A SYMPOSIUM: A TRIBUTE TO ANGEL MORALES, FRIEND AND SCIENTIST

Instituto Veneto di Scienze, Lettere ed Arti

NEUTRINOLESS DOUBLE BETA DECAY

Frank Avignone, Department of Physics and Astronomy
University of South Carolina, and
INFN, Laboratori Nazionale del Gran Sasso

February 10, 2006,
Palazzo Franchetti, Venice, Italy


NEUV CAVAL 'D BRÔNS

Angel Morales and I created the IGEX Collaboration and Experiment in 1987. We started by having meetings with a number of colleagues at the Moriond Conference at Les Arcs in February. We had already begun to collaborate in neutrinoless double-beta decay earlier that year in the Canfranc Underground Laboratory. The following is a photo taken on top of Condonchu above the lab

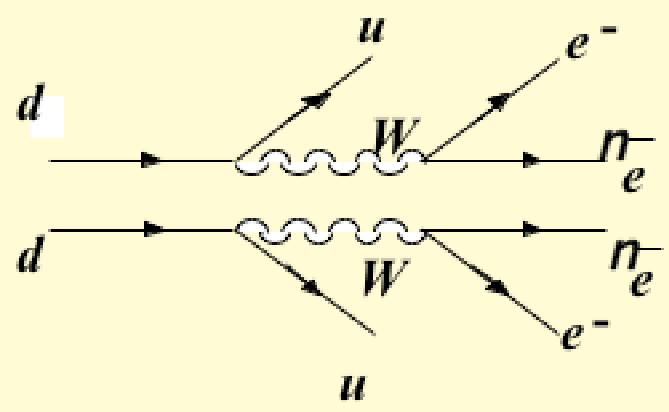
Notice the brown hair on the speaker

On this visit to Canfranc, Angel told me his dream of a full laboratory in galleries cut from the railway tunnel. This dream has come to pass as Julio Morales will show next.

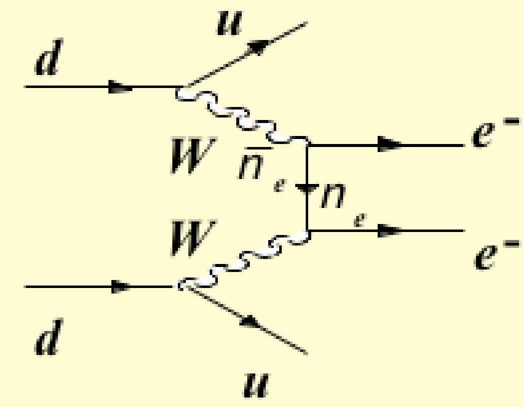
Now on to DOUBLE-BETA DECAY!

WHAT COULD WE LEARN IF OBSERVED

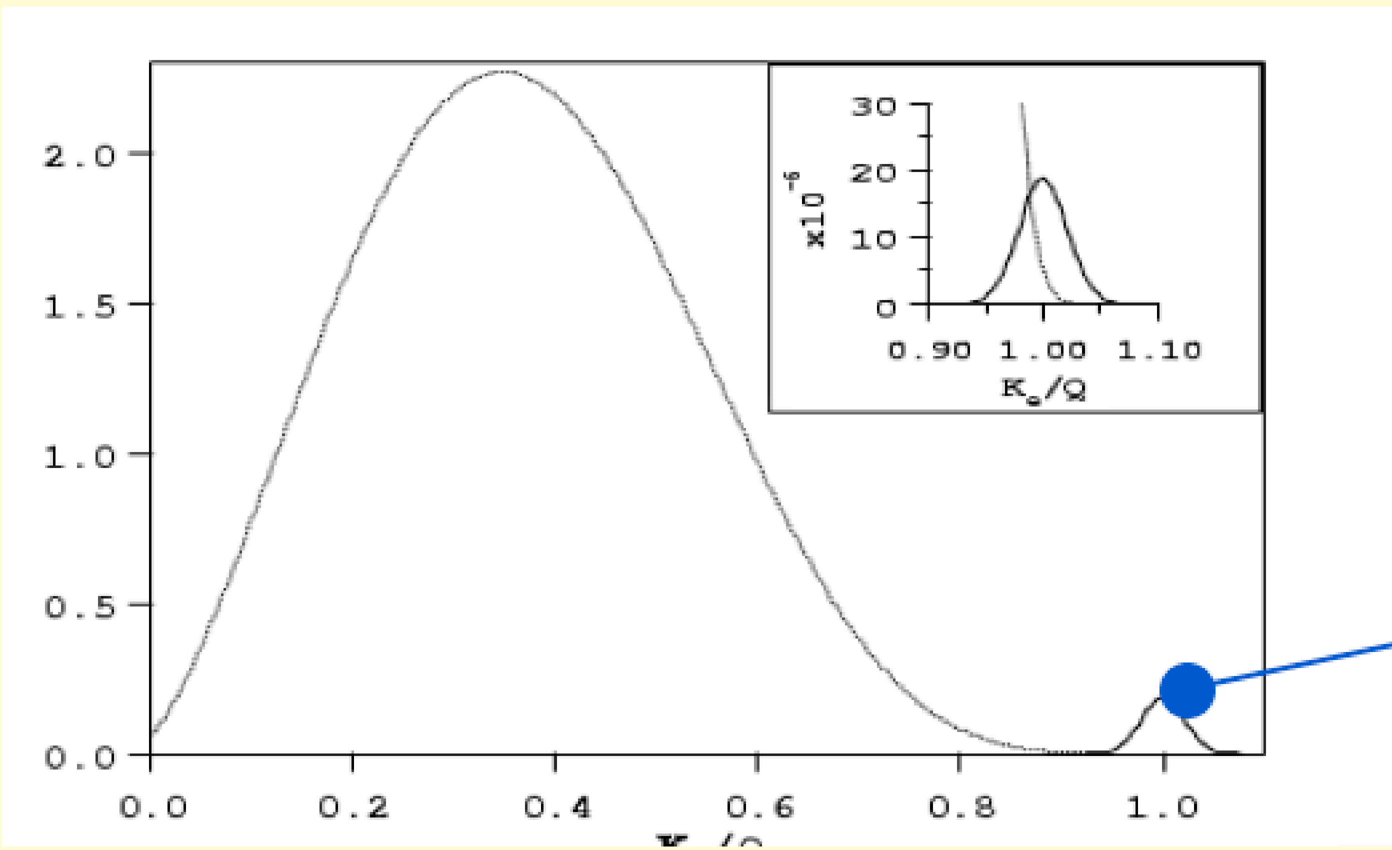
- NEUTRINOS ARE MAJORANA PARTICLES (Leptogenesis is possible)
- A MEASURE OF THE MAJORANA MASS OF THE ELECTRON NEUTRINO
- HENCE, THE NEUTRINO MASS EIGENVALUES
- ARE NEUTRINOS A COMPONENT OF THE DARK MATTER?



2n - bb decay

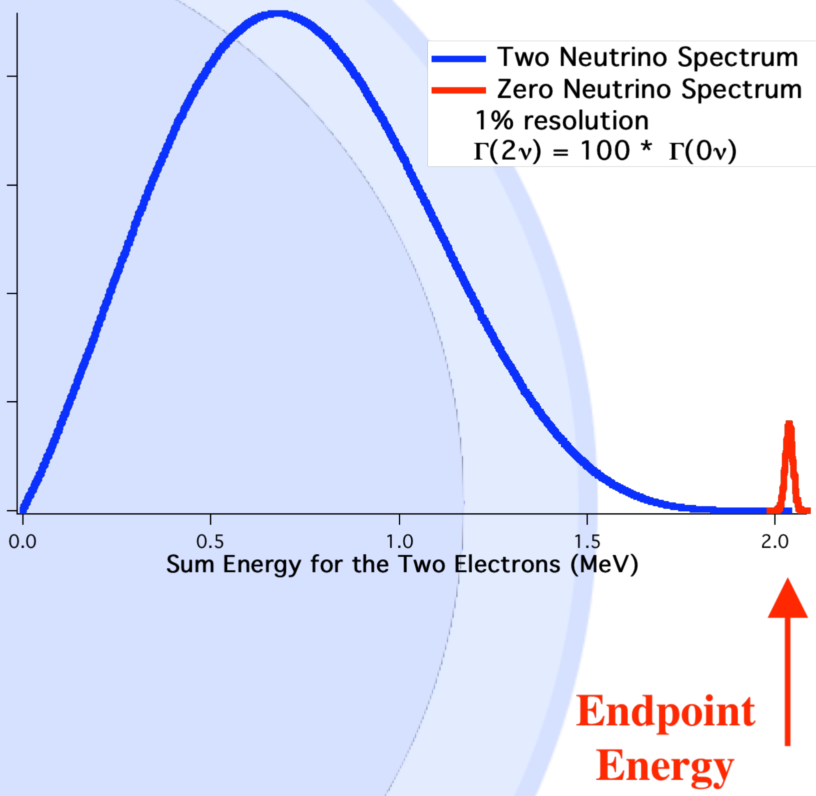


0n - bb decay



Neutrinoless bb decay

Energy Spectrum for the 2 e^-



Neutrino Mass-Eigenstate Mixing

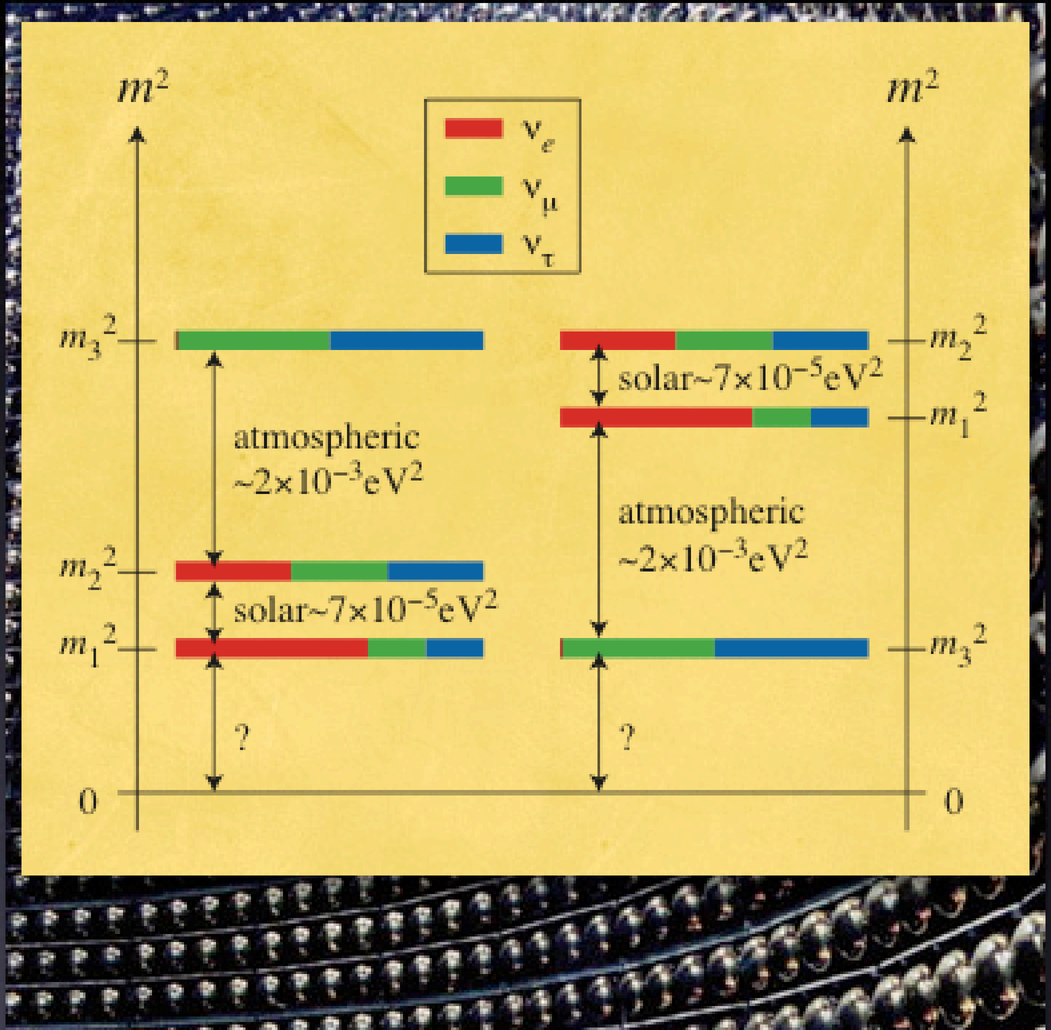
$$\begin{bmatrix} |\nu_e\rangle \\ |\nu_\mu\rangle \\ |\nu_\tau\rangle \end{bmatrix} = \begin{bmatrix} u_{e1} & u_{e2} & u_{e3} \\ u_{\mu 1} & u_{\mu 2} & u_{\mu 3} \\ u_{\tau 1} & u_{\tau 1} & u_{\tau 1} \end{bmatrix} \begin{bmatrix} |\nu_1\rangle \\ |\nu_2\rangle \\ |\nu_3\rangle \end{bmatrix}$$

$$u = \begin{bmatrix} c_3 c_2 & s_3 c_2 & s_2 e^{-i\delta} \\ -s_3 c_1 - c_3 s_1 s_2 e^{i\delta} & c_3 c_1 - s_3 s_1 s_2 e^{i\delta} & s_1 c_2 \\ s_3 s_1 - c_3 s_1 s_2 e^{i\delta} & -c_3 s_1 - s_3 c_1 s_2 e^{i\delta} & c_1 c_2 \end{bmatrix}$$

Decay Rate

$$\frac{1}{T_{1/2}^{0\nu\beta\beta}} = G^{0\nu}(E_0, Z)(\frac{\langle m_\nu \rangle}{m_e})^2 |M_f^{0\nu} - (g_A/g_V)^2 M_{GT}^{0\nu}|^2$$

Oscillations



Neutrino Mass Eigenstates

Normal Hierarchy

$$|\langle m_\nu \rangle| = \left| c_2^2 c_3^2 m_1 + c_2^2 s_3^2 e^{i\phi_2} \sqrt{\delta m_s^2 + m_1^2} + s_2^2 e^{i\phi_3} \sqrt{\delta m_{AT}^2 + m_1^2} \right|$$

Inverted Hierarchy

$$|\langle m_\nu \rangle| = \left| s_2^2 m_1 + c_2^2 c_3^2 e^{i\phi_2} \sqrt{\delta m_{AT}^2 - \delta m_s^2 + m_1^2} + c_2^2 s_3^2 e^{i\phi_3} \sqrt{\delta m_{AT}^2 + m_1^2} \right|$$

Useful Approximations

$$c_2^2 c_3^2 \approx 0.75 \quad c_2^2 s_3^2 \approx 0.25 \quad s_2^2 \approx 0 \quad \delta m_s^2 \ll \delta m_{AT}^2$$

A General Approximation

Normal Hierarchy

$$|\langle m_\nu \rangle| = \left| m_1 \left\{ 0.70^{+0.02}_{-0.04} + e^{i\phi_2} \left(0.30^{+0.03}_{-0.03}\right) \left(1 + \frac{\delta m_s^2}{2m_1^2}\right) \right\} \right|$$

Inverted Hierarchy

$$|\langle m_\nu \rangle| \cong \left| \sqrt{\delta m_{AT}^2 + m_1^2} \right| \left[e^{i\phi_2} \left(0.07^{+0.02}_{-0.04}\right) + e^{i\phi_3} \left(0.30^{+0.03}_{-0.02}\right) \right]$$

$$Note\ here\ that\ |\langle m_\nu \rangle| \gtrsim 0.045\ eV\ if\ \phi_2$$
$$and\ \phi\ are\ in\ phase,\ even\ when\ m_1 \equiv 0.$$

It is absolutely necessary to consider what ever knowledge of the nuclear matrix elements we have in evaluating the discovery potential of a given technique.

