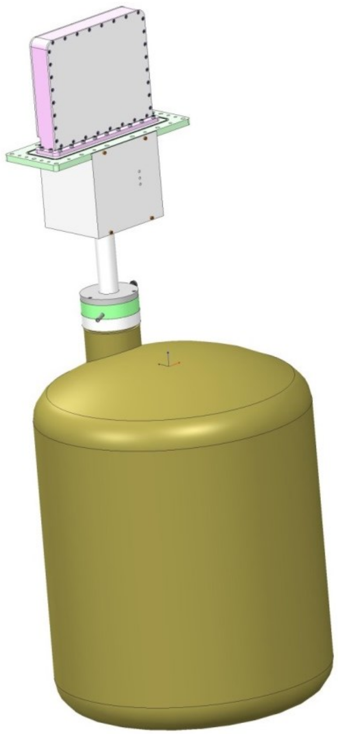

HPGe cryostat design, build and operation *(The BEGe for JYFL)*

Presented by Ian Lazarus
DSG and NPG, Daresbury Laboratory

UNIVERSITY OF LIVERPOOL

Science & Technology Facilities Council

MIRION TECHNOLOGIES

Overview

- Cryostats designed and built at Daresbury
  - XH/XSTRIP
  - ProSPECTus
- GREAT BEGe for Jyvaskyla
  - Why upgrade to a BEGe?
  - Why design our own cryostat?
  - Results

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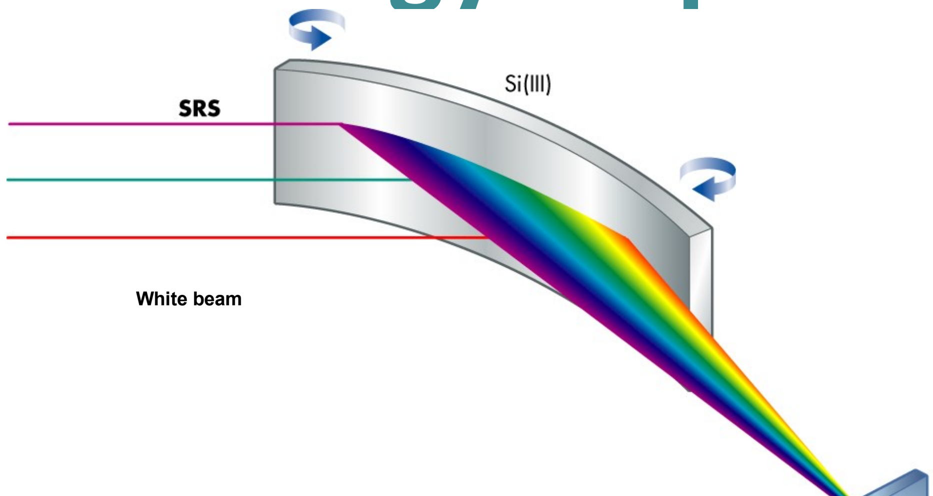
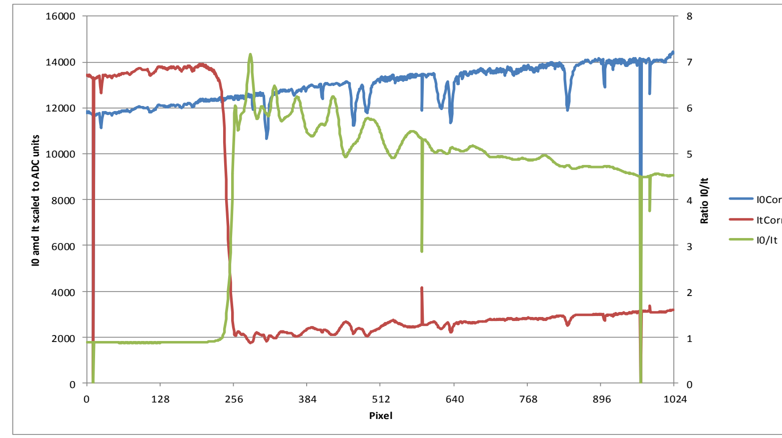
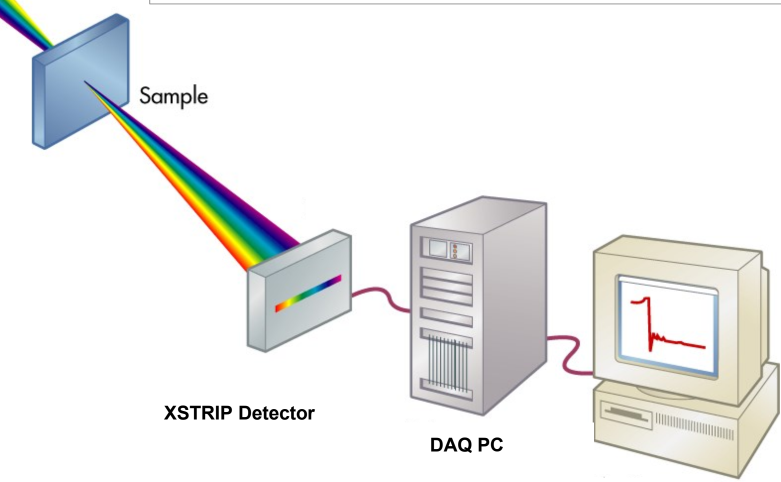
Energy Dispersive EXAFS







Poly-chromator spatially separates photon energy

All energies cross at the sample position.

Measure I_t with and I_0 without sample, possibly at different integration times

Measure dark levels for I_t and I_0.

