GERDA

status report

Mark Heisel

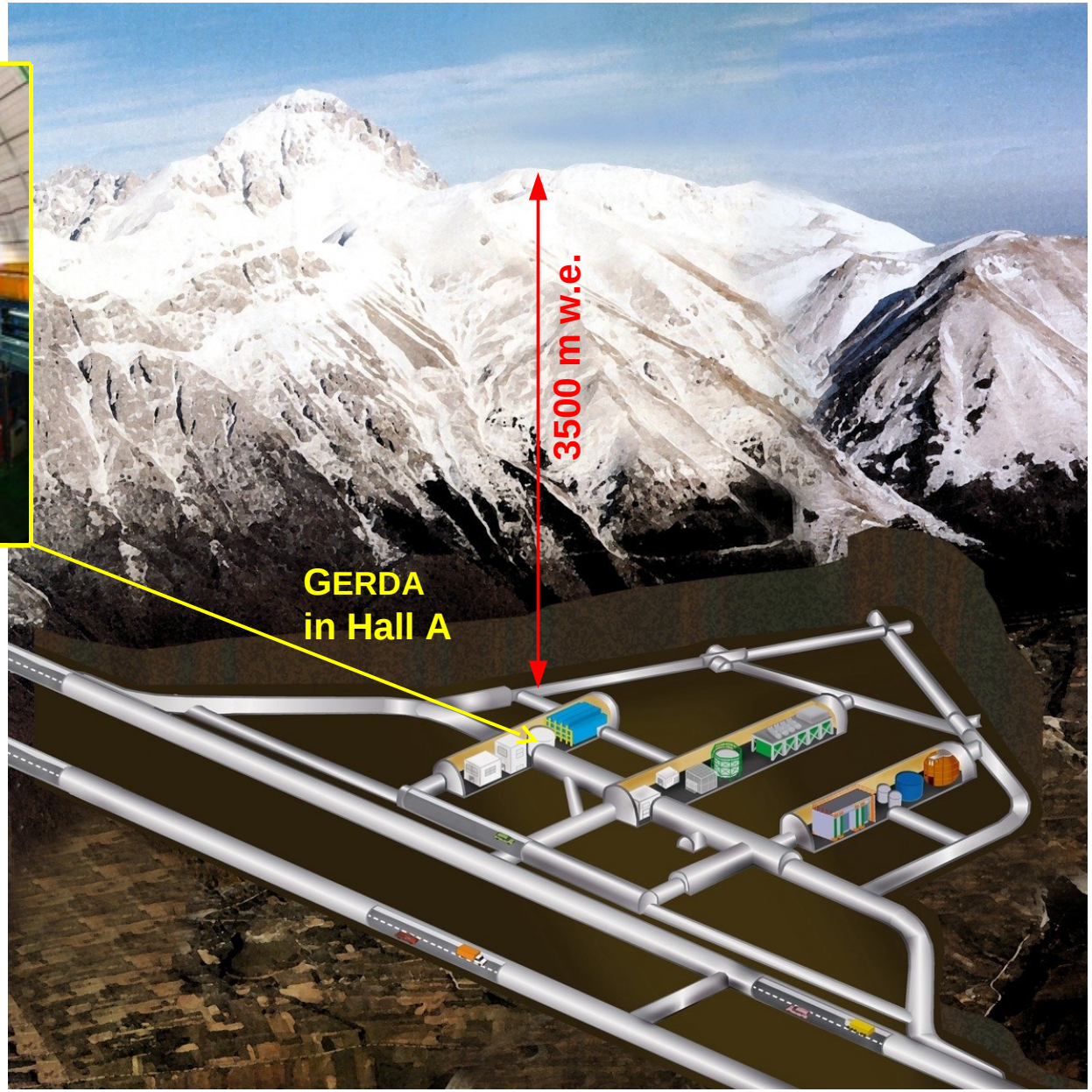
for the GERDA collaboration

DPG Frühjahrstagung,

Dresden 2013,

HK 43.2

GERDA at Gran Sasso



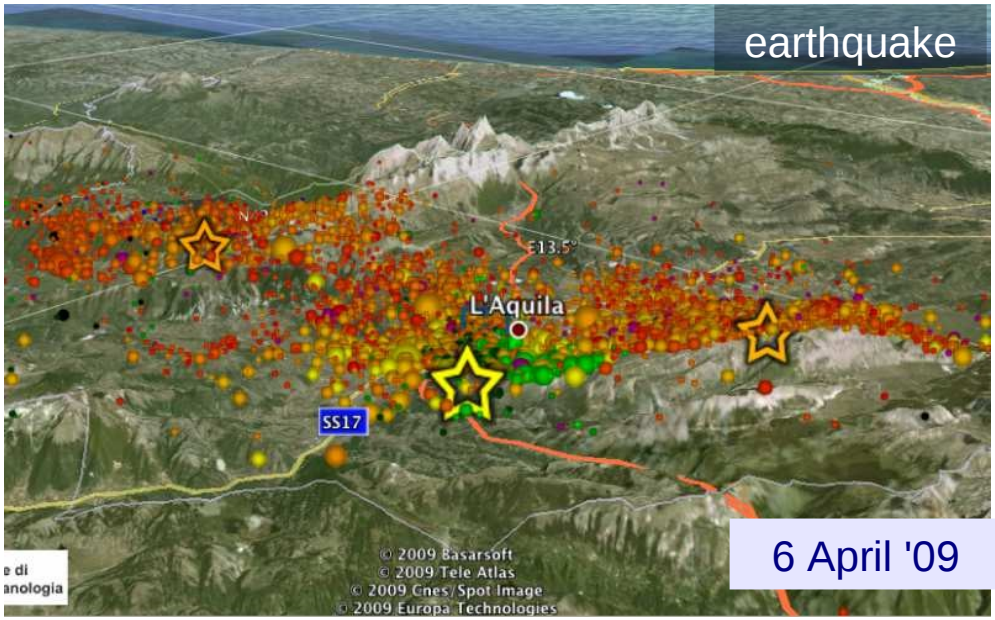
Underground site to reduce cosmic muon flux by ~1,000,000

GERDA history (1)

6 March '08

5 May '08

29 February '09



6 April '09

GERDA history (2)