Parameters of $T_{1/2}^{0\nu}$ Sensitivity

$$T_{1/2}^{0\nu} \simeq \frac{ln2Nt\epsilon}{\gamma\sqrt{bMt\,\delta E}}$$

$$T_{1/2}^{0\nu} \simeq \frac{ln2(A_0/W) \times 10^3(Mat\epsilon)}{\gamma\sqrt{bMt\,\delta E}}$$

$$T_{1/2}^{0\nu} \propto \frac{a\epsilon}{W}\sqrt{\frac{Mt}{b\,\delta E}}$$

$a \equiv isotopic\,abundance$

$b \equiv background\,rate\,in\,c/(keV \cdot kg \cdot y)$

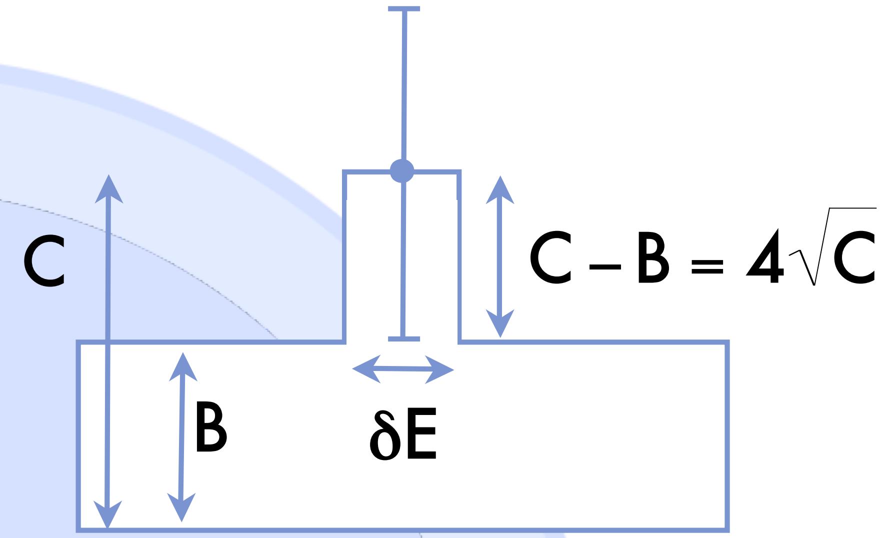
$M \equiv source\,mass$

$\delta E \propto energy\,resolution$

$\epsilon \equiv detection\,efficiency$

$W \equiv molecular\,weight$

Detection with a 4_σ CL



$$T^{0\nu}_{1/2} \simeq 4.74 \times 10^{25} \frac{a\epsilon}{W} \sqrt{\frac{Mt}{b\,\delta E}}\;\; y$$

$a \equiv isotopic\,abundance$

$b \equiv background\,rate\,in\,c/(keV \cdot kg \cdot y)$

$M \equiv source\,mass$

$\delta E \propto energy\,resolution$

$\epsilon \equiv detection\,efficiency$

$W \equiv molecular\,weight$

Neutrinoless Double-Beta Decay

Experimental Figure of Merit

$$f \equiv \frac{\overline{\eta} a \epsilon}{W} \sqrt{\frac{M}{b \delta E}}$$

$$\eta \equiv G^{0\nu} |\mathcal{M}^{0\nu}|^2 \times 10^{13} = F_N \times 10^{13}$$

$$\overline{\eta} \equiv \langle \eta \rangle_{nuclear\ models}$$

Available Experimental Techniques

Cryogenic Bolometry
Ionization Detectors
Scintillation Detectors
Time Projection Chambers
Tracking Chambers

Available Enriched Isotopes

^{48}Ca - AVLIS† (USA
^{76}Ge - Centrifuge (Russia)
^{82}Se - Centrifuge (Russia)
^{100}Mo - Centrifuge (Russia) & AVLIS† (USA)
^{116}Cd - Centrifuge (Russia) & AVLIS† (USA)
^{130}Te - Centrifuge (Russia)
^{136}Xe - Centrifuge (Russia)
^{150}Nd - AVLIS† (USA)

† Technology available at LLNL. No known production program.

Average Theoretical Nuclear Structure Factors

Parent Isotope	$\langle F_N \rangle \equiv \left\langle G^{0\nu} \left| M^{0\nu} \right|^2 \right\rangle \; y^{-1}$
^{48}Ca	$(5.4^{+3.0}_{-1.4}) \times 10^{-14}$
^{76}Ge	$(7.3 \pm 0.6) \times 10^{-14}$
^{82}Se	$(1.7^{+0.4}_{-0.3}) \times 10^{-13}$
^{100}Mo	$(1.0 \pm 0.3) \times 10^{-12}$
^{116}Cd	$(1.3^{+0.7}_{-0.3}) \times 10^{-13}$
^{130}Te	$(4.2 \pm 0.5) \times 10^{-13}$
^{136}Xe	$(2.8 \pm 0.4) \times 10^{-14}$
^{150}Nd	$(5.7^{+1.0}_{-0.7}) \times 10^{-12}$

Table of Values of $\overline{\eta}$

$$\overline{\eta} \equiv \langle G^{0\nu} |\mathcal{M}^{0\nu}|^2 \rangle \times 10^{13}$$

Isotope	$\overline{\eta}$
^{48}Ca	0.54
^{76}Ge	0.73
^{82}Se	1.70
^{100}Mo	10.0
^{116}Cd	1.30
^{130}Te	4.20
^{136}Xe	0.28
^{150}Nd	57.0

NEW VALUES OF ⟨η⟩ USING Rodin et al.

ISOTOPE	⟨η⟩ new	⟨η⟩ aver.
^{48}Ca	0.71	0.74
^{76}Ge	1.00	1.00
^{82}Se	3.06	2.32
^{100}Mo	1.72	6.84
^{116}Cd	1.78	1.78
^{130}Te	1.65	5.85
^{136}Xe	1.14	0.38
^{150}Nd	20.6	78.1

Proposed Experiments

CAMEO	^{116}Cd	$CdWO_4$ crystals in liq. scint.
CANDLES	^{48}Ca	CaF_2 crystals in liq. scint.
COBRA	^{116}Cd	CdTe semiconductors
CUORE	^{130}Te	TeO_2 bolometers
DCBA	150Nd	Nd foils & tracking chambers
EXO	^{136}Xe	Xe TPC
GEM	^{76}Ge	Ge detectors in LN
GENIUS	^{76}Ge	Ge detectors in LN

Proposed Experiments

GSO	^{160}Gd	Gd_2SiO_5 crystals in liq. scint.
Majorana	^{76}Ge	Segmented Ge Detectors
MOON	^{100}Mo	Mo foils & plastic scint.
GERDA	^{76}Ge	Ge detectors in LN
SUPER NEMO	^{82}Se	Foils with tracking
Xe	^{136}Xe	Xe dissolved in liq. scint.
XMASS	^{136}Xe	Liquid Xe

CUORE:

high sensitive Double Beta Decay cryogenic Experiment

Cryogenic Detector

CUORE/CUORICINO (Gran Sasso)
760 kg of TeO_2(nat. abundance = 33.8%)
988 bolometers at ~ 8 mK
19 Towers of 52 bolometers per tower
CUORICINO ~ 1 tower, operating with result

$$T_{1/2}^{0\nu} = 1.8 \times 10^{24} y$$

The CUORE Collaboration

J. Beeman[1], *M.Dolinski*[1], *T.D. Gutierrez*[1], *E.E. Haller*[1,2], *R. Maruyama*[1], *B. Quiter*[1], A.R. Smith[1] and N. Xu[1]

[1]Lawrence Berkeley National Laboratory [2]University of California, Berkeley CA 94720, USA

A. Giuliani, M. Pedretti and S.Sangiorgio

Dipartimento di Fisica e Matematica dell'Università dell'Insubria e Sezione di Milano dell' INFN, Como I-22100, Italy

M. Barucci, E. Olivieri, L. Risegari, and G. Ventura

Dipartimento di Fisica dell' Università di Firenze e Sezione di Firenze dell' INFN, Firenze I-50125, Italy

M. Balata, C. Bucci, and S.Nisi

Laboratori Nazionali del Gran Sasso, I-67010, Assergi (L'Aquila), Italy

V. Palmieri

Laboratori Nazionali di Legnaro, Via Romea 4, I-35020 Legnaro (Padova)

A. de Waard

Kamerling Onnes Laboratory, Leiden University, 2300 RAQ Leiden

E.B. Norman

Lawrence Livermore National Laboratory, Livermore, California, 94550, USA

C. Arnaboldi, C. Brofferio, S. Capelli, F. Capozzi, L. Carbone, M.Clemenza, O. Cremonesi, E. Fiorini, C.Nones, A. Nucciotti, M. Pavan, G. Pessina, S. Pirro, E. Previtali, M. Sisti, L.Torres and L.Zanotti

Dipartimento di Fisica dell'Università di Milano-Bicocca e Sezione di Milano dell'INFN, Milano I-20126, Italy

R. Ardito, G. Maier

Dipartimento di Ingegneria Strutturale del Politecnico di Milano, Milano I-20133, Italy

E.Guardincerri, P. Ottonello and M.Pallavicini

Dipartimento di Fisica dell'Universita' diGenova e Sezione di Genova dell'INFN, Genova I-16146, Italy

D.R. Artusa, F.T. Avignone III, I. Bandac, R.J. Creswick, H.A. Farach, and C. Rosenfeld

Department of Physics and Astronomy, University of South Carolina, Columbia S.C. 29208 USA

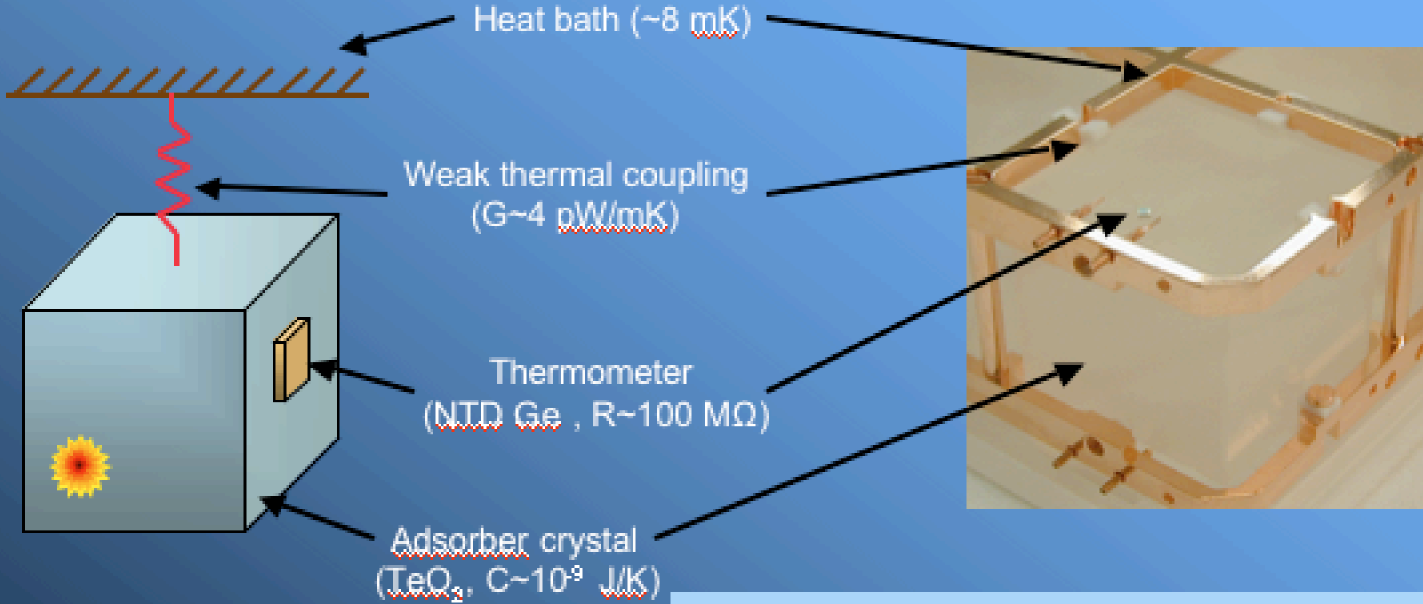
S. Cebrian, P. Gorla, I.G. Irastorza

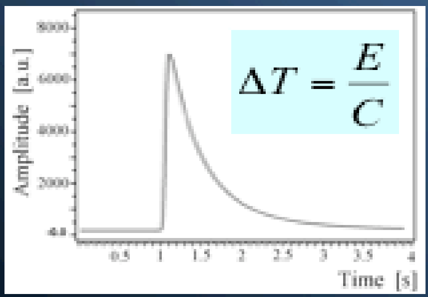
Lab. of Nucl. and High Energy Physics, University of Zaragoza, 50009 Zaragoza, Spain

