

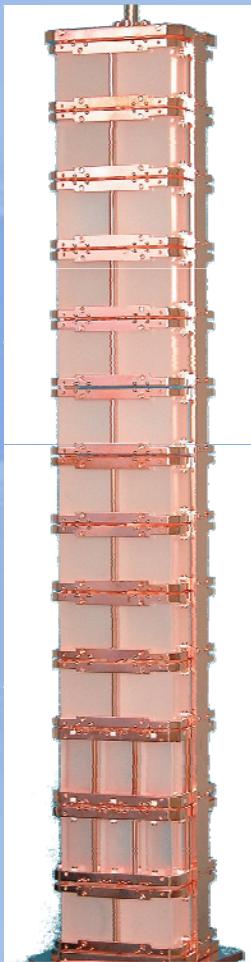


IDEA Meeting

Cuoricino status, current issues

Luca Gironi

Paris – 19 - 20 November 2007



TeO₂ thermal calorimeters

Active isotope: ¹³⁰Te

- high natural abundance (a.i. = 33.9%)
- high transition energy ($Q_{\beta\beta} = 2530$ keV)

Absorber material: TeO₂

- Low heat capacity
- Large crystals available
- Radiopure

11 modules with 4 big detectors (5x5x5 cm³ – 790g)

2 modules with 9 small detectors (3x3x6 cm³ – 330g)

↓
62 TeO₂ crystals
4 crystals
are enriched



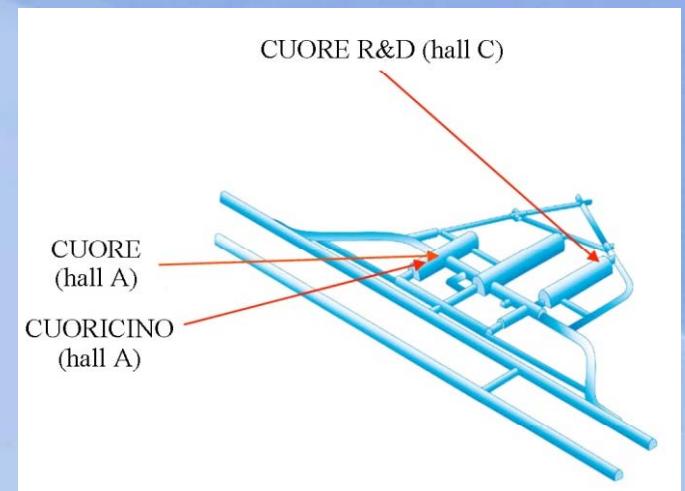
Total active mass

40.7 kg TeO₂
11.2 kg ¹³⁰Te



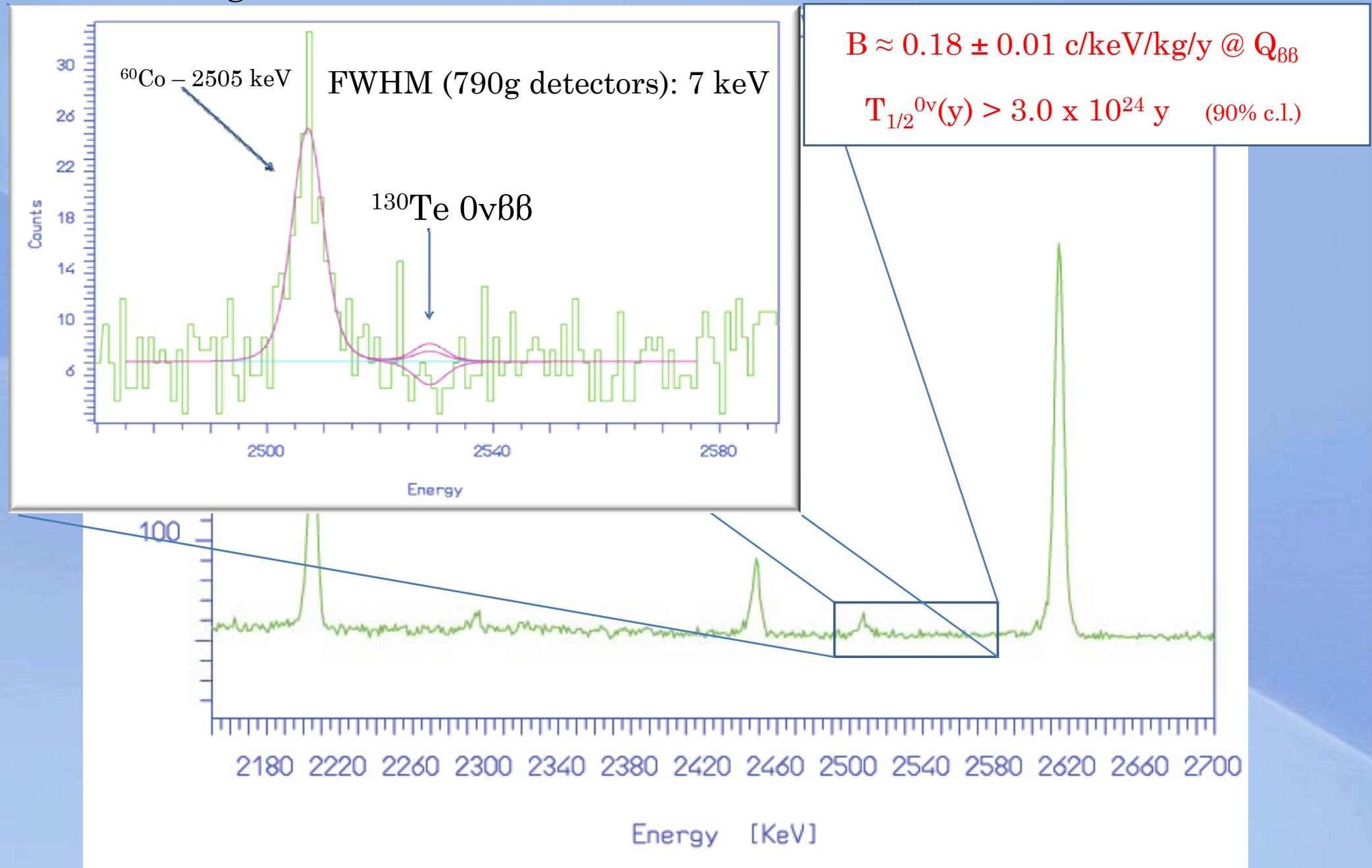
Underground National Laboratory of Gran Sasso

3500 m.w.e.

