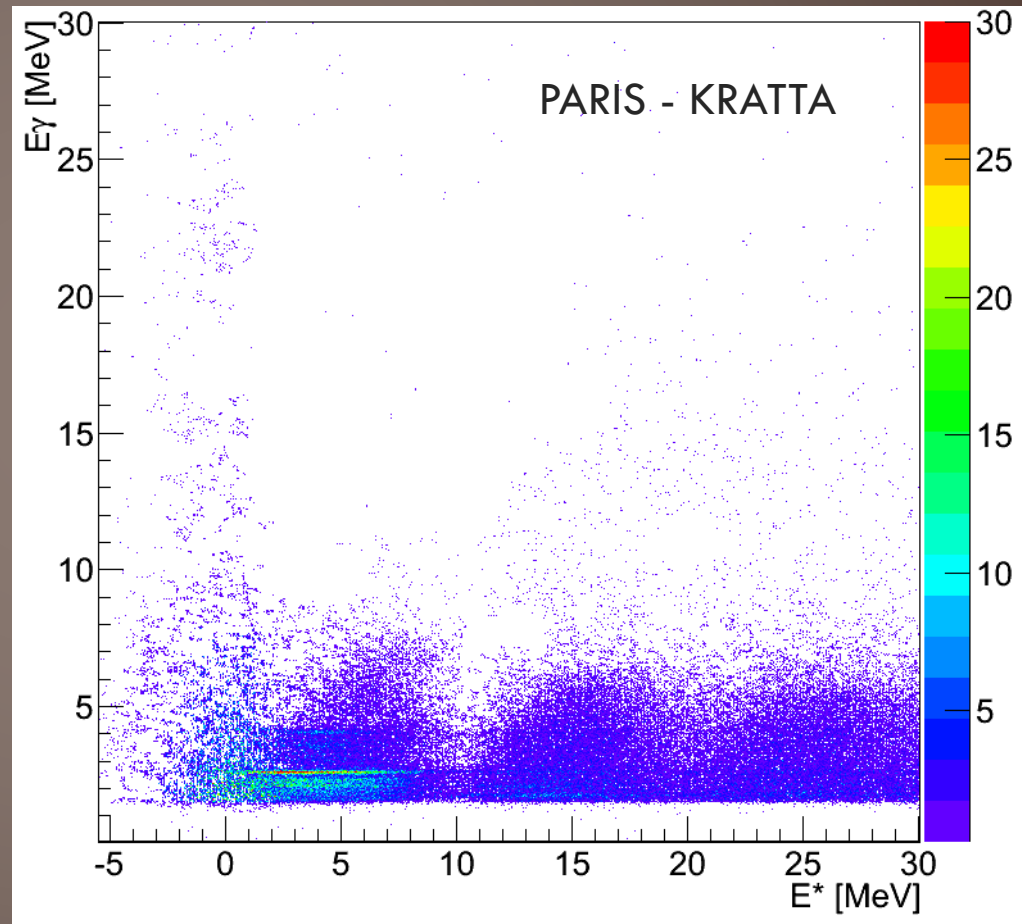
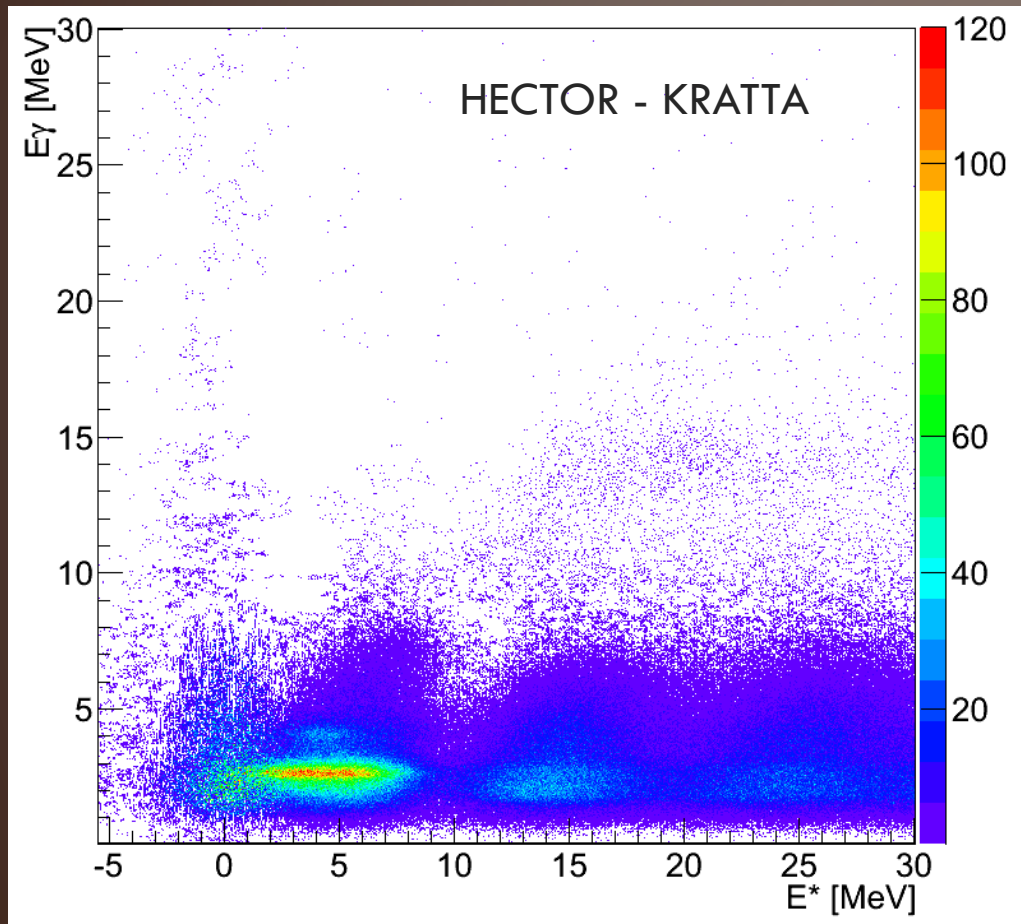
KRATTA

