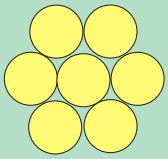
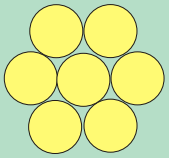
GERDA

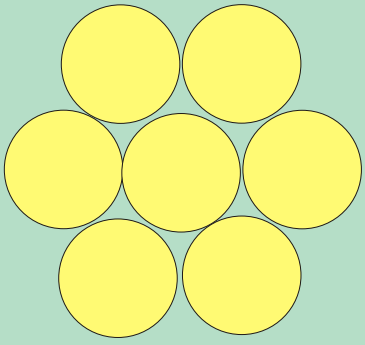
GERmanium Detector Assembly





I.Abt

MPI
Project Review
December 2005



The Group

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Guests: 3 x 3 months

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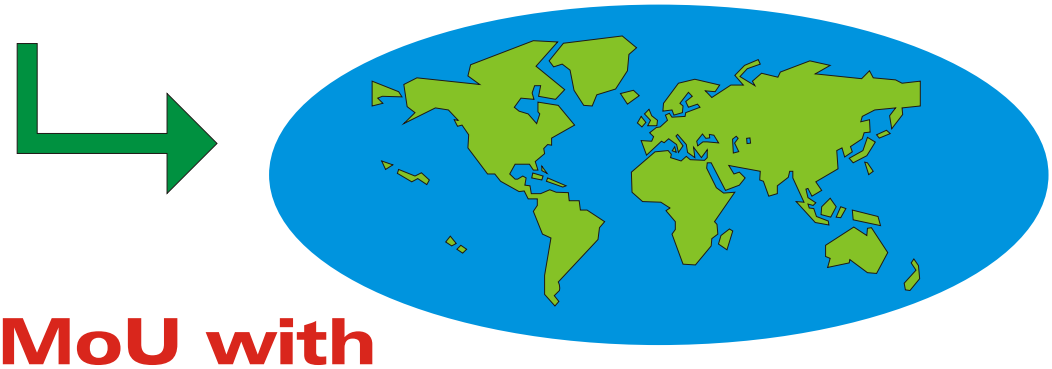
Collaboration

Currently:

INFN LNGS , Assergi, I
JINR, Dubna, R
MPI-K Heidelberg, D
INFN Univ. Milano, I
INFN Padua, I
INR Ac.of Sc., Moscow, R
ITEP, Moscow, R
HADES, B
Jagiellonian Univ., P
Res. C. Kurchatov, Moscow, R
MPI München, D
Phys.Inst,Uni Tübingen, D

Long Term Future:



MoU with
Majorana

This Review

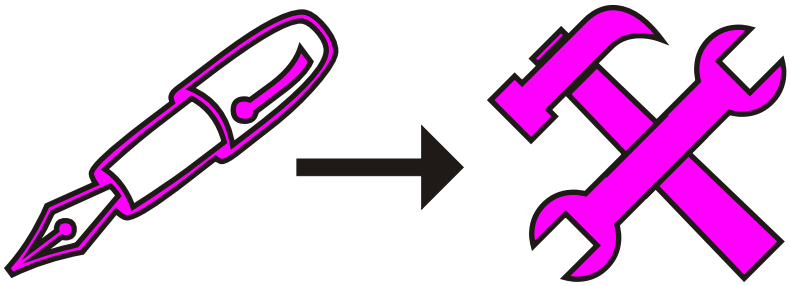
- **Why Neutrinos**
- **Neutrinoless Double Beta Decay**

  Germanium
- **GERDA at Gran Sasso**

  Expectations and Goals
  Backgrounds
- **MPI Responsibilities**

  Germanium→Detectors→
  Suspension→Loading→
  Lock → Clean–room

  Test-Facilities and MC
- **Status and Plans**

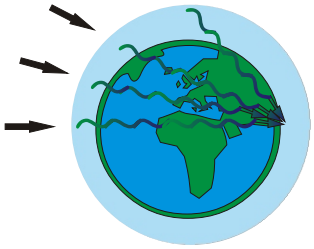


Why Neutrinos

The flavor eigenstates we learned to love are not mass eigenstates.

$\Delta m^2(sun) = 7.1 \cdot 10\text{-}5\ eV^2$

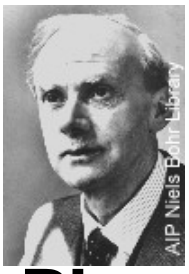
Oscillations everywhere



$\Delta m^2(atm) = 2.0 \cdot 10\text{-}3\ eV^2$

Absolute Mass Scale?

Nature?

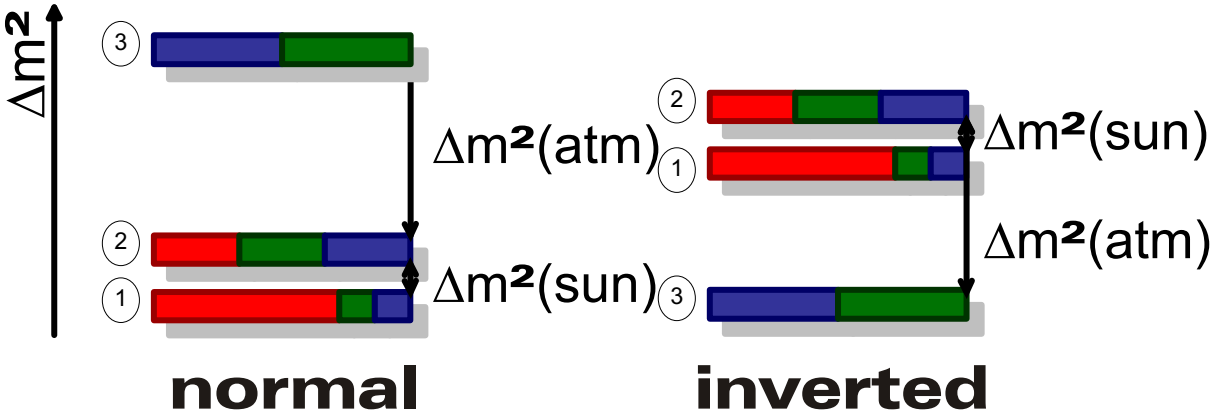


Dirac or

Majorana

Hierarchies?

e μ τ



Double Beta Results

What you want is not what you measure ...

matrix elements

Experiment	Isotope	$\langle m_{\beta\beta} \rangle$ [meV]	$T_{1/2}$ [y]
Heidelberg-Mosow	^{76}Ge	440	$1.2 \cdot 10^{25}$
IGEX	^{76}Ge	< 360 – 1070	$> 1.6 \cdot 10^{25}$
CUORICINO	^{130}Te	< 200 – 1100	$> 1.8 \cdot 10^{24}$
NEMO-3	^{100}Mo	< 700 – 1200	$> 3.5 \cdot 10^{24}$
NEMO-3	^{82}Se	< 1300 – 3200	$> 1.9 \cdot 10^{23}$

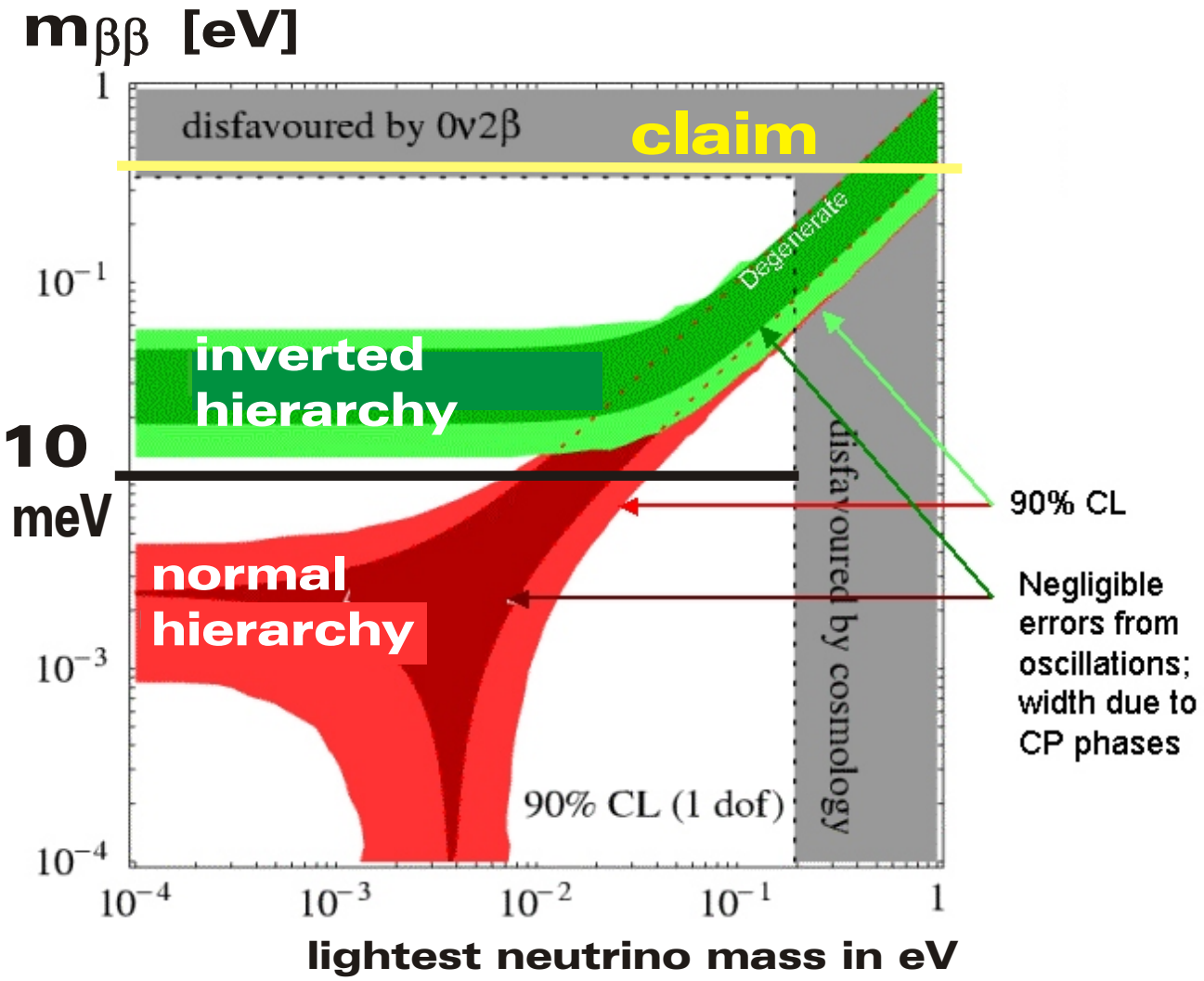
The same collaboration, Heidelberg-Moscow, published a limit and a claim.