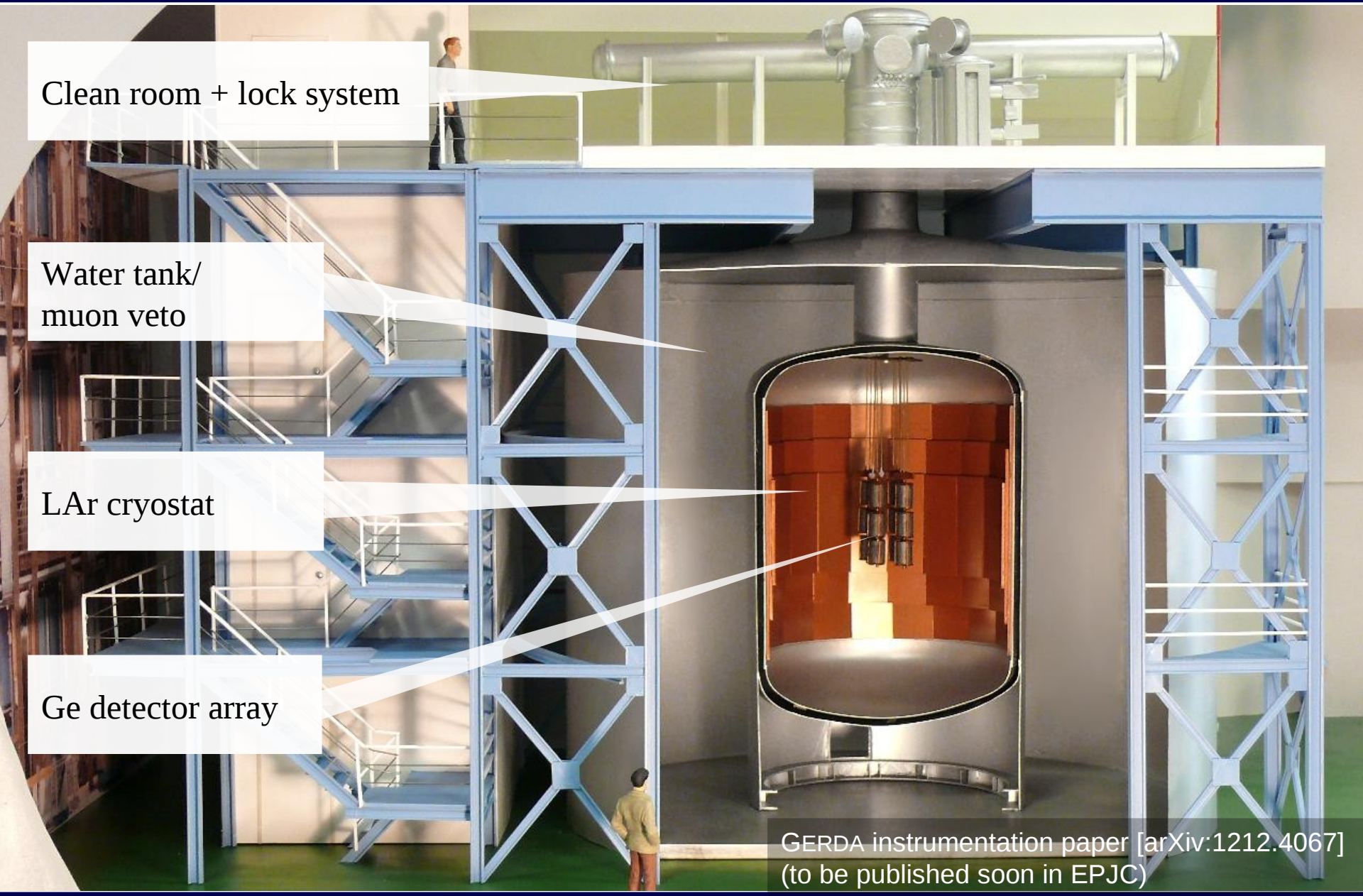
August '09

18 July '09

18 May '10

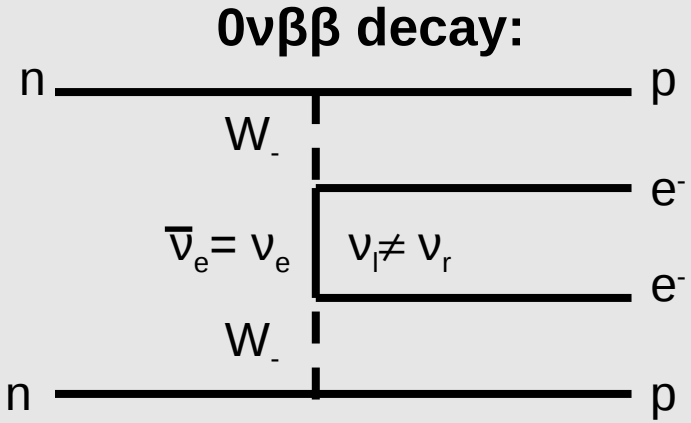
9 November '11

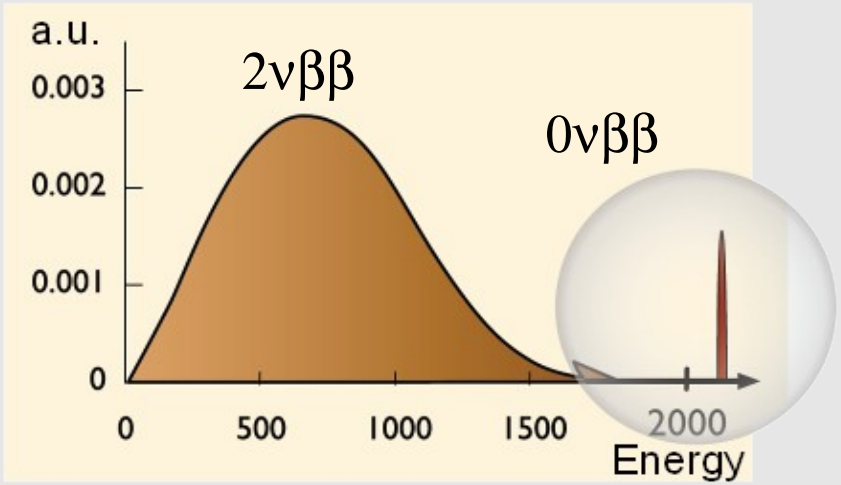
Germanium **D**etector **A**rray



GERDA instrumentation paper [arXiv:1212.4067]
(to be published soon in EPJC)

Double Beta Decay detection in GERDA





electron-energy spectrum

Detector = Source

detectors enriched to 86% ^{76}Ge

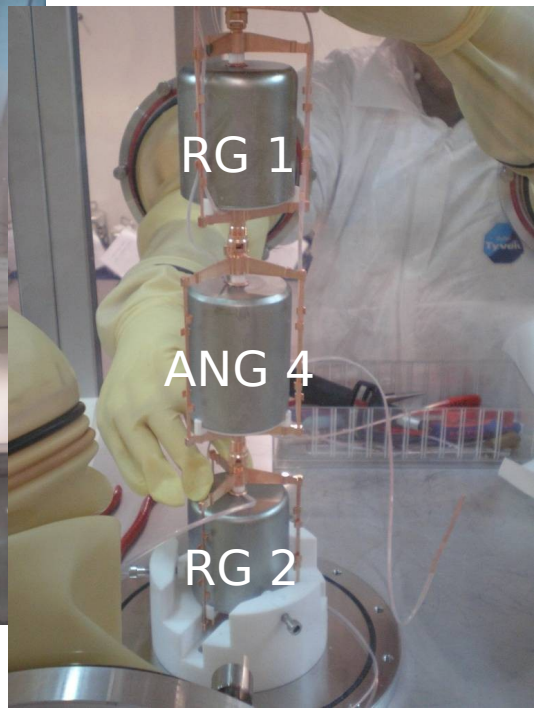
Phase	I	II
Exposure [kg ·yr]	15	100
Bg [counts/(keV·kg·yr)]	10^{-2}	10^{-3}
Upper limit $m_{\beta\beta}$ [eV]	0.23-0.39	0.09-0.15

A. Smolnikov, P. Grabmayr PRC 81 028502(2010)

GERDA Phase I detectors

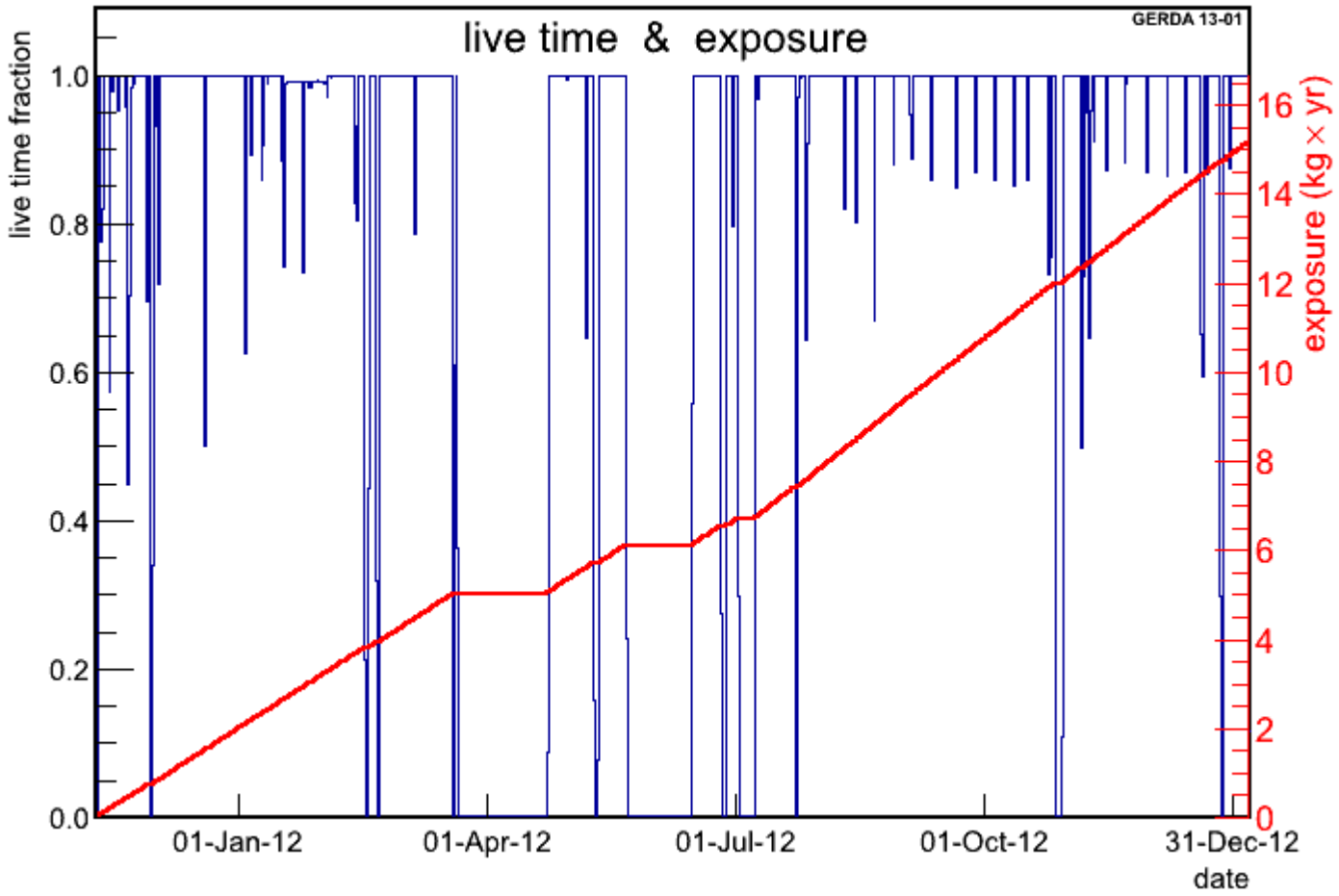
- 8 refurbished diodes from HdM & IGEX
- 2 detectors shut off due to high leakage current
  → mass of operational detectors **14.2 kg** (~87% active mass)
- 1 natural Ge detector (GTF)

coaxial germanium detector



Duty cycle & exposure

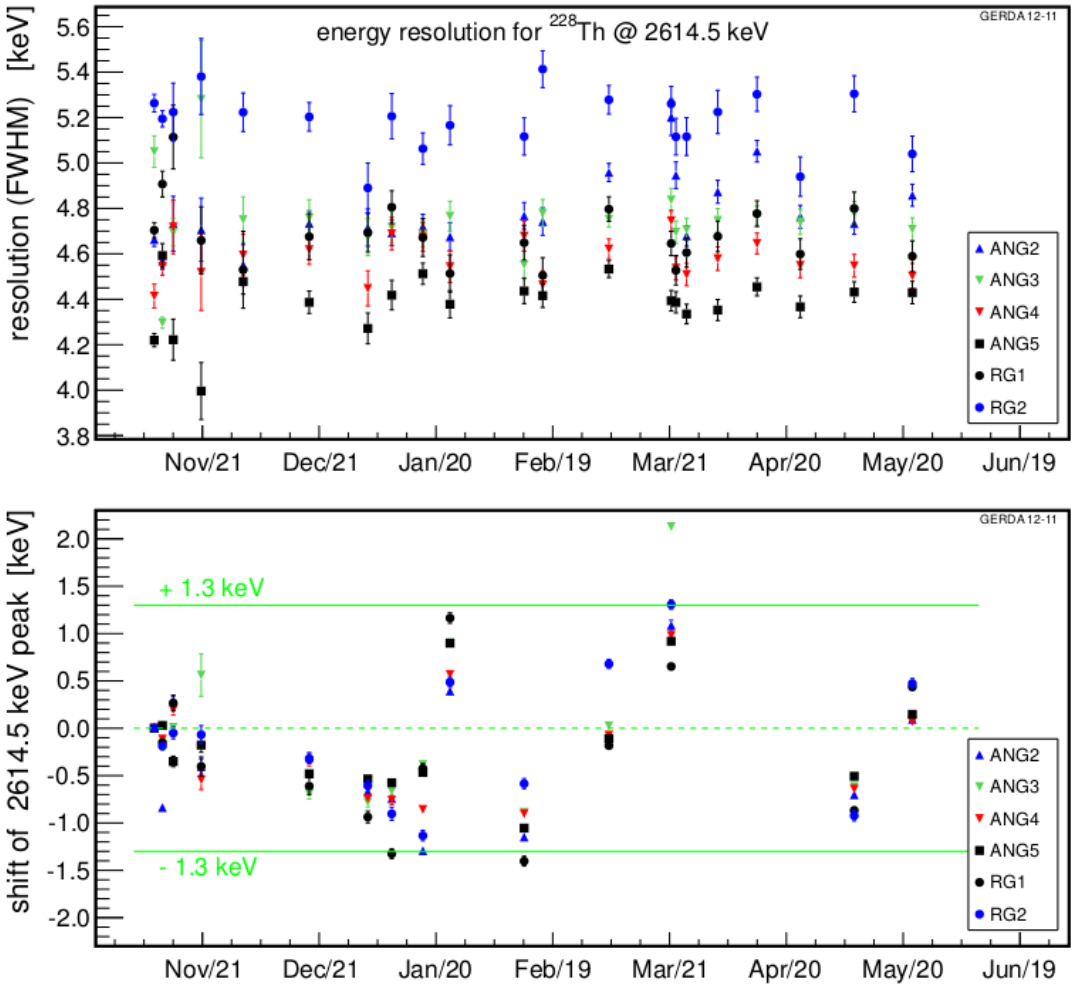
- start phase I: November 9, 2011
- total exposure: (until January 11, 2013) 13.65 kg·yr ^{enr}Ge (+1.51 kg·yr with BEGe)
  4.69 kg·yr ^{nat}Ge
- duty factor: ~90%



