The CRESST-II Experiment

Searching for new Detector Candidates

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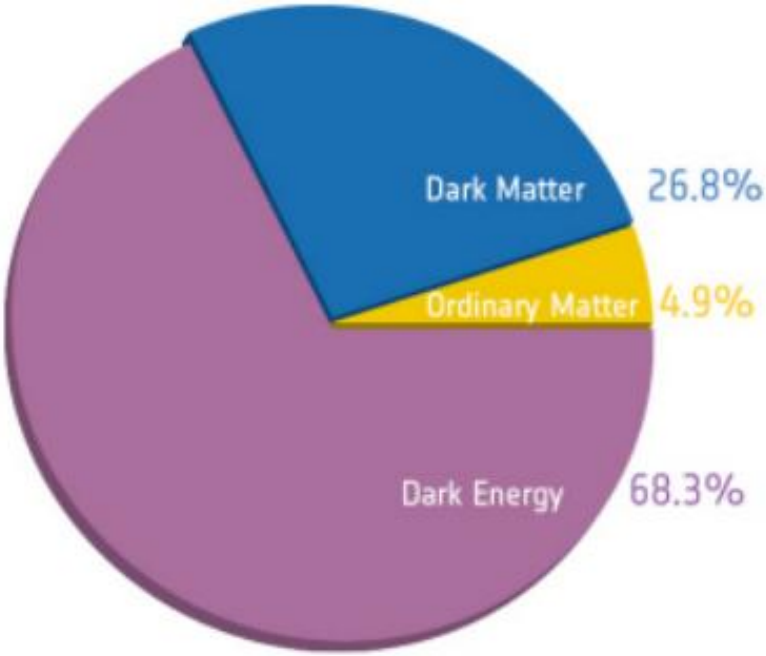
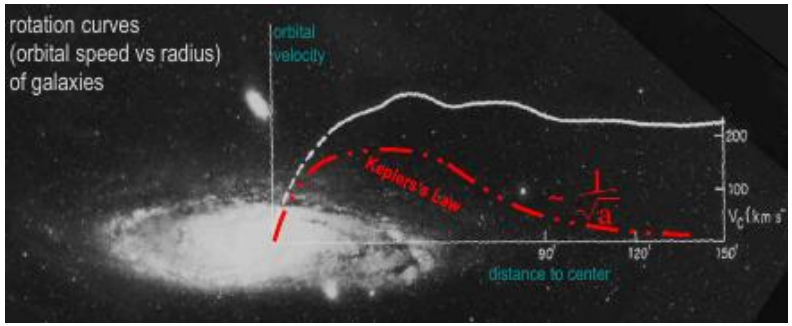
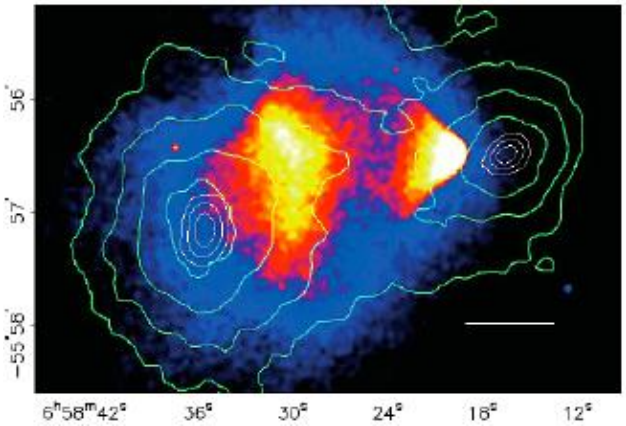
Motivation



(sci.esa.int/planck)



(C.Tenzer, IAAT)



