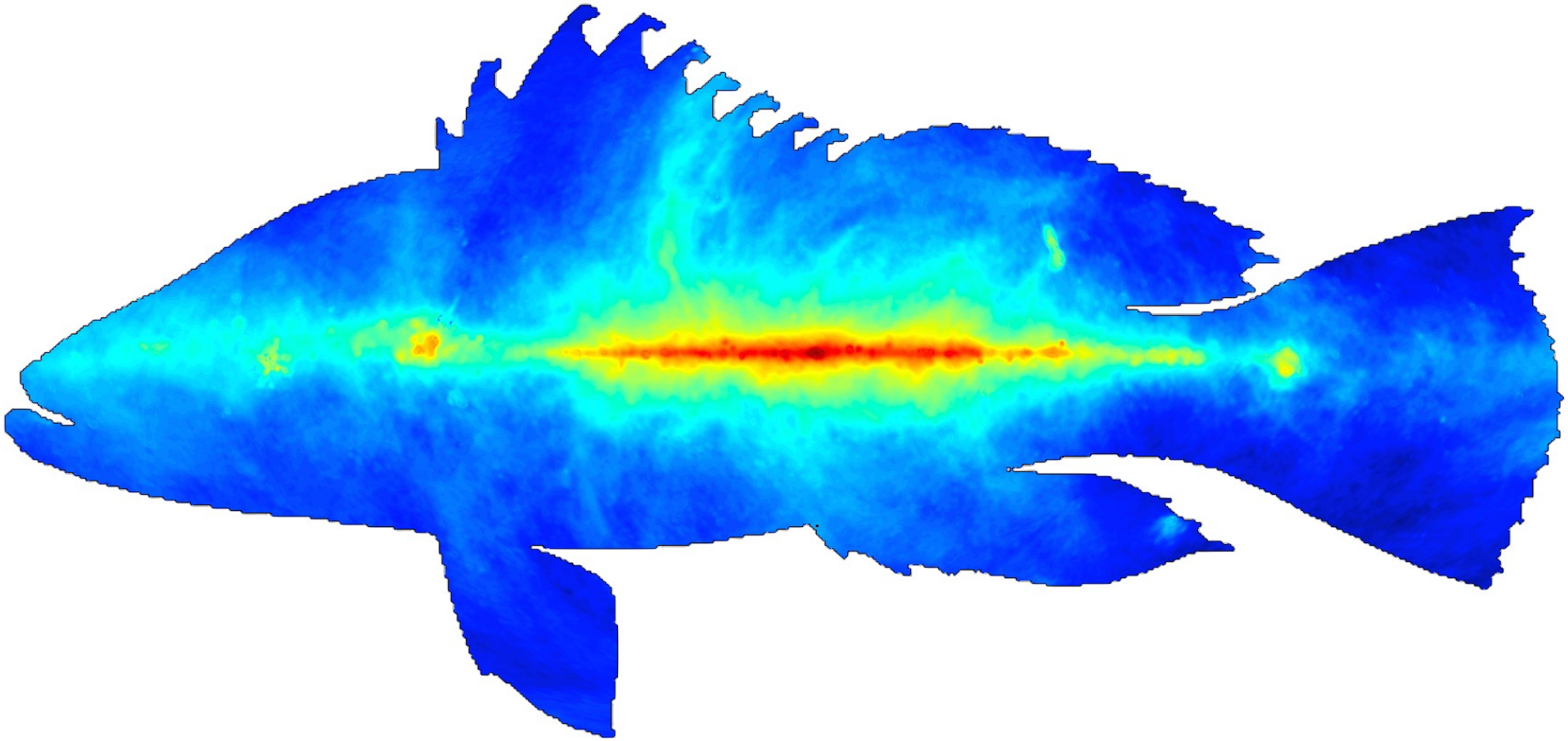
An Overview of the C-Band All Sky Survey



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THE ROYAL SOCIETY

What is C-BASS?

