Study of pulse shape discrimination for beta events on the n^+ contact with BEGe detectors.

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DPG Göttingen, t113.2; 27th February, 2012

Outline

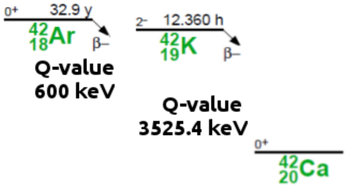
Introduction
- ^{42}K GERDA background
- Slow-Pulses on n^+ contact
- The A/E method.

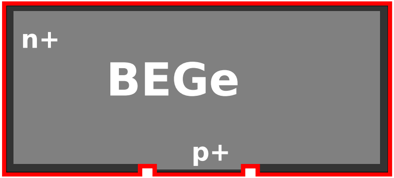
Measurements and results
- ^{90}Sr measurements
- ^{106}Ru measurements
- Summary.

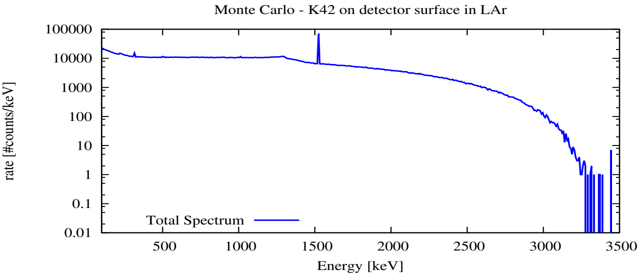
Simulated ^{42}K background suppression

Conclusion

Potential background problem for GERDA phase II.

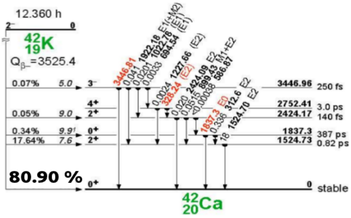


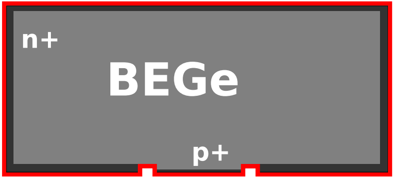


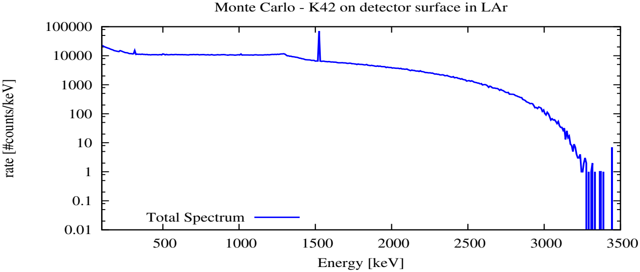


Simulation of a BEGe in liquid Ar with ^{42}K on the detector surface.

Potential background problem for GERDA phase II.







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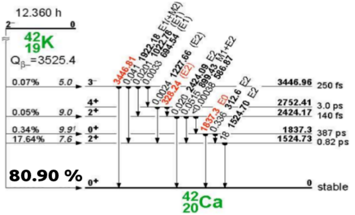
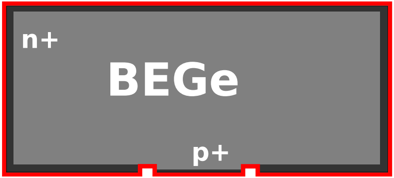
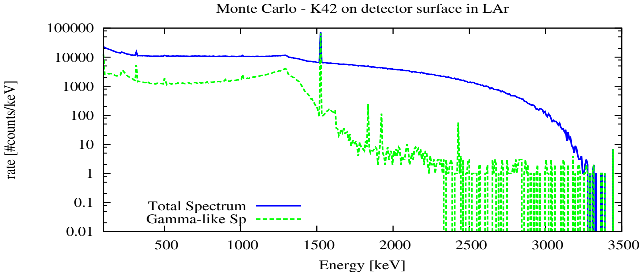
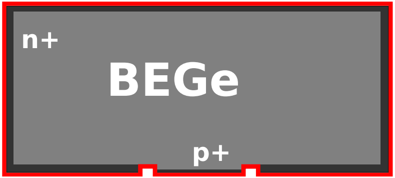


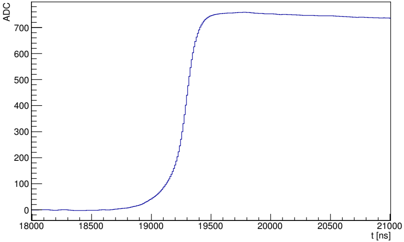




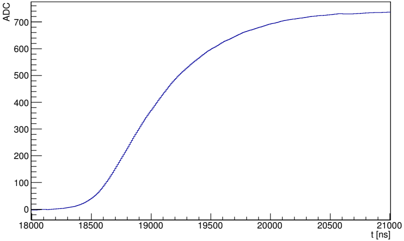
gamma-like ≡ event releasing energy only in the bulk.
It means no beta passing trough the dead layer.

