Characterization of BEGe detectors for GERDA

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27^{th} February 2012

bmb+f - Förderschwerpunkt
Astroteilchenphysik
Großgeräte der physikalischen Grundlagenforschung

GERDA

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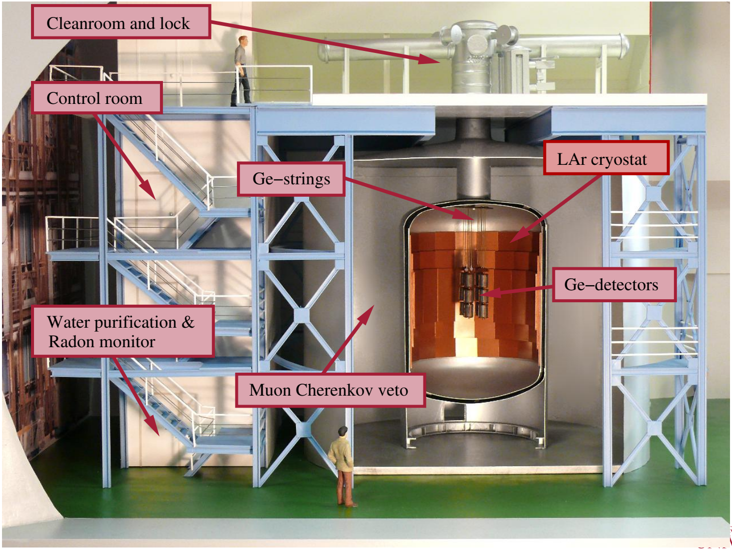
Germanium Detector Array (GERDA)



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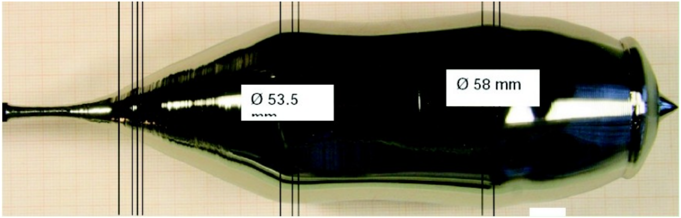
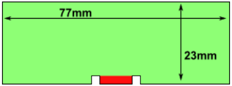
Why do we use Germanium

- ^{76}Ge decays via $2\nu\beta\beta$
  $\rightarrow 0\nu\beta\beta$ possible if it exists.
- High radio purity.
- Energy resolution FWHM 1.6 keV@1.3 MeV .
- Source and detector at the same time.
- Commercially used $\rightarrow$ Production well approved (Canberra).



Broad Energy Germanium Detector (BEGe)

- P-type Point Contact (PPC) germanium detector
- very small ($\varnothing 1 - 2$mm), point-like electrode contact
- PSA: Decoding of multi site events from the waveforms
- Determination of surface events. $\rightarrow$ Crucial for BG Reduction.
- Enrichment of Ge in ^{76}Ge.
- Phase II: BEGe detectors.
- Depleted BEGe detectors from the remaining material for testing.



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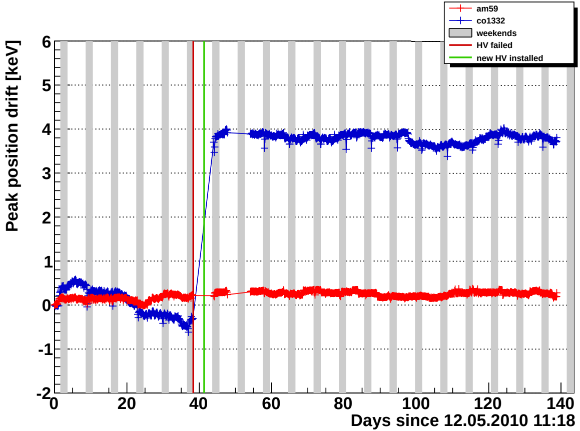
Stability measurements - centroid

