Characterisation of Small Electrode HPGe Detectors

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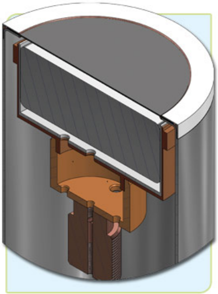
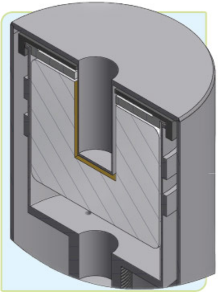
BEGe and SAGe Well Detectors

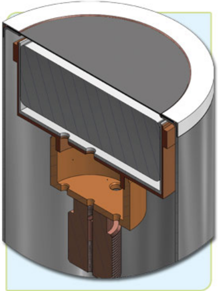
- Small electrode configuration for reduced capacitive noise.
- BEGe Detectors in use for some years for spectroscopy with low-medium gamma-ray energies.
- FWHM @ 60 keV = 0.58
- FWHM @ 1332 keV = 1.69

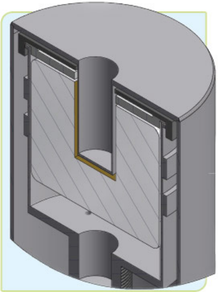




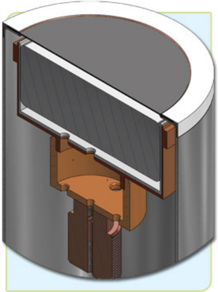
BEGe and SAGe Well Detectors

- SAGe detectors employ novel well-like geometry to enable large volume crystals to fully deplete.
- Based on design of point contact detector by David Radford and Ren Cooper at ORNL.
- *A novel HPGe detector for gamma-ray tracking and imaging, Cooper Et Al, NIM A 2011.*
- FWHM @ 60 keV = 0.72
- FWHM @ 1332 keV = 2.11

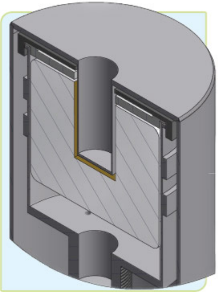




BEGe and SAGe Well Detectors



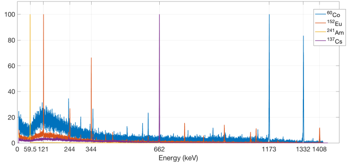
- Simple readout through resistive feedback CSP.
- **No intrinsic position sensitivity in these detectors.**

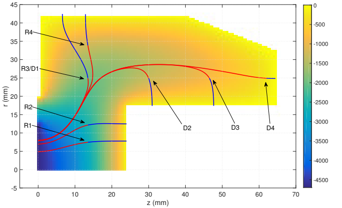


Goals of This Work

Characterisation of both detector types carried out in Liverpool over the last 2 years. Goals include:

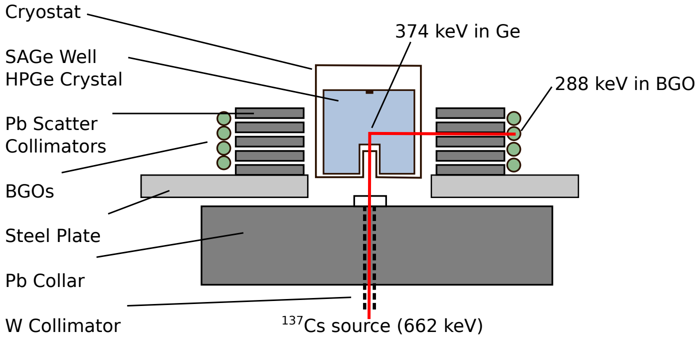
- Understand signal formation in these detectors.
  - Long drift of holes through low field region not well reproduced by existing simulations.
  - Accurate simulation crucial for development of future instruments.
- Develop algorithms for improved spectral quality through PSA.
  - Fast methods based on risetime gating for implementation in existing DAQ hardware.



