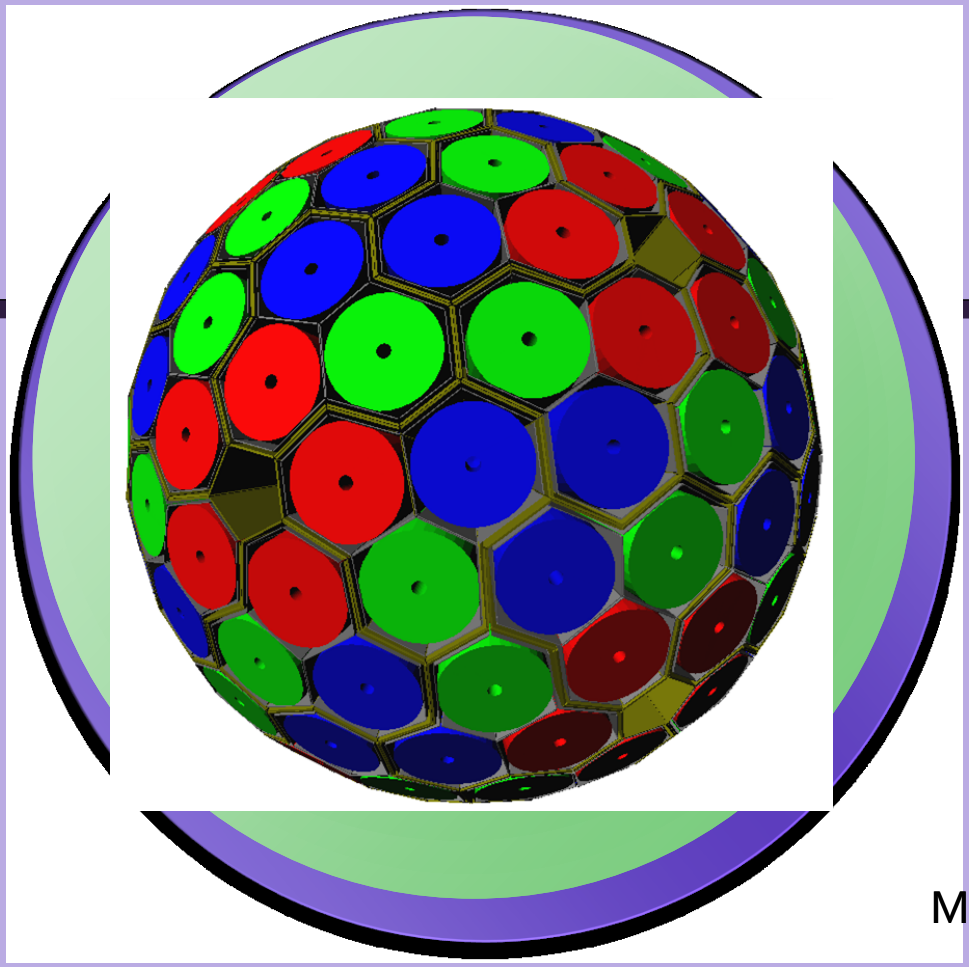


UNIVERSITY OF LIVERPOOL

Characterization of AGATA detectors for Pulse Shape Analysis

S. J. Colosimo, A. J. Boston, H. C. Boston, J. Cresswell, I. Lazurus, S. Moon, P. J. Nolan, M. J. Norman, J. Simpson, T. Stanios, C. Unsworth and the AGATA Collaboration

NPPD Nuclear and Particle Physics Conference,
University of Glasgow
Tuesday April 5, 2011

AGATA
ADVANCED GAMMA TRACKING ARRAY

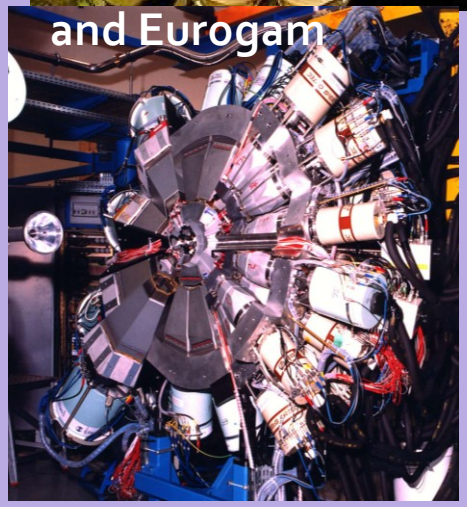
Overview

- Introduction to AGATA
- Motivation: Gamma Ray Tracking and Pulse Shape Analysis
- Scanning procedure at Oliver Lodge Laboratory
- Coincidence Scanning of A006
- Summary and Further Work

a fundamental tool

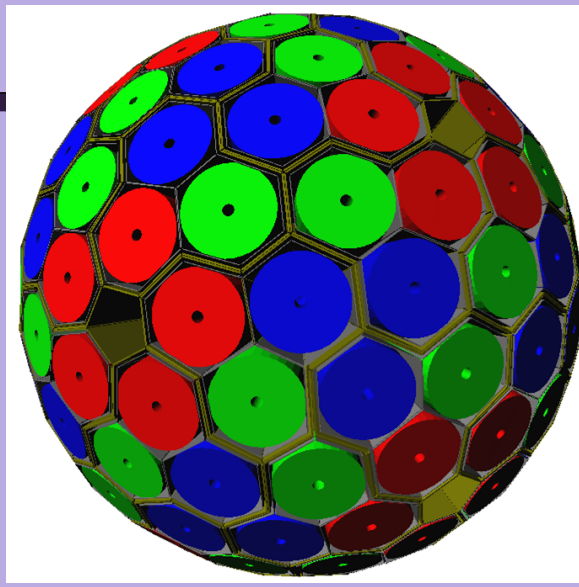
- **Gamma-ray spectroscopy** with germanium detectors has been use to further the knowledge of nuclear structure.
- **High spin, superdeformation, proton and neutron drip lines**
- **Compton suppressed large volume HPGe arrays** have the current best efficiency and peak to total ratios.
- New Radioactive Ion Beam (RIB) facilities: FAIR, SPIRAL2, HIE-ISOLDE, EURISOL will continue to push the limits of the nuclear chart.


Gammasphere


and Eurogam

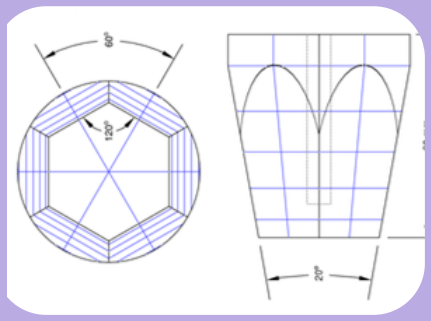
the next generation spectrometers

- RIB Facilities: **Large background, low intensity, high Doppler broadening, high count rates and high multiplicities**
- **AGATA – Advanced GAmma Tracking Array**: 4π coverage of highly segmented HPGe detector and gamma-ray tracking.



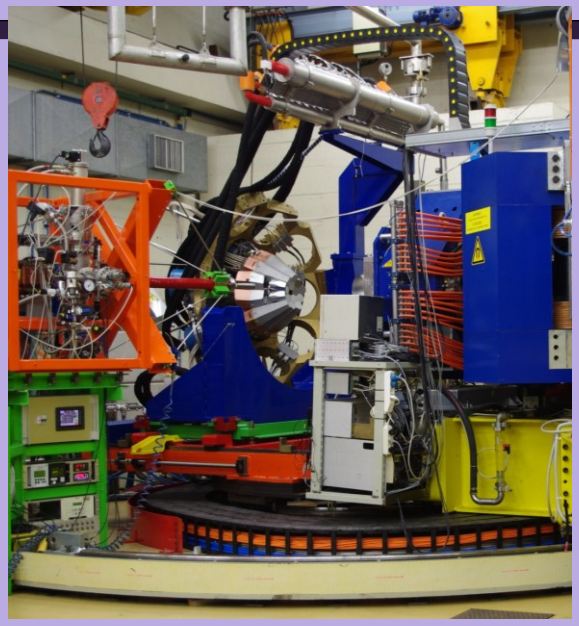
Completed AGATA 4π Ball

	Current Spectrometers	AGATA
Efficiency	10 % ($M_\gamma = 1$)	43 % ($M_\gamma = 1$)
	5 % ($M_\gamma = 30$)	28 % ($M_\gamma = 30$)
Peak/Total	55 % ($M_\gamma = 1$)	58 % ($M_\gamma = 1$)
	40 % ($M_\gamma = 30$)	49 % ($M_\gamma = 30$)

