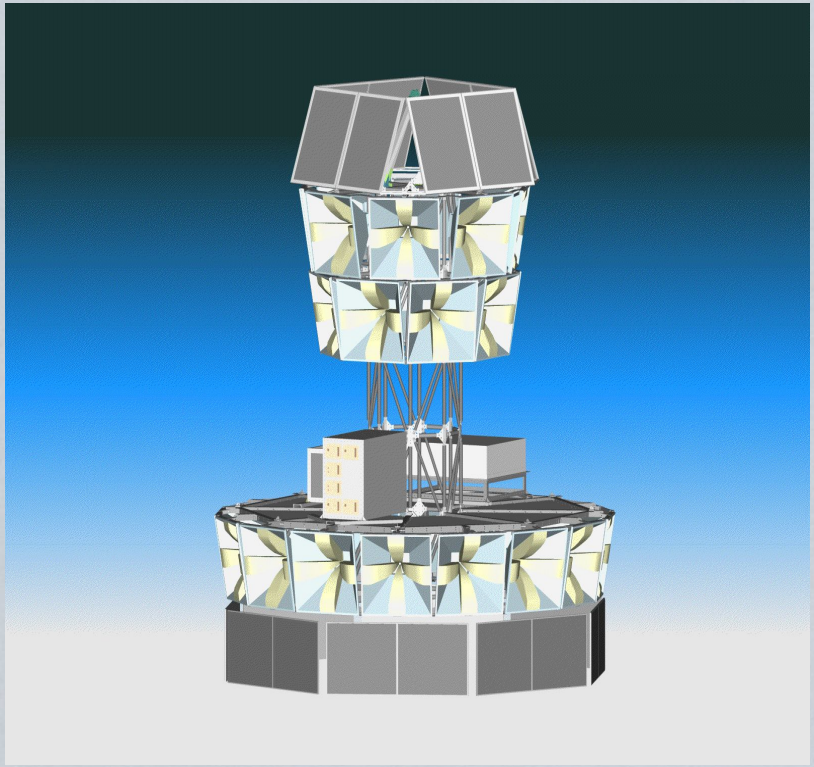
Current Status of the ANITA experiment



Shige Matsuno (U. Hawaii)
for the ANITA collaboration

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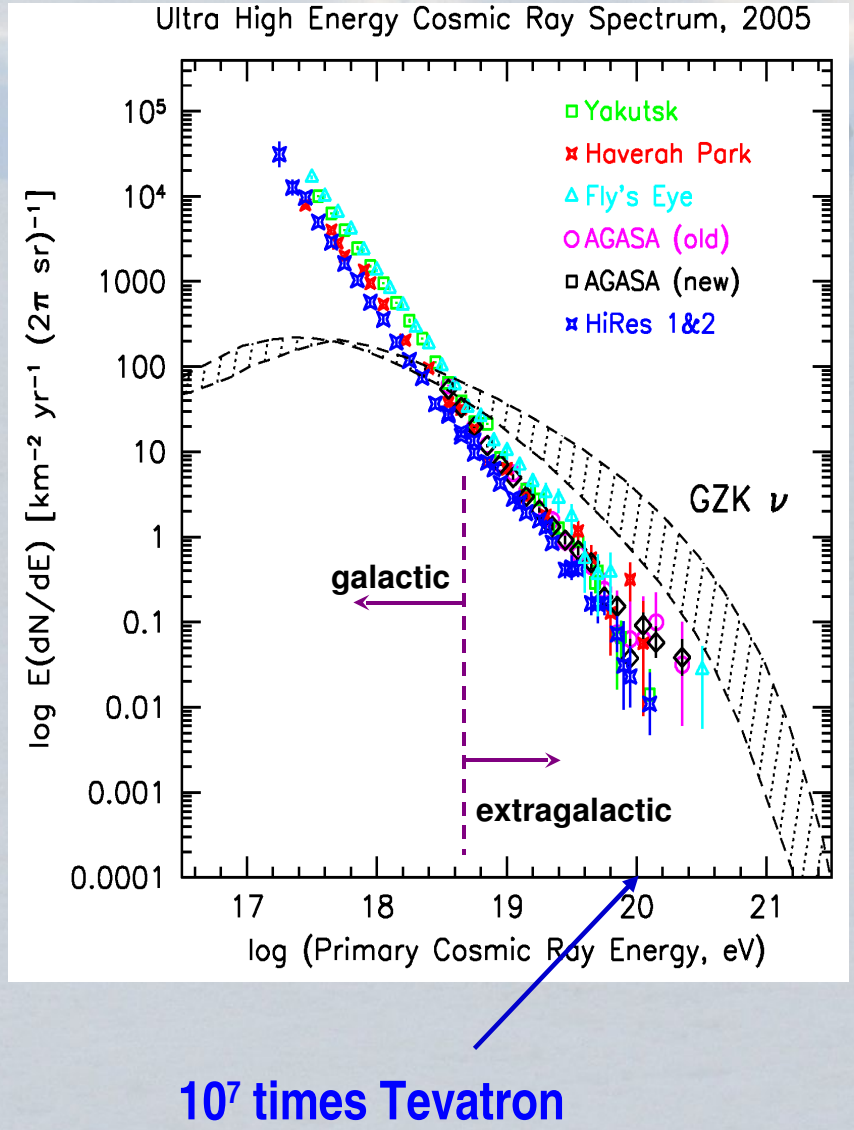
ANITA collaboration

(Antarctic Impulsive Transient Antenna)

- Bartol: J. Clem, D. Seckel
- UC Irvine: S. Barwick, D. Goldstein, K. Kuehn, J. Nam
- UCLA: A. Connolly, D. Saltsberg, D. Williams
- U. Hawaii: P. Gorham, C. Hebert, J. Learned, J. Kowalski, S. Matsuno, R. Milincic, P. Miocinovic, M. Rosen, A. Romero-Wolf, G. Verner
- JPL: K. Liewer, C. Naudet, F. Wu
- Kansan: D. Besson
- U. Minnesota: M. DuVernois, E. Lusczek
- NASA: D. Gregory, J Link
- Ohio State: J. Beatty, B. Mercurino, R. Nichol, K. Palladino
- SLAC: P. Chen, C. Field, C. Hast, j. Ng, K. Reil
- Washington U., St. Louis: R. Binns, P. Dowkontt, M. Isreal, M. Olevitch

High Energy Astroparticle Physics

- For cosmic rays above 10^{19} eV,origin nor acceleration mechanism not well known
  - No nearby sources observed
  - distant sources excluded due to GZK process
- Neutrinos at $10^{17\text{-}19}$ eV required by standard-model physics* through the GZK process -- observing them is crucial to resolving the GZK paradox
- 2006 update: UHECR spectra fits (HiRes) indicate that CR sources follow a quasar/star-formation-like distribution (eg. GRBs?)

