



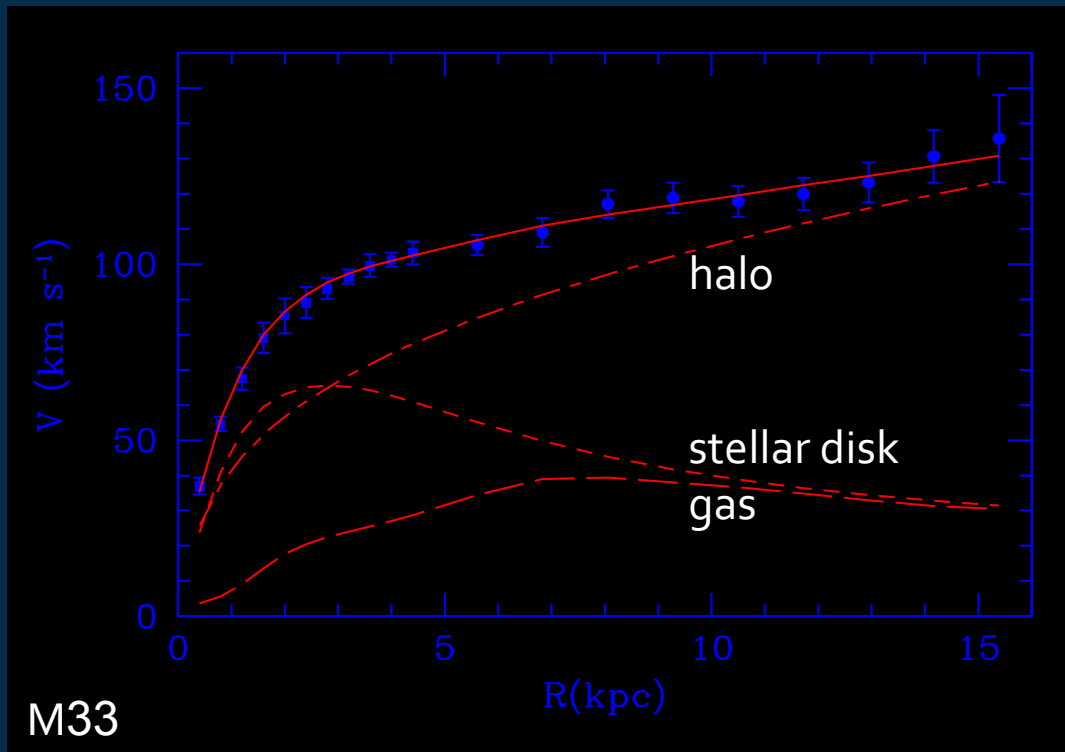
DM-Ice: A Dark Matter Detector at the South Pole