Form attenuation = $(I_0\text{-dark})/(I_t\text{-dark})$

Average many scans to improve noise.

Looking at direct beam.

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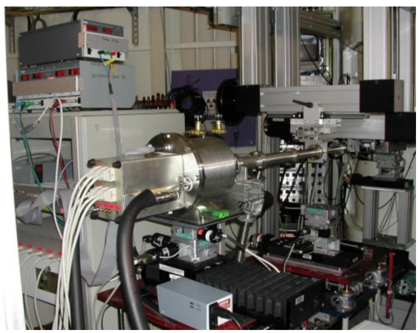
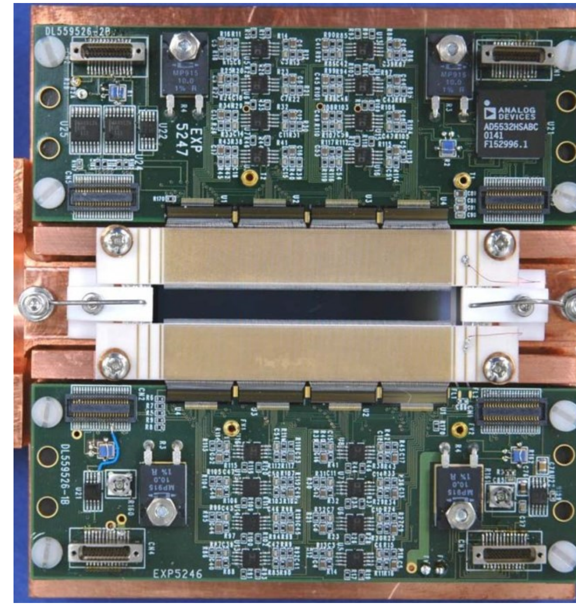
XH and XSTRIP





XH

- Ge 1024ch
- 50um pitch
- 1mm thick (max 40keV)
- LN2 cooled
- LBNL

XSTRIP

- Si 1024ch
- 25um pitch
- 500um thick (max 15keV)
- Water cooled

Energy Dispersive EXAFS

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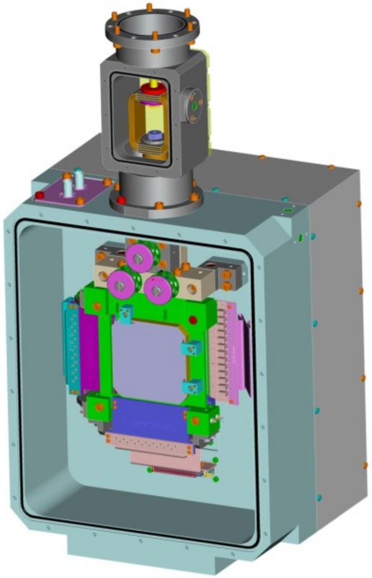
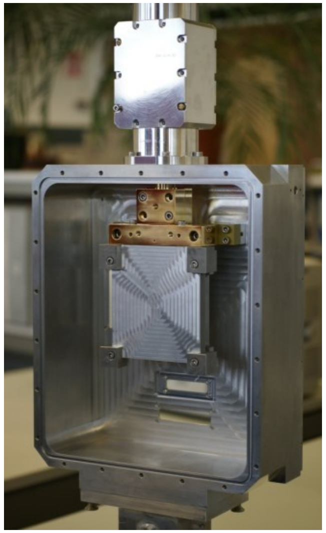
ProSPECTus

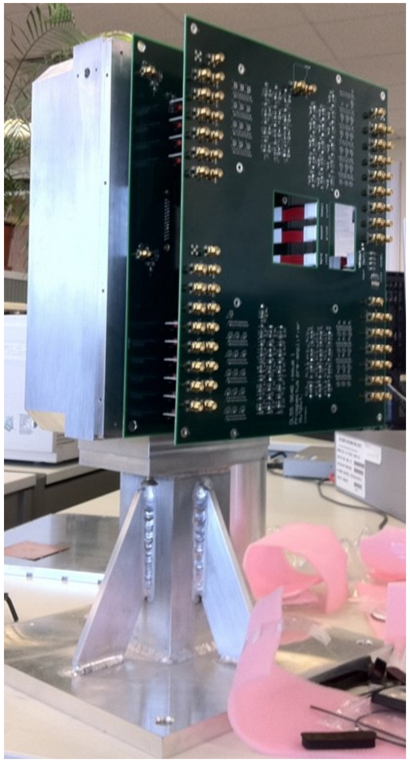
- Compton Camera for SPECT imaging
- SiLi scatterer (60 x 60 x 9) mm double sided with 4mm strips
- Ge Absorber(60 x 60 x 20) mm double sided with 5mm strips
- Detectors need to be close so best to put them in 1 cryostat.



