

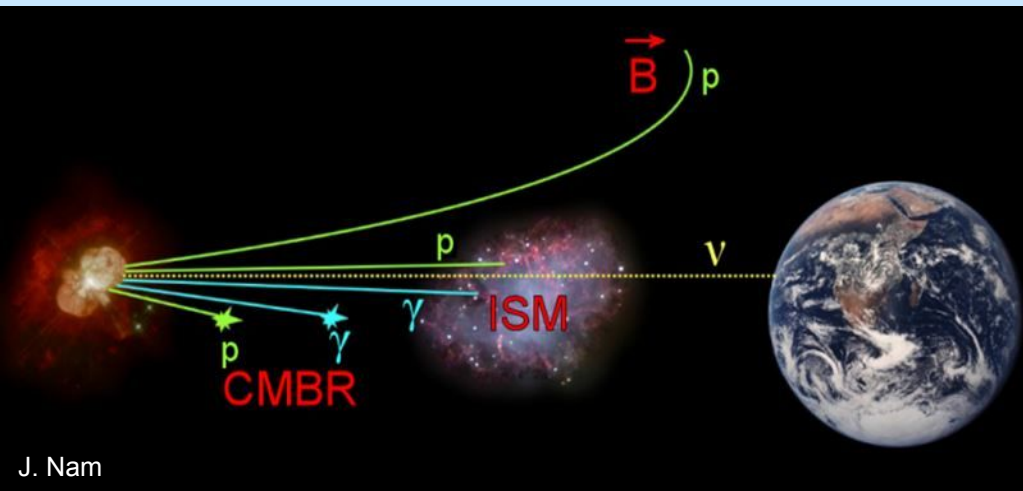
New Results From ANITA



APS April Meeting 2019
Andrew Ludwig
University of Chicago



Neutrinos: The Ideal Messenger Particle



Neutrinos are the only way to view the distant ultra-high energy (UHE) universe

Photons are lost to pair production on the CMB and IR above 100 TeV

Protons and nuclei deflect in magnetic fields

Neutrons decay

Neutrinos point back to sources, travel unimpeded through universe

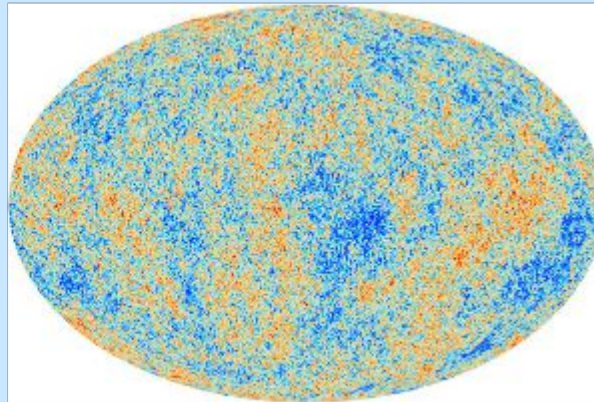
Ultra-High Energy Neutrino Production

GZK process: Cosmic ray protons ($E > 10^{19.5}$ eV) interact with CMB photons

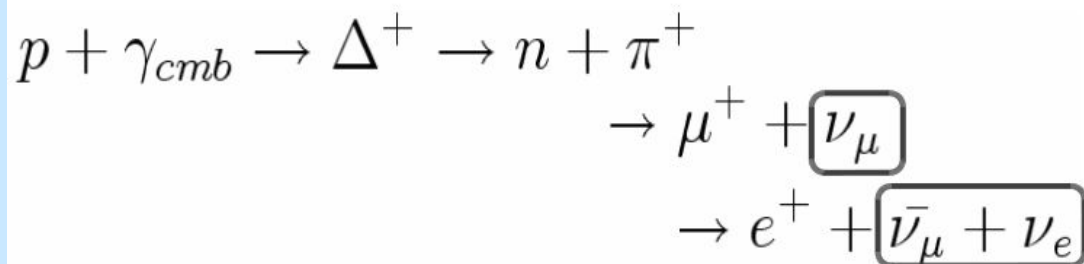
UHE neutrinos can also be produced directly in sources



+



= Neutrinos!

