This scientific work uses data obtained from:

Paul Wild Observatory, Narrabri. We acknowledge the Gomeroi people as the traditional owners of the observatory site.

Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory. We acknowledge the Wajarri Yamaji people as the traditional owners and native title holders of the observatory site.


Credit: A. Fujil

GINAN:
Global Imprints from Nascent Atoms to Now

Precision spectral radiometry for all-sky cosmology

Dr Aaron Chippendale | 19 Feb 2026
Prof. Ravi Subrahmanyan, Prof. Ron Ekers,
Dr Luke McKay, and much input from across ATNF
Australia's National Science Agency

Ginan:
"a small dilly bag full of knowledge, songs of knowledge that were passed on"

Wardaman people

Our observatory: a critical resource for experimentation

Inyarrimanha Ilgari Bundara boasts excellent **radio quietness** and **infrastructure** to support the development of precision radio astronomy experiments.

GINAN's global 21 cm experiments may ultimately deploy to **extremely remote** sites to avoid RFI (particularly FM), antenna-ground interactions, and the ionosphere.

...to the middle of the continent, the ocean, the Antarctic, or even space.


Inyarrimanha Ilgari Bundara
October 2024


Inyarrimanha Ilgari Bundara
October 2024

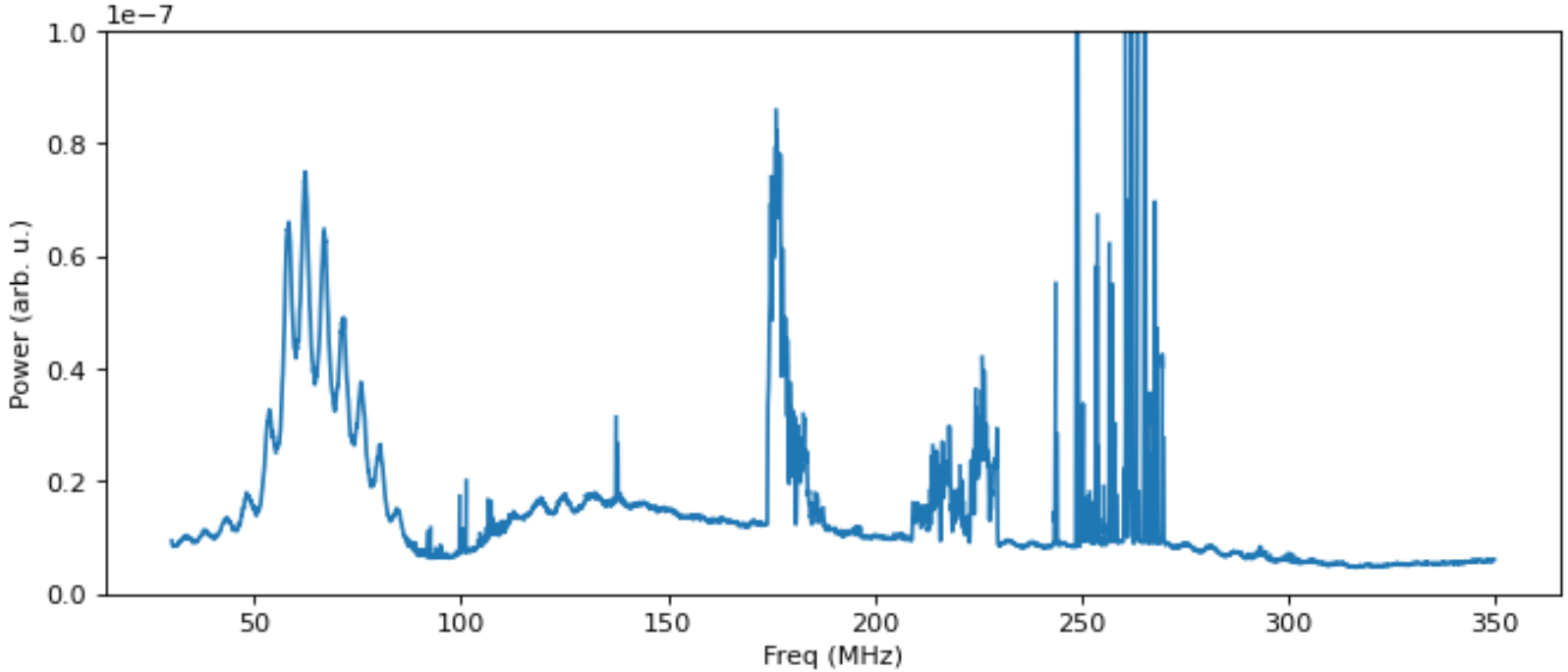
GINAN today: 2026

Today: we have made a precision measurement of the radio sky brightness over 60-350 MHz using a new self-calibrating receiver that enables continuous and precise absolute calibration in situ, when connected to an antenna in the field.

- The low-frequency radio sky is 20% brighter than previously thought.
- Uncertainty in our corrected GSM2016 sky model is less than 2 % below 160 MHz.
- Our measurements can be used to set the primary flux scale for SKA-Low.
- Our results imply 17 % increase to unaccounted-for uniform sky brightness previously detected by ARCADE 2.
    - This requires higher photon efficiency for possible explanations:
        - nanojansky source populations
        - dark matter decay

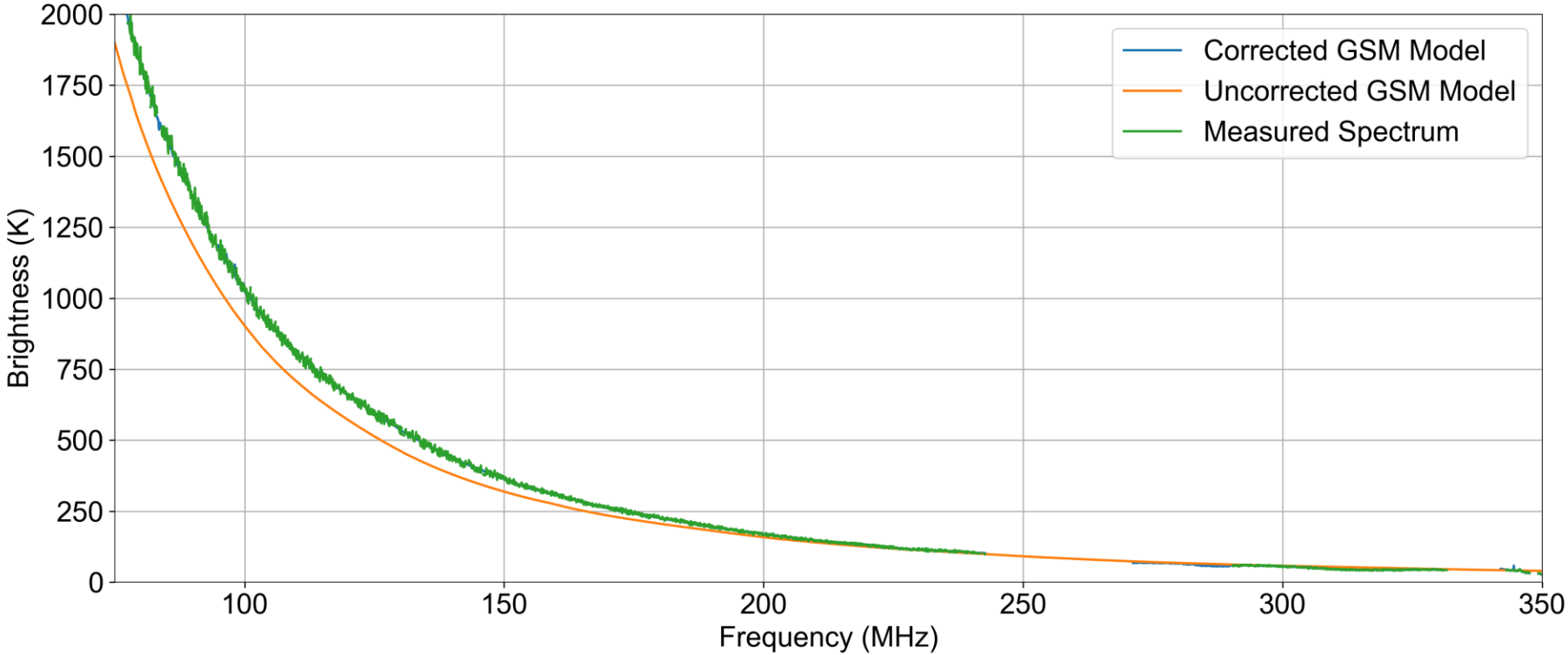
McKay, Subrahmanyan, Chippendale, et al. (arXiv:2509.11846, 2026)