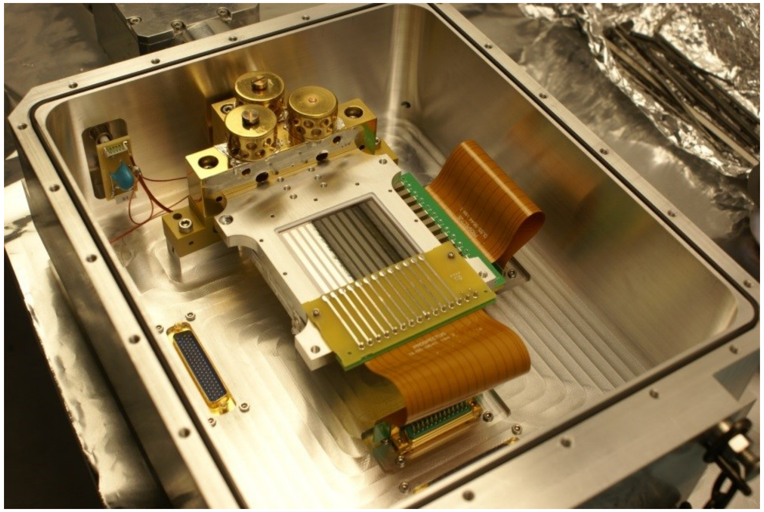


ProSPECTus

Cryostat and preamp board



Ge Sensor with Flexi Circuits



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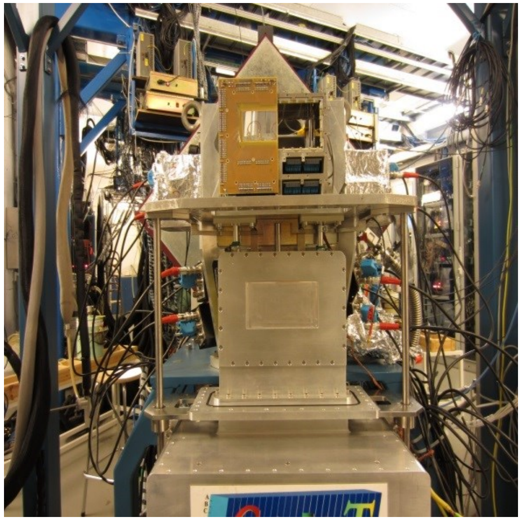
GREAT BEGe Science Case: X-rays



- BEGe detector has
  - Great Energy Resolution
  - Large area coverage
  - Excellent efficiency between 15 and 250 keV
  - Replaces existing GREAT Planar detector

- Superheavy elements have the highest electronic binding energies:

  $E_K > 150$ keV

  $E_L > 30$ keV

  Thus X-ray energies lie in the most sensitive range of the BEGe.

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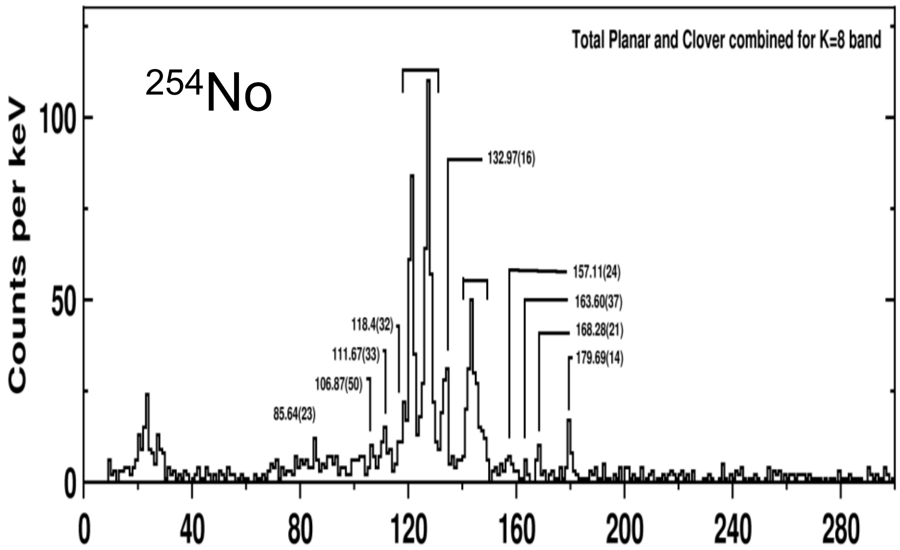
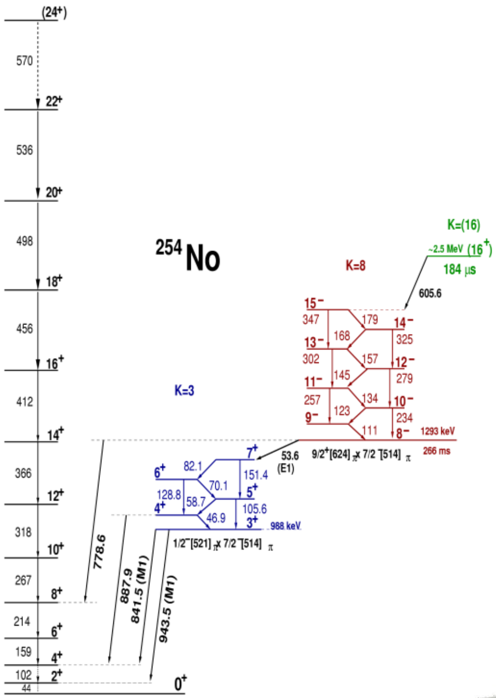
Low-energy gamma rays

The heaviest nuclei around ^{254}No are very well deformed and have a number of low-lying gamma transitions: e.g. Isomer spectroscopy:





Data: JYFL + GSI

C. Gray-Jones PhD thesis 2008
B. Sulignano, PhD thesis 2007

See: Herzberg et al, Nature 442, (2006) 896

X-ray energies from Atomic theory

- Measurements exist up to Cm (Z=96)
- Calculations precise to eV levels
- Contribution to Binding energy from Vacuum polarisation, self-energy and Breit energy is now more than 1% in the heaviest elements
- Precision measurements of X-ray energies in elements with Z=100 to 104 will be done at the RITU Separator in Jyvaskyla
- Needs excellent energy resolution!

