BEGe detectors in GERDA Phase I:
performance, physics analysis and surface events

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on behalf of the GERDA collaboration

Chair for Experimental Physics
and Astroparticle Physics

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Outline

BEGe in GERDA Phase I

Background from external β-emitter

PSD for n+ surface events

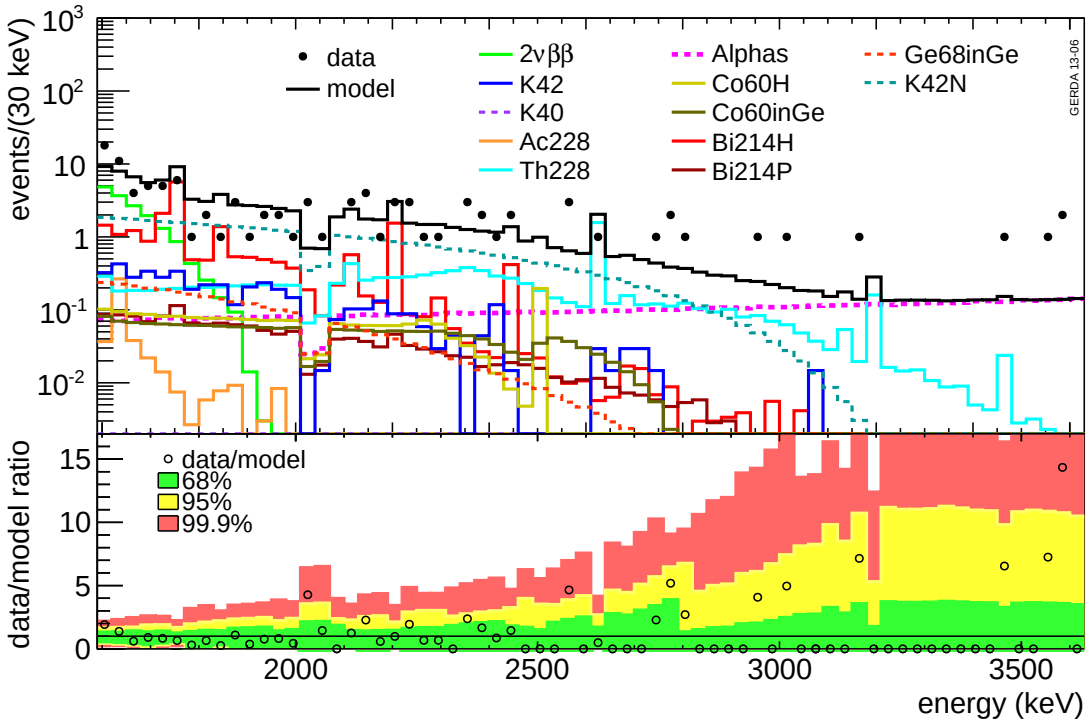
BEGe PSD in GERDA Phase I

Toward Phase II

BEGe in Phase I

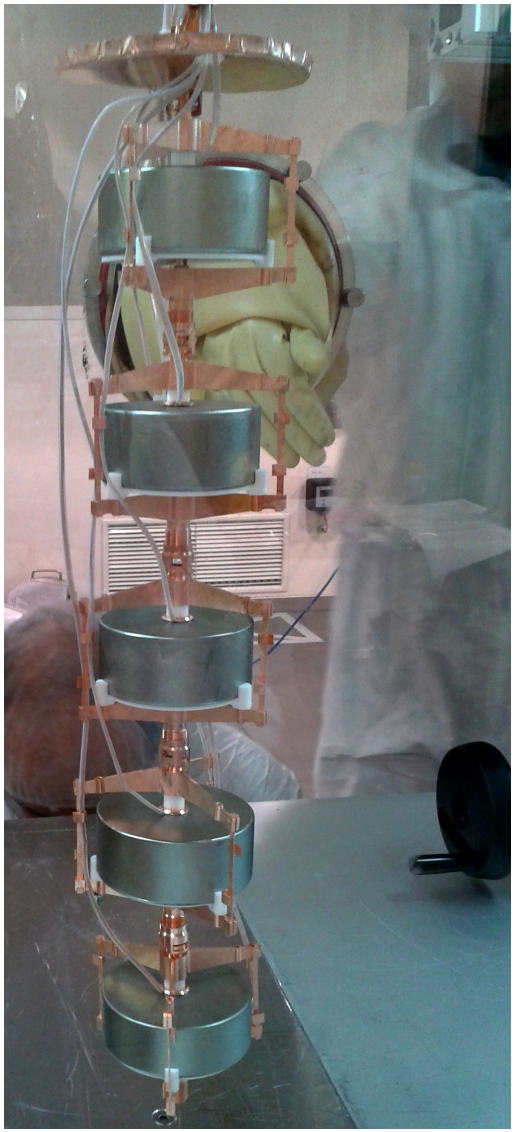
Background study

BEGe data set: 10% the exposure (2.4 of $\sim 20\ kg \cdot yr$)



Background index w/o PSD: 4.2 10^{-2} cts/(keV · kg · y)

^{42}K on the surface is the dominant component in ROI.



