



# New Results from the CRESST Experiment

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MPI München  
TeVPA/IDM, Amsterdam,  
23.6.2014

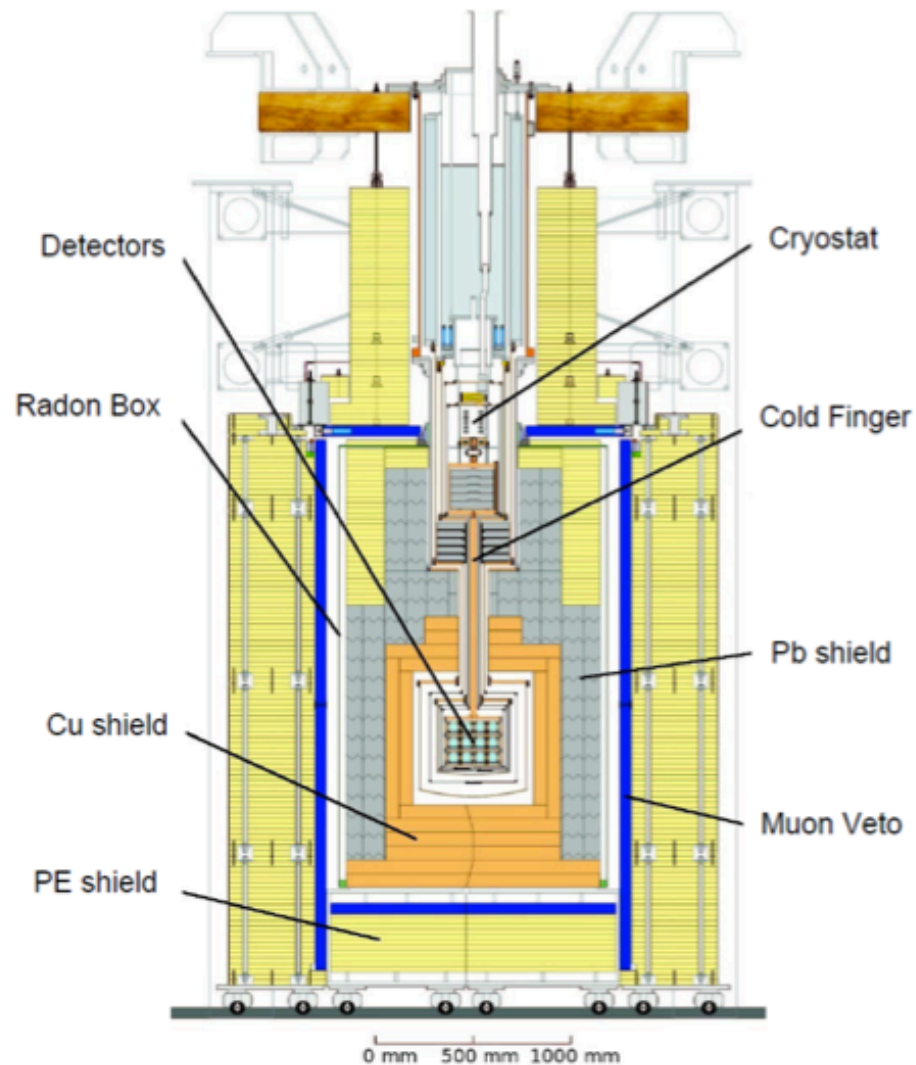


**OAW**  
Austrian Academy  
of Sciences



# The CRESST Experiment

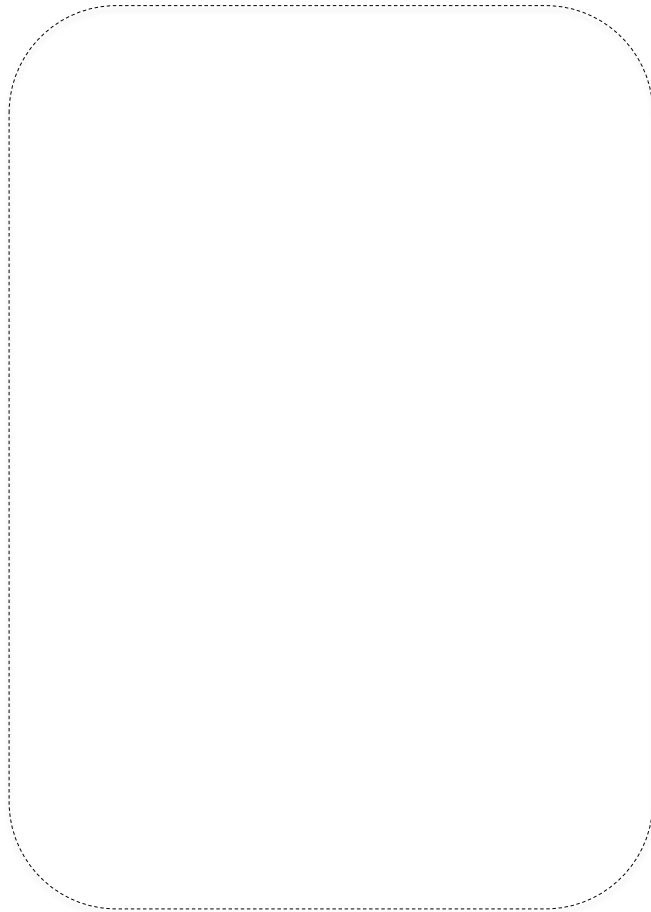
Cryogenic Rare Event Search with Superconducting Thermometers



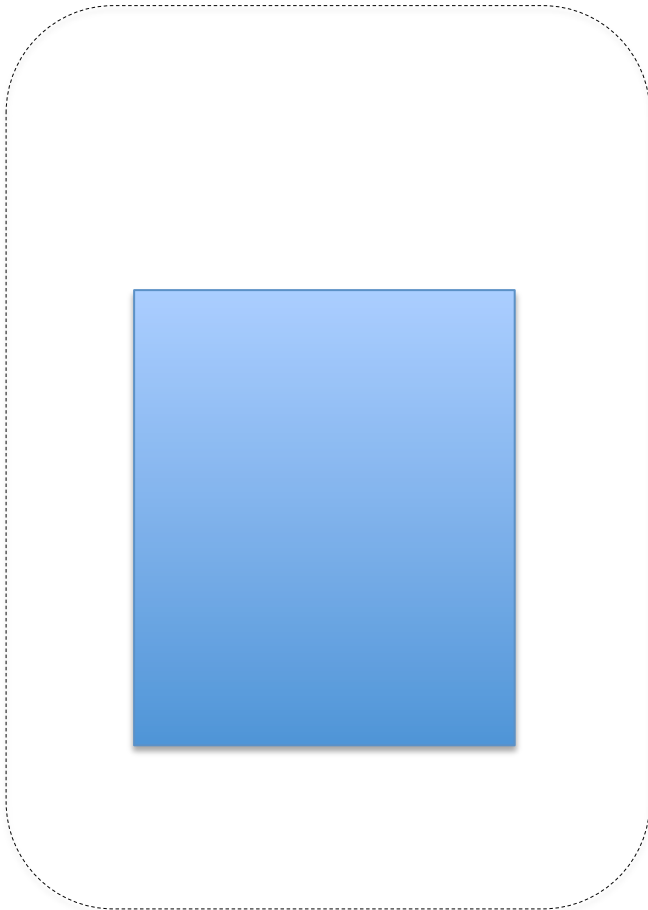
- Underground installation
- Ultra-low background environment
- Cryogenic detectors



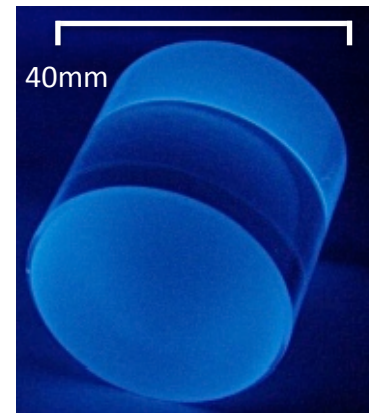
# The CRESST Detector Module



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CaWO<sub>4</sub> Target Crystal



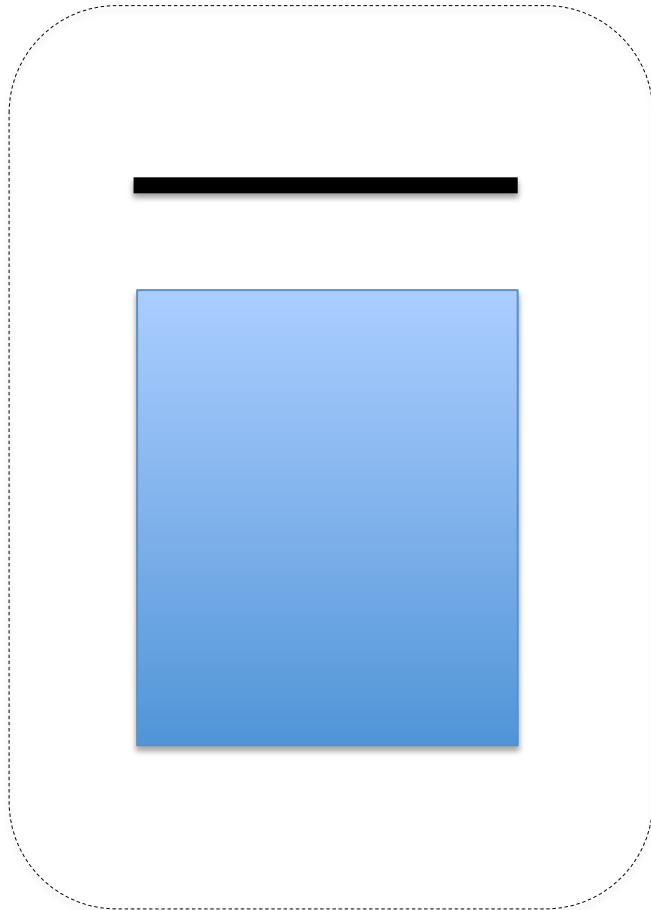
- scintillating
- multi-element target
- mass: 200 – 300 g



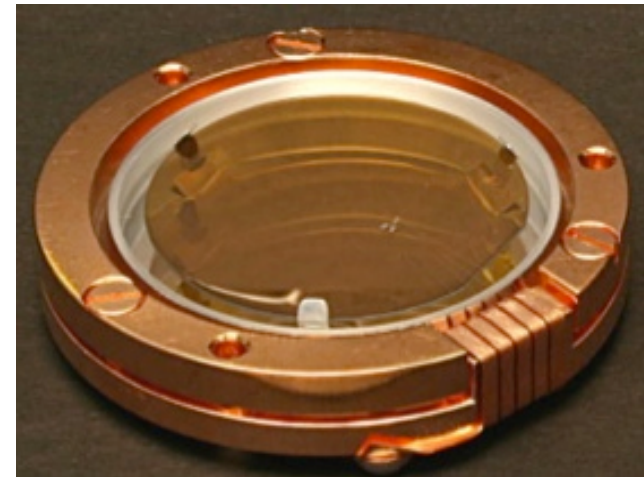
In-house production and processing  
at our institutes



# The CRESST Detector Module

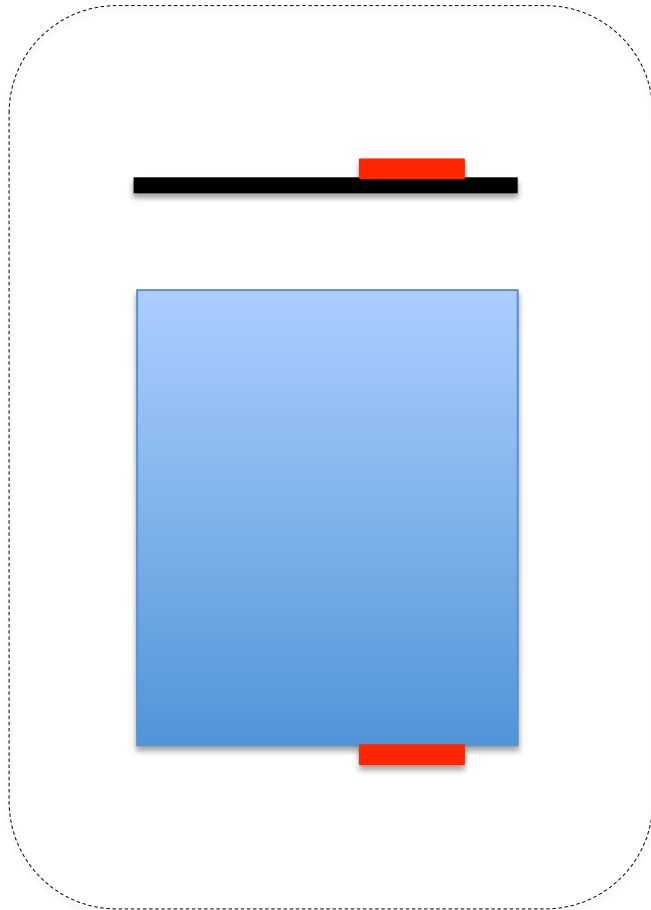


Light Absorber  
for scintillation-light detection



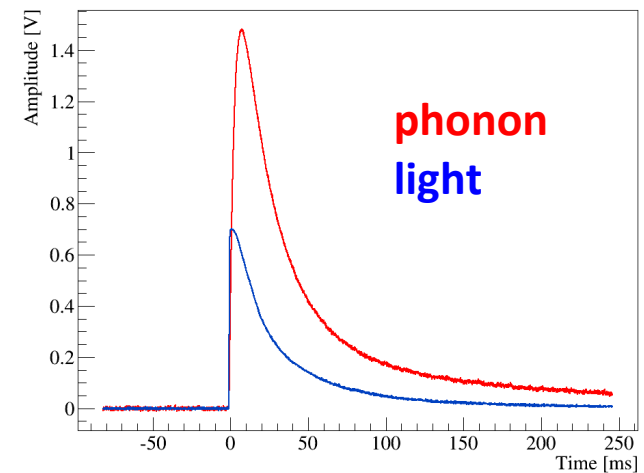
- silicon-on-sapphire disc
- diameter: 40mm
- thickness: 500 $\mu$ m

# The CRESST Detector Module



## Transition-Edge-Sensors

→ 2 independent calorimeters



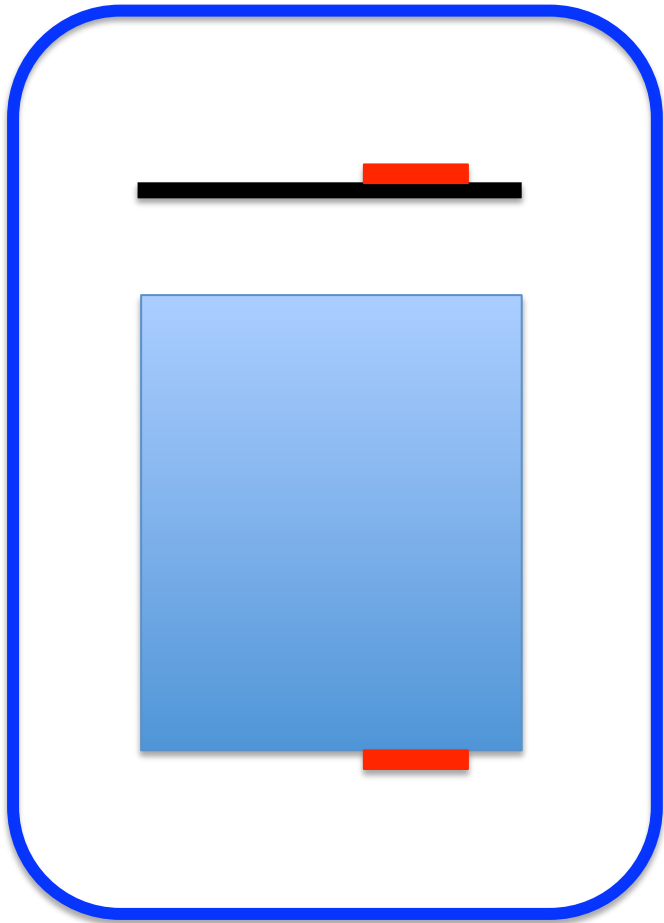
### Phonon detector ( $\text{CaWO}_4$ )

- Threshold:  $E_{\text{th}} \lesssim 1\text{keV}$
- Resolution:  $\sigma \approx 100\text{-}200\text{ eV}$

### Light detector (SOS)

- Threshold  $E_{\text{th}} \approx 5\text{eV}$

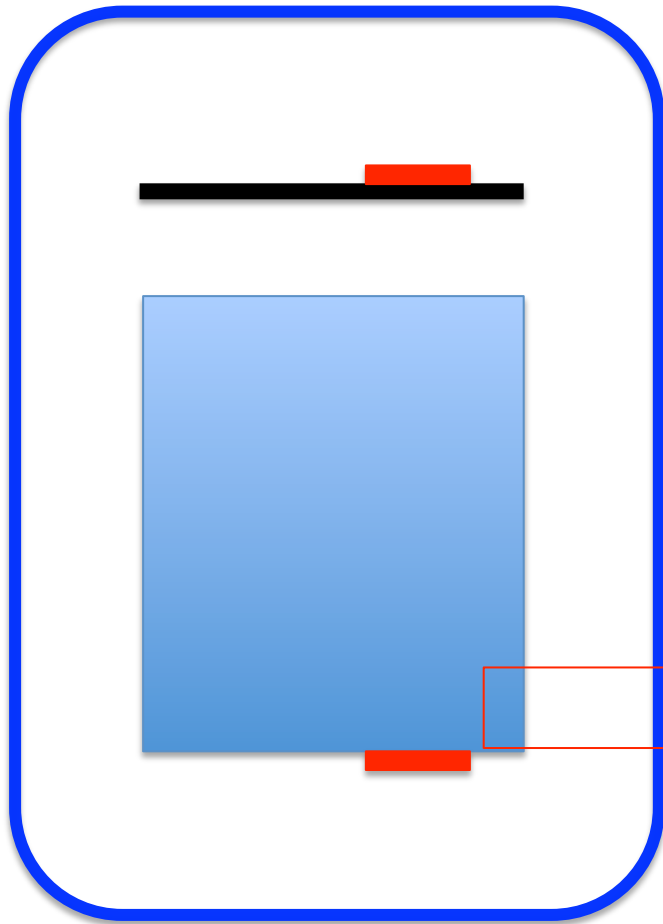
# The CRESST Detector Module



## Polymeric Foil

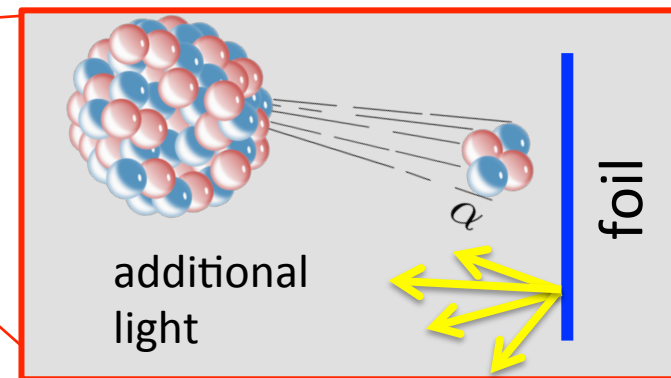
- ① Highly reflective
  - light collection
- ② Scintillating
  - rejection of surface events

