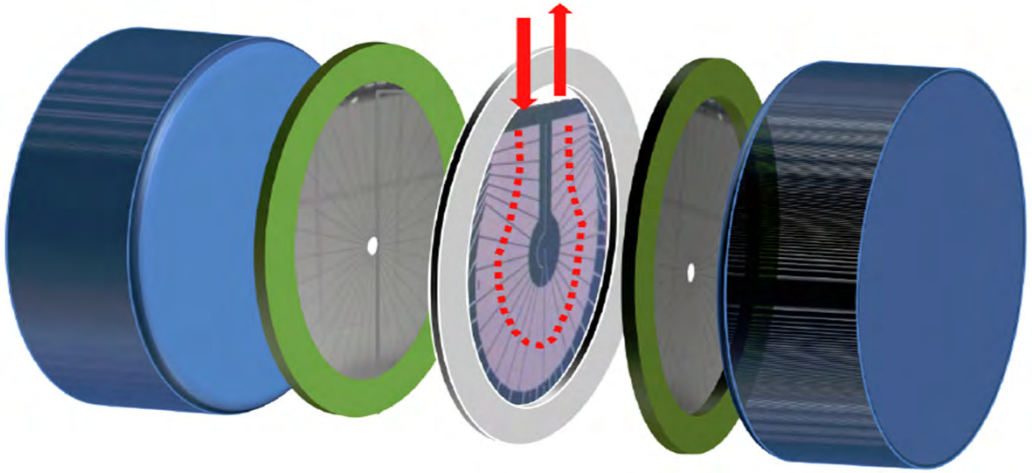
Point-like contact germanium detectors for high-resolution γ-ray spectroscopy

Dr Laura Harkness-Brennan



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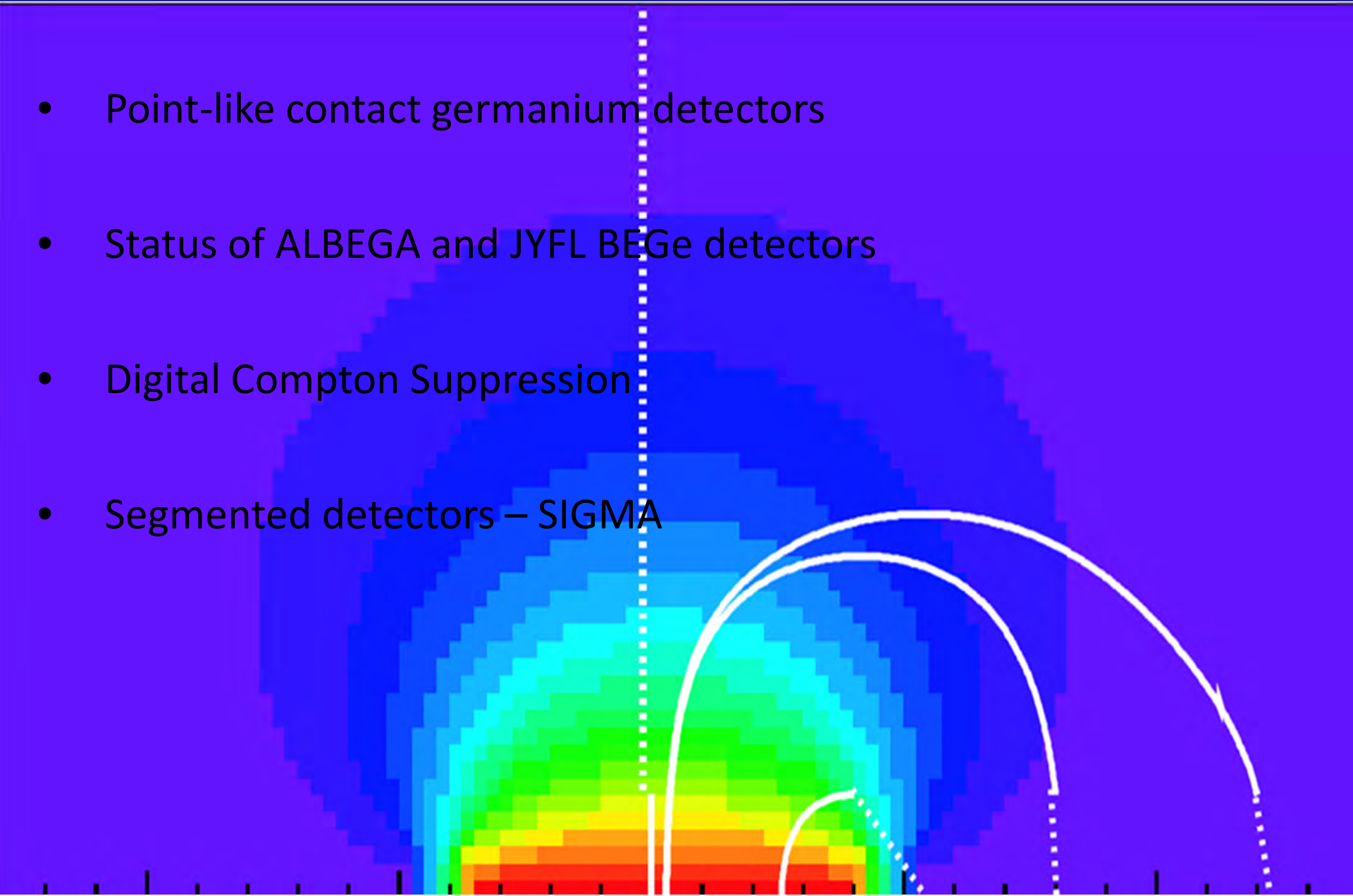
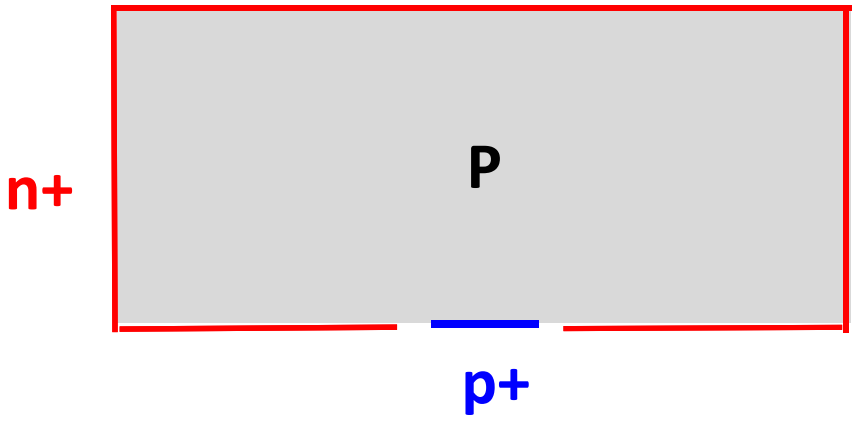
TASCA 15
GSI, Darmstadt, October 23, 2015
14th Workshop on
Recoil Separator for Superheavy Element Chemistry

Outline

- Point-like contact germanium detectors
- Status of ALBEGA and JYFL BEGe detectors
- Digital Compton Suppression
- Segmented detectors – SIGMA

