Bayesian Data Analysis for REACH

2nd Global 21cm Workshop 2019

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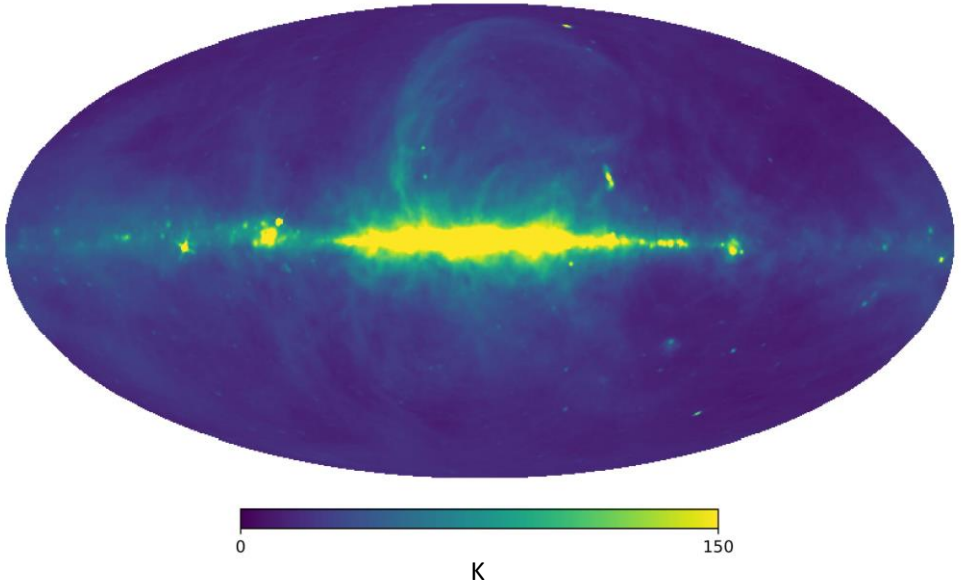
PhD Student

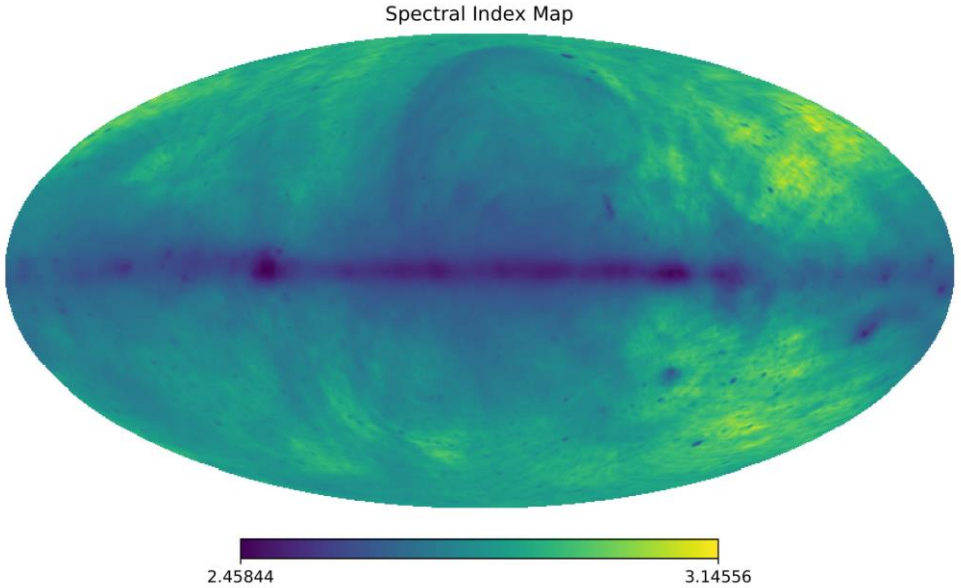
Bayesian Analysis

PolyChord – Bayesian Nested Sampling Algorithm (Handley, Hobson & Lasenby 2015)

- Model comparison through Bayesian Evidence
- Ranking parameter evaluation speeds

