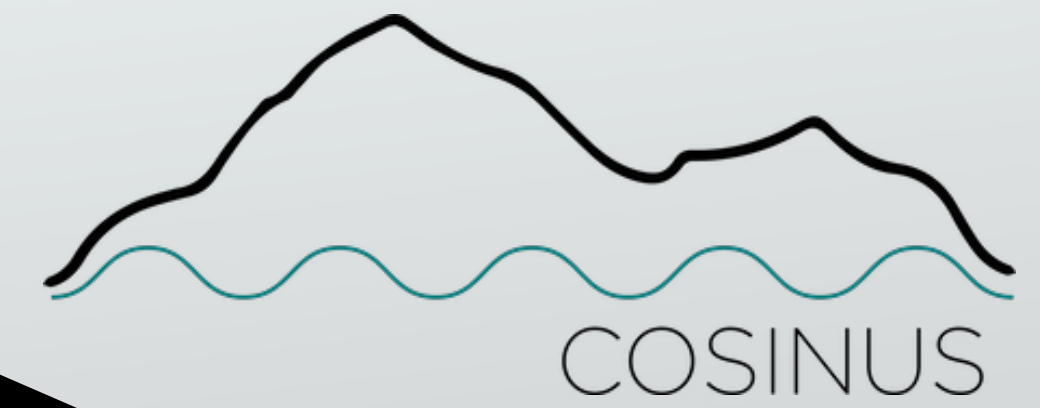


The COSINUS Experiment:



Direct Search for Dark Matter with Scintillating NaI Calorimeters

M. Stahlberg for the COSINUS Collaboration



World Summit on Exploring the Dark Side of the Universe 2022
La Reunion, France

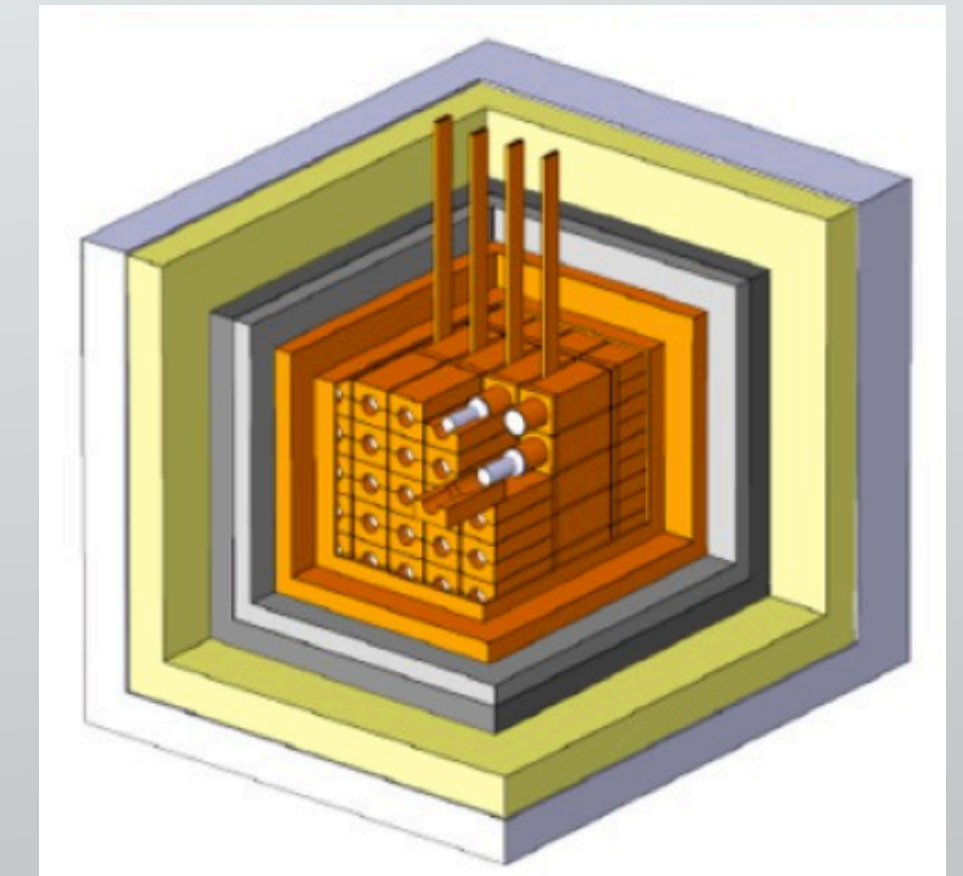
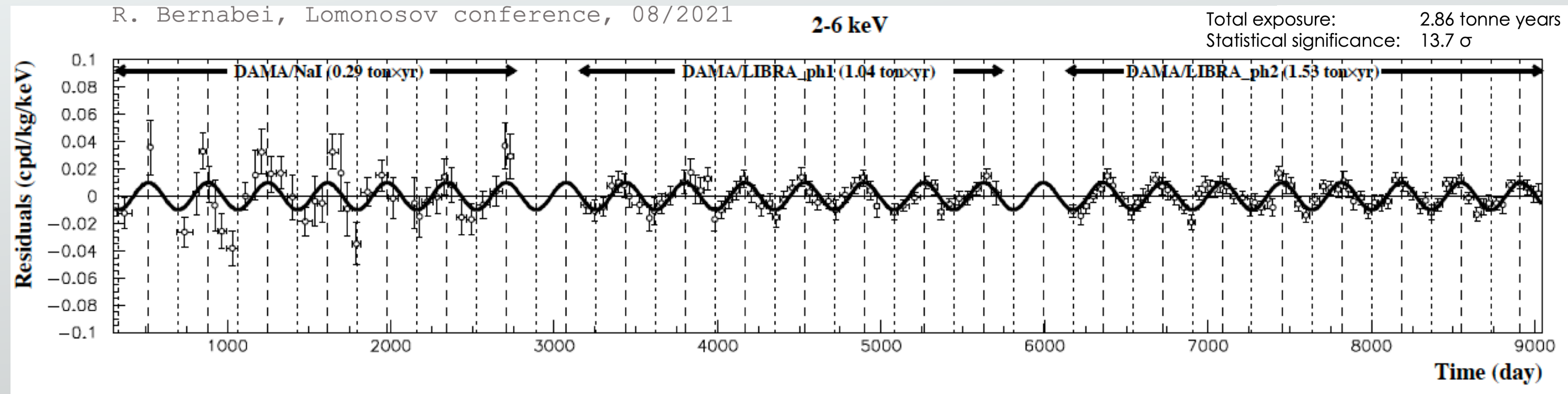
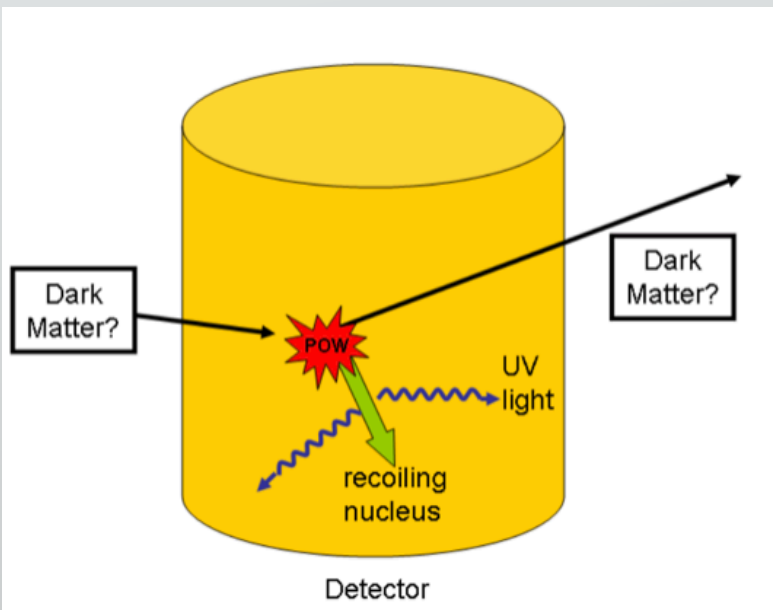
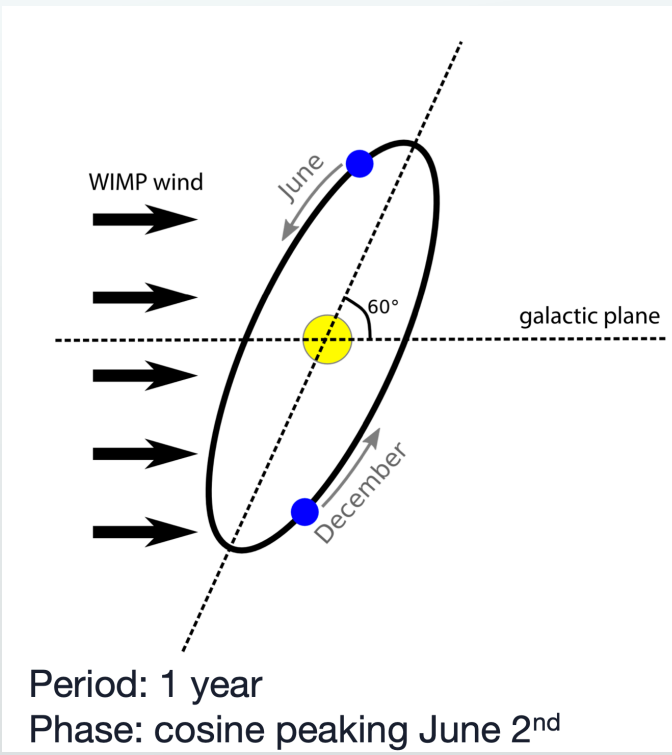
1) Introduction: DAMA/LIBRA

