ANITA

Amy Connolly (UCL)
for the ANITA Collaboration

ARENA '08
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Rome, Italy

ANITA-1 collaboration: P. Gorham (PI, UH Manoa), S. Barwick, D. Goldstein, F. Wu, UCI; J. Beatty, K., Palladino, B. Mercurio, OSU, D. Besson, KU; W. Binns, P. Dowkonnt, M. Israel, Wash. U. St. Louis, C. Chen, C. Hast, K. Reil, D. Walz, SLAC; J. Clem, D. Seckel, U Del., M. DuVernois, U. Minn., K. Liewer& C. Naudet, JPL/NASA; R. Nichol, A. Connolly, UC London, D. Saltzberg, A. Goodhue, S. Hoover UCLA, G. Varner, J. Learned, S. Matsuno, P. Allison, A. Romero-Wolf, J. Kowalski, C. Miki, UH Manoa, P. Chen, J. Nam, Y. Wang, NTU.

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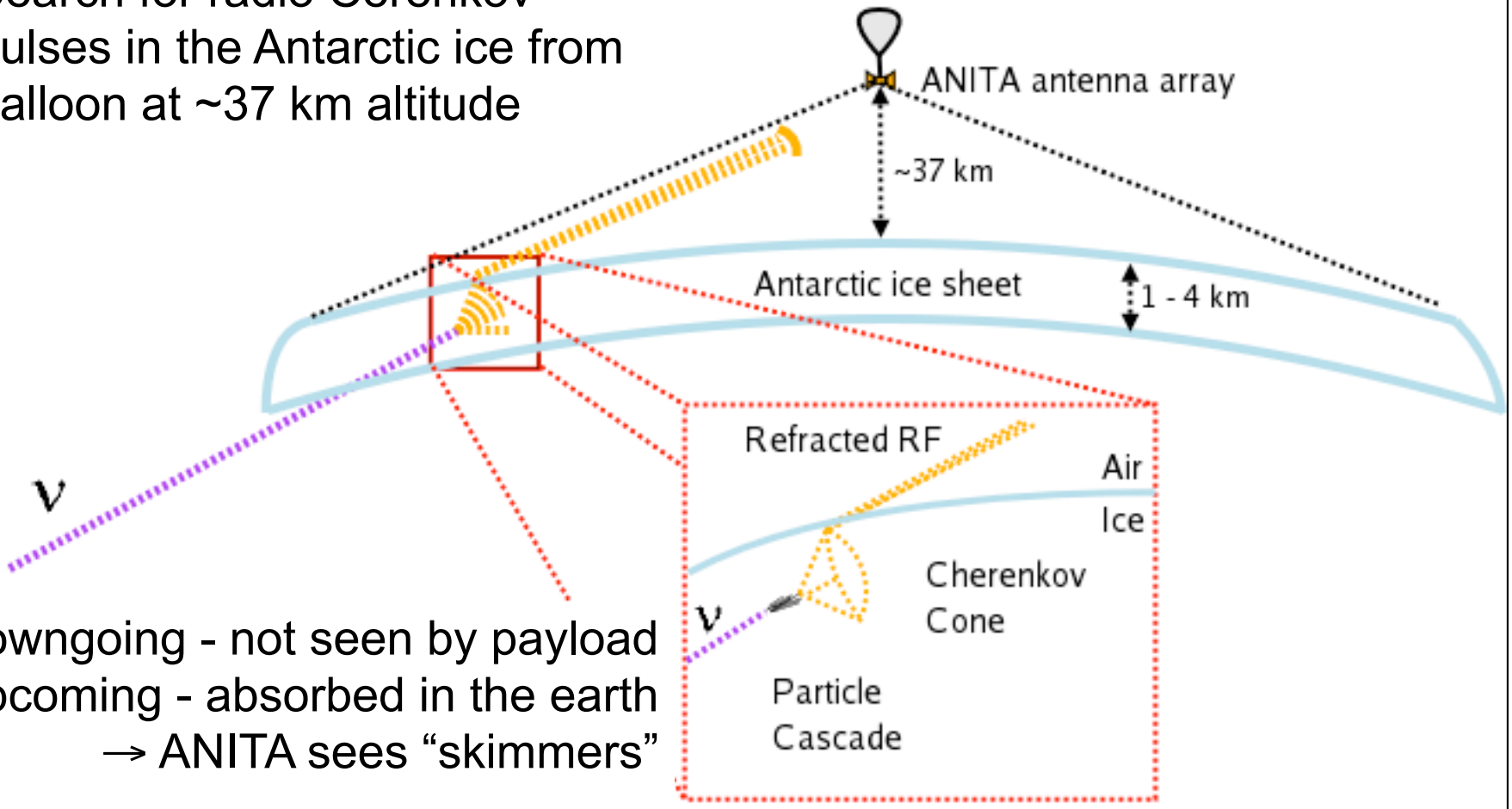
The Detector Concept

Search for radio Cerenkov pulses in the Antarctic ice from balloon at ~37 km altitude

