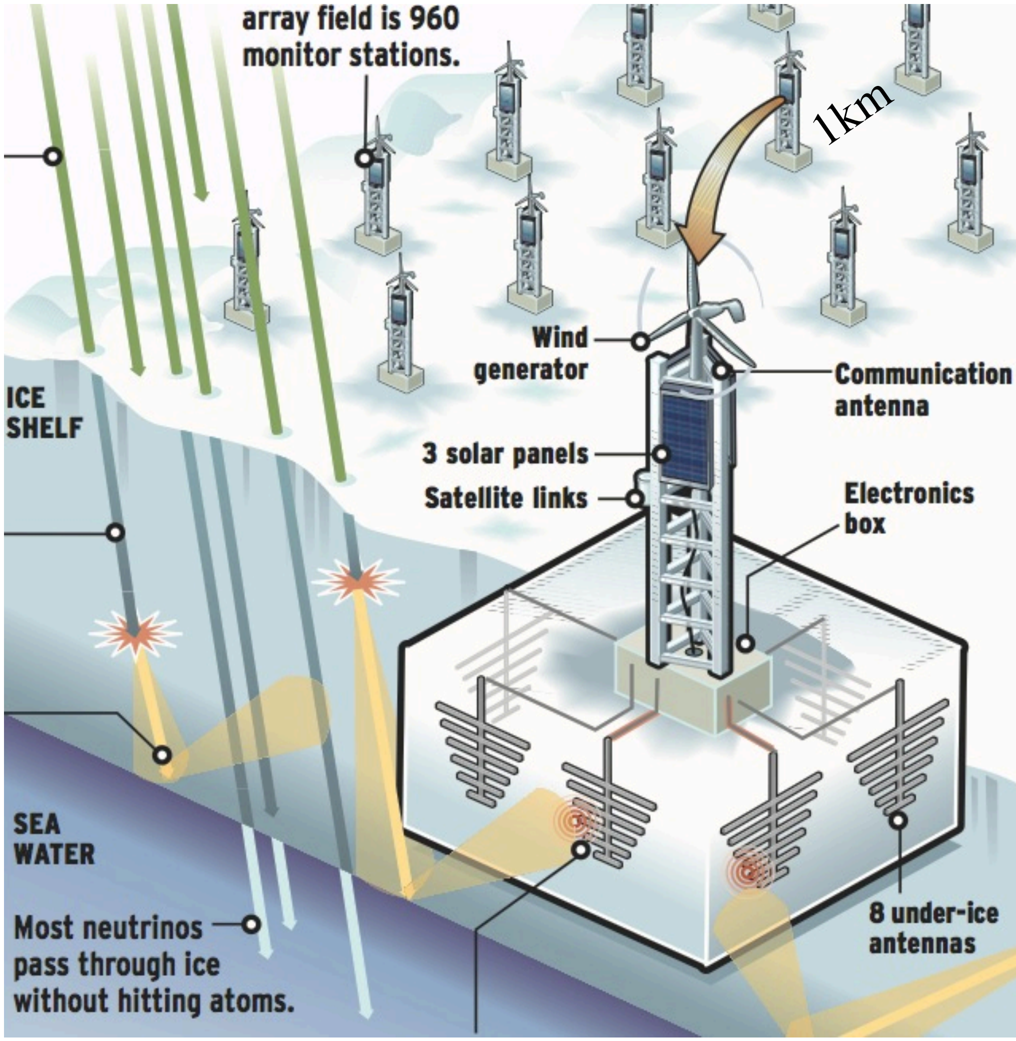
ARIANNA Progress

UHECR Zion Oct. 2014



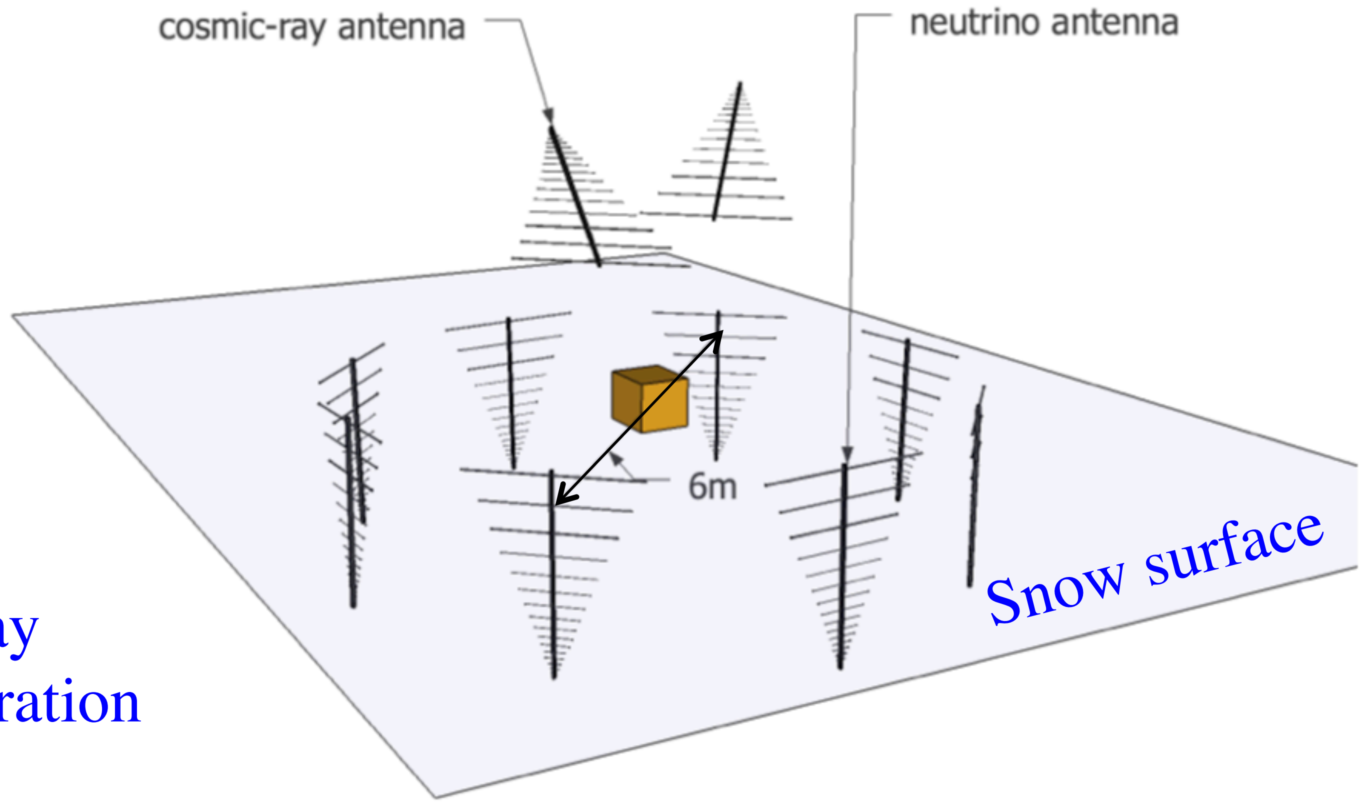
Steven W. Barwick

UCI University of California, Irvine

for the ARIANNA collaboration

US
Sweden
Denmark
Netherlands
New Zealand

ARIANNA Station



36x36 array
1 km separation

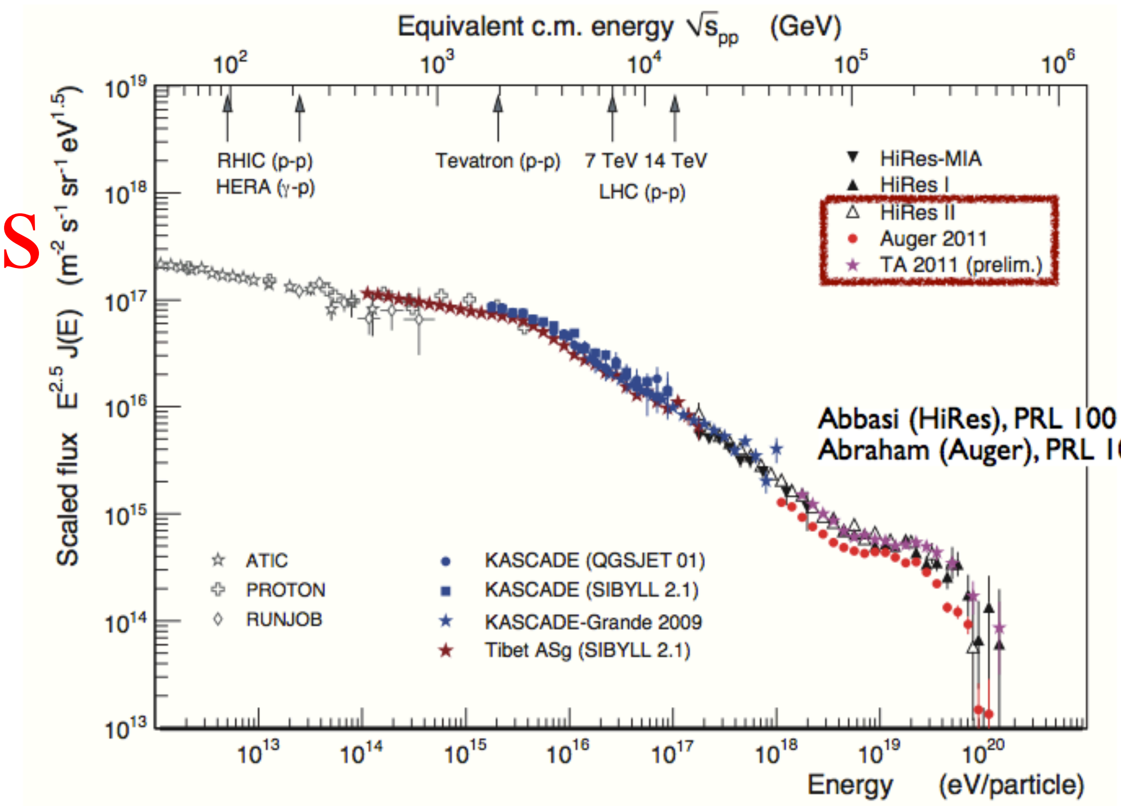
HRA Pilot station: 4 down antenna and no CR up antenna

Big Questions

What are cosmic rays?

Where do cosmic rays come from?