Raw uncalibrated sky spectrum



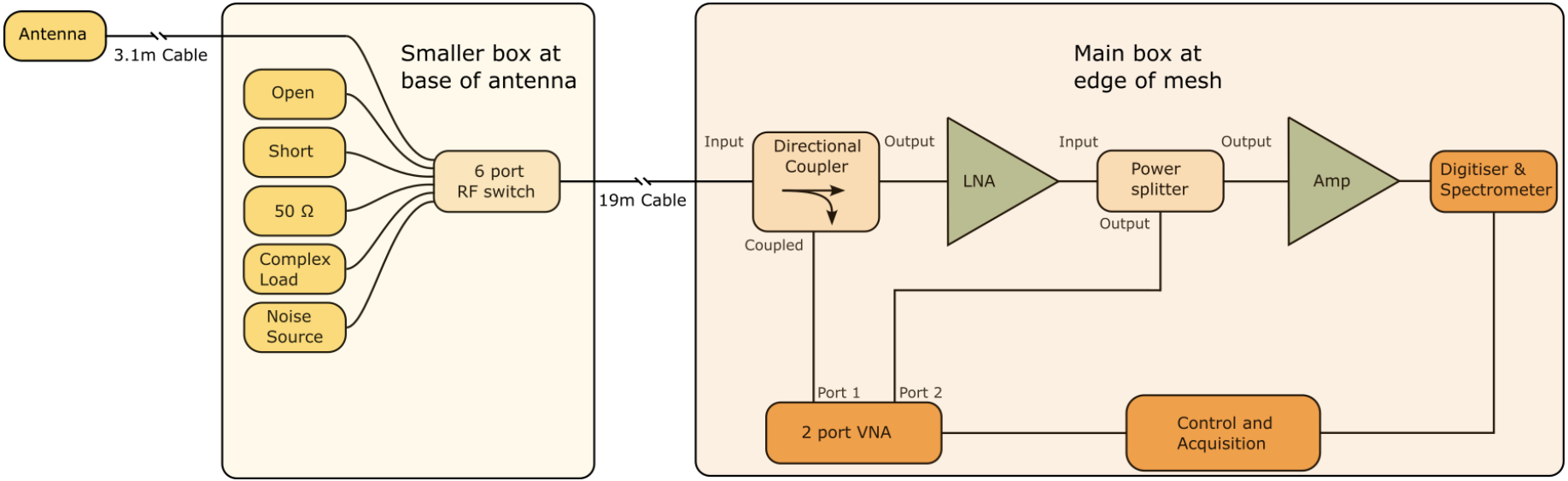
GINAN: Narrabri, unpublished

Calibrated sky spectrum



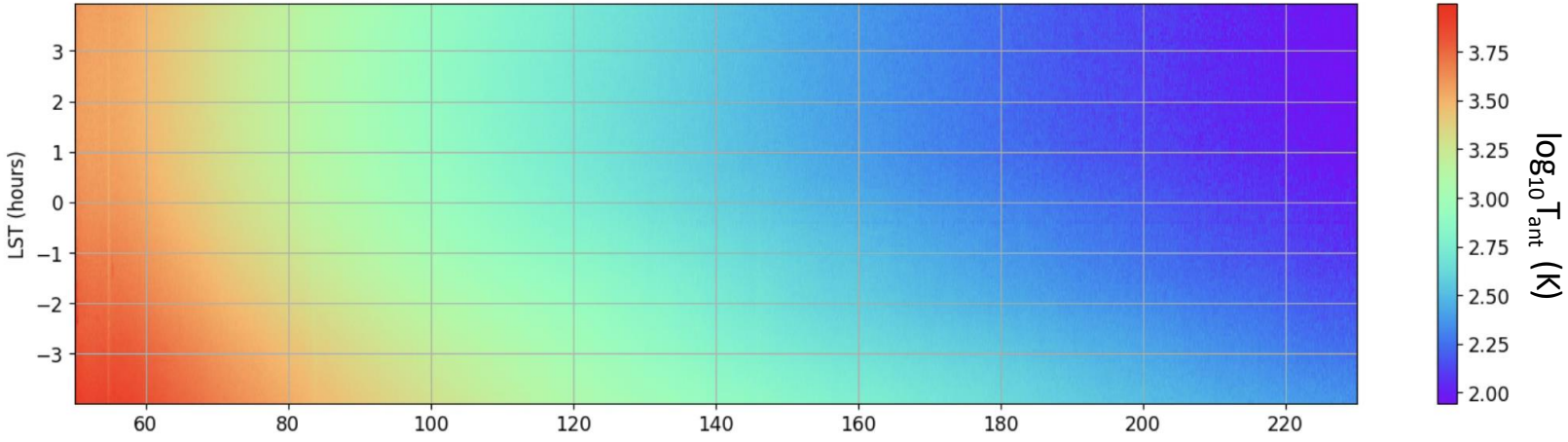
McKay, Subrahmanyan, Chippendale, et al. (arXiv:2509.11846, 2026)

New self-calibrating receiver

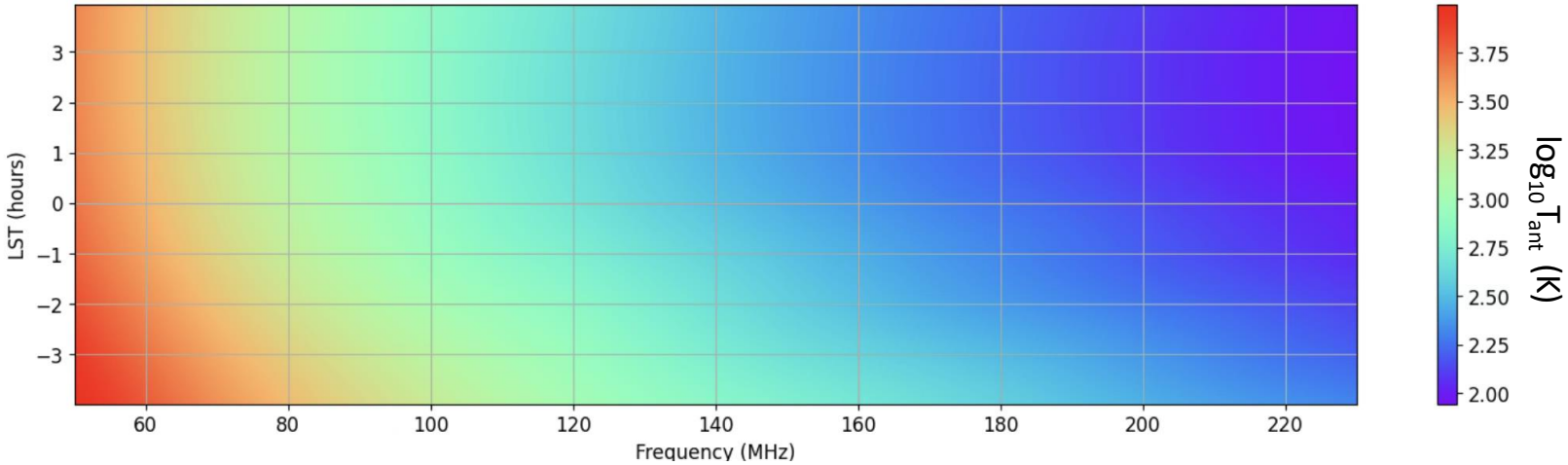


Australian patent application 2025901969 filed 21 May 2025
McKay, Subrahmanyan, Chippendale, et al. (arXiv:2509.11846)

