Construction of @

Karl Tasso Knöpfle
MPI Kernphysik, Heidelberg
ktkno@mpi-hd.mpg.de

Inauguration, LNGS,
9 November 2010

Construction of GERDA @ LNGS

design considerations
progress of puzzle
special aspects

Inauguration, LNGS,
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Construction of GERDA @ LNGS

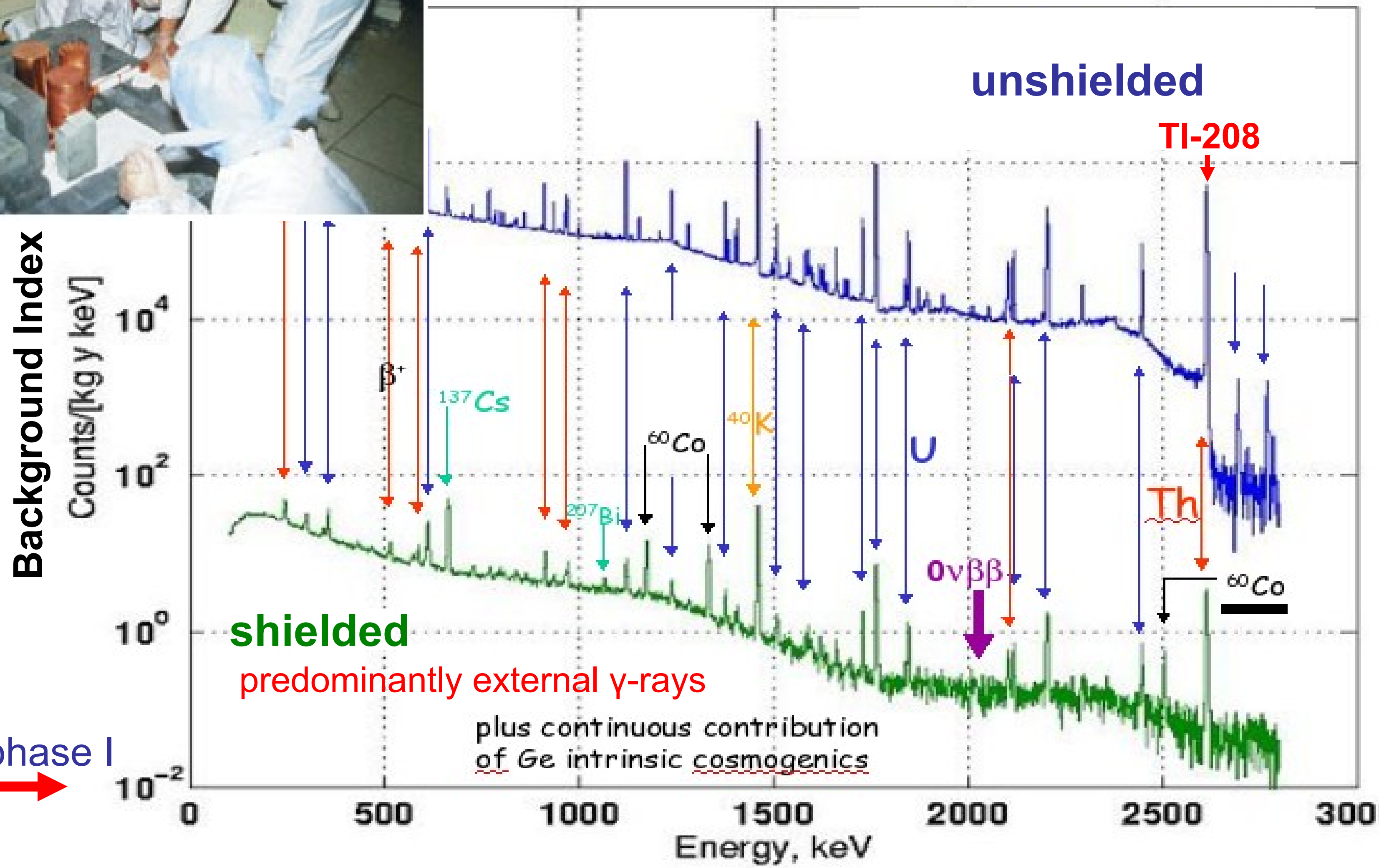
Inauguration, LNGS, 9 November 2010

Purpose of Setup

'Provide environment for stable operation of Ge diodes with - at given constraints - the lowest possible external radioactive background'

background spectra

spectra measured at LNGS with Ge diode

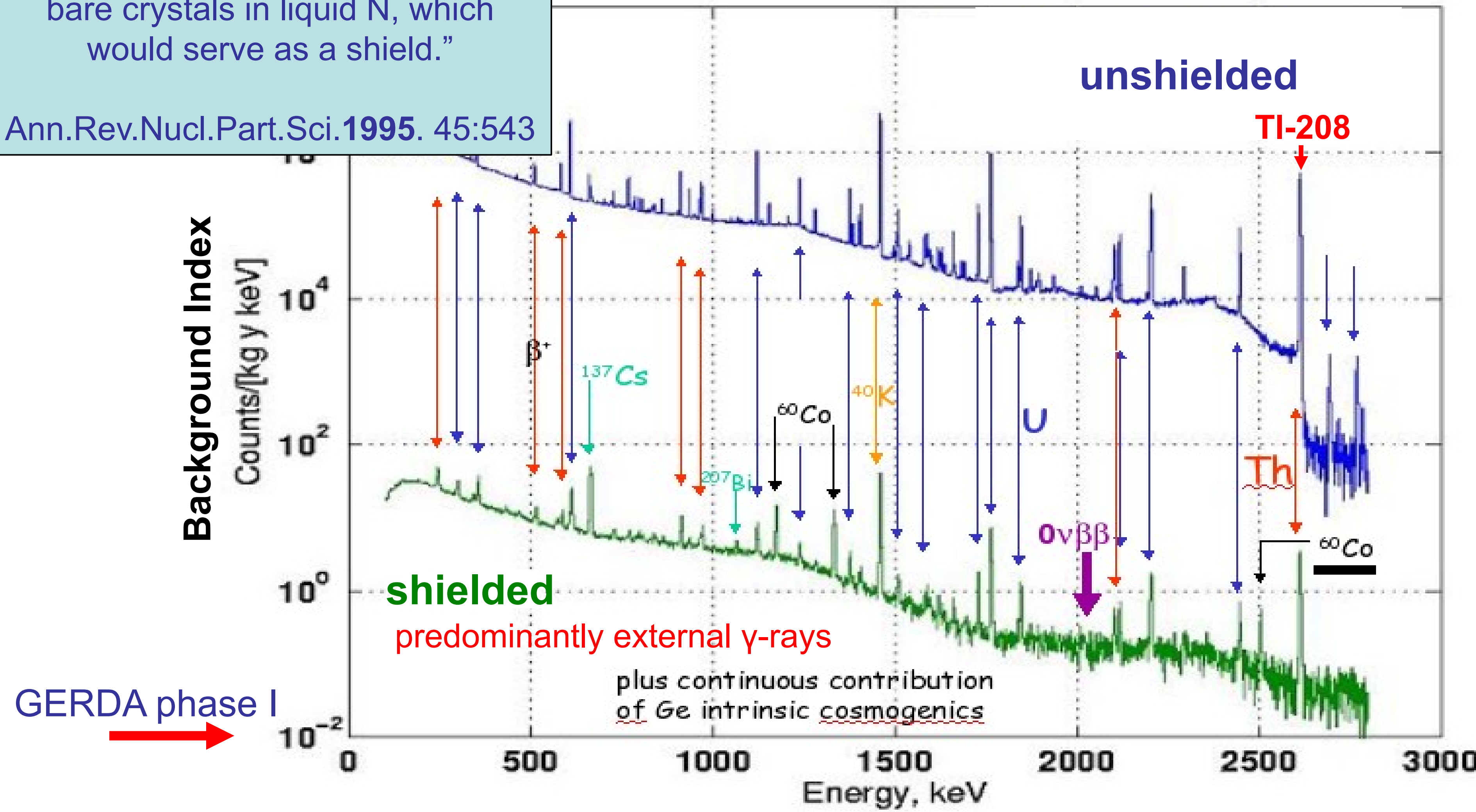


Gerd Heusser
:
"One option for background reduction is to immerse the almost bare crystals in liquid N, which would serve as a shield."

