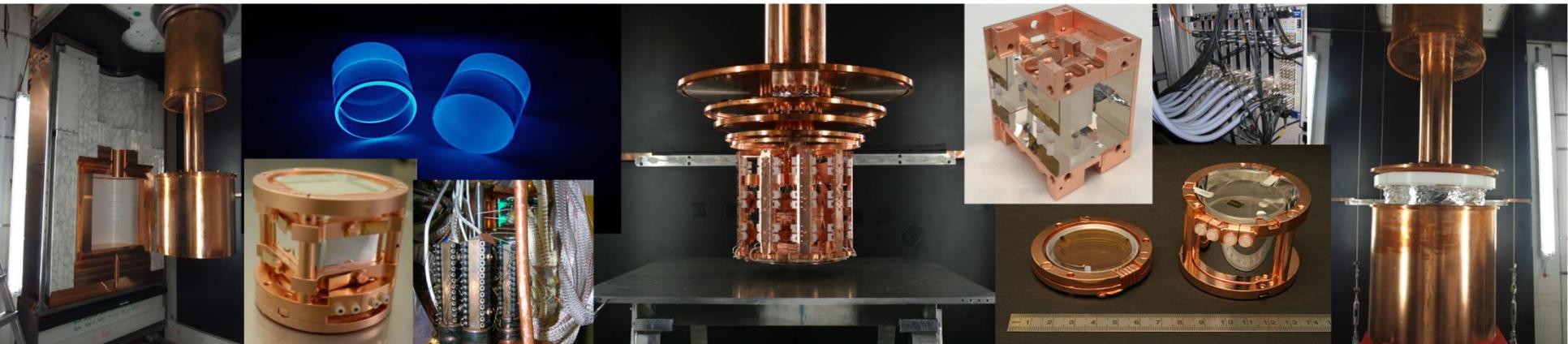


## CRESST



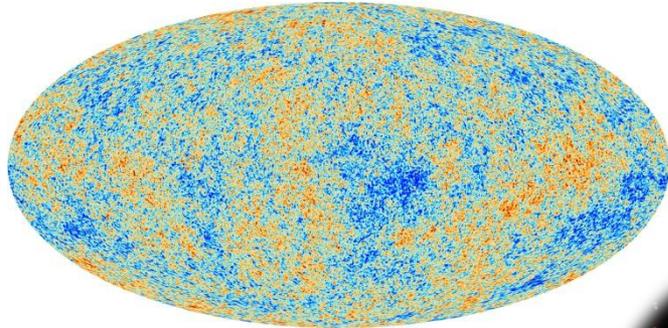
Cryogenic Rare Event Search with Superconducting Thermometers

# Current status of the CRESST experiment

Holger Kluck (TU Wien & HEPHY)  
for the CRESST collaboration

# Dark matter

From cosmic ...

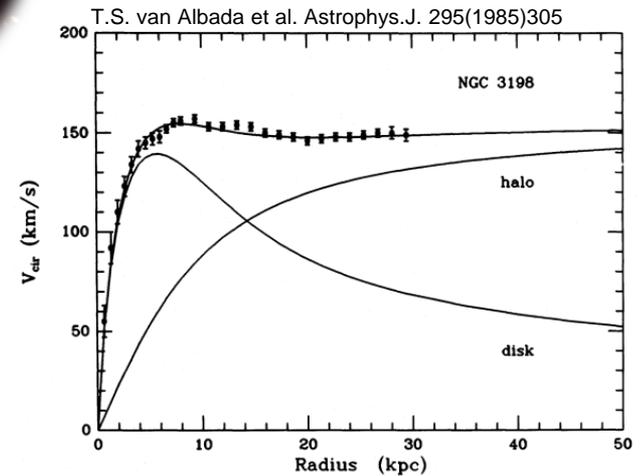


ESA and the Planck Collaboration



NASA/CXC/SAO

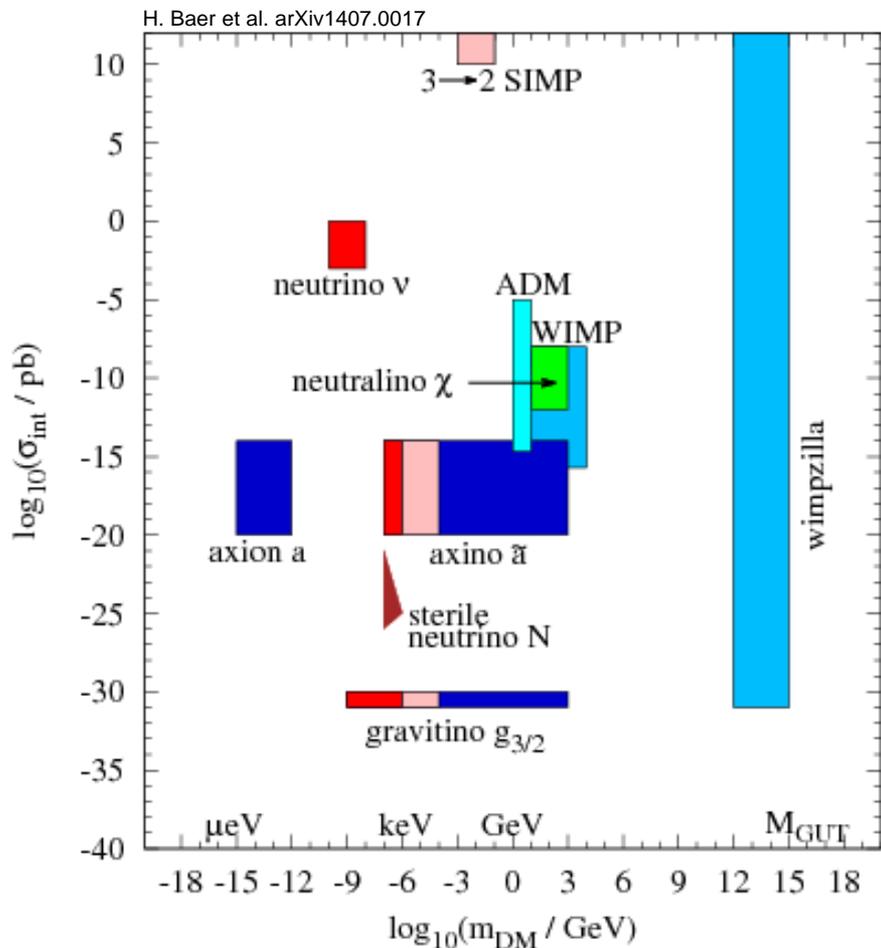
Several astrophysical and cosmological evidences for dark matter on different length scales:



... to galactic

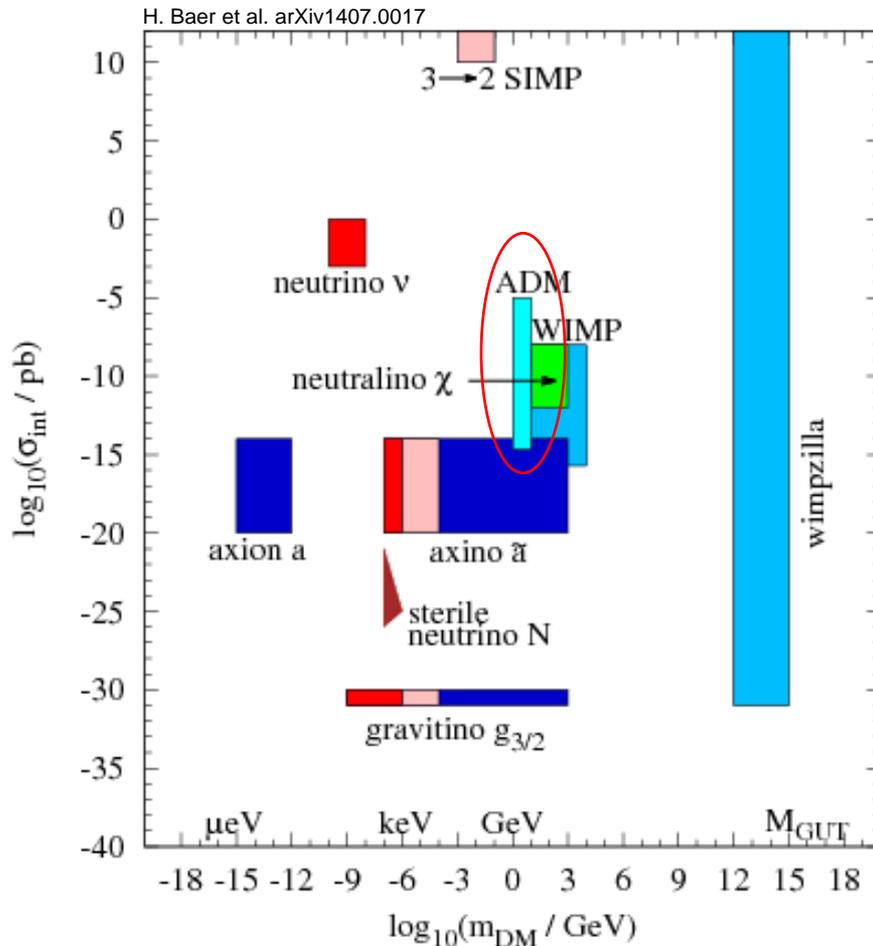
# Dark matter

... but there are also several particle candidates:



# Dark matter

... but there are also several particle candidates:



Particle candidate could be lighter than standard WIMP, e.g. **asymmetric dark matter (ADM)**.

→ CRESST is ideally suited to search in the **low-mass range**  $m_{\text{DM}} \leq 10 \text{ GeV}/c^2$

## Outline

- CRESST basics:  
How the experiment works
- Legacy from CRESST-II:  
Why we're ideally suited for low-mass DM
- Current status of CRESST-III:  
What we aim for

