The **CRESST-II** Experiment

Status Update

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on behalf of the CRESST Collaboration

IDM 2012 Chicago

EBERHARD KARLS UNIVERSITÄT TÜBINGEN

TECHNISCHE UNIVERSITÄT MÜNCHEN

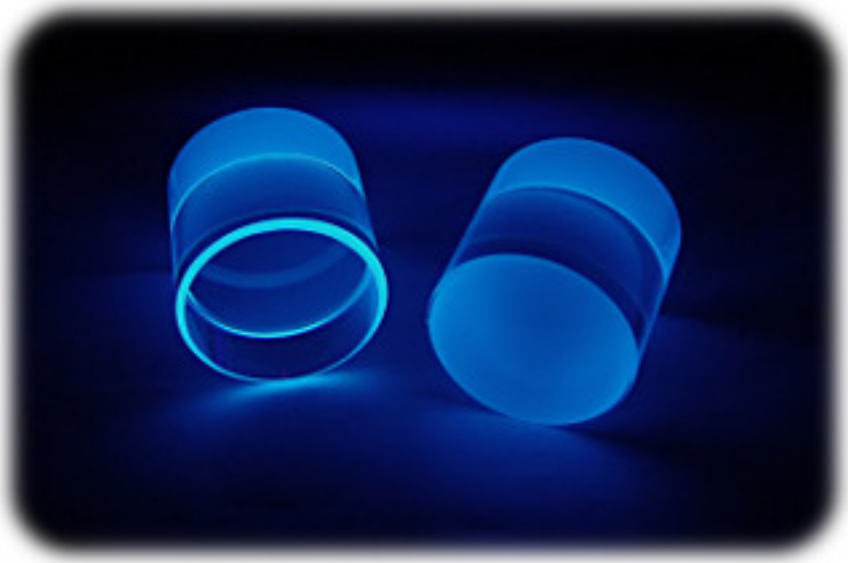
Max-Planck-Institut für Physik (Werner-Heisenberg-Institut)

LNGS

UNIVERSITY OF OXFORD

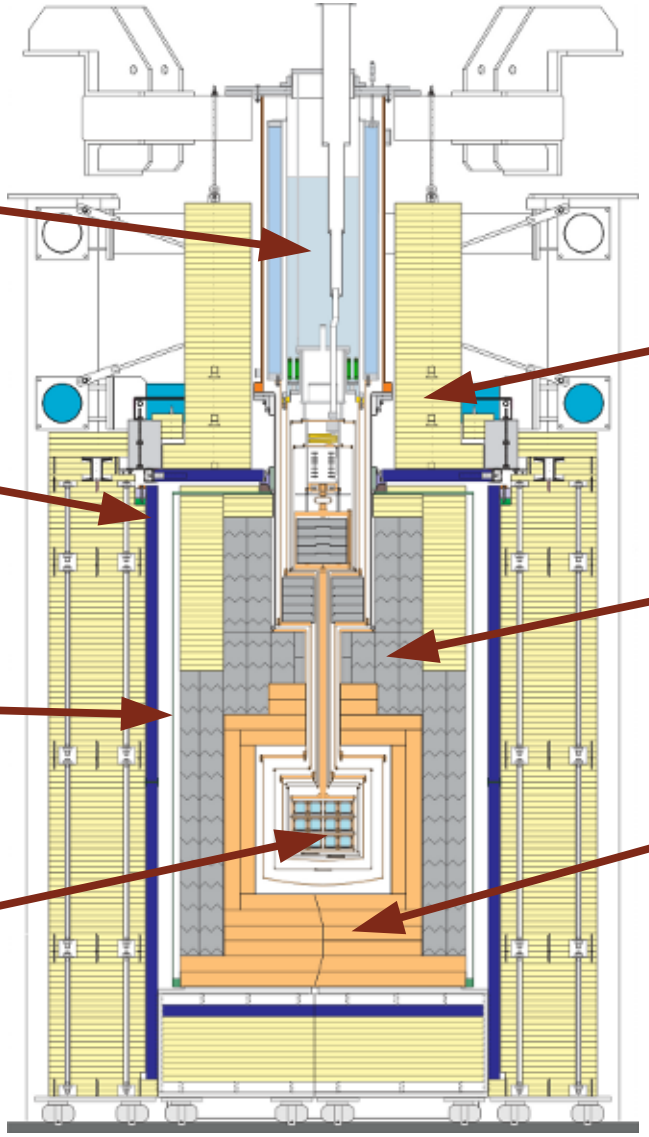
The CRESST-II Experiment

- direct dark matter search with cryogenic detectors
- target material: scintillating $CaWO_4$ crystals



- located in hall A of the LNGS
- up to 10 kg target mass

The CRESST-II Setup at LNGS



cryostat

muon veto

radon box

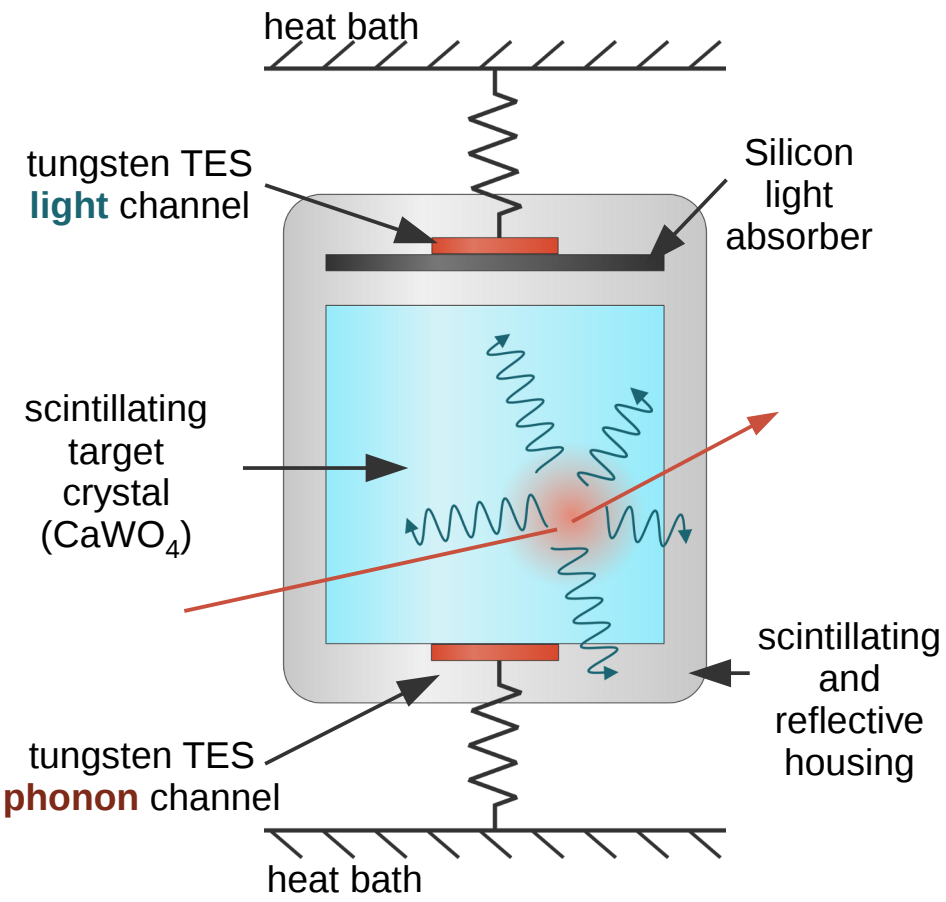
detectors

PE shielding
(45 cm)

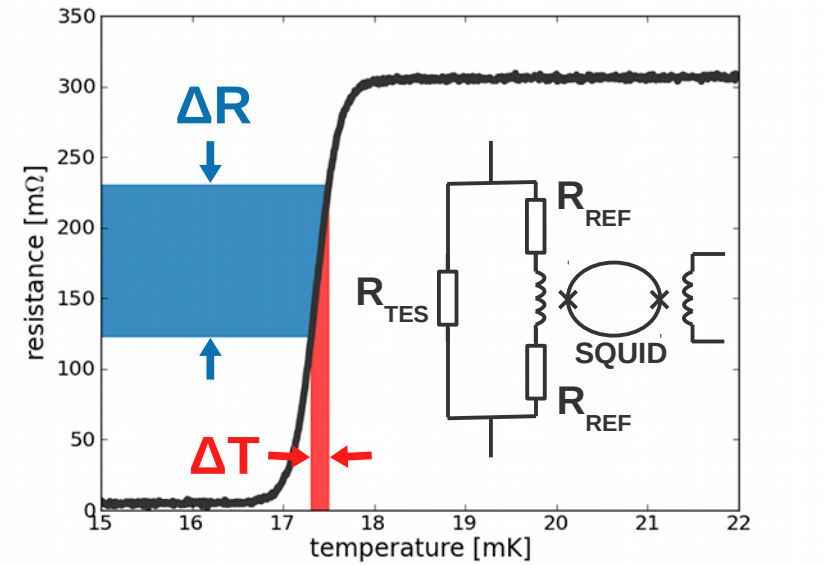
lead shielding
(20 cm)

copper shielding
(14 cm)

CRESST-II Detectors



Transition Edge Sensors (TES)