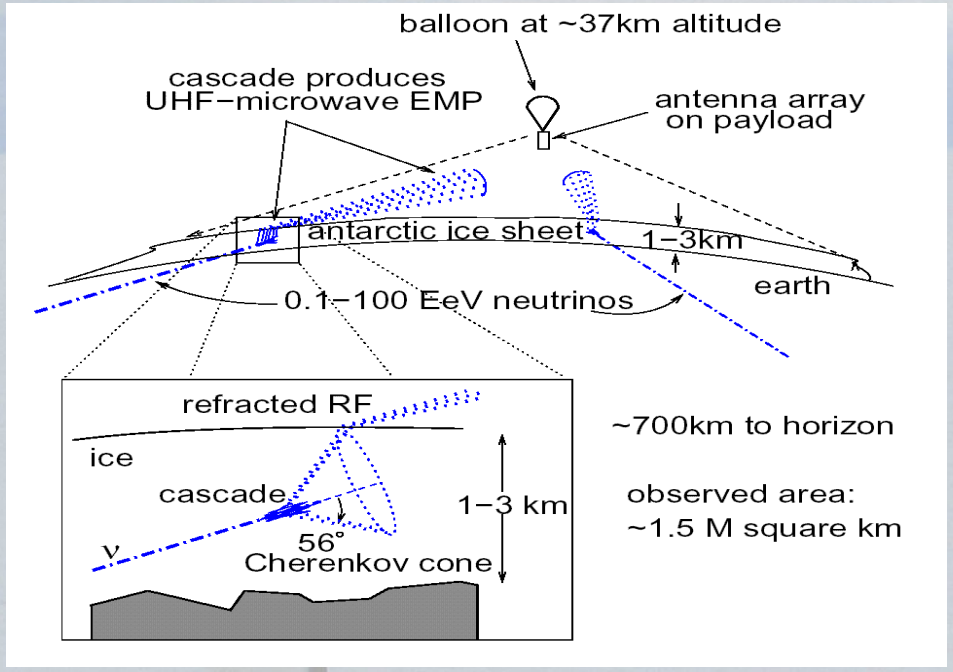


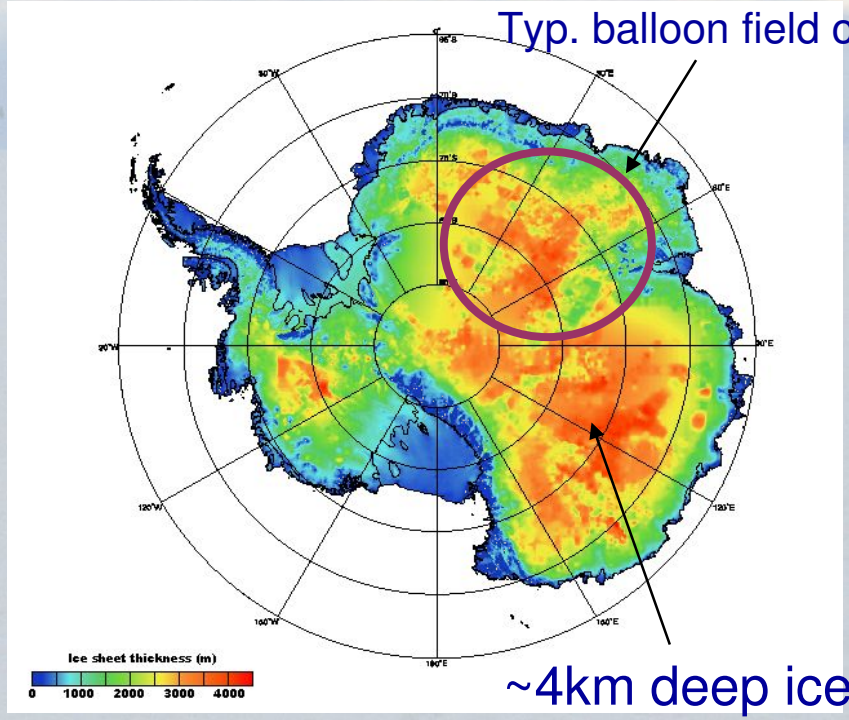
10^7 times Tevatron

* Berezinsky et al. 1971.

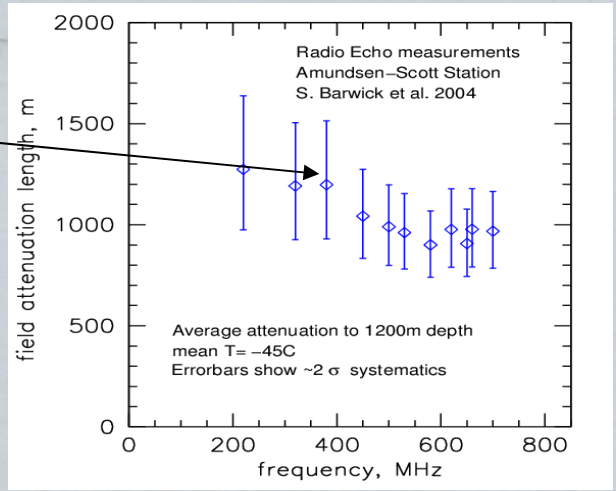
ANITA concept

"detect UHE neutrinos from a balloon by using radio Cerenkov signal from Antarctic ice sheet"





