First Results
from the Cuoricino Experiment

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Double Beta Decay

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

Allowed in SM
observed in several nuclei with $\tau^{2\nu} \sim 10^{18} - 10^{21}$ y

- Leptonic number violation
- Majorana neutrino
- $n = n^c$
- $m_n \neq 0$
**Sensitivity**: Lifetime corresponding to the minimum number of detectable events above background at a given C.L.

\[
S_{0\nu} = \ln 2 \frac{N_A}{\Lambda} \times \frac{M_T}{\Gamma} \times \frac{1}{2} \times \epsilon \times \text{Detector mass (kg)} \times \text{Measurement Time (y)}
\]

- **Isotopic abundance**
- **Atomic mass**
- **Background (counts/keV/kg/y)**
- **Energy resolution (keV)**
- **Efficiency**
Mibeta ($^{130}\text{Te}$)

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

Every detector was a $\text{TeO}_2$ crystal $3\times3\times6 \text{ cm}^3$ (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

\[ \tau_{1/2}^{0\nu} \geq 2.1 \times 10^{23} \text{ y} \left( 90\% \text{ CL} \right) \]

\[ \langle m_\nu \rangle \leq 1.1 - 2.6 \text{ eV}^* \left( 90\% \text{ CL} \right) \]

\* Dependent on the value for the nuclear matrix elements

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Total statistic \(~ 4.3 \text{ kg \times y.}\)
The 790 g detectors

R&D on new detectors 5x5x5 cm$^3$ of TeO$_2$ (790 g)

The best 790 g detector:

- 1.5 keV FWHM @ 0.351 MeV
- 2.4 keV FWHM @ 0.911 MeV
- 3.8 keV FWHM @ 2.615 MeV
- 4.2 keV FWHM @ 5.407 MeV

(The best $\alpha$ spectrometer ever realized)
A. Alessandrello et al, NIM A440 (2000) 397-402

Better design of the 790 g detectors allowed performances comparable with the 340 g crystals
The central detectors are almost completely surrounded by active materials. Substantial improvement in BKG reduction.

11 modules
4 detectors each
Dimension: 5x5x5 cm³
Mass: 790 g

2 modules
9 detectors each,
Dimension: 3x3x6 cm³
Mass: 330 g

Total mass
40.7 kg
Detectors assembling

All the operations done in nitrogen atmosphere
Cuoricino module

A Cuoricino module

Ge NTD thermistor
Tower assembling
Cuoricino

11 modules
4 detectors each
Dimension: $5 \times 5 \times 5$ cm$^3$
Mass: 790 g

Total mass
40.7 kg

2 modules
9 detectors each,
Dimension: $3 \times 3 \times 6$ cm$^3$
Mass: 330 g
Detector performances

Some electrical connection were lost during the cooling of the tower, as a result 13 detectors cannot be read-out (until next warm up the cryostat)

- Average 5x5x5 cm³ = 340 µV/MeV
- Average 3x3x6 cm³ = 440 µV/MeV

Pulse height (normalized to 1 kg of TeO₂)

- Average 5x5x5 cm³ ~ 7 keV
- Average 3x3x6 cm³ ~ 9 keV

ΔE_{FWHM} @ 2615 keV

- 5x5x5 cm³ crystals
- 3x3x6 cm³ crystals
232Th Calibration

2615 keV 208TI

∑EFWHM = 7 keV @ 2615 keV

Sum spectrum of all the 5x5x5 cm³ detectors
Preliminary result on $^{130}$Te $\beta\beta-0n$ decay

Anticoincidence background spectrum of the 5x5x5 cm$^3$ crystals around the $\beta\beta-0n$ region

$\tau_{1/2}^{0\nu} \geq 5.0 \cdot 10^{23}$ y (90% CL)

$\langle m_\nu \rangle \leq 0.7 - 1.7$ eV* (90% CL)

* Dependent on the value for the nuclear matrix elements

Total statistic $\sim 2.3$ kg $\times$ y
Cryogenic Underground Observatory for Rare Events

Array of 1000 detectors:
- 25 towers - 10 modules/tower
- 4 detectors/module
- \( M = 0.79 \text{ ton di TeO}_2 \)

Sensitivity DDB-0v (ext. background 1 c/keV ton y)
- \( T^{5y} \sim 6.6 \times 10^{26} \text{ y} \)
- \( <m_\nu> \sim 15 - 40 \text{ meV} \)

25 towers CUORICINO-like
Moore’s Law

![Graph showing the trend of Moore's Law with mass in kg and year on the x-axis and y-axis, respectively. The graph includes data points for Cuoricino, Mibeta, and a 4 detectors array, with mass values of 340 g and 73 g.]