2) NaI Searches

3) COSINUS

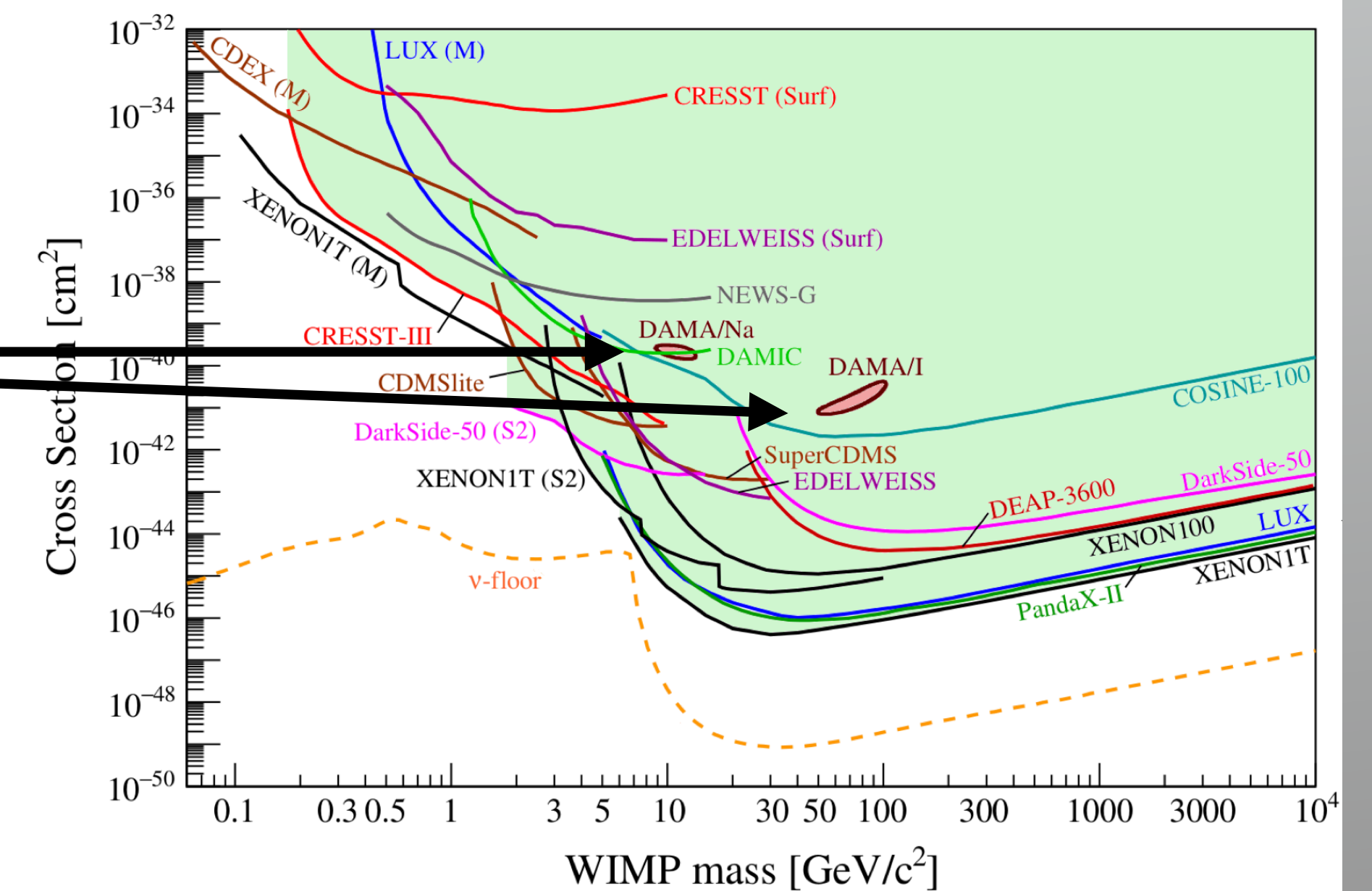
- Working Principle
- Experimental Setup
- Prototype Results
- Time Schedule

DAMA/LIBRA

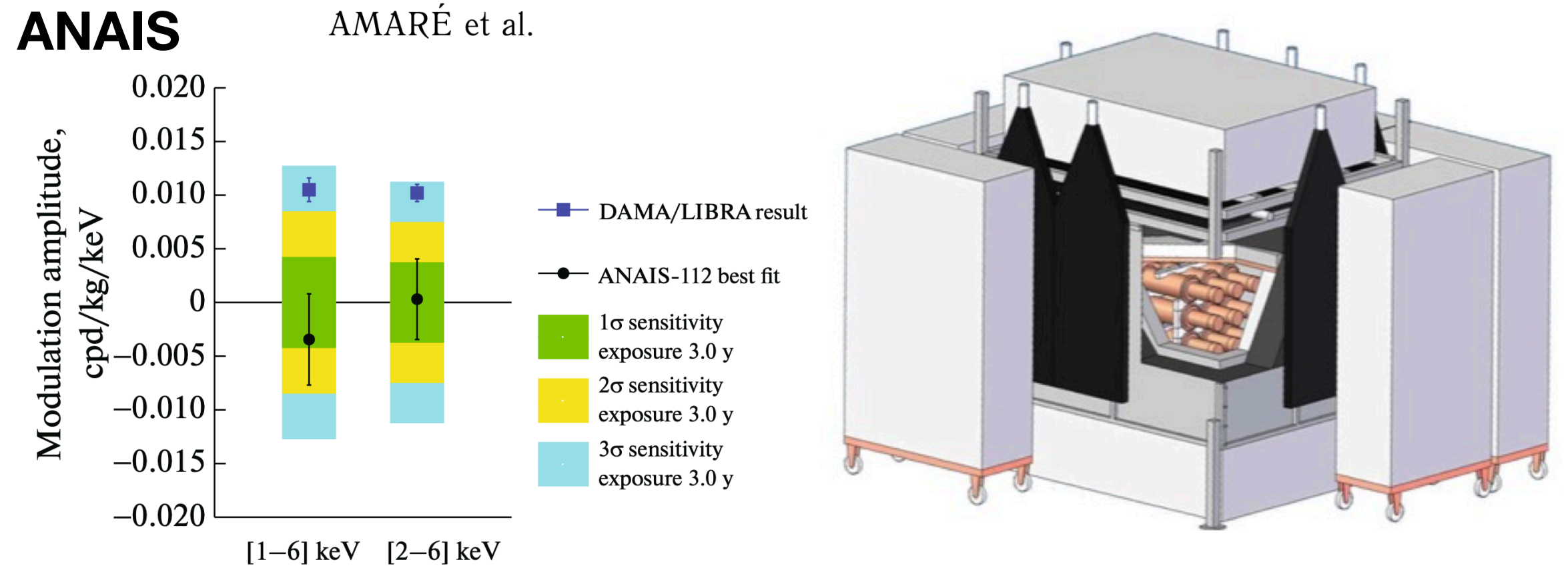


- Modulation measured since ~25y
- Incompatible with other direct DM searches
...with different target materials
...in „standard scenario“

Astroparticle Physics European Consortium APPEC, v1.02



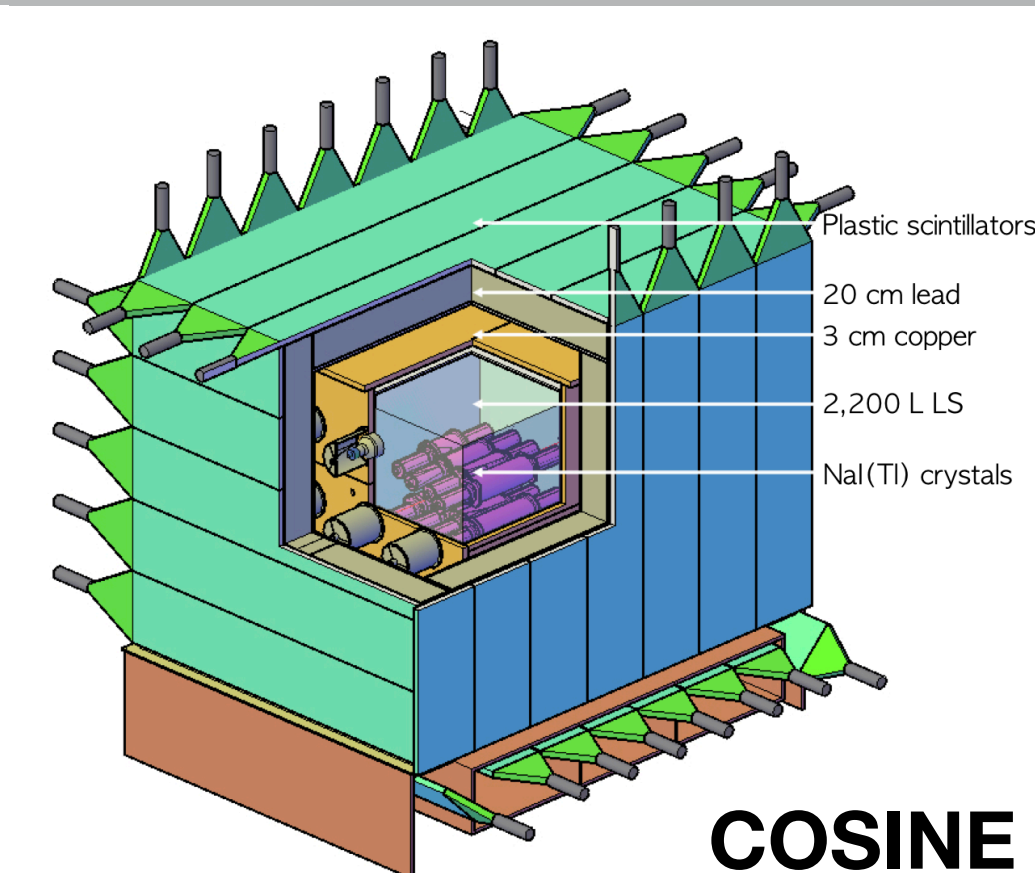
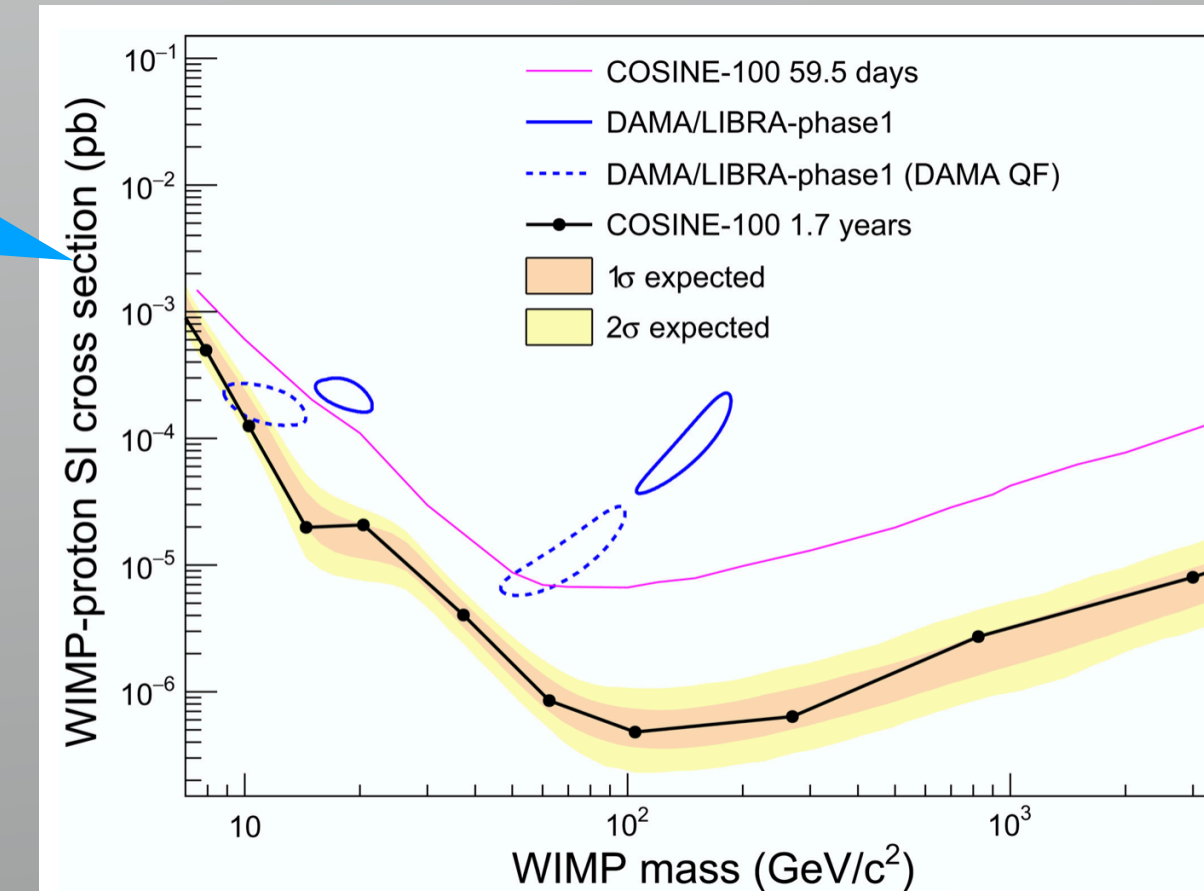
NaI Experiment Landscape