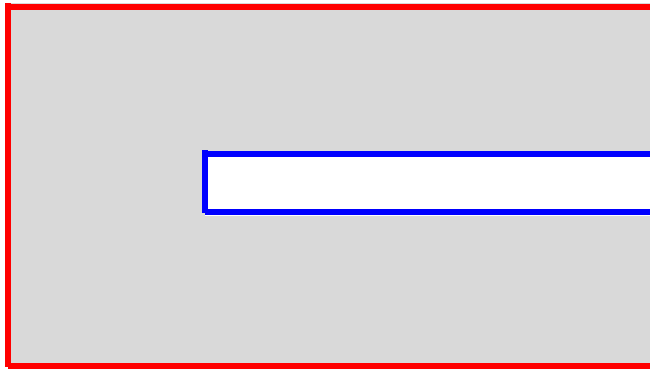


Point (small) contact detector technology

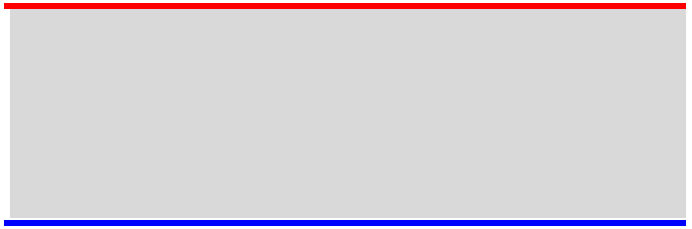


- Low capacitance C~1pF (coaxial detector ~20pF)
- Excellent energy resolution *(~0.5keV @ 122keV, 1.6keV @ 1332keV)*
- GERDA, MAJORANA, **ALBEGA**

Coaxial

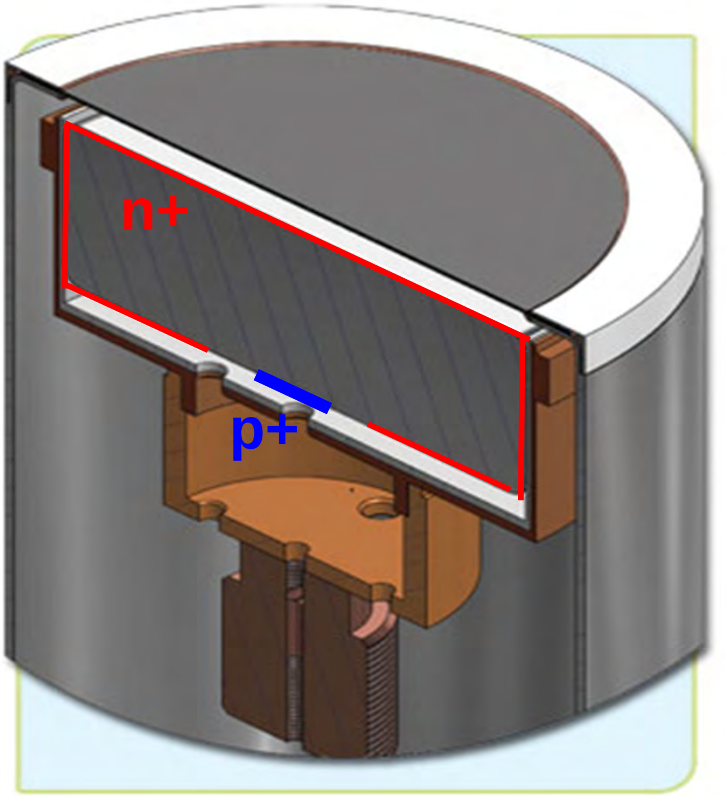


Planar

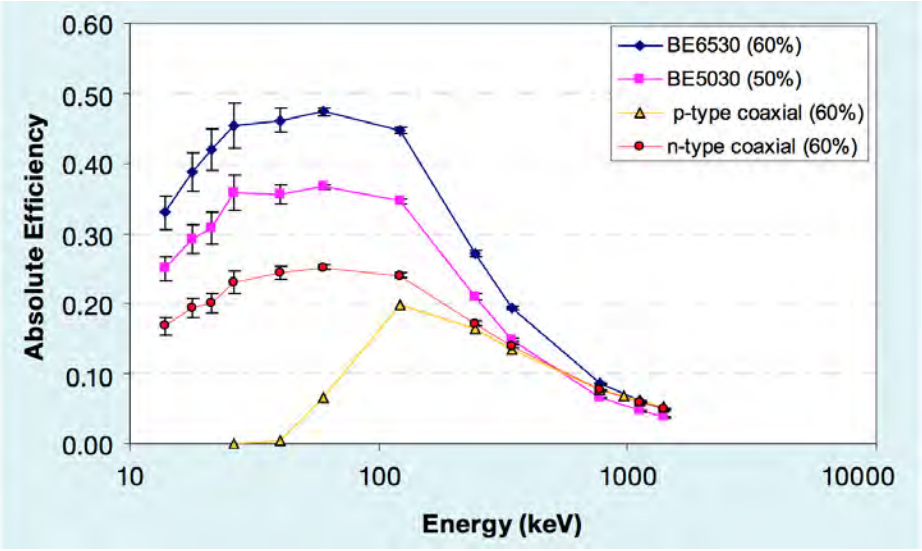


BEGe detectors

- BEXY: Cross-sectional areas of X = 20 to 65 cm^2 and thicknesses of Y = 20 to 30 mm
- Entrance window transmission: aluminium (30keV), composite carbon (10keV) or Beryllium (3keV)



Images: www.canberra.com



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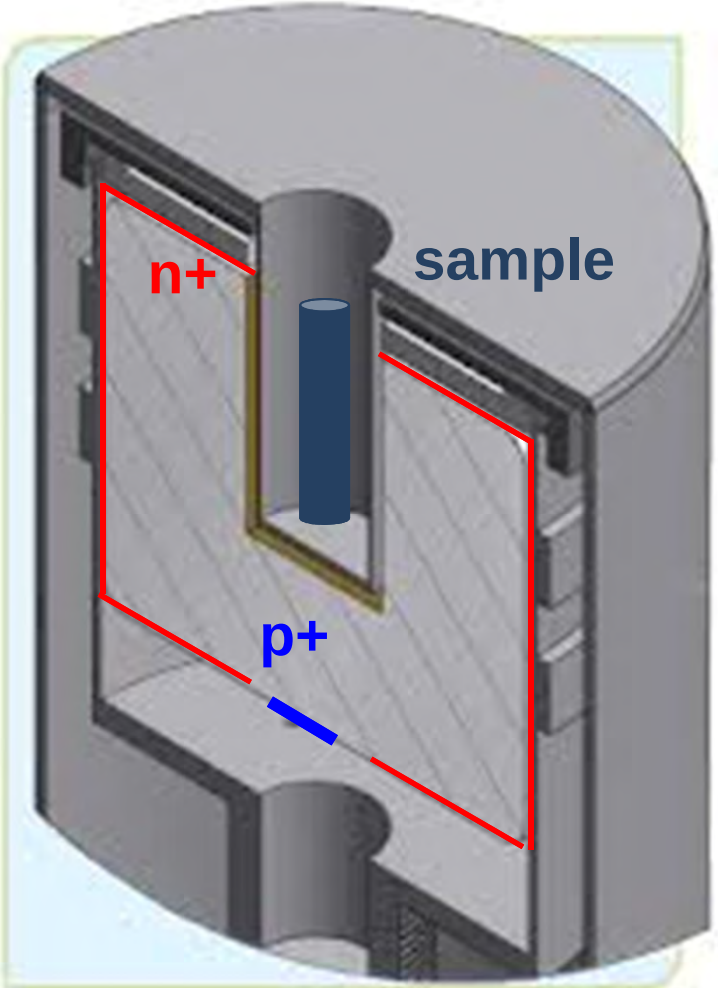
SAGe-well detectors

- SAGe-well detector developed by Canberra for environmental sample measurements
- Excellent efficiency (well)
- Point-like contact for excellent energy resolution
- Relatively poor timing resolution
- Long charge collection times ideal for PSA



