

A photograph of a radio telescope antenna in a field. The antenna is a metal structure with a central pole and several legs extending outwards, forming a tripod-like shape. It is situated in a field of dry, yellowish-brown grass. In the background, there are rolling hills and a blue sky with a faint rainbow. The text "Observing the <100 MHz radio sky from the sub-Antarctic and Arctic" is overlaid on the image in a large, bold, black font with a white outline.

# Observing the $<100$ MHz radio sky from the sub-Antarctic and Arctic

**H. Cynthia Chiang**  
**McGill University**

**Global 21cm workshop**  
**8 October 2019**

# *PRI<sup>2</sup>M: Probing Radio Intensity at high-Z from Marion*



Command module



70 MHz antenna

100 MHz antenna



# PRIZM antennas

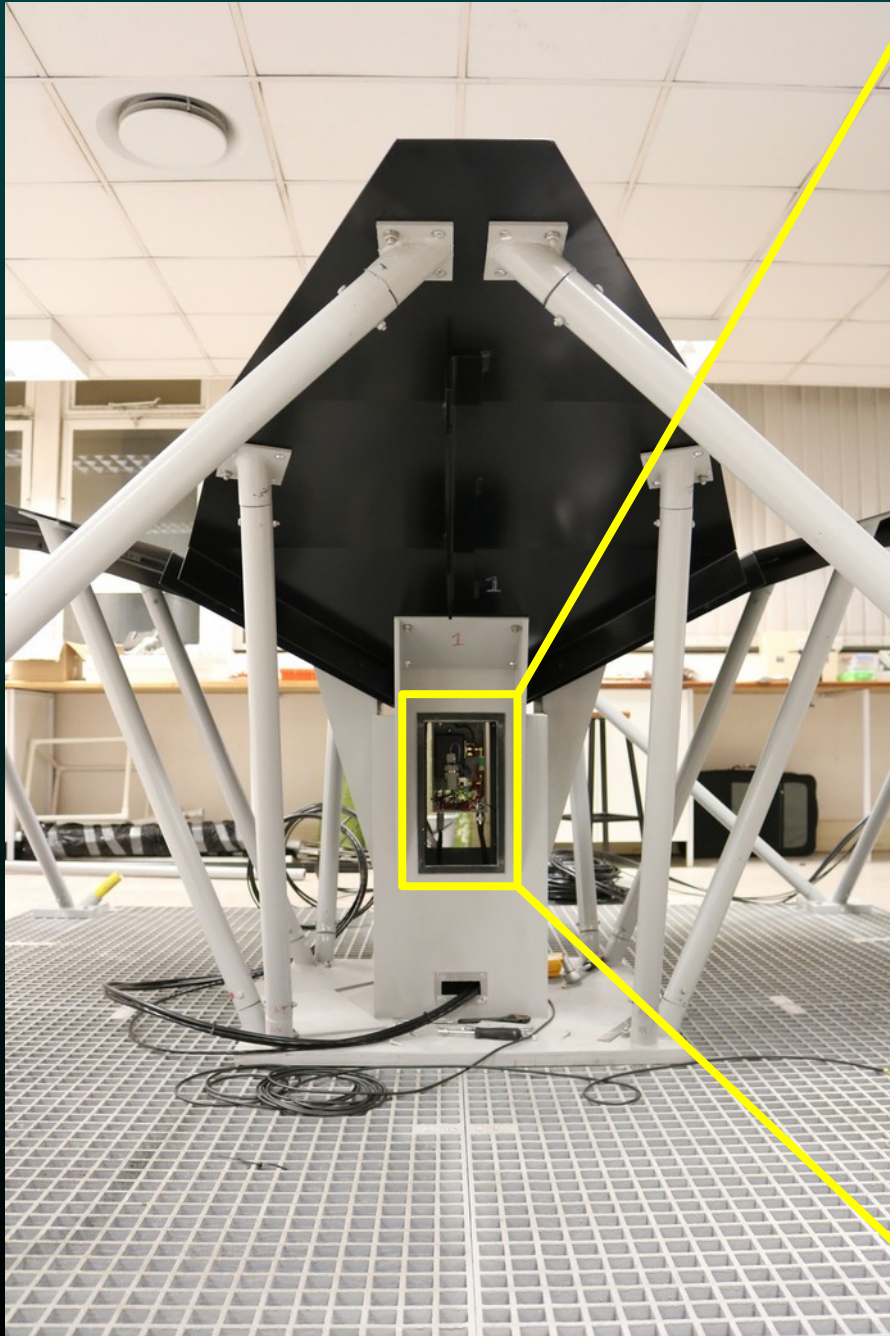
Modified four-square design  
inherited from SCI-HI