# The CRESST Detector Module

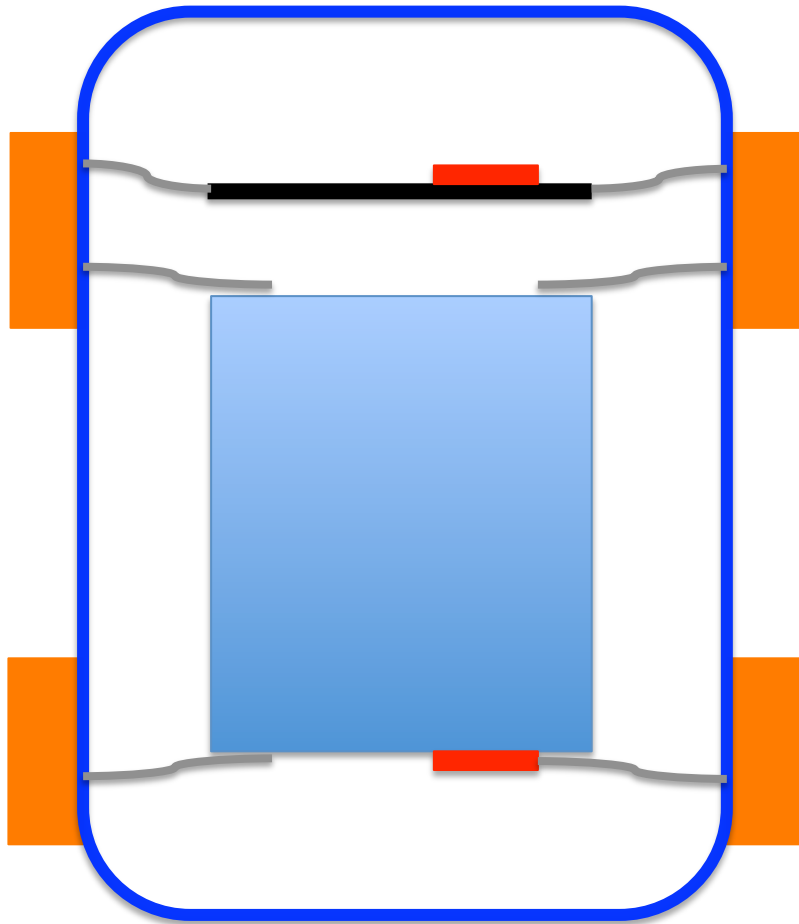


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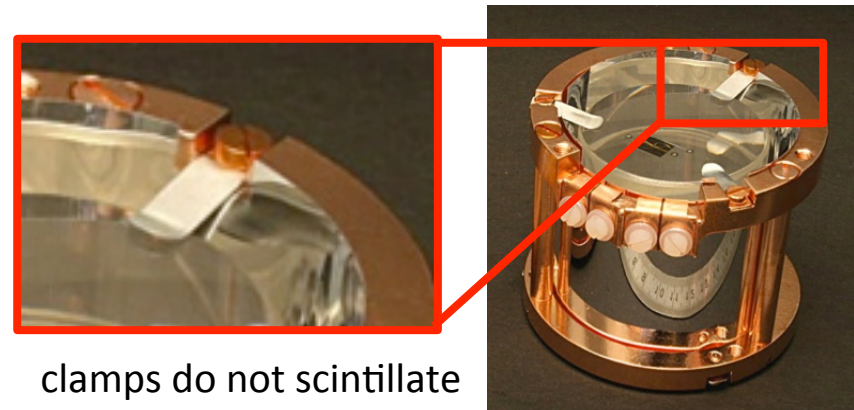


# The CRESST Detector Module



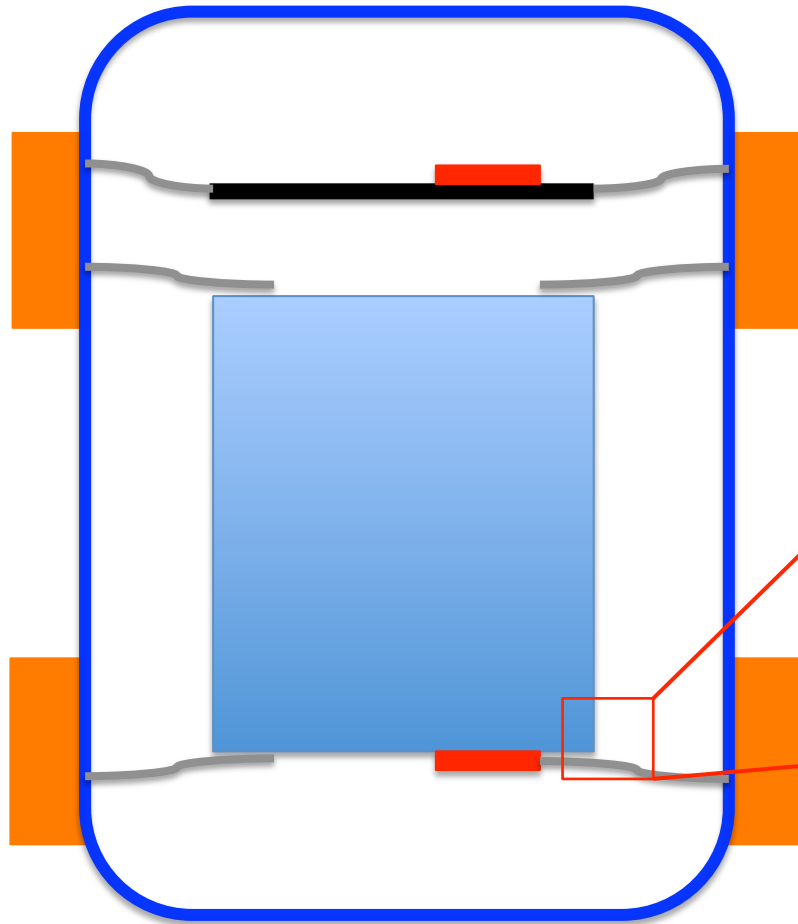
## Support Structure

- radio-pure copper
- flexible bronze clamps

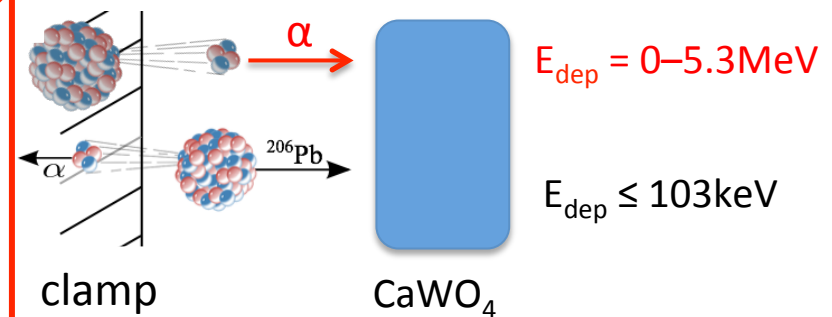
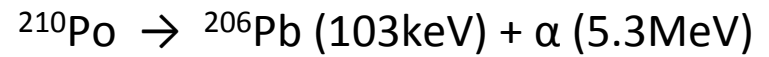




# The CRESST Detector Module



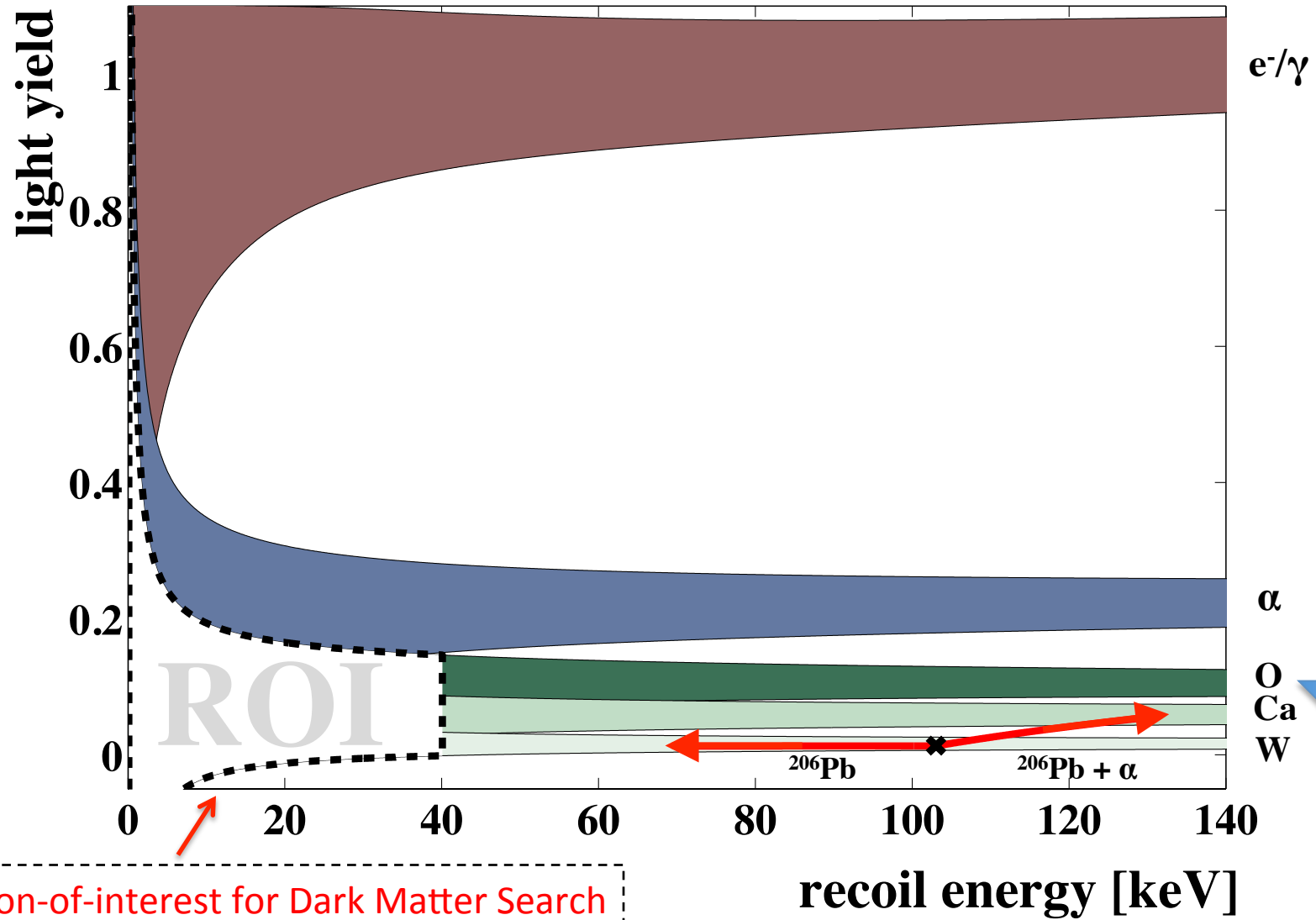
## Dangerous Surface Backgrounds



→ Lead/alpha recoils can mimic WIMPs

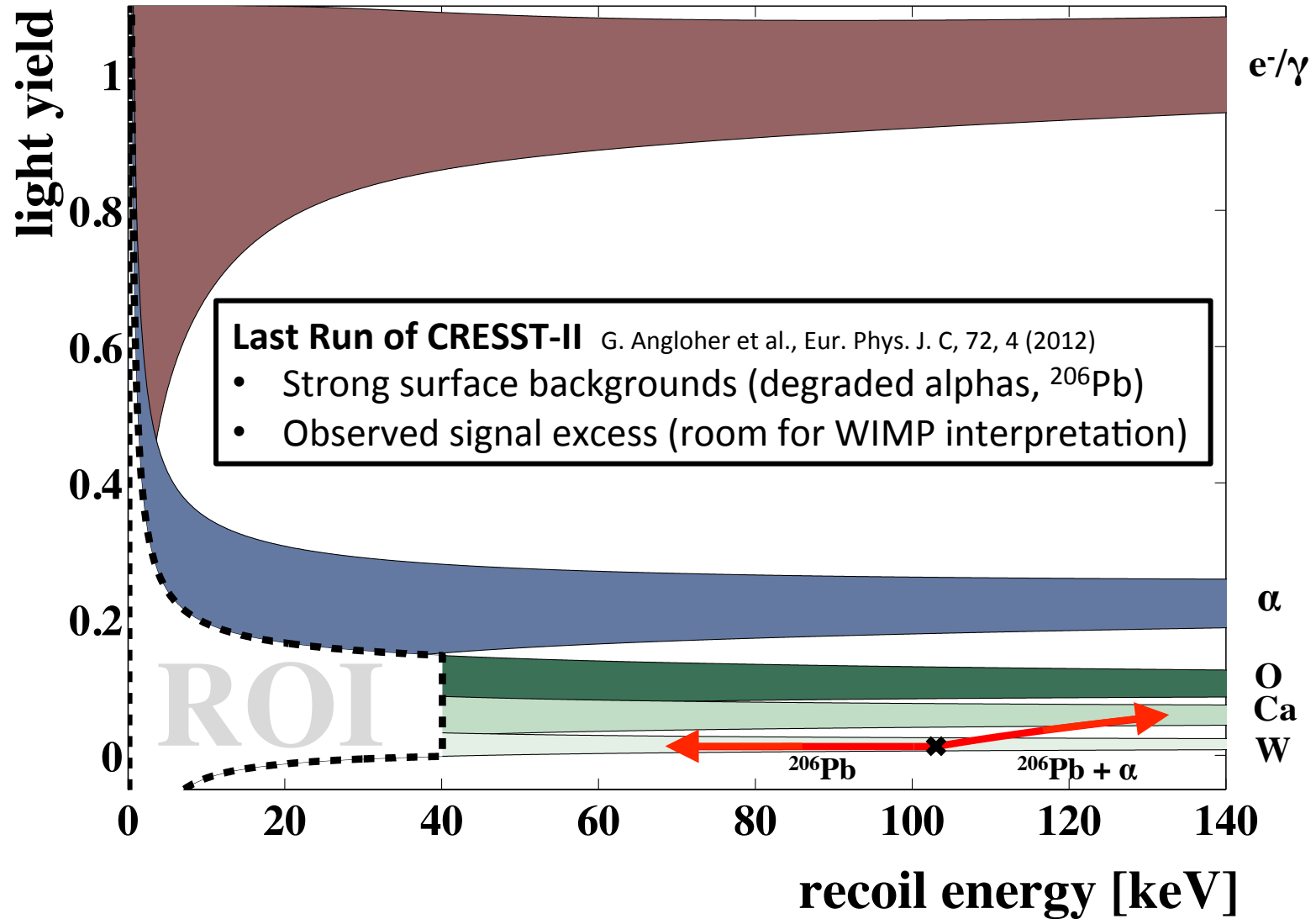
→ Avoid non-scintillating materials!

