Search for Light Dark Matter with CRESST-III

Status and First Results

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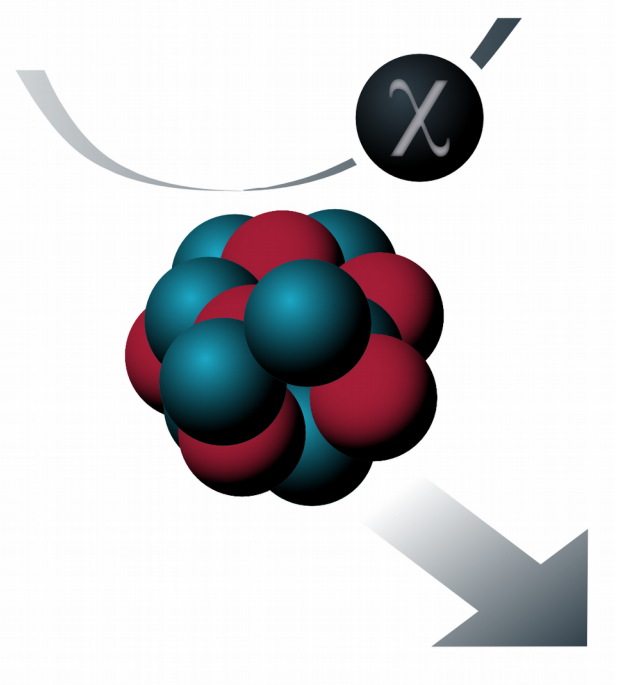
Searching for (Light) Dark Matter

plenty of evidence from astronomical observations points to the existence of dark matter particles

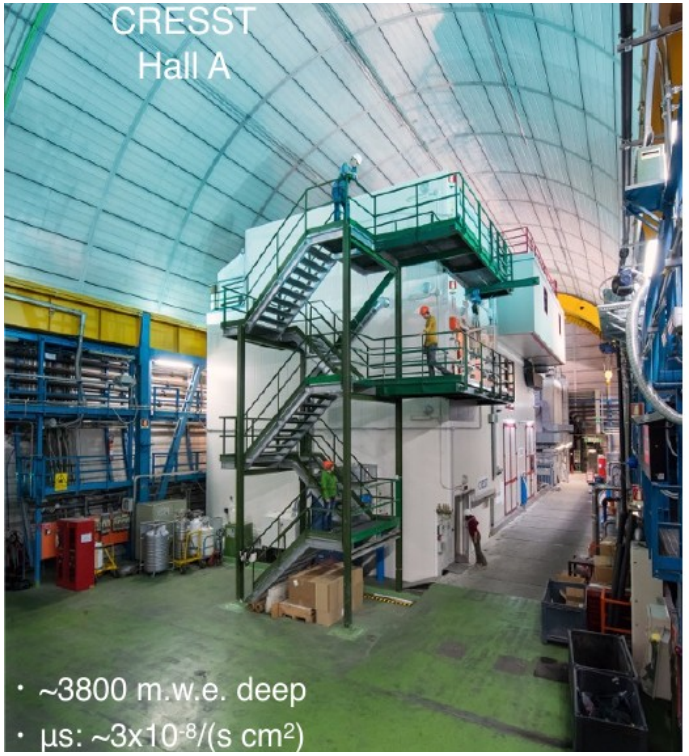
DM particle scatters off nucleus
→ **nuclear recoil**

