Dark Matter Direct Detection

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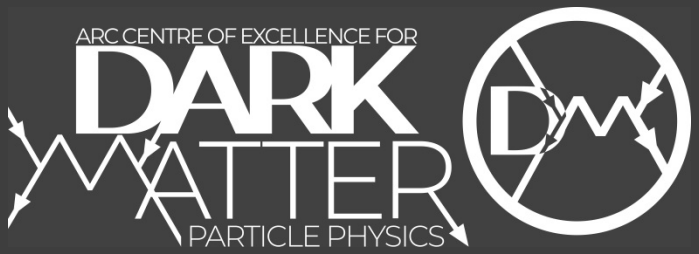
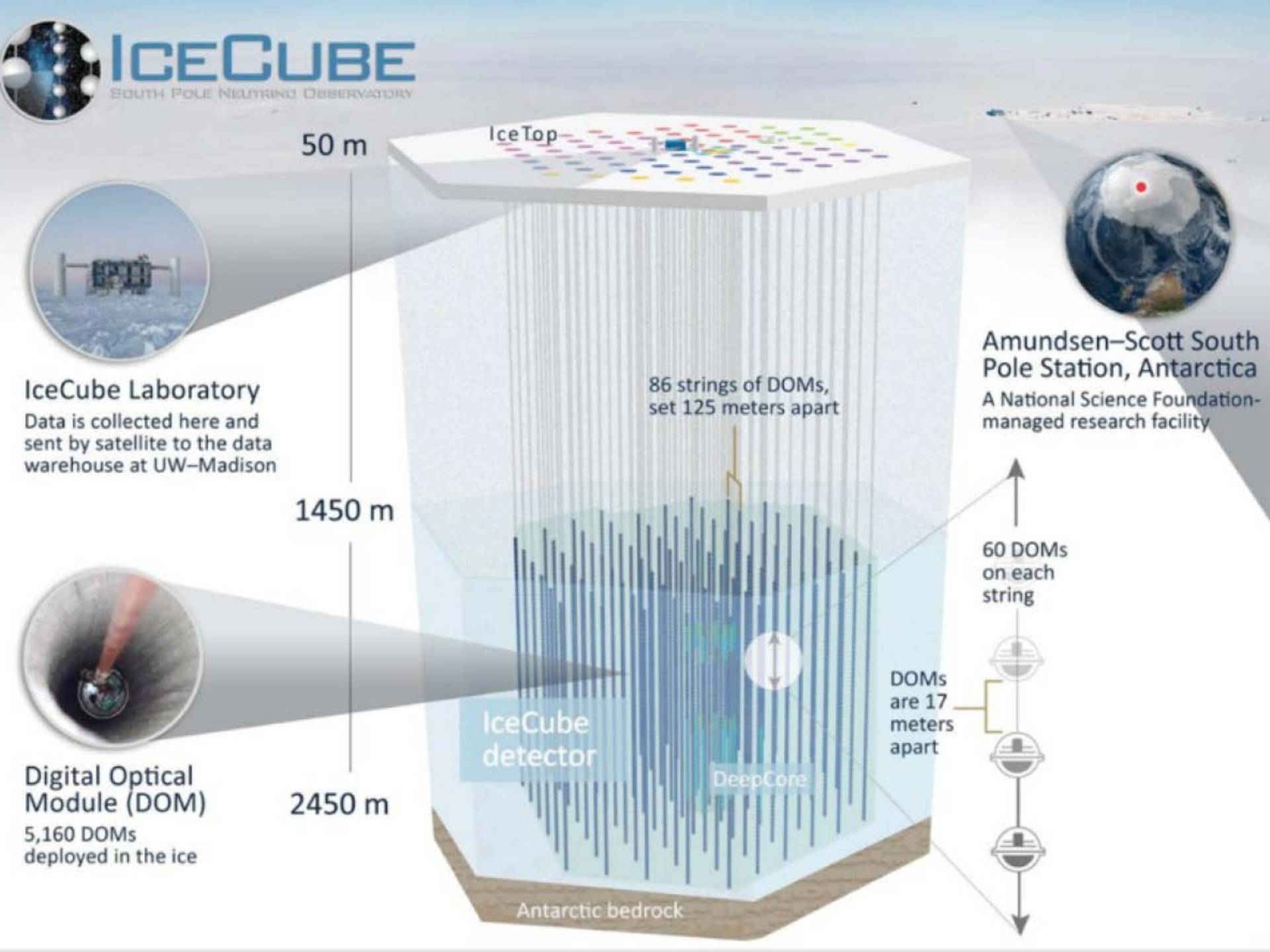
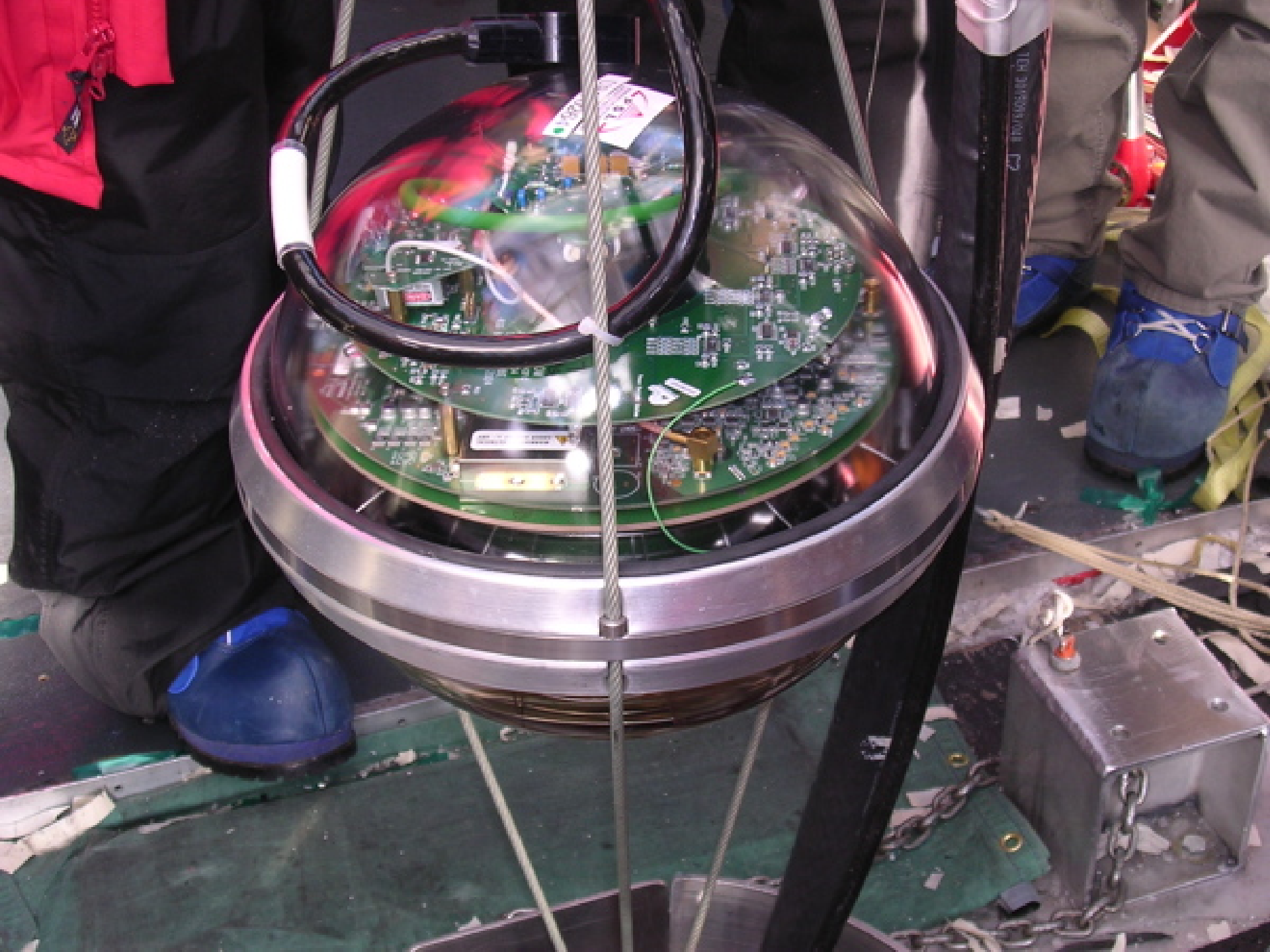
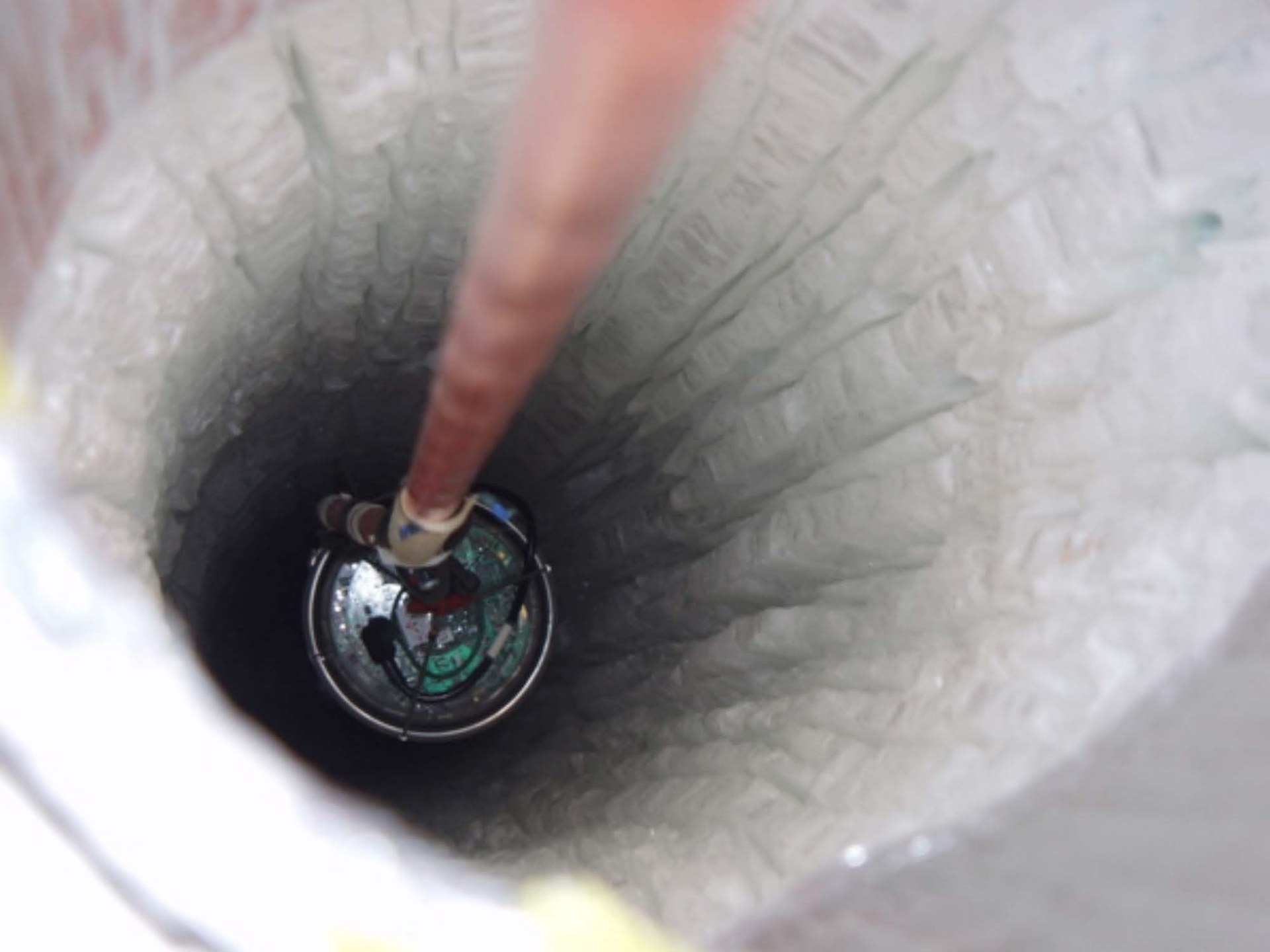


