

Detector Characterisation in Europe



THE UNIVERSITY
of LIVERPOOL

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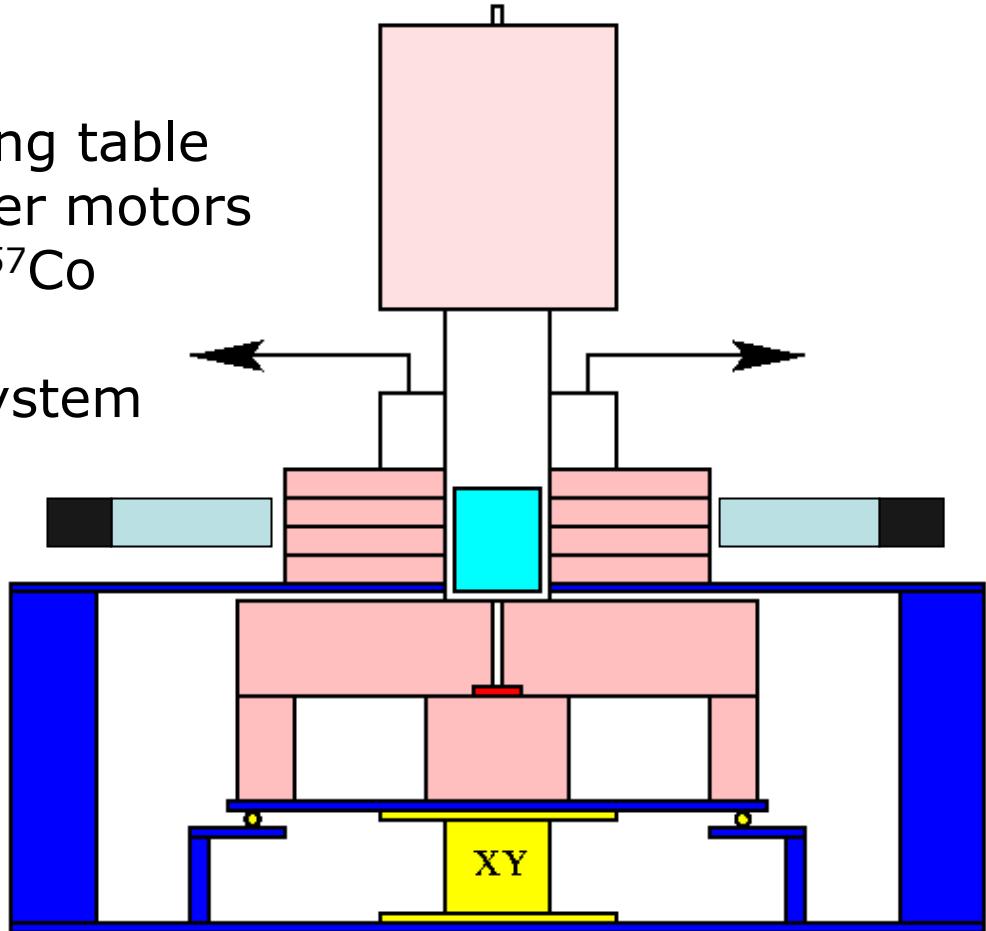
What is characterisation?

- How do you calibrate highly segmented detectors?
 - For energy
 - For position
-
- Determine the experimental response characteristics of a reference segmented germanium detector.
 - Calculation of reference pulse shapes.
 - Full characterisation of prototype crystals.
 - Define how to characterise detectors.

Automated Scanning Tables

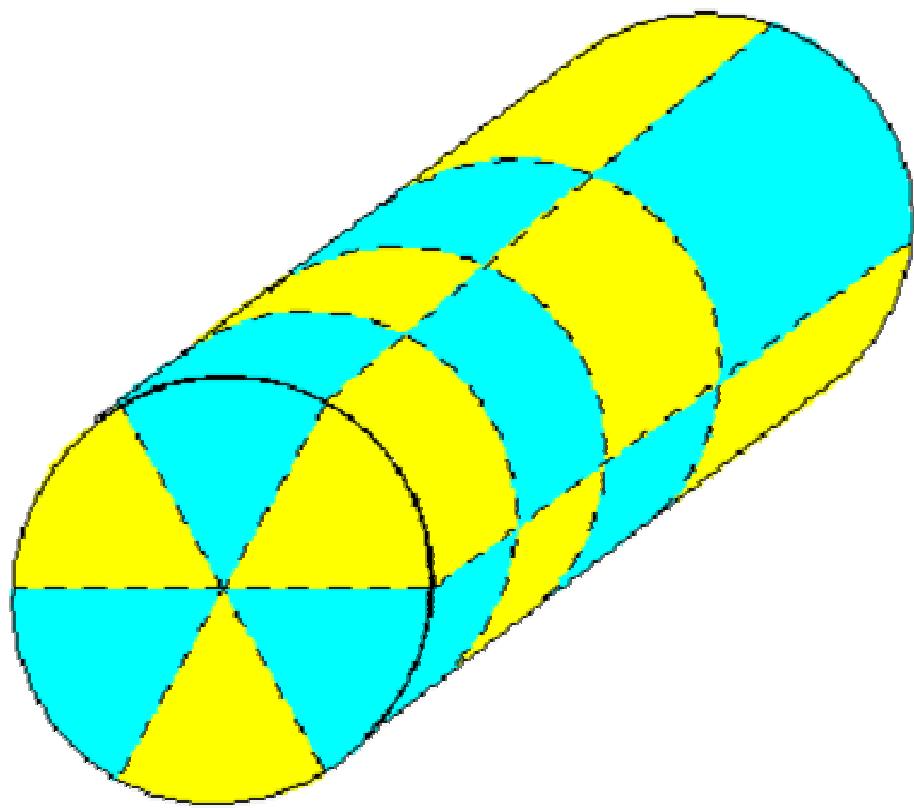
Liverpool System

- Parker linear positioning table
- Pacific scientific stepper motors
- 0.3mCi ^{137}Cs /0.2mCi ^{57}Co
- 1-2mm collimator
- Singles/coincidence system



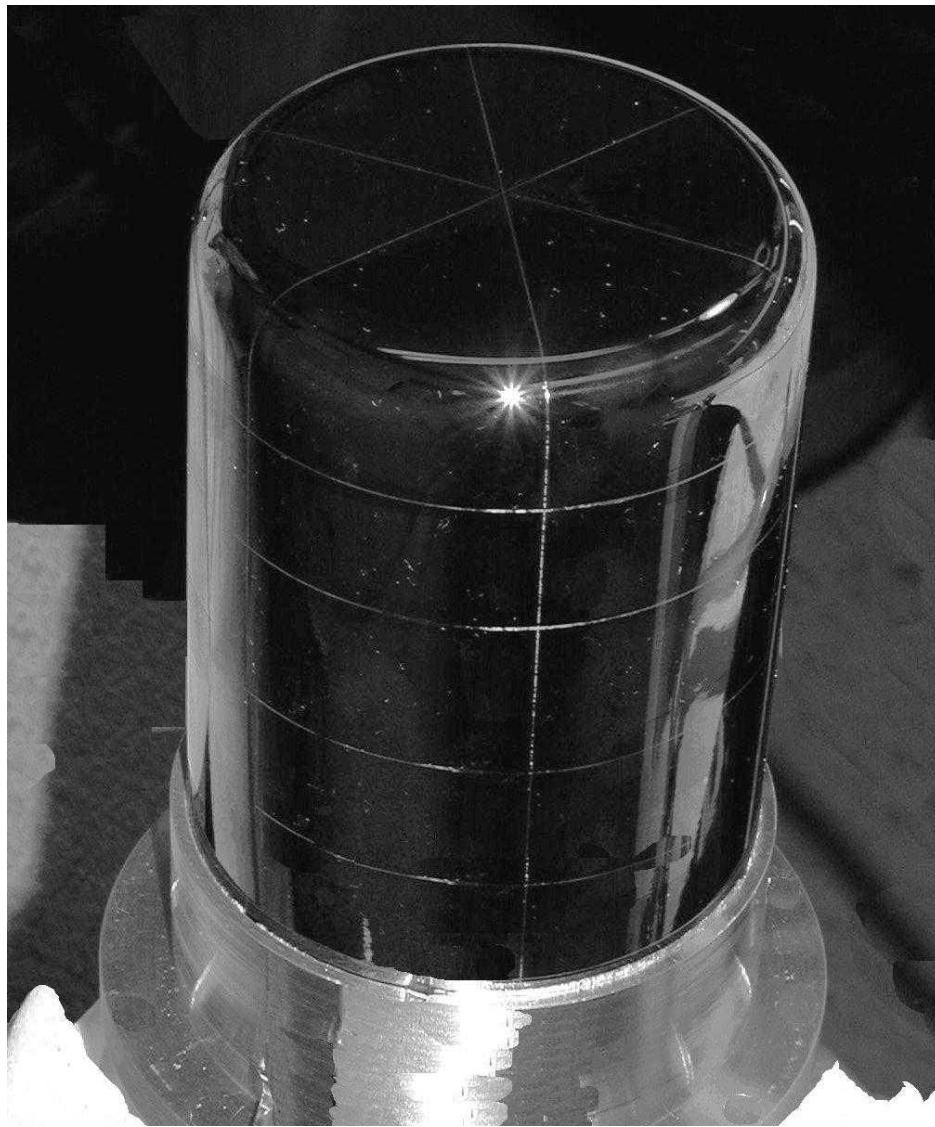
GSI / CSNSM Orsay

Ortec 6x4 Segmented Detector



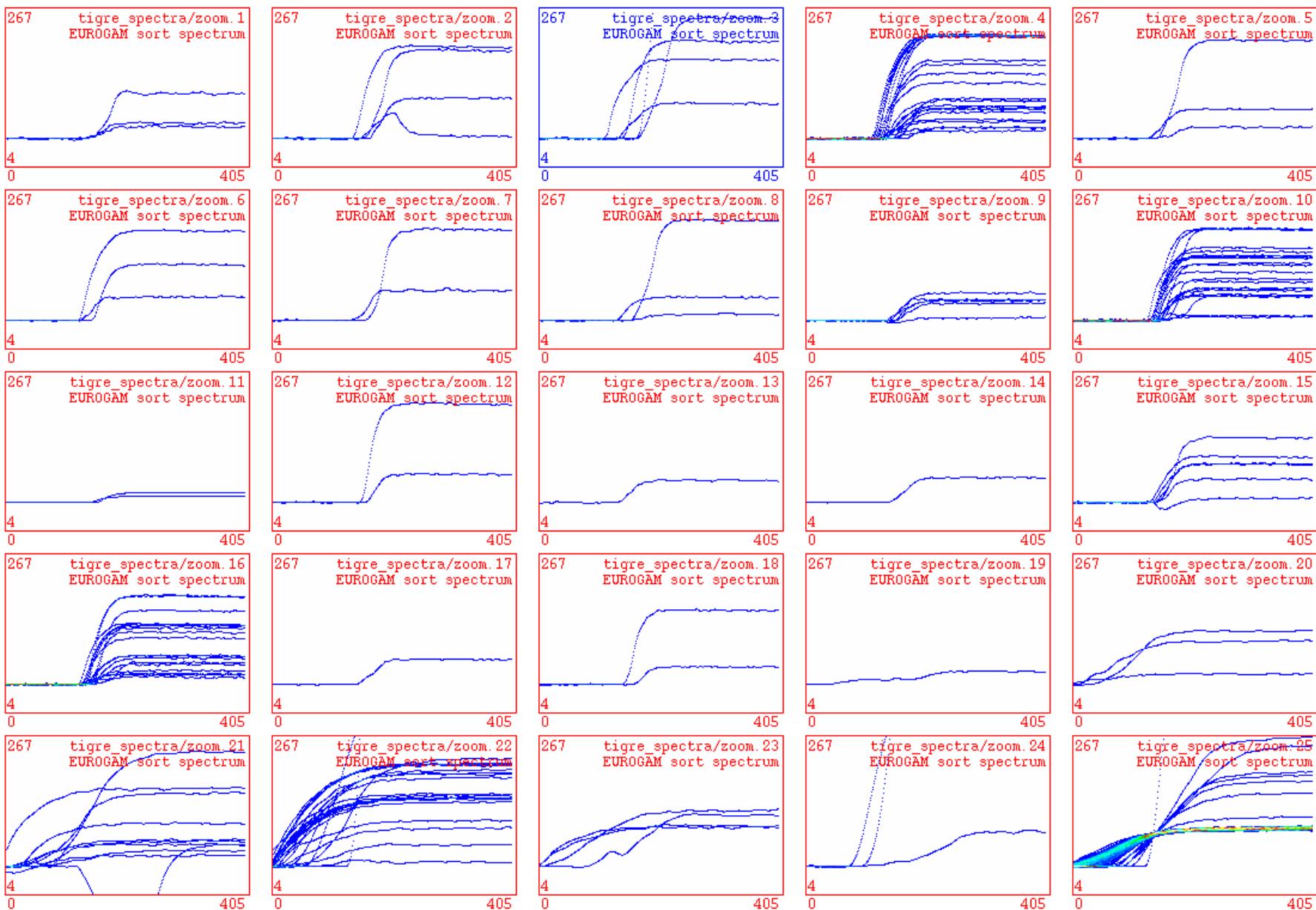
- One 65mm diameter 80mm length crystal
- 24 way segmentation of outer boron implanted contact.
- Warm FET configuration.

Ortec 6x4 Segmented Detector

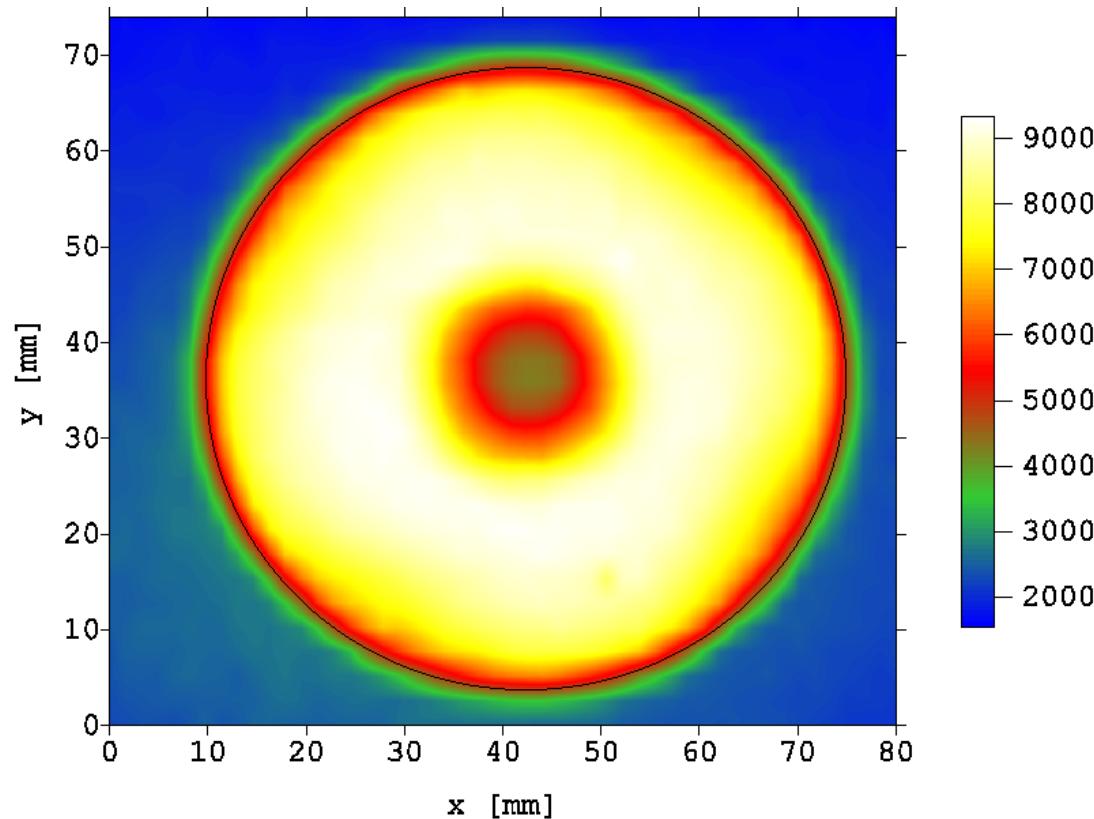


- Electrical segmentation of the outer boron implanted contact.
- $150\mu\text{m}$ separation between adjacent electrodes.