The interpretation of all experiments suffers from badly known matrix elements.

Quite a number of experiments planned.

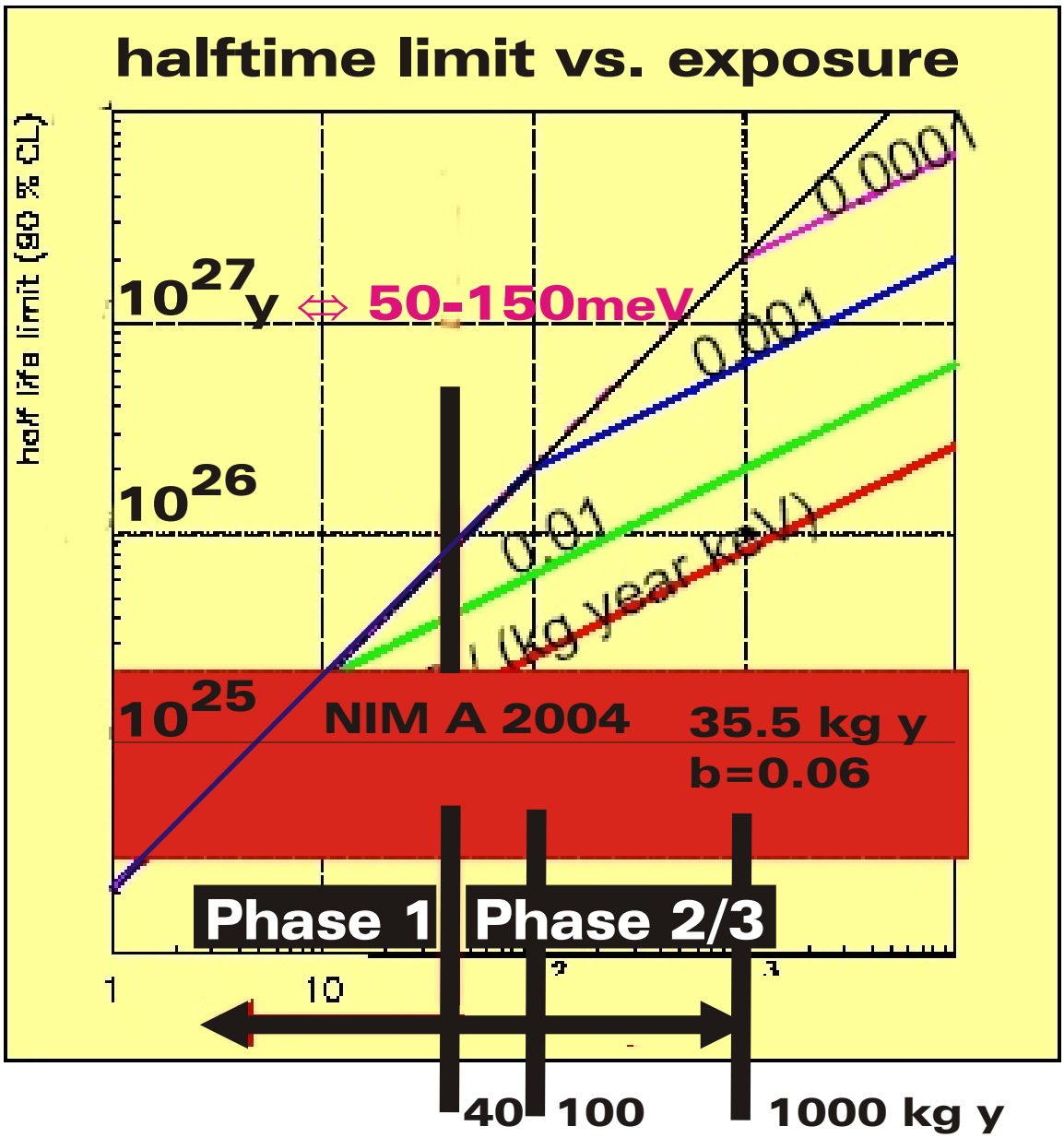
Need experiments with different isotopes.

What is expected ?



In order to exclude an inverted hierarchy, one has to get to the 10 meV level.

Phases of Gerda



Phase 1: verify concept
check on previous claim
Phase 2: b<0.001 and 100 kg y
Phase 3: move from b=0.001 to
b<0.0001 and 1 t y exp.

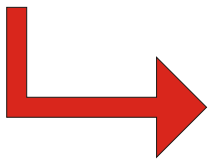
External and Internal Background

External is whatever comes from outside:

- **Walls of the Laboratory**
- **Infrastructure of the experiment**
- **dominated in the past**

Internal is whatever comes from inside:

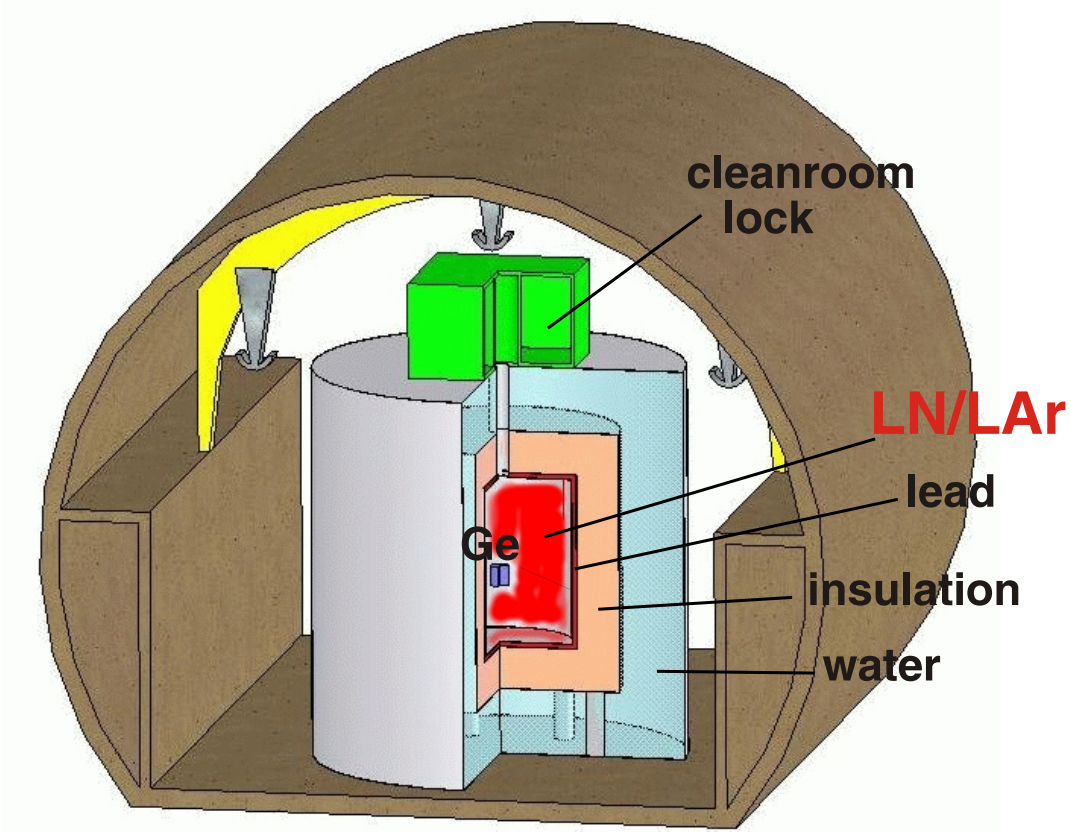
- **Contaminations of the studied isotopes**



