

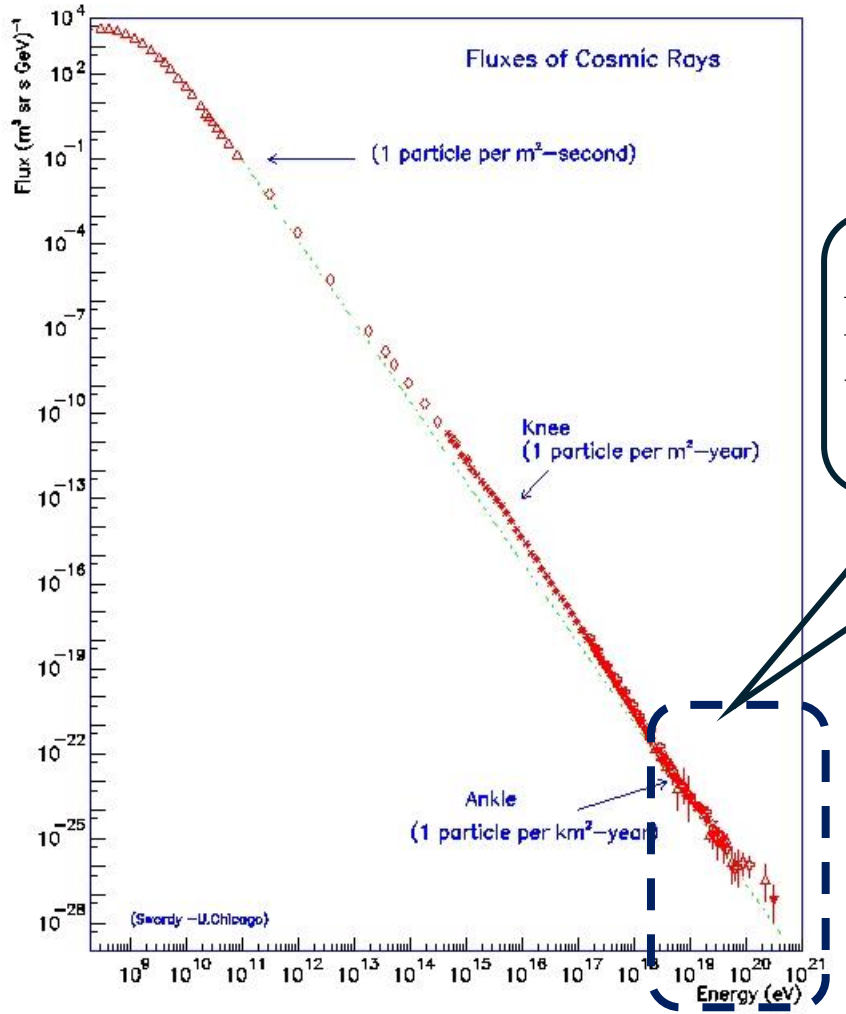
An aerial photograph of a vast, flat, snow-covered landscape under a clear blue sky. In the center of the sky, a white, parachute-like object is suspended, with a thin line extending downwards. The ground is covered in snow with visible tracks and shadows. In the distance, there are some small structures and a dark rectangular object on the left side.

A Journey of ANITA Experiment

Po-Wei Huang
Graduate Symposium

Motivation - UHE Neutrino Search

Cosmic Rays Spectrum [4]

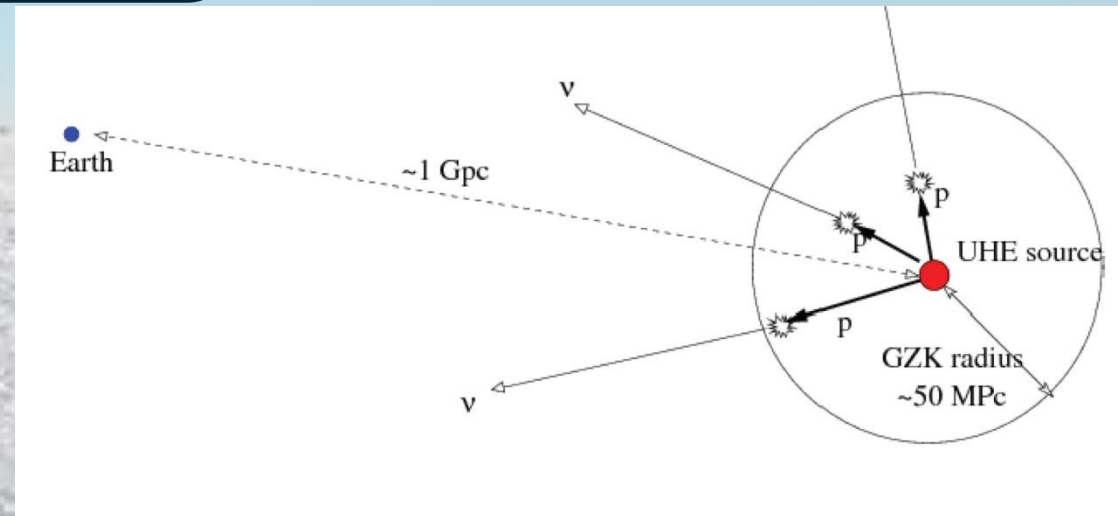


Do you think the flux would be endless?