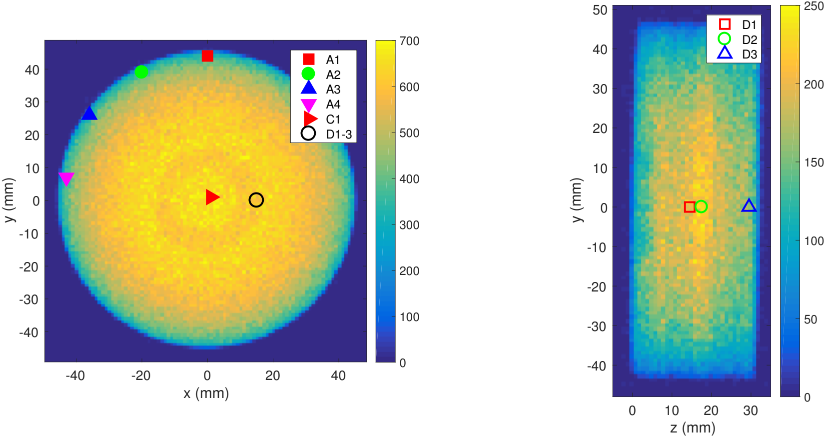


Characterisation Methods

- Detectors scanned with collimated beam of 662 keV photons.
- Coincidences with secondary BGO detectors measured to locate single-site interaction in three dimensions.
- Mean of multiple events formed at each position to reduce noise contribution.

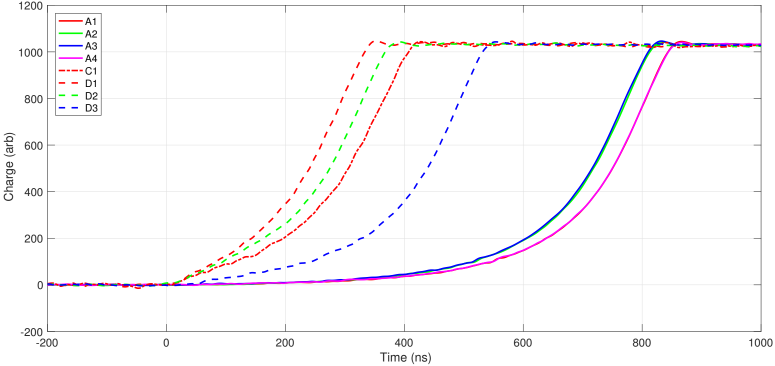


Signal Shapes in BEGe 6530



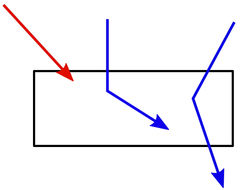
- Intensity of singles interactions in BEGe reveals crystal geometry.
- Coincidences recorded at selected points only.

Signal Shapes in BEGe 6530

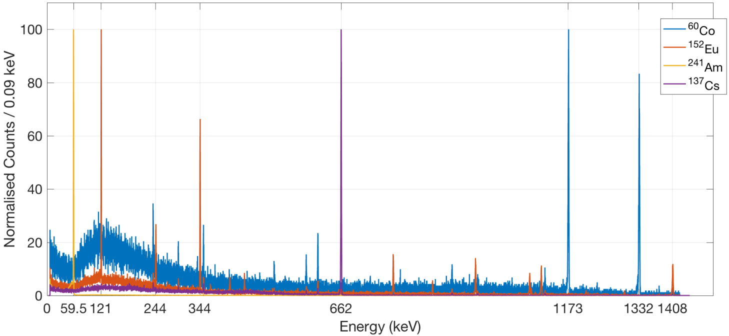


- Signal shapes depend on interaction position.
- Faster risetime near to the electrode, particularly in the first 20% of the height.
- This difference is more pronounced in smaller BEGe's but still noticable here.