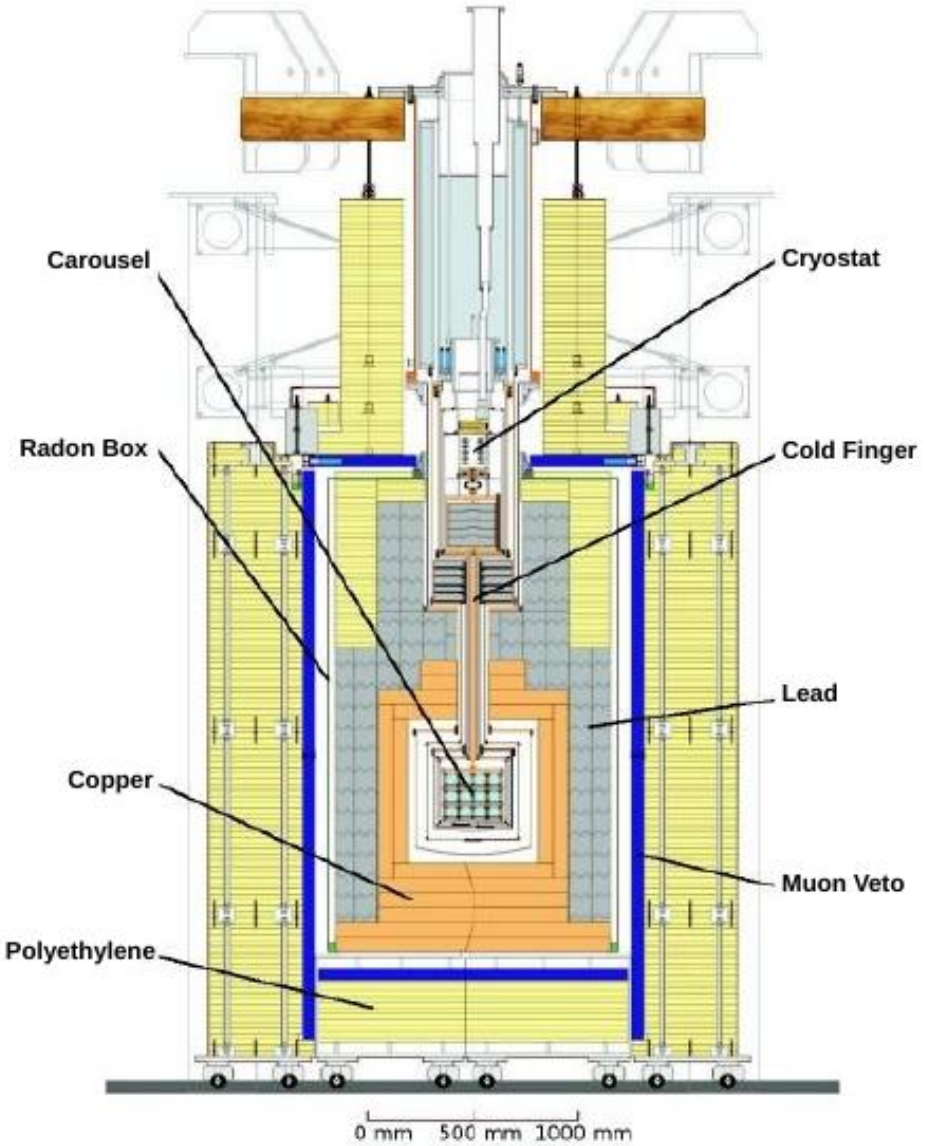
(physics.stackexchange.com)

CRESST-II Experiment

(lngs.infn.it)

- **C**ryogenic **R**are **E**vent **S**earch with **S**uperconducting **T**hermometers
- Located at the Laboratori Nazionali del Gran Sasso (LNGS), Italy
- Direct detection via elastic scattering off nuclei with cryogenic detectors
- Suitable for detection of low mass WIMPs

CRESST-II Experimental Setup



(cresst.de)

CRESST-II Experimental Setup

Why do we need so many layers to suppress the background?

Expected Rate

$$R = N \frac{\rho_\chi}{m_\chi} < v > \sigma_\chi A^2$$

N: Number of target atoms

$\frac{\rho_\chi}{m_\chi} = 3\,\mathrm{l}^{-1}$: Particle density

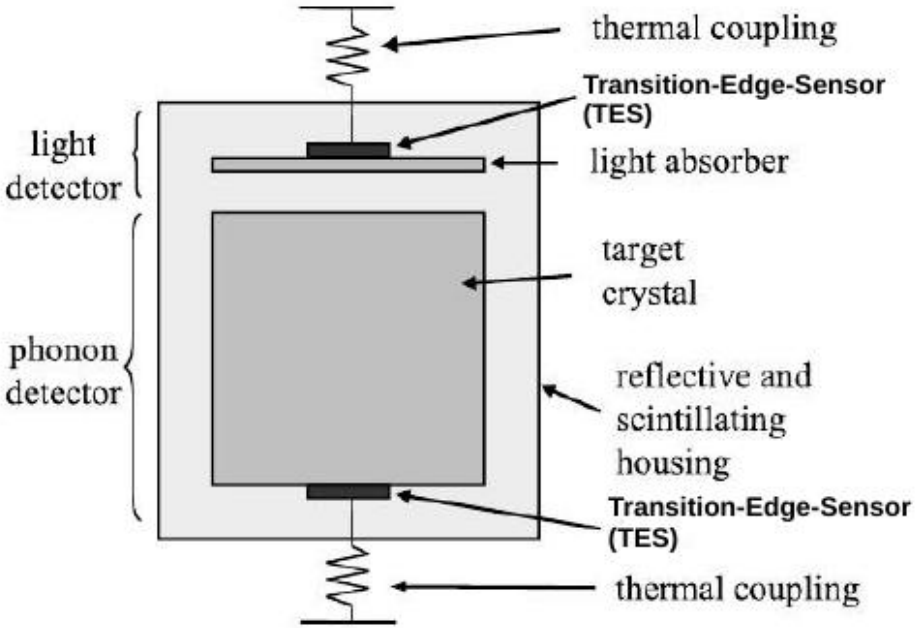
$< v >= 10^5\,\mathrm{s}^{-1}\,\mathrm{cm}^{-2}$: Dark Matter flux

$\sigma_\chi A^2$: coherent scattering with $\sigma_\chi = 10^{-36}\,cm^2$

Fact

Less than 1 event per kg and day!

