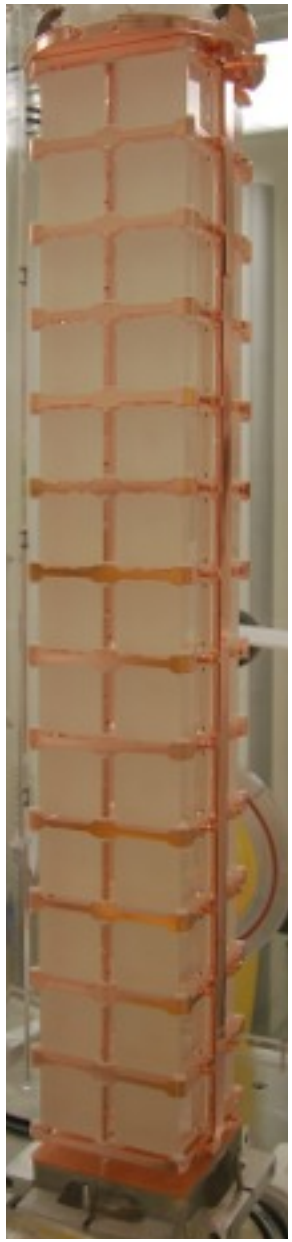


First data from CUORE-0

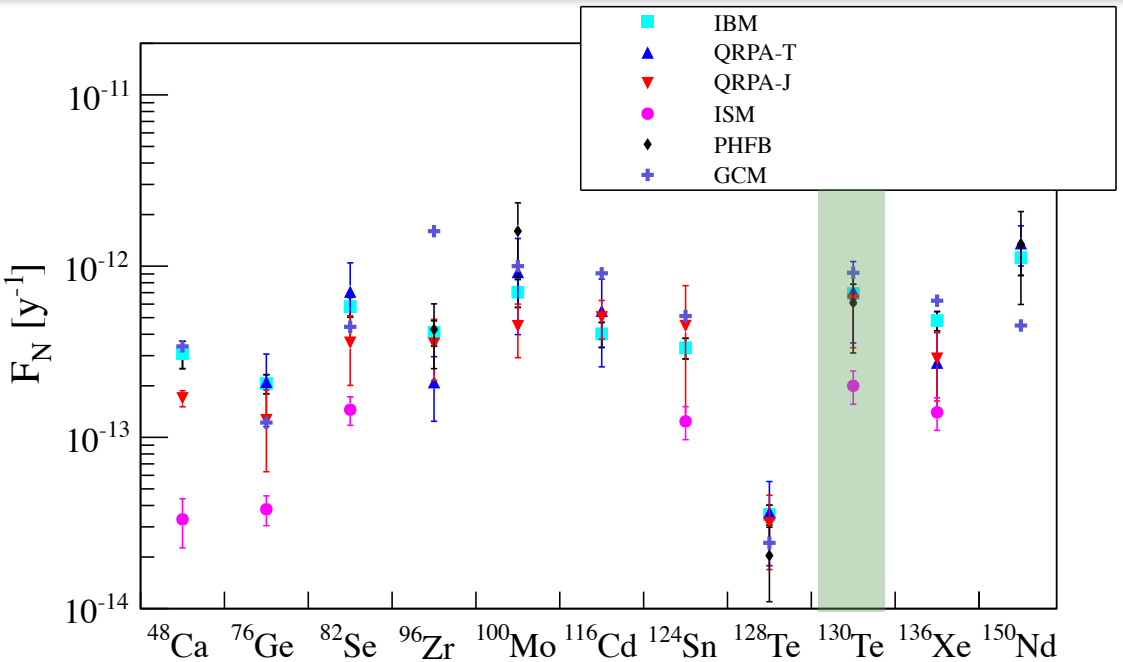
Marco Vignati
Istituto Nazionale di Fisica Nucleare - Roma
on behalf of the CUORE collaboration

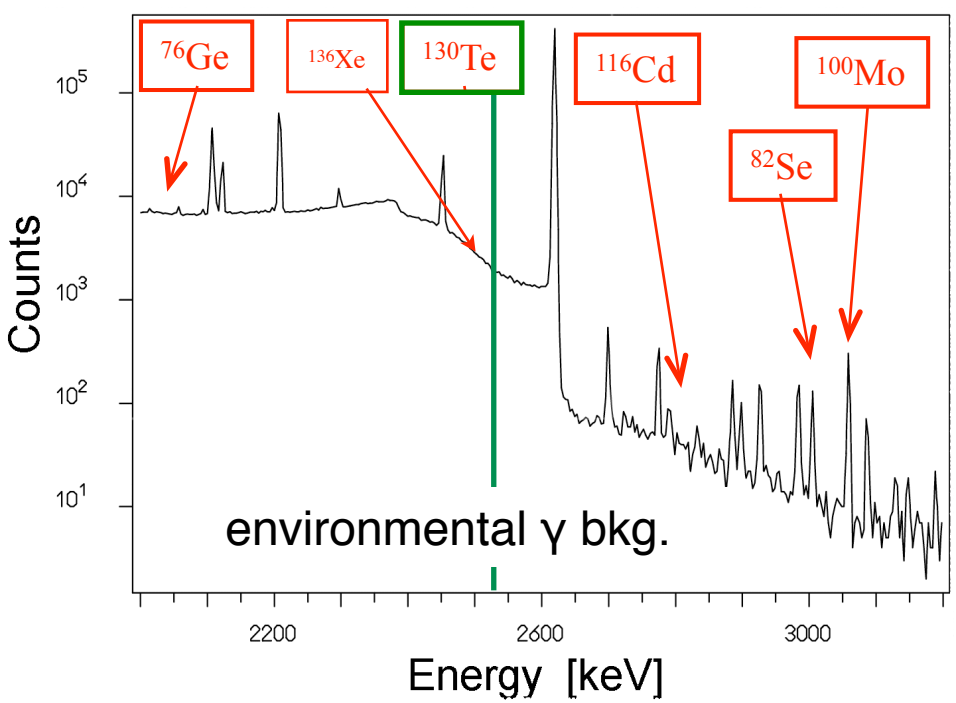
TAUP 2013, Asilomar - 11/September/2013

Double beta decay with Tellurium

Sensitivity to the Majorana mass $m_{\beta\beta}$ goes as:

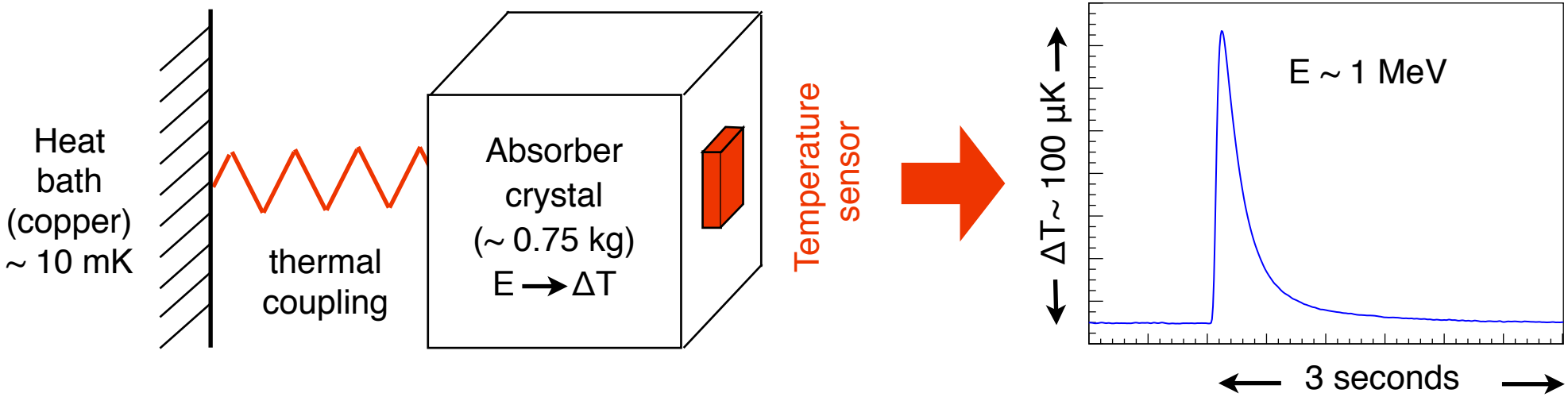
$$\frac{1}{|m_{\beta\beta}|^2} \sim F_N \cdot \text{I.A.} \times \sqrt{\frac{\text{Mass} \cdot \text{livetime}}{\text{bkg.} \cdot \Delta E}}$$