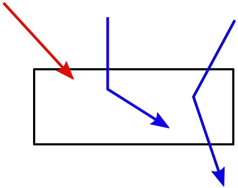
Gamma-ray Interactions



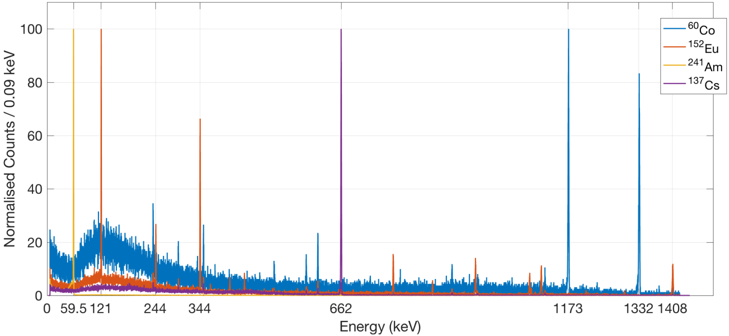
- Full-energy peaks produced by photoelectric interactions or multiple Compton scatters.
- Background at low energy mainly due to Compton scatter of high-energy gamma rays.



Gamma-ray Interactions

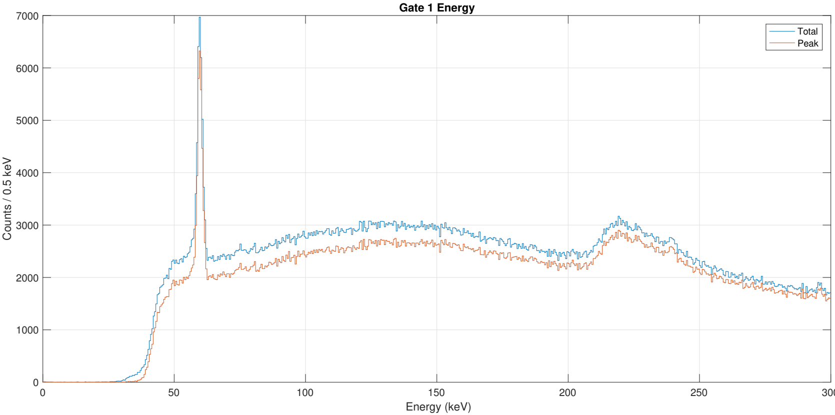


- Low-energy background critical to sensitivity in a number of applications:
  - Lake sediment dating with 46.5 keV gamma from ^{210}Pb.
  - Identification of Uranium decay products in presence of background from fission fragments ^{137}Cs and ^{60}Co.



Testing PSA in BEGe 6530

- Can we gate on the risetime to supress low energy interactions far from the surface?



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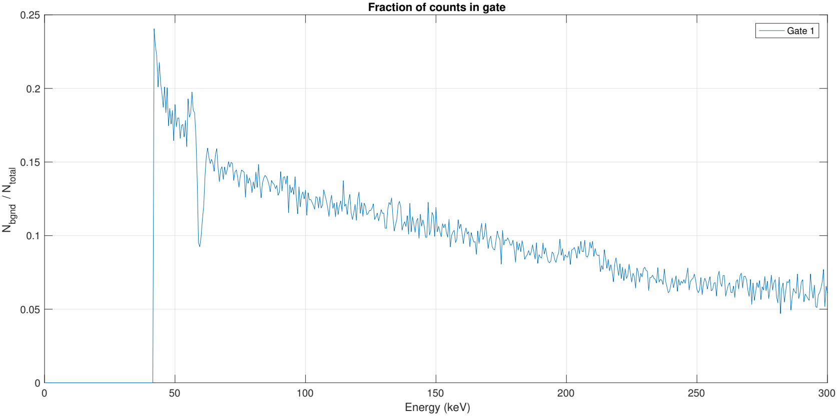
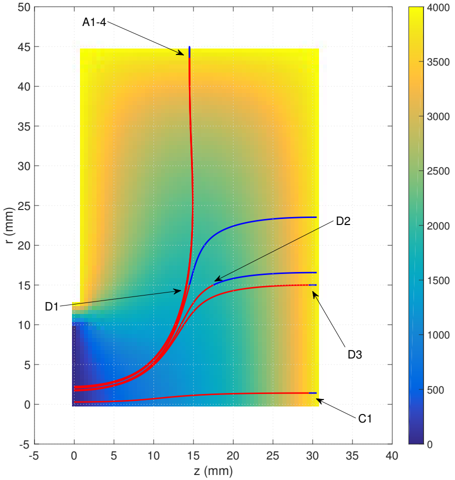
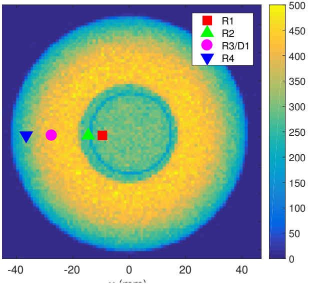


