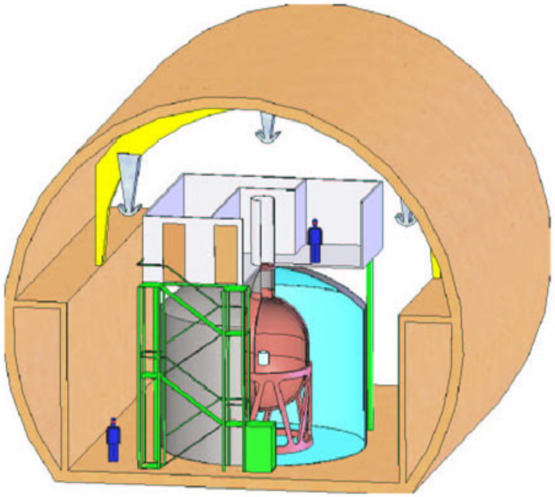
GERDA

Motivation, Concept, Status



Allen Caldwell
Max-Planck-Institut f. Physik

Motivation

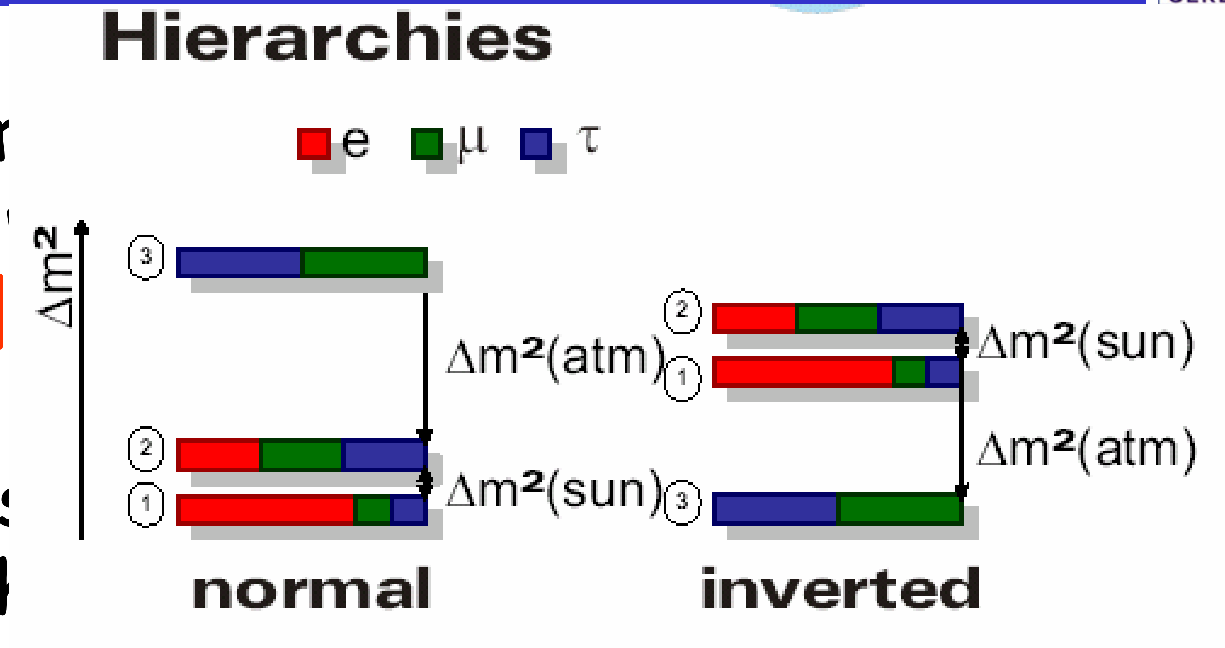
Oscillation experim

angles (θ_{12}, θ_{23}) as

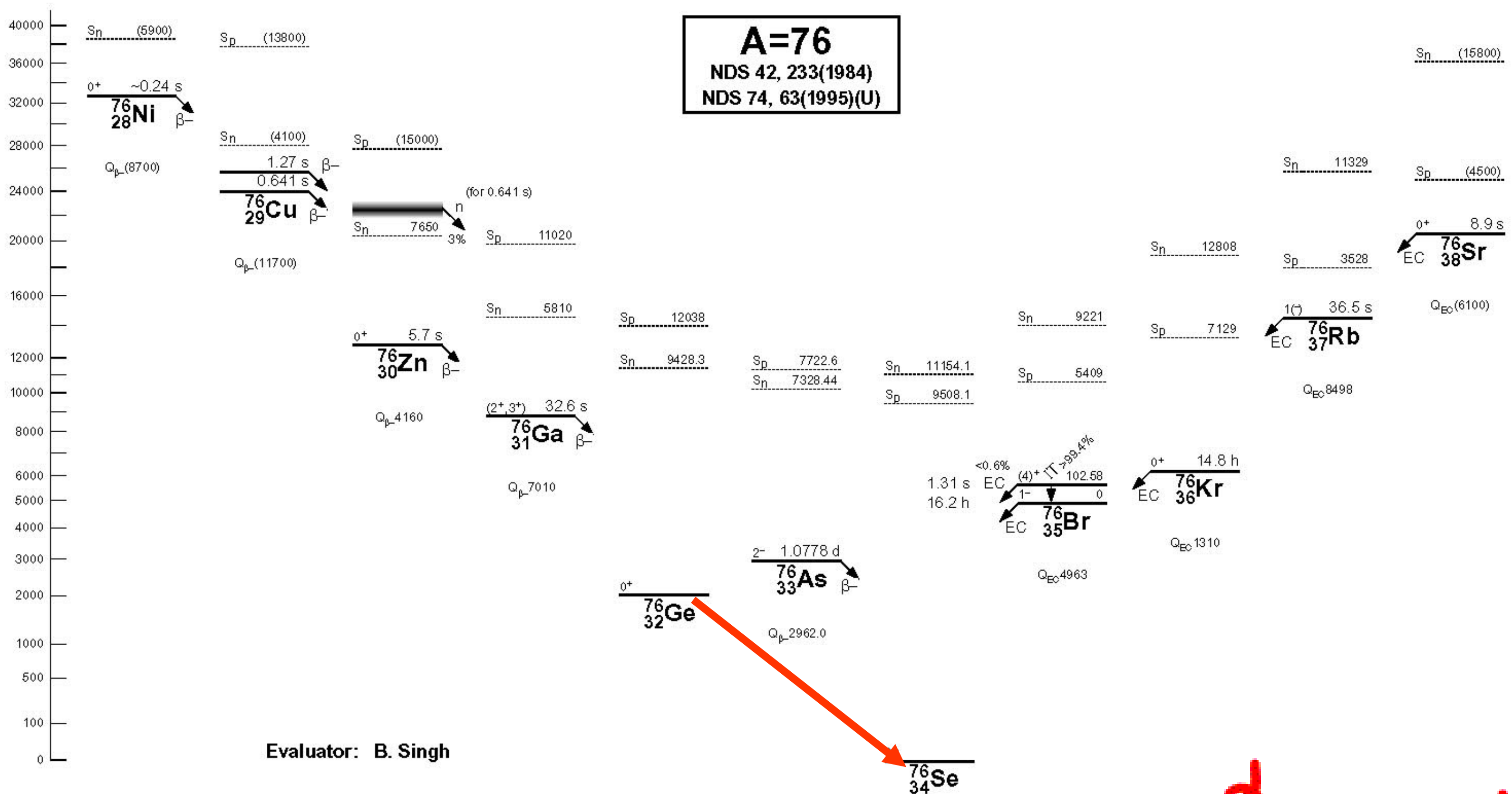
(m_2^2-m_1^2, |m_1^2-m_3^2|

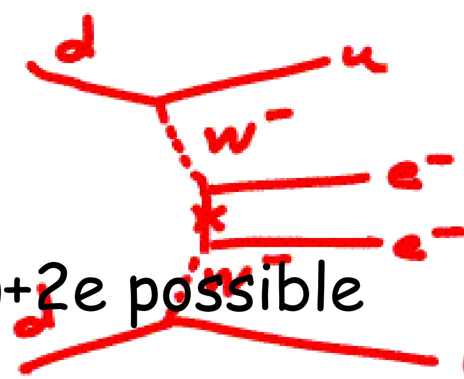
third mixing angle.

