New results on low mass dark matter from the CRESST-II experiment

TAUP 2015
Torino, September 7

Federica Petricca
Max-Planck-Institute for Physics Munich

on behalf of the CRESST collaboration

The CRESST collaboration

HEPHY
Institut für Hochenergiephysik

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

TECHNISCHE UNIVERSITÄT MÜNCHEN

INFN
Laboratori Nazionali del Gran Sasso

UNIVERSITY OF OXFORD

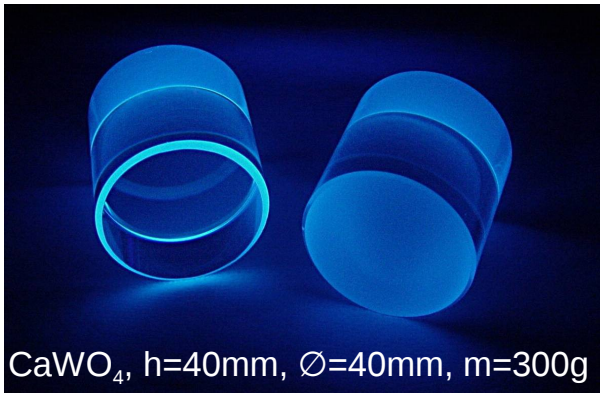
EBERHARD KARLS UNIVERSITÄT TÜBINGEN

The CRESST experiment

Cryogenic Rare Event Search with Superconducting Thermometers

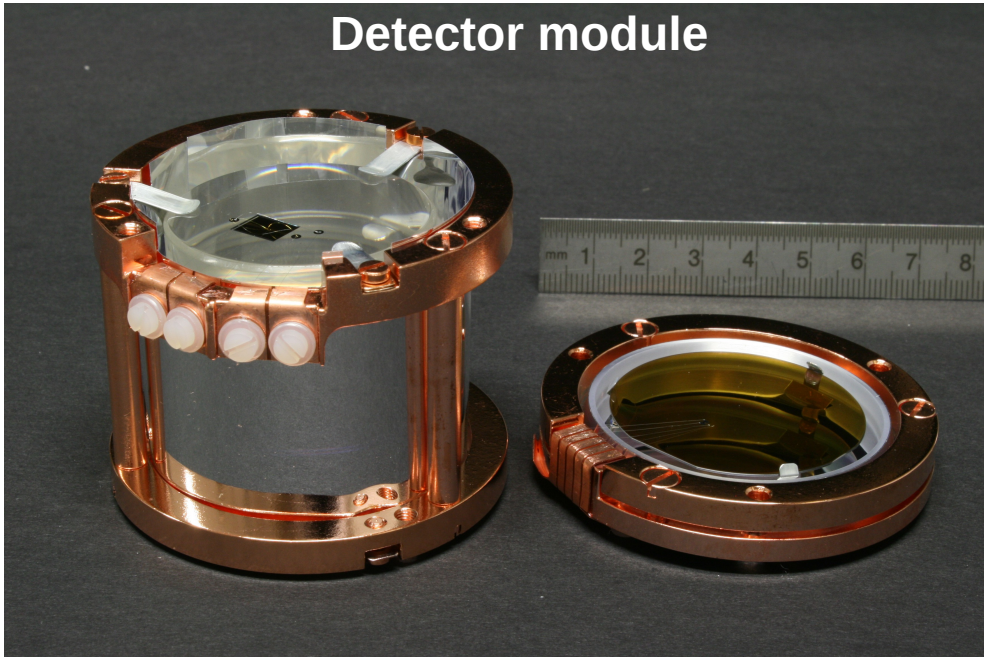
Direct detection of dark matter particles via their scattering off target nuclei

Scintillating $CaWO_4$ crystals as target



Target crystals operated as **cryogenic calorimeters** (~15mK)

Separate **cryogenic light detector** to detect the scintillation light signal



Detector module

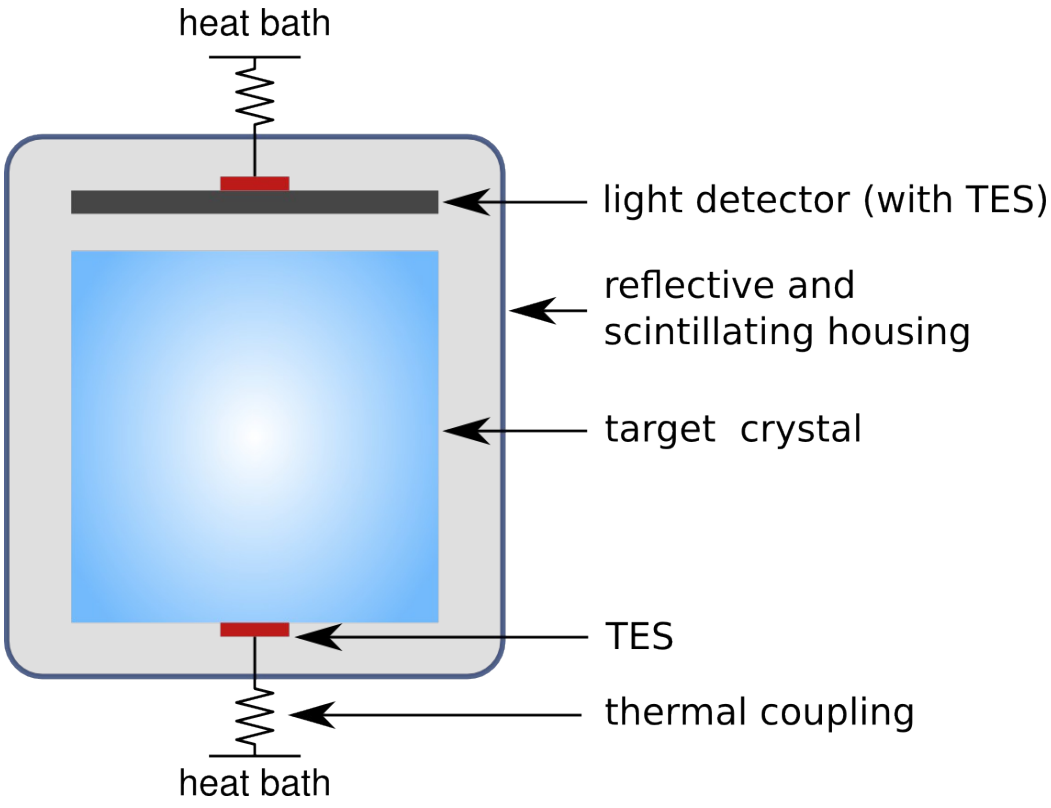
Energy deposition in the crystal:

- mainly phonons

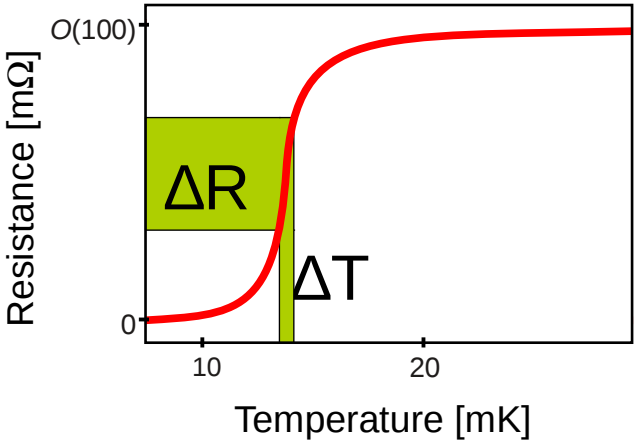
(independent of the type of particle)
Measurement of deposited energy

- small fraction into scintillation light

(characteristic of the type of particle)
Particle discrimination



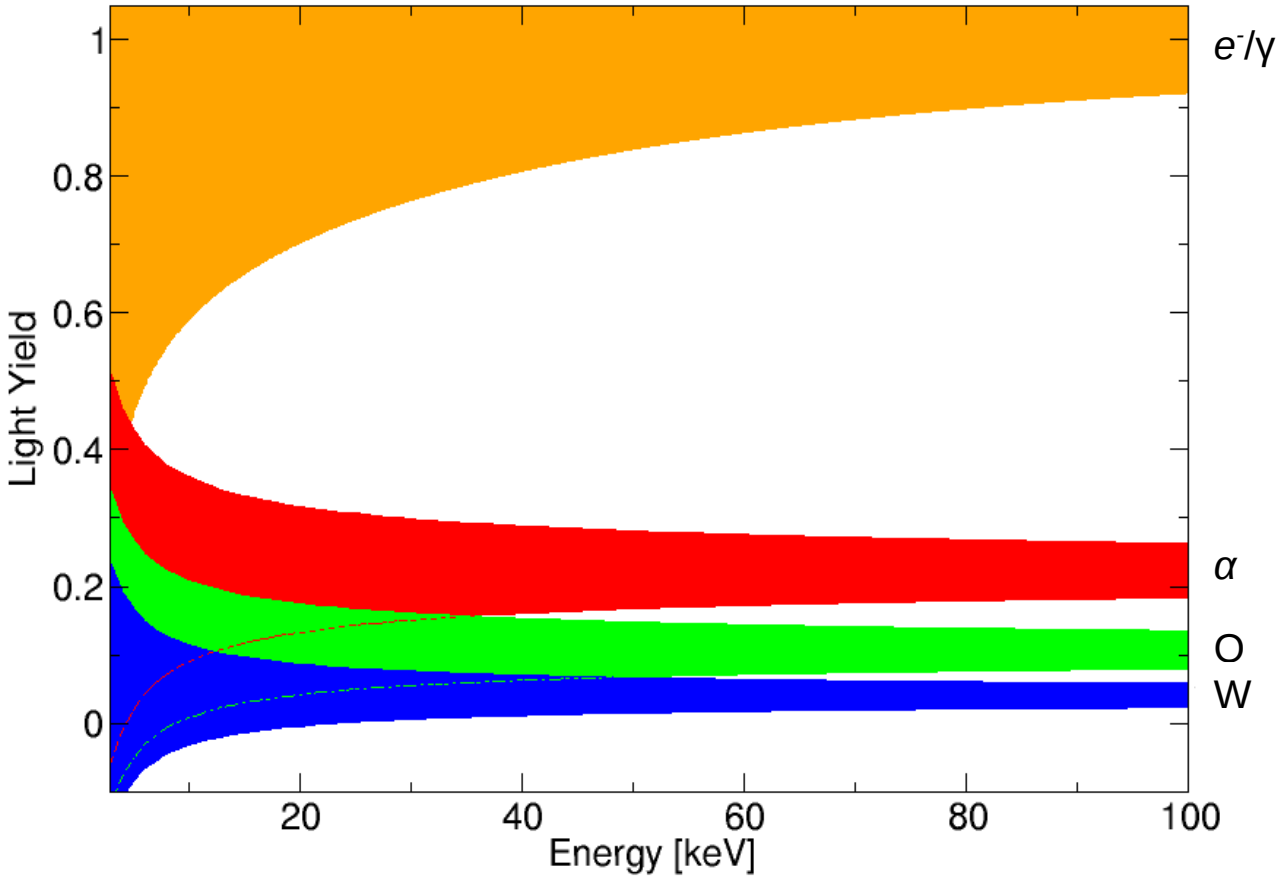
Two simultaneous signals from the two transition edge sensors (**TES**)



Event discrimination

$$\text{Light Yield} = \frac{\text{Light signal}}{\text{Phonon signal}}$$

Characteristic of the event type



Excellent **discrimination** between potential signal events (**nuclear recoils**) and dominant radioactive background (**electron recoils**)

CRESST II Phase 2

Data taking: July 2013 – August 2015

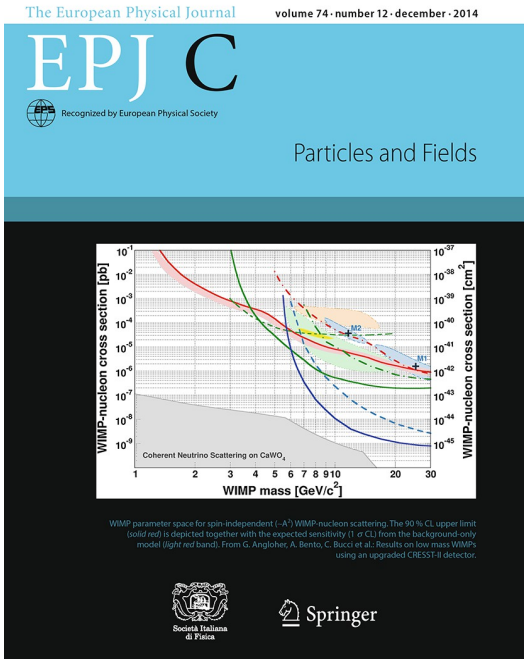
First Phase 2 results on low mass dark matter particles:

- July 2014
- Single module TUM40
- Self grown crystal
- Best overall performance
- 29 kg days of exposure
- Non-blind 2013 dataset

Trigger thresholds of several modules lowered

Final Phase 2 results on low mass dark matter particles:

- September 2015
- Single module Lise
- External supplier
- Lowest threshold
- 52 kg days of exposure
- Full blind data set



arXiv:1509.01515

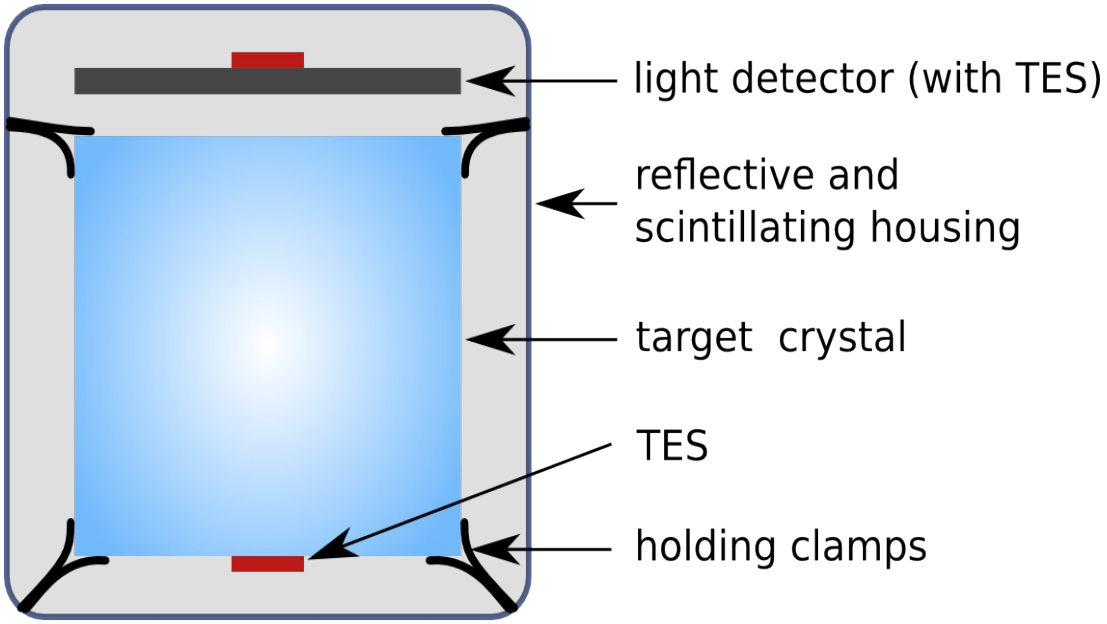
Detector Lise

Detector design: Conventional
No veto for surface alpha decays

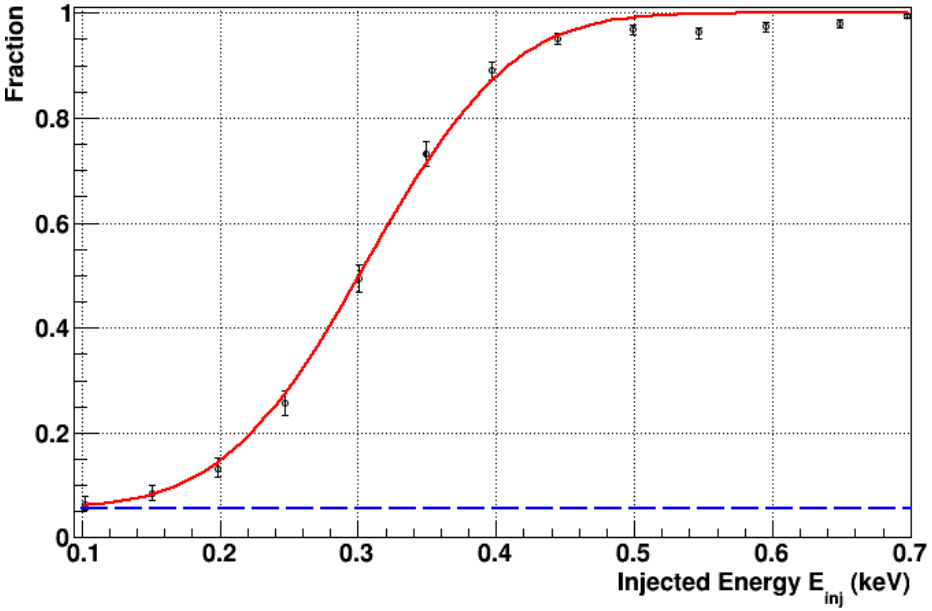
Crystal: Lise (external supplier)
Background level ~8.5 counts/keV kg day