CRESST-II Detector Module

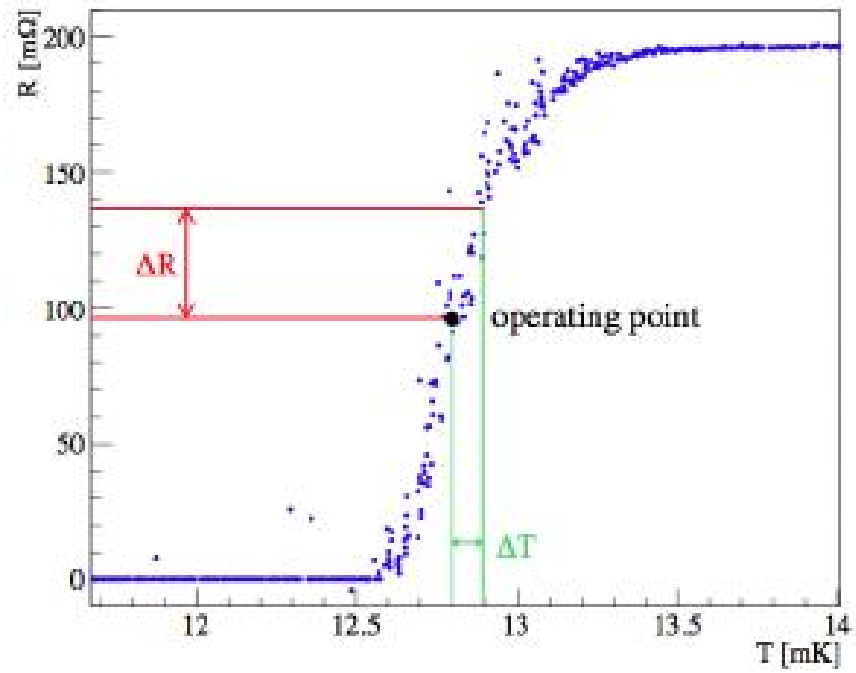


(Angloher et al., arXiv:1109.0702)

- Simultaneous measurement of heat/phonon and scintillation signal
- Phonon Detector: $CaWO_4$
- Operated at mK temperatures
- Light Detector: sapphire wafer silicon layer on one side (SOS)
- Scintillation permits rejection of potentially dangerous background

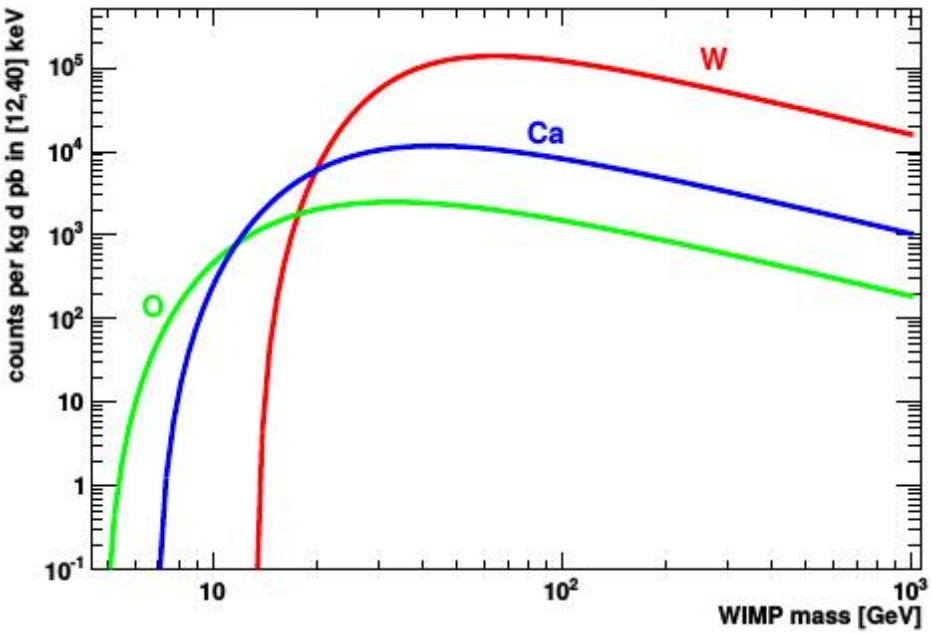
Transition-Edge-Sensor

- Thin W-film evaporated onto the crystal
- Superconducting phase transition
- Temperature change gives significant variation of the TES resistance
- Relaxes back to equilibrium via weak thermal coupling to heat bath



(R.Strauss, MPP)