Ann.Rev.Nucl.Part.Sci.**1995**. 45:543

background spectra

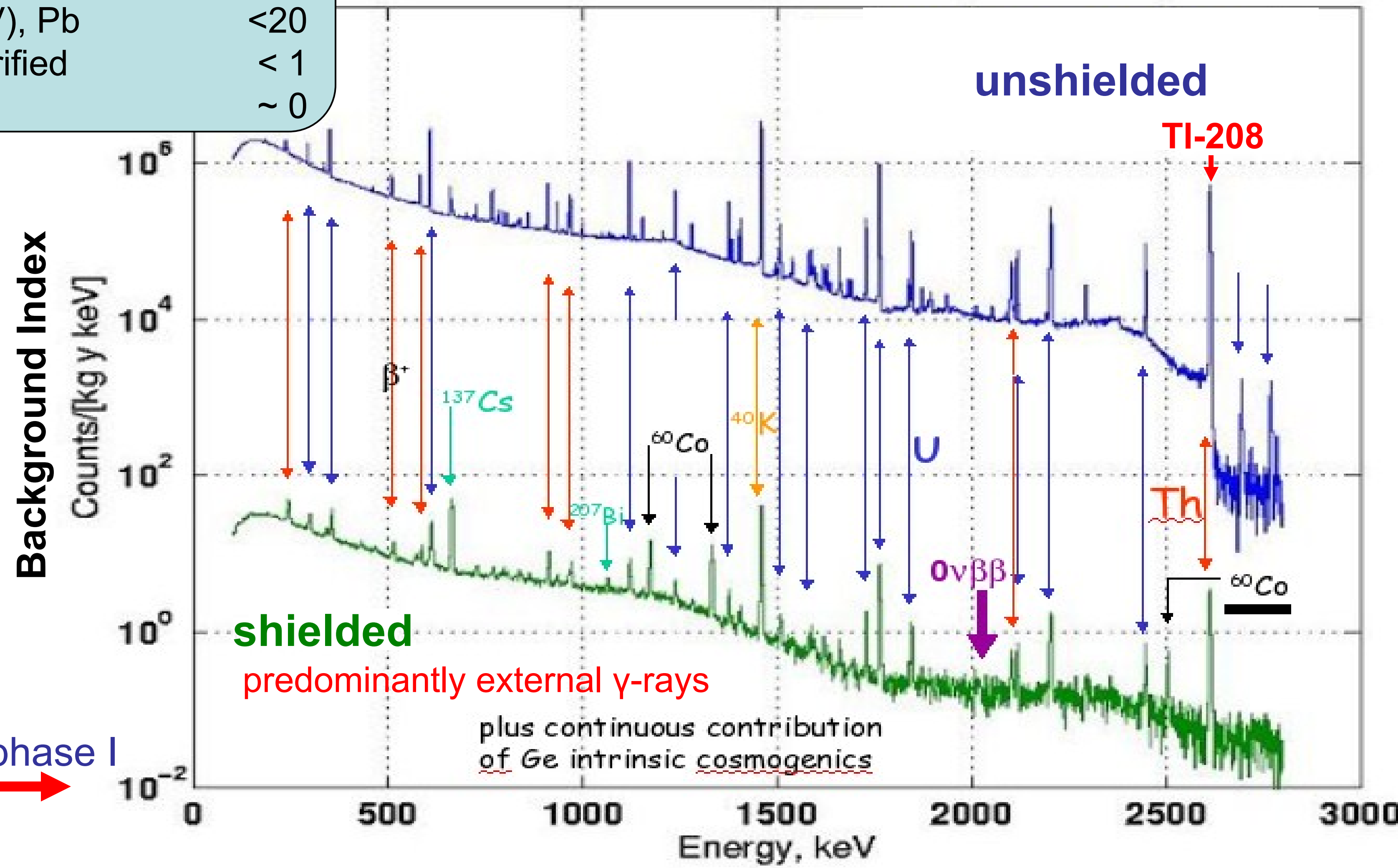
spectra measured at LNGS with Ge diode



background spectra

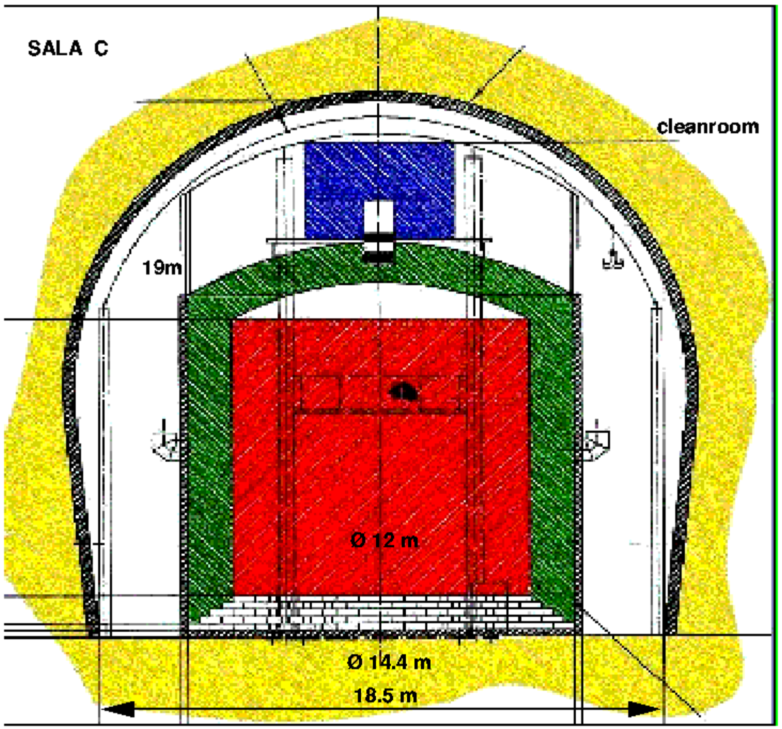
Activity of Tl-208	(µBq/kg)
rock, concrete	3000000
stainless steel	~ 5000
Cu(NOSV), Pb	<20
water, purified	< 1
LN2, LAr	~ 0

spectra measured at LNGS with Ge diode



GERDA phase I

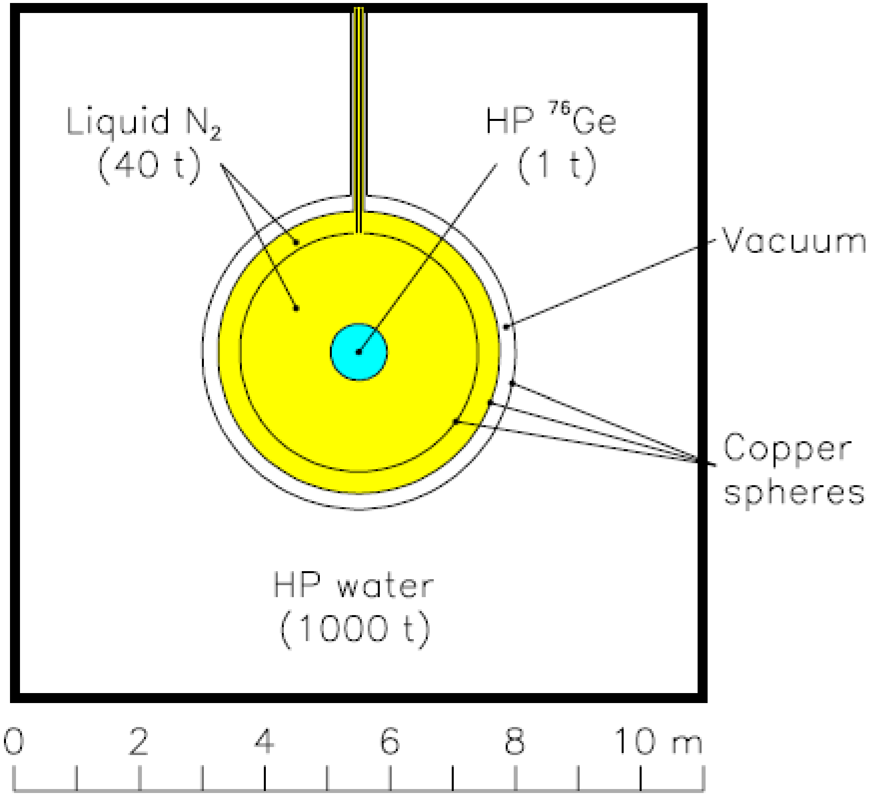
GENIUS 1999 **LN: Ø12x12m 1000t**
total: Ø14.4 x 16 m



flat bottom tank, polystyrol isolation

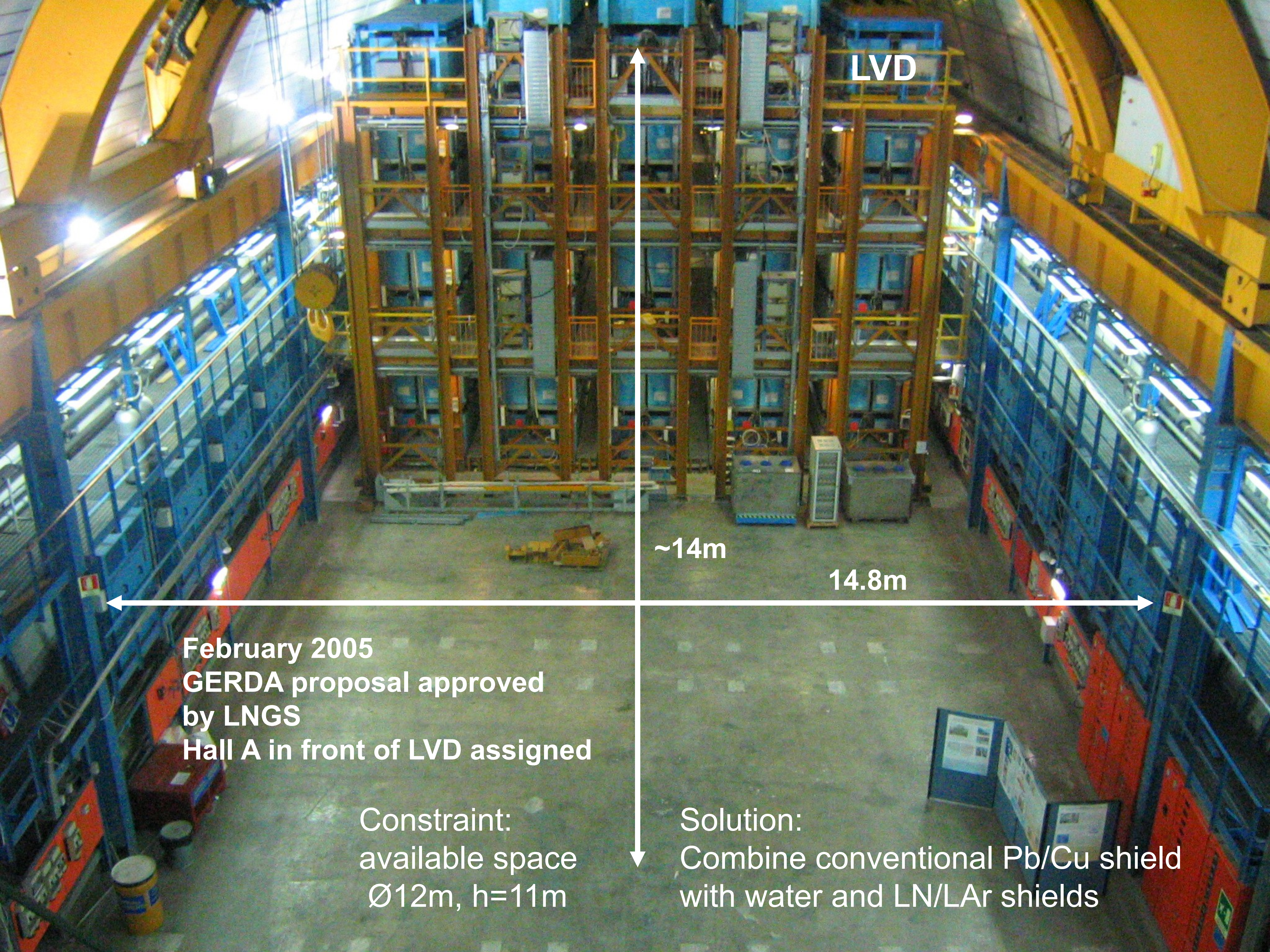
Klapdor-Kleingrothaus., Baudis, Heusser, Majorovits, Päs, hep-ph/9910205

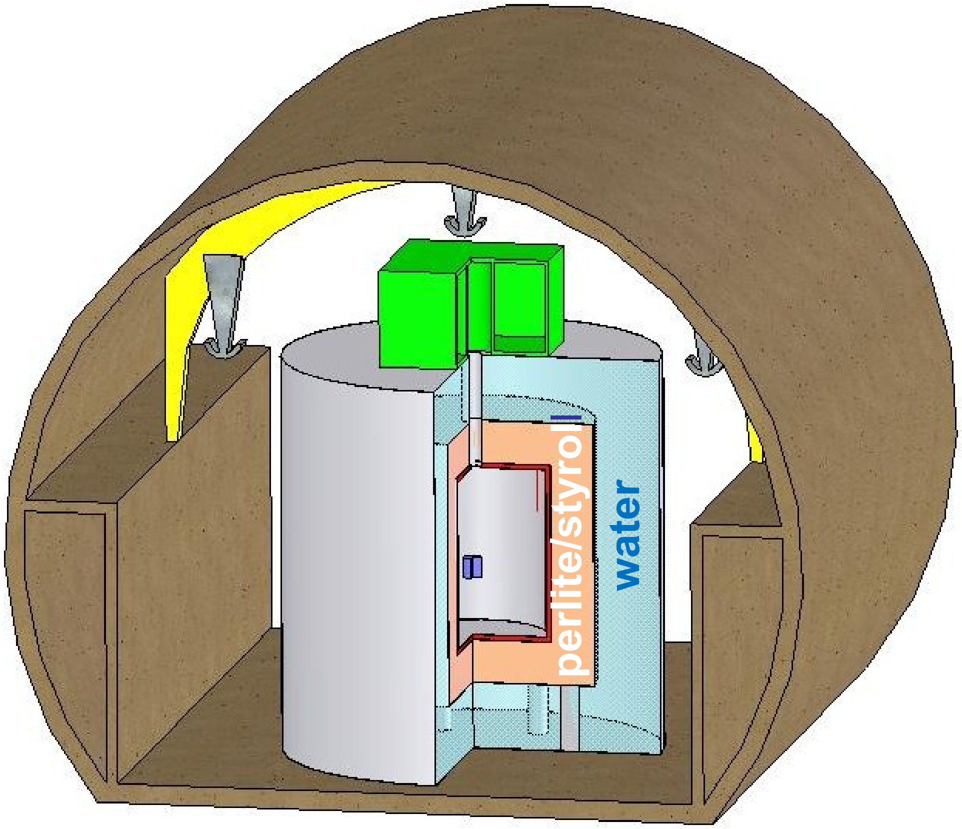
GEM 2001 **LN: Ø5m 40t, H_2O 1000t**
total: Ø11 x 11 m



superisolated Cu cryostat in water tank

Zdesenko, Ponkratenko, Tretyak,
J.Phys.G: Nucl.Part.Phys. 27 (2001) 2129


LVD
~14m
14.8m
February 2005
GERDA proposal approved
by LNGS
Hall A in front of LVD assigned
Constraint:
available space
Ø12m, h=11m
Solution:
Combine conventional Pb/Cu shield
with water and LN/LAr shields



custom-designed flat bottom tank
(thick) perlite/styrol isolation
inside (cold) Pb shield
immersed in water tank

