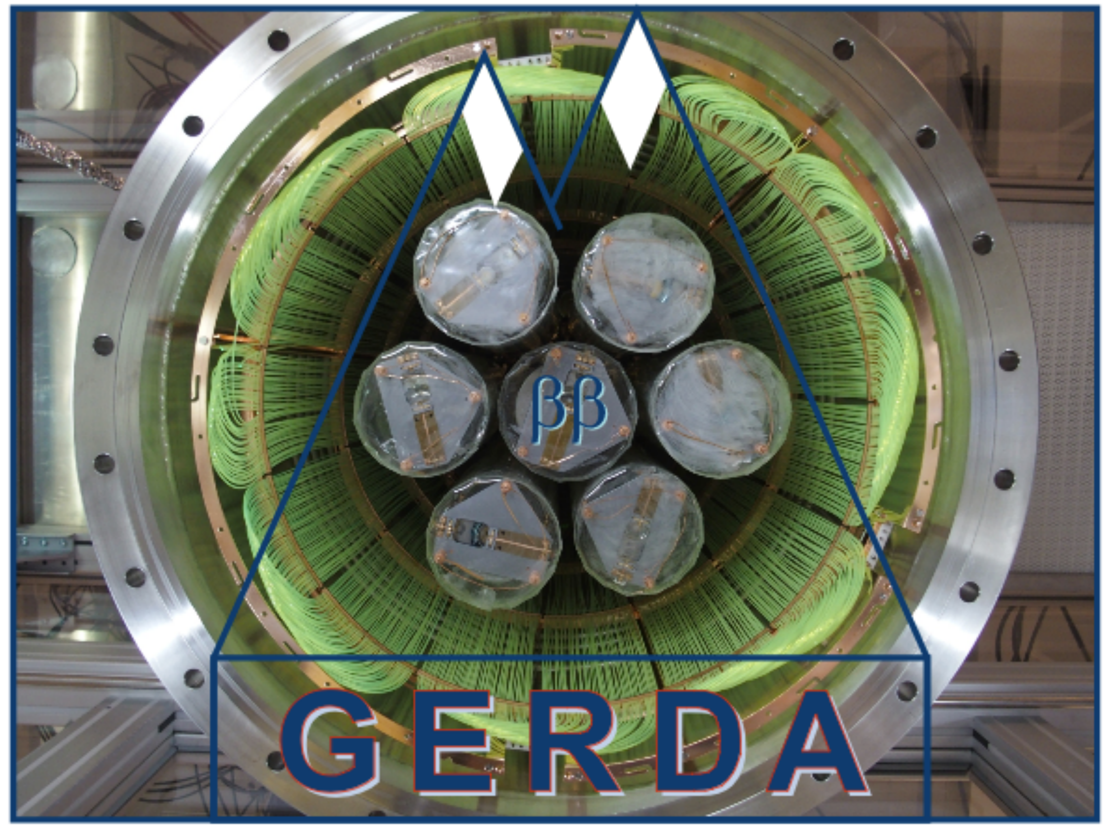


GERDA PHASE II INSTALLATION & STARTUP

Francesco SALAMIDA for the GERDA Collaboration

INFN & University of Milano Bicocca

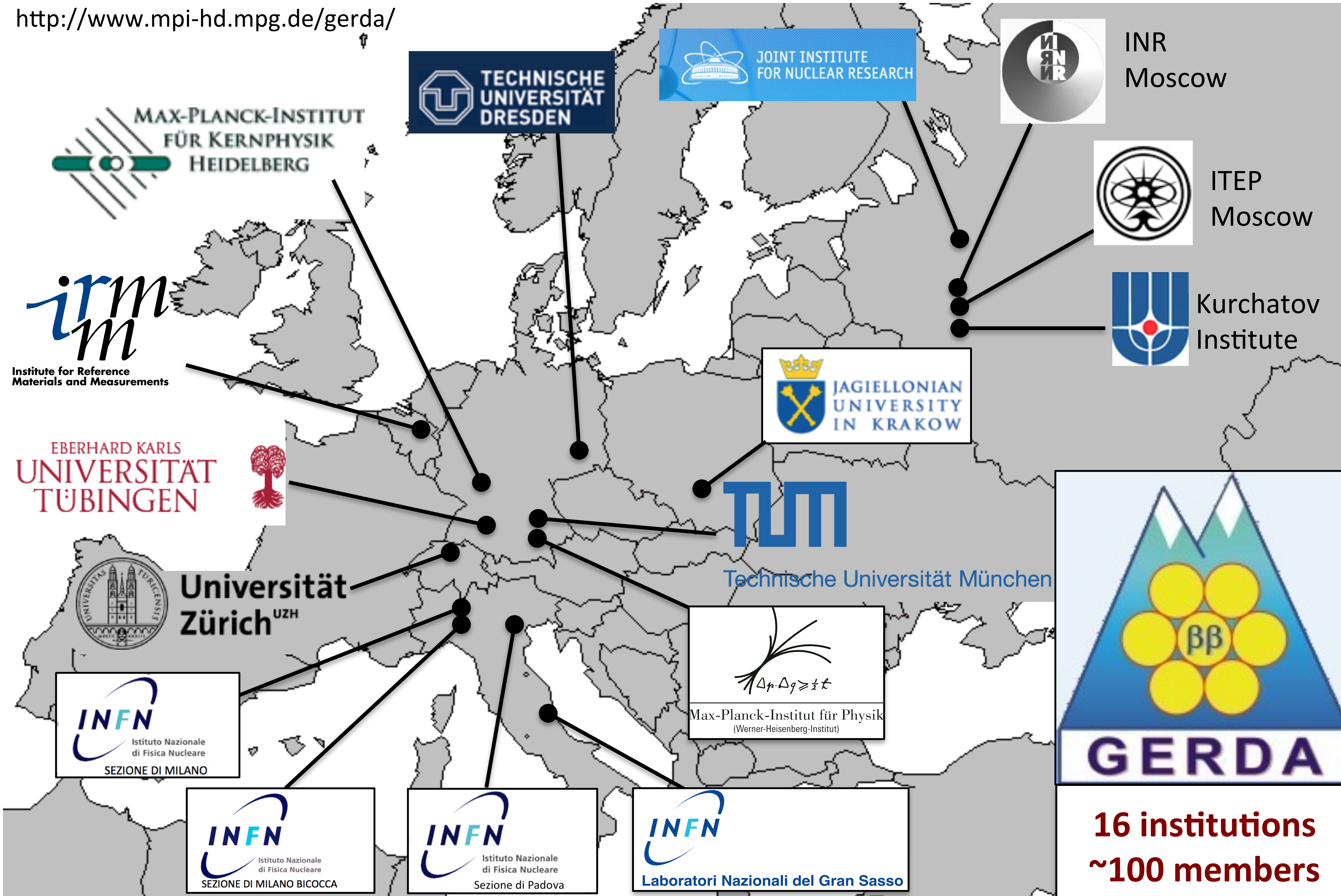
Meeting of the Gran Sasso Scientific Committee - April 11th-12th, 2016

OUTLINE

- Summary of GERDA Phase I
- GERDA Phase II
    - Phase II Upgrade
    - Germanium Detector Array
    - Liquid Argon (LAr) Veto
    - Final Configuration of GERDA Phase II
    - Performances
    - First Background Spectrum
- Summary

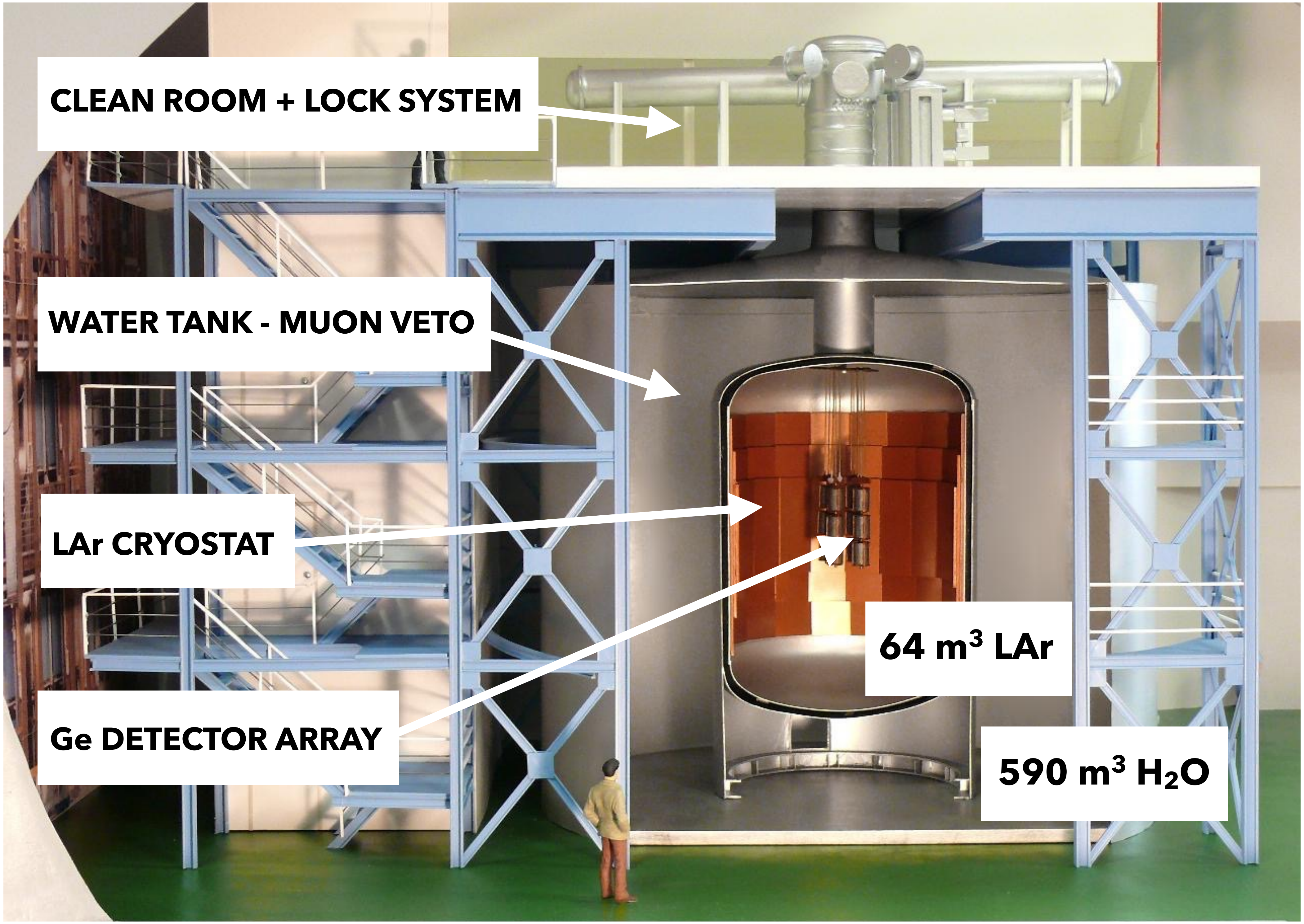
THE GERDA COLLABORATION

http://www.mpi-hd.mpg.de/gerda/



GERDA EXPERIMENT

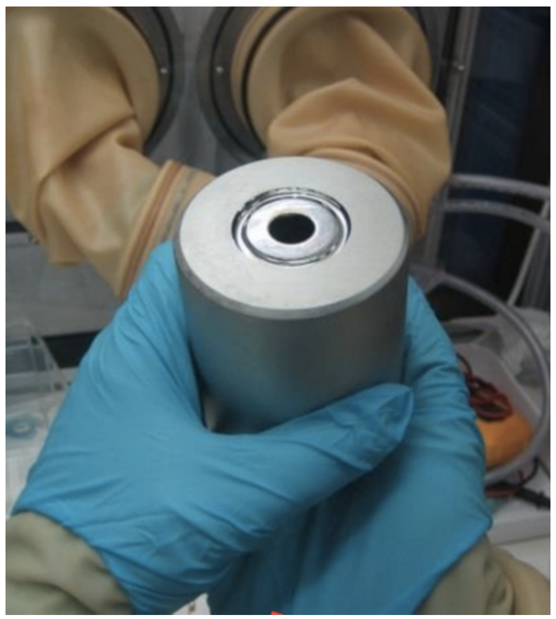
- array of bare HPGe detectors isotopically enriched in ^{76}Ge (~87%) in LAr
- water and LAr to shield against external radiation and temperature control