event rate depends on DM mass, target and **energy threshold**

CRESST is only sensitive to **spin-independent** interactions



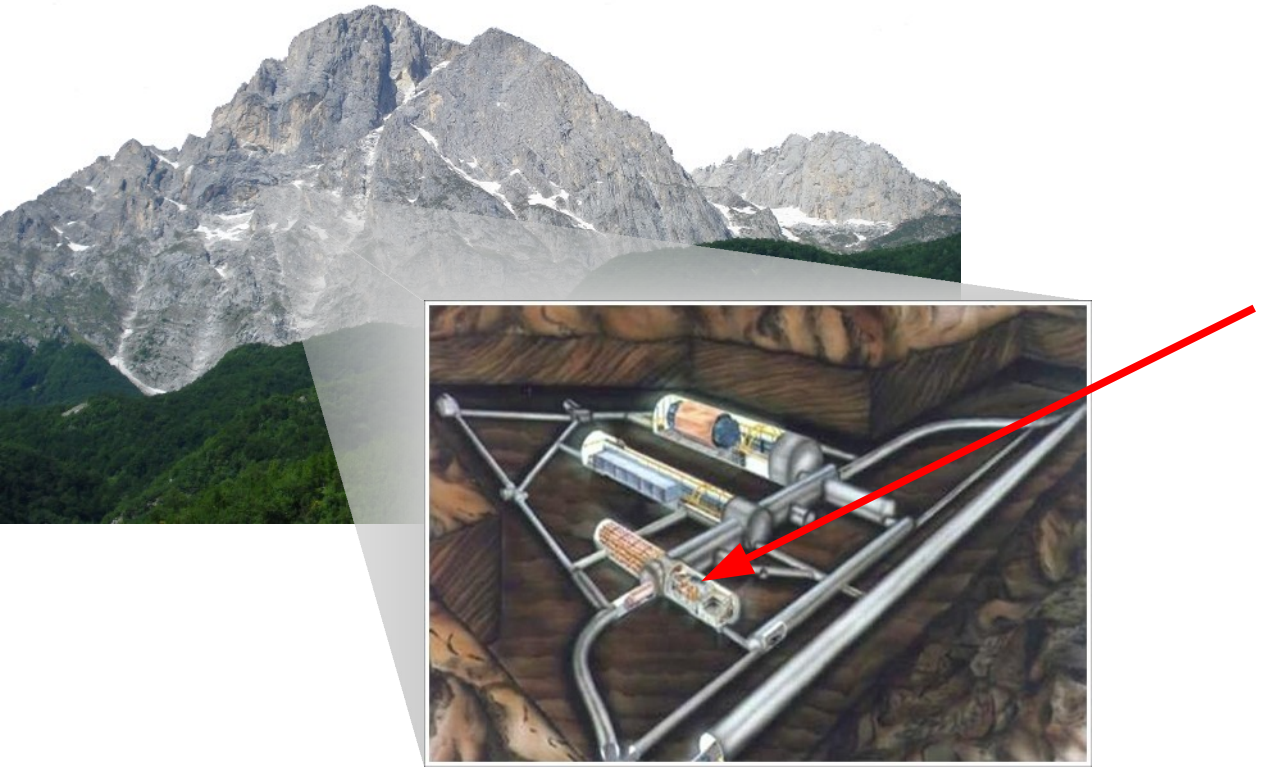
The CRESST Experiment

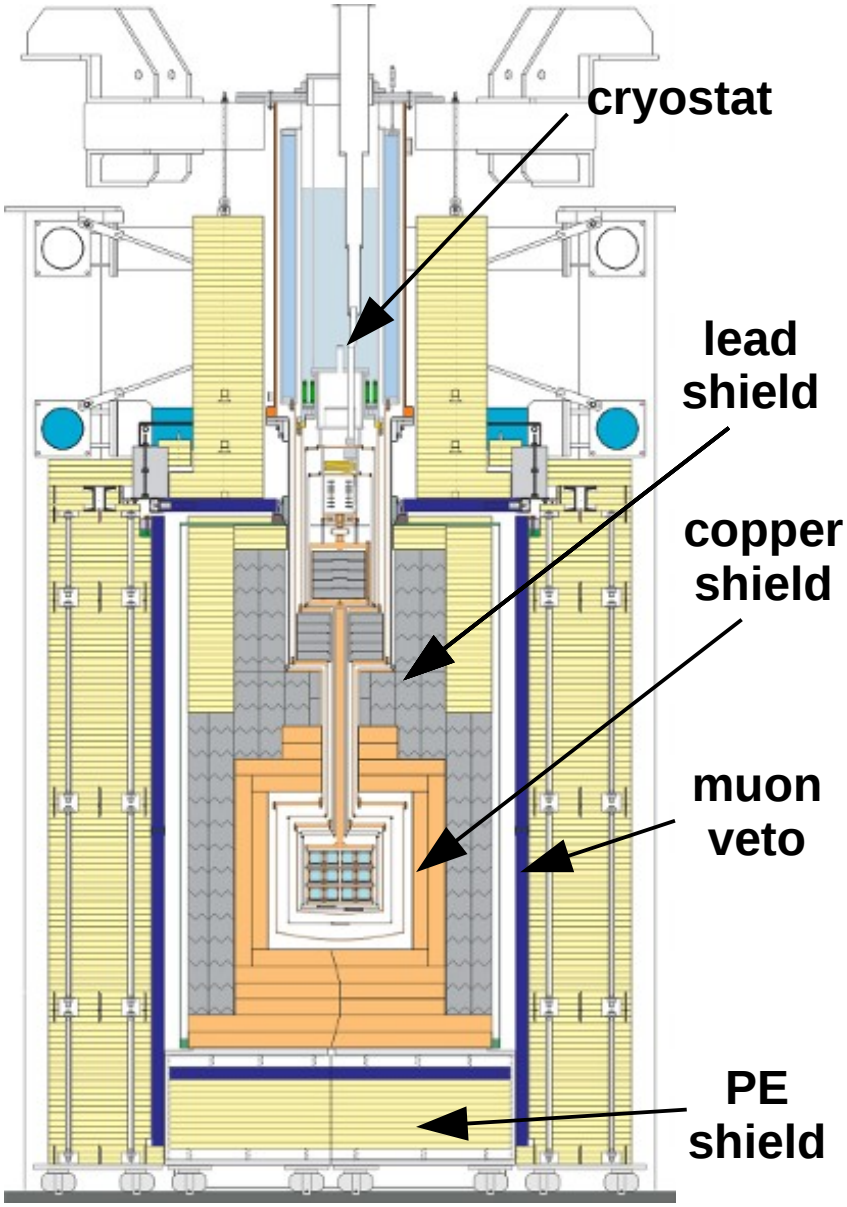


The CRESST Experiment

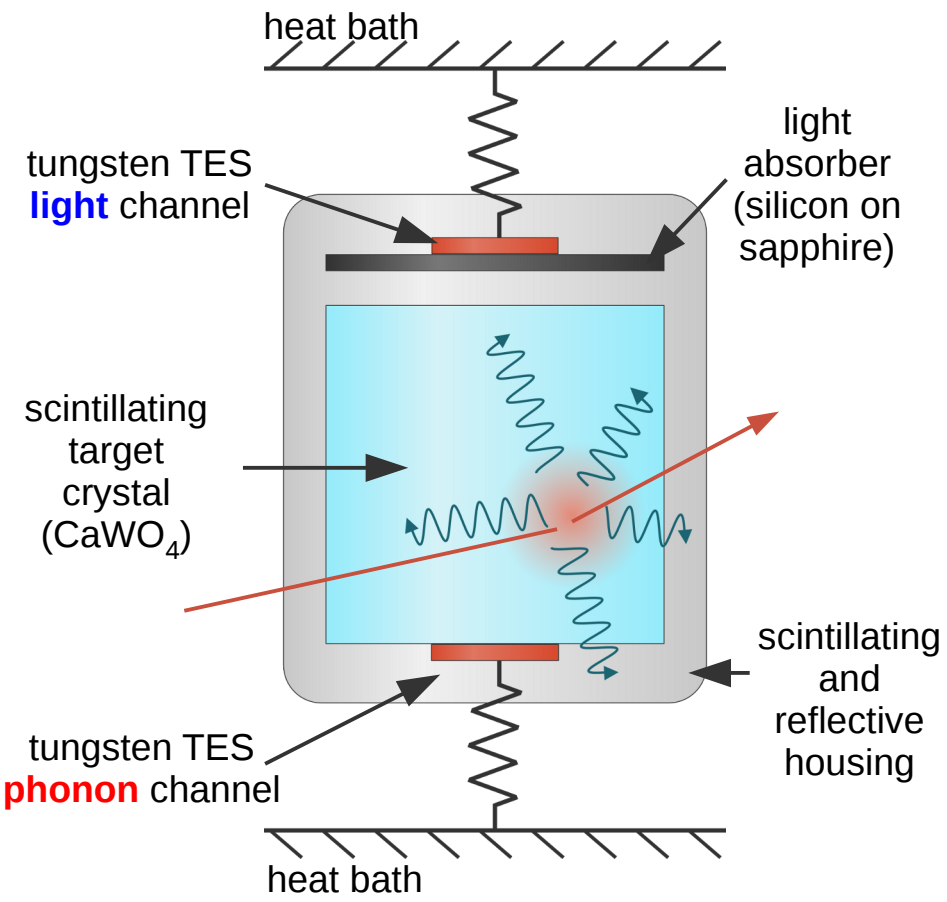
cryogenic particle detectors
operated in shielded cryostat located in the **LNGS underground lab** in Italy

(Laboratori Nazionali del Gran Sasso)





CRESST Detectors

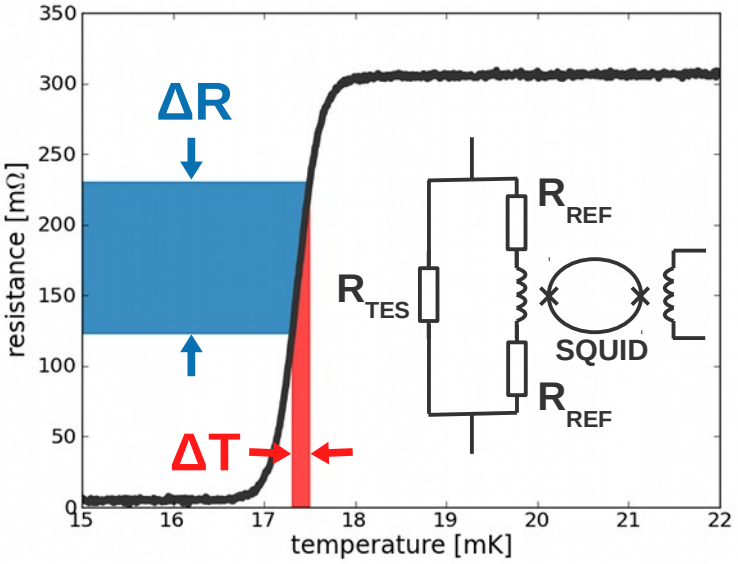


simultaneous read-out of two signals

phonon channel – measures **deposited energy** independent of particle type

light channel – different response for signal and background events

Transition Edge Sensors (TES)