Walter C. Pettus
UW – Madison

New Perspectives Conference
Wilson Hall, Fermilab
31 May 2011

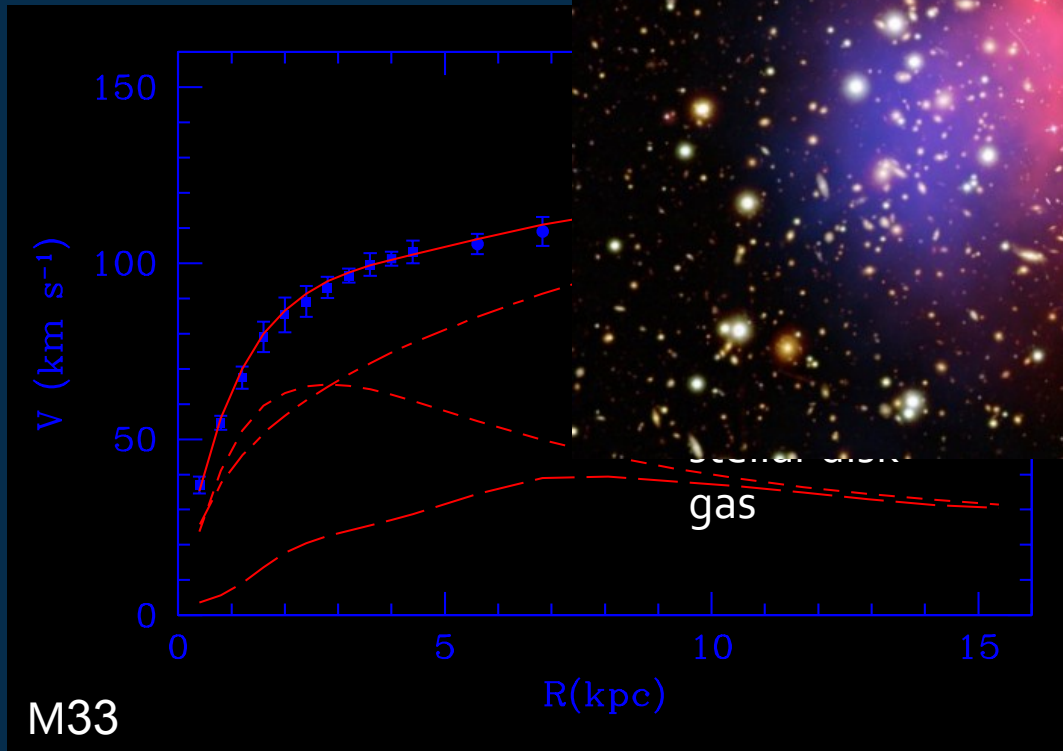
Dark Matter Primer

- Fritz Zwicky (1933)
 - Rotation in Coma galaxy cluster



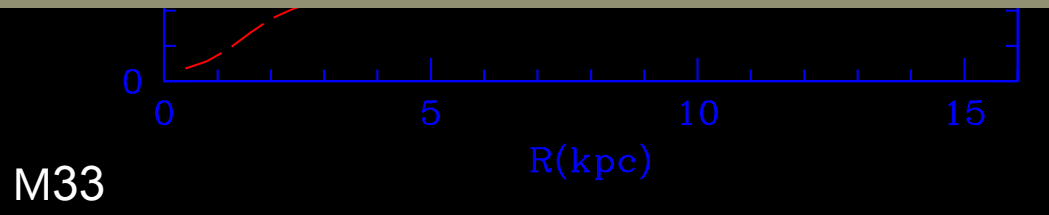
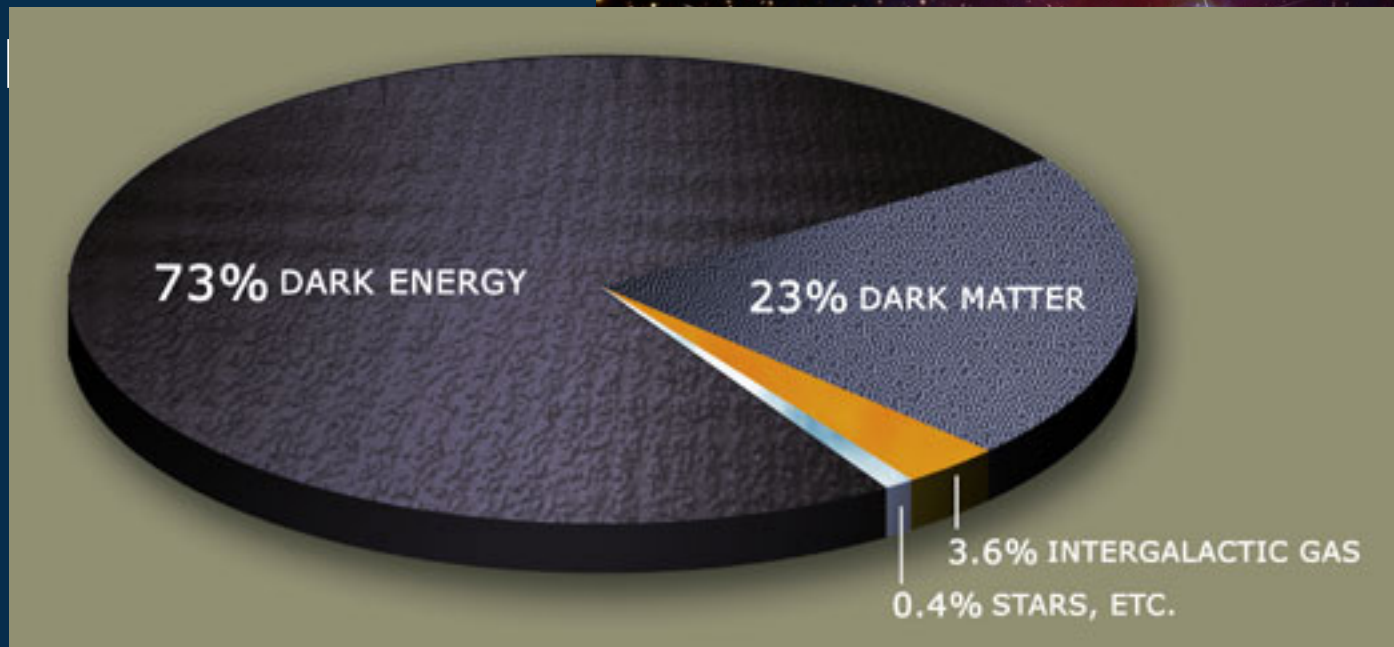
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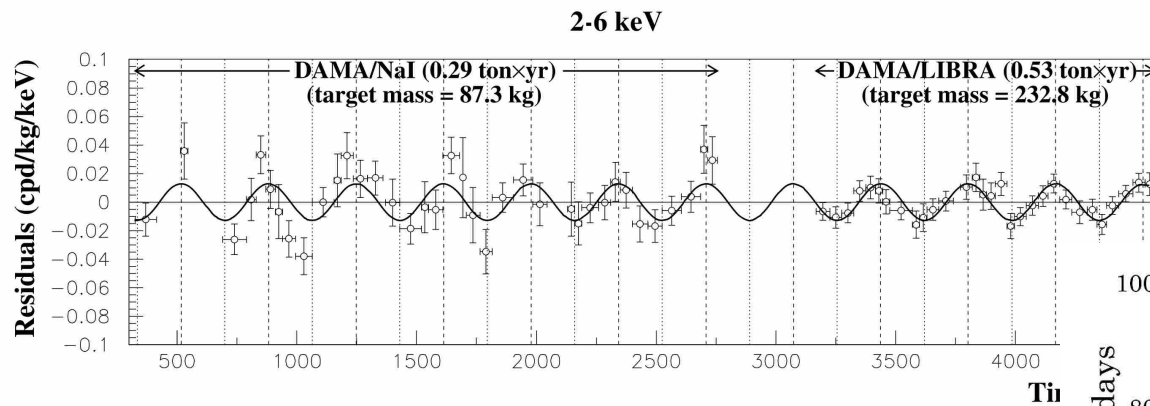


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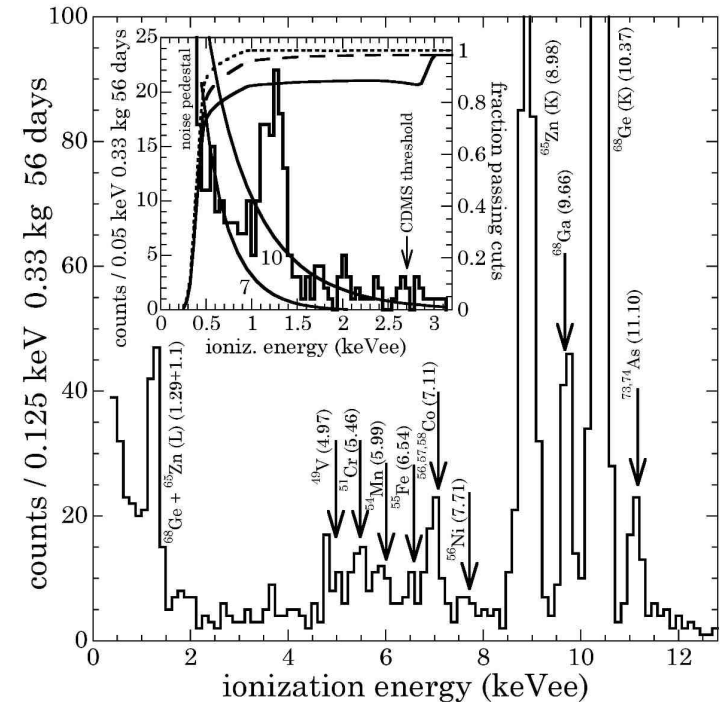
Dark Matter Signal Hints



■ DAMA Bernabei *et al.*, Eur Phys J C, (2008)