Bulk and surface events





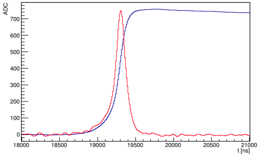
Example of typical single site bulk event.



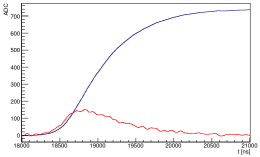
The signals from the n^+ contact have longer rise time.

The A/E method*.

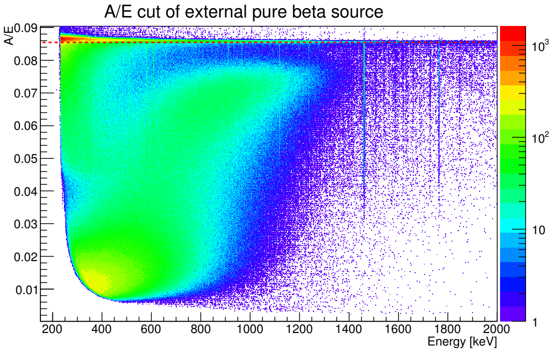
A $\equiv$ maximum value of the current.



For SSE A/E is constant.



The slow pulses stay under this line.



*see: JINST, 4 2009, P10007

Sources and detectors

Detector	Diameter [mm]	Thickness [mm]	Mass [kg]	DL [mm]
DD	74	32	0.700	0.45
CC	74.5	33	0.760	0.70
LD	71.5	50.5	1.018	0.60
BBS	75.1	30.7	0.734	0.50

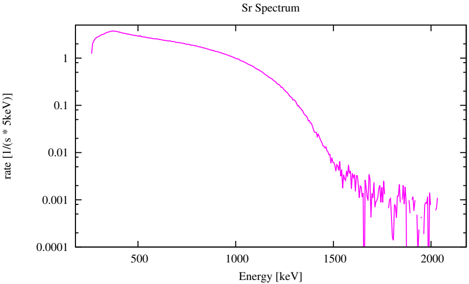
- Strontium pure beta source:
  - CC detector:
    0.70 mm dead layer with full aluminium cryostat end-cap.
  - DD detector:
    0.45 mm dead layer with full aluminium cryostat end-cap.
  - LD detector:
    0.60 mm dead layer with carbon epoxy thin entrance window.
- Ruthenium beta and gamma source:
  - BBS detector:
    0.5 mm dead layer with full aluminium cryostat end-cap.

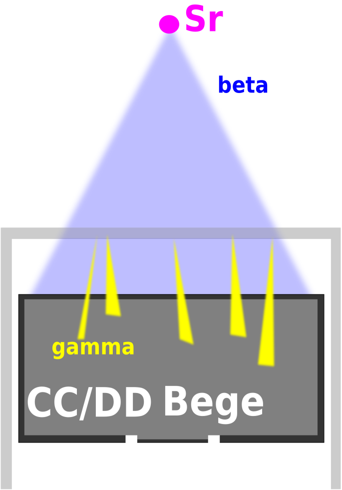
^{90}Sr measurements with CC&DD detectors

^{90}Sr source:

- Lower end-point,
- pure beta emitter,
- bremsstrahlung from Al end cap.

Simpler analysis, less systematics.
Tests in different set-ups.