GERDA PHASE I

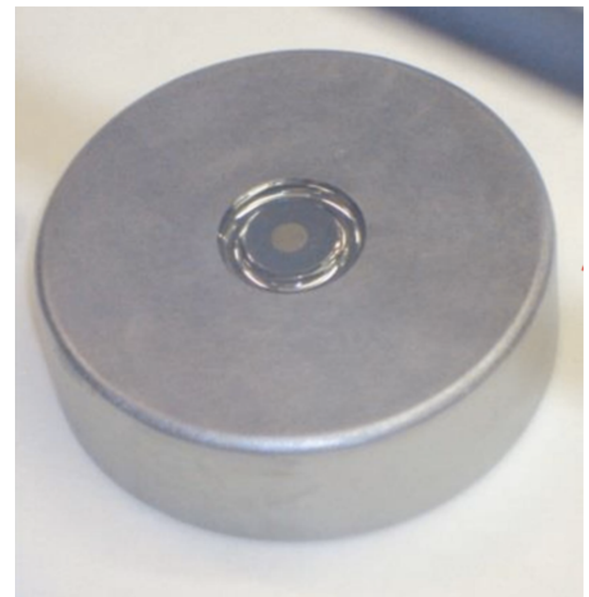
COAXIAL DETECTORS

- from previous experiments (HdM, IGEX)
- total mass 17.7 kg
- average FWHM of 4.3 keV at $Q_{\beta\beta}$



BEGe DETECTORS

- better PSD and FWHM
- 5 BEGes used since July 2012
- average FWHM of 2.8 keV at $Q_{\beta\beta}$



PHASE I STRING

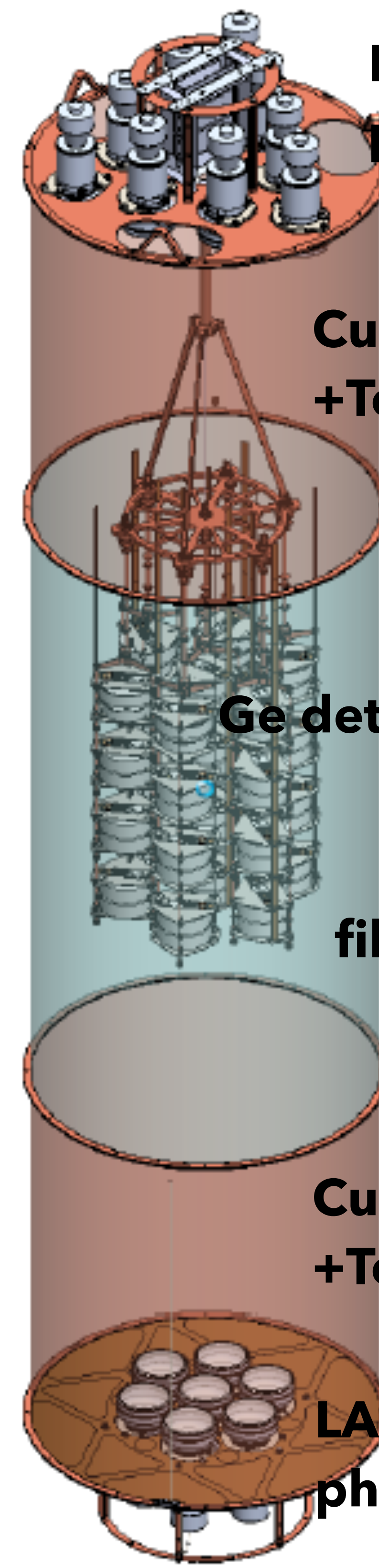
PHASE I RESULTS

- from Nov 2011 to May 2013: exposure = 21.6 kg·yr
- **BI = (11±2) 10^{-3} cts/(keV kg yr)**
- new limit on the 0νββ: **$T^{0\nu}_{1/2} > 2.1 \cdot 10^{25}$ yr 90% C.L**
- previous claim [Nucl. Instr. Meth. A 481, 149 (2002)] strongly disfavoured
- upper limit on neutrino mass 0.2 - 0.4 eV (depending on N.M.E.)

GERDA PHASE II UPGRADES

IMPROVEMENT W.R.T PHASE I

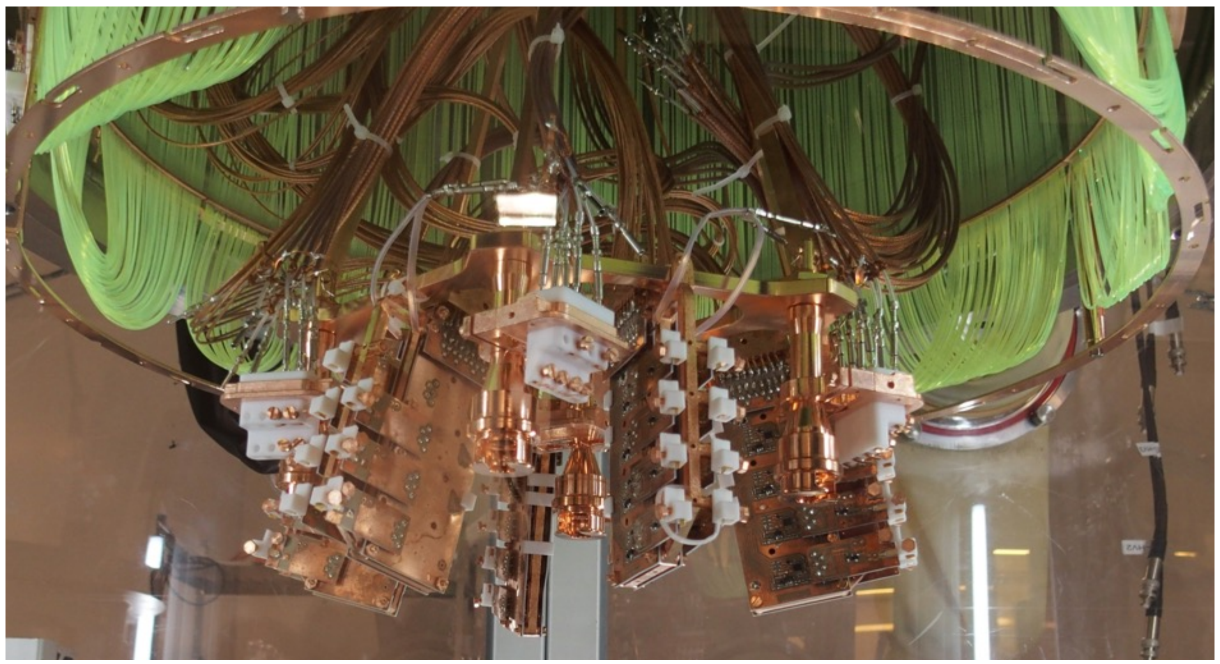
- 30 new BEGe detectors custom produced
- collect an exposure of ~100 kg·yr
  - more active mass (35.8 kg of ^{enr}Ge)
  - longer data acquisition (~ 3 - 4 yr)
- background reduction to ~10^{-3} cts/(keVkgyr)
  - new low mass holder, detector contacts and front End (FE) circuits
  - pulse shape discrimination with BEGes
  - LAr readout to veto residual external background

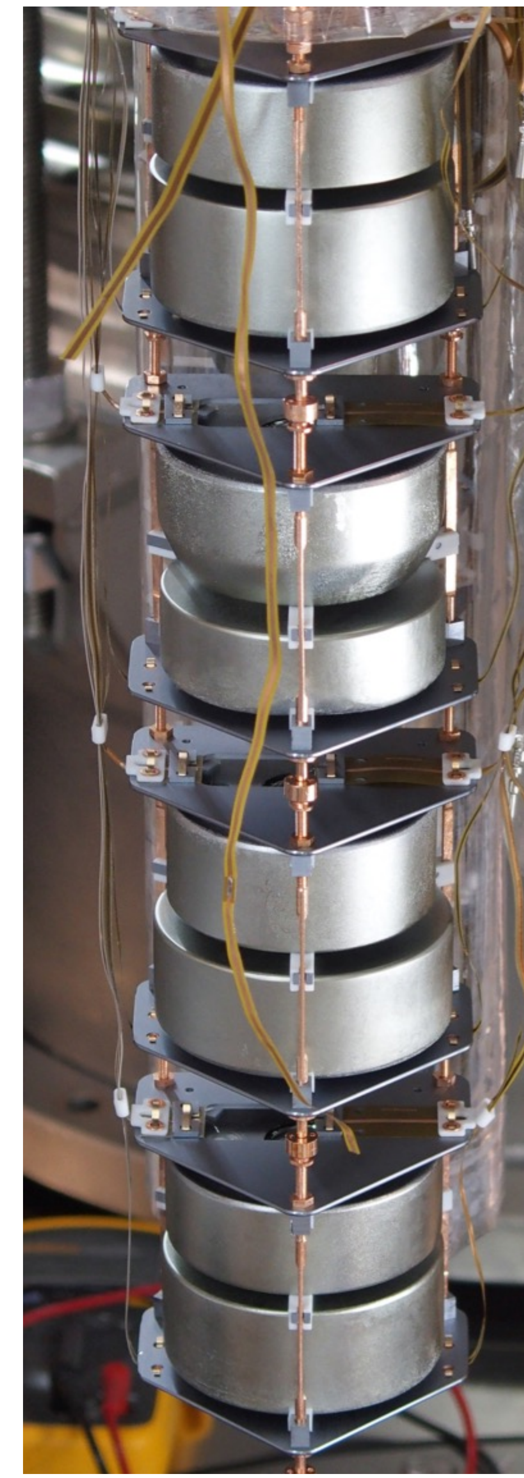


GERDA PHASE II UPGRADES: Ge ARRAY

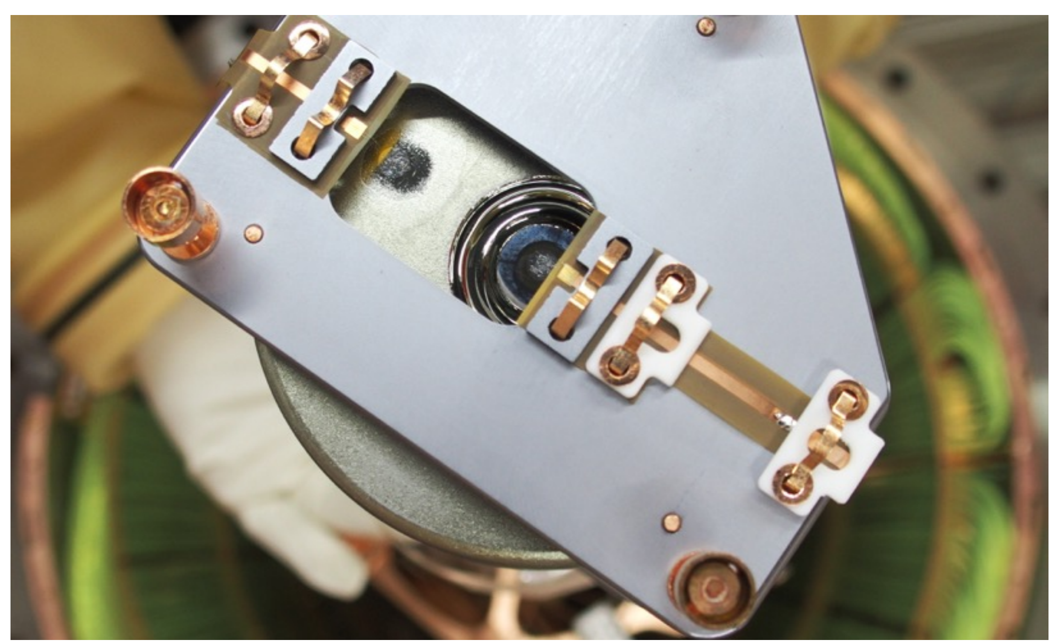
Holders: Si plates replace most of Cu parts (improved radiopurity)
Ge-string Mini Shroud (MS): nylon MS preventing ^{42}K from reaching Ge

FE Circuit: new custom design, improved radio purity, 75 (35) cm above bottom (top) detectors