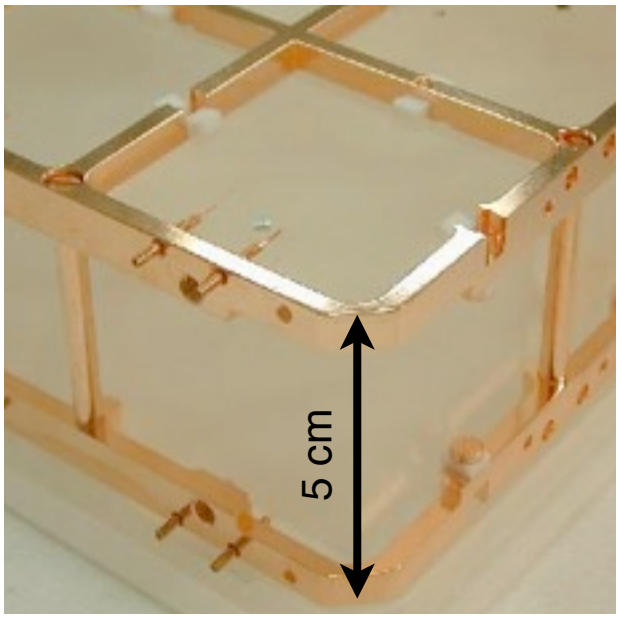


$\beta\beta$ Decay Reaction	Isotopic Abundance [atomic %]	Q-value [keV]
^{48}Ca→^{48}Ti	0.2	4274
^{76}Ge→^{76}Se	7.6	2039
^{82}Se→^{82}Kr	8.7	2996
^{96}Zr→^{96}Mo	2.8	3348
^{100}Mo→^{100}Ru	9.6	3034
^{116}Cd→^{116}Sn	7.5	2814
^{124}Sn→^{124}Te	5.8	2288
^{128}Te→^{128}Xe	31.8	866
^{130}Te→^{130}Xe	34.2	2528
^{136}Xe→^{136}Ba	8.9	2458
^{150}Nd→^{150}Sm	5.6	3368

Bolometric technique in CUORE



- $^{nat}TeO_2$ crystals (low heat capacitance)
- NTD-Ge thermistor (R ~ 50 MΩ)
- Resolution @$0\nu\beta\beta$ energy (2527 keV):
  ΔE = 5-7 keV FWHM



Gran Sasso lab in Italy

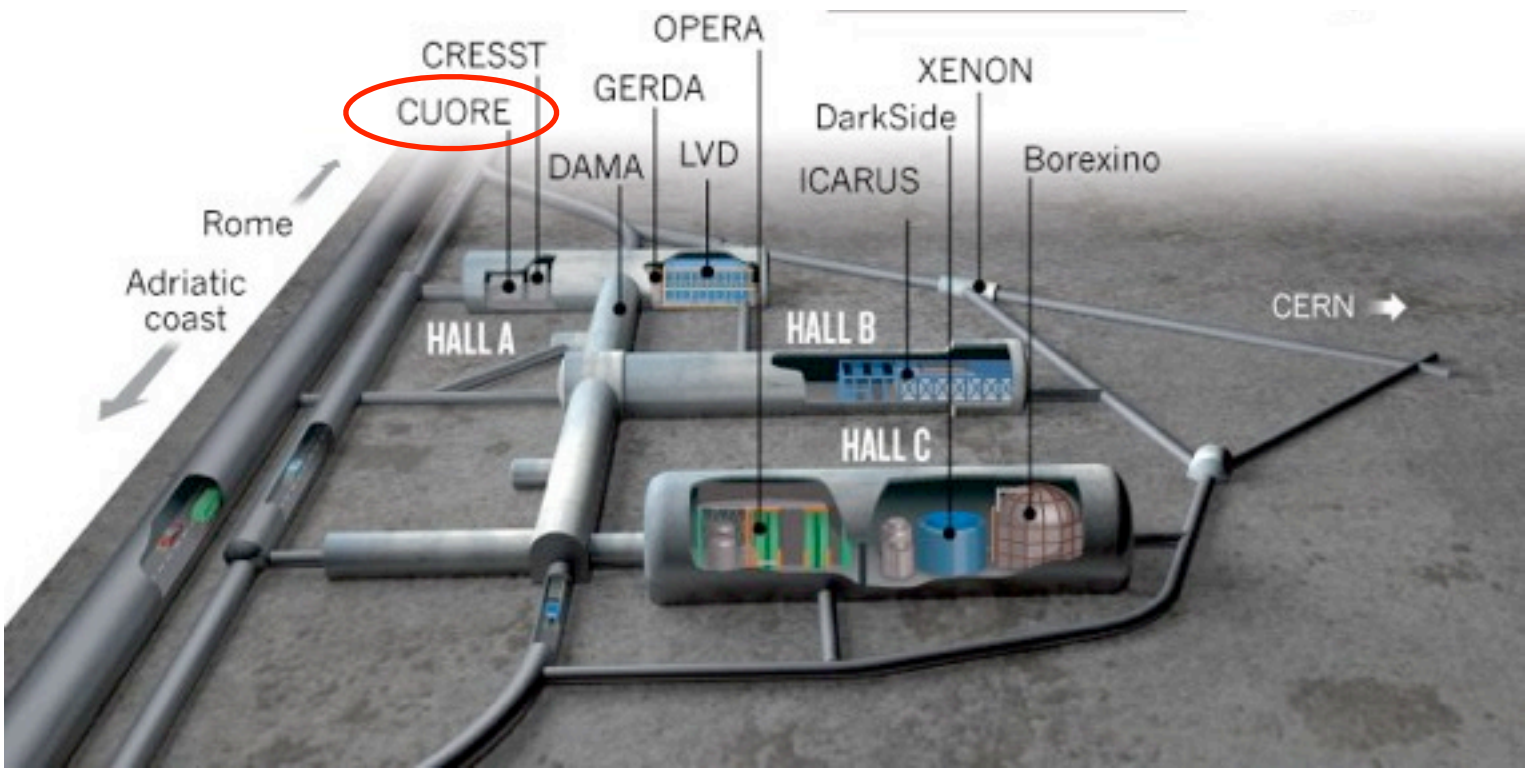
120 km from Rome

3650 m.w.e. deep

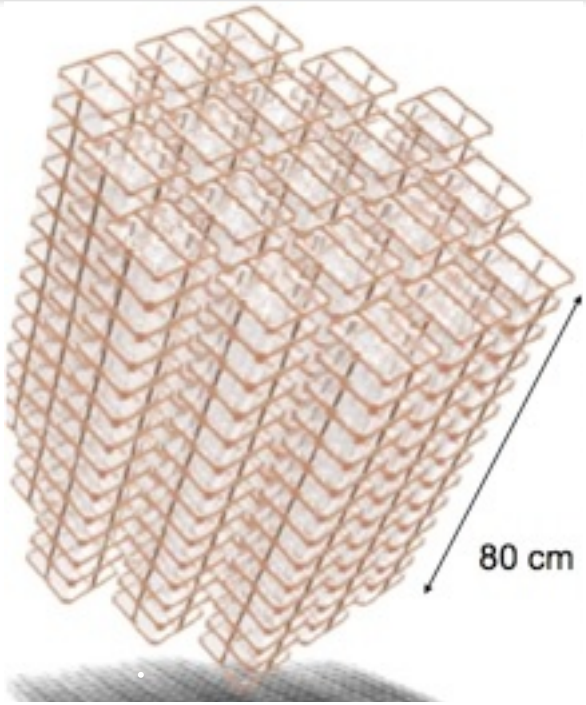
μs: 2.58x10^{-8}/(s cm^2)

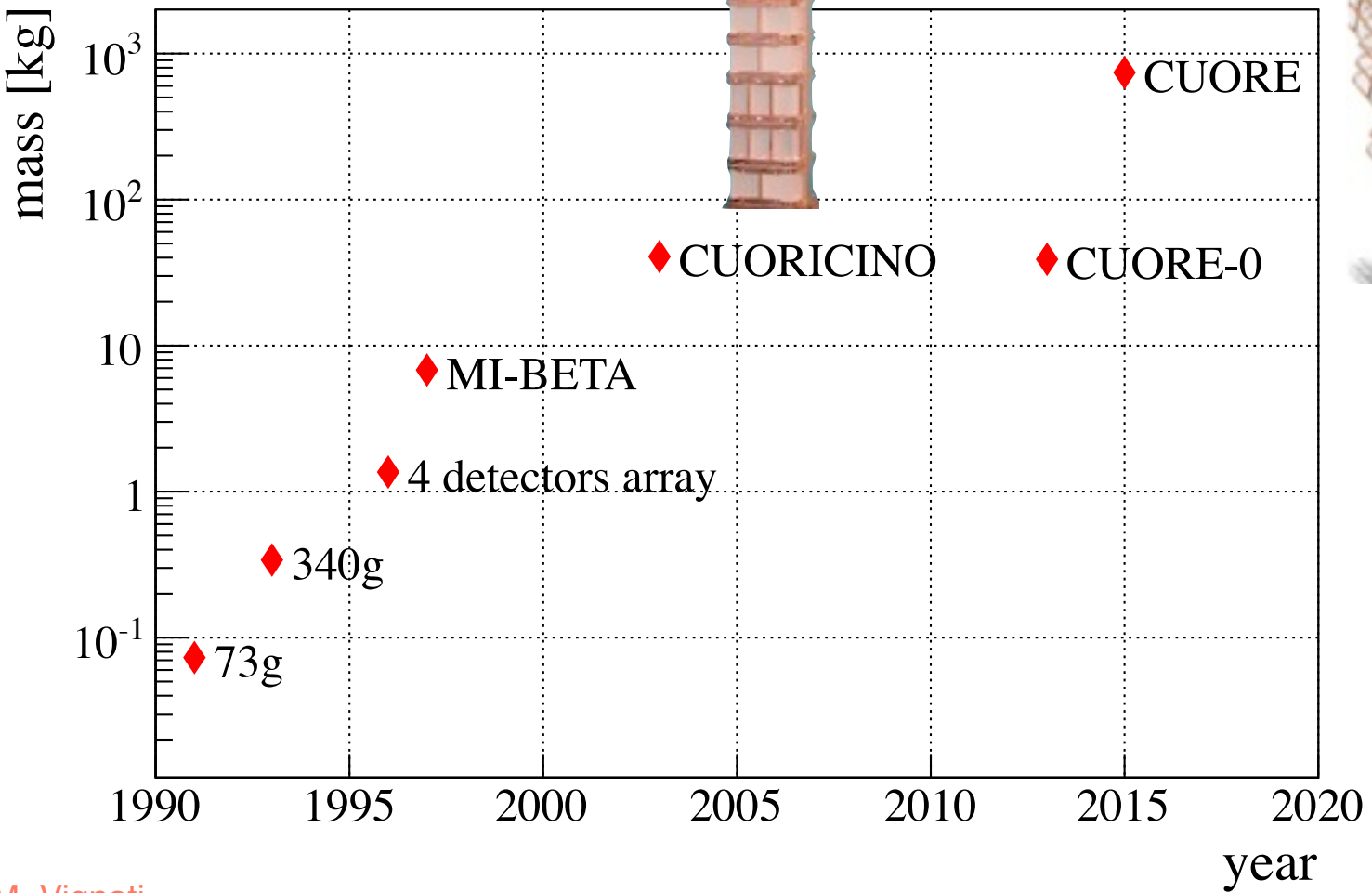
γs: ~0.73/(s cm^2)

