Status of the GERDA experiment

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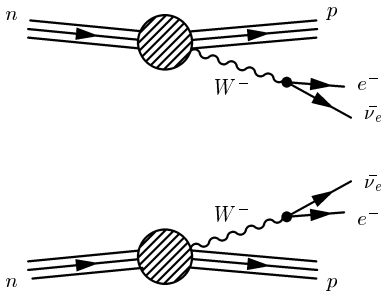
GERDA *GErmanium Detector Array*

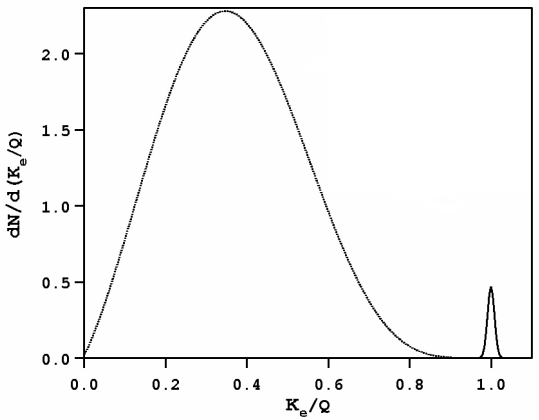
- Double β decay
- The GERDA experiment (Phase I)
- Phase II R&D

Double β decay

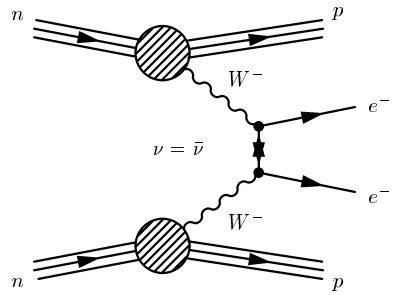
$2\nu2\beta$



$2\nu2\beta + 0\nu2\beta$ spectrum

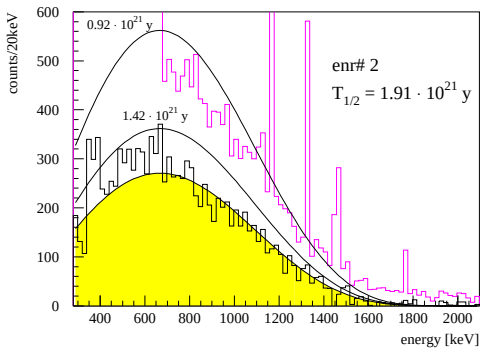


$0\nu2\beta$



In ^{76}Ge

$T^{2\nu}_{1/2} = 1.77 \pm 0.01 \pm 0.1 \times 10^{21}$ years

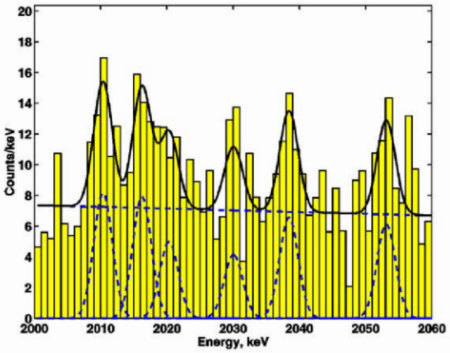


Phys. Rev. D 55 (1997) 54

$Q = 2039.0$keV

$T^{0\nu}_{1/2} > 1.9 \times 10^{25}$ years 90% C.L

($T^{0\nu}_{1/2} = 1.2 \times 10^{25}$ years 4σ C.L.)



