Wright Laboratory

WISCONSIN ICECUBE PARTICLE ASTROPHYSICS CENTER

THE UNIVERSITY of WISCONSIN MADISON

DM-Ice: Prototype Performance and Full Scale Outlook

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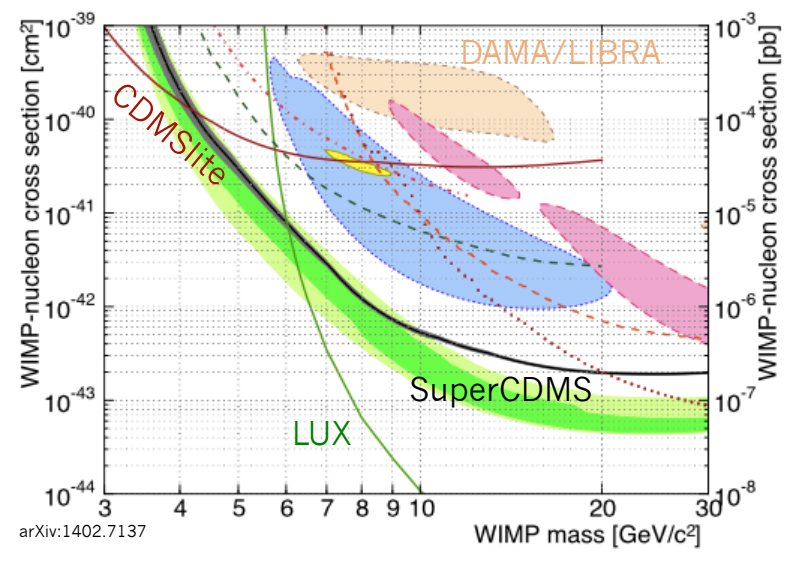
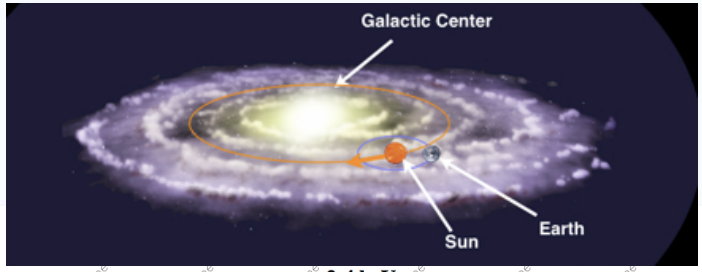
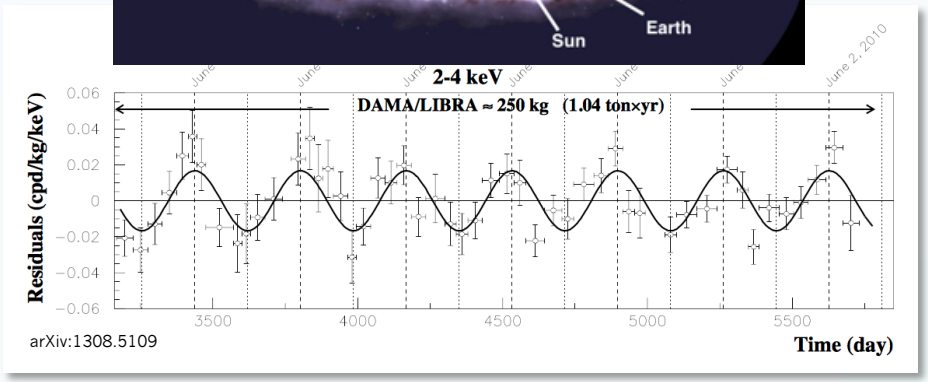
for the DM-Ice Collaboration
IPA, May 5, 2015