BEGe in Phase I

Background study

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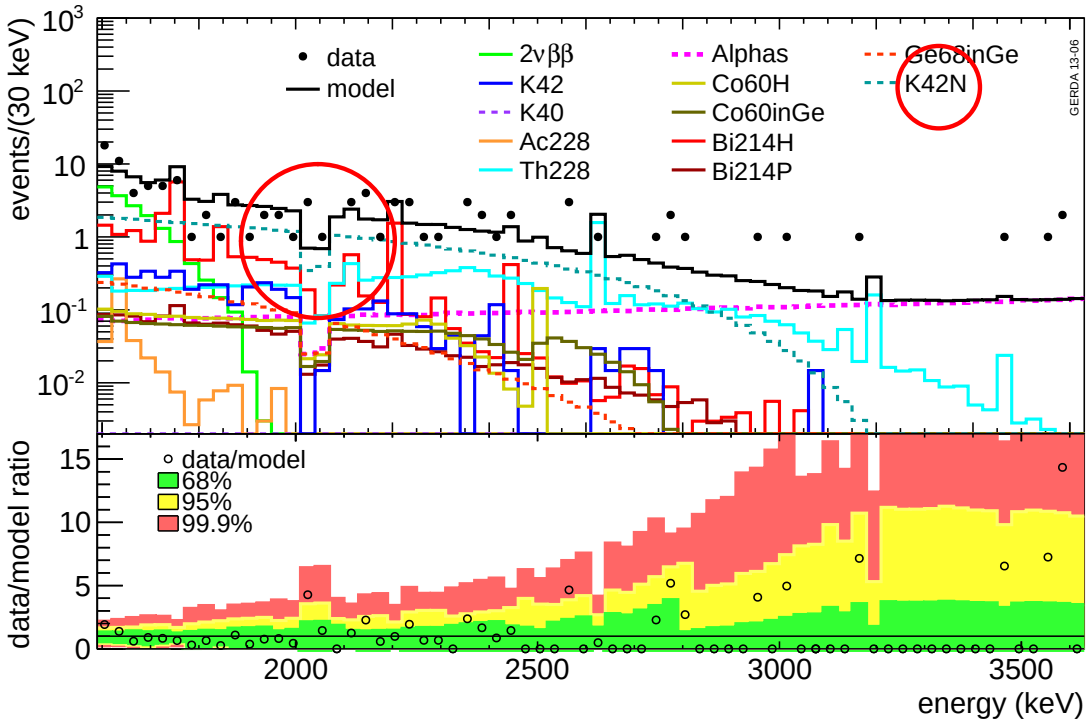

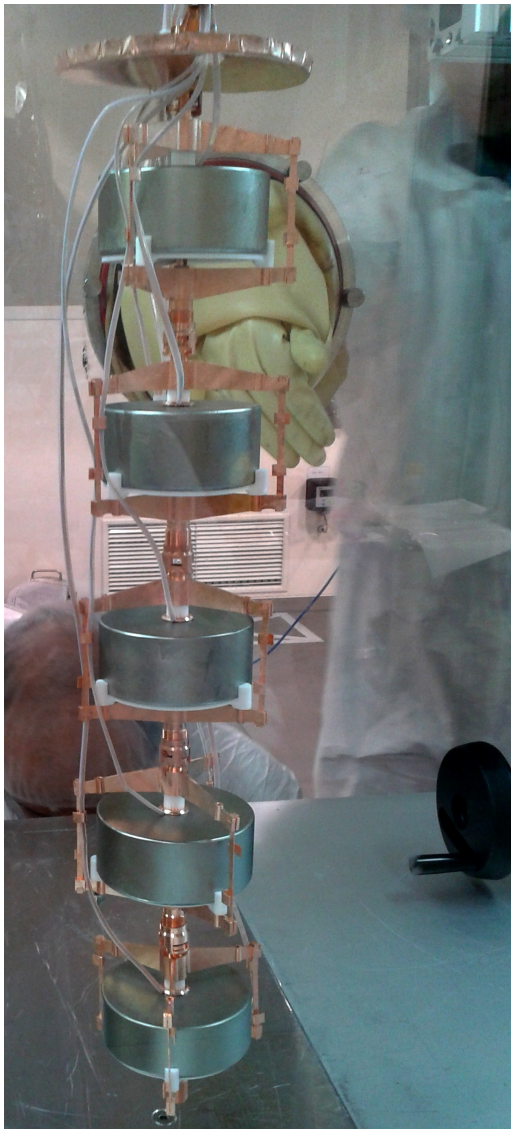

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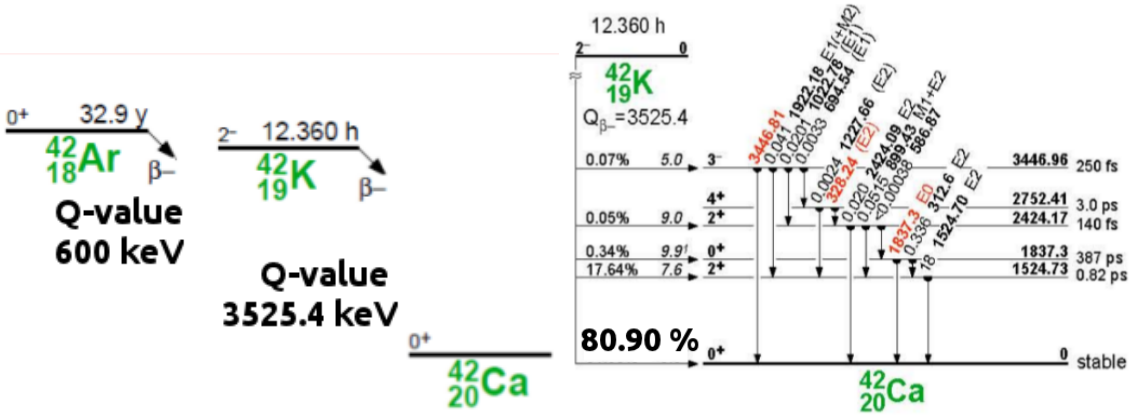
^{42}K in GERDA