1. absolute mas
2. mass hierarch
3. nature of neutrino (Majorana, Dirac particle)
4. value of third mixing angle
5. CP phases



Double beta decay experiment can address 3, and, if neutrinos are Majorana particles, then also a combination of 1,2,5 .





(A,Z) → (A,Z+1)+e+ν energetically forbidden

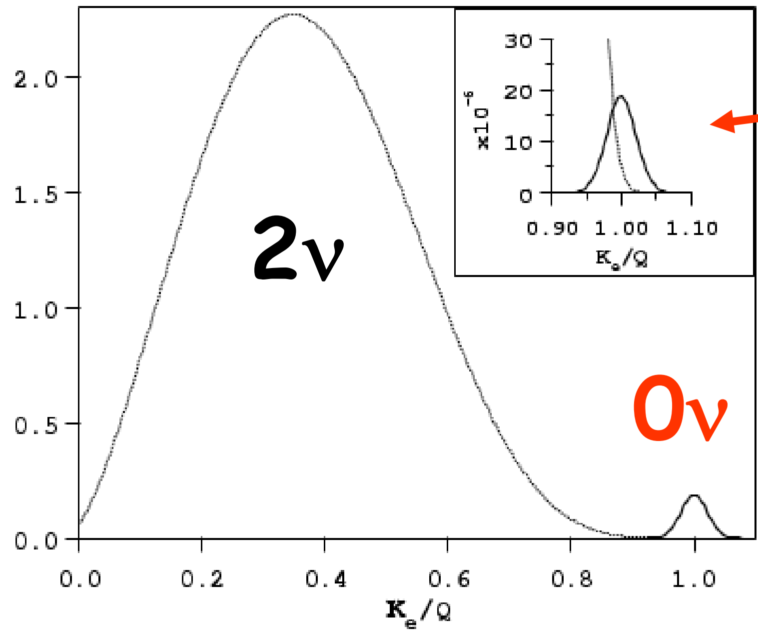
(A,Z) → (A,Z+2)+2e+2ν is allowed.

Then, for Majorana particle (A,Z) → (A,Z+2)+2e possible

Very rare decay lifetimes $>10^{20}$ years !

Decay Rate & Nuclear Matrix Element

Normalized energy spectrum



If resolution poor

If resolution good

0ν-DBD rate

Phase space $\propto Q^5$

Nuclear matrix element

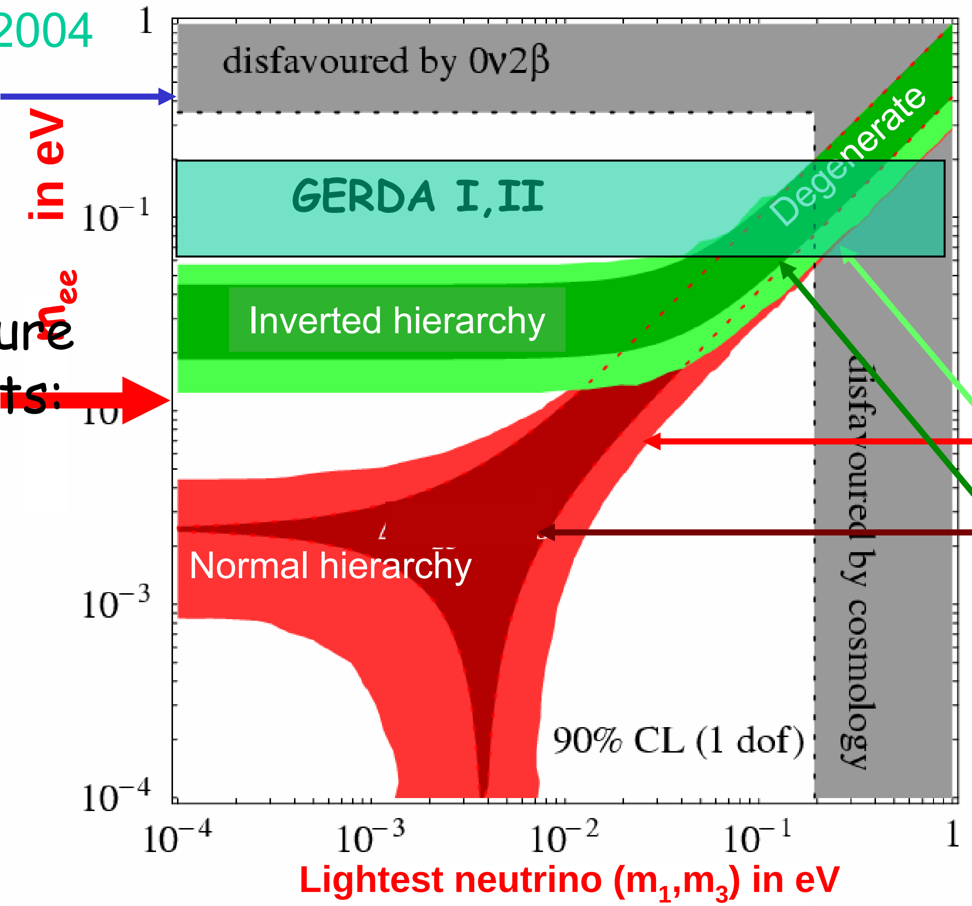
Effective Majorana mass

$$1/\tau = G(Q,Z)\,|M_{nucl}|^2\, m_{ee}^2$$

Effective Neutrino Mass

H.V. Klapdor-Kleingrothaus, I.V. Krivosheina, A. Dietz, O. Chkvorets
(Heidelberg, Max Planck Inst.)
Phys.Lett.B586:198-212,2004
best value

Long term goal of future generation experiments: 10 meV

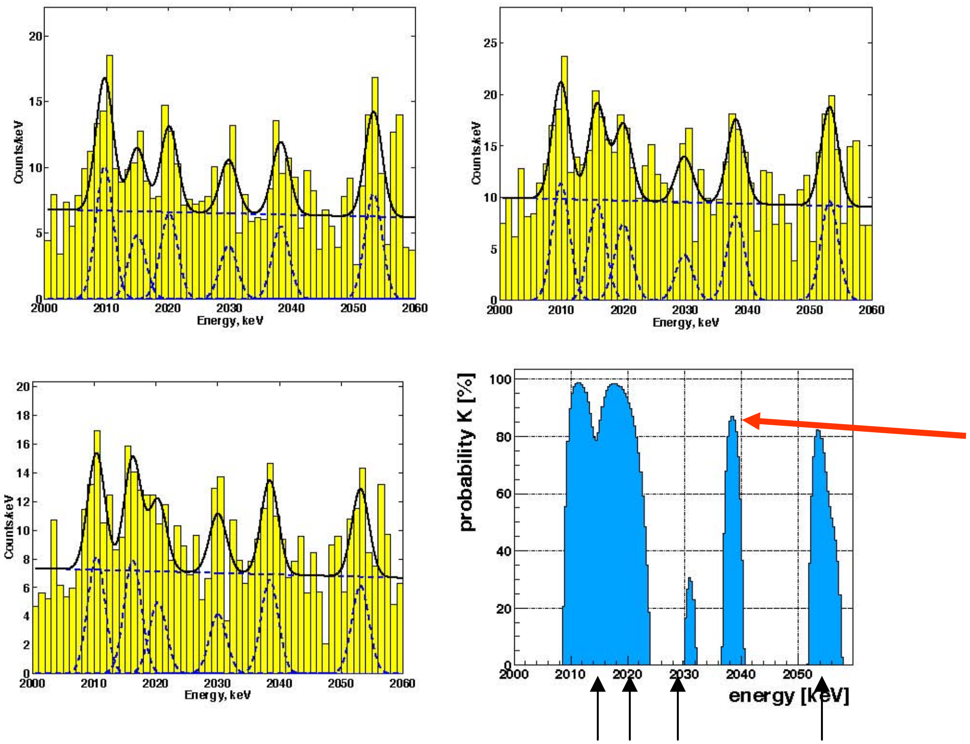


F.Feruglio, A. Strumia, F. Vissani, NPB 637

90% CL

Negligible errors from oscillations; width due to CP phases

Heidelberg-Moscow Experiment



Known Bi lines

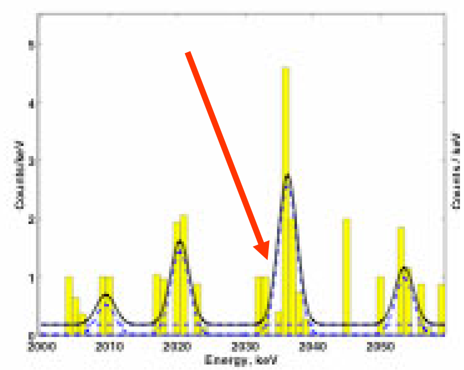
With pulse shape analysis

H.V. Klapdor-Kleingrothaus, I.V. Krivosheina, A. Dietz, O. Chkvorets (Heidelberg, Max Planck Inst.)