neutrons: 4x10^{-6} n/(s cm^2)



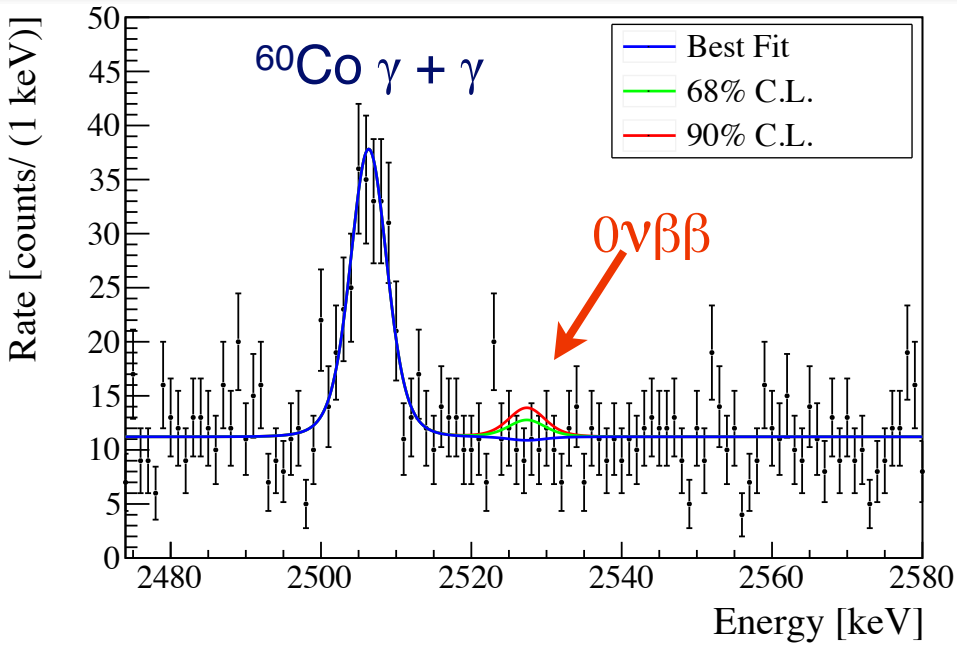
Arrays of TeO_2 bolometers

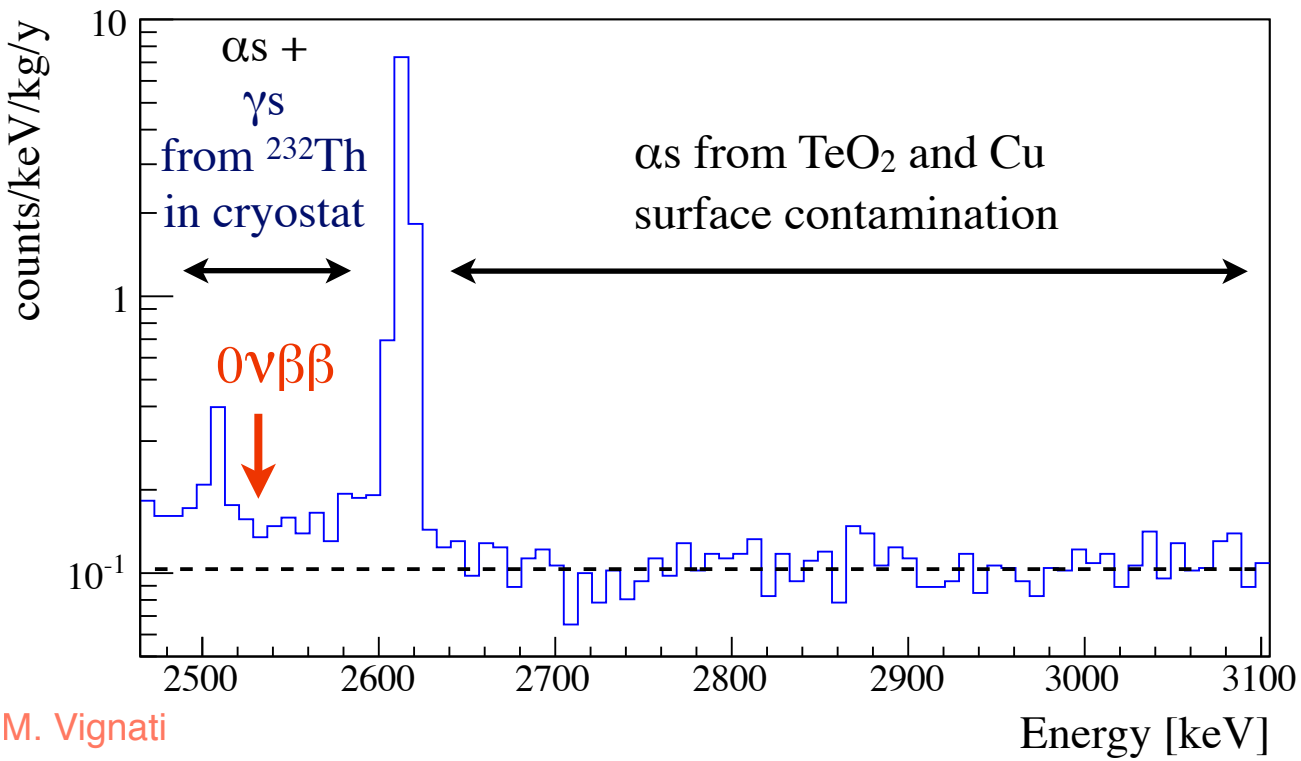


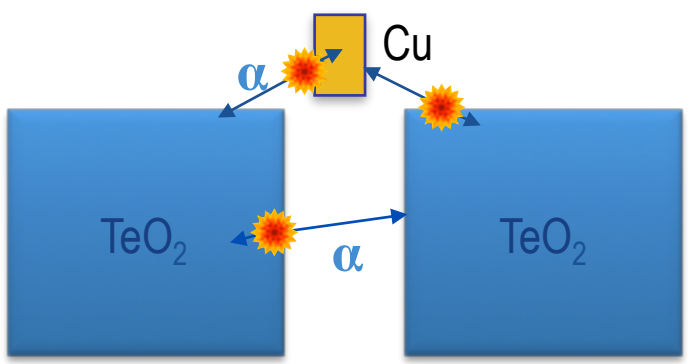


The CUORICINO experience

- 44x790g + 18x330g bolometers: 11 kg (^{130}Te)×2y
- $T^{0\nu}_{1/2} > 2.8\times10^{24}$ years (90% CL)
  $\langle m_{\beta\beta}\rangle < 300\sim710$ meV
- Background level (790g only): 0.15 counts/keV/kg/year







