Updates on 21-cm global signal analysis

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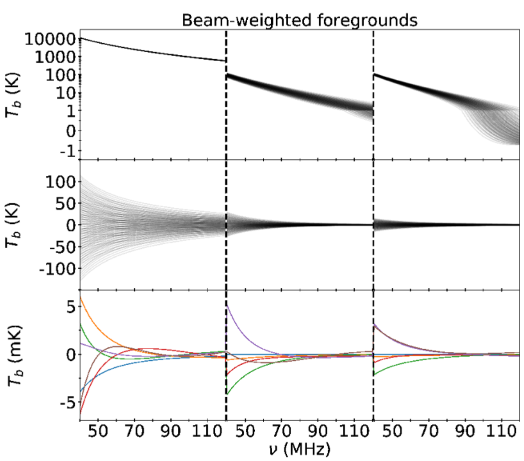
Keith Tauscher, David Rapetti

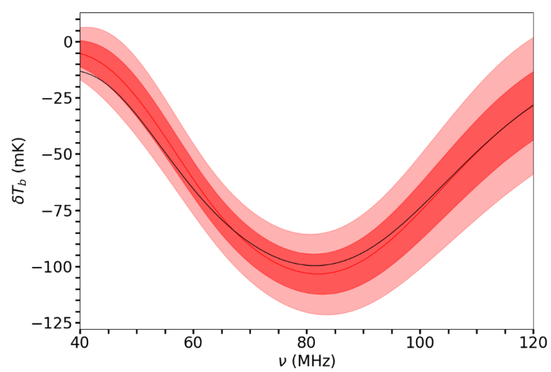
*pylinex** and 21-cm signal analysis pipeline

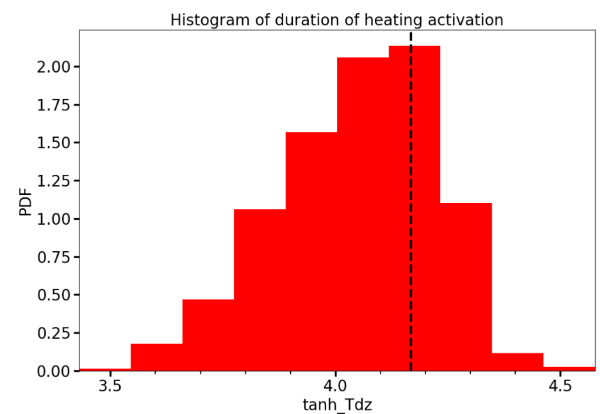
Simulate training sets → Fit with training set's eigenmodes → Initial distribution estimate for physical parameters → Markov Chain Monte Carlo (MCMC)

Paper published: Tauscher et al. (2018)**

Paper in progress (Rapetti et al.) for ApJ







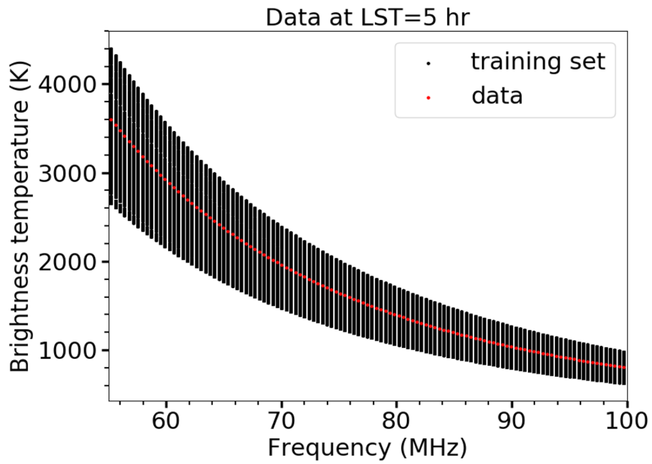
* https://bitbucket.org/ktausch/pylinex

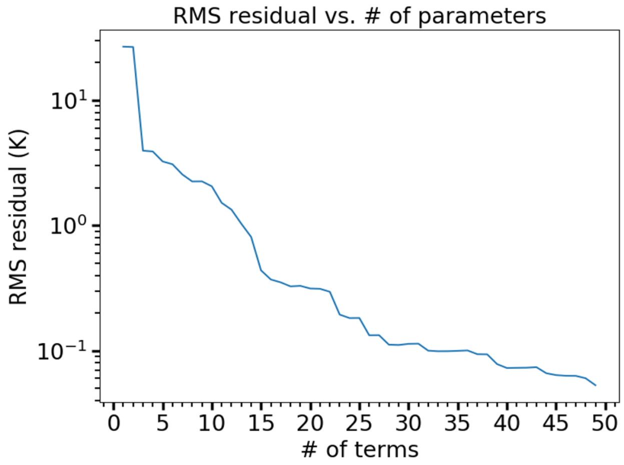
** Tauscher, K., Rapetti, D., Burns, J.O., Switzer, E., *ApJ* 853, 2018

