First Results of the Cuoricino Experiment

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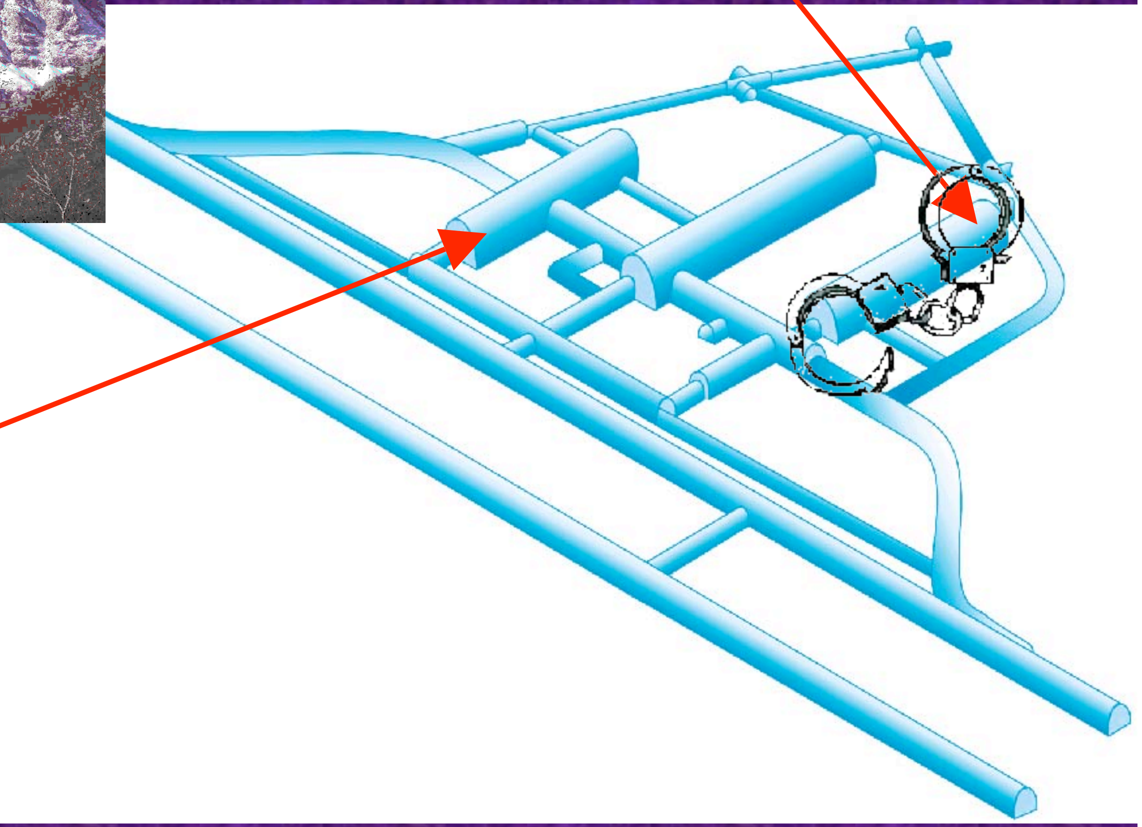
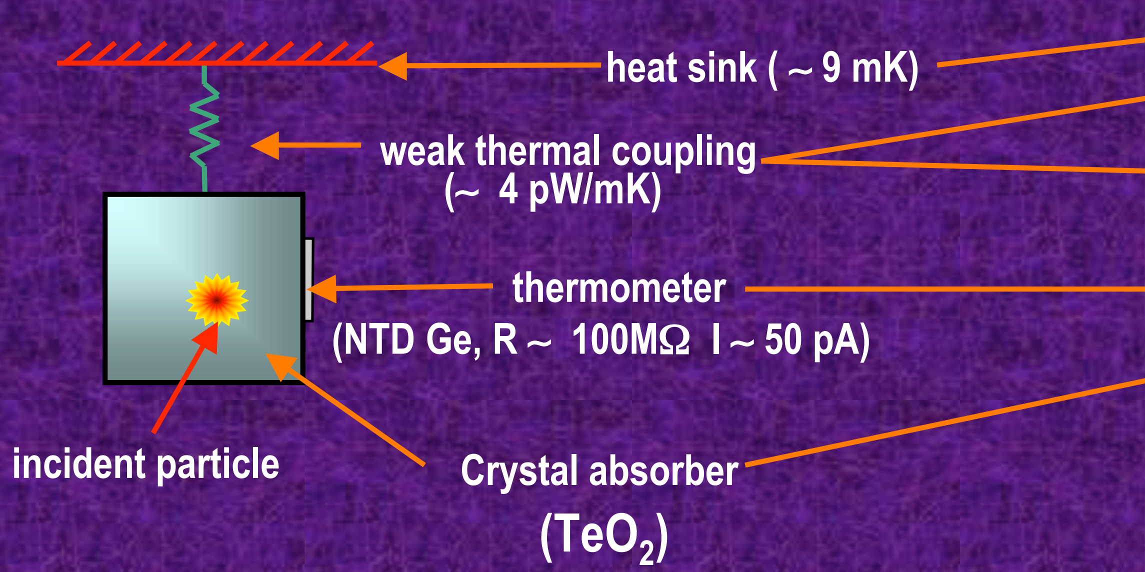
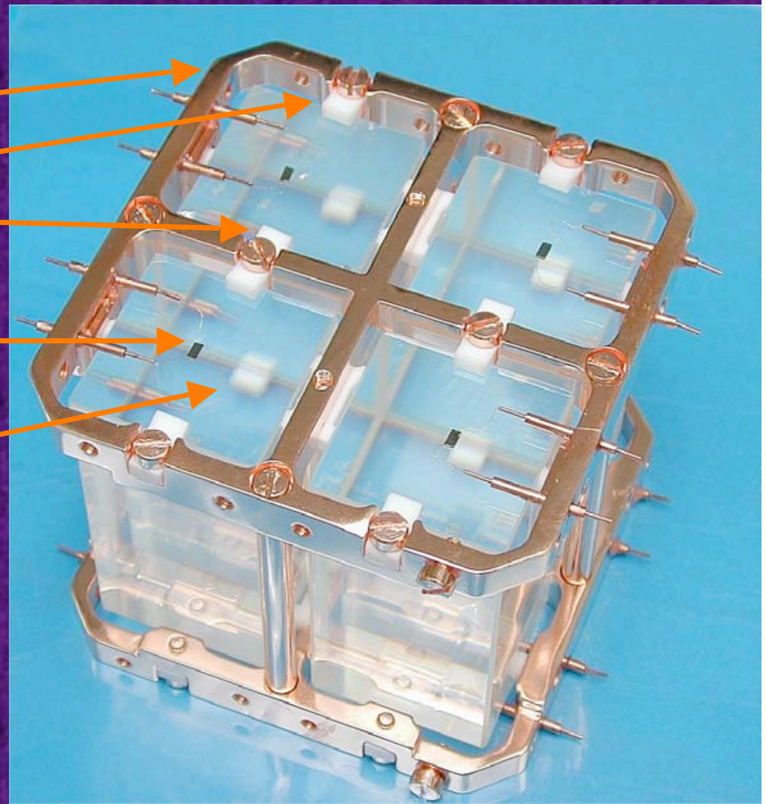
CUORicino @ LNGS