F.Bellini, C.Cosmelli, I.Dafinei, M.Diemoz, F.Ferroni, C.Gargiulo, E.Longo, S. Morganti

Dipartimento di Fisica dell'Universita' di Roma e Sezione di Roma 1 dell'INFN, Roma I-16146, Italy

Cryogenic Detectors

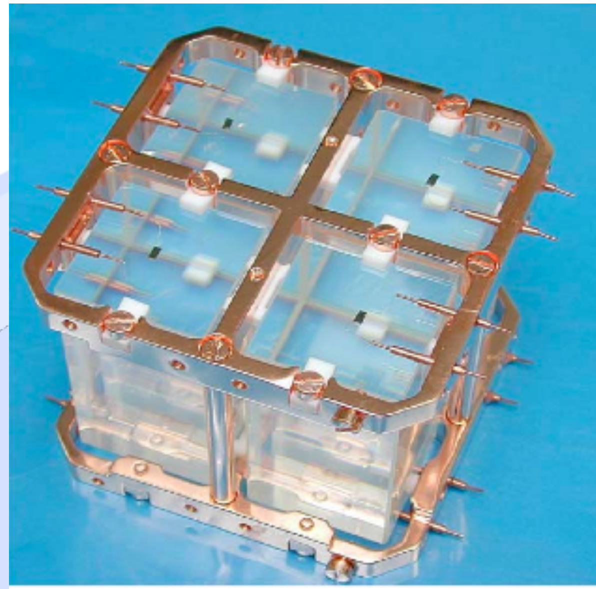


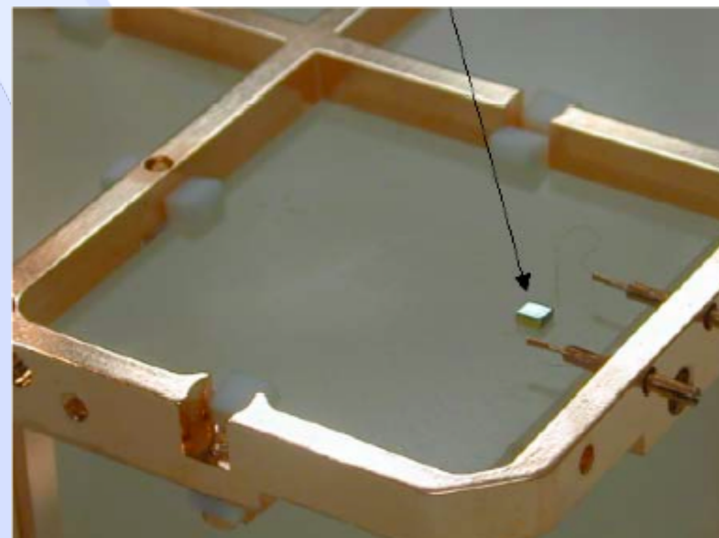


Cryodet features

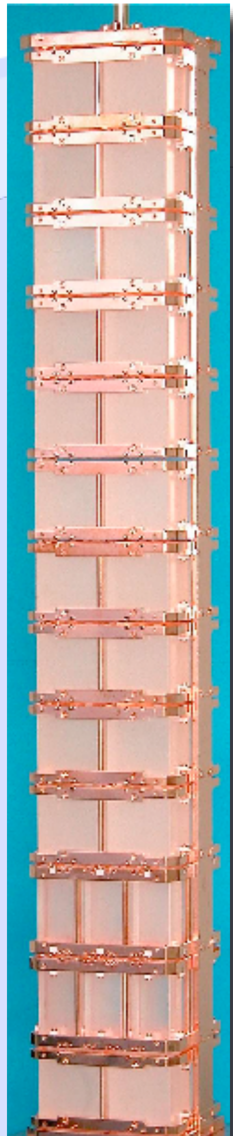
- ▲ wide choice of detector materials
- ▲ good energy resolution
- ▲ true calorimeters
- ▼ velocity

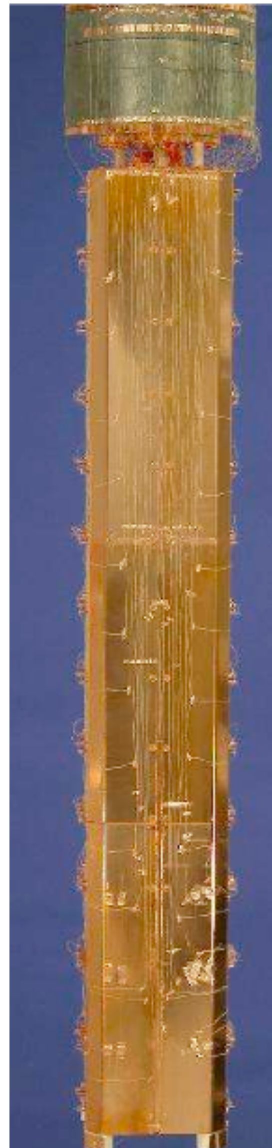
CUORICINO



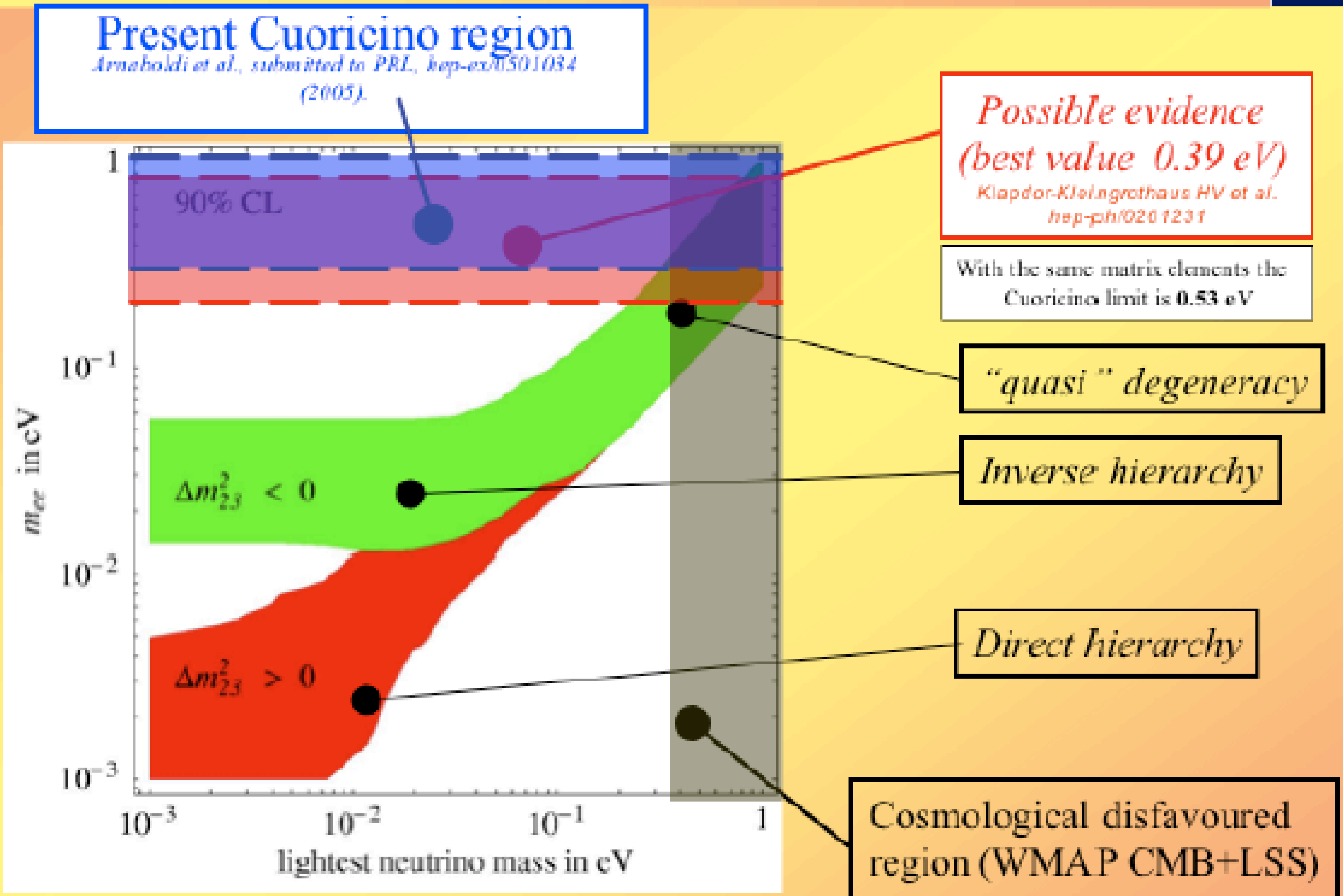


CUORICINO



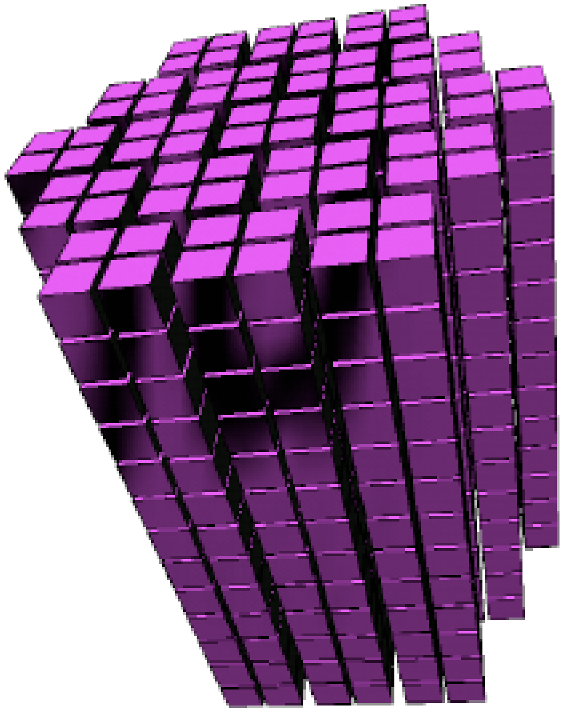


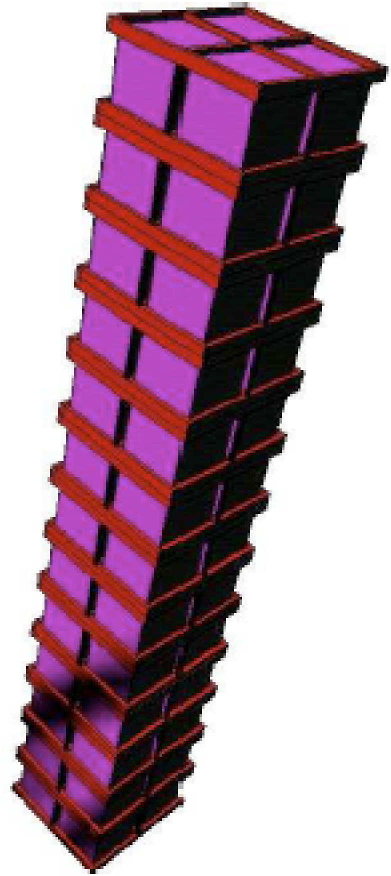
Cuoricino sensitivity



Feruglio F. , Strumia A. , Vissani F. hep-ph/0201291

- Cuoricino is presently the most sensitive DBD-0n running experiment, capable to confirm the KK-HM "evidence".
- Cuoricino demonstrates feasibility of a large scale bolometric detector (CUORE) with good energy resolution and bkg on many detectors.
- CUORE, a second generation detector developed on this new approaches, will be build and start up in the next 5 years.
- Recent results on background suppression confirm the capability to explore the inverse hierarchy mass region.

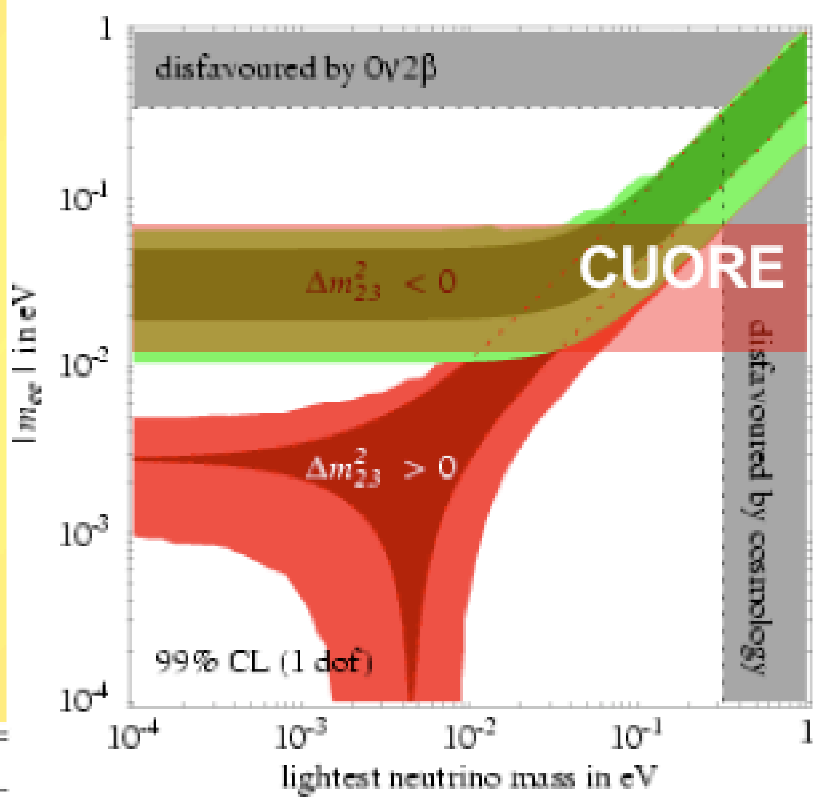




CUORE expected sensitivity

A.Strumia and F.Vissani.: hep-ph/0503246

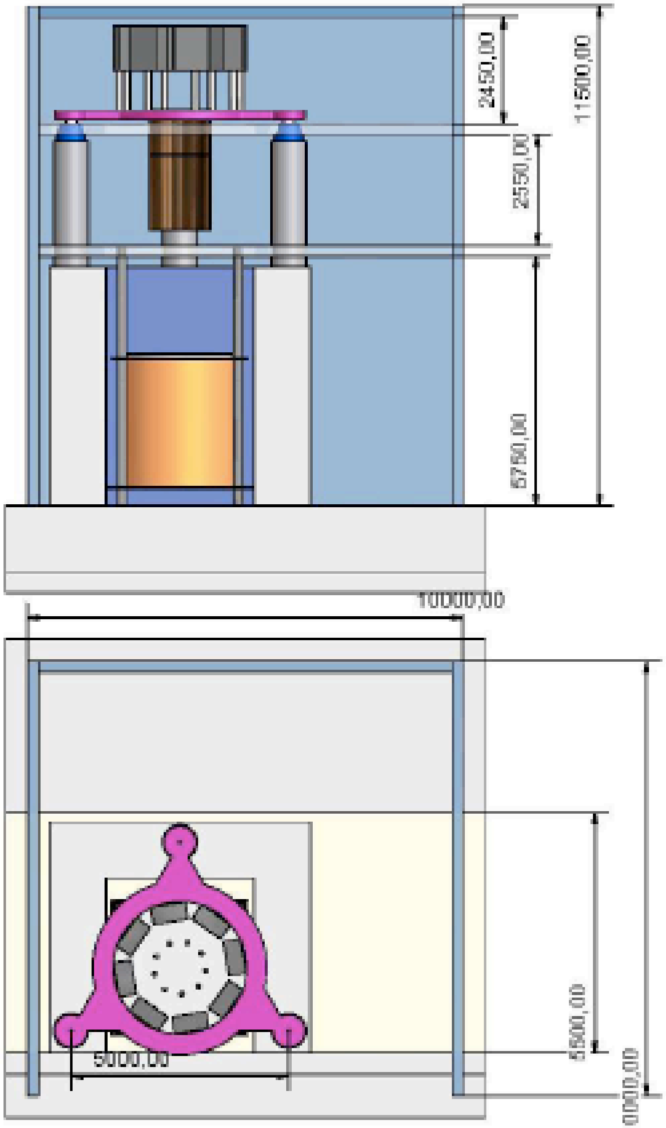
CUORE bb-0n sensitivity will depend strongly on the background level and detector performance.