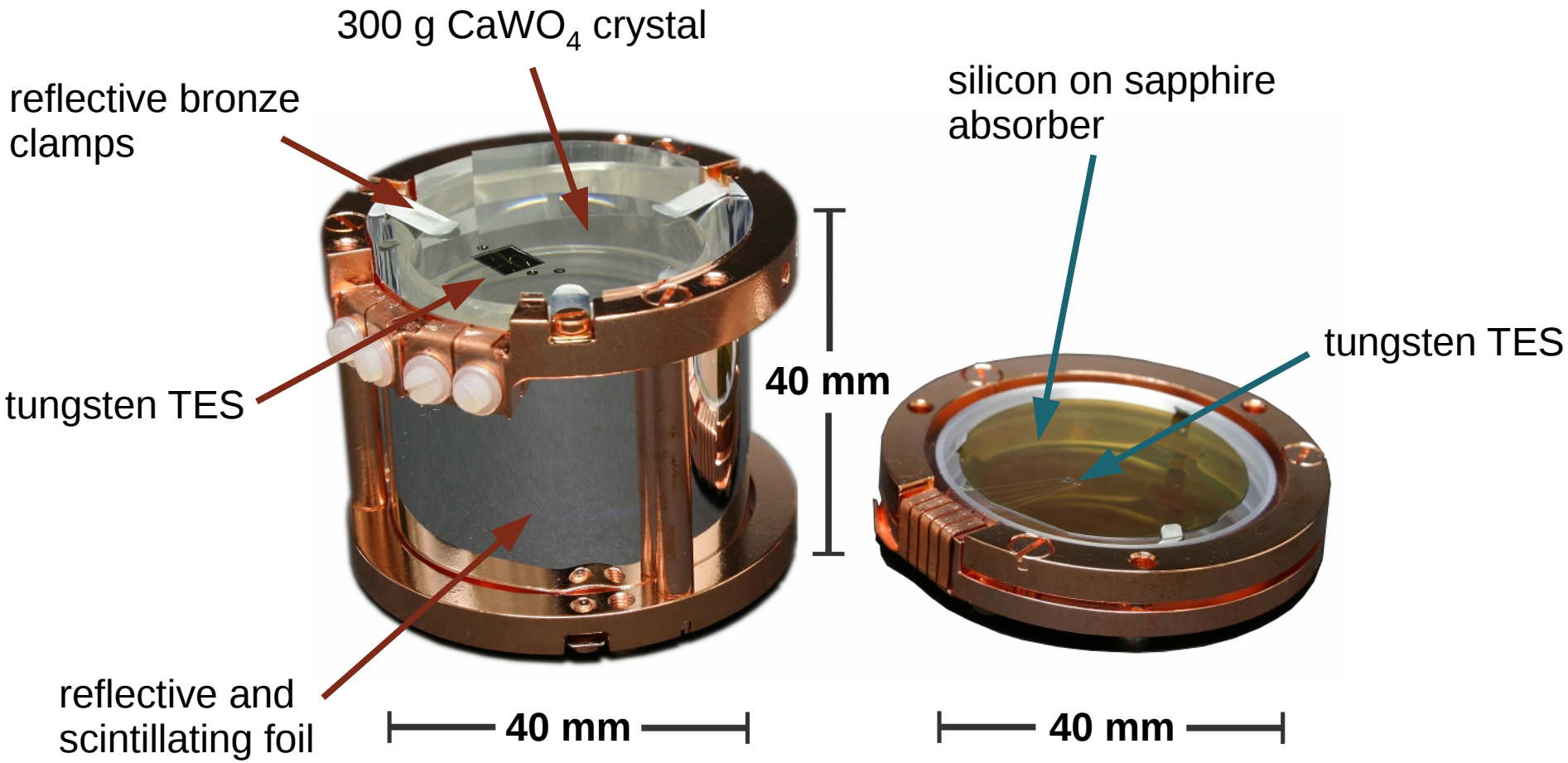
Advantages Of Our Detectors

- **precise calorimetric measurement** of deposited energy
- **low** energy **threshold** and **excellent** energy **resolution**
- possibility to use **different materials**