March 2004, Letter of Intent

Activity of Tl-208	(µBq/kg)
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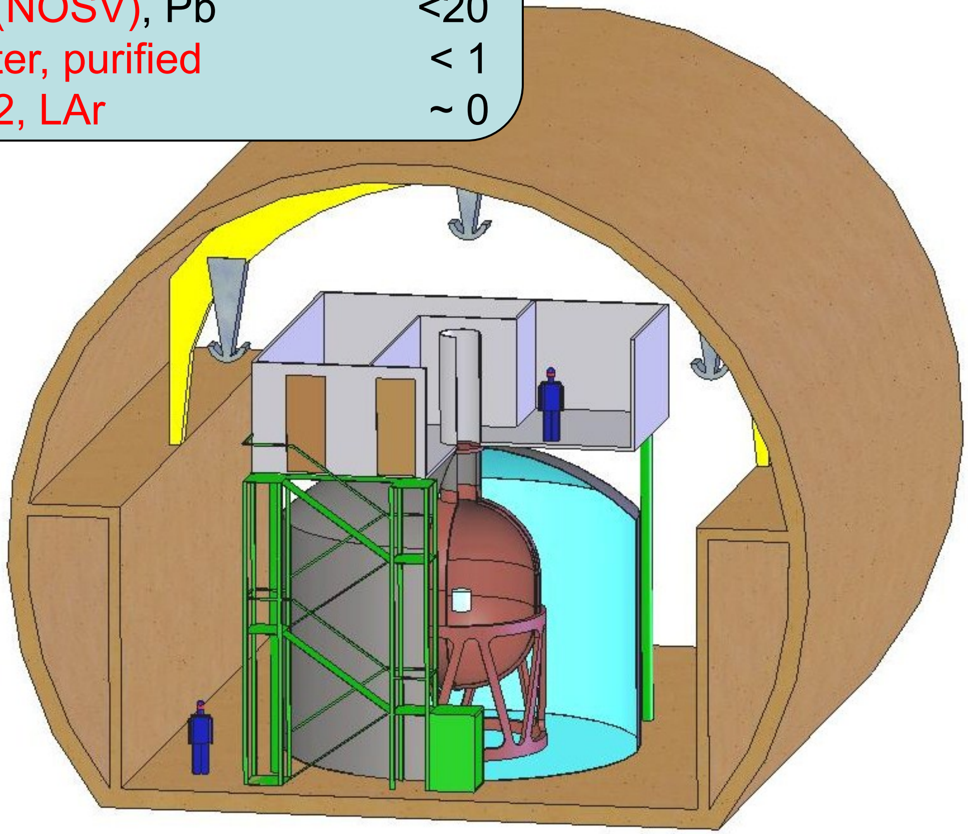
rather perfect graded shield:
steel – water – Cu – LN/LAr



copper cryostat Ø3.7m h=7.5(9)m
- electron beam welded
- superisolation (10cm)
- immersed in Ø10m water tank

September 2004, Proposal

(final) design

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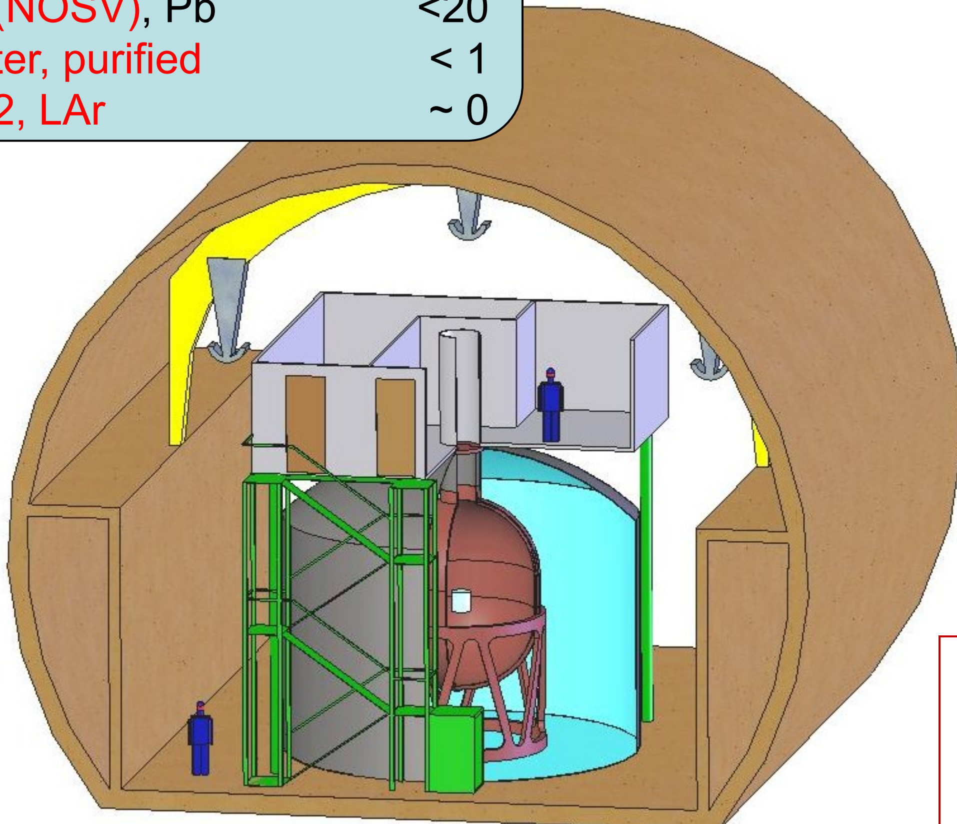

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copper cryostat Ø3.7m h=7.5(9)m
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Challenges:

Earth-quake tolerant design
Identify manufacturer
Cost estimate within budget
TÜV welding certification Cu-Cu, Cu-Fe
Safety

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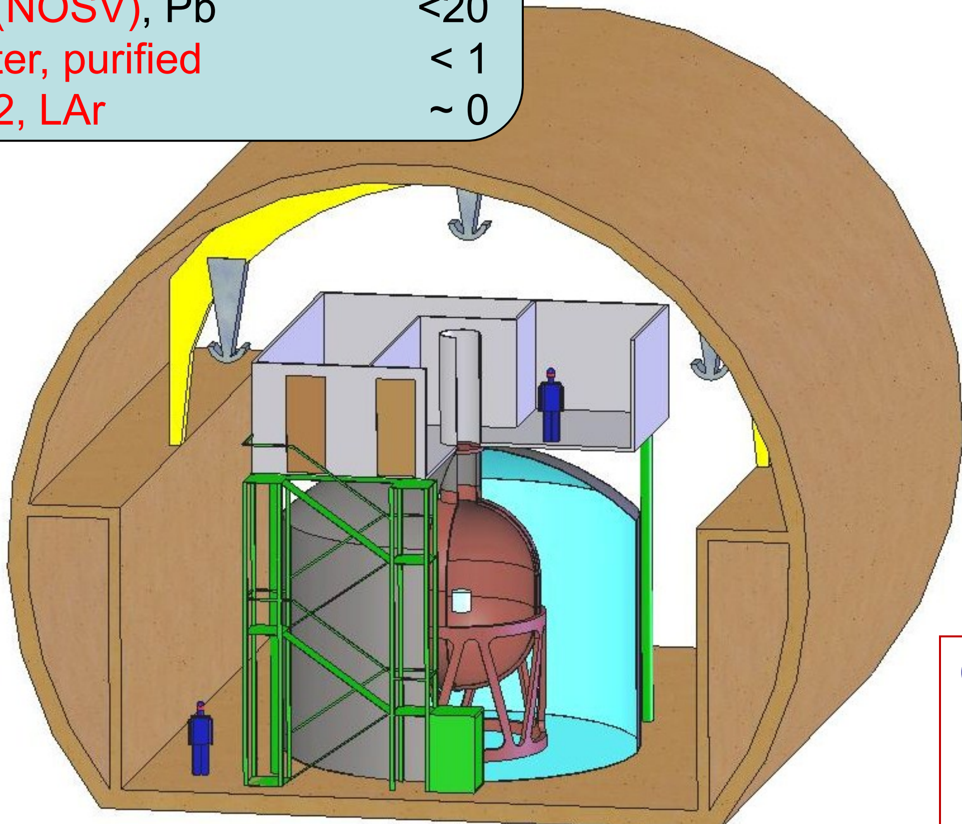

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electron beam welded
superisolation (10cm)
immersed in Ø10m water tank

Challenges: **Feb 2006**

Earth-quake tolerant design ✓
Identify manufacturer ✓
Cost estimate within budget ✓
TÜV welding certification Cu-Cu, Cu-Fe ✓
Safety ✓ with 3rd wall ✓

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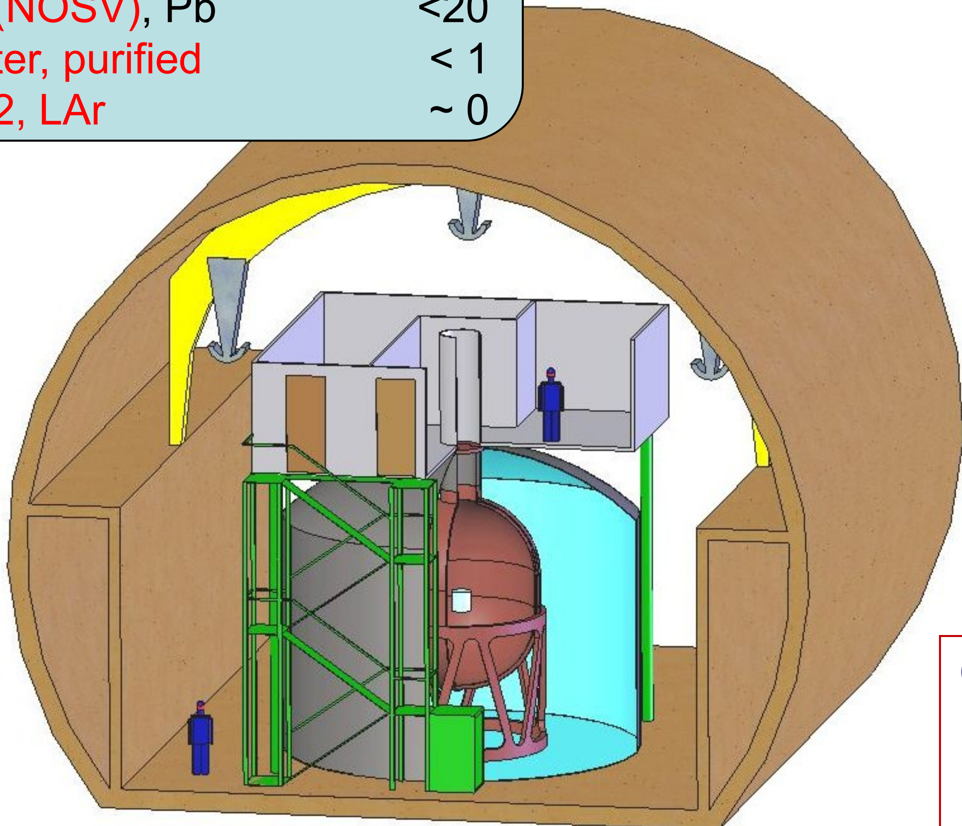

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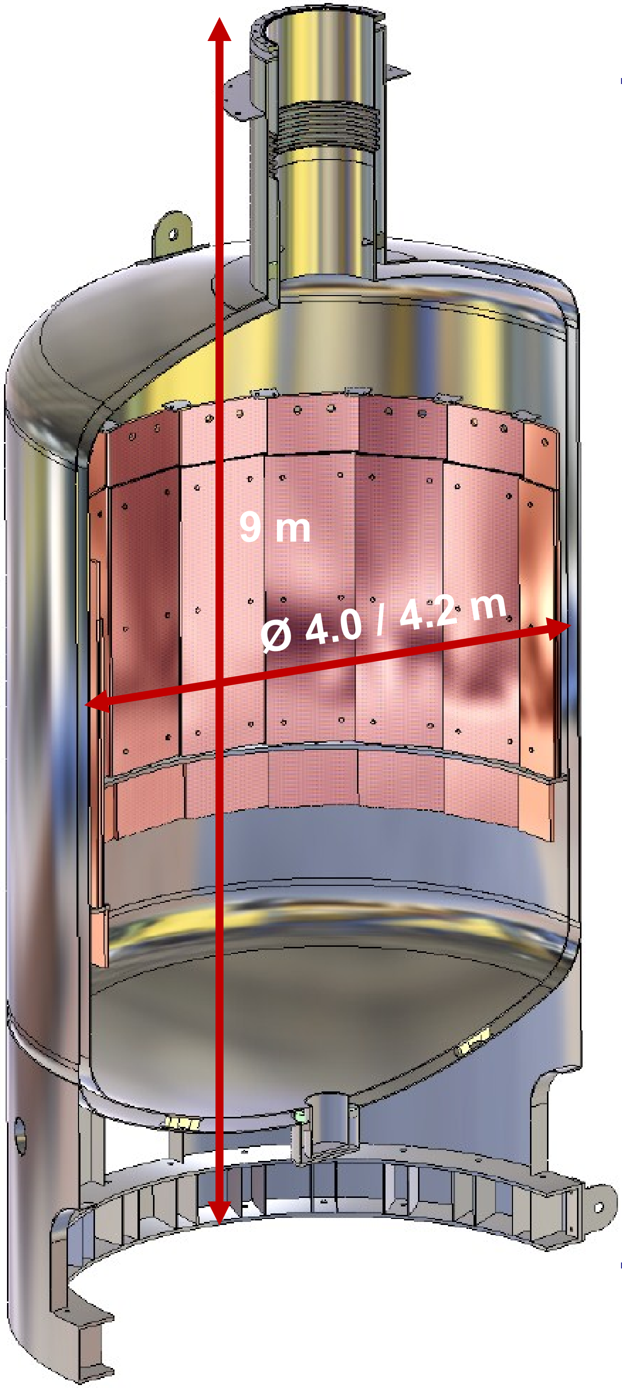
Earth-quake tolerant design ✓
Identify manufacturer ✓
Cost estimate within budget ✓
TÜV welding certification Cu-Cu, Cu-Fe
Safety ✓ with 3rd wall ✓ ✓

