Background Evaluation for the CUORE-0 Experiment

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On behalf of the **CUORE collaboration**

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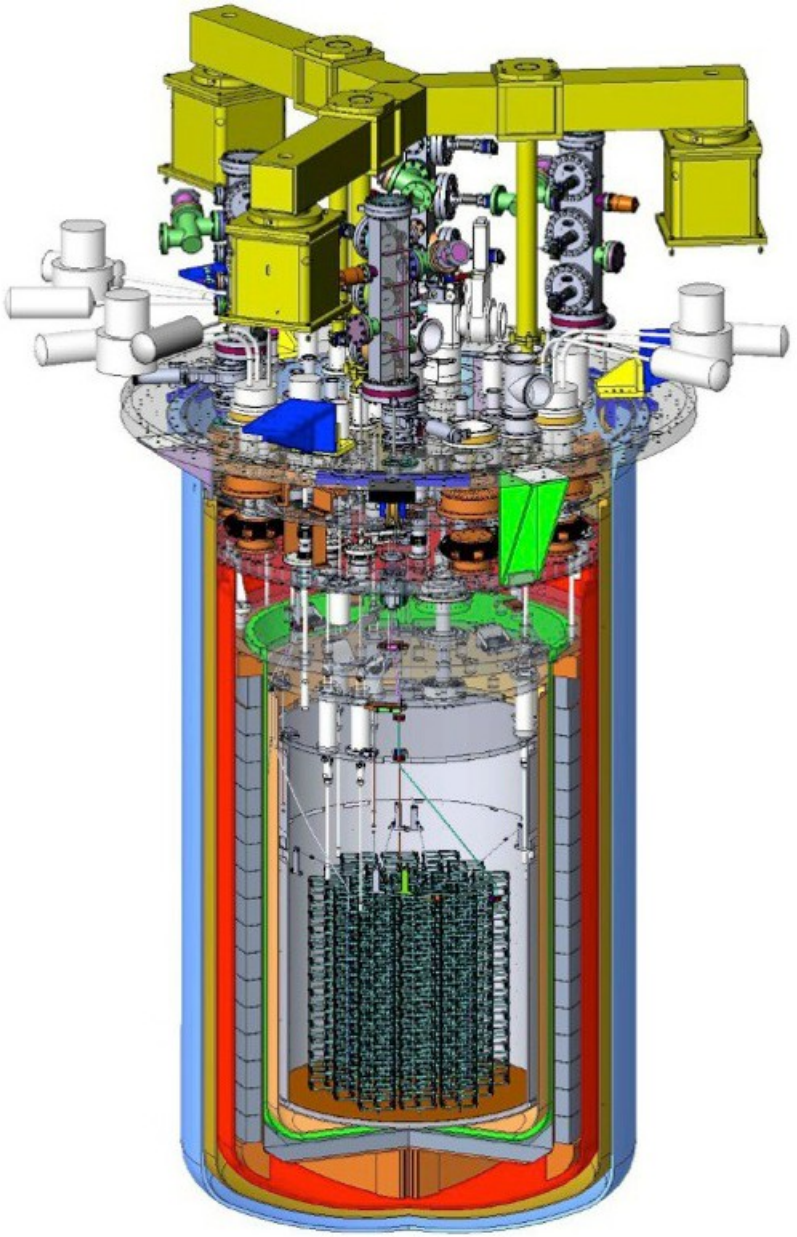
CUORE

Cryogenic **U**nderground **O**bservatory
for **R**are **E**vents

Construction nearing completion
@LNGS (Gran Sasso, Italy)

