Profile Of Third Flight Of The Antarctic Impulsive Transient Antenna (ANITA) In 2015

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The ANtarctic Impulsive Transient Antenna (ANITA)

- ANITA ~40km Cosmic Rays, Neutrino
- ARA ~200m, Neutrino
- UFFO ~550km, Gamma Ray Burst
- TAROGE ~1km, Cosmic Rays
The ANITA Concept

**Figure:** Cherenkov radiation is electromagnetic radiation emitted when a charged particle passes through a dielectric medium at a speed greater than the velocity of light in that medium.
Flight Path of ANITA & ANITA-II

Figure: flight path of ANITA & ANITA-II.
FoV of ANITA

Figure: The radius of FoV is about 500km.
Signal Type (Neutrino VS. Cosmic Rays)

**Cosmic Rays case: (H-pol dominantly)**
The polarization of Geo-synchrotron normal to shower and magnetic field direction

**Neutrino case**:  
V-pol dominantly
RF cherenkov by Askaryan effect.
low Fresnel coeff. For transverse EM-wave at boundary.
-> H-pol suppressed.

Air shower

- Neutrino
- Cosmic Rays
- B field
- Cherenkov cone in Ice (~45°)
- Rock
- Shower (L~10m)
The ANtarctic Impulsive Transient Antenna (ANITA-III)

Figure: ANITA-III instrument, 2014-1015.
ANITA-III Instrument:

- 48 dual polarized antennas 180-1200 MHz
- Deployable 600 W PV cells
- V-pol & H-pol noise-riding threshold trigger
- Custom SCA ASICS, 2.6 GHz bandwidth digitizers

- Real-time GPU-based event prioritizer & realtime mapper
Event Reconstruction

• Angular reconstruction is a crucial part in the ANITA data analysis.
• Powerful background rejection
  incoherent thermal events (99% of data set)
  anthropogenic RF events from existing bases
  air shower RF events.
• Neutrino reconstruction
  neutrino direction information
  provides R and refraction angle for energy measurement.
• Angular reconstruction using timing.
  time resolution; 40-60 ps
  (time difference between channels)
• Achieved angular resolution;
  $0.2^\circ$ (zenith) and $0.8^\circ$ (azimuth.)

from jiwoo Nam
Ground Pluser System

- Two Ground Pulser Systems @Williams Field and Taylor Dome
- System Verification
- Trigger Test
- Propagation and Surface
- Timing / Angular Resolution
Angular Resolution

Payload position During this segment

Reconstructed RF source positions

Zenith:
- Constant: 187.161
- Mean: -0.029
- Sigma: 0.199
- σ = 0.2°

Azimuth:
- Constant: 90.966
- Mean: 0.120
- Sigma: 0.810
- σ = 0.8°
The Candidates of UHECRs of ANITA-III

Figure: Predominately Hpol, no known bases, strong SNR.
Flight Path of ANITA-III 2014-2015

Figure: Flight path of ANITA III.

http://www.csbf.nasa.gov/antarctica/payloads.htm
Launch and landing

Figure: Photographs of the launch and landing of the ANITA-III payload. Credit to C. Miki and the Australian Antarctic program.
Summary of ANITA -III

- Flight in 14/15 austral summer lasted 22 days
- Several improvements → most sensitive trigger to date
- HiCal to measure surface roughness
- Several UHECR candidate events and more to come (dozens)
- At current limit, ANITA-III could see several neutrinos
- 84 M events recorded
ANITA-IV

• Planned flight in 2016/2017 Antarctic season
• Expected 50-60% improvement in energy threshold:
  • Low-noise amplifiers & receivers with 30-40K lower noise → 20%
  • Real-time 3-bit signal correlator trigger → 15%
  • Programmable notch filters → ~30% improvement in exposure
  • Improved GPU-trigger processor, higher trigger rates → 10-15%
Space
At energies above $\sim 10^{19.5}\text{eV}$ cosmic rays will interact with CMB photons producing neutrinos

Process is known as the GZK effect

Auger and HiRes measurements of UHE cosmic rays consistent with GZK cut-off

Guaranteed GZK neutrino flux, but how large?

*copy from Jonathan's slides*

Figure: The UHE neutrinos can point back to the original UHE source without bending of B field.
The UHE Neutrinos

- Trace particle UHECR hyper-accelerators to very early epochs
  Even at $z \sim 10$ or more, GZK neutrino energies peak at 10-100 PeV
  they all point back directly to the UHECR sources

- Their flux is constrained by UHECR sources, once determined
  Can become a quasi-isotropic “test beam” of UHE neutrinos

- Neutrino Flavor physics
  Can encode source information by flavor ratio, even new physics
  (neutrino decay? )
300k events pass thermal cuts
Cluster with:
  - Other events
  - Known bases of activity
  - “Hot-Spots”
- Neutrinos are single, isolated events!