TECHNISCHE UNIVERSITÄT WIEN

MARIETTA BLAU INSTITUTE FOR PARTICLE PHYSICS

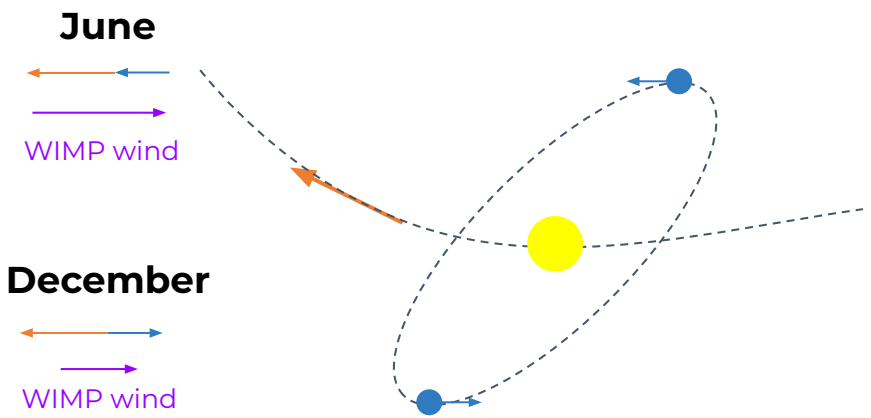
The COSINUS Experiment at LNGS
Commissioning and Start of the first Phase

Mariano Cababie

TU Wien / Marietta Blau Institute for Particle Physics
at Identification of Dark Matter: 1-5 June, 2026, Zaragoza, Spain

→ Movement of Earth respect to DM wind should lead to an annual modulation of the DM signal.

Based on arXiv:2003.04545



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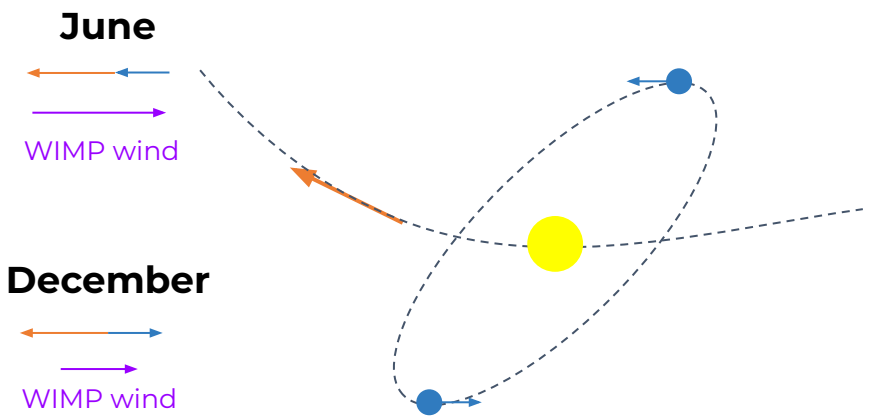

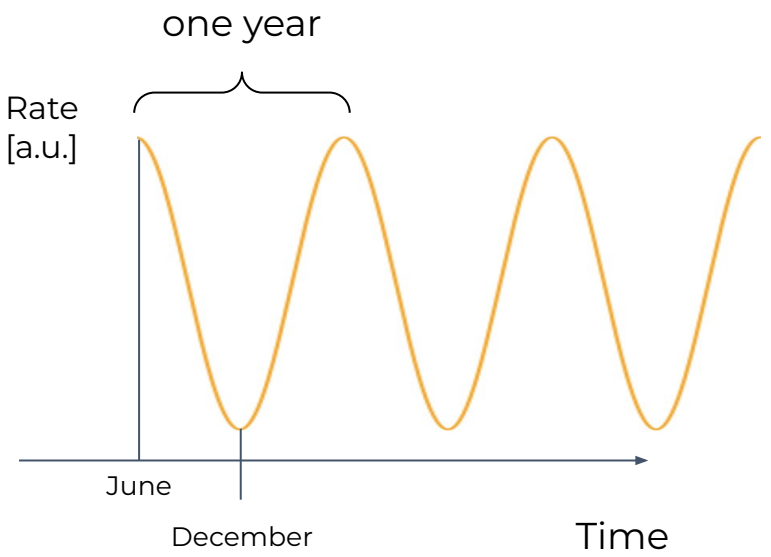

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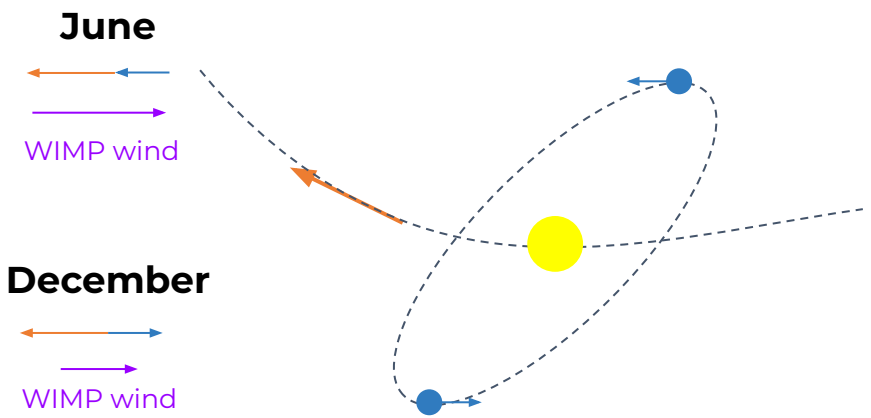
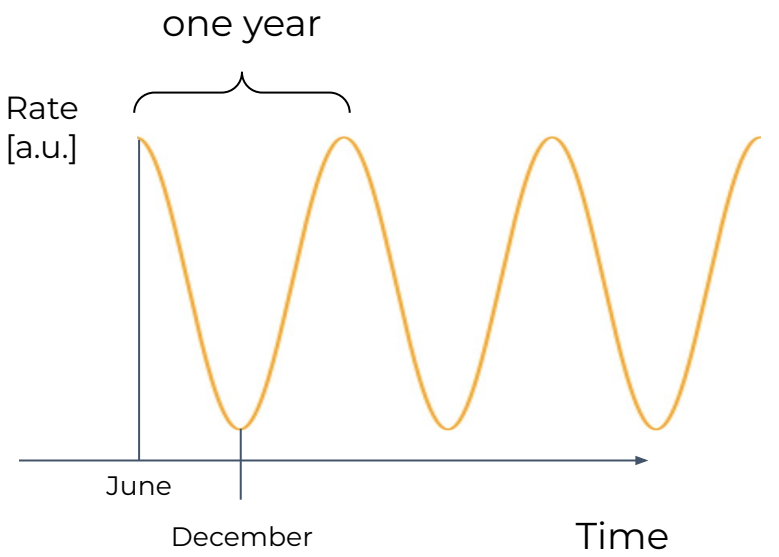
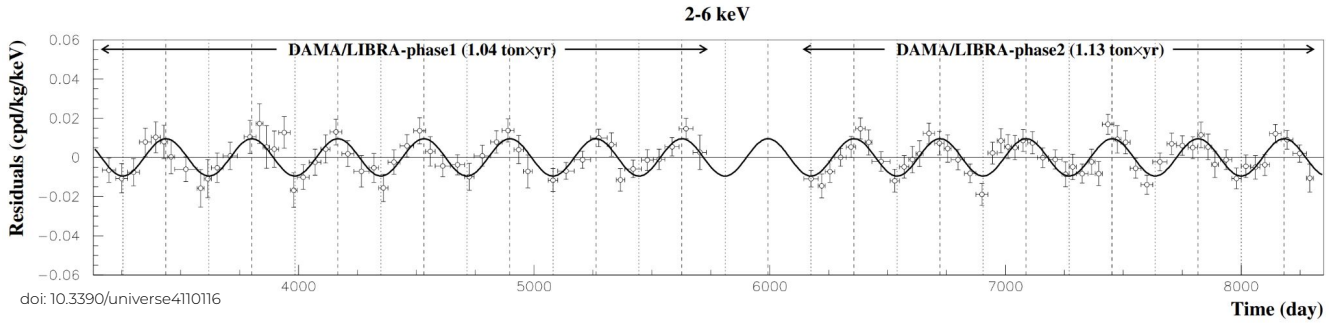




→ DAMA/LIBRA reports an annual modulation with a **13.7σ** significance.



doi: 10.3390/universe4110116

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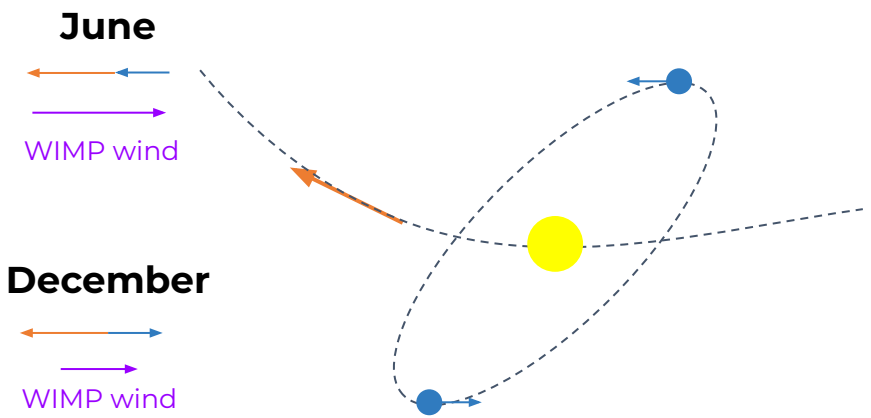

What about that new "DAMA" experiment?

Participants in the International Conference on the Identification of Dark Matter
Sheffield, 8–12 September, 1996

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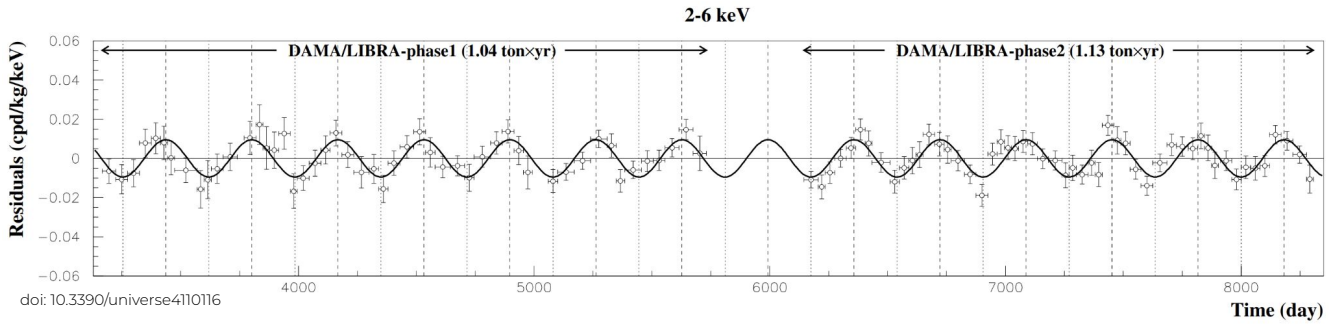

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→ Multiple experiments (COSINE, ANAIS, SABRE, PICOLON, DM-Ice, see last session) utilize the same material (NaI) and detector technique (scintillation light measurement) to either replicate or refute the DAMA/LIBRA claim

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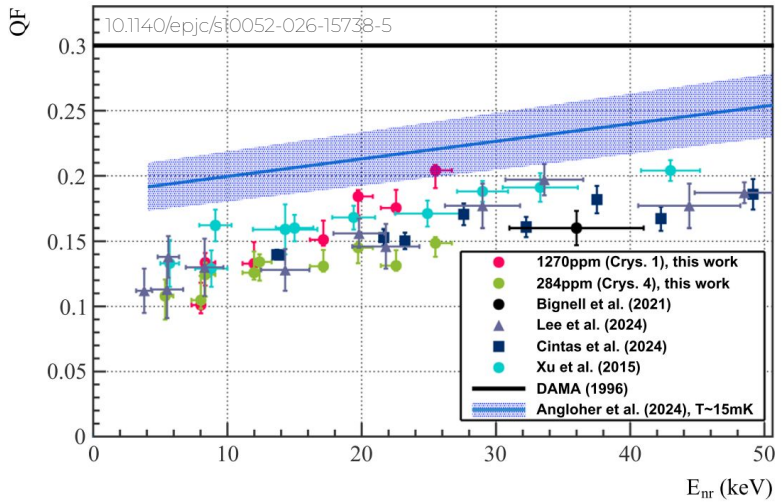
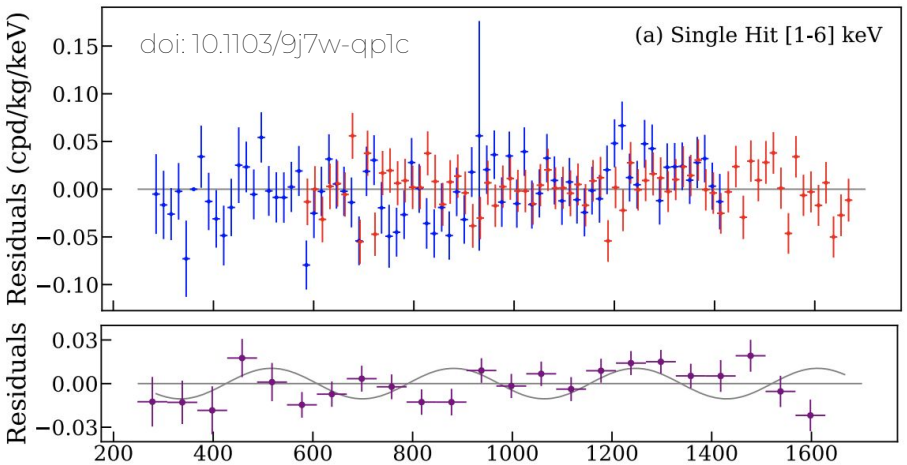
→ However, by doing this, their risk running into unavoidable systematics and/or modeling:



Quenching factor



Background modeling

What about COSINUS?

Cryogenic Observatory for SIgnatures seen in the Next-generation Underground Searches

Two (2) channels of detection!
Phonons (heat) and photons (light)

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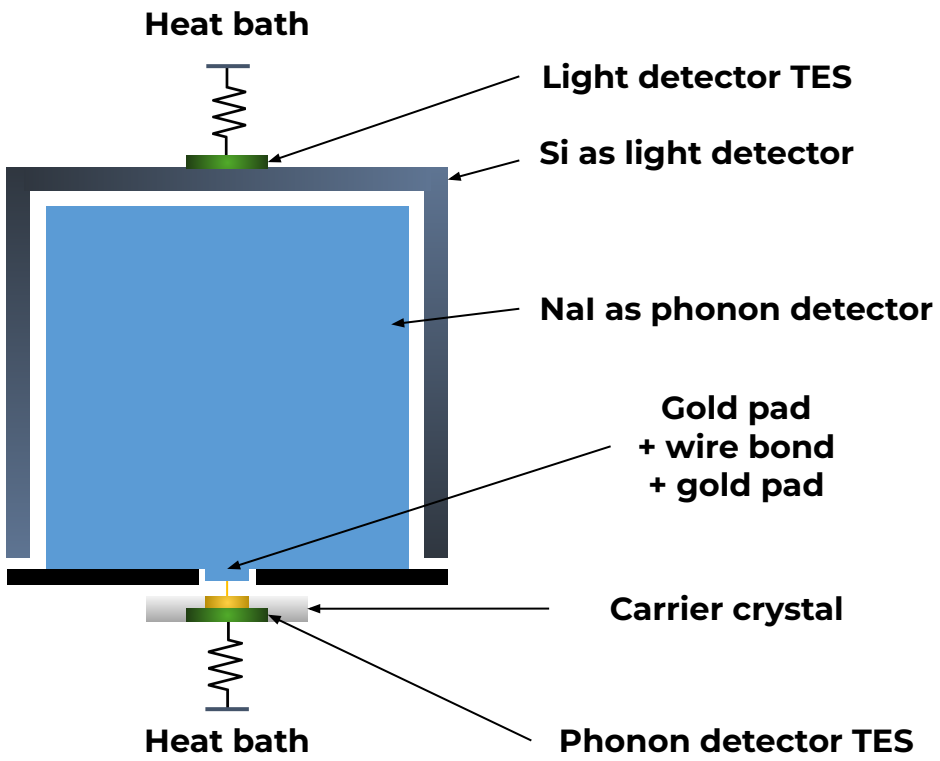

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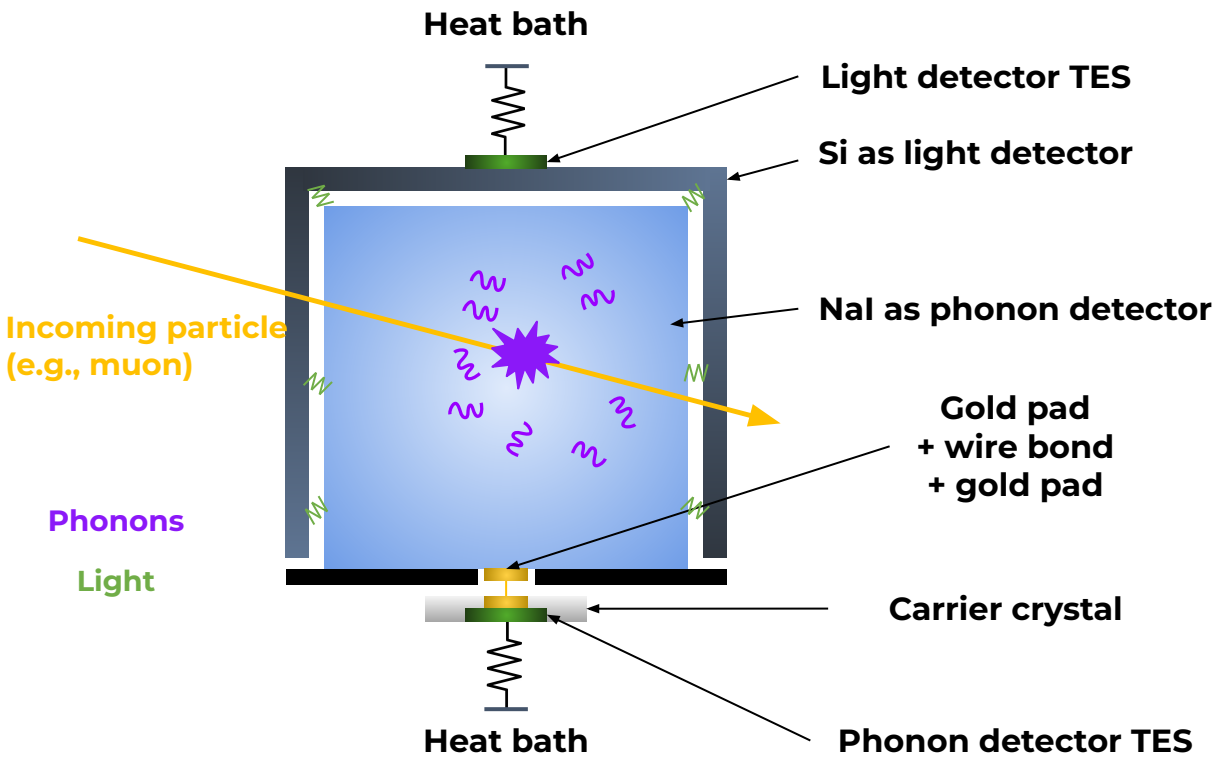