Eur. Phys. J. A 12 (2001) 147

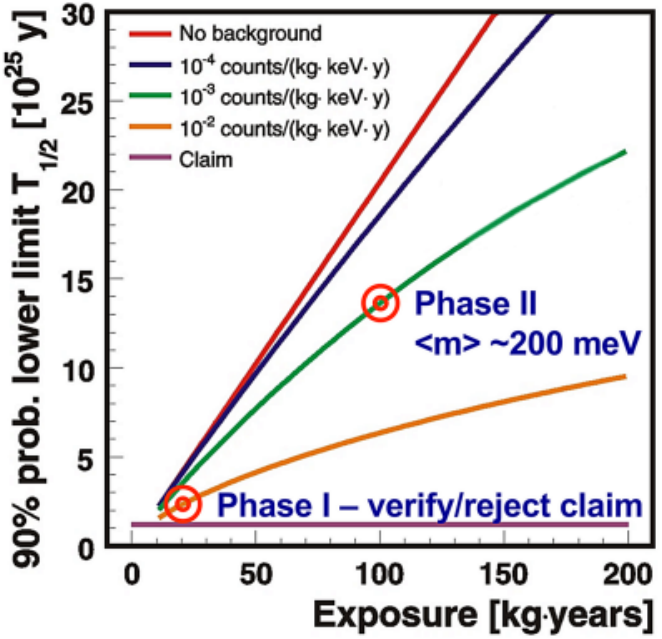
Phys.Lett.B 586 (2004) 198

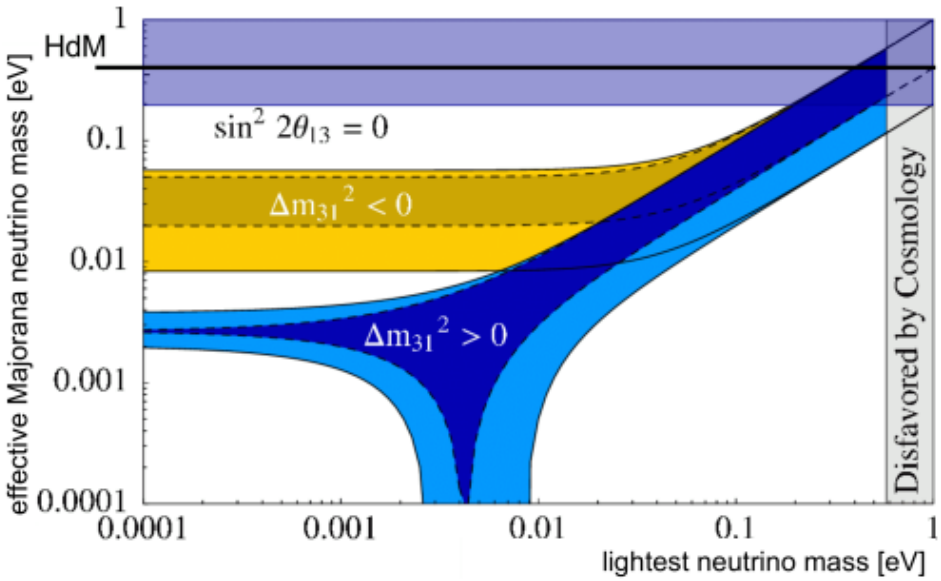
The GERDA concept

PHASE I: HM, IGEX enriched Ge detectors operated in liquid Argon
8 detectors, total mass of 17.8 kg
projected background level 10^{-2}cts/(keV kg y) in the ROI

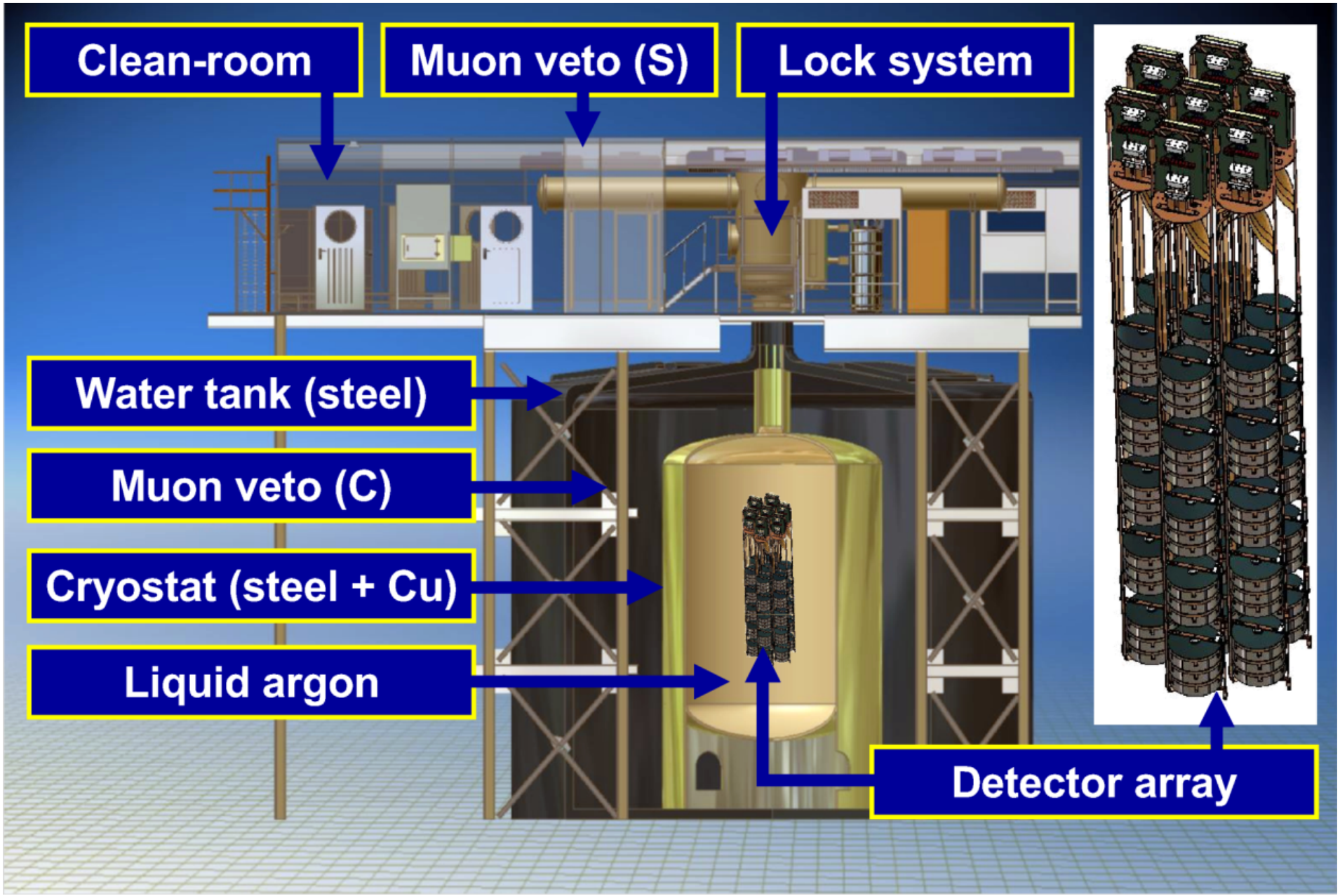
PHASE II: $\sim$30 kg enriched Ge 18 fold segmented detector added later
projected background level 10^{-3}cts/(keV kg y) in the ROI

PHASE III: 1 ton experiment. Possible collaboration with Majorana





GERDA setup


Clean-room
Muon veto (S)
Lock system
Water tank (steel)
Muon veto (C)
Cryostat (steel + Cu)
Liquid argon
Detector array

