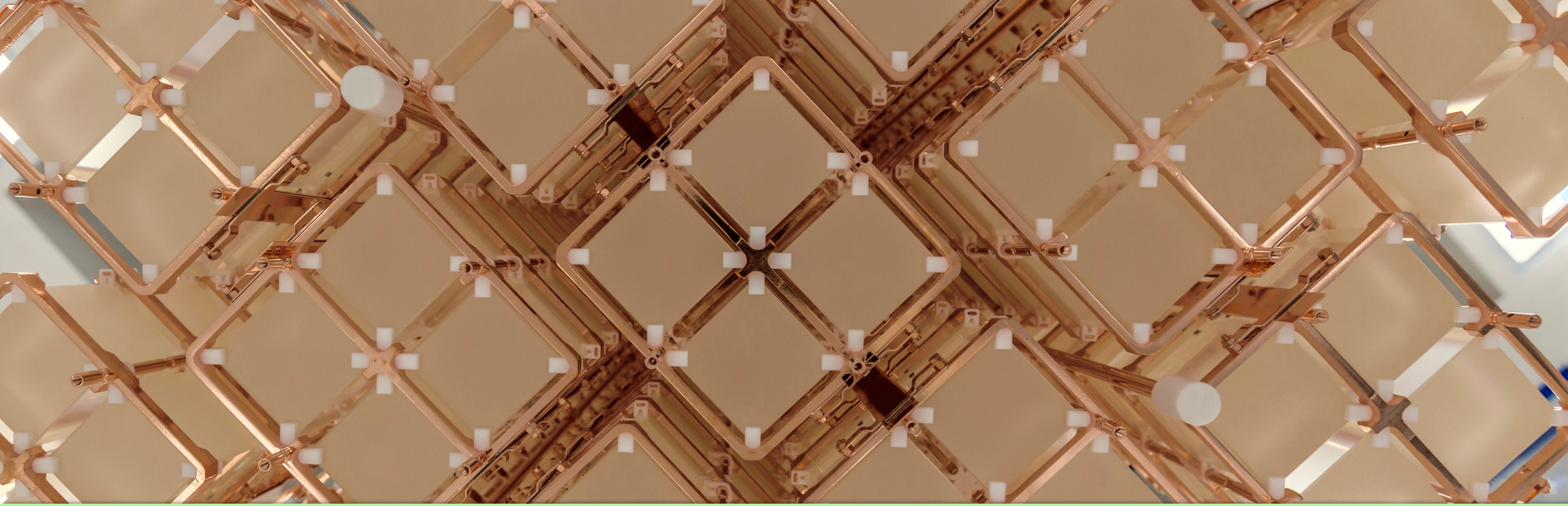

Search for neutrinoless double beta decay of ^{128}Te with the CUORE experiment

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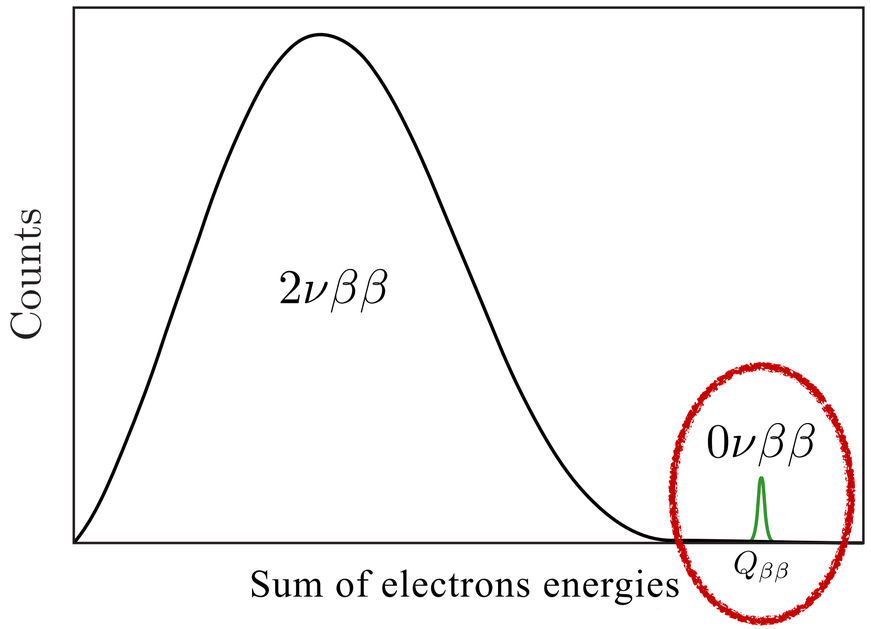
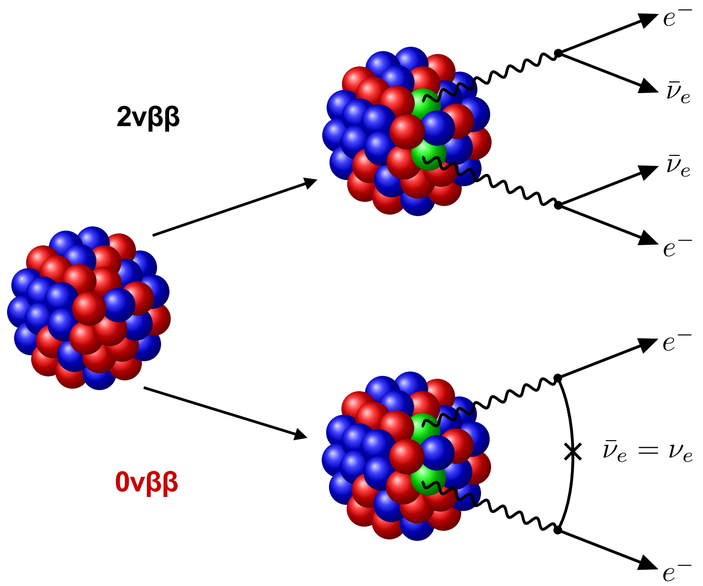