Phys.Lett.B586:198-212,2004

Background: 0.11/keV/kg/yr

0ν DBD signal ??



Claim: 4.2σ signal

$T_{1/2}$=1.2 10^{25} yr

Some of th

$^{48}Ca \rightarrow {}^{48}Ti$
$^{76}Ge \rightarrow {}^{76}Se$
$^{82}Se \rightarrow {}^{82}Kr$
$^{96}Zr \rightarrow {}^{96}Mo$
$^{100}Mo \rightarrow {}^{100}R$
$^{116}Cd \rightarrow {}^{116}Sn$
$^{128}Te \rightarrow {}^{128}Xe$
$^{130}Te \rightarrow {}^{130}Xe$
$^{136}Xe \rightarrow {}^{136}Ba$
$^{150}Nd \rightarrow {}^{150}Sn$

Nuclear Physics Los Alamos

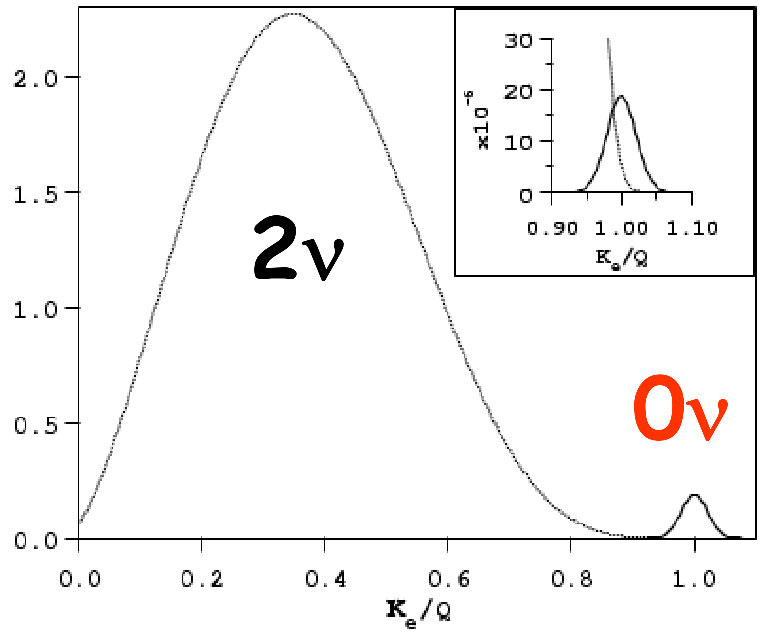
A Great Number of Proposed Experiments

COBRA	Te-130	10 kg CdTe semiconductors
DCBA	Nd-150	20 kg Nd layers between tracking chambers
NEMO	Mo-100, Various	10 kg of ββ isotopes (7 kg of Mo)
CAMEO	Cd-116	1 t $CdWO_4$ crystals
CANDLES	Ca-48	Several tons CaF_2 crystals in liquid scint.
CUORE	Te-130	750 kg TeO_2 bolometers
EXO	Xe-136	1 ton Xe TPC (gas or liquid)
GEM	Ge-76	1 ton Ge diodes in liquid nitrogen
GENIUS	Ge-76	1 ton Ge diodes in liquid nitrogen
GSO	Gd-160	2 t Gd_2SiO_5:Ce crystal scint. in liquid scint.
Majorana	Ge-76	500 kg Ge diodes
MOON	Mo-100	Mo sheets between plastic scint., or liq. scint.
Xe	Xe-136	1.56 t of Xe in liq. Scint.
XMASS	Xe-136	10 t of liquid Xe

Sept. 2003 Elliott, TAUP 2003, Seattle, WA 14

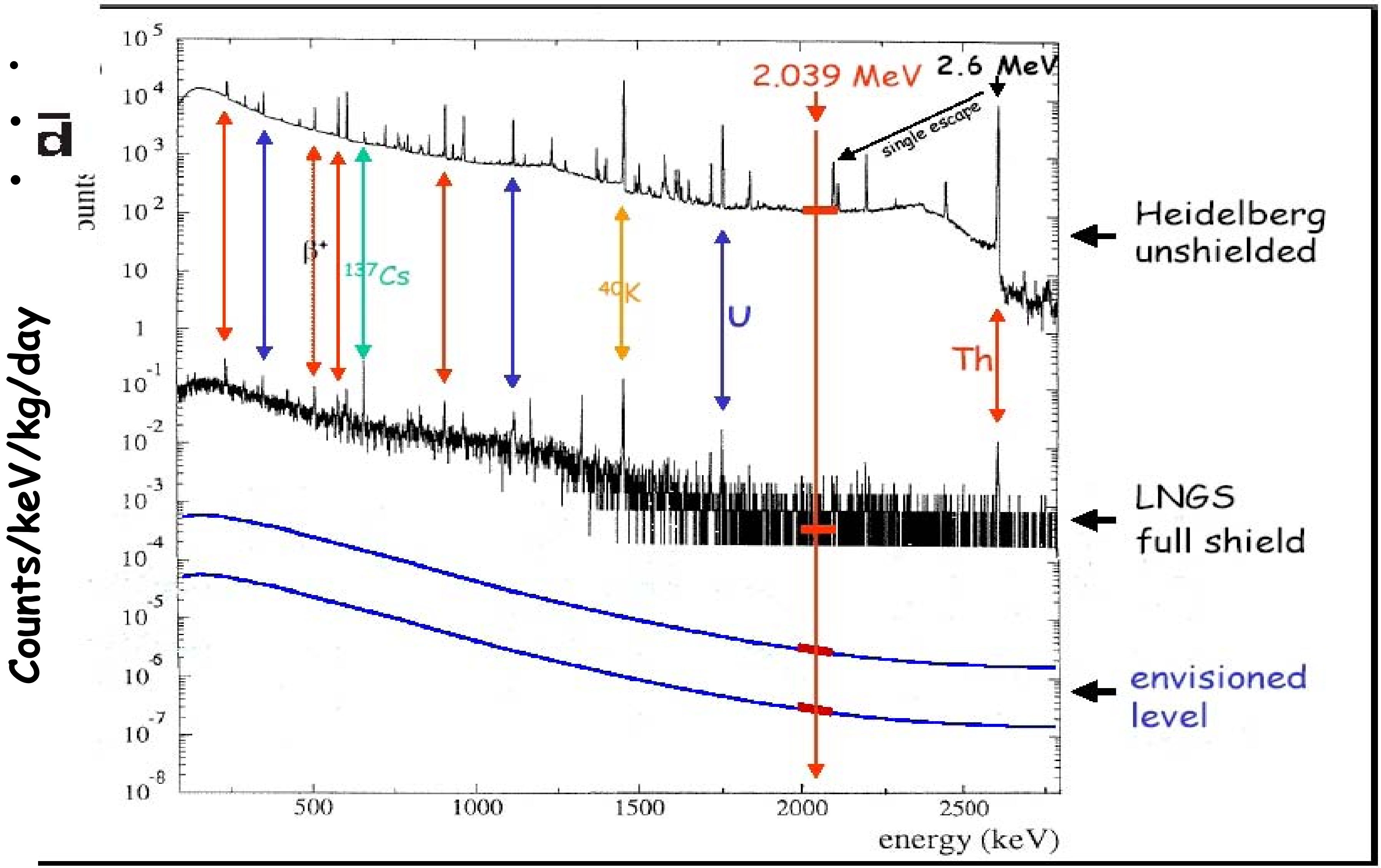
Germanium is a g

excellent energy ... lows finer
binning, so less bc ... e
irreducible backgr ... hich can
only be distinguisl