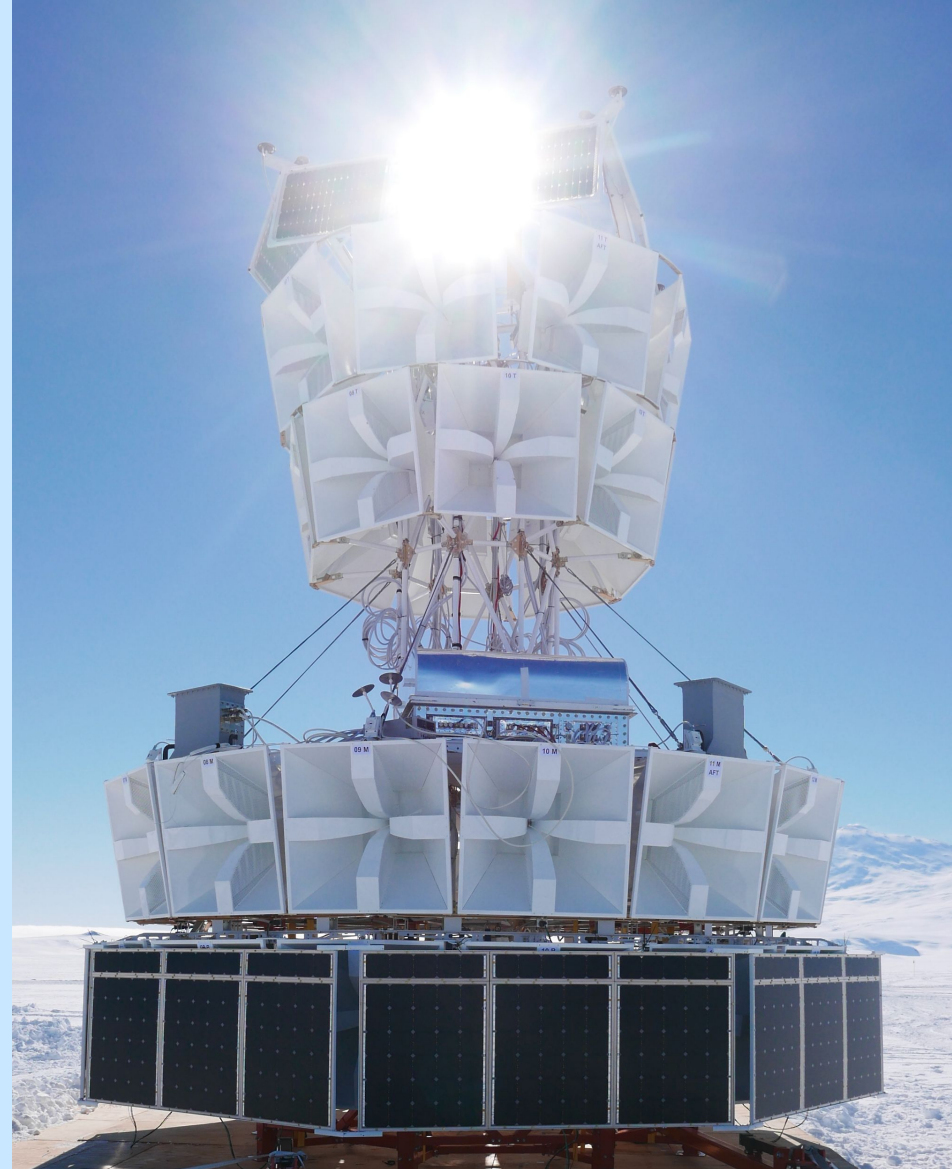


The ANITA Experiment



Purpose is to detect ultra high energy neutrinos

- 48 radio antennas -
- Dual polarization
- Directional
- 180 - 1200 MHz band



Flies at altitude of ~40km and sees over 1 million km³ of ice

Four flights (most recent 2016)