Ice RF clarity: ~1.2km(!) attenuation length

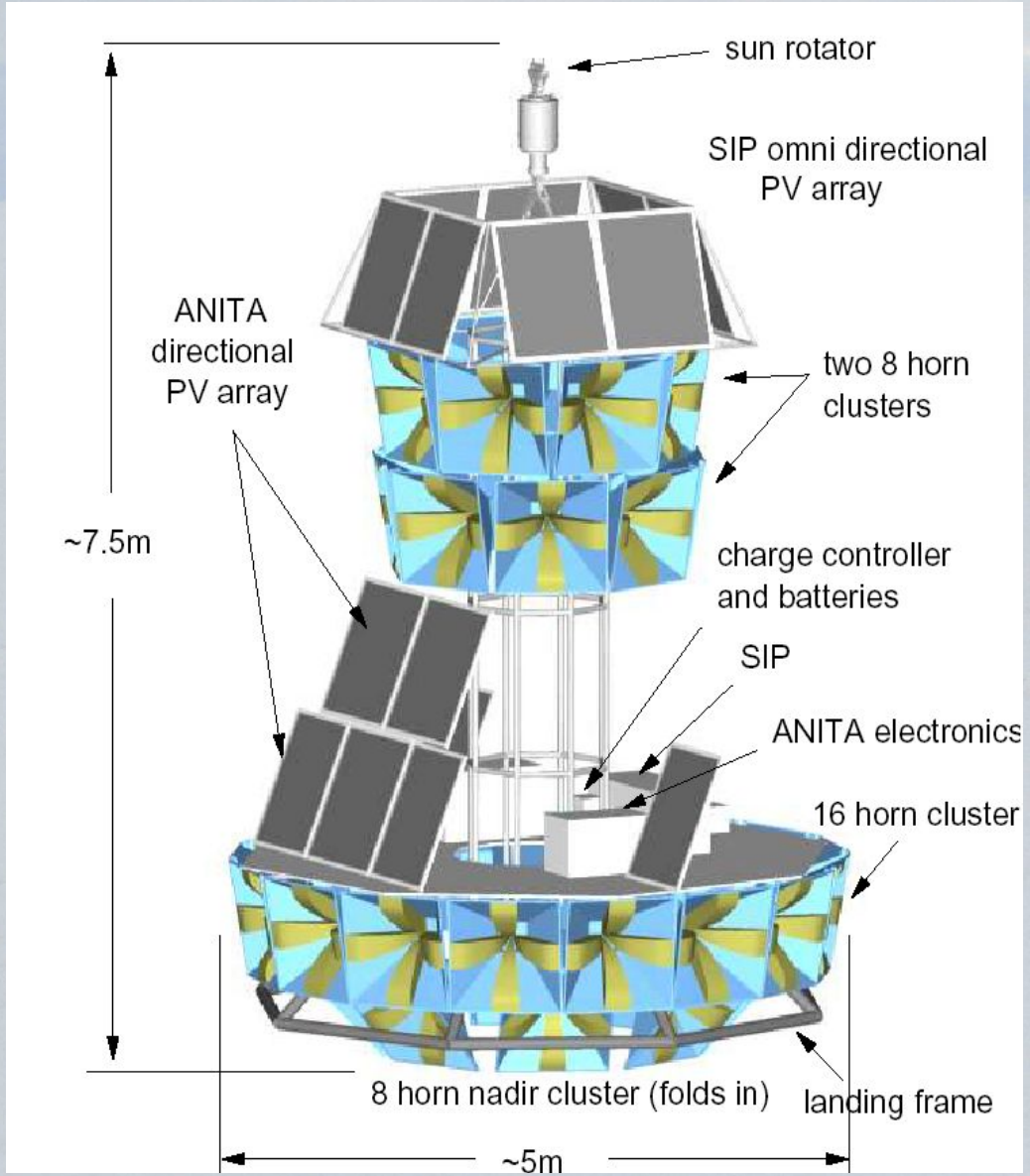


Effective "telescope" aperture:

- ~250 km^3 sr @ 10^{18} eV
- ~10^4 km^3 sr @10^{19} eV

(compare to ~1 km^3 at lower E)

ANITA Payload

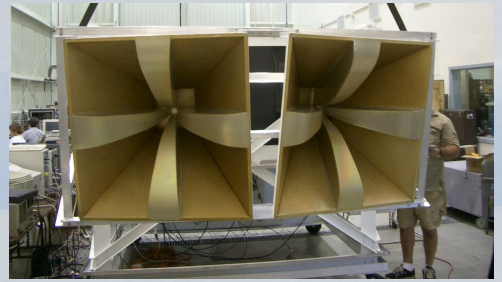


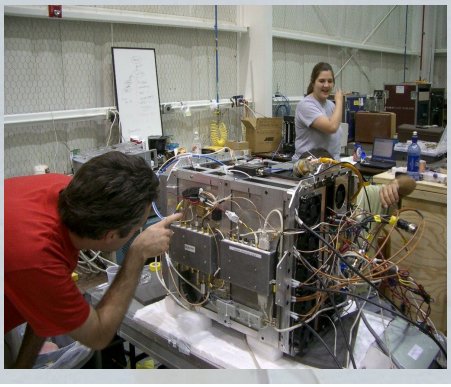
- 32 horn antennas (H and V polarities) view > 2π sr with 60° overlapping beam width
- Intensity gradiometry, interferometry, polarimetry used to determine pulse direction & thus original neutrino track orientation
- Angular resolution:
  0.5° for elevation and 1.5° for azimuth (for radio pulse),
  ~2° and 3~5° (for neutrino)
- weight ~1,600 kg,
  total power ~1.0 kW

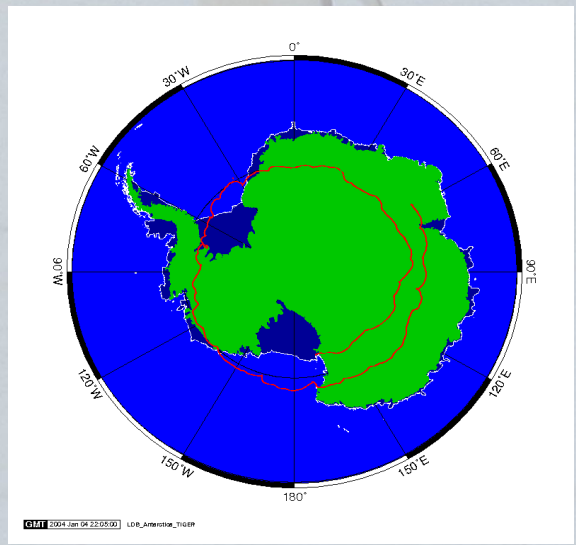
ANITA timeline

- Oct-02 ; forming ANITA collaboration
- Jan-03 ; ice transparency / RF noise measurement @ South Pole
- Jul-03 ; ANITA-lite payload passed hang test, ready for a flight
- Dec-03 ; ANITA-lite flight @ McMurdo station, Antarctica
- 04-05 ; design and develop ANITA full system
- Jul-05 ; ANITA-EM flight @ Ft. Sumner, NM
- May-06 ; ANITA full system integration @ UCI
- Jul-06 ; SLAC beam test & hang test of ANITA full system
- Dec-06 ; ANITA to be launched @ McMurdo

