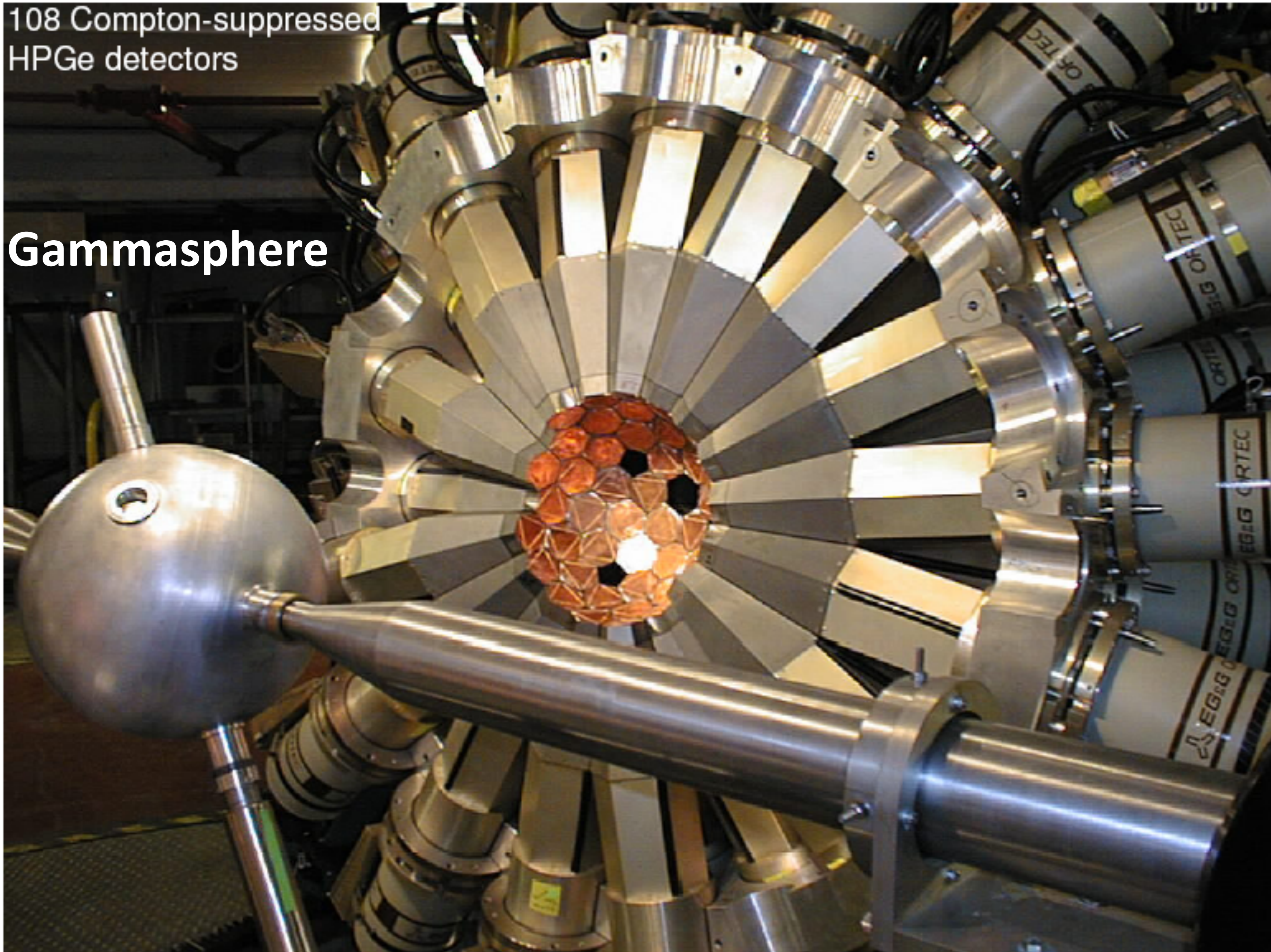
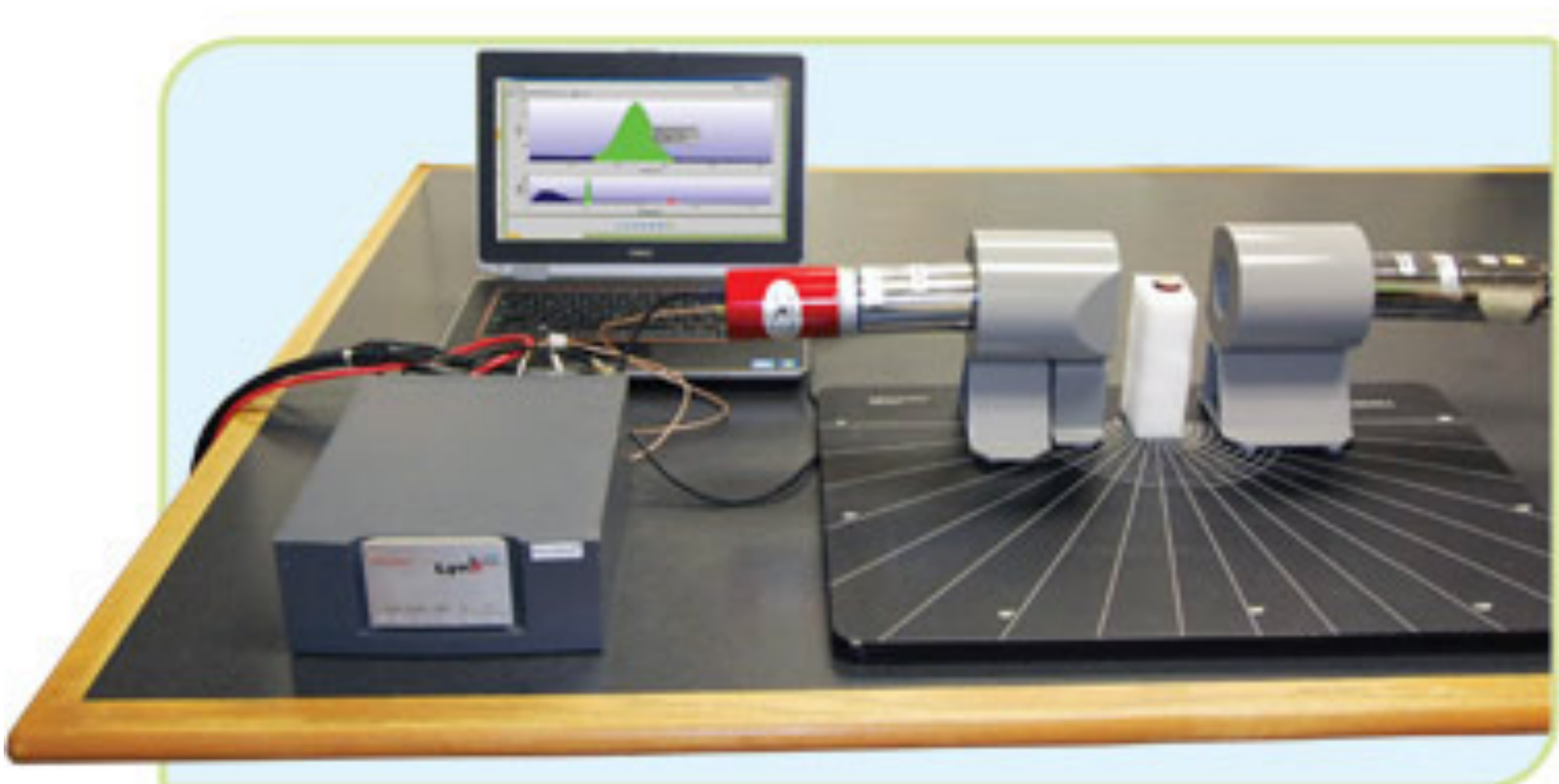