Varying B sky model

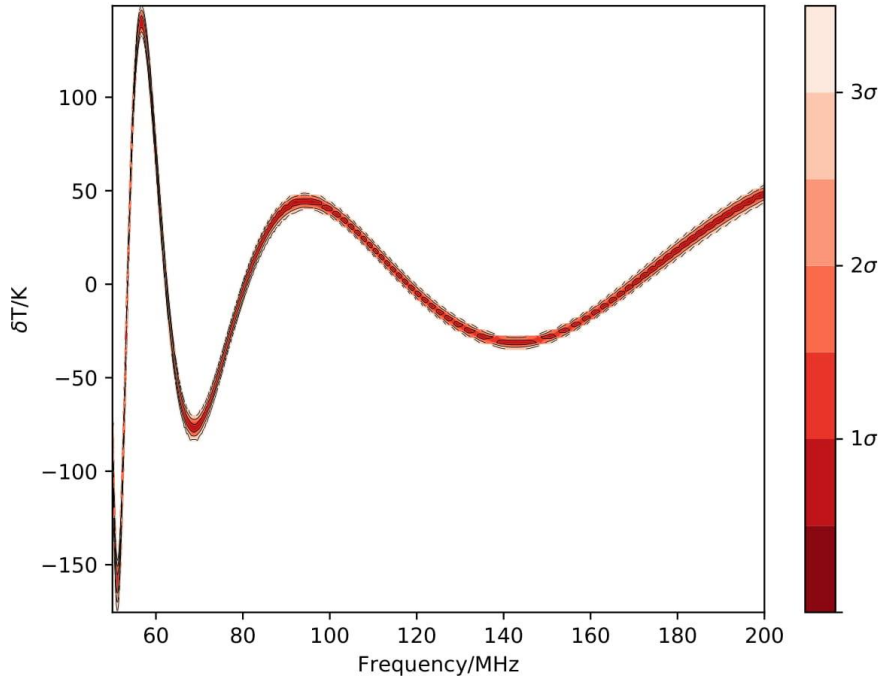




$$\ln(T_{foreground}(\nu)) = \sum_{i=0}^{4} a_i \left(\ln\left(\frac{\nu}{\nu_0}\right)\right)^i$$

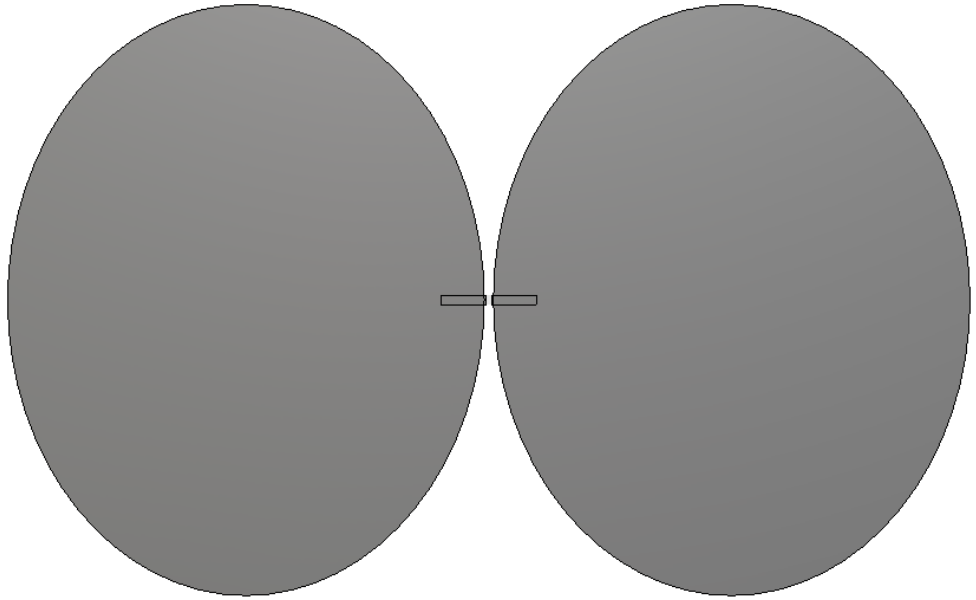
- Remazeilles et al. 2015
- de Oliveira-Costa et al 2008

Elliptical Dipole Antenna



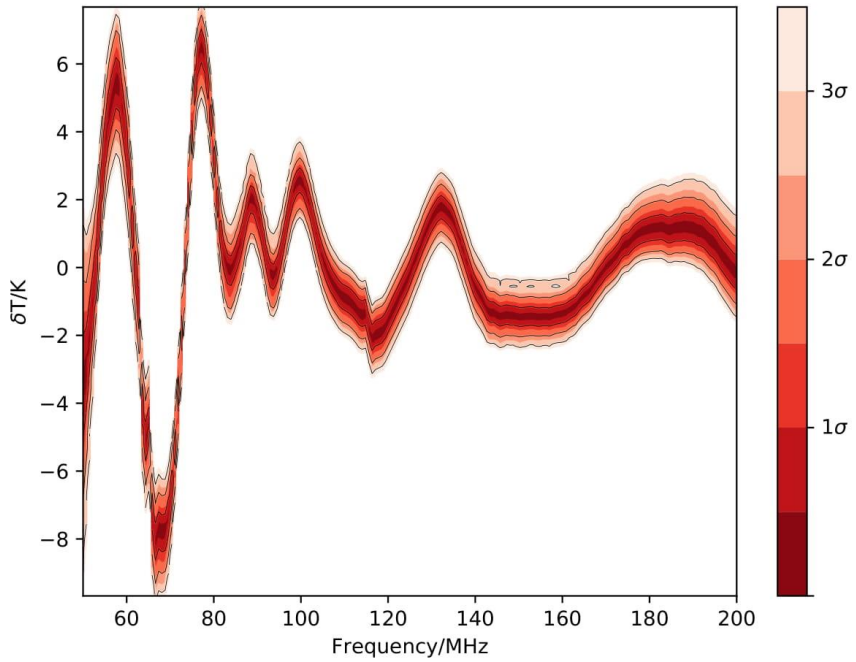
Anstey et al. 2019, in prep.

