

RARE EVENT SEARCHES

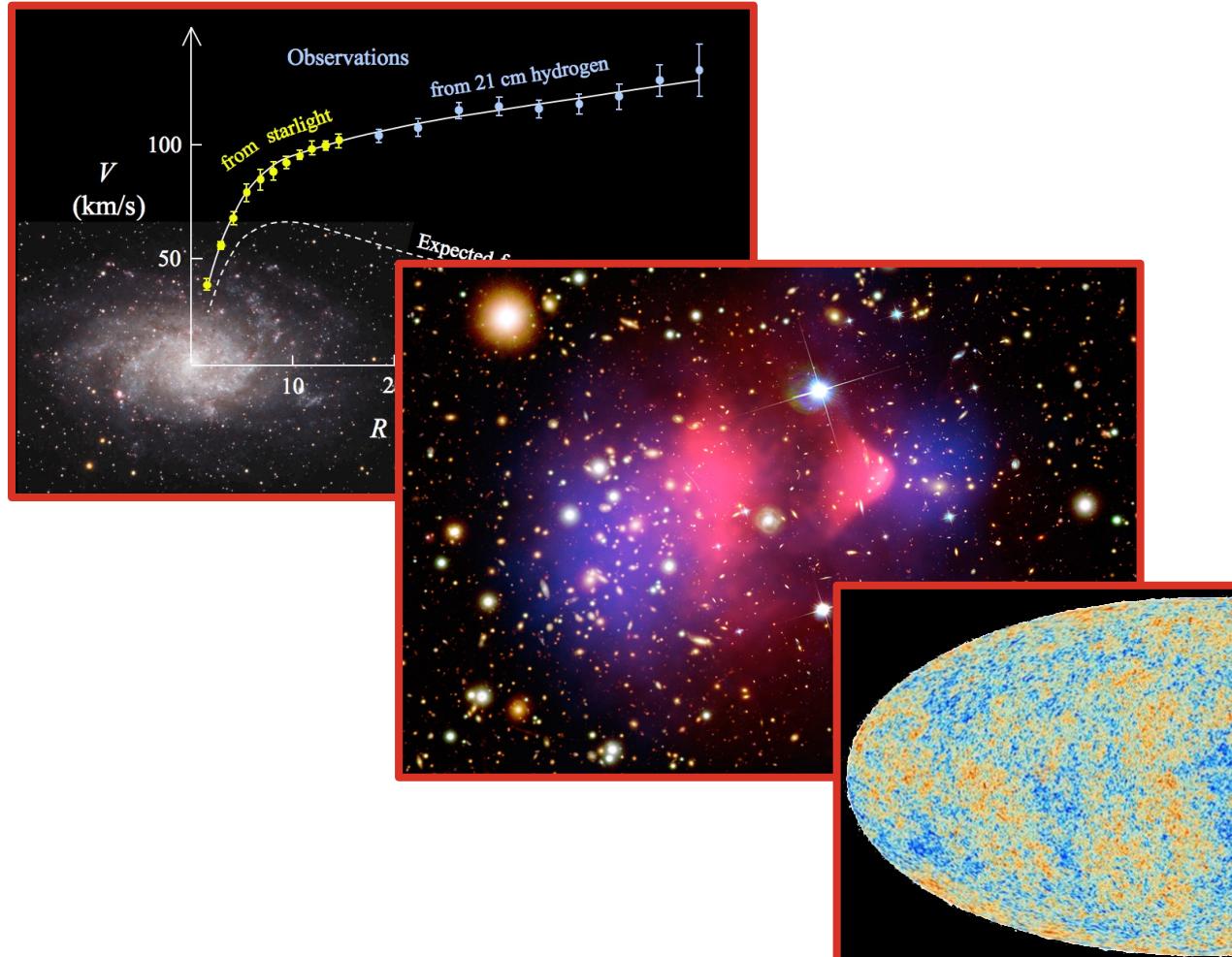
@HEPHY / TU WIEN

16.12.2024

Statistical Methods of Data Analysis

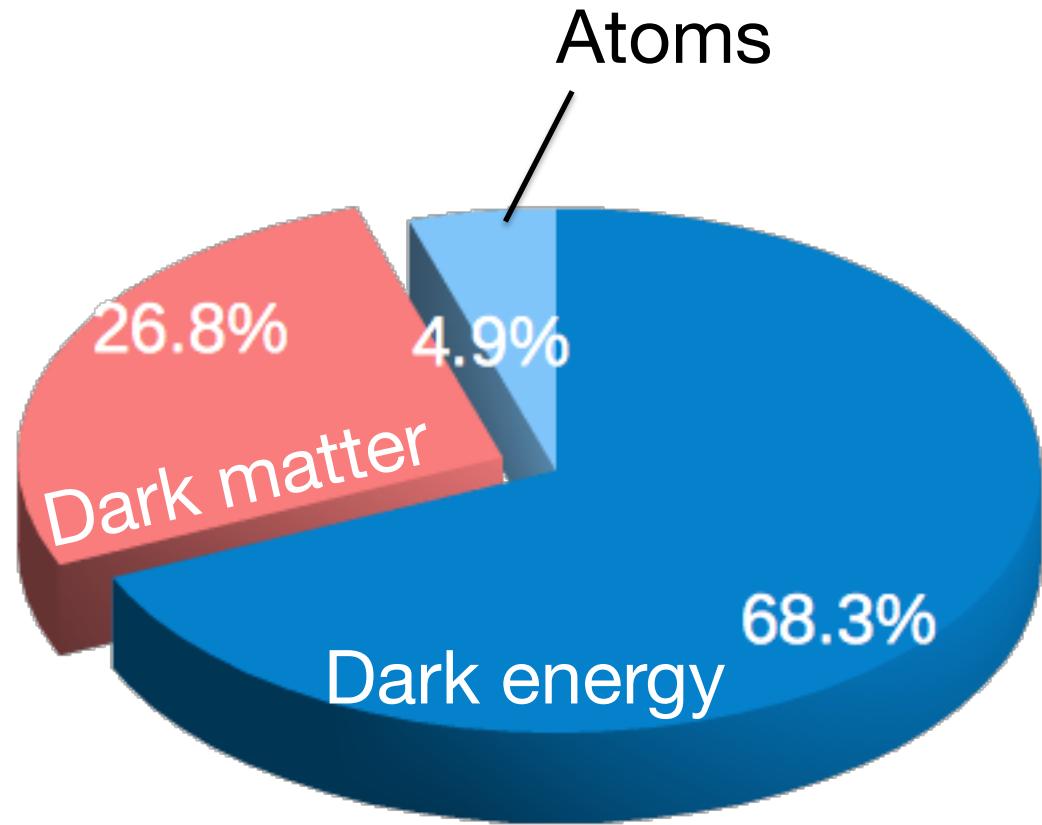
Philipp Schreiner and Florian Reindl, HEPHY & TU Wien

EVIDENCE FOR DARK MATTER



Compelling evidence for
dark matter on various
cosmological scales

DARK MATTER



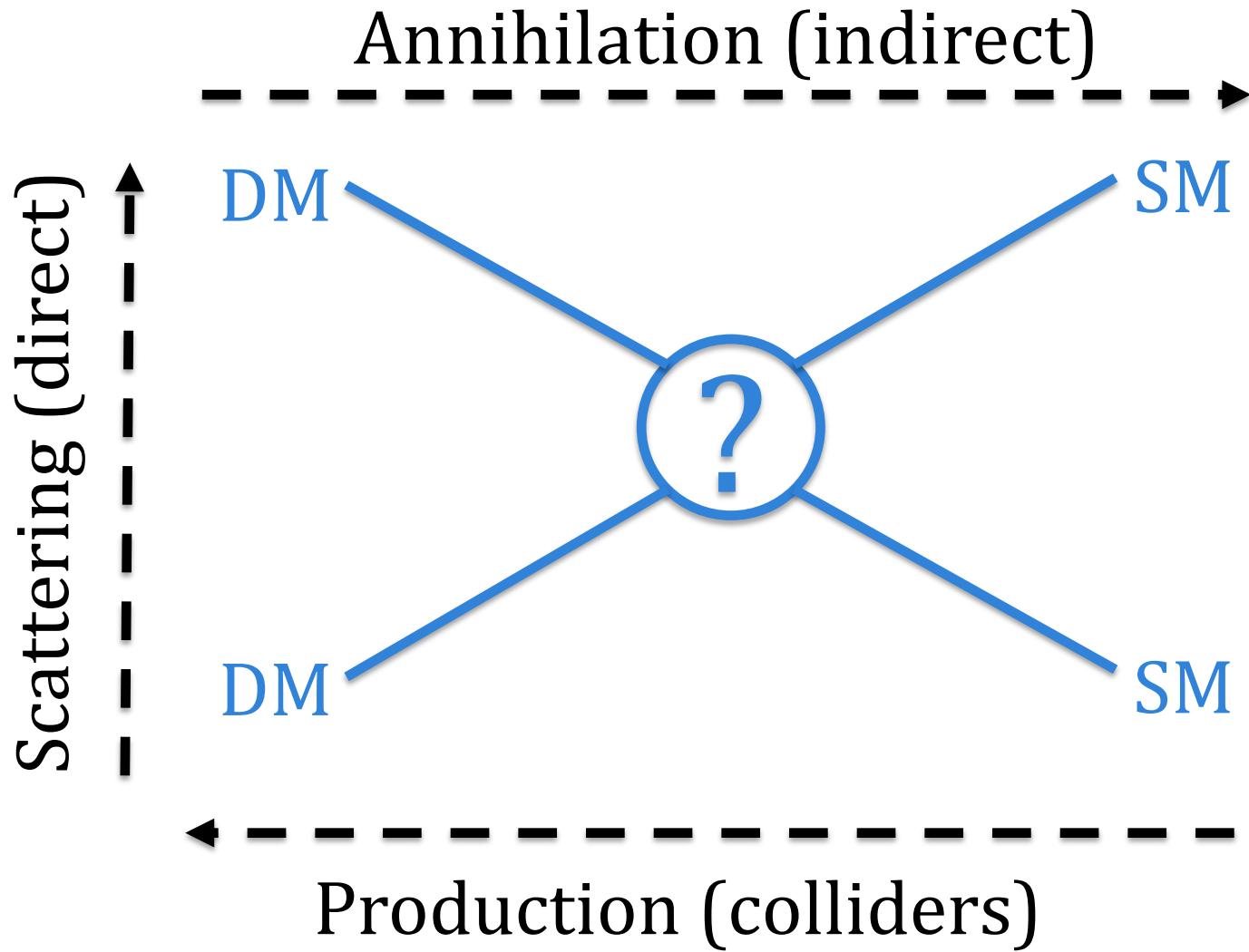
Astronomy

There is a lot of dark matter
in the Universe!