EDGES: status with *pylinex* code

- Training set includes:
  - Multiple simulated antenna beams
  - Uncertain rotation about the zenith direction
  - Haslam galaxy map with realistic errors
  - Simulated LST dependence

- Training set still not adequate to fit data to level required to compare to current EDGES analysis.





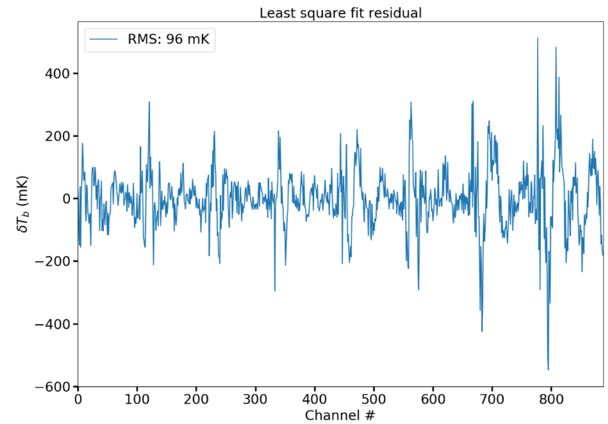
EDGES: simultaneous fits with multiple spectra

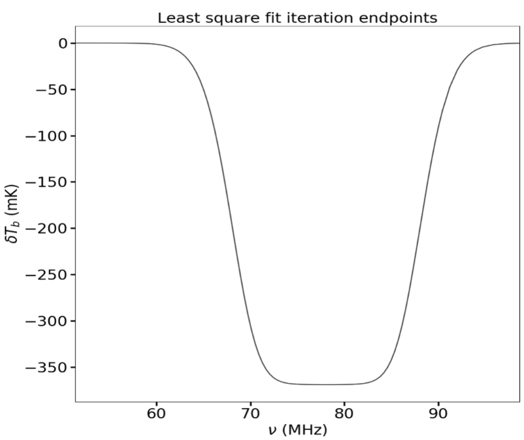
- To bridge the gap between the EDGES analysis method and *pylinex*, we have started working with a hybrid method: using experimental design (i.e. multiple spectra at the same time which should all have the same signal) but no training sets.
- This leaves open the question of which foreground model (both its form and number of terms) is preferred. Some sort of information criterion or evidence is required for that. Some foreground models we have tried:
    - Log-log polynomial, various numbers of terms
    - Power law times polynomial in frequency, various numbers of terms
    - Power law times polynomial in log frequency, various numbers of terms
    - Linearized physical model of Bowman et al. (2018)*

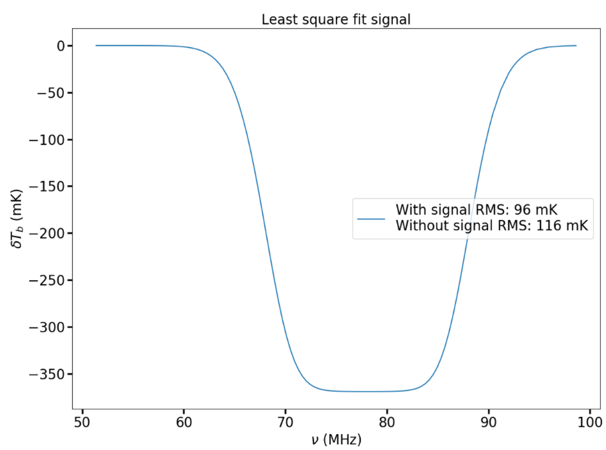
* Bowman, J.D., Rogers, A.E.E., Monsalve, R.A., Mozdzen, T.J., Mahesh, N., *Nature* 555:67, 2018.