Antenna designs not finalised



Antenna patterns and images provided by John Cumner and Quentin Gueuning

Log Spiral Antenna



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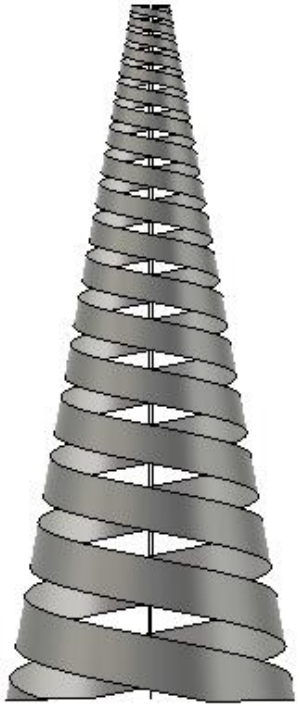

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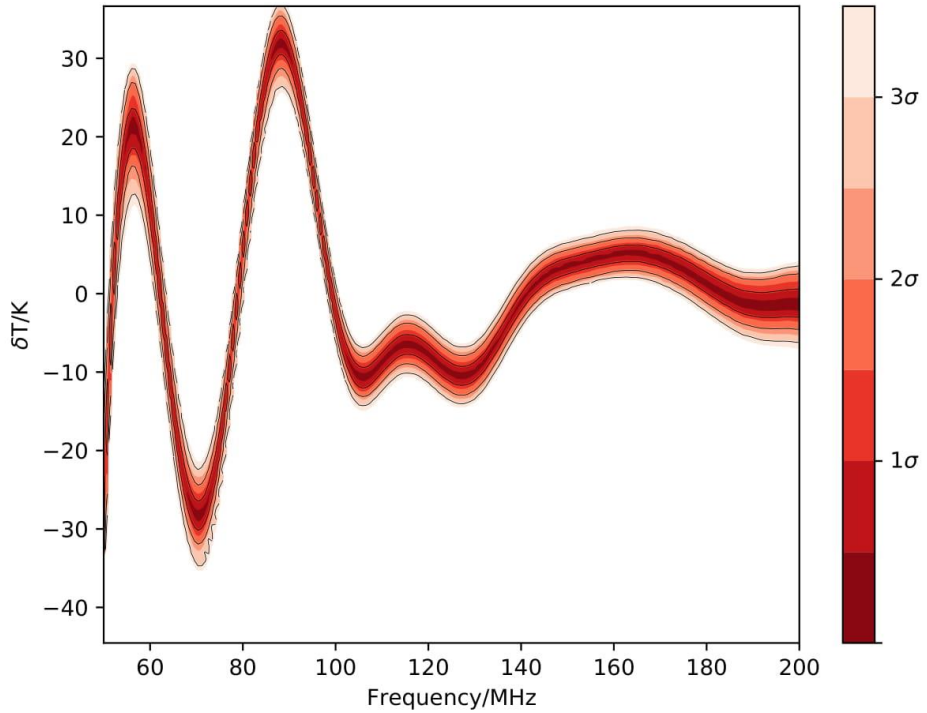
Conical Sinuous Antenna



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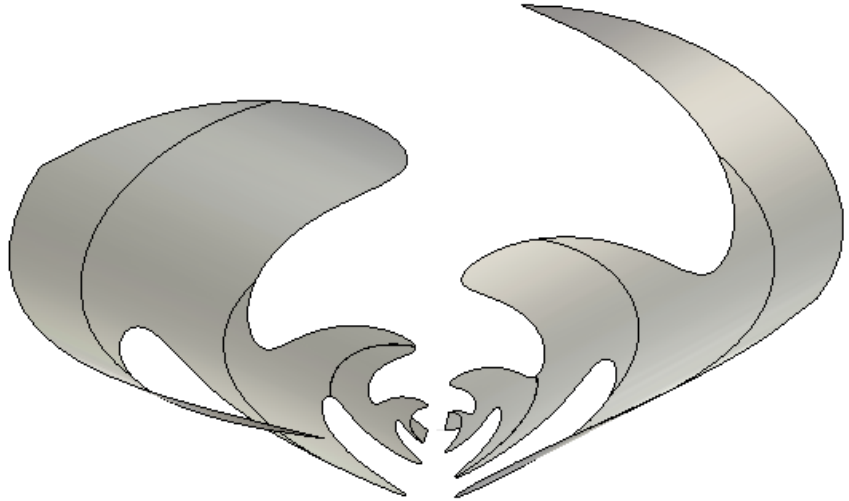

