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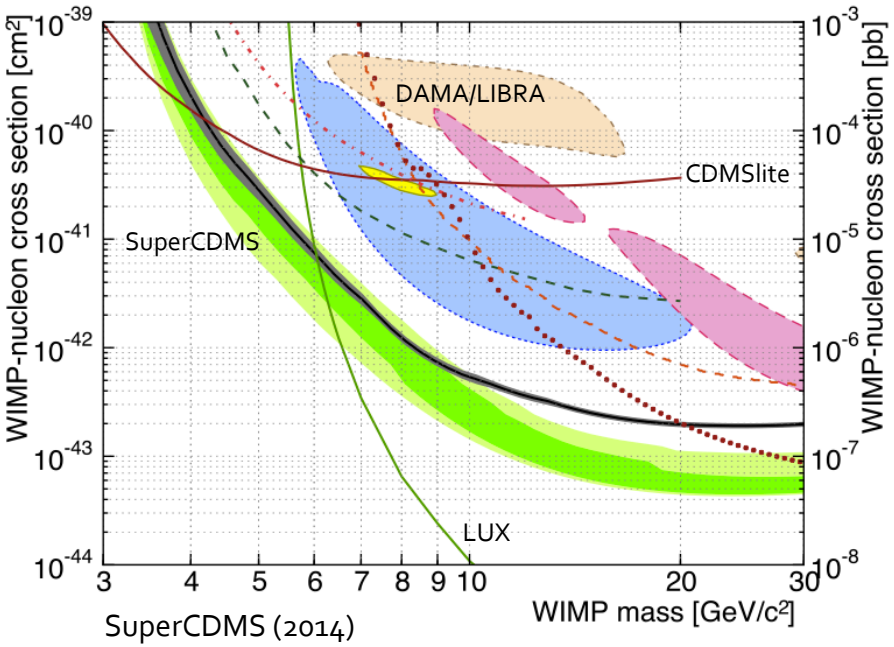
on behalf of the DM-Ice collaboration
University of Wisconsin – Madison

UCLA Dark Matter 2014
26 – 28 February 2014

DM-Ice: First Data & Future Prospects

Reconciling Division

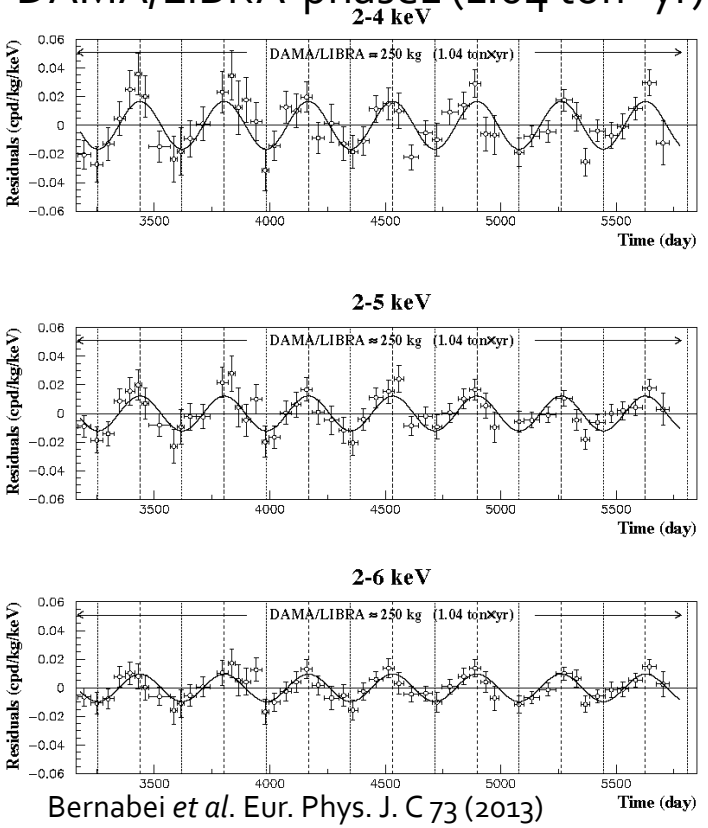
Exclusion Limits vs. Low-Mass WIMP Hints



SuperCDMS (2014)
(L. Hsu, UCLA DM)