Triple telescope – LCP detection

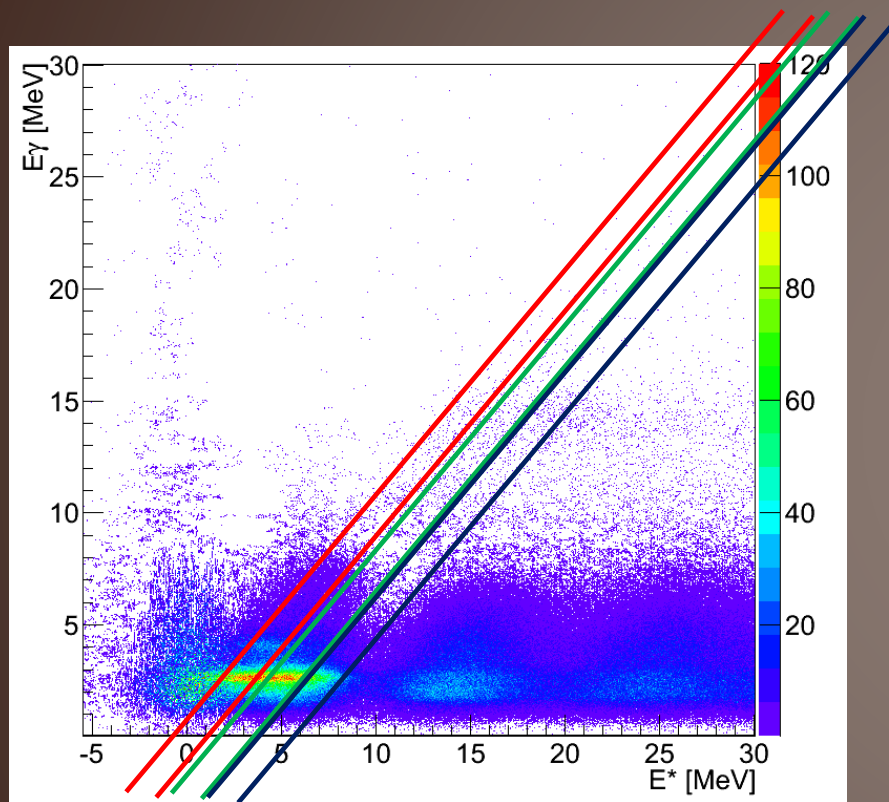


Coincidence matrix

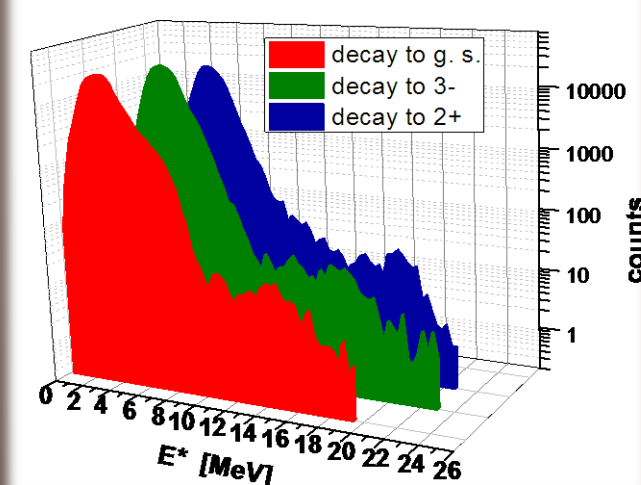
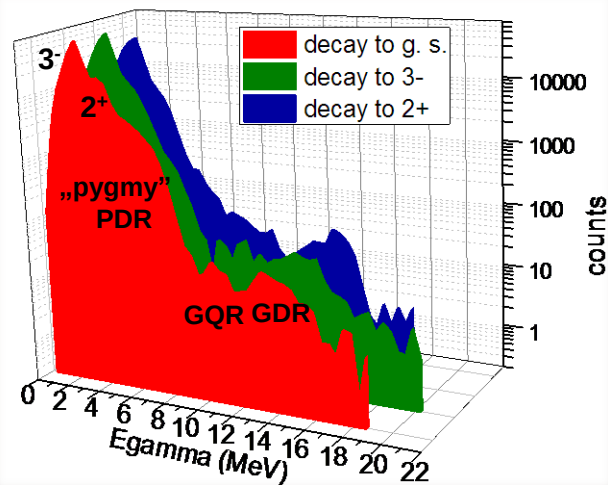
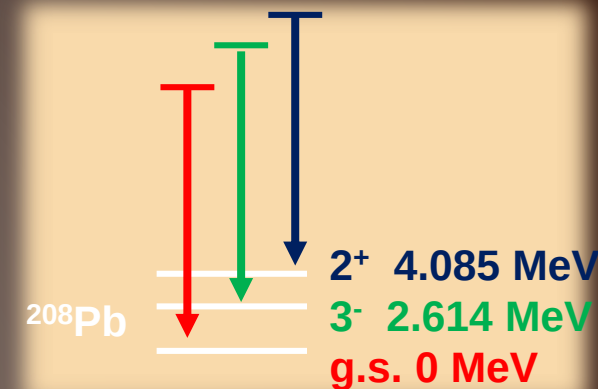
Observables: coincidence E^* and E_γ spectra with various conditions