# The CRESST experiment

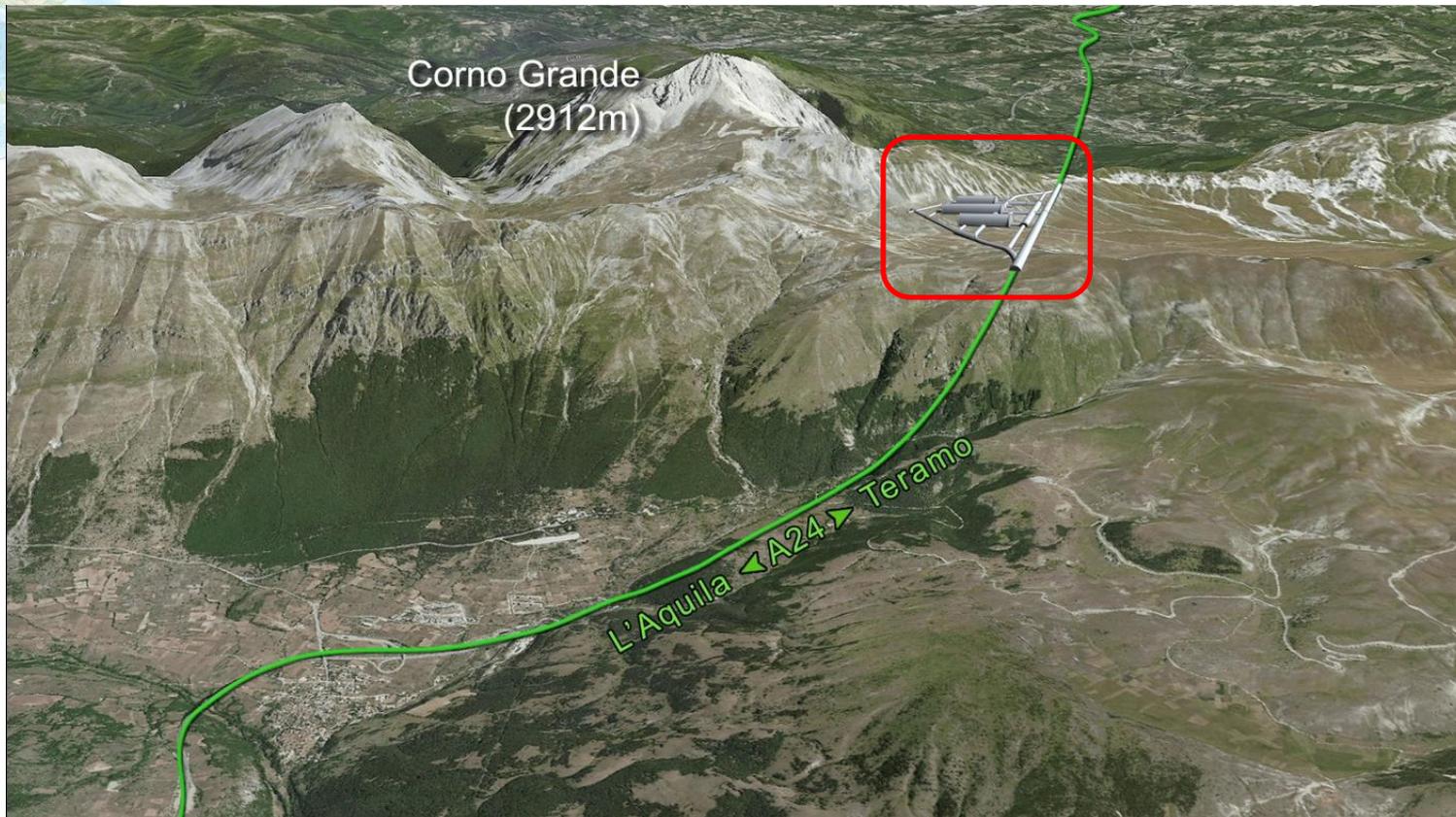
Located in Italy



Eric Gaba, NordNordWest

# The CRESST experiment

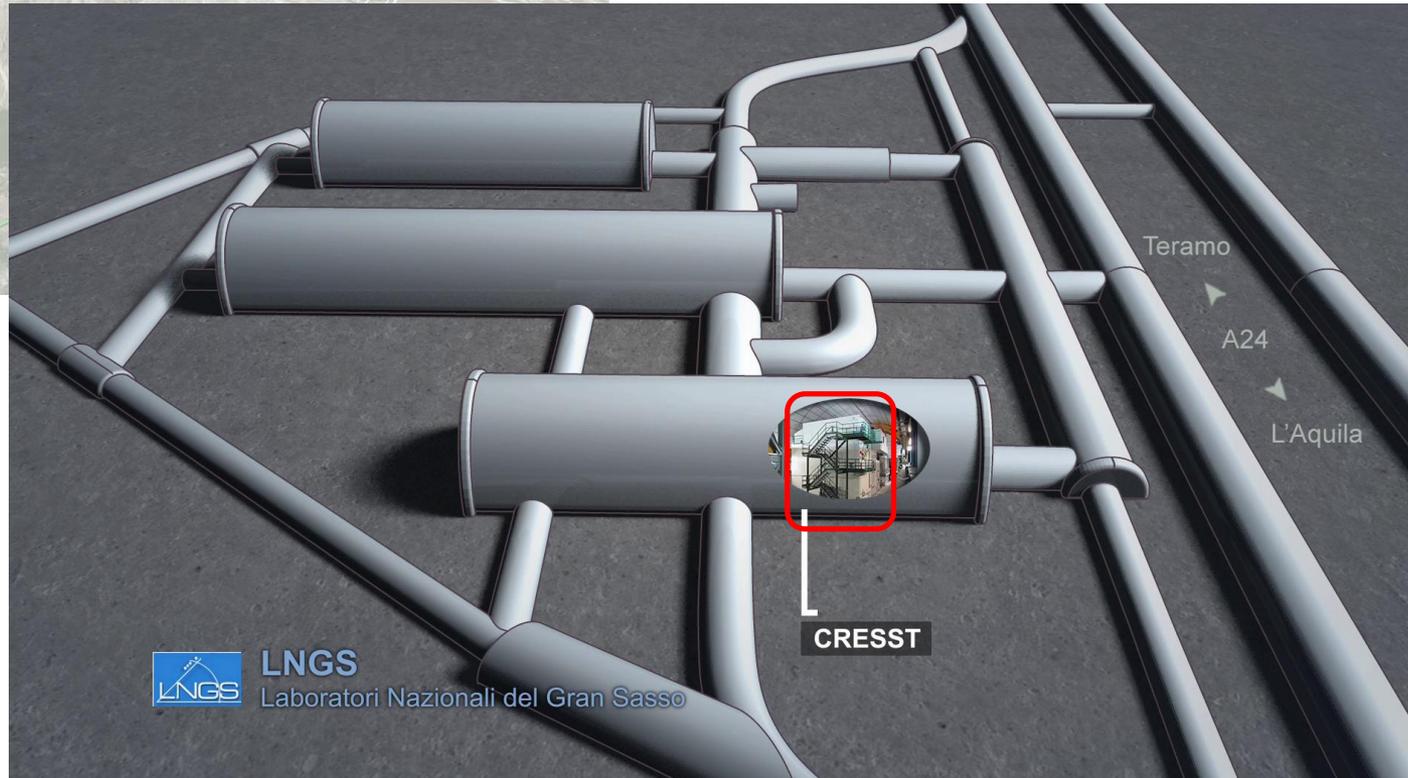
Located in Italy,  
under the Gran Sasso mountain



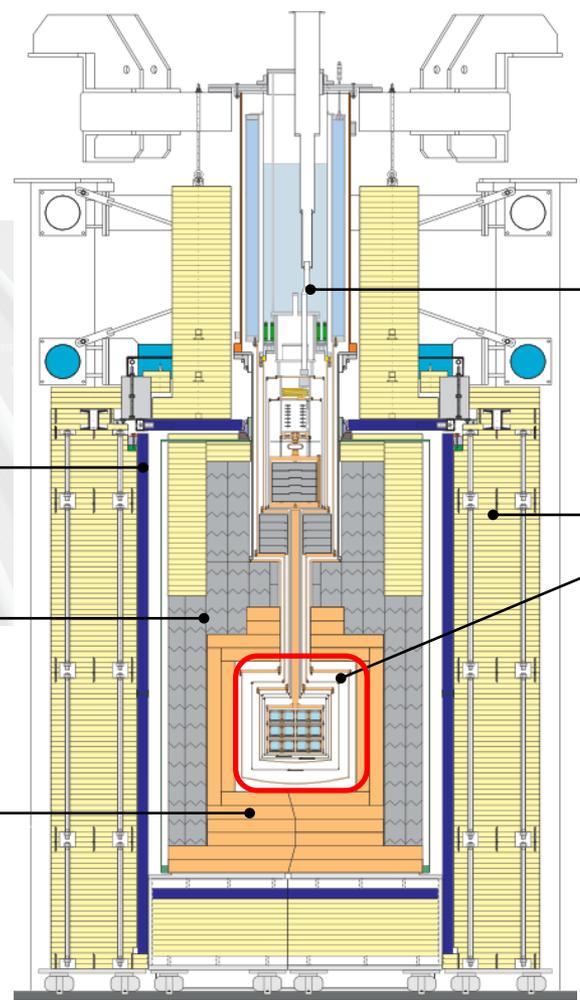
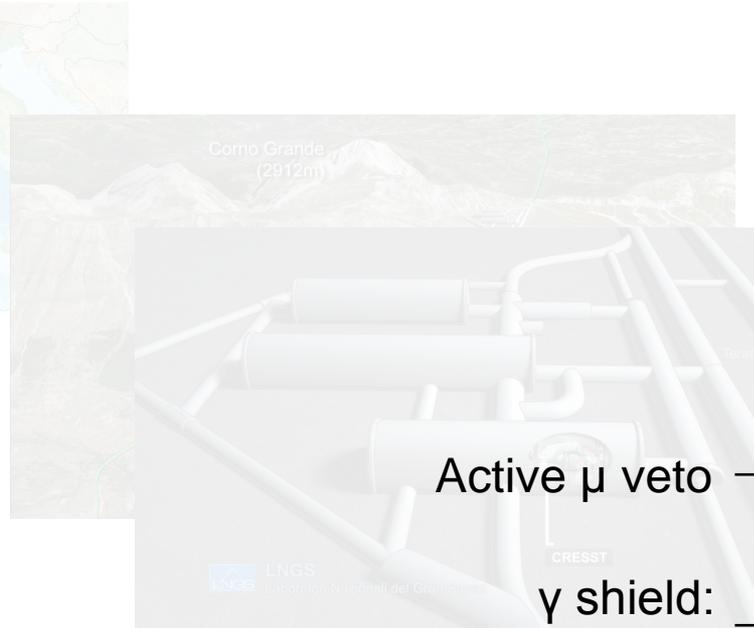
Max-Planck-Institut für Physik

# The CRESST experiment

Located in Italy,  
under the Gran Sasso mountain,  
at the LNGS @3500mwe



# The CRESST experiment



Cryostat

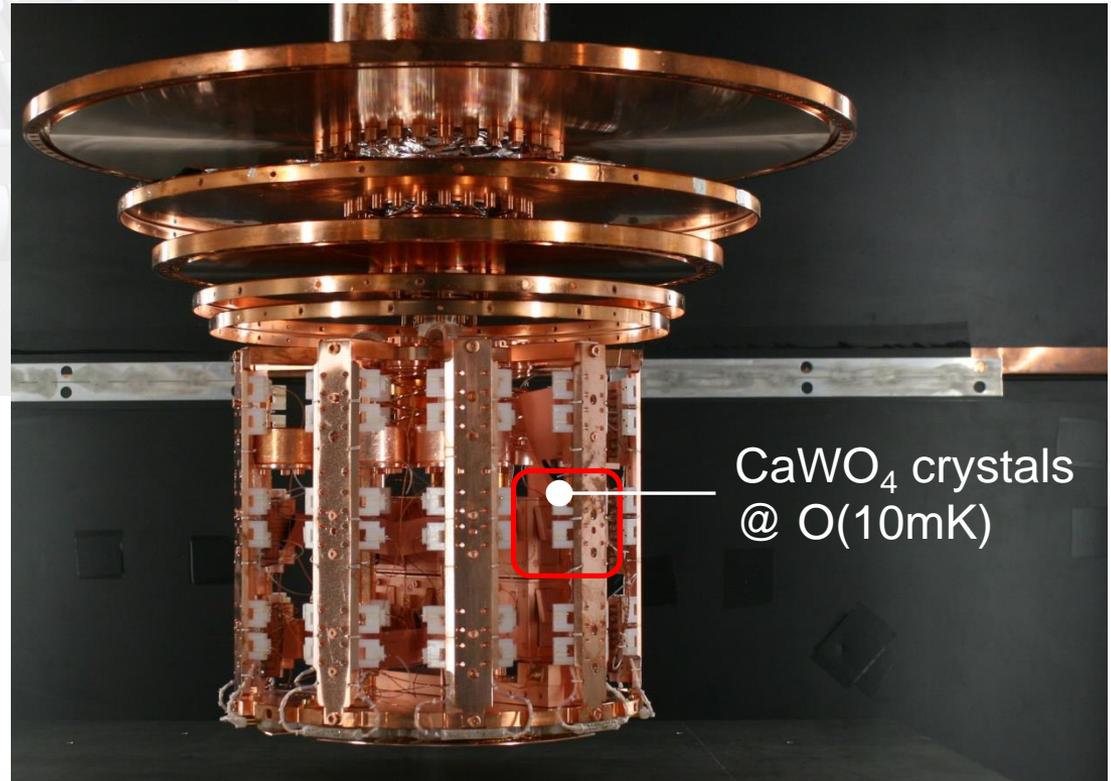
n shield:  
45cm PE  
+ inner PE

Active  $\mu$  veto

$\gamma$  shield:  
20cm Pb

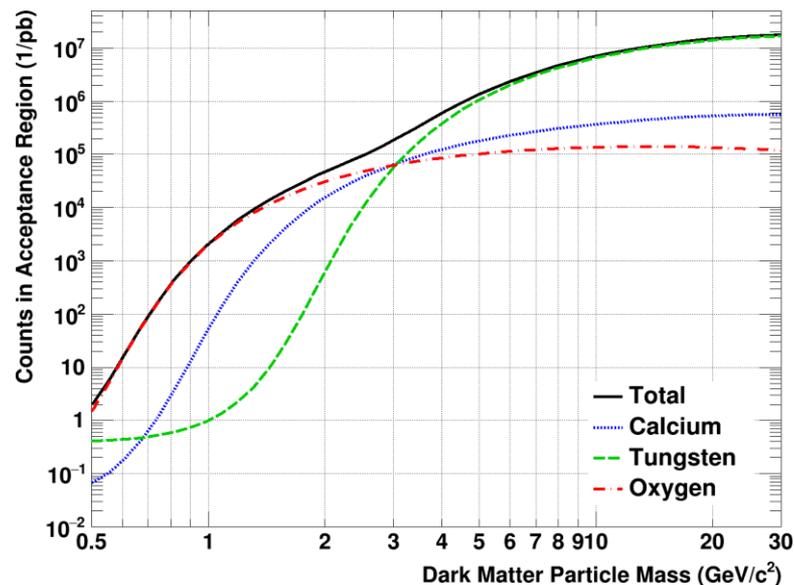
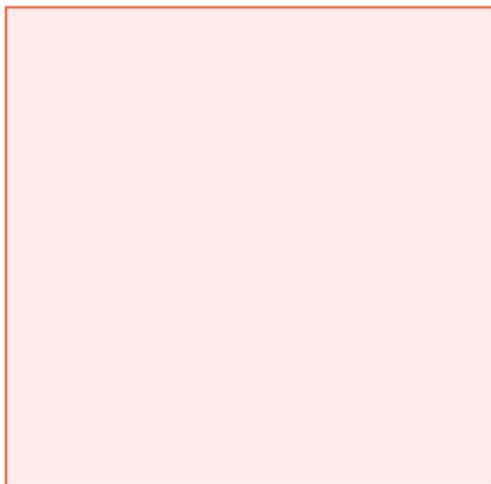
14cm Cu against  
background from Pb

# The CRESST experiment



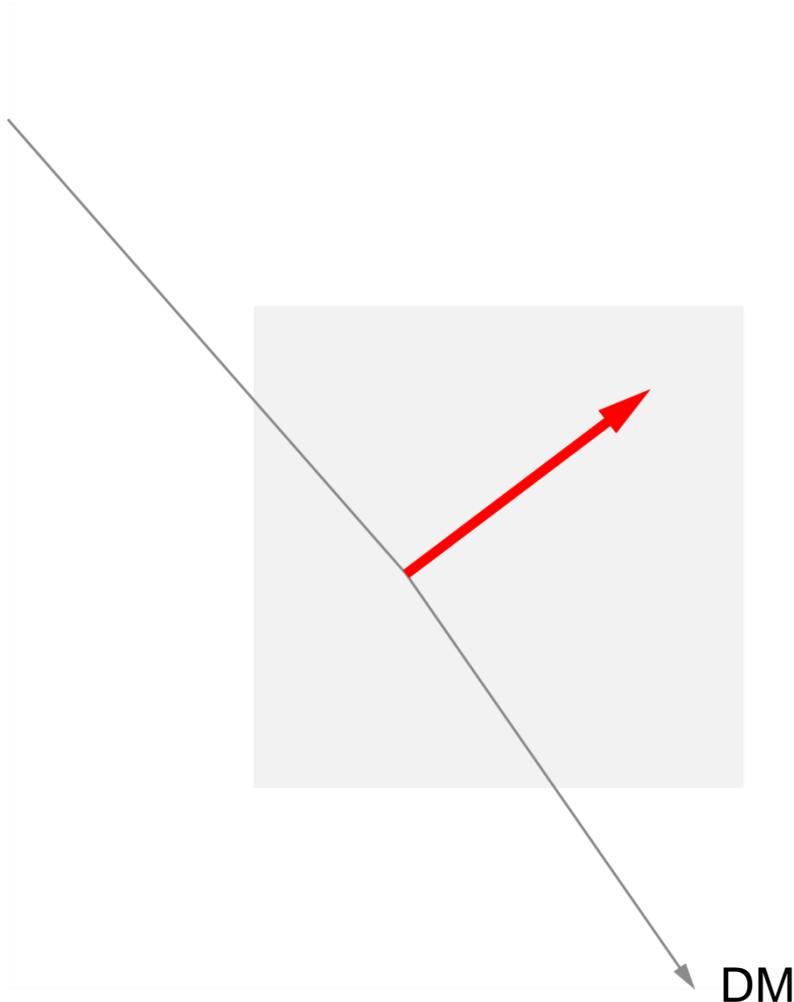
# The CRESST experiment

- **Multi-element** target  
CaWO<sub>4</sub>  
Sensitive to ...  
heavy DM via W,  
**light DM** via O