Minimize beam structure and  
variation within frequency range

Two antennas at 70, 100 MHz  
operating simultaneously



# Front end RF electronics

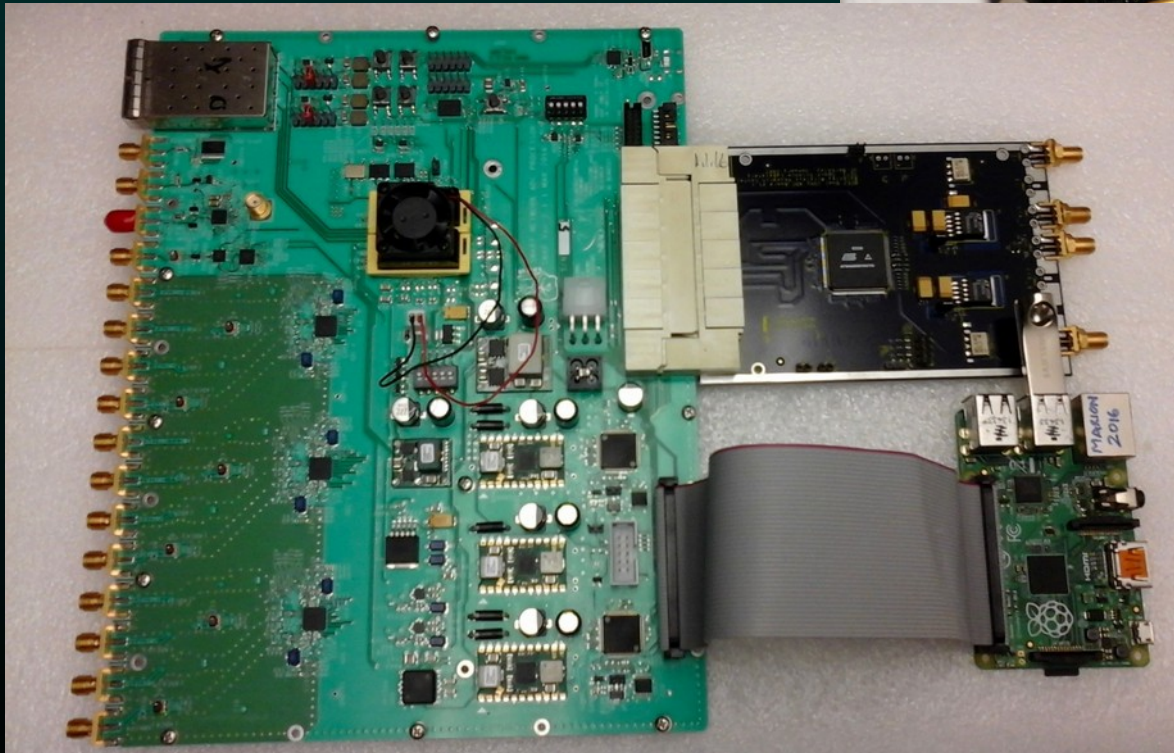
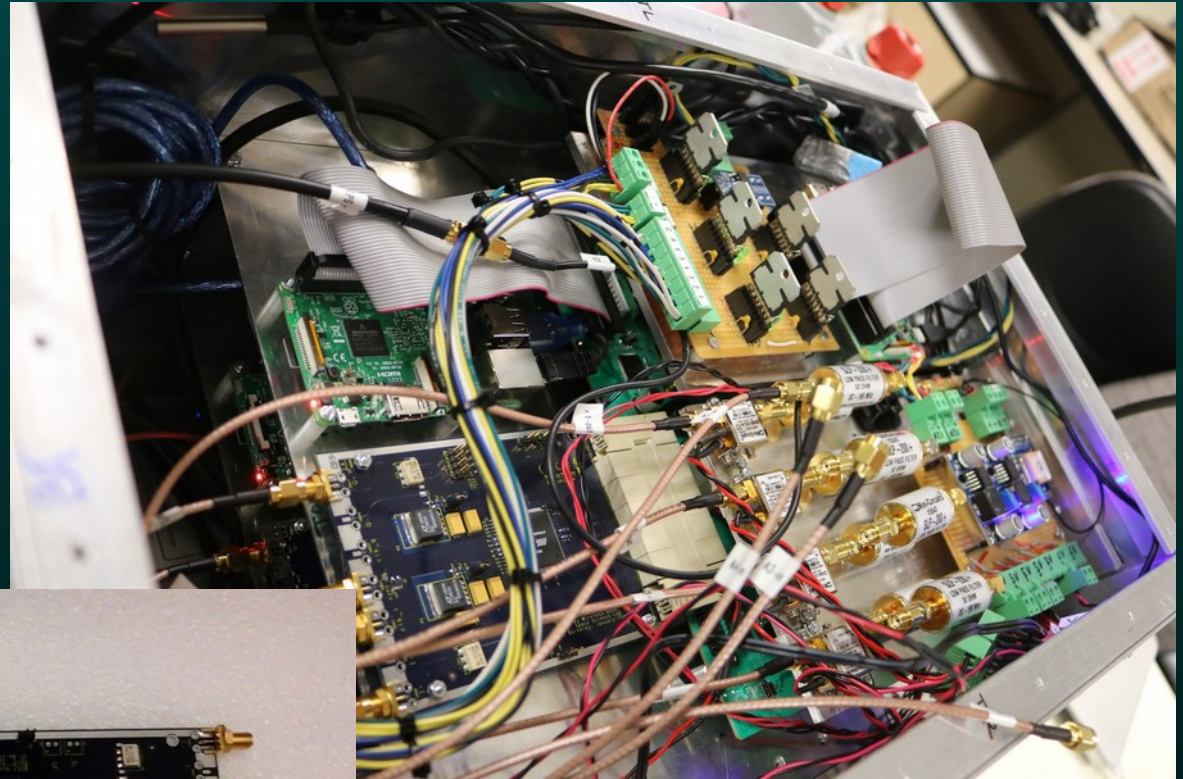


# Back-end and readout electronics

30 – 200 MHz filters + 2<sup>nd</sup> stage amps

2 x SNAP boards with external ADCs  
sampling at 500 Msamp/s

Spectrometer firmware: 0 – 250 MHz,  
4096 channels (61 kHz)



Total system power draw ~65 W, run time  
~1 week on 8x AGM 200-Ah batteries

Whole assembly is placed ~50 m from the  
antenna to reduce self-generated RFI

# On-site operations



Command module:  
electronics, batteries

Generator

“Hamster tube”  
feedthrough

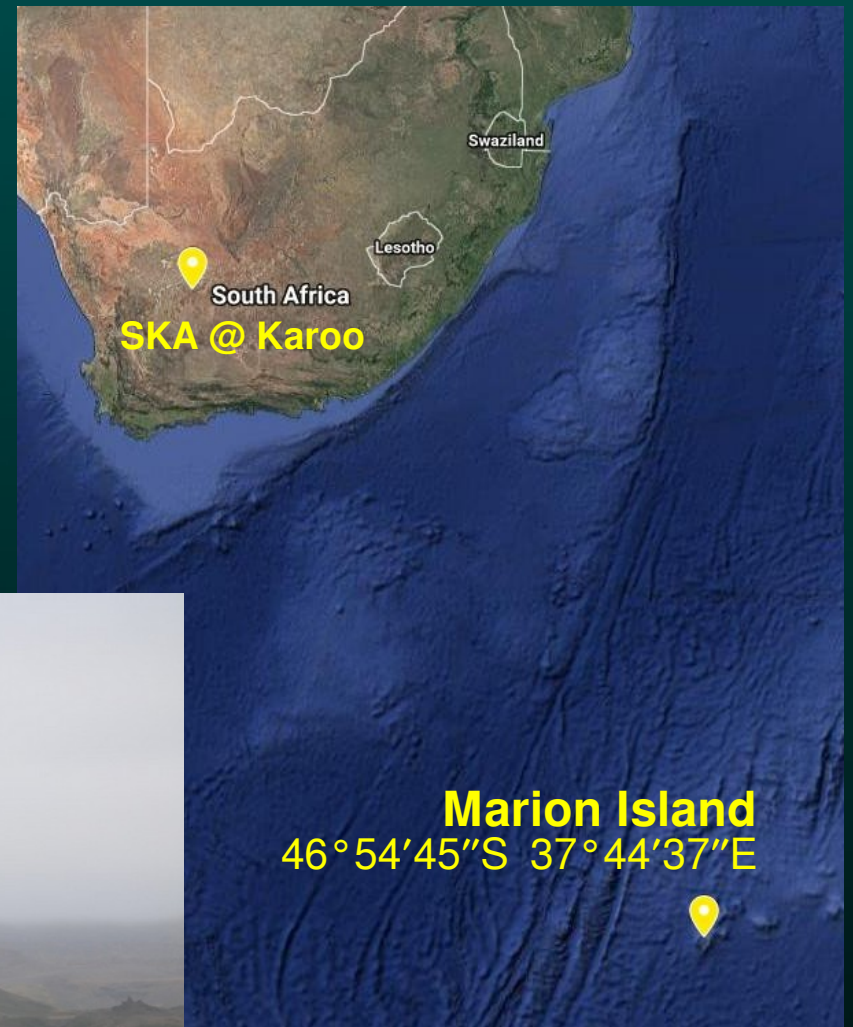
500L fuel + spares

# Marion Island

Marion Island base is operated by the South African National Antarctic Programme

2000 km from nearest continental landmass (also ~max distance for meteor scattering)