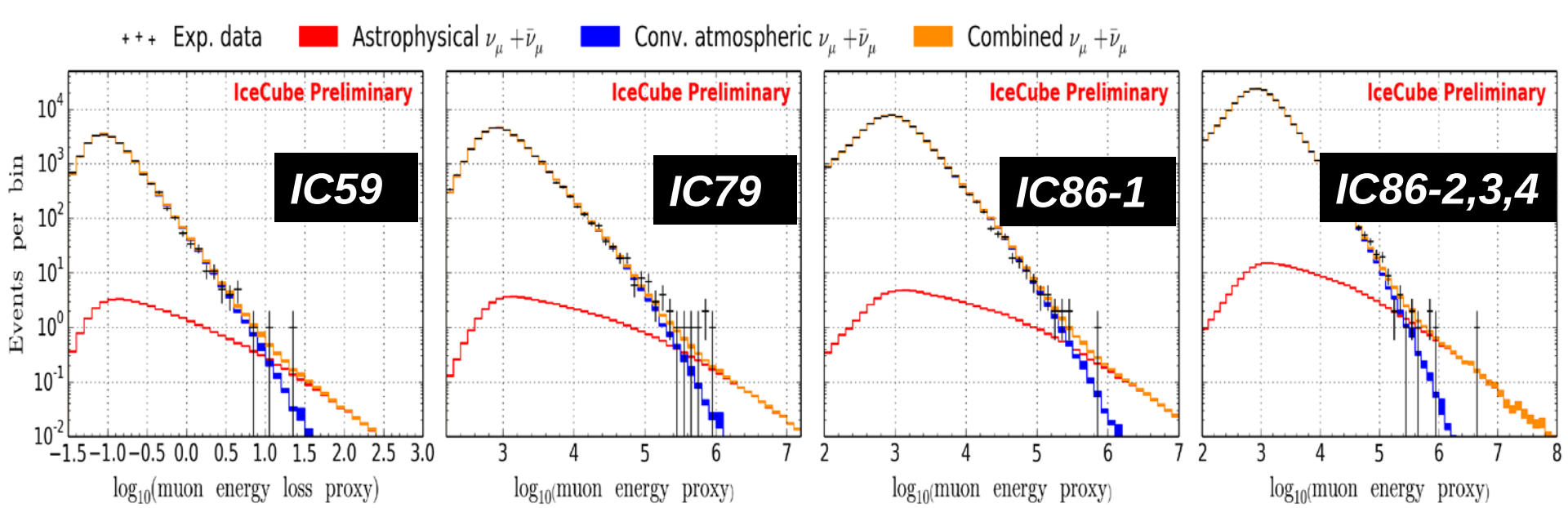
THE UNIVERSITY of ADELAIDE

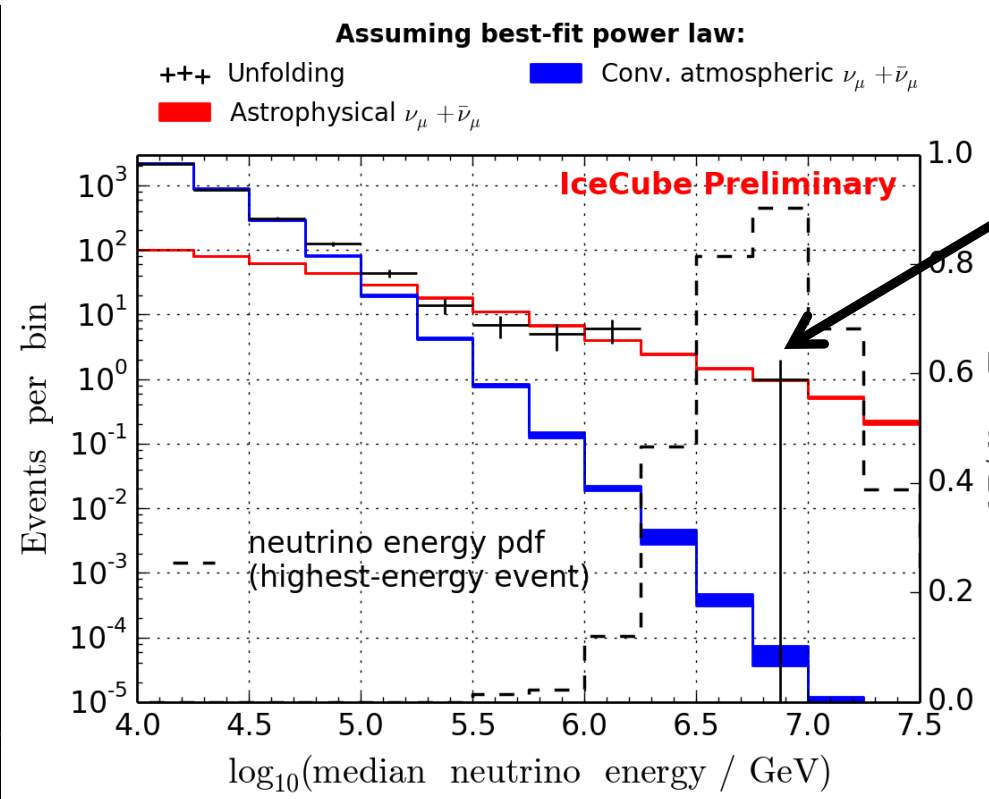
Where I’ve come from…

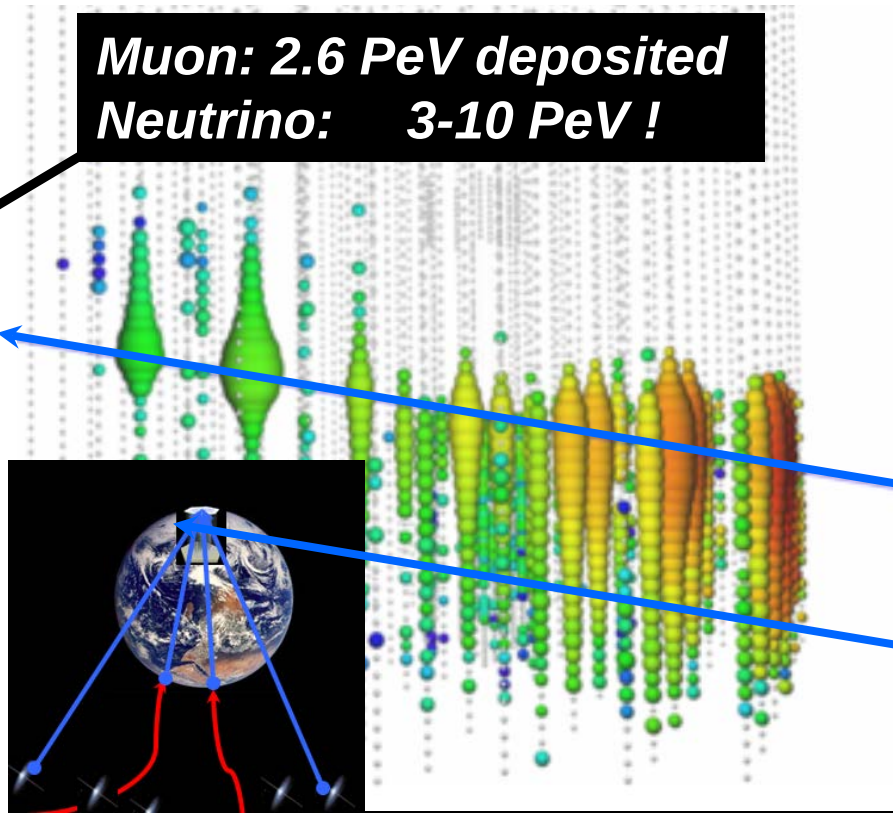

IceCube
South Pole Neutrino Observatory
50 m
IceTop
IceCube Laboratory
Data is collected here and sent by satellite to the data warehouse at UW–Madison
1450 m
86 strings of DOMs, set 125 meters apart
Amundsen–Scott South Pole Station, Antarctica
A National Science Foundation-managed research facility
60 DOMs on each string
DOMs are 17 meters apart
IceCube detector
DeepCore
Digital Optical Module (DOM)
5,160 DOMs deployed in the ice
2450 m
Antarctic bedrock