Threshold: 307eV

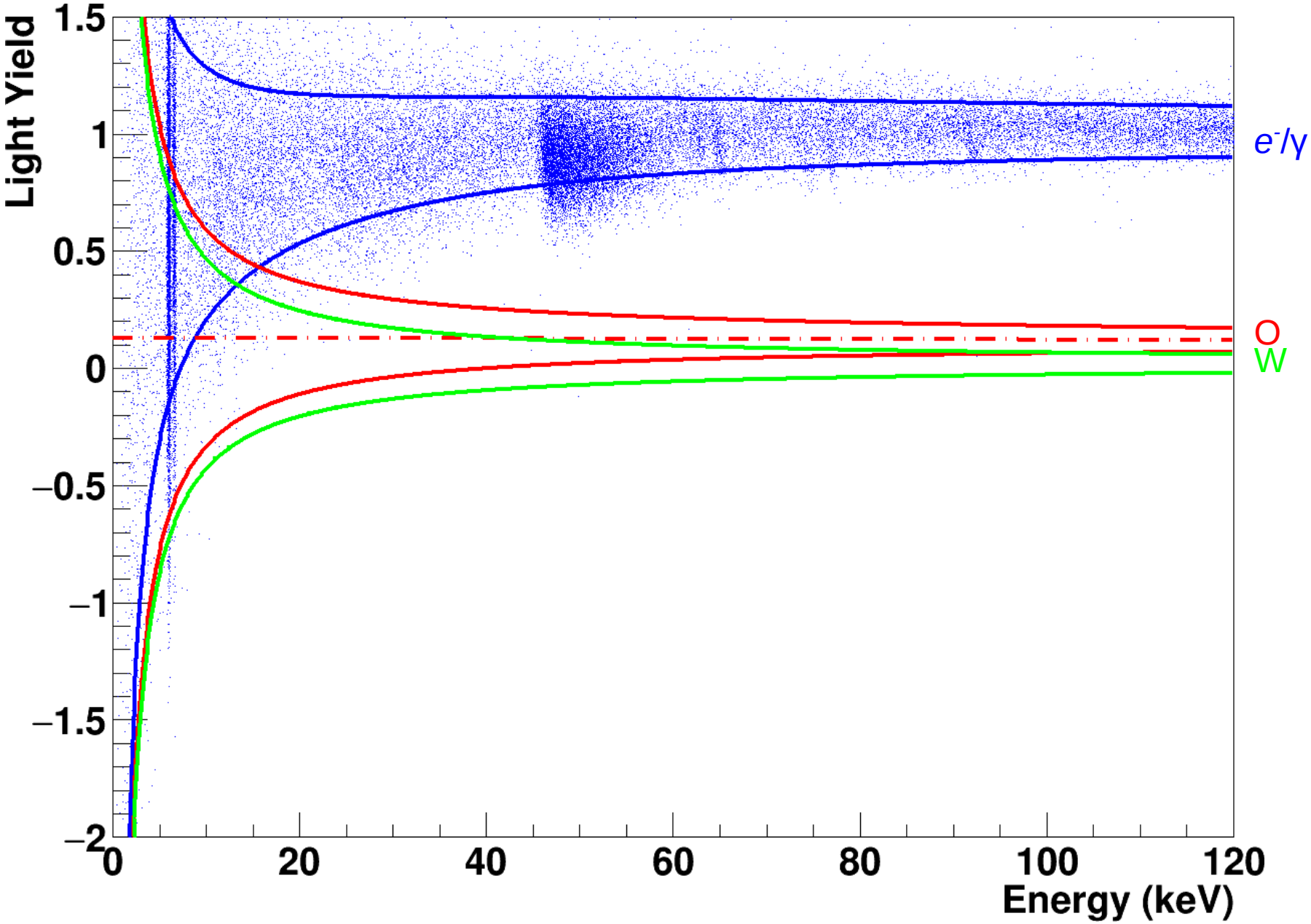
Resolution: 62eV at zero energy



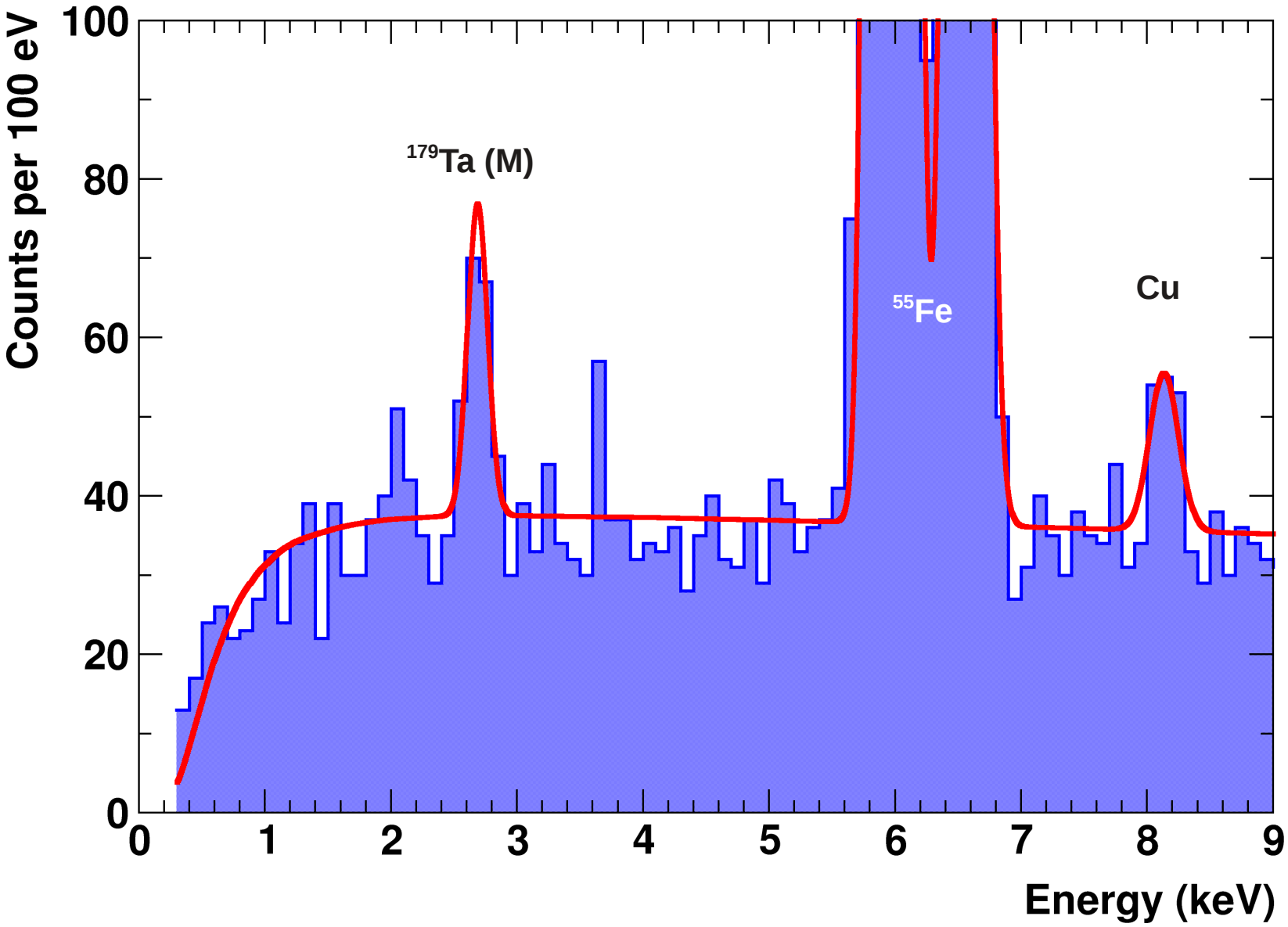
- **Average overall performance**
- **Lowest threshold**