In Germanium cosmic radiation creates

Co^{60} Ga^{68}

Liquid Nitrogen Shield

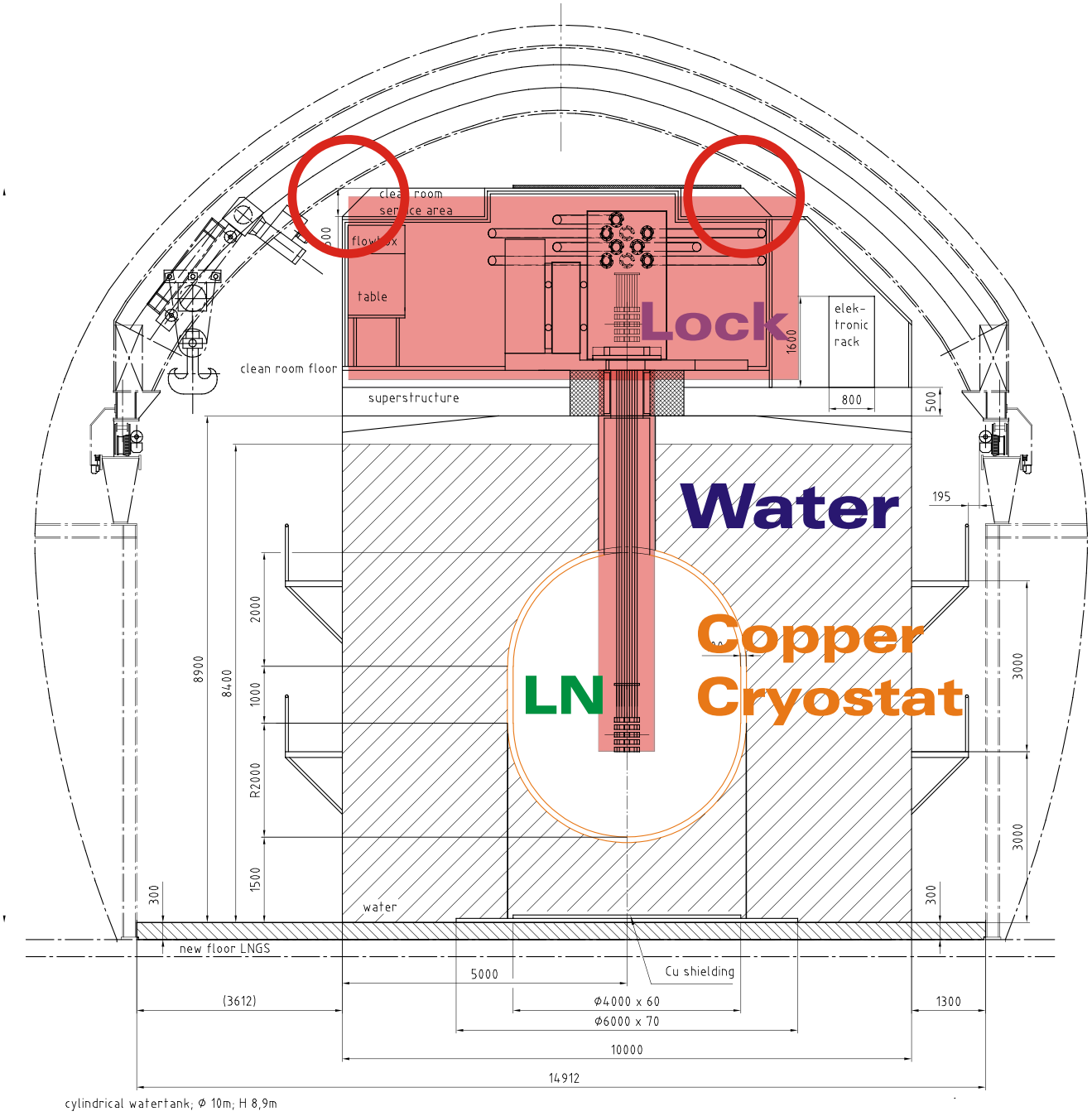


Shield against concrete of 10 Bq ^{228}Th/kg

- LN 5.6 m, LAr 3.5 m ⇒ 10^{-3} cts/keV/kg/y
- LN 6.4 m, LAr 4.0 m ⇒ 10^{-4} cts/keV/kg/y

environmental background

GERDA at Gran Sasso



Space is very limited

→ **LN plus Water**

MPI Responsibilities

Germanium Detectors

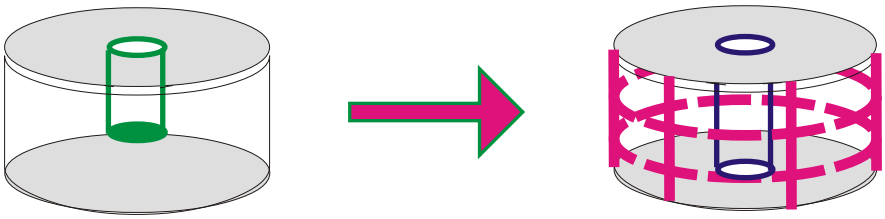
From Heidelberg-Moscow 5 and IGEX 3 detectors, each 2kg.

→ Phase 1

MPI

New detectors from 85% enriched germanium. Minimize exposure to cosmic radiation.

Optimization of core geometry and "segmentation":



→ **Phase 2**

Kill a couple of myths about Germanium detectors

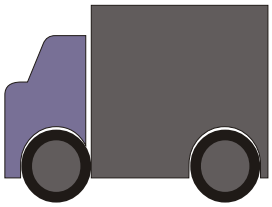
Prototype is ready!

Germanium Enrichment

37.5 kg of enriched material procured.

Chemical Purification is under way.

Transport procedure is established

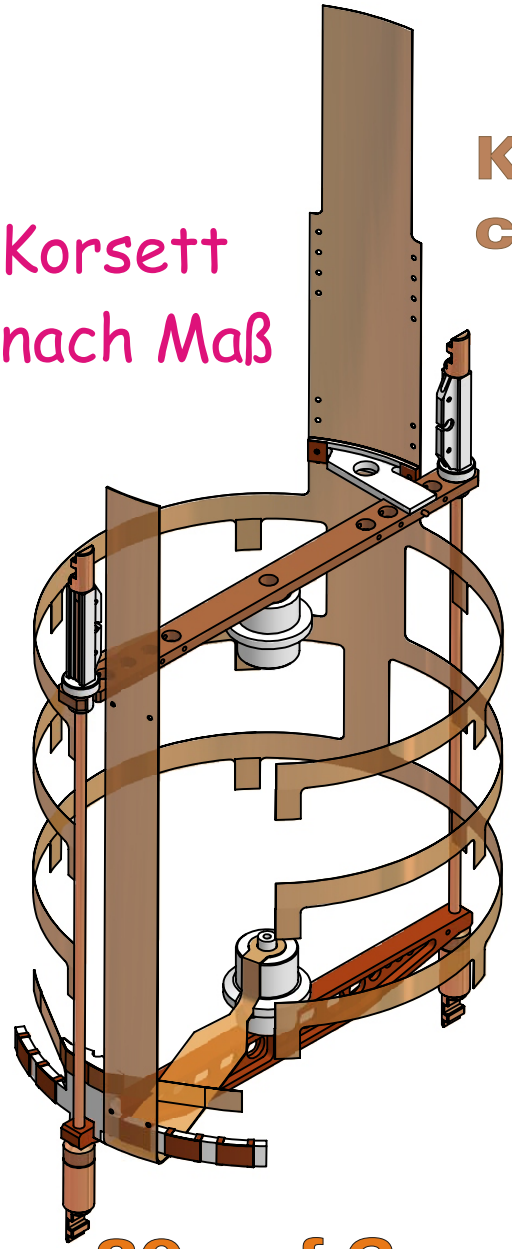


Crystal pulling is being negotiated.

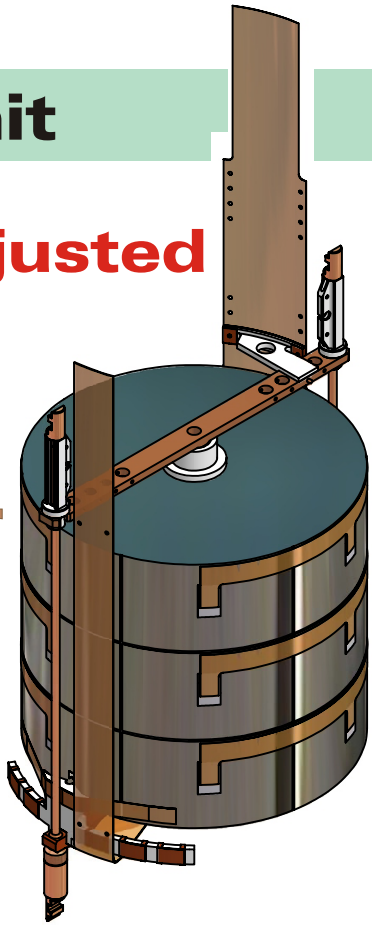
Detector Unit

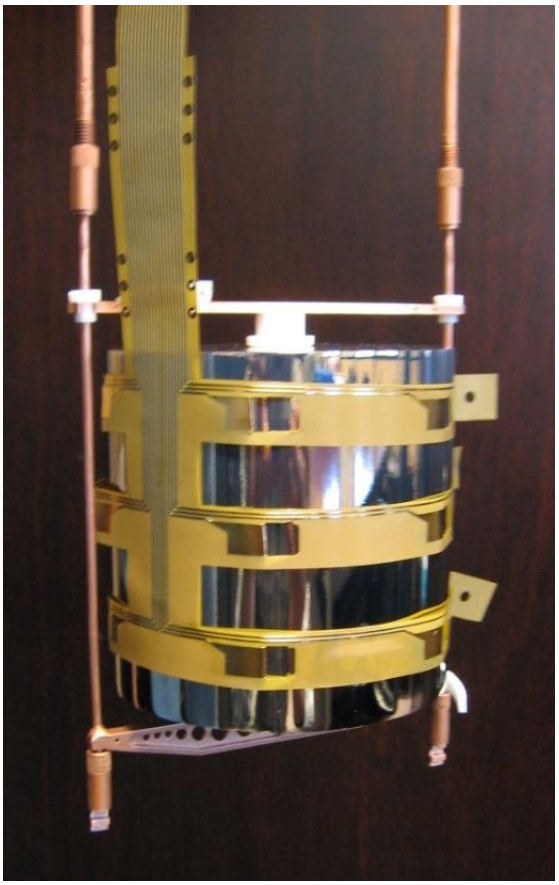
Holders are carefully adjusted to detector technology.