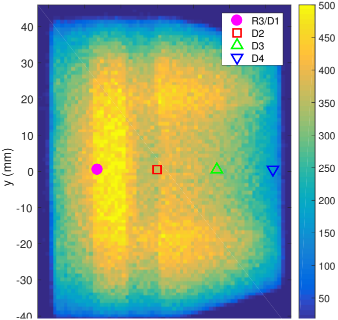
Testing PSA in BEGe 6530



- Results of background rejection modest with this very large BEGe.
- Wide range of charge drift times for surface interactions limit performance.
- Simulations suggest better results will be obtained for smaller detectors.
- Tests on 2020 and 2825 BEGe's underway.

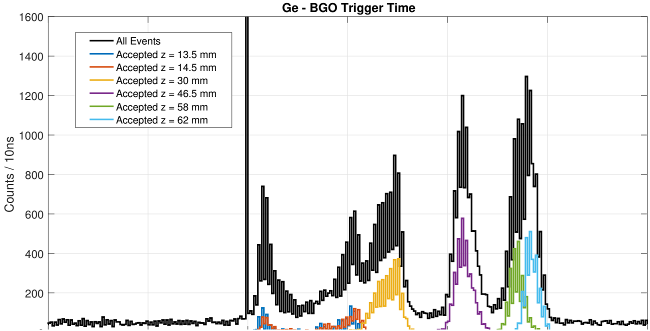
SAGe Characterisation





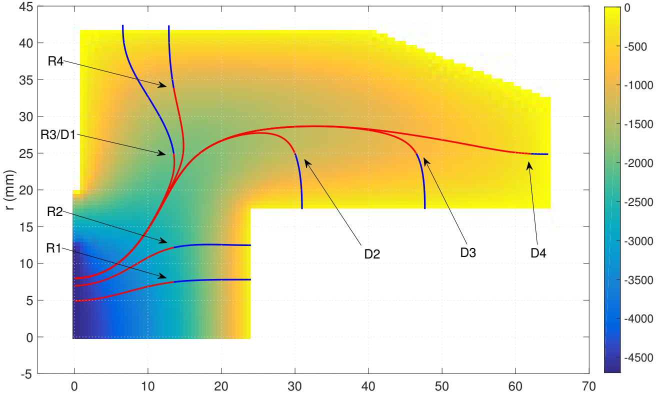
- As with BEGe, singles intensity used to determine crystal geometry and orientation.

SAGe Characterisation



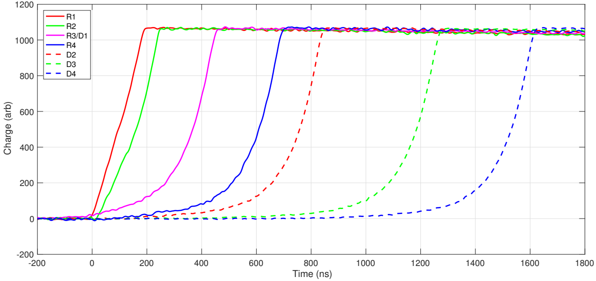
- Trigger time difference between Ge and BGO used to align very slow rising pulses.