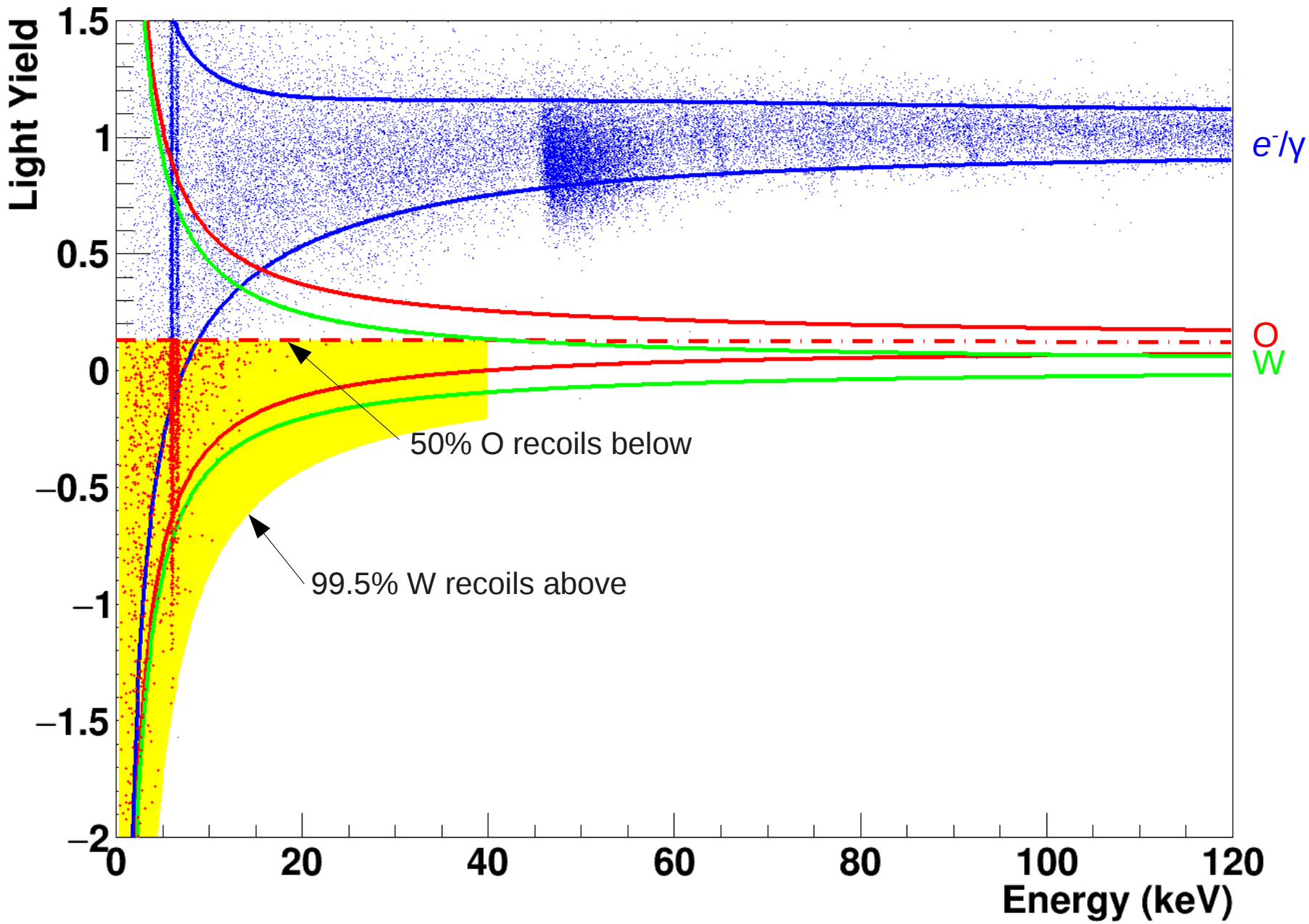
Data


Light Yield
1.5
1
0.5
0
−0.5
−1
−1.5
−2
0
20
40
60
80
100
120
Energy (keV)
e-/γ
O
W

Data


Counts per 100 eV
100
80
60
40
20
0
0
1
2
3
4
5
6
7
8
9
Energy (keV)
179Ta (M)
55Fe
Cu

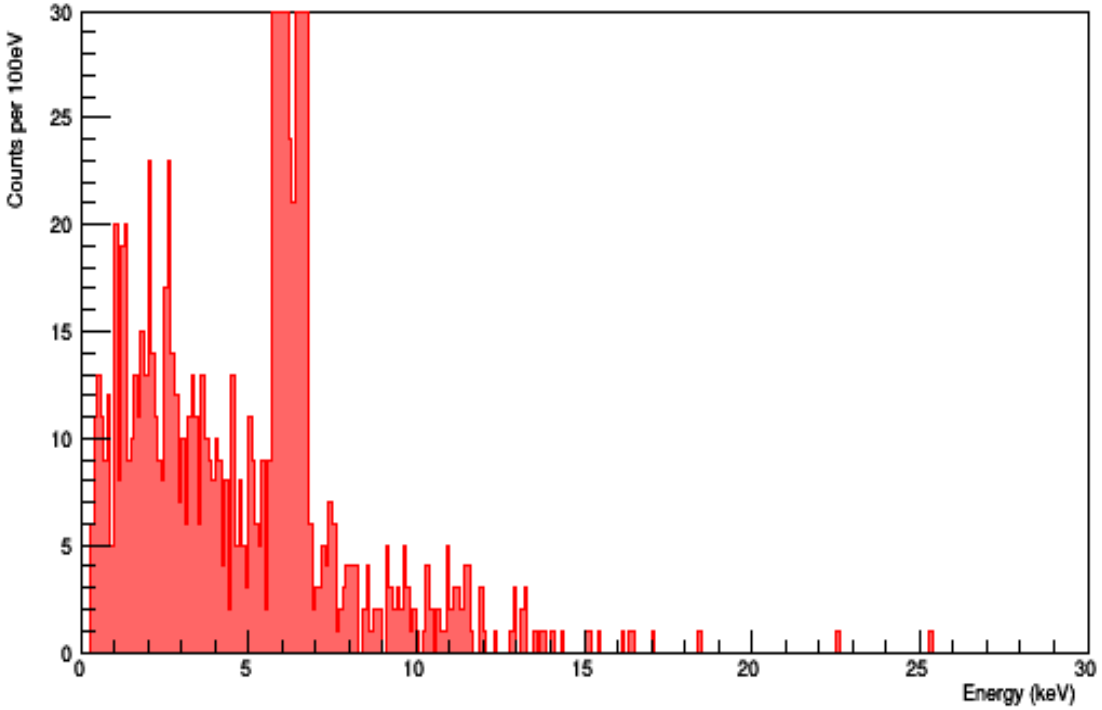
Data


Light Yield
1.5
1
0.5
0
−0.5
−1
−1.5
−2
0
20
40
60
80
100
120
Energy (keV)
e-/γ
O
W
50% O recoils below
99.5% W recoils above

Data

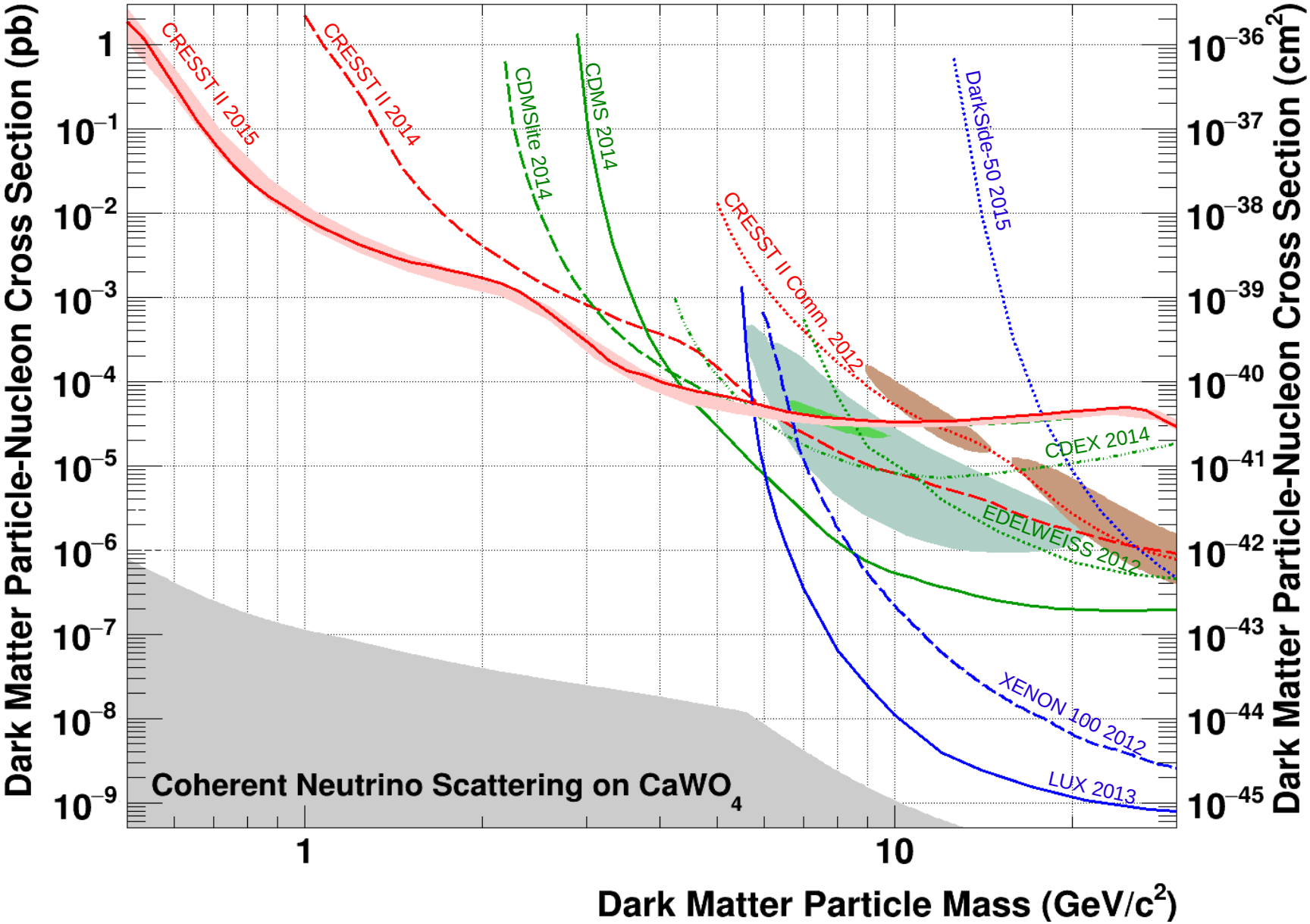
All accepted events considered as potential signal