Example Pulse Shapes

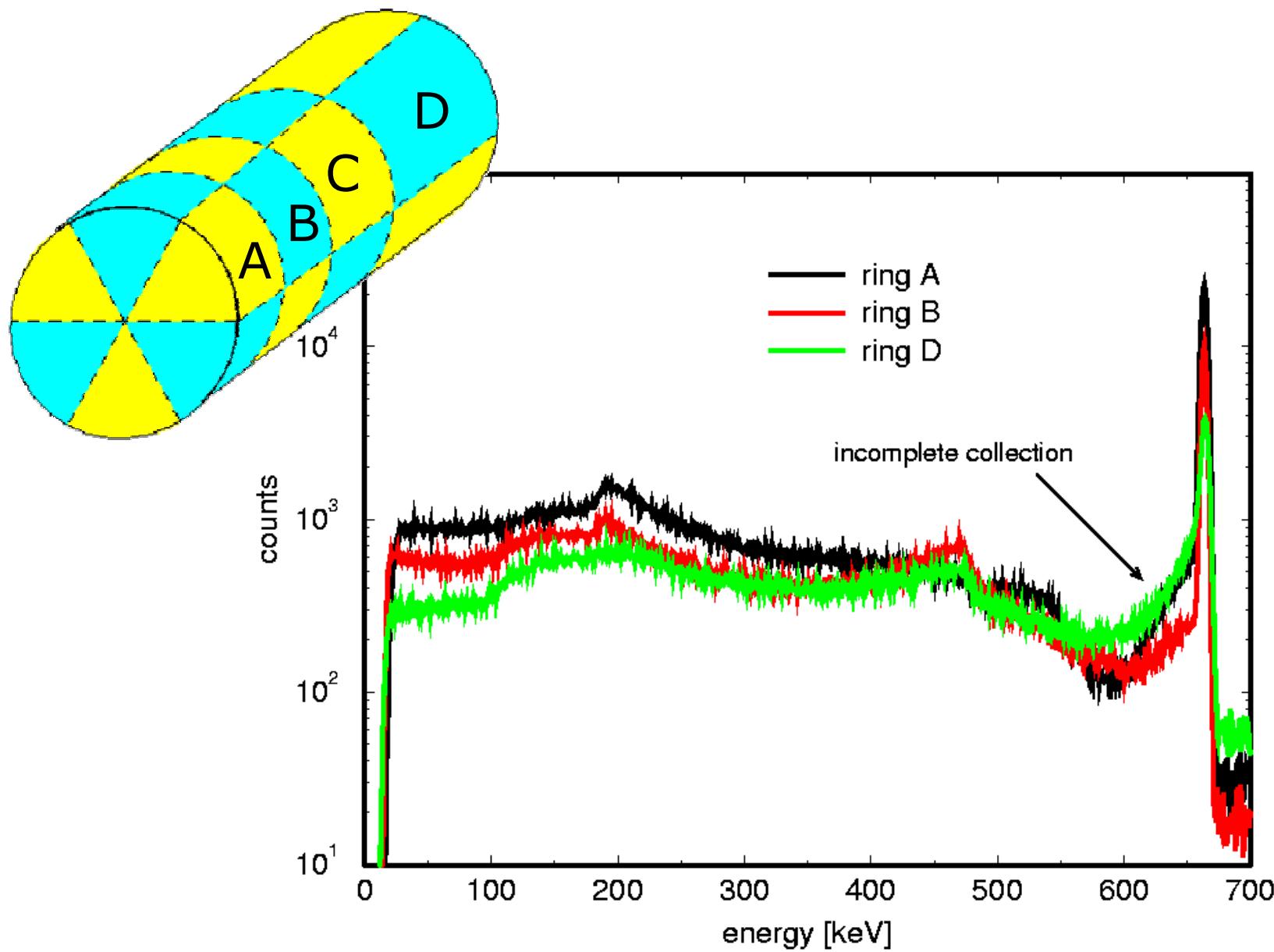


Detector Surface Scan

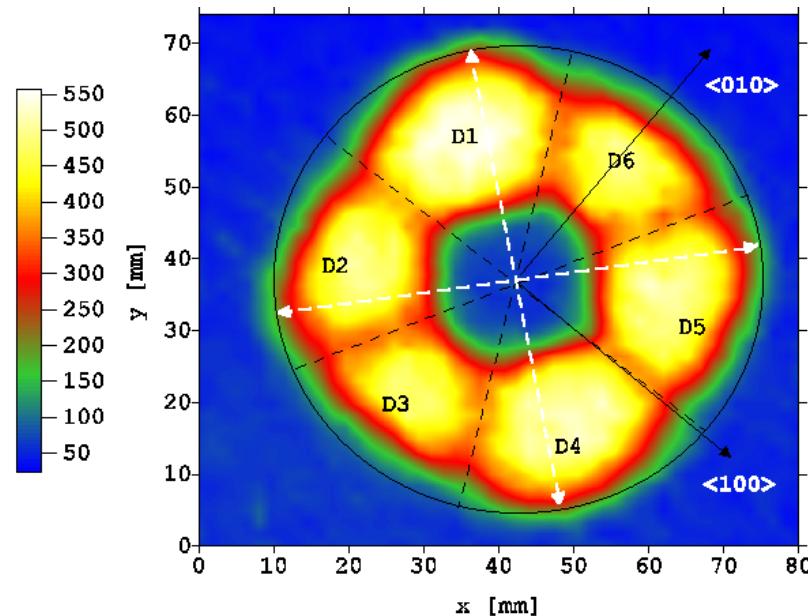
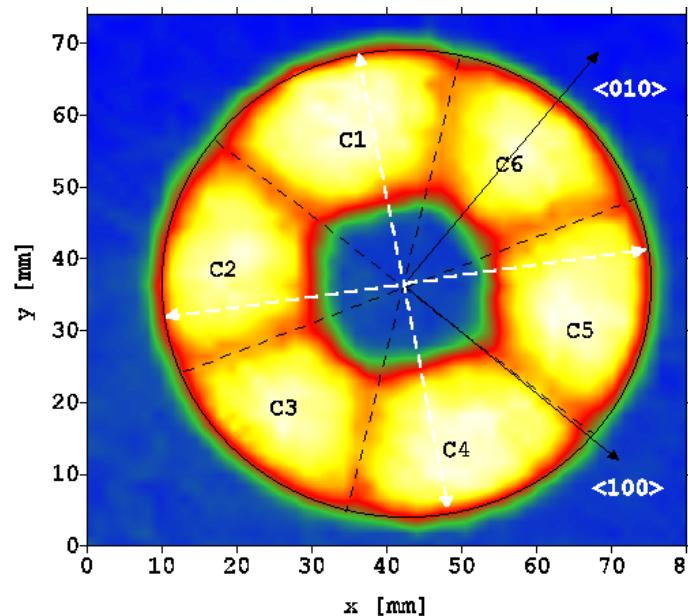
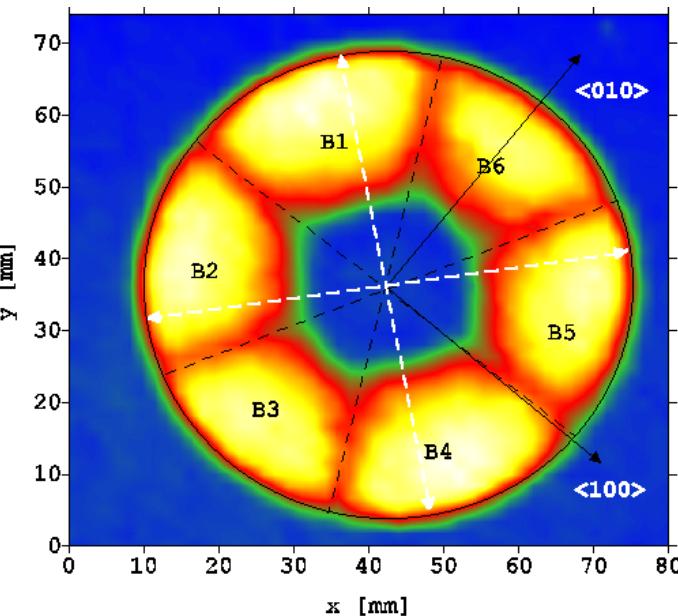
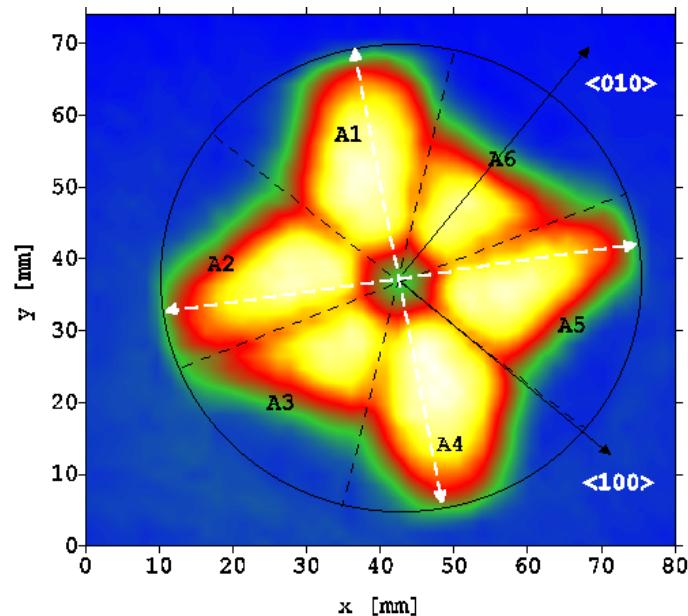


- Trigger on centre contact @ 662 keV
- Collimator width 2mm
- Scan step size 2mm
- Collect data for 5 minutes at each position
- 1681 positions, 5.85 days, 160Gb of data.

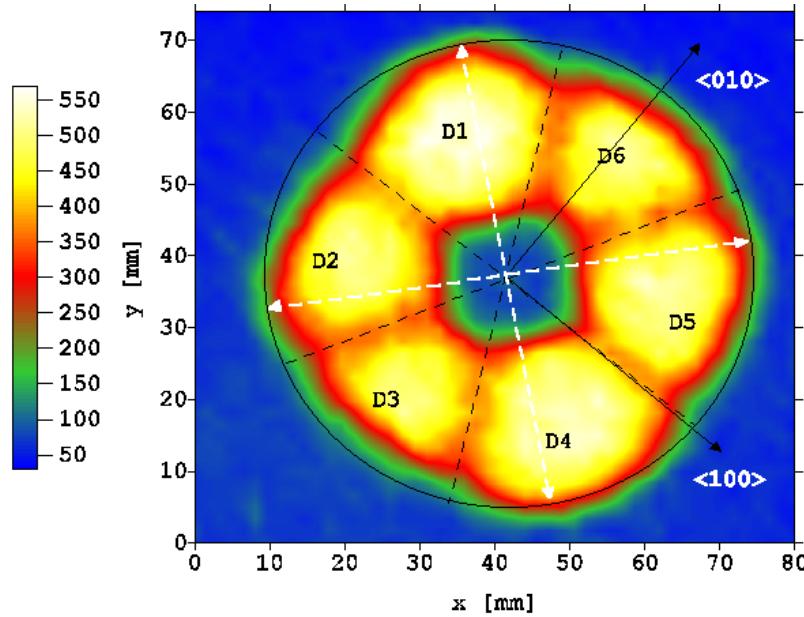
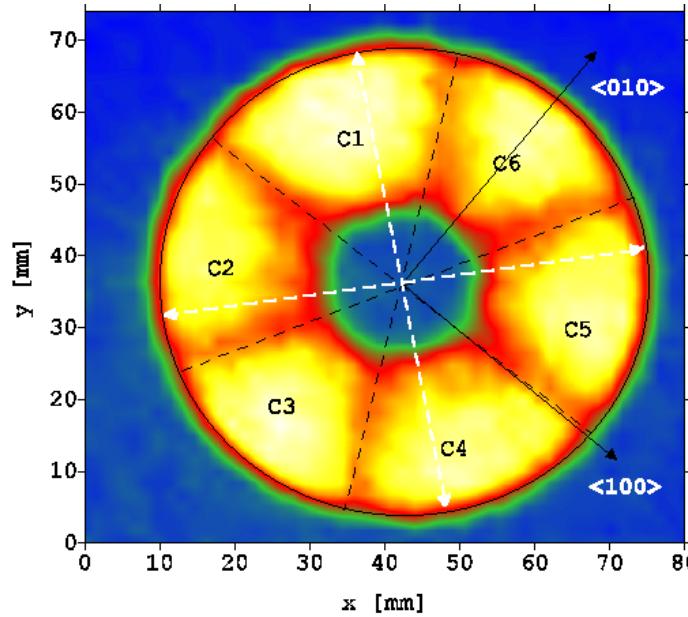
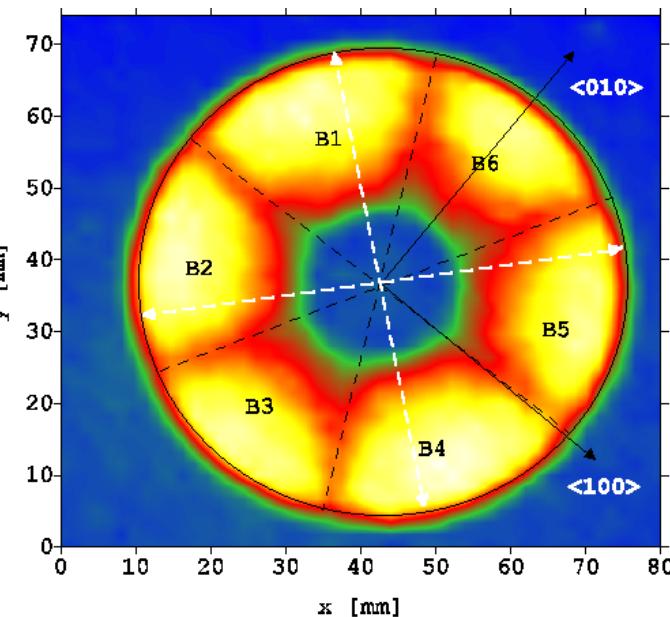
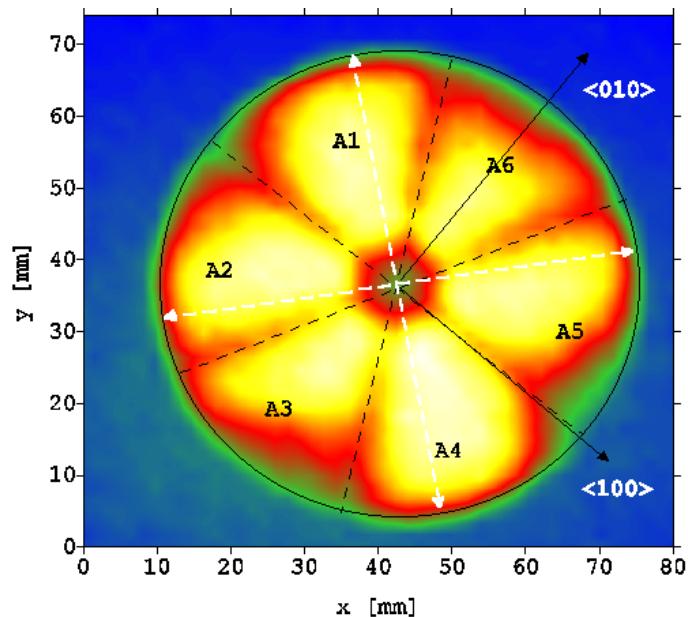
Detector Surface Scan