Korsett nach Maß



Kapton for cabling

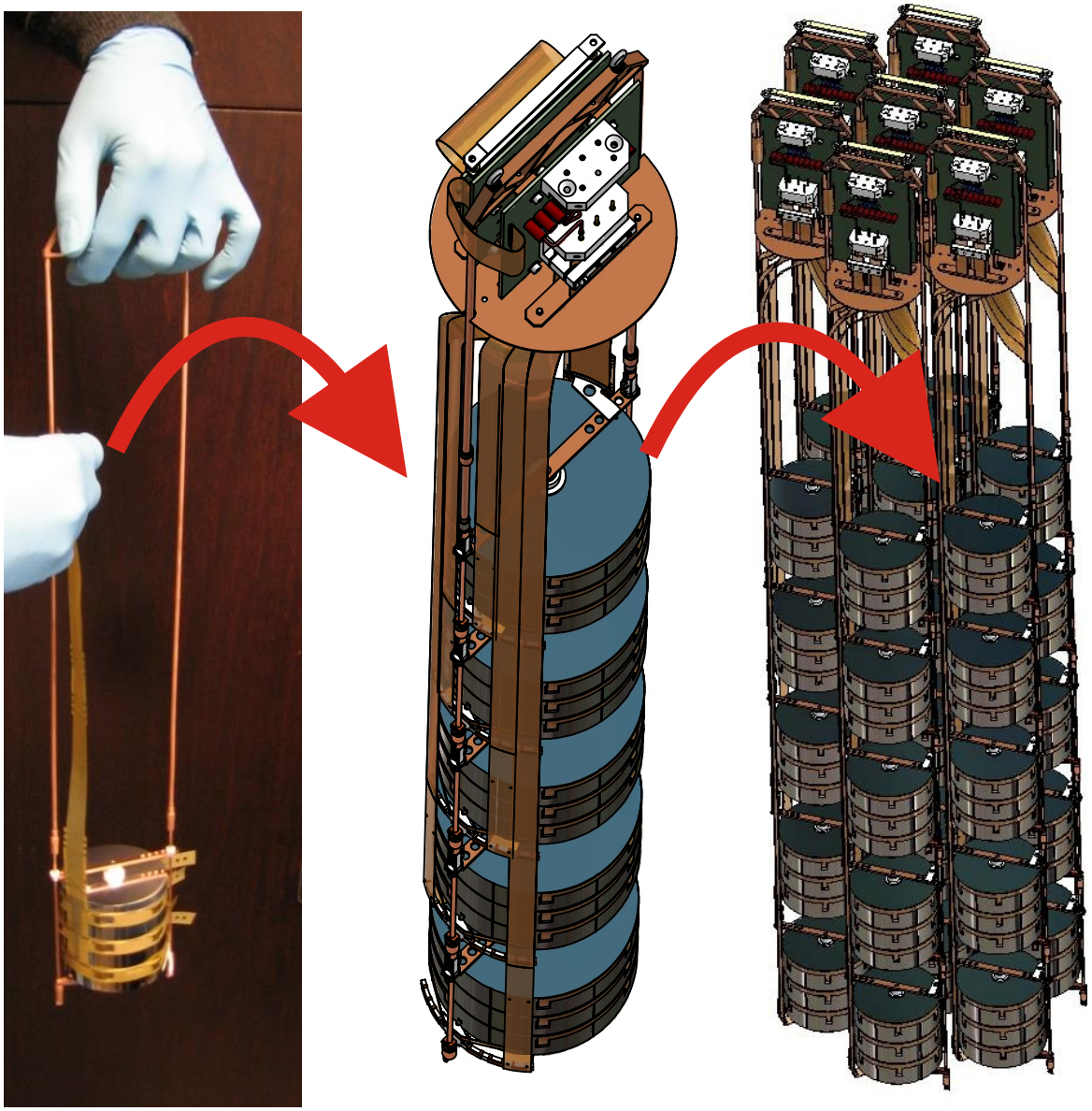




30g of Copper to hold 2kg of Germanium

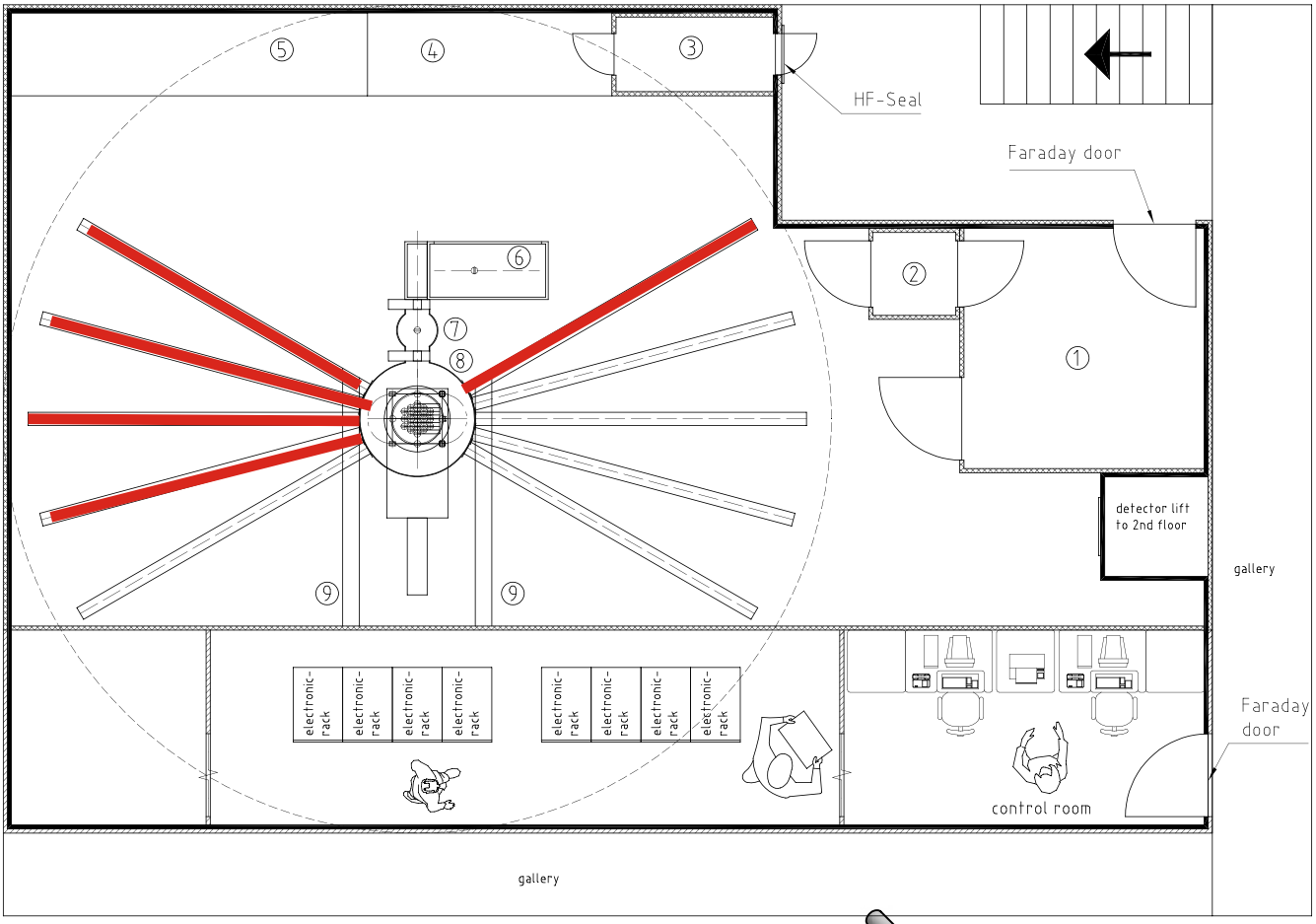
Detector Suspension

Separation into strings enables us to change and modify the set-up while the vessel stays cold.

