TABASCAL

Trajectory Based RFI Subtraction and Calibration

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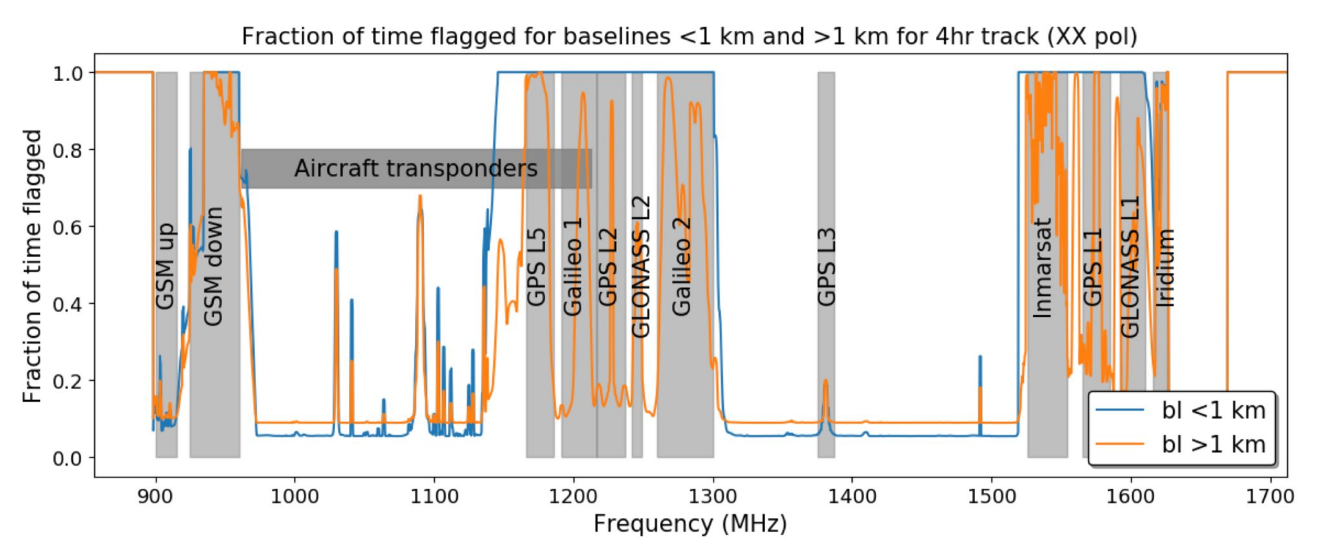
Radio Frequency Interference (RFI) - Motivation

- 30 % of the MeerKAT (SKA-Mid) L-band is contaminated.
- Much of it is (reasonably) predictable
- MeerKAT cost $ 330 M ➡ $ 100 M is being wasted.



TABASCAL

Goals

- Replace RFI flagging with RFI subtraction

  ↳ Recover astronomical visibilities

- Fit into the current data reduction workflow - 1GC then 2GC (self-cal) and beyond.