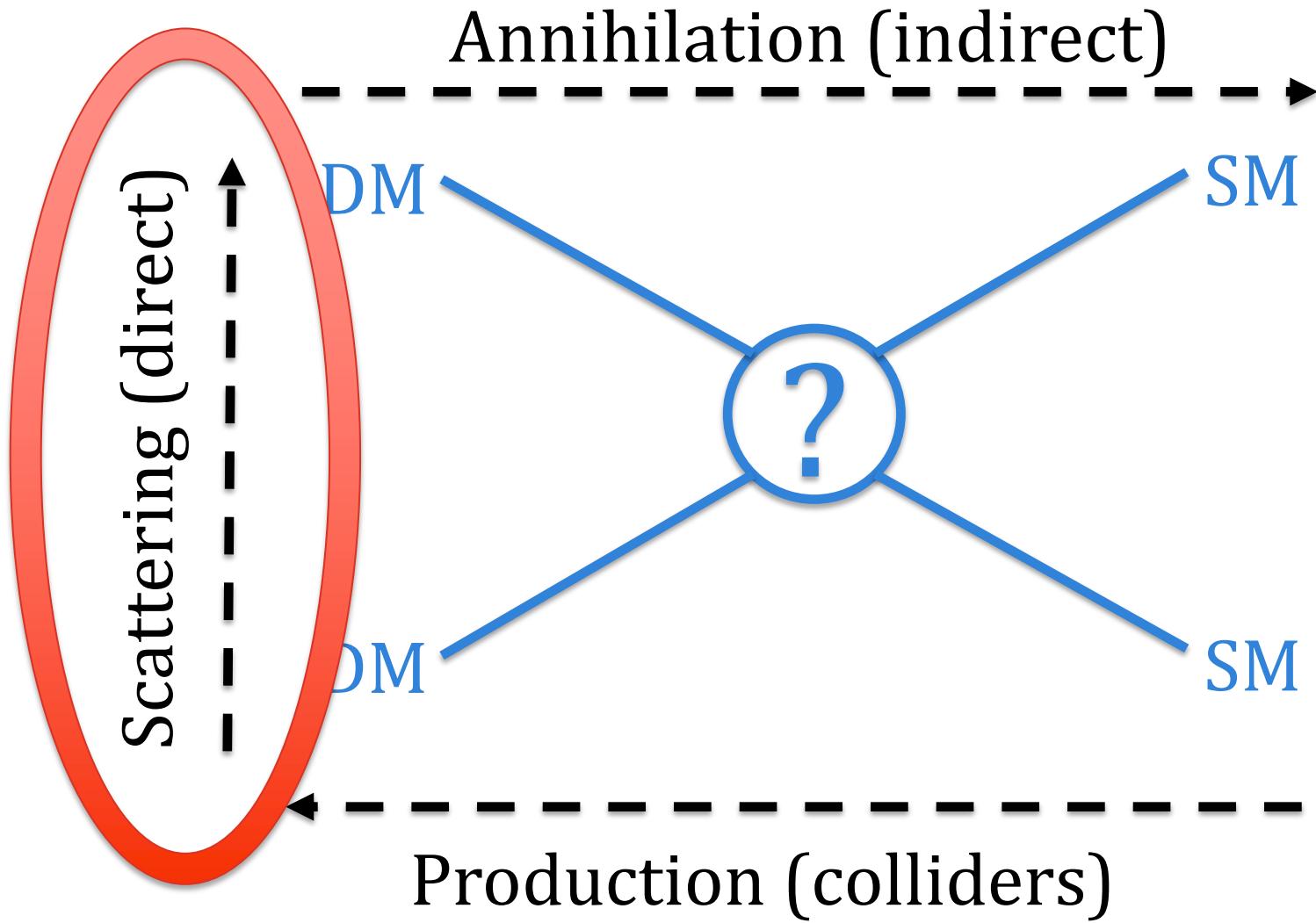
(Astro-) Particle Physics

What is it made of?

HOW TO DETECT DARK MATTER?



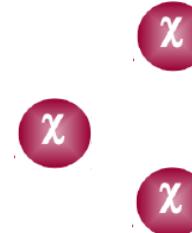
HOW TO DETECT DARK MATTER?



DIRECT DETECTION OF DARK MATTER

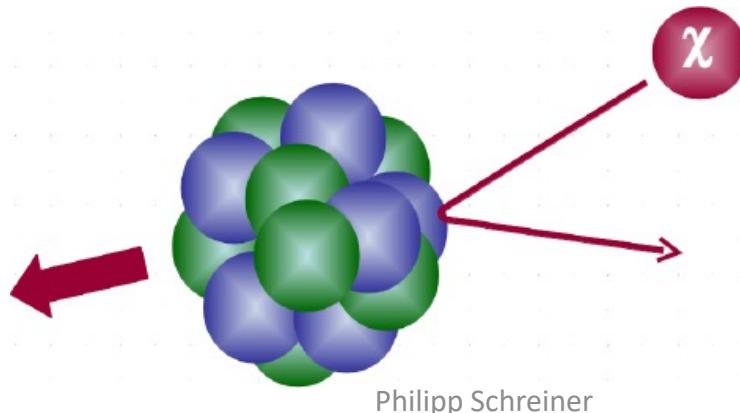
basic idea

dark matter is made of particles
which interact with Standard Model particles



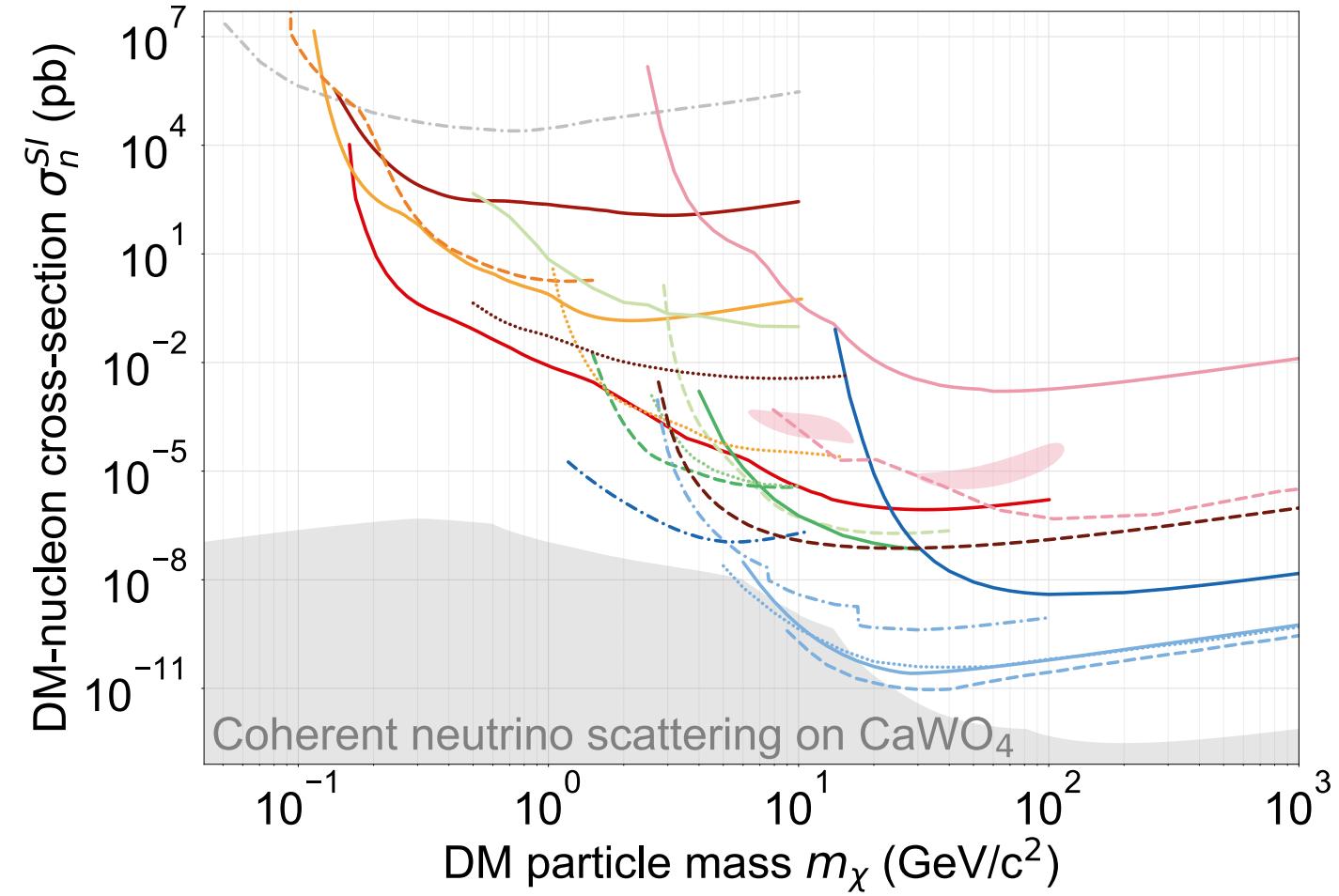
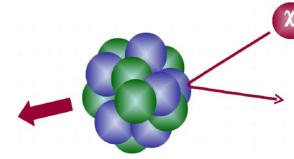
most common

dark matter particles induce nuclear recoils



Philipp Schreiner

STATUS DIRECT DARK MATTER DETECTION



Cryogenic Detectors:

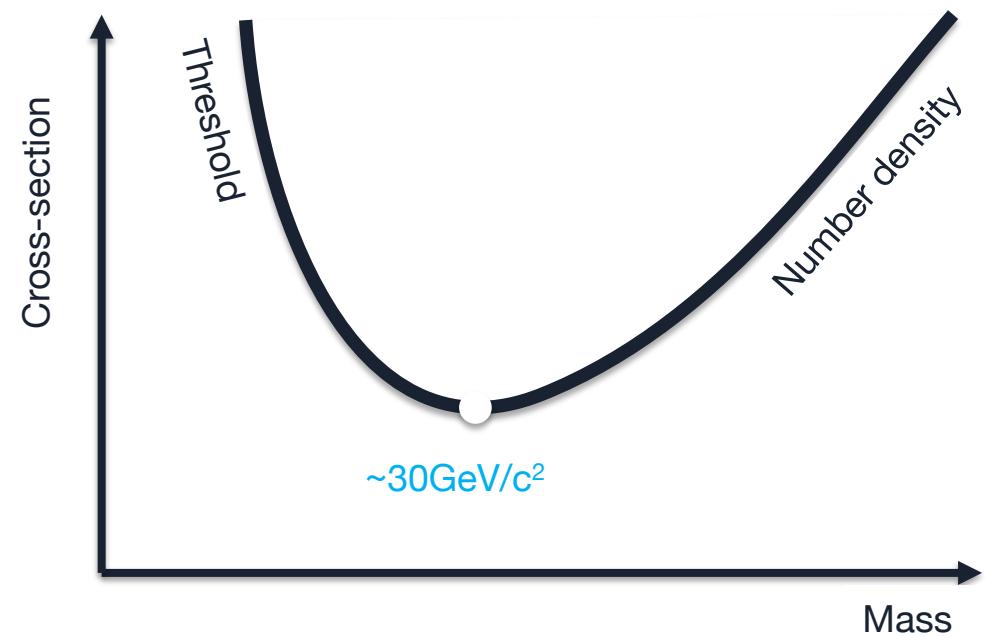
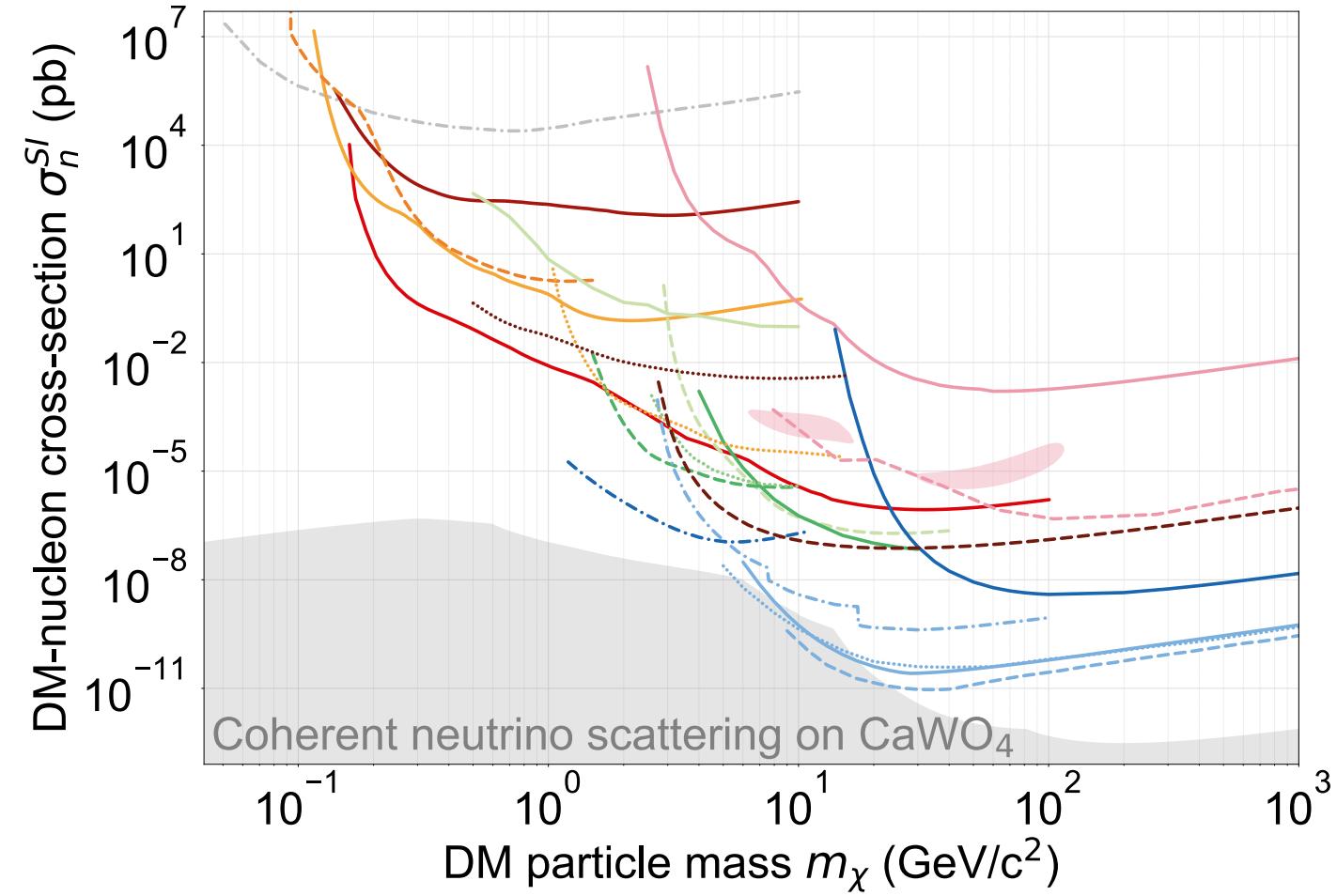
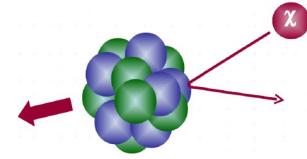
- CRESST-III CaWO₄ 2019
- CRESST-III Si 2023
- CRESST-surf Al₂O₃ 2017
- - SuperCDMS-CPD Si 2020
- - SuperCDMS Ge 2014
- - CDMSLite Ge 2019
- - EDELWEISS-III Ge 2016
- - EDELWEISS-surf Ge 2019
- - COSINUS NaI 2023