Persistent Signals

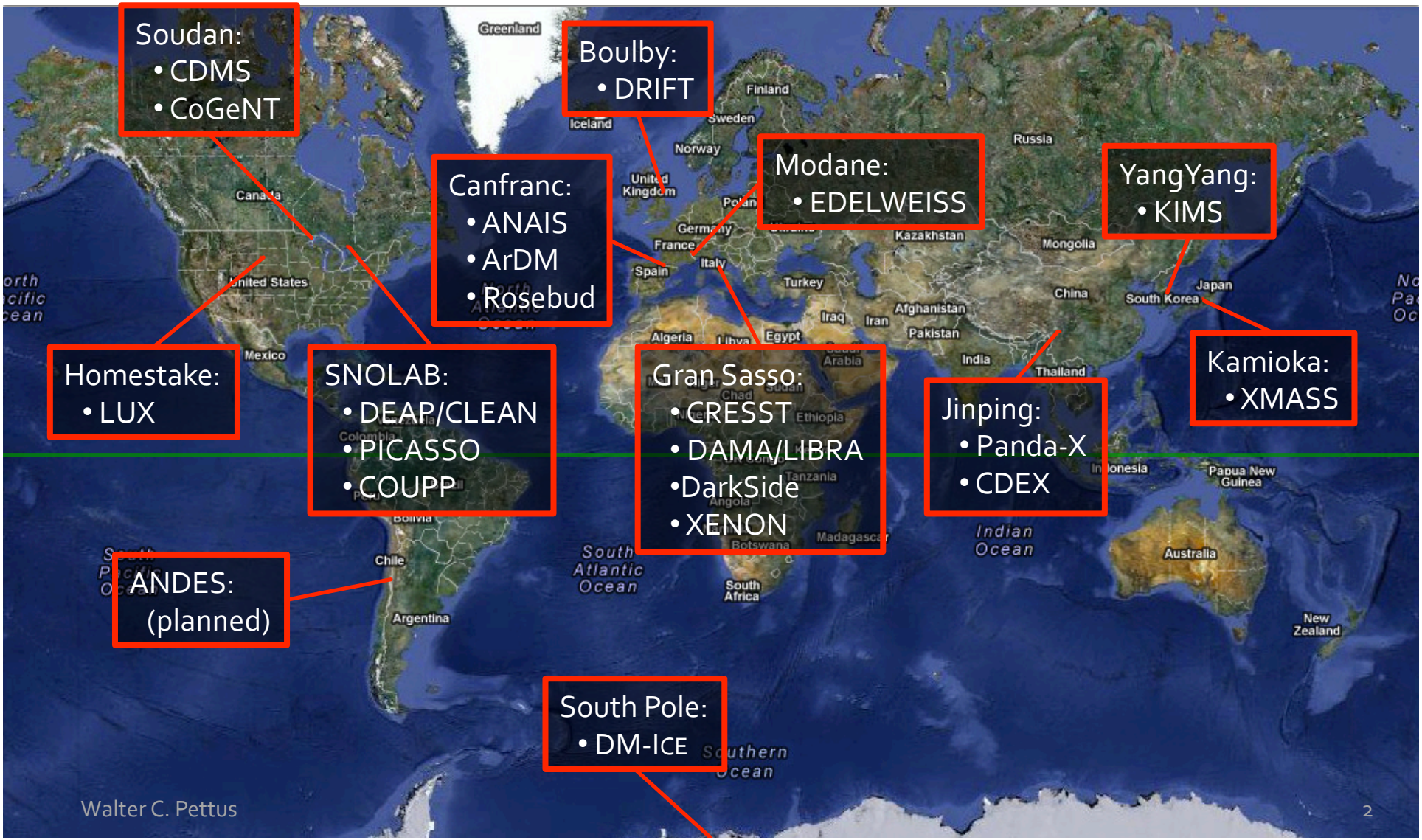
DAMA/LIBRA-phase1 (1.04 ton*yr):



Bernabei *et al*. Eur. Phys. J. C 73 (2013)

Resolution hidden in Astrophysics, Particle Physics, or Instrumental Effects?

A World of Dark Matter Searches



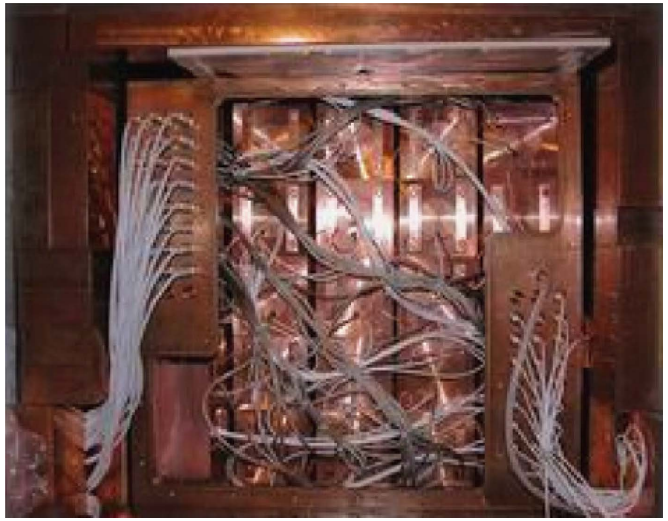
Addressing Potential Instrumental Effects

Solution:

Replicate experiment with same target material and setup, but different systematics and well-characterized backgrounds.