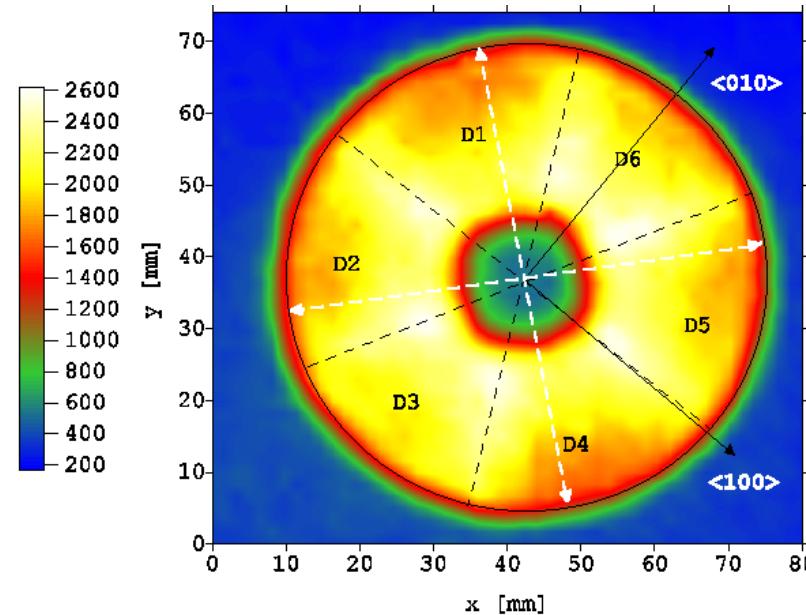
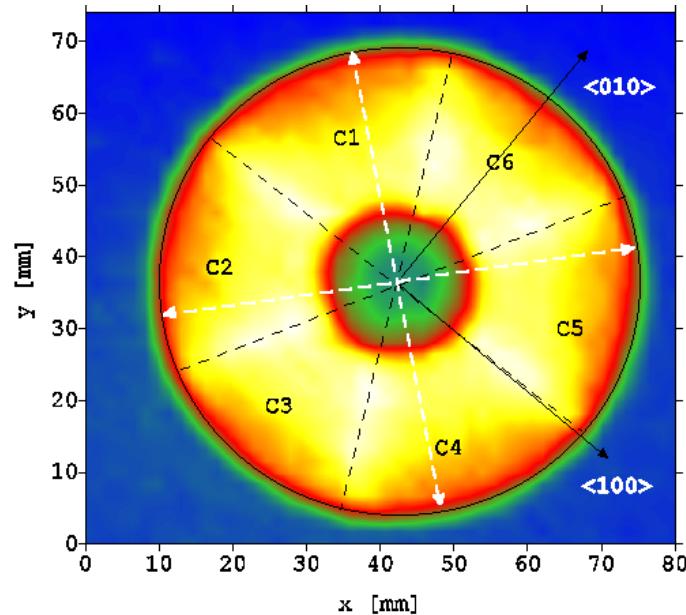
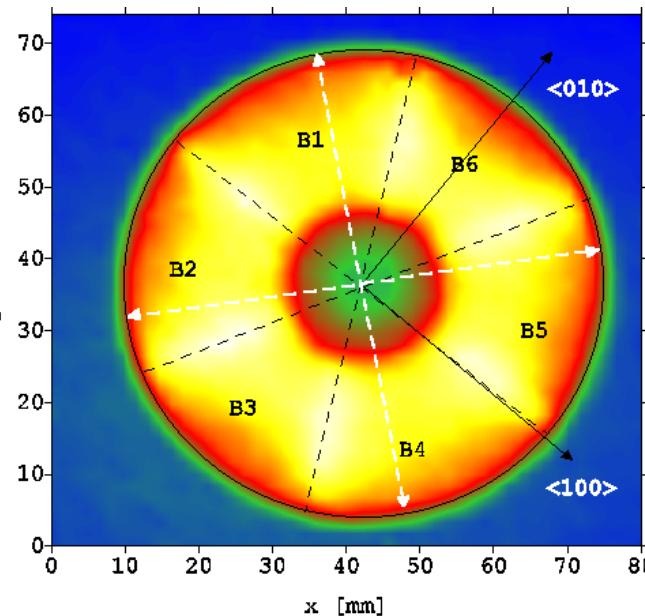
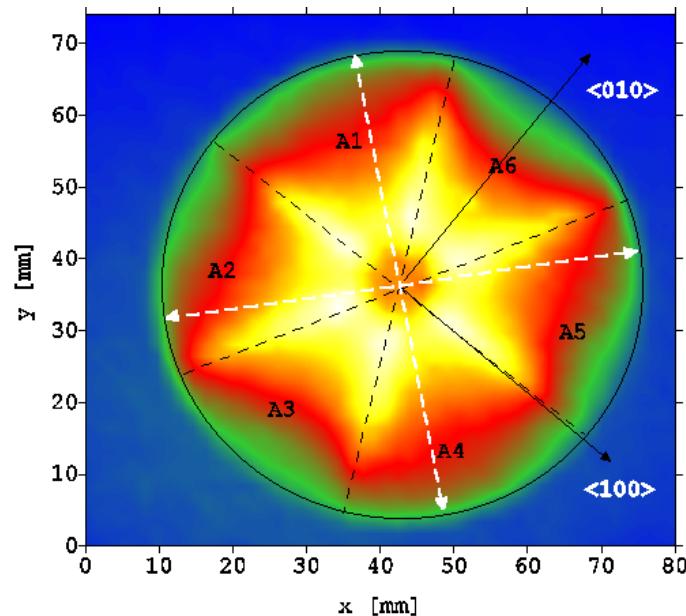
Intensity distribution: Narrow gate



Intensity distribution: Wide gate

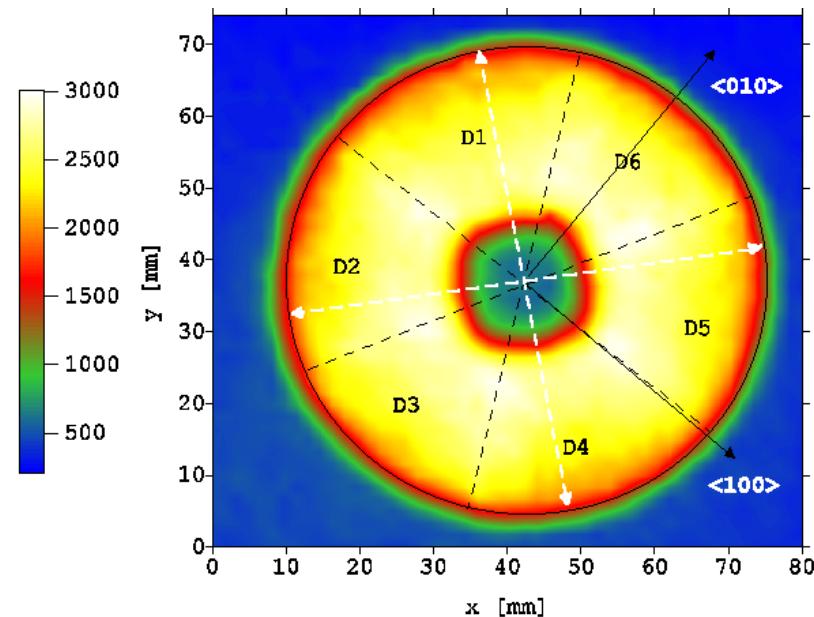
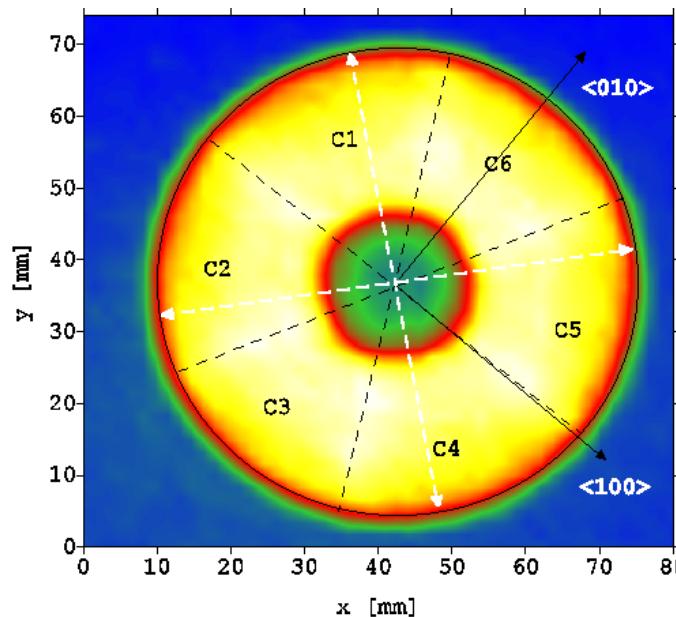
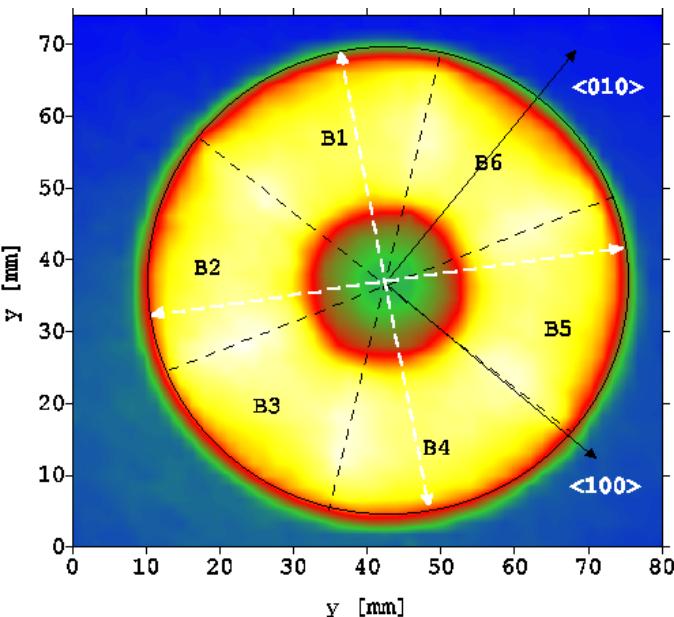
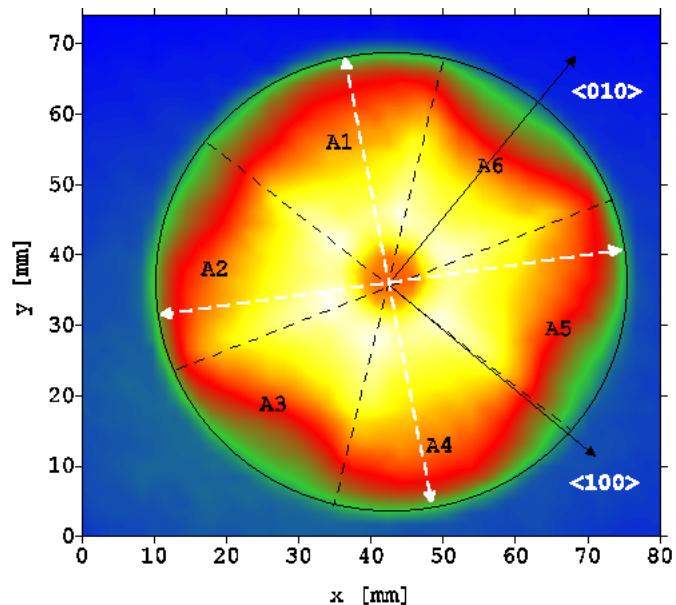


Intensity distribution: Compton



Detector Surface Scan

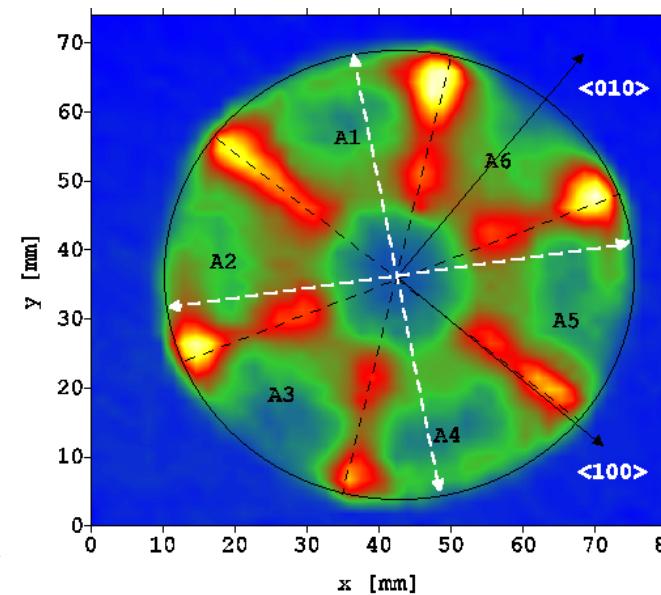
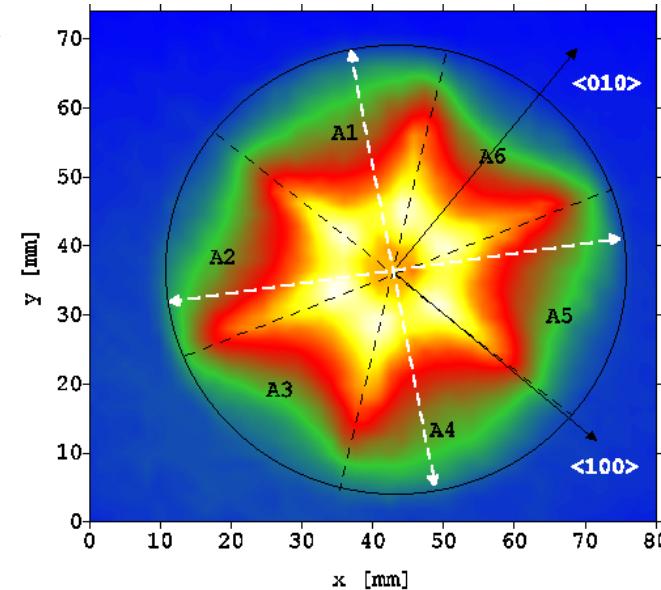
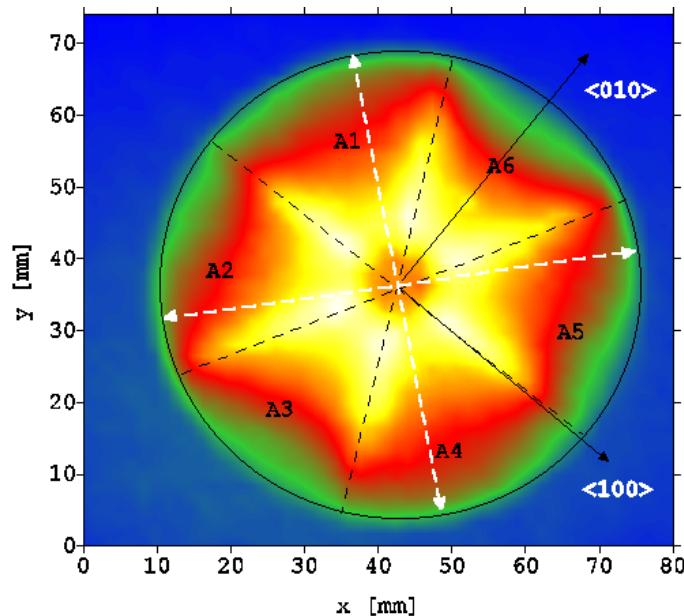
RIA : Advanced concepts in gamma-ray detection