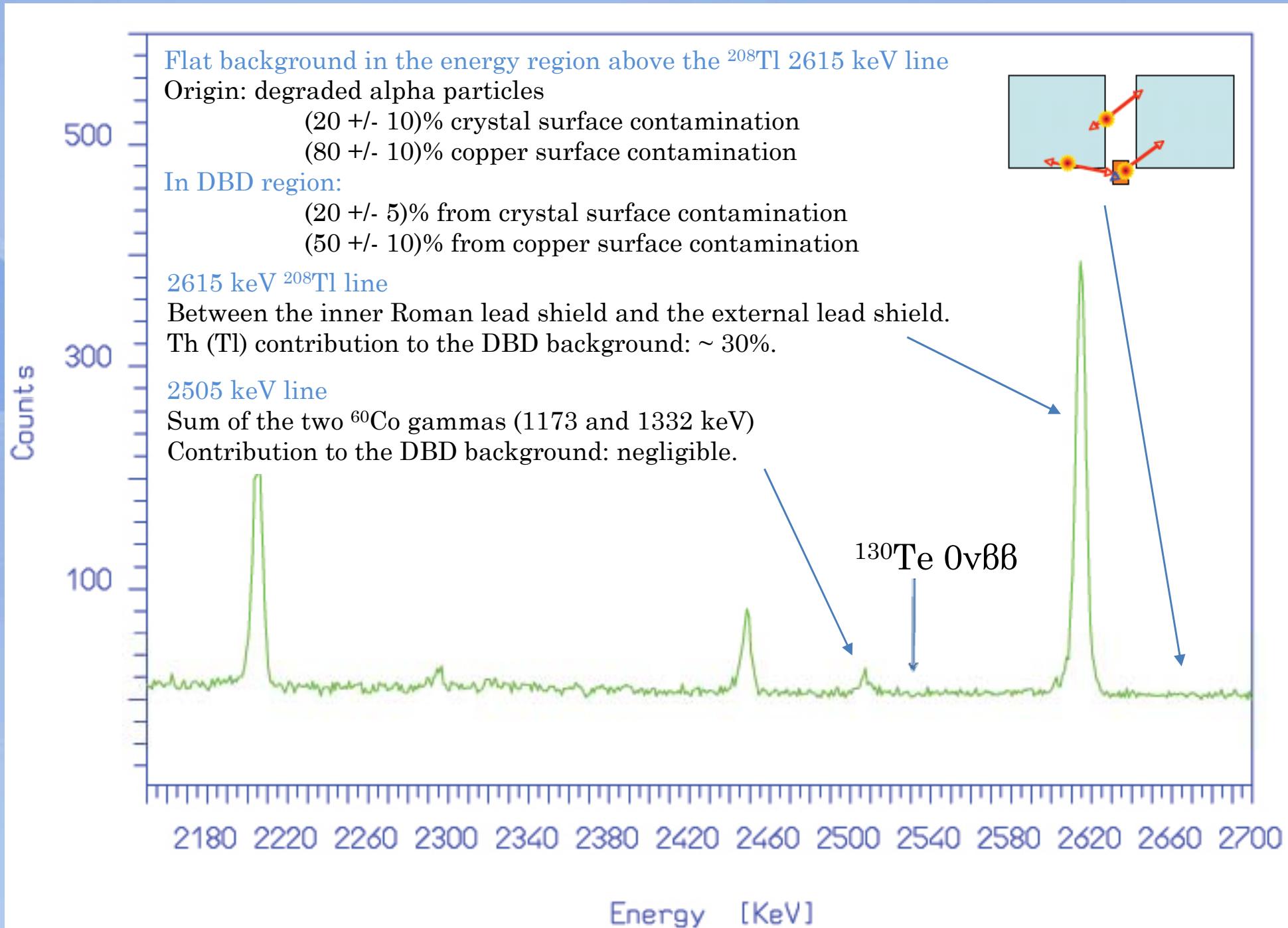


Cuoricino

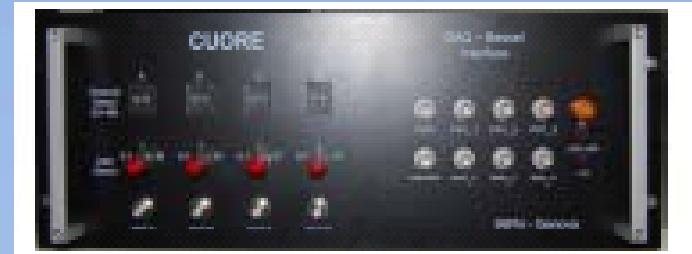
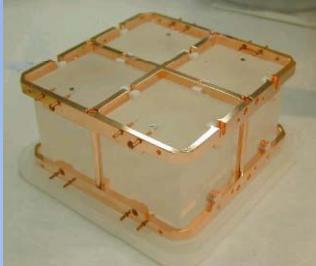
Data taking from 2003



Cuoricino

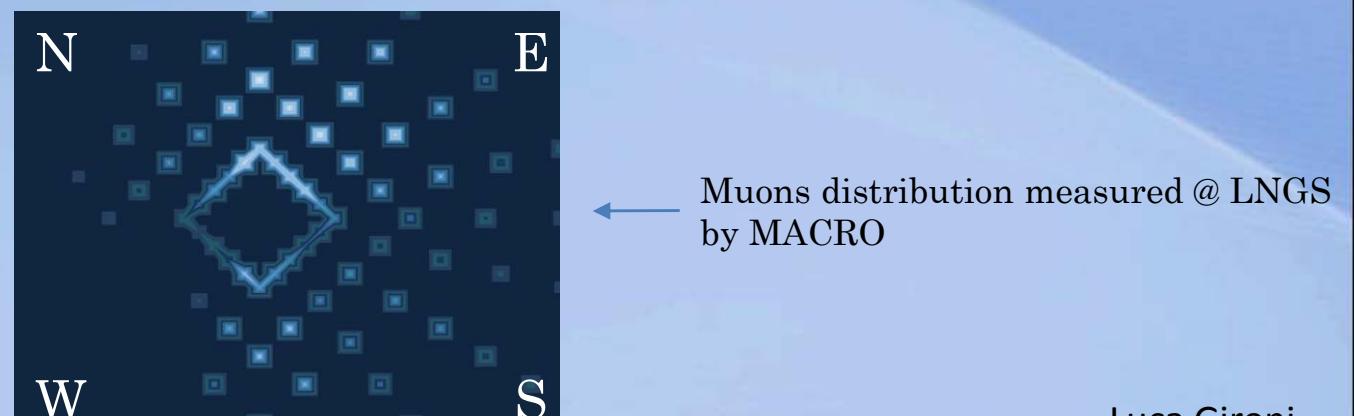


Cuoricino



Until Cuoricino will be stopped (June 2008)

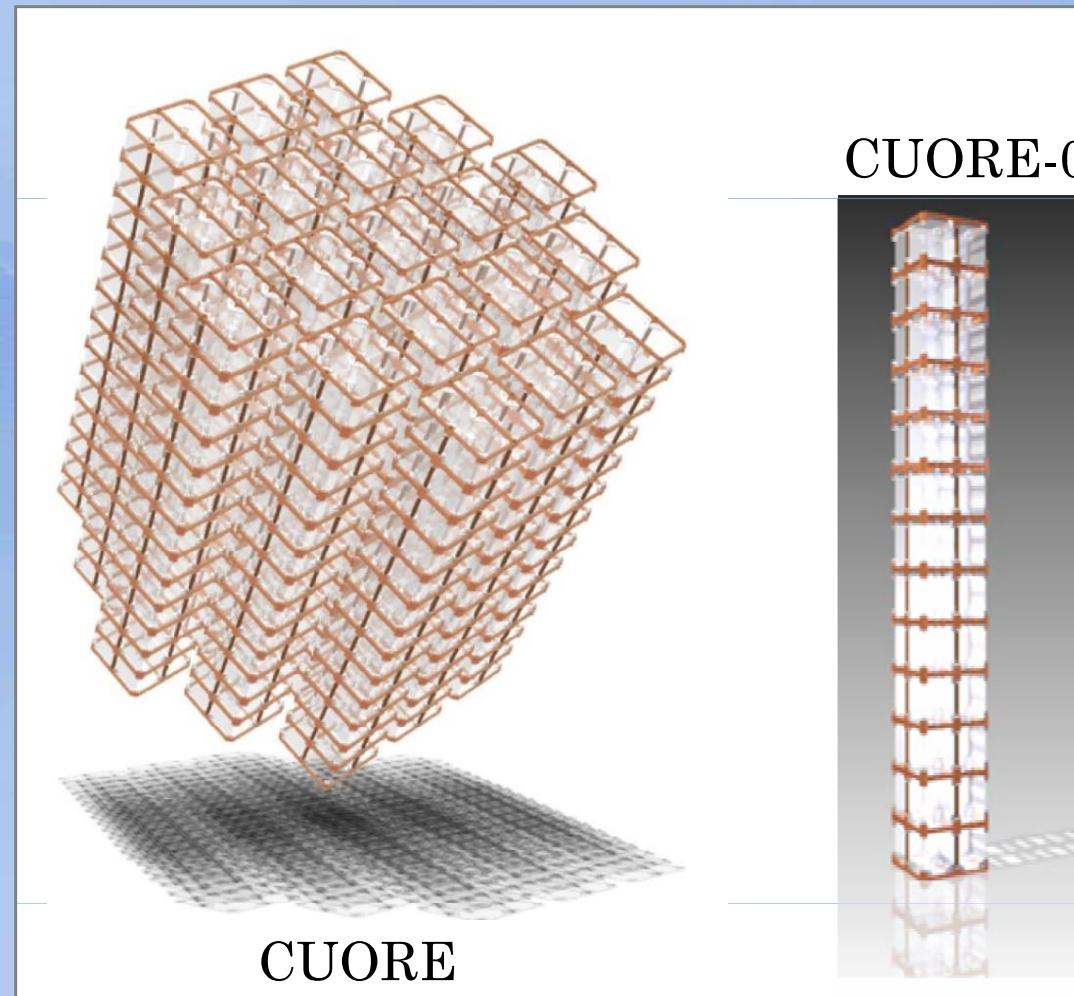
- Technical test (calibrations with ^{232}Th , ^{238}U , ^{40}K and ^{60}Co , tests on heater pile-up, measurements on sources activities for Monte Carlo verification, ...) to better study and understand the operation of detectors.
- Installation of the new data acquisition (CUORE like acquisition).
- Installation of plastic scintillator on the shielding of Cuoricino (this will allow us to study the contribution of the cosmic ray (μ) to the background of Cuoricino).



