AGATA Detector Characterisation

Objectives and status report

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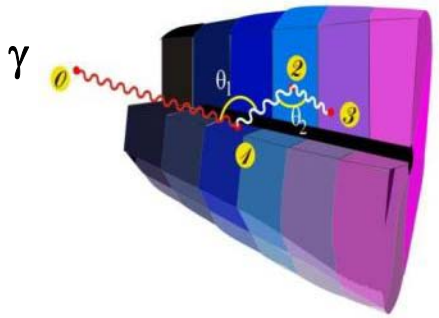
Ingredients of γ-Tracking

AGATA
ADVANCED GAMMA TRACKING ARRAY

1

Highly segmented HPGe detectors



2

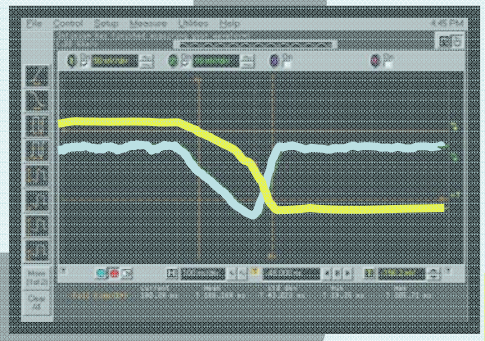
Digital electronics to record and process segment signals

Identified interaction

$(x,y,z,E,t)_i$

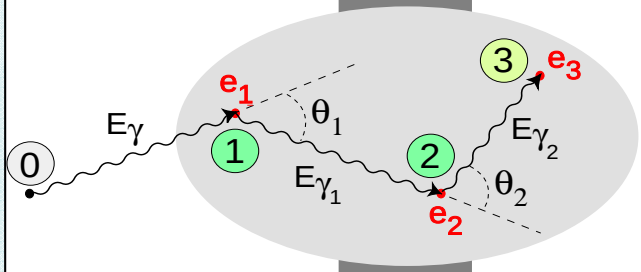
Pulse Shape Analysis to decompose recorded waves

3



4

Reconstruction of tracks e.g. by evaluation of permutations of interaction points



reconstructed γ-rays

UK Characterisation Tasks

- **Task 1**: Detector Characterisation
  - Supply high quality data to the collaboration
- **Task 2**: 3D simulation code comparison with experimental detector characterisation
  - MGS
  - JASS
- **Task 3**: Pulse-shape algorithm development
  - Testing and optimisation of existing algorithms

Characterisation Objectives

- How does the position performance of each AGATA detector vary with:
  - Crystal shape
  - Impurity gradient
  - HV
  - Axis orientation
  - Differential cross talk

Characterisation Methodology

- Perform a coincidence scan of 3 of each shape of detector
- Compare experimental data sets
- Optimise theoretical system basis

- Measurements from:
  - 3 symmetric detectors
  - C001 scan complete
  - Quick measurement from A004 complete
  - A006 ready to go

AGATA Scanning table status

- Liverpool (Conventional coincidence)
  - Fully operational
  - Only supplier of data to collaboration
  - GRETINA cards
- Orsay (New coincidence)
  - Initial validation data collected
  - Not operational (eta 12 months)
  - TIGRESS cards
- GSI/Strasbourg (New method)
  - Bidding for future funds (eta 18 months)

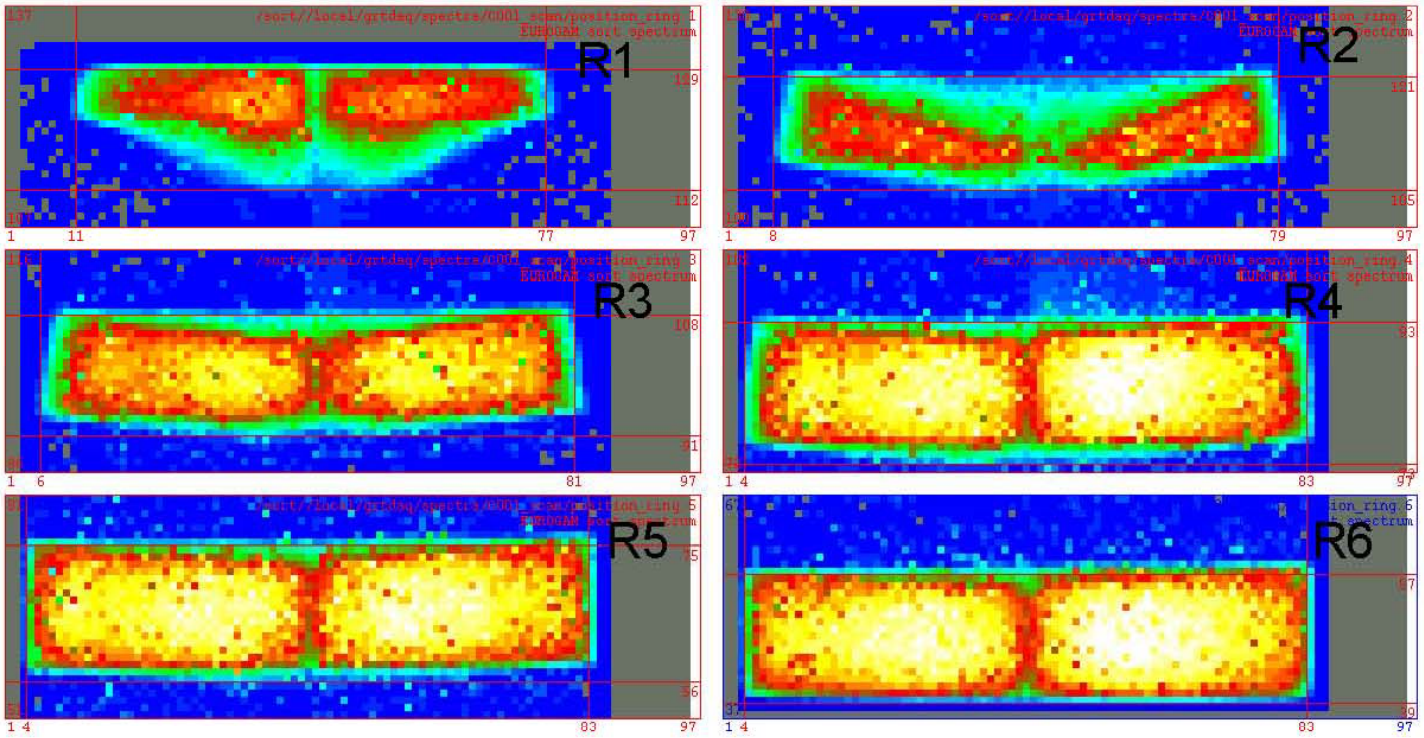
AGATA Scan Setup

- Storage Dewar provides 7 days LN_2 capacity.
- Filled every day to monitor rate of use.
- TTL bias shutdown device provided by IKP Cologne.
- 4 x GRETINA digitiser cards providing 40 channels of 100MHz, 14 bit, time-aligned, FADCs.
- VME64x crate with ~3.8MB/s maximum data rate, equating to approximately 420 events per second.

C001: Measurement timescale

Measurement	Started	Finished
Gain Matching for Core with ORTEC supply	12/9/09	12/9/09
Coincidence Scan with ORTEC HV Supply	13/9/09	3/11/09
Alignment Tests	3/11/09	5/11/09
Plane Illuminated Data	6/11/09	9/11/09
^{137}Cs Side Singles Scan	11/11/09	19/11/09
^{241}Am Side Singles Scan	20/11/09	21/11/09
^{60}Co Flood Measurement for Prop & Diff Xtalk	21/11/09	23/11/09
^{60}Co and ^{241}Am Prop Xtalk Measurement (traces)	23/11/09	25/11/09
^{60}Co and ^{241}Am Prop Xtalk Measurement (no traces)	25/11/09	30/11/09
^{241}Am Front Face Singles Scan	30/11/09	1/12/09

^{137}Cs Singles Side Scan

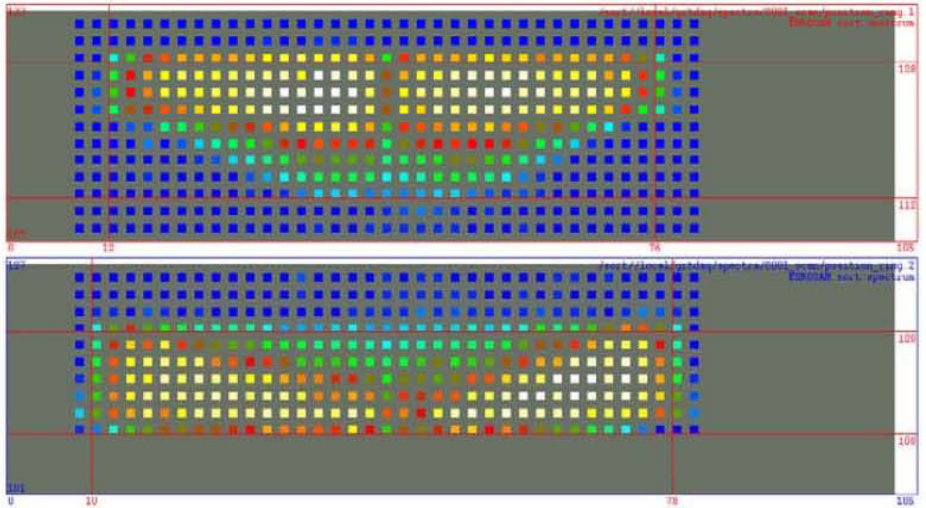


Detector scanned from side for 30s per position on a 1mm grid.

Triggered by >300keV on core.

