The University of Manchester

Introducing L-BASS

An instrument to tackle the ARCADE excess with absolutely calibrated observations at 1.4 GHz.

Phillip Black, 2026

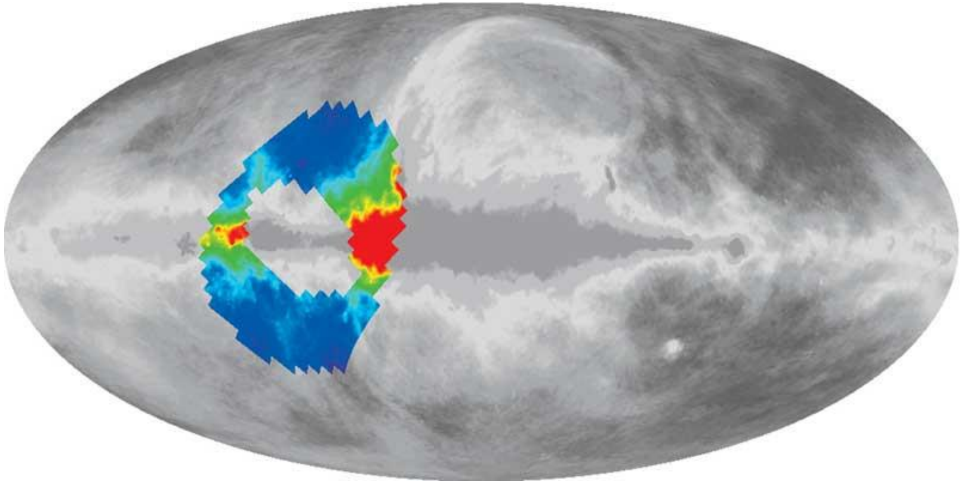
Jodrell Bank Centre for Astrophysics

LinkedIn Profile

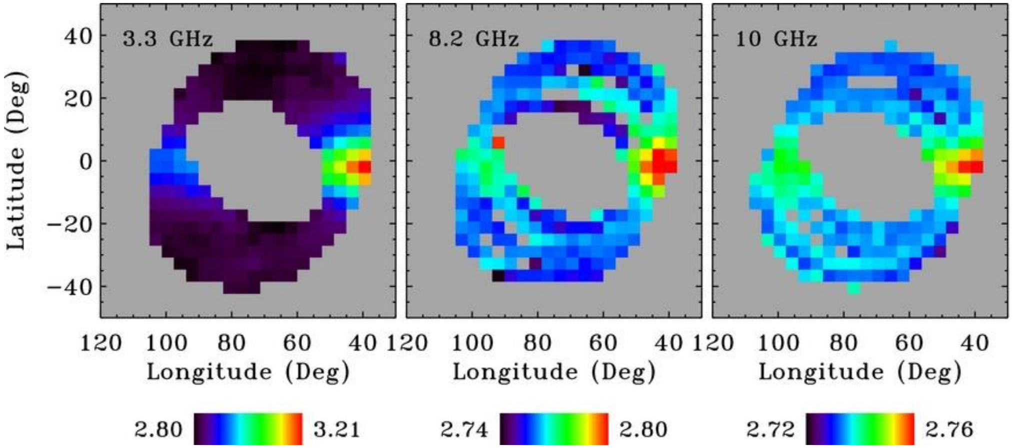
The University of Manchester

The ARCADE excess

ARCADE-2 reported an excess isotropic radio background that is too bright for known radio sources.



Extrapolated to 310 MHz:



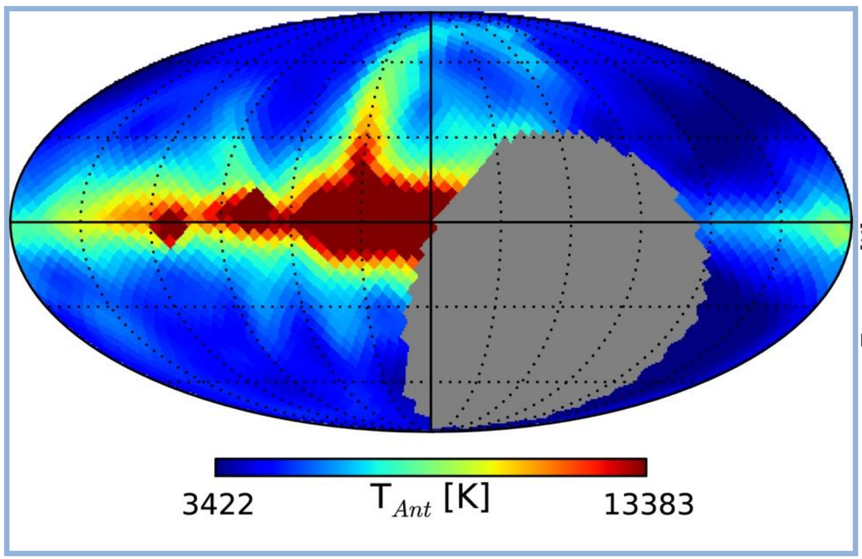
ARCADE2 + Literature:

T_{excess} = 24.1 ± 2.1 K
β = -2.599 ± 0.036

Fixsen et al. (2011)

The University of Manchester

LWA1 Support

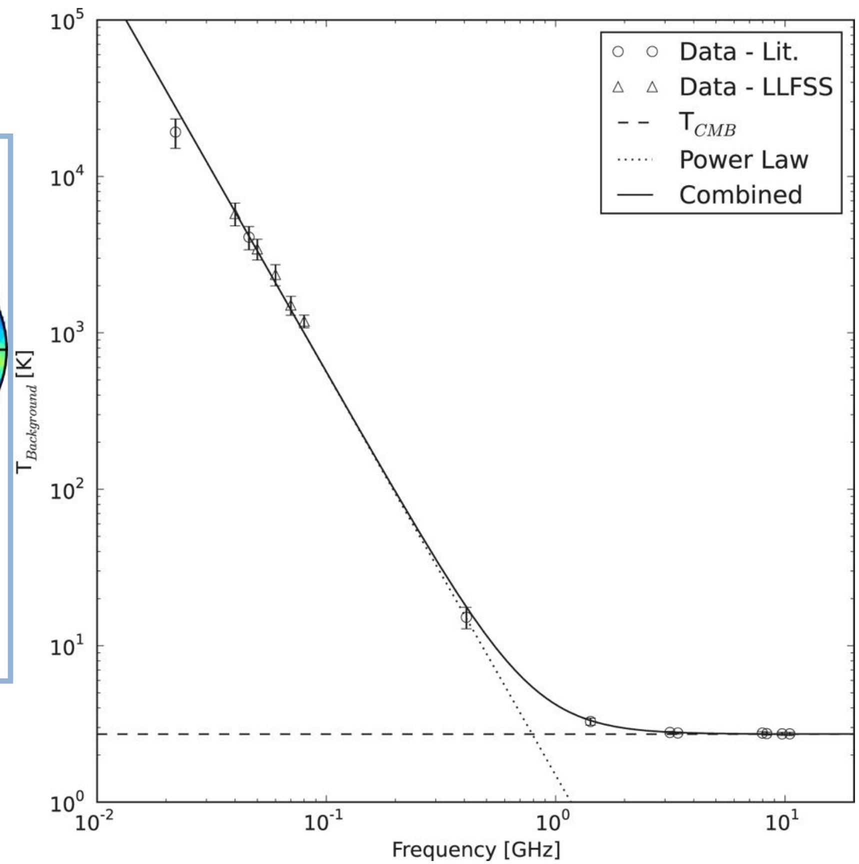


Extrapolated to 310 MHz:

<u>LWA1 + Literature:</u>

T_{excess} = 30.4 ± 2.6 K

β = -2.58 ± 0.05



Dowell & Taylor. (2018)

MANCHESTER 1824
The University of Manchester

Analysis using literature surveys:

22 MHz, northern sky, Roger et al. (1999)

45 MHz, southern sky, Alvarez et al. (1997)

45 MHz northern sky, Maeda et al. (1999)

40, 50, 60, 70, 80 MHz, northern sky, Dowell et al. (2017)

408 MHz all-sky, Haslam et al. (1981,1982)

1.4 GHz all-sky, Reich et al. (1982, 1986, 2001)

3, 8, 10 GHz, ARCADE2, Fixsen et al. (2011)