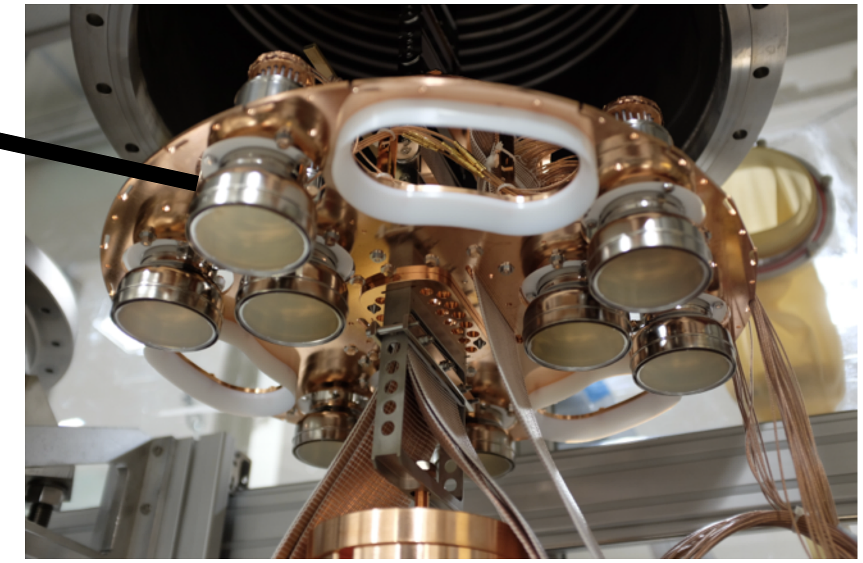
HV and signal contacts: bonding wire replace spring loaded contact
FE cables: custom low mass + low activity (Pyralux + Cuflon)



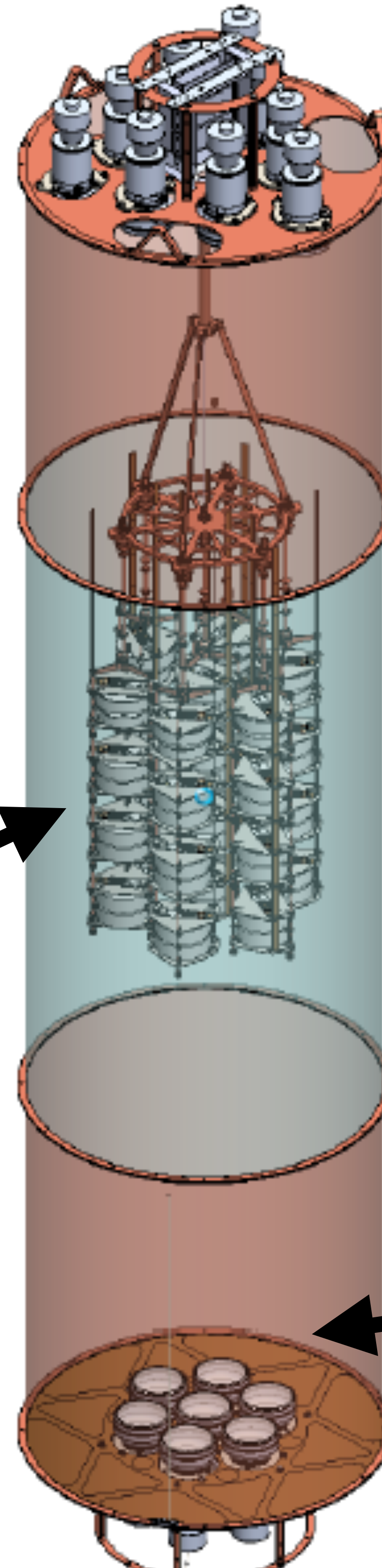
LIQUID ARGON VETO

Integrated and commissioned since May 2015

16 photomultiplier (PMTs)
9 TOP - 7 BOTTOM



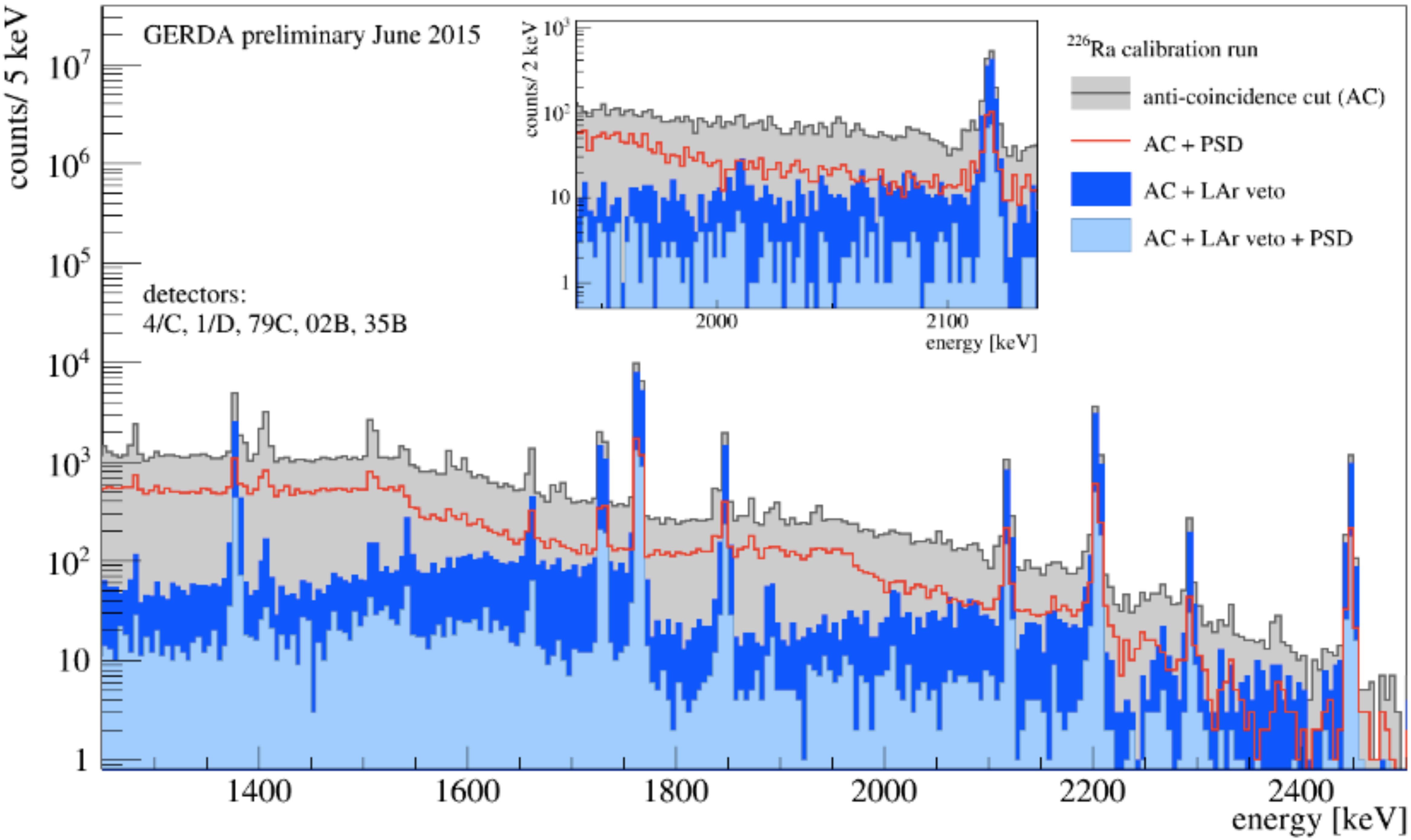
810 scintillating fibers coupled to 90 3x3 mm SiPMs (15 readout channels)



Cu cylinder covered with wavelength shifting reflector foil

LIQUID ARGON VETO

1 PILOT STRING ^{226}Ra POINT LIKE SOURCE

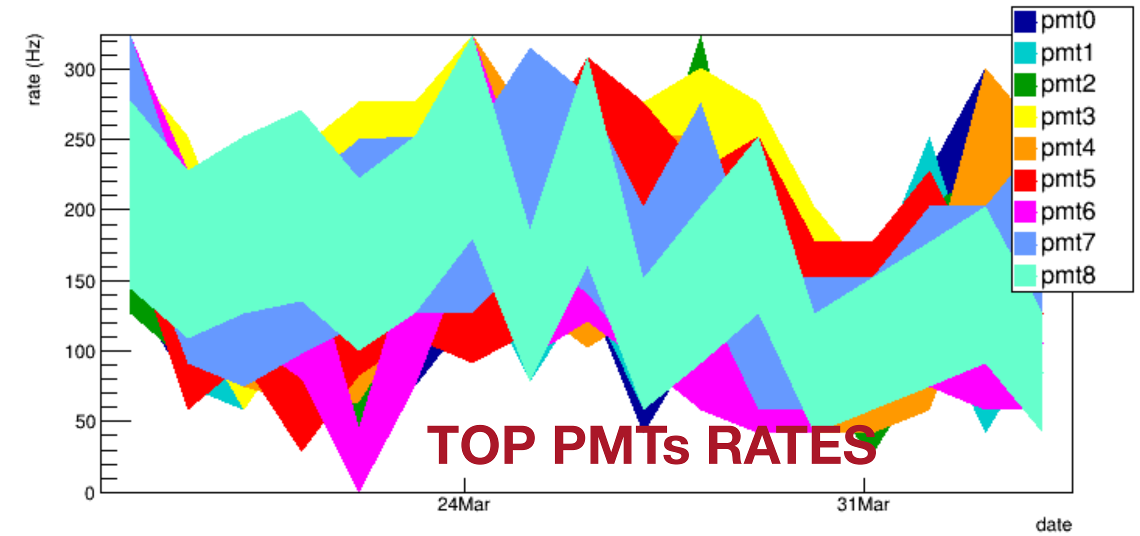


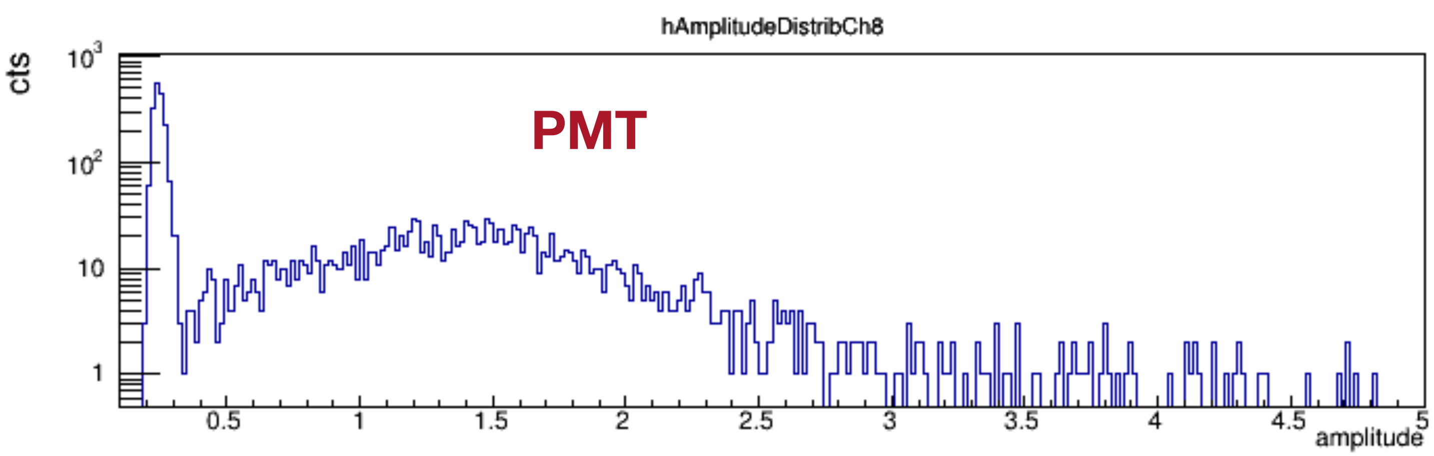
LAr veto background suppression ~ 5.1 ± 0.2