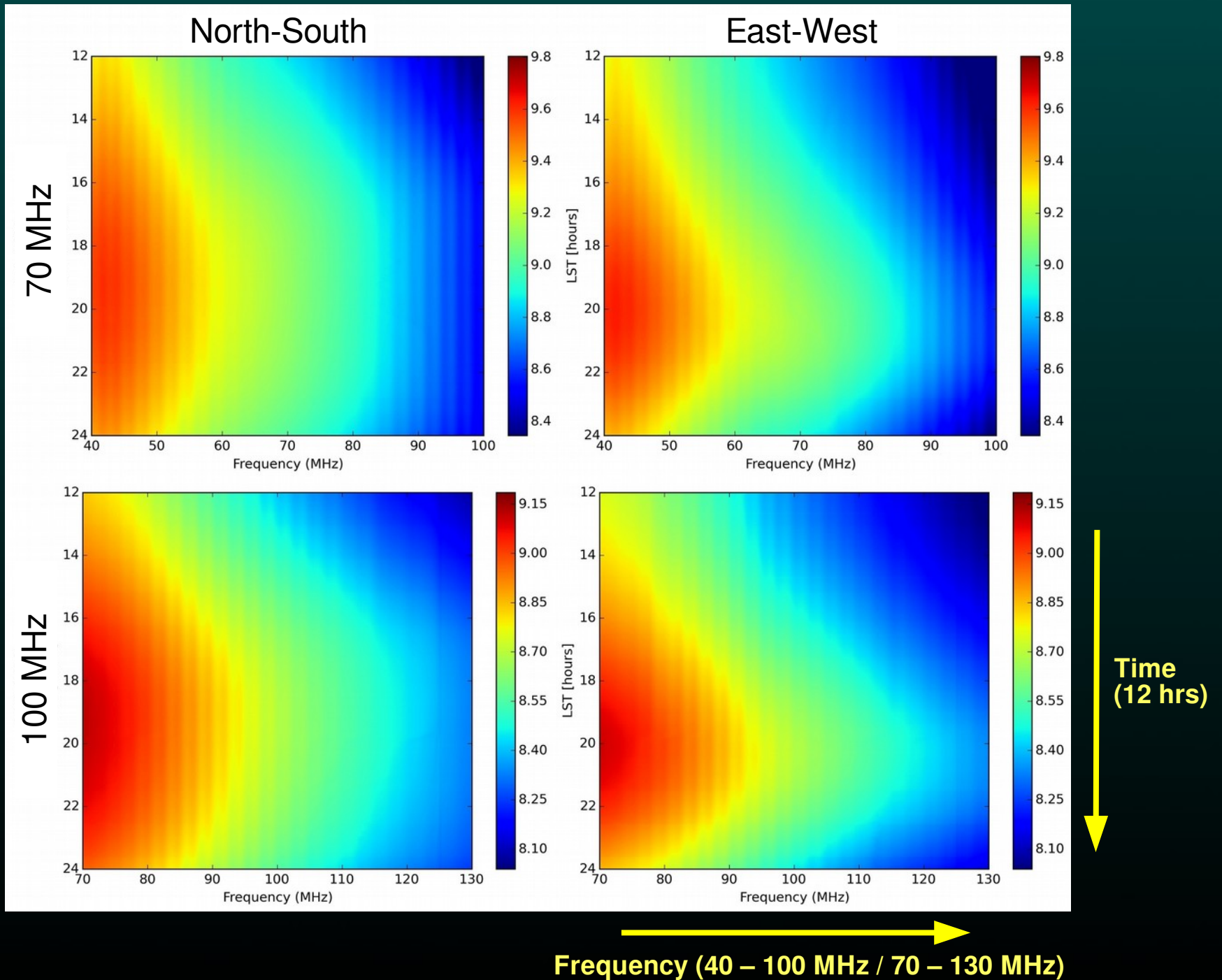
PRIZM = first astro experiment on Marion  
2016 engineering run, science ops since 2017



## Challenges:

- Access once per year
- 3 week deployment window
- Roaring Forties weather
- Mires and lava rocks
- @#\$\$% mice

# Preliminary PRISM raw data





# Details in PRIZM instrument paper

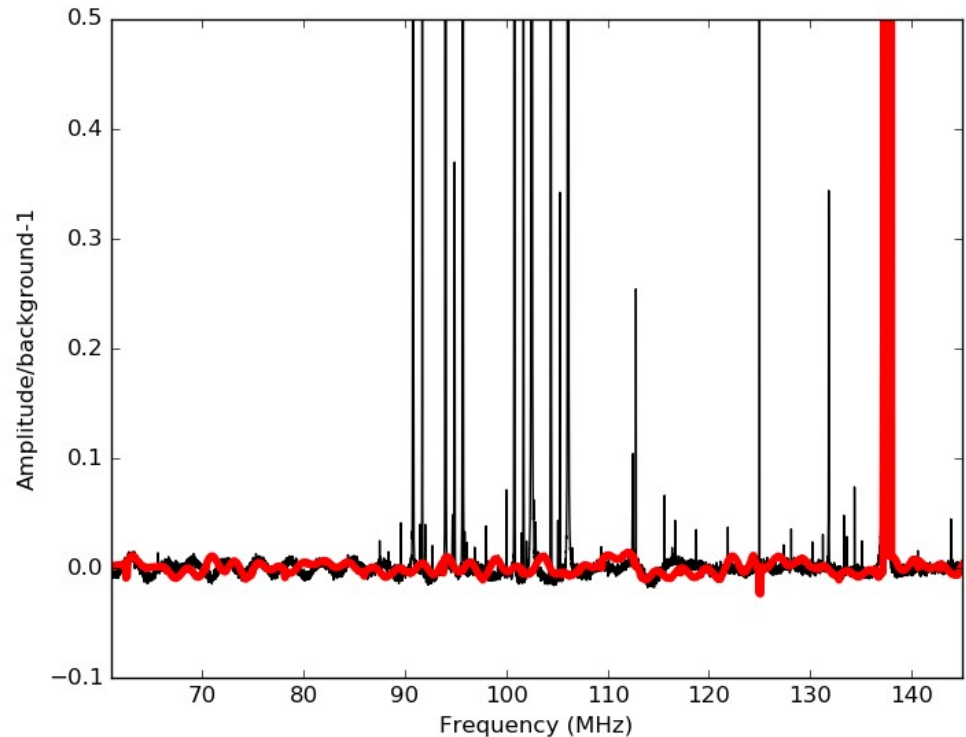
## Journal of Astronomical Instrumentation

Volume 8 • Number 2 • June 2019



 World Scientific

### Marion versus Karoo



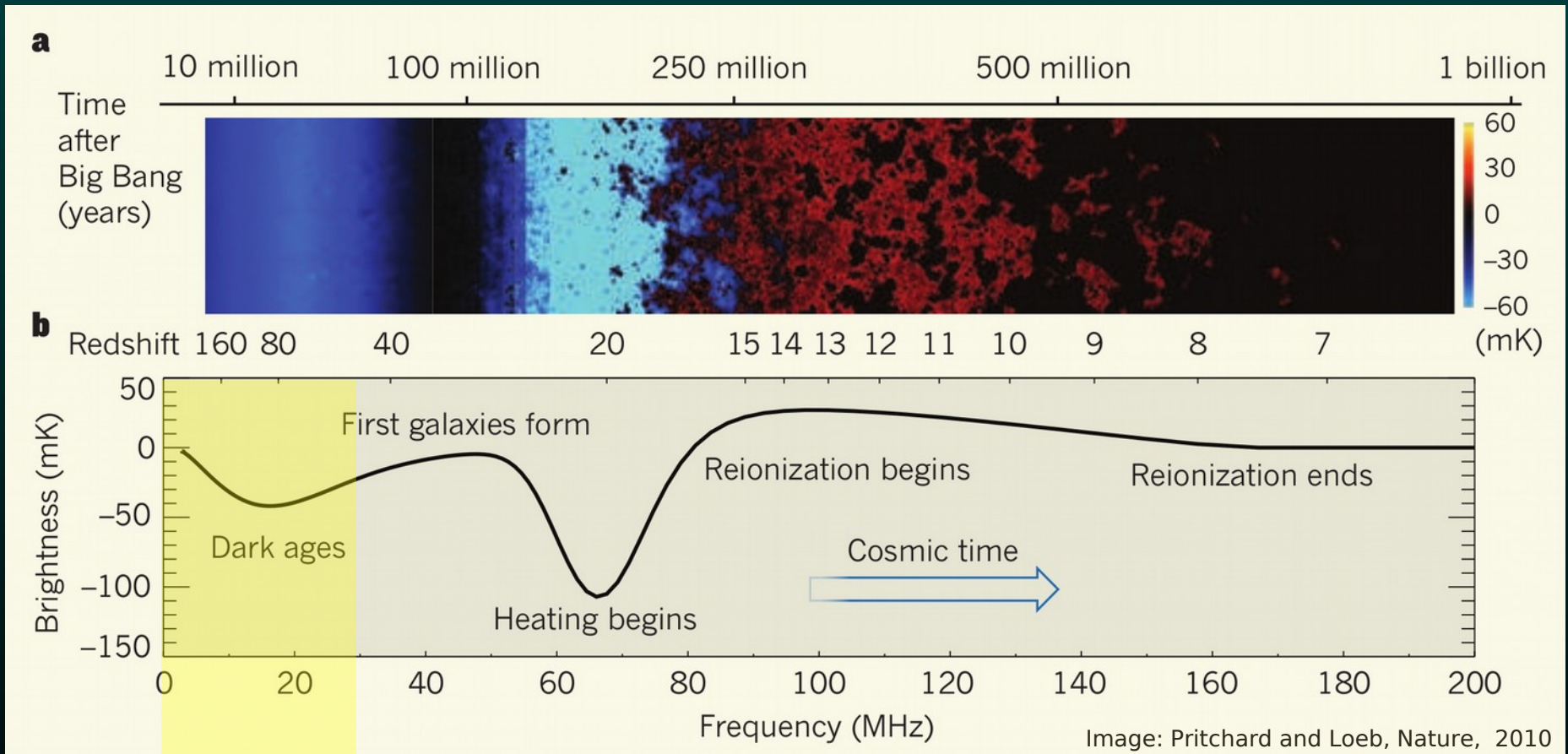
Marion is extremely radio quiet:  
no visible contamination in the FM band!