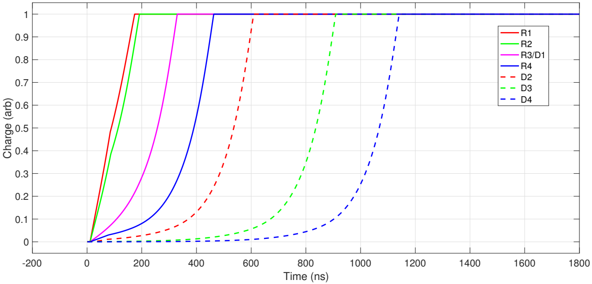
SAGe Simulations



- Field in detector calculated using finite difference approach.
- Charge then tracked through field using mobility parameterisation from *Characterization of large volume HPGe detectors. Part I: Electron and hole mobility parameterization, Bruyneel Et Al, NIM A, 2006*.

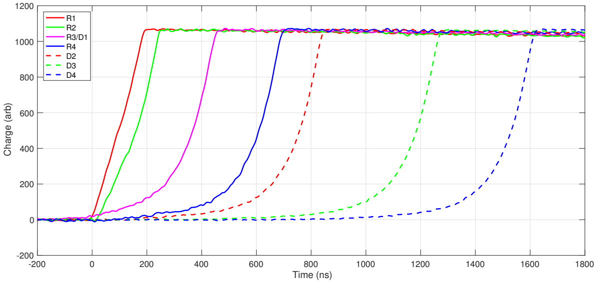
SAGe Simulations

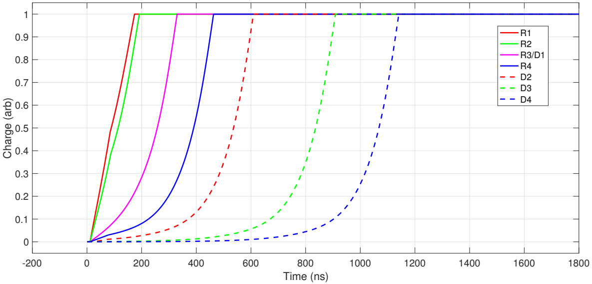




- Simulated signals much faster than experiment when drifting through weak field region.
- Same mobility parameterisation works well for coaxial detectors e.g. AGATA

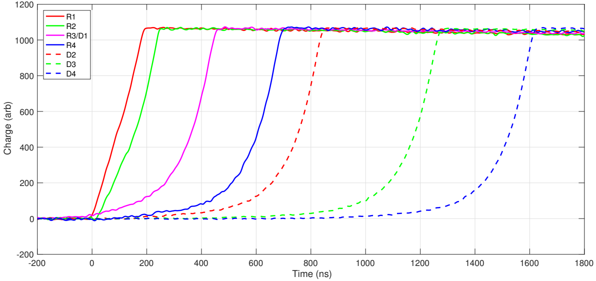
SAGe Simulations

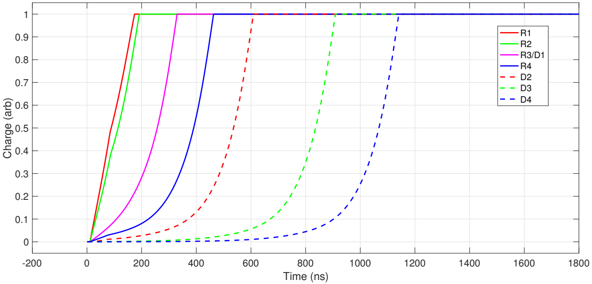




- Impurity gradient crucial in determining field in these detectors.
- Depletion bias provides check on manufacturer's quoted impurity concentrations.
- Temperature dependance of mobility likely playing a role.

SAGe Simulations





- Currently optimising simulation to match correct drift times.
- We can't explain the discrepency without reducing the value of <100> hole mobility.

Conclusions

- SAGe and BEGe detectors characterised at Liverpool.
- Data being used to inform simulation development for long-drift-time HPGe detectors.
- Modest results performing fully digital Compton background rejection on BEGe 6530.
- Measurements underway to exploit same techniques on smaller BEGe's.

Thank You

Thanks to collaborators and conference organisers.

A.J. Boston[1], L.J. Harkness[1], D.S. Judson[1], P.J. Nolan[1], O.S. Thomas[1], A.S. Adekola[2], J. Colaresi[2], W.F. Mueller[2]

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Extra Slides