CUORE-0

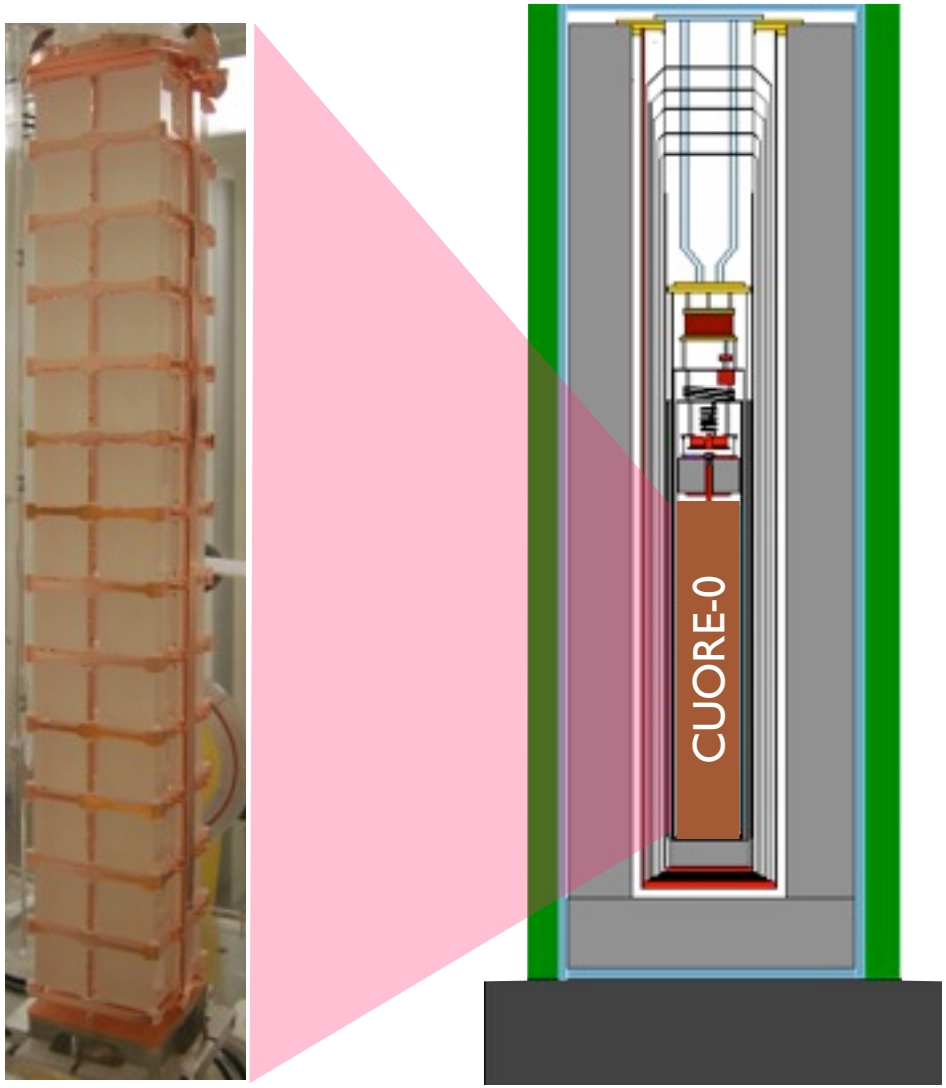
A single CUORE-like tower to test the cleaning and assembly techniques of CUORE

Size similar to CUORICINO:

- 52x750g bolometers
- 13 floor of 4 crystals each

Active mass:

- TeO_2: 39 kg
- **^{130}Te: 11 kg**



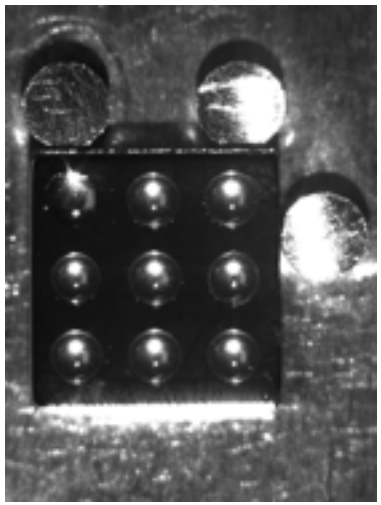
Cryostat:

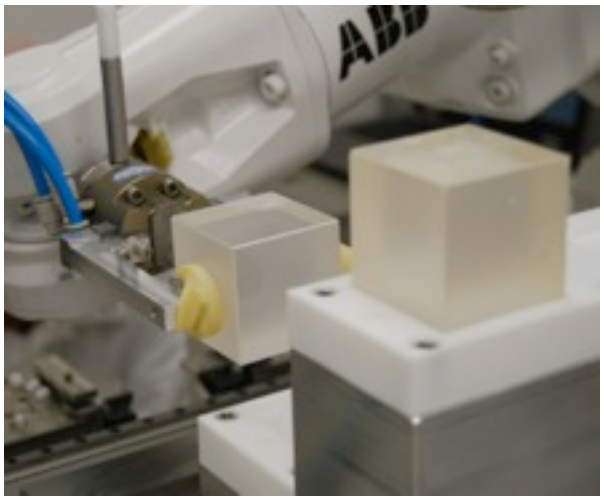
- Inner shield: 1cm Roman Pb A (^{210}Pb) < 4 mBq/Kg
- External Shield: 20 cm Pb 10 cm Borated polyethylene
- Nitrogen flushing to avoid Rn contamination.

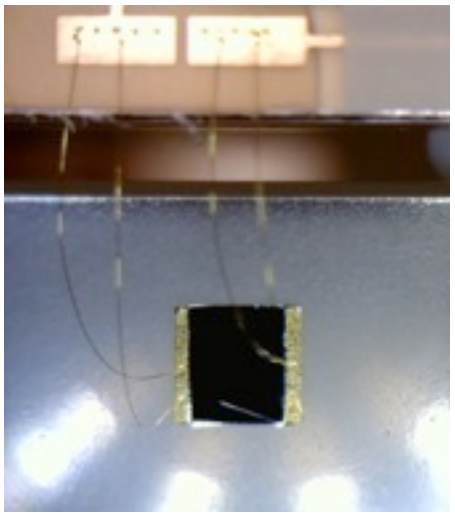
Same cryostat as CUORICINO:

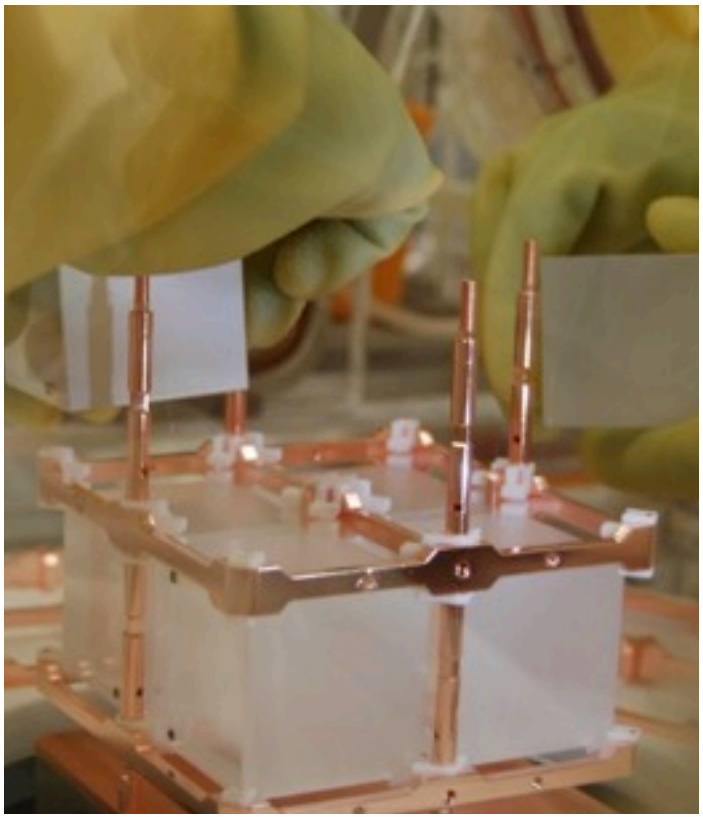
γ background (^{232}Th) not expected to change ⟶ test the α background