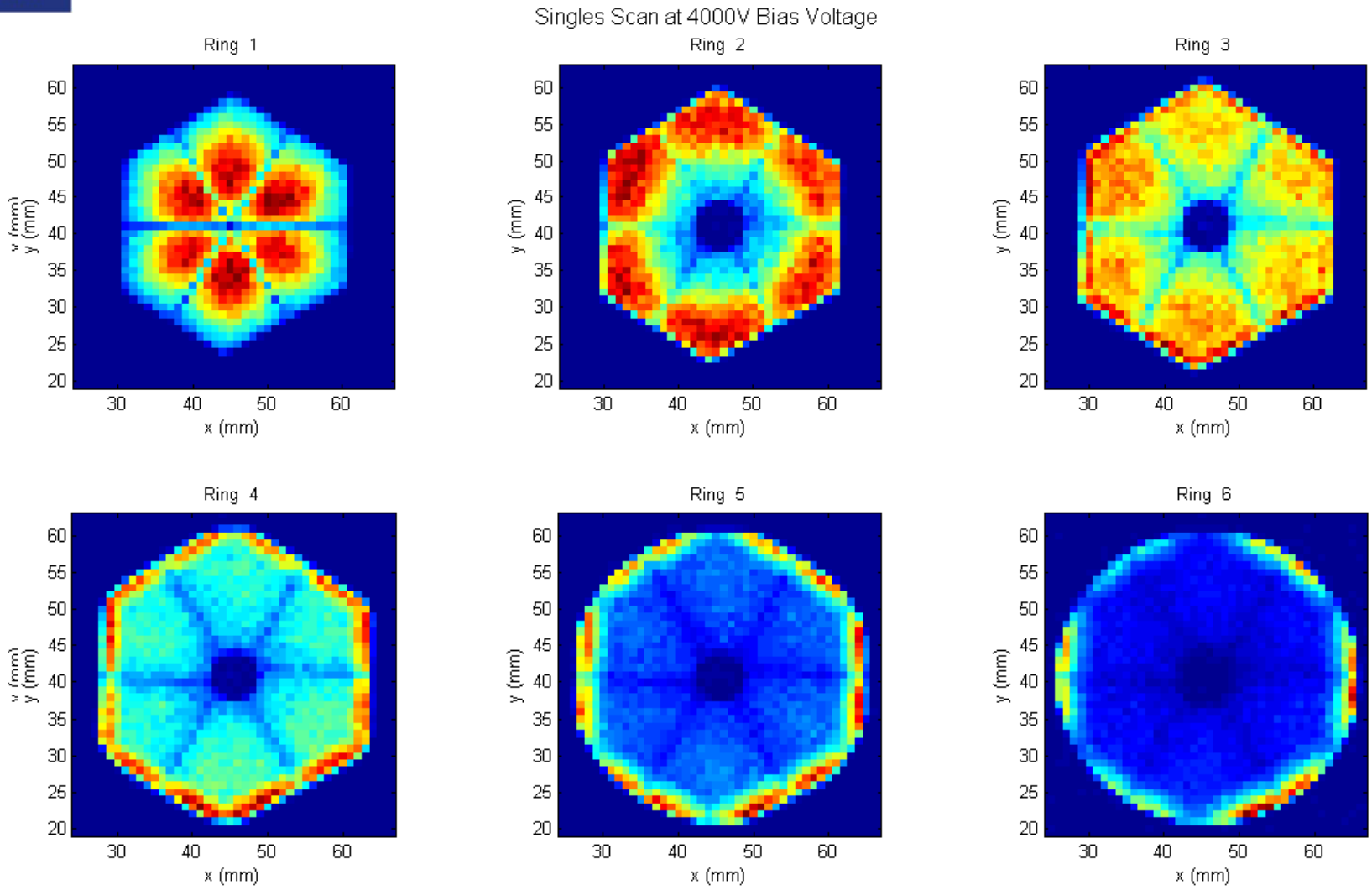
Fold 1, Photopeak intensity matrix shown.

Front of detector scanned on 2mm basis for 150s per position to ensure sufficient statistics for PSCS method.

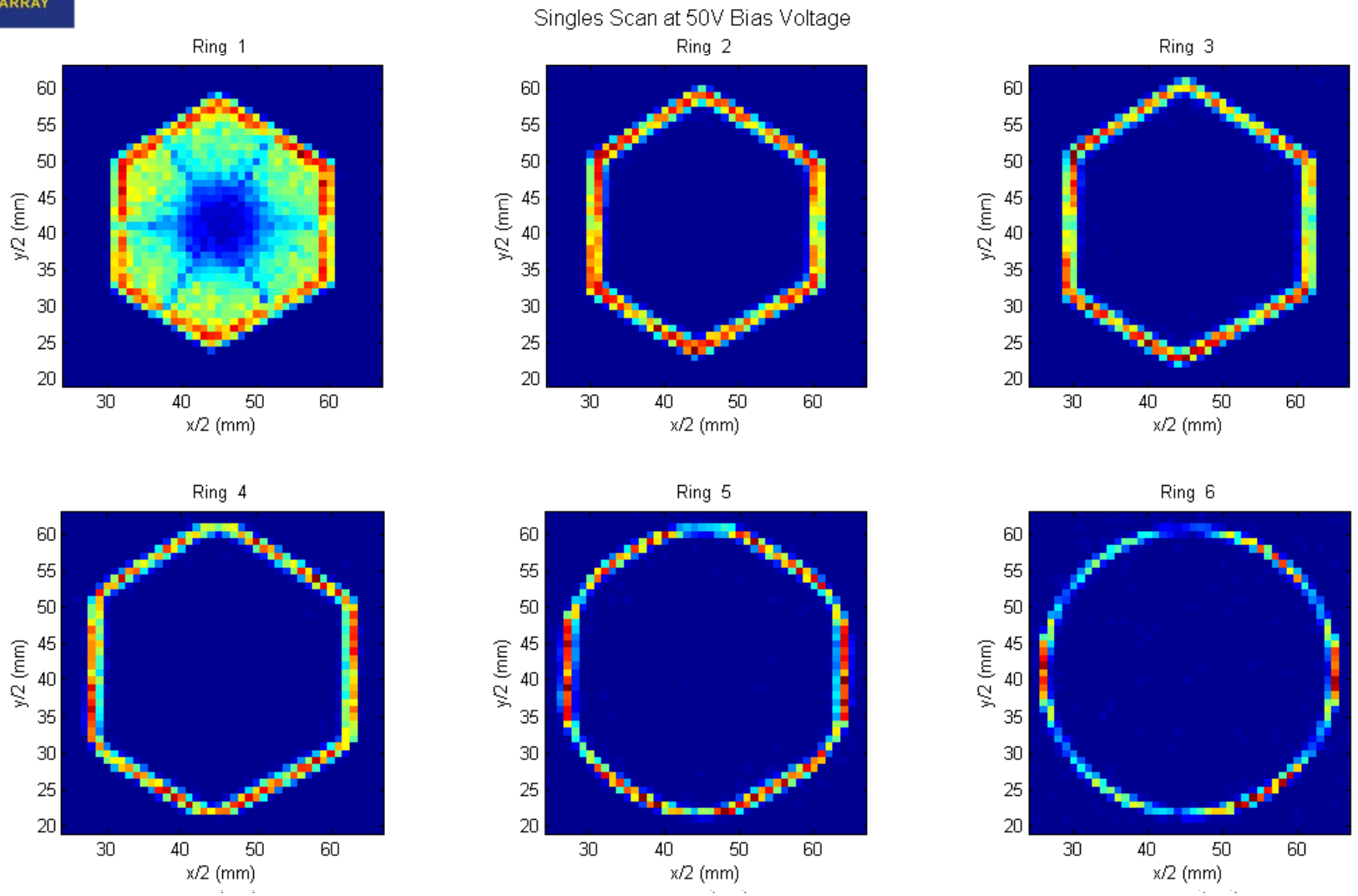


C001 singles scan results

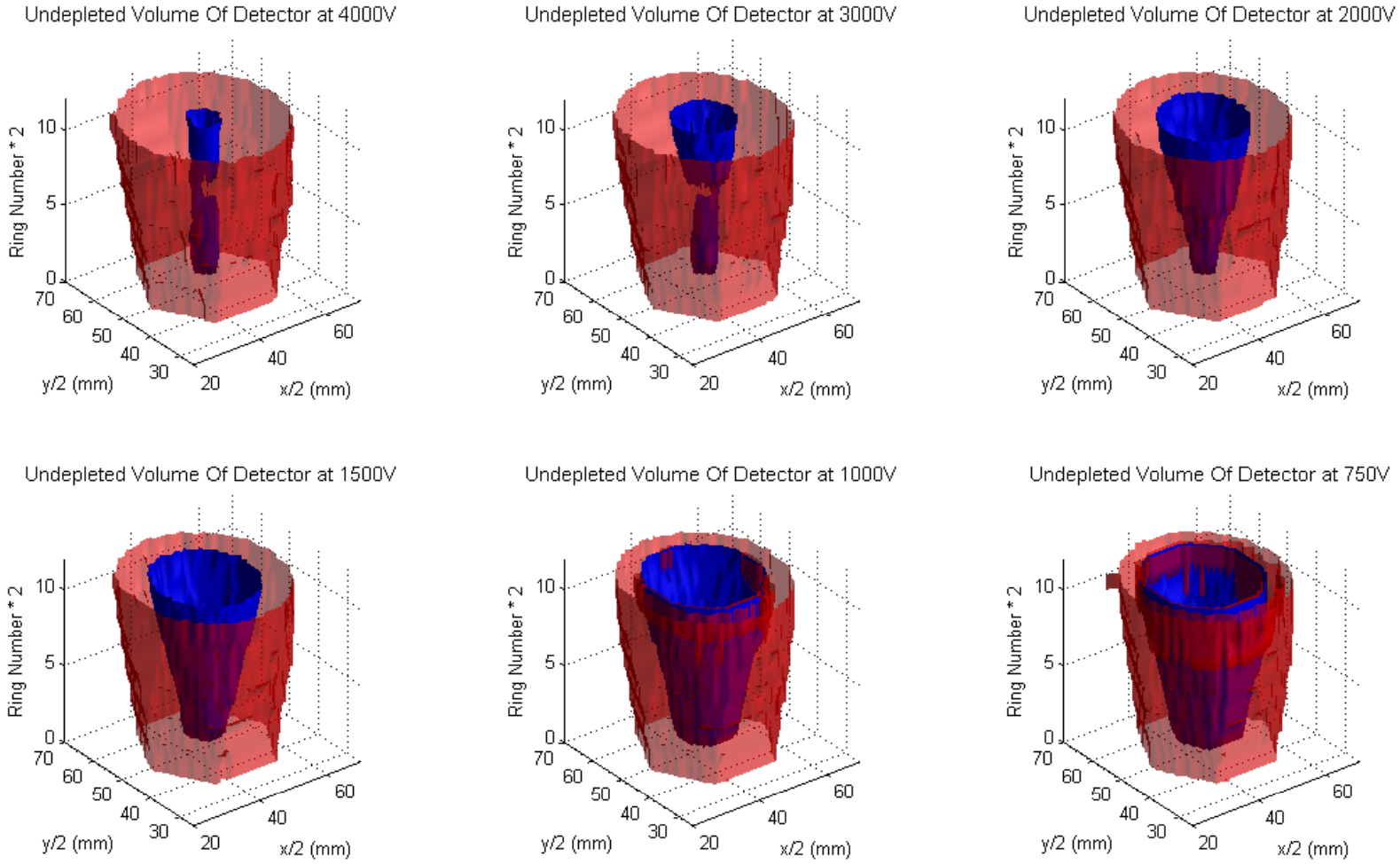
-
-



C001 singles scan results



• Results (cont.)

