Ice drilling for physics & astrophysics

Ice as an observatory

• Physics in ice drives ice drilling technology and expertise

Status Updates:
• IceCube EHWD disposition
• Low energy physics (PINGU, MICA, DM-Ice)
• Ultra-high energy neutrino astronomy (ARA)
IceCube
IceCube

EHWD Disposition Status

- EHWD has been broken up between 4 groups
  - IceCube/NSF (long-term storage at South Pole)
  - WISSARD (Univ. of Nebraska, tied up for at least 4 years, field work based out of McMurdo)
  - ARA (UW-Madison, equipment at South Pole, tied up indefinitely)
  - Support Contractor

- Critical equipment that is no longer under IceCube/NSF custodianship
  - Generators, Power Distribution Module, and Cabling - WISSARD
  - RWS (Rodwell System) - WISSARD
  - Main Drill Cable Reel - WISSARD
  - Return Water Cable Reel - WISSARD
  - Independent Firn Drill – WISSARD
  - Fuel Tower – WISSARD
  - Rolling Stock – Support Contractor
  - MECC - ARA
  - SHOP - ARA
Low-energy physics in IceCube: PINGU, MICA, DM-Ice
“Precision IceCube Next Generation Upgrade”
• ~20 strings
• Achieve ~1 GeV energy threshold
• WIMPs, atmospheric ν oscillations
• R & D new photon detection technology
  Very high density photocathode coverage
  Multi-PMT module
  Wavelength shifting
  Multi-channel plate PMTs
  Large area photodetectors
• Advanced ice calibration
  Short-distance optical properties
  Refrozen hole ice properties
• Possible proposal late 2012
• Earliest deployment 2014-15
“Multi-megaton Ice Cherenkov Array”
- ~250 strings
- 5 MT fiducial volume w/ 10 MeV threshold
- Supernova $\nu$ and proton decay
- Part of revamped S4 NSF funding
- 8 m triangular grid

“Dark Matter in Ice”
- 250 - 500 kg of NaI
- Direct detection of dark matter
- Complements NH experiments
- Two test modules deployed in 2010
- Currently applying for funding
- Hope to deploy 2014-15
HWD considerations for low energy physics

Close packing with HWDs
- 5 m = no go
- 7 m = marginal
- 10 m probably OK
- drilling straighter may help

HWD upgrades
- Stop condensate recycling
- Better filtration
- Add degassing capability
IceCube EHWD

Starting Estimate of Cost and Schedule

- Replace Equipment: $2.3M
- Upgrades: $0.7M
- Field Seasons: $7.9M
- Total: $10.9M

- $11M for 2-season, 18 holes total
  - Half of this needed upfront to begin replacing and upgrading
- 2-yr lead time
  - Would need to get started Sept 2012 to possibly drill in 14-15 season
Ultra-high-energy $\nu$ detection via radio Cherenkov (Askaryan) radiation

- $10^{16}$-$10^{17}$ eV threshold
- 80 km$^2$ area
- Strings spaced ~ few 100s m

$\Rightarrow$ Hundreds of holes
200 m deep

Hole cluster

Quad dipole
Slotted dipole
As expected, firn air loss is a serious problem

RAM probably not suitable for ARA
ARA drilling season 2011-12

- First season attempting 200 m hole, pumped dry
- One drill stuck, one pump stuck
- $200 \text{ m} \times \Ø 6''$ was not attained
- Power delivered not sufficient because of lost water
- Freeze-back faster than expected
- Future:
  - Recirculate water
  - Pump hole dry and drill simultaneously
ARA hole assessment