Other technologies:

- DEAP-3600 LAr 2019
- ... PandaX-4T LXe 2021
- - LUX-ZEPLIN LXe 2023
- XENONnT LXe 2023
- - XENON1T S2 LXe 2019
- - DarkSide-50 S2 LAr 2023
- - CDEX-10 Ge 2018
- - DAMIC Si 2020
- ... NEWS-G Ne 2018
- - PICO-60 C₃F₈ 2019
- - Collar H 2018
- - COSINE-100 NaI 2021
- DAMA/LIBRA 3σ NaI 2009

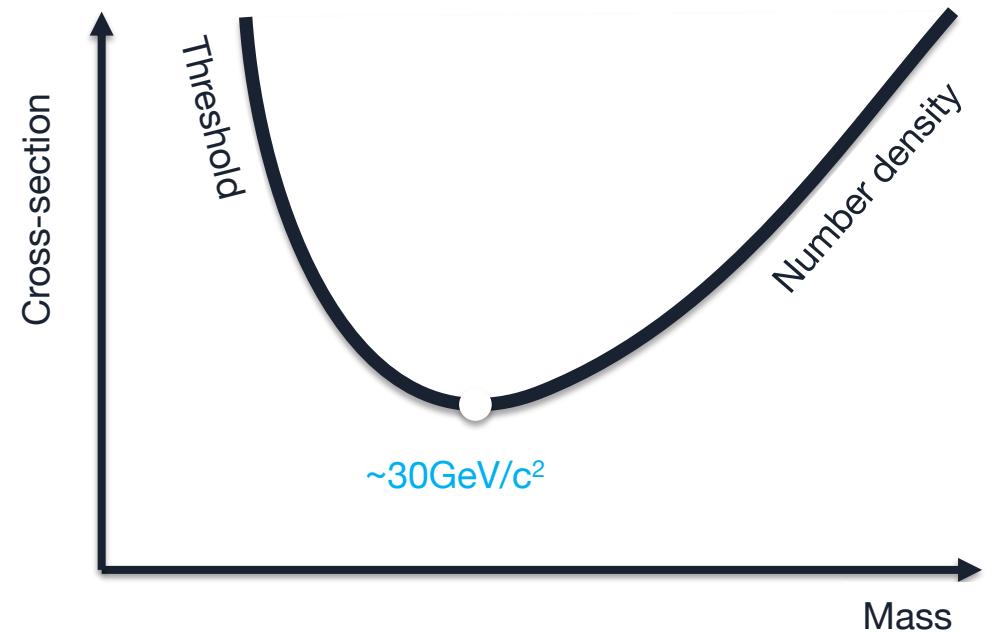
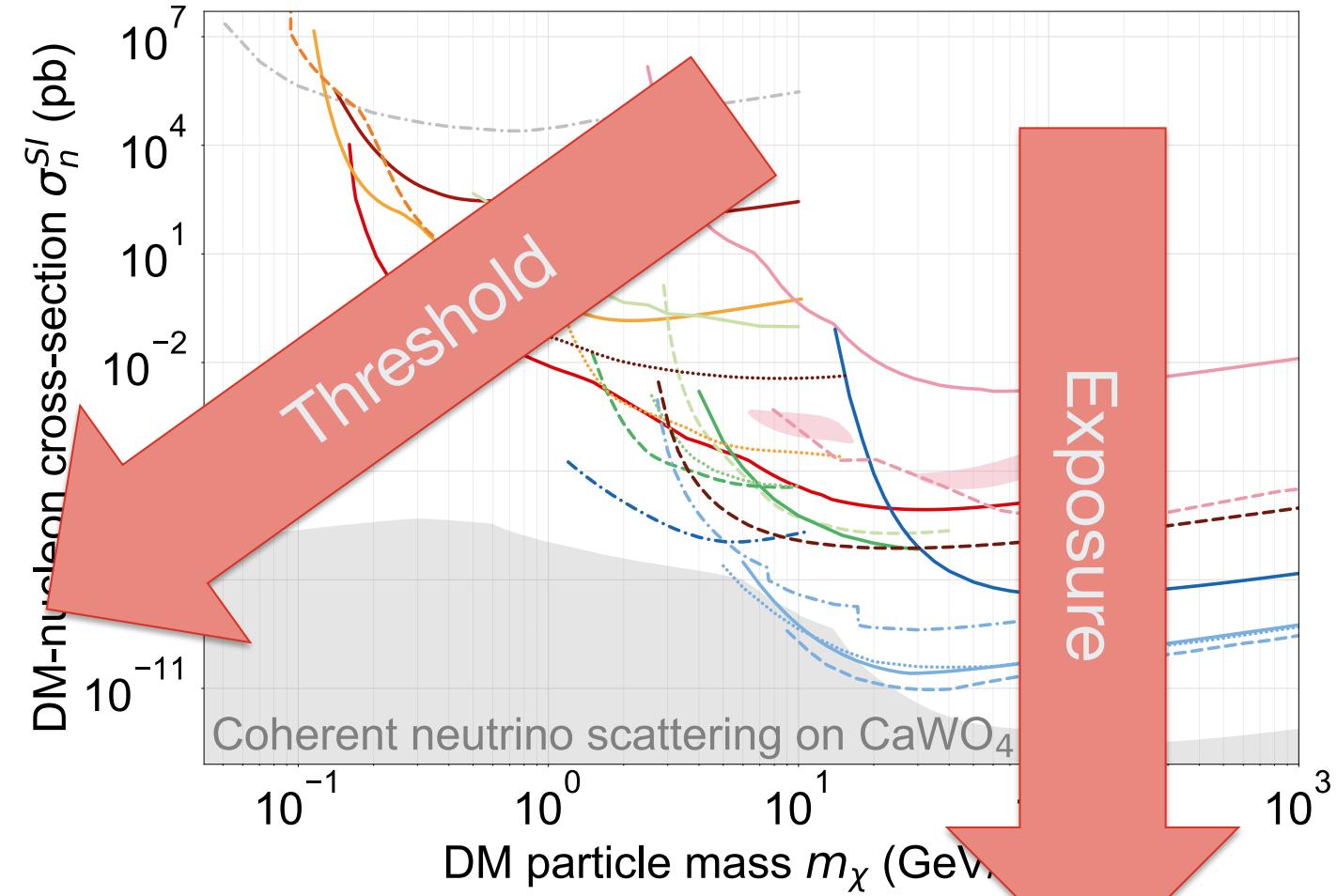
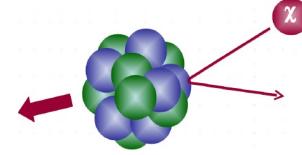
Plot: M. Kaznacheeva, K. Schäffner, Scintillating low-temperature calorimeters for direct dark matter search, to be published

STATUS DIRECT DARK MATTER DETECTION



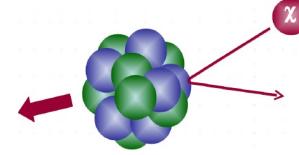
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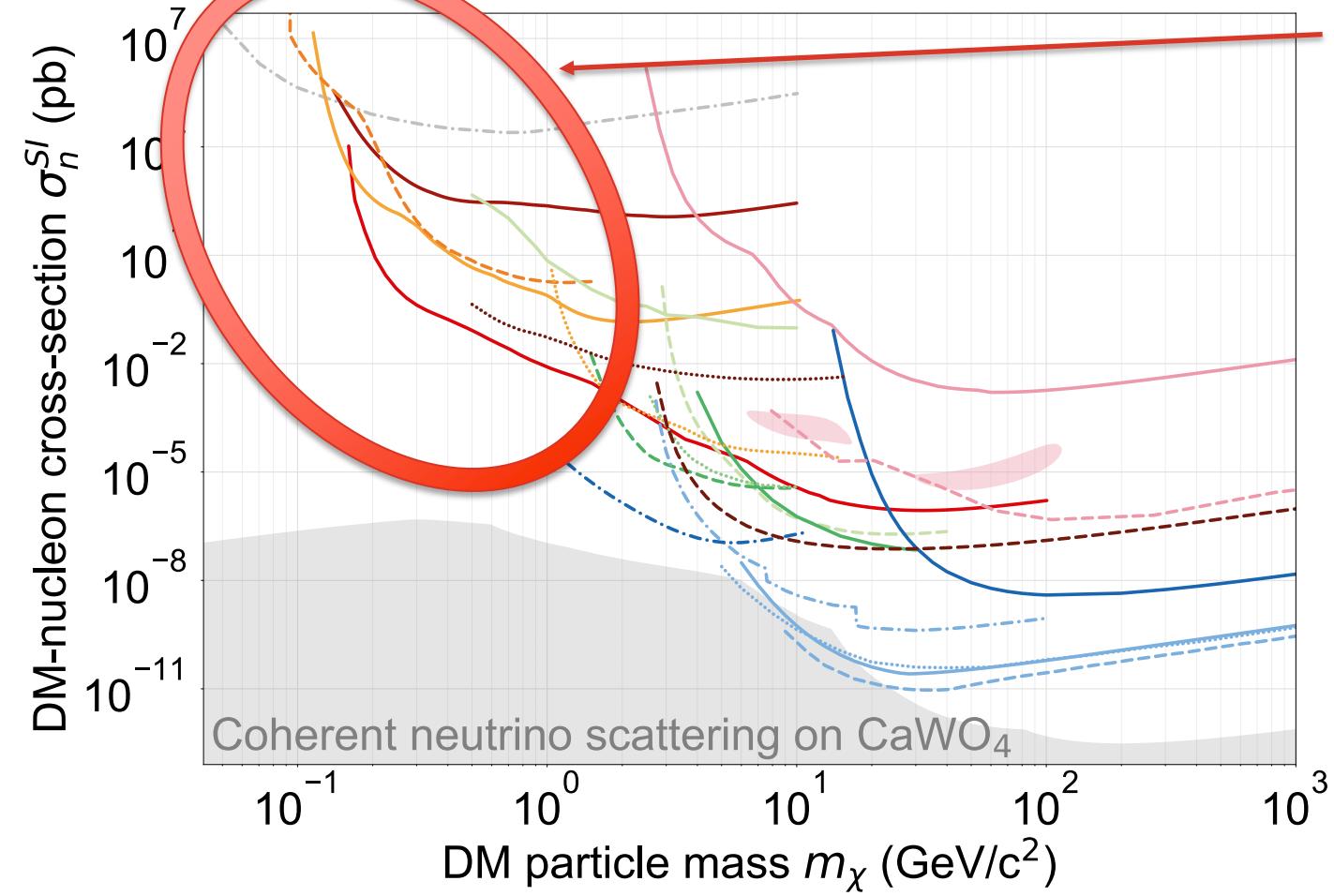