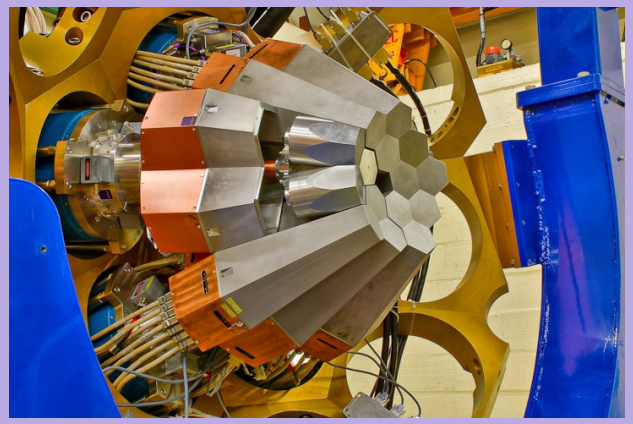


Highly segmented HPGe

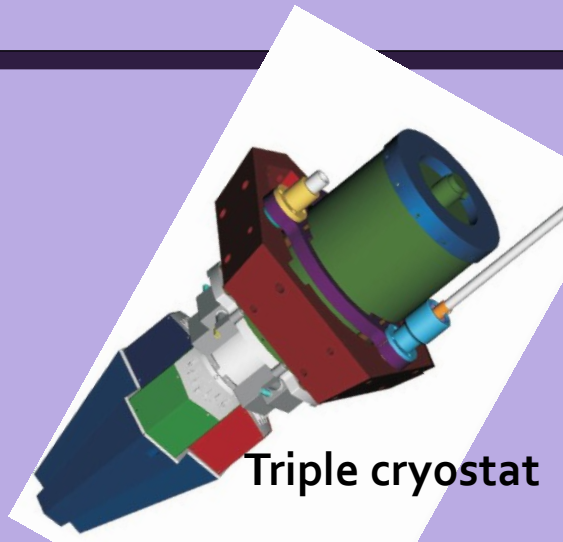
Advanced GAmma Tracking Array



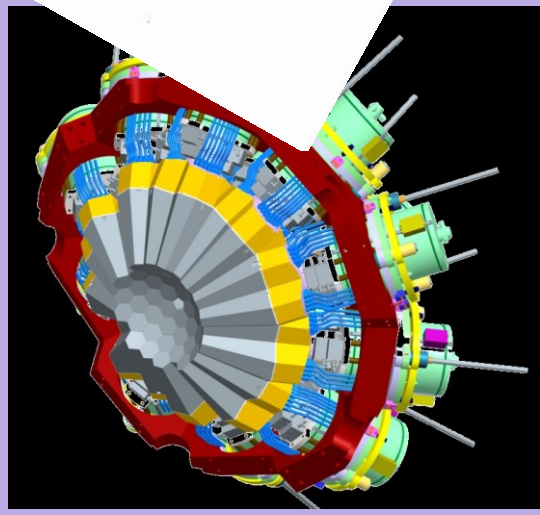
The AGATA Demonstrator



- **180** coaxial HPGe crystals
- **60** triple clusters
- **36** fold segmentation = **6660** detection elements
- Geodesics tiling, inner radius 15 cm.
- **5 triple clusters** to be mounted in the AGATA demonstrator in INFN Legnaro, Italy.

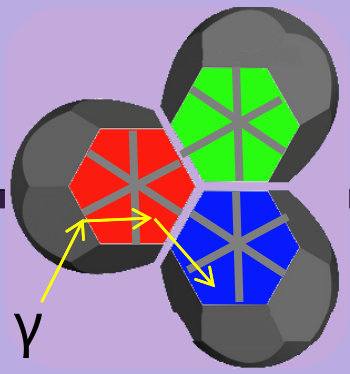


Triple cryostat



1 π of AGATA

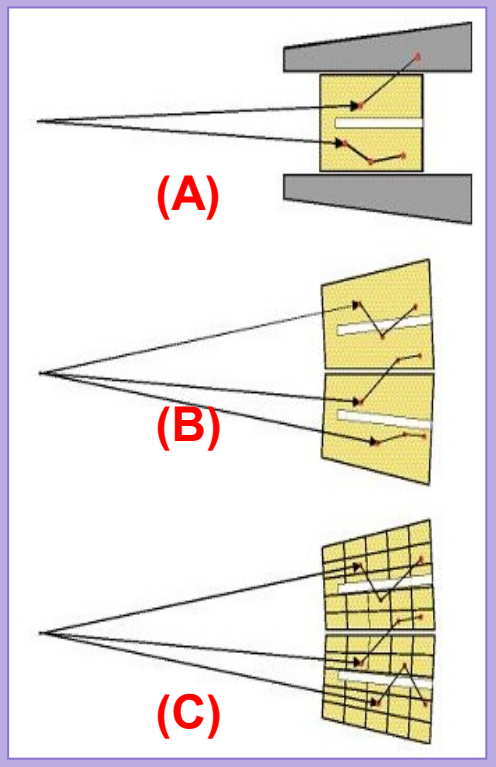
gamma-ray tracking



- **Compton shielded array (A)** → good peak-to-total, lowered efficiency due to limited angular coverage
- **Track (B)** Compton scattered photons to sum full energy?
- **Compton scattering** formula for tracking (in MeV):

$$E_{\gamma'} = \frac{E_\gamma}{1 - E_\gamma(1 - \cos\theta)/0.511}$$

- **Full Segmented HPGe array (C)** → track and sum scatters to reconstruct full energy of interactions
- γ-ray scatters between different segments and detectors can be tracked.



ingredients for GRT

Interaction with a segmented detector

Digital recording and pulse processing

Pulse Shape Analysis

(E_1, x_1, y_1, z_1)

(E_2, x_2, y_2, z_2)

(E_3, x_3, y_3, z_3)

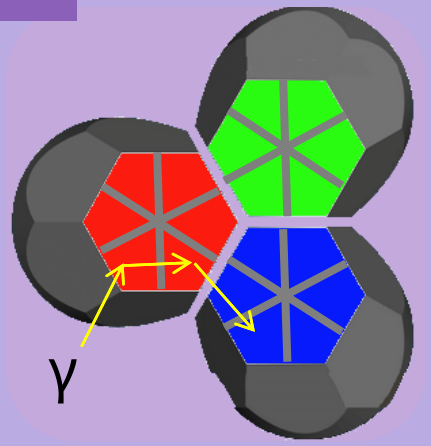
Gamma ray tracking

$(E_1^{\gamma} = E_1 + E_5 + E_4)$

$(E_2^{\gamma} = E_2 + E_6)$

$(E_3^{\gamma} = E_3 + E_7 + E_8)$

Event reconstruction

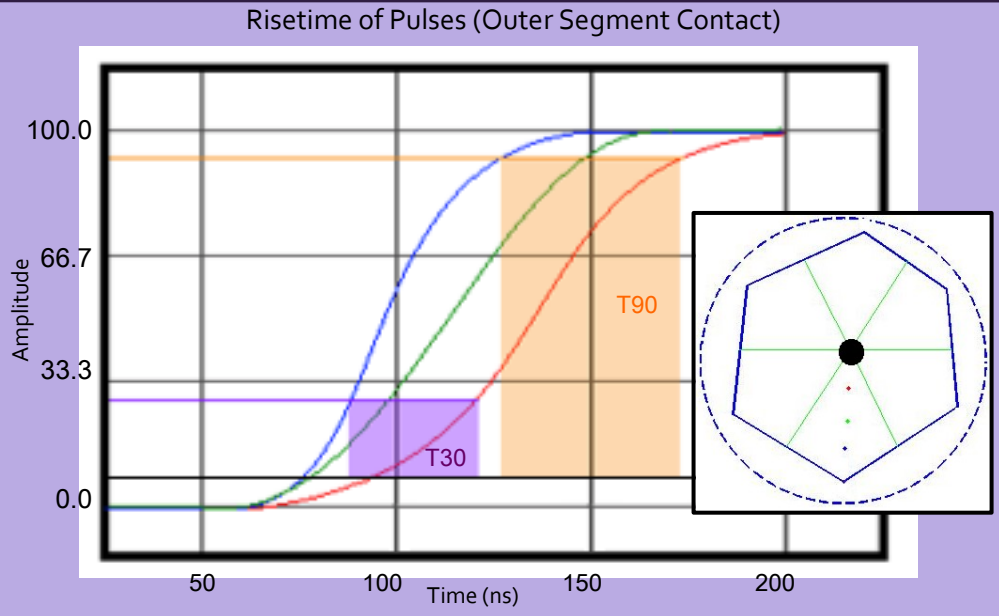


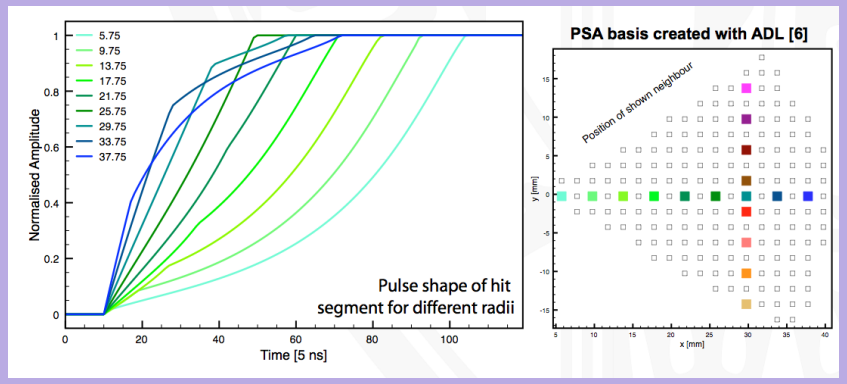
pulse shape analysis

- **pulse shape analysis** can identify interaction locations within few millimetres
- The shape of the charge collection pulses and image charges vary based on:

  electron and hole drift velocity, detector geometry, orientation of crystal axis and impurity concentration

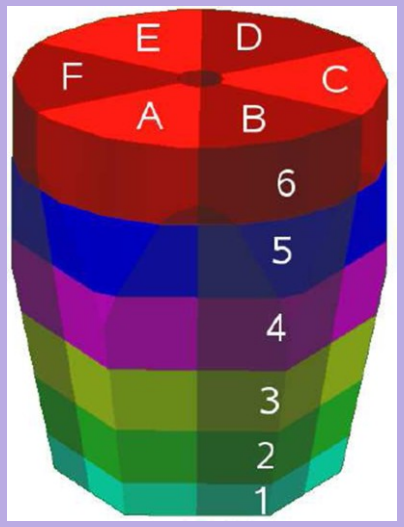
- Pulse shape libraries are generated for simulated AGATA detectors (MGS, JASS, ADL)