ANITA-lite Prototype flight





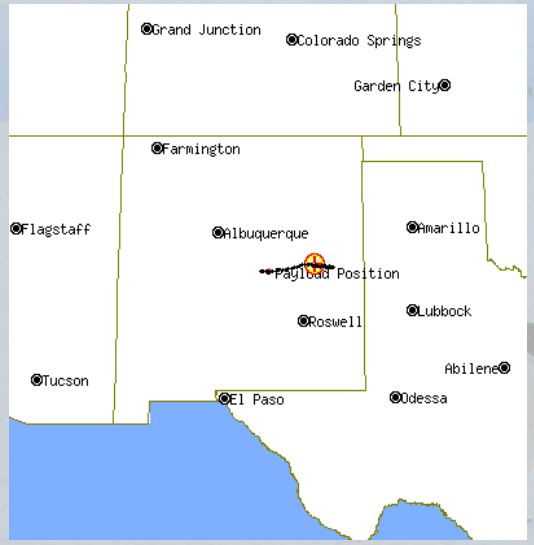


- Piggyback Mission of Opportunity on the 03-04 TIGER* flight, completed early-January 04
- ANITA prototypes & off-the-shelf hardware used
  - 2 dual-pol. ANITA antennas w/ low-noise amps
  - 4 channels at 1 GHz RF bandwidth, 2 GHz sampling
- 18.4 days flight time, 40% net livetime due to slow (4sec per event) GPS time readout
- "Heartbeat" event rate of several per minute, with~100K events recorded:
  - payload generated EMI + thermal noise + calibration triggers + forced/timeout triggers
- Set a new limit on UHE neutrino flux (ν limit page)

astro-ph/0551265 ; PRL 96 (2006) 171101

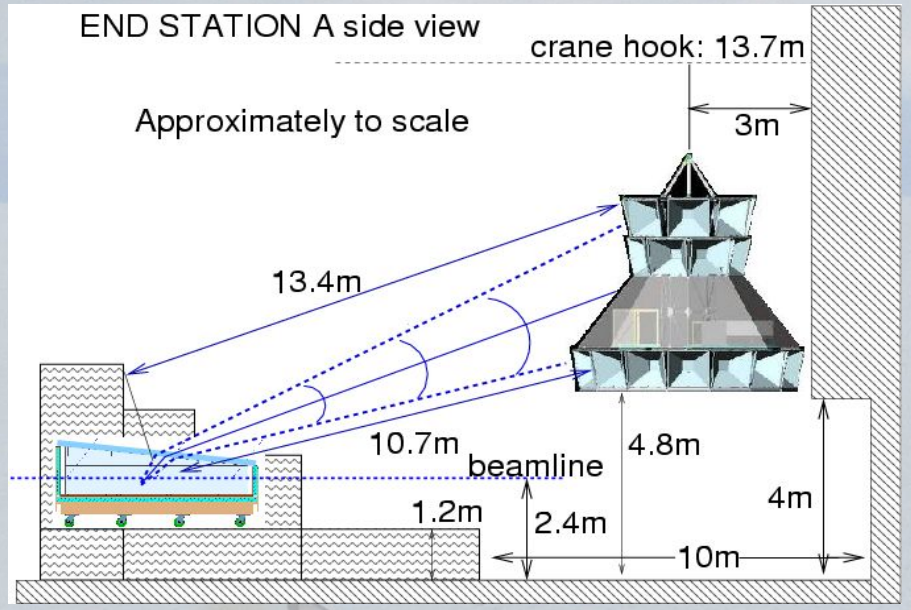
*Trans-Iron Galactic Element Recorder

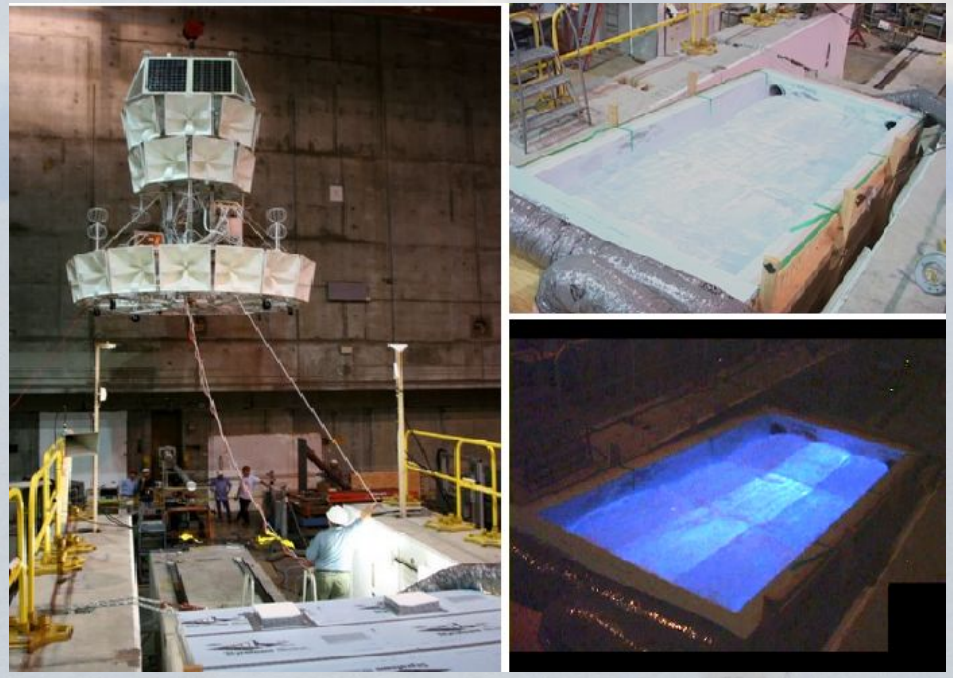
ANITA EM flight

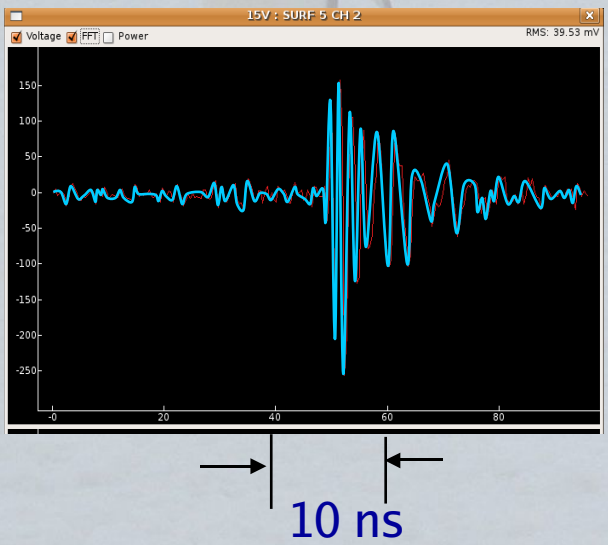


- EM (engineering model) flight @ Ft. Sumner in July 2005
- Tested gondola design, assembling procedure, and electronics in a real flight condition
- Gondola rotator found to be noisy and had to change design.

