EDGES-3: Deployments and Results

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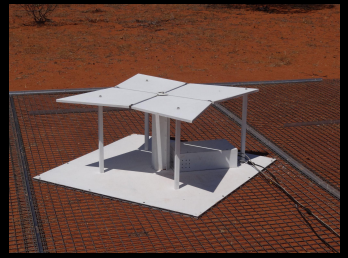
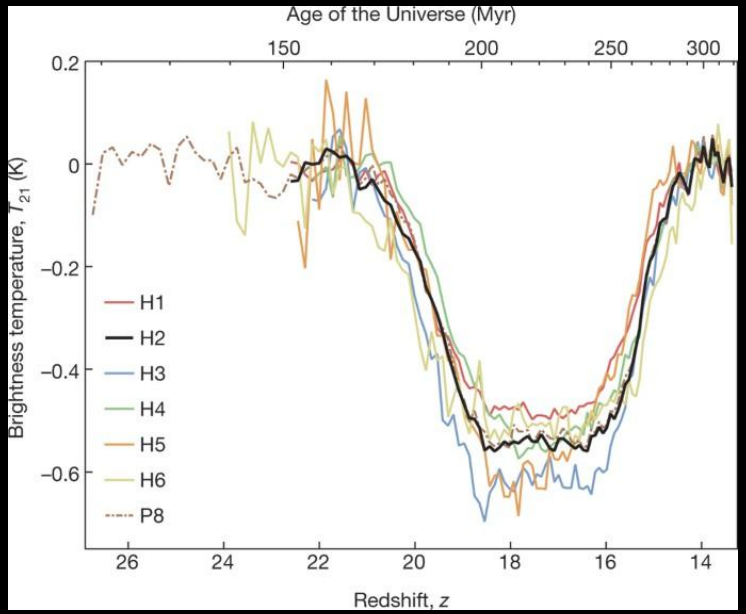
Outline

- Brief history of EDGES
- The EDGES-3 instrument
- Environmental considerations
- The 2022 Australian deployment
- The 2022 Devon Island deployment
- Lessons learned from the Devon deployment
- Preliminary results
- Summary
- Future plans

A (very) brief history of EDGES

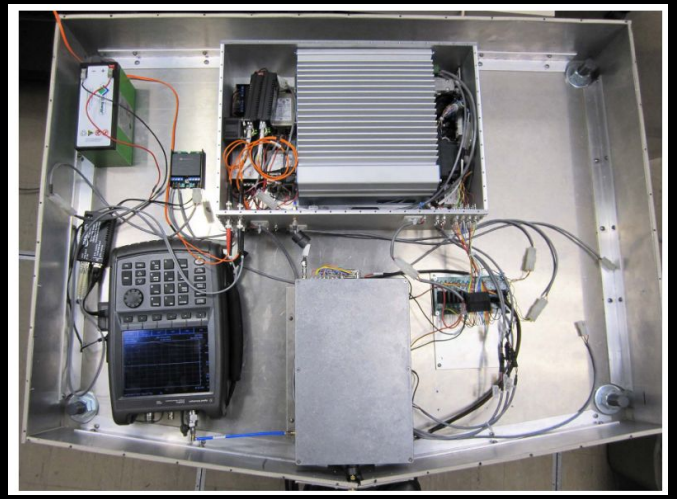


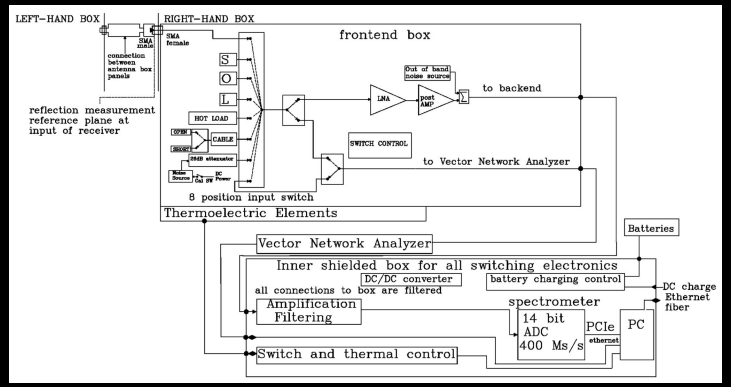


- Experiment to Detect the Global EoR Signature
- Originally designed in 2006 at MIT/Haystack by Alan E. E. Rogers
- Second design iteration resulted in a reported detection in 2018
- Result met with skepticism as absorption feature was significantly deeper than current popular cosmological models predict