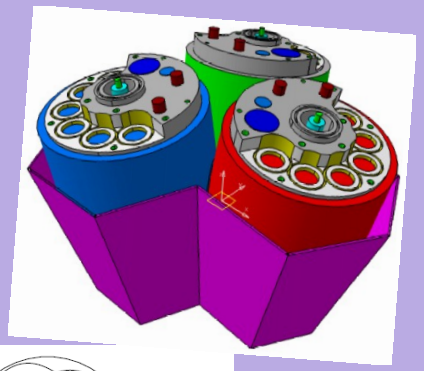


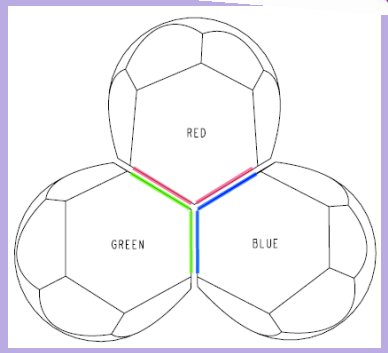
the AGATA detectors

AGATA HPGe Crystal

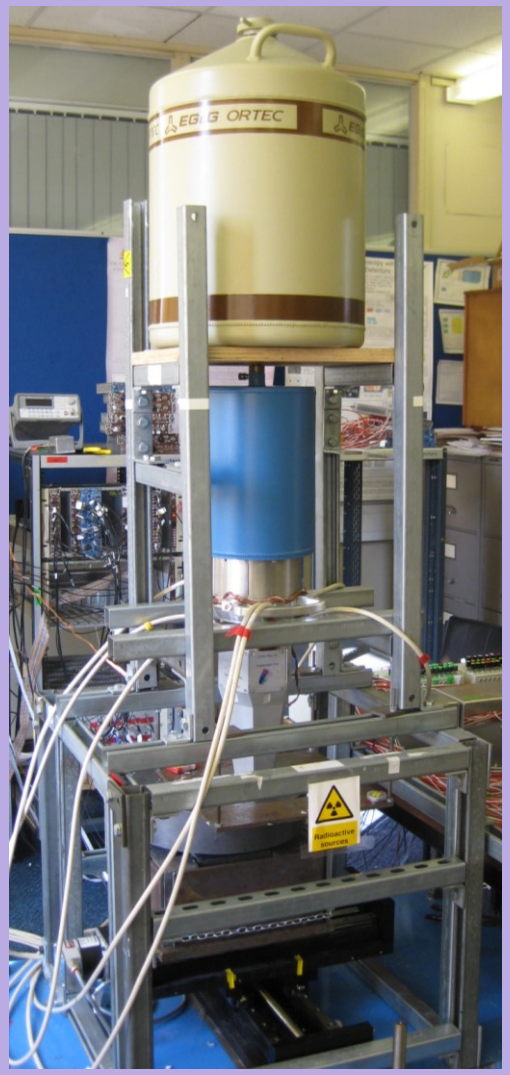


- n-type large volume semi-coaxial HPGe crystals.
- length = 90 mm , back diameter = 80 mm
- 10 mm bore hole for cold contact and core electrode.
- Segmented into 6 rings and 6 sectors, **36 total segments**
- Tapered to fit together in the **4π s**hell
- Three asymmetric semi-hexagonal front faces shapes (red, green and blue).

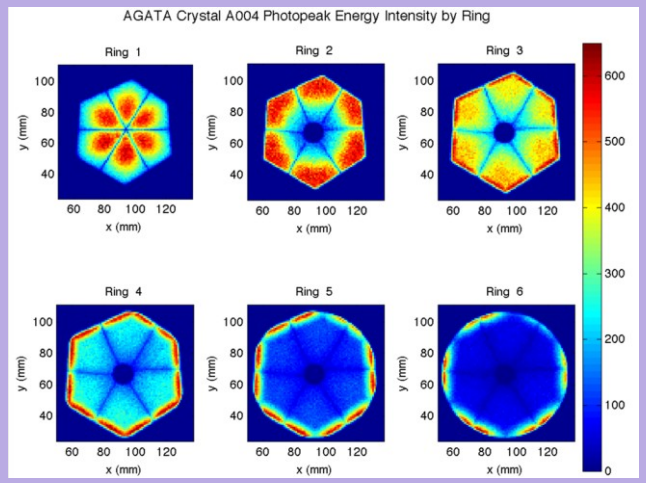


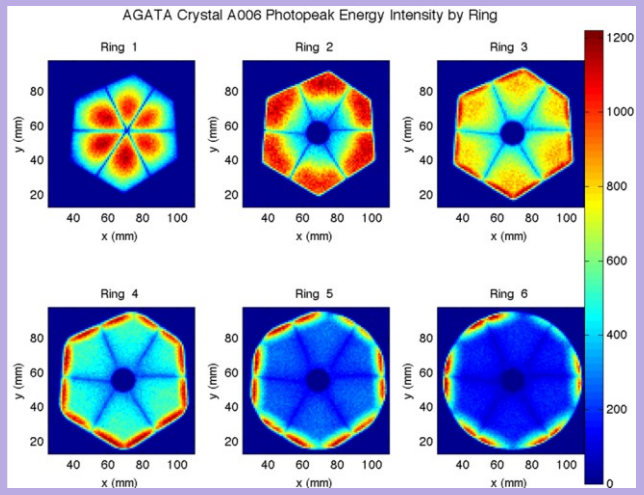


Liverpool scanning



- Detector front faces are scanned at 1mm steps by a collimated ^{137}Cs beam.
- 36 Channels + the Core are recorded with digital electronics

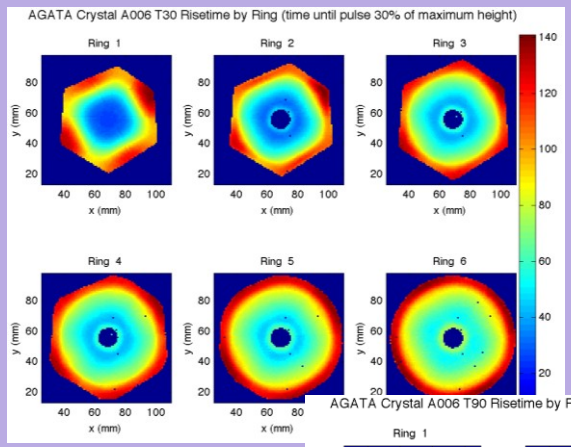


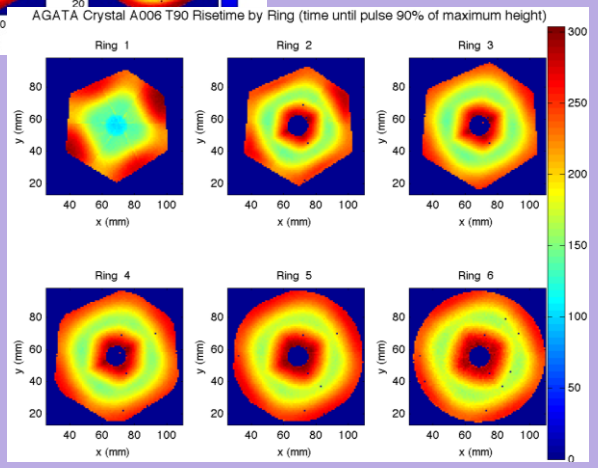


662 keV Photopeak gated ring spectra of AGATA detectors A004 and A006

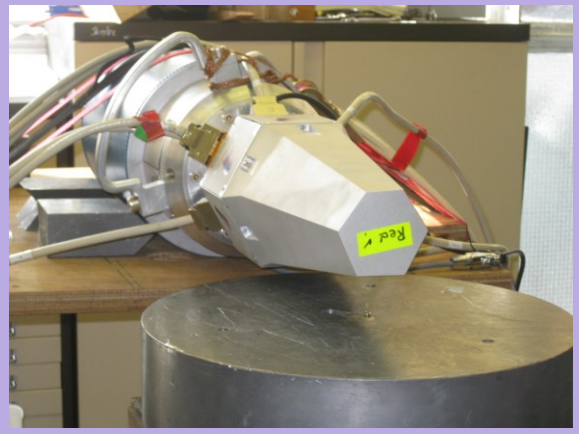
scanning continued

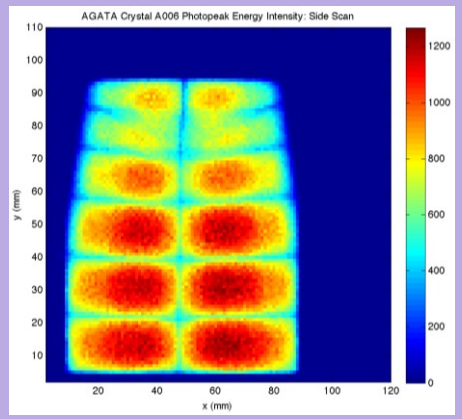
- Risetime maps of T30 and T90 measurements:



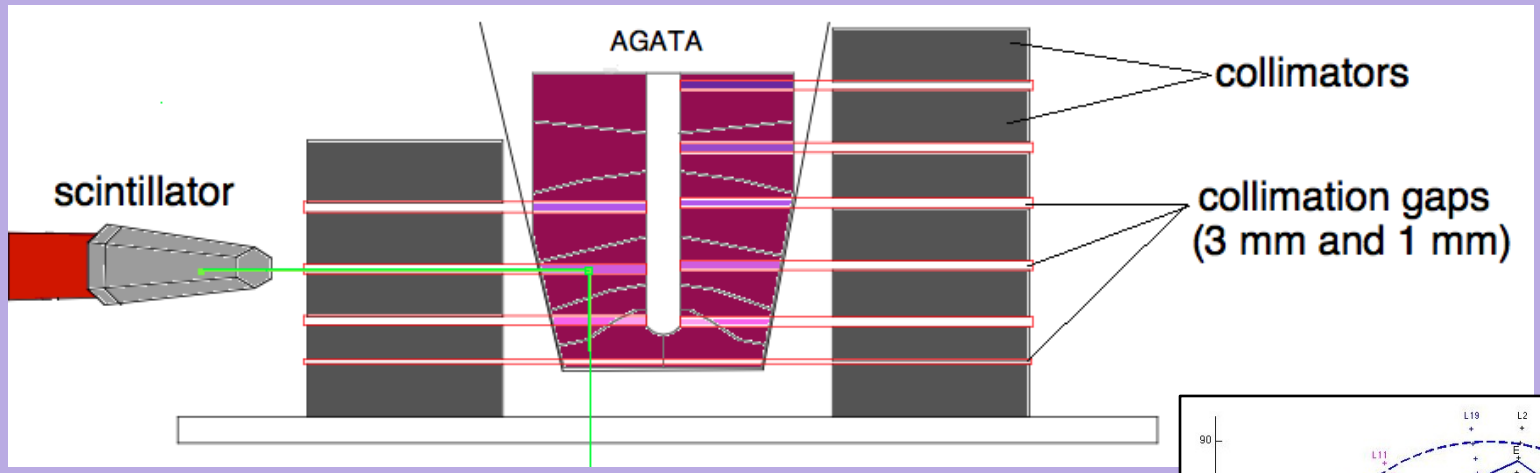


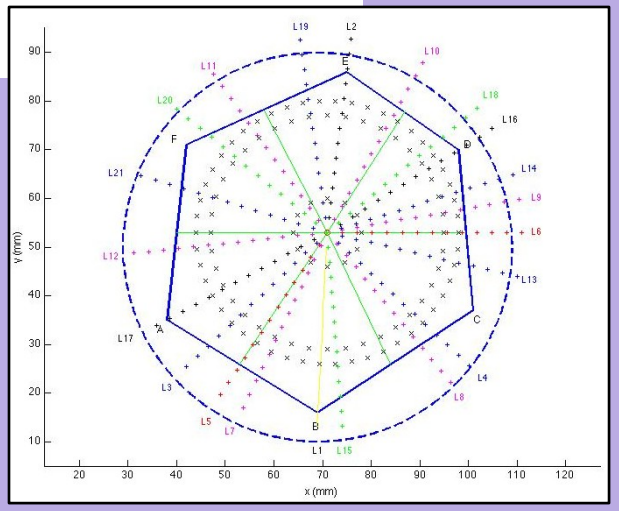
- Detector crystal mounted on its side for sidescan. 1mm steps, 40s per position