108 Compton-suppressed
HPGe detectors
Gammasphere

2) Gamma Ray Spectroscopy Coincidence Techniques



Principle

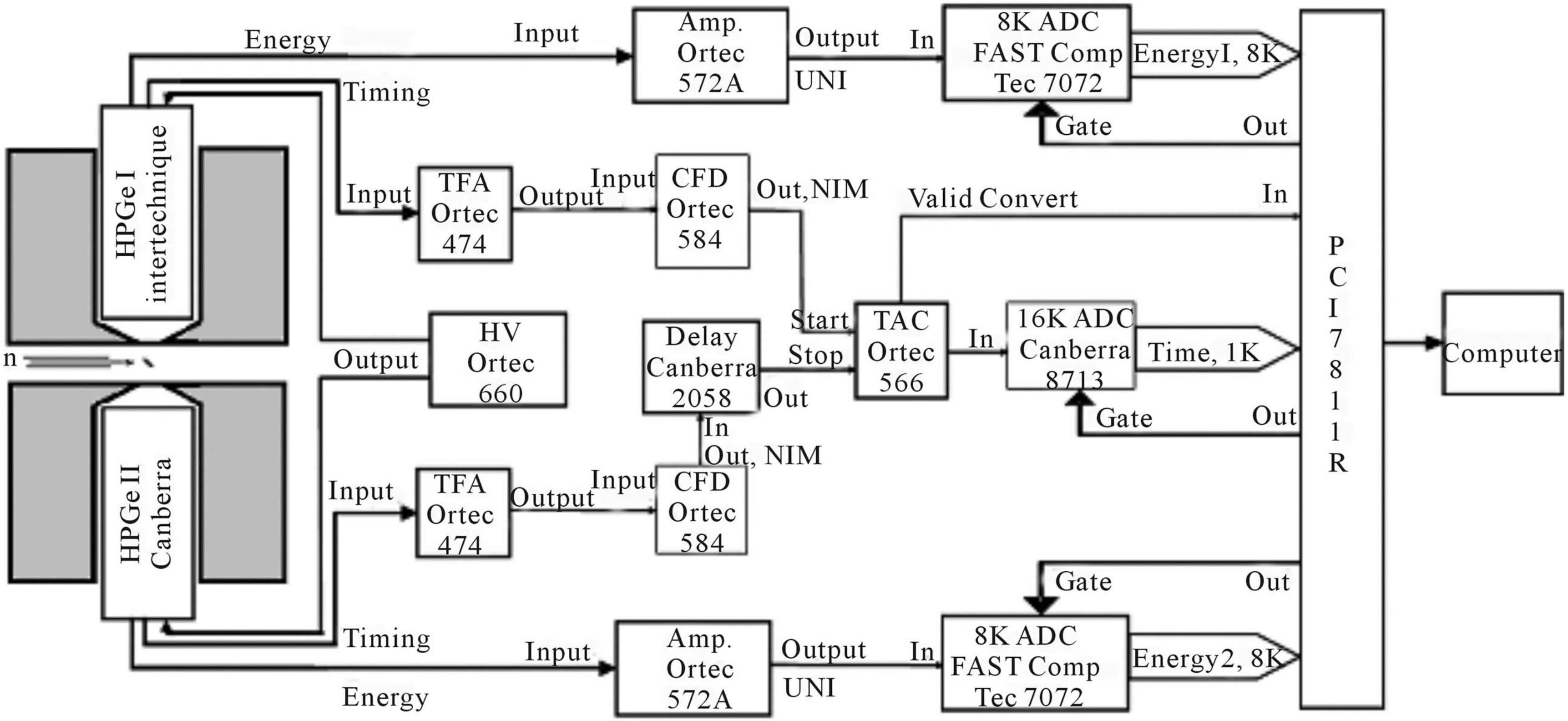
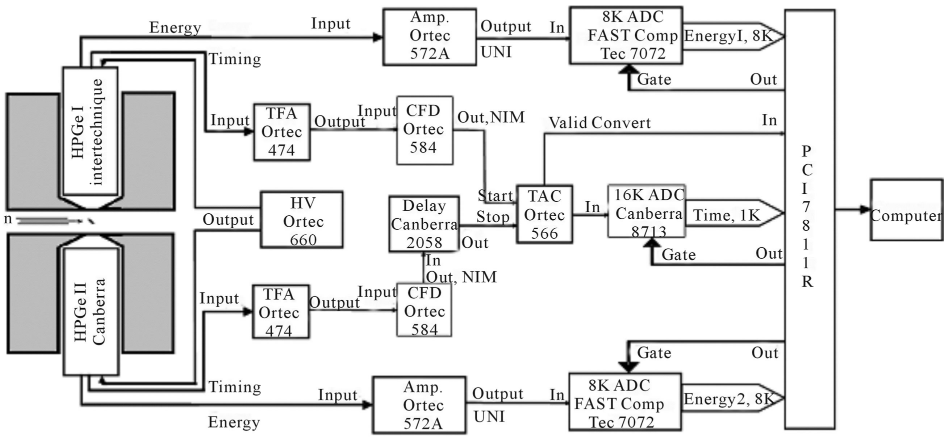
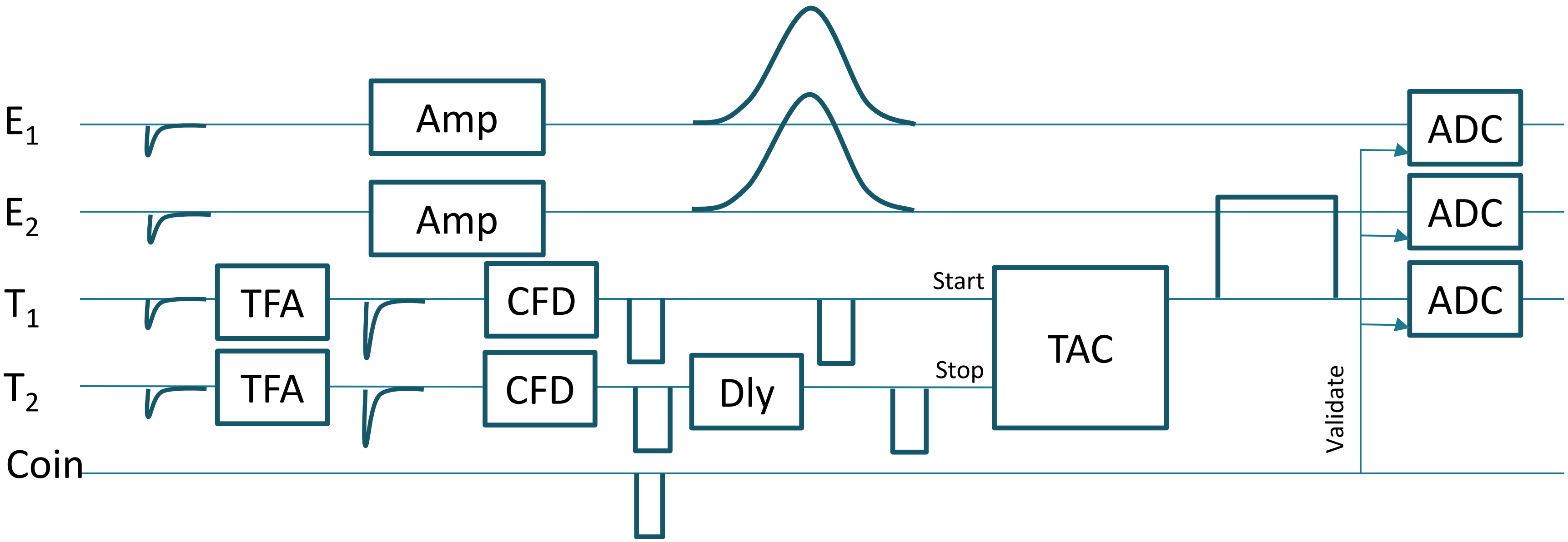


