Status of the GERDA Experiment

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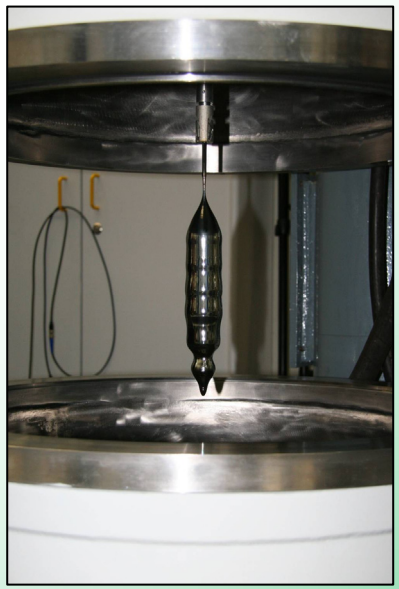
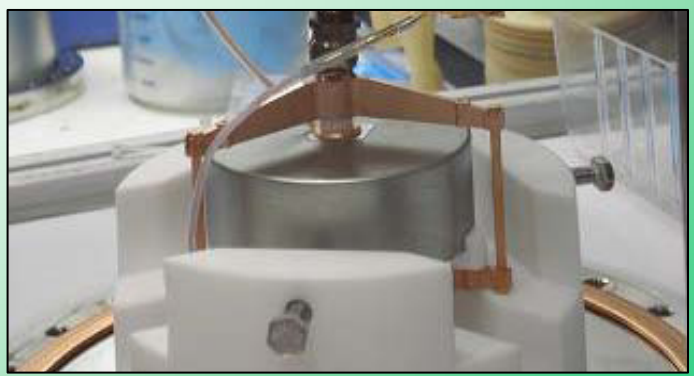
OUTLINE:

- A short GERDA history: Design and construction
- First background data: Understand the unexpected
- Background mitigation: control the unexpected
- First results with enriched detectors
- Installation of Phase I detectors: start of physics runs
- Plans for phase II: new detectors

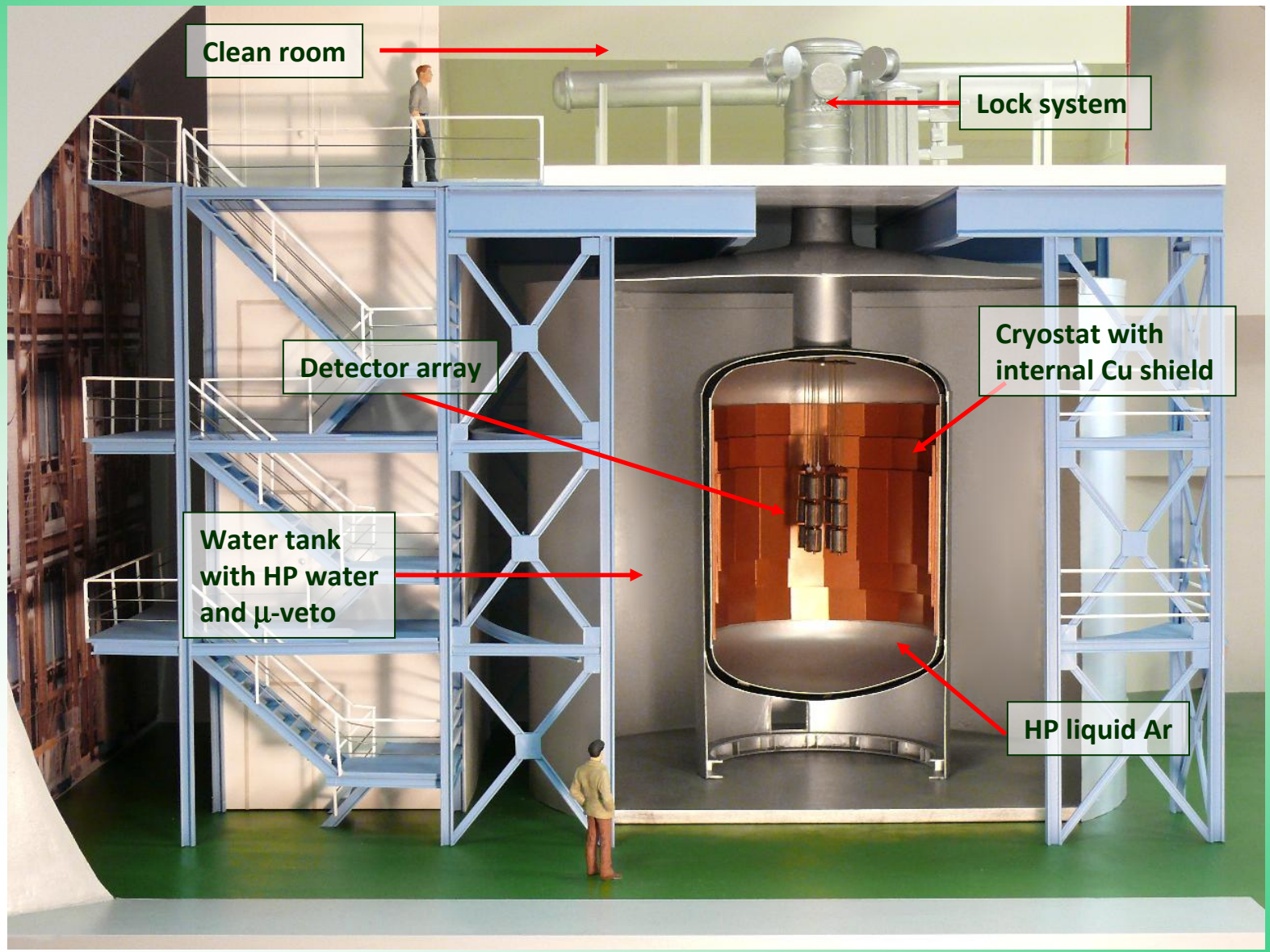
GERDA design: Use HP ^{76}Ge detectors

Source = ^{76}Ge = Detector	High signal detection efficiency
Detector material very pure (zone refinement, Czochralski growth)	Very low intrinsic internal background
Very good energy resolution	Background due to 2νββ decay negligible
Considerable experience	Industrial production, improvements possible
Natural abundance of ^{76}Ge 7,44%	Enrichment necessary

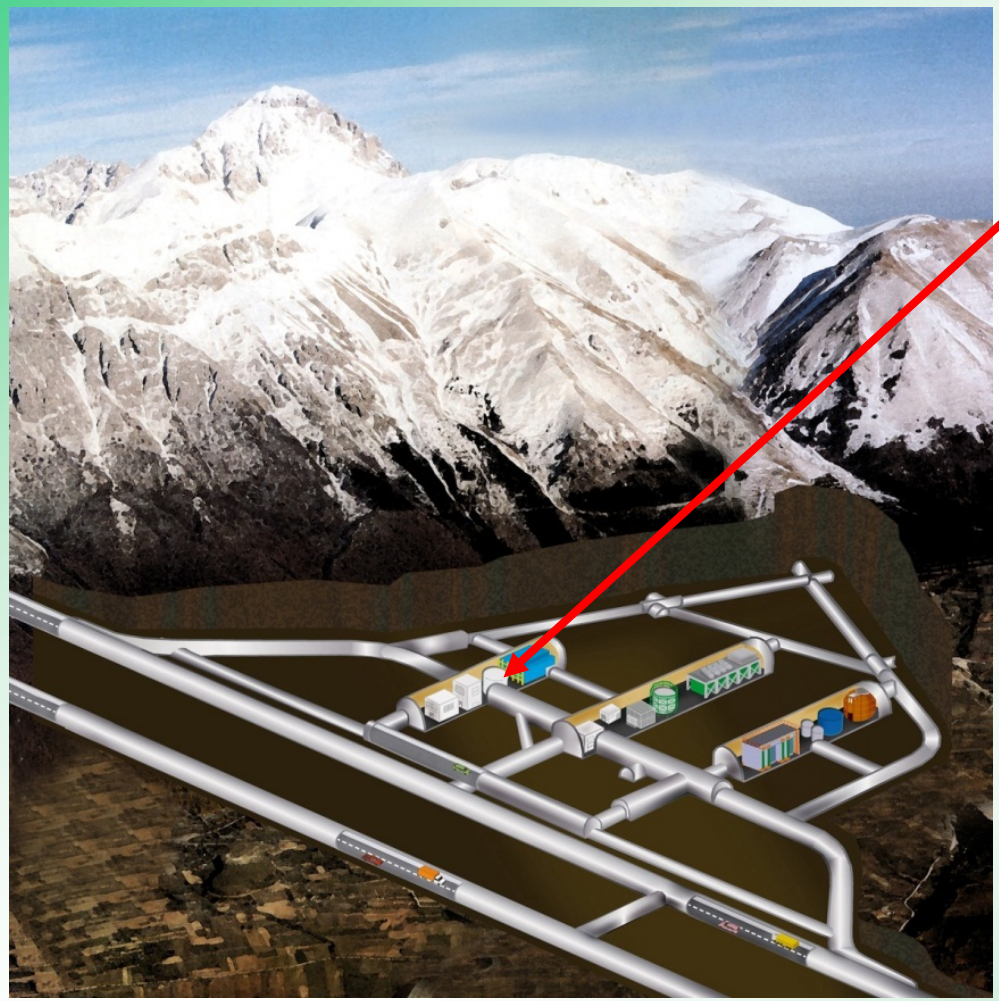




GERDA design:



GERDA design:

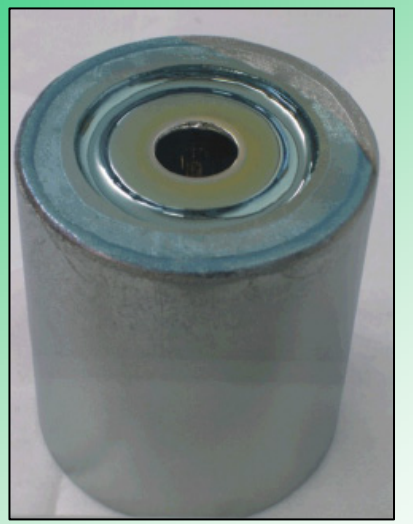


Location: Hall A of LNGS, Assergi, Italy
3500 mwe

Phase I: Use HdM and IGEX detectors
Phase II: Convert 37.5 kg of enriched germanium (87% ^{76}Ge) into detectors

GERDA design:

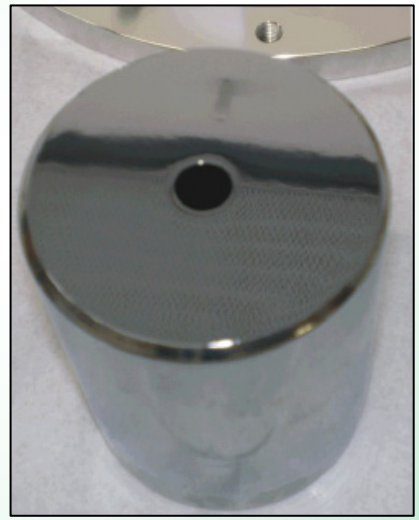
phase I Detectors (from HdM and IGEX) after dismounting from cryostats:



ANG1: 958g

ANG2: 2833g

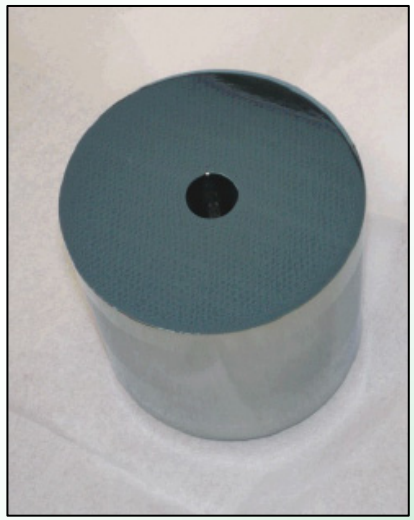
ANG3: 2391g



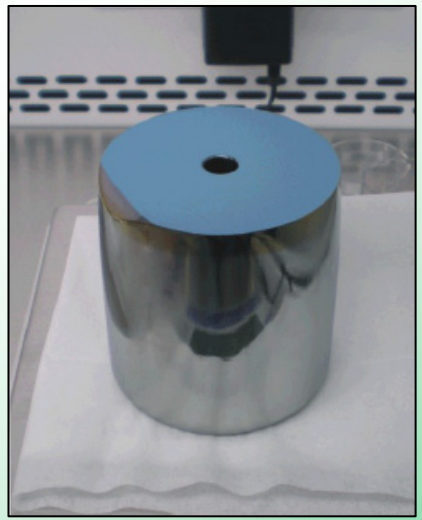
ANG4: 2372g

Total mass: 17.66 kg

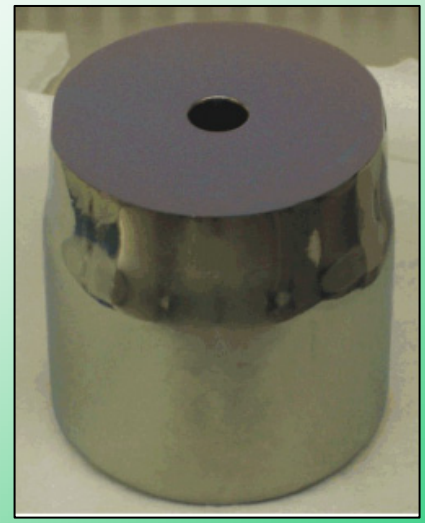
ANG5: 2746g



RG1: 2110g

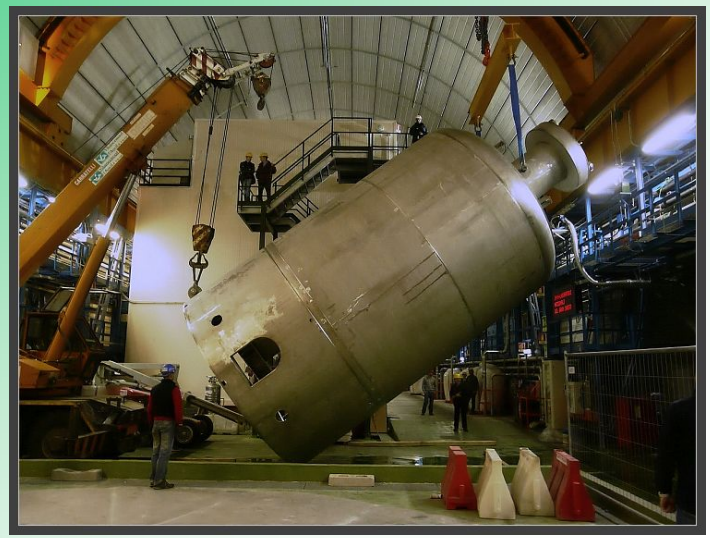


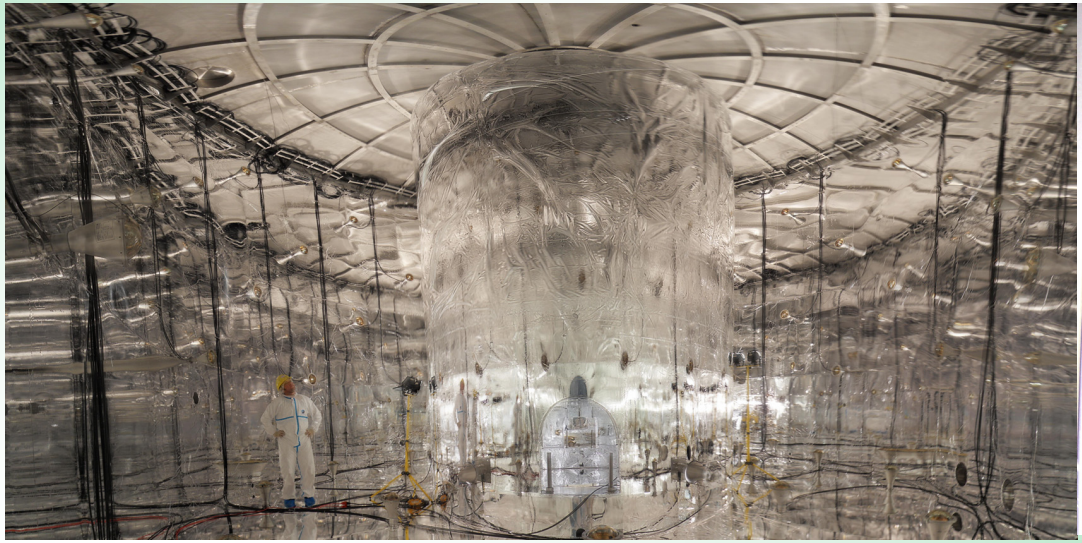
RG2: 2166g



RG3: 2087g

GERDA construction:



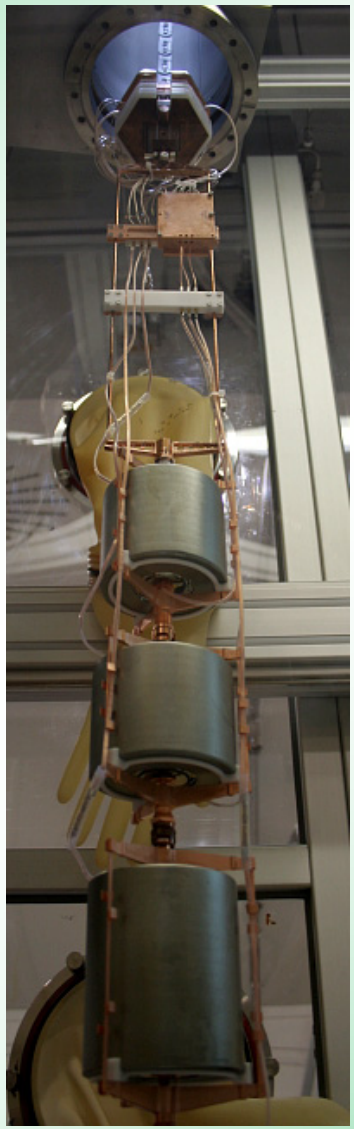


GERDA construction:

Preliminary infrastructure for deployment of three detectors completed in June 2010

Full phase I infrastructure for deployment of 12 detectors (all HdM and IGEX plus reference detectors) completed in May 2011

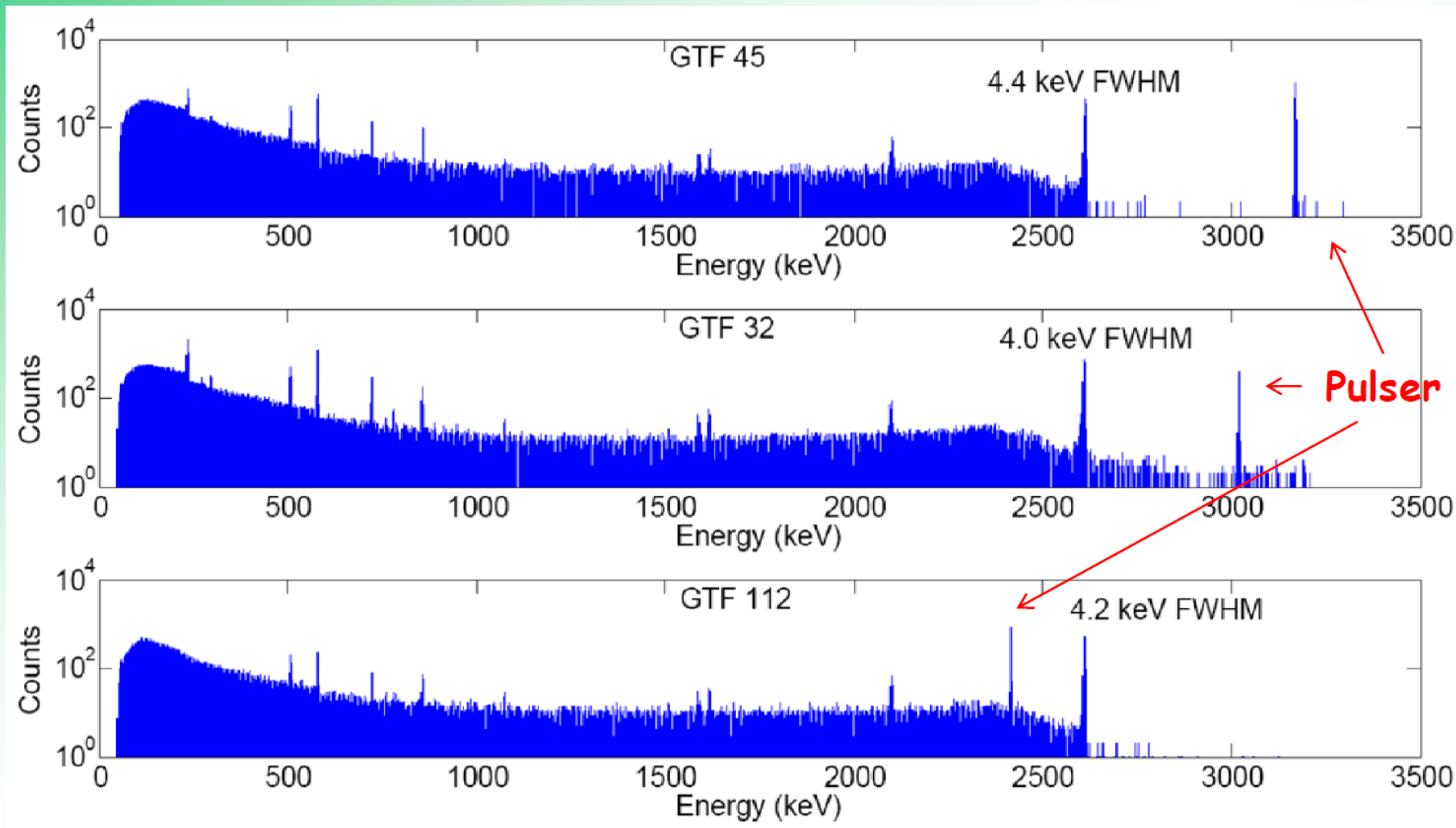
Deployment of first string:



First detectors three (natural) deployed in June 2010

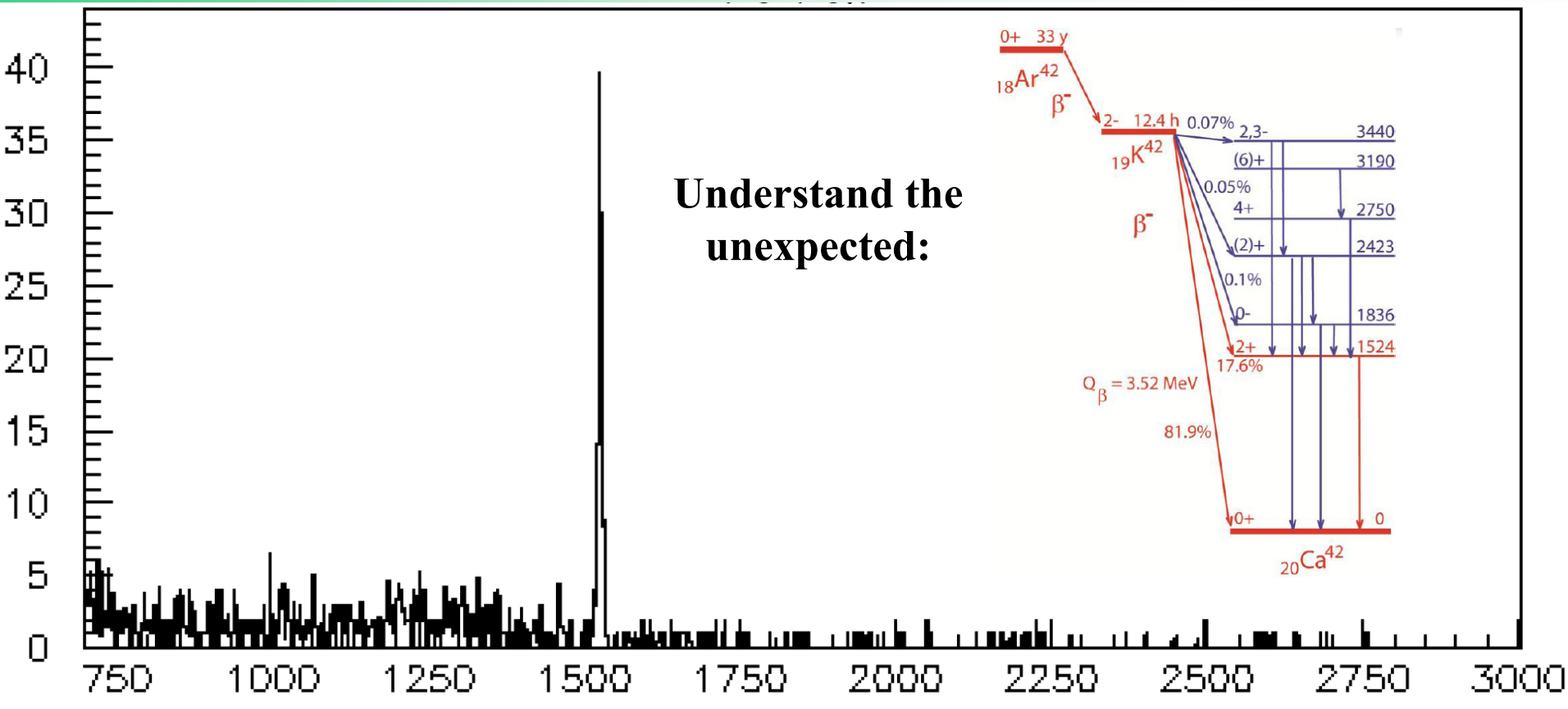
First calibration data:

Detectors: **GTF 45: 2334 g** **GTF 32:2321 g** **GTF 112: 2967 g**



FWHM @ 2.6 MeV: ~ 4.0 keV (<0.2%)

First background data:



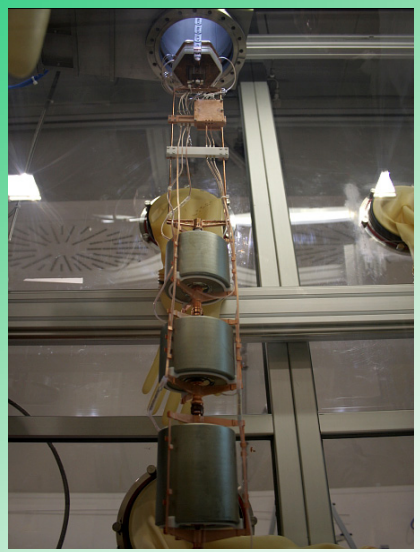
^{42}K ions have long life time in LAr (half life: 12.4 hours)

→ Drift in E-field

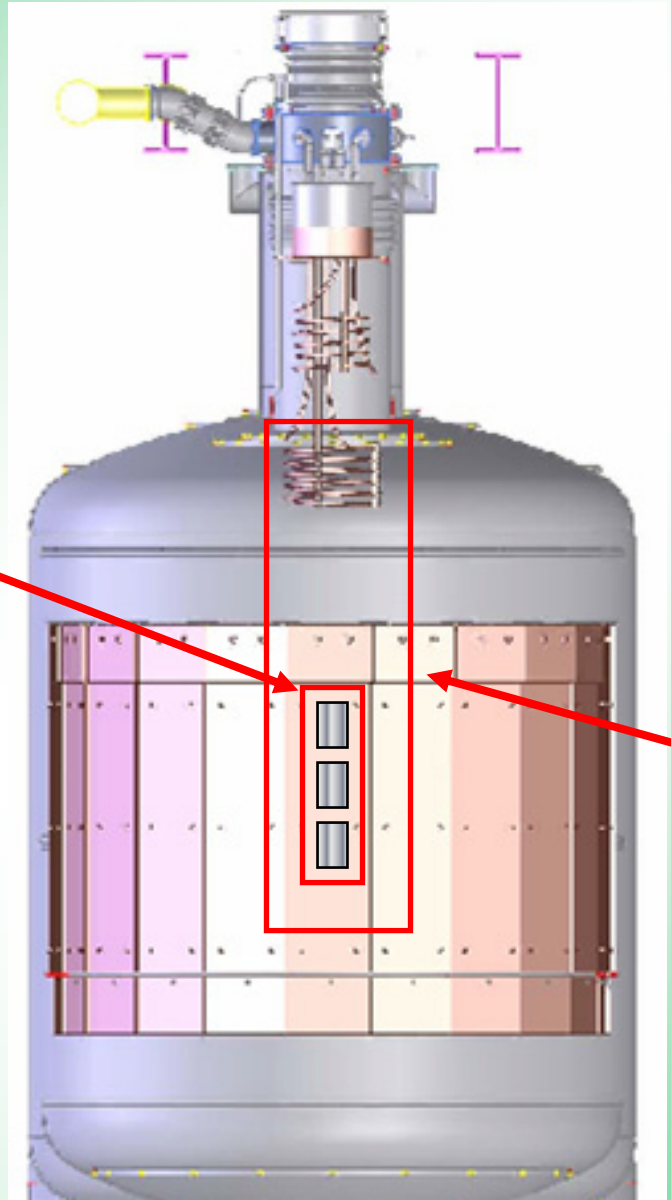
→ attracted to surfaces close to or on detector

First background data:

Background mitigation: control the unexpected



→ Mini Shroud (MS) against ^{42}K drift close to detector

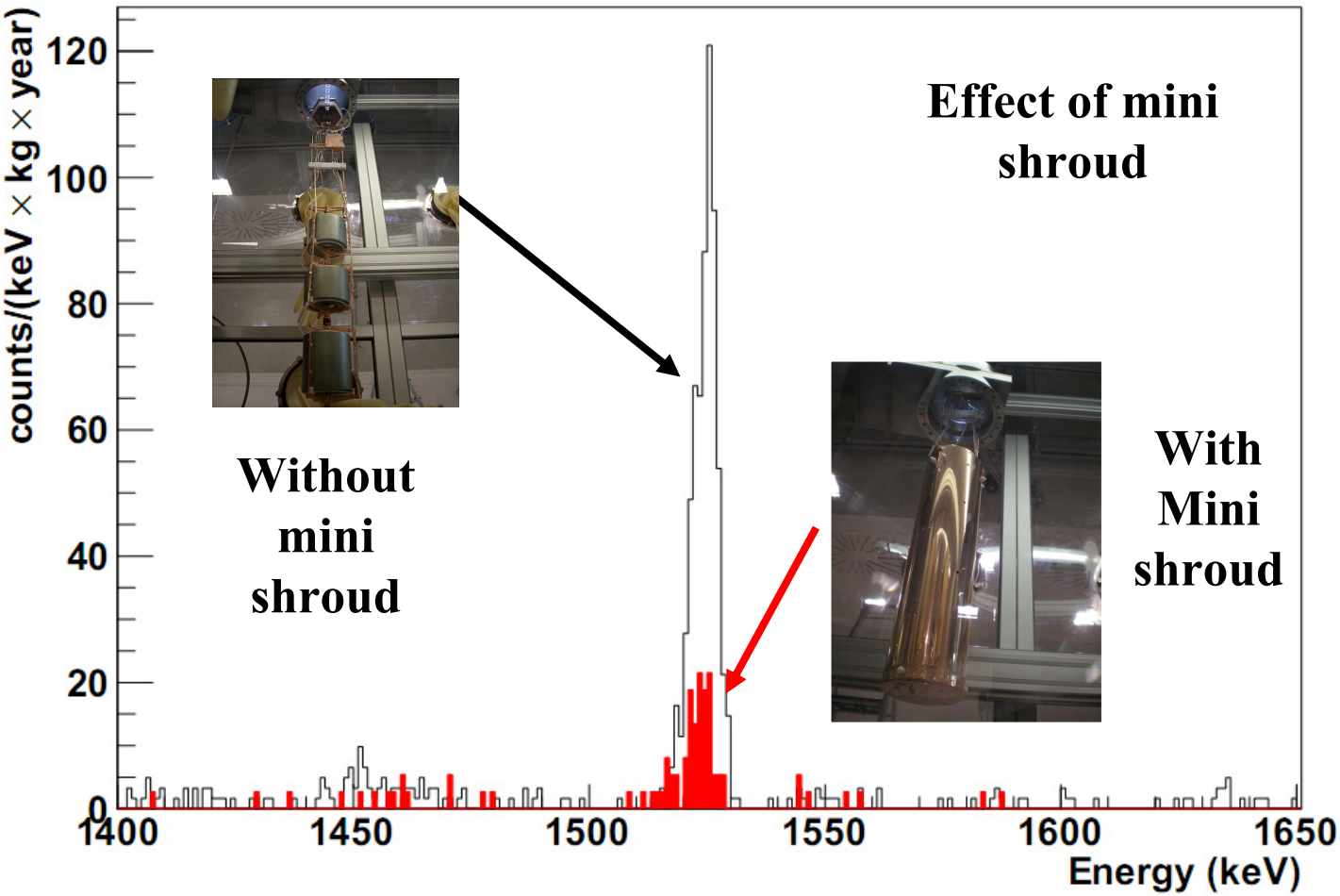


→Try Different field configurations to repel ions from detectors (HV or GND on MS,…)

Shroud against convection (^{222}Rn)

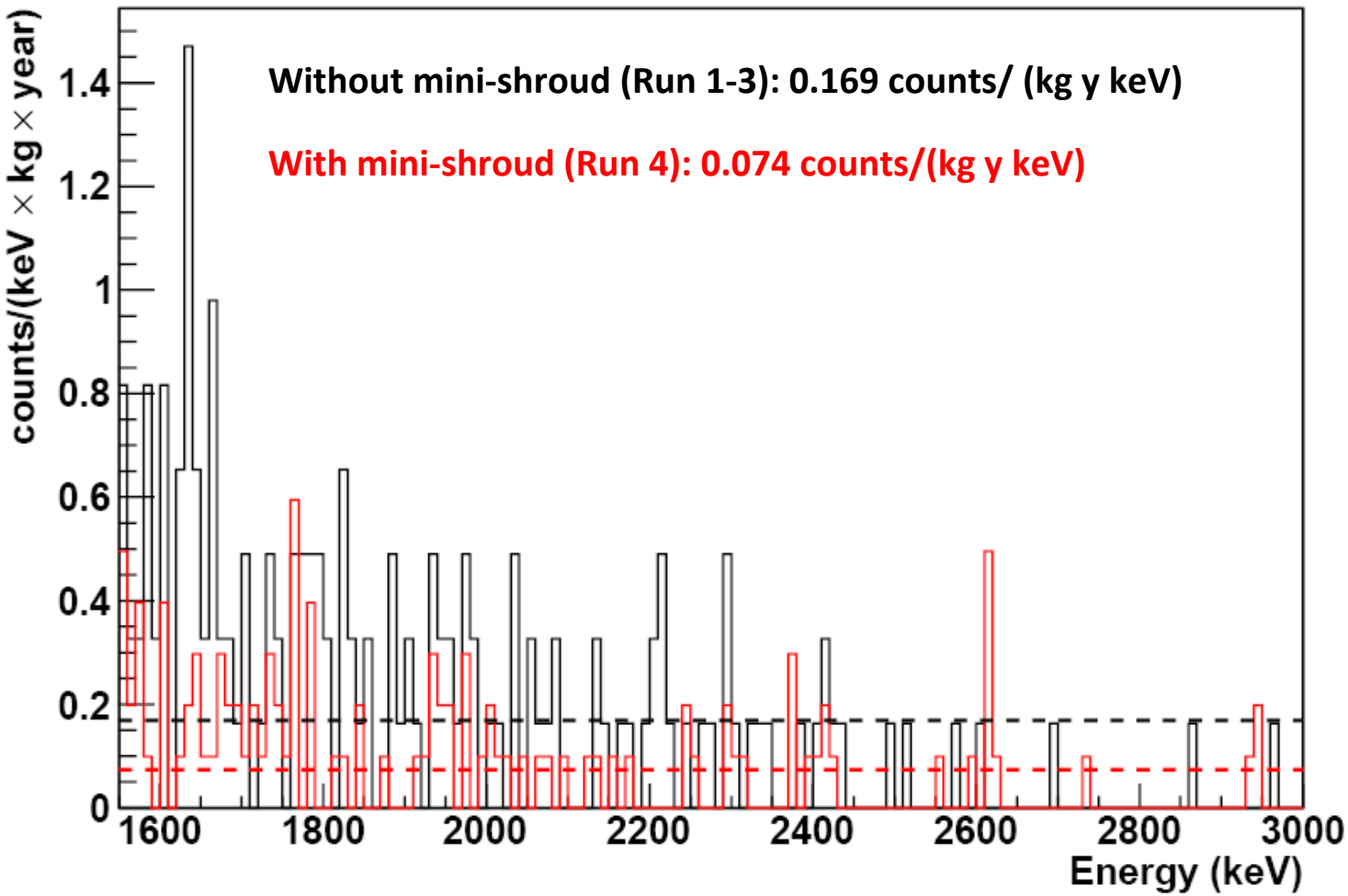
First background data:

Background mitigation: control the unexpected



First background data:

Background mitigation: control the unexpected



Run with "lowest BI" (Run 6): 0.04±0.02 counts/(kg y keV)

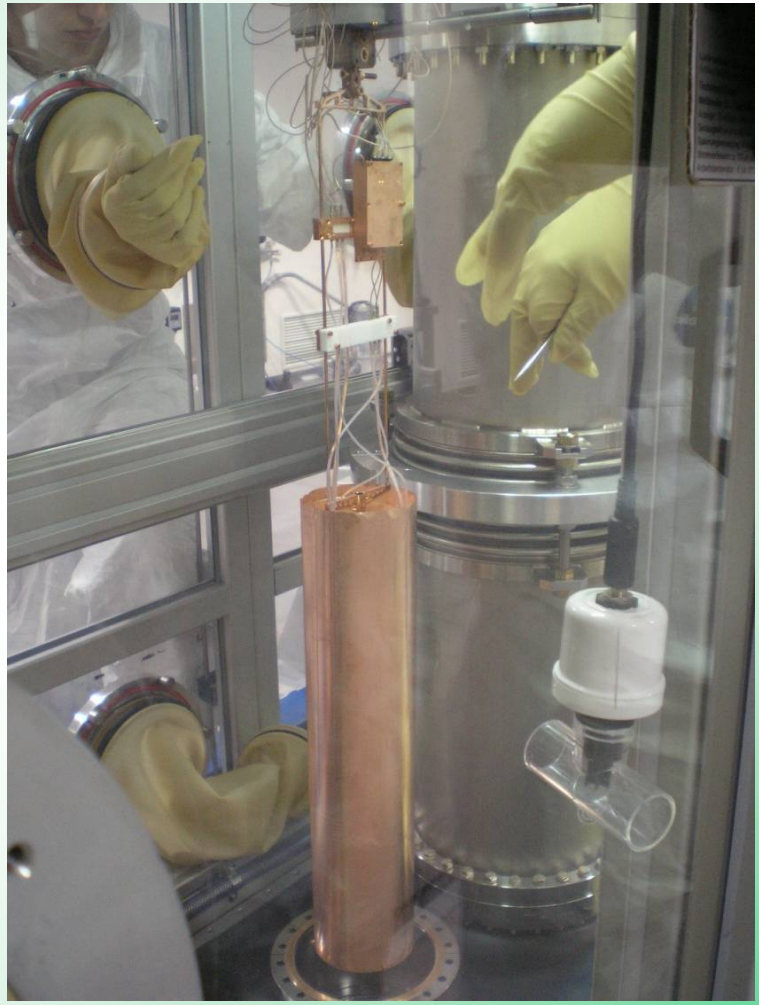
First background data:

Background lines in (not yet "optimized") runs 10,11,12 (1.6 kg y) and comparison with Heidelberg Moscow experiment (71.7 kg y)

isotope	energy [keV]	I_{HdM} [cnts] original	normalized	I_G [cnts]	R	comment
^{40}K	1460.8	13010 ± 134	287 ± 3	14.6 ± 5.8	19.7 ± 7.9	
^{60}Co	1173.2	3955 ± 88	87 ± 2	12.8 ± 5.8	6.8 ± 3.1	
	1332.3	3690 ± 90	81 ± 2	< 7.9	> 10	
^{137}Cs	661.6	20201 ± 164	445 ± 4	<2.5	> 180	
^{208}Tl	583.1	2566 ± 228	57 ± 5	9.9 ± 5.8	5.7 ± 3.4	^{232}Th
	2614.5	1184 ± 36	26 ± 1	$7.0\ ^{+3.8}_{-2.6}$	$3.7\ ^{+2.0}_{-1.4}$	
^{214}Bi	609.3	7552 ± 96	167 ± 2	36.7 ± 8.1	4.6 ± 0.8	^{238}U
	1120.3	1926 ± 86	43 ± 2	12.2 ± 5.5	3.5 ± 1.6	
	1764.5	2204 ± 51	49 ± 1	$7.0\ ^{+3.8}_{-2.6}$	$6.9\ ^{+3.8}_{-2.6}$	
^{228}Ac	910.8	2135 ± 115	47 ± 3	<7.7	> 6	^{232}Th
	968.9	1259 ± 82	28 ± 2	<6.4	> 4.8	

→ **Most important background peaks significantly less intense!**

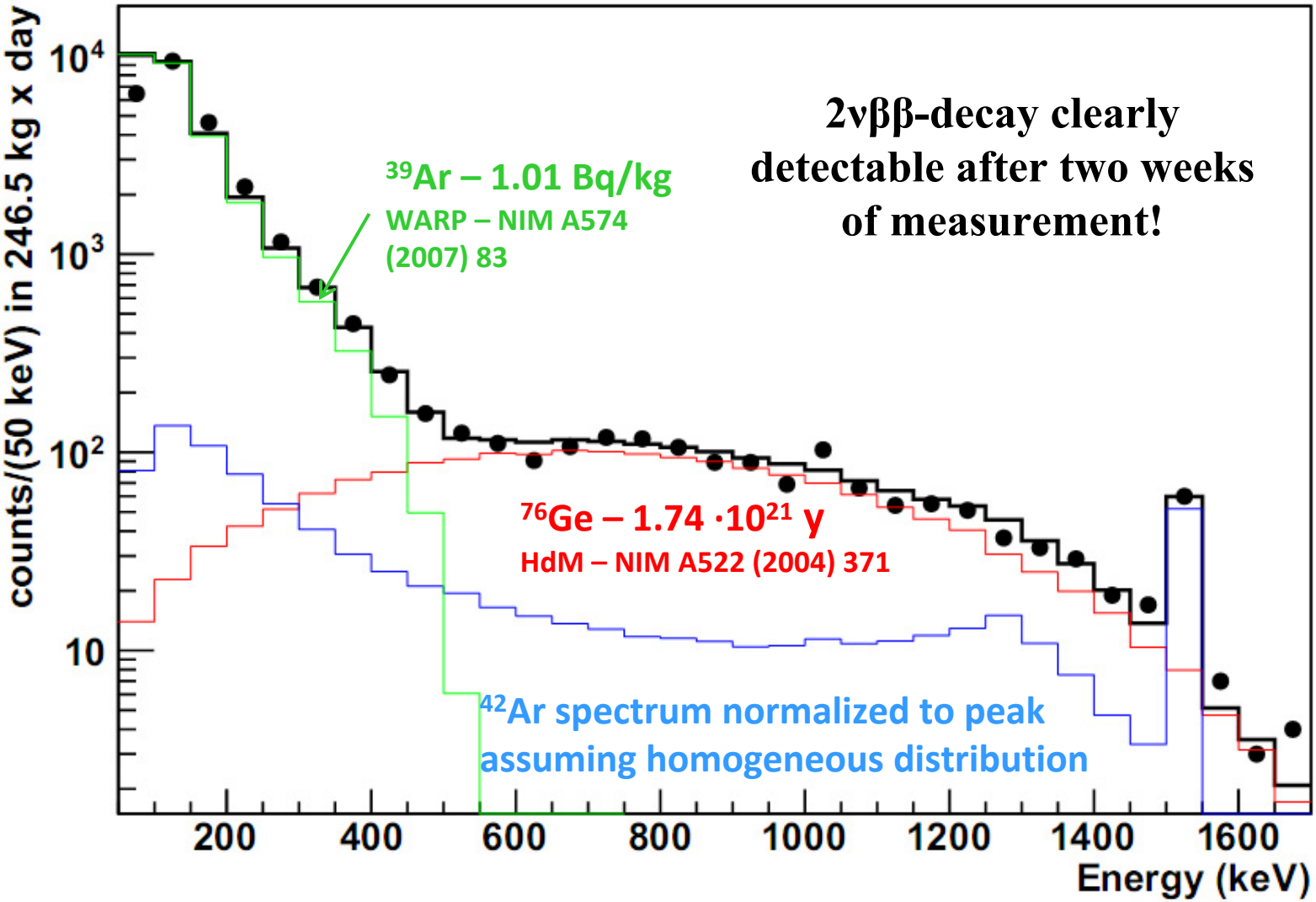
First deployment of enriched detectors :



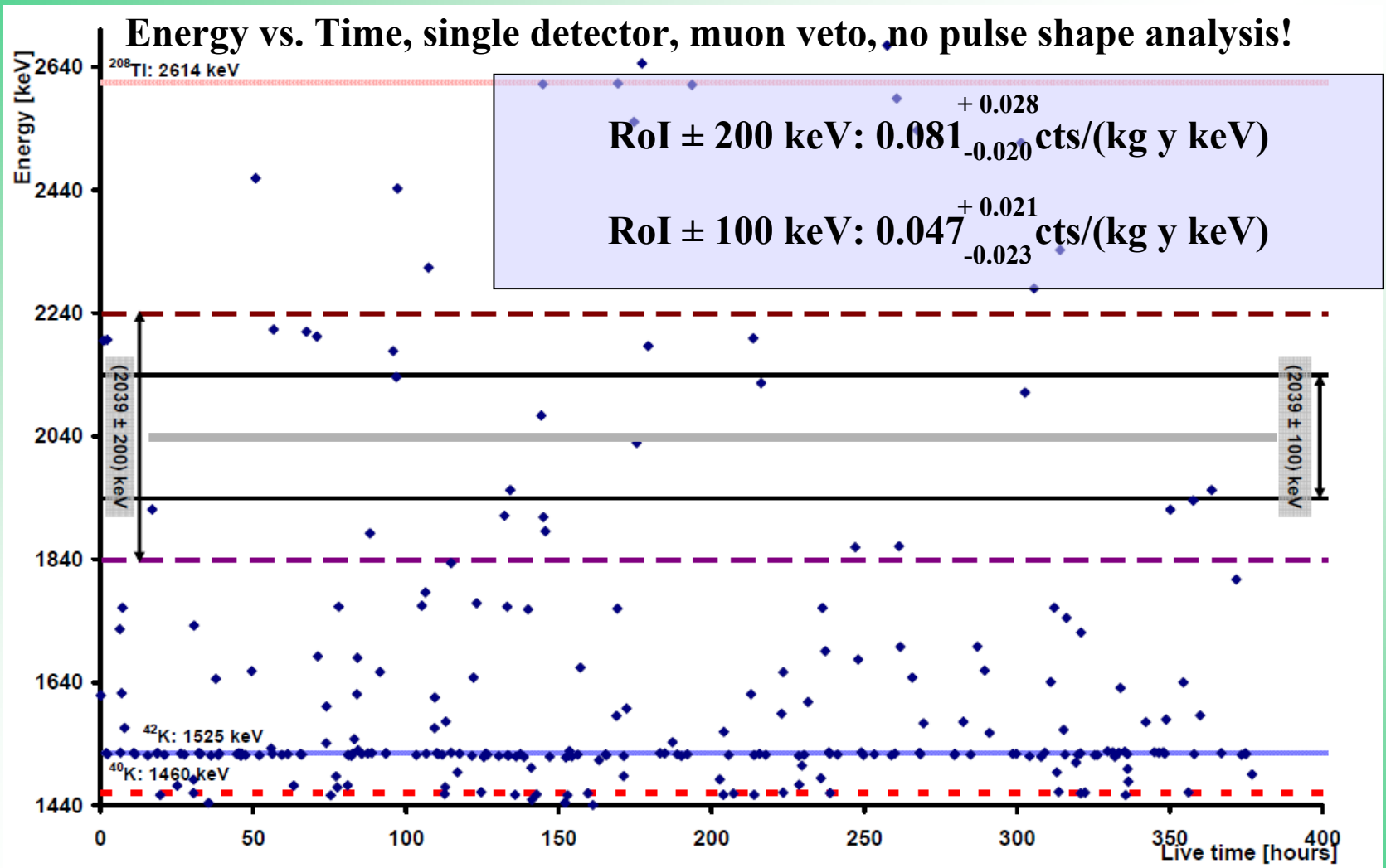
Deployed three detectors enriched in 76Ge in June 2011 together with 4 natural HPGe detectors

