CUORICINO lastest results and background analysis

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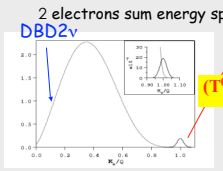
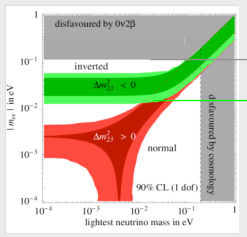
DOUBLE BETA DECAY RESEARCH

$DBD0\nu$: $(A,Z) \rightarrow (A,Z+2) + 2e^-$

- neutrino nature
- neutrino absolute scale
- mass hierarchy
- CP phases
- L violation

2 electrons sum energy spectrum



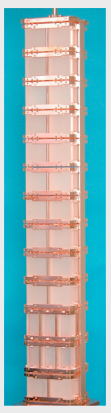


Actual $DBD0\nu$ experiments sensitivity

Required sensitivity for 2nd generation $DBD0\nu$ experiments: 10^{-2} eV

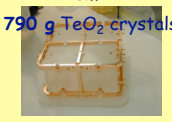
CUORICINO SET-UP

40.9 kg of TeO_2: the chosen nucleus is ^{130}Te



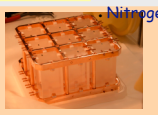
11 modules of 4 5x5x5 cm^3

790 g TeO_2 crystals



Mounted inside a dilution refrigerator (T≈10mK)

- Internal Roman Lead and Cu shields
- Borated PET shield
- External 20 cm Lead Shield
- Faraday Cage
- Nitrogen overpressure



2 modules of 9 3x3x6 cm^3

330 g TeO_2 crystals

4 enriched: 2 in ^{130}Te, 2 in ^{128}Te

STATISTICS:

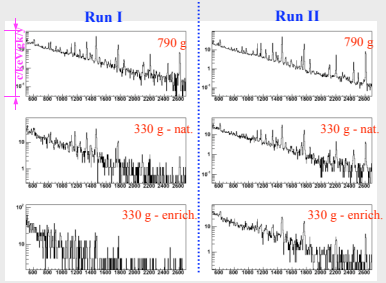
April 2003 - May 2006

8.38 kg ^{130}Te * y: Live-Time ~ 33%

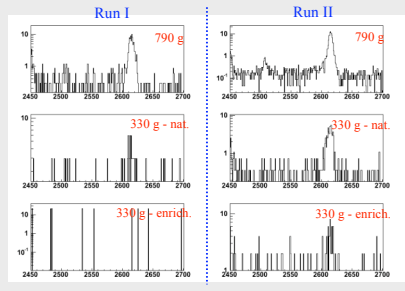
Bkg Live Time in "standard conditions" ~ 60%

Big stop between run1 and run2 in order to recover lost detectors

Gamma region



Double Beta Decay Region



Calculation of the half life life limit:

Fit with N gaussian + flat bkg

to account for the different energy resolutions we use -as response function - the sum of N Gaussians (N= number of detectors) having each a FWHM equal to the average FWHM measured (on the 2615 keV line of Th source) for that detector during the run considered

2505 keV peak included in the fit

the sum peak of the ^{60}Co gamma lines is ~ 3 FWHM away from the 0nDBD, therefore cannot be excluded from the fit region

Maximum Likelihood procedure:

likelihood of the 6 spectra are combined toghether

Big – Small – Enriched crystals are kept separated because of:

- different efficiency and i.a.
- different background

run I and run II are kept separate bacause of:

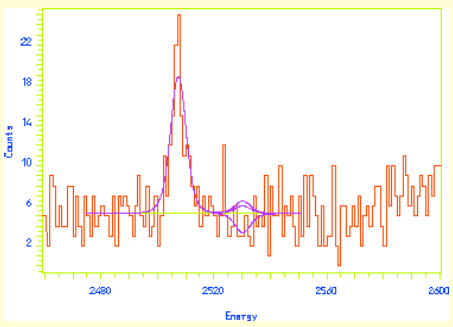
- different energy resolution
- different detectors

8.38 kg $^{130}Te \cdot y$

- **fit interval = 2475 – 2550 keV**
- **DBD transition energy = 2530.3 keV**
- **flat bkg**

free parameters { ^{60}Co peak intensity and position; $DBD0\nu$ peak intensity + bkg coefficients