CUORE-0

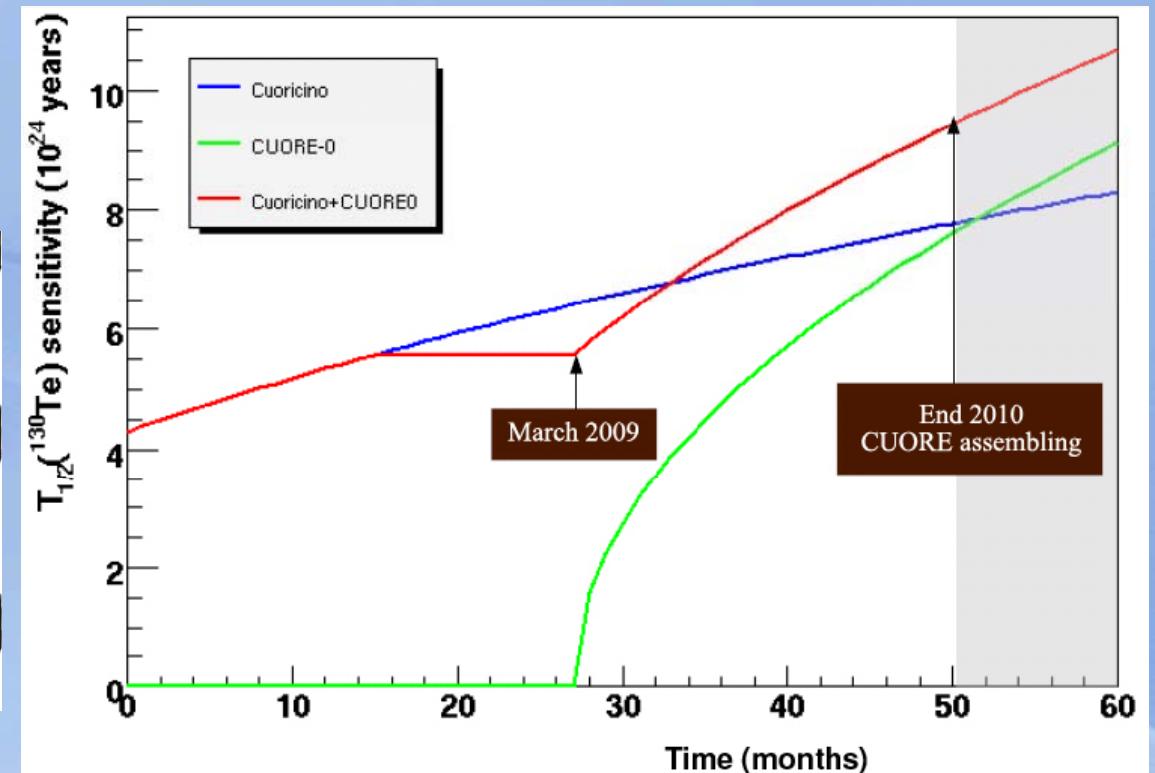
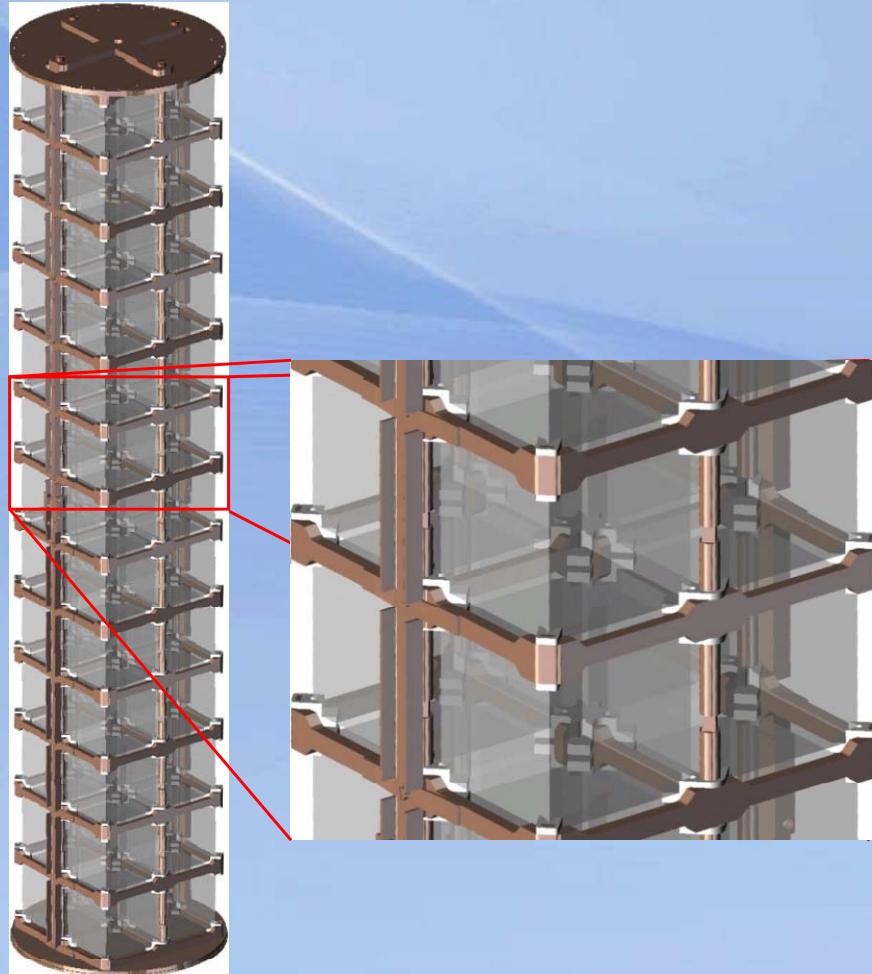


- The first tower of CUORE
- It will be installed in hall A of Laboratori Nazionali del Gran Sasso (replace Cuoricino)
- 52 TeO₂ crystals (5x5x5 cm³ – 750g)
- 5×10^{25} ¹³⁰Te nuclei



Some motivation for CUORE-0

- Assembly test
- Study and check of the background (CUORE-0 will have a higher sensitivity than the hall C)





General milestone for CUORE-0 assembly Dec 2008 - data taking Mar 2009

- Crystals In our hands in August 2008 (first 28) and in September 2008 (second 28)
Validation of the first batch: Hall C run in June-August 2008
- Thermistors and heaters Decision on the size of the flat-pack thermistors: Mar 2008
Dedicate April-May 2008 to production
- Tower design Final technical drawing ready in December 2007
- Copper Production of copper parts: February- April 2008
All copper parts ready in April 2008
Cleaning copper parts: May – October 2008
- Clean room preparation Borexino clean room ready to use in July 2008
- Packaging and storage Storage system ready in April 2008
- Assembly CUORE-0 tower assembled in December 2008
- Tower storage Storage and transportation ready in December 2008
- Tower-cryostat interface Interface ready in December 2007

RAD

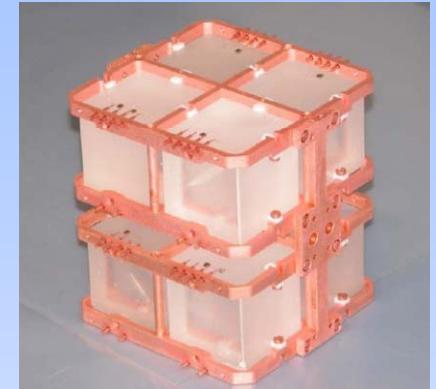
A dedicated array to study background in the hall C facility @ LNGS

What has already been done

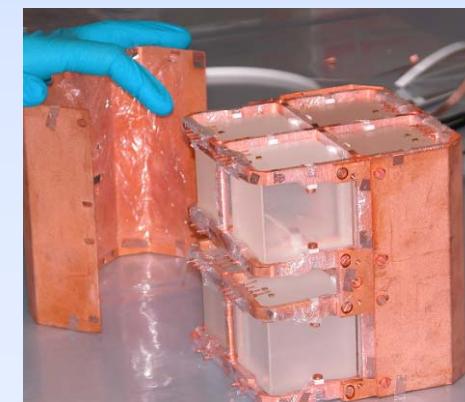
RAD 1: surface treatment (crystals and copper)
crystal surface contamination reduction ~ 4 times better than CUORICINO
3-4 MeV compatible with CUORICINO