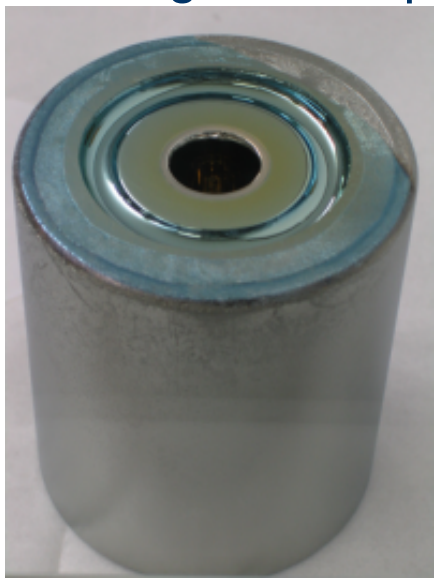
GERDA site at LNGS

Phase I detector status

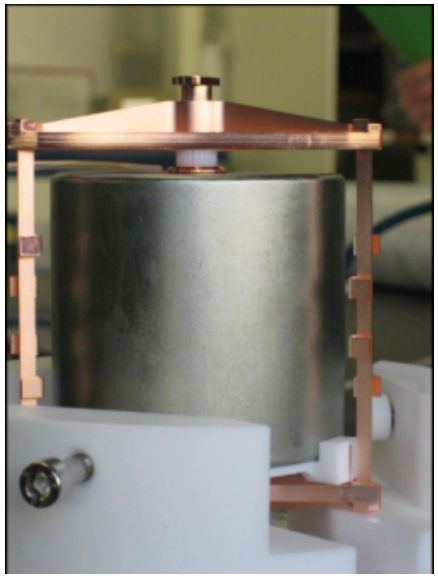
IGEX and HM crystals being refurbished, now stored underground

HM original setup

crystals removed from the cryostat



refurbished ...



fitted with GERDA support

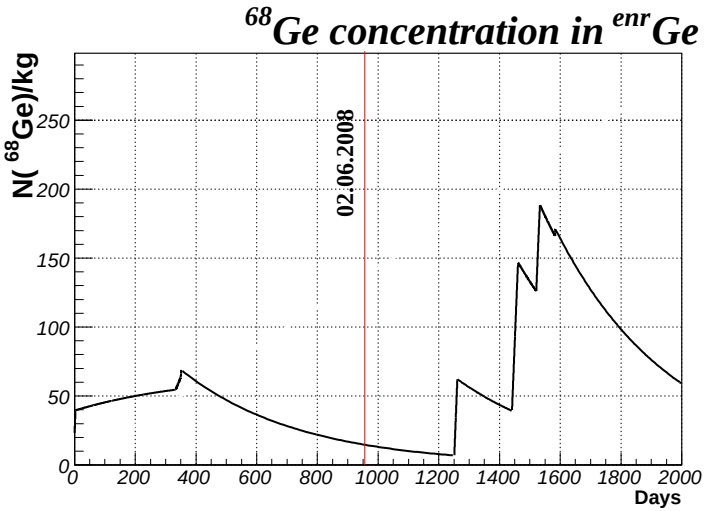
Phase II status

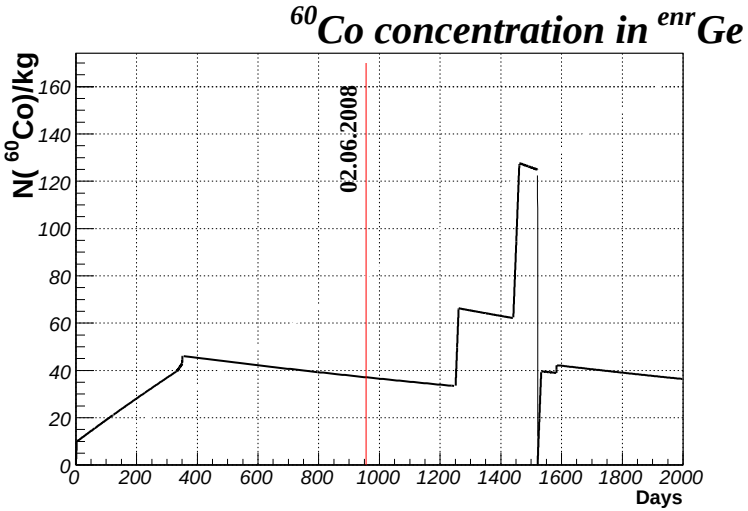
- Production of the Phase II crystals
  - Purification of the Ge
  - Crystal pulling
  - Detector production
- Prototype crystal testing

Procurement of Ge

- Natural Ge contains about 7% of ^{76}Ge. Enriched to 86% in Krasnoyarsk (Russia)
- 37.5 kg enriched Ge delivered to Munich in 2006, now stored underground.
- Also delivered 50 kg depleted Ge (leftover of the enrichment) used for purification and crystal pulling tests.

- Estimated background index for Phase I (HM, IGEX) crystals is only 10^{-2} mainly because of the cosmogenicaly produced ^{60}Co
- For the production of Phase II crystals we need to reduce exposure.
- With underground storage of the material between each step of processing the projected background contribution of ^{68}Ge is about $\sim 10^{-3}$cts/(keV kg y) and $\sim 10^{-5}$cts/(keV kg y) for ^{60}Co (GSTR-05-024)





Purification

Turning GeO_2 in 6N (99.9999%) purity metal is a metallurgical process done at PPM Pure Metals (Langelsheim, Germany)

1. Reduction: oxide to metal

2. Zone-refinement: purification based on the segregation of the impurities in the melt

All tested on depleted Ge

Purity checked with two different mass spectrometers, isotopic content was verified, etc...