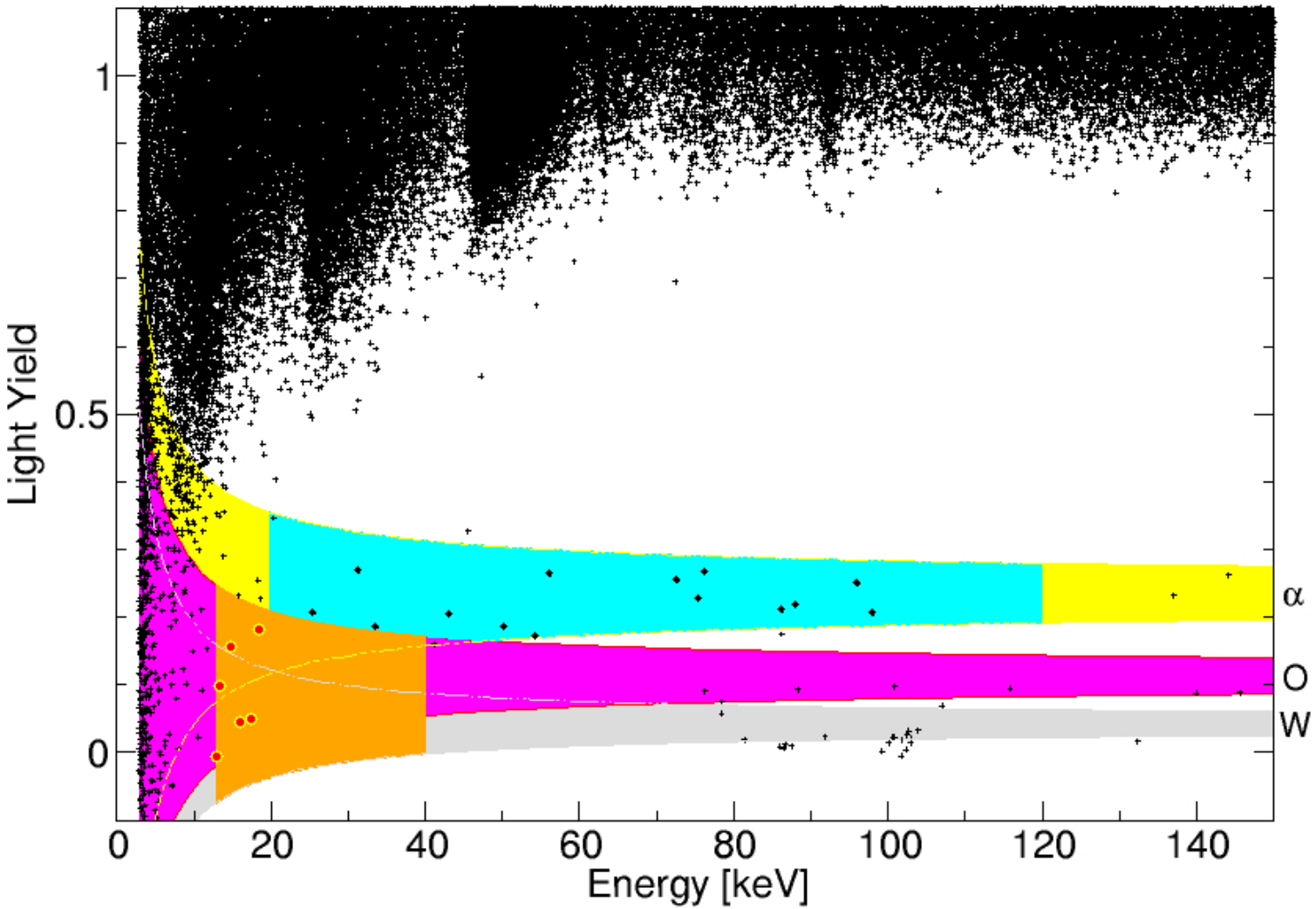
CRESST-II $CaWO_4$



(R.Strauss, MPP)

- $d = h = 40\,\mathrm{mm}$
- Multi-element target material
- High light output
- Heavy nucleus W which gives large factor $\propto A^2$
- Sensitive to the largest possible range of WIMP masses

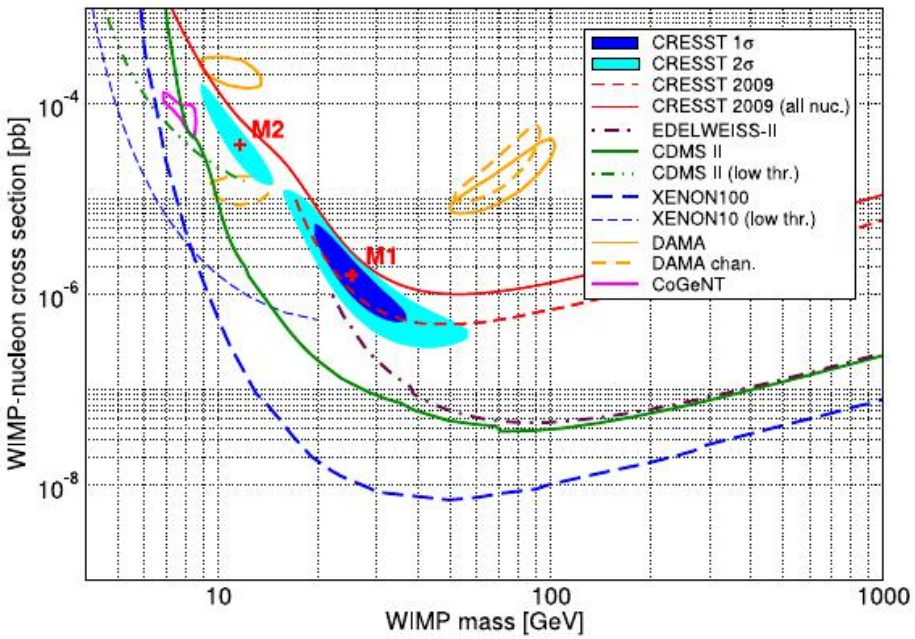
CRESST-II Detector Module



(Angloher et al., arXiv:1109.0702)