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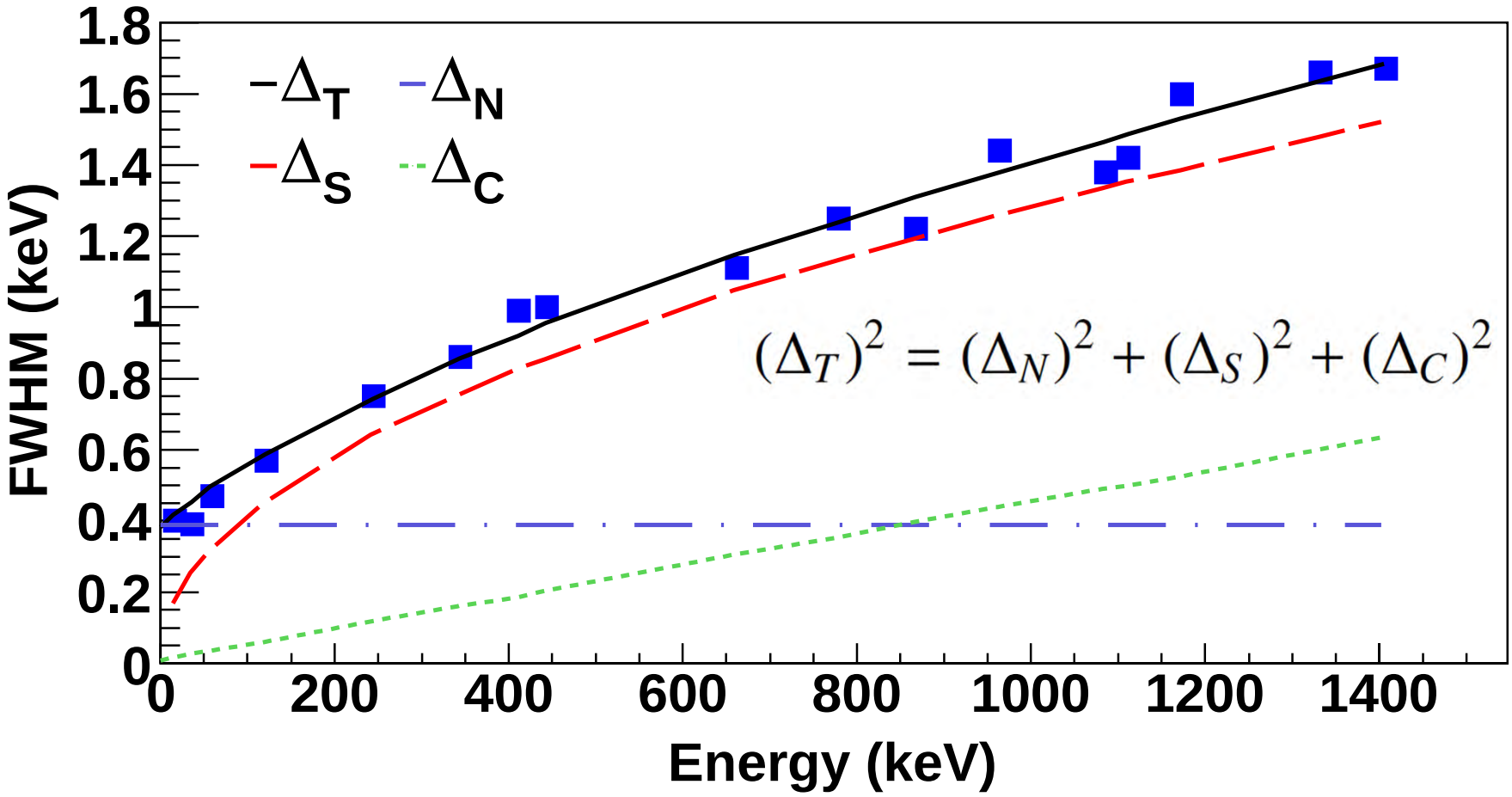
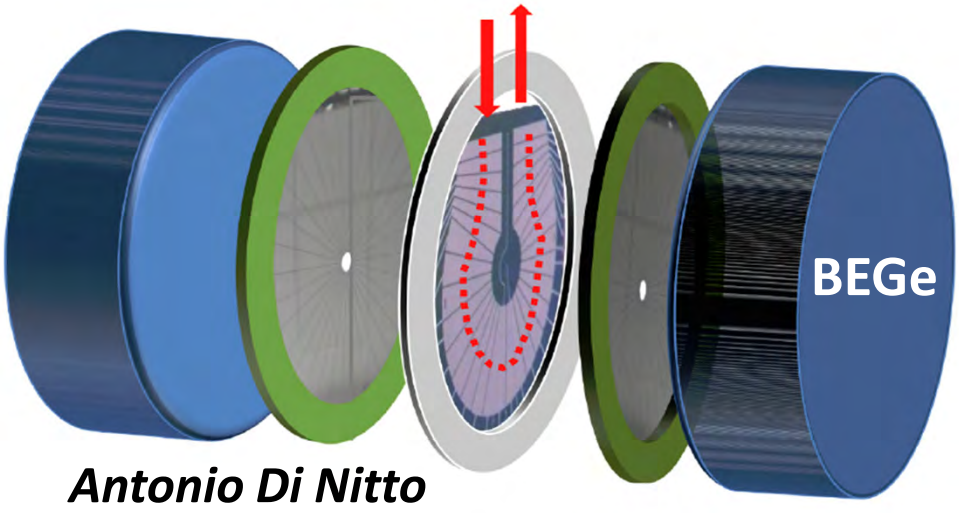
Energy Resolution

Total energy resolution: electronic **N**oise, **S**tatistical fluctuations in # of charge carriers and incomplete **C**harge collection

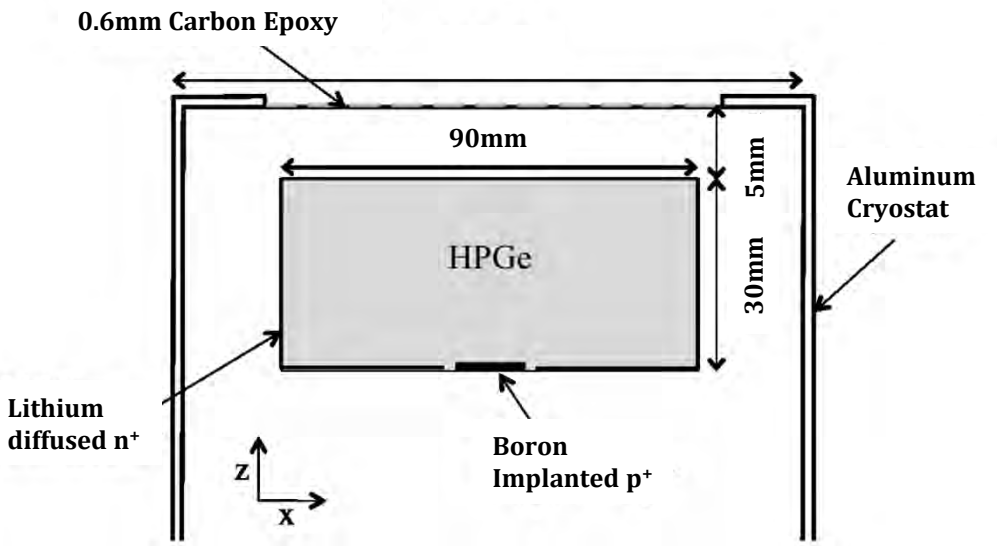


ALBEGA

- ALpha-BEta-Gamma multi-coincidence detection system for spectroscopy of chemically separated samples
- Correlations used to identify decay chains
- BE3830: gamma-rays and x-rays (I.C)
- MWD algorithms to calculate energy not yet optimised
- Background to be investigated