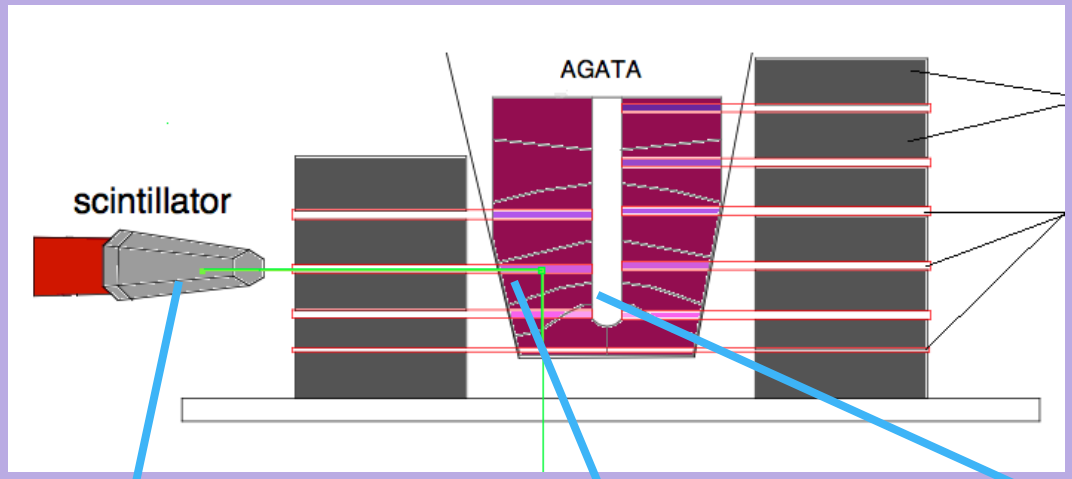
coincidence scanning

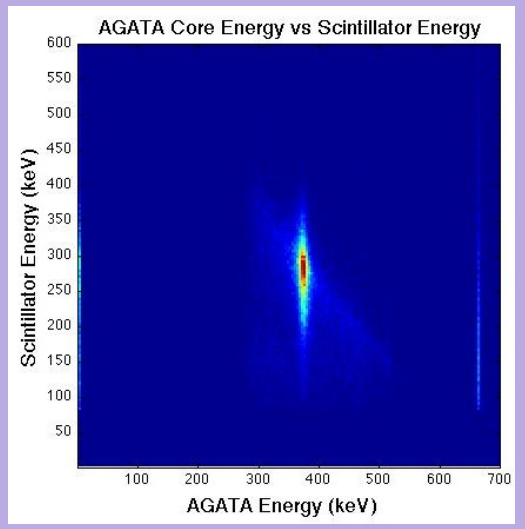


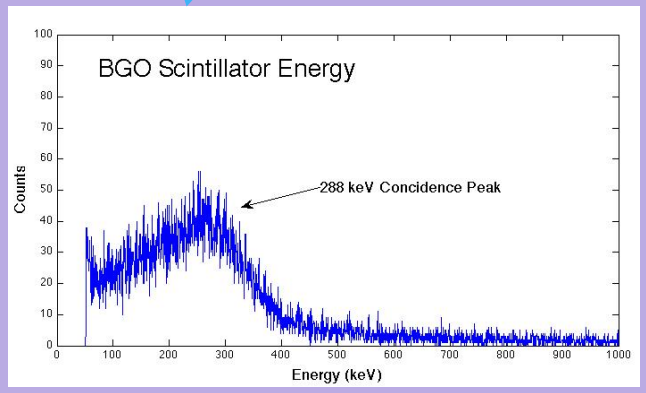


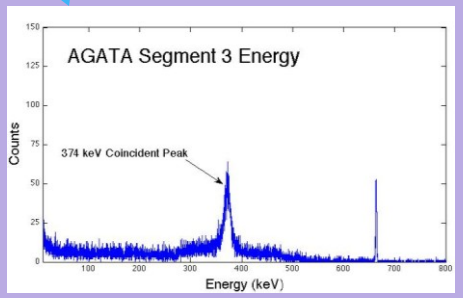
- Detector scanned by a collimated ^{137}Cs beam.
- Further collimation of the AGATA segmentation rings is achieved with lead semicircles
- 90 degree scatters are collected by scintillators
- **21 radial scans, 3 azimuthal scans**

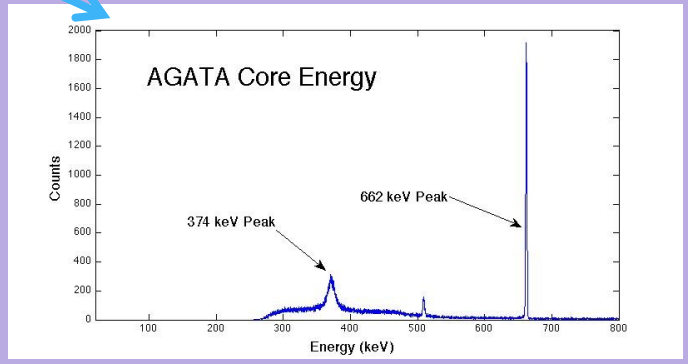
coincidence energy gating







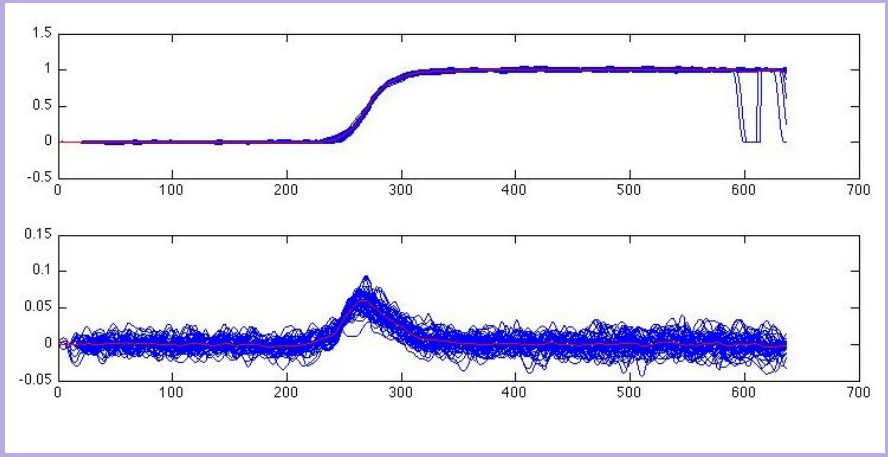




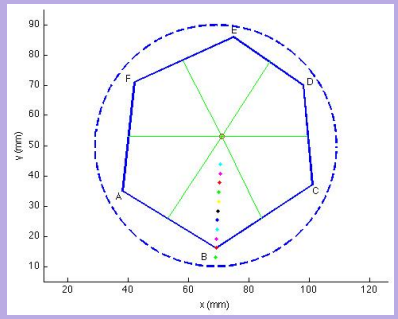
summing pulses

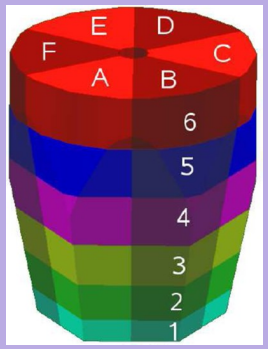
Superpulses:

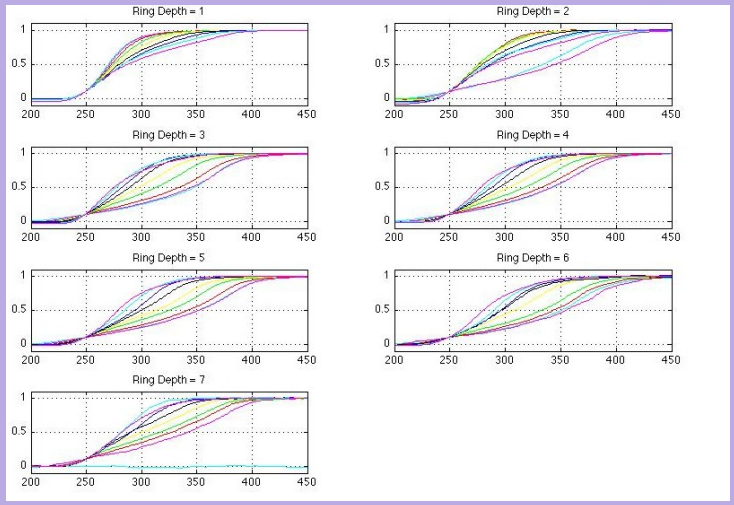
Ring 1 interaction and image charge in neighbouring segment



Pulses by Depth:

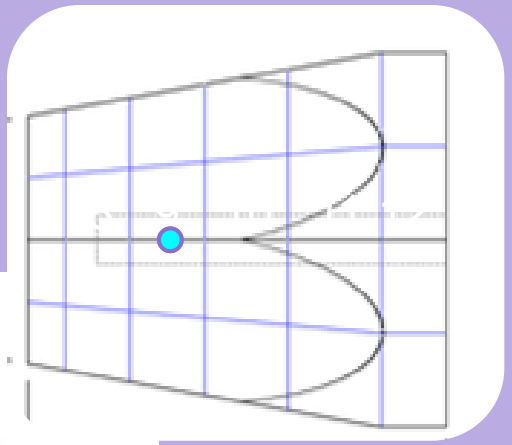


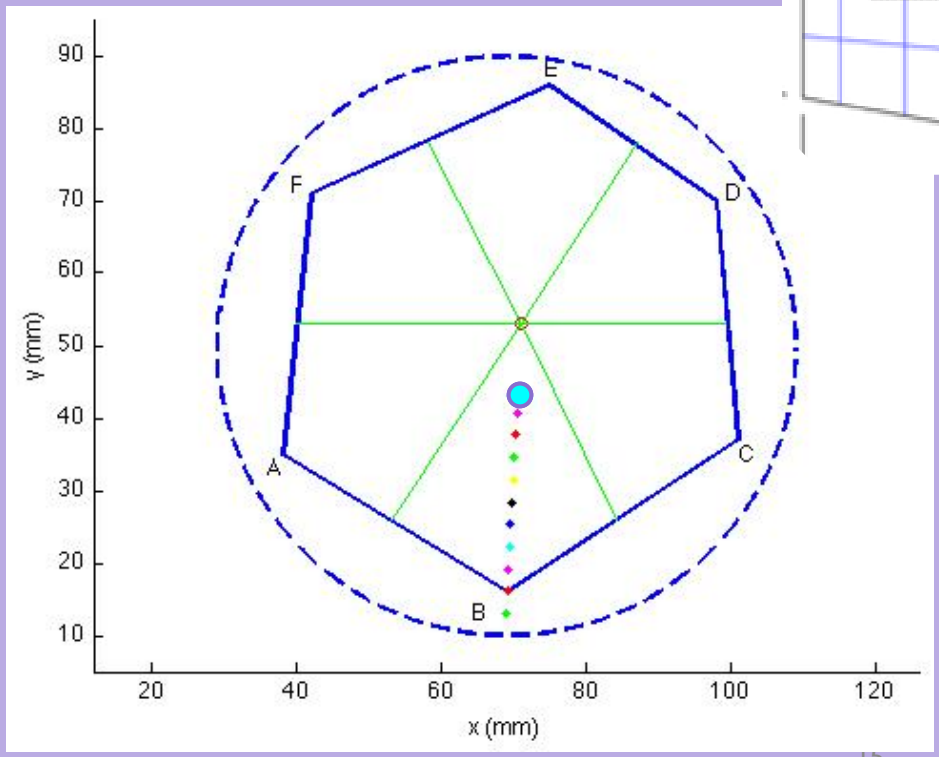


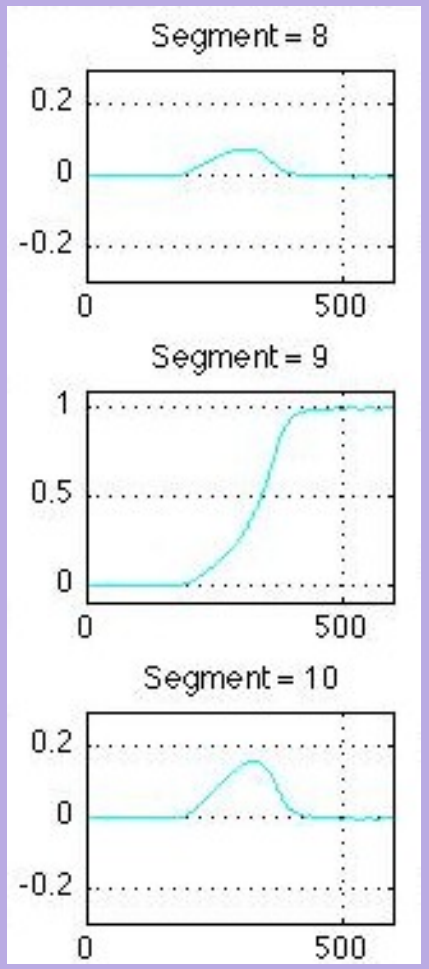


evolution of pulse shapes

- Line scan through sector B, Ring 3

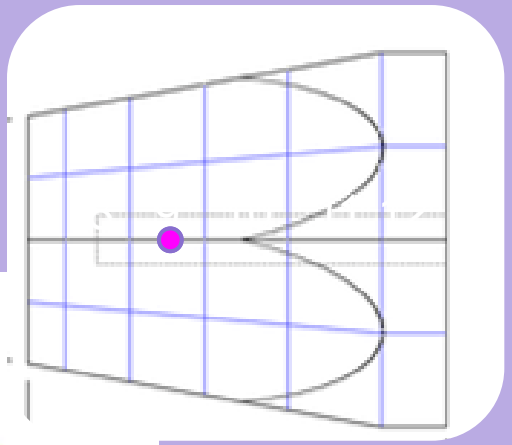


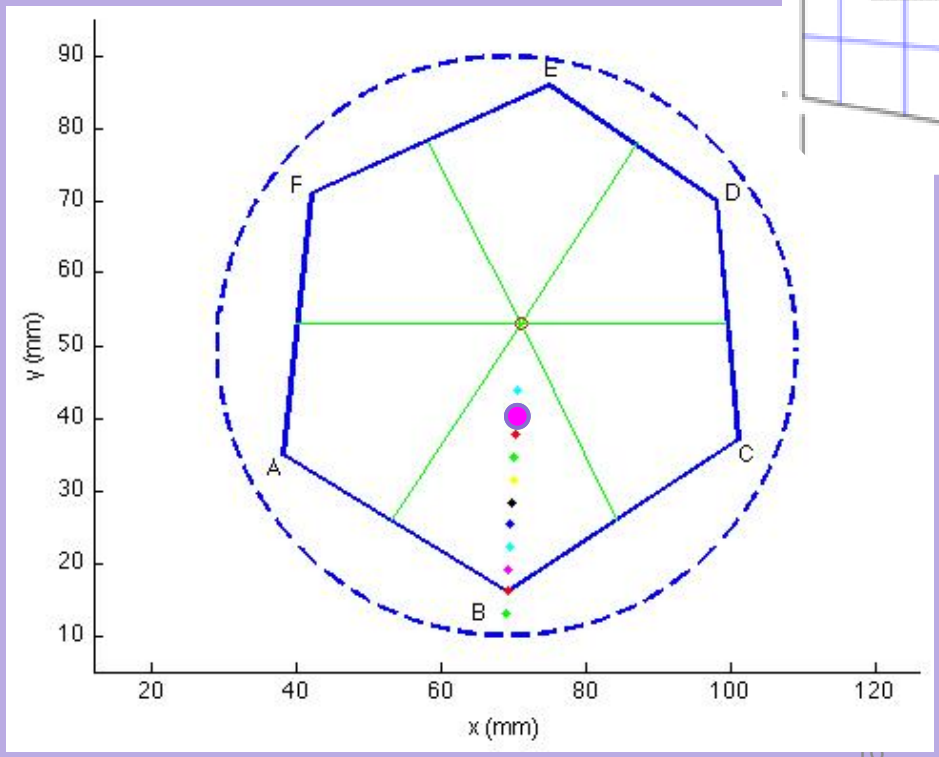


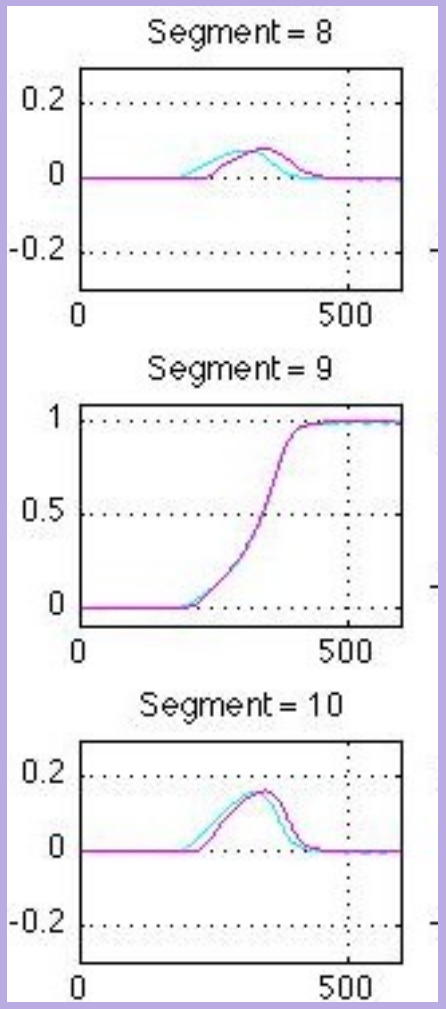


evolution of pulse shapes

- Line scan through sector B, Ring 3

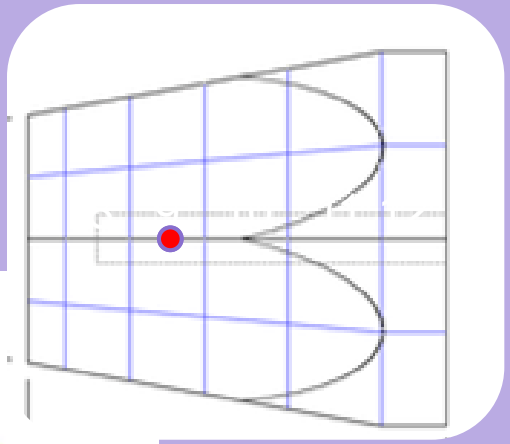


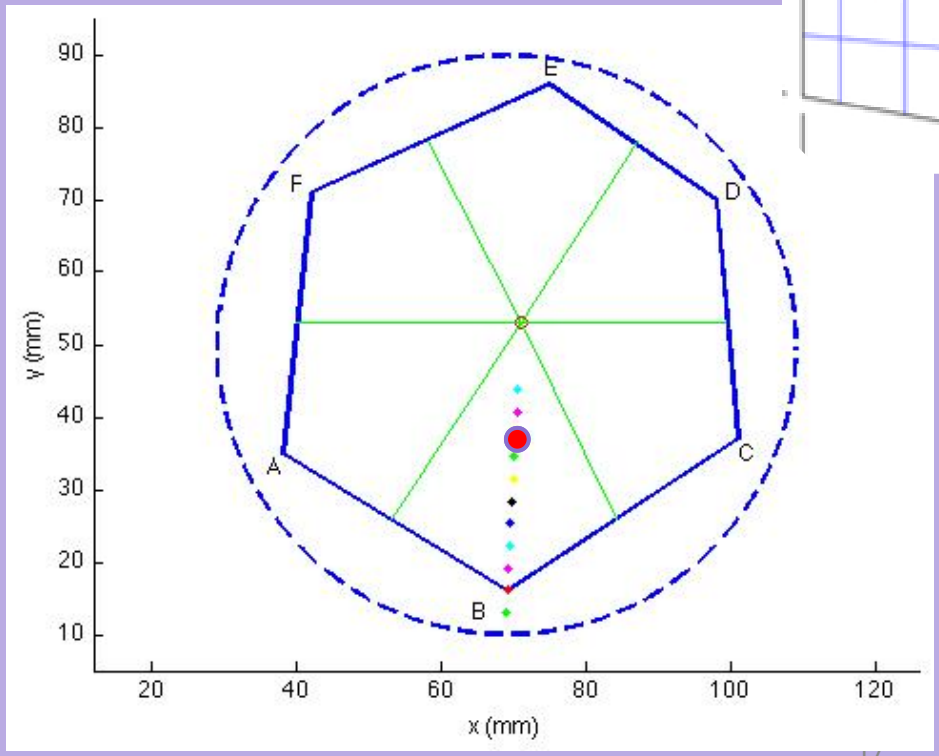


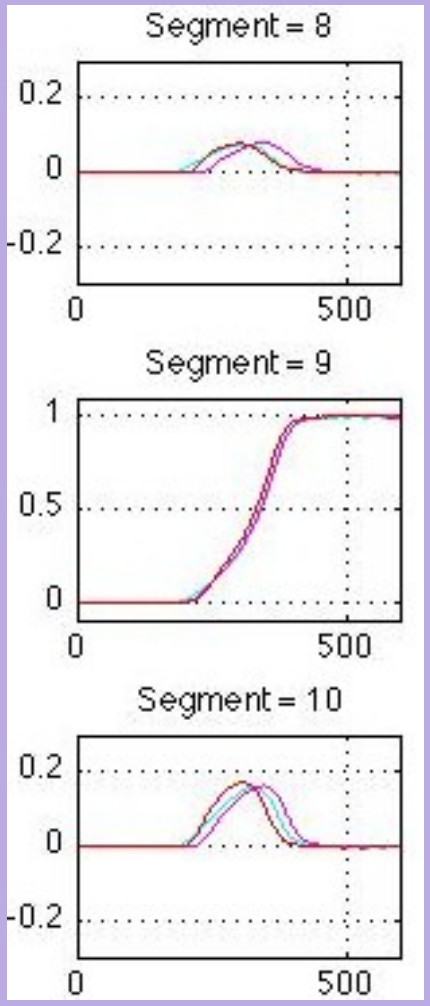


evolution of pulse shapes

- Line scan through sector B, Ring 3