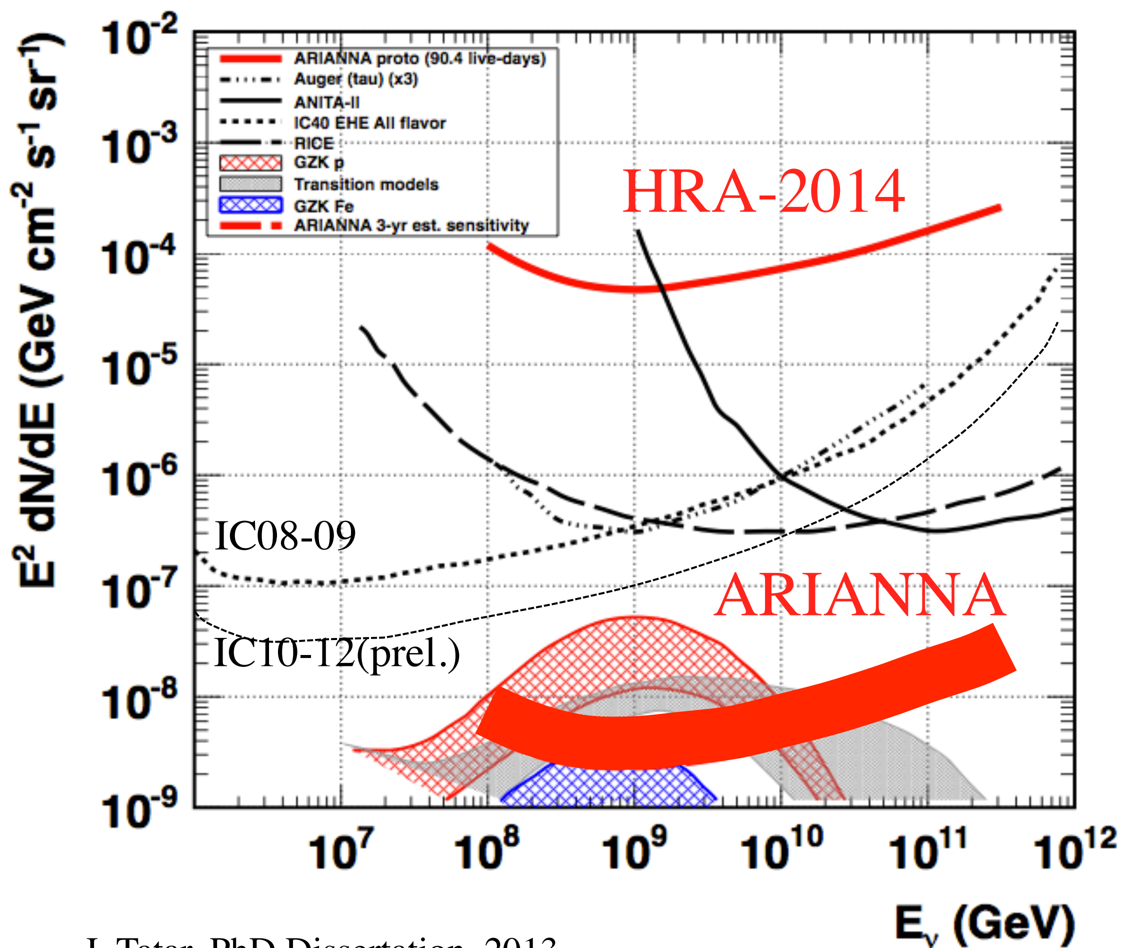
Is there physics beyond the standard model?



New Strategy

- Look for high energy neutrinos, which are a byproduct of cosmic ray factories
- Construct new kind of telescope

Cosmogenic (GZK) neutrino flux



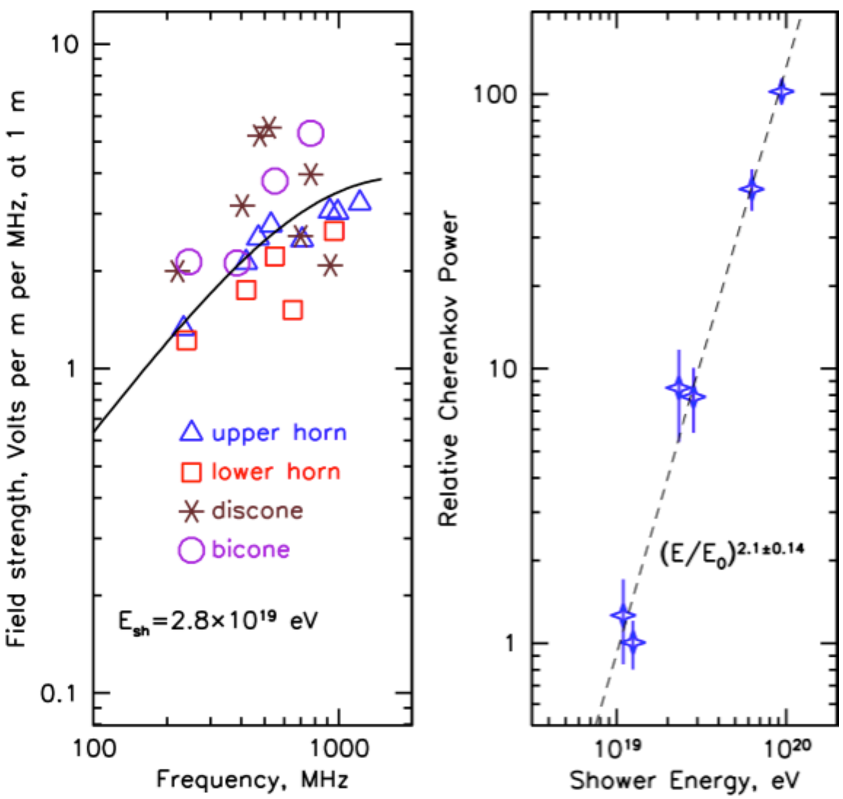
J. Tatar, PhD Dissertation, 2013
Fig. adapted from Kampert&Unger

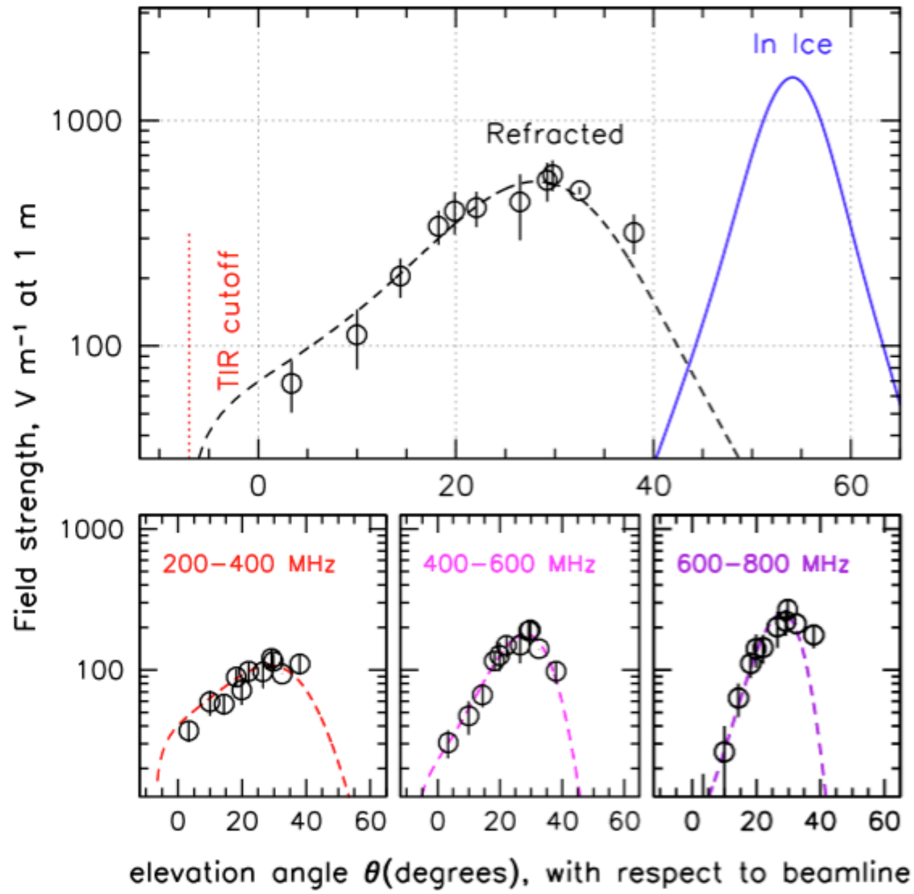
Calculations depend on:

1. Composition [p, mix]
2. Evolution of sources
3. Highest energy, E_{max}
4. Injection Spectrum
5. End of Gal. CR

Askaryan Radio Emission from SLAC beam in Ice

Gorham, Barwick, et al., astro-ph/0611008

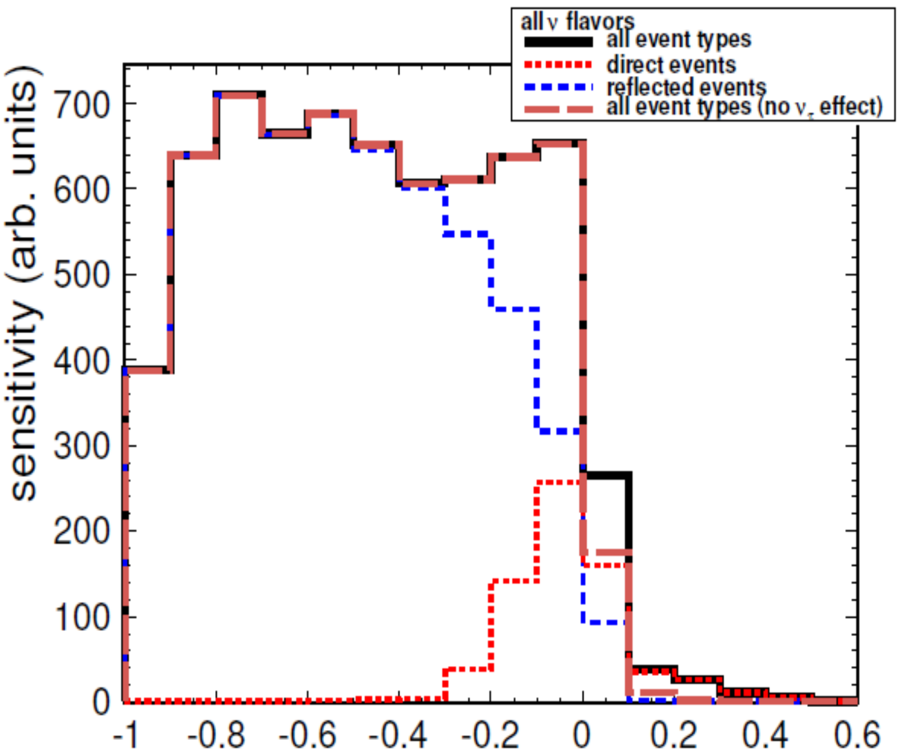




Absolute RF power and frequency dependence confirmed

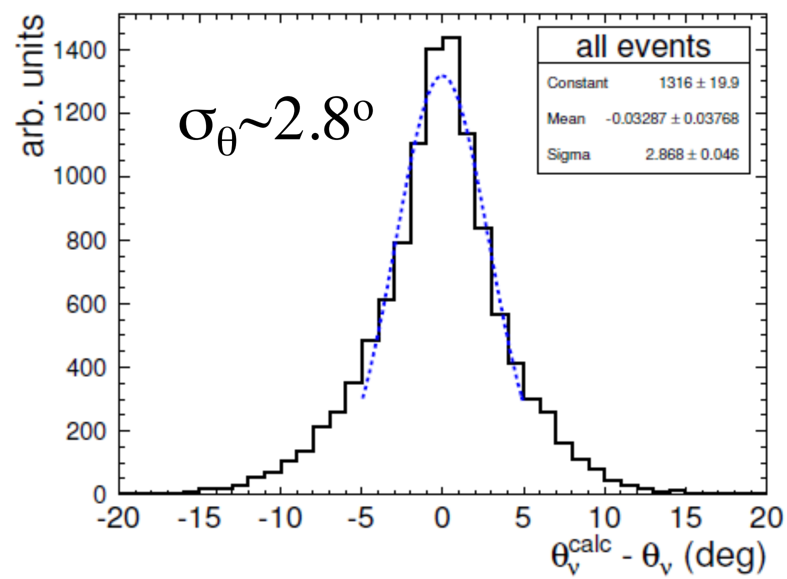
Width of cherenkov cone and frequency dependence confirmed