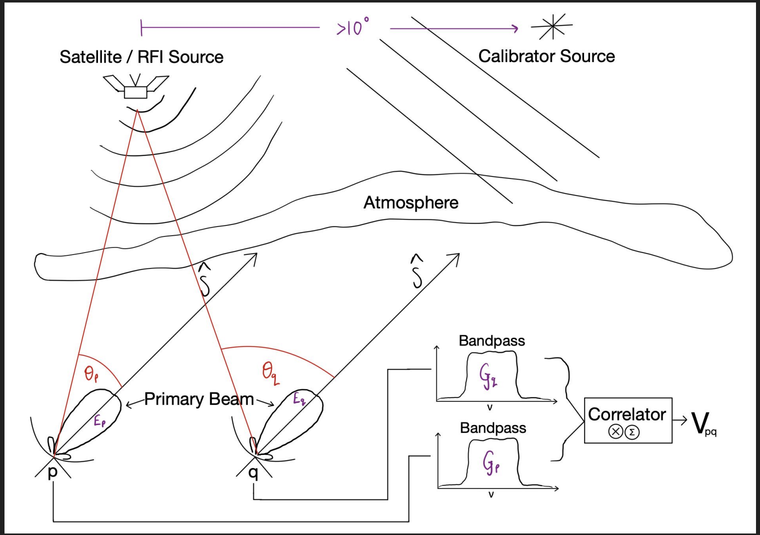
Ideas

- Use RFI trajectories to help estimate their visibility contribution.
- Estimate antenna gains by using prior information.
- Use baseline dependent smoothness of astronomical visibilities to help with estimation.

Data Simulations

Features

- Satellite and Ground-based RFI sources
- Correlator averaging (Fringe loss)
- Time & direction dependent gains
- Fast JAX implementation for CPU, GPU & TPU
- Scalable with Dask to multiple GPUs



https://github.com/chrisfinlay/tabascal

Radio Interferometry Measurement Equation (RIME)

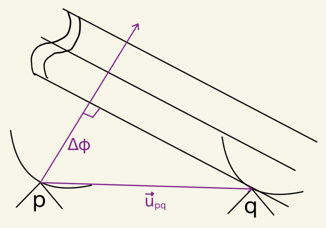
Co g

Correlator

⊗ Σ

Stokes Parameters
(I,Q,U,V)

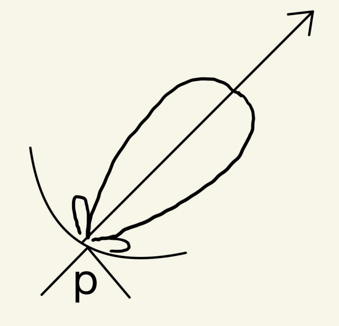
trix



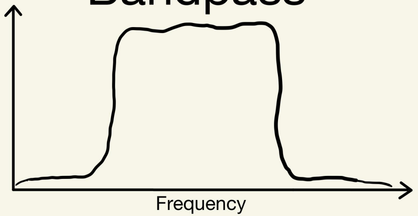
$$V_{pq}(t_j) = \frac{1}{\Delta t}\int_{t_j-\Delta t/2}^{t_j+\Delta t/2} dt\; G_p \left(\sum_s E_{ps}K_{ps}B_{pqs}K^H_{qs}E^H_{qs}\right) G^H_q$$