underground storage during the processing was also tested

Total yield of 90% (6N material) was demonstrated

from GeO_2 powder

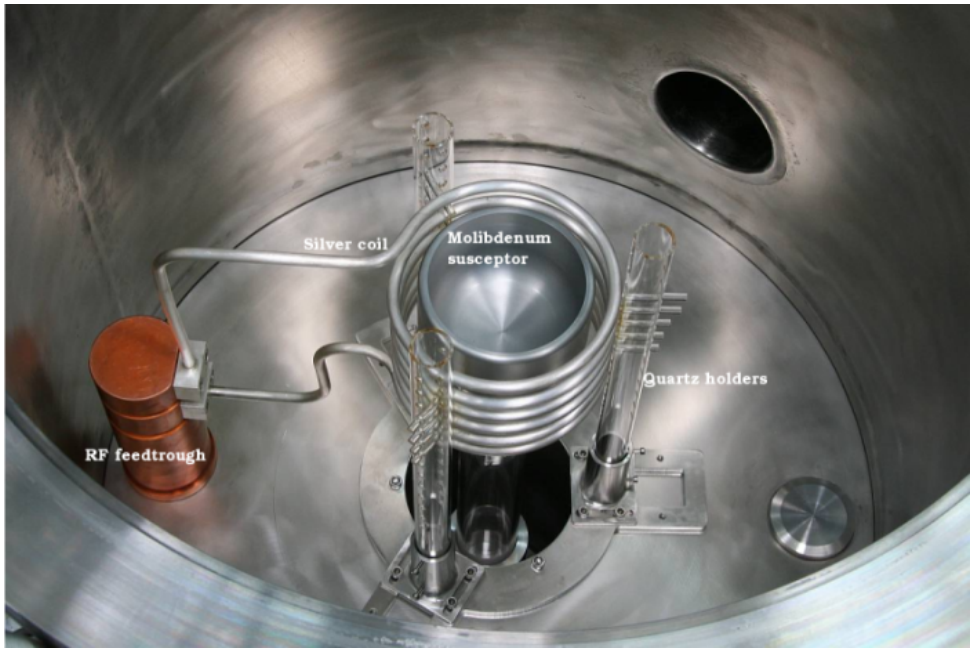
to 6N metal

Crystal pulling status

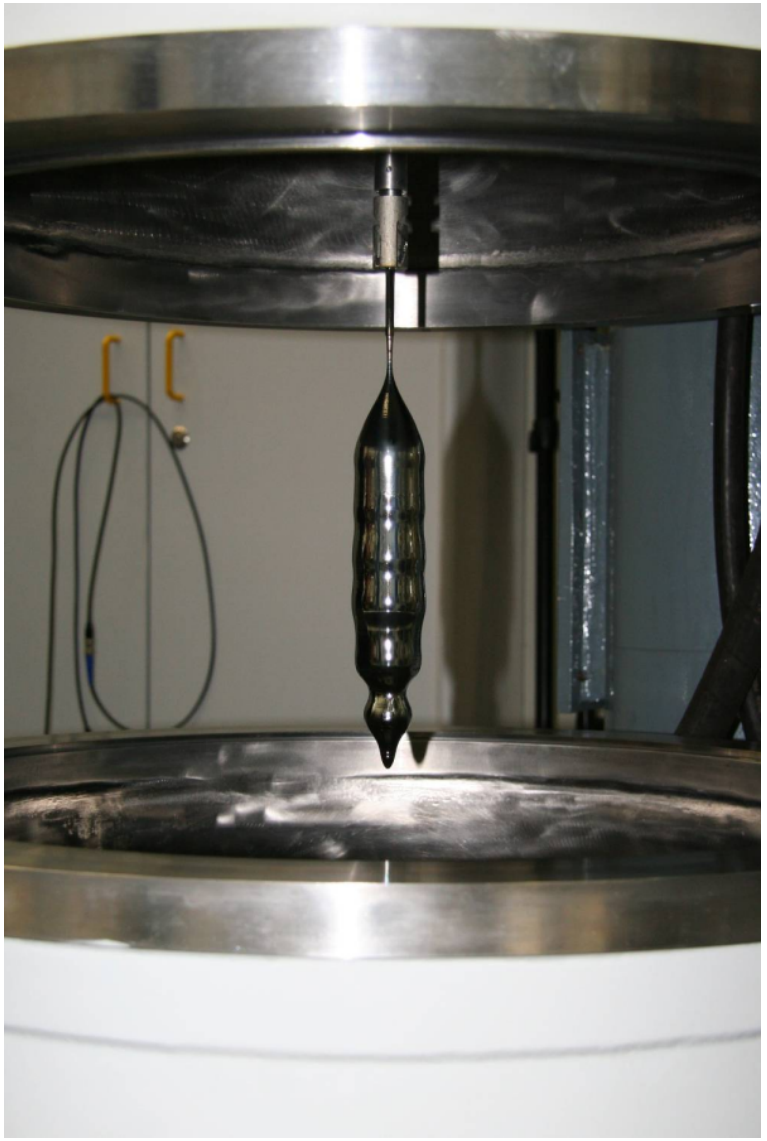
- A dedicated Czochralski puller was set up at Institut fur Kristallzüchtung (IKZ), Berlin
- After many modifications operated with success first on April 7, 2008
- 4 test crystals produced so far with 2” diameter
- Impurity concentration measured with Hall-effect measurement and contaminants identified with Photo-Thermal Ionization Spectroscopy (PTIS)
- One crystal pulled from zone-refined material