**Increasing effort in the last decade:
Verify/exclude DAMA/LIBRA modulation using SAME material (NaI)**

Caveats:

- Influence of threshold/efficiency
- Location?
- Quenching Factor (QF)

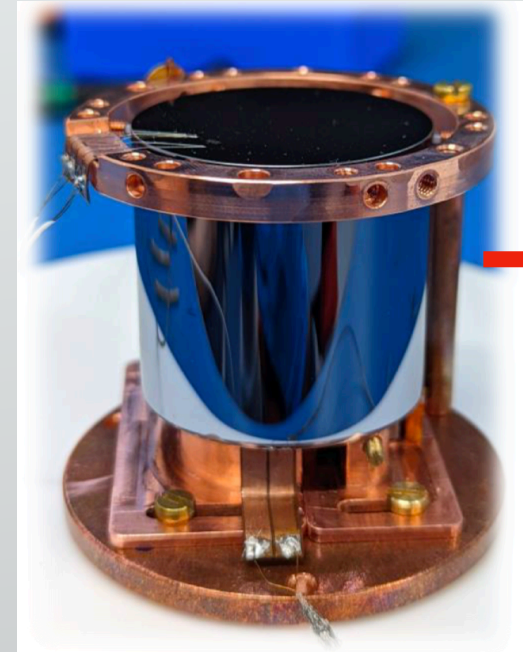
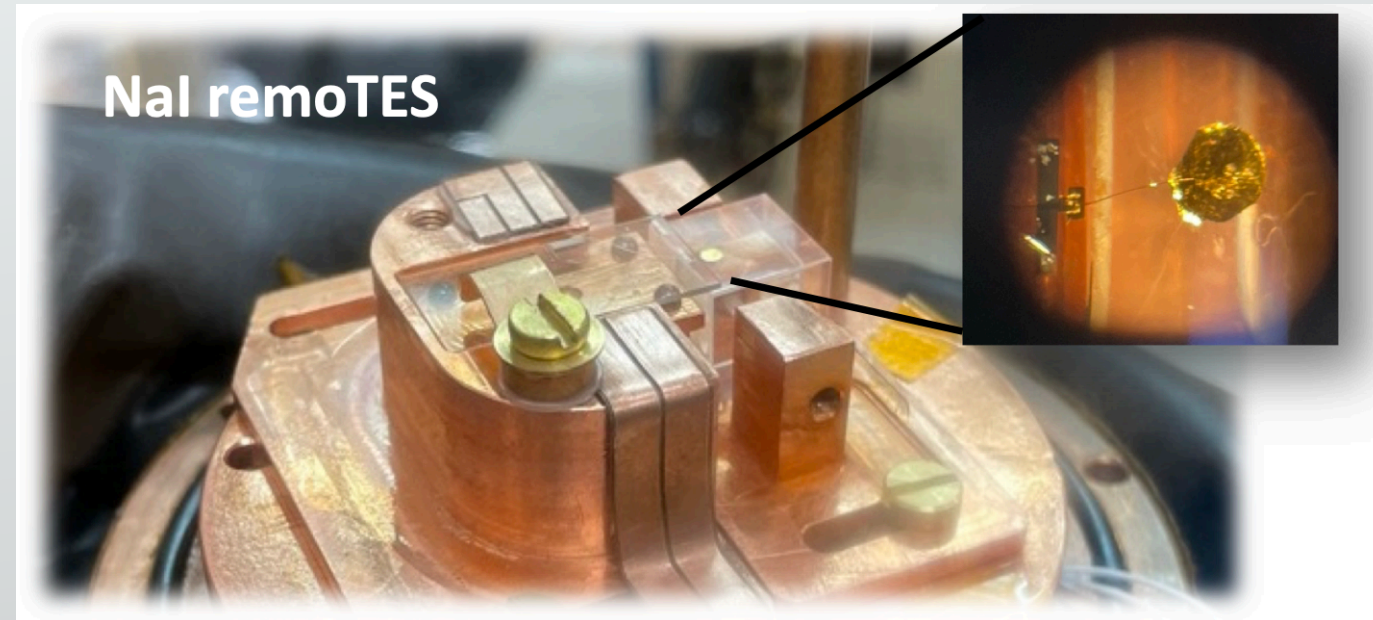


Adhikari, Govinda, et al. "Strong constraints from COSINE-100 on the DAMA dark matter results using the same sodium iodide target." *Science advances* 7.46 (2021): eabk2699.