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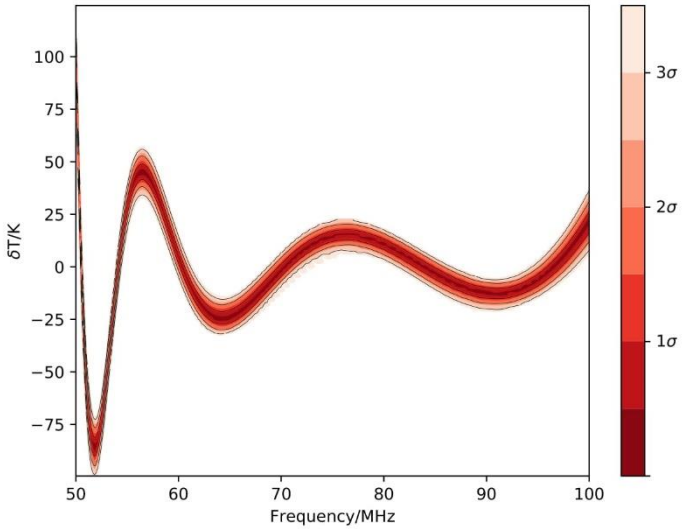
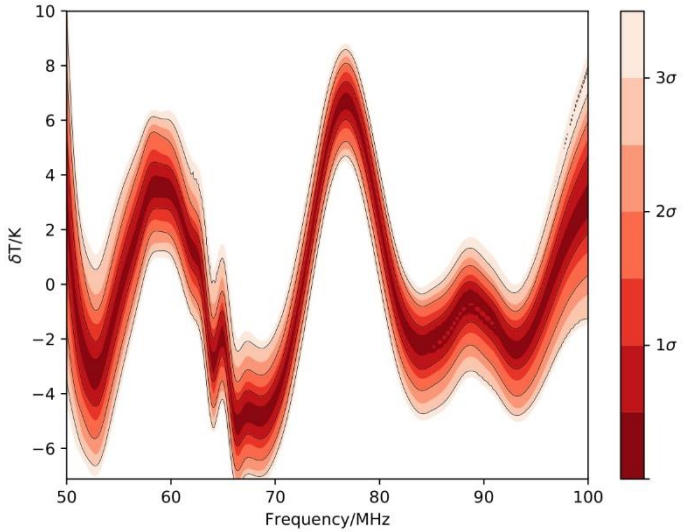
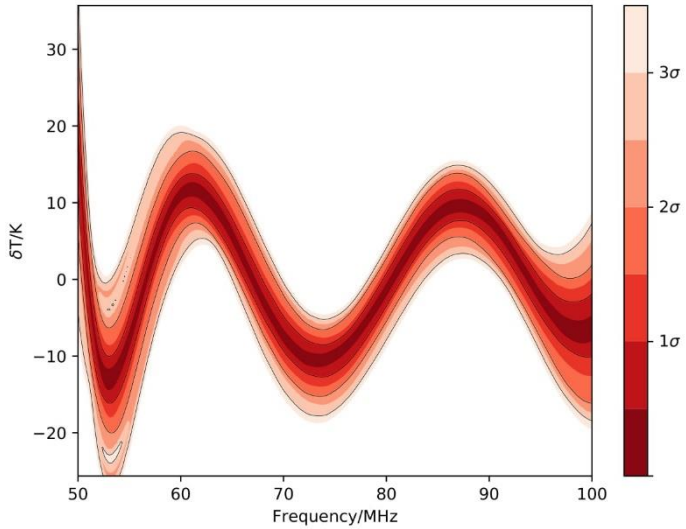
Narrow Frequency Band



Elliptical Dipole



Log Spiral



Conical Sinuous

Anstey et al. 2019, in prep.