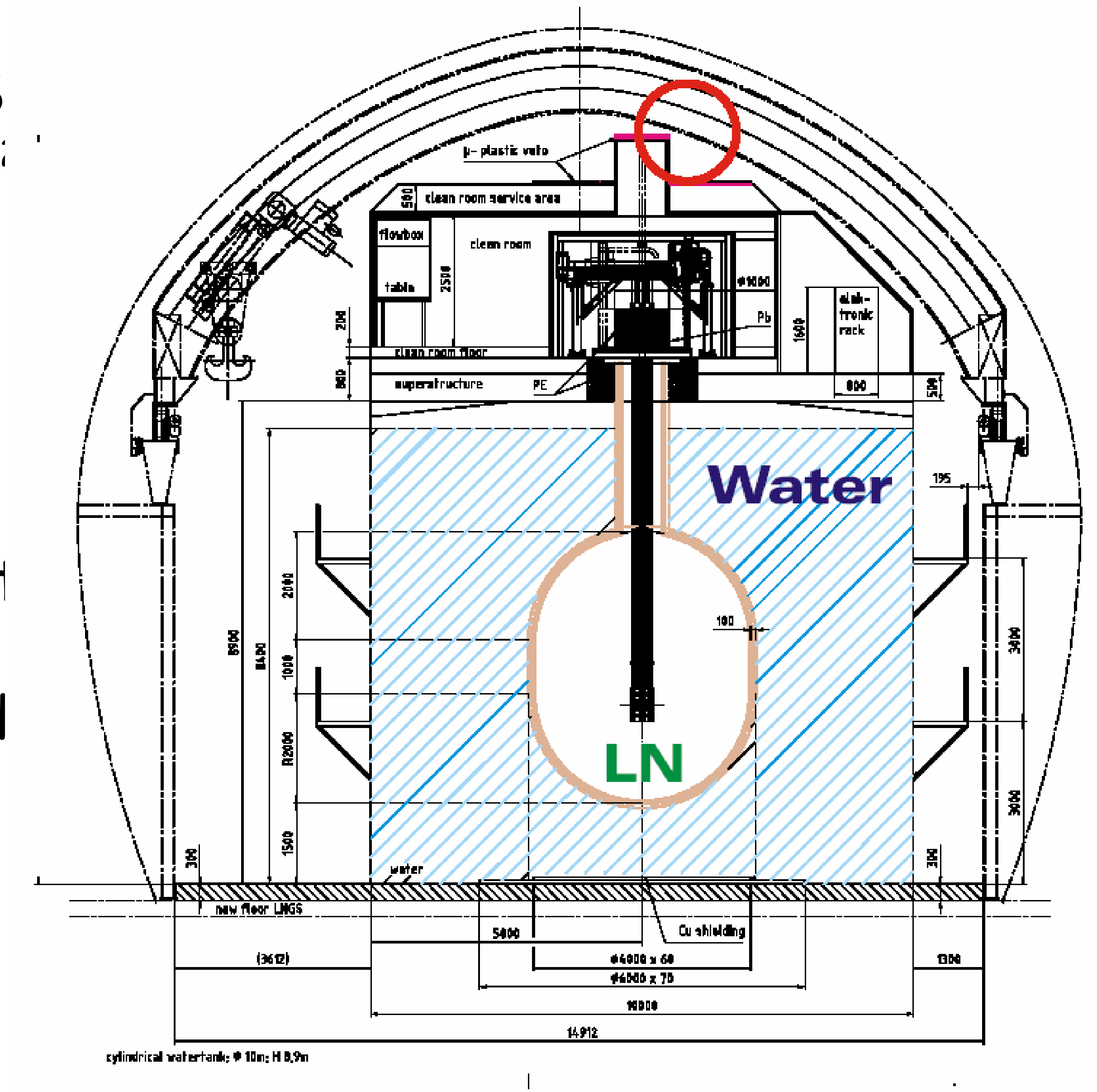


- considerable exp ... g Moscow, IGEX, Majorana. Some hope that we know background sources & can reduce it.
- enrichment possible (but expensive)
- possibilities for further development (segmentation)

Lesson from Previous Experiments



Suppressing External Backgrounds



Goal:

Reduce external backgrounds to 10^{-3}/keV/kg/yr with LN, factor 10 less with LAr

Ø 10 m water vessel
Ø 4 m Cu cryostat
45 m^3 of LN (LAr)
650 m^3 of water

Suppressing Internal Backgrounds

Background sources:

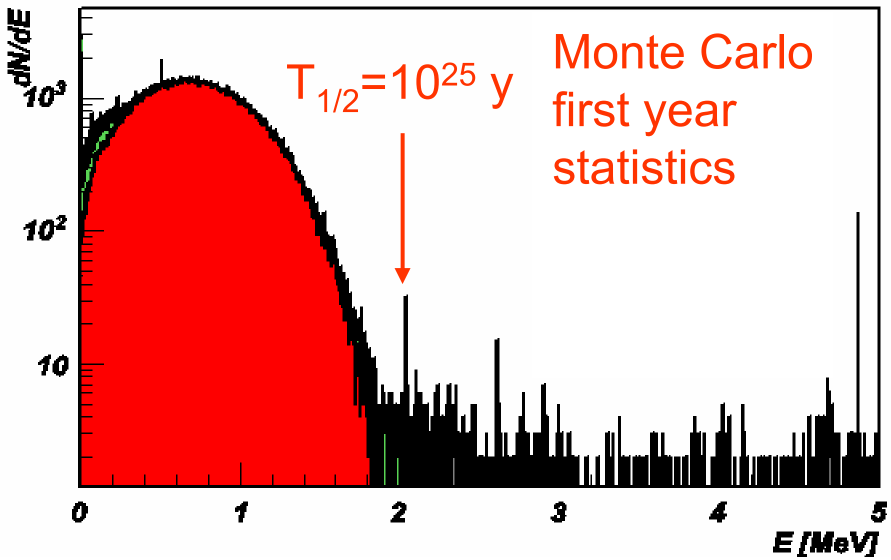
- Cosmogenically produced ^{68}Ge and ^{60}Co
- U/Th contamination, ^{210}Pb on surface

Signatures:

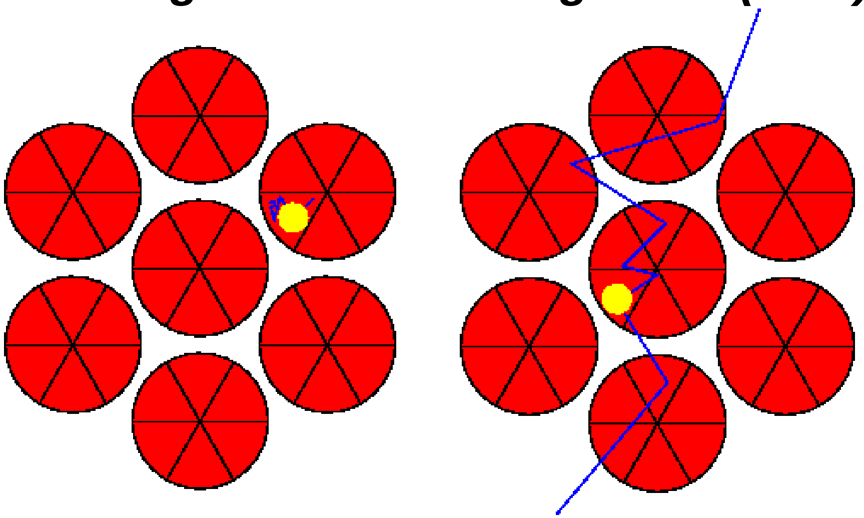
Signal has two electrons in final state → range ~mm