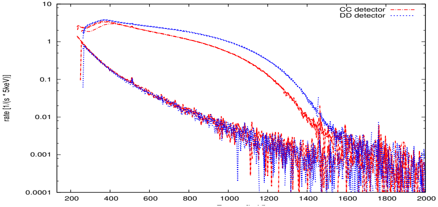


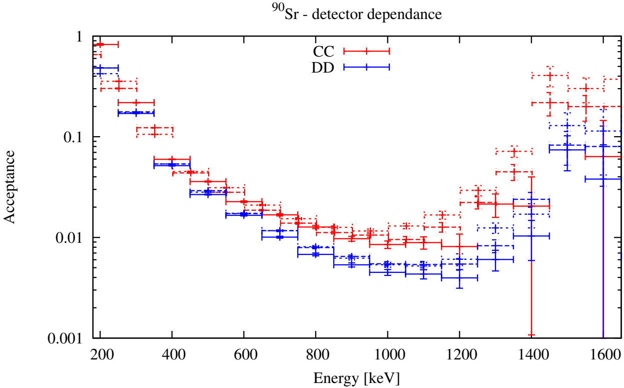


DD and CC
Bias Voltage and
Dead Layer dependence.

CC: 3.5,4.0,5.0 kV
DD: 4.0,4.5,5.0 kV

Dead Layer
CC:0.70 mm DD:0.45 mm



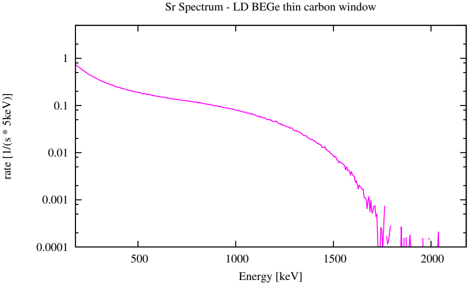


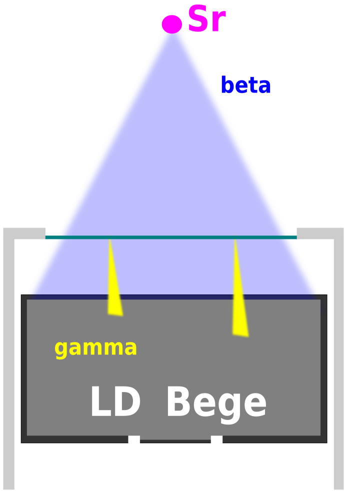
^{90}Sr measurements with low bremsstrahlung.

Measured with prototype low depleted *BEGe*.
Thin carbon epoxy entrance window.

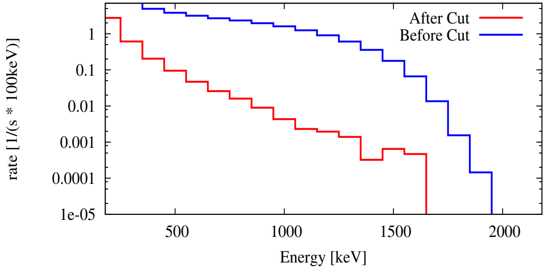
Less bremsstrahlung.

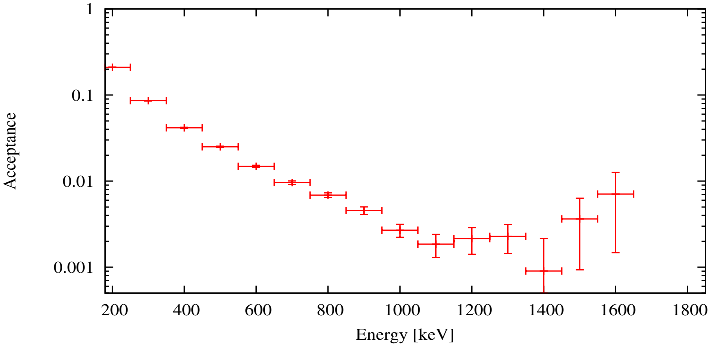
Higher end-point.





^{90}Sr rejection with *LD_BE*

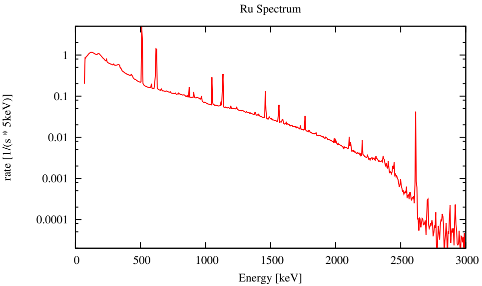


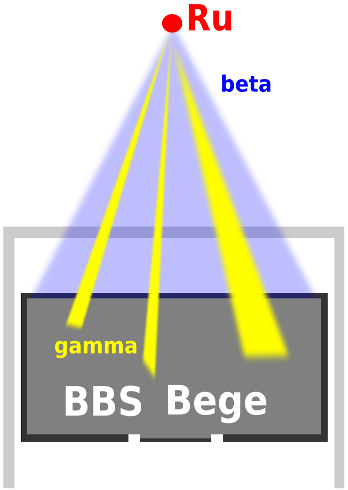


^{106}Ru measurements at $Q_{\beta\beta}$ energy.