First results with enriched detectors :

Low energy spectrum with enriched HPGe detectors

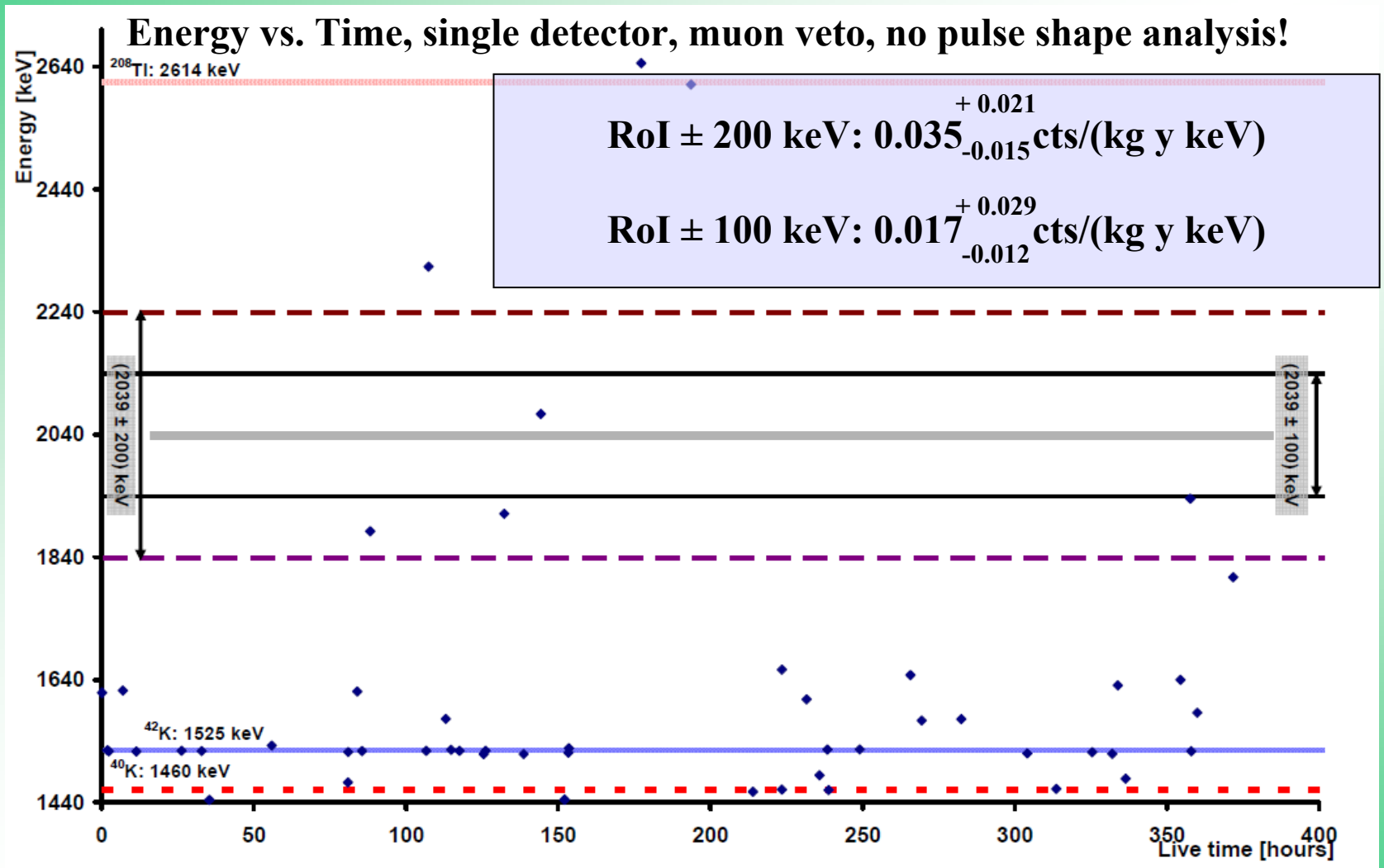


First results with enriched detectors :



3 enriched and 4 natural detectors	17.3 kg	0.75 kg y

First results with enriched detectors :



3 enriched detectors:	6.7 kg	0.29 kg y

Installation of phase I detectors :

Installation of phase I detectors :

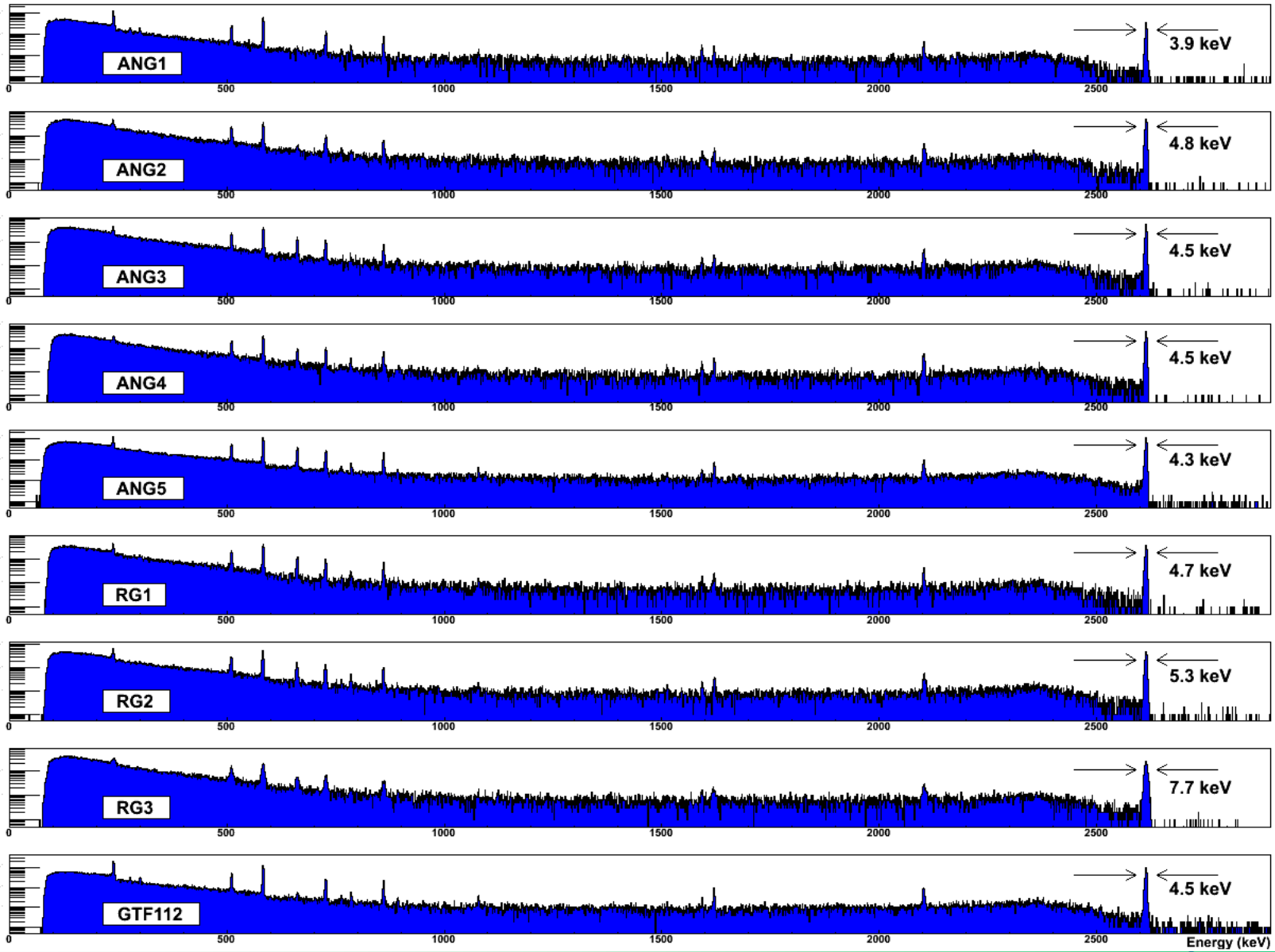
Phase I of GERDA started on 1.11.11 !

Now measuring!

Data will be blinded in ROI

Installation of phase I detectors :

^{228}Th calibration measurement



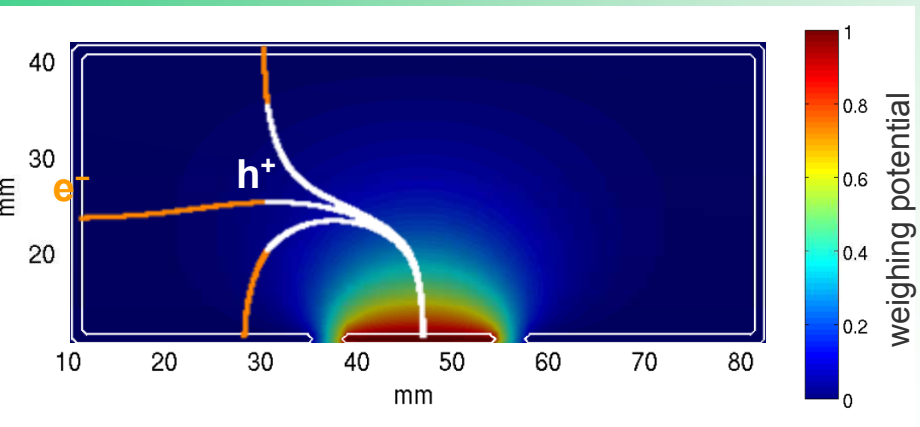
Installation of phase I detectors :