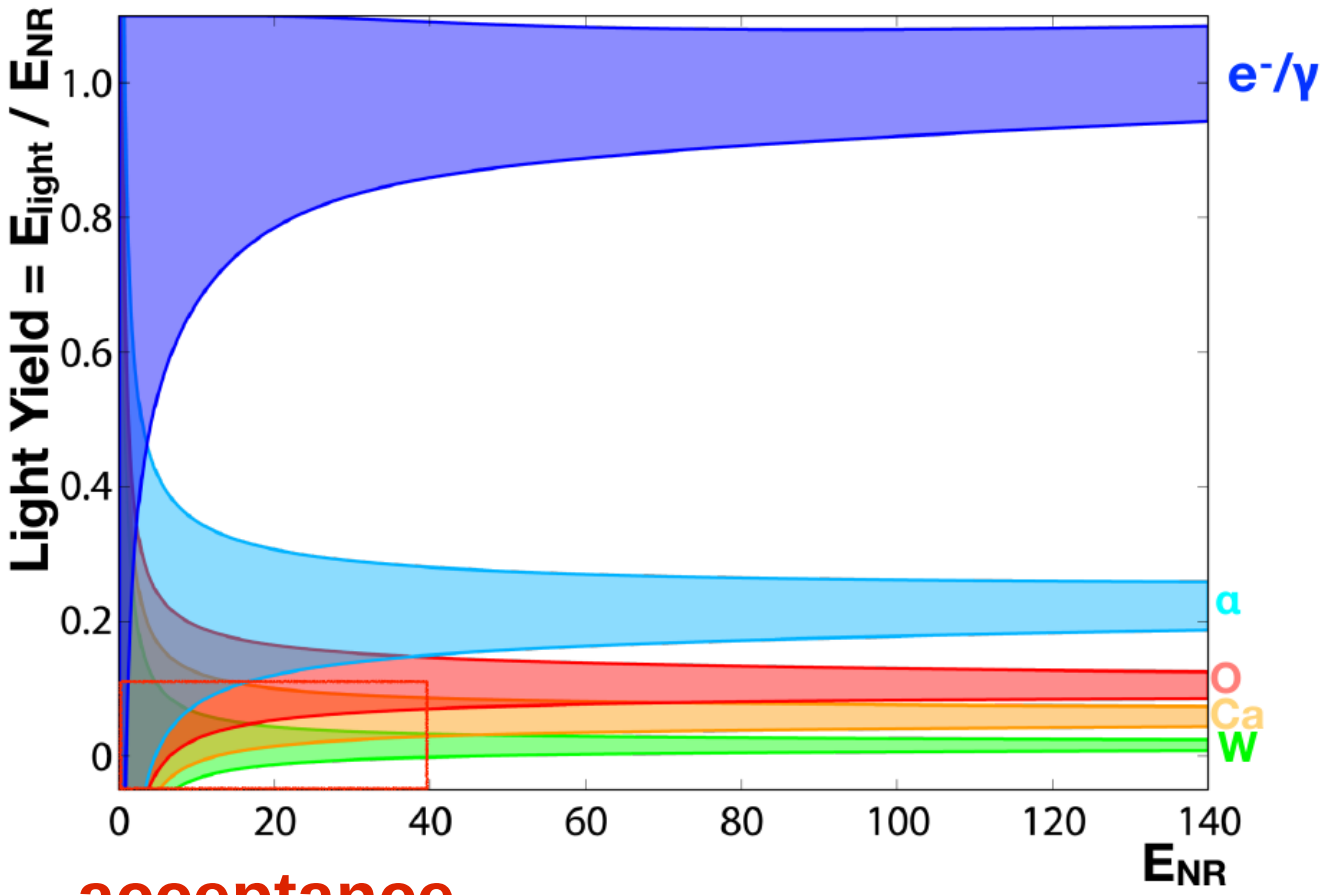
Signal-Background Discrimination

combination of light and phonon signals allows to **reduce backround**

nuclear recoils produce **less light** than e^-/γ background

width of bands is dominated by light detector resolution

bands are less separated at low energies



acceptance region

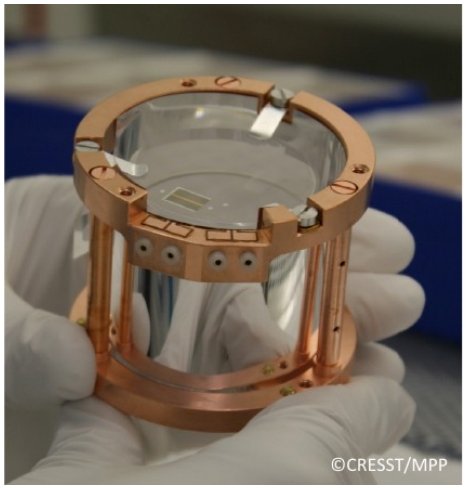
CRESST-II Results

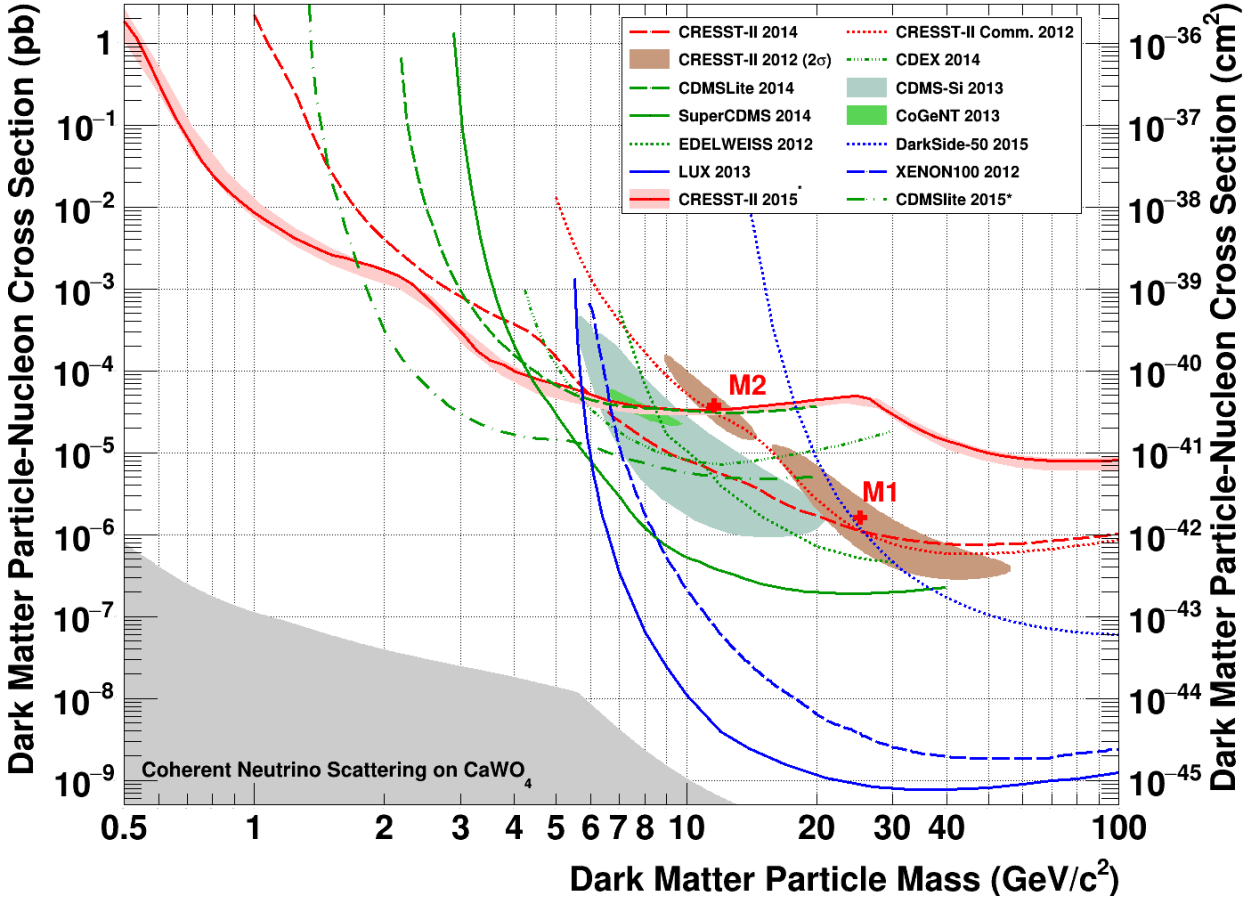
EPJ C **76** (2016) 25

detector “Lise”