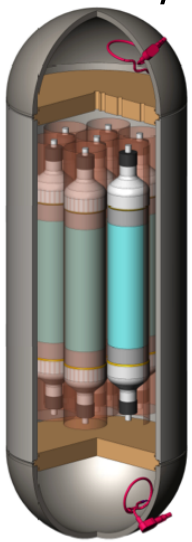
DAMA/LIBRA

- 250 kg NaI(Tl) crystals
- 5x5 array
- LNGS, Italy

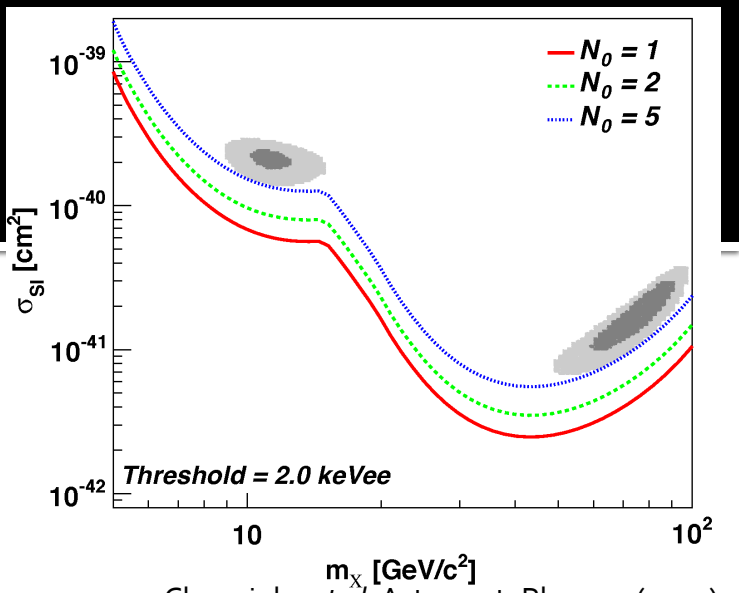


DM-Ice

- 250 kg NaI(Tl) crystals
- 7-crystal arrays (x2)
- Northern Hemisphere
  + South Pole, Antarctica



DM-Ice Phases



Cherwinka *et al*. Astropart. Phys. 35 (2012)

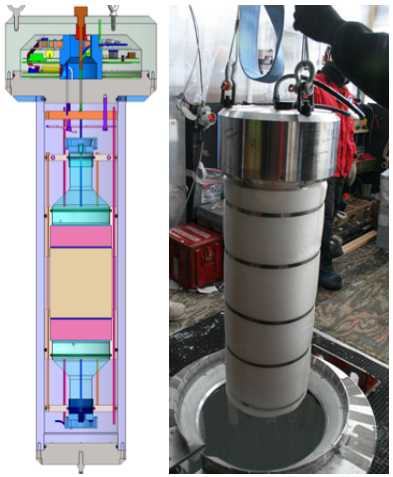
Goal:

Unambiguously test DAMA claim

- Exclusion within 500 kg*yr

Experimental Phases:

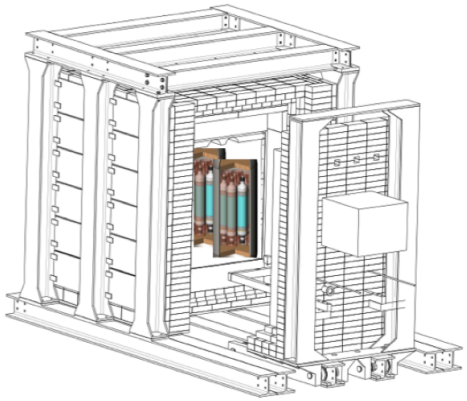
DM-Ice17



17 kg NaI(Tl) at 2450 m under South Pole ice

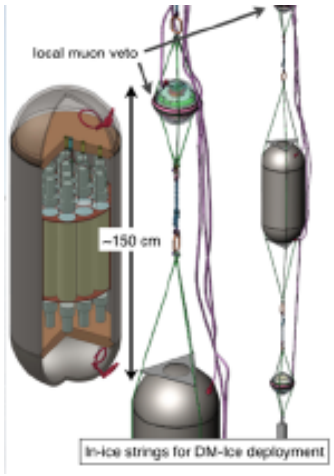
Operating since 2011

DM-Ice250 North



2x125 kg NaI(Tl) modules at underground lab

DM-Ice250 South



Same detectors deployed at South Pole (as necessary)

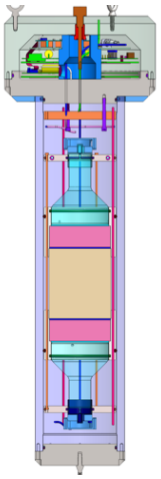
DM-Ice17 (Phase I)

