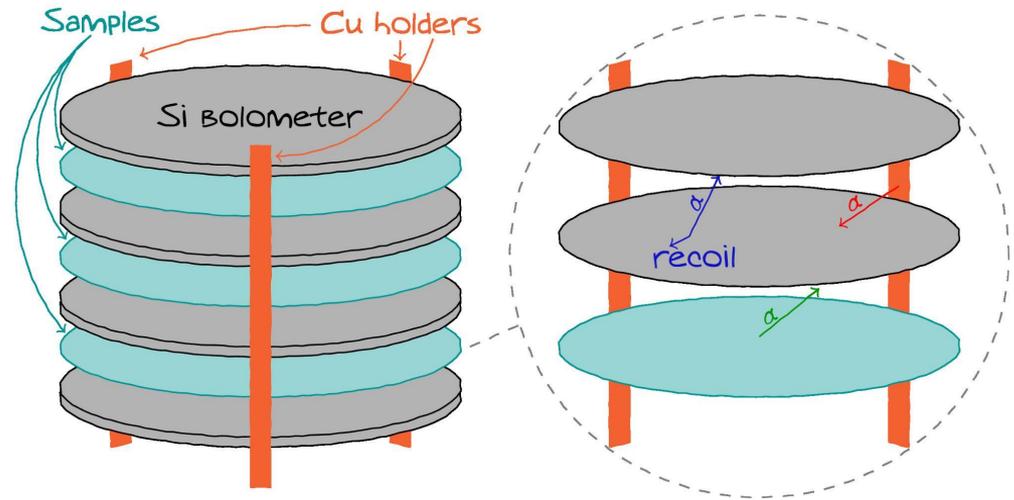


Silicon
Underground
Radiopure
Finder
of α
Contamination
Excesses



Giovanni Benato
GSSI Science Fair 2026

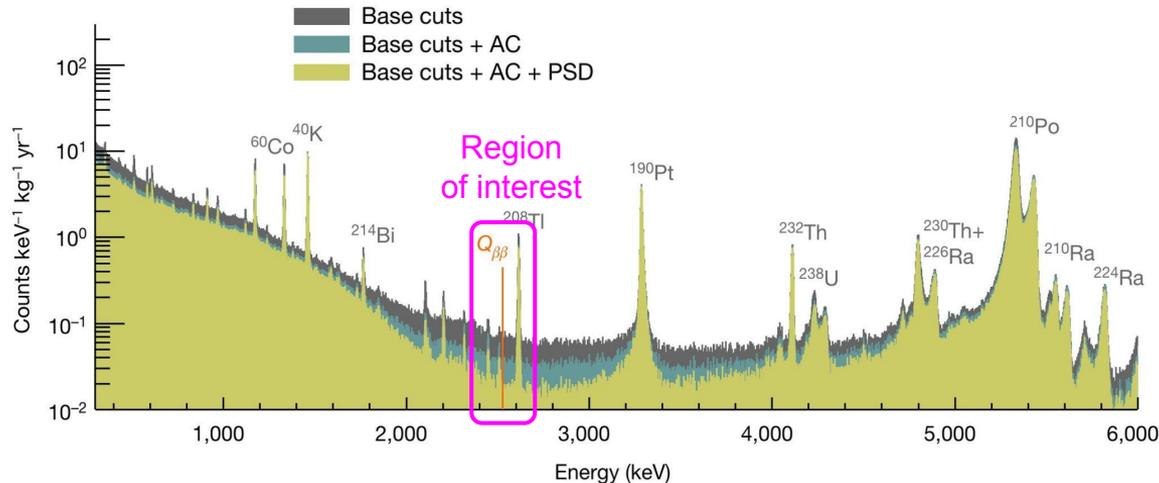
The need for low-background α spectroscopy

CUORE experiment for $0\nu\beta\beta$ decay

- Main background1: α 's from ^{238}U and ^{232}Th on copper surface
- Contamination level: $\sim 10 \text{ nBq/cm}^2$
→ Measured by CUORE itself over few years

CUPID: CUORE + particle discrimination

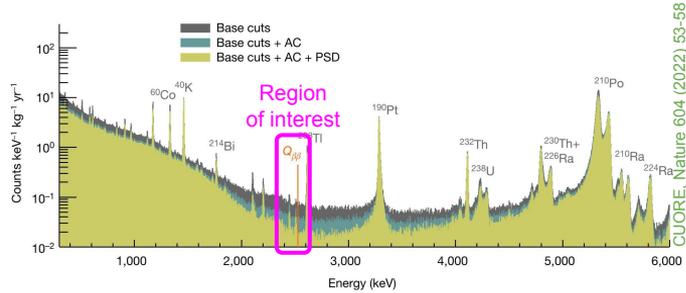
- Readout of scintillation light to suppress α 's
- Reducing surface contamination to 1 nBq/cm^2 would significantly improve the sensitivity