EDGES-3: A new design

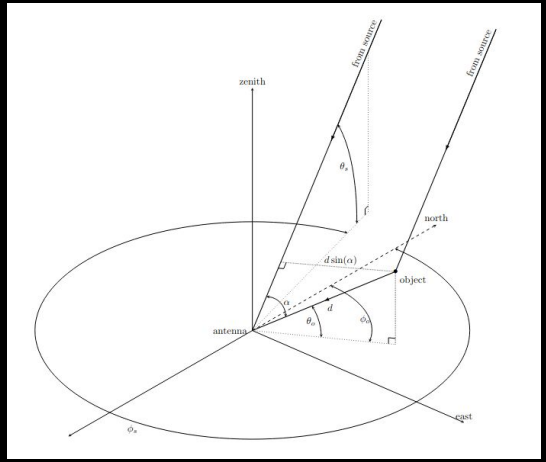
- Receiver electronics, ADC, spectrometer, and VNA all contained within the antenna
- Ambient, hot, open, and shorted loads, along with mechanical switches, also sit inside the antenna, allowing real-time, in situ calibration.
- The receiver box couples directly to the antenna box, eliminating the need for a balun: reduces delay in antenna S11 by 7 ns and eliminates 0.02 dB of loss.
- Shape of box blade dipole chosen to optimize S11 for 60 to 160 MHz
- Nuvo computer sits within an inner box for additional shielding.





Environmental considerations

- Need to be ~ 2000 km from FM transmitters
- Ground plane should be level and larger than 5 x 5 wavelengths to approach similar beam chromaticity realized on an infinite, level ground plane
- Antenna tilt - 8 degrees doubles chromaticity, 2 degrees ~ 10%, 1 degree is negligible
- Ground plane should be within 5 cm of soil to avoid significant chromaticity - equivalent to lowering the soil conductivity
- Need adequate distance from local scatterers (i.e. bushes, electronics hut, hills, etc…).
- More information on this effect can be found in Rogers et. al. (2022) - [arXiv:2212.04526]

