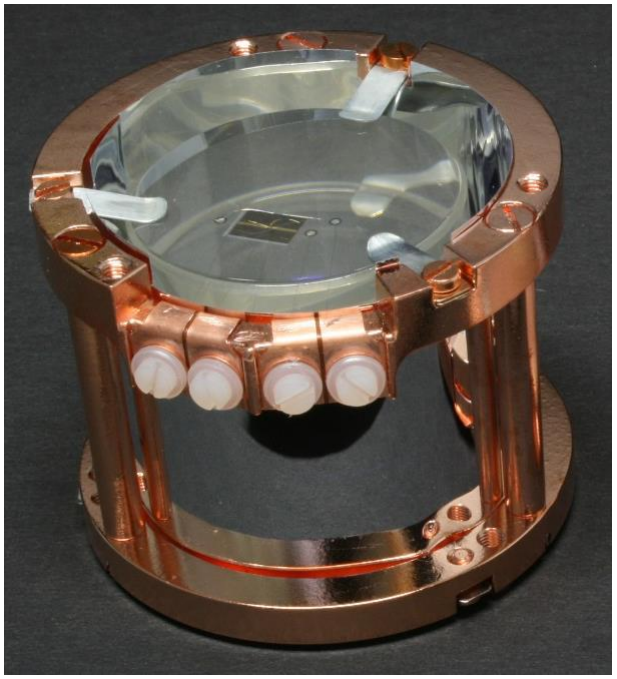


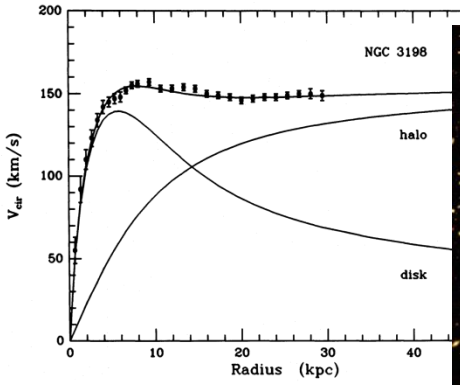
Current status of the CRESST experiment

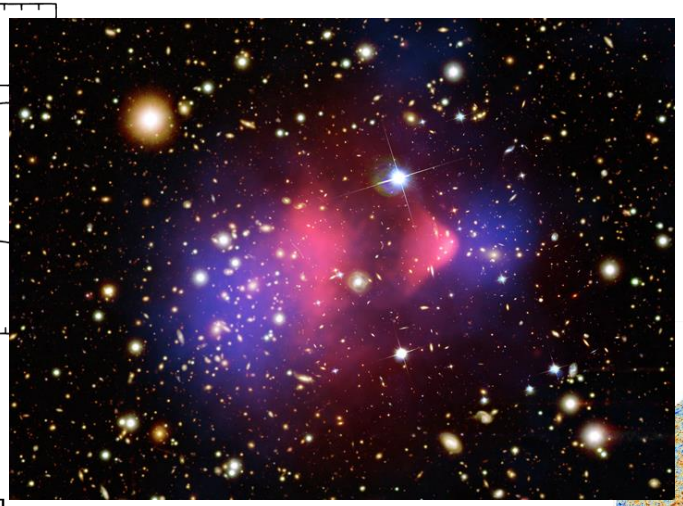
Holger Kluck (TU Wien & HEPHY)
for the CRESST collaboration

HAP Dark Matter 2015

22 September 2015

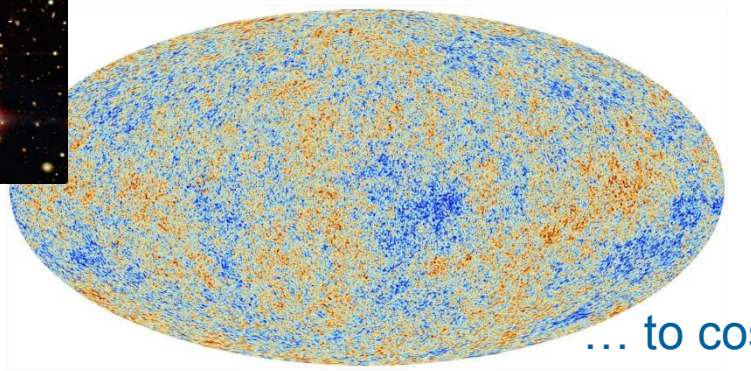
- CRESST: Basic principles
- Latest results from CRESST-II phase 2
- Outlook to CRESST-III





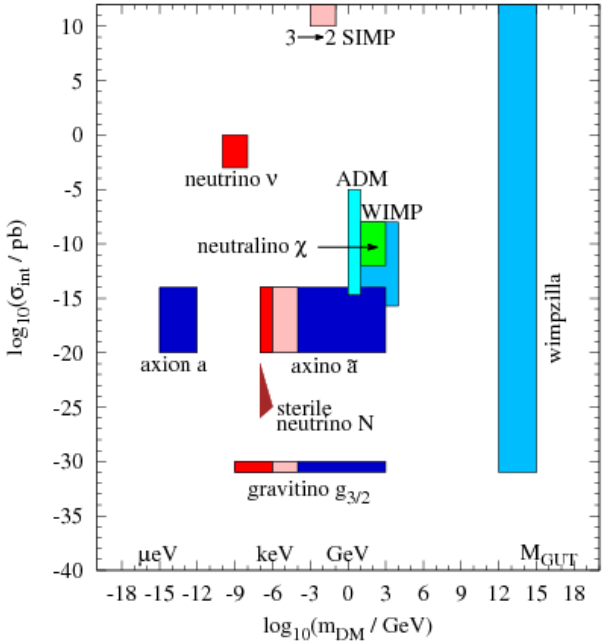
From galactic …

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



… to cosmic

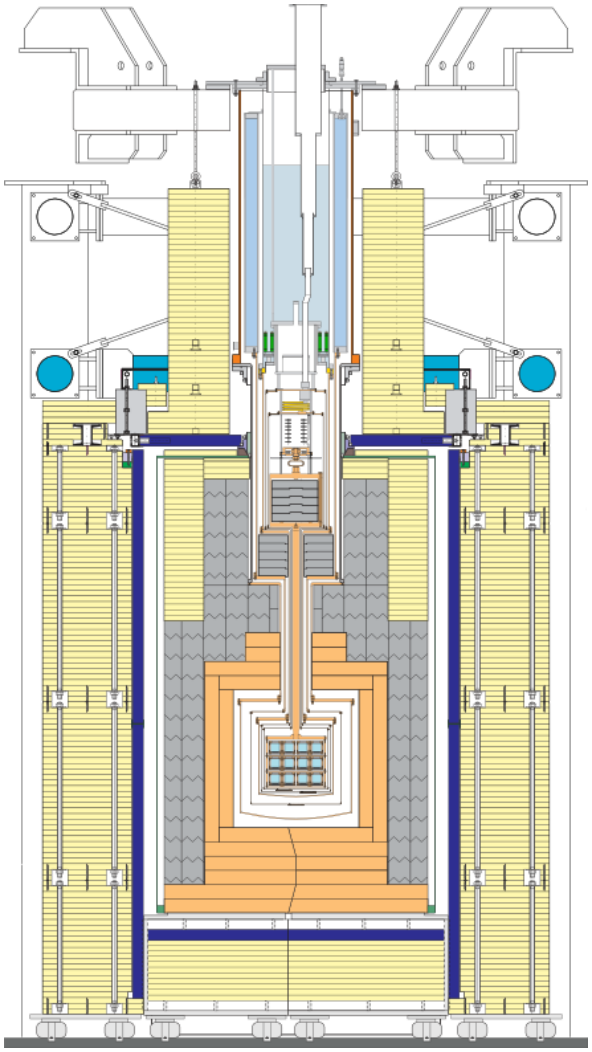
[H. Baer et al. arXiv1407.0017]



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 $m_{DM} \leq 10$ GeV/c²

CRESST: background suppression

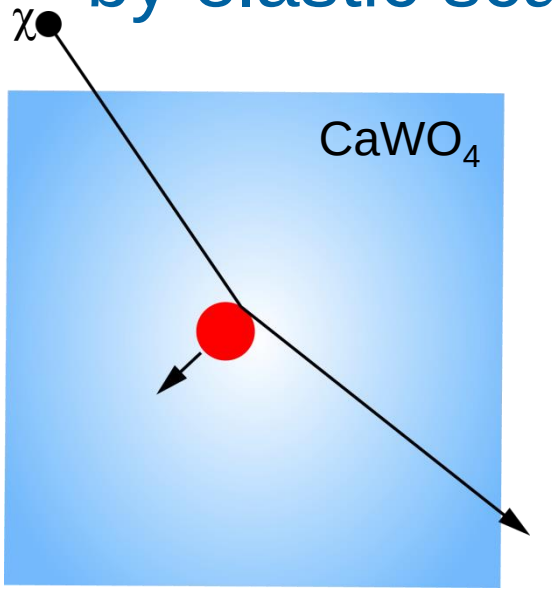


- Underground @ LNGS, 3500mwe

- μ veto + shields against n's (45cm PE, inner n shield) and γ (20 cm Pb, 14cm Cu)

CRESST: target

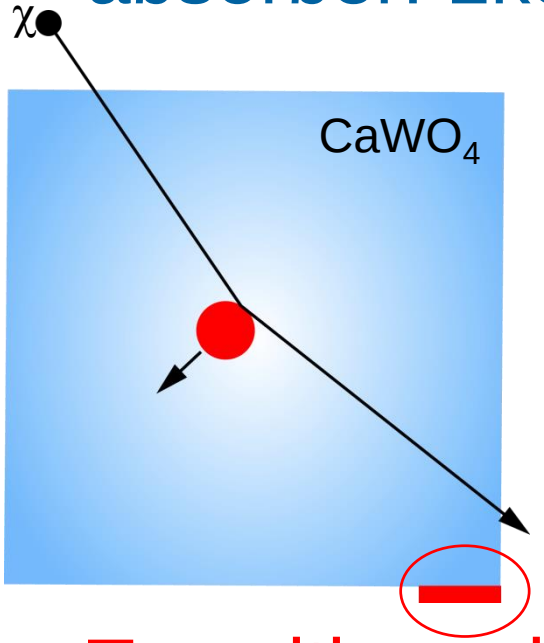
- Searched signal: single nuclear recoil caused by elastic scattering of e.g. WIMPs.

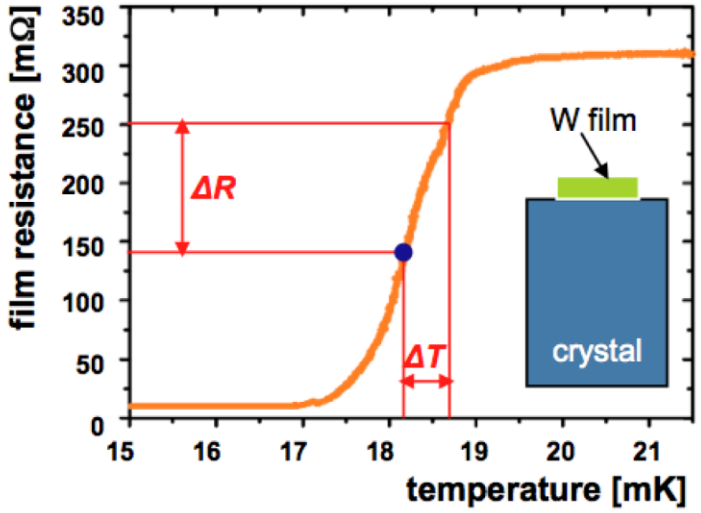


- Target: $CaWO_4$ (200g - 300g) → sensitive to low- and high-mass dark matter particles
- 2 signal channels:
  - Phonon signal
  - Light signal

CRESST: phonon signal

- $CaWO_4$ crystals @~10mK as calorimetric absorber: 1keV recoil ~ O(1µK)