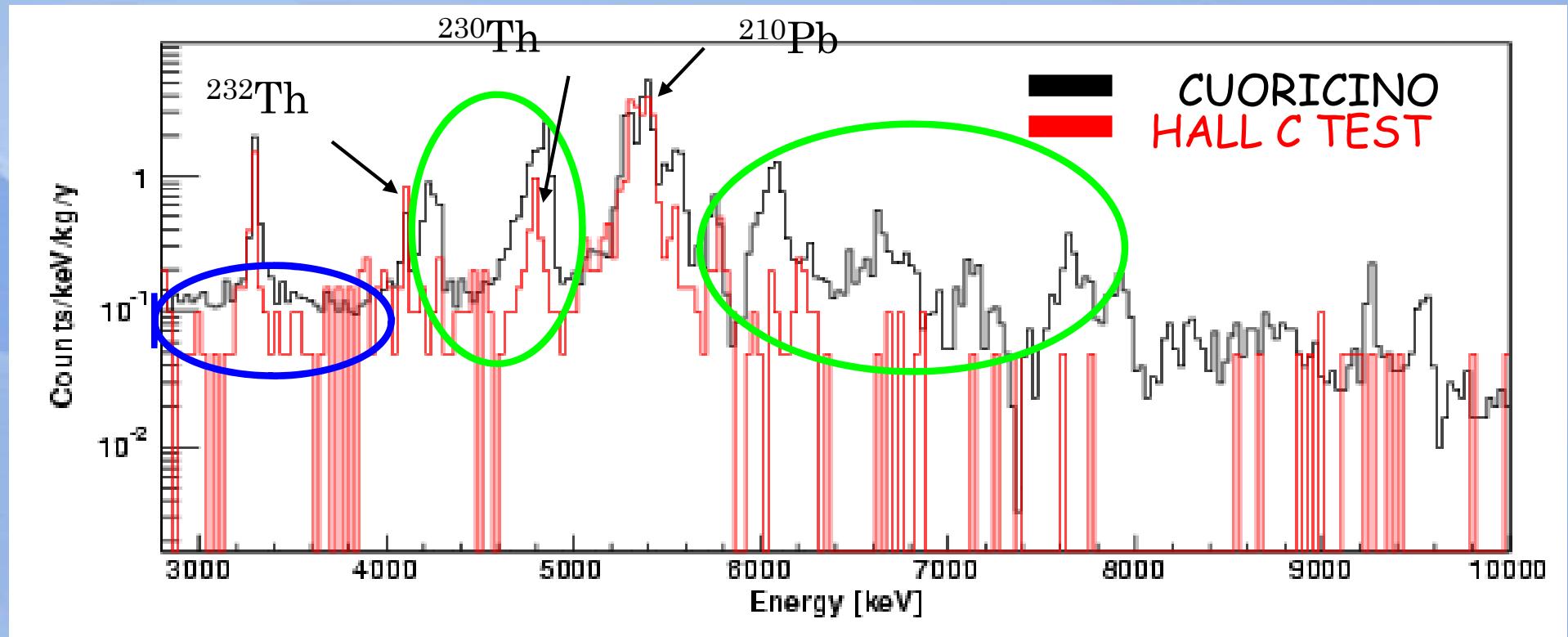
RAD 2: test on small parts (gold wires, heaters, teflon)
no evidence for contribution from small parts to the 3-4 MeV counting rate



RAD3+RAD4 : copper covered with polyethylene film
reduction of the 3-4 MeV counting rate (38 +/- 7)%



Hall C





RAD

A dedicated array to study background in the hall C facility @ LNGS

What we can do

- **Small parts**

- NTD thermistors not yet tested
- Sensitivity on teflon is not enough

- **Crystals**

- Reduction factor measured on peaks but not observed on continuum
Possibility to do a measurement in hall A between Cuoricino and CUORE-0. This measurement will allow us to have more stability and more statistic.

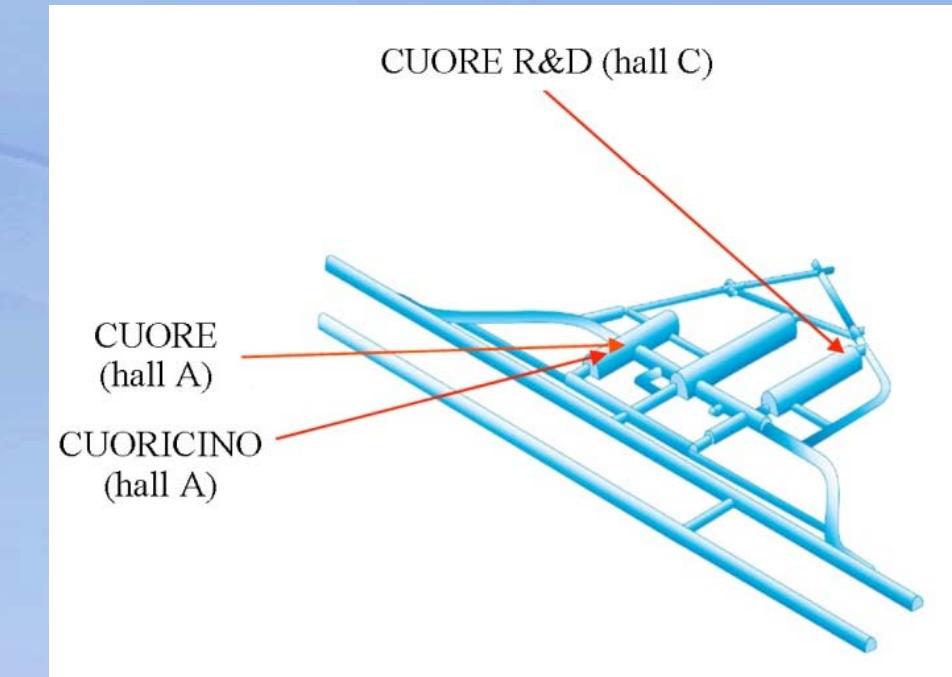
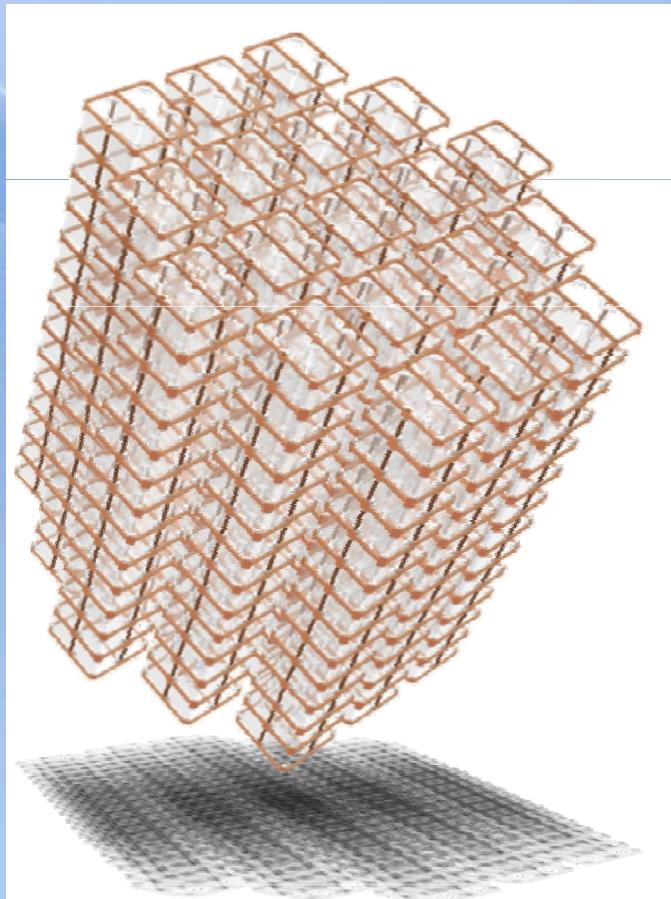
- **Copper**

- With RAD we demonstrated that contamination in ^{210}Pb on copper produces continuum background. When we covered copper with polyethylene we got a reduction of flat background but we have to verify that this technique can be used in CUORE.
- Different techniques for cleaning copper were taken into consideration
 - Other tests will be done in hall C.
 - Possibility to do a measurement in hall A between Cuoricino and CUORE-0.
 - Disc loaded with ^{222}Rn daughter and after cleaned with different technique. Screening of ^{210}Po with an alpha spectrometer.