Gate on transitions

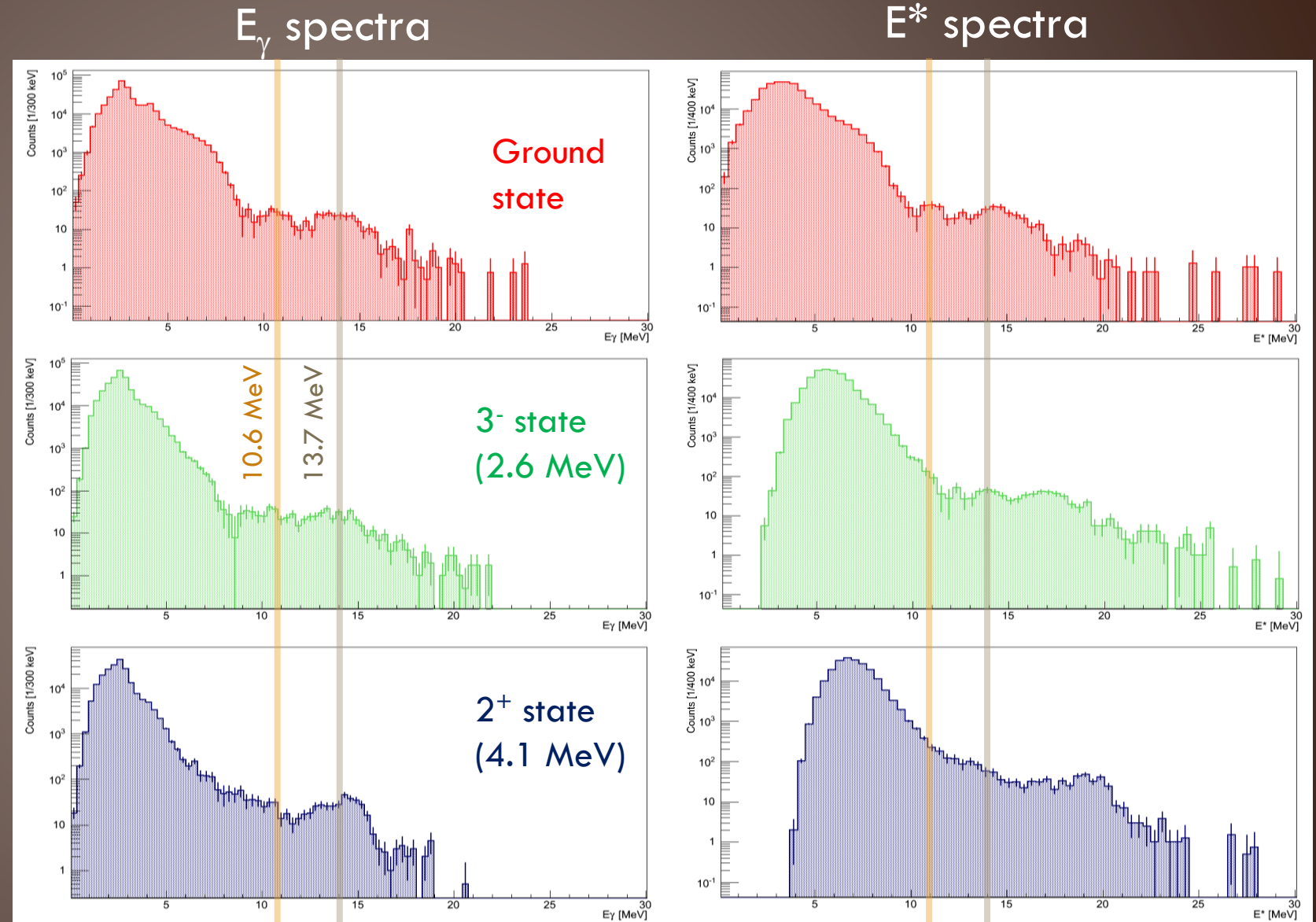


- *GDR*
 - *GQR*
 - *PDR*
- }
- observed*

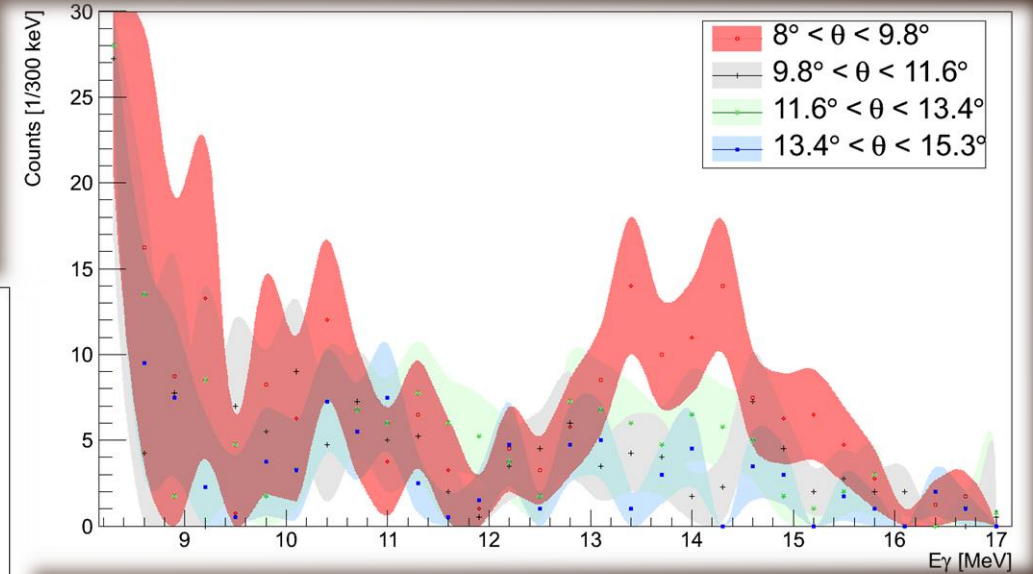