L. Philip et al., “Probing Radio Intensity at High-Z from Marion: 2017 instrument,” JAI, 2019

**2018 data in hand as of May, analysis is in progress**

# Exploring lower frequencies

$$\delta T_b \propto x_{HI} (1+z)^{1/2} (T_s - T_{CMB}) / T_s$$



What lurks down here...?

Most experiments operate here.

The dream: lay groundwork for exploring dark ages

Ultimate dream: image the fluctuations

# The state of the art at low frequencies

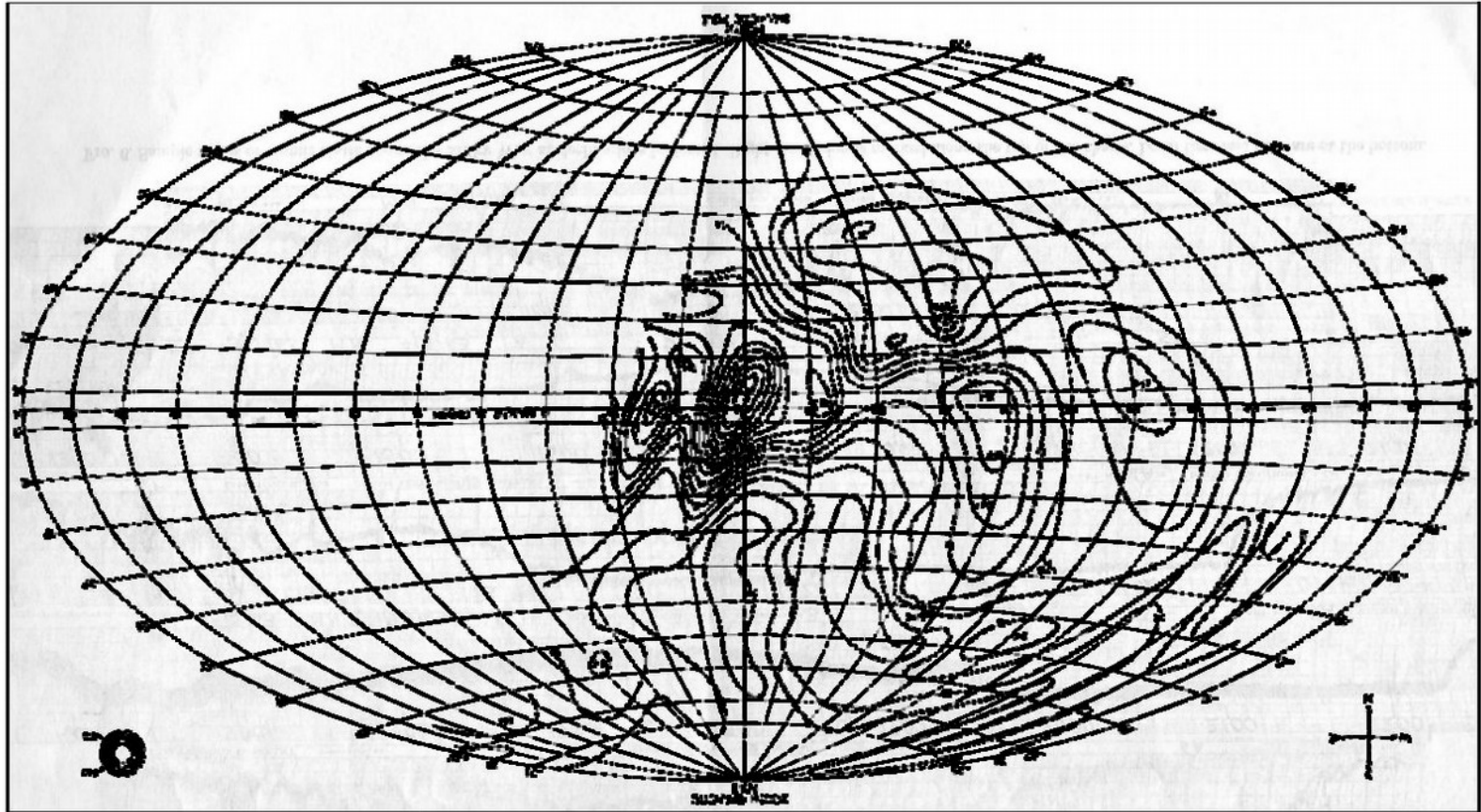
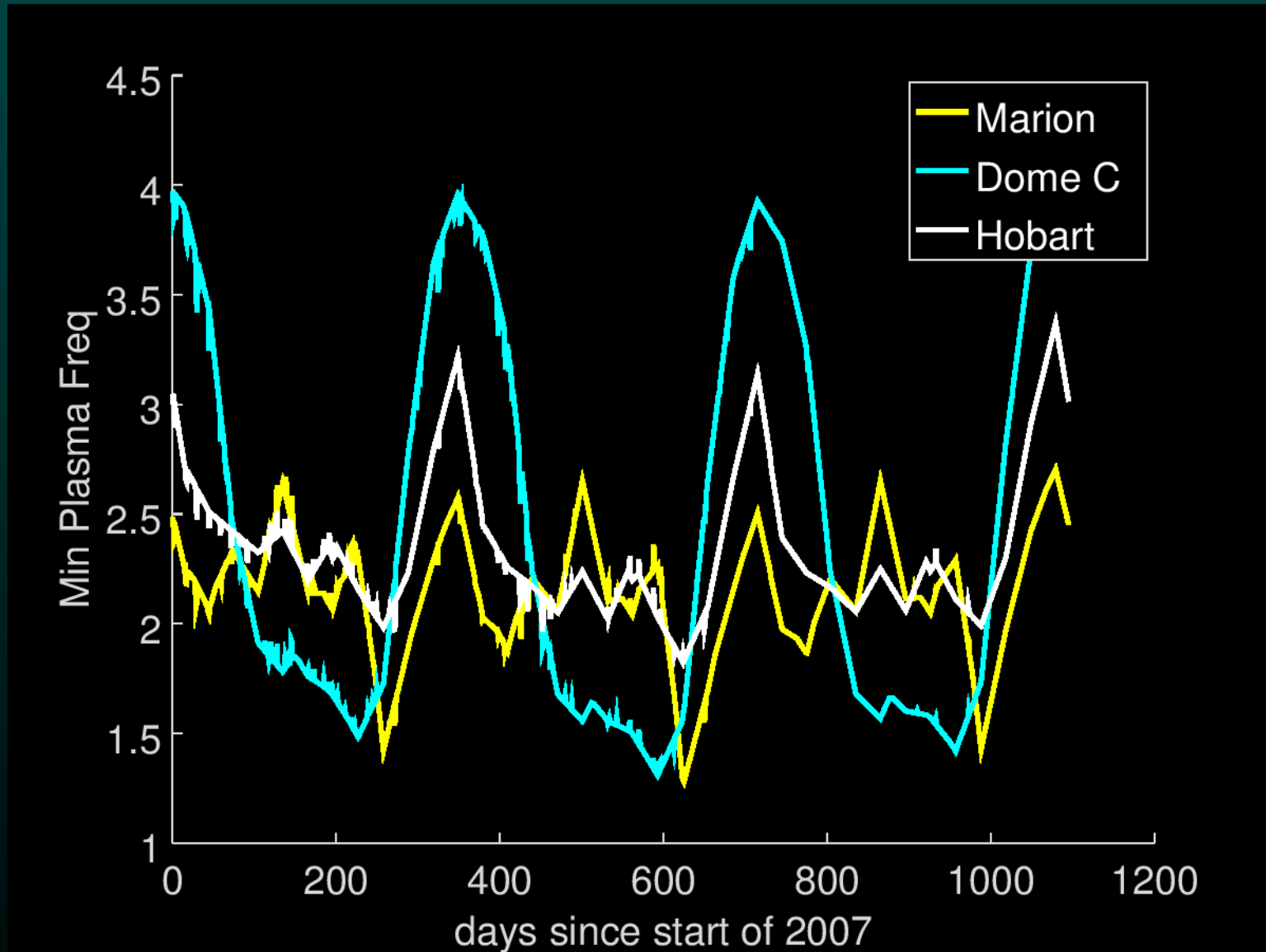