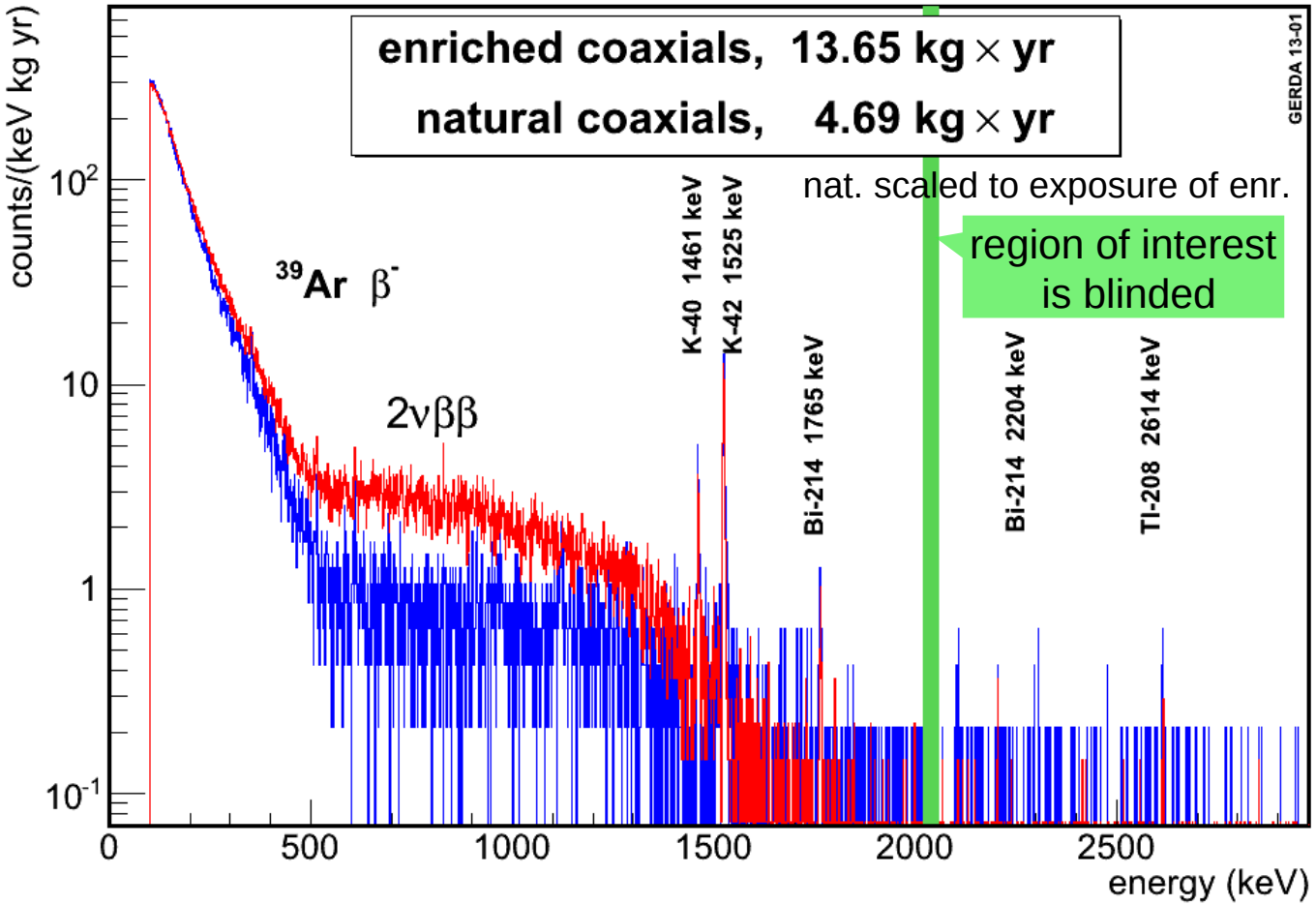
Detector performance

^{228}Th calibration every 1-2 weeks:

- energy resolution: 4.5 keV at $Q_{\beta\beta}$ (mass weighted average)
- stable gain within 1 keV at $Q_{\beta\beta}$



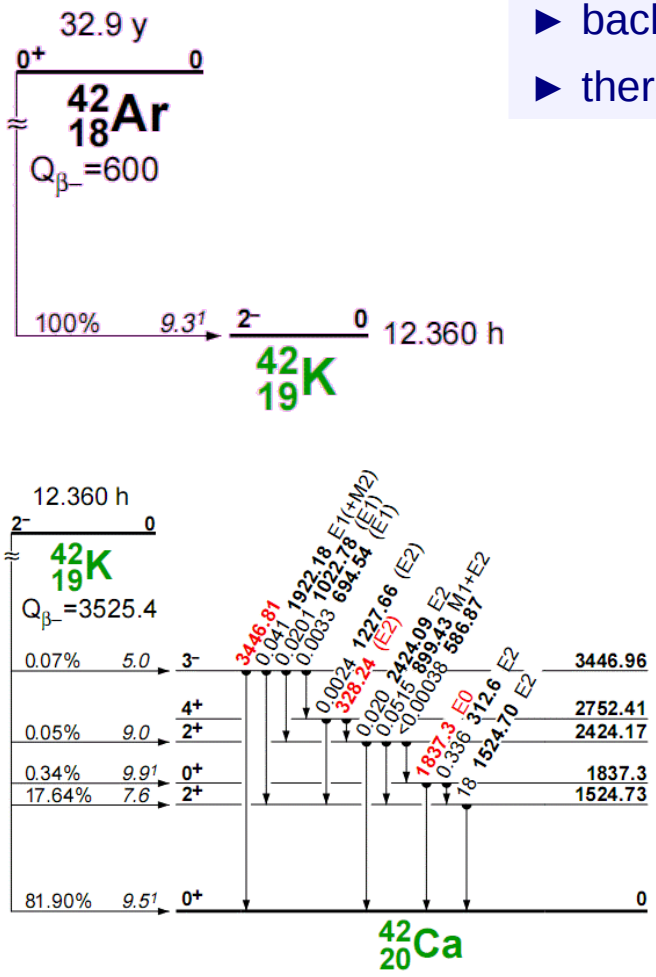
Phase I background spectrum



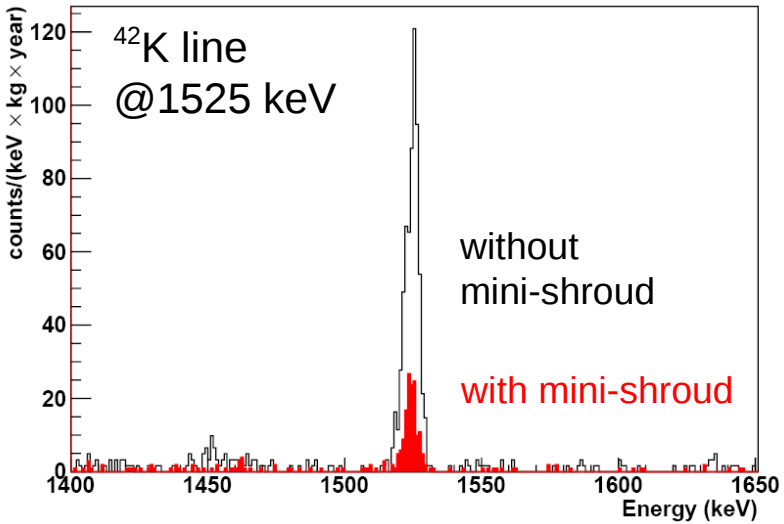
- since January 11, 2012: automatic blinding at $Q_{\beta\beta}$ (2039 ± 20) keV
- no pulse shape discrimination (PSD) applied so far

^{42}K background

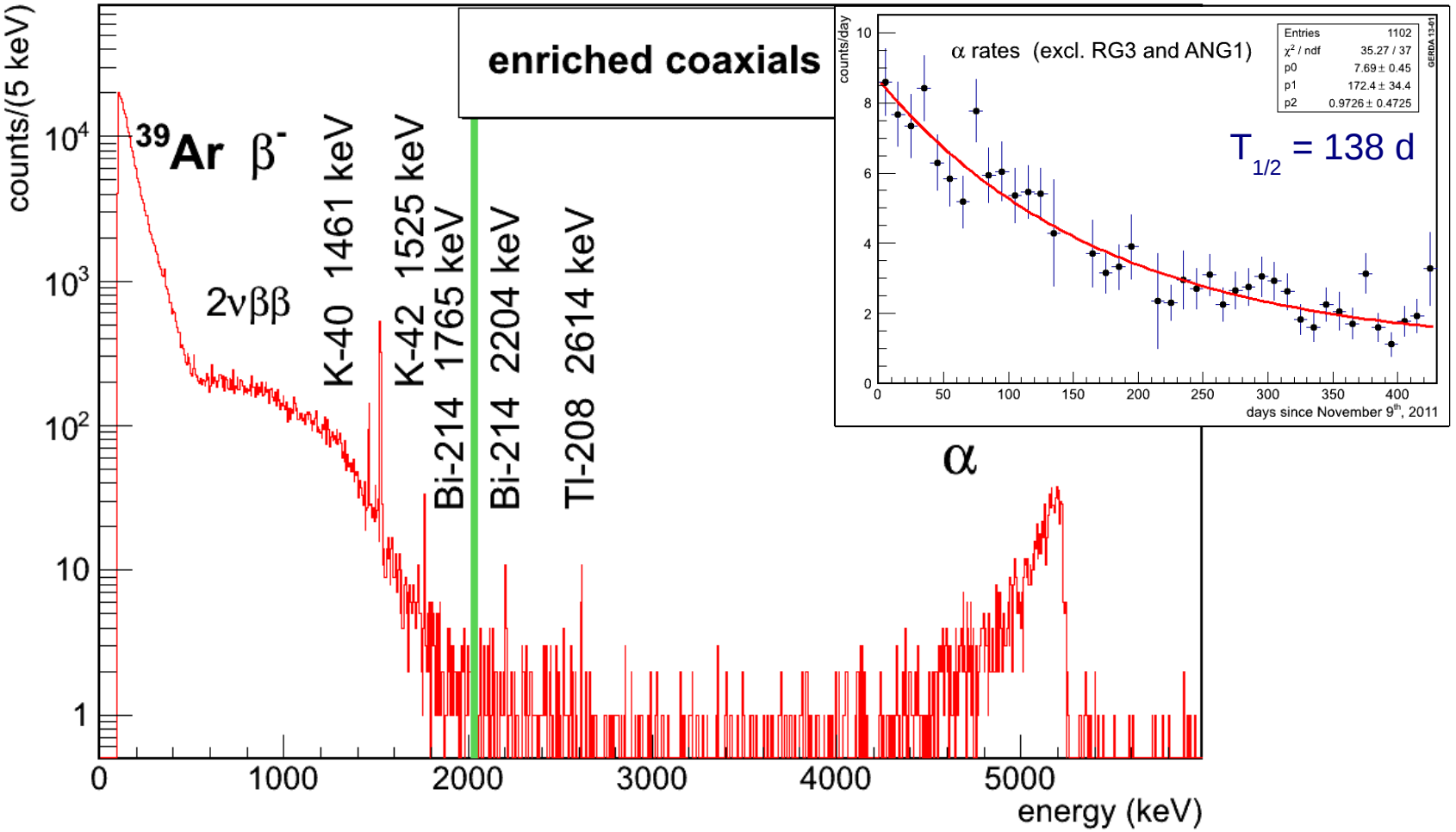
^{42}Ar activity used for proposal:	<41 µBq/kg @90% CL	[Barabash et al.,2002]
measured in GERDA:	(93.0 ± 6.4) µBq/kg	(preliminary result)



