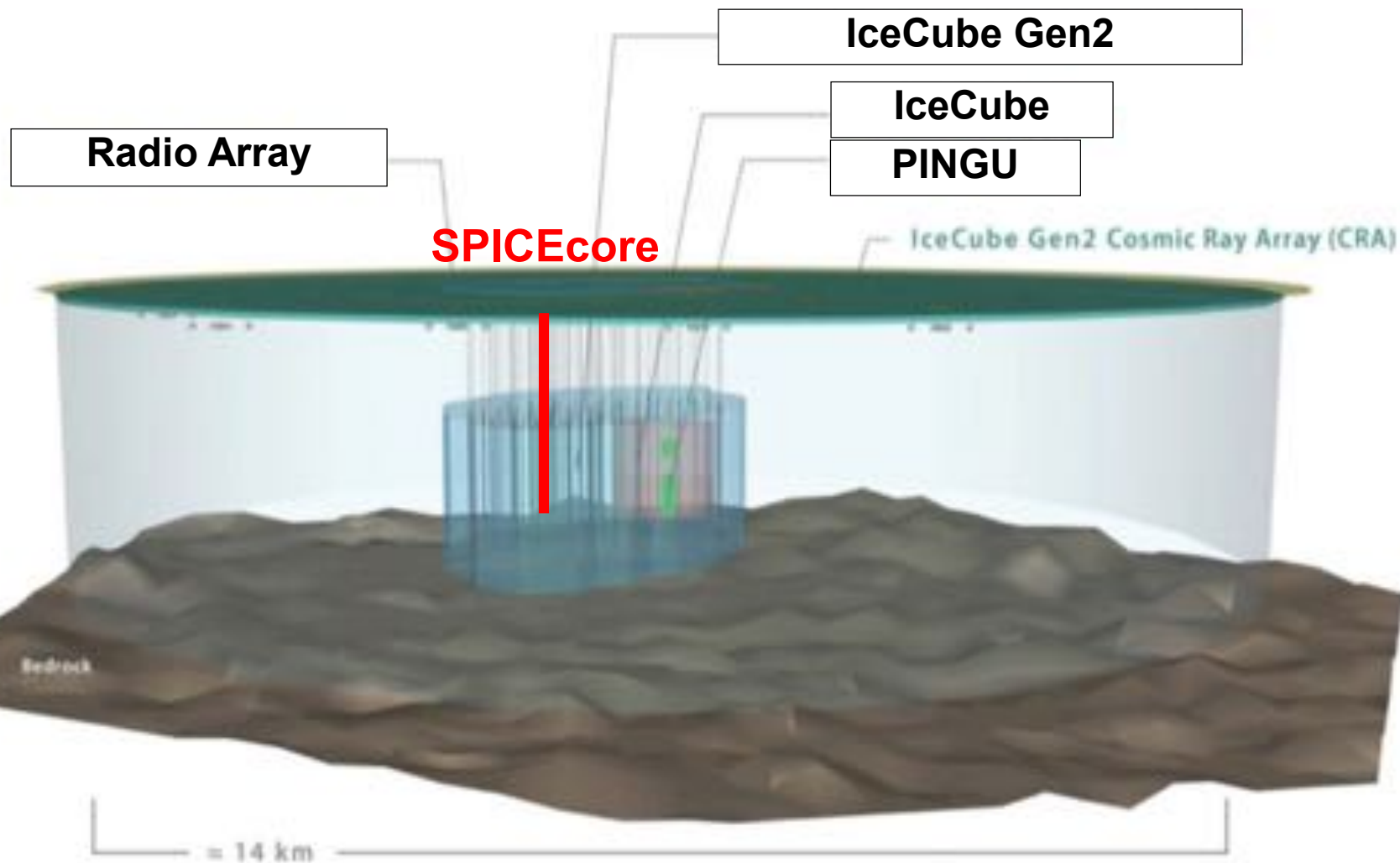


# Borehole logging & Ice observatories

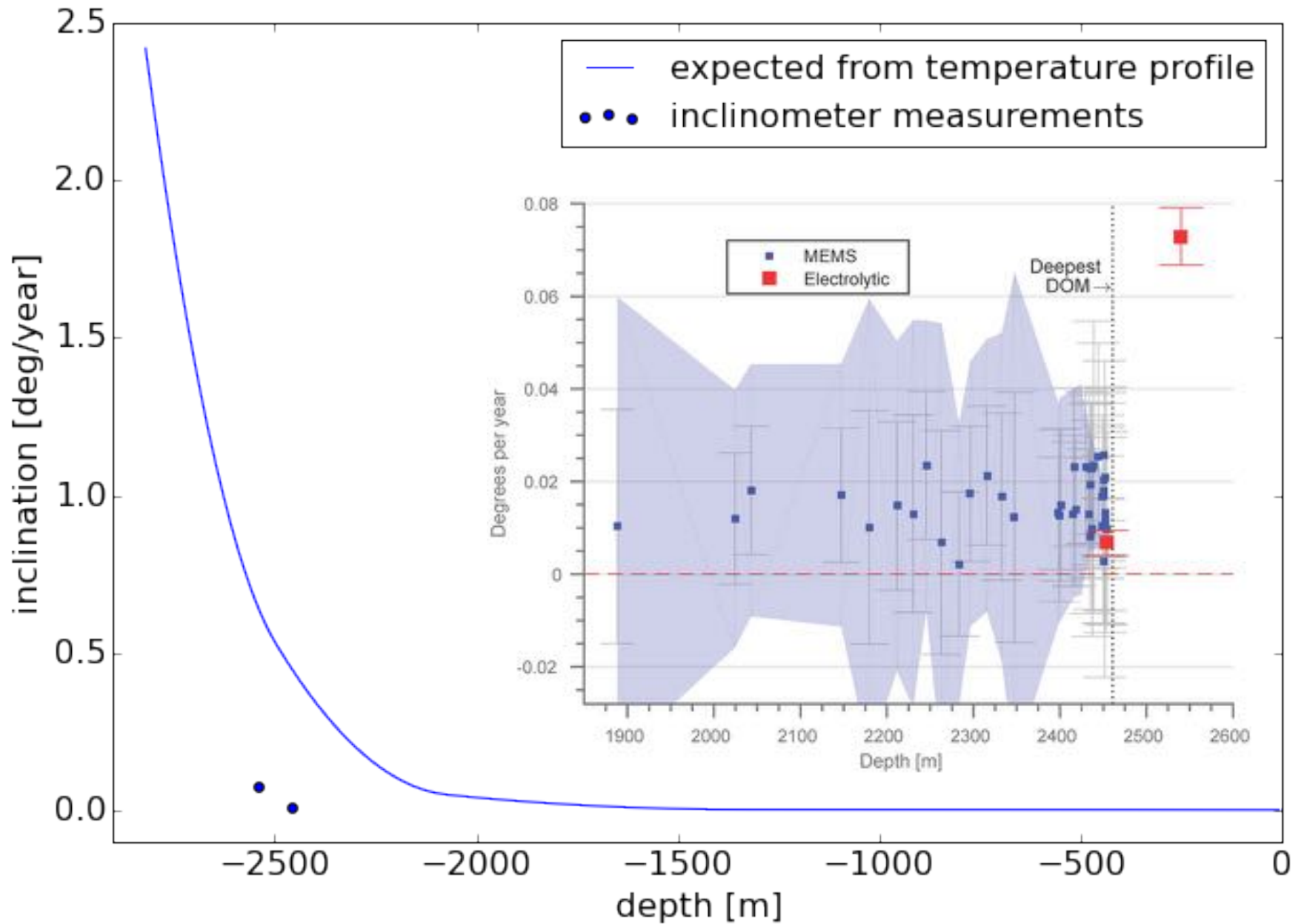
Ryan Bay  
IDDO Science Advisory Board  
March 6-7, 2017

- Updates
- South Pole as interdisciplinary observatory
- 2016-17 field season outcomes and BLWG concerns
- Pre-deployment testing
- Winch simulation filters

# South Pole – interdisciplinary observatory



# IceCube shear measurement



# Askaryan Radio Array (ARA)

South Pole neutrino detector in radio (200-800 MHz)