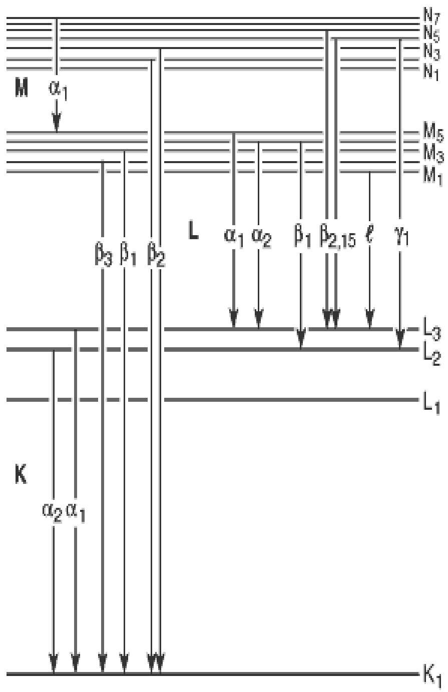


Image: Xdb.lbl.gov

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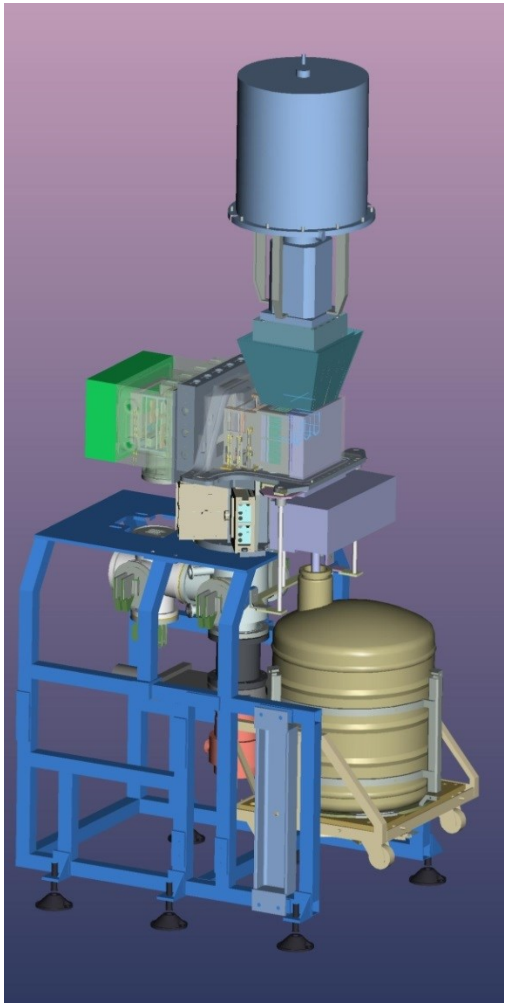
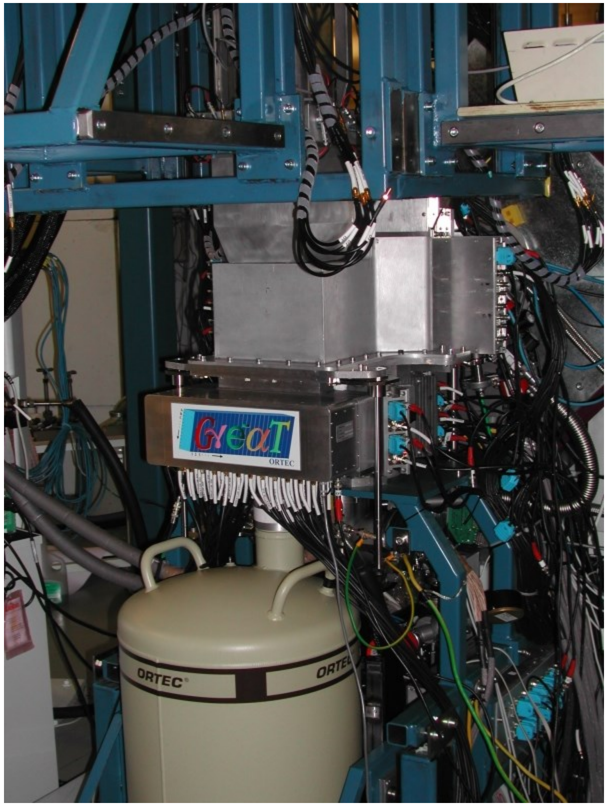
Why design our own cryostat?





Space already fixed-
"Letterbox"