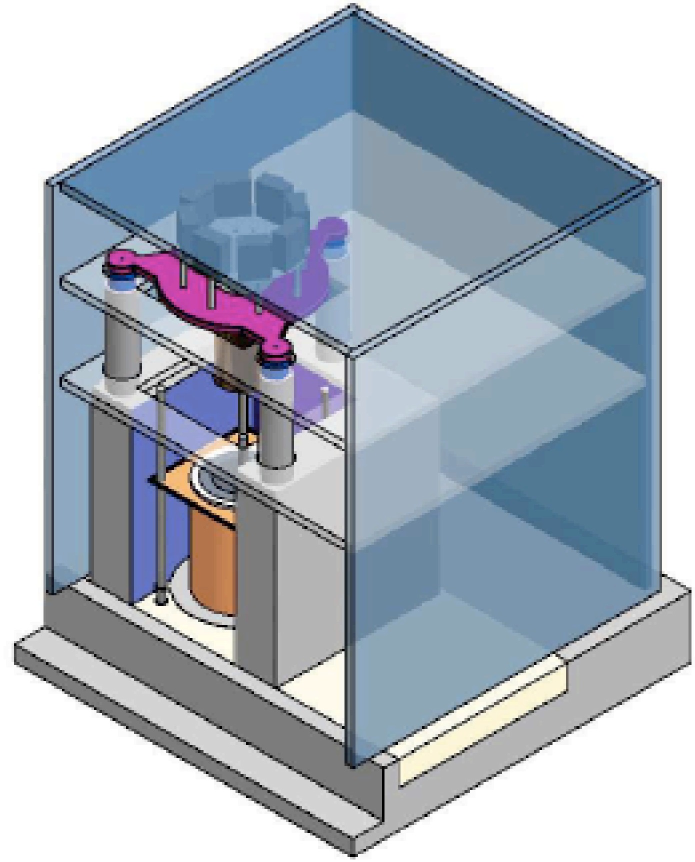


In five years:

B(counts/keV/kg/y)	Δ(keV)	$T_{1/2}$(y)	$\lvert\langle m_\nu\rangle\rvert$ (meV)
0.01	10	1.5×10^{26}	23–118
0.01	5	2.1×10^{26}	19–100
0.001	10	4.6×10^{26}	13–67
0.001	5	6.5×10^{26}	11-57

Spread in $\langle m_\nu \rangle$ from nuclear matrix element uncertainty





Designed by Carlo Bucci	Checked by	Approved by - date		Date 11/11/2004	
		Hut12		Edition	Sheet 1 / 1

Ionization Detectors

COBRA - CdTe
GEM - (Ge Crystals in LN)
GENIUS - (Ge Crystals in LN)
Majorana - (Ge Crystals in Cryostat)
GERDA- (Ge Crystals in LN)

COBRA

10 kg of CdTe (CdZnTe) Detectors

Measure Several double-beta isotopes at once

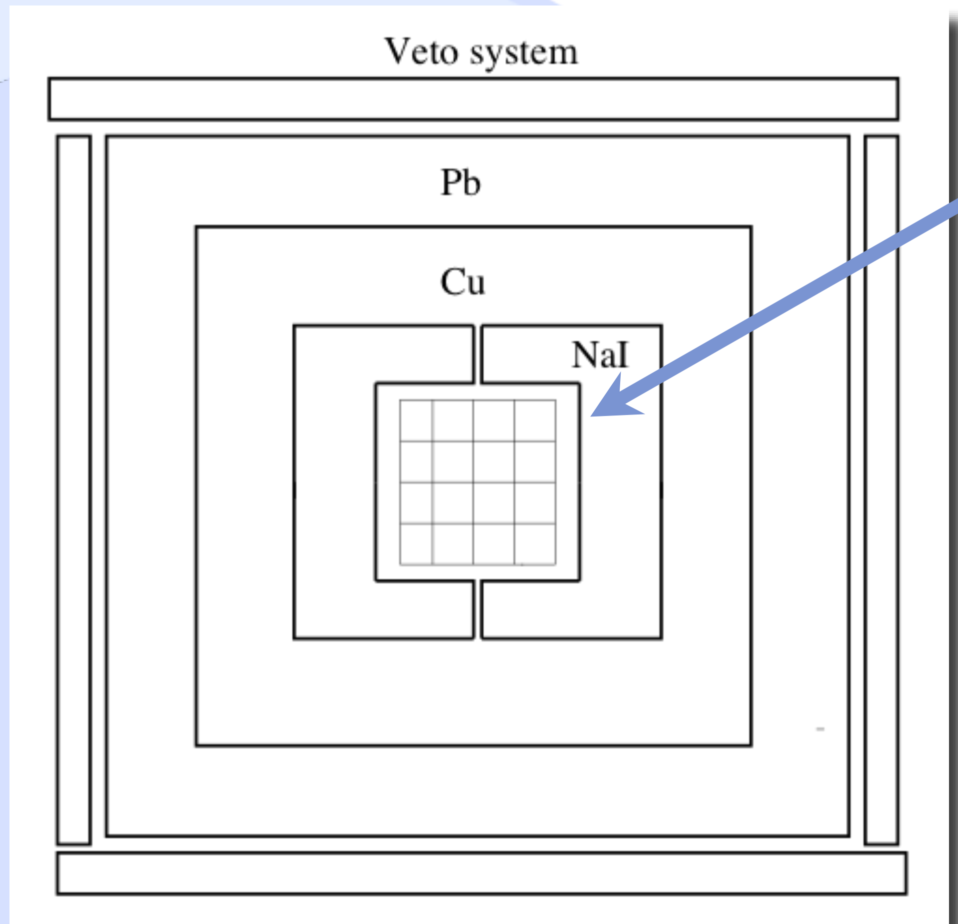
Systematic studies of Cd and Te isotopes

Rare beta decays of ^{113}Cd and ^{123}Te

Dark matter search

Slide adapted from presentation of K. Zuber at DESY Zeuthen, 19-21 June 2001

COBRA



CdTe - Array

1 cc crystals

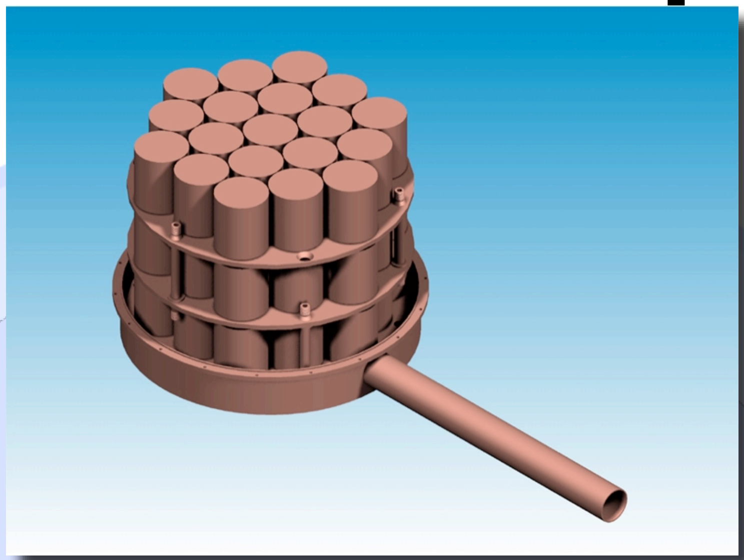
Option:

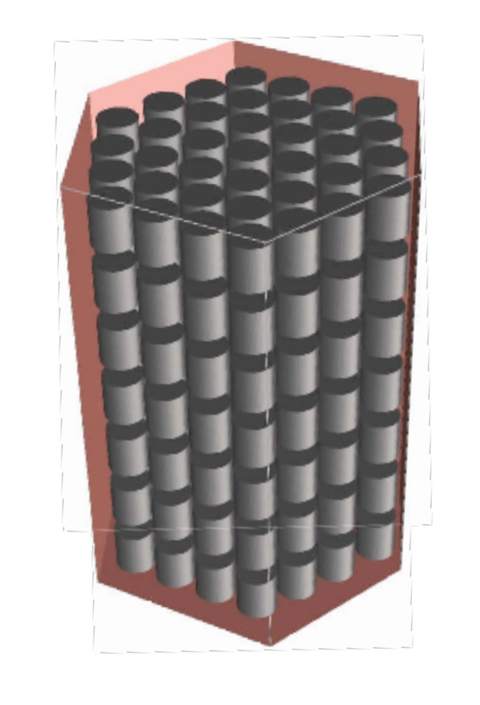
Pixel Detectors

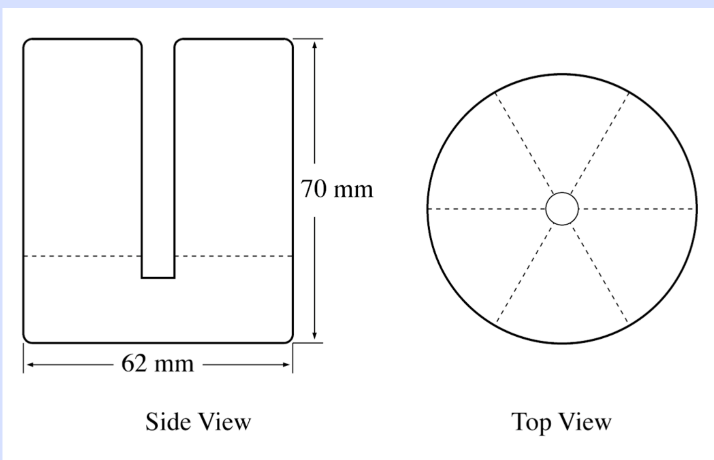
→ Tracking

Slide adapted from presentation of K. Zuber
at DESY Zeuthen, 19-21 June 2001

Majorana







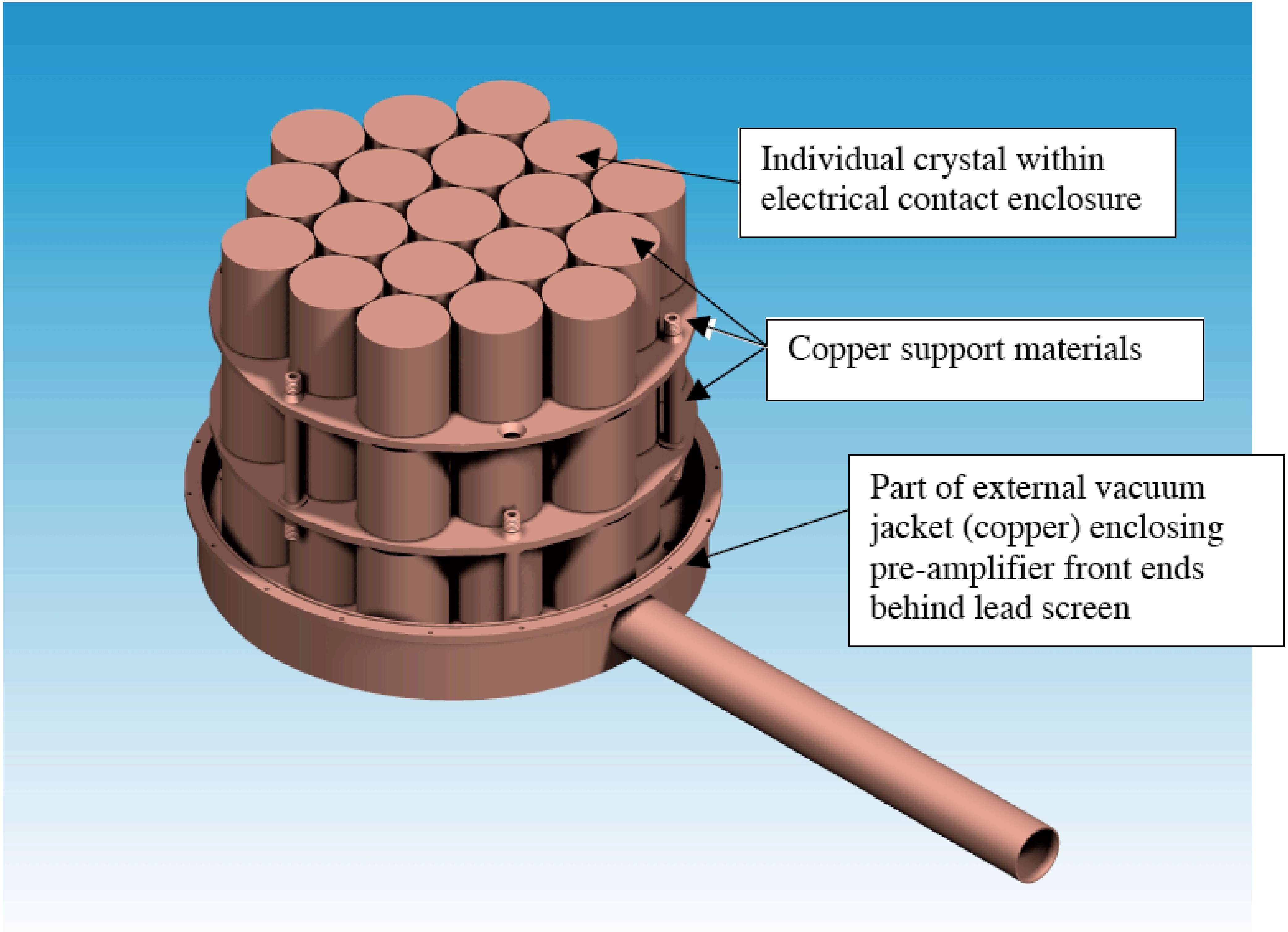


Figure 3-25. Highly-schematic view of close-packed arrangement of 57 germanium crystals inside a modular Majorana cryostat. Outer vacuum jacket is removed for clarity.