Neutrinoless double beta decay (0νββ)

Double beta decay:

- Rare second order Fermi weak nuclear transition
- Candidates: even-even nuclei, when single β decay energetically forbidden





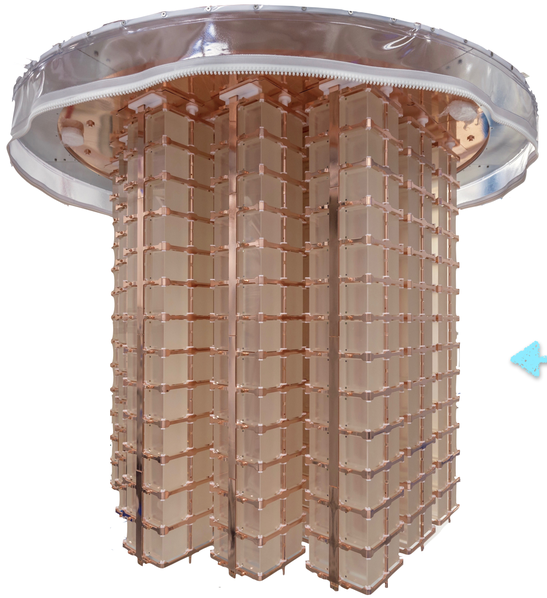
Standard Model allowed, observed in 11 nuclei