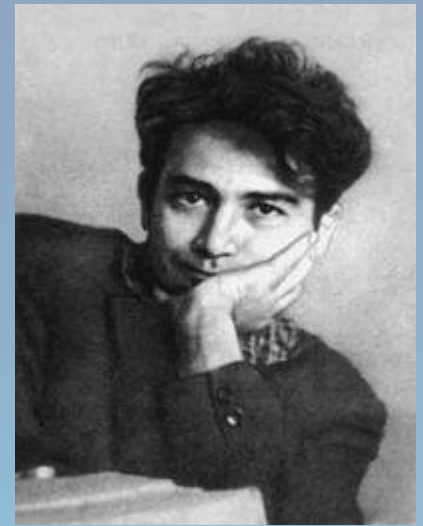
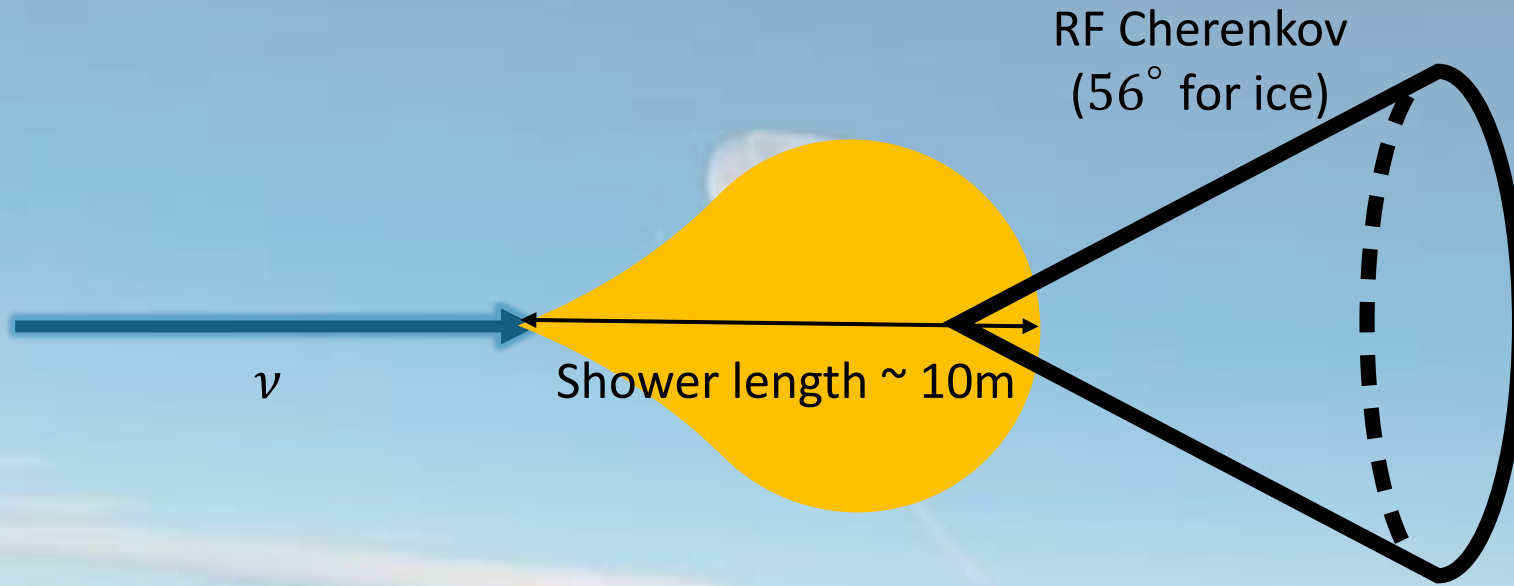
NO!

GZK Cutoff

- $p + \gamma_{CMB} \rightarrow \Delta^+ \rightarrow n + \pi^+$ [4]
when $E_p > 10^{19.5} eV$
- UHE ν from π^+ decay



Detection Method – Askaryan Effect

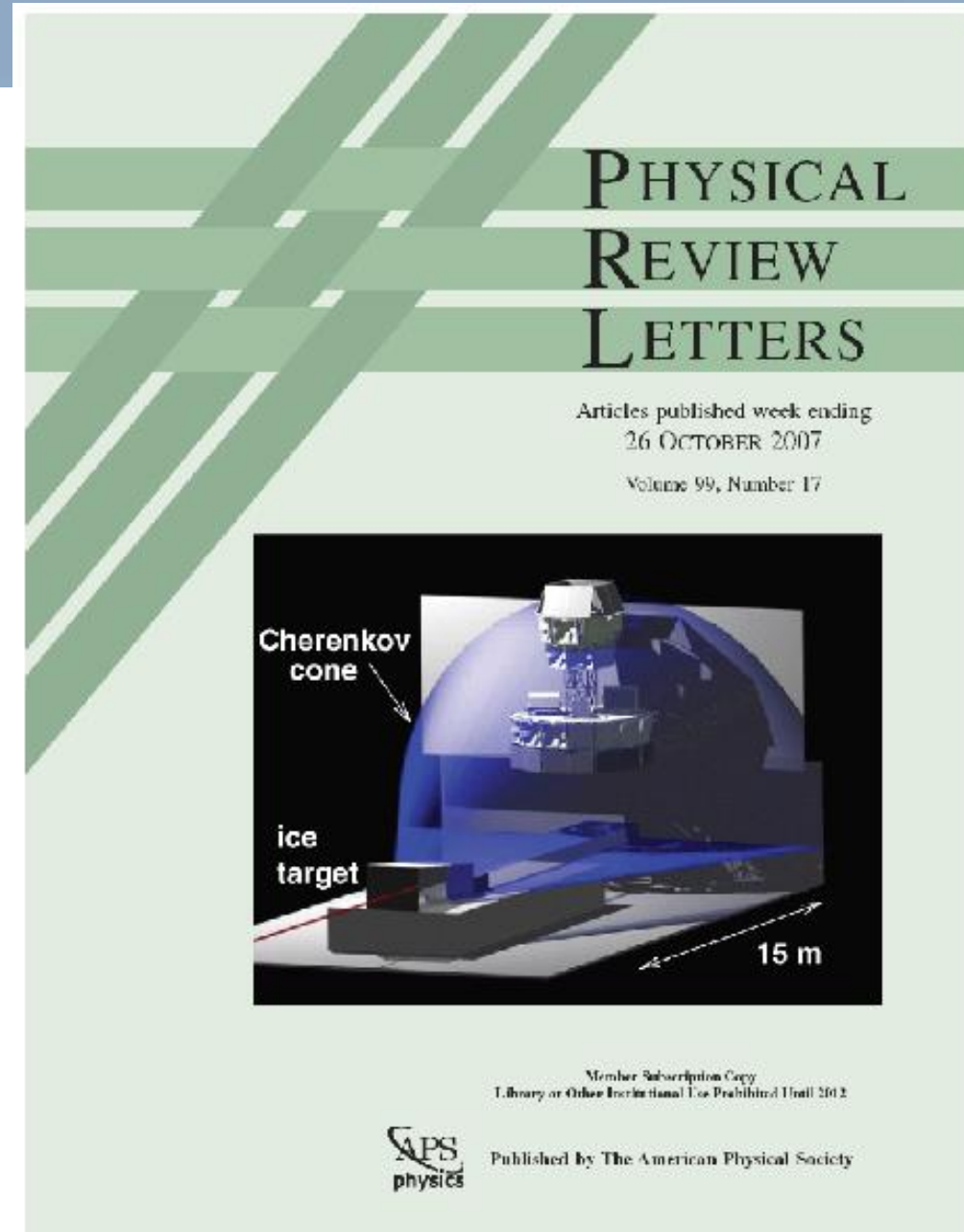
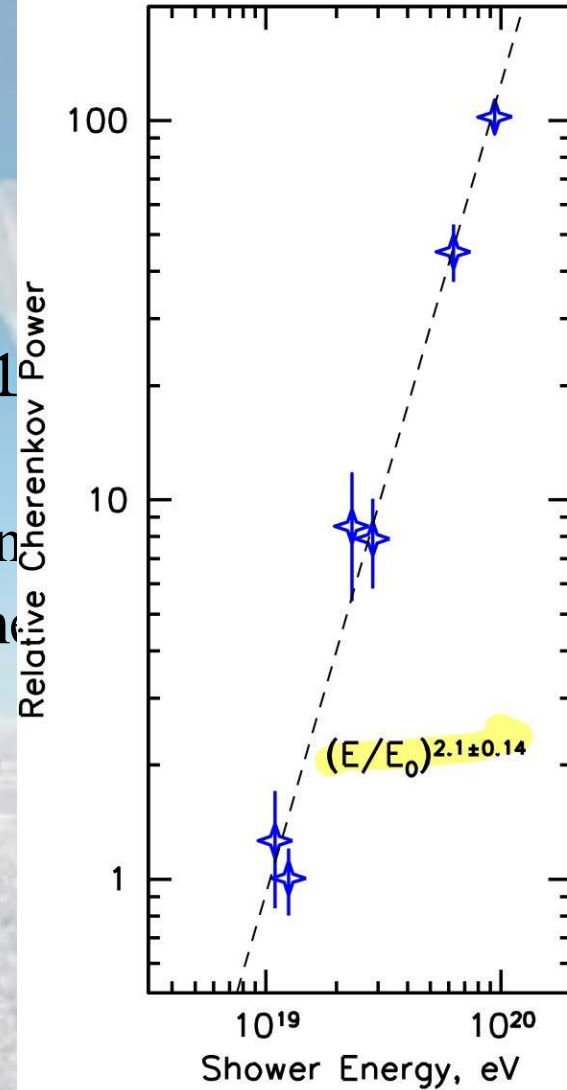