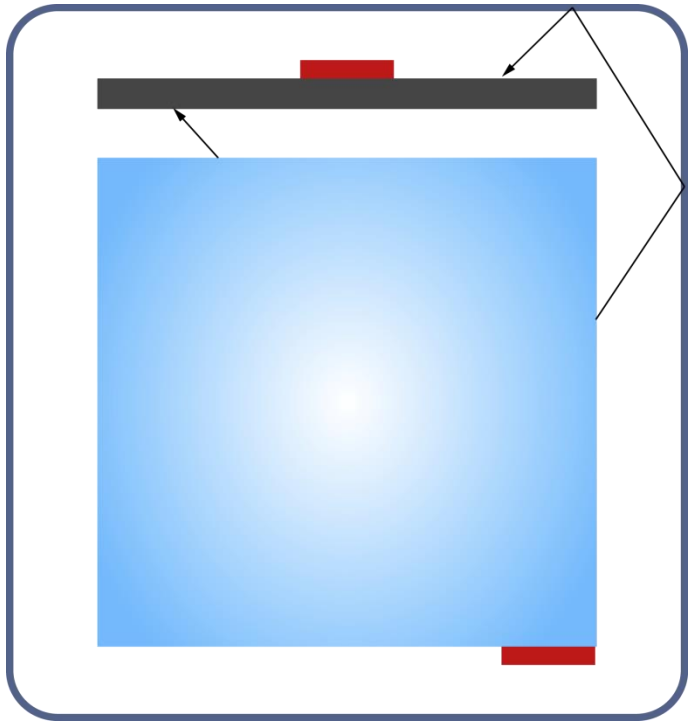




- Transition edge sensors (TES), SQUID readout

→ Get total deposited energy

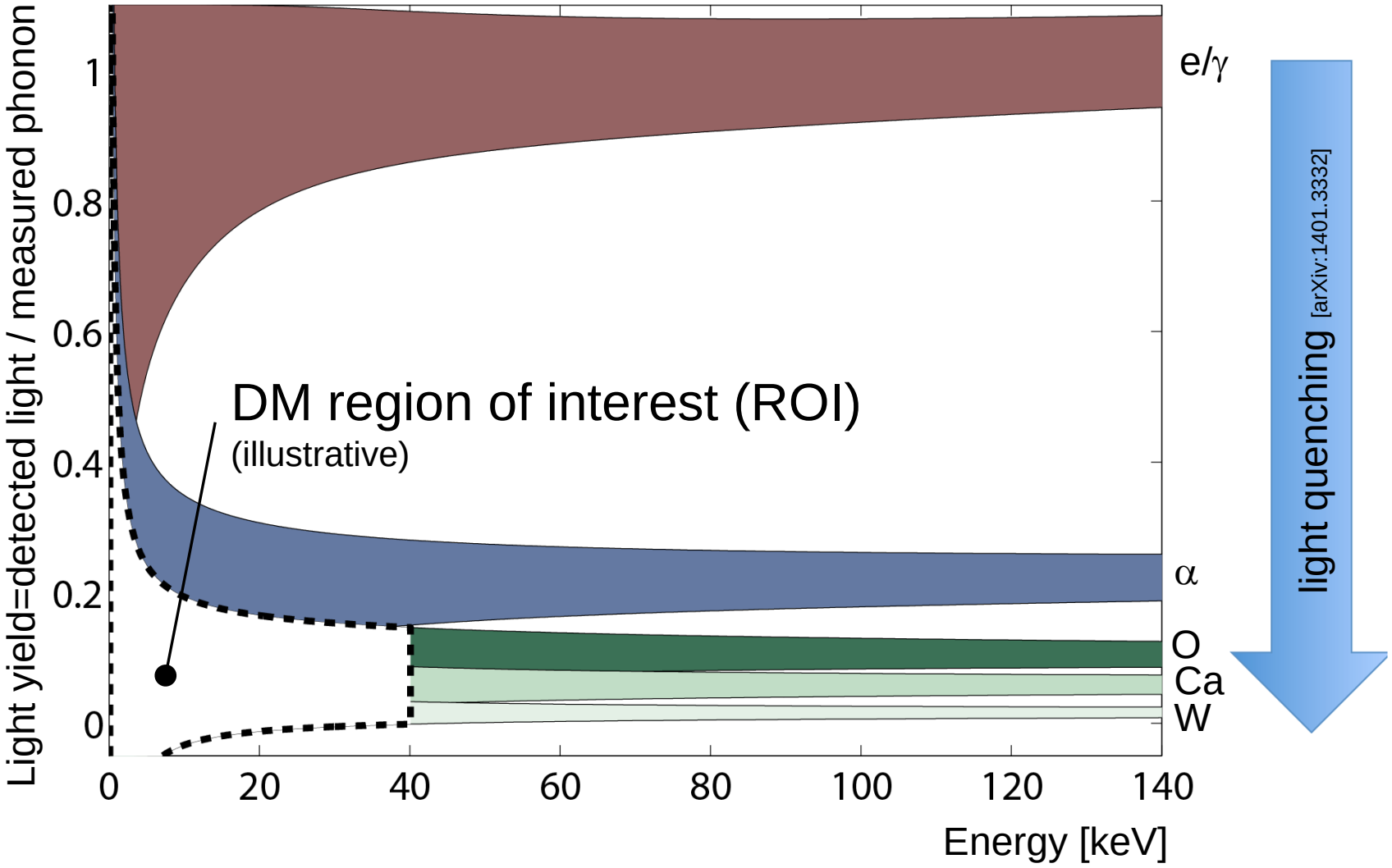
CRESST: light signal



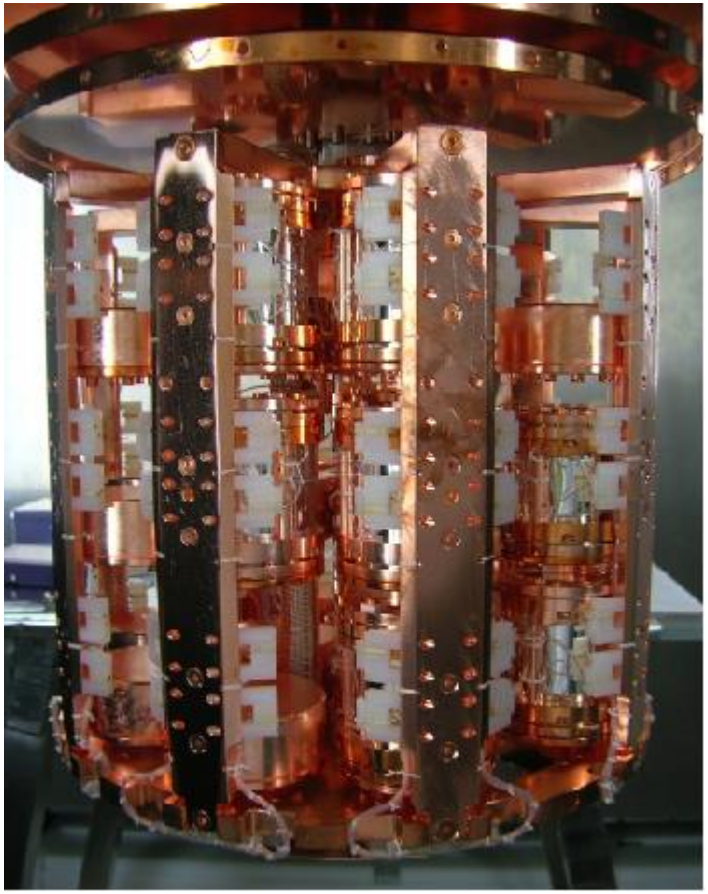
- $CaWO_4$ scintillates
- Silicon-on-sapphire as light absorber, equipped with 2nd TES.
- Light yield is particle specific

→ particle ID

CRESST: event categories

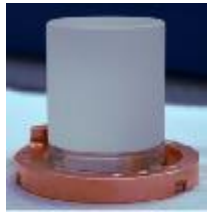


CRESST-II phase 2 (2013-2015)



- 18 modules mounted (~5kg),
  17 are fully operational
  End of run: August 2015
- 6 modules with active veto
  (3 designs)

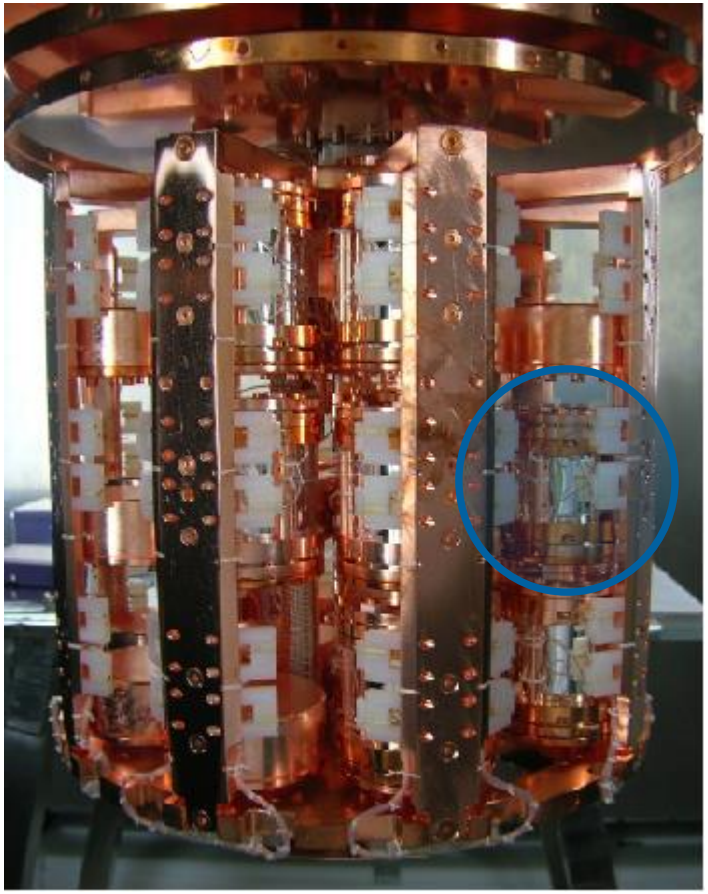




$CaWO_4$ sticks beaker carrier

- 11 conventional modules (improved)
  - Radiopure clamps
  - Radon prevention

CRESST-II phase 2 (2013-2015)

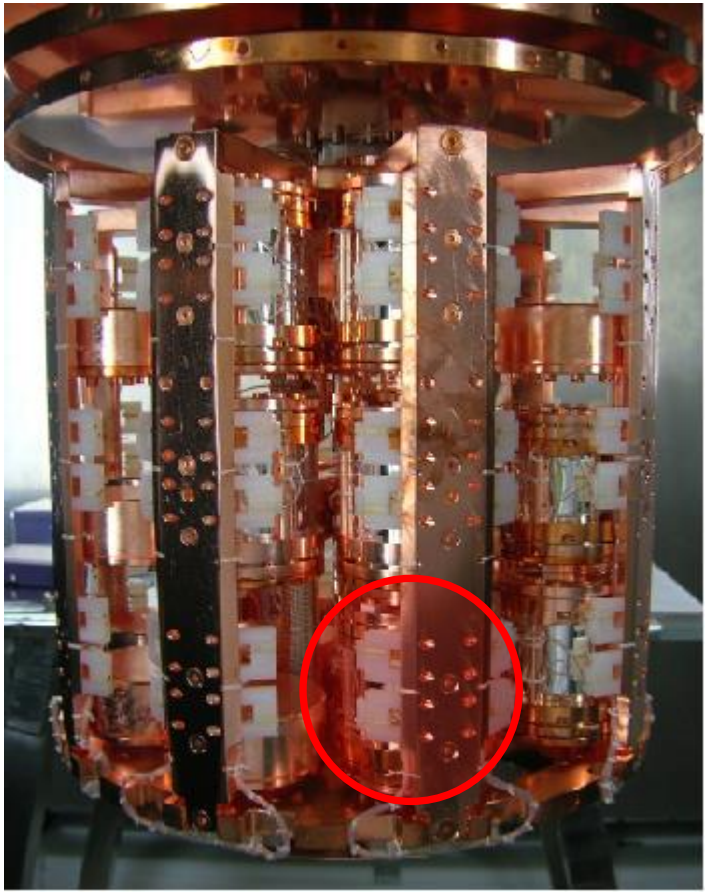


- 18 modules mounted (~5kg),
  17 are fully operational
  End of run: August 2015
- 6 modules with active veto
  (3 designs)

2014 result:
Module ‚TUM40‘
29 kg.d exposure
[Eur. Phys. J. 74(2014)3184]

- 11 conventional modules (improved)
  - Radiopure clamps
  - Radon prevention

CRESST-II phase 2 (2013-2015)



- 18 modules mounted (~5kg),
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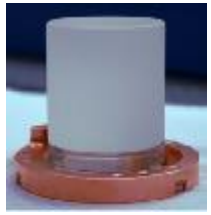
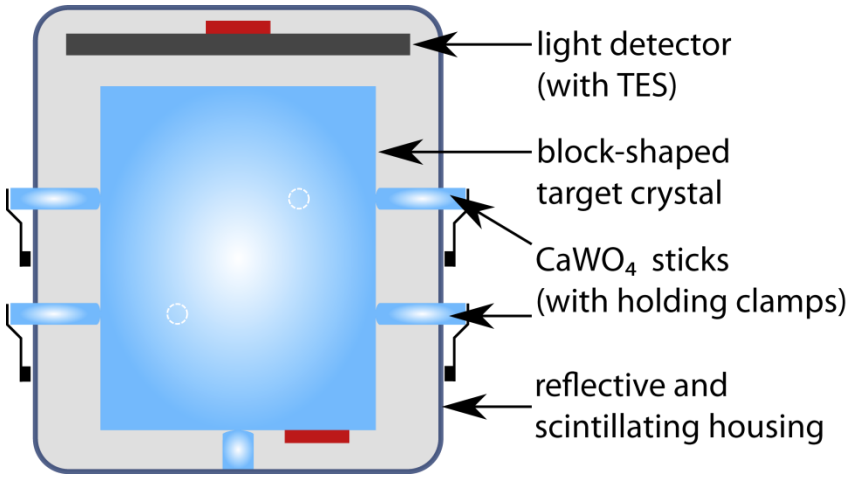