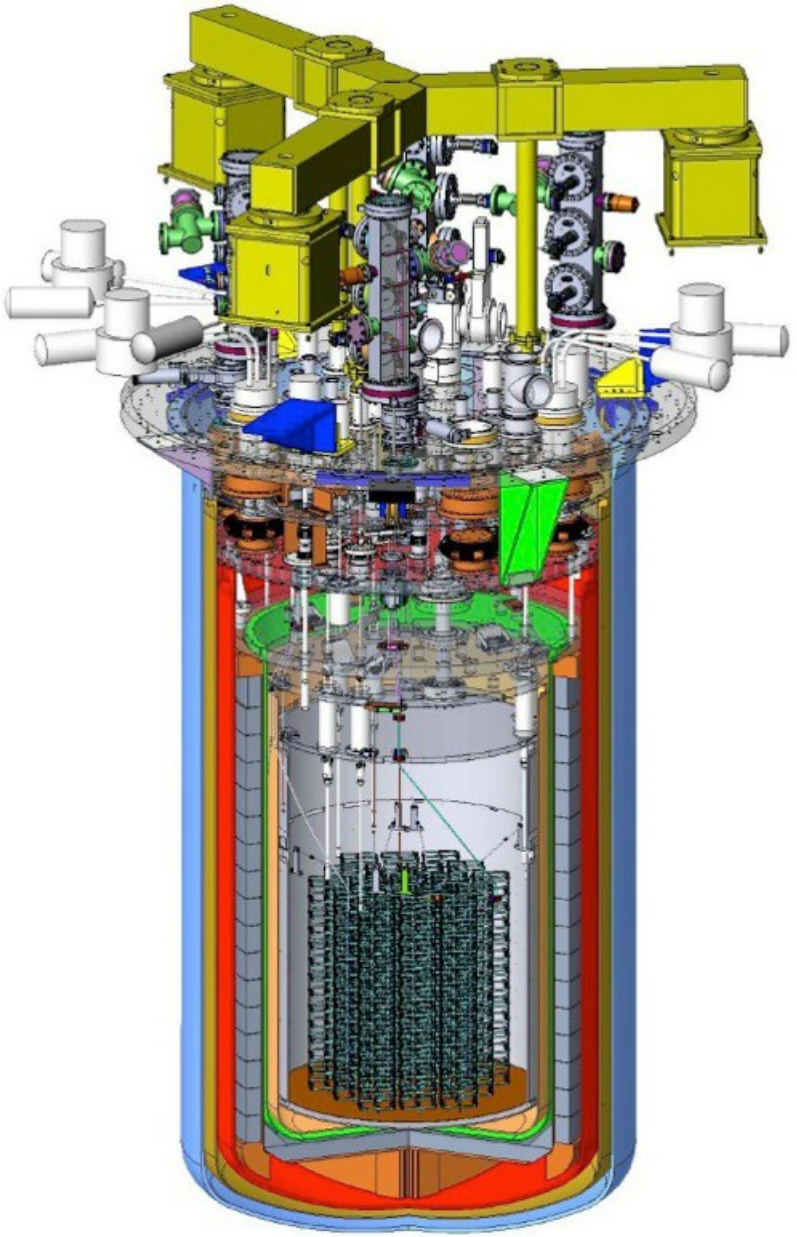
Search for the 0νββ decay of ^{130}Te

988 TeO_2 bolometers, 5x5x5 cm^3,
arranged in 19 towers (206 kg ^{130}Te)



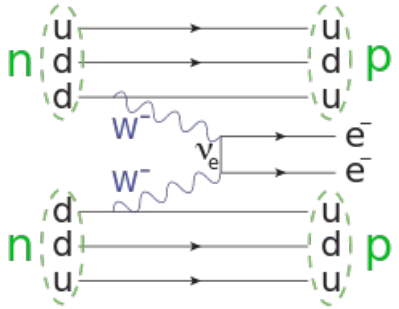
CUORE structure

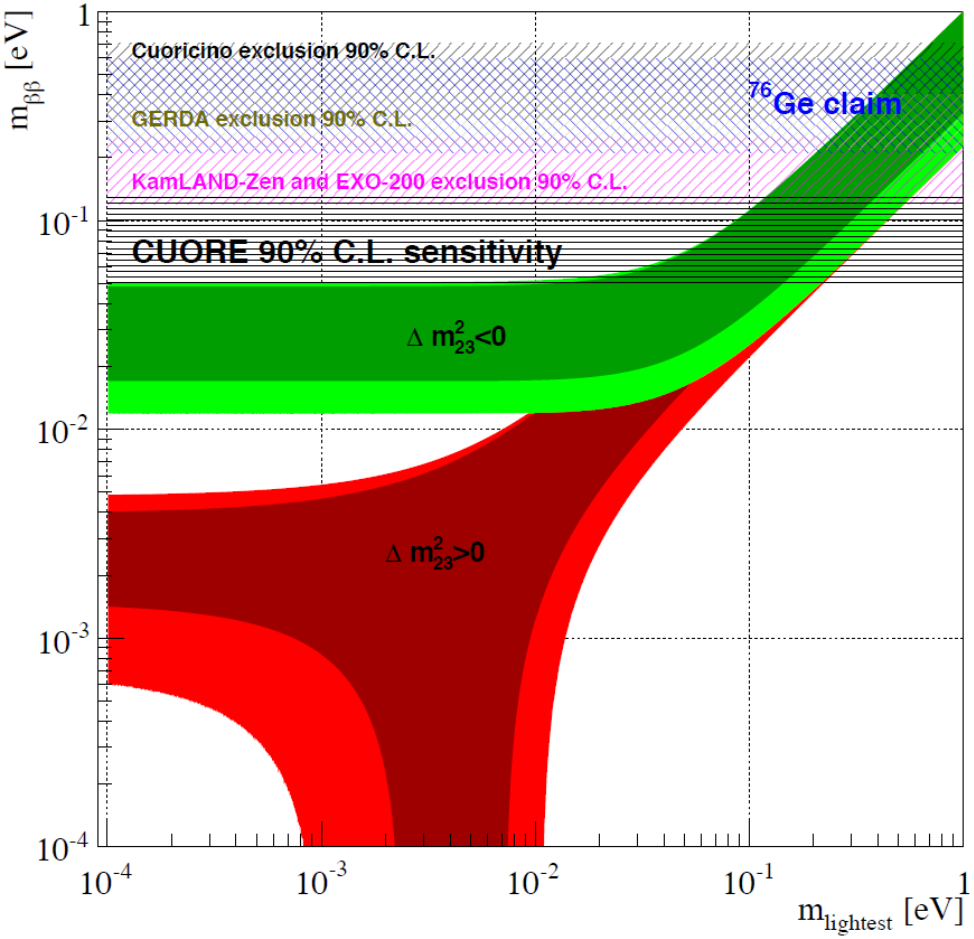
- External lead shield (γ shielding)
- Borated polyethylene (neutron shielding)
- Sequence of copper containers with progressively lower T
- Internal, ancient Roman lead shield (γ shielding, ultra-clean)
- Inner “CuBox” @ 10mK, containing the 19 CUORE towers



CUORE goal

Expected signature from ^{130}Te 0νββ:
line at the decay Q value - 2527.5 keV





Projected sensitivity @90% C.L:
$T_{1/2}^{0\nu} = 9.5 \times 10^{25}$ y

In order to obtain it:

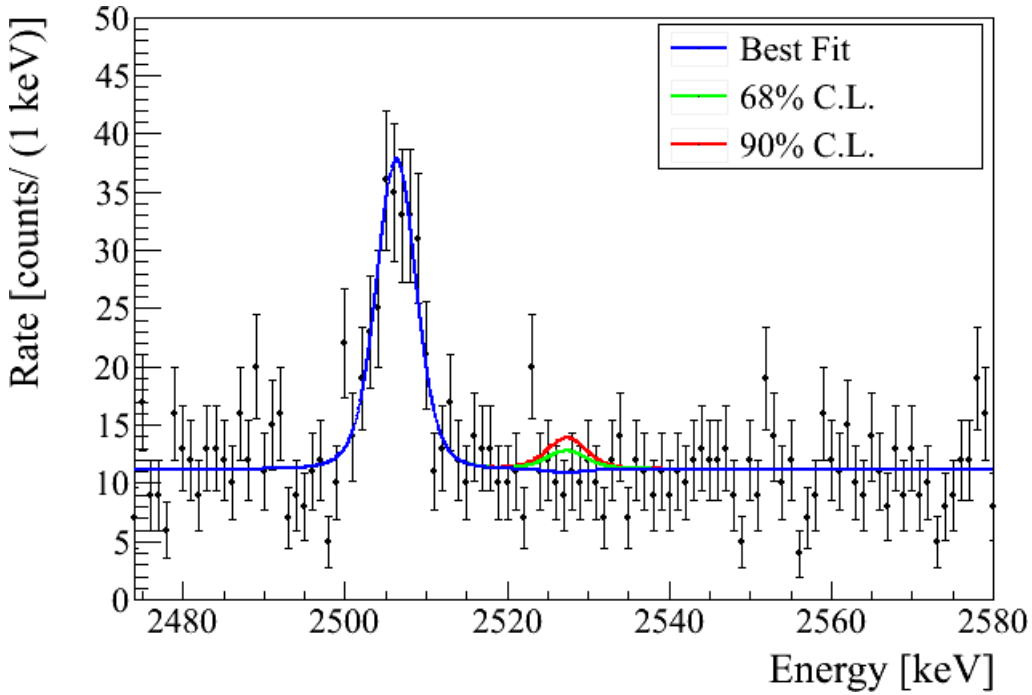
5keV FWHM

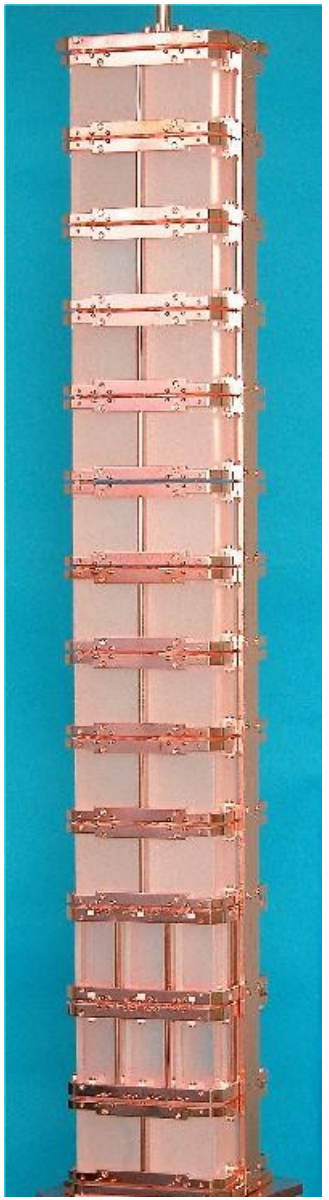
0.01 counts/keV/kg/y background

The first step: CUORICINO

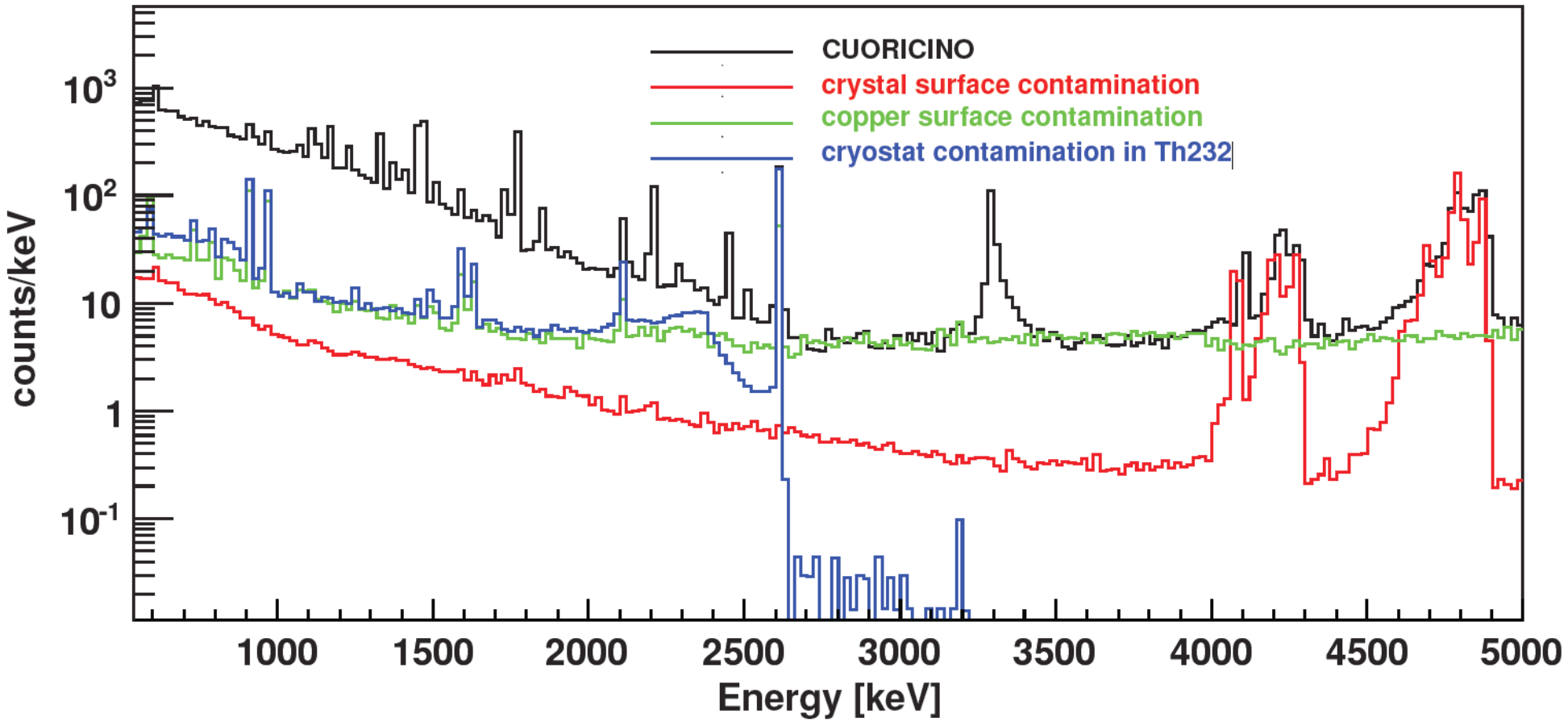
CUORICINO was an array of 62 TeO_2 bolometers that operated from 2003 to 2008 @LNGS

Set a lower bound on ^{130}Te 0ν half life:
$T_{1/2}^{0\nu} > 2.8 \times 10^{24}$ y





CUORICINO background



Background in the ROI:

- 40±10% from ^{208}Tl @ 2615 keV (^{232}Th in cryostat)
- 50±20% from materials facing the detector (copper)
- 10±5% from crystal surface

CUORE-0

CUORE-0 is the first tower built using the CUORE tower assembly line

52 TeO_2 bolometers (11 kg ^{130}Te)
in the old CUORICINO cryostat

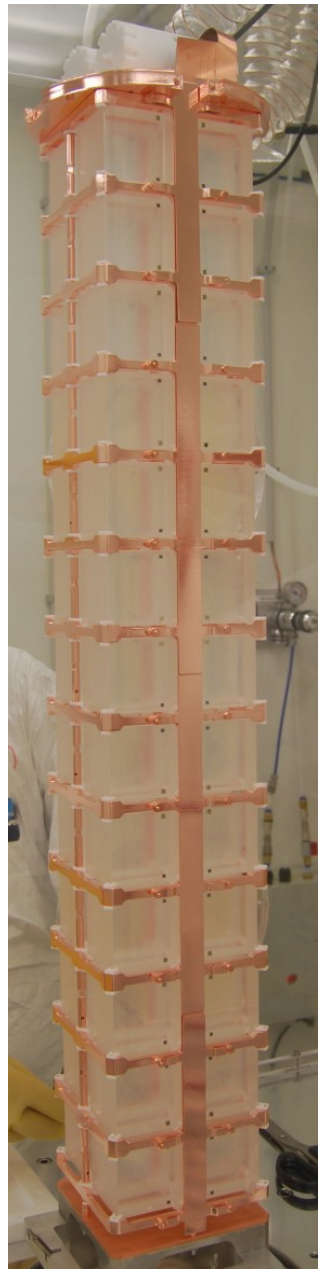
A lot of work has gone into background reduction to achieve the CUORE goal (0.01 counts/keV/kg/y in ROI)

Data taking started in 2013, will stop in 2015

Goals:

- Proof of concept for CUORE
- Test of the CUORE assembly line
- Test of the DAQ/analysis framework
- Background model for CUORE