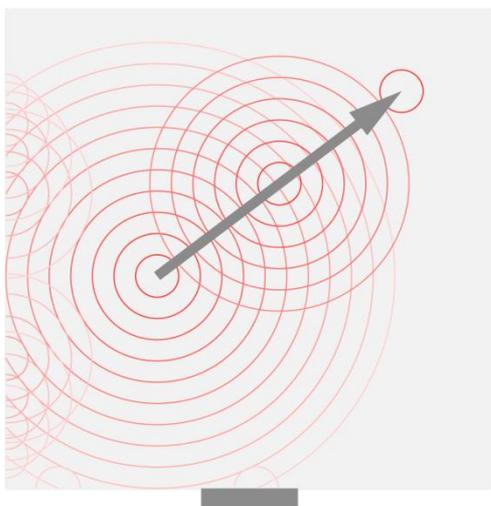


# The CRESST experiment

- Target:  $\text{CaWO}_4$
- Signature: **recoiling nucleus** induced by scattering off Dark Matter particle



# The CRESST experiment

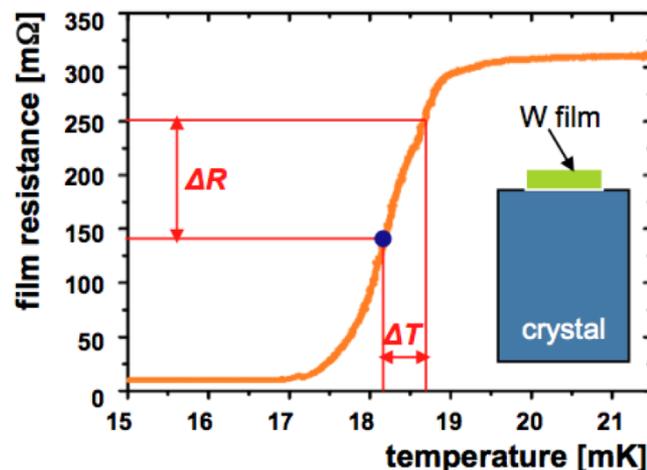
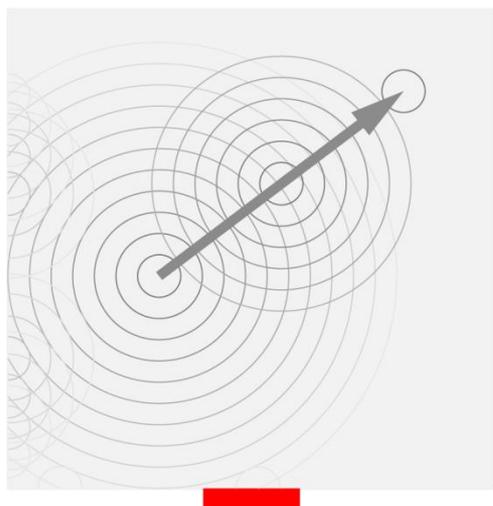


- Target:  $\text{CaWO}_4$
- Signature: recoiling nucleus
- **Phonon** signal: measurement of recoil energy

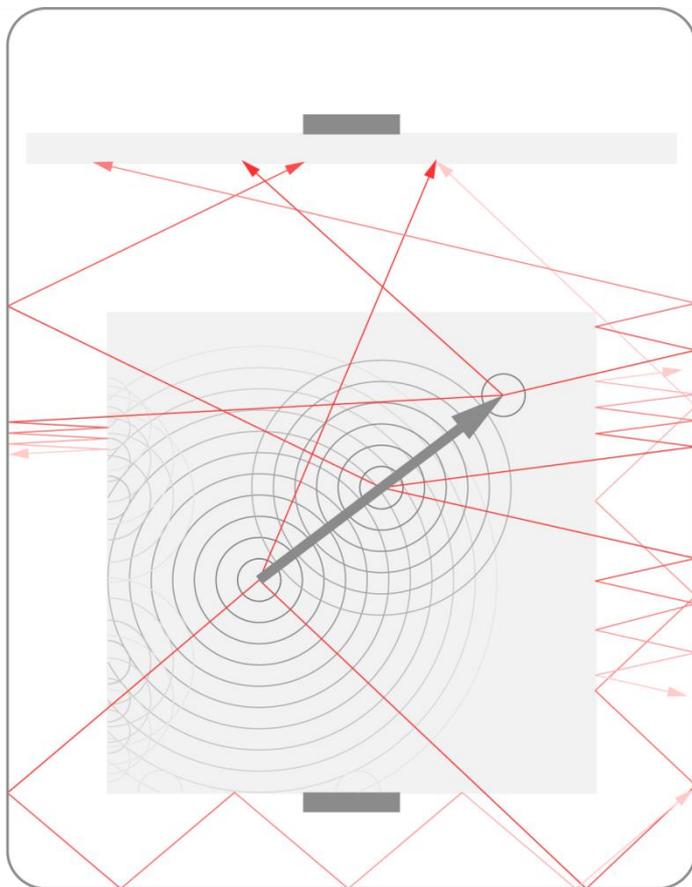
$$\Delta E/C = \Delta T$$
$$1\text{keV} \sim 1\mu\text{K}$$

# The CRESST experiment

- Target:  $\text{CaWO}_4$
- Signature: recoiling nucleus
- Phonon signal: energy
- Read-out by a **TES** (transition edge sensor)

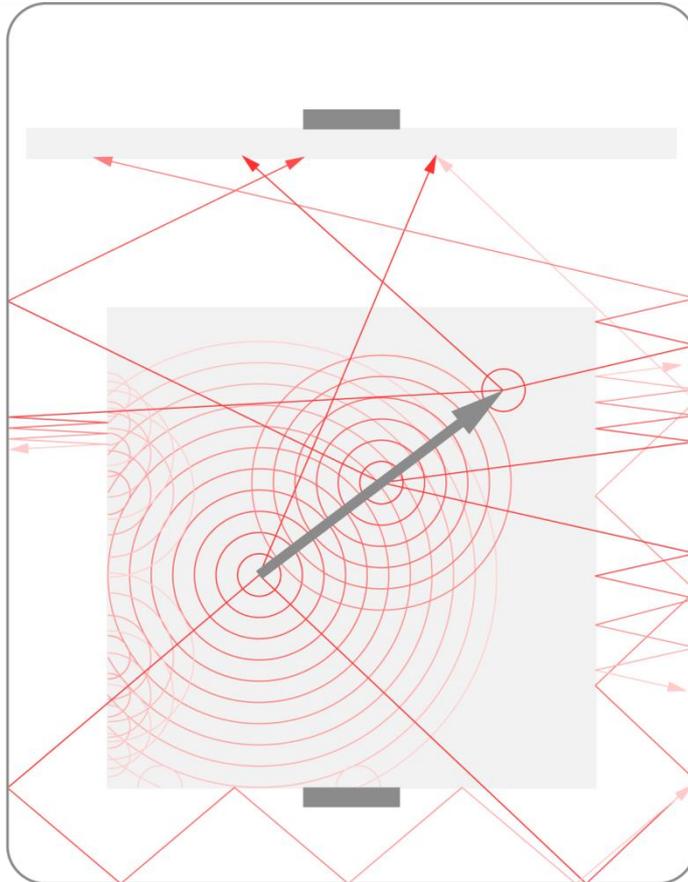


# The CRESST experiment



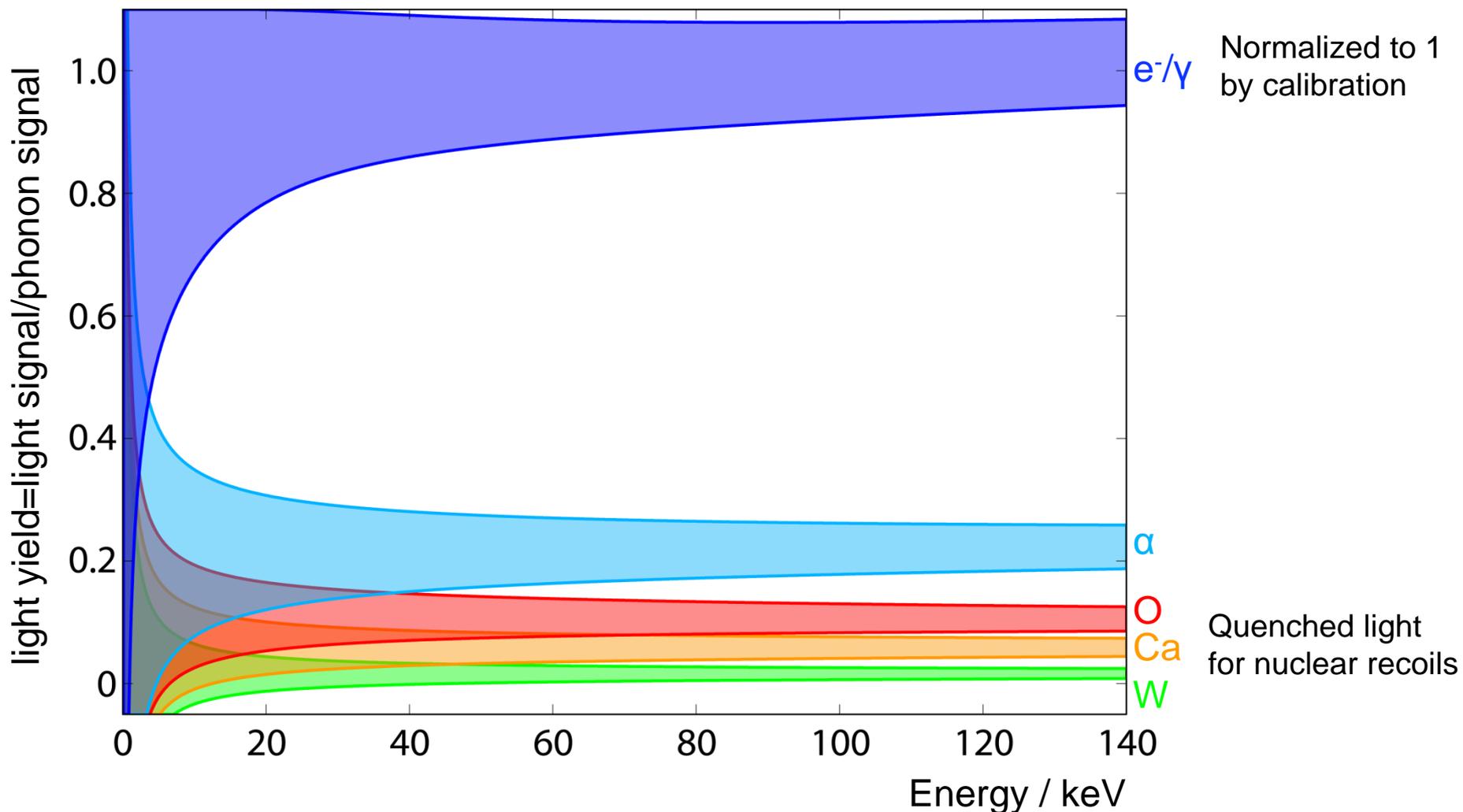
- Target: CaWO<sub>4</sub>
- Signature: recoiling nucleus
- Phonon signal: energy
- Read-out by a TES
- Scintillation **light signal**: dedicated detector inside a reflective & scintillating housing, particle dependent