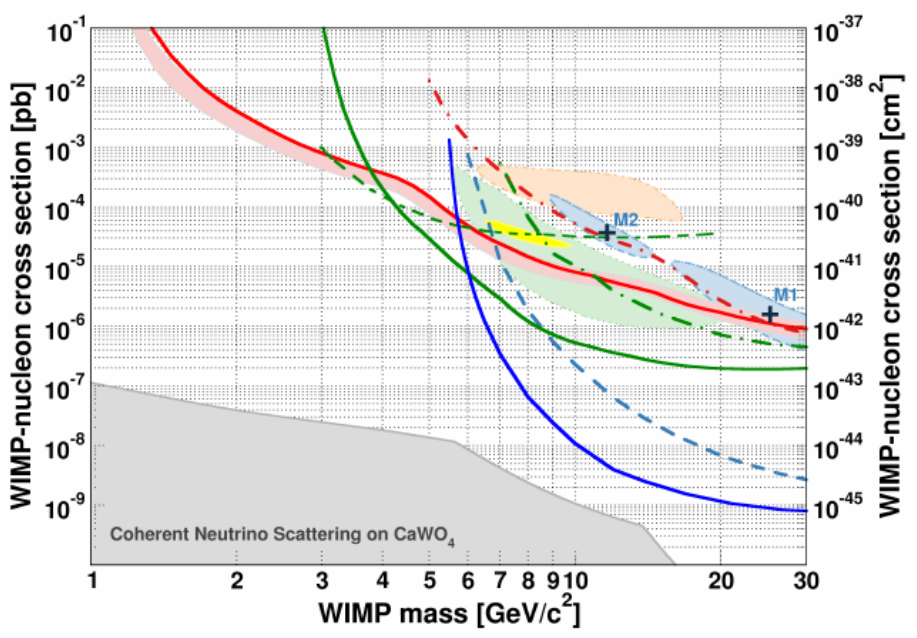
CRESST-II Results

Old:



(Angloher et al., arXiv:1109.0702)

New:



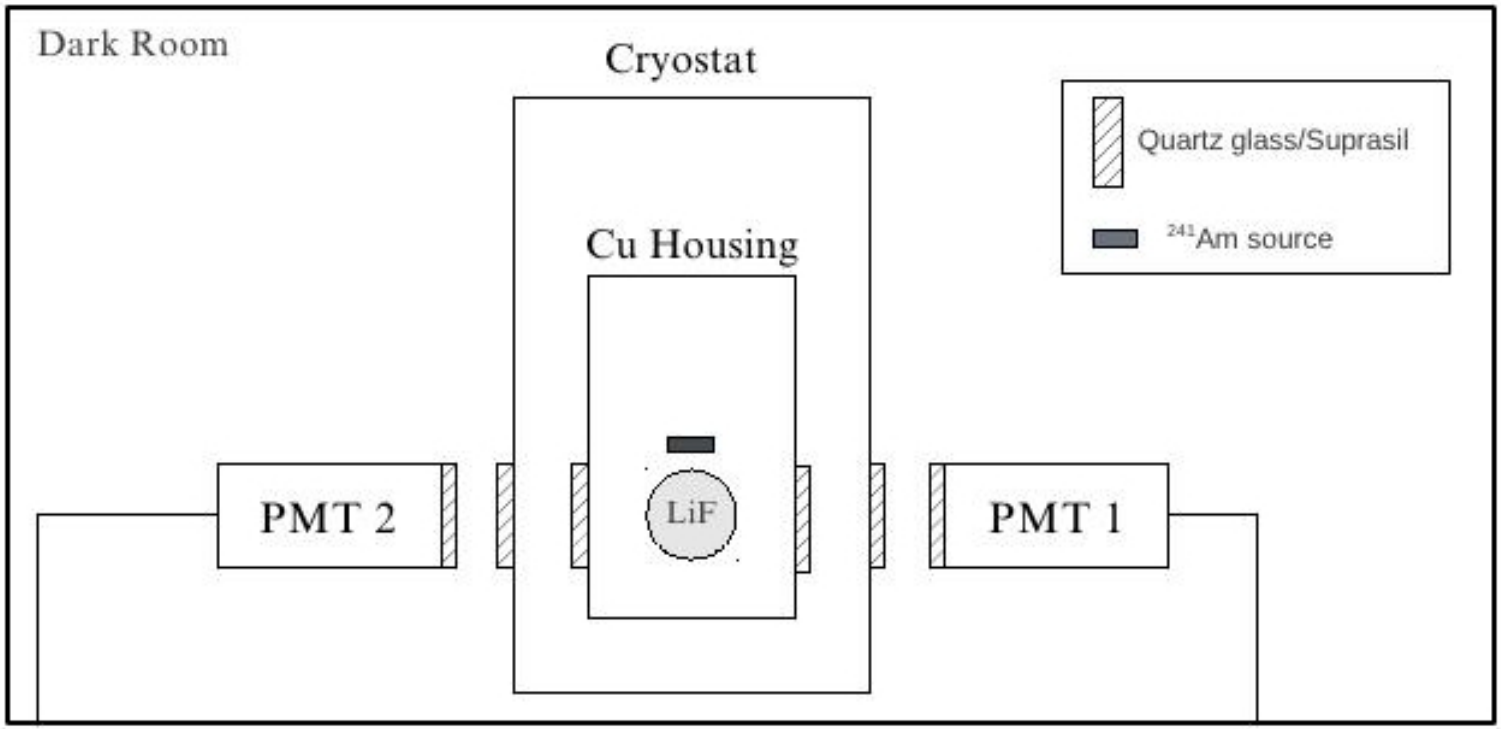
(Angloher et al., arXiv:1407.3146)