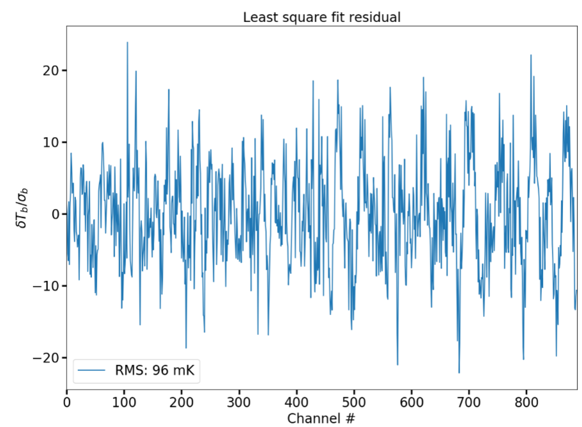
EDGES: simultaneous fits with multiple spectra

- $T_{FG}(\nu) = \left(\frac{\nu}{\nu_c}\right)^{-2.5} \left\{ a_0 + a_1 \ln\left(\frac{\nu}{\nu_c}\right) + a_2 \left[\ln\left(\frac{\nu}{\nu_c}\right)\right]^2 + a_3 \left(\frac{\nu}{\nu_c}\right)^2 + a_4 \left(\frac{\nu}{\nu_c}\right)^{0.5} \right\}$
- Used a least square fit from many different starting locations
- Estimated noise using radiometer equation
- RMS residuals for 8 spectra (51-99 MHz) covering 12 hours LST:
  - With signal: 96 mK
  - Without signal: 116 mK



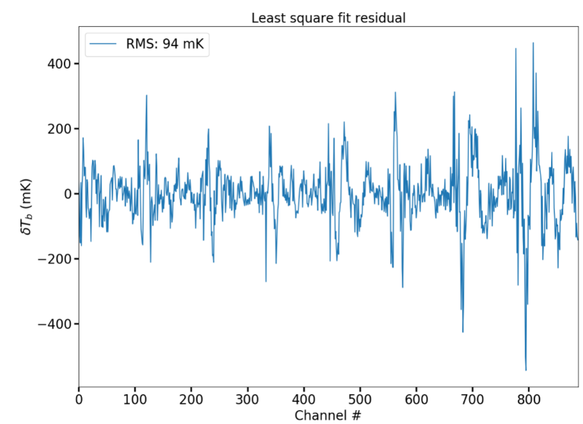


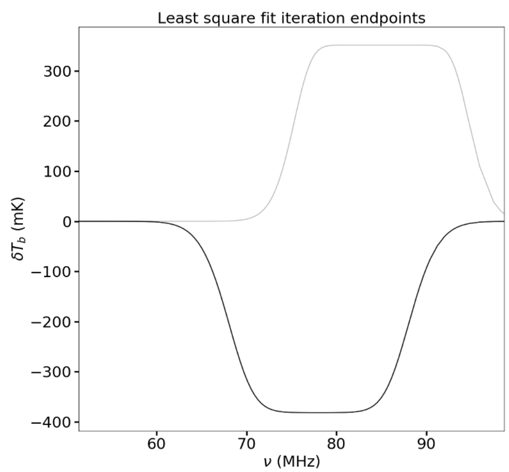


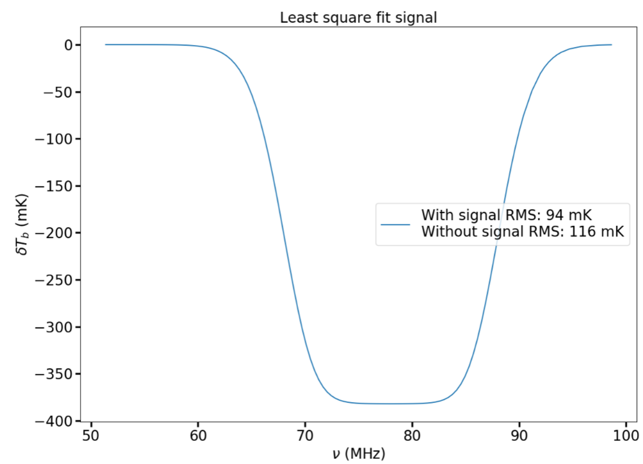


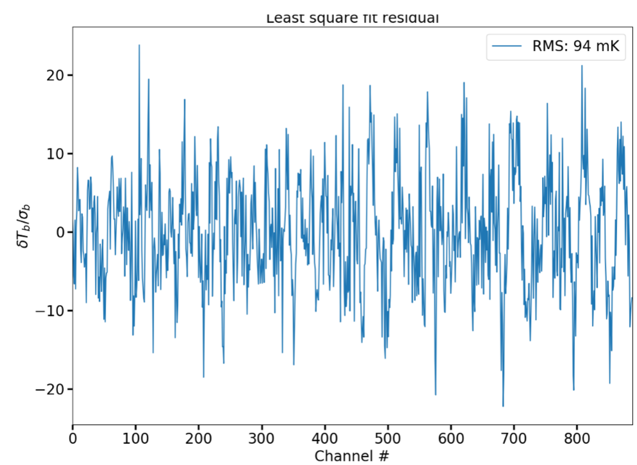
EDGES: simultaneous fits with multiple spectra