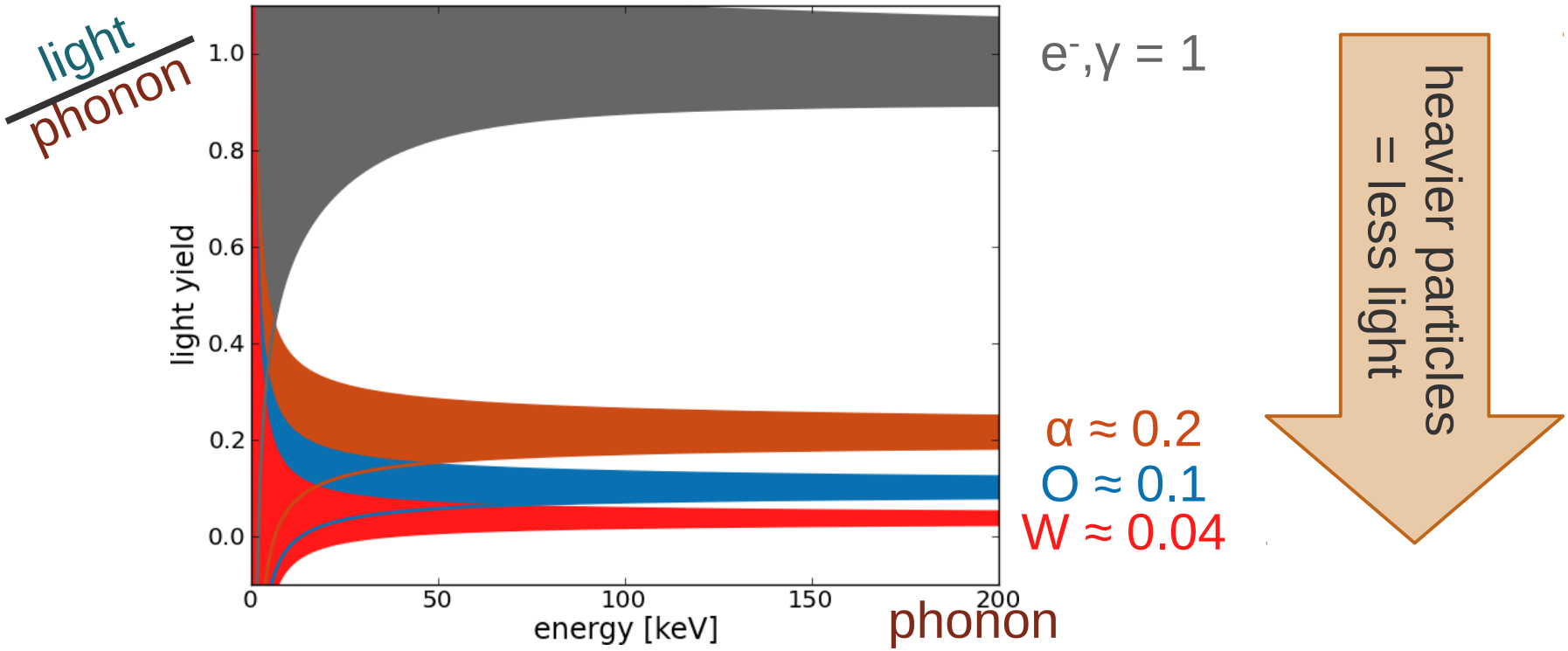
CRESST-II Detectors

Phonon Detector

Light Detector

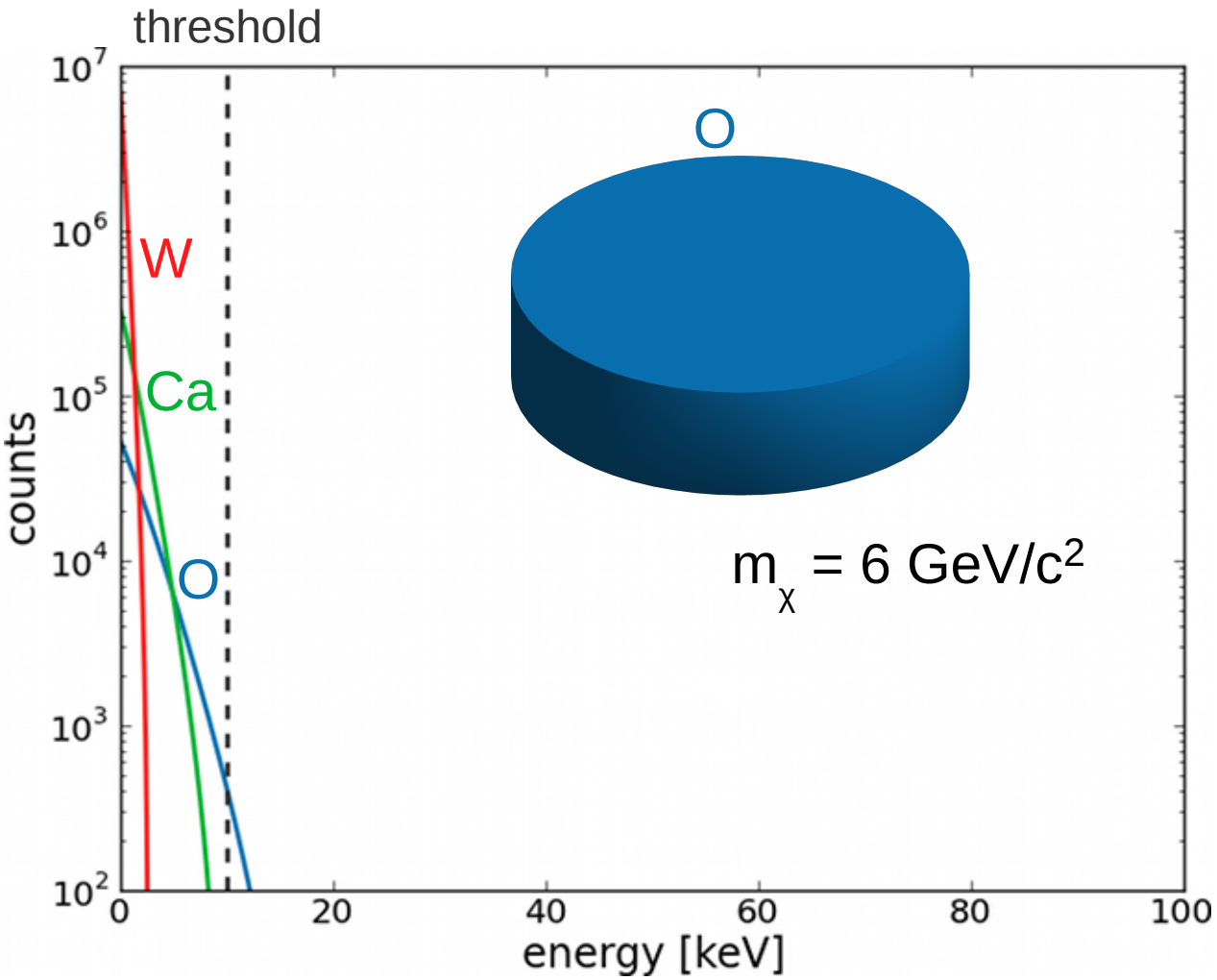


Discrimination Power

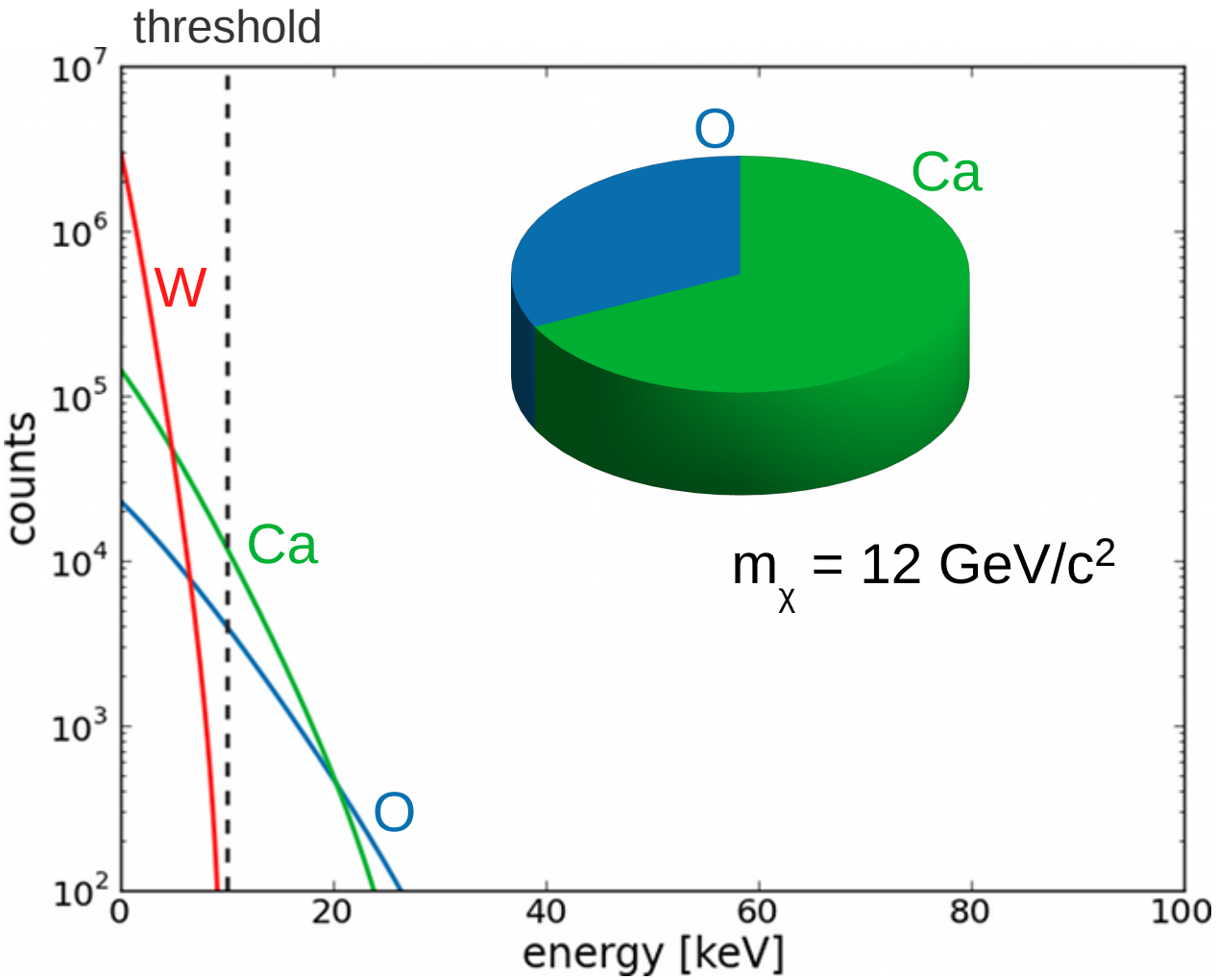


- excellent **event-by-event discrimination** of dominant background (e^-/γ) and signal (nuclear recoils)
- to some extent: **identification of recoiling nucleus**
  → probes WIMP interaction with **different targets simultaneously**
  → useful for **identification of backgrounds**