Lithium-Fluoride Crystal

Why Lithium-Fluoride?

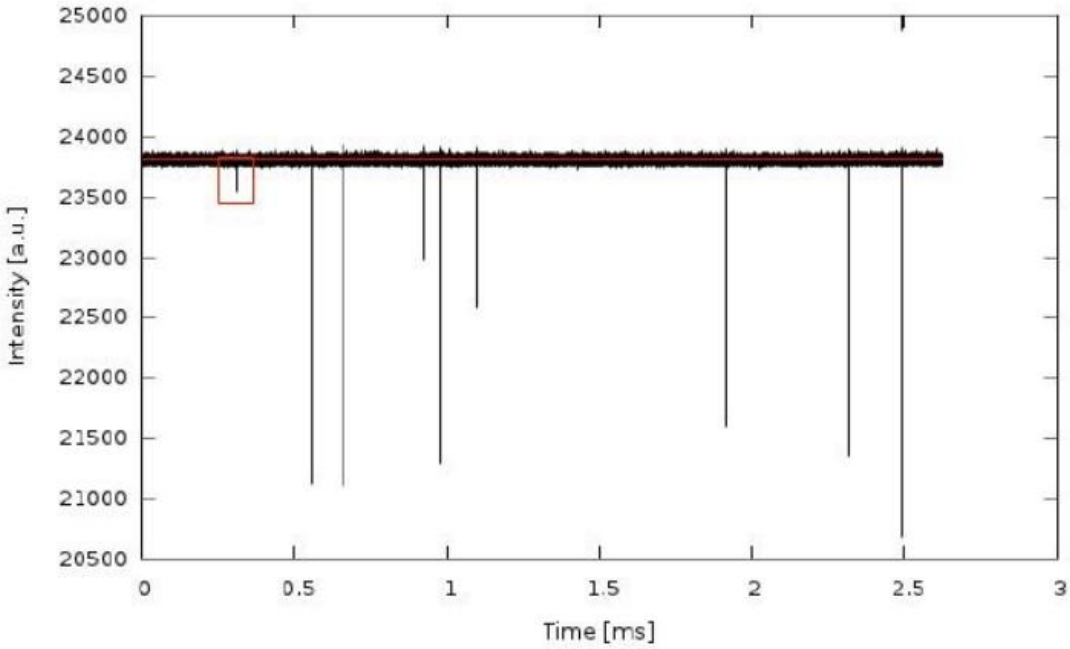
- Light output not really measured at low temperatures
- Possible use for measuring neutron rates to have better background discrimination
- Spin-dependent cross-section analysis