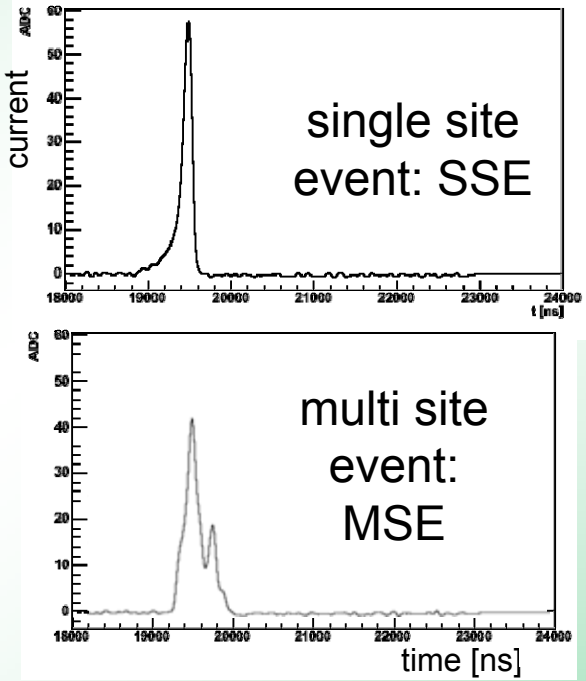
^{228}Th calibration measurement

Detector	Total mass, g	HV_{dep}, V	HV, V	FWHM (2.6 MeV)		LC , pA
				MCA	FADC	
Enriched						
ANG 1	958	3000	4000	3.6	3.8	40
ANG 2	2833	3000	3500	4.4-4.5	4.6	20
ANG 3	2391	3000	3500	4.4-4.6	4.9	<10
ANG 4	2372	2800	3200	4.0-4.5	4.4	<10
ANG 5	2746	1000	2000	4.0	4.2	<10
RG 1	2110	4200	4500	4.4-4.5	4.8	<10
RG 2	2166	3800	4000	4.7-5.0	5.1	<10
RG 3	2087	3300	3300	5.4 (6 μs)	6.1	1360
Non-enriched						
GTF 112	2957	2000	3000	3.7	4.3	<10

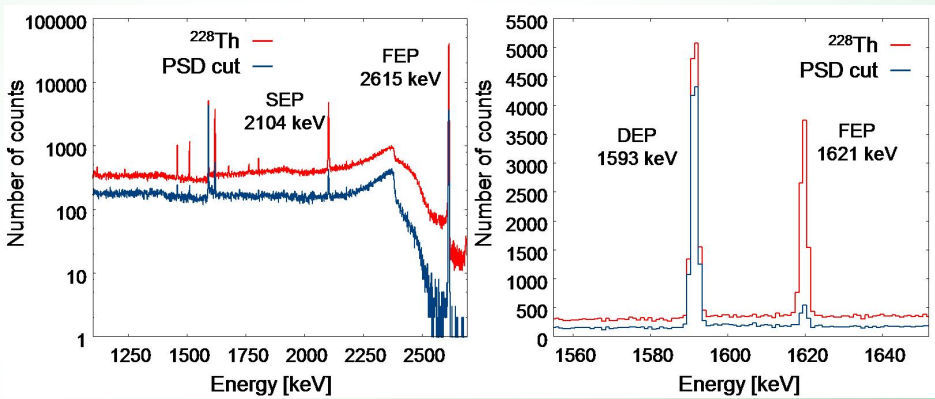
Plans for phase II: new detectors

BEGe for improved background recognition





- **Drift paths in point contact detectors are long**
- **Weighting potential is large around point contact and small in the rest of the detector**
- **Small "point contact"**
  - **→ Low capacity**
  - **→ Improved energy resolution: 1.6 keV @ 1.3 MeV!**



- **→ Very pronounced structures for individual energy deposits**
- **→ Improved multi site recognition efficiency by A/E parameter**

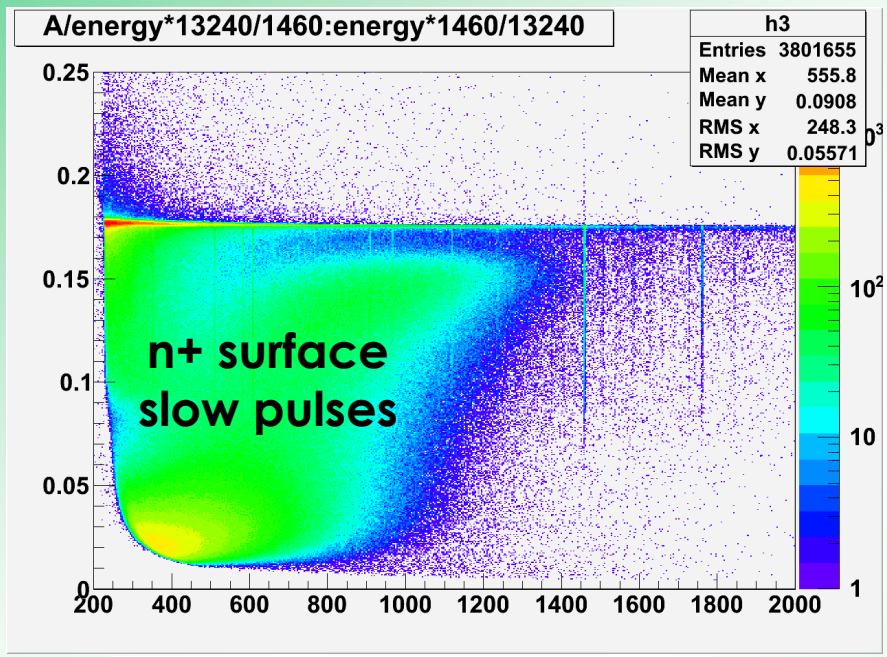
D. Budjas et al., JINST 4 P10007 (2009)

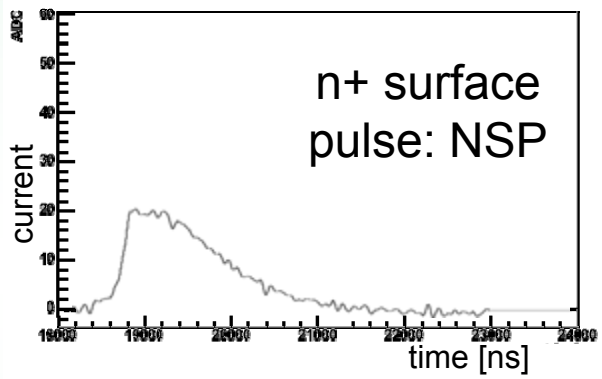
Plans for phase II: new detectors

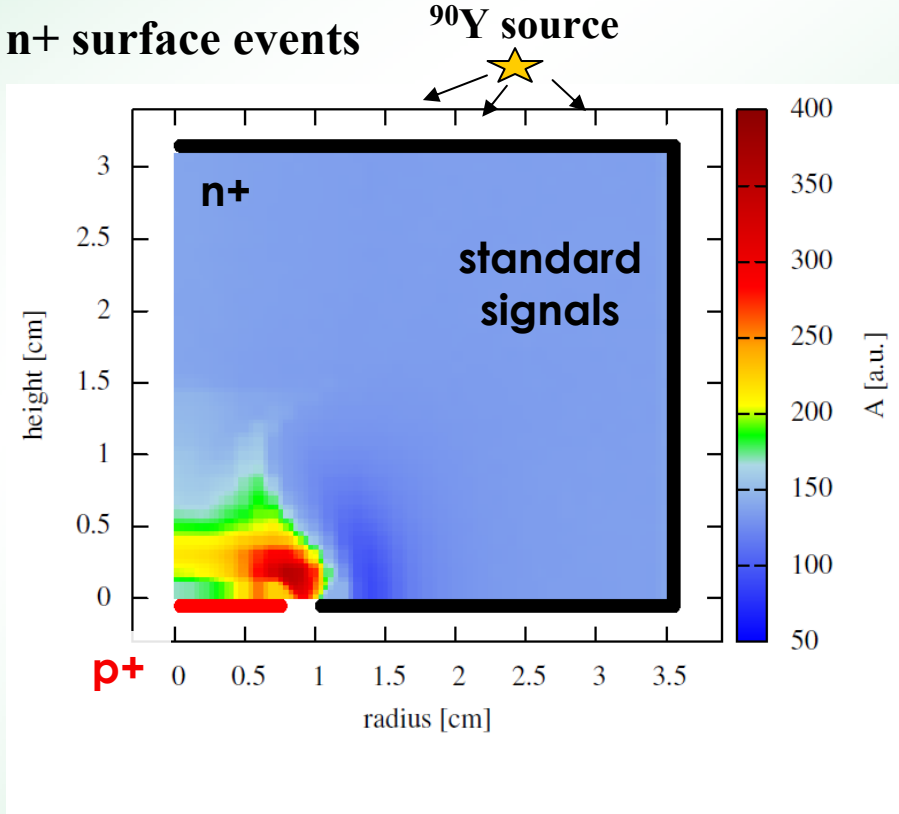
Background recognition powers of BEGes

Identify surface events:

Data taken with ^{90}Y β-source → n+ surface events







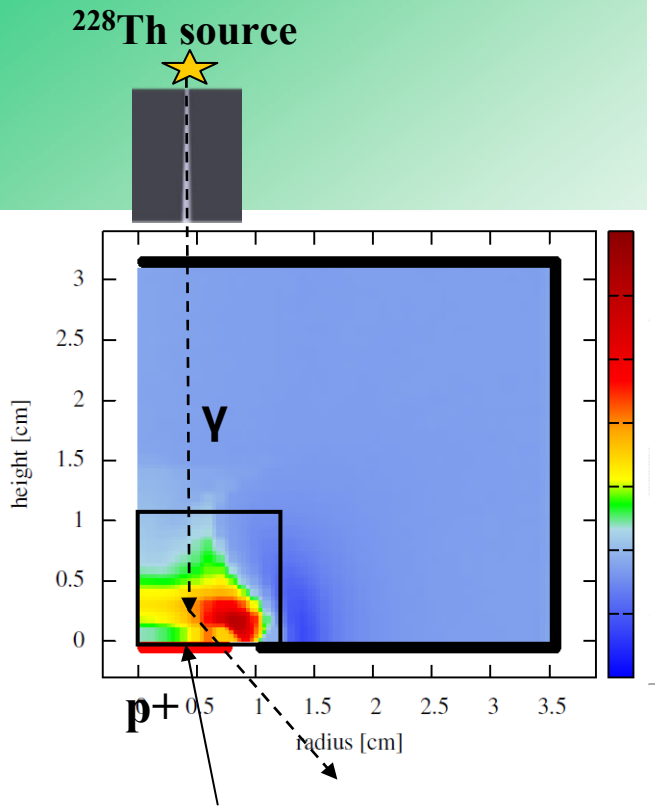
→Low E-fields in "partially" dead layer

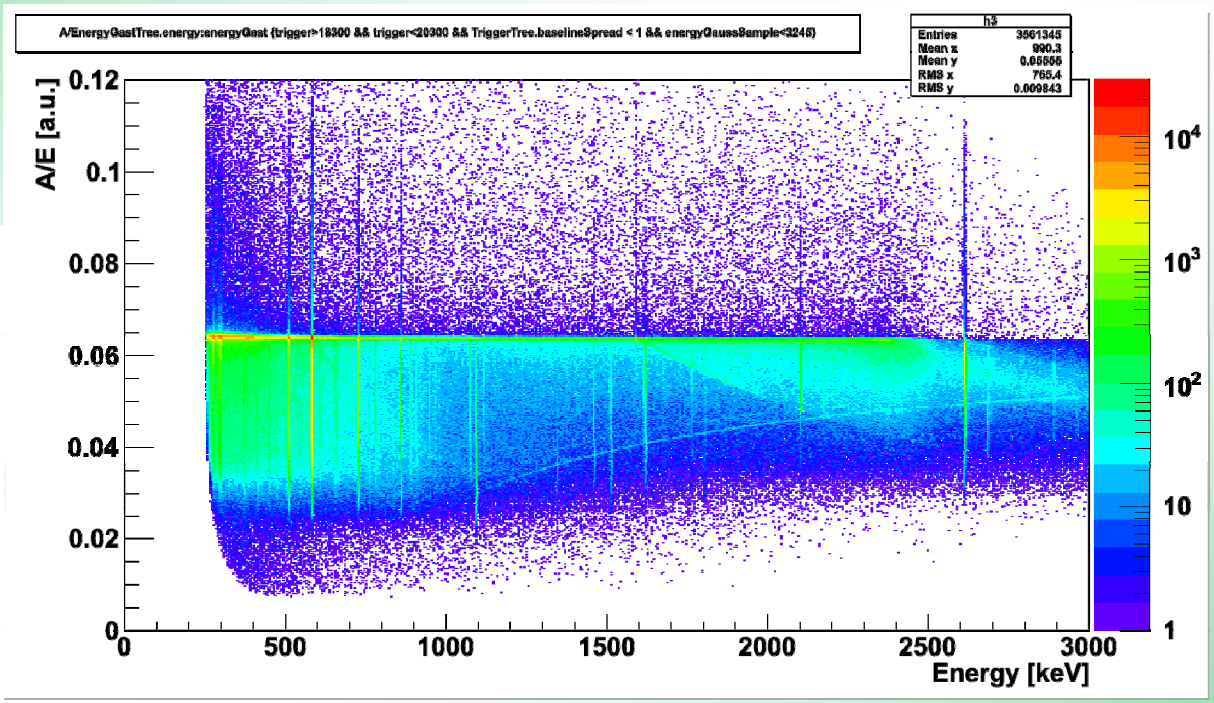
→Slow pulses

→Decrease A/E parameter

Plans for phase II: new detectors

Background recognition powers of BEGes

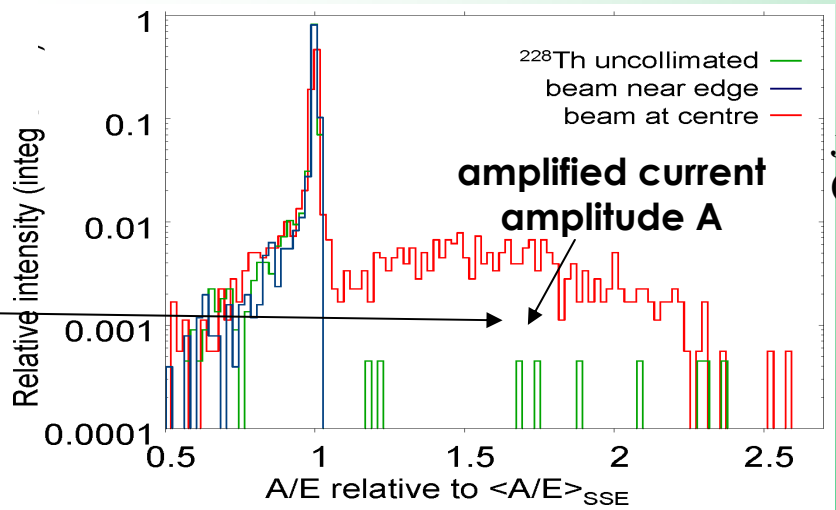




At p+ contact also e⁻ are "visible"

→ A_{max}/E is increased

M. Agostini et al., JINST 6 P03005 (2011)



D. Budjas et al., JINST 4 P10007 (2009)

Plans for phase II: new detectors

BEGe for improved background recognition

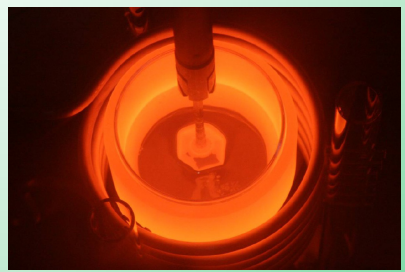
55 kg enriched germanium in form of GeO_2 ✓

Reduction to metal ingots:

36.5 kg enriched germanium in form of ingots ✓

35.5 kg zone refined 6N enriched germanium for crystal pulling ✓

Crystal pulling using Czochralski technique



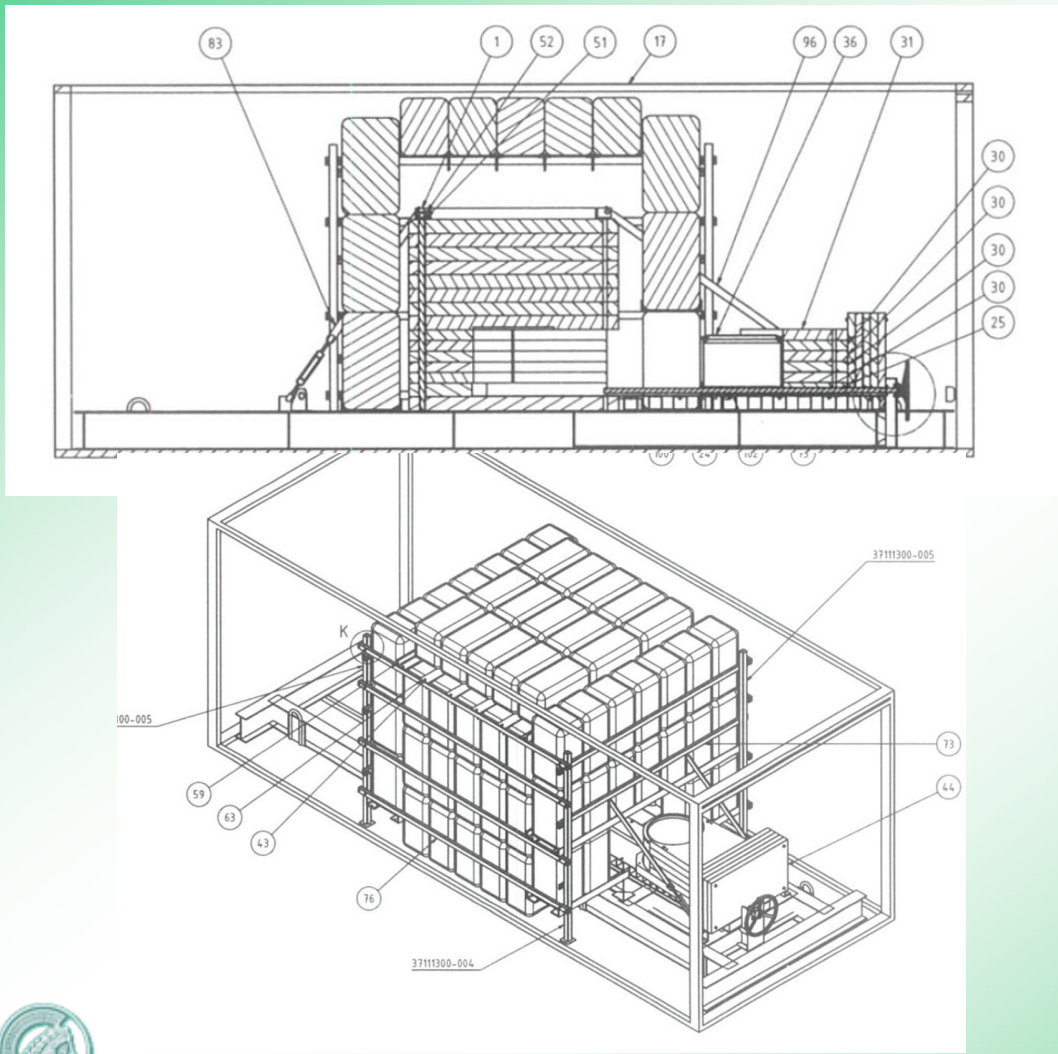
Production of $HP^{enr}Ge$ detectors.

Production chain has been tested and established using depleted germanium

→ 5 working $HP^{dep}Ge$ detectors available

Plans for phase II: new detectors

Transport of enriched metal ingots to Canberra US



Transport in shielded container:
70cm iron, 70cm salt- water

Plans for phase II: new detectors

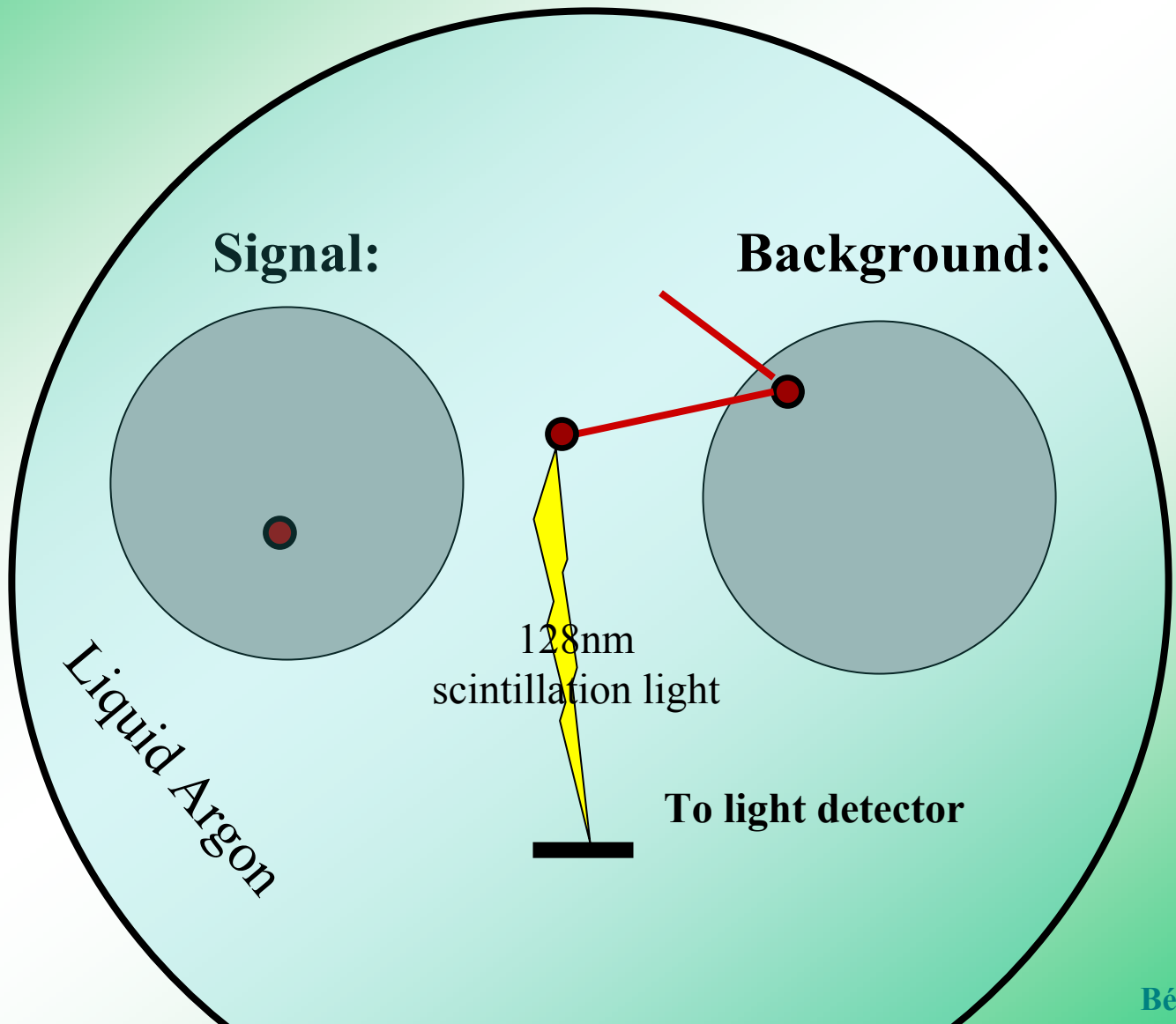
Transport of enriched metal ingots to Canberra US

Delivered enriched germanium to Canberra, US on 14th of October. Crystal production started on 17th of October