Figure 11: A 2.085 MHz contour map of galactic radio emission (after Reber, 1968: 10).

Experiment	Frequency	Resolution	Year
Grote Reber	2.1 MHz	~5 deg	1968
RAE-B satellite	4.7 MHz	~10 (??) deg	1978
DRAO	22 MHz	1.1–1.7 deg	1999
LWA	36.5 MHz	15 arcmin	2017

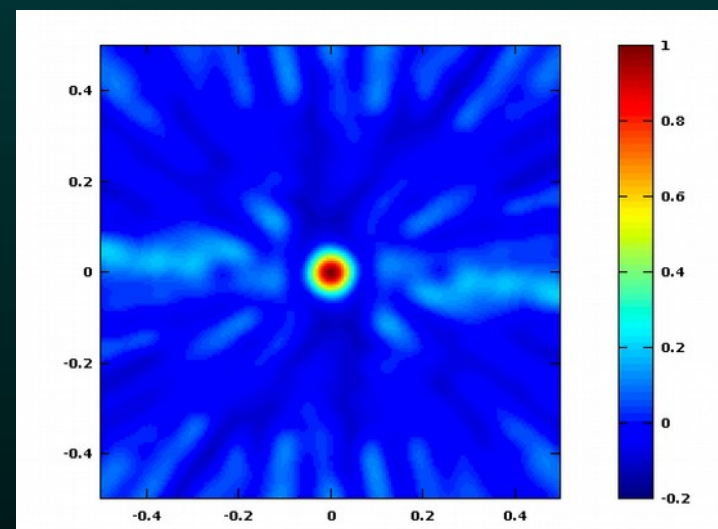
# How low can we go from Marion?



IRI model prediction: plasma frequency down to ~1.5 MHz during last solar minimum, next one is coming...

# Exploratory low frequency measurements

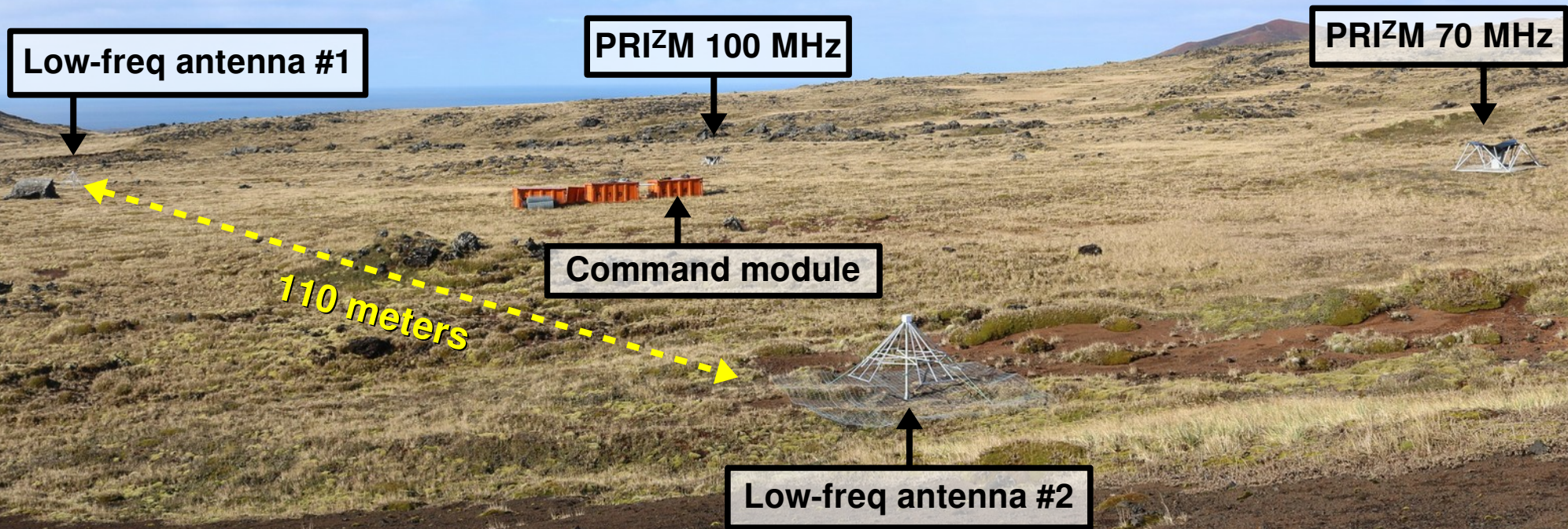
- Infrastructure: 9 huts around island perimeter, convenient ring-like layout for imaging
- The plan: deploy antennas at huts, save lowest 10–20 MHz baseband, correlate offline