Experimental Setup

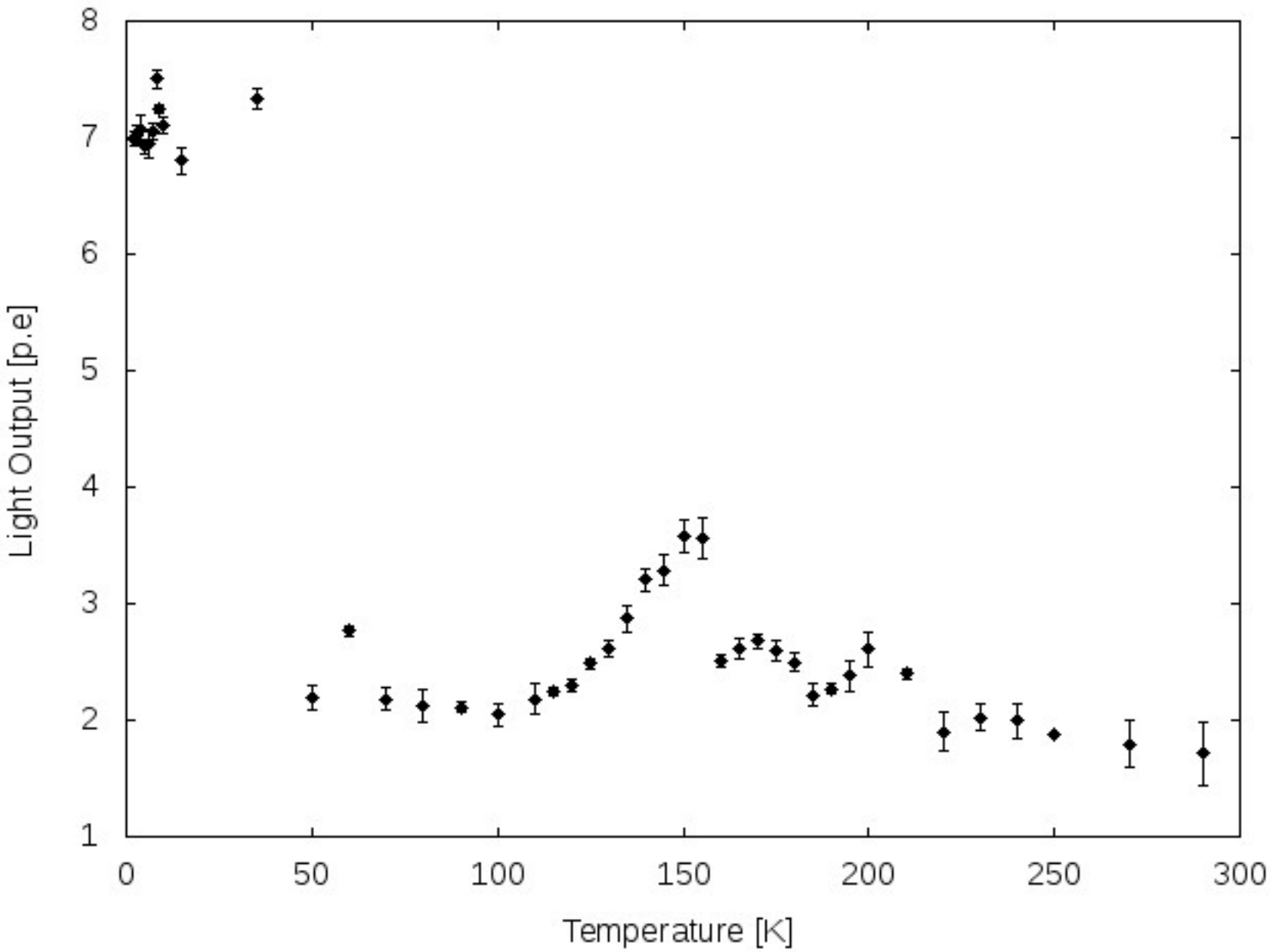


Data Analysis

- Multiple Photon Counting Coincidence (MPCC) Technique (DOI: 10.1016/j.nima.2005.07.011)
- 1.Step: delete pulses from trace to get baseline
- 2.Step: count pulses with a given threshold
- 3.Step: delete traces which contain early pulses