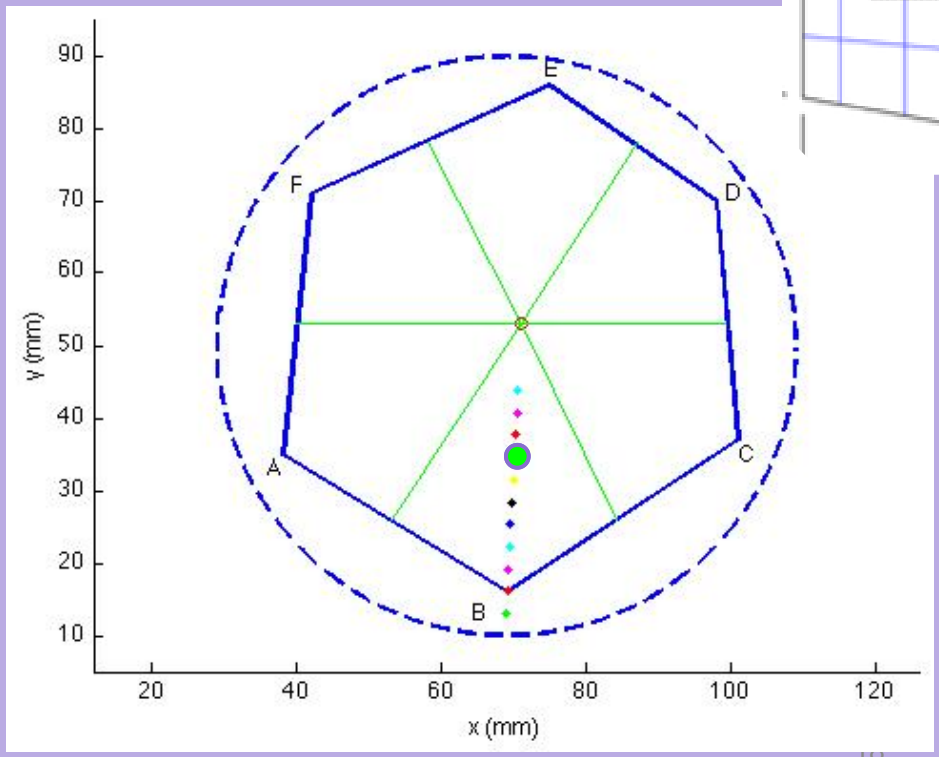


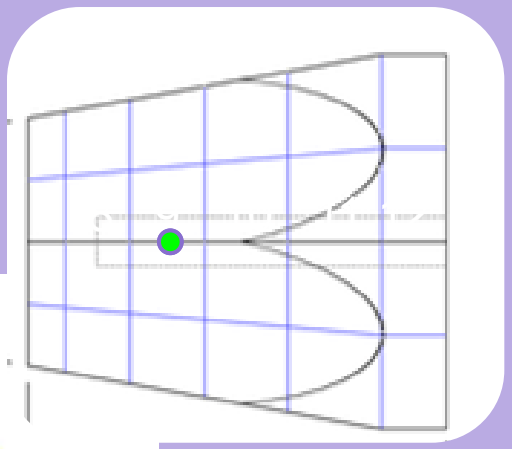


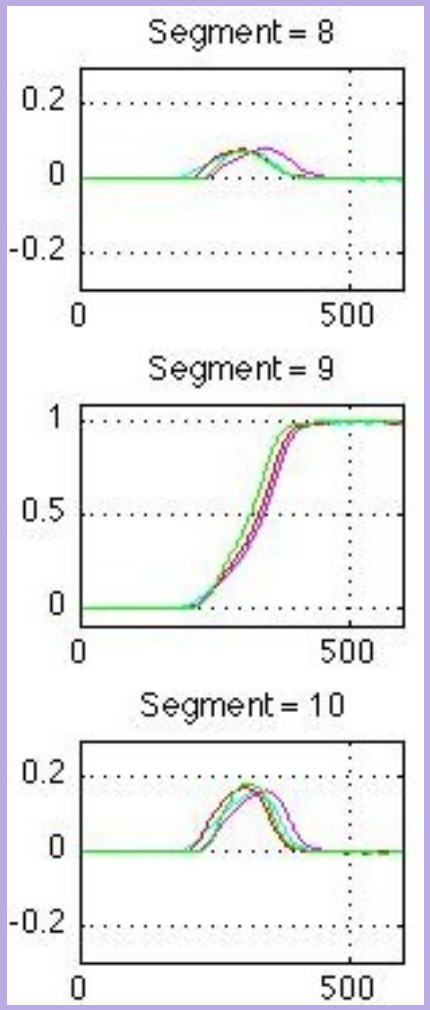


evolution of pulse shapes

- Line scan through sector B, Ring 3

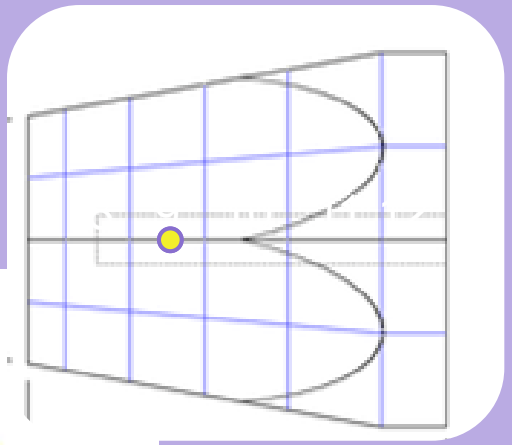


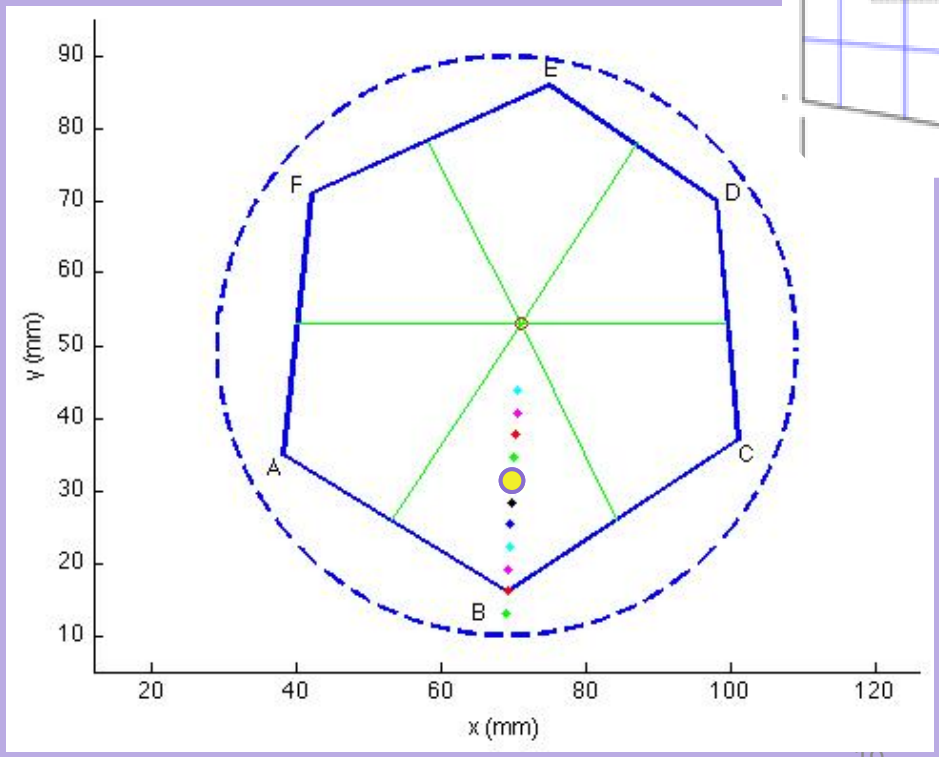


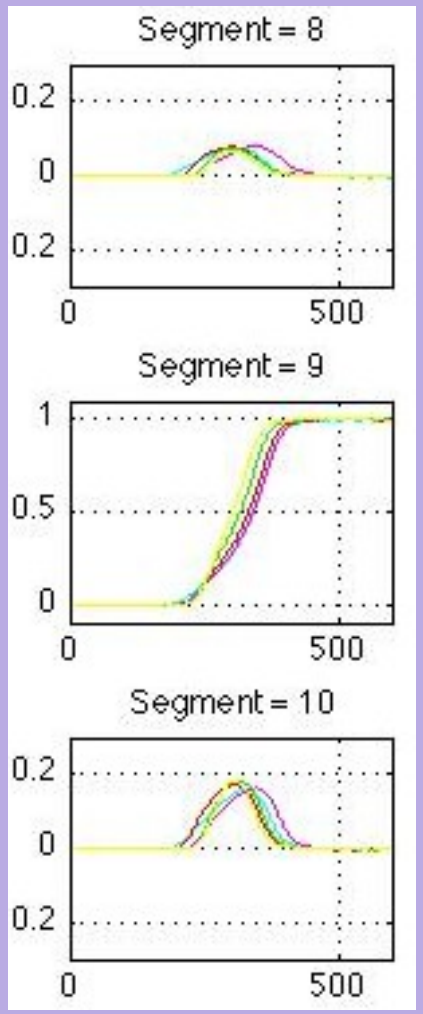


evolution of pulse shapes

- Line scan through sector B, Ring 3

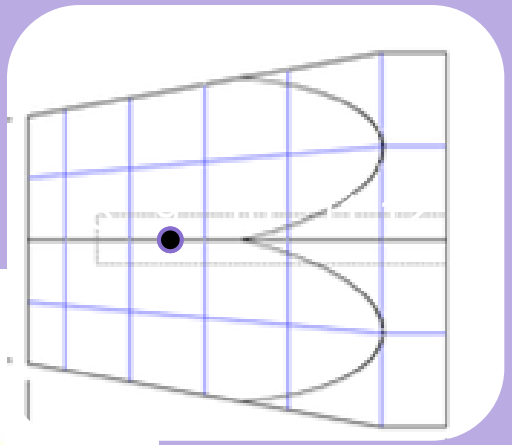


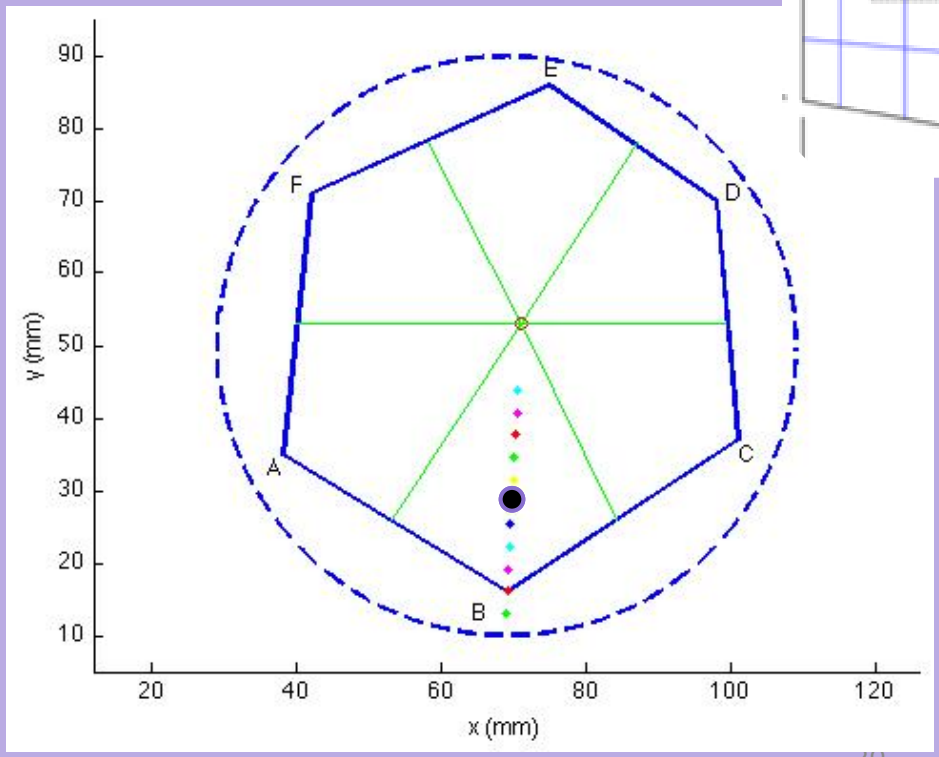


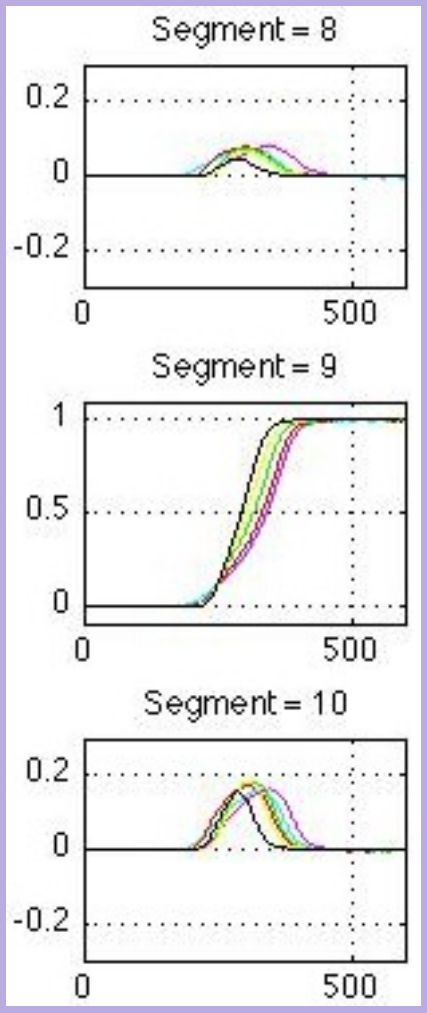


evolution of pulse shapes

- Line scan through sector B, Ring 3

