CUORE Present and Future

Pre-Snowmass Neutrino Physics Workshop
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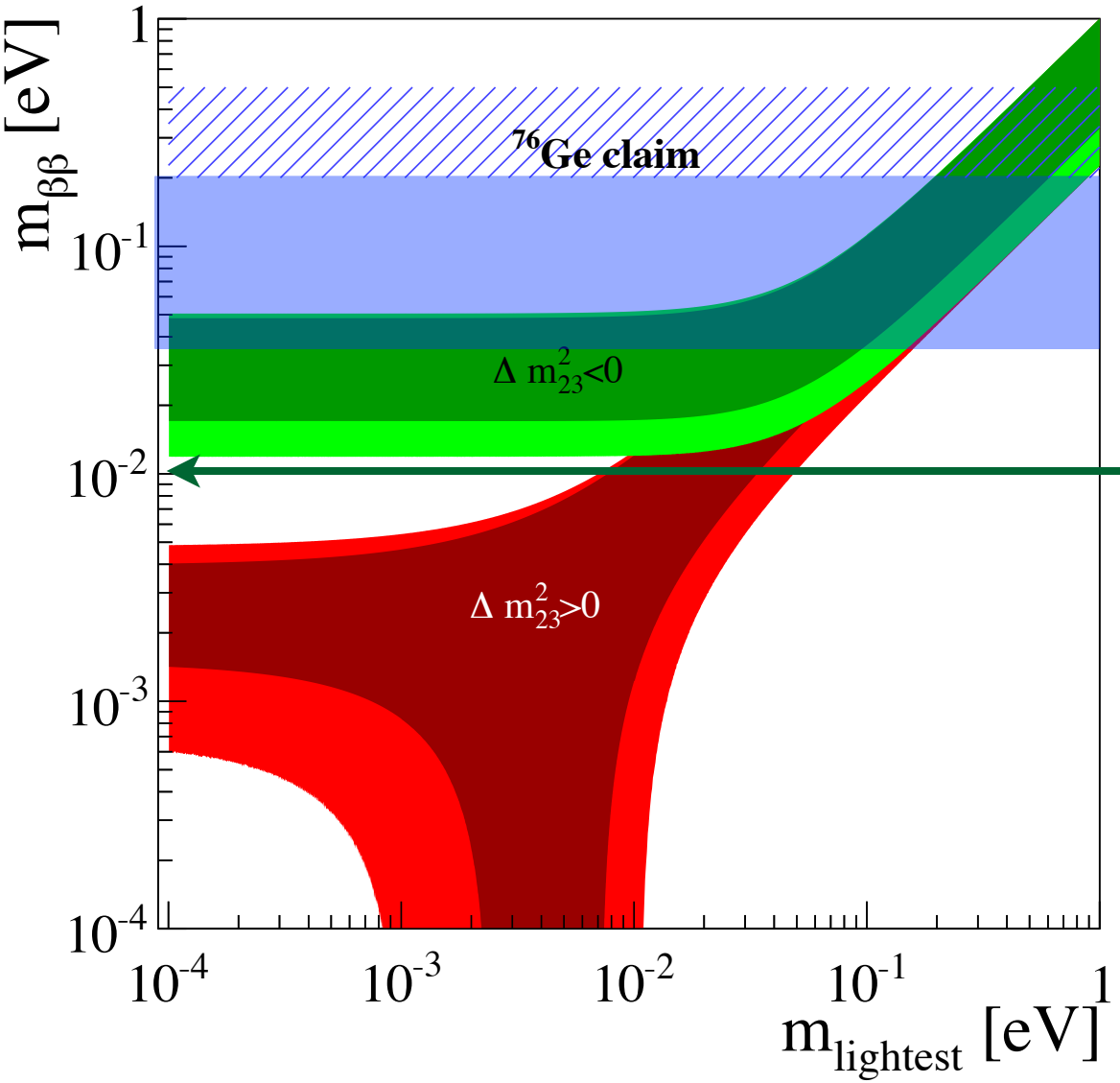
DBD and Neutrino Mass