# Signal and Backgrounds

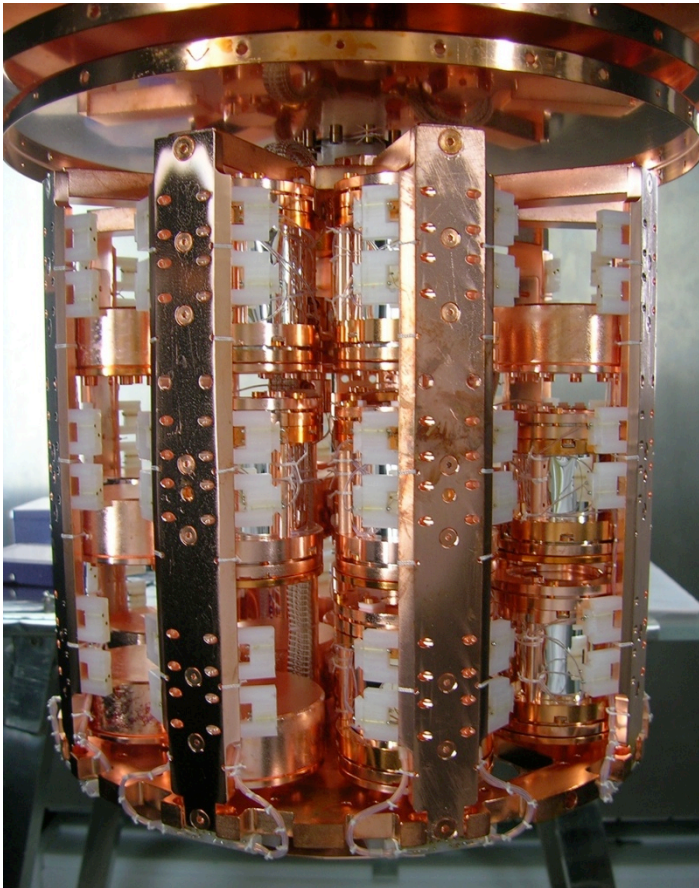


Region-of-interest for Dark Matter Search

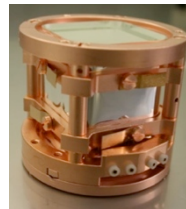
# Signal and Backgrounds



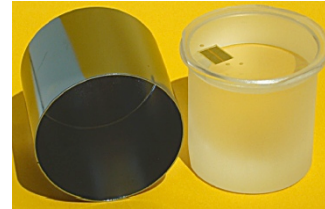
# New Run – CRESST-II Upgrade



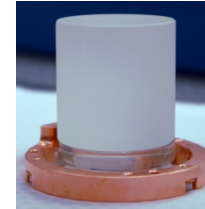
- Data-taking since July 2013
- 18 modules mounted (~ 5kg)  
→ 17 of 18 are fully operational
- ✓ **11 x conventional design (improved)**
  - Use of radiopure clamps
  - Radon prevention
- ✓ **6 x fully-scintillating new designs**



CaWO<sub>4</sub> sticks

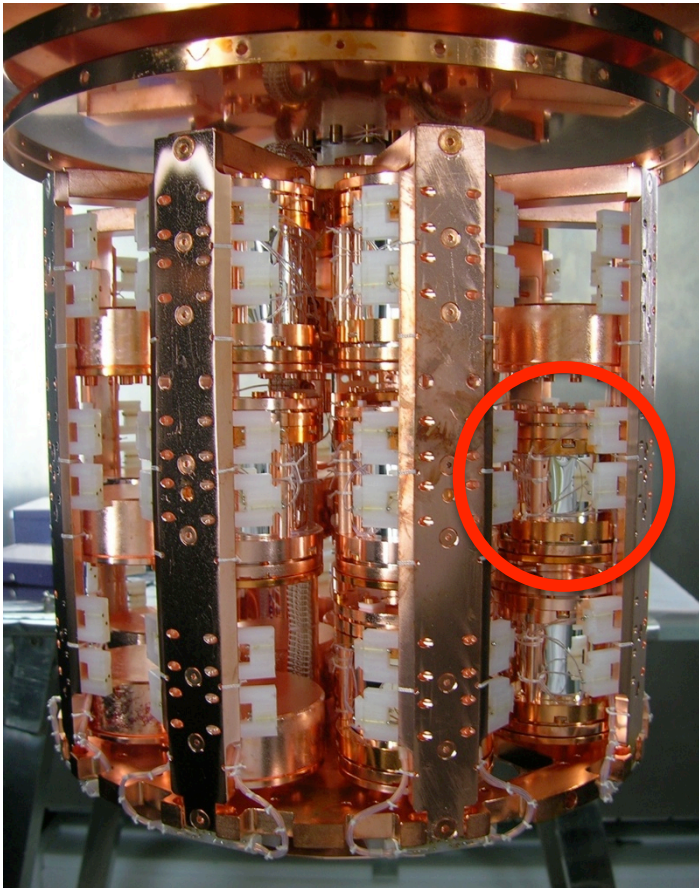


beaker

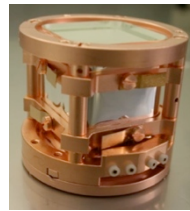


K-14

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this talk:

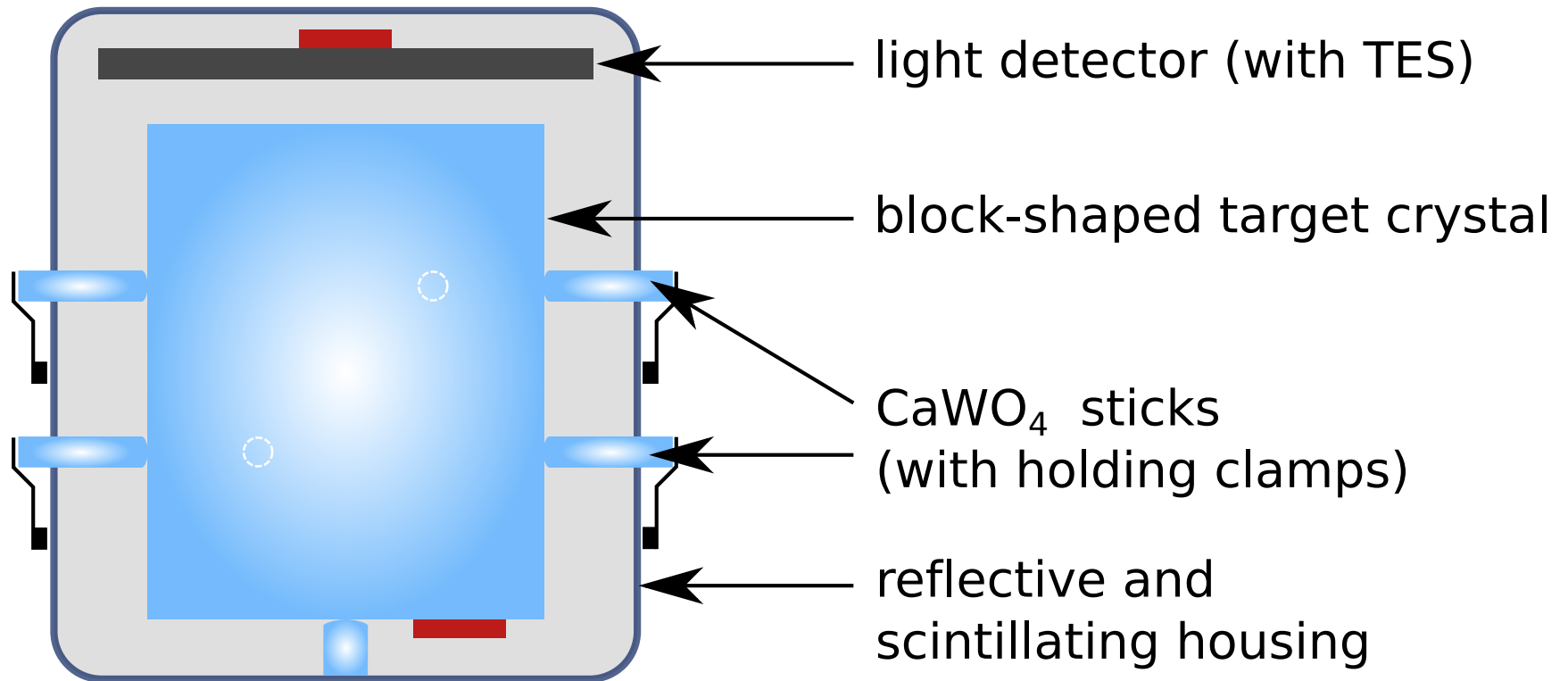
**focus on one detector  
module (TUM-40)**

mass: 250g

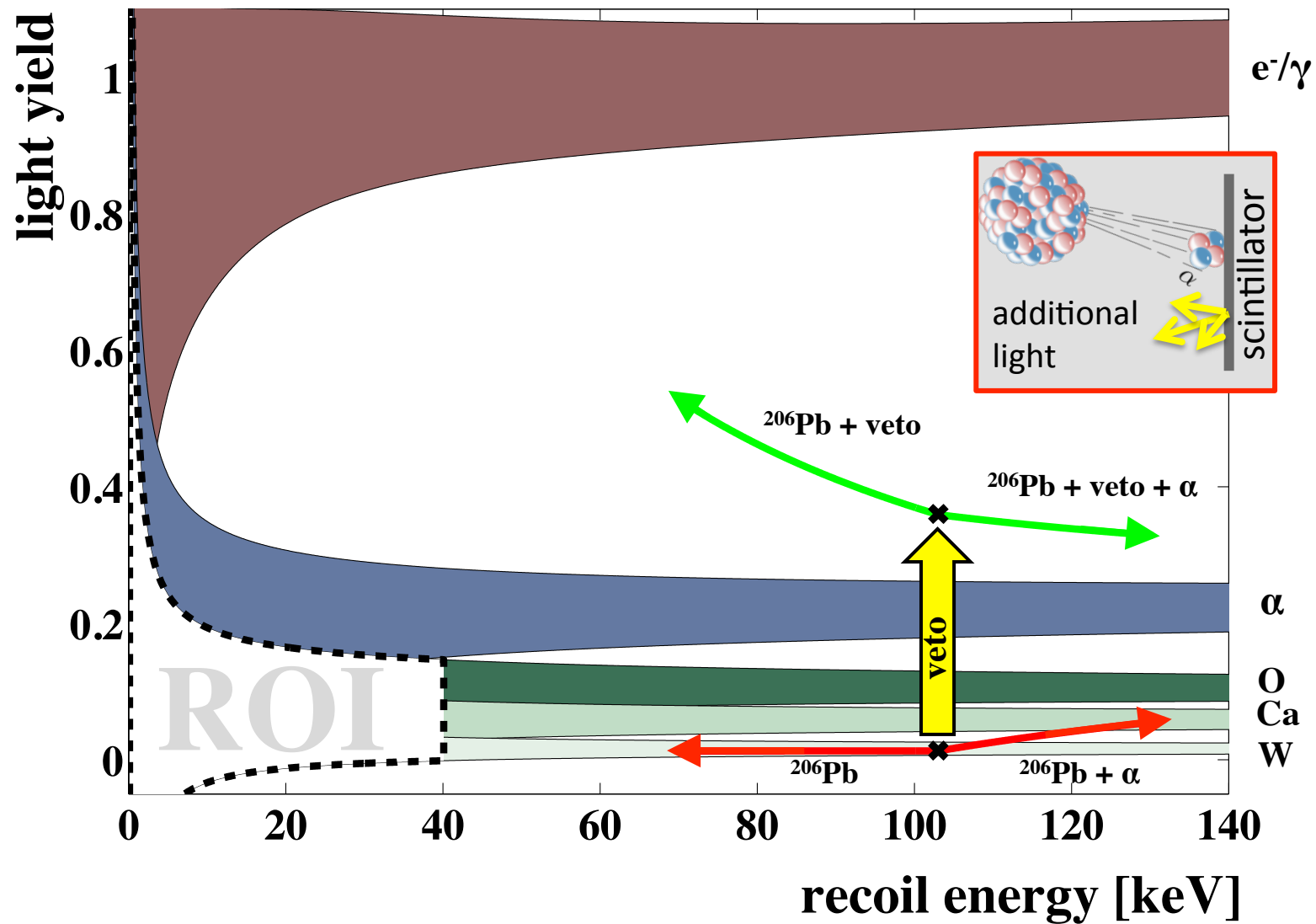
CaWO<sub>4</sub> sticks exposure: 29 kg-days