- background enhanced by collection of ^{42}K ions via E-field
- therefore: E-field & convection free configuration in 'mini-shroud'

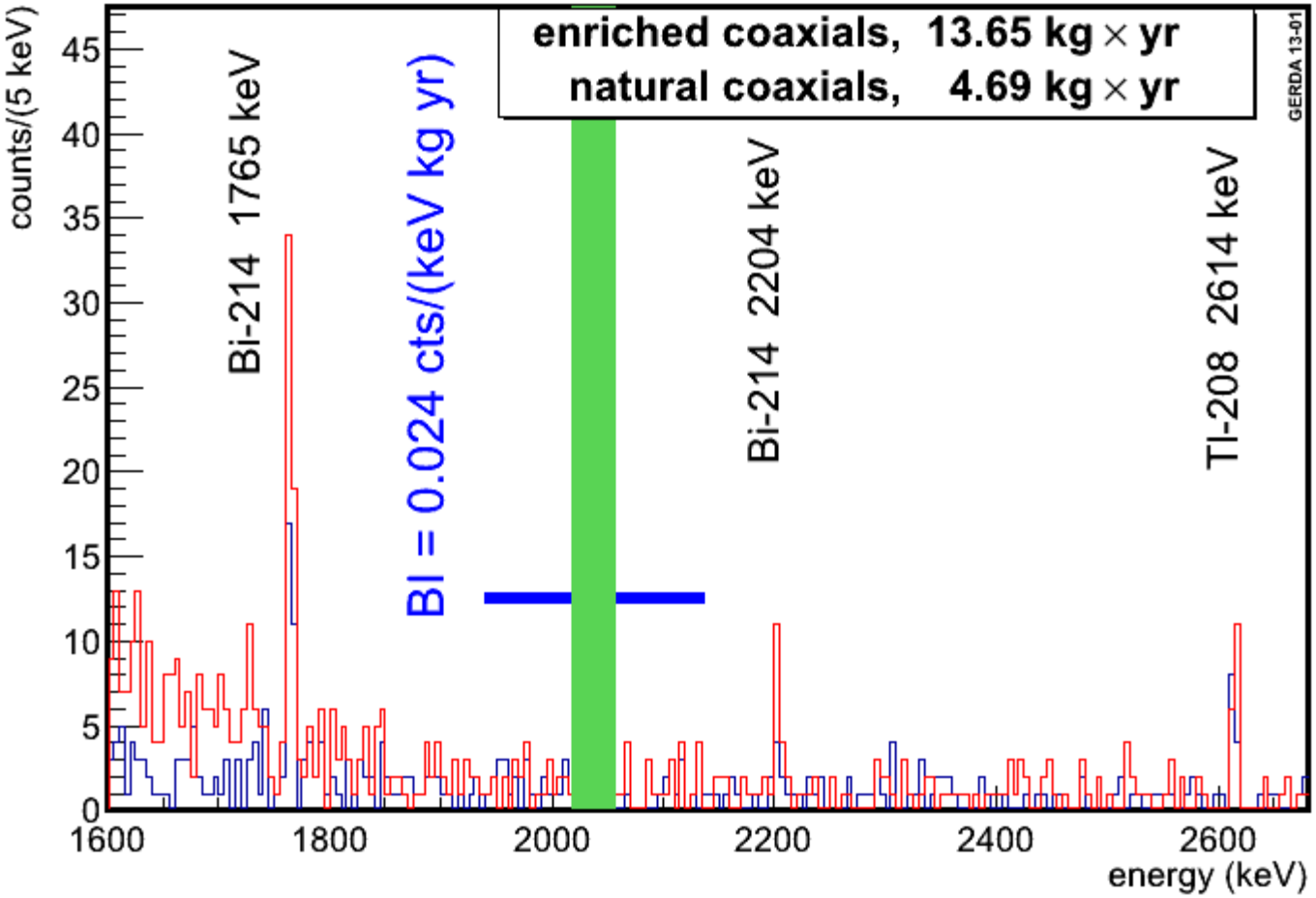


Alpha background

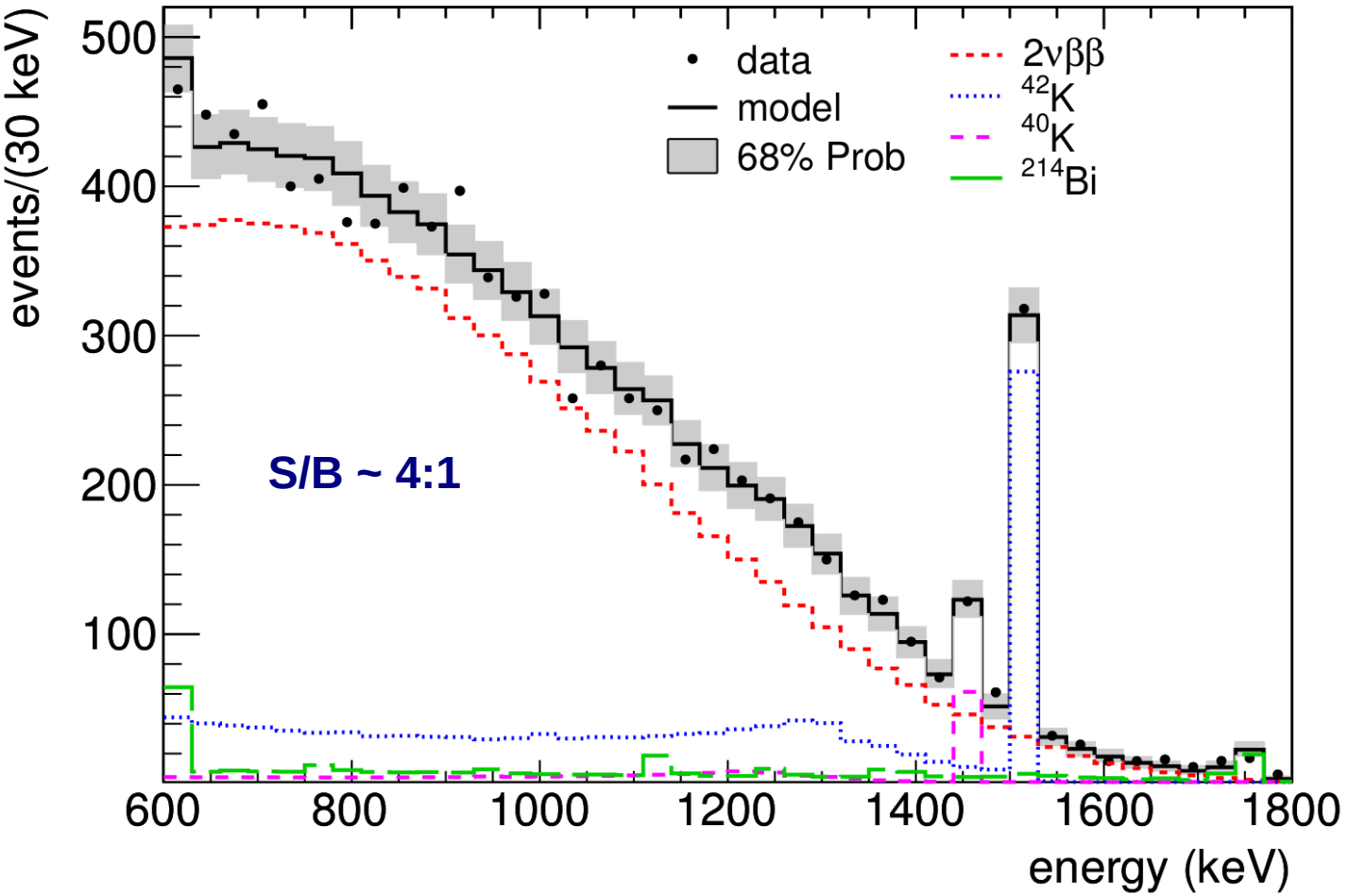


- alpha event rates are different for individual detectors
- MC suggest ^{210}Po contamination on p+ contact or groove