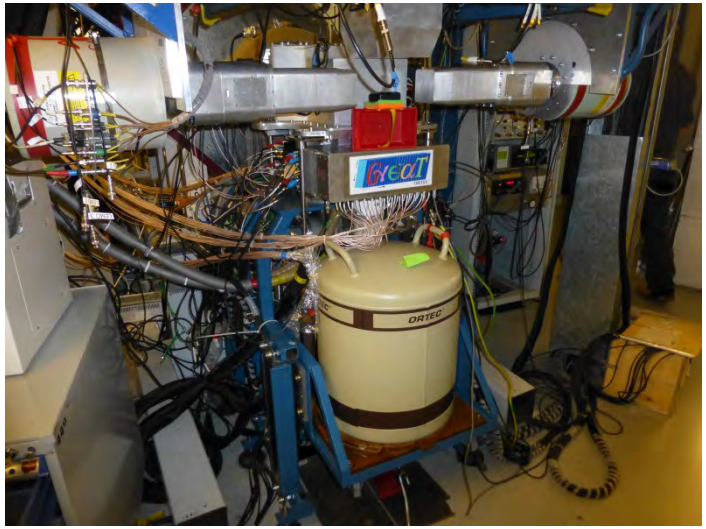
Antonio Di Nitto

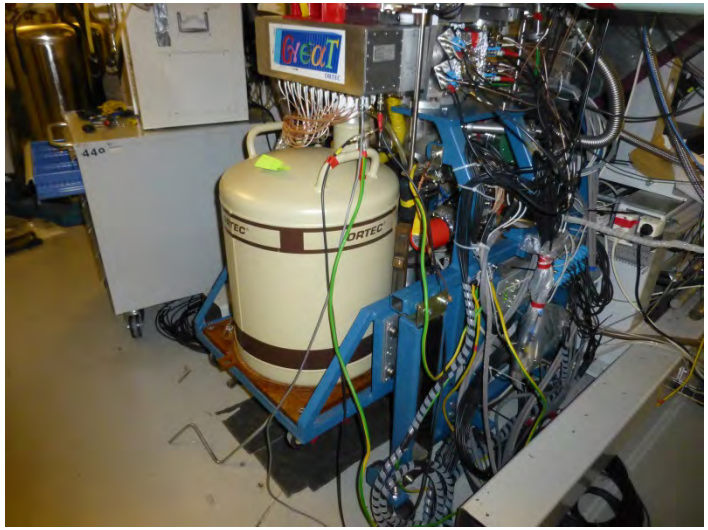


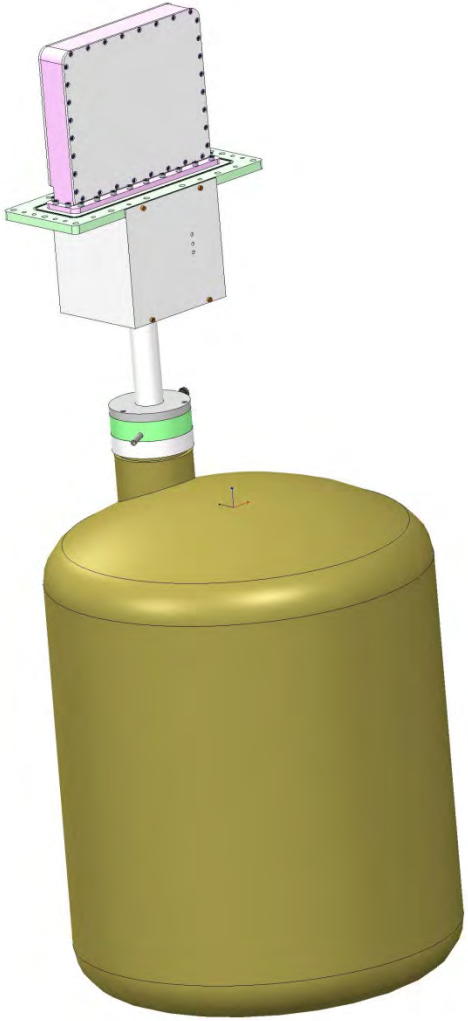
JYFL BEGe detector

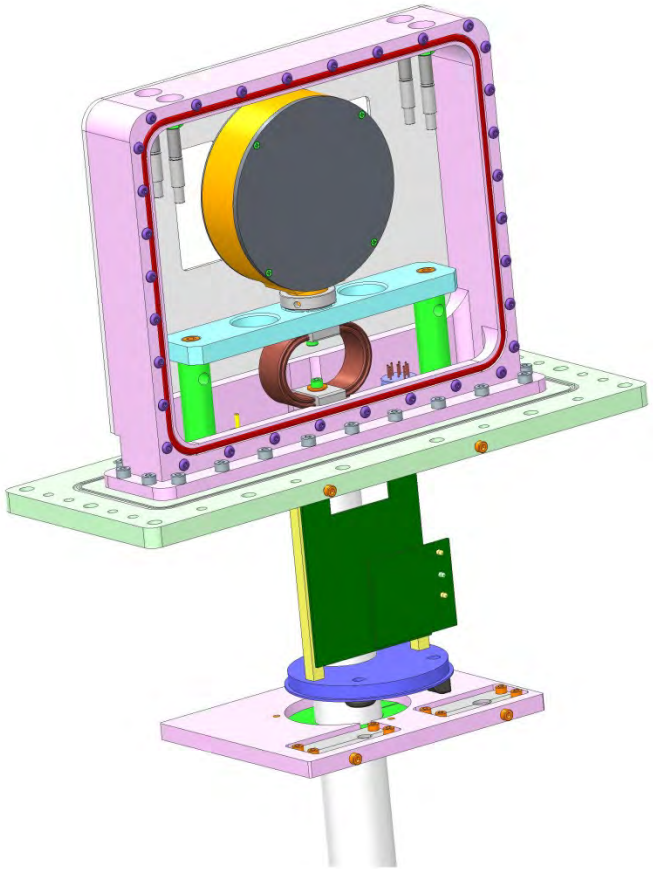
- Integrating a BEGe detector into GREAT, directly behind implantation detector
- BE5020: 102mm diameter, 20mm thick
- Energy resolution <0.5keV at 122 keV
- Cryostat constructed at Daresbury
- Precision calculations of atomic configurations of heavy elements (I.C. x-ray measurements)
- JYFL experiments 2016