- Low-frequency, ground-based all-sky survey
- 2 Telescopes, 1 in each hemisphere
- Observe at 5 GHz with a 1 GHz bandwidth, high enough to avoid Faraday rotation, low enough to maximize sensitivity to synchrotron radiation

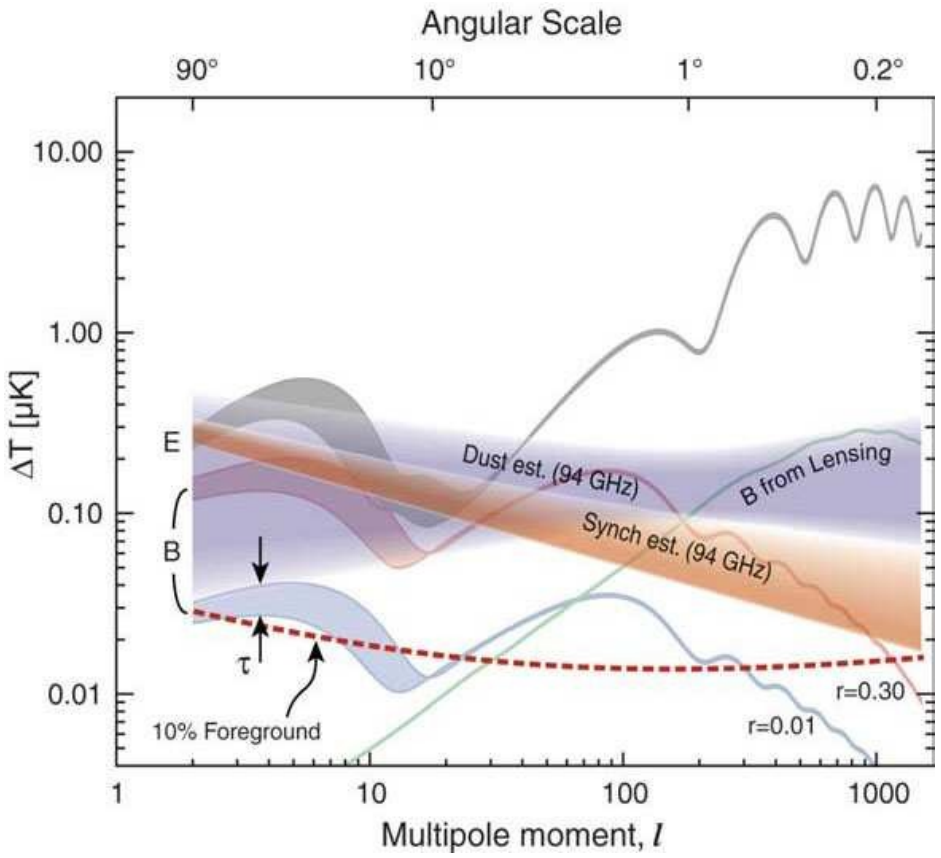
North vs South

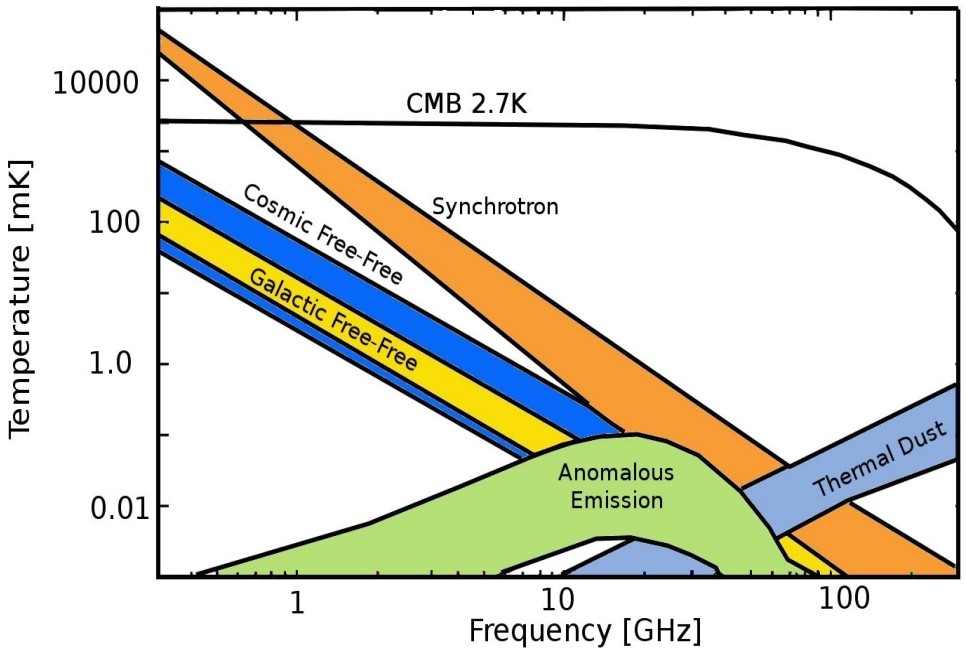
	North	South
Location	Owens Valley Radio Observatory	SKA Support Base in Klerefontein
Bandwidth	4.5 – 5.5 GHz across 1 channel	4.5 – 5.5 GHz across 128 channels
Backend	Analogue	Digital
Dish Diameter	6.1 m with absorbing baffles	7.6 m under-illuminated
Optical Configuration	Gregorian	Cassegrain
Angular Resolution	0.73 degrees	0.73 degrees
Sensitivity	0.1 mK per beam	0.1 mK per beam
Start of Observations	Nov 2012	Early 2015
End of Observations	Early 2015	