Front Segment Analysis

Front →

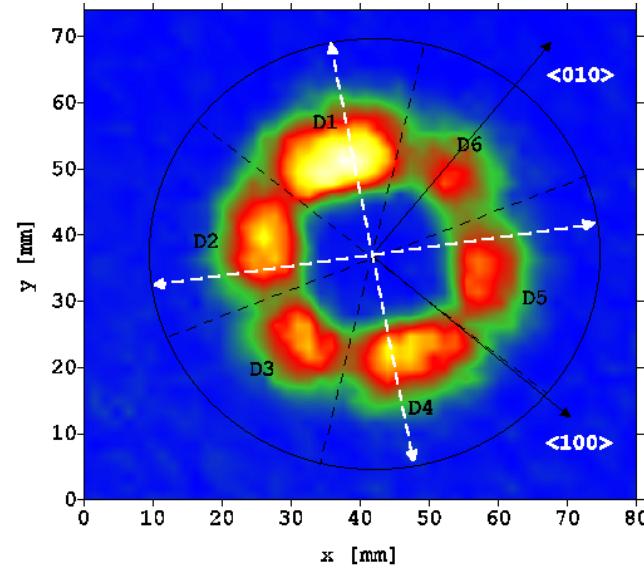
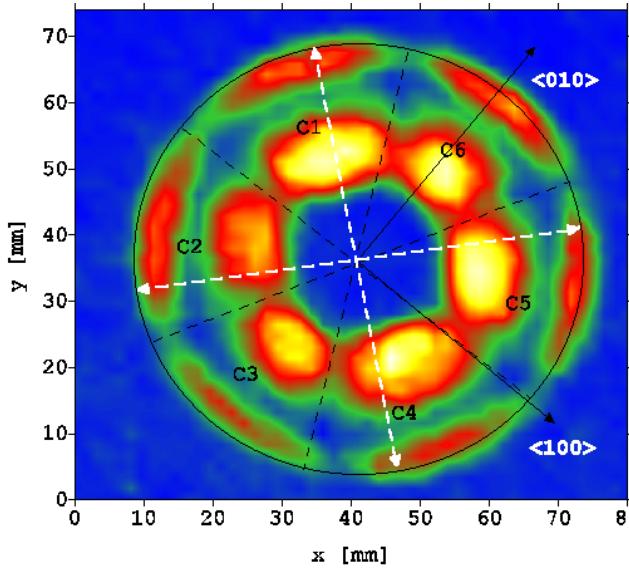
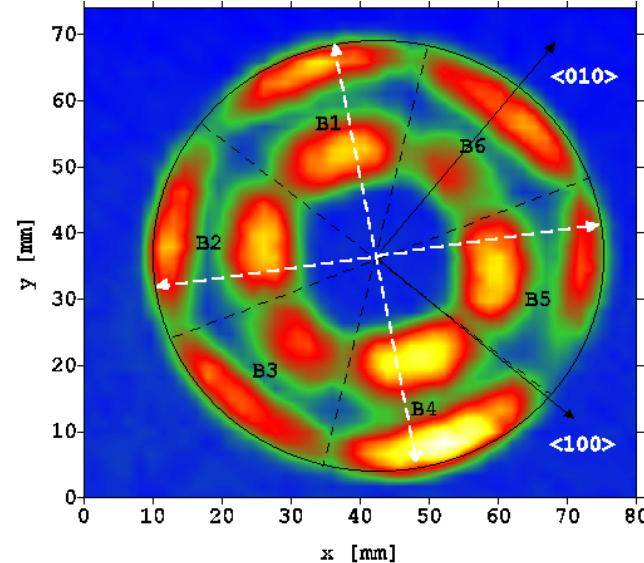
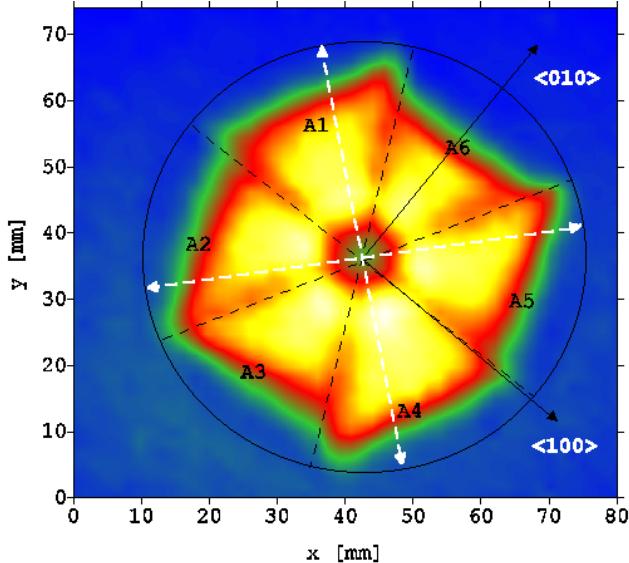
- Intensity distribution in front segment (preliminary).



Back →

- Image charge gate on interaction depth.

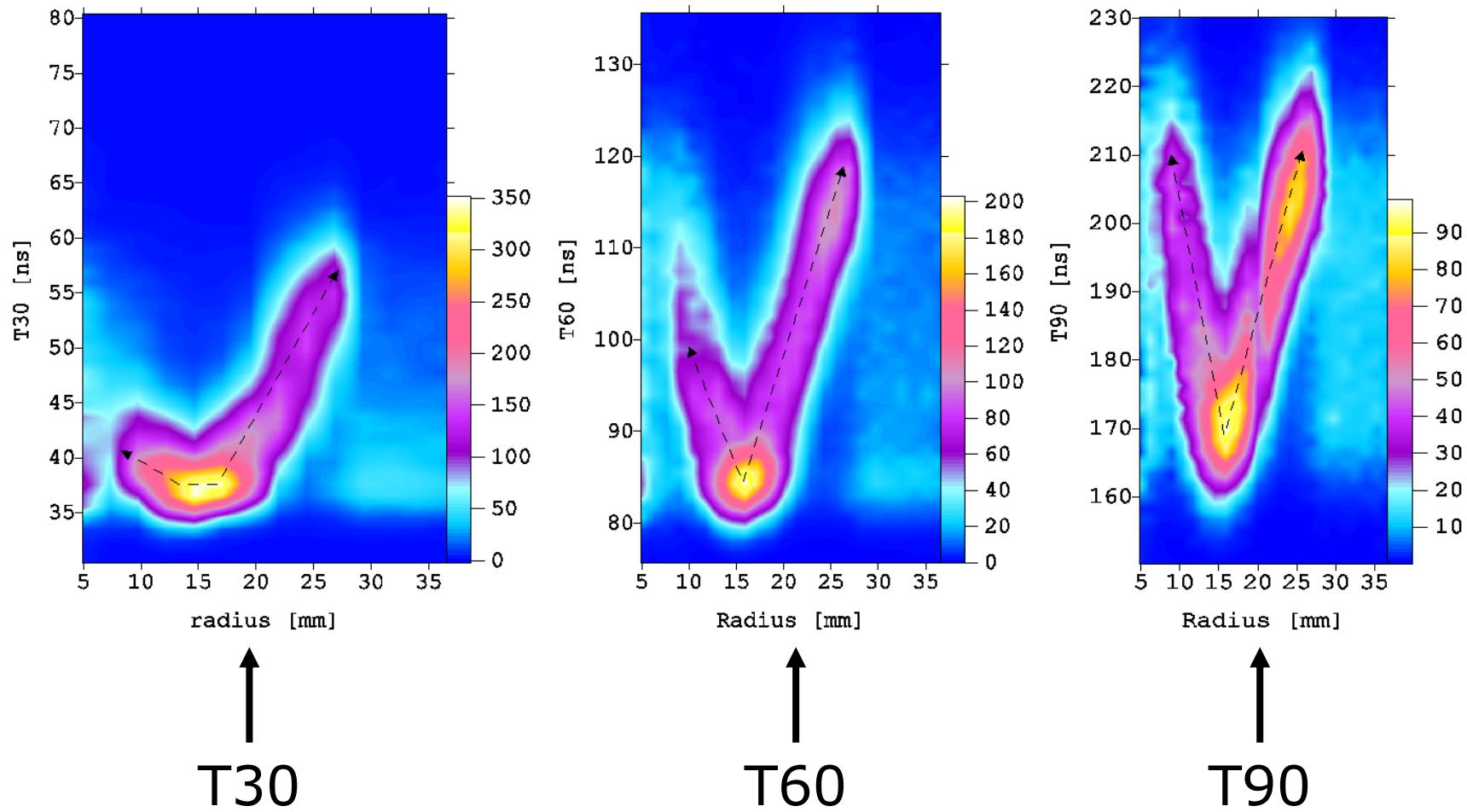
All Segment Analysis



RIA : Advanced concepts in gamma-ray detection

- Gated on adjacent z-image charge

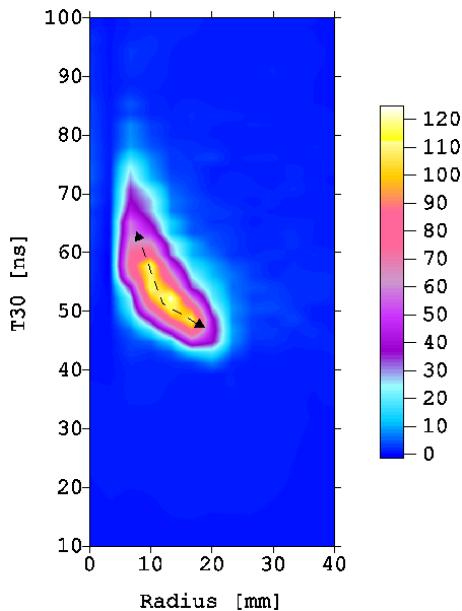
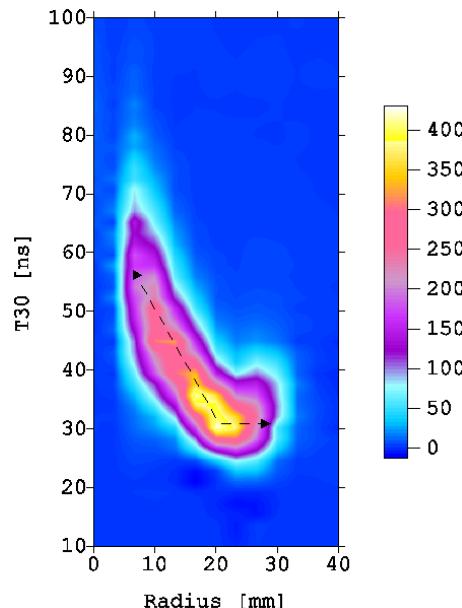
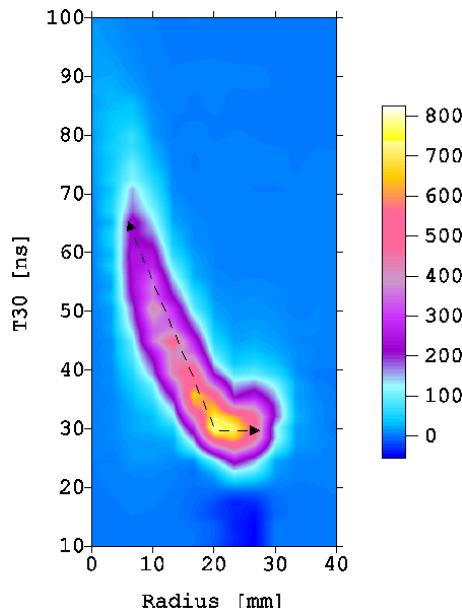
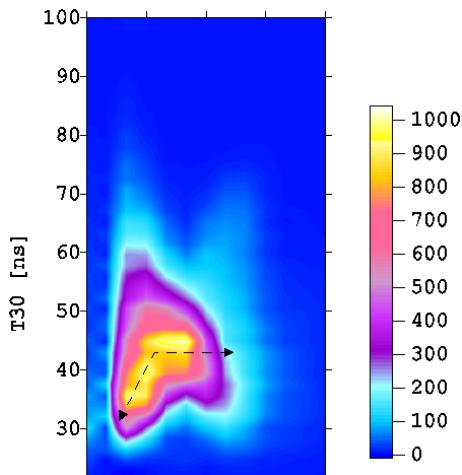
Rise Time Analysis



- Centre contact rise times as a function of radial interaction position.

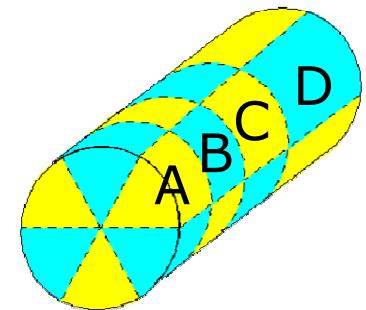
Rise Time Analysis

RIA : Advanced concepts in gamma-ray detection

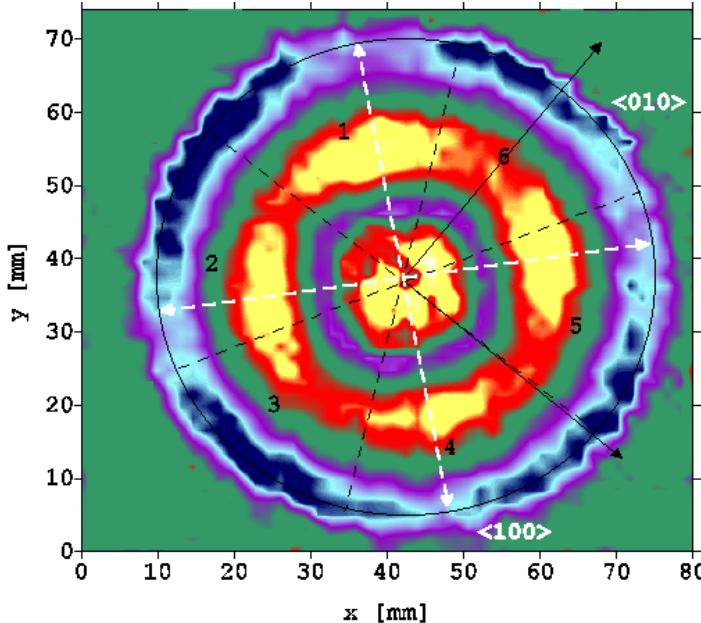
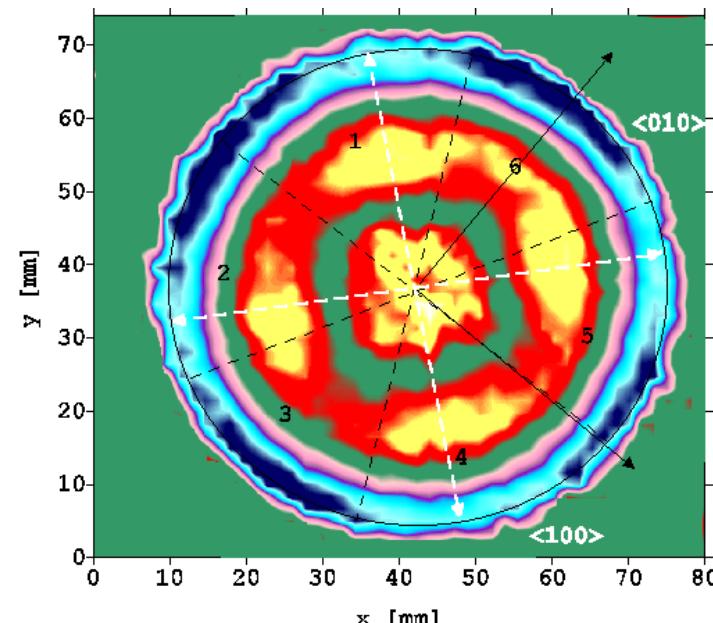
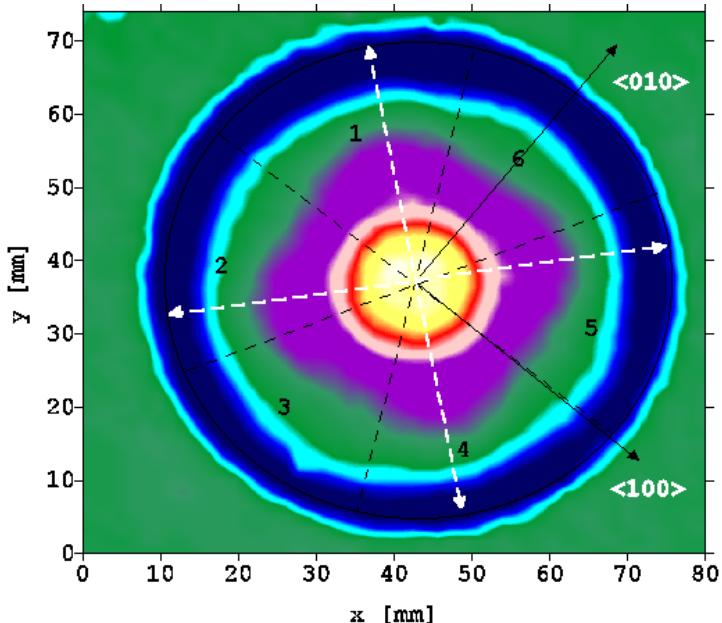


A
B
C
D

- Radius of interaction vs T30 on outer contacts for 662 keV interactions.