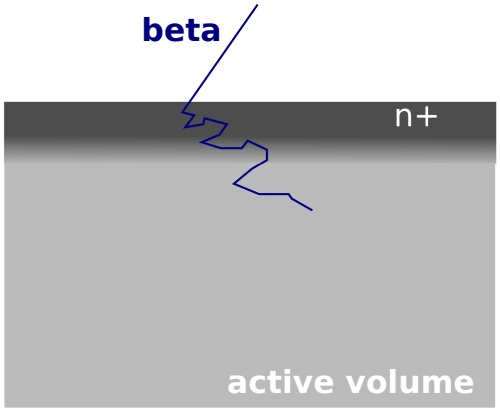
^{42}Ar cosmogenic, long half-life

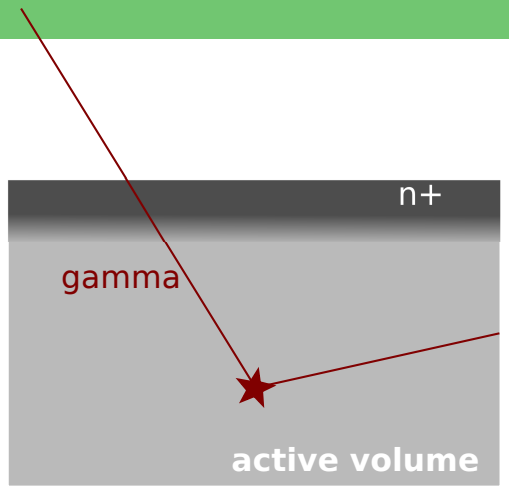
^{42}K beta emitter $Q = 3.5MeV$

Locate on detector surfaces

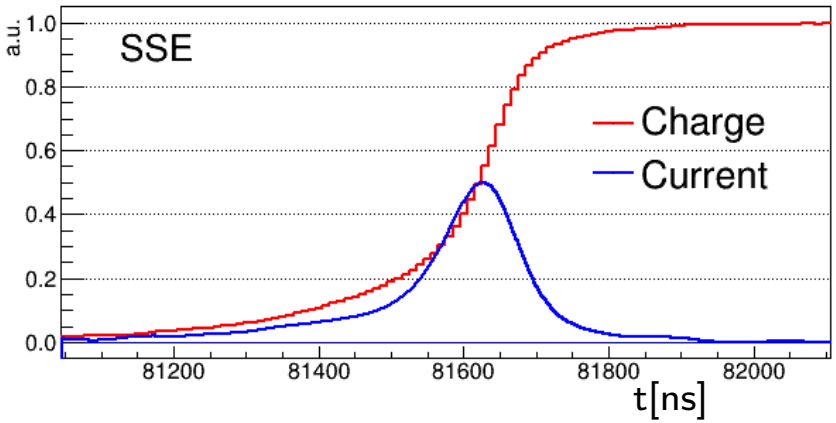
Phase I solution

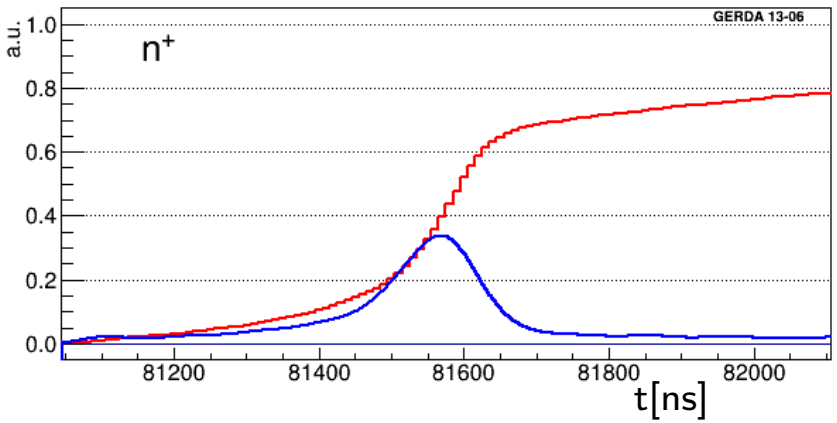
Surface β PSD





Dead Layer	Transition	Active volume
high Li concentration	gradient n doping	high E field
no charge collection	slow thermal diffusion	fast charges drift