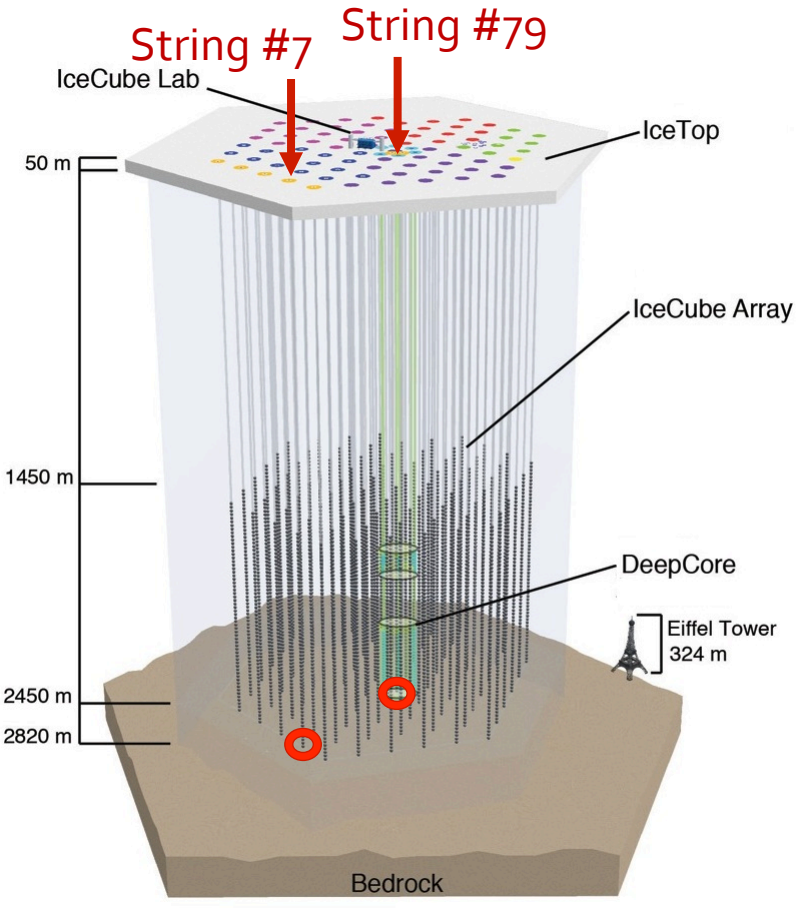
(2x) 8.5-kg NaI(Tl) modules

- Installed Dec 2010
- Data run from June 2011

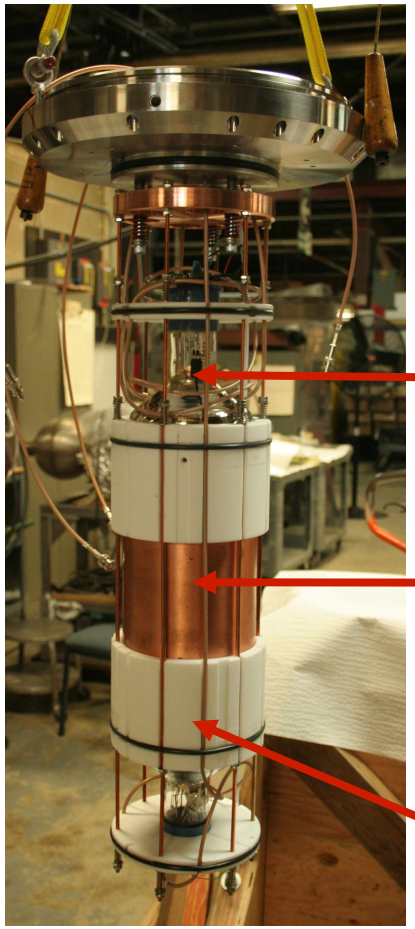
Goals:

- Demonstrate the feasibility of deploying NaI(Tl) crystals in the Antarctic Ice for a dark matter detector
- *In-situ* measurement of the radiopurity of the Antarctic ice / hole ice at 2450 m depth
- Study environmental stability
- Study the capability of IceCube to veto muons





DM-Ice17 Detectors

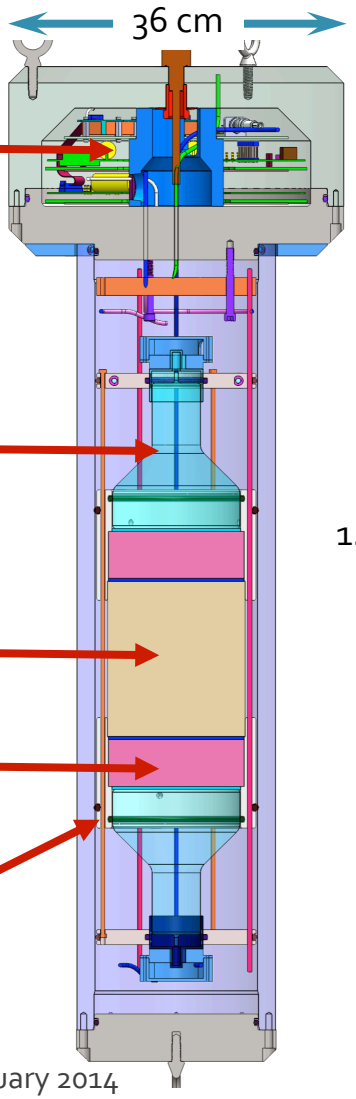


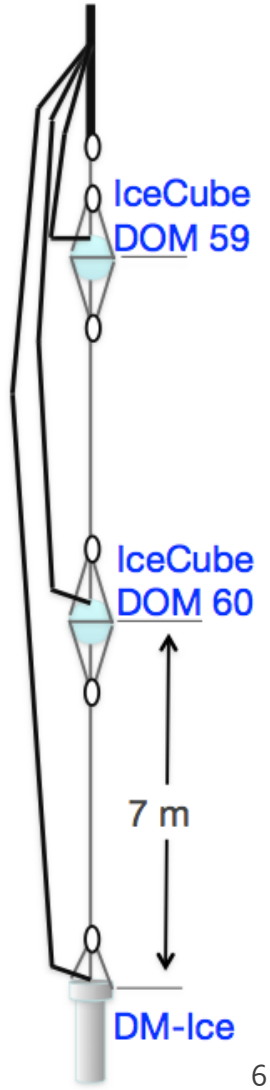
IceCube mainboards
+ HV control (x2)

ETL 5" PMTs (x2)

Encapsulated NaI crystal
(8.47 kg, from NaIAD)
Quartz Lightguides (x2)

PTFE light reflector (x2)