# Fully-Scintillating Design

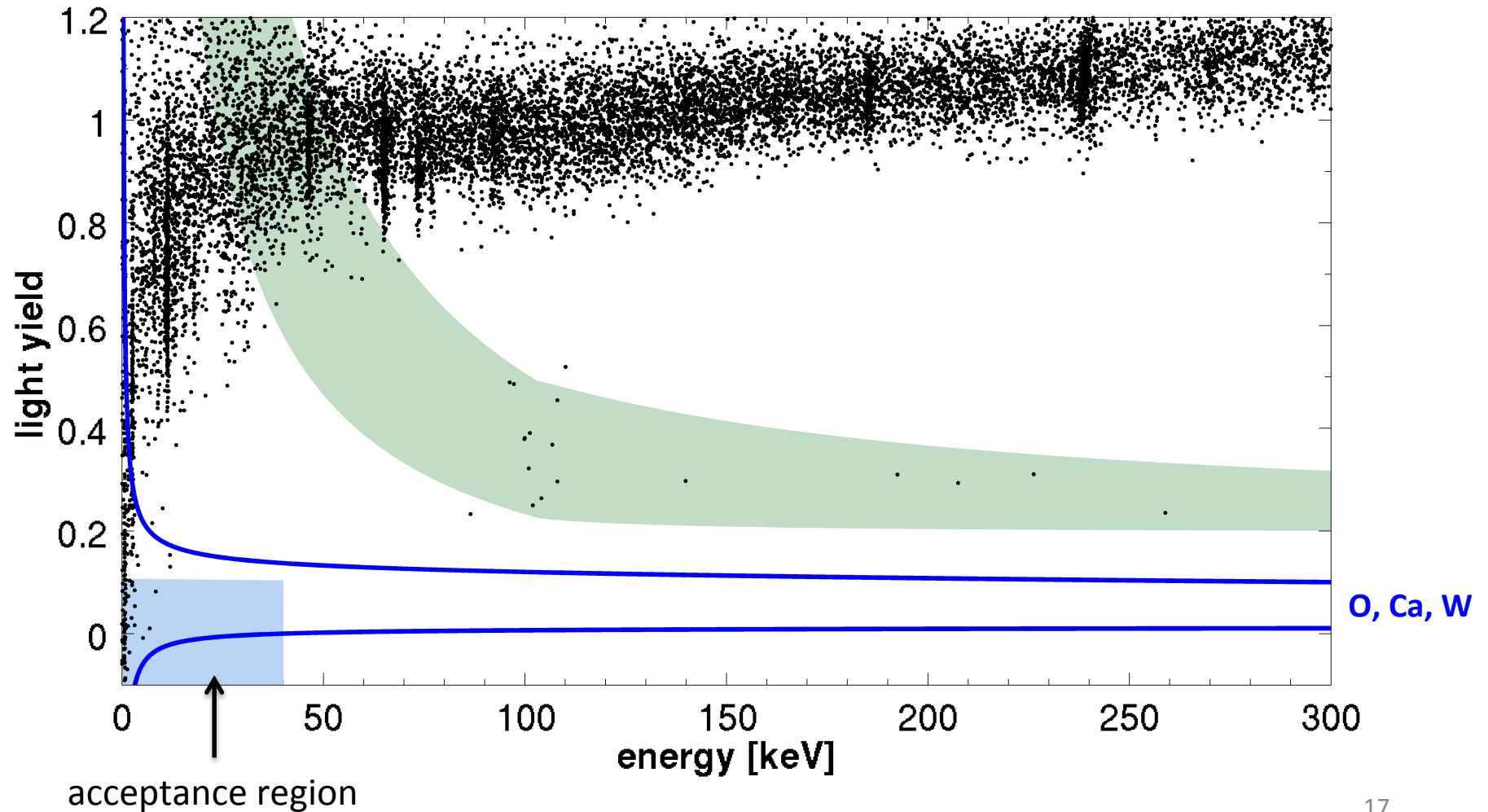


# Efficient Veto of Surface Backgrounds



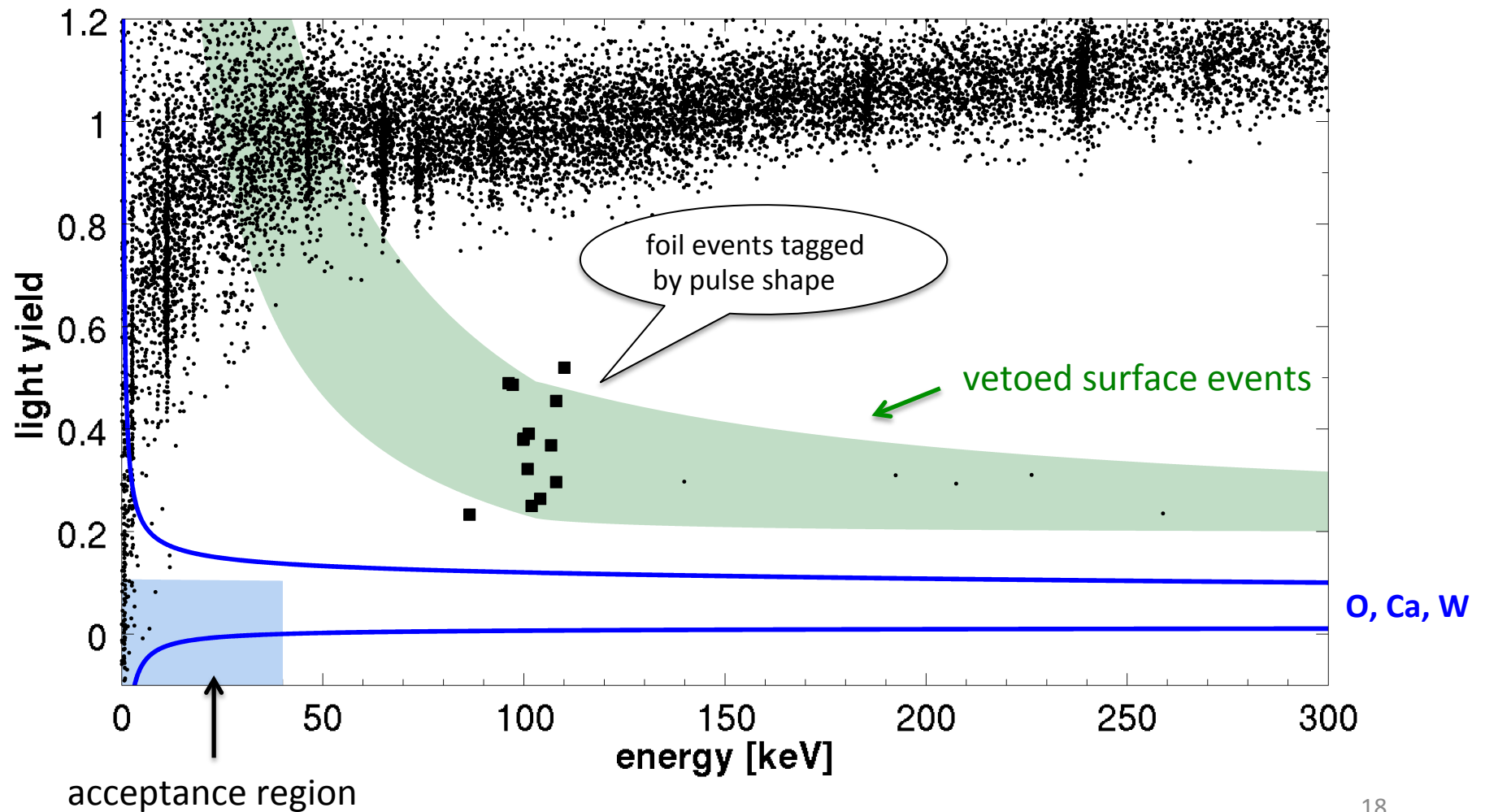
# TUM-40: Surface Backgrounds

exposure: 29 kg-days



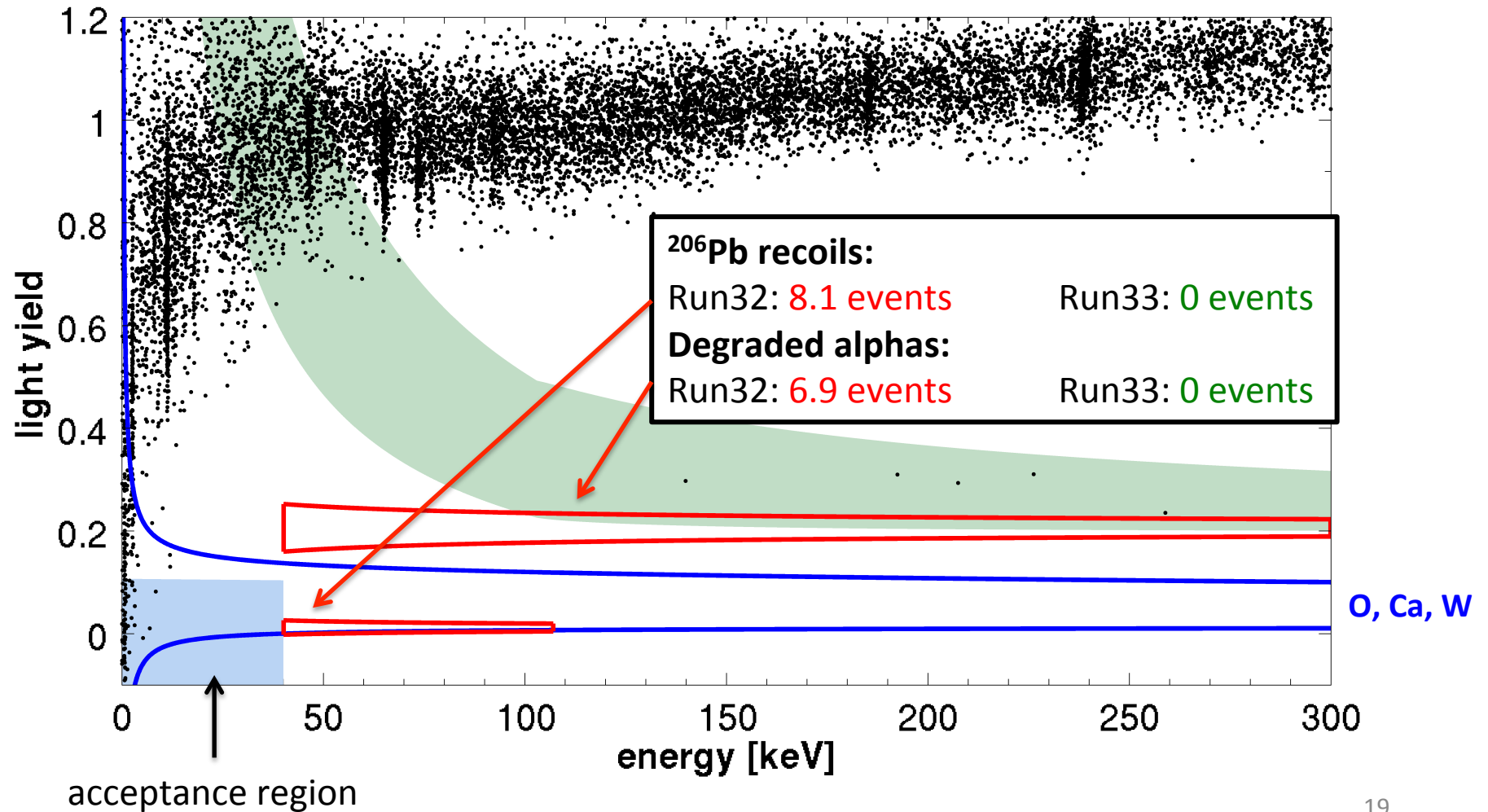
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# TUM-40: Surface Backgrounds

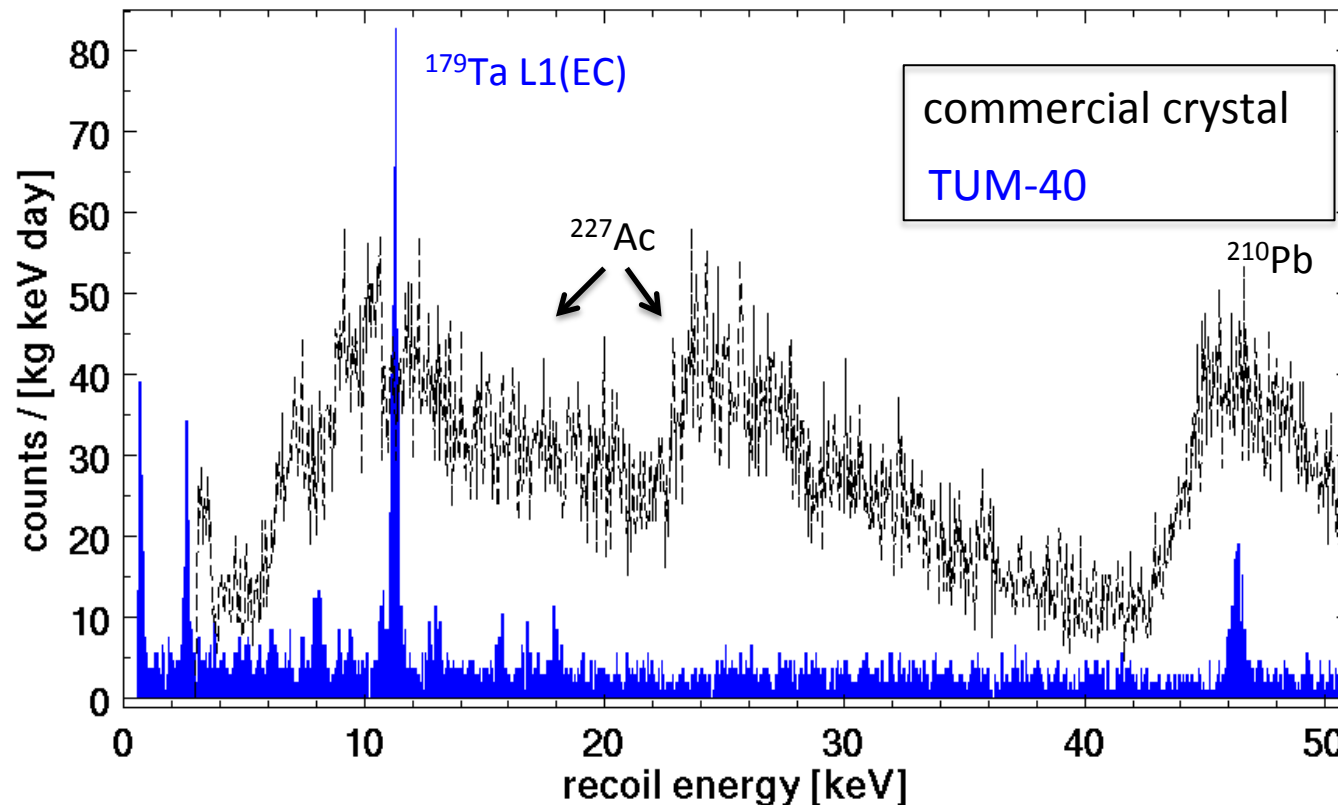
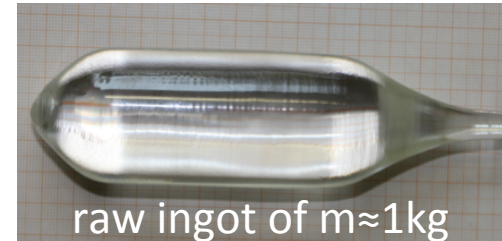
exposure: 29 kg-days





# TUM-40: Radiopurity

- $\text{CaWO}_4$ -crystal **production at TU Munich**
- Unprecedented radiopurity (by factor 2-10)
- Room for further improvements



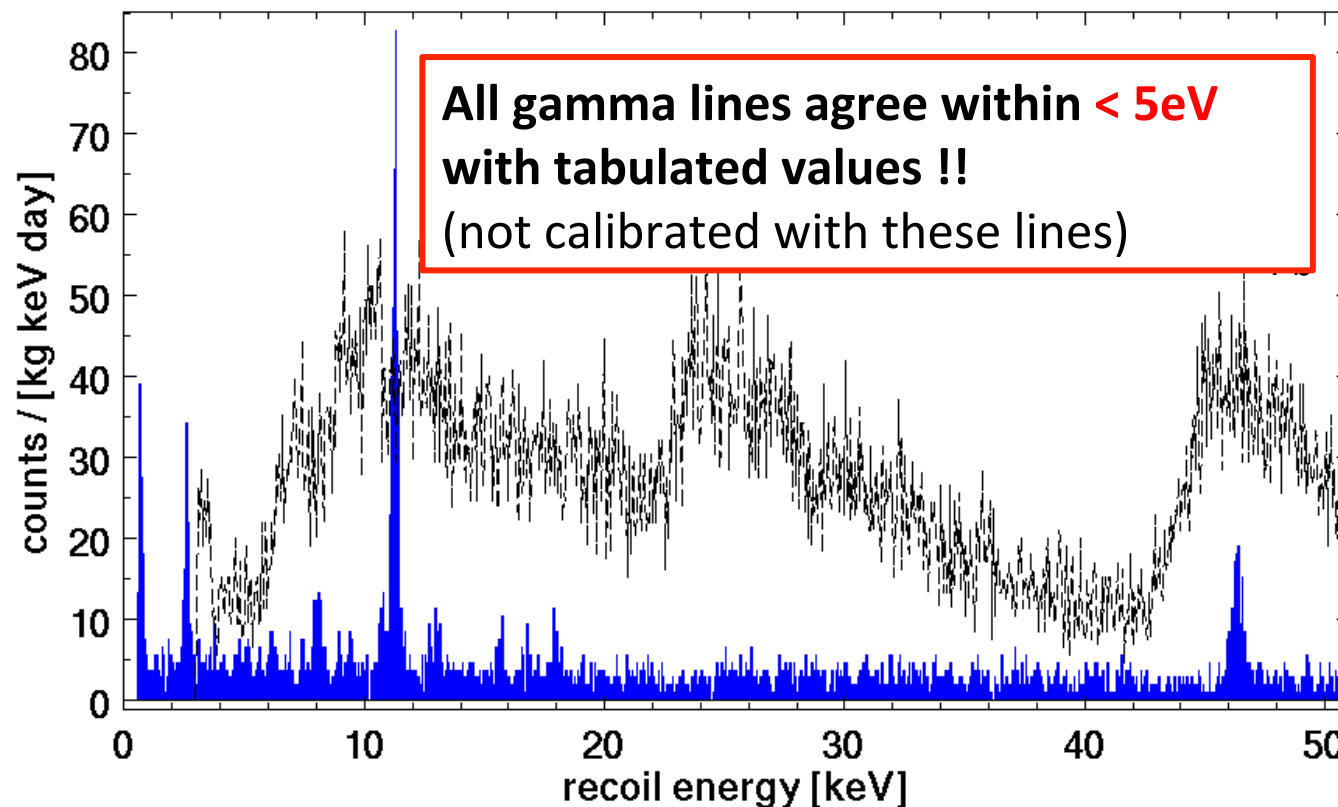
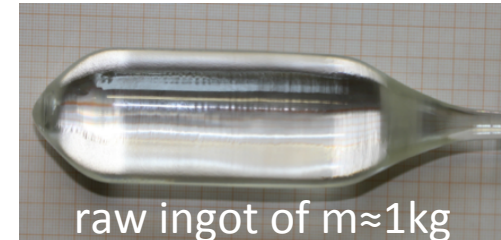
Average rate:  
**~3.5 counts /**  
**[kg keV day]**

Gamma-lines  
from **cosmogenic**  
**activation**

Excellent  
resolution:  
 $\sigma \approx 100\text{eV}$

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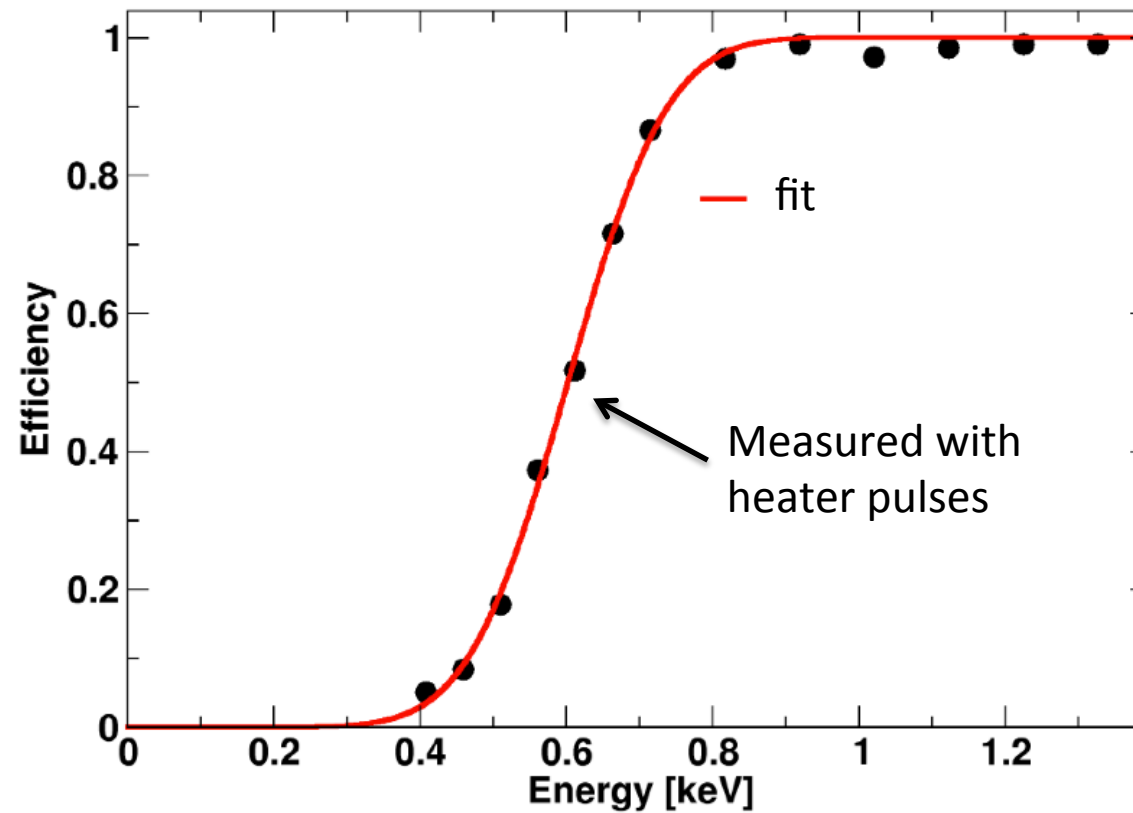


Average rate:  
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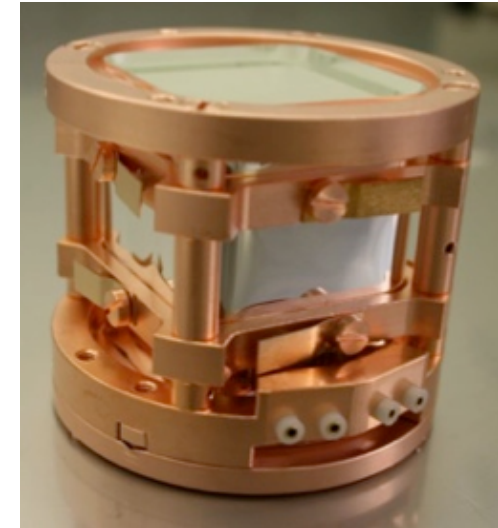
# TUM-40: Trigger Threshold



- Extremely low trigger threshold of  $E_{th} \approx 603\text{eV}$
- Resolution of  $\sigma \approx 107\text{eV}$  in agreement with resolution of gamma lines
- Nuclear-recoil energy **precisely known!**