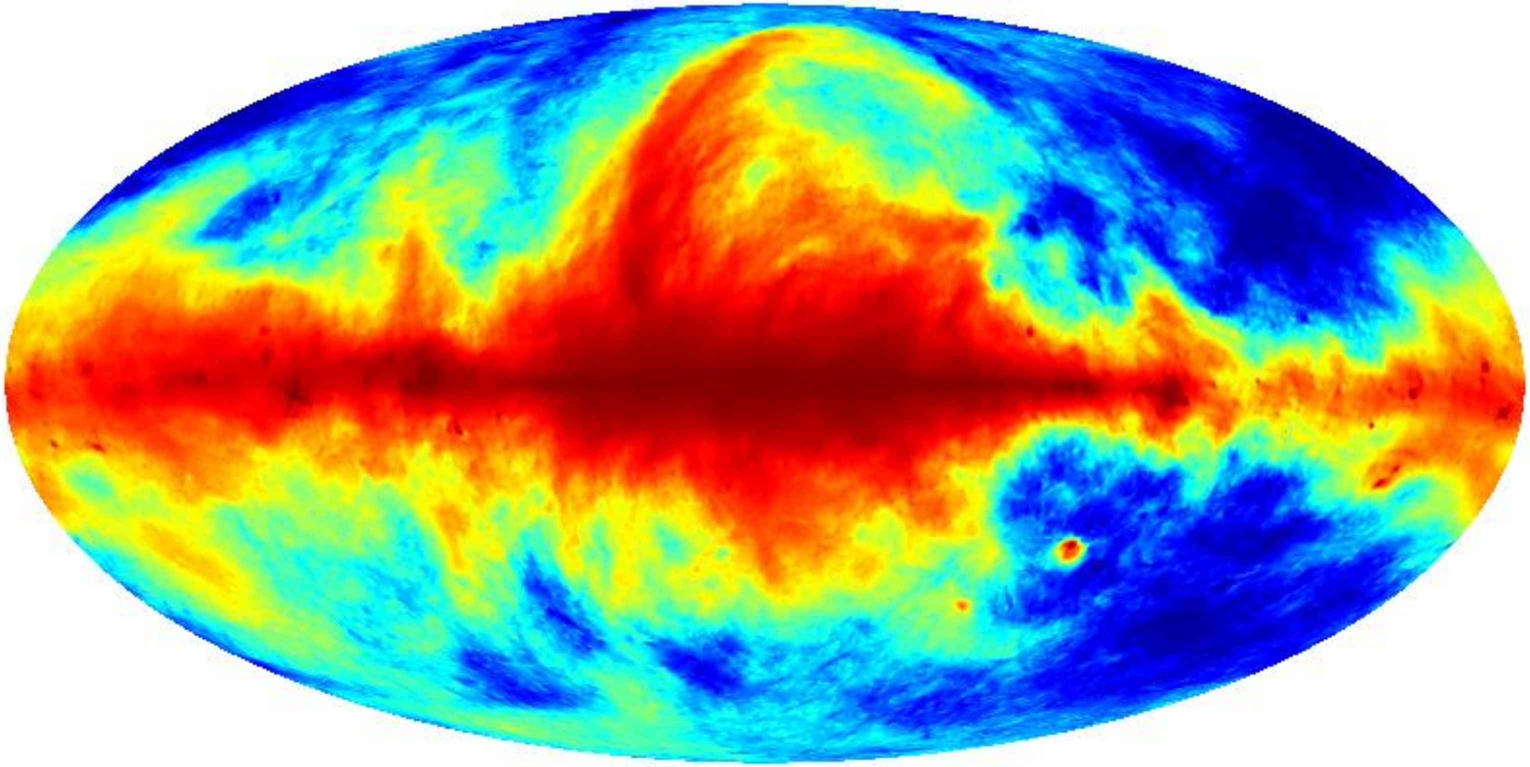
30, 90 GHz, ARCADE2, Fixsen et al. (2011)

~250 GHz, COBE/FIRAS, Fixsen & Mather (2002)