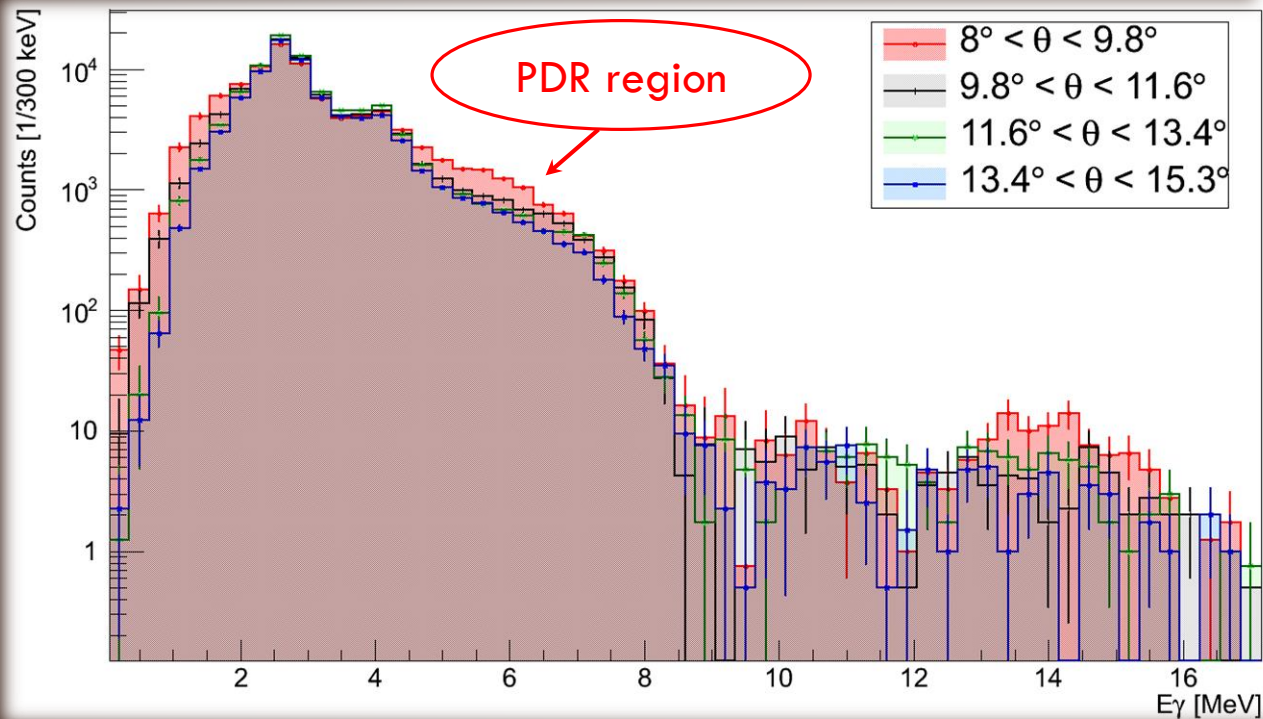


Gate on transitions

- Excess of γ rays in GDR and GQR region for all of the gates
- Possible Brink-Axel Hypothesis confirmation