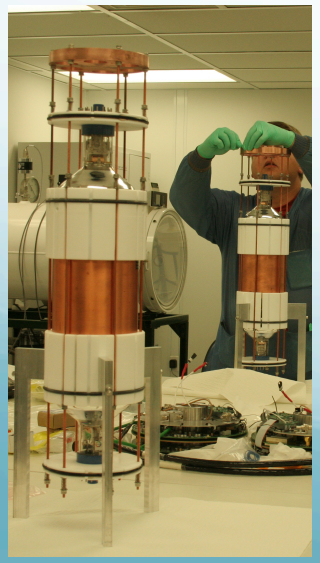
DM-Ice

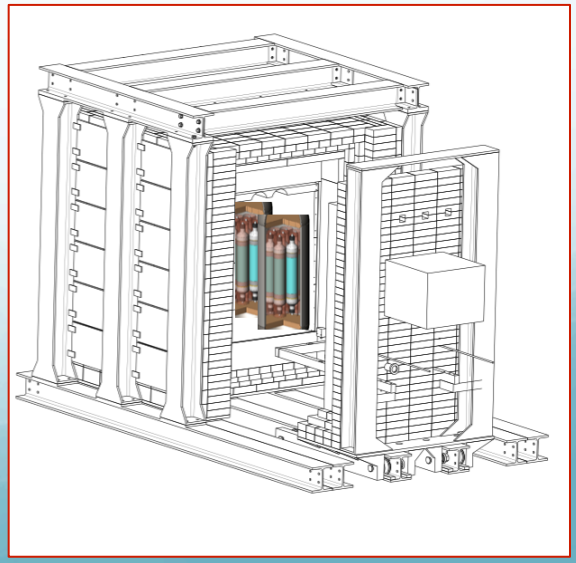






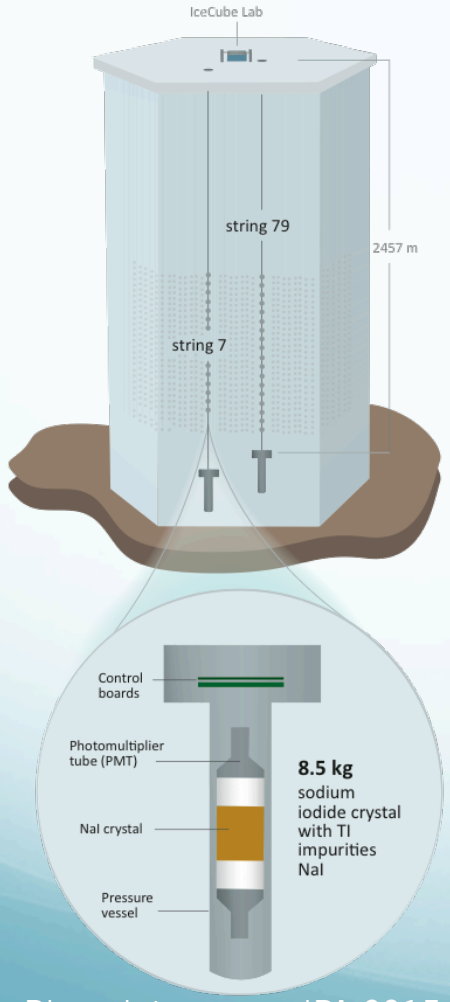
Goal: Unambiguously test DAMA's claim of dark matter detection.



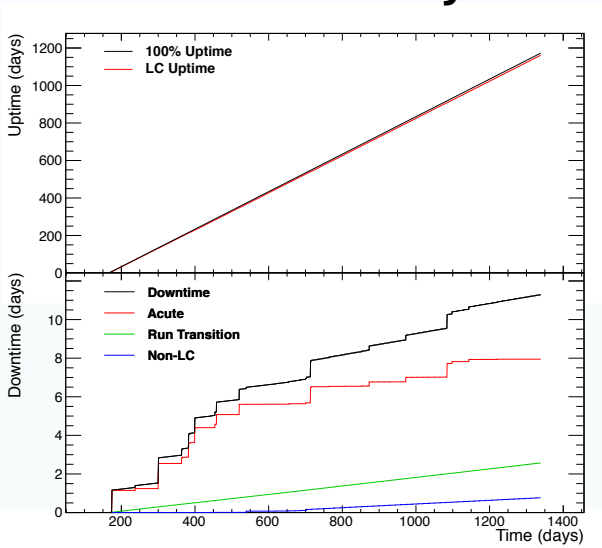


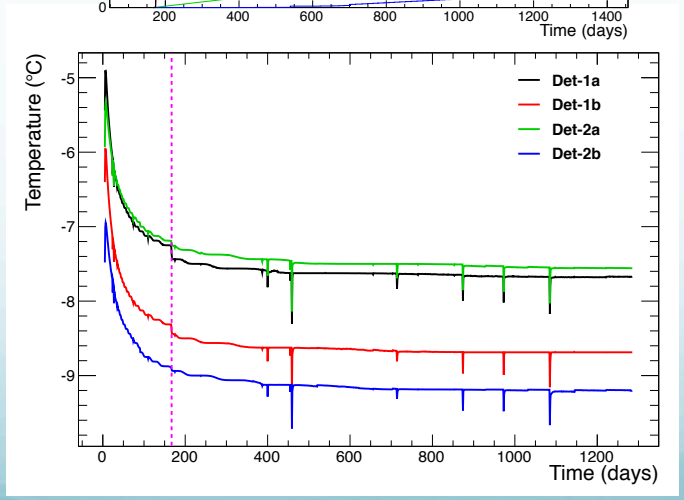
DM-Ice17

DM-Ice17 and IceCube



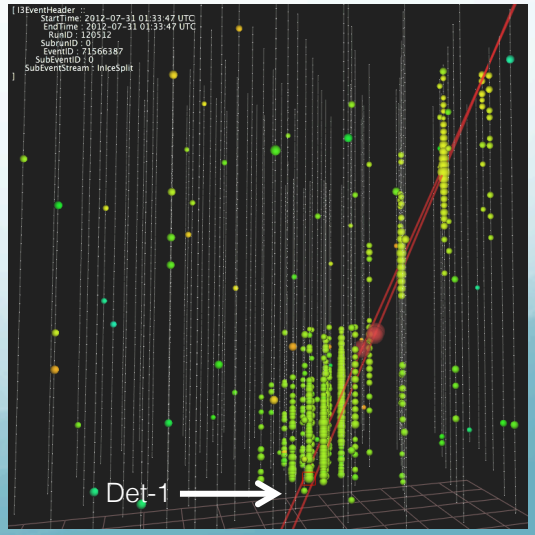
Detector Performance and Stability





DM-Ice17 Attributes

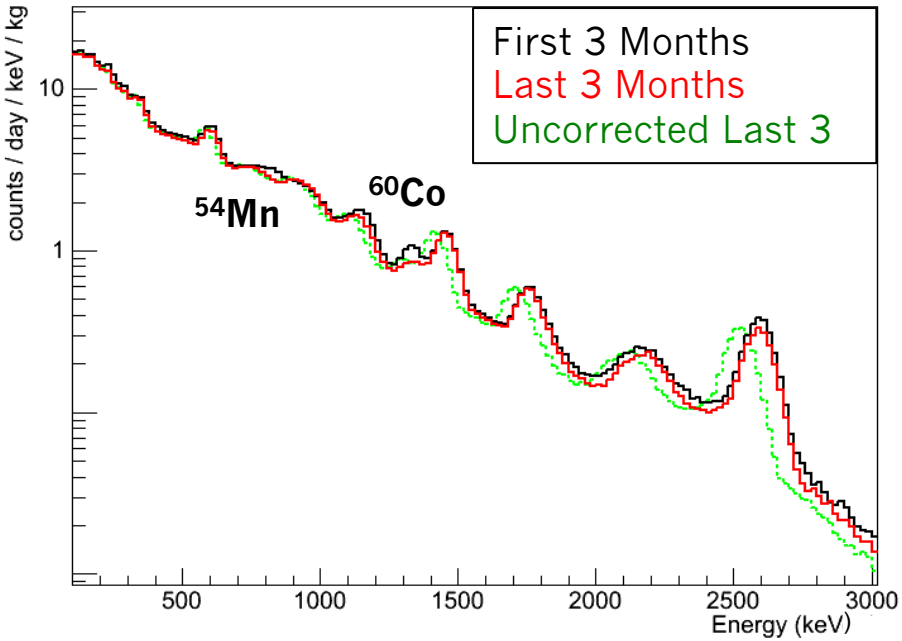
- Two 8.47 kg test crystals
- Deployed at the south pole in December 2010.
- 2200 m.w.e. overburden
- Essentially continuous (>99% uptime) physics data taking for 3.5 years
- Temperature stable to <0.3° C over the entire run
- Muon coincidence with IceCube
  - *See Antonia's talk next*