JYFL BEGe detector





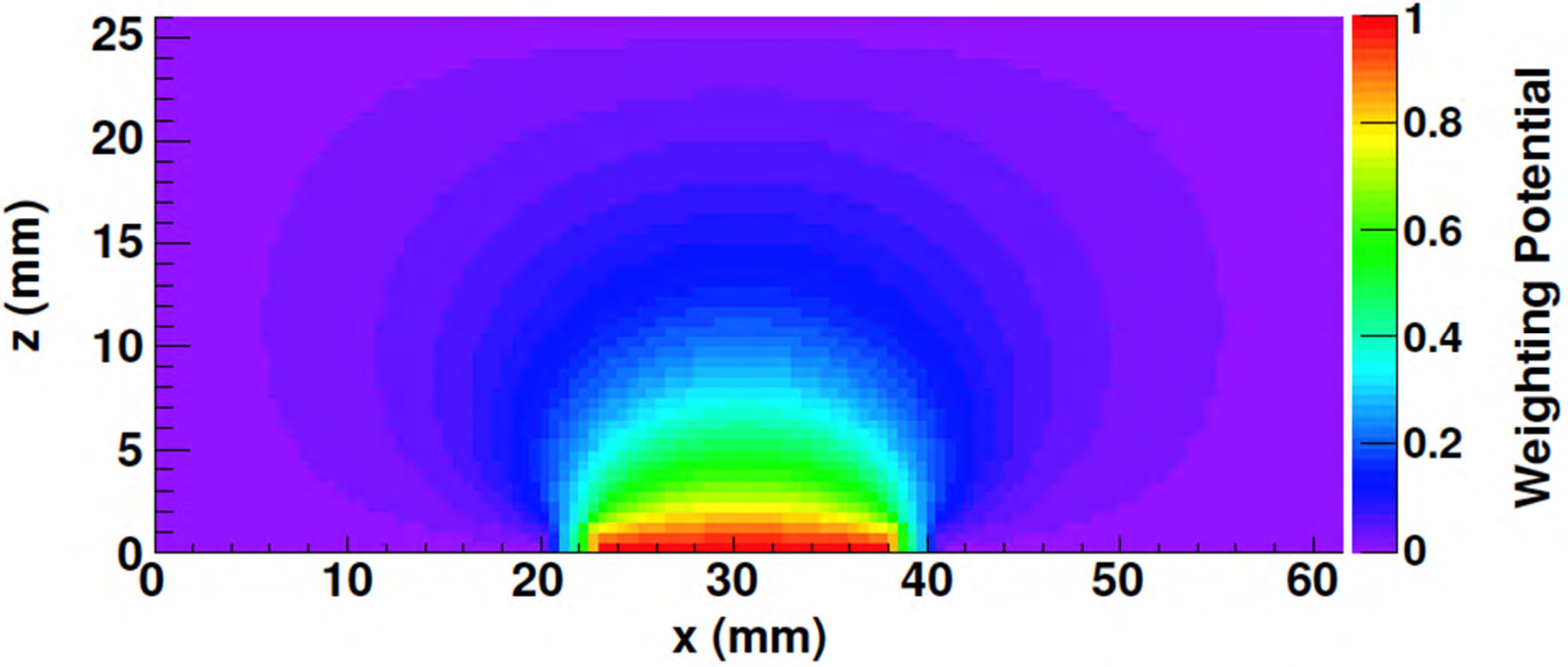




Digital Background Suppression

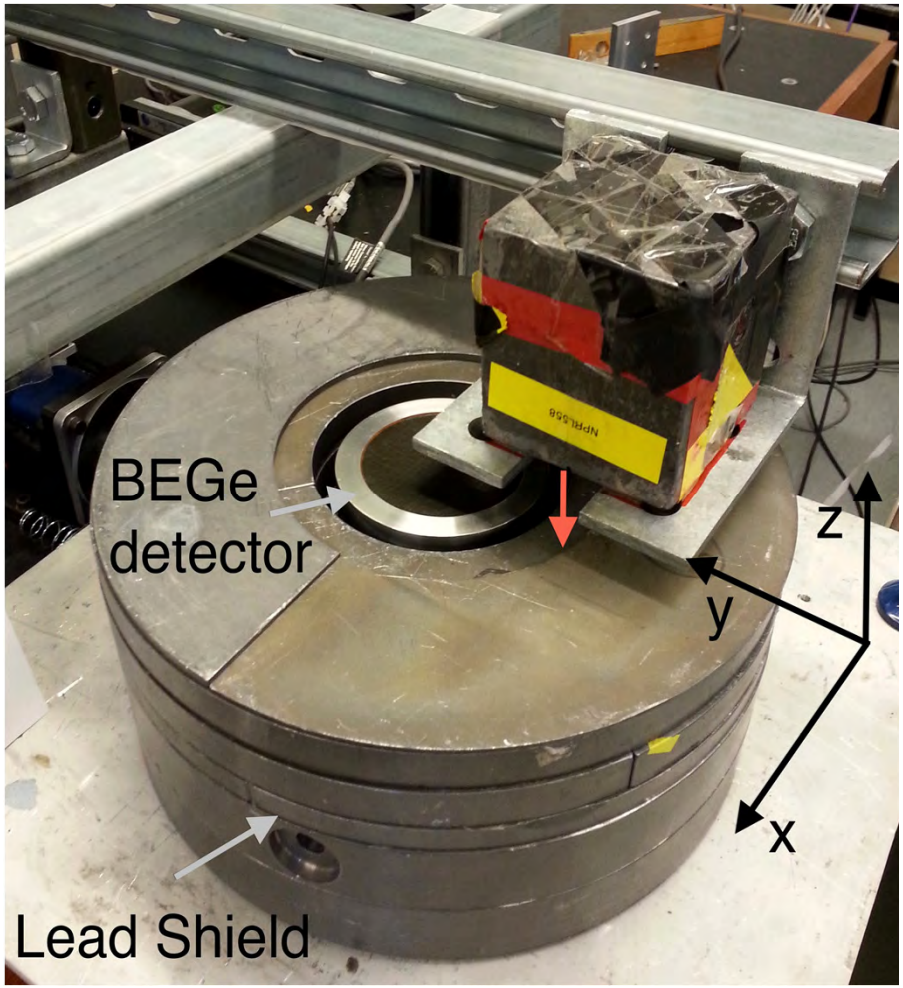
Shape of preamplifier signal on p+ contact defined by weighting potential (Shockley Ramo theorem)

$$i = q\,\vec{v}\cdot\vec{E}_w \qquad Q = q\Delta\varphi_0$$



Pulse Shape Characterisation

- ^{241}Am source collimated into a 1mm beam
- Preamplifier with 100mV/MeV gain input to a CAENV1724 card (±1.125V dynamic range and 256 samples per trace)
- Collimator moved in 1mm steps from (0,0) mm to (100,100) mm, for 5s per step, using an automated x-y positioning table