Visibility

Directio



Bandpass



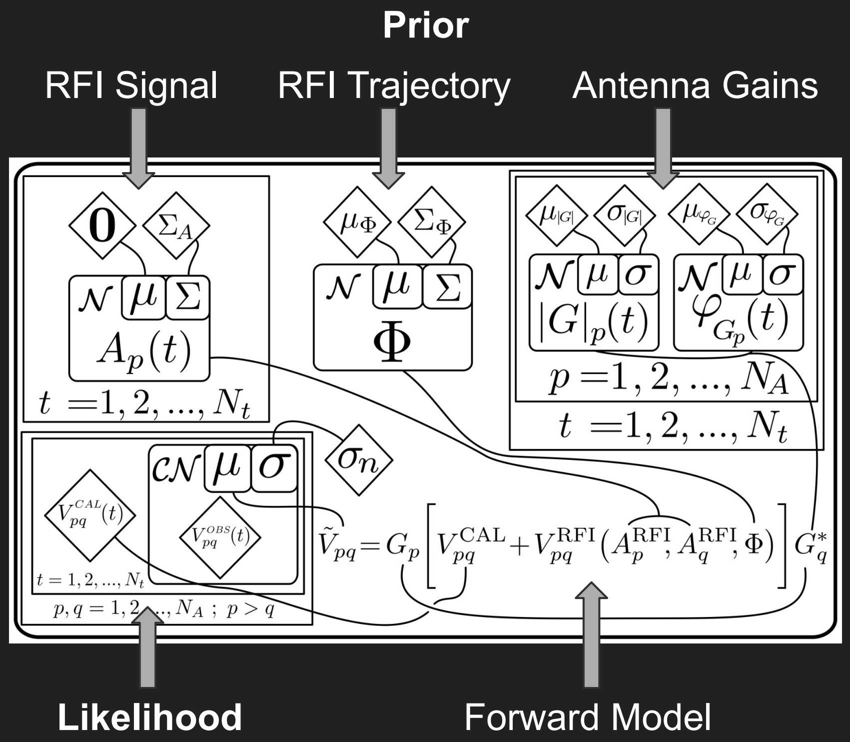
ects

TABASCAL I
(Calibration Observation)

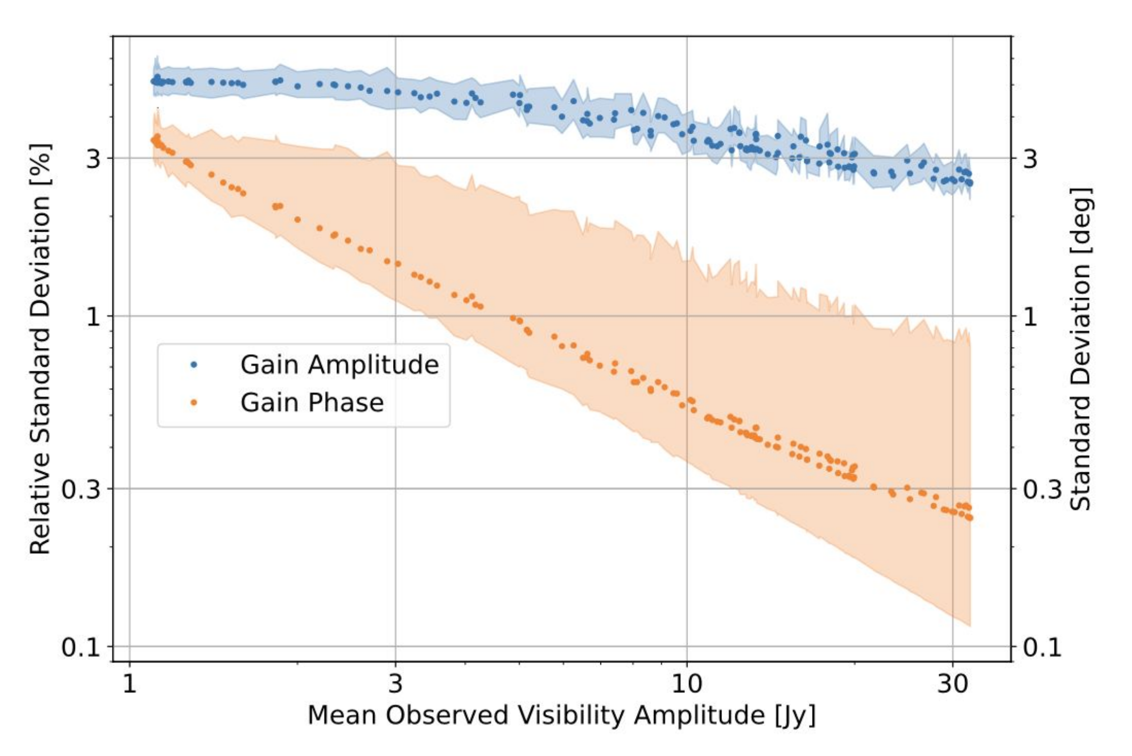
[DOI:10.1093/mnras/stad1979](https://doi.org/10.1093/mnras/stad1979)

- Jointly estimate RFI signal/trajectory and antenna gains.