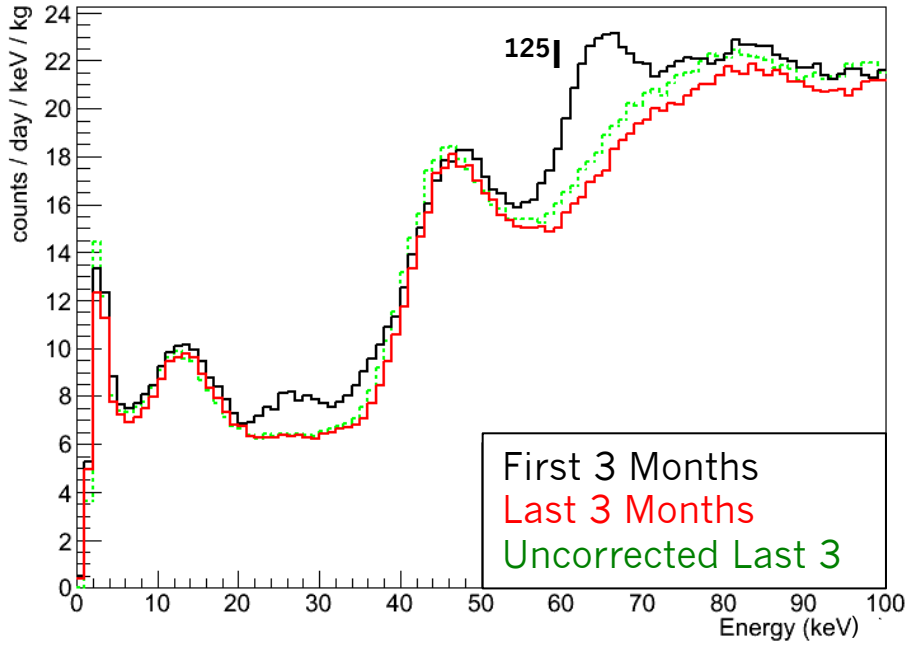
DM-Ice17 Calibration

- Calibration performed via internal contamination lines.
- Short lived isotopes decay away providing a strong verification of this calibration.