Sensitivity of current DBD experiments

Next generation must aim here

$$m_{\beta\beta} = |\sum_i m_i \cdot U_{ie}^2|$$

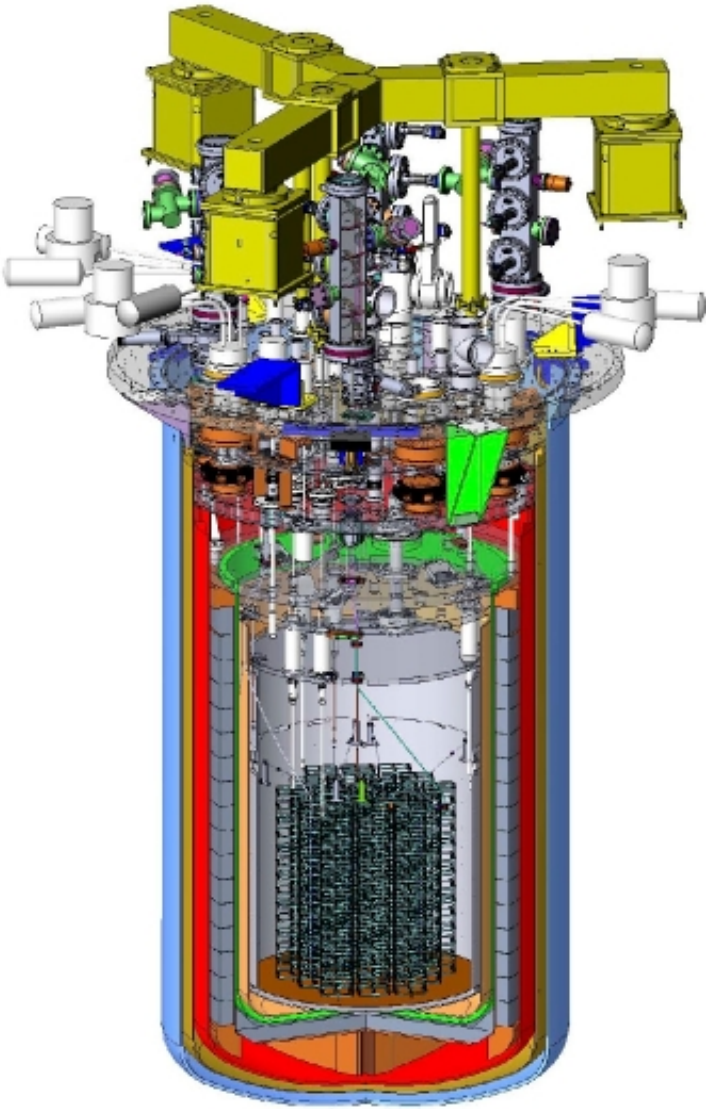
CUORE

Array of 988 TeO_2 crystals

- **19** towers suspended in a cylindrical structure
- **13** levels, **4** crystals each
- 5x5x5 cm^3 (750g each)
- ^{130}Te: 33.8% natural isotope abundance

750 kg TeO_2 => 200 kg ^{130}Te

- New pulse tube refrigerator and cryostat
- Radio-purity techniques and high resolution achieve low backgrounds
- Joint venture between Italy (INFN) and US (DOE, NSF)
- Under construction (expected start of operations by end of 2014)
- Expect energy resolution of 5 keV FWHM and background of ~0.01 counts/(kg*keV*year) in ROI



Background Mitigation

Background model: CUORICINO

- (40±10)% in ββ0ν region from ^{208}Tl at 2615 keV
- α and β from inert material facing detector (e.g. Cu): (50±20)%
- α and β from surface contamination of crystals: (10±5)%
- Negligible contributions from neutrons and ^{60}Co at 2505 keV

CUORE strategy:

