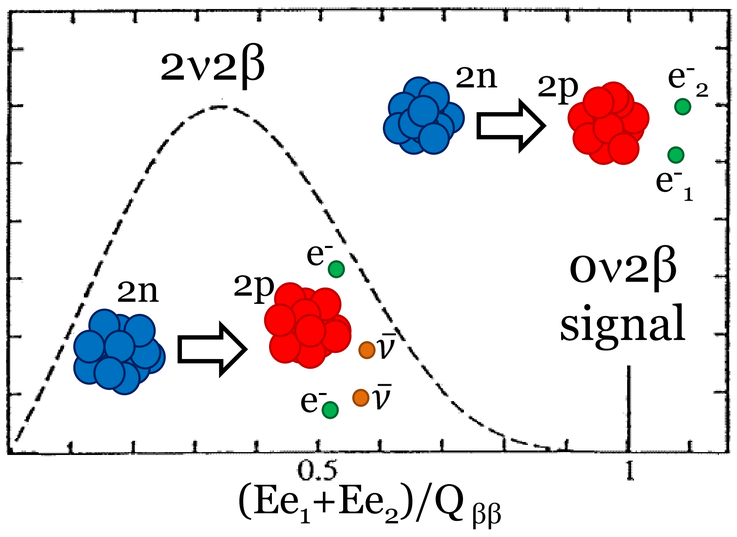
Full alpha background rejection in a CUORE-size TeO_2 bolometer using a Neganov-Luke-effect light detector

Valentina Novati, Centre de Sciences Nucléaires et de Sciences de la Matière (CSNSM)
valentina.novati@csnsm.in2p3.fr

Neutrinoless double beta (0ν2β) decay

A hypothetical rare nuclear process with a lifetime longer than $10^{24\text{-}26}$ years



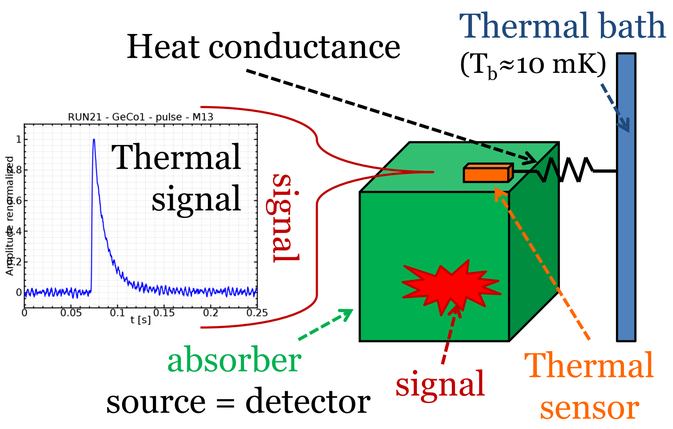
✓ Majorana neutrino nature: $\nu = \bar{\nu}$

✓ Lepton number violation: $2n \rightarrow 2p + 2e^-$

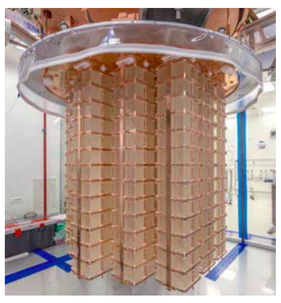
✓ Neutrino mass scale: $T_{1/2} \propto m_\nu^{-2}$

Bolometric technique

Bolometers are calorimetric detectors working at low temperatures and characterized by high energy resolution