High Energy



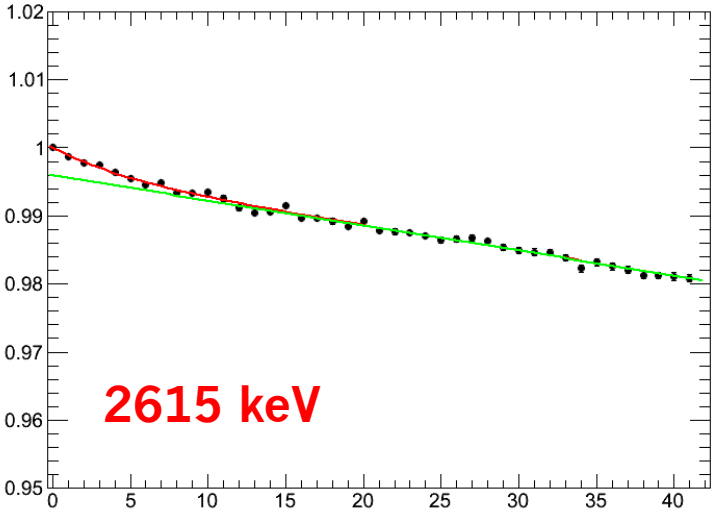
Low Energy

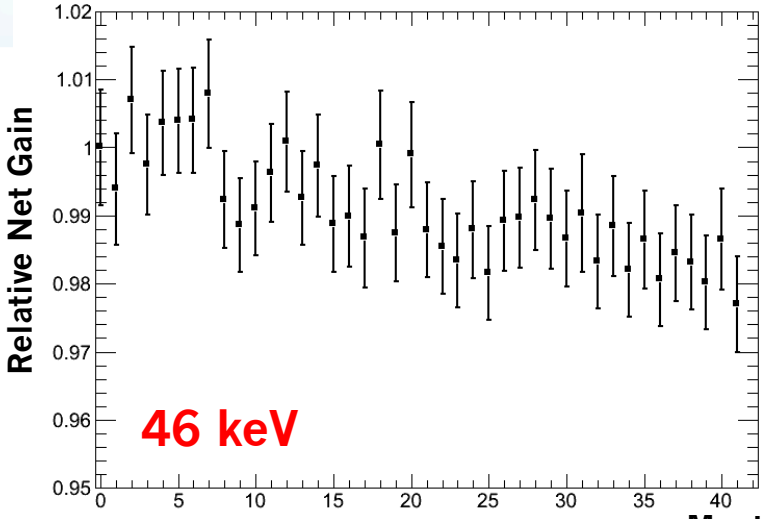


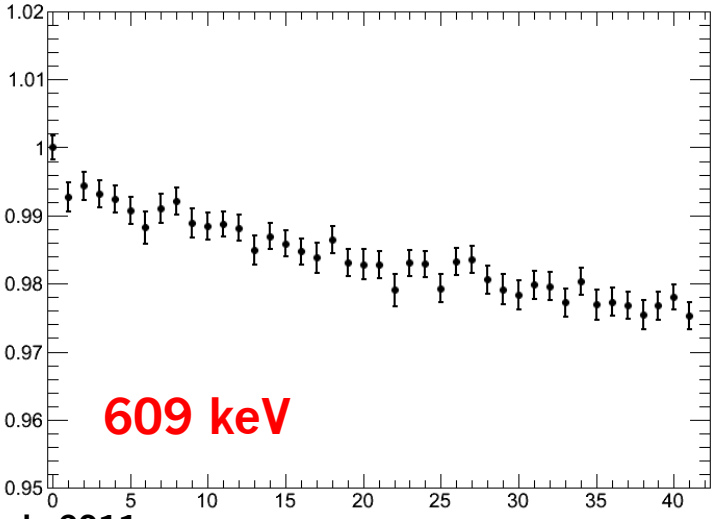
- We observe a small light loss, but this is corrected for with a time dependent energy calibration.

DM-Ice17 Calibration

- A general decreasing trend in apparent gain of ~2% over the 3.5 years is evident at all energies.
- At the highest energies, it appears that there are two different time constants involved.

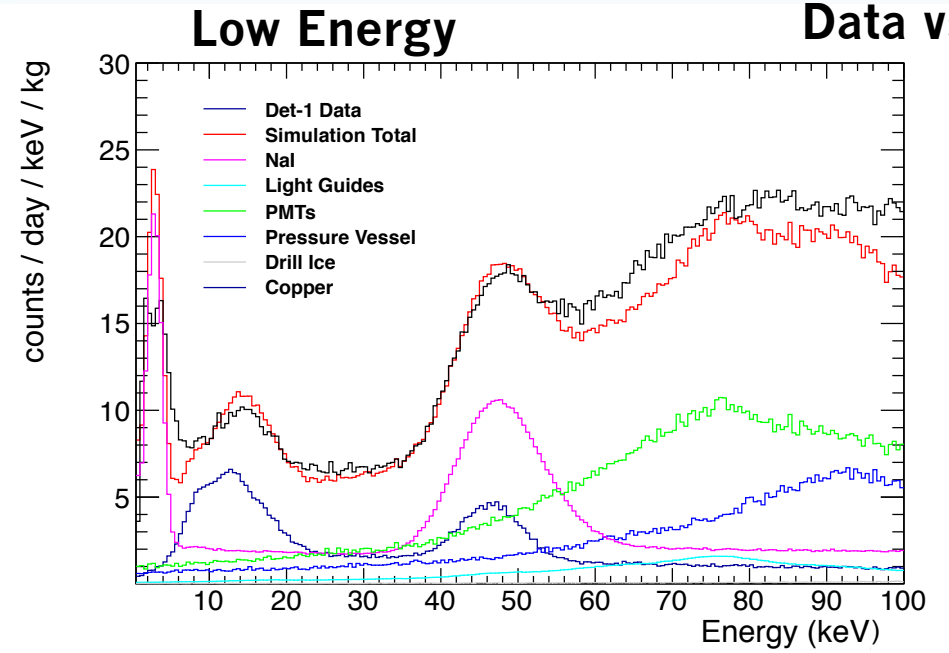


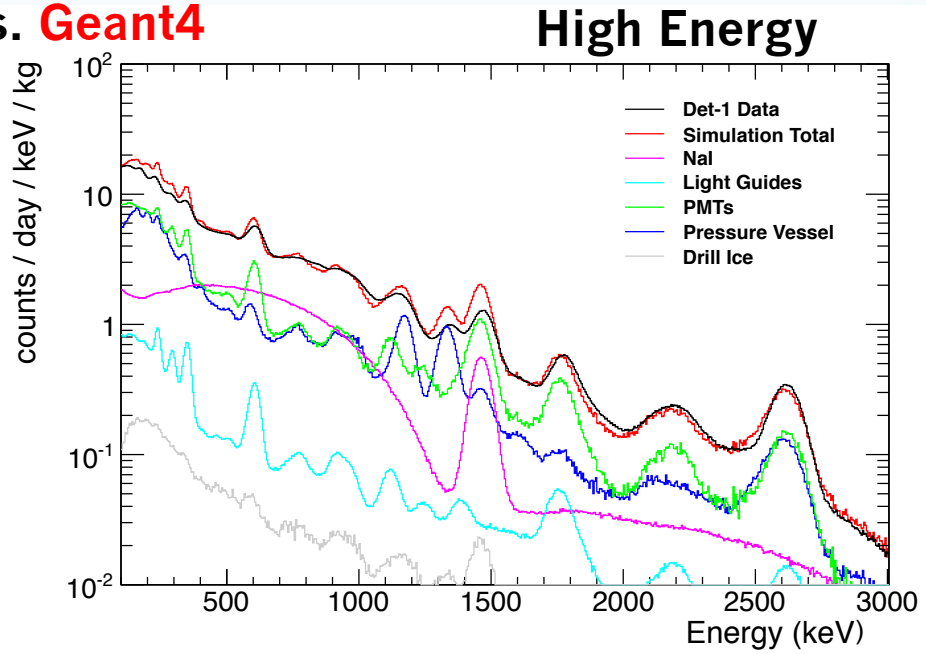




Background Model

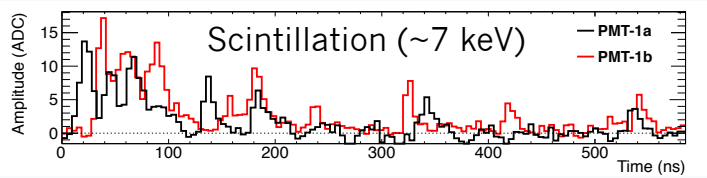
- Detector response and behavior are well predicted by the background model (from radio assay and Geant4).
- We are working on incorporating time dependent contamination rates accounting for short lived isotopes.