^{106}Ru source:

- High end-point,
- Several gamma lines,
- Compton continuum.



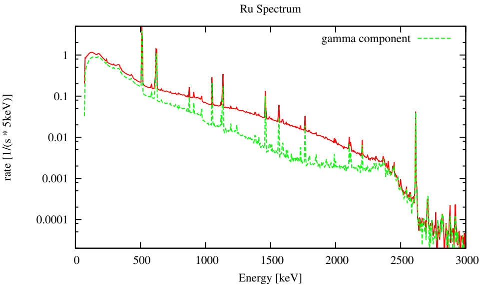


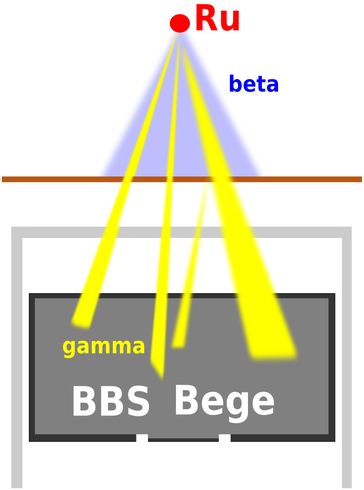
^{106}Ru measurements at $Q_{\beta\beta}$ energy.

^{106}Ru source:

- High end-point,
- Several gamma lines,
- Compton continuum.

Copper layer to stop betas
and to measure the gamma component.



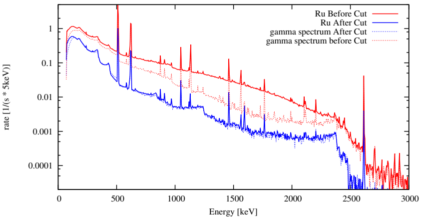


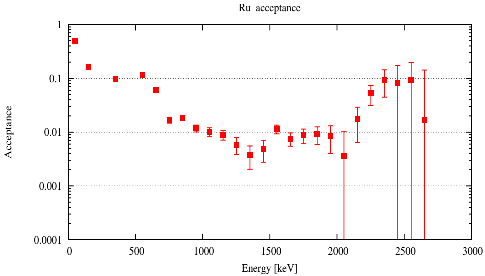
^{106}Ru rejection with BBS BEGe.

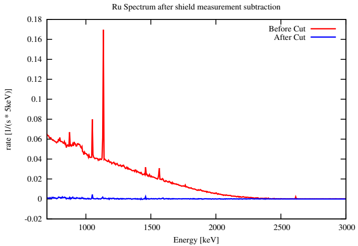
BBS detector.

Shield measurement for γ component subtraction.

Same residual spectrum with and without shield.







^{106}Ru rejection with BBS BEGe.

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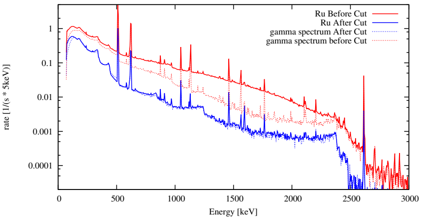
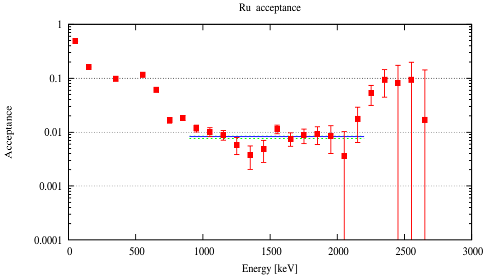
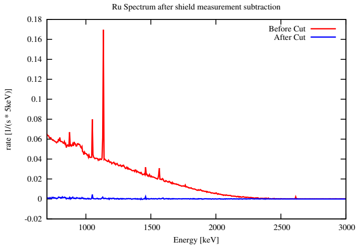
Shield measurement for γ component subtraction.

Same residual spectrum with and without shield.