Decay to the ground state – rings

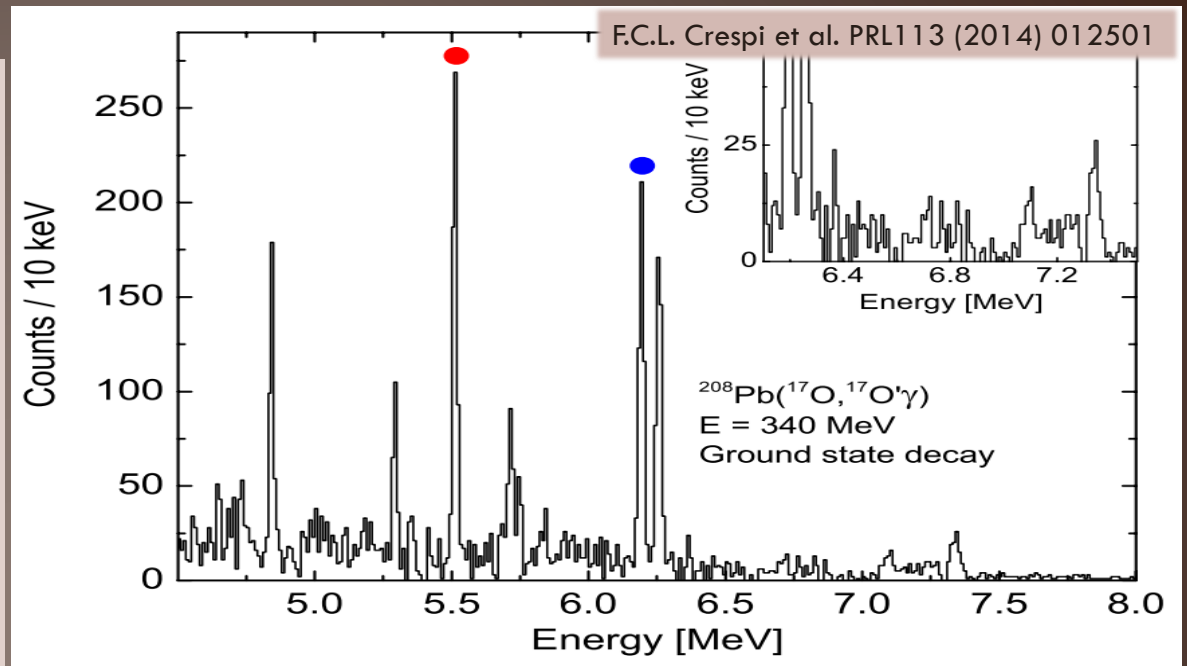


- More PDR γ rays forward – as expected
- Angular sensitivity