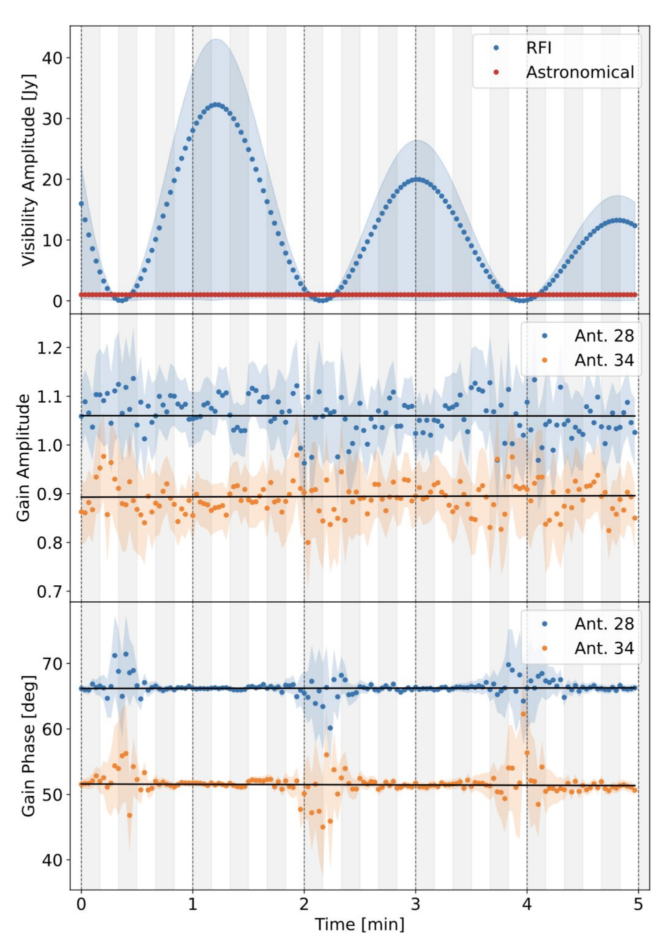
- Bayesian model to reliably estimate parameter errors.



TABASCAL I



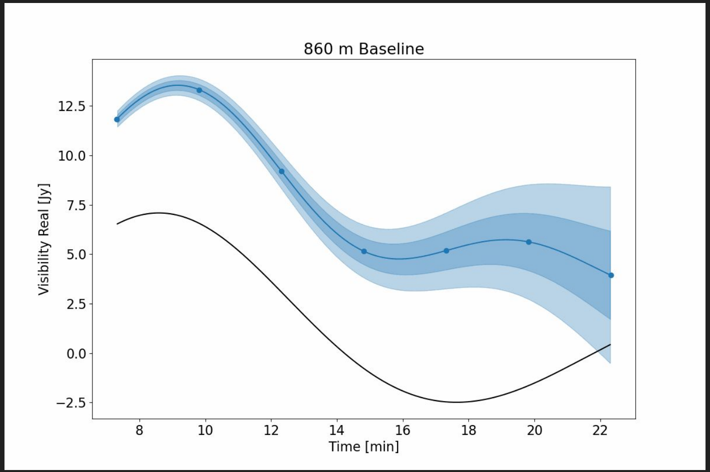
Relative Standard Deviation [%]
Standard Deviation [deg]
Mean Observed Visibility Amplitude [Jy]
Gain Amplitude
Gain Phase
0.1
0.3
1
3
1
3
10
30