Cryogenic Underground Observatory for Rare Events

- array of 988 TeO₂ crystals 5×5×5 cm³ (750 g)
- 741 kg TeO₂ granular calorimeter
- 600 kg Te = 203 kg ¹³⁰Te
- Start data taking on January 2011





Situation of activities

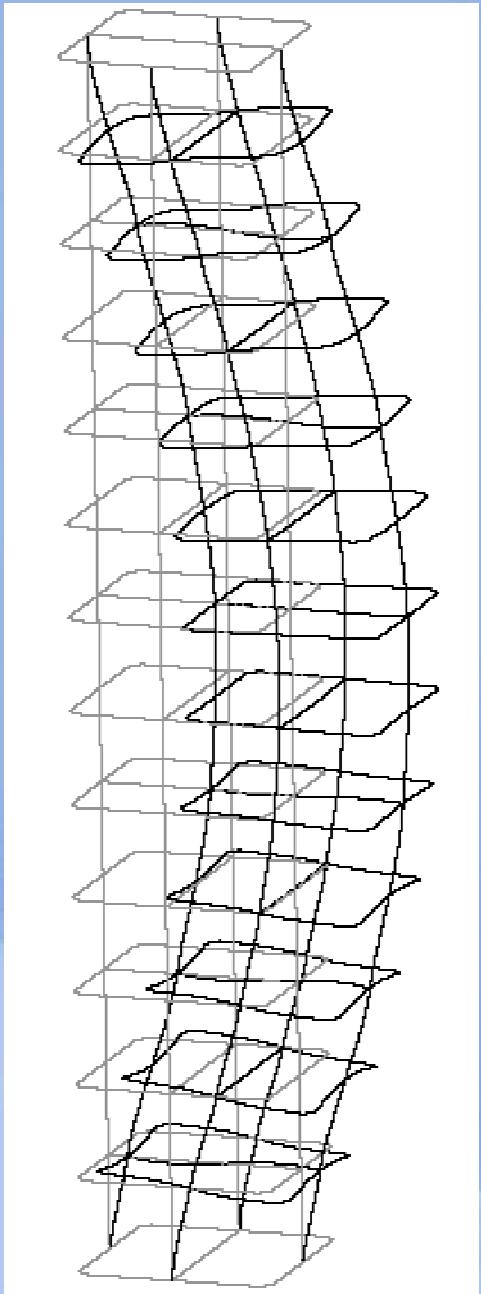
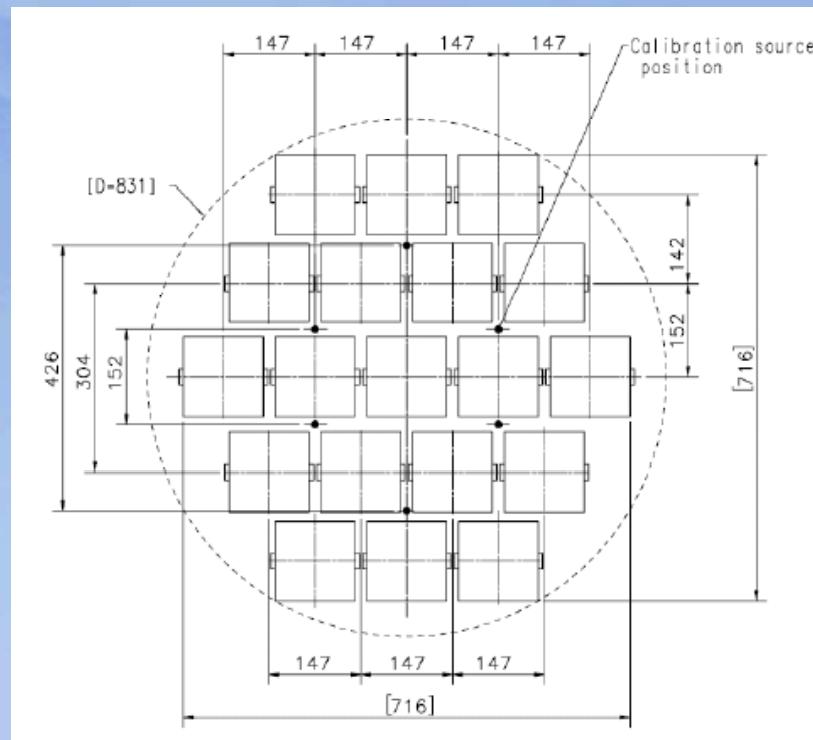
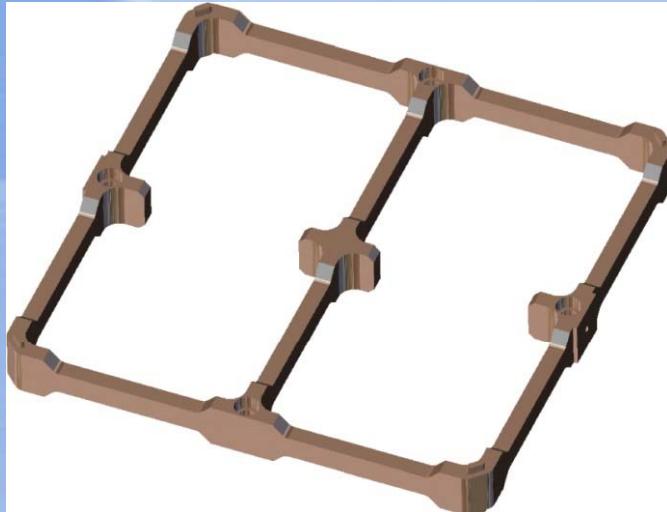
final definition of parameters of experimental setup and preparation procedures

- Detector
 - Structure
 - Crystals
 - Superficial treatment
- Cryostat
 - Cryogenics
 - Wire
 - Shielding
 - Detector Calibration System
- Hut
 - Structure
 - Cleaning room
 - Movement
- Electronics and DAQ
 - Improvement of design



• Structure

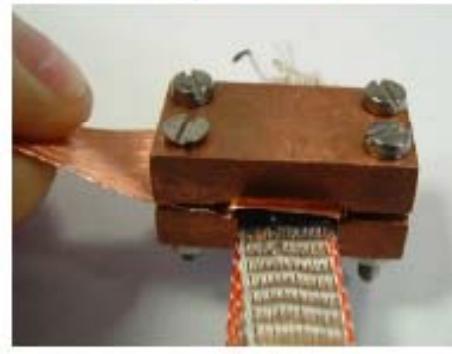
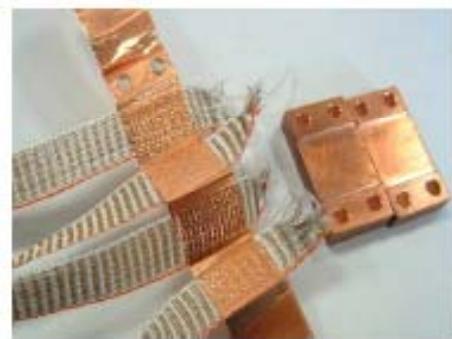
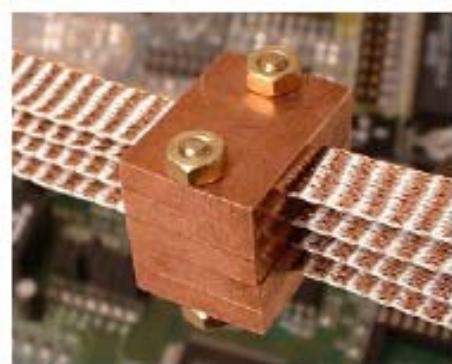
- Detector structure defined
- Tower position defined
- Some vibration simulations already done