The need for low-background α spectroscopy

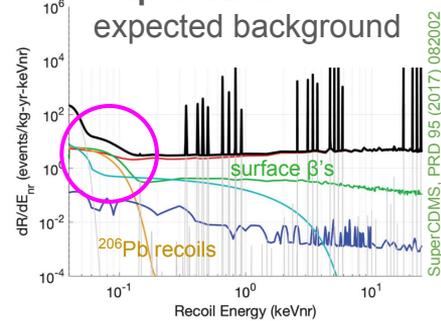
Bolometric searches for $0\nu\beta\beta$ decay

CUORE data (no particle identification)

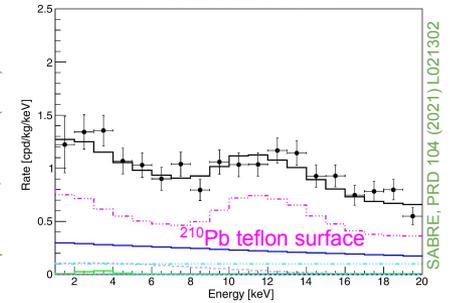


Direct Dark Matter searches w/ crystals

Super-CDMS HV-Ge expected background

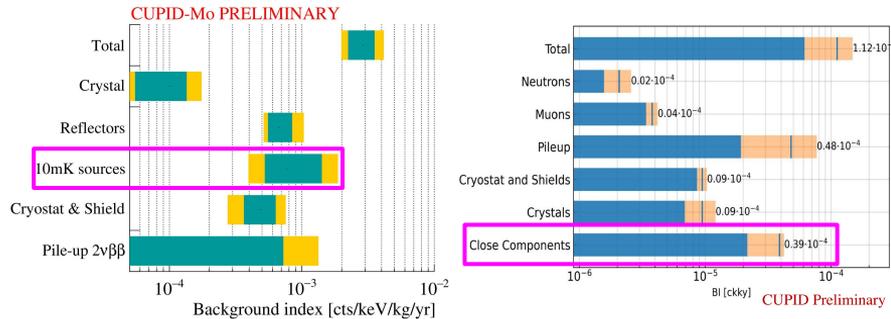


SABRE data



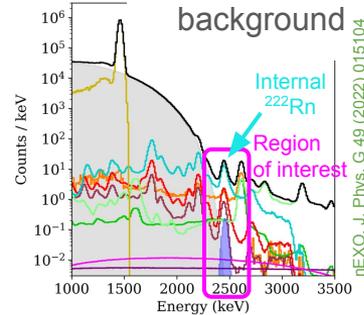
CUPID (with particle identification)