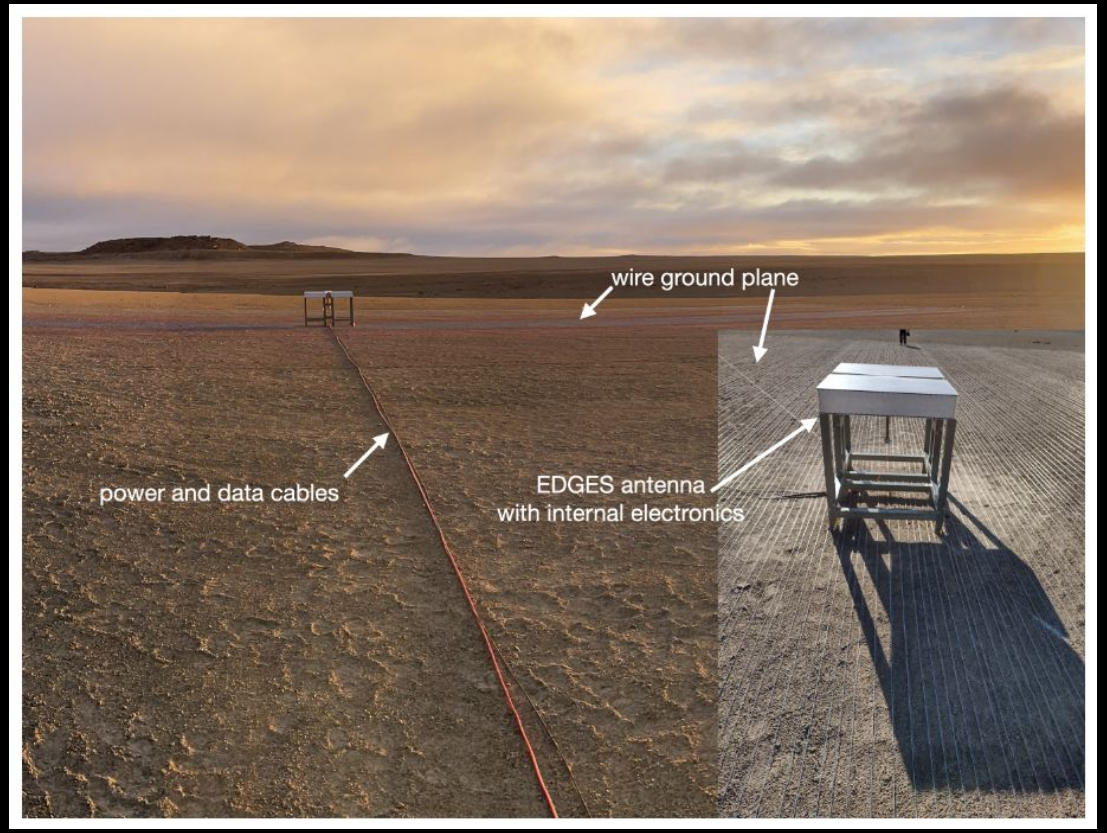


2022 MRO deployment

- Located at Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory in WA
- Permanent deployment completed in November 2022.
- A 48 x 48 m welded mesh ground plane was installed, with EDGES-3 on a baseplate in the center.
- Installed an air circulation system, as VNA is quite sensitive to temperature changes.
- Has been on sky since November 25th, and data continues to come in daily.

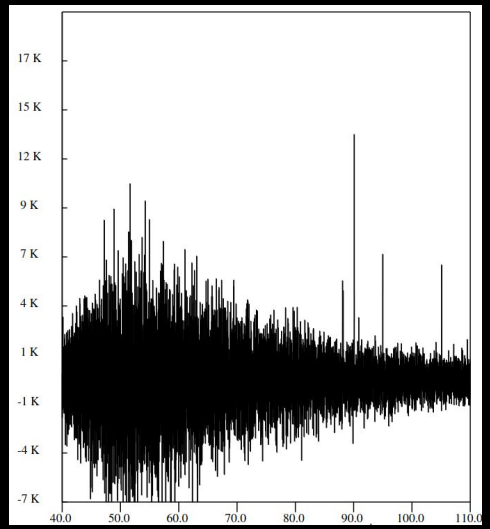
2022 Devon Island deployment

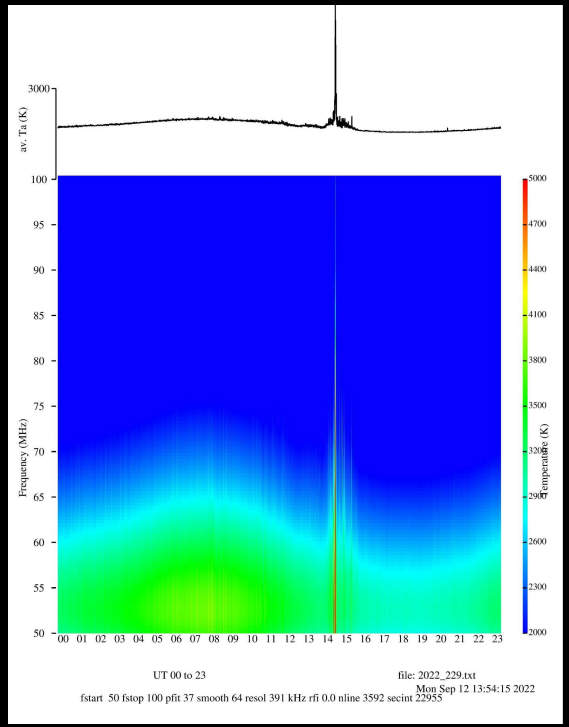
- Devon Island is the largest uninhabited island in the world, at 75^0 N in the Canadian Arctic - generally free of RFI
- Team of three from Haystack hitched a ride with five members of the Haughton Mars Project, led by Pascal Lee
- 50 x 25 m ground plane was constructed using ~ 9 km of meandering copper wire
- Total time on island was 25 days, only able to obtain 12 days of usable data
- Expedition was in August, thus the sun was always up