C-BASS Science Goals

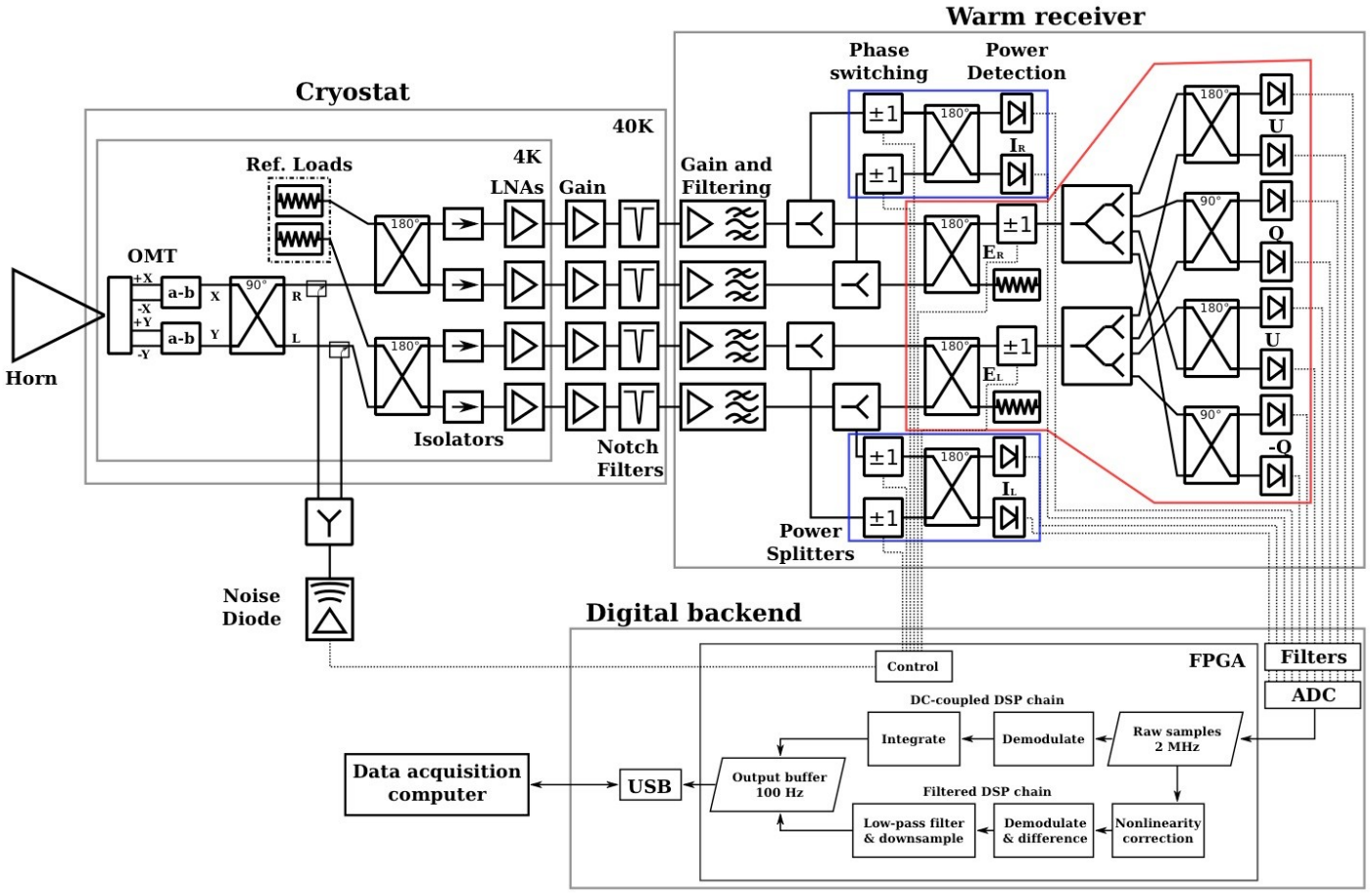
- To produce all-sky Stokes I,Q and U maps of Galactic synchrotron emission to be used in foreground component separation in CMB polarization experiments. These maps would aid in the measurement of primordial B-modes
- Probe Galactic magnetic field, using synchrotron radiation which is weakly affected by Faraday rotation at 5 GHz
- Search for new regions of anomalous microwave emission (AME)
- C-BASS fits between S-PASS (2.3 GHz) and WMAP (22 GHz)