Exp. data
Astrophysical $\nu_\mu + \bar{\nu}_\mu$
Conv. atmospheric $\nu_\mu + \bar{\nu}_\mu$
Combined $\nu_\mu + \bar{\nu}_\mu$
IceCube Preliminary
IC59
IC79
IC86-1
IC86-2,3,4
Events per bin
$\log_{10}$(muon energy loss proxy)
$\log_{10}$(muon energy proxy)


Assuming best-fit power law:
Unfolding
Conv. atmospheric $\nu_\mu + \bar{\nu}_\mu$
Astrophysical $\nu_\mu + \bar{\nu}_\mu$
IceCube Preliminary
neutrino energy pdf
(highest-energy event)
Events per bin
$\mathrm{d}P/\mathrm{d}\log E_\nu$
$\log_{10}$(median neutrino energy / GeV)


Muon: 2.6 PeV deposited
Neutrino: 3-10 PeV !

Chasing the ammonia economy *p. 120*

Time invested matters for mice, rats, and humans *pp. 124 & 178*

Two spindles are better than one *pp. 128 & 189*

Science

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AAAS

NEUTRINOS FROM A BLAZAR

Multimessenger observations of an astrophysical neutrino source *pp. 115, 146, & 147*

RESEARCH ARTICLE

NEUTRINO ASTROPHYSICS

Multimessenger observations of a flaring blazar coincident with high-energy neutrino IceCube-170922A

The IceCube Collaboration, *Fermi*-LAT, MAGIC, *AGILE*, ASAS-SN, HAWC, H.E.S.S, *INTEGRAL*, Kanata, Kiso, Kapteyn, Liverpool Telescope, Subaru, *Swift/NuSTAR*, VERITAS, and VLA/17B-403 teams*†

Previous detections of individual astrophysical sources of neutrinos are limited to the Sun and the supernova 1987A, whereas the origins of the diffuse flux of high-energy cosmic neutrinos remain unidentified. On 22 September 2017, we detected a high-energy neutrino, IceCube-170922A, with an energy of ~290 tera–electronvolts. Its arrival direction was consistent with the location of a known γ-ray blazar, TXS 0506+056, observed to be in a flaring state. An extensive multiwavelength campaign followed, ranging from radio frequencies to γ-rays. These observations characterize the variability and energetics of the blazar and include the detection of TXS 0506+056 in very-high-energy γ-rays. This observation of a neutrino in spatial coincidence with a γ-ray–emitting blazar during an active phase suggests that blazars may be a source of high-energy neutrinos.

RESEARCH ARTICLE

NEUTRINO ASTROPHYSICS

Neutrino emission from the direction of the blazar TXS 0506+056 prior to the IceCube-170922A alert

IceCube Collaboration*†

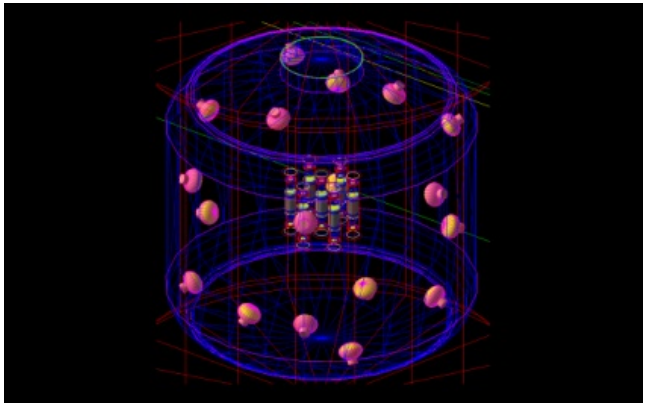
A high-energy neutrino event detected by IceCube on 22 September 2017 was coincident in direction and time with a gamma-ray flare from the blazar TXS 0506+056. Prompted by this association, we investigated 9.5 years of IceCube neutrino observations to search for excess emission at the position of the blazar. We found an excess of high-energy neutrino events, with respect to atmospheric backgrounds, at that position between September 2014 and March 2015. Allowing for time-variable flux, this constitutes 3.5σ evidence for neutrino emission from the direction of TXS 0506+056, independent of and prior to the 2017 flaring episode. This suggests that blazars are identifiable sources of the high-energy astrophysical neutrino flux.

IceCube Science has included a lot of indirect dark matter searches;

- WIMP annihilations in Sun and Earth
- nearby galaxies

Now: direct detection of dark matter with

SABRE South



- involved from very beginning
- current organisational roles:
    - convene weekly general meeting
    - member executive board
    - physics oversight

SABRE Adelaide

Senior: Gary Hill, Tony Williams, Paul Jackson

postdoc: Irene Bolognino (awaiting visa)
- cosmic rays, gamma rays, dark matter (SABRE North)
neutrinos (reactor anomaly - SOLID) + industry
- optical calibration system for veto vessel, physics simulations and analysis

staff: Paddy McGee (IT and Research Support Specialist)
- web/computing support (SABRE/COE)
- optical calibration system

students:
Minh Tan Ha (PhD) (cosmic backgrounds, hardware)
Geoffrey McNulty (Honours 2018) (cosmic backgrounds)

Optical Calibration

- need to understand how backgrounds (e.g. neutrons) interacting in the large veto vessel volume make photon signals detected in the surrounding PMTs