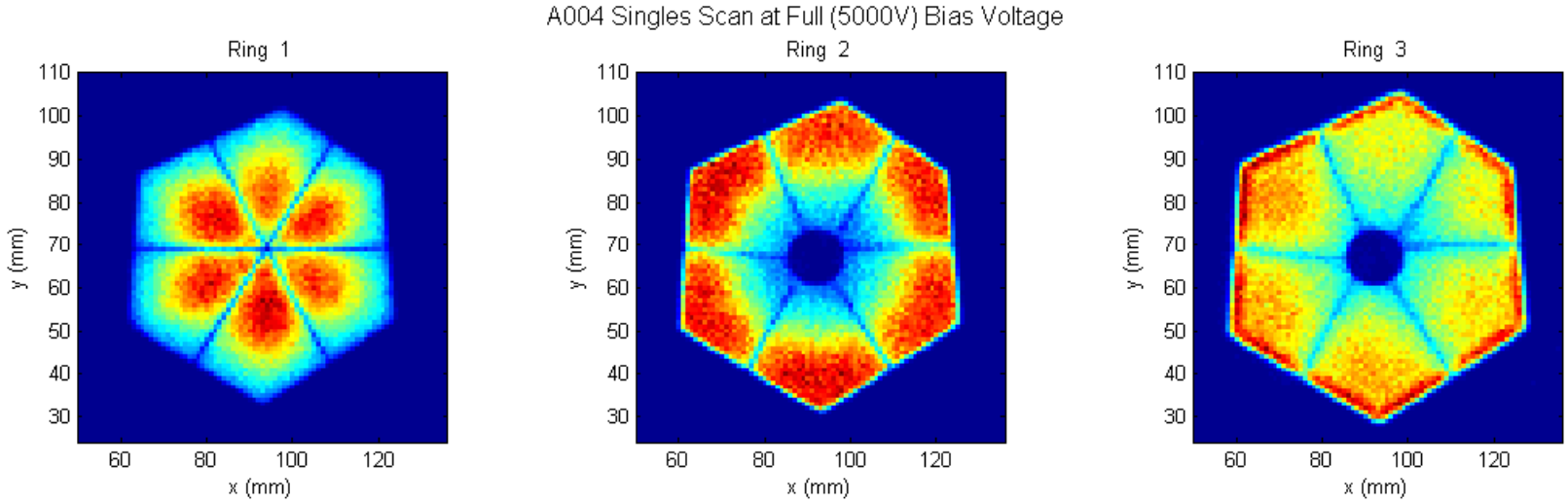


Timeline of A004 Measurements

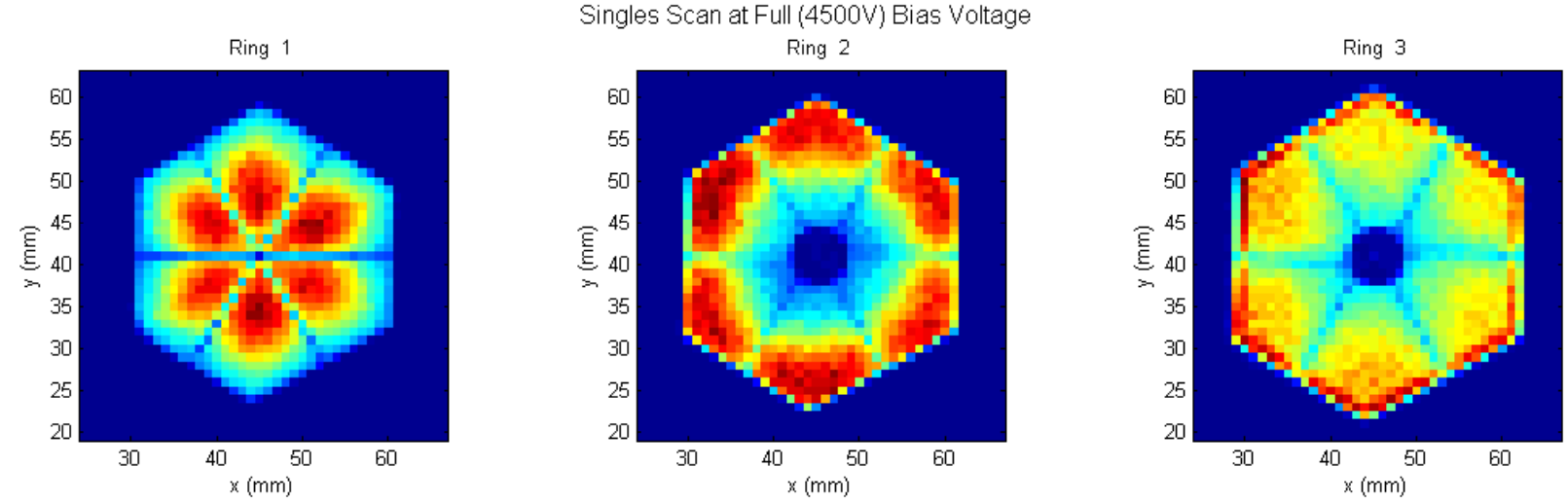
Event	Date
A004 arrives in Liverpool. Attached to pump.	10/12/09
Cooling.	11/12/09
Testing shows segment E6 missing. Warming begins.	14/12/09
Repairs to cold/warm feedthrough. Pumping begins.	18/12/09
Cooling.	22/12/09
Testing shows D6 missing. Warming starts.	23/12/09
Ribbon cable to D6 repaired. Pumping.	5/1/10
Cooling.	7/1/10
Testing shows all sector D channels missing. Warming.	8/1/10
Sector D feedthrough repaired.	12/1/10
Cooling.	13/1/10
All segments working. Acceptance tests begin.	14/1/10