Gurgun Ashotovich Askaryan
a.k.a Гурген Аскаръян
(1928 -1997)

- $\sim 20\%$ Negative Excess Charge produce Cherenkov Radio Signals^[4]
- $P_{Cherenkov} \propto N_e^2 \propto E^2$ [2]
- Size of shower depends on frequency

Test of Askaryan Effect

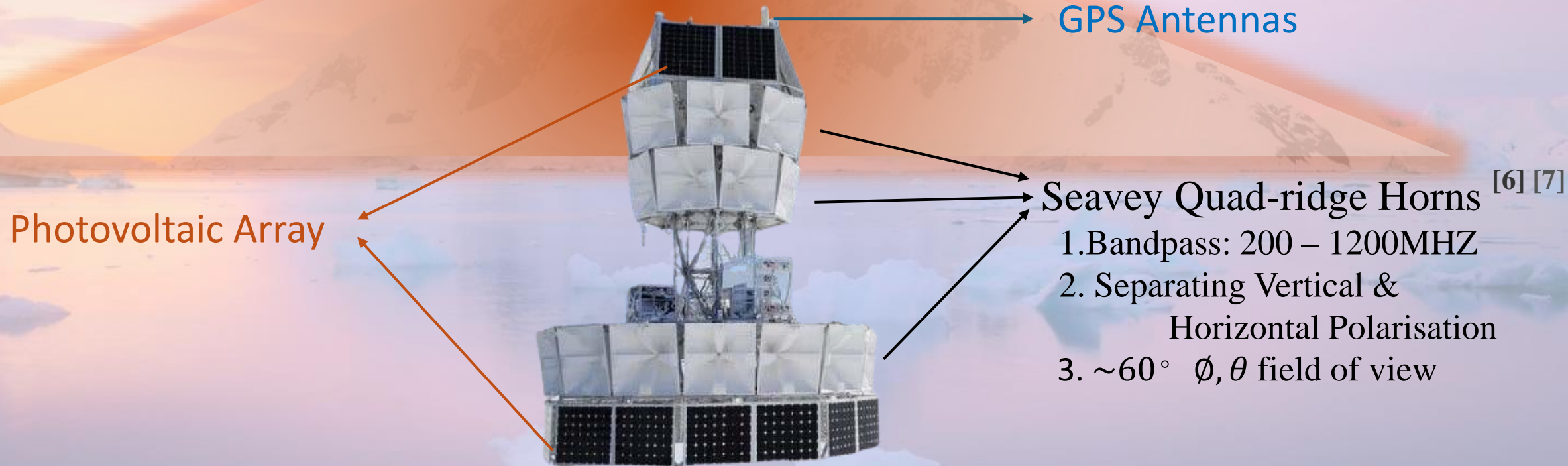
- Silica Sand (2000)
- Rock Salt (2002)
- Ice Test in SLAC (2006)
 - 28.5 GeV e^- beams with 10 tons of ice
 - 10 tons of ices covering 90% of the beam area
 - Angular, Frequency response
 - Shower Energy Measurement



ANITA Detector



- $N_\nu = flux \otimes Area \otimes \sigma_\nu \otimes \epsilon_{Det} \otimes T$
 - Area matters ! → Where to put detector?