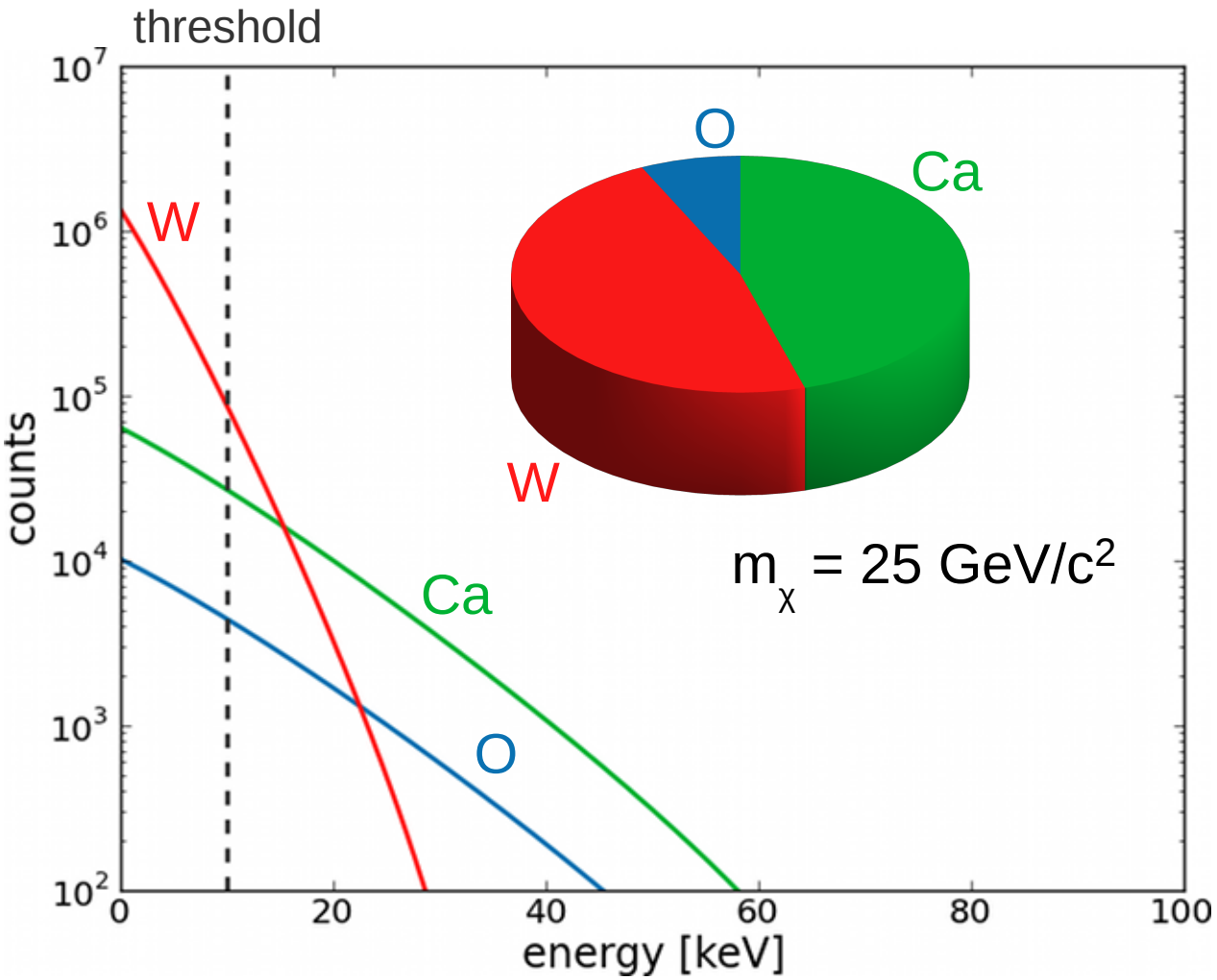
Scanning the WIMP Mass Range



Scanning the WIMP Mass Range



Scanning the WIMP Mass Range



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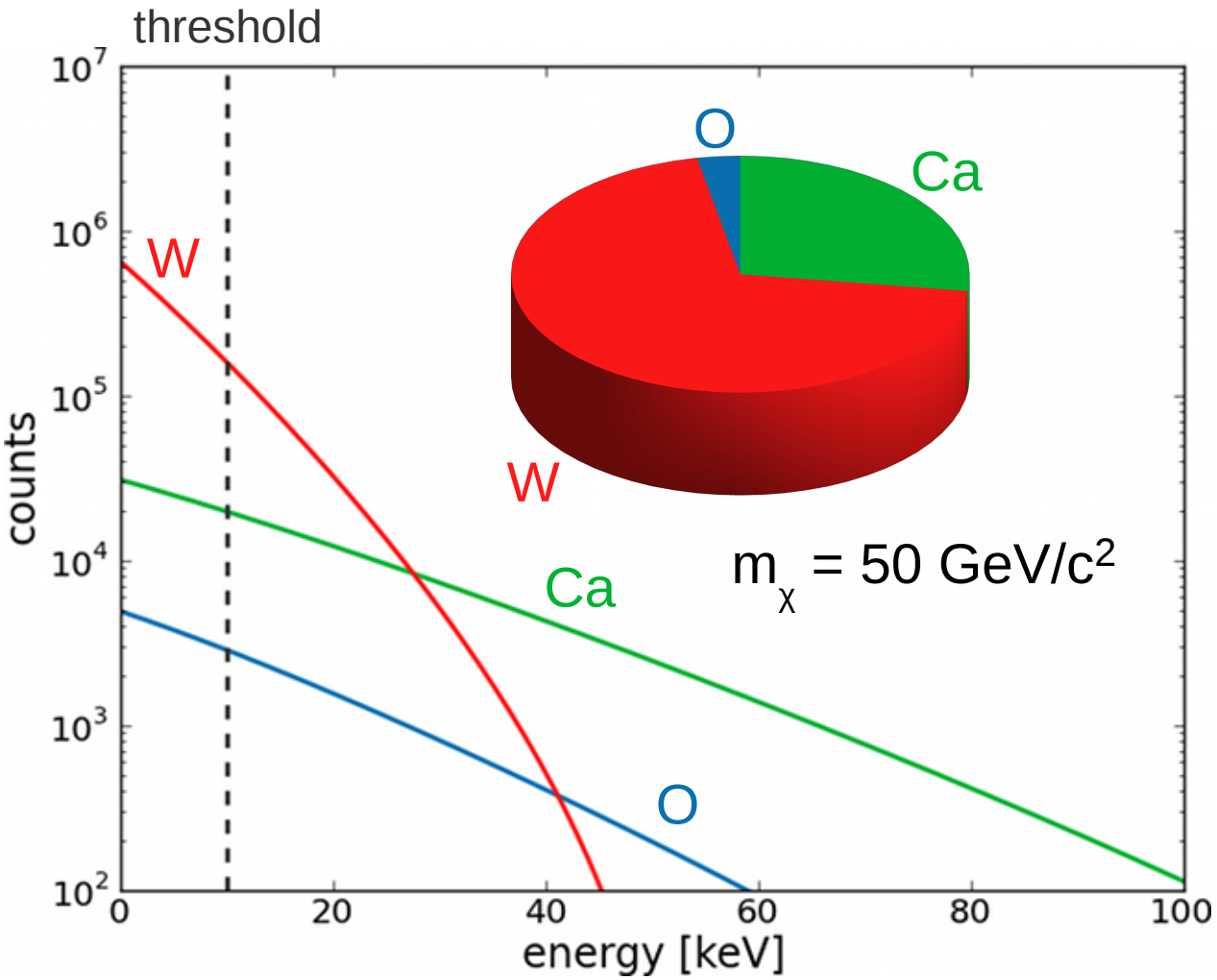

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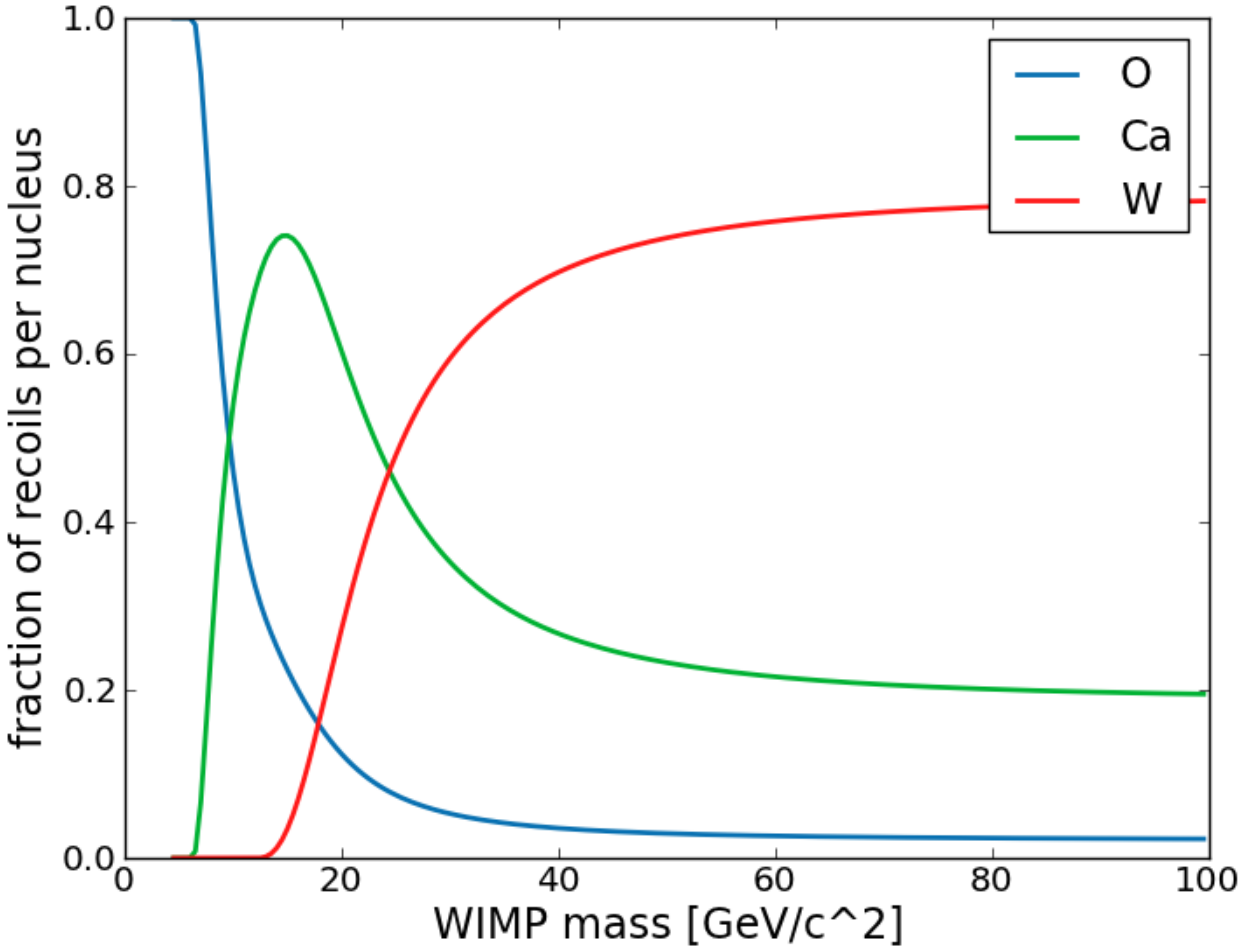


Latest Results

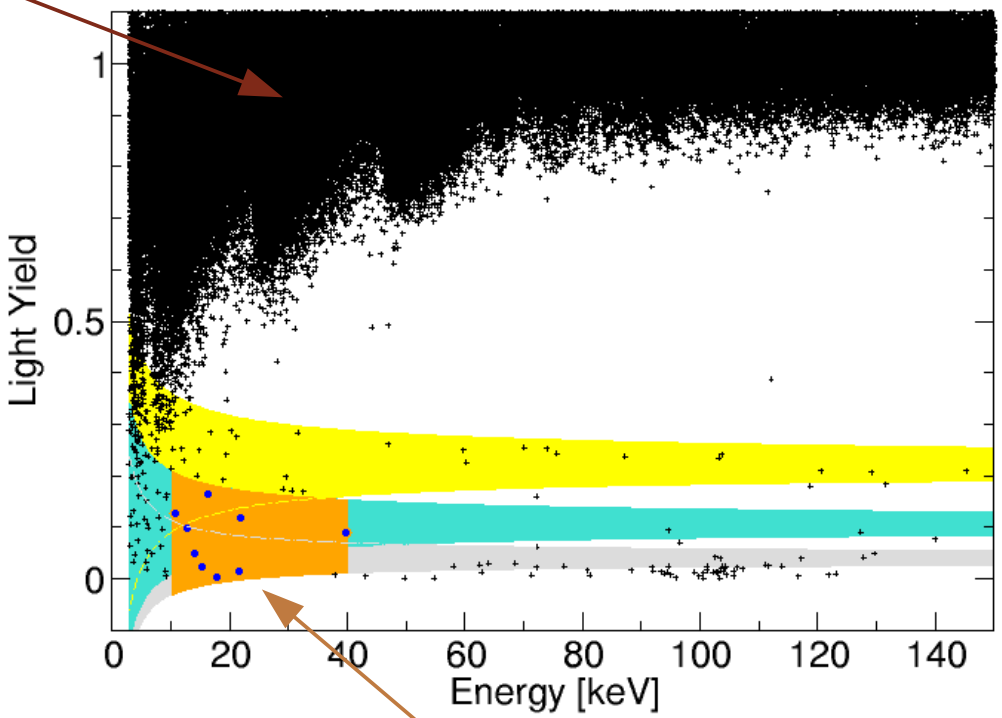
- extensive, successful physics run of CRESST-II (July 2009 – March 2011)
- **8 $CaWO_4$ modules** (300g each) used in analysis
- net exposure of **~730 kg days**
- **67 events** observed in acceptance region
- likelihood analysis considering all known backgrounds in

"Results from 730 kg days of the CRESST-II Dark Matter Search"
Eur. Phys. J. C (2012) 72-1971; arXiv: 1109.0702

Typical Detector Module - Backgrounds

γ / e^- background

- dominant background source
- ~10^4 events/kg/yr
- **excellent discrimination**
- **expected gamma leakage** of 1 event per module **defines lower threshold** of acceptance region