Image taken from WJNST 42520 (14), doi: [10.4236/wjnst.2014.41007](https://doi.org/10.4236/wjnst.2014.41007)

Principle

Image taken from WJNST 42520 (14), doi: [10.4236/wjnst.2014.41007](https://doi.org/10.4236/wjnst.2014.41007)





Here we know we
have a coincidence

Coincidence timing

- Depends on:
  - the time resolution of the detector
  - the physics (lifetimes of levels)
  - electronic response

- Typical values for Ge detectors
  - Coincidence window of 100 ns

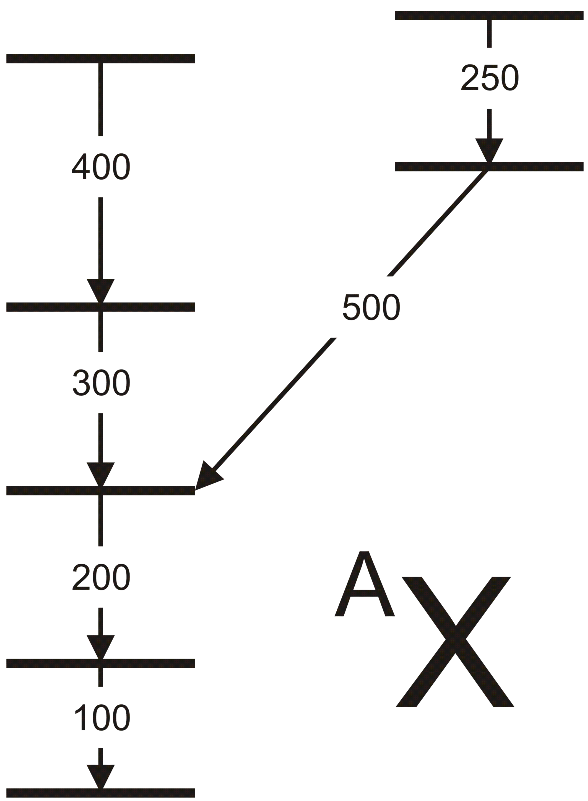
Generating spectra from high-fold coincidence data.

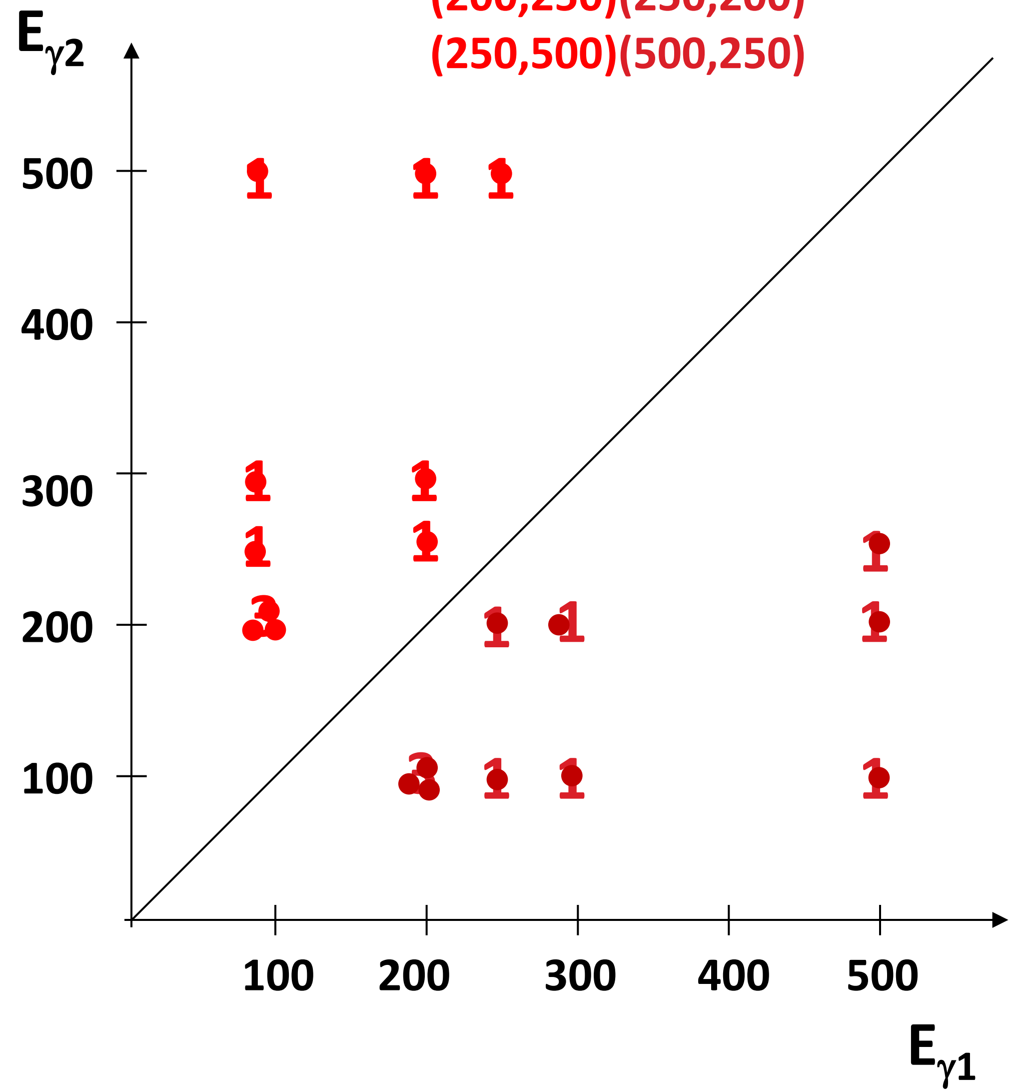
Raw Event 1: 100, 200.
Raw Event 2: 100, 200, 300.
Raw Event 3: 100, 200, 500, 250.