# TUM-40: Performance

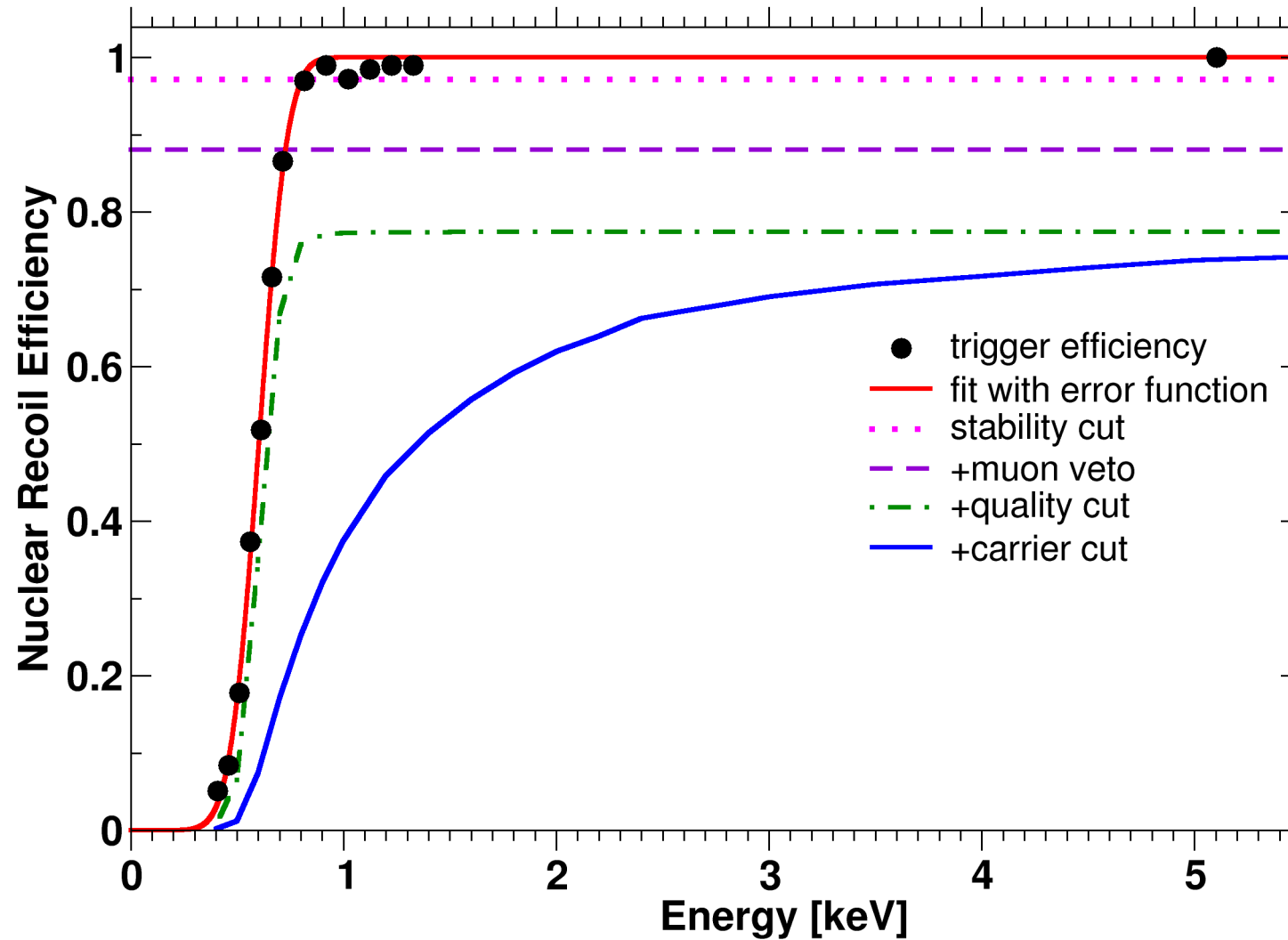
- **No surface backgrounds**
- **Best radiopurity** ( $\approx 3.5$  / [kg keV day])
- **Low trigger threshold** ( $\approx 0.60$  keV)
- **High resolution** ( $\sigma \approx 100$  eV)



→ **Low-threshold** Dark Matter analysis possible

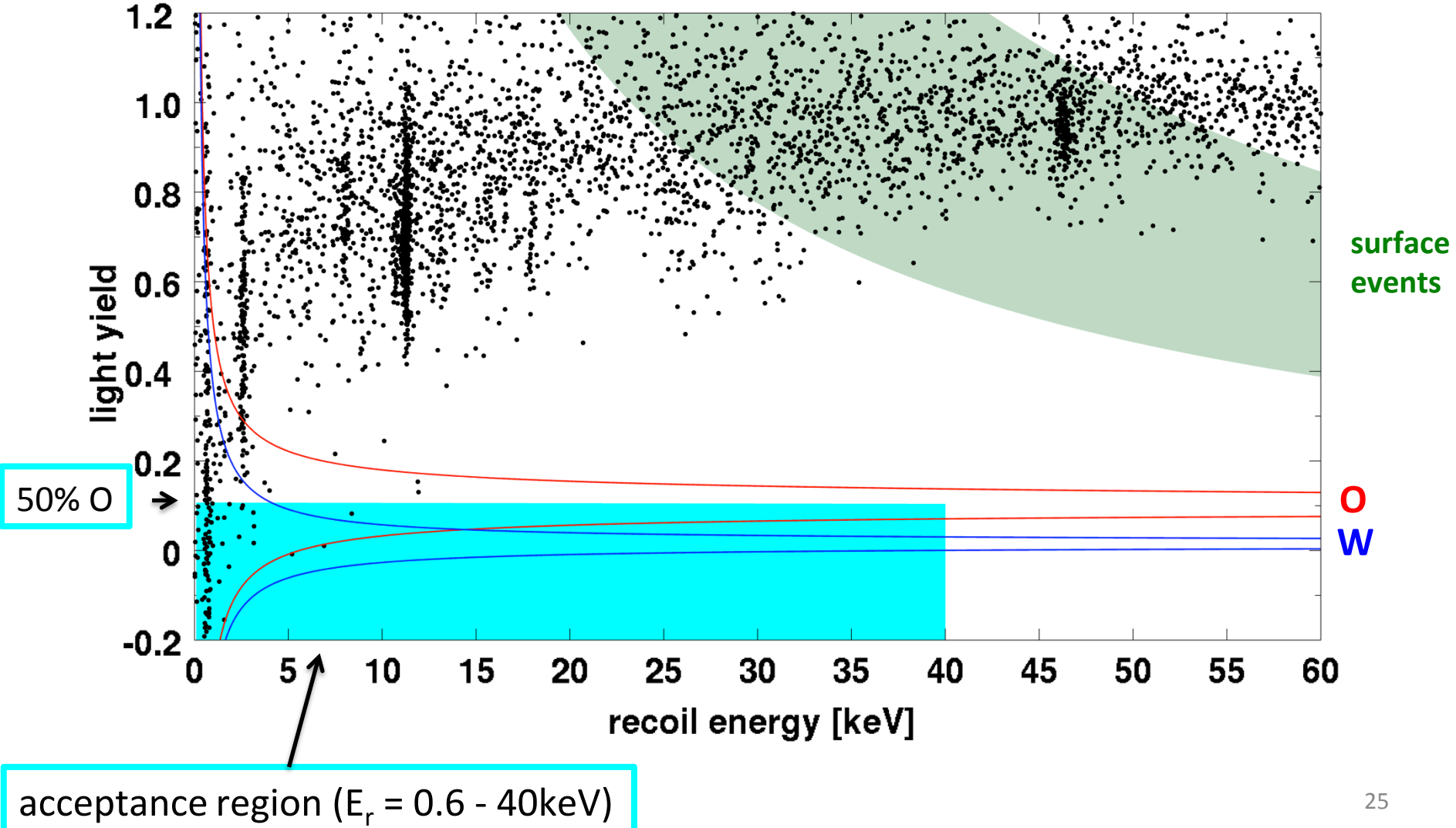
→ Use non-blinded dataset of 29kg-days

# TUM-40: Acceptance at Lowest Energies

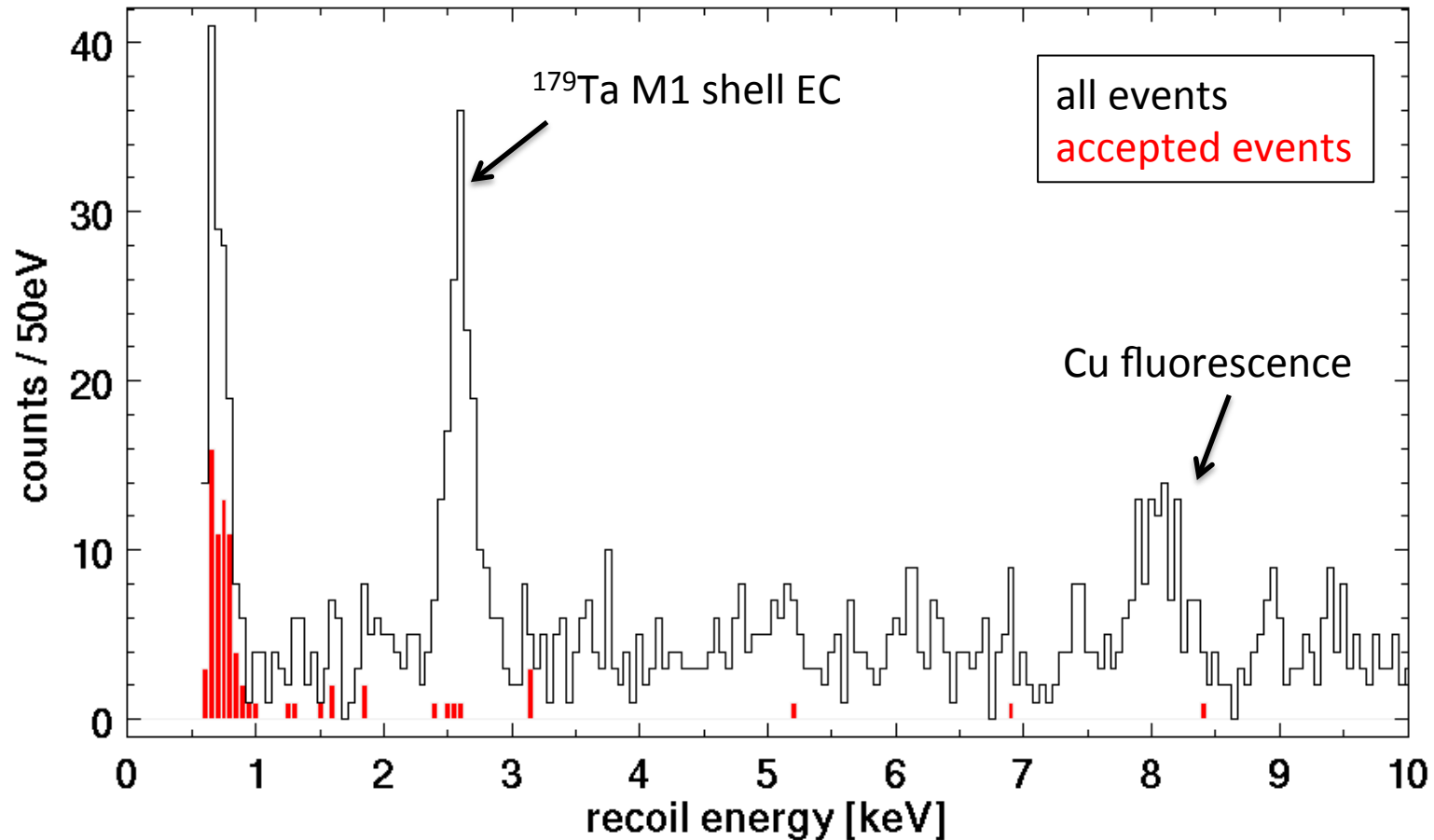




# WIMP-Acceptance Region

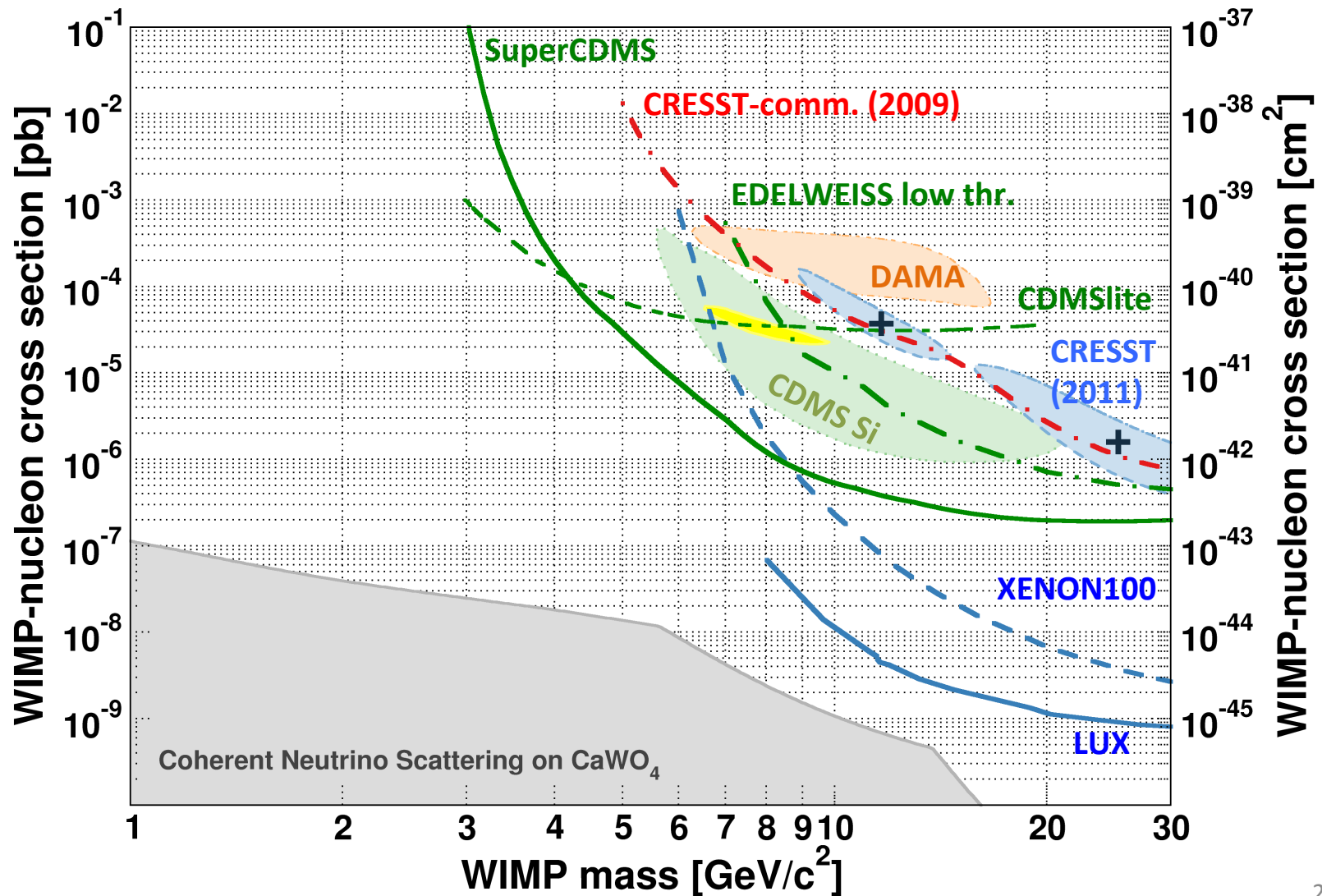


# Events in Acceptance Region

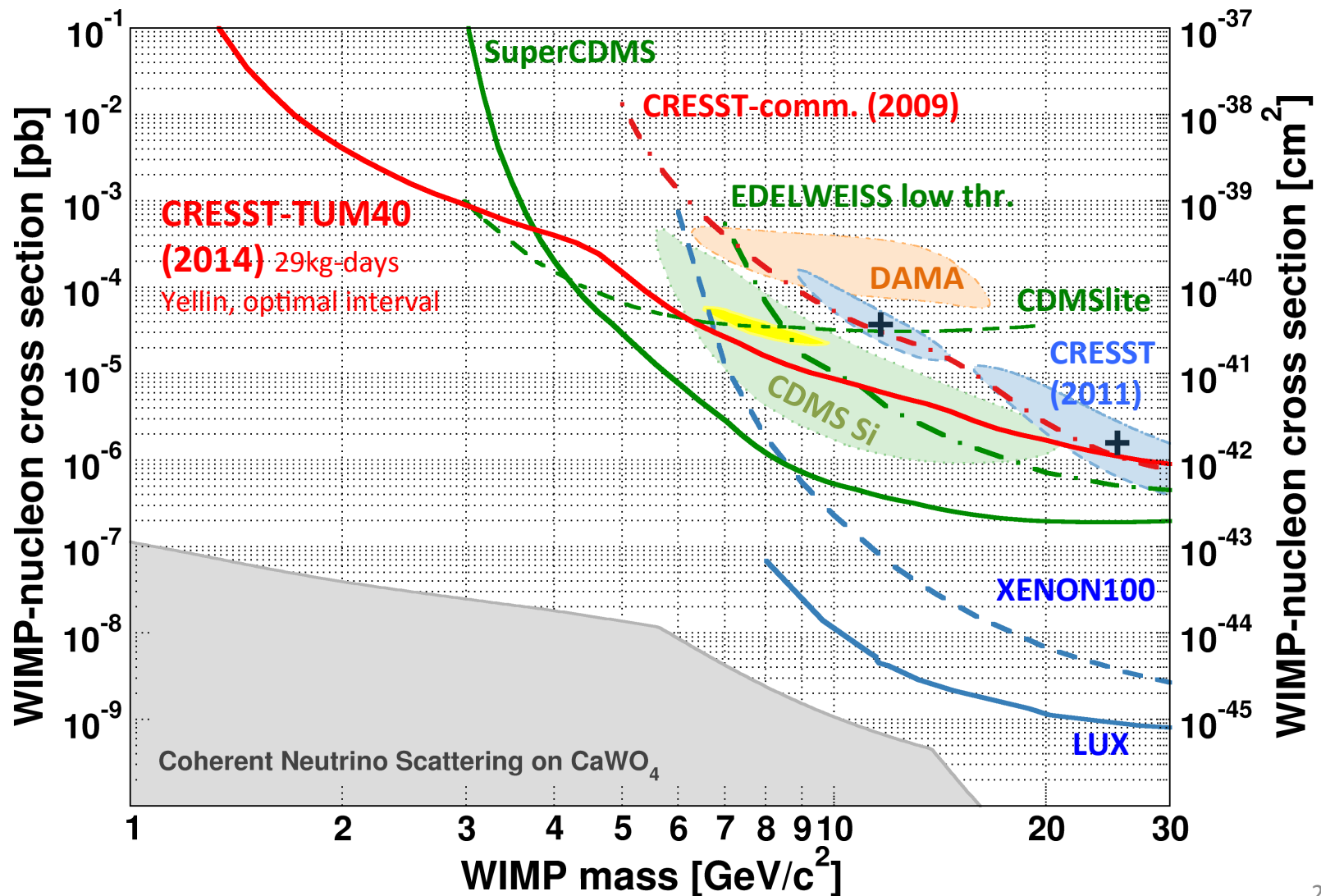


All 79 events accepted are conservatively considered as WIMP scatters!