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STATUS DIRECT DARK MATTER DETECTION



Cryogenics



Cryogenic Detectors:

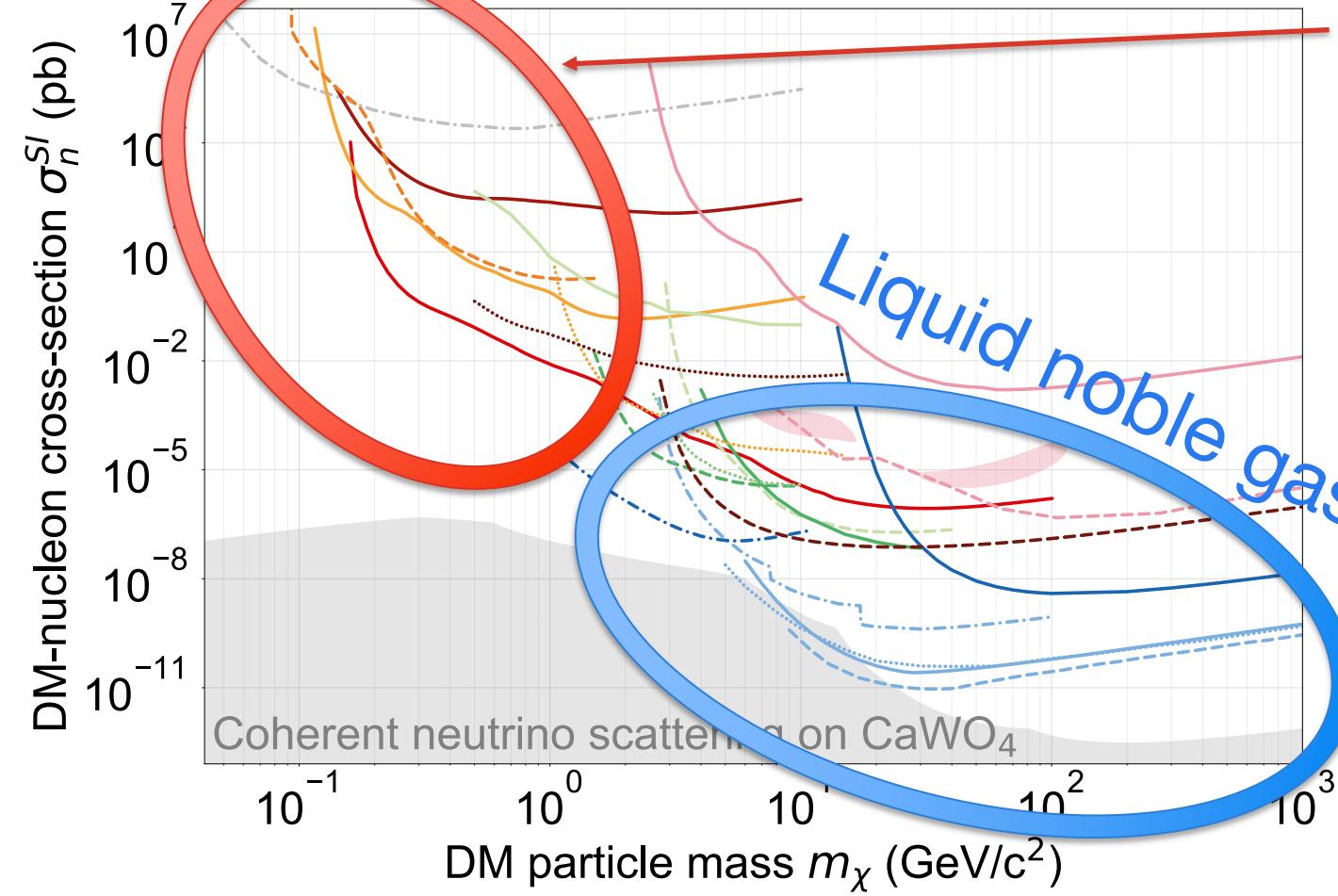
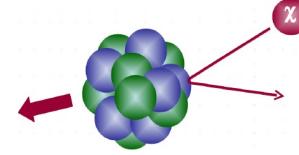
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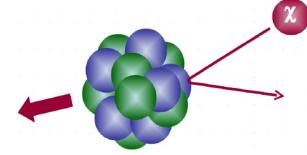
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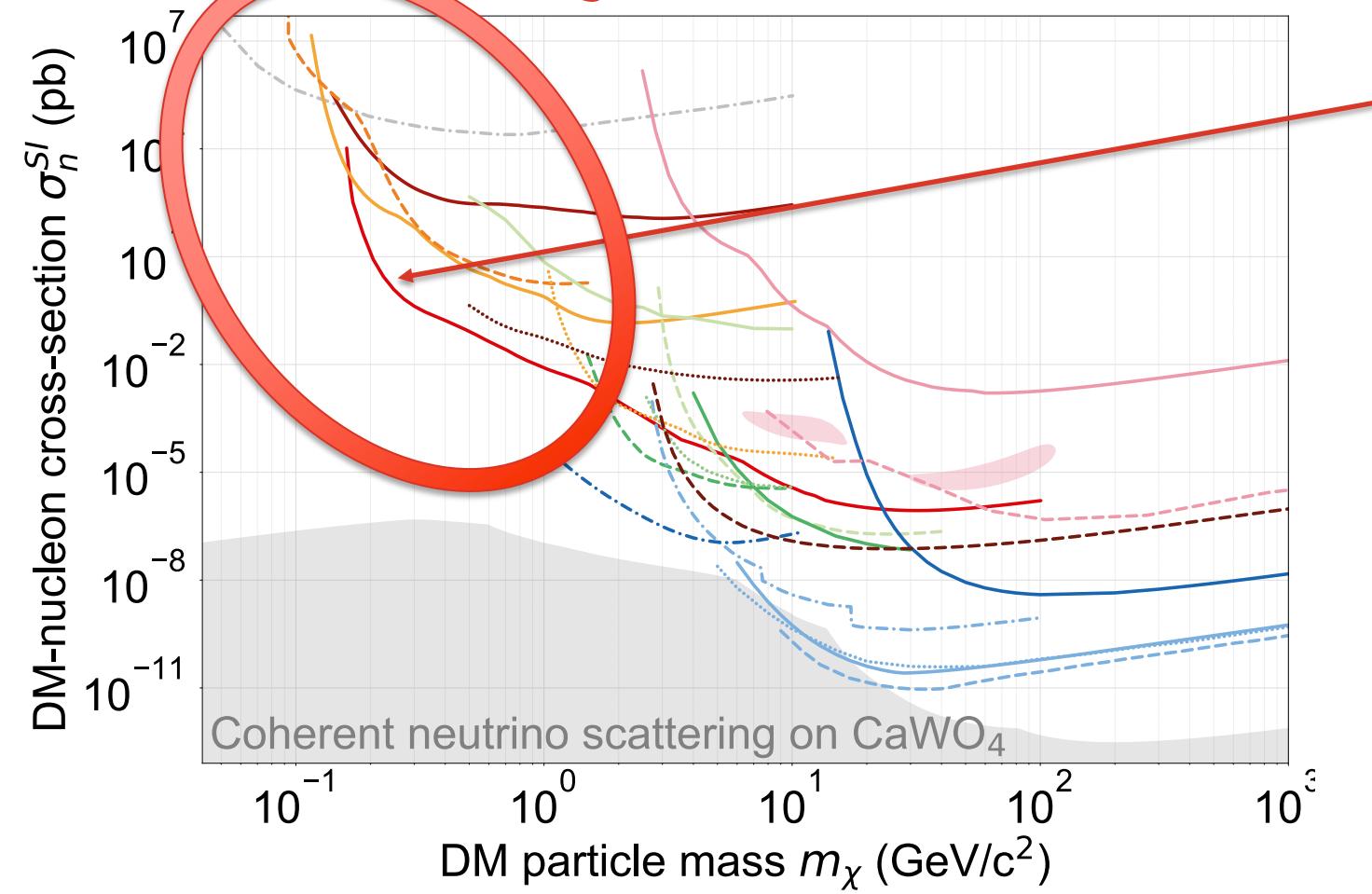
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STATUS DIRECT DARK MATTER DETECTION



Cryogenics

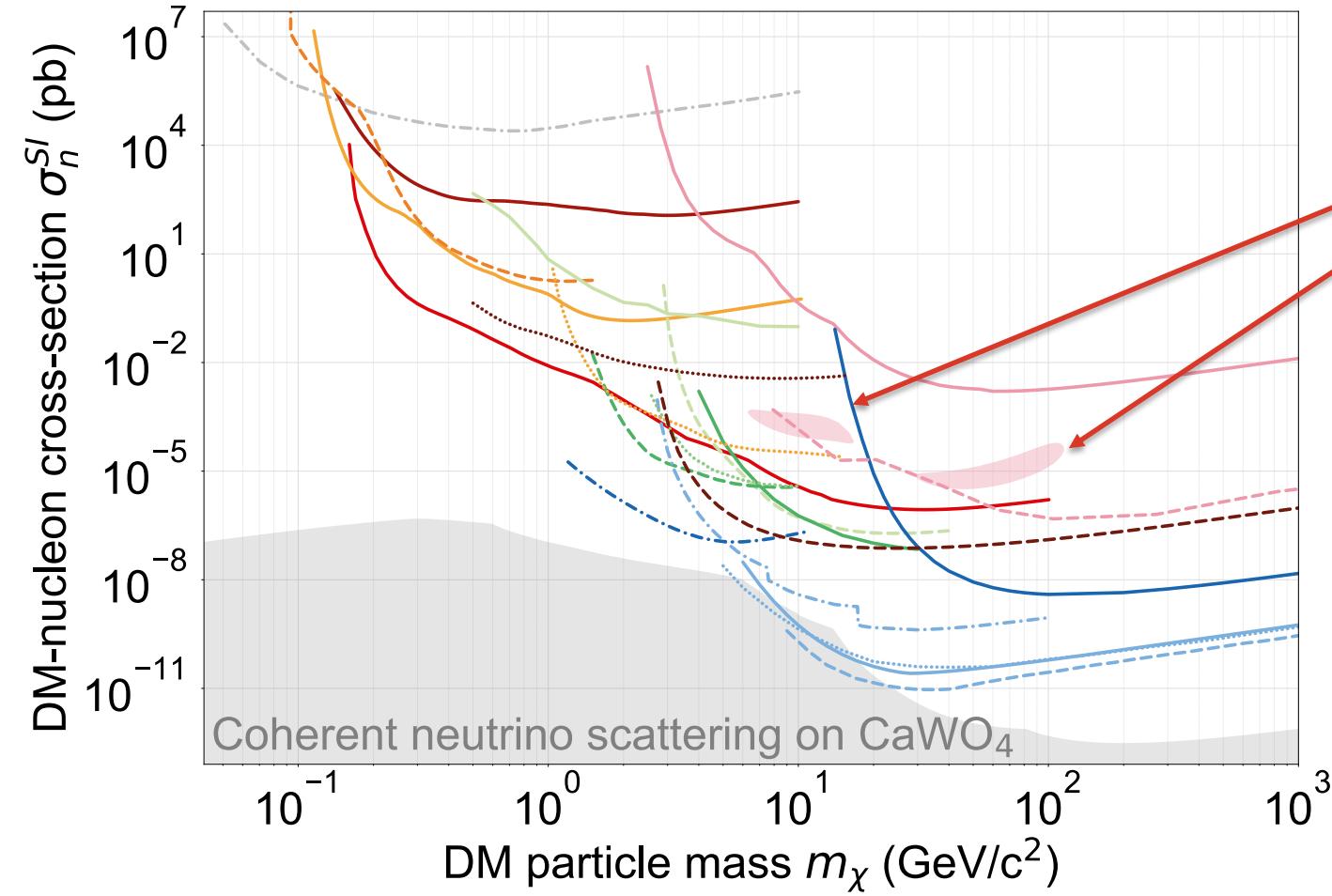
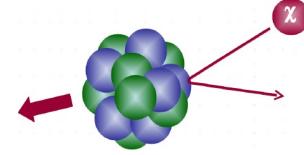