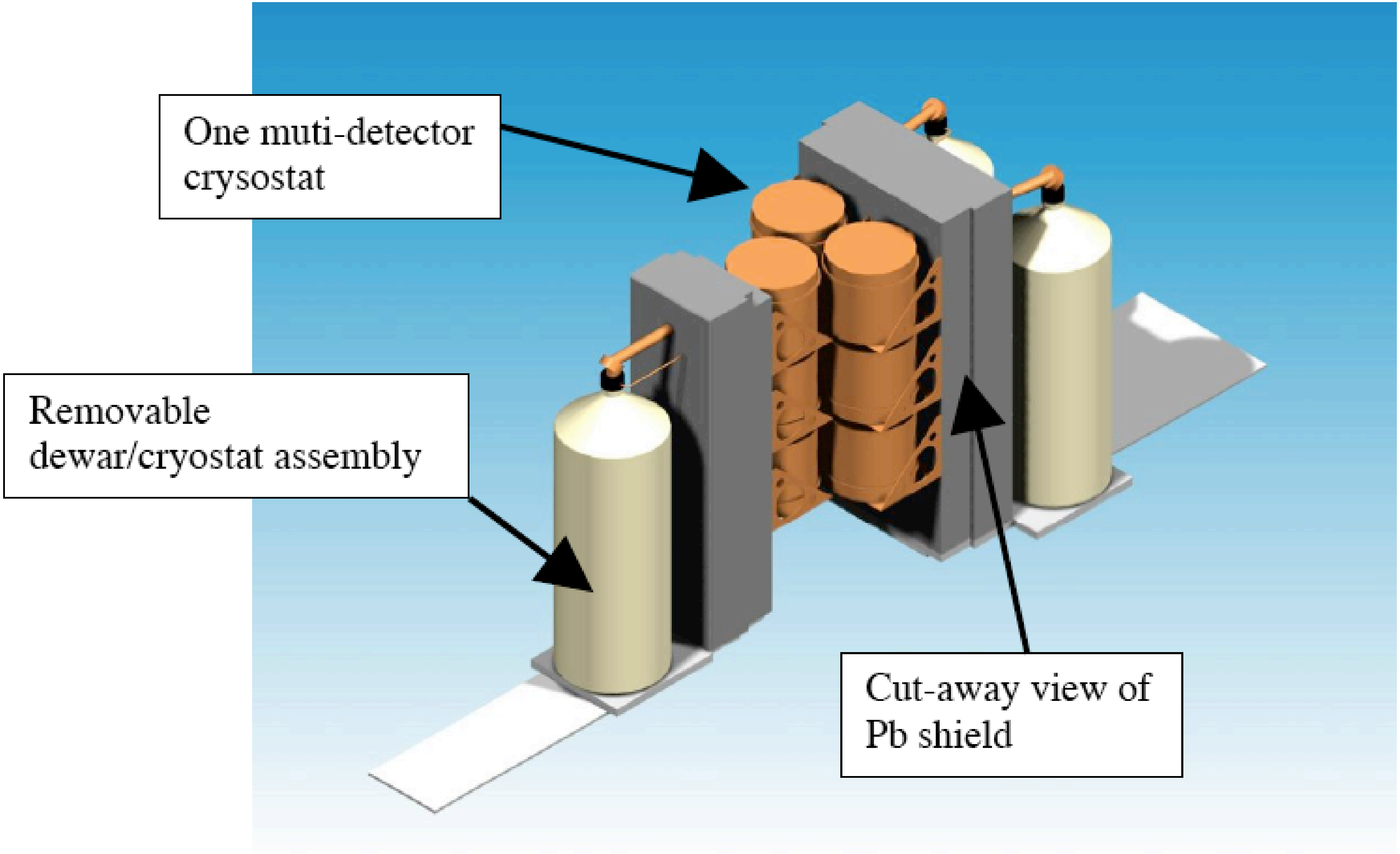
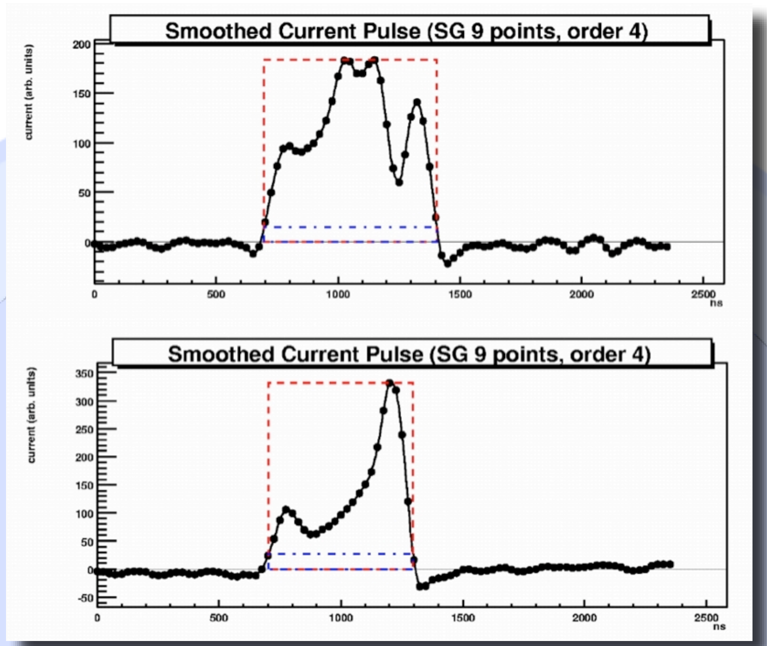
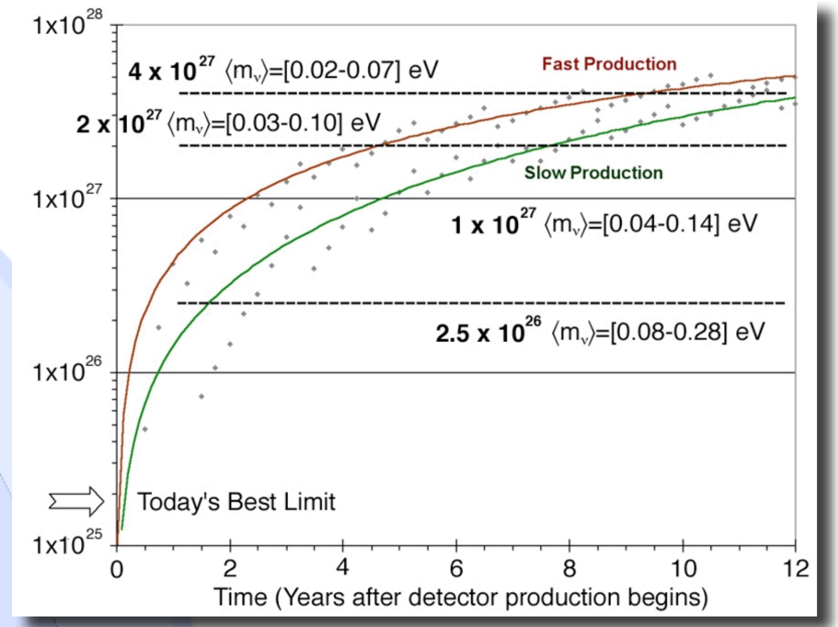
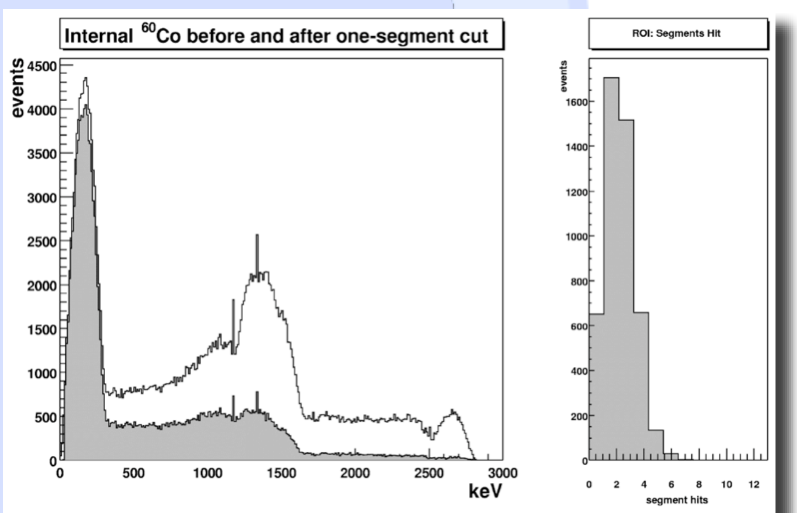


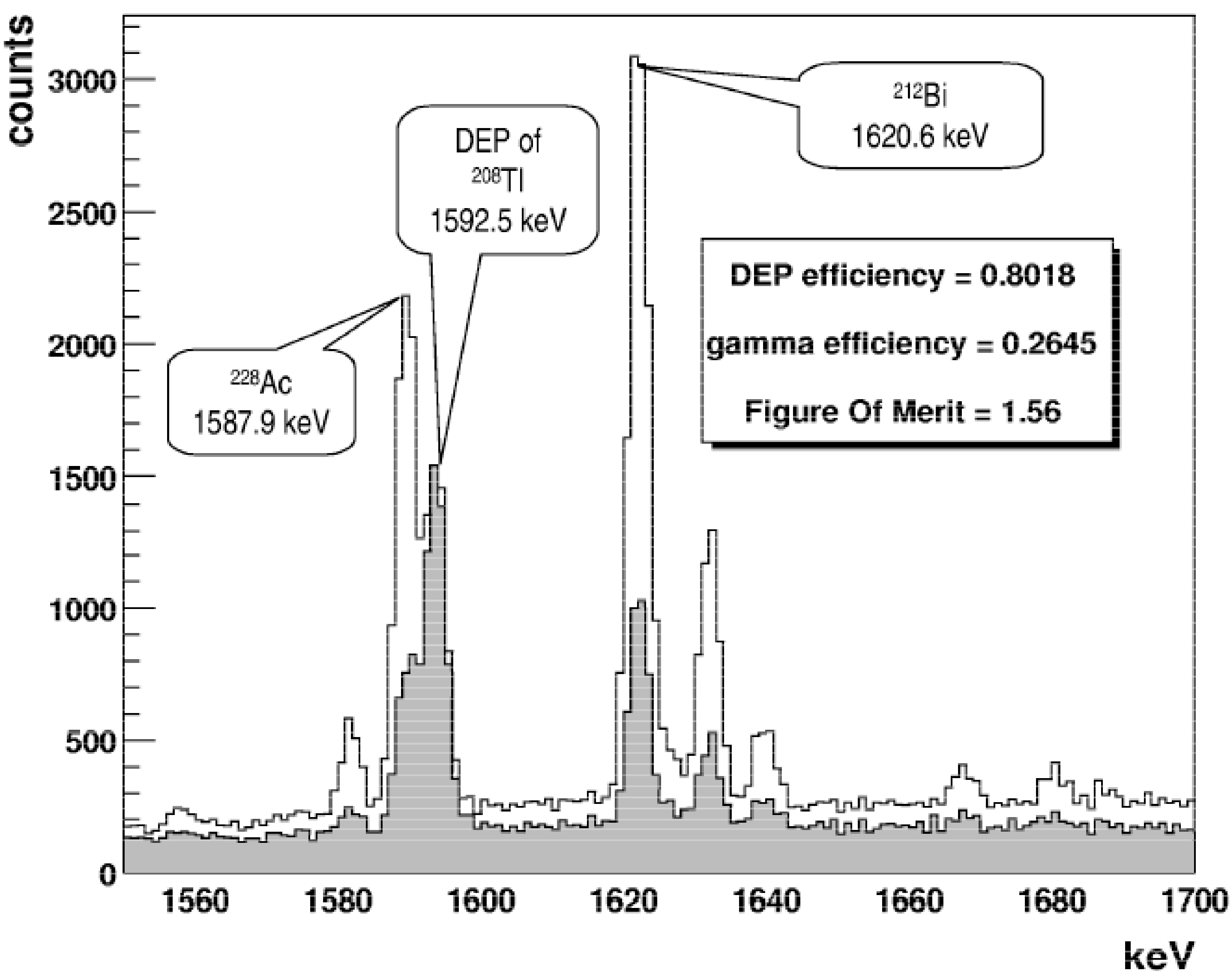
Figure 3-2. Majorana apparatus.