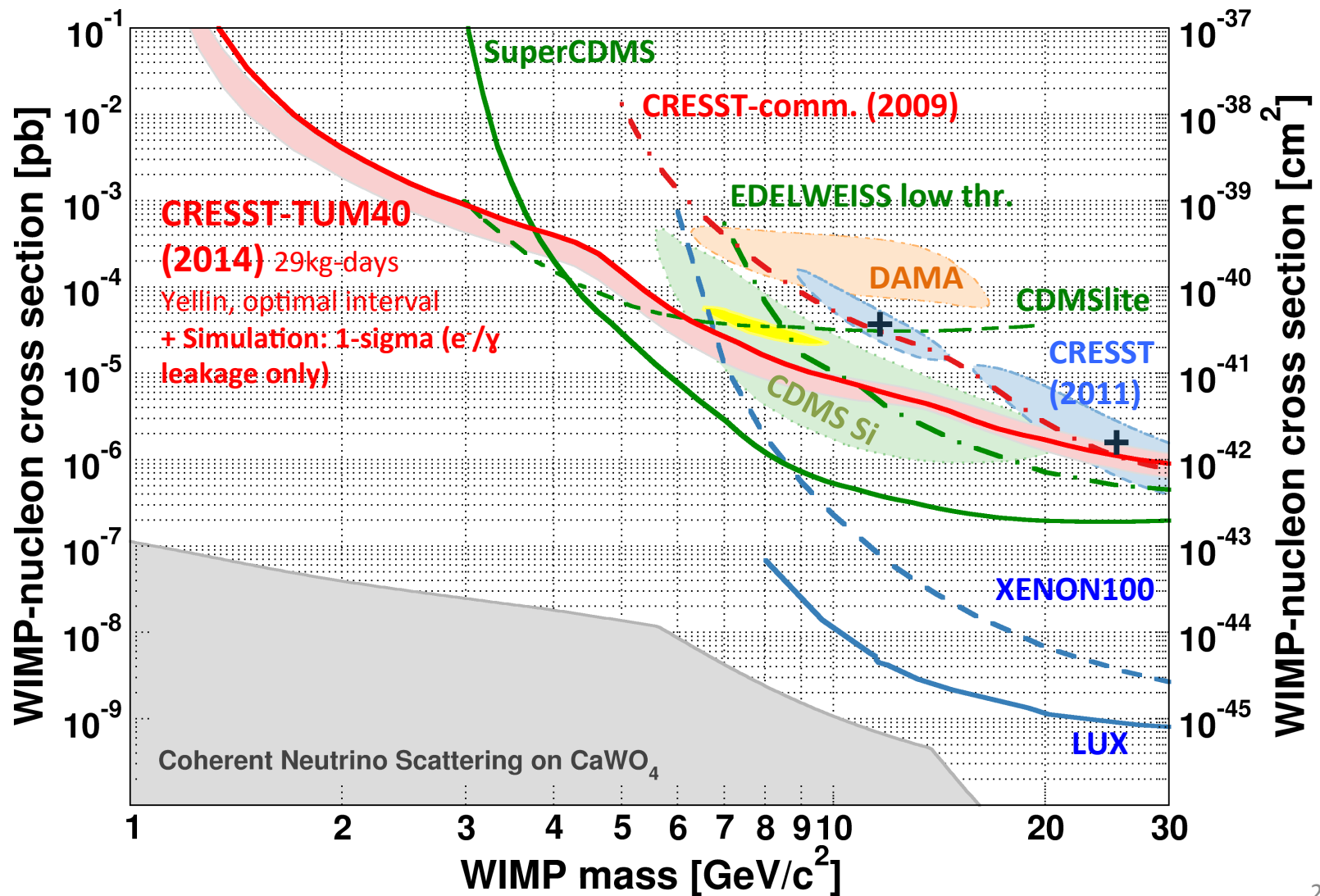
# Present WIMP Landscape



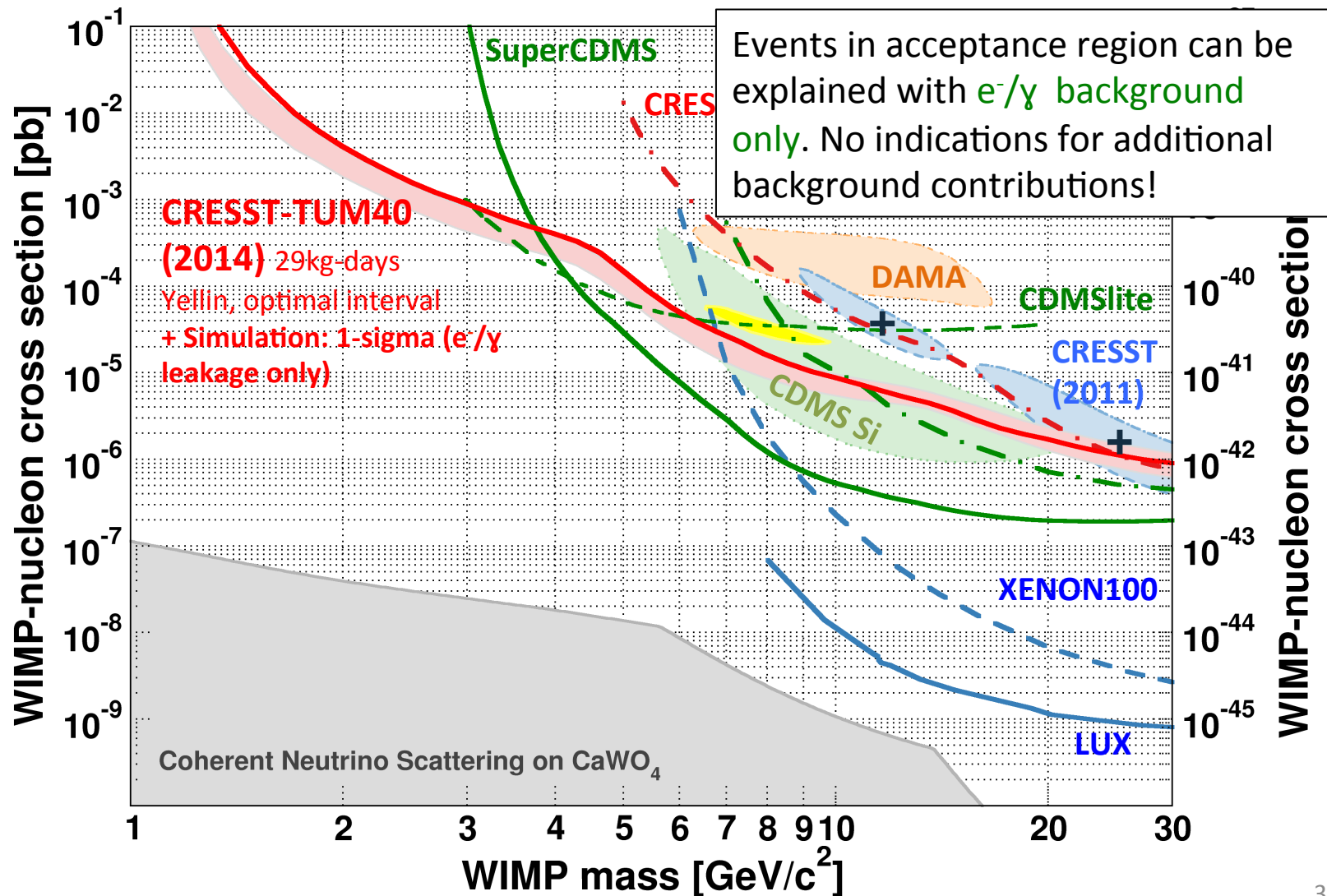
# Results from 29kg-days of TUM-40



# Data vs. Simulation



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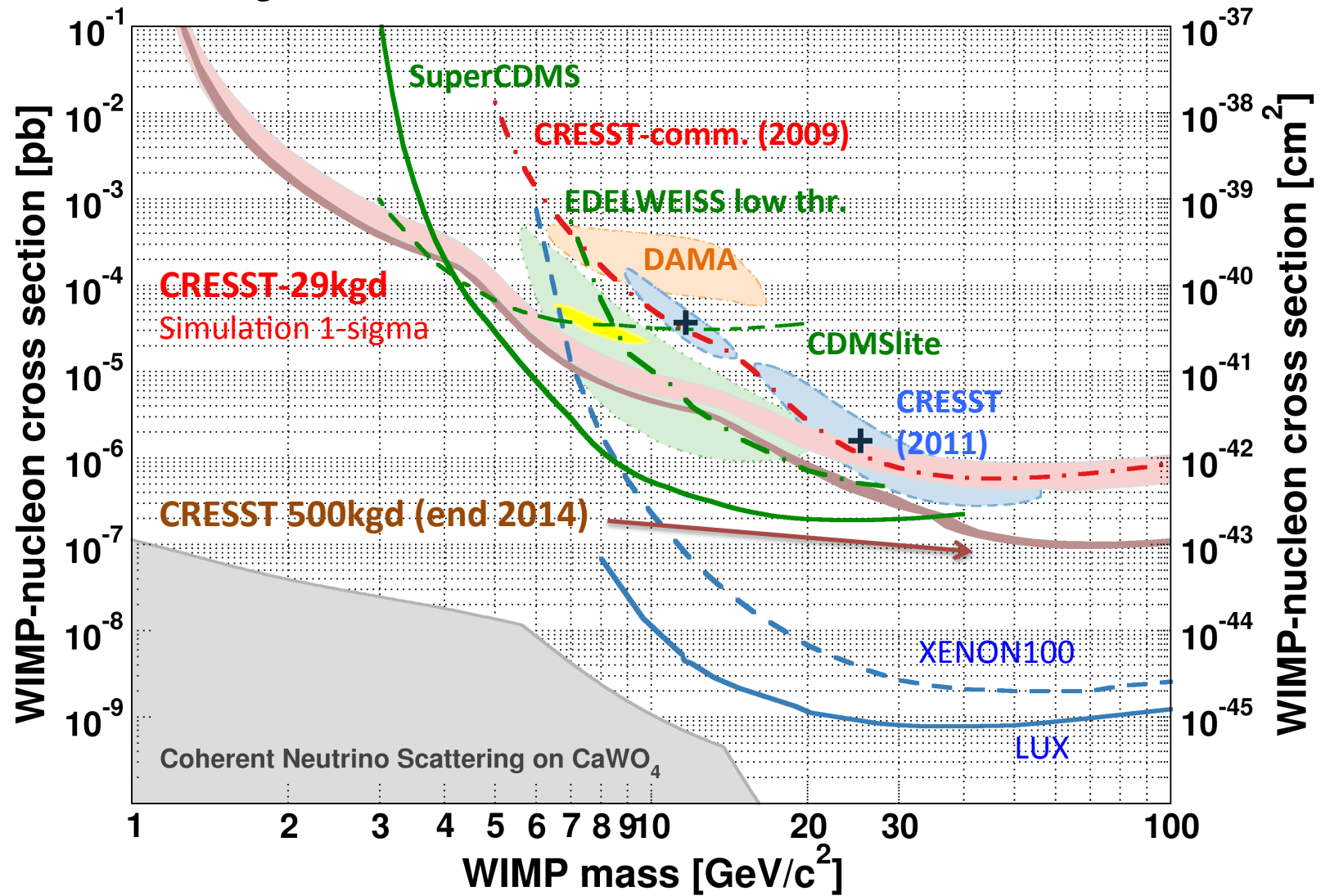
# Present Run - Analysis Strategy

Non-blinded data set (115 live days) defines:

- all data quality cuts
- trigger efficiencies
- selection of detectors

Since Jan 2014 – **blinded data**

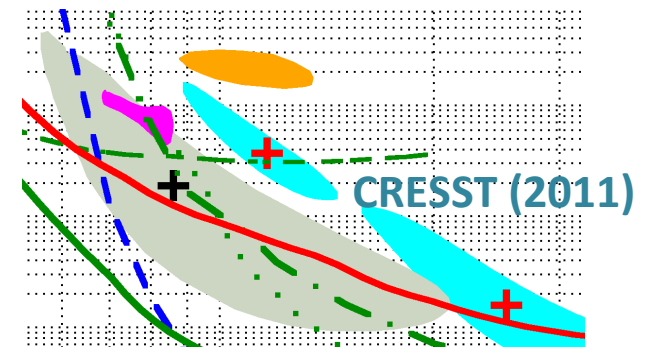
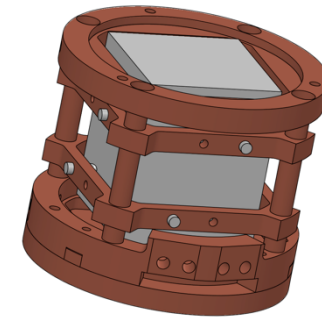
# Projection for Current Run





# Summary

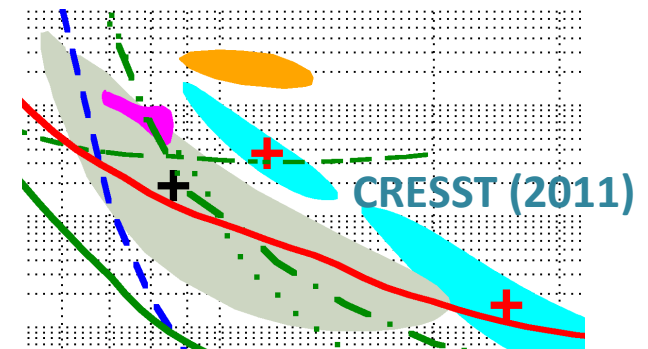
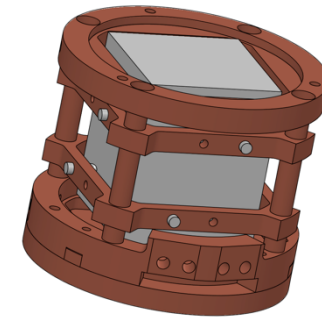
- Significant improvement in radiopurity of  $\text{CaWO}_4$  crystals (3.5 counts/[keV kg day])
- Efficient rejection of surface backgrounds with fully-scintillating detector design
- CRESST low-mass WIMP solution (M2) completely ruled out
- New WIMP parameter space explored ( $<3\text{GeV}/c^2$ ) with one single  $\text{CaWO}_4$  detector



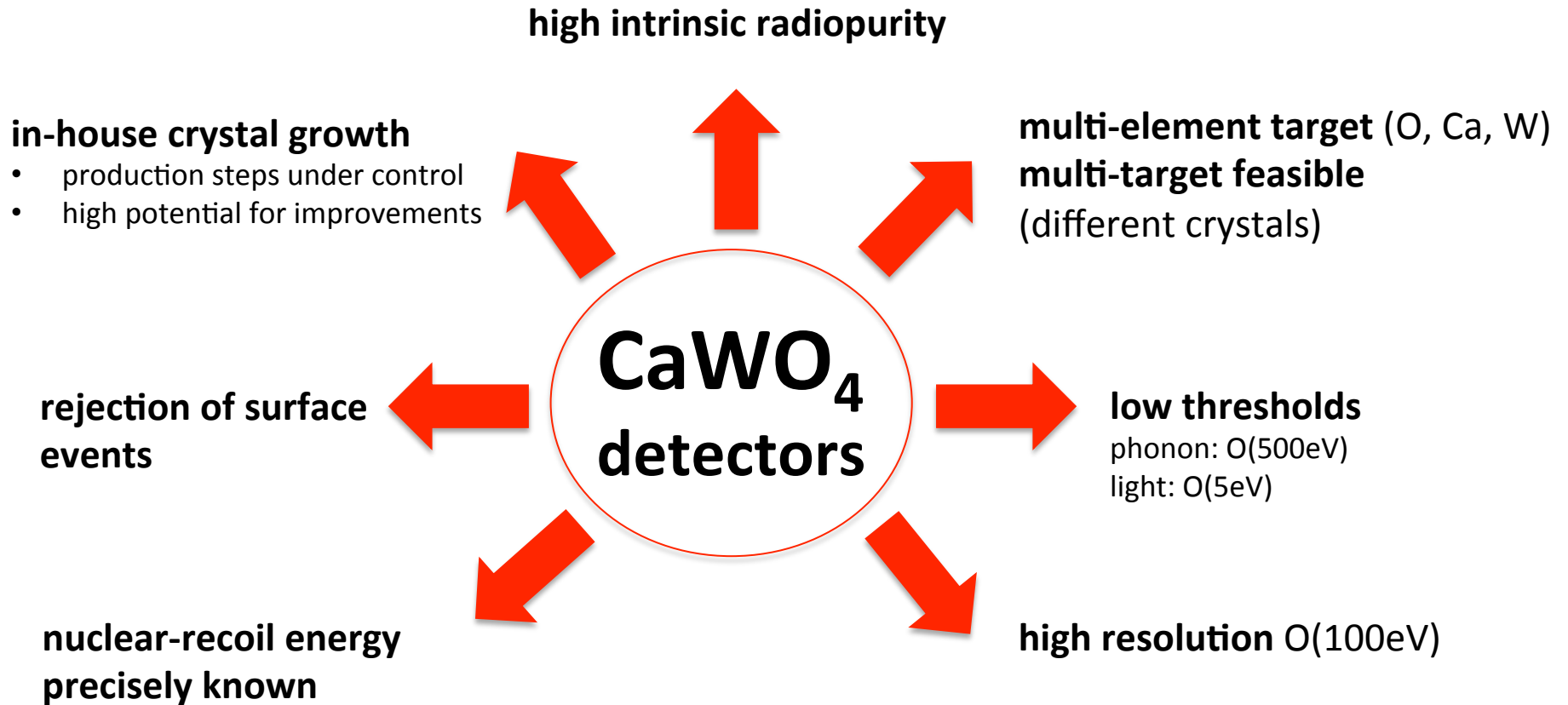
# Summary

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- Efficient rejection of surface backgrounds with fully-scintillating detector design
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- New WIMP parameter space explored ( $<3\text{GeV}/c^2$ ) with one single crystal detector