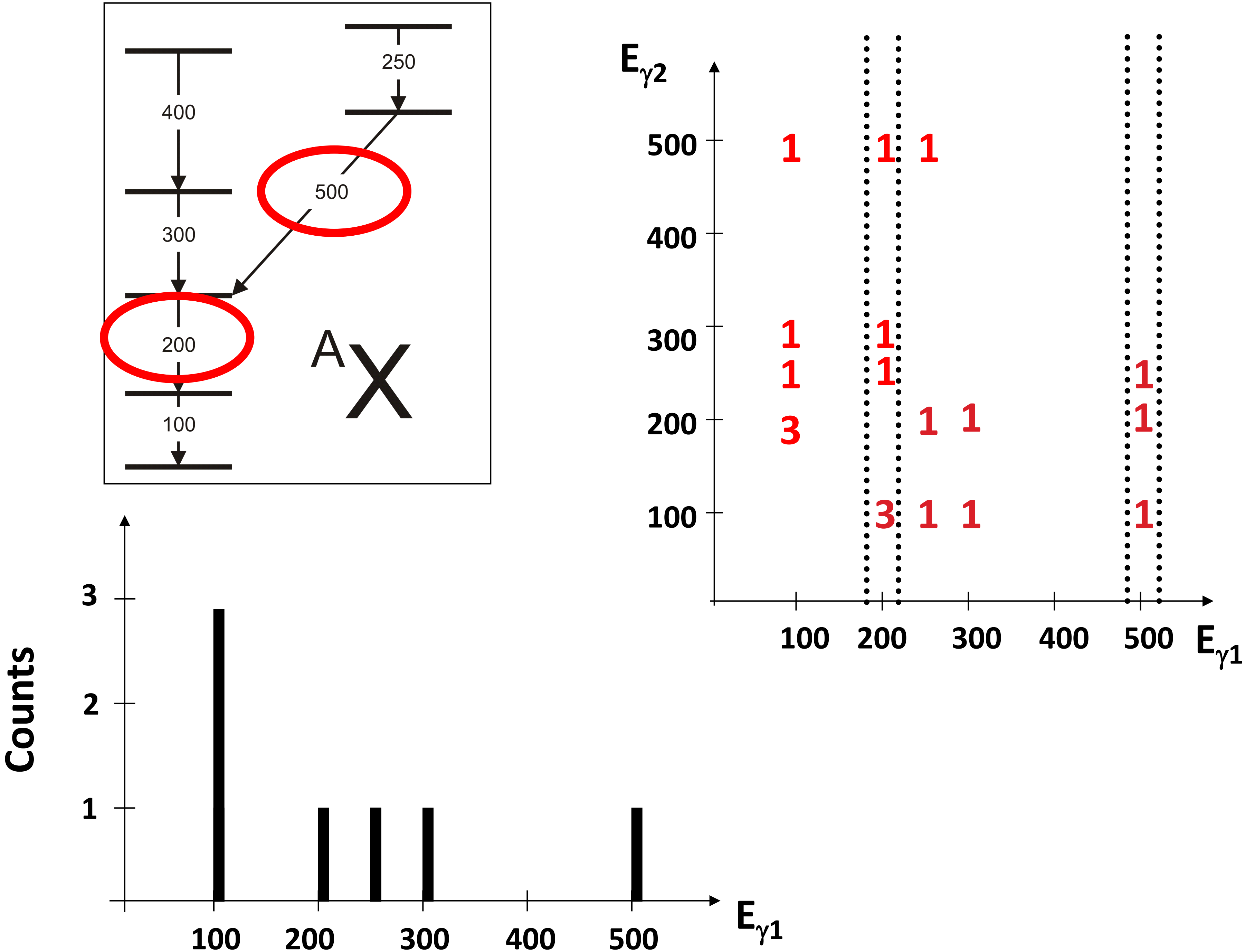
Event 1 (100, 200)(200,100)

Event 2 (100,200)(200,100)
(100,300)(300,100)
(200,300)(300,200)

Event 3 (100,200)(200,100)
(100,500)(500,100)
(100,250)(250,100)
(200,500)(500,200)
(200,250)(250,200)
(250,500)(500,250)