Galactic Foregrounds





Northern Receiver Architecture



Intensity and Polarization Calibration

- C-BASS receiver is a continous-comparison radiometer combined with a correlation polarimeter, providing direct, continuous measurements of the *I*, *Q* and *U* Stokes parameters
- Phase and gain imbalances within the polarimeter lead to mixing of the Stokes parameters – polarization leakage
- Polarization leakage described by the telescope response matrix R^T

$$\boldsymbol{d = R^T P s}$$

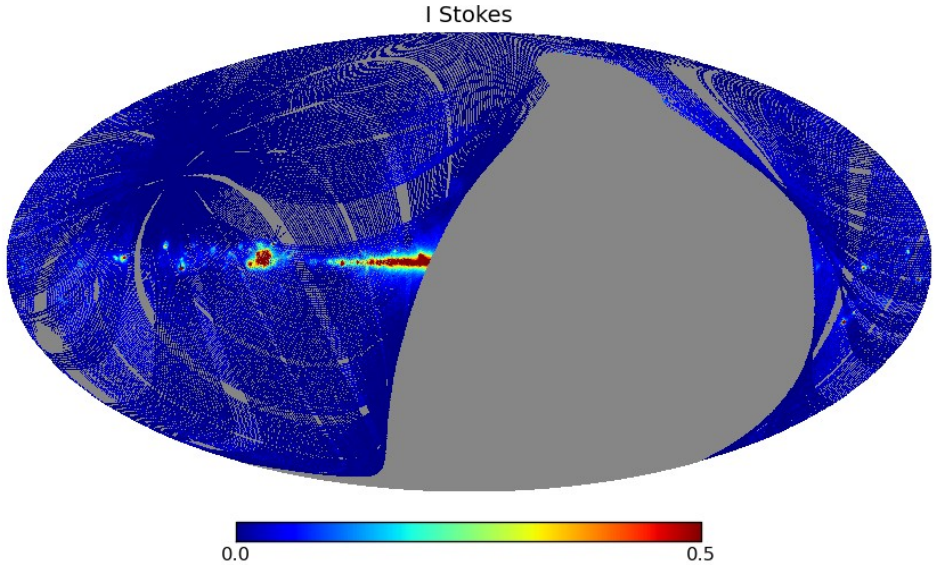
Where $d = (I1,Q1,U1,I2,Q2,U2)^T$, P is the rotation matrix due to the parallactic angle and s is the true Stokes vector in sky co-ordinates

- Calibrate by observing Tau A (~6% polarized)
- Leakage is small (<0.5%)

Intensity and Polarization Calibration

- Intensity is calibrated using the primary flux calibrator, Tau A and cross-checked against Cyg A and Cas A
- Calibration observations are made every couple of hours
- Also use a noise diode source between azimuth scans to maintain temperature calibration stability over much shorter time scales
- Atmospheric opacity effects, typically ~1% at zenith at 5 GHz, are measured using sky dips