ANITA Flights

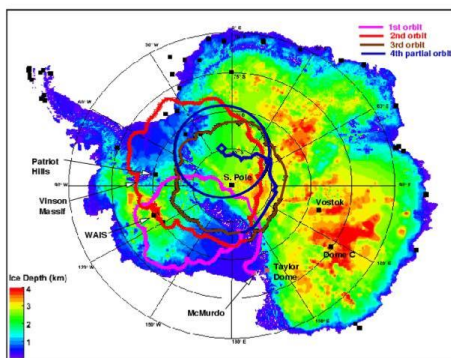
ANITA-I (2006-2007)



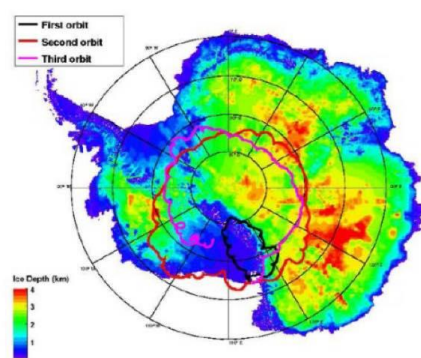
ANITA-II (2008-2009)



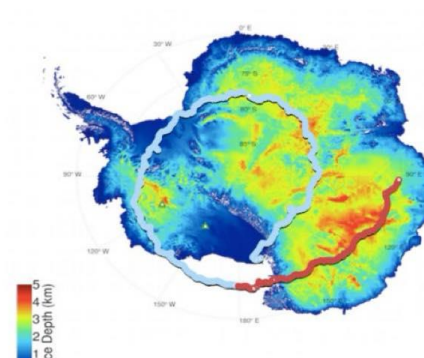
ANITA-IV (2016)