■ CoGeNT

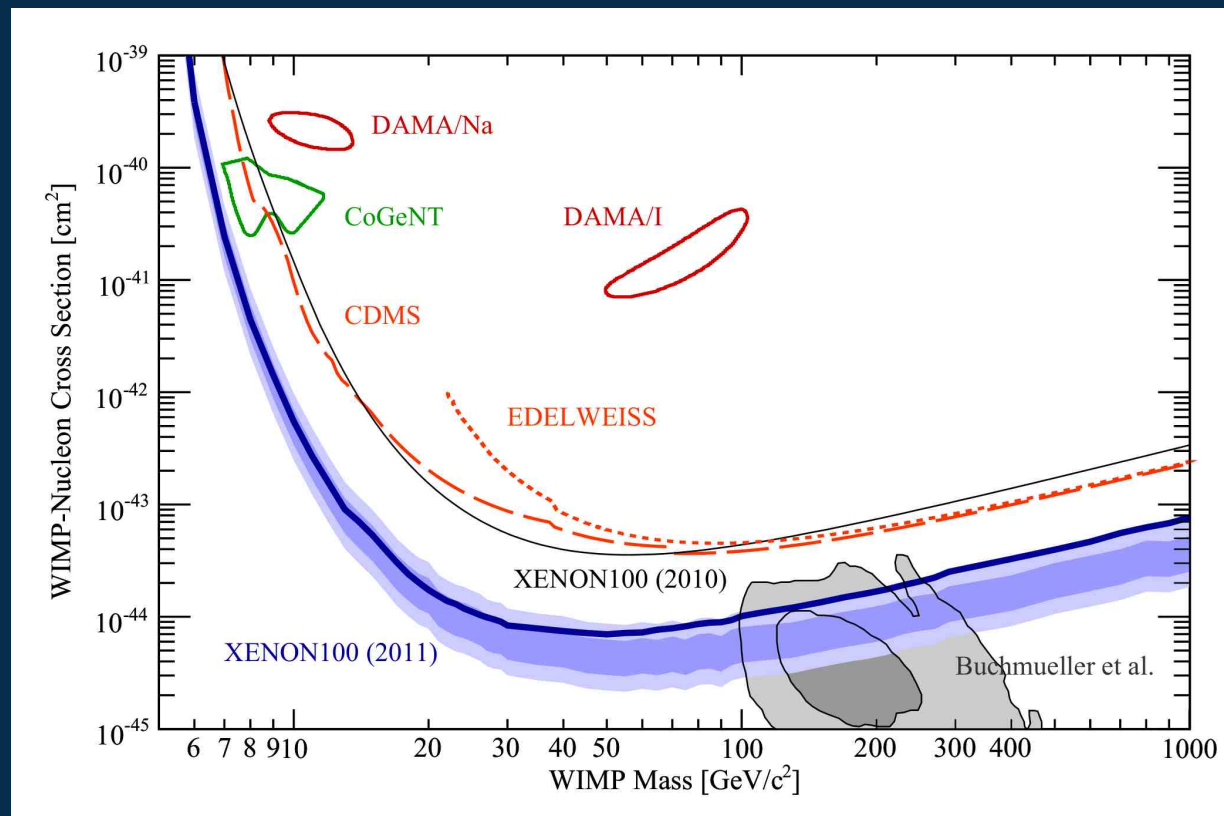
■ CRESST?



Aalseth *et al.* Phys Rev Lett, (2011)

Dark Matter Limits

- Excluded by other experiments (spin-independent):



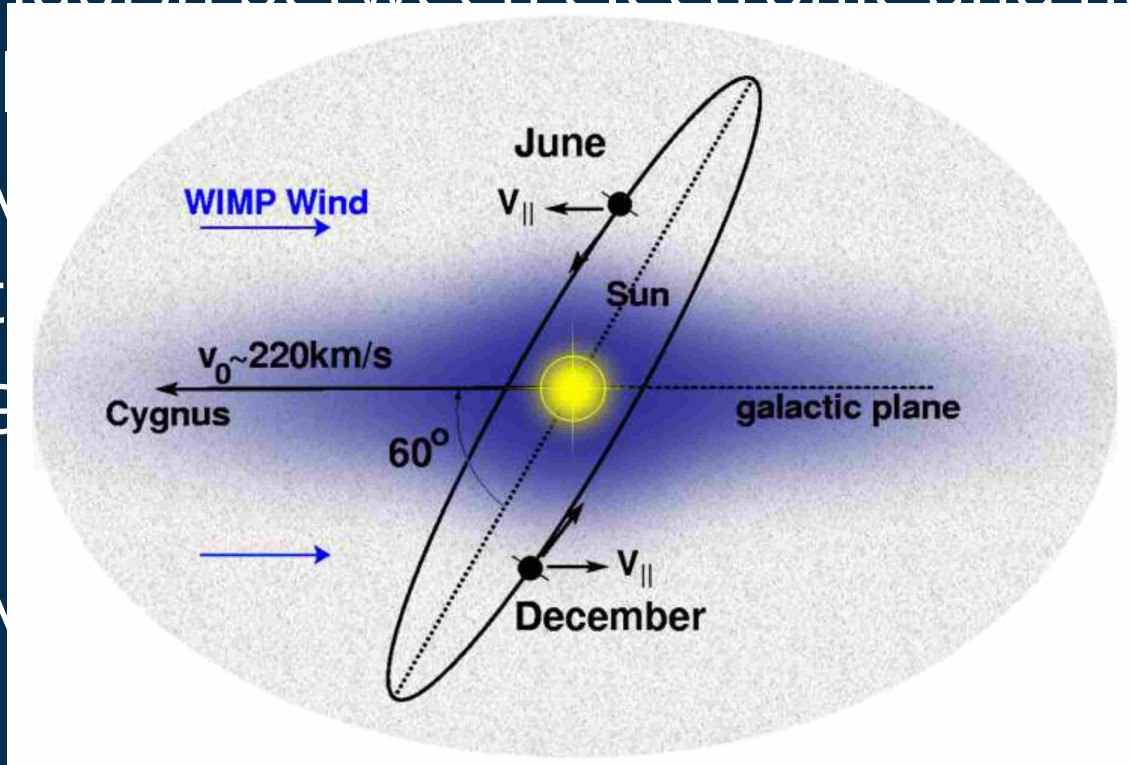
Aprile *et al.*, arXiv:1104.2549v2 (2011)

Advanced Background Rejection

- Distinguish between electronic and nuclear recoil events
 - CDMS, XENON, etc.
- Identify all peaks with energy resolution
 - CoGeNT
- Look for modulating signal
 - DAMA, CoGeNT

Advanced Background Rejection

- Distinguish between electronic and nuclear recoils
 - CDMS
- Identify WIMP signal
 - CoGeNT
- Look for dark matter
 - DAMIC



Reconciling Experiments

- Experimental effects
 - Quenching factor, L_{eff}
 - Channeling
- Theoretical explanation
 - Isospin-violating dark matter
- Seasonal modulation is not DM