- improve shields & material quality
- improve bulk contamination in TeO_2 (SICCAS)
- reduce surface contribution from
  - TeO_2 crystals
  - components facing TeO_2 crystals (mainly copper)
- increased coincidence efficiency to reject surface background events
- Overall goal: 0.01 c/y/kg/keV
- Demonstrated <0.02-0.03 c/y/kg/keV (90% C.L. upper limit)

CUORE Status

Clean room & assembly line

Underground storage

Dilution Unit

300K vessel

- Hut and clean room: fully equipped
- Radon abatement system: operating
- Cryostat: in commissioning
- Dilution unit: delivered, <8 mK reached
- Copper parts: cleaning proceeding, to be delivered by end of 2013
- Crystals: 95% in LNGS underground storage, last batch being produced
- Thermistors: 90% delivered, last batch being produced
- Detector assembly line: operational, first tower being assembled
- CUORE-0 (single tower in Cuoricino cryostat): operations restarted

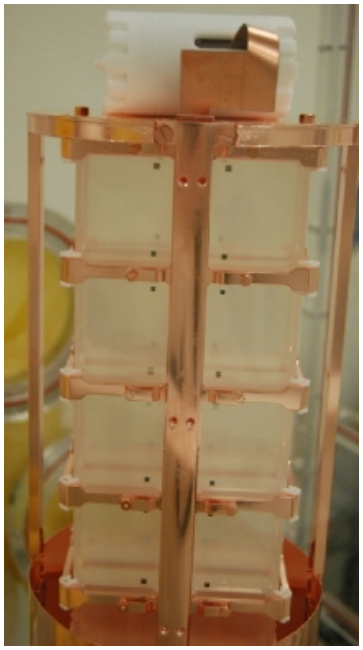
CUORE-0

1 CUORE-like tower of 13 planes - 4 crystals each
52 TeO_2 5x5x5 cm^3 crystals (750 g each)
Detector Mass: 39 kg TeO_2
^{130}Te mass (natural i.a.): 11 kg of ^{130}Te

- All detector components manufactured, cleaned and stored with protocols defined for CUORE
- Assembled with the same procedures foreseen for CUORE
- In the 25 years-old CUORICINO cryostat

GOALS:

- Proof of Concept for CUORE in all stages
- Test and debug the CUORE assembly line (thermistor gluing, signal wires bonding, tower assembly)
- Test of the CUORE DAQ and analysis framework
- Extend the physics reach beyond CUORICINO while CUORE is being assembled
- Demonstrate potential for DM and Axion detection