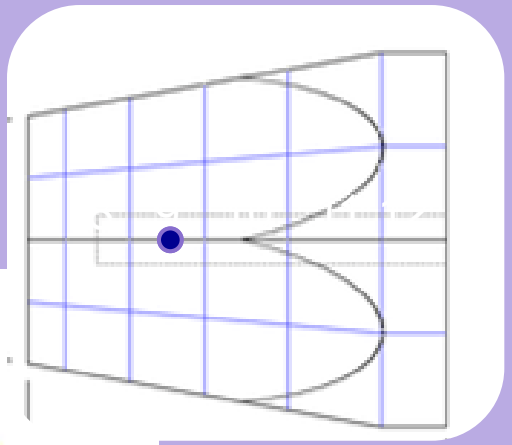


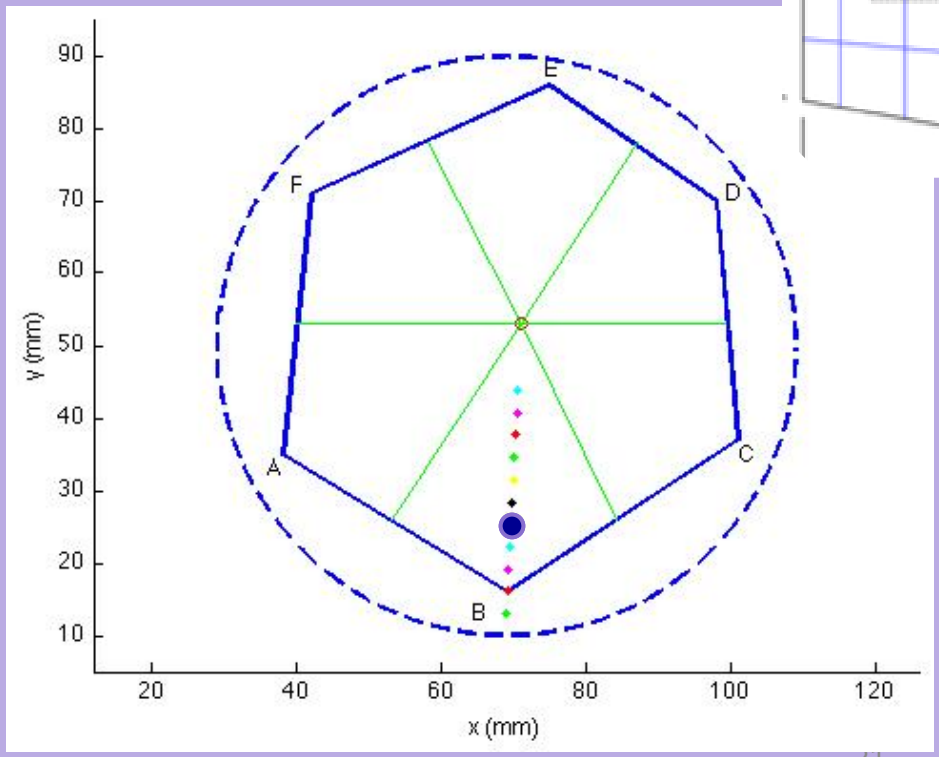


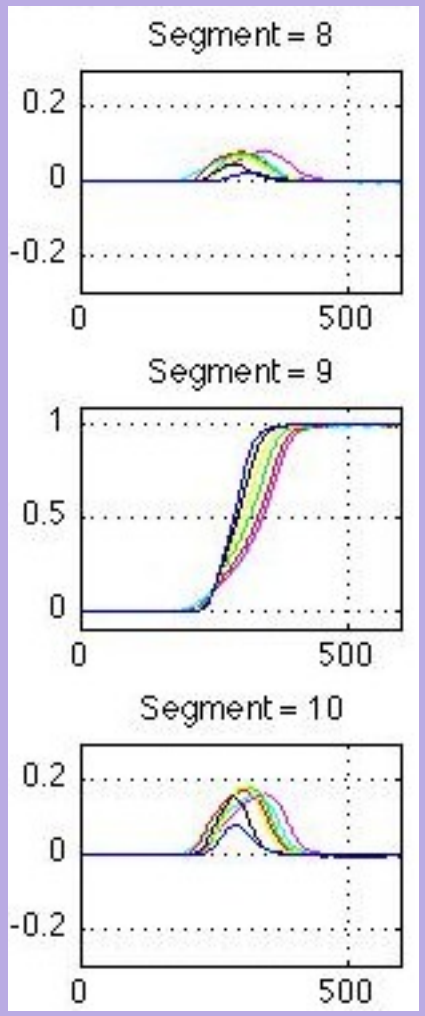


evolution of pulse shapes

- Line scan through sector B, Ring 3

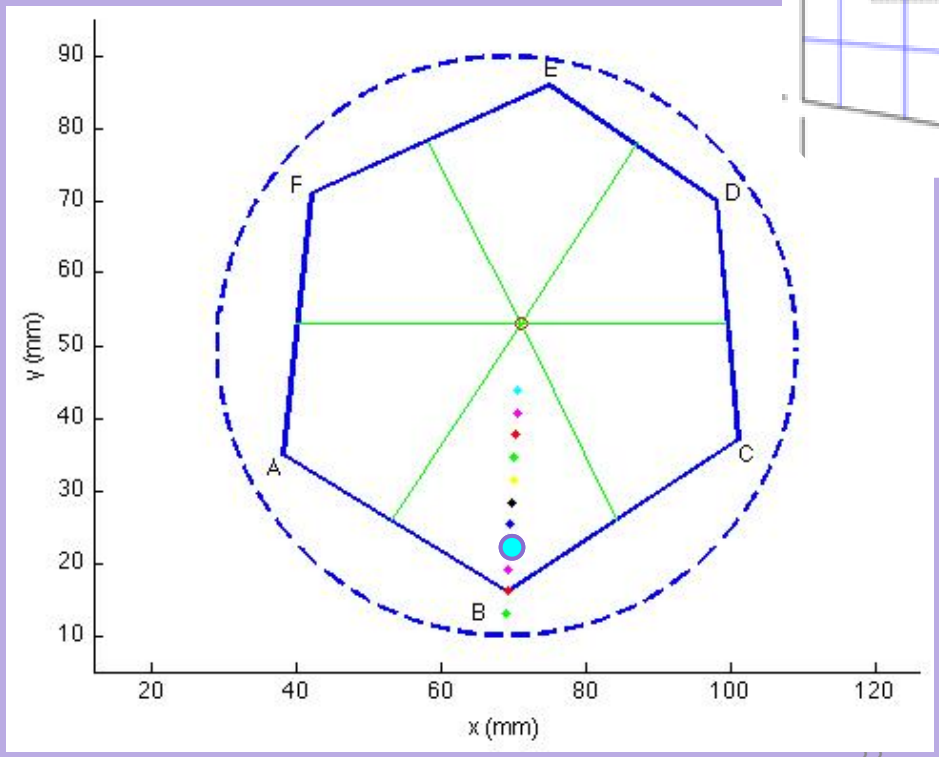


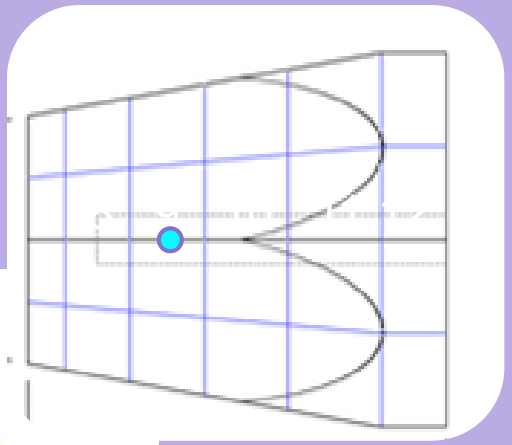


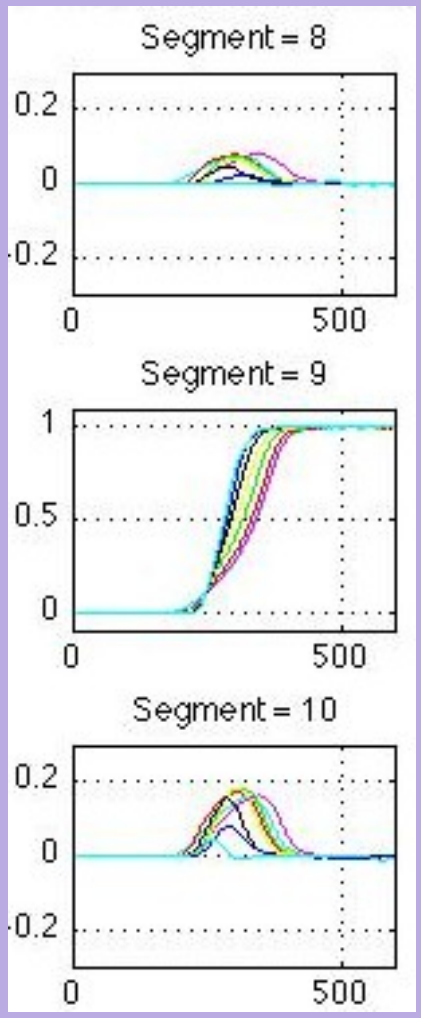


evolution of pulse shapes

- Line scan through sector B, Ring 3

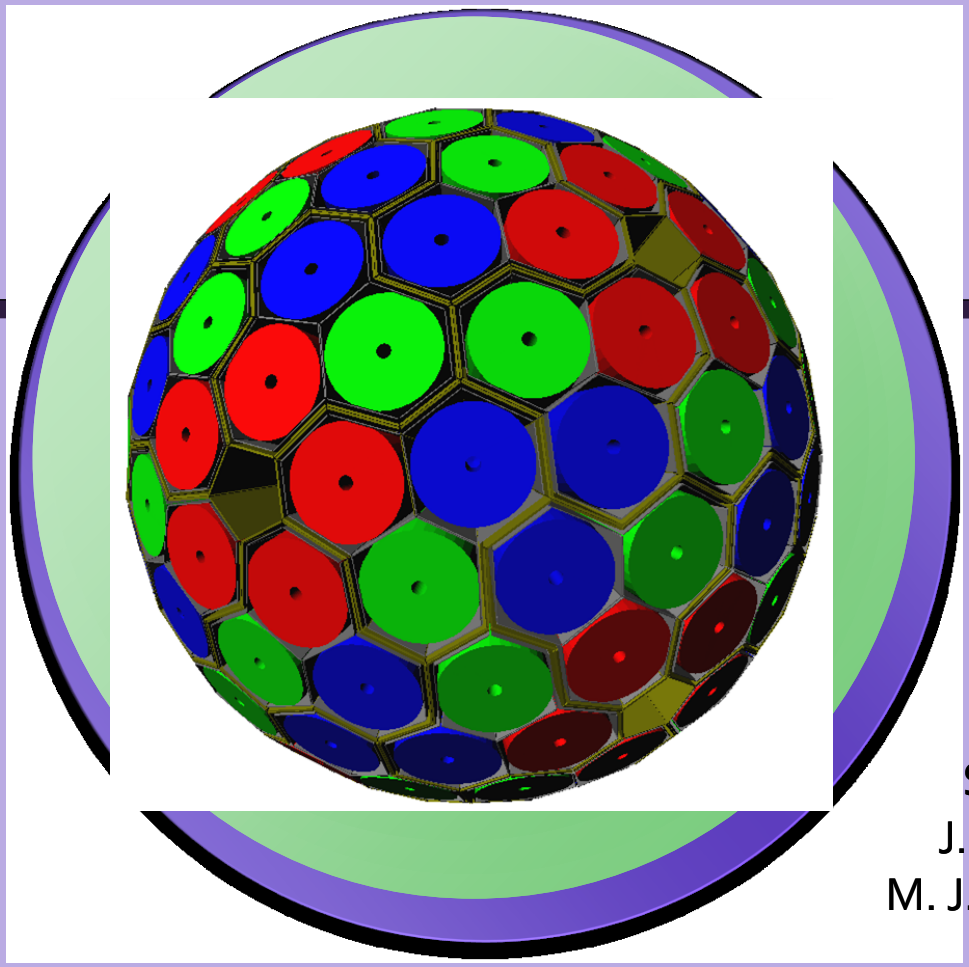






Summary and Next Steps

- AGATA is the next step in high efficiency gamma-ray spectroscopy.
- AGATA Asymmetric crystal characterization is a key step towards improved gamma-ray tracking through PSA.
- Mean pulses have been generated at very specific x,y,z positions within these detectors.
- Continuing work: Generate mean pulses from simulation codes for direct comparison with experimental results



UNIVERSITY OF LIVERPOOL

Thanks

S. J. Colosimo, A. J. Boston, H. C. Boston,
J. Cresswell, I. Lazurus, S. Moon, P. J. Nolan,
M. J. Norman, J. Simpson, T. Stanios, C. Unsworth
and the AGATA Collaboration

NPPD Nuclear and Particle Physics Conference,
University of Glasgow
Tuesday April 5, 2011

AGATA
ADVANCED GAMMA TRACKING ARRAY