- some sort of outside laser system via optical fibre to emitting sites inside the vessel

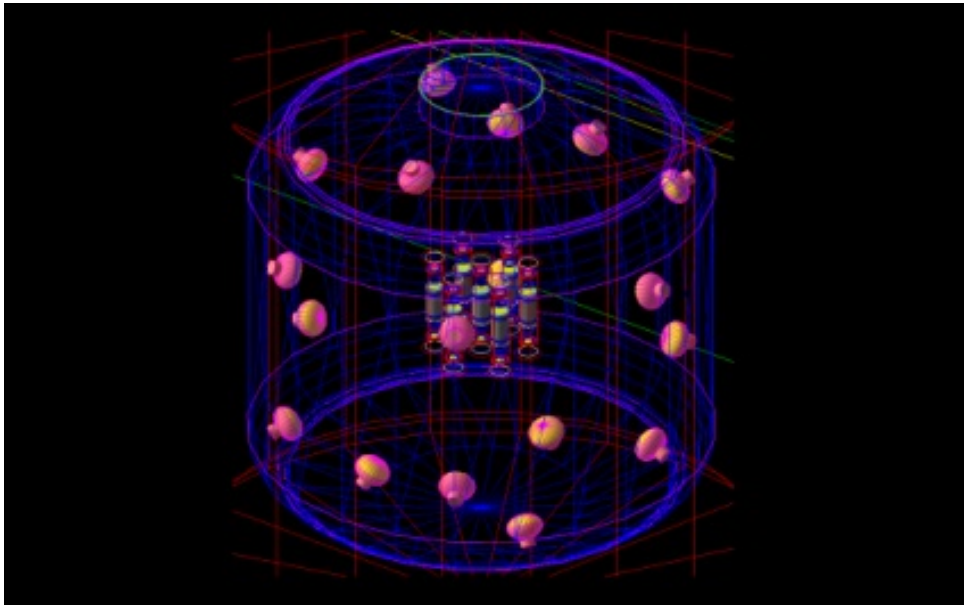
- critical for understanding that we are vetoing correctly (and thus correctly identifying the dark matter signals in the sodium iodide crystals)

Cosmic backgrounds

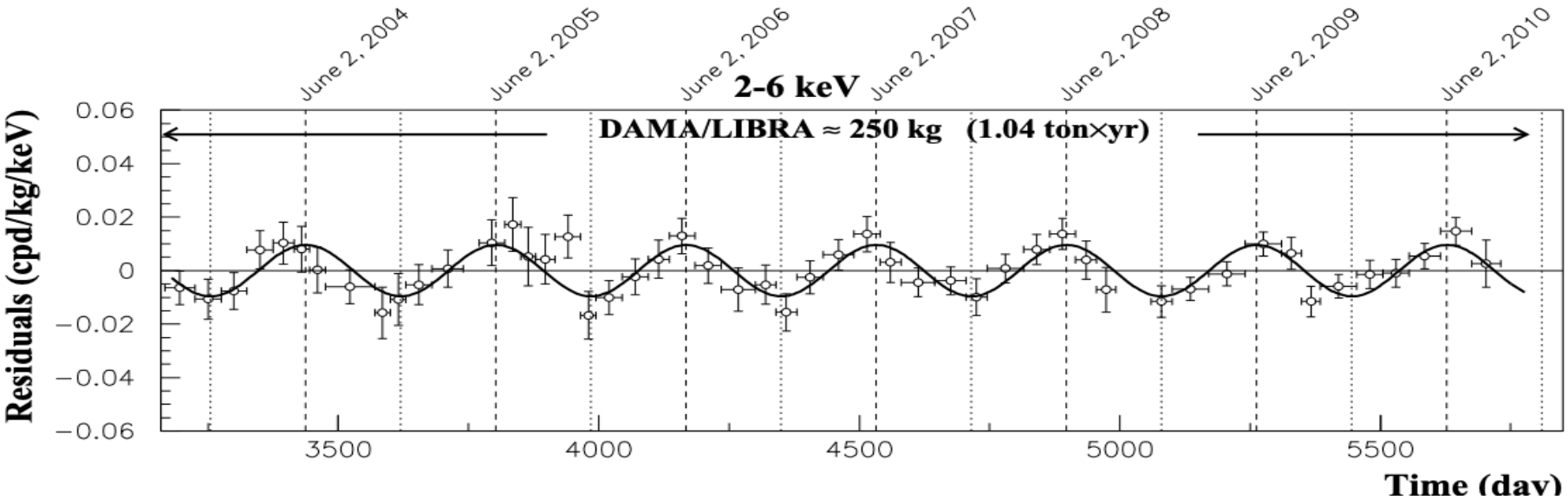
- downgoing muons kick neutrons out of rock that can interact in the detector