Stability of line centroid: ^{241}Am 59 keV, ^{60}Co 1333 keV



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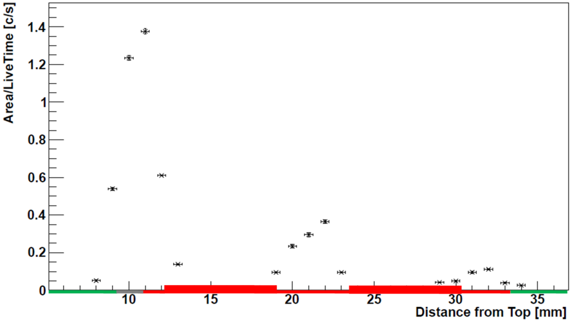
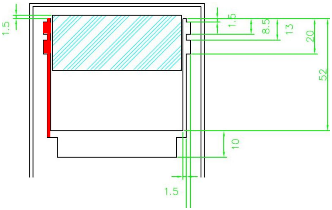
Surface scan

Sidescan: Collimated ^{241}Am source





- ^{241}Am source collimated to $\varnothing$ 1 mm
- In agreement with the technical drawing.

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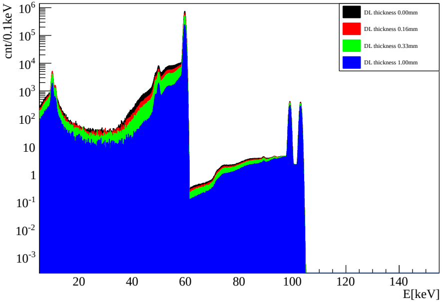
Dead Layer determination - Monte Carlo (MC)

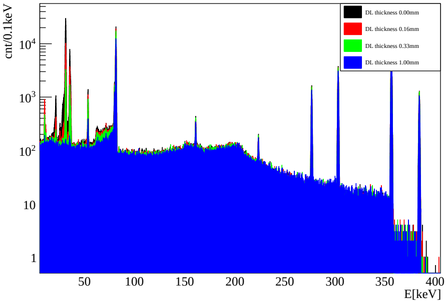
^{241}Am - MC



- MC: 60 keV, 99 keV, 103 keV
- Calculate the ratio:

$$\frac{\text{Area}(60\,\text{keV})}{\text{Area}(99\,\text{keV}) + \text{Area}(103\,\text{keV})}$$

^{133}Ba - MC



- MC: Ion decay
- Calculate the ratio:

$$\frac{\text{Area}(80\,\text{keV}) + \text{Area}(81\,\text{keV})}{\text{Area}(356\,\text{keV})}$$

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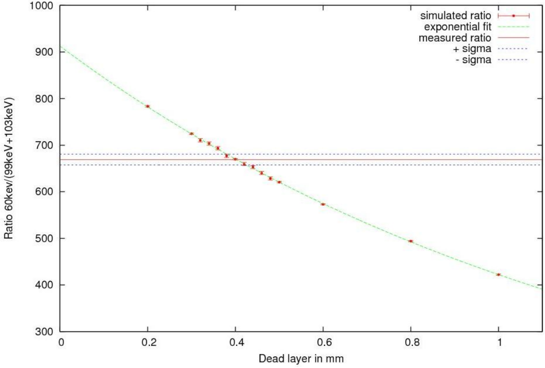
Dead Layer determination

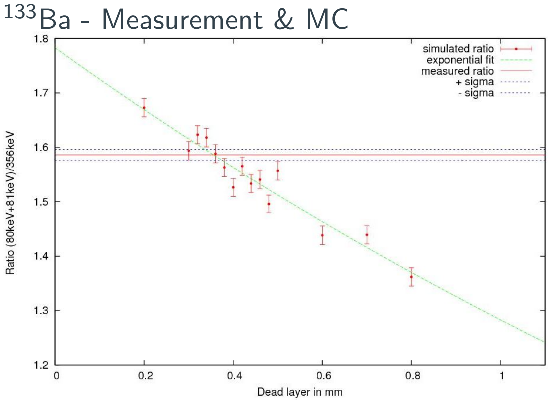
- MC with different DL thicknesses
- Comparison with measurement
- ^{241}Am: DL $\approx 0.4\,\mathrm{mm}$