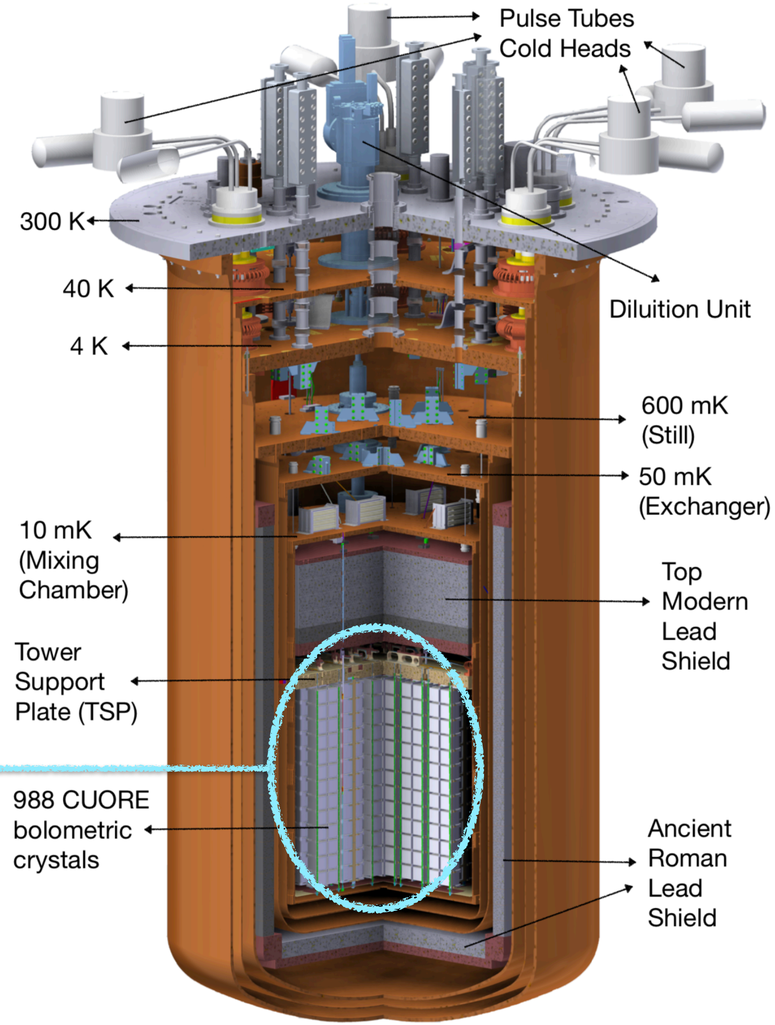
Beyond Standard Model, not yet observed

- Lepton number violating process: ΔL = 2 , would demonstrate that **L is not a symmetry of nature**
- Only possible if neutrinos have a **Majorana component ($\nu = \bar{\nu}$)**: new possible mechanism giving rise to ν mass
- Possible explanation of **matter-antimatter asymmetry** origin via Leptogenesis

CUORE: Cryogenic Underground Observatory for Rare Events

- Main Physics goal: search for 0νββ decay of ^{130}Te
- Ton-scale array of 988 natural TeO_2 crystals (742 kg of TeO_2, 206 kg of ^{130}Te)
- Crystals operated as thermal detectors at ~10 mK
- Located at the underground Laboratori Nazionali del Gran Sasso of INFN, Italy
- Ultra-low background level:
  $(1.49 \pm 0.04) \cdot 10^{-2}$ counts/(keV · kg · y)
- Energy resolution (FWHM) in physics data:
  (7.8 ± 0.5) keV at ^{130}Te $Q_{\beta\beta}$
- **Latest 90% C.I. limit on ^{130}Te 0νββ decay half life:**
  $T_{1/2} > 2.2 \cdot 10^{25}$ y