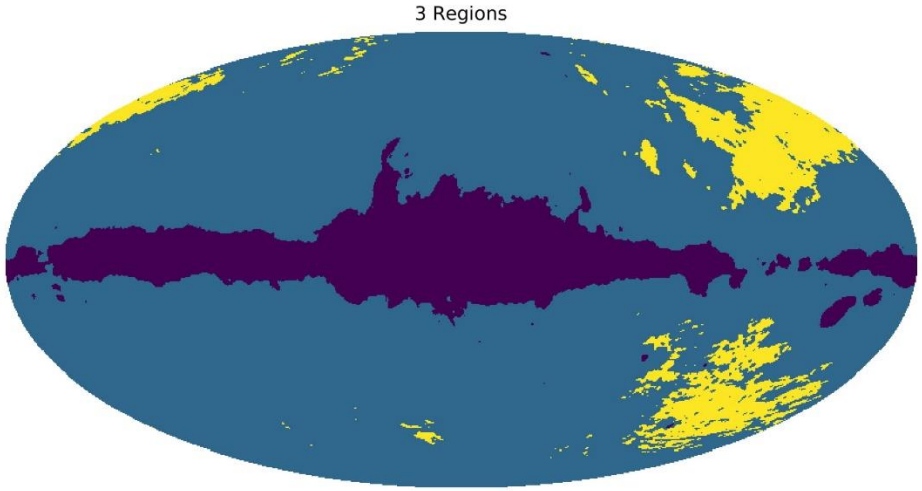
General Modelling Protocol

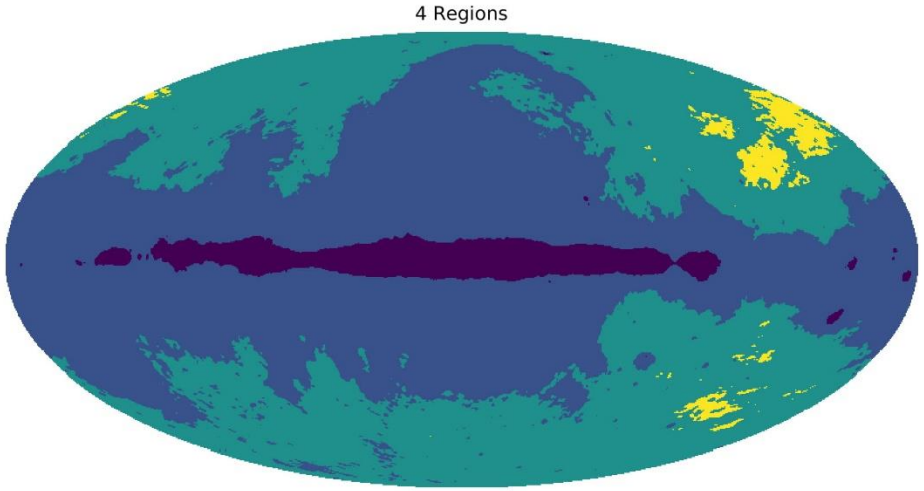
- Generate a parameterised model of the entire sky across the whole frequency range

- Generate a parameterised model of the antenna pattern

- Fit a foreground model of the convolution of the pattern model with the sky model

Sky Division





Anstey et al. 2019, in prep.

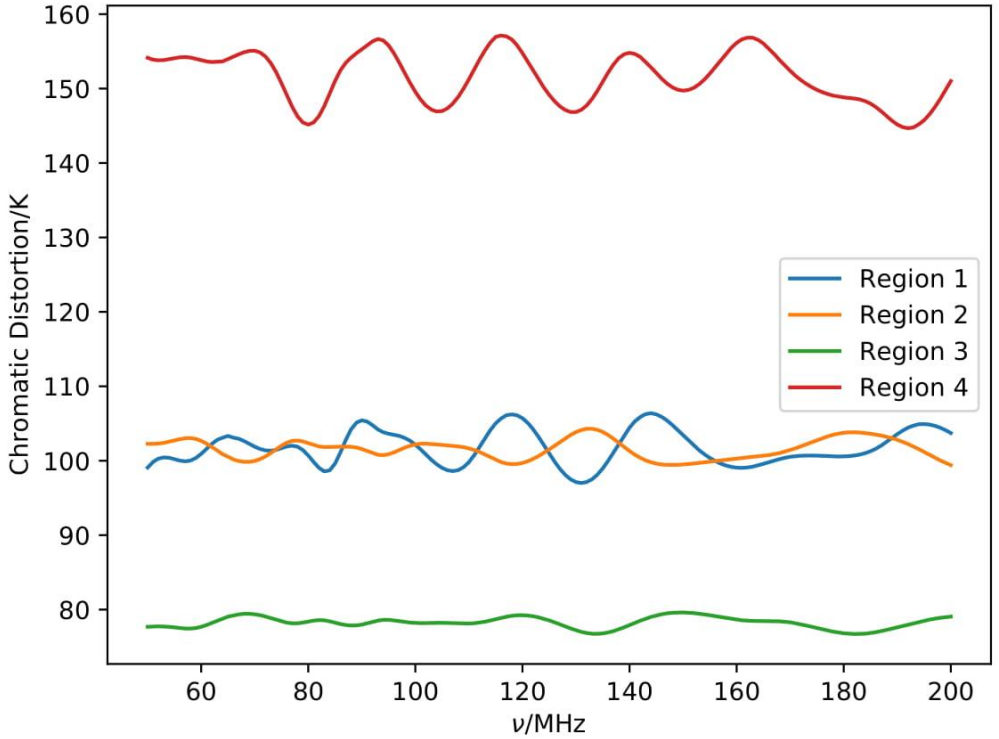
Foreground Model Function

$$K_i(\nu) = \frac{1}{4\pi}\int_{sky} G(\theta,\varphi,\nu) M_i(\theta,\varphi) \int_{time} [T_{base}(\theta,\varphi) - T_{CMB}]\, dt d\Omega$$

$$T_{foreground}(\nu) = A\sum_{i=1}^{N} K_i(\nu)\left(\frac{\nu}{\nu_{base}}\right)^{-\left(B_i + C_i ln\left(\frac{\nu}{\nu_0}\right)\right)}$$

Anstey et al. 2019, in prep.

