

Characterization of new structures in octupole-deformed radium and thorium nuclei

Current status

Spokespersons: J. F. Smith and D. Mengoni

30th June 2011
EGAN Workshop 2011, Padova



Reflection asymmetry in light-actinide nuclei

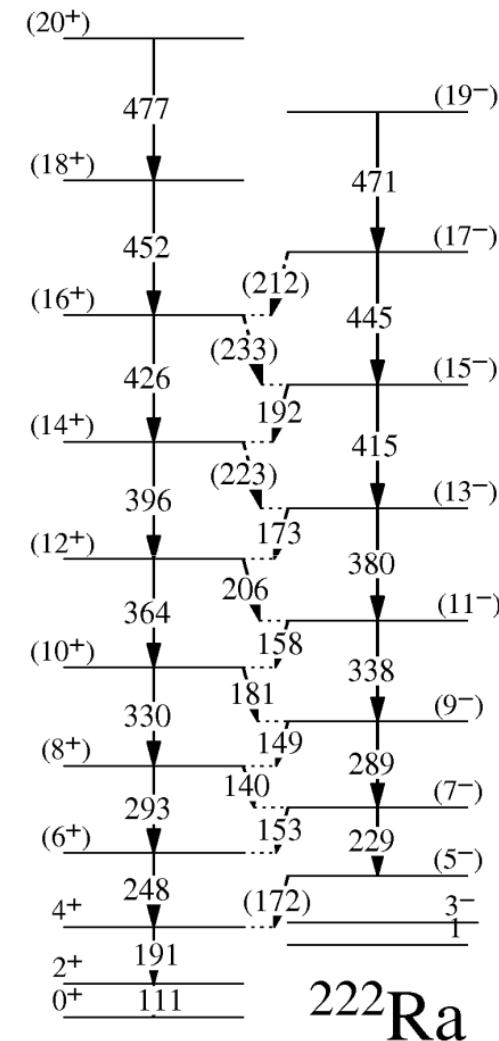
Light actinide nuclei: $Z \approx 90$ $N \approx 134$
 $\nu(j_{15/2})\nu(g_{9/2})$ and $\pi(i_{13/2})\pi(f_{7/2})$: $\Delta l = \Delta j = 3$

- Enhanced E1 transitions
 - Low-lying negative-parity states
 - Interleaving positive- and negative-parity states

s=+1: $0^+, 1^-, 2^+, 3^-, 4^+, 5^- \dots$

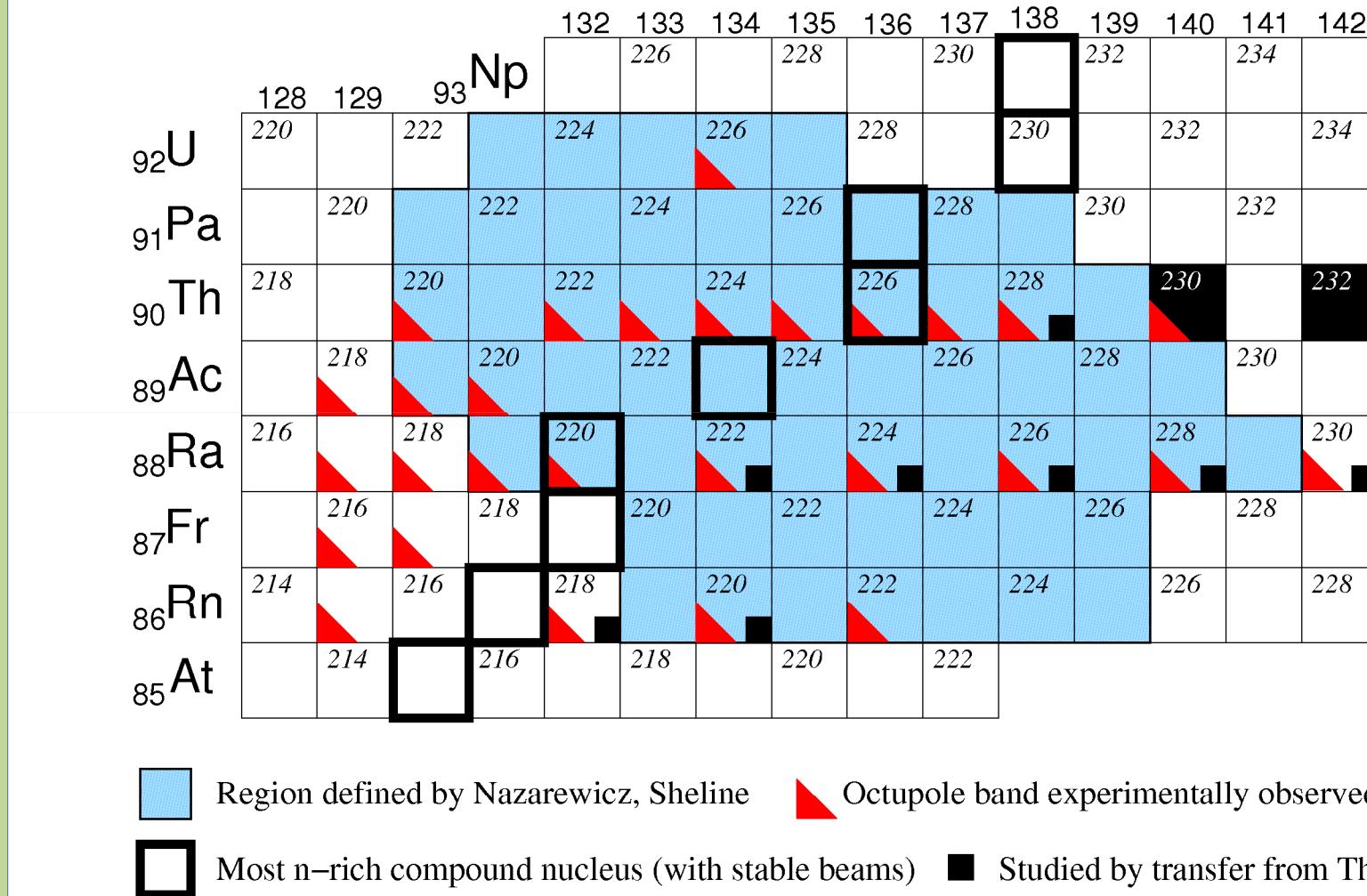
s=-1: 0⁻, 1⁺, 2⁻, 3⁺, 4⁻, 5⁺...

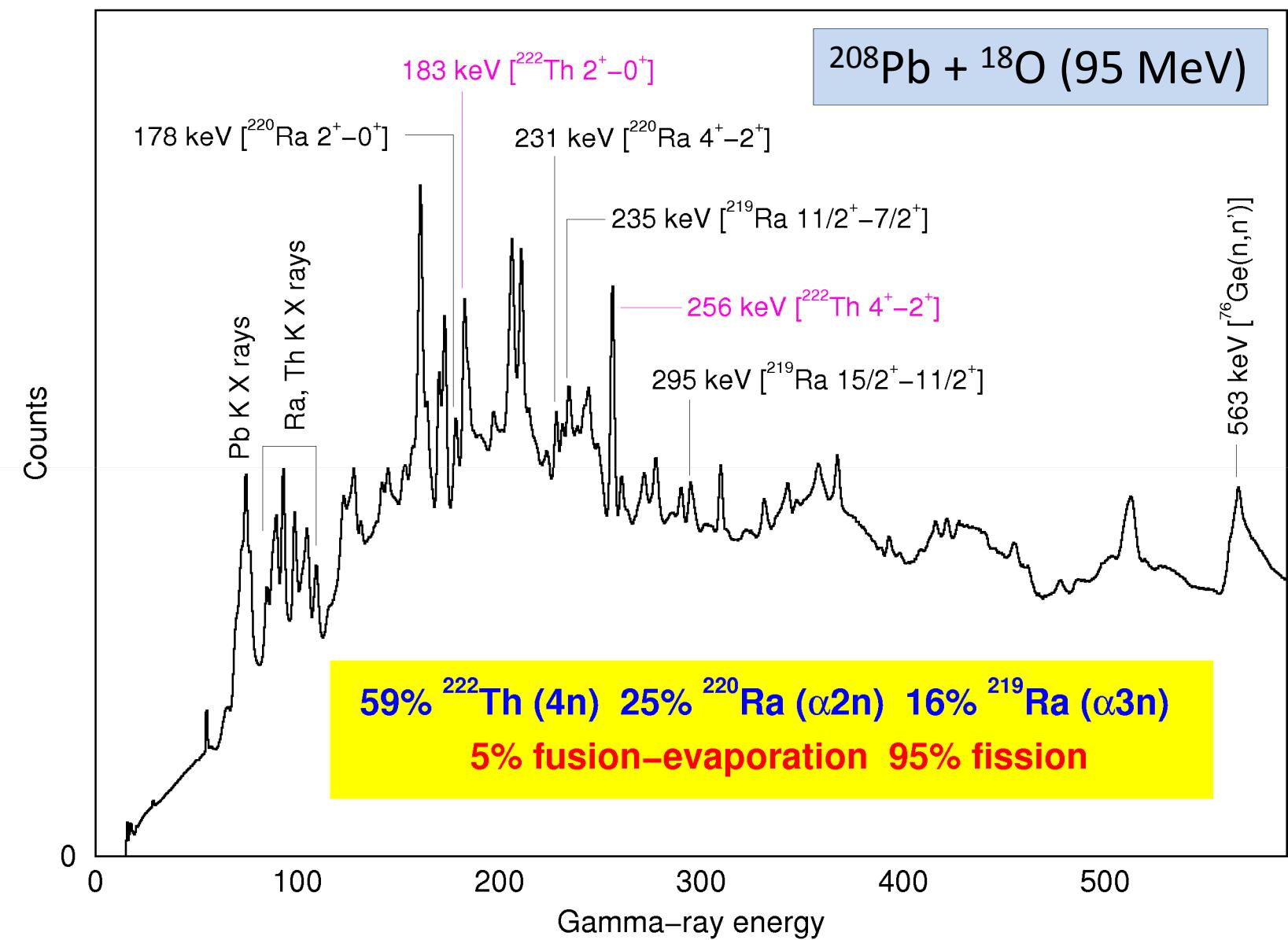
$s=+1$ bands have been observed in many light-actinide nuclei