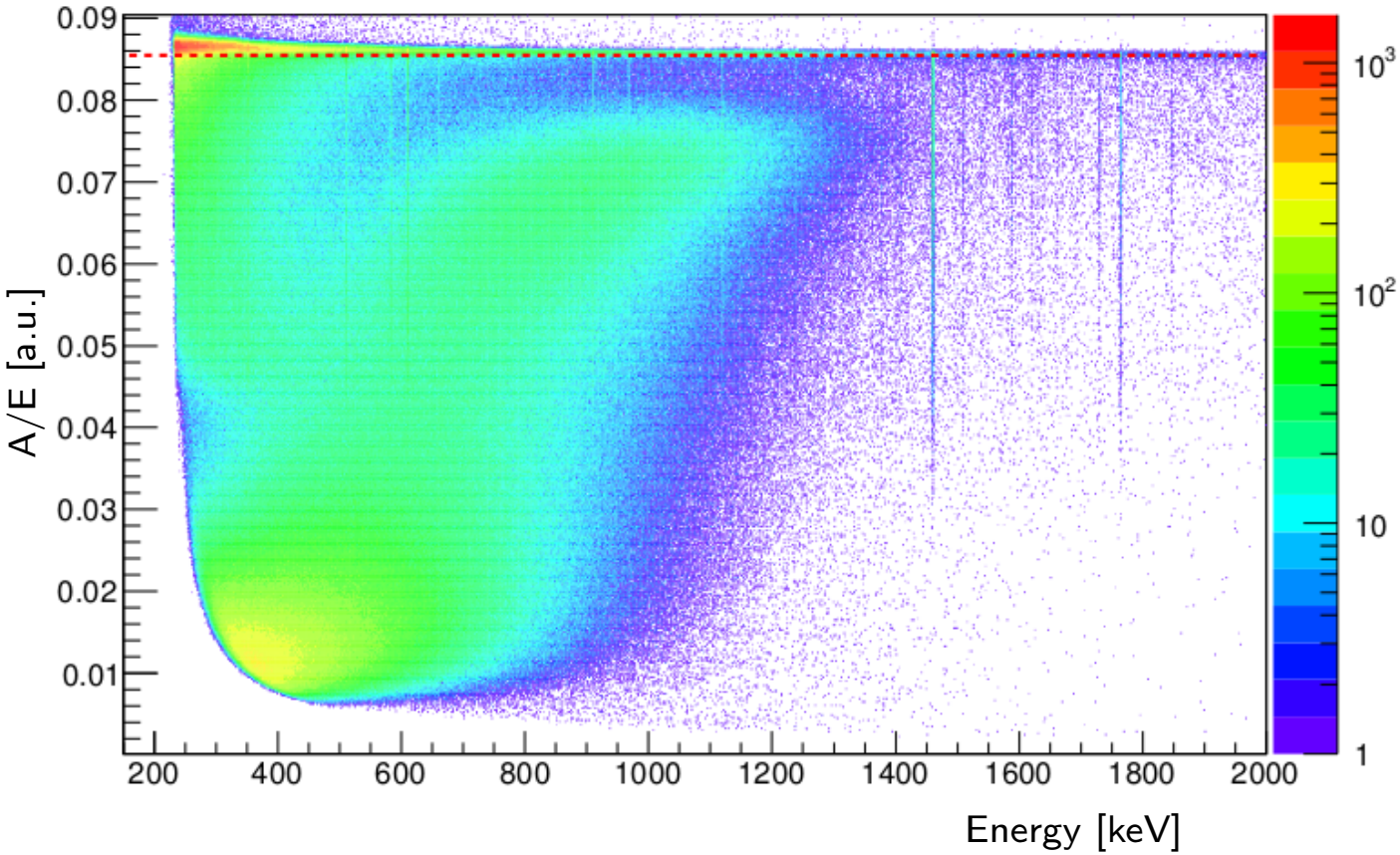
A/E distribution for betas

Lower A/E than SSE

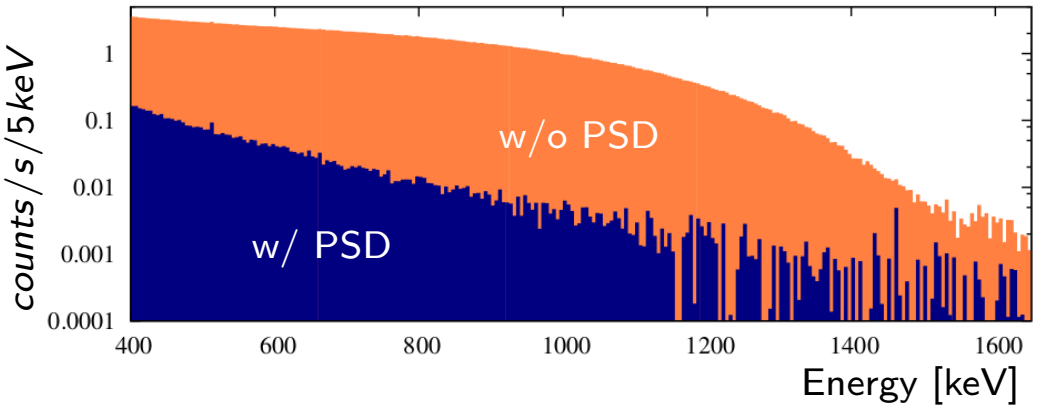
Small gap at high energies

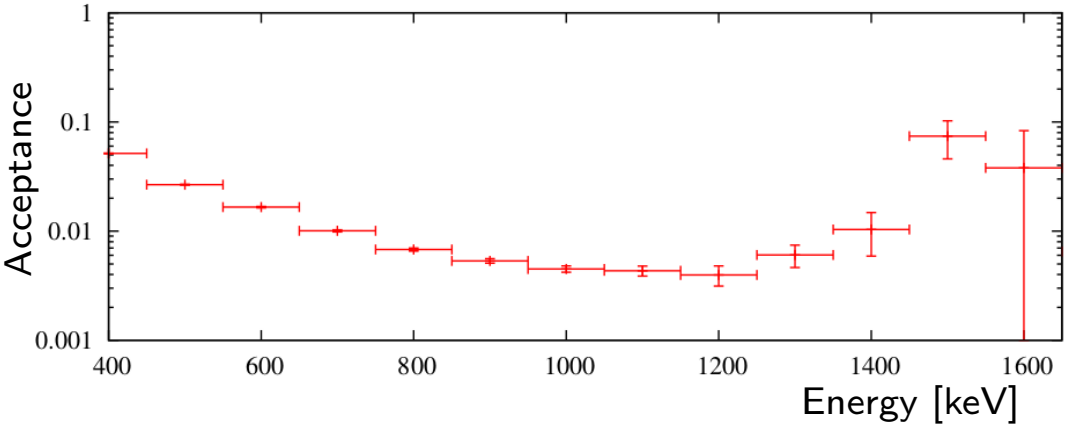
Same region of MSE

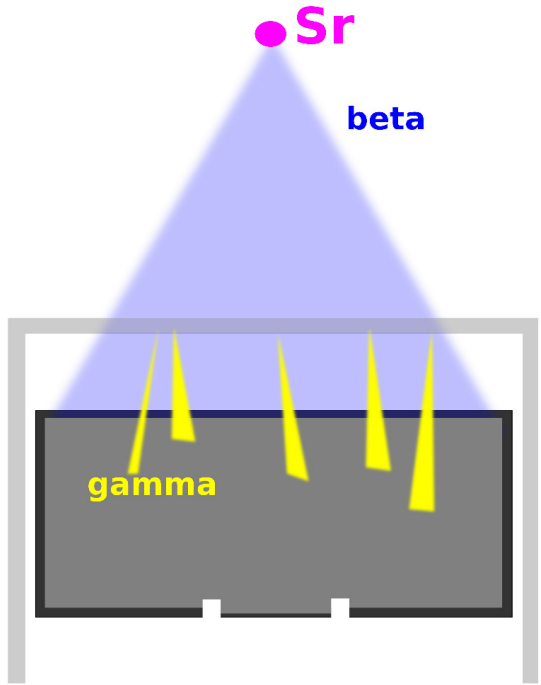
