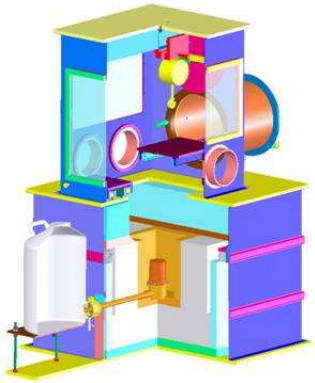
High Sensitive Gamma-Spectrometers of GERDA for Material Screening: Part 2



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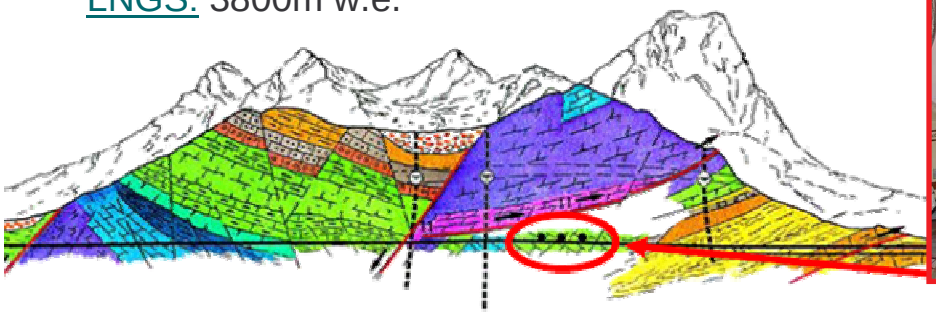
Outline

- basic design considerations
- setup of the CORRADO spectrometer (15m w.e.)
- setup of the GeMPI III spectrometer (3800m w.e.)
- comparison of achieved background-reduction

GeMPI III:

LNGS: 3800m w.e.



Basic Design Considerations

The central question:

How to decrease the lowest detectable specific activity:

$$A_{spec} \approx \frac{\sqrt{B}}{M \cdot \varepsilon \cdot t}$$

- optimize signal count rate (i.e. $M \cdot \varepsilon$ is maximal)
  - use large Ge-crystal
  - use high sample masses in efficient geometry
    i.e. choose optimal sample chamber dimensions
- low background

Background Reduction Techniques

- § external background (environmental radioactivity, radon & progenies, neutrons from fission and (α,n)-reactions)
  - passive shielding (Pb, Cu, polyethylene)
  - air tightness, N_2-flushing
- § internal background in detector & shielding material
  - strict material selection (iterative process)
  - minimize cosmogenic production in detector & shielding copper during production
  - surface cleaning, machining
- § cosmic rays
  - go underground
  - active muon veto (in shallow depth)

Design of CORRADO

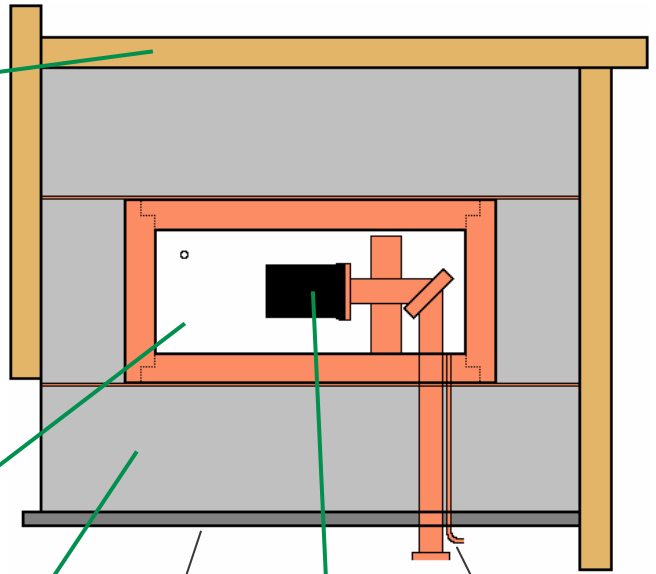
at 15m w.e.