ANITA Detection Channels

Neutrino detection channel: Askaryan radiation

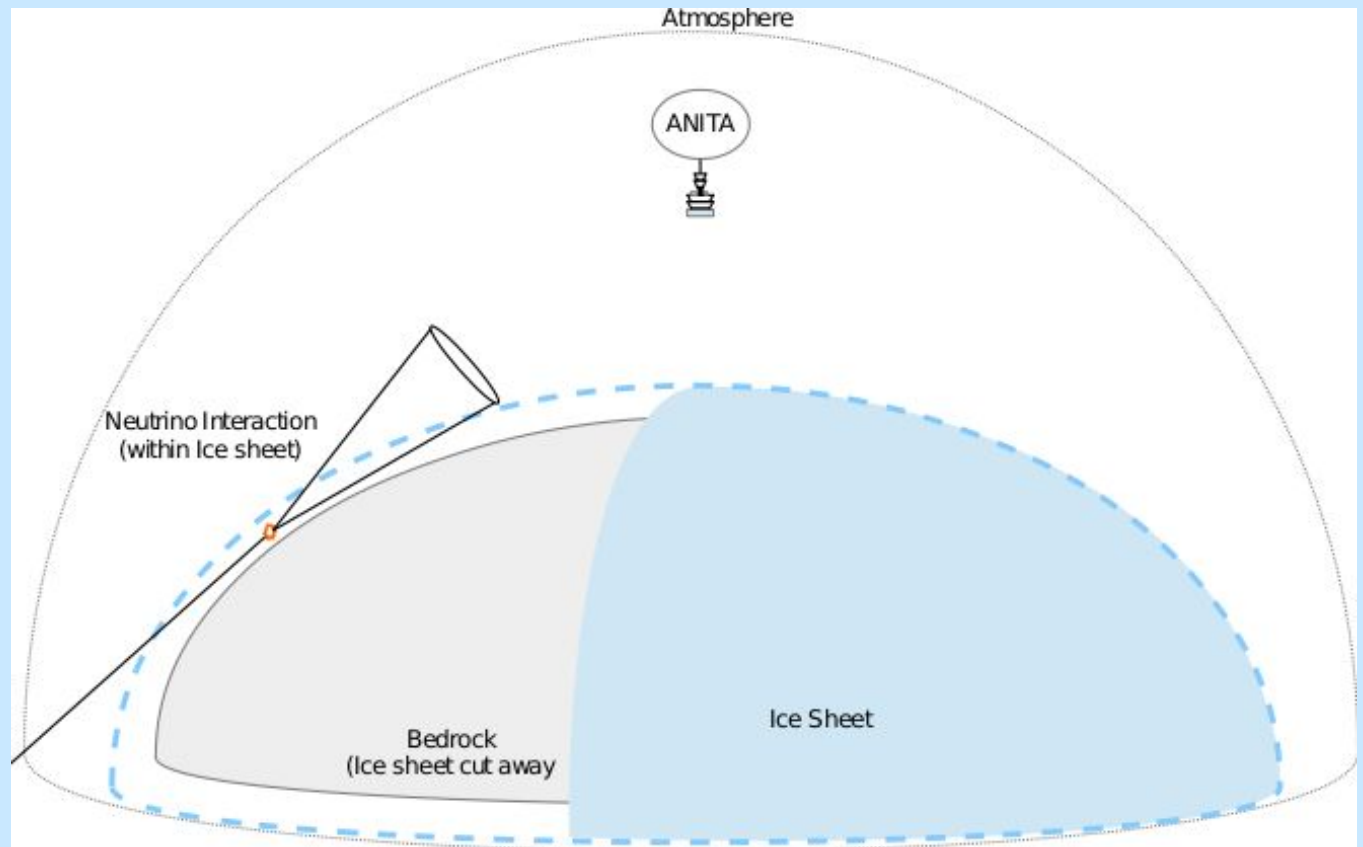
EM shower in dielectric (ice) creates a moving disk of negative charge excess

Coherent radio Cherenkov radiation if $\lambda > \text{Moliere radius}$

Typical Dimensions:

$L \sim 10 \text{ m}$

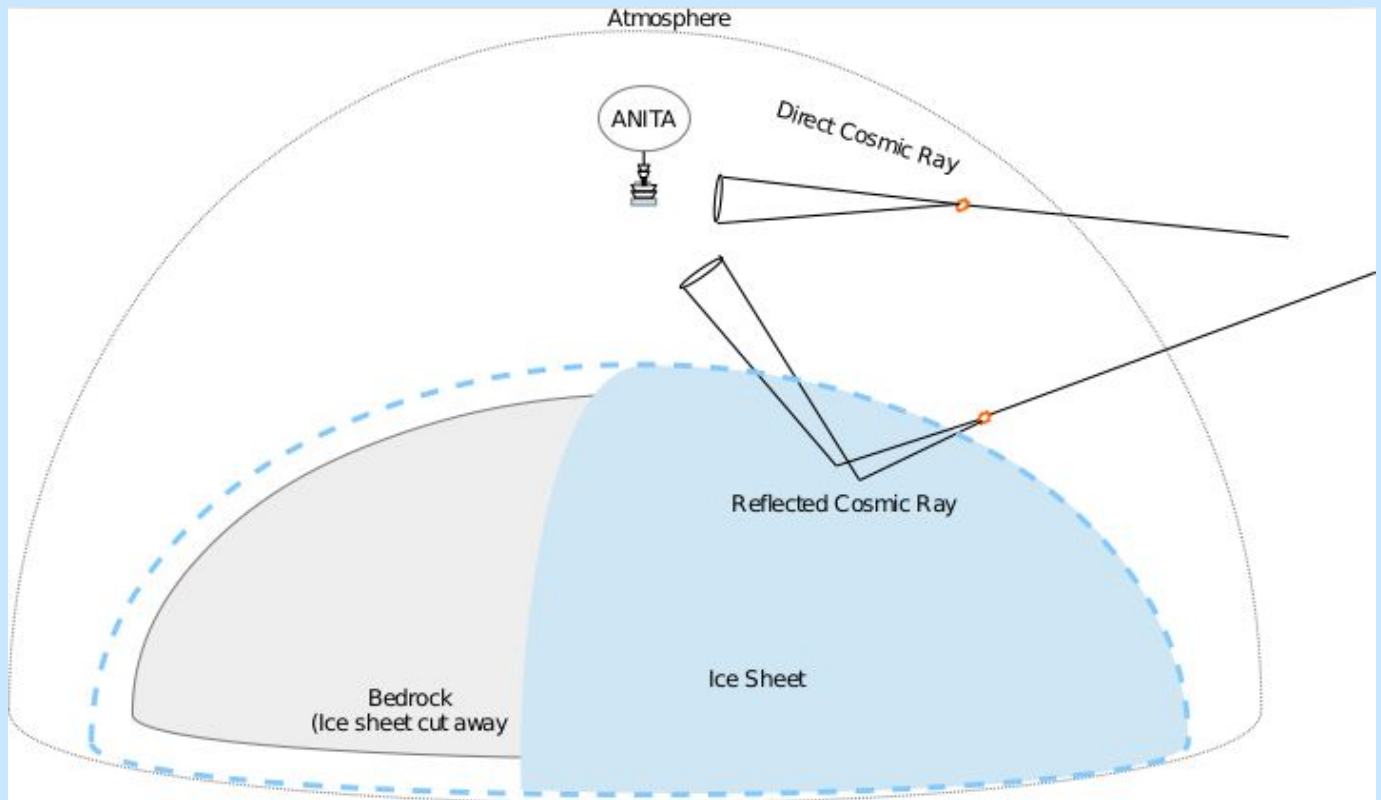
$R_{\text{moliere}} \sim 10 \text{ cm}$



B. Rotter, 2017

ANITA Detection Channels

Cosmic ray detection channel:
Geomagnetic emission

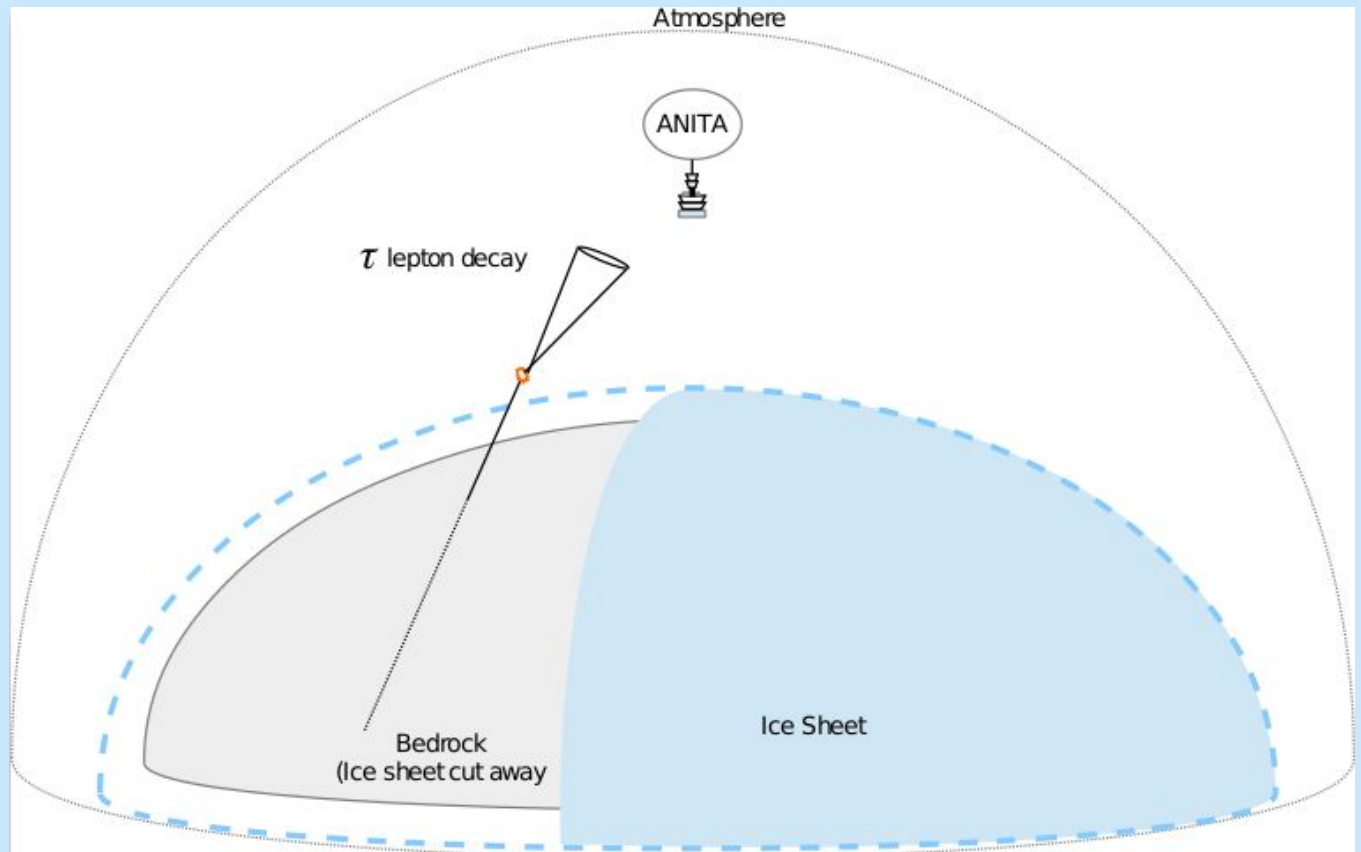


B. Rotter, 2017