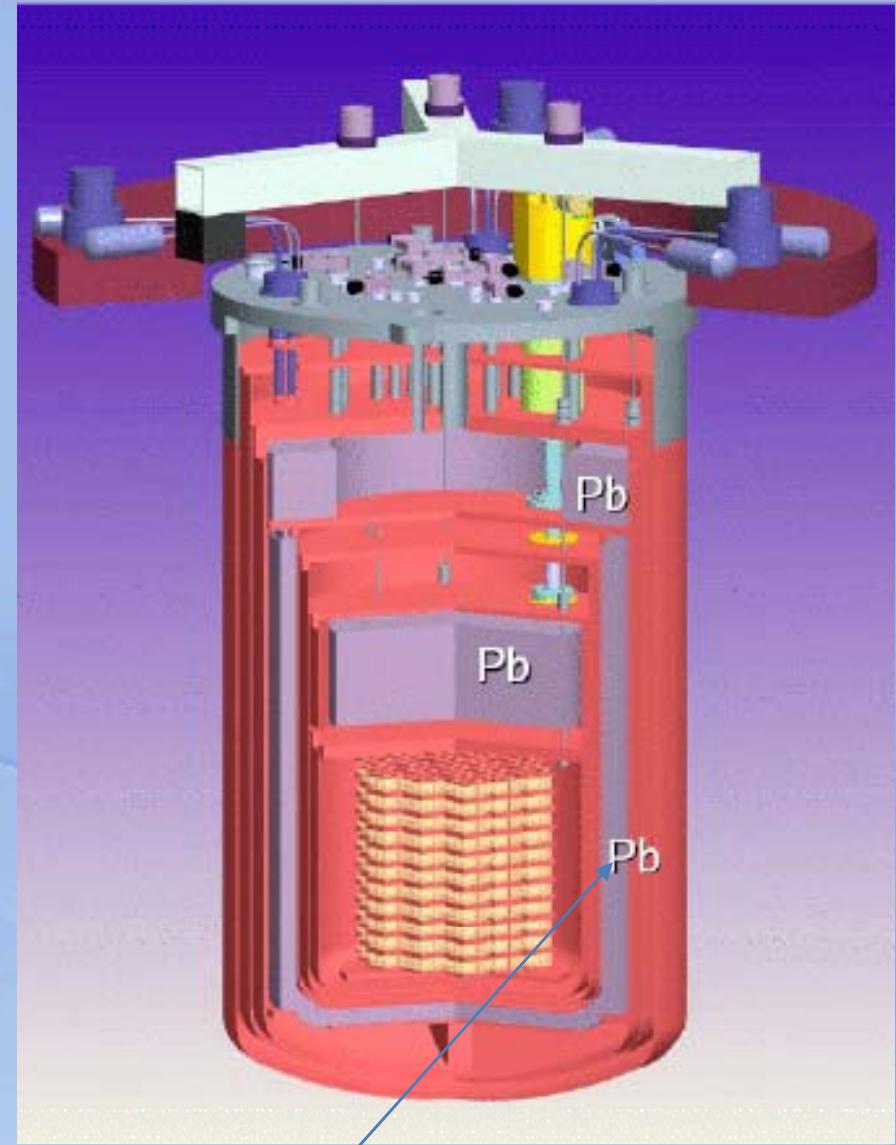
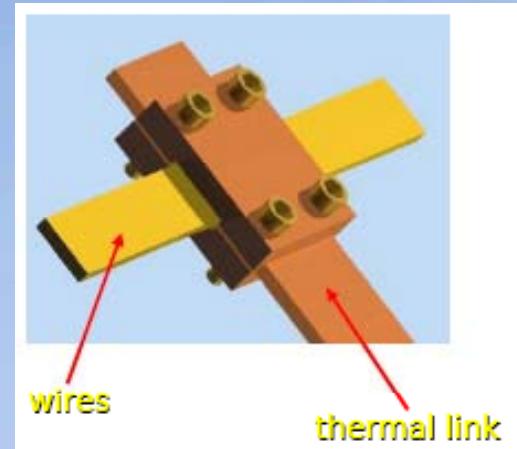
CUORE - Cryostat



- Cryogenics
- Wire



Some studies on wire
(position, dimension, ..) and
thermal link already done.



New measurements on roman lead (^{210}Pb)
Neutron Activation Analysis

Results on $^{232}\text{Th} \leq 8.2 \times 10^{-12} \text{ g/g}$ 90% c.l.
Simulations already done



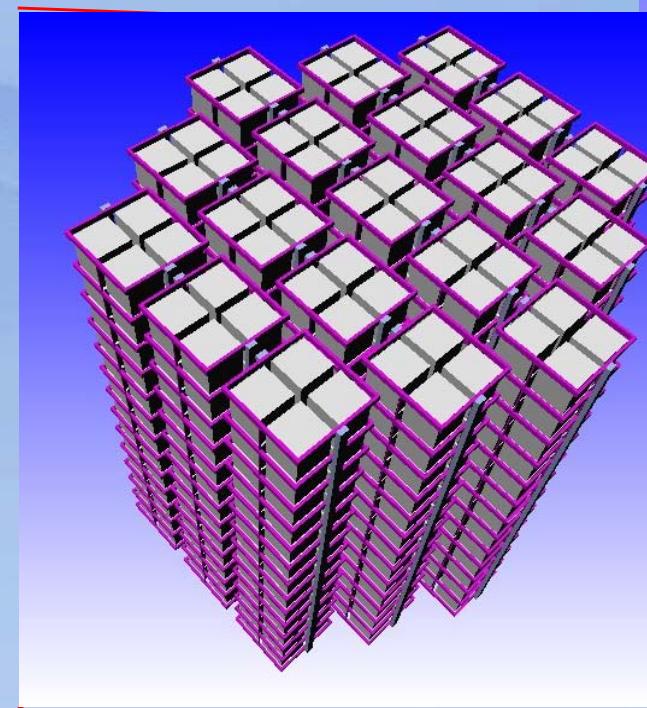
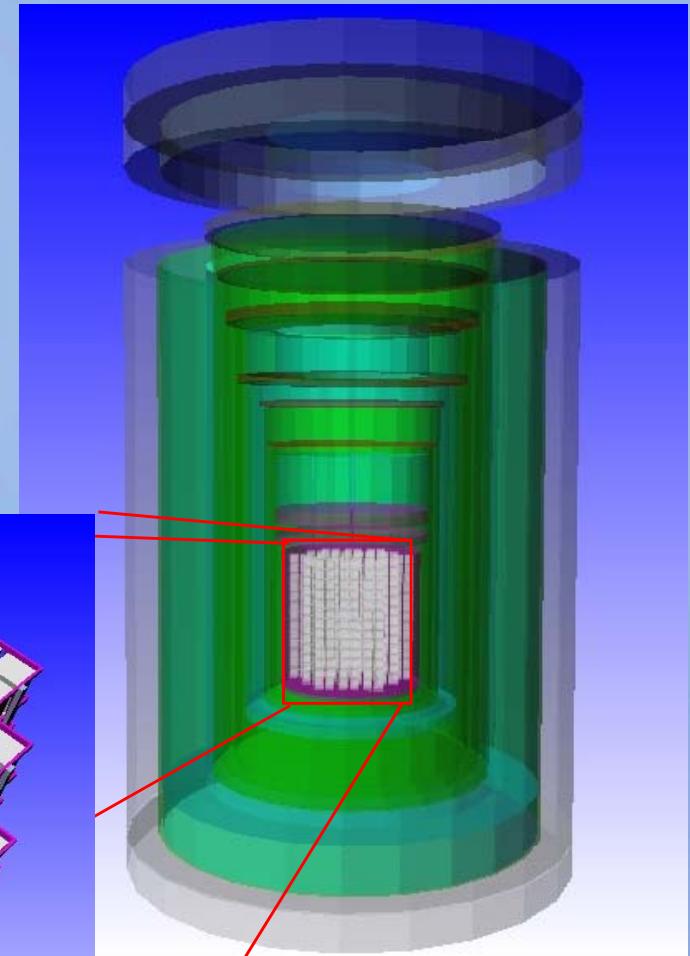
• Shielding

Some simulations with GEANT4 & FLUKA to study the impact of:

- γ radioactivity (environmental radioactivity & material contaminations)
- Superficial contamination
- Environmental neutron and muon induced neutrons
- Cosmic ray (muons)

Other simulations are needed to study all the possible contributions to the background.