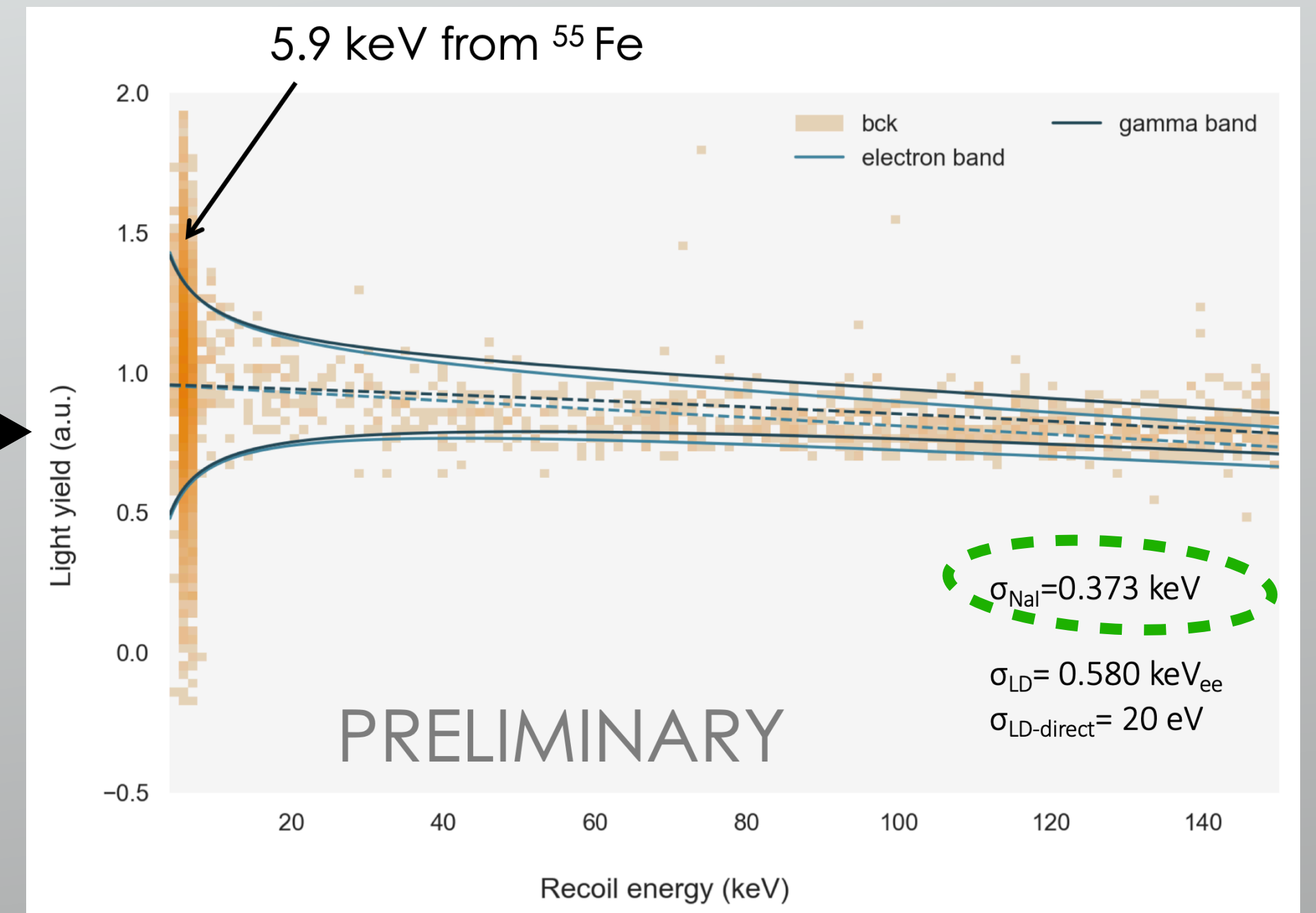
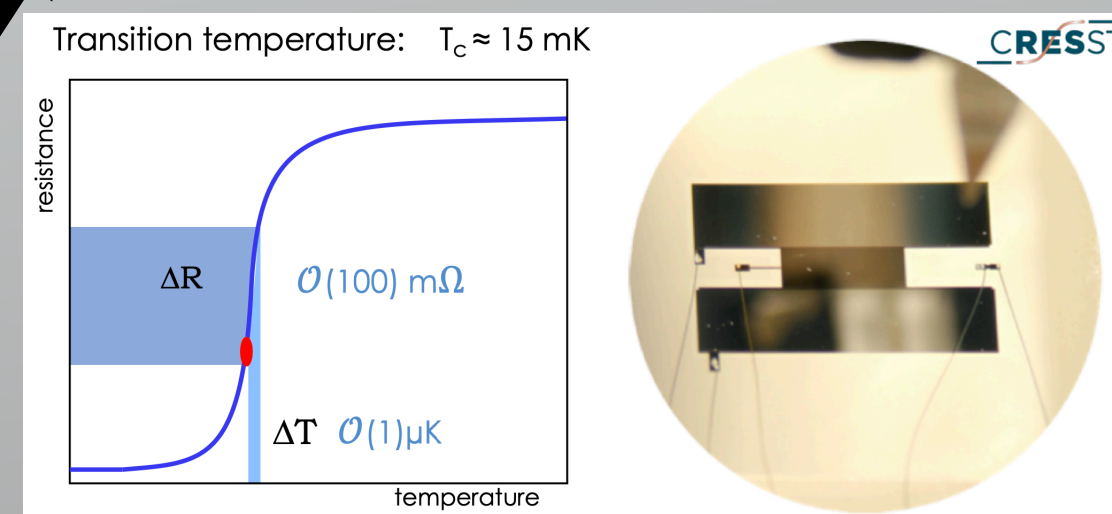
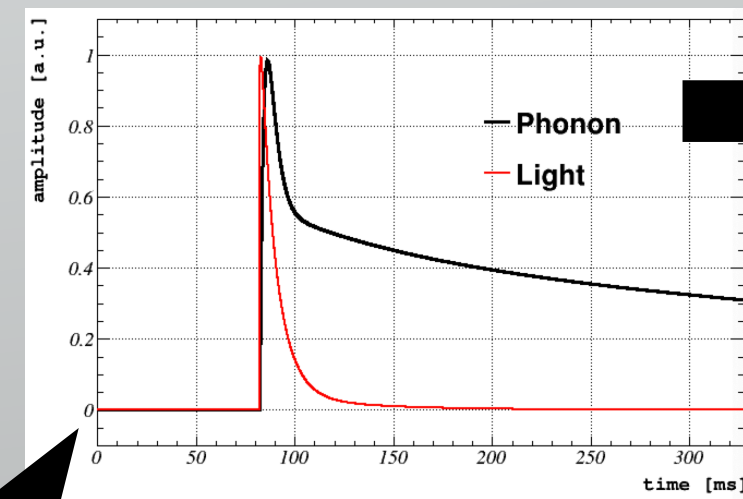
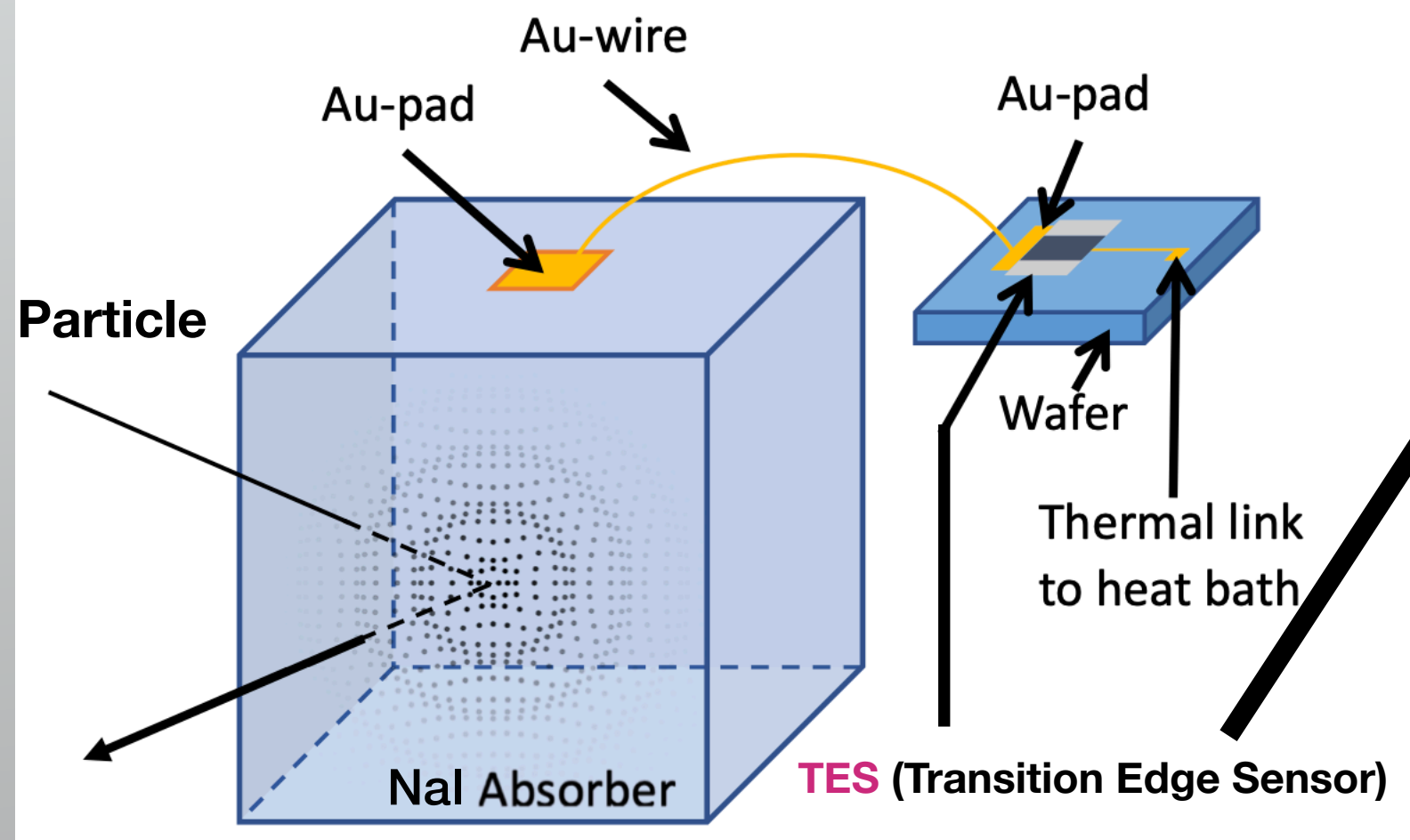
COSINUS

(Cryogenic Observatory for Signals seen in Next-generation Underground Searches)

Idea: Measure nuclear recoil energy directly instead of electron-equivalent (=scintillation light) only.

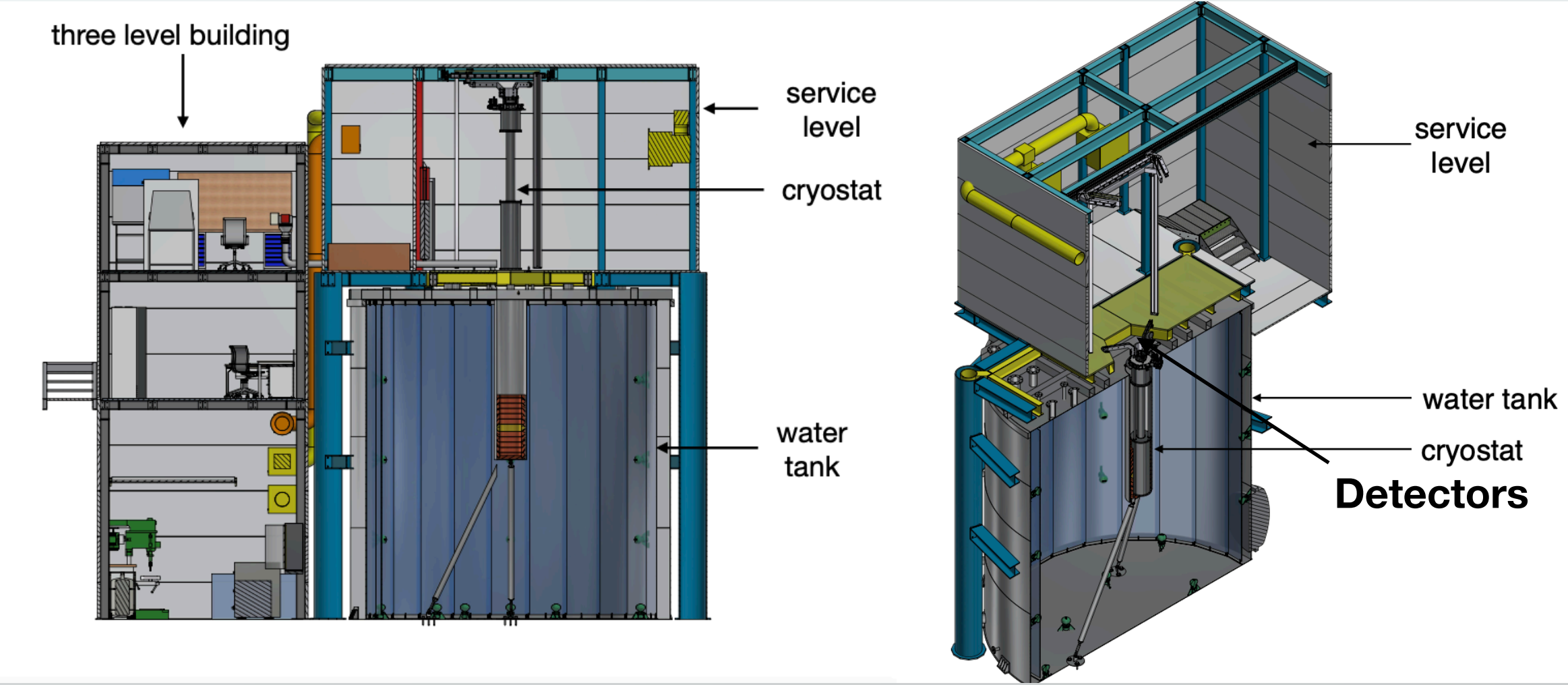


Angloher, G., et al. "First measurements of remoTES cryogenic calorimeters: easy-to-fabricate particle detectors for a wide choice of target materials." *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment* 1045 (2023): 167532.