- $T_{FG}(\nu) = \left(\frac{\nu}{\nu_c}\right)^{-2.5} \sum_{k=0}^{4} a_k \left[\ln\left(\frac{\nu}{\nu_c}\right)\right]^k$
- Used a least square fit from many different starting locations
- Estimated noise using radiometer equation
- RMS residuals for 8 spectra (51-99 MHz):
  - With signal: 94 mK
  - Without signal: 116 mK



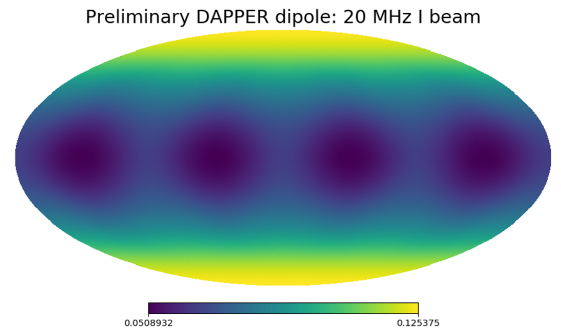


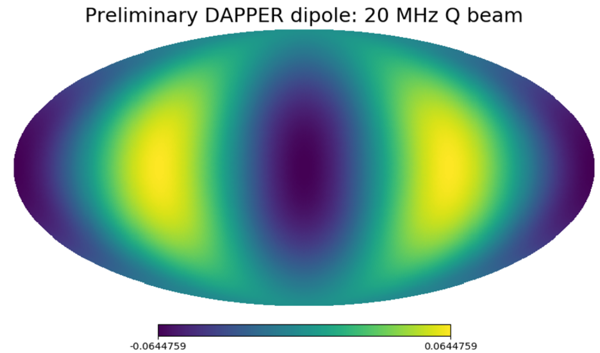


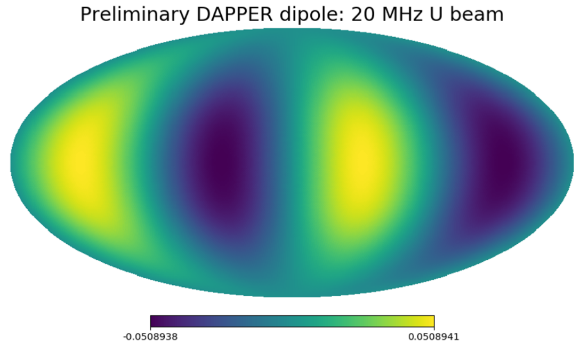