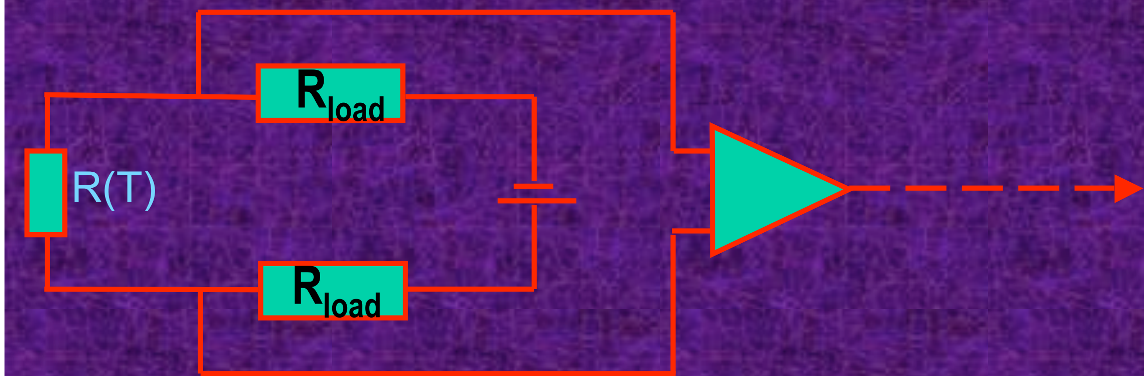


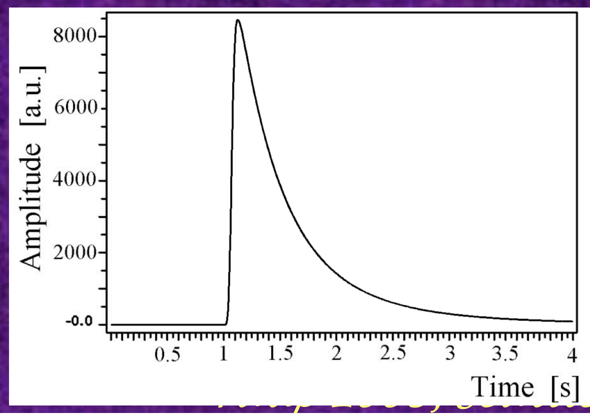
Thermal Detectors



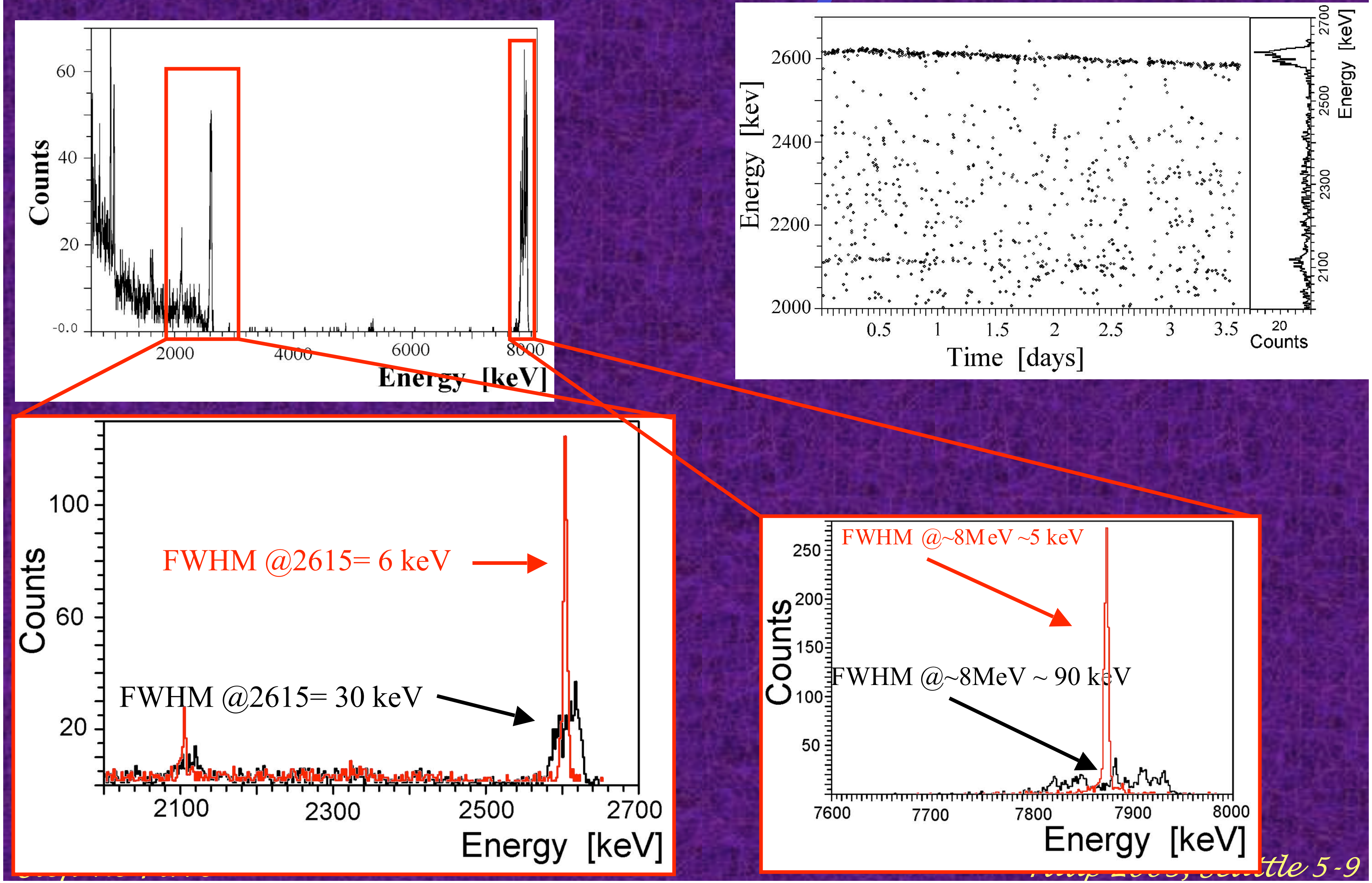


$dR/dE \cong 20\ k\Omega/keV$

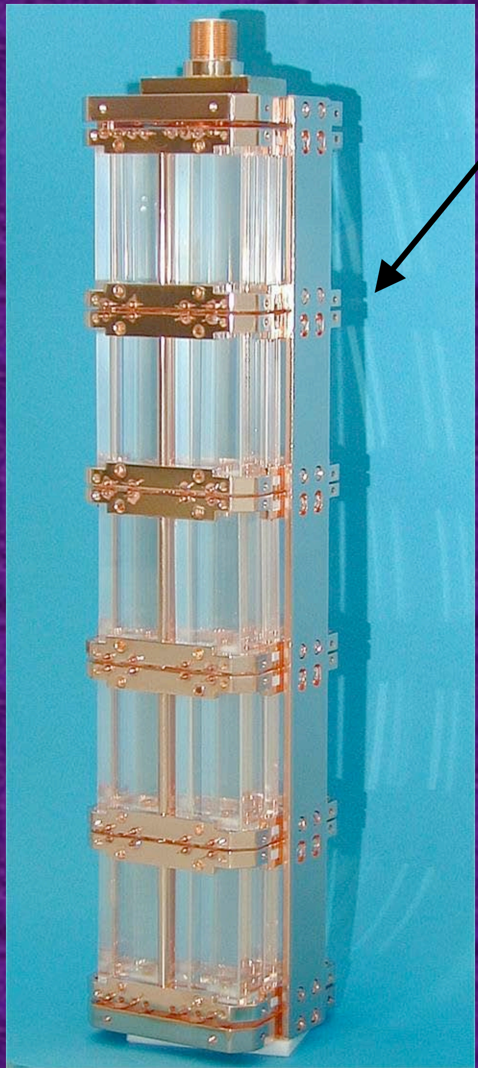




Thermal Detectors-stability



Mibeta (^{130}Te)

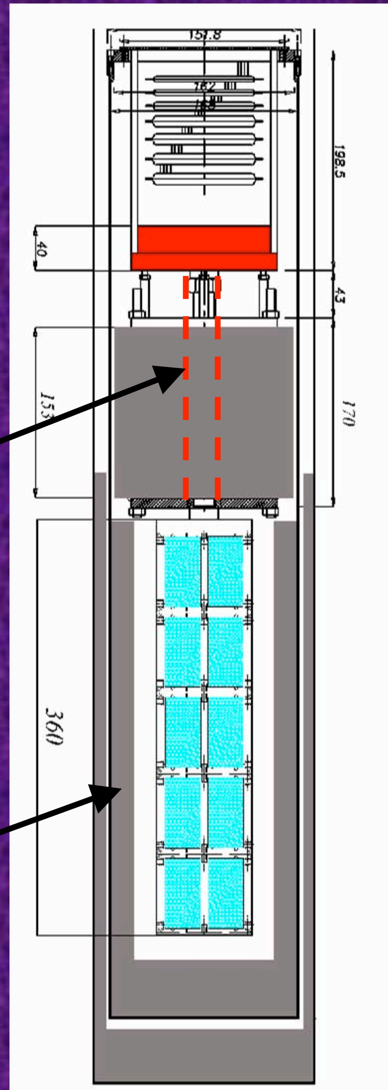


5 modules, 4 detectors each, arranged in a tower-like structure (6.8 kg)