Capabilities



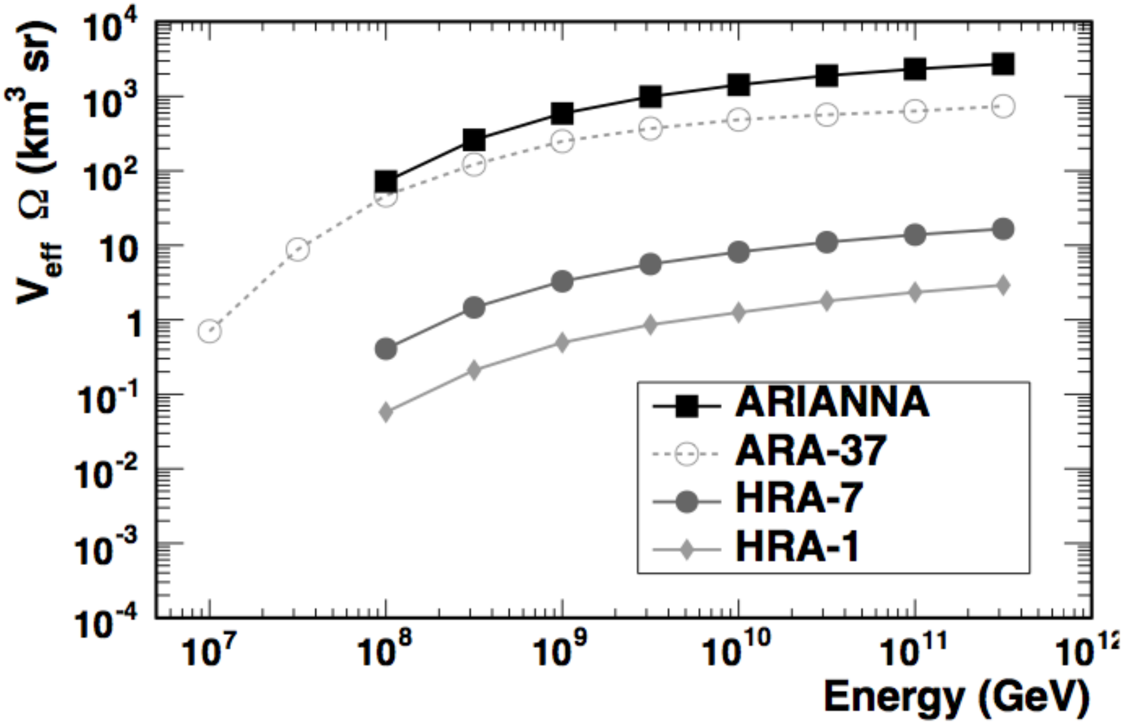
Down horizon cos(θ)

Angular resolution



K. Dookayka, UCI PhD dissertation, 2011

Effective Volume

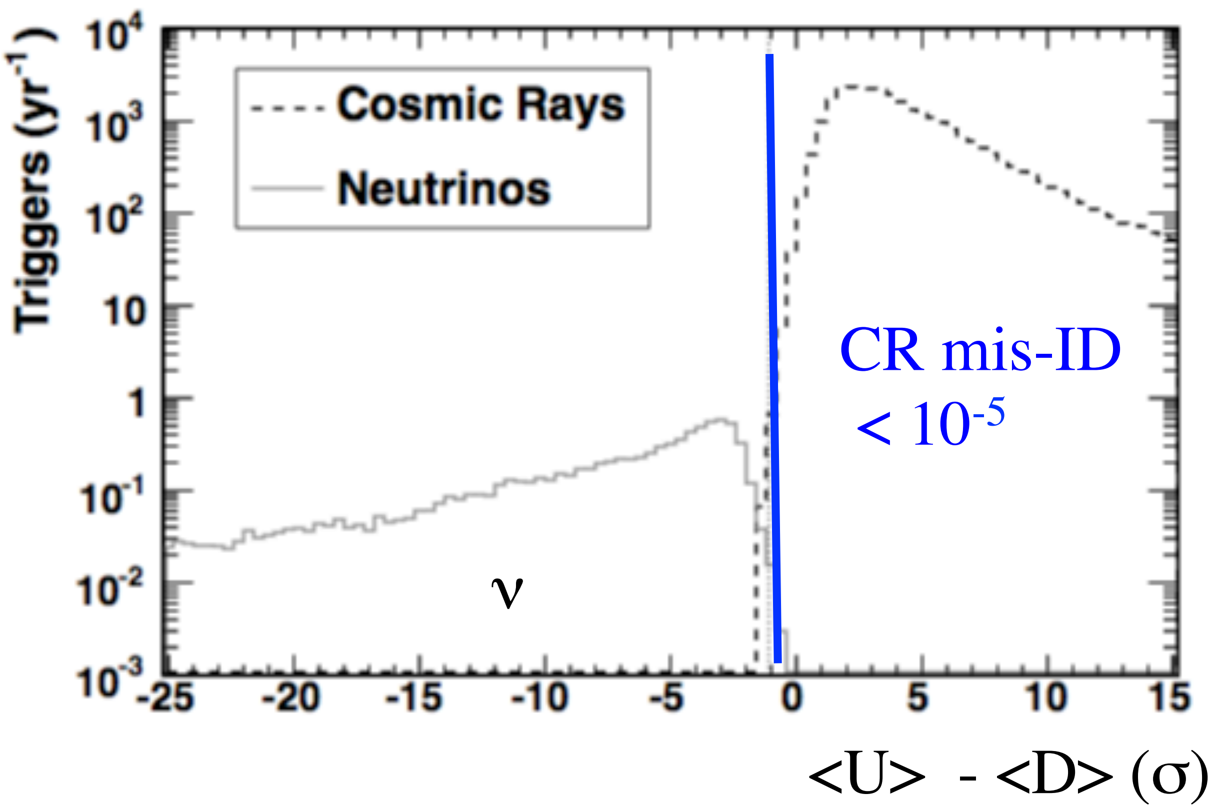


Extends to lower energy but simulation accuracy must be improved

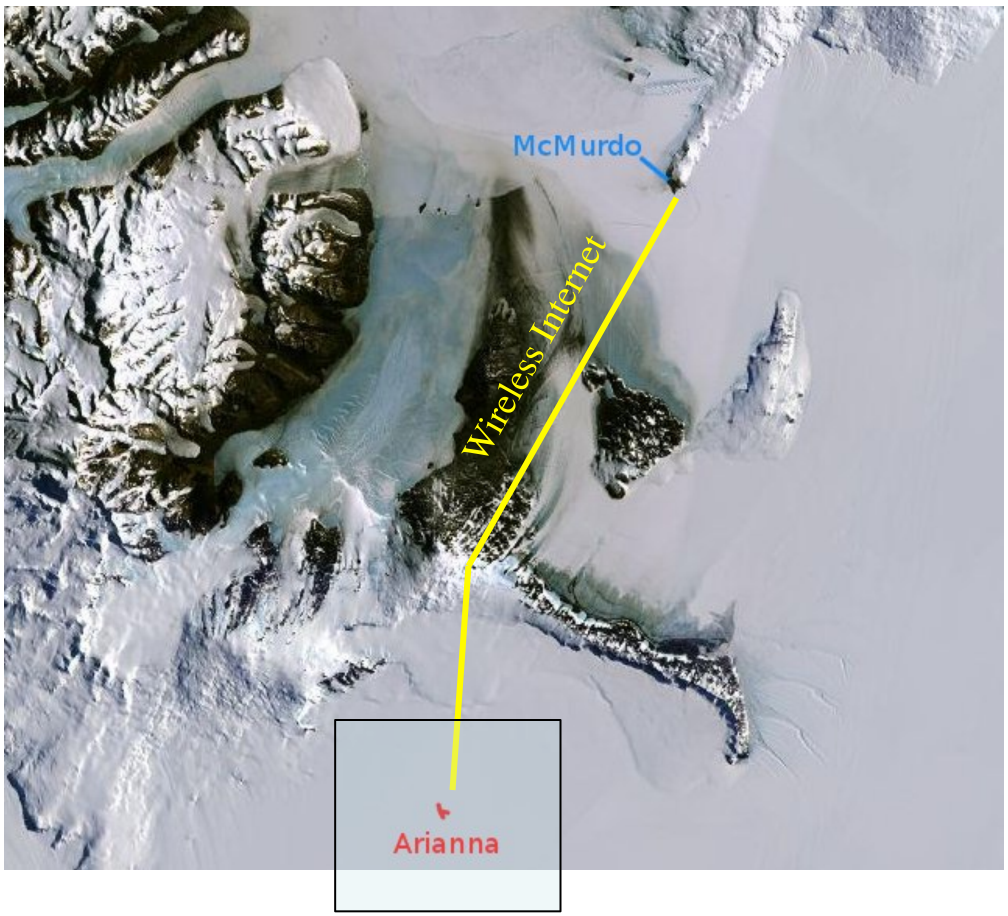
S. Barwick, et al. , in prep., 2014

Cosmic Ray Event Tagging

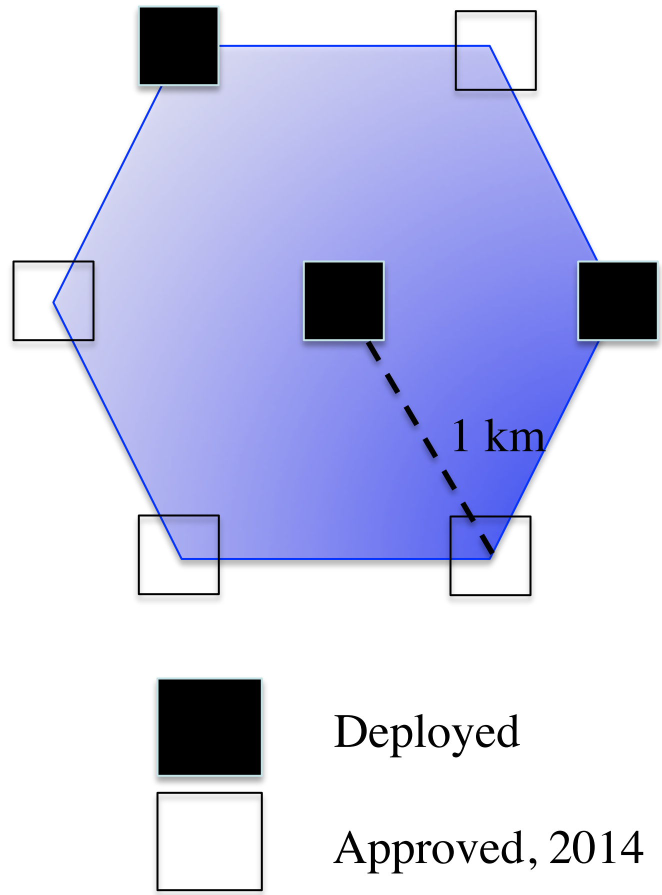
- CR air showers produce radio pulses; ~10^4 CR/year
- Use difference in signal strength for Up ant (U) and down ant. (D)