→ Residual β 's from $\sim 10 \text{ nBq/cm}^2$ surface contamination

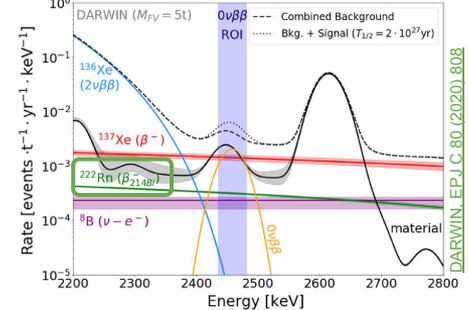


TPCs for $0\nu\beta\beta$ decay and Dark Matter searches

nEXO expected background



DARWIN background goal

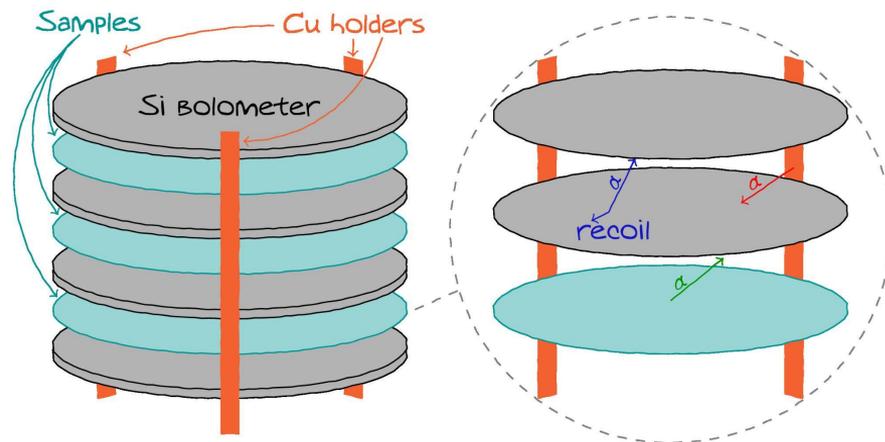


The SURF α CE concept

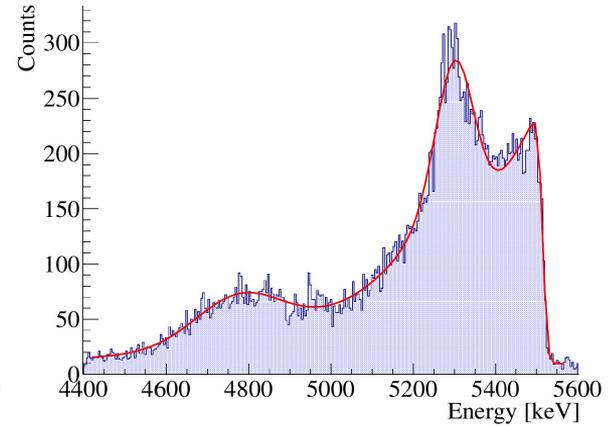
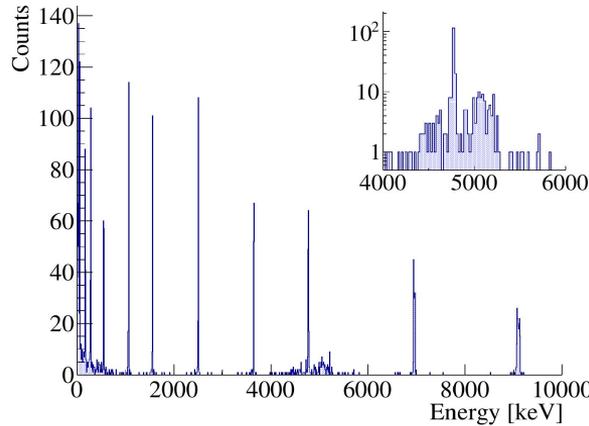
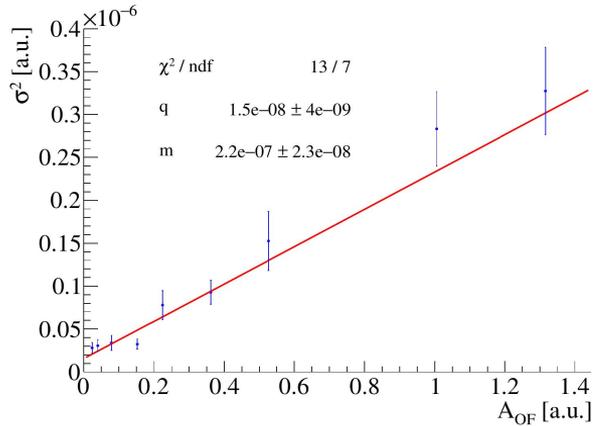
Requirements

- **Sensitivity of ~ 1 nBq/cm²** with a few weeks of measurement
 - **Area ≥ 1 m²**
 - **α background $\leq 10^{-8}$ counts/s/cm²**
- Measure all parts of the ²³⁸U and ²³²Th chain that are out of secular equilibrium
 - **Energy resolution $\lesssim 20$ keV (FWHM)**
- Easy operation of sample insertion/removal
- Possibility to clean or replace the detector

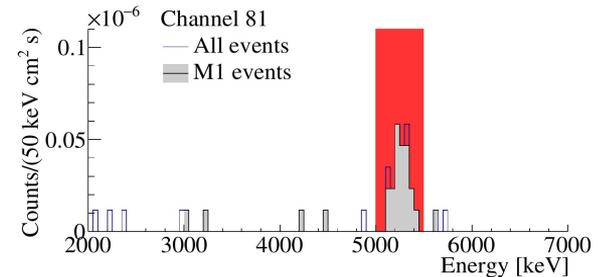
None of the current technologies satisfies all the requirements!



The SURFαCE prototype



- Operated underground @Canfranc in Jan-Mar 2024
- Proof of principle for LED-based calibration in [10 keV, 10 MeV] range
- Resolution on α peak from ^{222}Rn -irradiated sample ~ 110 keV FWHM
 →Space dependence of detector response? Self-absorption?
- Lowest background: $6 \cdot 10^{-8}$ events/cm²/s excluding ^{210}Po peak
 →**Lowest α background ever!**



Possible PhD topics

- Study of detector performance (HW+SW)
 - Study spatial dependence of detector response; optimize resolution; ...
- Development of calibration strategies (HW+SW)
 - Light-based calibration; ion-implanted alpha sources
- Background minimization (HW+SW)
 - Optimize cleaning procedures; test different absorber materials; minimize passive material
- Understanding of background (SW)
 - Background model and simulations

Research groups involved in SURF α CE:

GSSI-LNGS, IJCLAB-Orsay, MPI-Heidelberg, UC Berkeley, Bicocca, Legnaro

If you want a superficial PhD...

Join SURF α CE!