# The CRESST experiment

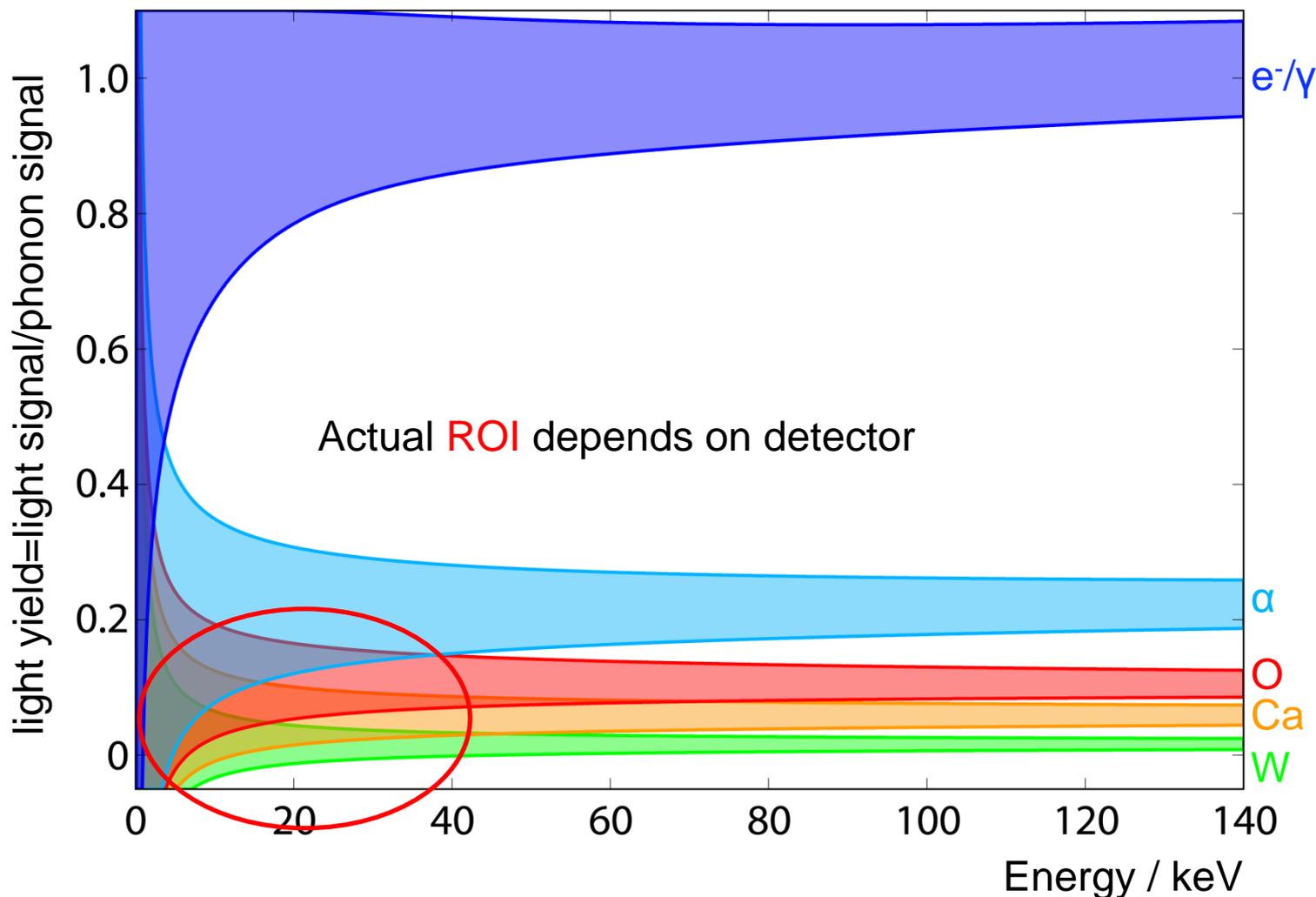


- Target:  $\text{CaWO}_4$
  - Signature: recoiling nucleus
  - **Phonon signal**: energy
  - Read-out by a TES
  - Scintillation **light signal**: particle dependent
- Particle identification