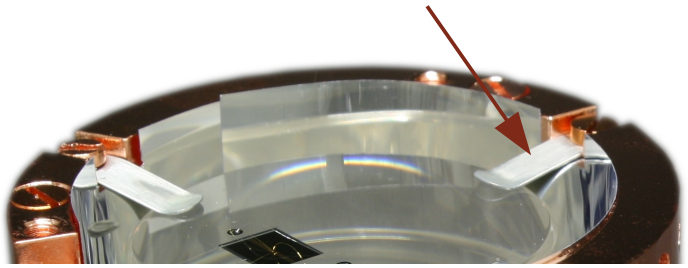


acceptance region:
O,Ca,W bands; ~10-40 keV

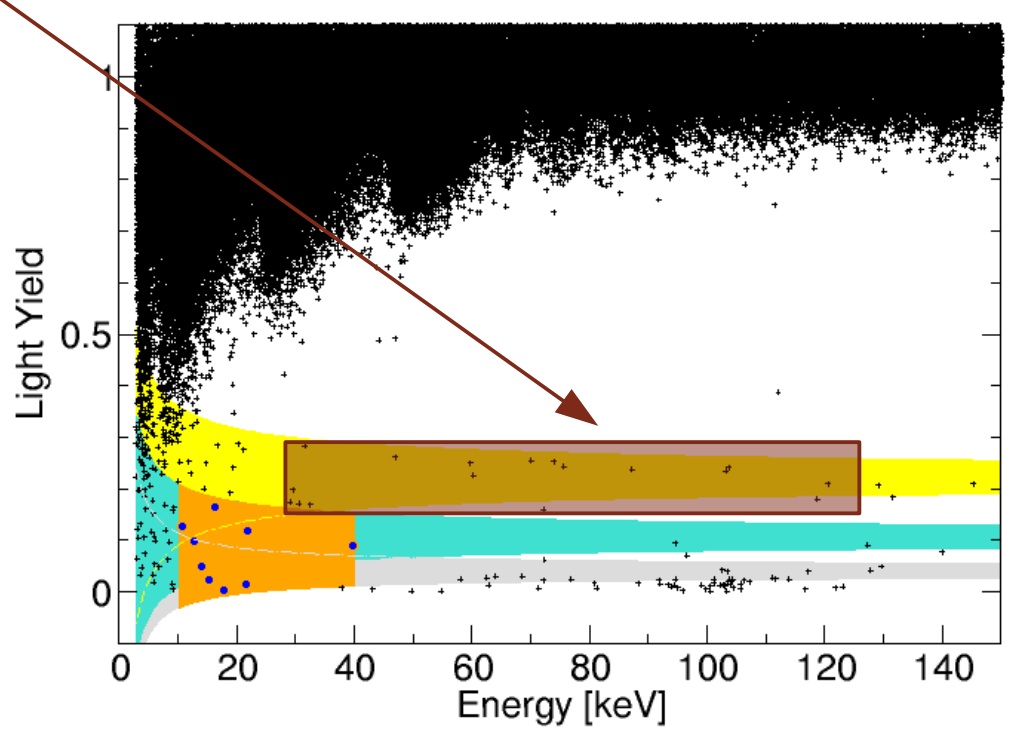
Typical Detector Module - Backgrounds

alpha background

- usually: discrete **alpha line** in **MeV** regime
- **alpha emitters** in clamps holding the crystals (e.g. ^{210}**Po**)



- **degraded alphas** down to keV
  - ➔ **overlap** with acceptance region

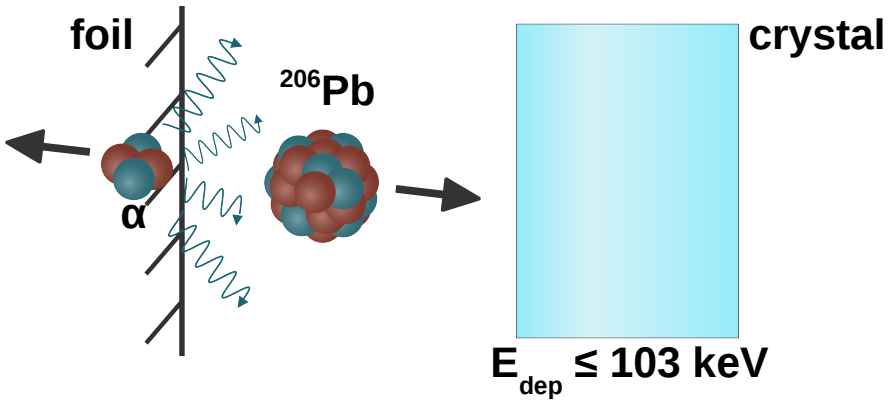


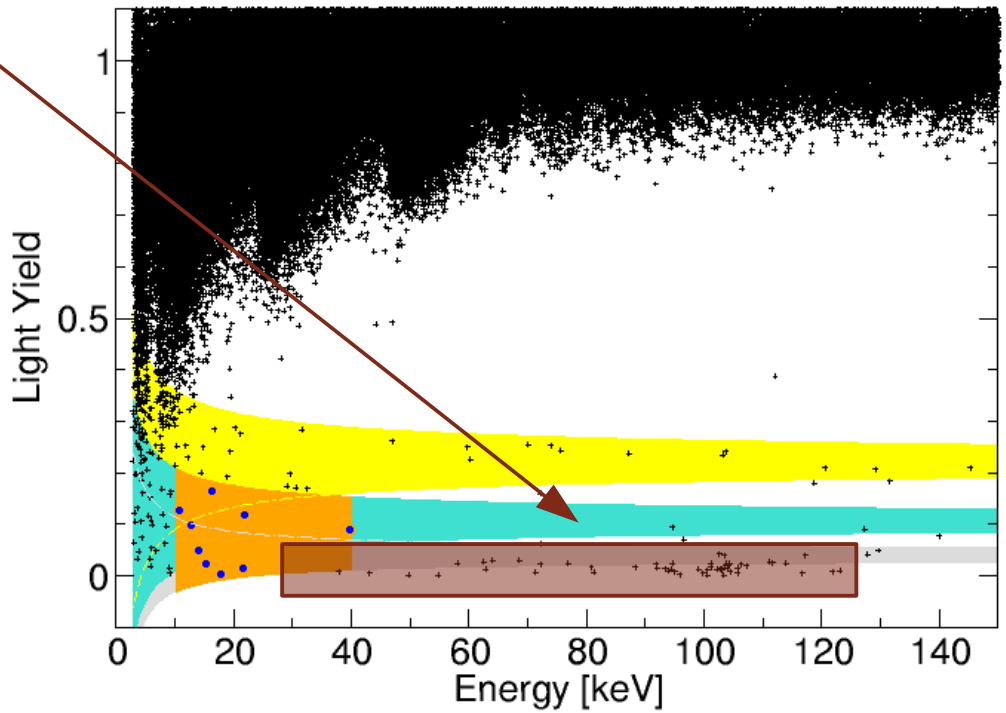
Typical Detector Module - Backgrounds

Pb recoil background

- **^{210}Po decay** on surface

^{210}Po → ^{206}Pb (103 keV) + α (5.3 MeV)





- if α hits **scintillating foil**:
  - light emission
  - event **can be identified** via signal in light detector

Typical Detector Module - Backgrounds

Pb recoil background

- **^{210}Po decay** on surface

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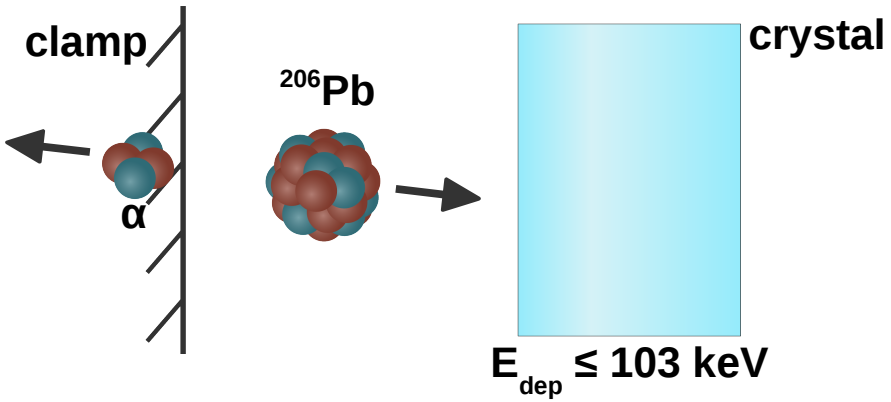
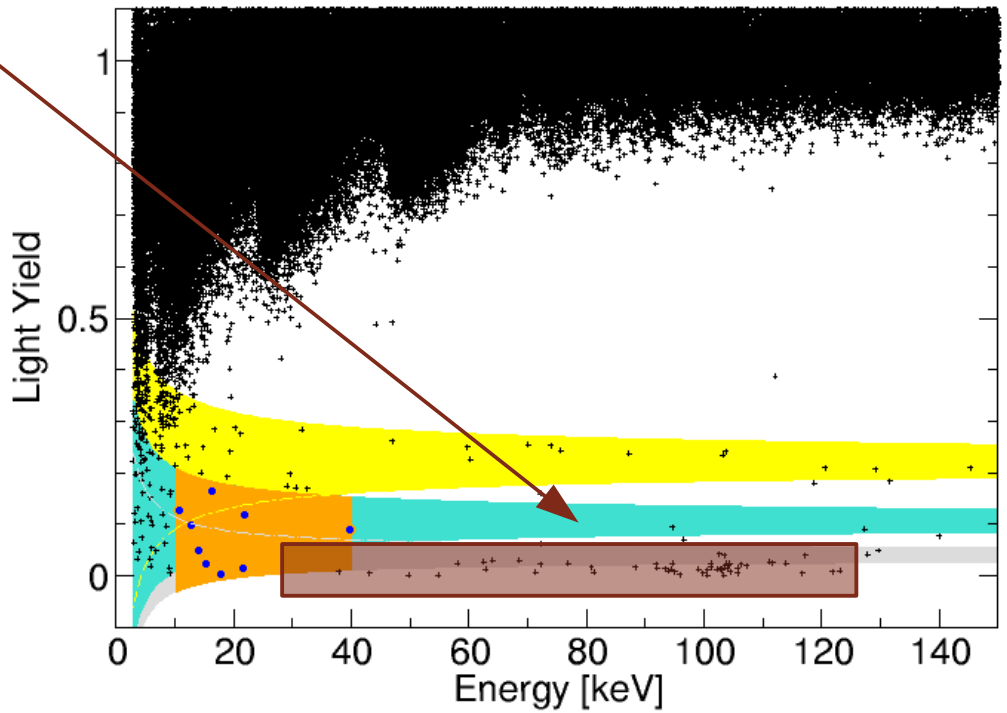