Search for 0νββ decay of ^{128}Te: Motivations

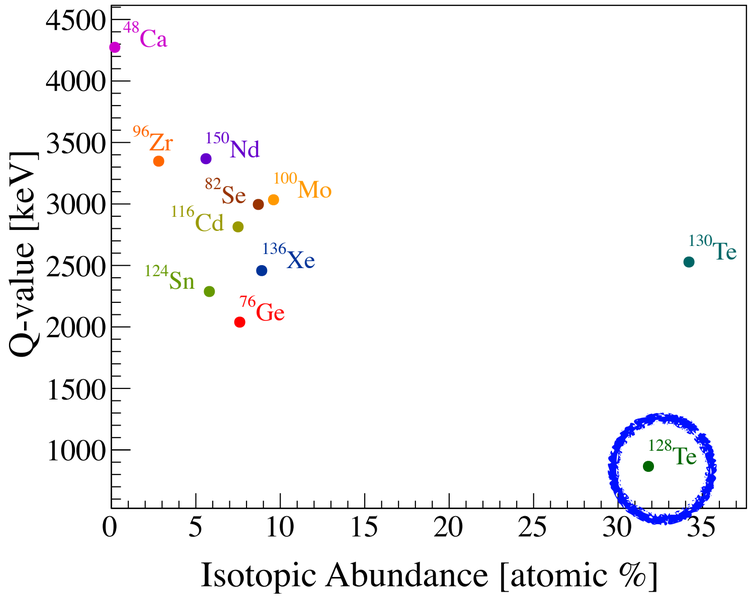
- ^{128}Te is another ββ emitting tellurium isotope: ^{128}Te ⟶ ^{128}Xe
- High natural abundance: 31.75%
- $Q_{\beta\beta}$ = (866.6 ± 0.9) keV ⟶ Highly populated region: natural γ radioactivity, ^{130}Te 2νββ decay
- <u>Latest ^{128}Te 0νββ decay results:</u>

  ➡ From direct experiments (MiDBD in 2003, 6.8 kg of TeO_2, 2 crystals enriched in ^{128}Te at 82.3%):

  $$T^{0\nu}_{1/2} > 1.1 \cdot 10^{23}\, y$$

  ➡ From geochemical experiments: **(refers to the sum of 2v and 0v modes)**

  $$T^{^{128}Te}_{1/2} = (2.0 \pm 0.3) \cdot 10^{24}\, y$$



CUORE:

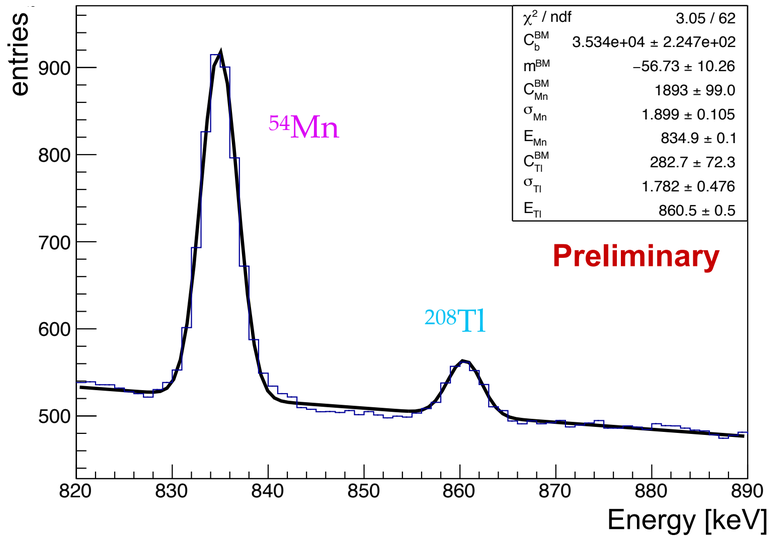
a factor ~10 higher sensitivity is expected, competitive with geochemical results

- N. of ^{128}Te ββ emitters in CUORE: $9.519 \cdot 10^{26}$
- ^{128}Te mass in CUORE: 188.5 kg

Search for 0νββ decay of ^{128}Te: Method

- **Statistical approach: Bayesian binned fit** based on BAT software
- **Parameter of interest: 0νββ decay signal rate**
- Full containment efficiency from MC simulations: 97.59%
- Background structures in the ROI: ^{208}Tl γ line at 860.56 keV
  ^{54}Mn γ line at 834.8 keV
- Analysis validated on toyMC simulations produced exploiting the knowledge from CUORE Background Model