It has already reached 5 keV resolution @ 2615keV

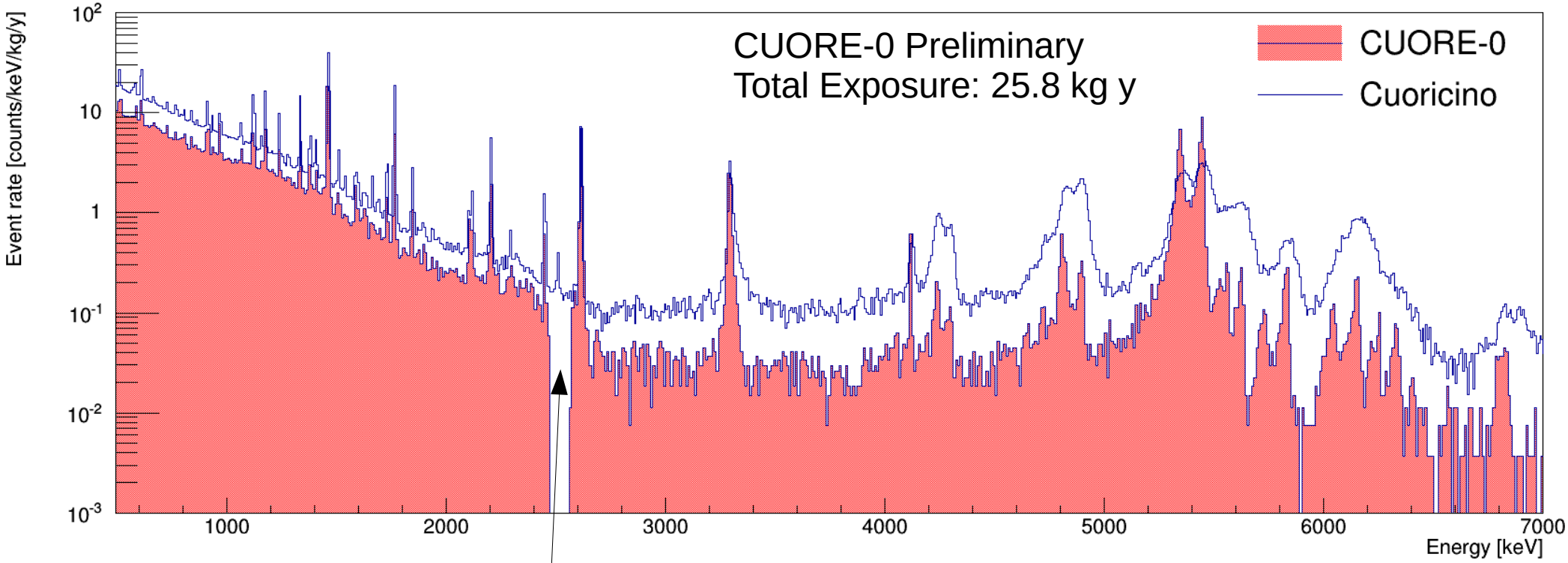


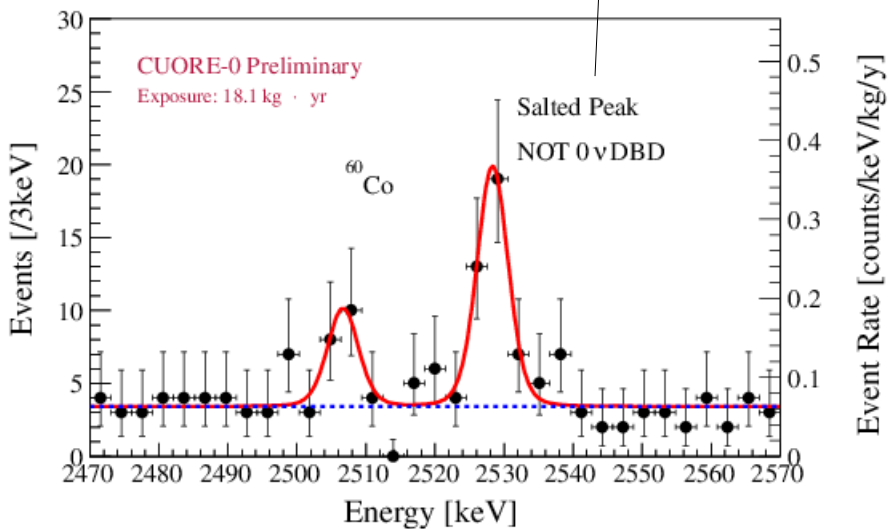
Background reduction

Background reduction strategy for CUORE and CUORE-0:

- Material screening to minimize bulk contaminations (Copper, Lead..)
- TeO_2 bulk contaminations: clean production, minimized cosmogenic activation (shipped by boat, stored underground)
- TeO2 surface contaminations: crystal polishing
- Copper facing detector: TECM cleaning (sequence of mechanical, chemical, electro-chemical and magneto-plasma treatments)
- Improved tower structure: less copper facing the detectors

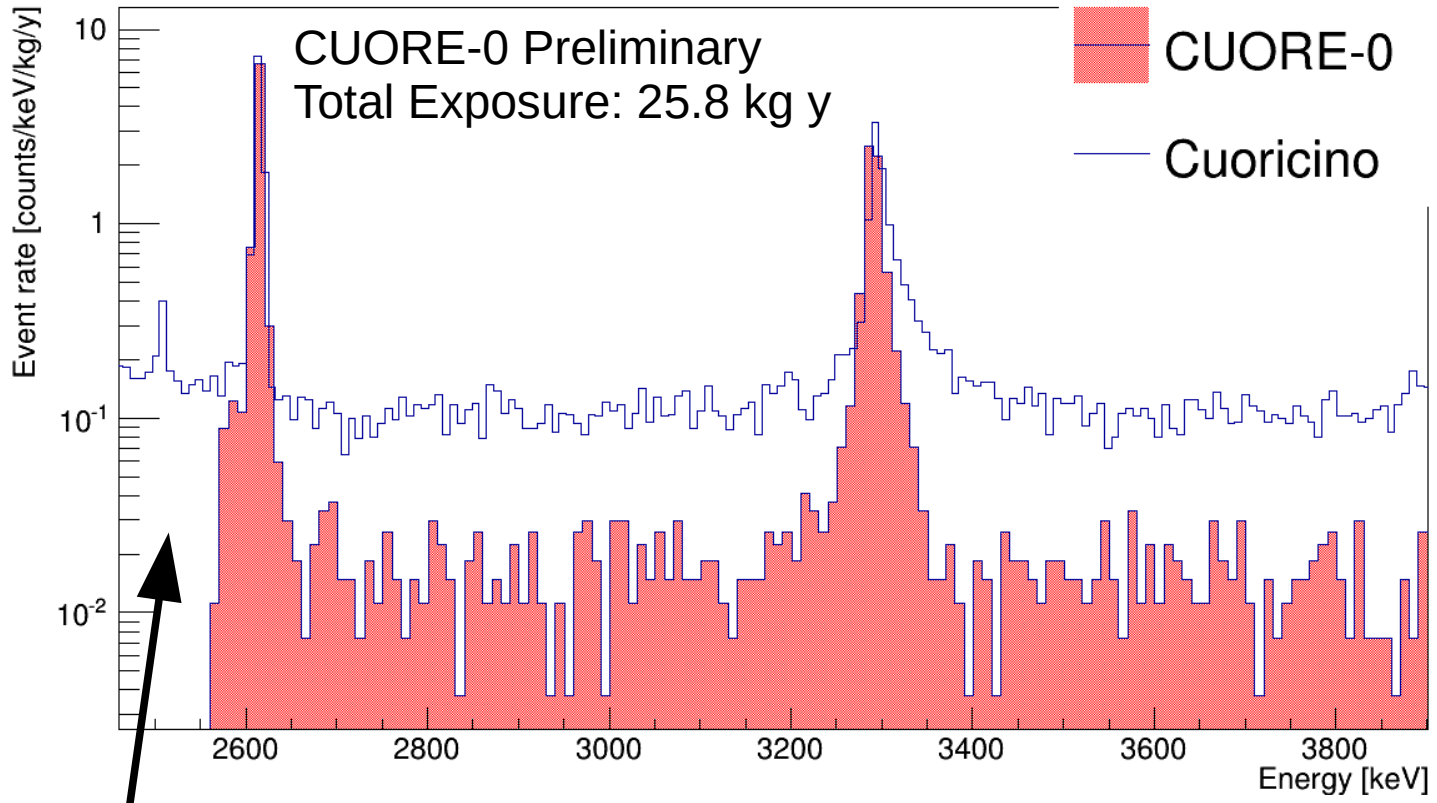
CUORE-0 vs. CUORICINO



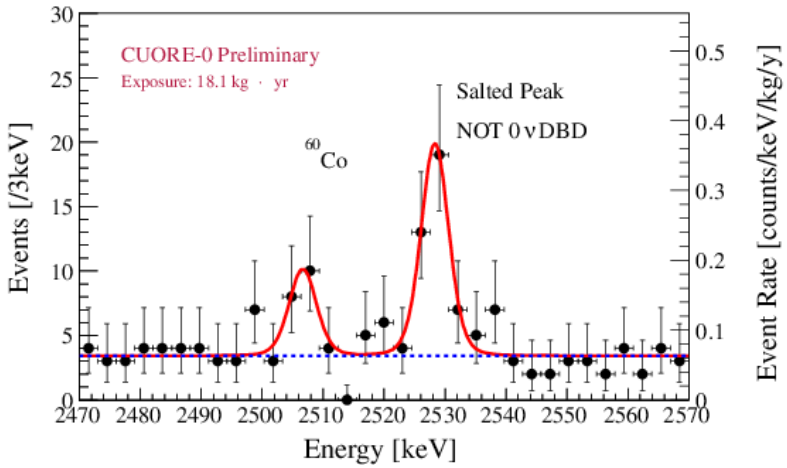


Blinding procedure: random number of events swapped between ROI and ^{208}Tl @ 2615 keV