J. F. C. Cocks et al., Phys. Rev. Lett. 78, 2920 (1997)

The octupole-deformed light-actinide region





Contrasting Behavior in Octupole Structures Observed at High Spin in ^{220}Ra and ^{222}Th

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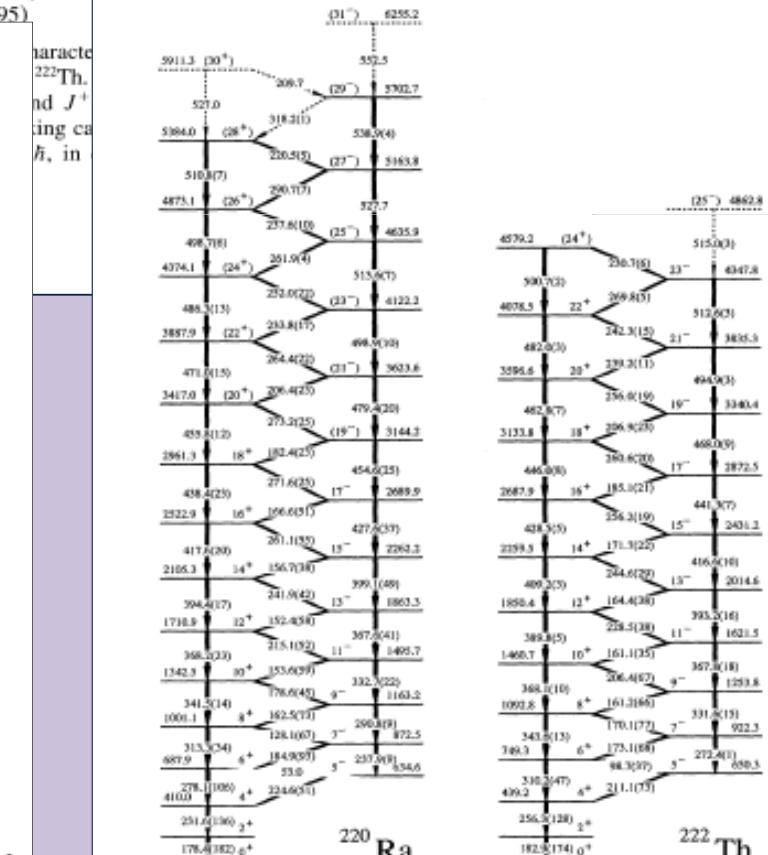
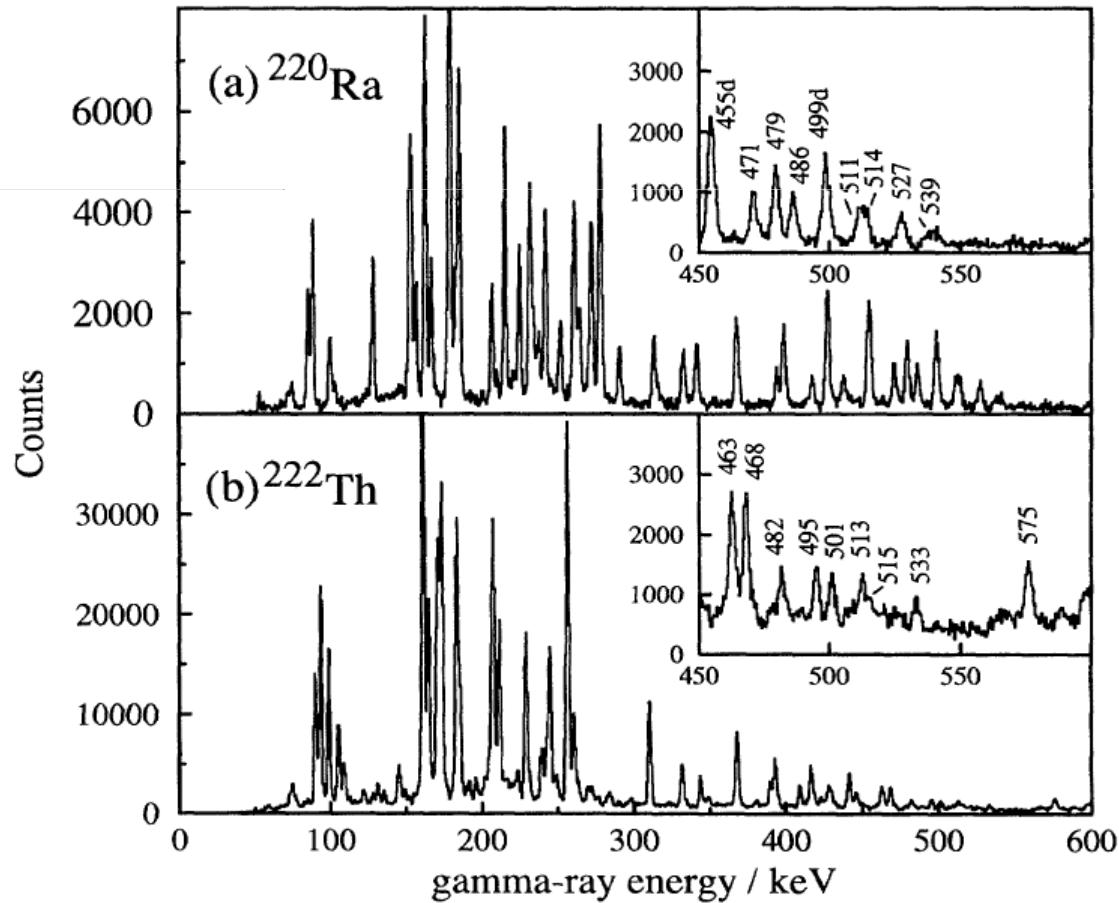
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(Received 2 March 1995)