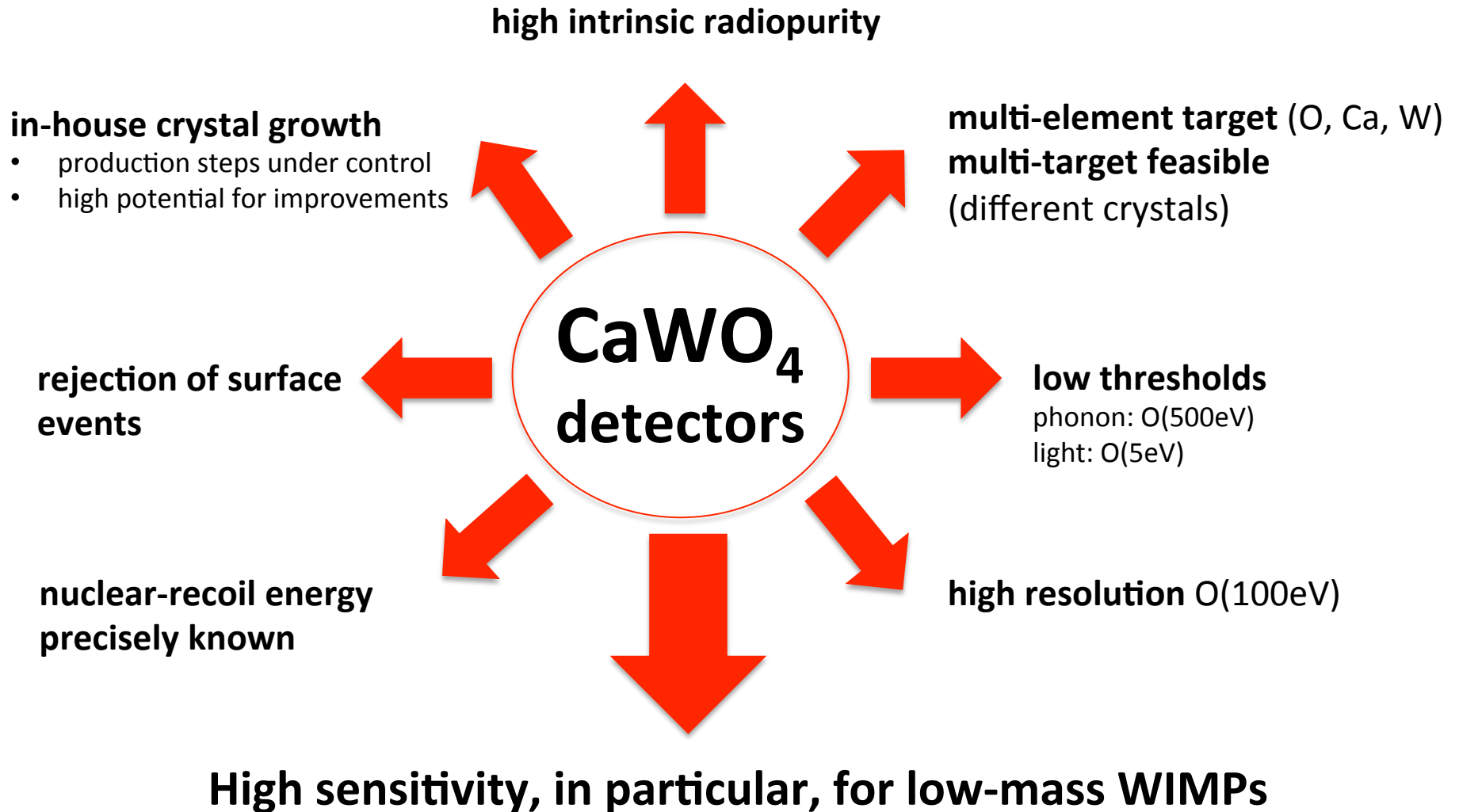
*New publication within next weeks.*



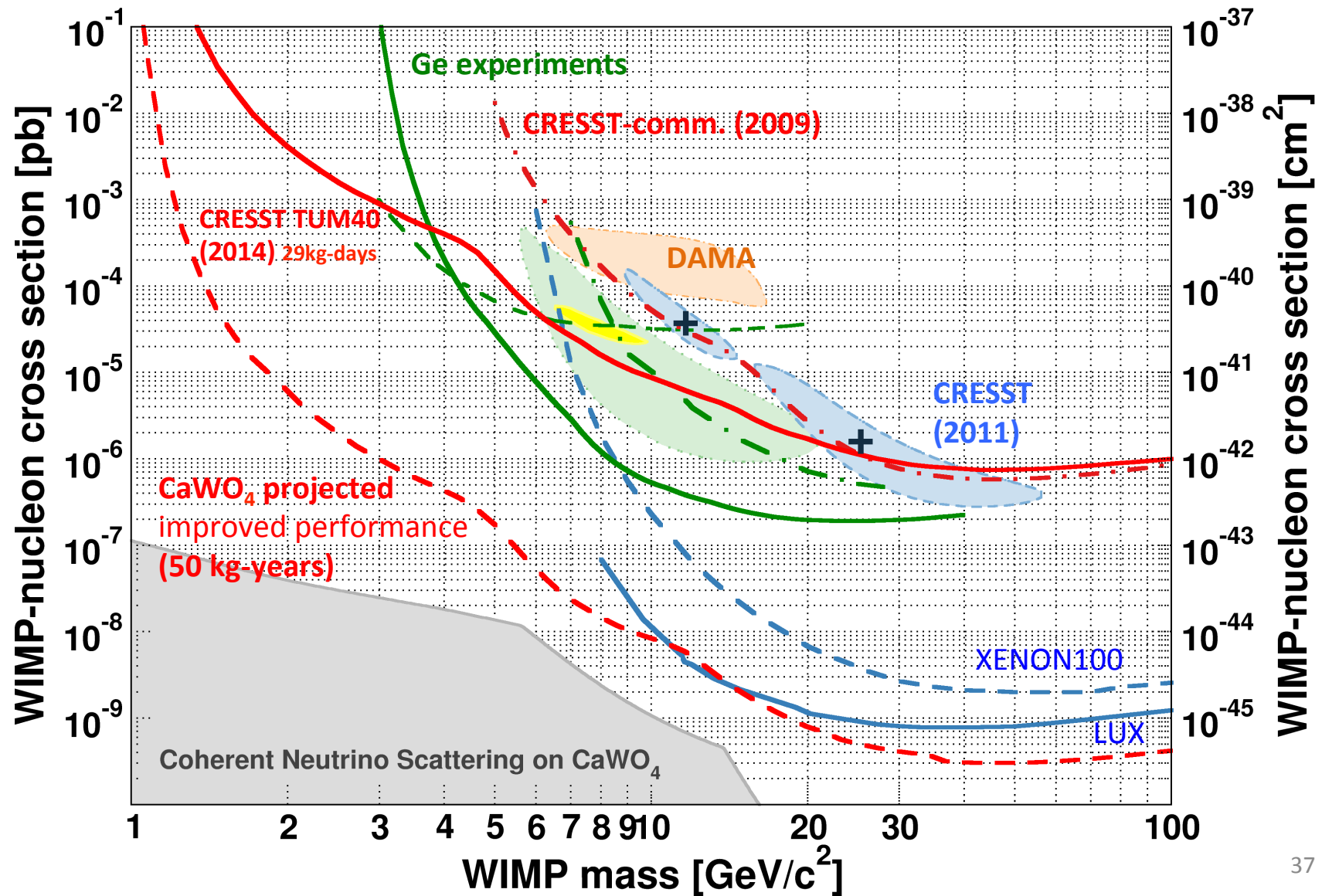
# Outlook: Future Potential



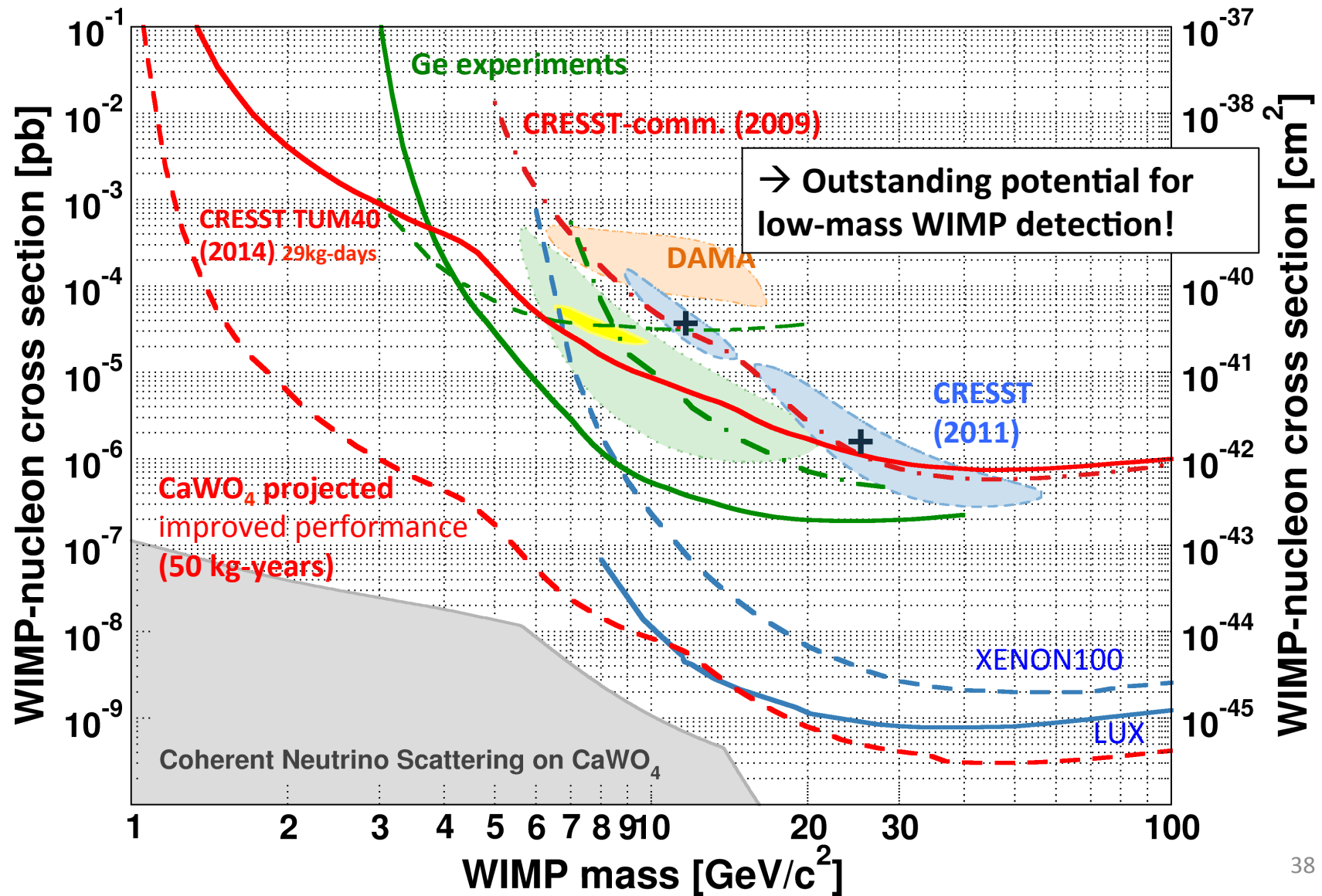
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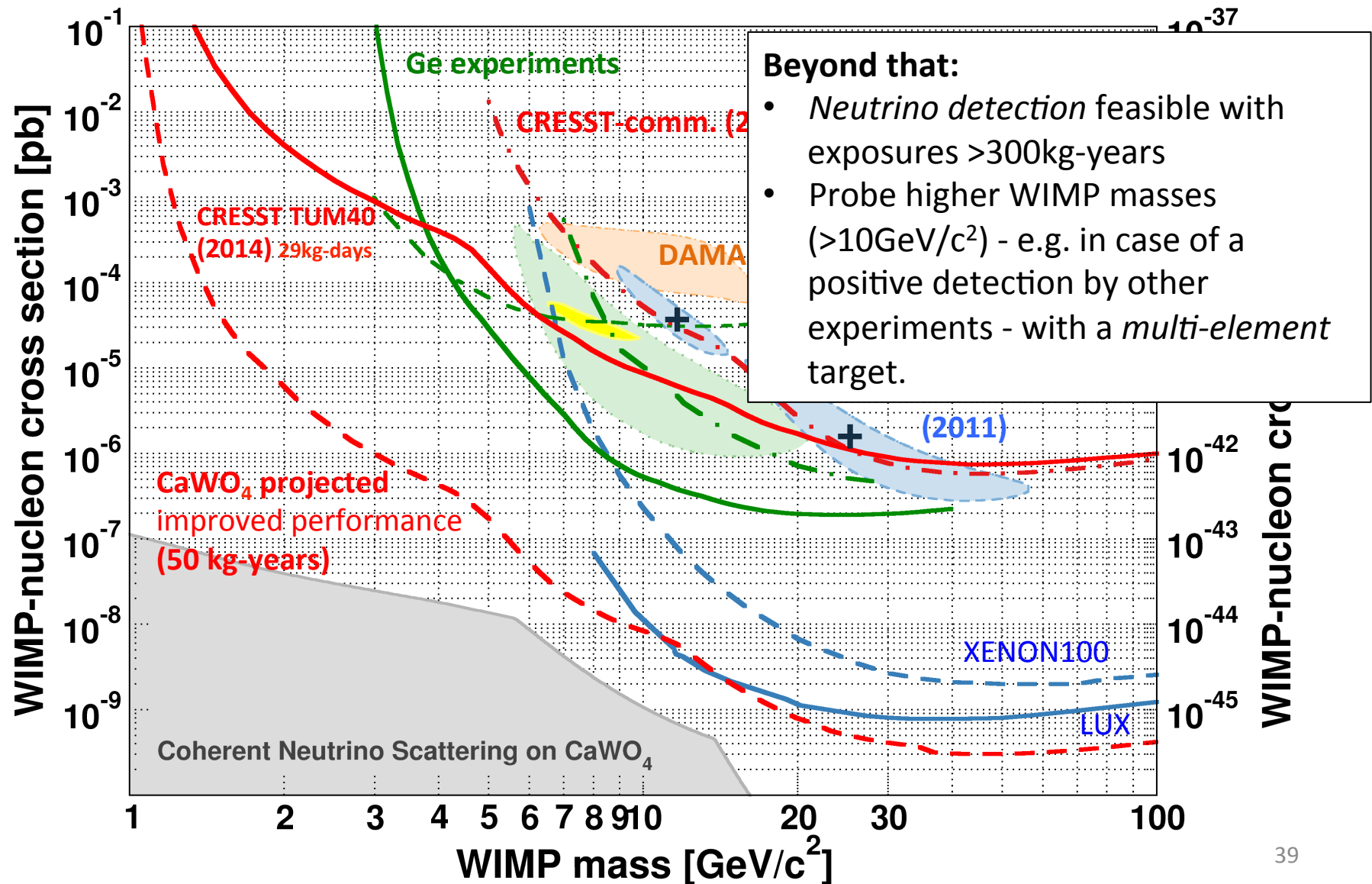
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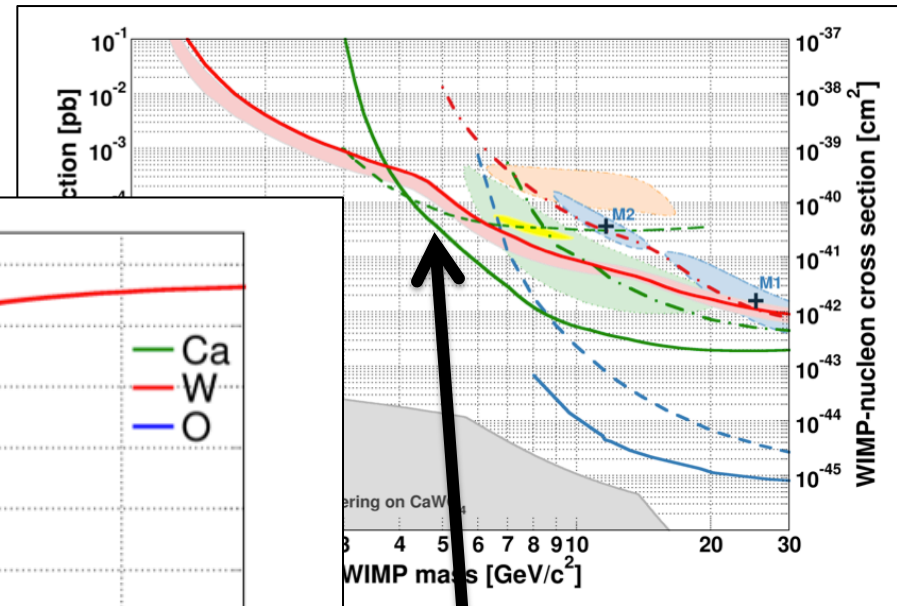
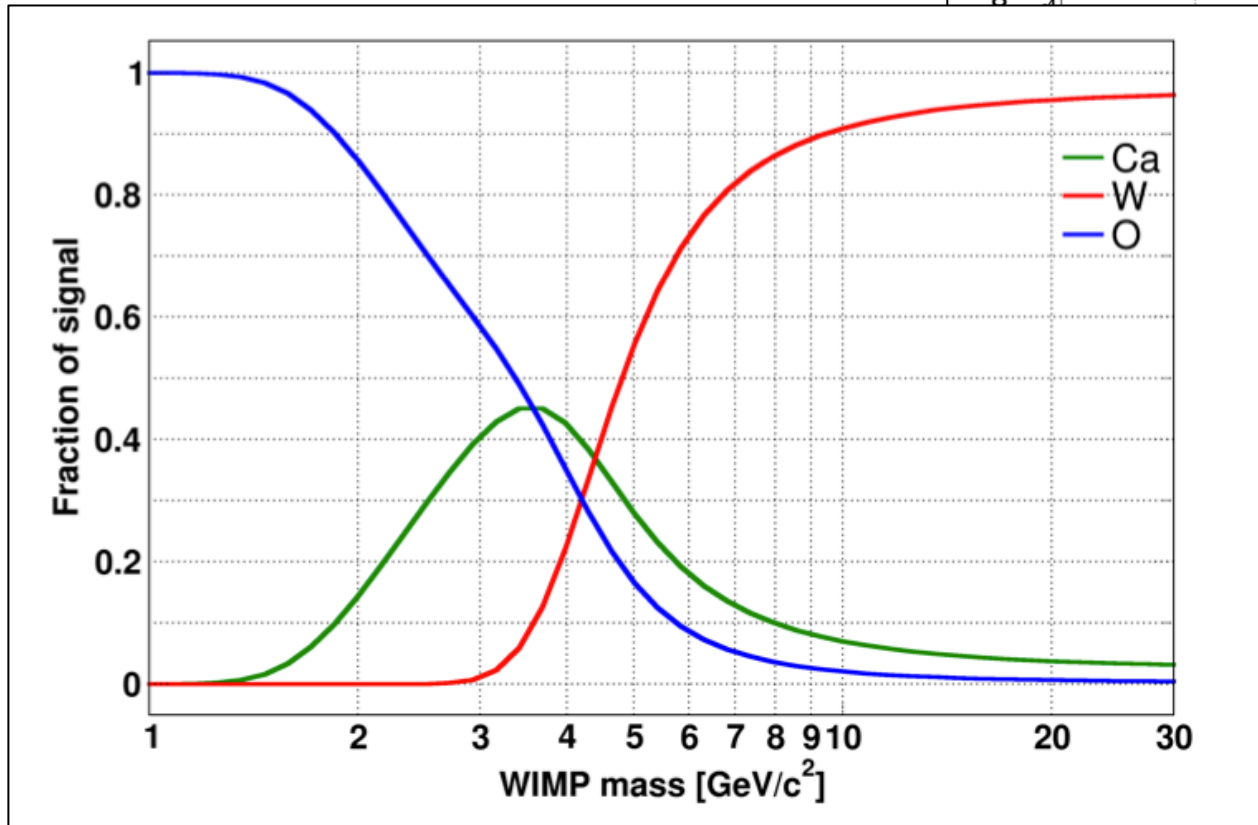