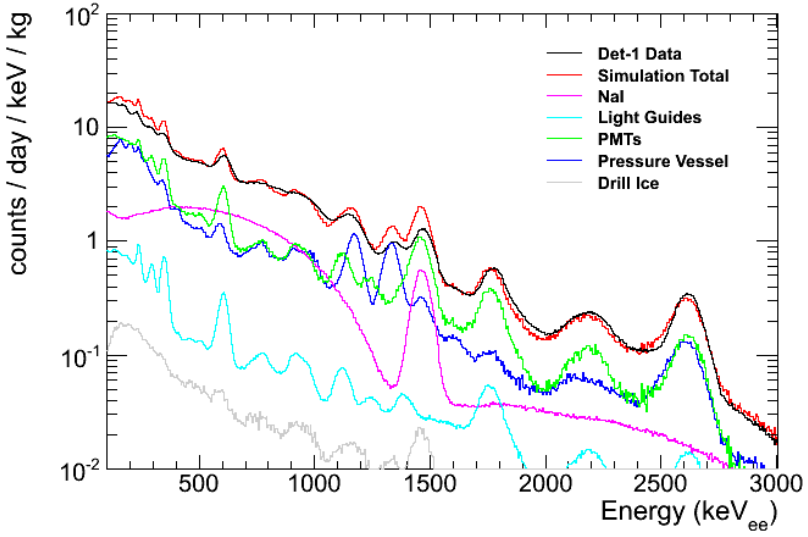
DM-Ice17 Background

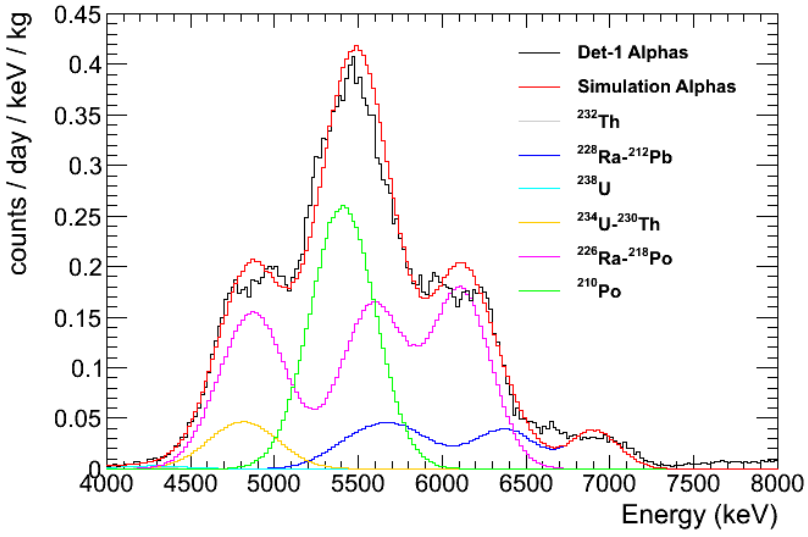
Betas & Gammas:

- Internal contamination lines allow calibration
- Match measured component background

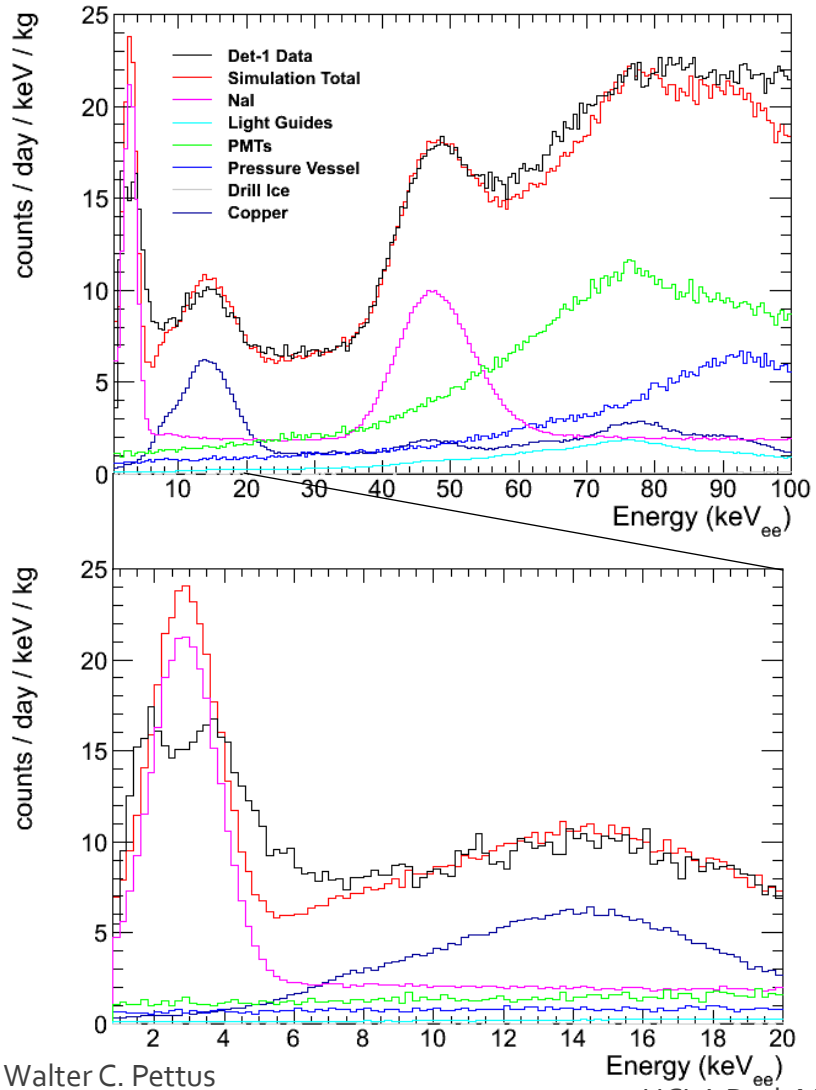
Alphas

- Crystal contaminants only
- Constrains ^{232}Th-, ^{235}U-, ^{238}U- and chain levels