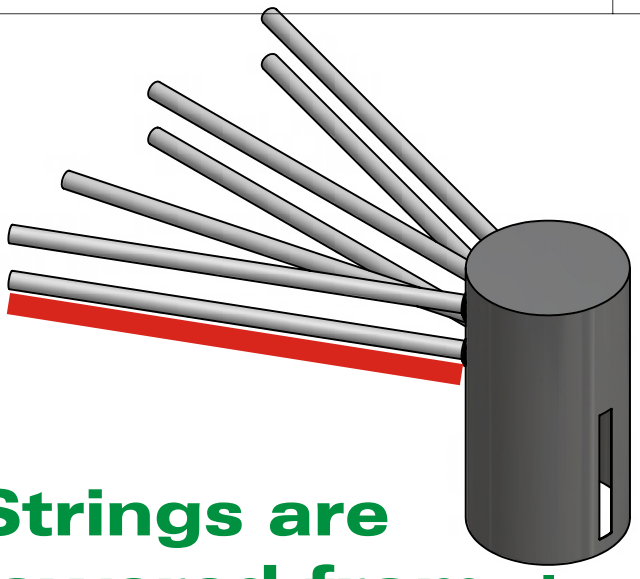


Siemens Lufthaken would be nice!

Clean-Room and Lock

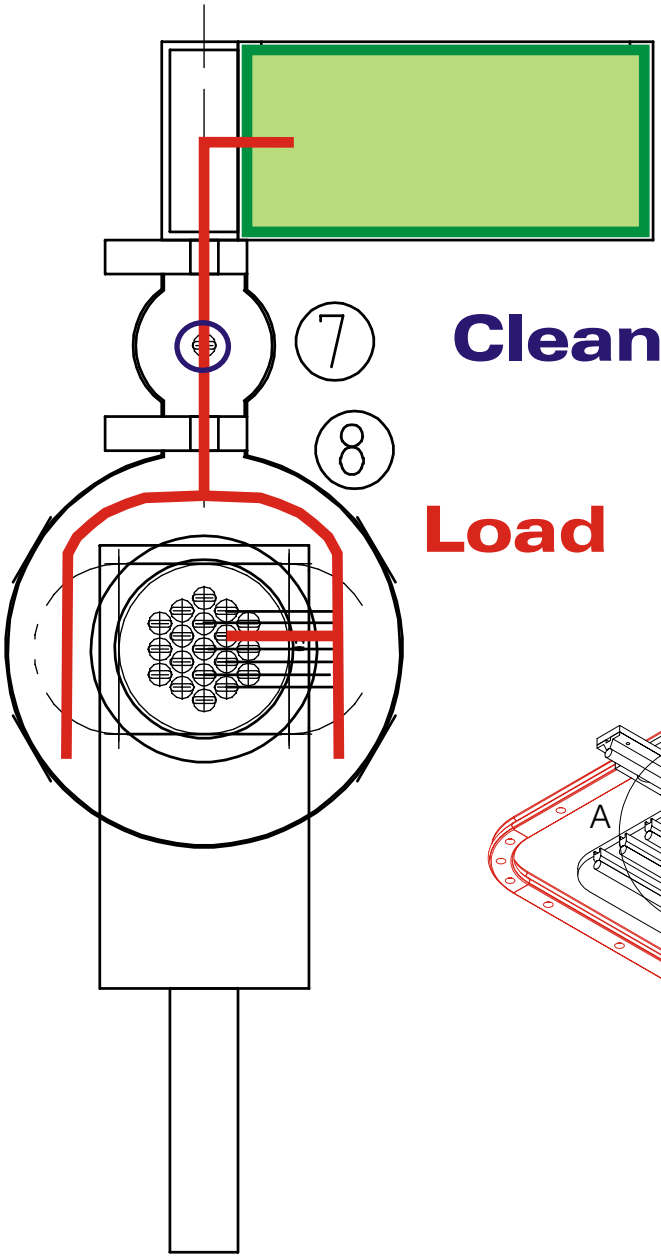


Each string has its personal pipe for cables and support.



Strings are lowered from the lock.

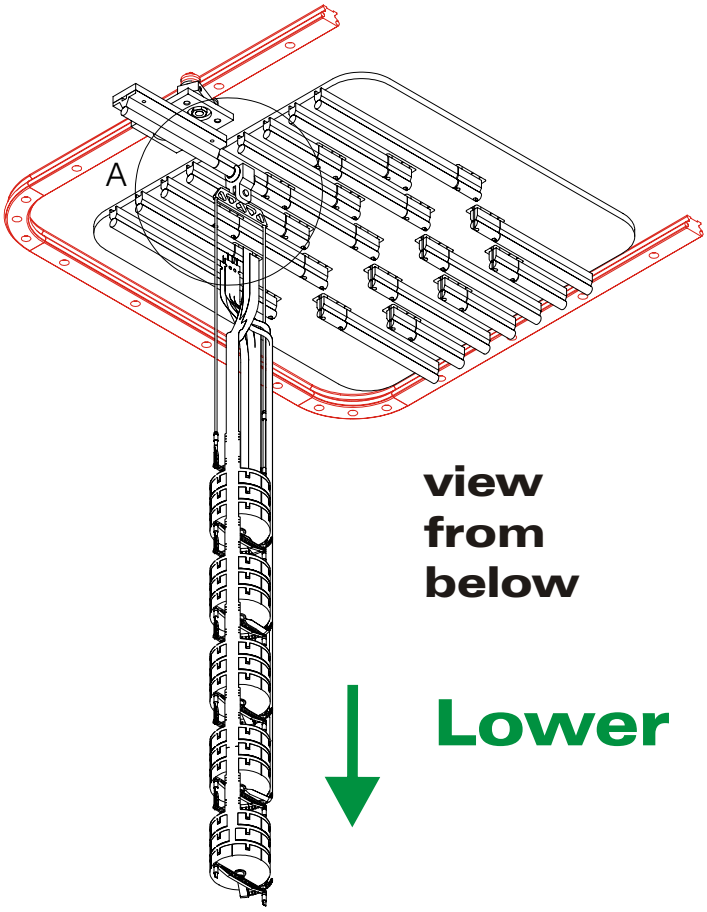
Lock Mechanics



Prepare Strings

Clean

Load



view from below

Lower

Monte Carlo

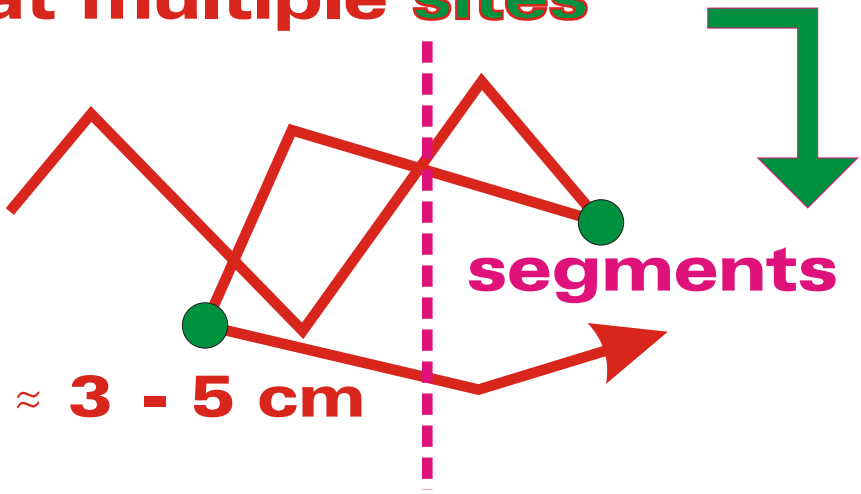
Signal is composed of 2 electrons.

→ **Localized energy deposition**

d ≈ 1 mm

Backgrounds have energy deposion from photons.