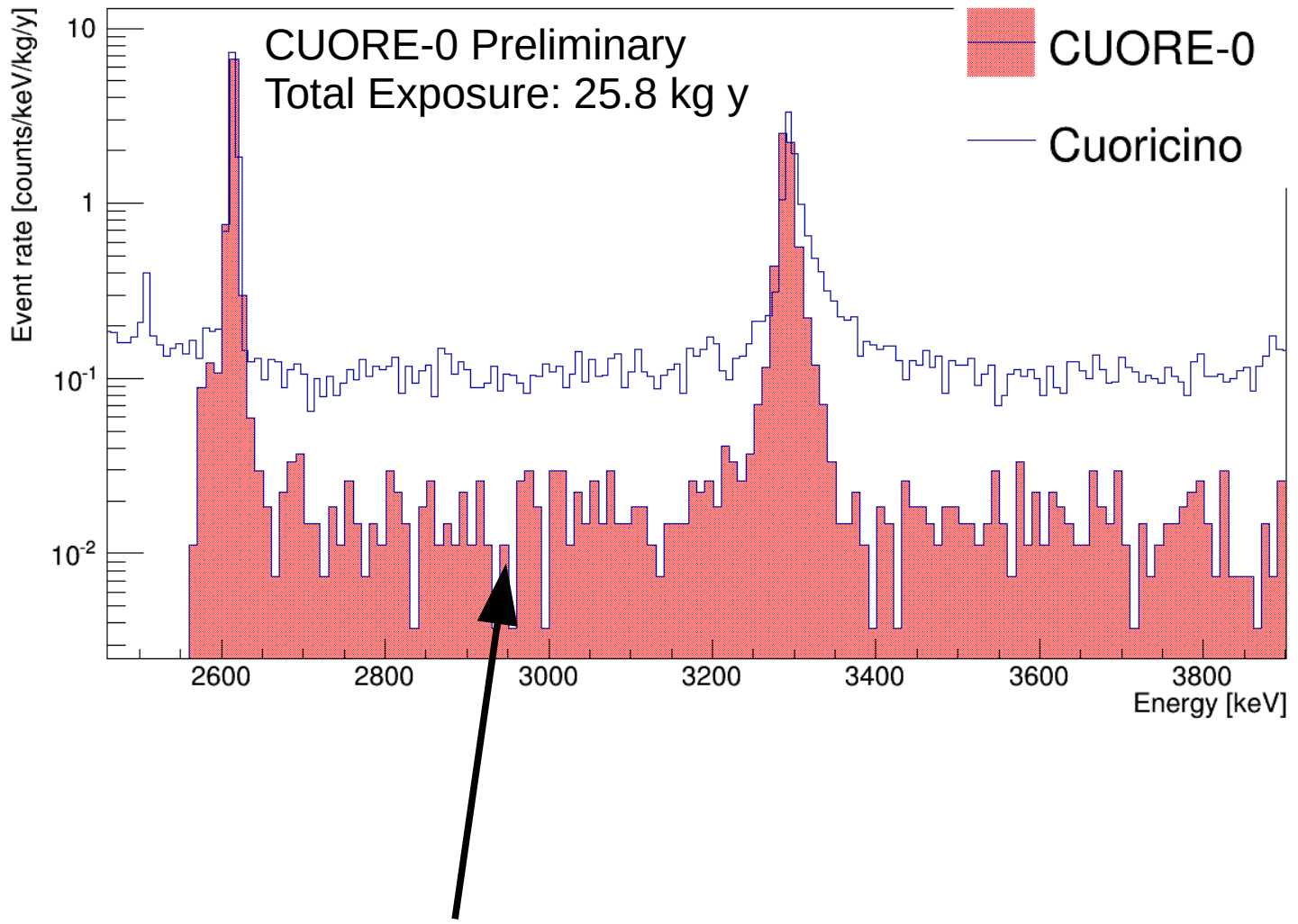
CUORE-0 vs. CUORICINO



Reduction by a factor ~2.5 in ROI

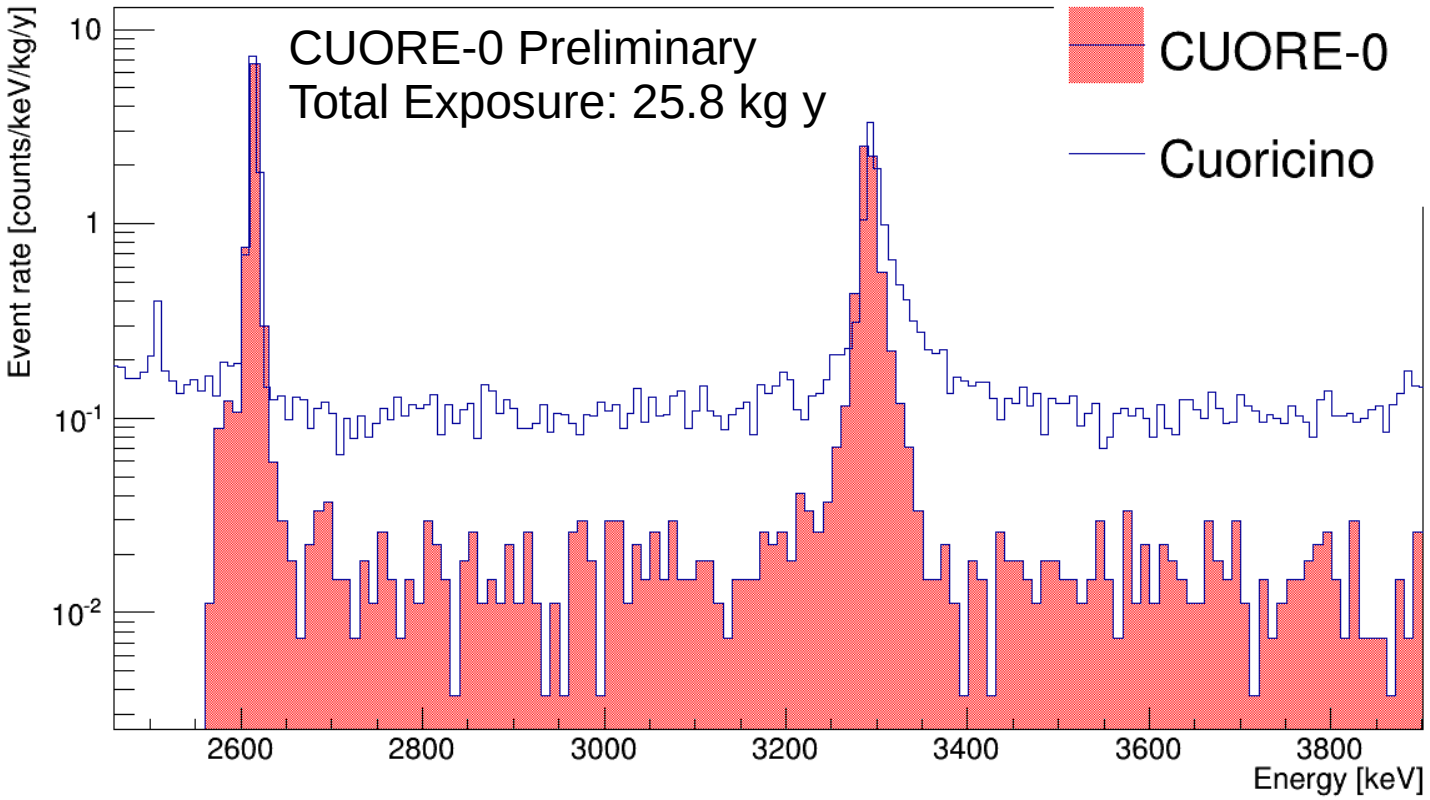


CUORE-0 vs. CUORICINO



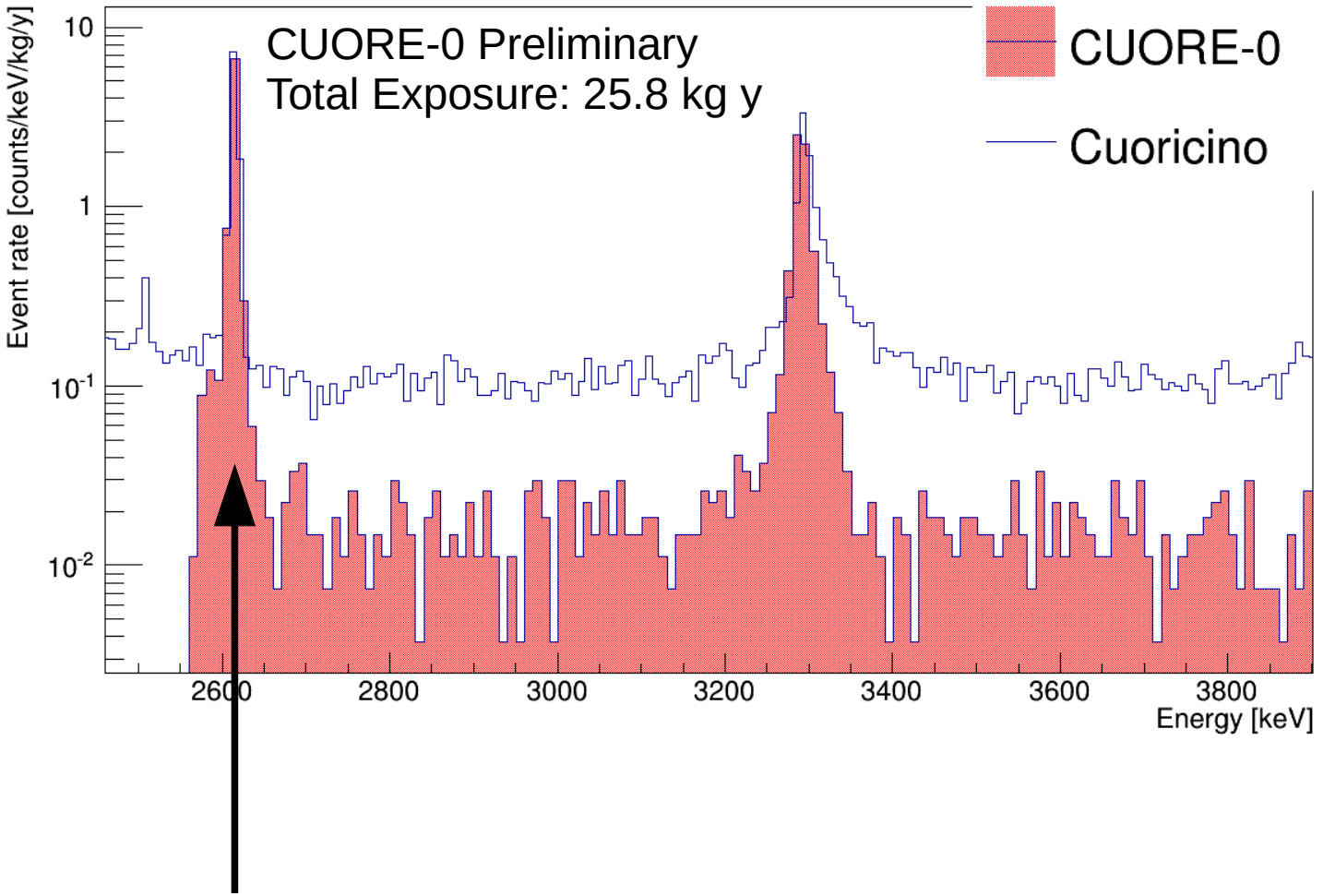
Reduction by a factor ~6 in the α flat background