Background sources mostly γ with E_γ>2 MeV

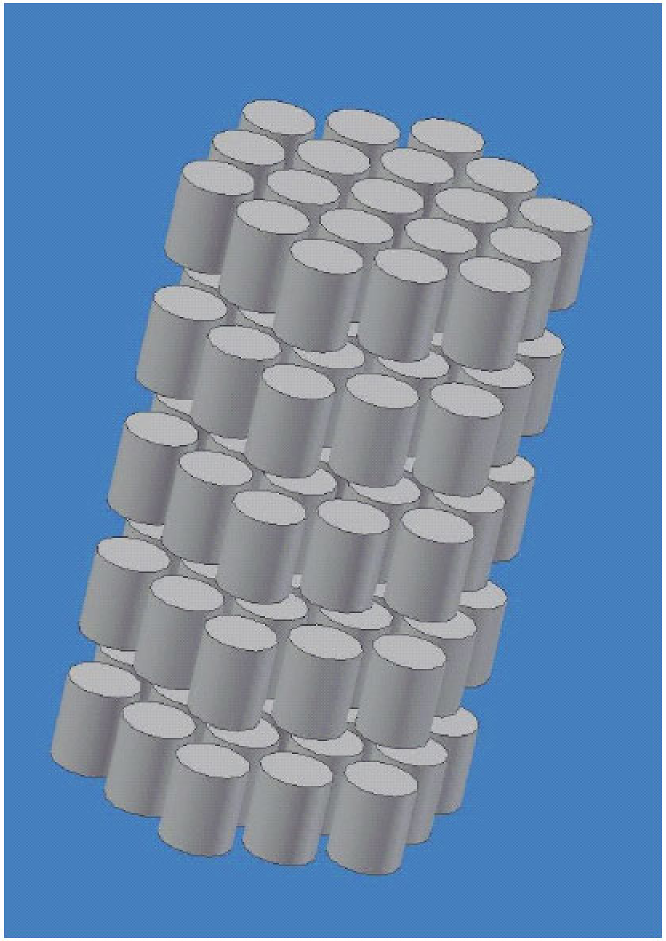
Compton scattering dominant interaction, range ~few cm