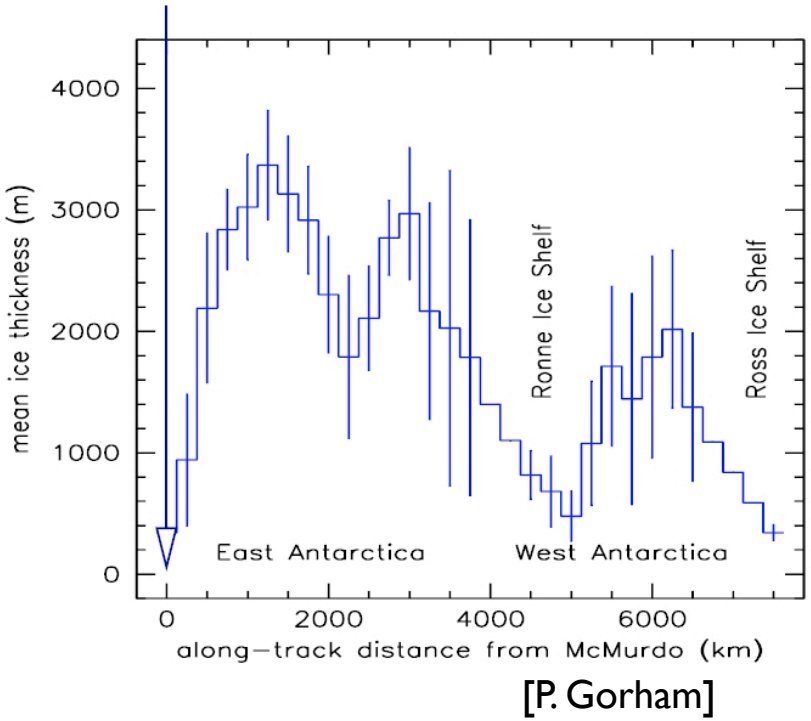


Downgoing - not seen by payload
Upcoming - absorbed in the earth
→ ANITA sees "skimmers"

ANITA observes ~1.5 x 10^6 km^2 of ice at once!

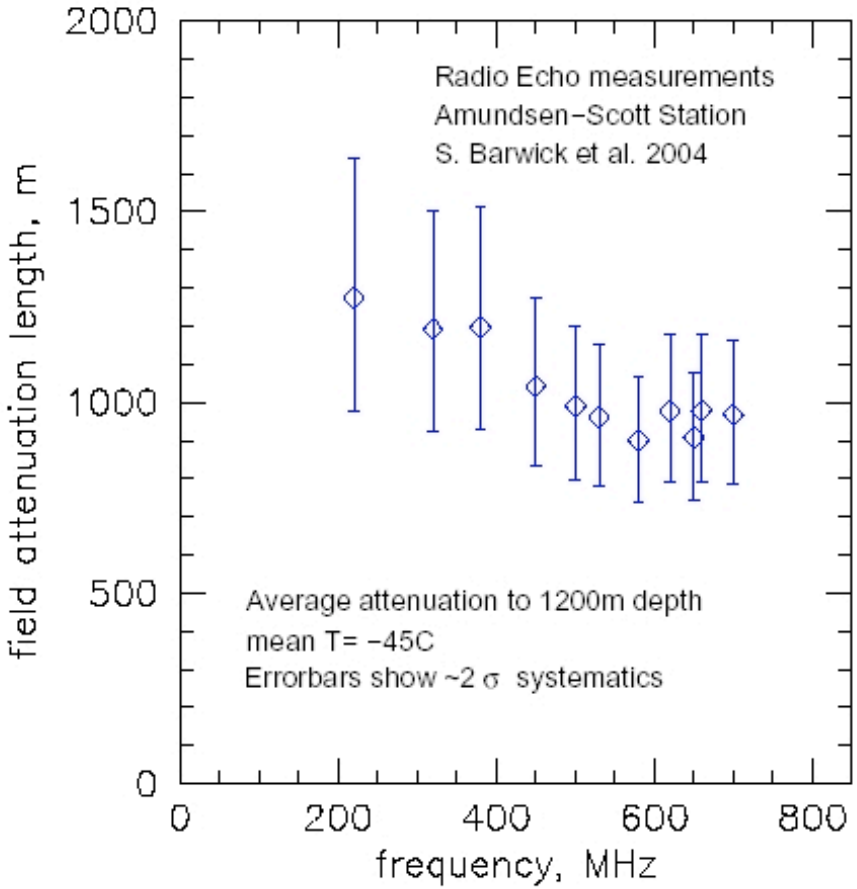
The Medium: Antarctica

Ice thicknesses across continent:



[P. Gorham]

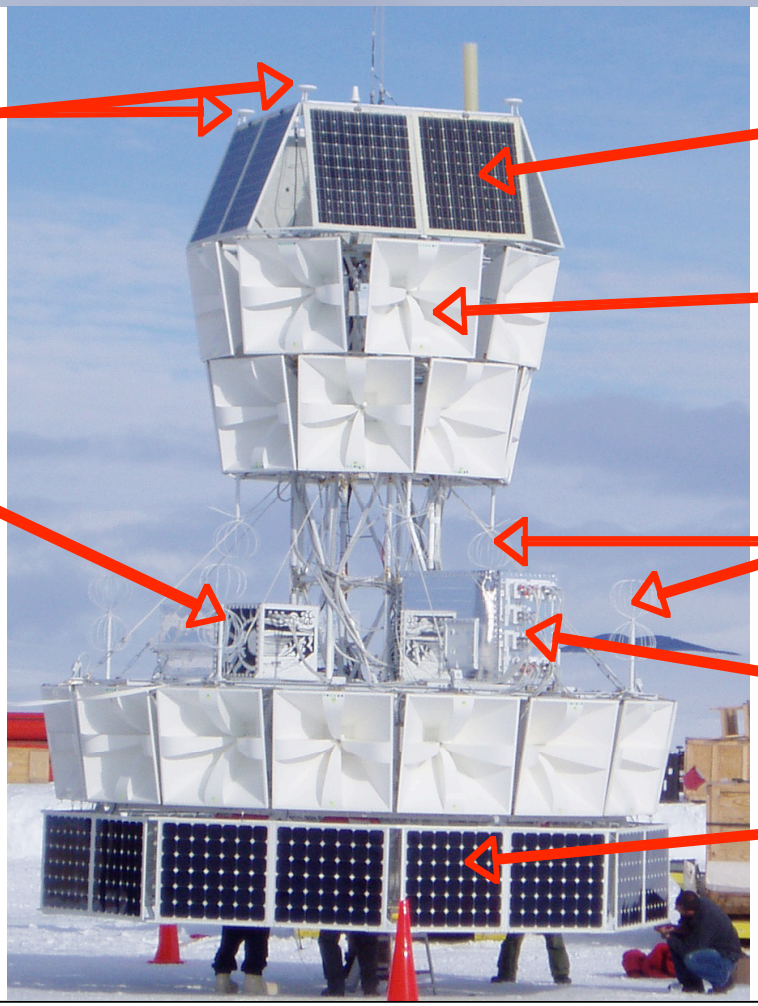
Attenuation lengths the South Pole:



2.5 km depths are typical across the continent

~1 km attenuation lengths

The Face of ANITA

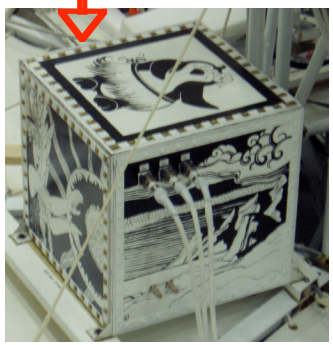


GPS Antennas

Solar cells for NASA equipment

32 Quad-ridge horn antennas in 3 layers
- 200 MHz to 1200 MHz
- 10 degree down angle

Battery box
(Art by residents
of McMurdo)

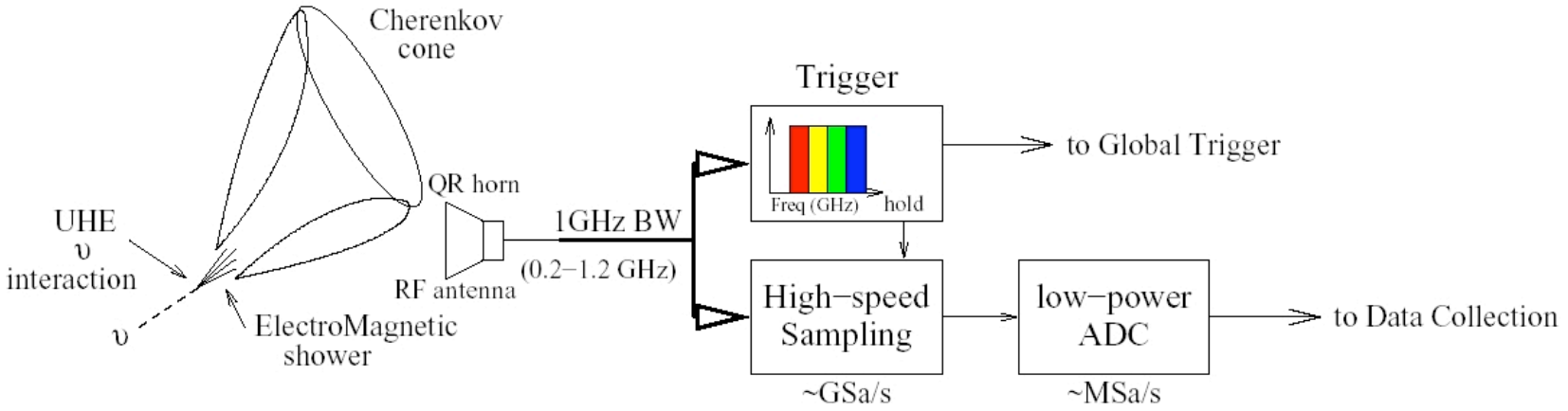


8 low gain antennas to monitor payload-generated noise

ANITA electronics box (mirrored to minimize solar heating)

Power for science mission

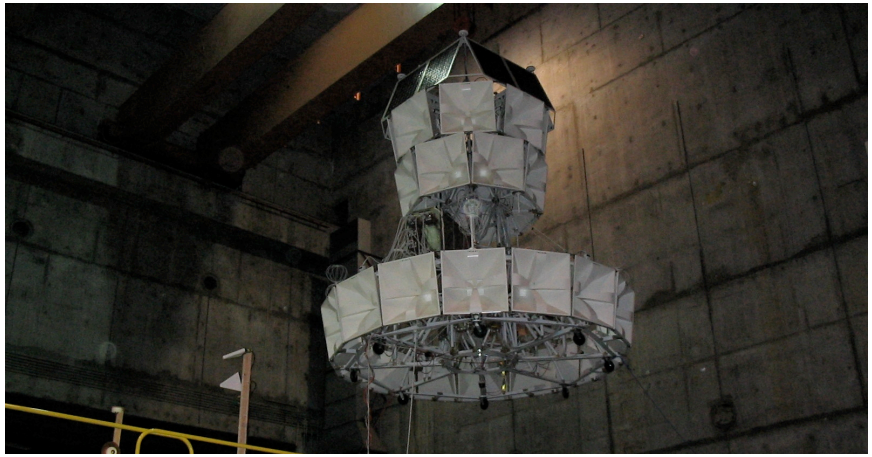
Signal Acquisition



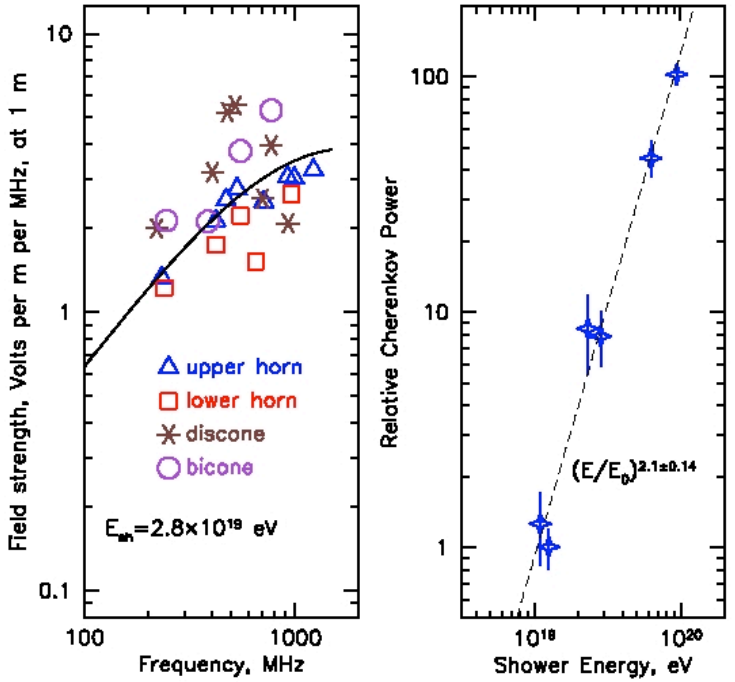
- Trigger: Signal divided into frequency sub bands (channels)
  - Powerful rejection against narrow bandwidth backgrounds
  - Multi-band coincidence allows better noise rejection
- 8 channels/ antenna
- Require 3/8 channels fire for antenna to pass L1 trigger
- Global trigger analyzes information across antennas