SLAC T486 (Jul '06): Askaryan on ice

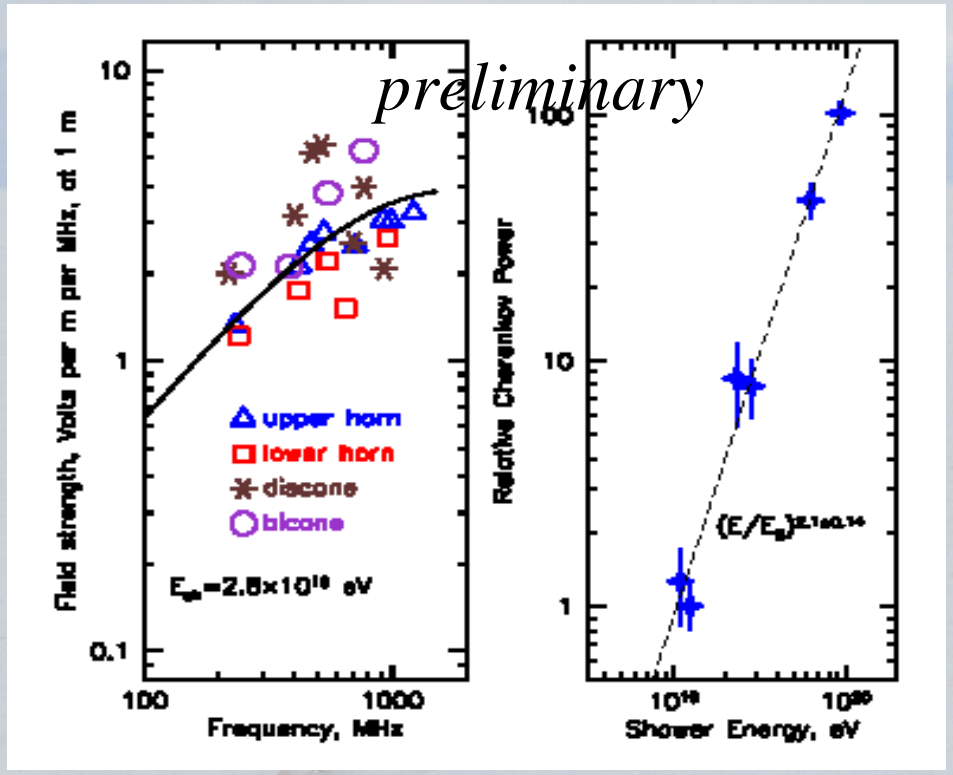


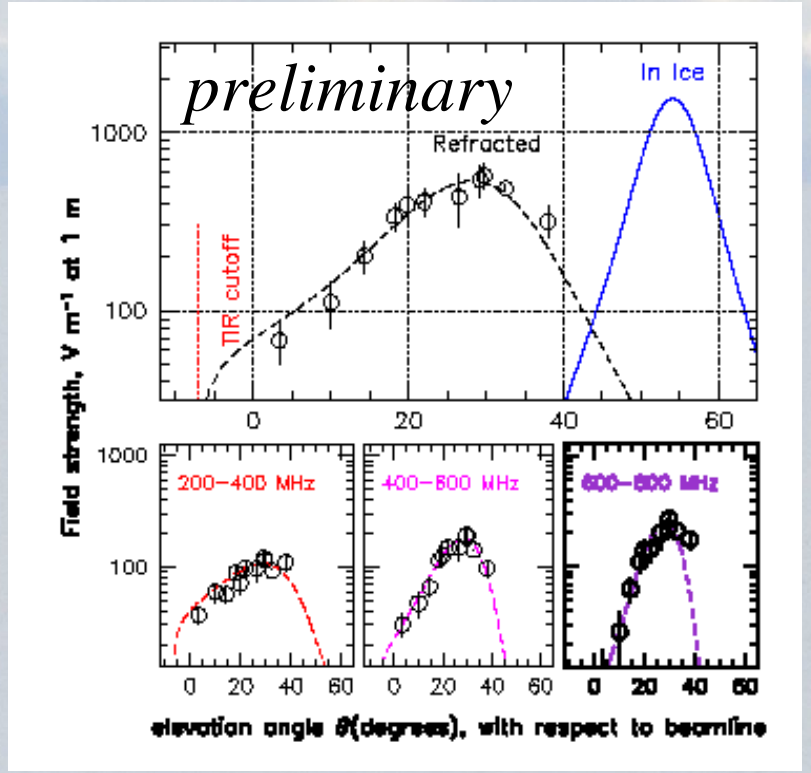




- Opportunity to test the effect in a medium relevant to several current and future experiments: ANITA, RICE, etc.
- 12-tons of ice + ANITA + End Station A + SLAC beam = Ideal ANITA calibration + comprehensive validation of Askaryan