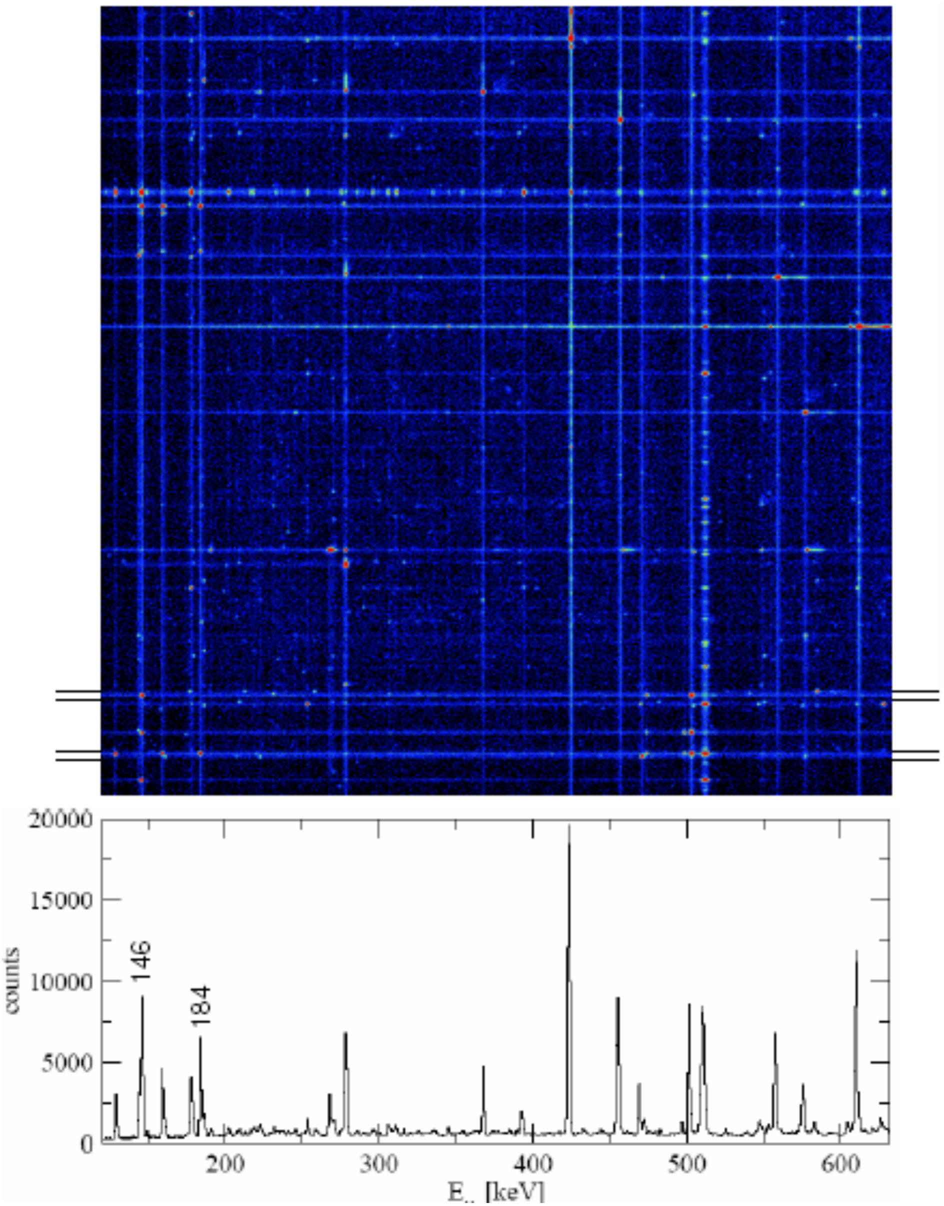


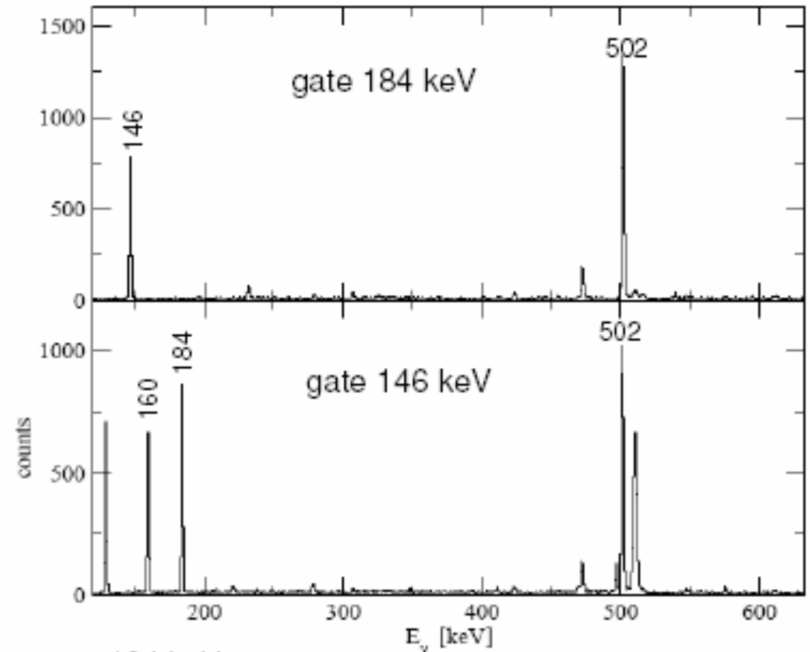


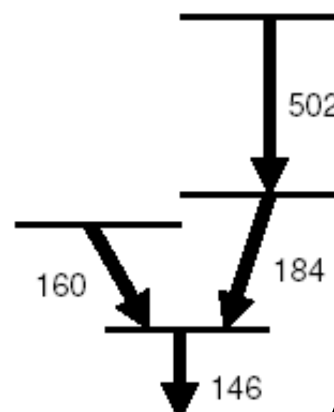


250
400
500
300
200
100
^{A}X
$E_{\gamma 2}$
500
400
300
200
100
1 1 1
1 1
1 1 1
3 1 1 1
3 1 1 1
100 200 300 400 500
$E_{\gamma 1}$
Counts
3
2
1
100 200 300 400 500
$E_{\gamma 1}$

Coincidence technique







A. Goergen

Big example

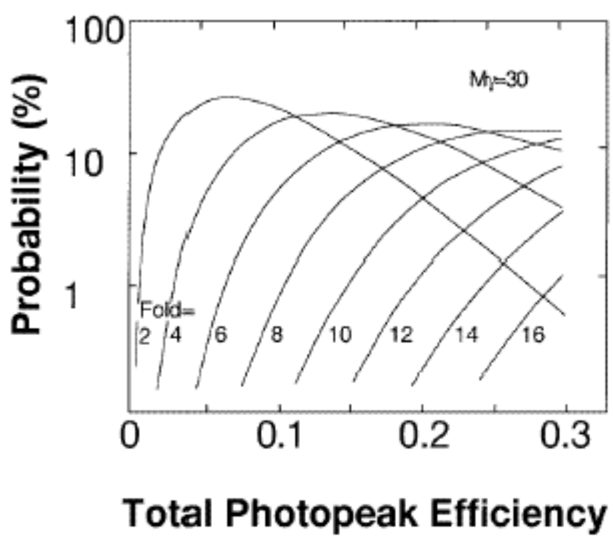
- Homework Challenge!

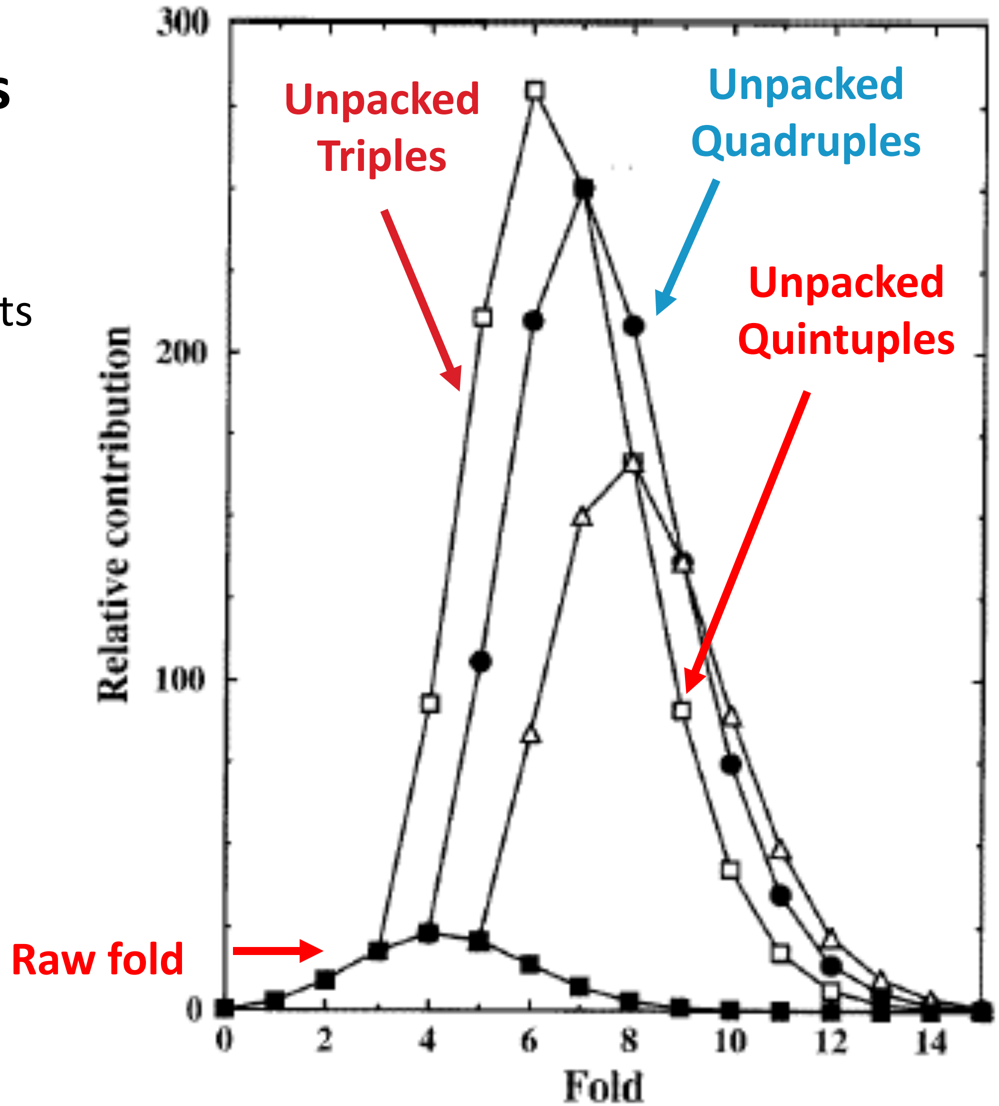
High-fold Data
&
Multidimensional Analysis

$$^{32}S + ^{112}Sn \rightarrow ^{152}Dy + 4n$$

EUROGAM II

Probability of detecting high-fold events increases with increased photopeak detection efficiency.