CRESST

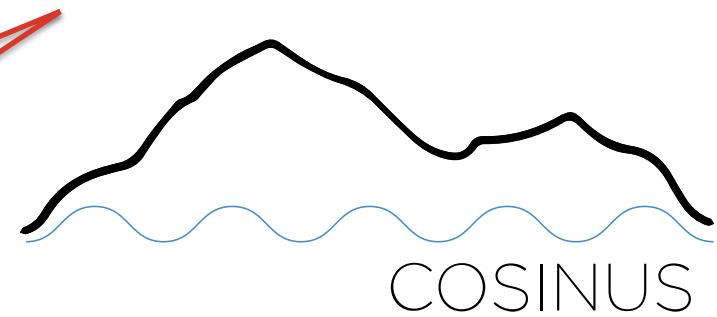
search for light dark
matter with low-
threshold cryogenic
detectors

Plot: M. Kaznacheeva, K. Schäffner, Scintillating low-temperature calorimeters for direct dark matter search, to be published

STATUS DIRECT DARK MATTER DETECTION



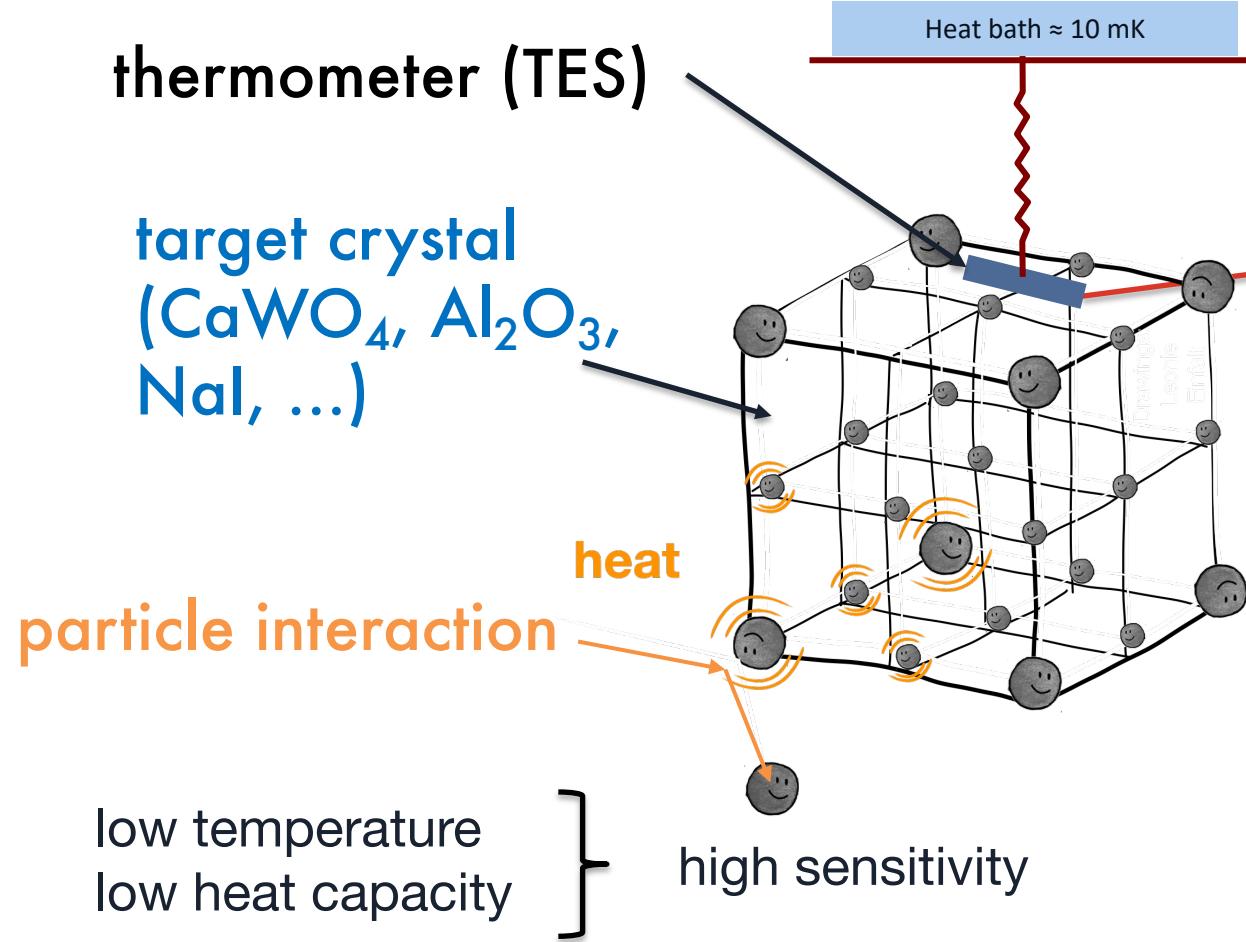
DAMA: strong DM claim (13.7σ)



clarify the DAMA claim in a
model-independent way
using a same-material
(NaI) cryogenic detector

Plot: M. Kaznacheeva, K. Schäffner, Scintillating low-temperature calorimeters for direct dark matter search, to be published

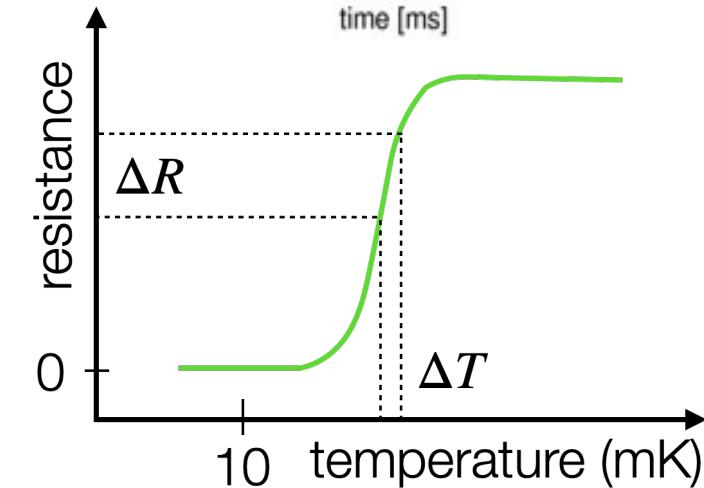
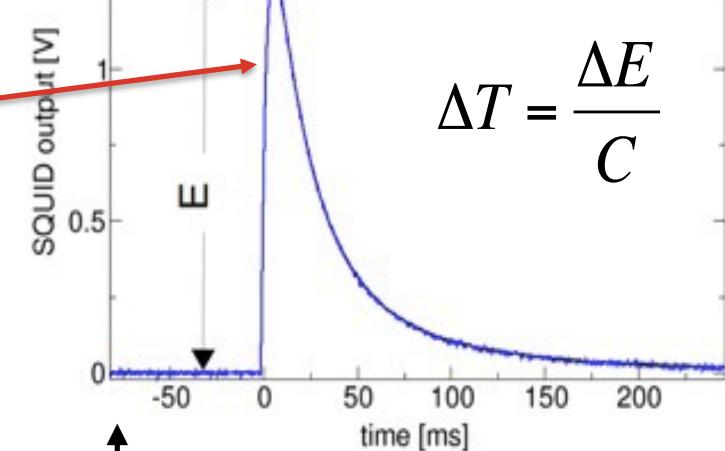
CRYOGENIC DETECTOR



