Composite Detectors for the CRESST-II Experiment

Michael Kiefer

Max-Planck-Institut für Physik, München

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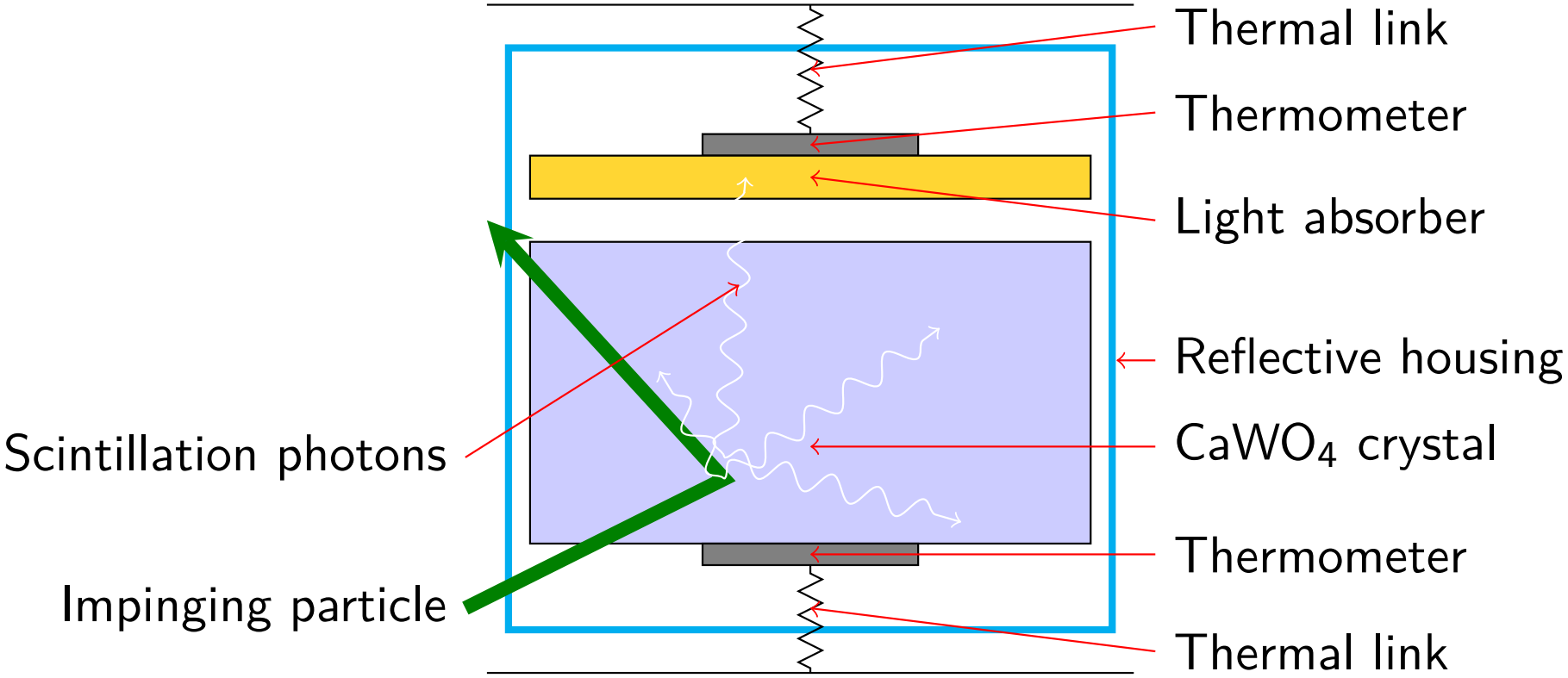
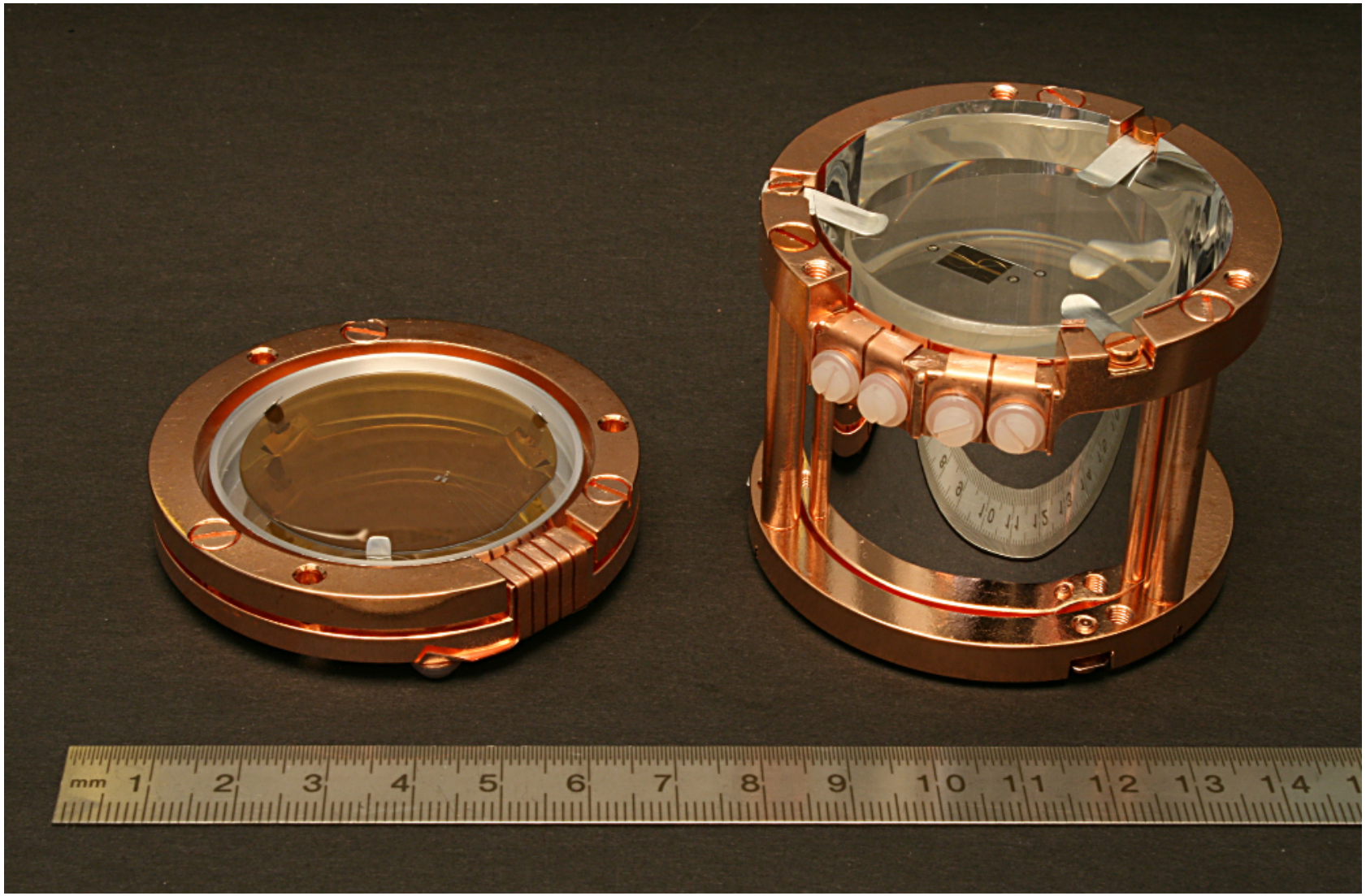
Dark Matter Search with CRESST-II

- Direct search for WIMPs
- Elastic scattering on nuclei
- Cryogenic experiment
- Calorimeters with superconducting thermometers