M1 spectrum from Background Model Simulations

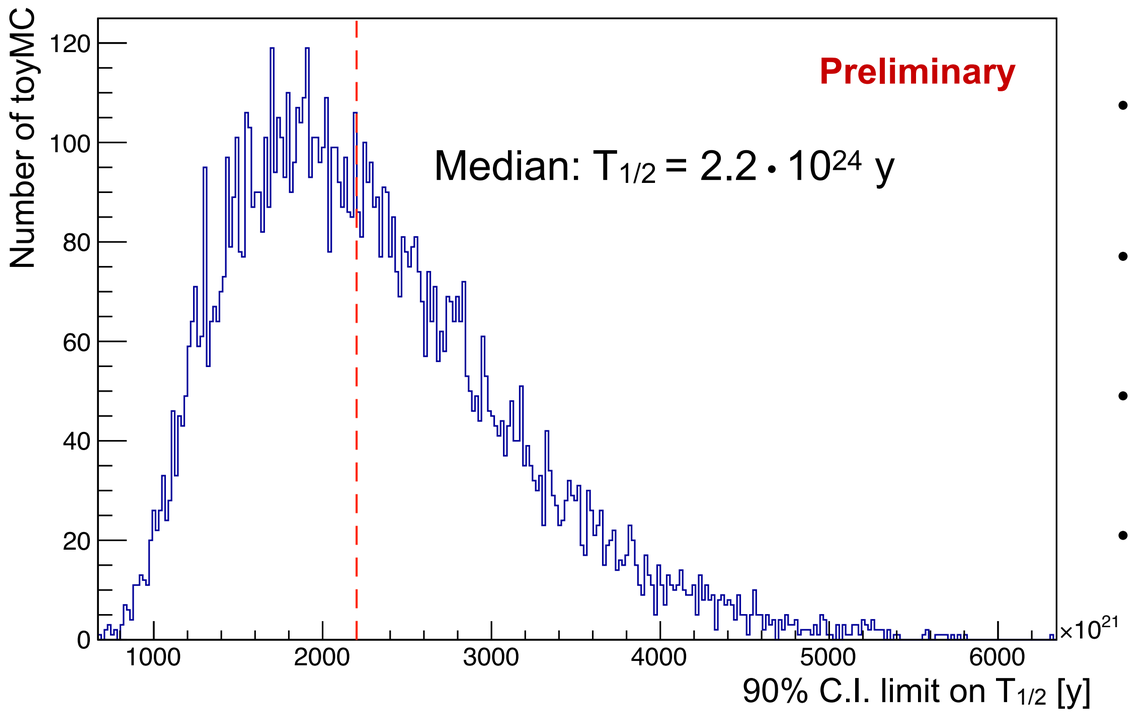


Extracted values, used to produce the toyMC simulations

Parameter	*Units*	*Value for toyMC*
Γ^{toy}_{Mn}	cts/(kg • y)	16.27
Γ^{toy}_{Tl}	cts/(kg • y)	0.95
BI^{toy}	cts/(keV • kg • y)	1.68
$slope^{toy}$	1/keV	-0.4

CUORE Sensitivity on 0νββ decay of ^{128}Te

Limit Setting Sensitivity: median of the distribution of the 90% C.I. limits on $T_{1/2}$



- 10^4 toyMC simulated spectra with background components only from the CUORE Background Model
- Bayesian fit with signal + background components independently run on each toyMC
- Extraction of the 90% C.I. half life limit from each of the 10^4 Bayesian fits
- Distribution of the half life limits and extraction of the median

Limit Setting sensitivity: $T_{1/2} = 2.2 \cdot 10^{24}$ y

CUORE:

- **can improve >10 times the limit on ^{128}Te 0νββ half-life from the last direct experiment**
- **can possibly overcome the geochemical results.**