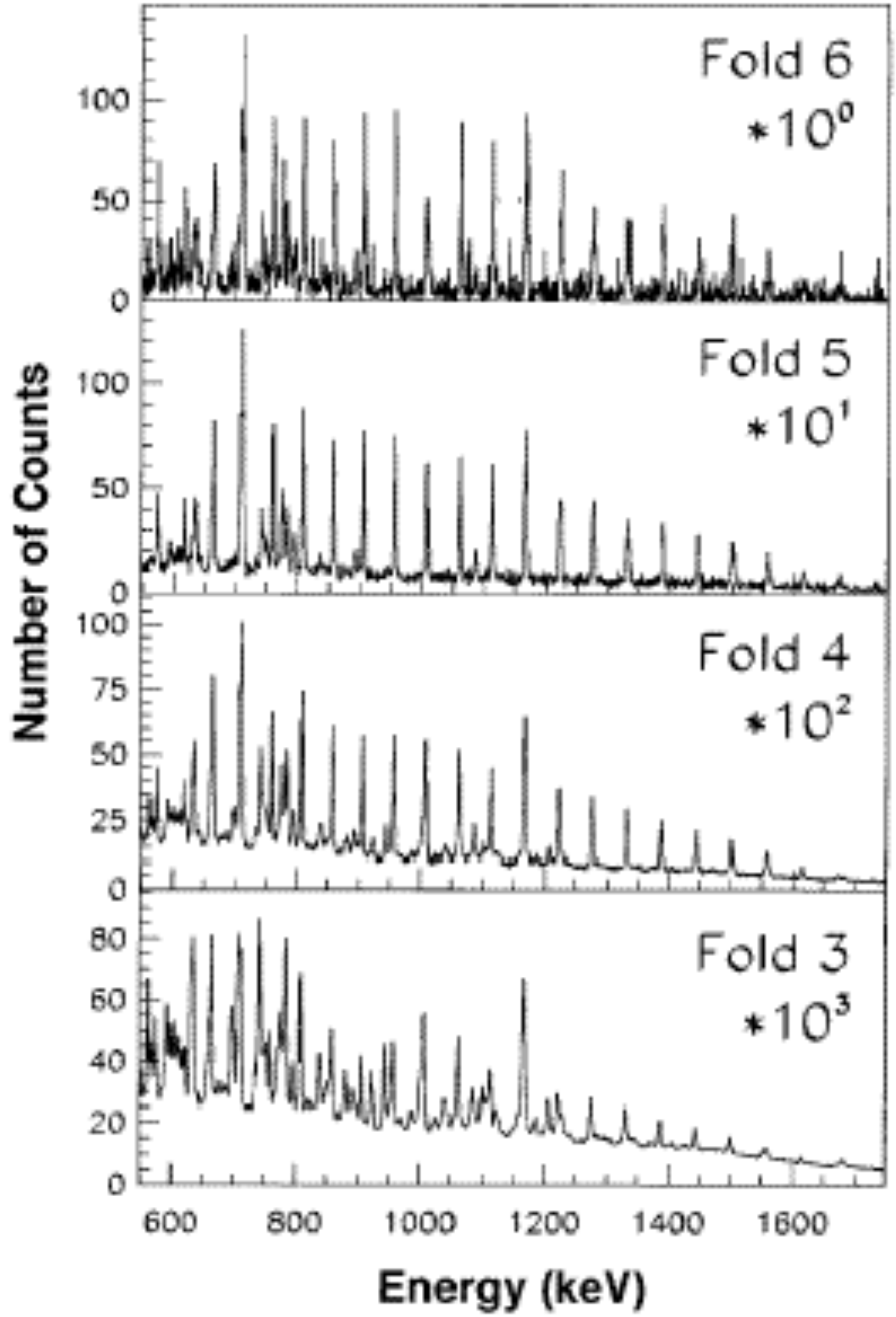


A superdeformed band in ^{149}Gd.

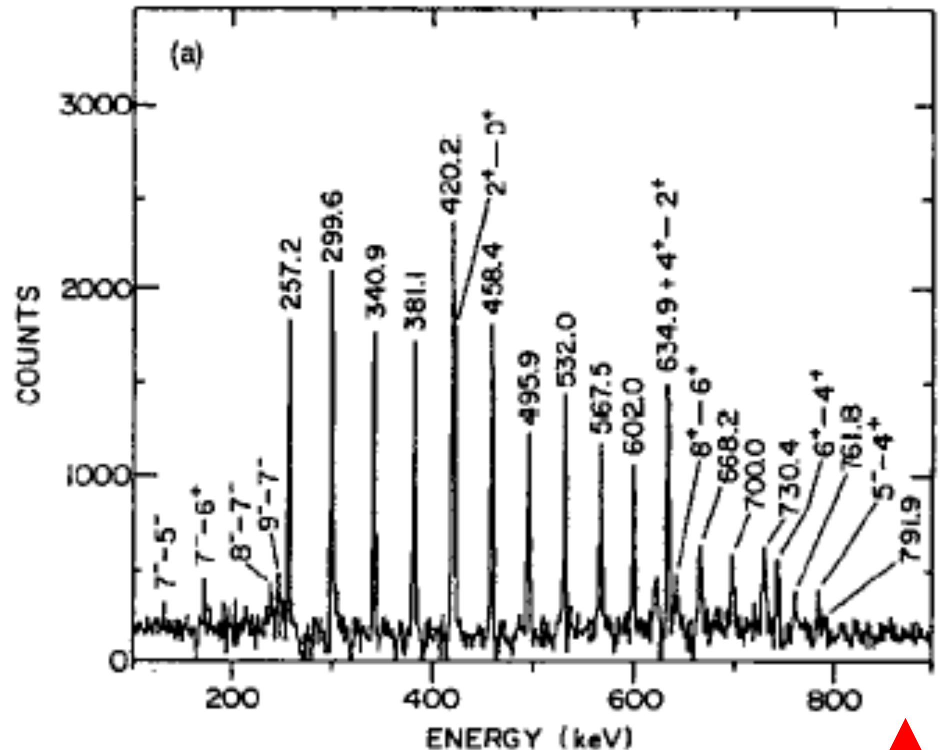
Spectra showing the effect
of ‘gating’ on coincident transitions.

For a review of spectrometer arrays
and their properties see

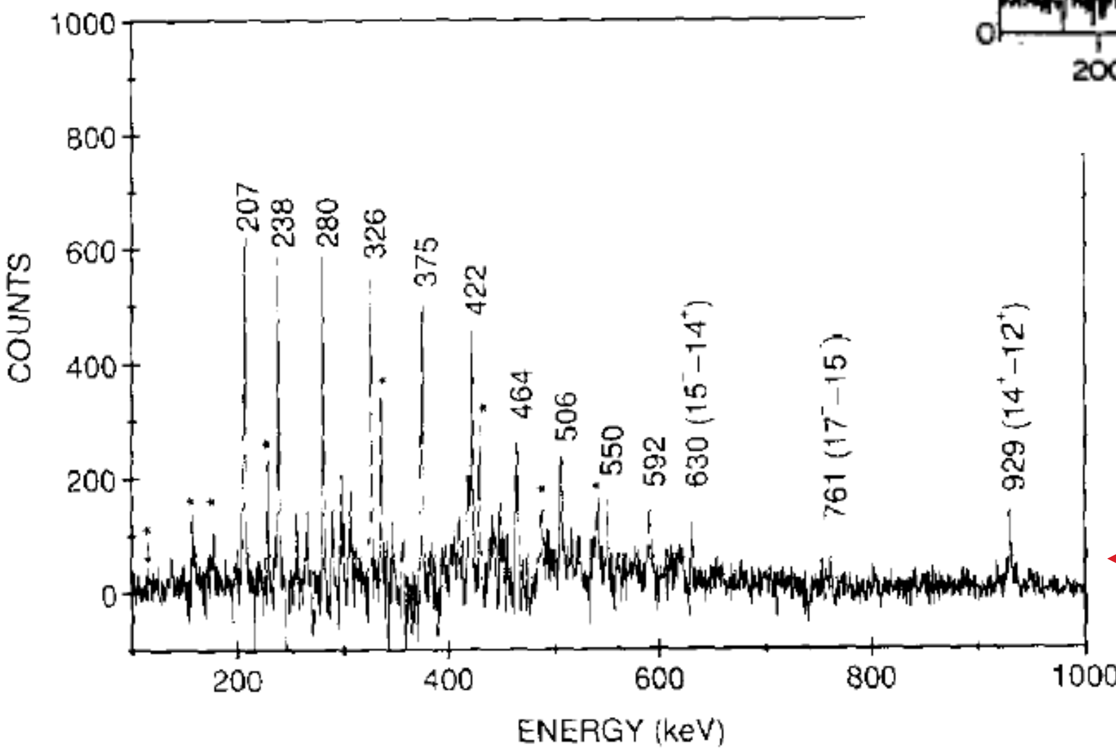
C.W. Beausang & J.Simpson,
J. Phys. G22 (1996) 527.