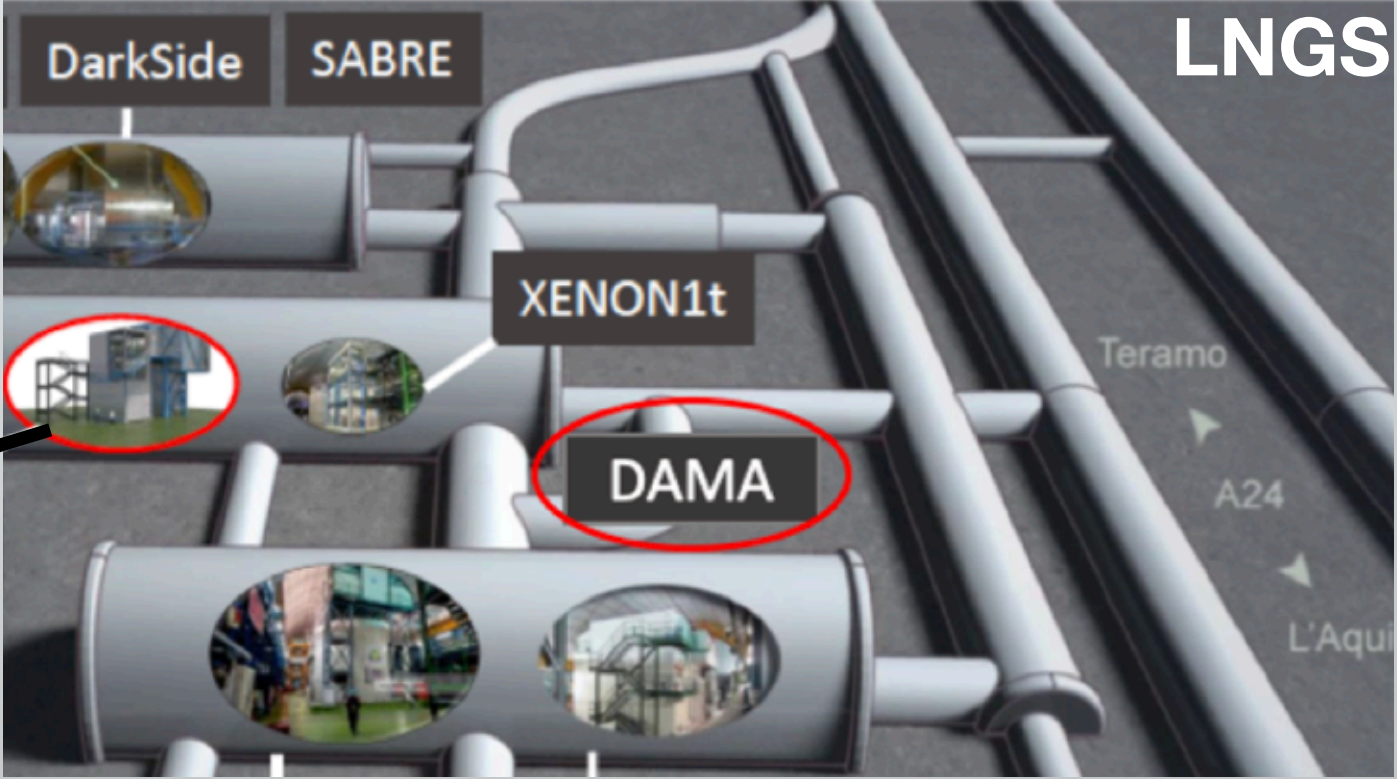


- NaI as calorimeter -> heat signal read out by TES sensor; technology from CRESST
- Additional Si beaker to detect scintillation light -> second channel for particle discrimination
- High-purity NaI crystals produced by SICCAS
- Test both NaI and NaI(Tl) crystals

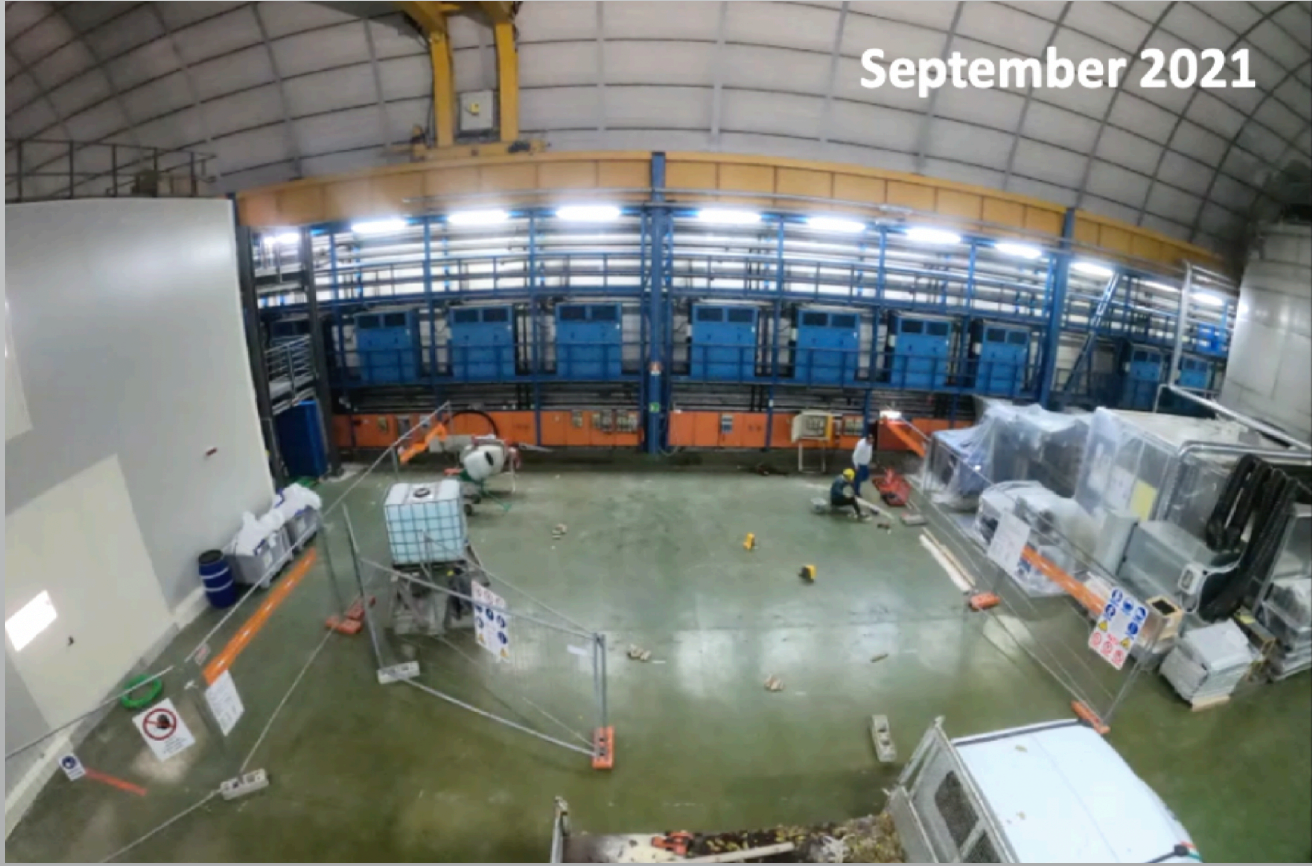
Experimental Setup



COSINUS



- Access to cryostat from the top level (cleanroom)
- Adjacent building for controls & maintenance

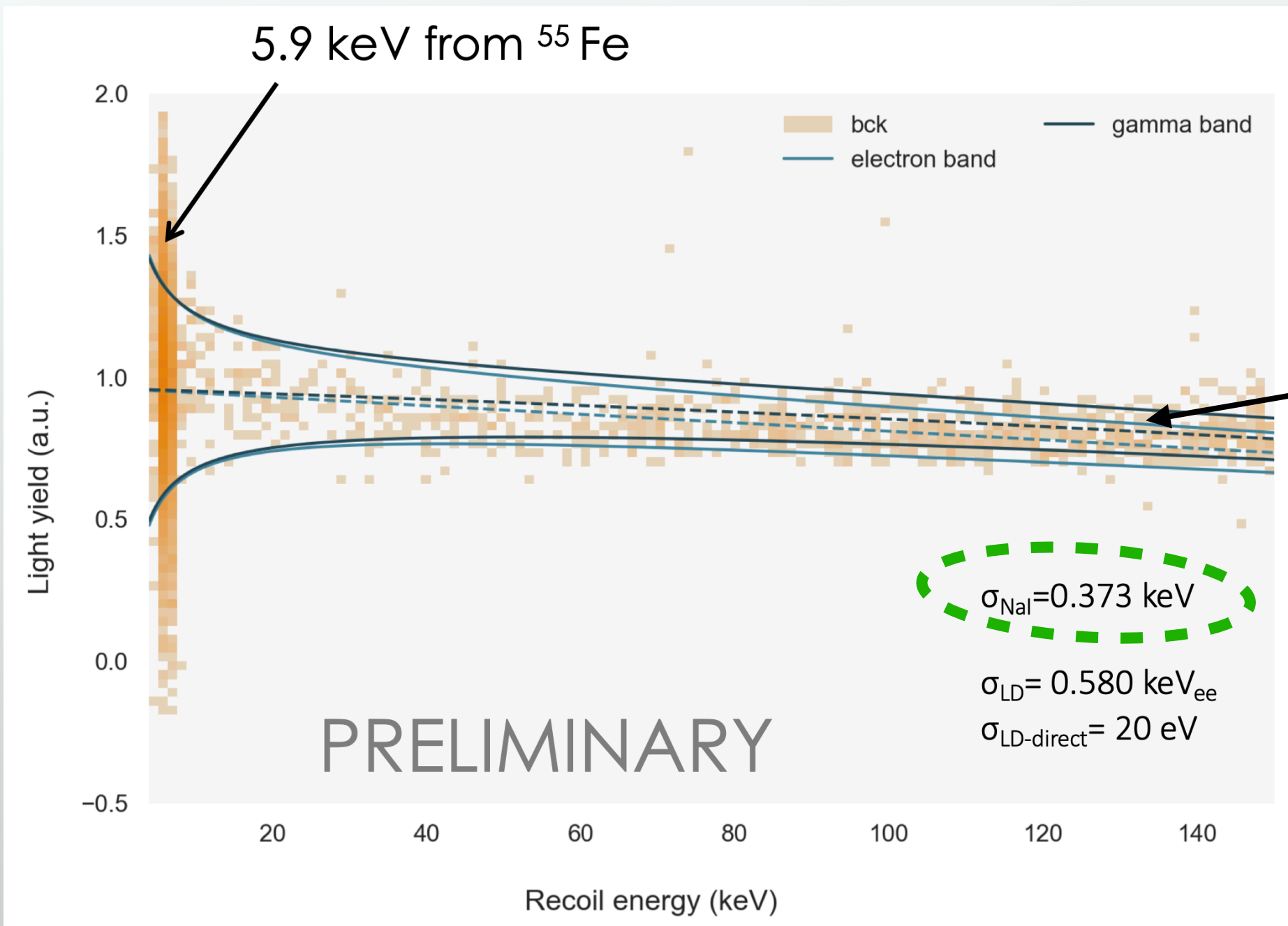


- Planned: 10 detectors à ~100g NaI = 1kg target
- Detectors operated in dry (!) dilution cryostat
- Surrounded by Cu shielding
- Additional Cherenkov veto (water tank & PMTs)