Advantages of the South Pole

- Expect the same DM signal
- Opposite muon rate
 - Tagging of muons by IceCube/DeepCore
- Drilling to 2500m in ice established
 - No temperature fluctuation
 - Ice is relatively radiopure
 - No radon
 - ppt U/Th, ppb ^4K
 - Ice as a neutron moderator
- Infrastructure at Amundsen-Scott South Pole Station

Muon Flux: Seasonal Variation

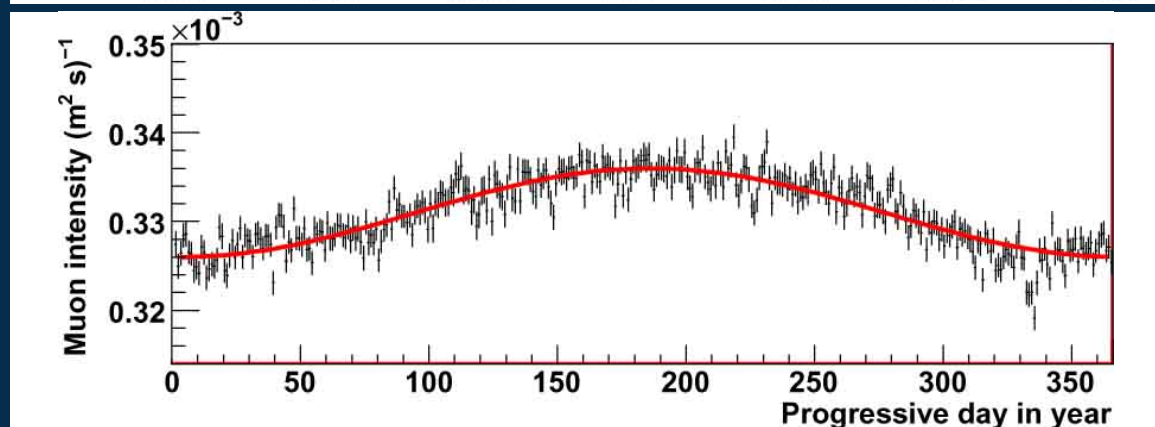
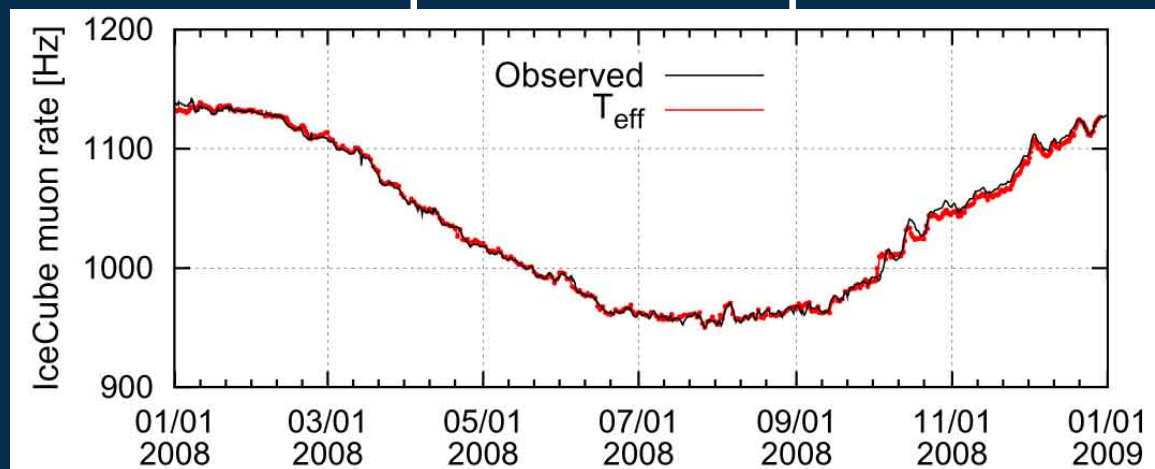
- Muon rate follows atmospheric temperature

- South Pole
(IceCube)

Tilav, Proc 31st ICRC

- Gran Sasso
(LVD)