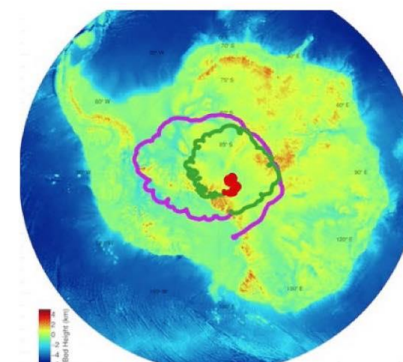
● 35 days



● 30 days

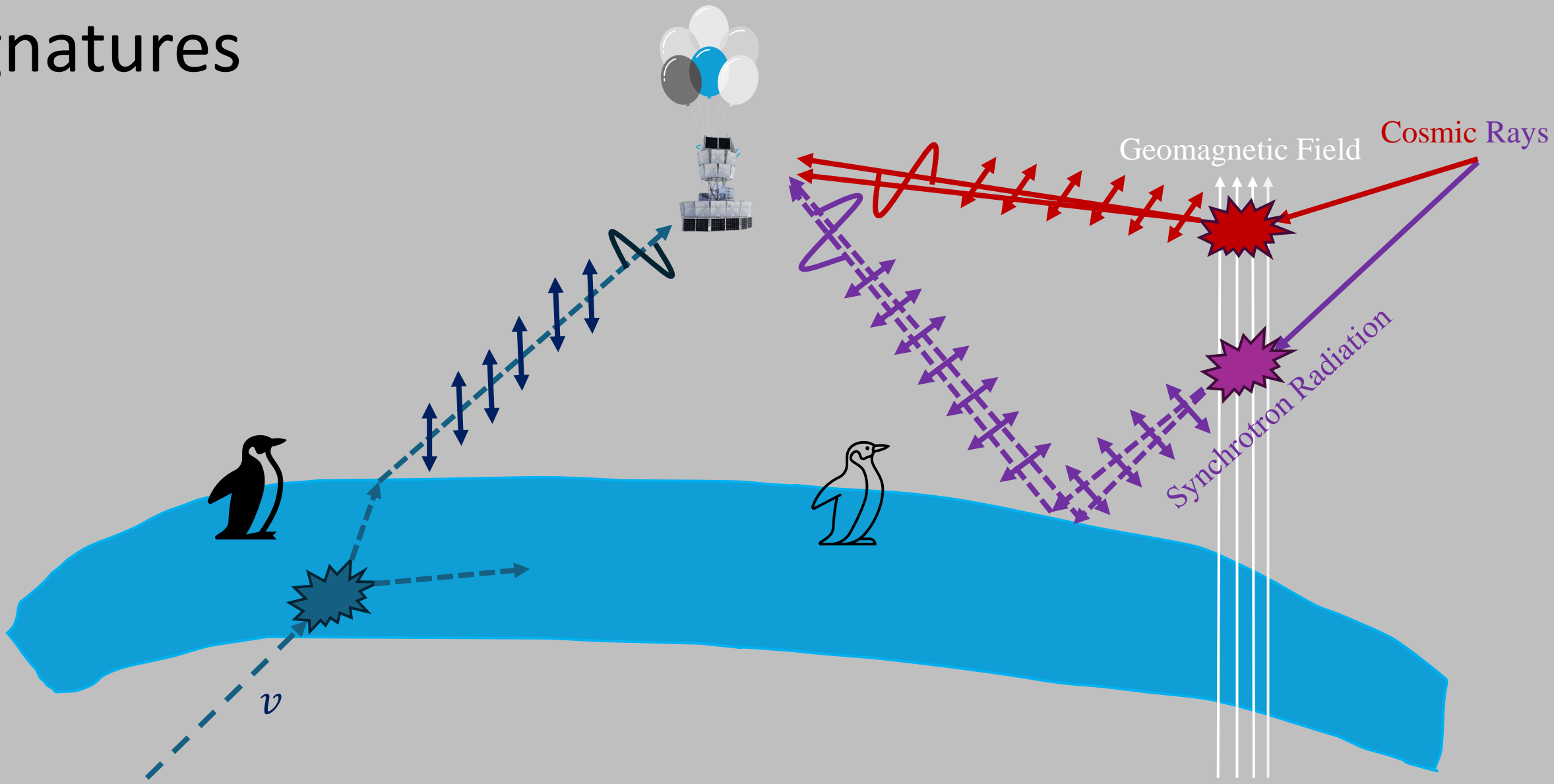


● 22 days



● 28 days

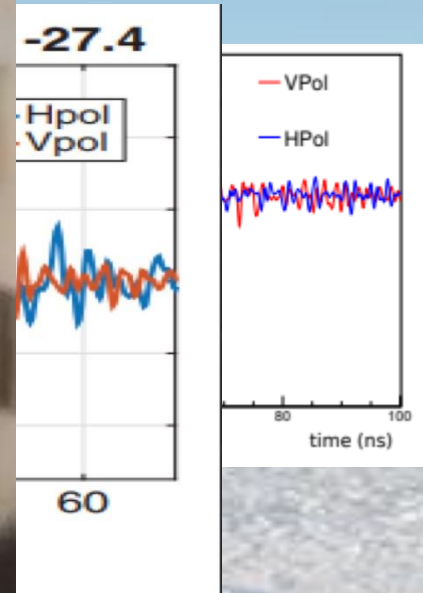
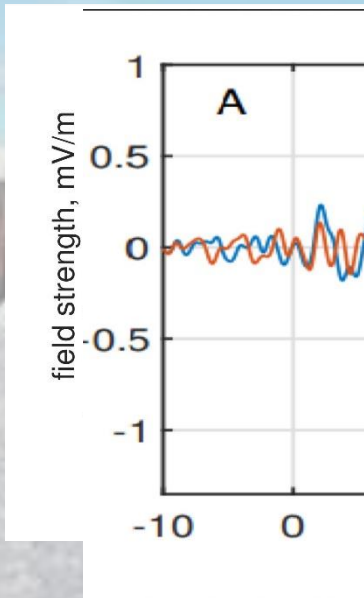
Signatures



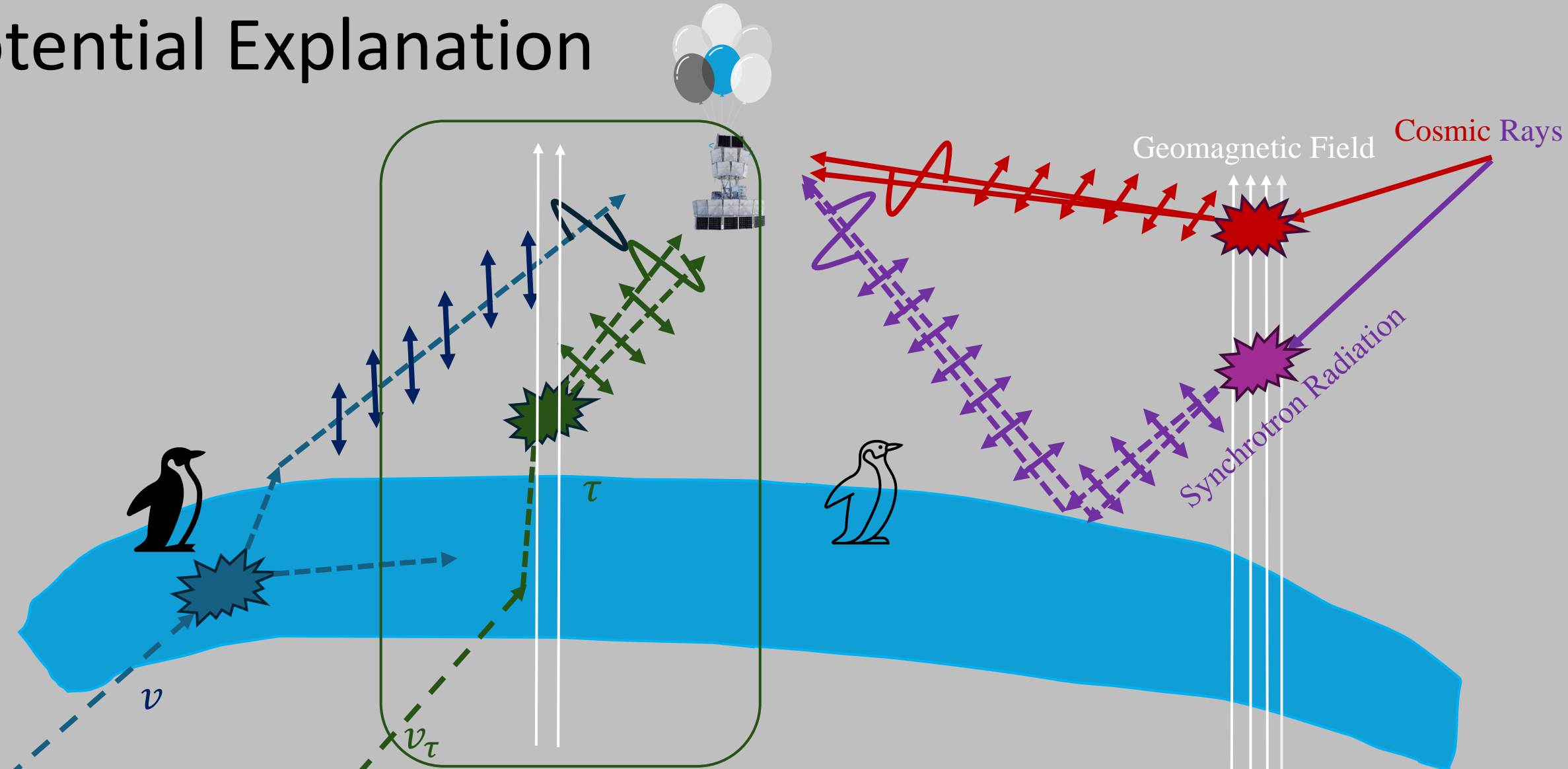
Test your Understanding

[5]

Origin	RF Direction	Signature, Polarity
CR-reflected	Below Horizon	H-Pol, Inverted
CR-Direct	Above Horizon	H-Pol, Normal
Neutrino	Below Horizon	V-Pol, Normal