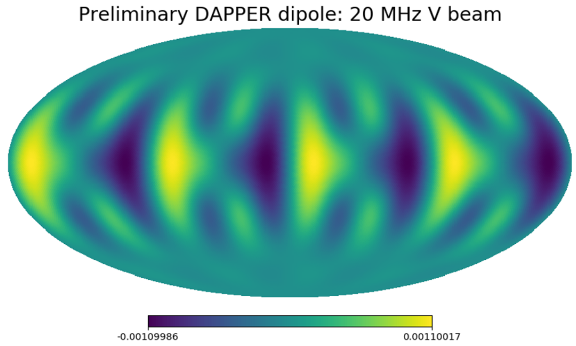
DAPPER: Instrument simulations

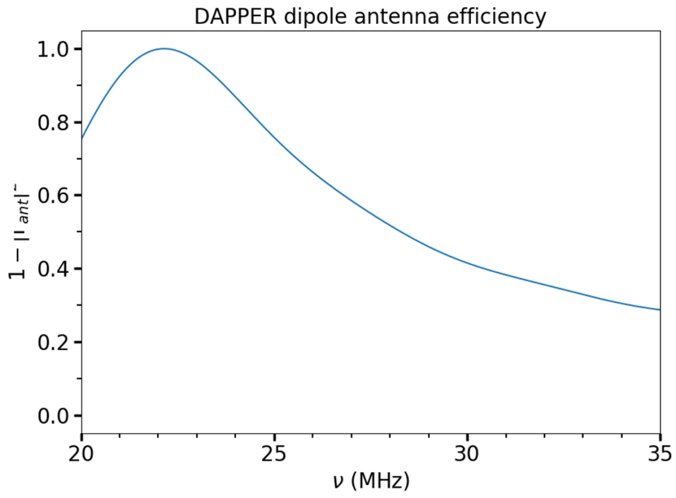
- R. Bradley has simulated antenna patterns with CST for dipole at frequencies between 20 and 35 MHz.











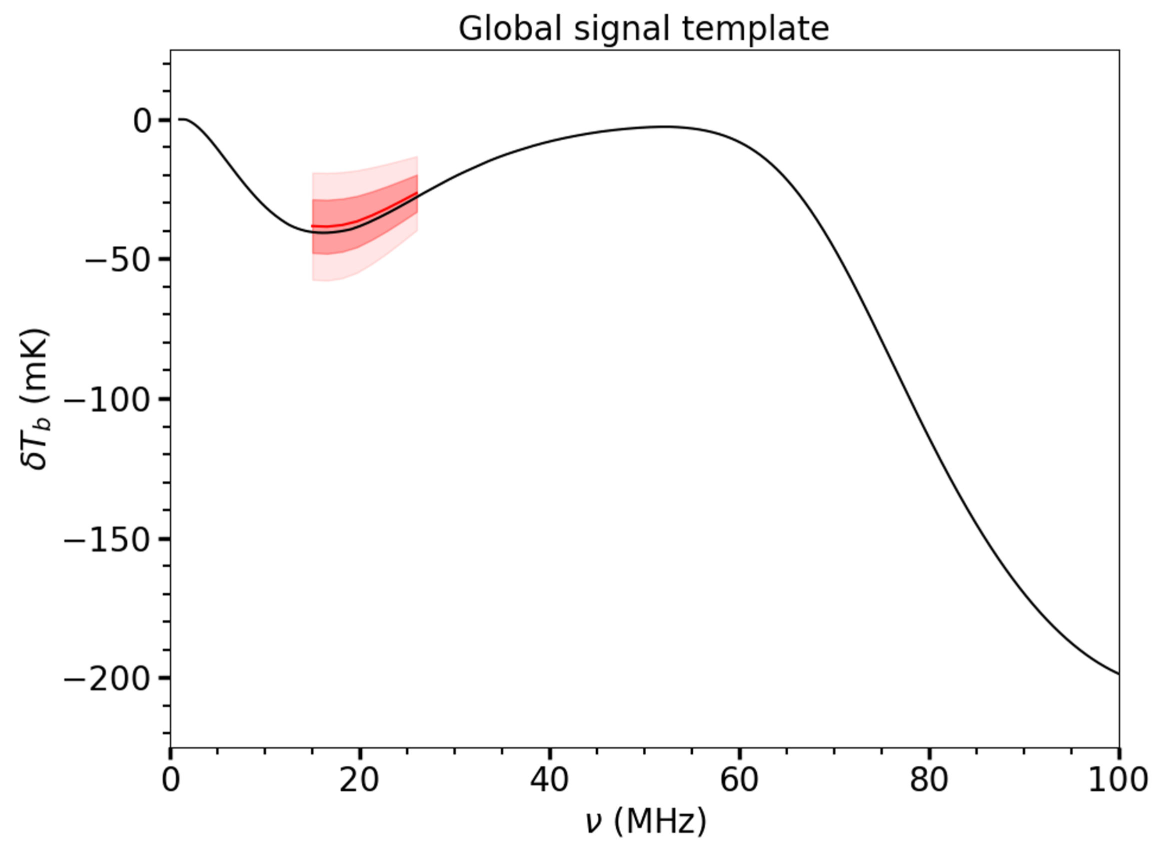
DAPPER: error forecasts

- Using simulations based around the 408 MHz Haslam map of galactic synchrotron radiation, we made training sets with which to create forecasts for DAPPER's errors.