16.12.2024

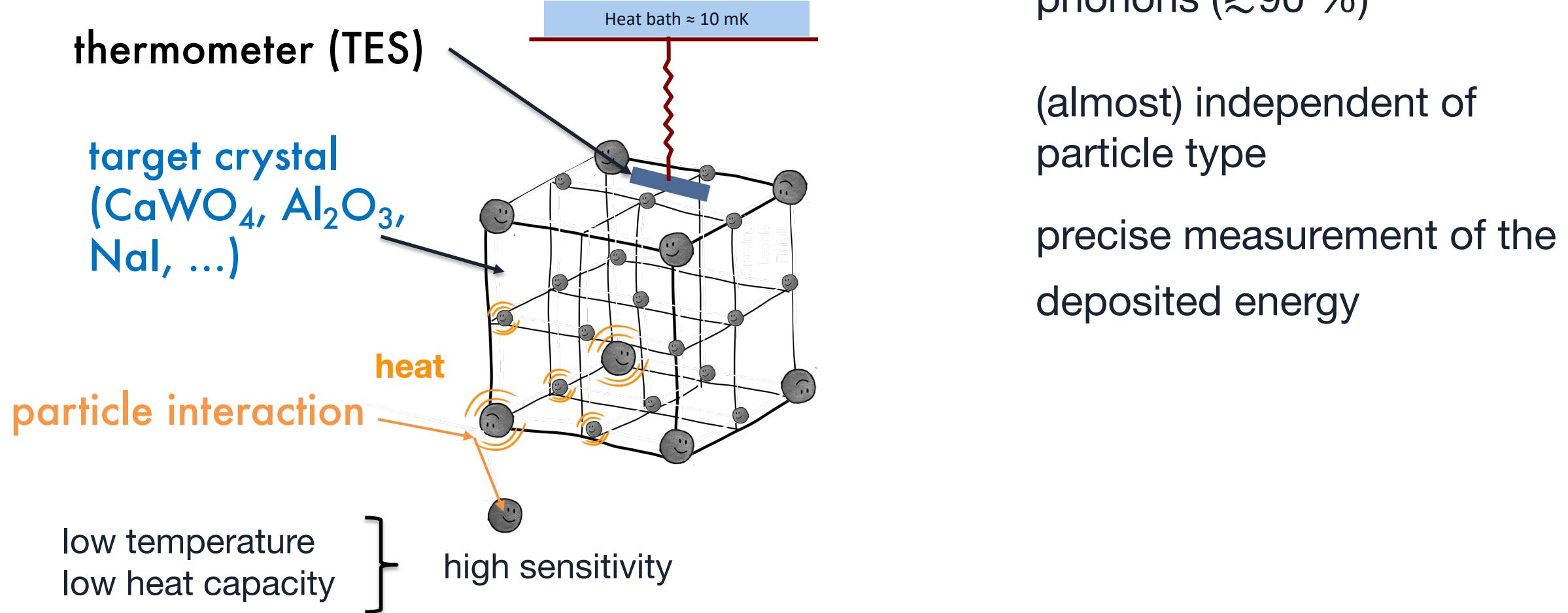
Philipp Schreiner

temperature pulse

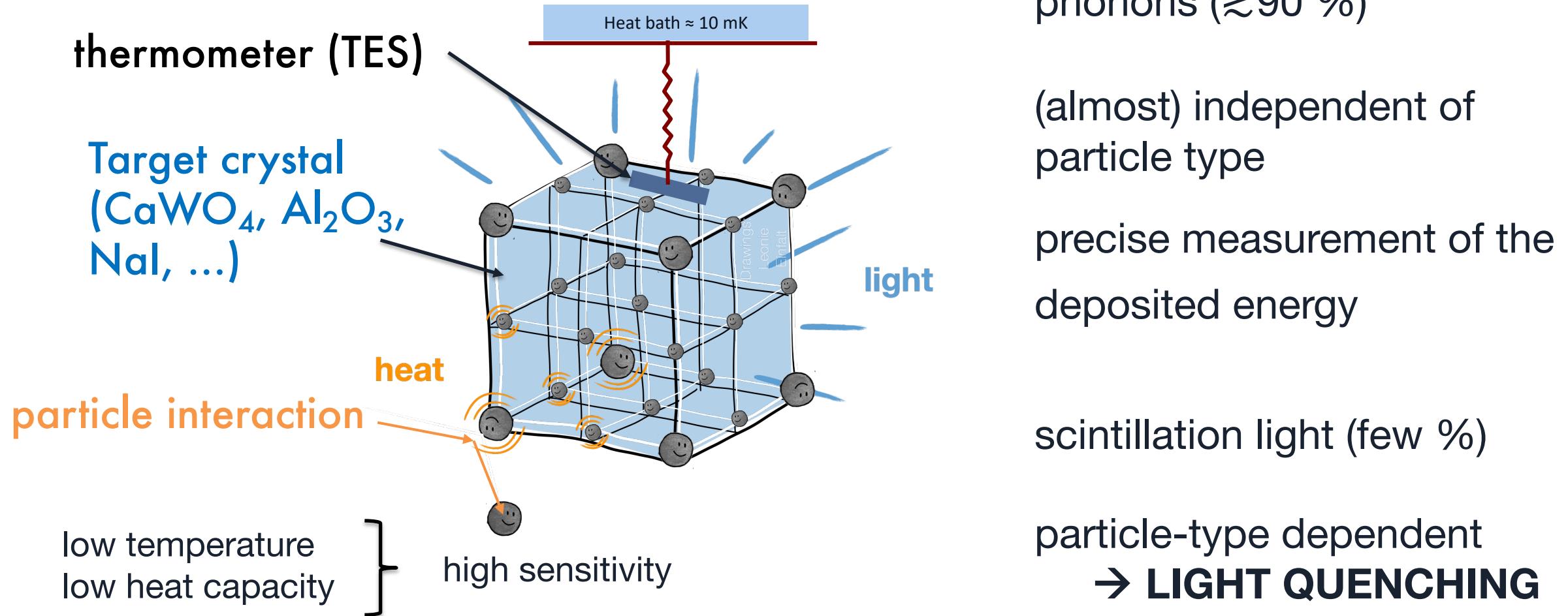


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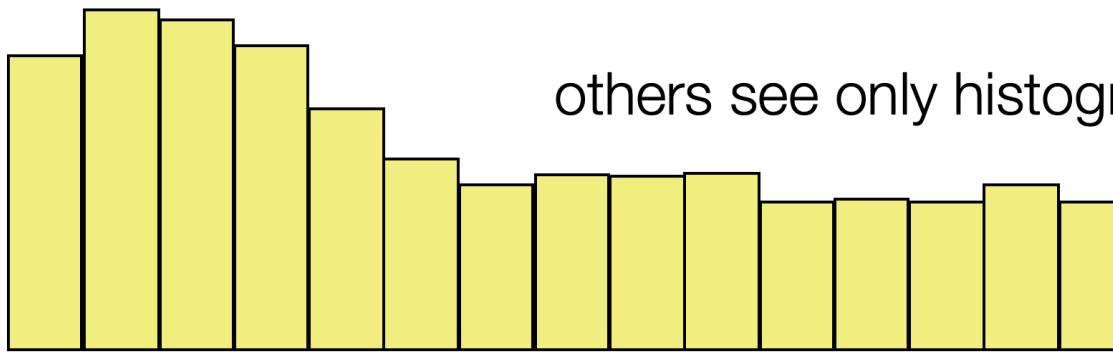
CRYOGENIC DETECTOR