MANCHESTER
1824
The University of Manchester

Galactic Synchrotron Emission

- Ground based single-dish or phased array surveys
- Galactic Foreground Subtraction
- CMB (COBE, WMAP, Planck), GSM (21cm cosmology e.g. EDGES)



Haslam et al. (1981,1982) and Remazeilles et al. (2015)

Ideally images

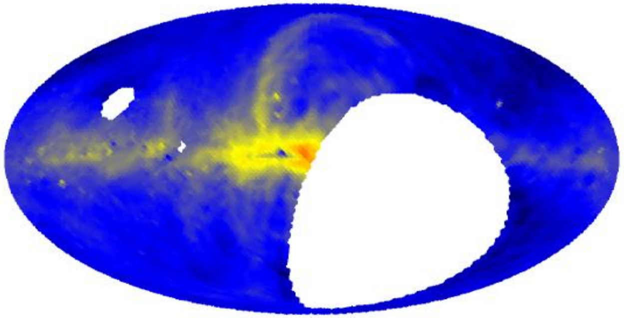
Zero-level offset uncertainty,

- Should fill the screen
- With minimum or no text

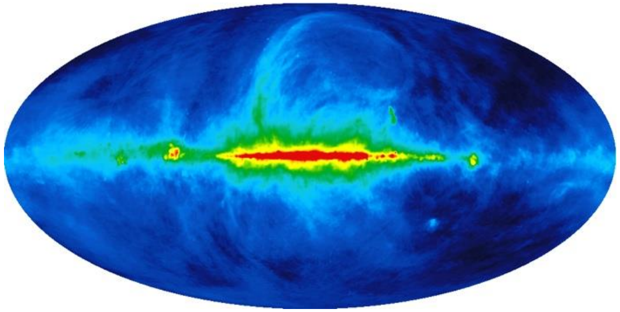
$$V(t) = G(t)B * T_{Sky} + N(t) + M$$

Russian Doll Calibration

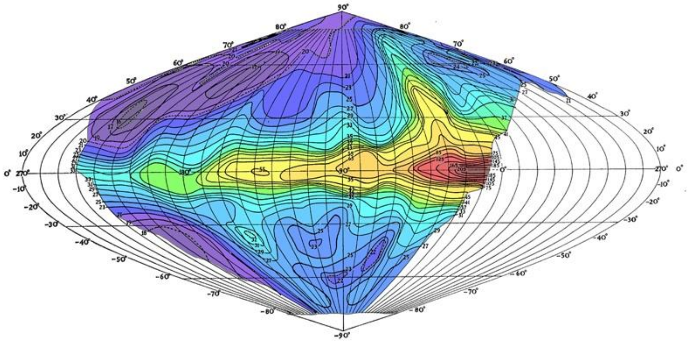
The 22 MHz example



Roger et al. (1999)