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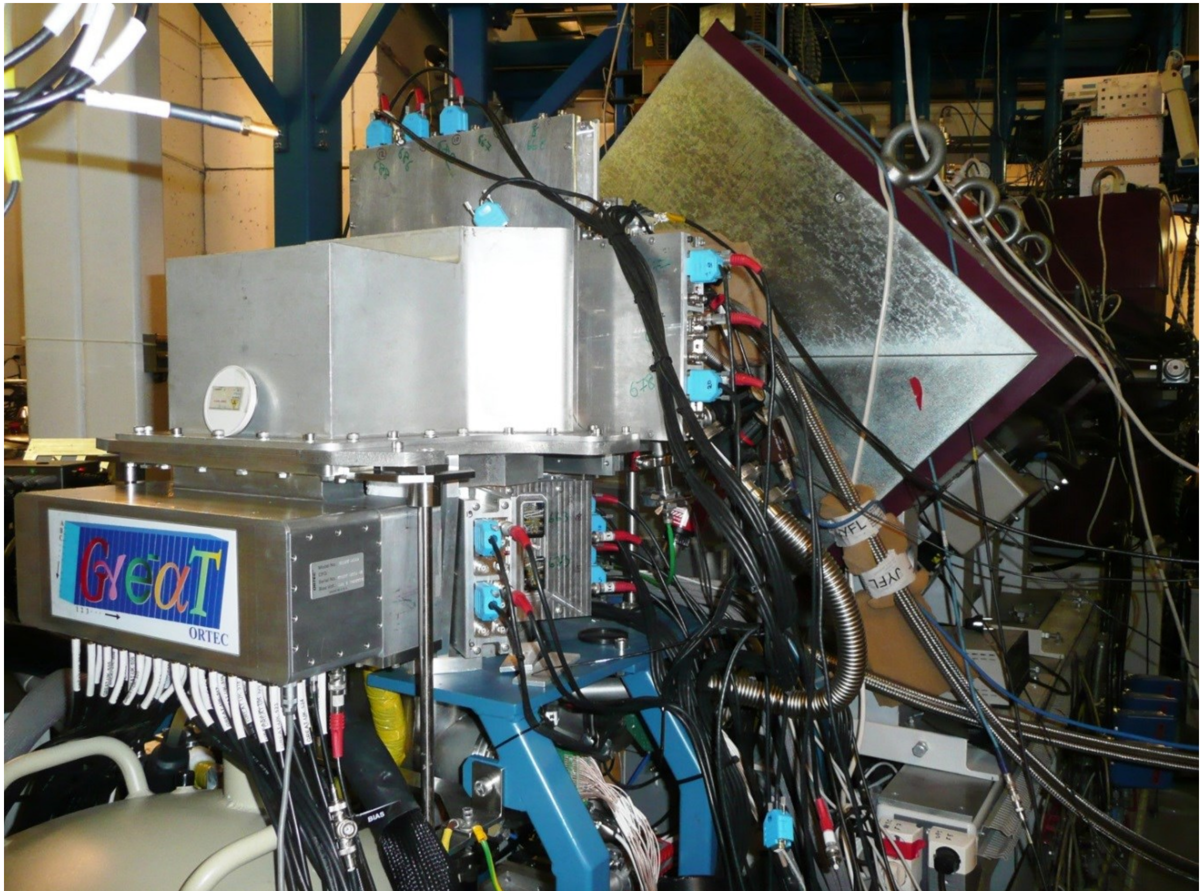
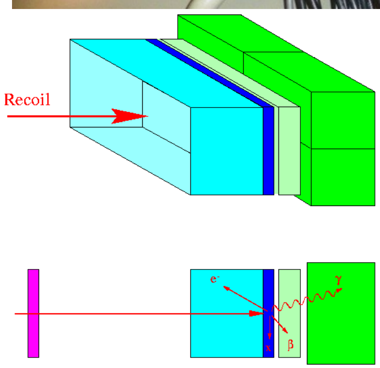
The GREAT Spectrometer



- 2 x 60mm x 40mm DSSD (4800 pixels)
- 28 x 28mm x 28mm PIN Diodes
- 12cm x 6cm Segmented Planar Ge **or new BEGe**
- Compton-Suppressed Segmented Ge Clover
- Position-Sensitive MWPC



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The BEGe as delivered

Canberra 5020
delivered to
Liverpool

9/2012

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Baseline Energy Resolution Measurements

A comparison was made of the energy resolution between those taken at Liverpool and results obtained at DL in the original Canberra cryostat. Spectroscopic performance was measured using ^{241}Am and ^{137}Cs sources.

Liverpool

@ 60 keV: FWHM = 0.74 keV,
FWTM = 1.58 keV
@ 662 keV: FWHM = 1.30 keV,
FWTM = 2.44 keV

Measured using an Ortec 671 spec amp with 6μs shaping time and an Ortec 927 MCA using the Maestro software.The baseline noise directly out of the pre amp is approximately 5mV peak-to-peak.

Daresbury

@ 59.54 keV: FWHM = 0.75 keV,
FWTM = 1.58 keV
@ 662 keV: FWHM = 1.40 keV,
FWTM = 2.49 keV

Measured using an Ortec 570 spec amp with 6μs shaping time and a USB EasyMCA using the Maestro software.
The baseline noise directly out of the pre amp is approximately 2mV peak-to-peak.

Good performance!

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DL measurements with temporary cryostat

Concern that 3mm gap between crystal and outer can would cause noise issues.
Cryostat test head designed

Operating temperature 102K (top of cold finger)

End 2014

@ 59.54 keV: FWHM = 0.72 keV,
FWTM = 1.31 keV
@ 662 keV: FWHM = 1.36 keV,
FWTM = 2.44 keV

Measured using an Ortec 570 spec amp with 6μs shaping time and a USB EasyMCA using the Maestro software. The baseline noise directly out of the pre amp was again approximately 2mV peak-to-peak.

Still get good performance!