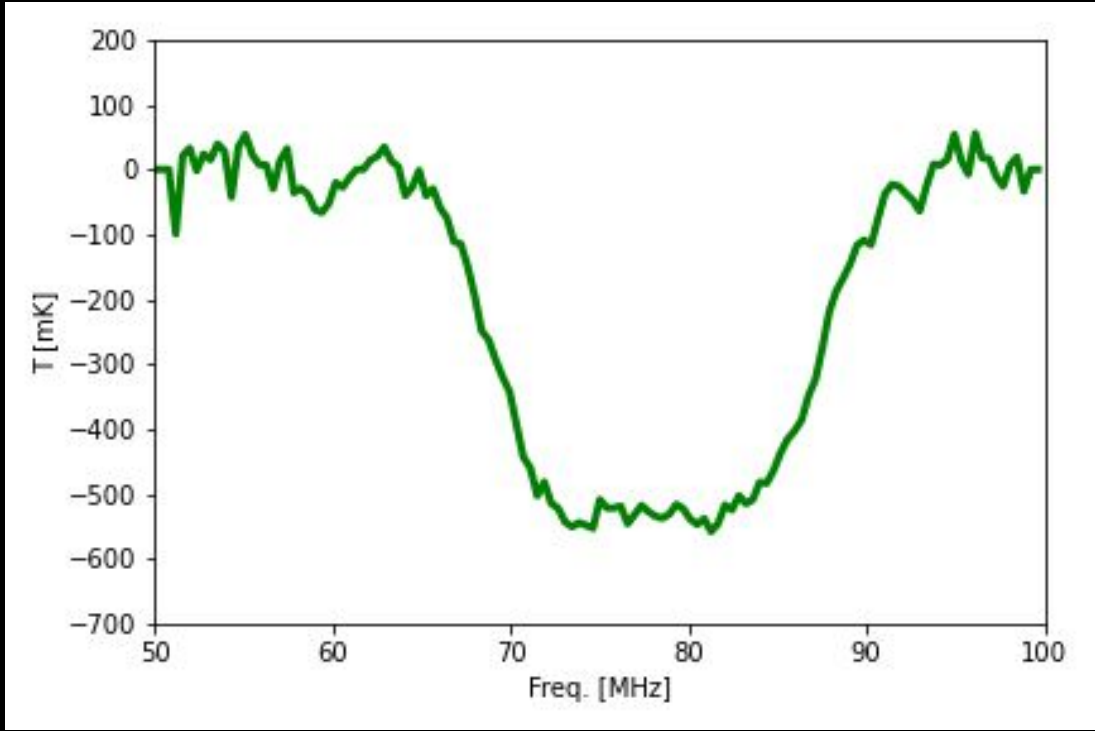
Devon Island - lessons learned

- Sun extremely active currently
- Sporadic-E caused FM stations (and perhaps power line noise) to contaminate data from ~ 2000 km away.
- Temperature control is extremely important for VNA functionality
- In situ power supply is necessary
- Meandering copper wire functions sufficiently as a ground plane
- Currently unexplained RFI at low end (50 to 60 MHz)