$CaWO_4$ sticks beaker carrier

- 11 conventional modules (improved)
  - This talk:
    Module ‚Lise‘
    52 kg.d exposure
    [arXiv:1509.01515]

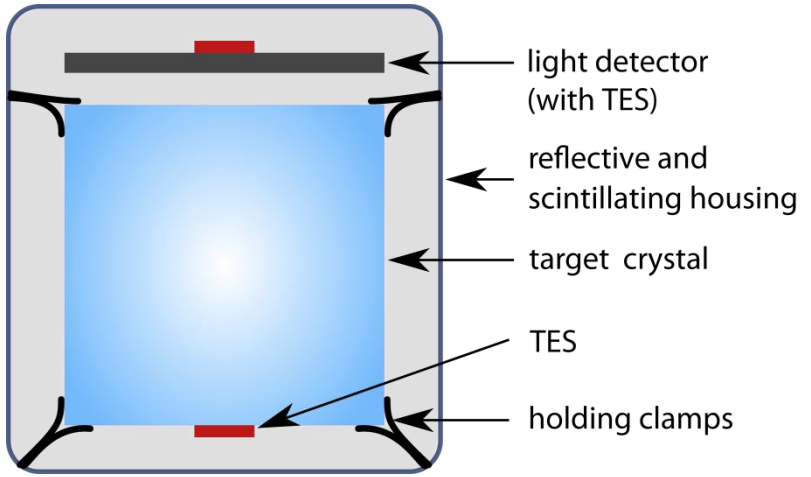
Comparison TUM40 vs Lise

Stick: TUM40 (2014)



- Veto for recoil backgrounds
- Background level:
  ~3 counts / keV kg.day
- 600eV threshold
- 100eV resolution

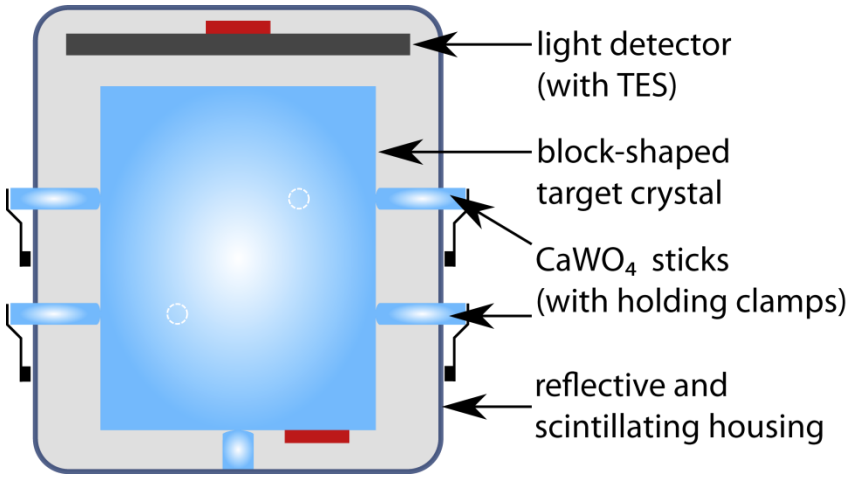
Conventional: Lise (preliminary)



- ***No*** veto for recoil backgrounds
- Background level:
  ~7 counts / keV kg.day
- 300eV threshold
- 60eV resolution

Comparison TUM40 vs Lise

Stick: TUM40 (2014)



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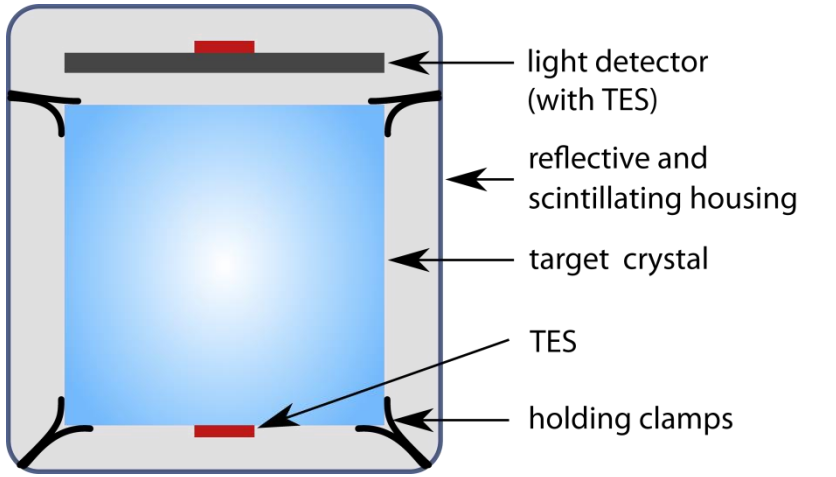

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- Background level:
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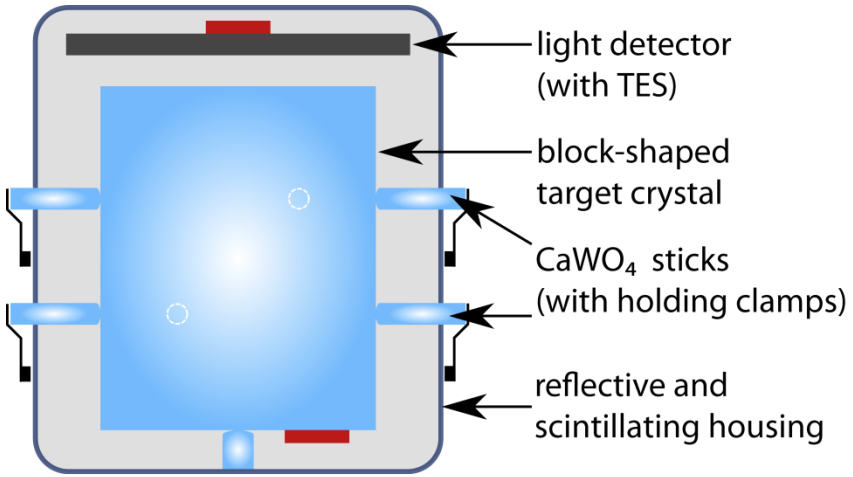
- 300eV threshold
- 60eV resolution

Comparison TUM40 vs Lise

Stick: TUM40 (2014)



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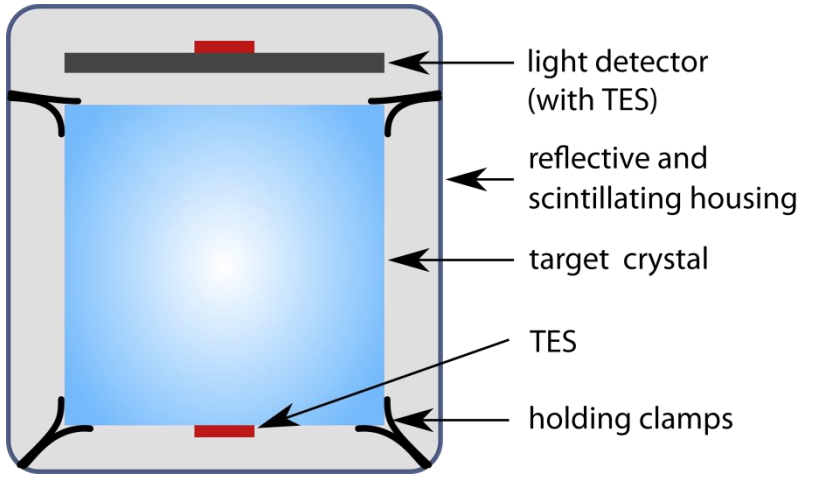

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- Background level:
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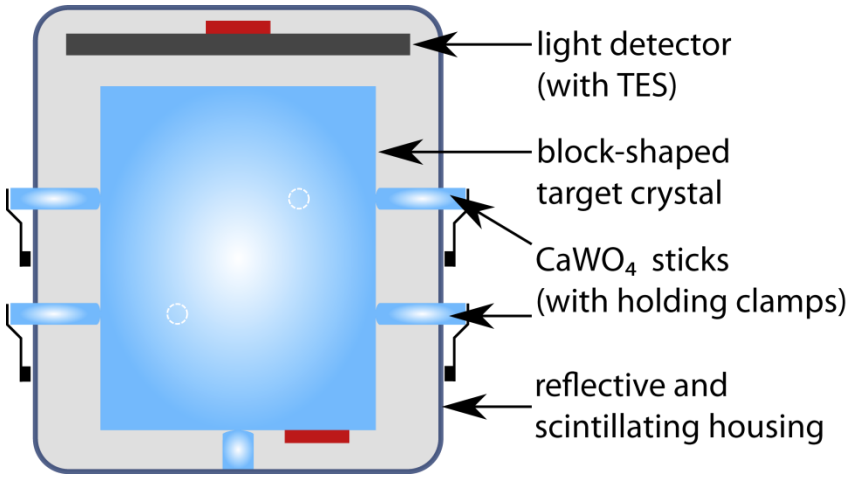
- 300eV threshold
- 60eV resolution

Comparison TUM40 vs Lise

Stick: TUM40 (2014)



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- Background level:
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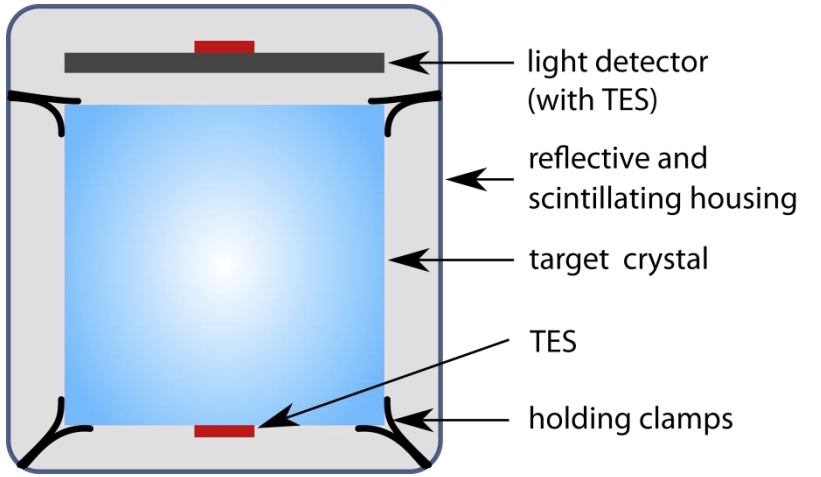
- 100eV resolution

Conventional: Lise (preliminary)

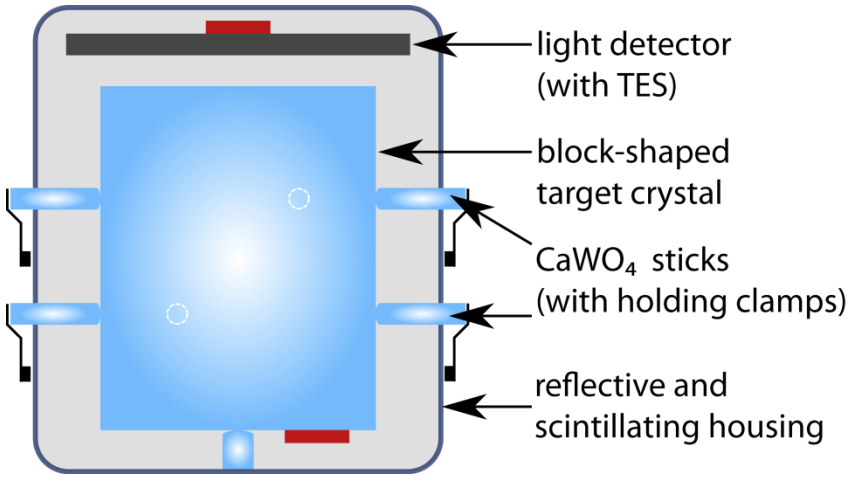


- ***No*** veto for recoil backgrounds
- Background level:
  day
- 300eV threshold
- 60eV resolution

➔ See talk by M. Willers
for details about crystal production

Comparison TUM40 vs Lise

Stick: TUM40 (2014)



- Veto for recoil backgrounds
- Background level:
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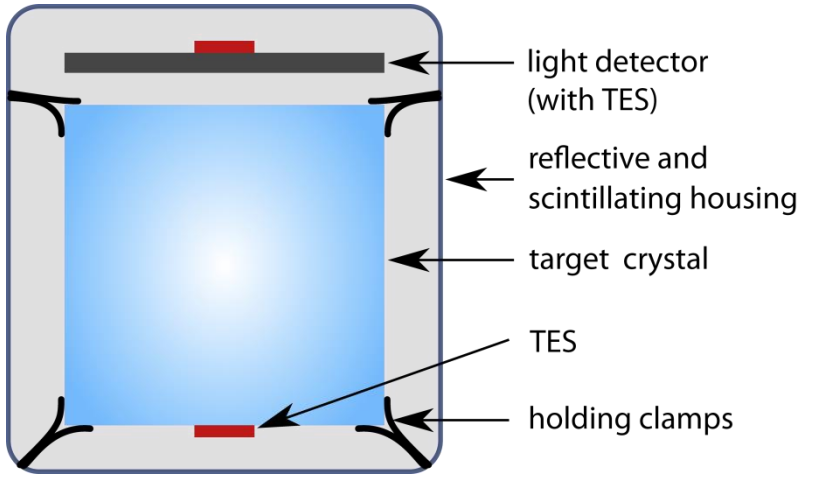
- 600eV threshold
- 100eV resolution

