



CUORE

Italian Contribution

INFN

Sezione di Milano

Sezione di Genova

Sezione di Firenze

Sezione di Roma 1

Laboratori Nazionali del Gran Sasso

Laboratori Nazionali di Legnaro

Universita' di Milano-Bicocca

Universita' di Insubria

Universita' di Genova

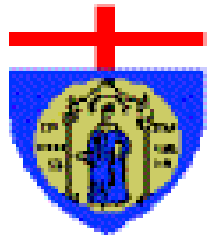
Universita' di Firenze

Universita' di Roma 1

Oliviero Cremonesi

INFN Sezione di Milano

and Universita' di Milano-Bicocca



CUORE Time Schedule

Start date: 1st July 2004	2004	2005	2006	2007	2008	2009	
Crystals							
US							
Material Selection							
Procedure settling							
Growth and preparation							
	25	100	1400	2800			4325
Thermistors							
US							
R&D and Ge irradiation							
Decay period							
Production							
	50	50	250	250			600
Detector structure							
INFN							
Design							
Material Selection							
Production							
	50	120	200	150	150		670
Cleaning							
	25	125	300	125	125		700
Cryostat & cryogenics							
INFN							
Design and material selection							
Construction							
Installation and test							
	10	1000		100			1110
Shieldings							
INFN							
Design and material selection							
Construction							
		100		250	250		600
Underground Laboratory							
INFN							
Design							
Installation							
	25	25	500	300			850
Electronics							
US							
Design and test							
Production							
Installation							
	20	40	260	240		30	590
Data Acquisition							
INFN							
R&D and prototyping							
Final design							
DAQ SW development							
Production							
Installation							
	5	20	80	150	150	120	525
CUORE assembly							
INFN/US							
Installation				50	50	900	1000
Contingency	150	375	750	675	600	450	3000
Total cost	360	1955	3740	5090	1325	1500	13970

LETTER OF INTENT FOR CUORE (A Criogenic Underground Observatory for Rare events)

The proposal for CUORE (for Cryogenic Underground Observatory for Rare Events) has been approved on April 2 2004 by the Scientific Committee of the Gran Sasso Laboratory with the following milestones:

1. To construct a dilution refrigerator capable to cool the CUORE structure as soon as possible,
2. The simultaneous construction of a Hut in the Gran Sasso Laboratory to house CUORE,
3. To decrease of the surface radioactive contamination of the copper by at least a factor of ten in one year,
4. To decrease of the surface radioactive contamination of the crystals by at least a factor of four in two years.

A detailed description of the CUORE proposal can be found in the WEB site <http://crio.mib.infn.it/wig>

This experiment is designed to reach a sensitivity of a few tens of millielectronvolts in the effective Majorana mass of the neutrino , and is the only next generation double beta decay proposal for which a definite location has already been indicated (and requested to the Director of the LNGS).

After the CUORE Collaboration meeting in Milano on May 13 and 14, and following the approval of CUORE, the CUORE collaboration requested that a letter of intent be prepared, with the list of items for which financial contributions would be requested from the various funding agencies.

We would like to point out that while the Zaragoza group will contribute to CUORE with its wide experience in double beta decay experiments and in the background reduction, and with personnel working in Gran Sasso, no other relevant financial contribution to the construction of CUORE is foreseen.

The Leiden group , one of the leaders in the world in the construction and operation of large dilution refrigerators, will contribute to the design and construction of the dilution refrigerator and to its installation. This corresponds to a substantial contribution to the experiment.

As a consequence funding for the realization of the CUORE structure will be requested to INFN (Italy), with the participation of four Sezioni and two Laboratori Nazionali, and DOE and the NSF (USA) with the participation of UC Berkeley (the world leader in preparation of thermistors), the Lawrence Berkeley and Livermore National Laboratories and of the University of South Carolina.