Can you tell the difference between these bands?



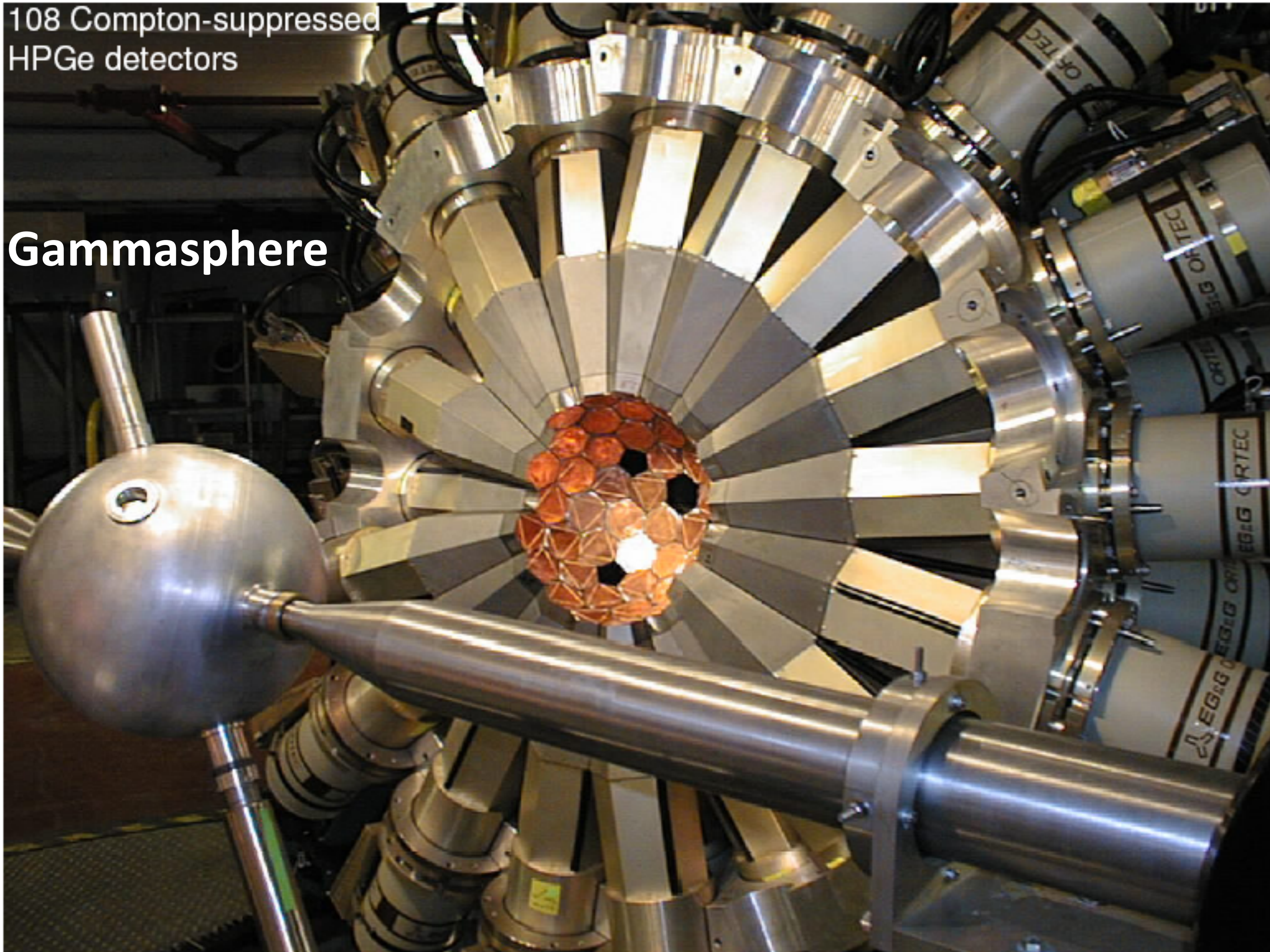
Differences revealed
by
angular distributions



Superdeformed Band in ^{192}Hg (Cascade of E2 transitions)

M1 cascade in ^{198}Pb

UNIVERSITY OF LIVERPOOL


108 Compton-suppressed
HPGe detectors
Gammasphere
ORTEC

Aspects of spectrometer array design

There are many gamma-ray spectrometers in use around the world.

Requirements for a good spectrometer.

(a) High photopeak detection efficiency.

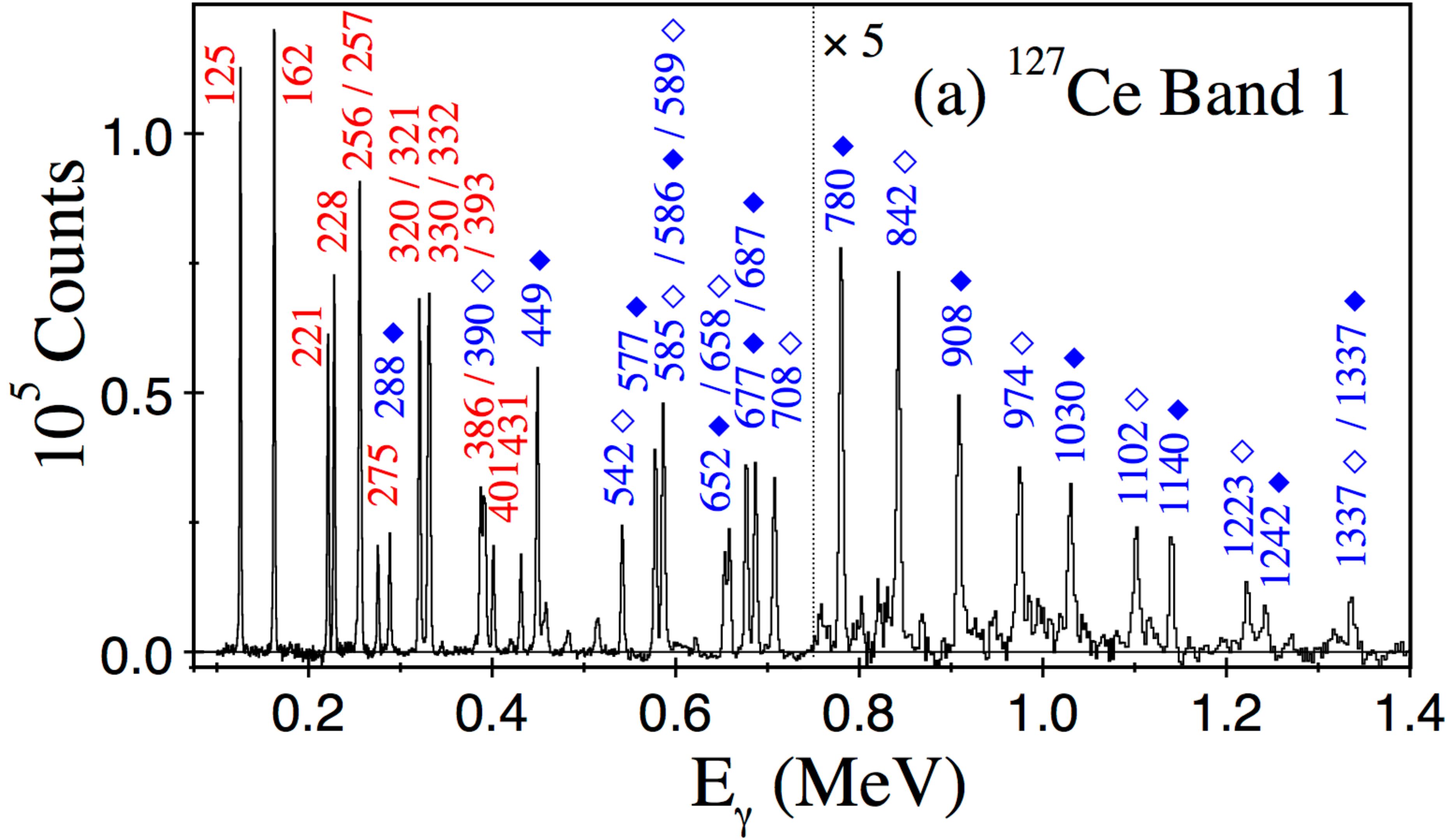
(b) Excellent resolution.