Conventional: Lise (preliminary)



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- Background level:
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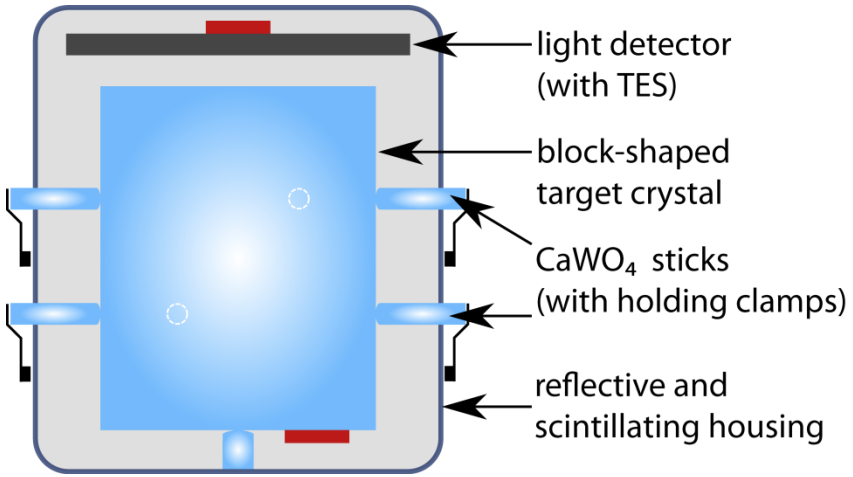
- 60eV resolution

Comparison TUM40 vs Lise

Stick: TUM40 (2014)



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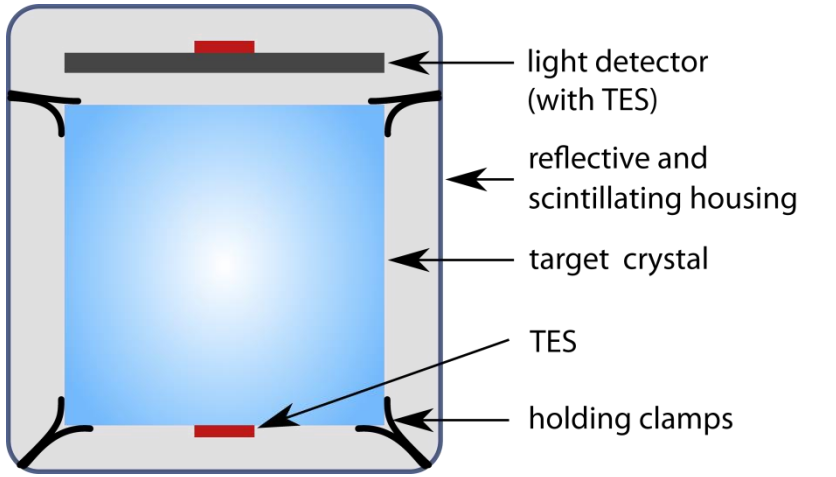

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- Background level:
  ~7 counts / keV kg.day
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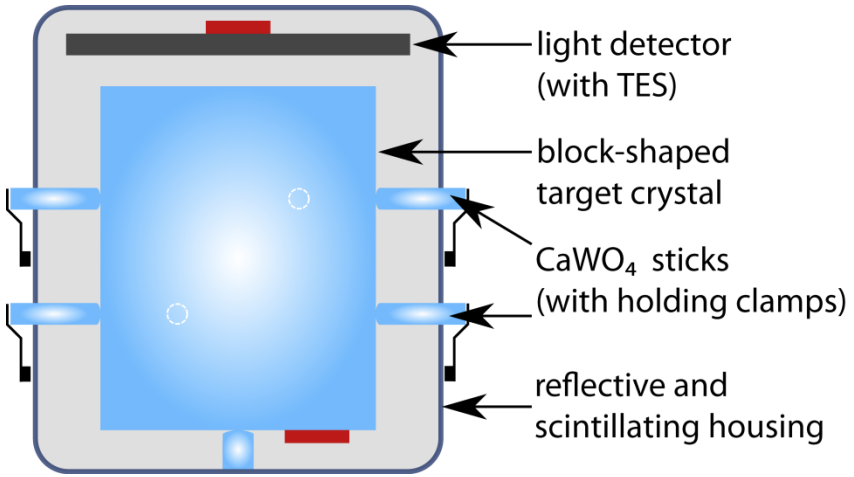
- 60eV resolution

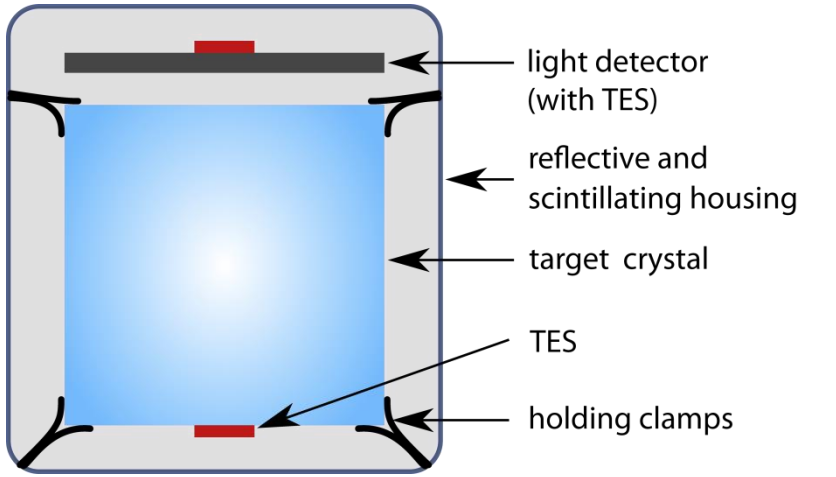
Comparison TUM40 vs Lise

Stick: TUM40 (2014)



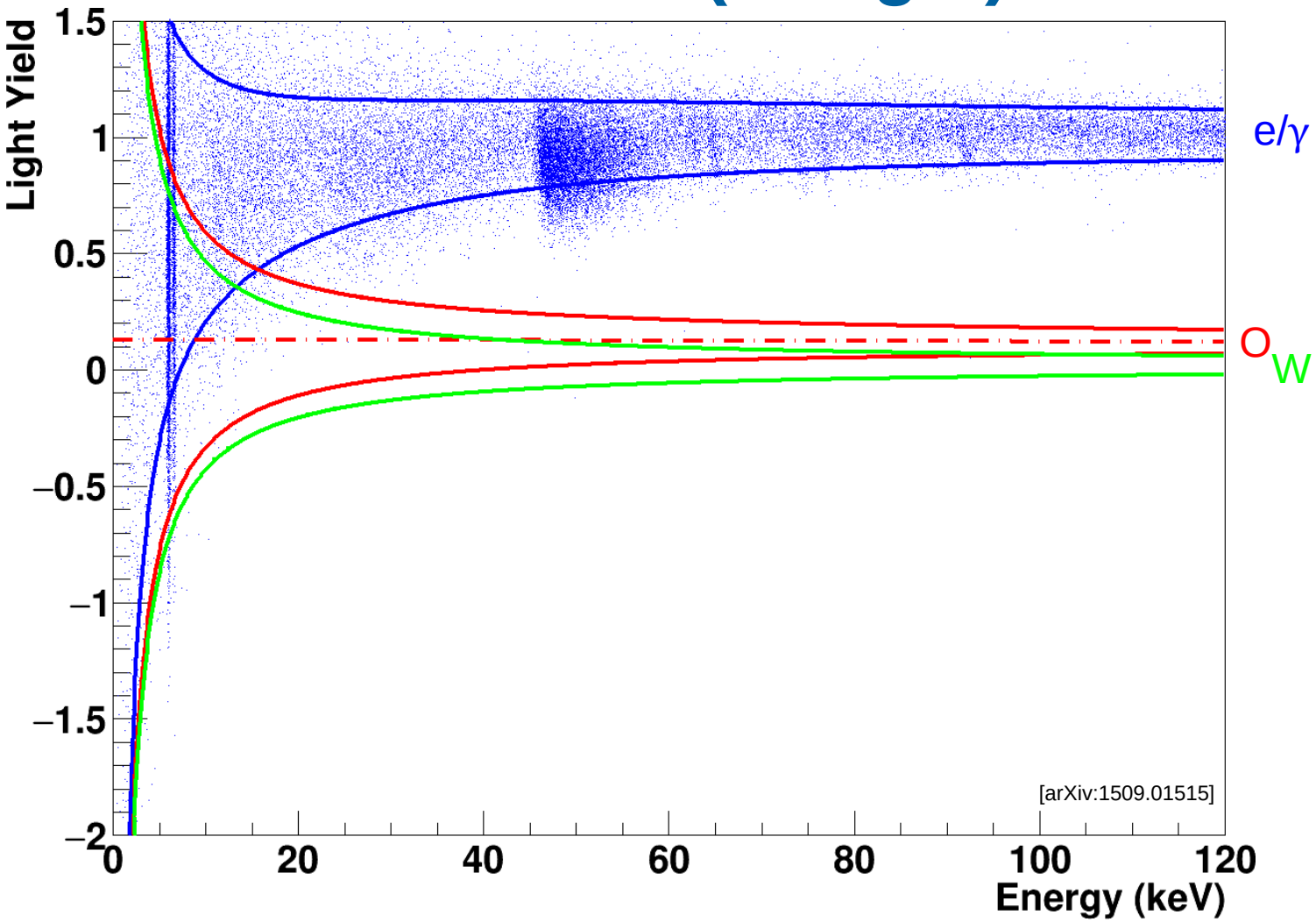
Superior overall performance

Conventional: Lise (preliminary)