Phase I background index around $Q_{\beta\beta}$



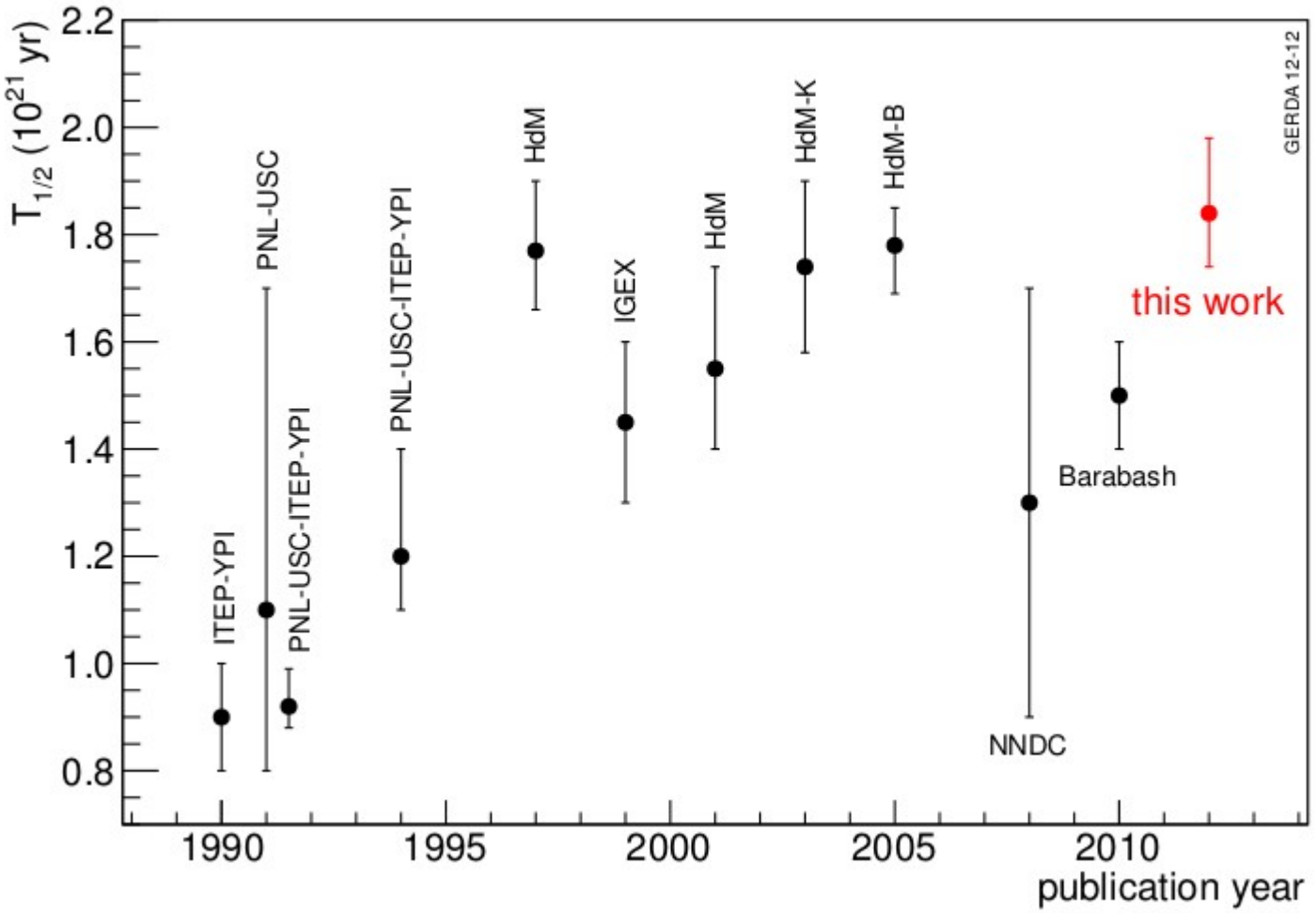
GERDA result: halflife of 2νββ



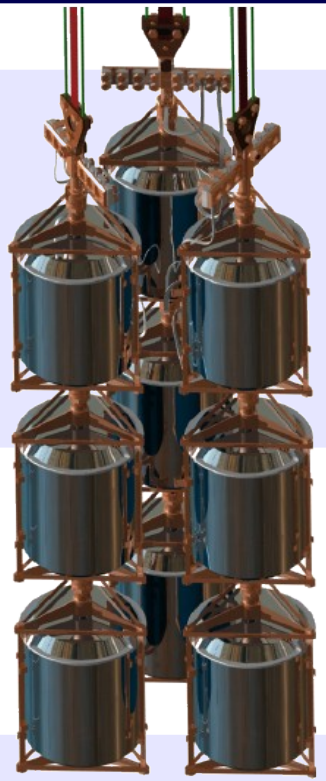
$$T^{2\nu}_{1/2} = (1.84^{+0.09}_{-0.08\ \text{fit}}\ ^{+0.11}_{-0.06\ \text{syst}}) \cdot 10^{21}\ \text{yr} = (1.84^{+0.14}_{-0.10}) \cdot 10^{21}\ \text{yr}$$

[J. Phys. G: Nucl. Part. Phys. 40 (2013) 035110]

Comparison of 2νββ measurements



Summary GERDA Phase I



- collected exposure to date: 13.65 kg·yr
- achieved background index: 2.4×10^{-2} cts/(keV·kg·yr)
- halflife $T_{1/2}$ of $2\nu\beta\beta$: $(1.84^{+0.14}_{-0.10}) \times 10^{21}$ yr
- unblinding & completion of phase I by mid 2013

Plans for GERDA Phase II

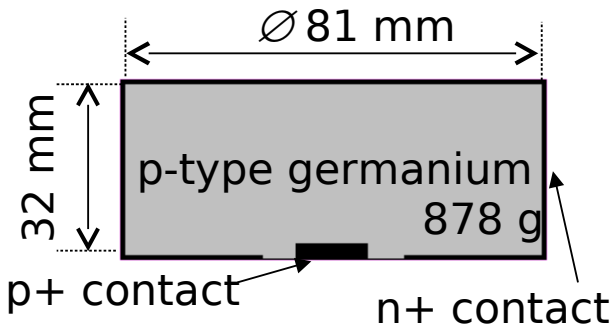
- collect total exposure: 100 kg·yr

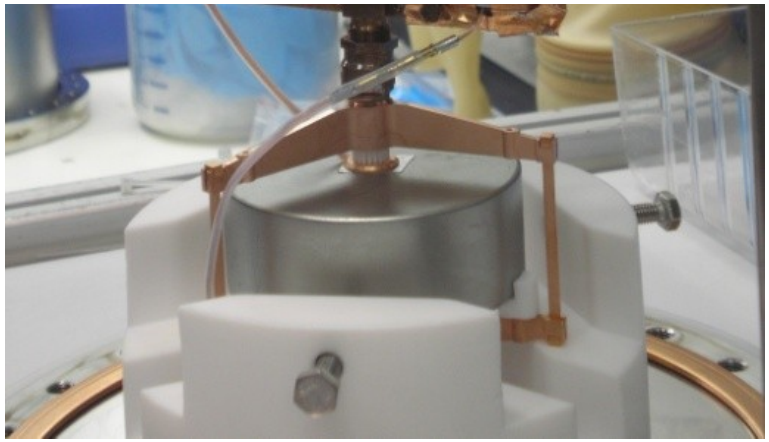
  → produce ~20 kg more detectors
- aspired background index: 1×10^{-3} cts/(keV·kg·yr)

  → use improved detector support & electronics

  → use active background suppression

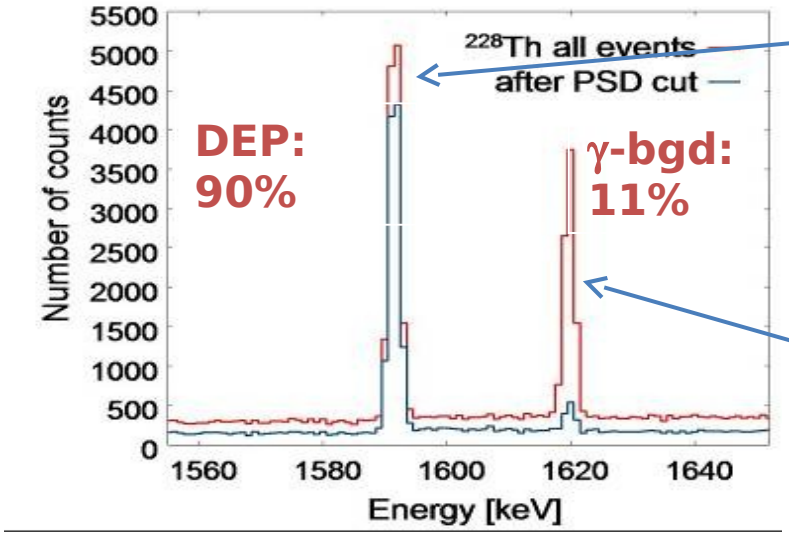
BEGe detectors & pulse shape discrimination



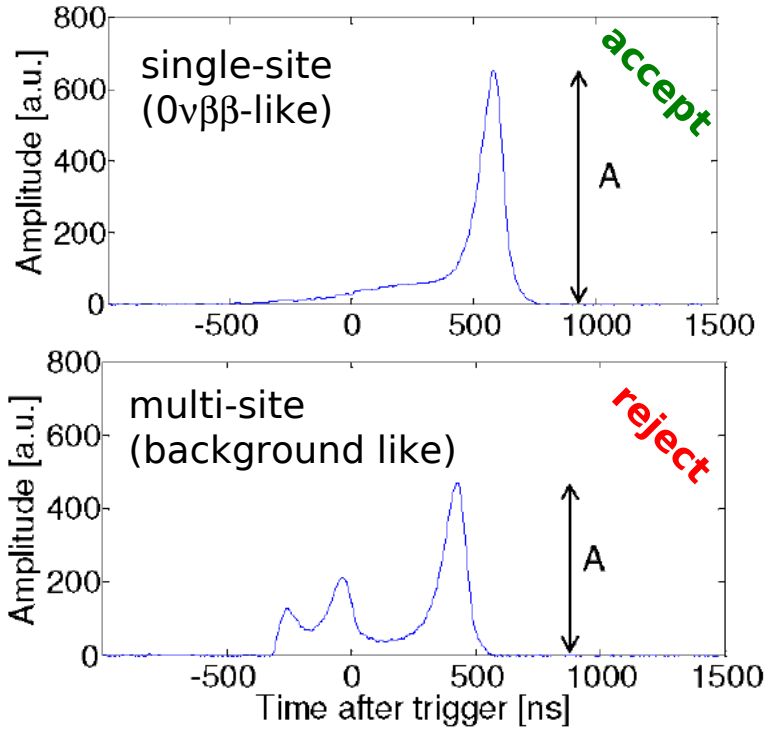


Example of BEGe detector:
resolution: 1.59 keV FWHM @1.33 MeV

powerful Pulse Shape Discrimination (PSD):



[see HK 66.6]



Phase II diode production completed

- 30 enriched BEGe detectors (~20.5 kg) were produced & successfully tested in the HEROICA test facility