Mar 2006: Final quote almost 3x higher than estimated

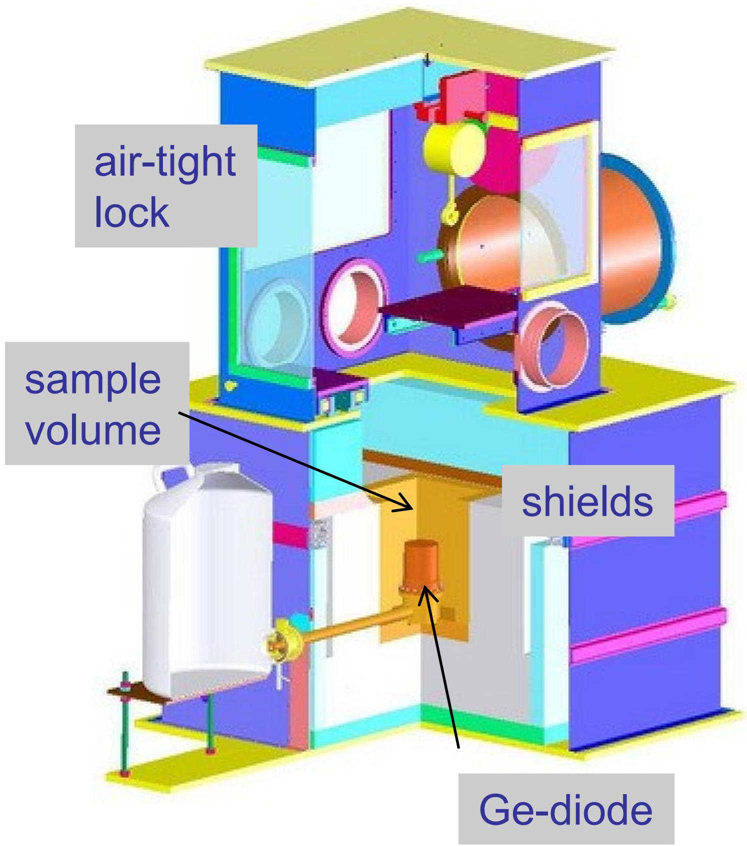
adoption of fallback solution



Threefold increase of fabrication cost,
and strong increase of copper price,
and safety concerns by experts (3rd walll)

► July 2006 decision (~1 year lost):
full copper cryostat to be replaced by
stainless steel cryostat

64 m^3
multilayer superisolation
internal copper shield ~~40~~ 16 tons
(3 to 6 cm thick)



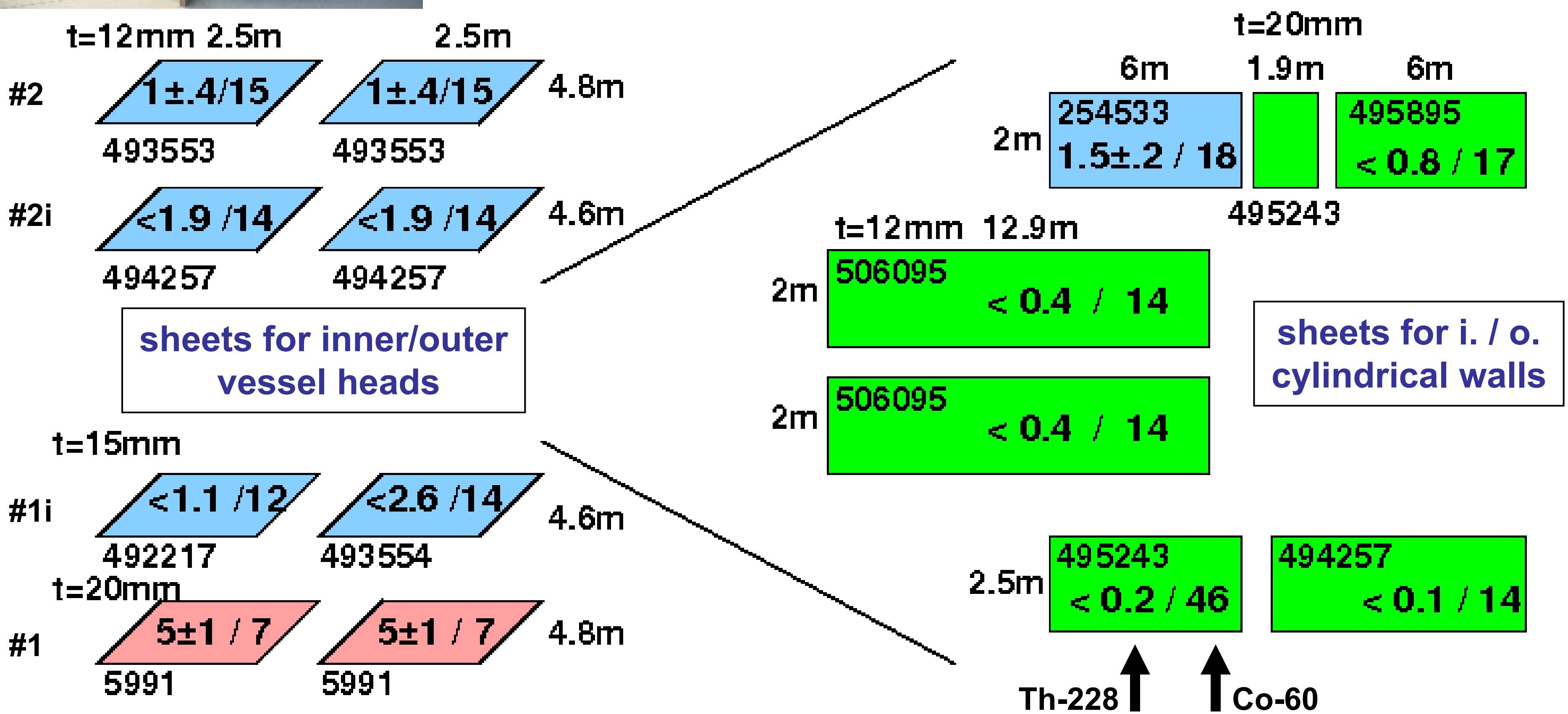
GeMPI γ spectrometers located at
MPI-HD and LNGS
worldwide most sensitive devices

used to determine Th-228 activity of EACH steel sheet used for cryostat production

NB: similarly unique device 'MOREX'
used to determine the Rn-222 emanation in cryostat volume

screening of cryostat’s ss sheets

results from γ spectroscopy at LNGS and MPI HD
(more data available)



unexpected low Th-228 activity, typ. <1 mBq/kg ► less massive Cu shield needed

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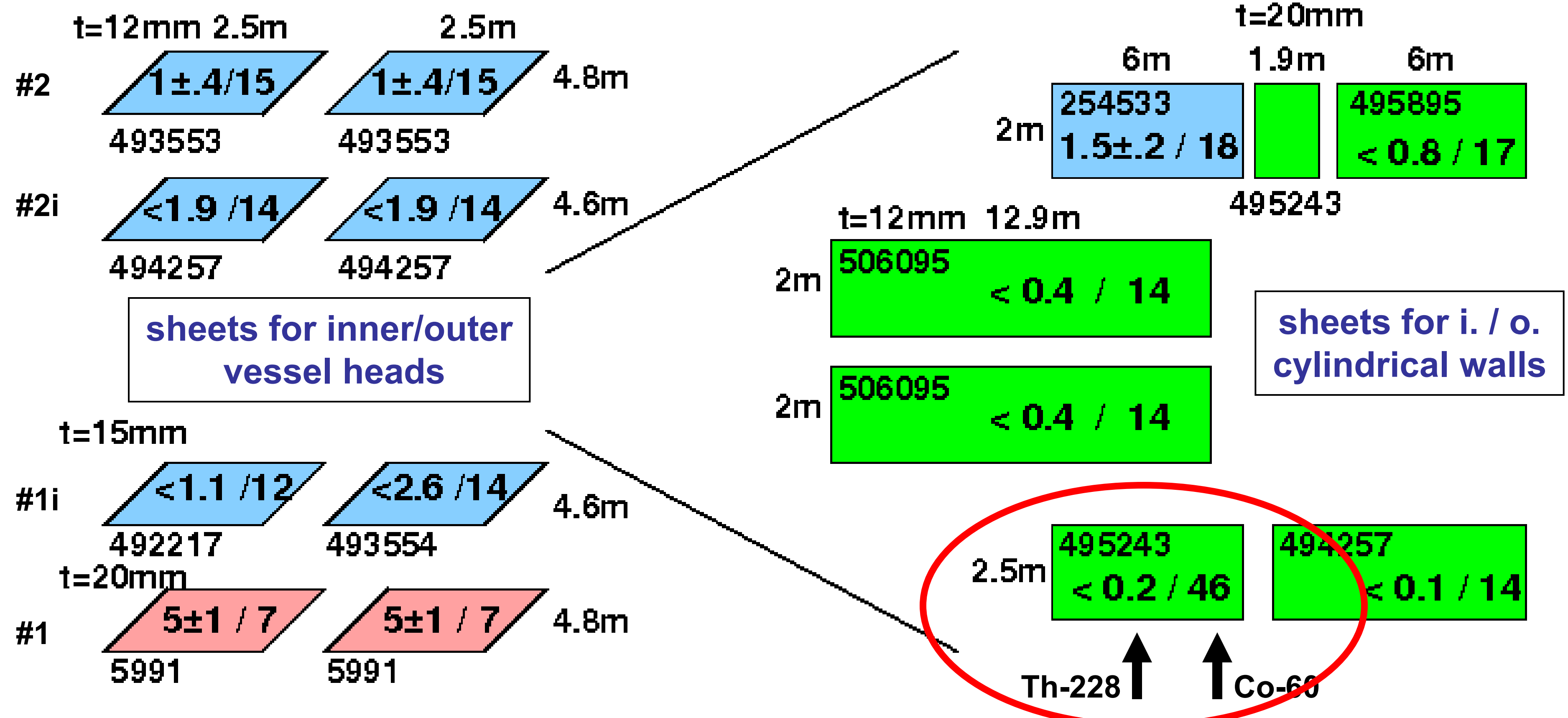