CUORE-0 vs. CUORICINO



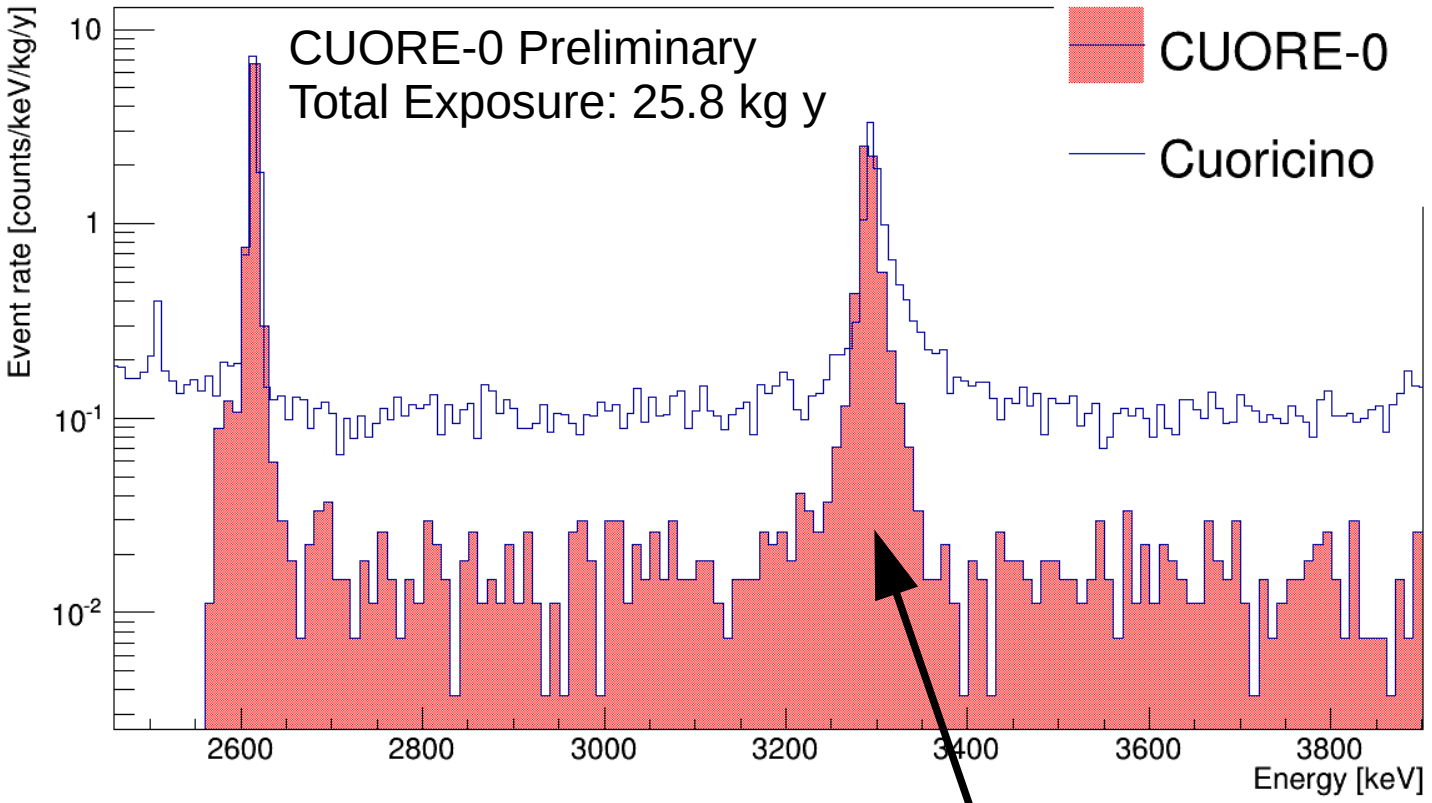
	0νββ region cnts/(keV kg y)	*2700-3900 keV cnts/(keV kg y)*	*ε(%)*
Cuoricino	0.153 ± 0.006	0.110 ± 0.001	83
CUORE-0	**0.063 ± 0.006**	**0.020 ± 0.001**	78