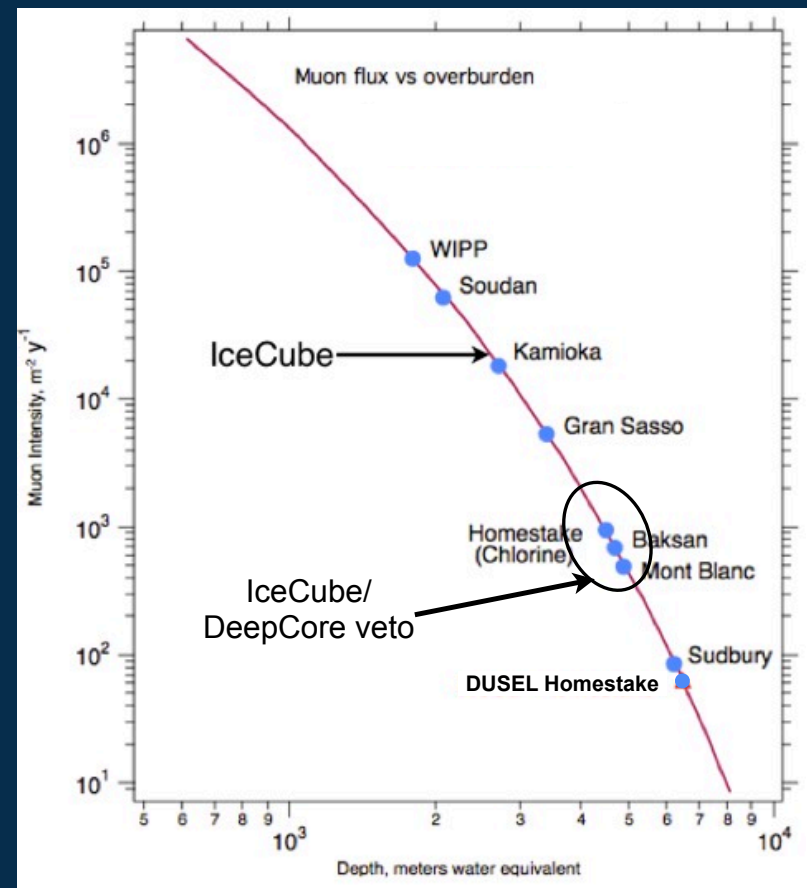
Selvi, Proc 31st ICRC



Walter C. Pettus

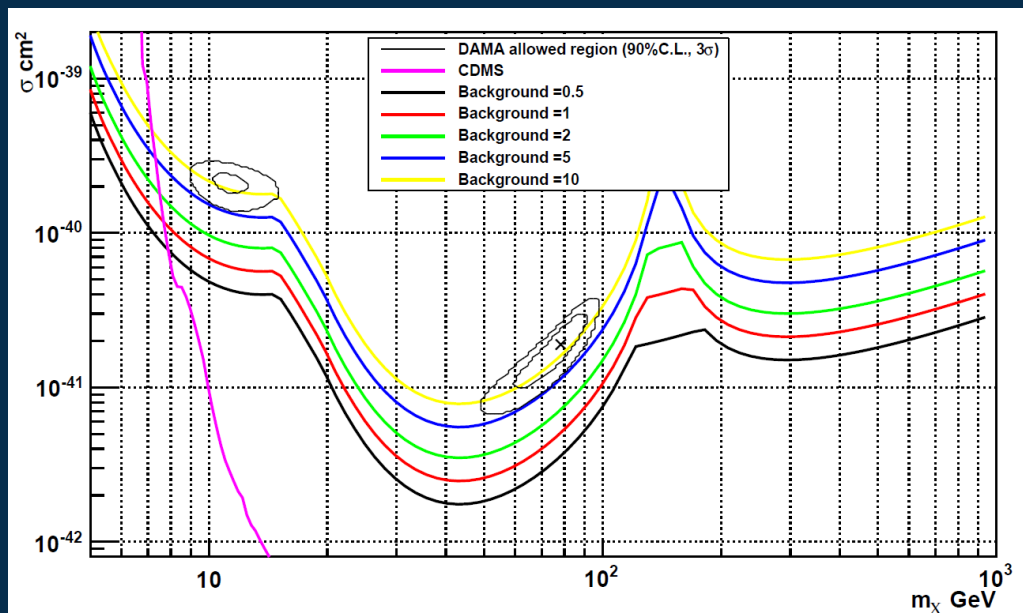
Muon Flux: Overburden

- Overburden of ~ 2200 m.w.e.
 - Expect ~ 85 muons/m²/day
- IceCube may serve as a veto
 - 1-2 order of magnitude
- Ice as a neutron moderator



Simulation – testing DAMA

- Can test DAMA within a few years of running

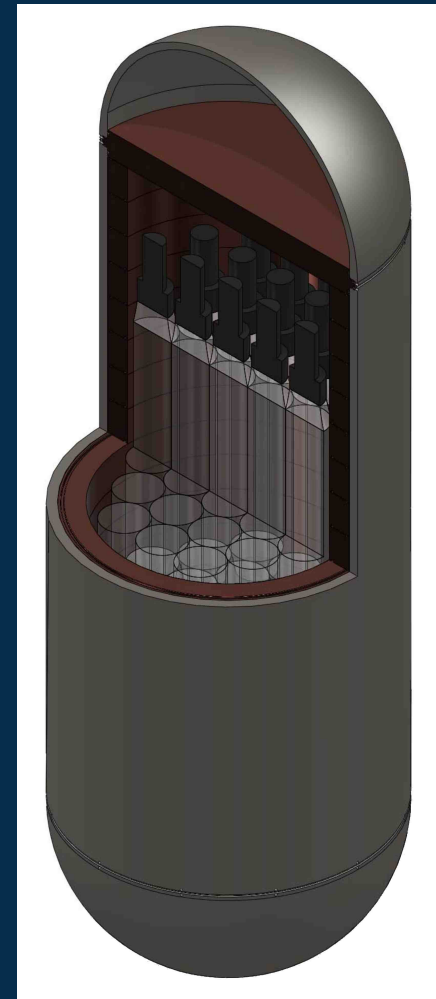


	Years	2 NAIAD 17.0 kg	NAIAD size 44.5 kg	DAMA size 250 kg
NAIAD background	1	0.45	0.72	1.71
	3	0.77	1.25	2.96
	5	1.00	1.61	3.82
	7	1.18	1.91	4.52
50% NAIAD background	1	0.63	1.02	2.42
	3	1.09	1.77	4.18
	5	1.41	2.28	5.40
	7	1.67	2.70	6.39
Double DAMA background	1	0.85	1.37	3.26
	3	1.47	2.38	5.64
	5	1.90	3.07	7.29
	7	2.25	3.64	8.62
DAMA background	1	1.20	1.94	4.61
	3	2.08	3.37	7.98
	5	2.69	4.35	10.31
	7	3.18	5.14	12.19
1/10 DAMA background	1	3.80	6.15	14.57
	3	6.58	10.65	25.24
	5	8.50	13.75	32.59
	7	10.06	16.27	38.56

Sensitivity of 500 kg*yr exposure over 2-6 keV

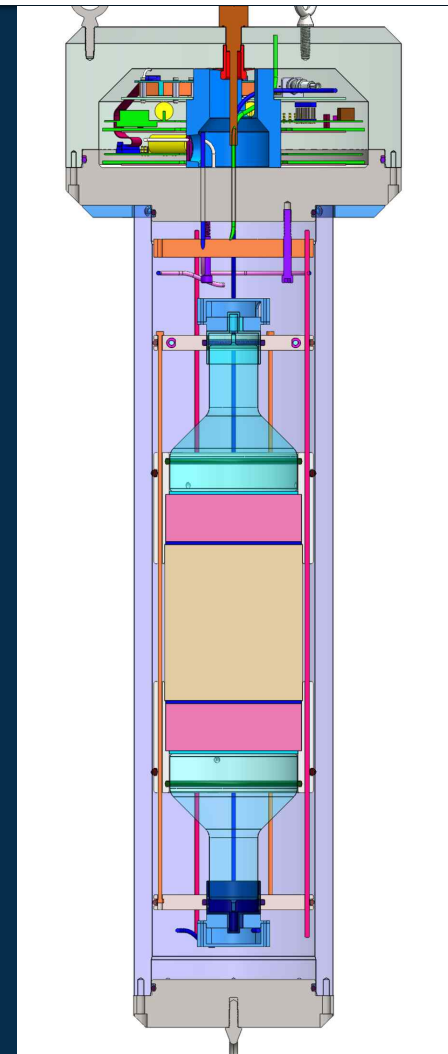
Full Detector Concept

- NaI Crystals
 - 38 total, 6.5 kg each
 - 95.6 mm diameter
 - 250 mm length
 - Arrayed for anticoincidence
 - Light collection by 2 PMTs/crystal
- 50-60 mm copper radial shield
- SS External Pressure Vessel
 - 650 mm (25.6 in) outer diameter
 - 1.7 m (67 in) length