8' FWHM  
synthesized  
beam @ 5 MHz

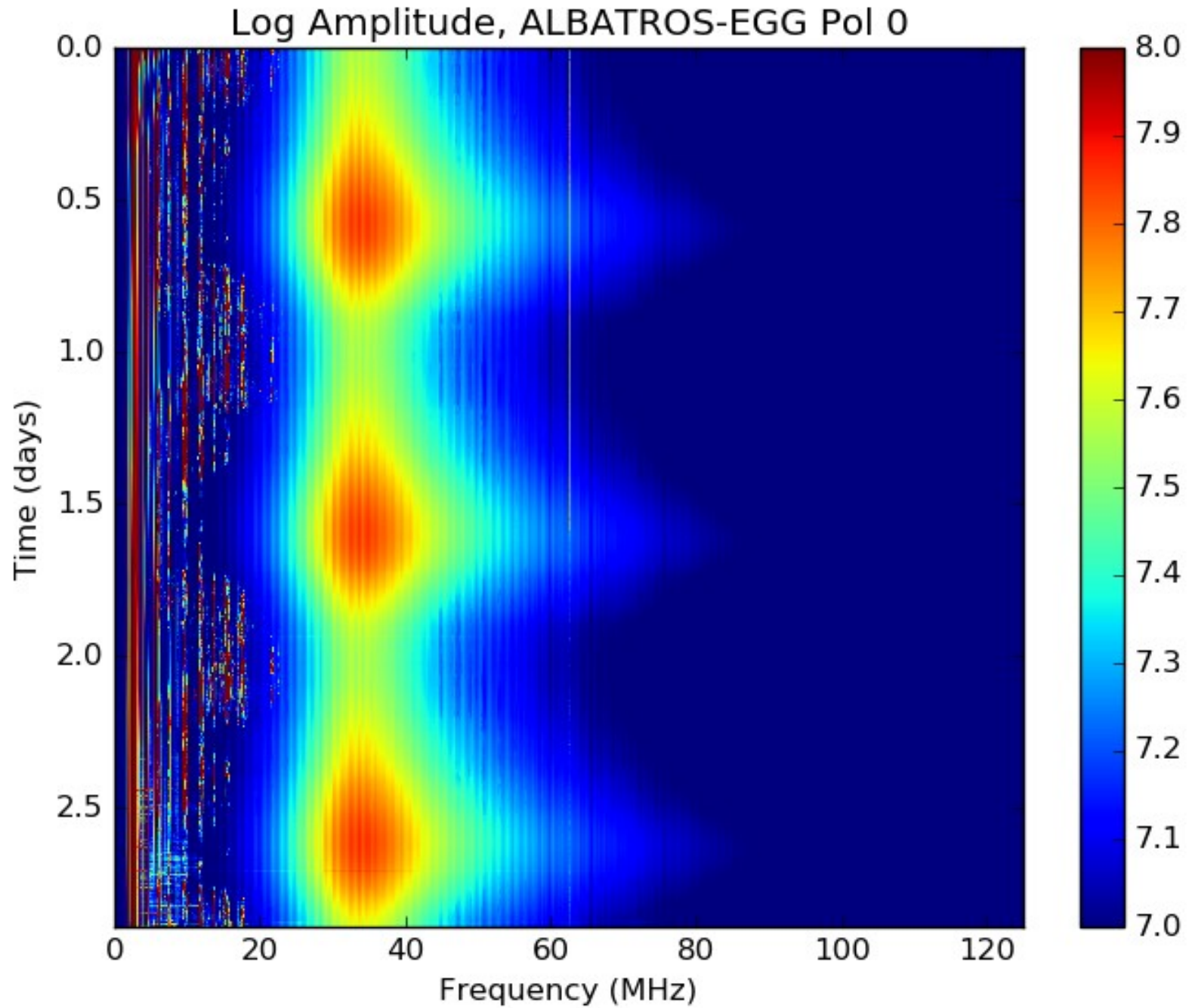
**ALBATROS = Array of Long Baseline Antennas for Taking Radio Observations from the Sub-antarctic / Seventy-ninth parallel**

# *Two-element pathfinder installed in 2018*

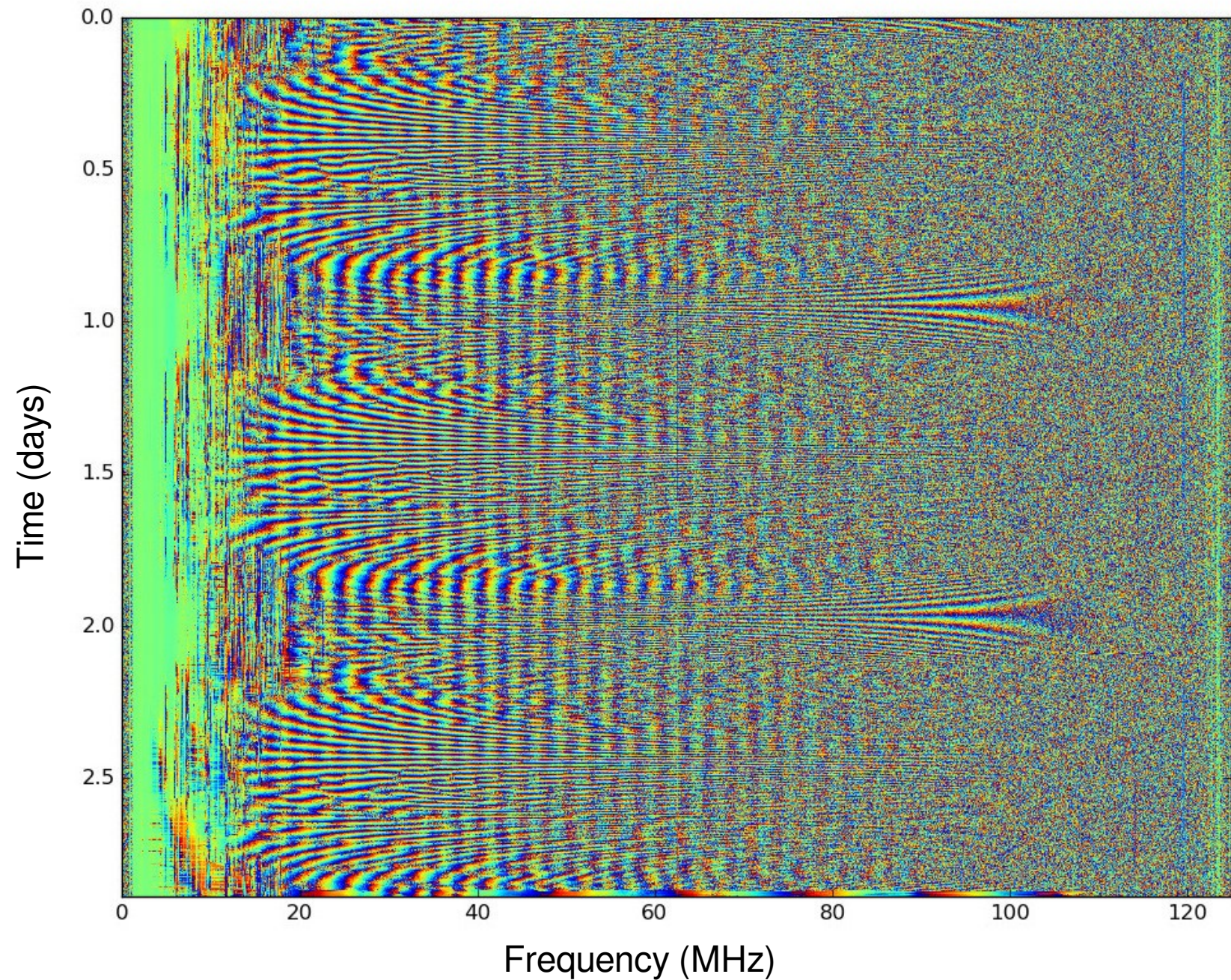


Signals are band limited to 1.2 – 81 MHz  
Directly cross-correlating 2 dual-pol antennas