CUORE-0 vs. CUORICINO



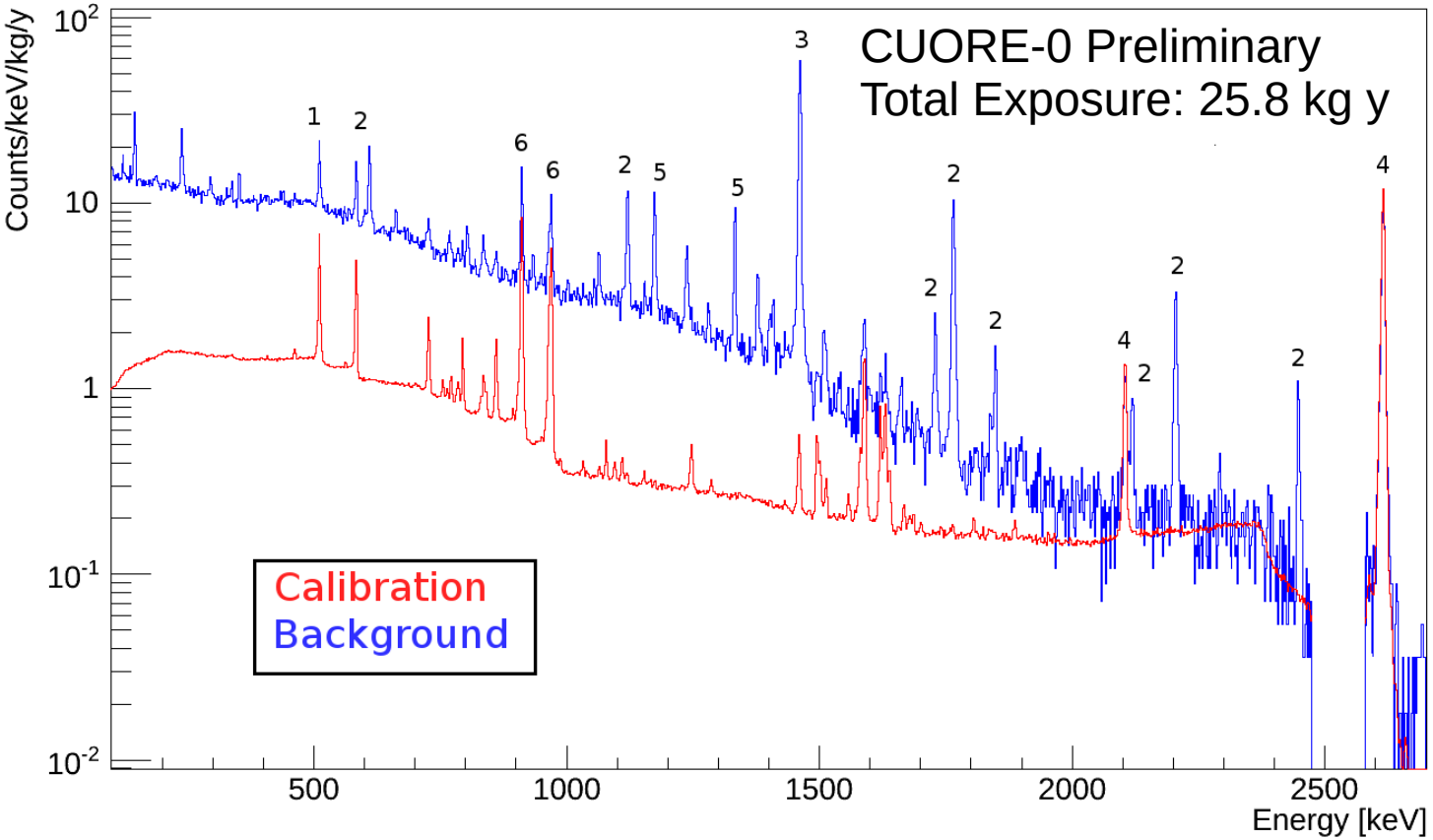
^{208}Tl line @ 2615 keV
Same rate, ^{232}Th contamination comes from the cryostat (same as CUORICINO)

CUORE-0 vs. CUORICINO



^{190}Pt line @ 3249 keV
Crystal growth in Pt crucible; ^{190}Pt naturally present

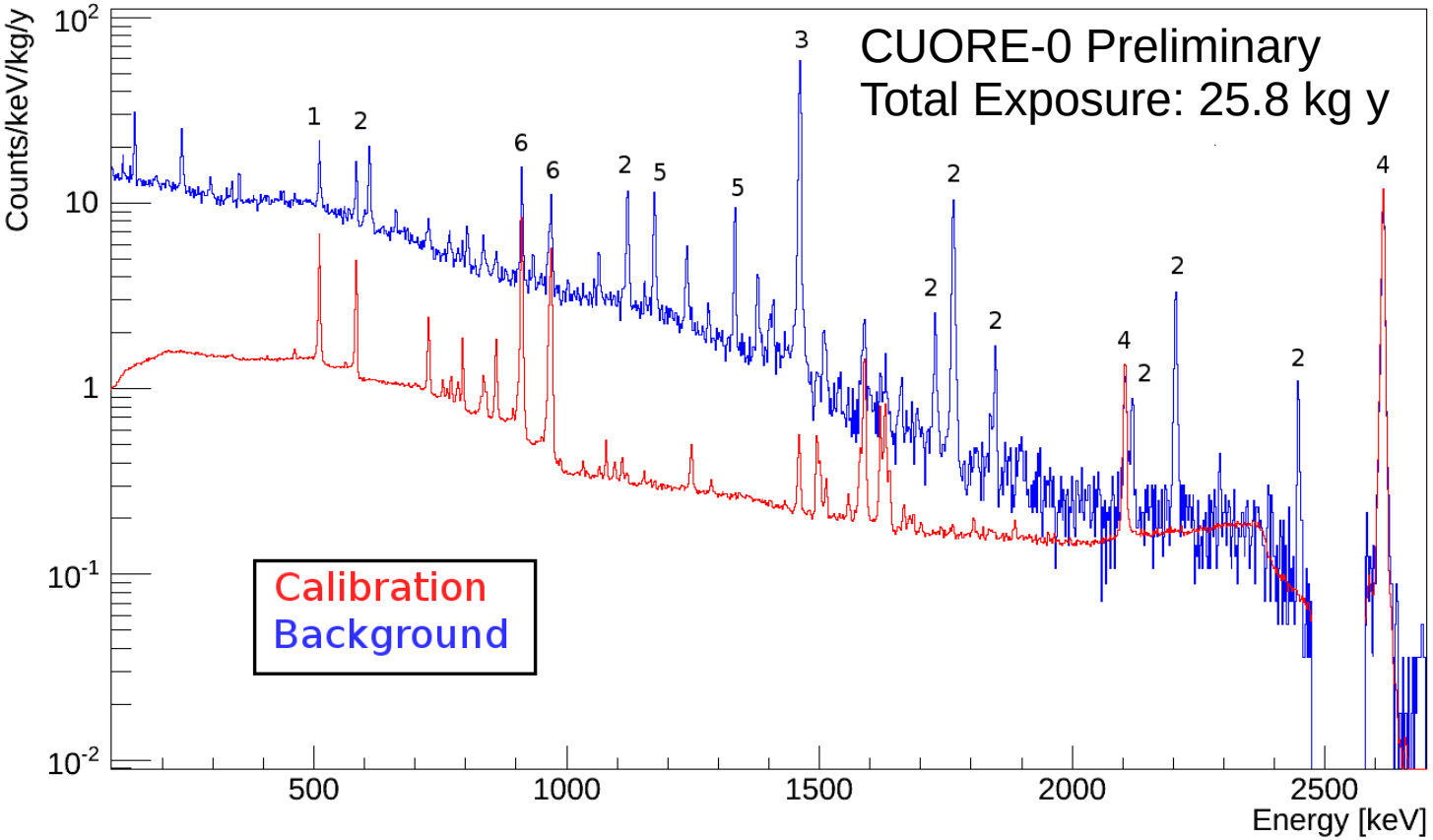
CUORE-0: Background



1. e^+e^- annihilation
2. ^{214}Bi (^{238}U chain)
3. ^{40}K
4. ^{208}Tl (^{232}Th chain)
5. ^{60}Co
6. ^{228}Ac (^{232}Th chain)