Identifying Noise

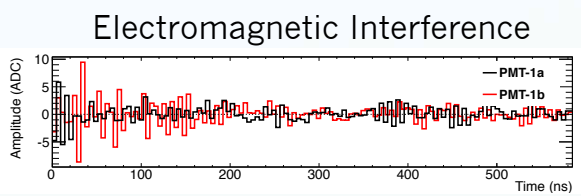
Signal

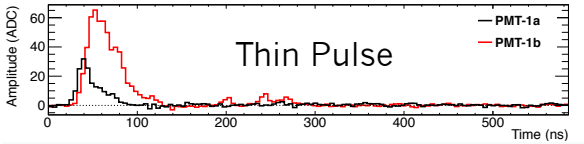


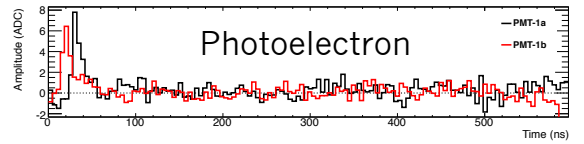
PMT-A waveform

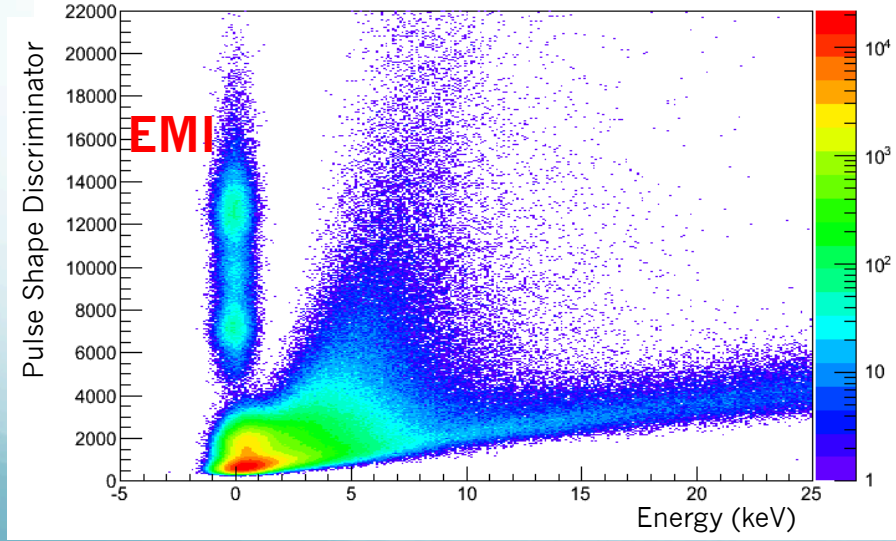
PMT-B waveform

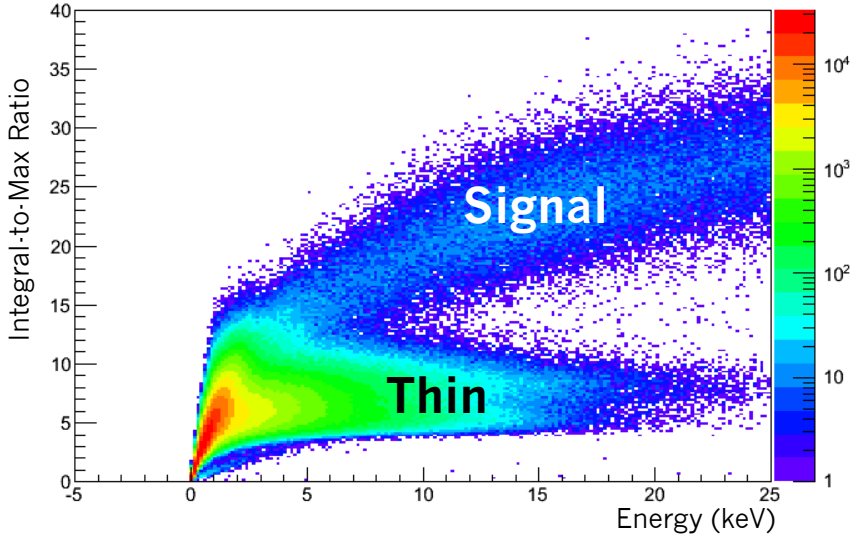
Noise



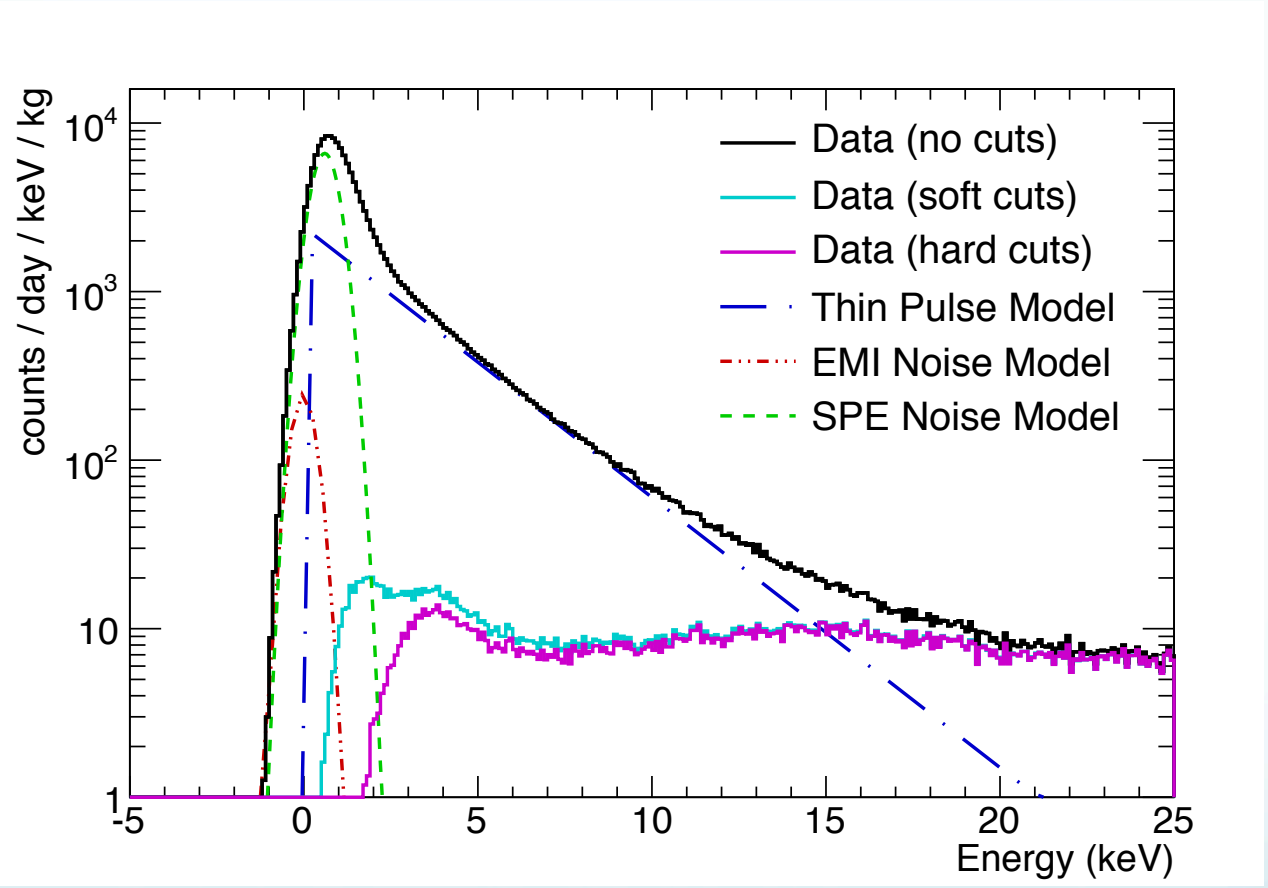








Noise Removal

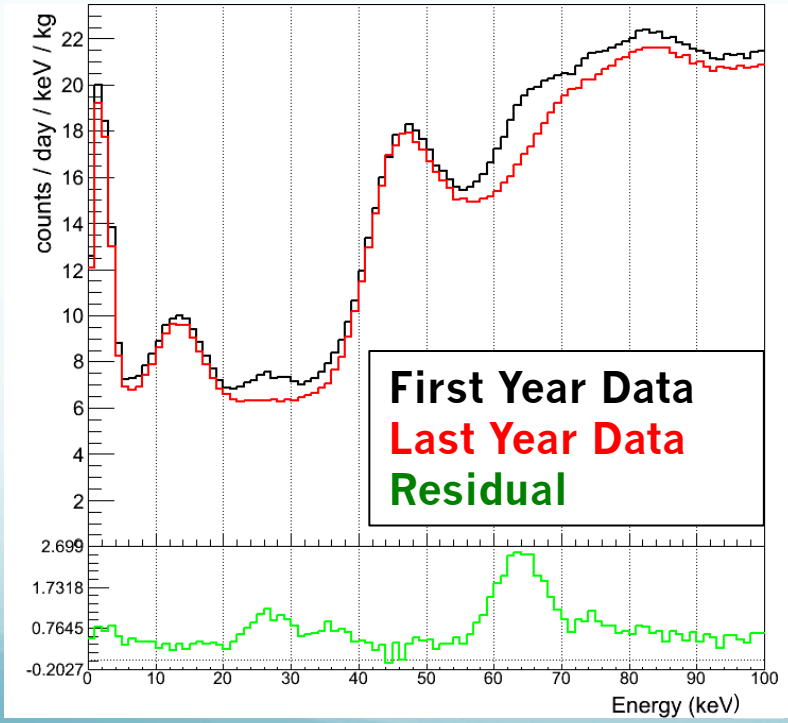