Scan Strategy for Northern System Latitude: 37°

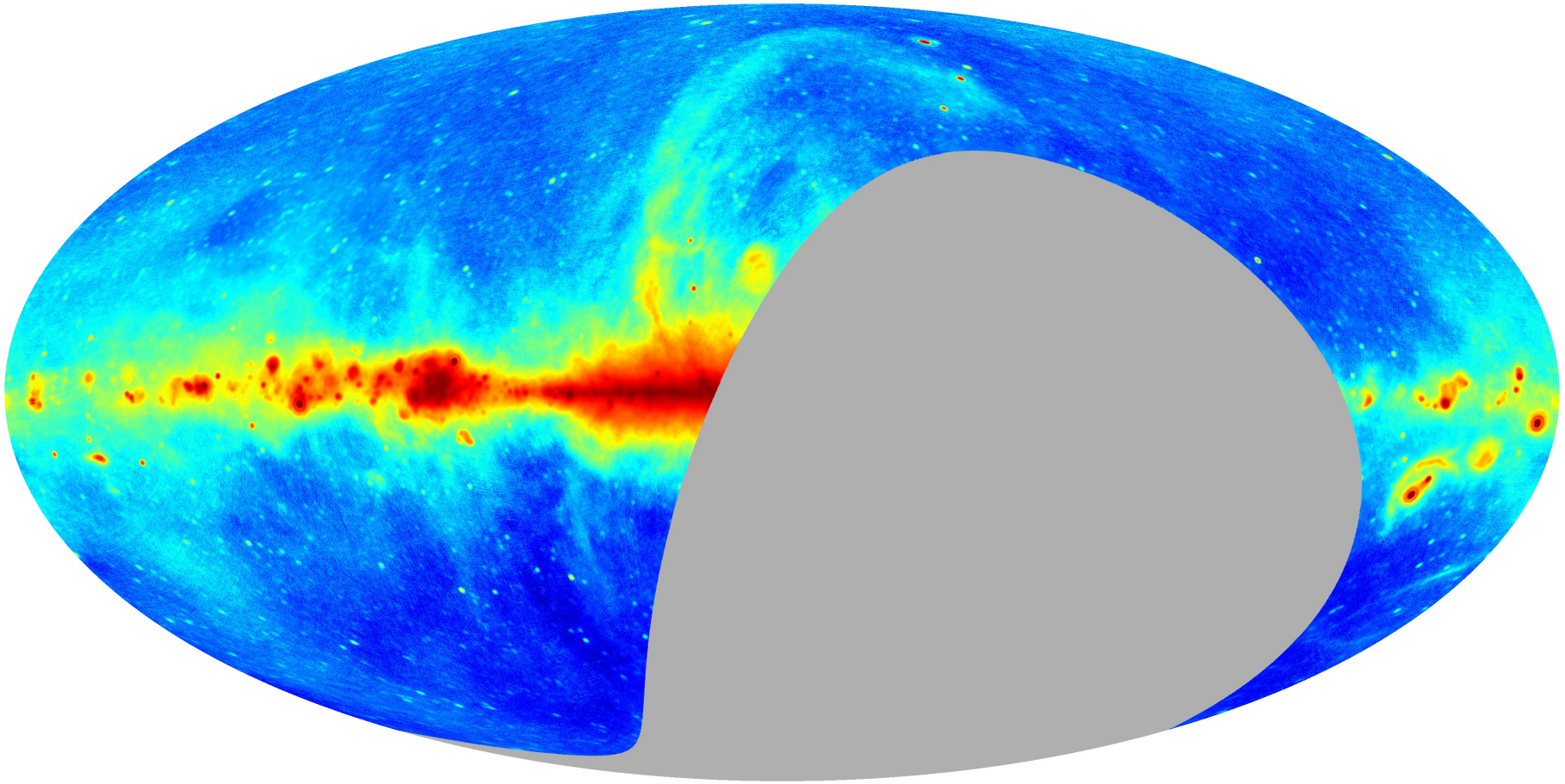


- Constant elevation scans through constant airmass at elevations of 37, 47, 67 and 77 degrees minimize atmospheric emission variation
- Scan speeds of between 3.8 and 4.2 deg/s
- Several elevations ensures more uniform integration time across the sky and leads to each sky pixel being crossed with a wider range of position angles – more effective destriping at the mapping stage