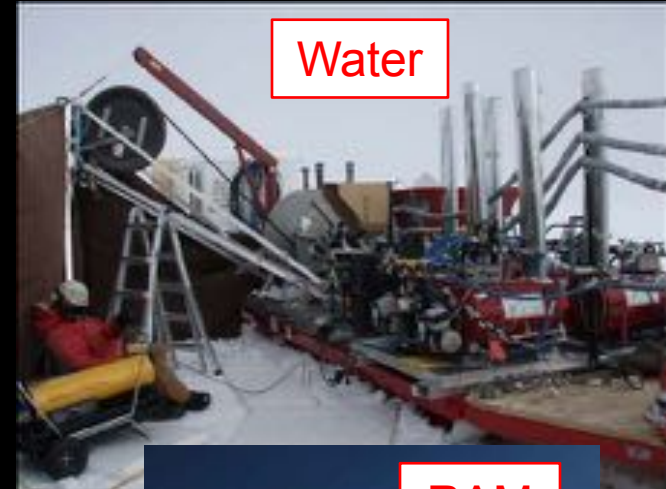
Two stations taking data

Planned 80 km<sup>2</sup> area, >200 holes  
150-200 m deep, 5-6", dry

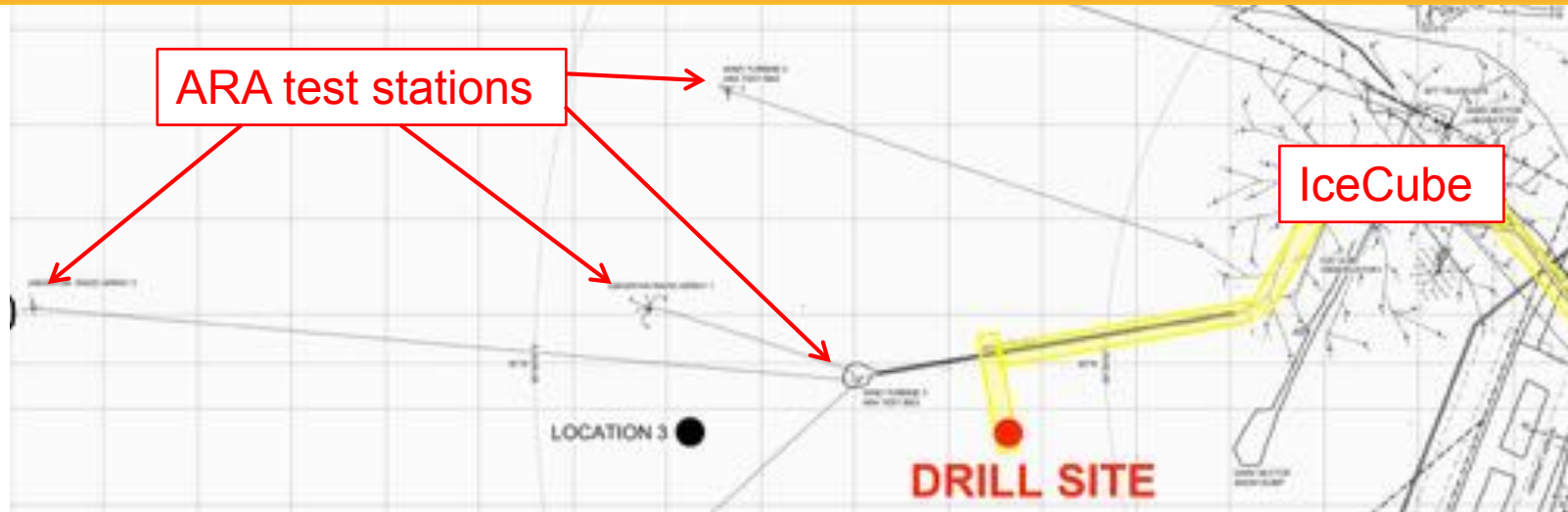
Investigating switching (back) to RAM