Calibration at SLAC

Produced Askaryan pulses in ice from 28.5 GeV electron beam at SLAC



~10^9 particles per bunch
→ 10^{19}- 10^{20} eV showers

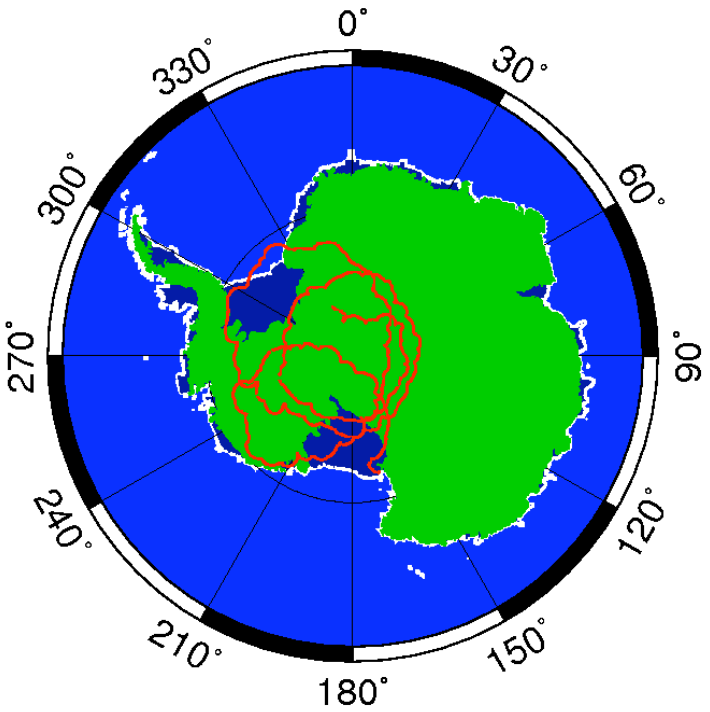


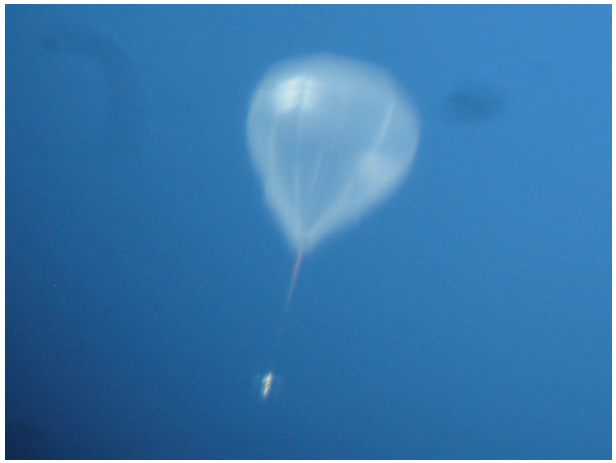
ANITA Collaboration (P.W. Gorham et al.)
hep-ex/0611008

From there, ANITA was off to Antarctica…

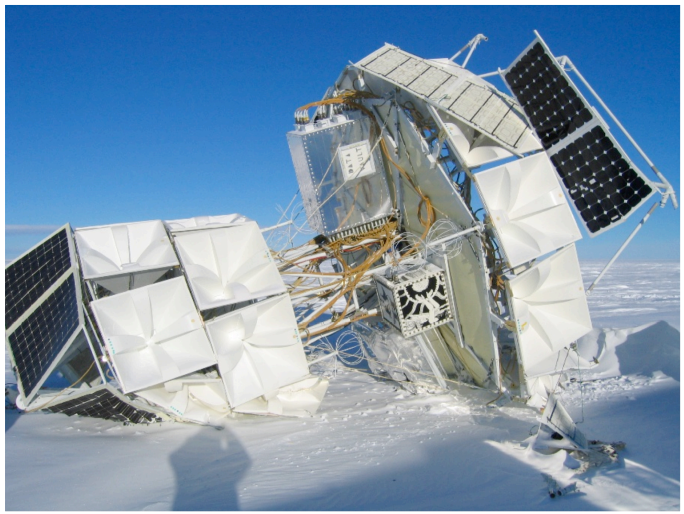
The Flight

- Dec. 15th 2006 - Jan 18th 2007
- 3.5 trips around Antarctica
- Further "west" than average
- In view of radio noise (S. Pole and McM) 50% of time
- 18 days good livetime
- 1.2 km average depth



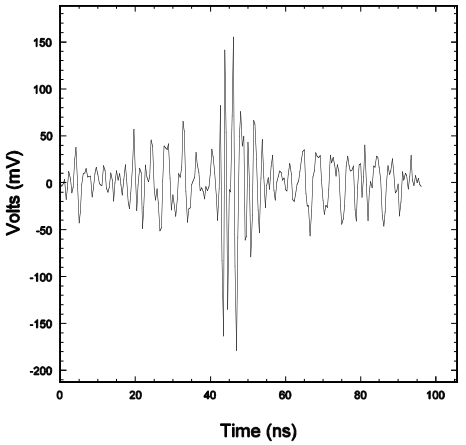


View of ANITA from the South Pole
Picture taken by James Roth

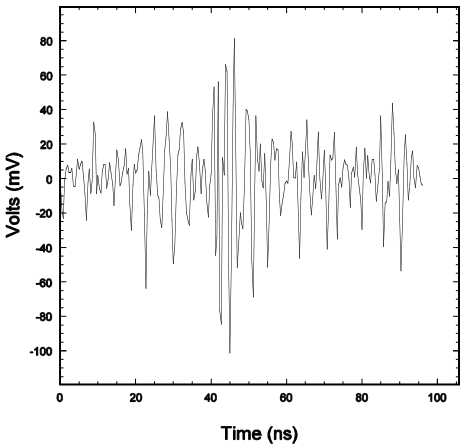


Calibration Signals

Upper antenna (facing source)