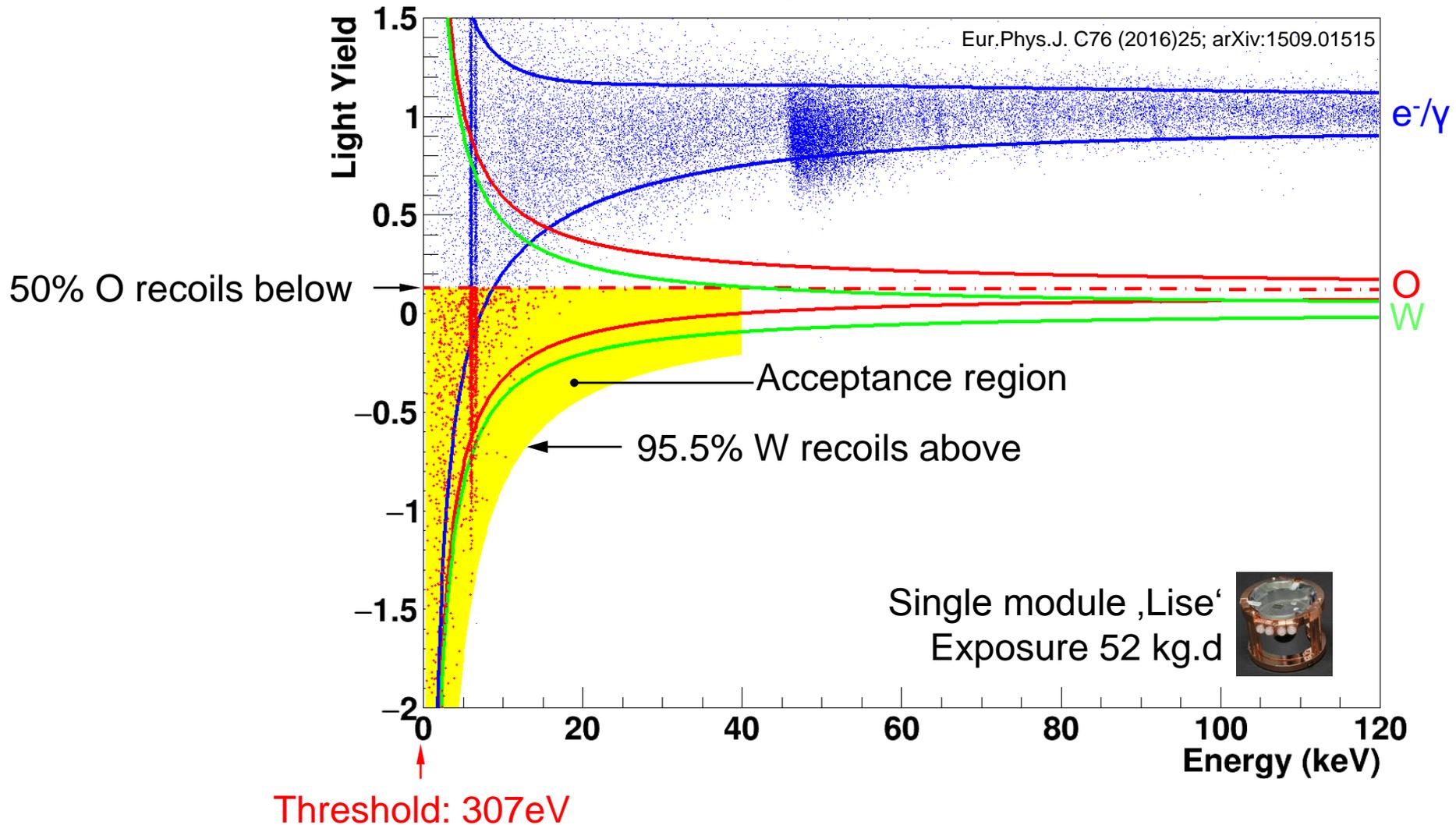
# The CRESST experiment



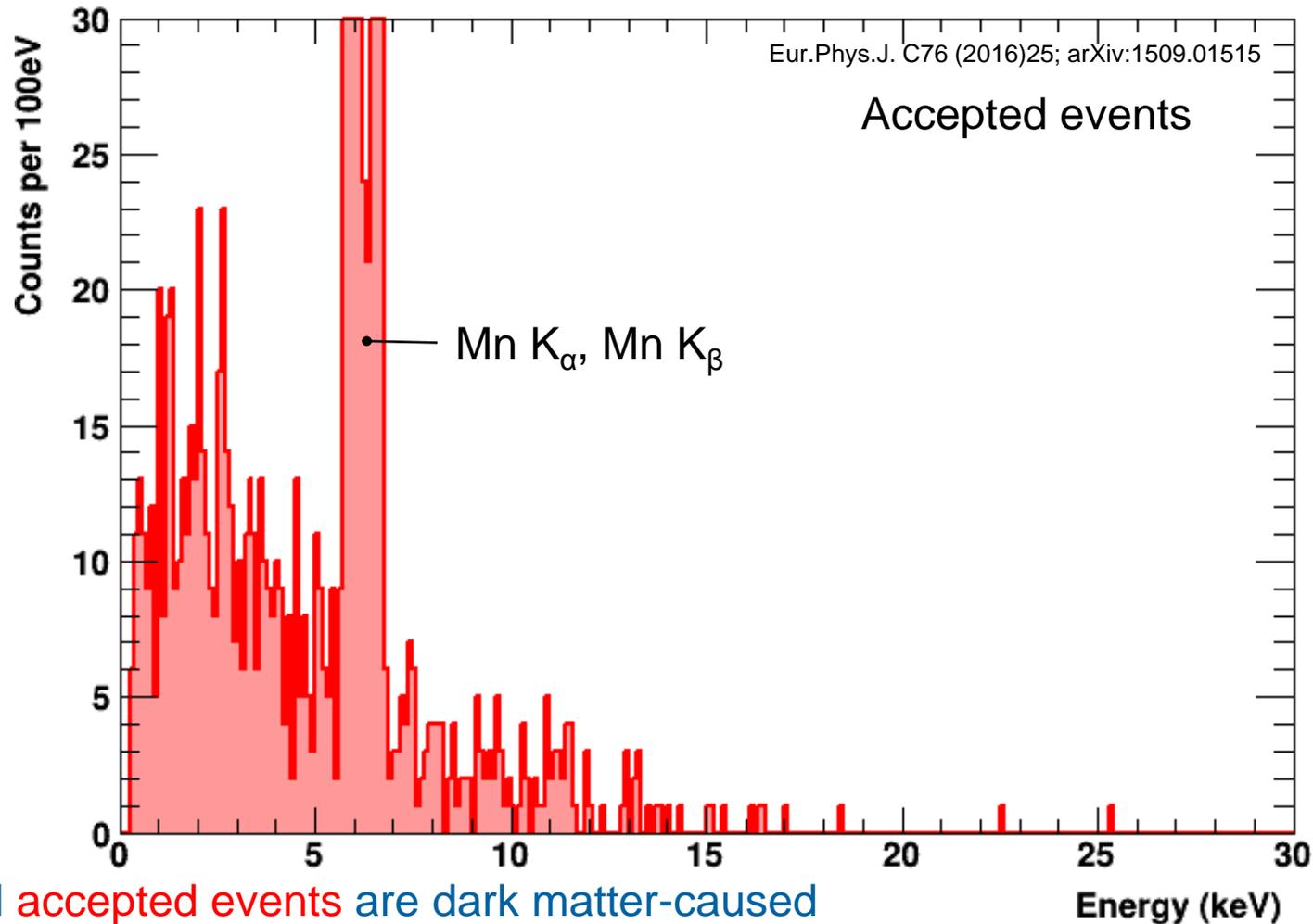
# The CRESST experiment



# Last CRESST-II phase 2 data



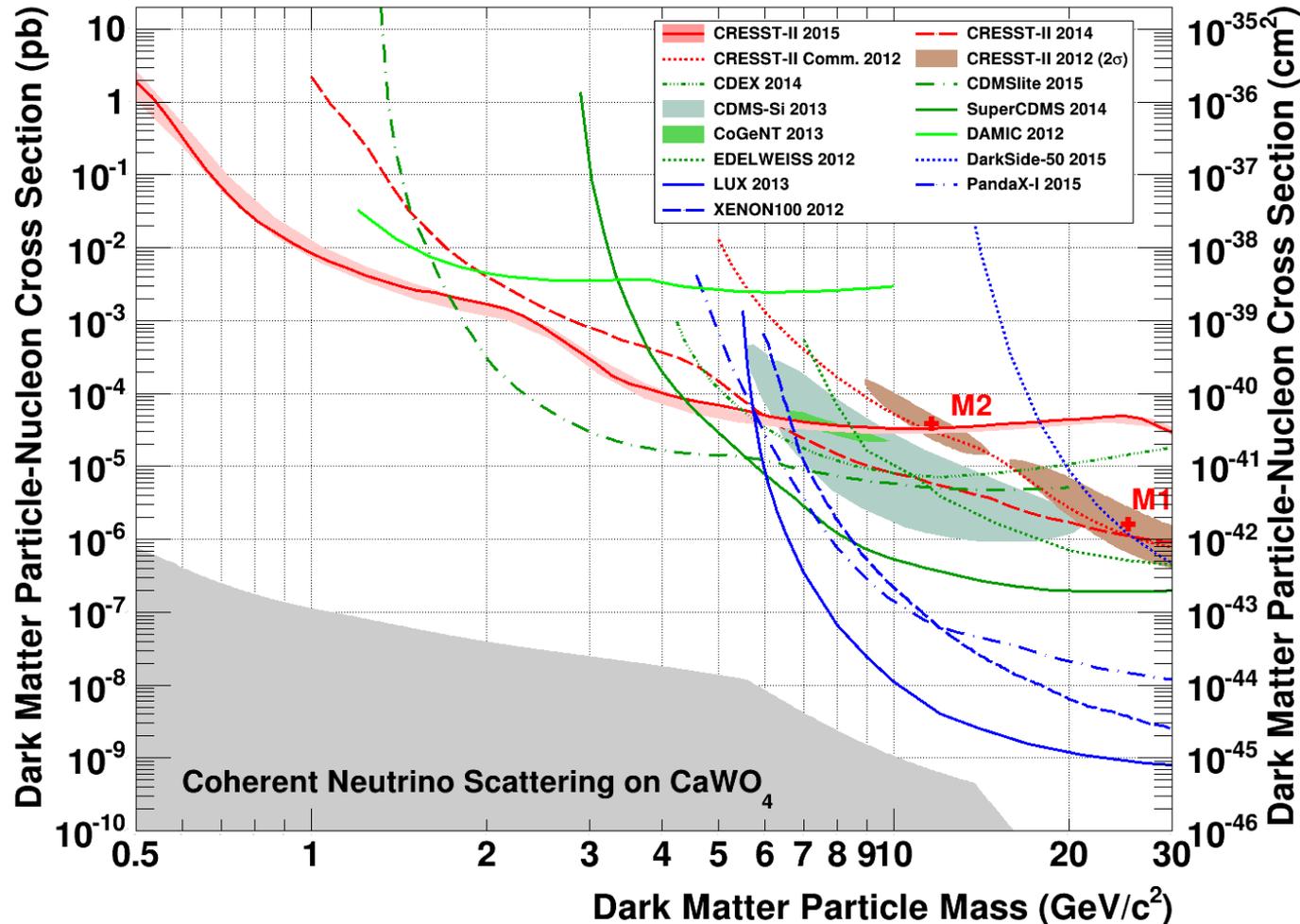
## Last CRESST-II phase 2 data



Assume all **accepted events** are dark matter-caused

→ Use Yellin's optimum interval method to set an exclusion limit

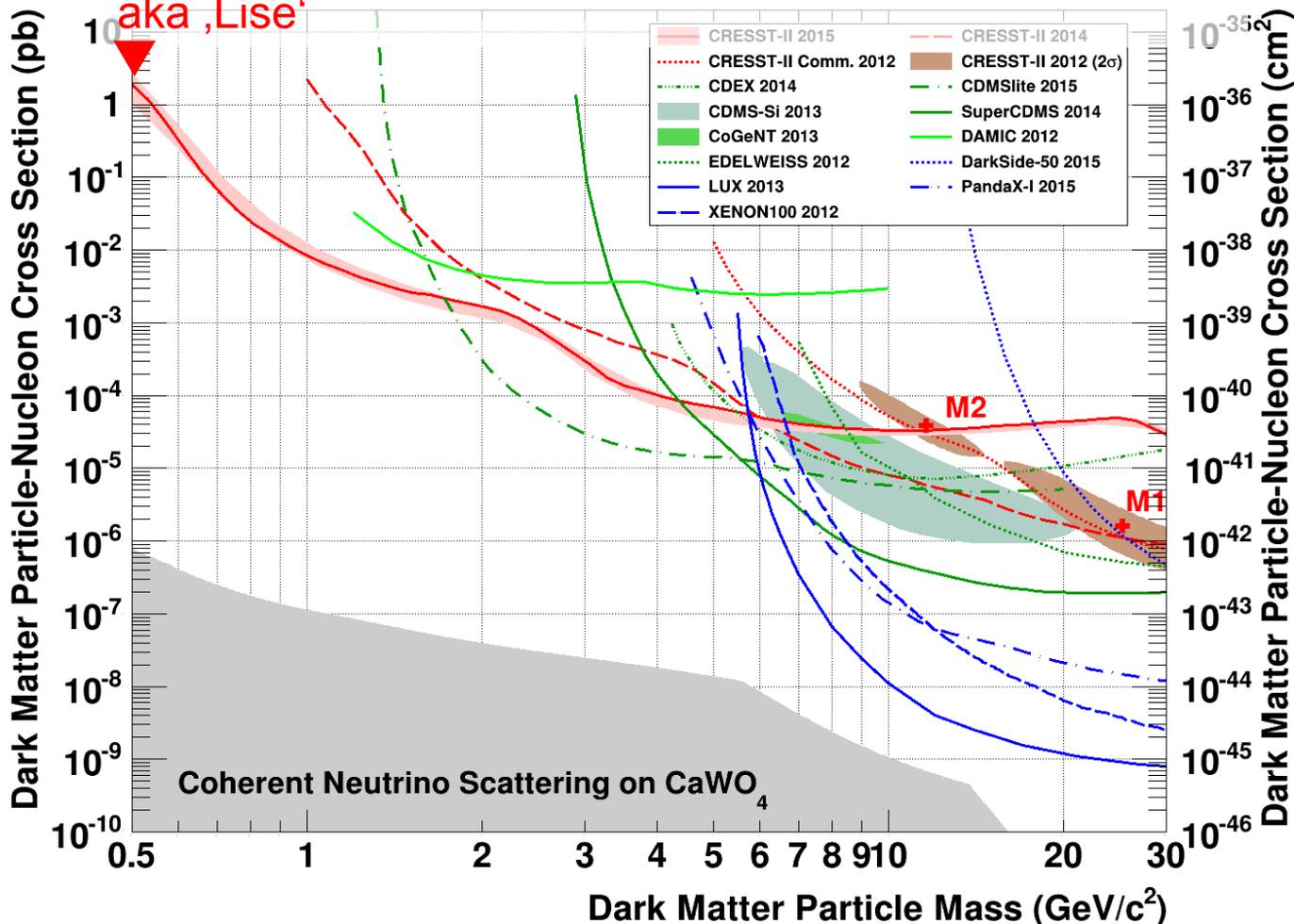
# Results of CRESST-II phase 2



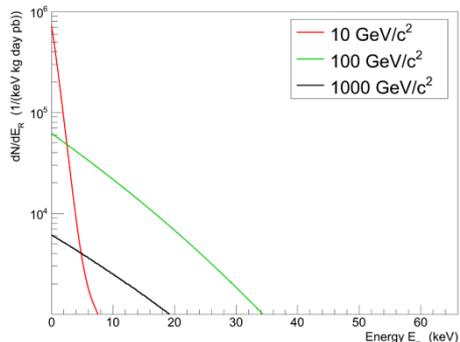
# Results of CRESST-II phase 2

CRESST-II phase 2 (2015), Eur.Phys.J. C76 (2016)25

aka 'Lise'



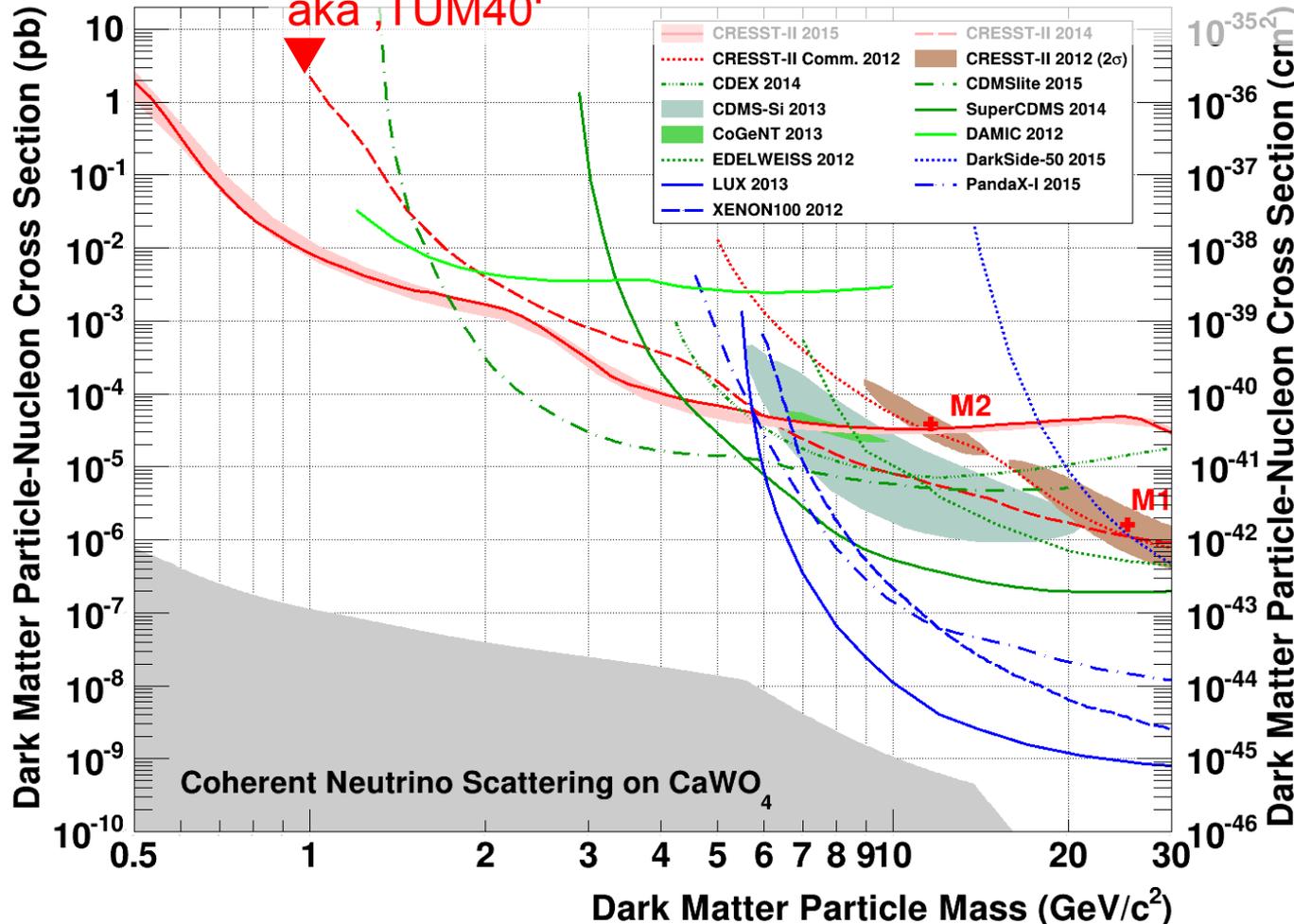
- Low-mass search  
→ low threshold  
Lise: 307eV



# Results of CRESST-II phase 2

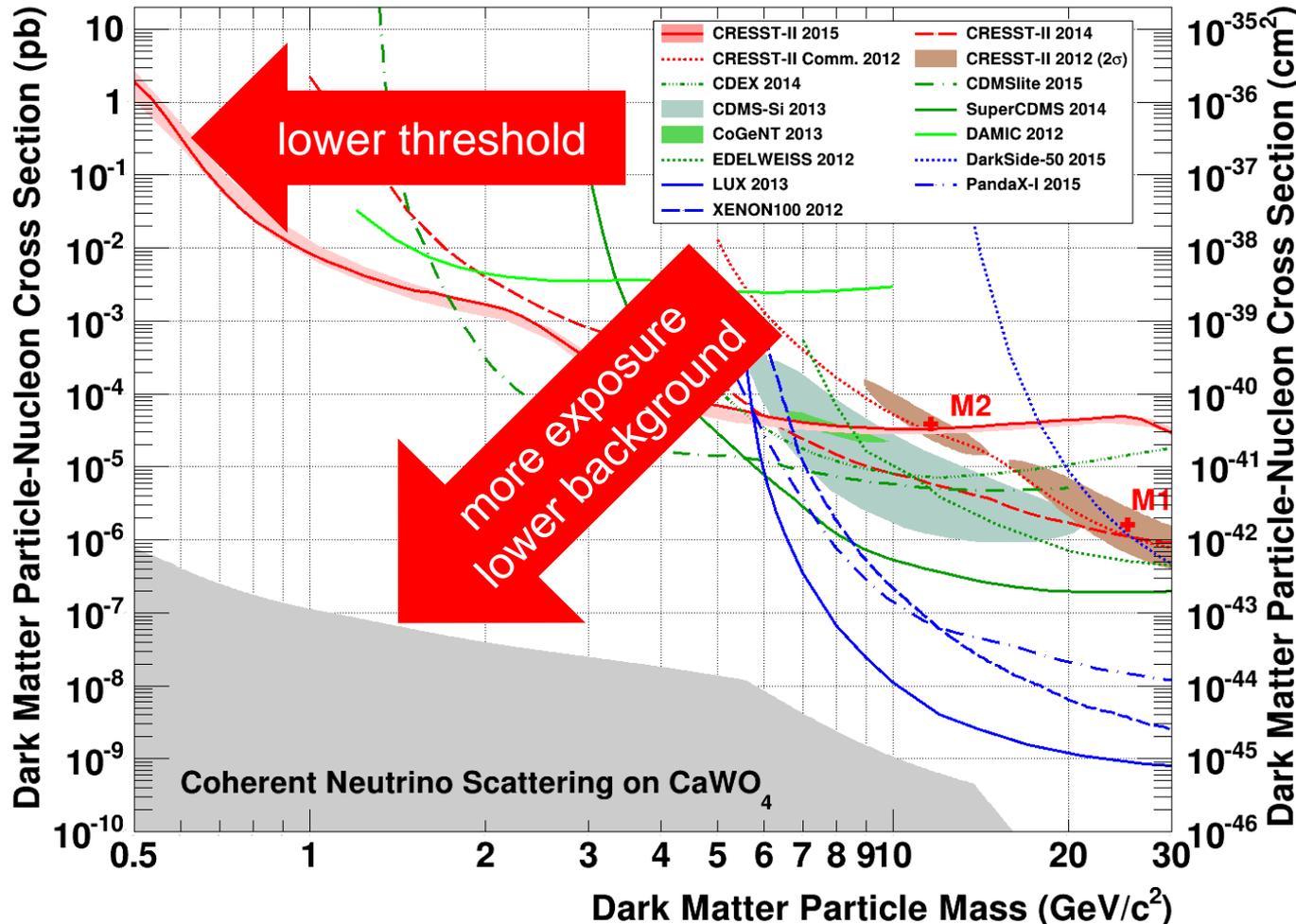
CRESST-II phase 2 (2014), Eur.Phys.J. C74 (2015)3184

aka 'TUM40'



- Low-mass search  
→ low threshold  
Lise: 307eV
- TUM40: successfully  
reduced intrinsic  
background

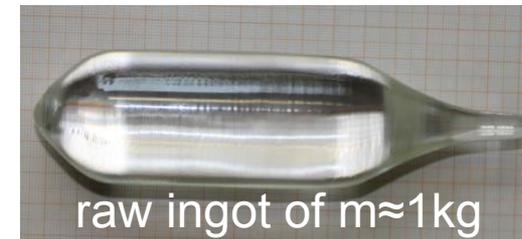
# Results of CRESST-II phase 2



- Low-mass search  
→ low threshold  
Lise: 307eV
- TUM40: successfully reduced intrinsic background
- → combine both in CRESST-III