Some concern over Conway et al. GPR  
conflict in 2016-17

Will use SPICEcore borehole for calibration  
beacons in 2017-18



# SPICEcore borehole as testbed

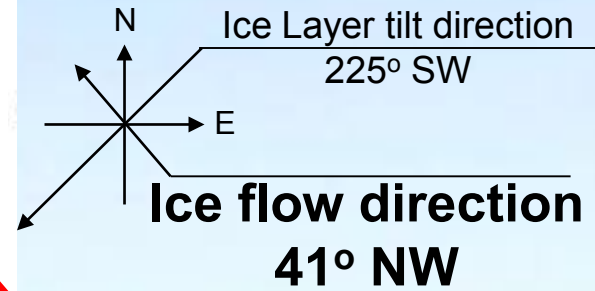
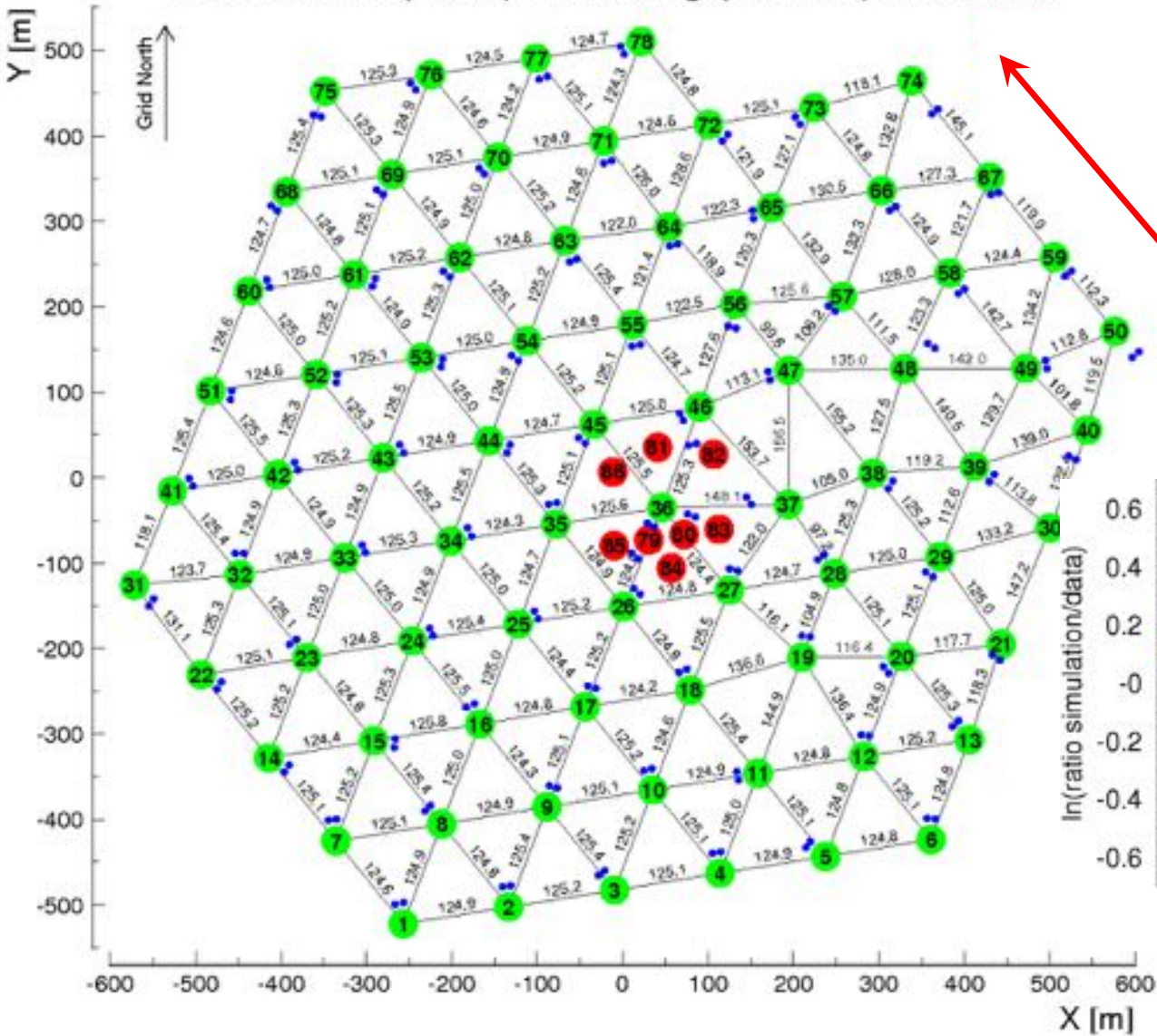