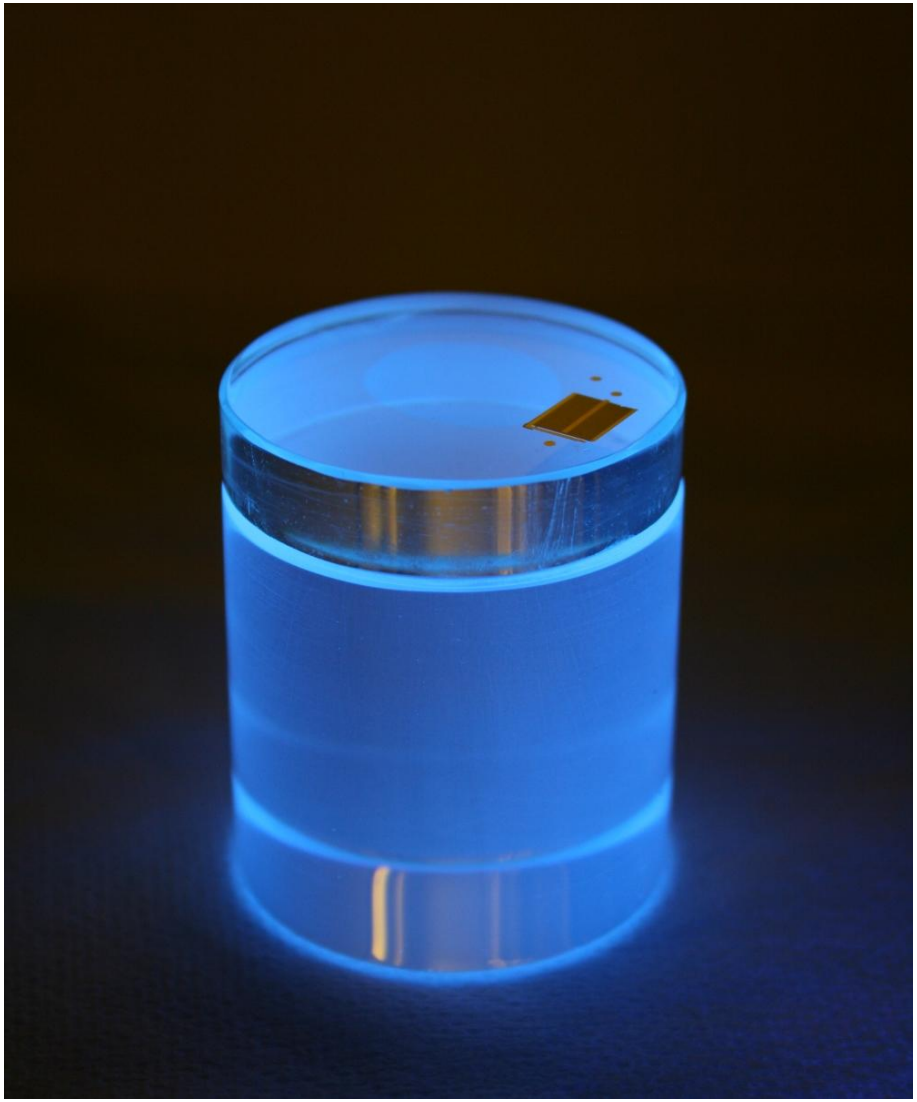
Detector module: schematic



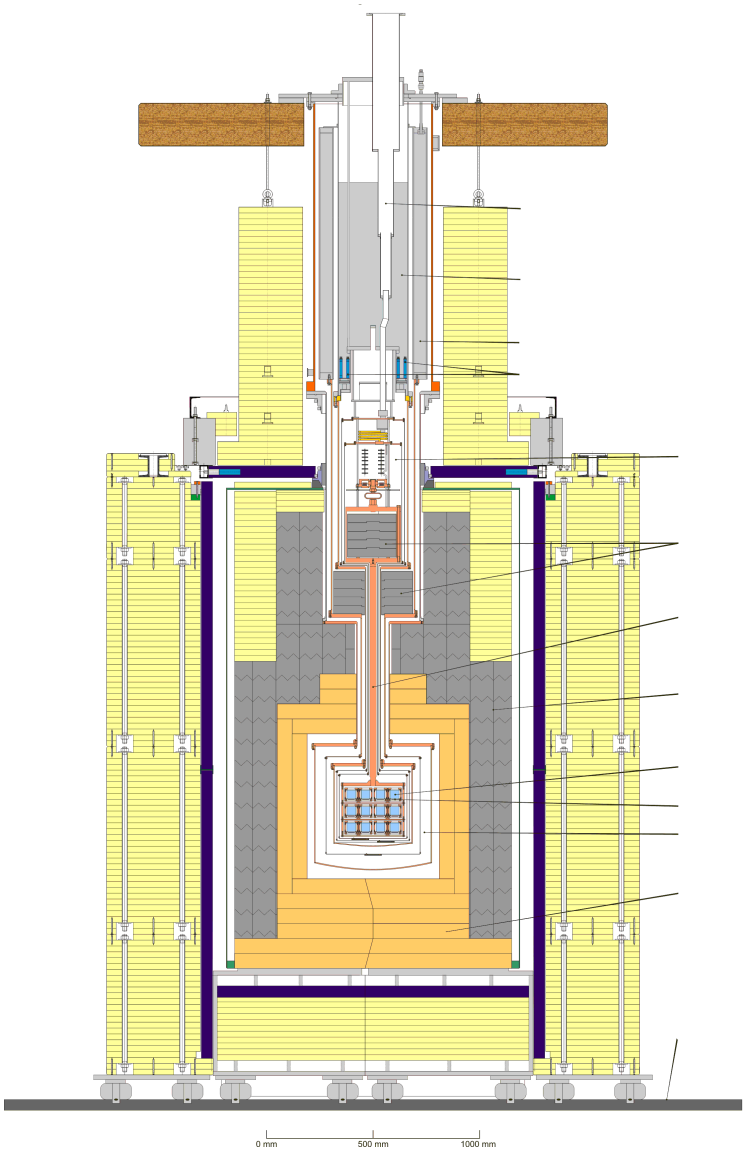
Detector module: picture



Scintillation in UV light

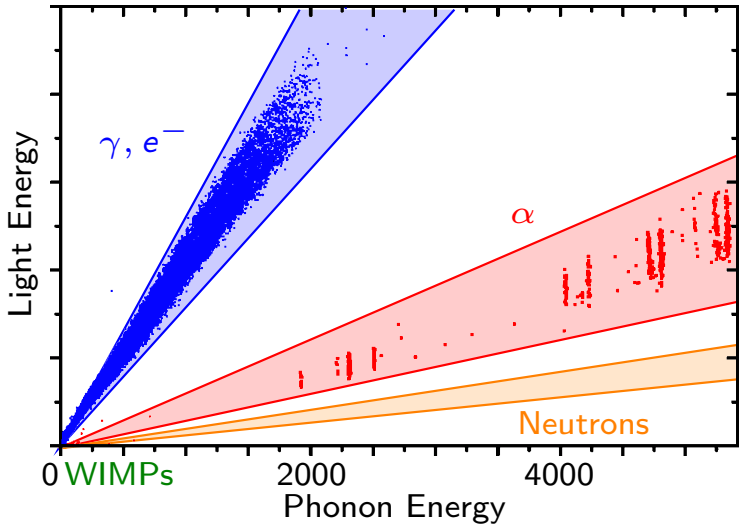


Shielding against Background



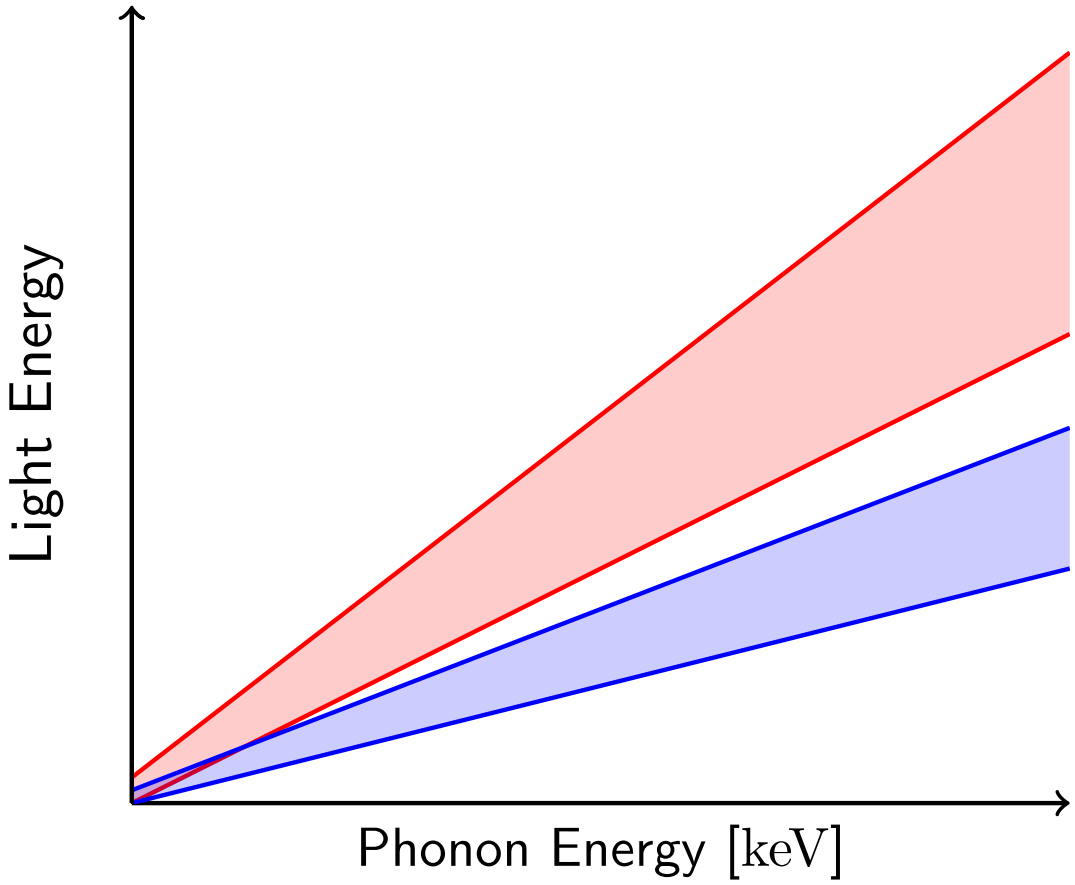
- Background $\gg$ expected Signal
- Underground lab + μ-Veto
- Shields + Radon box