DM-Ice17 Low Energy

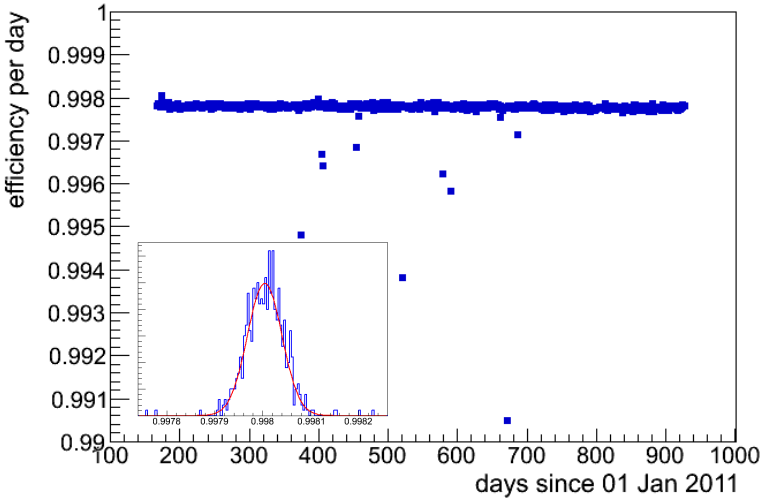


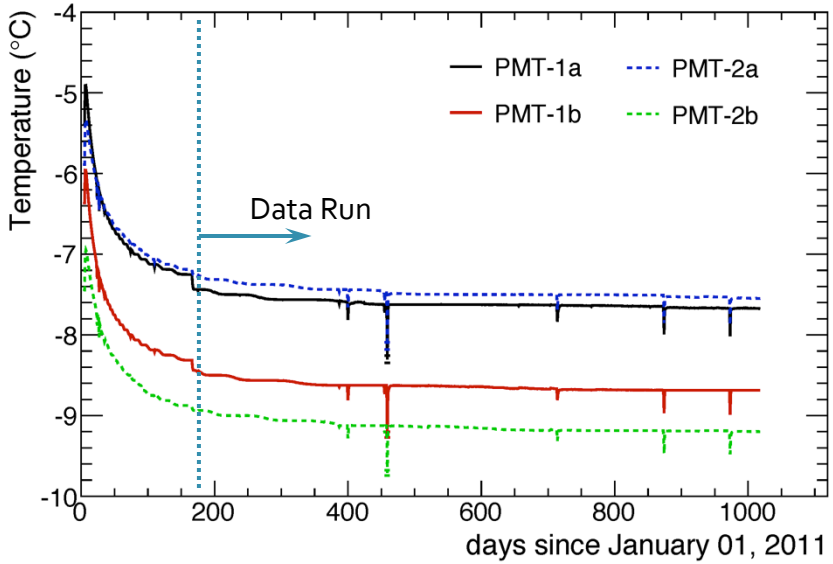
Dominant LE features:

- 3 keV ^{40}K Auger e$^-$/X-rays
  - (crystal)
- ~14 keV ^{238}U-chain X-rays
  - (copper encapsulation surface)
- 46.5 keV ^{210}Pb gamma
  - (crystal)
- 65.3 keV ^{125}I gamma+X-ray
  - (crystal, cosmogenic)

DM-Ice17 Lessons

- Calibration achieved using internal contamination
- Negligible environmental background
  - Drill Ice and Glacial Ice ≲ 0.1 dru
- Temperature stability
- High livetime (> 98%)





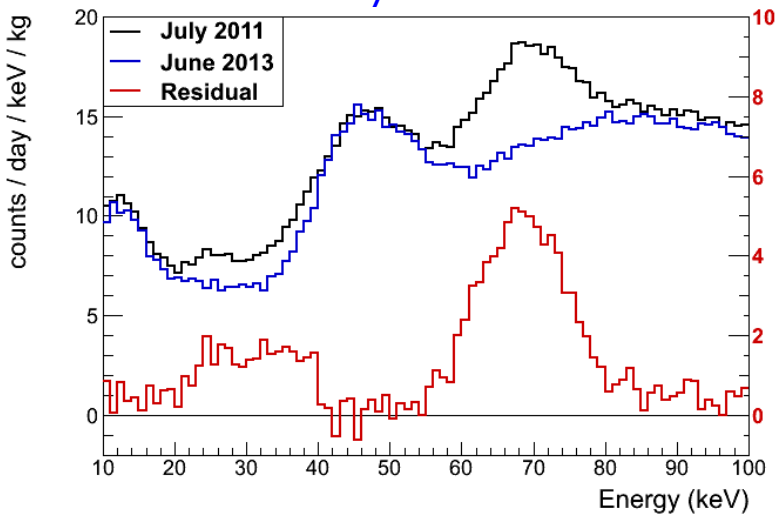
See arXiv:1401.4804 for more detailed discussion.