Gamma line analysis: identify source isotopes

CUORE-0: Background



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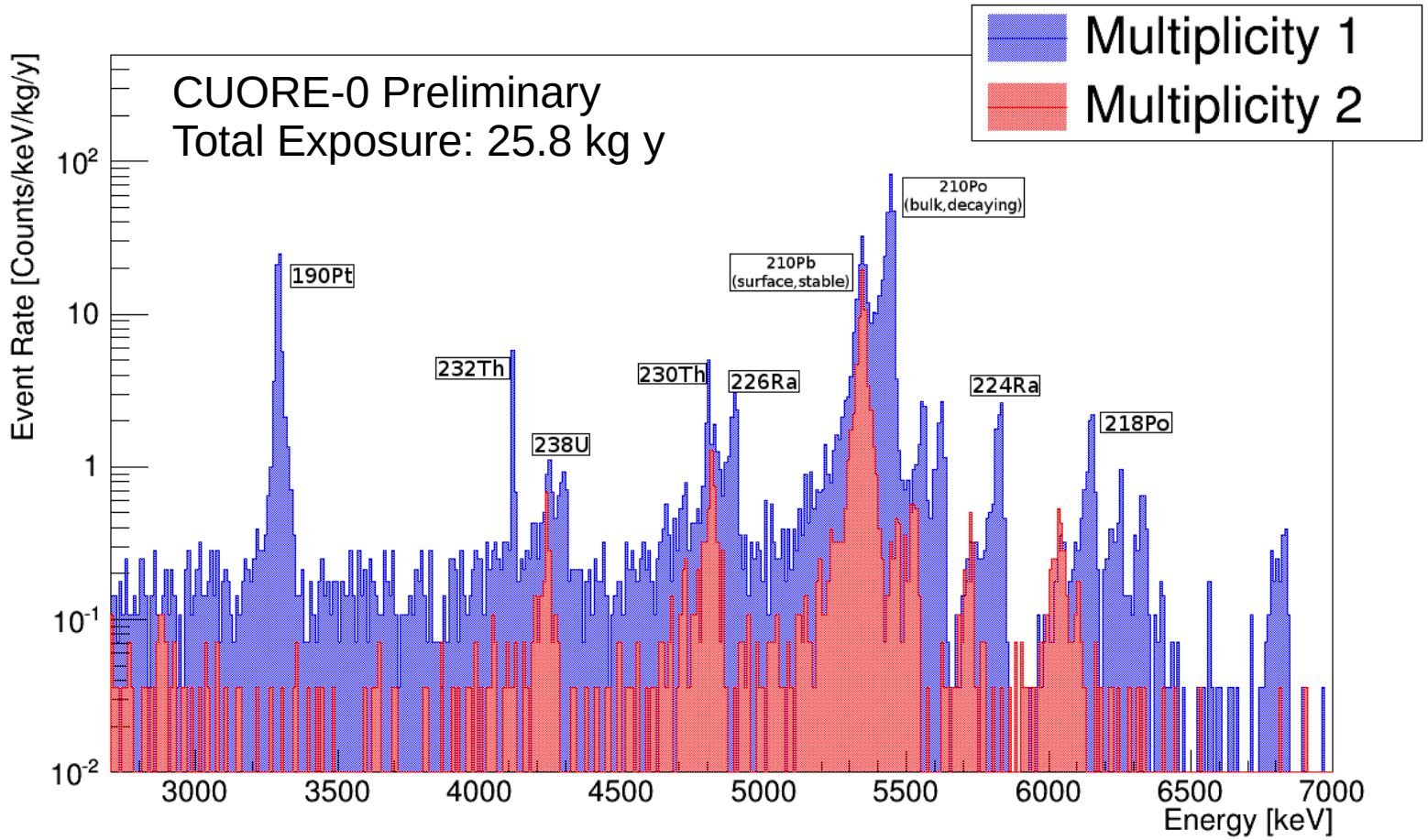
4. ^{208}Tl (^{232}Th chain)
5. ^{60}Co
6. ^{228}Ac (^{232}Th chain)

Continuum analysis + ratios: identify source position

Calibration (^{232}Th): example of external source (outer cryostat shielding)
^{232}Th source in the outer shielding

CUORE-0: Background

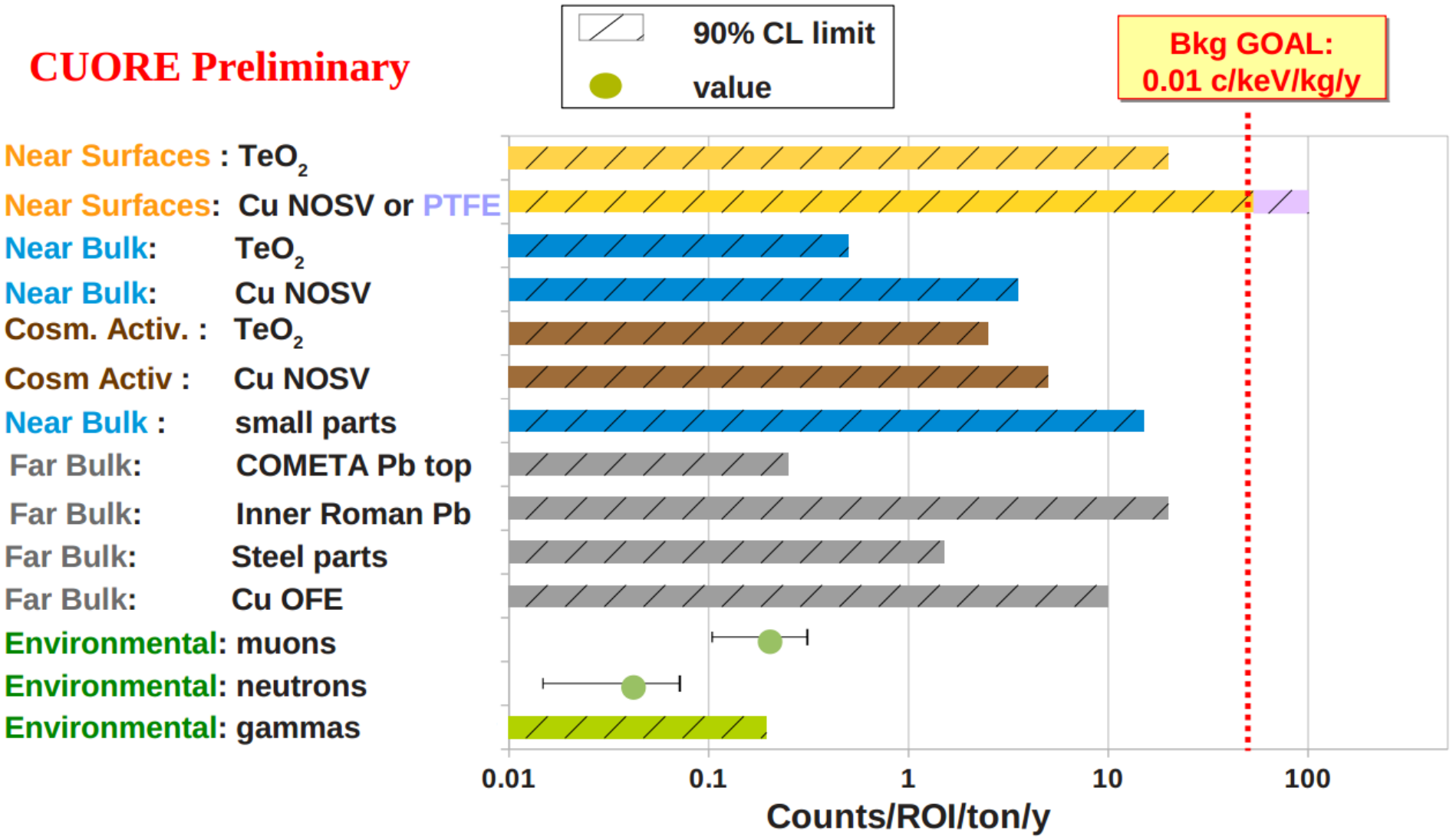


Event multiplicity + tail shape: surface contamination depth and location (α particles)

M2	**Crystal surface**
M1, only α line	**Copper (near) surface**
M1, only Q value line	**Crystal bulk**

CUORE background budget

All data is used in MC simulations to estimate contributions to CUORE



Summary

- CUORE-0 shows a substantial background reduction with respect to CUORICINO, thanks to improved material selection and cleaning
  - Factor 2.5 in the ROI
  - Factor 6 in the alpha region
- The 5 keV FWHM goal has already been reached by CUORE-0
- Background analysis and extrapolation to CUORE show that the background goal (0.01 counts/keV/kg/y) is within reach

Thanks for your attention