Rise Time Analysis



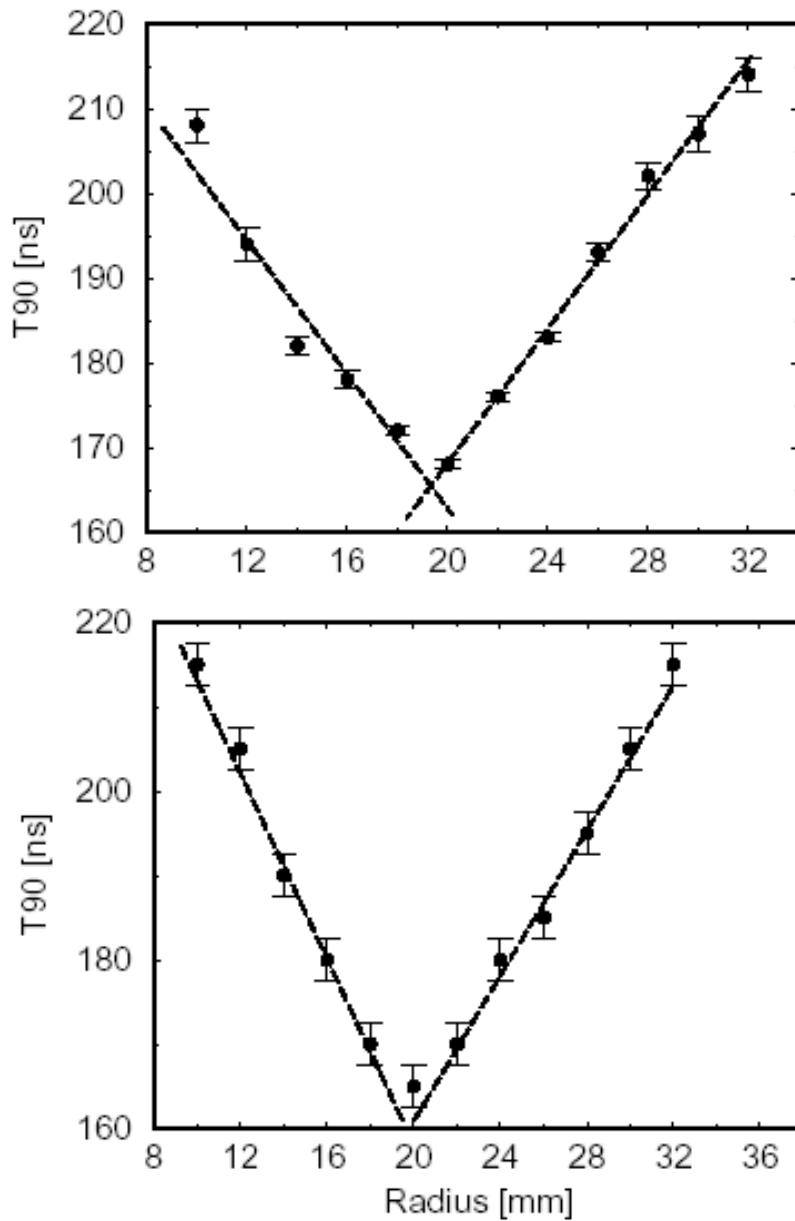
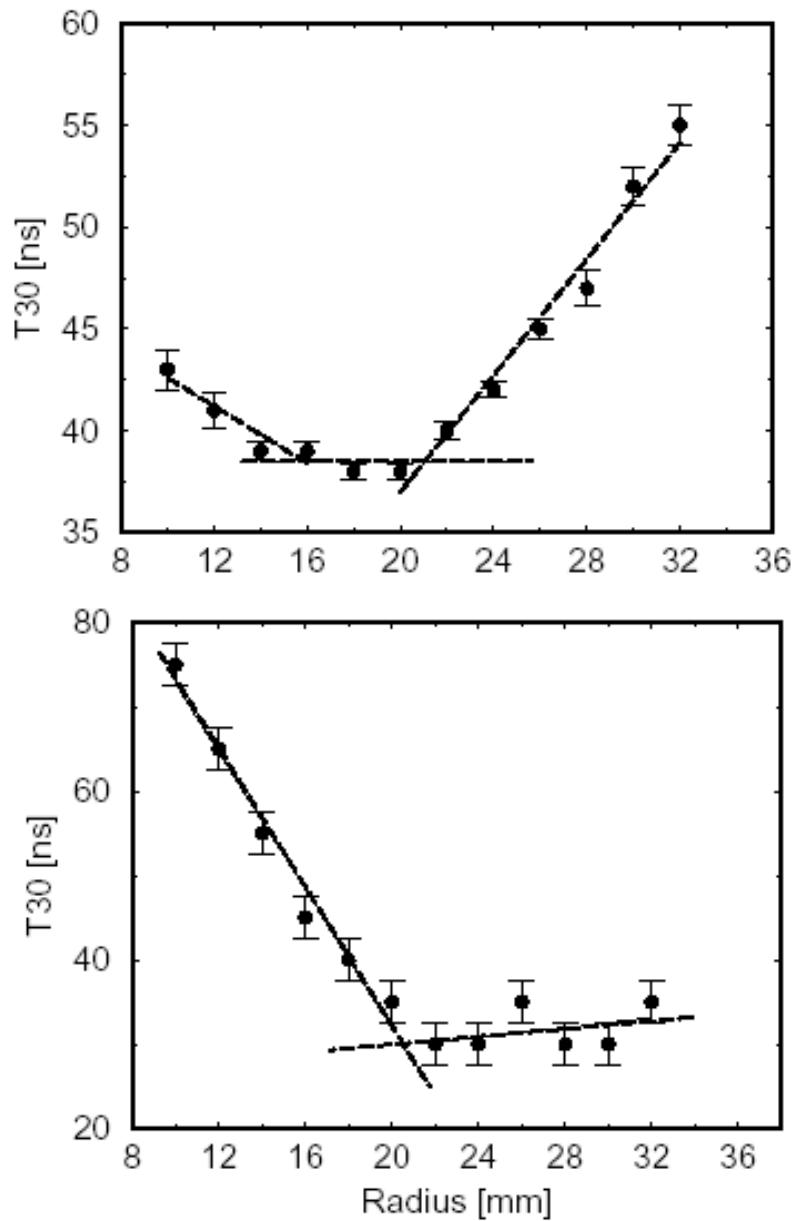
T30 T60

T90 →

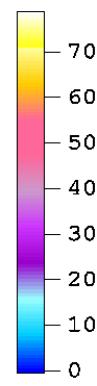
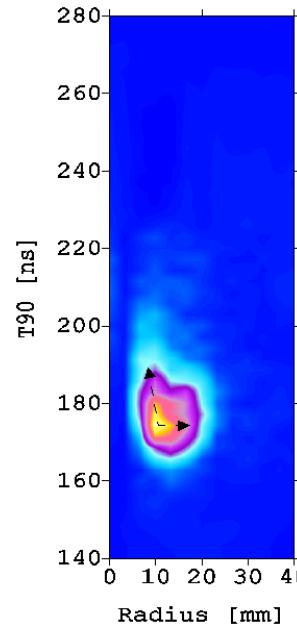
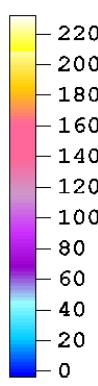
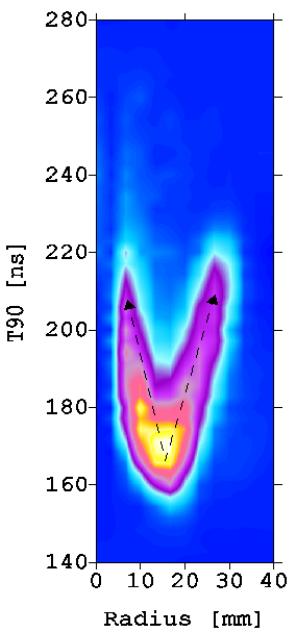
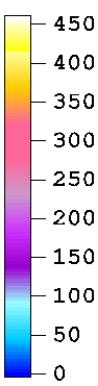
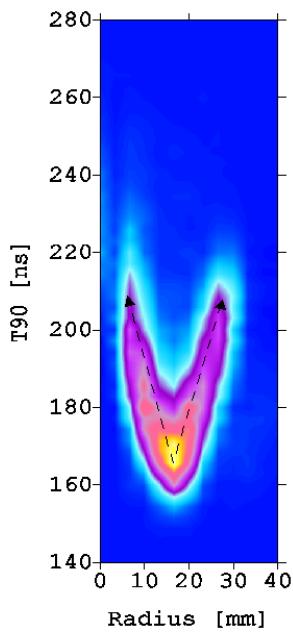
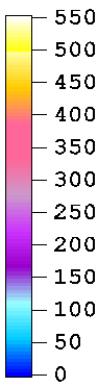
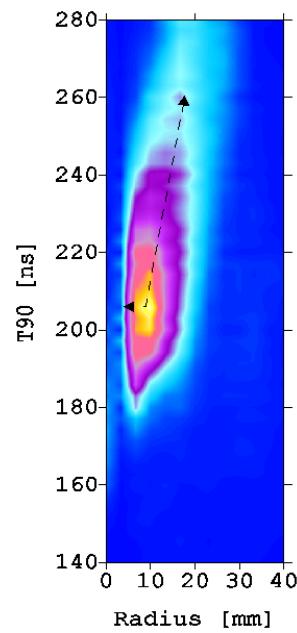
- Centre contact rise time results for 662keV interactions.

Risetime: Linear fits for radius

RIA : Advanced concepts in gamma-ray detection



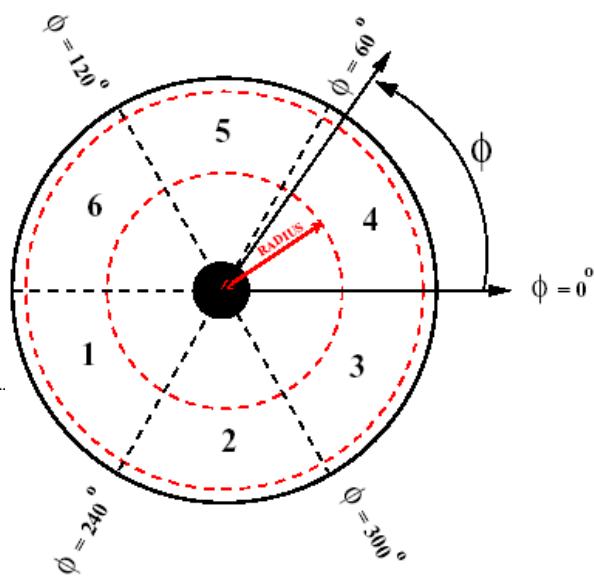
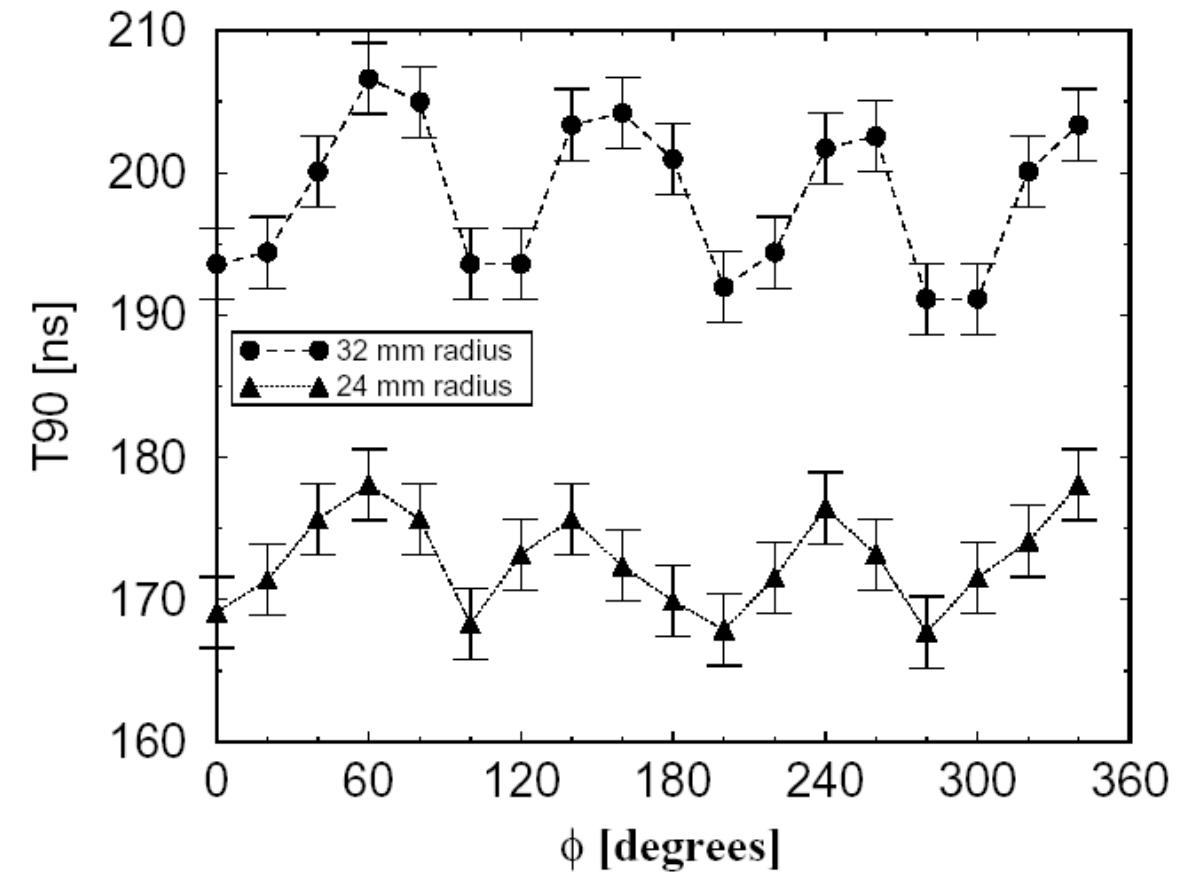
Rise Time Analysis



A
B
C
D

- Radius of interaction vs T90 on outer contacts for 662 keV interactions.