The list of items to be requested and the institution to which this request will be addressed are as follows:

1. Crystals (Material selection, procedure settling, growth and preparation, possible enrichment) USA
2. Thermistors (R&D and Ge irradiation. Production) USA
3. Detector structure (design, material selection, production) INFN
4. Cryostat & cryogenics (design and material selection, construction, installation and test) INFN
5. Passive shielding (design and material selection, construction) INFN
6. Underground laboratory (design, installation) INFN
7. Electronics, design and test, production, installation) USA
8. Data acquisition, R&D and prototyping, final design, DAQ SW development, production, installation) INFN
9. CUORE assembly INFN & USA

As suggested by the Scientific Committee, item 4. and 6. should be pursued immediately, and appropriate funding will be requested in June to INFN.

F. Avignone, E. Fiorini, E. Norman

LNGS Scientific Committee: 2nd April 2004

CUORE:

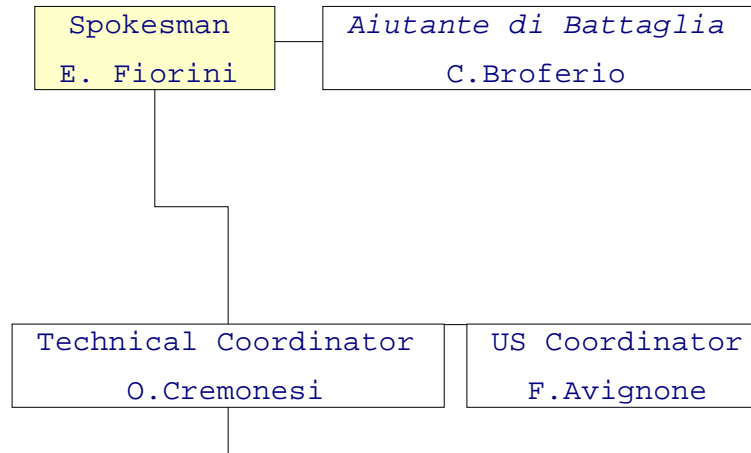
The SC congratulates the Collaboration for their new result on ^{130}Te with CUORICINO. The group has made remarkable progress in identifying quantitatively the remaining sources of background.

In view of these developments **the SC recommends the conditional approval of the CUORE project** (a 750 kg detector aiming at a background of 0.01 counts/keV/kg/y).

The design and construction of the cryostat, cryogenic system and underground laboratory should proceed as rapidly as possible. The detector structure construction is dependant on a **first milestone, which should be achieved in about one year or less, showing that the copper surface contamination can be reduced by about a factor of 10 compared to what us presently achieved in CUORICINO.**

Before the procurement of the large number of crystals, **a second milestone (in about two years from now) should be reached showing that crystal surface contamination can be measured and reduced by about a factor of 4, compared to present contamination.** As indicated in the latest collaboration plans, if a method of surface contamination measurement is not developed meanwhile, a first tower should be built and measured in the new cryostat before the main crystal procurement

CUORE Working Groups



1. SINGLE MODULE DEVELOPMENT [Coordinator: A. Giuliani]

[Institutions: Como, Firenze, Gran Sasso, LBNL, Leiden, Milano]

2. CRYSTAL PREPARATION [Coordinators: F. Avignone and E. B. Norman]

[Institutions: Como, LBNL, Milano, USC]

3. CUORE ASSEMBLY [Coordinators: S. Pirro, C. Brofferio]

[Institutions: Como, Gran Sasso, Leiden, Milano]

4. LAB-FACILITIES AND ELECTROTECHNICS [Coordinator: C. Bucci]

[Institutions: Gran Sasso, LBNL, Milano, USC]

5. CRYOGENICS [Coordinator: G. Frossati]

[Institutions: Firenze, Gran Sasso, Leiden, Milano]

6. RADIOACTIVITY [Coordinator: E. B. Norman and F. Avignone]

[Institutions: Como, Gran Sasso, Legnaro, LBNL, Milano, USC, Zaragoza]

7. DATA ACQUISITION AND SYSTEM MONITOR [Coordinator: M. Pallavicini]

[Institutions: Genova, Gran Sasso, Milano]