→ **Energy is deposited at multiple sites**



→ **GEANT4 in MaGe**

Majorana Gerda

Coincidence Analysis

Signal efficiency = 90%

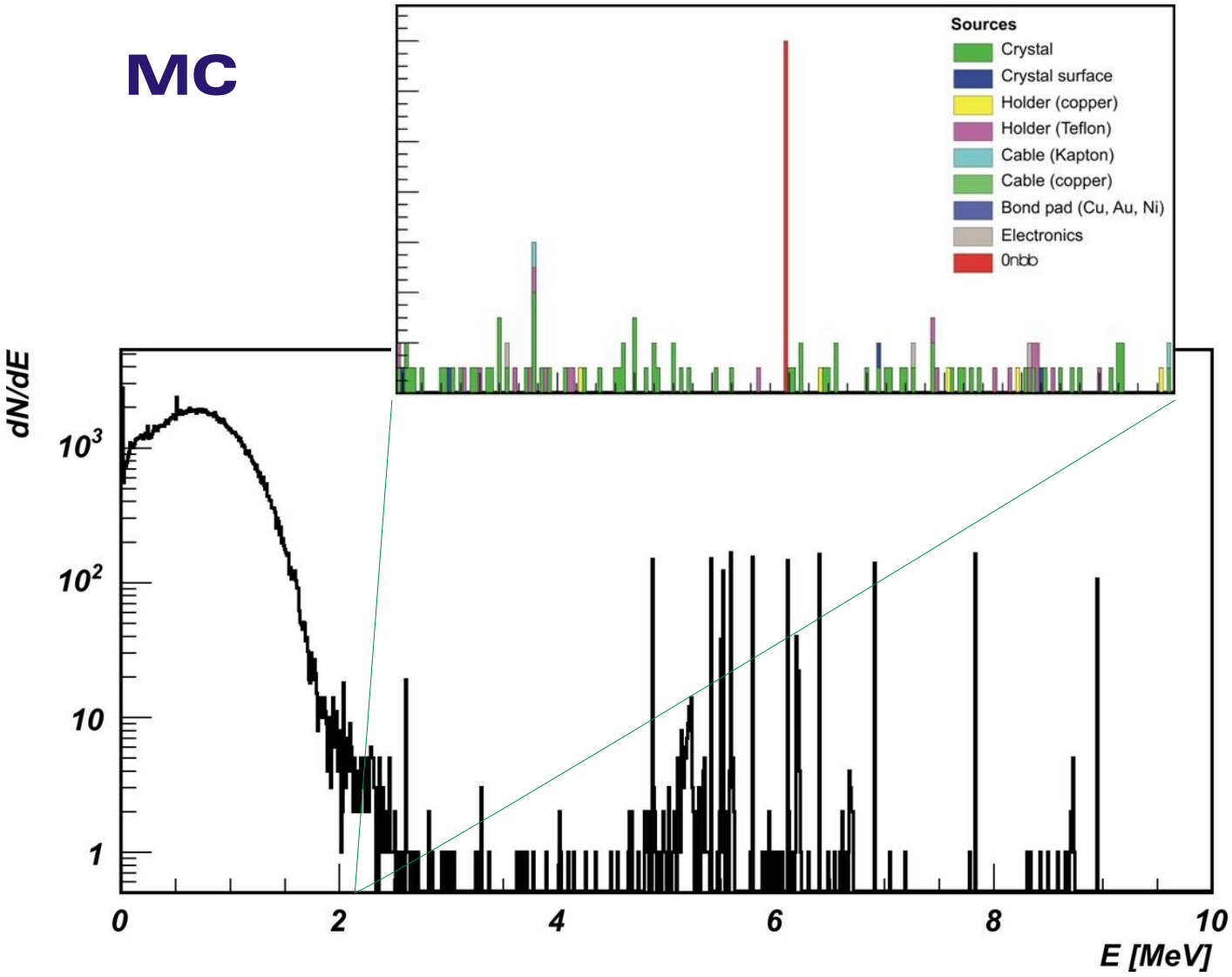
100 kg y → **30 events**

$T^{1/2}=2\ 10^{25}$

Background:

Part	Source	Rate [10^{-3}]	
Crystal	U-238	0.25	
	Th-232	0.05	
	Co-60	0.03	
	Ge-68	*1.53*	← patience
	Pb-210 (s)	0.13	
	Th-232 (s)	0.17	
Support	all (copper)	0.14	
	all (Teflon)	0.20	
Cable	all (copper)	0.02	
	all (Kapton)	~1.5	← work
Sum		~4	

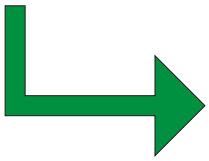
Spectrum after 1 year



Spectra can be used to develop analysis and study sensitivity.

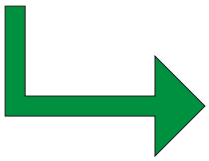
Work on Backgrounds

Reduce material



flimsy [well washed] cables

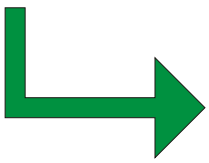
Find better materials



best copper
other cable

It is a bit of a problem to measure activities on the micro Bq level....

Work on analysis

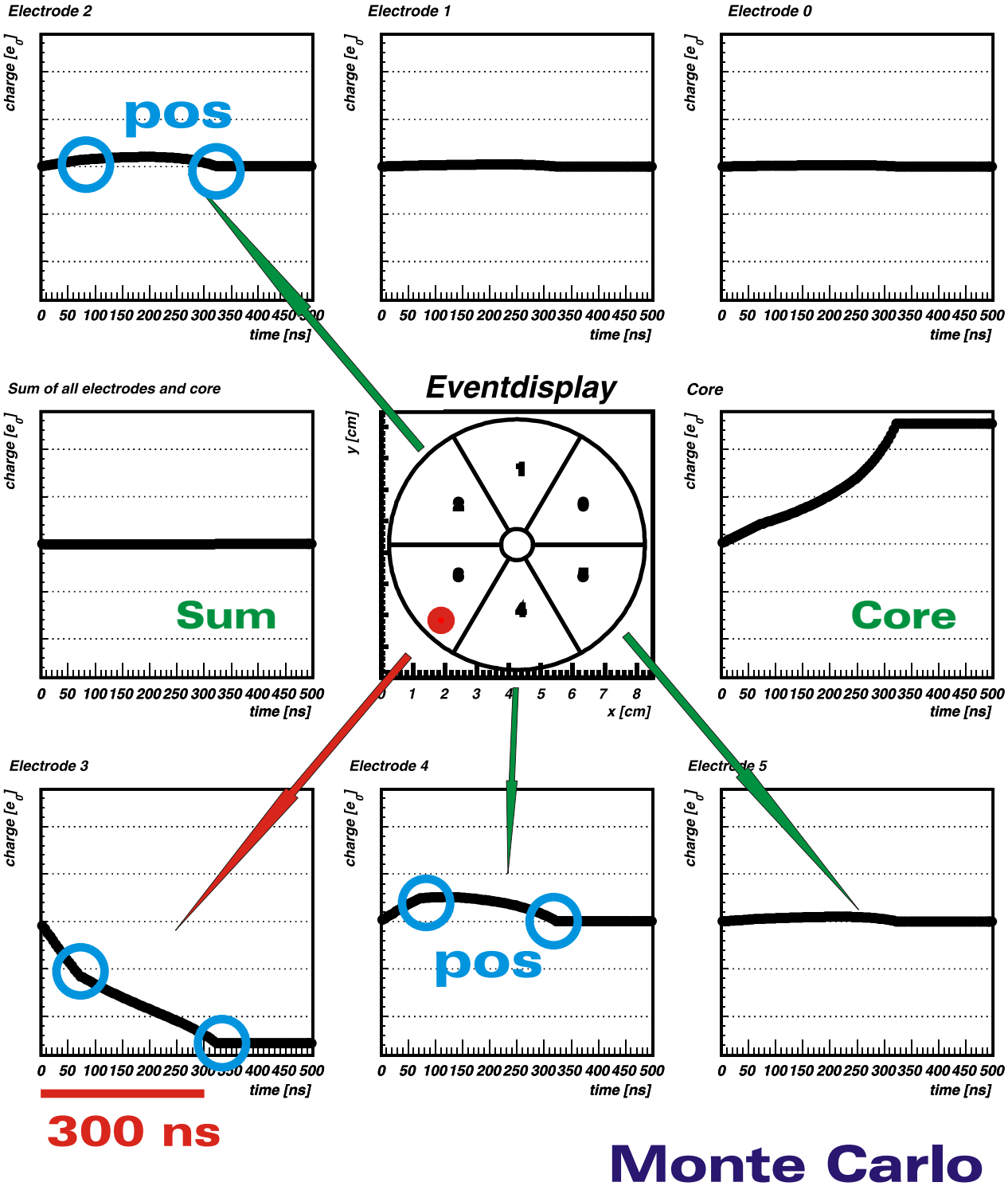


Pulseshapes and Mirror Charges

expect a factor 2~3

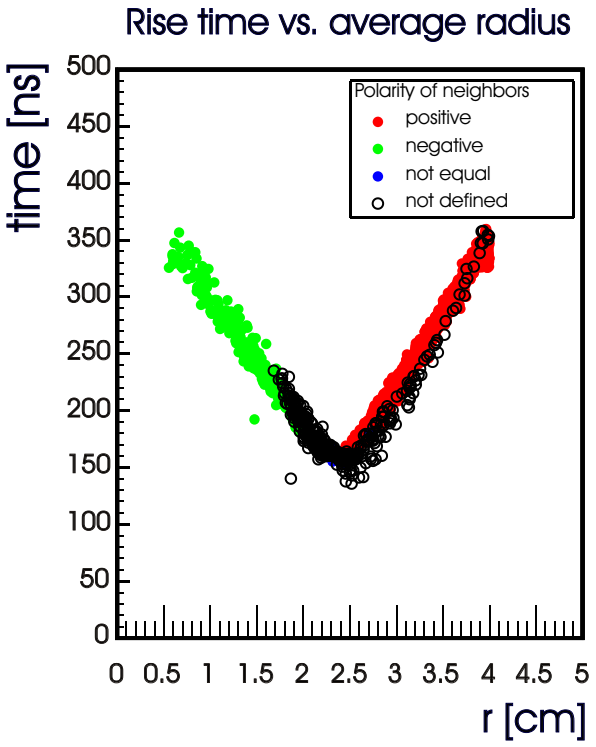
Pulseshapes

Segment Information



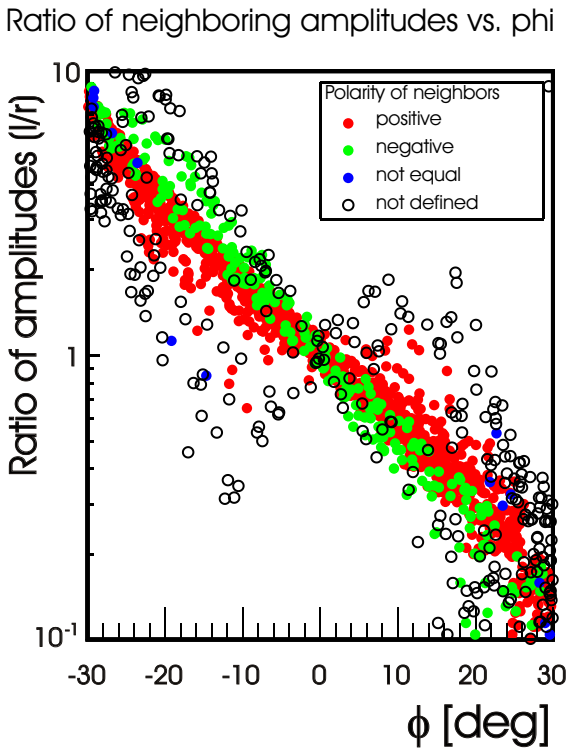
Monte Carlo

Spatial Resolution



Clear Correlation between time of 90% charge collection and radius.