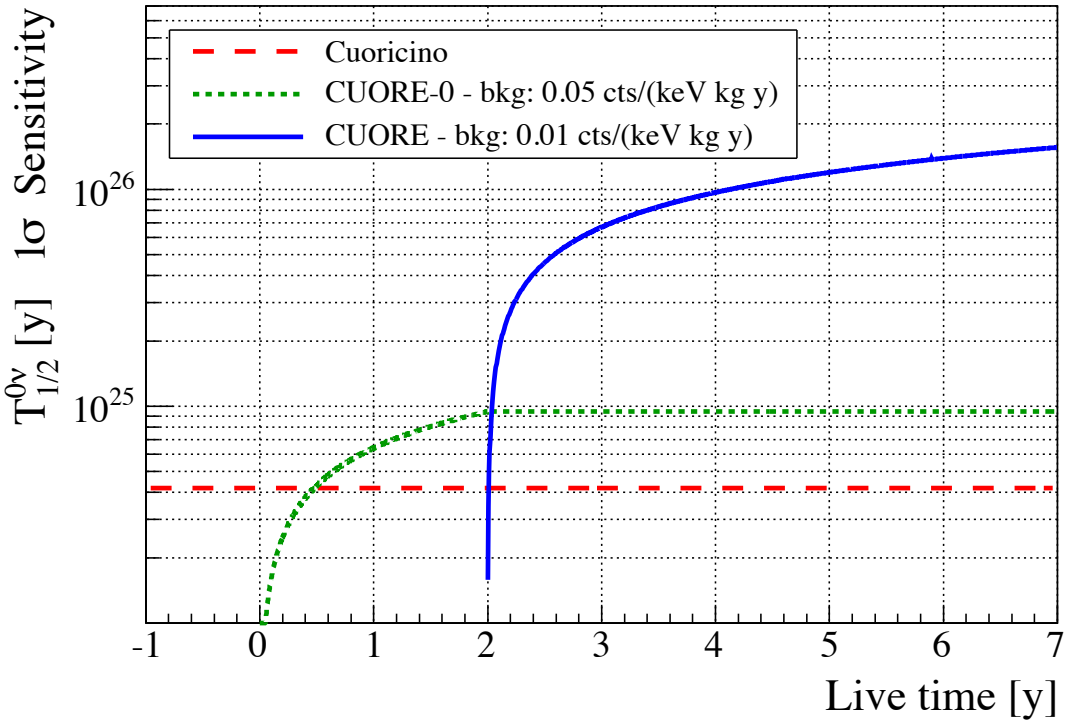
CUORE Sensitivity

5 year sensitivity

Setup	t (y)	b (cts/(keV kg y))	$\widehat{T^{0\nu}_{1/2}}(1\sigma)$ (y)	$m_{\beta\beta}$ (meV) QRPA-F	QRPA-S	ISM	IBM
CUORE-0	2	0.05	9.4×10^{24}	170–310	190–320	310–390	200
	zero-bkg. case at 68% C.L.:		5.3×10^{25}	*70–130*	*81–130*	*130–160*	*85*
CUORE baseline	5	0.01	1.6×10^{26}	41–77	48–78	76–95	50
	zero-bkg. case at 68% C.L.:		2.5×10^{27}	*10–19*	*12–19*	*19–24*	*12*

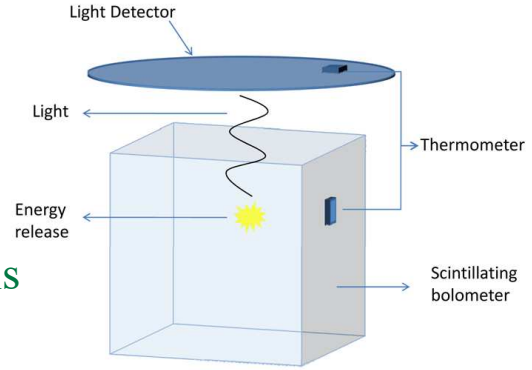
Five year sensitivity based on detector resolution (5 keV FWHM), background, and matrix element spread

First tower (CUORE-0) to be operated until the start of CUORE.