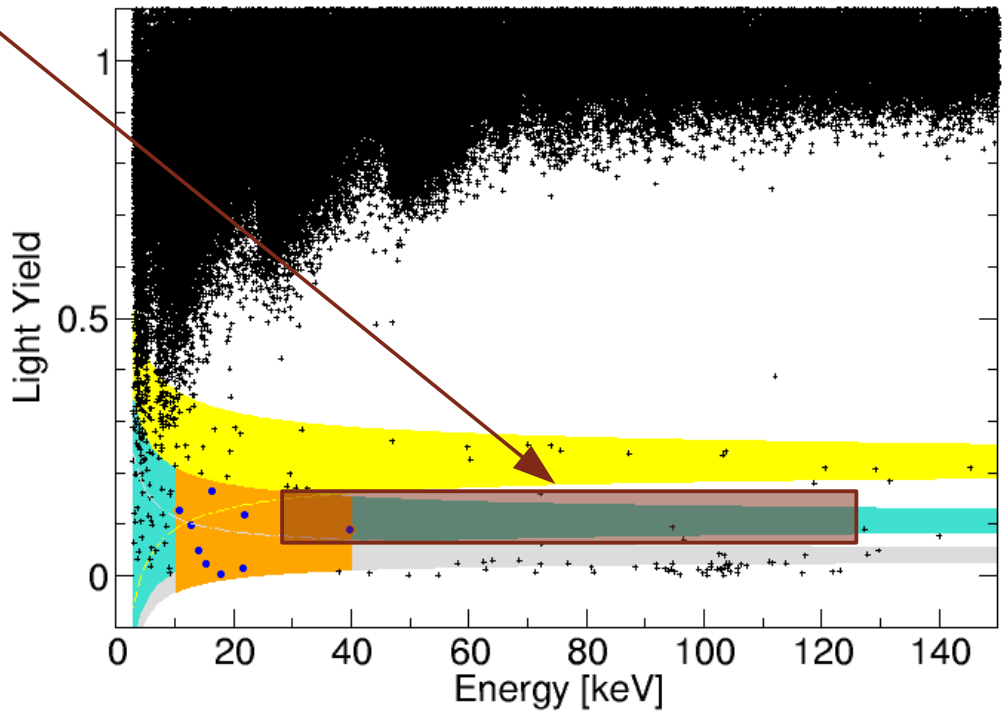


- if α hits **non-scintillating clamp**:
  - **no** light emission
  - **energy loss** in clamp leads to **leakage** into acceptance region

Typical Detector Module - Backgrounds

neutron background

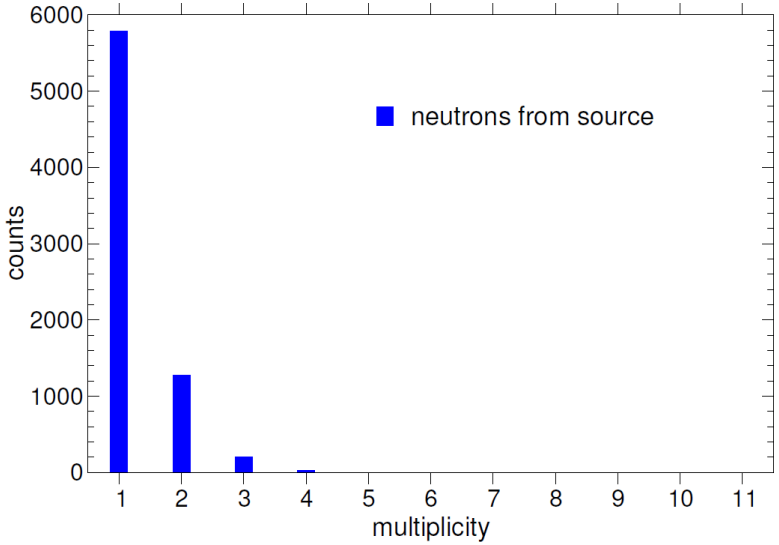
- neutrons mainly **scatter off oxygen**
- unlike WIMPs they have the chance to **scatter in multiple detectors**
- **3 events** with a signal in multiple detectors observed
- **measured** distribution of detector **multiplicities** is used to estimate neutron background



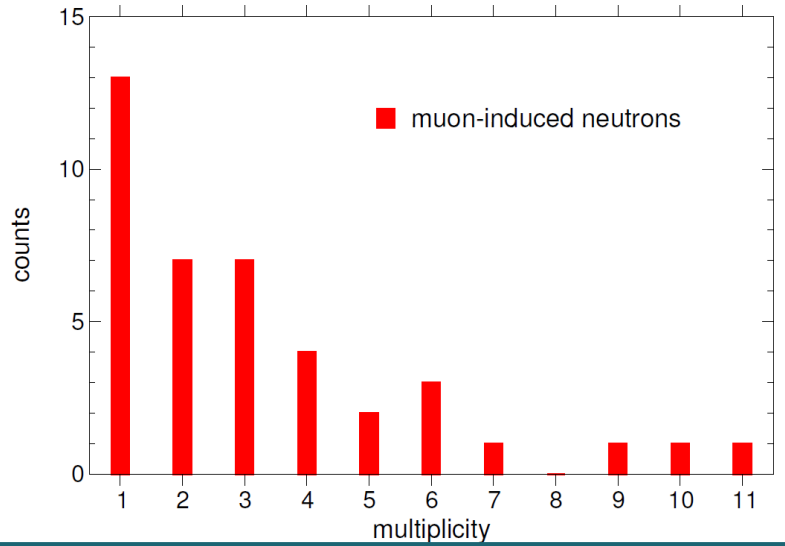
Estimation Of Neutron Background

there are **two classes of neutrons** exhibiting different multiplicity characteristics

neutrons from AmBe source



muon-coincident neutrons



3 multiple scatters observed in acceptance region (67 single events)

~ 11.4 single events expected

~ 1.5 single events expected

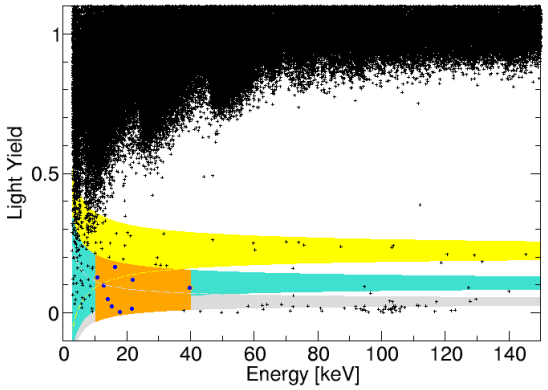
neutrons can only explain a fraction of the observed events

Results from Likelihood Analysis

- background-only hypothesis rejected with high statistical significance → **additional source of events needed**
- WIMPs would be a source with suitable properties → **two solutions** found depending on composition of recoil spectrum

	M1	M2
e^-/γ-events	8.00 ± 0.05	8.00 ± 0.05
α-events	$11.5^{+2.6}_{-2.3}$	$11.2^{+2.5}_{-2.3}$
neutron events	$7.5^{+6.3}_{-5.5}$	$9.7^{+6.1}_{-5.1}$
Pb recoils	$15.0^{+5.2}_{-5.1}$	$18.7^{+4.9}_{-4.7}$
signal events	$29.4^{+8.6}_{-7.7}$	$24.2^{+8.1}_{-7.2}$
m_χ [GeV]	25.3	11.6
σ_{WN} [pb]	$1.6 \cdot 10^{-6}$	$3.7 \cdot 10^{-5}$
stat. significance	4.7 σ	4.2 σ

2D Spectral Distribution of Observed Events



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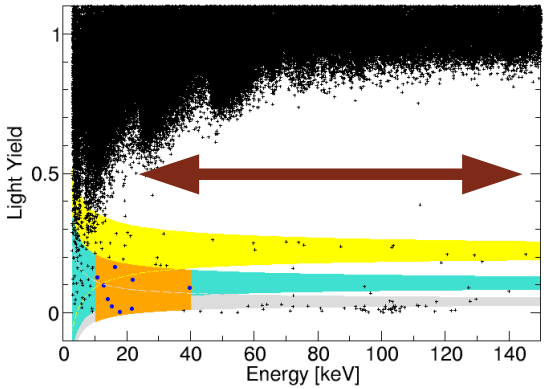
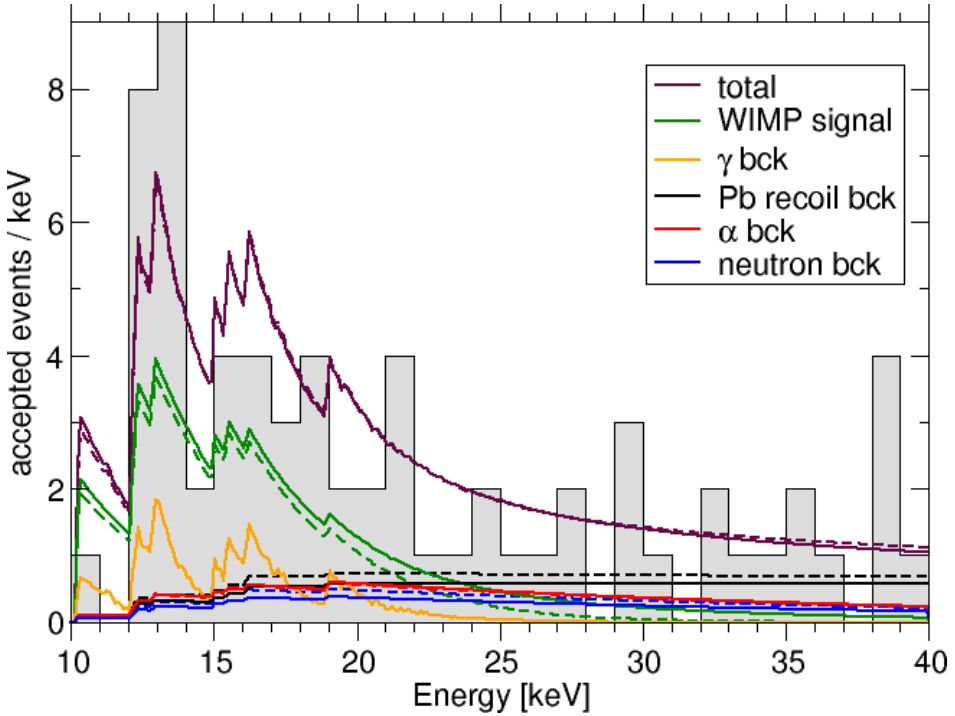