Performances depends on A/E resolution

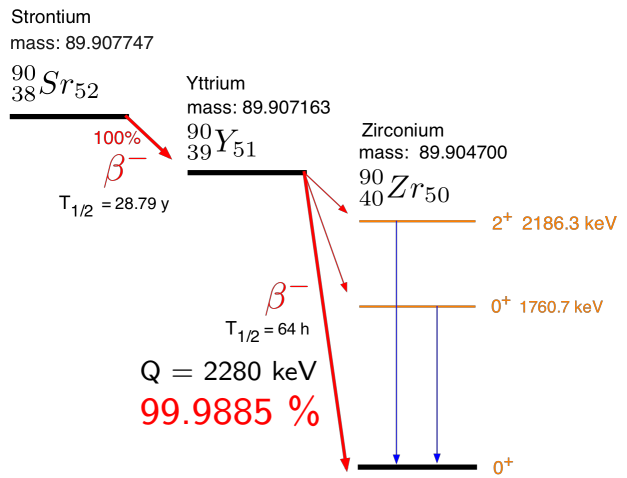


β rejection in vacuum cryostat





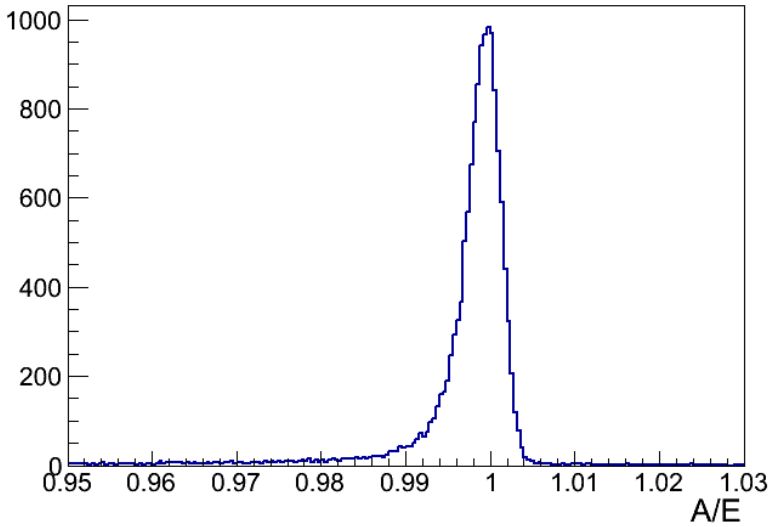




Survival spectrum compatible with MC bremsstrahlung SSE.