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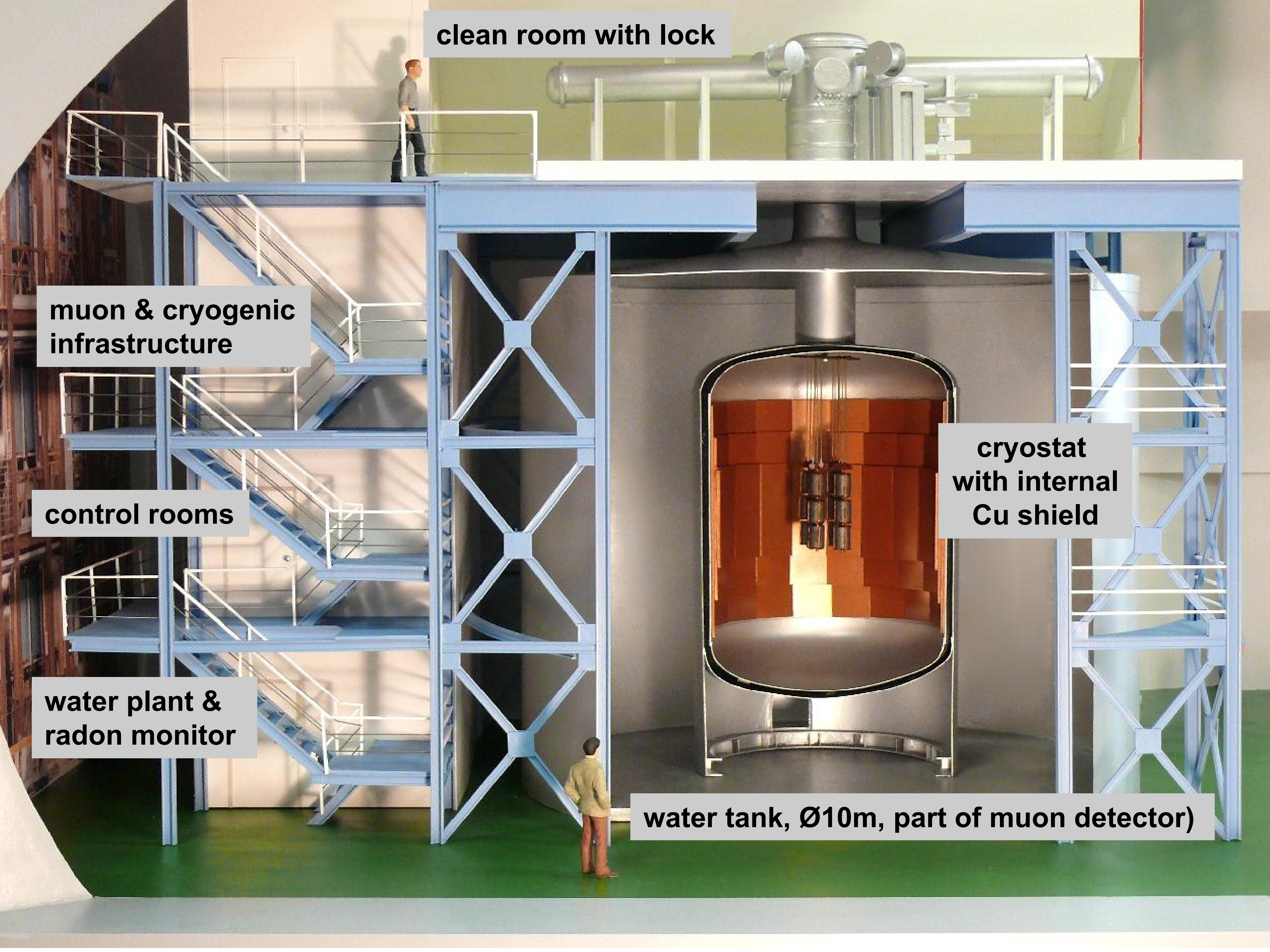

clean room with lock
muon & cryogenic infrastructure
control rooms
water plant & radon monitor
cryostat with internal Cu shield
water tank, Ø10m, part of muon detector)