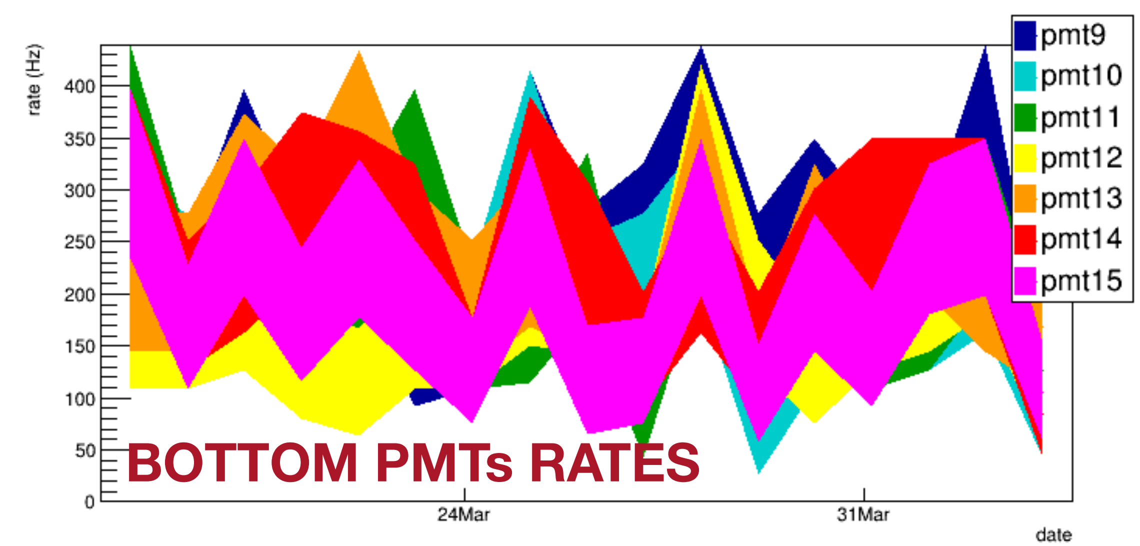
LAr + PSD + anti coincidence cut ~ 25 ± 2.2

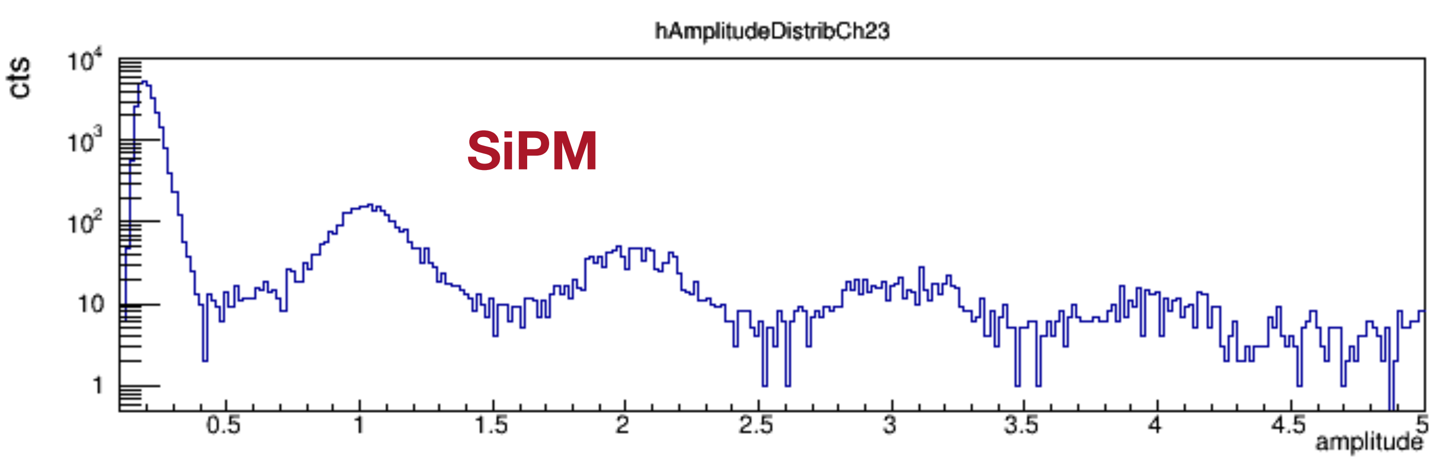
LIQUID ARGON VETO: PERFORMANCES

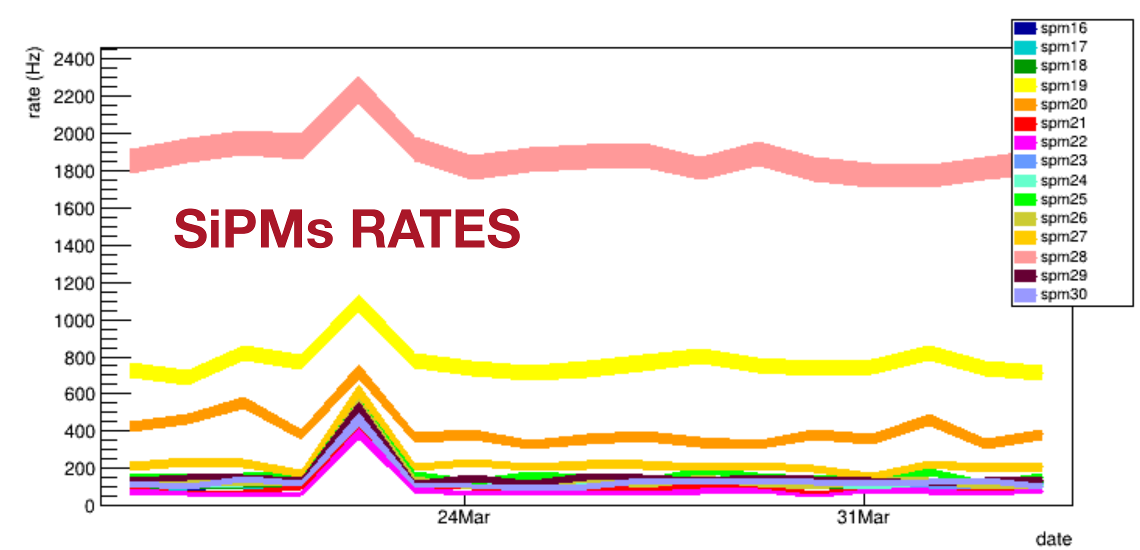
- single photoelectron peak well visible in both PMTs and SiPMs
- PMTs and SiPMs rates are stable during DAQ









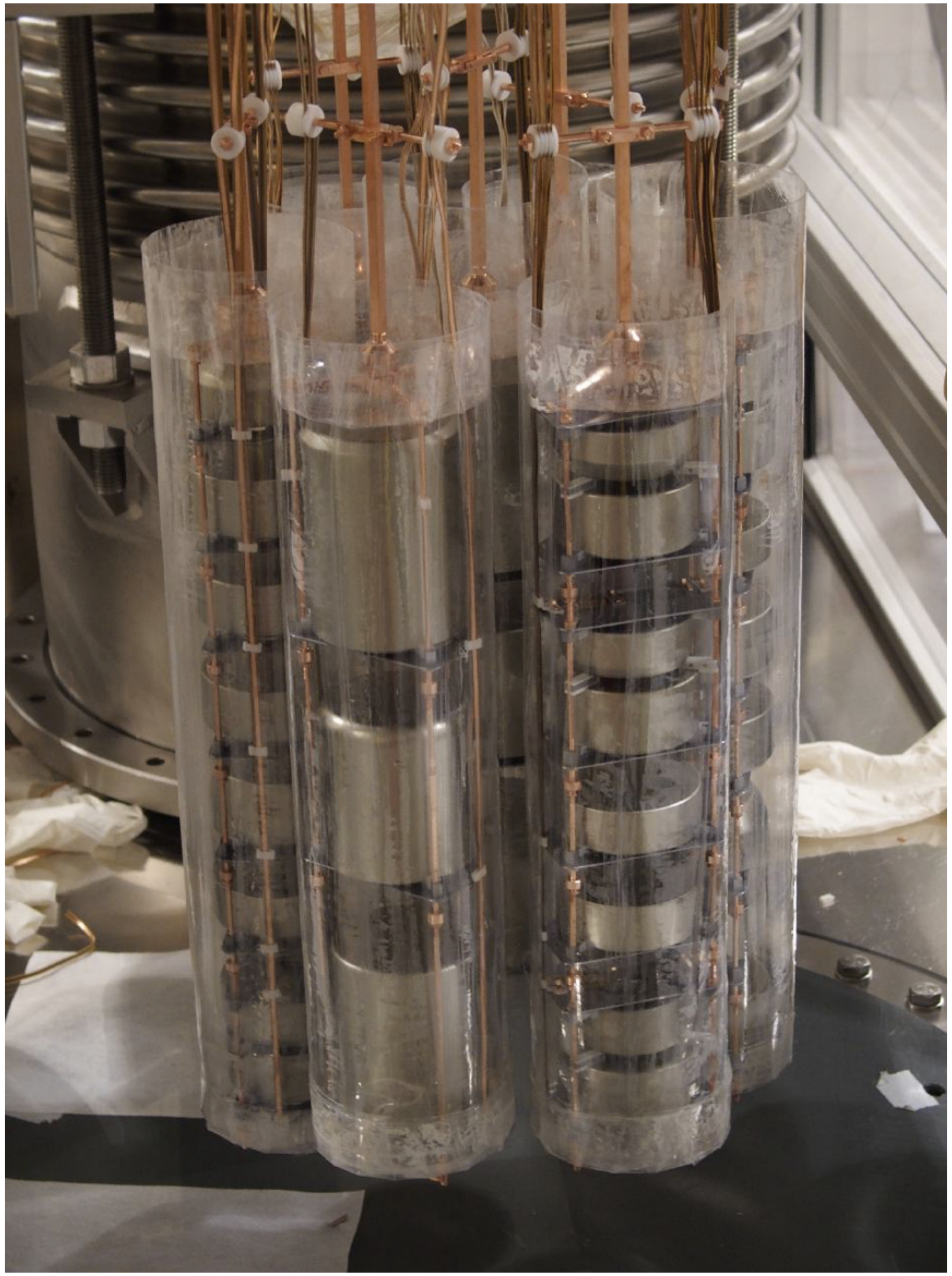


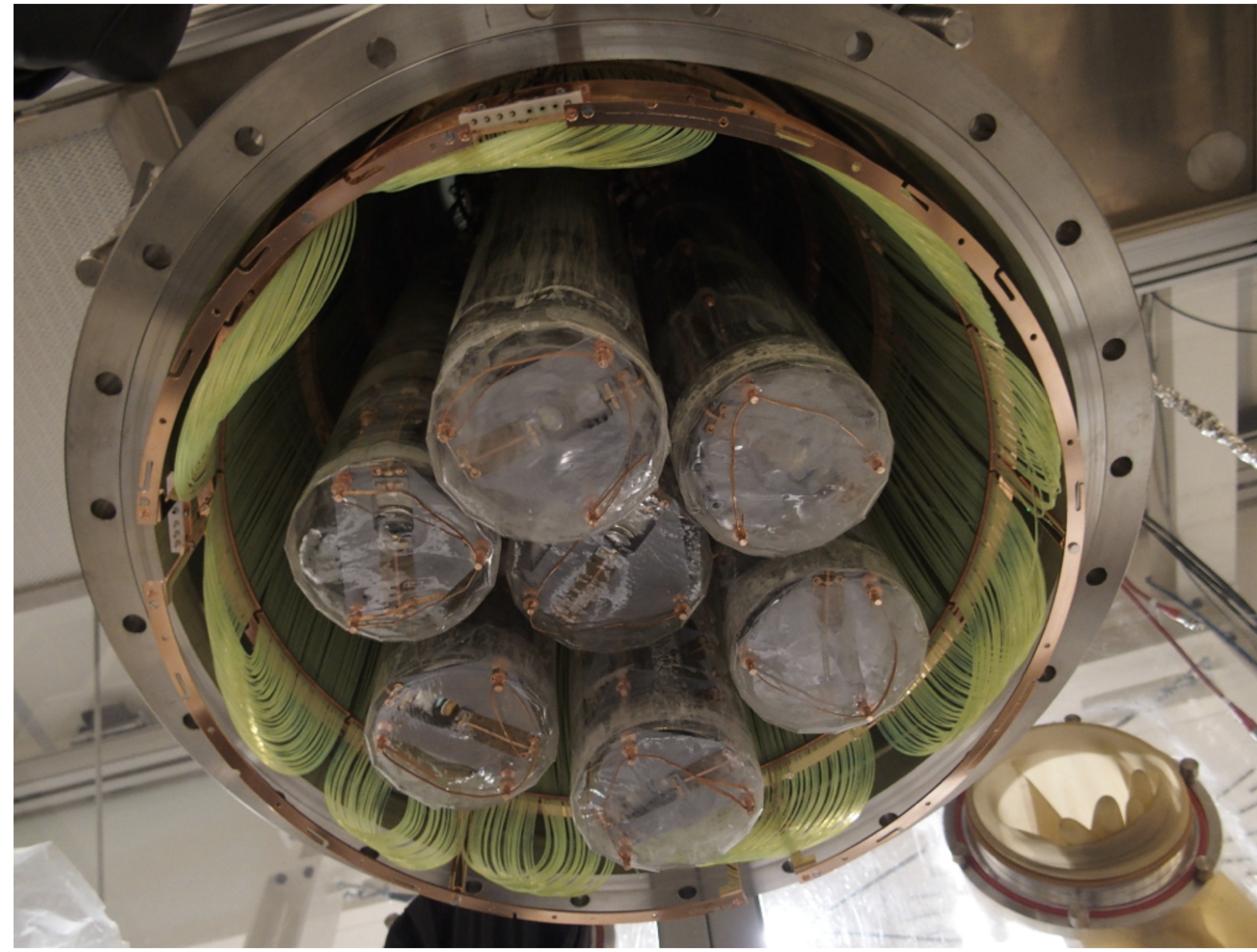
GERDA PHASE II : FINAL CONFIGURATION

40 detectors arranged in 7 strings:

- 30 ^{enr}Ge BEGes (20 kg)
- 7 ^{enr}Ge coaxials (15.8 kg)
- 3 natural coaxials (7.6 kg)

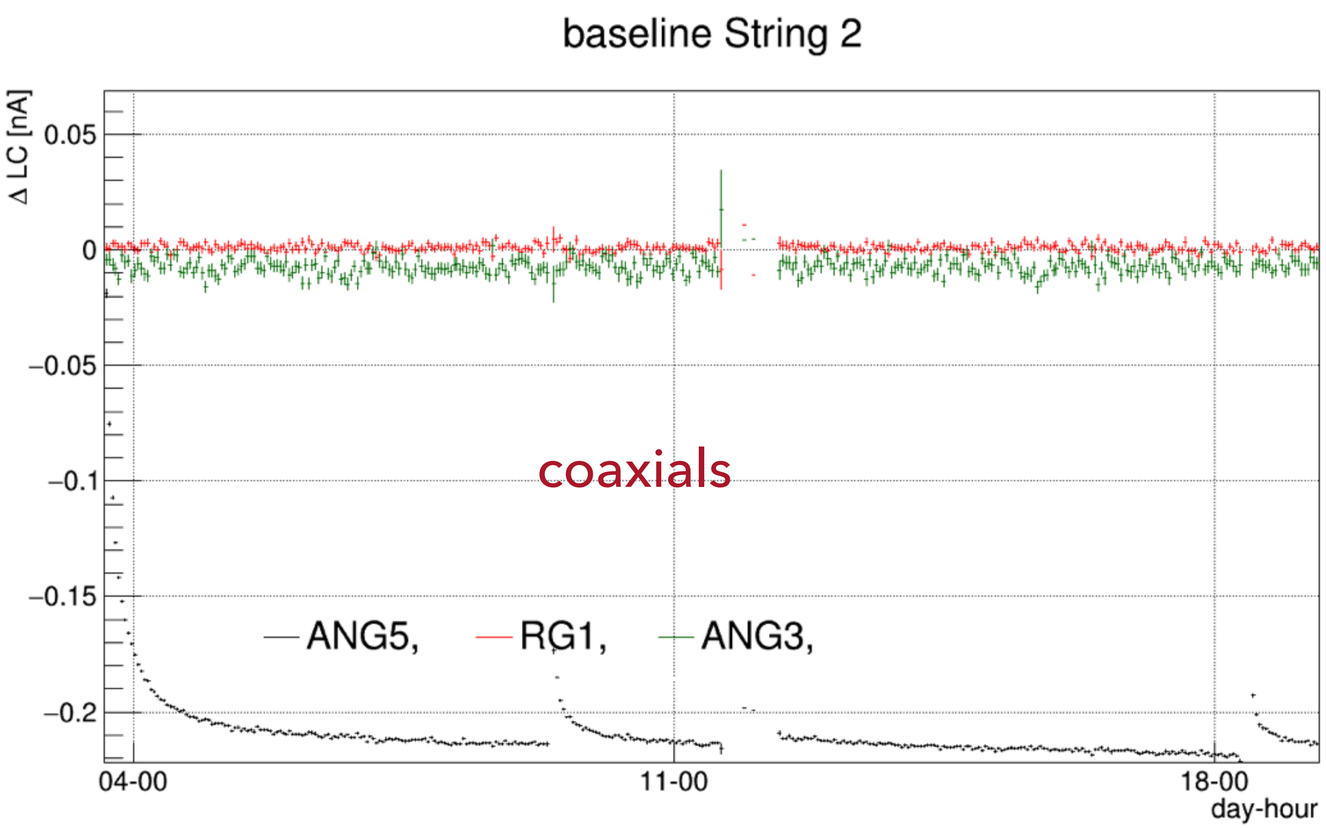
GERDA PHASE II : FINAL CONFIGURATION

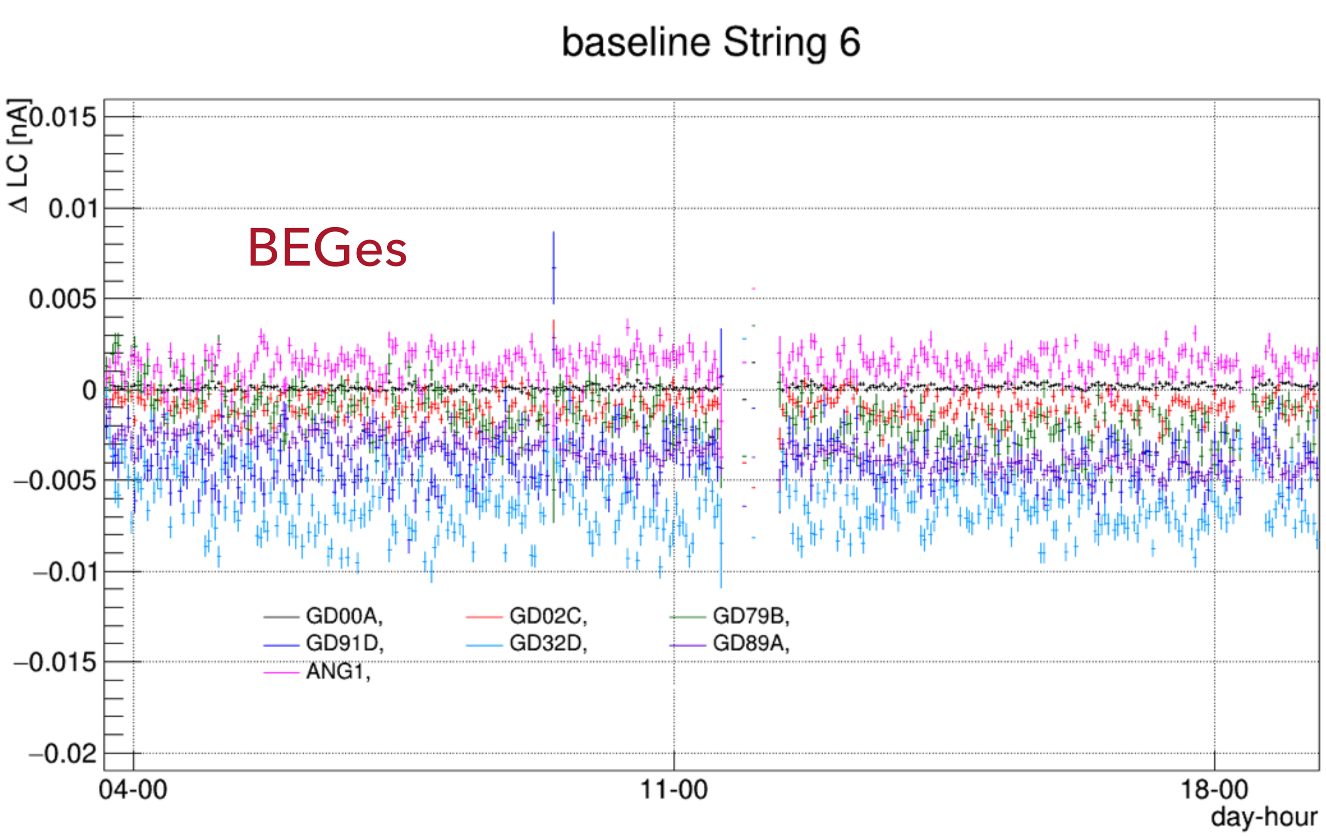




- final Phase II configuration with 7 strings installed
- strings surrounded by a nylon shroud to prevent ^{42}K from reaching Ge detectors