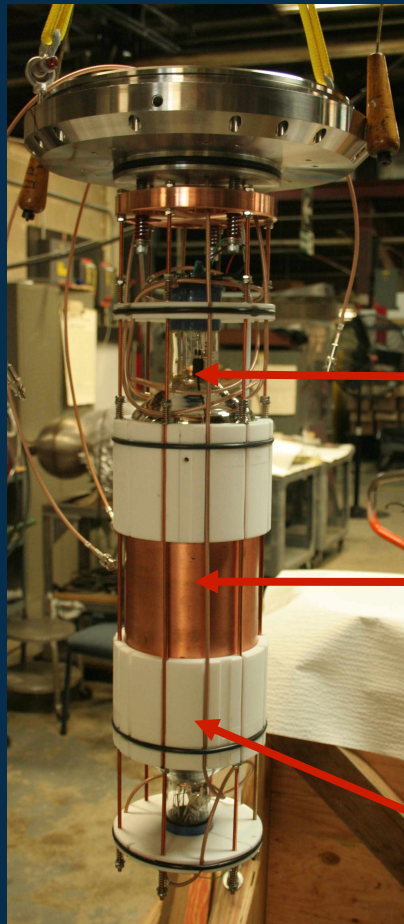


Feasibility Study Detectors

- NaI Crystals
 - 8.5 kg each
 - 5" diameter, 5" height
 - Grown by Bicron
 - NAIAD-measured background:
 - ~7.5 cpd/kg/keV over 4-10 keV
- 5" ETL 9390KB53 PMTs
 - C636AFP voltage divider
- 5 cm quartz lightguide
- Q900 silicone gel (optical coupling)



Feasibility Study Detectors



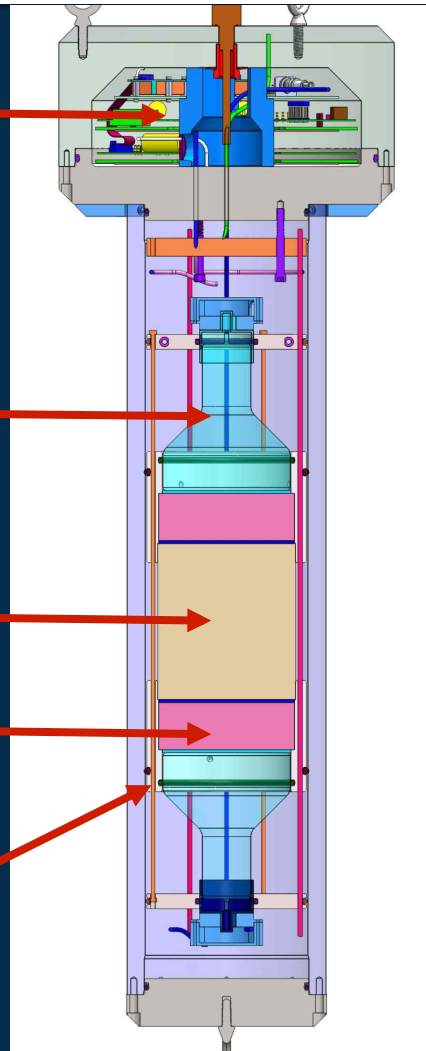
IceCube mainboards
+ HV control (x2)

ETL 5" PMTs (x2)

Encapsulated NaI crystal

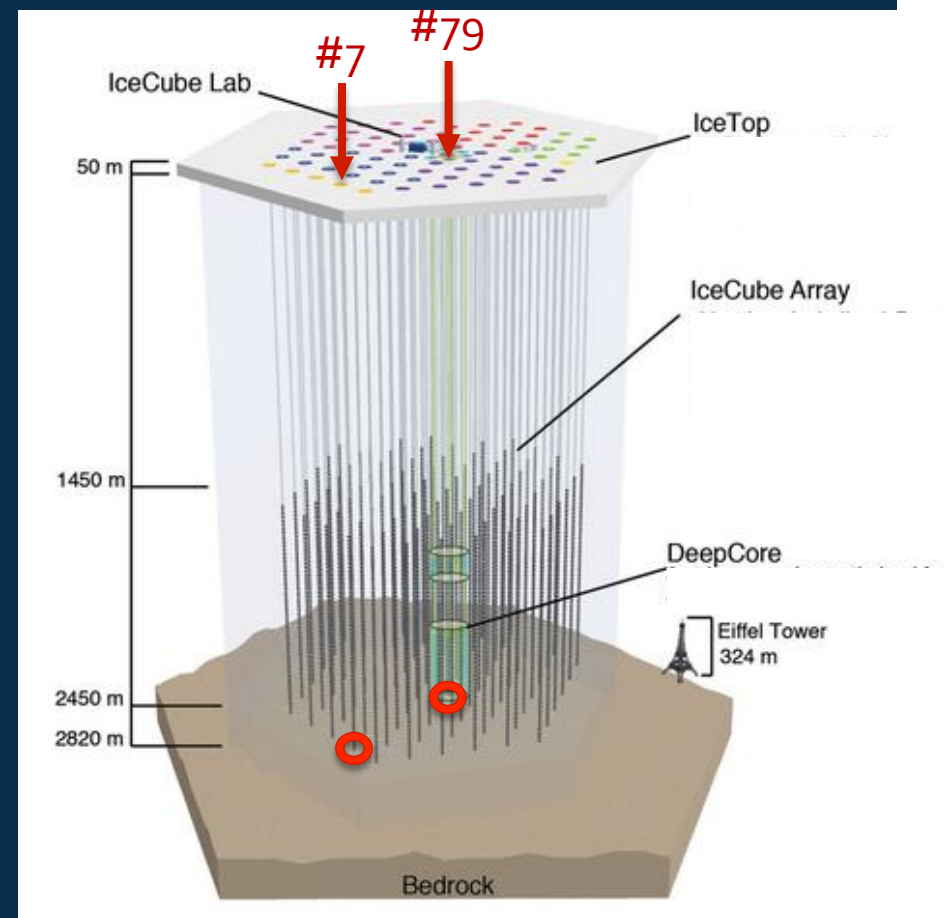
Quartz Lightguides (x2)

PTFE light reflector (x2)