Singles Scanning Observations

A4

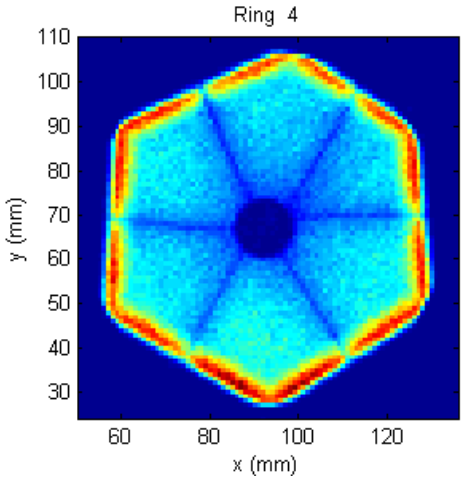


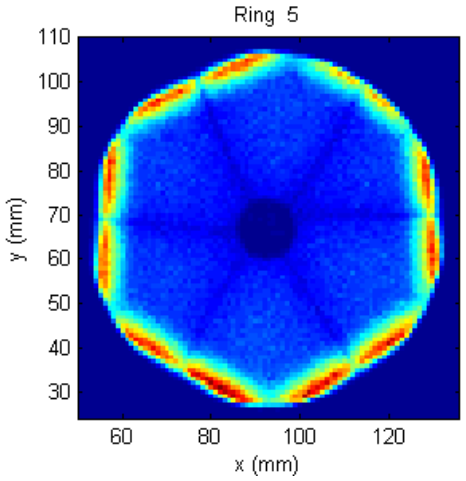
C1

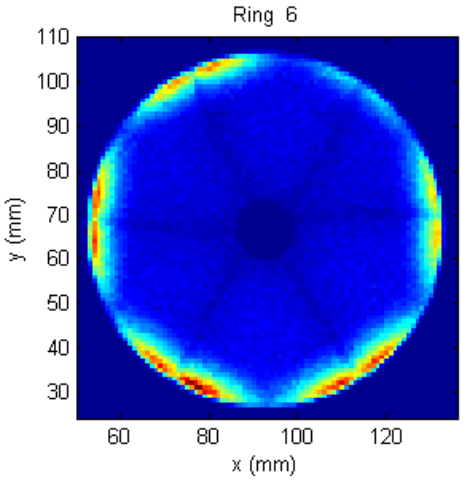


Singles Scanning Observations

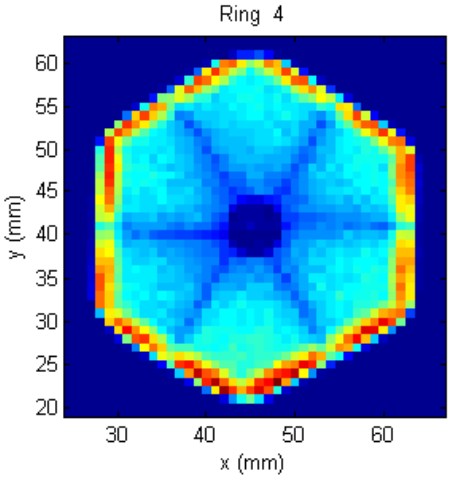
A4

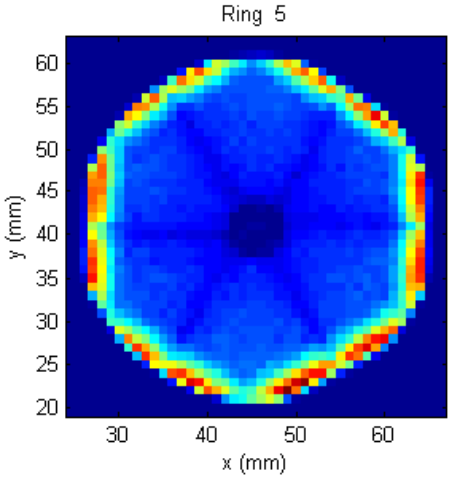


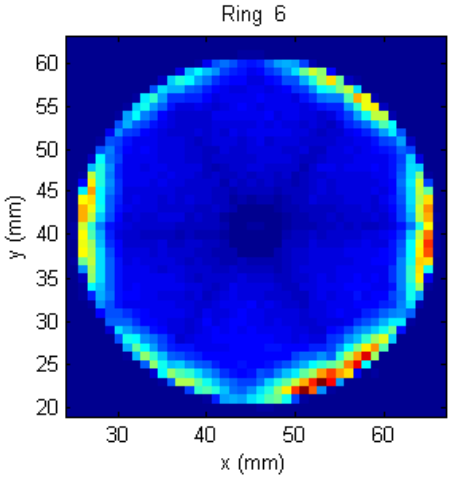




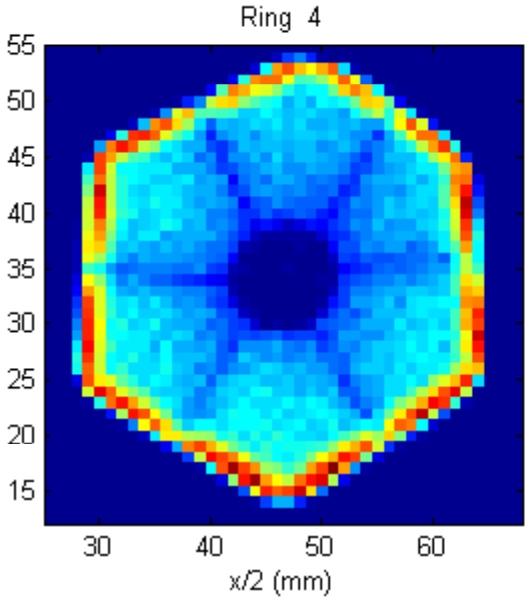
C1

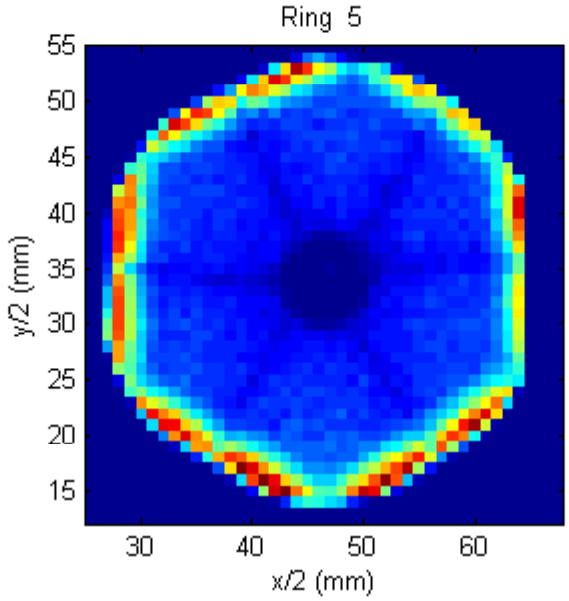


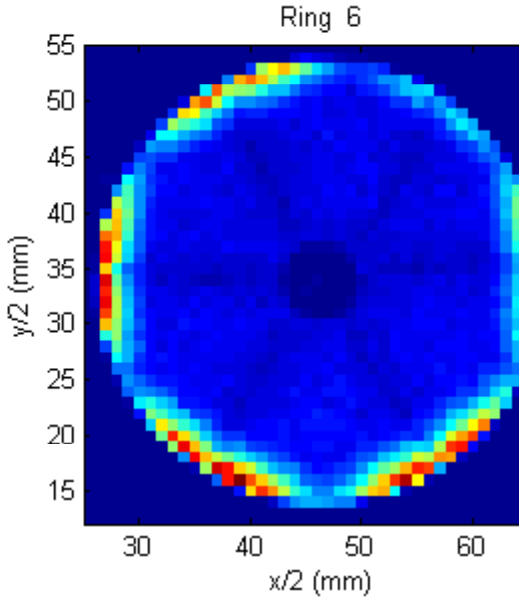


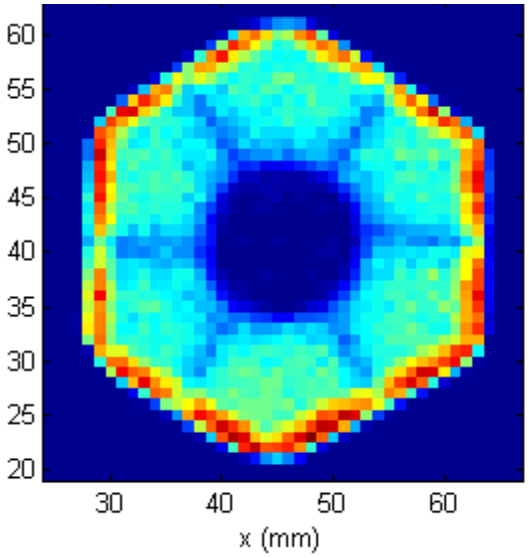


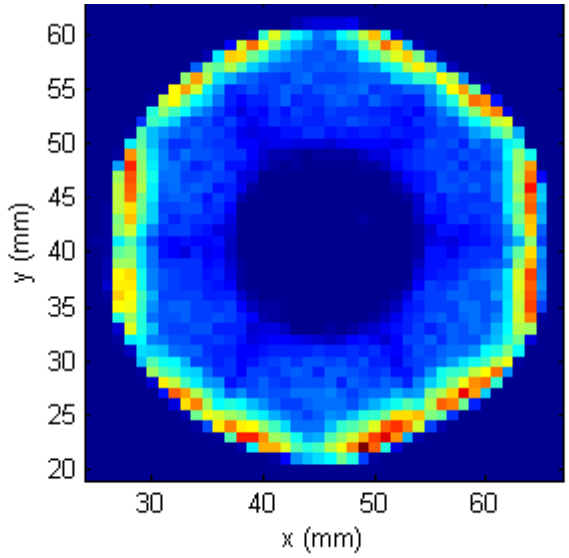
Singles Scanning (2000V)

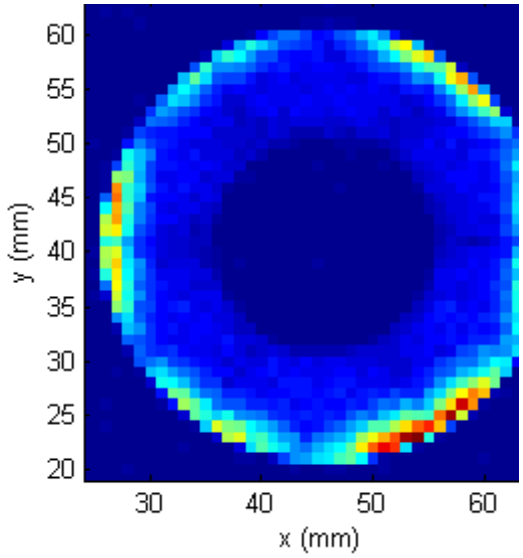




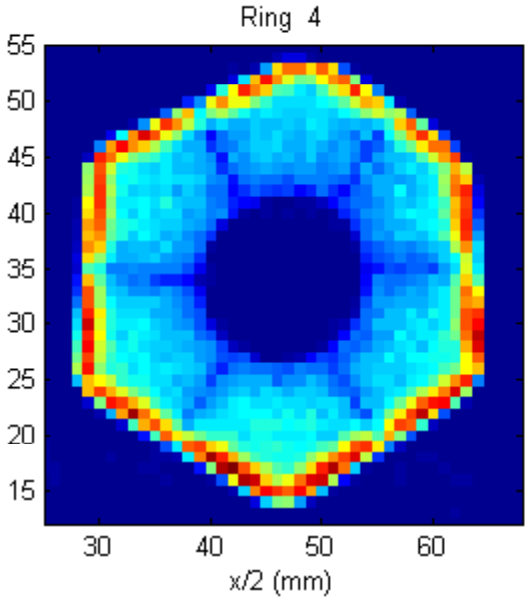


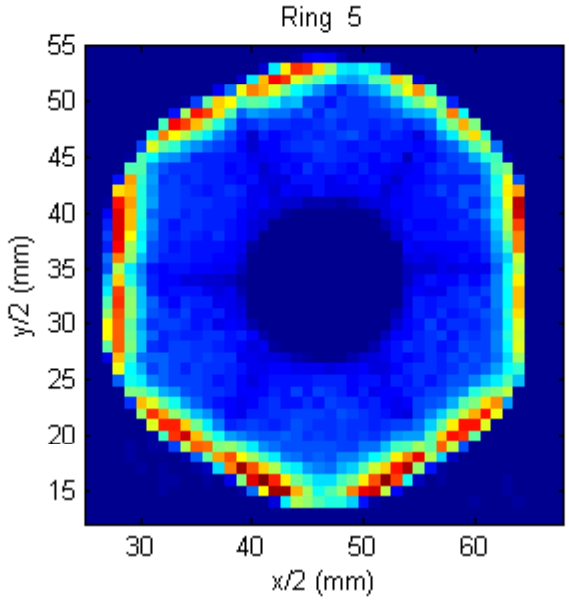


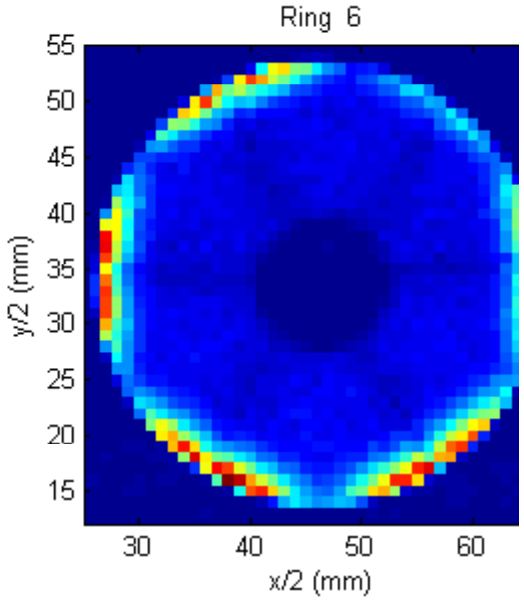


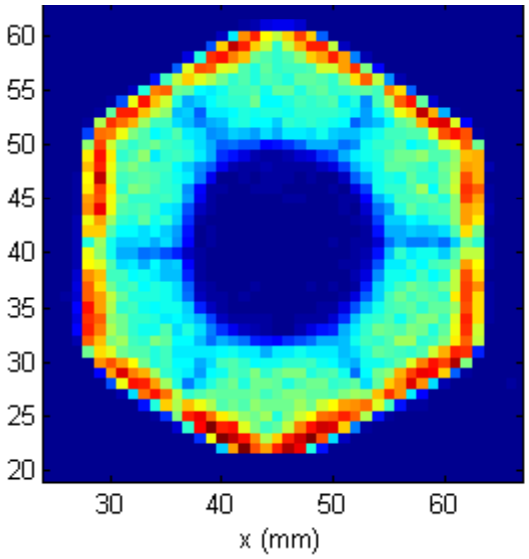


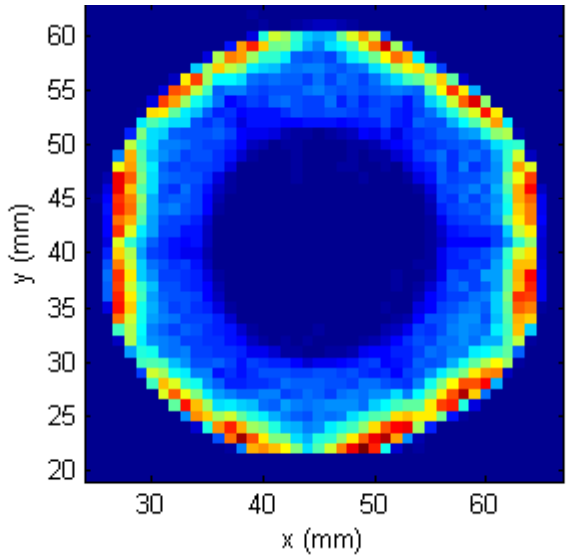
Singles Scanning (1500V)