STATUS OF Ge DETECTORS



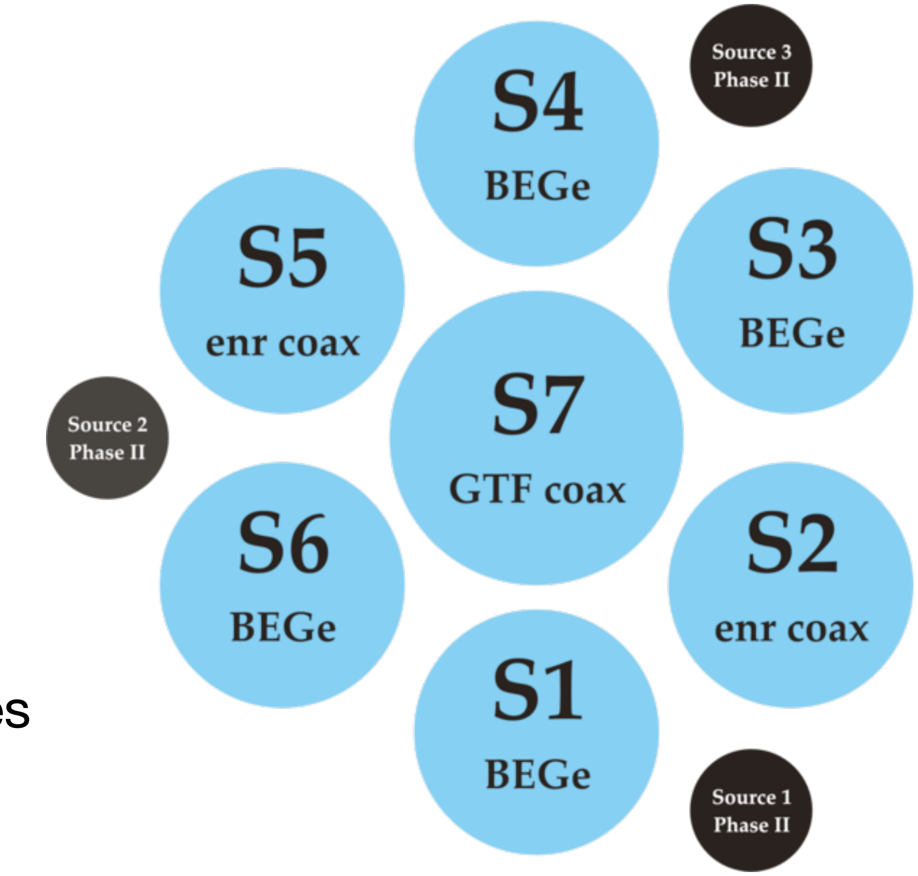


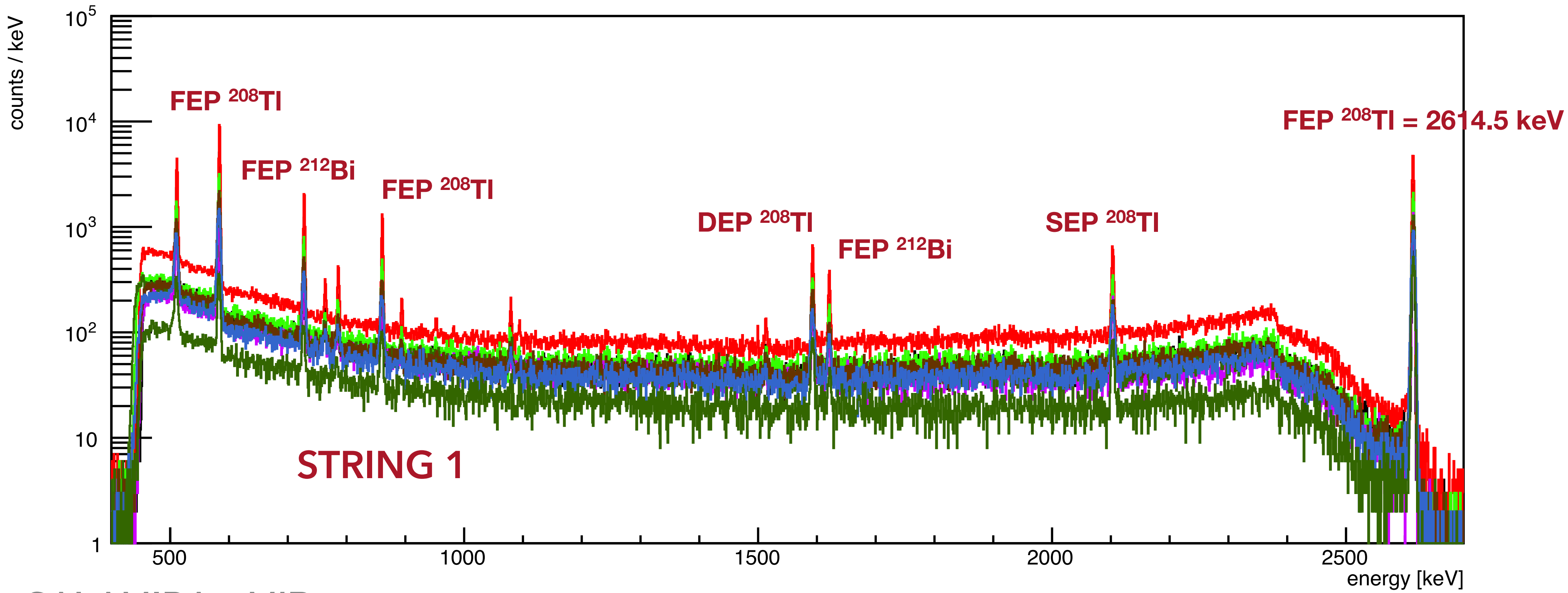
- 34 out of 37 enriched detectors used for first physics data release: 3 BEGe show gain instabilities
- leakage current is negligible for all detectors
- small leakage current increase for few detectors during calibration

DATA TAKING AND PROCESSING

- since December 20th up to March 17th:
  - live-time: ~ 63 days (not all used in physics analysis)
  - all enriched detector exposure ~ 5.3 kg yr
  - enriched BEGe exposure ~ 3.1 kg yr
  - enriched Coax exposure ~ 2.2 kg yr
  - natural exposure ~ 1.2 kg yr
- blinding applied on raw data: ±25 keV around $Q_{\beta\beta}$ (2039 keV)
- physics Runs are weekly calibrate: irradiation with ^{228}Th sources
- **first data release expected for summer conferences**

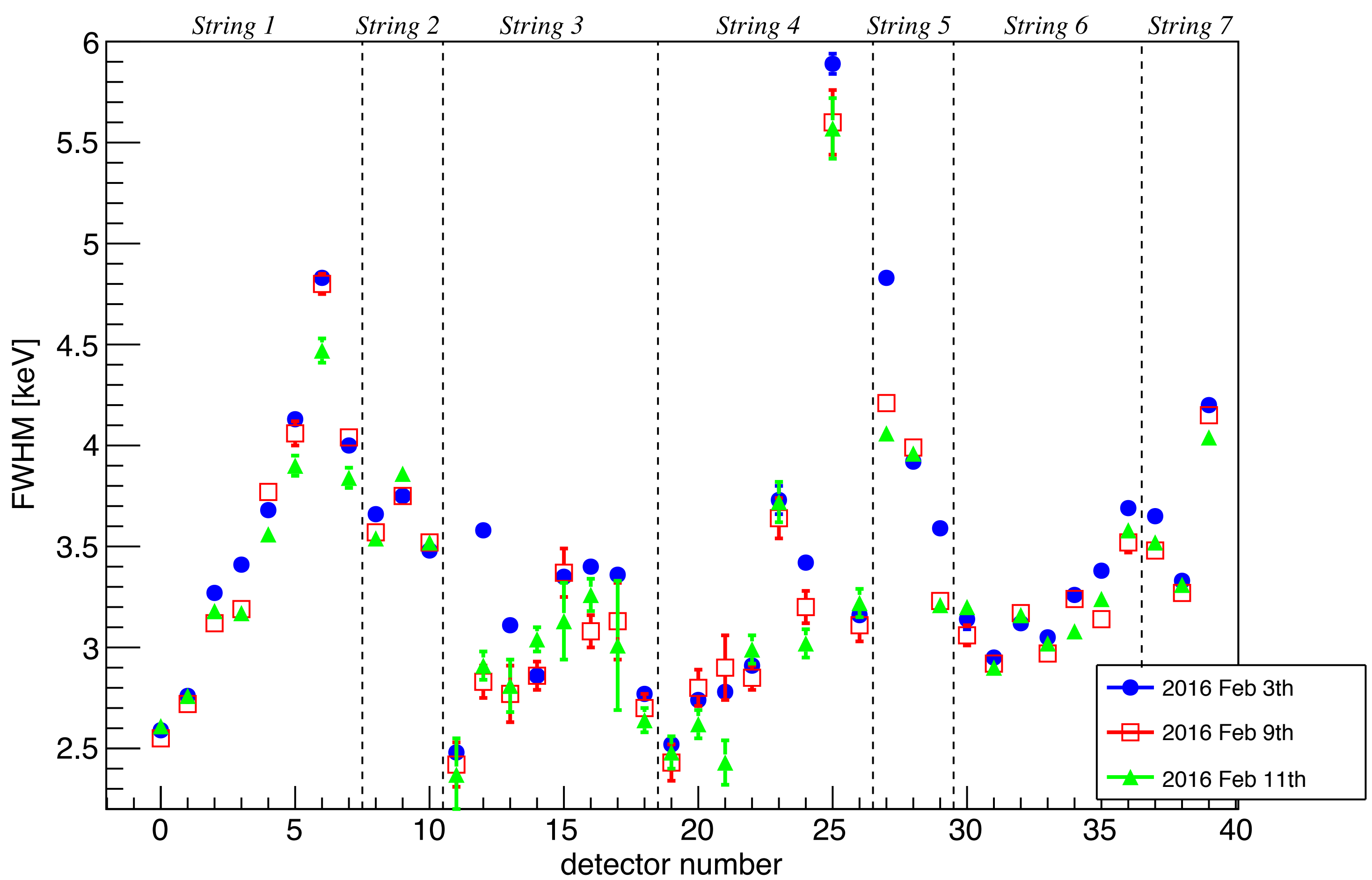
top view of detector array



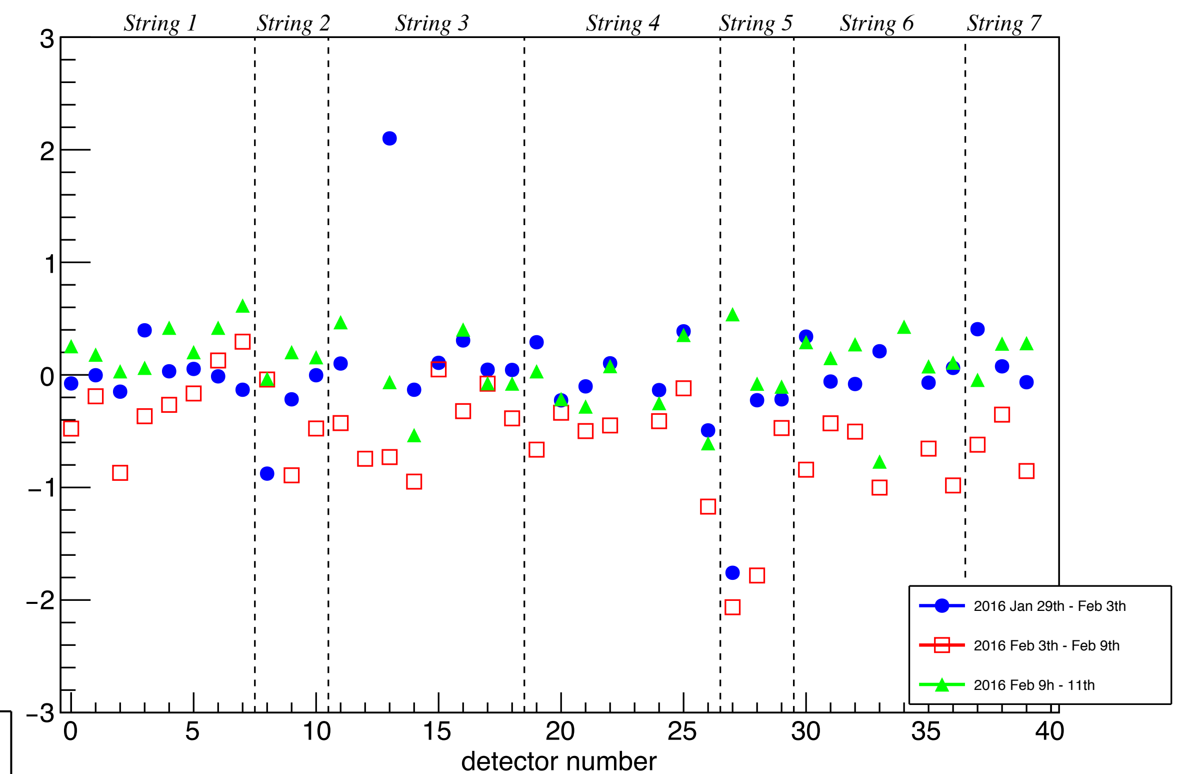


PHASE II STARTUP PERFORMANCES: ENERGY RESOLUTION

FWHM of the 2614.5 keV peak
evaluated with an optimised cusp-like filter



Energy shift between calibration runs

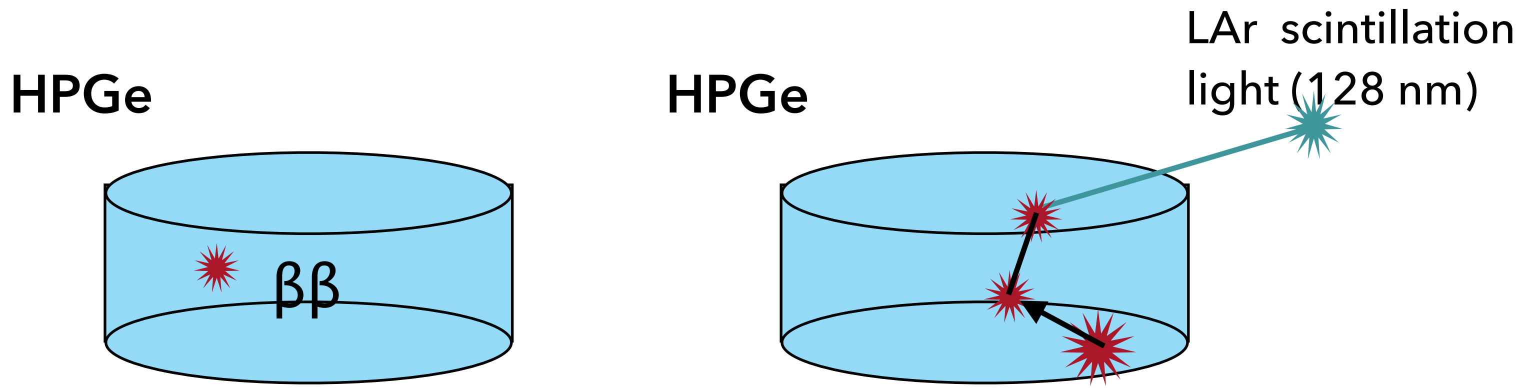


mostly in the range ±1 keV

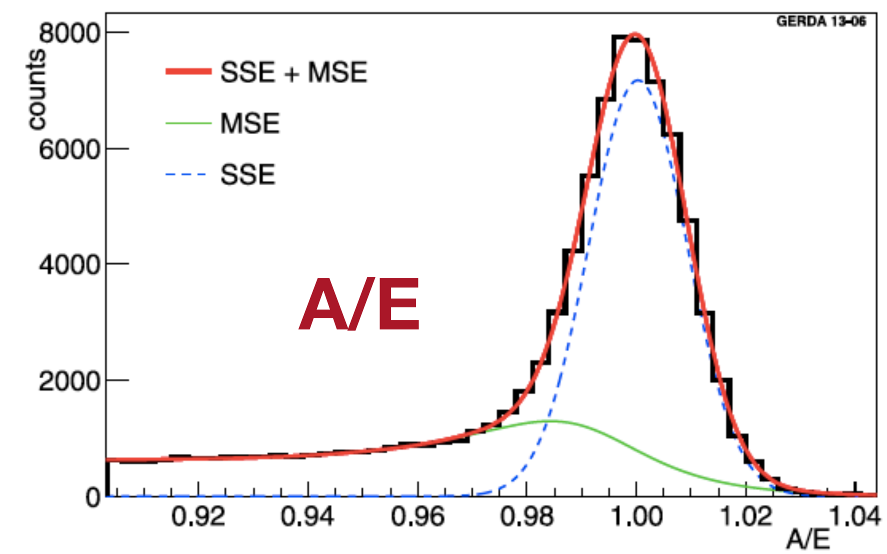
- COAXIAL: in the range 3.2 keV - 4.1 keV
  - better resolution w.r.t. Phase I (~ 4.3 keV with cusp-like filter)
- BEGe: in the range 2.4 keV - 4.0 keV (trend with the position in the string)
  - resolution is worse than in Phase I (~ 2.8 keV with cusp-like filter)
  - due to excess of series white noise : under investigation