Risetime vs Azimuthal position



Mirror Charge Asymmetry Analysis

$$A = \frac{Q_l - Q_r}{Q_l + Q_r}$$

- Q_l and Q_r are magnitudes of mirror charge signal in the left and right neighbour.
- The asymmetry cancels out the radial contribution and yields information regarding the azimuthal position of the main interaction.

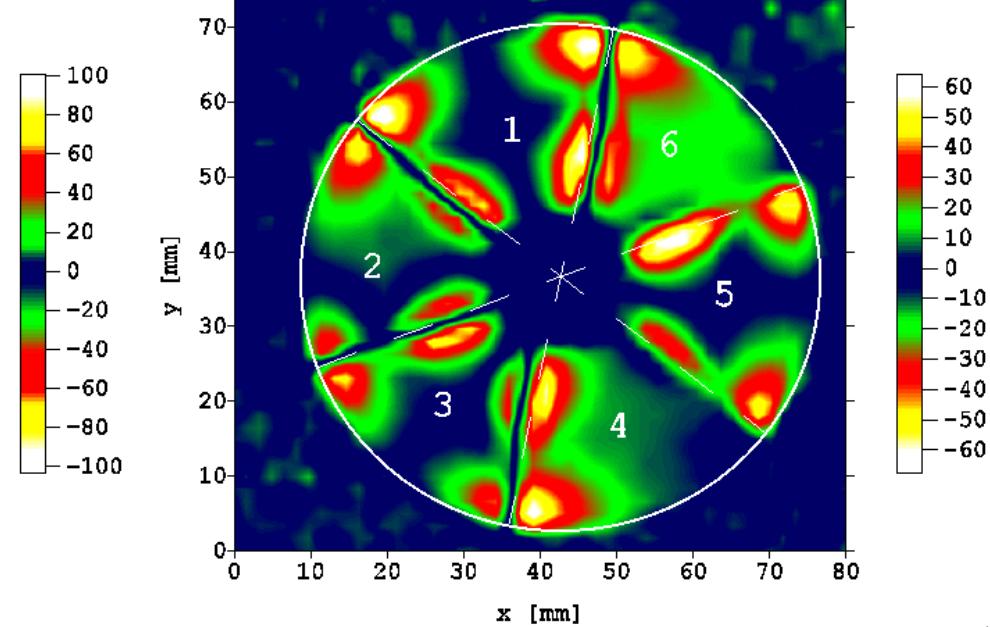
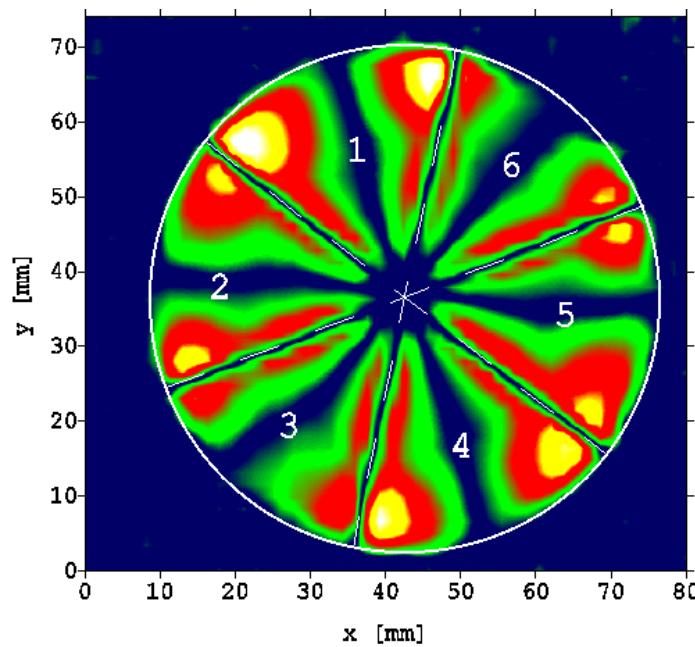
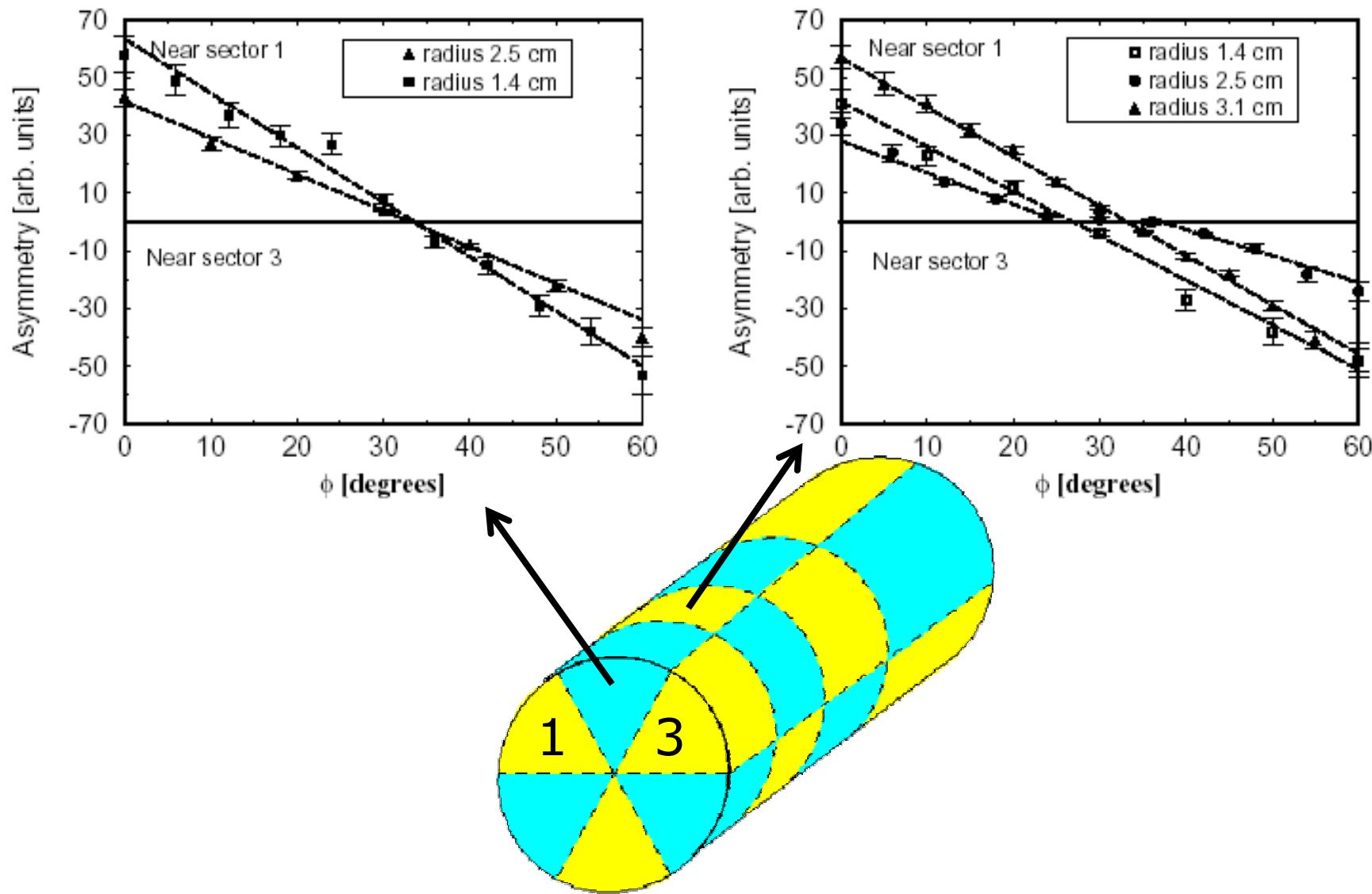
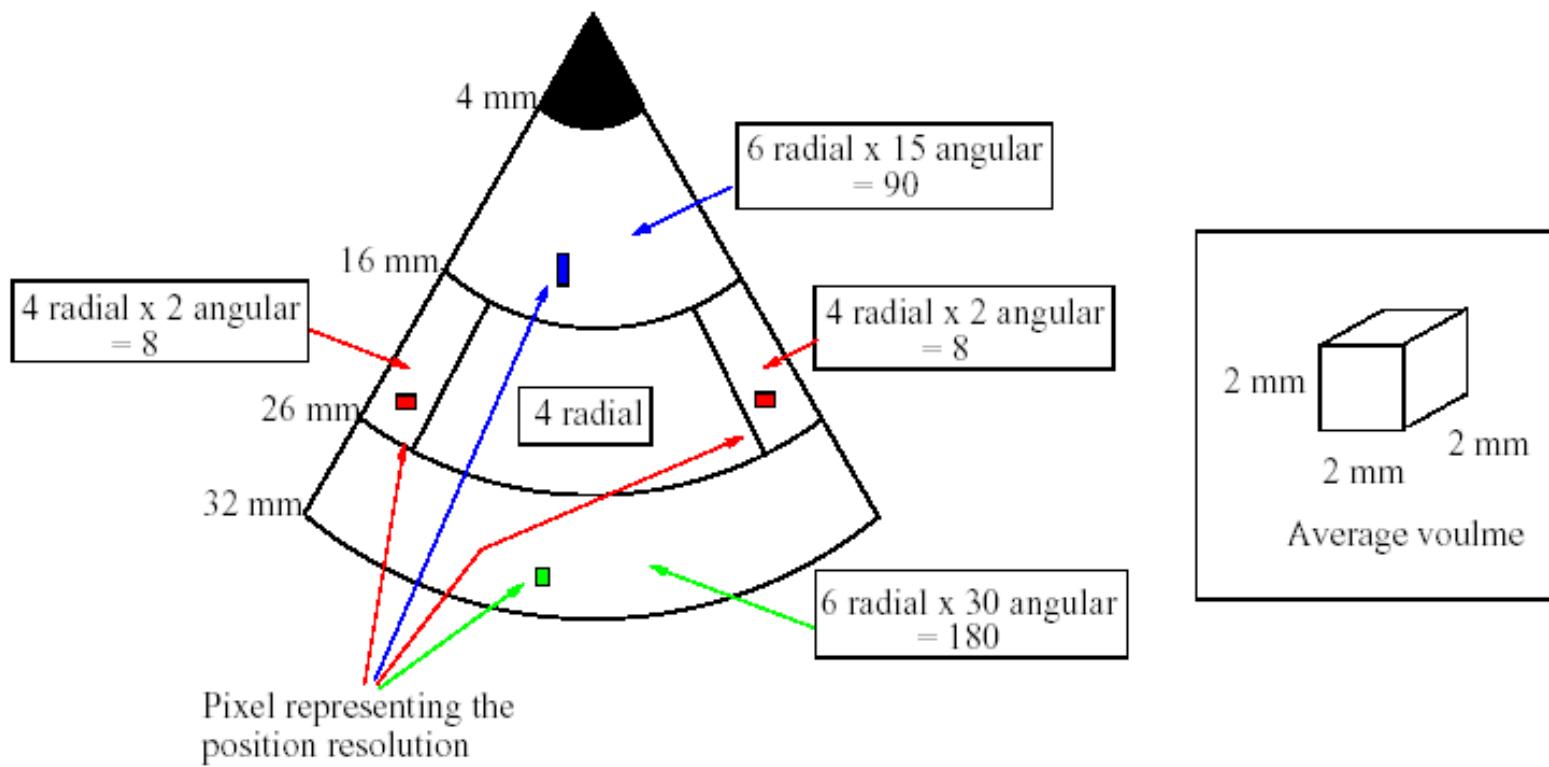


Image charge asymmetry results



What can be achieved?



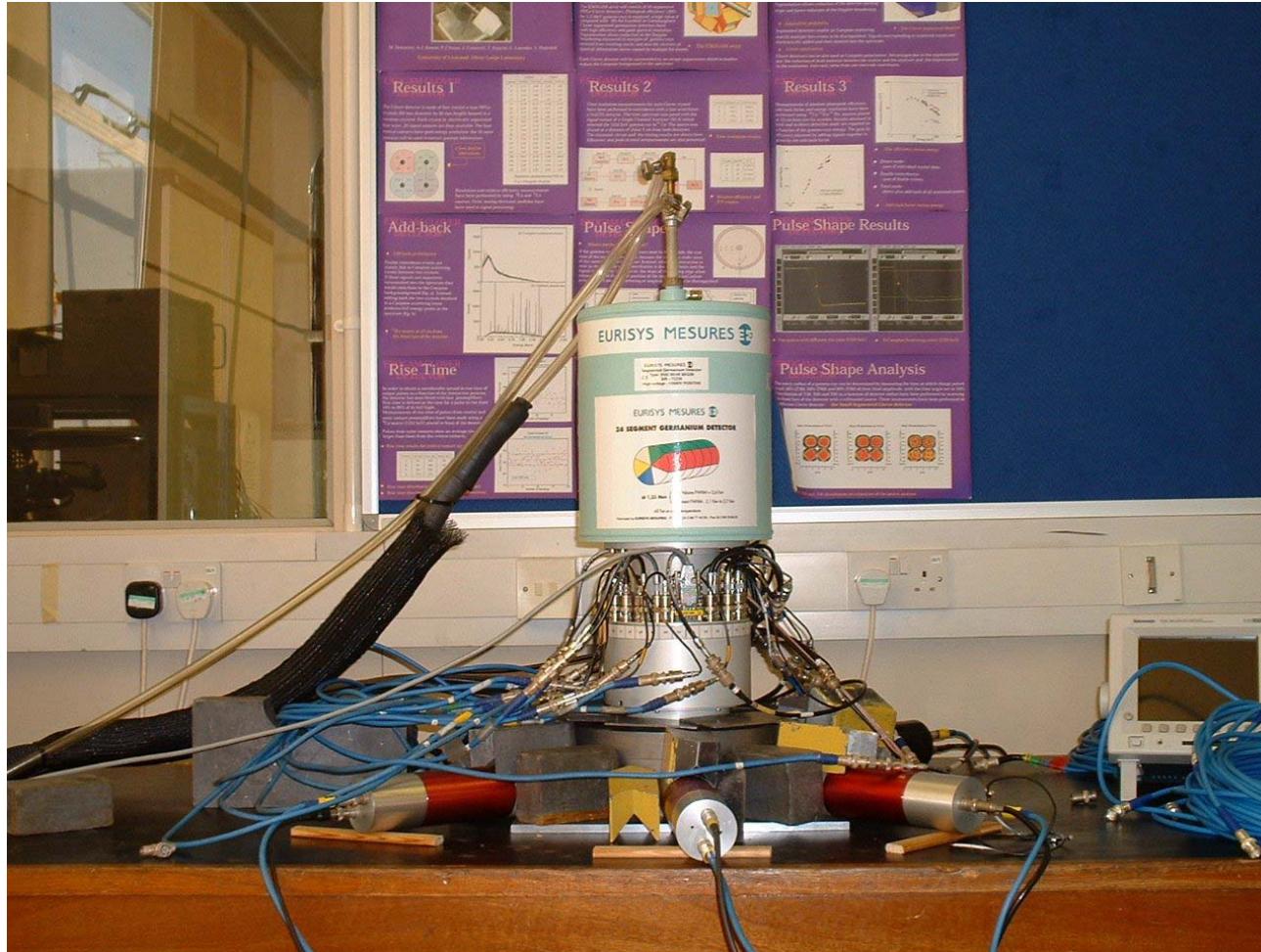
The Daresbury GRT4 VME Module

- 4 channel VME module
- Each channel:
 - 14 bit 80Mhz FADC
 - Two dedicated Xilinx Spartan 2 FPGAs
 - First contains circular buffer, traces in this buffer are tagged with 16 bit header and 48 bit timestamp.
 - Differentiated or non-differentiated configuration.
- Trigger in/out and gate in.
- MIDAS user interface to control card and write to tape.