Chromatic Functions



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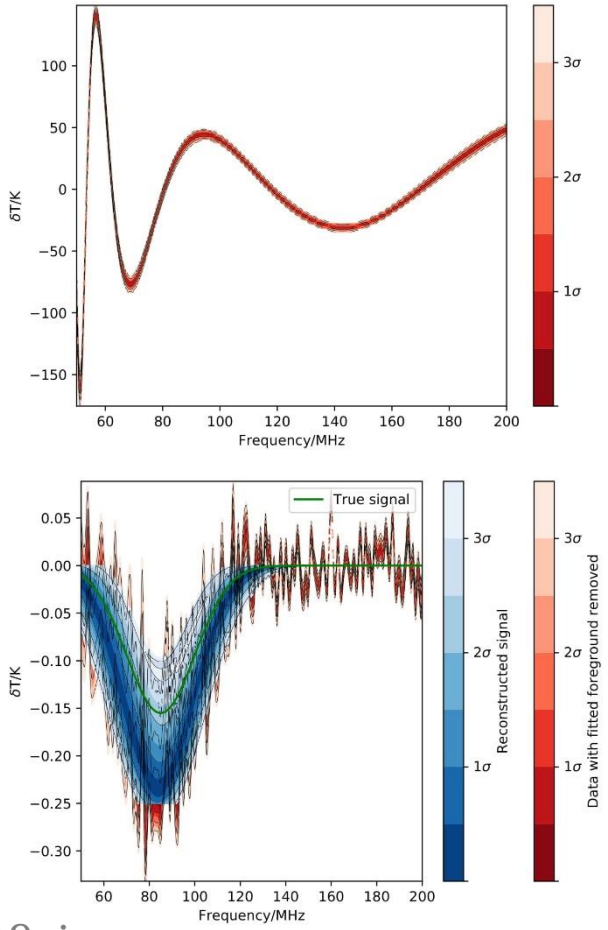
Results



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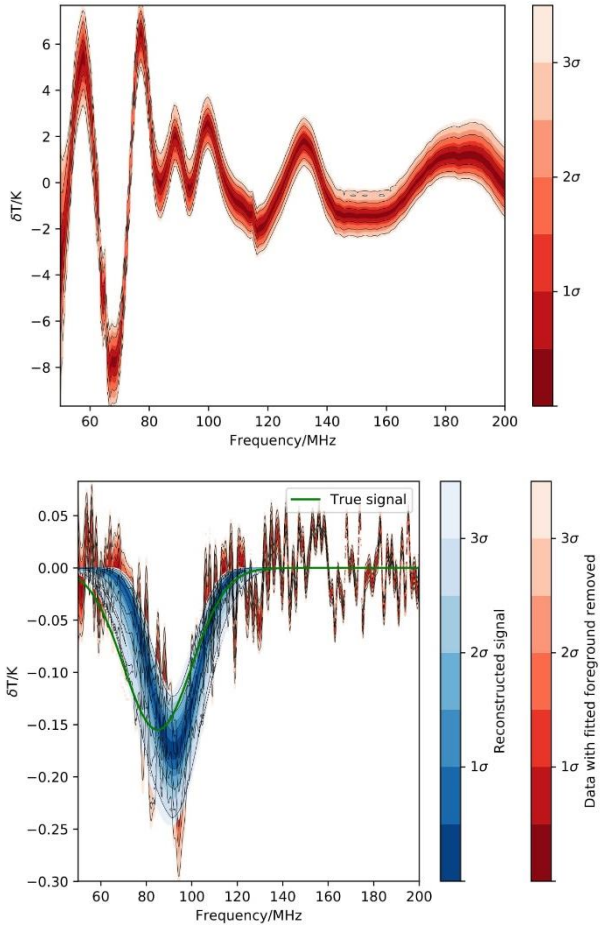