Active Background Discrimination

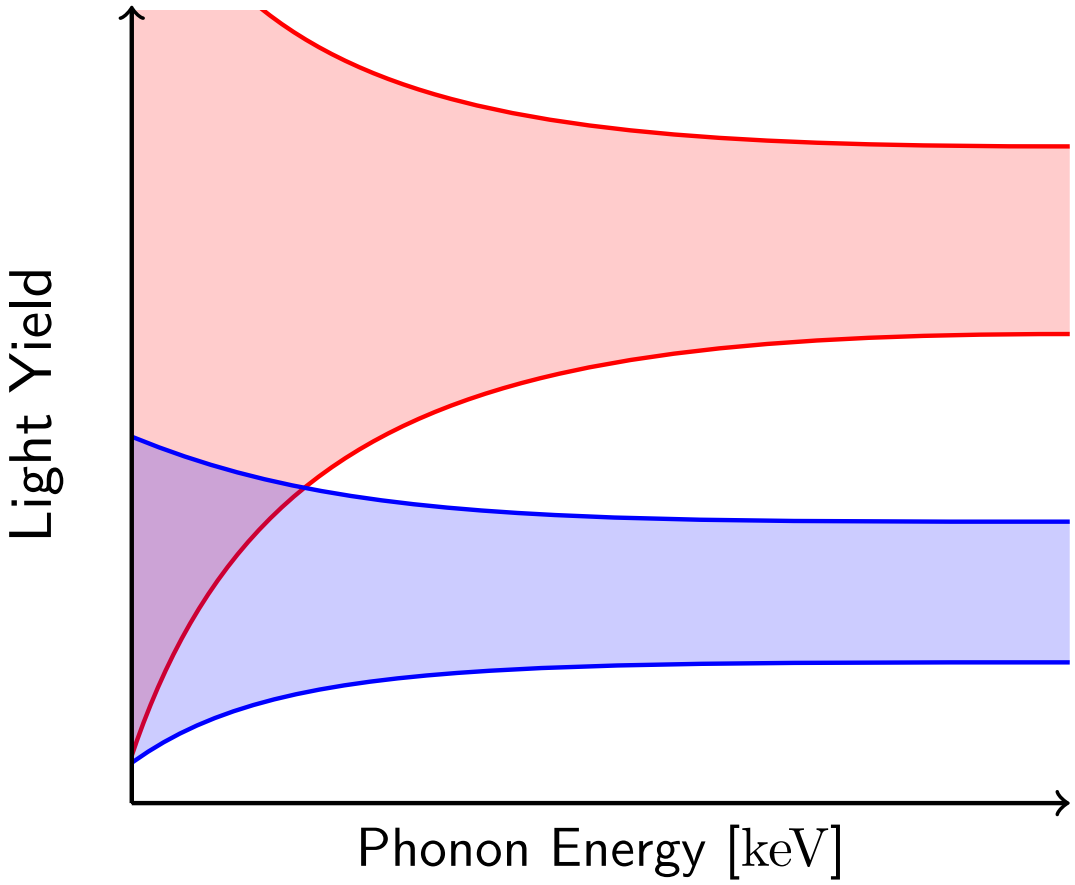


- Two readout channels
- Phonons give energy
- Light used for identification

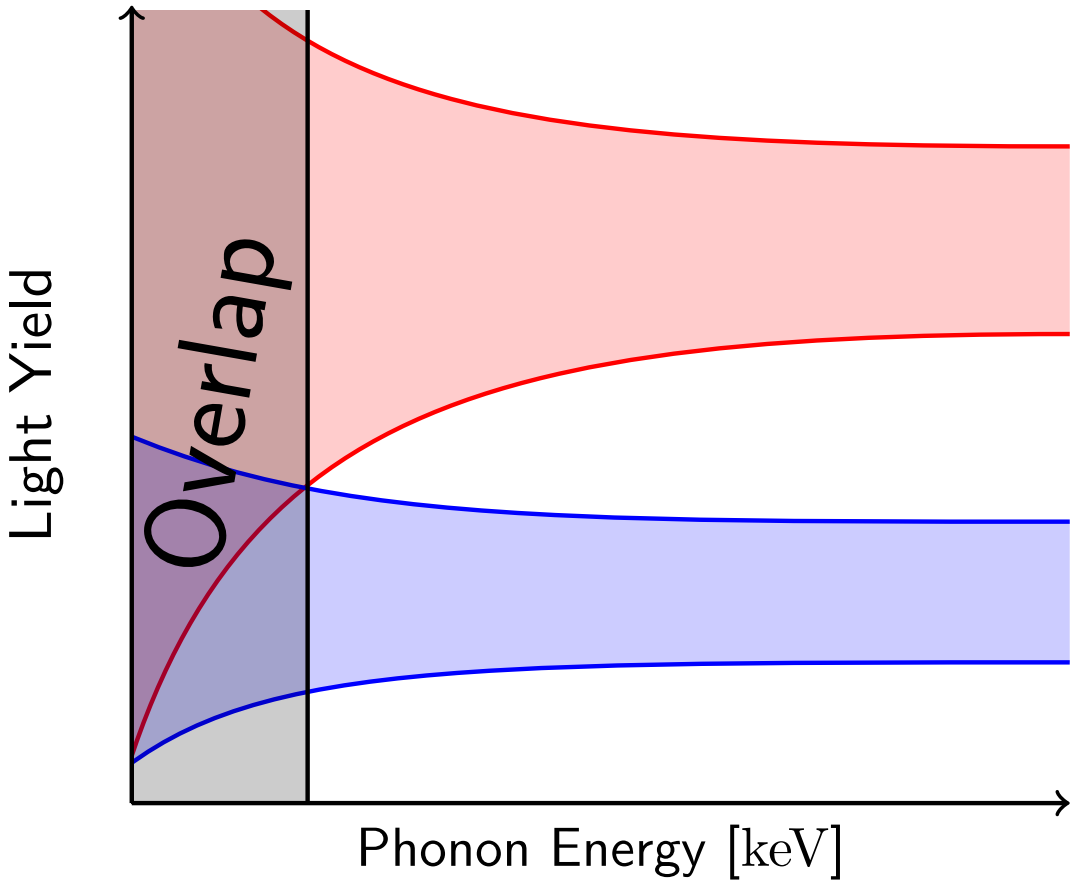
Band Separation



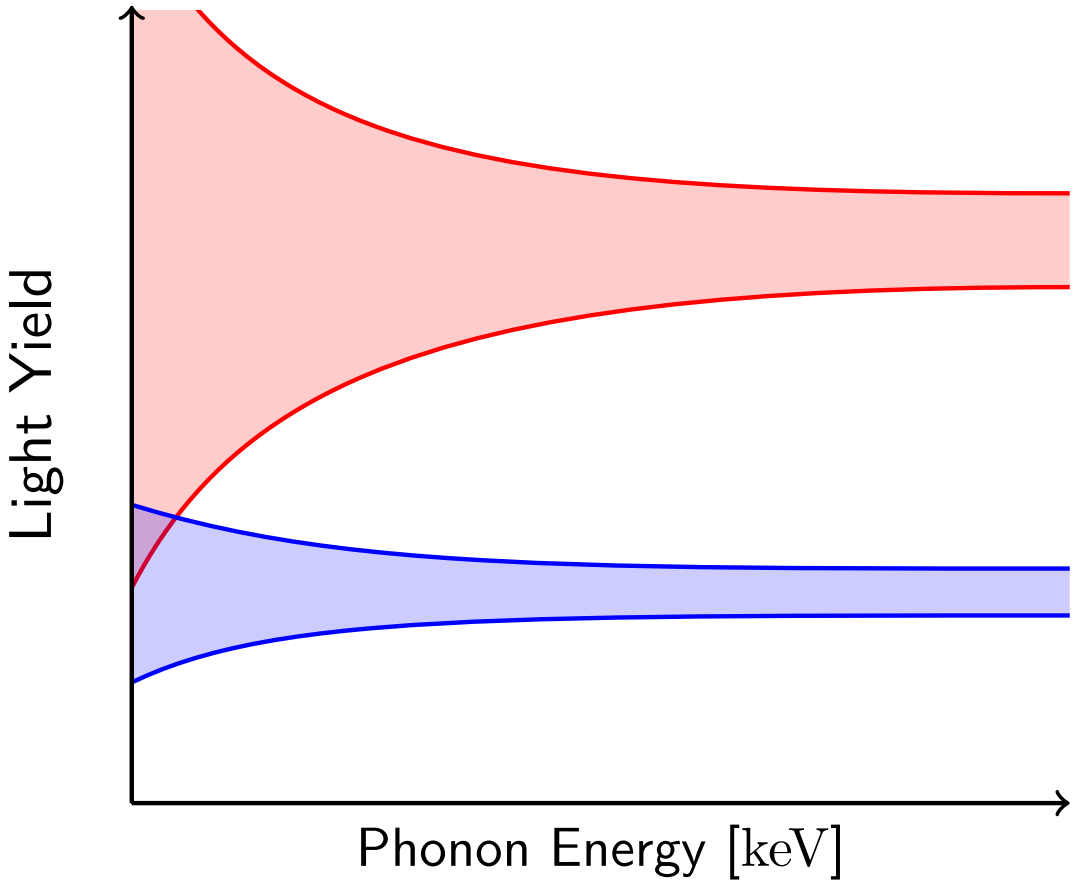
Band Separation



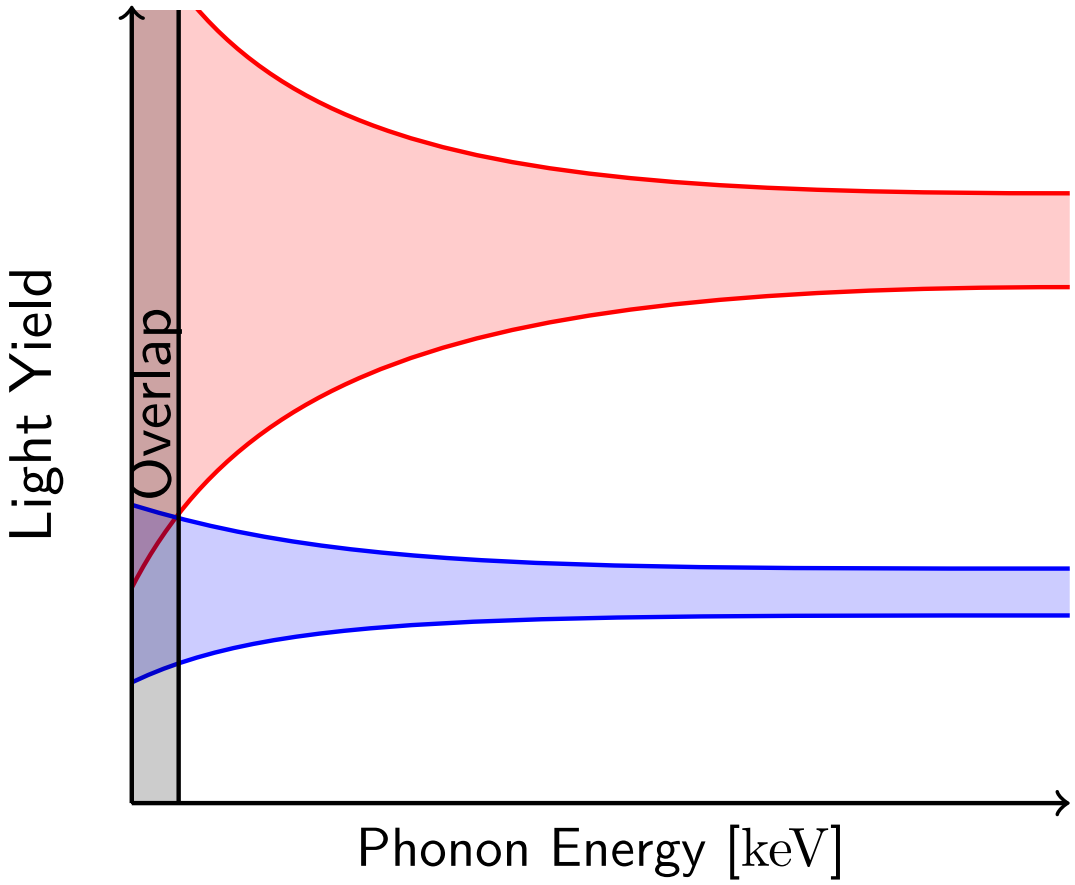
Band Separation



Band Separation



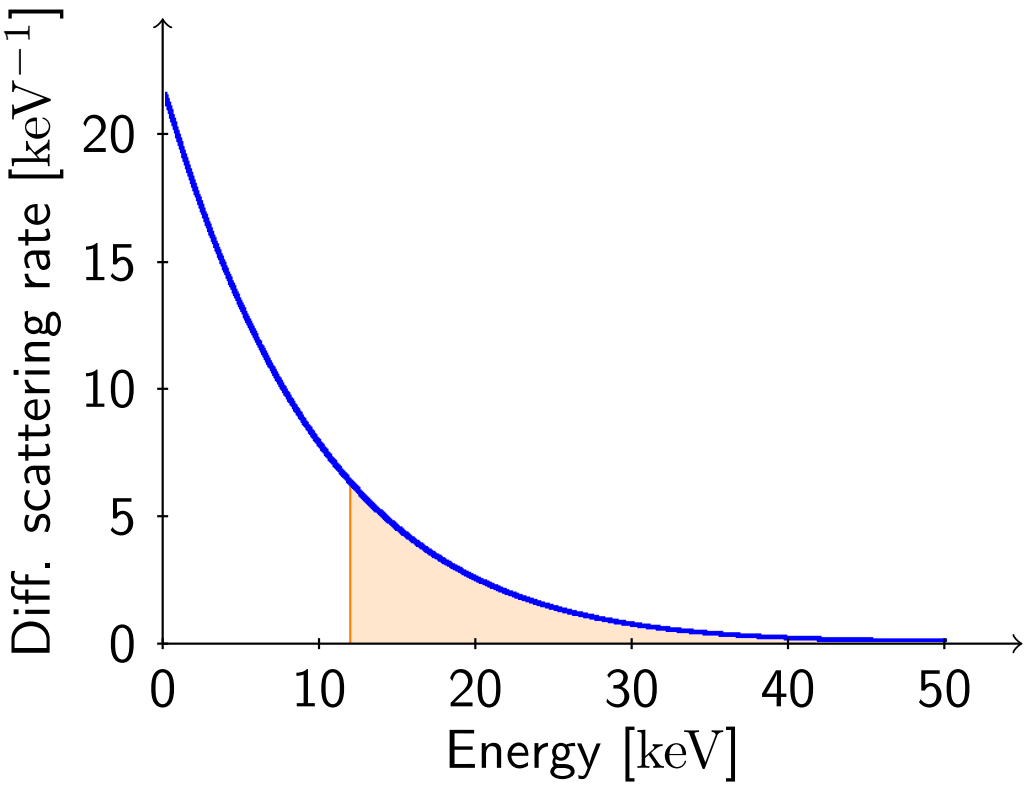
Band Separation



Consequence:

Additional light significantly lowers discrimination threshold

100 GeV WIMPs with $\sigma = 10^{-18}\,\mathrm{b}$ on $1\,\mathrm{kg}$ $CaWO_4$ for 1 yr



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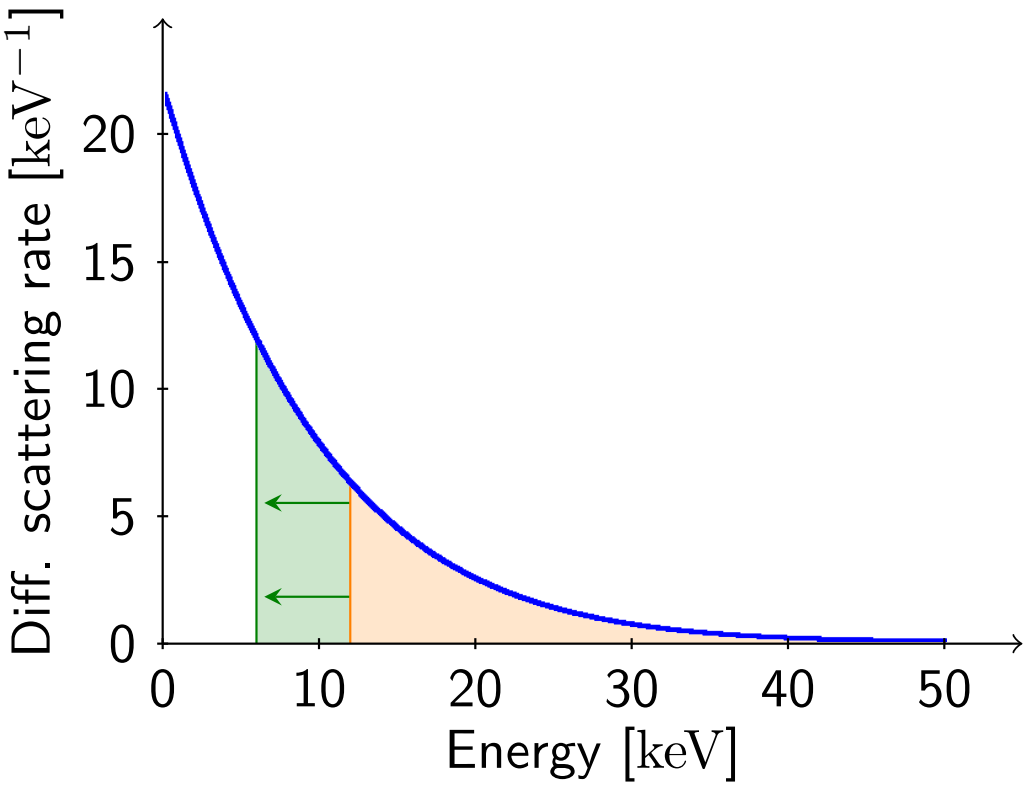
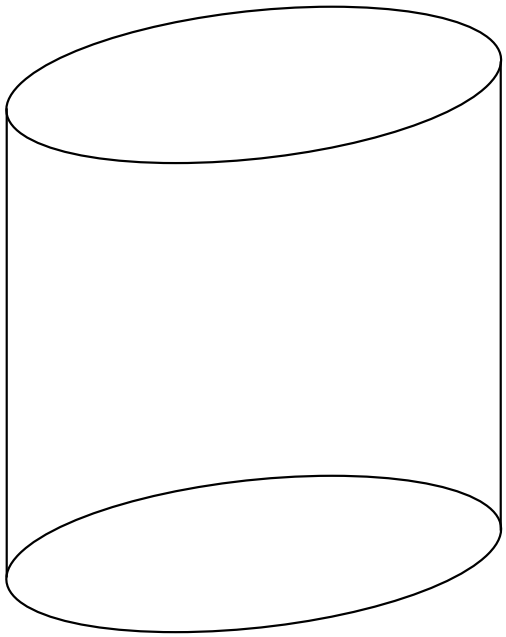


Consequence:

Lower discrimination threshold raises expected WIMP count rate

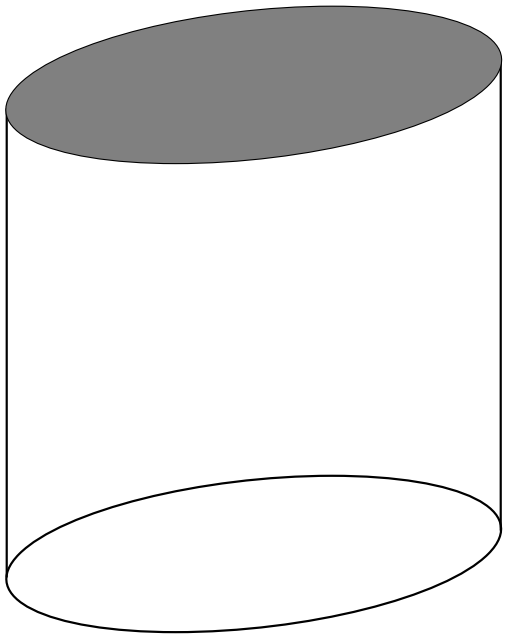
Problem During Detector Production



Steps

- Scintillating crystal

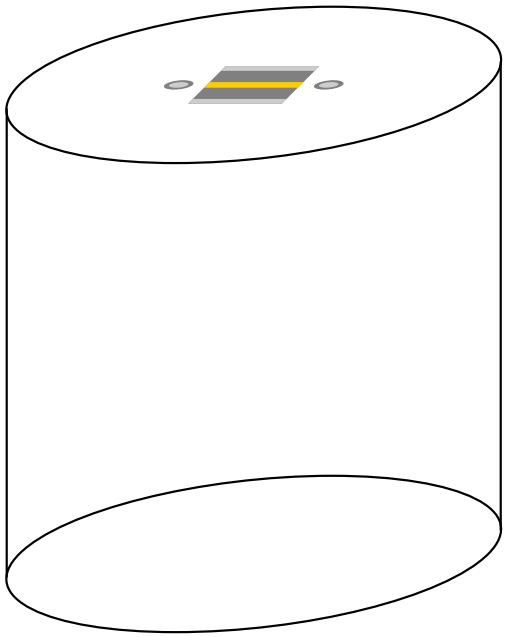
Problem During Detector Production



Steps

- Scintillating crystal
- Evaporation

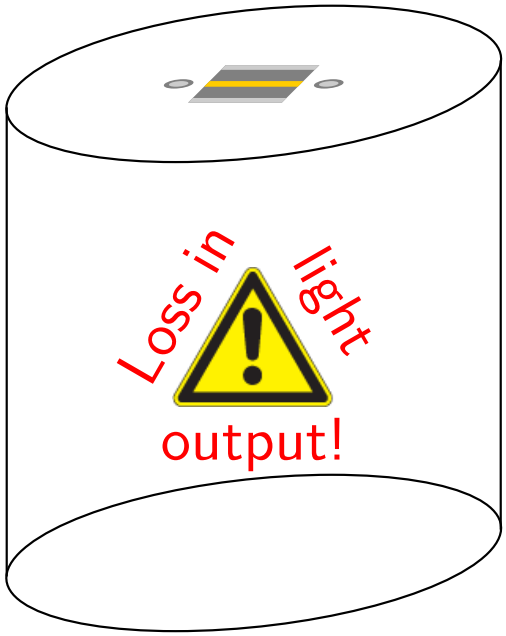
Problem During Detector Production



Steps

- Scintillating crystal
- Evaporation
- Structuring

Problem During Detector Production



Steps

- Scintillating crystal
- Evaporation
- Structuring

Problem

- High temperatures needed for evaporation
- Change in chemical composition
- Degradation of light output

Idea for the Solution

Glue a small thermometer carrier

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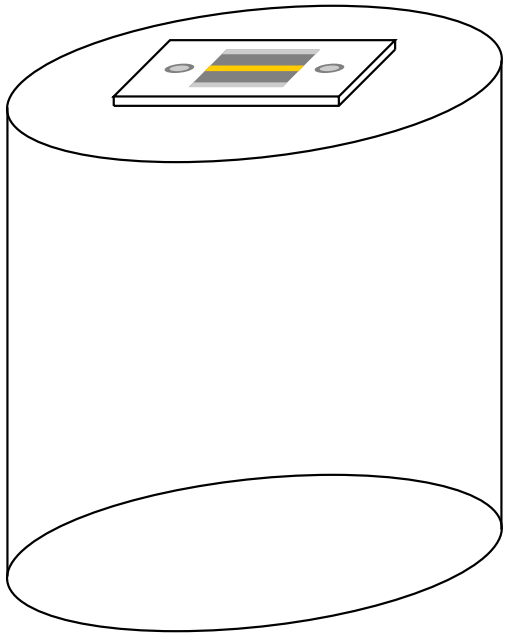
Glue a small thermometer carrier onto a big absorber

- Improves the light output
- Mass production of detectors



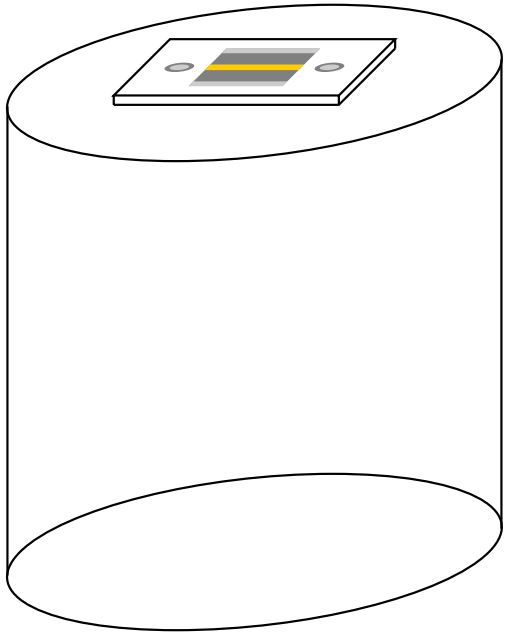
Idea for the Solution

Glue a small thermometer carrier onto a big absorber

- Improves the light output
- Mass production of detectors

My work: Investigate in gluing technique

- Is it technically possible?
- Is the light gain worth a phonon performance loss?