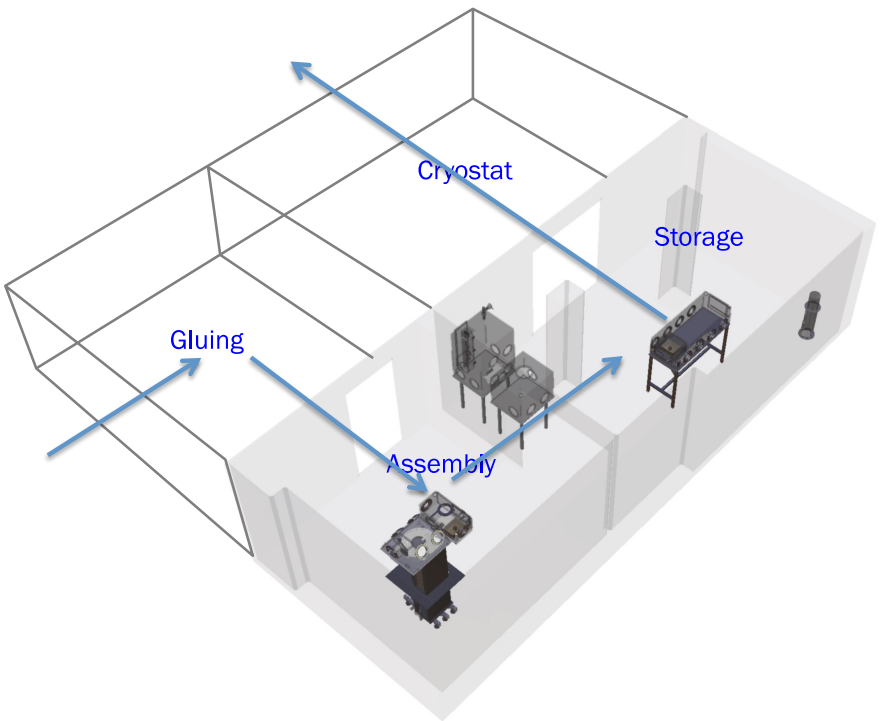
Construction and installation



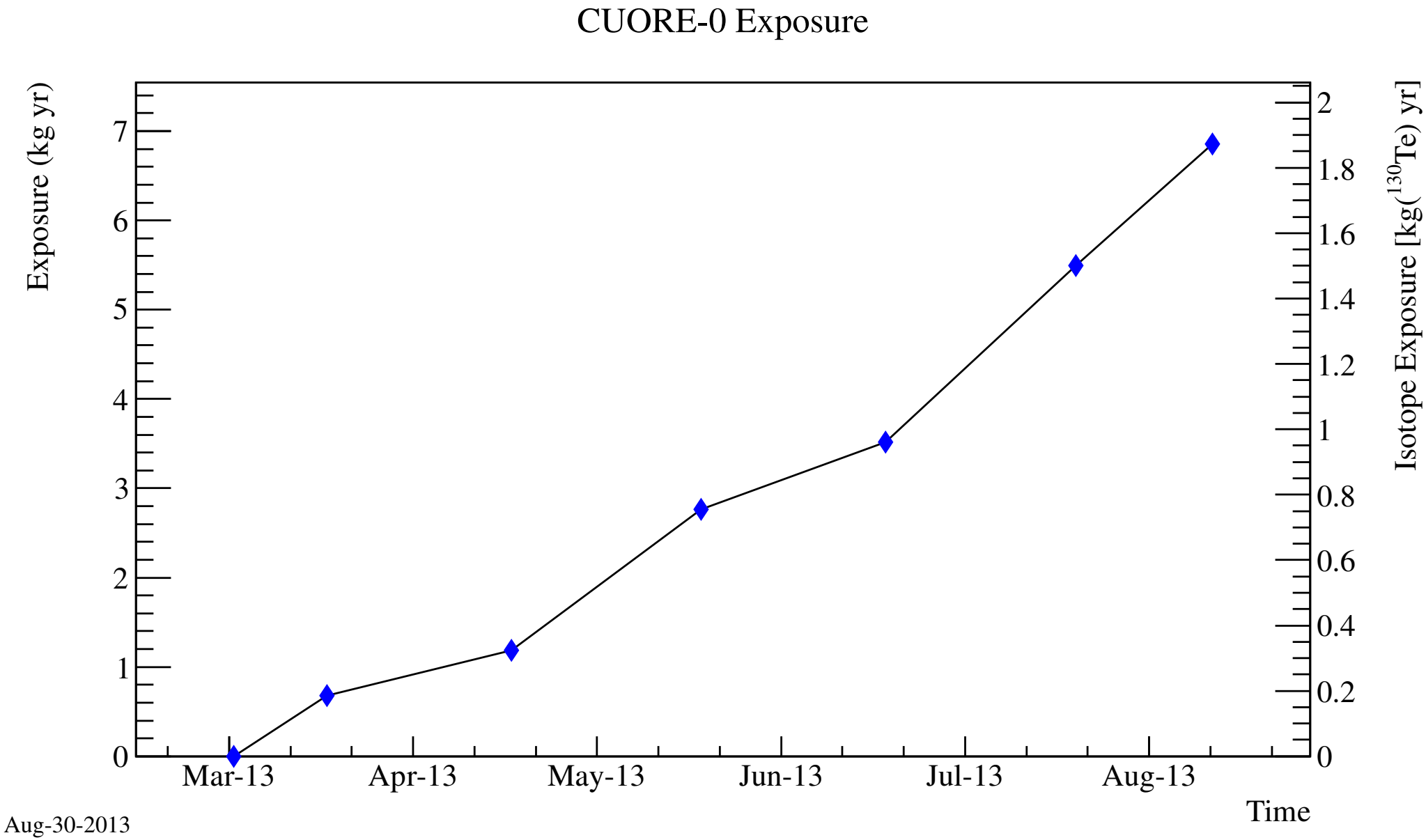




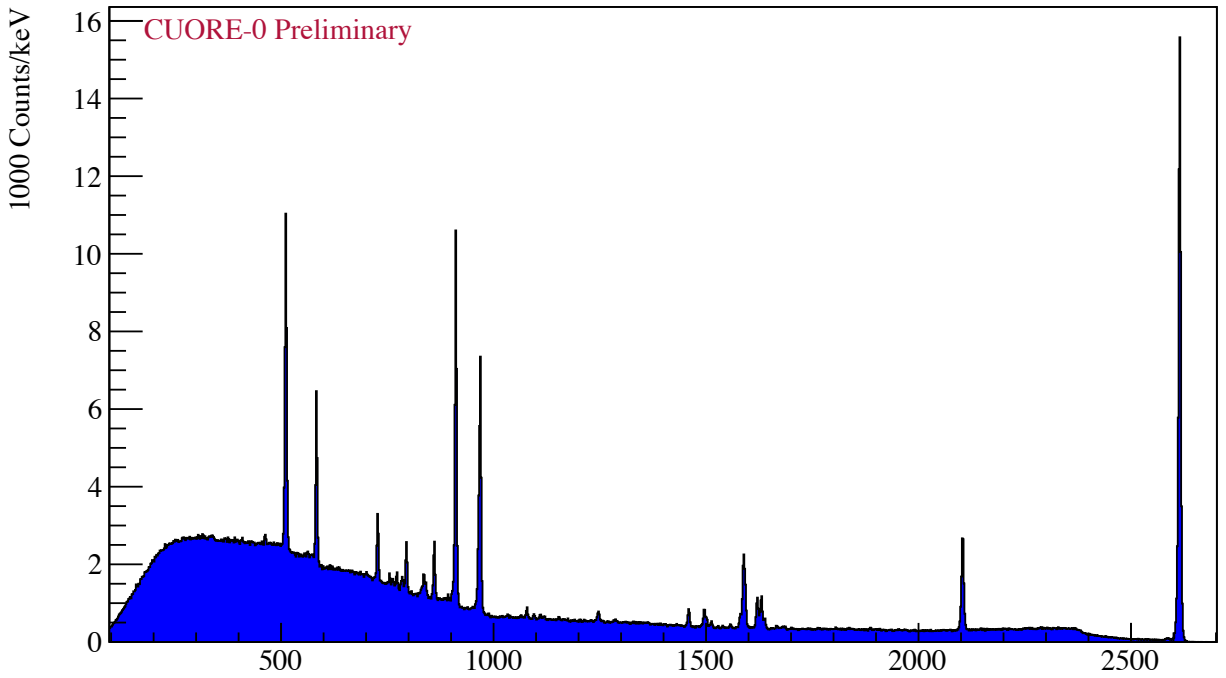


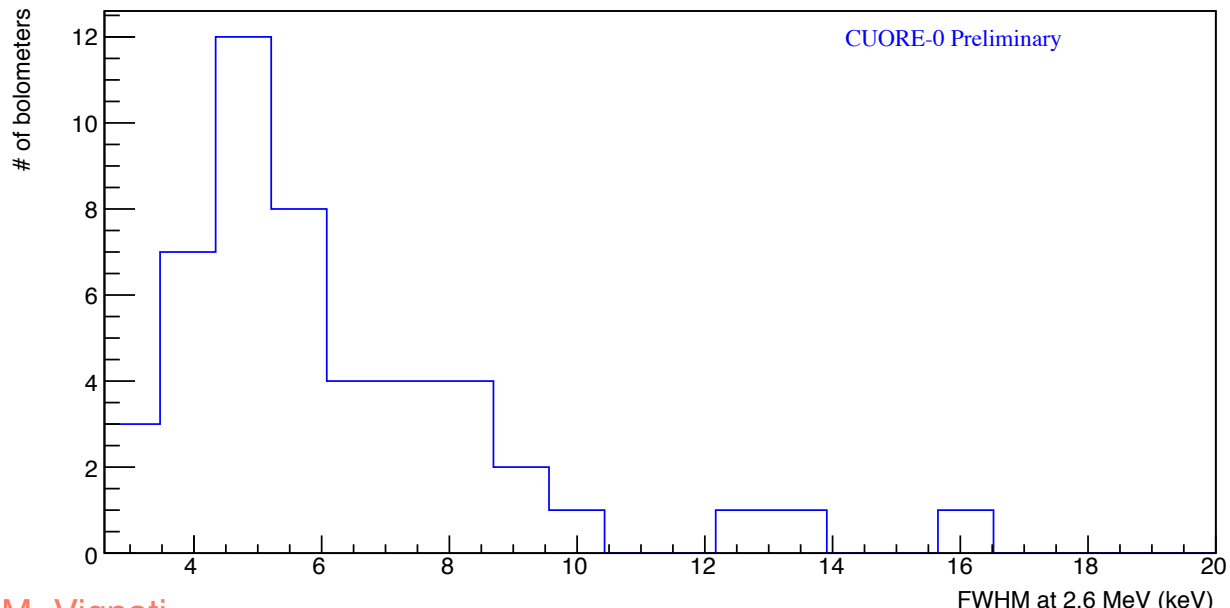


Data taking

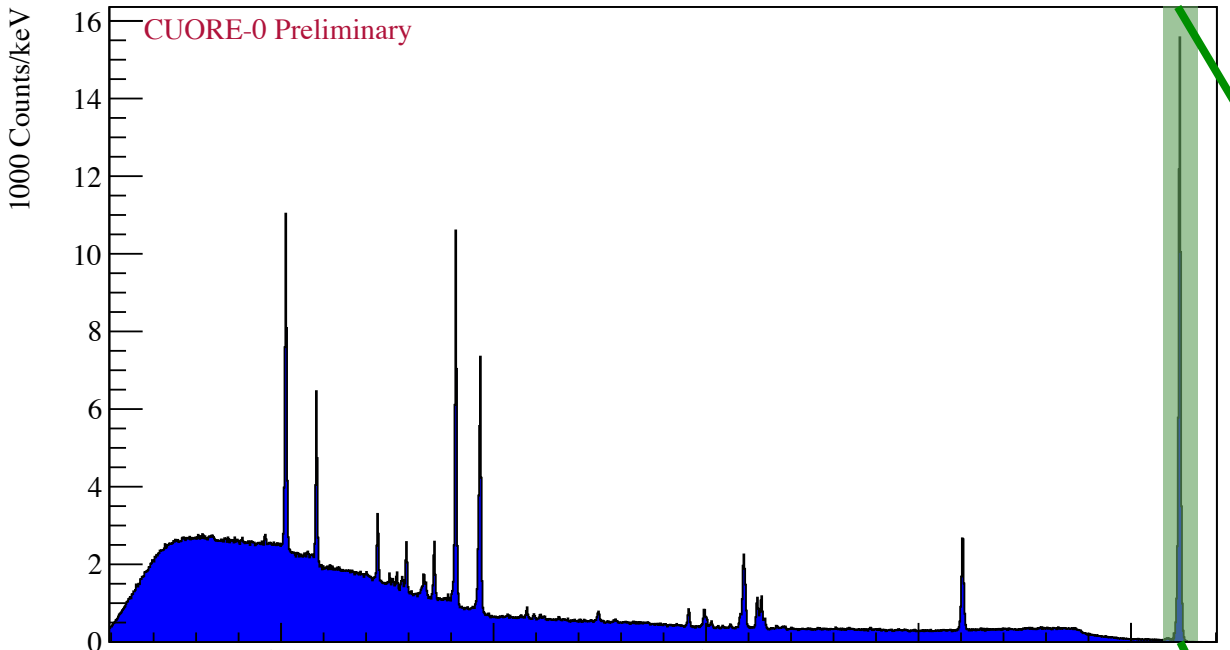

CUORE-0 Exposure
Exposure (kg yr)
Isotope Exposure [kg(^{130}Te) yr]
0
1
2
3
4
5
6
7
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Mar-13
Apr-13
May-13
Jun-13
Jul-13
Aug-13
Time
Aug-30-2013