07 jun 2007
repair of vesselhead

cryostat assembly


3 mar 2008
cryostat leaving manufacturer, ~750 km to go

6 mar 2008

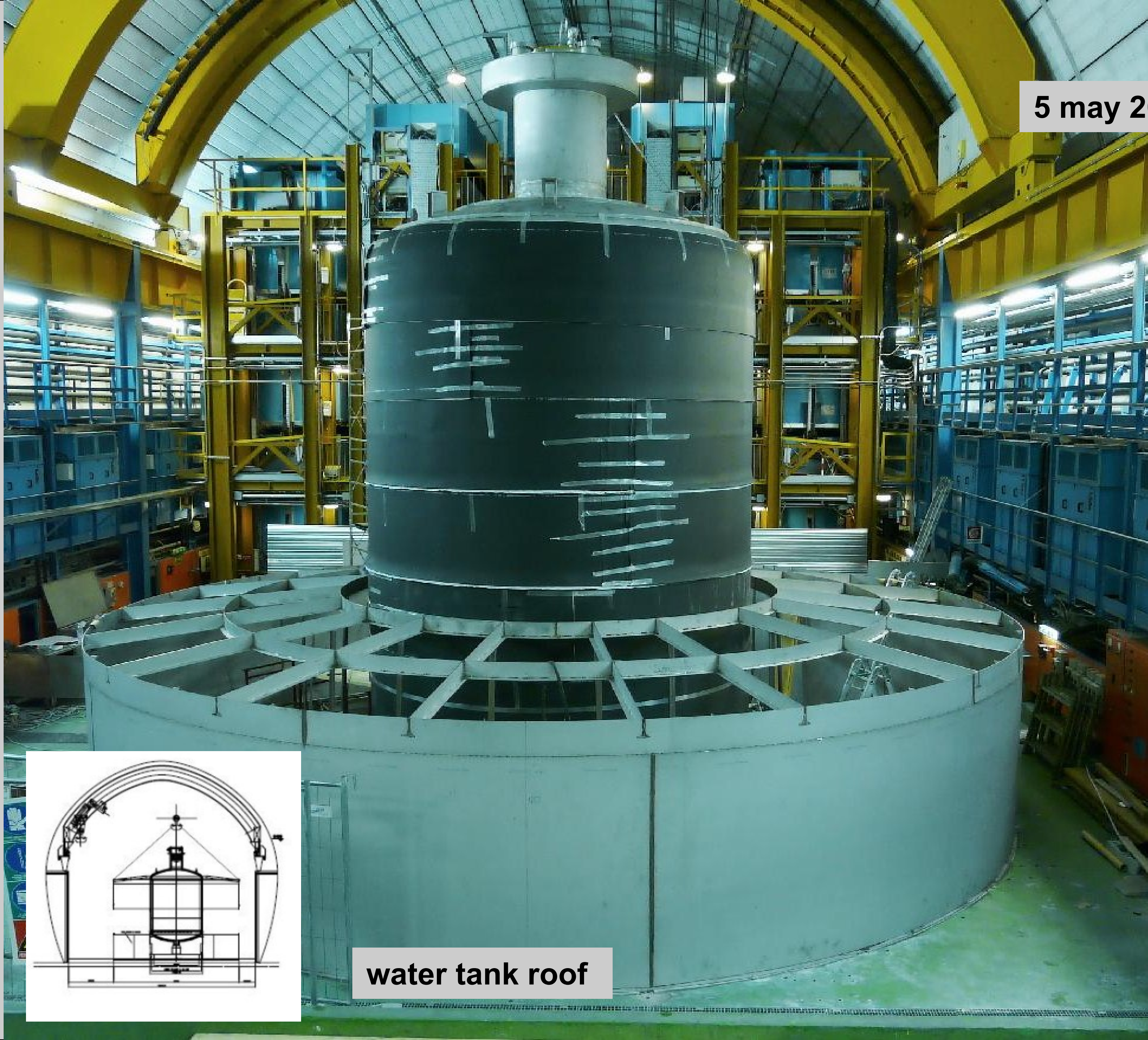
cryostat arriving in Hall A


7 mar 2008


6 mar 2008

internal copper shield installation

13 mar 2008


5 may 2008
water tank roof

28 may 2008

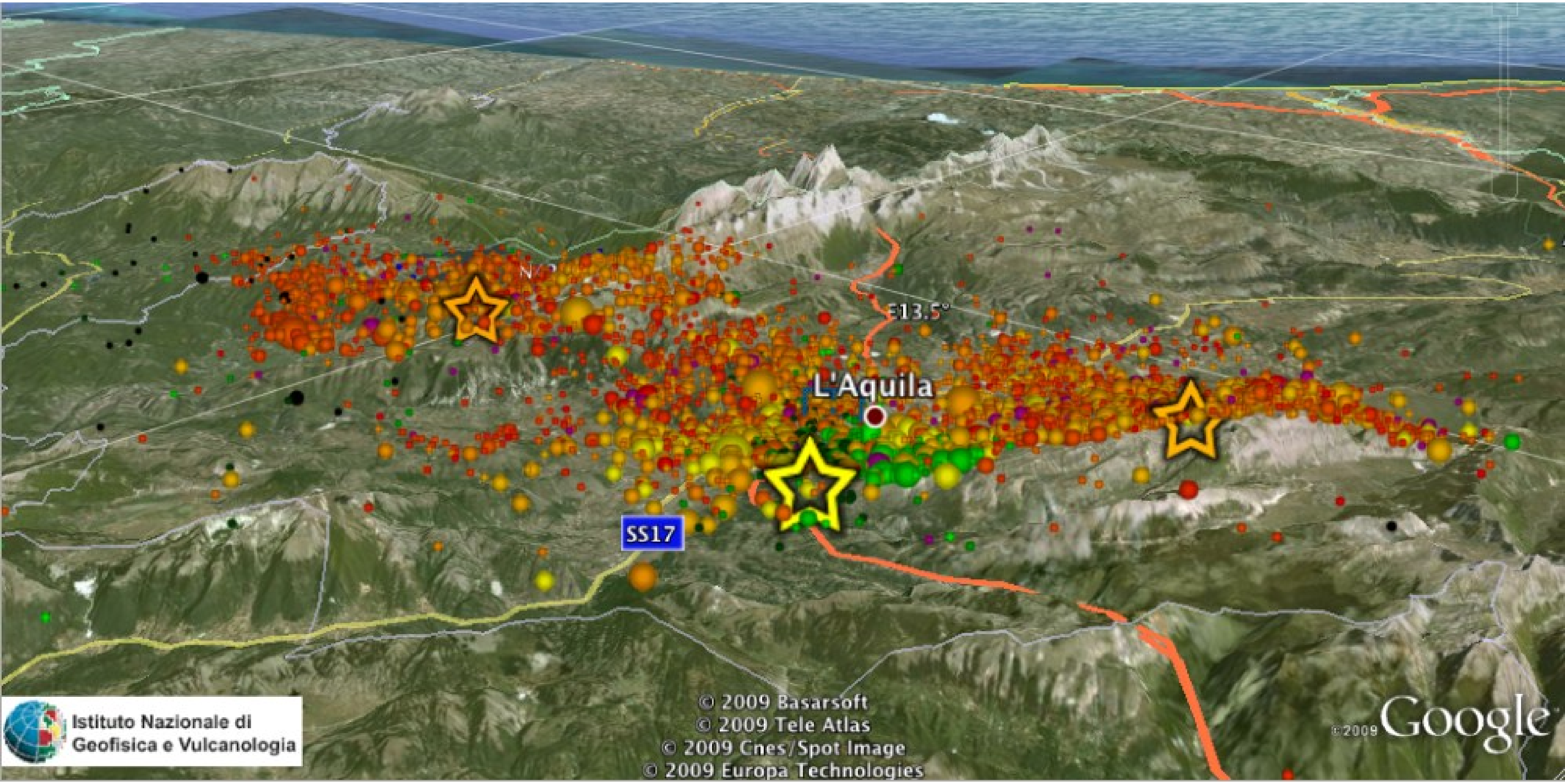
water tank construction


18 jul 2008
GERDA building construction


29 feb 2009
clean room construction

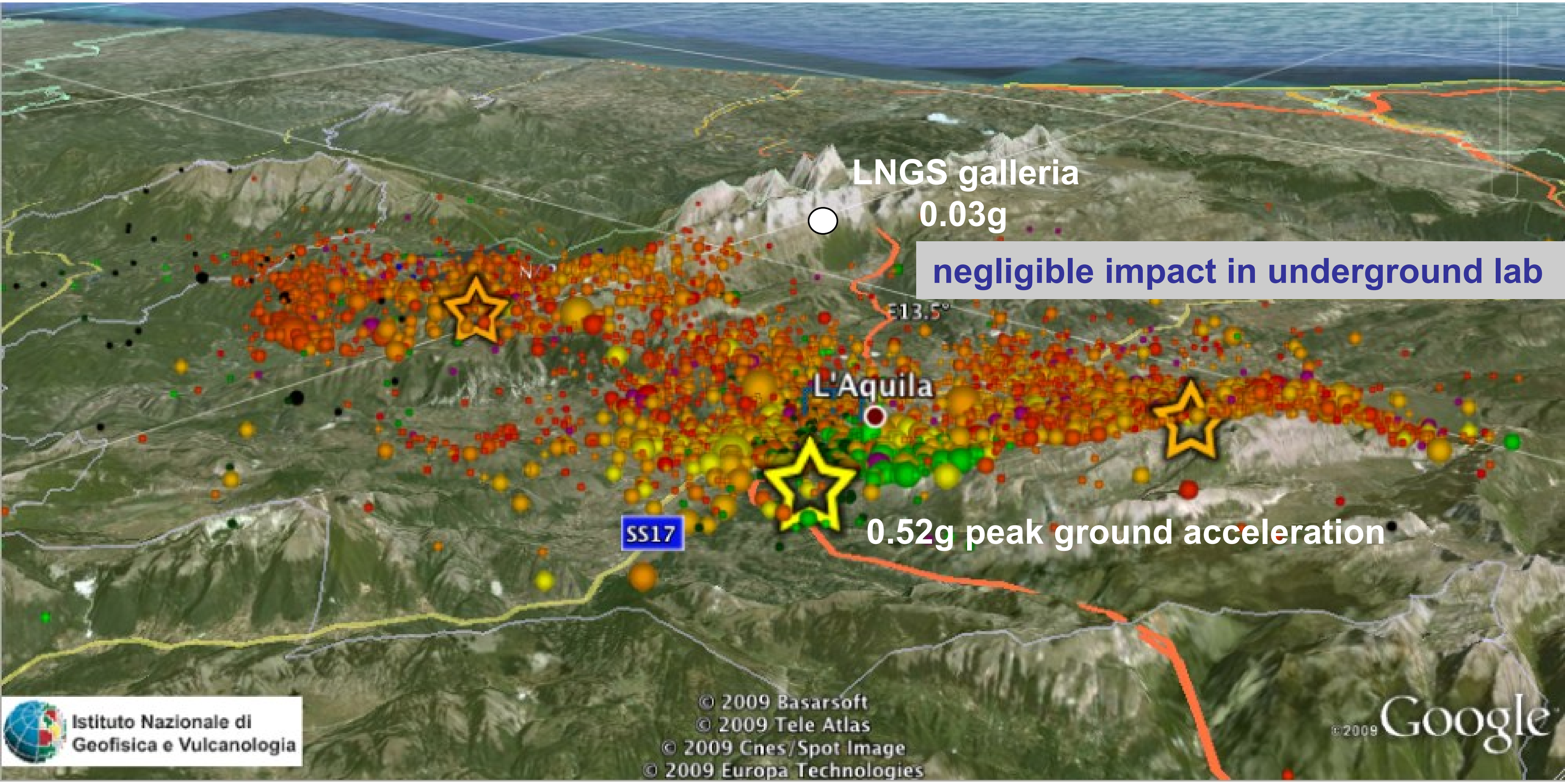
L'Aquila M=6.3 earthquake & aftershocks

6 April 2009

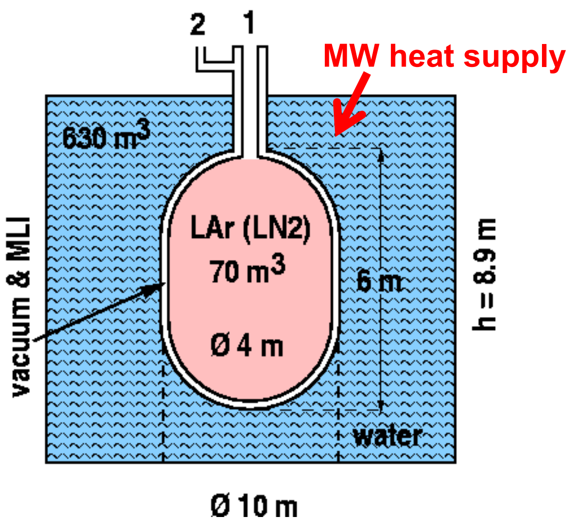


L'Aquila M=6.3 earthquake & aftershocks

6 April 2009



Risk	**Mitigation**
earthquakes	cryostat, water tank, GERDA building designed and built to withstand 0.6g
cryostat in water tank	cryostat: two independent containers; no penetrations below fill level; AD2000 pressure vessel design; certified for 1.5 bar overpressure while operated at at 0.2 bar overpressure, and more
	cryogenic and vacuum infrastructure: redundant sensors and safety valves
	water tank: drainage within less than 2 hours; triggered automatically by cryostat's PLC

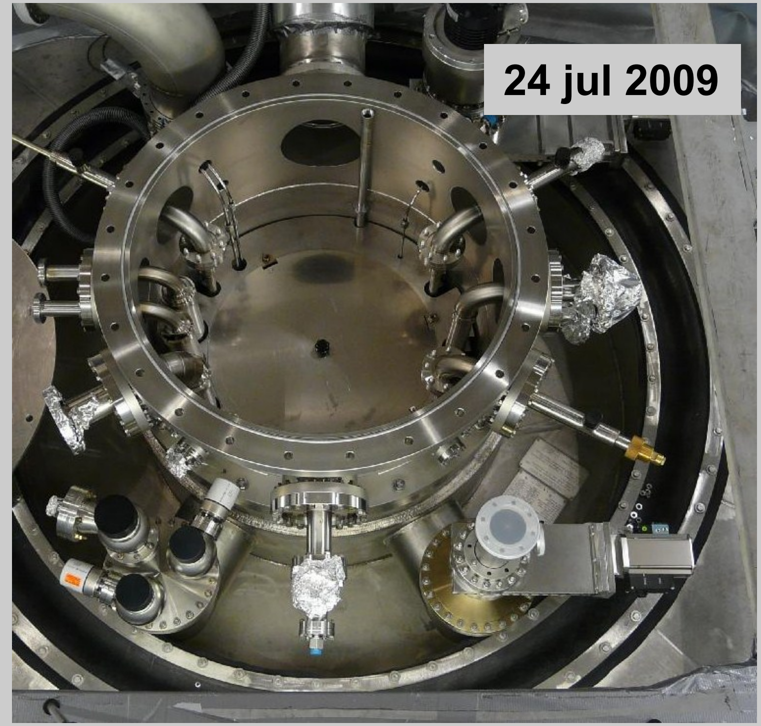


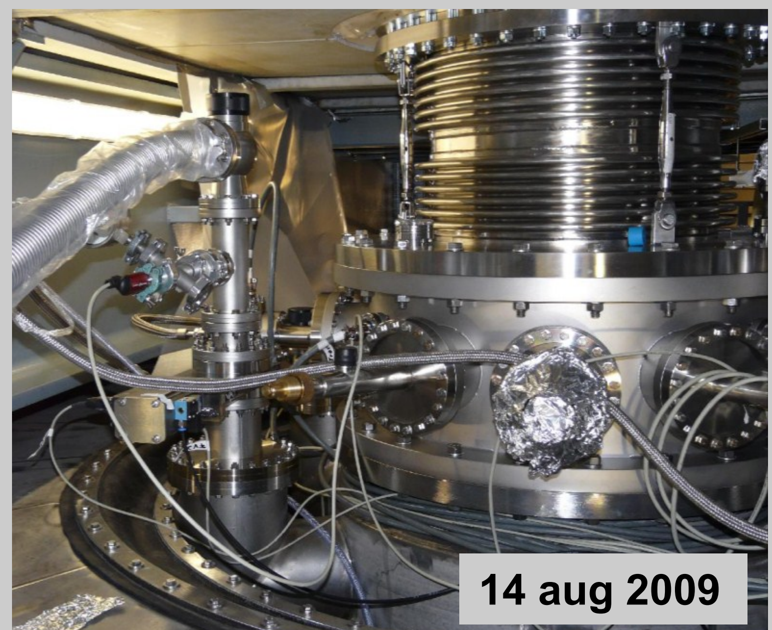
From start in 2005 detailed risk analysis by external experts – evaluated by LNGS – green light for construction June 2007