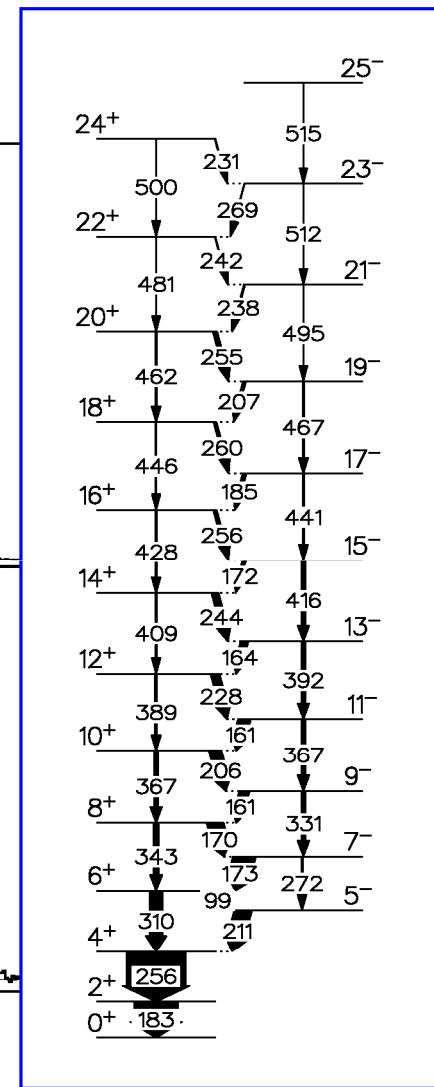
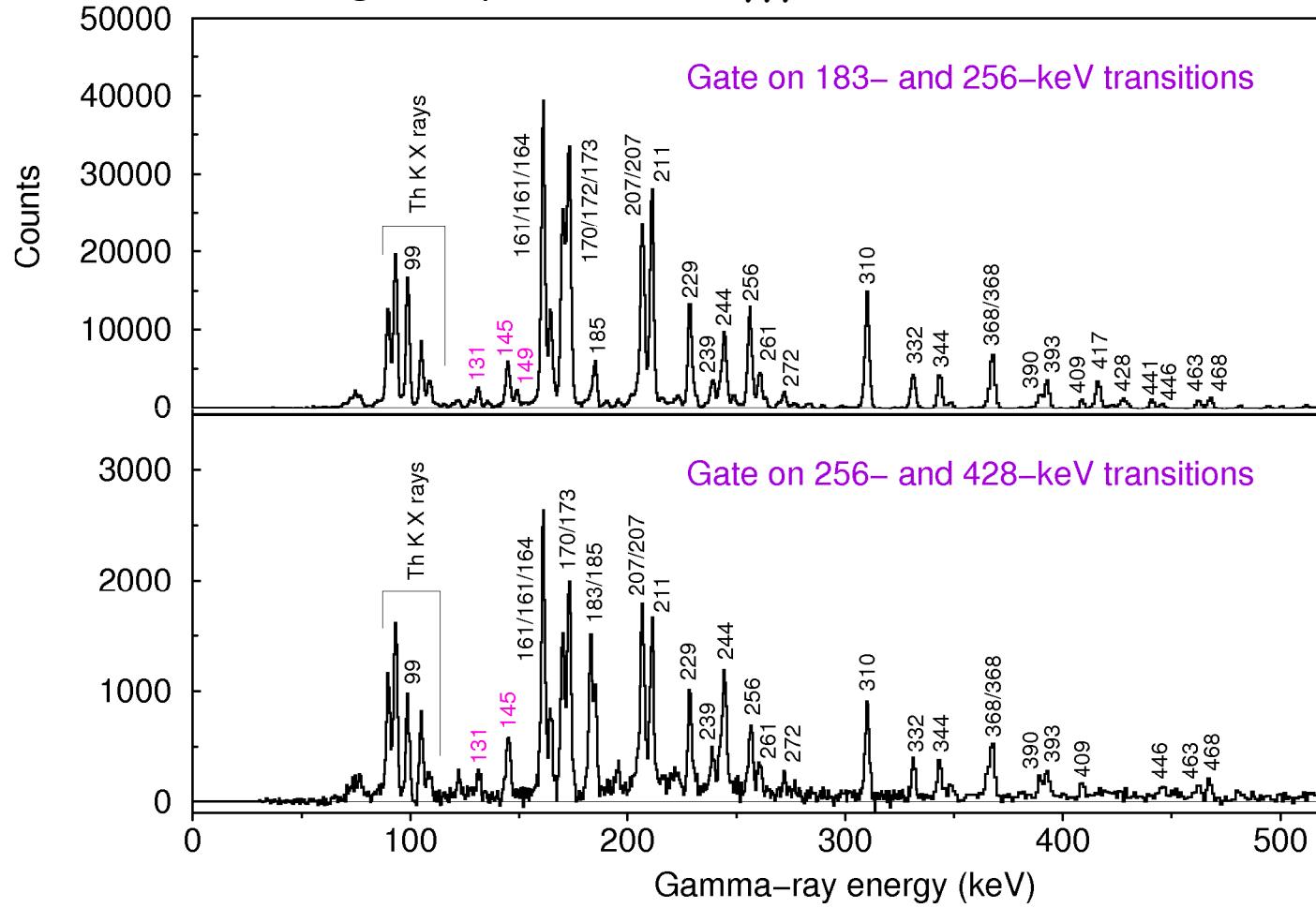


(a)

(b)

Spectra of the ^{222}Th yrast octupole band

double-gated spectra from a $\gamma\gamma\gamma$ cube



Experiment with Gammasphere and HERCULES



HERCULES

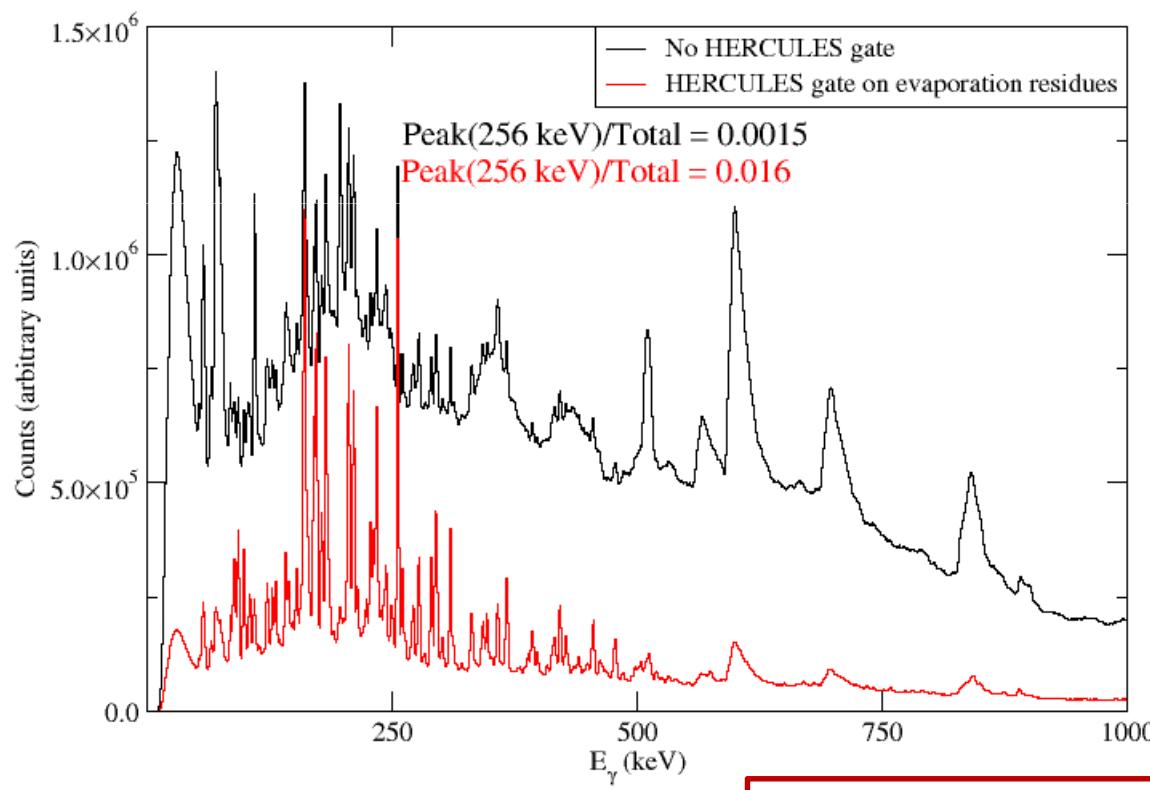
The High-Efficiency Residue Counter Under Lots of Elastic Scattering