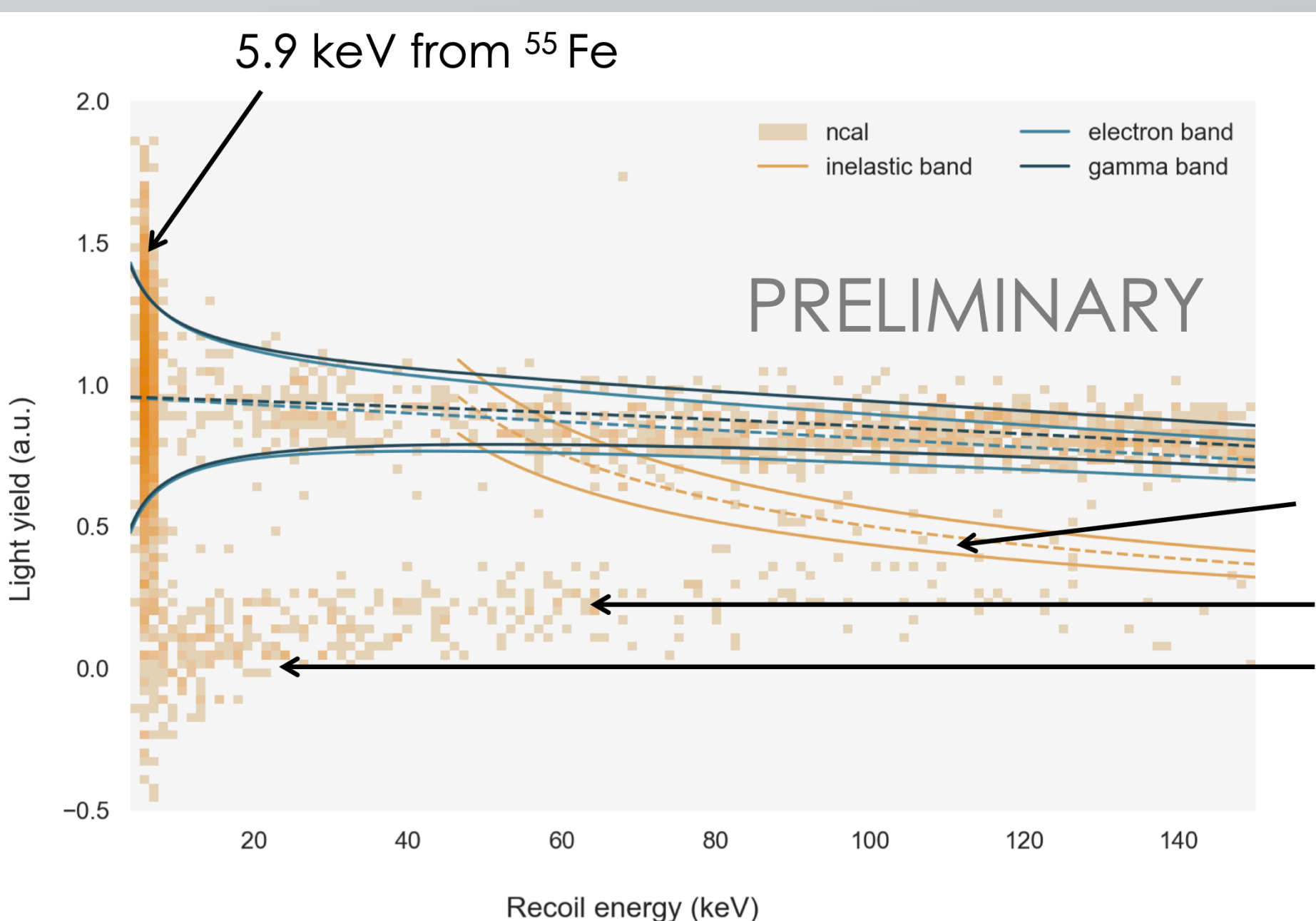
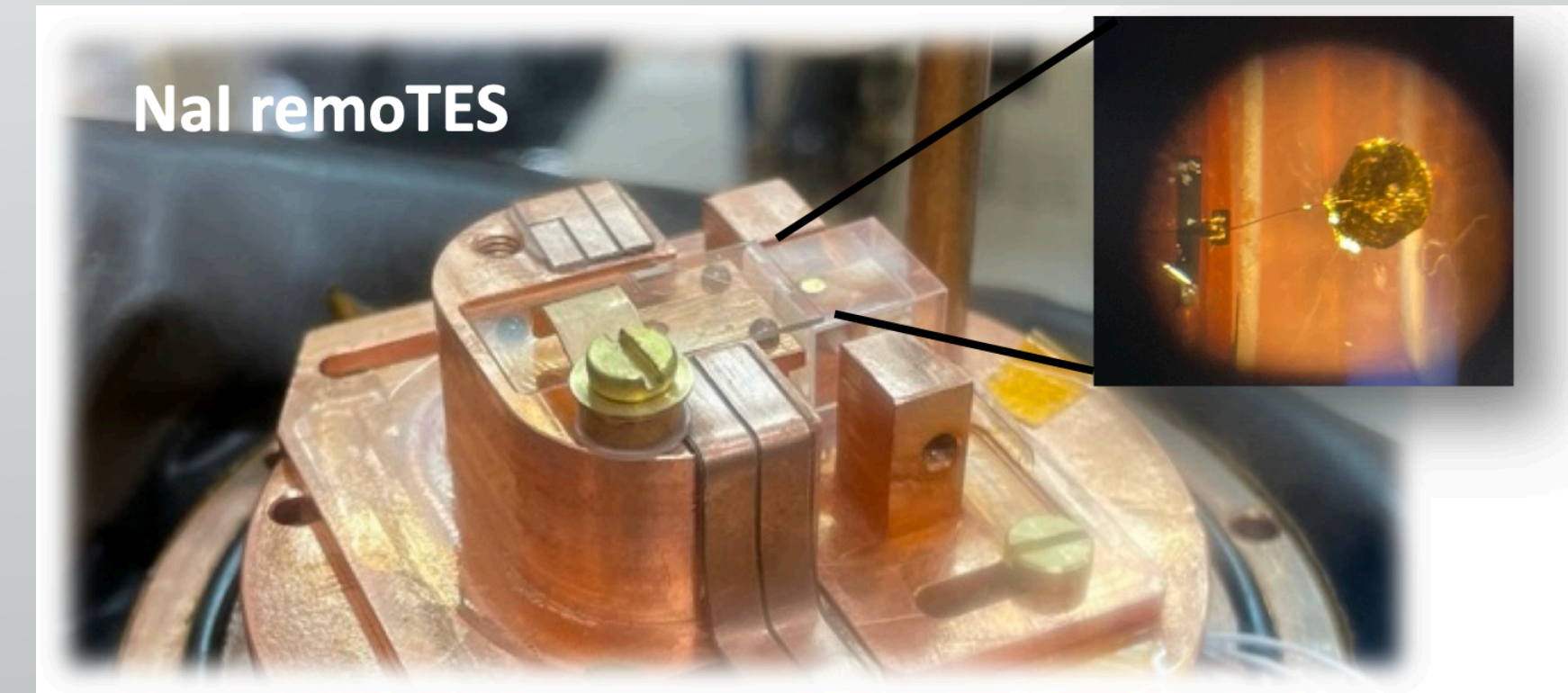
Prototype Results

Measurement: June 2022



Background: 136h

e/gamma background

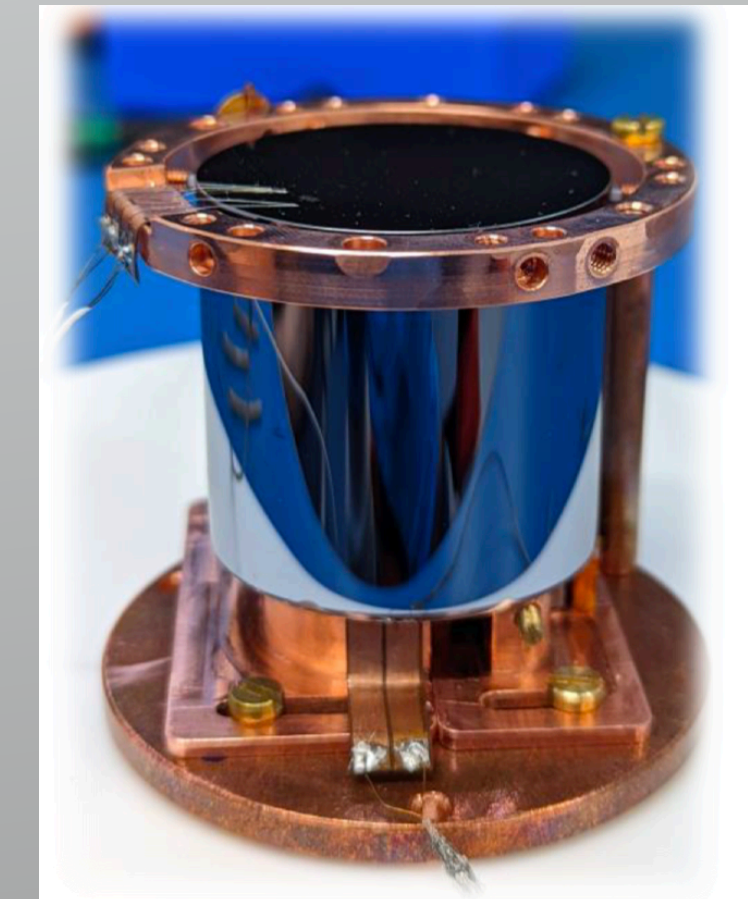


AmBe neutron calibration: 26h

events due to inelastic scattering

Na recoil events (elastic scattering)

I recoil events (elastic scattering)



(with Si beaker)

Particle Identification in NaI-based detector.