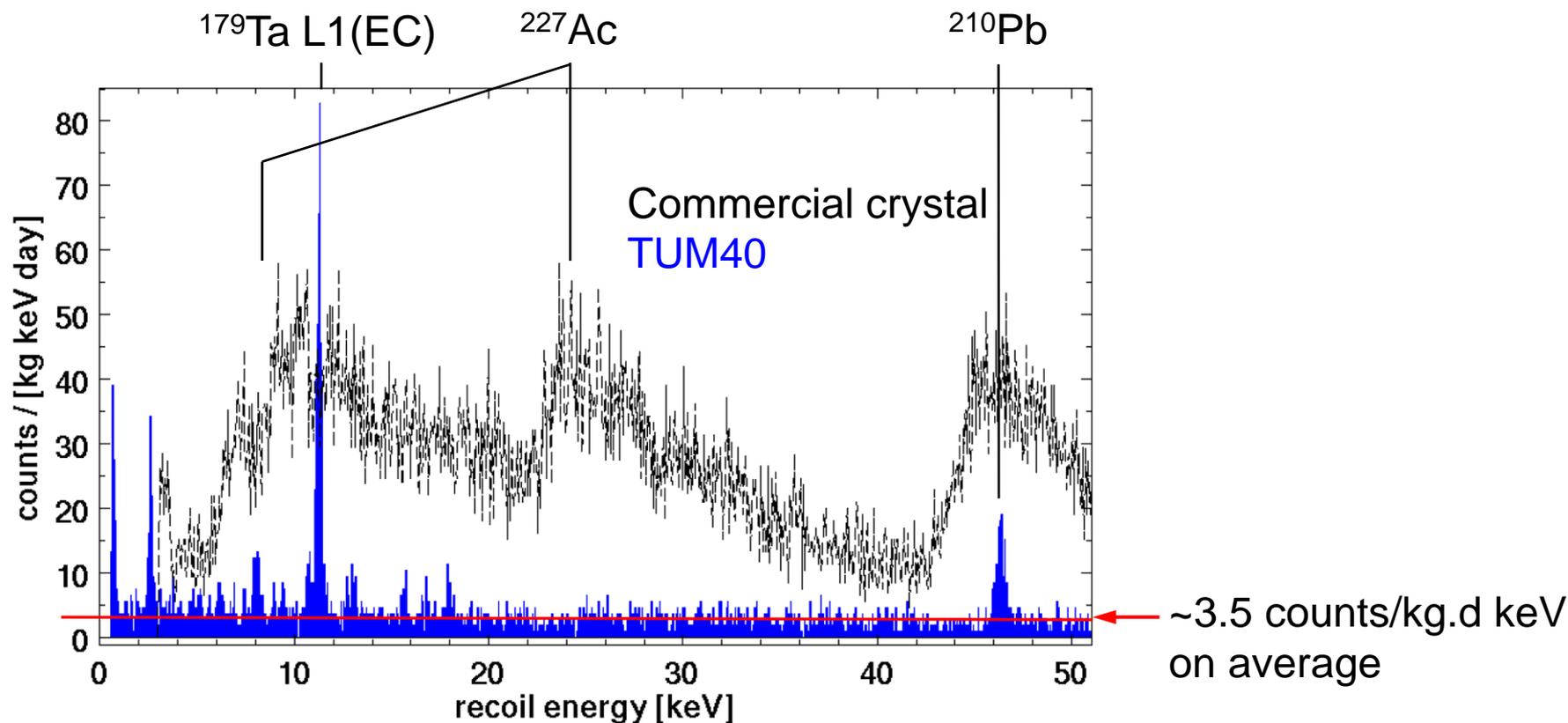
# Crystal production

- $\text{CaWO}_4$  crystal production in-house at TU Munich in **dedicated** furnace: preventing pollution [Cryst. Eng. Comm. 015(2013)2301]



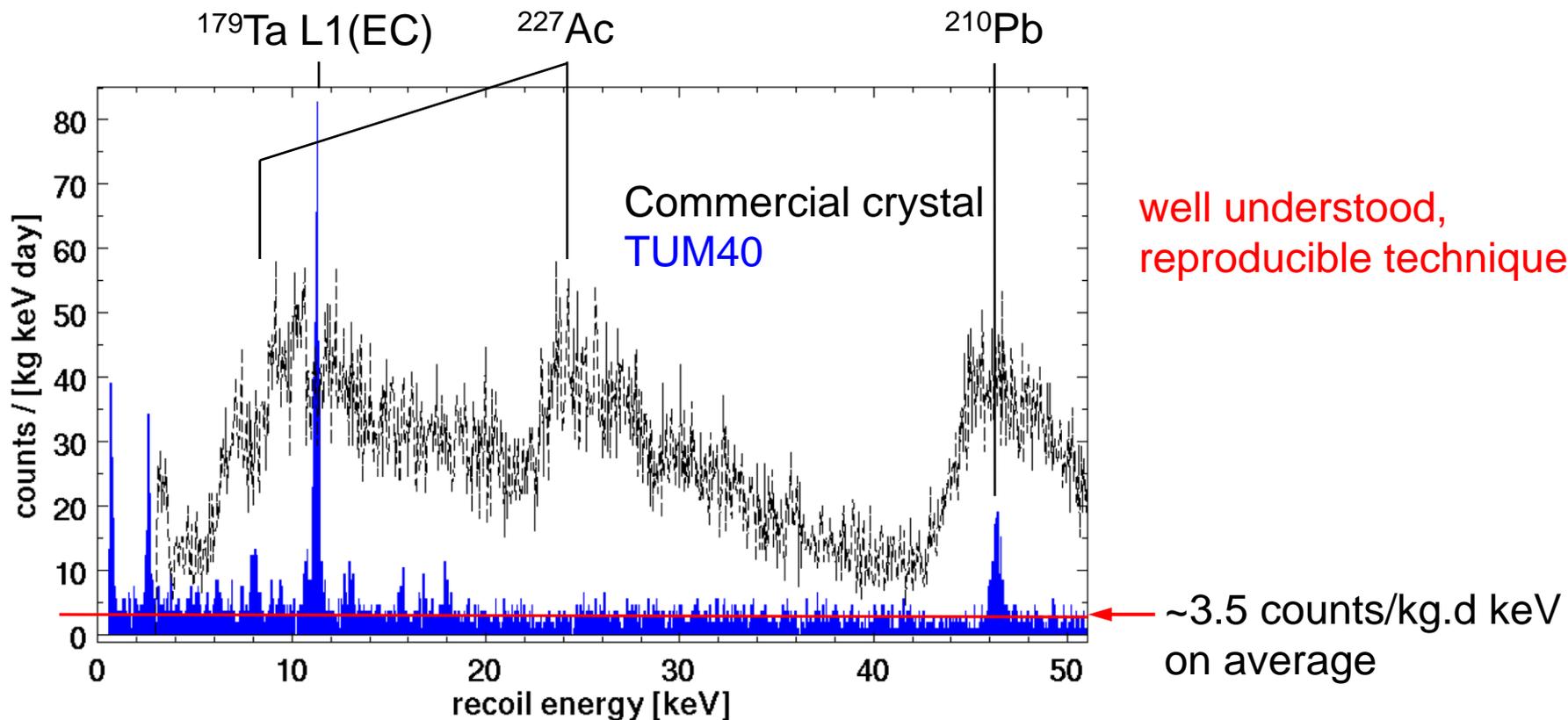
# Crystal production

- $\text{CaWO}_4$  crystal production at TU Munich [Cryst. Eng. Comm. 015(2013)2301]
- TUM40: radiopurity improved by factor 2-10 [JCAP 5(2014)18]



# Crystal production

- $\text{CaWO}_4$  crystal production at TU Munich [Cryst. Eng. Comm. 015(2013)2301]
- TUM40: radiopurity improved by factor 2-10 [JCAP 5(2014)18]



# Going beyond 'TUM40' radiopurity

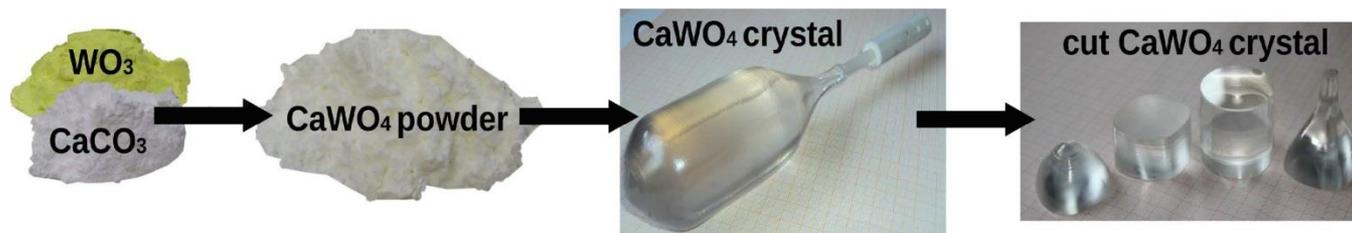
- Cleaning procedure e.g. by re-crystallization, chemical purification of raw materials
- Recently: First steps in **chemical purification of  $\text{CaCO}_3$**  powder.

*work by H.H. Trinh Thi, A. Münster, A. Erb*



# Going beyond 'TUM40' radiopurity

- Cleaning procedure e.g. by re-crystallization, chemical purification of raw materials
- Recently: First steps in chemical purification of  $\text{CaCO}_3$  powder.  
*work by H.H. Trinh Thi, A. Münster, A. Erb*
- Measured contamination decreased by ...
  - factor 2-7 for Th
  - factor 15-35 for U



# Decreasing the detection threshold

## CRESST-II phase 2

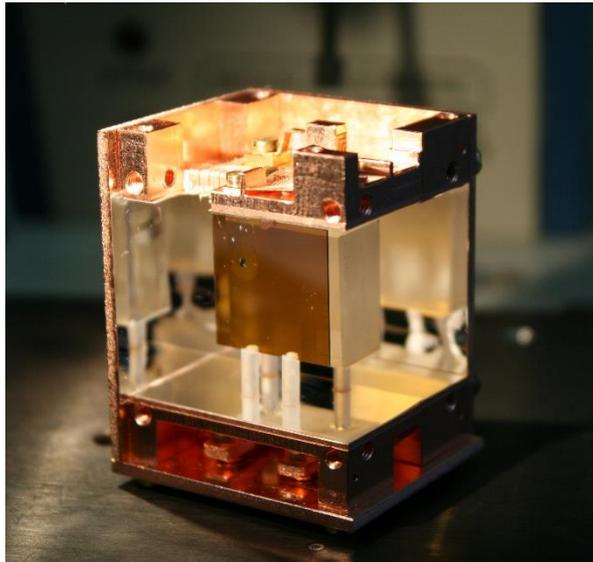
- Mass: 250g
- Phonon threshold:  $\lesssim 500\text{eV}$
- Light resolution:  $\approx 5\text{eV}$

## CRESST-III phase 1 design goal

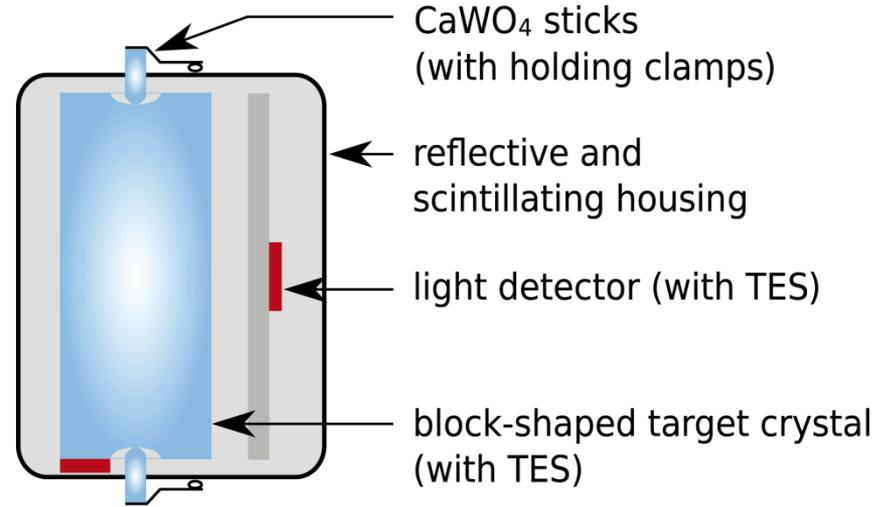
24g  
 $\approx 100\text{eV}$   
 $\approx 2.5\text{eV}$