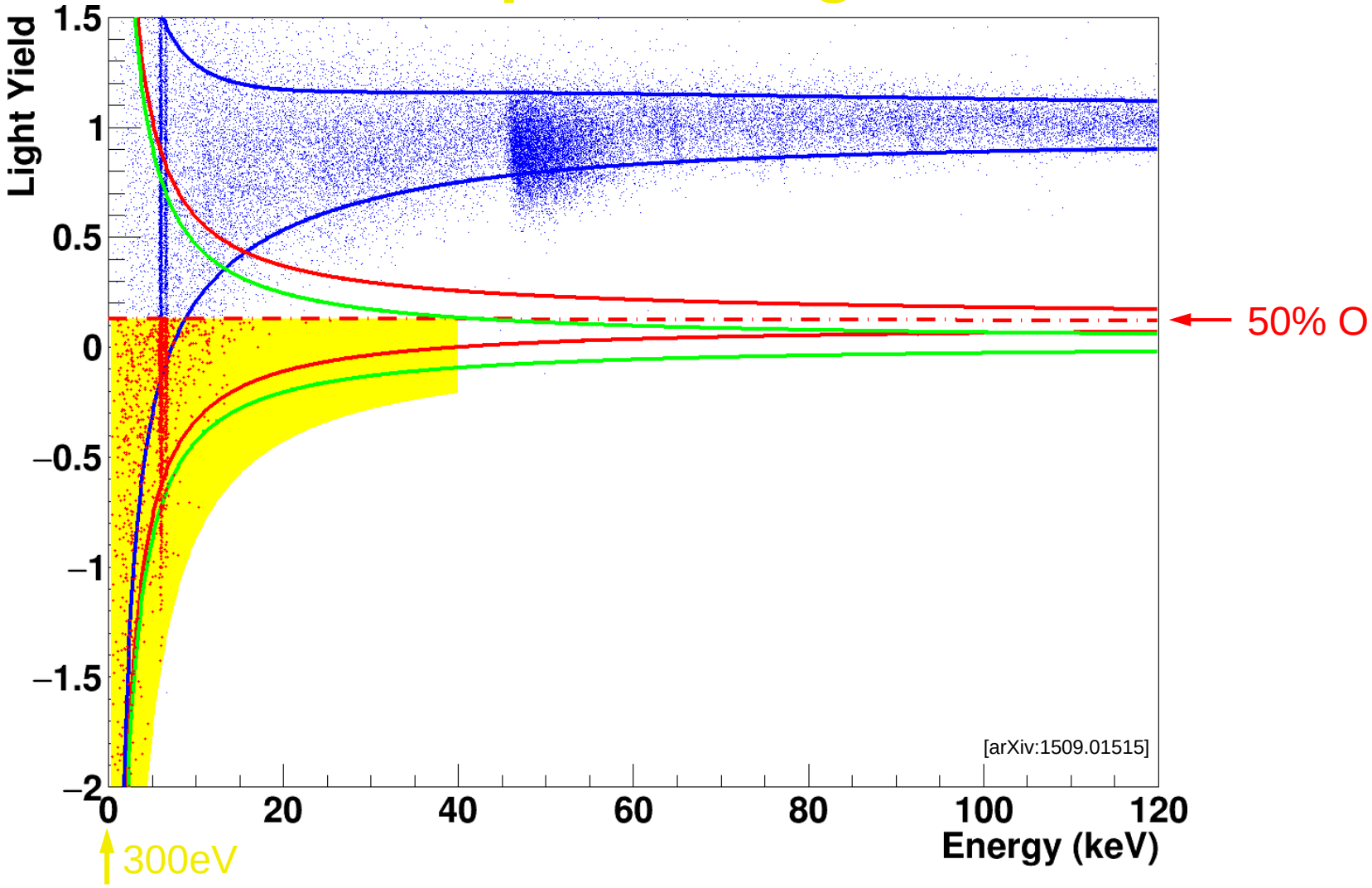


Lowest trigger threshold

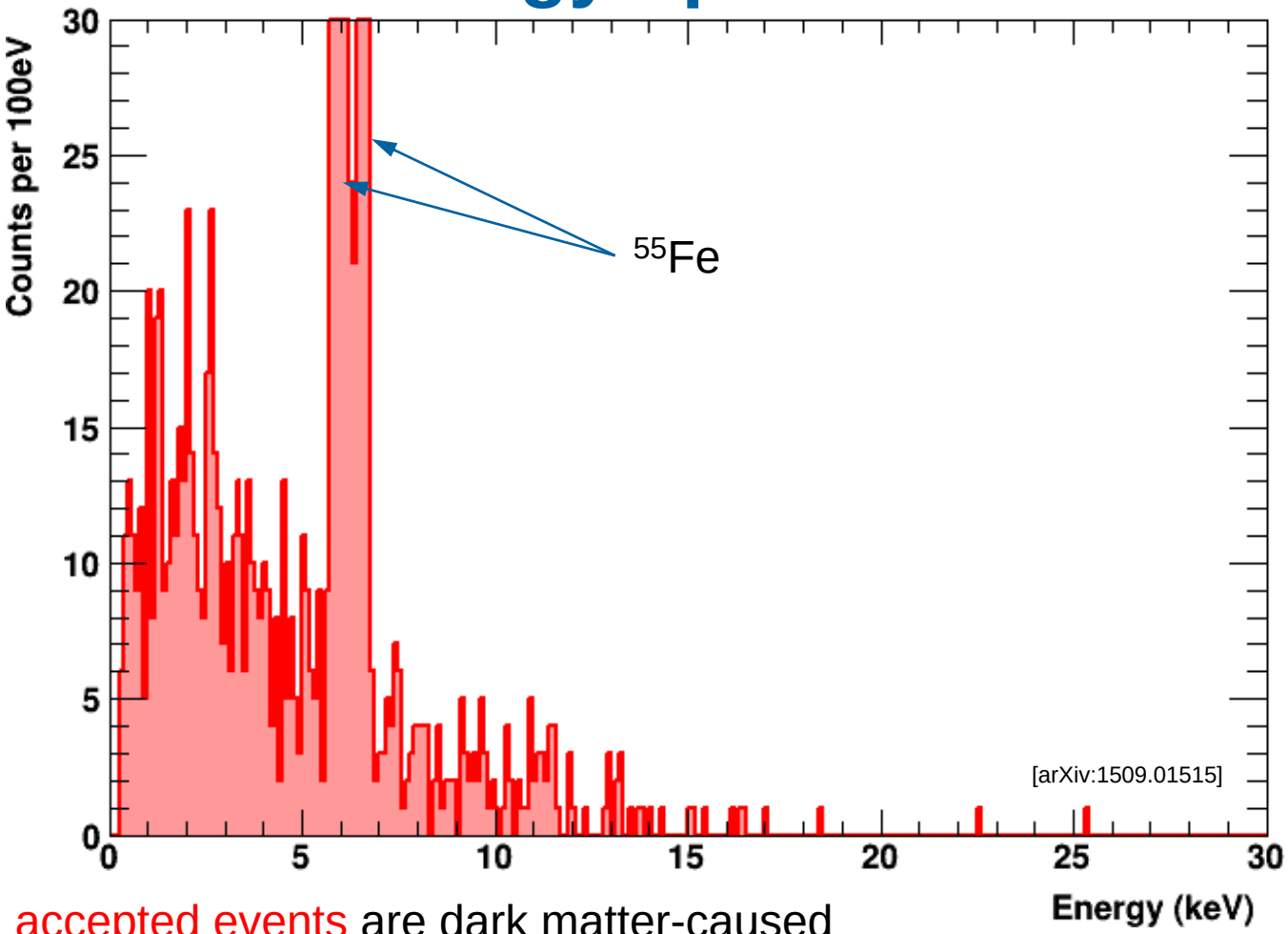
New data (52 kg.d)



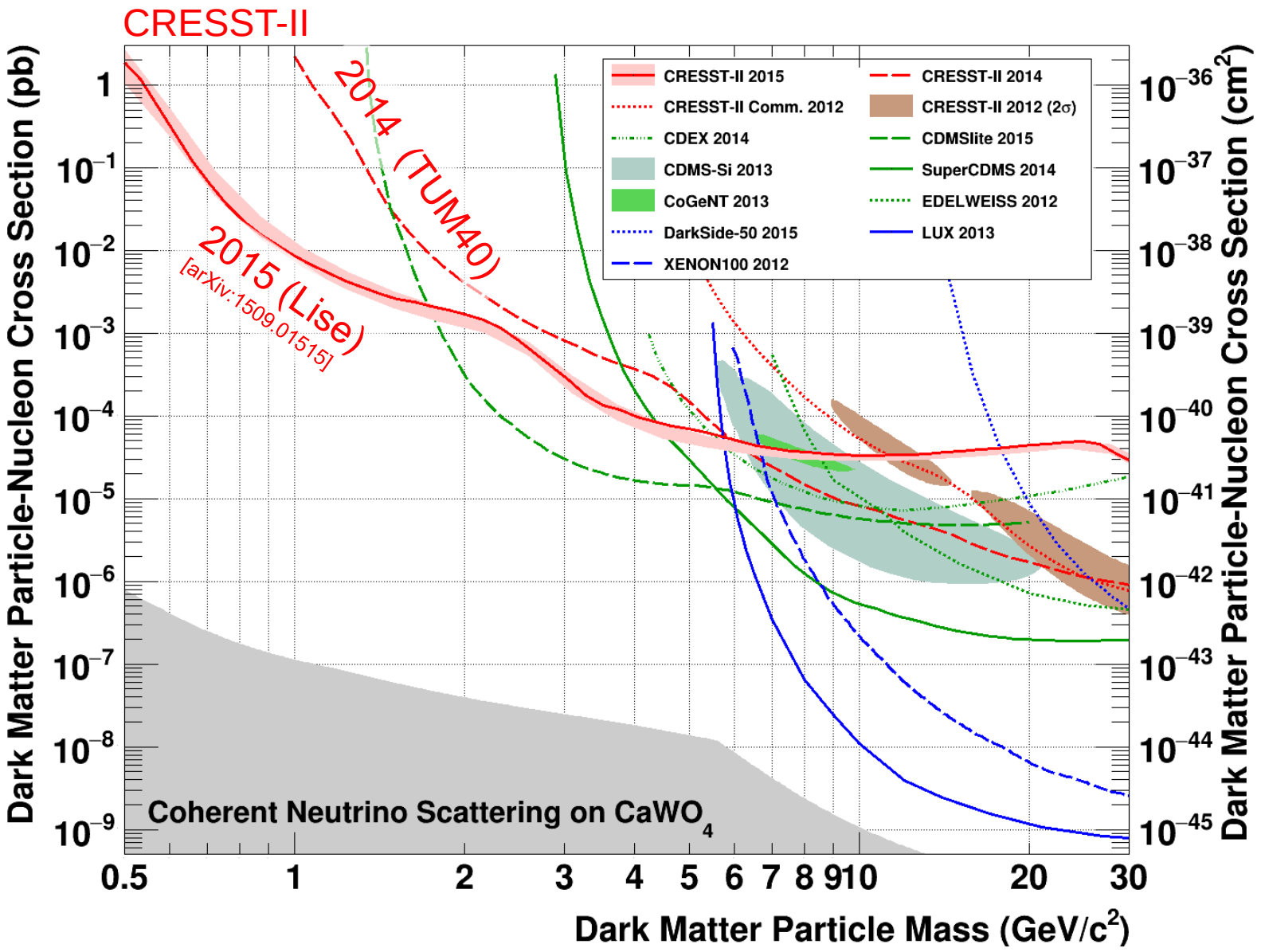
Acceptance region



Energy spectrum



Assume all accepted events are dark matter-caused
→Use Yellin‘s optimum interval method to set an exclusion limit


CRESST-II
2014 (TUM40)
2015 (Lise)
[arXiv:1509.01515]
CRESST-II 2015
CRESST-II Comm. 2012
CDEX 2014
CDMS-Si 2013
CoGeNT 2013
DarkSide-50 2015
XENON100 2012
CRESST-II 2014
CRESST-II 2012 (2σ)
CDMSlite 2015
SuperCDMS 2014
EDELWEISS 2012
LUX 2013
Coherent Neutrino Scattering on CaWO4
Dark Matter Particle-Nucleon Cross Section (pb)
Dark Matter Particle-Nucleon Cross Section (cm²)
Dark Matter Particle Mass (GeV/c²)
1
10⁻¹
10⁻²
10⁻³
10⁻⁴
10⁻⁵
10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
10⁻³⁶
10⁻³⁷
10⁻³⁸
10⁻³⁹
10⁻⁴⁰
10⁻⁴¹
10⁻⁴²
10⁻⁴³
10⁻⁴⁴
10⁻⁴⁵
0.5
1
2
3
4
5
6
7
8
9
10
20
30

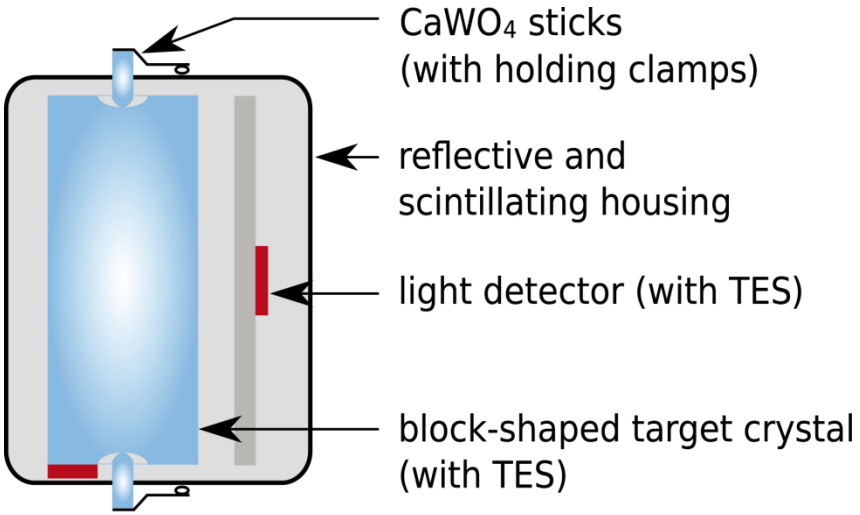
Summary I

- TUM40 (2014) [Eur. Phys. J. 74(2014)3184]:
  →Improved background suppression
  →Improved radiopurity by in-house crystal growth

- Lise (2015) [arXiv:1509.01515]:
  → Detector of CRESST-II phase 2 with lowest trigger threshold (~300eV)