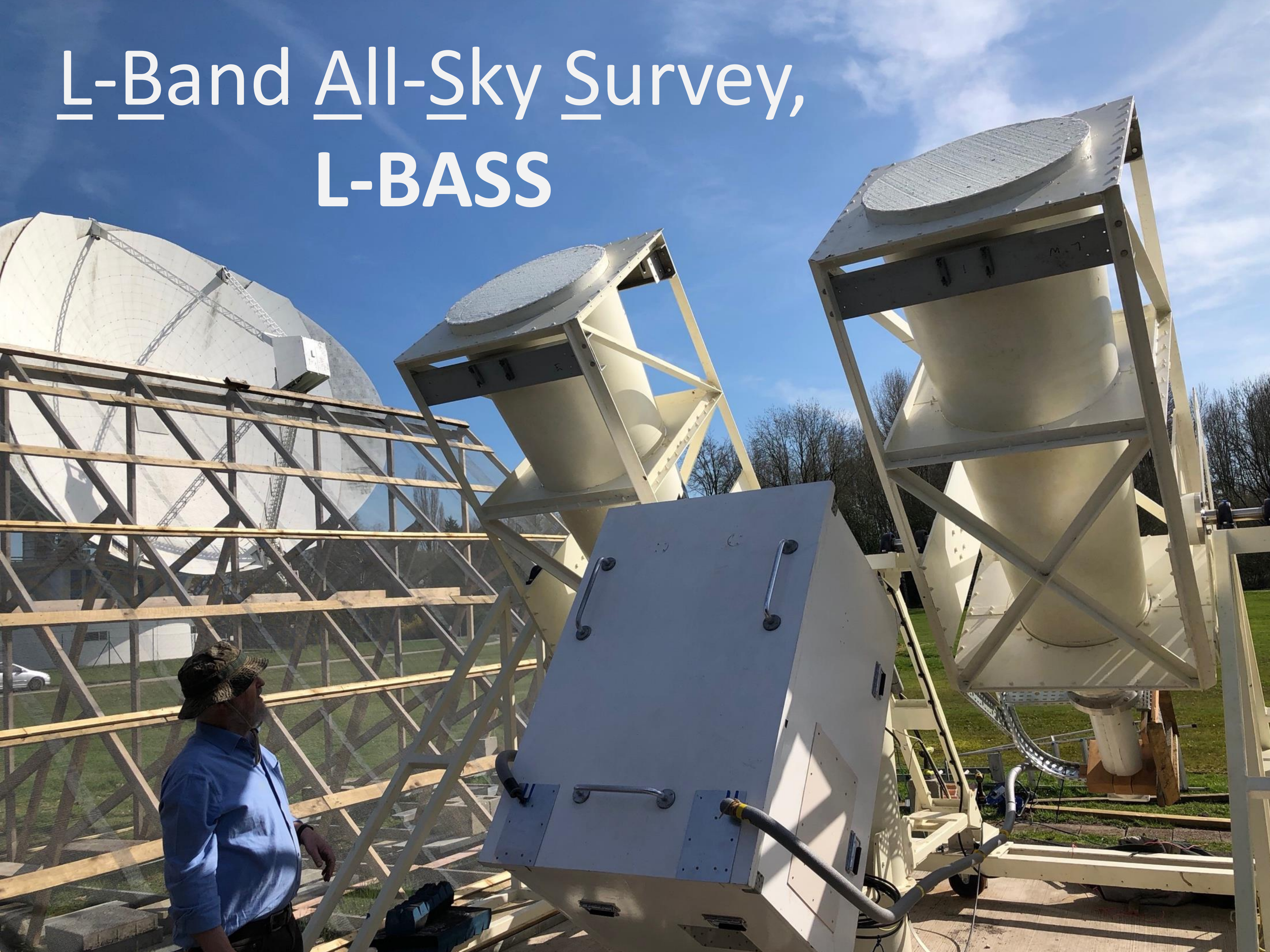


Haslam et al. (1981,1982)



Pauliny-Toth & Shakeshaft (1962)

L-Band All-Sky Survey,
L-BASS



MANCHESTER
1824
The University of Manchester

L-BASS Objectives

- Observe in radio astronomy protected frequency range: 1400 – 1425 MHz
- Achieve radiometric accuracy ≤ 0.1 K
- Establish an absolute zero-level using a cryogenic reference load
- Map the northern sky (initially)
- Test the ARCADE excess (~ 0.5 K at 1.4 GHz)
- Offer zero-level correction to other surveys

L-BASS

The announcement paper:

The University of Manchester

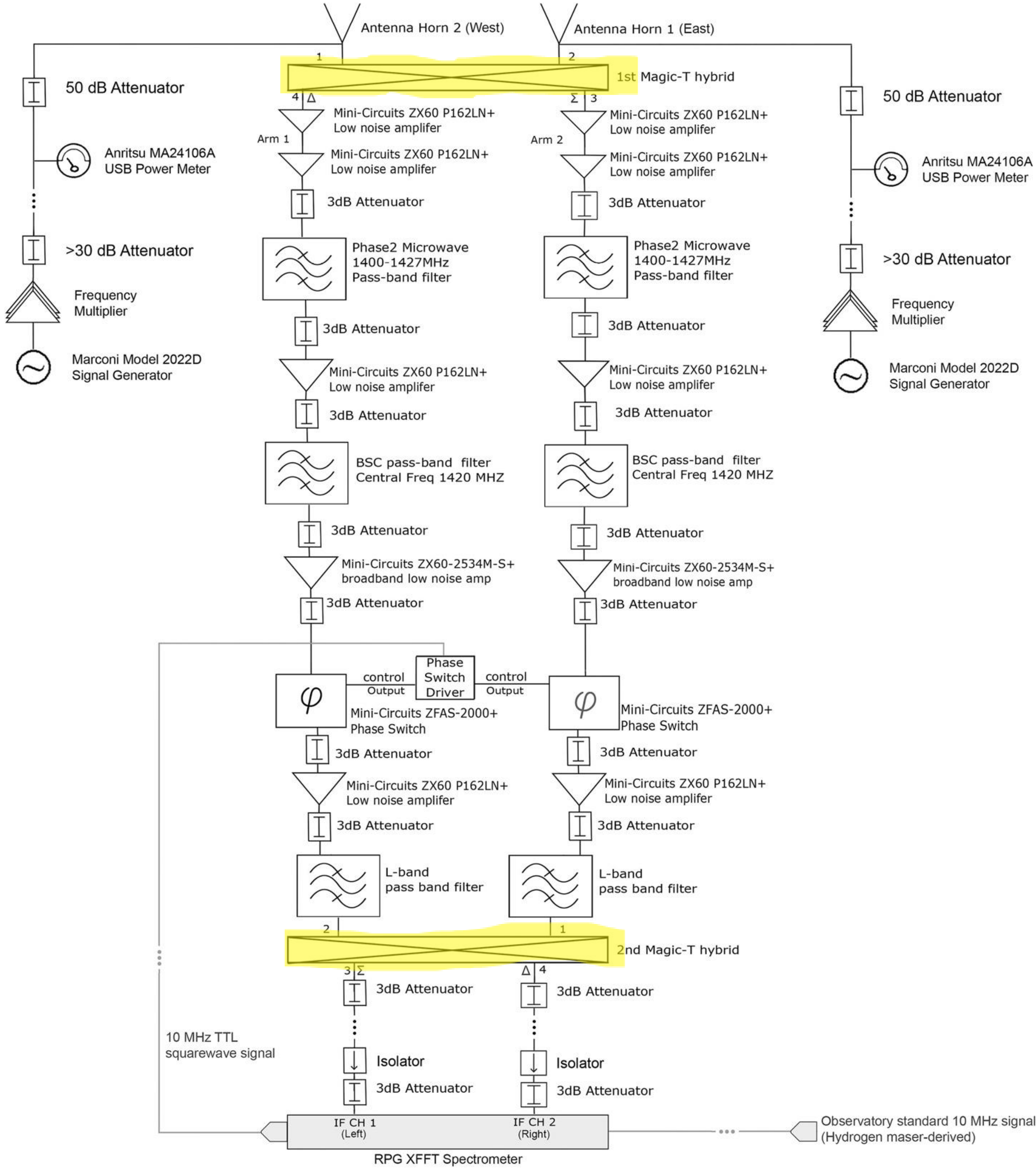
The Instrument

- Twin conical horn antennas (reference and science)
- Low-sidelobe pickup
- Diameter: 0.78 m
- Beam width: 23°
- Circular polarisation
- Digital spectrometer back-end