Destriped Map Making

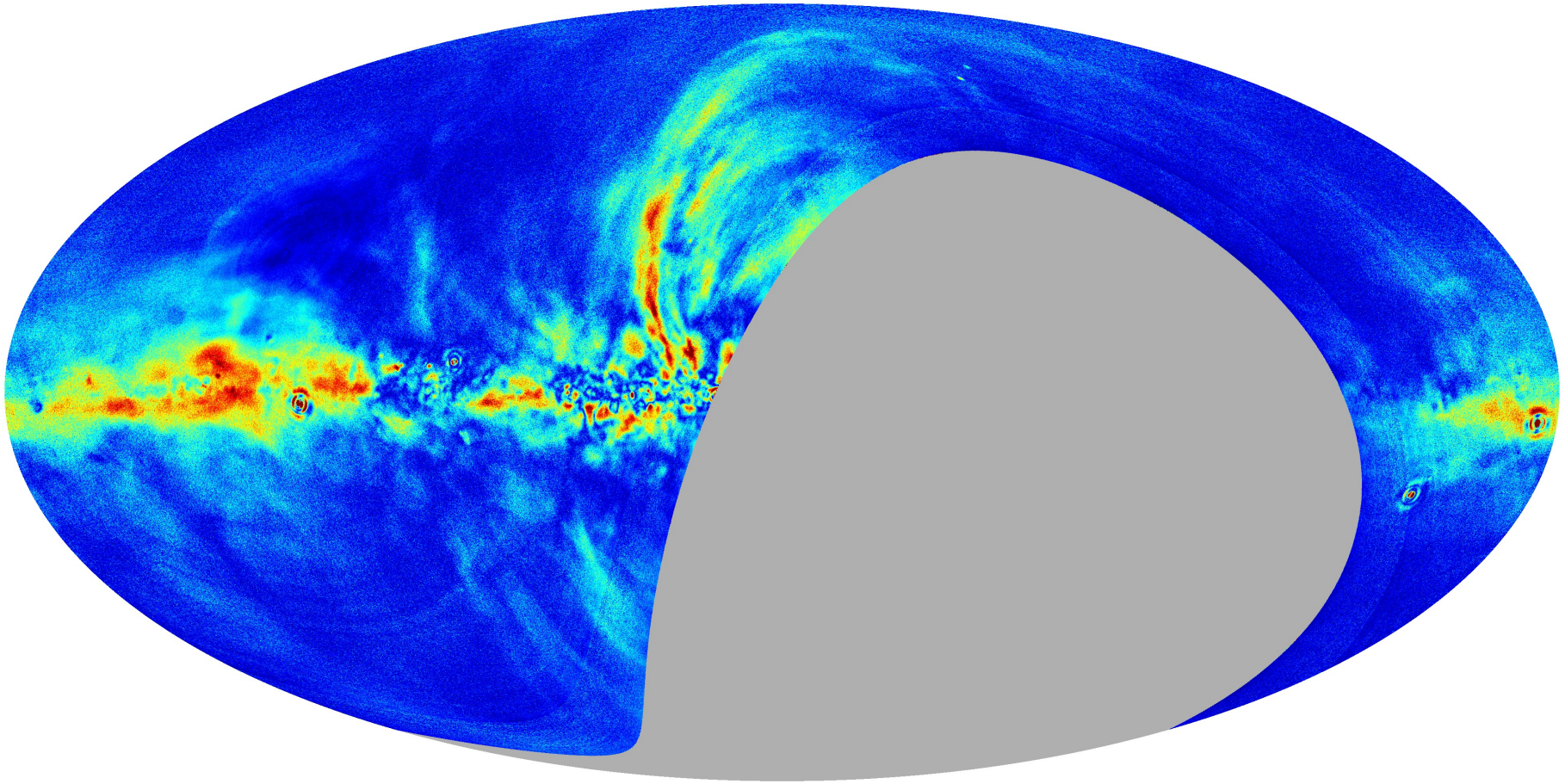
- C-BASS maps are constructed from the time-ordered data using an optimized parallel destriping code called DESCART (DEStriping CARTographer)
- DESCART performs a maximum-likelihood fit to the correlated noise in the timestream by modelling the noise vector as an uncorrelated white-noise component plus a series of discrete offset functions to represent the correlated noise
- In order for this method to work effectively, each pixel must be crossed by several scans at widely separated angles