  ➔ Explored new parameter space for $m_{DM} \leq 1$ GeV/c²

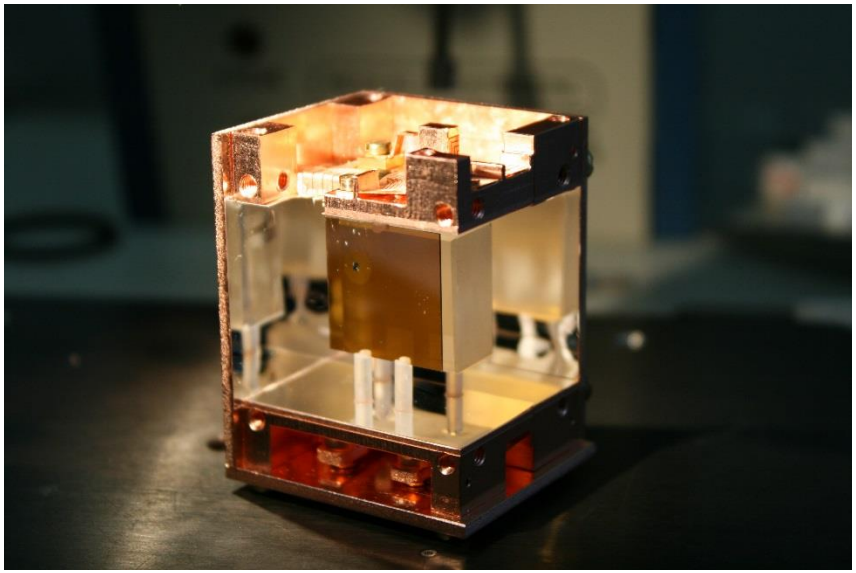
Outlook: CRESST-III



- Available crystal quality
- Smaller crystals
  250g → 24g

→Trigger threshold
~100eV

Outlook: CRESST-III



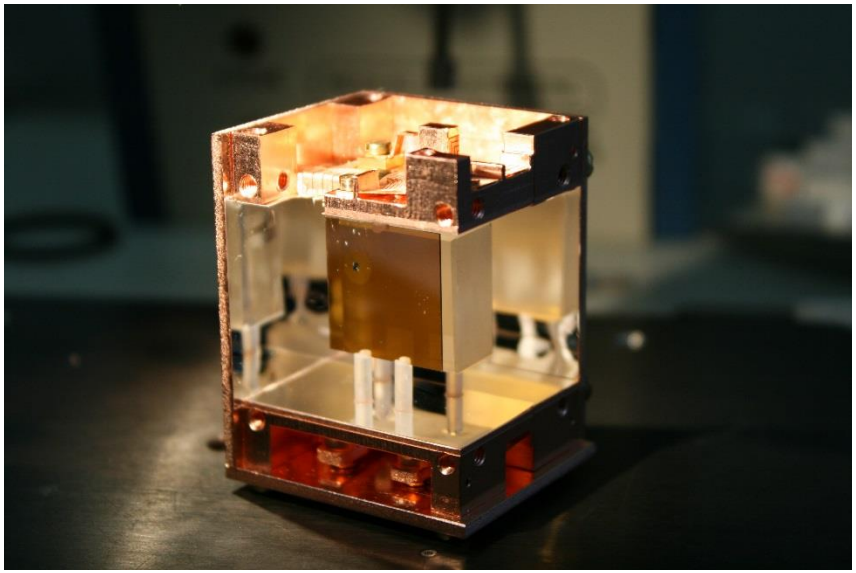
- Available crystal quality
- Smaller crystals
  250g → 24g

→Trigger threshold
~100eV

→Successfully tested

→Production ~15 modules underway

Outlook: CRESST-III



- Available crystal quality
- Smaller crystals
  250g → 24g

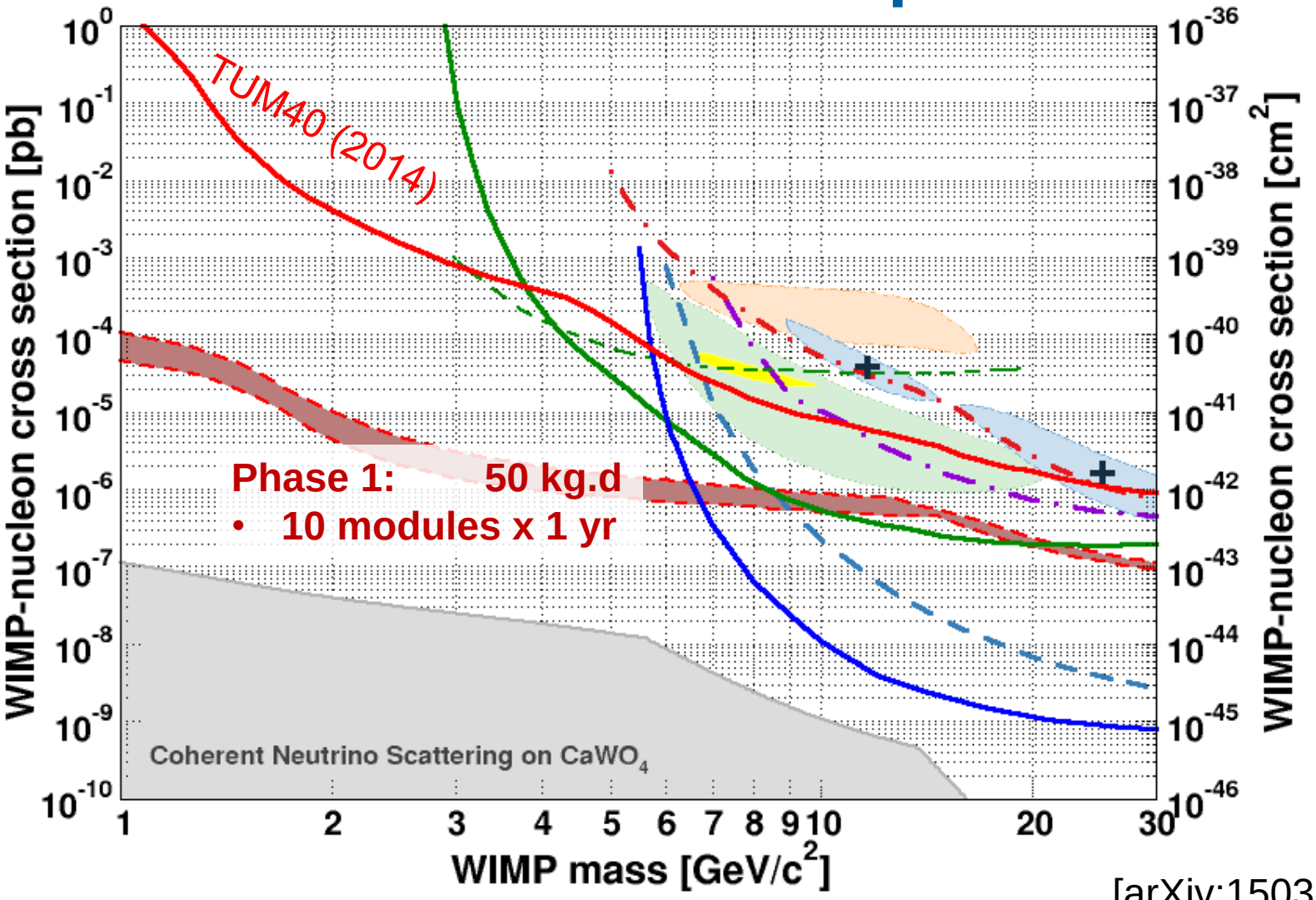
→Trigger threshold
~100eV

→Successfully tested

→Production ~15 modules underway

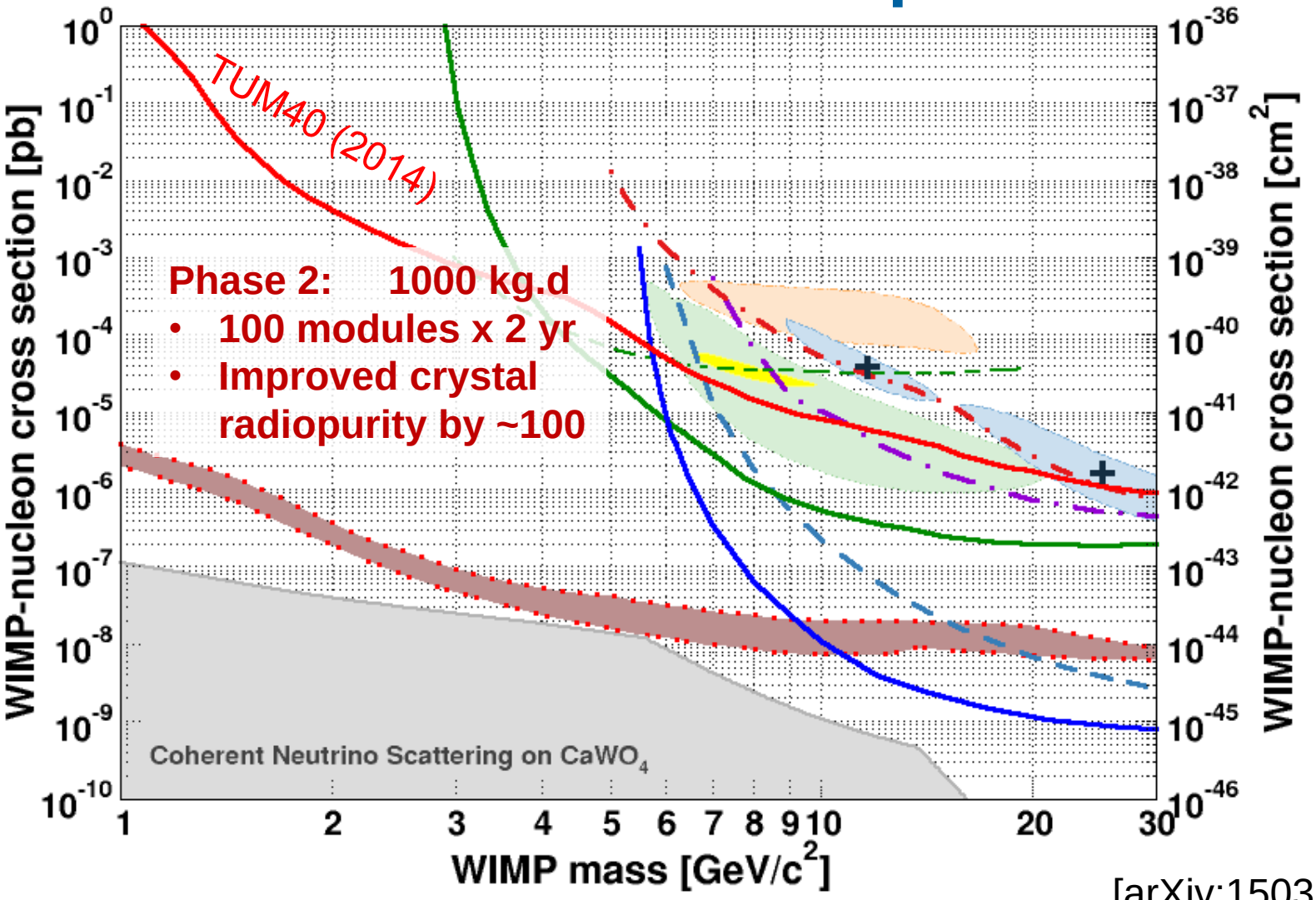
→Start CRESST-III end of this year

Outlook: CRESST-III phase 1



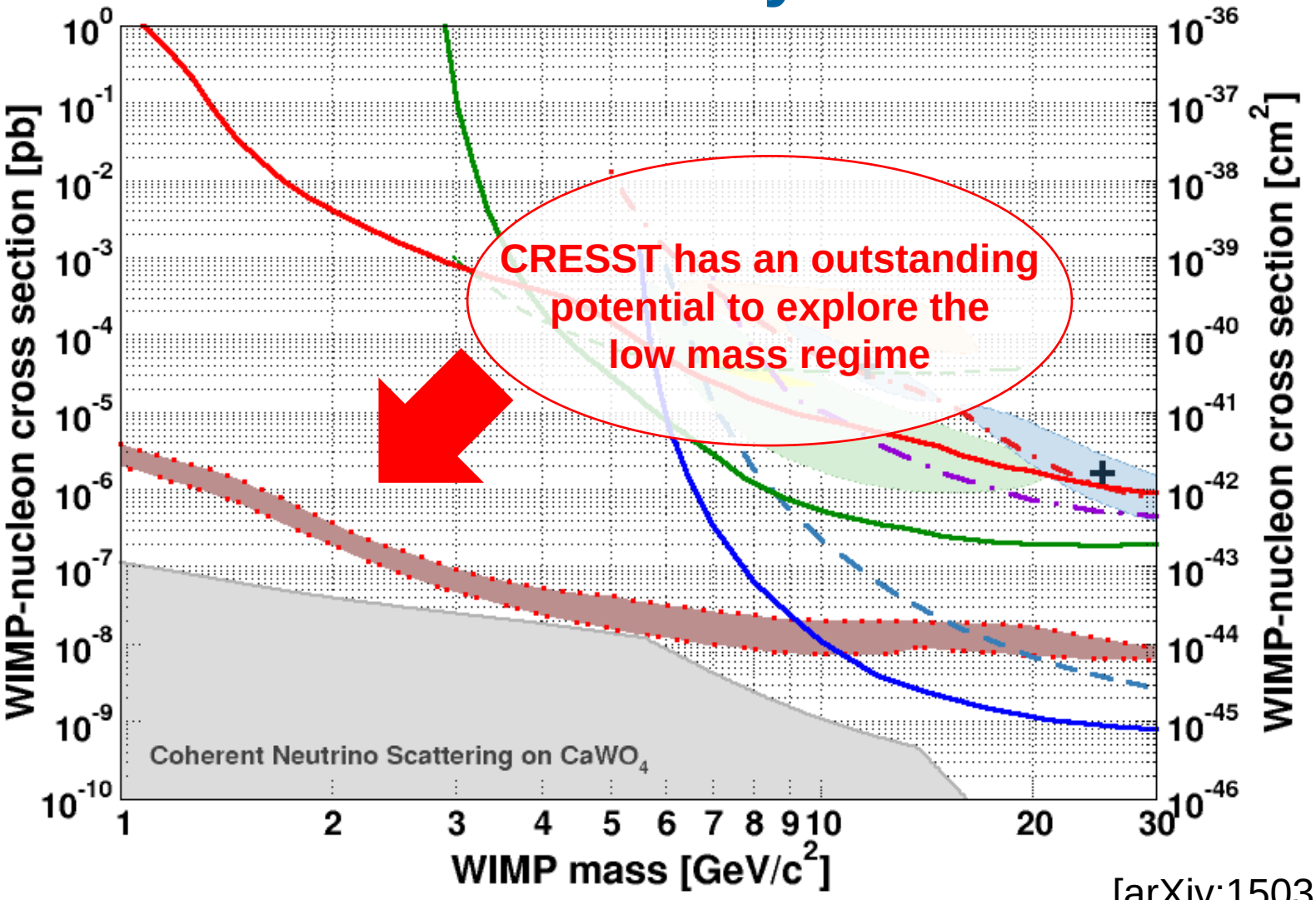
[arXiv:1503.08065]