Every detector is a TeO_2 crystal 3x3x6 cm^3 (340 g)

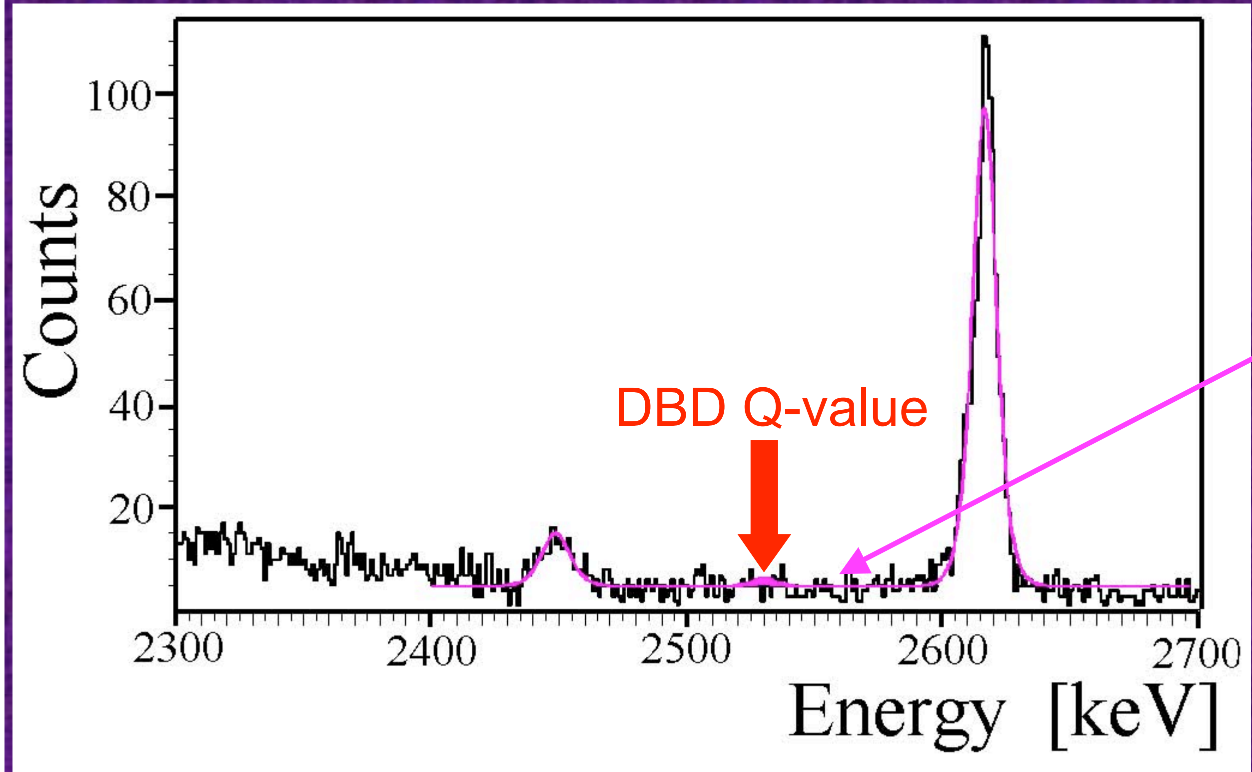
Cold finger: 7 mK

The tower was surrounded by a Roman lead inner shield



Mibeta Results

Total background spectrum of the 20 crystal array around the DDB0ν region



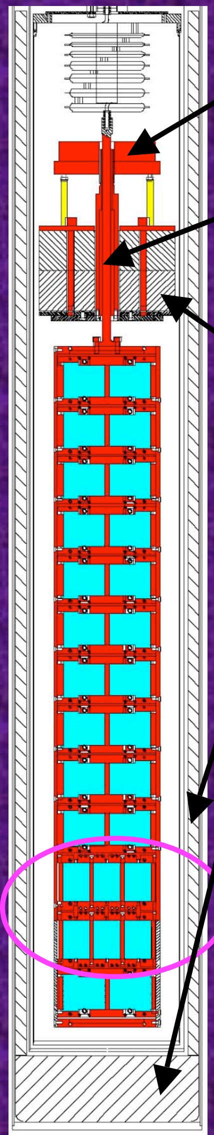
Total statistic ~ 4.3 kg x y.

Bkg ~ 0.3 c/keV/kg/y

$\tau^{0\nu}_{1/2} \geq 2.08 \cdot 10^{23}\, y\, (90\%\, CL)$ ⇨ $\langle m_\nu \rangle \leq 1.1 - 2.6\, eV^{*} \quad (90\%\, CL)$

* *Phys. Lett. B 557 (2003) 167-175*

Cuoricino

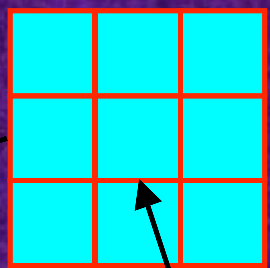


Mixing chamber

Cold finger

Roman Pb
shield

Planar section

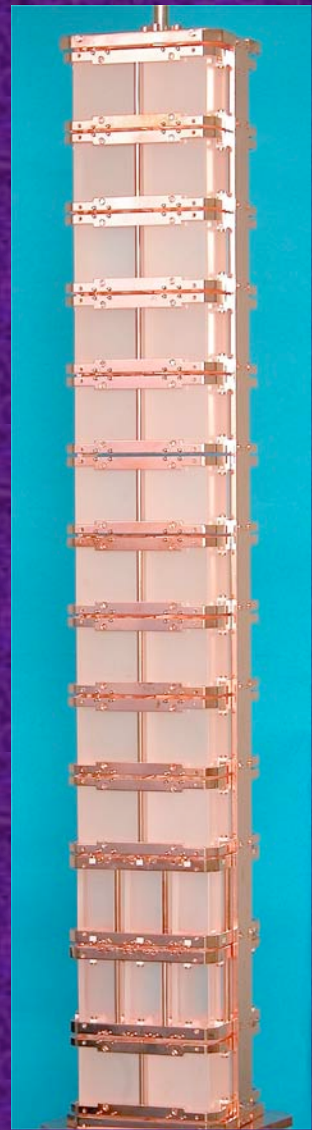


The central detectors are almost completely surrounded by active materials. Substantial improvement in BKG reduction