Run 31

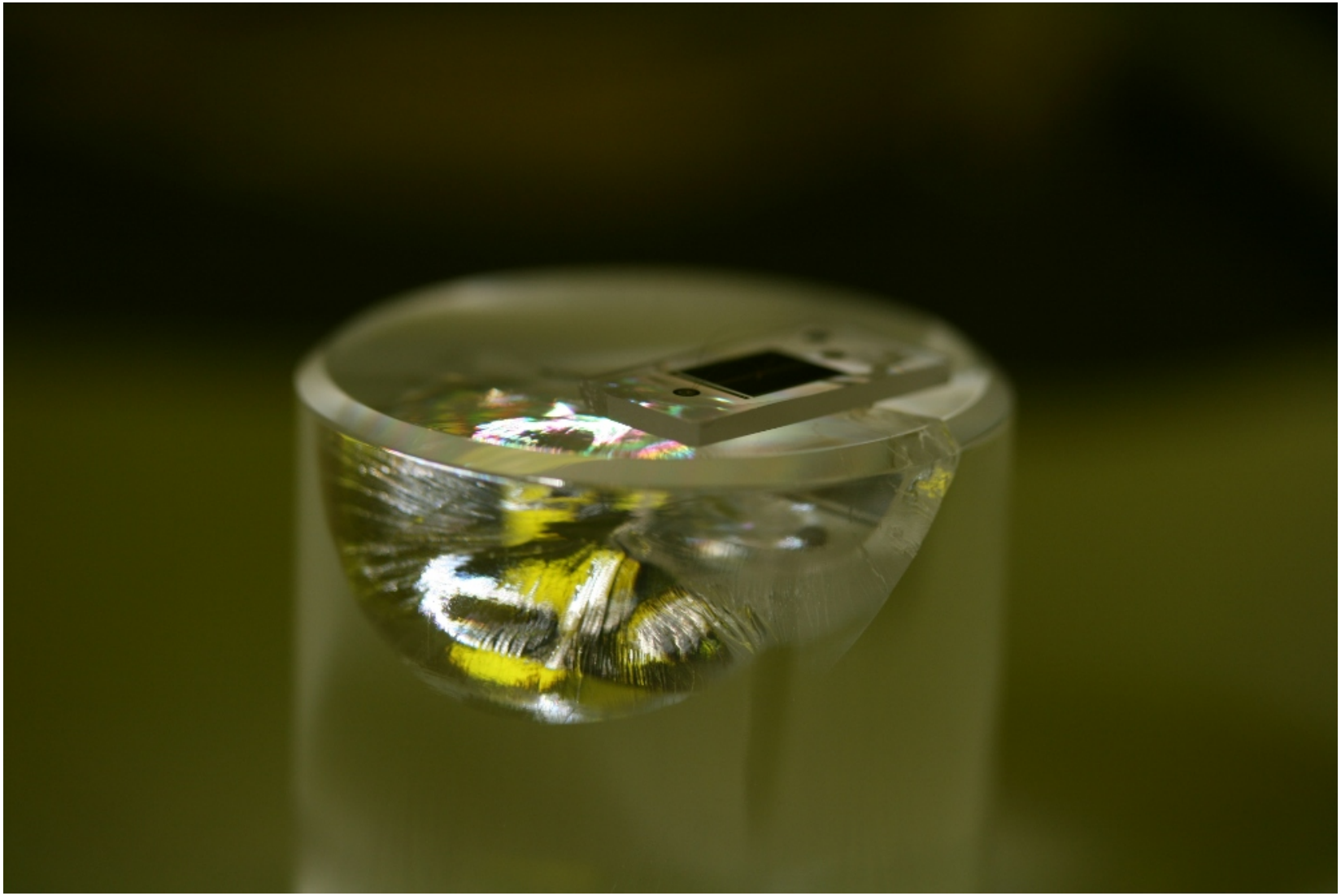
Characteristics

- Spring - Winter 2008
- 17 Detector modules inside
- 4 Composite modules
- Araldite and EpoTek