64 plastic scintillators for evaporation-residue detection

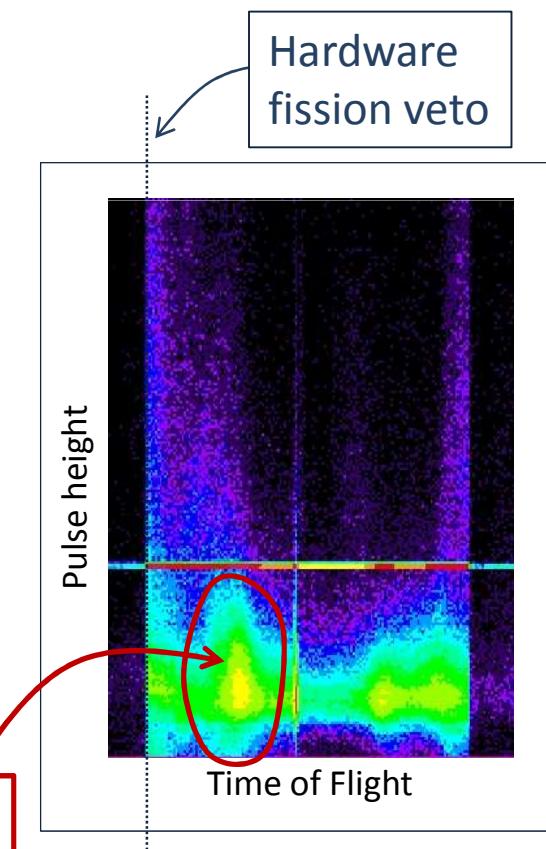
W. Reviol et al. Nucl. Inst. Meth. A451 (2005)

Experiment with Gammasphere and Hercules

- $^{208}\text{Pb}(^{18}\text{O}, 4\text{n})^{222}\text{Th}$ at ATLAS, Argonne National Laboratory
- Target: $\sim 300 \mu\text{g}/\text{cm}^2$ self-supporting ^{208}Pb (thin target)
- Beam: Ebeam=95 MeV; Q=5⁺; I= $\sim 4\text{-}5 \text{ pnA}$; pulsed with period 260 ns
- Recoil pulse height vs. time-of-flight used to select evaporation residues

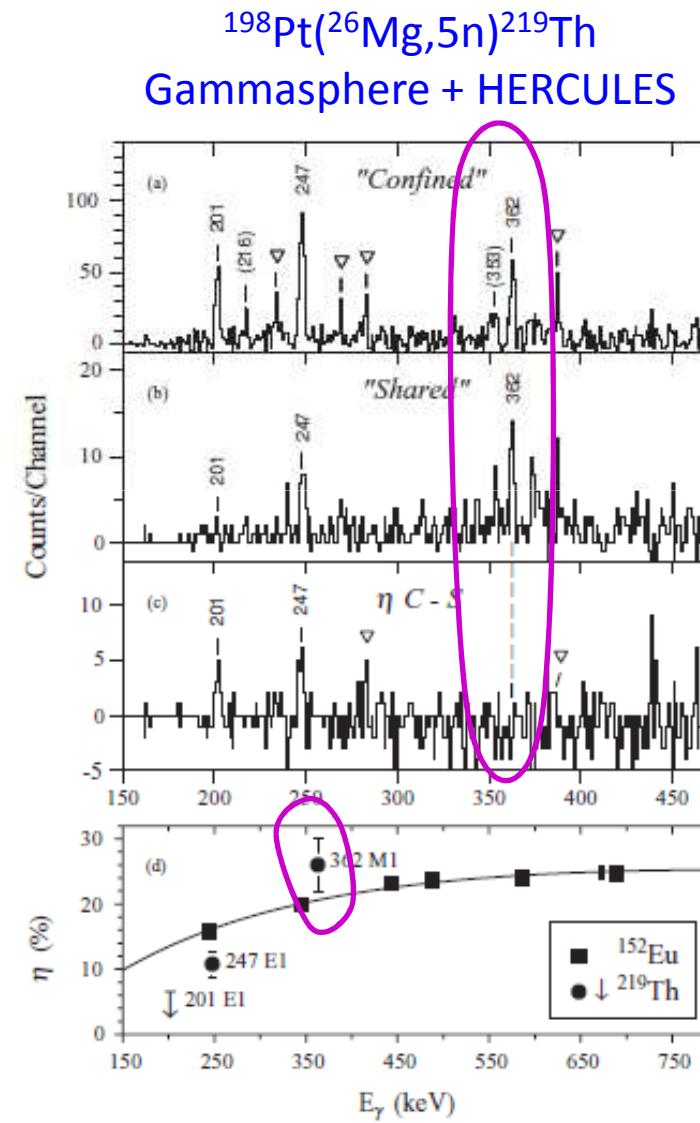
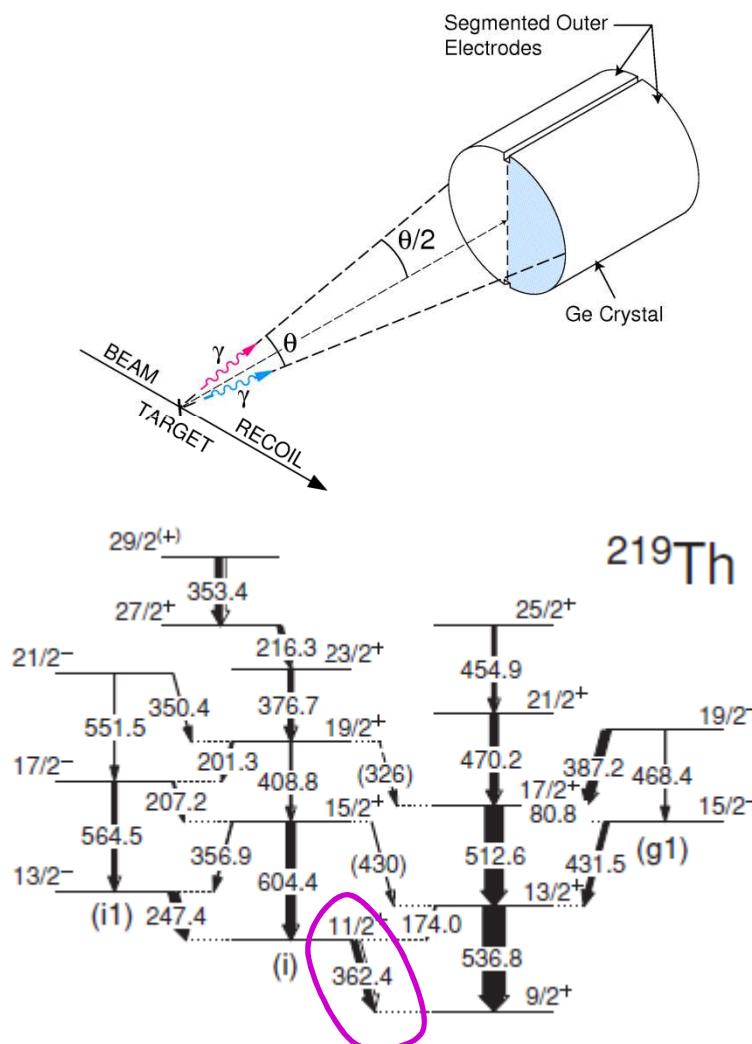