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Tasks: Design, Construction and testing

Tasks: Design, Construction and testing

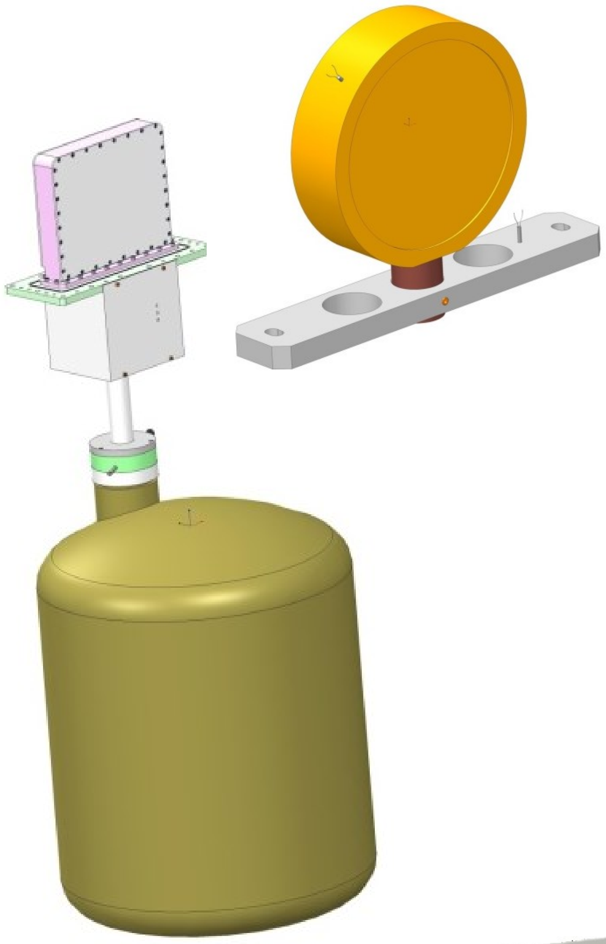
- Stripping down of original detector.
- Designing and manufacture new holding structure (GREAT compatible)
- Design of new cryostat
- Thermal modelling
- Design of electrical connections
- Assembly of detectors in new cryostat
- Thin window, Al and carbon fibre.
- Testing (Detector Assembly Laboratory Daresbury)

- Difficulties
  - Cooling
  - Vacuum
  - Details of cryogenic and electrical connections

- Close working relationship under NDA with Mirion (Canberra)

- Many techniques and methods learned
- Skills acquired

- From FDR to delivery took approximately 12 months



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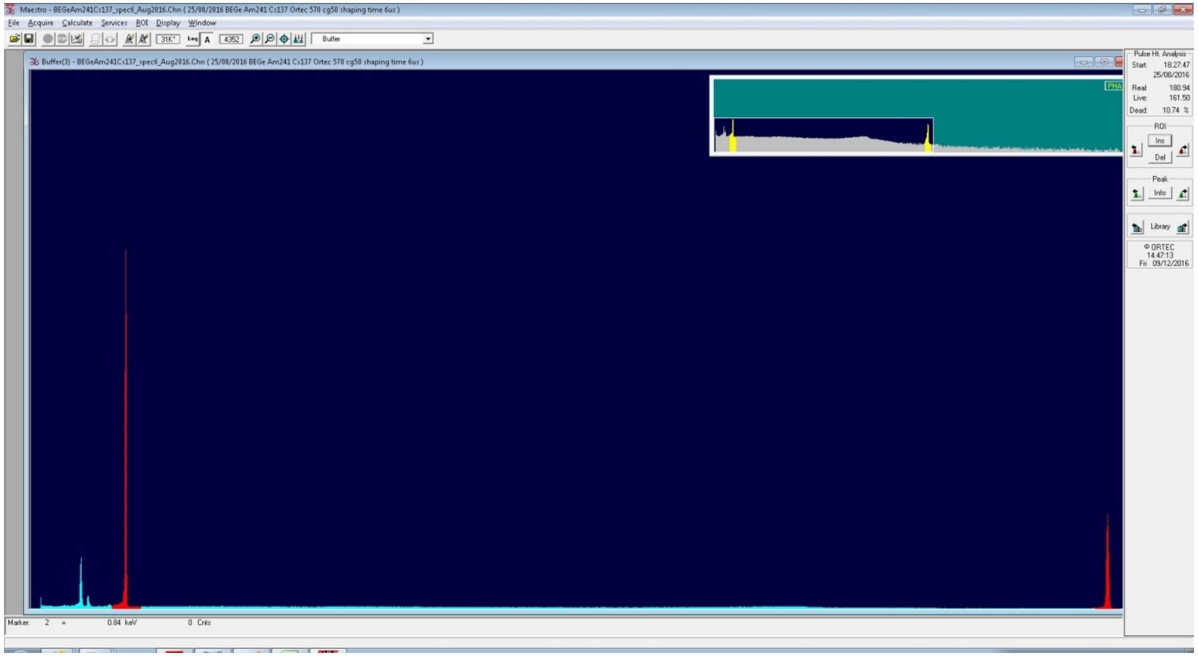
Test results- 1.00mm Aluminium Window

Baseline Energy Resolution Measurements in the new cryostat.

Spectroscopic performance was measured using 241Am and 137Cs sources.

Energy	FWHM	FWTM
^{241}Am @ 60 keV	0.70 keV	1.33 keV
^{137}Cs @ 662 keV	1.36 keV	2.58 keV