After cuts, the ^{40}K noise 3 keV noise peak is revealed, though ~50% of the peak is removed by the hard cuts.

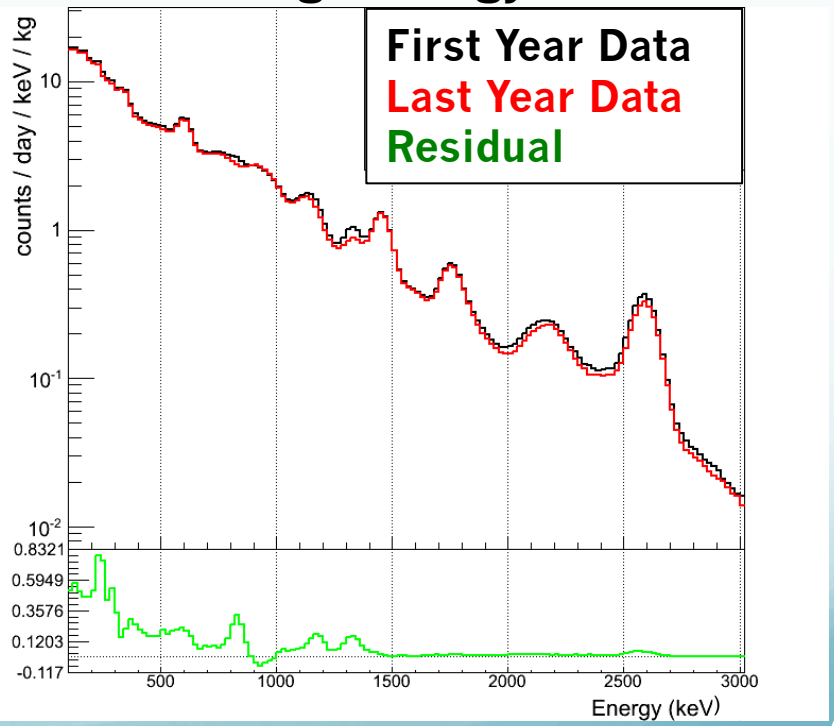
Time Varying Scintillation Rates

- Cosmogenically activated isotopes and broken decay chains in detector components lead to a time varying energy spectrum.
- The region of interest exhibits a non-insignificant rate decrease that is not well correlated with any of the short-lived isotopes explored thus far.