Hexagonal Radio Array (HRA): 2012-2014

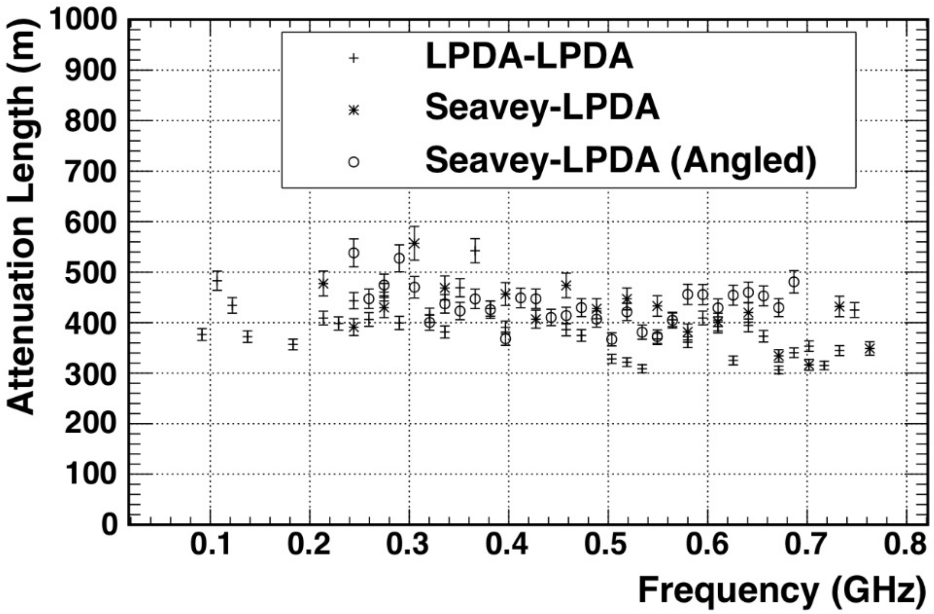


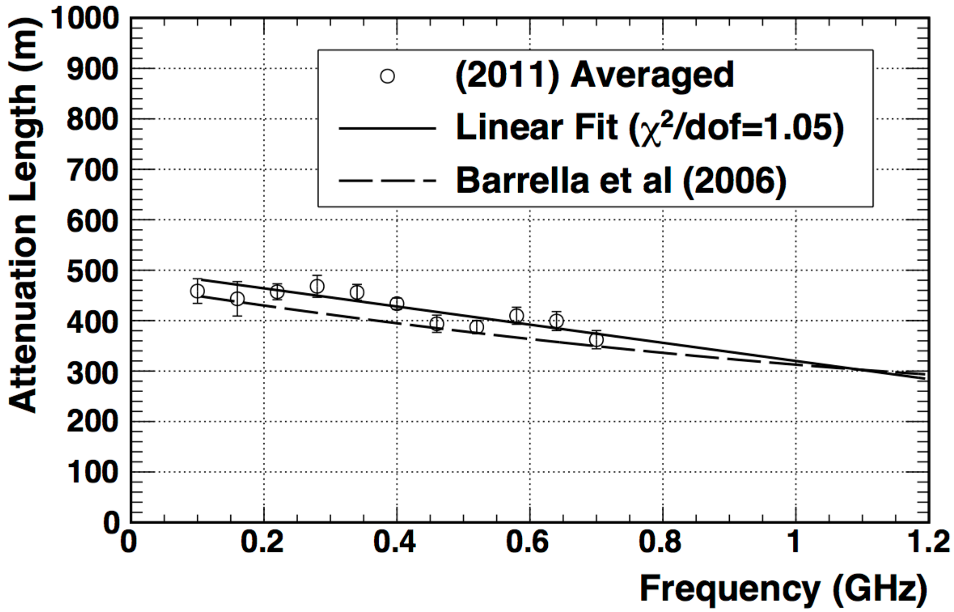
Moore's Bay, 110 km from McMurdo Station



Ave. Attenuation Length

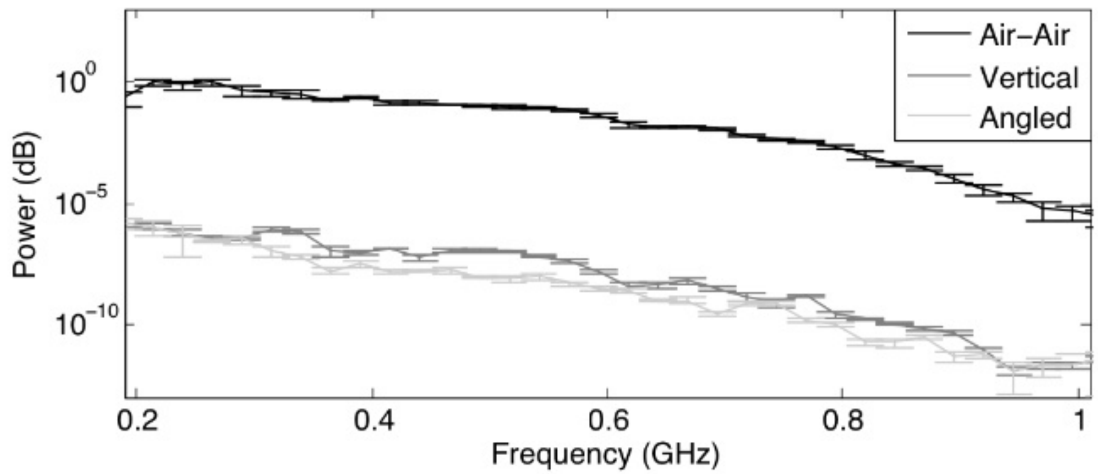
S. Barwick, et al., in prep, 2014



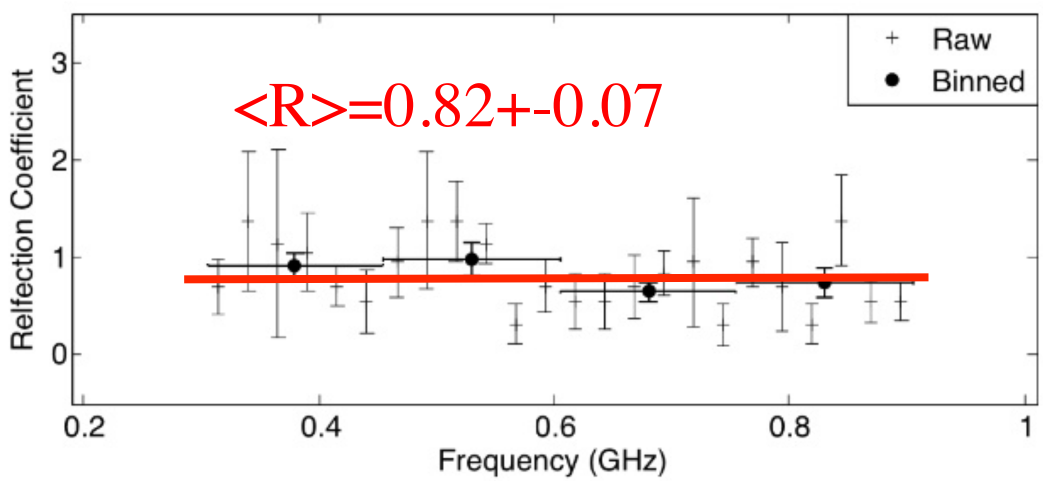


Attenuation length averaged over full depth of ice
No evidence of birefringence from combination of data