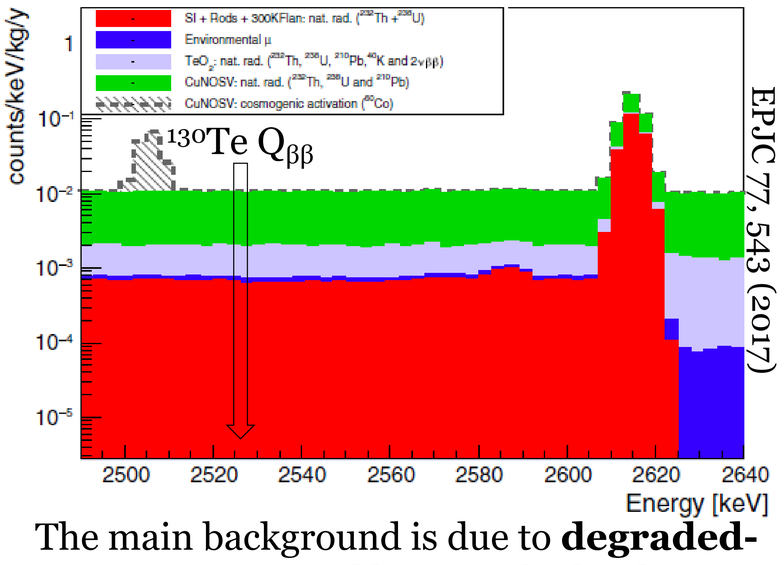


The CUORE experiment



✓ Underground laboratory: Laboratori Nazionali del Gran Sasso (Italy)
✓ candidate isotope ^{130}Te embedded in TeO_2 crystals:
→ $Q_{\beta\beta}$ (^{130}Te) = **2527.5 keV**
→ high isotopic abundance (34.2%)
→ high energy resolution at $Q_{\beta\beta}$ (7.7(5) keV FWHM [1])

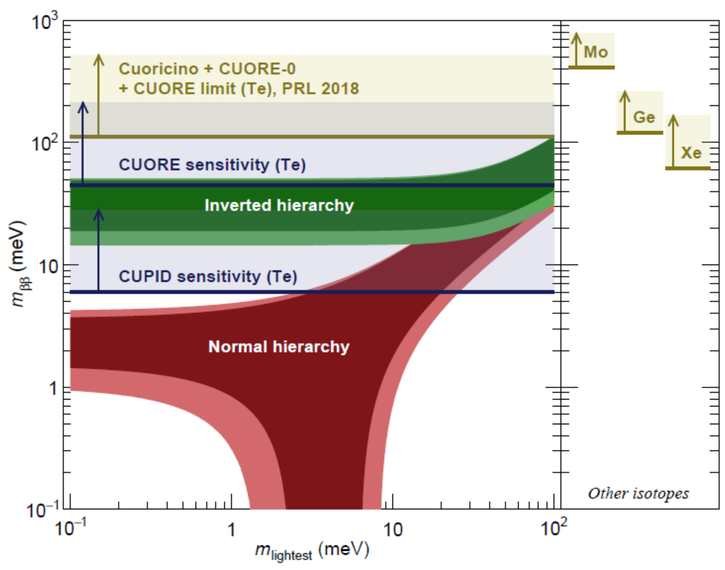
0.75-kg 988 bolometers:
total TeO_2 mass = 742 kg



The main background is due to **degraded-energy α** originated by a residual radioactive contamination close to the detector surface

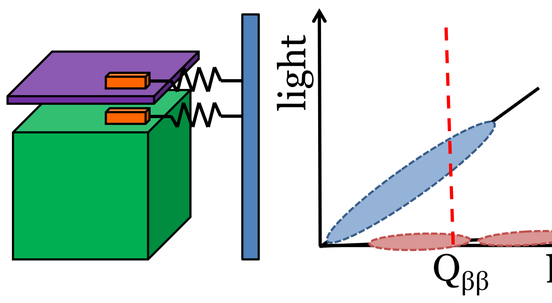
The CUPID experiment

A follow-up of the CUORE experiment is foreseen to cover the inverted hierarchy region: **CUPID** (CUORE Upgrade with Particle IDentification) [2]



Among wide R&D activities toward CUPID [3], one of the investigated options is the detection of the **Cherenkov radiation** [4] emitted by TeO_2 bolometers

✓ β/γ threshold = 50 keV
✓ α threshold = 400 MeV
⇨ Only β/γ events emit Cherenkov light in the $Q_{\beta\beta}$ region