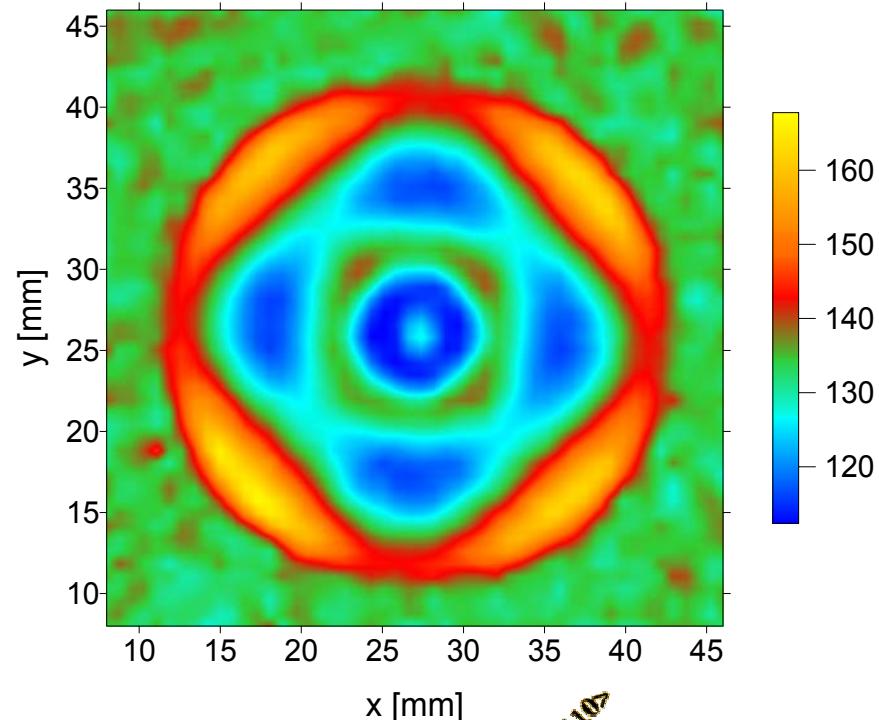
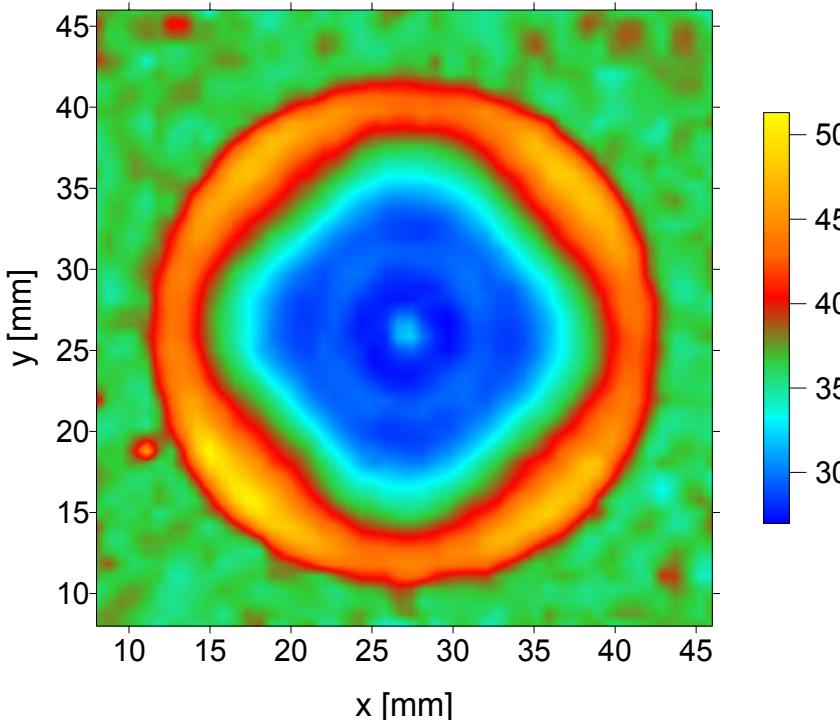


Eurisys Mesures 6x6 Segmented Detector

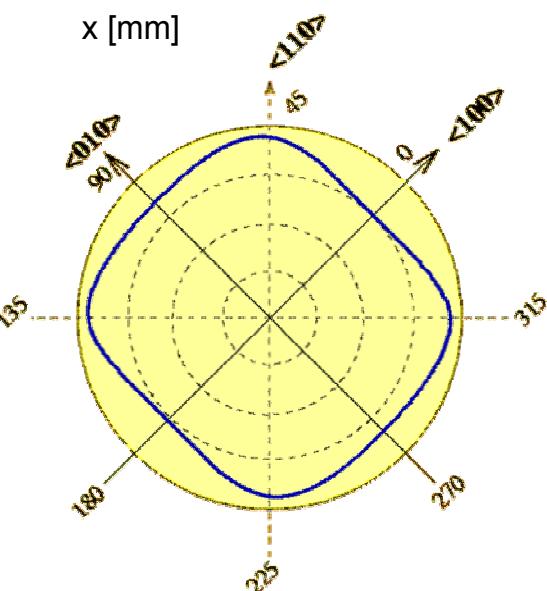
RIA : Advanced concepts in gamma-ray detection



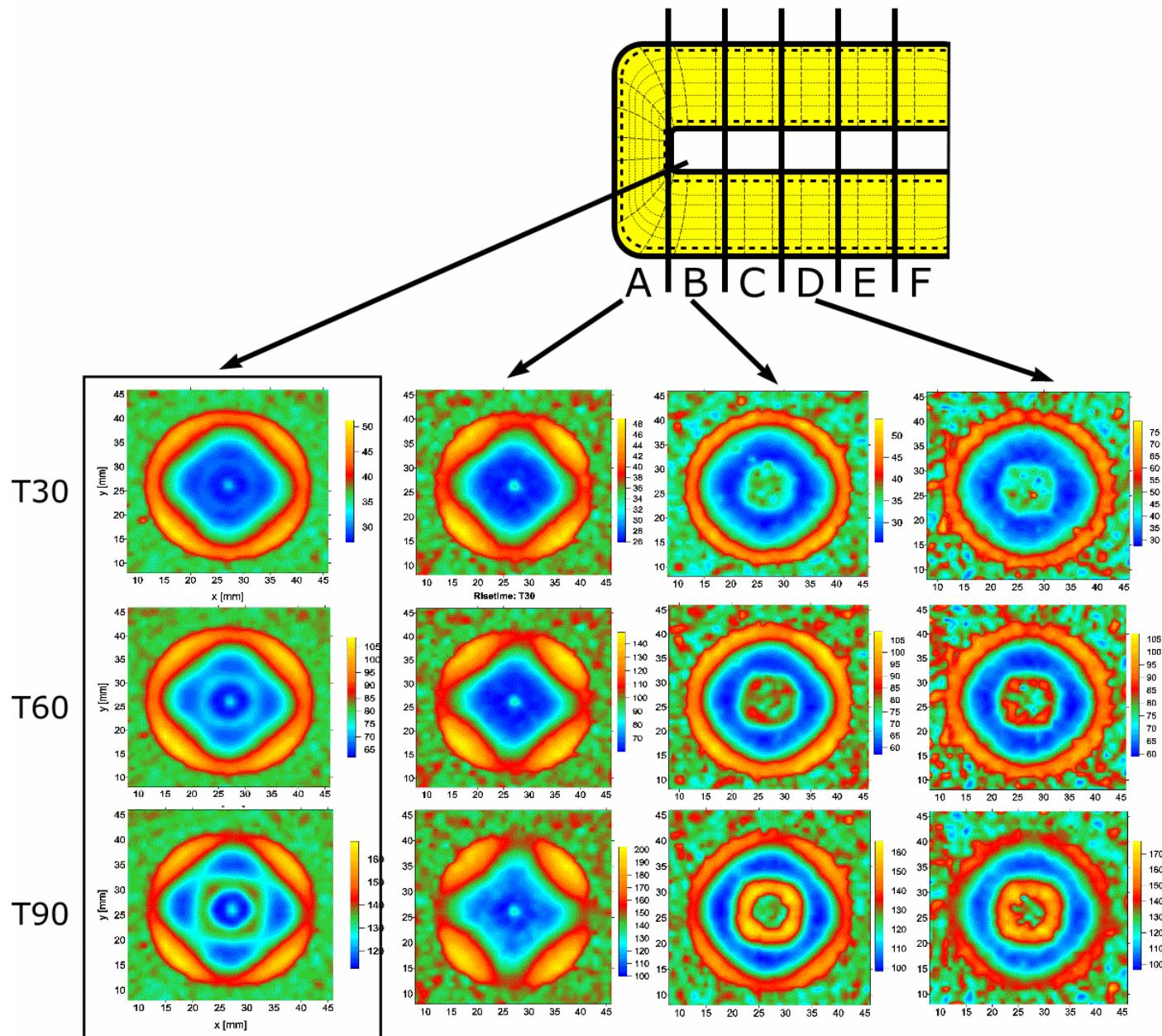
Rise Time Analysis



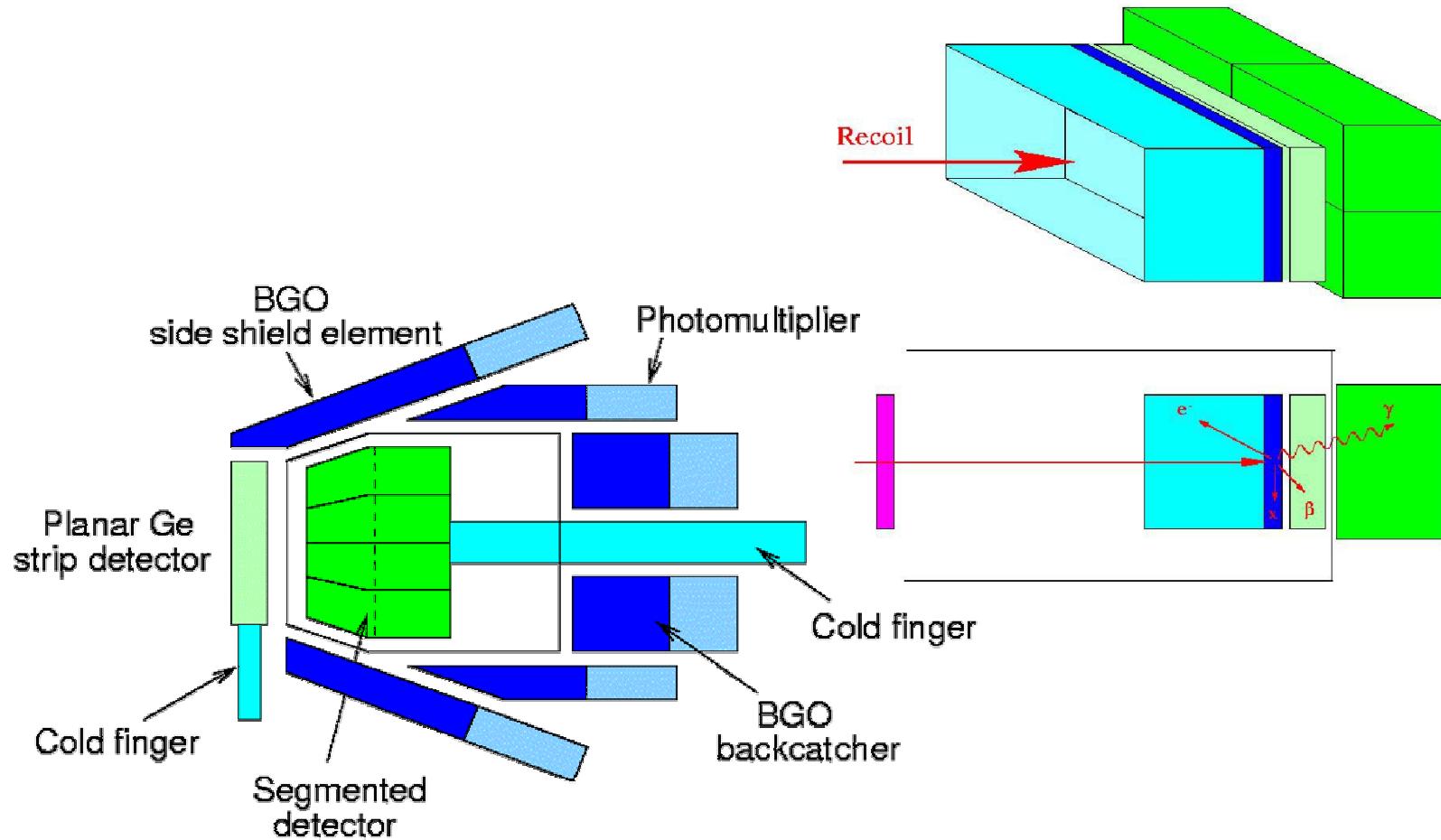
- Response to interactions from 662 keV gamma-ray photons at different positions on the front face of a coaxial germanium detector.