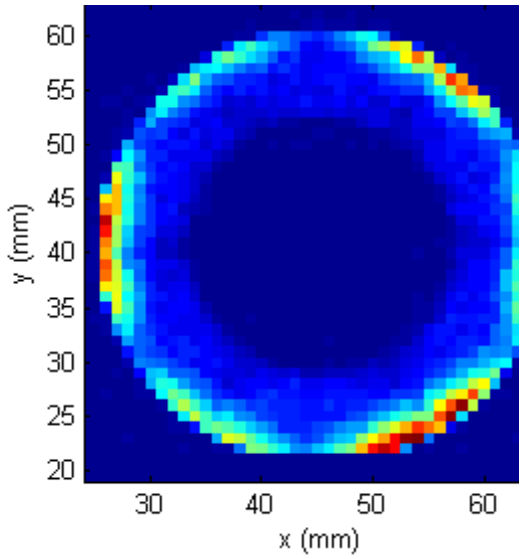




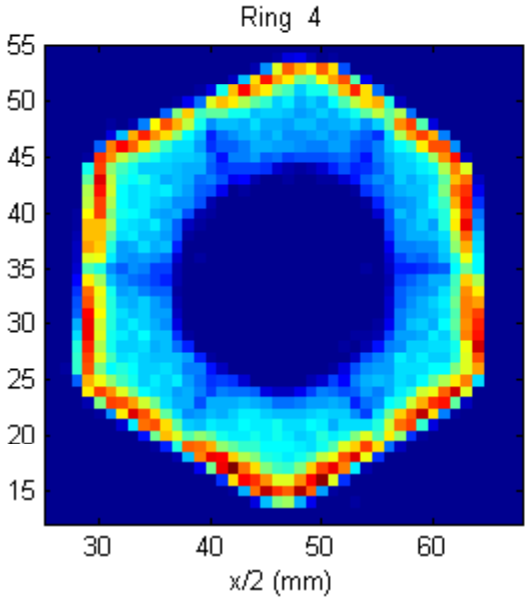


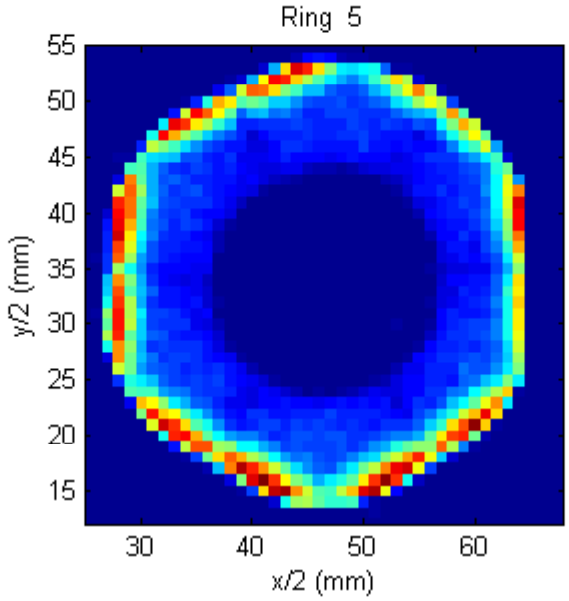


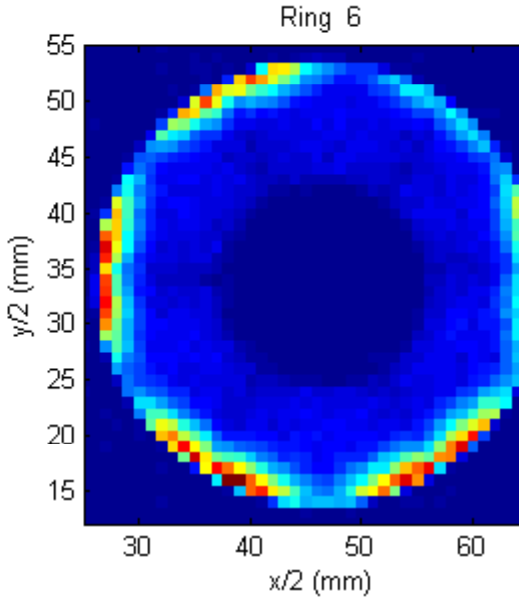


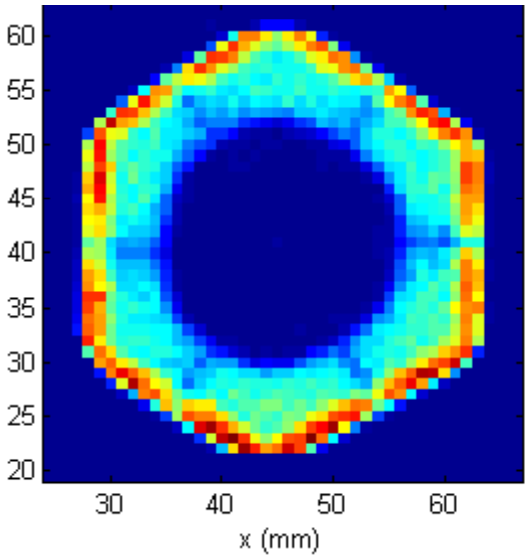


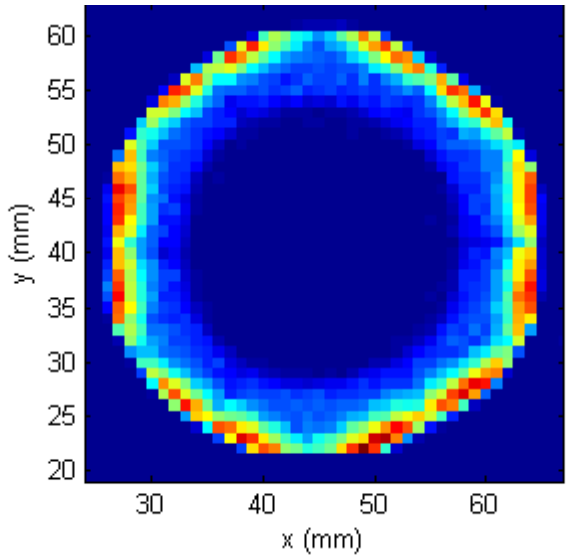
Singles Scanning (1000V)