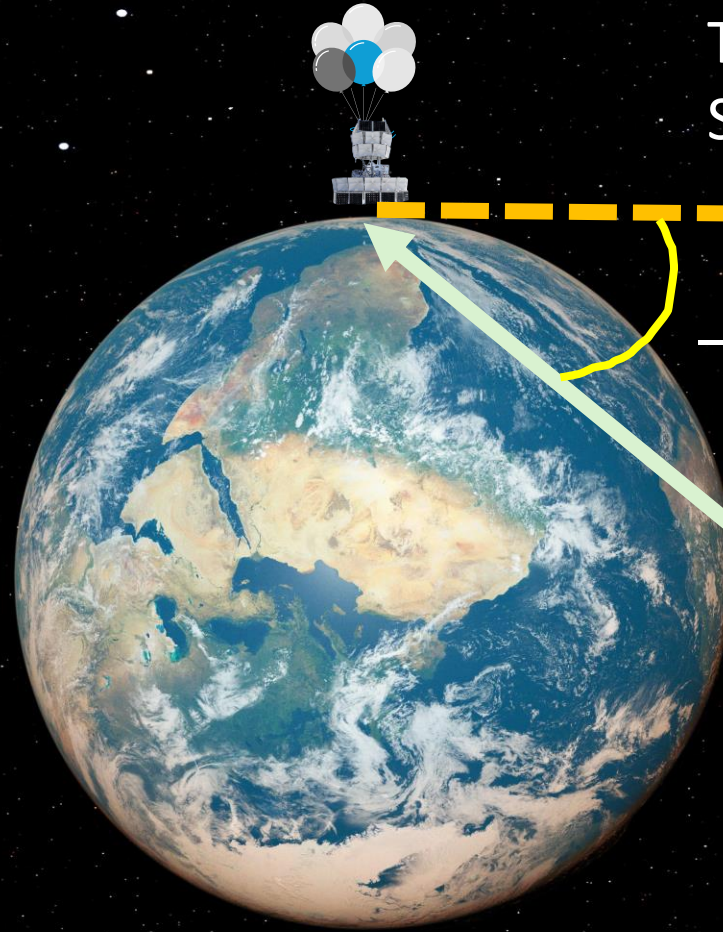


Potential Explanation



Origin	RF Direction	Signature, Polarity
v_τ	Below Horizon	H-Pol, Normal

Are they really τ neutrino ?



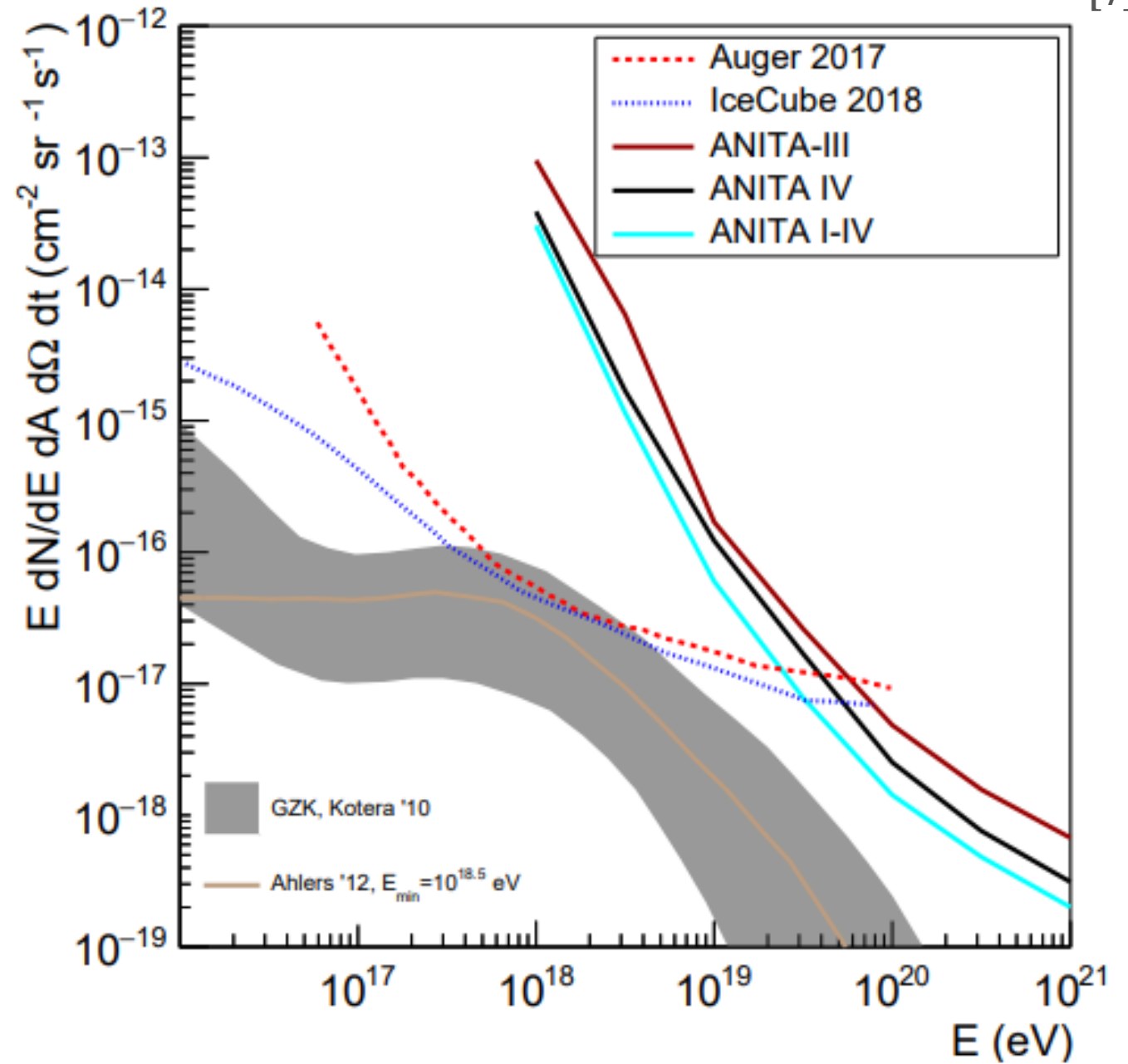
Travel 100 times more than
Standard Model Prediction

-27° or -35°

	Elevation	Cord Length
Event 3985267	-27°	5500km
Event 15717147	-35°	7000km

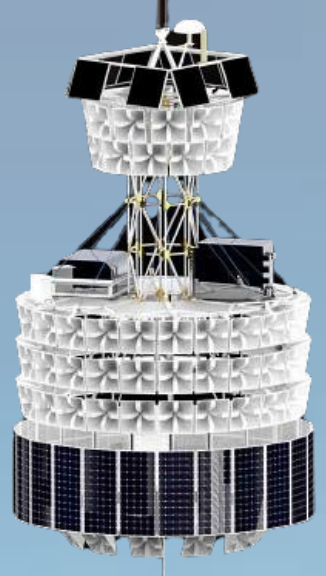
Flux Result

- Flux limit was set under the treatment of neutrino candidate as background



Conclusion

- Motivation: UHE Neutrino Search
- Signatures to exclude direct and reflected CR
- Two anonymous events in ANITA-I and ANITA-III



Thanks for joining the ANITA journey!!!