- m = 300 g
- E_{thr} = 307 eV
- exposure 52 kg days

exploring new parameter space between **0.5 GeV/c²** **and 1.7 GeV/c²**

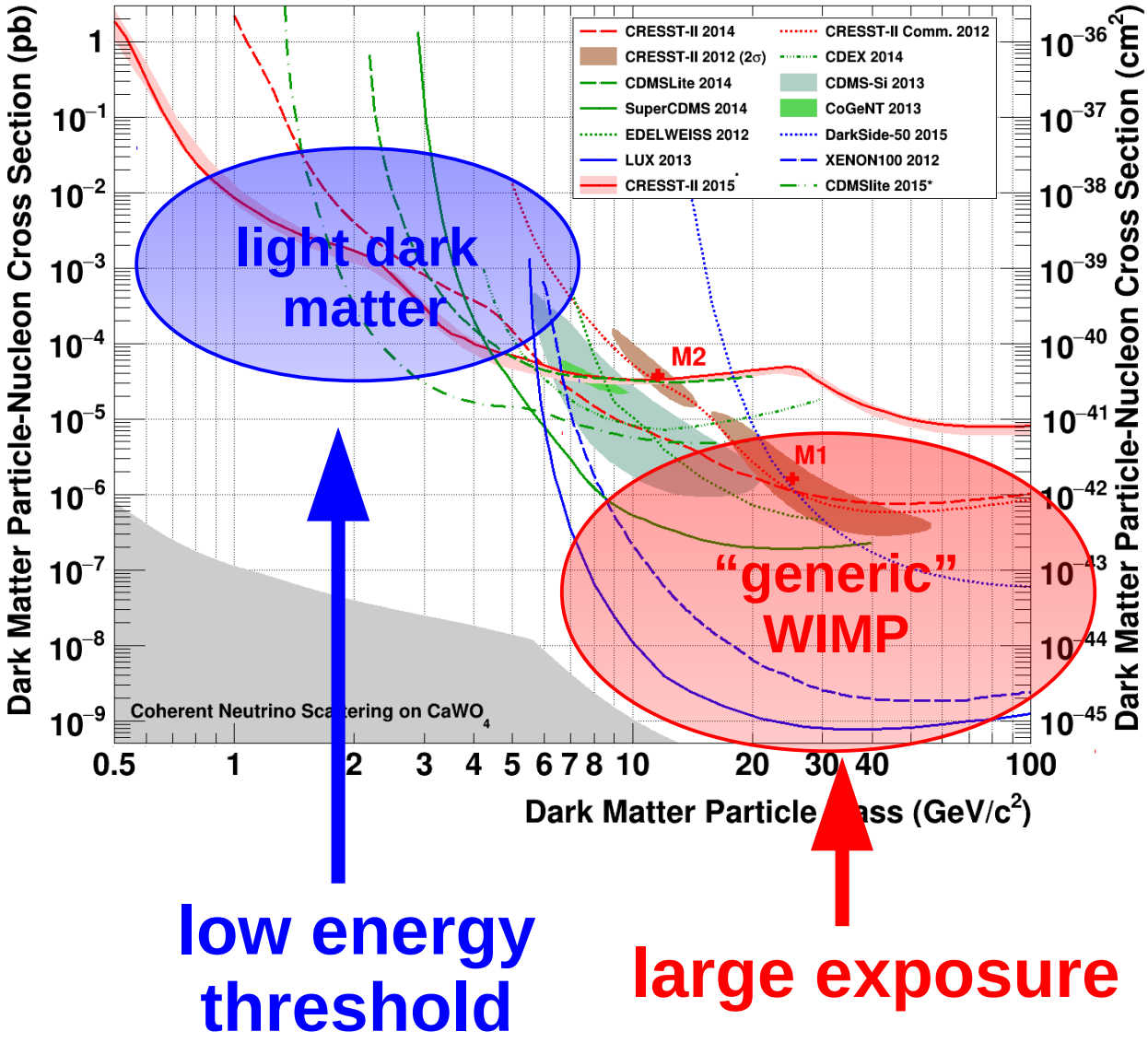




CRESST-II Results

EPJ C **76** (2016) 25

different mass ranges have **different requirements** on detector technology

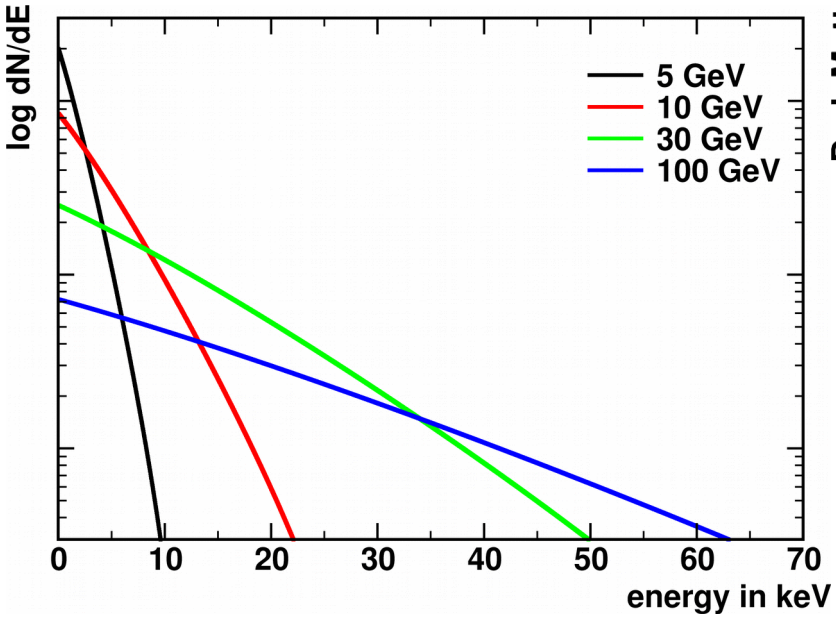


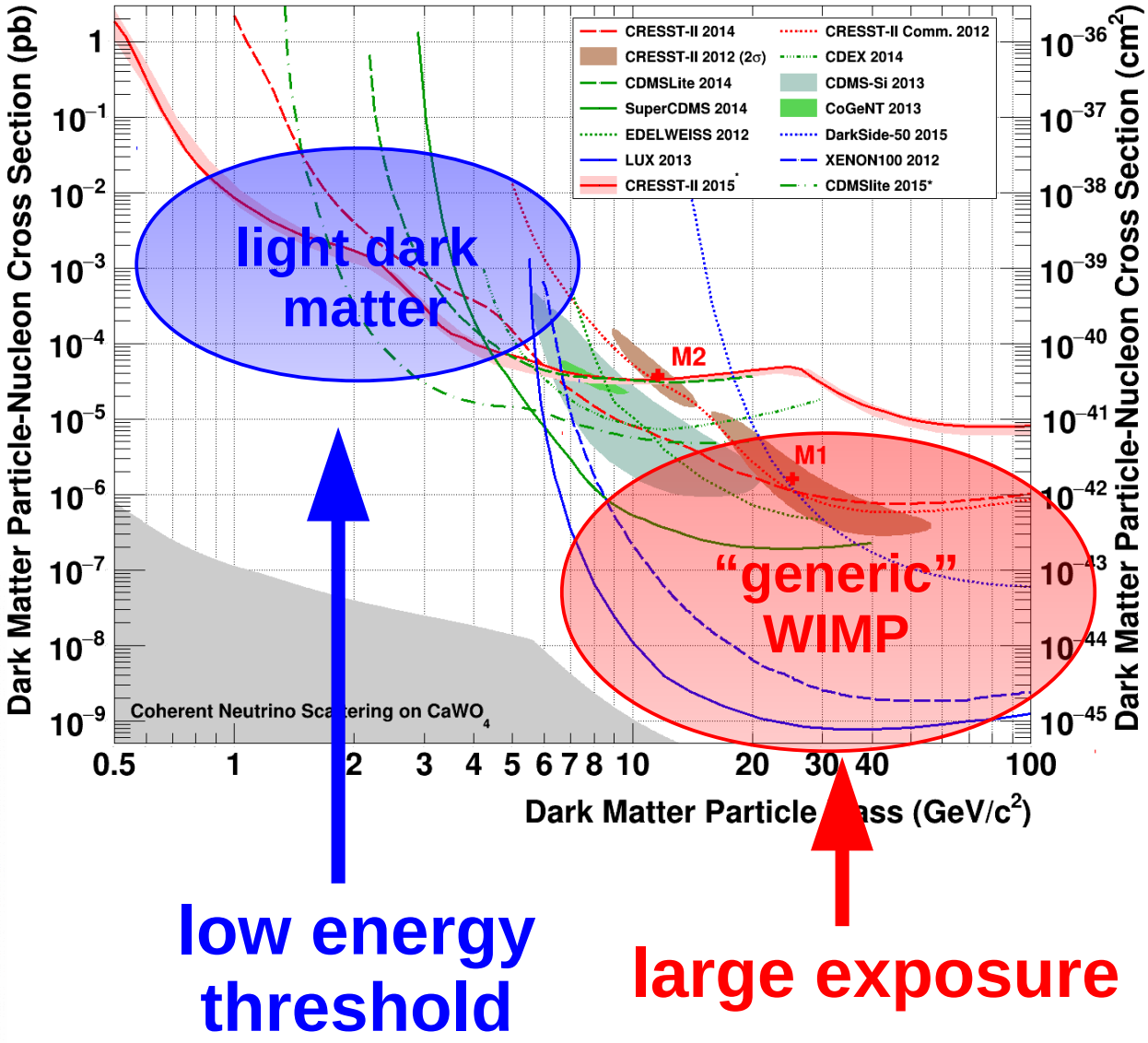
CRESST-II Results

EPJ C **76** (2016) 25

different mass ranges have **different requirements** on detector technology

light dark matter requires **low energy threshold**



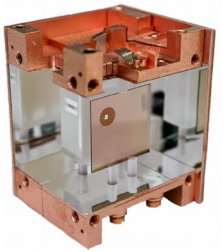


CRESST-III Results

CRESST-III Detectors

CRESST-II (TUM-40)