- very rare that they would make it into the crystal

- but, important that we understand such rare processes

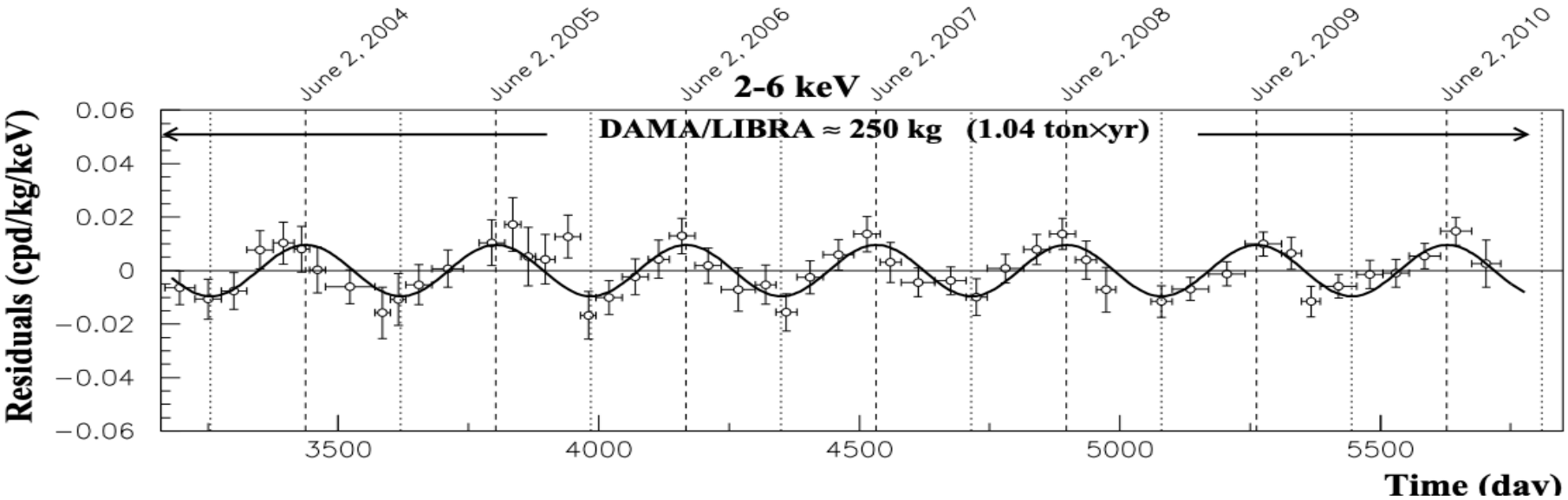


Thinking about the DAMA observation



- matches what you would expect for the Earth going around the Sun in and out of the WIMP wind.

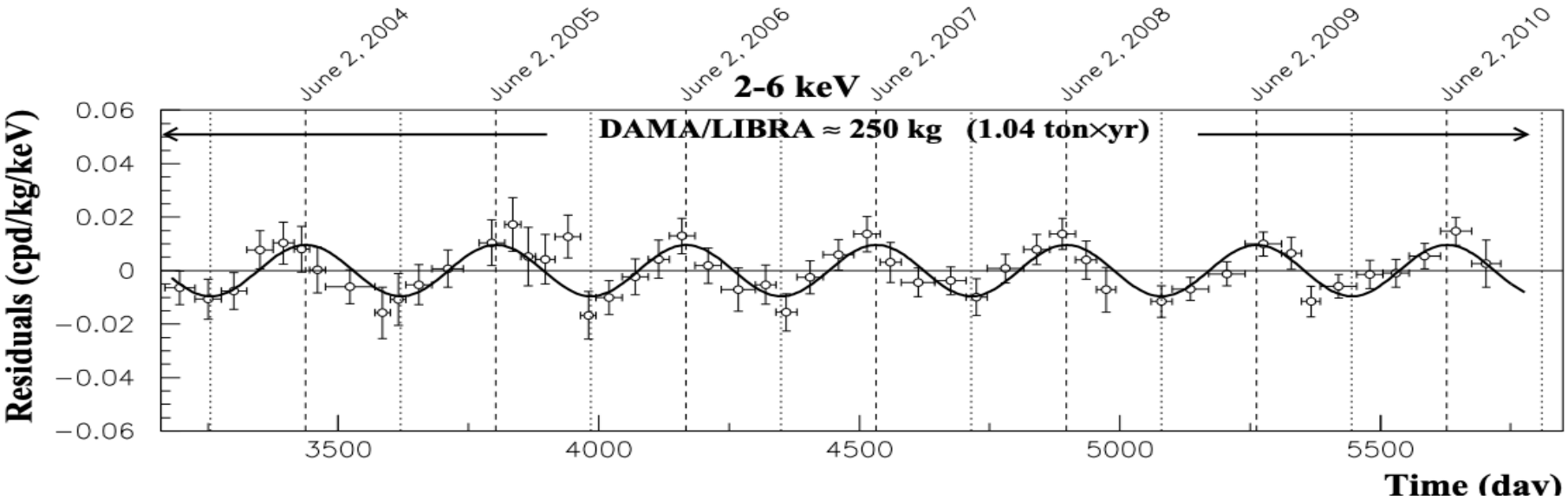
Thinking about the DAMA observation



- what if it's just a seasonal effect in the North?
- then we'd expect the phase to reverse in the South, rule out dark matter signal