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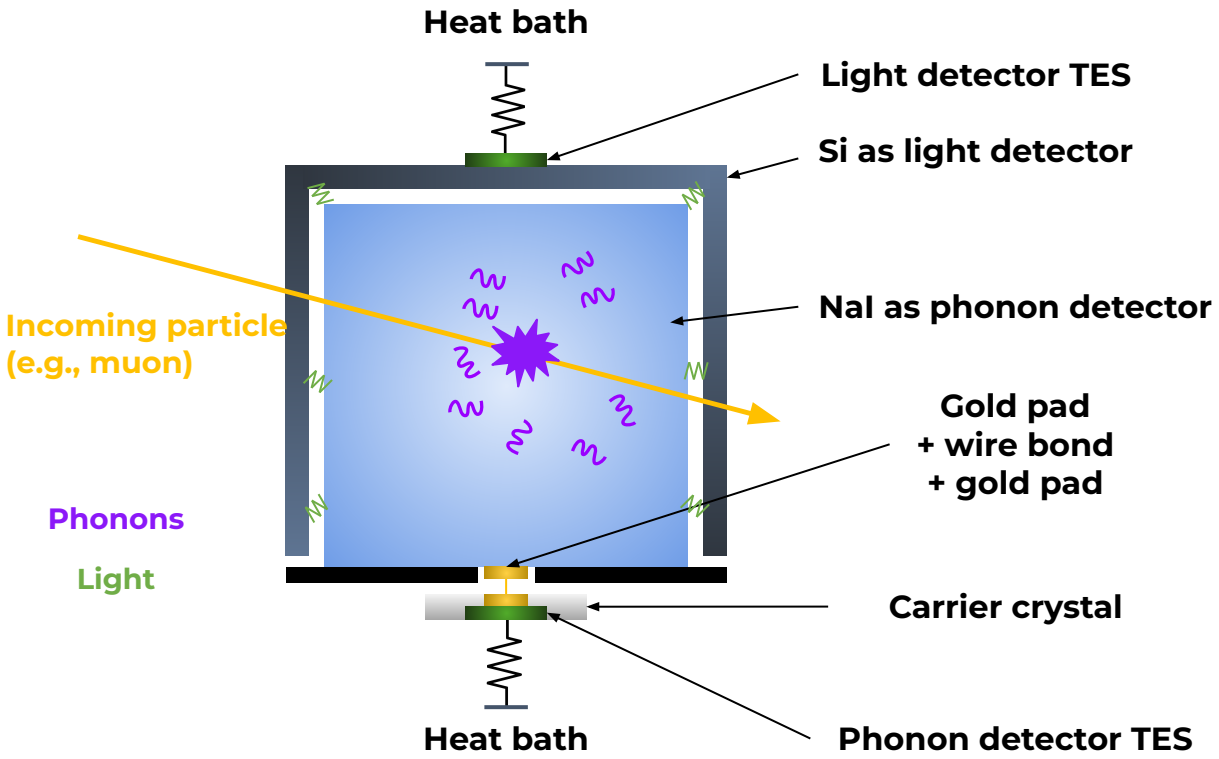
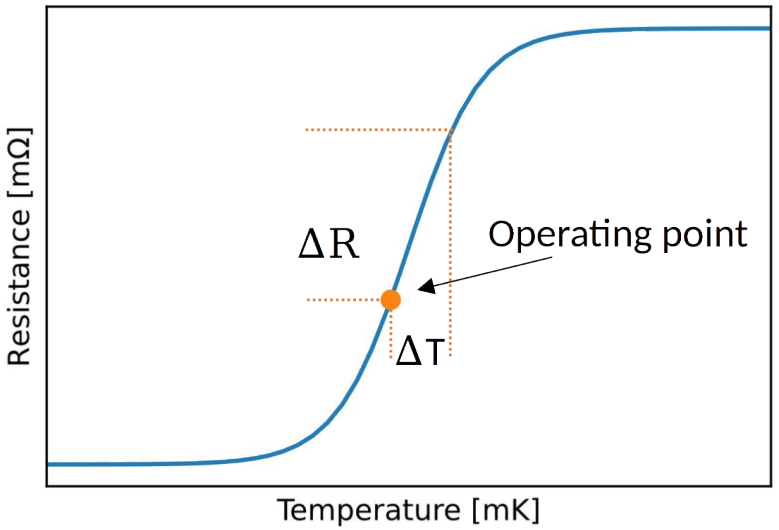


Transition Edge Sensors



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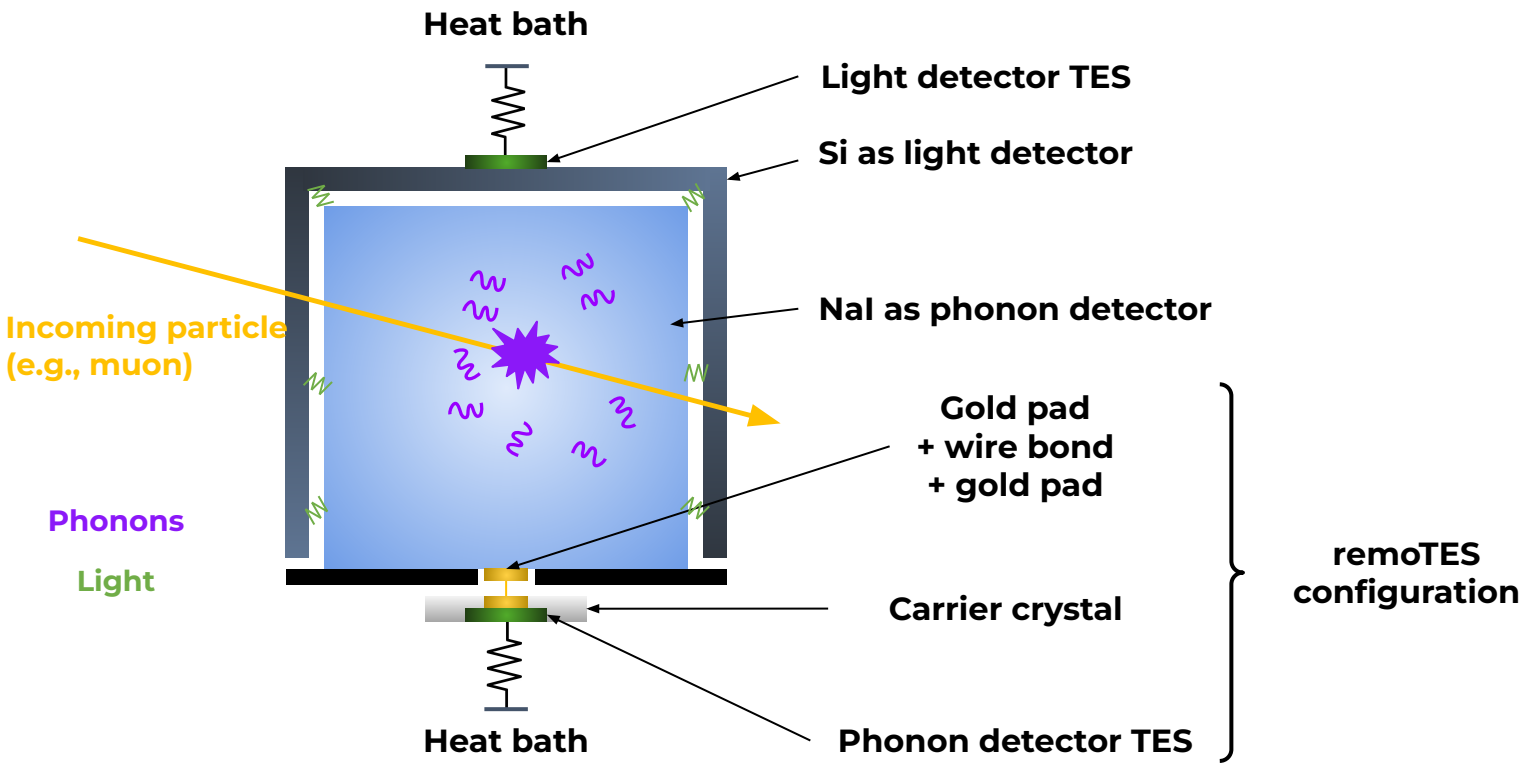

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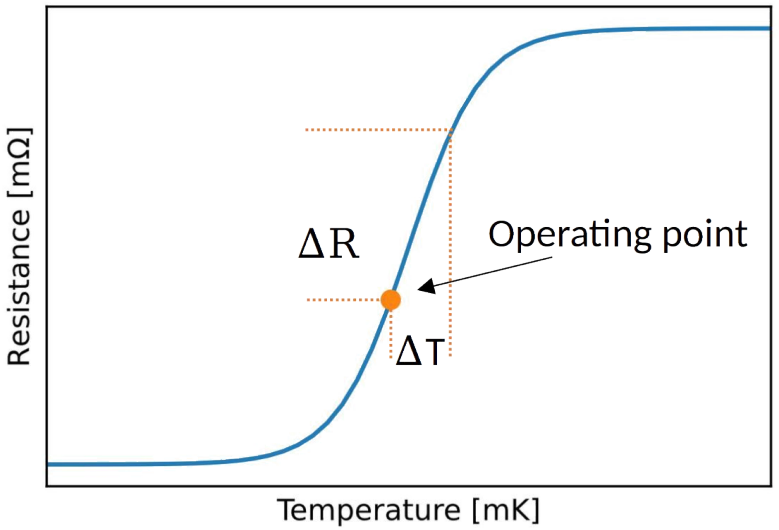

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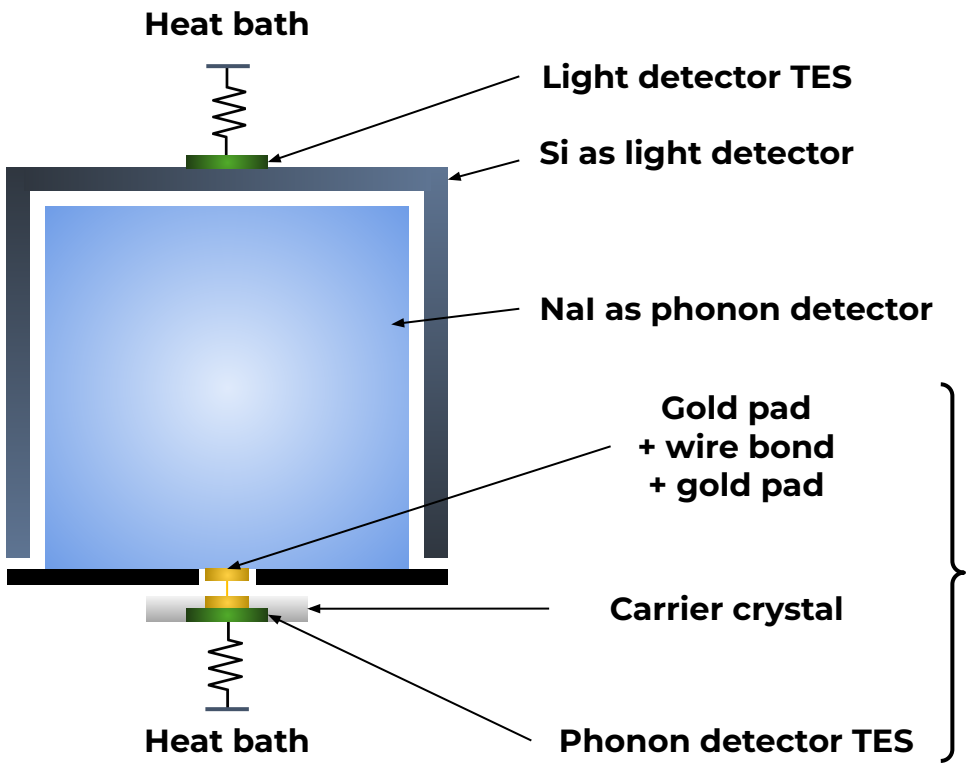
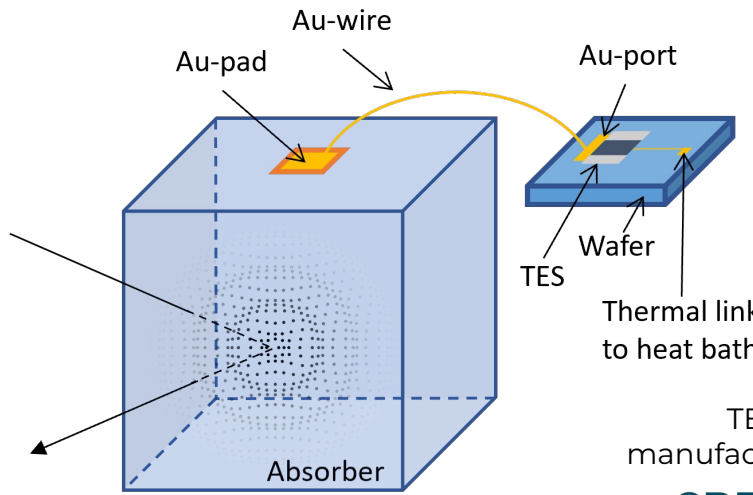
NIM A 1045, 167532



→ NaI is highly **higroscopic**, **soft** and has a **low-melting point**!



TES manufactured by CRESST

RemoTES is a **key technology** enabler!

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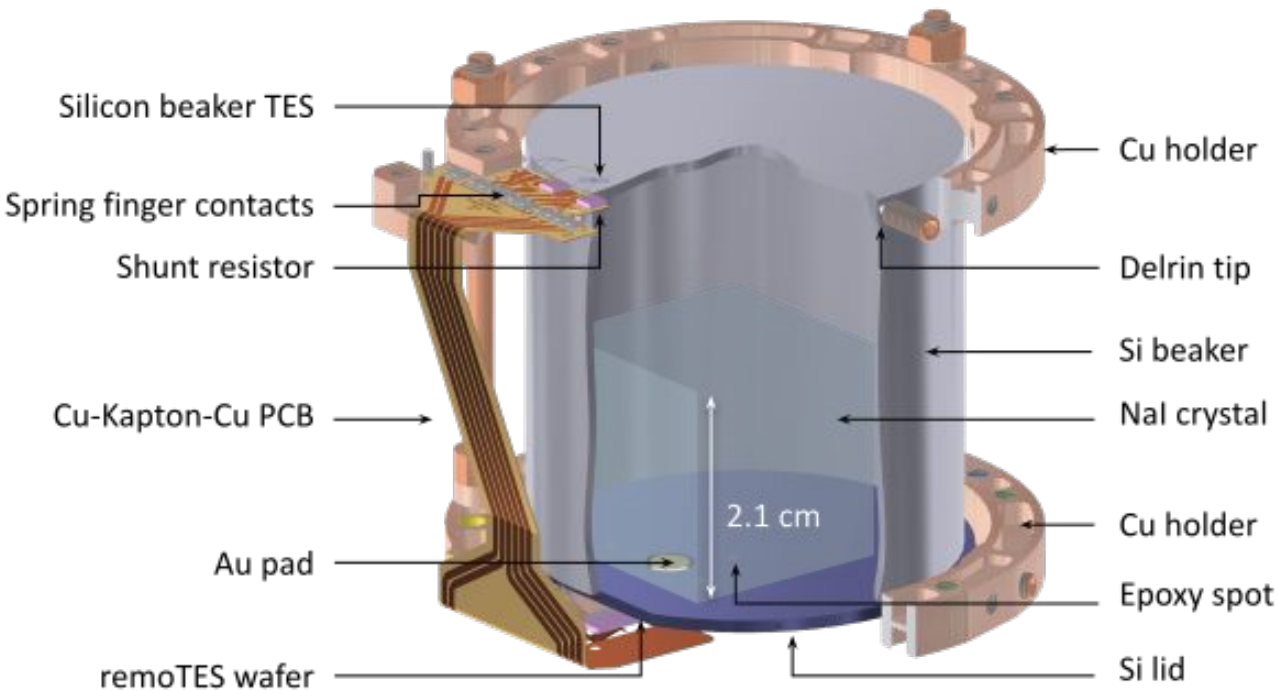

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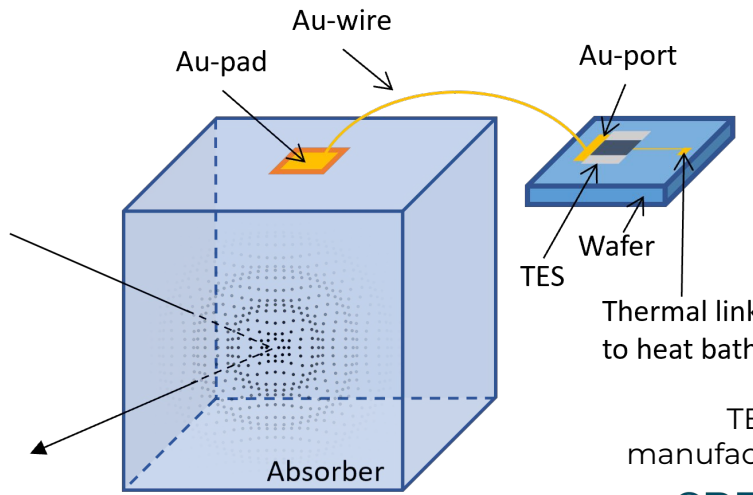