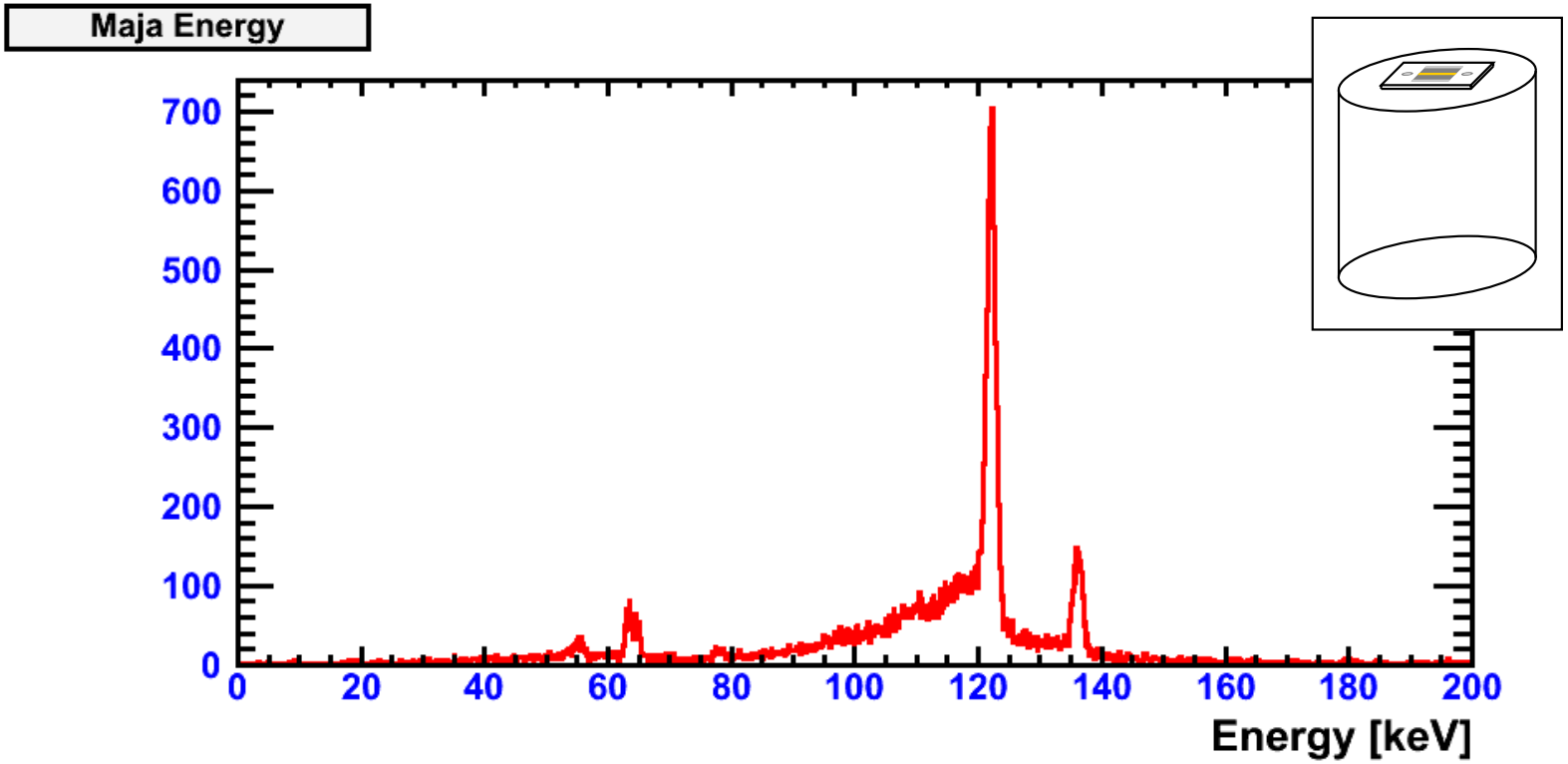
Results

- Composite detectors are working
- EpoTek is the better choice

Hanna after Run 31

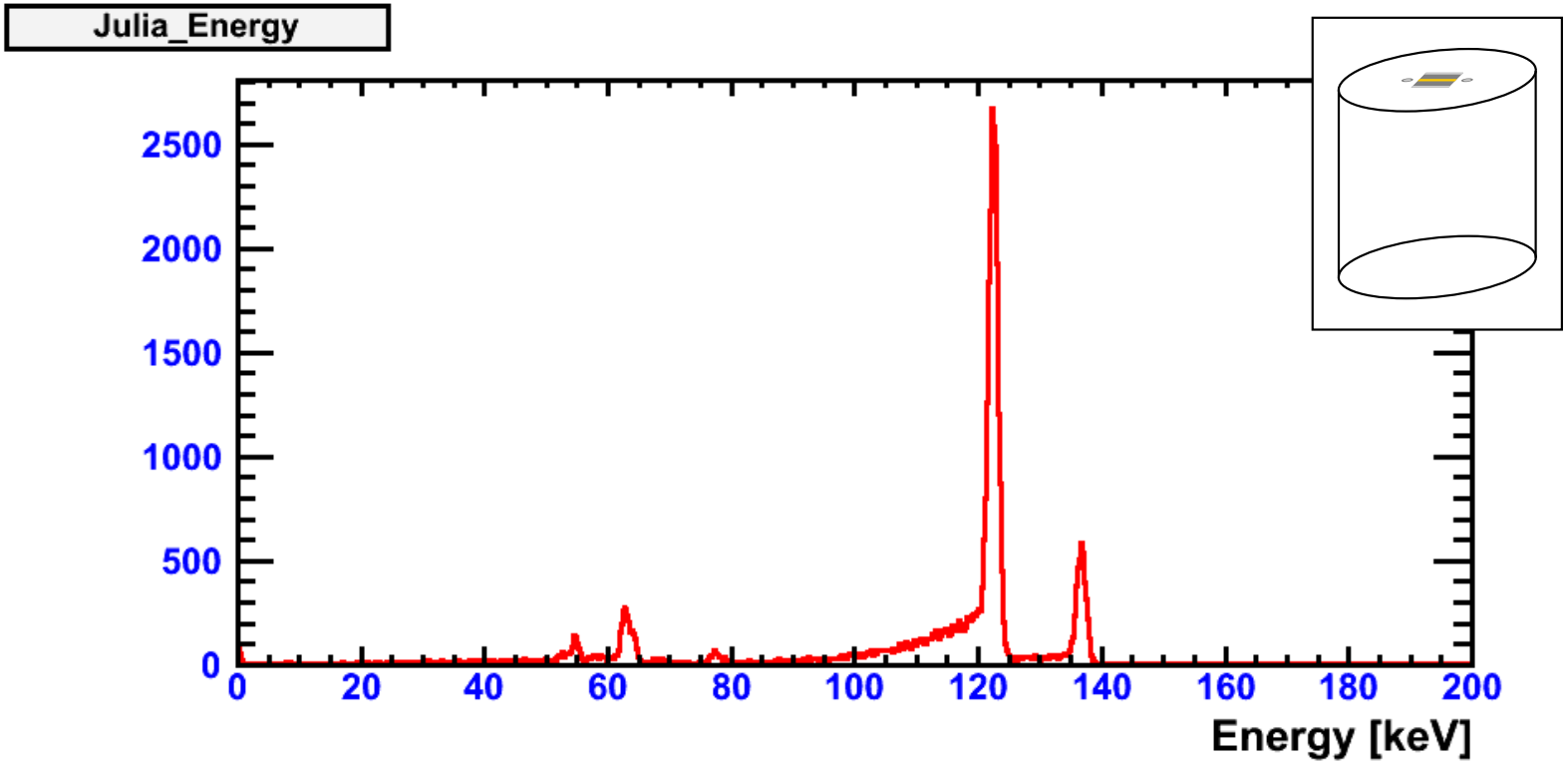


Calibration Spectrum for Maja



Resolution @122 keV:2.5 keV

Calibration Spectrum for Julia



Resolution @122 keV:2.0 keV

Run 32

Modifications

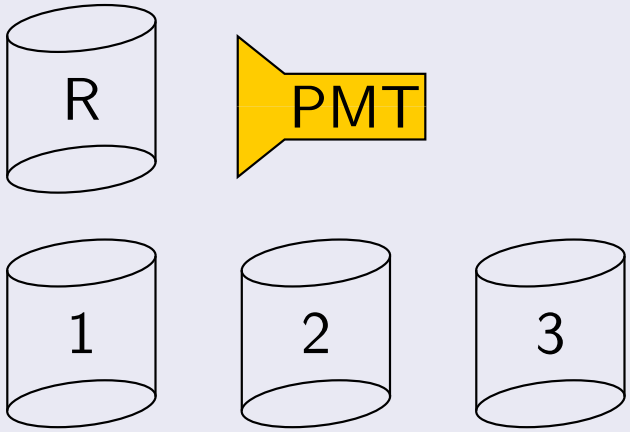
- 18 Detector modules inside
- 5 Composite modules, 3 $CaWO_4$, 2 $ZnWO_4$
- 1 $CaWO_4$ module with two light detectors
- Composite detectors have calibration source

Results

- (More DM data)
- Characterization of modules

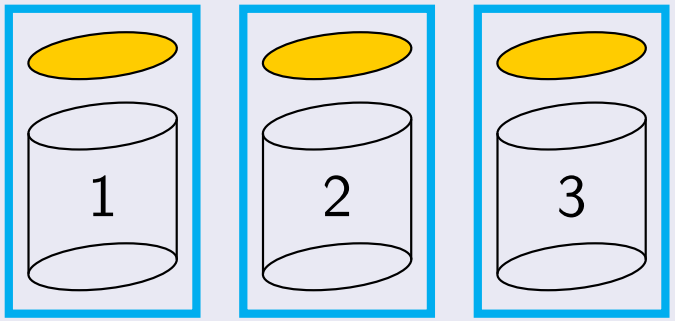
“Standard candles” for Comparison of Scintillators

Reference: Crystal



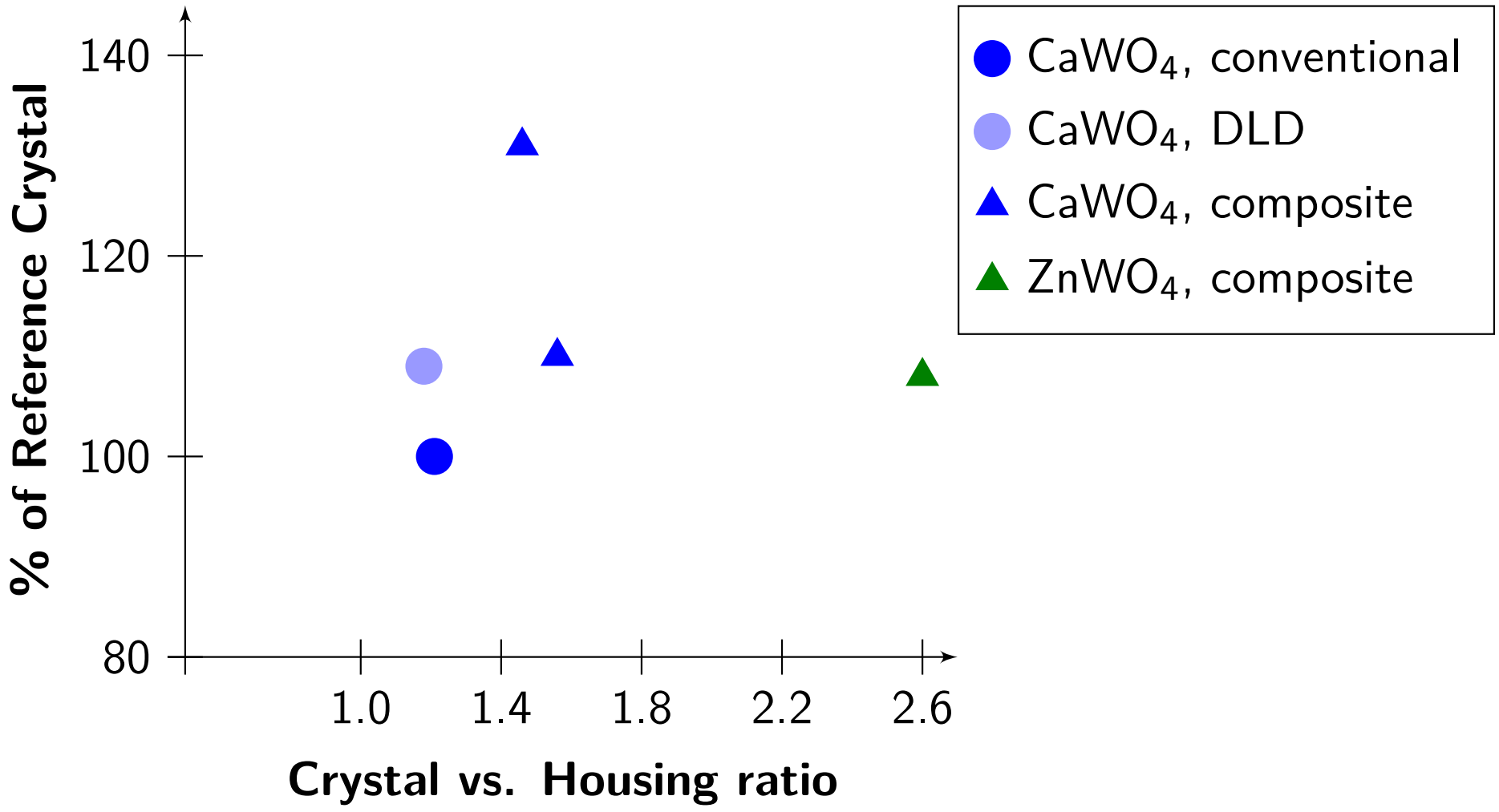
- “Ex situ”
- Room temperature
- Always the same PM tube