8. ELECTRONICS [Coordinator: G. Pessina]

[Institutions: LBNL, Milano, USC, Zaragoza]

9. 1st LEVEL DATA ANALYSIS [Coordinator: M. Pavan]

[Institutions: LBNL, Milano, USC, Zaragoza]

10. 2nd LEVEL DATA ANALYSIS [Coordinator: E. Fiorini (DBD) + A. Morales (DM)]

[Institutions: LBNL, Milano, USC, Zaragoza]

Italian contributed items

CUORICINO experience teaches that
CUORE construction is straightforward
What we still need is
mainly optimization and engineering

Italian contribution:

- Detector Structure
- Cryostat and Cryogenics
- Shieldings
- Underground Laboratory
- Data Acquisition
- Detector Assembly

CUORICINO

Detectors: 60/62 working

- ▲ 4 x 11 = 44 large size crystals (5x5x5 cm³, <m>=790 g) → 42 working
- ▲ 9 x 2 = 18 small size crystals (3x3x6 cm³, <m>=330 g) → 18 working

Natural Te active mass: 39.12 kg TeO₂ = 10.6 kg ¹³⁰Te

- ▲ 42 x 0.79 = 33.18 kg
- ▲ 18 x 0.33 = 5.94 kg

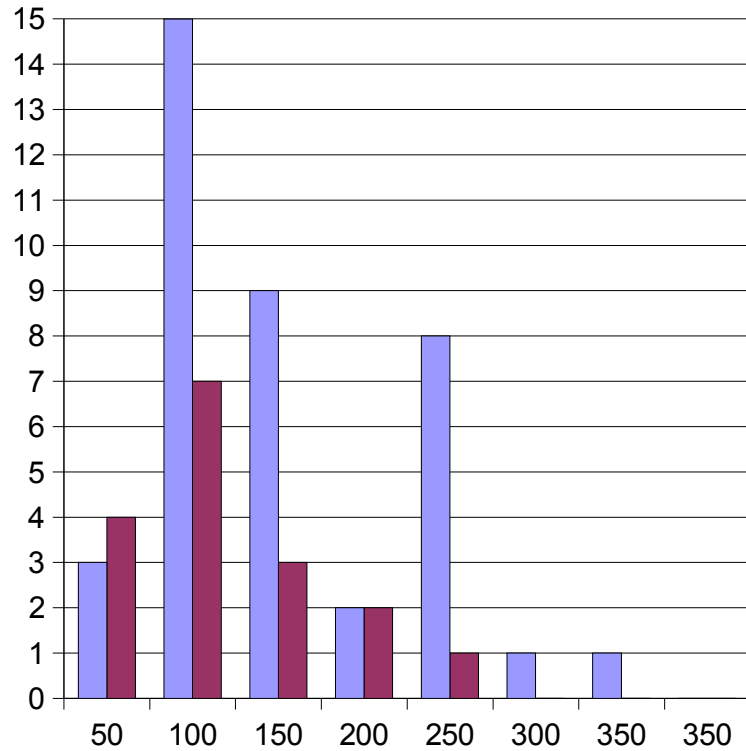
Isotopically enriched crystals

- ▲ 2 (¹³⁰Te) x 0.33 = 0.66 kg = 0.495 kg ¹³⁰Te
- ▲ 2 (¹²⁸Te) x 0.33 = 0.66 kg = 0.543 kg ¹²⁸Te