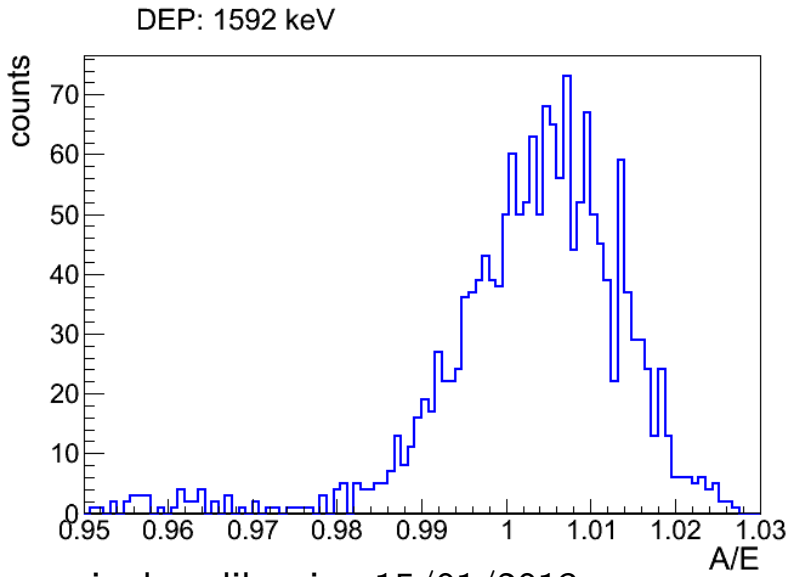
Gerda A/E resolution

BEGe in vacuum cryostat



FWHM 0.5% – 1%

BEGe in GERDA Phase I

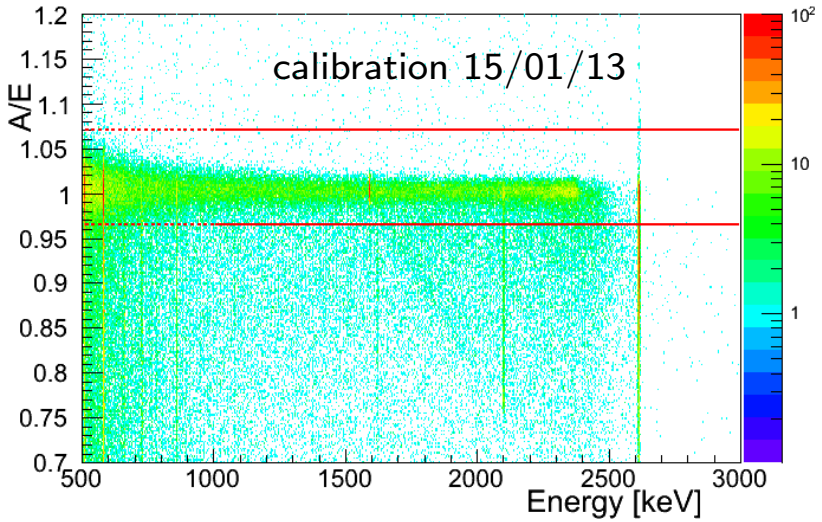


single calibration 15/01/2013

FWHM $\sim$ 1.6%

The goal for Phase II is FWHM $< 1.0\%$

PSD cut definition



Phase I conservative cut:

$$0.965 < A/E < 1.07$$

$0\nu\beta\beta$ acceptance 92% $\pm$ 2

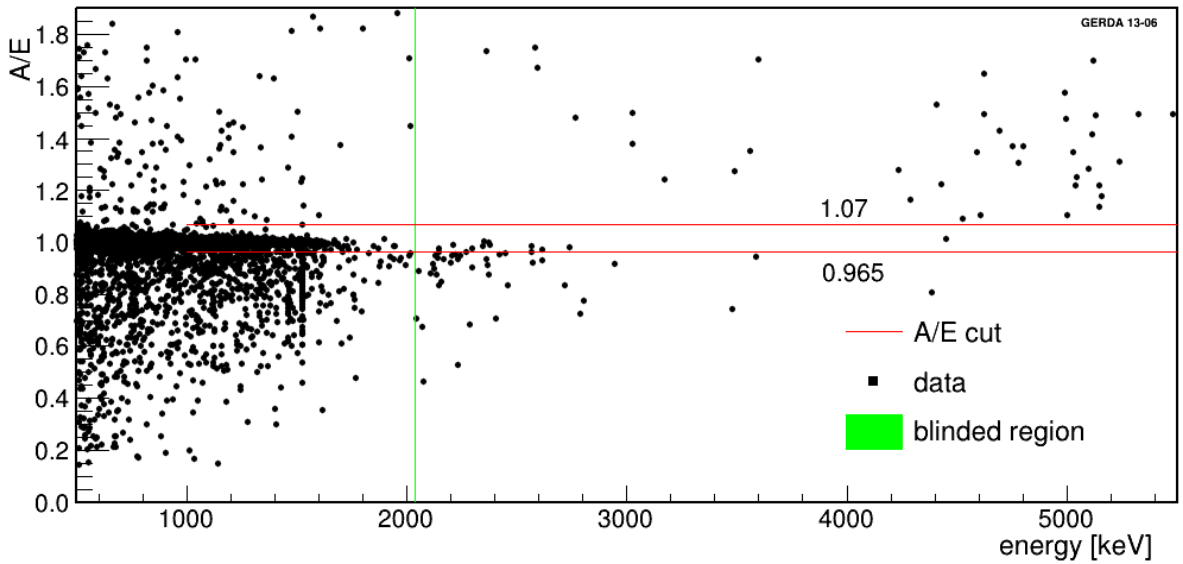
Background index:

$42 \cdot 10^{-3}$ cts/(keV $\cdot$ kg $\cdot$ y) before PSD

$5 \cdot 10^{-3}$ cts/(keV $\cdot$ kg $\cdot$ y) after PSD

^{228}Th calibration	with PSD
DEP 1592 keV	93.1%$\pm$0.3
FEP 1621 keV	22.0%$\pm$0.8