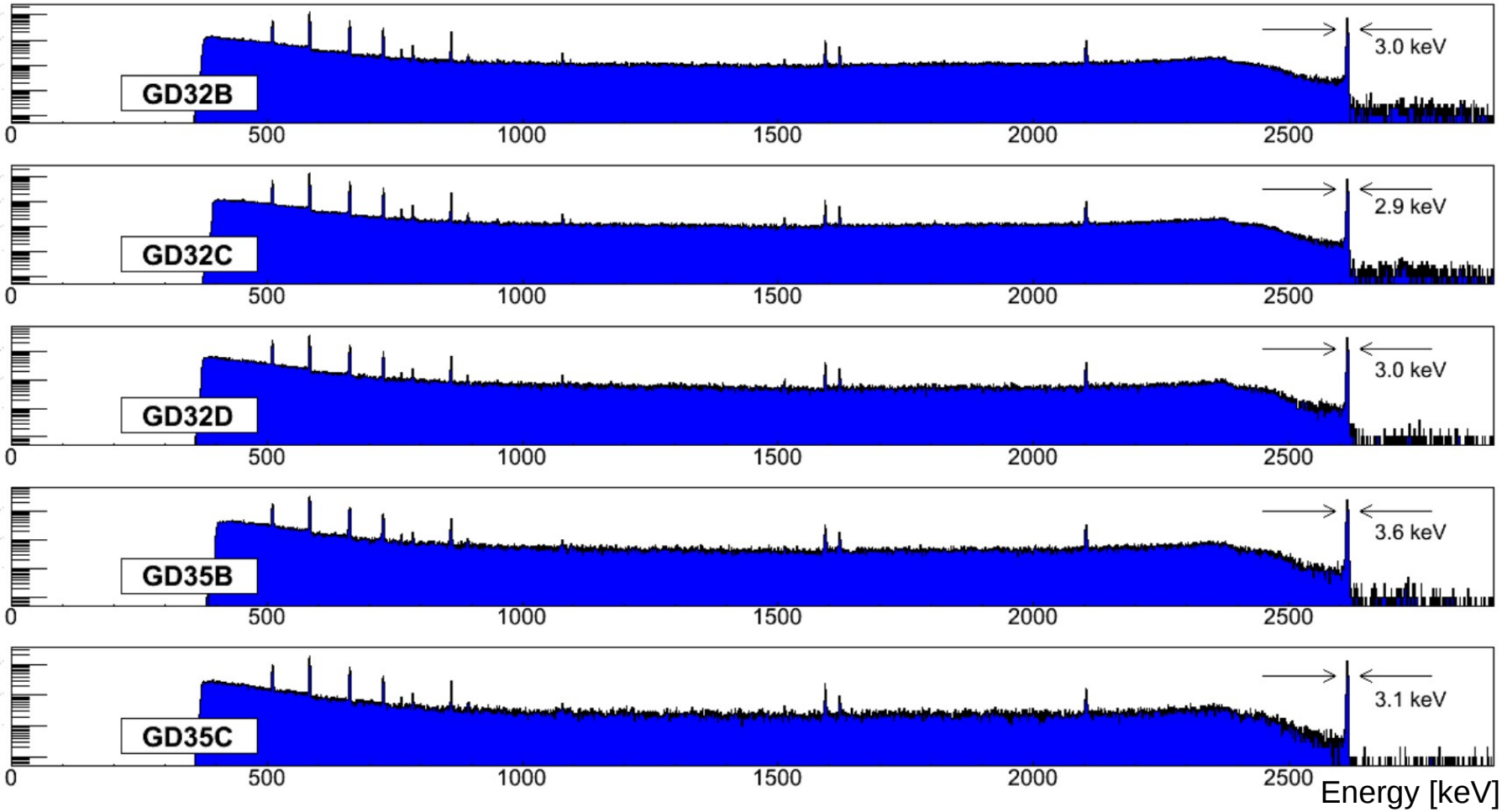
2010: reduction & zone refinement, PPM Metals GmbH, Langelsheim, Germany

2005: isotope enrichment at ECP in Zelenogorsk, Russia (37.5 kg GeO_2)

2011/12: Crystal pulling & cutting at Canberra, Oak Ridge, USA

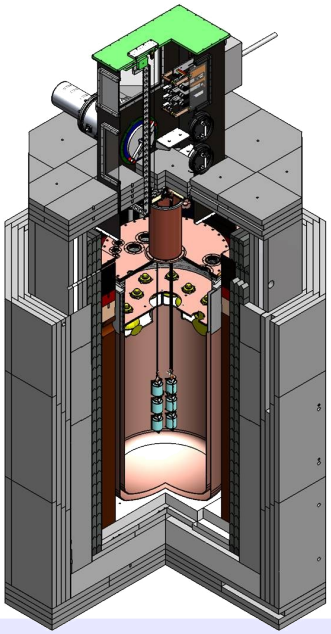
2012: diode production at Canberra Olen, Belgium & acceptance tests in HEROICA test facility

July 2012: 5 ^{enr}BEGe's deployed in GERDA



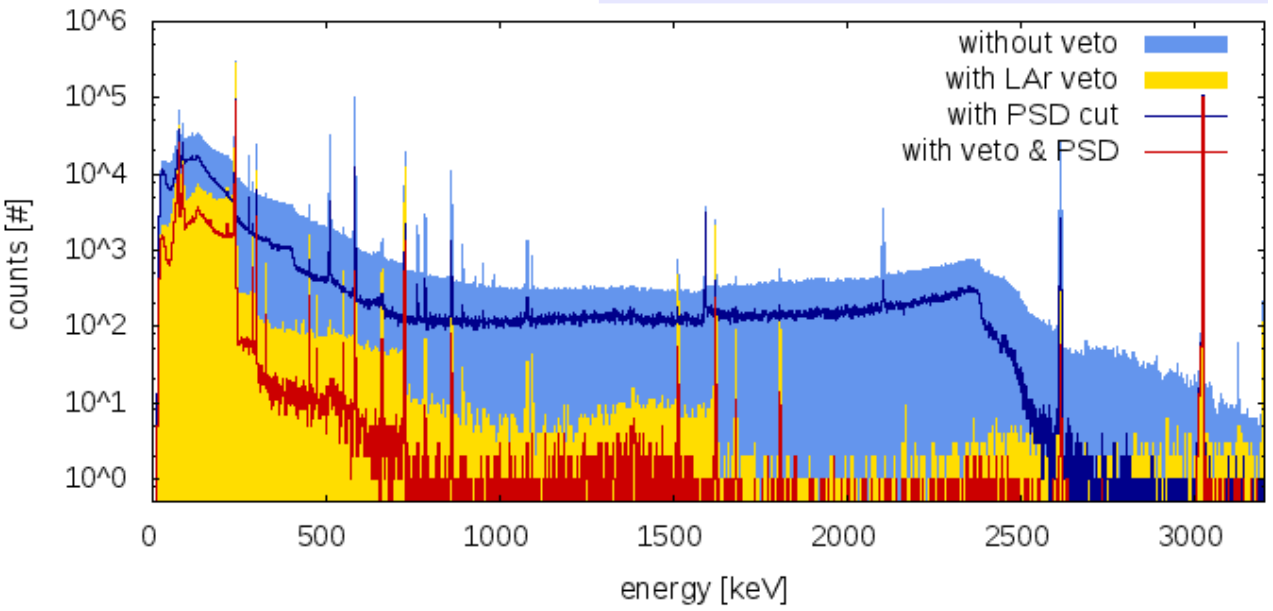
total mass: 3.6 kg

Liquid argon scintillation veto R&D



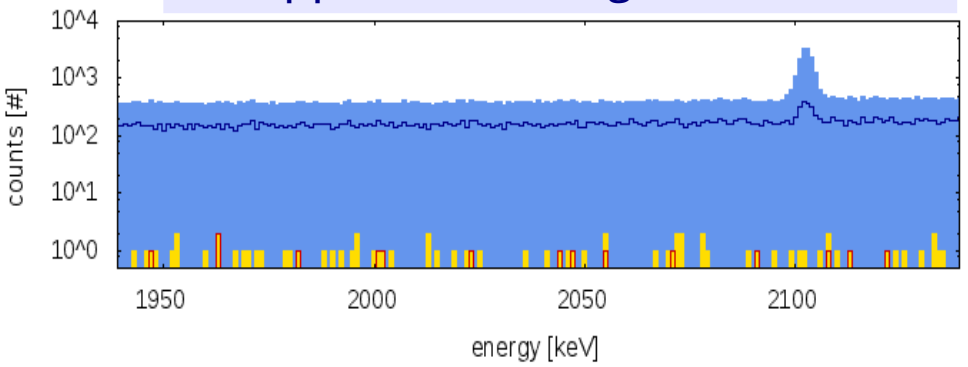
LArGe testbench at Gran Sasso

e.g. internal Th-228 source



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

... suppression at region of interest



Liquid argon light instrumentation for GERDA

9x 3“ PMT

Cu shroud & wavelength-shifter

Ge detectors

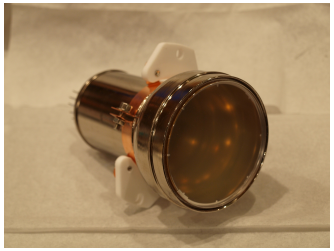
scintillating fibres & SiPM read-out

Cu shroud & wavelength-shifter

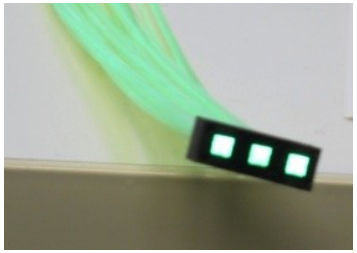
7x 3“ PMT

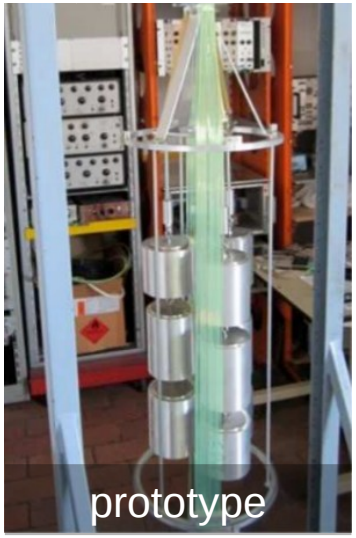
- MC optimization campaign completed
- hardware is beeing tested & prepared