# *Raw autospectra from low-freq antenna*



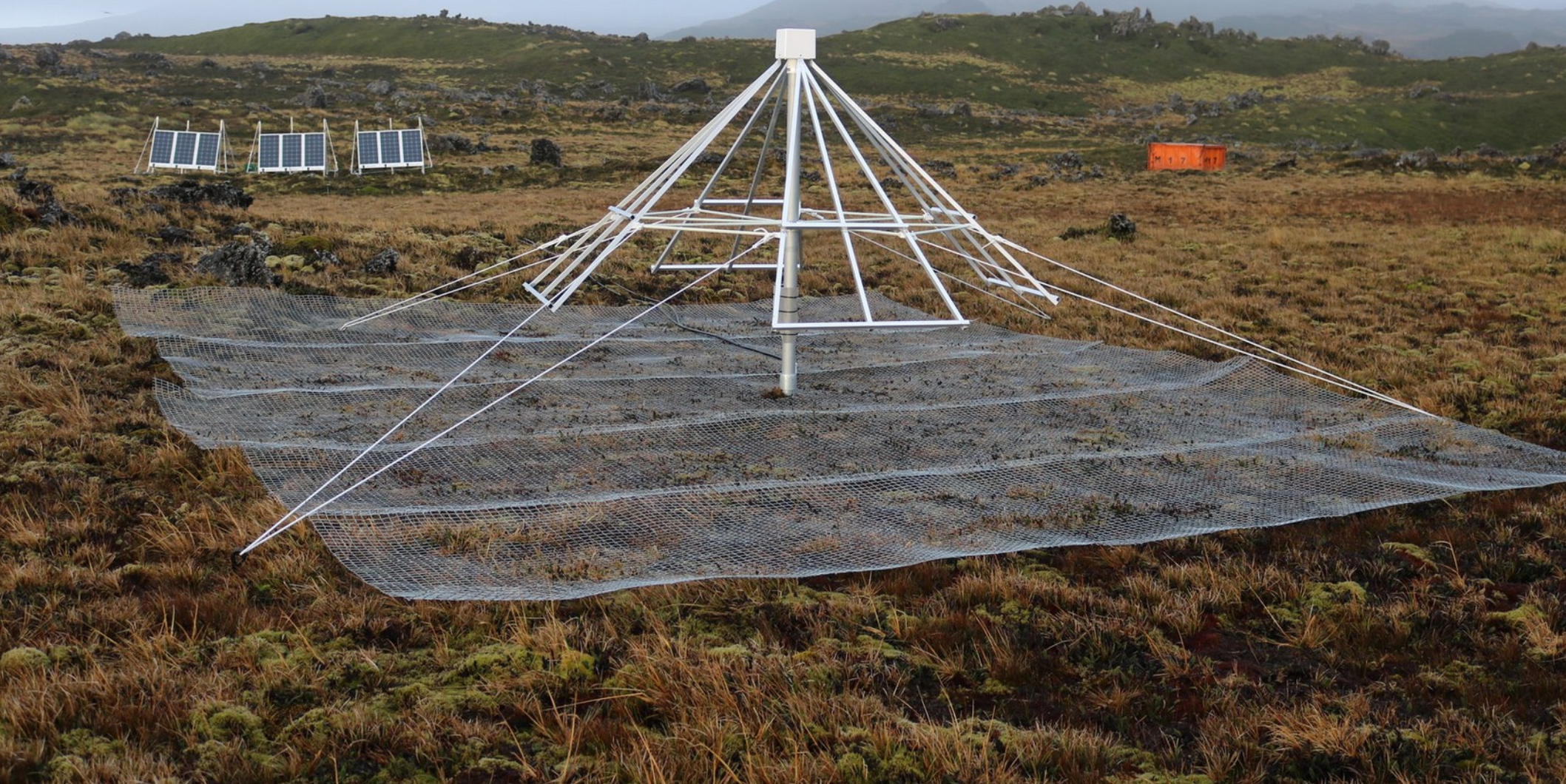
# *First fringes from low freq antennas*





# *First autonomous station installed in April 2019*

- Solar powered operation
- New dual-input SNAP enclosure
- Recording baseband + auto/cross-spectra
- GPS disciplined clock



*First autonomous station installed in April 2019*





All your baseband are belong to us

A satellite view of the Arctic region of the Earth. The image shows the Arctic Ocean, the Canadian archipelago (including Ellesmere Island, Devon Island, and the Northwest Territories), and parts of Greenland and the northern coast of North America. A red location pin is placed on the Canadian archipelago, specifically on the island of Ellesmere. Overlaid on the image is the text 'McGill Arctic Research Station' in yellow, with the coordinates '79°26'N 90°46'W' below it.