Log Spiral

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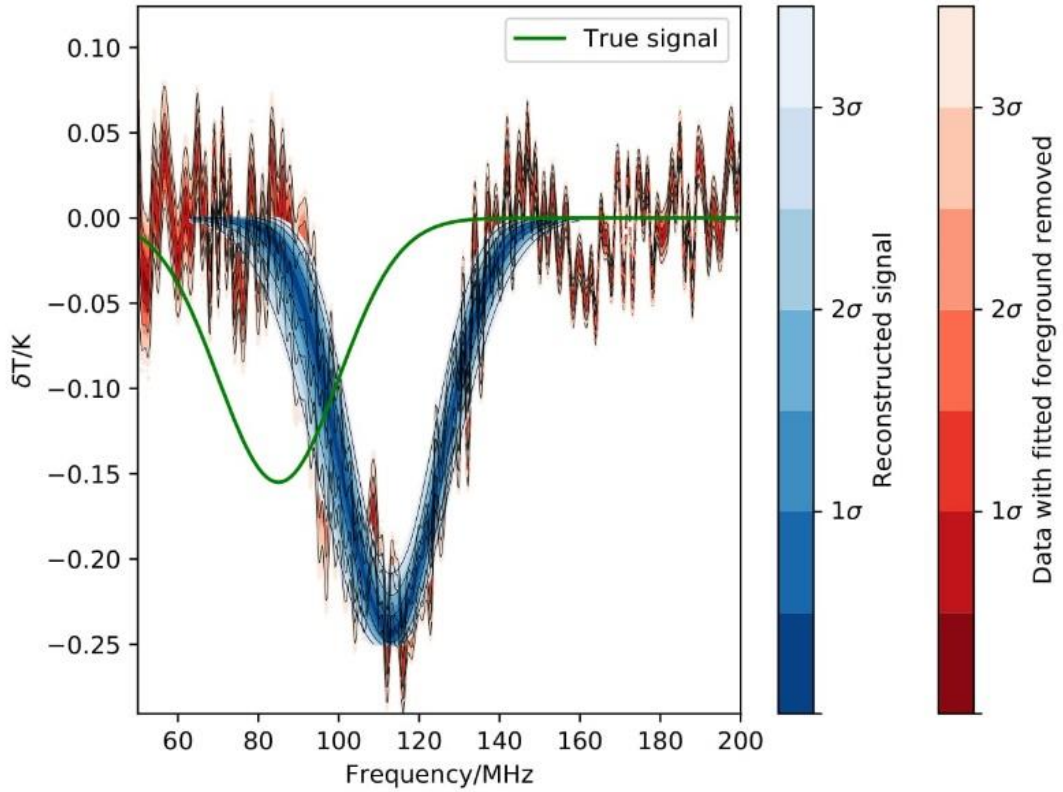
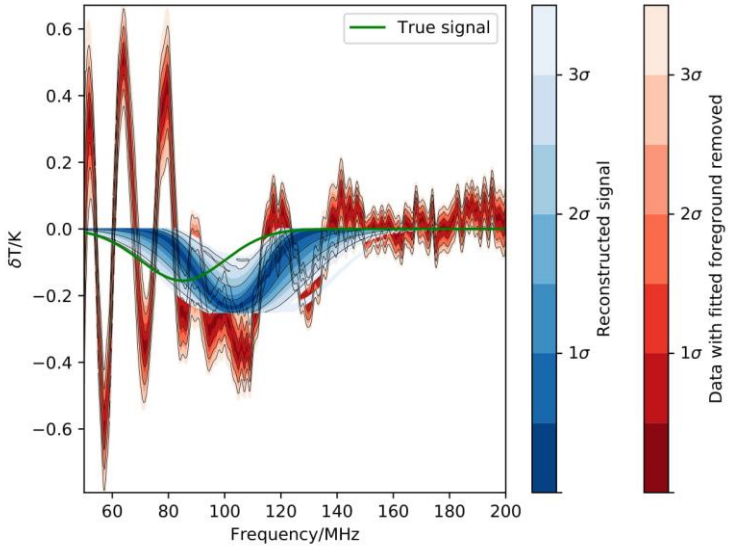
Inefficiencies