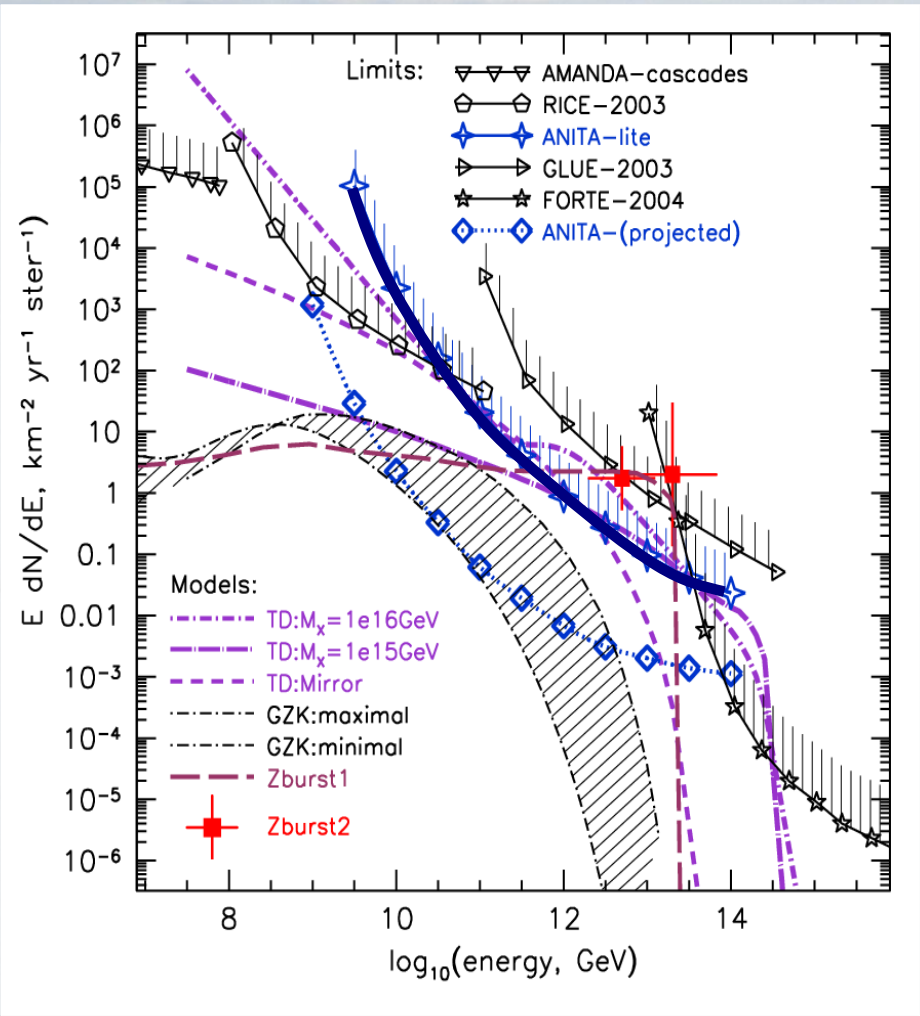
SLAC T486: Initial Results





- Radio coherence: quadratic power vs. beam current as predicted
- Frequency dependence and total power: as predicted by Askaryan's theory
  (in Zas-Halzen-Stanev form)
- Report under preparation, available soon

UHE neutrino limits & projections



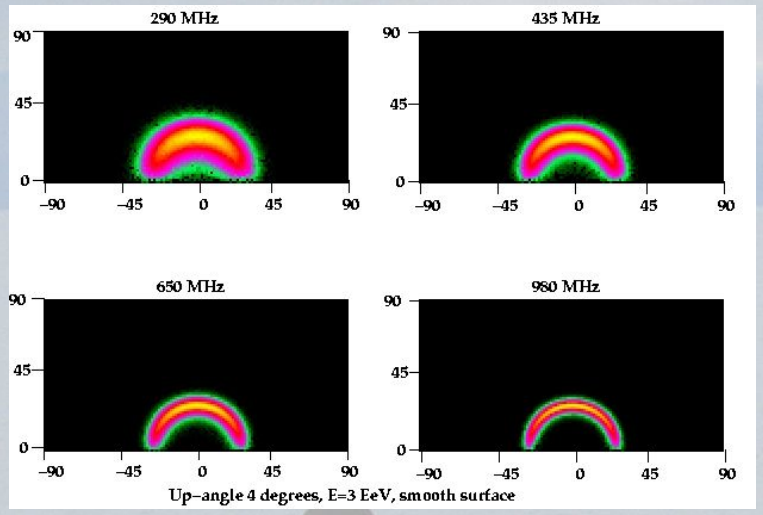
Strongest limits: all radio

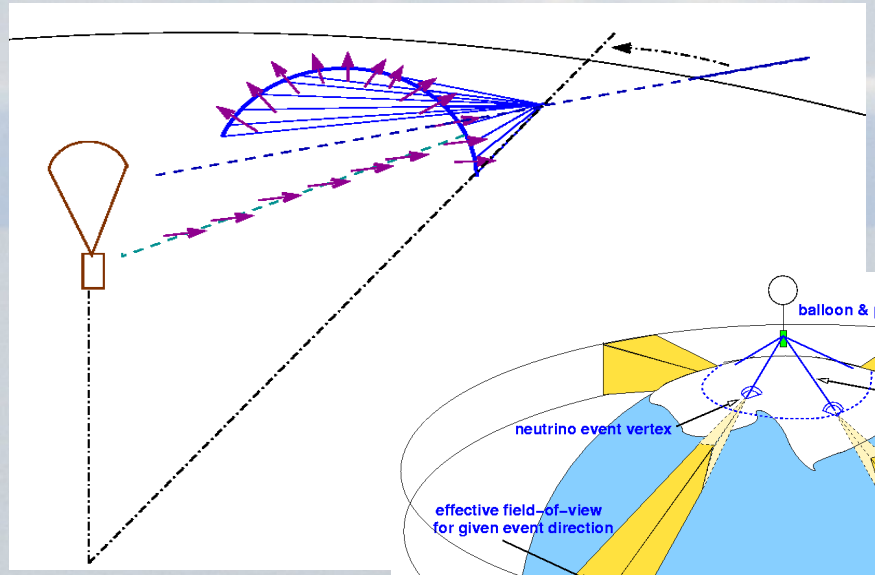
- **RICE** limits for 3500 hours livetime
- **GLUE** limits 120 hours livetime
- **FORTE** limits on 3.8 days of livetime
- **ANITA-lite**: 18.4 days of data, net 40% livetime with 60% analysis efficiency for detection
  - No candidates survive
  - Z-burst UHECR model (νν annihilation --> hadrons) excluded:
    - we expect 6-50 events, saw none
  - Highest Topological defect models also excluded
- **ANITA projected sensitivity (45 days):**
  - ν_e ν_μ ν_τ included, full-mixing assumed
  - **1.5-2.5 orders of magnitude gain!**