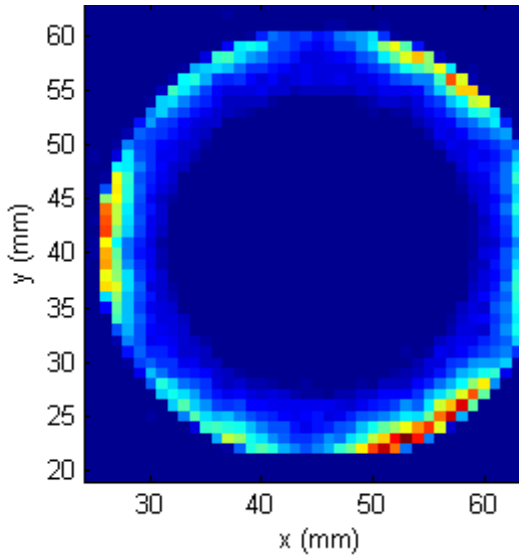




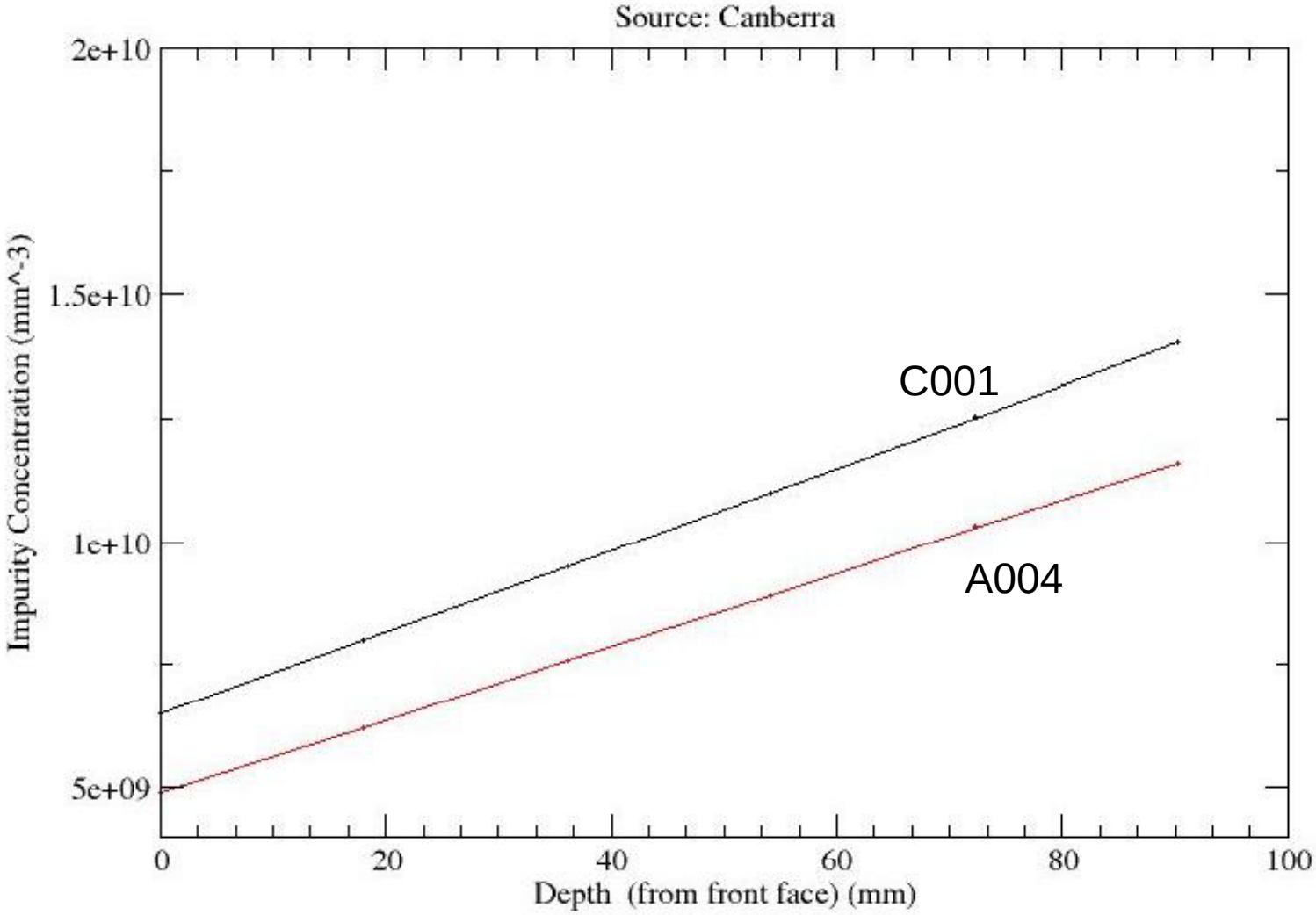




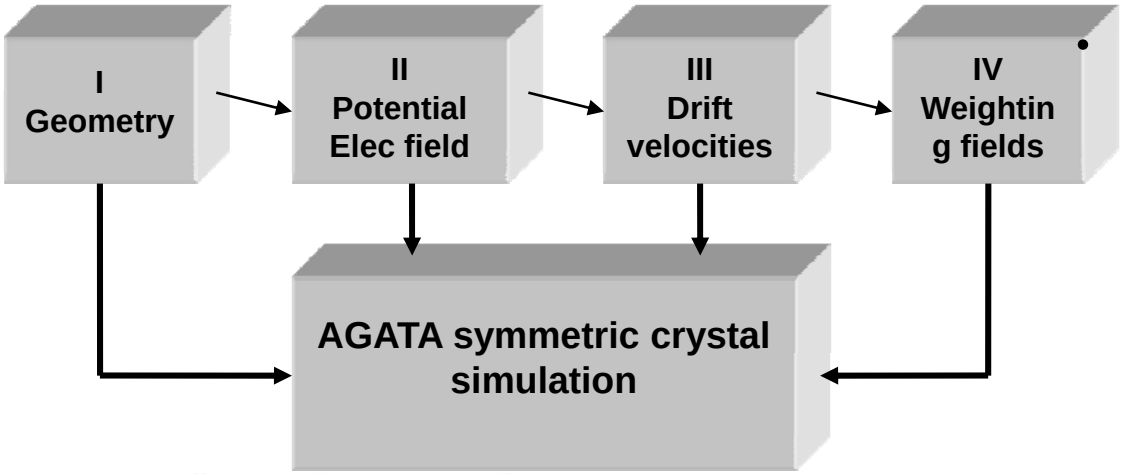




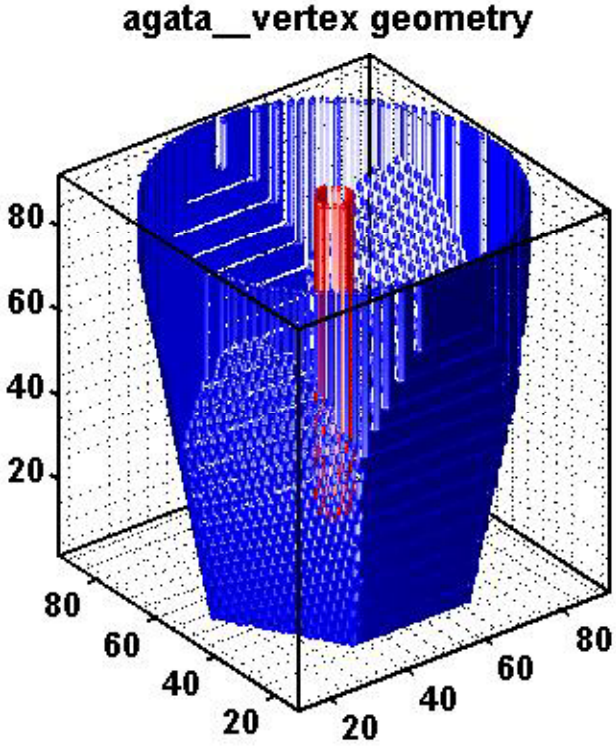
Impurity concentration

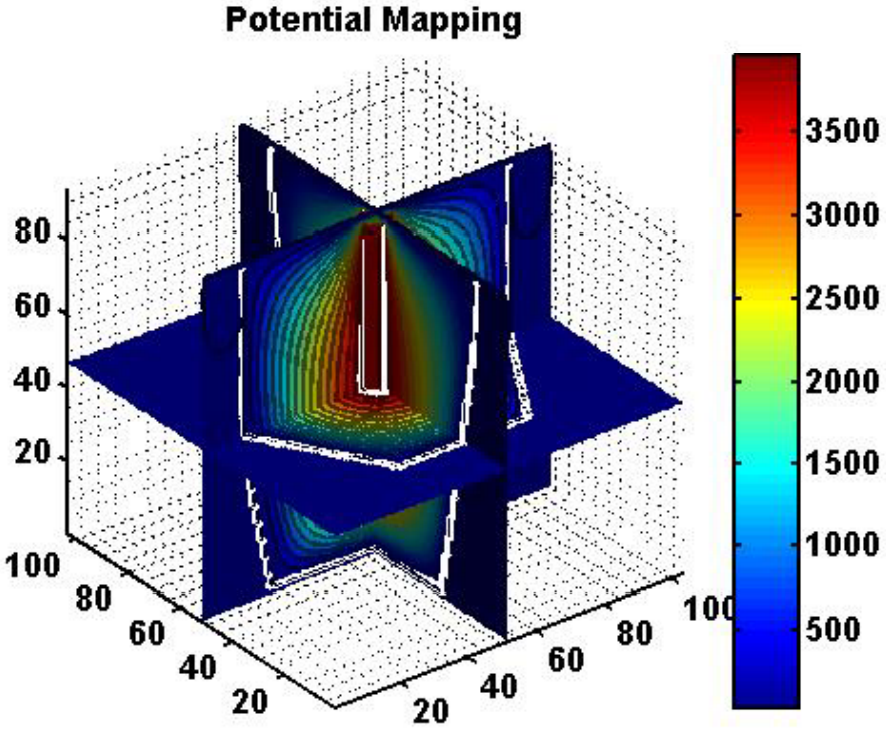


Electric Field Simulations: MGS/JASS



Electric field simulations have been developed and are being optimised with experimental pulse shape data.



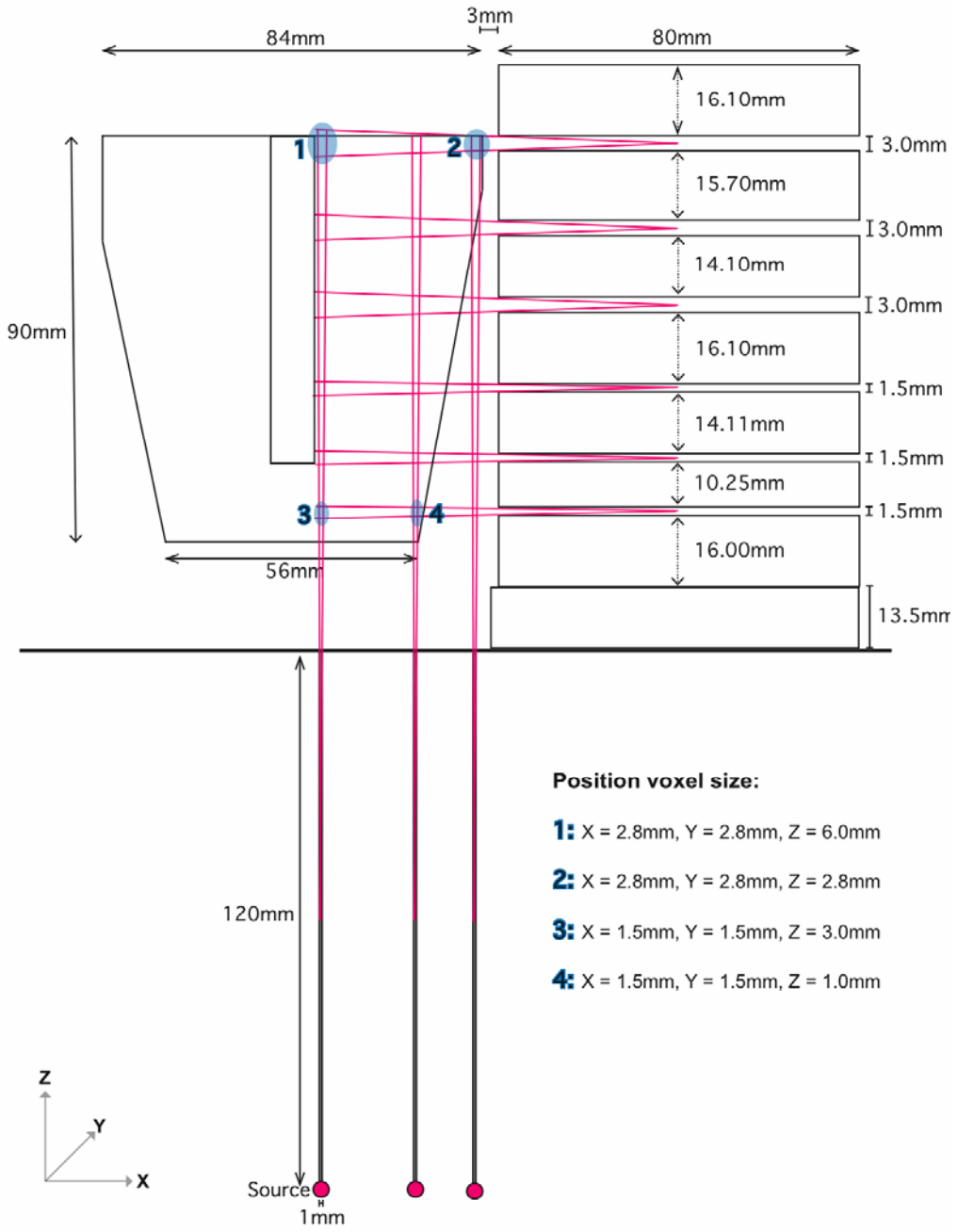


Coincidence Scanning

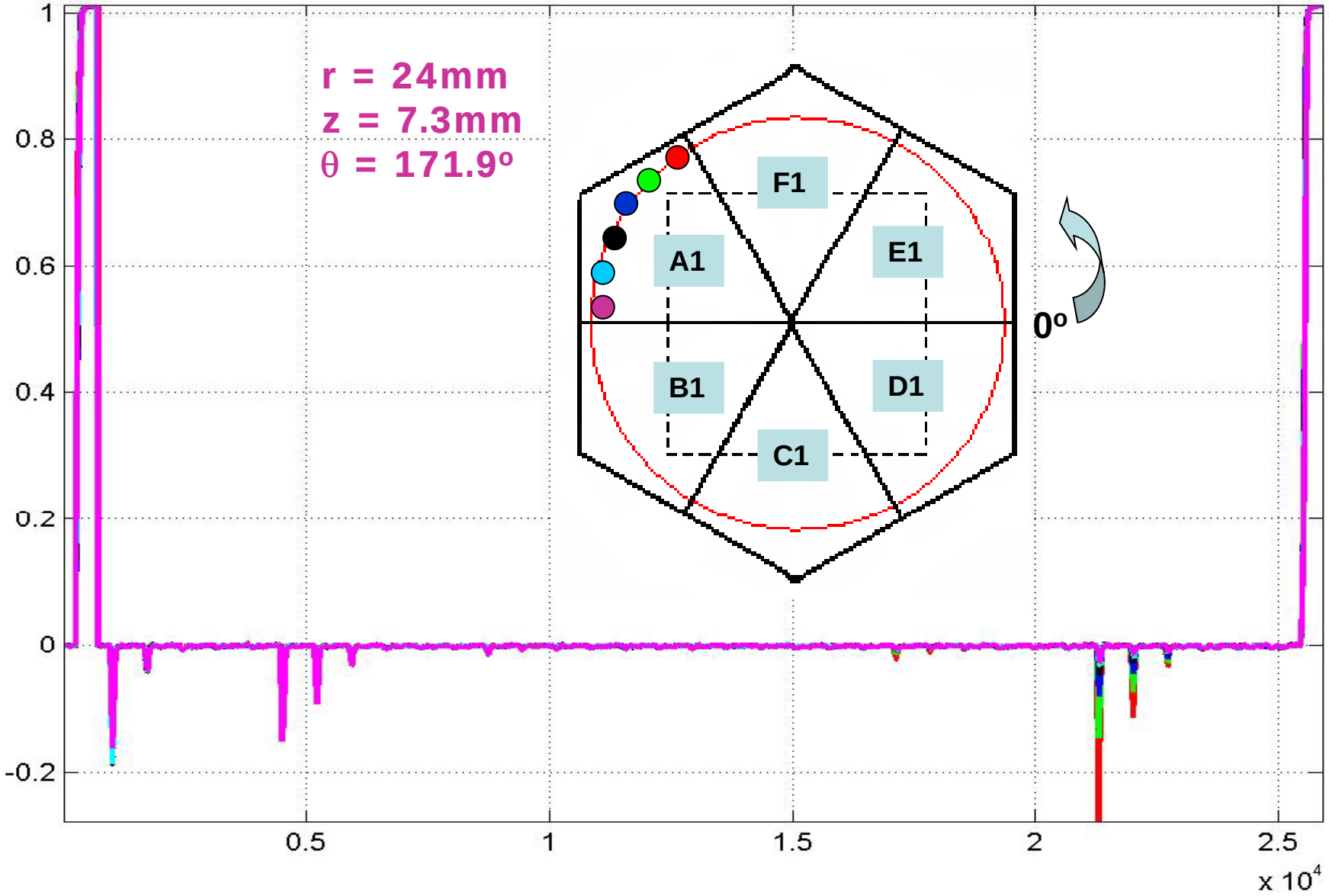
- Precise characterisation
- Slow
- Proven method