SCINTILLATING CALORIMETER

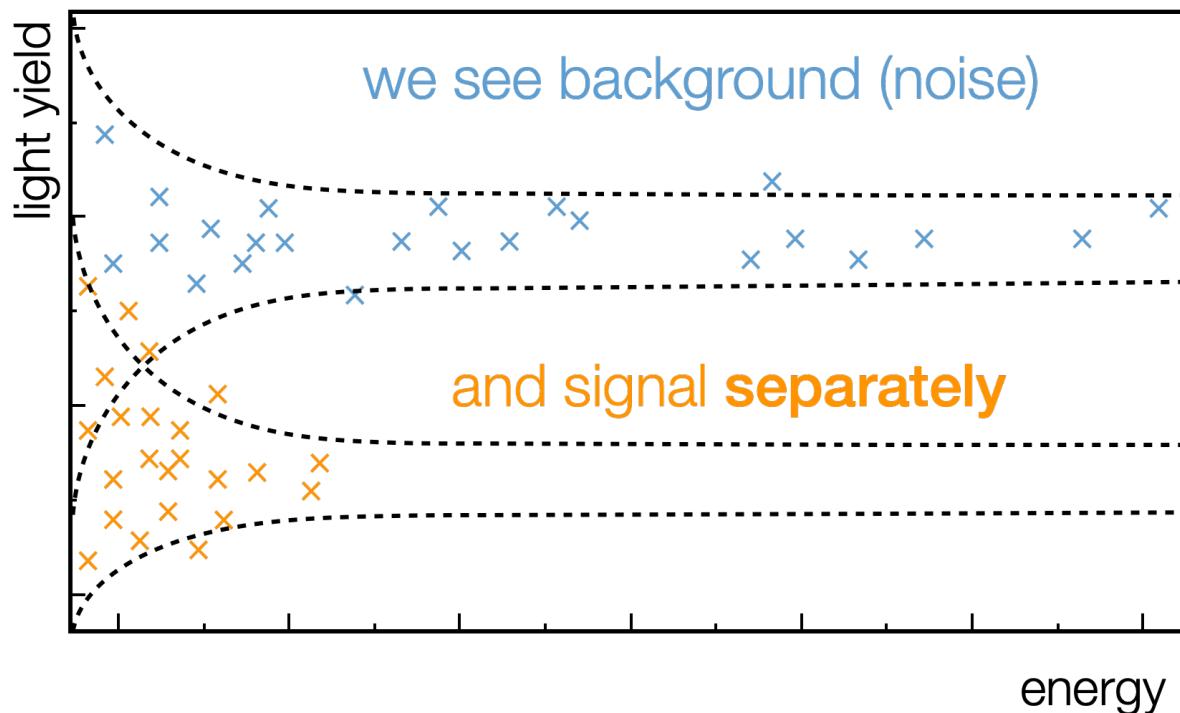


THE CRUCIAL DIFFERENCE



others see only histogram

experiments (like DAMA/LIBRA)
which read only one channel

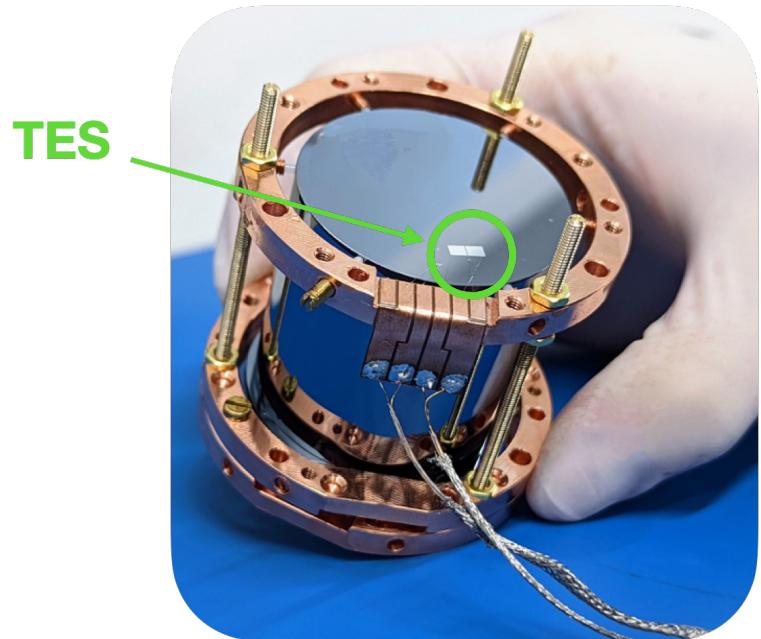


experiments (like COSINUS
and CRESST) who read two
channels

scintillating NaI crystal



COSINUS detector module



16.12.2024

COSINUS test
cryostat in
Munich



Philipp Schreiner

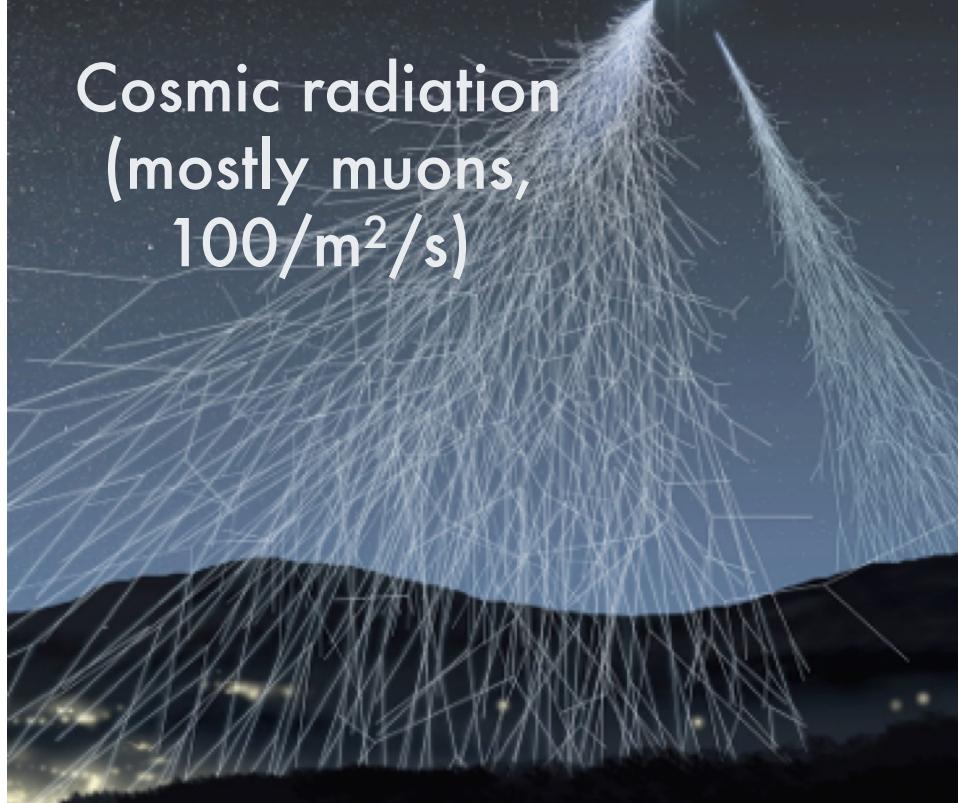
lots of shielding

COSINUS
cryostat at
LNGS



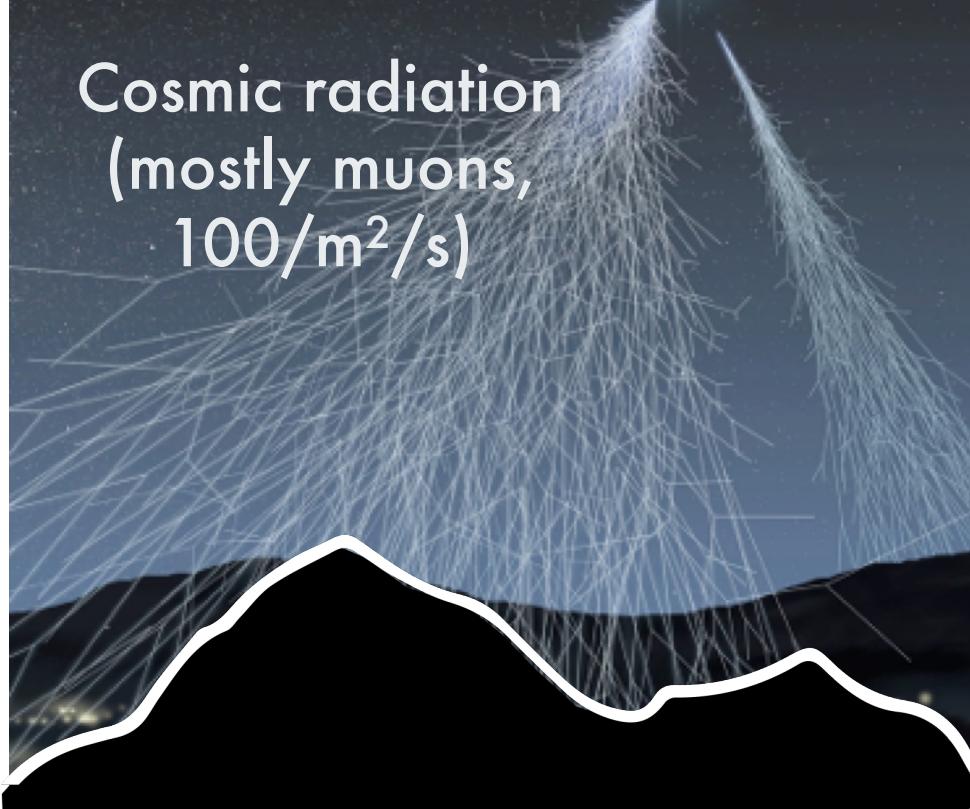
18

SENSITIVE DETECTOR - BLESSING AND CURSE



SENSITIVE DETECTOR = BLESSING AND CURSE

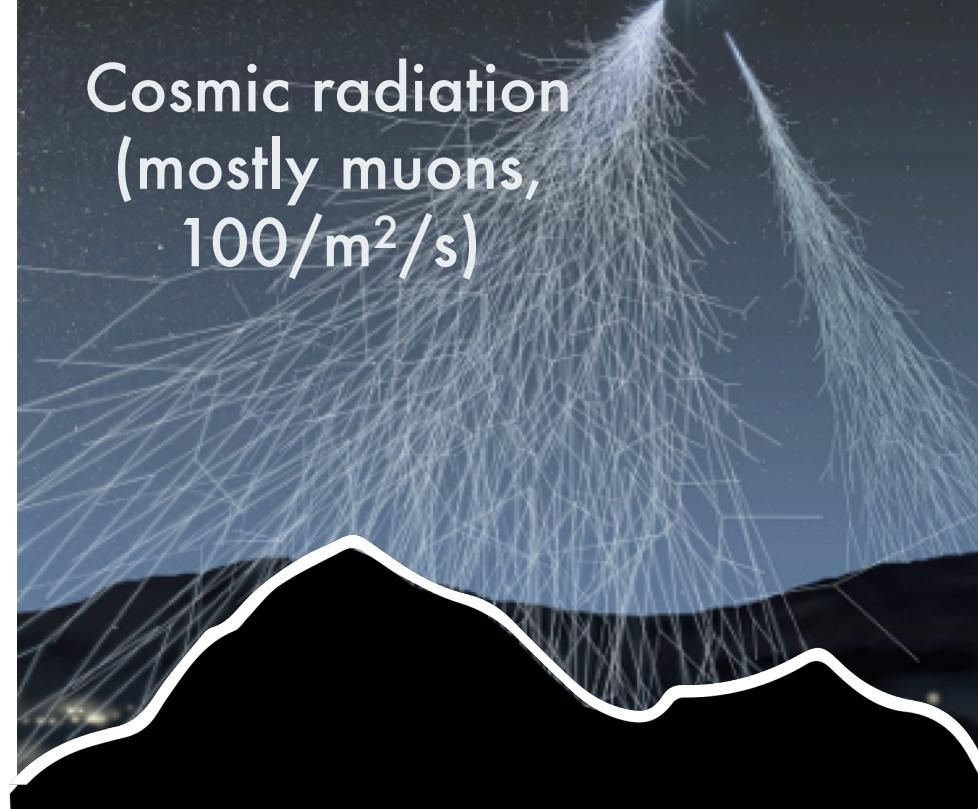
roughly factor
1 Mio. less muons



natural
radioactivity
(neutrons,
gammas)

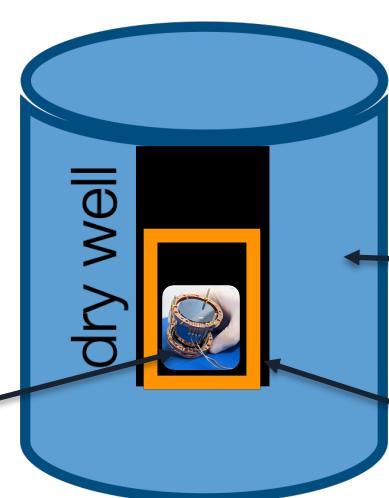
SENSITIVE DETECTOR

= BLESSING AND CURSE



roughly factor
1 Mio. less muons

detector in center of
shielding

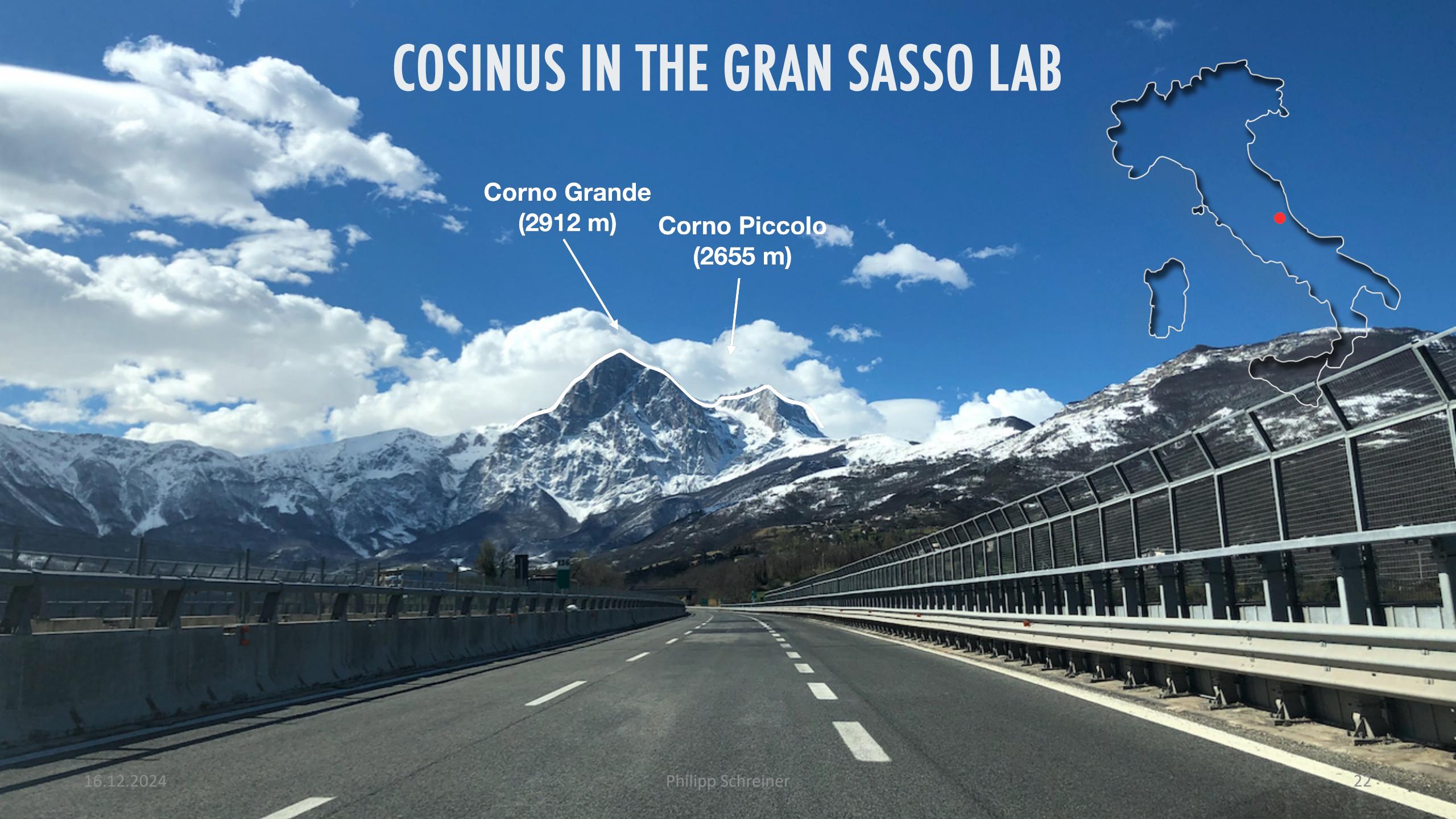


natural
radioactivity
(neutrons,
gammas)

water tank to moderate
neutrons (and veto muons)

copper shield to stop gammas

COSINUS IN THE GRAN SASSO LAB



Corno Grande

(2912 m)

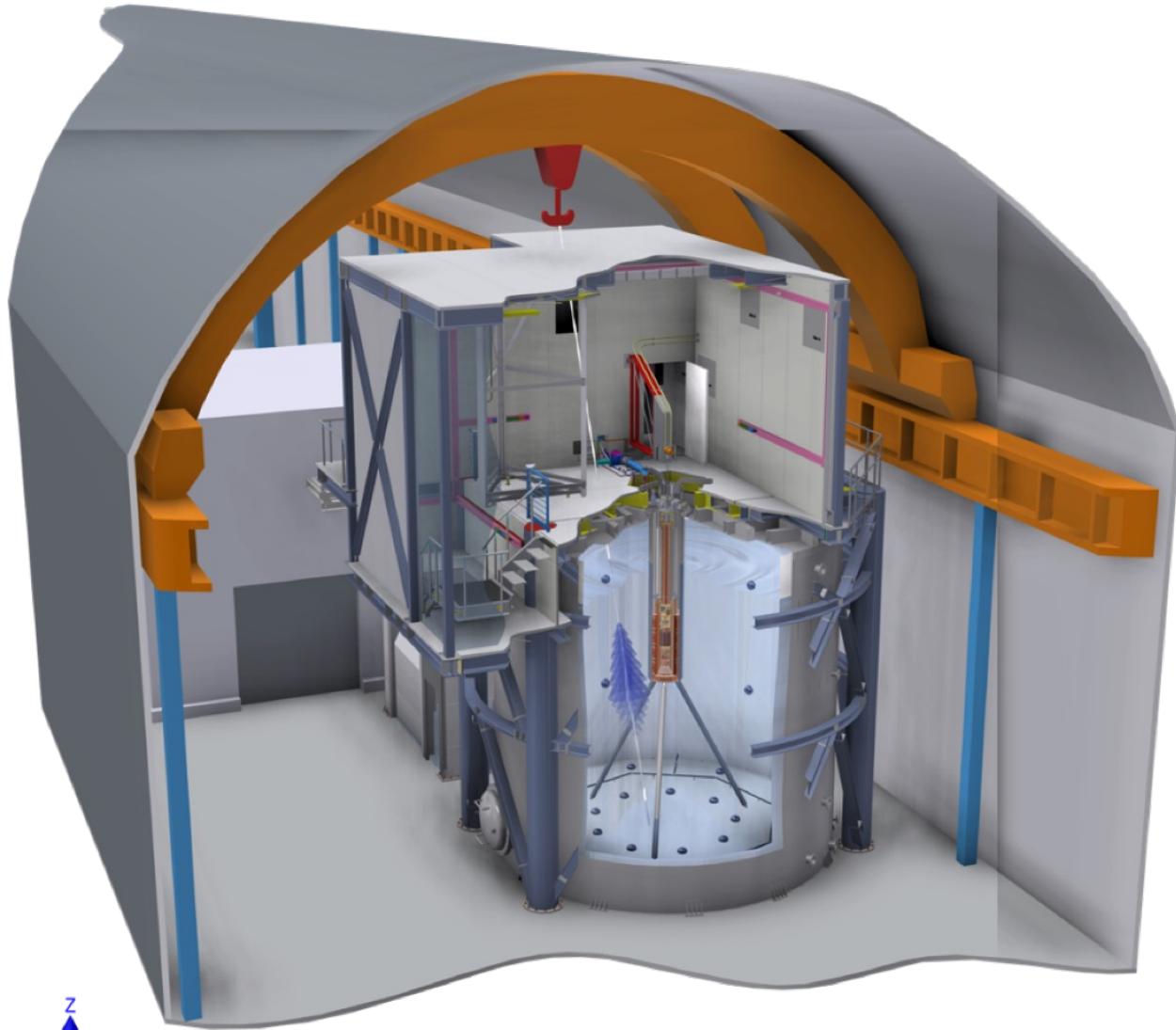
Corno Piccolo

(2655 m)