muon-veto:
- MWPC in anticoincidenz
- ~10^4µ/min

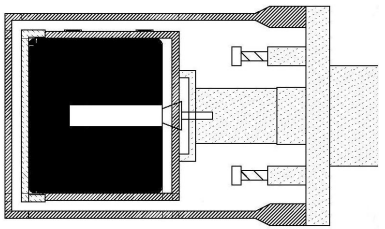
insertion of sample

sample chamber:
- large volume (25x25x33 cm^3)
- can be evacuated & flushed with boil off nitrogen

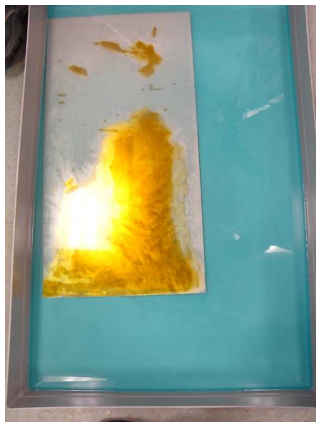
passive shield:
- inside: 5cm copper
- outside: 15-20cm lead

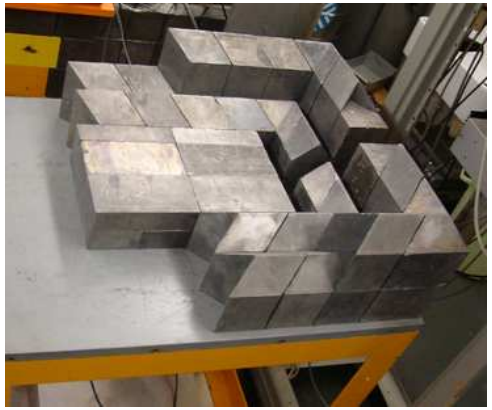


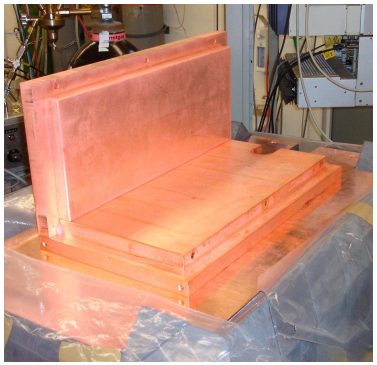
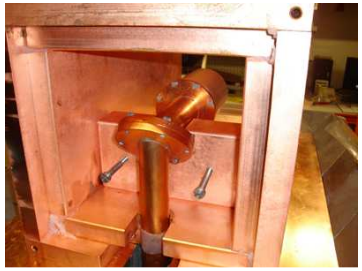
HP Ge-crystal
- coaxial, p-type
- active mass: 0,93kg
- relative efficiency: 37%
- aluminum cap



Assembly of CORRADO






Background Reduction of CORRADO

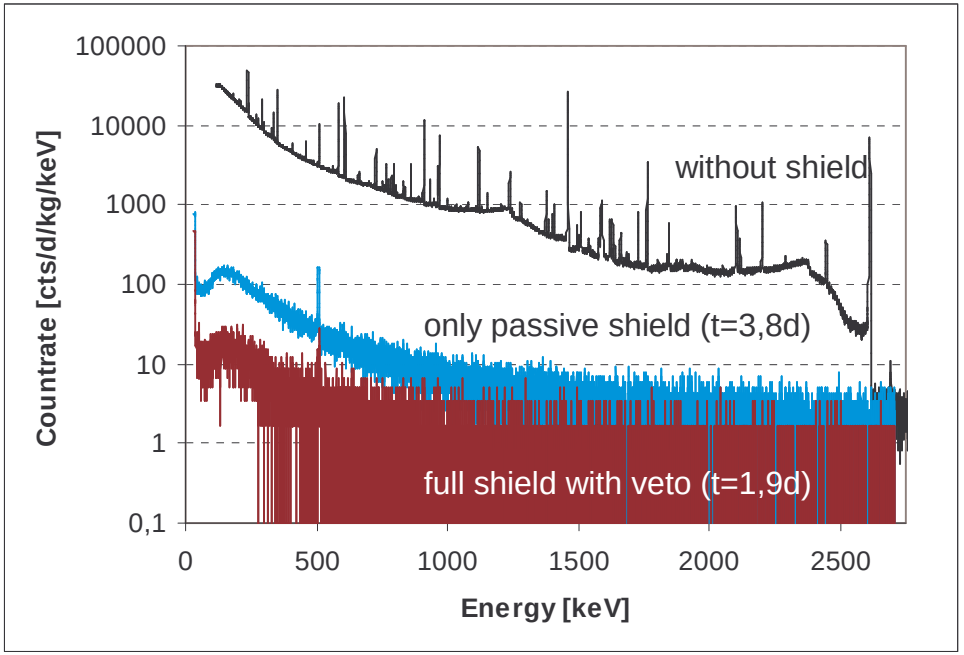
- based on first preliminary background spectrum:

- passive shield: reduction of environmental & airborne radioactivity by factor ~100
- active shield: supression of muon induced background by factor ~10 (88%)
- still no background lines observable

count rate [cts/day]

40-2700 keV		5600
609 keV	(^{214}Bi)	<13
1461 keV	(^{40}K)	<2.3
2615 keV	(^{208}Tl)	<2.9

- coming up: long term back-ground measurement



expected sensitivity:

~1 mBq/kg

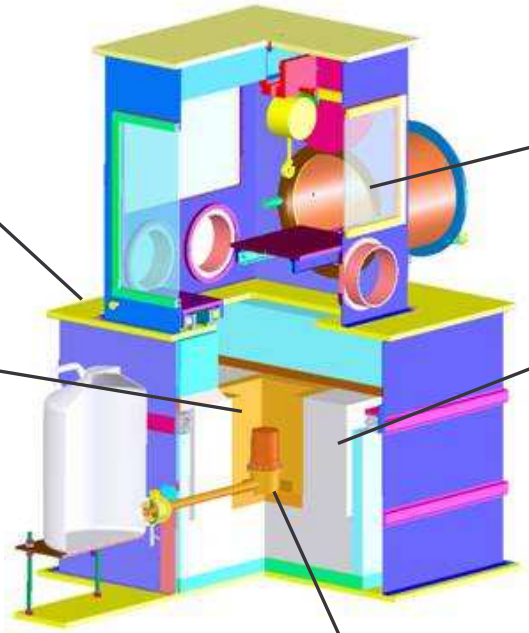
Design of GeMPI III

at LNGS: 3800m w.e.

steel casing
- radon tight
- permanentely flushed with N_2

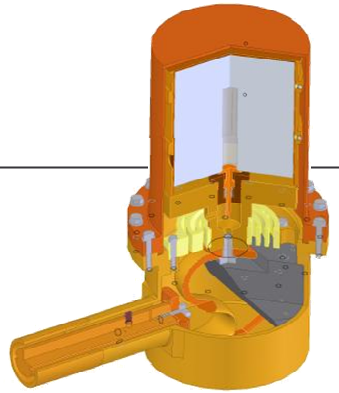
sample chamber:
- 25x25x30 cm^3
- flushed with N_2

HP Ge-crystal:
- coaxial, p-type
- mass: 2.3kg



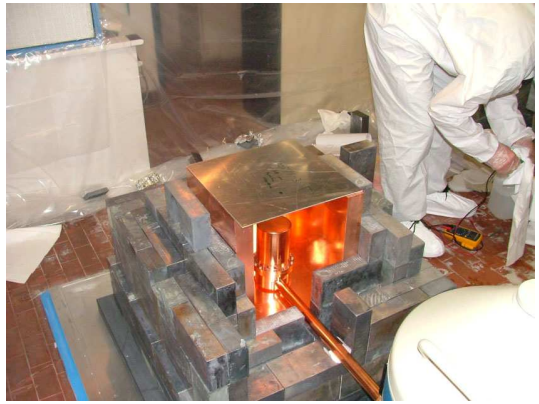
airlock & glovebox
for insertion of sample