- Access point for ARA and IceCube calibration
  - Cross-borehole tomography
  - Timing pulses, tone bursts, polarization
  - Layering and bedrock mapping
  - Anisotropy / birefringence
  - Complex permittivity vs. depth & T
  - UV attenuation in ice

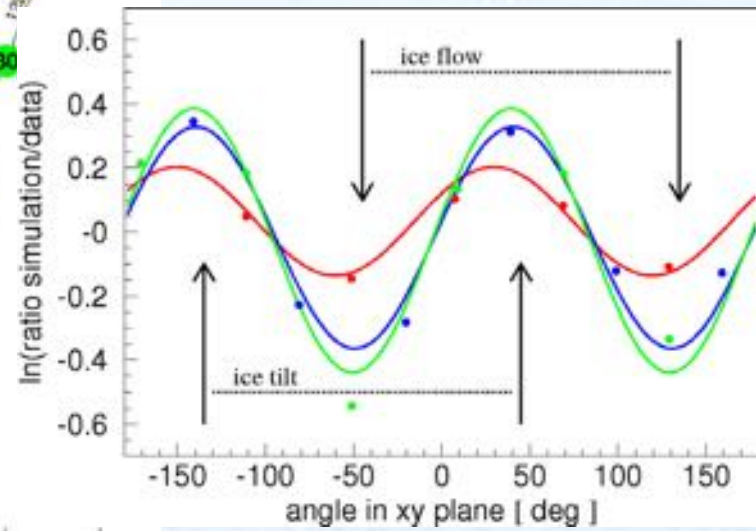


# Anisotropy in South Pole ice

IceCube-86 (78+8) interstring (surface) distances

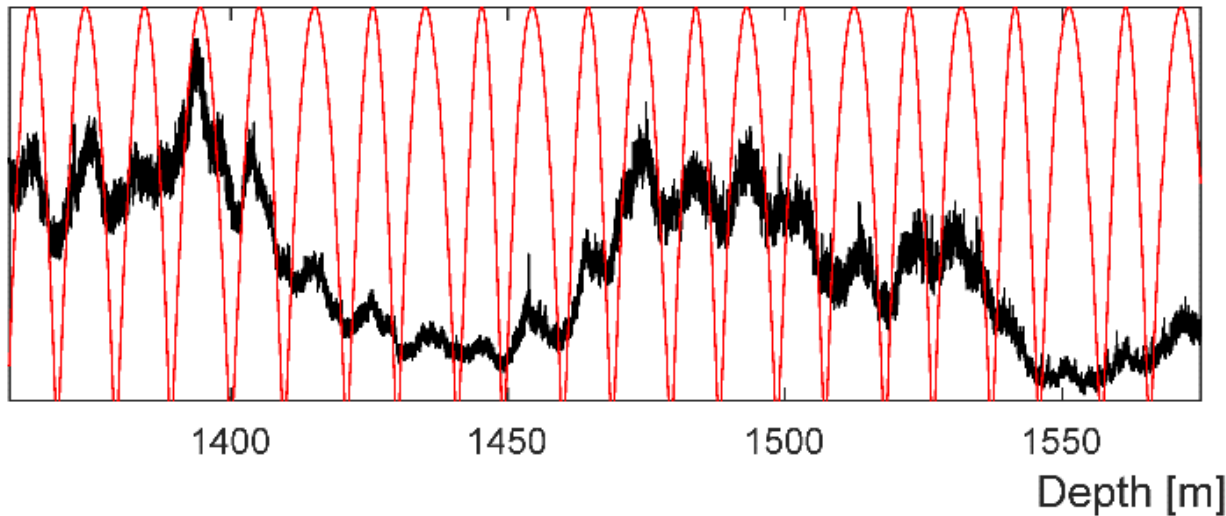
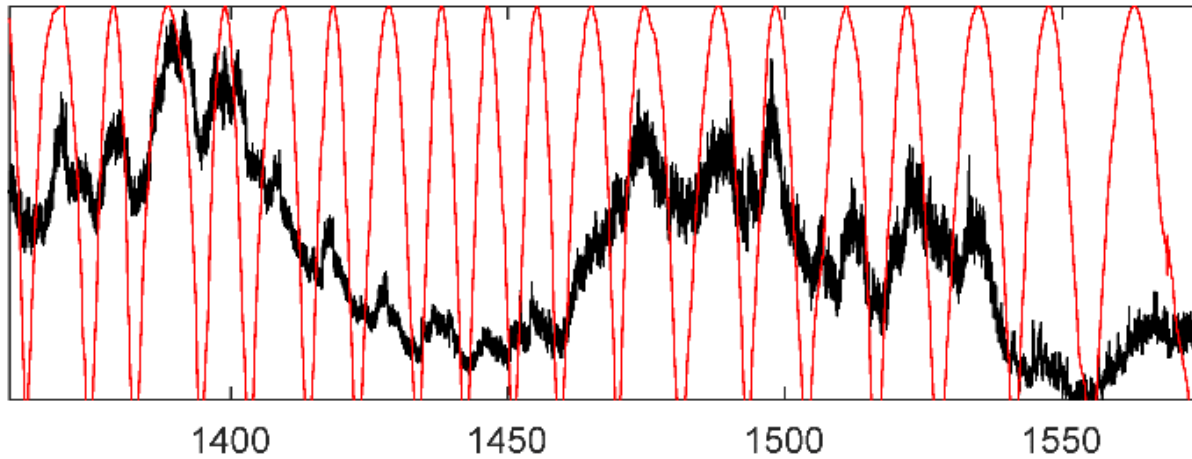