- (40x40x40) mm³
- mass ~250 g
- threshold ~600 eV



CRESST-III (design goals)

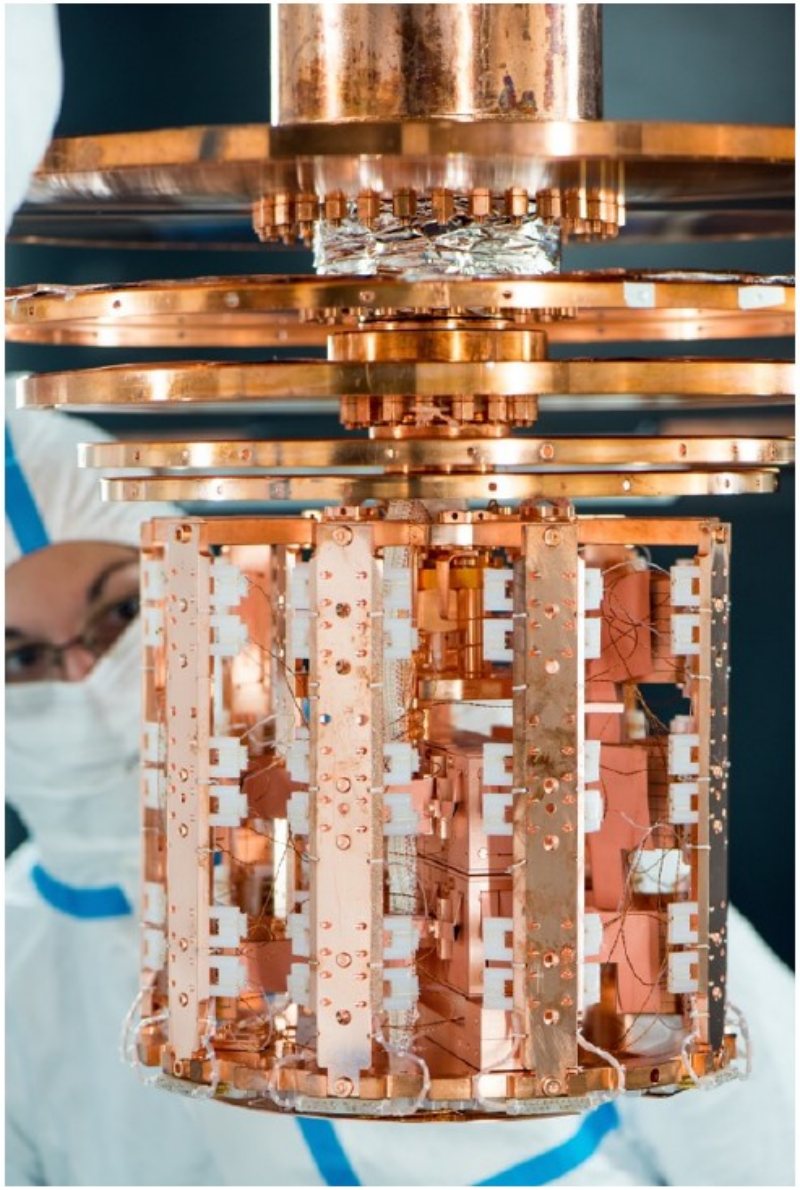
- (20x20x10) mm³
- mass ~25 g
- threshold ~100 eV

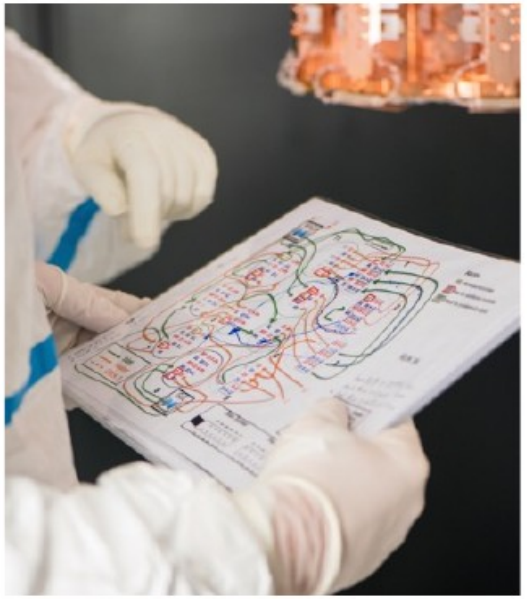
detector layout optimized for detection of light dark matter