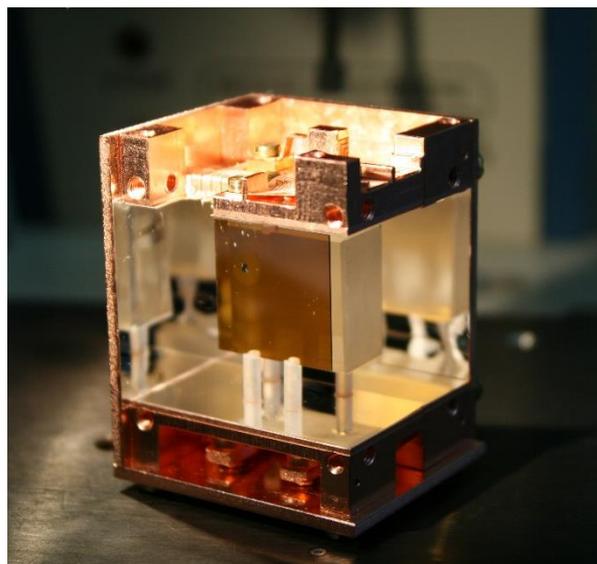
# Decreasing the detection threshold



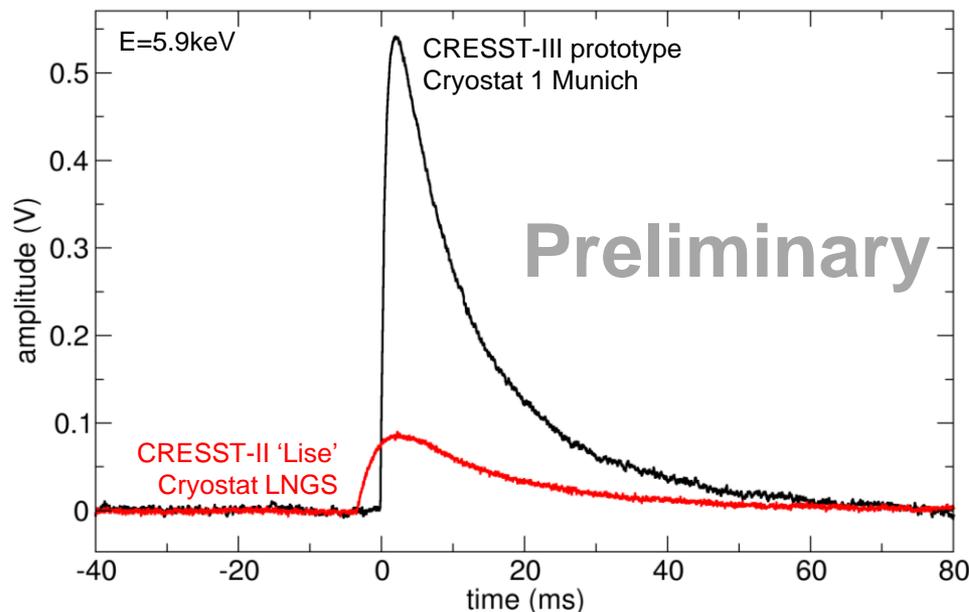
CRESST-III prototype



# Decreasing the detection threshold



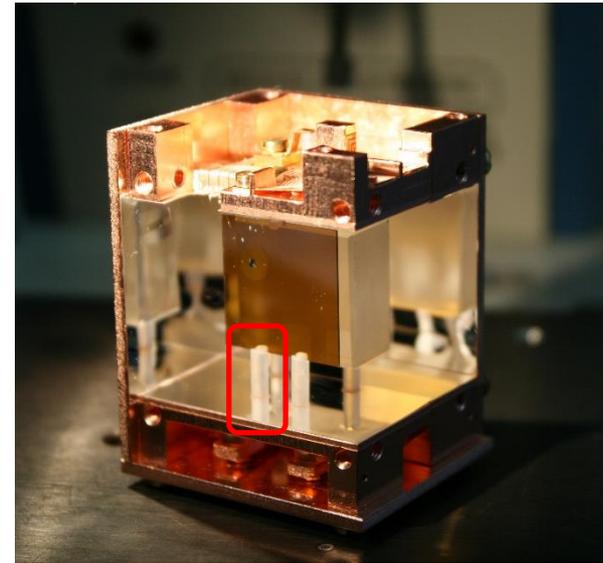
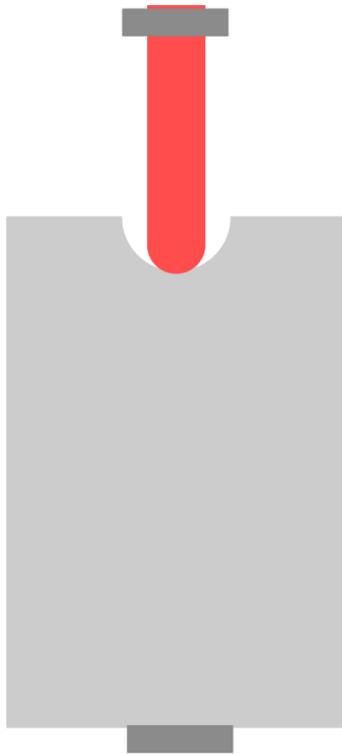
CRESST-III prototype



- Signal/noise improved by  $\sim 6x$
- Threshold: 45-60eV
- Design goal of 100eV exceeded

# Holder-related backgrounds

- Target is held by  $\text{CaWO}_4$  sticks

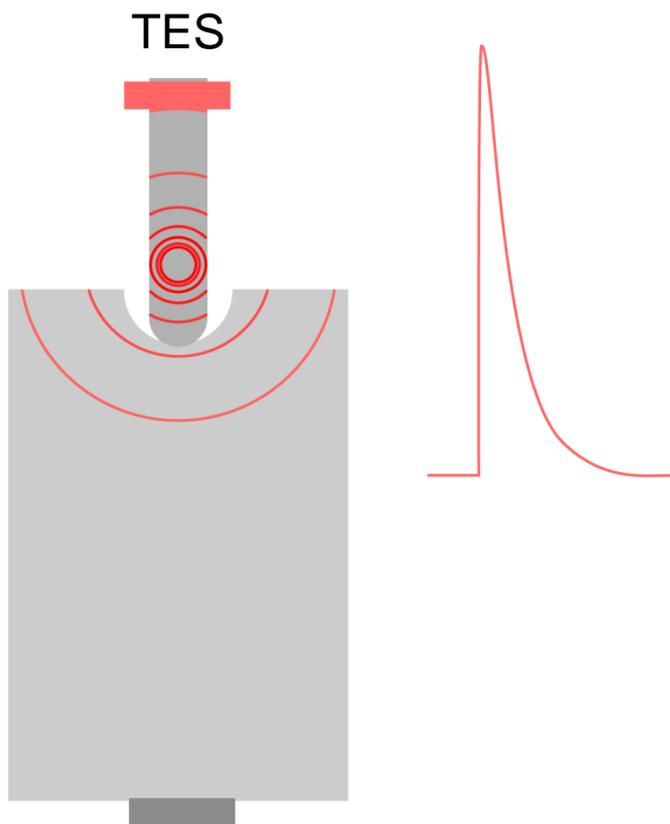


# Holder-related backgrounds

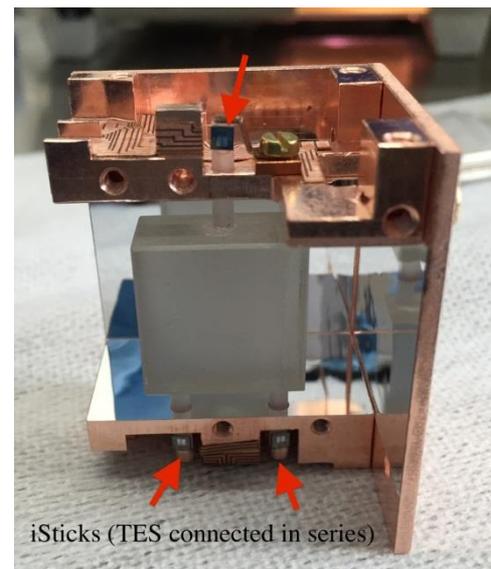


- Target is held by  $\text{CaWO}_4$  sticks
- **Event in stick:** surface background, relaxation, ...

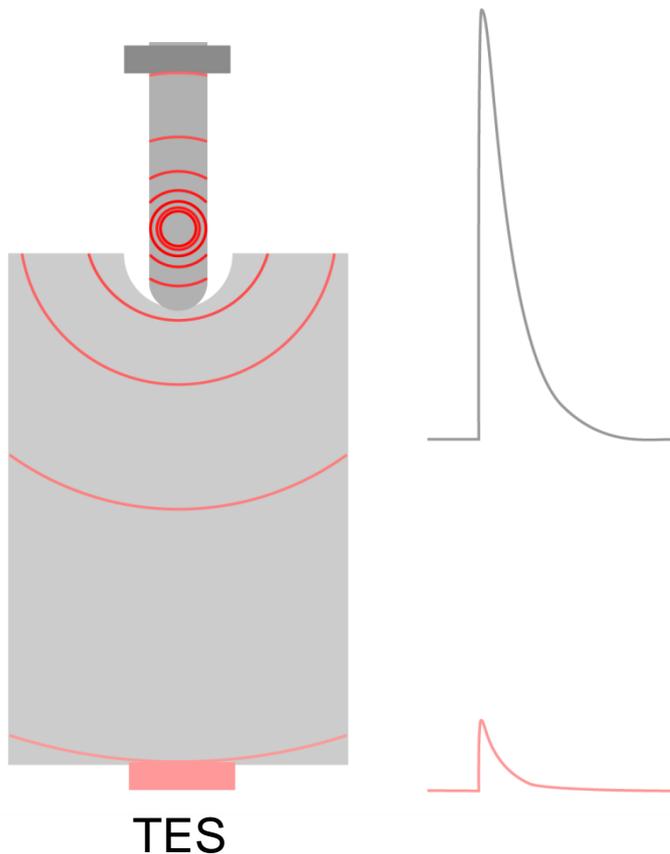
## Holder-related backgrounds



- Target is held by  $\text{CaWO}_4$  sticks
- Event in stick: surface background, relaxation, ...
- Signal in **instrumented stick (iStick)**

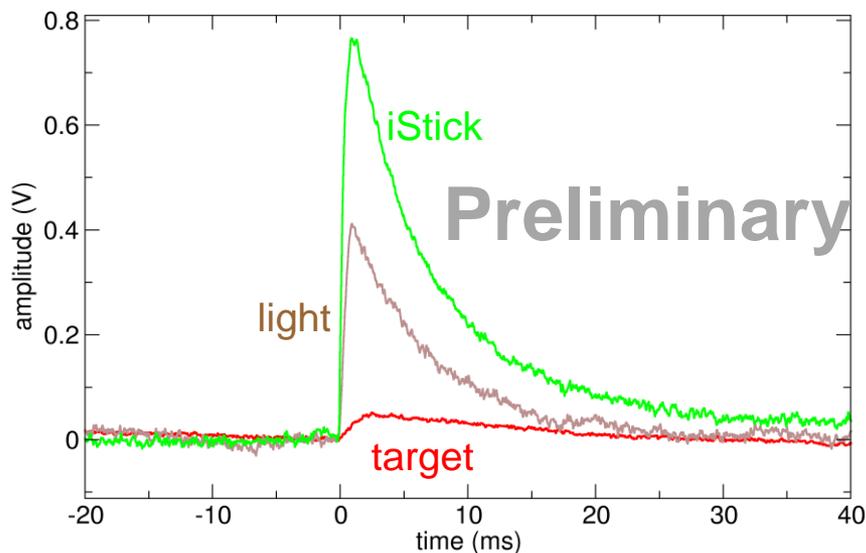


## Holder-related backgrounds



- Target is held by  $\text{CaWO}_4$  sticks
- Event in stick: surface background, relaxation, ...
- Signal in instrumented stick (iStick)
- **Degraded signal** in target

# Holder-related backgrounds

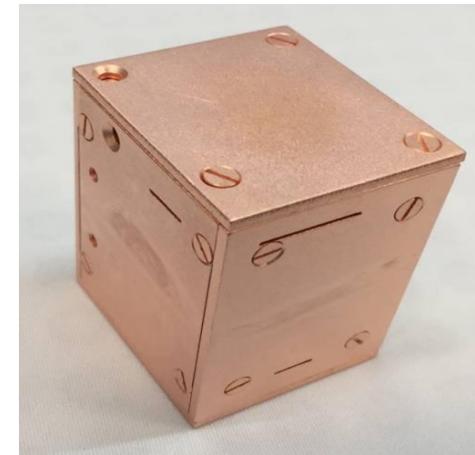
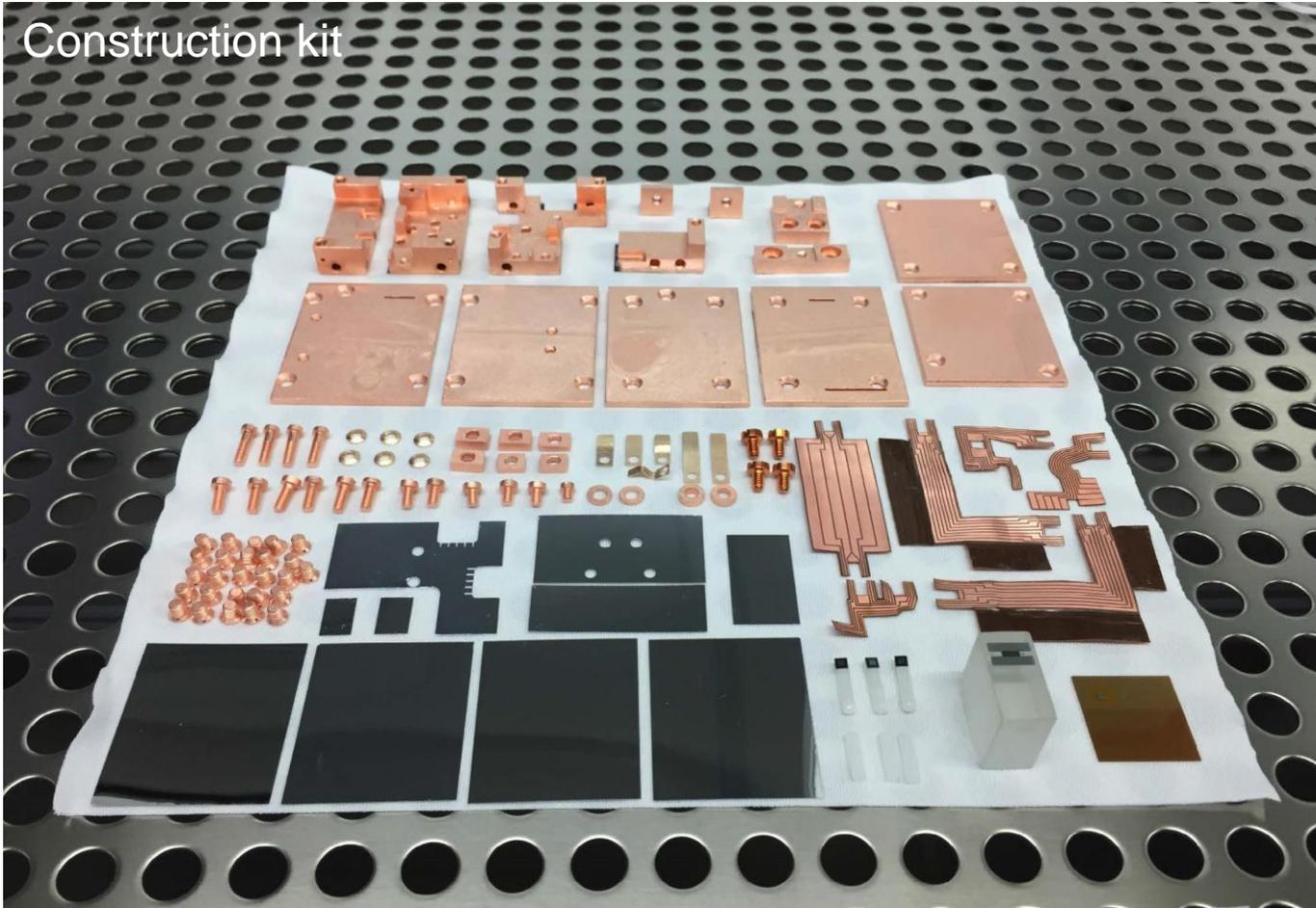