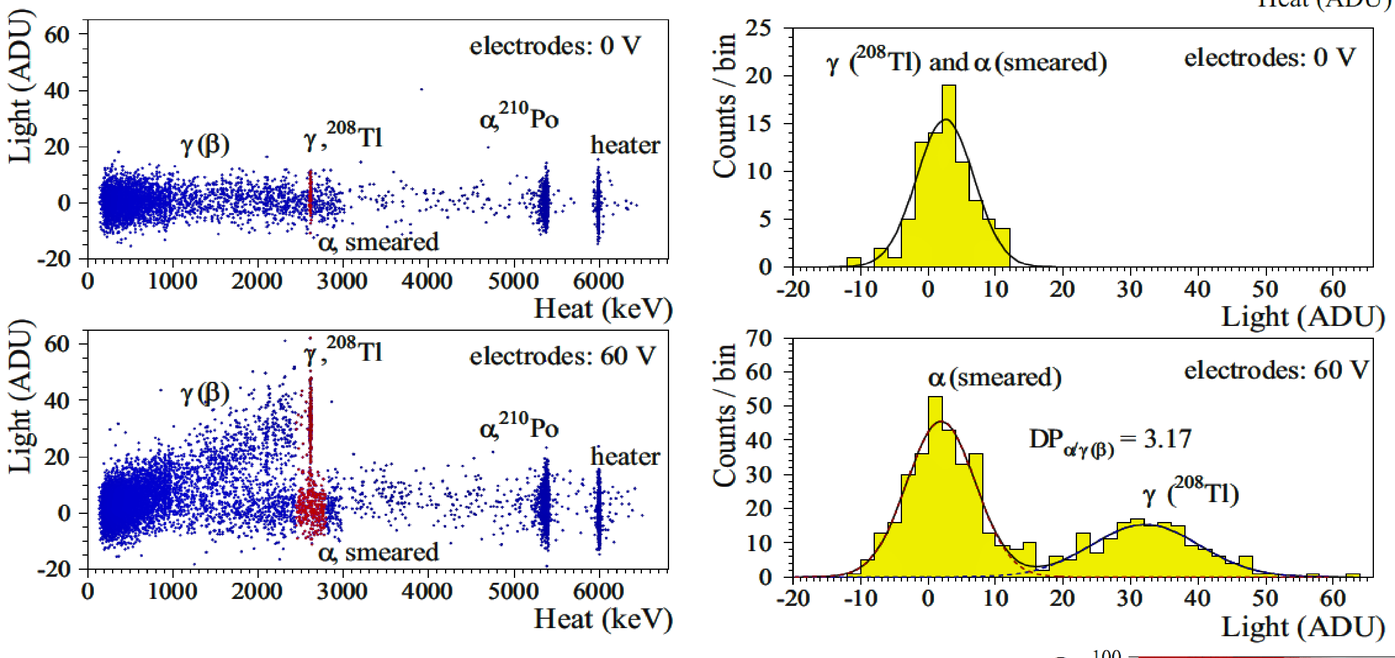
A double read-out with an additional bolometric light detector is needed

The expected light signal is tiny:
~100 eV light signal for a 0ν2β decay
⇨ It cannot be detected by standard bolometric light detectors [5]

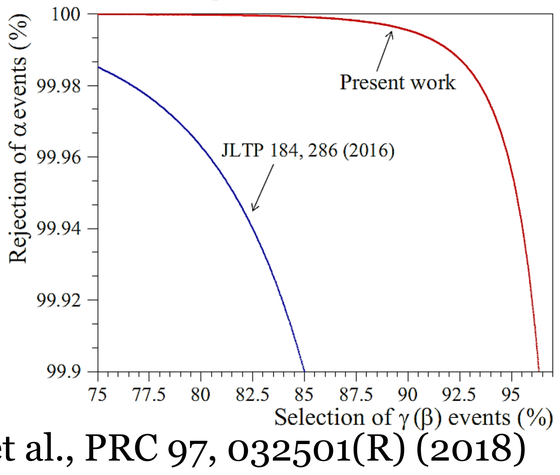
One can use **Neganov-Luke-enhanced** light detectors