- Standard assumptions on dark matter halo
- Helm form factors
- Yellin one-dimensional optimum interval method

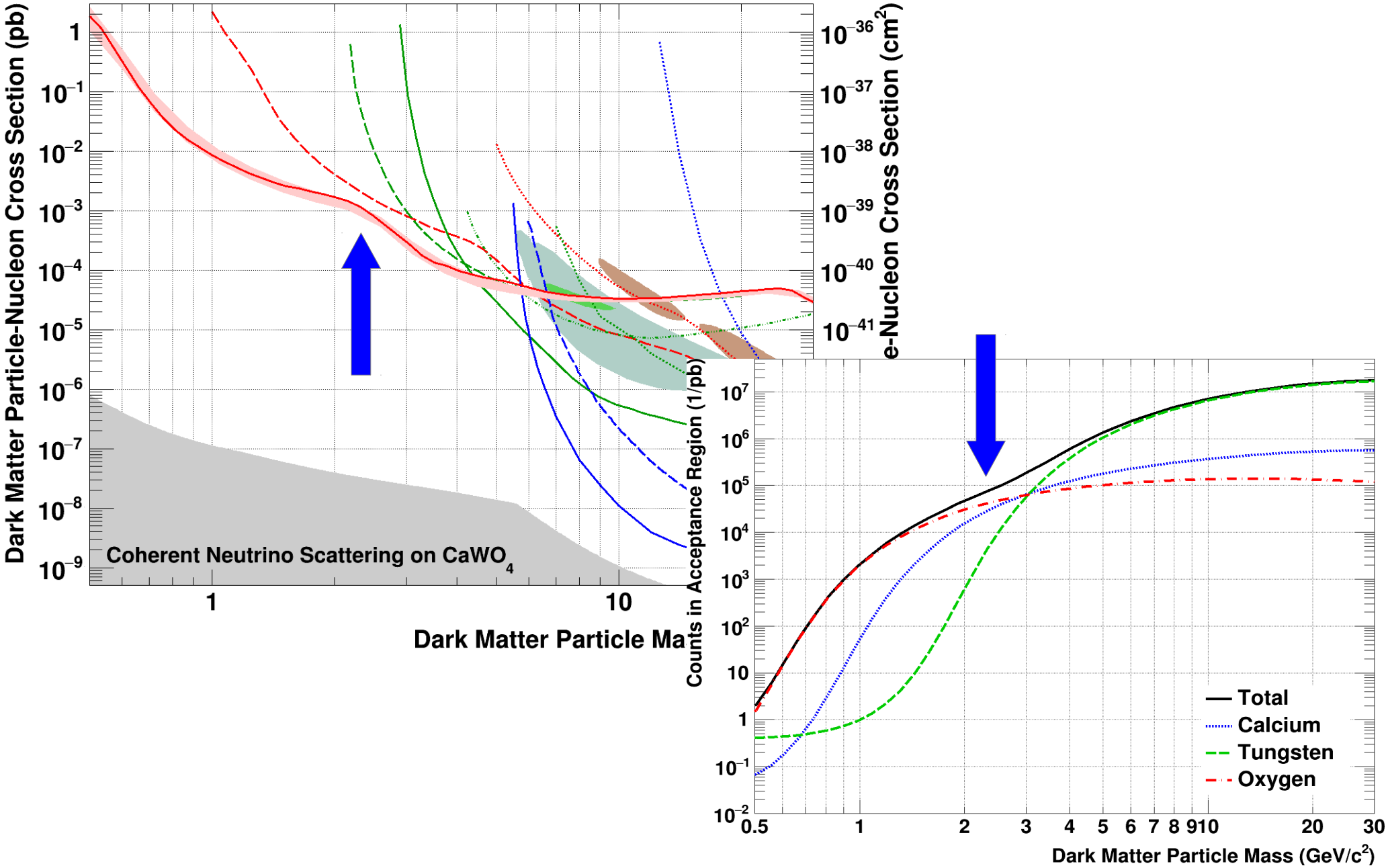


Exclusion limit

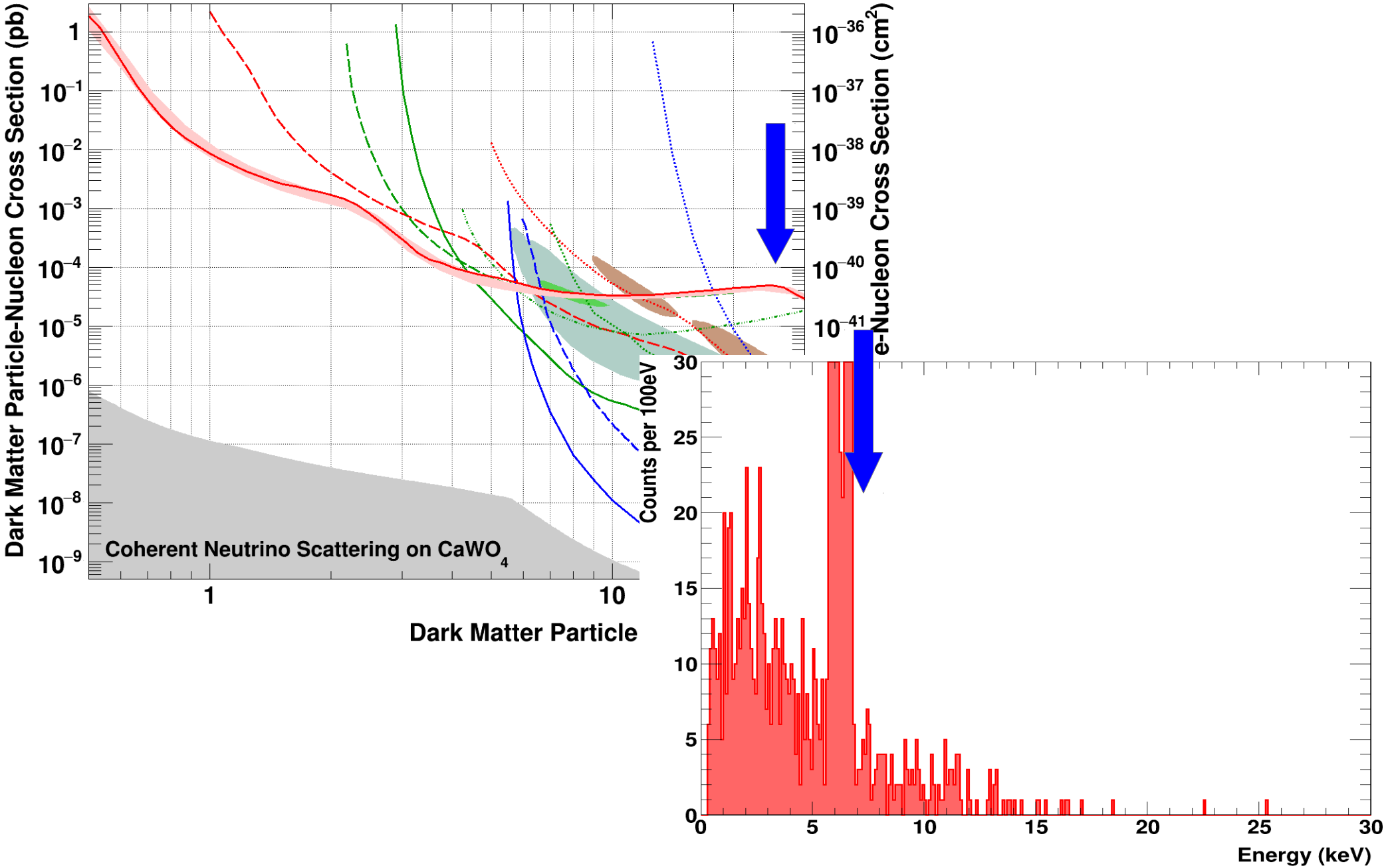
Explore masses in the sub-GeV/c^2 range



Exclusion limit



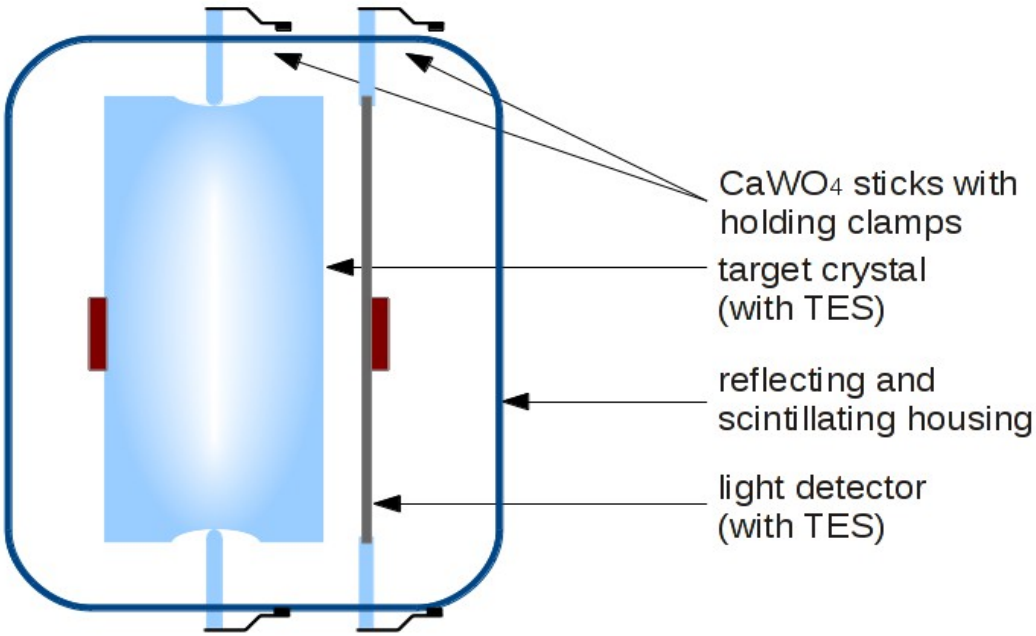
Exclusion limit