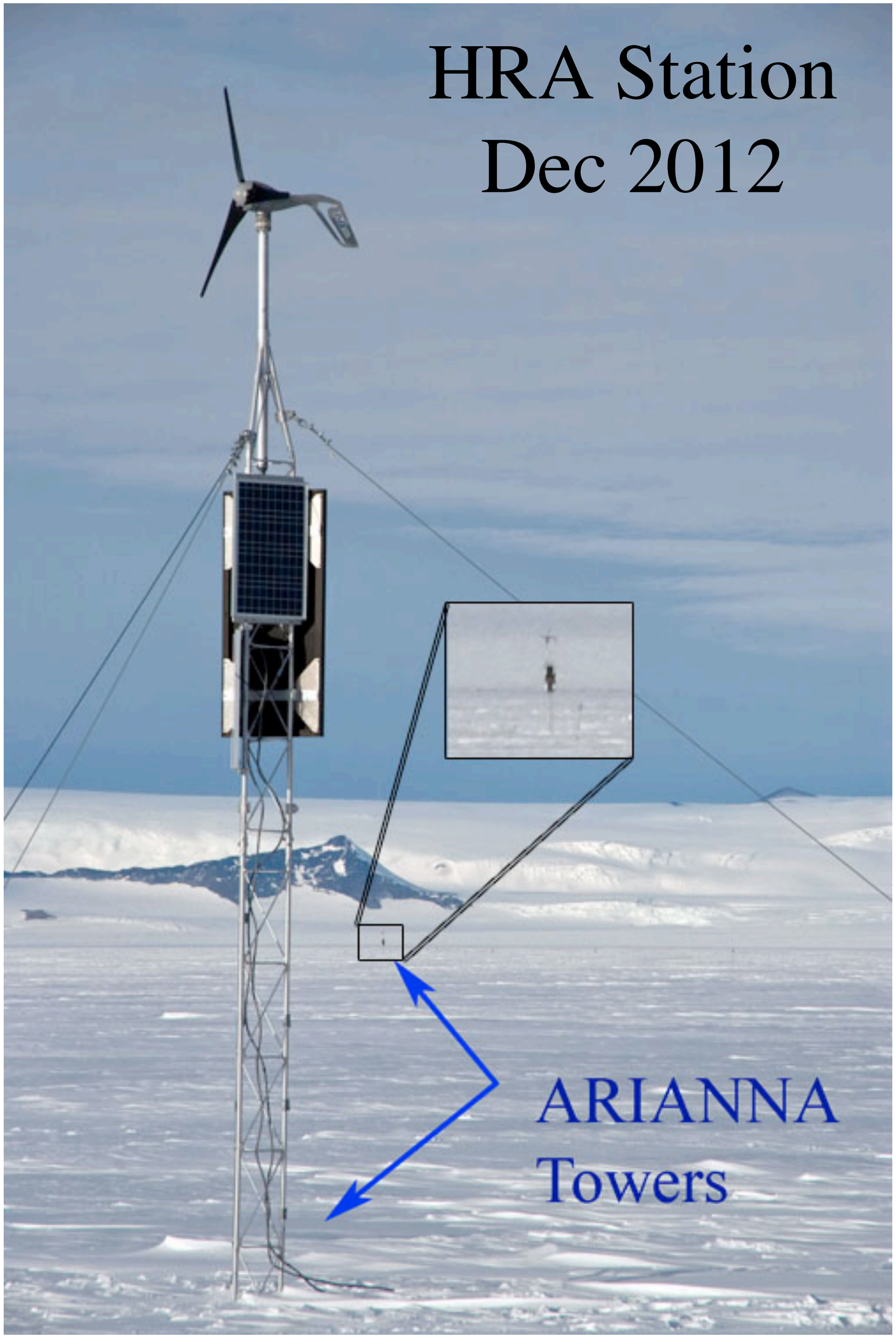
Reflection from bottom



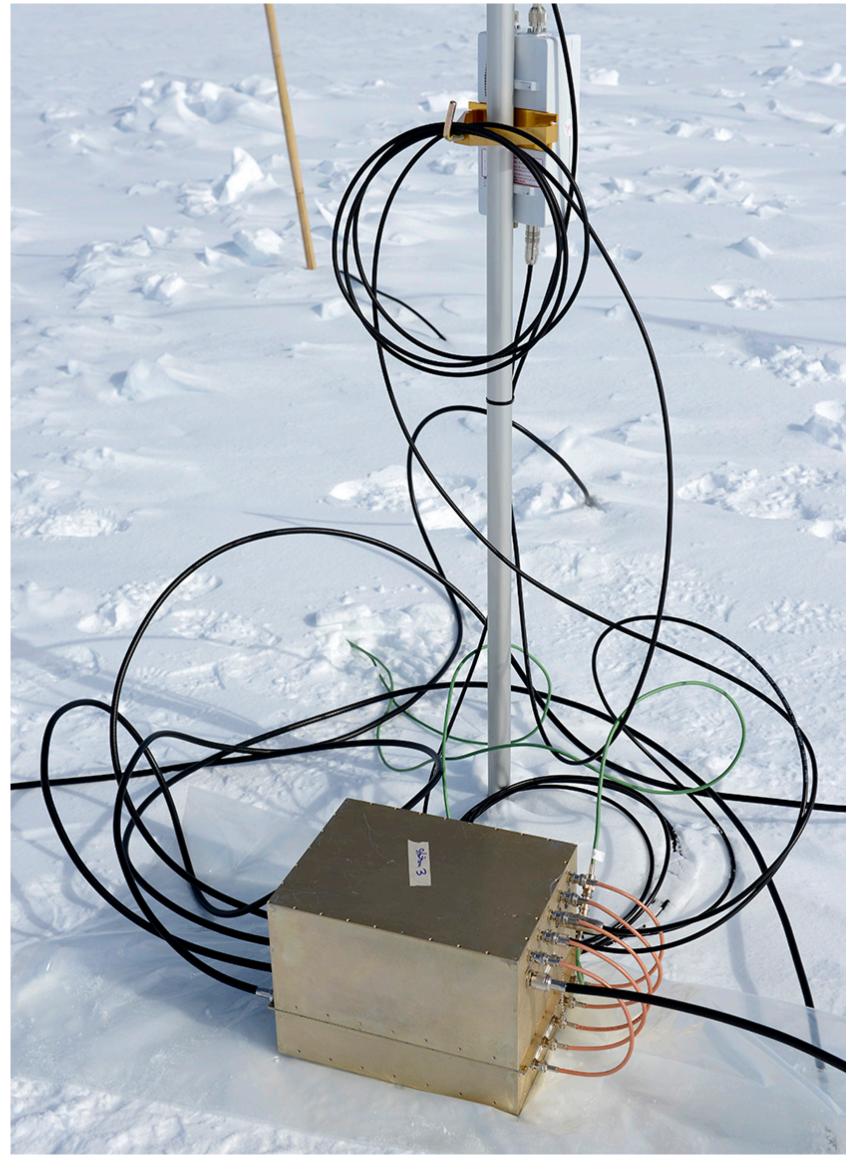
S. Barwick, et al., in prep, 2014



$R^{1/2}$ consistent with theoretical expectation of 0.92

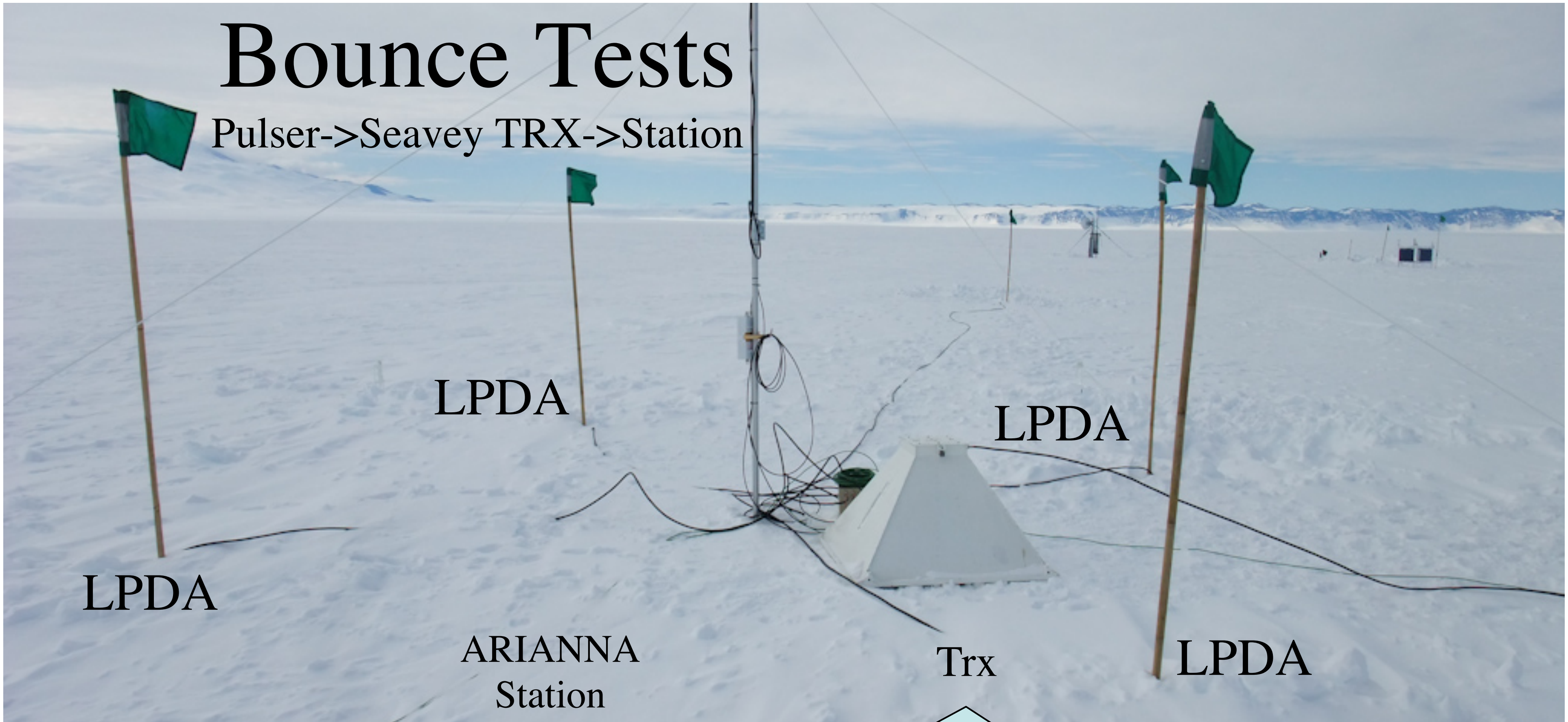


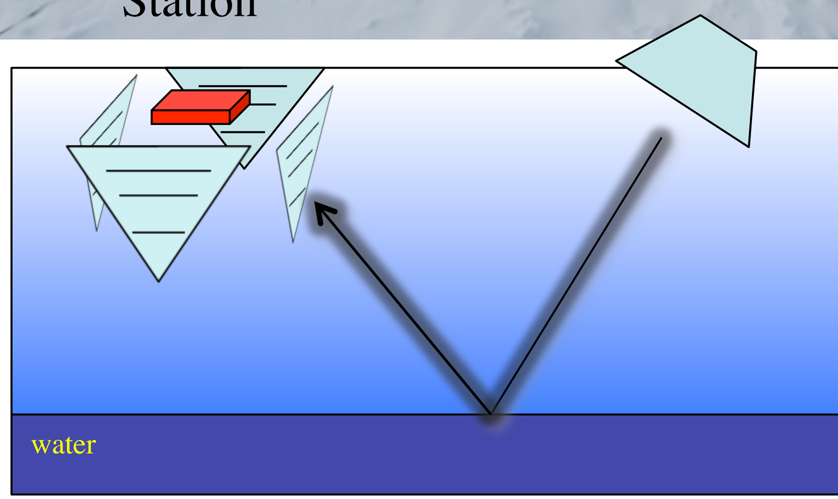
Electronics and base of
comms tower (AFAR+Irid)