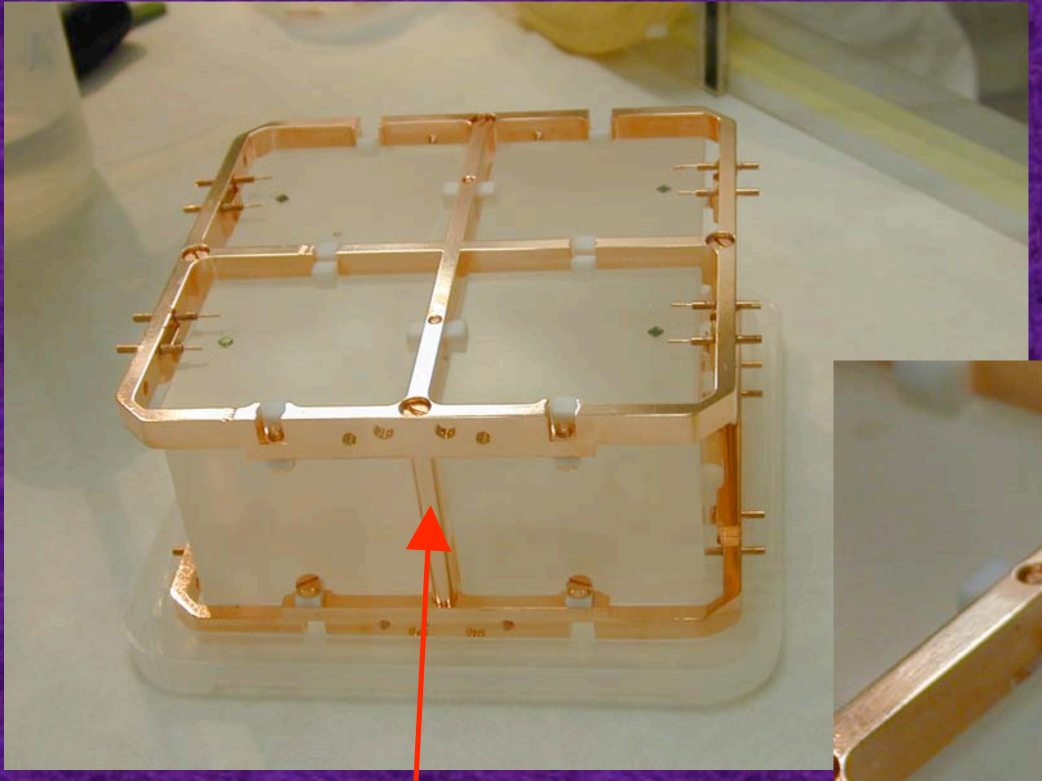
11 modules
4 detectors each
Dimension: 5x5x5 cm^3
Mass: 790 g

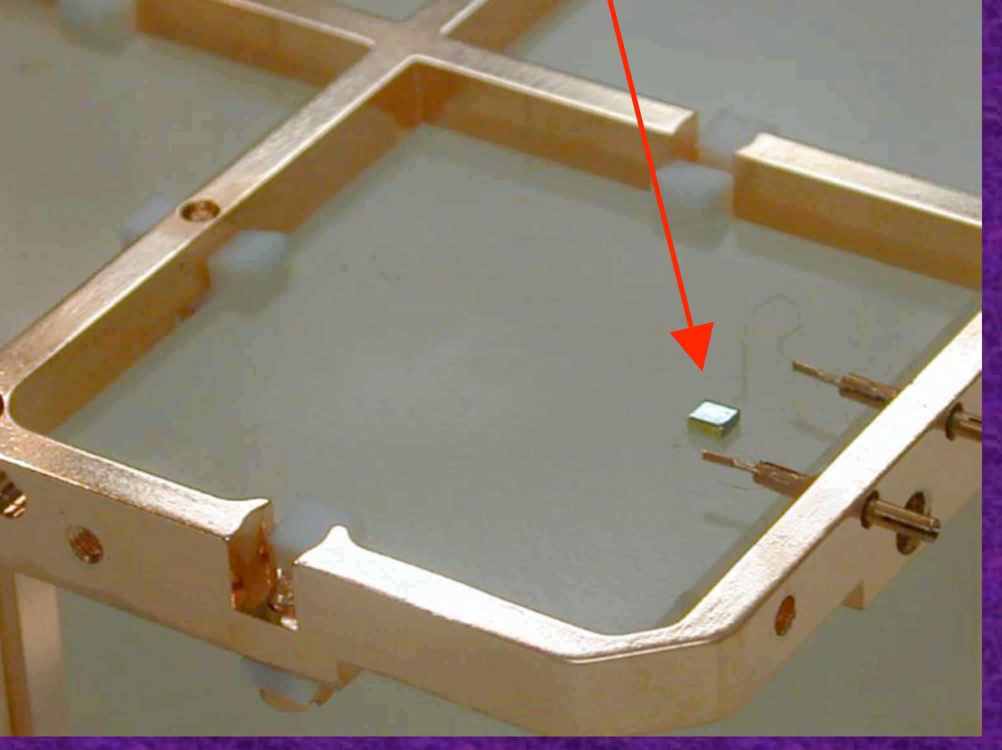
2 modules
9 detectors each,
Dimension: 3x3x6 cm^3
Mass: 340 g

Total mass
40.9 kg



Cuoricino Single Module





Ge NTD thermistor

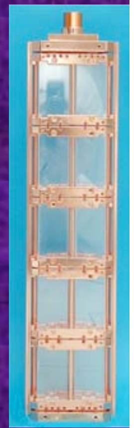
A Cuoricino module

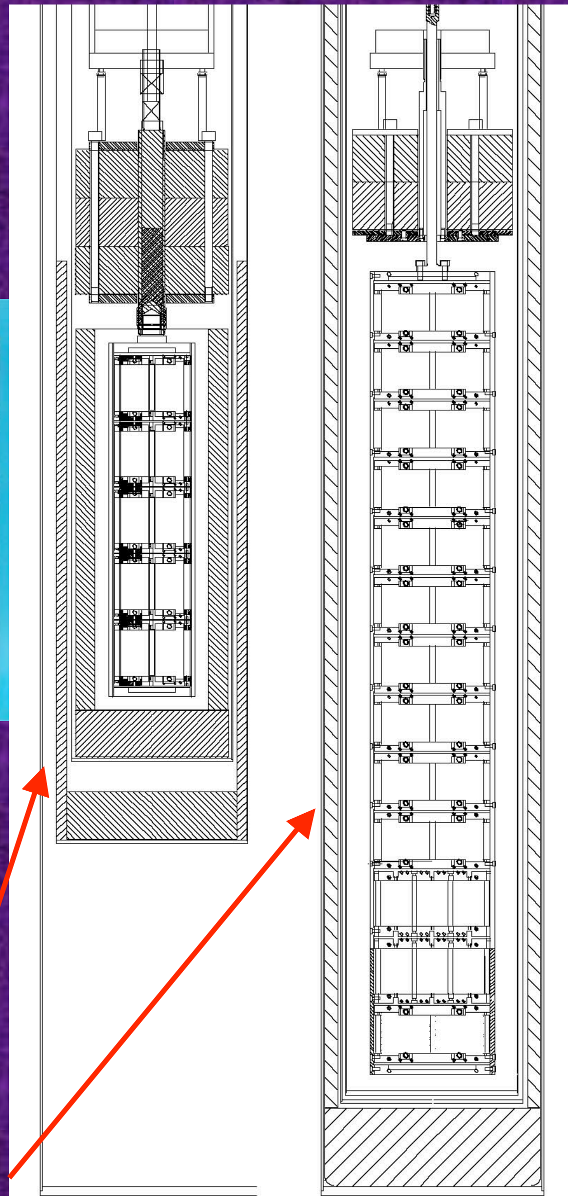
Detectors assembling

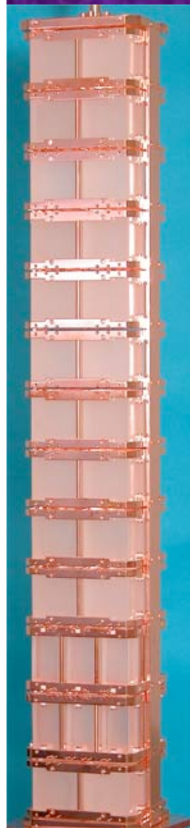
Almost all the operations done in nitrogen atmosphere

Tower assembling

Overall Layout







CUORICINO performances

Cool down: february 2003

Detectors: 14 electrical connection were lost during the cooling of the tower, as a result 14 detectors cannot be read-out (to recover the electrical connections it is necessary to warm up the cryostat)

4x11 = 44 large size crystals (~5x5x5 cm^3 av. mass = 790 g) → 32 working

9x2 = 18 small size crystals (~3x3x6 cm^3 av. mass = 330 g) → 16 working

Active mass during this run:

32 x 0.790 = 25.28 kg

12 x 0.330 = 3.96 kg

2 (^{130}Te-enriched) x 0.330 = 0.495 kg ^{130}Te

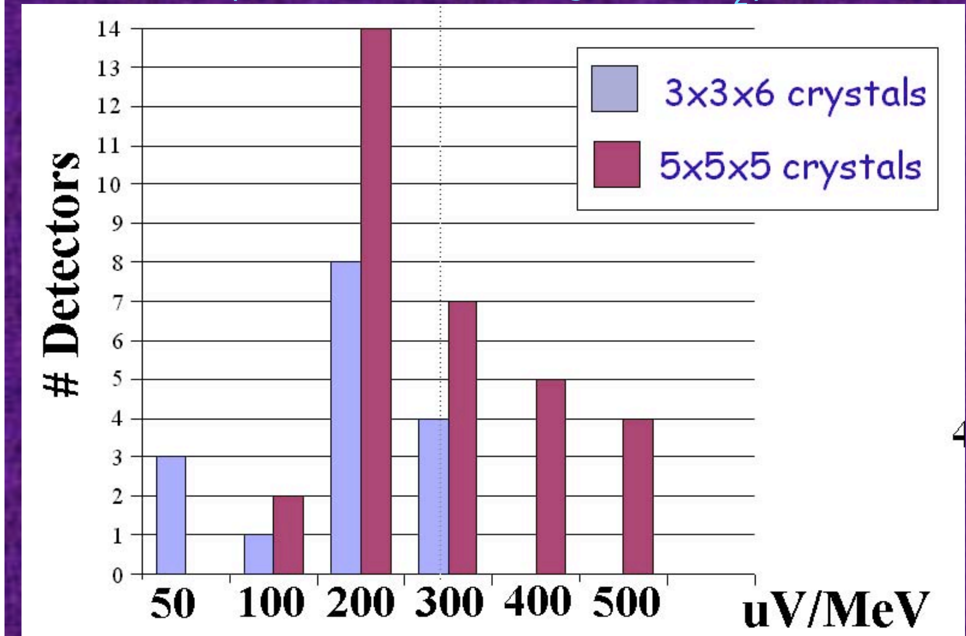
2 (^{128}Te-enriched) x 0.330 = 0.543 kg ^{128}Te

→ **10.4 kg ^{130}Te**

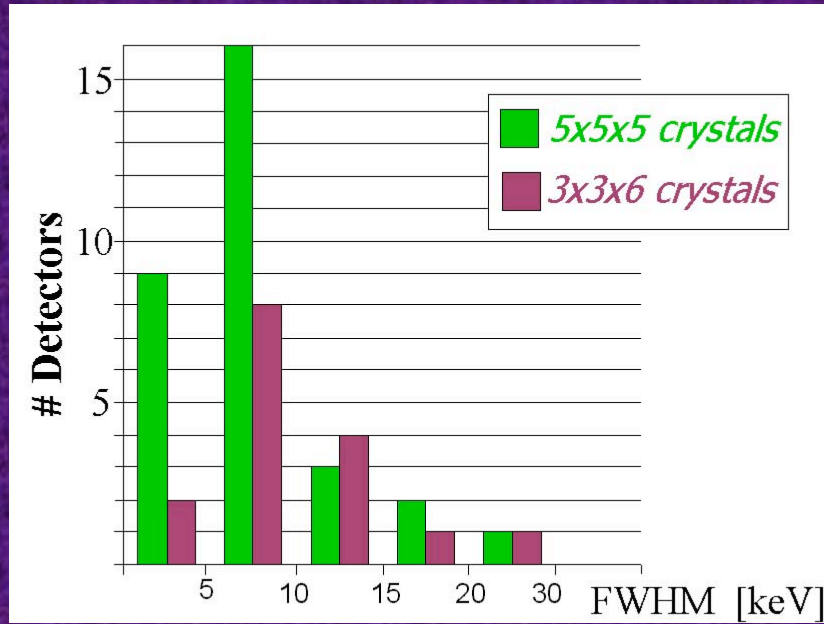
Detectors performances

Pulse height distribution μV/MeV

(normalized to 1 kg of TeO_2)



Pulse height distribution μV/MeV

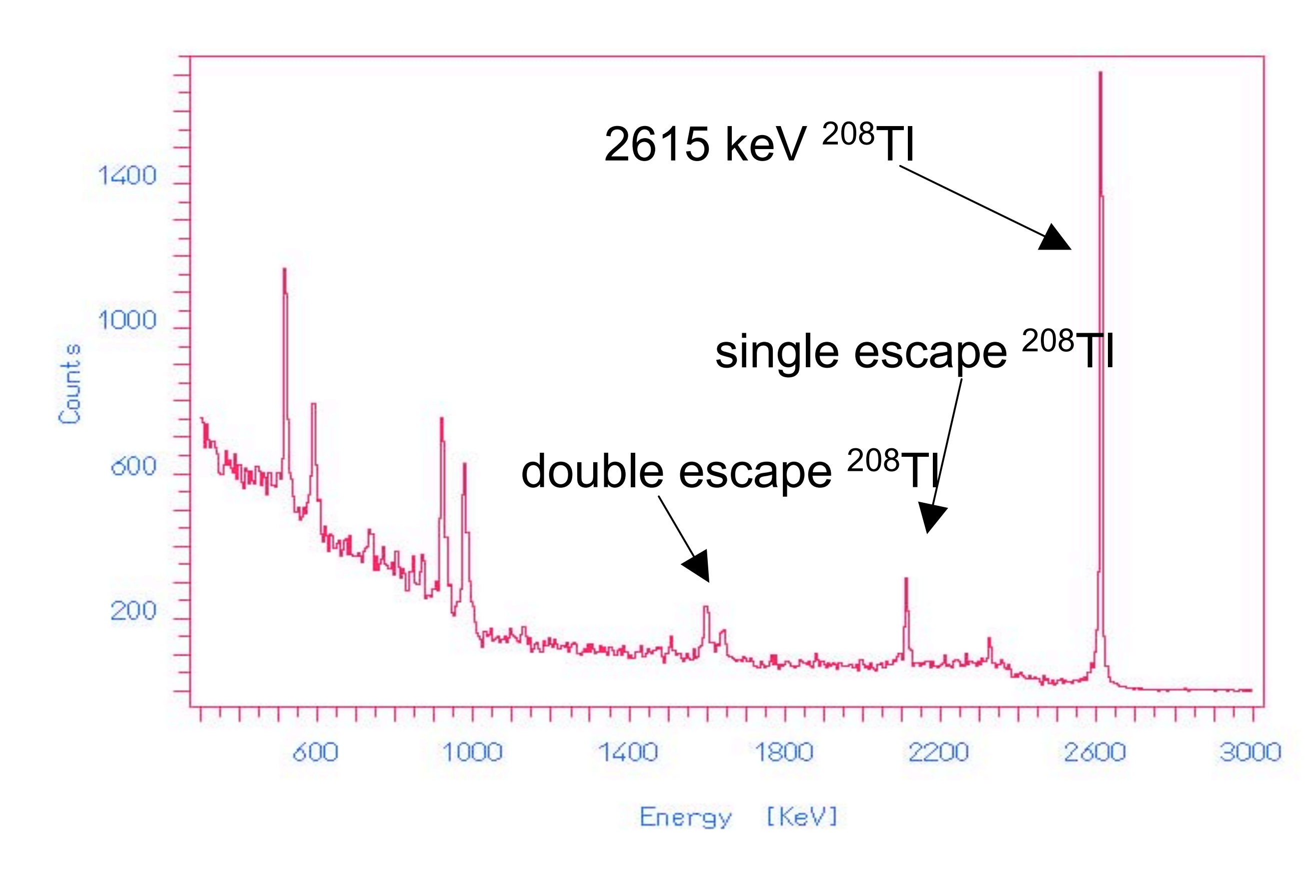


average pulse height for 5x5x5 crystals = 340 μV/MeV
average pulse height for 3x3x6 crystals = 440 μV/MeV