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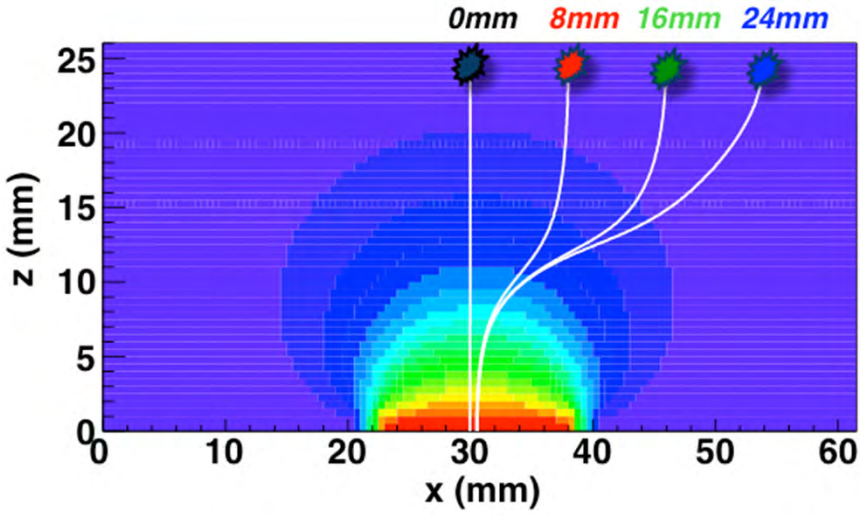
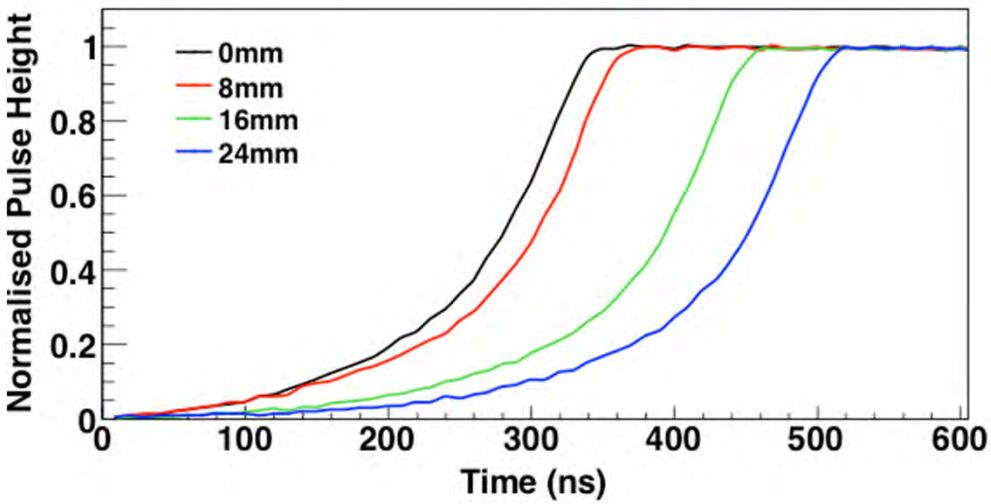
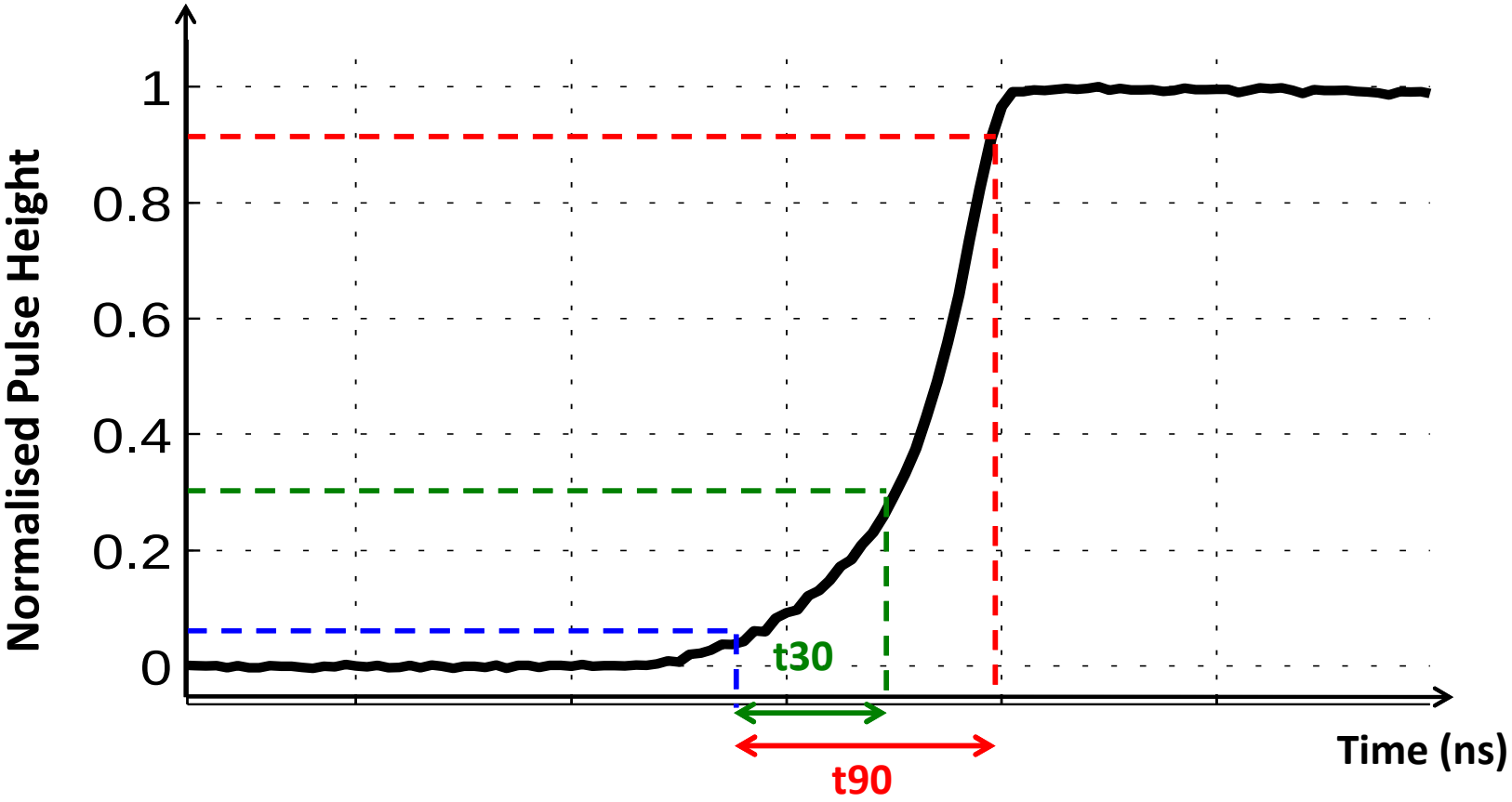
Pulse Shape Characterisation





- Normalised average pulse shapes generated at 4 radial distances
- Time aligned to t_0 offline (with 20ns error)
- Pulse shape variation - some position of interaction sensitivity

Pulse Shape Characterisation



Rise time parameters: t30 and t90, time taken to rise from 5% to 30% and 5% to 90% of the pulse height.