DM-ICE17 – Coming Soon

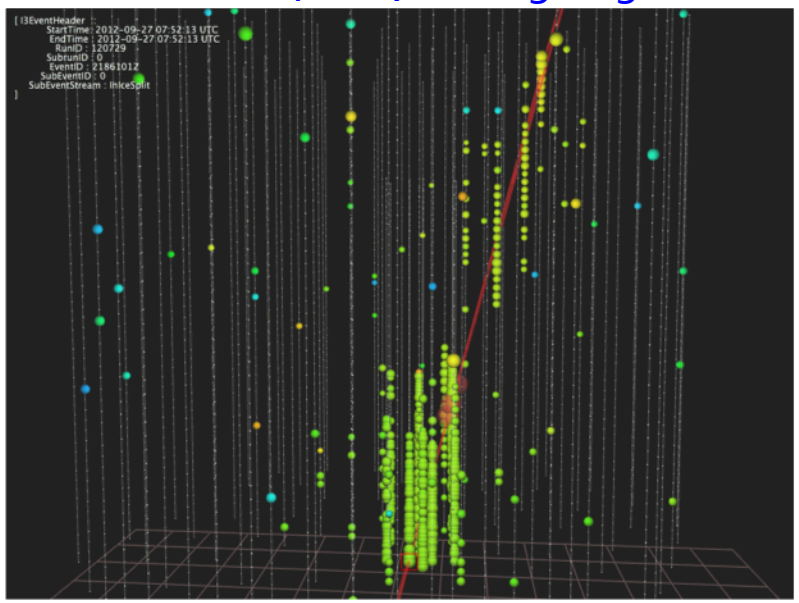
More analyses of DM-ICE17 are in the pipeline:

- Coincidence muons with IceCube
- Low-energy modulation
- Cosmogenic production

^{125}I in DM-ICE17:



IceCube muon veto:
(7 TeV, downgoing muon)

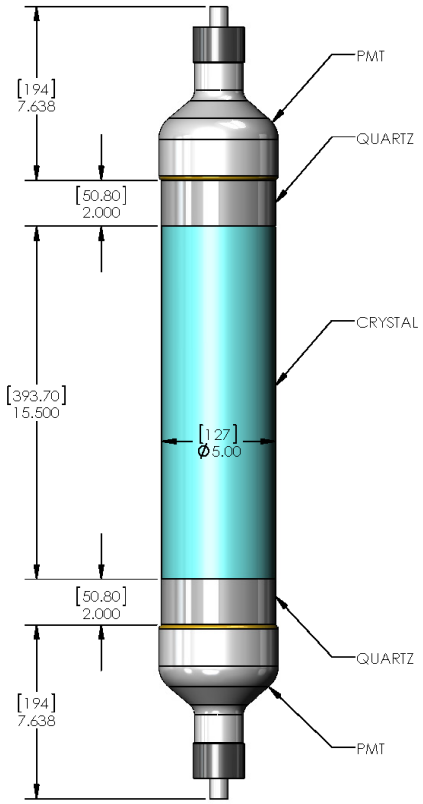


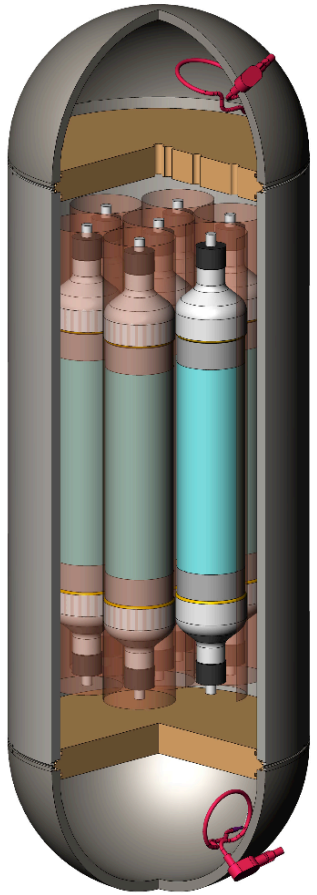
DM-Ice250 (Phase II and III)

Modular detector

- 125 kg NaI(Tl)
- 7-crystal array
  - 3:1 aspect ratio

Test crystal work begins next month!





NaI R&D: Pure Powder

- Crystal background dominates much of low-energy spectrum
  - 3 keV ^{40}K problematic in region of interest
- DAMA/LIBRA crystals

  NIM A 592 (2008):
  - ^{238}U : 1 – 10 ppt
  - ^{232}Th : 1 – 10 ppt
  - ^{nat}K : < 20 ppb
- DM-ICE17 crystals

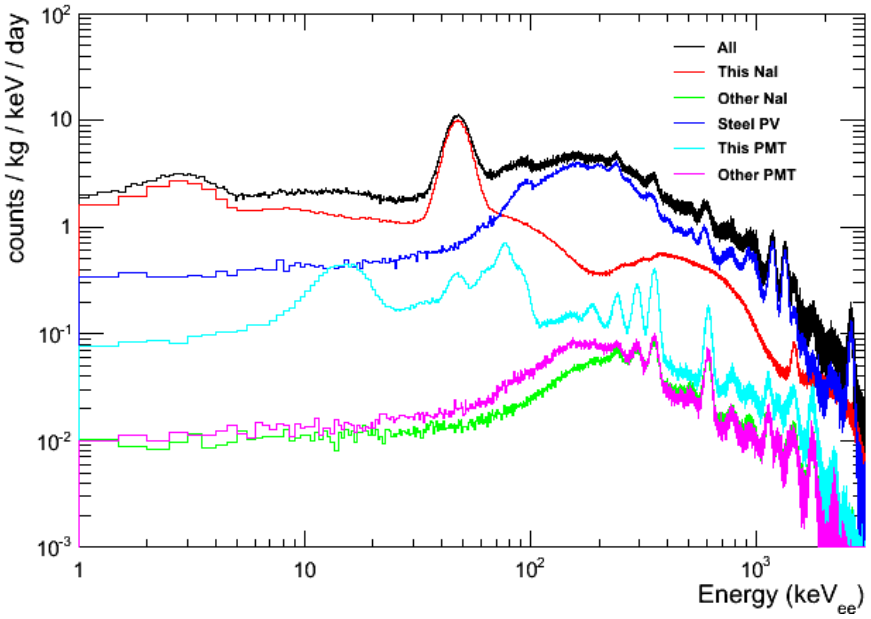
  arXiv: 1401.4804
  - ^{238}U : 1.4 – 120 ppt
  - ^{232}Th : 2.5 – 40 ppt
  - ^{nat}K : 550 ppb