- Target is held by  $\text{CaWO}_4$  sticks
- Event in stick: surface background, relaxation, ...
- Signal in instrumented stick (iStick)
- Degraded signal in target

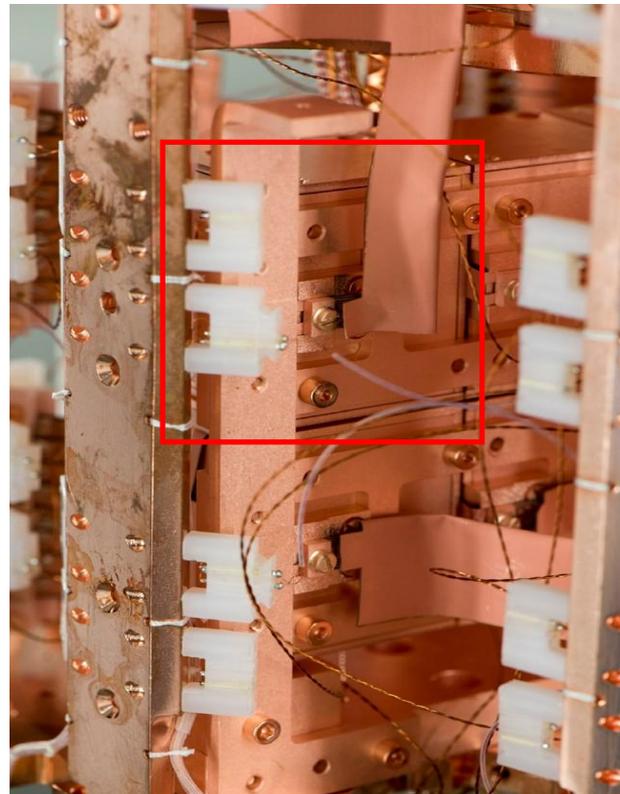
→ iStick/target is a **powerful tool** to reject holder-related backgrounds

# From prototype to 'serial production'

Construction kit



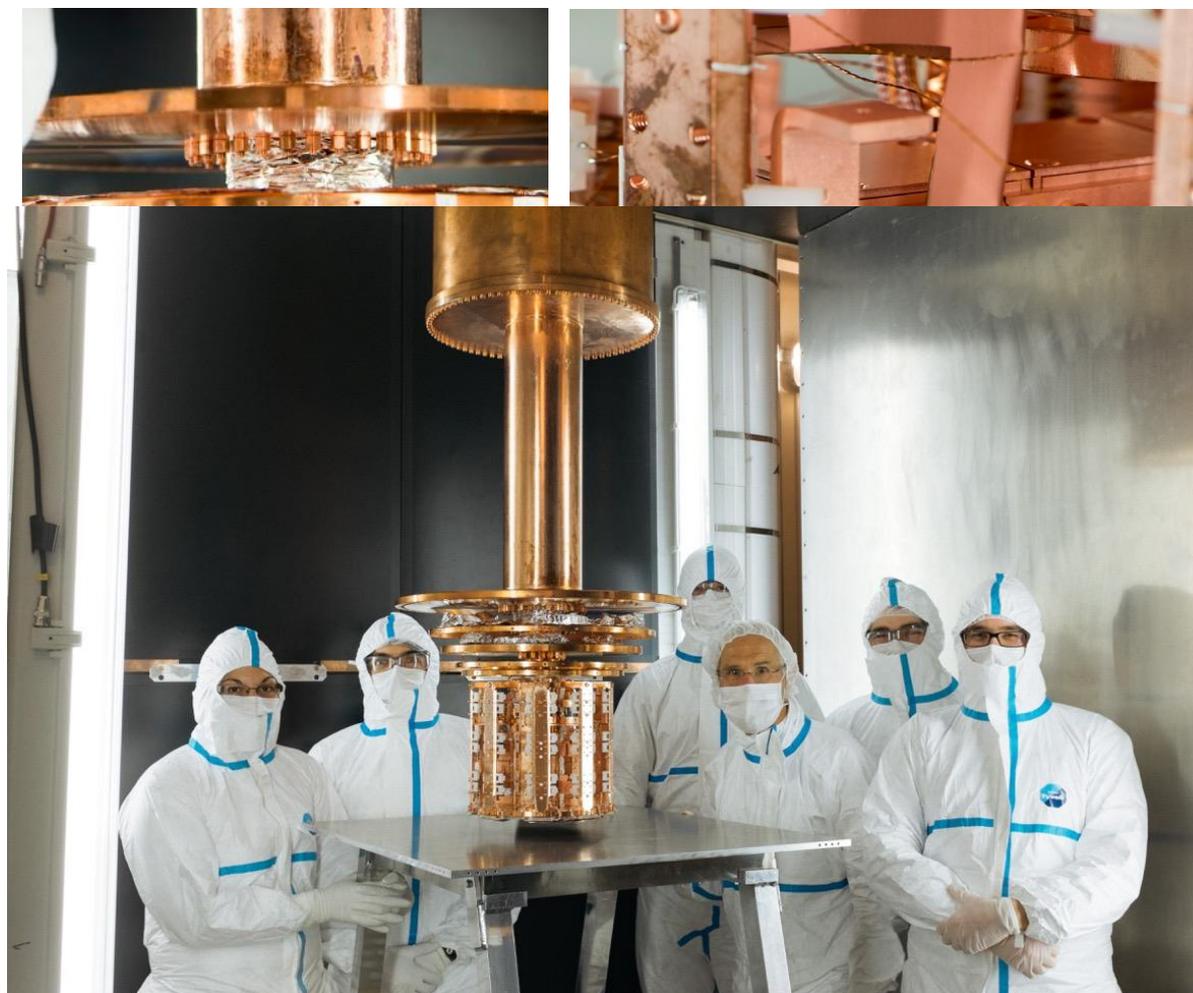
# Status of CRESST-III phase 1



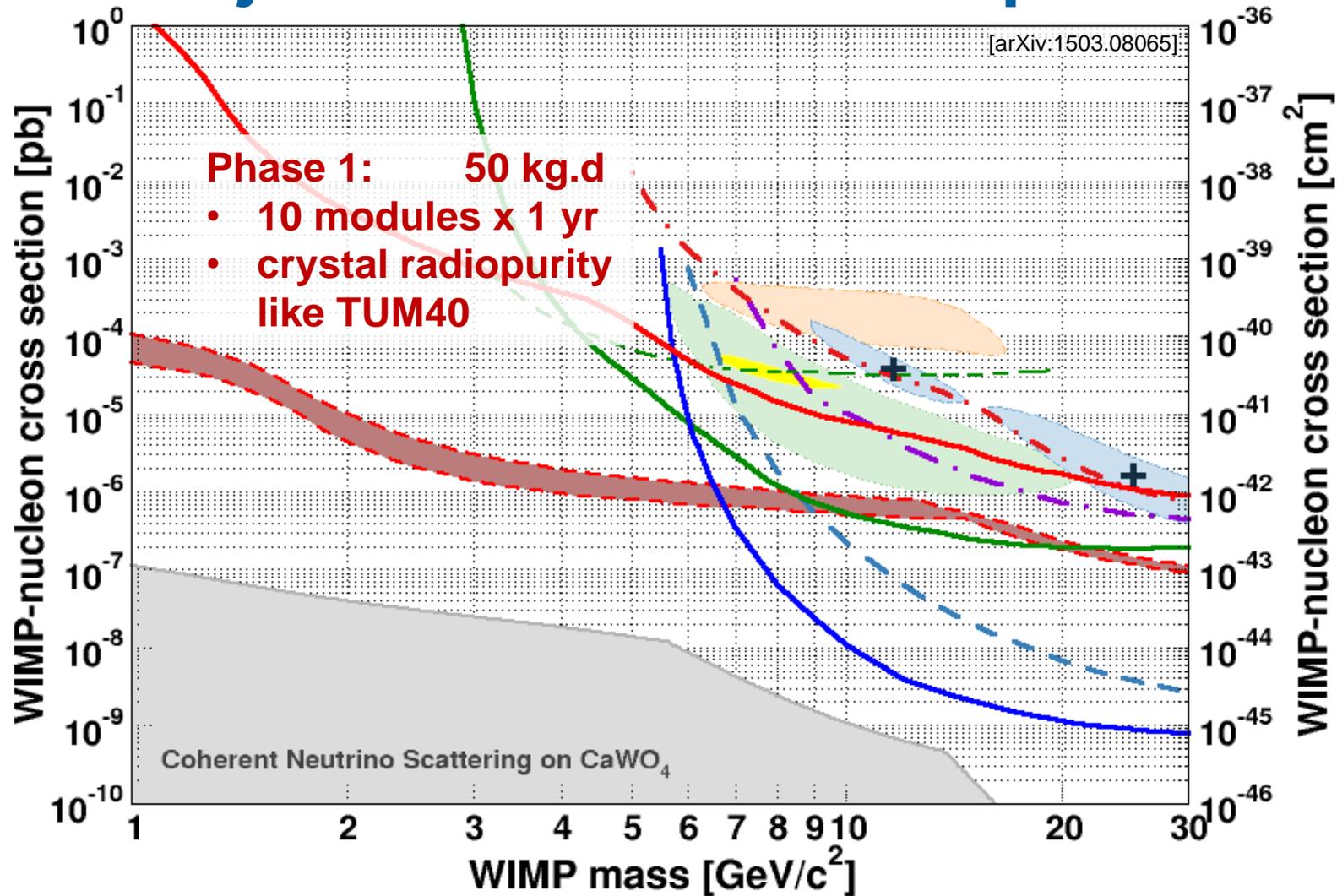
- **10 CRESST-III** modules installed
  - 8 modules with TUM40 radiopurity
  - 2 modules with further improved radiopurity

# Status of CRESST-III phase 1

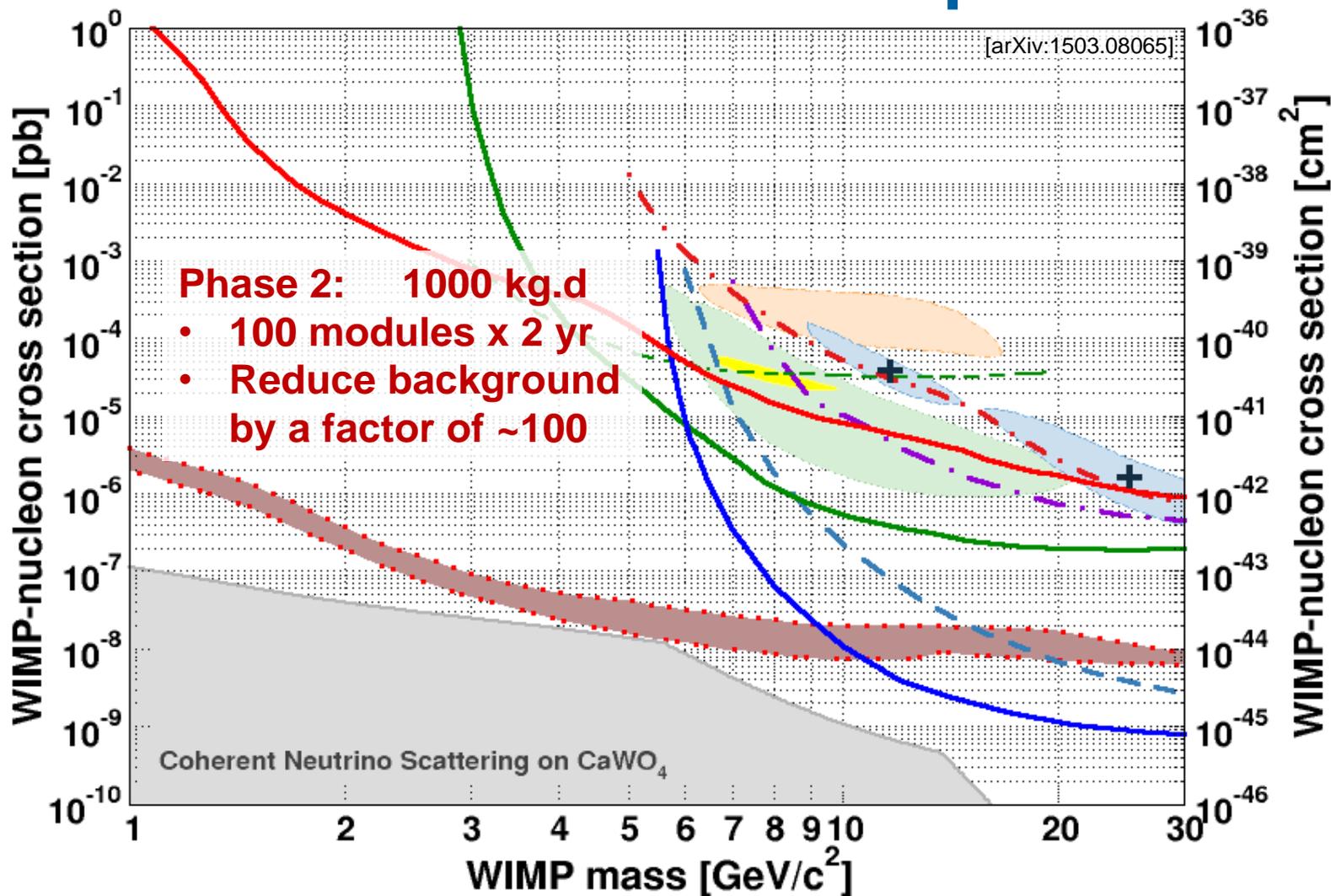
- 10 CRESST-III modules installed
- Since **May**
  - Complete installation
  - Cool-down
  - **Start commissioning CRESST-III phase 1**



# Projection for CRESST-III phase 1



# Outlook to CRESST-III phase 2



# Summary