Total ¹³⁰Te mass: 11.64 kg

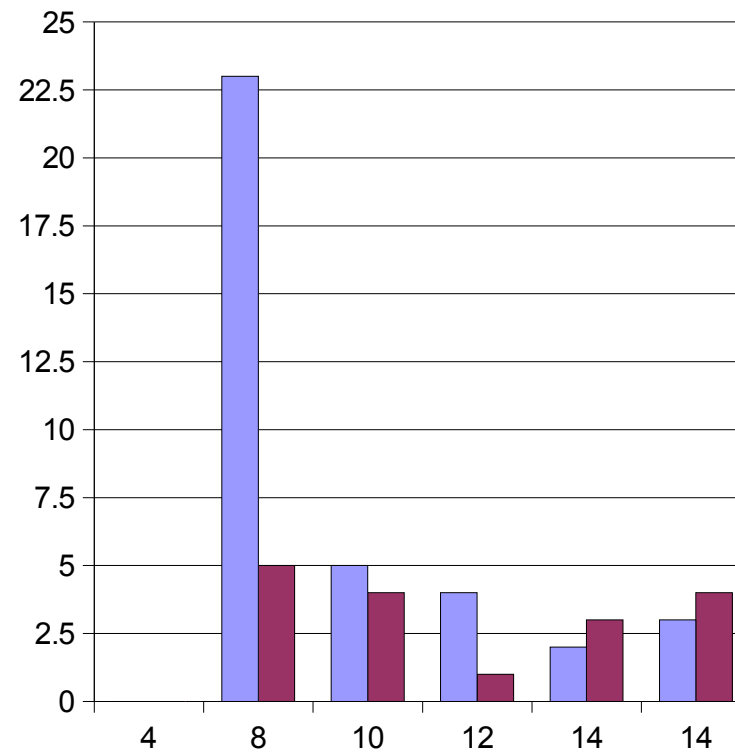
CUORICINO (2)

Pulse height



5x5x5 TeO2 crystals
3x3x6 TeO2 crystals

FWHM(2615keV)



Detector structure

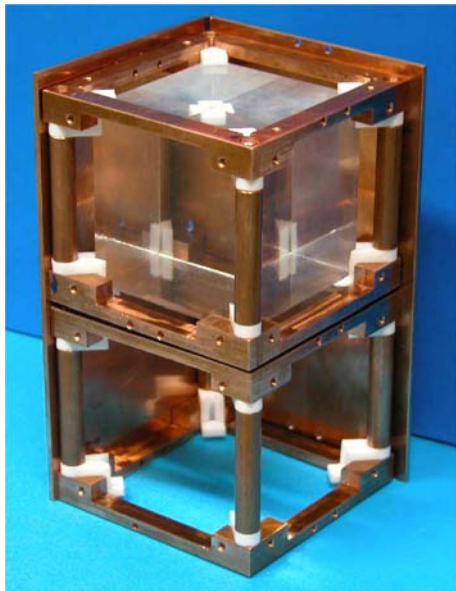
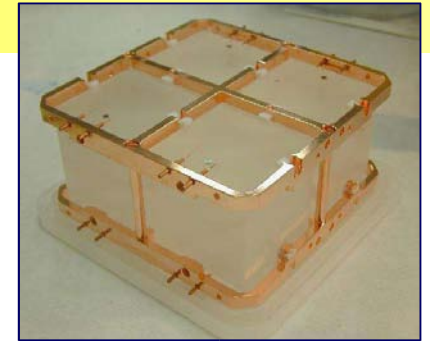
Baseline:

4 detector modules successfully operated in CUORICINO

High reproducibility

Modularity

Easy assembly technique



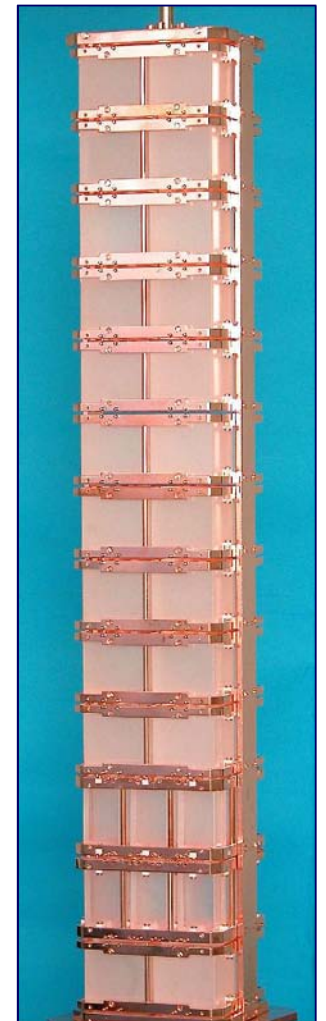
Single module optimization

- ✓ lower number of screws
- ✓ reduce copper surface and volume
- ✓ new holder design (stability)