Bounce Tests

Pulser->Seavey TRX->Station





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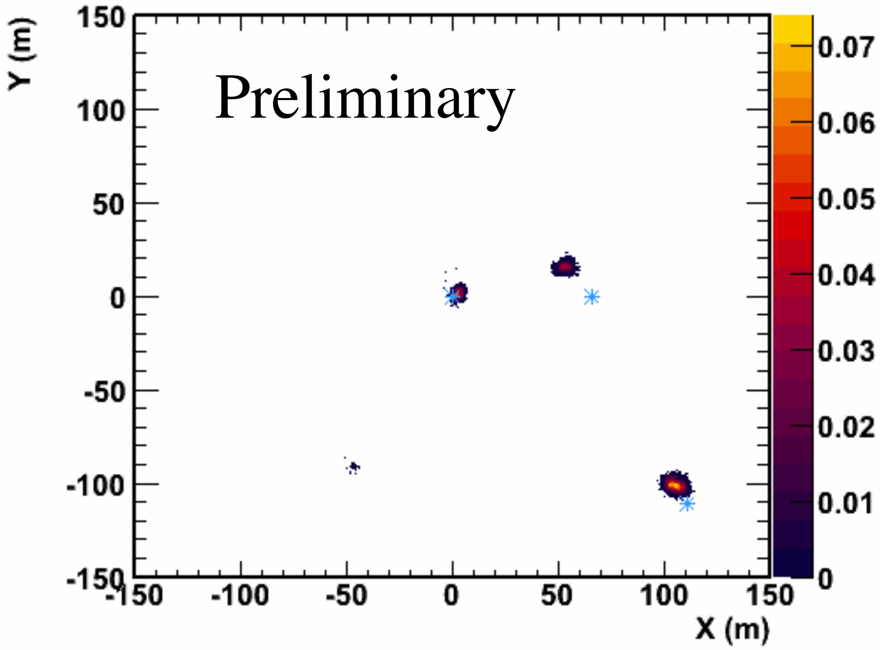
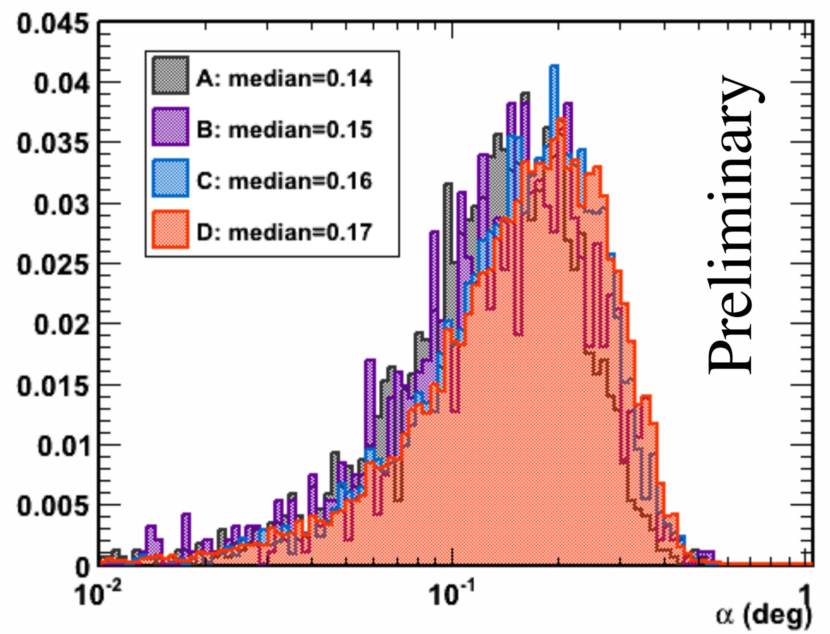
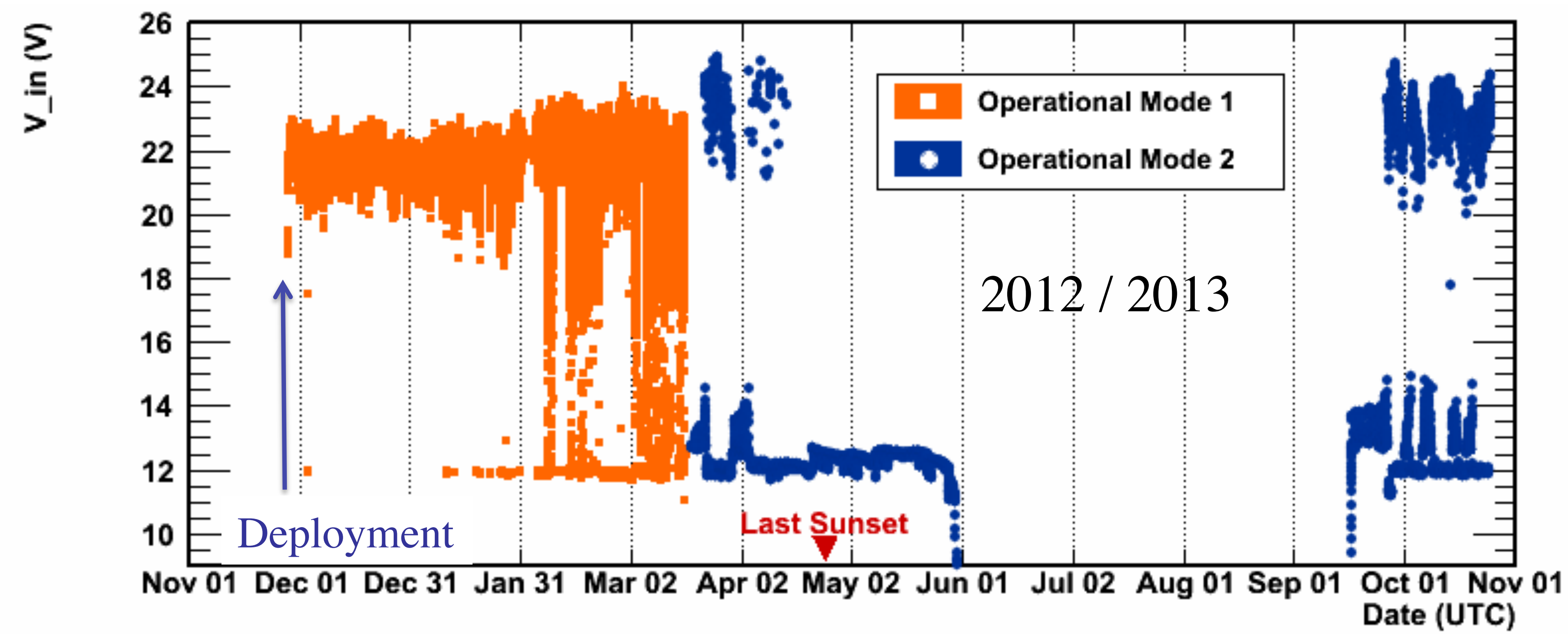




~0.16 deg angular resolution for EM wave

C. Reed, ICRC 2013

Station Operation On-time



Operational for 58% of year

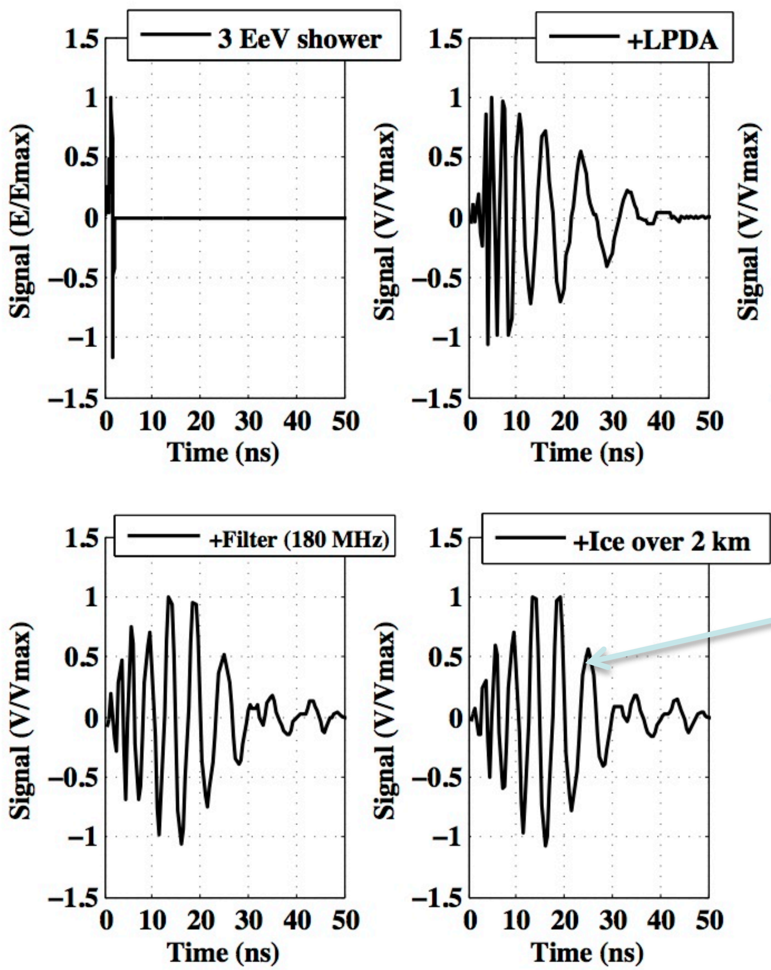
Operational Modes based on access to wireless network

Building a Neutrino Template

(J. Hanson, KU)

Signal scales with energy.

Small variation in shape due to emission angle

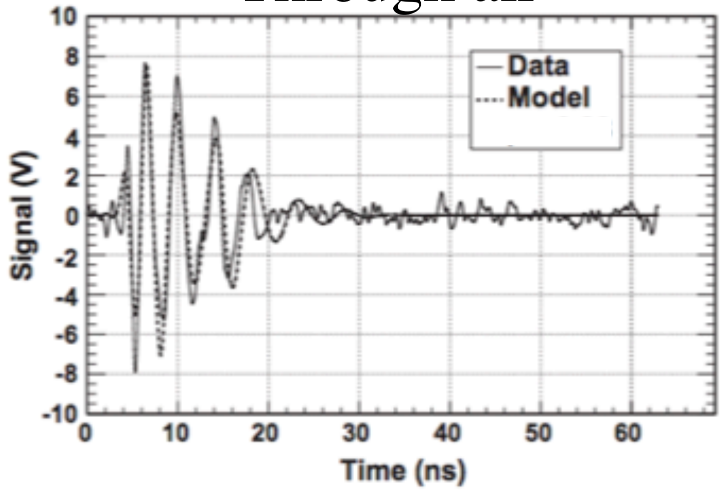


Procedure checked with bounce events, χ>0.8

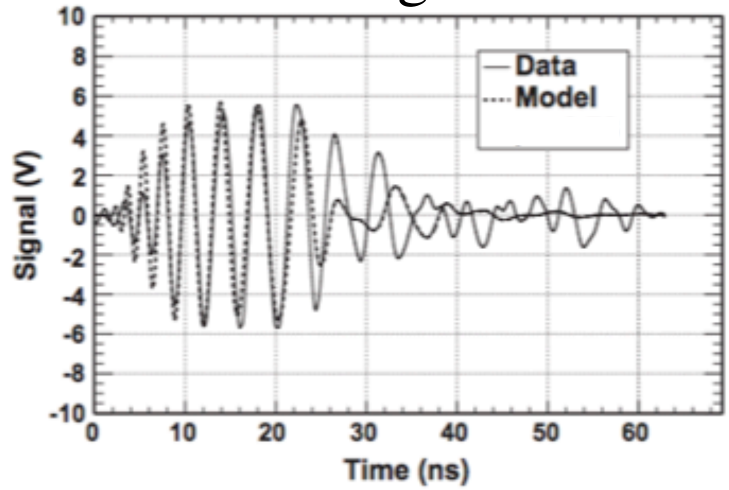
Barwick et al,
Astropart. Phys 2014, accept
arXiv:1406.0820