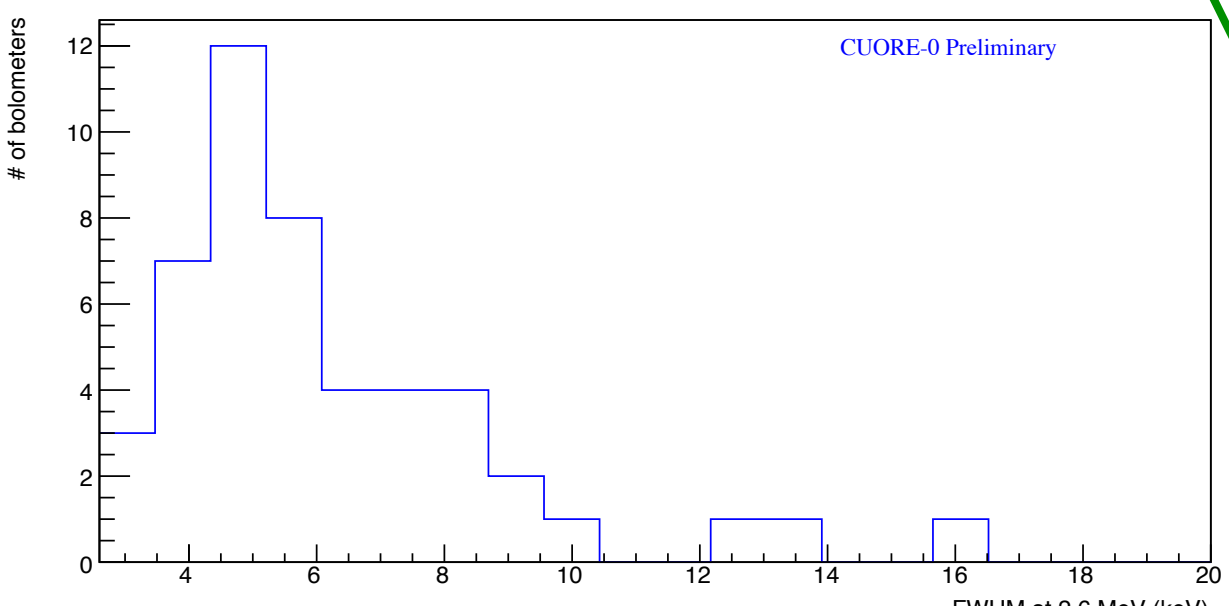
Energy calibration with ^{232}Th

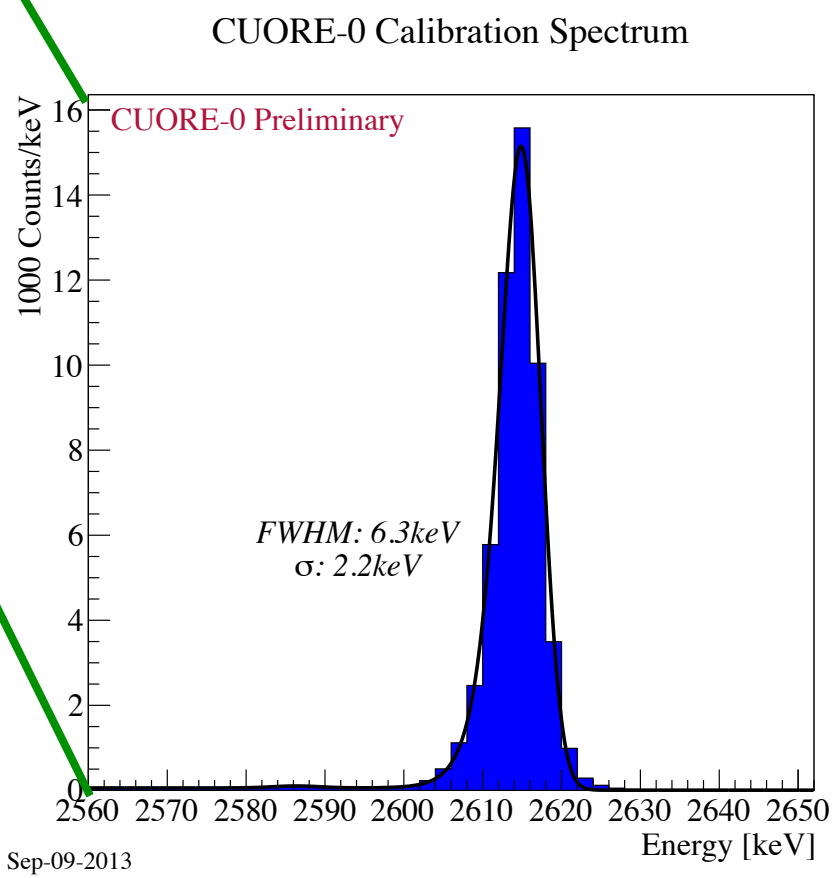




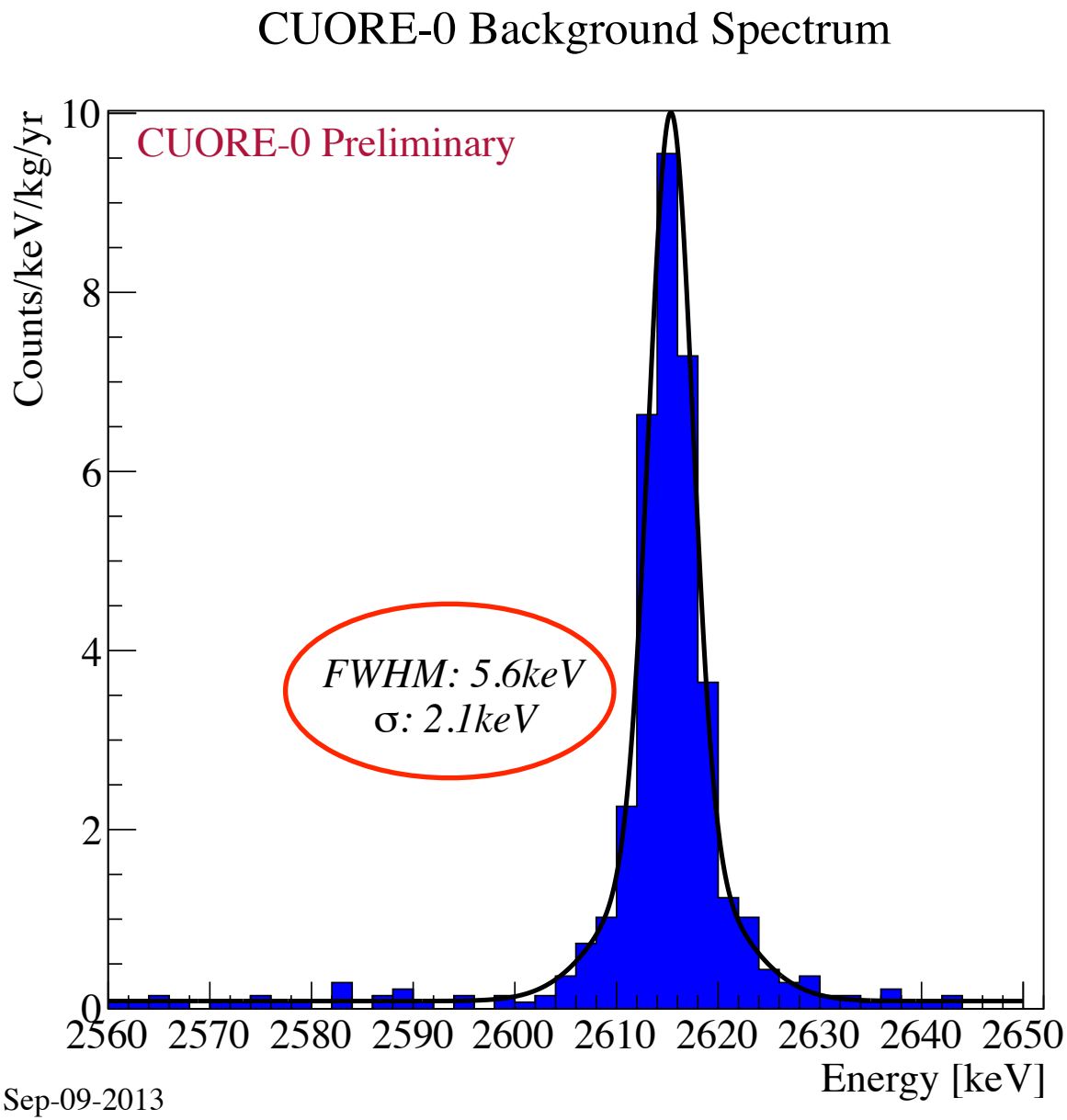
Energy calibration with ^{232}Th



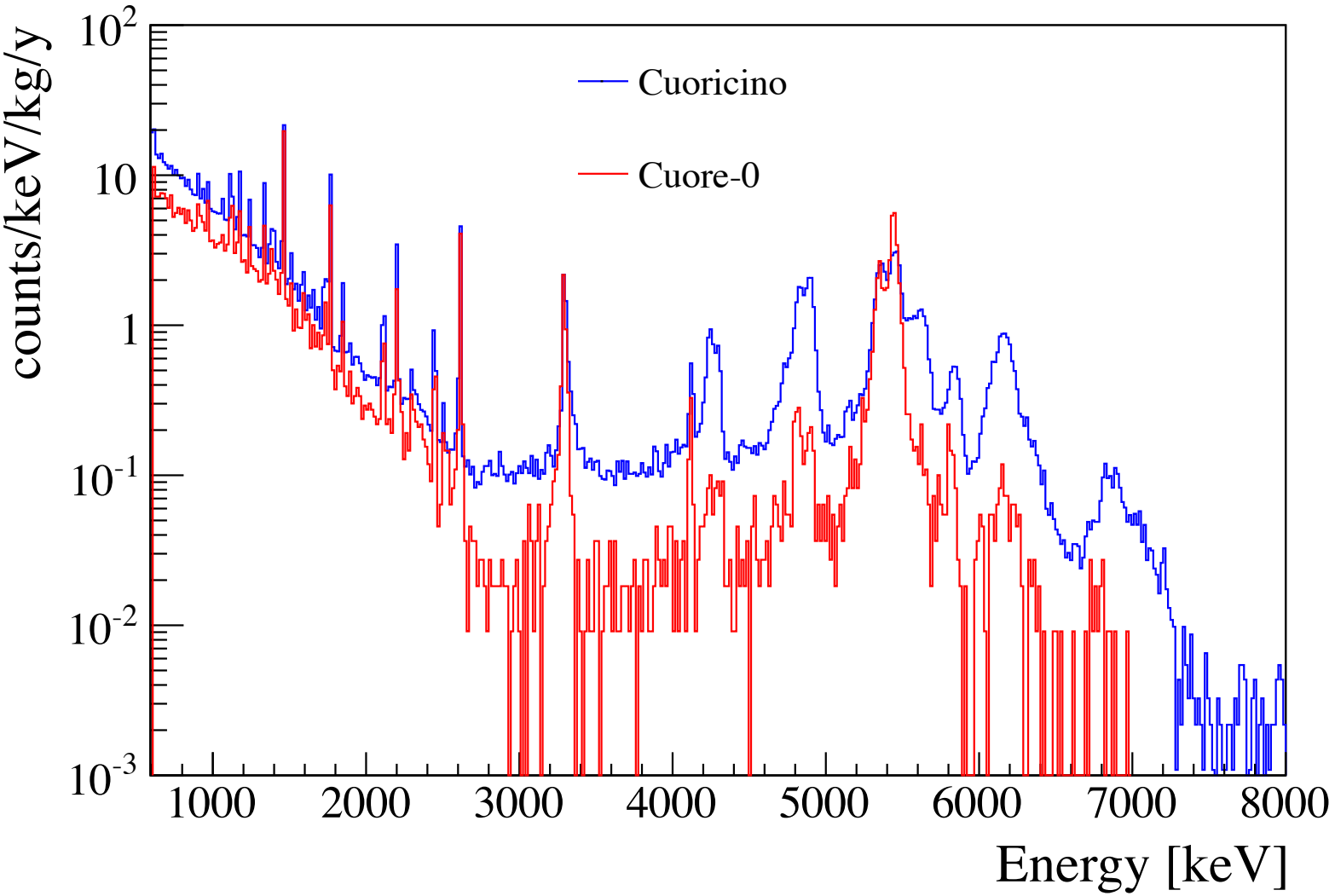