Test prototypes already successfully tested @ LNGS

Heaters and NTD thermistors optimization

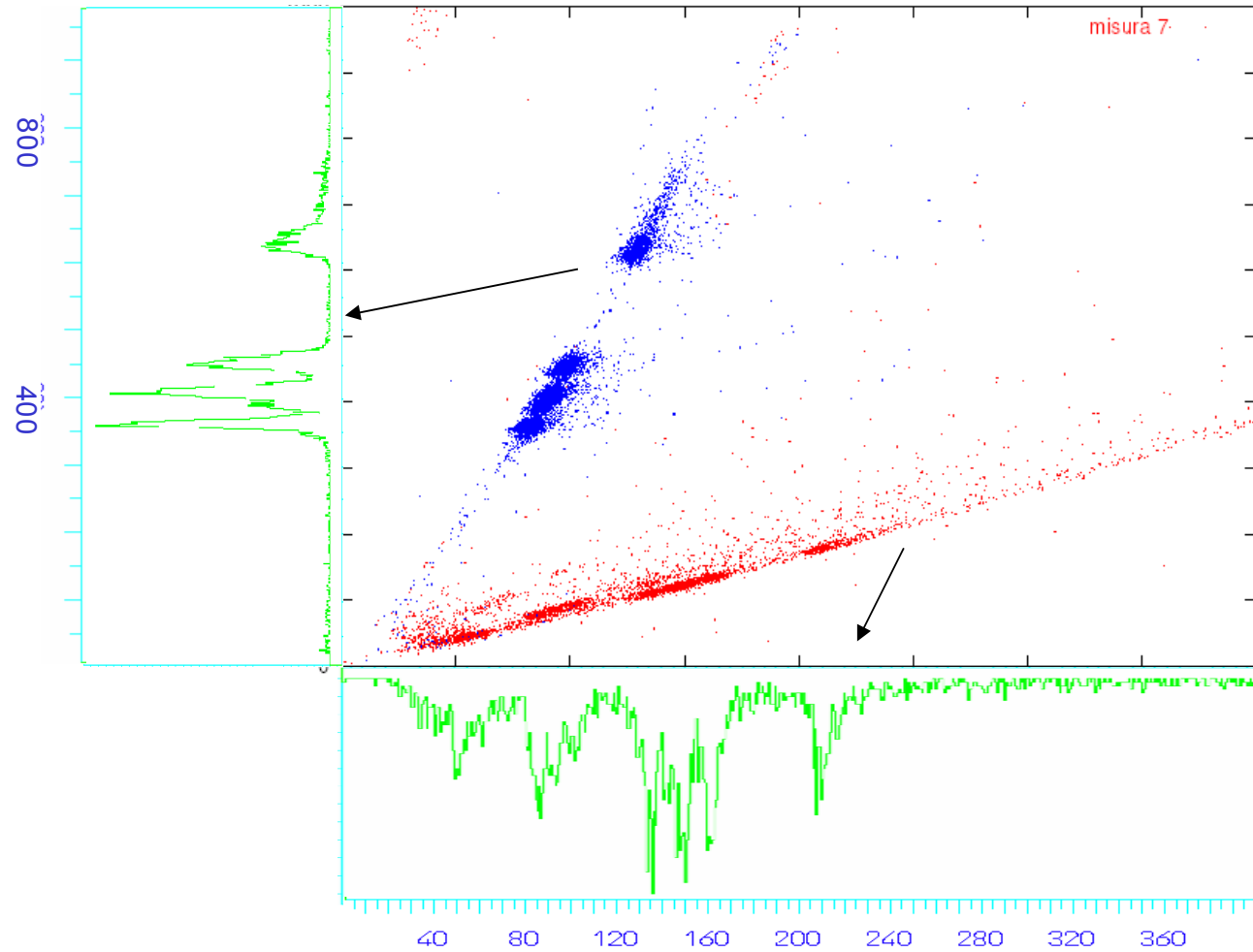
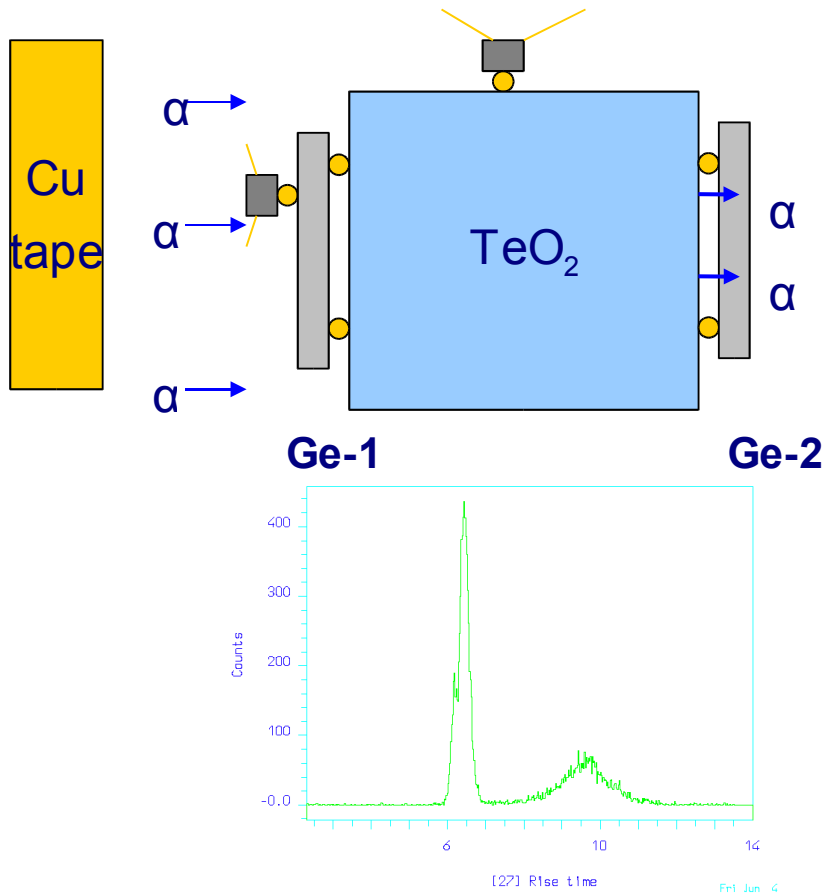
Material delection and surface cleaning