Light detector performance

Electrodes bias	Baseline RMS	Signal/Noise
0 V	108 eV	0.6
60 V	10 eV	7



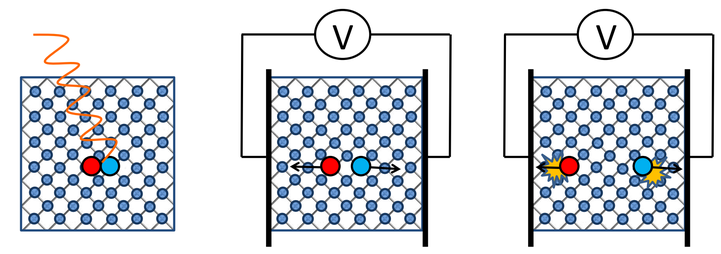
Thanks to a Neganov-Luke-assisted light detector, a **99.9% α rejection** - with **96 % acceptance for β(γ)** - has been demonstrated with a CUORE-size TeO_2 bolometer for the first time.



Comparison with the selection efficiency previously obtained with a crystal of the same size

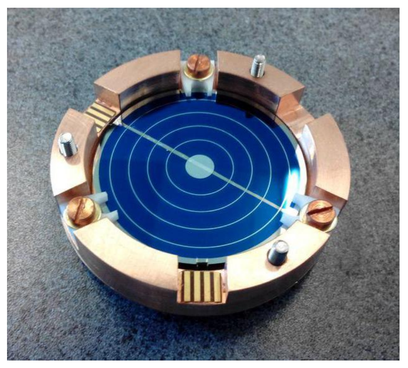
Neganov-Luke-assisted light detectors

The bolometer thermal signal is amplified thanks to an electric field



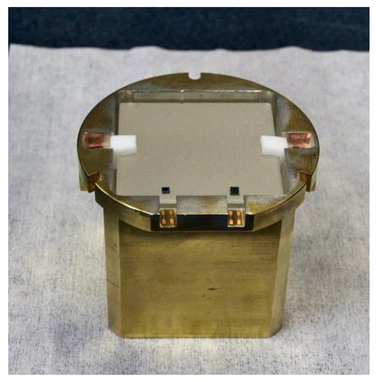
1. photons produce electron-hole pairs
2. they are drifted by the electric field
3. and collide with the lattice, increasing the temperature

Results

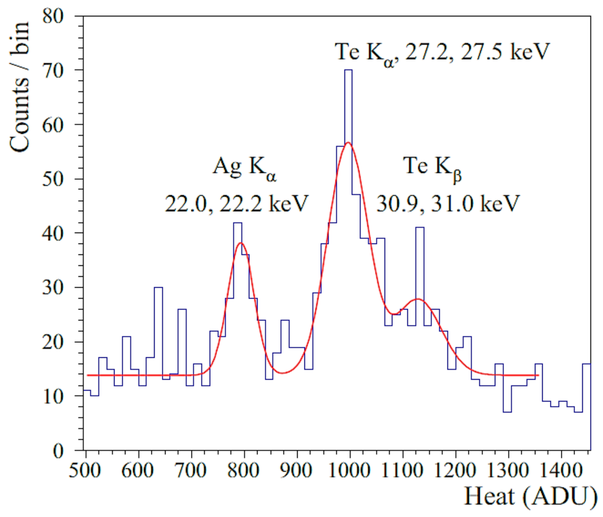


Neganov-Luke assisted light detector:
• Ø44-mm Ge absorber with an antireflective 70-nm-thick SiO coating
• the bias is applied on the annular Al electrodes

0.78-kg TeO2 bolometer



The measurements were carried out in the EDELWEISS set-up at Laboratoire Souterrain de Modane (France)



Light detector calibration with an intense ^{60}Co source @ 0 V electrodes bias

More details about the present work can be found in L. Bergé et al., PRC 97, 032501(R) (2018)

[1] PRL 120, 132501 (2018)
[2] arXiv: 1504.03599
[3] arXiv: 1504.03612
[4] EPJC 65, 359 (2010)
[5] EPJC 75, 12 (2015)