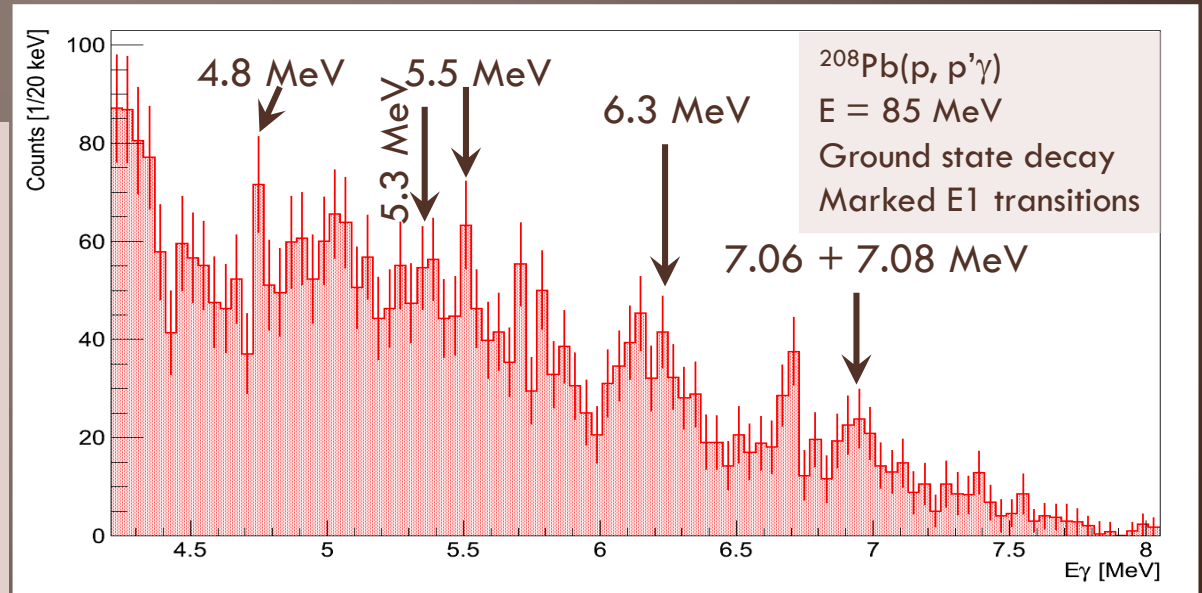
PDR region

- Same lines as in previous experiments visible
- Additional peaks also visible