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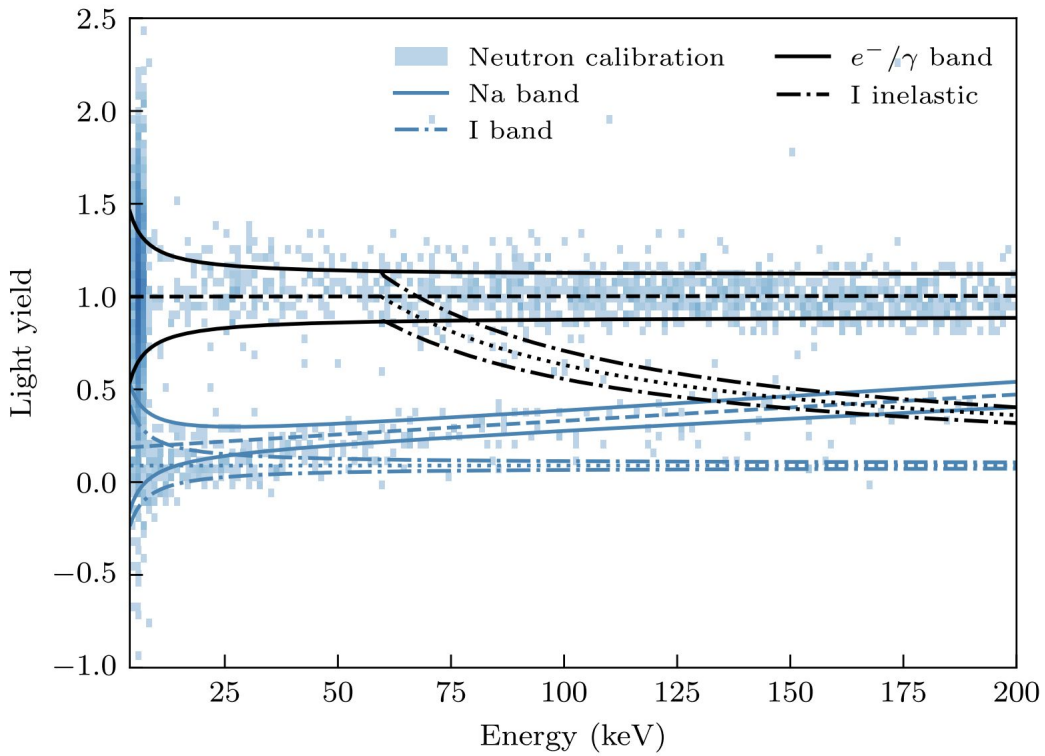
$$LY = \frac{E_{light}}{E_{phonon}}$$



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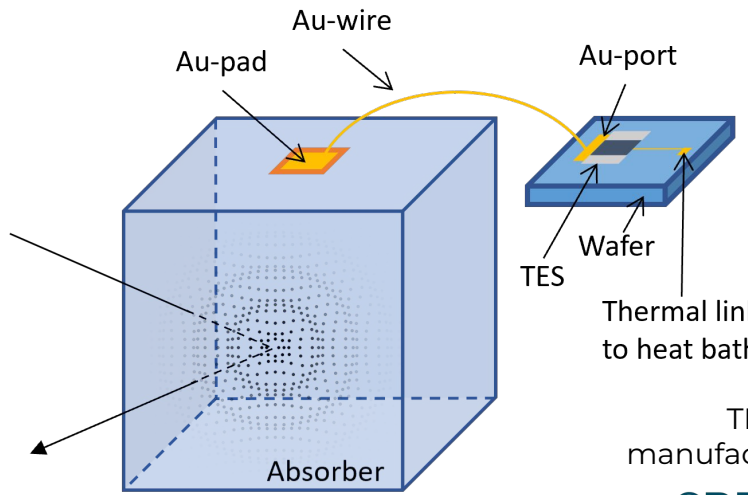

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What about COSINUS?

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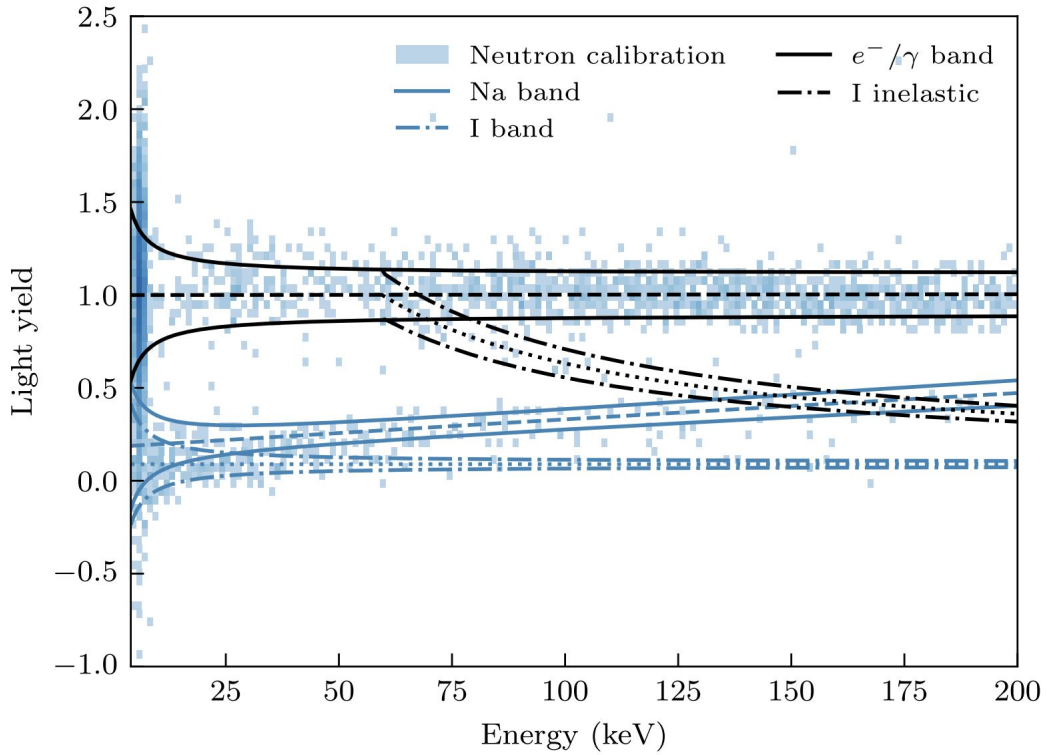
10.1103/PhysRevD.110.043010



→ **We can do it in-situ via neutron irradiation!**

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→ **Interaction channel:** by measuring both phonon and light signals, COSINUS can discriminate the interaction channel of the event, i.e. whether it arises from nuclear or electron-recoils.

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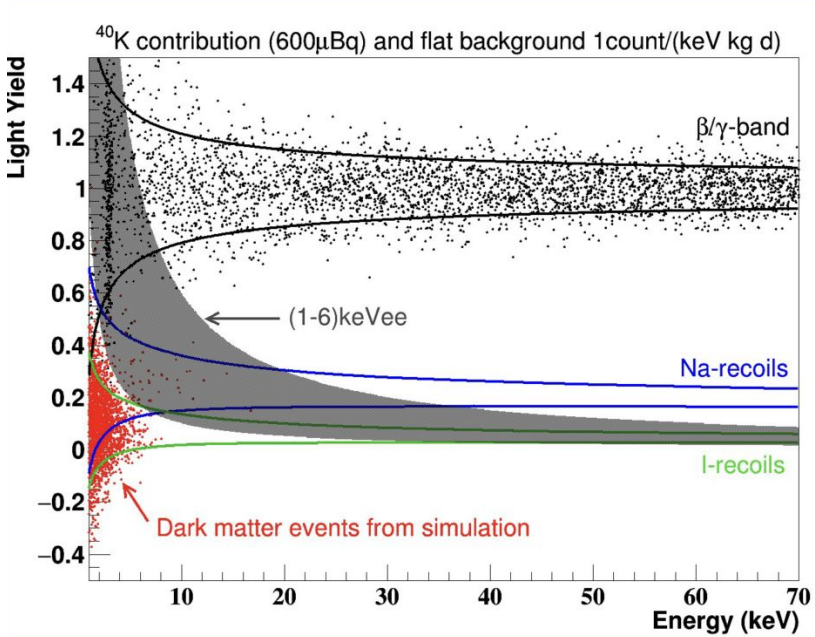
- **Around 75-85% of the interaction signal stays in the phonon channel!**



https://www.cosinus.it/detection-principle/

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→ Measure **total rate** (instead of modulated rate): total energy reconstruction allows for lower thresholds and thus higher sensitivity to the DAMA/LIBRA claim, enabling the use of total rates. This reduces reliance on **modulation analyses** and **time-dependent background systematics**.

Total rate > modulation amplitude

10.1088/1475-7516/2018/05/074

The COSINUS experimental facility at Laboratori Nazionali del Gran Sasso

INFN LNGS

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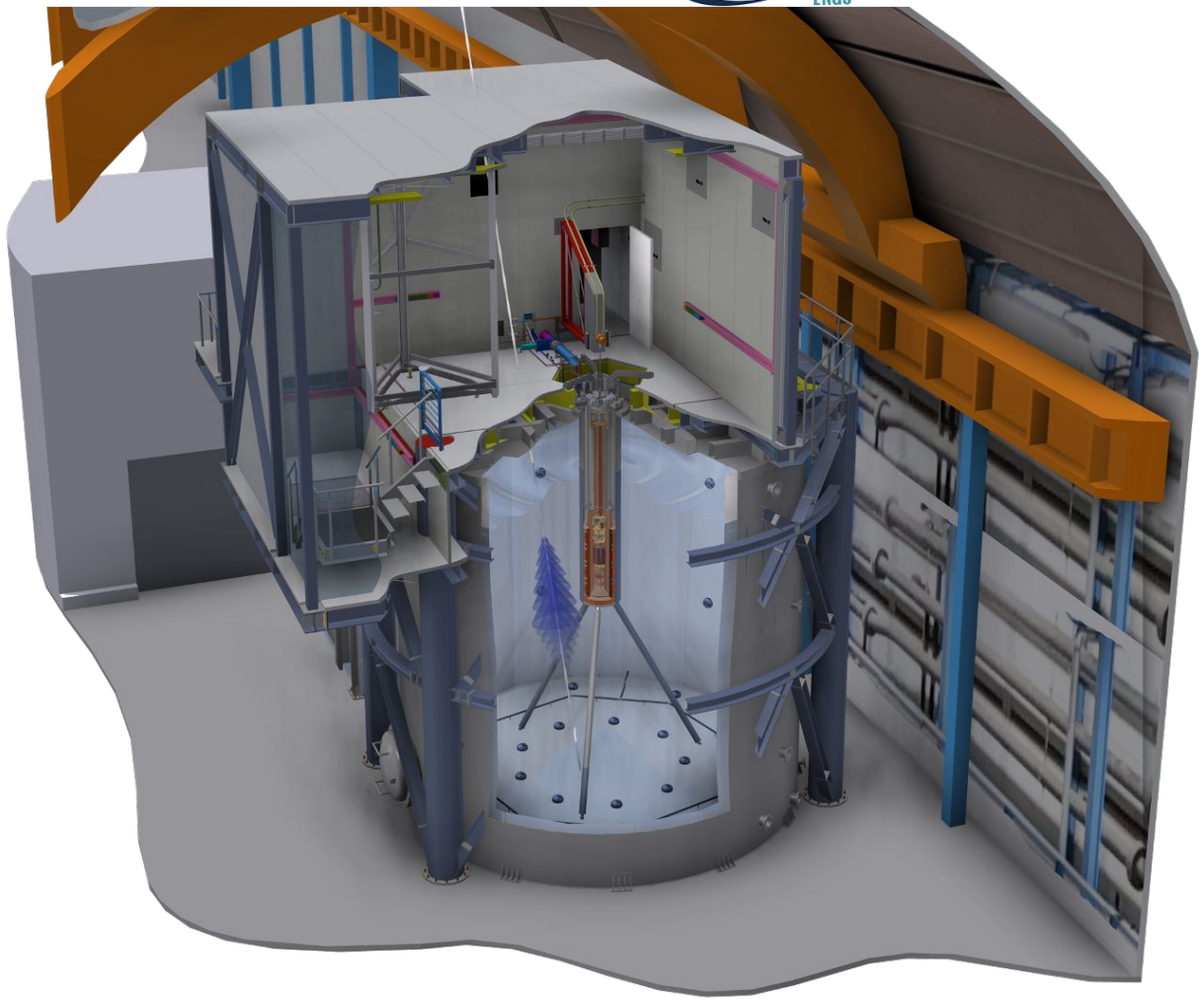


The COSINUS experimental facility at Laboratori Nazionali del Gran Sasso

INFN LNGS

TODO list:

→ Muon veto

→ Cryostat commissioning and testing

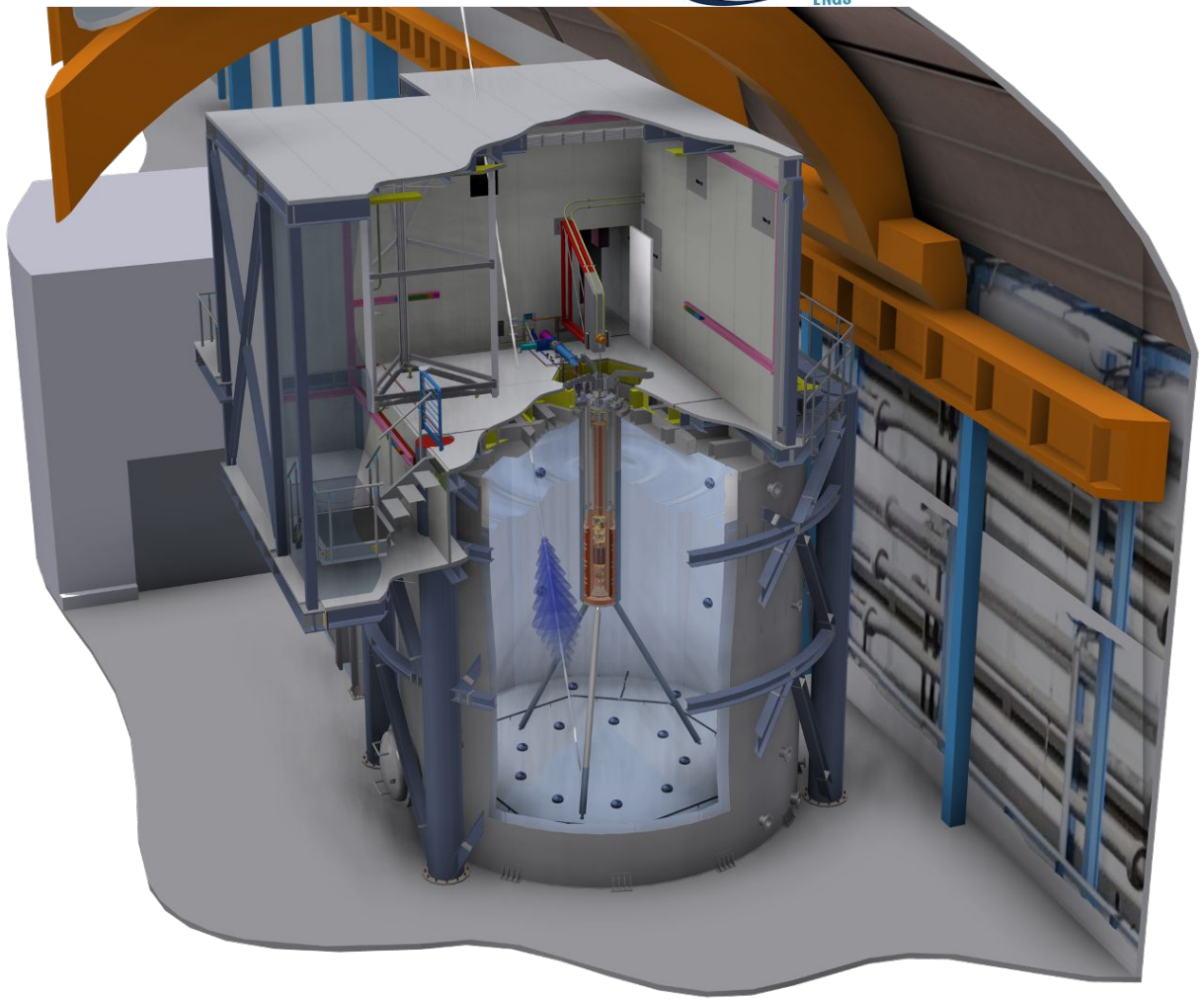
→ Vibration decoupling system

→ Magnetic field compensation

→ Electronics

→ Background estimation

→ Cabling



The COSINUS experimental facility at LNGS

To be integrated with SNEWS!