GINAN Measurement



GSM Model: Zheng et al. (MNRAS, 2017)

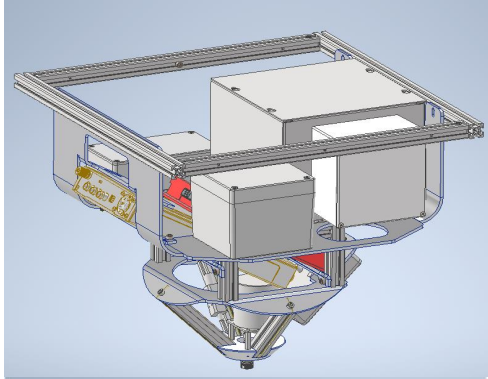


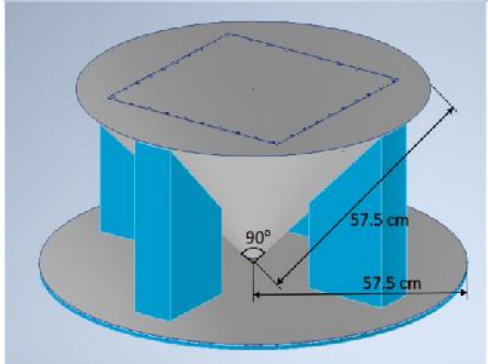
McKay, Subrahmanyan, Chippendale, et al. (arXiv:2509.11846, 2026)

GINAN futures: 2026-2030

Tomorrow: we aim to...

- Confirm or reject EDGES' detection of global 21 cm from cosmic dawn (Bowman et al. Nature, 2018).
  - achieve 10 mK accuracy over 40-160 MHz band for high confidence;
  - inform frequency range for deep power spectrum searches with SKA-Low;
  - provide zero-spacing measurement to SKA-low, to determine if 21 cm power-spectrum is in emission or absorption.
- Work towards space deployment with 1 mK accuracy.
- Prototype a cm-wavelength spectral radiometer.





GINAN futures: beyond 2030

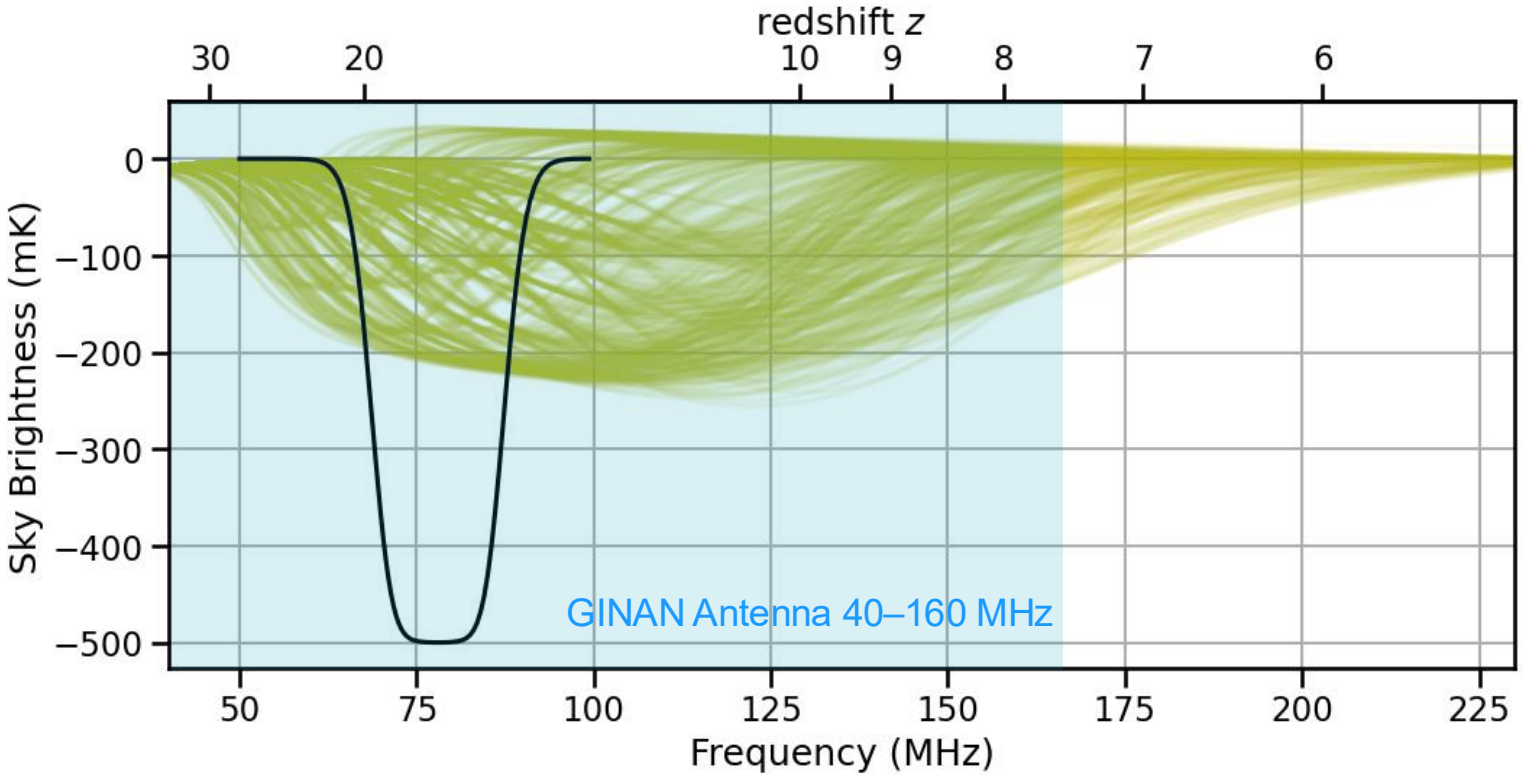
1) GINAN cosmic dawn space mission

2) Apply self-calibrating precision radiometry to all-sky cosmology with a cm-wave aperture array to:
   - search for dark-matter
   - resolve ARCADE 2's claim of excess radio synchrotron background (via accurately calibrated cm-wave sky maps and joint modelling with SKA-Low maps to separate spectral components)
   - work towards detecting extremely faint (~ 10 nK) cosmological recombination lines of hydrogen

This requires:

- octave band somewhere in 2-6 GHz
- absolute calibration with high dynamic range (> 1 ppm)
  - on one element to calibrate maps to understand radio synchrotron background
  - on all elements to detect dark matter and cosmological recombination lines
- all-sky imaging with moderate resolution required for ARCADE 2 investigation
- sensitivity required for cosmological recombination lines
  - ~100 independent measurements with state-of-the-art LNAs and ~1 yr integration