Detector structure (2)

Innovative design:

Surface sensitive detectors



Scintillation+Heat detectors

Cryostat and Cryogenics

Large cryostat to host CUORE detector and part of the radiation shields

Exploit experience gained in

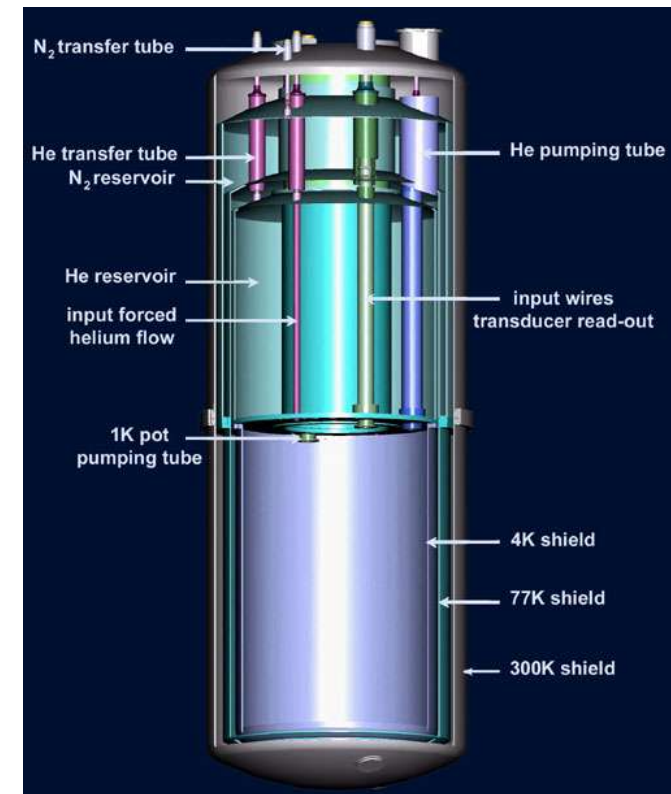
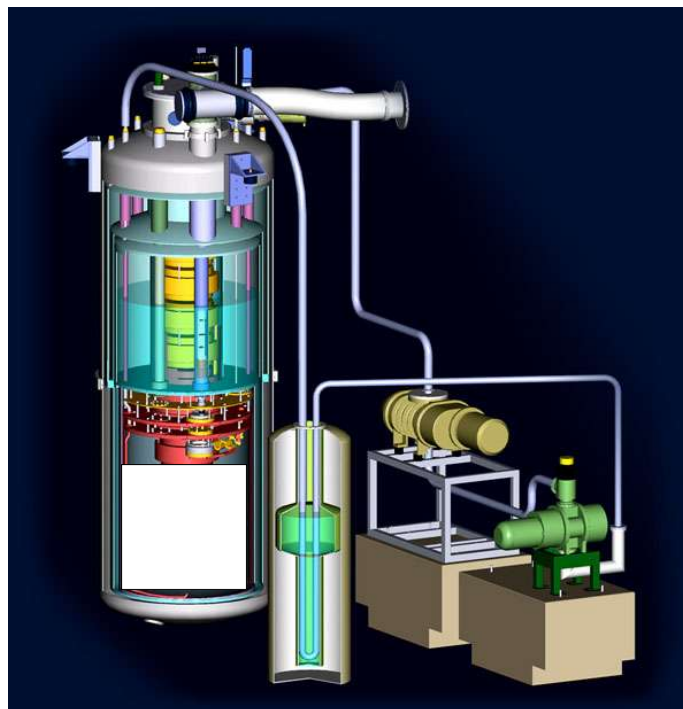
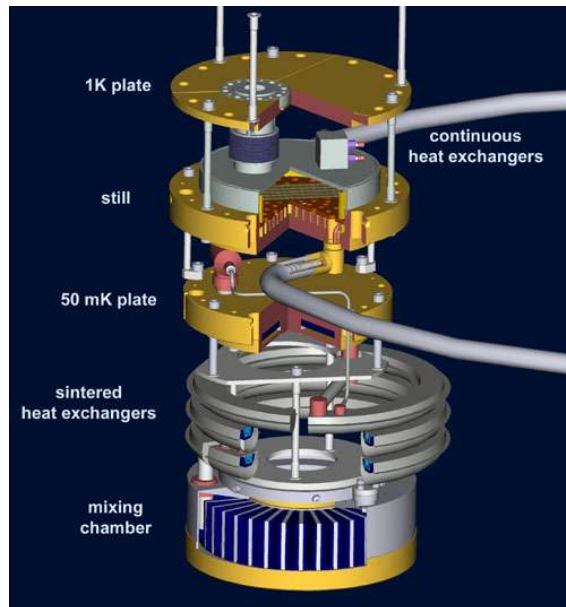
20 year of LTD's operation @ LNGS

large cryostats development for GW antennas

Final design almost completed:

no cryogenic liquids nor superinsulating shields

Start material selection



Shieldings

Heavy radiation shields to avoid background contributions from

- environmental radioactivity
- setup material bulk radioactive contaminations

External:

- ▲ Lead (normal+low ^{210}Pb)
- ▲ Borated Polyethylene

Internal:

- Lead top disc (low ^{210}Pb)
- Roman Lead detector surrounding box

Underground Laboratory

Logistics and lab. engineering (air, water, ventilation, gases...)