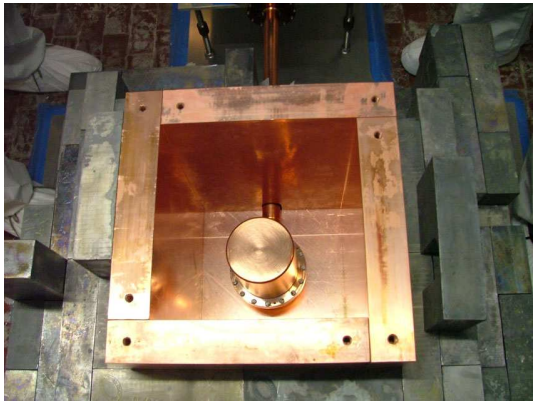
passive shield:
- inside: 5cm copper
- outside: 20cm lead
- + 5cm polyethylene

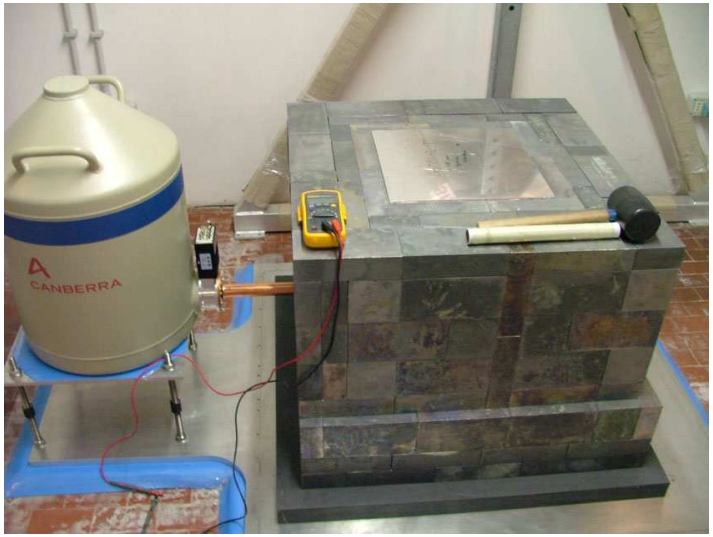


custom made copper cryostat:
- strict material selection to minimize bulk contamination
- avoid materials with high neutron activation cross section
- cleaning by electropolishing & acid cleaning
- roman lead as FET-shield