- A002/A003 + C001

- Next A006



Azimuthal detector sensitivity



Experiment vs Theory

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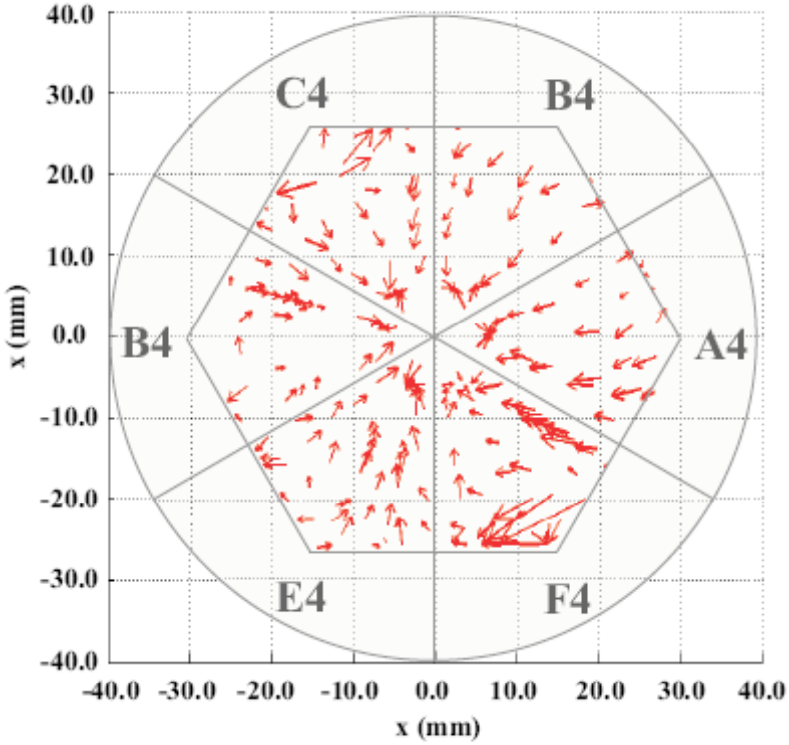
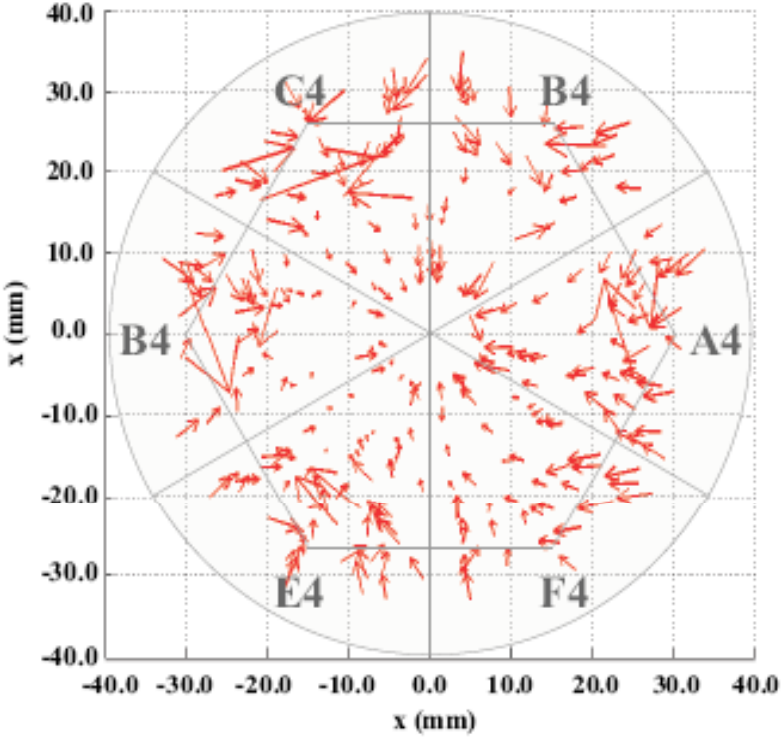


a) Displacement vectors, z = 4.8±0.3mm



a) Displacement vectors, z = 48.8±0.9mm

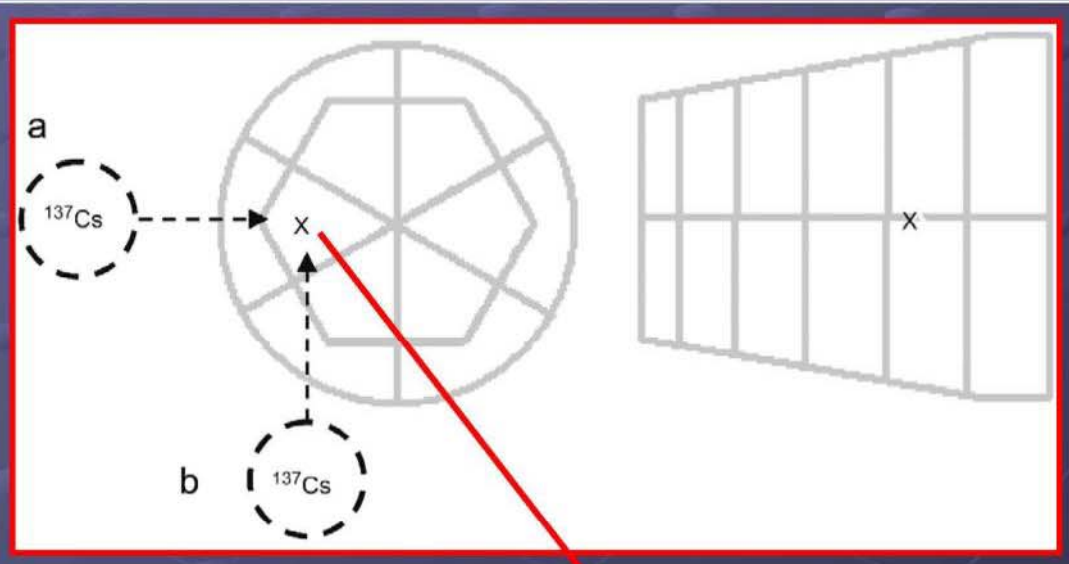
Depth (mm)	Ring	Min Displacement (mm)	Max Displacement (mm)	<Displacement (mm)>
4.2±0.3	1	0.1±0.4	11.9±0.4	2.2±0.4
15.7±0.3	1	0.2±0.6	17.3±0.6	2.7±0.6
48.8±0.3	4	0.1±0.7	17.0±0.7	2.6±0.7

Pulse Shape Comparison based Scan (PSCS): BASIC IDEA

- Only measurements in single mode, characterized by a defined collimation of the gamma ray source (→ significant decrease of time consumption, as compared with the standard coincidence techniques)

- **Events of Interest** are selected by means of a specific signal shape comparison procedure

  Energy release concentrated in a (known a priori) position inside the detector volume

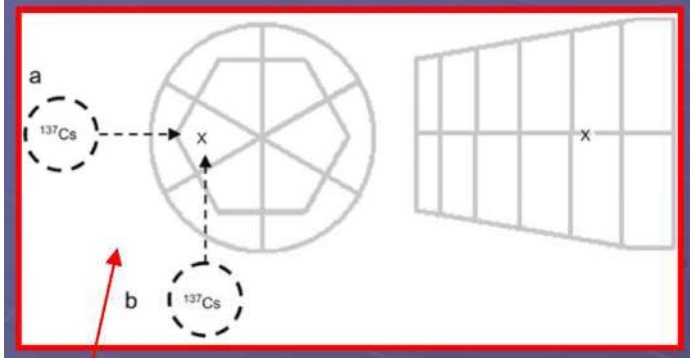


The pairs of signals that have the SAME SHAPE (i.e. that minimize the χ^2) are associated to an energy release concentrated in the point where the 2 collimation lines cross

VALIDATION TEST WITH SIMULATED EVENTS

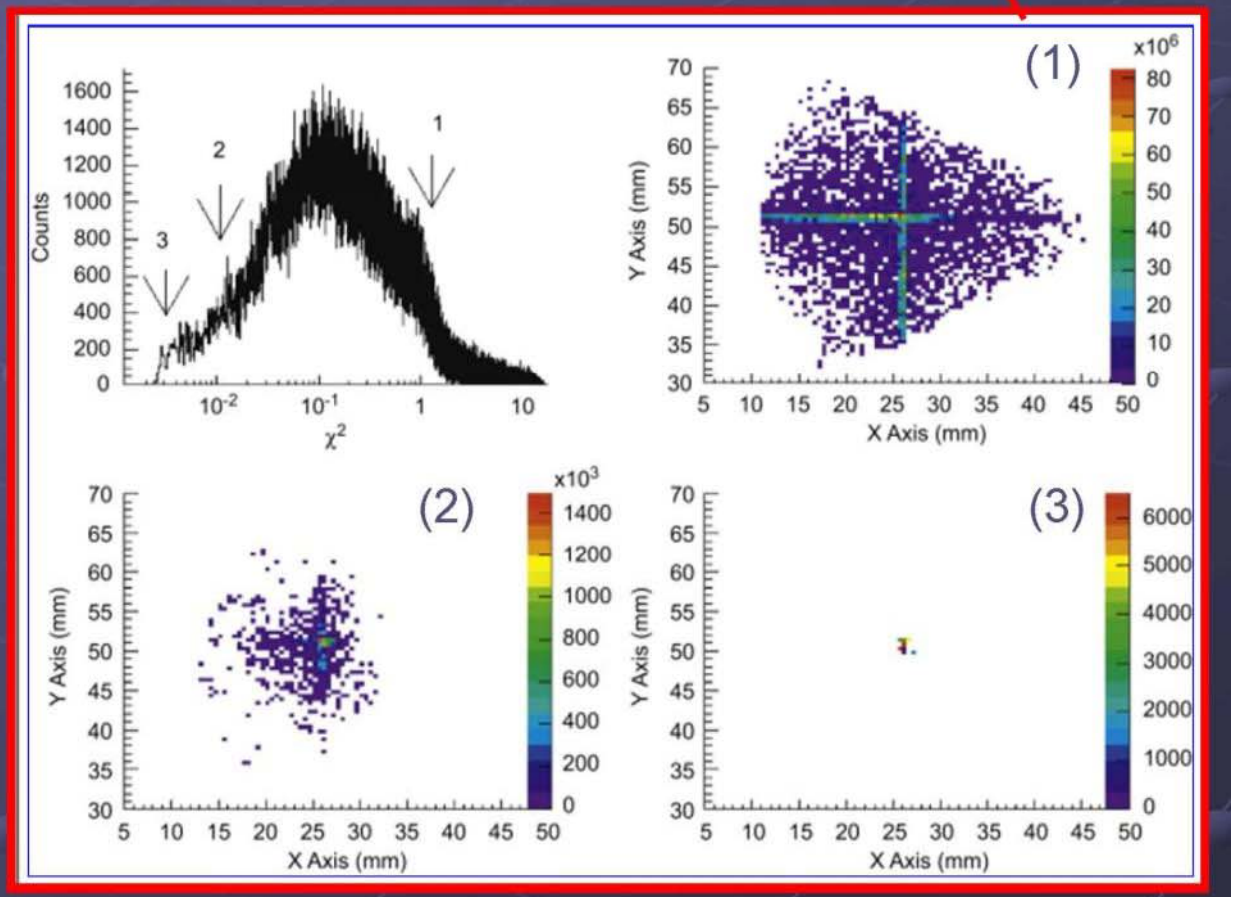
PSCS method applied to a simulated 36-fold segmented HPGe AGATA detector:**
→ calculated pulses are produced using the MGS signal basis. In the simulation the effect of noise and electronic chain response is taken into account.