Average pulse shape response

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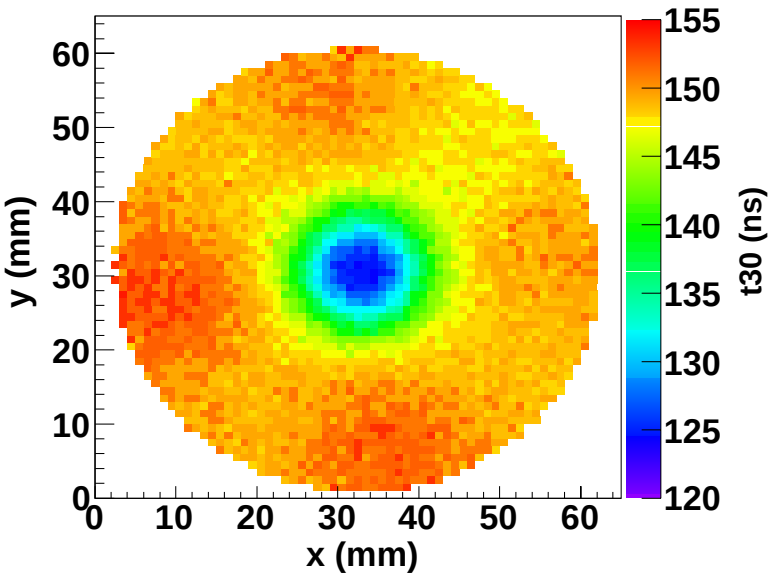
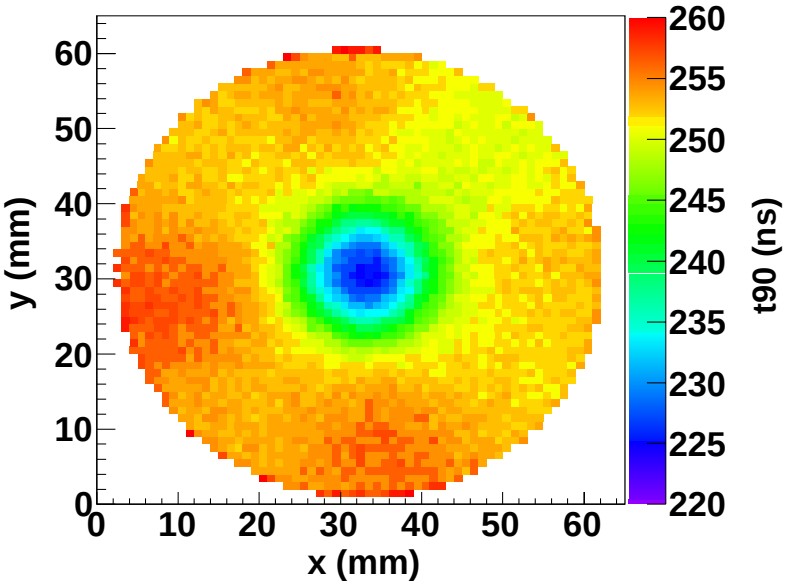
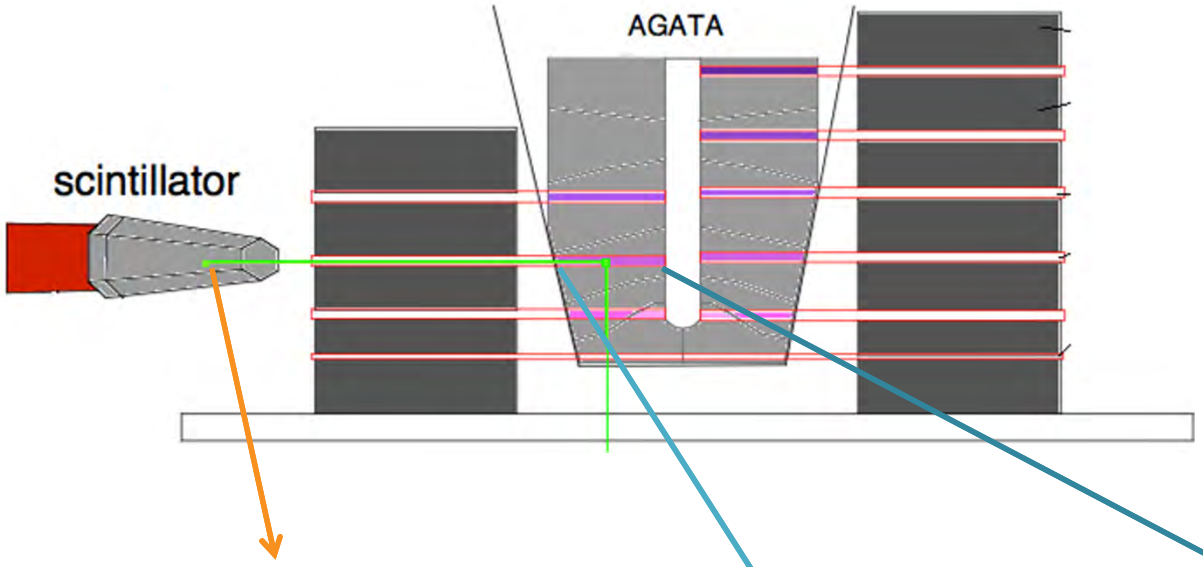
Pulse Shape Characterisation

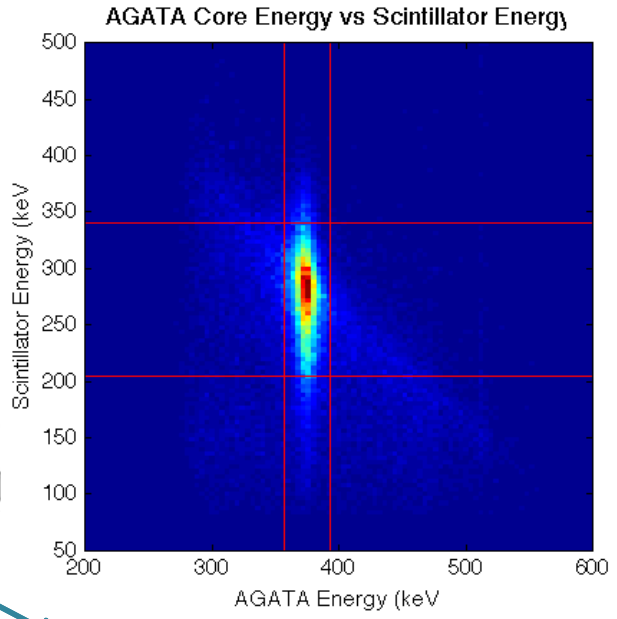


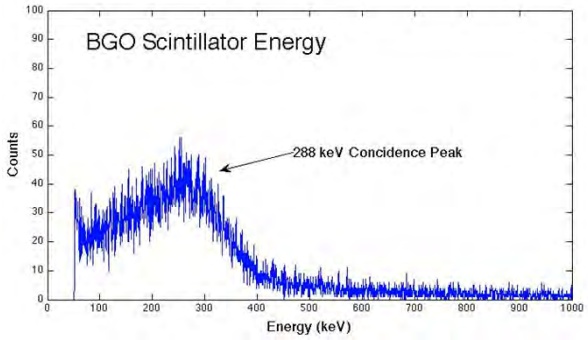


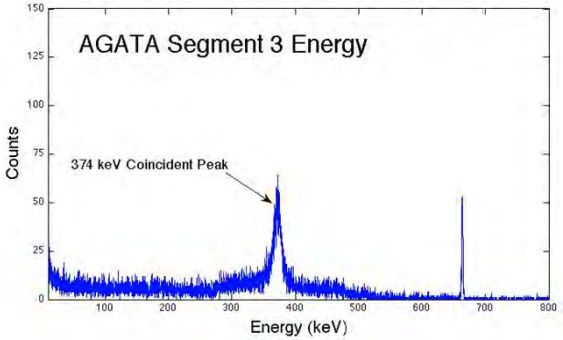
- Average t30 and t90 calculated for 58-62keV events as a function of scanning table position
- Fast t30 and t90 values at the centre of the detector
- The results highlight the crystallographic axes of the detector