Crystal pulling - First crystals

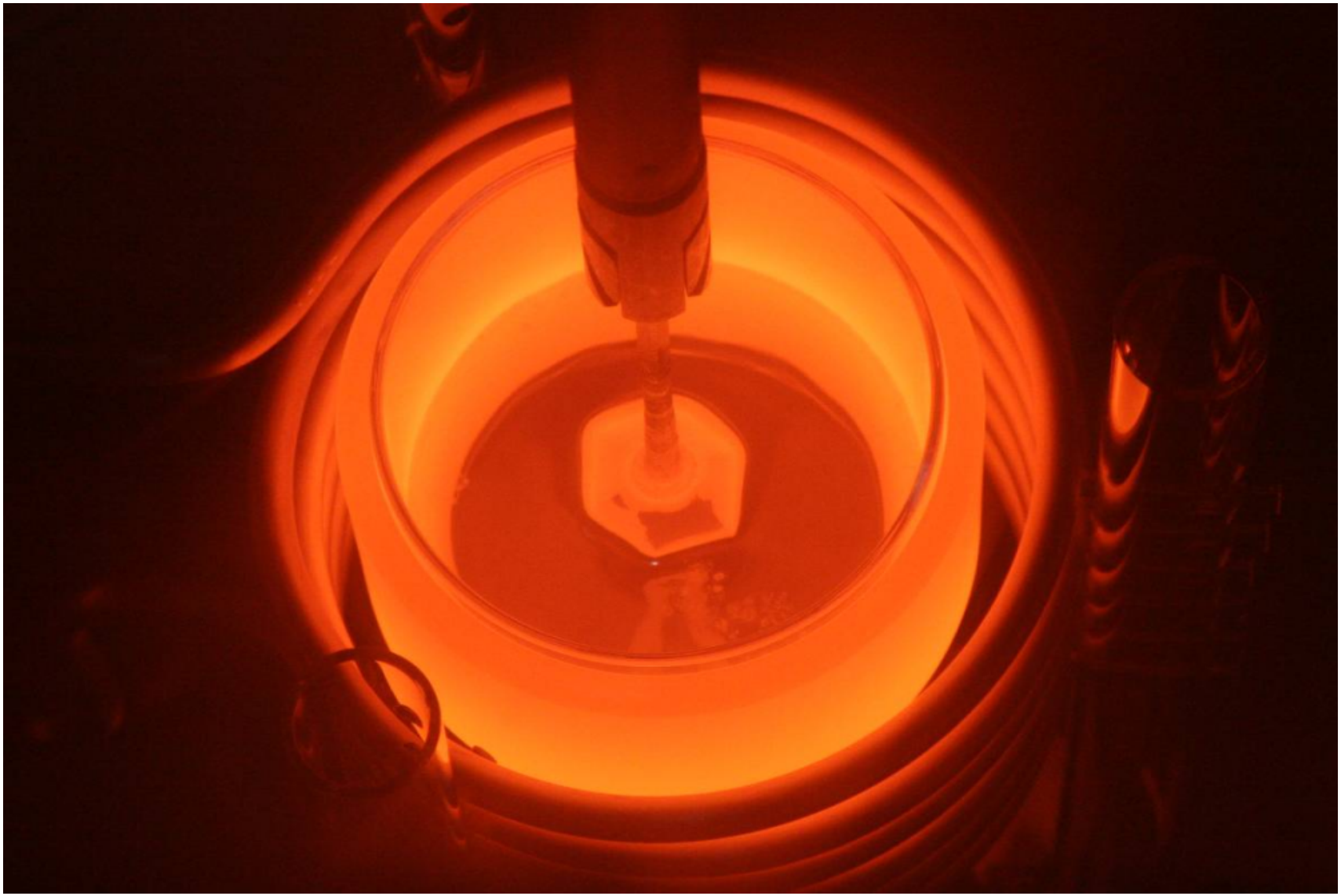
- Already four successful crystalpulling attempts were made using 6N Ge
- Cristal pulling now is a routine business