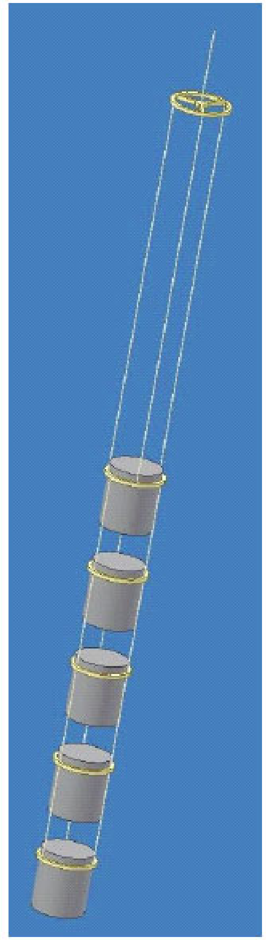


Signal: ***Background (^{60}Co):***



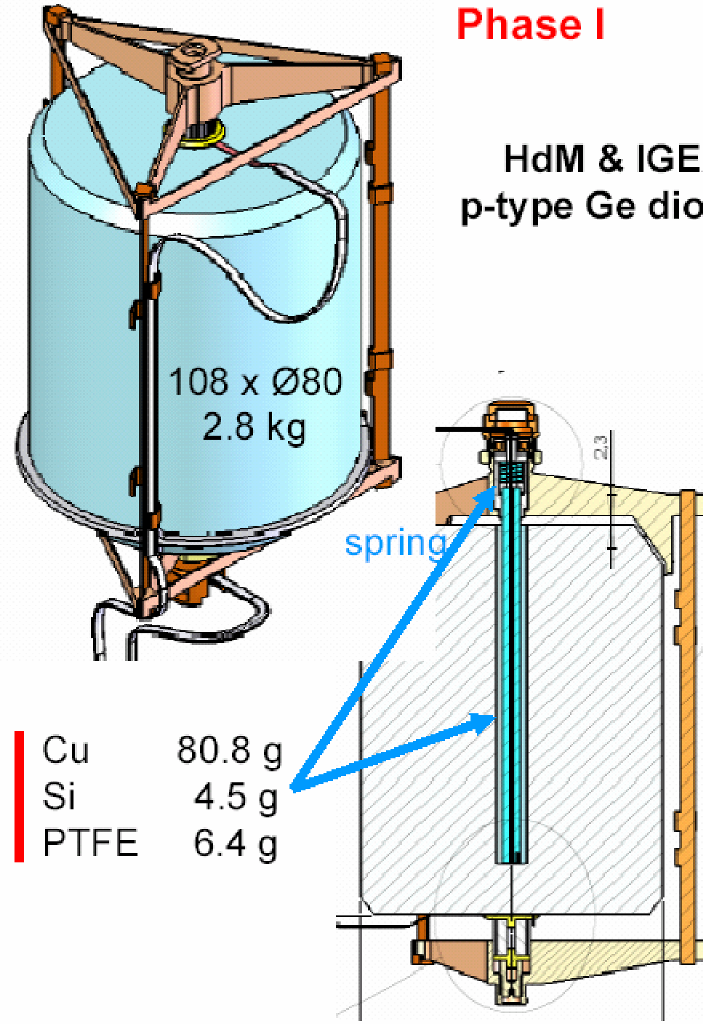
Detector Setup





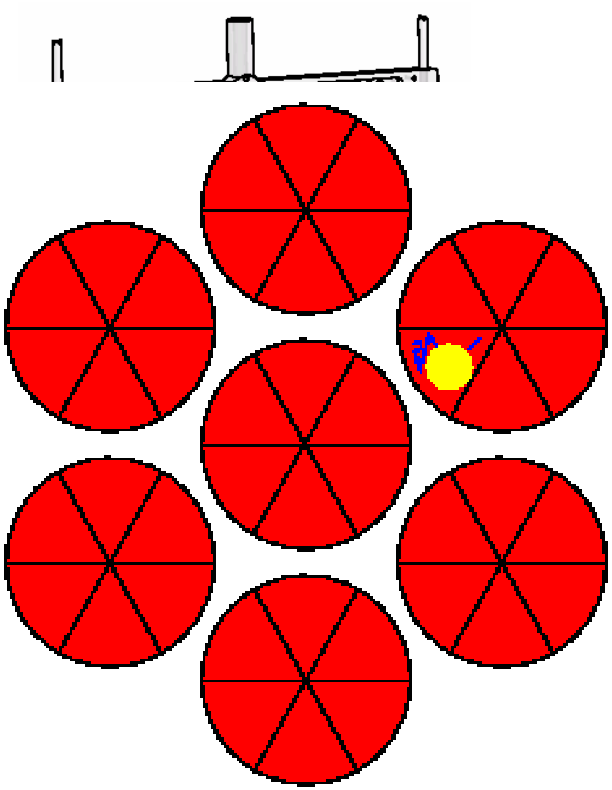
Phase I

HdM & IGEX
p-type Ge diodes

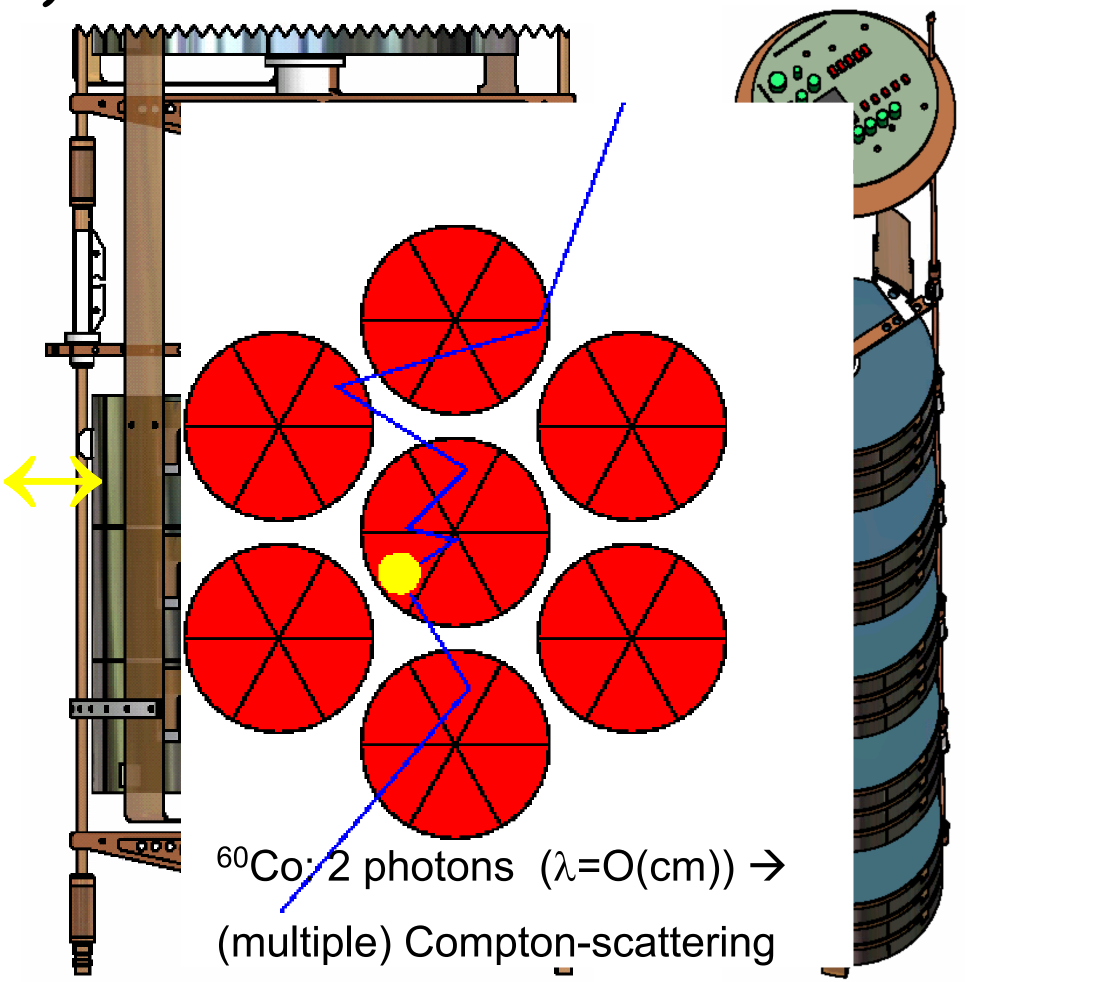


Phase II detectors

18-fold segemented detectors
(true-coaxial, 3x6, n-type)



2 electrons deposit energy locally (d = O(1 mm))

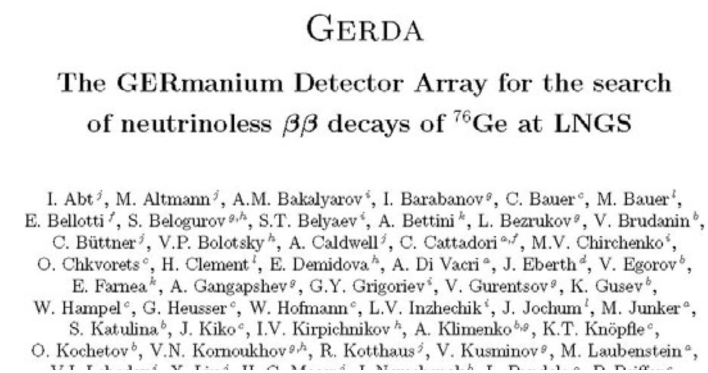


^{60}Co: 2 photons (λ=O(cm)) → (multiple) Compton-scattering

GERDA H

• LoI to LNGS with proto-colla
to submit proposal

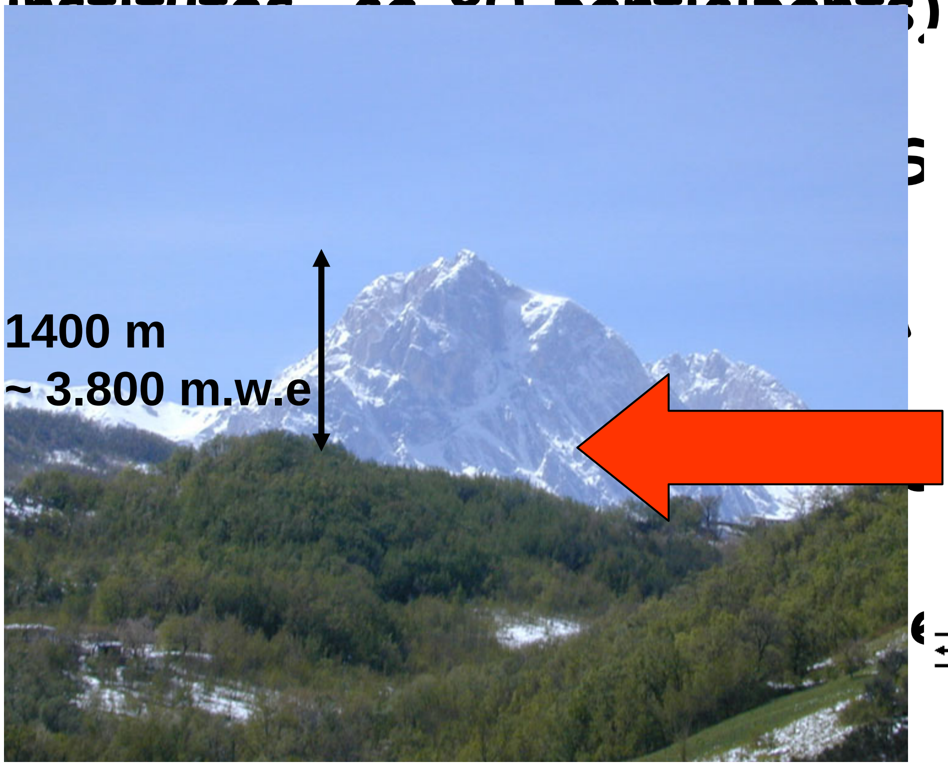
• Collaboration was officially fo
institutes, ca 80 participants)

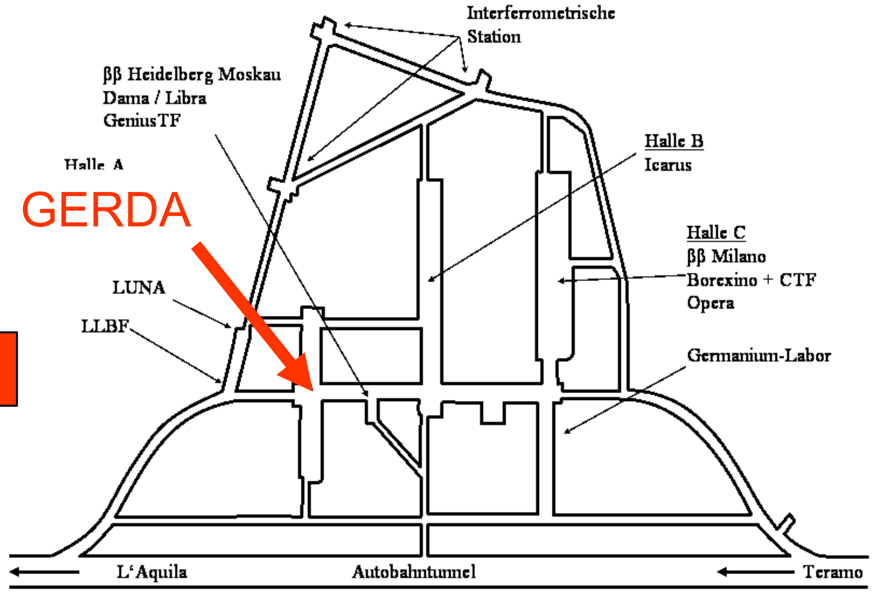


GERDA

The GERmanium Detector Array for the search of neutrinoless $\beta\beta$ decays of ^{76}Ge at LNGS

I. Abt[j], M. Altmann[j], A.M. Bakalyarov[i], I. Barabanov[g], C. Bauer[c], M. Bauer[l], E. Bellotti[f], S. Belogurov[g,h], S.T. Belyaev[i], A. Bettini[k], L. Bezrukov[g], V. Brudanin[b], C. Büttner[j], V.P. Bolotsky[h], A. Caldwell[j], C. Cattadori[a,f], M.V. Chirchenko[i], O. Chkvorets[c], H. Clement[l], E. Demidova[h], A. Di Vacri[a], J. Eberth[d], V. Egorov[b], E. Farnea[k], A. Gangapshev[g], G.Y. Grigoriev[i], V. Gurentsov[g], K. Gusev[b], W. Hampel[c], G. Heusser[c], W. Hofmann[c], L.V. Inzhechik[i], J. Jochum[l], M. Junker[a], S. Katulina[b], J. Kiko[c], I.V. Kirpichnikov[h], A. Klimenko[b,g], K.T. Knöpfle[c], O. Kochetov[b], V.N. Kornoukhov[g,h], R. Kotthaus[j], V. Kusminov[g], M. Laubenstein[a],