PMTs



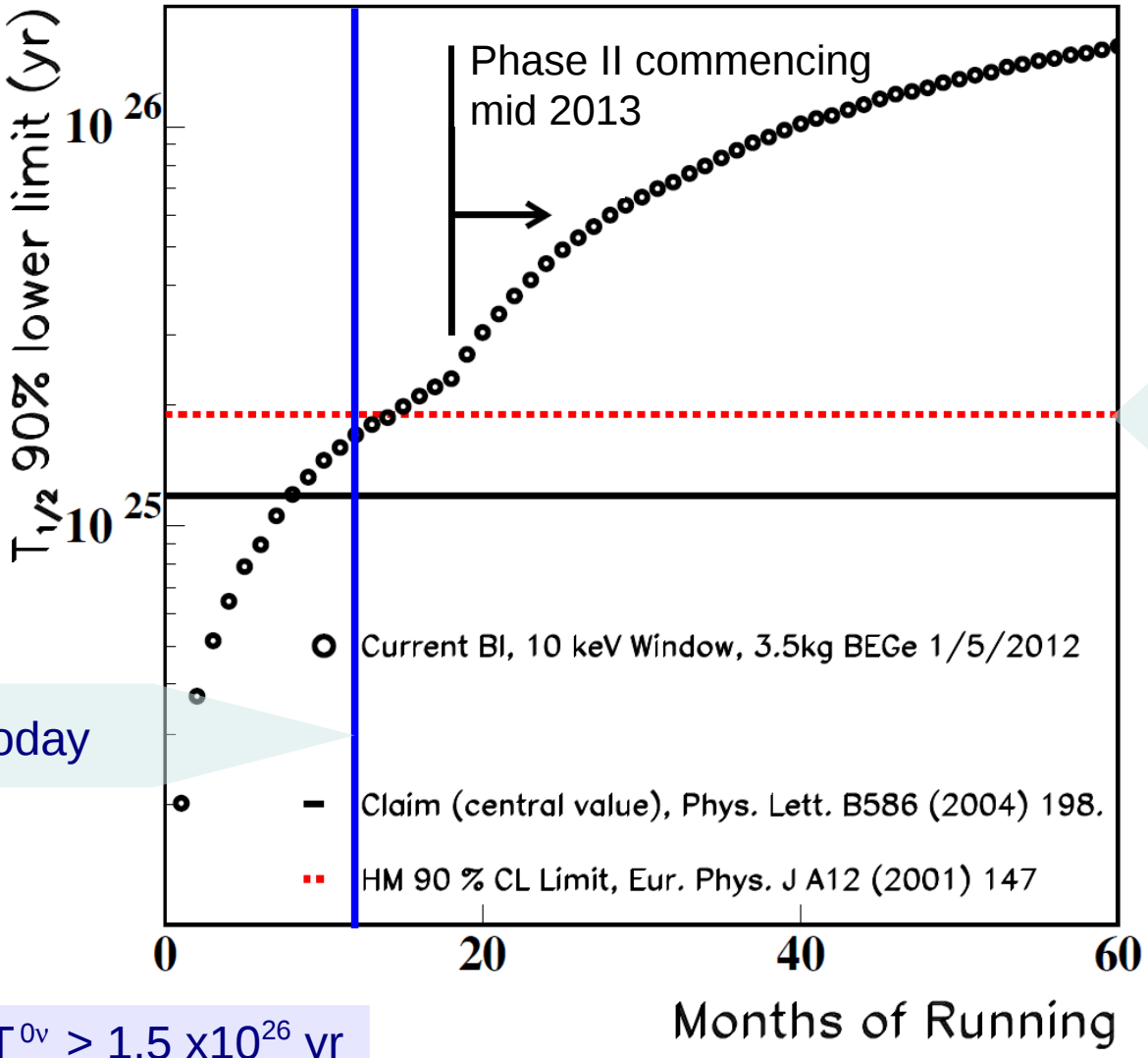
'fibres'





[see T 109.1/HK 22.1]

GERDA 0νββ sensitivity projection



Heidelberg-Moscow Claim

here we are today

Phase II goal: $T^{0\nu}_{1/2} > 1.5 \times 10^{26}$ yr

Conclusions & outlook ...

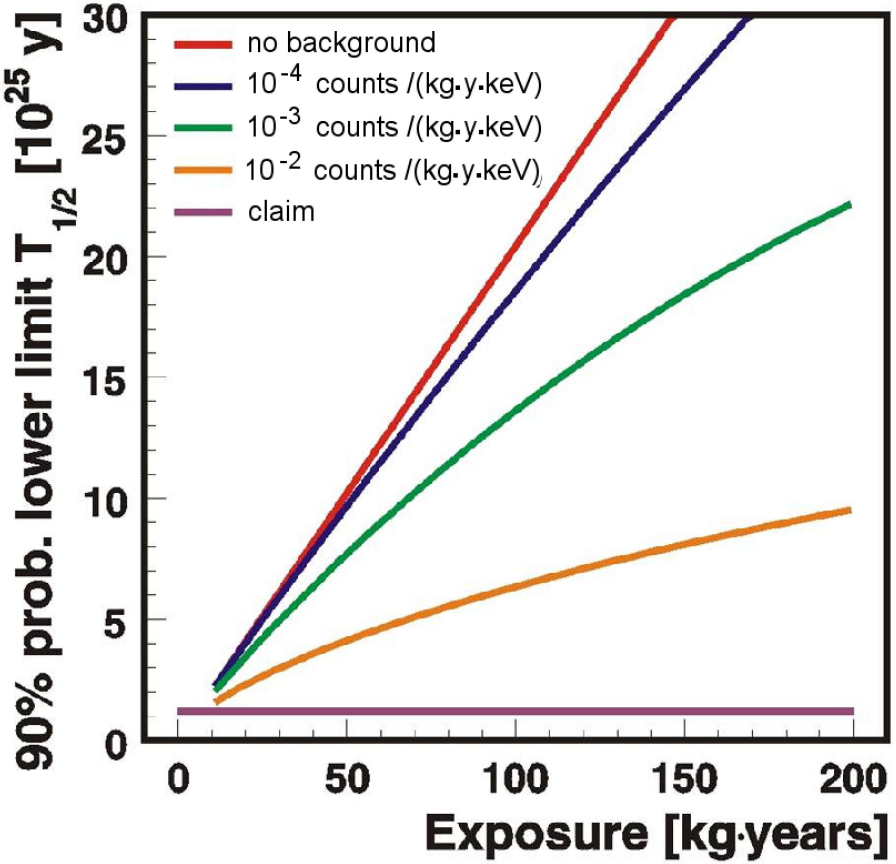
Phase I

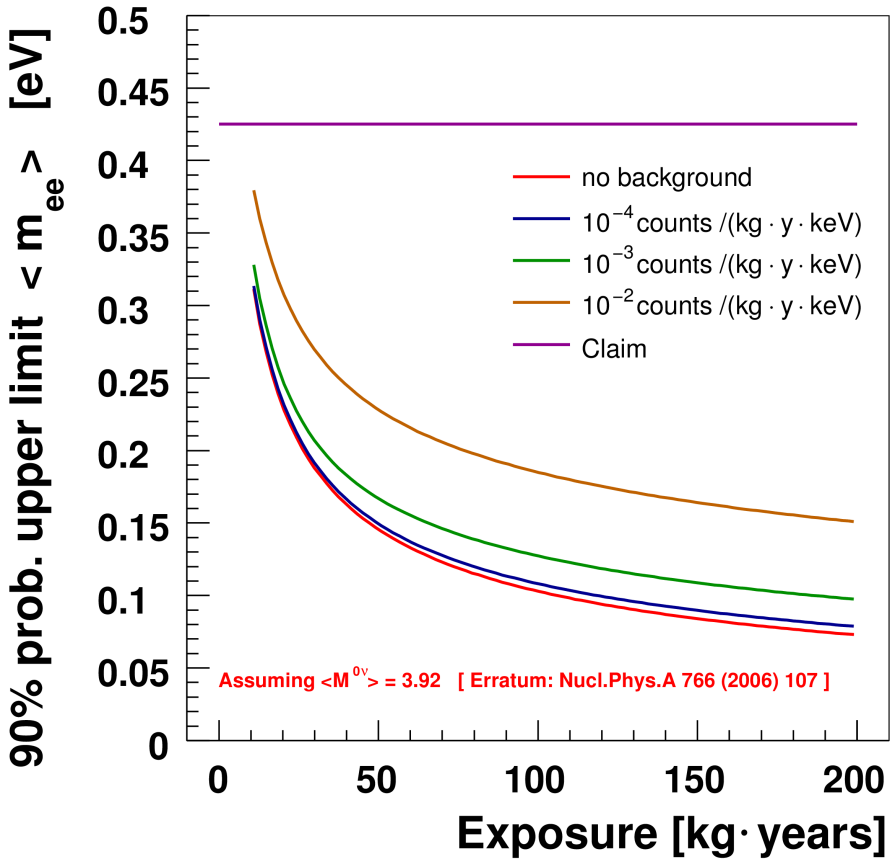
- collected exposure to date: 13.65 kg·yr
- achieved background index: 2.4×10^{-2} cts/(keV·kg·yr)
- halflife $T^{2\nu}_{1/2}$ of $2\nu\beta\beta$: $(1.84^{+0.14}_{-0.10}) \times 10^{21}$ yr
- unblinding & completion of phase I by mid 2013