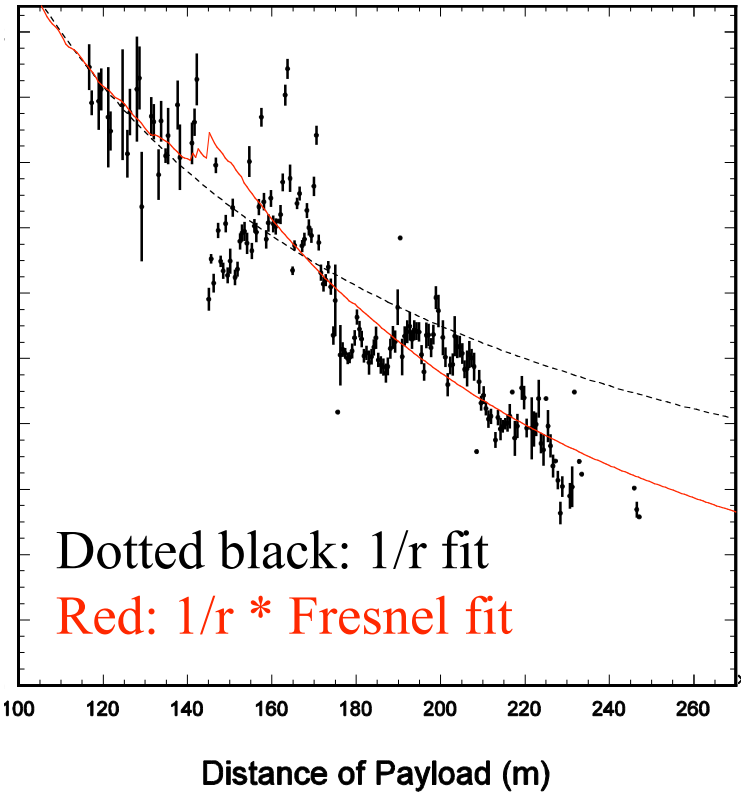


Lower antenna (facing source)

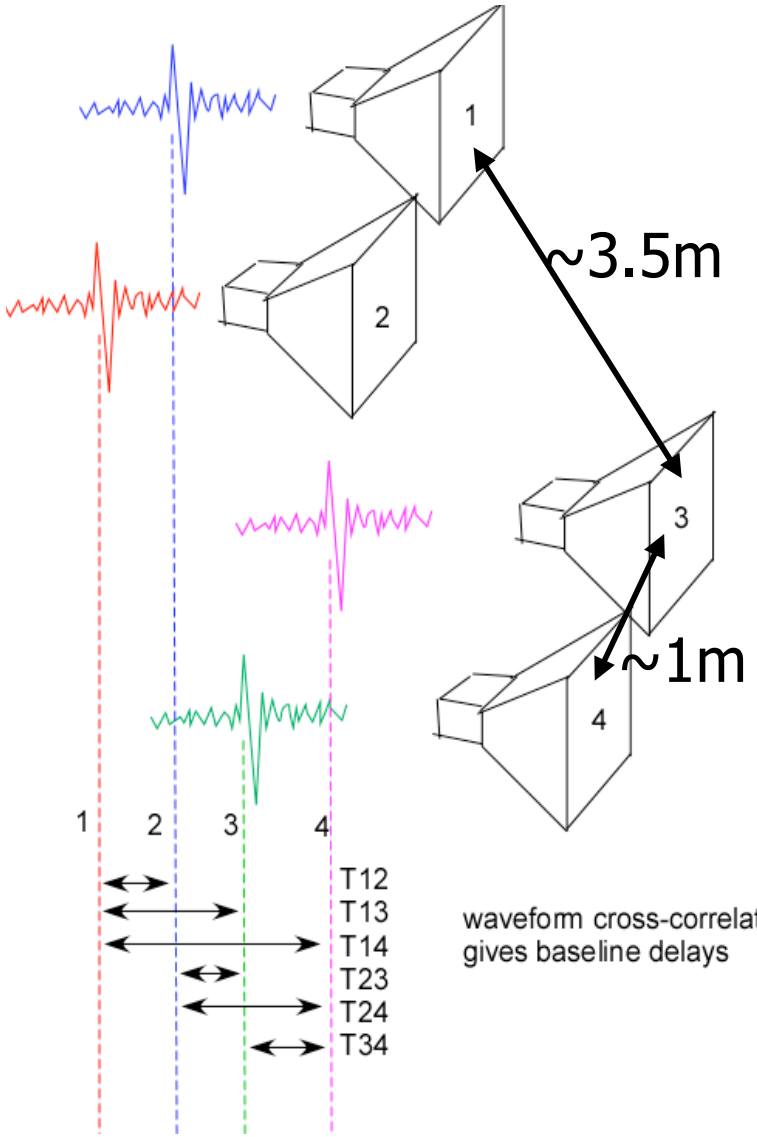


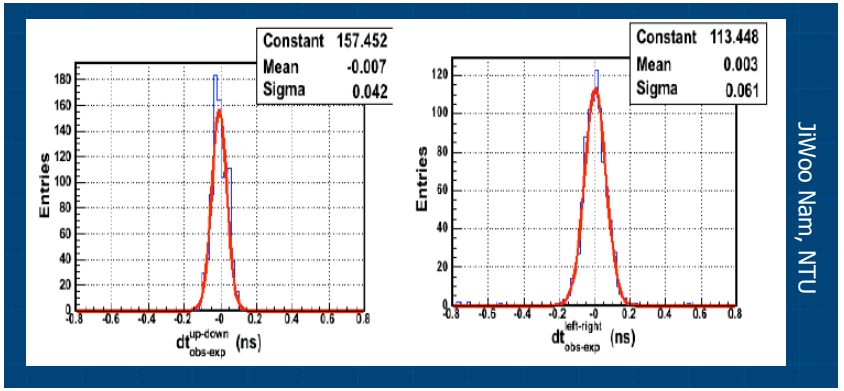
- Calibration signals
  - Surface & Borehole
  - McMurdo & Field camp
- Signals used for
  - Calibration
  - Instrument health
  - Tests of analysis methods