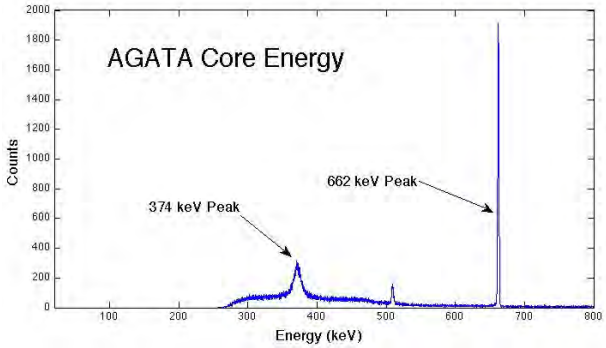
3D Position Sensitivity











Collimated Coincidence scanning

AGATA
ADVANCED GAMMA TRACKING ARRAY

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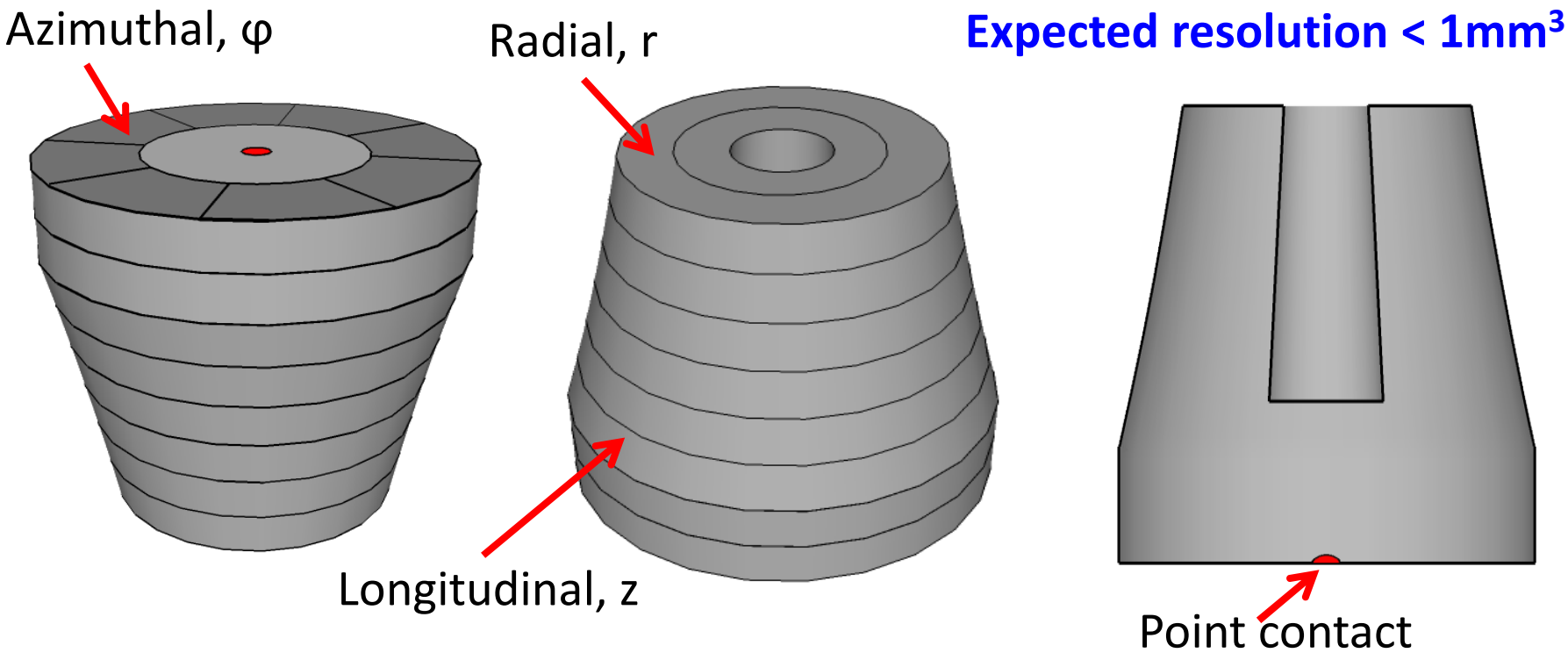
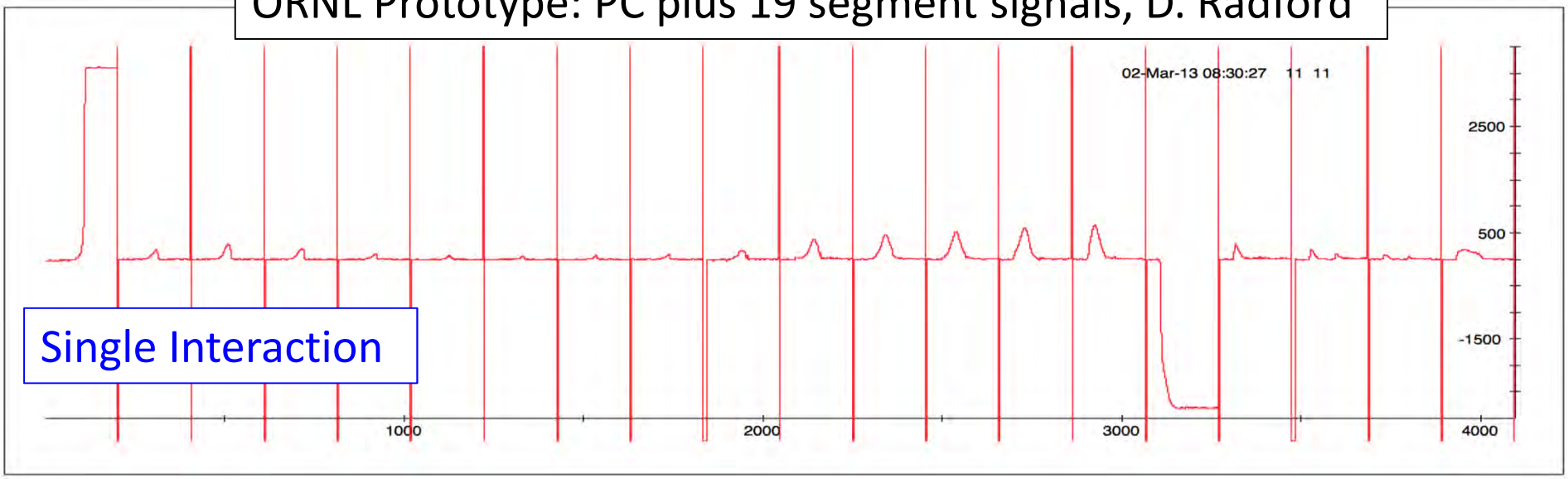
Development of the SIGMA detector

- Segmented Inverted-coaxial GerMAnium Detector
- 8 longitudinal rings, 2 concentric segments on front face, 8 sectors, 1 core segment, 1 point-like contact
- Digitised signals processed through PSA algorithms

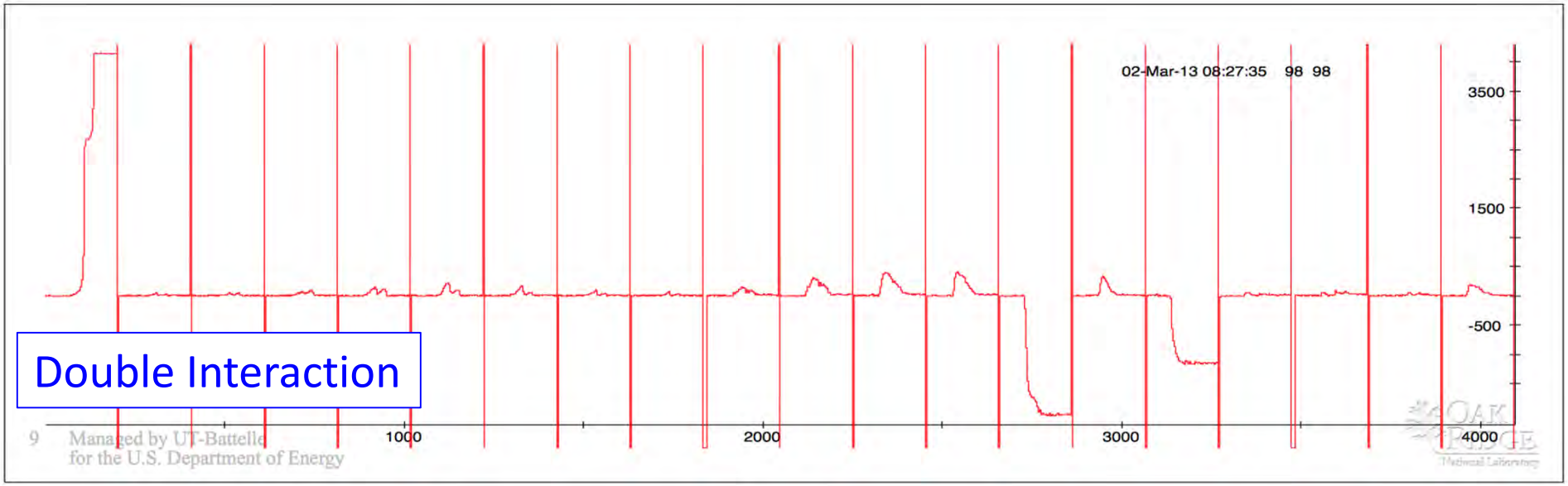


ORNL Detector

ORNL Prototype: PC plus 19 segment signals, D. Radford



Single Interaction



Double Interaction

Conclusions

- Point-like contact technology provides excellent energy resolution
- BE3830 detectors in use at ALBEGA, BE5020 will be used in JYFL
- Position sensitivity using Pulse Shape Analysis - > digital Compton suppression
- SIGMA detector will be evaluated for γ-ray tracking and event-by-event correlation

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