Preliminary Intensity Map



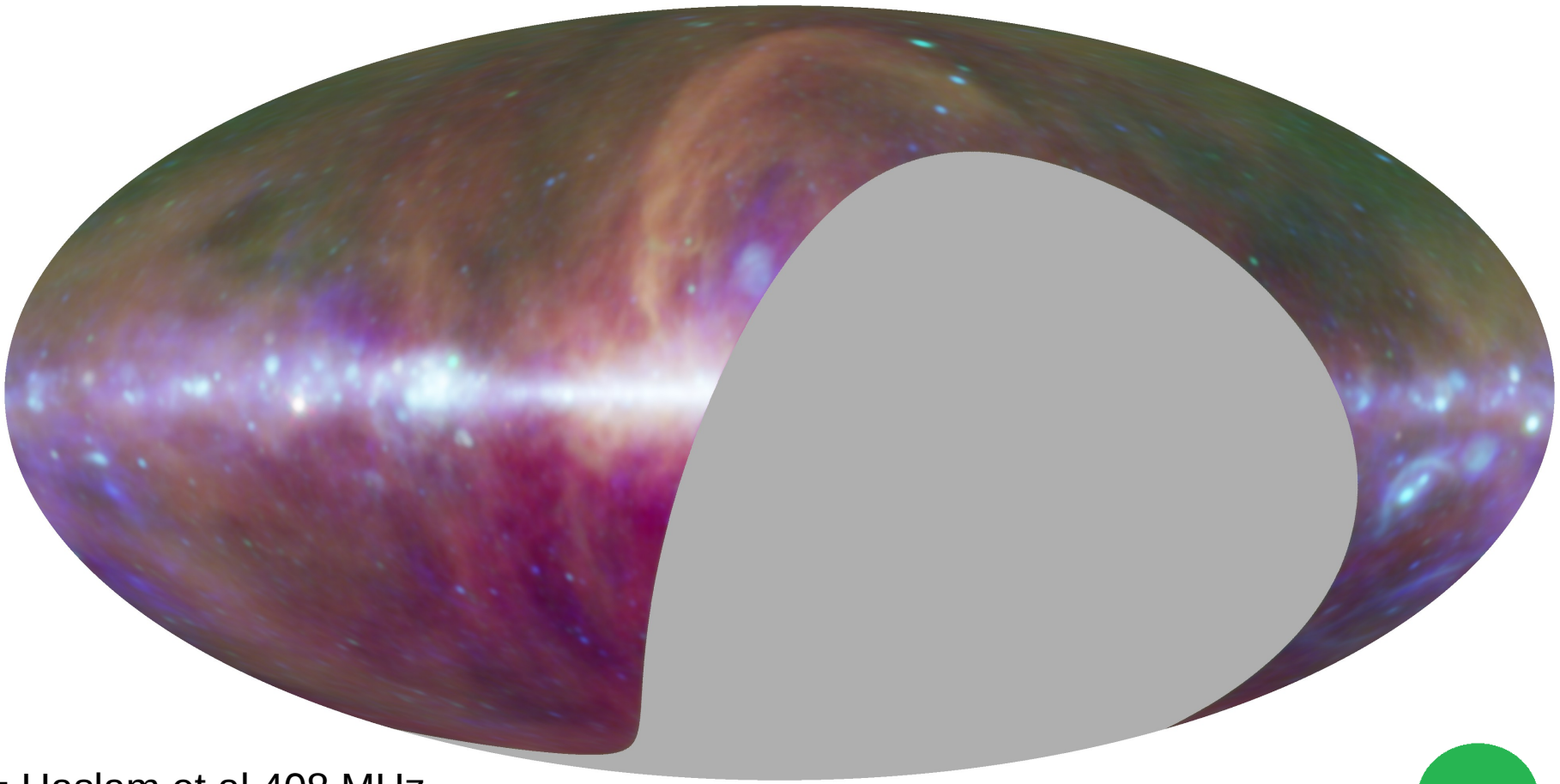
Stokes I, 20 months night time data. Highly non-linear colour scale to show features at all brightness levels. The ratio of the brightest pixel to thermal noise level in the map is over 10,000:1

Preliminary Polarized Intensity Map

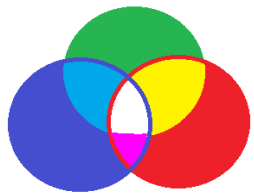


$(Q^2 + U^2)^{1/2}$ on a linear intensity scale

Three Colour Combination of Haslam, C-BASS and WMAP



Red = Haslam et al 408 MHz
Green = C-BASS *I* 5 GHz
Blue = WMAP K–V band



The colours are balanced such that a temperature spectrum of index -2.7 would appear white.
The intensity scale is highly non linear