Expected global 21 cm hydrogen signal

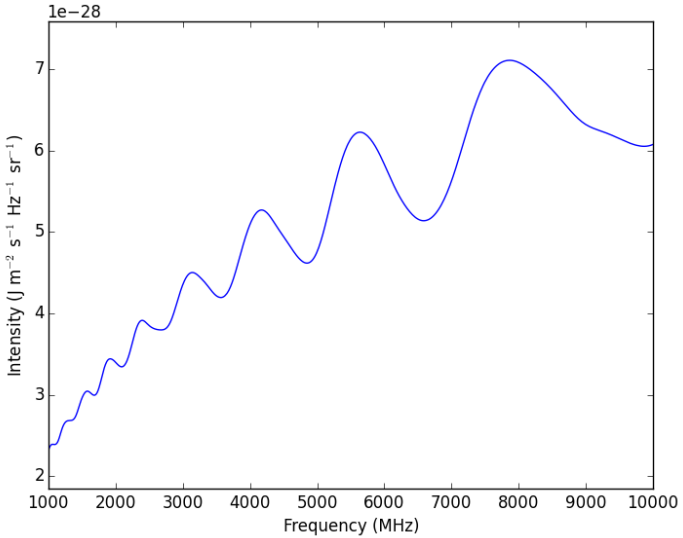


21cmGEM Model: Cohen, Fialkov et al. (2020)

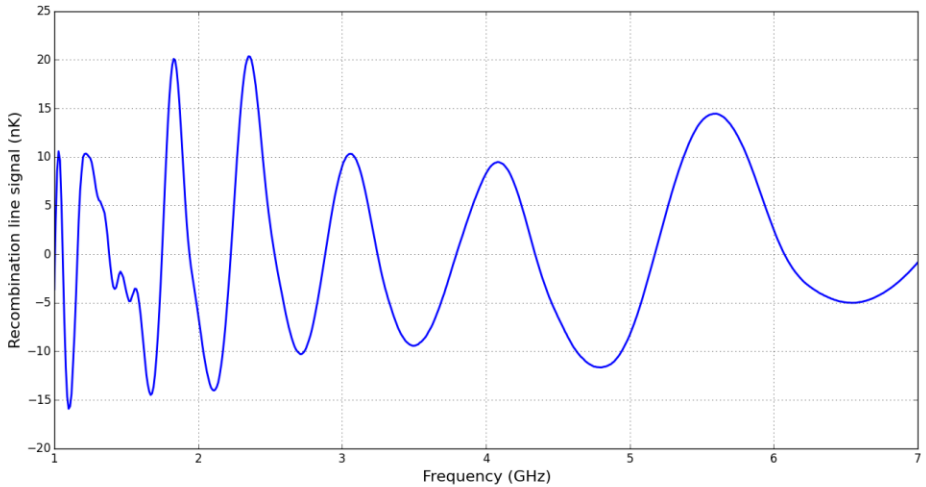
OFFICIAL

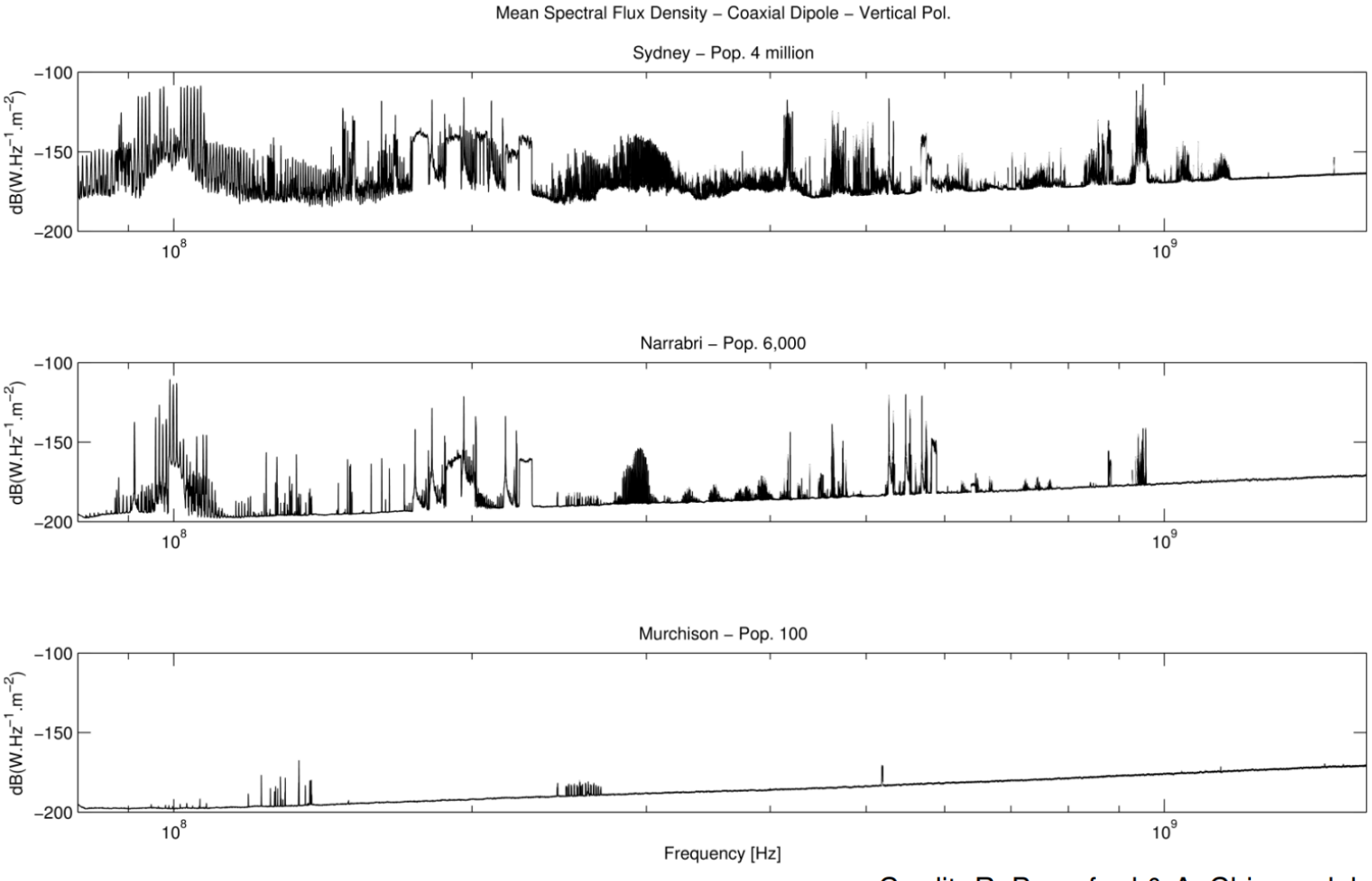
EDGES Measurement: Bowman et al. (2018)

Expected cosmological recombination signal



With a baseline subtracted:





Credit: R. Beresford & A. Chippendale

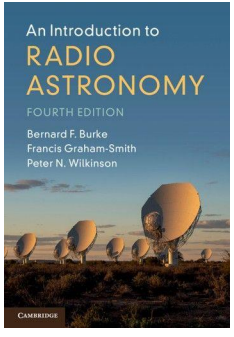


Fig 1.2

A clean window to the early Universe

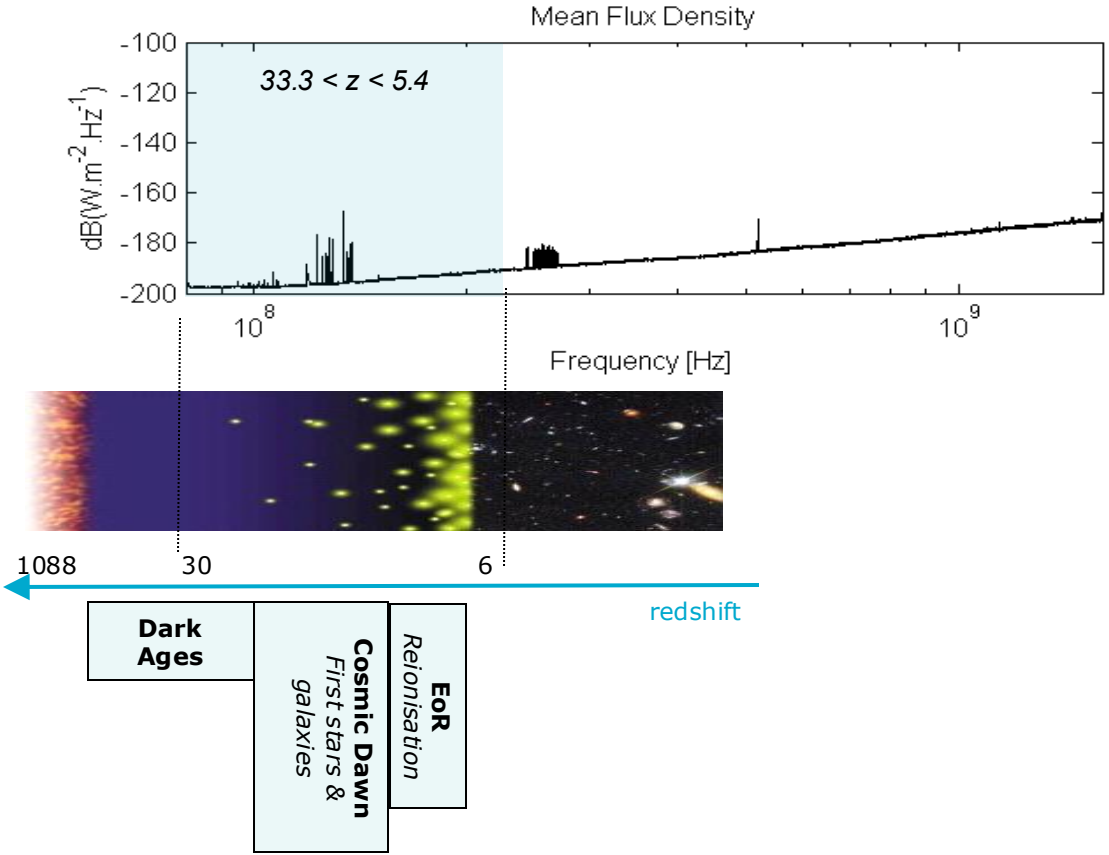
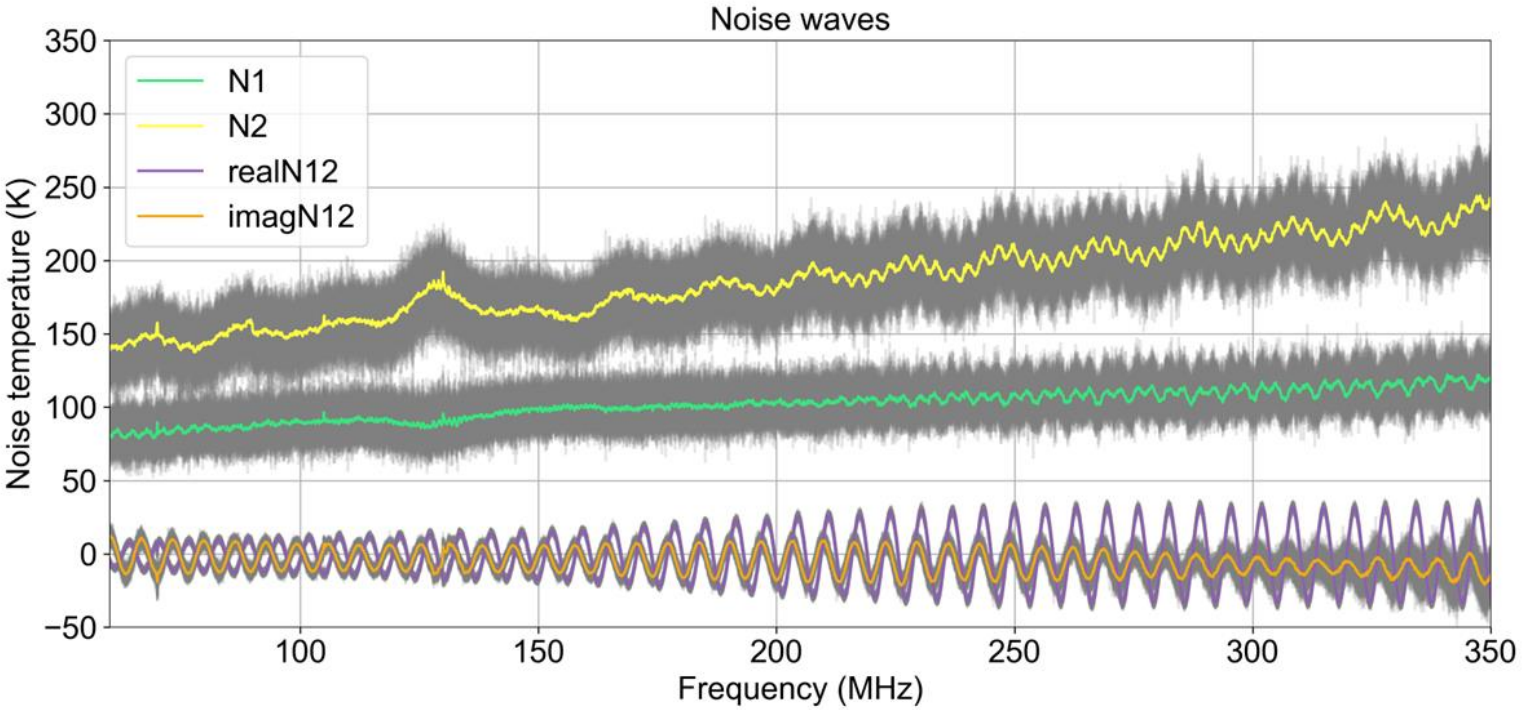
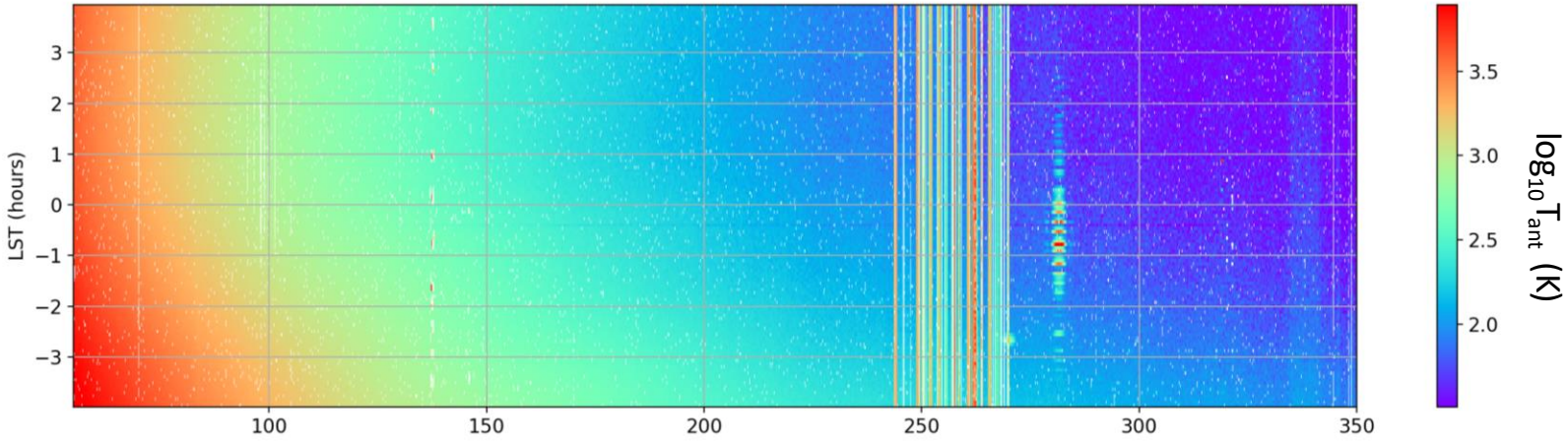