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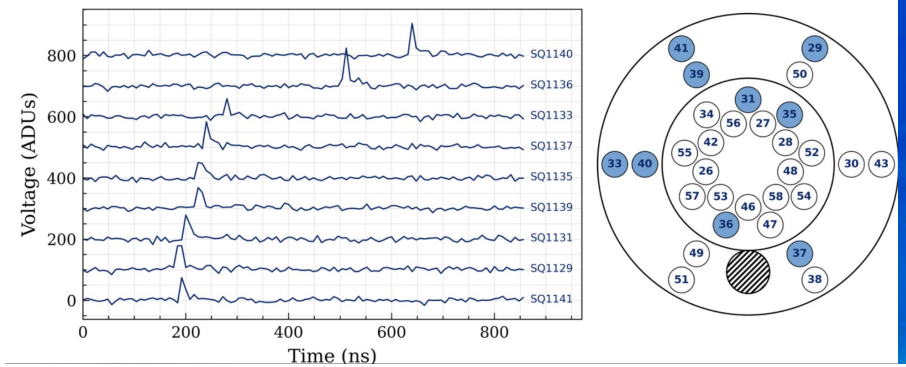

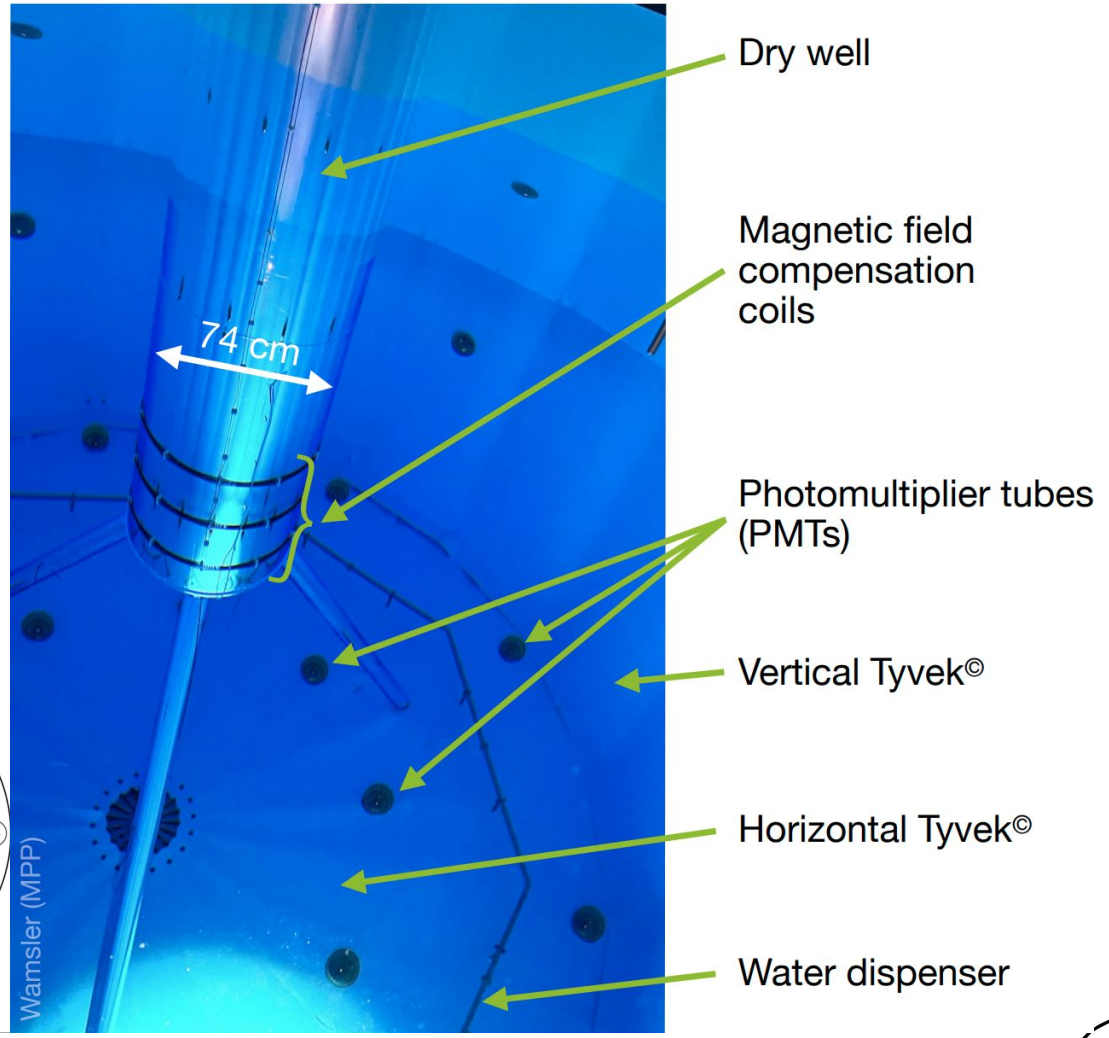

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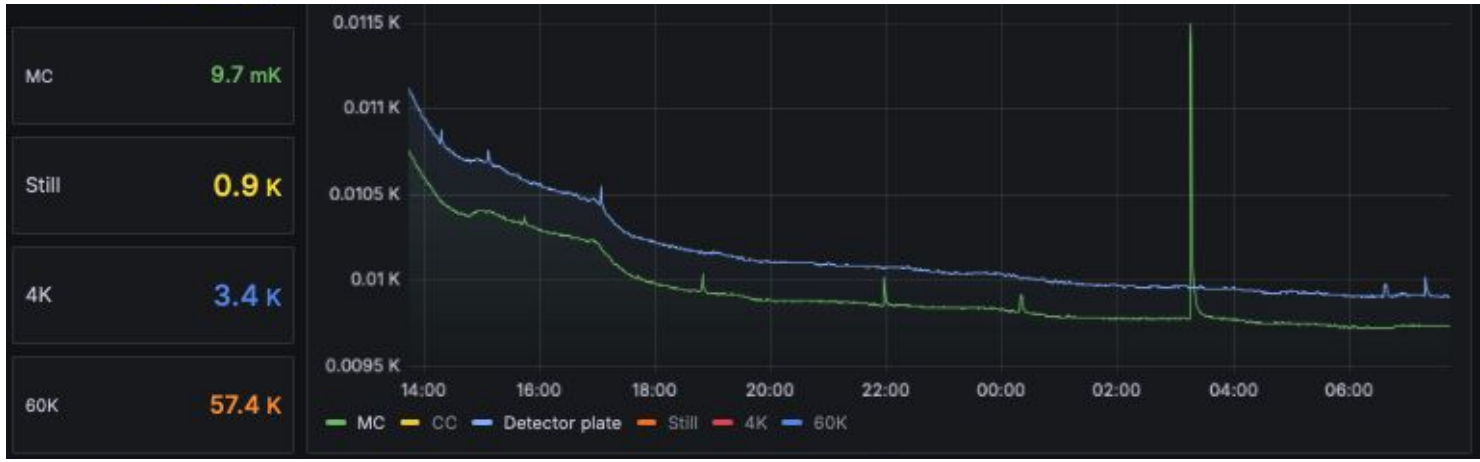

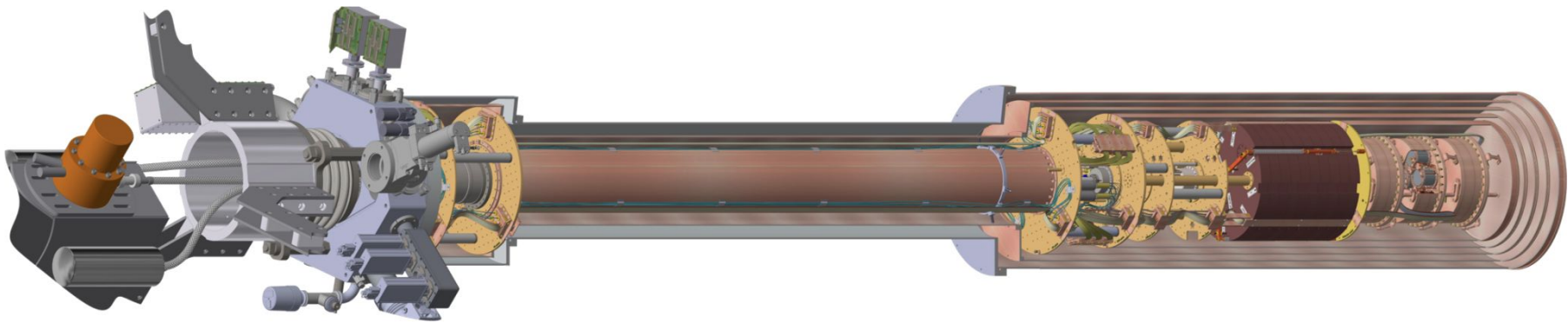

The COSINUS experimental facility at LNGS

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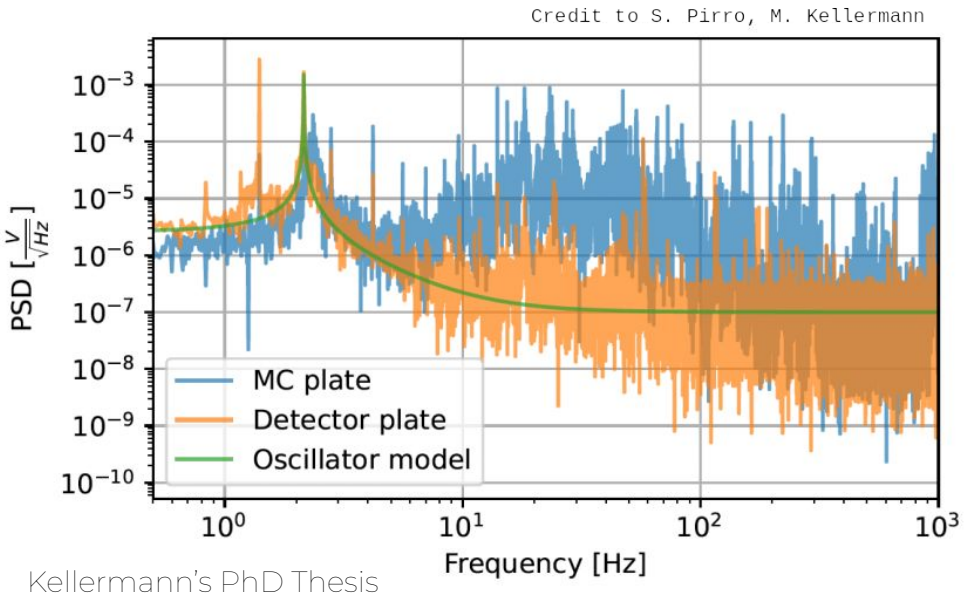
- **Geophone on MC plate**
- **Decoupling system**
- **Geophone on detector plate**



Kellermann's PhD Thesis

The COSINUS experimental facility at LNGS

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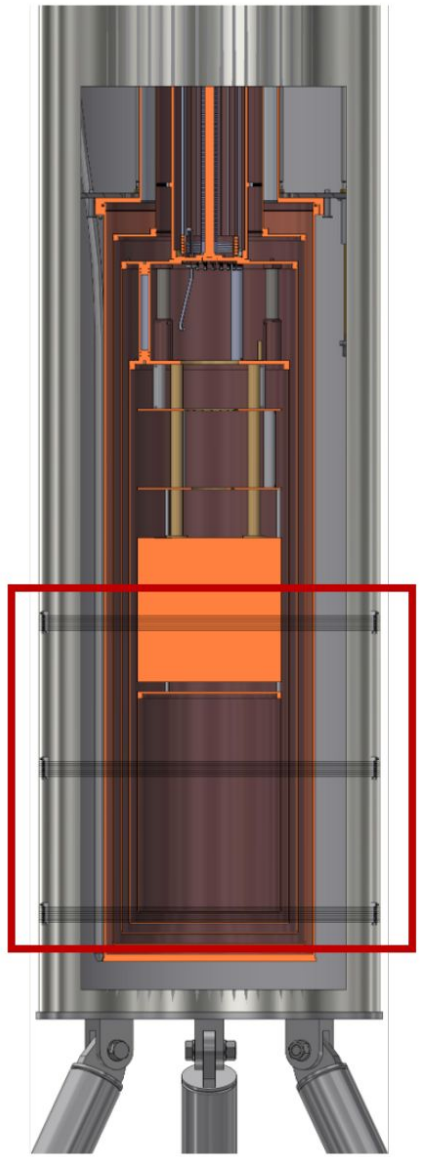
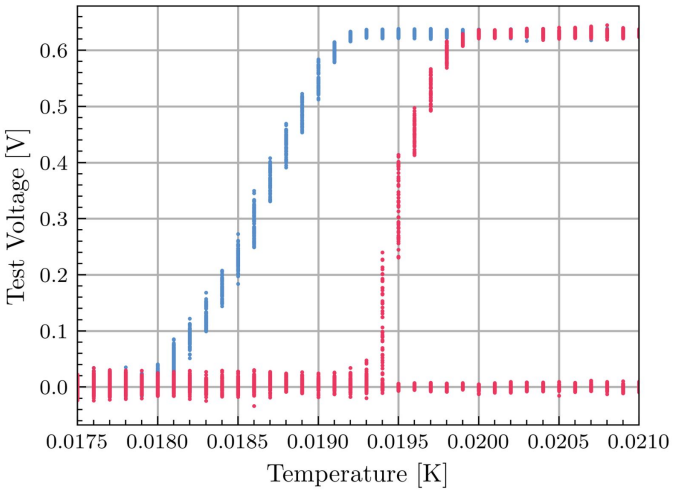


→ **Compensation OFF**

→ **Compensation ON**



(Si remoTES detector introduced in two slides!)

The COSINUS experimental facility at LNGS

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→ Magnetic field compensation ✅

→ Electronics ✅

→ Background estimation

→ Cabling

32 SQUID-amplifiers per unit

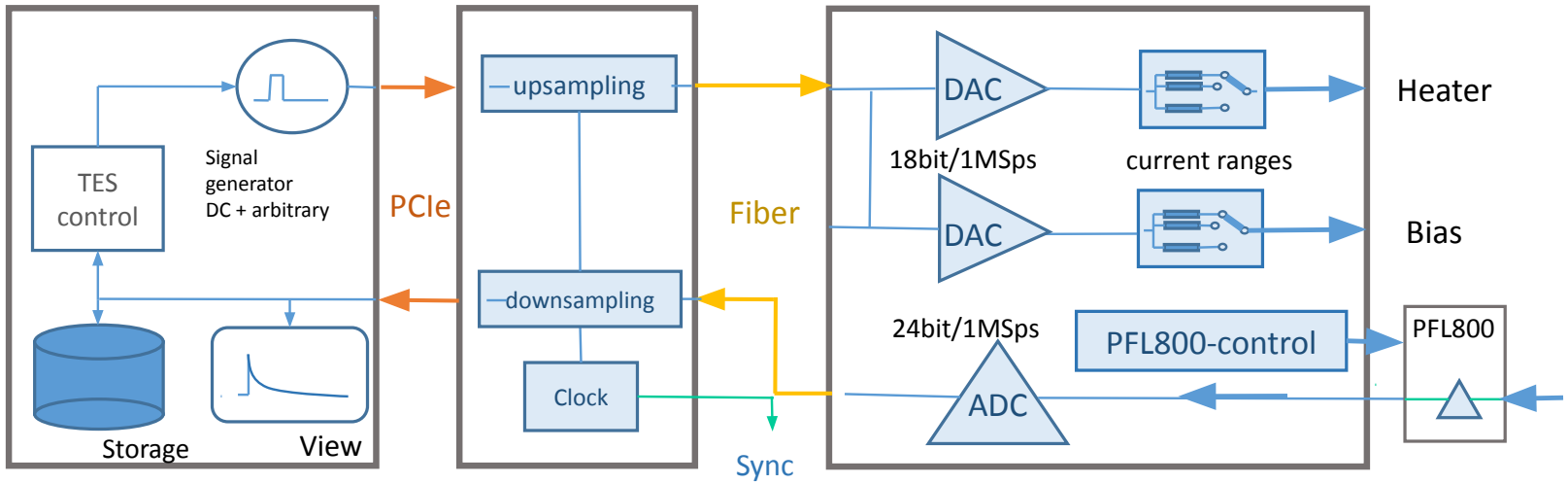
→ Custom-made

→ Integrated system for current sources and digitizers

→ Optical link to the server

→ Continuous data taking (24bits, 1MHz)

√daq3



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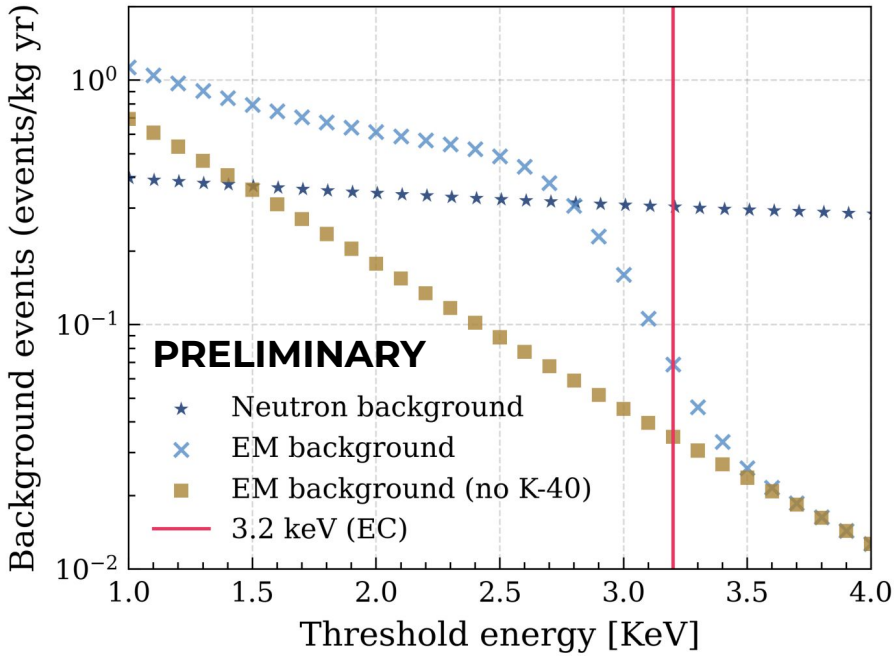
PRELIMINARY

Neutron background
0.21 (0.13)
events kg^{-1} yr^{-1}
for 1 (4) keV thresholds
Nearly two orders of magnitude below the DAMA/LIBRA modulation scale.



Paper out soon!

The COSINUS experimental facility at LNGS

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Successful cabling run in Spring 2026!

- 48 SQUID channels
- NaI + Si detector
- Si detector with remoTES configuration

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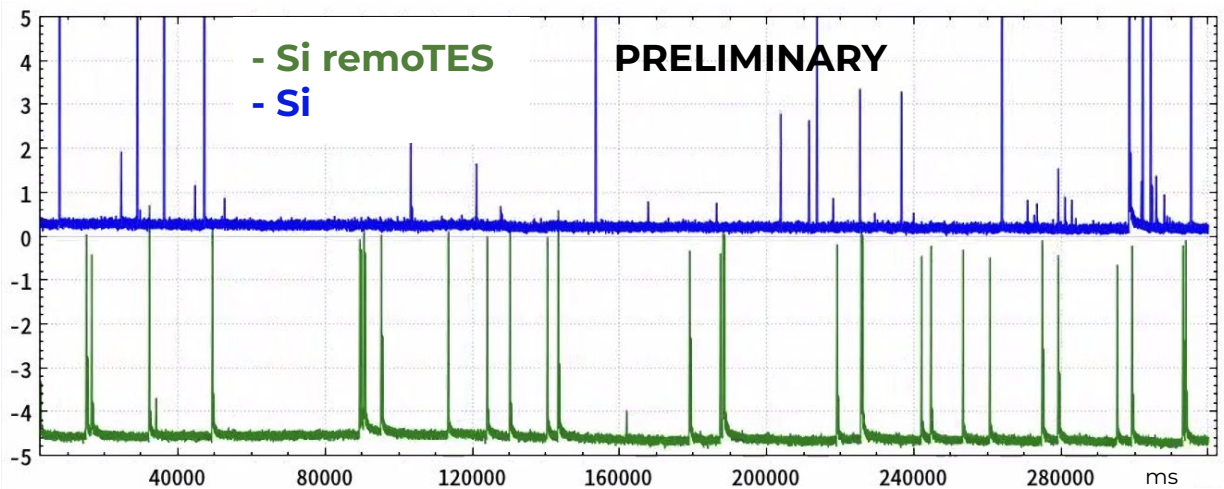

Flat baselines!