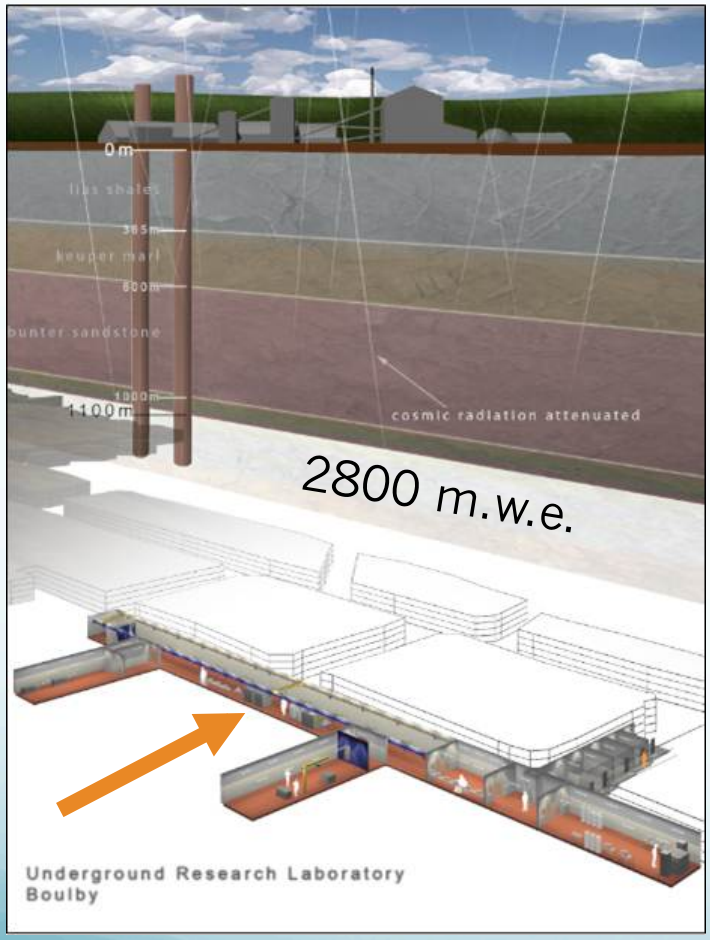
Low Energy



High Energy

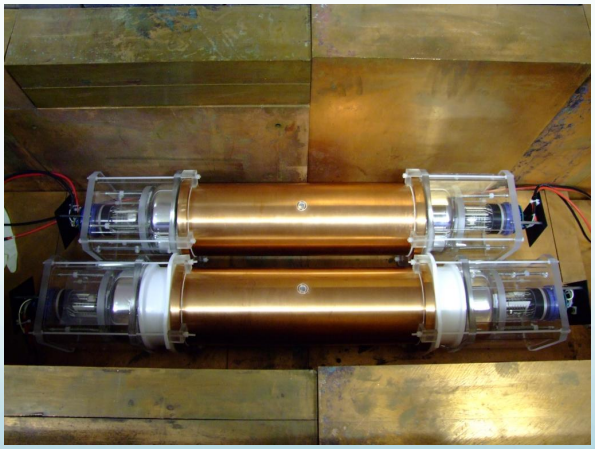


Next Step: DM-Ice37 @ Boulby



Two 18.3 kg test crystals were deployed at the Boulby Underground Laboratory in Dec' 2014.

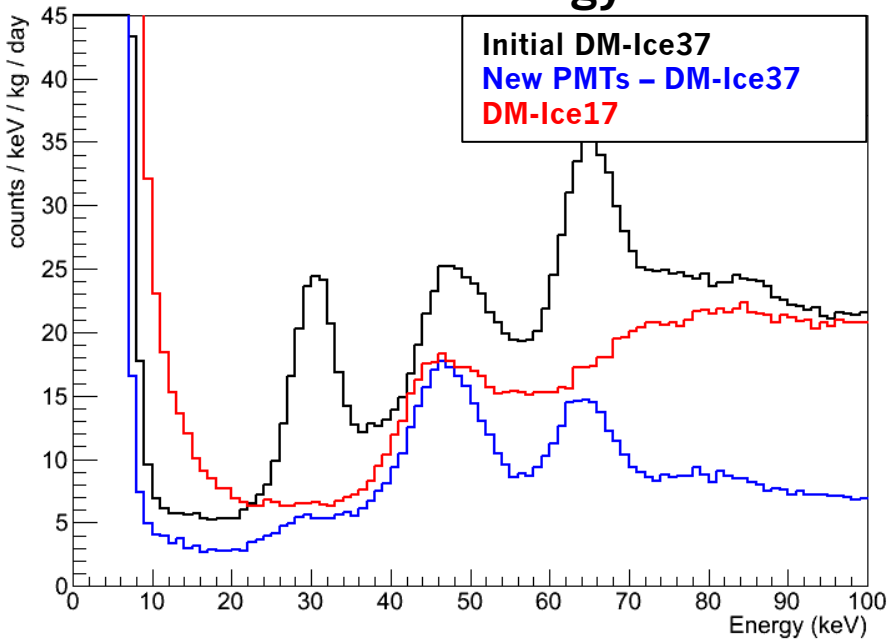
Crystals	^{40}K [mBq/kg]	^{238}U chain-^{210}Pb [μBq/kg]	^{232}Th chain-^{228}Ra-^{208}Tl
DM-Ice17	17	1500	160
DM-Ice37	<3	2100	--
DAMA	0.6	24.2	8.5
Crystal R&D	1.5	188	2