The more stringent the χ^2 threshold is set
(i.e. the more the signal shapes are similar), the more the energy release is concentrated in the position of interest



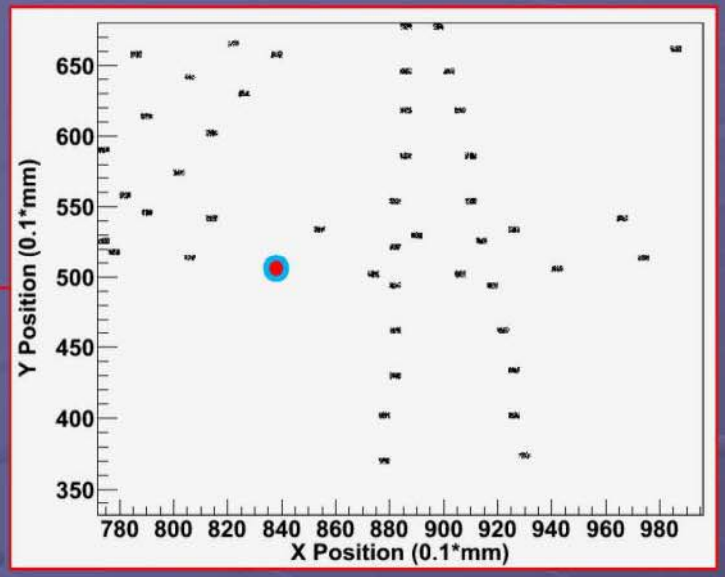
Simulation:**
A 662.7 keV γ-ray pencil beam hits a segment of the AGATA detector, in two perpendicular directions [a)] [b)]

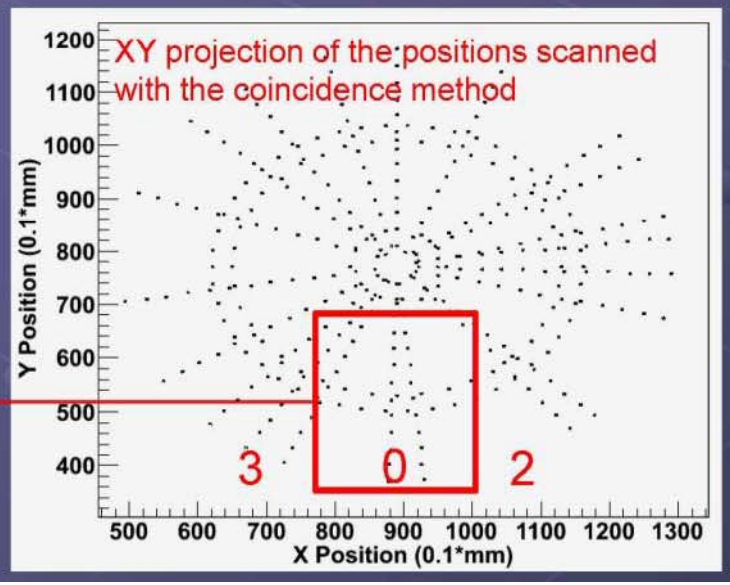
**Simulation performed using Enrico Farnea's "Agata" code



A Simple Test

Before applying the PSCS, a simple test for checking consistency of datasets.
The coincidence scan traces are compared with the front face singles scan ones.
The X and Y coorindates have to be the same for identical shapes.

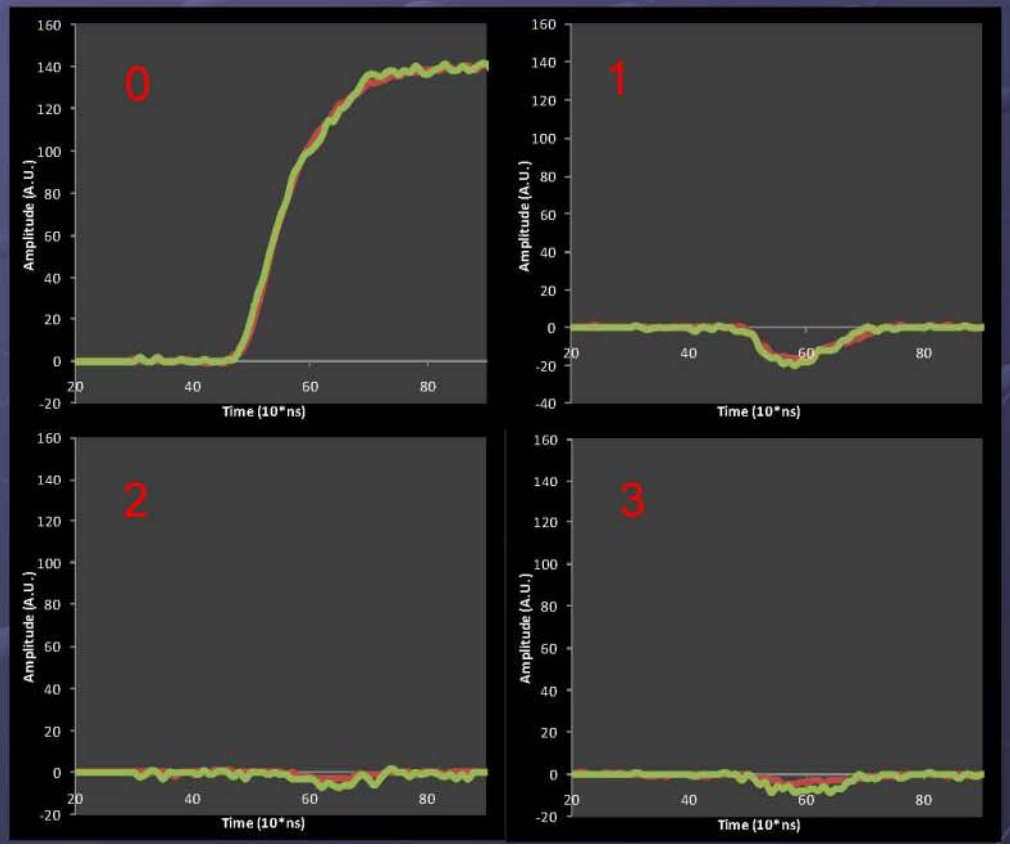




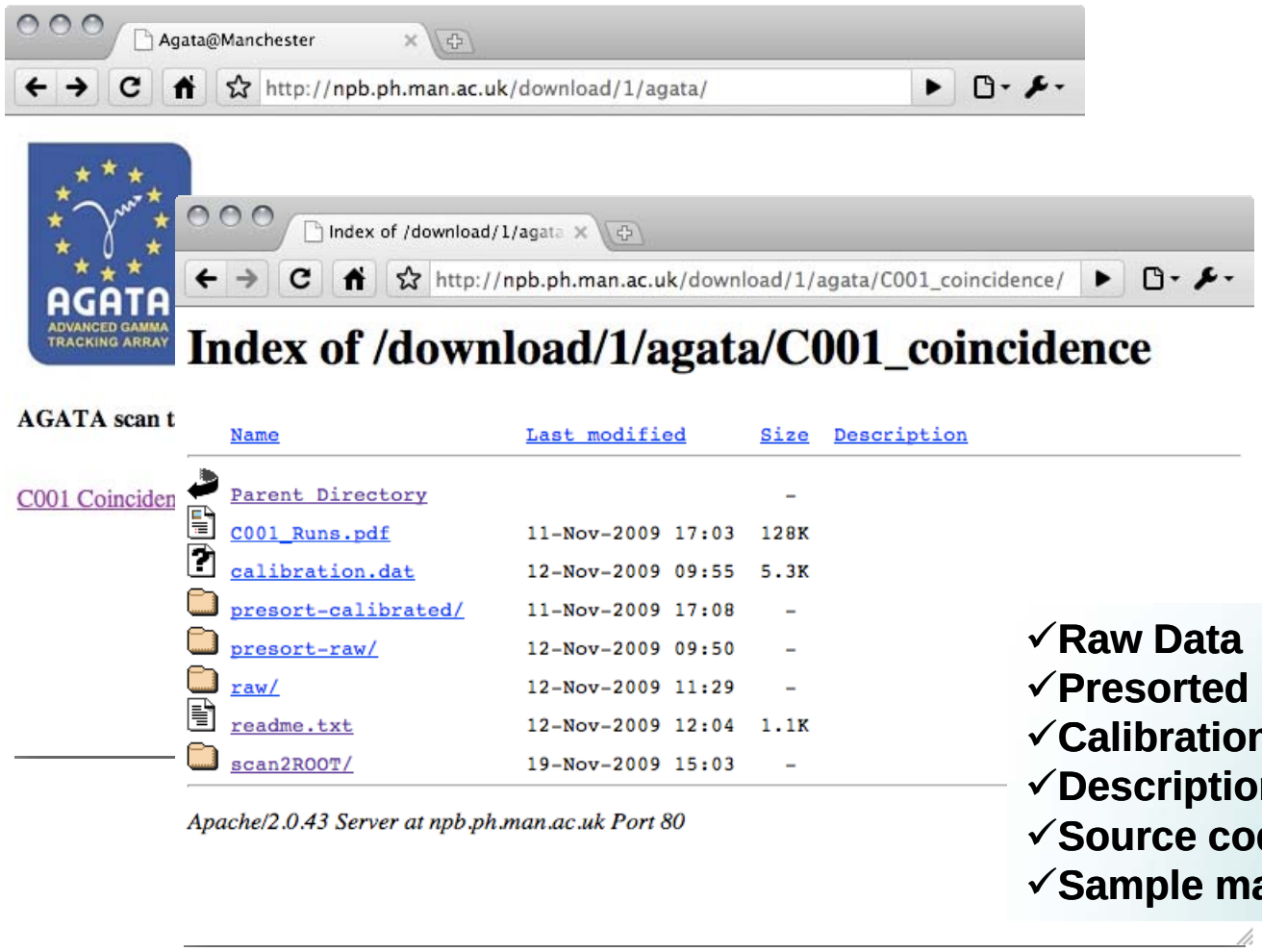
Pos X 840 (0.1*mm), Pos Y 510 (0.1*mm), Pos Z 50.5 (0.1*mm)

Front Face Singles Scan Data

Coincidence Scan Data



Distribution



- ✓Raw Data
- ✓Presorted Data
- ✓Calibration coefficients
- ✓Description of scan
- ✓Source code
- ✓Sample macros

npb.ph.man.ac.uk/download/1/agata/

PSA Algorithms

AGATA Crystal

New Producer for Scan Data

Producer
Front End Electronics

Adapt
Pre Processing

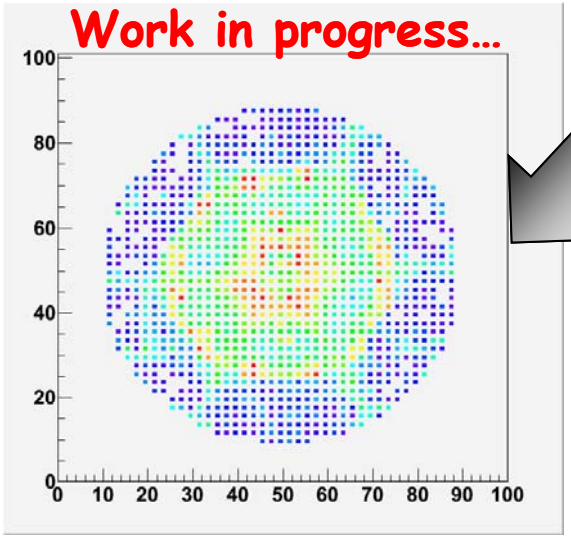
Pre Processing

Use existing PSA algorithms

Pulse Shape Analysis

Simple Grid Search
Adaptive Grid Search
Jass Basis
MGS Basis

Work in progress...



Event Building

Tracking

Consumer

Next Steps

- Basis generation
  - A006 coincidence measurement & make data available
  - Assemble and scan next sensor
  - Optimise E-field simulation, include differential x-talk component
- Test the basis
  - Test Scan Data Producer actor with latest actors (Adaptive grid search)
  - C001 flood source measurements – pencil beam reconstruction
  - C001 coincidence scan measurements (reproduce known positions of interaction)