17 aug 2009

thermal isolation & reflecting foil installation

infrastructure built into and on top of cryostat



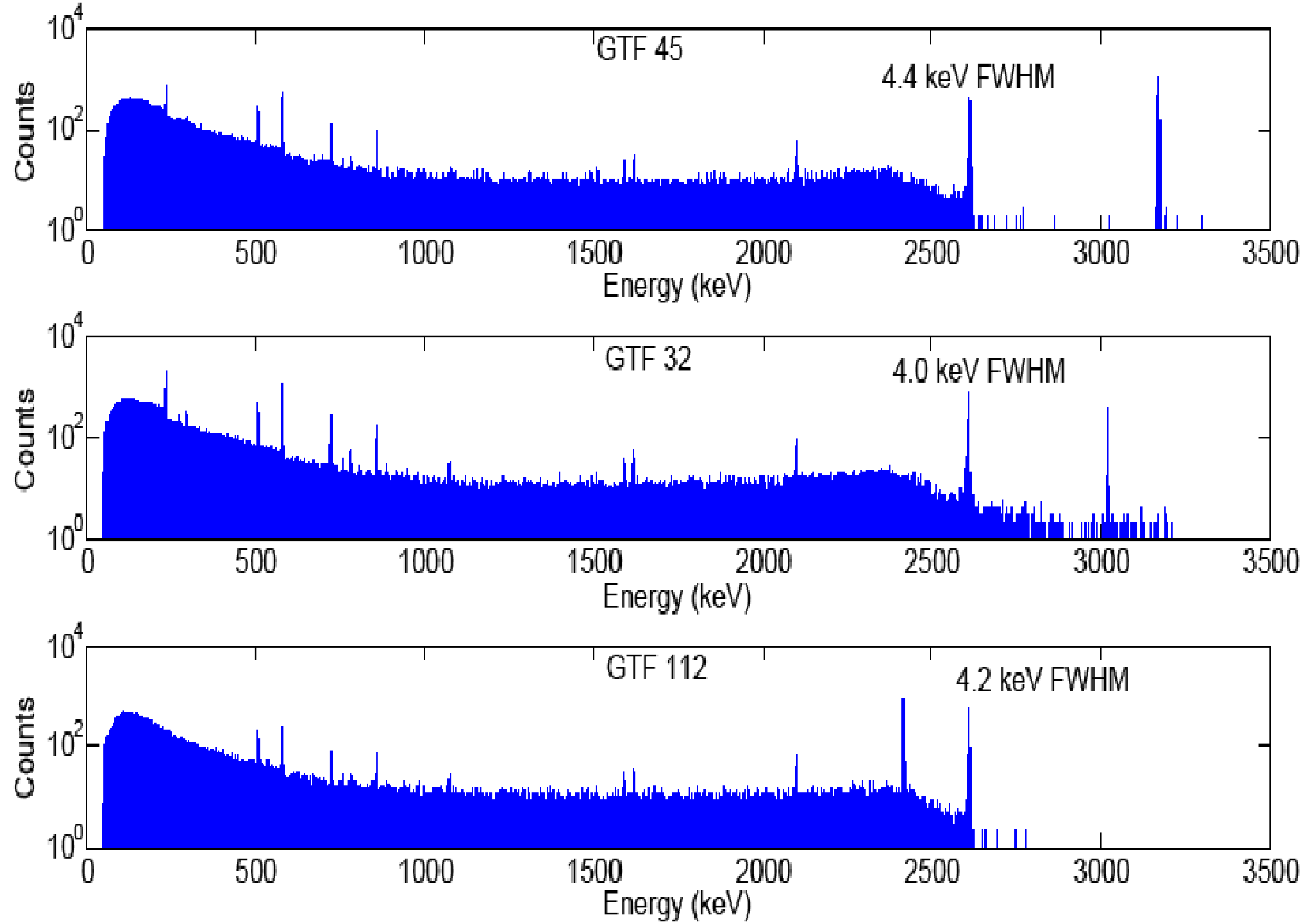



17 nov 2009
clean bench on its way into the clean room

23 apr 2010

Part of commissioning lock and clean bench

3-detector string & in-situ calibration spectra



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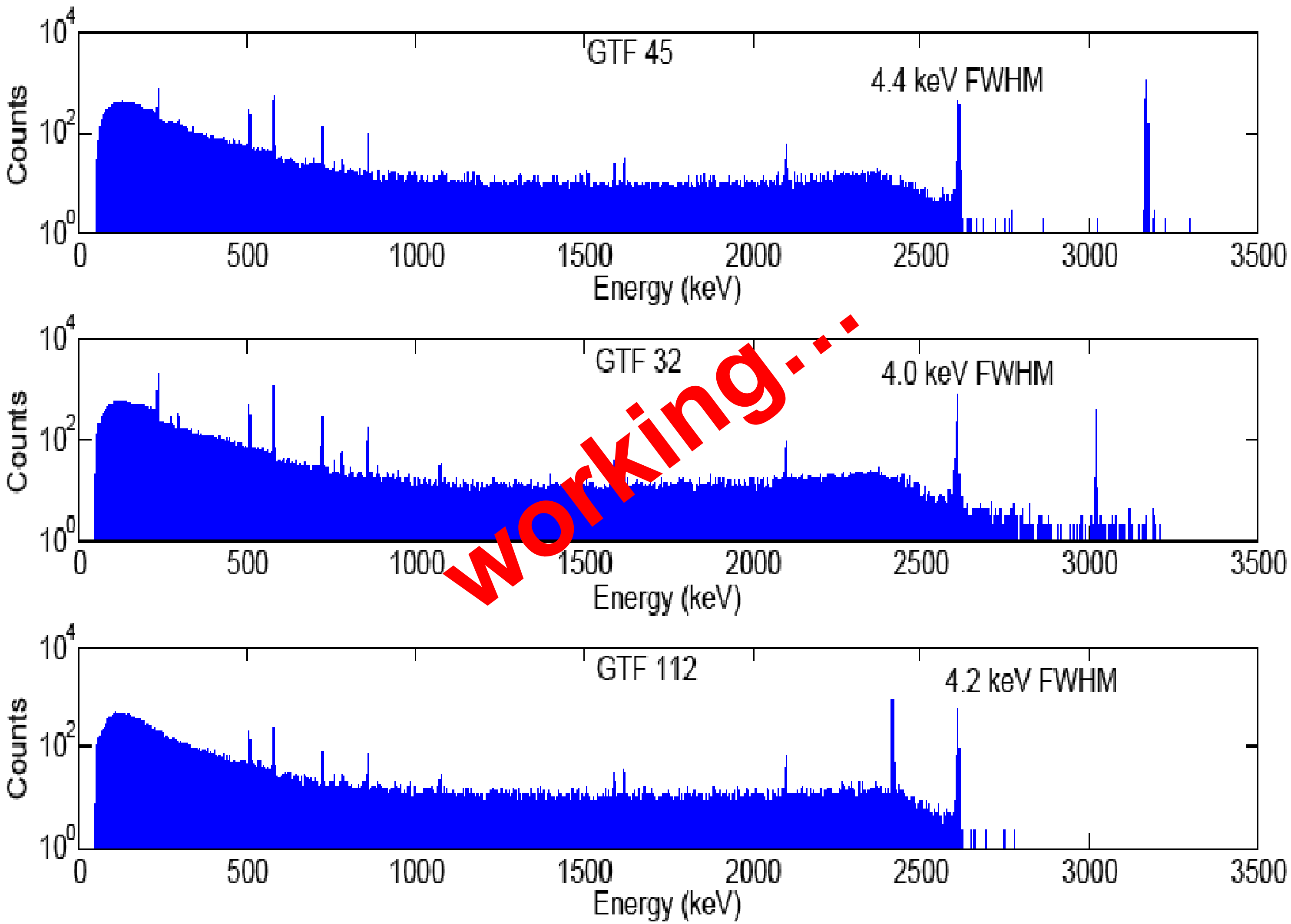
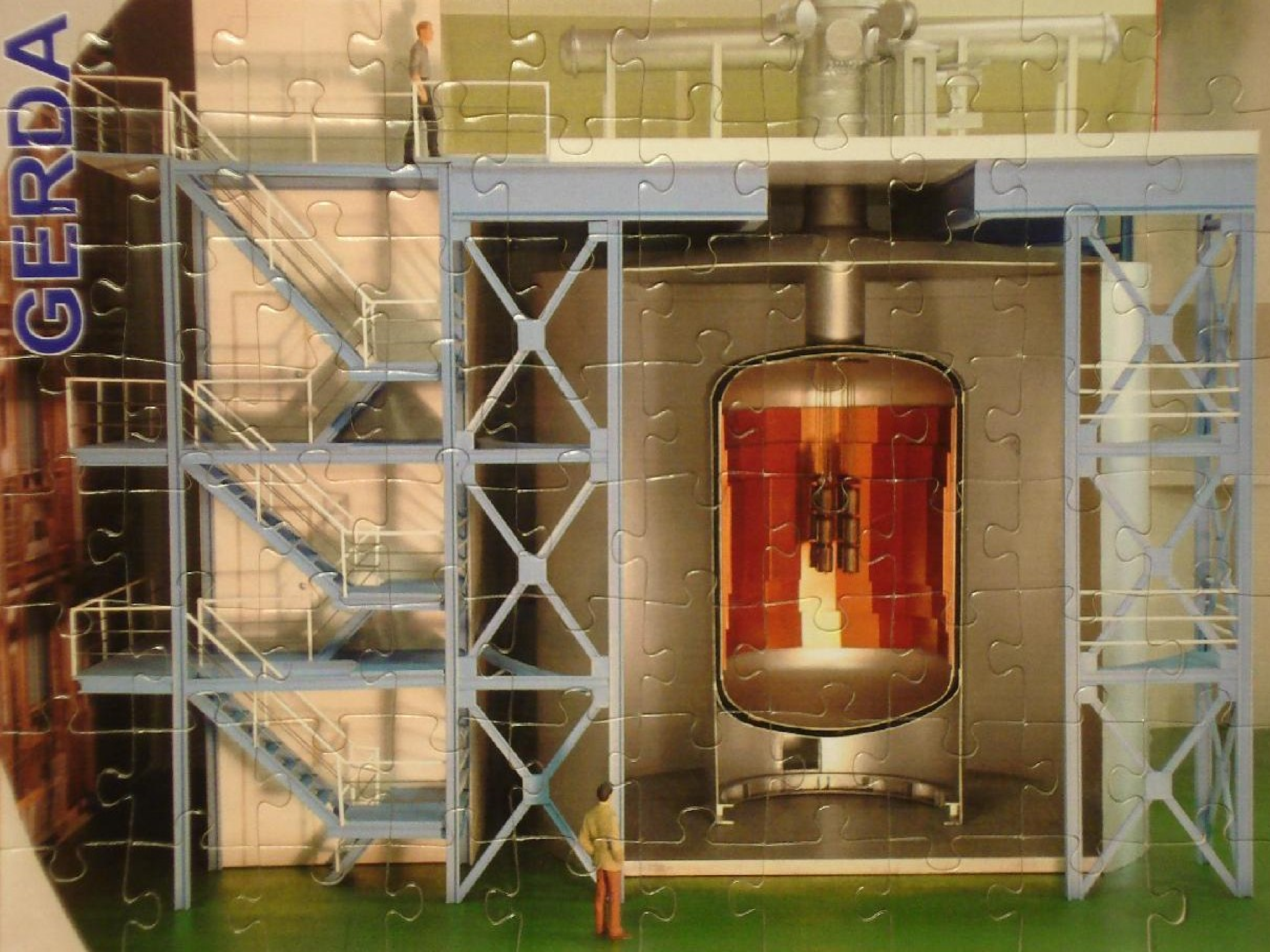
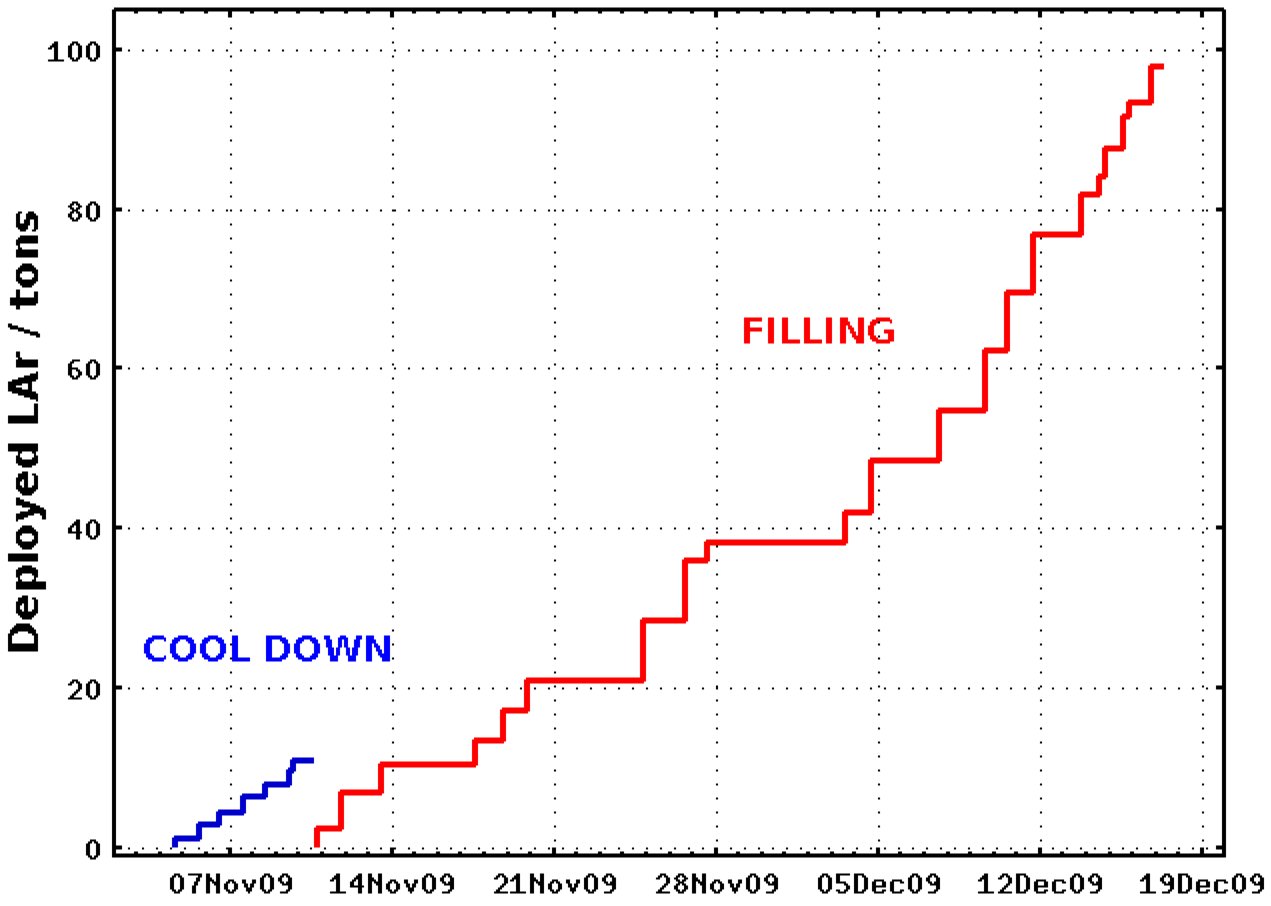



GERDA

GERDA

Sincere thanks to all who have contributed!