C-BASS South Commissioning Status

- Completed receiver commissioning at HartRAO
- Assembled in Klerefontein and undergoing final preparations before beginning observations in early 2015

- Drive system operational
- Check receiver operation
- Photogrammetry
- Optical Pointing

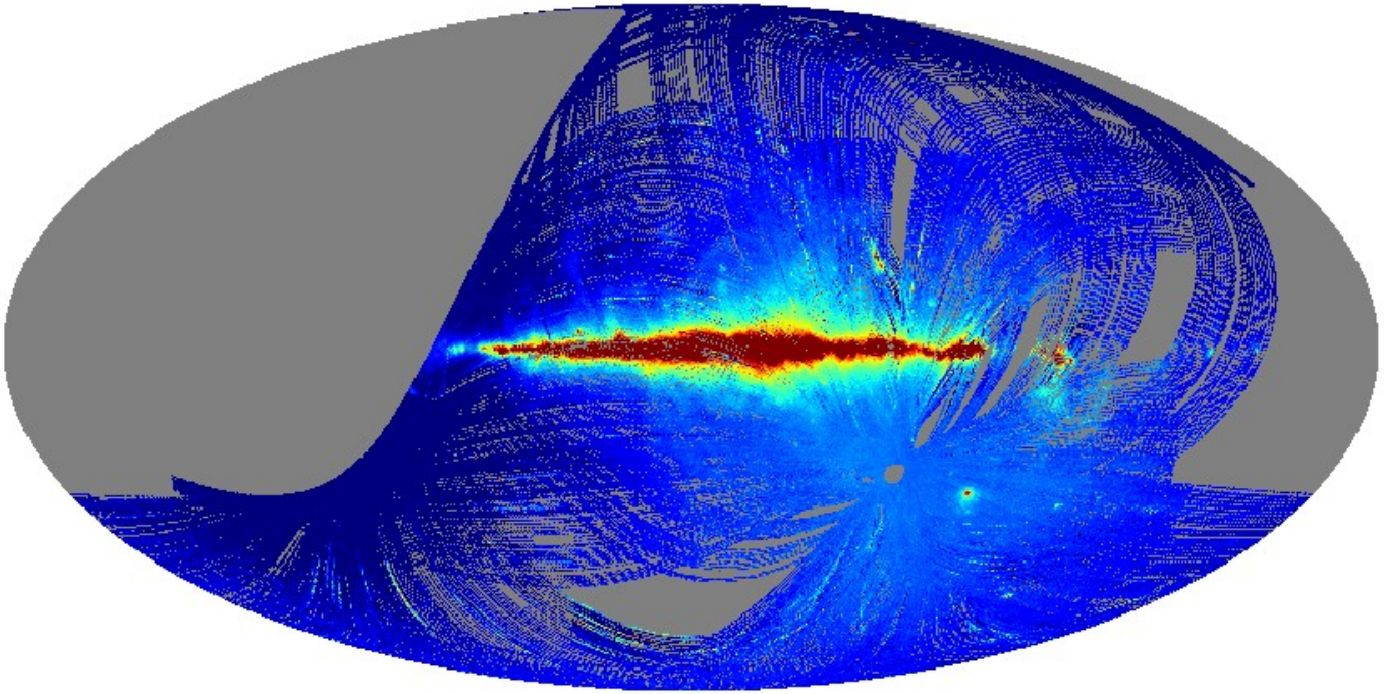
Major Setbacks:

- Rapid power fluctuation
- Lightening strike

Damage:

- Control computer
- GPS 1PPS
- iADCs

First Light!



* Note: This map is completely preliminary!
  - No refined pointing model
  - No RFI flagging
  - Only a few hours data

Summary

- C-BASS is a 2 telescope low-frequency, ground-based, all-sky survey centred at 5 GHz
- Our main aim is to produce maps of the entire sky in Stokes I, Q and U
- The northern survey is ending observations and maps are in production
- The southern survey is about to begin observations
- The collaboration has just released a paper:

  http://arxiv.org/abs/1501.06069