Reference

- [1] P.W. Gorham, J.Nam, Characteristics of Four Upward-Pointing Cosmic-Ray-like Events Observed with ANITA, *Phys. Rev. Lett.* 117, 071101 (2016)
- [2] P. W. Gorham *et al.* (ANITA Collaboration), Observations of the Askaryan Effect in Ice, *Phys. Rev. Lett.* 99, 171101 (2007)
- [3] Cosmin Deaconu, Recent Results from ANITA, [arXiv:1810.00820](https://arxiv.org/abs/1810.00820) (astro-ph) (2018)
- [4] JiWoo Nam, Cosmic Rays Experiments, Lecture Slides in Instrumental Methods in Particle Physics (2023)
- [5] JiWoo Nam, Introduction Sides in Instrumental Methods in Particle Physics (2023)
- [6] M. Detrixhe *et al.* (ANITA Collaboration), Ultrarelativistic magnetic monopole search with the ANITA-II balloon-borne radio interferometer, *Phys. Rev. D* 83, 023513 (2011)
- [7] Cosmin Deaconu , Searches for Ultra-High Energy Neutrinos with ANITA, 36th International Cosmic Ray Conference –ICRC (2019)

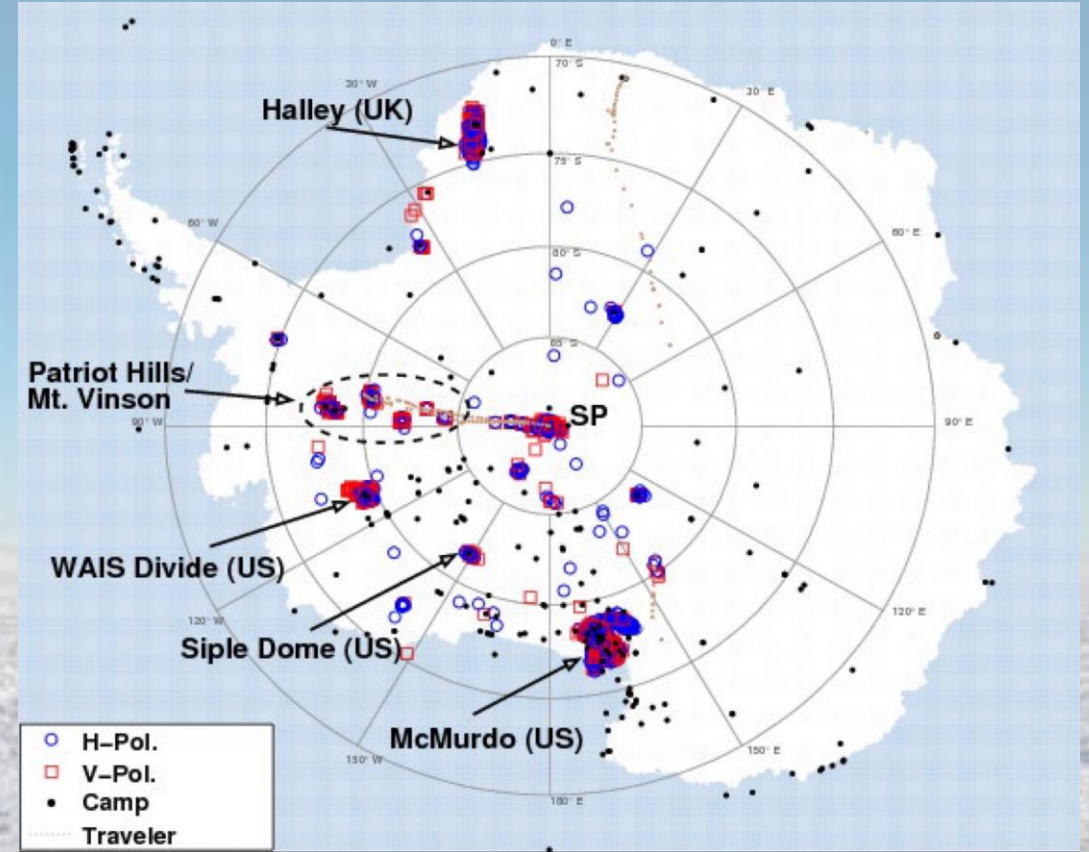
A wide-angle photograph of a snowy, flat landscape under a clear blue sky. In the center, a white, parachute-like object floats in the air, tethered to the ground. The ground is covered in snow with visible tracks. In the distance, there are several small structures and a small boat on the horizon. The text "Back up" is overlaid in the center of the image.