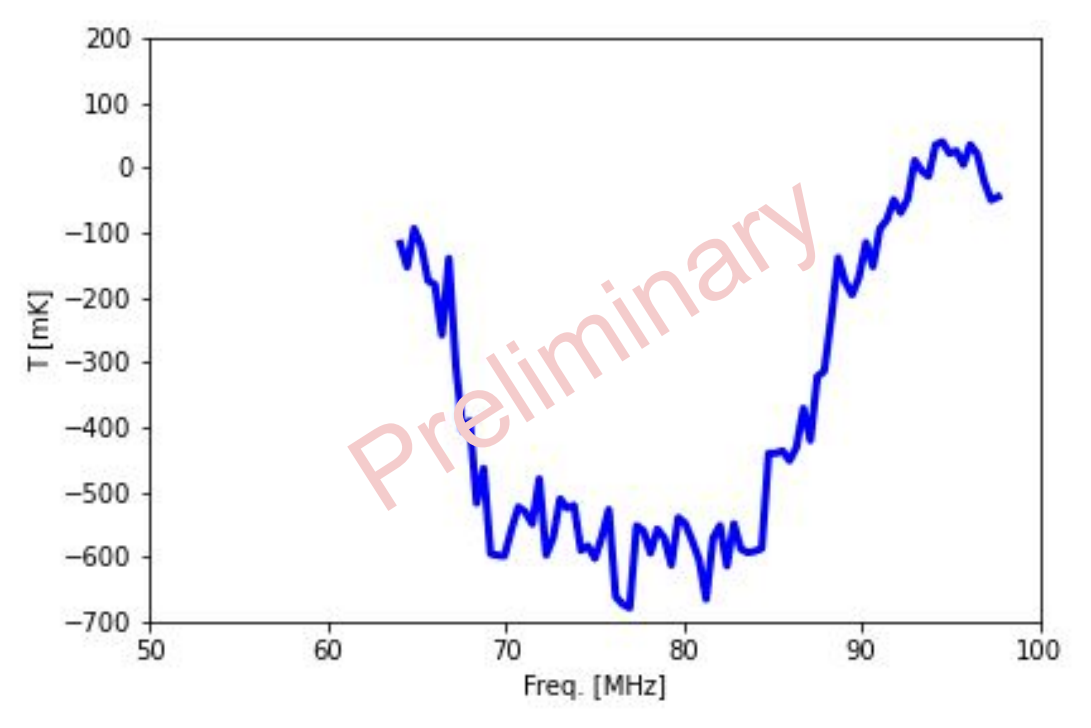
Very Preliminary Results



Center freq:	78.1 MHz
Width:	18.7 MHz
RMS:	0.025 K
SNR:	37
Depth:	0.53 K

Bowman et al. (2018) Result

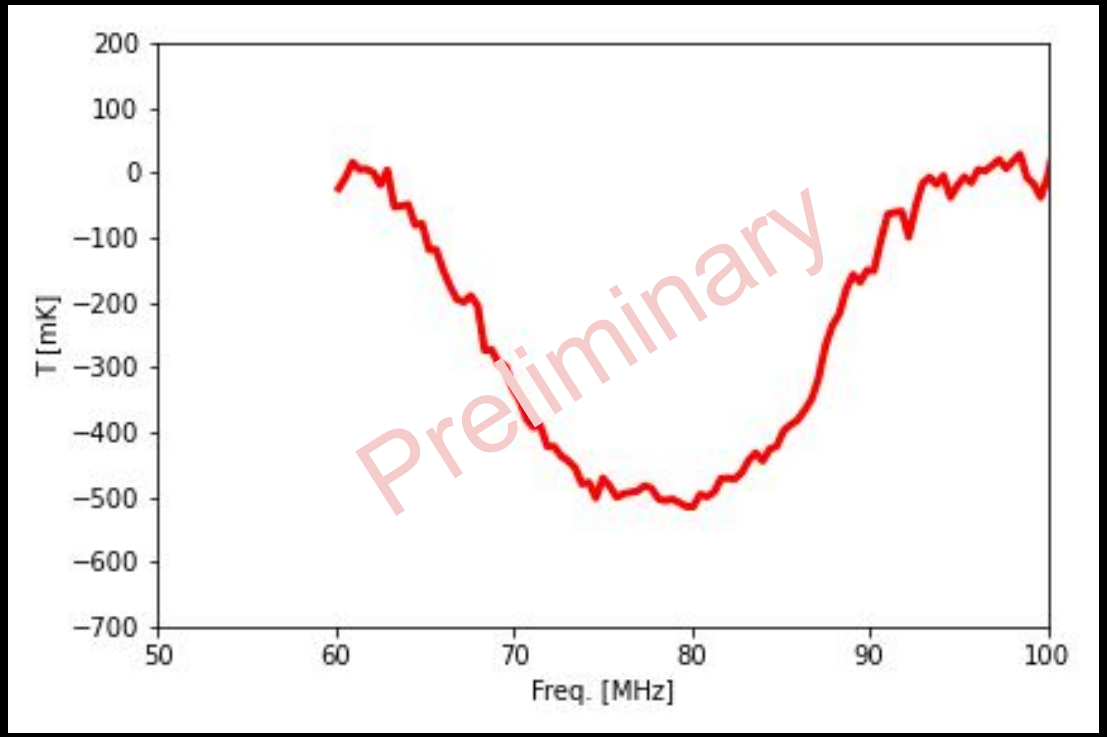
Very Preliminary Results



Center freq:	77.4 MHz
Width:	20.9 MHz
RMS:	0.046 K
SNR:	14
Depth:	0.63 K

Devon Island Result

Very Preliminary Results