Image credit: S. G. Djorgovski et al. & Digital Media Centre, Caltech

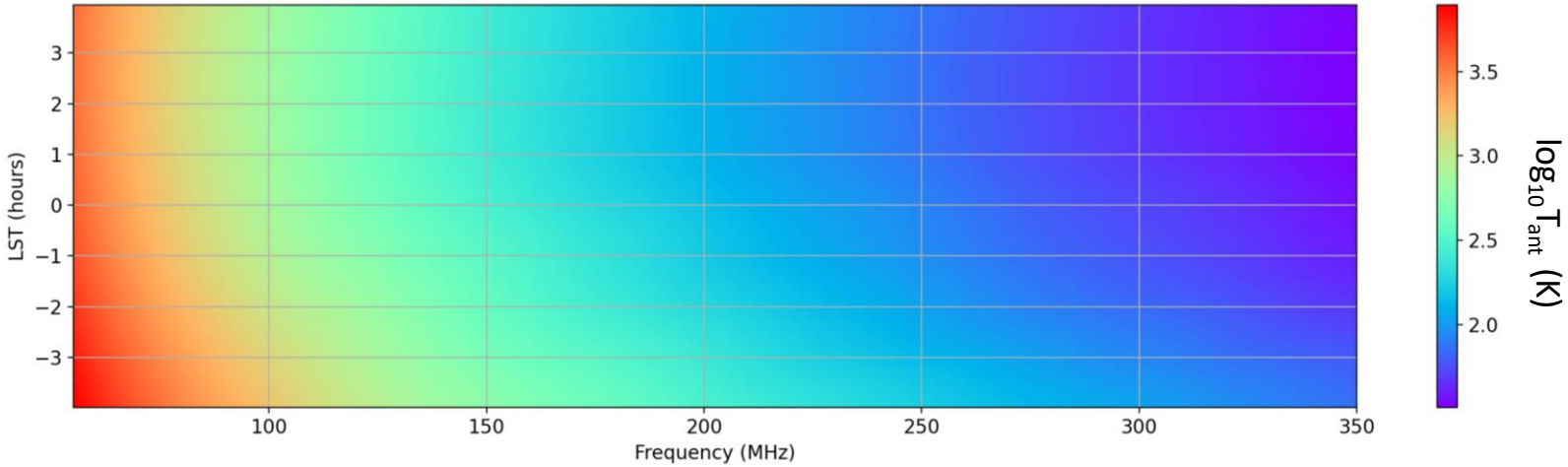
Receiver noise waves calibrated and corrected, including ripple from 19 m cable!



GINAN Measurement

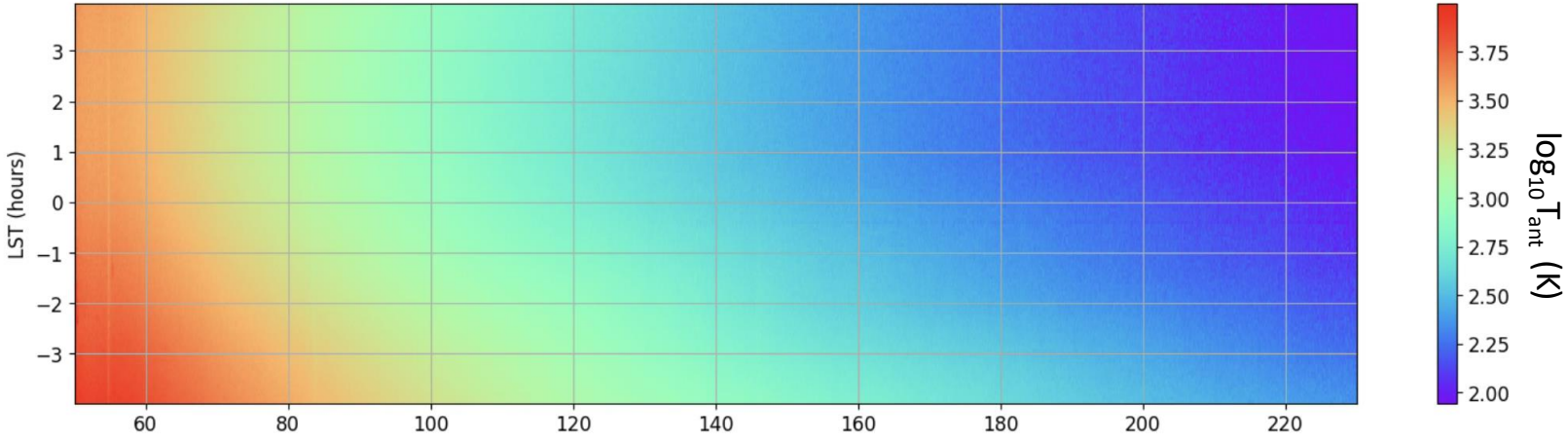


GSM Model: Zheng et al. (MNRAS, 2017)

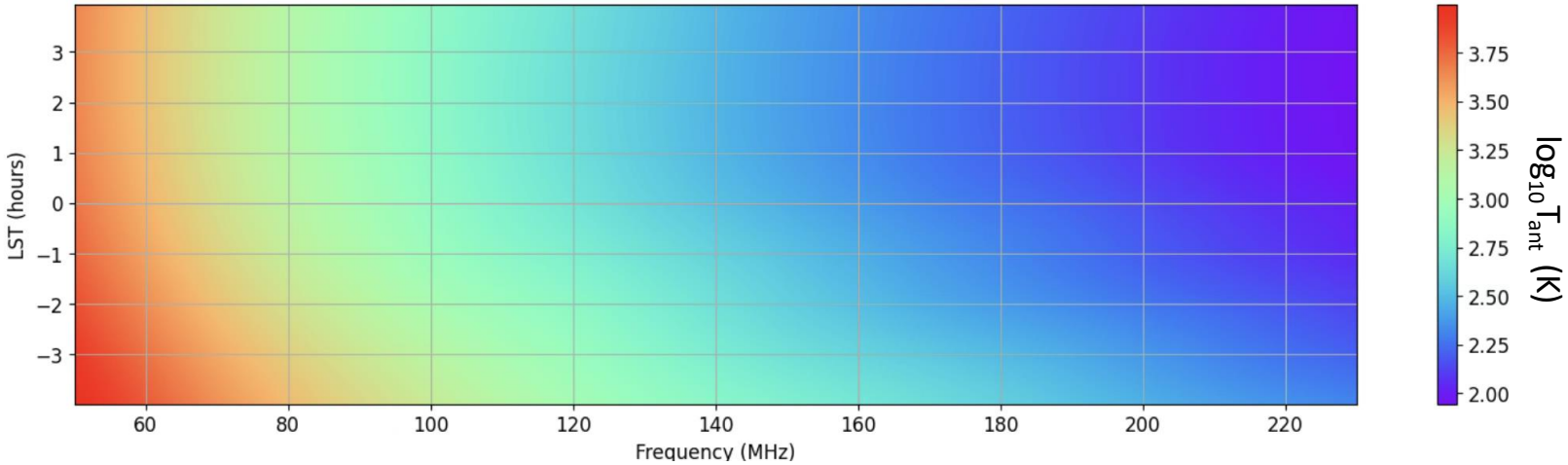


McKay, Subrahmanyan, Chippendale, et al. (arXiv:2509.11846, 2026)