Assembly of GeMPI III

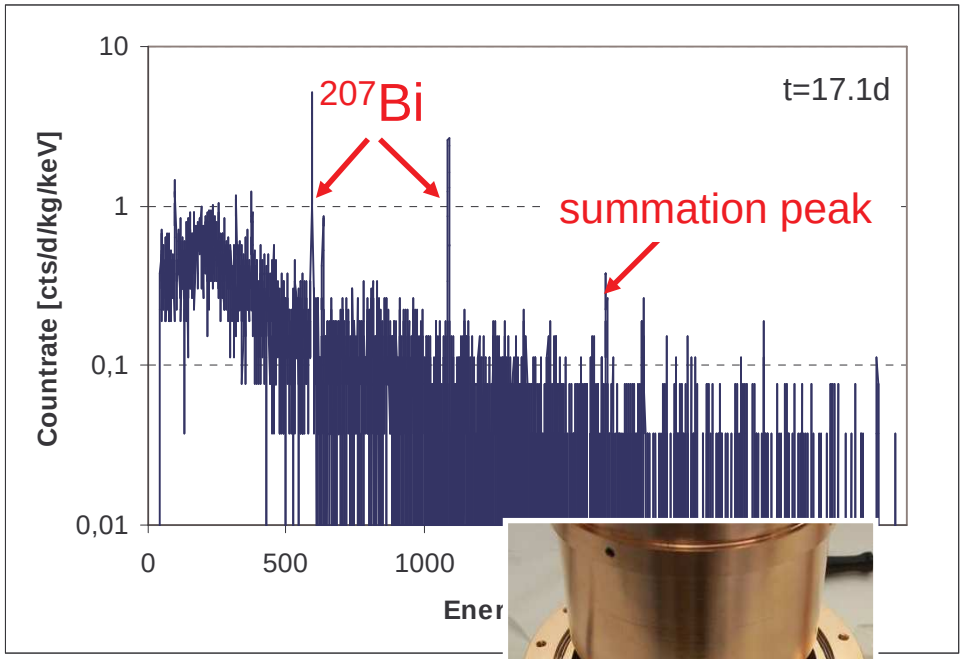


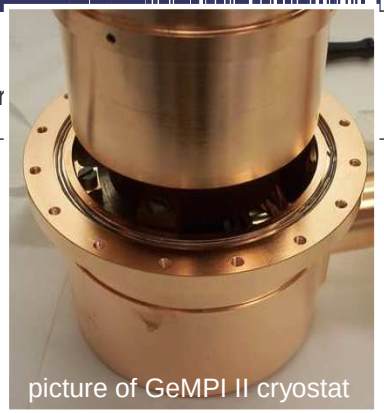




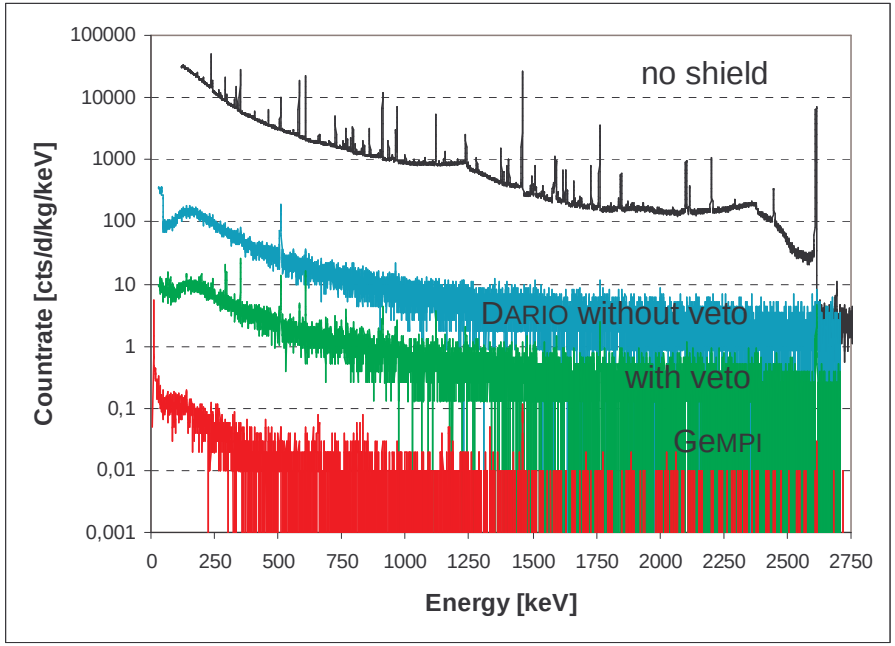
First Spectra of GeMPI III

- ^{222}Rn (^{214}Bi) lines from air in sample chamber visible (due to provisional tightness)
- high **^{207}Bi contamination**!
  570keV: (37,8+/-1,6) cts/d
  1064keV: (21,2+/-1,2) cts/d
  sum: (3,0+/-0,5) cts/d
- from line ratio: contamination is inside of shielding
- suspecting the lead: possible production via (p,n)-reaction on ^{207}Pb
- screening of candidates in progress
- from summation peak & MC: distance & direction information (in progress)




picture of GeMPI II cryostat

Comparison of Background Reduction



background countrates [1/(kg·y)]			
longlive isotopes	Energy	GeMPI	DARIO
^{226}Ra	352keV 609keV	<24 <25	4790 ± 590 4070 ± 460
^{228}Th	583keV 2615keV	<21 18 ± 5	1440 ± 330 4520 ± 280
^{40}K	1461keV	86 ± 12	302 ± 161
^{60}Co	1173keV 1332keV	43 ± 10 35 ± 8	<375 <348
total	100-2730	6840 ± 110	1320000 ± 4400

achieved sensitivity: **GeMPI** **~10 µBq/kg**

DARIO/CORRADO **~1 mBq/kg**

Conclusion

- new high sensitive Ge-spectrometers are being build in order to provide sufficient screening capacity for GERDA.
- with a shielding system appropriate to the depth of the detector site sensitivities of

  ~1mBq/kg @ 15m w.e.

  ~10µBq/kg @ 3800m w.e.

  can be achieved.
- a good knowledge of the detector‘s background, it‘s geometry, as well as large sample masses at long measurement times are required.