Center freq: 78.1 MHz

Width: 19.7 MHz

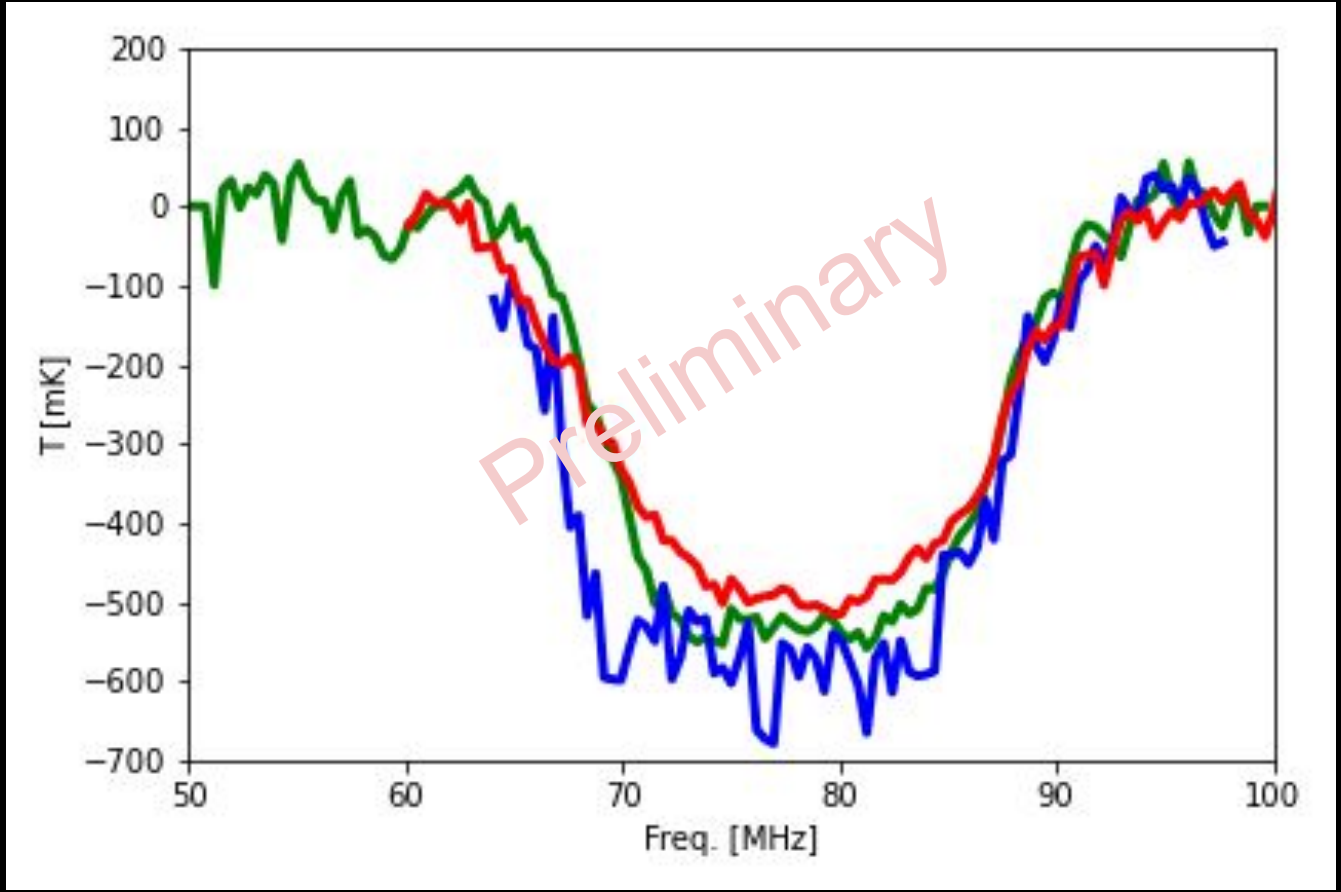
RMS: 0.017 K

SNR: 28

Depth: 0.51 K

WA Observatory Result

Very Preliminary Results

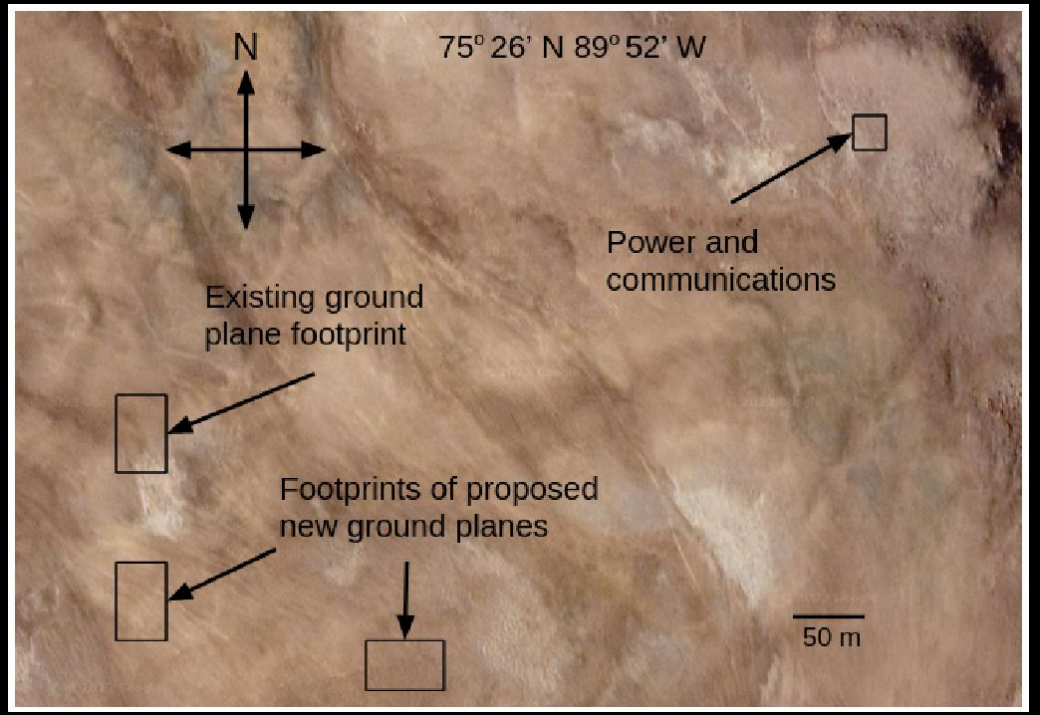


Summary

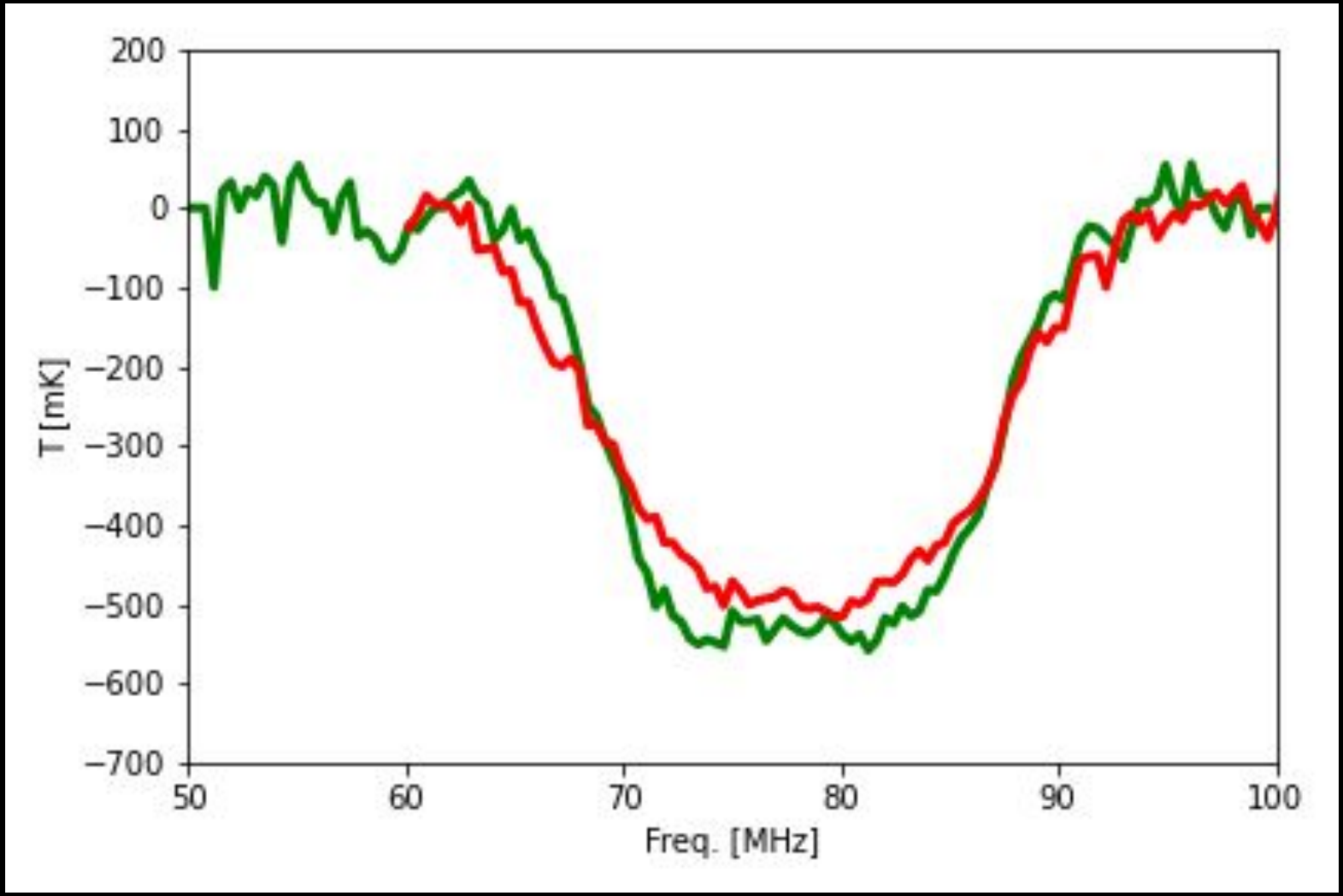
- Two deployments of an EDGES-3 system have occurred in the last 13 months
- Observations in the Arctic have unique challenges, including an active ionosphere and formidable environmental conditions
- A permanent deployment of the EDGES-3 system resides at the WA Observatory, sending data daily
- Both deployments have returned results in agreement with the 2018 result, albeit with smaller statistical significance

Future Plans

- Currently writing proposals to design and deploy autonomous EDGES-3 systems at multiple sites
- Upon successful deployment, data will arrive immediately via a satellite link.
- All results and information contained in this presentation are available publicly on the Internet in the Haystack EDGES memo series (https://www.haystack.mit.edu/haystack-memo-series/edges-memos/)



Questions?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