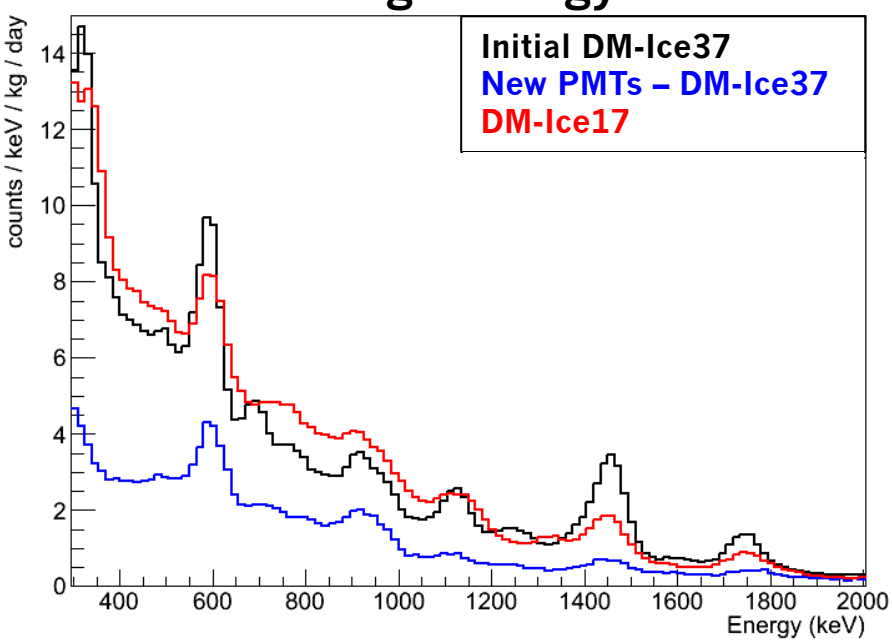
DM-Ice37 – First Data

- Initial installation competitive with DM-Ice17 backgrounds for the full detector assembly.
- Newer PMTs and cleaner assemblies were installed after an initial one month run, reducing overall backgrounds by a factor of ~2.

Low Energy

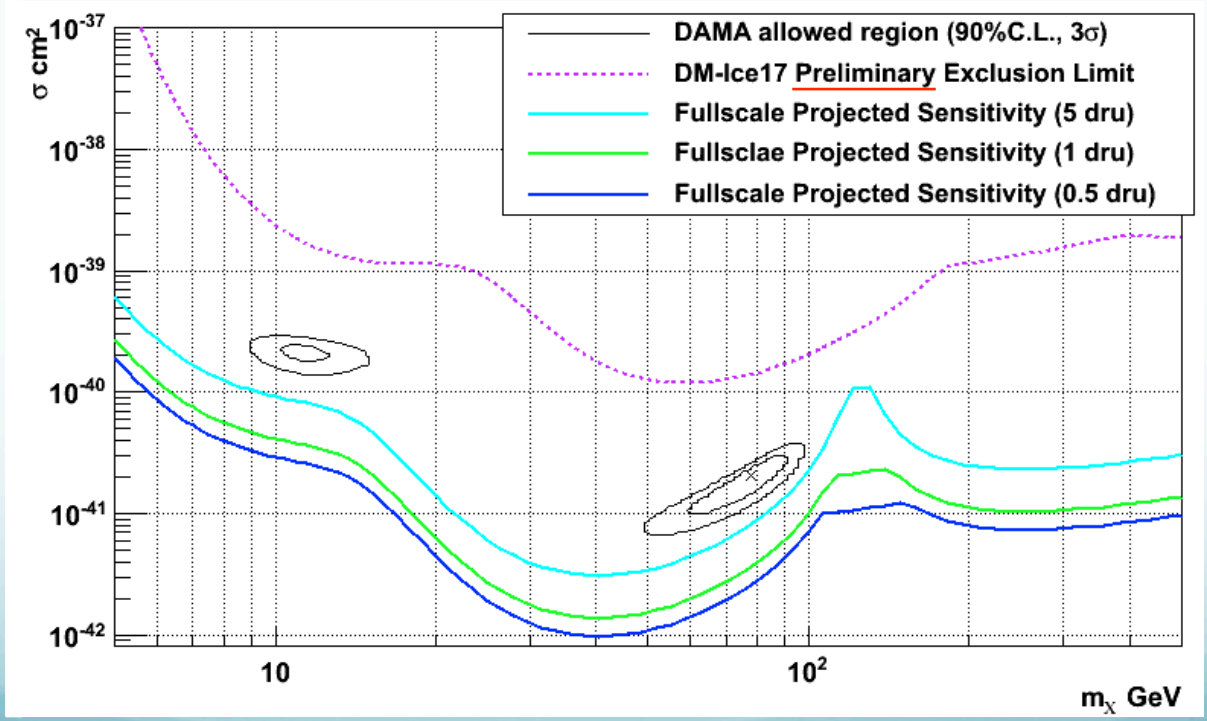


High Energy



Projected Sensitivity

- Long-term DM-Ice17 data being analyzed, in particular exploration of the low energy rate decrease.
- With higher mass and lower backgrounds, full scale DM-Ice will be able to provide a strong prove of the DAMA-favored dark matter region.



Summary

- DM-Ice17
  - Successfully deployed and operated continuously for **3.5 years**
  - Demonstrated the feasibility of deploying and remotely operating direct detection dark matter experiments in the South Pole ice
  - The ice is incredibly low in background, and the environment is very stable.
  - 4-6 keV backgrounds are 7x higher than DAMA
  - ^{40}K contamination 30x larger than DAMA
- DM-Ice37
  - currently operating at Boulby
  - factor of 15 reduction in ^{40}K compared to DM-Ice17
  - on-going R&D with crystal growers and NaI powder vendors to further reduce ^{40}K & U/Th contamination