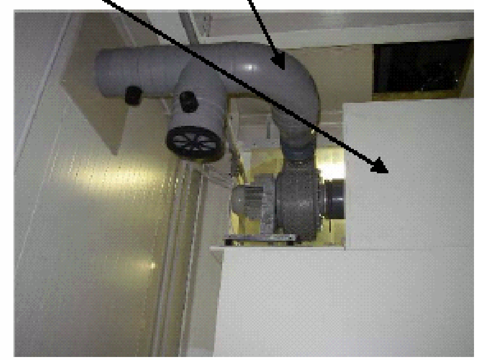
Some Pictures

LArGe Facility @ LNGS

Underground laboratory for detector refurbishment and testing of phase-I detectors

Washstand with high-purity water supply

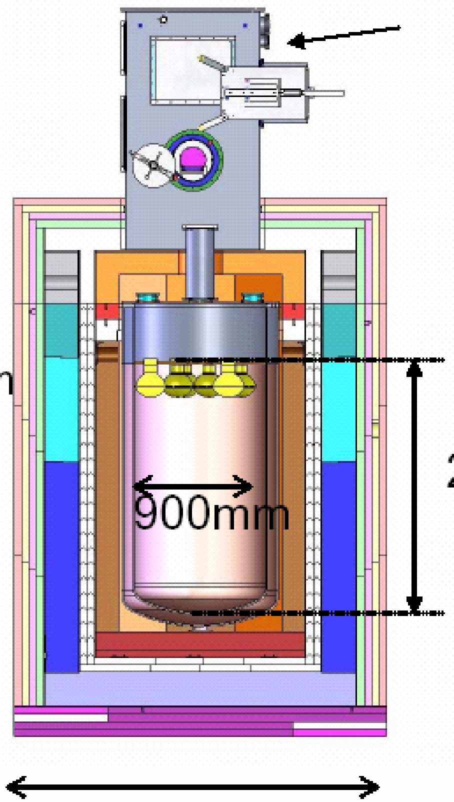
Fume hood with charcoal filter and vent



(June 05)

Mounting of LArGe shield

Graded shield:
Copper 150 mm
Lead 100 mm
Steel 230 mm
PE 200 mm



Copper & lead: < 20 μBq/kg (Th-228)

Some Pictures

HD-Moscow's KI-detectors were handed over to GERDA

Some Pictures

Production of 37.5 kg enriched Ge in Siveria (ECP)

Enrichement completed - next steps:

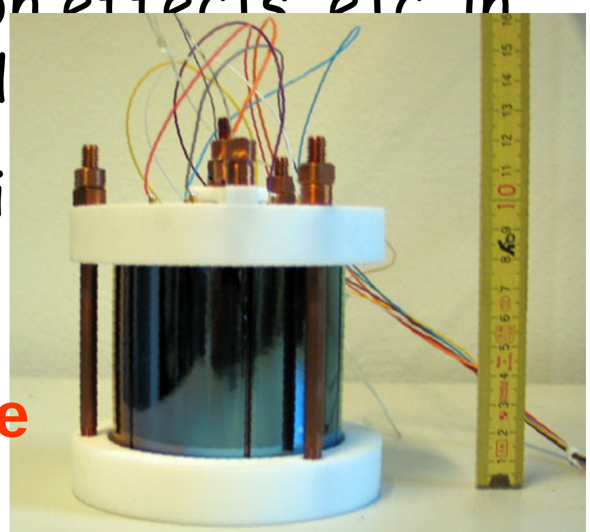
- purification of enriched Ge (99.9% →99.9999% pure)
- reduction
- monozone, polyzone refining
- crystal growing
- detector production

Teststands at the MPI Munich are under construction:

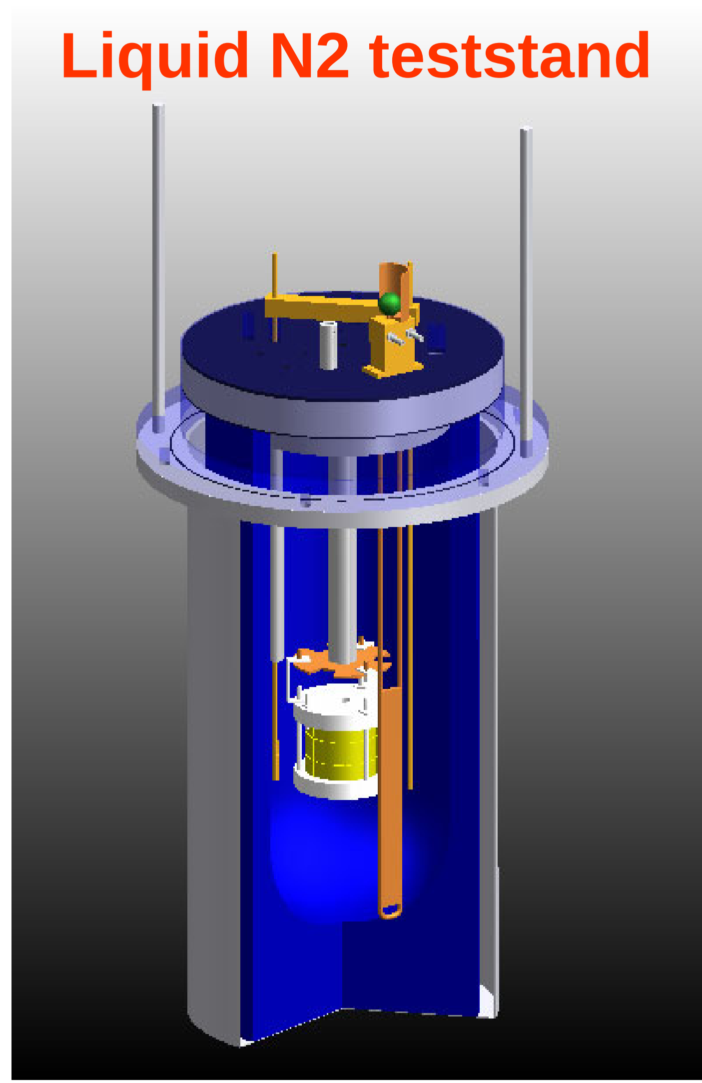
Test bare crystals in liquid nitrogen for handling, robustness, resolution (n-type and p-type)

Investigation of detector properties such as dead layers, segmentation, crystal orientation effects, etc. in vacuum teststand