Physics data	with PSD
FEP 1525 keV	29.0%$\pm$0.5
1839–2230 keV	7/40
$2\nu\beta\beta$	91$\pm$5



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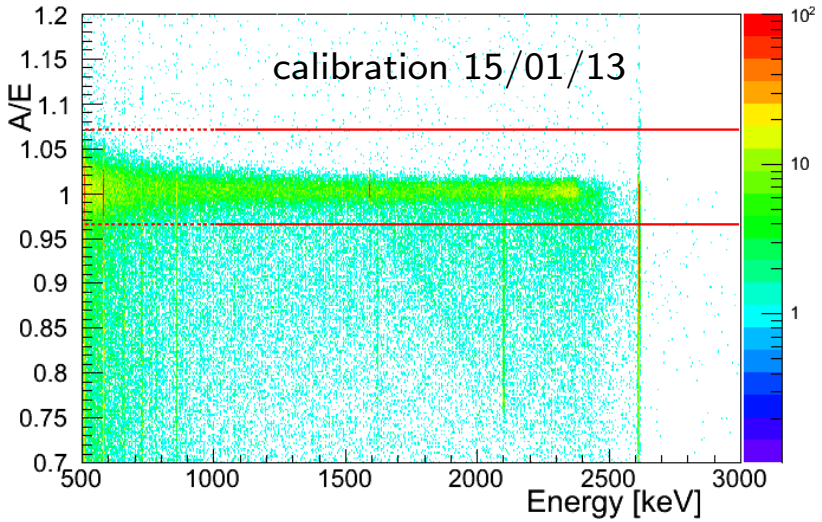

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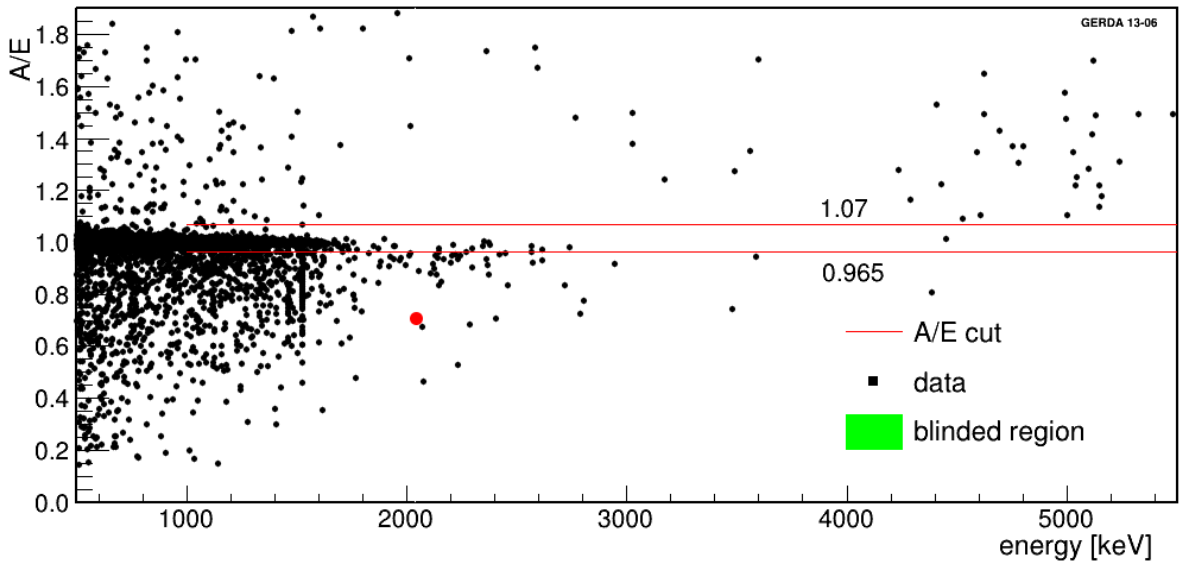
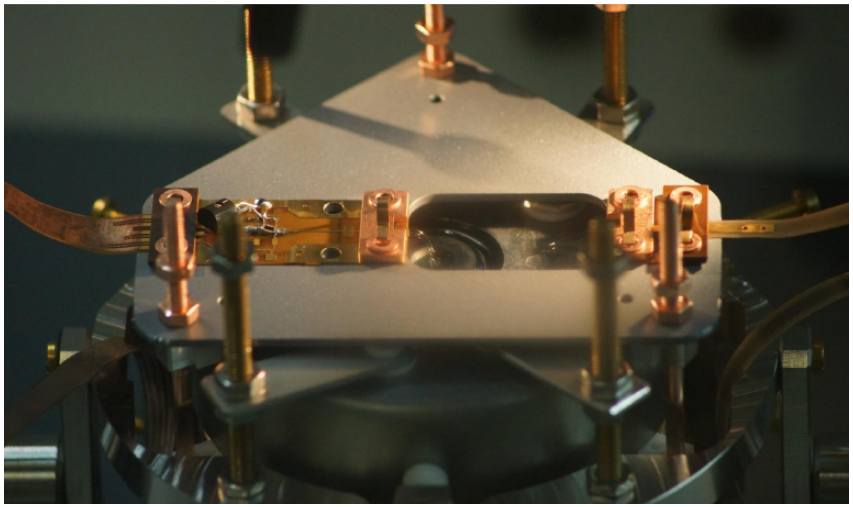