ANITA Detection Channels

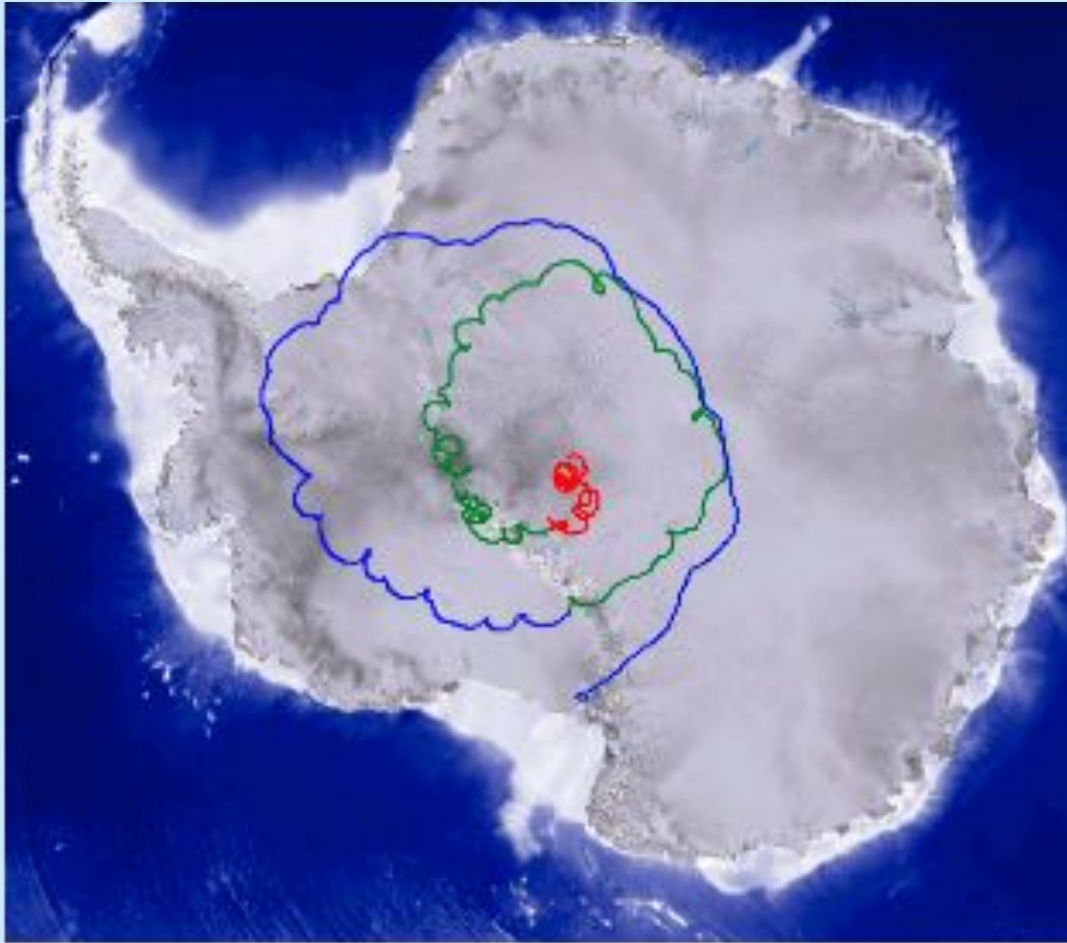
Tau Leptons

Same as cosmic ray channel



B. Rotter, 2017

ANITA-4 flight

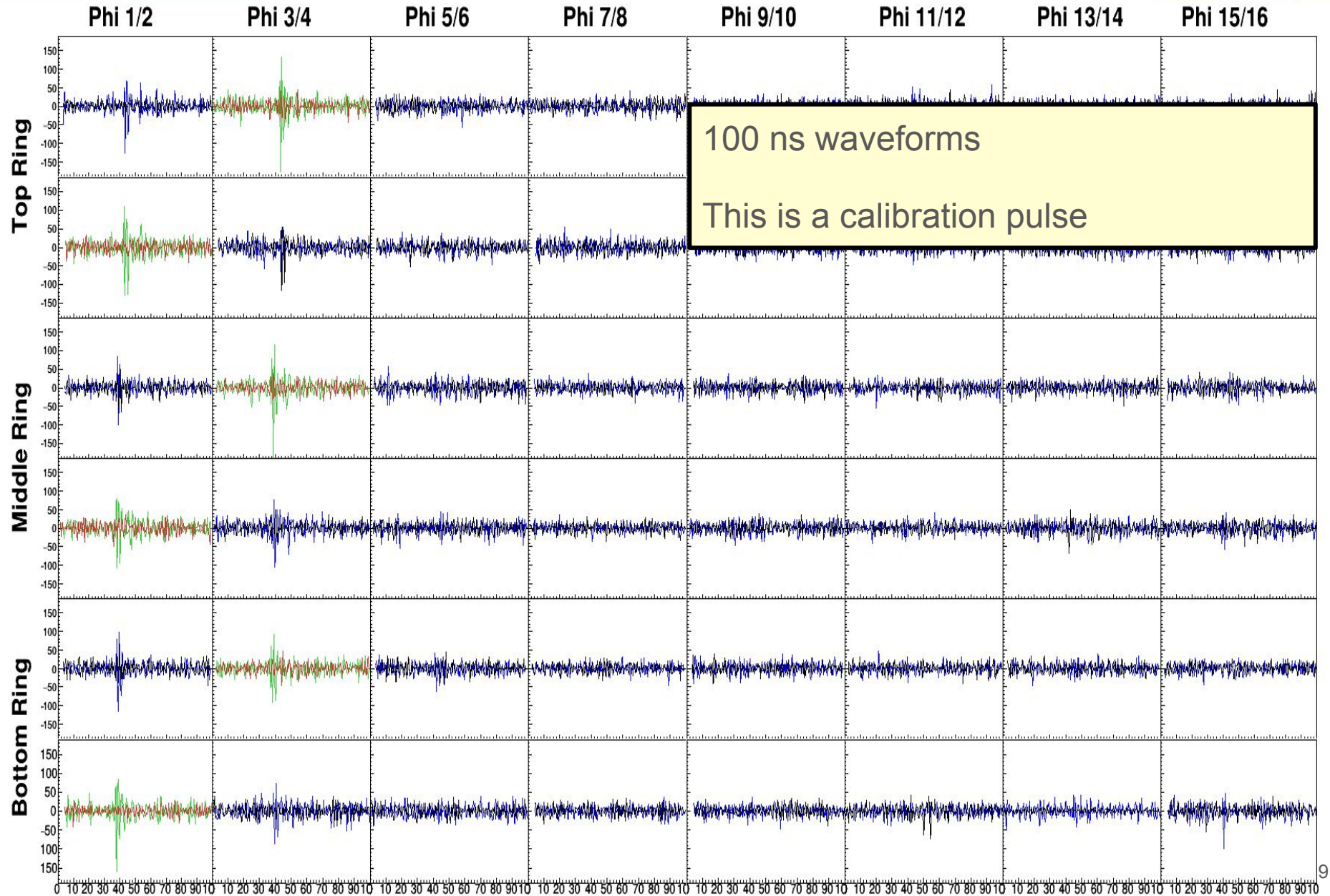


ANITA-4 Flight Path

Flew for 28 days

Data recovered a month after flight