**9% less scattering  
41° NW**

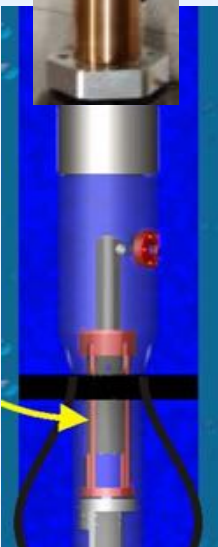
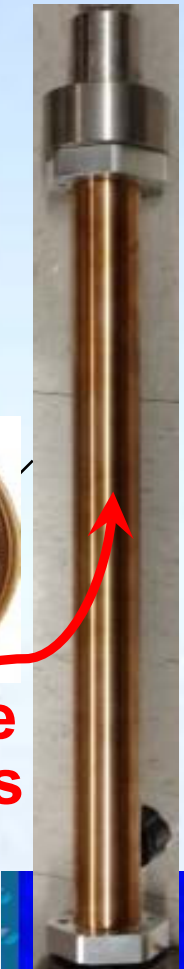


# Anisotropy in SPICEcore dust log (preliminary)

...oriented core?



Fluxgate  
compass



# Ice Diver



- Dale Winebrenner / Tim Elam, U. Washington
- 6 kW melter probe
- Lab testing “reversibility” using ethanol antifreeze



# Winches (logging lifelines)

## Heavy (4 km) logging winches

- **USGS** (formerly) **winch** used for predeployment testing 2016
- **IDDO winch** deployed WAIS Divide 2016-17 for sonic logging
  - leveling issue
  - telemetry problems (!)
- **Intermediate (1500 m) logging winch**
  - deployed as backup (and used) South Pole Ice Core 2016-17
  - deployed to Minna Bluff field test
  - some minor issues
- **Intermediate Depth Drill winch**
  - used for temperature logging South Pole Ice Core 2016-17
  - cable had been partially compromised
  - new tougher cable(s) purchased

# Some 2016-17 Logging activity (U.S.)

- **SPICEcore (South Pole Ice Core)**

- Laser dust logging

- Intermediate Depth Logging Winch (IDLW) <1600m

- Also logged temperature to bottom using IDD winch

- Upstream ice/firn dynamics (Conway, Koutnik, Hawley)

- Shallow cores, accumulation, temperature, water isotopes, flow

- **RAID**

- Field test at Minna bluff

- Insufficient augers for thick firn → retry 2017-18

- Optical televiewer firn log

- Slim-line dust logger built & fielded to test post-drilling optical

- High potential for borehole logging science

- ~5 sites per season, ~40 total

- Borehole preservation ↔ logistics

- BLWG ↔ RAID WG + RAID SCO

- ⇒ Fast logging tools for baselines immediately after drilling

- How many hours do we have?