The COSINUS experimental facility at LNGS

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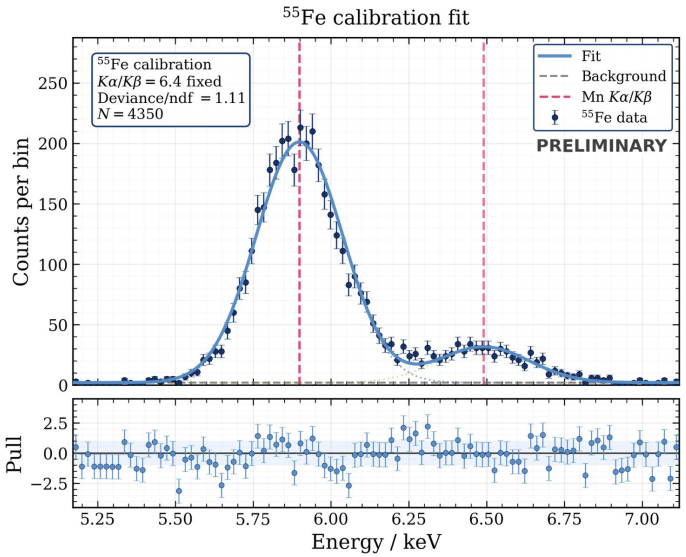

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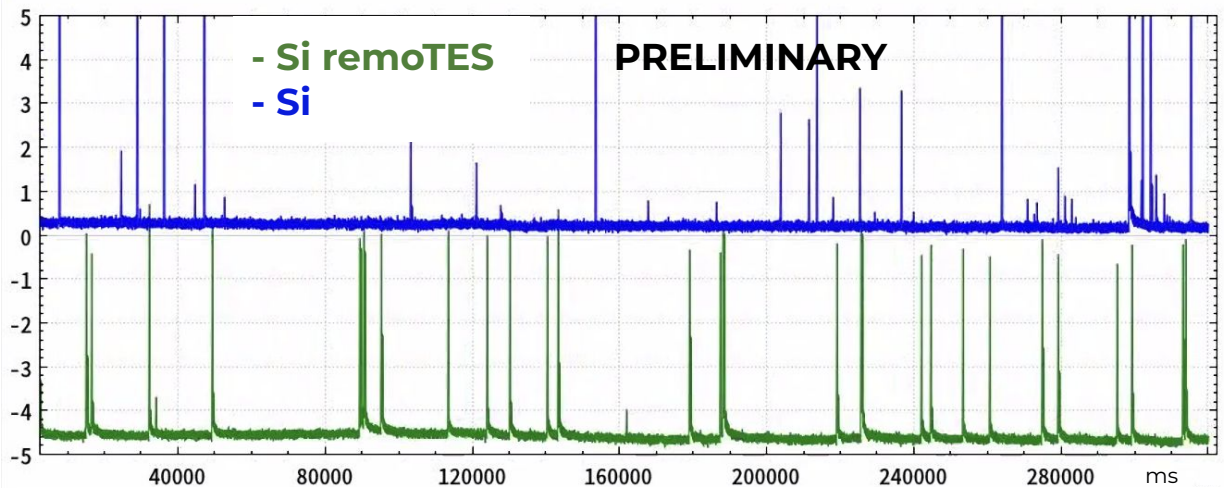


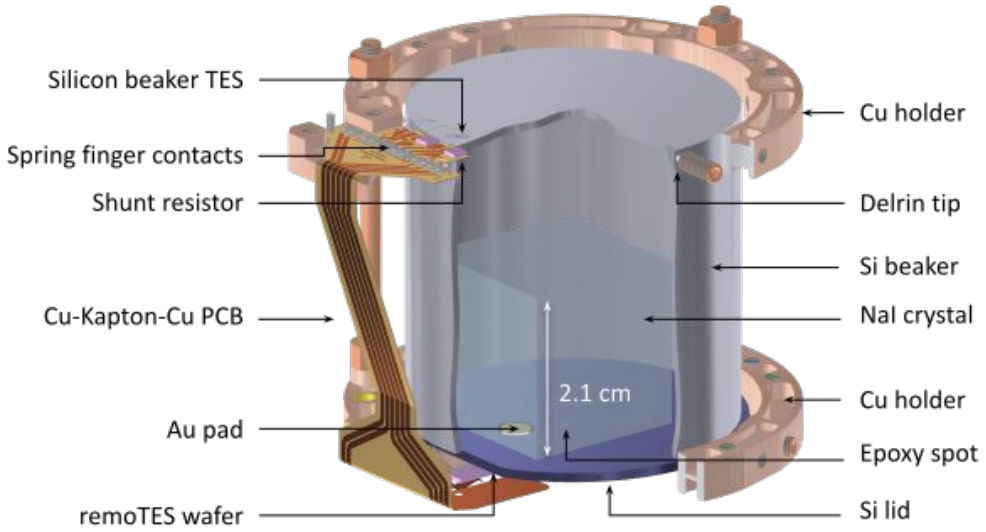
Flat baselines!

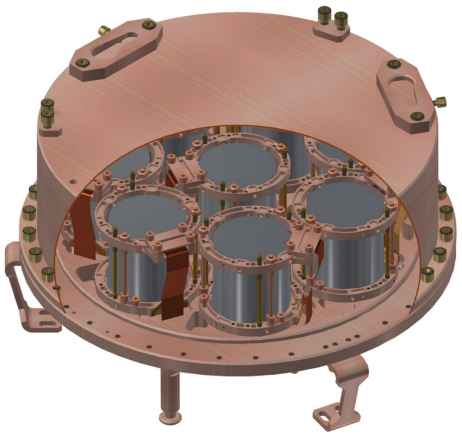
Light detector achieved **3.9(2) eV** resolution!

New cabling run starting next week.

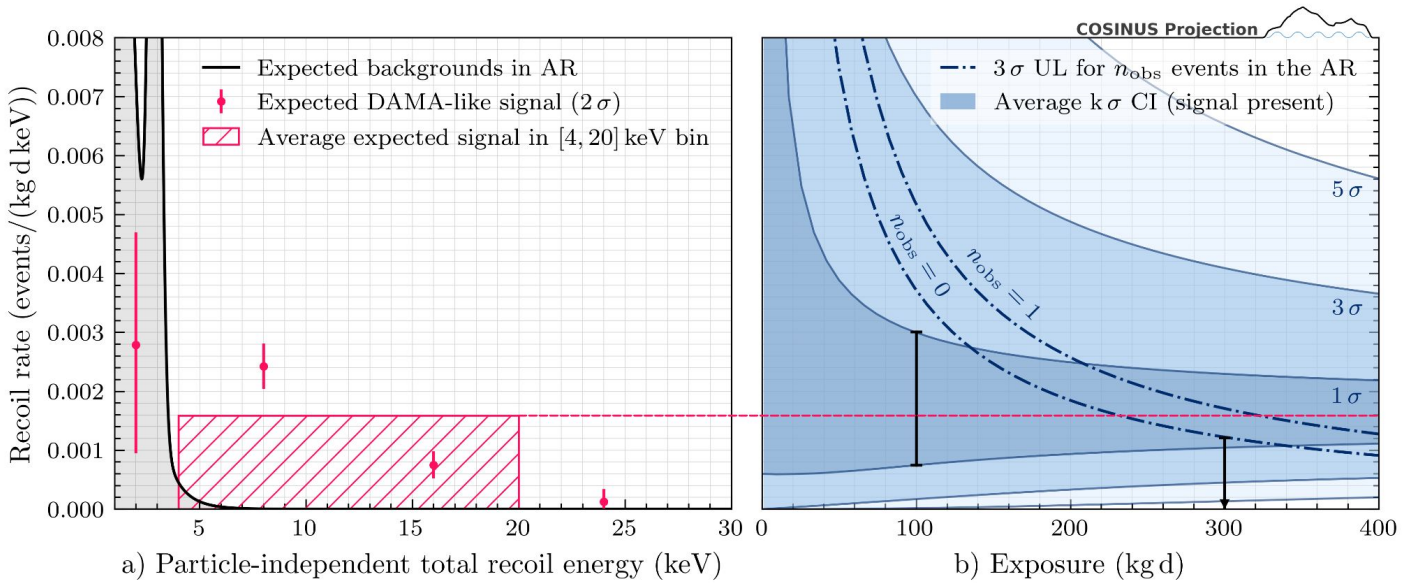
Plans for COSINUS-1π Run1

- → Target exposure: 100 kg days (should take 12-18 months)
- → NaI absorber: (21×21×21) mm³, 34.8 g
- → Si beaker: 41 mm diameter and height, 15.4 g
- → 8 modules (NaI + Si) → 16 SQUID channels

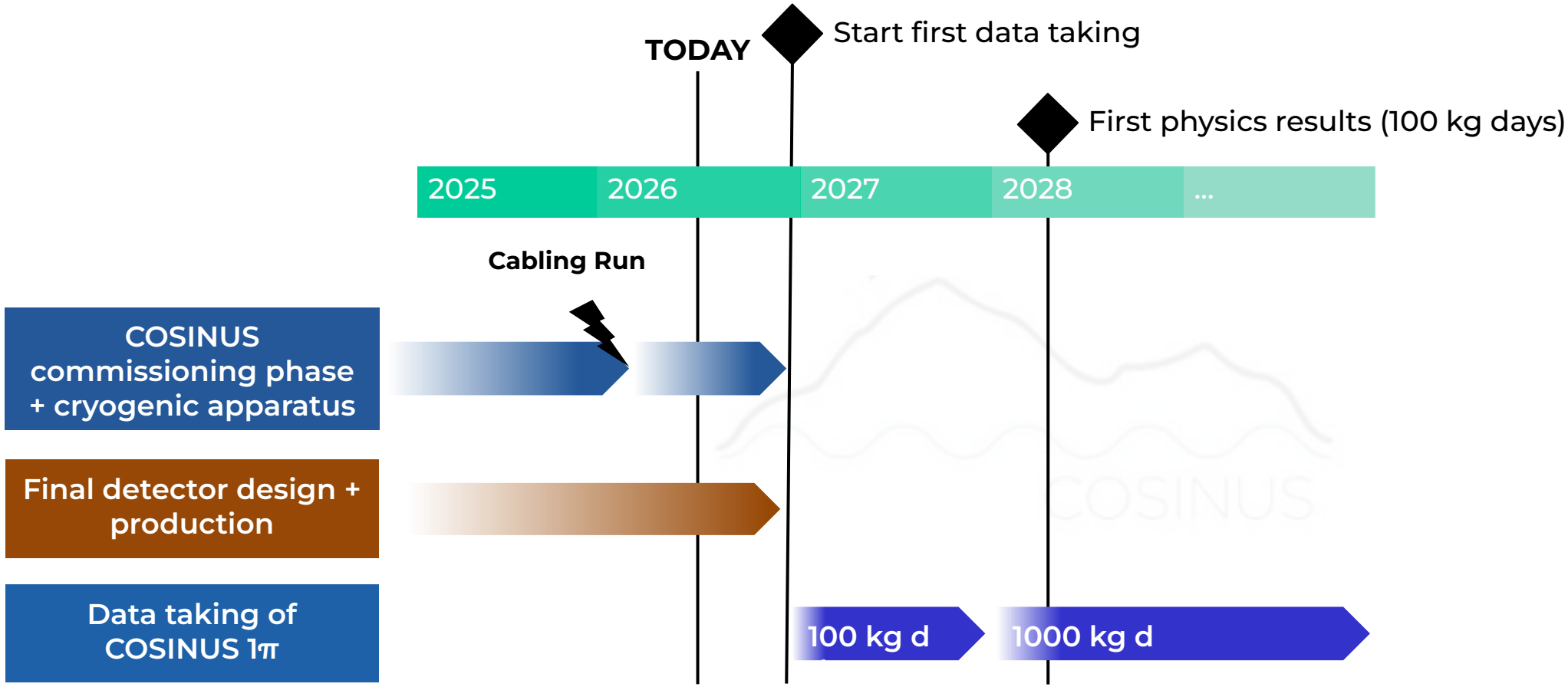




Detailed discussion in [10.1038/s42005-026-02620-9](https://doi.org/10.1038/s42005-026-02620-9)



Projections and timeline



Still want to hear more about COSINUS(-related) initiatives?

High pileup event reconstruction and single photon statistics in cryogenic scintillating calorimeters

Cryogenic scintillating calorimeters are particle detectors widely used in direct detection dark matter searches. They can measure the full, unquenched recoil energy of an interaction while simultaneously distinguishing nuclear recoils from

Philipp Schreiner (TU Wien, Marietta Blau Institute for Particle Physics)
01 June 2026 17:30
Aula Magna
Identification of Dark Matter 2026

Development of Cryogenic Single-Photon Detectors to Study the Light Output of Sodium Iodide Crystals for Rare Event Searches

In collaboration between the Cryogenic Observatory for SIgnatures seen in Next-generation Underground Searches (COSINUS)—a dual-channel dark-matter direct-detection experiment employing sodium iodide (NaI) as target material —and the Observa

Lutz Ziegele (Max-Planck-Institut für Physik)
03 June 2026 16:15
Pedro Cerbuna
Identification of Dark Matter 2026

Bayesian Pulse-Shape Inference for TES-Based Cryogenic Calorimeters

Sarah Braun on behalf of the COSINUS collaboration

Operation of COSINUS sensors
now and in the future
Identification of Dark Matter 2026, Zaragoza, Spain
Alexander Böhmer

Material Radioassay and Background Estimation for COSINUS Run 1

Clemens Dittmar on behalf of the **COSINUS Collaboration**
Contact: Dittmar@mpp.mpg.de

The COSINUS remoTES: Phonons from NaI and Beyond

M. Stahlberg on behalf of the COSINUS Collaboration
martin.stahlberg@mpp.mpg.de
16th International Workshop on the Identification of Dark Matter 2026

3 talks
5 posters

Kilian Heim
On behalf of the COSINUS collaboration
kheim@mpp.mpg.de

Run 1 Overview
- Anticipated start date: within 2026
- Projected detector resolution: 1 keV (at least)
- 8 sodium iodide (NaI) modules → 100 kg d exposure after one year

Thank you for listening!

Since 1928 SICCAS

SNOLAB

HELSINKI INSTITUTE OF PHYSICS

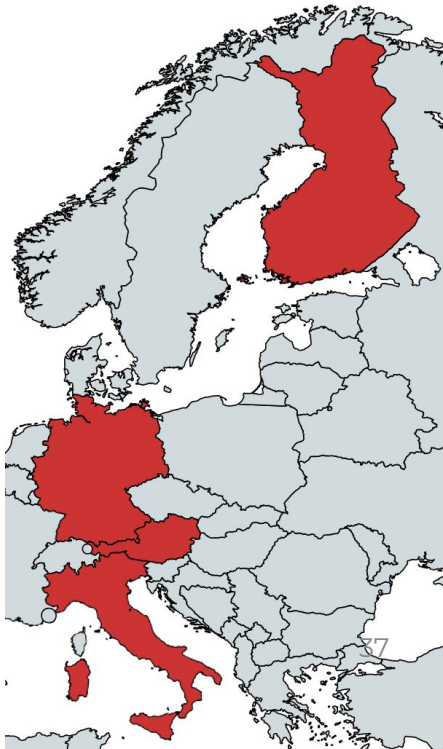
Max-Planck-Institut für Physik (Werner-Heisenberg-Institut)

MARIETTA BLAU INSTITUTE FOR PARTICLE PHYSICS

TU WIEN

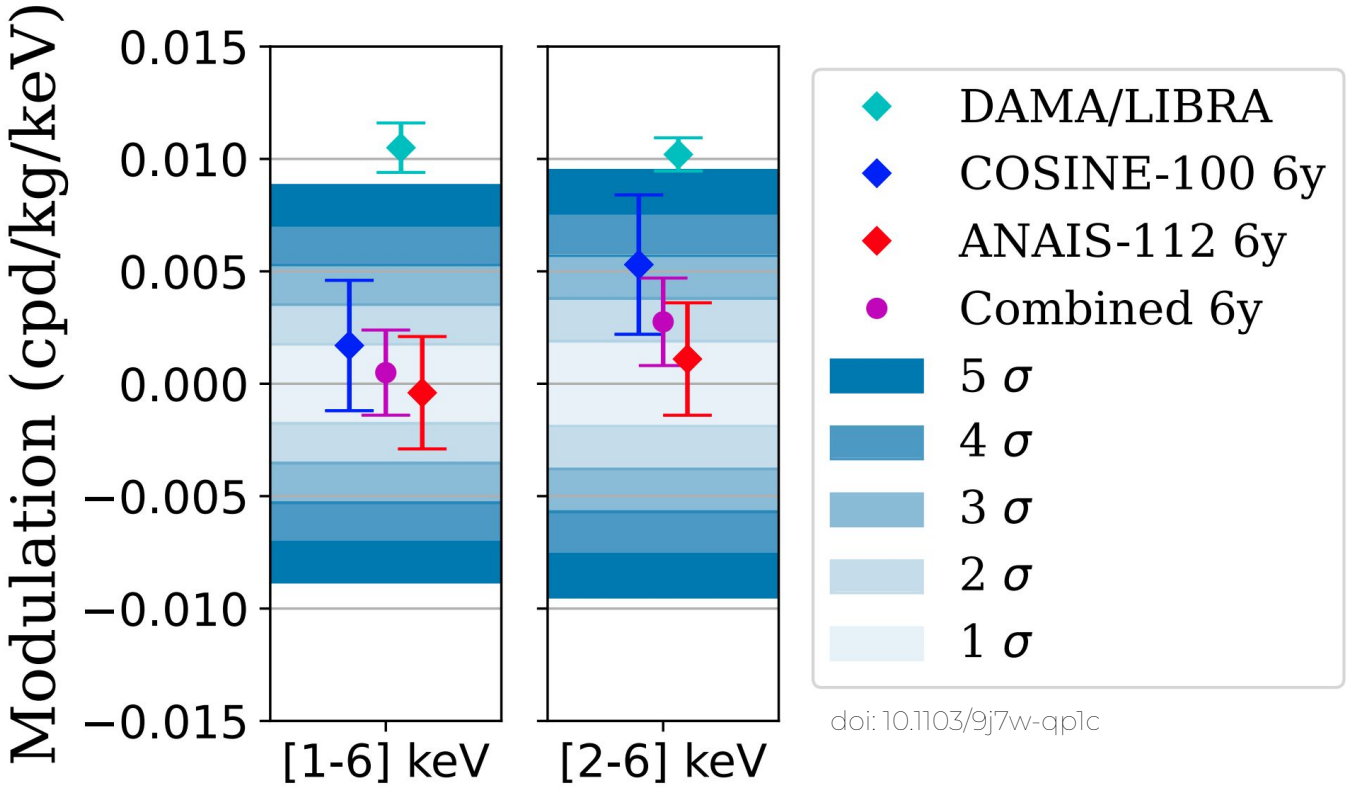
INFN LNGS

GSSI



→ Multiple experiments utilize the same material (NaI) and detector technique (scintillation light measurement) to either replicate or refute the DAMA/LIBRA claim

→ Last year, COSINE+ANAIS published a combined 6 years (almost 1 **ton** year) analysis

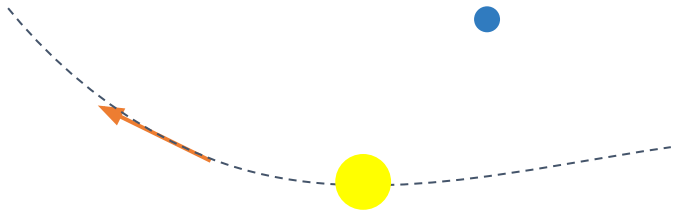


doi: 10.1103/9j7w-qp1c

"(For the 1-6 and 2-6 keVee energy range,) these values are incompatible with the DAMA/LIBRA signal to significances of **4.7σ** and **3.5σ**, respectively..."