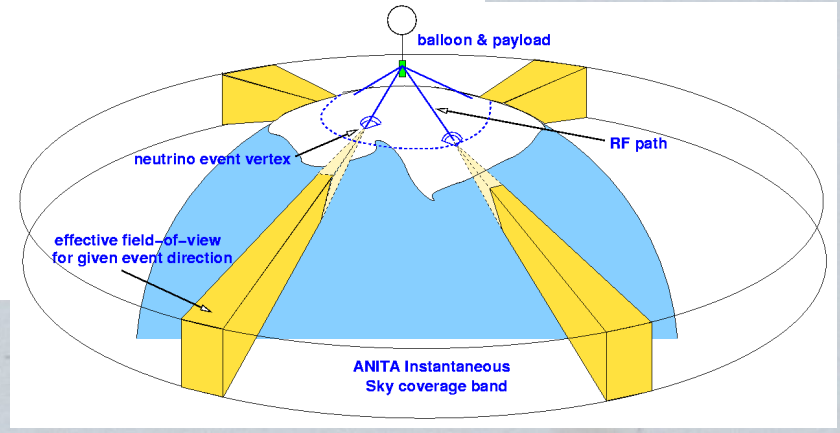
Summary

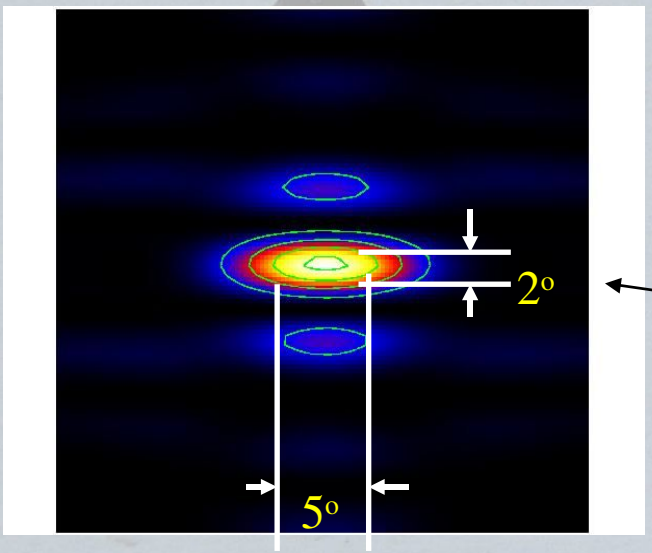
- ANITA project has been progressing in amazing pace
- instrument is well tested, understood, and calibrated with SLAC electron beam
- ANITA is now ready to detect UHE neutrinos
  - collaborators heading for Antarctica
  - two calibration radio sources scheduled to be set up.
- a nominal 15 days flight should cut into expected GZK flux
- hope to have a longer flight (like 42days CREAM '04-05 flight) and a positive detection of GZK neutrinos