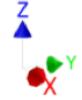
COSINUS IN THE GRAN SASSO LAB



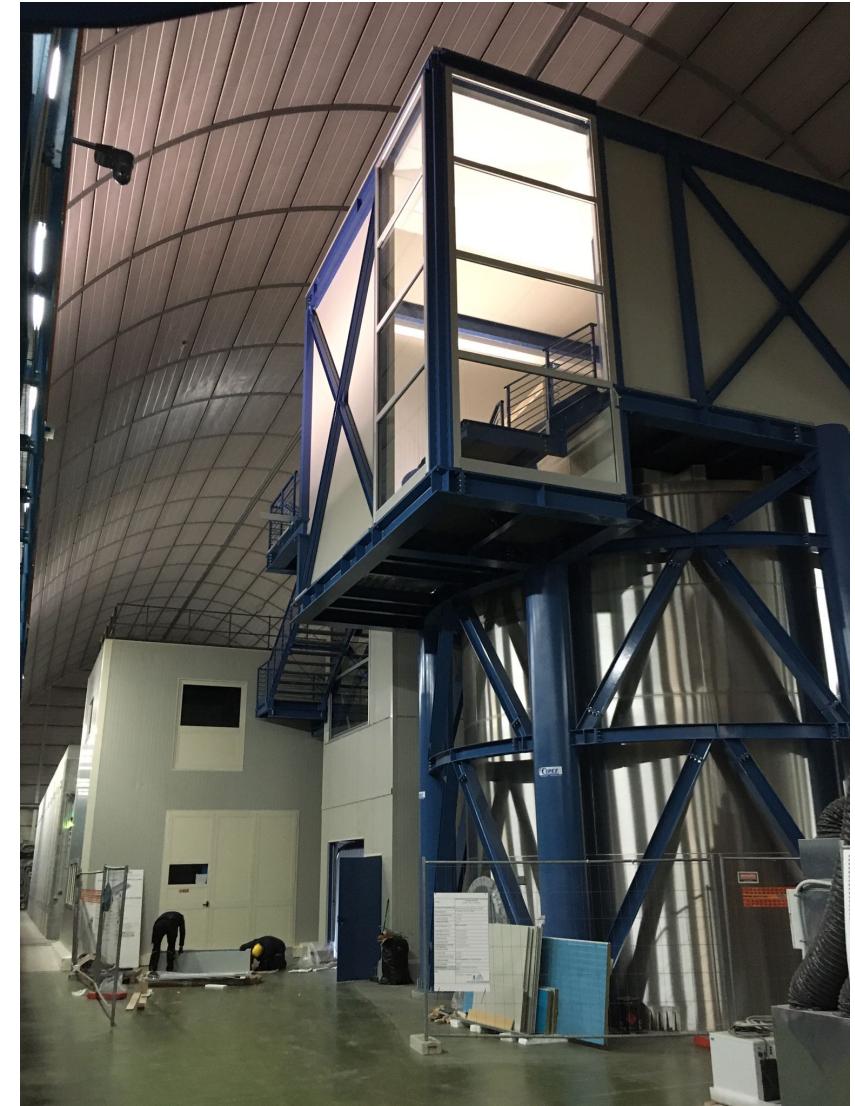
COSINUS EXPERIMENTAL SITE



16.12.2024

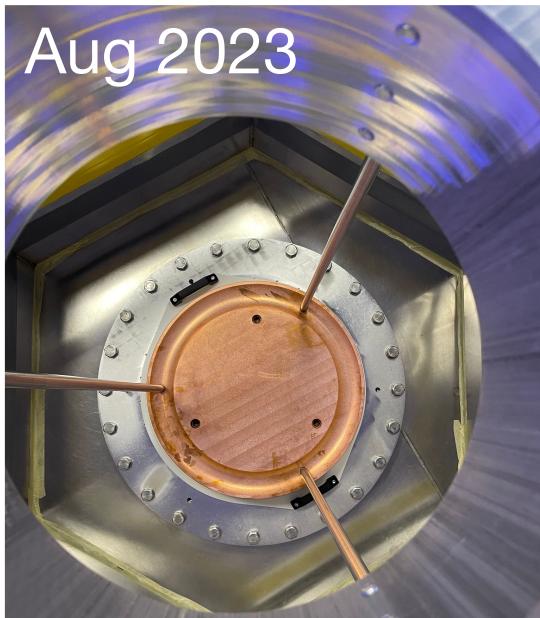
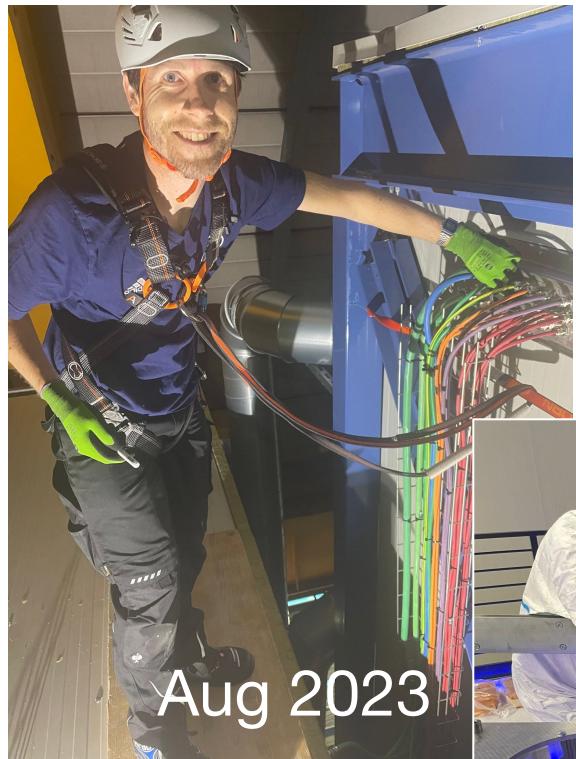


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RECENT COSINUS UPDATES



RECENT COSINUS UPDATES



Mar 2024



Aug 2024

RECENT COSINUS UPDATES



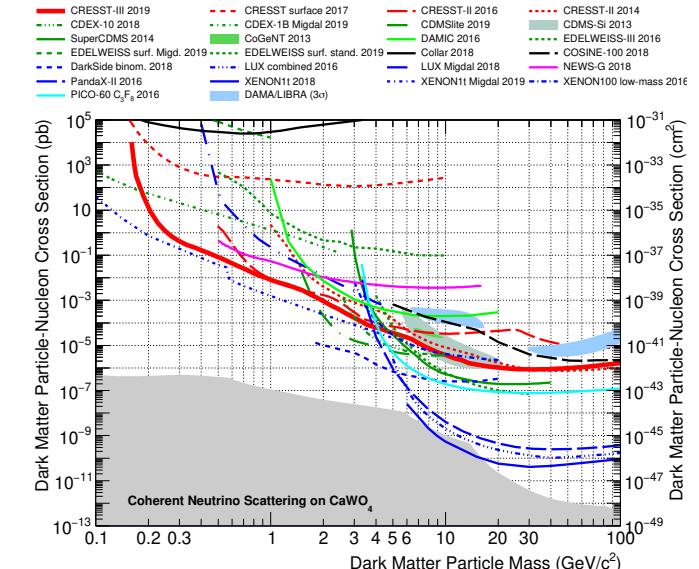
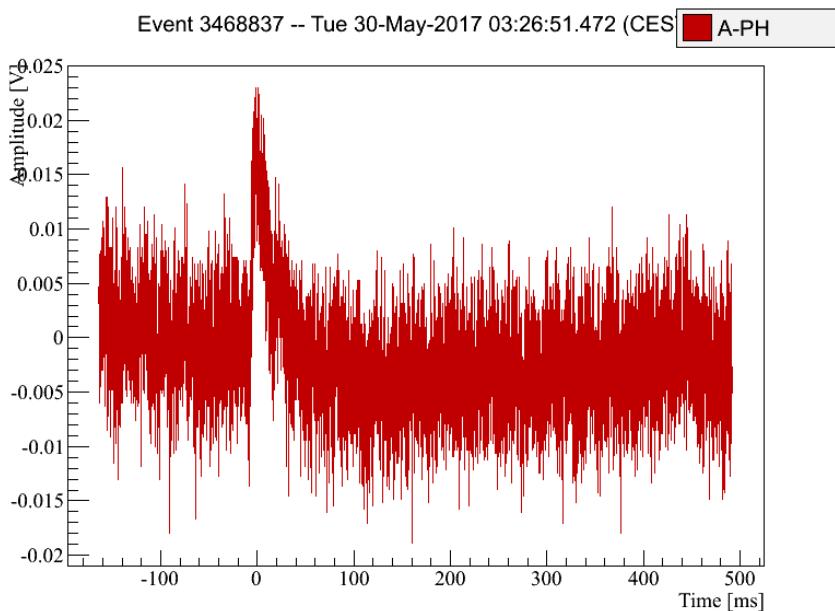
April 2024

The collage includes:

- A news article from "1400 METER UNTER DER ERDE" titled "Neues Experiment im weltgrößten Untergrundlabor soll Dunkle Materie finden". It discusses the start of an experiment at the Gran-Sasso facility to detect dark matter.
- A news article from "16 | Österreich" titled "Der eiskalte Griff nach der Dunklen Materie". It features a photo of Philipp Schreiner working in a lab.
- A news article from "COSINUS-EXPERIMENT AM START" titled "Auf der Suche nach der kosmischen Schattenwelt". It shows a star-filled galaxy image.

ACTIVITIES OF THE GROUP

All analysis steps from raw signal to final result



+ Monte Carlo simulations, electronics ...

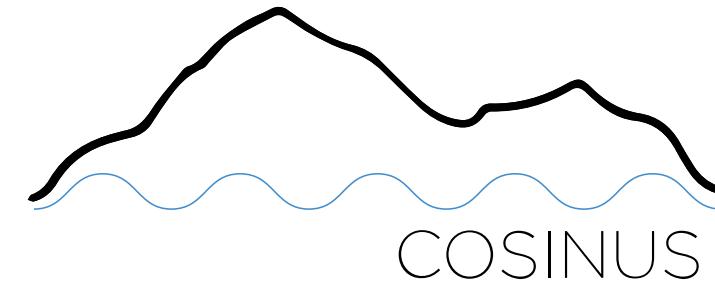
CRESST AND COSINUS



search for light dark matter with
low-threshold detectors

currently taking data

~45 scientists



clarification of the DAMA dark
matter claim

start of data taking in 2025

~25 scientists

If you want to work with us, please contact:
Prof. Jochen Schieck and/or **Prof. Florian Reindl**

Potential theses:

- muon veto calibration
- detector combination (statistics)**
- wavelet filtering
- detector setup (reinforcement learning)**
- raw data analysis (beta-VAE)
- muon veto LED calibration**
- muon shielding cryo lab (PSK)
- low energy excess in ncal (CRESST)

Potential projects:

- file converter**
- muon detector
- calibration sources simulation**
- daily modulation signatures

“A world-leading experiment requires world-leading understanding of the background via high performance simulations” (Us, 16.12.2024)

- ⇒ ImpCRESST (Geant4-based in-house made soft) allows us to characterize in detail possible backgrounds that could be highly detrimental to COSINUS goals and ***new particles discovery potential***
- ⇒ Radiogenic backgrounds (nuclear decays), cosmogenic backgrounds (muons and cosmic rays), among others
- ⇒ Simulations are instrumental to the development of new ***cutting-edge*** cryogenic-based experiments in **Austria** and **Worldwide**

Projects availability:

- 👑 Background model (see Fig)
- 🏰 Non-proportionality in NaI
- 🕯 Phonon propagation
- 🐴 Supernovae neutrino directionality capabilities

mailto: mariano.cababie@tuwien.ac.at

16.12.2024