→ **1cm resolution**

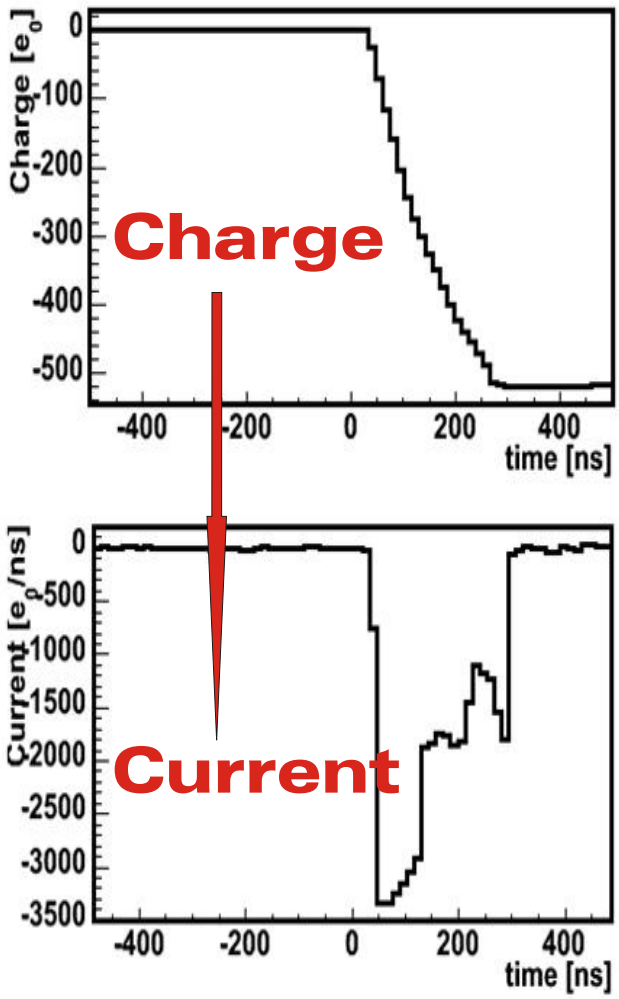


Clear Correlation between ratio of amplitudes of neighbors and angle phi.

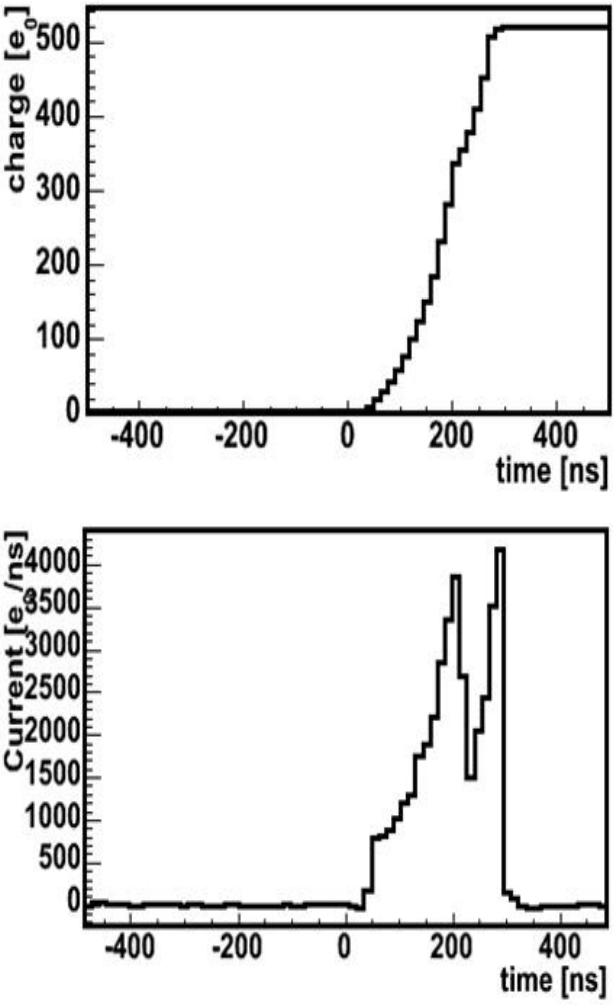
→ **in 3d**

Multiple Site Events

Core



Segment



Find double peak in current.

All this MC needs confirmation from data.

→ **Teststands**

A Teststand named Milchkanne

Start with the basics !

Europium

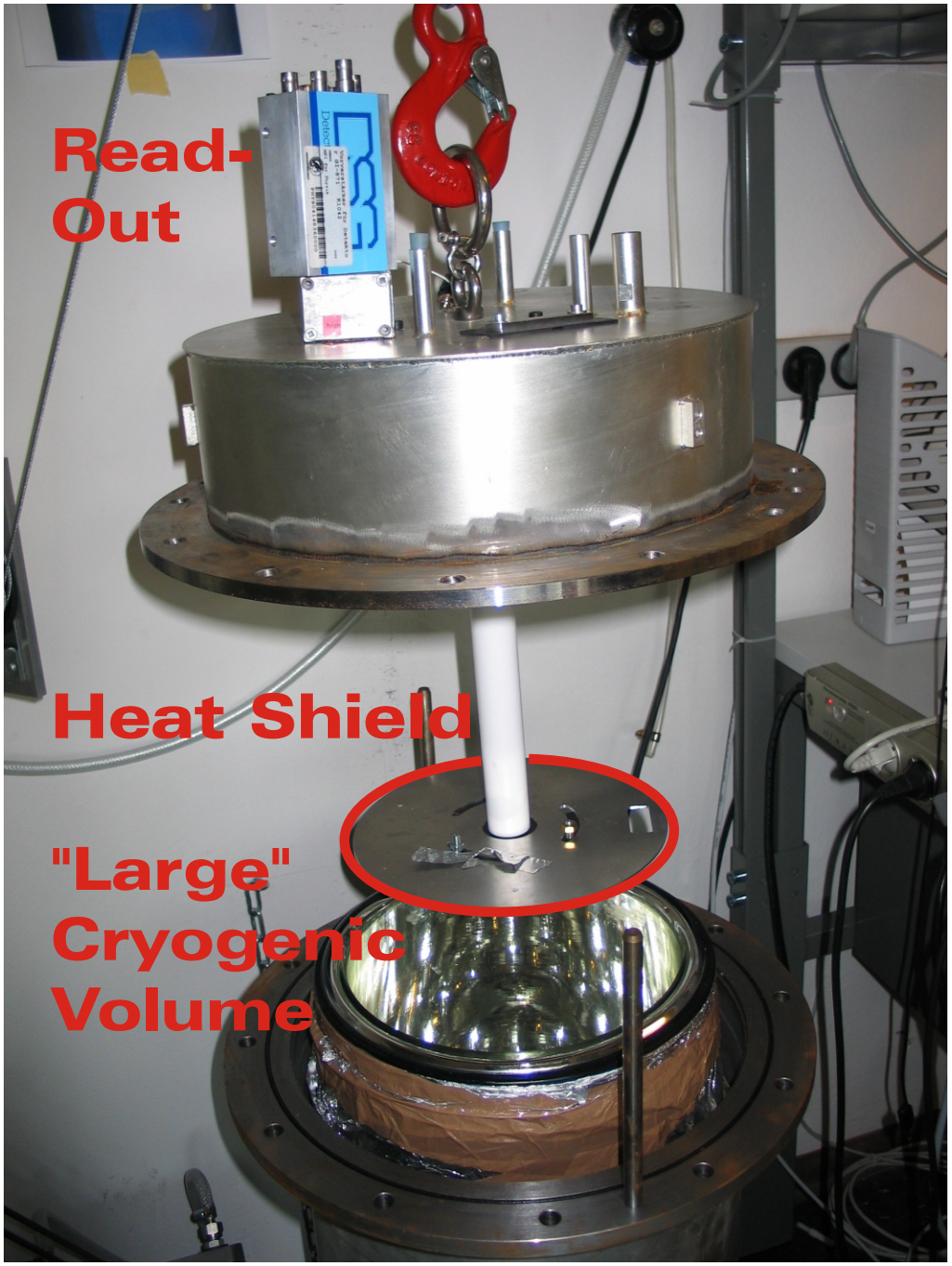
Naked n-type Germanium Crystals in LAr and LN

First Myth eliminated:

n-type detectors work in LN and LAr

Gerdalinchen

Create an environment like in GERDA in order to test detectors, holders, cables.....