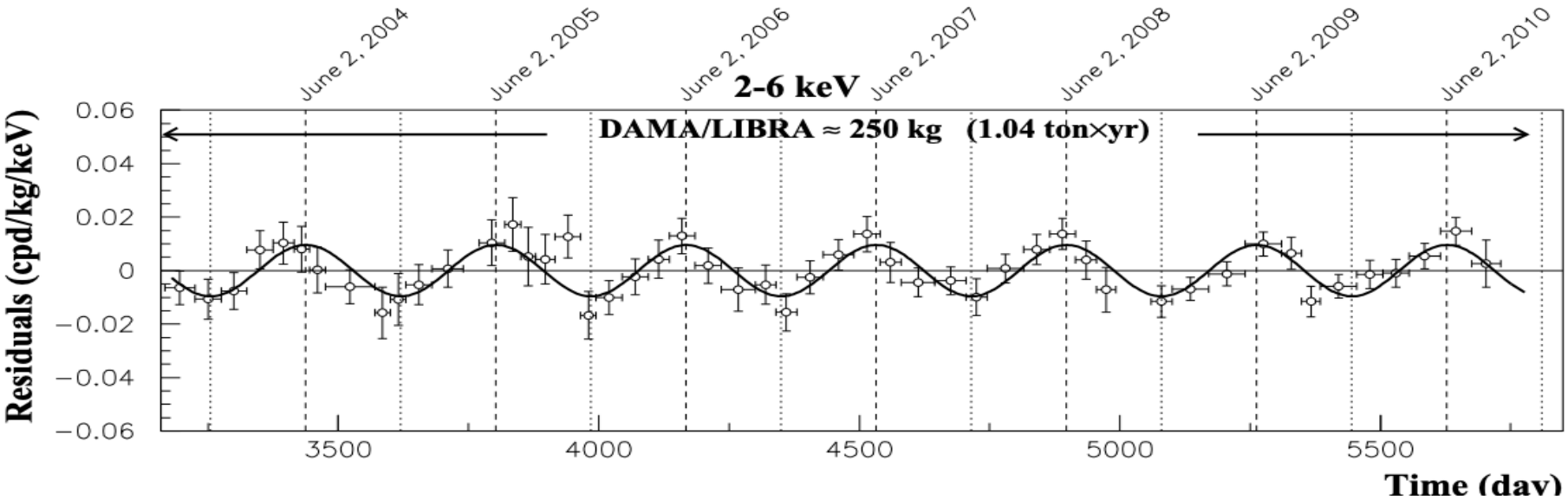
  (of course might not see anything, ruling it out)

Thinking about the DAMA observation



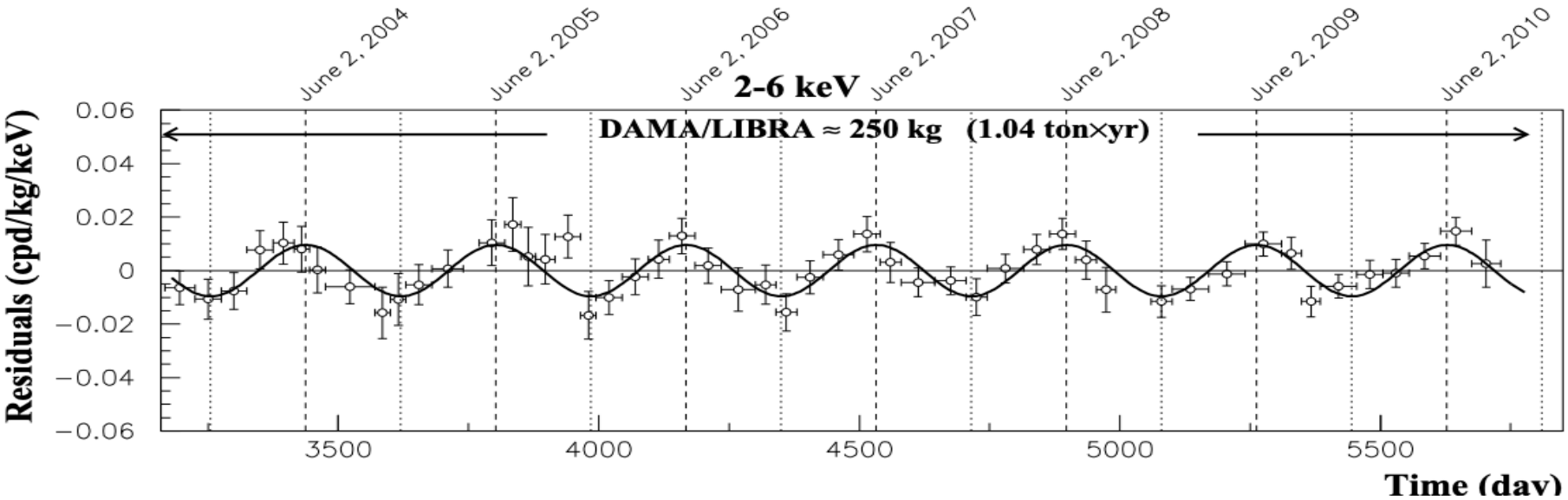
- what if it's a real dark matter signal?
- then we'd expect the same phase in the south

Thinking about the DAMA observation



- what if it's a real (non-seasonal) xxxxx?
- then we'd expect the same phase in the south

Thinking about the DAMA observation



- we need to think carefully about periodic backgrounds that might mimic DAMA but not have the seasonal N-S difference