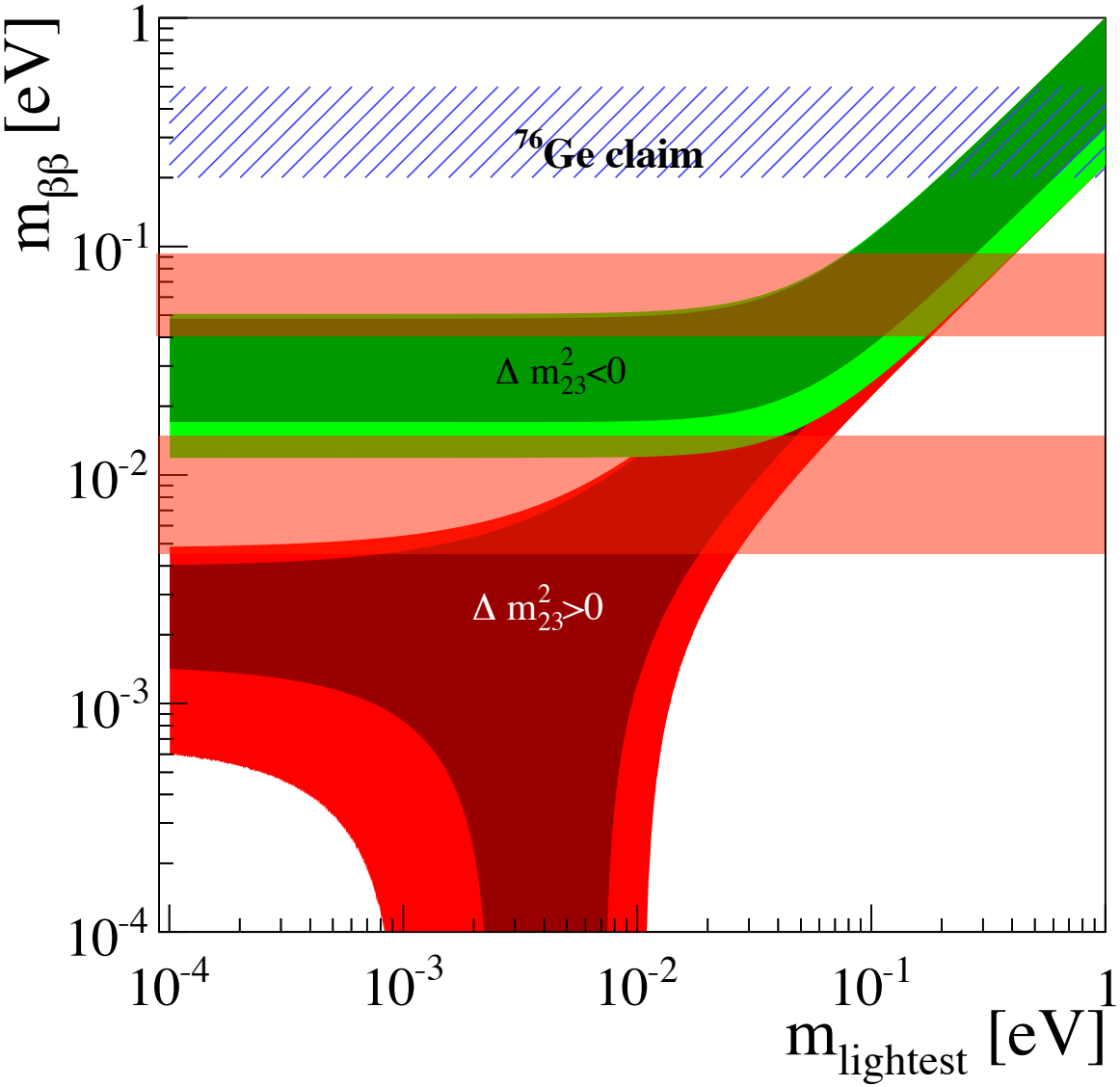
Beyond CUORE

- CUORE design is scalable to O(1 ton) detector
  - Relatively inexpensive isotopic enrichment of ^{130}Te
    - ☞ 740 kg of ^{130}Te
    - ☞ A factor of 3 increase in isotope mass
  - Other DBD isotopes can also be used bolometrically
    - ☞ E.g. ZnSe with isotopically enriched ^{82}Se
- Active background suppression to reduce background in ROI to ~zero
  - Energy resolution improvements (TES sensors)
  - Scintillating/Cherenkov bolometers or ionization
  - Surface-sensitive bolometers
  - Pulse shape discrimination through non-equilibrium phonons



- Important direction for future R&D
  - Efforts in the US and Italy underway; several techniques already demonstrated
  - Technology demonstration by 2015-2016: background rejection + CUORE ops

DBD and Neutrino Mass



CUORE goal

Upgraded CUORE for 10 years
$m_{\beta\beta} < 5\text{-}15$ meV

$$m_{\beta\beta} = |\sum_i m_i \cdot U_{ie}^2|$$

0νββ: one of the top priorities in neutrino physics

- Probe Majorana nature of neutrinos and the absolute scale of neutrino mass
- CUORE: one of the leading DBD experiments in near future; to start operations in 2014
- Will start probing inverted hierarchy
- Upgrade path to 1 ton scale experiment to cover the inverted hierarchy