Evaporation residues



Linear polarization measurements in ^{219}Th using Gammasphere

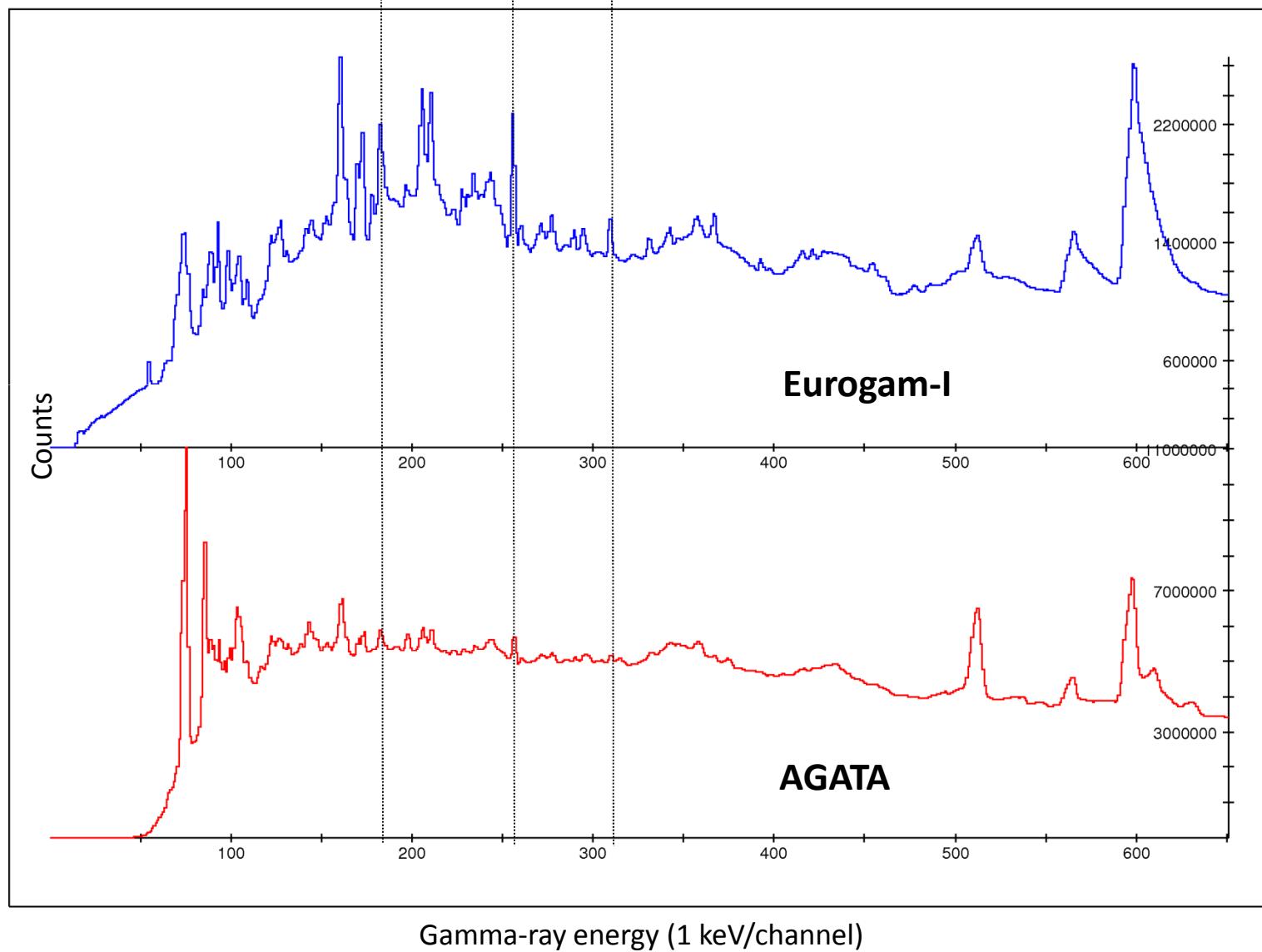
W. Reviol et al Physical Review C 80, 011304(R) (2009)

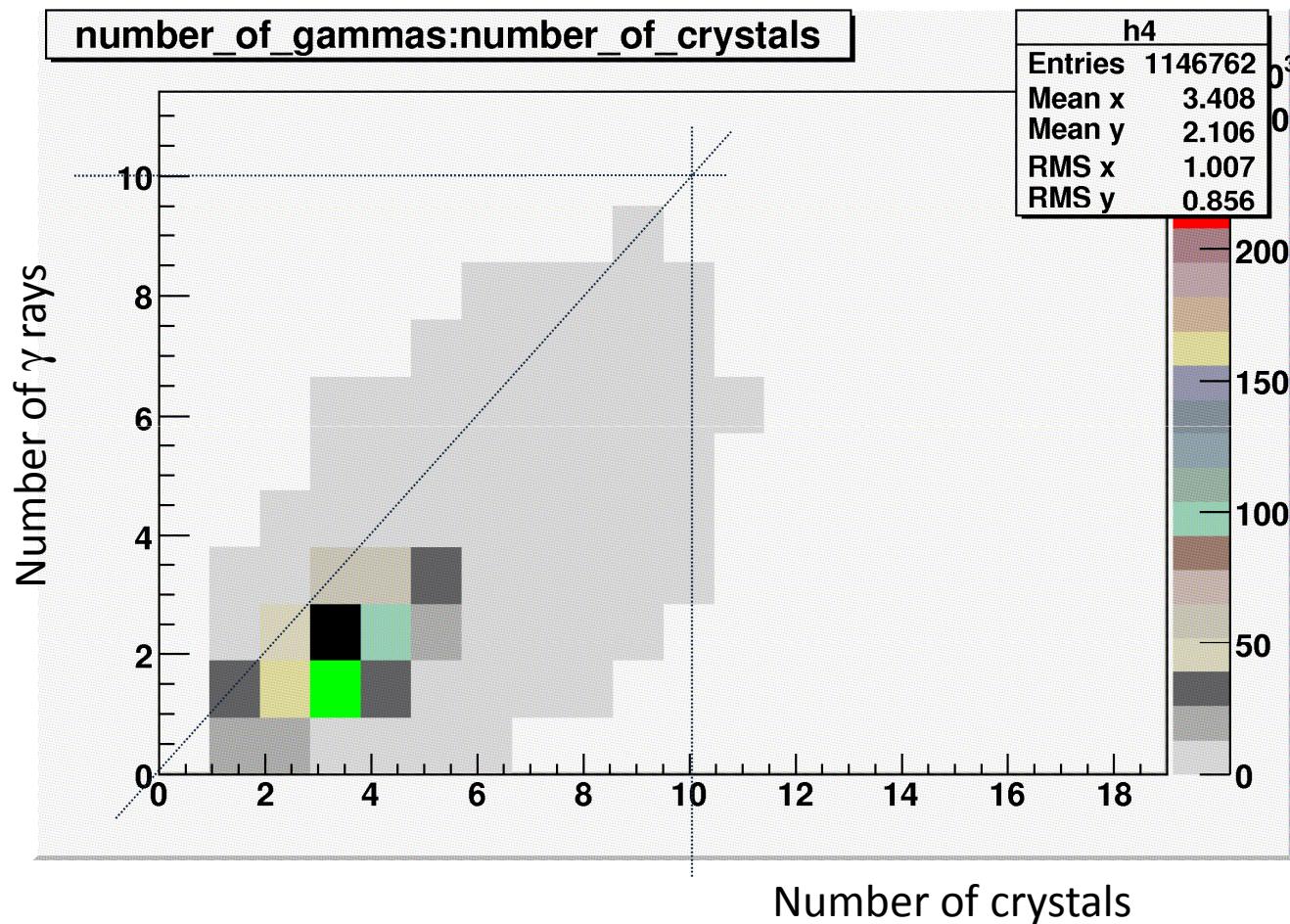


AGATA Week11 2011: Experimental Details

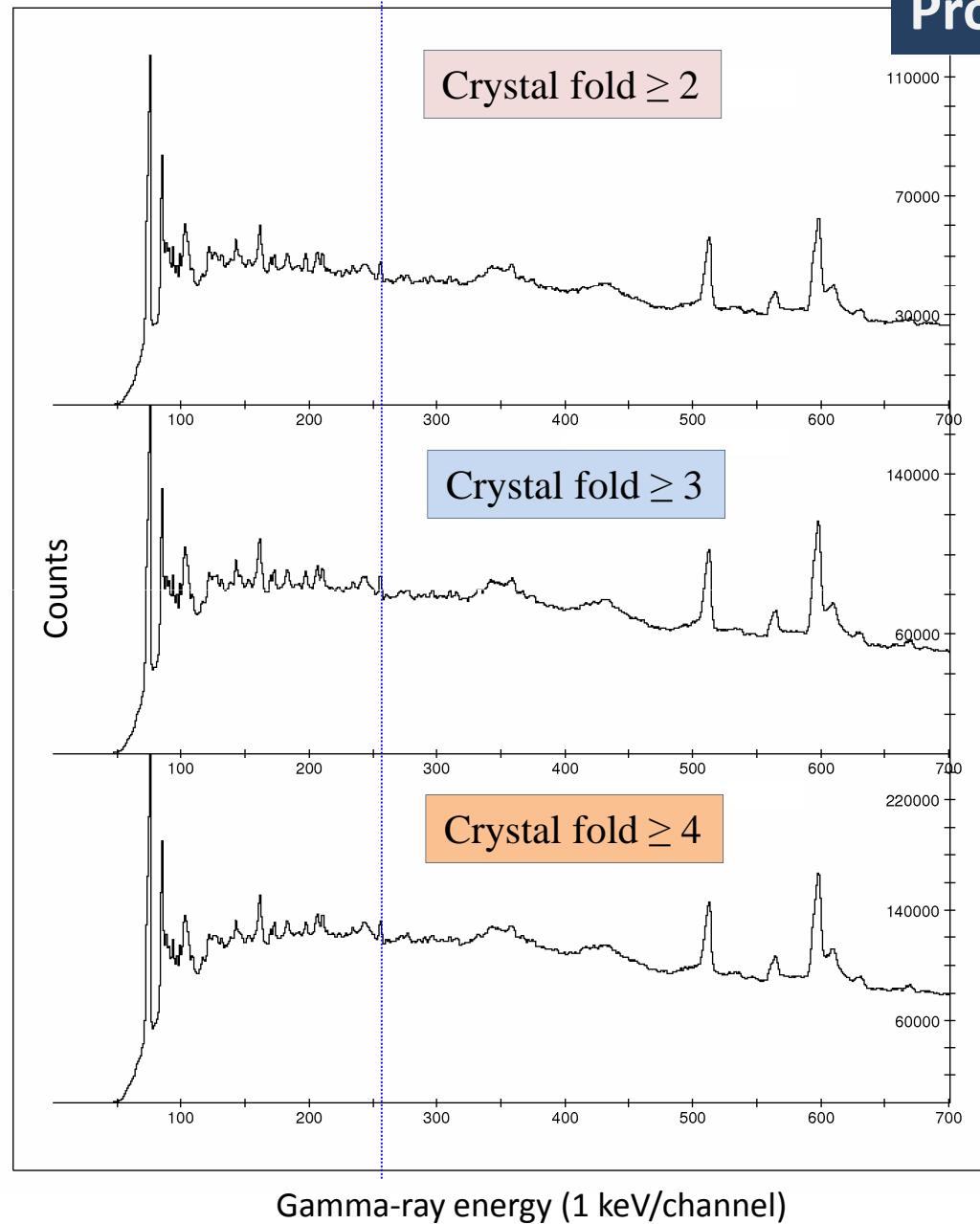
- **Dates:** 17th – 22nd March 2011 (Week 11) [~6 days beam time]
- **AGATA:** 4 ATCs; target-to-AGATA distance = 230 mm, close to $\theta=90^\circ$
- **Beam:** ^{18}O ; Q=6⁺; Intensity=~17-20 enA (~3 pnA)
- **Target:** 1 mg/cm² ^{208}Pb
- **Trigger:** ≥ 2 , ≥ 3 , or ≥ 4 , crystals. (Varied. Mostly ran with ≥ 3 .)
- **Typical rates per crystal:** ~3 kHz
- **Typical event rates:** ~9 kHz
- **Data rate:** ~90 MB/s (instantaneous) \approx 5.4 GB/minute
- **Total data collected:** 33 TB.
- Collection of 33 TB in 6 days gives **average data rate** of 63.5 MB/s
- **Total number of $\gamma\gamma$ coincidences** (from offline analysis): 2.8×10^9
- **No problems** with the beam in the 6-day duration of the experiment
- **No major problems** with AGATA: one NARVAL node crashed
~twice losing a maximum of ~2 hours in total.