Manufacturer	Form	Measurement	^{238}U (ppt)	^{232}Th (ppt)	^{nat}K (ppb)
Saint Gobain	Powder	DAMA (HPGe)	< 20	< 20	< 100
Saint Gobain	Crystal	DAMA/LIBRA	0.7 - 10	0.5 - 7.5	< 20
Saint Gobain	Crystal	ANAIS-0	6.1	3.2	410
Sigma-Aldrich	Powder (standard grade)	DM-Ice (HPGe)	40	89	440
Sigma-Aldrich	Powder (astro grade)	DM-Ice (HPGe)	63	< 95	< 126
Sigma-Aldrich	Powder (astro grade)	S-A (ICPMS)	-	-	~ 4
Sigma-Aldrich	Powder (astro grade)	Seastar/PNNL	<1	<1	18
Alpha-Spectra	Powder	DM-Ice (HPGe)	< 100	< 200	< 120
Alpha-Spectra	Powder	ANAIS-25 (HPGe)	< 55	< 130	< 90
Alpha-Spectra	Crystal	ANAIS-25	(see arXiv:1308.3478)		40

See also Jingke Xu talk on SABRE for best contamination limits

DM-Ice250: Background

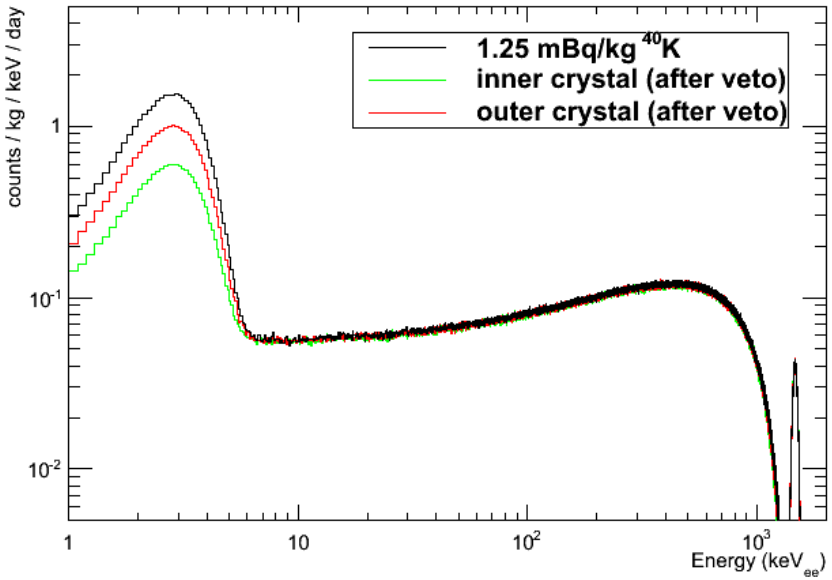
DM-Ice250 Simulated Raw Spectrum



- 40 ppb ^{40}K in crystal
- Low-background R6233 PMTs (as DAMA/LIBRA-phase2)
- Lightguides unnecessary

With 40 ppb ^{nat}K, 3 keV peak contributes ~1.5 counts/kg/keV/day

Multi-crystal veto can remove ~50% of 3 keV ^{40}K decays:



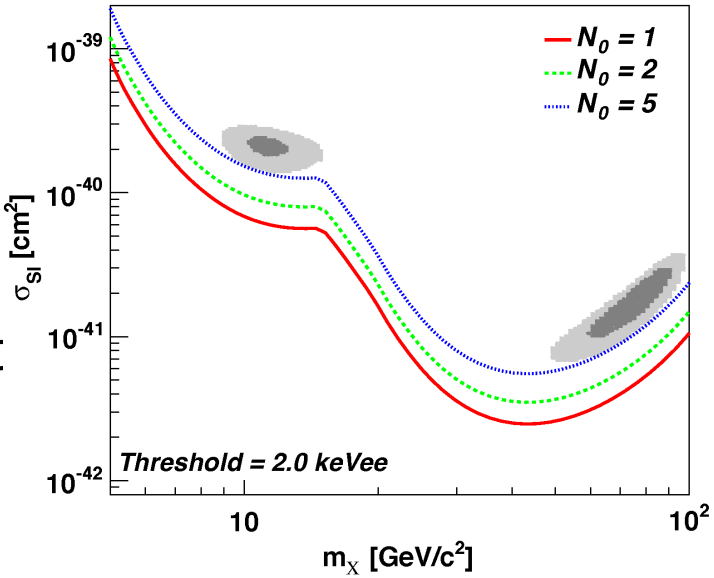
DM-Ice250: Prospects

DM-Ice17 has demonstrated feasibility of running a NaI(Tl) dark matter detector at the South Pole

- Studies are ongoing to demonstrate background control for future deployments

DM-Ice250 is the only planned experiment in the Southern Hemisphere

- Phased approach allows for better understanding of detector
- New crystal background levels allow test of DAMA signal with same target



Cherwinka *et al*. Astropart. Phys. 35 (2012)

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