finis / backup slides



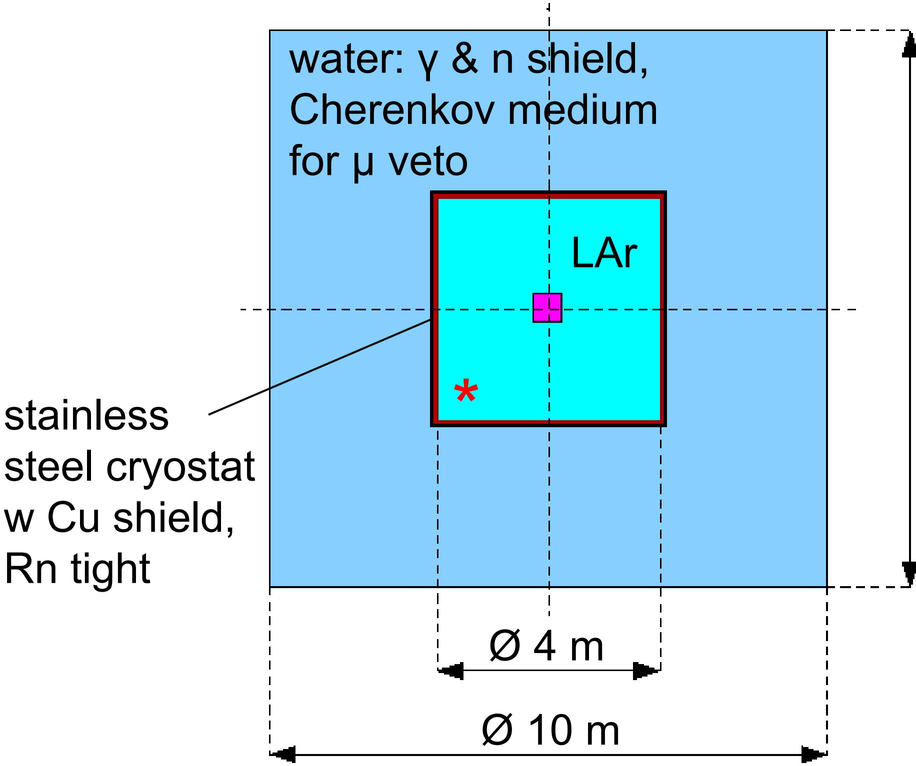
100
80
60
40
20
0
Deployed LAr / tons
FILLING
COOL DOWN
07Nov09
14Nov09
21Nov09
28Nov09
05Dec09
12Dec09
19Dec09

generic external background shields

GERDA (low Z shield)

bare Ge diodes in high-purity LAr

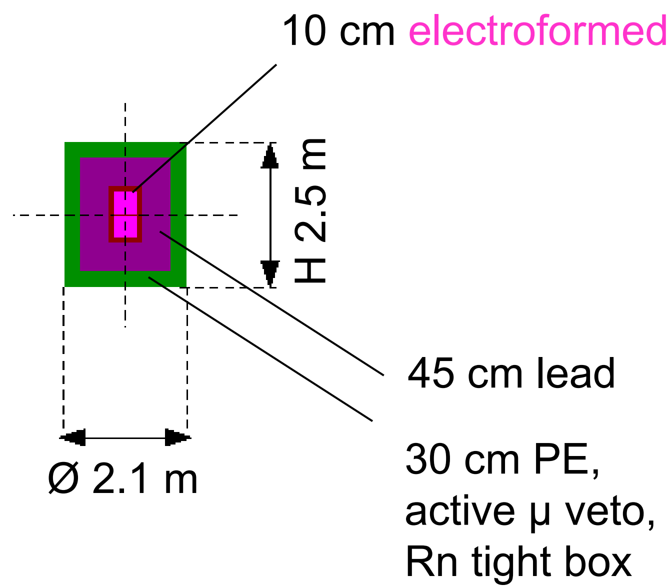
< 1µBq/m^3 STP Rn-222 (established)



Majorana (high Z shield; deep underground)

Ge diodes housed in vacuum cryostat,
ultra-high-purity electroformed Cu shield

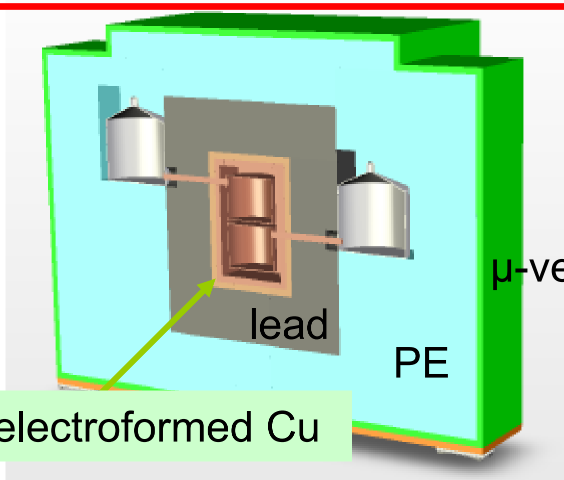
< 1 µBq/kg Th-232 (not yet established)

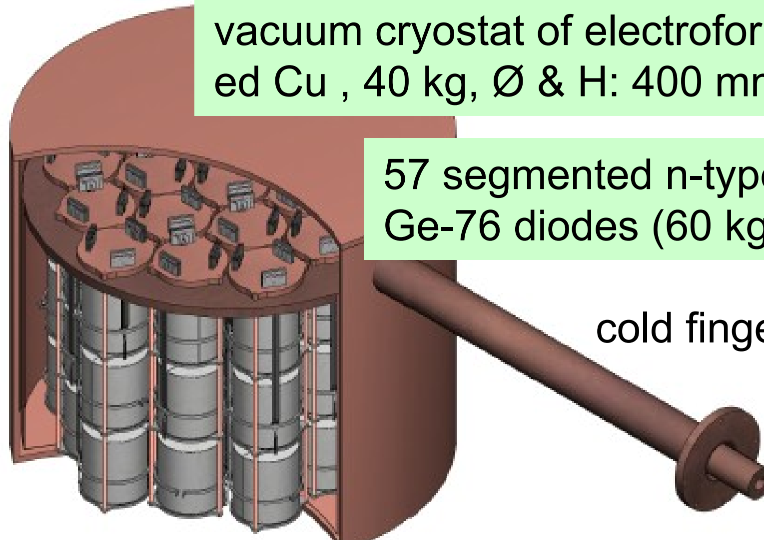


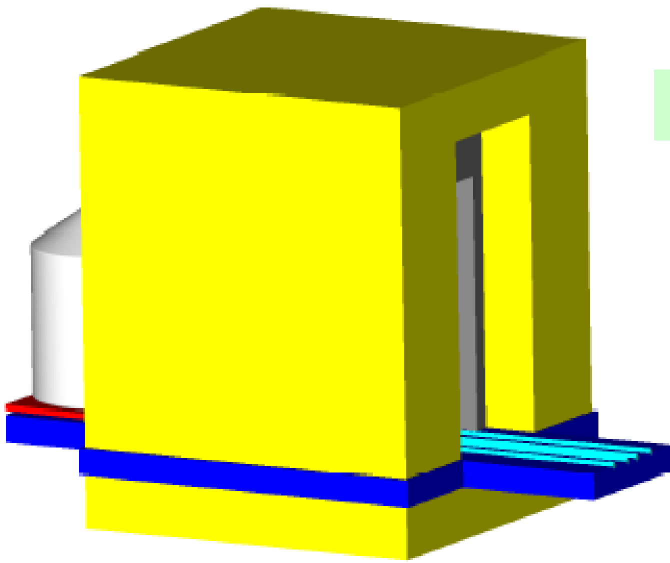
* LAr can be also active shield !

α(LAr) = 0.050/cm   α(Cu) = 0.34/cm
α(H_2O) = 0.043/cm   α(Pb) = 0.48/cm

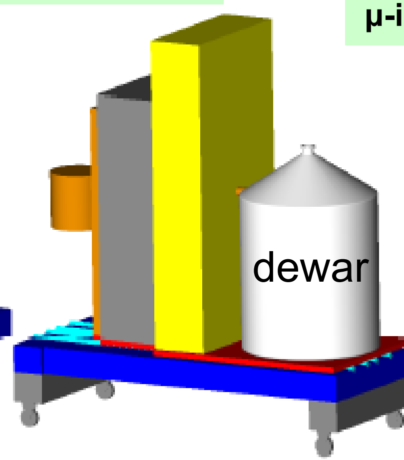
▲ 5000 m w.e. rock above ▲



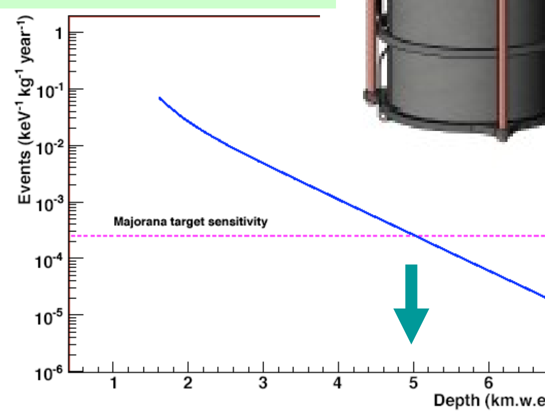




'monolith'



μ-induced events vs depth



R&D: material screening / purification

Ge γ spectrometers

- Baksan 600 m w.e. (soon → 4900 m w.e.) 4-fold spectrometer
- Hades 500 m w.e. Ge-2 – Ge-9
- MPI-K 15 m w.e. 3 diodes
- LNGS 3500 m w.e. GeMPI 1,2,(3) S : ~ *O*(10[100]) μBq/kg for heavy [light] samples

Rn-222 diagnostics / monitoring

- emanation technique S : 0.5 μBq / m^2 , 10 μBq / kg
- gas purity analysis
- electrostatic chamber : 0.1 – 1 mBq / m^3

α spectrometer

- Baksan (ionization chamber) S : 10 Bq/m^3 (quick), background: 0.002 / (cm^2·h)
- Krakow

ICPMS **(inductively coupled plasma mass spectrometry)**

- Frankfurt U S : U/Th ~ 1 μBq / kg > secular equilibrium? <
- LNGS & commercial

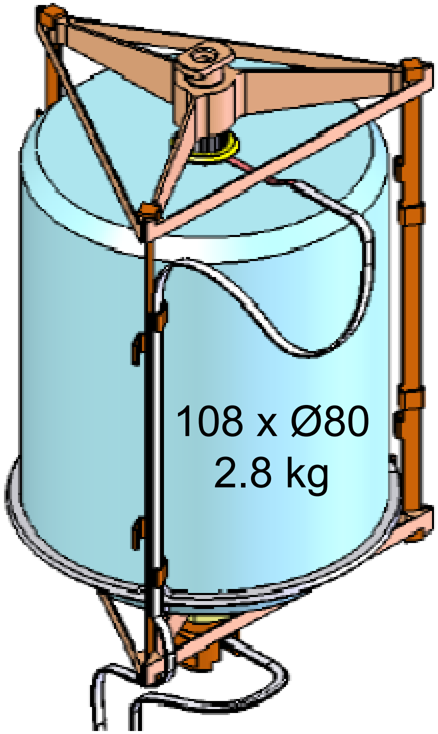
(measured materials: Kapton, Teflon, Torlon, MLI, PMT glass, Cu, steel, Cu/P granulate)

►Challenge: screening of plastic materials at required Th sensitivity

Surface purification studies **(cryostat > 100 m^2)**

- Cu disks radiated with strong Rn source S : 1 μBq / m^2

R&D: low mass diode supports and contacts



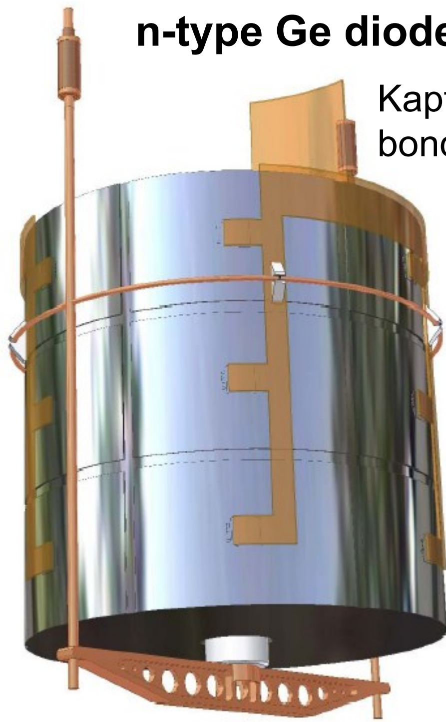
Cu	80.8 g
Si	4.5 g
PTFE	6.4 g

phase I

HdM & IGEX
p-type Ge diodes

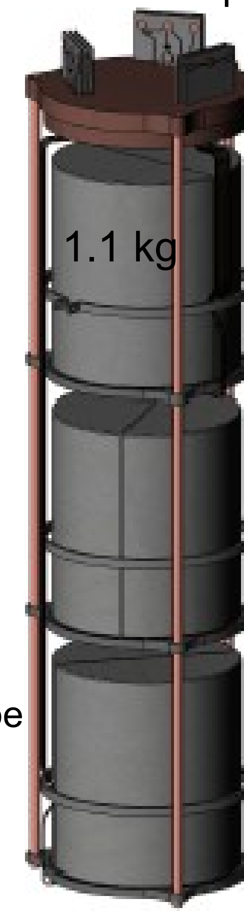
phase II

true-coaxial 3x6 segmented
n-type Ge diode



total of ~30g mounting material

Majorana



Cu tubes	11g
plastics	24g
cables	4g