# **BACKUP SLIDES**



# Multi-Element Target

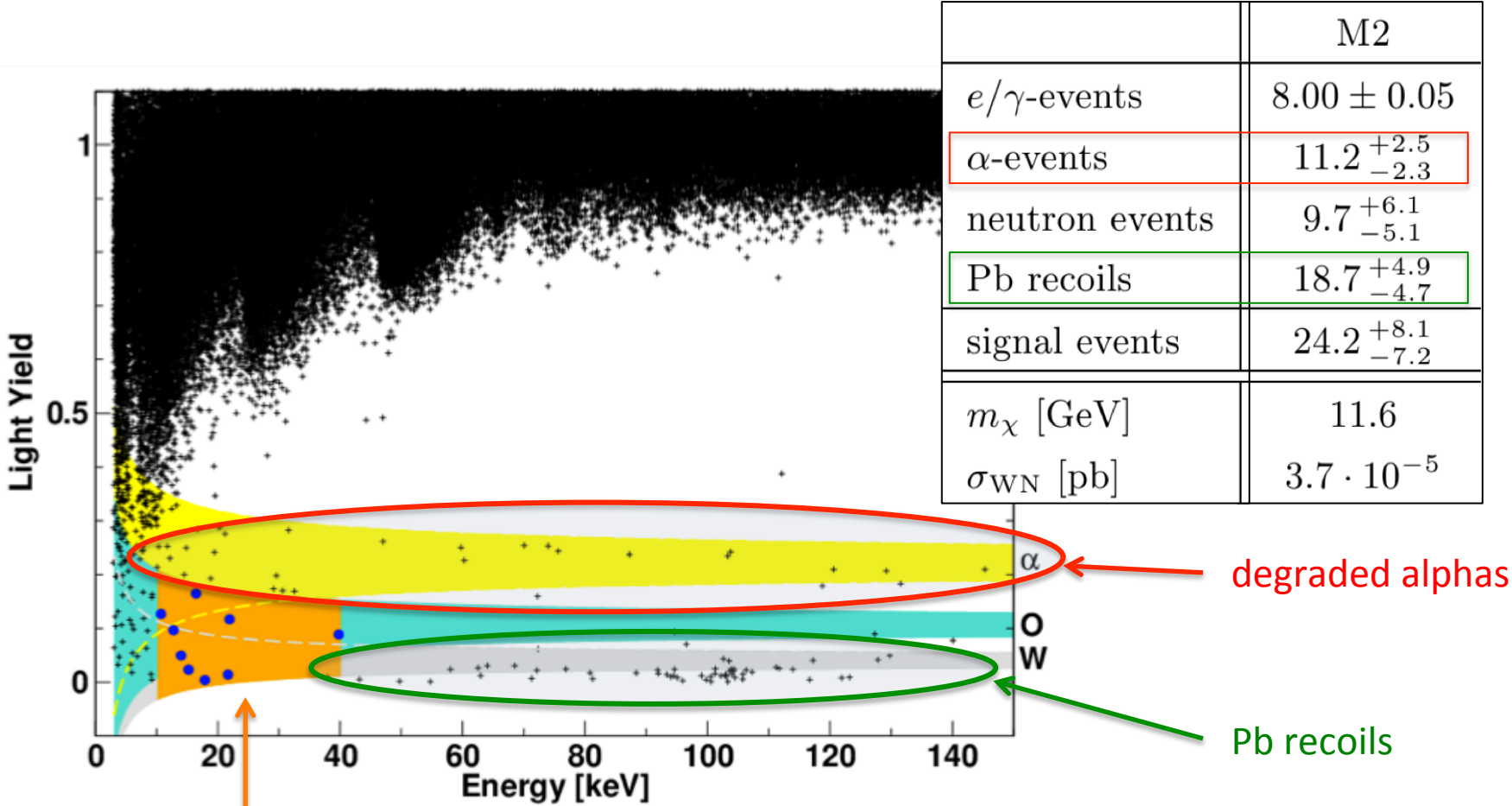
Expected fraction of WIMP scatters on O, Ca and W for TUM-40:



**Kink** in limit at 5 GeV/c<sup>2</sup>:

- Below: O dominates
- Above: W dominates

# Results of the Last Run of CRESST-II



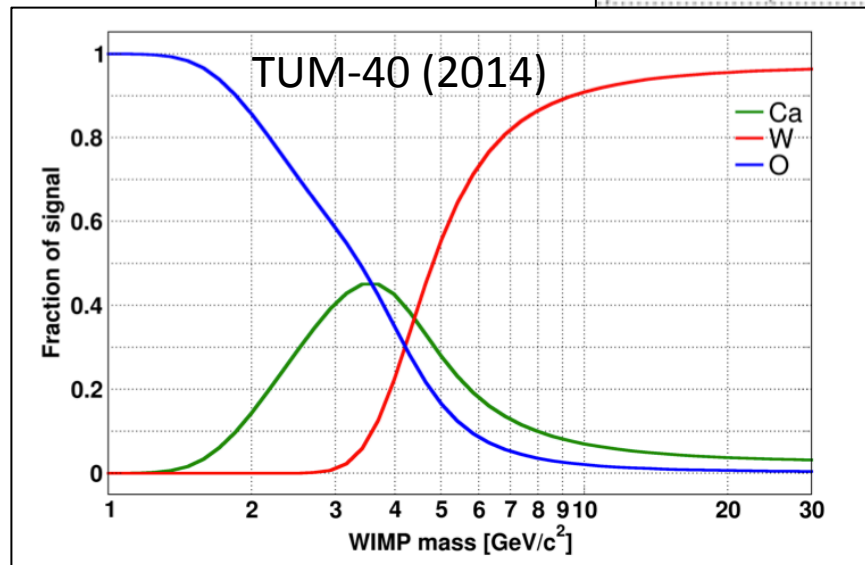
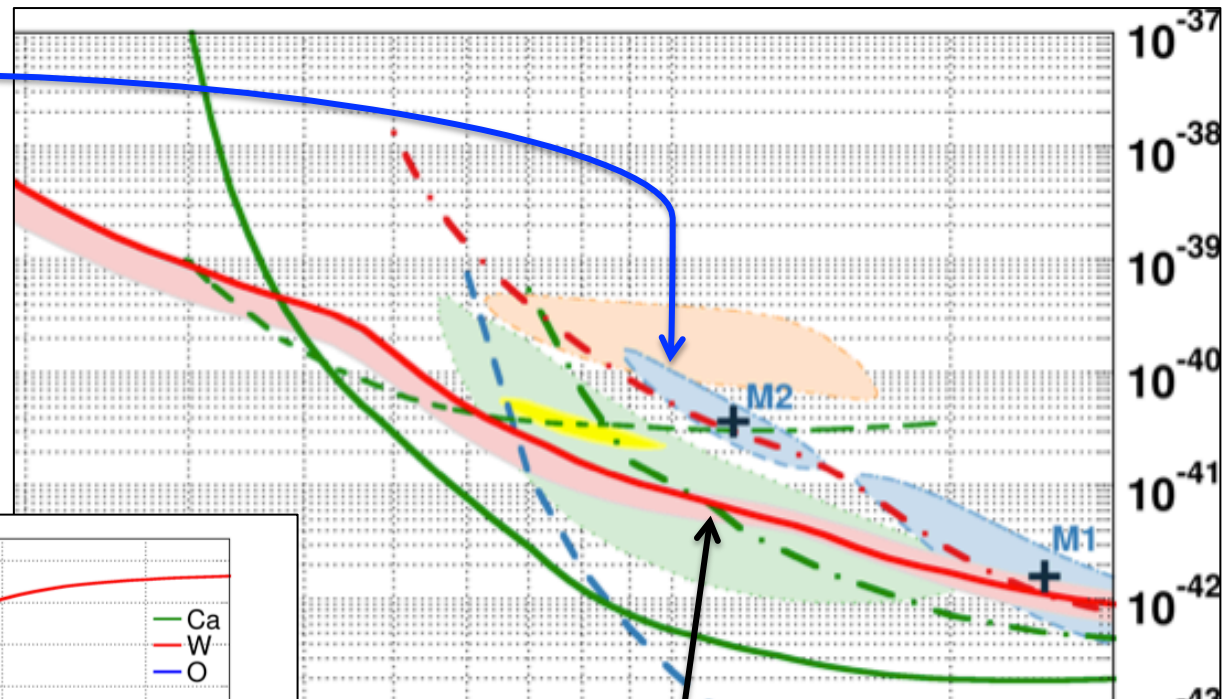
ROI 10-40keV

G. Angloher et al., Eur. Phys. J. C, 72, 4 (2012)

# Exclusion of CRESST (M2) Solution

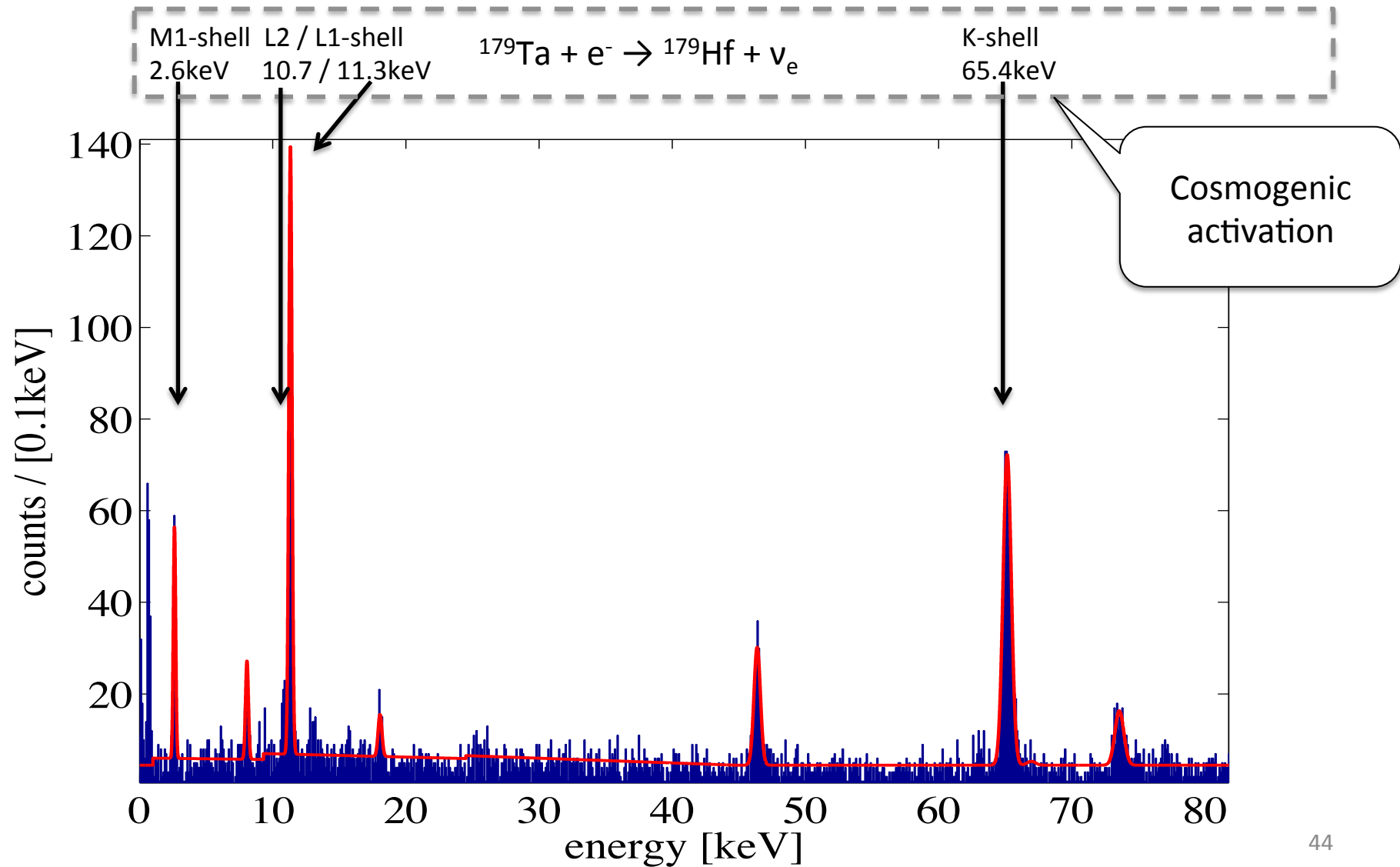
## CRESST-II (2011)

Low-mass WIMP solution at 11GeV (M2) mainly due to **O** (52%) and **Ca** (48%) scatters

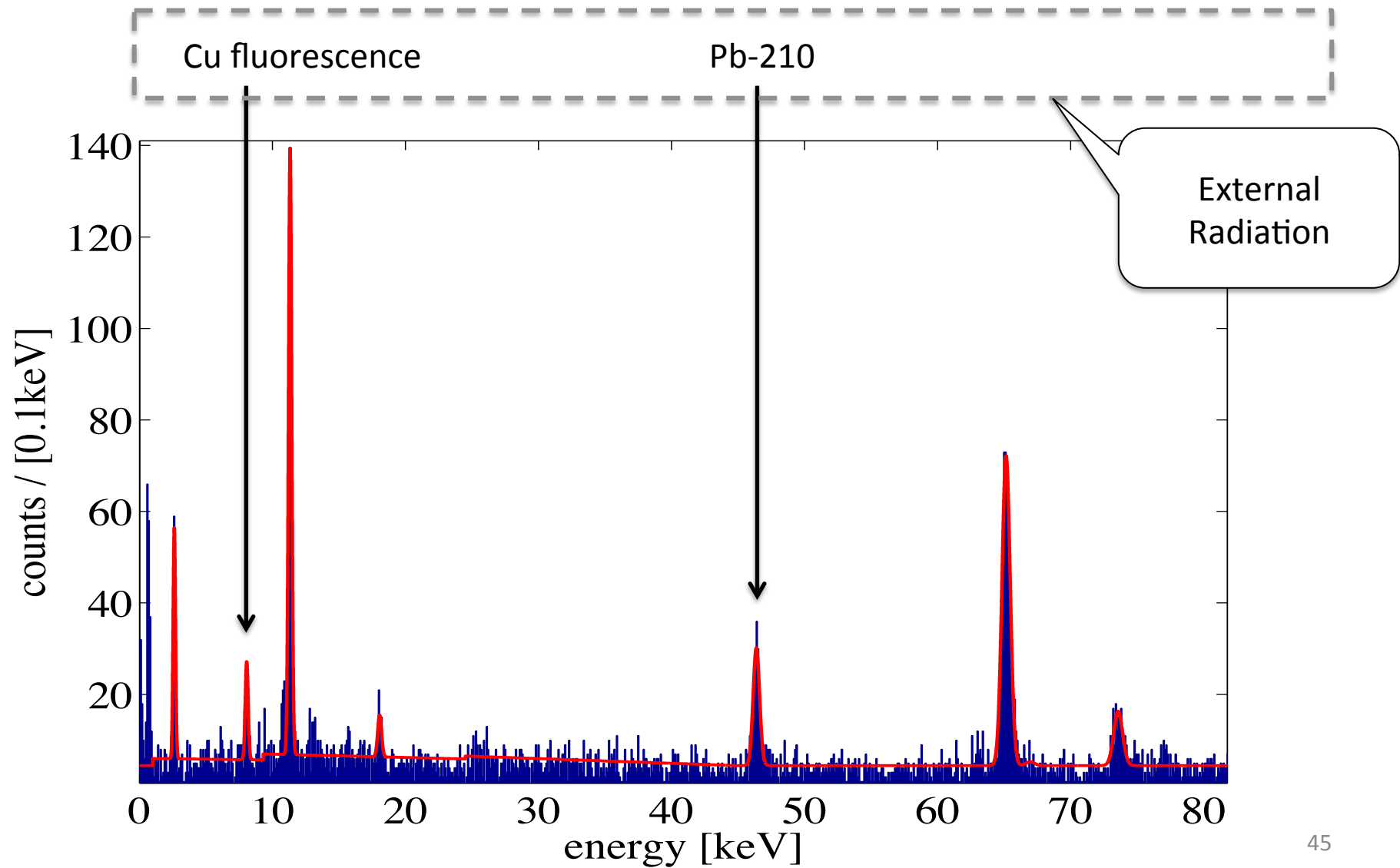


← **CRESST-II upgrade (2014)**  
At  $\sim 11\text{GeV}/c^2$  dominated by **W** (>90%) scatters!

# TUM-40: Low-Energy Spectrum



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# Carrier-Event Discrimination



Large pulse-shape difference