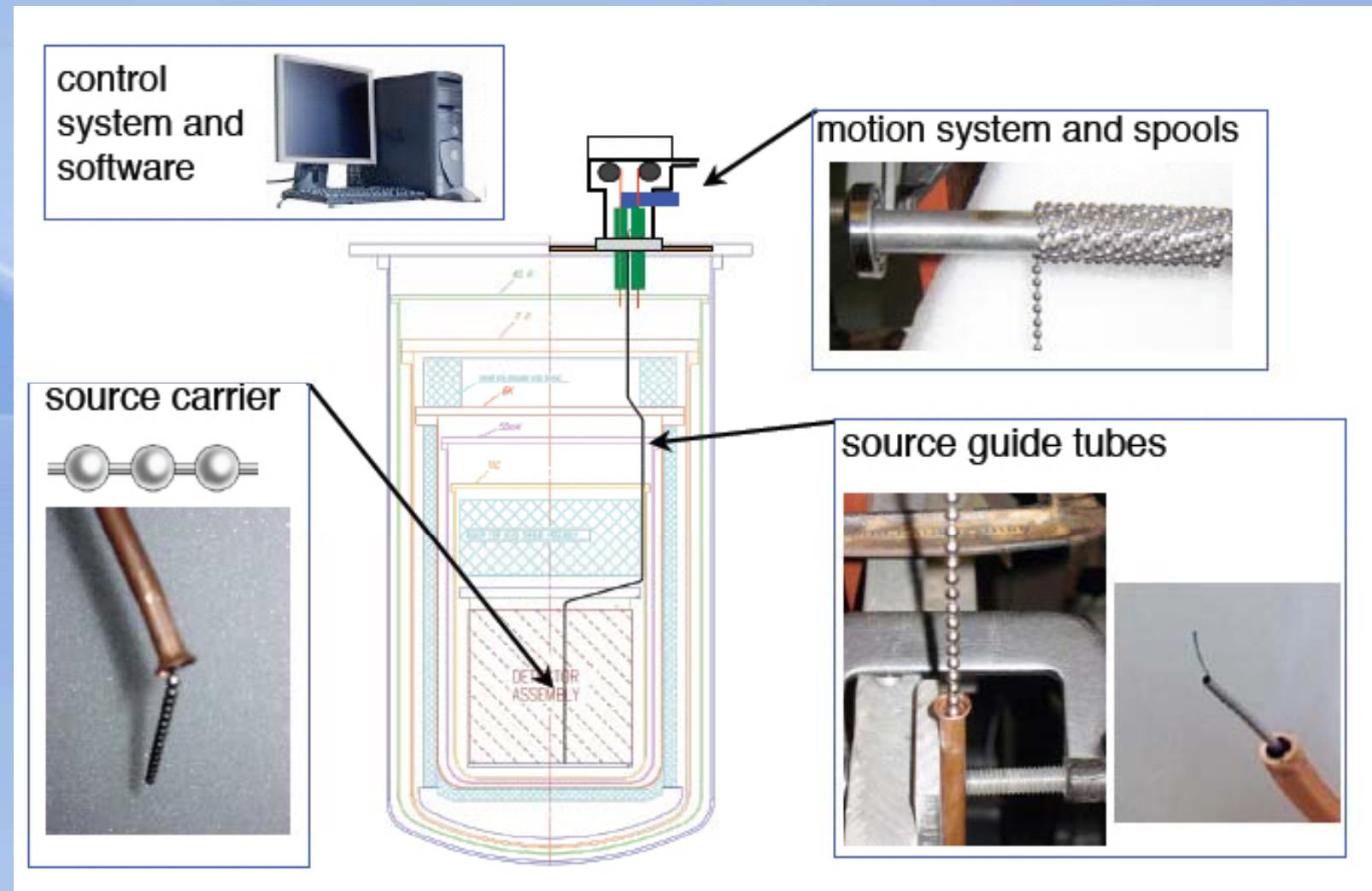
GEANT4 Simulation





CUORE - Cryostat

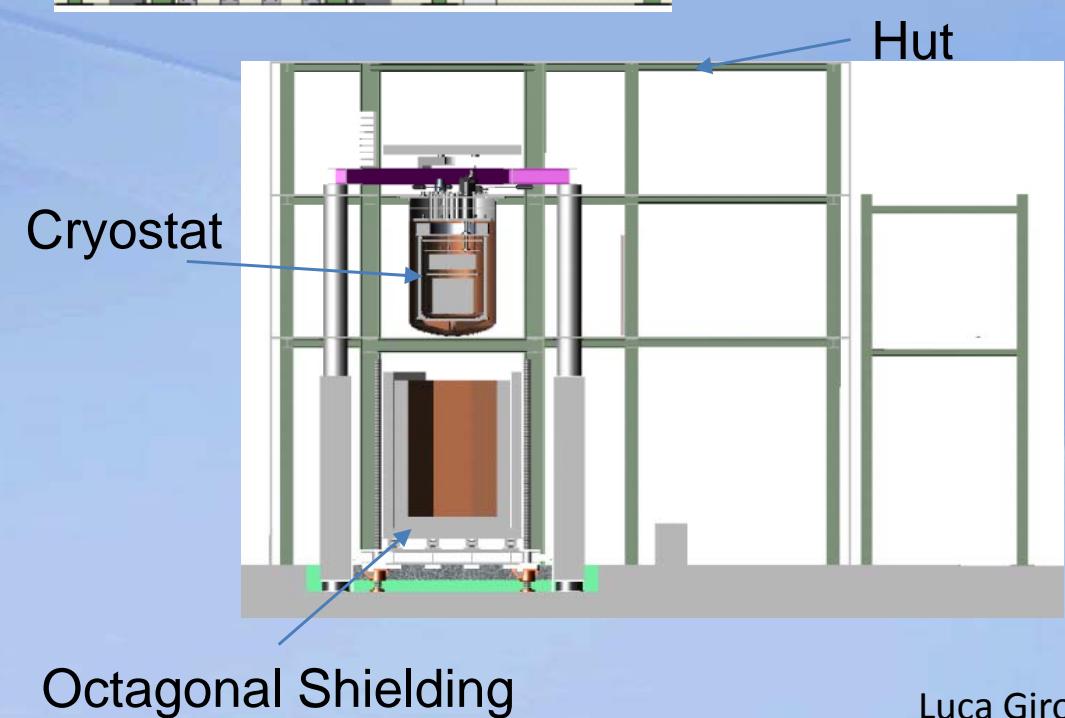
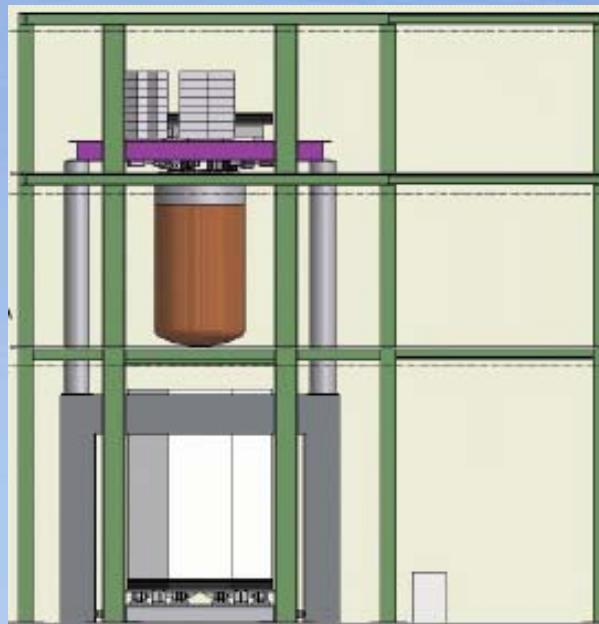
- Detector Calibration System



Some simulations to study calibration sources position and intensity already done