**Total projection
of the $\gamma\gamma$ matrix**





256 keV ($2^+ \rightarrow 0^+$ in ^{222}Th)



Projections of $\gamma\gamma$ matrices

Crystal Fold ≥ 2

- 382GB data sample (R40)
- $\gamma\gamma/\text{GB}$: 59×10^3
- 256 keV γ 's/GB: 50
- 256 keV/total: 4.3×10^{-4}

Crystal Fold ≥ 3

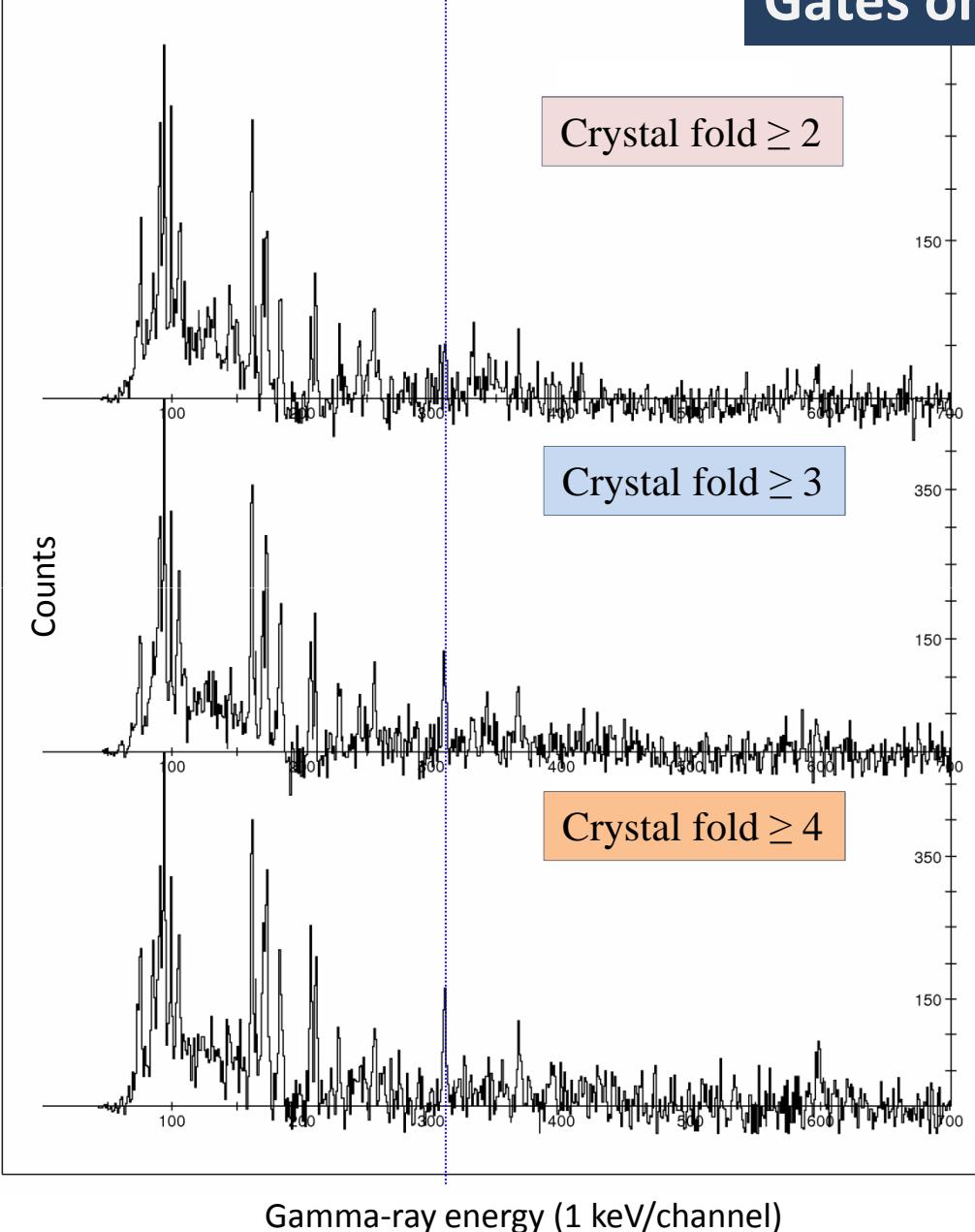
- 578GB data sample (R53)
- $\gamma\gamma/\text{GB}$: 87×10^3
- 256 keV γ 's/GB: 26
- 256 keV/total: 1.5×10^{-4}

Crystal Fold ≥ 4

- 498GB data sample (R50)
- $\gamma\gamma/\text{GB}$: 113×10^3
- 256 keV γ 's/GB: 28
- 256 keV/total: 1.24×10^{-4}

310 keV ($6^+\rightarrow4^+$ in ^{222}Th)

Gates on 256 keV (^{222}Th $4^+\rightarrow2^+$)



Crystal Fold ≥ 2

- 382GB data sample (R40)
- 310 keV γ rays: 107
- 310 keV γ 's/GB: 0.28
- 310 keV/total: 0.0112