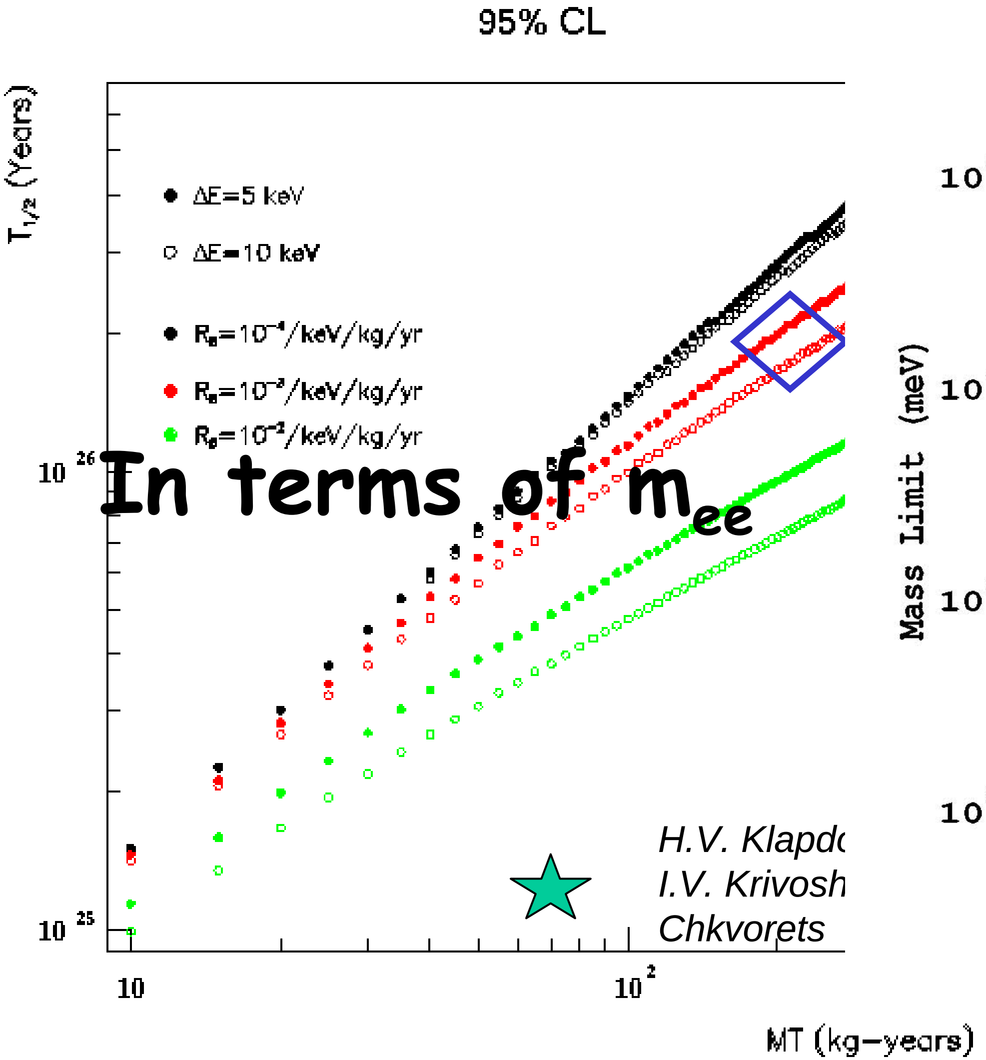
Compare calculati
with data



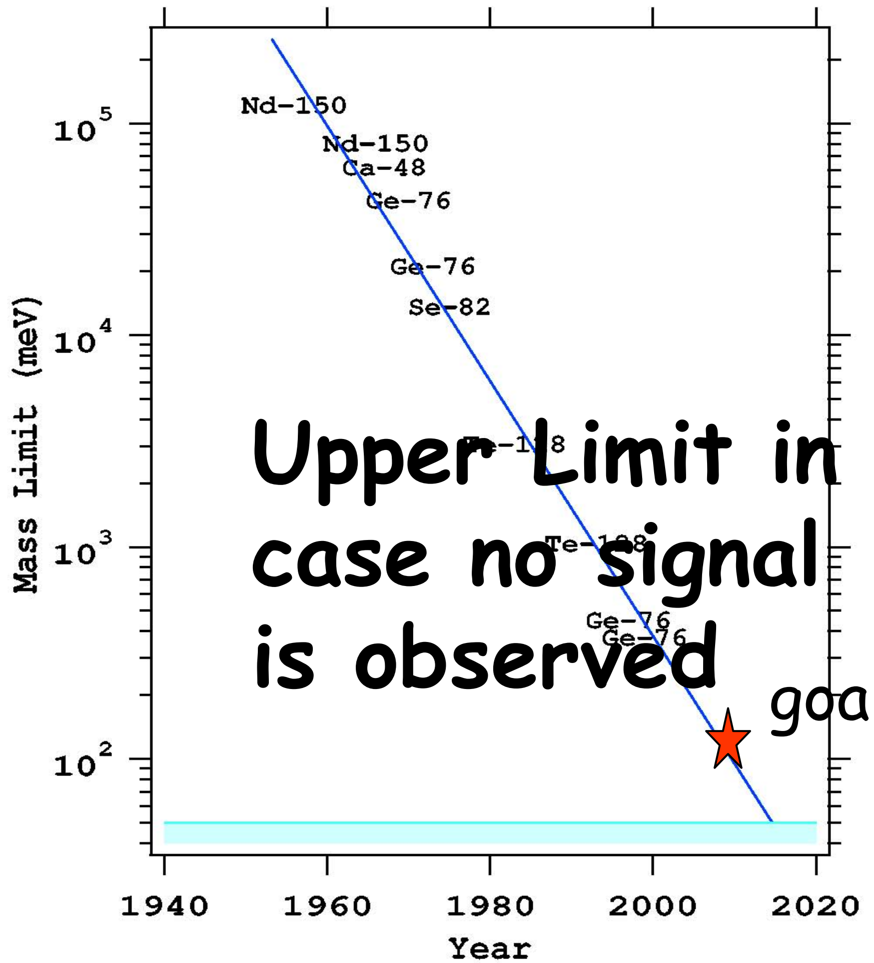
p-type



GERDA Physics Goal

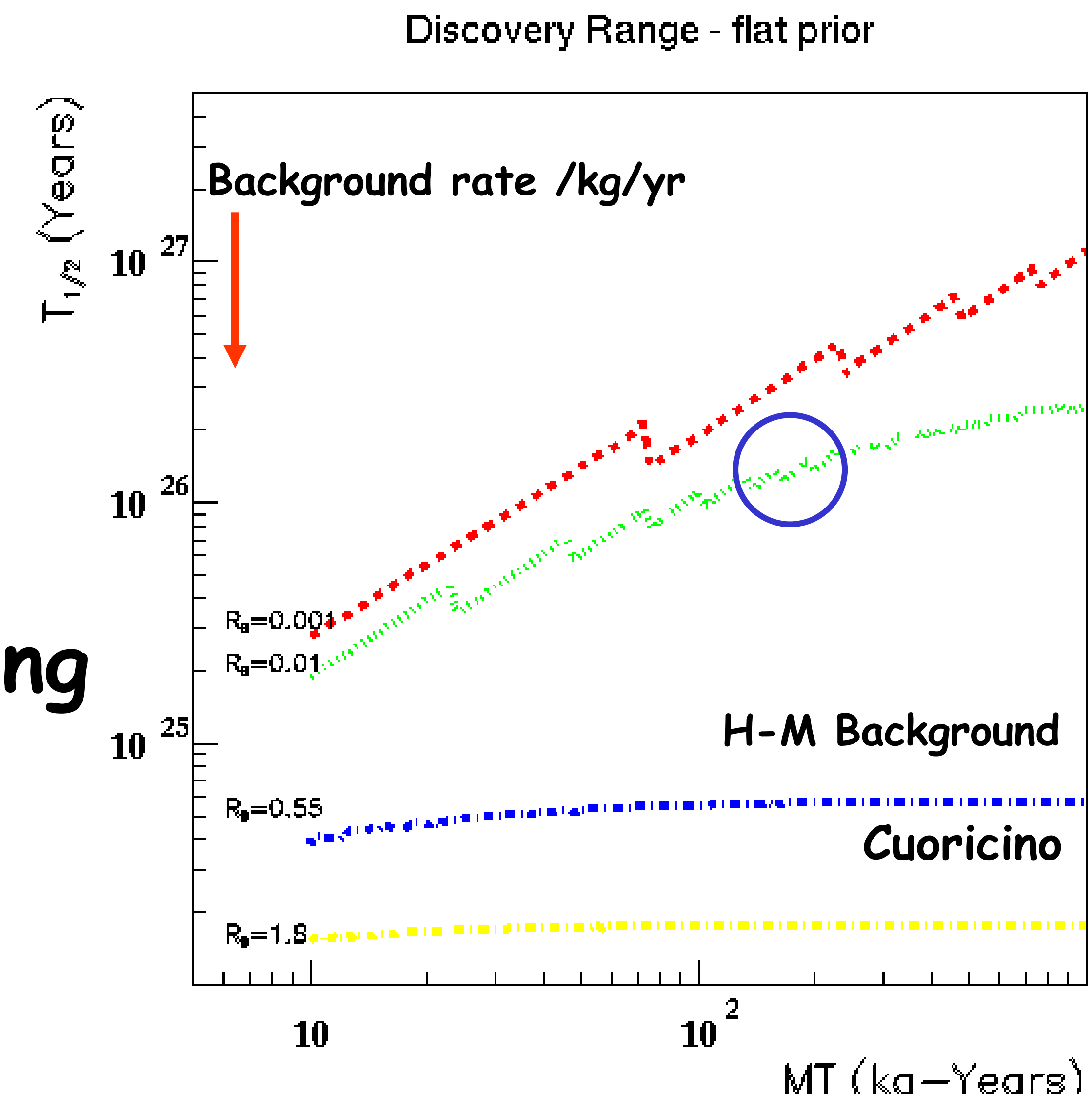


In terms of m_{ee}



Upper Limit in case no signal is observed

Of course, we hope for a discovery !



Commissioning
2007