- Two different analysis methods:
    - Less general, smaller errors: search specifically for deviations from the standard cosmological model by using a signal template
    - More general, larger errors: characterize the signal directly through the use of a complete training set of signals simulated

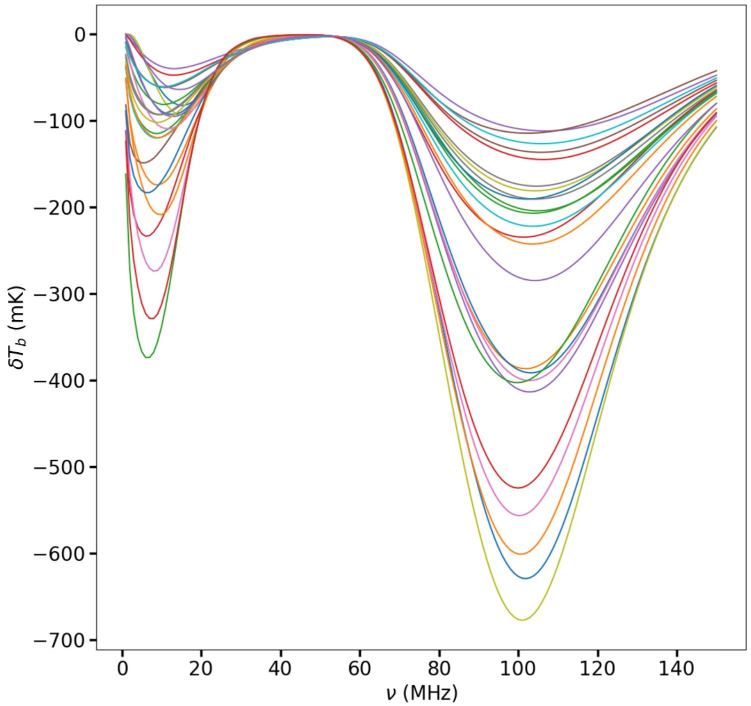
DAPPER: deviations from standard model

- Standard cosmology predicts the position of the low-frequency trough in the global signal. Using the expectation as a template, limits can be placed on deviations from the signal.

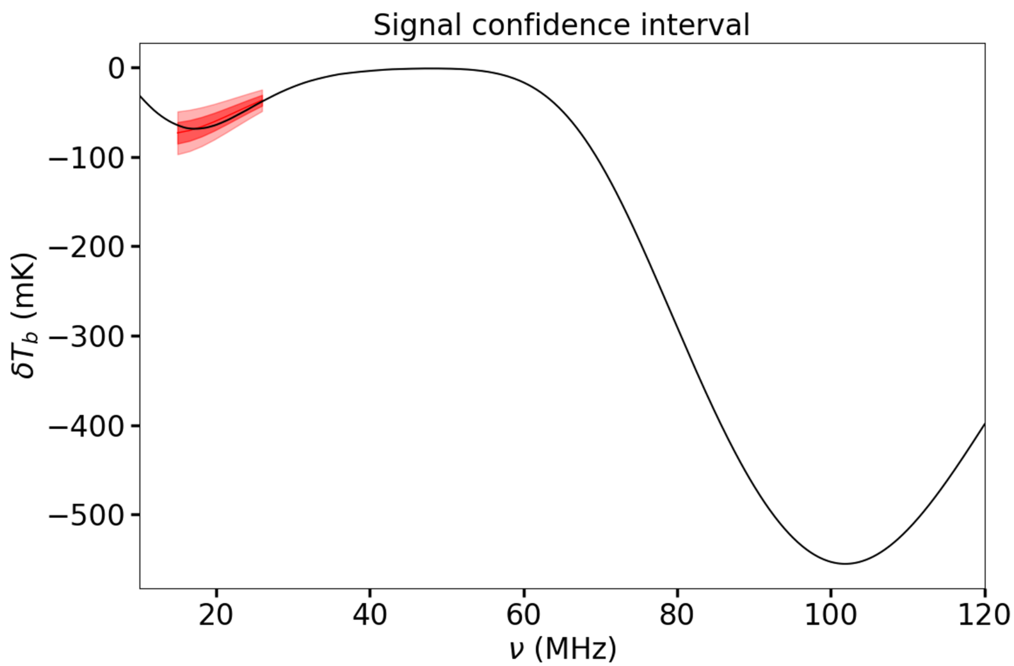


DAPPER: directly characterizing signal

Training set



Forecast



DAPPER: Summary

- Preliminary simulations of DAPPER instrument concepts are under way.

- Error forecasts using two different methods show promise that if foreground can be well characterized a priori, then errors are reasonable and scientifically interesting.

- Before proposal is submitted, we wish to include instrument model in training sets and error forecasts.