GINAN Measurement

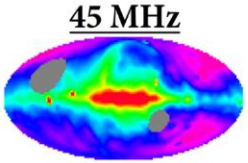


GSM Model: Zheng et al. (MNRAS, 2017)



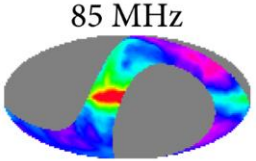
McKay, Subrahmanyan, Chippendale, et al. (arXiv:2509.11846, 2026)

Measurement vs model

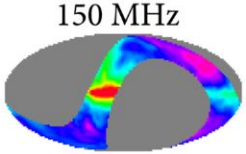


Bandwidth

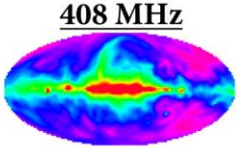
1 MHz, 1.65 MHz



1 MHz



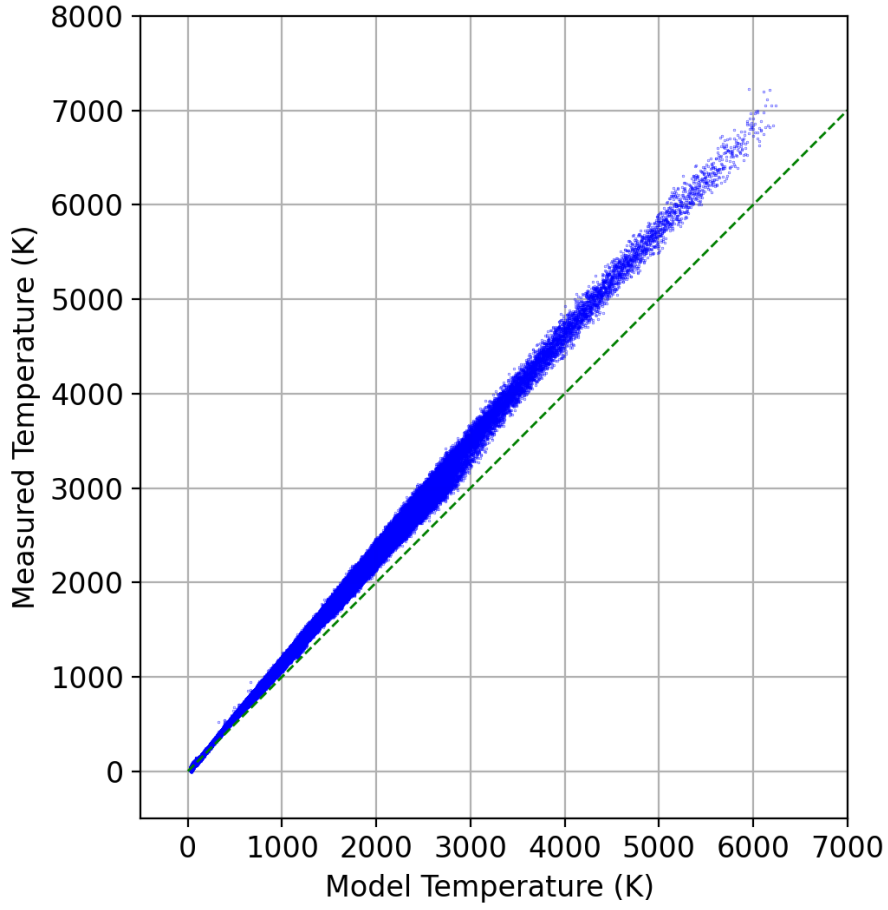
2 MHz



4 MHz

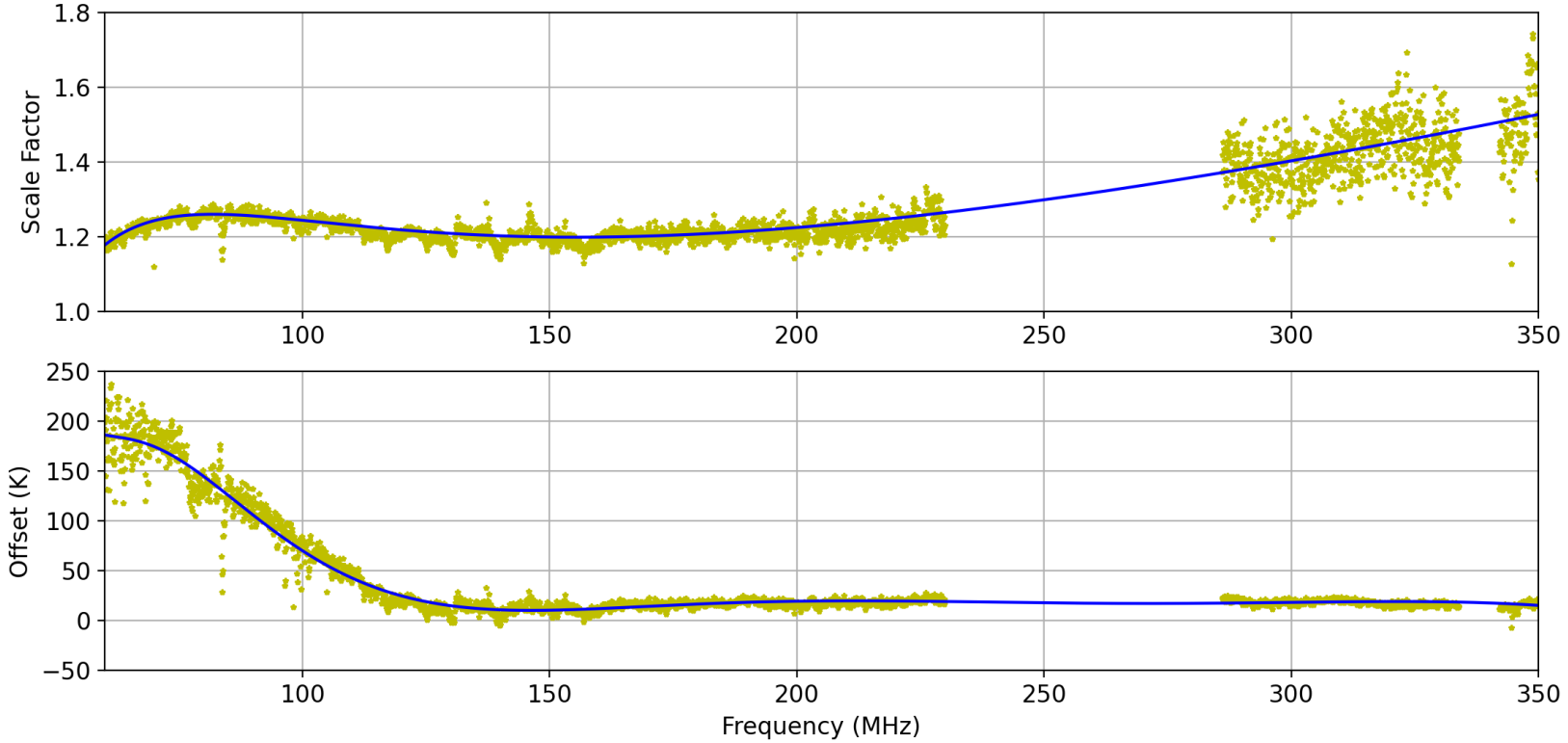
PCA interpolation

McKay et al.(arXiv:2509.11846)