reduced mass for lower energy threshold

design goal: E_{thr} < 100 eV

CRESST-III Status





March 2016

- 10 modules installed with 24 g each

May 2016

- successful cool-down

July/August 2016

- calibration campaign completed

end of August 2016

- physics run started

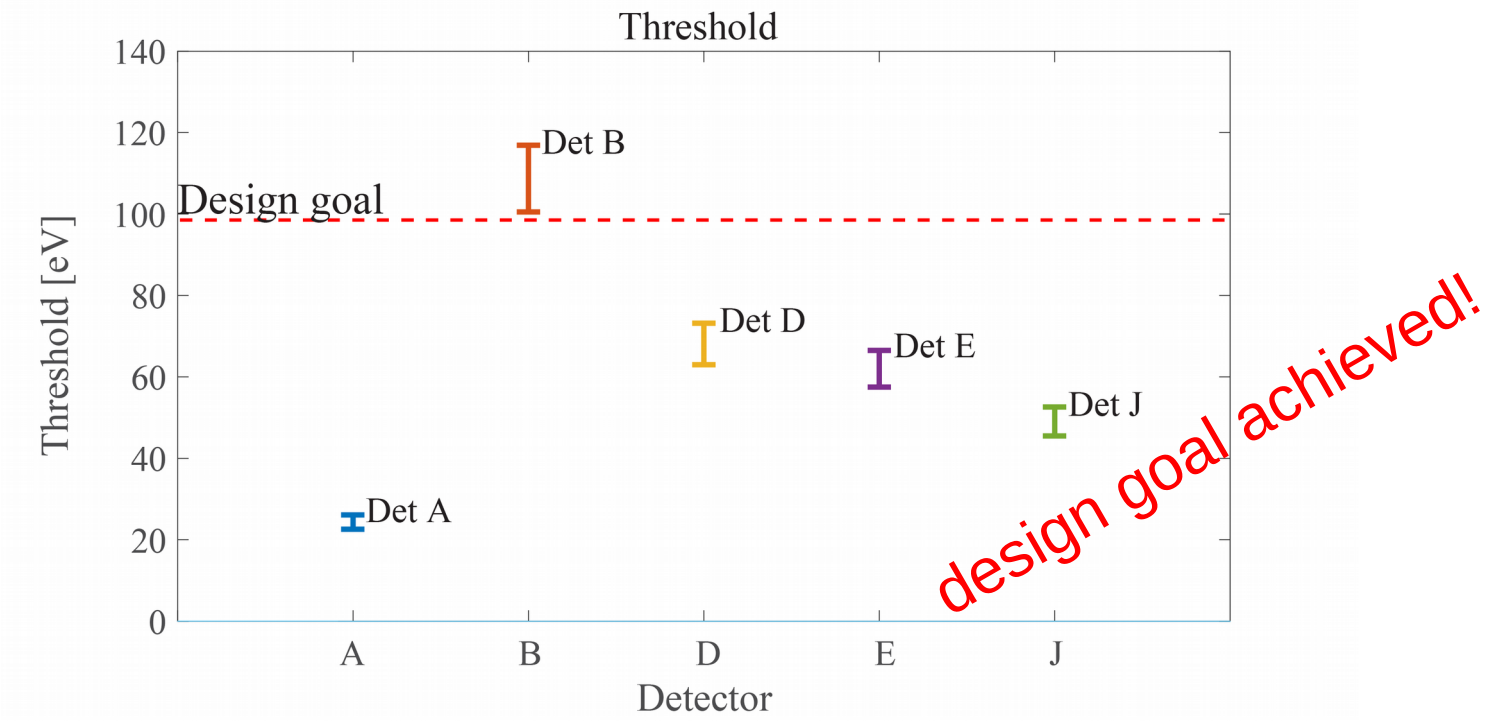
Energy Thresholds

new DAQ system installed in parallel to the old one

continuously records full data stream

→ allows for **offline software trigger**

→ even lower thresholds than with hardware trigger



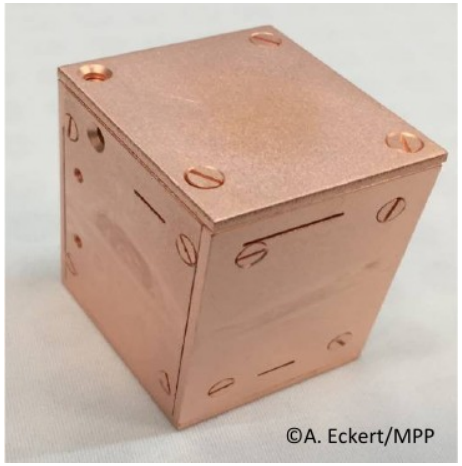
First Results – Detector A

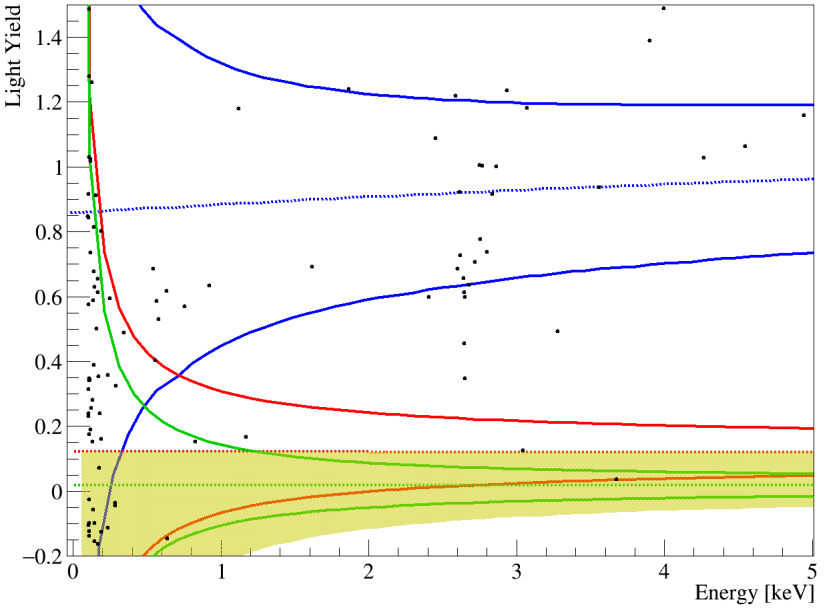
so far only one detector fully analysed and unblinded

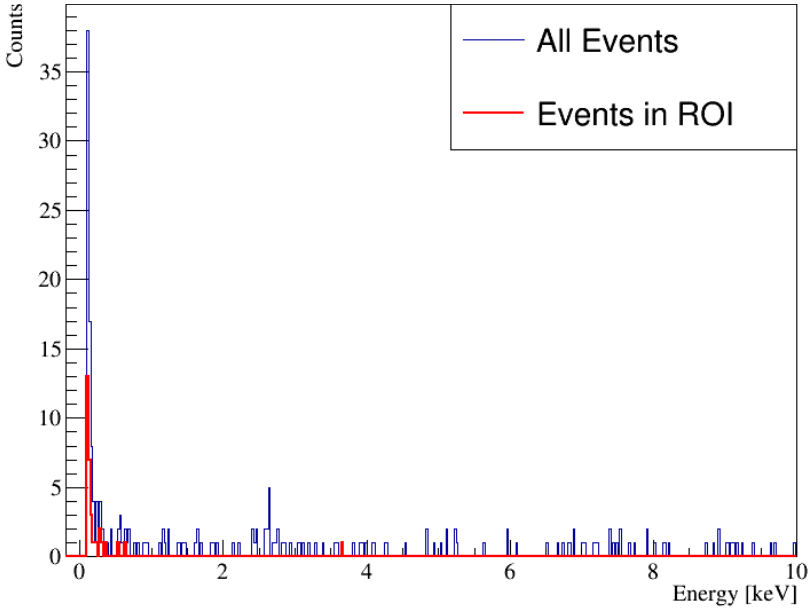
software trigger not yet used

analysis **threshold set at 100 eV** (clearly above hardware threshold)

