Detector Characterisation in Europe

THE UNIVERSITY of LIVERPOOL


AGATA


* Now at LBNL
Detector Characterisation

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

Precise position calibration

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 µm 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

RIA: Advanced concepts in gamma-ray detection

Detector Surface Scan

Counts vs. Energy (keV)

- Black: Ring A
- Red: Ring B
- Green: Ring D

Incomplete collection

Graph showing energy distribution and counts for different rings.
Intensity distribution: Narrow gate
Intensity distribution: Wide gate
Intensity distribution: Compton
Front Segment Analysis

Front

- Intensity distribution in front segment (preliminary).

- Image charge gate on interaction depth.

Back
• Gated on adjacent z-image charge
• Centre contact rise times as a function of radial interaction position.
Rise Time Analysis

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

- Centre contact rise time results for 662keV interactions.
Risetime: Linear fits for radius

![Graphs showing risetime vs. radius](image)
Rise Time Analysis

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

A → B → C → D
Risetime vs Azimuthal position

![Graph showing risetime vs azimuthal position with data points for 32 mm and 24 mm radius](image)

- **T90 [ns]**
  - 210
  - 200
  - 190
  - 180
  - 170
  - 160

- **φ [degrees]**
  - 0
  - 60
  - 120
  - 180
  - 240
  - 300
  - 360

- **Data Points**
  - Solid line with circles: 32 mm radius
  - Dashed line with triangles: 24 mm radius
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

![Graphs showing asymmetry results for near sector 1 and near sector 3 with different radius values.](image)
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
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

RIA: Advanced concepts in gamma-ray detection

T30

T60

T90
• 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$\mu$g/cm$^2$.
- $v/c \sim 6\%$
- Aim 2167keV transition in $^{38}\text{Ar}$
- There is also population of this level following the $\beta$-decay of $^{38}\text{Cl}$ 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
- Number of 662keV photons detected as a function interaction position. For (a) Centre and (b) Outer contacts.
• Centre contact rise time results for 662keV interactions.
• The rate of change of intensity and risetime.