Reference: Housing

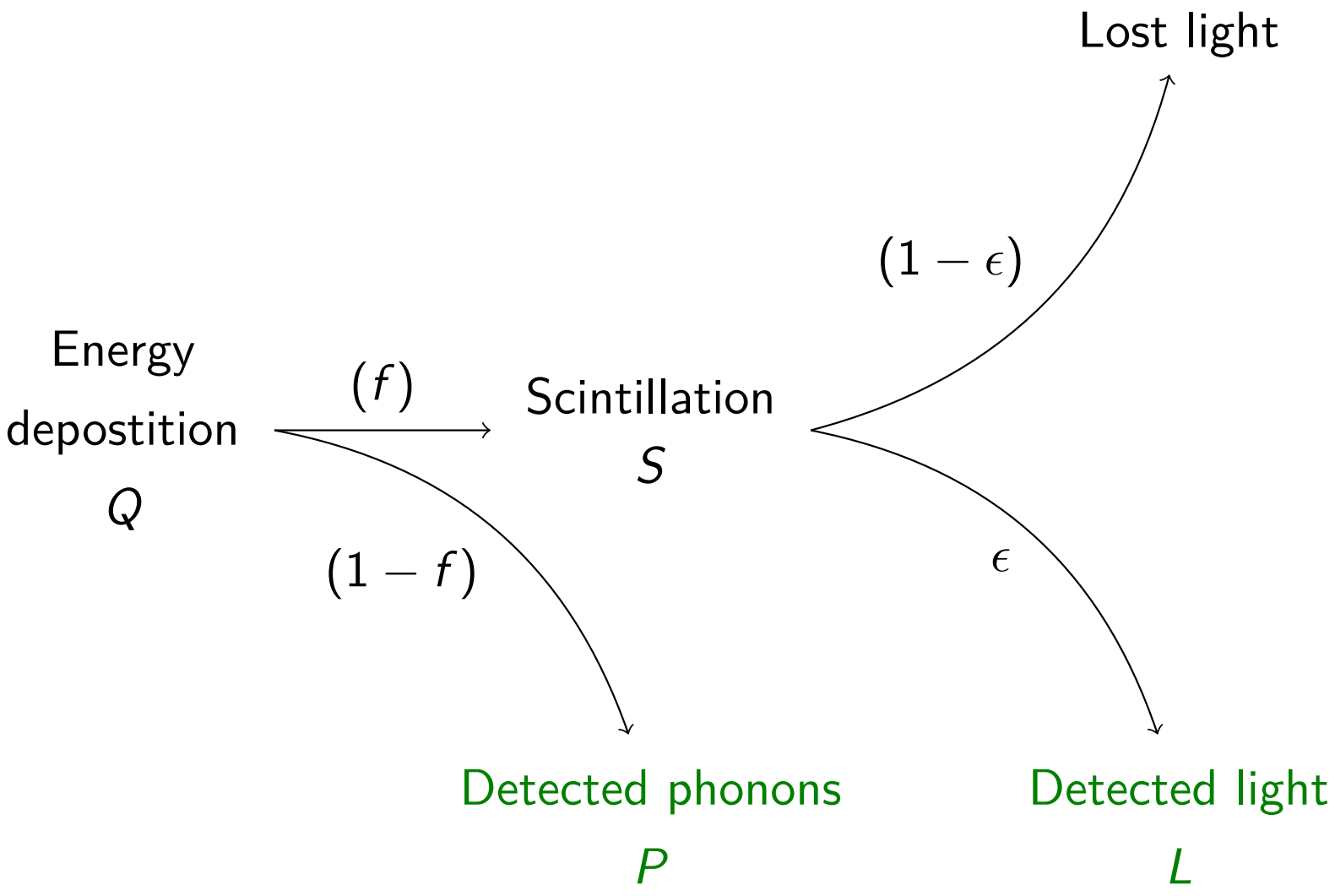


- “In situ”
- Cold
- Individual light detectors

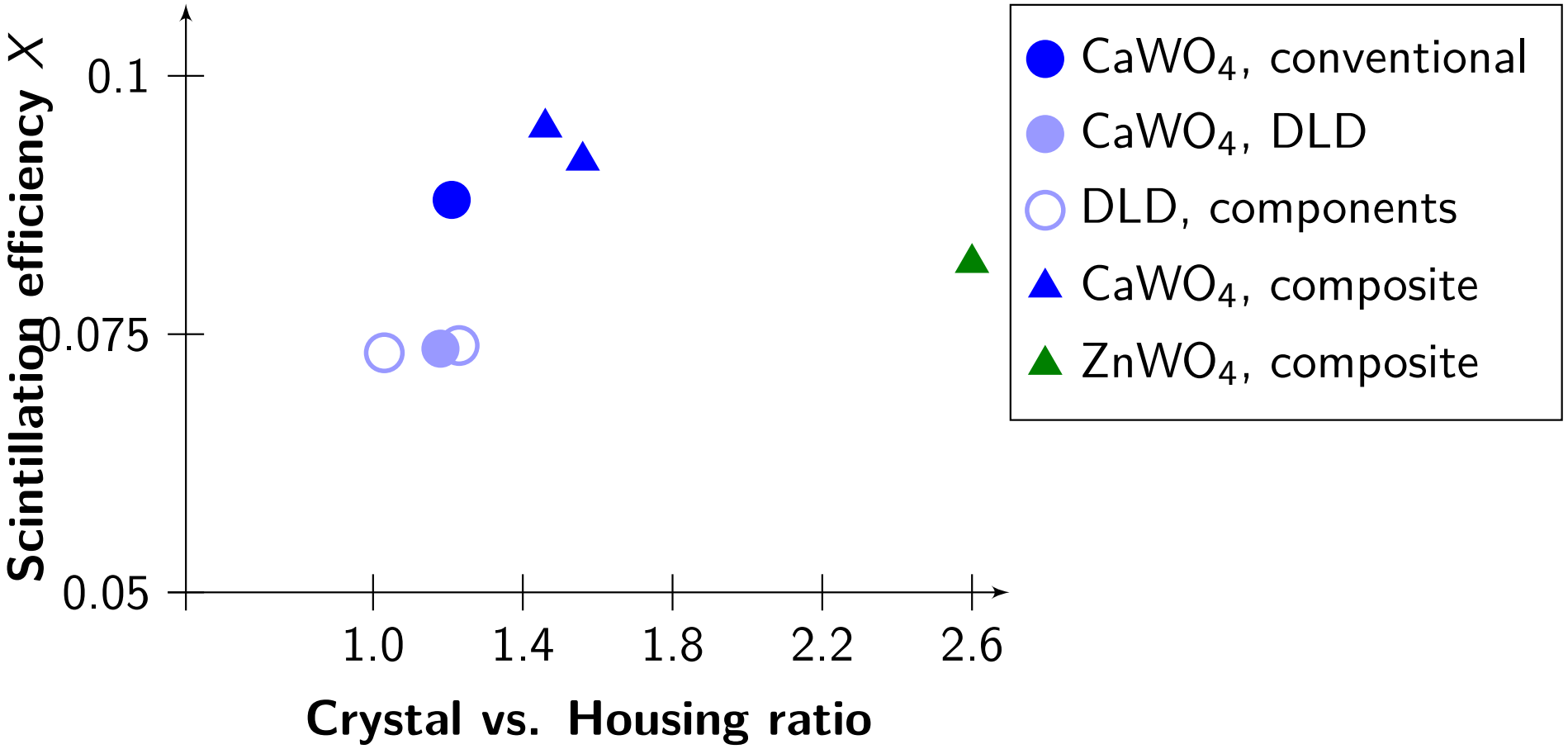
Scintillator characteristics: "Standard candles"



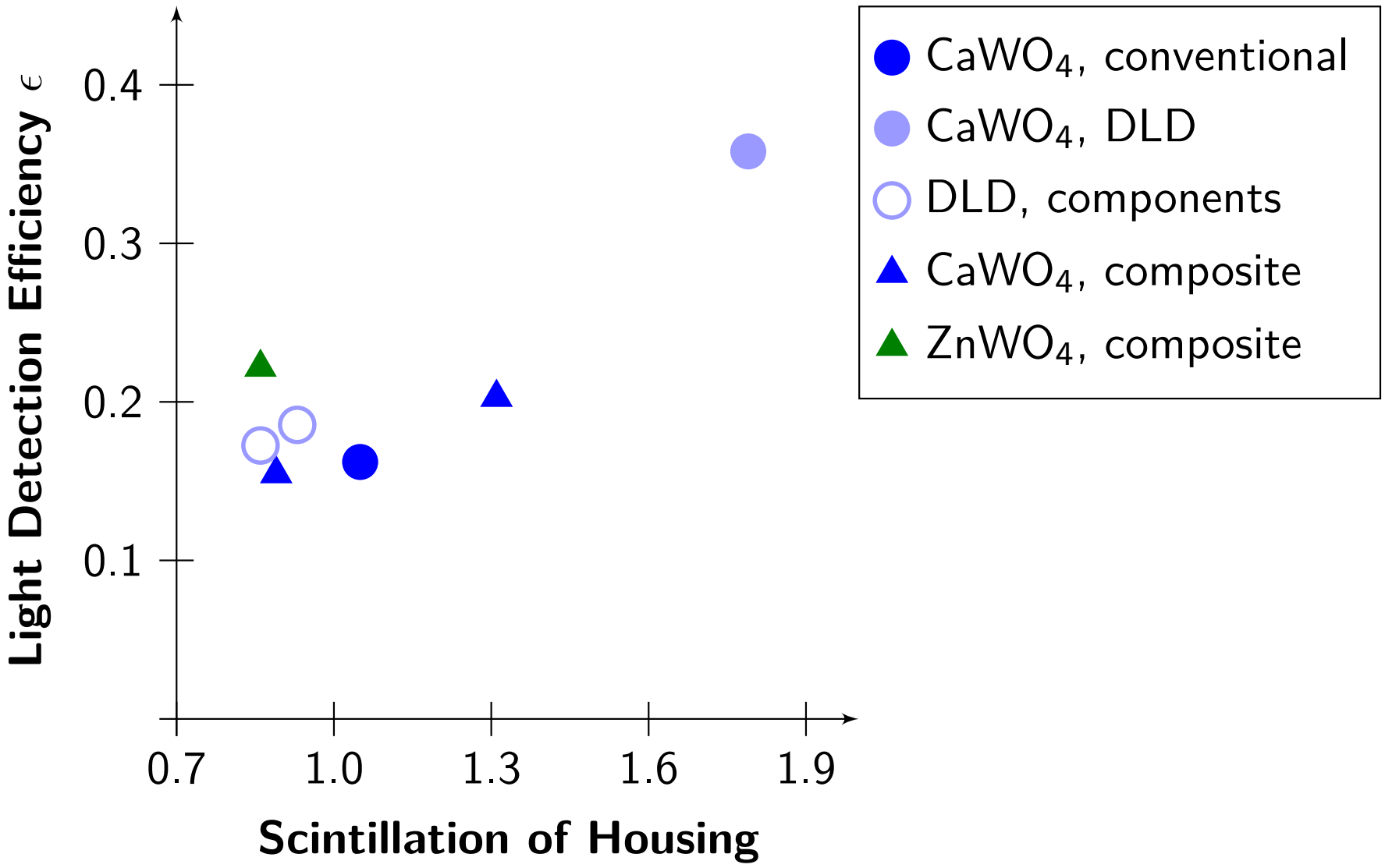
Distribution of Energy in the Module



Scintillator Characteristics: Energy Distribution



Detector Characteristics

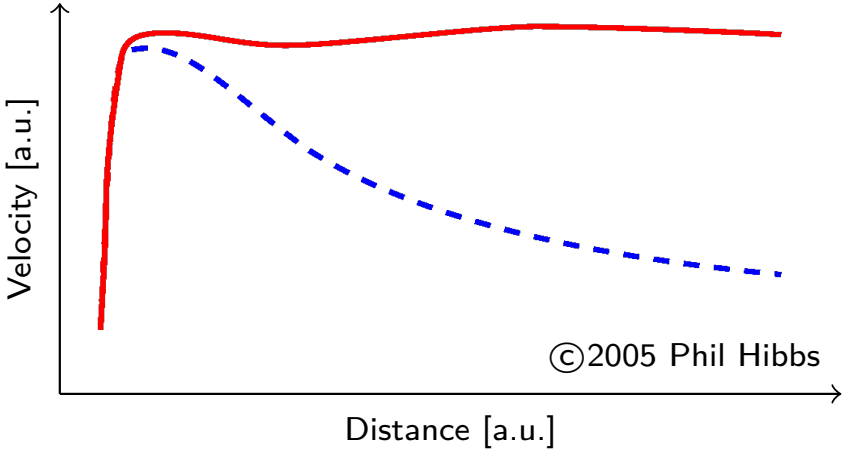


Conclusion

- Composite detectors produce more light
- $CaWO_4$ is better than $ZnWO_4$in terms of scintillation efficiency
- Second light detector improves the detection
- Does the benefit of a second LD justify the sacrifice of channels?