data collected between **10/2016** and **07/2017**
→ exposure **2.39 kg days**



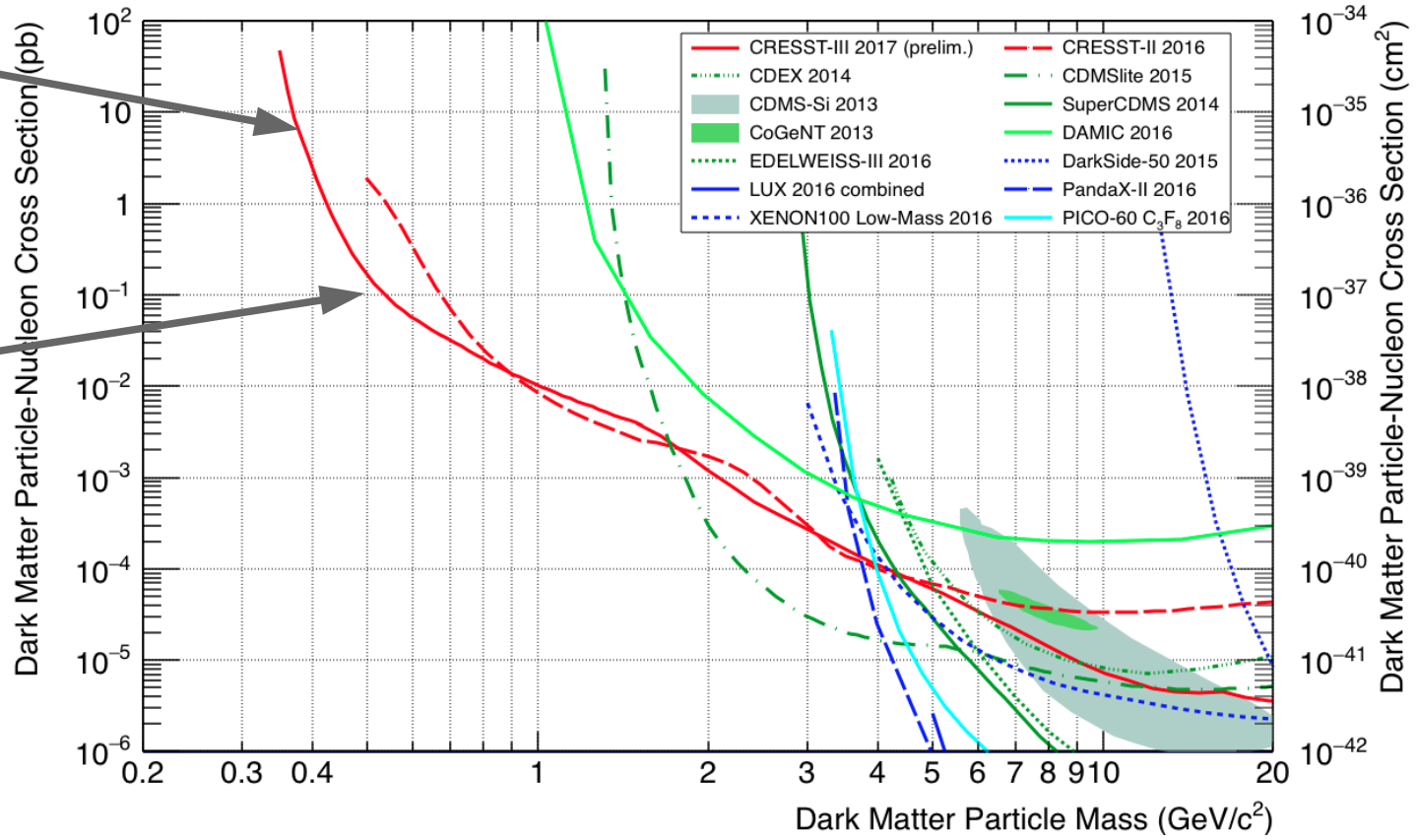




First Results – Detector A

extending reach to **0.35 GeV**

~ factor 10 improvement at 0.5 GeV

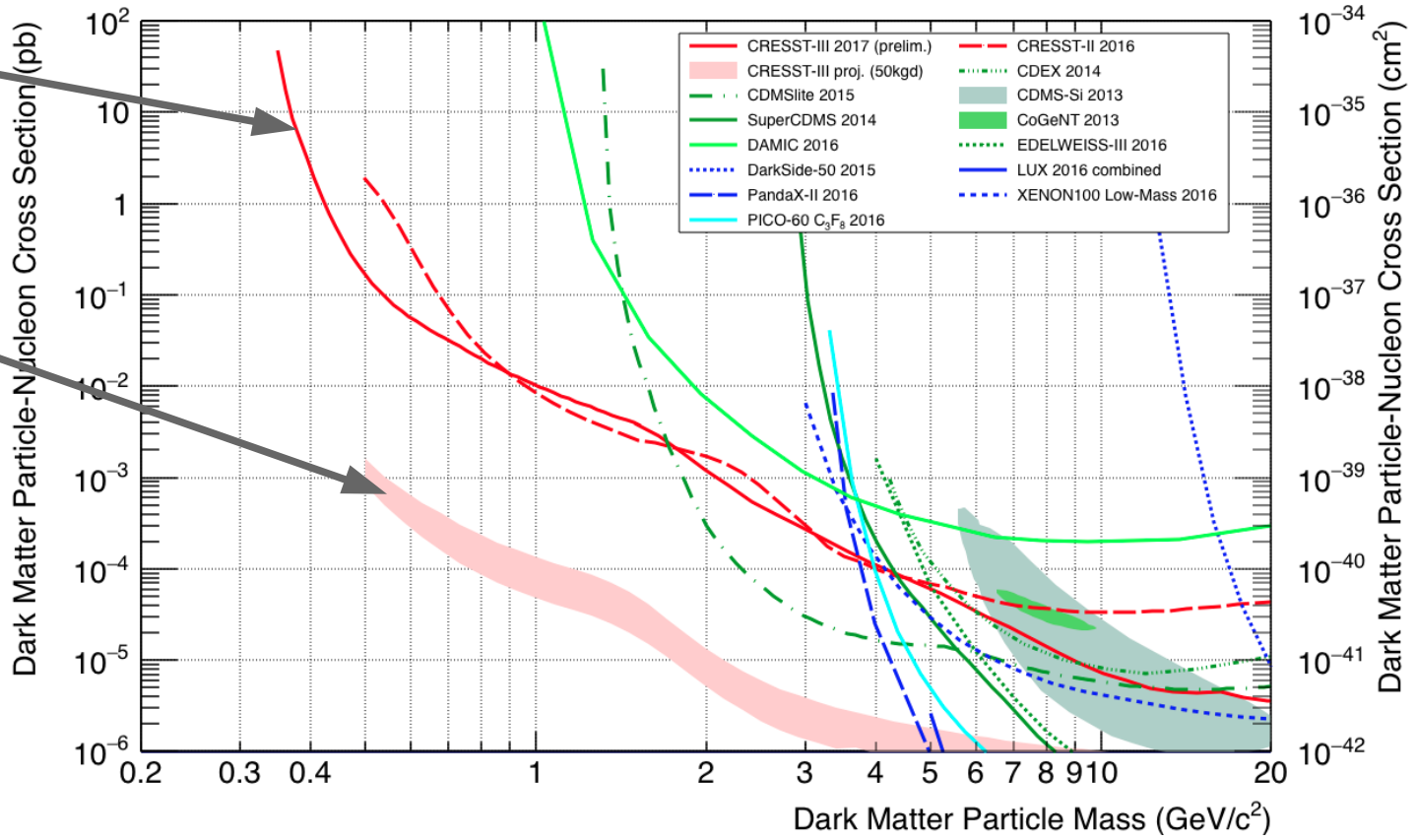


First Results – Detector A

2.39 kg days

50 kg days (projected)

arXiv 1503.08065



still room for improvement:

- more detectors and more statistics
- even lower thresholds possible

Conclusion

- **CRESST** searches for light dark matter with cryogenic detectors made out of $CaWO_4$
- **CRESST-III** running **10 detectors** since August 2016
- **new CRESST-III detectors** have energy thresholds for nuclear recoils **< 100 eV**
- preliminary analysis of 1 detector shows great potential to explore **light dark matter**
- analysis of other detectors and lower thresholds ongoing