Example ANITA Event Display



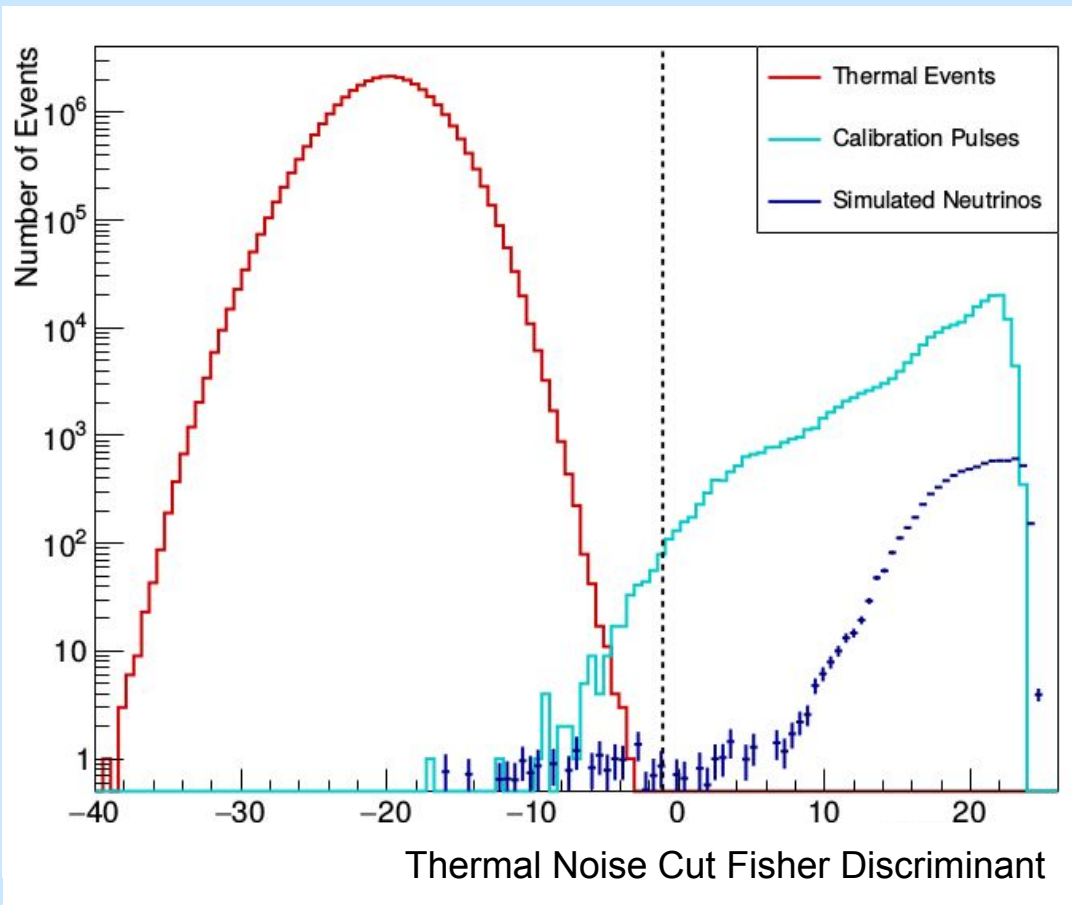
Round 1 and 2 Cuts - Thermal Noise

We had ~100M events

Our blind analysis applied 3 rounds of cuts:

- Round 1: “Quality cuts” to remove glitches, etc.
- Round 2: Thermal noise cuts to remove 99% of events