PHASE II PULSE SHAPE DISCRIMINATION (PSD)

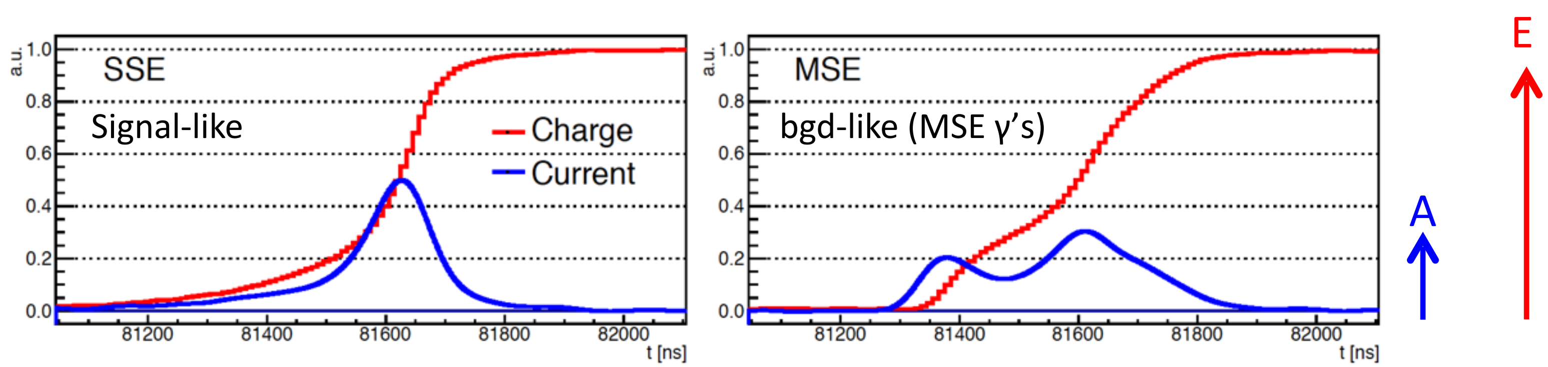
Signal | **Background**



SINGLE SITE EVENT (SSE) | MULTI SITE EVENT (MSE)



BEGes



Pulse shape parameter for BEGes is

$$A/E = \frac{\text{amplitude of Current pulse}}{\text{amplitude of Charge pulse}}$$

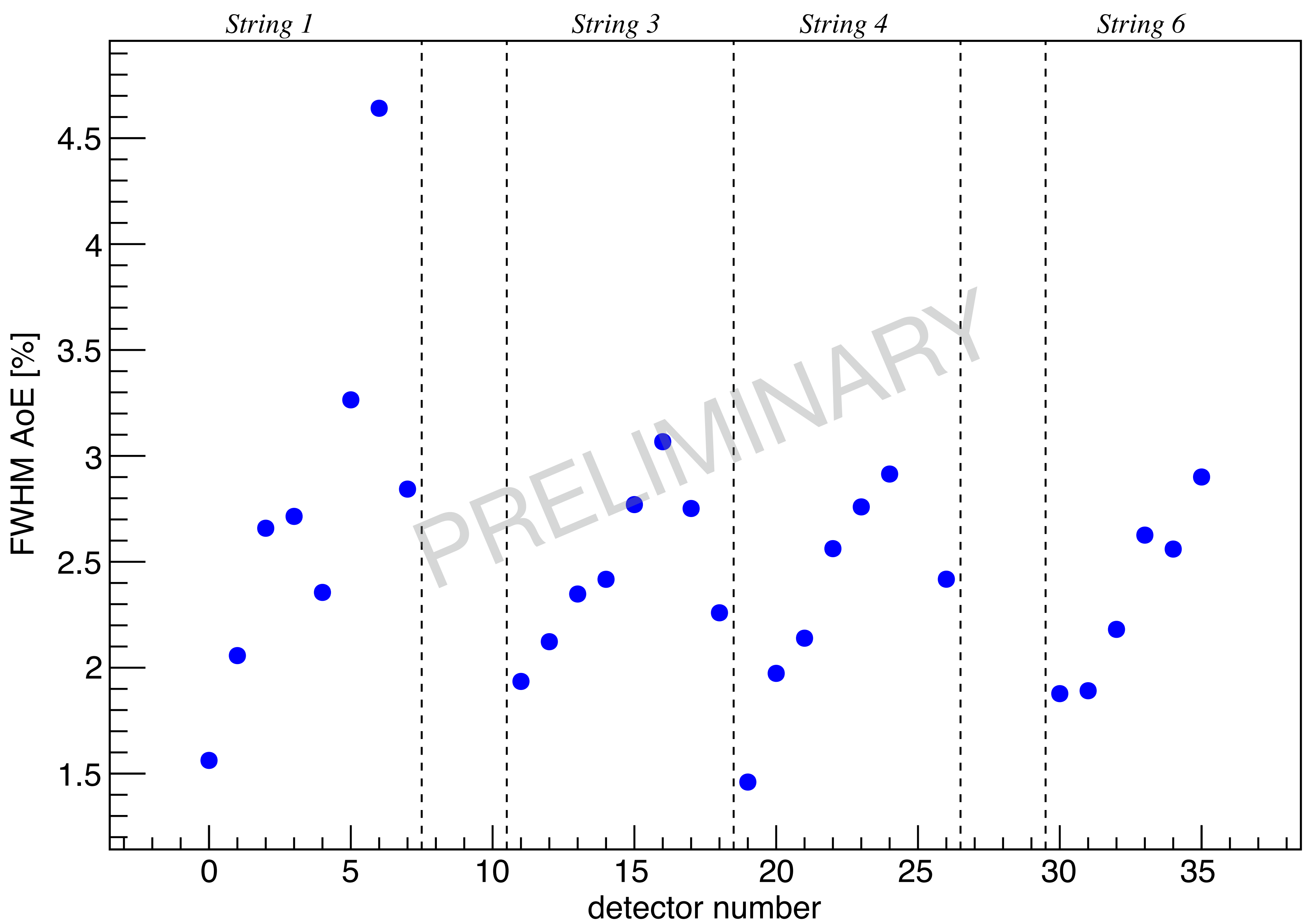
characteristic value for SSE events

COAXIALs

For COAXIAL detectors pulse shape is based on a Neural Network Analysis of the CHARGE pulse see Eur. Phys. J. C (2013) 73:2583

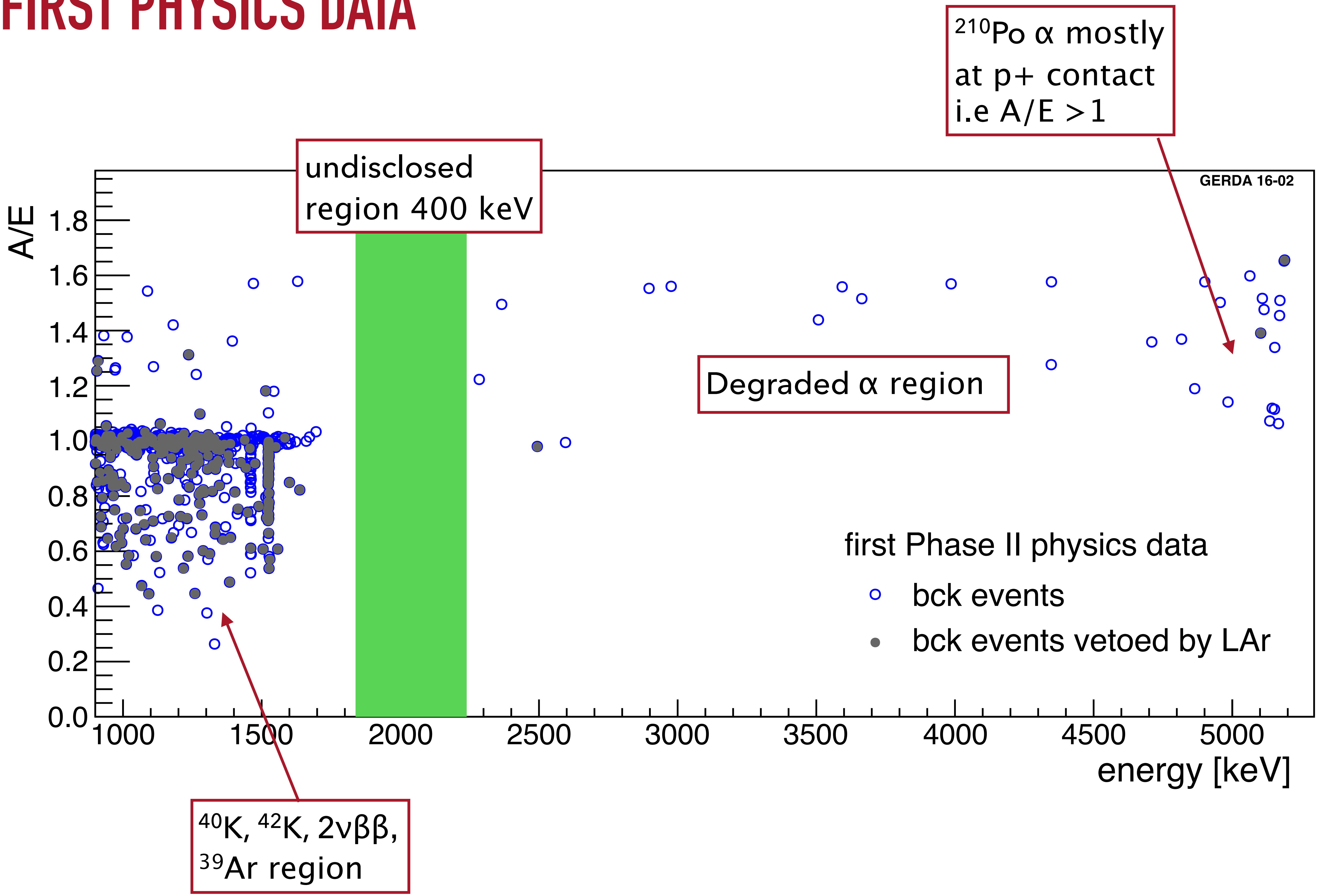
Alternative method based on multivariate analysis on both BEGEs and COAXIAL

BEGe PSD CALIBRATION: A/E RESOLUTION



- A/E FWHM in the range 2% - 3%
- trend with the position in the string
- resolution is worse than in Phase I (1.5% - 1.9%)