Majorana

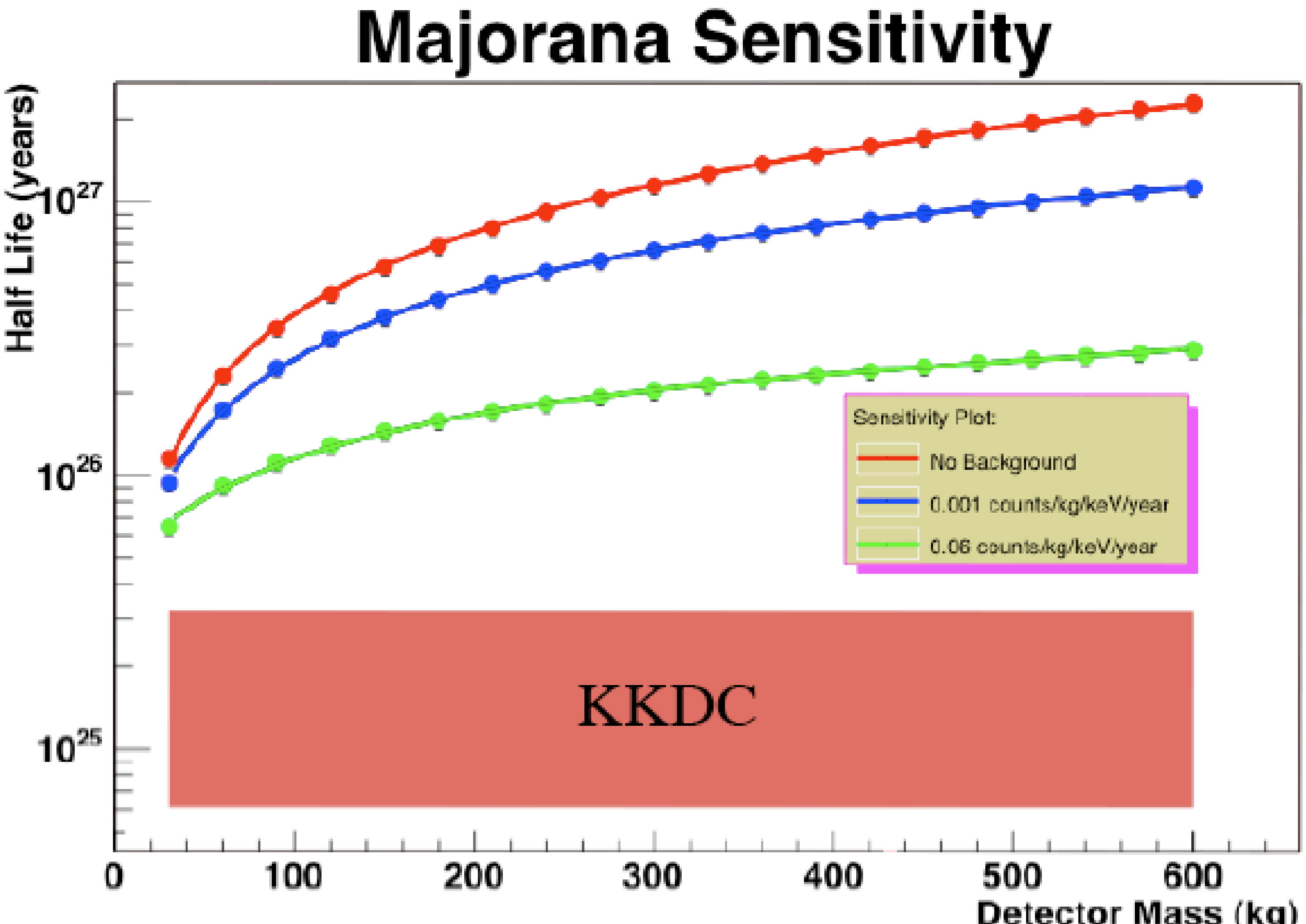

Smoothed Current Pulse (SG 9 points, order 4)
current (arb. units)
ns
Smoothed Current Pulse (SG 9 points, order 4)
current (arb. units)
ns


4 x 10^27 ⟨m_ν⟩=[0.02-0.07] eV
Fast Production
2 x 10^27 ⟨m_ν⟩=[0.03-0.10] eV
Slow Production
1 x 10^27 ⟨m_ν⟩=[0.04-0.14] eV
2.5 x 10^26 ⟨m_ν⟩=[0.08-0.28] eV
Today's Best Limit
Time (Years after detector production begins)


Internal 60Co before and after one-segment cut
events
keV
ROI: Segments Hit
events
segment hits



counts
3000
2500
2000
1500
1000
500
0
1560
1580
1600
1620
1640
1660
1680
1700
keV
DEP of
208Tl
1592.5 keV
212Bi
1620.6 keV
228Ac
1587.9 keV
DEP efficiency = 0.8018
gamma efficiency = 0.2645
Figure Of Merit = 1.56



Majorana Sensitivity
Half Life (years)
10^27
10^26
10^25
0
100
200
300
400
500
600
Detector Mass (kg)
Sensitivity Plot:
No Background
0.001 counts/kg/keV/year
0.06 counts/kg/keV/year
KKDC

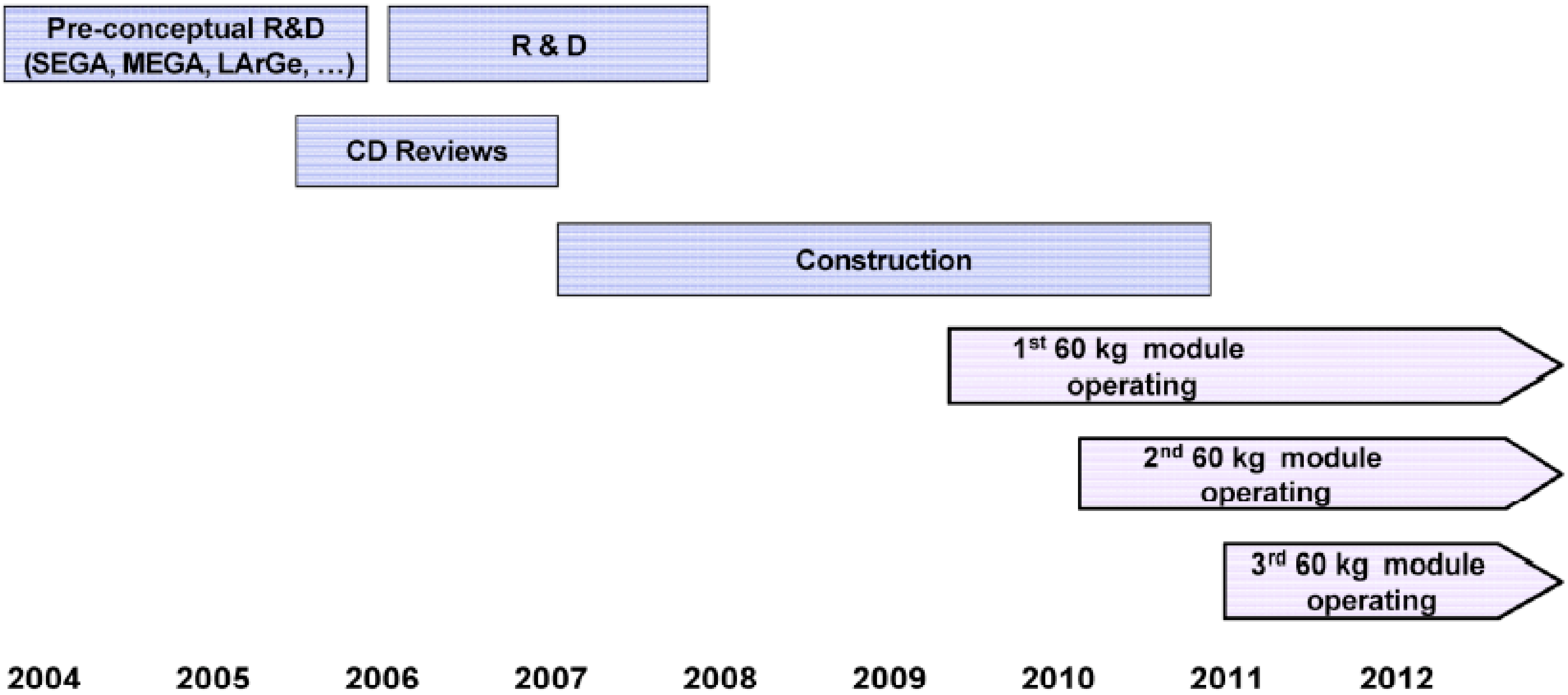
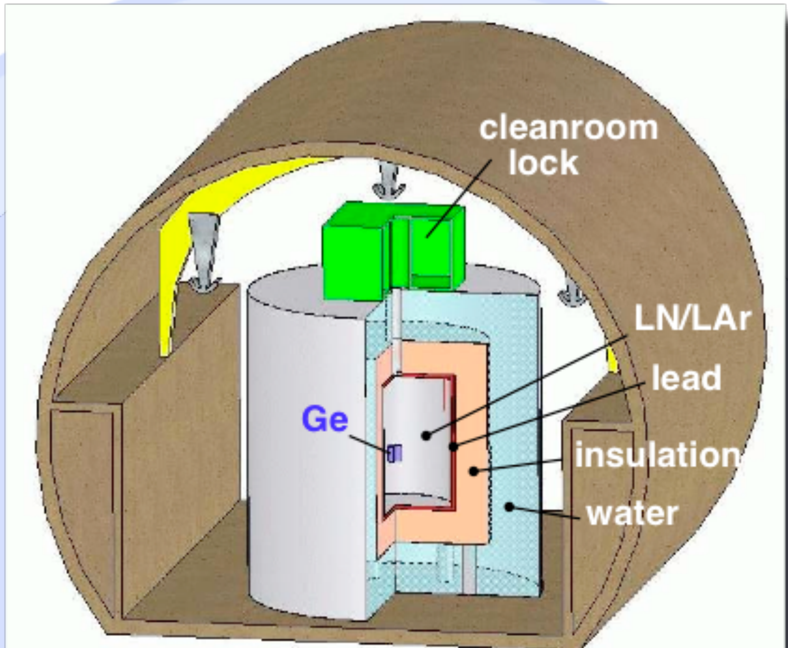


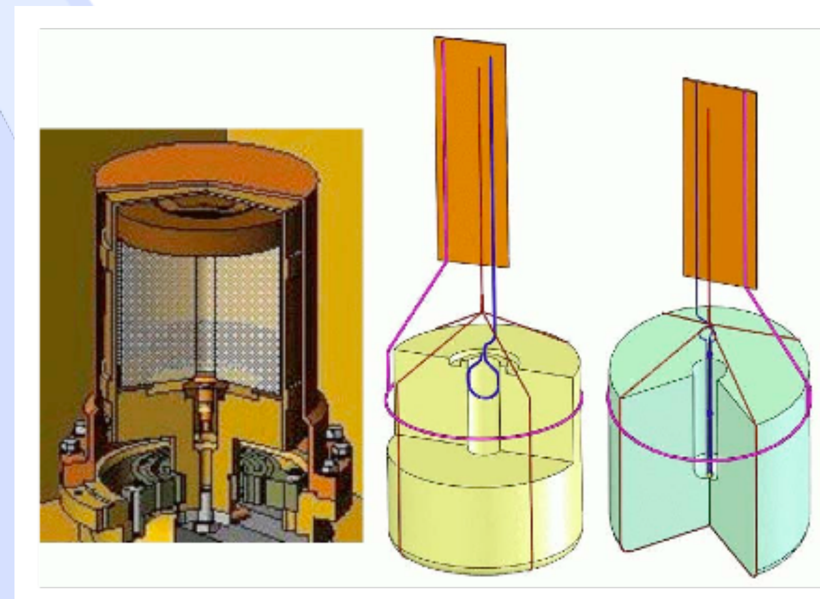
Figure 2 Proposed Schedule for Phase 1 Majorana

^{76}Ge Proposal for Gran Sasso GERDA

- Bare Ge detectors in pure LN/LAr
- Phase 1: ~ 20 kg, HM/IGEX; 86% ^{76}Ge
- Phase 2: Add 20 kg new enriched detectors
- Physics Reach
- Phase 1: refute claim at 99.6% or confirm at 5σ
- Phase 2: 10% measurement if KKDK correct. Push limit to 2×10^{26} years if not.
- Start construction early 2005
- Begin data acquisition 2006

MPI ^{76}Ge Proposal





The GERDA Collaboration

INFN LNGS, Assergi, Italy
A.Di Vacri, M. Junker, M. Laubenstein, C. Tomei, L. Pandola

JINR Dubna, Russia
V. Brudanin, V. Egorov, K. Gusev, S. Katulina, A. Klimenko, O. Kochetov, I. Nemchenok, V. Sandukovsky, A. Smolnikov, J. Yurkowski, S. Vasiliev,

MPIK, Heidelberg, Germany
C. Bauer, O. Chkvorets, W. Hampel, G. Heusser, W. Hofmann, J. Kiko, K.T. Knöpfle, P. Peiffer, S. Schönert, J. Schreiner, B. Schwingenheuer, H. Simgen, G. Zuzel

Univ. Köln, Germany
J. Eberth, D. Weisshaar

Jagiellonian University, Krakow, Poland
M.Wojcik

Univ. di Milano Bicocca e INFN, Milano, Italy
E. Bellotti, C. Cattadori

IMMR, Geel, Belgium
M. Hult

INR, Moscow, Russia
I. Barabanov, L. Bezrukov, A. Gangapshev, V. Gurentsov, V. Kusminov, E. Yanovich

ITEP Physics, Moscow, Russia
S. Belogurov, V.P. Bolotsky, E. Demidova, I.V. Kirpichnikov, A.A. Vasenko, V.N. Kornoukhov

Kurchatov Institute, Moscow, Russia
A.M. Bakalyarov, S.T. Belyaev, M.V. Chirchenko, G.Y. Grigoriev, L.V. Inzhechik, V.I. Lebedev, A.V. Tikhomirov, S.V. Zhukov

MPP, München, Germany
I. Abt, M. Altmann, C. Büttner. A. Caldwell, D. Kollár, K. Kroeninger, X. Liu, B. Majorovits, H.-G. Moser, R.H. Richter

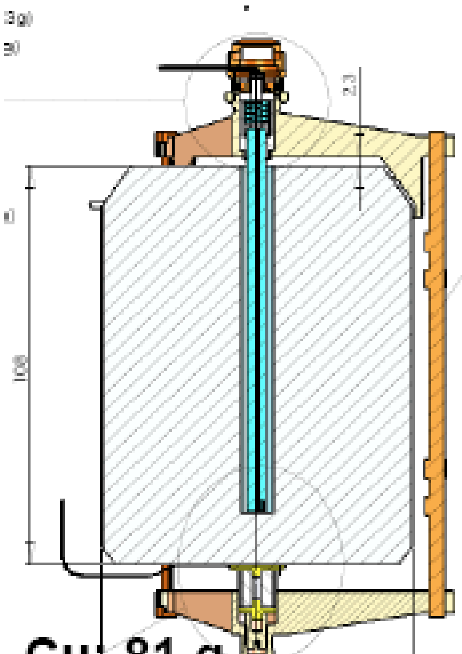
Univ. di Padova e INFN, Padova, Italy
A. Bettini, E. Farnea, C. Rossi Alvarez, C.A. Ur