^{241}Am - Measurement & MC



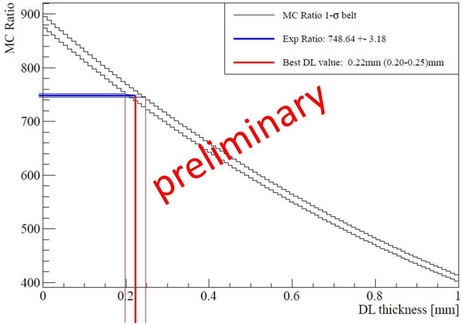
Dead Layer determination

- ^{133}Ba: DL $\approx$ 0.36 mm
- Large error due to MC
- Both in agreement with 0.35 mm stated my Canberra.

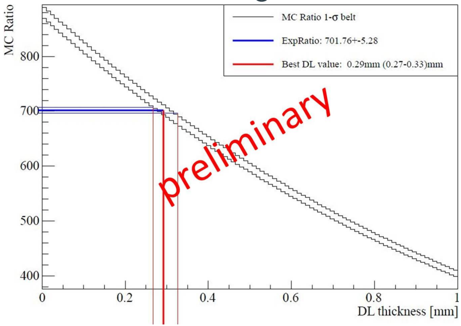


Dead Layer determination - postprocessing (pp)

^{241}Am - counting



^{241}Am - fitting



- MC is the most time consuming analysis step!
- Idea: Only one simulation of the whole crystal
- posterior cut events that occur in the Dead Layer
  $\rightarrow$ postprocessing

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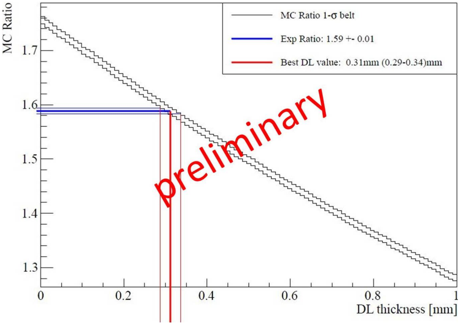
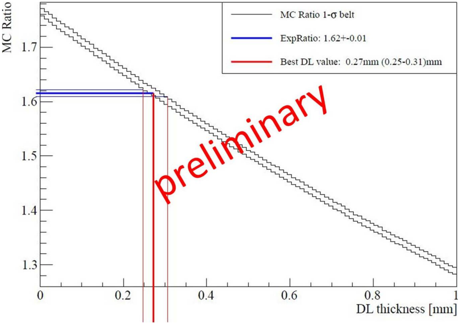
Dead Layer determination - postprocessing (pp)

^{133}Ba - DL pp counting



^{133}Ba - DL pp fitting



- Postprocessing needs fine tuning
- But: looks promissing

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Active Volume determination

Approach

- ^{241}Am and ^{133}Ba γ penetrate only the surface.
  Higher energys needed to "look" inside the crystal.
  $\rightarrow$ Potential bubble depletion.
- Measurement: ^{60}Co spectrum
- Comparison: Rate of 1333 keV line to MC

Issues

- Source geometry has to be very carefully implemented into MC.
- Activity of the source has to be well known.

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Active Volume determination

Possible Solution

- Better: Measure a ratio between lines
  to get rid of the uncertainty of the source activity.

- Solution: ^{228}Th spectrum has a high γ line of ^{208}Ta (2614 keV)
  Measurement of the double- to single-escape-peak ratio would be possible due to pair production.

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Summary

- BEGe detectors are stable → no significant drifts.
- Geometry of detector and holder can be checked with a collimated source → surface scan.
- Dead Layer determination is in agreement with DL stated by Canberra.
- MC postprocessing looks promising.
- AV determination with ^{228}Th will be further inverstigated.
- Successful testing of depleted BEGe detectors
- Transfer knowledge from depleted detectors to enriched detectors
- First enrichted detectors are being tested at SCK in Belgium
  → See also: Kai Freund T 109.1 → And the following talks...

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