→ Movement of Earth respect to DM wind should lead to an annual modulation of the DM signal.

Based on arXiv:2003.04545



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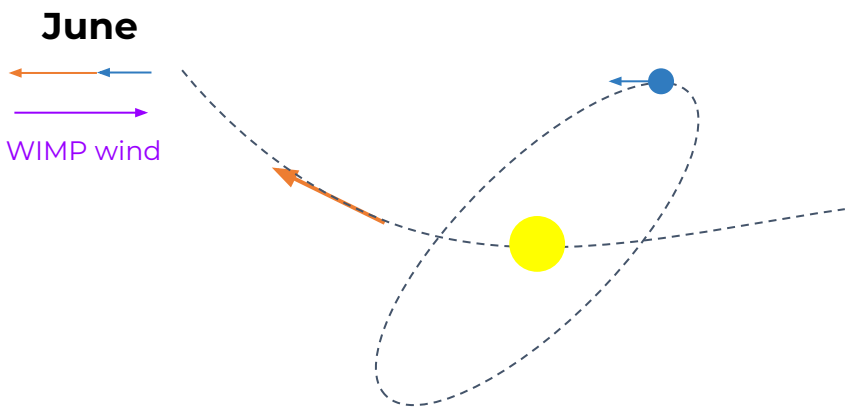

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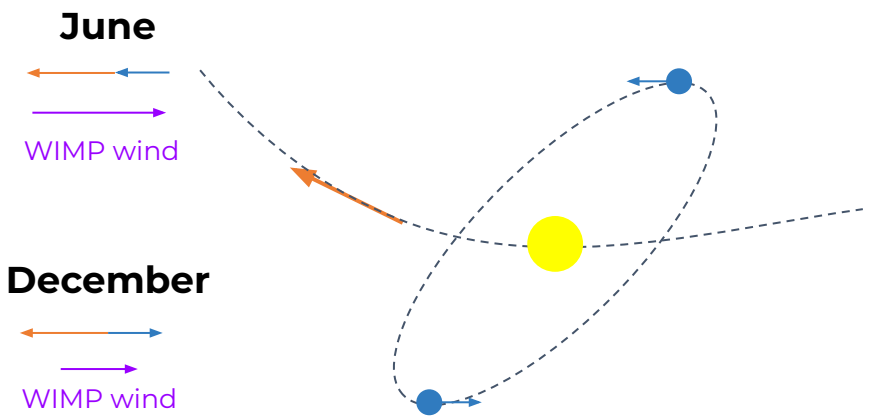

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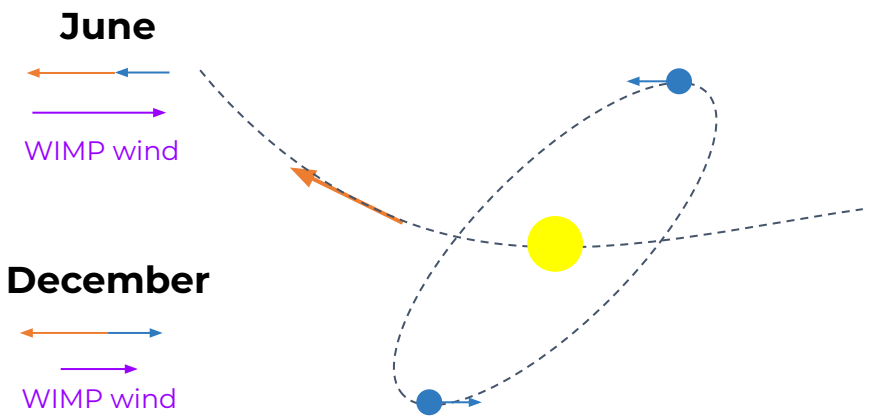

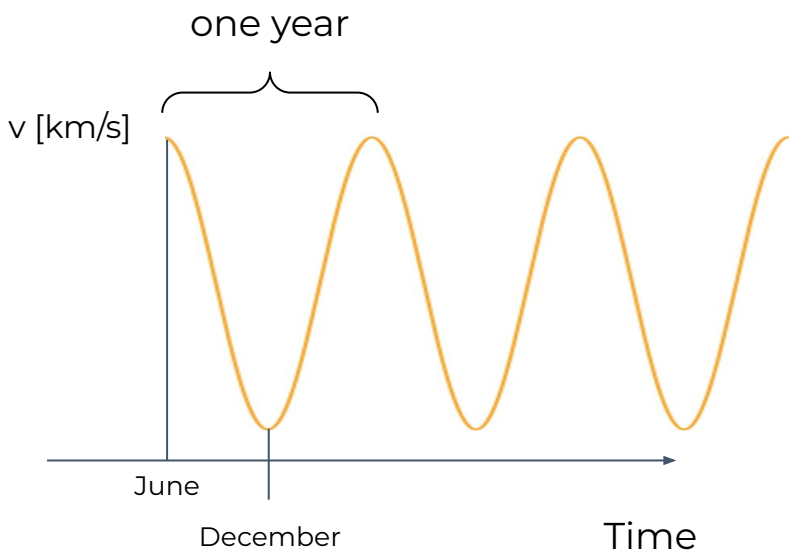

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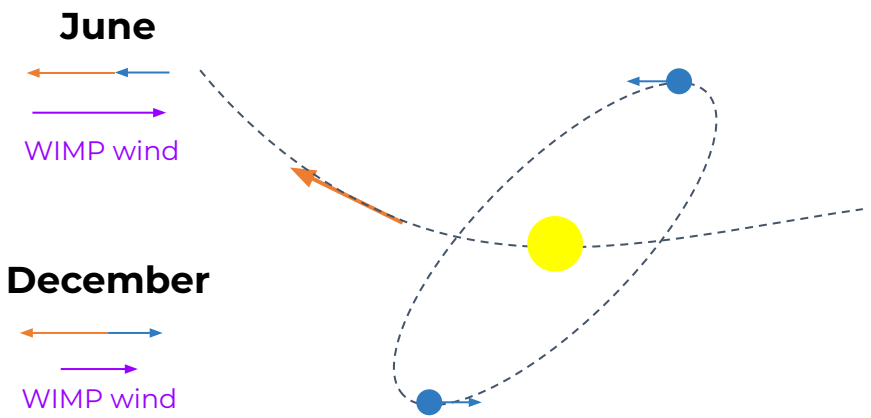
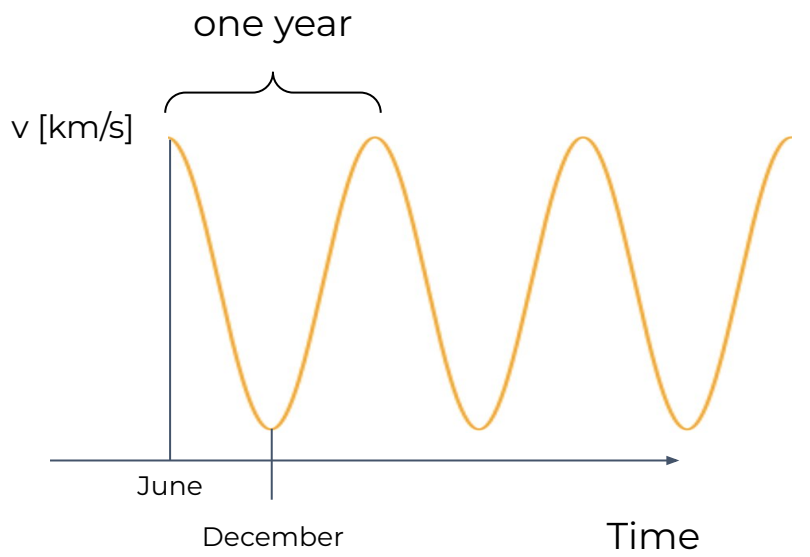
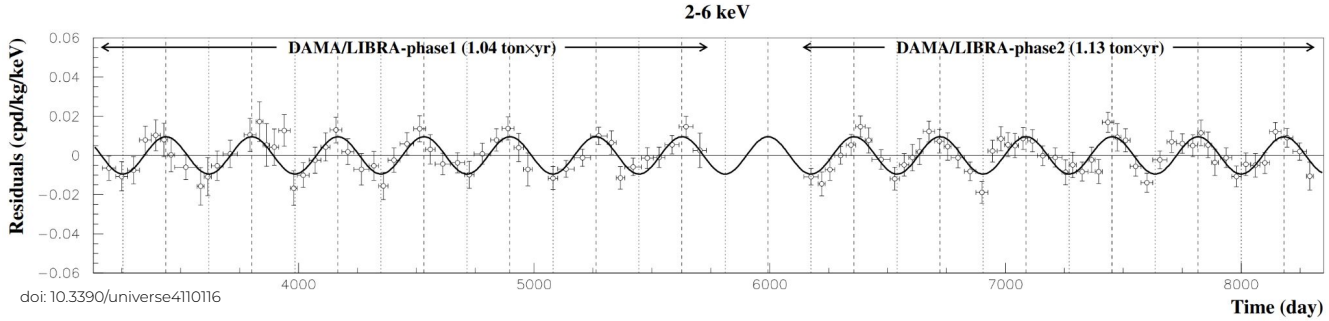




→ DAMA/LIBRA reports an annual modulation with a **13.7σ** significance.



doi: 10.3390/universe4110116

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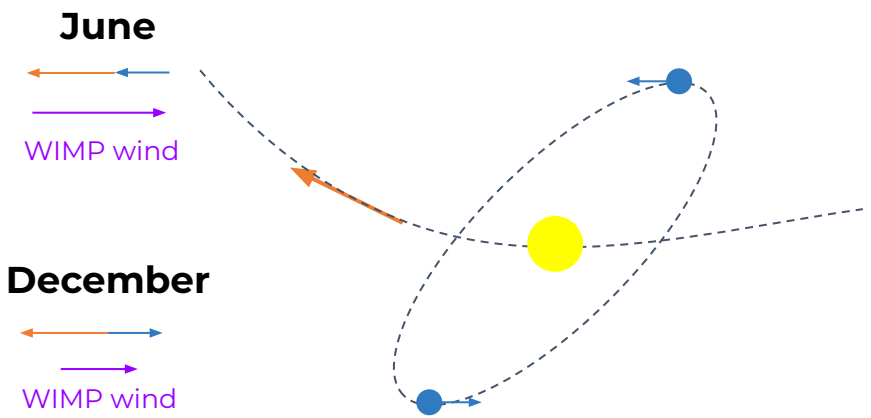
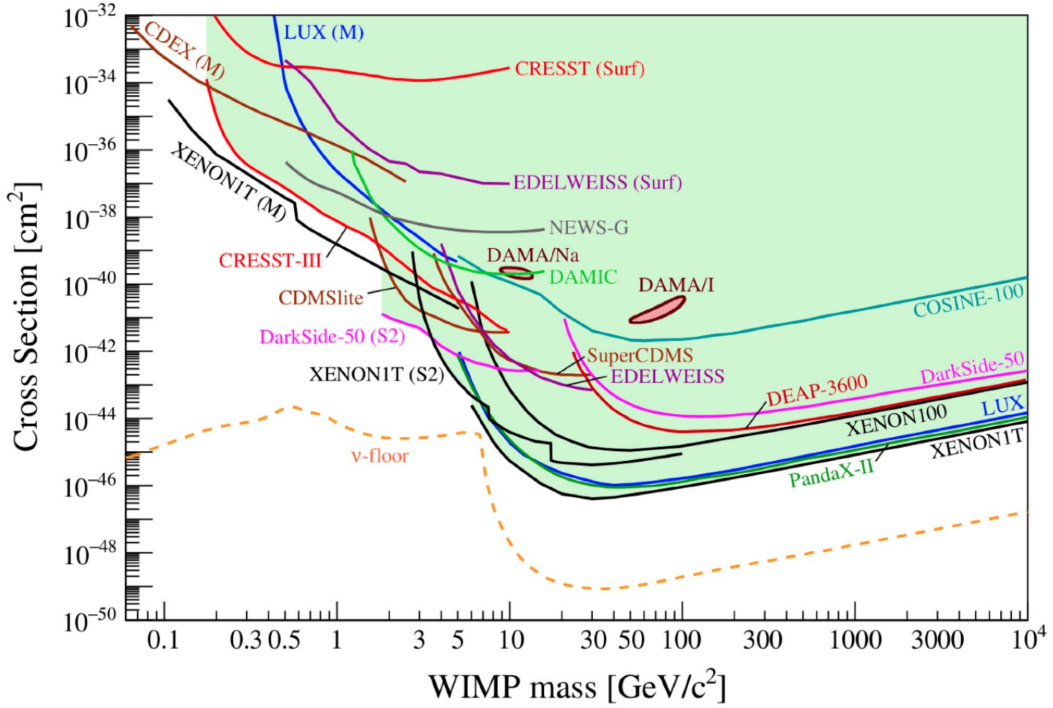


Astroparticle Physics European Consortium (APPEC), v1.02



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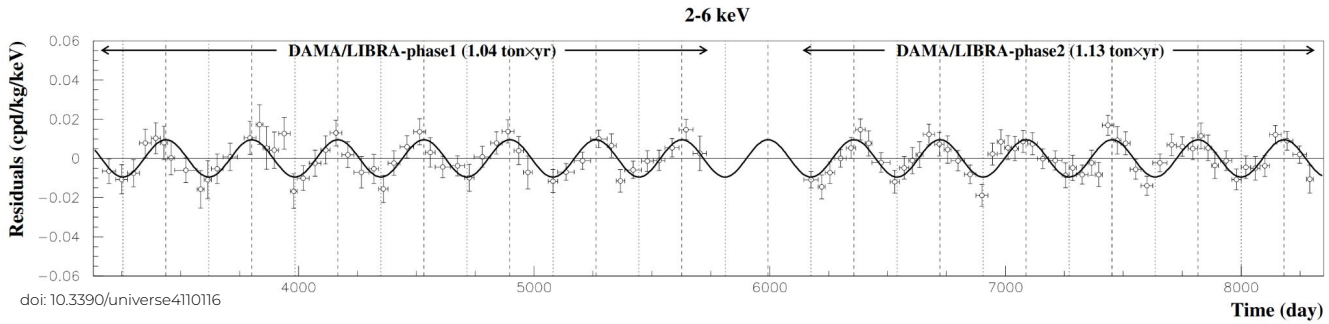


doi: 10.3390/universe4110116

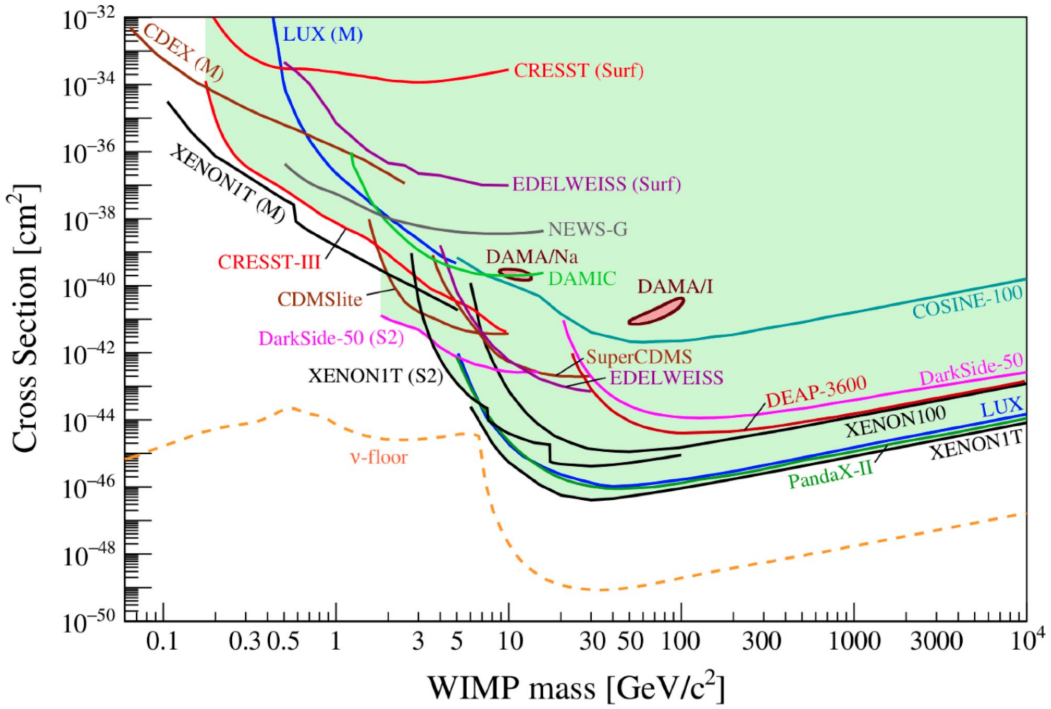
However, DM exclusion limits are **model dependent**:

→ **Astrophysical assumptions**
Halo model, local DM density, velocity distribution

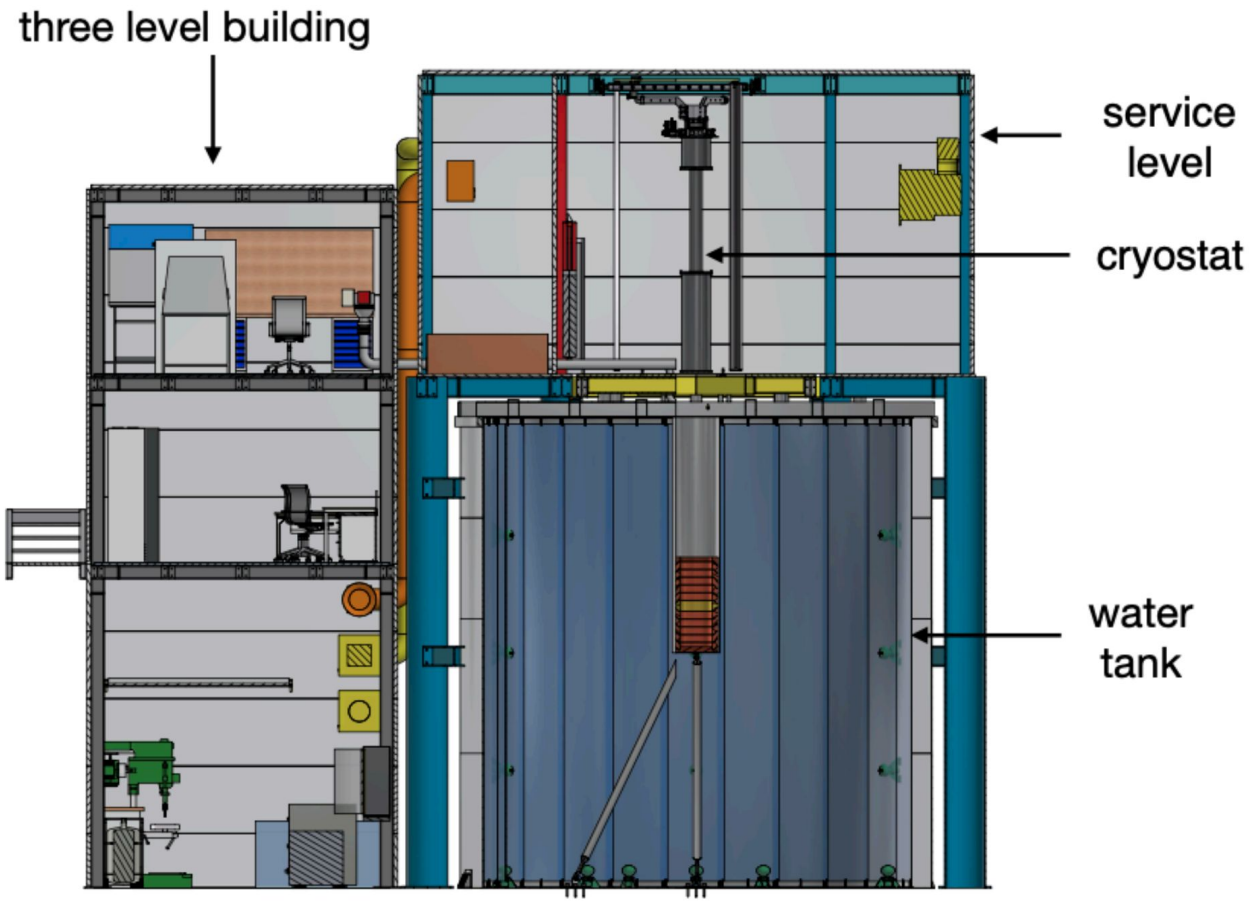
→ **Particle-physics assumptions**
DM mass, interaction channel, mediator, coupling structure, cross-section scaling

→ **Target/detector response**
Nuclear target, quenching factors, threshold, energy scale

Astroparticle Physics European Consortium (APPEC), v1.02



The COSINUS experimental facility at LNGS



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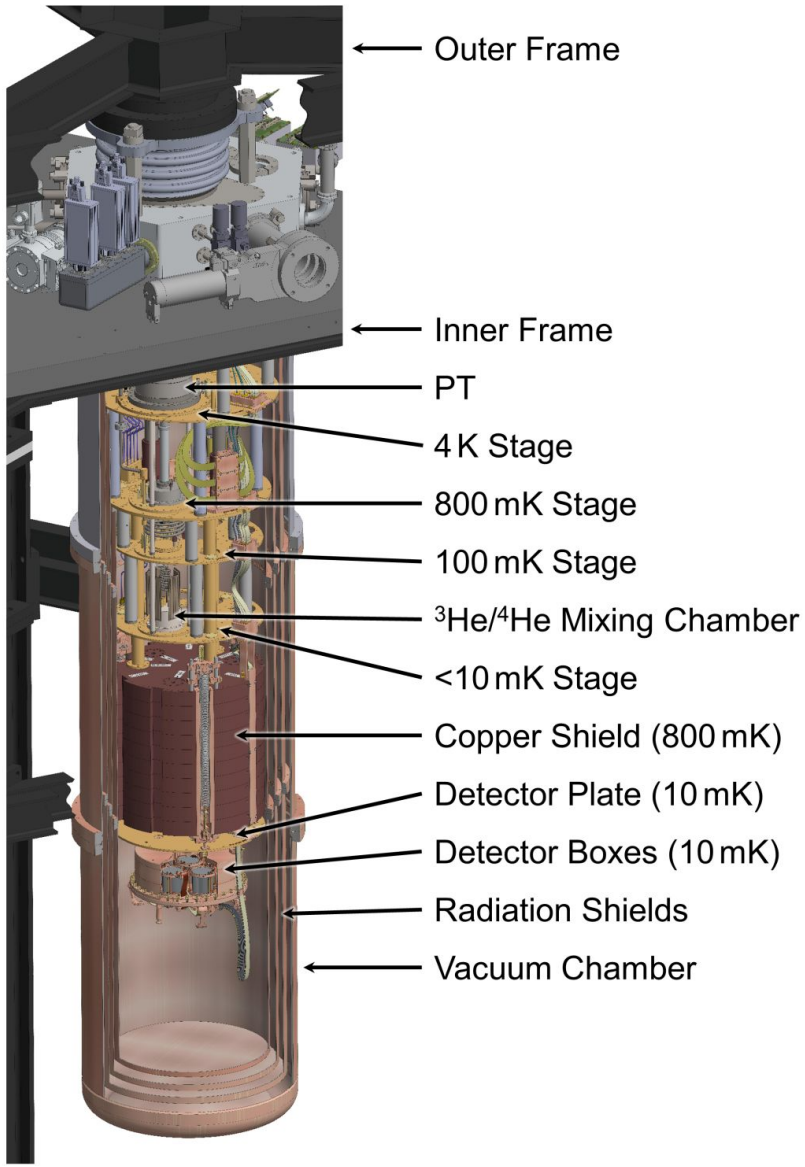
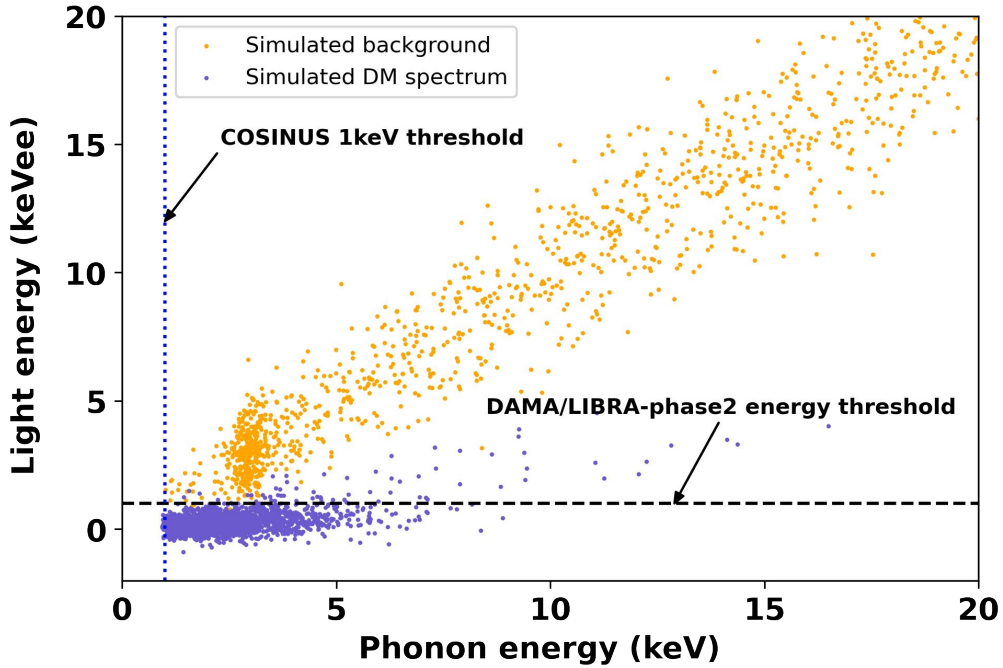


What about COSINUS?

→ **Quenching factor**: scintillation-only NaI experiments rely on a dedicated measurements of the quenching factor (how much light is produced for nuclear recoils, in comparison to electron recoils).

→ **Interaction channel:** by measuring both phonon and light signals, COSINUS can discriminate the interaction channel of the event, i.e. whether it arises from nuclear or electron-recoils.



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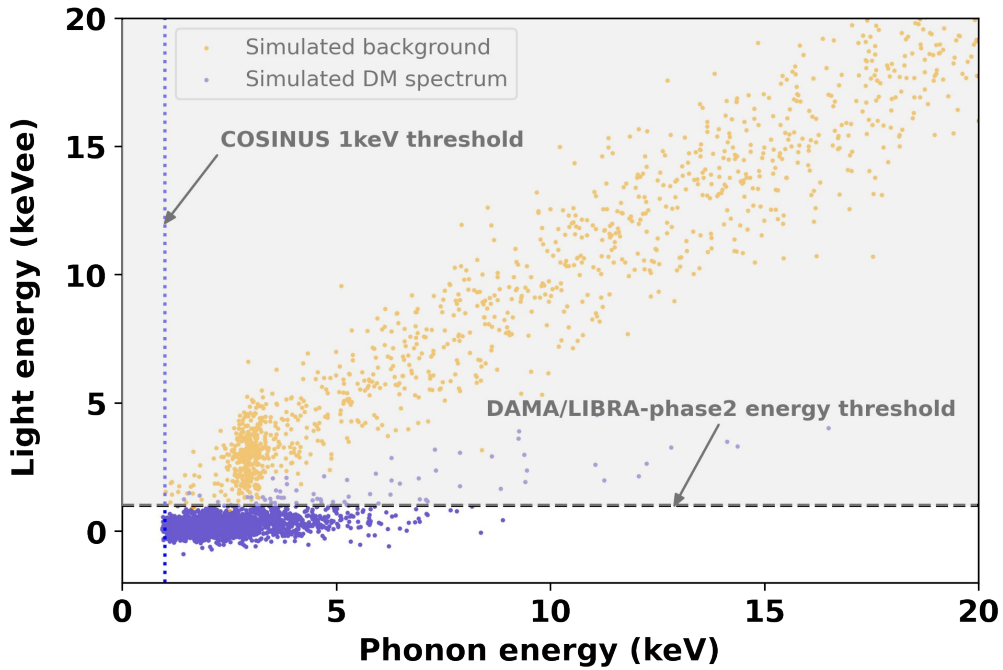

What DAMA/LIBRA sees...

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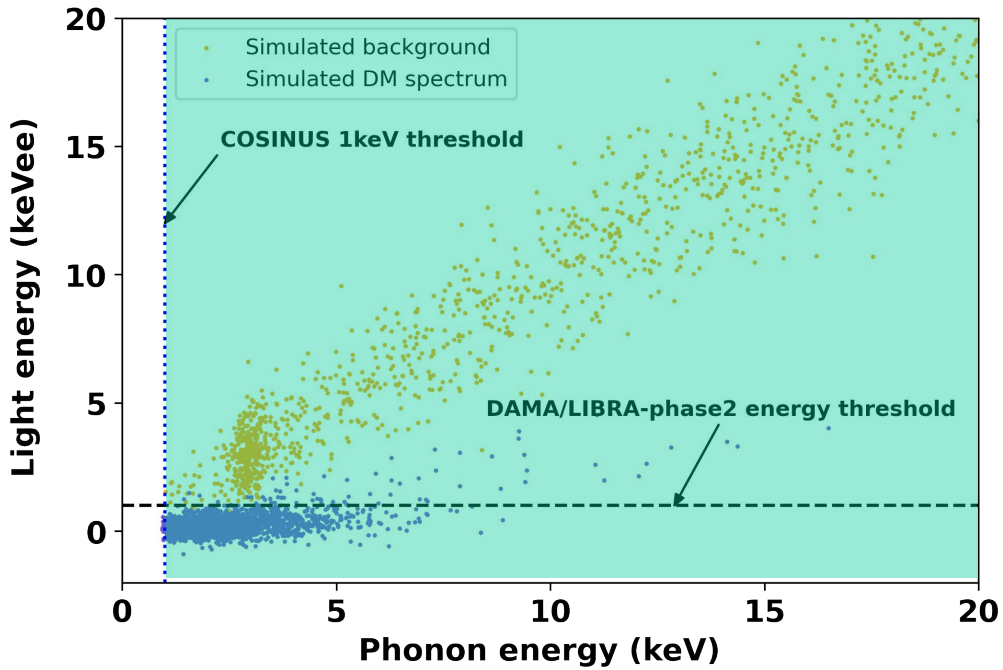
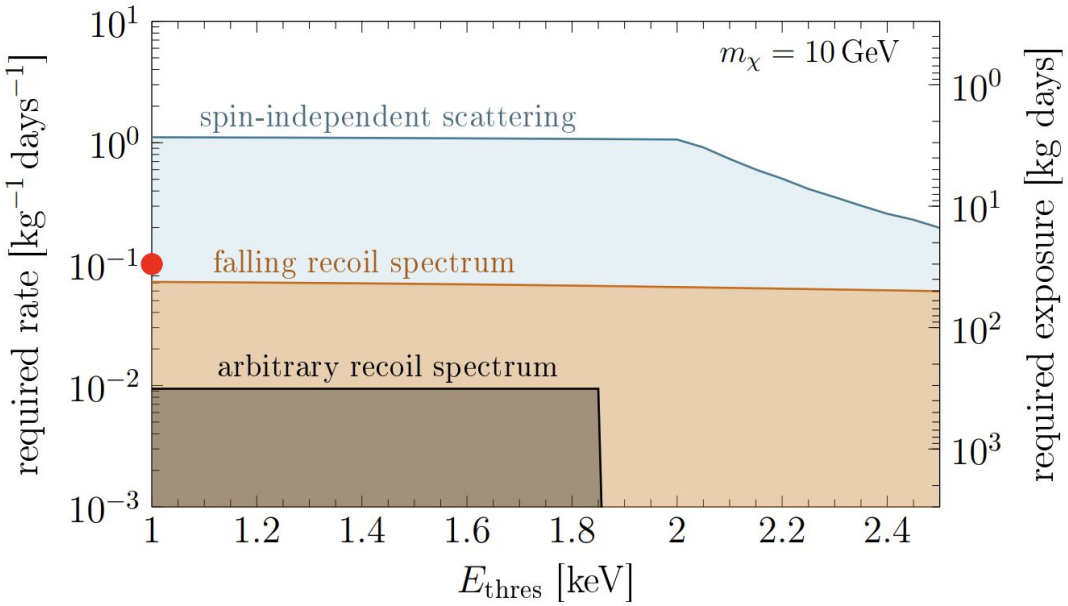


What COSINUS sees...

→ Same cryogenic technology used by CRESST, utilizing NaI crystals, to carry out a **model-independent verification** of the DAMA/LIBRA signal.