Background resolution



Background spectrum

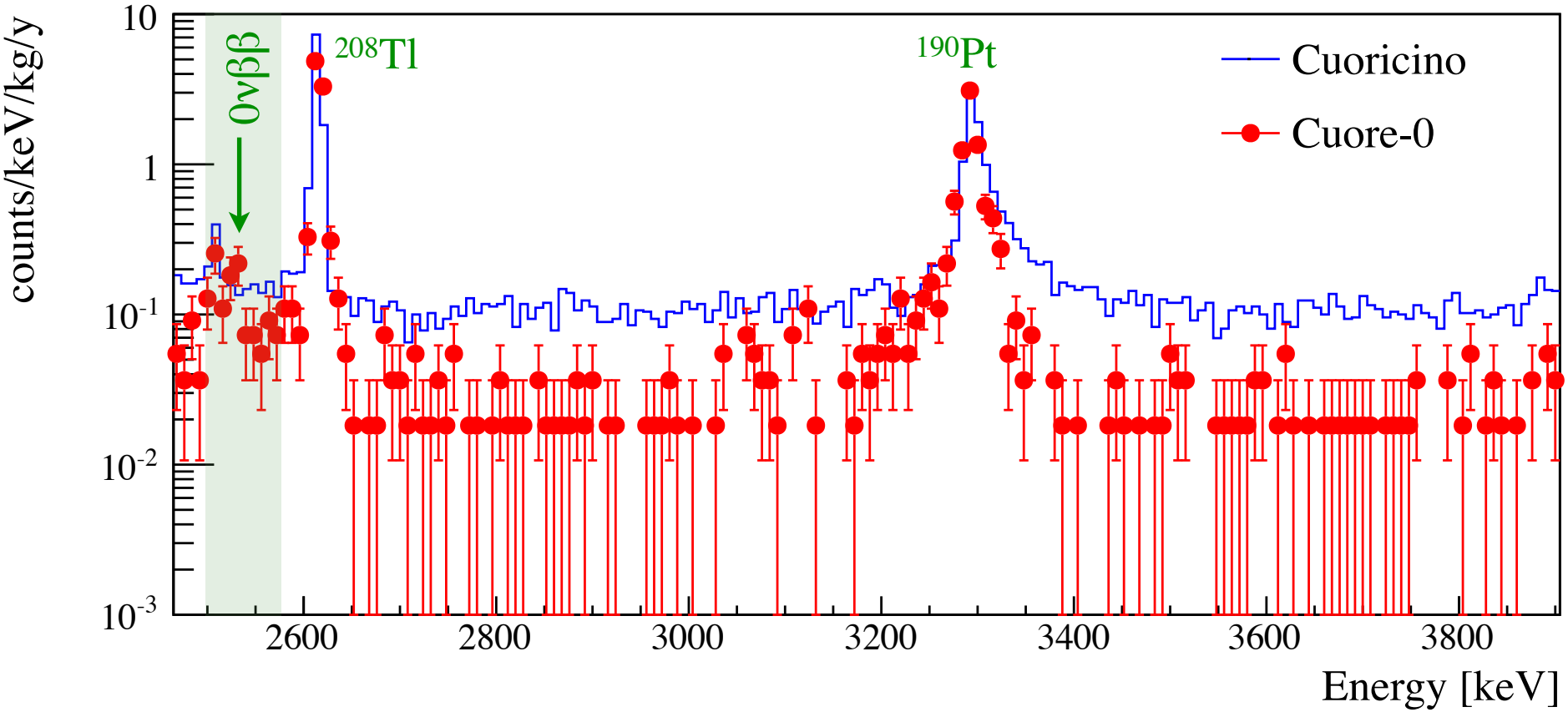


^{238}U γ lines reduced by a factor 2 (better radon control),

^{232}Th γ lines not reduced (originate from the cryostat).