(c) Good peak-to-total signal.

(d) High granularity.

Spectrometers are designed for specific reaction mechanisms / applications.

e.g. High gamma-ray multiplicities and large Doppler shifts require high granularity.



(a) ^{127}Ce Band 1
× 5
10^5 Counts
E_γ (MeV)
0.0
0.5
1.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
125
162
221
228
256 / 257
275
288
320 / 321
330 / 332
386 / 390
401
431
/ 393
449
542
577
585
/586
/ 589
652
/ 658
677
/ 687
708
780
842
908
974
1030
1102
1140
1223
1242
1337
/ 1337

Sensitivity

Average separation of consecutive γ rays in a cascade.

Peak-to-Total ratio

Resolving power
(as large as possible)

$$R = \left(\frac{SE_\gamma}{\Delta E_\gamma^{\mathrm{final}}} \right) PT$$

FWHM of detector resolution for γ rays in spectrum

$$\left(\frac{N_P}{N_B} \right)_F = \alpha_0 (0.76R)^F$$

Fold

Limit of observation (array)

Final peak-to-total ratio with F-1 gating condition.

Factors effecting resolution

The major factors affecting the final energy resolution (FWHM) of the array at a particular energy are as follows.

$$\Delta E_{\gamma}^{\mathrm{final}} = \left(\Delta E_{\mathrm{Int}}^{2} + \Delta E_{\mathrm{Open}}^{2} + \Delta E_{\mathrm{Ang}}^{2} + \Delta E_{\mathrm{Vel}}^{2}\right)^{\frac{1}{2}}$$

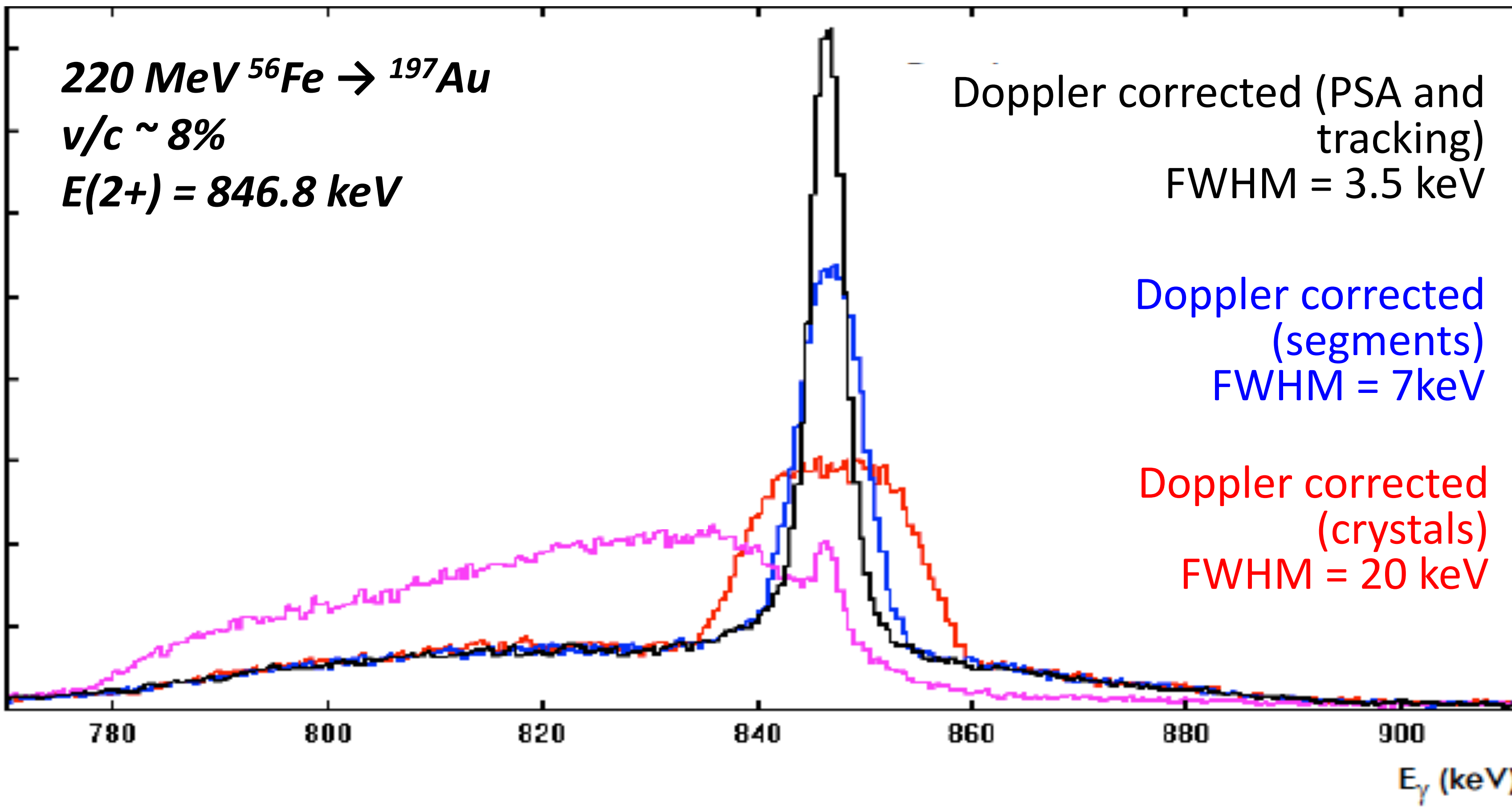
ΔE_{Int} - The intrinsic resolution of the detector system. This includes contributions from the detector itself and the electronic components used to process the signal.

ΔE_{Open} - The Doppler broadening arising from the opening angle of the detectors.

ΔE_{Ang} - The Doppler broadening arising from the angular spread of recoils in the target.

ΔE_{Vel} - The Doppler broadening arising from the velocity (energy) variation of the recoils across the target.

The main contribution to poor resolution arise from **Doppler effects**. Require detector granularity!



Tutorial question: Derive Doppler broadening formula for Ge detector at 90º to beam direction.

Resolving Power through the ages