ANITA as a neutrino telescope



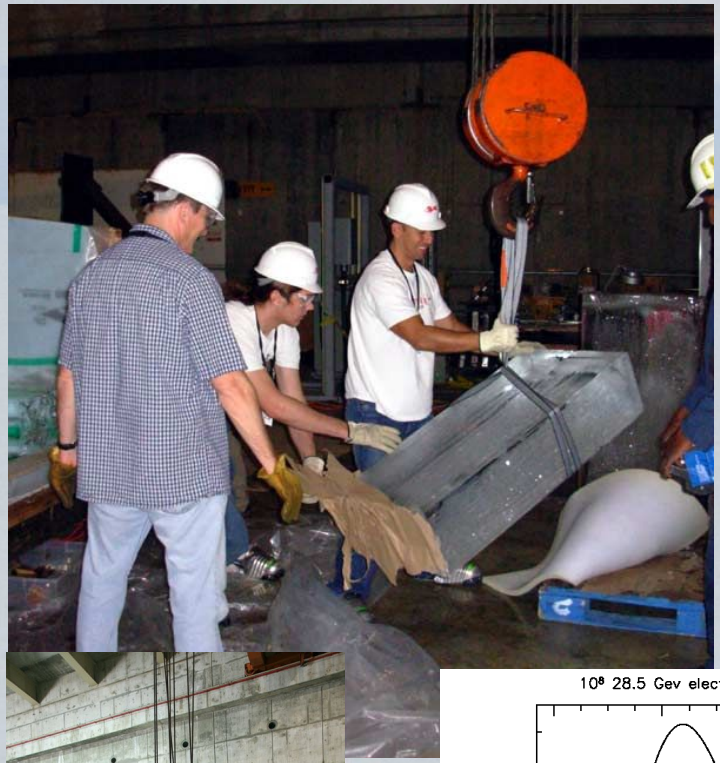


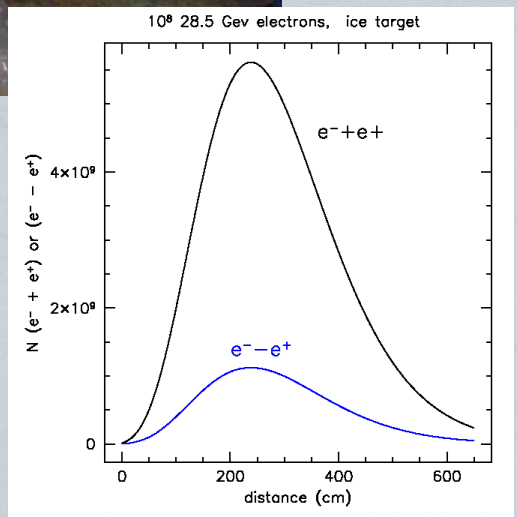




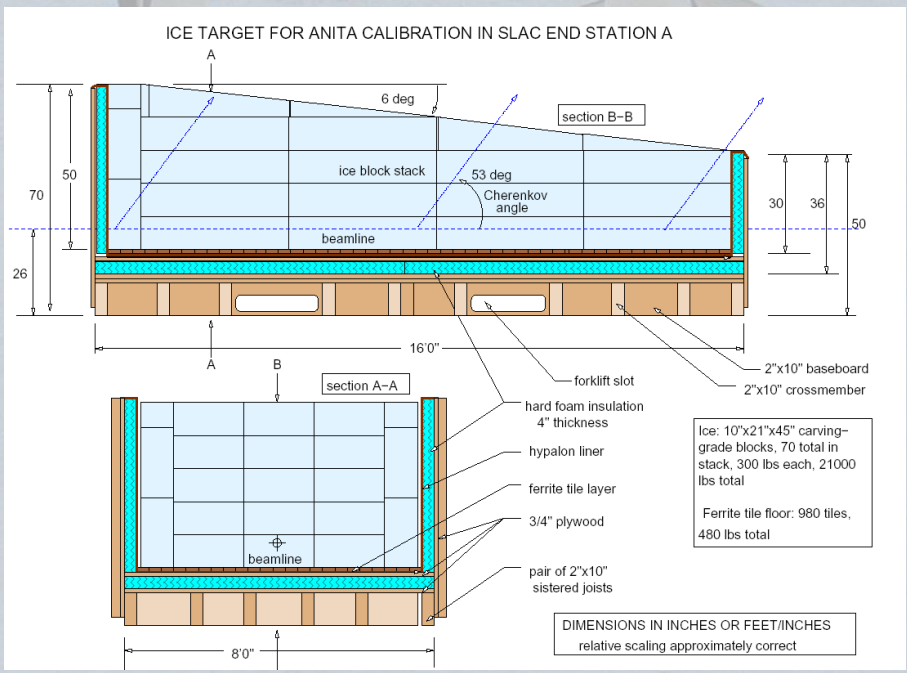
- Pulse-phase interferometer (150ps timing) gives intrinsic resolution of <1° elevation by ~1° azimuth for **arrival direction** of radio pulse
- **Neutrino direction** constrained to ~<2° in elevation by earth absorption, and by ~3-5° in azimuth by polarization angle

T486: ice target

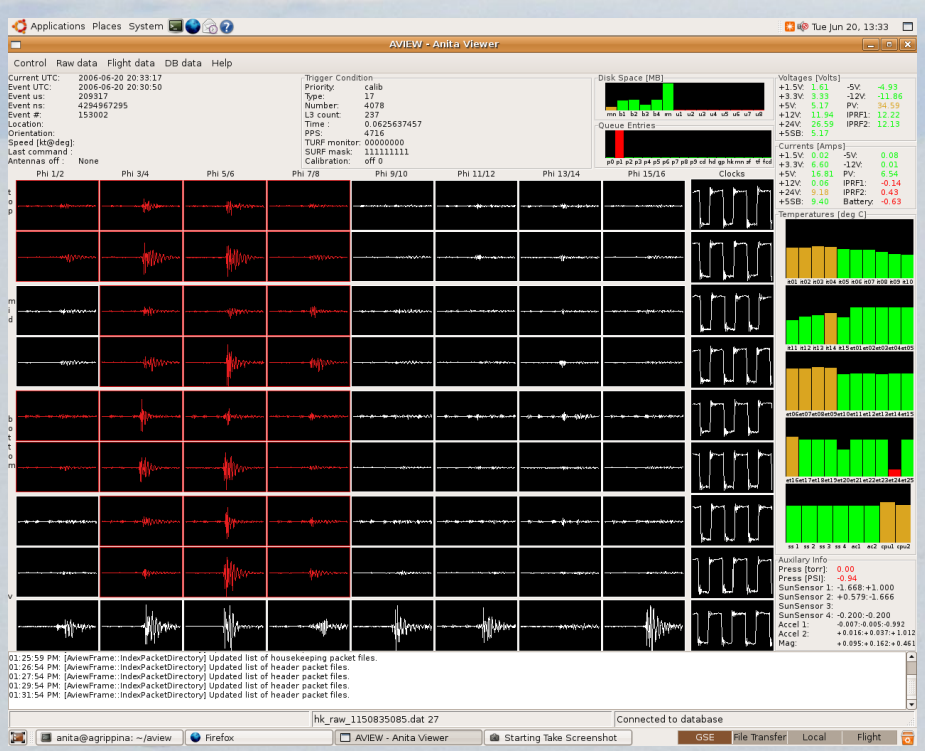


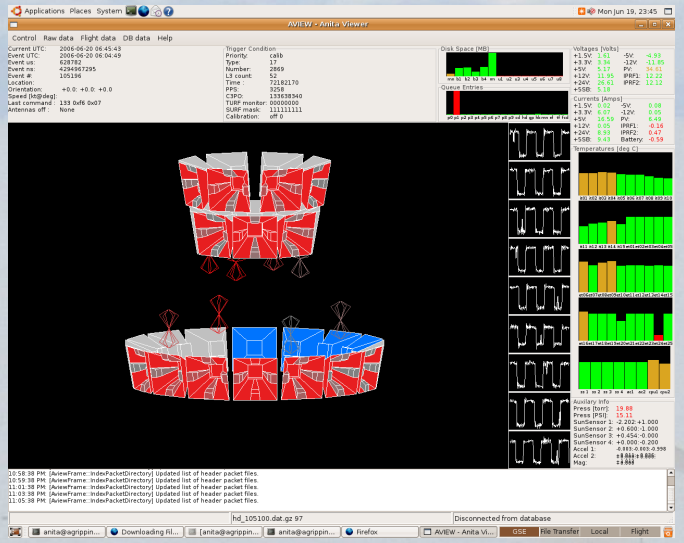


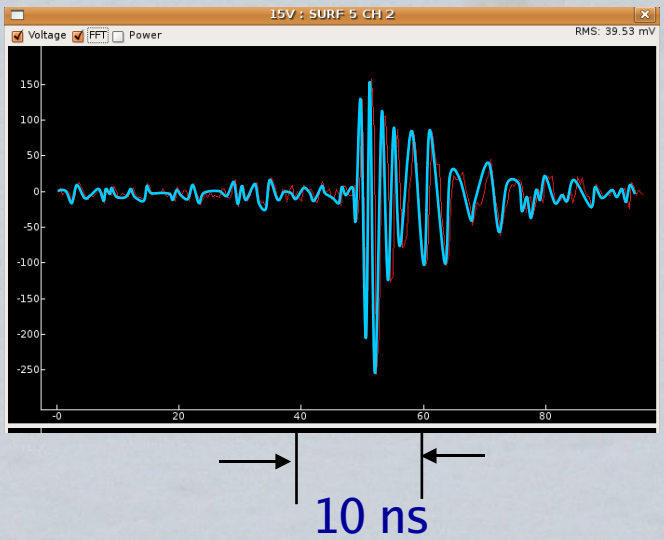
- Carver-grade ice, very pure
- 300 lb blocks, about 70 used to make target with >0.6 λ (in ice) at >200MHz in all directions around beam axis
- Target length: 12 radiation lengths=5 m of ice



Full Ground software system tested:
First observations of Askaryan effect in ice







- Impulses are band-limited, highly polarized, as expected
- Very strong--need 20dB pads on inputs (eg, -95dB compared to Antarctic configuration)