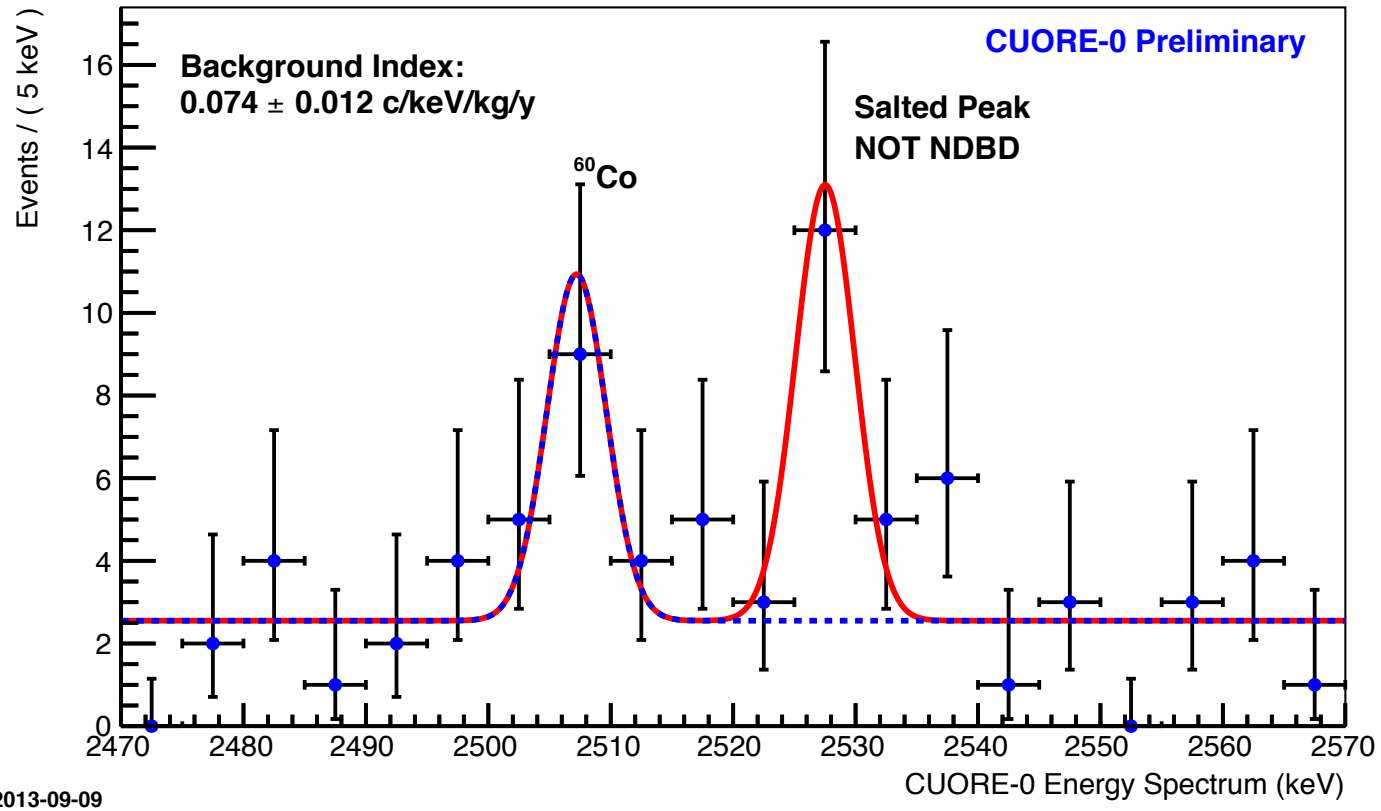
^{238}U and ^{232}Th α lines reduced thanks to the new detector surface treatment.

Continuous α background



	Avg. flat bkg. [counts/keV/kg/y]		signal eff. [%] (detector+cuts)
	0νββ region	2700-3900 keV	
CUORICINO	0.153 ± 0.006	0.110 ± 0.001	83±1
CUORE-0	0.074 ± 0.012	0.019 ± 0.002	78±1

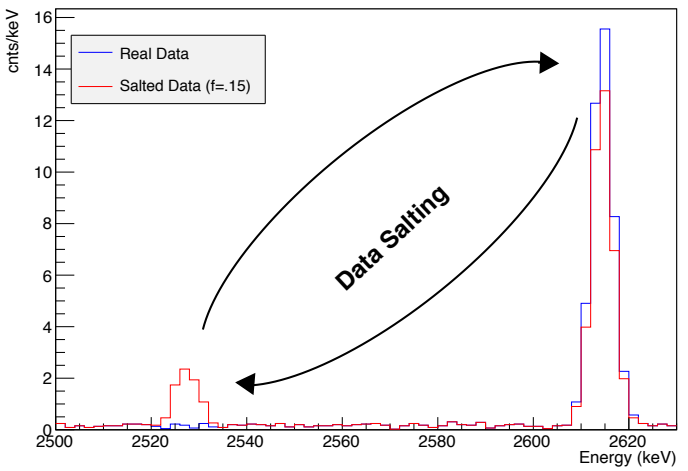
$0\nu\beta\beta$ region (blinded)



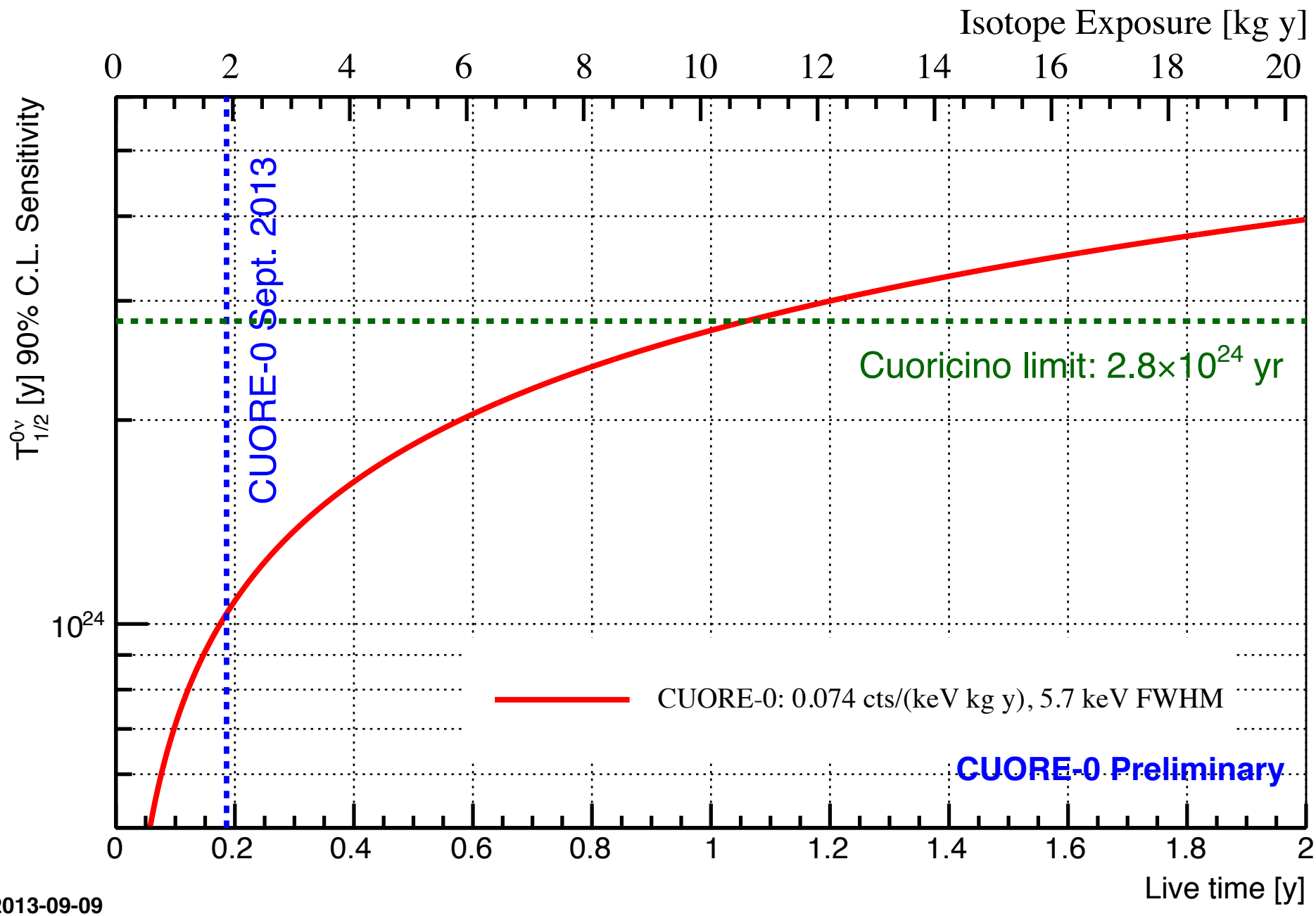
Pulse shape cuts not yet optimized

Our way of blinding is to salt the data:

exchange a small (and blinded) fraction of ^{208}Tl events (2615 keV) with events in the $0\nu\beta\beta$ region, producing a fake peak.



Sensitivity



2013-09-09

Conclusions

The background from surface contamination in CUORE-0 (0.019±0.002 counts/keV/kg/y) is ~ 6 times smaller than in CUORICINO:

- CUORE assembly and cleaning techniques validated

CUORE-0 will continue to take data up to the CUORE start:

- With a background of 0.074±0.012 counts/keV/kg/y at the $0\nu\beta\beta$ (surface + cryostat) it will overcome the CUORICINO sensitivity in about an year of data taking.
- Pulse shape cuts are being optimized: background level could improve.