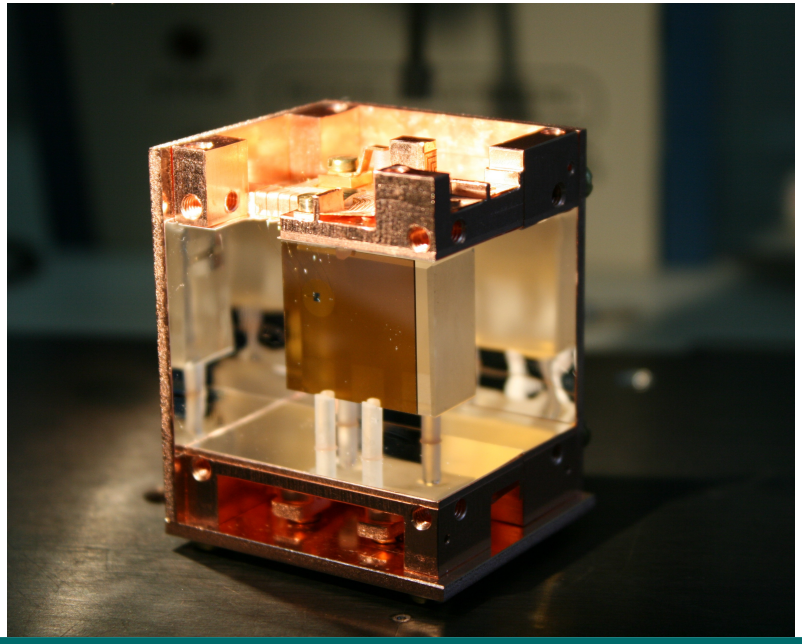


Modules for CRESST III

Detector layout optimized for low mass dark matter

- Available self grown crystals (background level ~3 counts/keV kg day)
- 100 eV threshold
- Cuboid crystal of $(20\times20\times10)mm^3$ (~ 25g)
- Fully scintillating housing
- Light detector $(20\times20)mm^2$