energy spectrum



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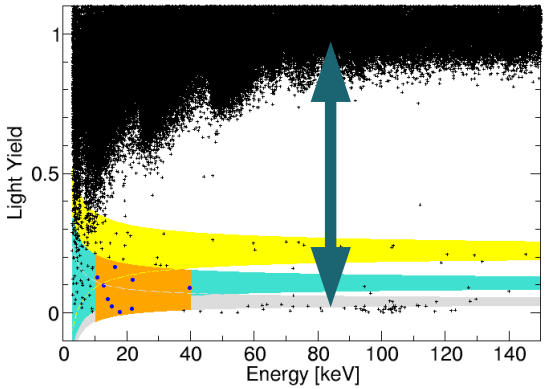
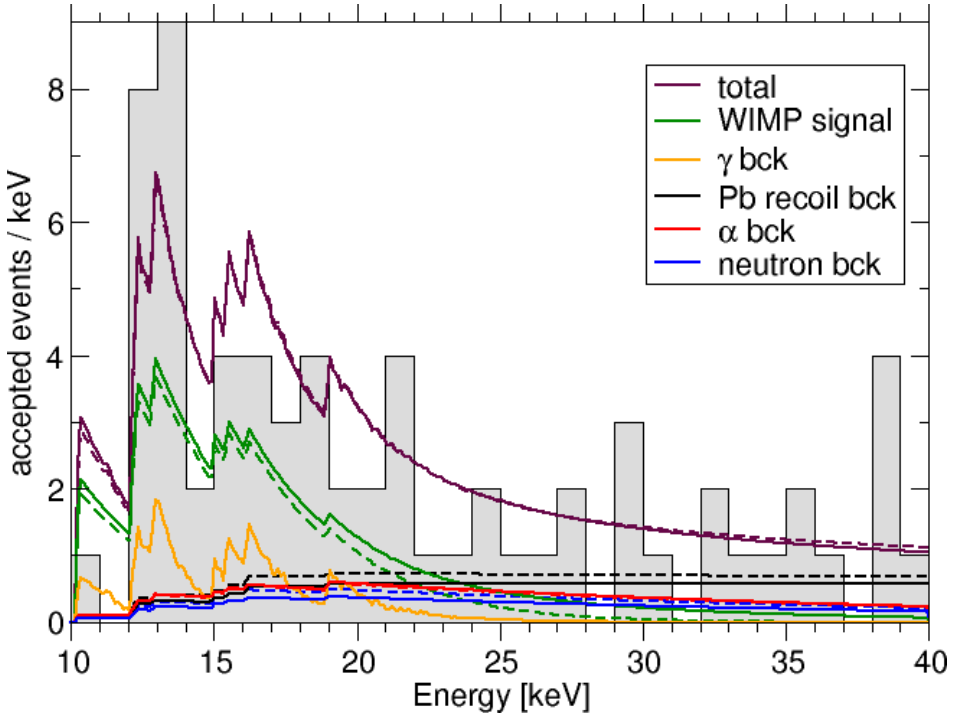
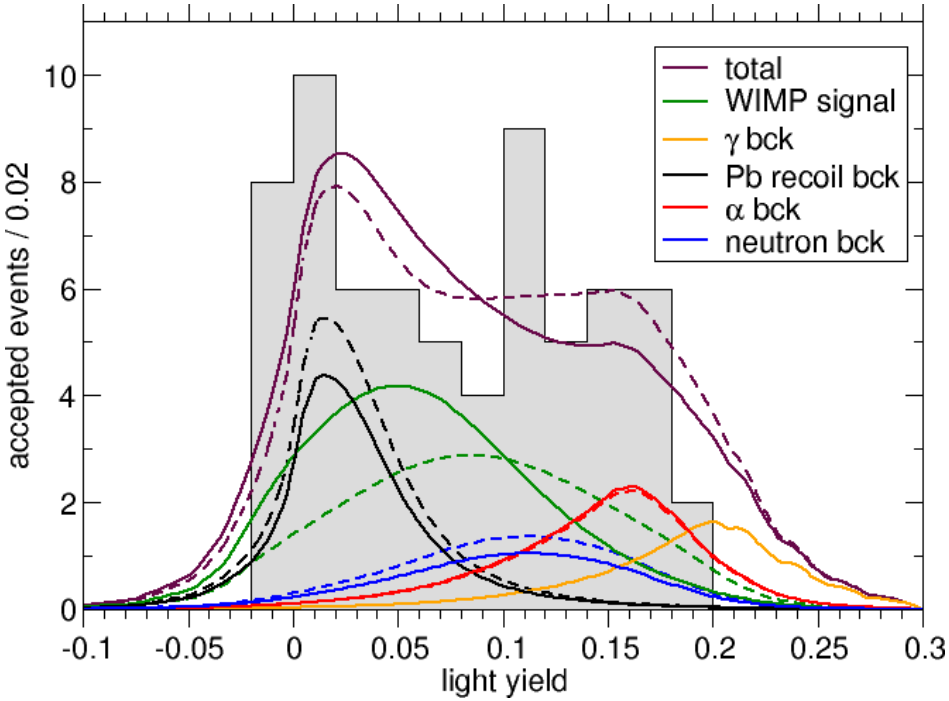


energy spectrum



light yield distribution



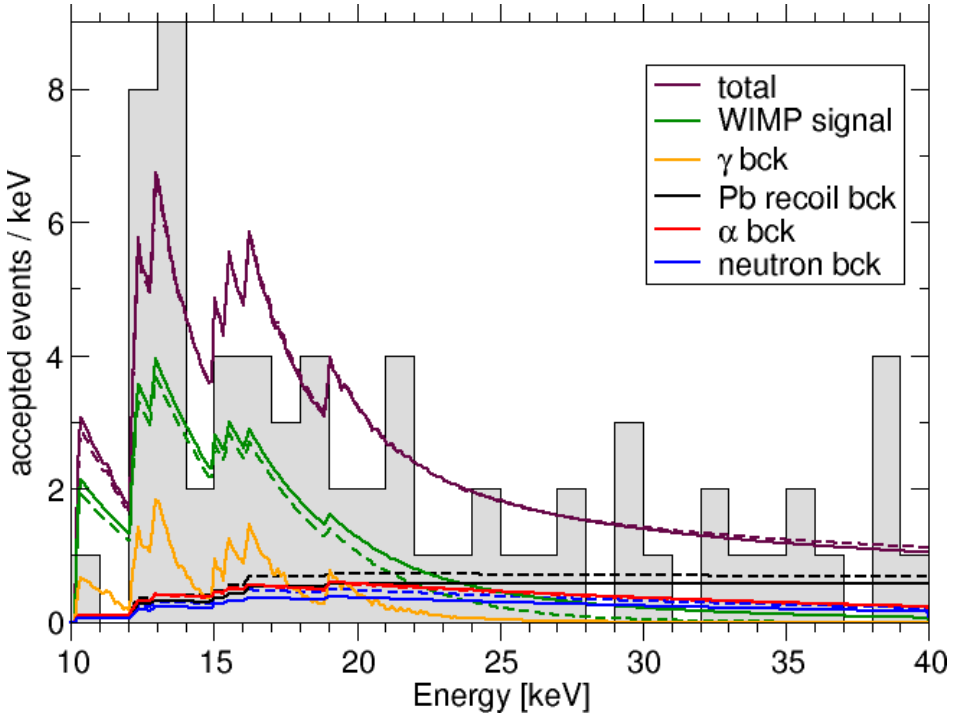
2D Spectral Distribution of Observed Events