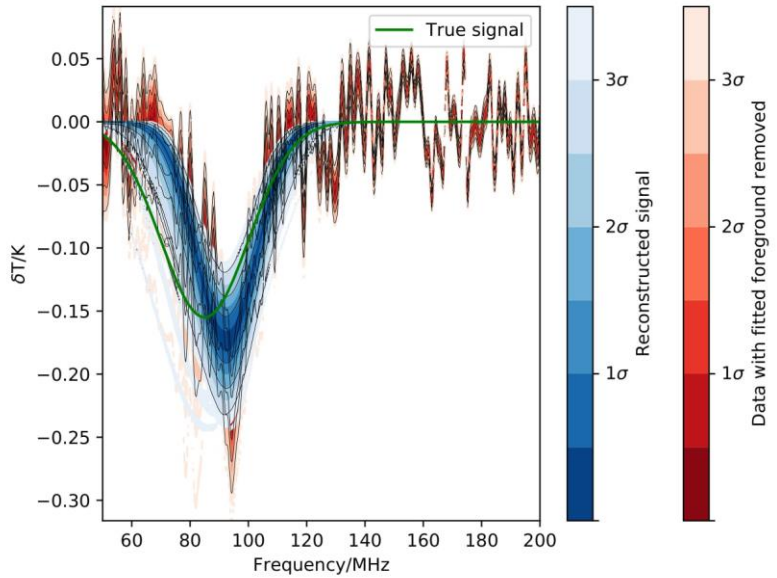
Conical Sinuous Antenna

Numbers of sky regions

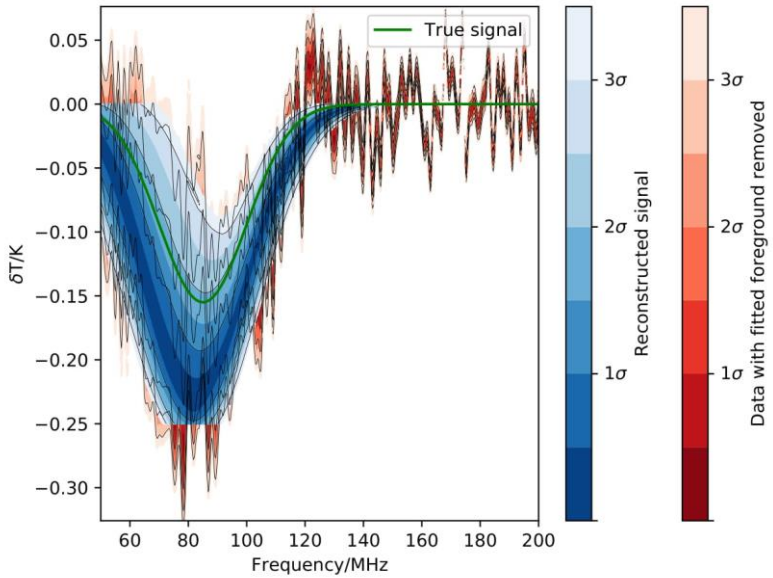
3 Regions



4 Regions



5 Regions



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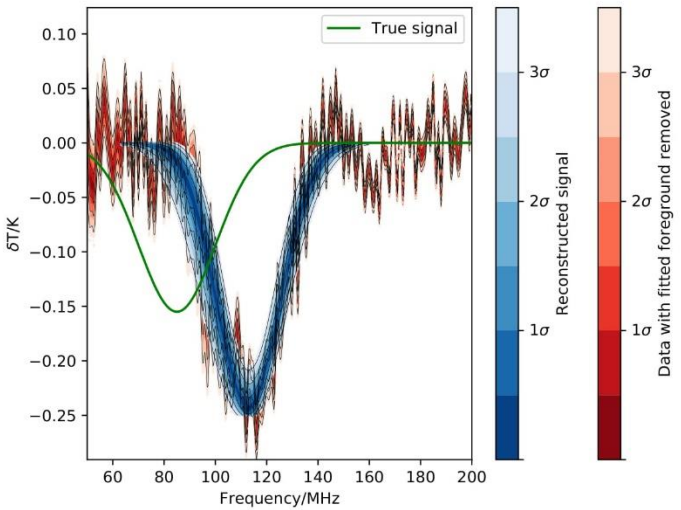
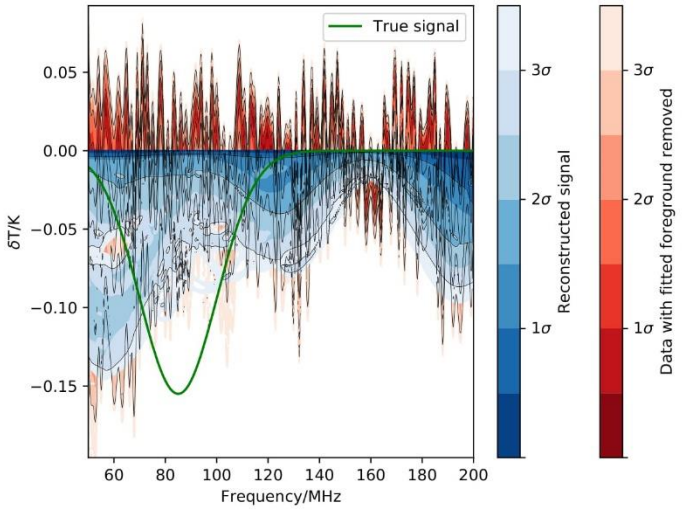
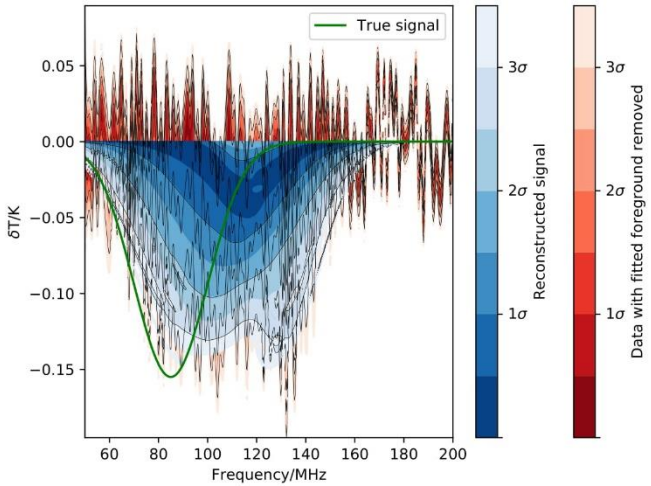


8 Regions



11 Regions



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Summary

- Even smooth, simple antennae produce enough chromatic distortion to conceal the 21cm signal when the spectral index varies

- The proposed method of fitting the foregrounds via modelling can correct for this distortion sufficiently for the 21cm signal to be identified, provided the antenna is quite smooth.

- Increasing the number of regions the sky model is divided into improves the quality of the chromaticity correction

- The distortion cannot be accurately modelled if too few regions are used

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Plots produced using fgivenx tool: Handley, 2018