Checking Template Procedure

Through air



Through ice



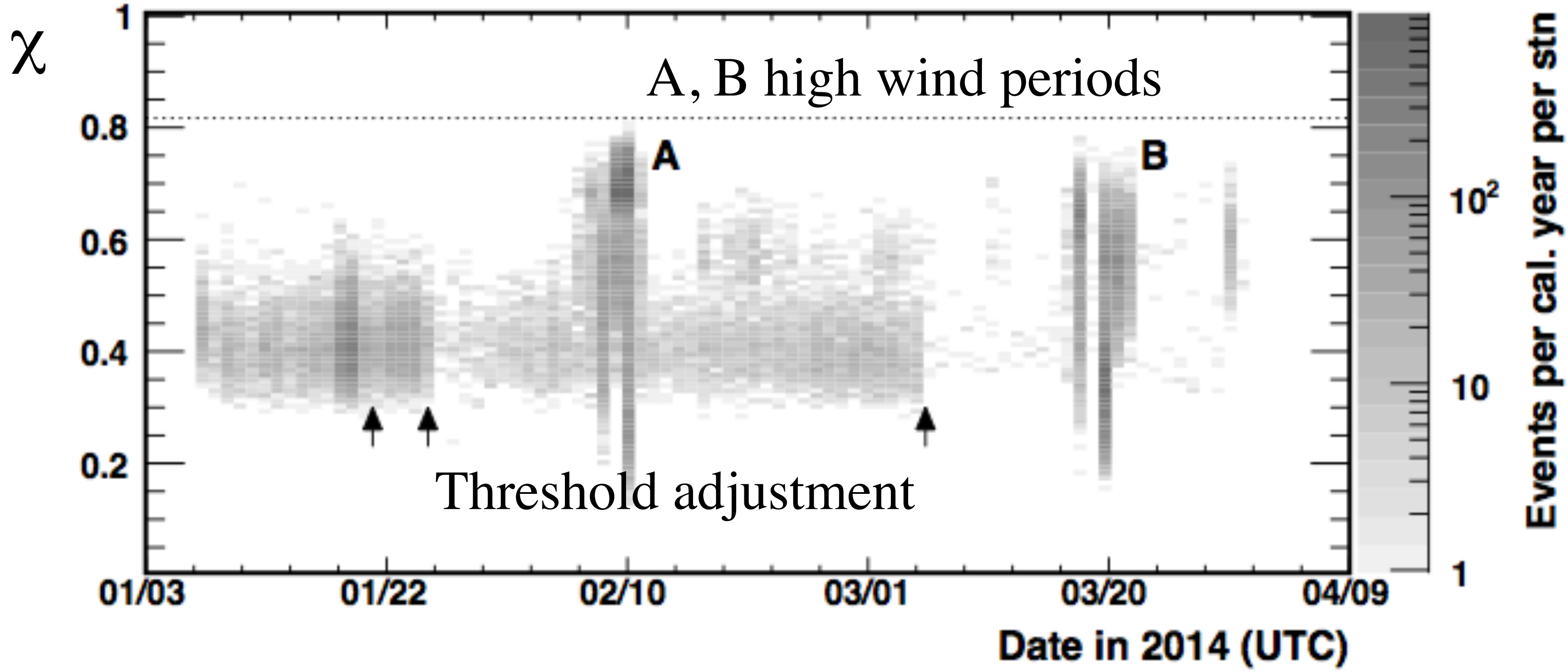
Average cross-correlation over all tests is $\chi = 0.84$

Can be improved with better amp response model

Barwick et al, Astropart. Phys 2014, accept arXiv:1406.0820

Cross-Correlation analysis (χ)

2 of 4 majority, $4V_{rms}$

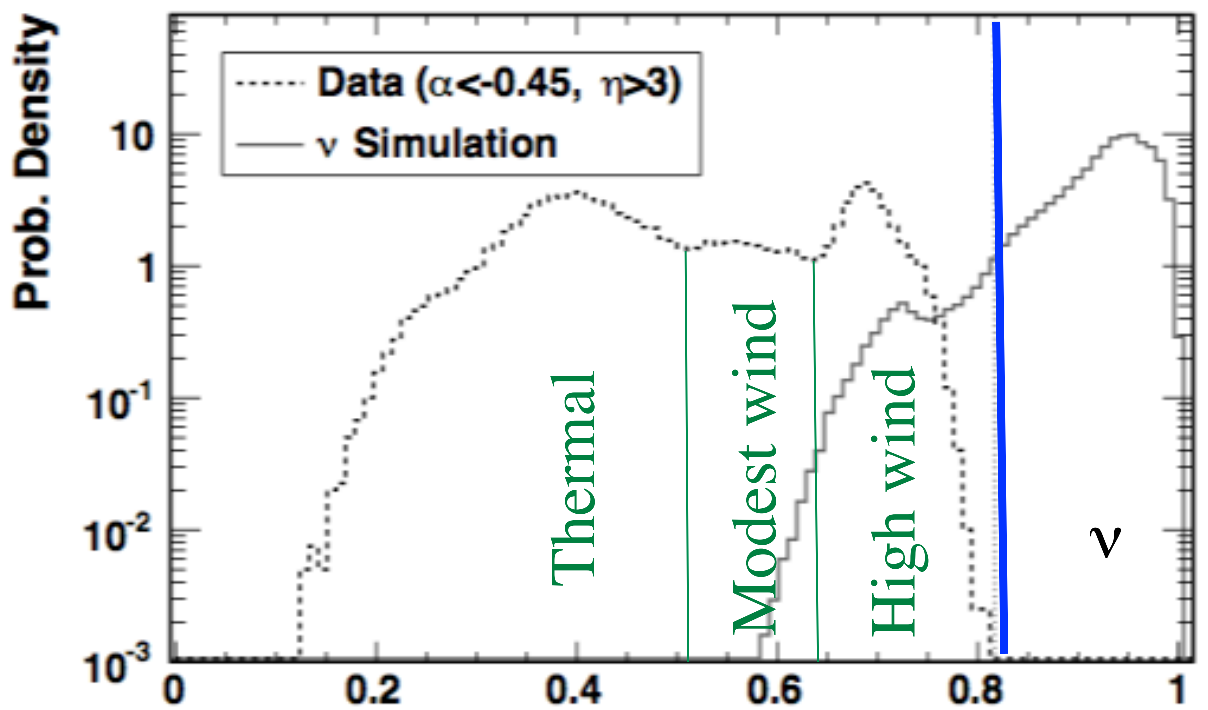


- High wind periods produce max $\chi < 0.8$.

S. Barwick et al, in prep 2014

Cross-Correlation analysis (χ)

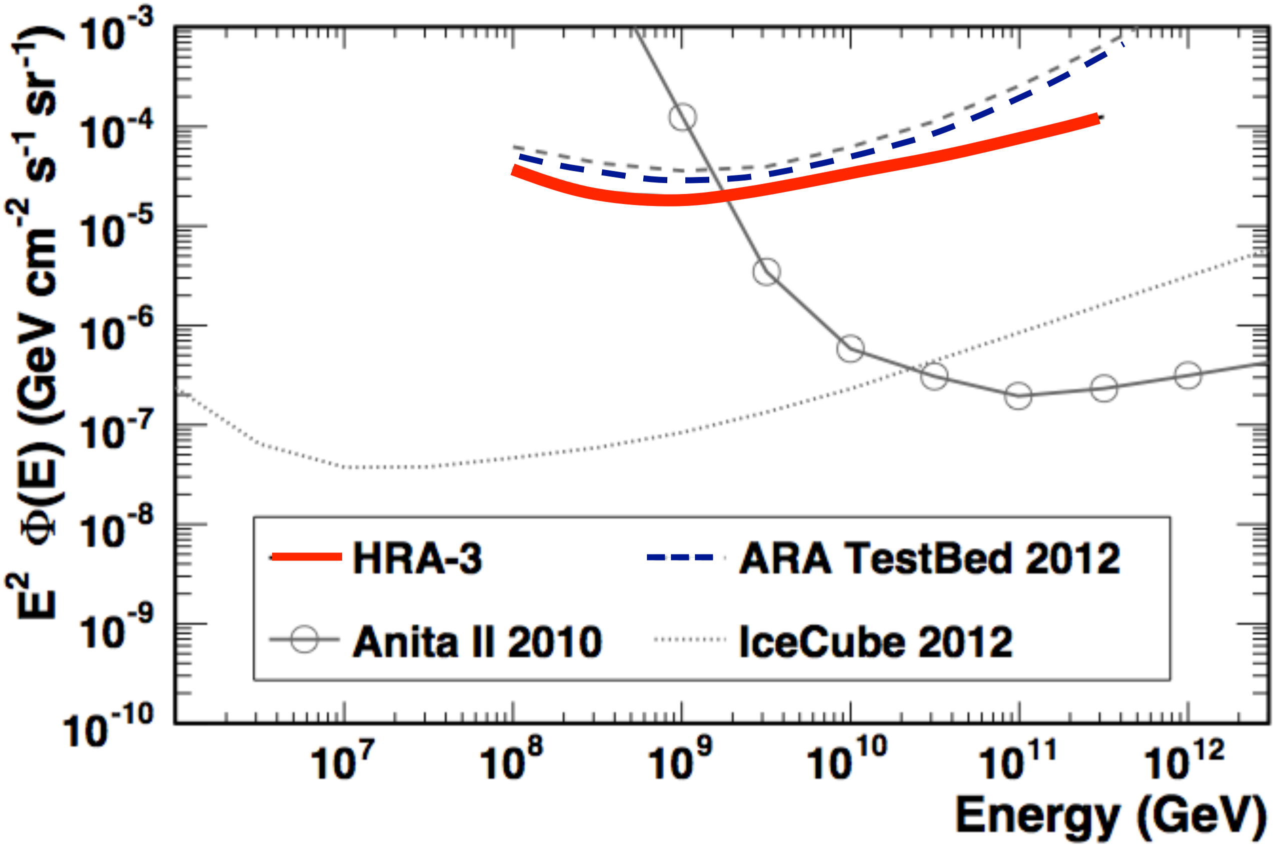
2 of 4 majority, $4V_{rms}$



- 90% of signal retained with full rejection of background.

S. Barwick et al, in prep 2014

ARIANNA HRA Limits (2014)



ARA: 2 years

HRA: 3 months

Barwick, et al., in prep, 2014

ARIANNA Projected Costs

Very hard to give precise number until HRA completed in December, 2014 and full proposal developed by collaboration, but here goes

Hardware: $9.5k/station	~ 12 M	
Personnel:	~ 14 M	
Logistics (4 year install):	~ 5 M	guess
Total:	~31M	

Summary: So far, so good

- New DAQ electronics function as expected and latest design operates on <10 Watts/station
- Station communicates via high speed wireless and Iridium satellites
- Stations automatically restarted during austral spring, so technology survives winter.
- No evidence of impulsive background that resembles neutrinos ---> straightforward analysis yielding 0.9 analysis efficiency
- Significant power from wind gen (reliability an issue)
- Angular resolution of 0.16 deg of EM plane wave
- Station repair accomplished in 2 hours or less

All major milestones have been met!