Outlook: CRESST-III phase 2



[arXiv:1503.08065]

Summary II

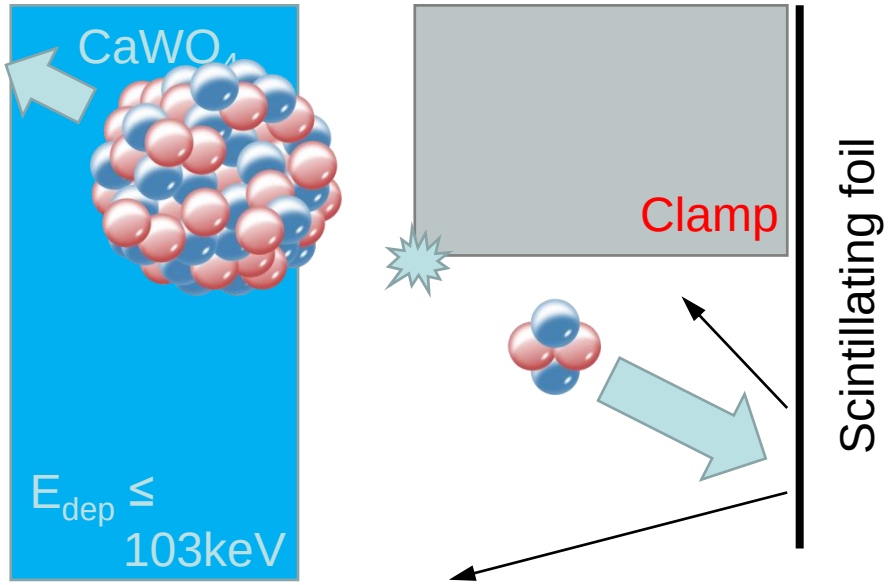


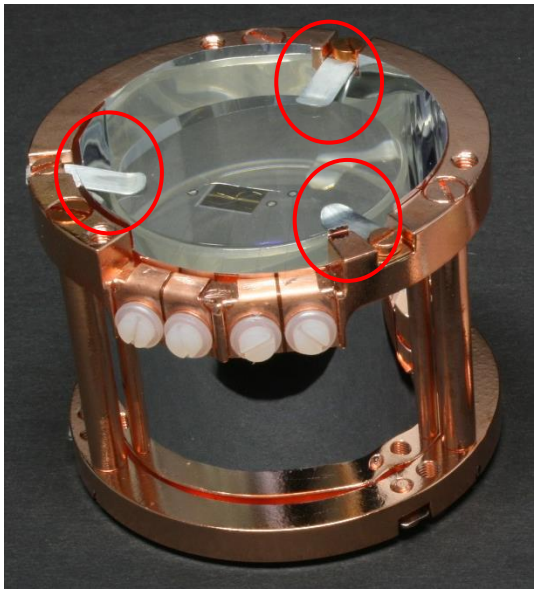
[arXiv:1503.08065]

Backup slides

Surface α-events

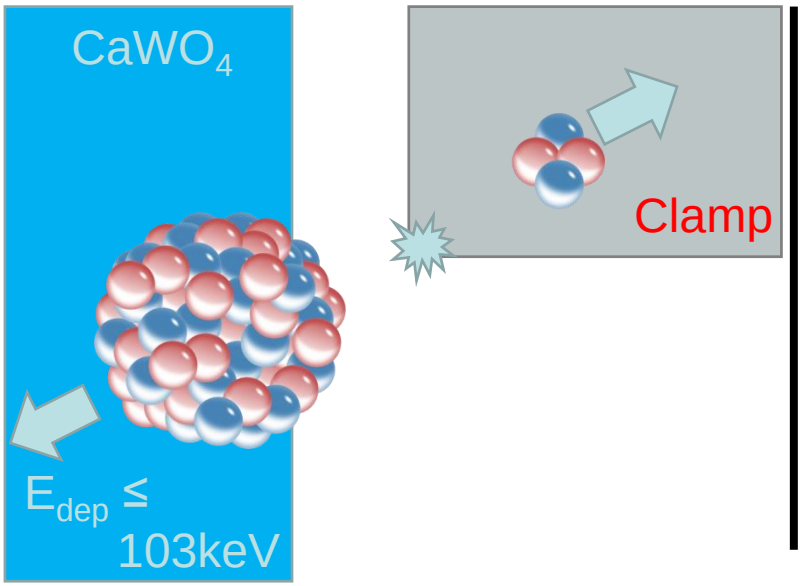
$^{210}Po \rightarrow {}^{206}Pb$ (103keV) + α (5.3MeV)

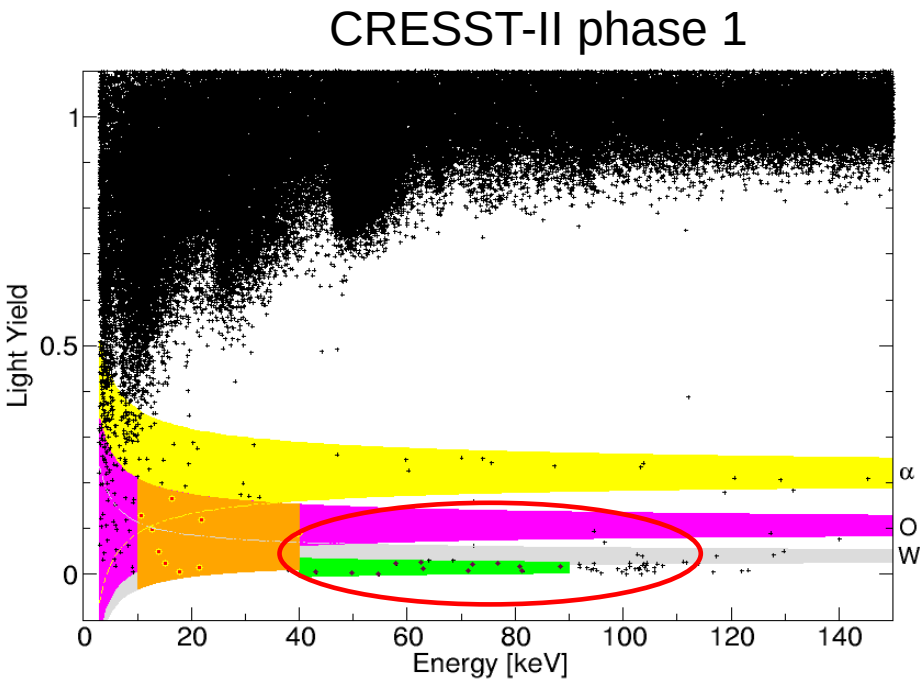




Surface α-events

$^{210}Po \rightarrow {}^{206}Pb$ (103keV) + α (5.3MeV)

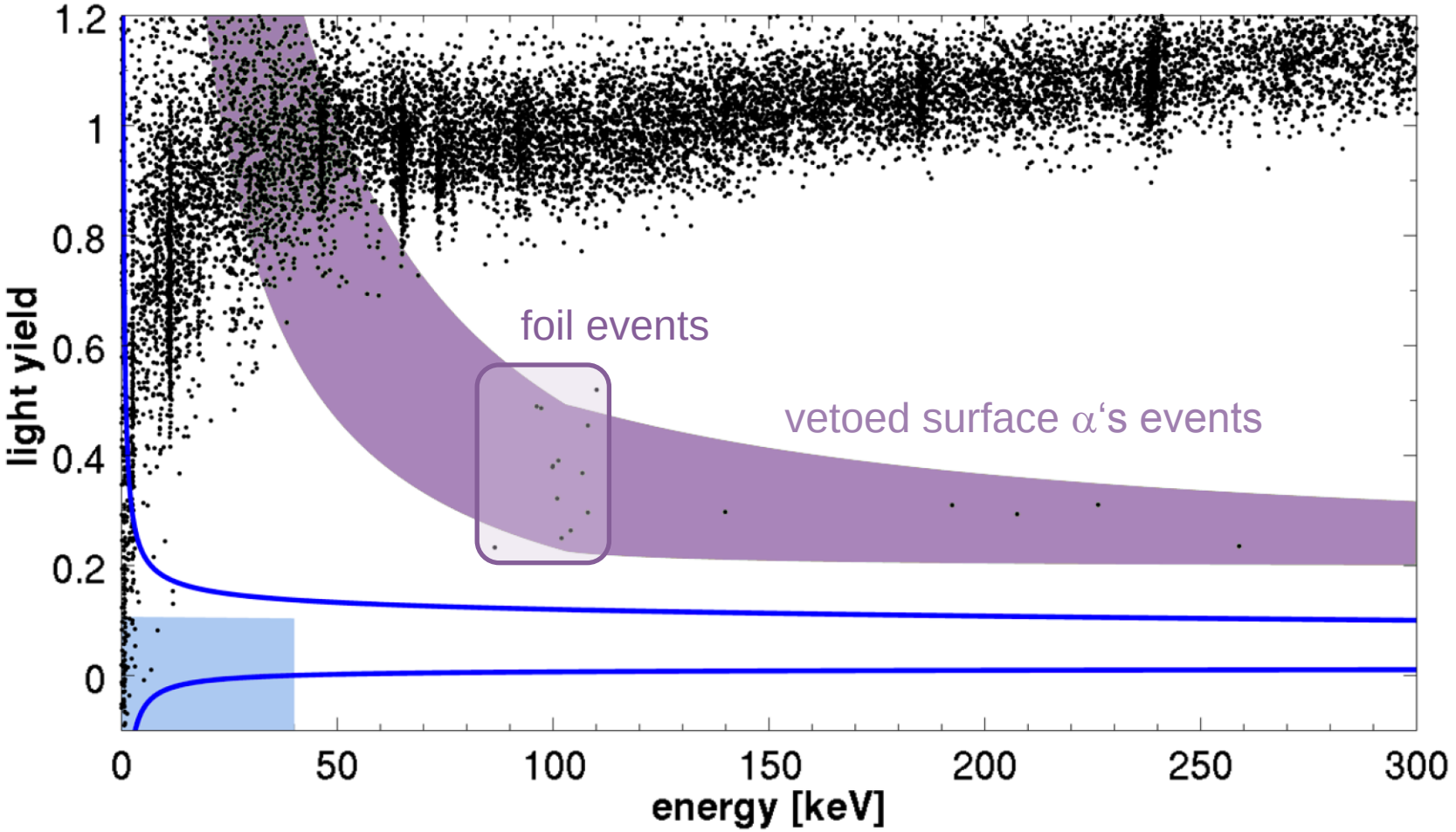




[Eur. Phys. J C 72(2012)1971]