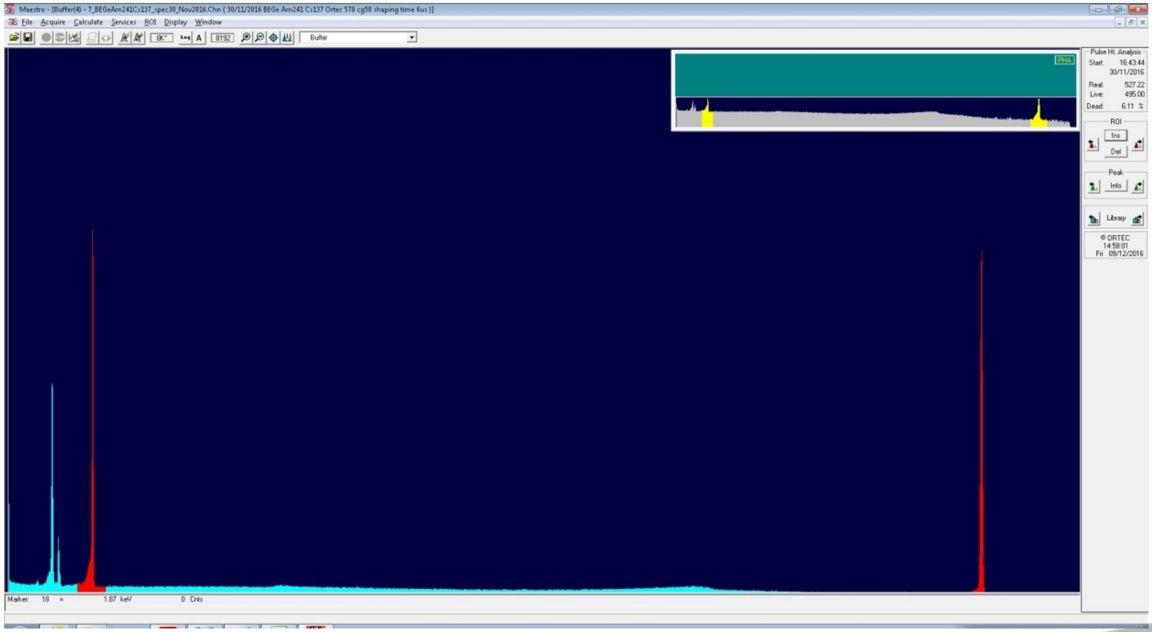


Test results 0.6mm Carbon Window

Spectroscopic performance was measured using 241Am and 137Cs sources.

Energy	FWHM	FWTM
^{241}Am @ 60 keV	0.71 keV	1.44 keV
^{137}Cs @ 662 keV	1.29 keV	2.45 keV
^{152}Eu @1408 keV	1.74 keV	3.37 keV

Measured using an Ortec 570 spec amp with 6μs shaping time and a USB EasyMCA using the Maestro software.