Evidence for Dark Matter

Rotation curves of galaxies

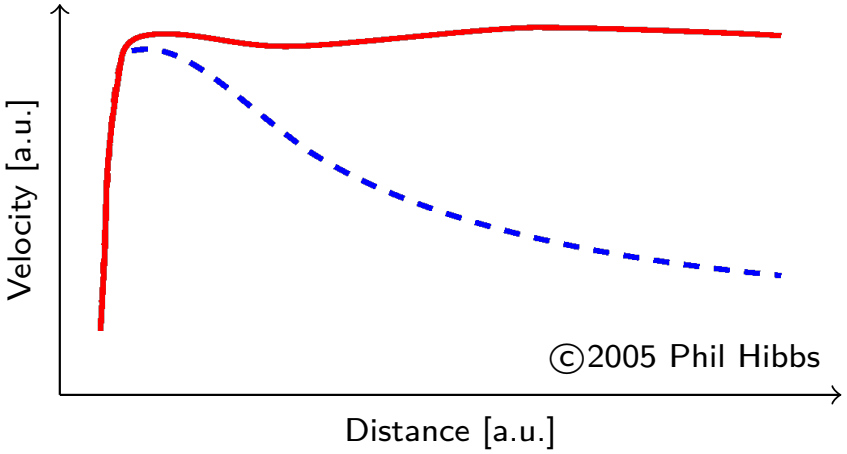


Theory vs. Measurement

Evidence for Dark Matter

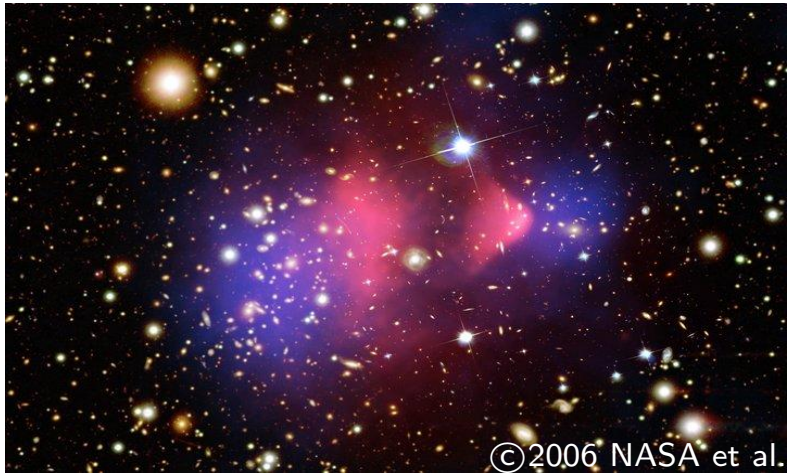
Rotation curves
of galaxies

$\Rightarrow$ Dark Matter



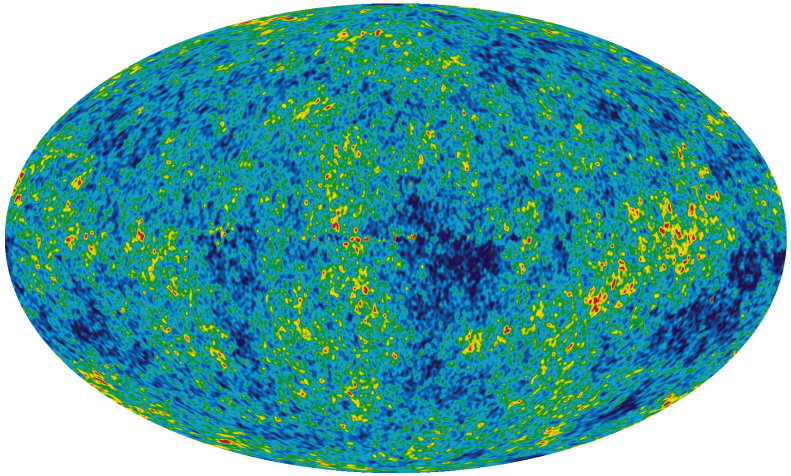
Theory vs.
Measurement

Evidence for Dark Matter 2



Structures in
the Bullet cluster

⇒ Dark Matter



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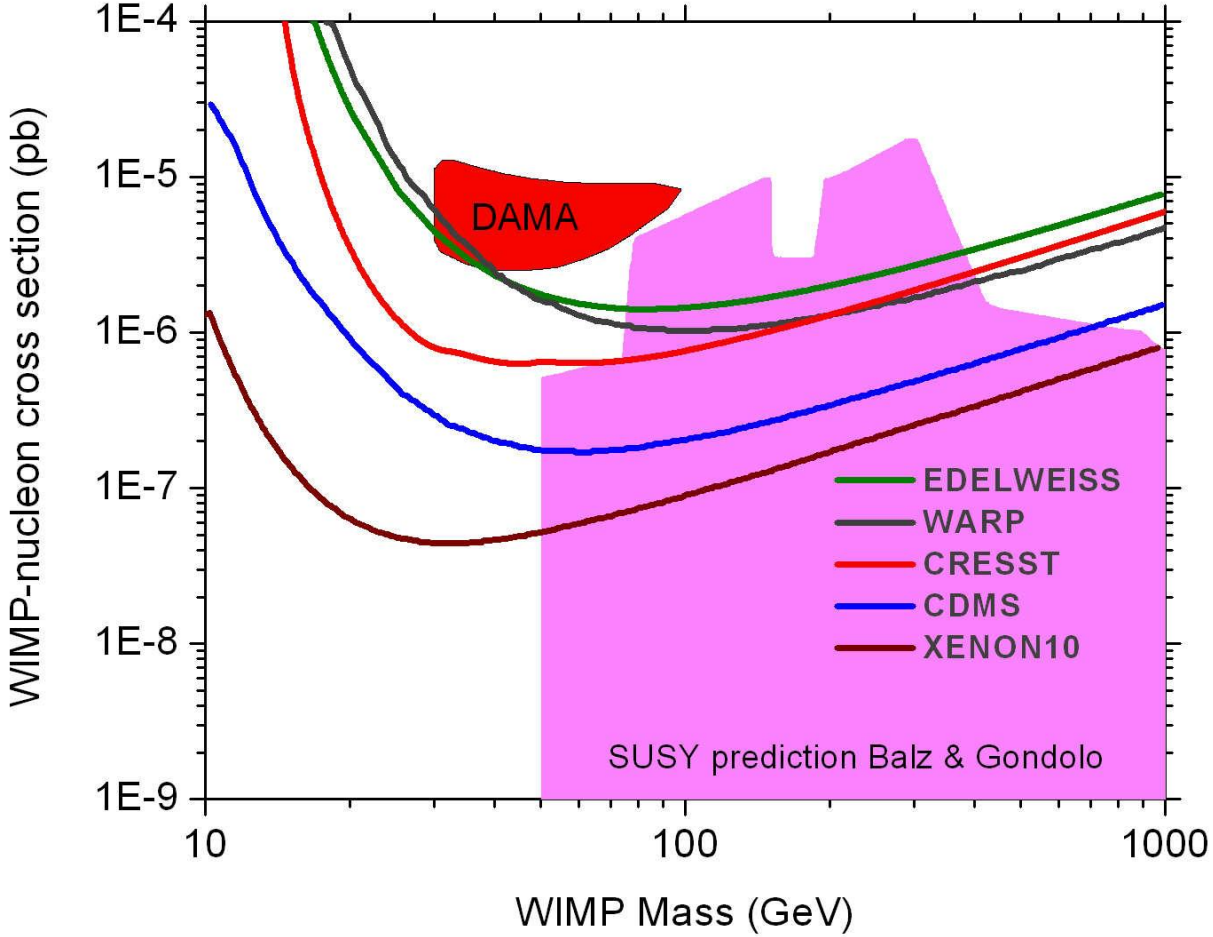
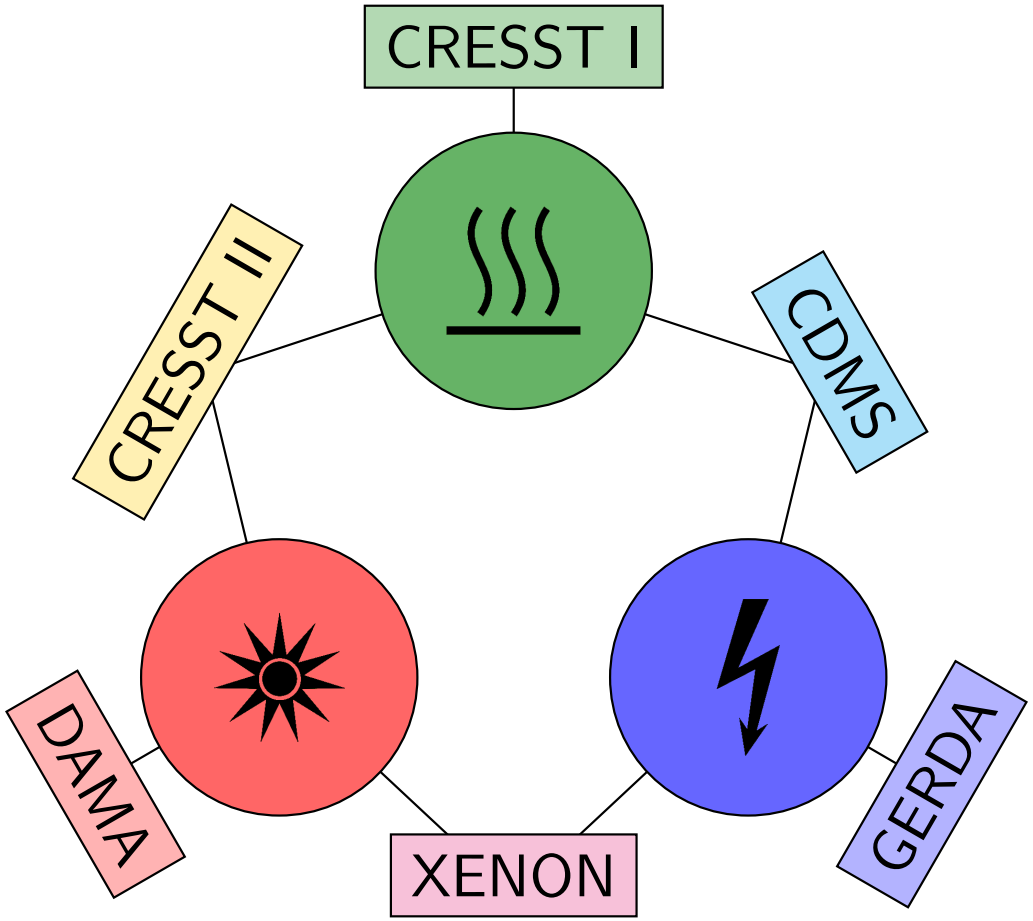
Cosmic
Microwave Background

Current Exclusion Limits



Dark Matter Experiments