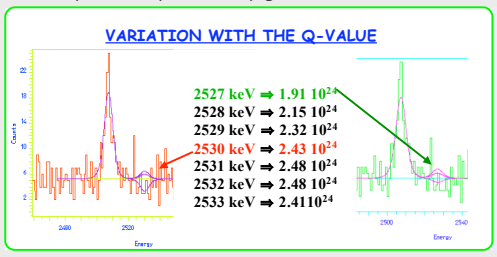
$\tau_{1/2} > 2.4\ 10^{24}$ at 90% C.L.



Sistematics to consider:

- The energy transition (Q-value) has large errors (+/- 2 keV)
- Which is the energy calibration error ?
- The background IS NOT flat
- Is the peak shape exactly gaussian ?

VARIATION WITH THE Q-VALUE



BACKGROUND ANALYSIS:

By analysing **coincidences**, **rates** in different energy regions, gamma and alpha **peaks** position, intensity, rates and shapes and by comparison of the **measured spectrum** (coincidence and anticoincidence) with **MonteCarlo** (GEANT4) spectra obtained for different sources and localizations

the most probable sources contributing to the measured bkg can be identified:

Gamma lines:

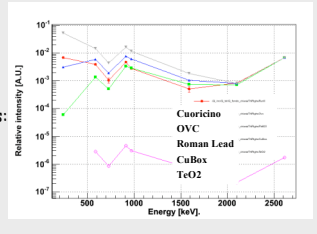
All the gamma lines observed in the measured spectrum are identified:

the lines are due to isotopes from ^{232}Th and ^{238}U chains, ^{40}K, cosmogenic material activation (^{60}Co, ^{54}Mn, ^{58}Co), TeO_2 neutron activation, fallaut elements (^{137}Cs, ^{207}Bi)

^{208}Tl line at 2615 keV:

By comparison of the measured spectrum with MC simulations of ^{232}Th contaminations in different experimental parts we concluded that at least two sources are needed to explain all the ^{232}Th gamma line intensities:

- one near to the detector (Cu surface), responsible of the low energy lines
- one far away (cryostat parts), responsible of the high energy lines and of the ^{208}Tl line at 2615 keV.



Alpha peaks position and shape :

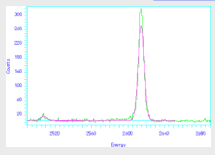
Sharp { E=α+R => crystal bulk; E=α => thin surface layer (crystals or facing materials)

With low energy tail => thick surface layer (crystals or facing materials)

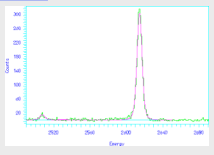
Flat continuum 3-4 MeV (0.122 +/- 0.003 c/keV/kg/y) :

From the coincidence/anticoincidence study and comparisons with MC spectra we concluded that the main fraction of the counts in this region is due to sources outside the crystal, the most probable one being Cu surface.

PEAK SHAPE:



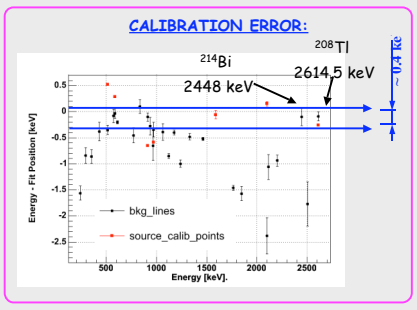
single simmetric gaussian *FWHM evaluation from sum bkg spectrum*



N simmetric gaussians *FWHM evaluation from source measurement spectra*

... however no change in the limit evaluation using the one or the other response function

CALIBRATION ERROR:



Sources identified as possible responsible for the bkg in the $DBD0\nu$:

- β and α from TeO_2 surface
- β and α from surface of materials facing the crystals (the bigger surface is Cu)
- ^{208}Tl multi-compton events

(^{232}Th contaminations of distant parts)

Estimated contributions to the DBD0n region:

	@DBD	3-4 MeV
TeO_2 surface	~ 10 ± 10 %	20 +/- 10%
Cu surface	~ 50 ± 20 %	80 +/- 10%
Th on the set-up	~ 30 ± 10 %	--