Univ. Tübingen, Germany
M. Bauer, H. Clement, J. Jochum, S. Scholl, K. Rottler

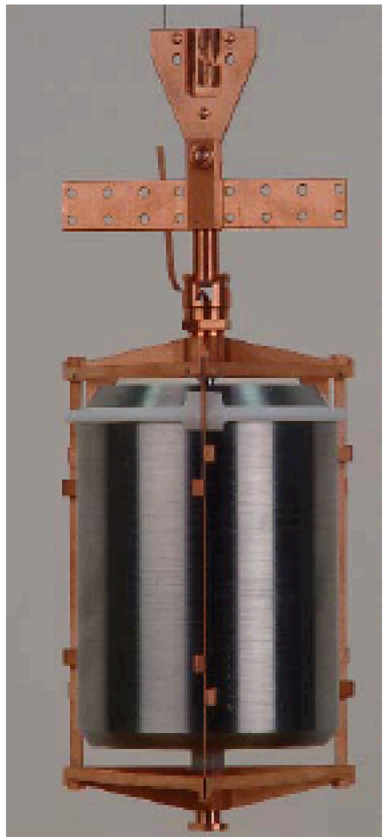
Germanium Detectors I

Phase I:

- p type crystals
- <2 kg per detector



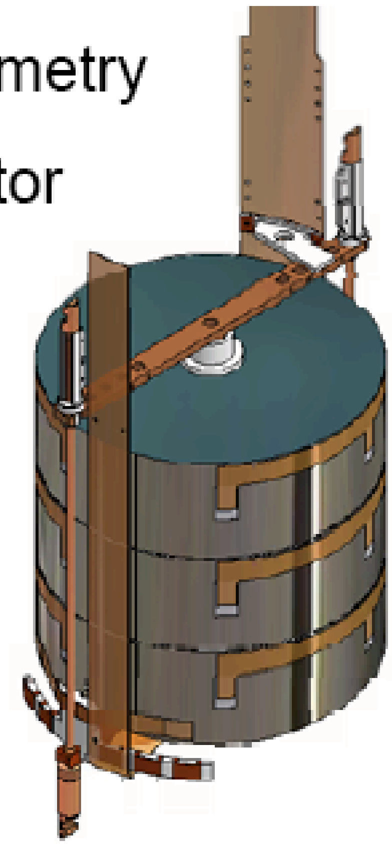
Cu: 81 g
PTFE: 6.4 g
Si: 4.2 g



Prototype

Phase II:

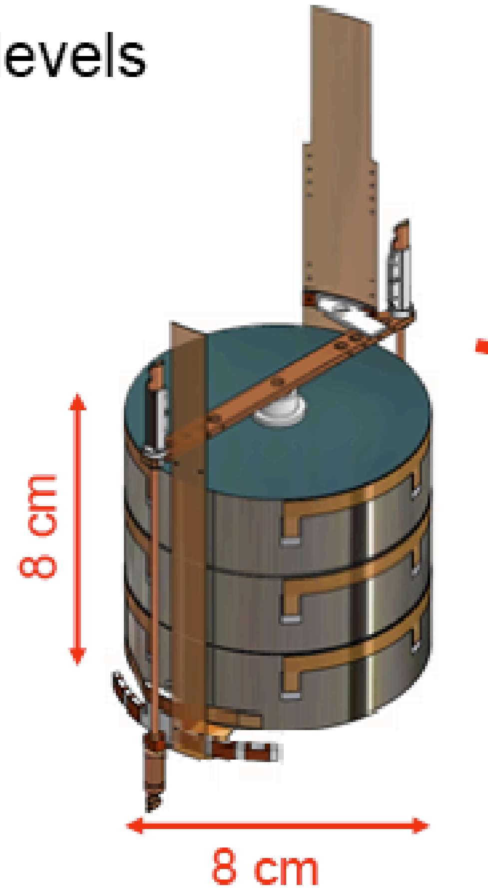
- n type crystals
- „true-coaxial" geometry
- ~2.1 kg per detector
- ***lithographic segmentation***
  3 z x 6 φ = 18
- Light holders
  (~31+6 g)

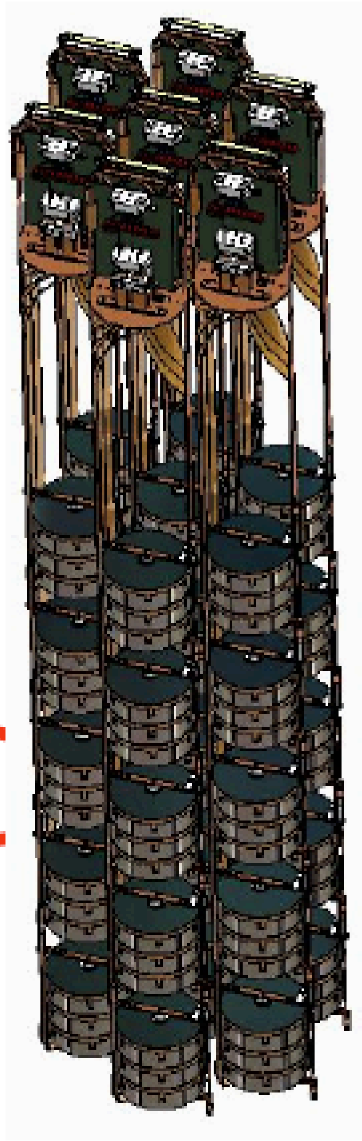


Germanium Detectors II

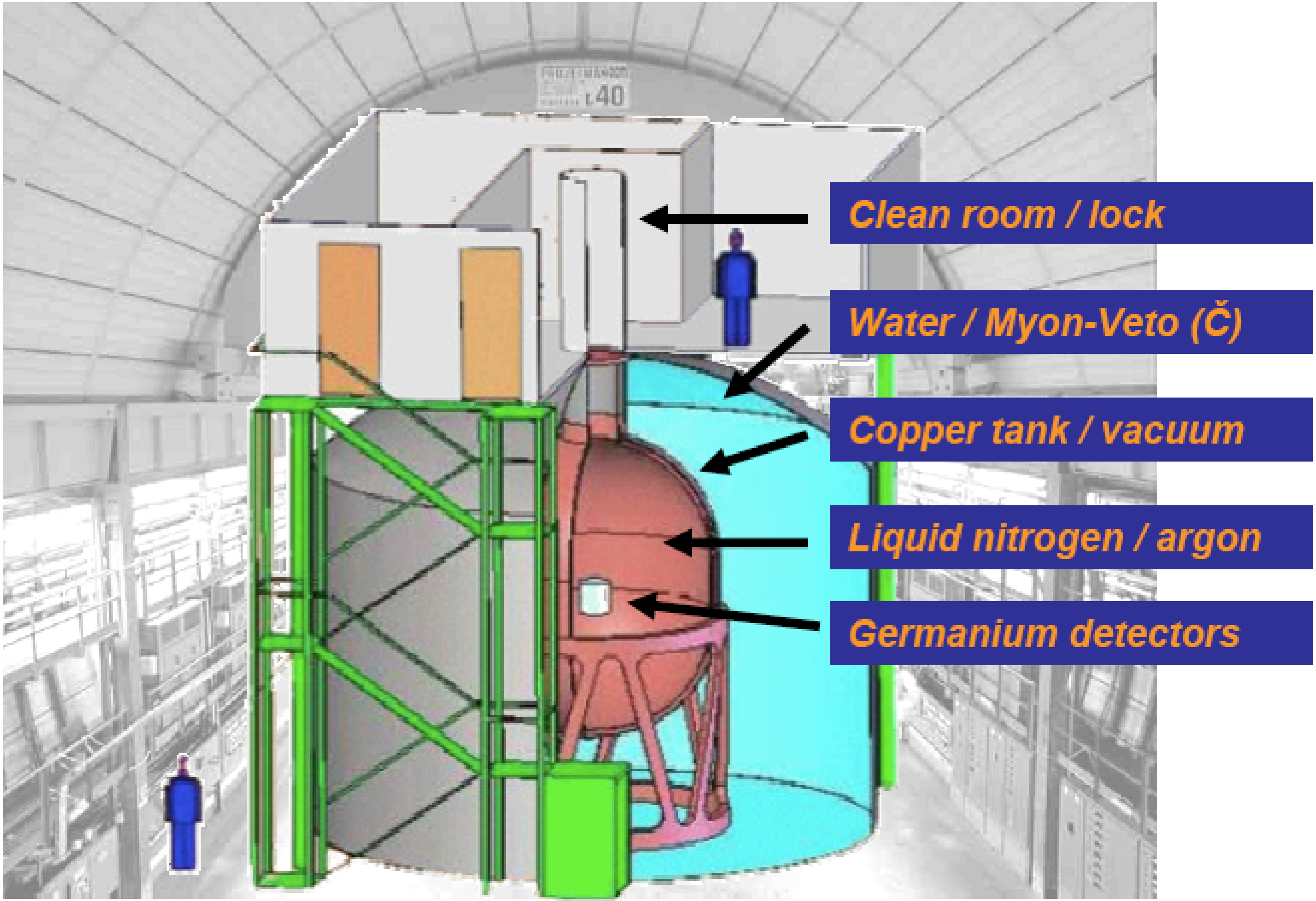
GERDA = GERmanium Detector Array

- Hexagonally placed detectors
- 3 - 5 levels





The GERDA Experiment II



Physics Potential

3 Phase approach:

- ***Phase I:***

~15 kg detectors (HdM, IGEX)