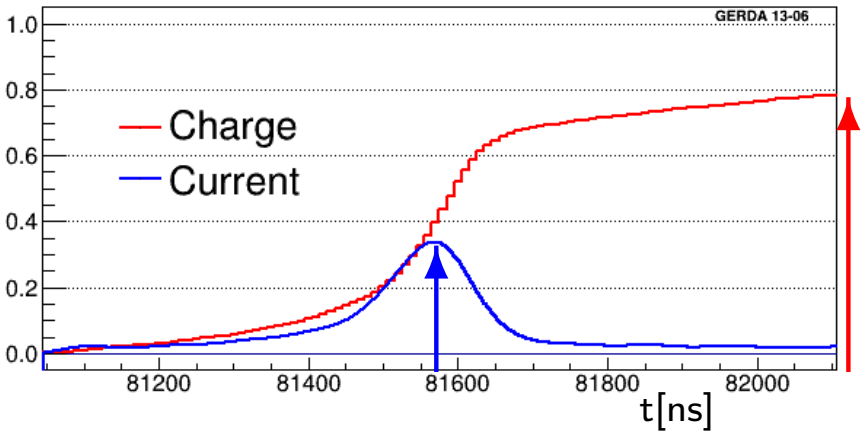
New frond end apparatus:



Optimization for BEGe and PSD

Close pre-amp, less noise

Details in the next talk (HK 15.5)



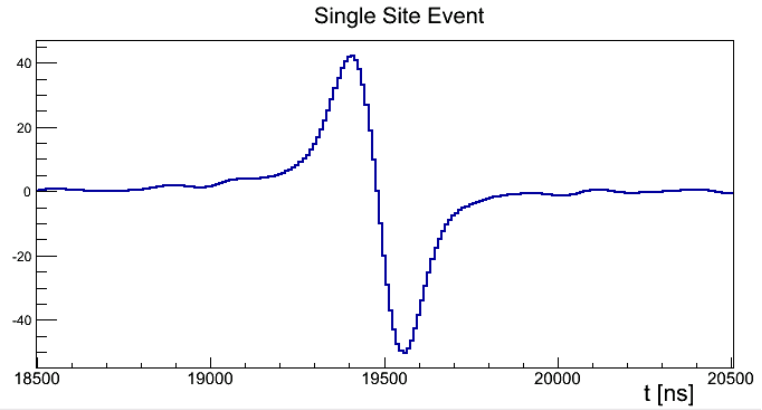
Improving PSD:

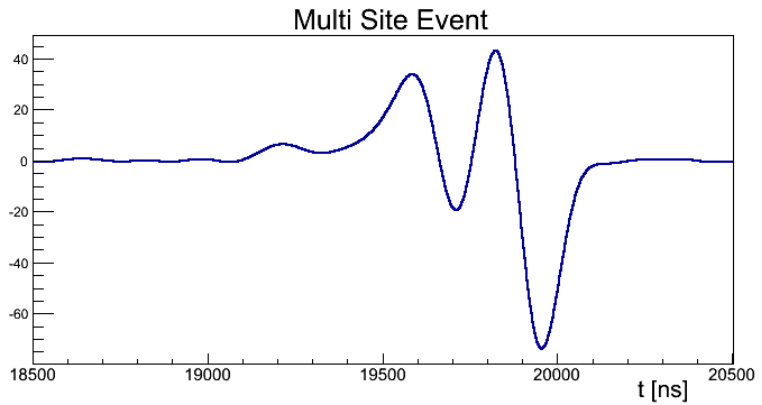
A/E based on a locale information

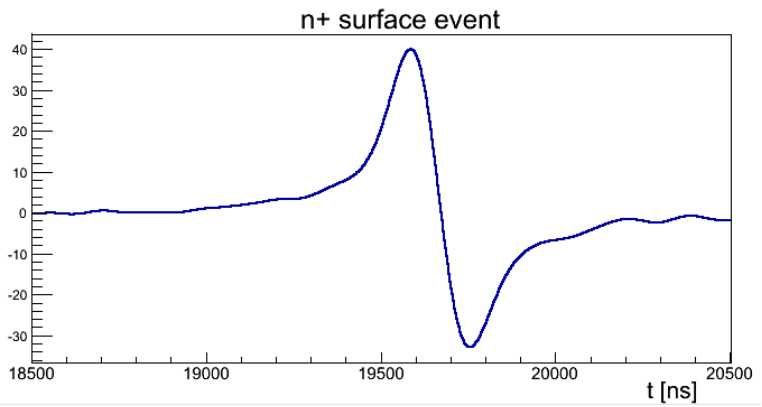
increase sensitivity on pulse tail

distinguish MSE and surface events

New Classification [WORK IN PROGRESS]







Second derivative charge signal:

Resolve the number of interaction:

- Δt max–min
- trigger on MSE-oscillations

Ratio minimum/maximum:

- max $\propto$ energy (for SSE)
- min relate to the tail shape

Conclusions

The first set of BEGe detectors have been operated in GERDA.
No unforeseen contaminations have been measured.

With a conservative PSD, 92% acceptance of $0\nu\beta\beta$, we reach:

$$5 \cdot 10^{-3} \text{ cts}/(\text{keV} \cdot \text{kg} \cdot \text{y})$$

^{42}K is the challenge for Phase II.
A/E method will reduce it below Phase II goal.
Other background sources will be further veto by liquid Ar scintillation.