Sanity Check: Distance vs. Received Signal Strength (using under-ice calibration transmitter)

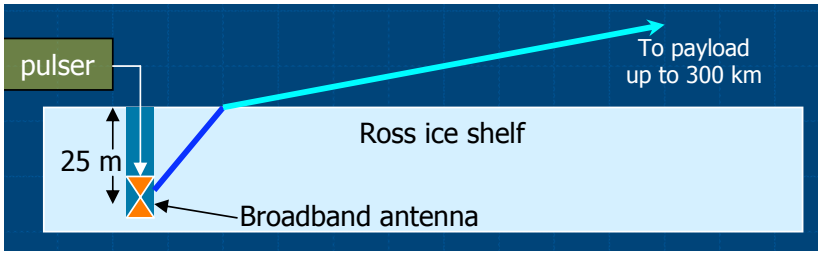


Event Reconstruction





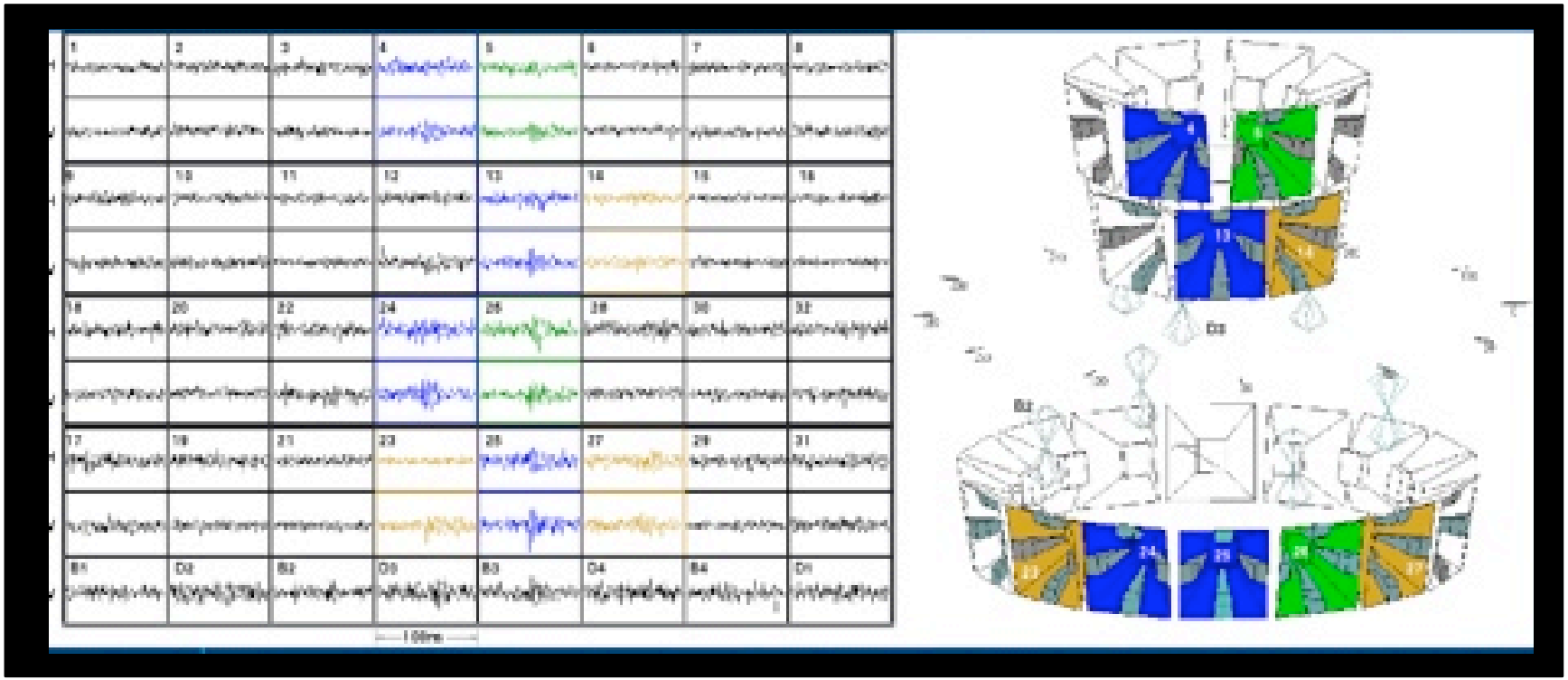
- Waveform cross-correlation delay precision determines angular resolution
  - ~30-40 ps vertical at SNR~5
  - ~60-80 ps horizontal
- Expect $\Delta\theta \sim c\,\Delta t/2D$
  - Altitude: 0.21° obs., 0.3° exp.
  - Azimuth: 0.8° obs., 1.7° exp.