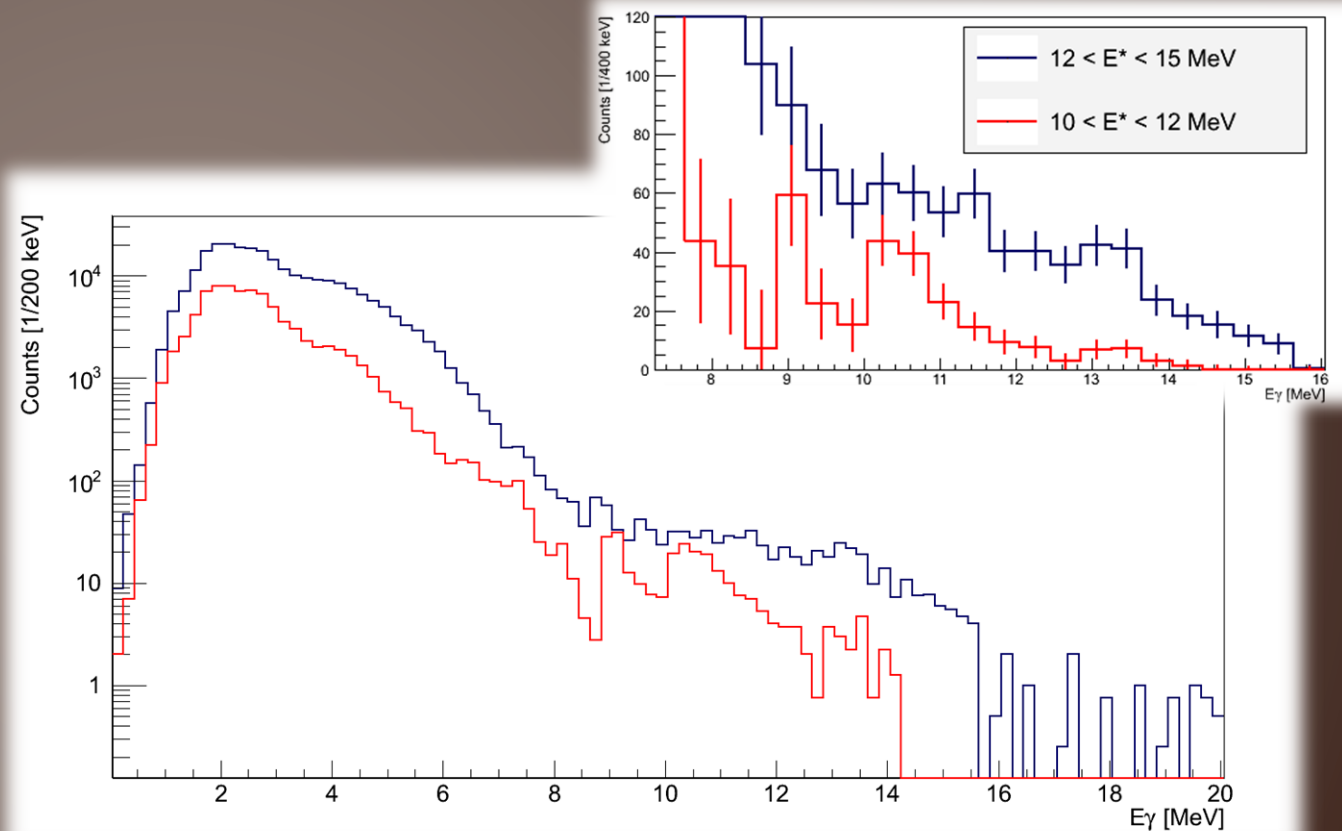
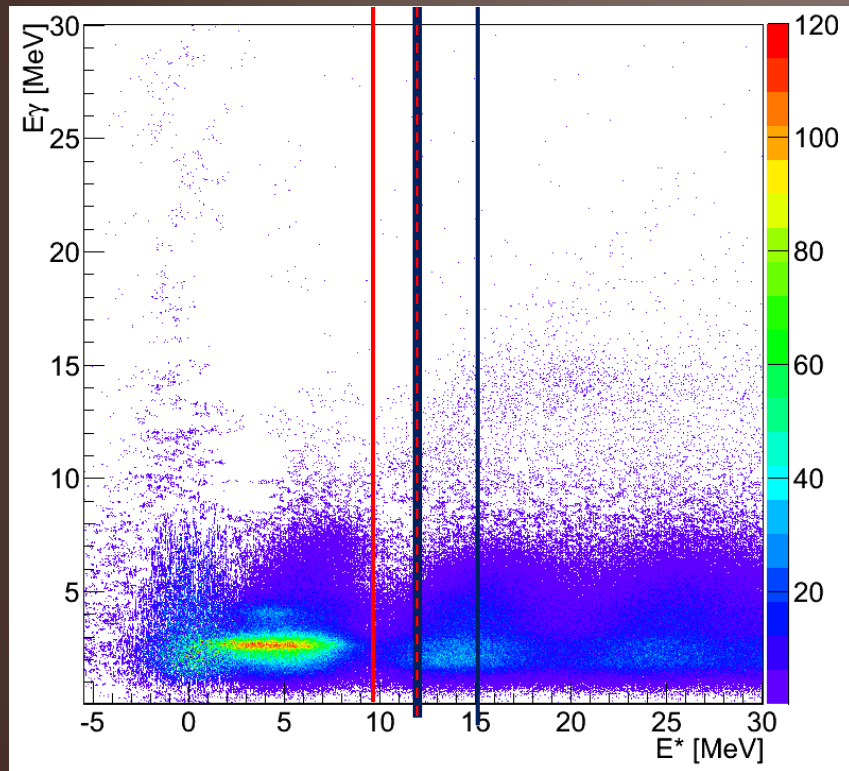
AGATA demonstrator
Measurement@LNLegnaro