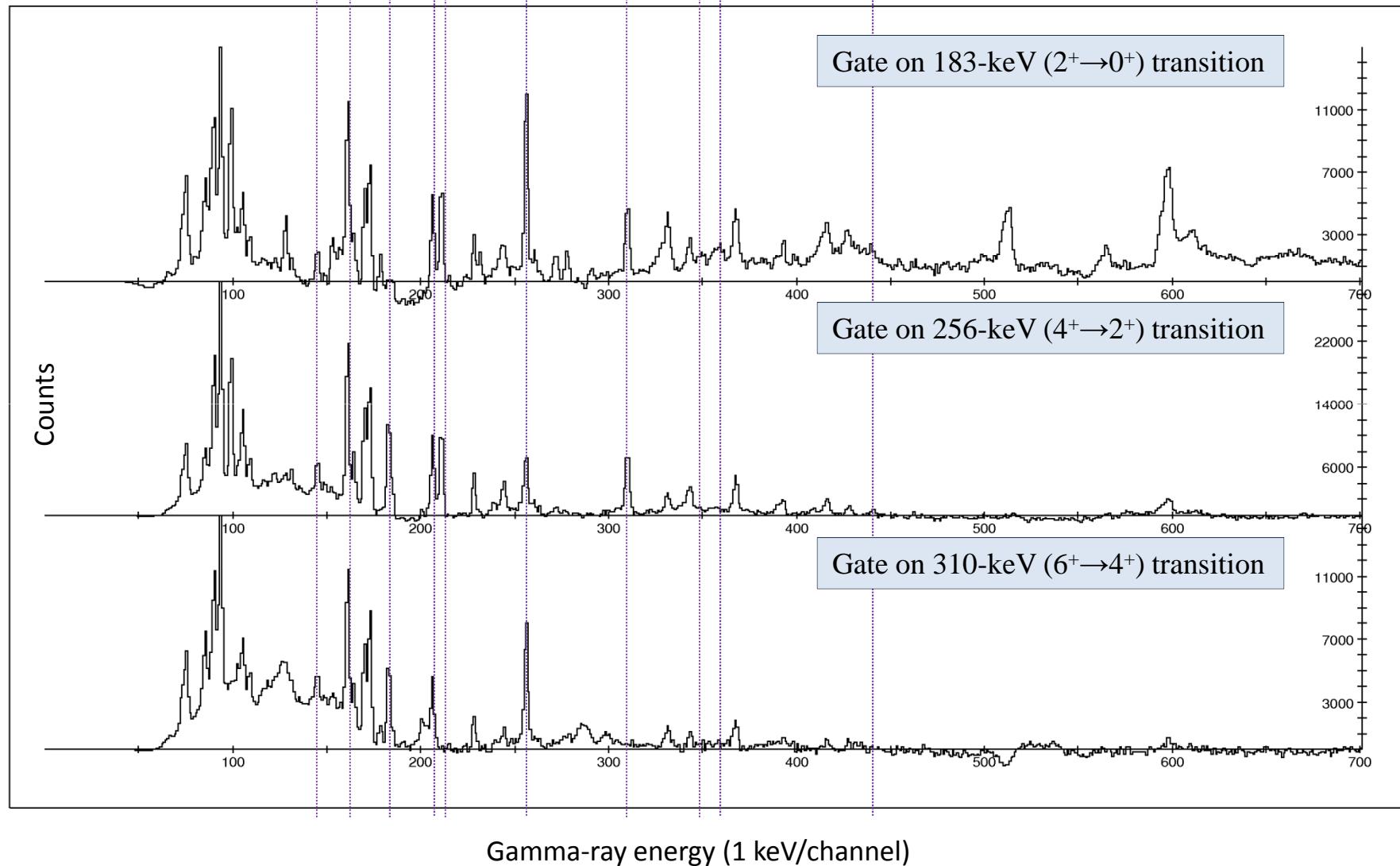
Crystal Fold ≥ 3

- 578GB data sample (R53)
- 310 keV g rays: 333
- 310 keV γ 's/GB: 0.58
- 310 keV/total: 0.0209

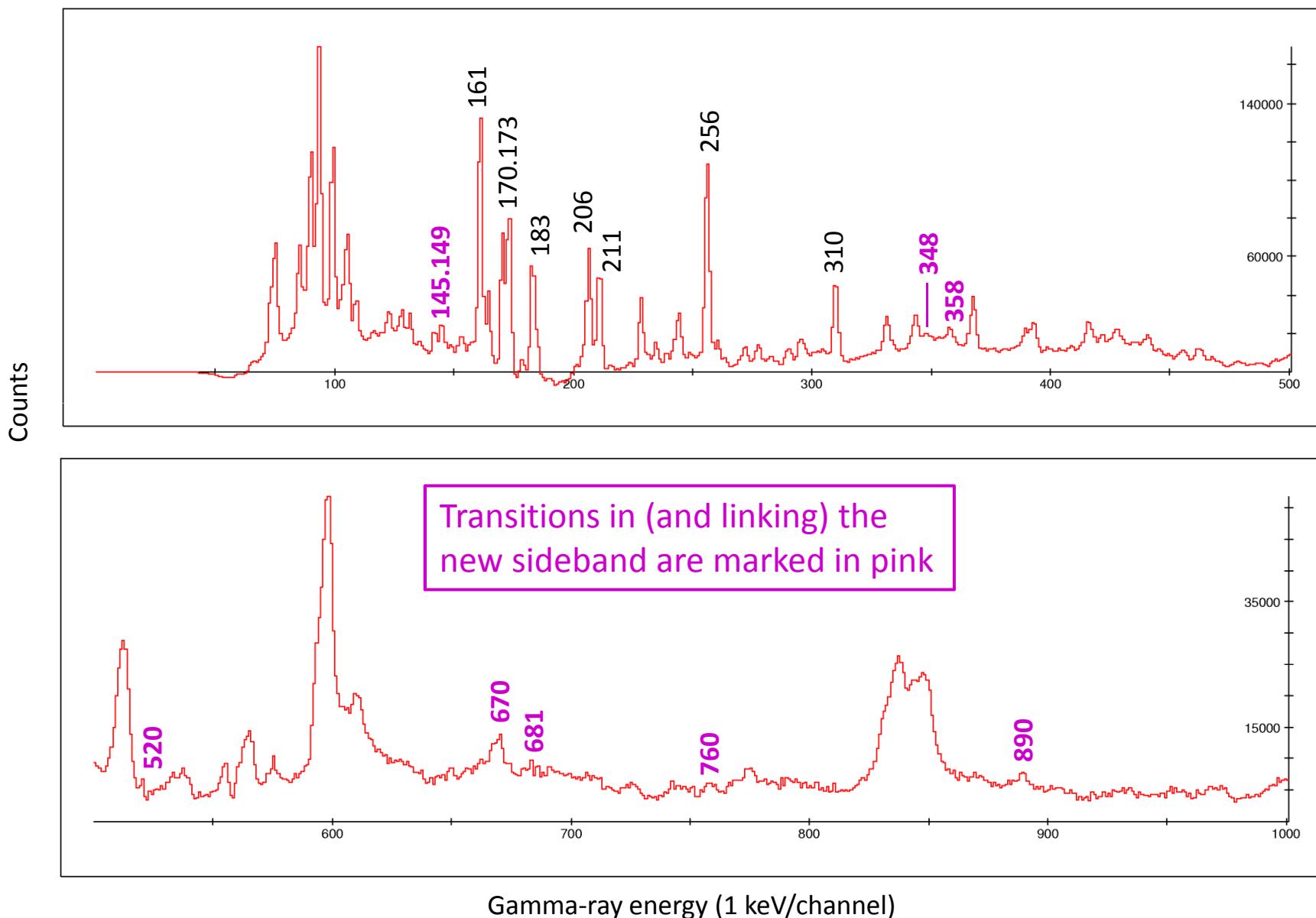
Crystal Fold ≥ 4

- 498GB data sample (R50)
- 310 keV γ rays: 411
- 310 keV γ 's/GB: 0.83
- 310 keV/total: 0.0197