Roadmap

COSINUS – 1 π (2022-2025)

exclude or confirm nuclear recoil
origin of DAMA:

- independent of DM halo
- for any interaction of DM with nuclei

COSINUS – 2 π (\geq 2025)

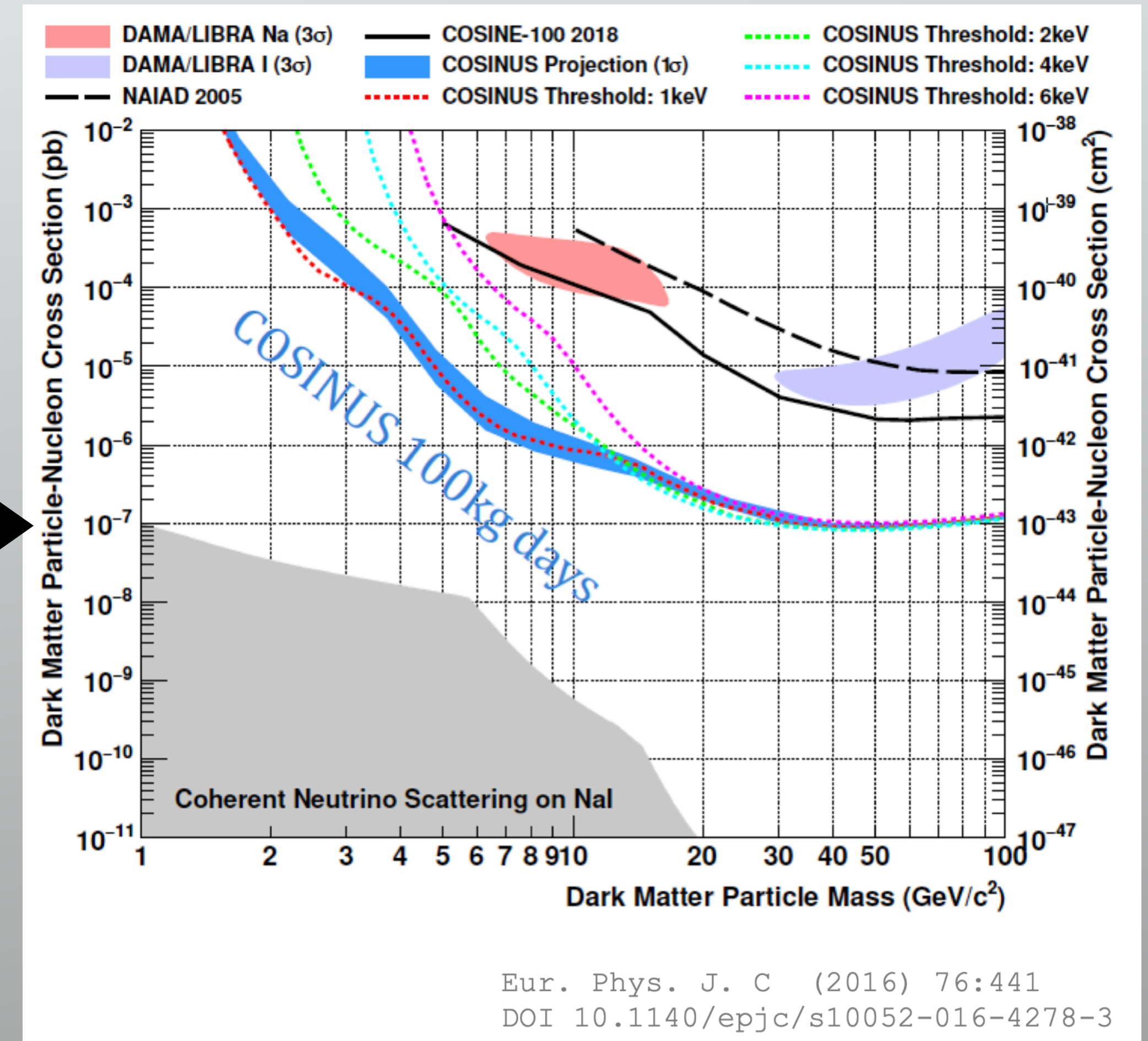
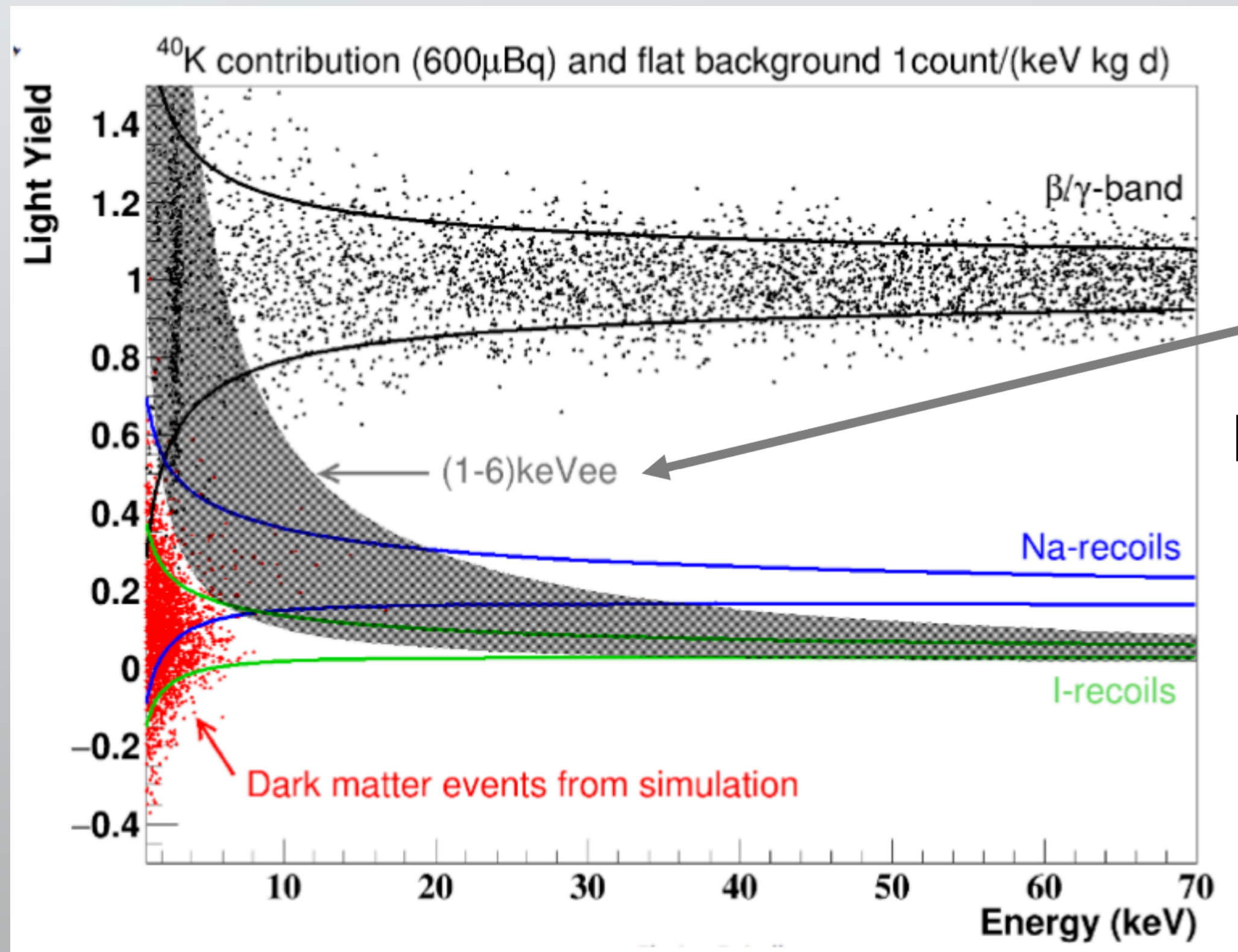
Investigate annual modulation
signature with COSINUS

- **First results expected for 2024**
- **Low exposure (= short time) needed to crosscheck DAMA/LIBRA**
- **COSINUS measures absolute rate -> no rate=no modulation**

Physics Reach

Signal in DAMA/LIBRA in $(1-6) \text{ keV}_{ee}$,
 Location in the plot depends on the nature of the signal (!)

(Simulation)