- Round 3: Clustering cuts to remove man-made noise

After Round 1 and Round 2 cuts, expect 0.05 thermal events remaining in signal region



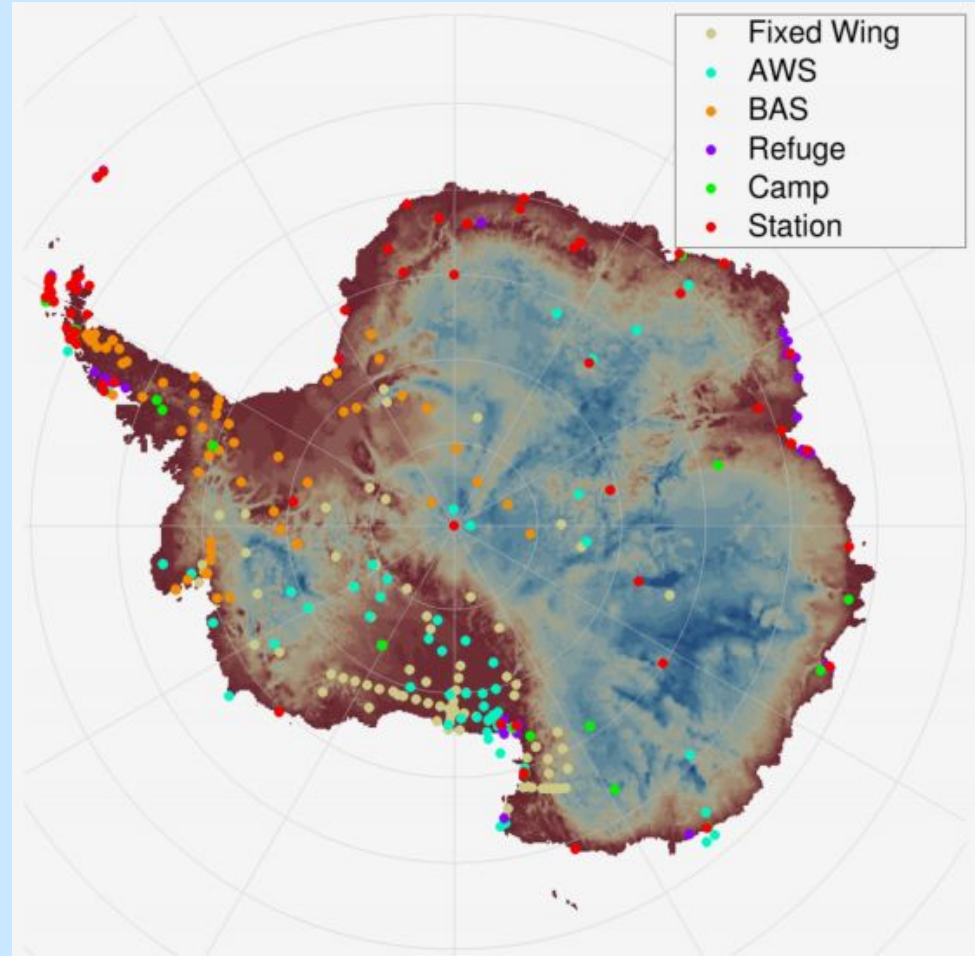
Round 3 Cuts - Clustering to Find Isolated Events