**McGill Arctic  
Research Station**  
79°26'N 90°46'W

**New radio explorations in the north:  
first site surveying in July 2019**

# *Site surveying in Resolute*



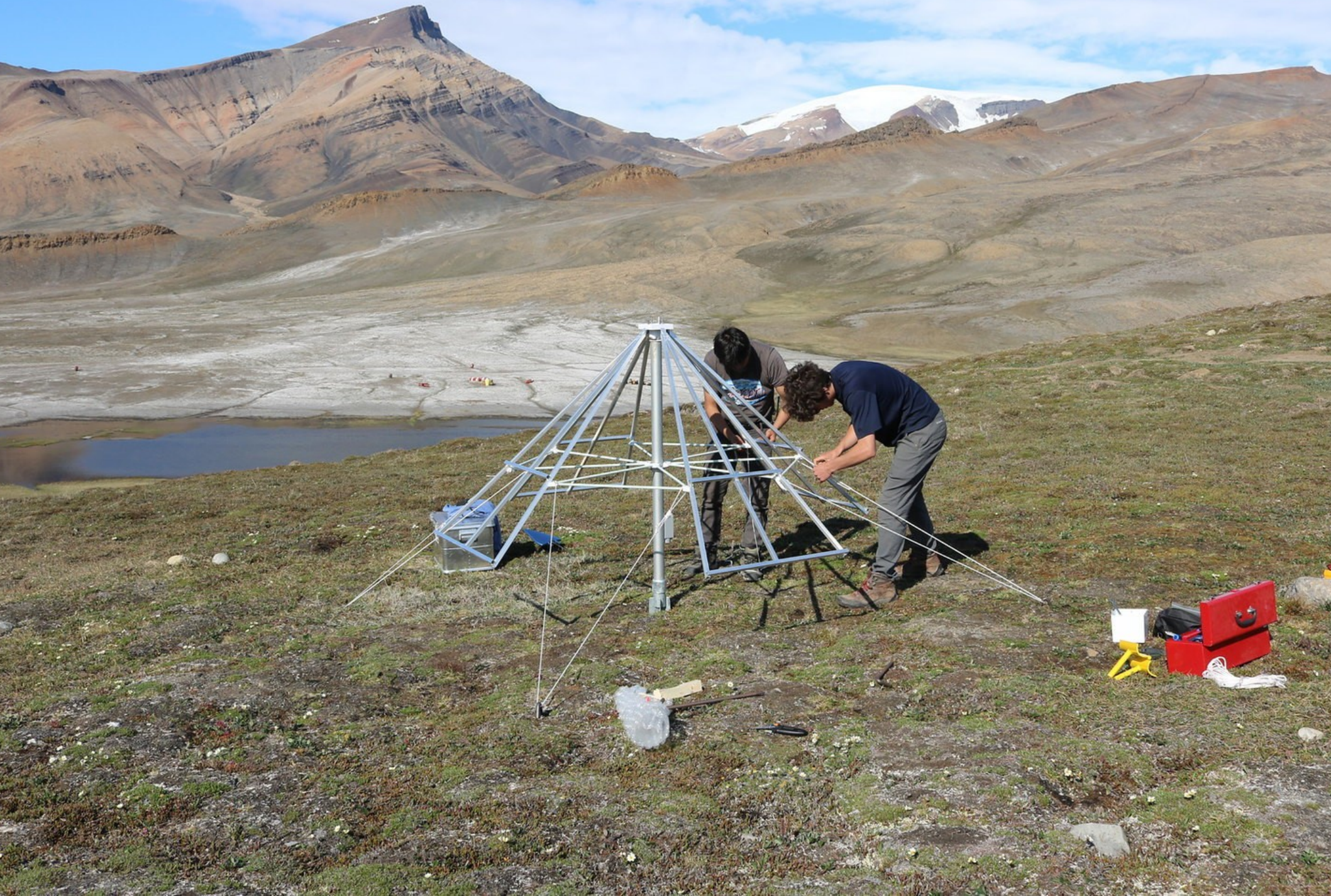
*Not particularly quiet...*



# *The McGill Arctic Research Station*



# *On-site installation*

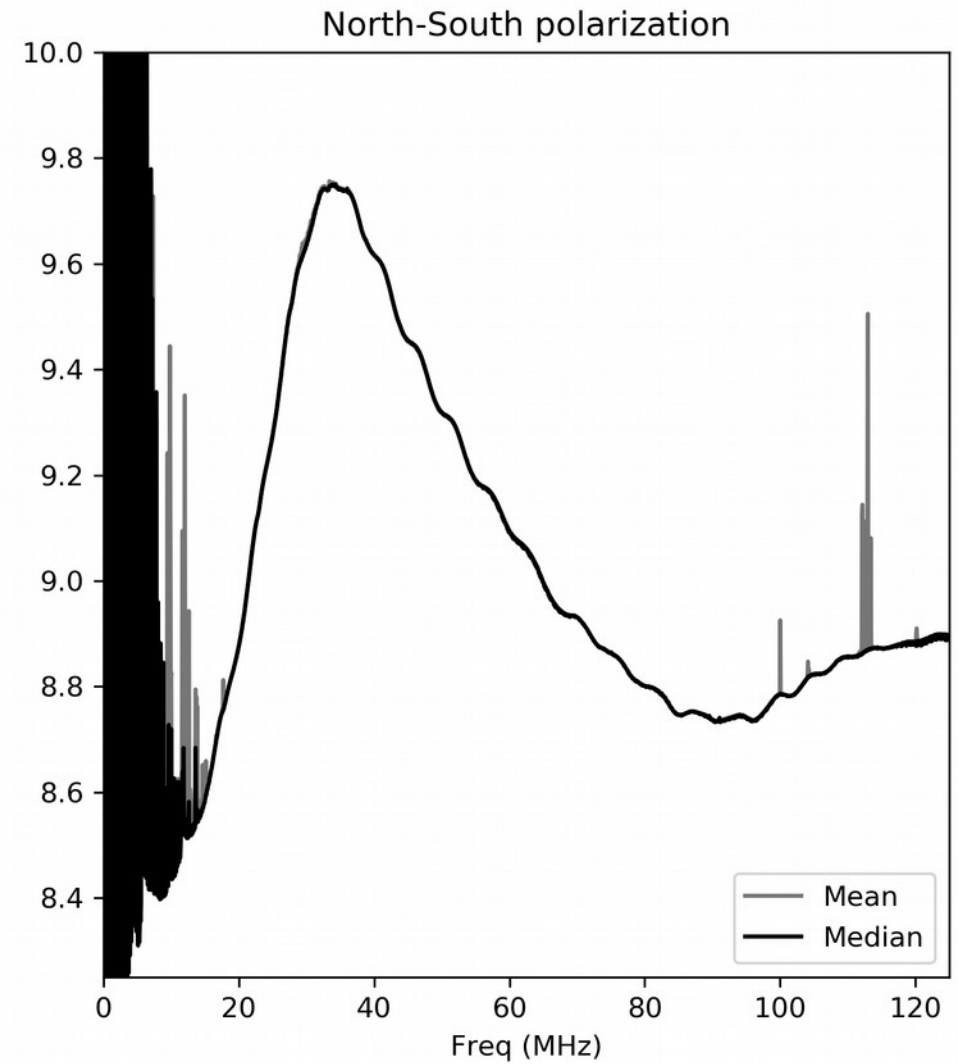
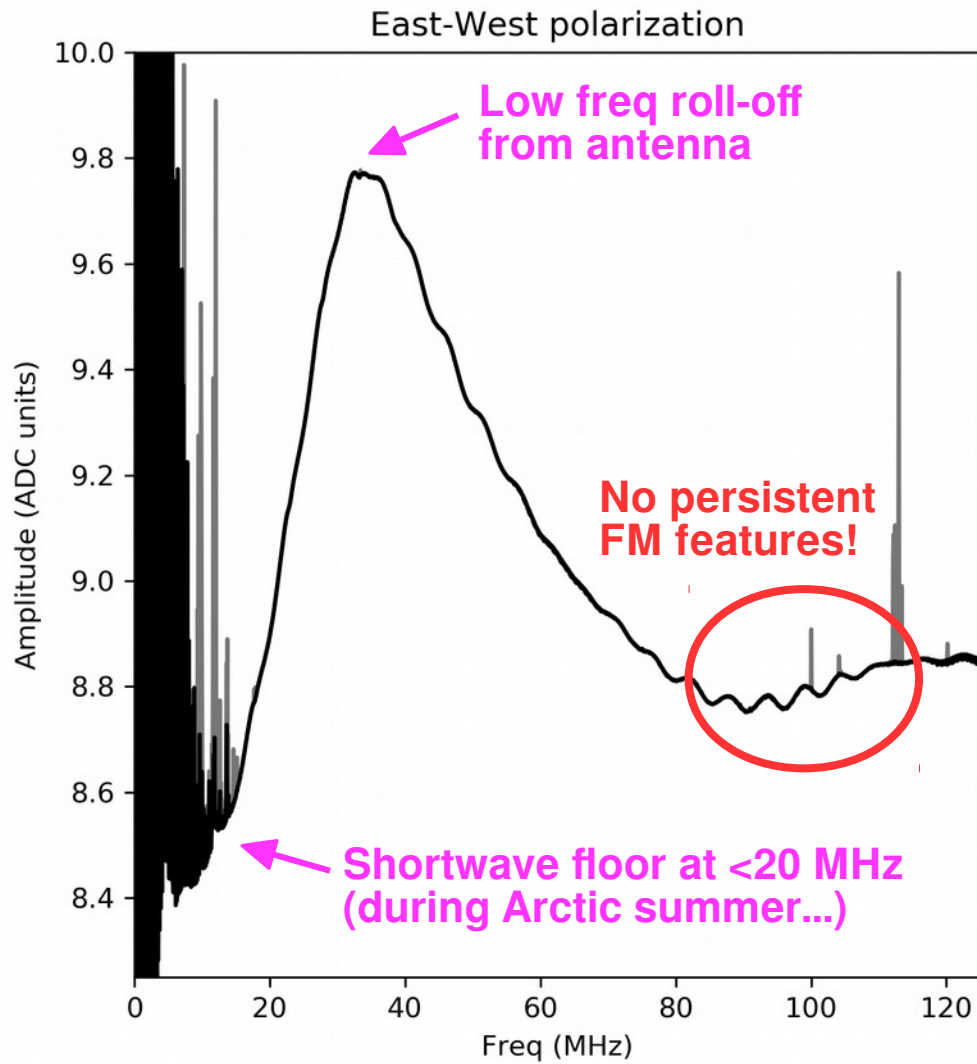




# *Completed antenna at MARS*



# Preliminary spectra



# *Upcoming work*

- Next Marion voyage is April 2020, will service PRIZM and install additional autonomous ALBATROS stations
- Next Arctic deployment is summer 2020, aiming to run “mini-MIST” and install two “super-autonomous” ALBATROS stations for winter operations
- Current R&D: boosting antenna response at low frequencies, clock stability and baseband tests, data storage, long-term power (wind? fuel cells?)