Results of the Light Yield



Summary and Outlook

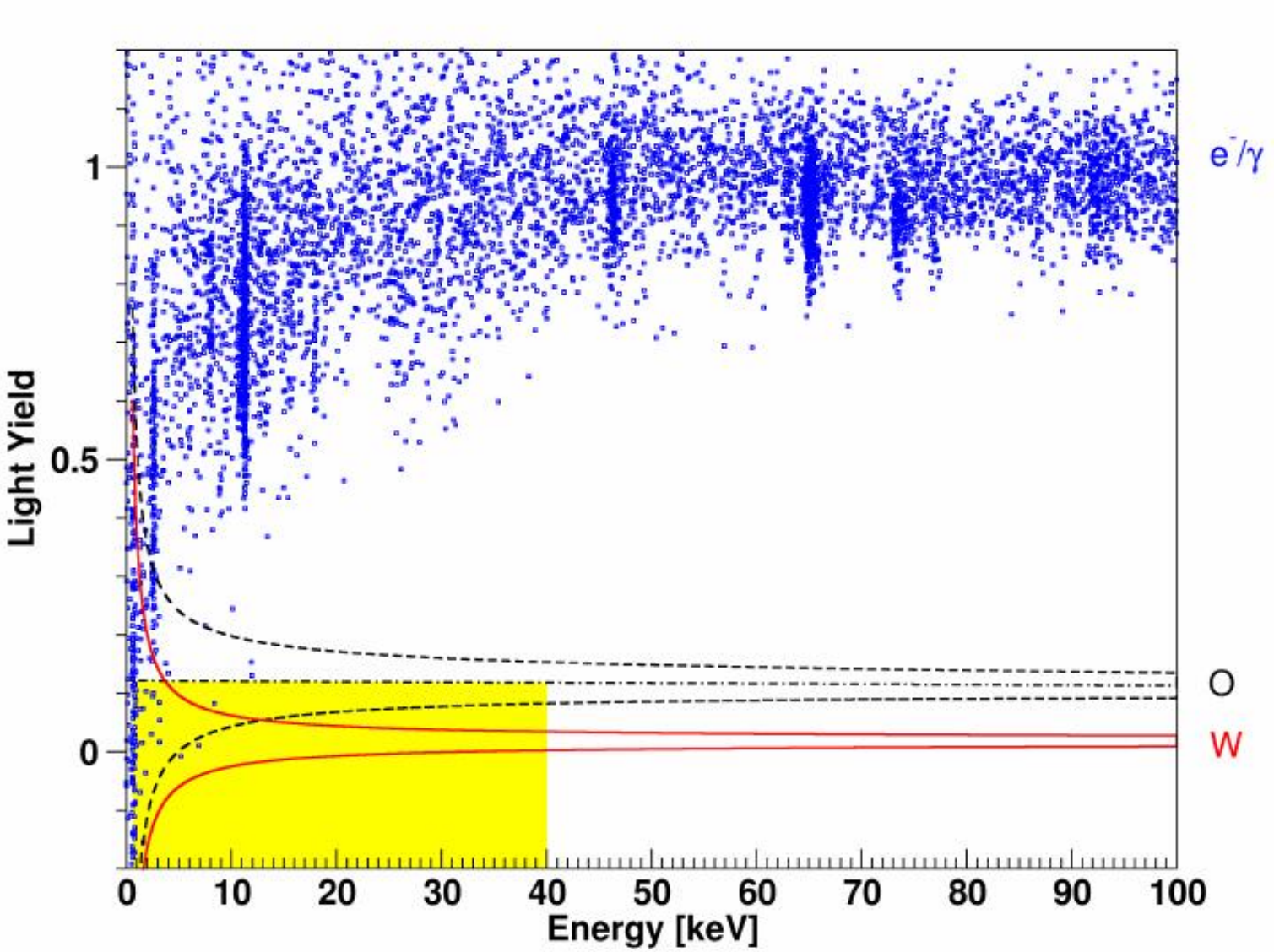
Summary

- Detection of WIMPs with multi-element target with large possible range of WIMP masses operated at mK detectors
- Target material can be exchanged
- Very low light output of LiF $\rightarrow$ not a possible detector candidate

Outlook

- Search for other possible detector candidates
- Change experimental setup and use n-scattering facility to calibrate new detectors

Backup



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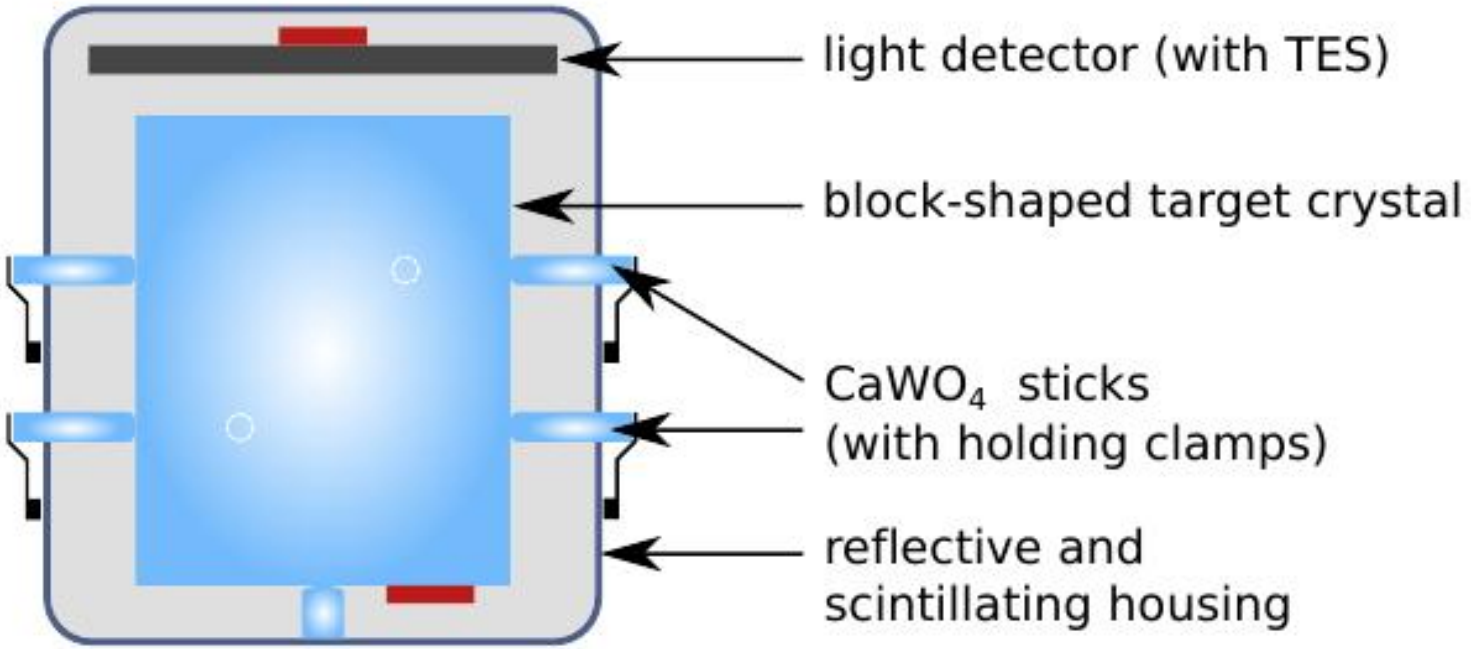

(Strauss et al.)