Back up

Background

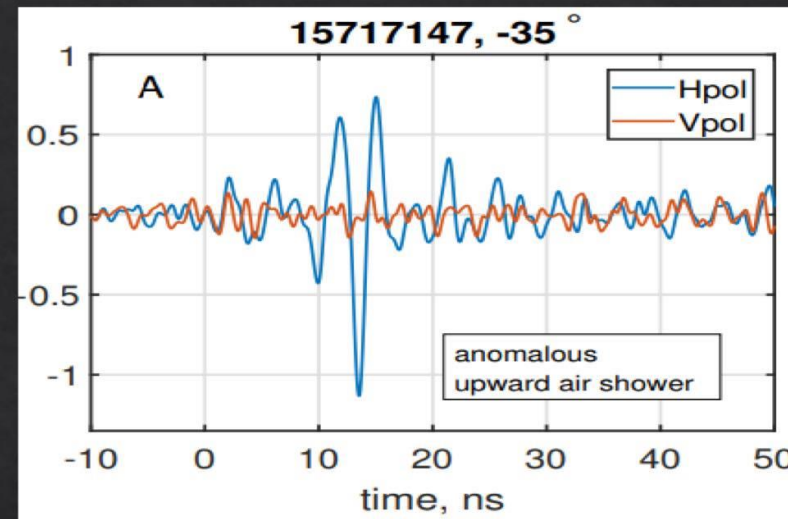
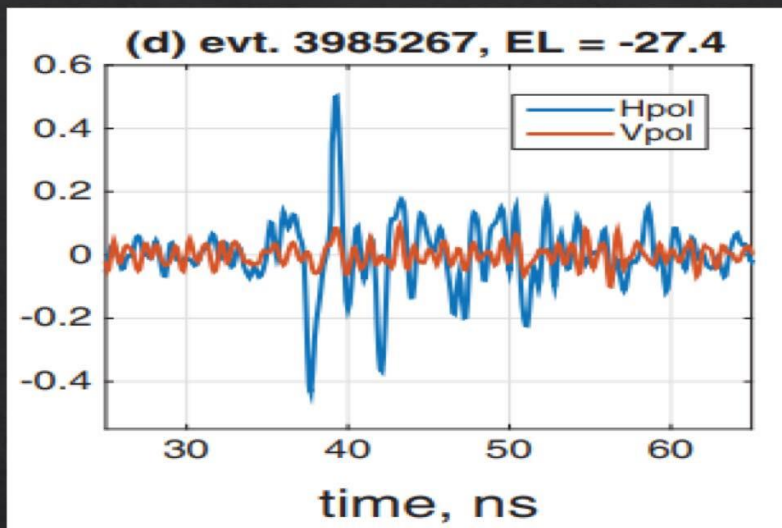
- **CW (Continuous Wave)** from geostationary military communication satellites
 - Masking out azimuthal sectors with high trigger rate
- **Thermal Noise**
 - Incoherent waveform
 - Set triggering threshold, Coincidence tagging
- **Anthropogenic Signals**
 - Tend to cluster spatially
 - Only events that are outliers survive for final cuts
- **Digitizer Glitch**
- **Payload Blast**

[5]



Info of two Anonymous Events

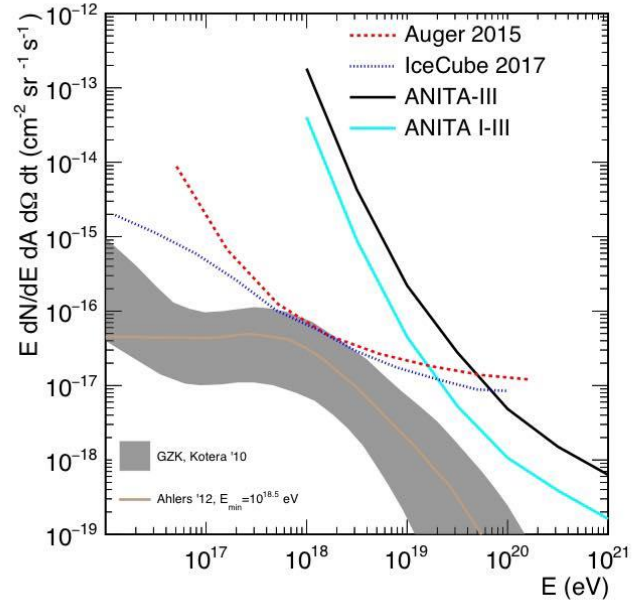
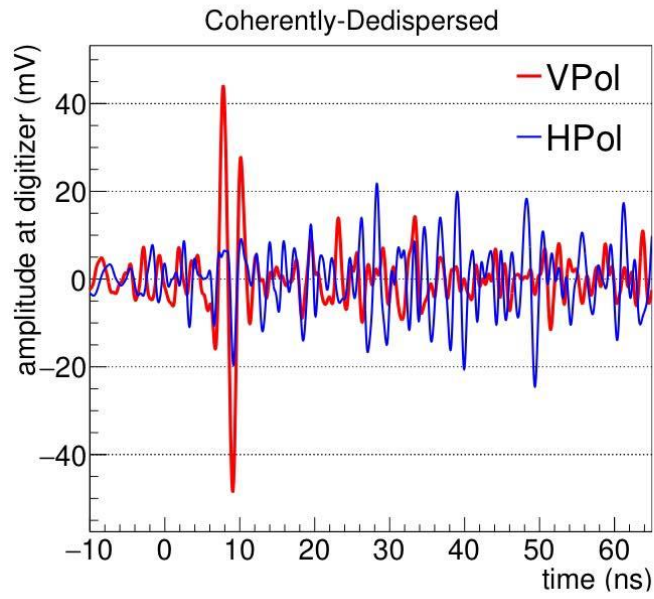
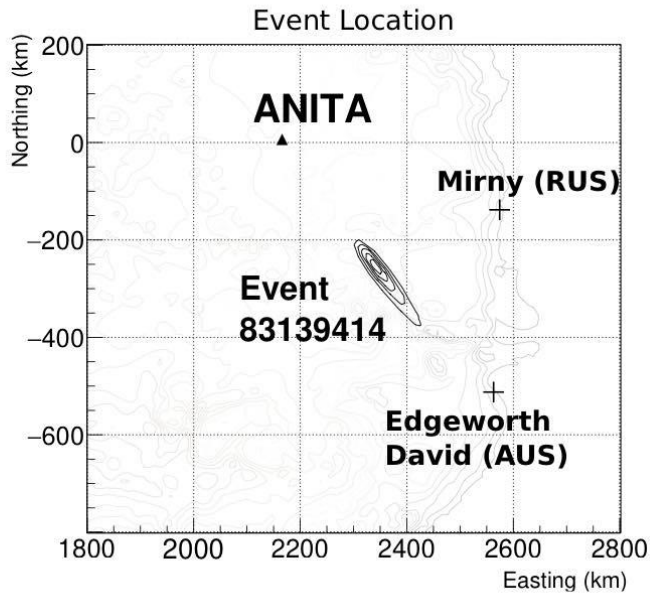
[5]



Event, flight	3985267, ANITA-I	15717147, ANITA-III
Date, time	2006-12-28	2014-12-20
El, Az	$-27.4 \pm 0.3^\circ$, $159.6 \pm 0.7^\circ$	$-35.4 \pm 0.3^\circ$, $61.41 \pm 0.7^\circ$
RA, Dec	282.14, +20.33	50.78, +38.65
E_{shower}	0.6 ± 0.4 EeV	$0.56^{+0.3}_{-0.2}$ EeV
Cord length trough Earth	~5500 km	~7000 km

Potential Neutrino Events In ANITA-III

[3]



Setup in SLAC Ice Experiment