# Some 2016-17 Logging activity (U.S.)

- **WAIS Divide logging**

- MHz sonic (borehole deformation) Pettit / Obbard
- kHz sonic (fabric) Waddington / Anandakrishnan
- P.I. - IDDO winch “co-piloting”

## **More telemetry issues...**

- ⇒ Could be specific to WD? Noisy power? Bad ground?
- ⇒ **Substitute winch** used for predeployment testing
- ⇒ Winch simulation filter LRSP Priority 2

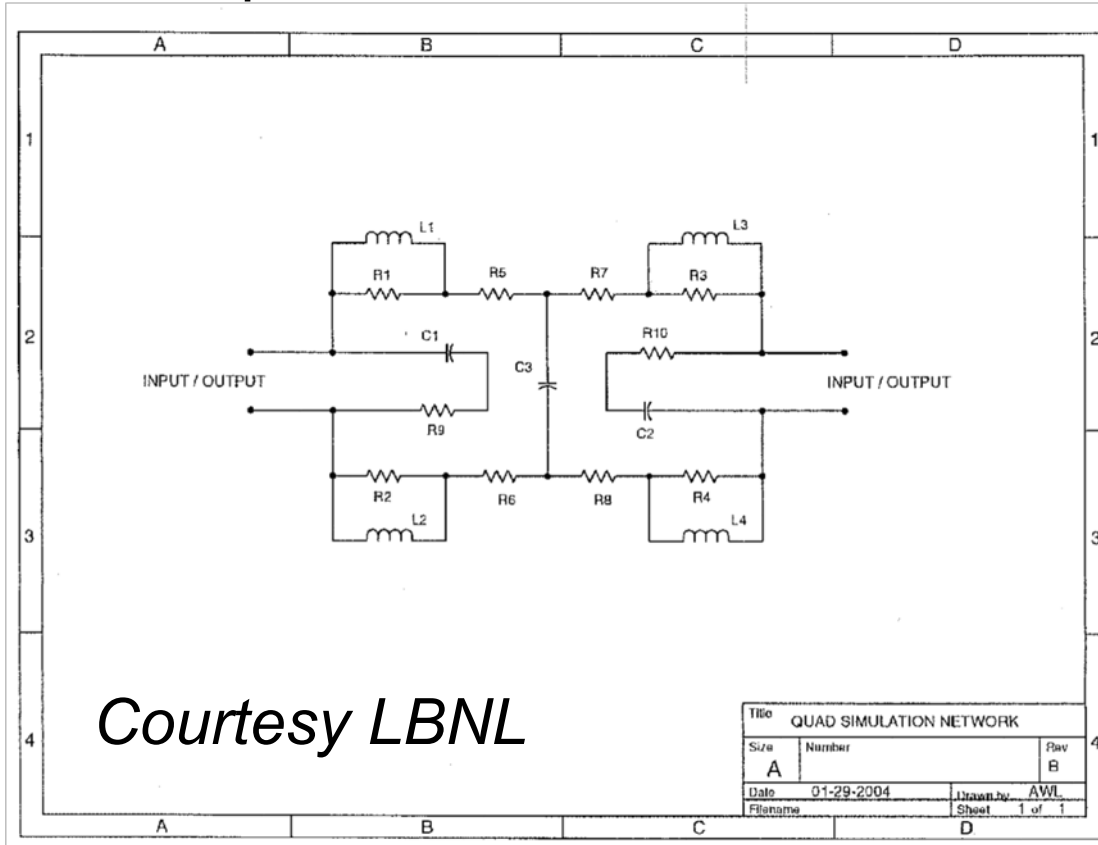
# Logging telemetry

- Winches provide transport, power and communication
- Power  $P = \frac{V^2}{R}$  ← cable has voltage limits  
R ← power is lost over long cables
- Analog communication
- Digital communication
  - Data rates:
    - ~1 kbyte/sec – temperature probes
    - ~10 kbyte/sec – optical, sonic loggers, SUBGLACIOR
    - ~100 kbyte/sec (Mbps) – IceCube, oil & gas
  - Encoding schemes:
    - Amplitude keying (ASK), phase keying (PSK)
    - OFDM

# Winch simulation filters

Zachary Meulemans(IDDO) + Bay

Example:



Courtesy LBNL