PARIS cluster
Measurement@CCB



Gate on excitation energy – HECTOR



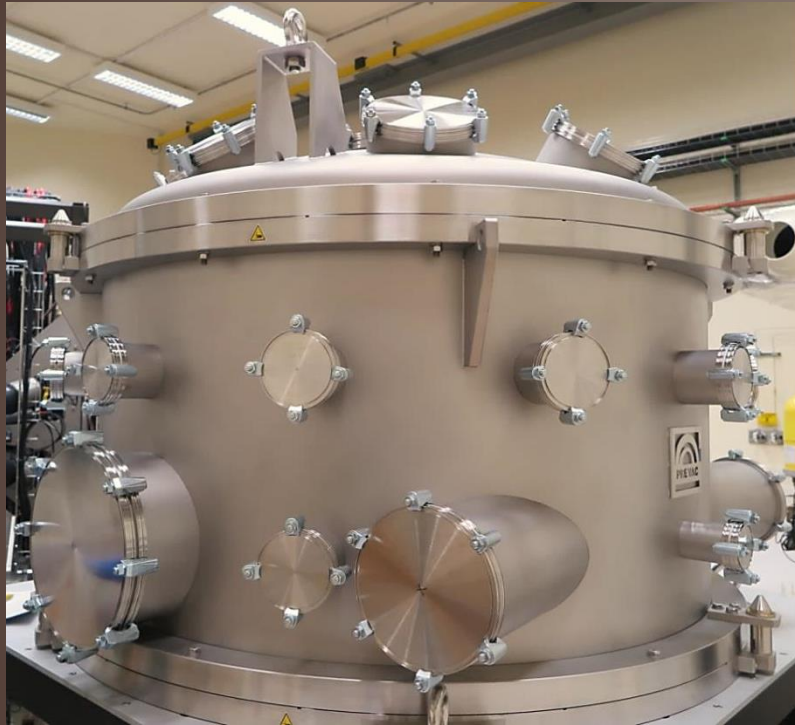
Response matrix under preparation

Need for theoretical calculations

- Precise $^{208}\text{Pb}(p, p'\gamma)@85\text{MeV}$ reaction description (E^* up to 30 MeV)
 - ❖ Differential cross sections for GR excitations
- Giant resonances γ -decay description
 - ❖ particle emission/ γ -decay branching
 - ❖ multi γ -decay via discrete states

Connection between shell and statistical models
Check for Brink-Axel Hypothesis

Future plans



- 4 $\text{LaBr}_3\text{:Ce}$ 3.5" x 8"
- 2 PARIS clusters
- KRATTA in vacuum
- $E_{\text{beam}} = 150 \text{ MeV}$
- ^{208}Pb and ^{90}Zr



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