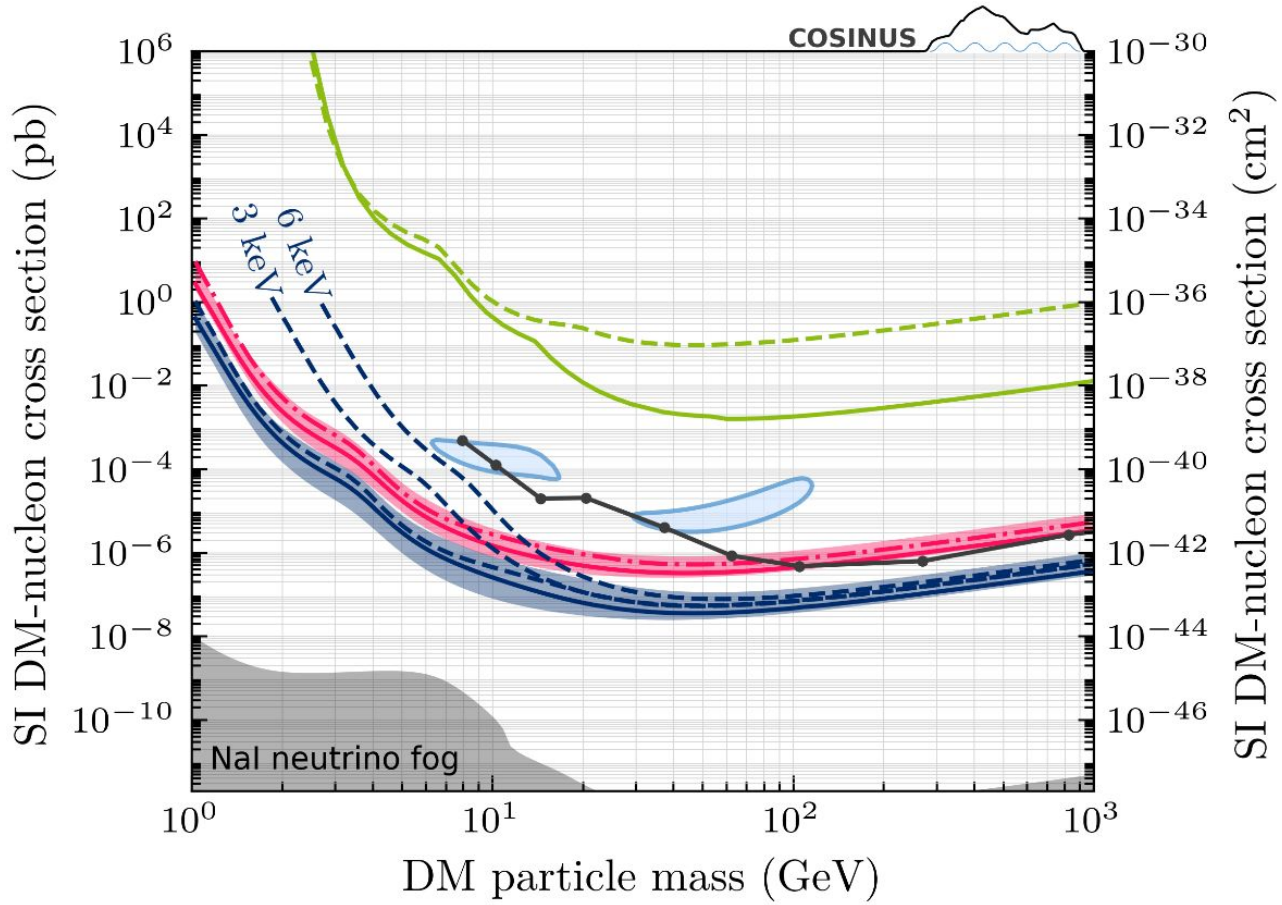
→ Same site as DAMA/LIBRA (LNGS)

→ Practically background freedom (active and passive shielding), particle discrimination and better energy resolution allow COSINUS to look not for annual modulation, but **total event rate**, eliminating the possibility of other annually-modulated background sources.



10.1088/1475-7516/2018/05/074

- First underground measurement + projections



DAMA/LIBRA compatible islands ($3\,\sigma$)
COSINUS 2024, with PD (11.6 g d)
COSINUS 2024, without PD (11.6 g d)
COSINE-100 2021 (35.7 t d)

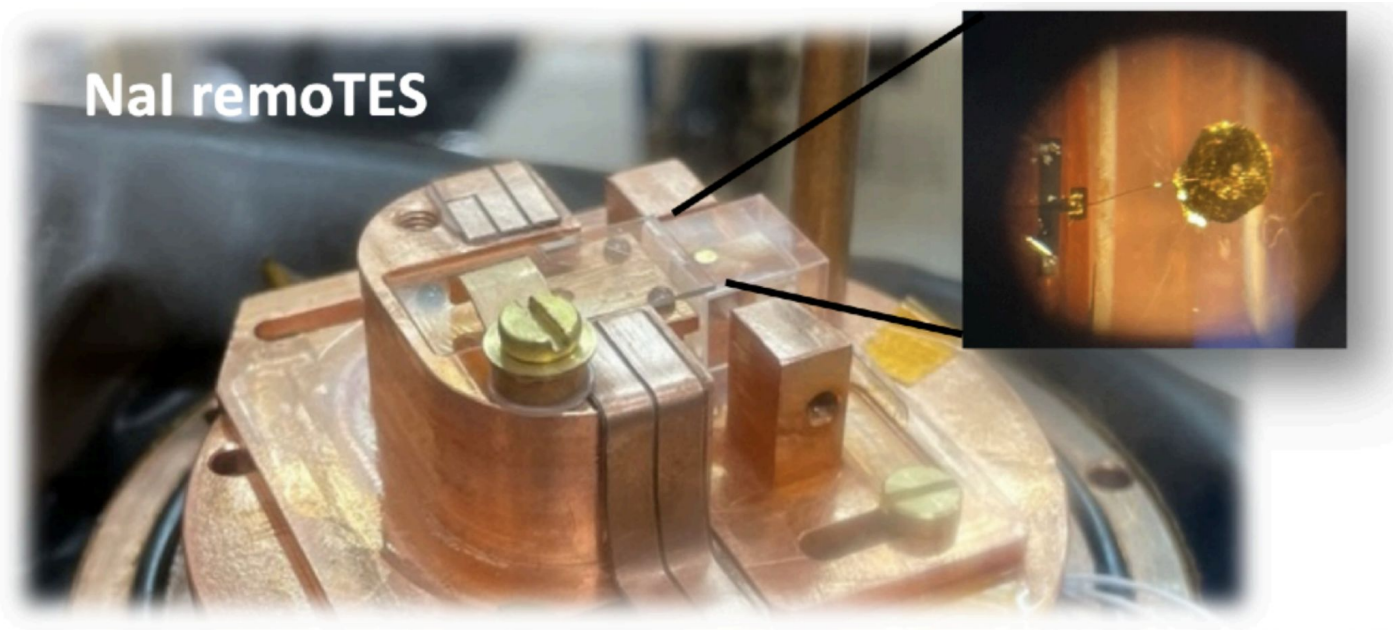
COSINUS-1π Run1 projections:
1 detector, 1 year (9.7 kg d), Yellin (90 %)
100 kg d, different E_{thr}, Yellin (90 %)
Respective PLR bands ($3\,\sigma$)

10.1038/s42005-026-02620-9

Cryogenic Observatory for SIgnatures seen in the Next-generation Underground Searches

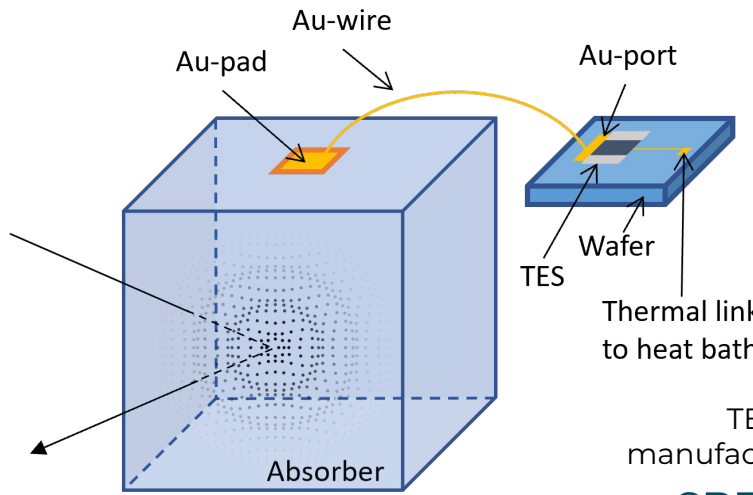
Two (2) channels of detection!
Phonons (heat) and photons (light)

NIM A 1045, 167532



*(prototype version)

→ NaI is highly **higroscopic**, **soft** and has a **low-melting point**!



TES manufactured by CRESST

RemoTES is a key technology enabler!

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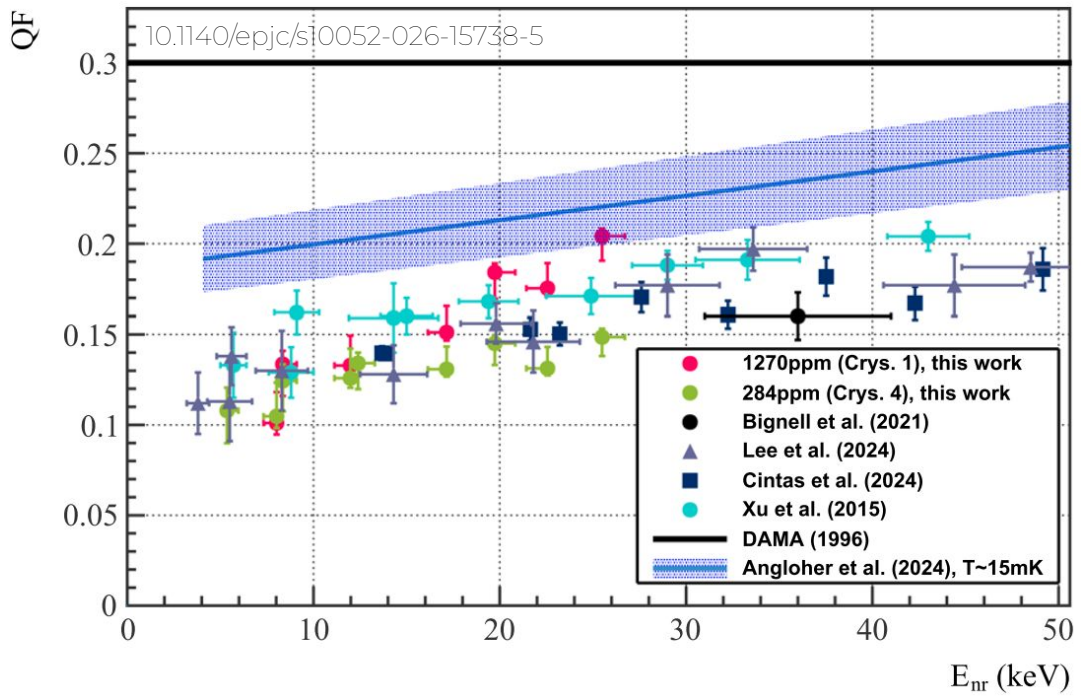

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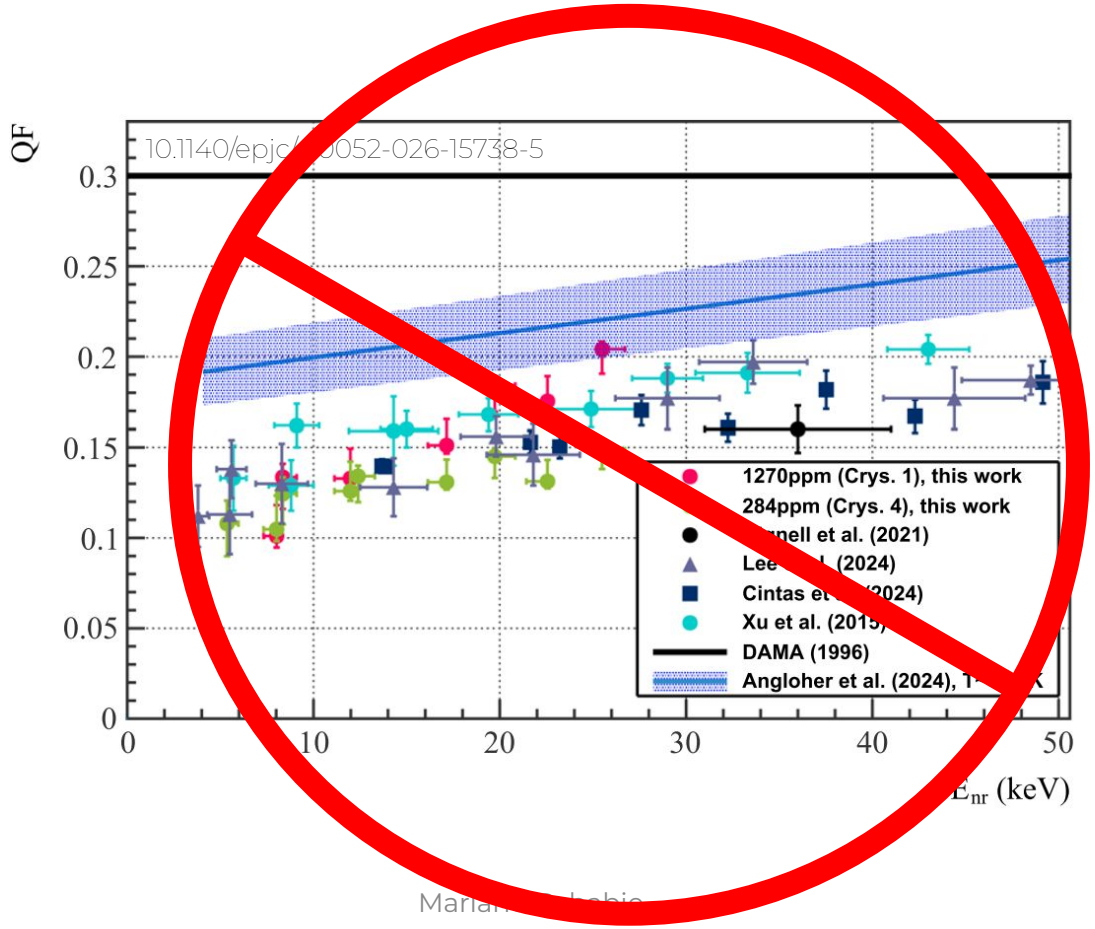

→ **No need for dedicated measurements!**

→ **Measurement in-situ, detector by detector**

→ **No more quenching factor systematic**

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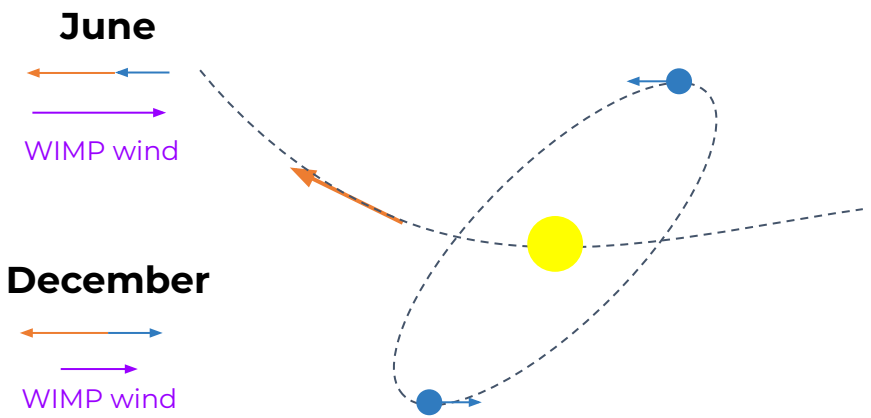
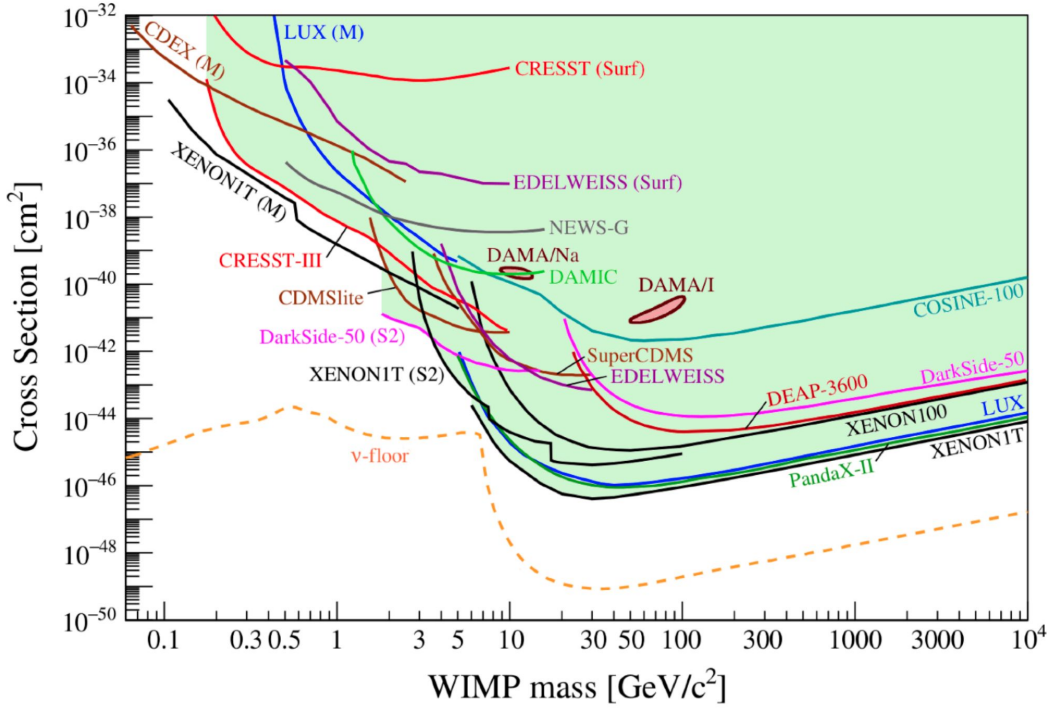
Based on arXiv:2003.04545



Astroparticle Physics European Consortium (APPEC), v1.02



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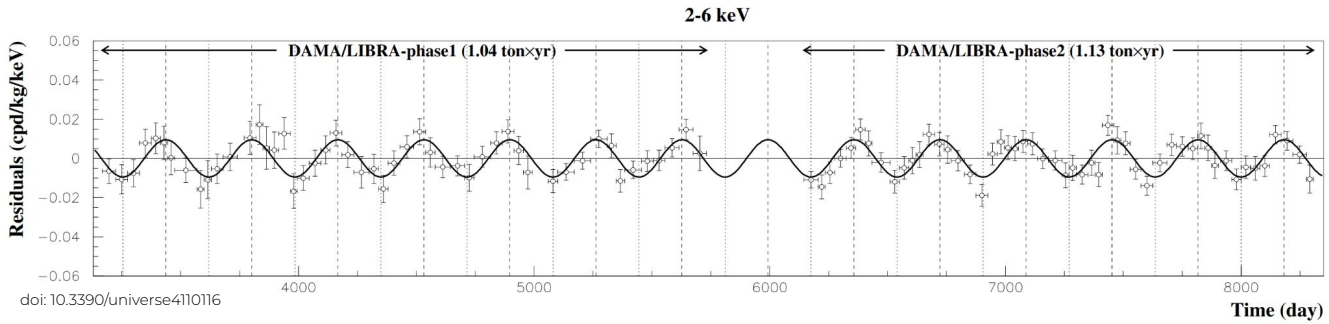

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