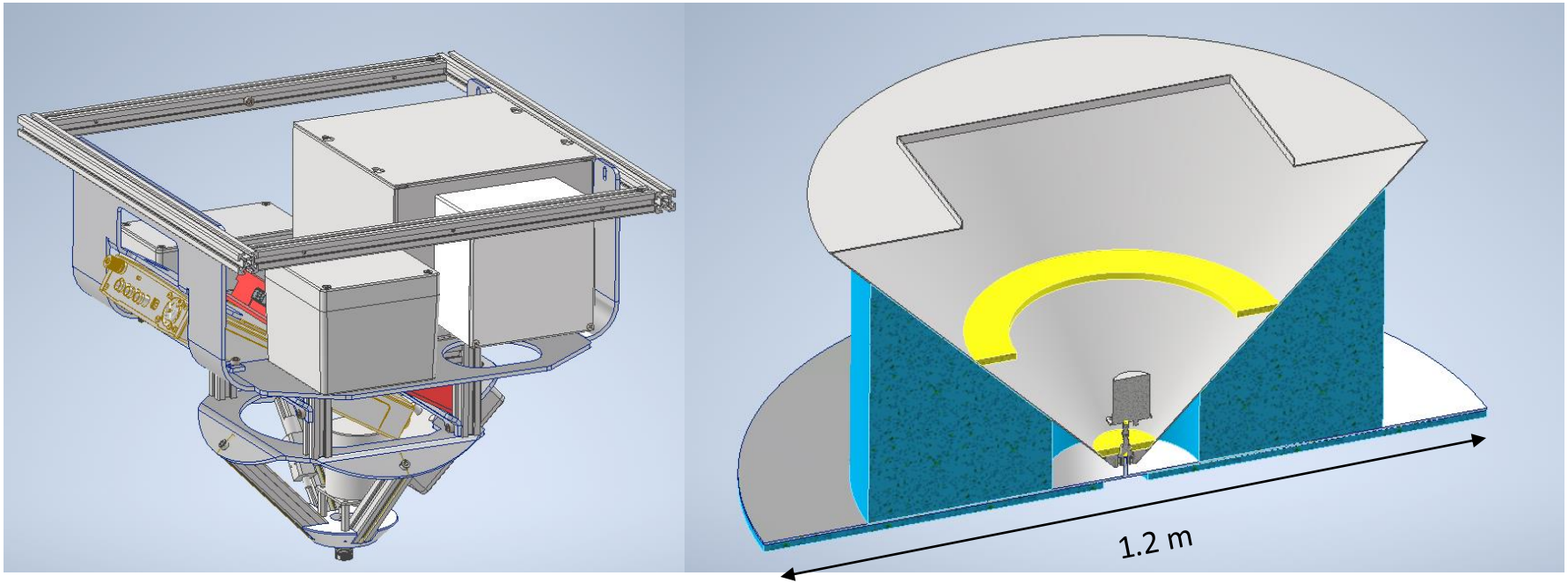
GSM: Zheng et al. (MNRAS, 2017)

Correction to GSM (subtract offset then scale up)

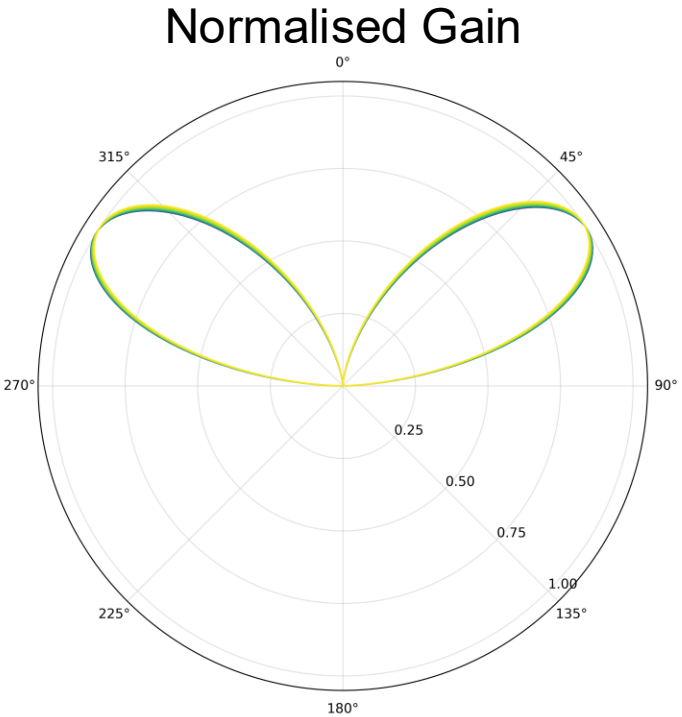


McKay, Subrahmanyan, Chippendale, et al. (arXiv:2509.11846, 2026)

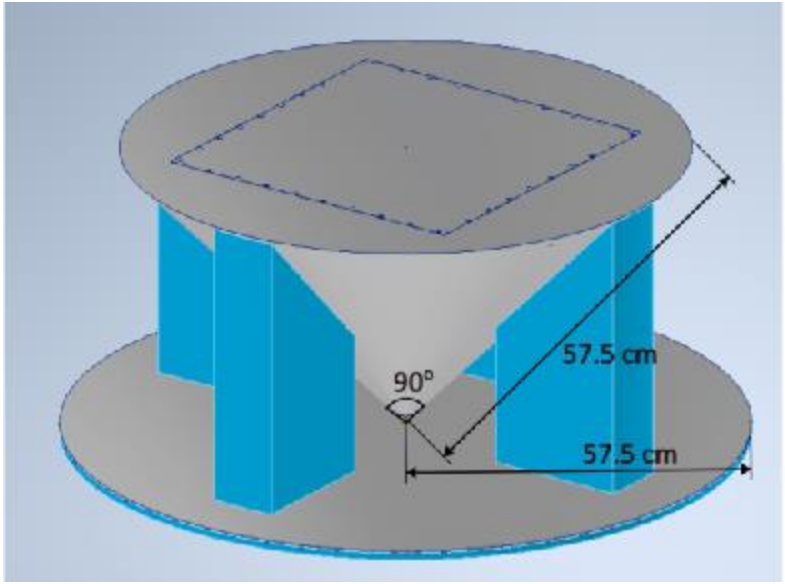
Next: tight integration with custom antenna



GINAN inverted discone antenna over soil



40 – 160 MHz
(every 5 MHz)



McKay, Mohamadzade, Chippendale et al., (ISAP, 2024)

Thank you

Space and Astronomy
Dr Aaron Chippendale
Principal Research Engineer,
Cosmology & RFI

+61 2 9372 4296
aaron.chippendale@csiro.au
www.atnf.csiro.au