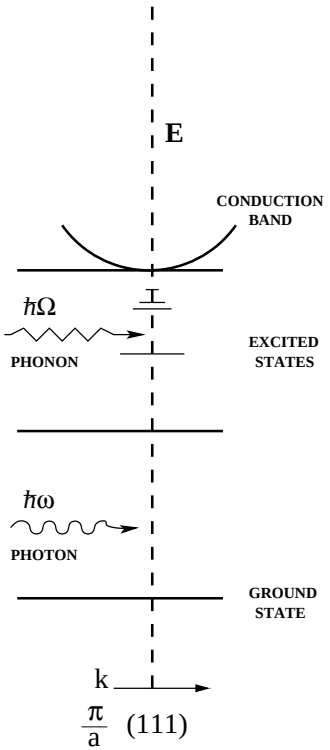
Inside the puller



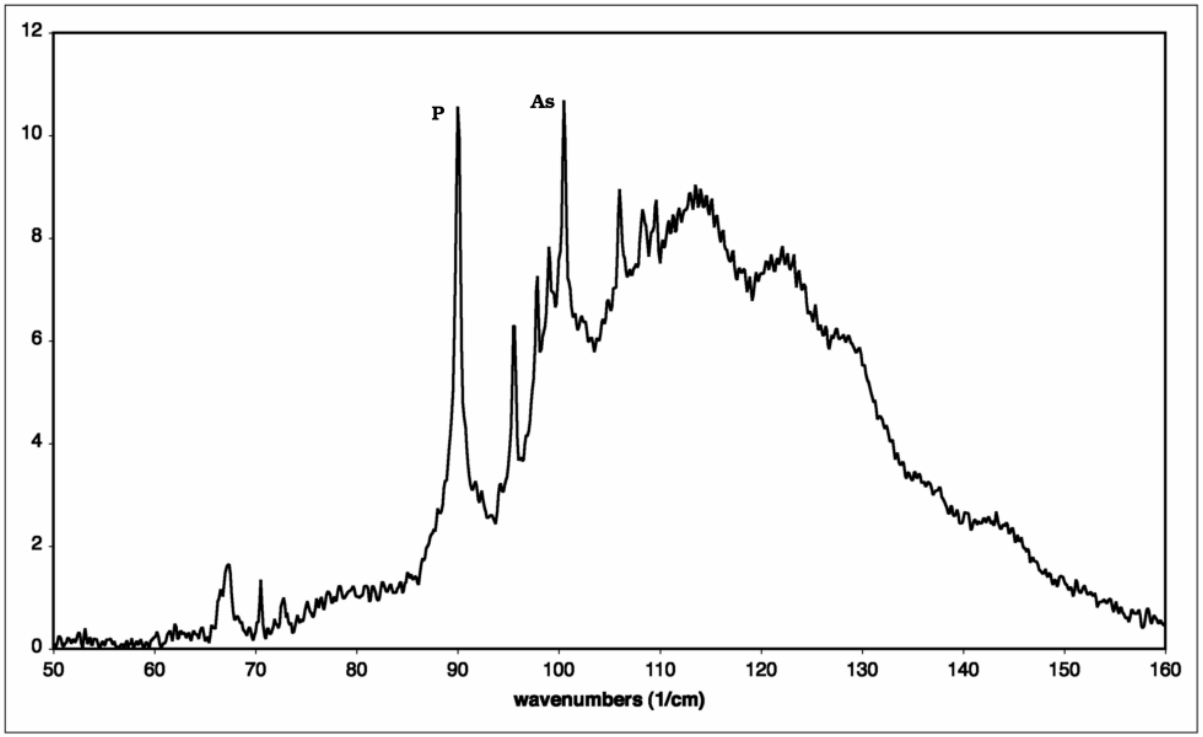
Czochralski puller at work



For a HPGe detector $10^{10}/cm^3$ net charge carrier concentration has to be achieved ($\sim$ ppt !! the purest material on Earth).
The first crystalpulling attempts produced crystals with 10^{13} impurity concentration
PTIS measurements are done to identify the impurities and the planed upgrade of the puller with Ultra-High purity components should improve the quality



PTIS principle

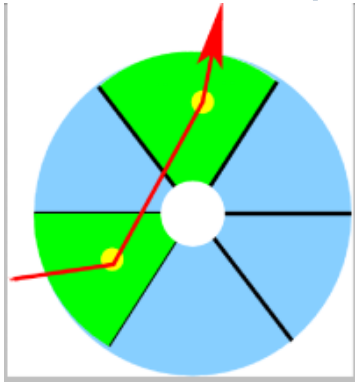


PTIS spectrum of a crystal grown at IKZ, measured at Berkeley

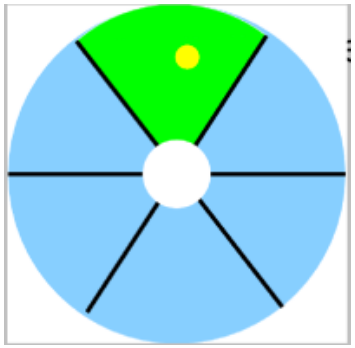
Phase II prototype crystals

Segmentation + Pulse Shape analysis for background reduction

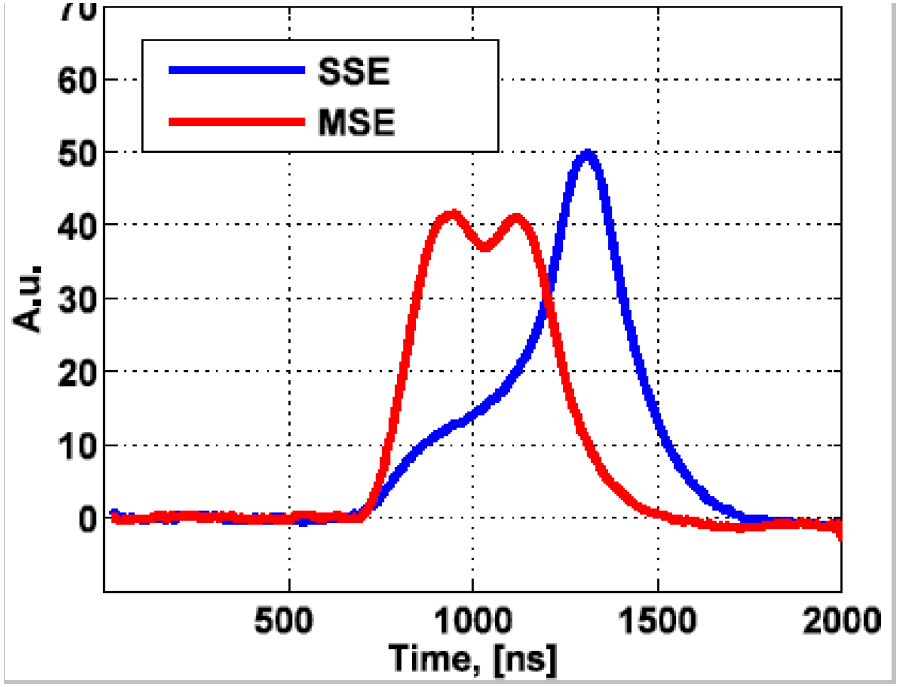
γ background typically Multi Segment Event