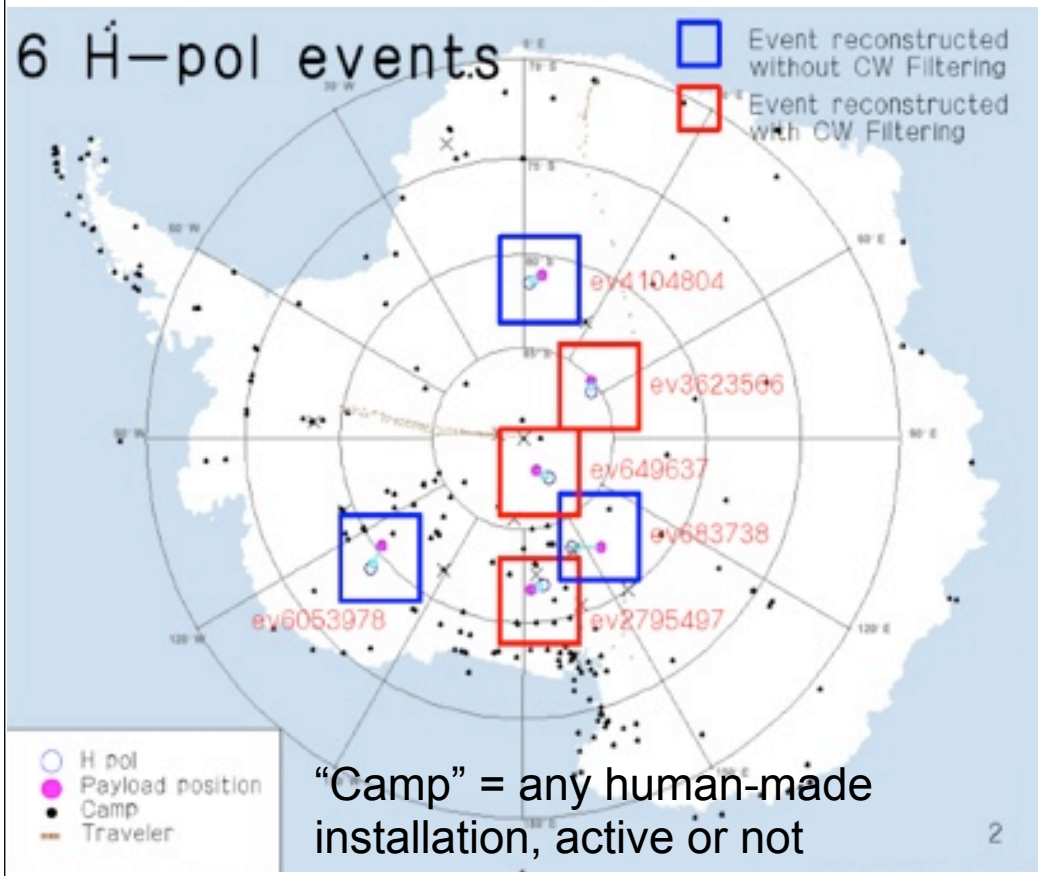
Initial unblinded higher threshold event set

Initial Selection

- Raw data: RF plane-wave lights up one side of payload
- V>3σ in front phi sector
- Interferometry gives 40-60 ps timing
- Reconstruct ground position and error ellipse
- If <3σ from camp or any other event, reject

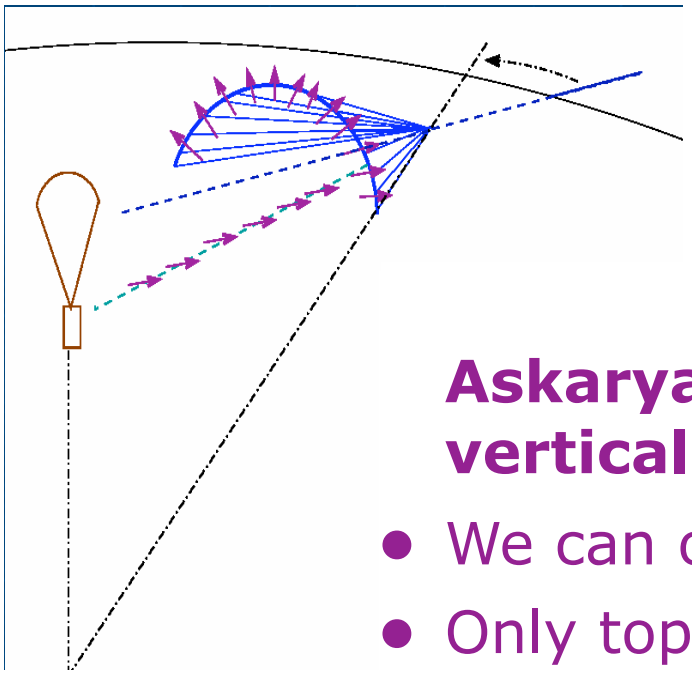


Initial unblinded higher threshold event set



- ~19K events (9.6K Vpol & 10K Hpol) are impulsive, reconstruct to Ant. ice
- Exclude all repeating locations (H, V, H+V)
- Exclude single events within 50 km of known sites
- After these cuts:
  - 0 V pol. (no Askaryan-like pulses no neutrinos)
  - 6 H pol.

Horizontal Polarization?



Cerenkov radiation is:

- Linearly polarized
- In the plane containing particle cascade momentum and Poynting vector