FWHM [keV] of the 2615 keV gamma line of ^{208}Tl (calibration with a ^{232}Th source ~ 3 days)

average 5x5x5 cm^3 crystals ~ 7 keV
average 3x3x6 cm^3 crystals ~ 9 keV

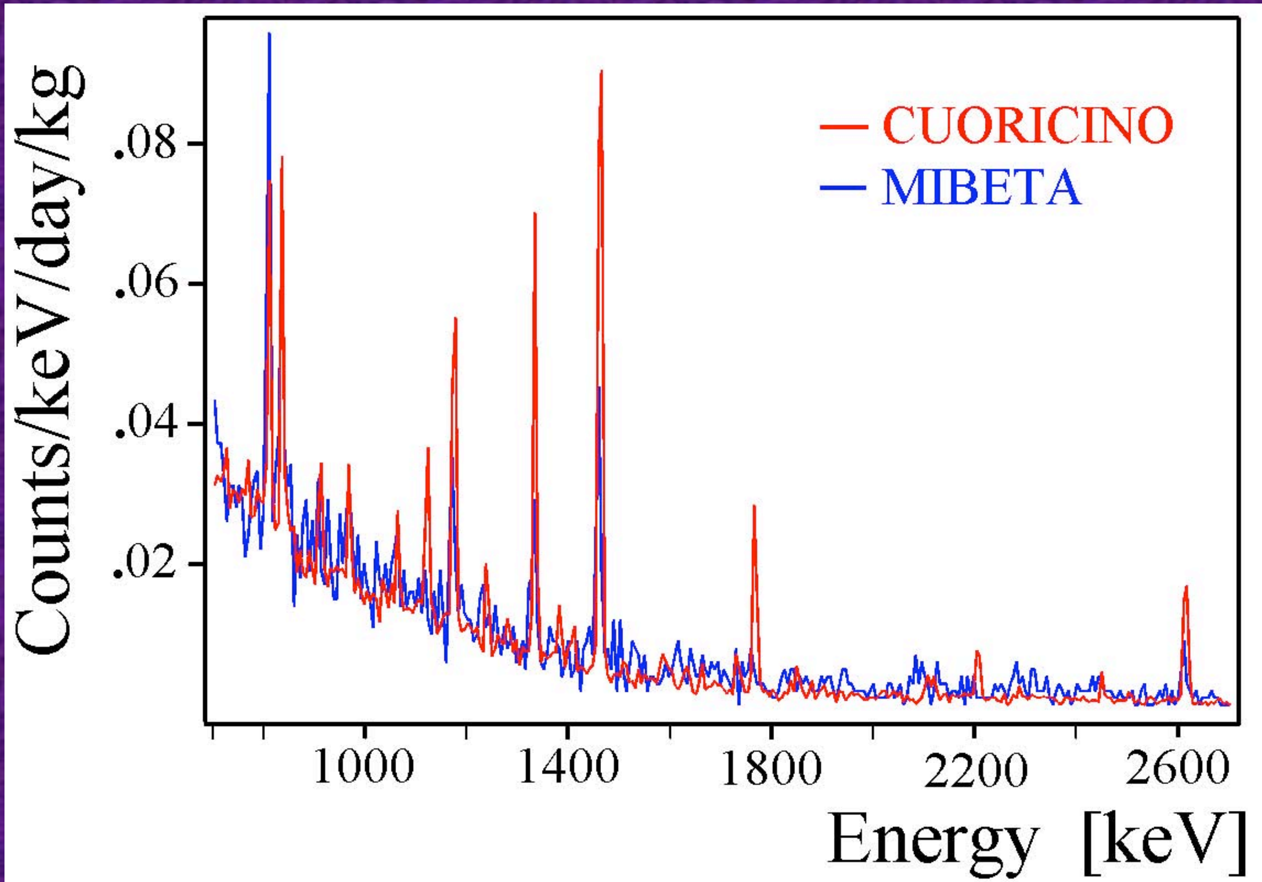
^{232}Th Calibration



Sum spectrum of all the 5x5x5 cm^3 detectors

ΔE_{FWHM} = 7 keV @ 2615 keV

Background in the γ region

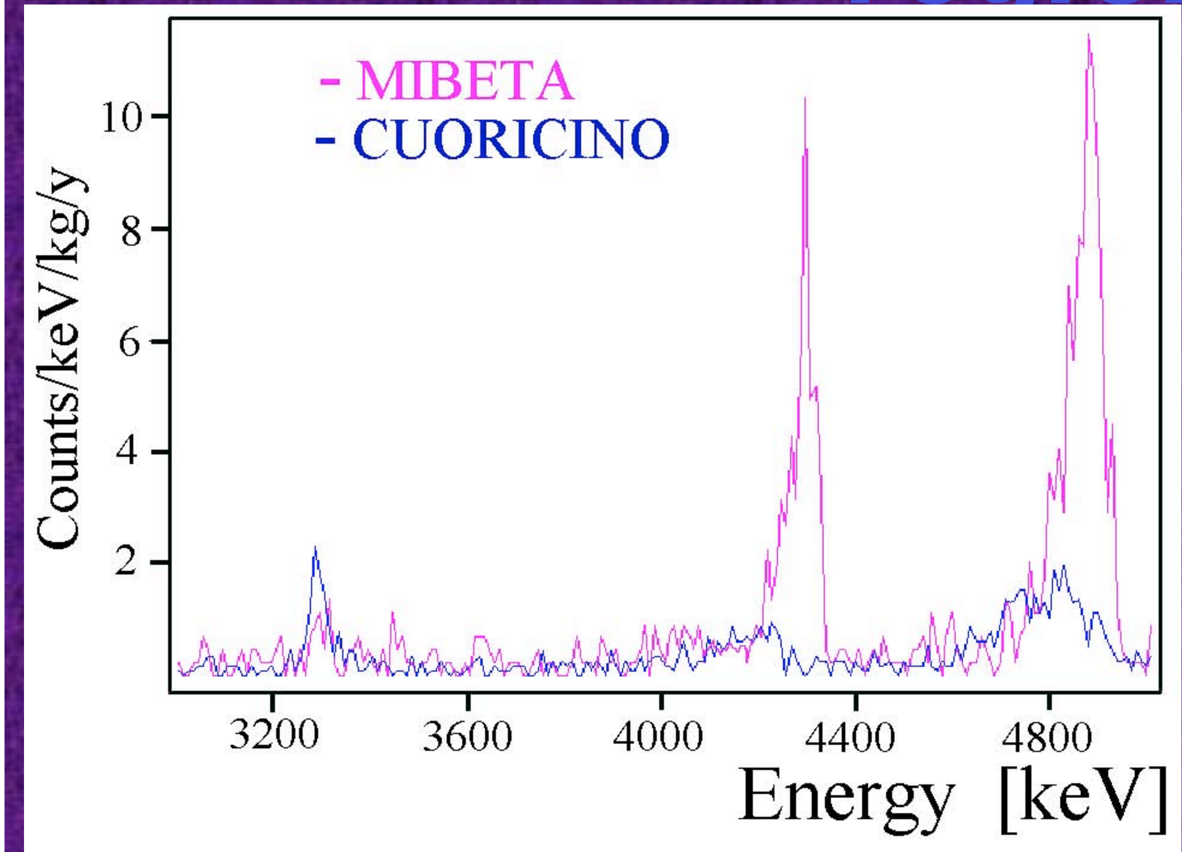


γ peaks from ^{60}Co ^{40}K and ^{208}Tl have a higher intensity in CUORICINO

But the lateral lead shielding is is now 2 cm less

We see the 2505 sum line of ^{60}Co (4 ± 1.5) c/kg/y

Background in the α region

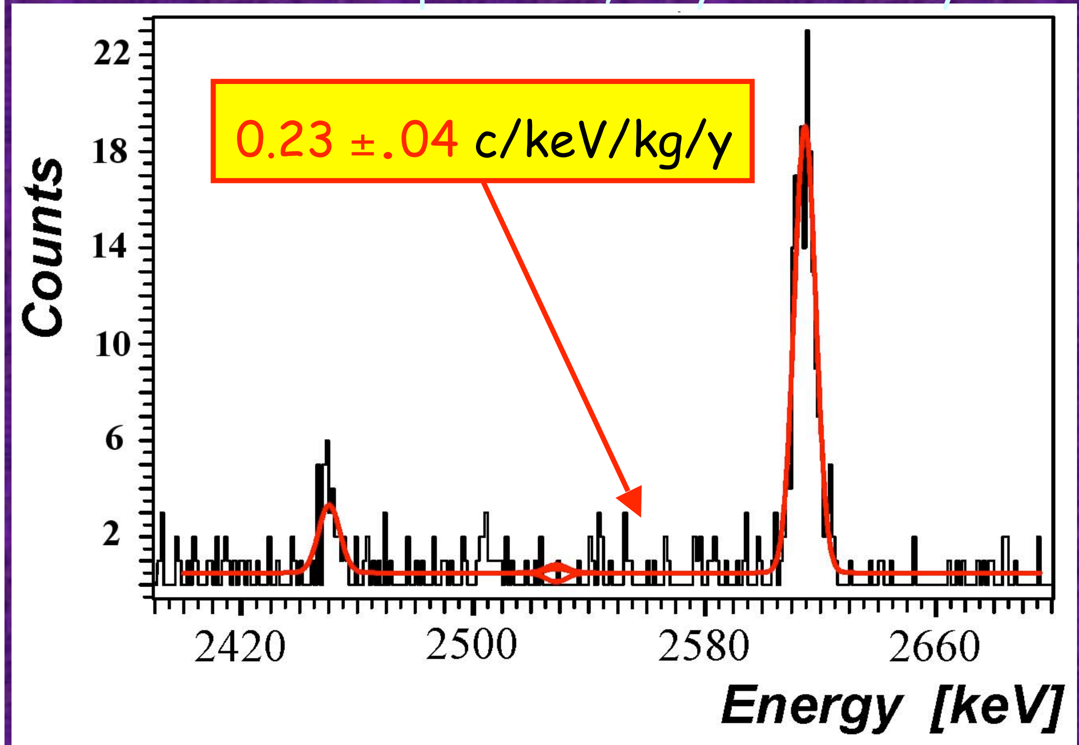


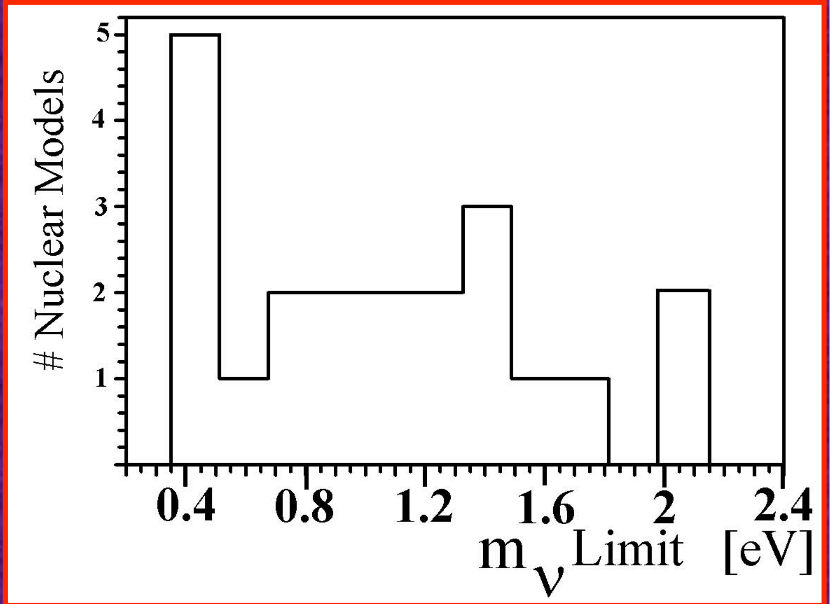
Uranium α line are reduced

	1000-2000 c/keV/kg/y	2000-3000 c/keV/kg/y	3000-4000 c/keV/kg/y	4000-5000 c/keV/kg/y
MiDBD-II	3.07±.1	0.533 ± .004	0.243 ± .003	1.84 ± .01
Cuoricino	3.39 ± .05	0.38 ± .02	0.23 ± .02	0.55 ± .02