Look for isolated events

Things that cluster are probably from an anthropogenic source

Events that remain after clustering are isolated and signal-like

At right, the locations of all known human activity on the continent



Neutrino Results

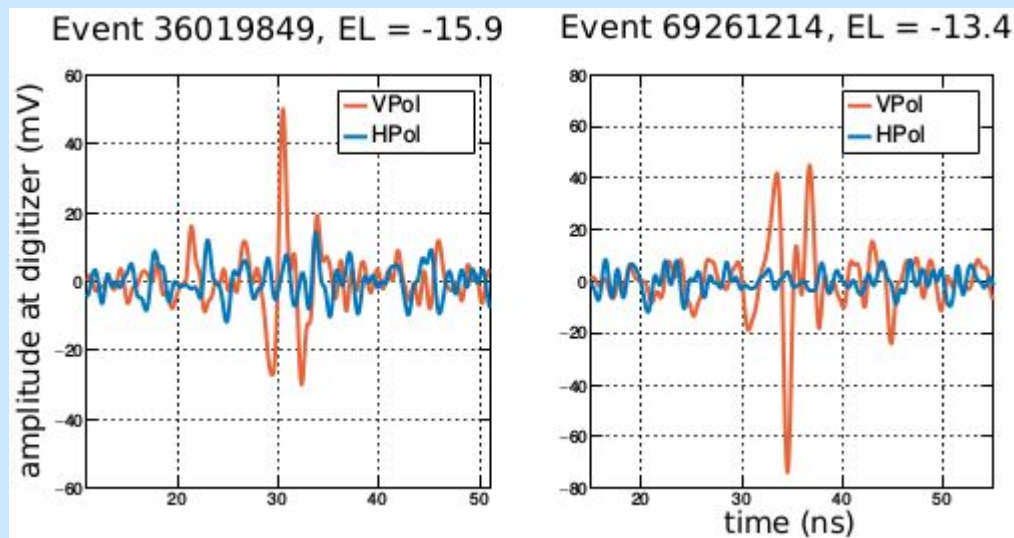
Two independent analyses found 1 event each.

First analysis' background was: $0.34^{+0.66}_{-0.14}$ with an efficiency of $\sim 71\%$

Second analysis' background was: $0.64^{+0.69}_{-0.45}$ with an efficiency of $\sim 82\%$

Events are shown below

Paper at: <https://arxiv.org/abs/1902.04005>



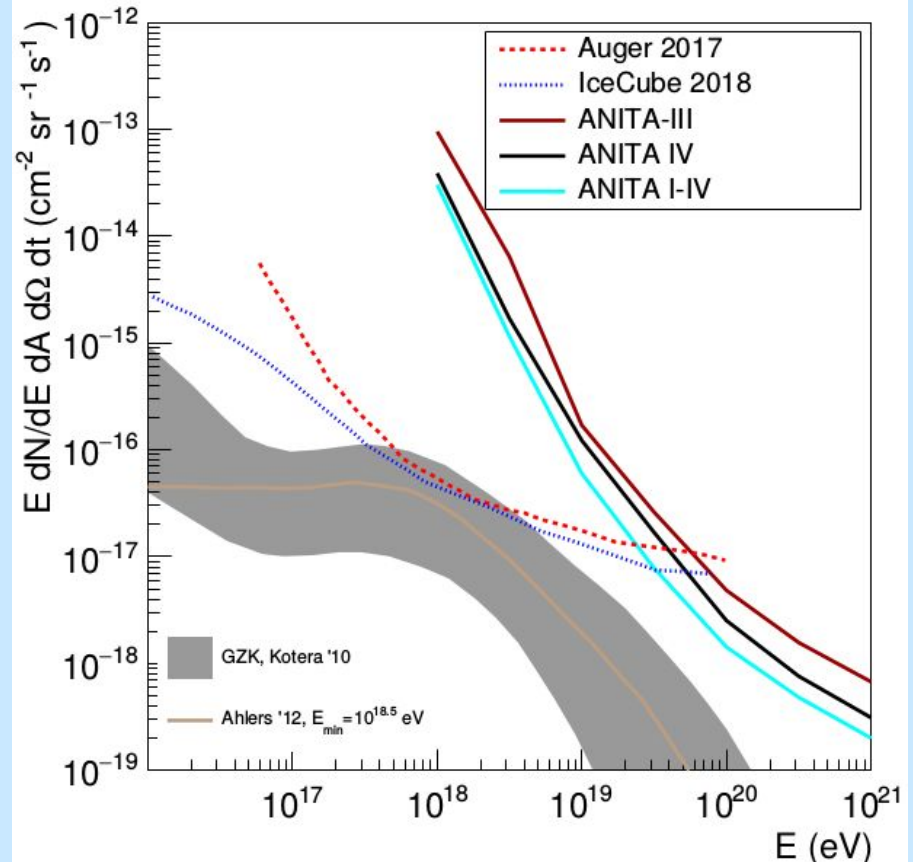
New Limit

No significant excess above background observed

Limit is shown at right

World leading between $\sim 10^{19.5}$ eV and 10^{21} eV

ANITA is probing an energy range above others, with an enormous instantaneous effective volume, great for point source and multi-messenger searches



Outlook



ANITA-4 CR/EAS analysis should be done within a few months

ANITA-3 and -4 multimessenger coincidence search analysis should also be out soon

ANITA's successor, PUEO, is proposed and awaiting review