Eur. Phys. J. C (2016) 76:441
 DOI 10.1140/epjc/s10052-016-4278-3

Summary

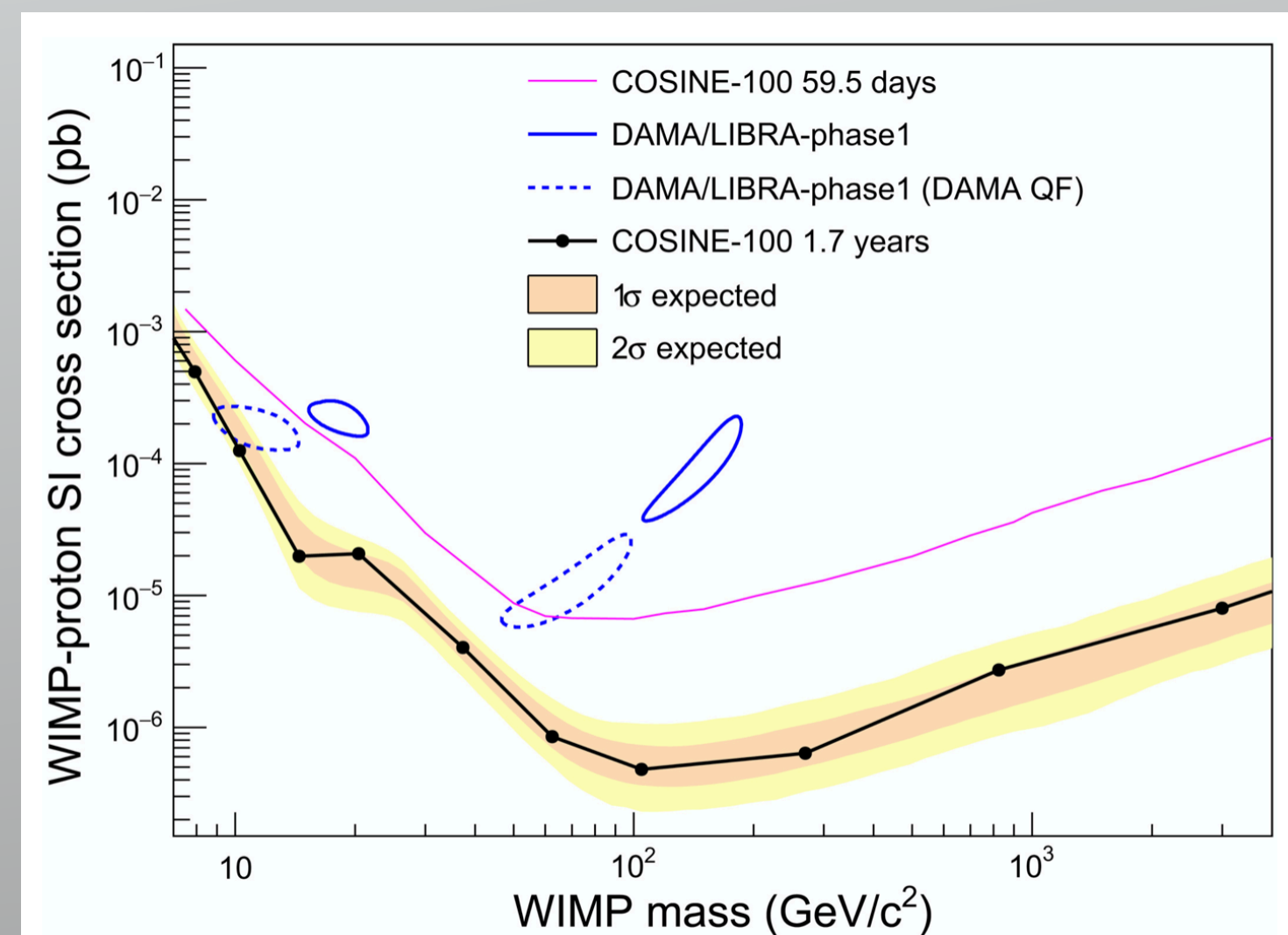
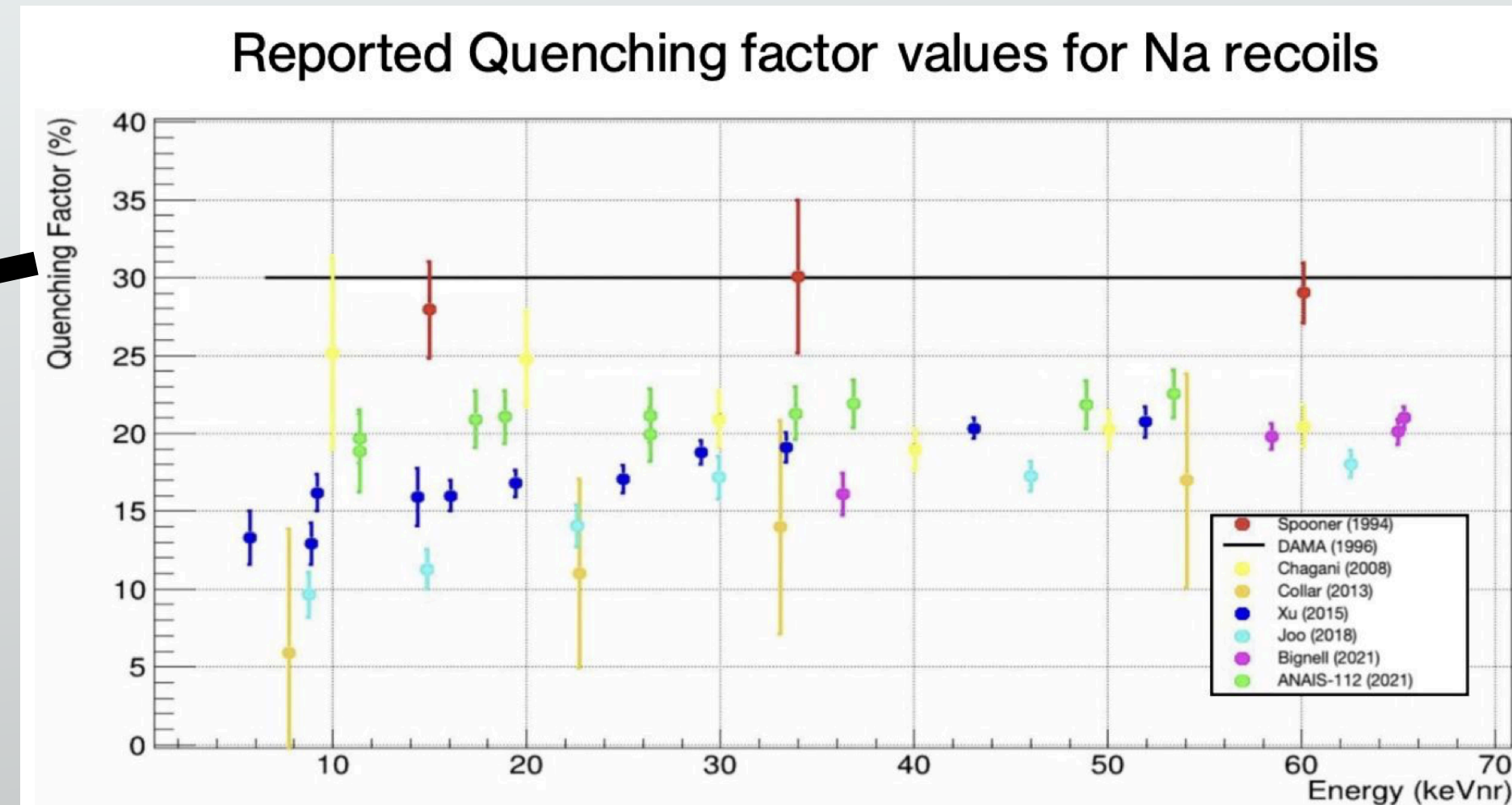
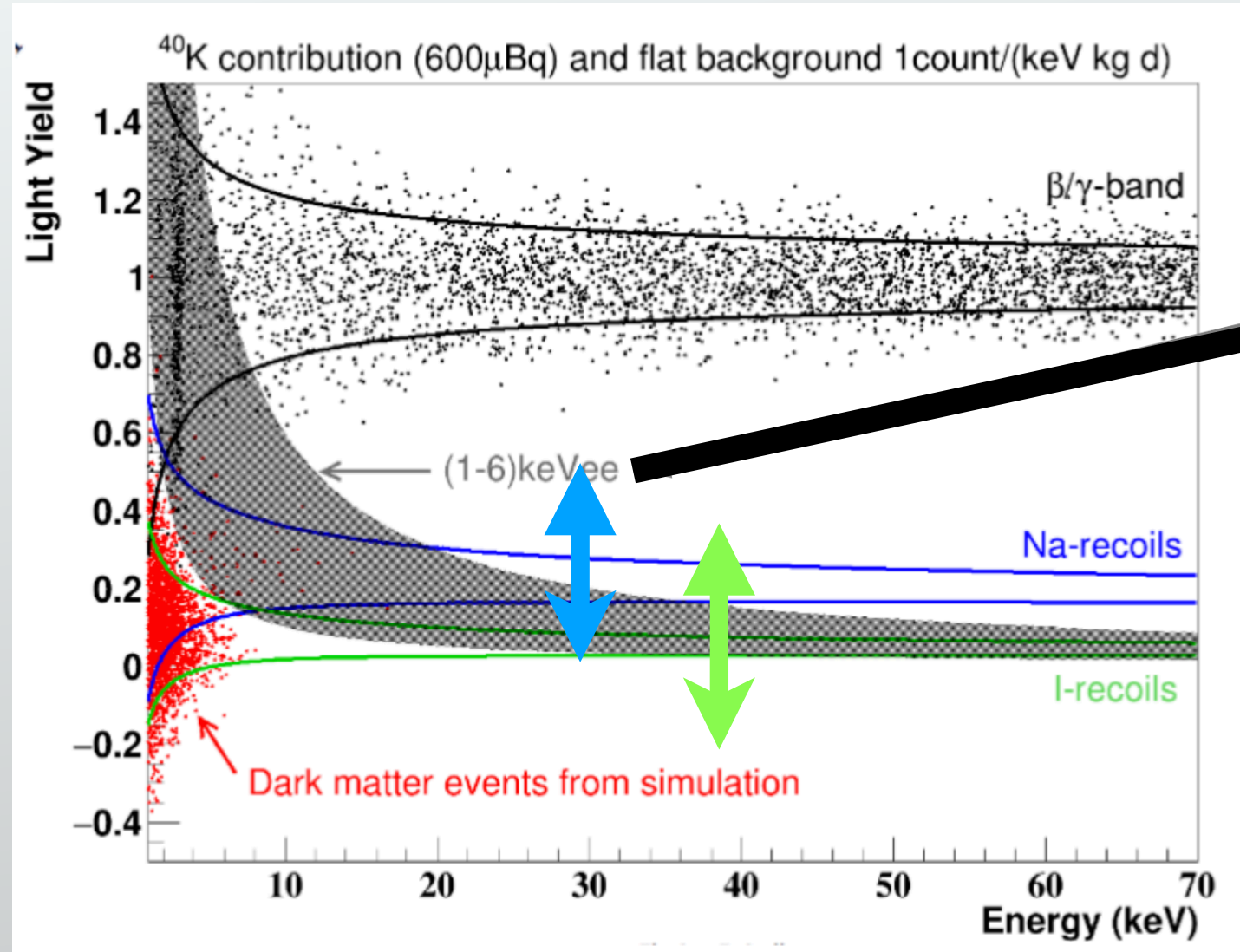
April 2022

- Several attempts in recent years to study DAMA/LIBRA signal using NaI targets
- So far, COSINUS is the only experiment featuring a measurement of the nuclear recoil energy in addition to the scintillation light
- Systematic uncertainties such as QF remain a topic of discussion and need to be studied in detail -> COSINUS is uniquely suited to answer these questions
- Particle discrimination in NaI calorimeters proven in prototypes
- Modern cryogenic facility at LNGS under construction
- First results from full setup expected for 2024.

K. Schäffner

... thank you for your attention!

Quenching Factors



Adhikari, Govinda, et al. "Strong constraints from COSINE-100 on the DAMA dark matter results using the same sodium iodide target." *Science advances* 7.46 (2021): eabk2699.

n Beam measurement of COSINUS crystals at TUNL



... analysis not finished yet