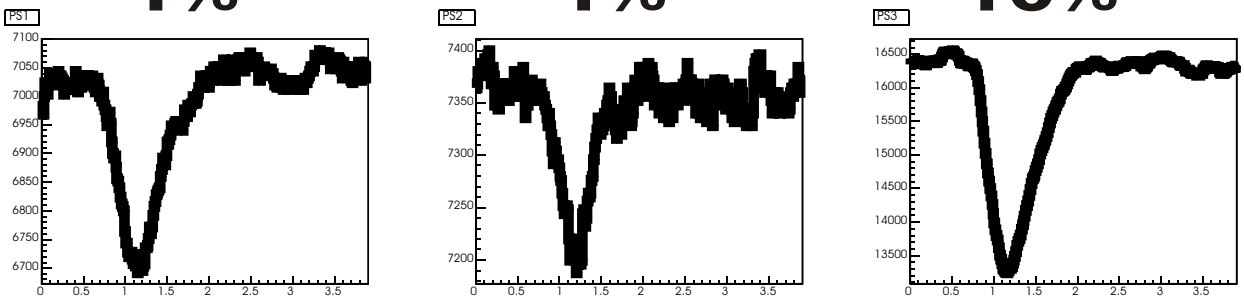
Also many tests done by/in the technical department ....

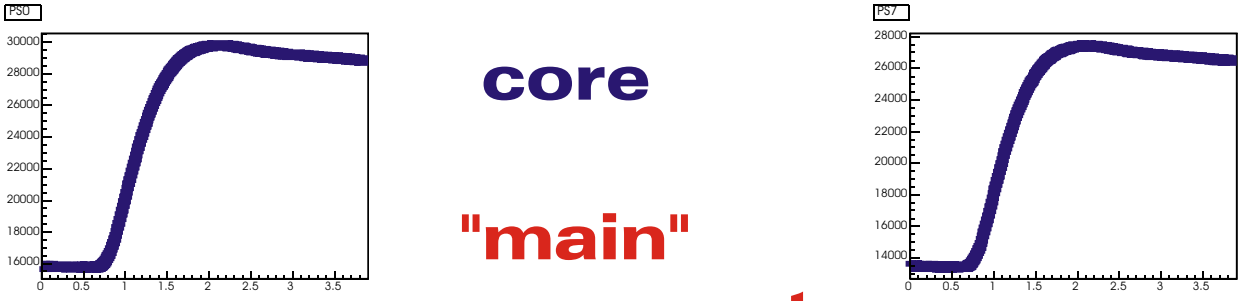
Measured Pulseshapes

Roland II:

mirror segments

1% 1% 10%

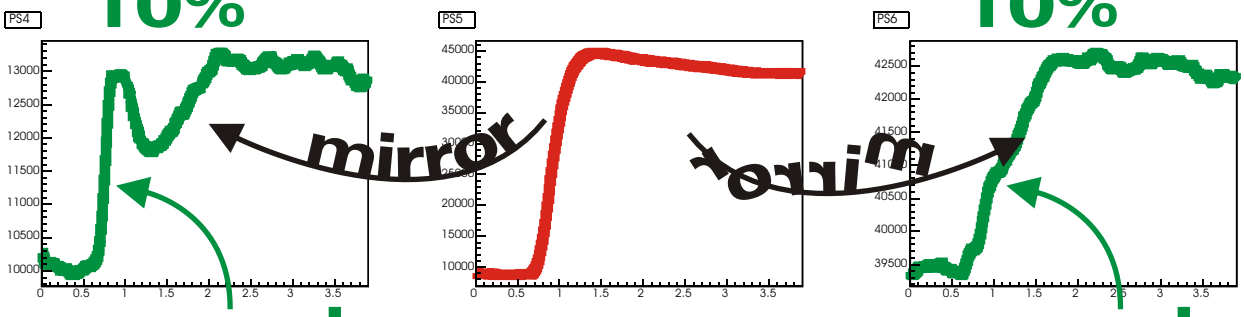




core

"main" segment

10% 10%



mirror

mirror

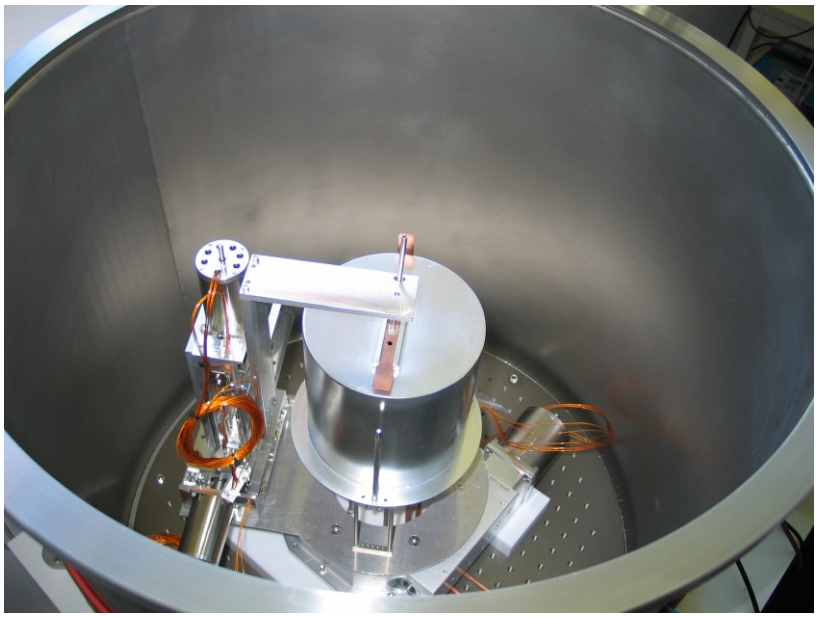
secondary segment

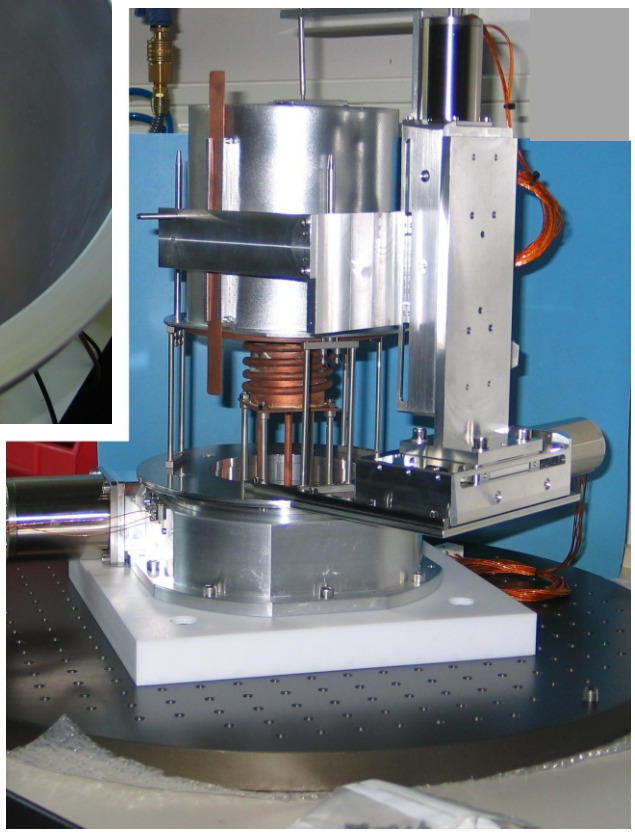
secondary segment

Gerdalinchen is operational.

GALATEA

GermAnium Laser TEst Apperatus





Vacuum

Laser

alpha

beta

gamma

dead layers

surface contaminations

pulse shapes

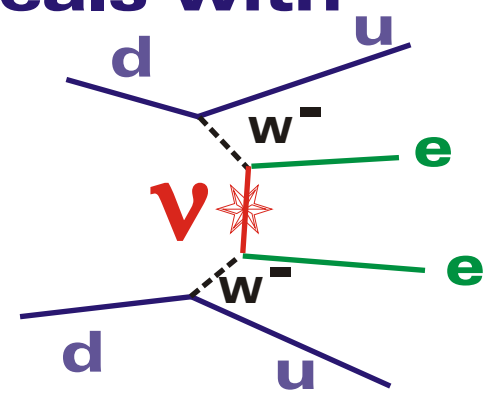
Extensive Germanium Detector Research Program

Summary

The MPI is a lead institute in GERDA.

The experiment deals with

Neutrinoless Double Beta Decay



Status

- **Germanium has been enriched.**
- **The first detector is ready.**
- **The first suspension is ready.**
- **The lock design is under way.**
- **Test facilities are being commissioned.**
- **MC and analysis are worked on. [cooperation with Majorana]**

GERDA itself is in the final design stage.