While not being processed enriched germanium is stored in cave

Plans for phase II: new detectors

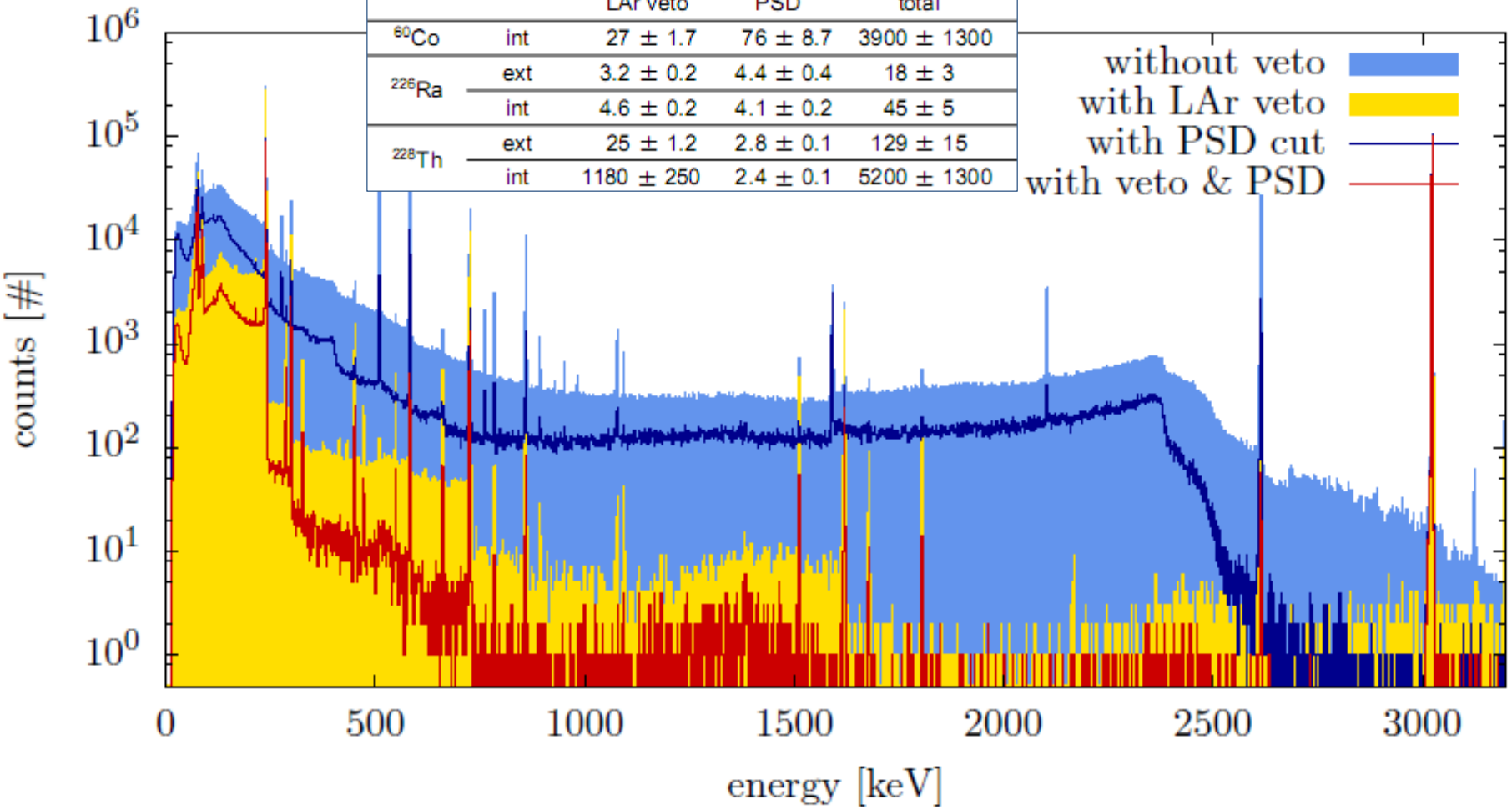
Background rejection by detection of LAr scintillation light



Plans for phase II: new detectors

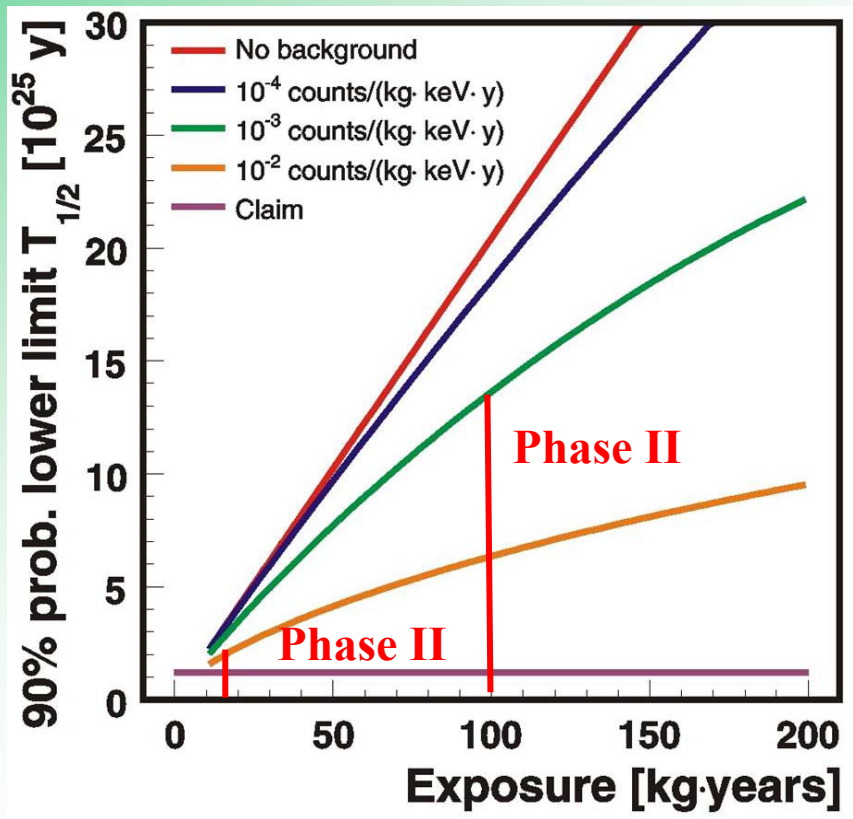
Background rejection by detection of LAr scintillation light

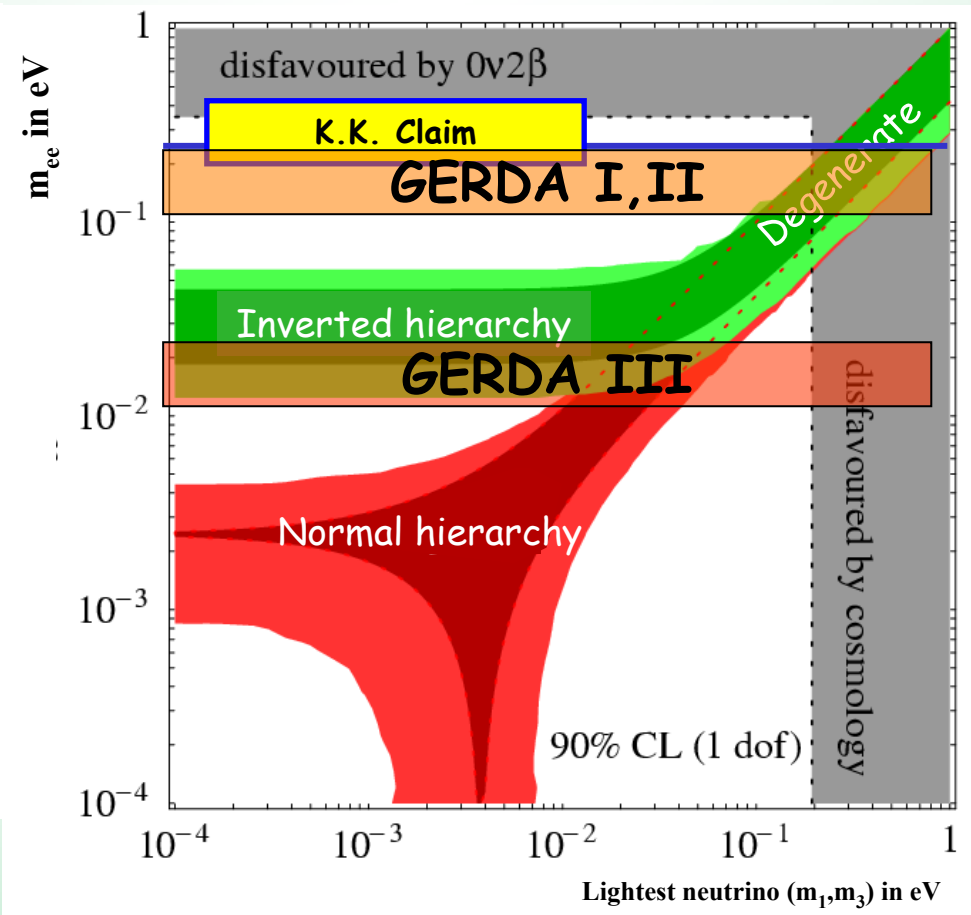
source	position	suppression factor		
		LAr veto	PSD	total
^{60}Co	int	27 ± 1.7	76 ± 8.7	3900 ± 1300
^{226}Ra	ext	3.2 ± 0.2	4.4 ± 0.4	18 ± 3
	int	4.6 ± 0.2	4.1 ± 0.2	45 ± 5
^{228}Th	ext	25 ± 1.2	2.8 ± 0.1	129 ± 15
	int	1180 ± 250	2.4 ± 0.1	5200 ± 1300



Design sensitivities

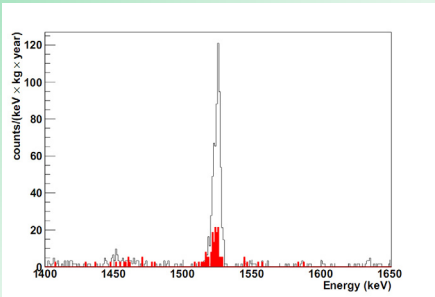
Exposure [kg·years]	Background [counts/(kg·keV·y)]	Limit $T_{1/2}$ [y]	Limit $\langle m_{\beta\beta} \rangle$ [meV]
15 (Phase I)	10^{-2}	$>2 \cdot 10^{25}$	<270
100 (Phase II)	10^{-3}	$>1.4 \cdot 10^{26}$	<110

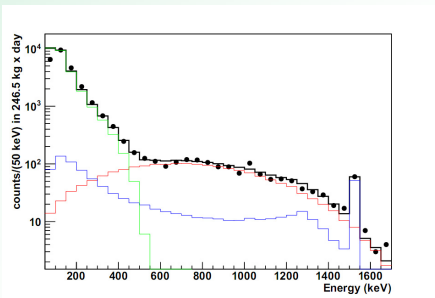


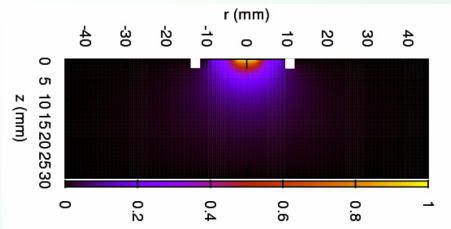


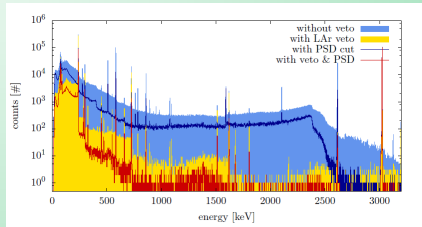
Conclusions:

- GERDA infrastructure ready since 2010
- ^{42}K background reduced by Mini shroud and field free configuration
- Enriched LE spectra are dominated by 39Ar, 2νββ and ^{42}K
- GERDA phase I started on 1.11.11
- Phase II detector crystals presently being pulled
- Improved background rejection efficiency → improve sensitivity
- LAr scintillation light detection will be implemented in phase II









First results with enriched detectors :