only γ-leakage can explain shape of energy spectrum

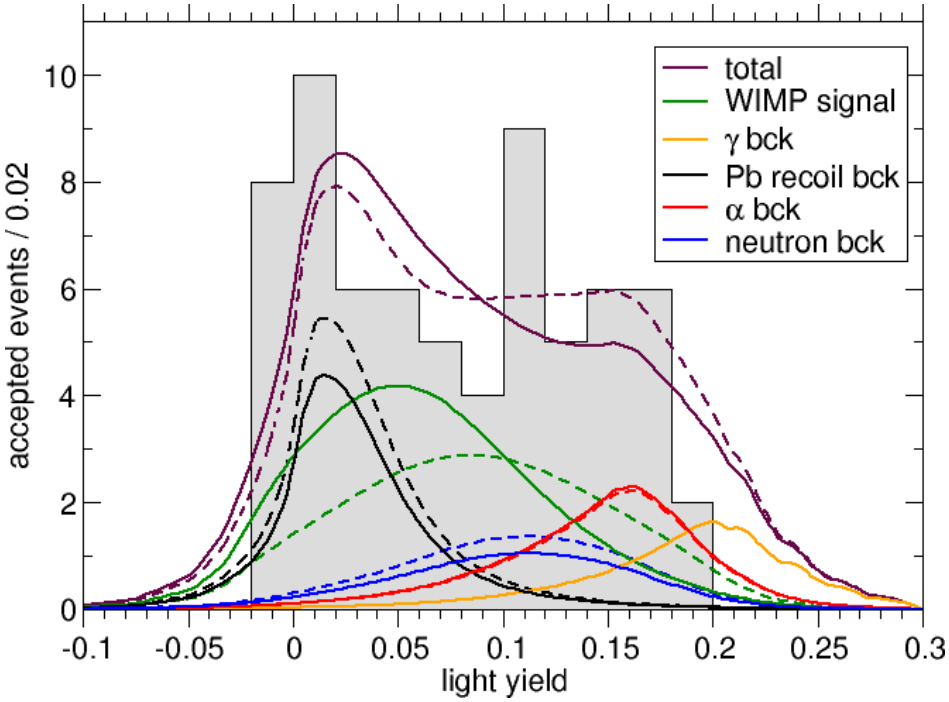
but

light yield of γ-leakage is too high

energy spectrum



light yield distribution



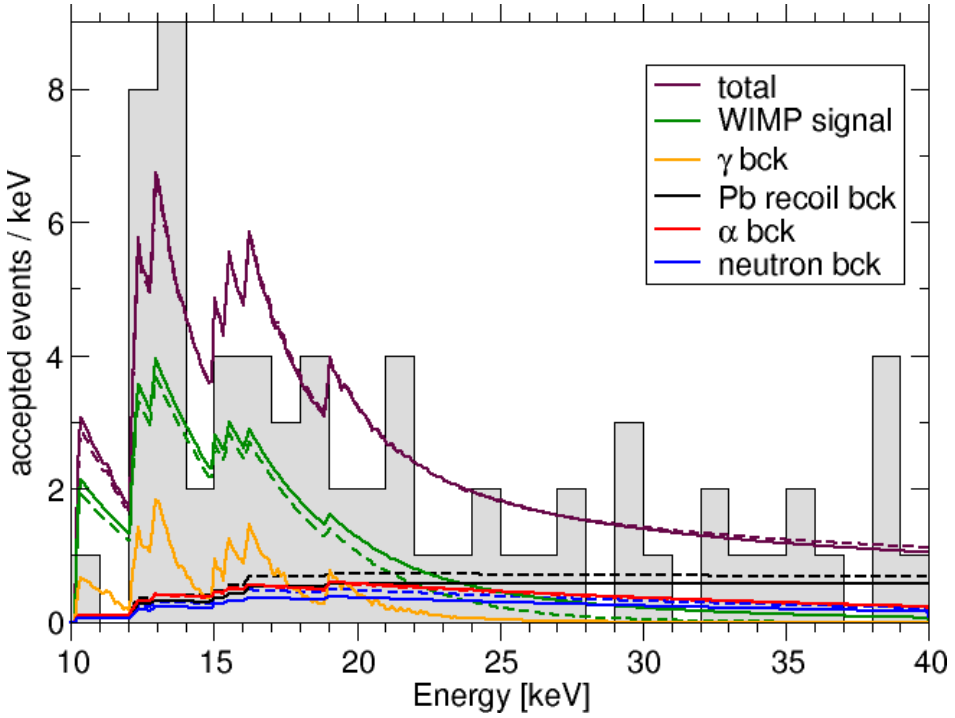
2D Spectral Distribution of Observed Events

energy spectrum of Pb recoils has the wrong shape

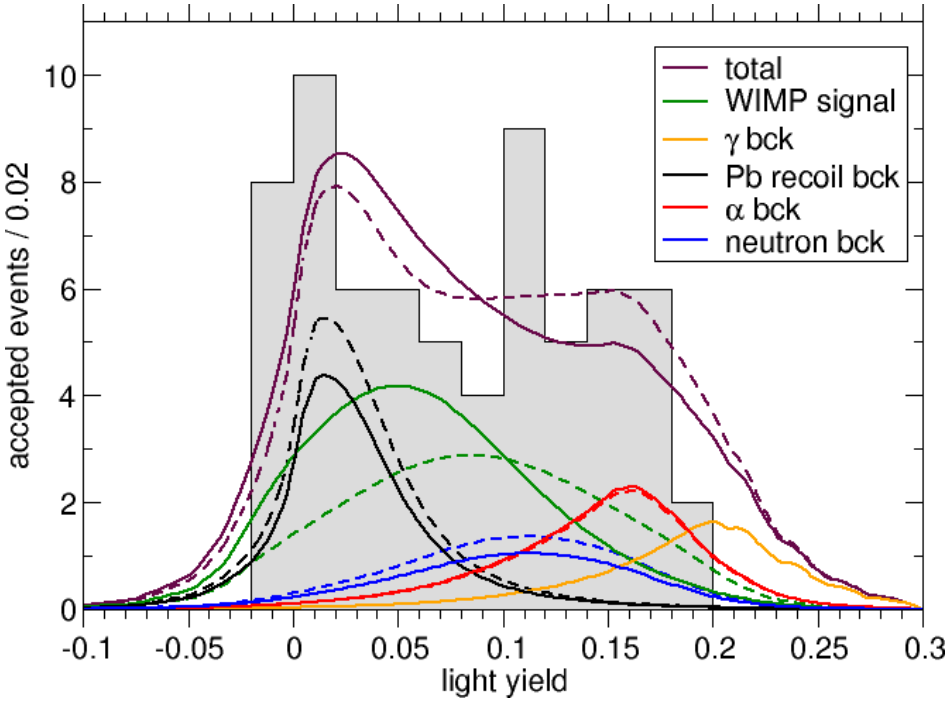
but

only Pb recoil background can explain low light yield events

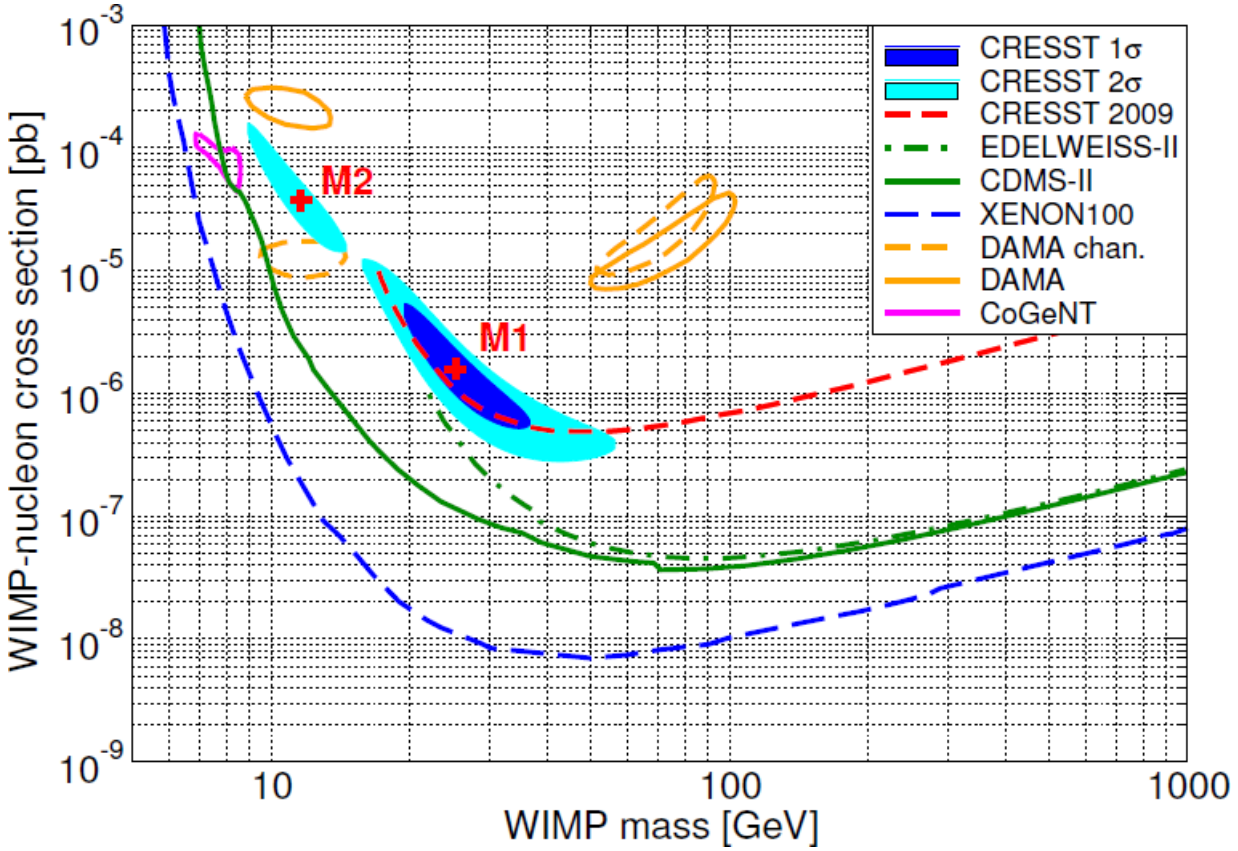
energy spectrum



light yield distribution



Results from Likelihood Analysis



strong tension with other experiments and large background contributions

➡ for clarification: **background reduction** needed

Next Run ...

highest priority:
reduction of α and Pb recoil background

- new material for clamps
  → more radio-pure
- reduce radon exposure during mounting
- fully scintillating modules to identify recoil background events

Summary/Conclusion

- succesful physics run over two years
- **67 events observed** in acceptance region
- **multimaterial target** has proven to be valuable for identification of backgrounds
- unclear situation: light WIMPs or background?
- preparations for next run are ongoing
  → **reduction of backgrounds** of highest priority

Thank You.