# RADAR ECHO TELESCOPE


Presented by:
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on behalf of
the Radar Echo Telescope Collaboration

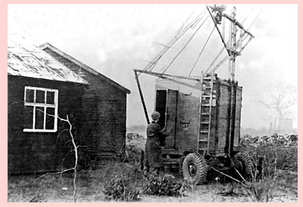

## Introduction

The Radar Echo Telescope is a new proposed detector to target neutrinos with energies in excess of 10 PeV. Our international collaboration has recently made the first definitive observation of a radar echo from a particle caacade during experiment T576 at SLAC. Here we describe the radar echo idea, present experiment T576, and discuss the path from here toward a full-scale neutrino detector, the Radar Echo Telescope.

## What is Radar Echo detection?

-High energy particle ($\nu$, cosmic ray) interactions produce cascades of secondary particles
-These cascades *ionize* the medium (air, ice) as they progress through
-A transmitting antenna (TX) can broadcast radio frequency (RF) fields that are reflected by this ionization, to be detected by receiving antennas (RX).
-Can illuminate a large region with relatively sparse apparatus

## Radar detection goes back decades...



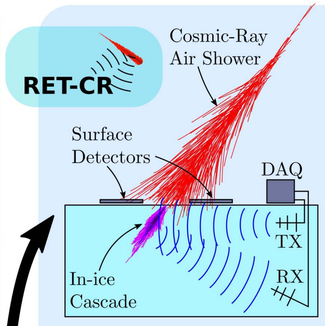
Blackett and Lovell @ Jodrell Bank, 1941

-1941, Blakett and Lovell set up their radar system at Jodrell Bank, UK to detect cosmic rays
-They saw some 'anomalous reflexions' from the upper atmosphere...but it turned out they were only seeing meteors

-2000's, renewed interest, and a dedicated experiment TARA [1,2]
-No signal, won't work in air for cosmic rays

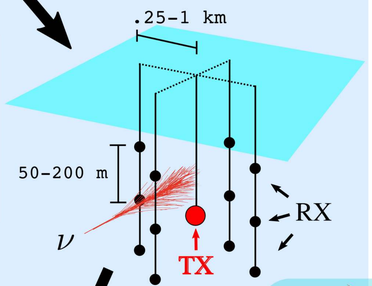
The TARA phased transmitter array

**But what about in-ice detection of $\nu$? [3-5]**

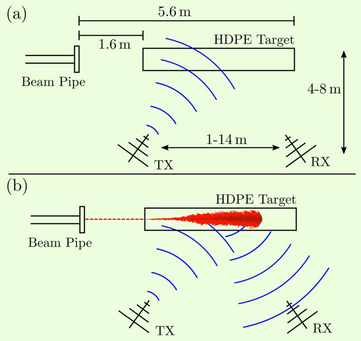



-UHECR deposit 5-20% of their energy at the surface of a high-elevation ice sheet
-Can trigger on in-air cascade, capture radar echoes from in-ice cascade
-Prototype station for neutrino detector (proposal pending)

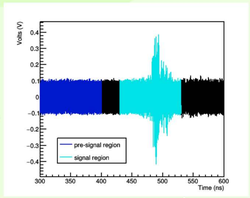
-To detect neutrinos, a transmitter and receivers will buried in the ice
-neutrino mode will have very low RF backgrounds
-Good projected sensitivity at 10-100 PeV

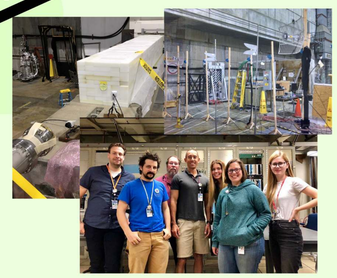



**T576** -SLAC's electron beam (10b e- at 10b eV/e-) was fired into a plastic target
-Target was interrogated with 500MHz-2.5GHz RF
-2 experimental runs, May [6] and October [7] 2018

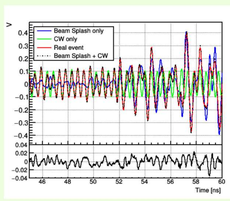



From Raw Data..

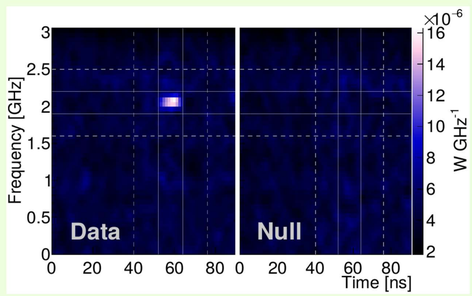


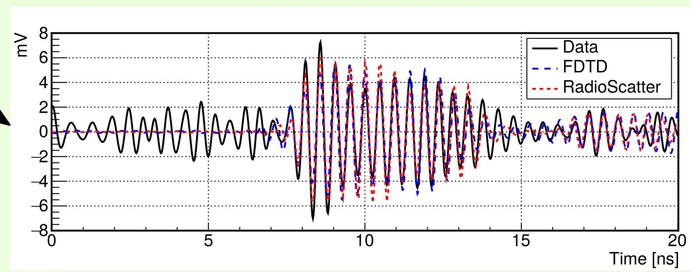
...to null data
(used for analysis, see [8])




High amplitude backgrounds (10-100x signal amplitude) required sensitive analysis




-Signal observed in multiple antennas and at multiple transmit frequencies
-Here, 2.1 GHz transmitter frequency. A signal is observed as an excess in the "data" spectrogram

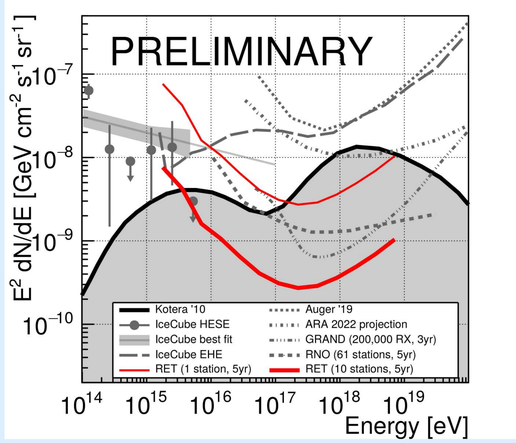



A comparison to 2 independent simulations (each scaled here by approx -30%) shows good agreement with theory. (see also [9] for an a-priori discussion of expected signal characteristics)

**From The Lab → Into Nature**

-In nature, RF background (like at SLAC) will be minimal
-Prototype system to detect cosmic ray induced cascades in the ice called RET-CR
-Full scale neutrino detector RET-N buried in deep ice, detector layout studies ongoing!

**Please see poster abstract #469 for details about our simulation work!**




Five year sensitivities compared to other experimental, theoretical, and projected curves.

## References


[1] R. Abbasi et al., NIM A 767 (2014) 322-338
[2] R. Abbasi et al., Astropart.Phys. 87 (2017) 1-17
[3] M. Chiba et al., NIM A 604 (2009) S233-S235
[4] KD de Vries et al., Astropart.Phys. 60 (2015) 25-31
[5] R. Abbasi et al., PoS ICRC2017 (2018) 1049
[6] S. Prohira et al., Phys.Rev.D 100 (2019) 7, 072003
[7] S. Prohira et al., Phys.Rev.Lett. 124 (2020) 9, 091101
[8] S. Prohira, arxiv:1910.11314, 2019
[9] S. Prohira and D. Besson, NIM A 922 (2019) 161-170