DM-Ice Prototype

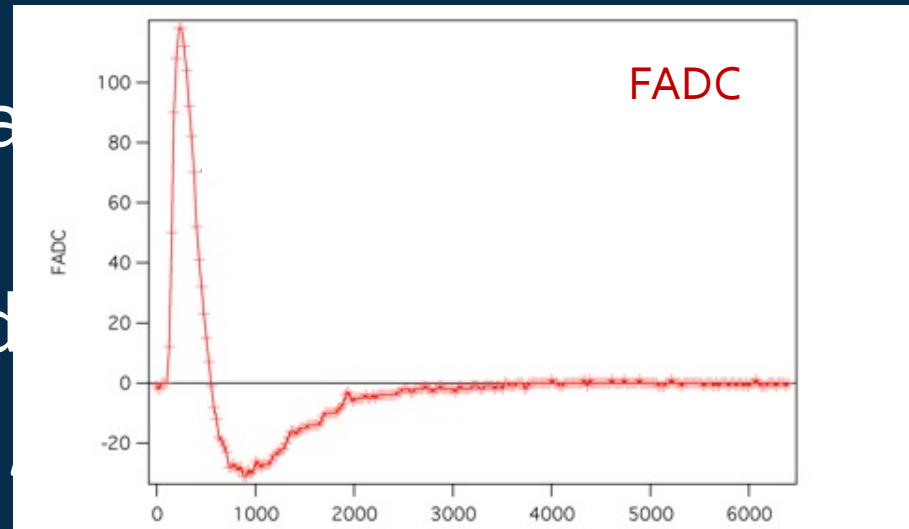
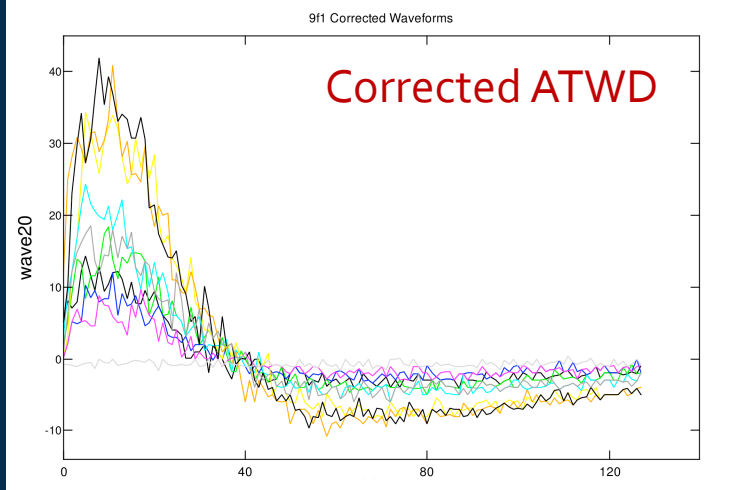
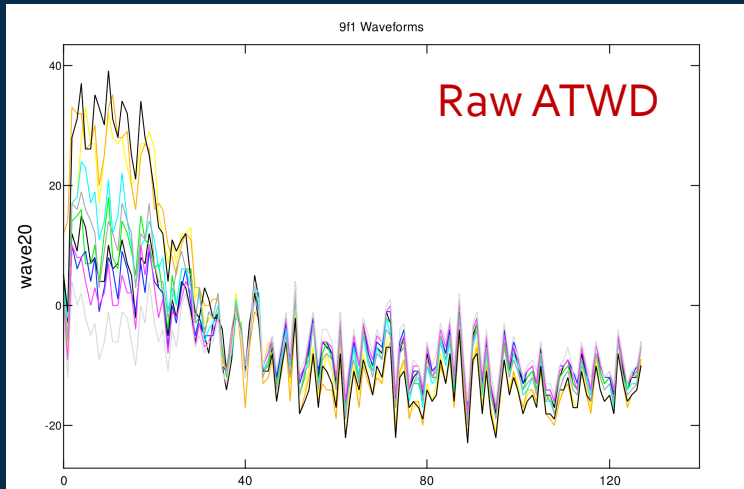
- Two 8.5-kg NaI detectors
- Installed Dec 2010
- Data since Jan 2011
- Goals:
 - Assess the feasibility of deploying NaI(Tl) crystals in the Antarctic Ice for a dark matter detector
 - Establish the radiopurity of the antarctic ice / hole ice
 - Explore the capability of IceCube to veto muons



Data Readout

- Trigger on individual PMT hit or require coincidence hit
- Waveform digitized with two channels:
 - FADC (255 pts) $\sim 6.4 \mu\text{s}$
 - ATWD (128 pts)
 - 3 gain settings
 - Highly customizable

Data Readout



DM-Ice: A Growing Collaboration

- UW-Madison
 - Francis Halzen*, Karsten Heeger, Albrecht Karle*, Reina Maruyama*, Walter Pettus, Antonia Hubbard*, Bethany Reilly, Benjamin Broerman
- University of Sheffield
 - Neil Spooner, Vitaly Kudryavtsev, Dan Walker, Sean Paling, Matt Robinson
- University of Alberta
 - Darren Grant*
- Penn State
 - Doug Cowen*
- Fermilab
 - Lauren Hsu
- University of Stockholm
 - Seon-Hee Seo*
- and working closely with IceCube

** Indicates member of
IceCube collaboration*

What does it take to do science at the South Pole?