6x6 Risetime Analysis



GREAT detector configuration

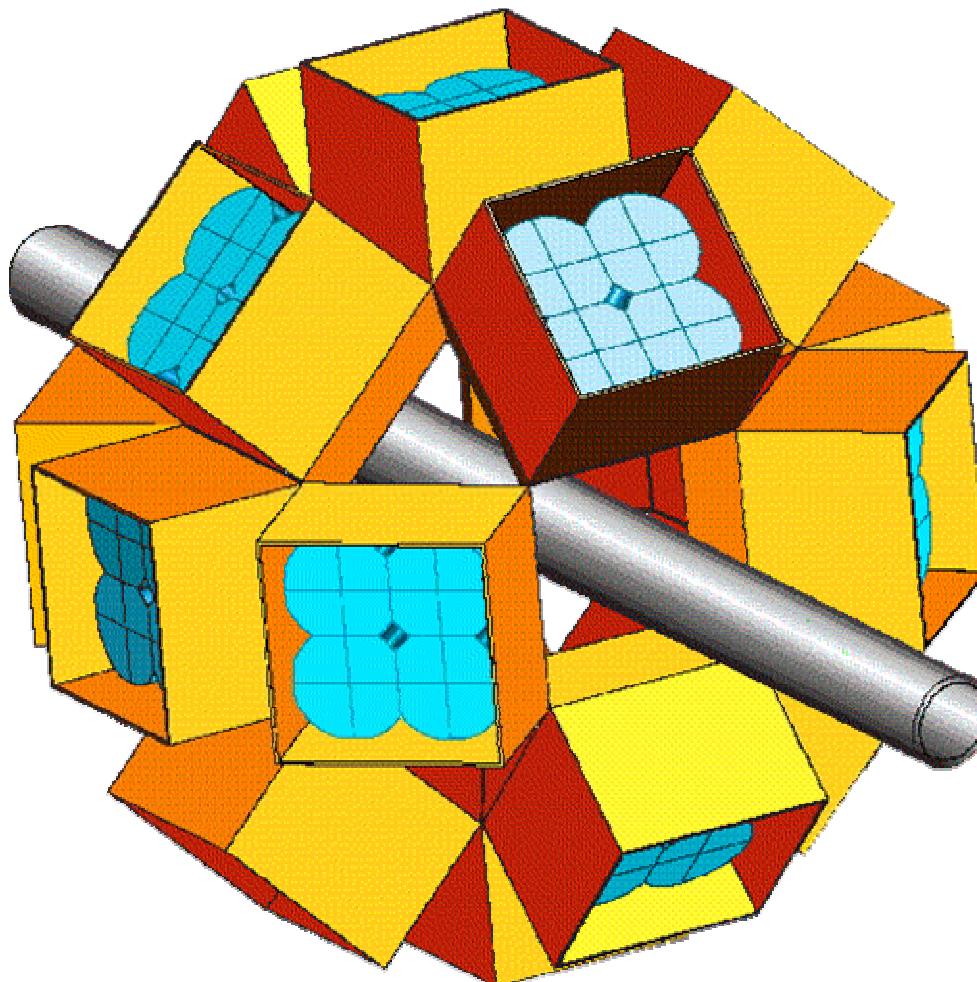


- Planar germanium crystal 24x12 way segmentation of 12cm x 6cm crystal.
- Large Clover Germanium detector

Cologne Experiment

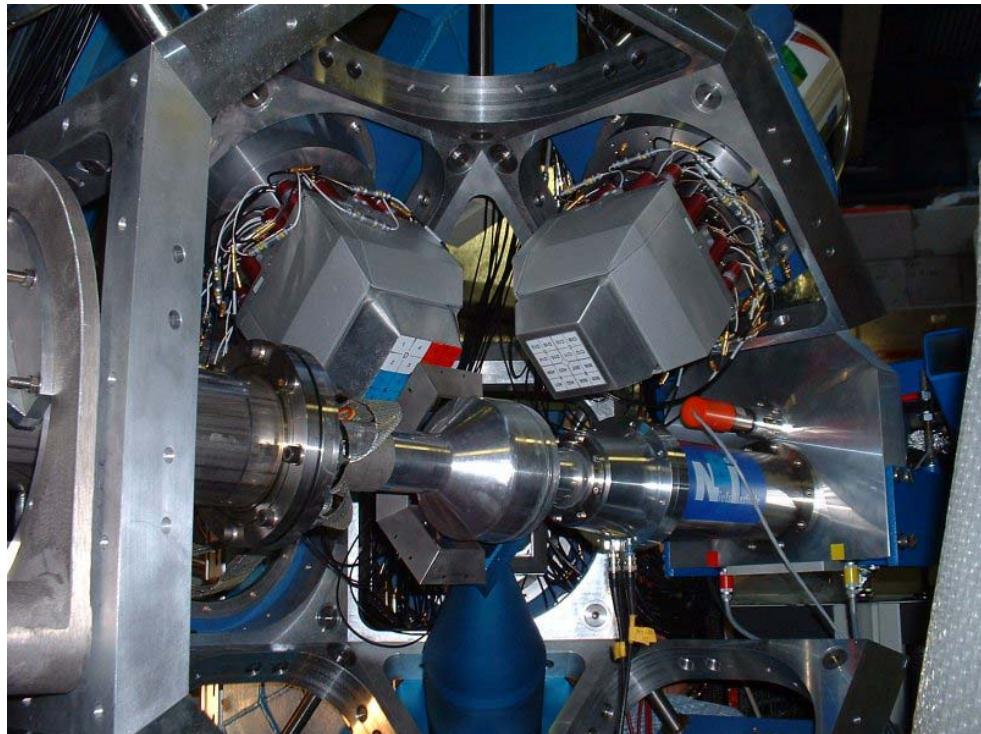
- February 2003
- Cologne Tandem accelerator beam @70MeV.
- Pickup reaction in inverse kinematics
- $^{37}\text{Cl} + \text{D} \rightarrow ^{38}\text{Cl} + \text{p}$
- $^{37}\text{Cl} + \text{D} \rightarrow ^{38}\text{Ar} + \text{n}$
- Deuterated Ti-foil $500\mu\text{g}/\text{cm}^2$.
- v/c $\sim 6\%$
- Aim 2167keV transition in ^{38}Ar
- There is also population of this level following the β -decay of ^{38}Cl produced in same reaction. – stopped \rightarrow gives intrinsic resolution.
- Angular spread of recoiling nuclei $\sim 7.8\text{keV}$ best.

The EXOGAM Project

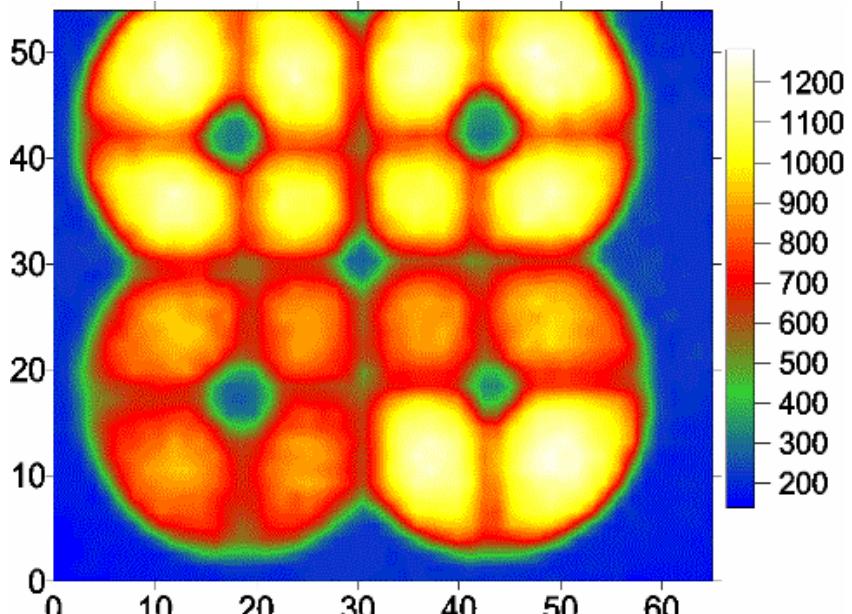
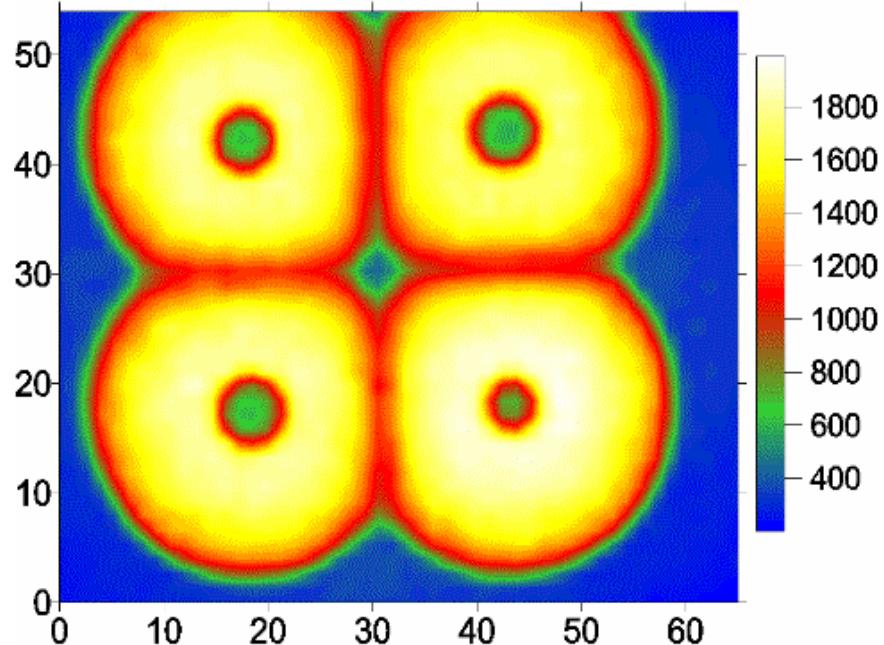


- 16 Segmented Clover detectors with modular BGO Suppression shields

The EXOGAM Project



Centre contact intensity

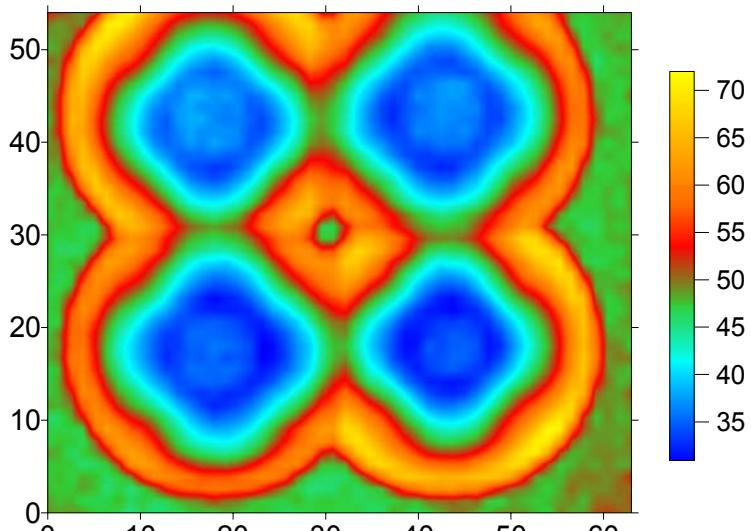


Outer contact intensity

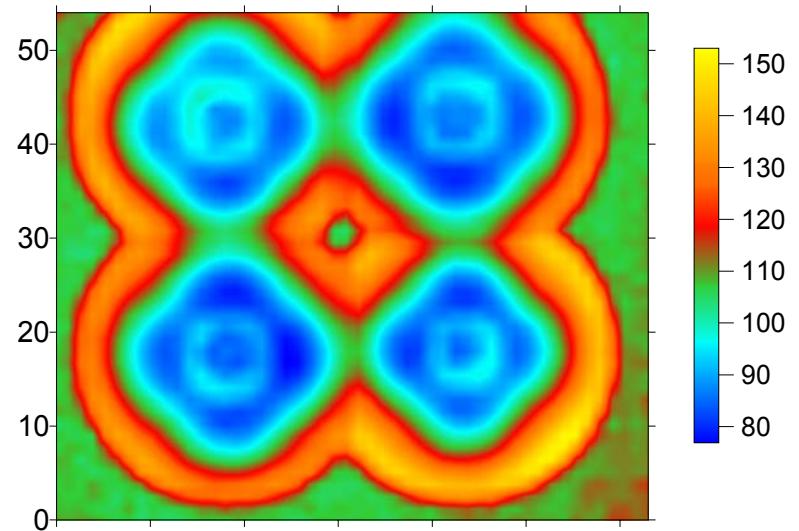
- Number of 662keV photons detected as a function interaction position. For (a) Centre and (b) Outer contacts.

EXOGAM Scan

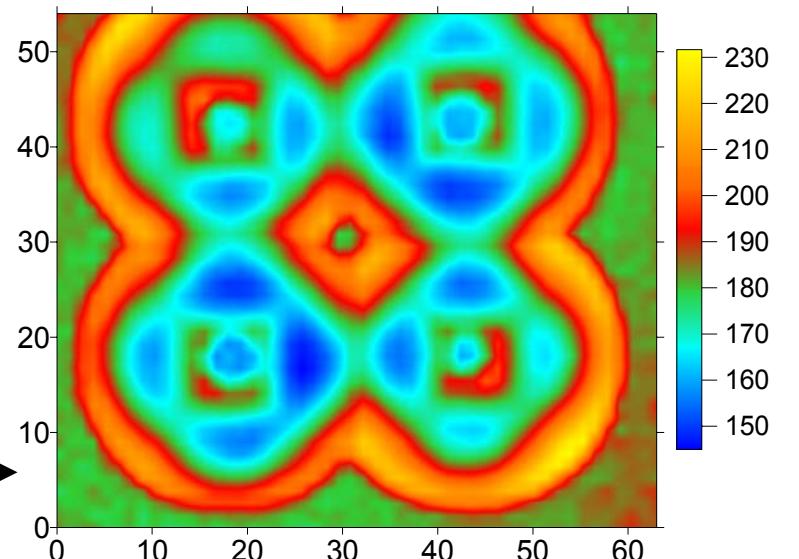
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T30



T60

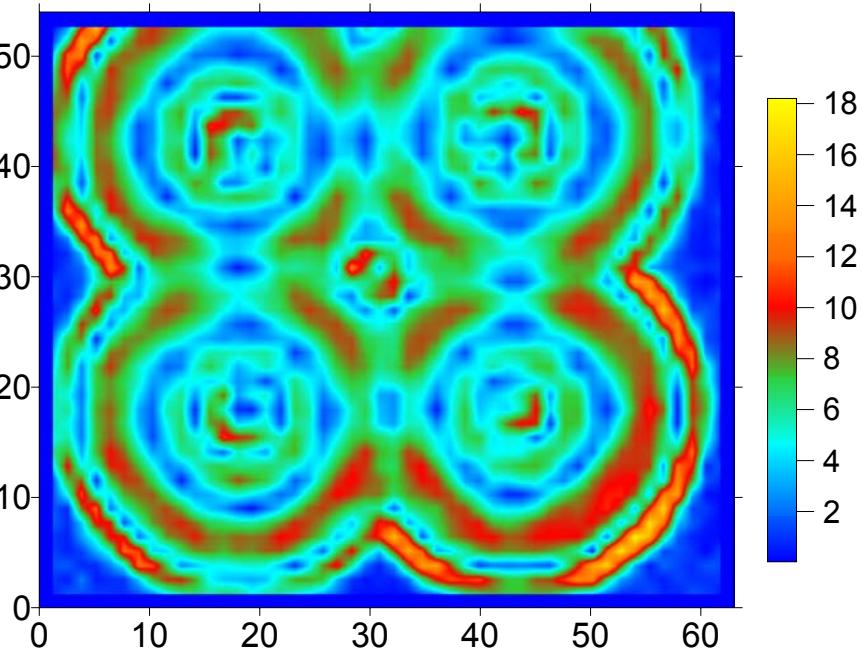
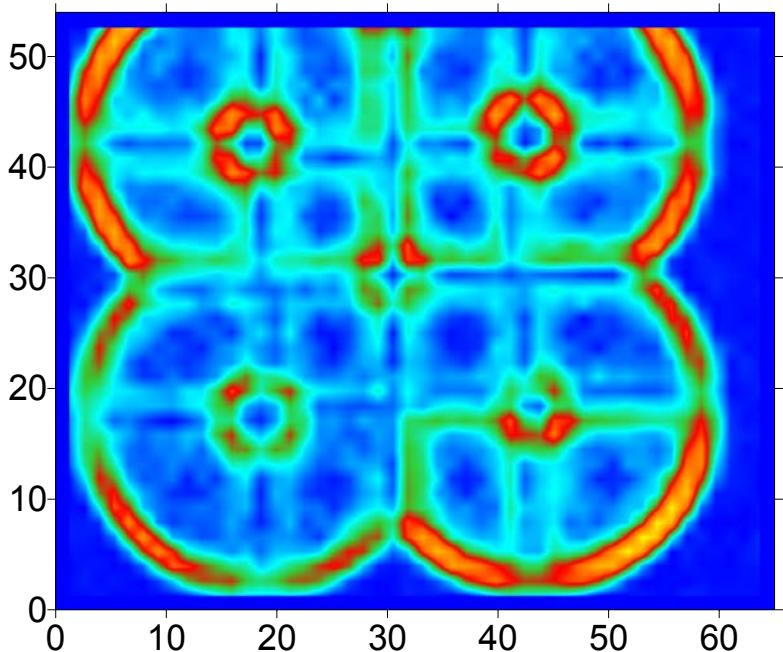


T90

- Centre contact rise time results for 662keV interactions.

EXOGAM Scan

RIA : Advanced concepts in gamma-ray detection



- The rate of change of intensity and risetime.