Complete design of the lab, taking into account all experimental needs

- Faraday cage
- Multi-stage clean rooms
- Radiation shields
- Cryogenic system

Front-end electronics

Connections with the LNGS staff

Mains supply and problems connected (UPS, ground loops, interference)

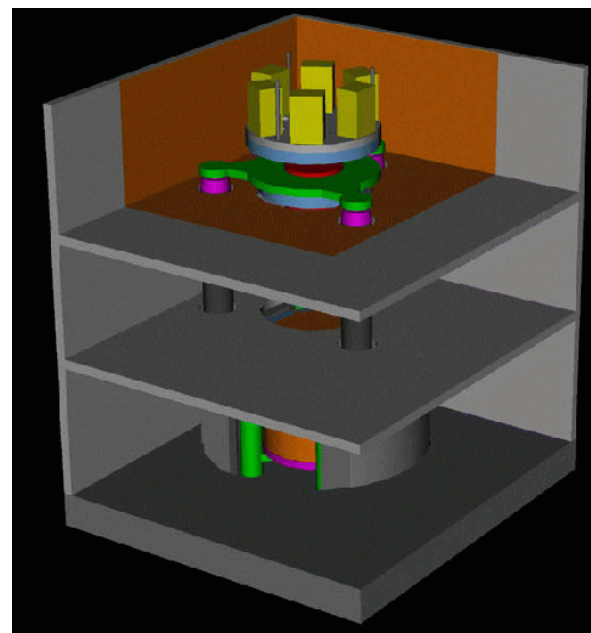
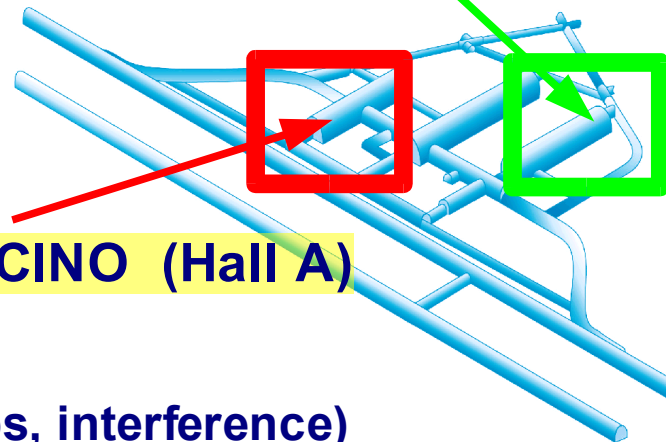
Design of main supply distribution, care in the elimination of ground loops and interferences

Dedicated supplies

Safety

CUORE R&D (Hall C)

CUORICINO (Hall A)



Data Acquisition

Hardware for data acquisition

Software for data acquisition
Trigger shaping

Thermal detector stabilization

Remote acquisition monitor

“real time” monitor

“real time” analysis

Remote monitor and control of the cryogenic systems

“real time” monitor

“real time” remote control

DAQ details almost fixed

Prototype board tests on CUORICINO detectors within 2005

Detector Assembly

Design and test of the complete CUORE detector structure

Detailed study with CAD tools

Response of the structure to vibrations induced by the cryostat or by external sources and reduction of it.

Multi-stage

Detectors construction standardization and engineering

Reproducibility of all the components, particularly of copper and PTFE frames. Mounting procedures

Special techniques for the realization “Hi-tech” of the various components

Single module structure

Standardization and “engineering” of crystal mounting

Integrate readout wires on the structure

New module design with less copper and/or different materials

Thermal detector stabilization

Implementation of thermal feedback for detector stabilization

Successful preliminary tests @LNGS (CUORICINO + CUORE R&D)

Engineering under study

1st Level Data Analysis

Data storing and handling

Software for a low threshold trigger (I or II level)

On line data display

Raw data analysis software: "from pulses to spectra"

Info Data Base