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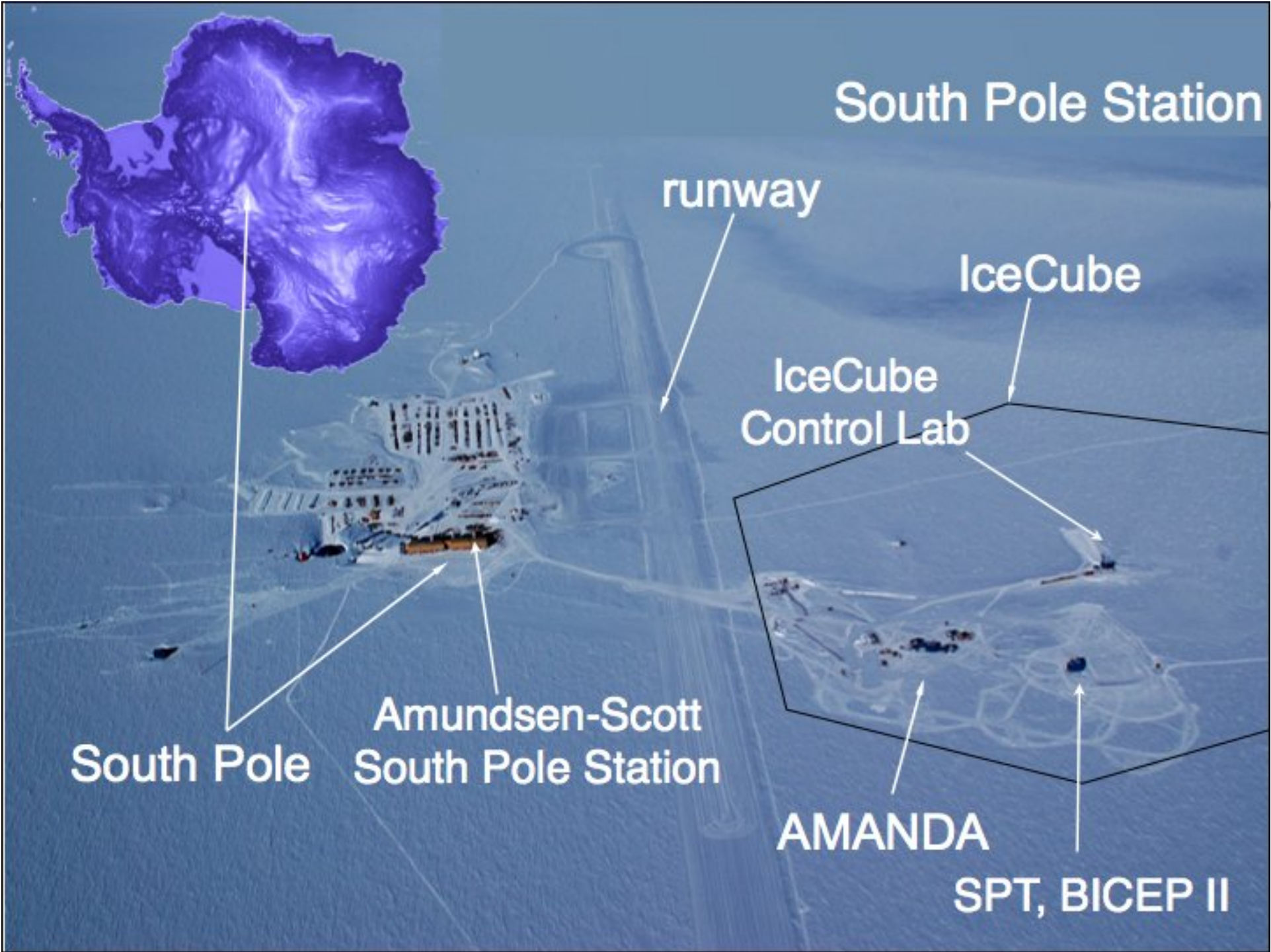


31 May 2011

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South Pole Station

runway

IceCube

IceCube
Control Lab

South Pole
Amundsen-Scott
South Pole Station

AMANDA

SPT, BICEP II



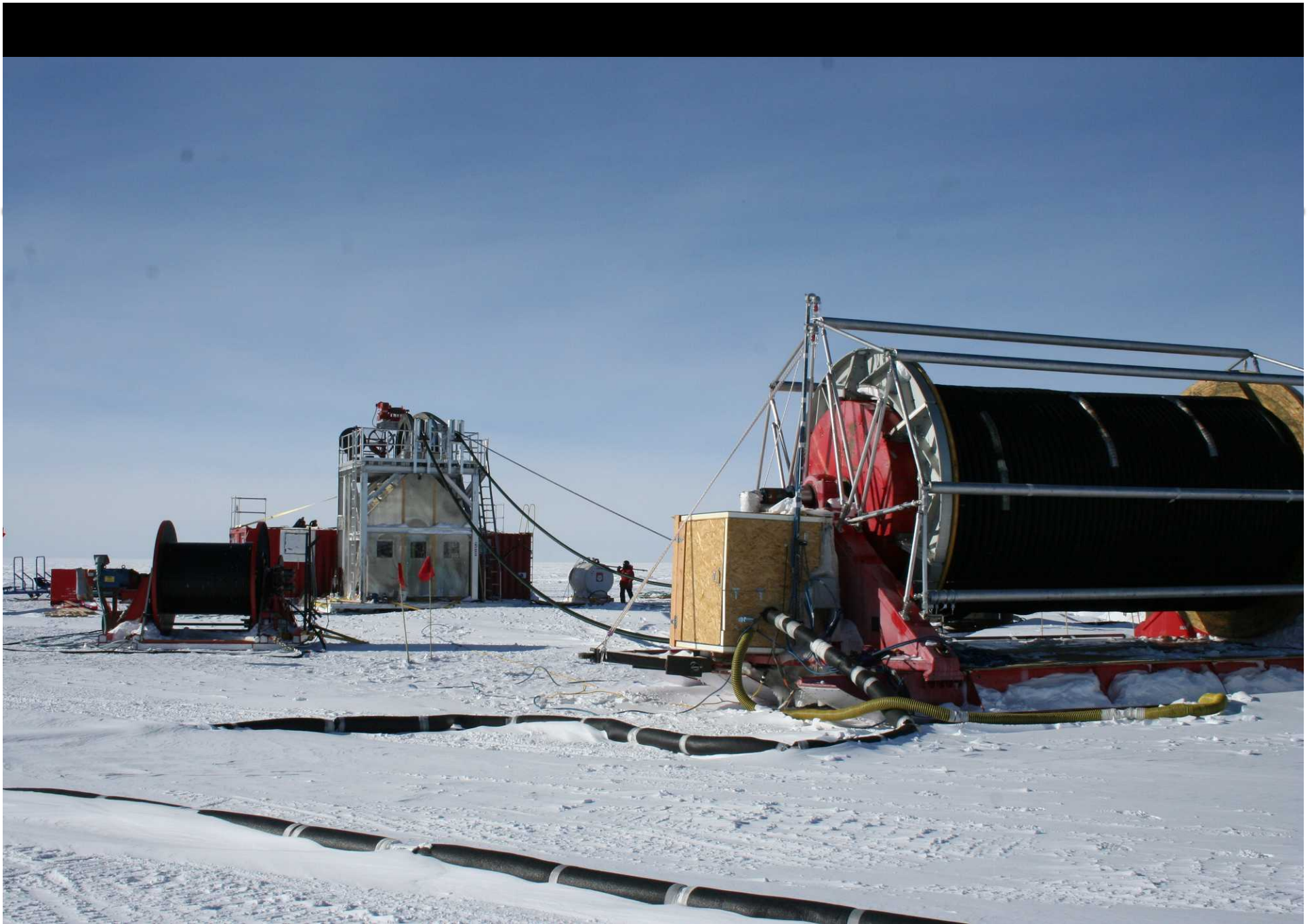




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