Prototype successfully tested
Production of modules ongoing

Start of CRESST III end of 2015

For details see poster Strauss, Pröbst, Petricca

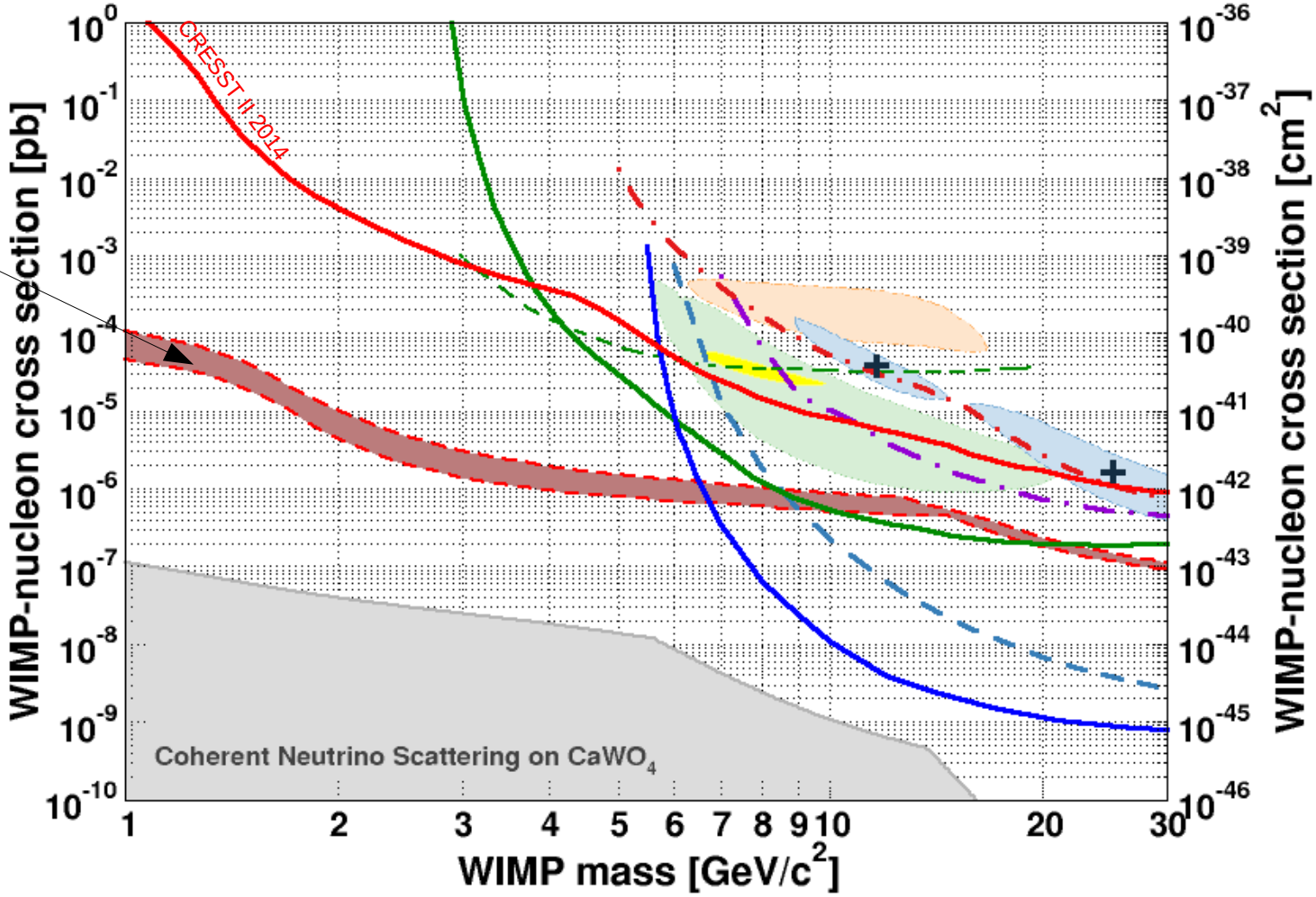
CRESST III projections

arXiv:1503.08065 [astro-ph.IM]

Phase 1

- 50 kg-days

1 year of running with
10 small modules



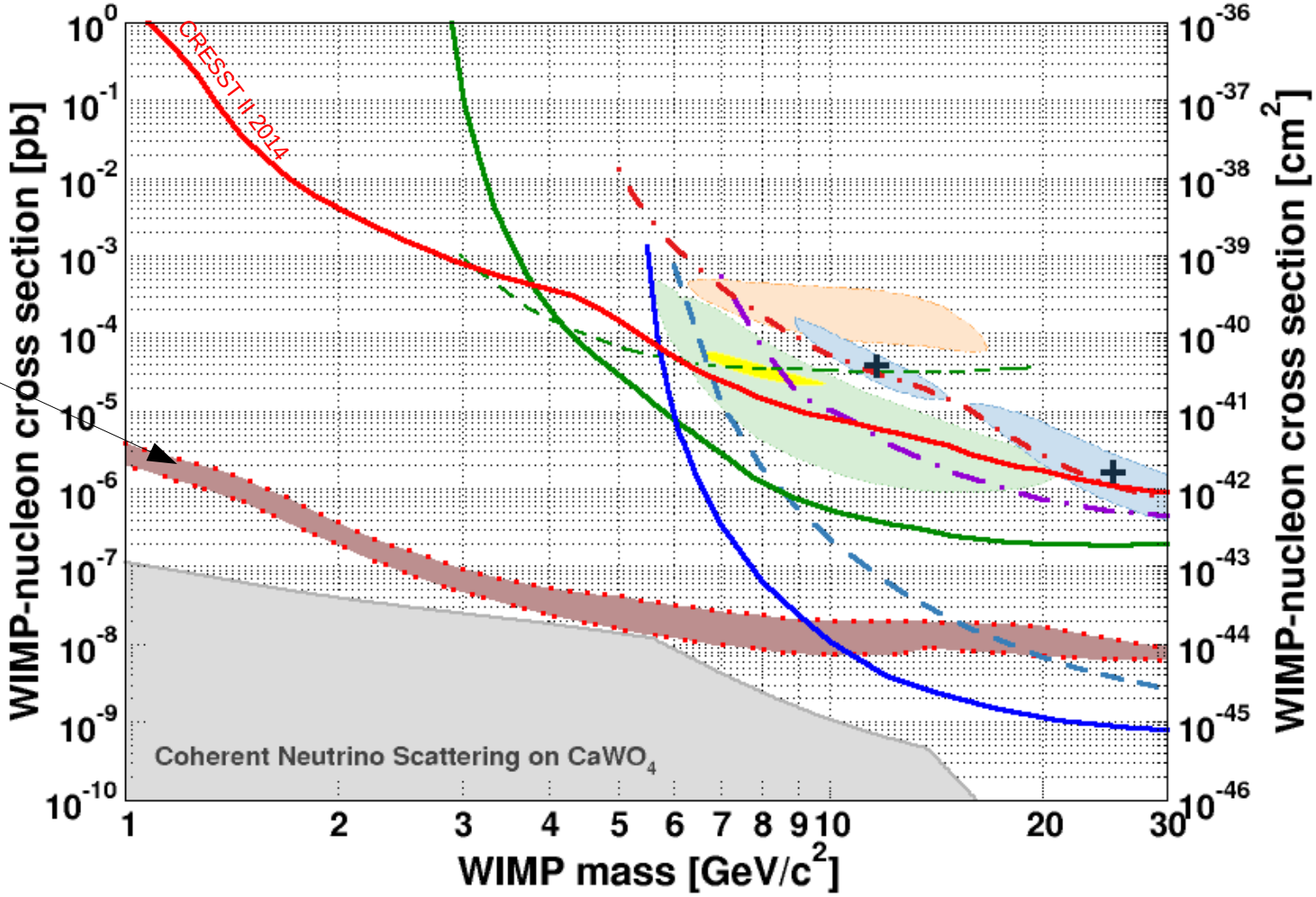
CRESST III projections

arXiv:1503.08065 [astro-ph.IM]

Phase 2

- 1000 kg-days
2 years of running with
100 small modules

- factor 100 reduction in background



Take home message