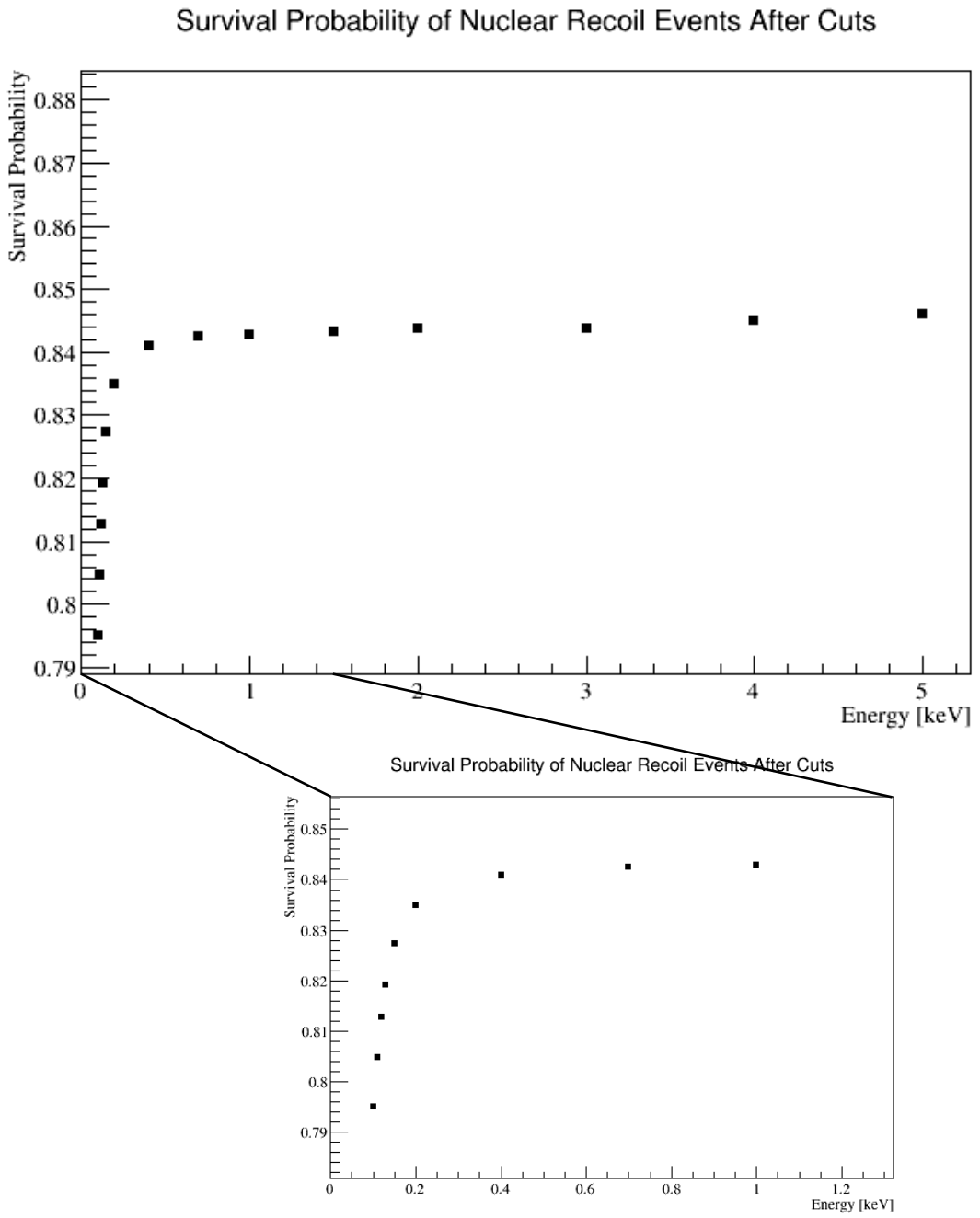
BACKUP

Cut Acceptance

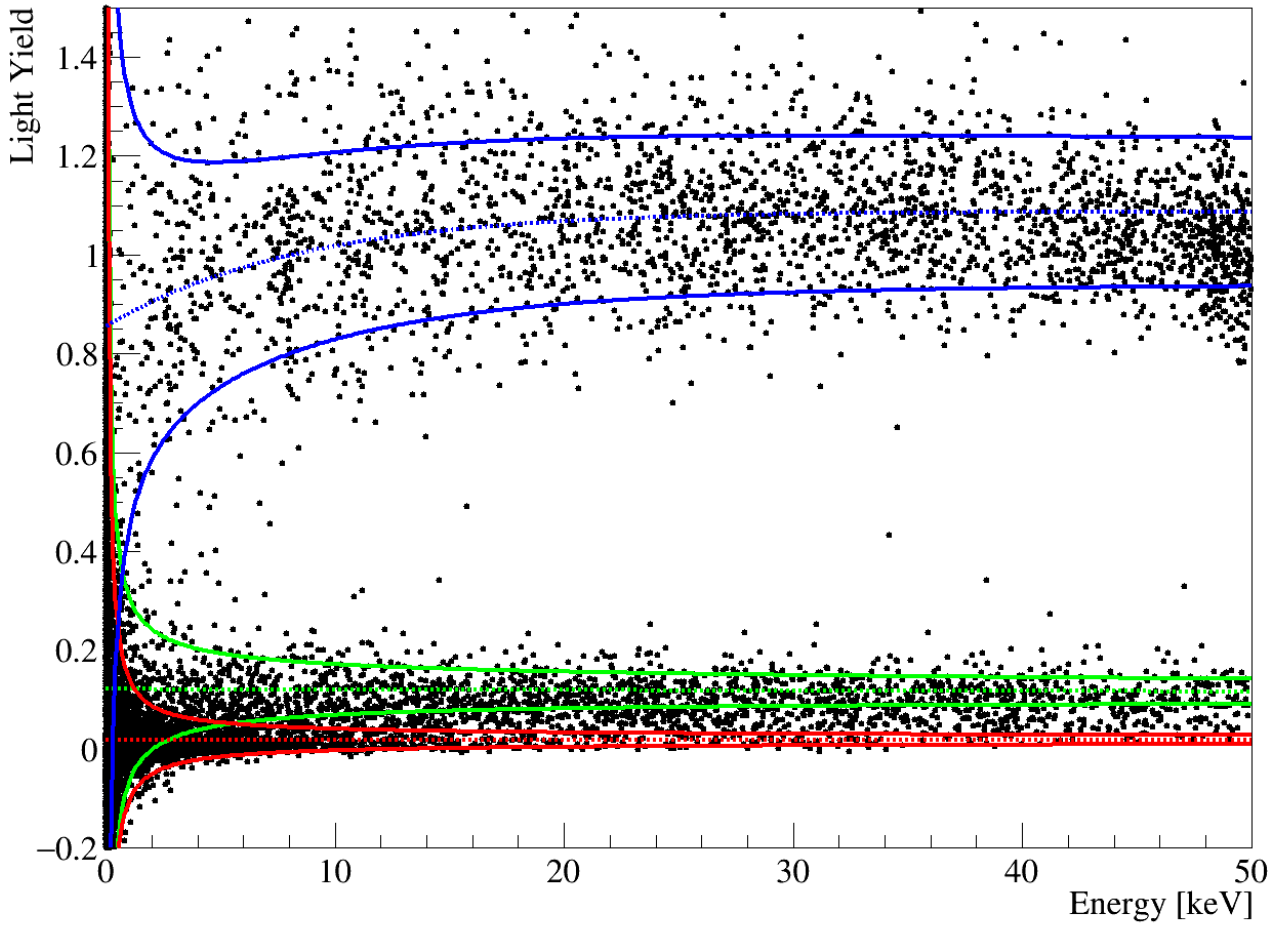
pulses where correct amplitude reconstruction cannot be guaranteed are removed by cuts

cuts are designed on a small non-blind training set (20% of full exposure) not included in final exposure

energy-dependent cut acceptance is taken into account in dark matter analysis



Neutron Calibration



position and width of fitted nuclear recoil bands can be validated with data from neutron calibration

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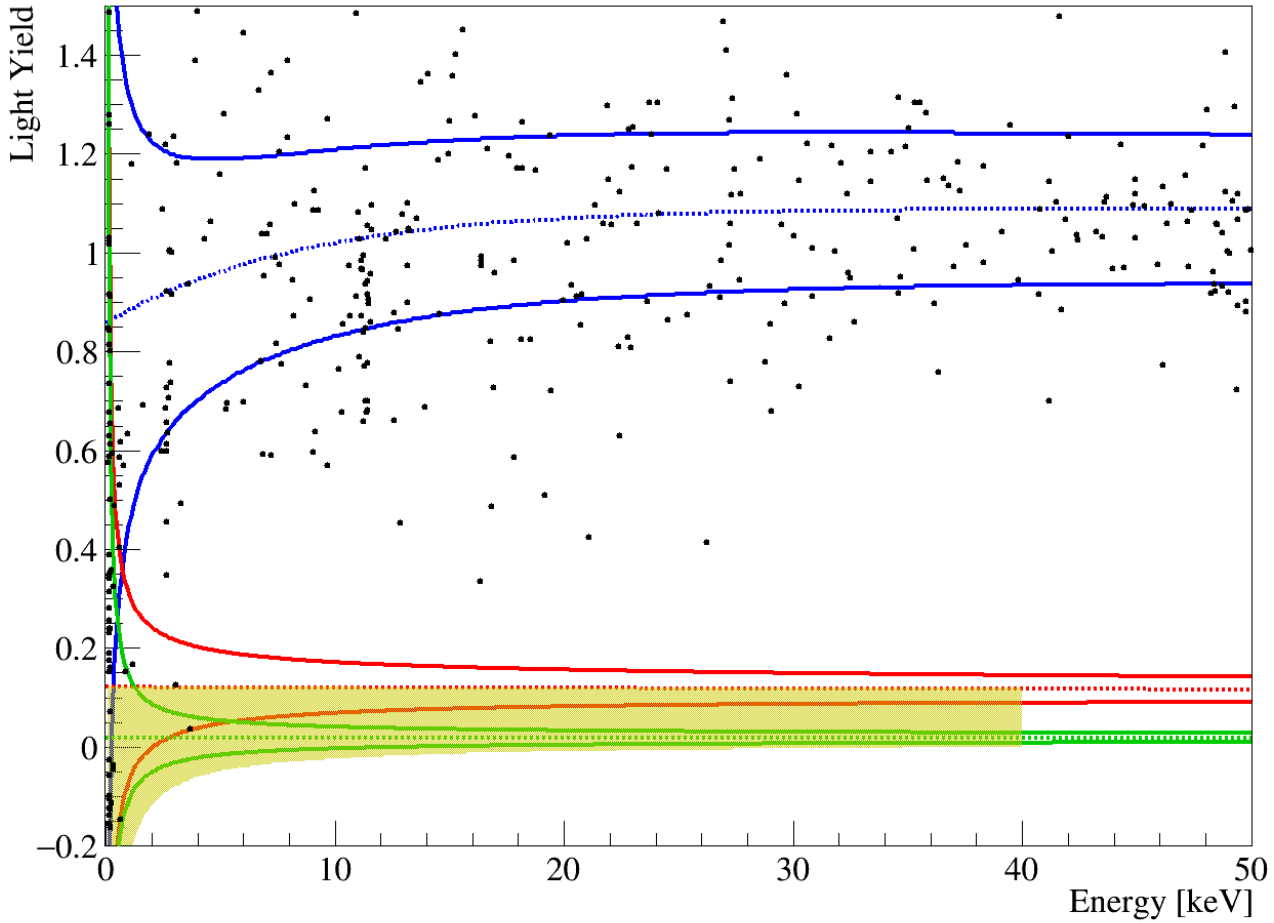

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