Stable acceptance above 1 MeV

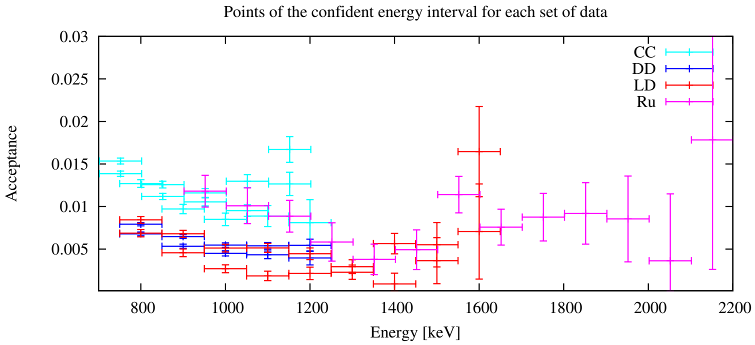






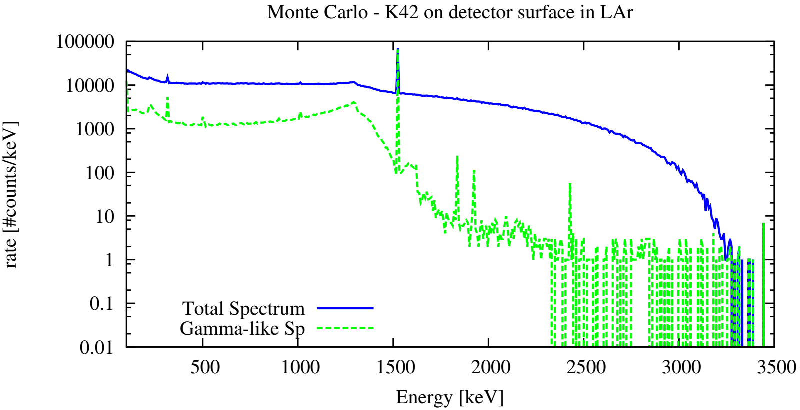
Summary

	DL [mm]	E[MeV]	Acceptance	Comments
DD Sr	0.45	0.8 - 1.2	$6.08 \pm 0.07\ 10^{-3}$	Al end cap bremsstrahlung
CC Sr	0.70	0.8 - 1.2	$12.7 \pm 0.1\ 10^{-3}$	Al end cap and 0.7 mm DL
LD Sr	0.60	0.8 - 1.6	$3.5 \pm 0.2\ 10^{-3}$	non standard *BEGe*
BBS Ru	0.5	1.0 - 2.5	$8.8 \pm 0.7\ 10^{-3}$	direct γ background



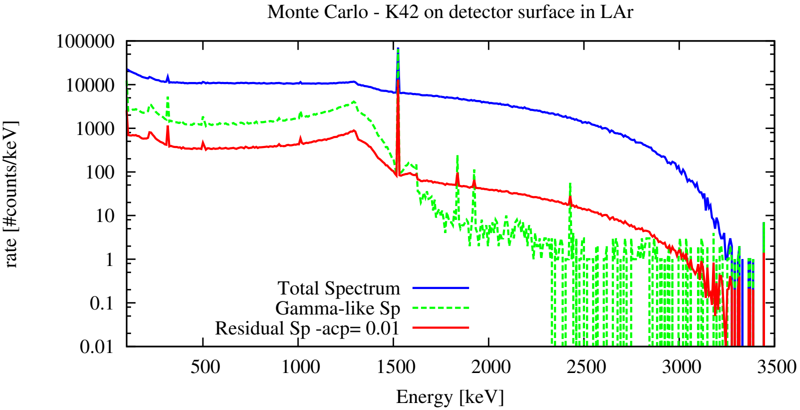
^{42}K in LAr simulation

Estimation of background rejection, combining Slow pulse and MSE discrimination.



^{42}K in LAr simulation

Residual background after 0.01 cut of beta-like and 0.2 cut of gamma-like events.



Total BI of phase I $=$ 0.016 counts/(keV kg y)

Potential ^{42}K BI after PSD in phase II $<$ 0.00016 counts/(keV kg y)

Conclusion

DONE:

- Characterization of BEGe detectors response to interactions in the n^+ contact.
- Study of external beta backgrounds suppression with A/E PSD method: evaluated suppression factor > 100 for all the detectors tested in different set-ups.
- Potential reduction of ^{42}K background for GERDA phase II within specifications.

ON GOING:

- Test with bare *BEGe* in liquid argon spiked in ^{42}Ar (LArGe).

TO COME:

- Test with GERDA phase II electronics