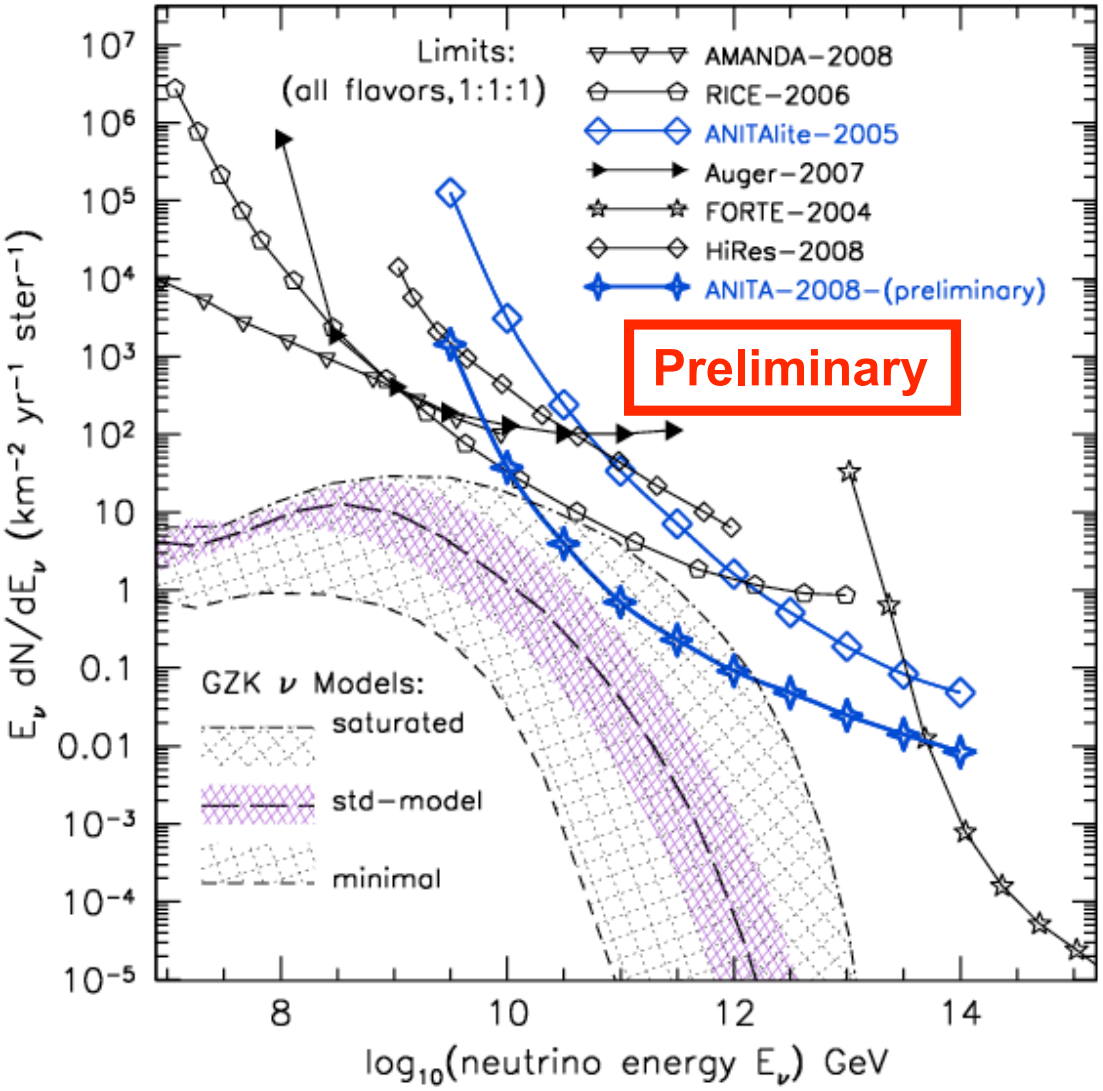
Askaryan signals strongly favor vertical polarization

- We can only see "skimmers"
- Only top of the cone escapes total internal reflection

Fresnel coefficients: Reflections from above strongly favor horizontal polarization (3:1) Could be:

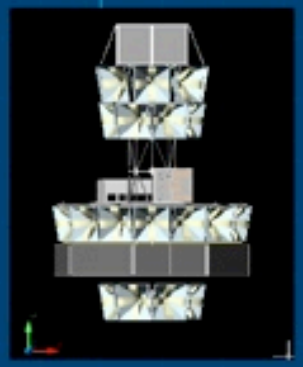
- Air shower radio (geo-synchotron)
- Solid state relays on satellites

Limits



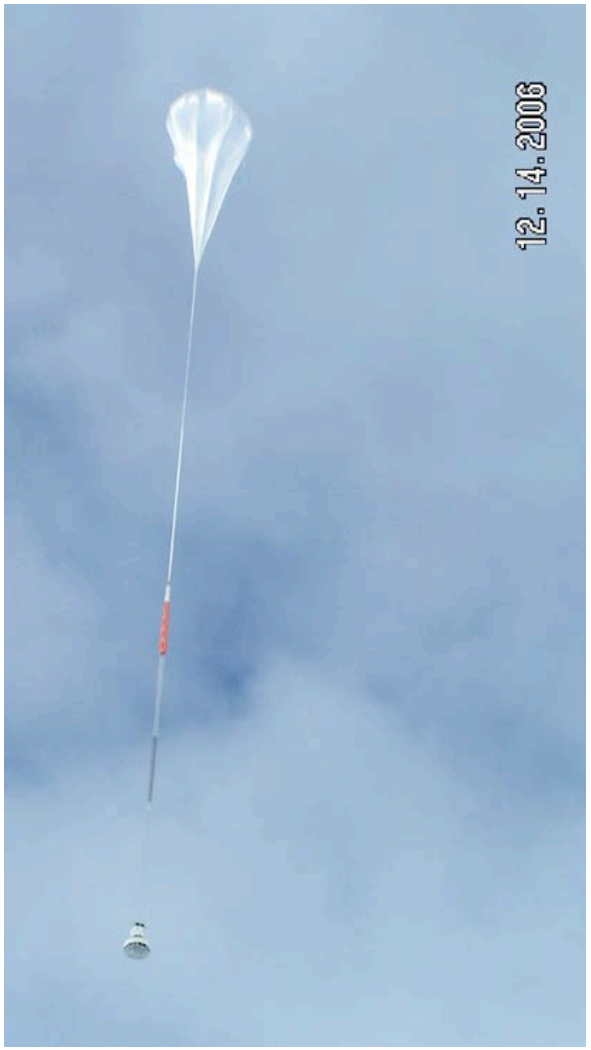
- ANITA I has begun to constrain highest, less likely models
- ANITA II (Dec. 2008) should reach range of standard models

ANITA 2 (2008-2009) improvements



- **Improve system temperature by 40K (new front end)**
- Improve efficiency ~20%
  - active direction mask for trigger to blank out direction of camps & stations
- Improve trigger sensitivity by ~30% (Vpol-based trigger)
- Drop-down antenna ring: ~30% sensitivity increase
- ➔ Net improvement:
  - Factor of ~1.7 in energy threshold (Tsys+trigger+drop-down)
  - ANITA gains as ~ E_{thr}^{-2} ➔ 1.7^2 = factor of 3 in event rate increase
  - 30% in exposure for better flight trajectory & direction mask
  - 40% improvement in livetime possible
  - **3 x 1.3 x 1.4 = factor of >5 in neutrino event rate**

Conclusions



- Radio Cerenkov signal has been experimentally confirmed in salt, sand and now ice
- Preliminary ANITA I results constrain the most optimistic GZK models - more analysis still ongoing
- With ANITA II's improved sensitivity we should be able to start digging into standard parameter space