Look for 3 ARIANNA papers in late October on arXiv

Thank You

1993

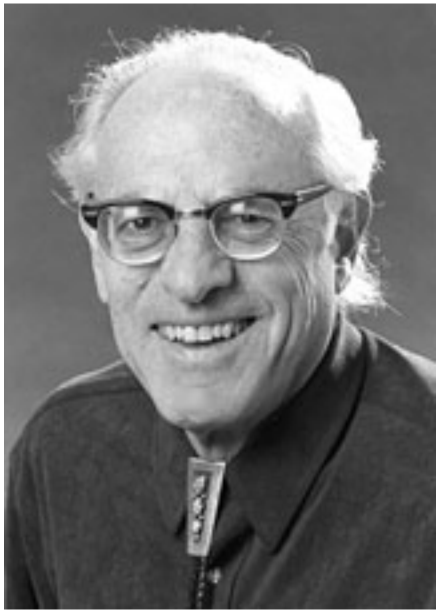
EHE ν detectors: Comments

EHE neutrino detectors:

- Contribute to ongoing quest to understand EHE CRs
  - Neutrino measurements provide independent confirmation of GZK mechanism
  - Combined with CR and photon measurements, can help to constrain source class, evolution, Emax, and composition of CR
- Search for new physics
  - Beam of EeV neutrinos can uncover new physics at ~5-10 x E_{cm} of LHC through cross-section and spectral modifications
- Search for new sources:
  - EeV neutrinos must point back to sources and direction can be measured with good precision and can be improved.

Huge upside at modest cost, development time, deployment and risk

Why Neutrinos?



Fred Reines
Nobel Laureate
UCI founding father
Discovered neutrino

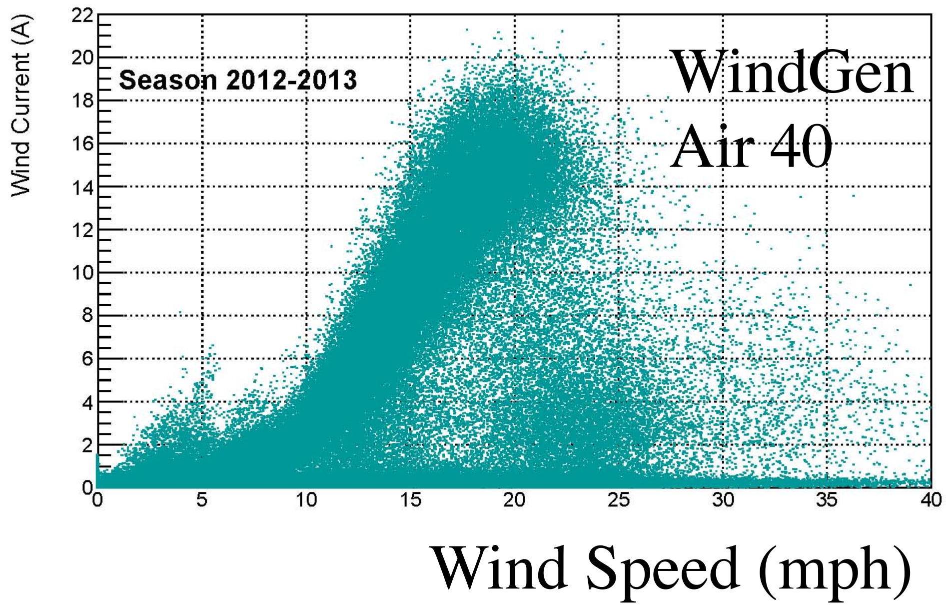
- Little mass, no electric charge, stable
- Unlike photons, neutrinos can escape from just about any environment
- Unlike photons, they penetrate through just about anything in the way
- Like photons, they travel in straight lines, so you can look back to see what made them

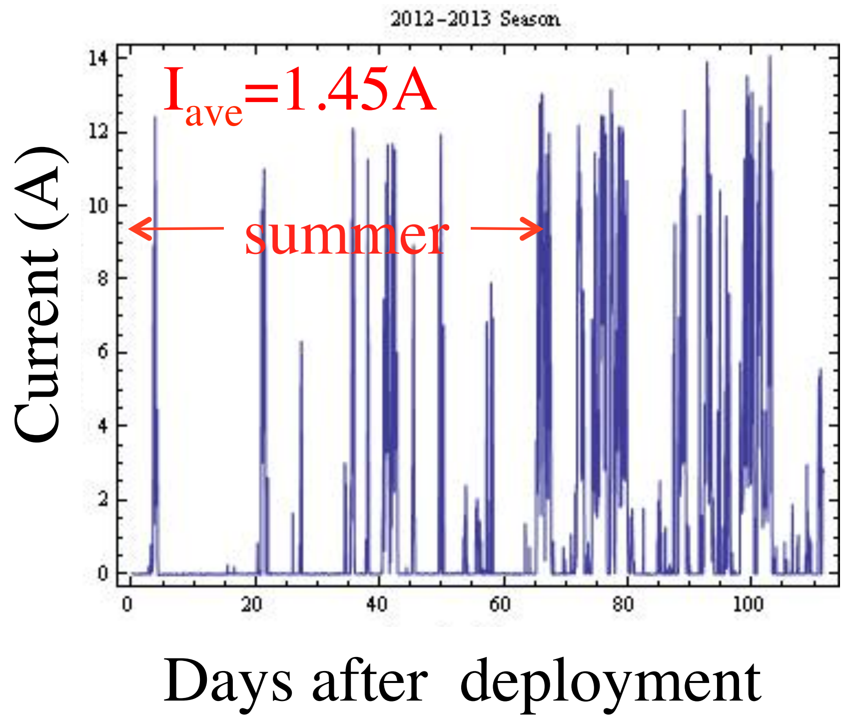
Neutrinos are created in extreme sources, like supernova explosions and cosmic ray collisions

Wind Power is Sufficient!

(Southwest WindPower Air 40)

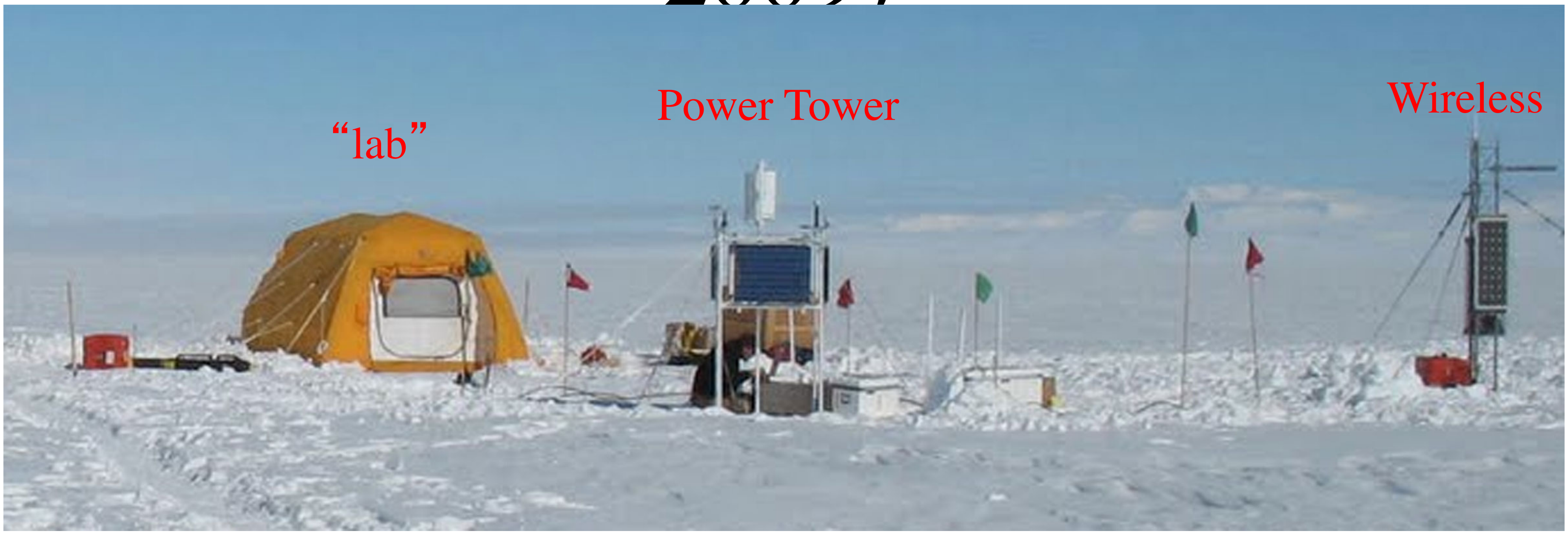
V_{ave}= 7.4 mph during summer

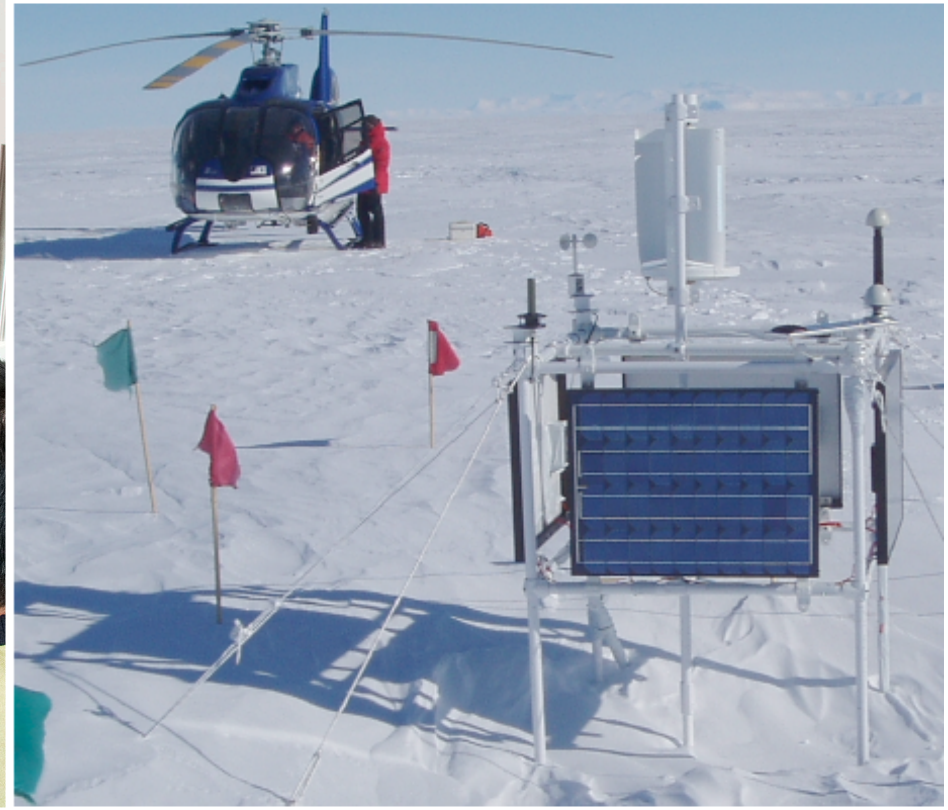




Require ~0.9A to operate station and station produced 1.45A
Wind expected to stronger in winter
However, low temps in winter lead to loss of efficiency

ARIANNA Prototype Station(deployed in Antarctica Dec. 2009)





Heart of ARIANNA.
Designed and built by
UCI faculty member
Stuart Kleinfelder