MANCHESTER 1824
The University of Manchester

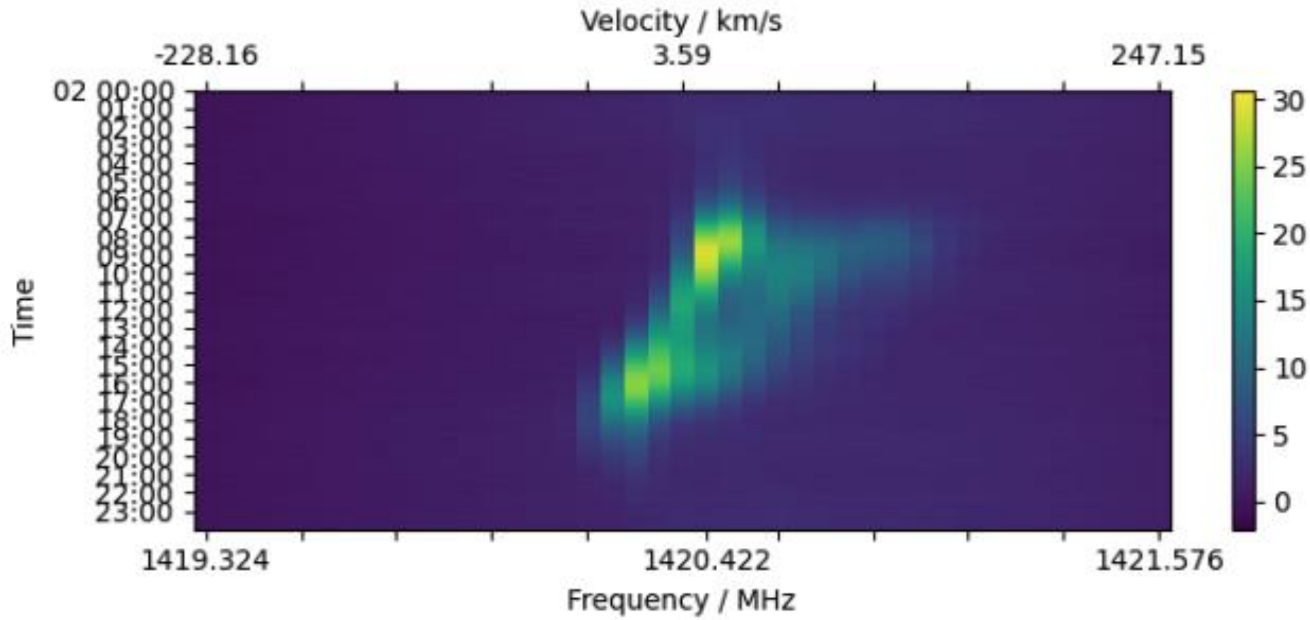
Receiver Architecture

- Continuous-comparison radiometer
- Suppresses gain fluctuations
- Reduces 1/f noise
- Architecture similar to WMAP and Planck-LFI



Calibration Methods

- Solar Flux observations (Flux Scale)
- Y-factor (Flux Scale)
- Cryogenic load (Absolute zero-level)
- CW (tone) injection (Gain drift)
- Galactic H_I (Sanity check)



MANCHESTER 1824
The University of Manchester

Controlling Systematics

- Ground screen
- Atmospheric emission
- Passive components (loss & noise)
- IR cloud detection

MANCHESTER 1824
The University of Manchester

Summary

- L-BASS will create an absolutely calibrated all-sky map at 1.4 GHz of ≤0.1 K accuracy.
- L-BASS will seek to verify the ARCADE excess. Our results will better characterise the excess and offer further constraints to theorists.
- L-BASS will offer zero-level corrections to other low frequency (ground-based) surveys. This will improve synchrotron foreground subtraction for several cosmological experiments.

MANCHESTER 1824
The University of Manchester

Galactic explanations for the ARCADE excess:

- **Radio Emissive Galactic Halo** – Subrahmanyan & Cowsik (2013) / Orlando & Strong (2013)
- **The Local Bubble** – Krause & Hardcastle (2021)

Extragalactic explanations for the ARCADE excess:

- **Dark Matter** – Fornengo et al. (2011)
- **High Redshift Particle Decay** – Cline & Vincent (2013)
- **Cosmic Strings** – Gessey-Jones et al. (2023)
- **Non-equilibrium State Turbulent Early Universe** – Baiesi et al. (2020)
- **Accreting radio-loud Black Holes** – Ewall-Wice et al. (2020)
- **Gravitational Waves** – Domcke & Garcia-Cely (2021)
- **Cluster Mergers / Acceleration Effects** – Fang & Linden (2015, 2016)
- **Fast Transients** – Kehayias et al. (2015)
- **Dark Photons** – Pospelov et al. (2018); Acharya & Chulba (2023)
- **Population III Supernovae** – Jana et al. (2019)

Extra-galactic source counts, and modelled synchrotron brightness associated with known populations are considered by Singal et al. (2010), Murphy & Chary (2018), Vernstrom et al. (2015), Condon et al. (2012) and Gervasi et al. (2008). Known extra-galactic synchrotron emitters such as quasars, AGN, radio galaxies and star forming galaxies are variously discounted as being able to produce the excess, e.g. in Ponente et al. (2011) and Ysard & Lagache (2012).