Phase II

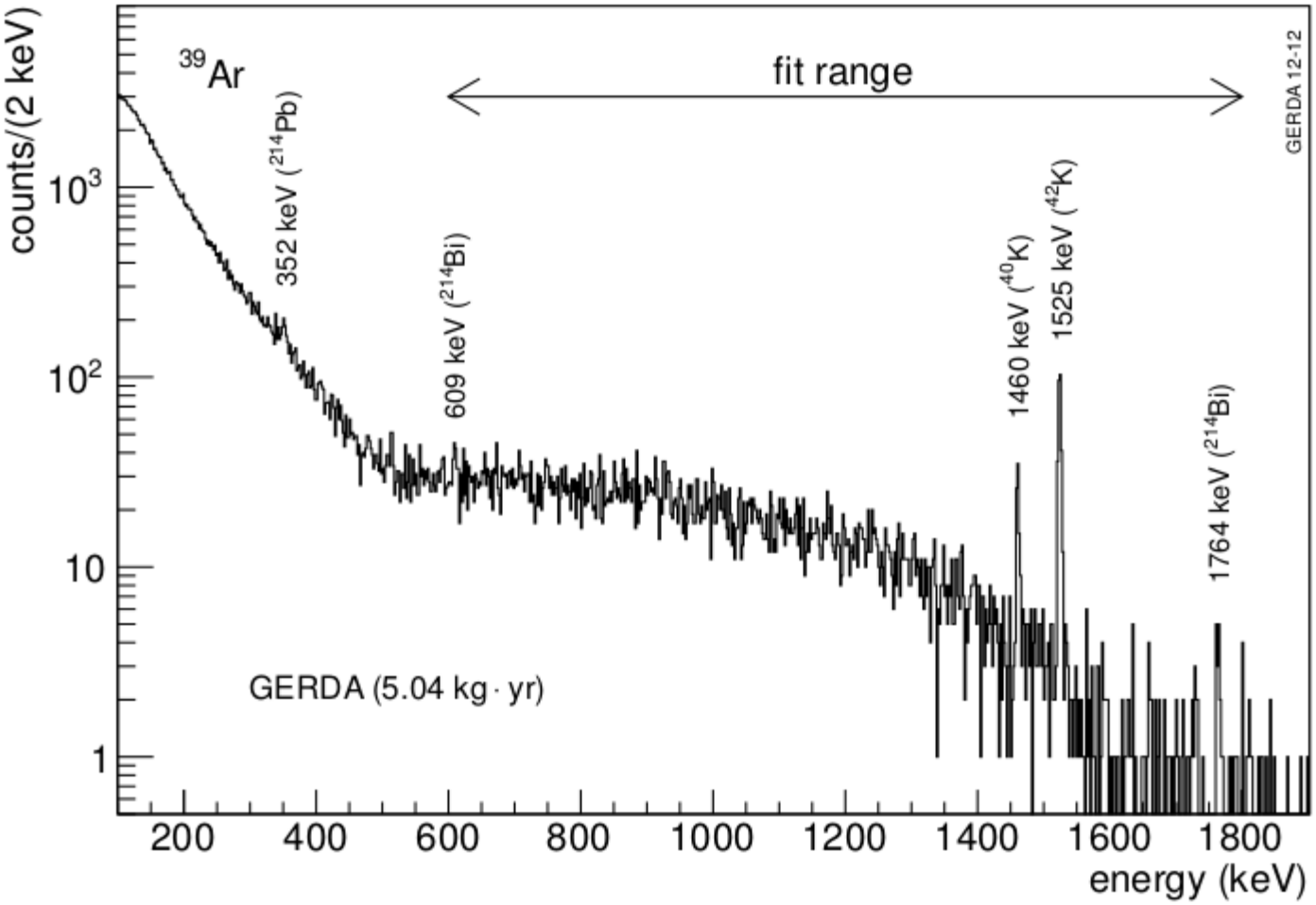
- goals: exposure: 100 kg·yr
  background index: 1×10^{-3} cts/(keV·kg·yr)
  } $T^{0\nu}_{1/2} > 1.5 \times 10^{26}$ yr
- ~20.5 kg BEGe detectors produced & tested (5 are operating in GERDA)
- active bgr suppression: superior pulse shape discrimination
  install LAr light instrumentation as veto
- use improved detector support & electronics

GERDA 0νββ sensitivity projection

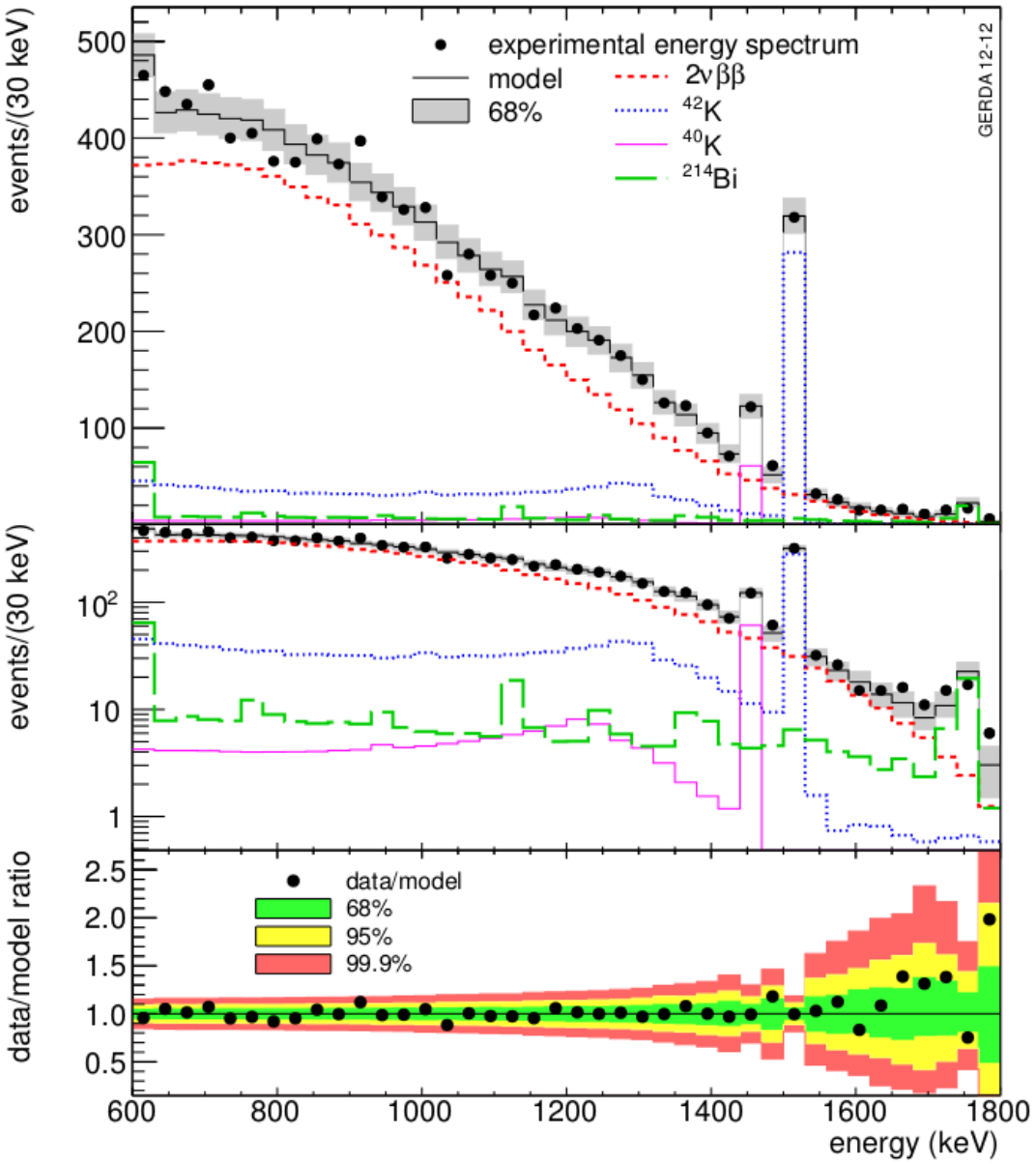




Background spectrum for 2νββ fit



Background composition in 2νββ fit



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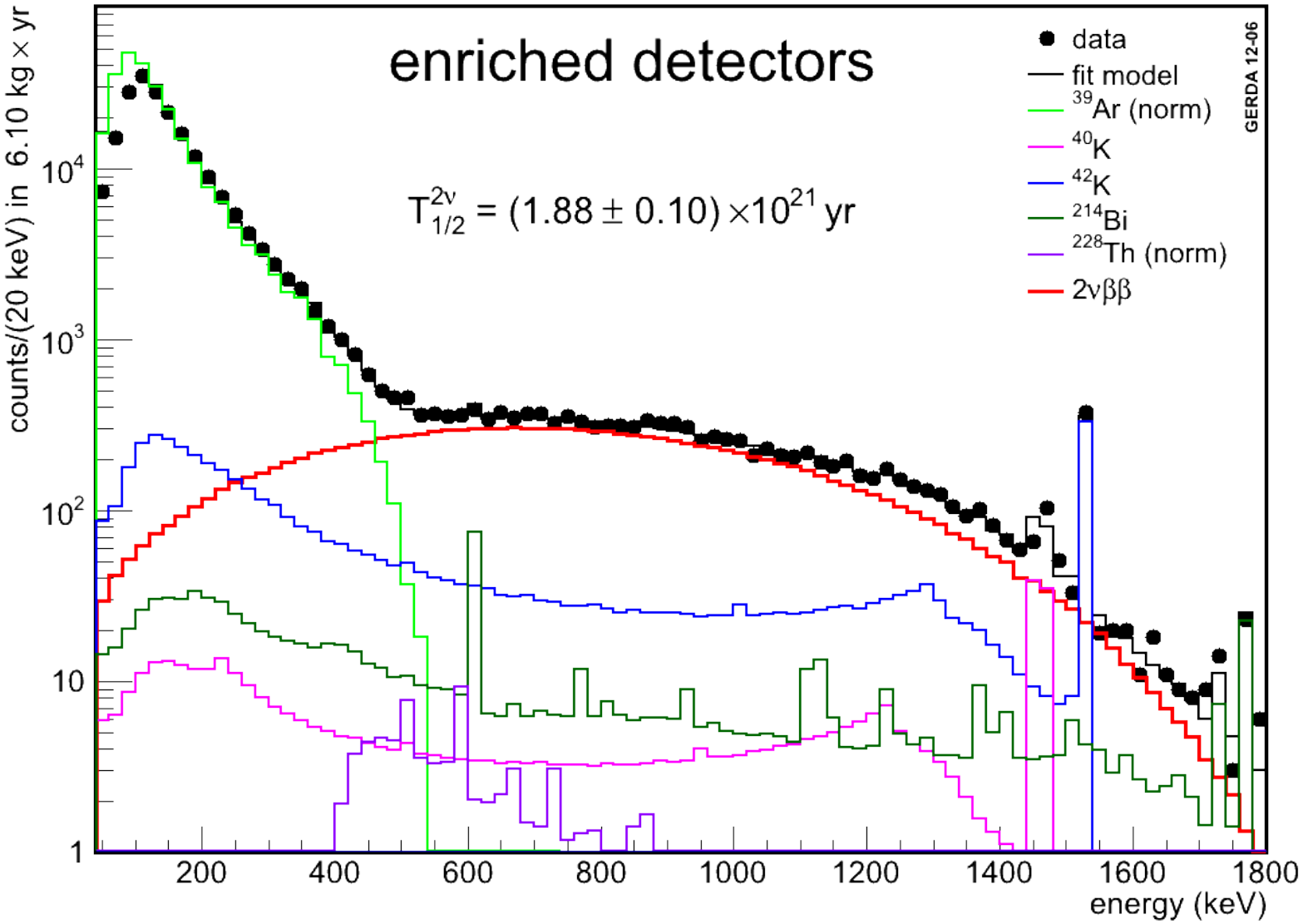

July 2012: 5 ^{enr}BEGe's deployed in GERDA