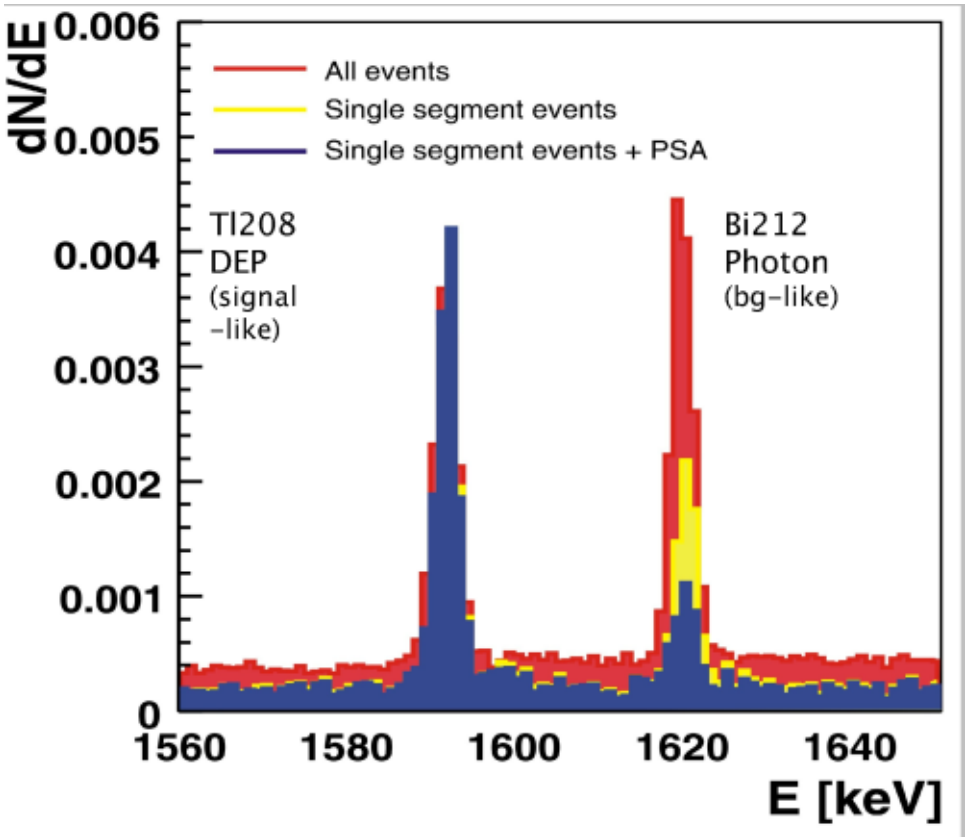
signal like event is always Single Segment Event



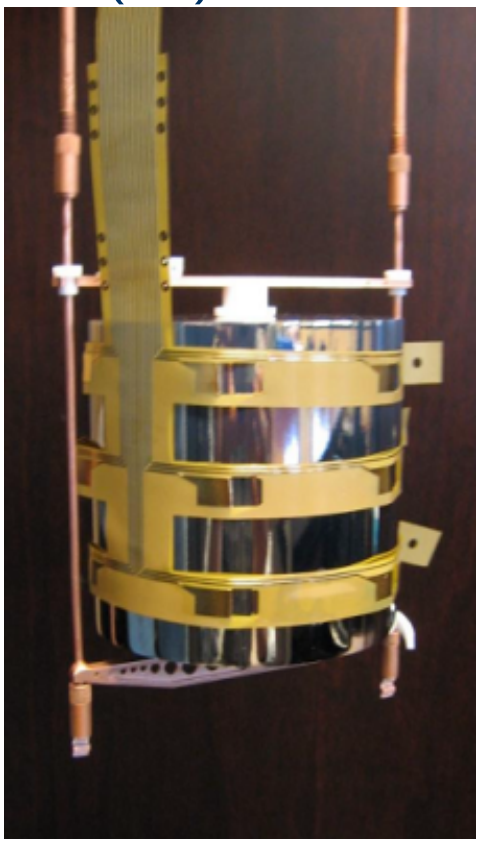
Pulse Shape Analysis can also distinguish SSE and MSE



Applying PSA and Single Segment most of multisite events can be removed: NIM A 583 (2007) 332



By consequence we need segmented detector working in LAr (LN)

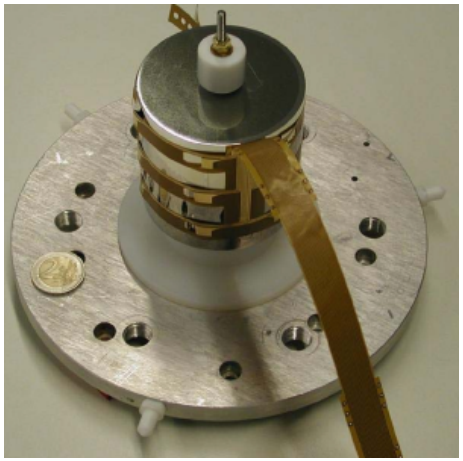


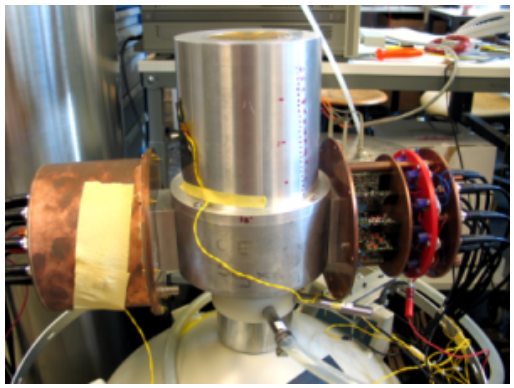
18 contacts, 18 diodes on one crystal

Phase II prototype crystals

First 18 fold segmented N type prototypes tested in vacuum:

Prototype I.