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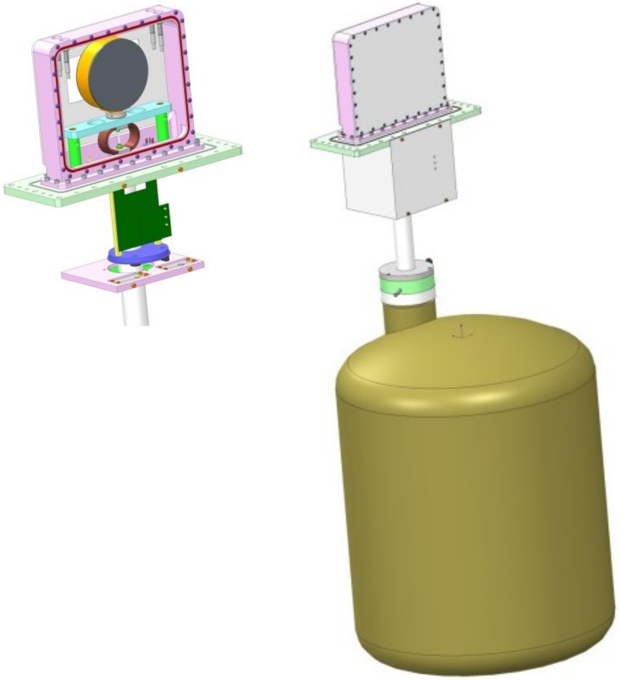
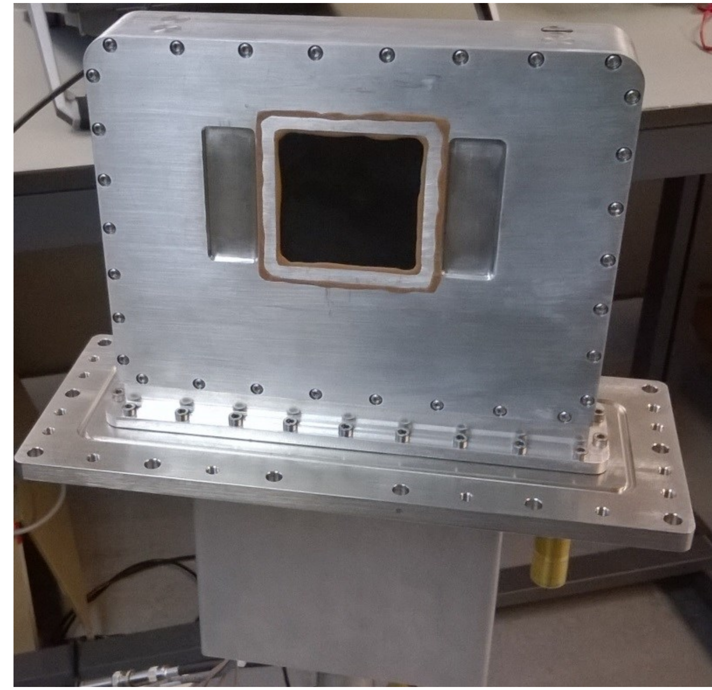
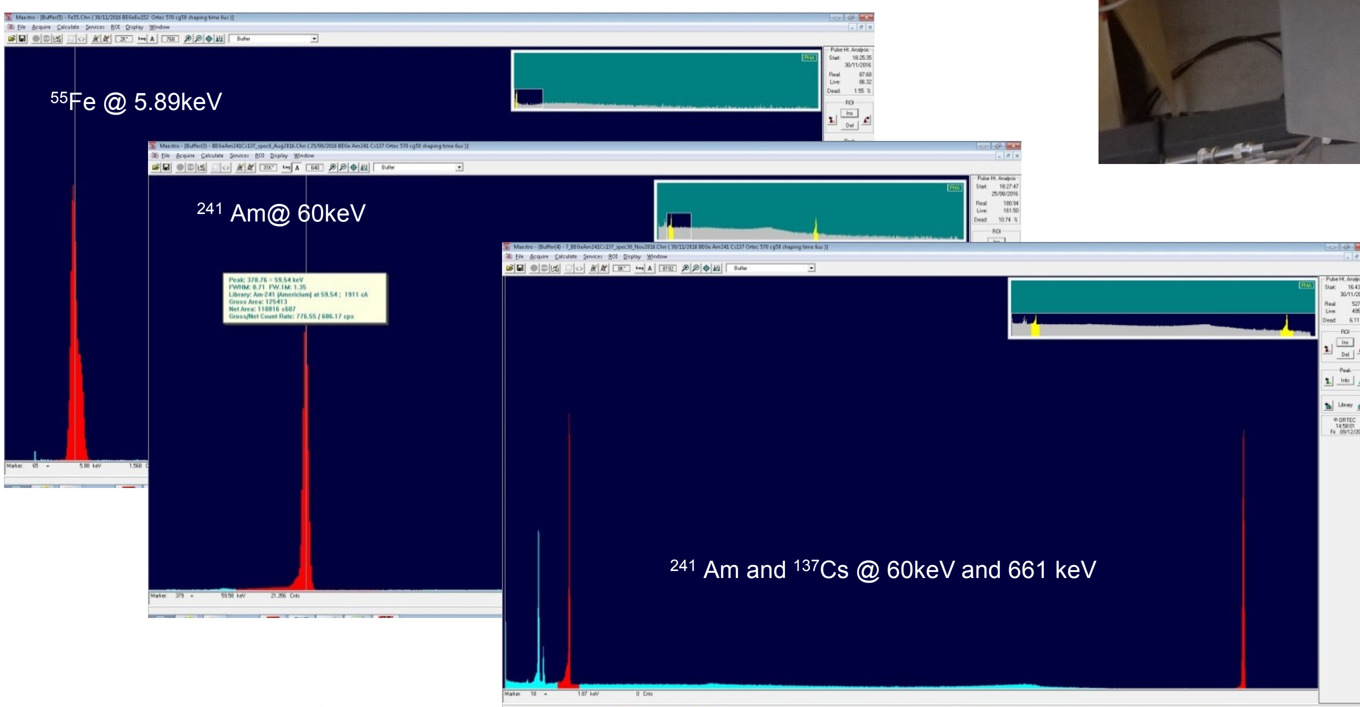
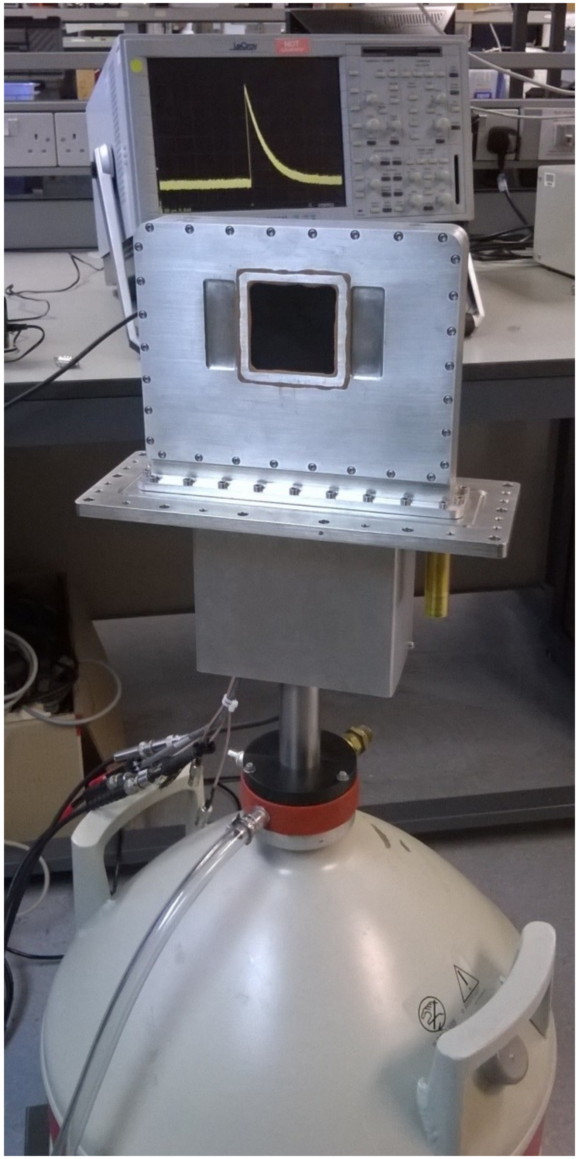
BEGe delivered Dec 2016







Post-delivery tests at Liverpool



	FWHM	FWTM
^{137}Cs	1.22	2.25
^{241}Am	0.64	1.18

Detector survived 20km journey

Next step is 3000km to Jyvaskyla!

THANKS

Nuclear Physics Groups at Daresbury and
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Projects and Mechanical Engineering Group Daresbury

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Paul Morrall
John Simpson

Andy Boston
Helen Boston
Laura Harkness-Brennan
Dan Judson
Paul Nolan
Carl Unsworth

Mirion advice