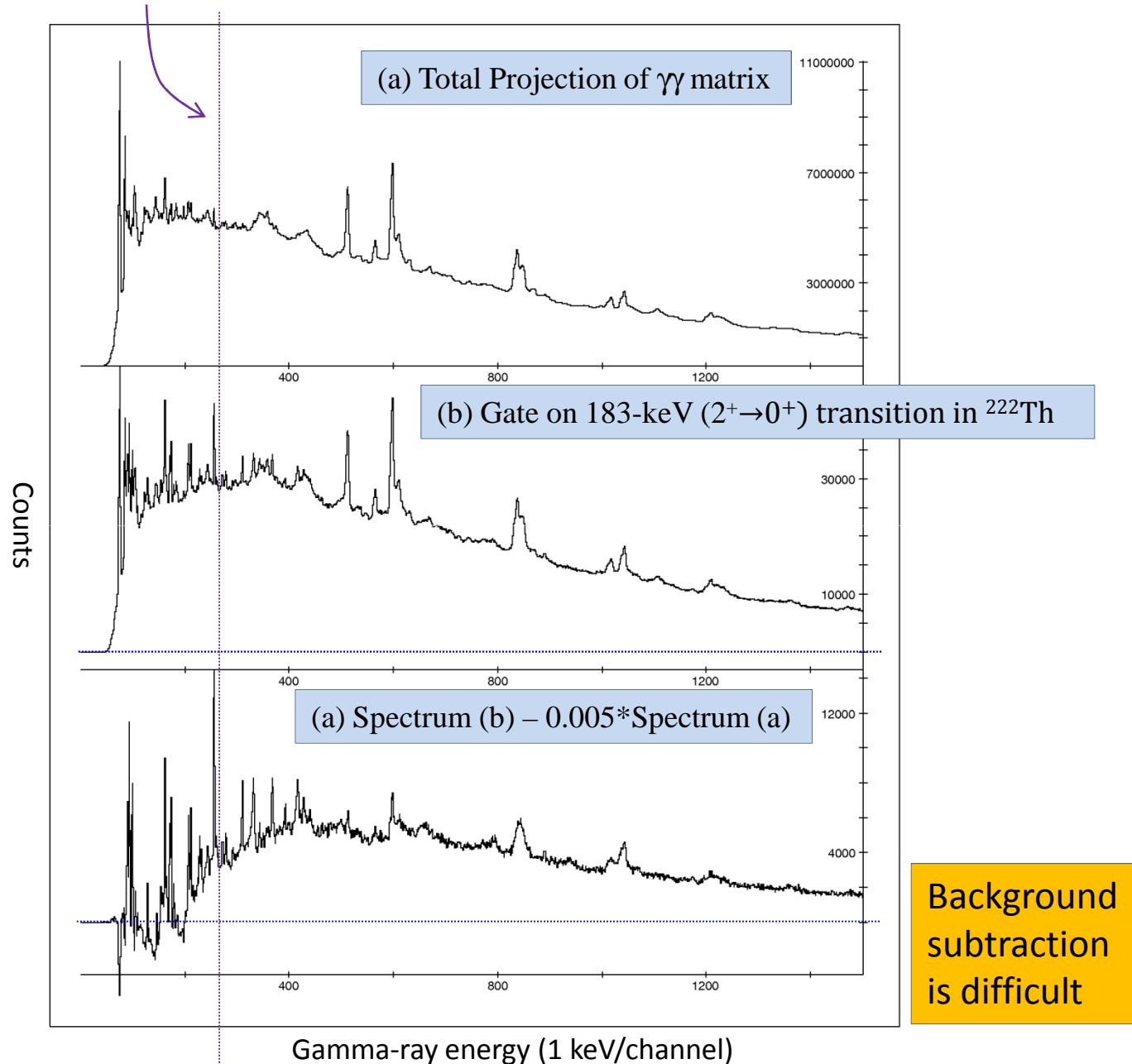
Gates on ^{222}Th transitions in
the $\gamma\gamma$ matrix (Preliminary)



Sum of Gates on the ^{222}Th yrast octupole band from the AGATA data
(161, 170, 173, 183, 206, 211, 256, 310 keV)

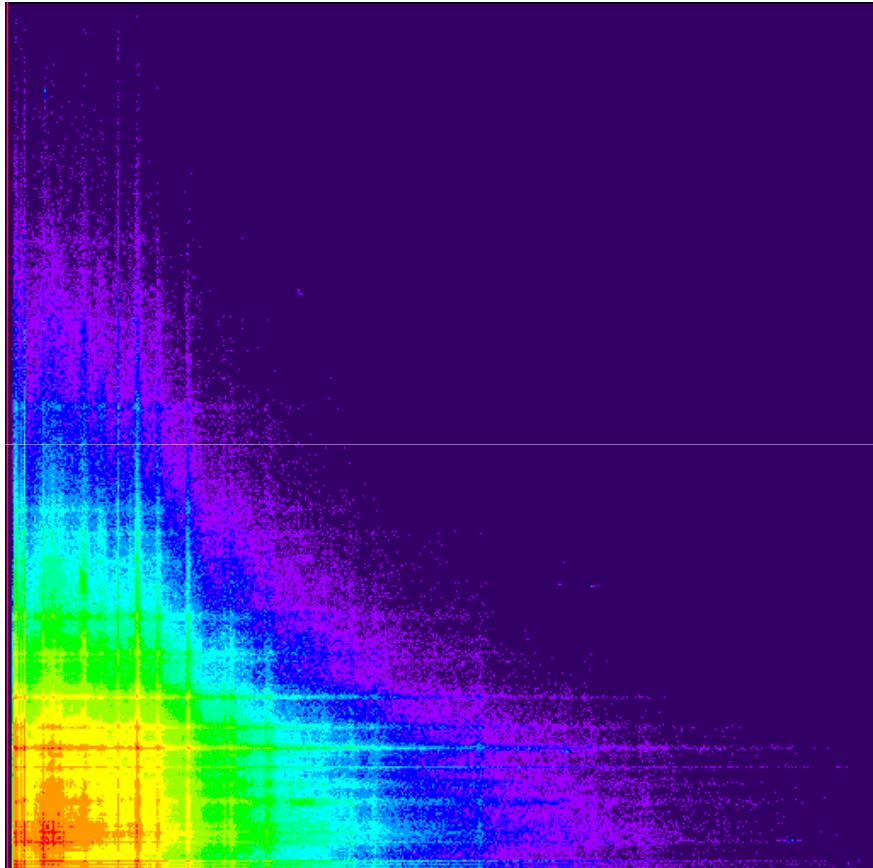


256-keV ($4^+ \rightarrow 2^+$) transition in ^{222}Th



Comparison of $\gamma\gamma$ matrices from AGATA and Gammasphere

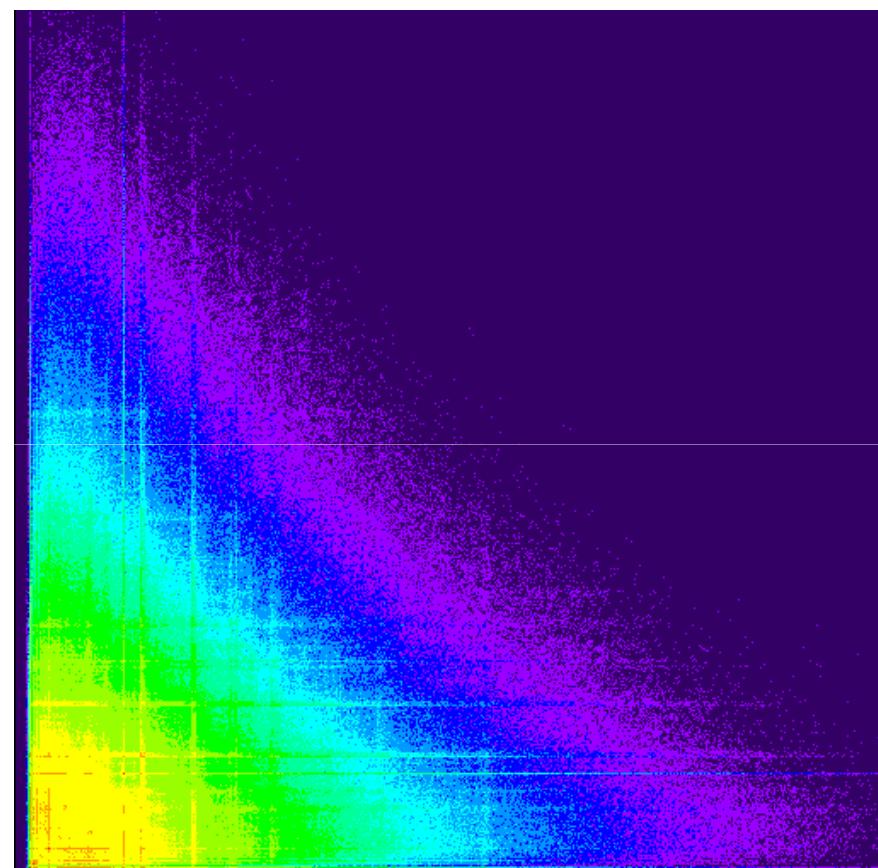
$^{208}\text{Pb} + ^{18}\text{O}$ (at 95 MeV) [4 MeV on each axis]



Gammasphere

10.5 GB data; $0.3 \times 10^9 \gamma\gamma$ events

1 keV per channel



AGATA

3.4 TB data; $0.3 \times 10^9 \gamma\gamma$ events

1 keV per channel

Summary

- The $^{208}\text{Pb} + ^{18}\text{O}$ reaction has been studied with AGATA (4 ATCs) in order to measure linear polarizations of new transitions.
- There is evidence that the states in the new sideband in ^{222}Th have been populated.
- The data analysis is ongoing.
- There are issues with background subtraction that need to be resolved before we attempt to extract linear polarizations.

Participants in the experiment...

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... and the AGATA Collaboration