FIRST PHYSICS DATA

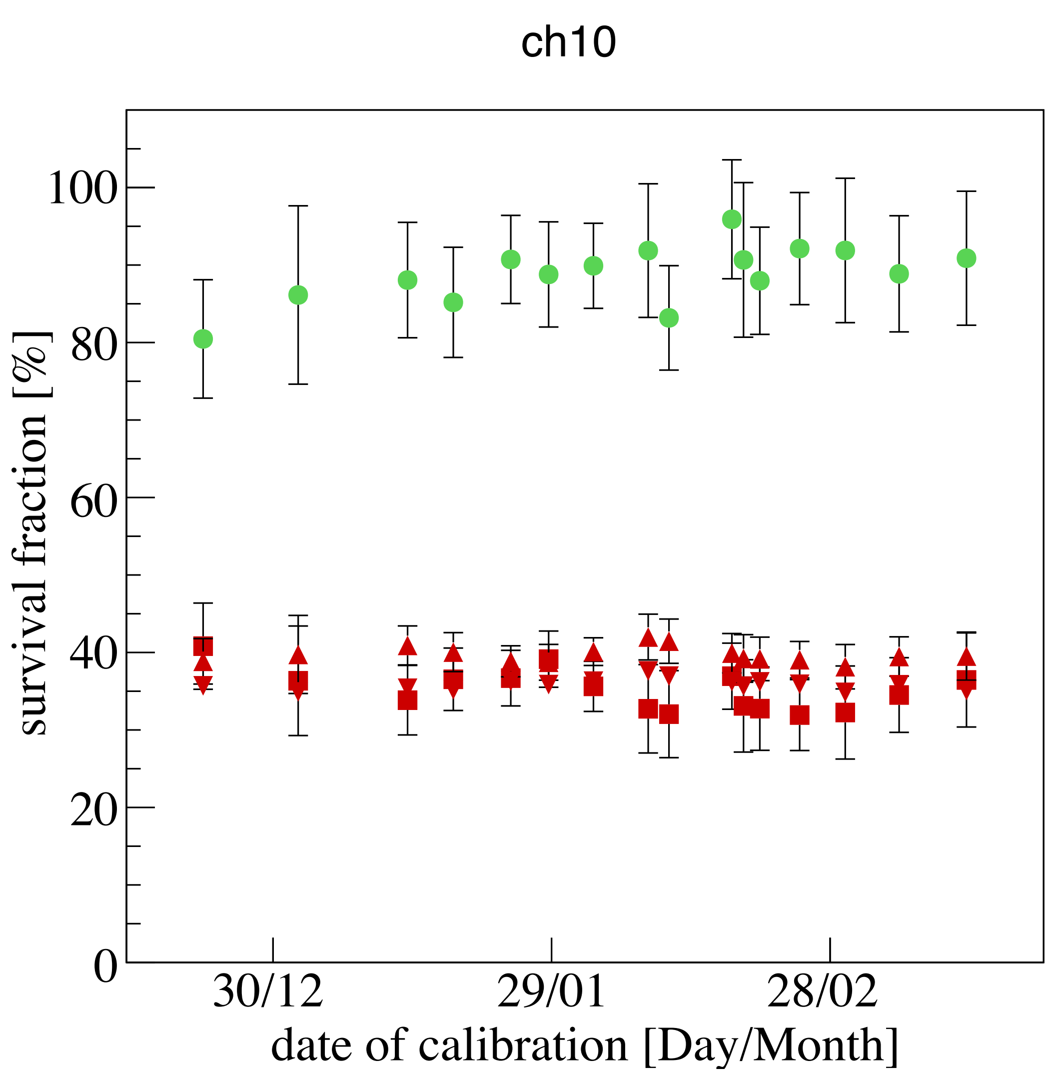


PULSE SHAPE PERFORMANCE COAX

same methods like in Phase I:

- neural network trained with 1593 keV DEP (SSE) & 1621 keV FEP (50 variables)
- MVA: projective likelihood trained with (7 variables)

ANG2 survival for different ^{228}Th calibration

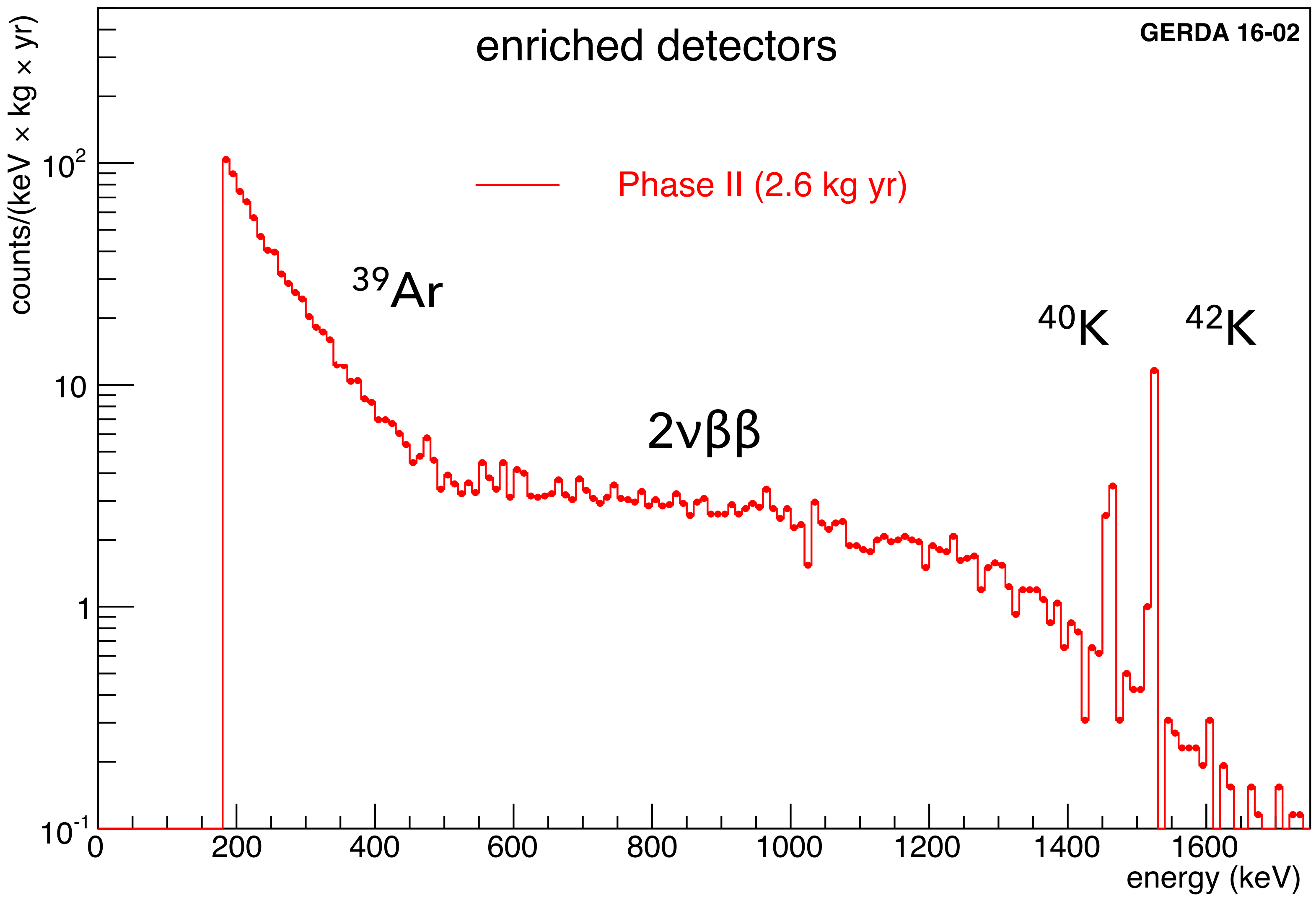


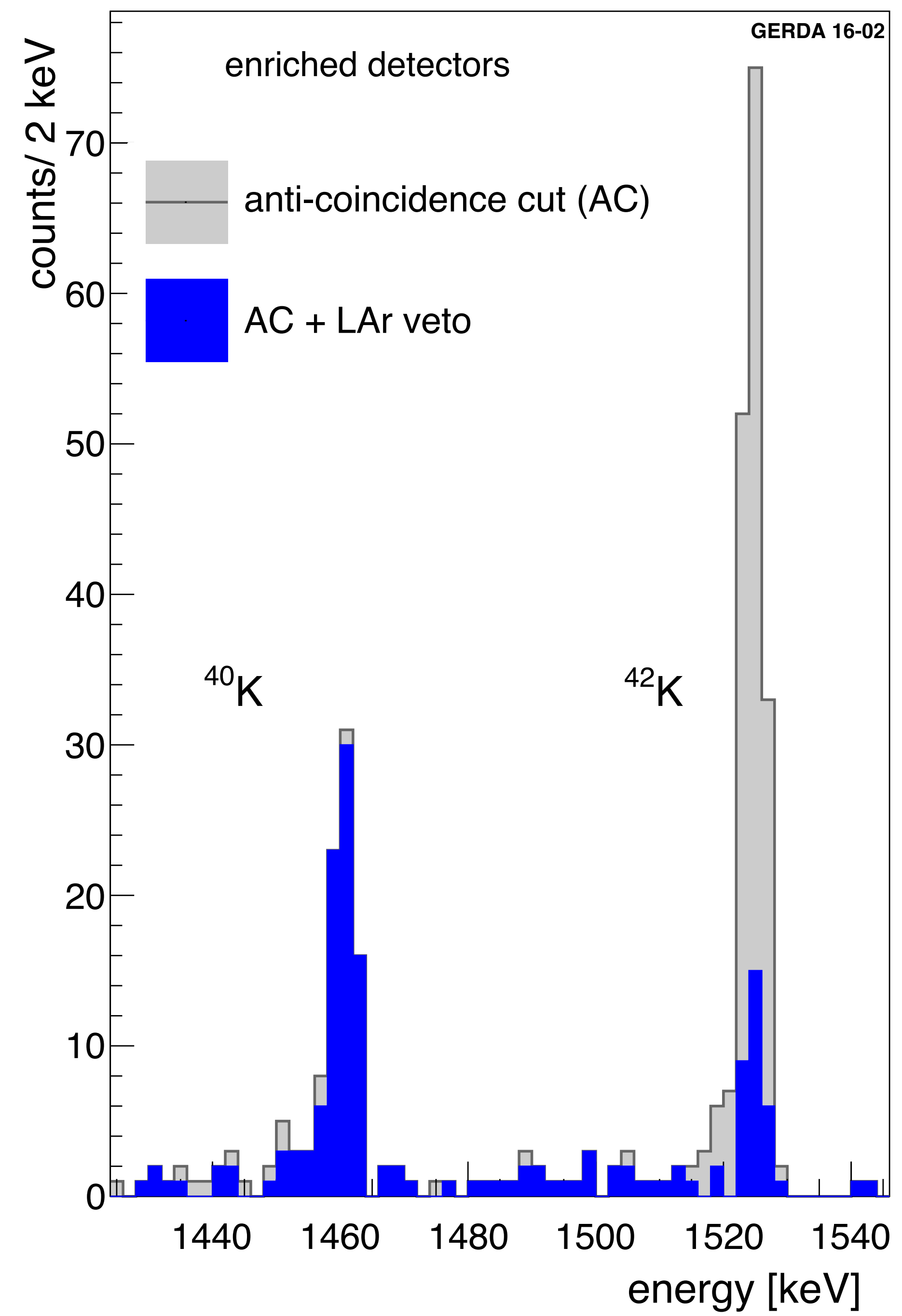
survival fractions for combined ^{228}Th calibration data for cut set to 90% DEP survival fraction

	Phase I	Phase II	Phase I	Phase II
	SEP (2104 keV)		FEP (2615 keV)	
ANG2	42%	32%	37%	31%
ANG3	37%	37%	39%	35%
ANG4	35%	34%	37%	32%
ANG5	31%	31%	33%	31%
RG1	41%	43%	41%	43%
RG2	37%	32%	39%	33%

PHASE II BACKGROUND SPECTRUM

background spectrum in K peaks region





- expected prominent structures of the background
- ^{42}K peak reduced by the LAr veto of a factor of ~5

SUMMARY

- Gerda Phase II data taking has started on December 20th 2015
- 39 out of 40 installed detectors are working at or above depletion HV
- Energy and A/E performances satisfactory for physics data taking
  - energy scale stable (within 1 keV)
  - BEGes energy and A/E resolution can be improved identifying/reducing the noise sources

MAIN GOALS

- aim for first data release this summer
- reach ~100 kg·yr of exposure with a background of 10^{-3} counts/(keV·kg·yr)
- **more statistics needed**
- improved limits on $T^{0\nu}_{1/2}$ (> $2 \cdot 10^{26}$ yr) and m_ν upper limit (≤ 0.09 - 0.15 eV) expected when combining Phase I and Phase II exposures