Preliminary result on ^{130}Te $\beta\beta-0\nu$ decay

anticoincidence spectrum, only 5x5x5 crystals

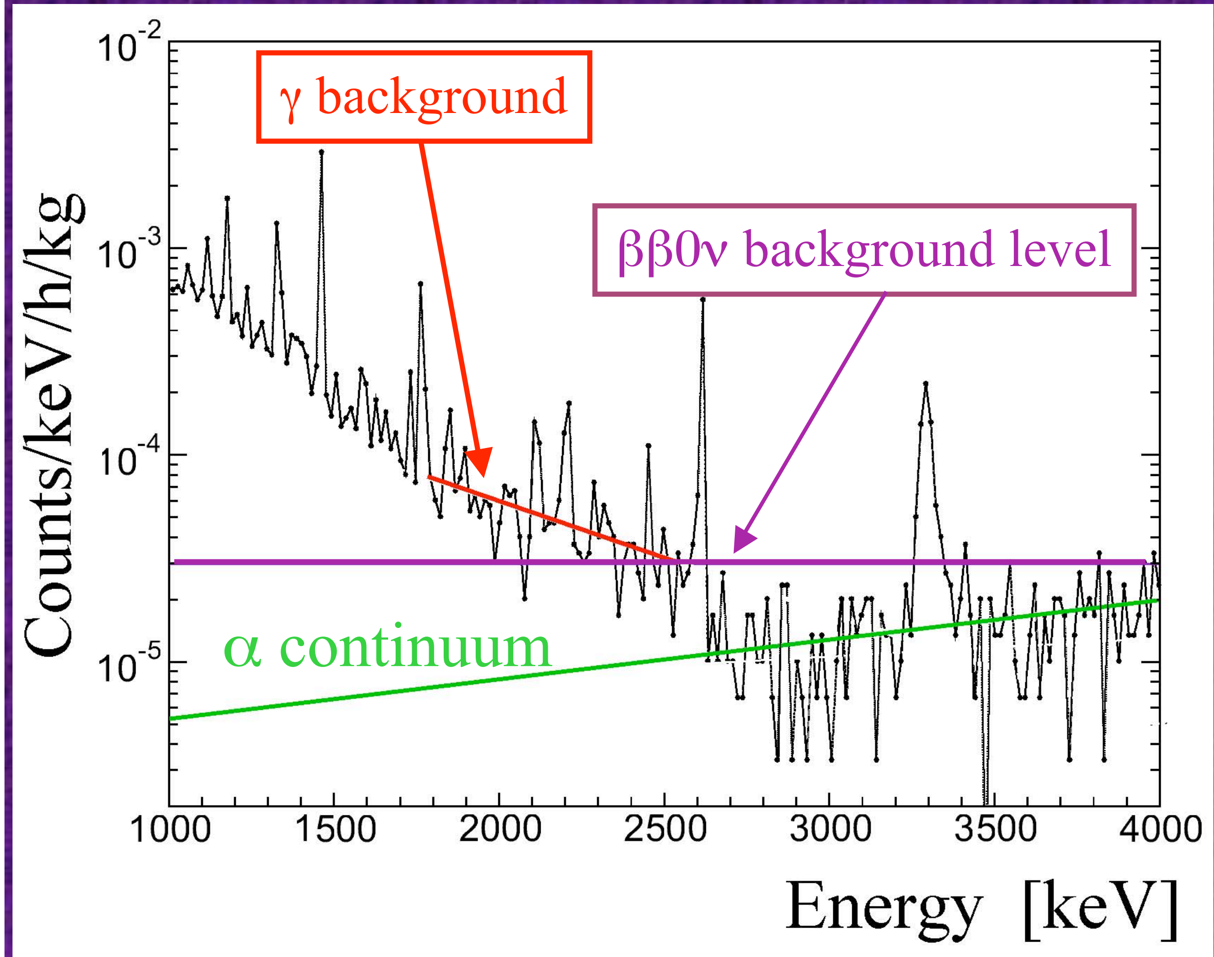




Statistic collected: 2,26 kg x y

$$\tau^{0\nu}_{1/2} \geq 5 \cdot 10^{23}\, y\,(90\%\, CL)$$

Background sources



Preliminary

Extremely low statistics, need to be confirmed also by simulations

BKG in the ββ0ν seems to be due to ^{208}Tl γ's

Cuoricino Sensitivity

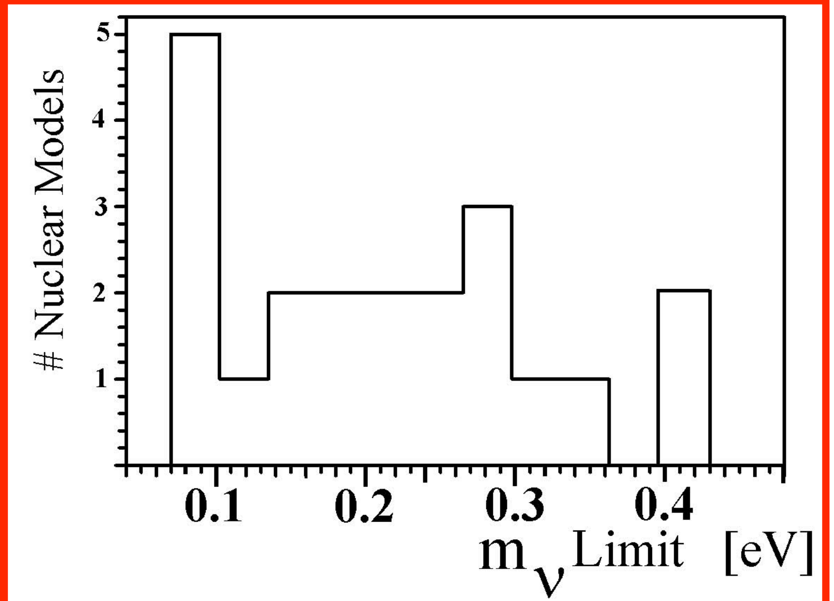
2480-2600 keV ($\beta\beta$ ^{130}Te transition energy = 2528.8 keV)

anticoincidence spectrum, only 5x5x5 crystals

b = 0.23 +/- 0.04 c/keV/kg/y

3 year sensitivity CUORICINO (full mass): b=0.23 Γ=8 keV

$F^{0\nu}_{3\ years} \approx 1 \times 10^{25}$ y



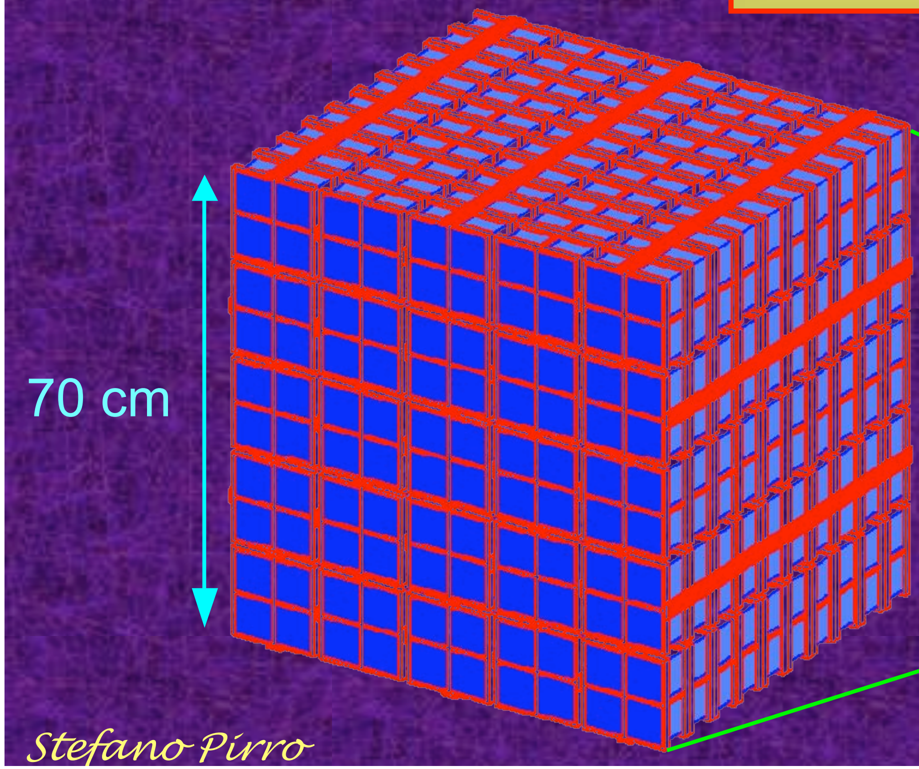
CUORICINO TO CUORE

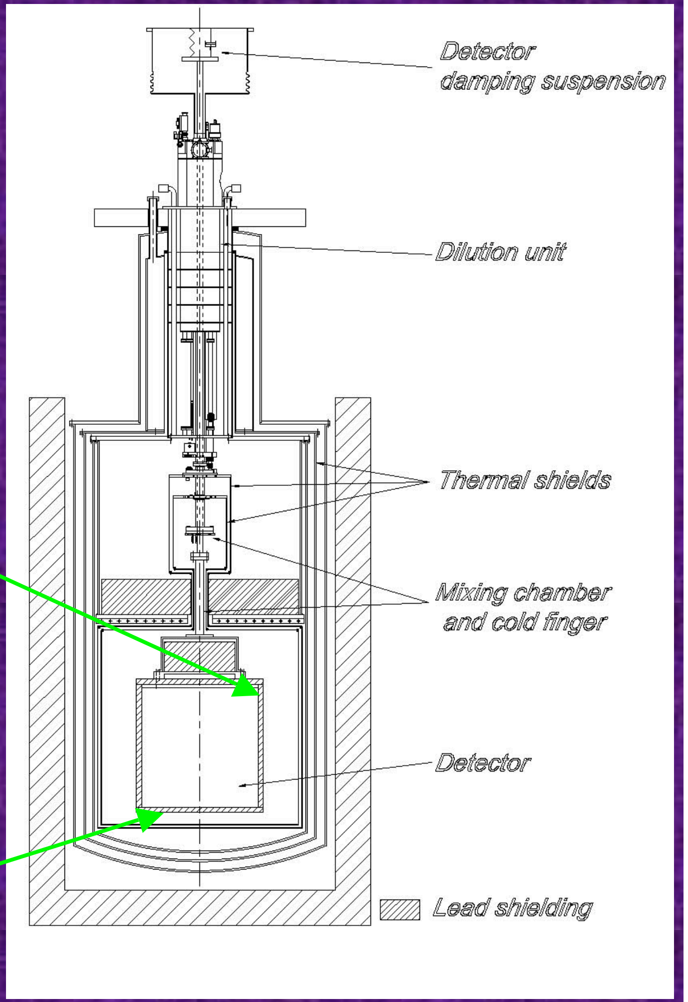
CUORICINO proves the feasibility of a large bolometric array with the tower-like structure

Detector performances are not affected by the increase in crystal size (from 340 g to 790 g)

Array of 1000 detectors:
25 towers - 10 modules/tower -
4 detectors/module

M = 0.75 ton





BACKGROUND ESTIMATION

- A completely new set-up will allow the *optimization of shielding*
- CUORE is specifically designed to reduce as far as possible the amount of materials interposed between the crystals.
- The high granularity of the CUORE detector will allow to use with high efficiency the coincidence/anticoincidence technique to identify and reject background events

Contribution to the $\beta\beta0\nu$ region from bulk contaminations

TeO_2	4.1 10^{-4} c/keV/y/kg
copper	2.7 10^{-4} c/keV/y/kg
lead	3.5 10^{-4} c/keV/y/kg

1 10^{-3} c/keV/y/kg

TeO_2	4.4 10^{-4} c/keV/y/kg
copper	10 10^{-4} c/keV/y/kg
lead	45 10^{-4} c/keV/y/kg

6 10^{-3} c/keV/y/kg

Almost done

⇒The main task is the reduction of *surface radioactivity*

To reach the background goal we need to improve by a factor ≈ 200

From geometry we can gain a factor 5÷10

⇒ *we need to reduce surface radioactivity "only" by a factor 20 ÷ 40*

Conclusions

- CUORICINO gave the first encouraging results
- It also demonstrated the feasibility of a larger Experiment
- We plan to recover in October all the detectors
- We will start within this year the R&D on CUORE detectors