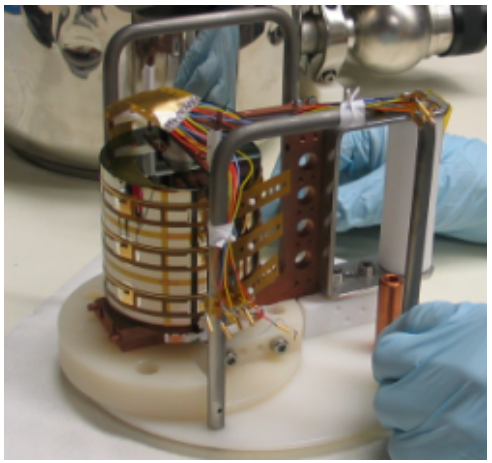


Results published:

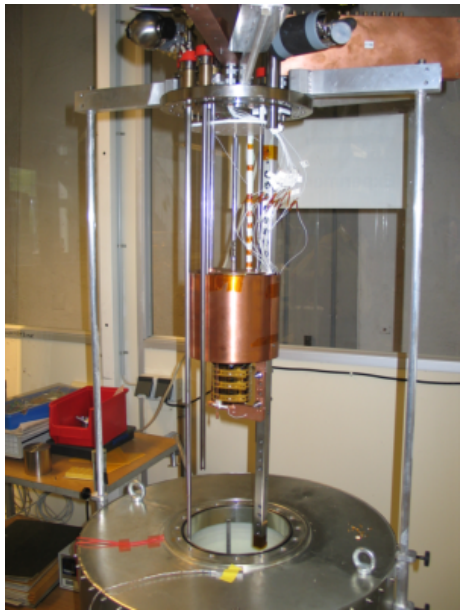
I.Abt et al. NIM A 577 (2007) 574

I.Abt et al. NIM A 570 (2007) 479

Prototype II



in LN



Segmented detector in LN is a world premier.

Being tested now.

leakage current 25 ± 5 pA stable since 4 month.

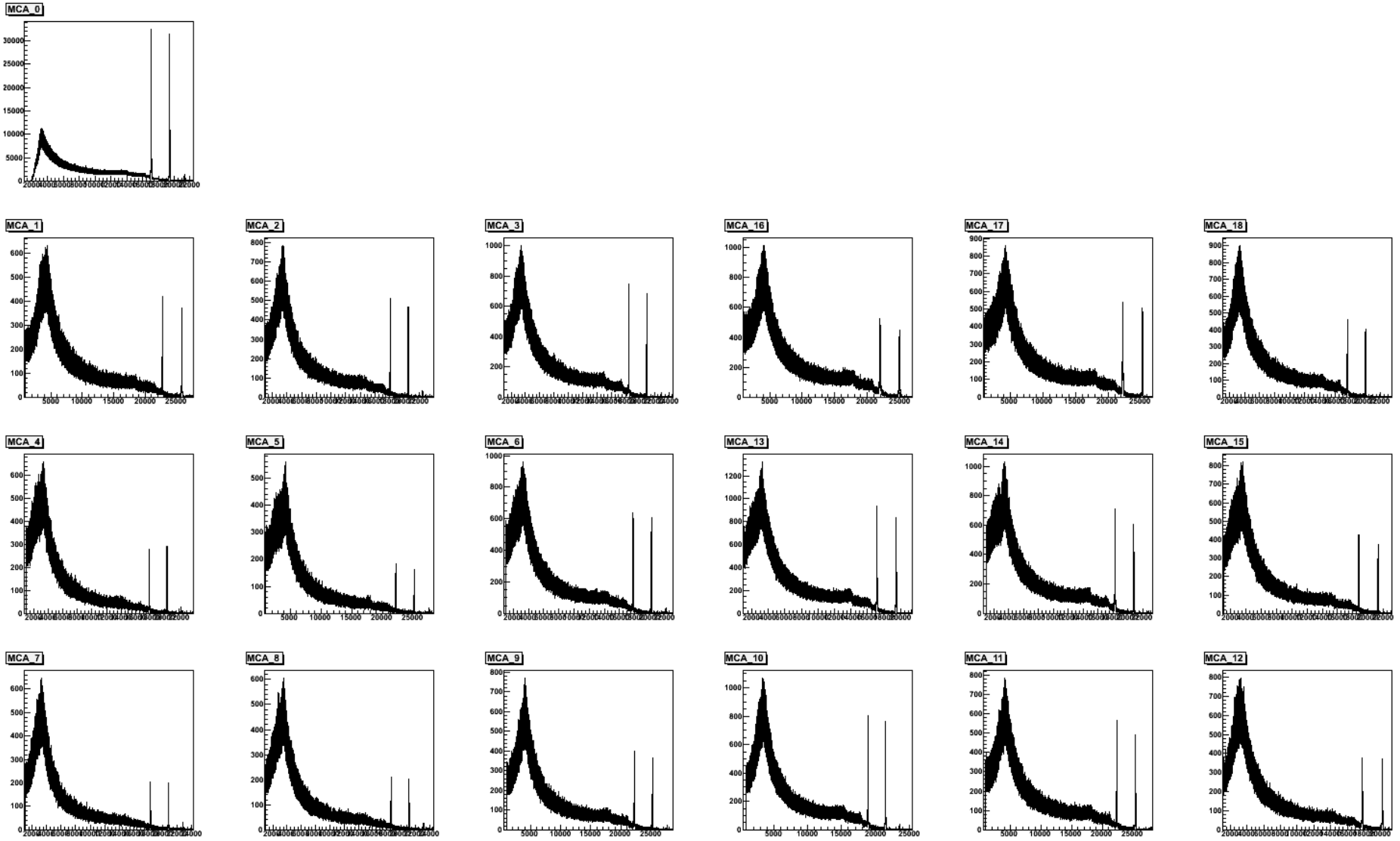
Resolution 4 keV at 1332 keV.

Results soon

Prototype III: a 19 fold segmented crystal being tested in vacuum

Co60 spectrum in 18 segments

Prototype II works in LN since April



Conclusion - Summary

- GERDA is under construction
- Construction of Phase I expected to be finished soon, start of datataking expected in 2009
- Development of Phase II detectors is on the way
- Detector grade Ge crystals (Ph. II) expected in 2009
- 18 fold segmented prototypes are working in vacuum and in LN
- Many other R&D projects with possible application in Ph.II are running in parallel: point contact detectors, scintillation light detection in LAr etc.