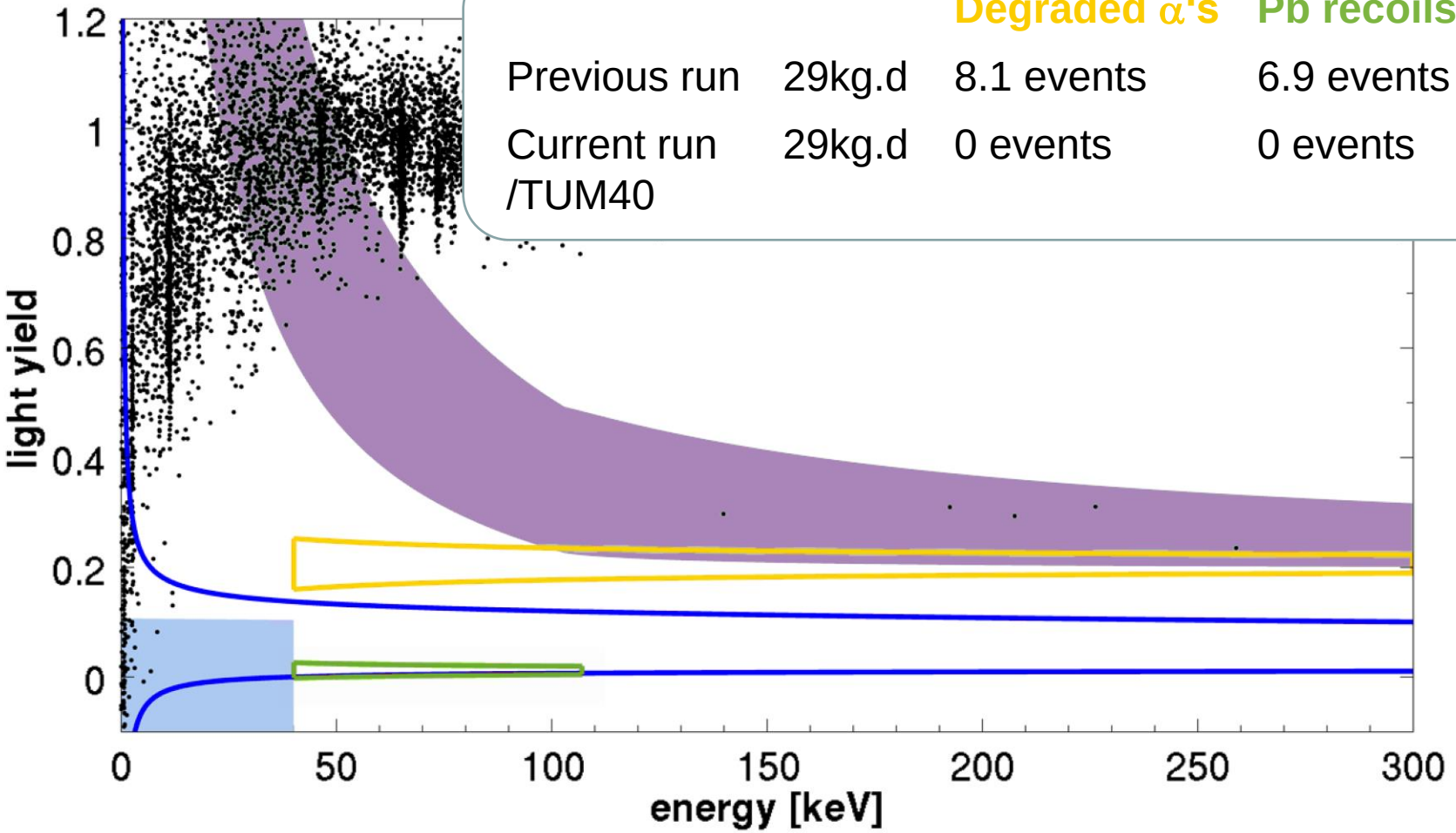
Clamps do not scintillate!

TUM40: Pb recoil suppression



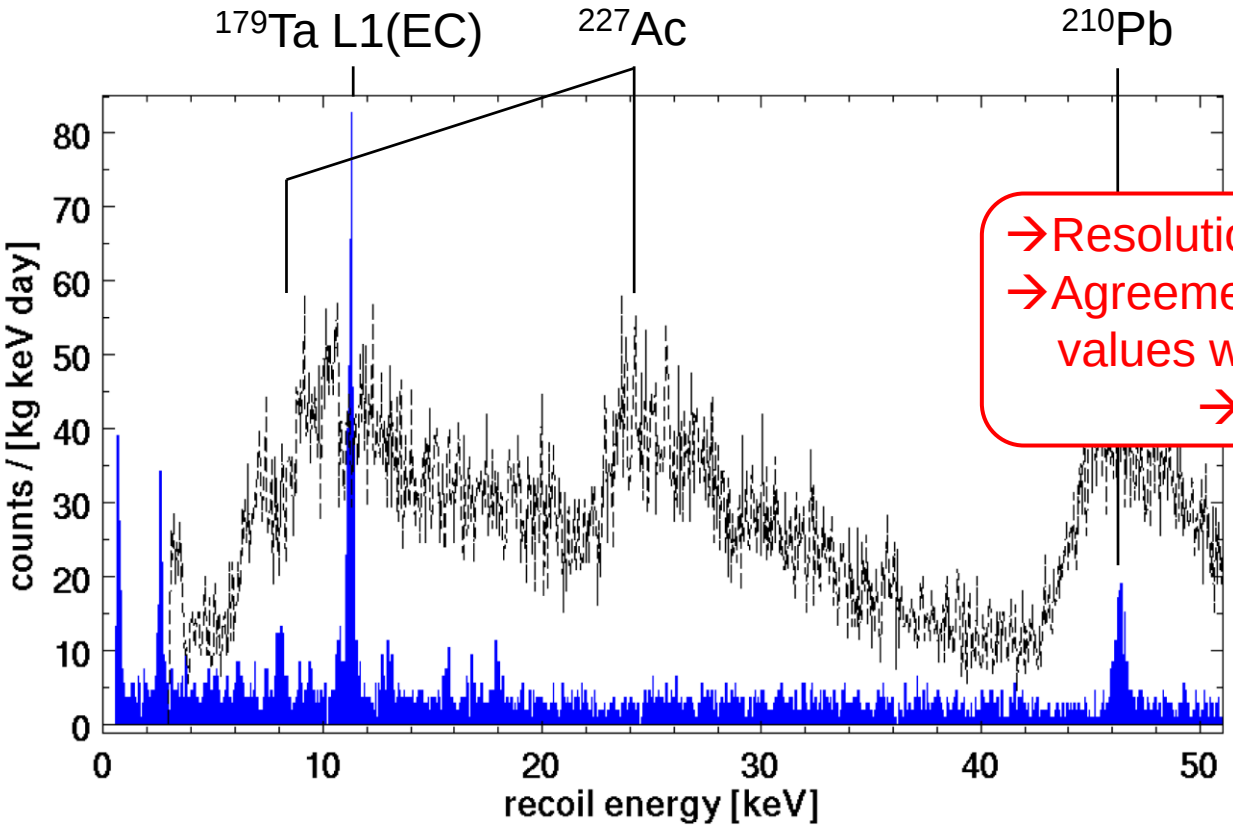
TUM40: Pb recoil suppression

		Degraded α's	Pb recoils
Previous run	29kg.d	8.1 events	6.9 events
Current run /TUM40	29kg.d	0 events	0 events



TUM40: radiopurity

- $CaWO_4$ crystal production at TU Munich [Cryst. Eng. Comm. 015(2013)2301]
- Unprecedented radiopurity (factor 2-10 improvement) [JCAP 5(2014)18]



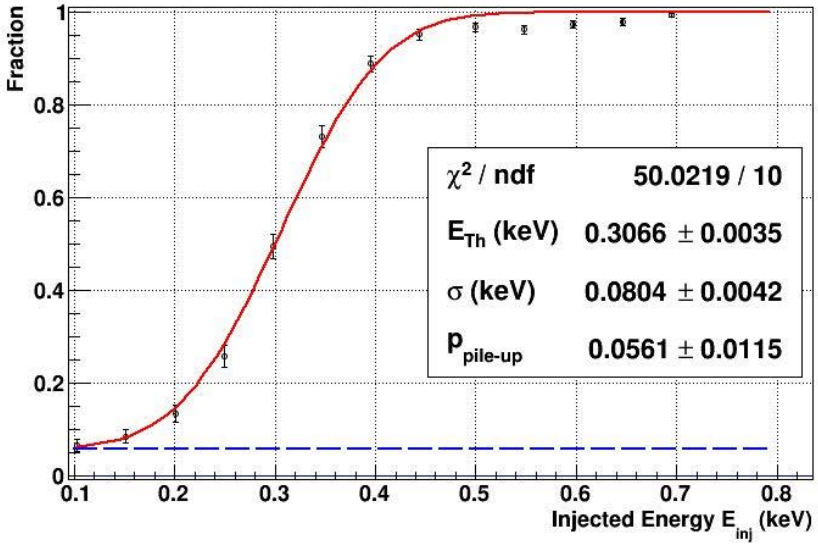
→Resolution ~100eV
→Agreement with tabulated values within <5eV
→ Energy precisely known

Commercial crystal

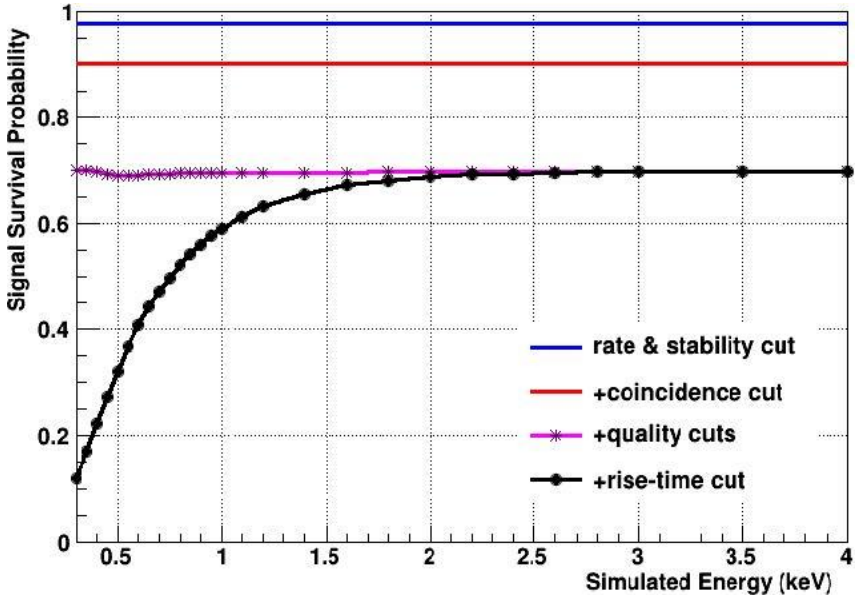
TUM40

Lise: efficiencies

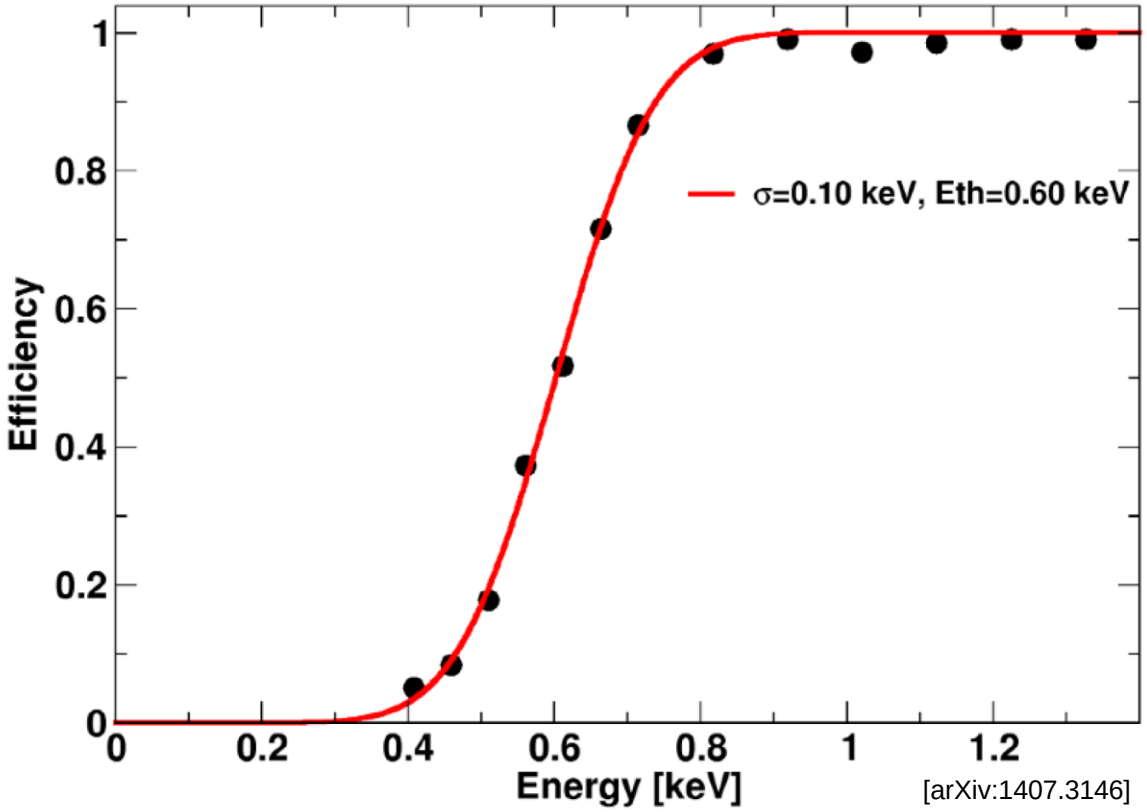
[arXiv:1509.01515]



[arXiv:1509.01515]



TUM40: trigger efficiency



[arXiv:1407.3146]

- Resolution agrees with γ lines: 107(3)eV
- Extremely low threshold: 603(2)eV

Lise: signal fraction

[arXiv:1509.01515]