background ~10^{-3} counts/kg/keV/y

- ***Phase II:***

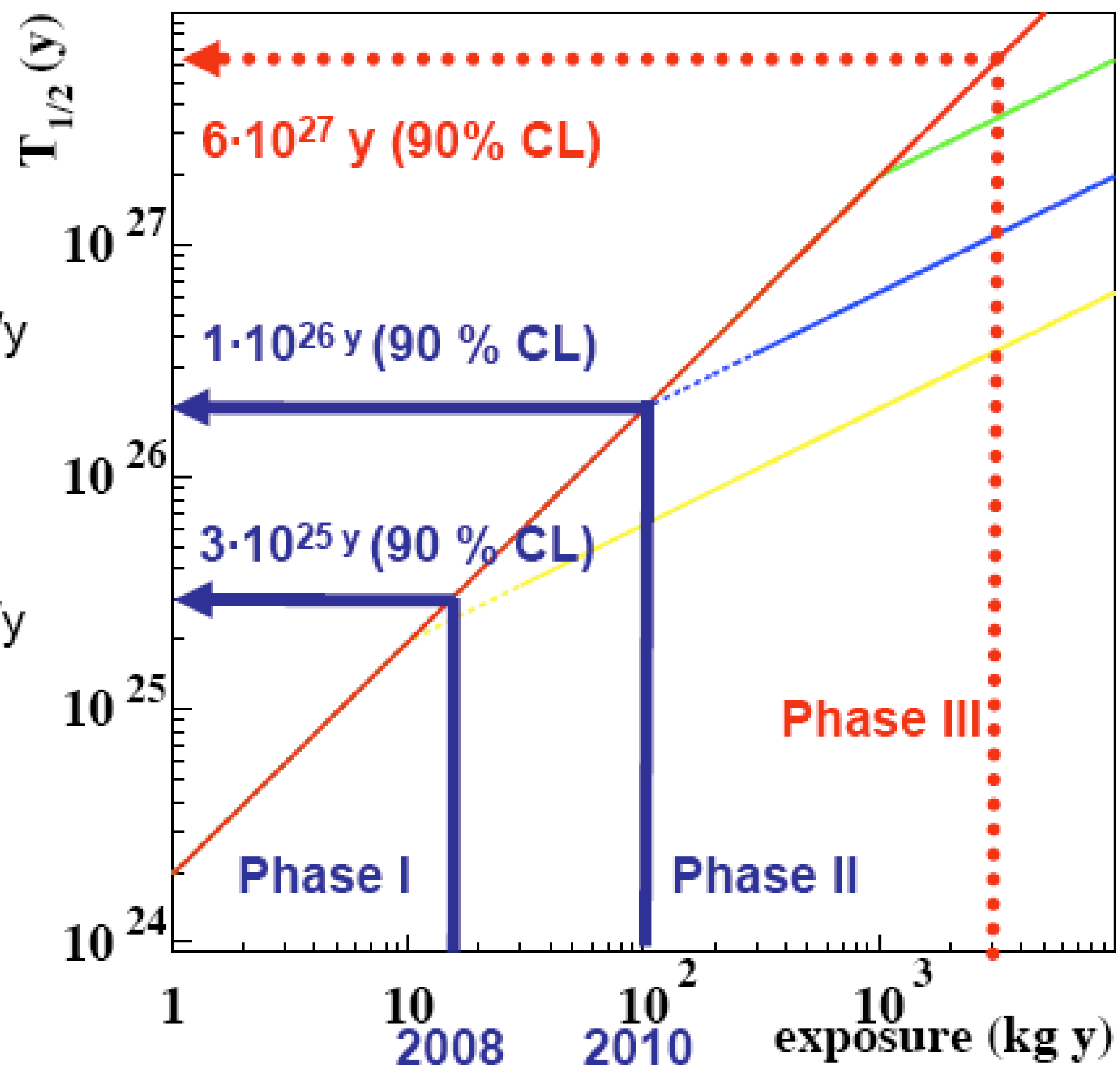
additional ~25 kg germanium

background ≤10^{-3} counts/kg/keV/y

- ***Phase III:***

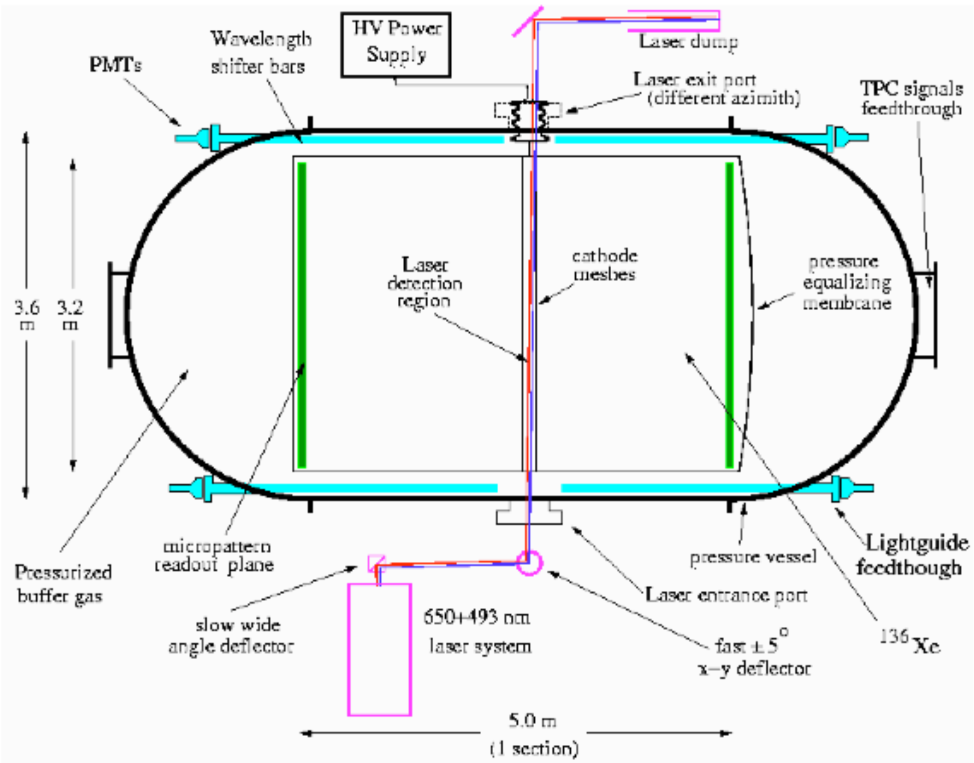
collaboration with MAJORANA

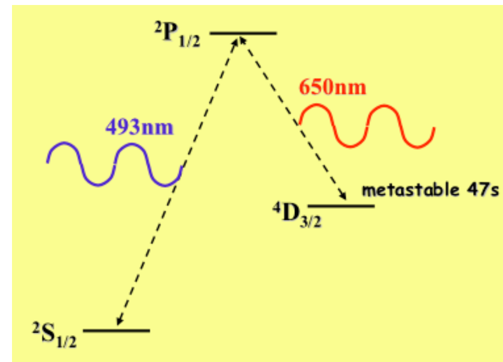
~500 kg germanium

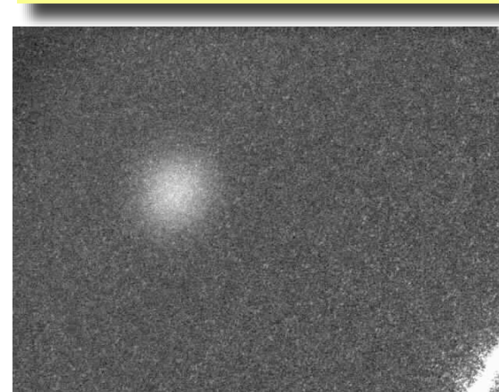


EXO

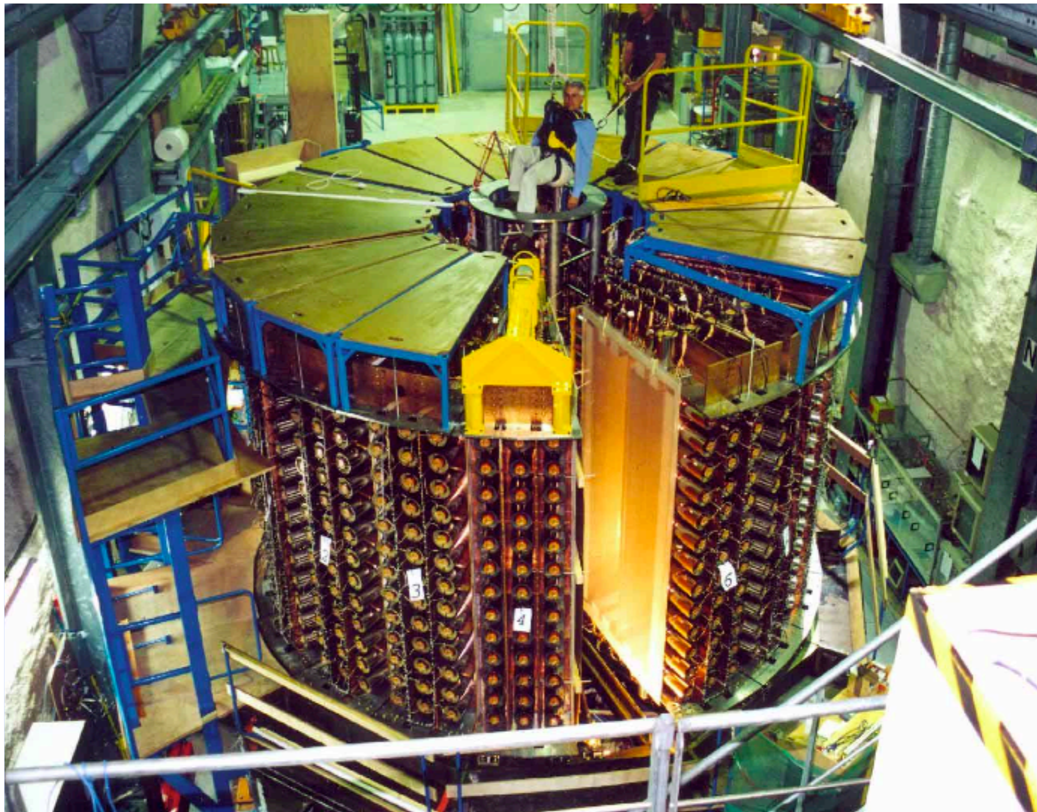
Conceptual scheme of a high pressure Xe gas TPC with laser tagging

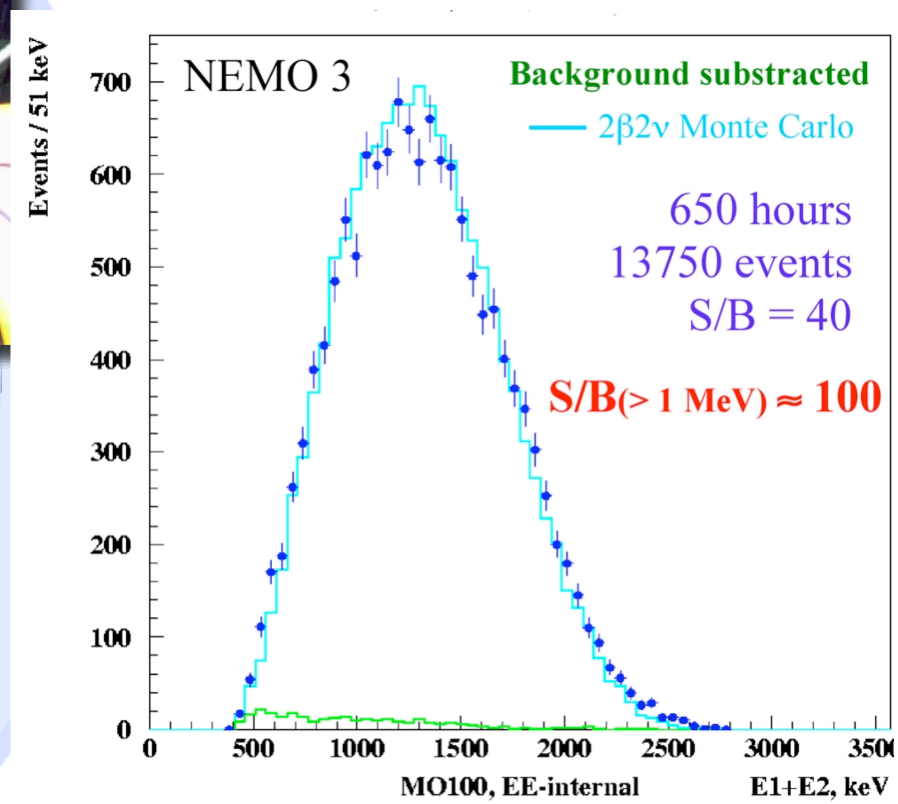






NEMO





NEMO 3
Background substracted
2β2ν Monte Carlo
650 hours
13750 events
S/B = 40
S/B(> 1 MeV) ≈ 100
Events / 51 keV
MO100, EE-internal
E1+E2, keV

The Super-NEMO Double-Beta Decay Expression of Interest

At least 10 times the capacity of NEMO-3

~ 100 kg of enriched isotopes

Sensitivity $\langle m_\nu \rangle \sim 30 \; \text{meV}$

^{82}Se, ^{100}Mo, ^{116}Cd, ^{130}Te, ^{136}Xe

Sample Figures of Merit

$$\epsilon = 0.8 \qquad b = 0.005$$

500 kg of Ge enriched to 86% ^{76}Ge

$$f = \frac{(0.73)(0.86)(0.8)}{76}\sqrt{\frac{500}{(0.005)(4)}} \simeq 1.05$$

760 kg of TeO_2 nat. ab. 33.8% ^{130}Te

$$\epsilon = 0.84 \qquad b \simeq 0.01 \qquad f = 0.89$$

122 kg of TeO_2 enriched to 85% ^{130}Te

$$\epsilon = 0.84 \qquad b \simeq 0.01 \qquad f = 0.90$$

Large Tracking Detector (Super NEMO?)

$$M = 100\ kg \quad a = 0.9 \quad \epsilon = 0.3 \quad b = 0.003 \quad \delta E = 125\ keV$$

$$f = \frac{\overline{\eta} a \epsilon}{W} \sqrt{\frac{M}{b\ \delta E}} = \frac{\overline{\eta}}{W}(4.4)$$

^{82}Se: $\frac{\overline{\eta}}{W} = \frac{1.7}{82} = 0.002$ $\quad f \simeq 0.09$

^{150}Nd: $\frac{\overline{\eta}}{W} = \frac{57}{150} = 0.38$ $\quad f \simeq 1.7$

Target Half-Lives for $\langle m_\nu \rangle = 0.04$ eV

Isotope	$T^{0\nu}_{1/2}$
^{48}Ca	3.0×10^{27}
^{76}Ge	2.3×10^{27}
^{82}Se	9.4×10^{26}
^{100}Mo	1.6×10^{26}
^{116}Cd	1.3×10^{27}
^{130}Te	3.9×10^{26}
^{136}Xe	5.8×10^{27}
^{150}Nd	2.9×10^{25}

Table of Decay Rates for Various Candidate Nuclides
For an Effective Majorana Mass $|\langle m_\nu \rangle| = 40$ milli eV

ISOTOPE FORM	$\lambda_{0\nu\beta\beta}(y^{-1})$	$N\lambda_{\beta\beta}(ton^{-1}\ y^{-1})$	Abund.(%)
$^{48}CaWO_4$	2.3(-28)	0.31	80 %
$^{48}CaF_2$	2.3(-28)	0.0033	0.187 %
^{76}Ge	3.0(-28	3.0	86%
$^{82}SeO_2$	7.4(-28)	3.4	85 %
^{100}Mo	2.1(-27)	11.0	90 %
$^{116}CdWO_4$	5.3(-28)	0.7	80 %
$^{130}TeO_2$	1.8(-27)	2.3	33.8 %
$^{130}TeO_2$	1.8(-27)	5.8	85%
^{136}Xe	1.2(-28)	0.43	80%
$^{150}NdO_3$	2.4(-26)	35.0	85%

RECENT NUCLEAR STRUCTURE CALCULATIONS BY V. RODIN, A. FAESSLER, F. SIMKOVIC AND PETR VOGEL

arXiv:nucl-th/0503063 v1 25 March 2005

QRPA (RQRPA) setting g_{pp} to the value that correctly predict the experimental $2\nu\beta\beta$ – decay half-life.

Predicted ratios of decay rates, Γ, for $0\nu\beta\beta$ – decay for a given value of $\langle m_\nu \rangle$:

$\Gamma(^{130}Te/^{76}Ge) = 1.65$

$\Gamma(^{100}Mo/^{76}Ge) = 1.72$

$\Gamma(^{82}Se/^{76}Ge) = 3.06$

$\Gamma(^{150}Nd/^{76}Ge) = 20.6$

$\Gamma(^{150}Nd/^{76}Ge) = 12.5$

$\Gamma(^{100}Mo/^{130}Te) = 1.04$

$\Gamma(^{136}Xe/^{76}Ge) = 1.14$ **(These values are for g_A=1.00)**

For $\langle m_\nu \rangle$ = 50 milli Volts, $\tau^{-1}(^{76}Ge) = 2.78 \times 10^{-27}\ y^{-1}$

COMPARRISON WITH RODIN et al.

	New Values	Average Values
$^{130}Te/^{76}Ge$	1.65	5.53
$^{82}Se/^{76}Ge$	3.06	2.33
$^{100}Mo/^{76}Ge$	1.72	6.84
$^{150}Nd/^{76}Ge$	20.6	78.1
$^{136}Xe/^{76}Ge$	1.14	0.74

New $\langle m_{ee} \rangle$ =50 meV, $T^{1/2}(0v, {}^{76}Ge)$= $2.5x10^{26}$ y

Old $T^{1/2}$= $2.7x\ 10^{27}$ y

Conclusions (cont.)

Many good ideas of a few years ago are out of date.

The target Mass is now 55 meV to cover the inverted hierarchy.

Only experiments that can do this will be competitive, but,

This is a worse case scenario!

A More Positive View

We do not really know the mass of the lightest neutrino mass eigenstate !

Just the observation of the neutrinoless double-beta decay process would have great impact !

Could KKDK be correct ? Test it!

Angel is no longer with us but he has made a lasting list of contributions while working with many of us throughout the world. We all miss him.

Next we will hear from Julio Morales about what I would call:

the "ANGEL MORALES CANFRANC UNDERGROUND LABORATORY"?


IL LAVORO MI PERSEGUITA,
MA IO SONO PIU' VELOCE!