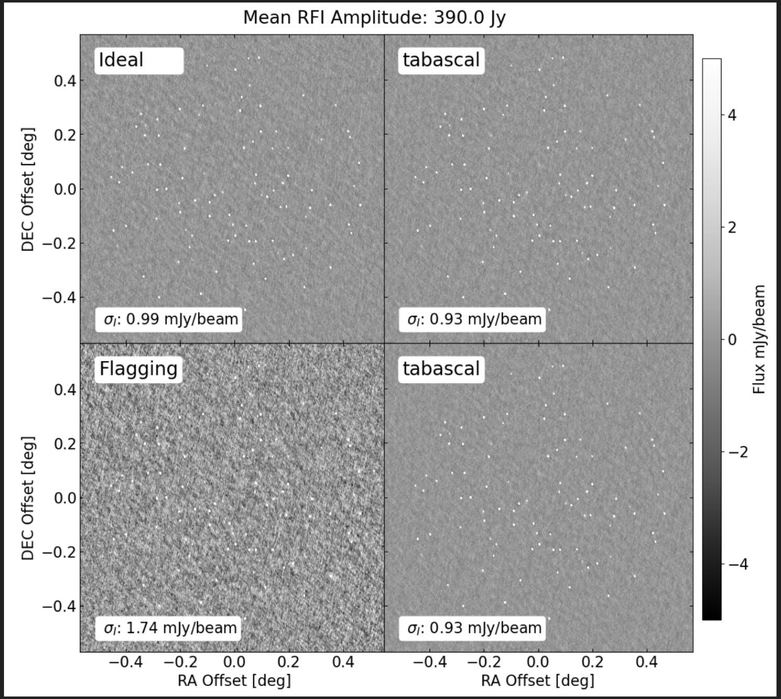
Visibility Amplitude [Jy]
RFI
Astronomical
Gain Amplitude
Ant. 28
Ant. 34
Gain Phase [deg]
Ant. 28
Ant. 34
Time [min]

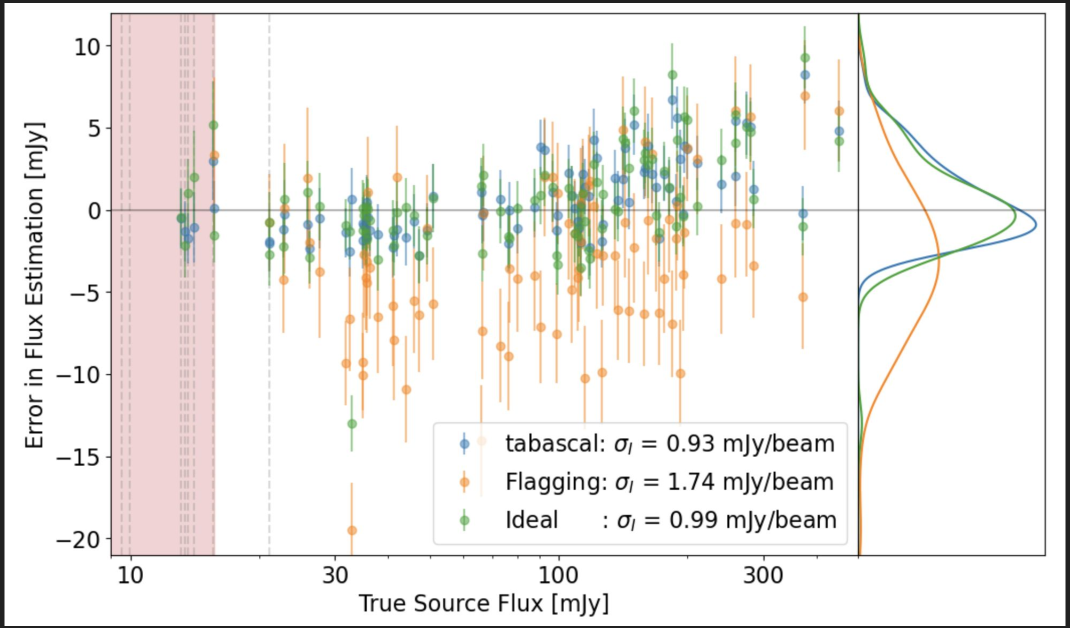
TABASCAL II
(Target Observation)

- Use TABASCAL I estimates as a prior for TABASCAL II.
- Use Gaussian processes to reduce the parameter space and enforce smoothness.



TABASCAL II (Preliminary Results)





Conclusion

- TABASCAL II can subtract RFI → recover astronomical visibilities.
- At the expense of more computation
  - Stronger RFI is possible
  - Multiple RFI sources are possible

Upcoming Work

- Test the limits of TABASCAL
- TABASCAL II paper write-up
- Test on real data