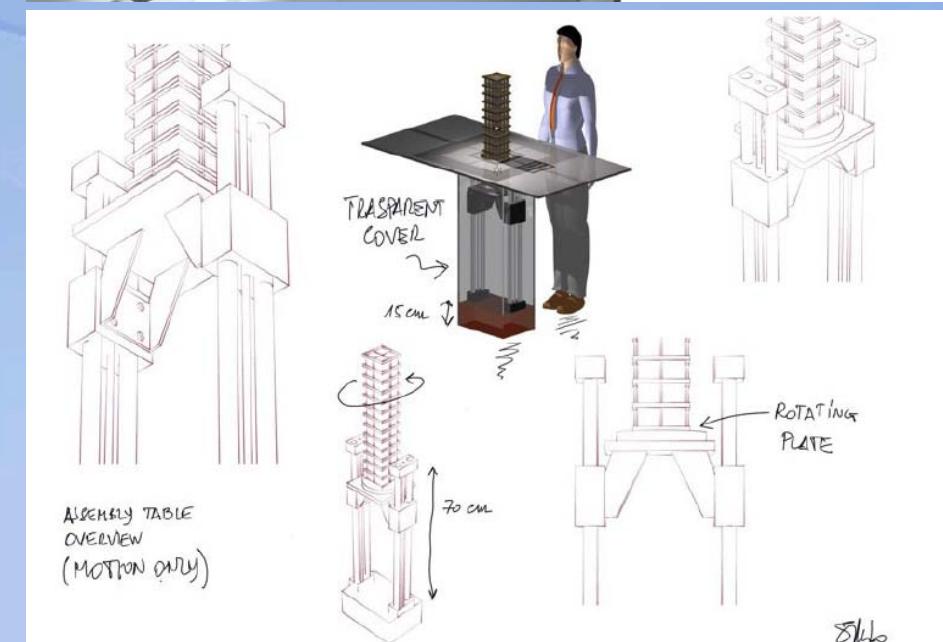
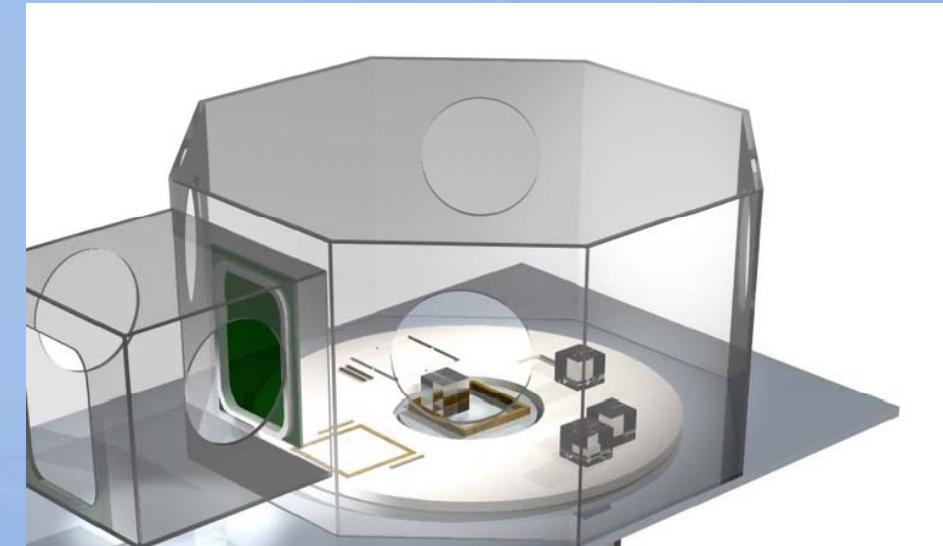
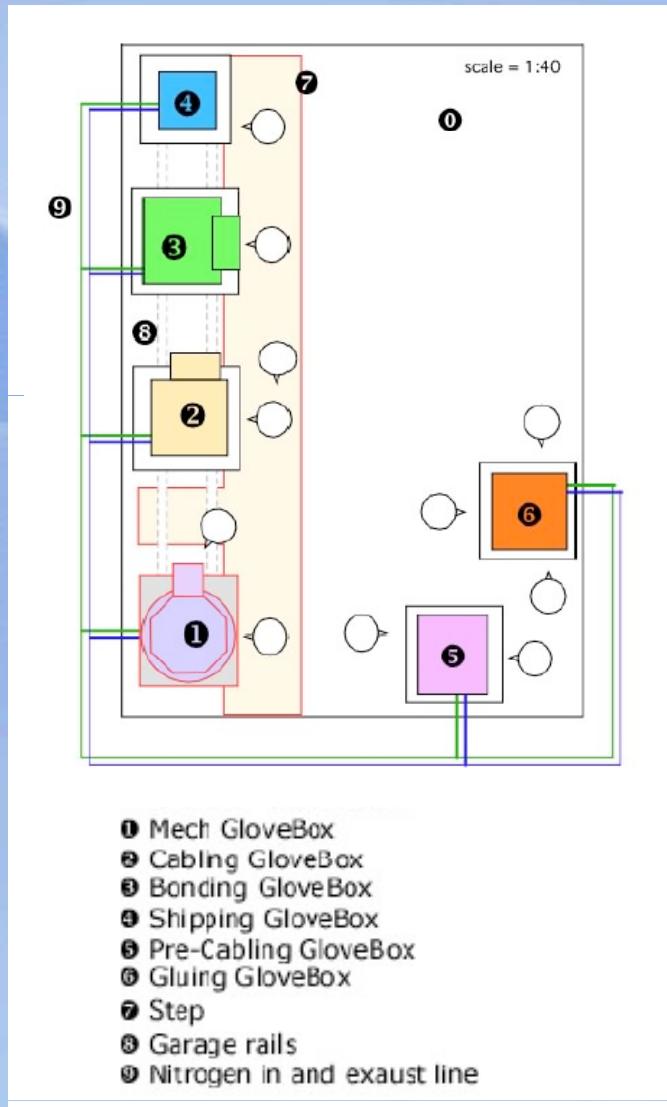
- Structure





- Clean room

Clean room layout and conceptual design of the detector handling tools: done



CUORE – Background Model



Primary GOAL of CUORE: 0.01 counts/keV/kg/y @ 2530 keV

b(c/keV/kg/y)	Γ (keV)	$T_{1/2}^{0\nu}$ (y)
0,01	10	$1,5 \times 10^{26}$
0,01	5	$2,1 \times 10^{26}$
0,001	10	$4,6 \times 10^{26}$
0,001	5	$6,5 \times 10^{26}$

CUORE strategy:

- Improve shields & material quality
- Reduce surface contribution for
 - TeO_2 crystals
 - Faced components (mainly copper)

CUORE strategy (2):

- Cuoricino background analysis
- CUORE-0
- Active R&D program

CUORE – Background Model



TeO₂ Bulk contamination

from the visible peaks and assuming secular equilibrium crystal bulk contaminations have been evaluated

$$^{232}\text{Th} \Rightarrow (2 +/- 0.4) \times 10^{-13} \text{ g/g}$$

$$^{238}\text{U} \Rightarrow (1.0 +/- 0.2) \times 10^{-13} \text{ g/g}$$

$$^{210}\text{Pb} \Rightarrow (8 +/- 1) \times 10^{-6} \text{ Bq/kg}$$



Contribution to CUORE DBD bkg
(Montecarlo simulation)

$$\sim 10^{-4} \text{ c/keV/kg/y}$$

Surface contaminations:

$$\text{CUORICINO DBD bkg: } 0.18 \pm 0.01 \text{ c/keV/kg/y} =$$

$$\left\{ \begin{array}{l} 30 \pm 5 \% \text{ } ^{232}\text{Th} \text{ in cryostat} \\ 20 \pm 5 \% \text{ TeO}_2 \text{ Surface} \\ 50 \pm 10 \% \text{ Cu Surface} \end{array} \right.$$

- Selected and optimized shields
- Factor ~ 5 reduction in TeO₂ cont.
- Factor ~ 1.8 reduction in Cu cont.
 - New structure geometry ($\sim 1/2$ Cu facing crystals)



negligible cryostat contribution
 $\sim 7 \cdot 10^{-3} \text{ c/keV/kg/y}$
 $\sim 2.5 \cdot 10^{-2} \text{ c/keV/kg/y}$



Environmental sources @ LNGS

Environmental γ	$< 10^{-3}$ counts/keV/kg/y
μ induced γ	Simulation to be done
Rock neutrons	$< 10^{-4}$ counts/keV/kg/y
μ induced neutrons	$< 10^{-4}$ counts/keV/kg/y
μ	$(4+/-1) \times 10^{-3}$ counts/keV/kg/y

Summary

Cuoricino

- 40.7 kg of TeO₂
- Data taking from 2003
- $B \approx 0.18 \pm 0.01 \text{ c/keV/kg/y} @ Q_{\text{bb}}$
- $T_{1/2}^{0\nu}(y) > 3.0 \times 10^{24} \text{ y}$ (90% c.l.)
- Good technical performance
- Crucial information for background source identification

CUORE-0

- The first tower of CUORE
- It will be installed in hall A of Laboratori Nazionali del Gran Sasso (replace Cuoricino)
- 52 TeO₂ crystals ($5 \times 5 \times 5 \text{ cm}^3$ – 750g)
- Start data taking on March 2009

Hall C

- Crucial tests to study bolometric detector background
- Crystal surface contamination reduction ~ 4
- Reduction of the 3-4 MeV counting rate (38 +/- 7)%

CUORE

- array of 988 TeO₂ crystals $5 \times 5 \times 5 \text{ cm}^3$ (750 g)
- 741 kg of TeO₂
- Many studies on background already done
- Construction phase in progress
- Start data taking on January 2011

CUORE Collaboration

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