

Foreground subtraction & instrumental calibration

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Reionization and Cosmology with 21 cm Fluctuations

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Key Words

Abstract Measurement of the spatial distribution of neutral hydrogen via the redshifted 21 cm line promises to revolutionize our knowledge of the epoch of reionization and the first galaxies, and may provide a powerful new tool for measuring dark energy from redshifts 1–4. In this review we concentrate on recent advances in our theoretical understanding of the epoch of reionization (EoR), the application of 21 cm tomography to dark energy observations after reionization,

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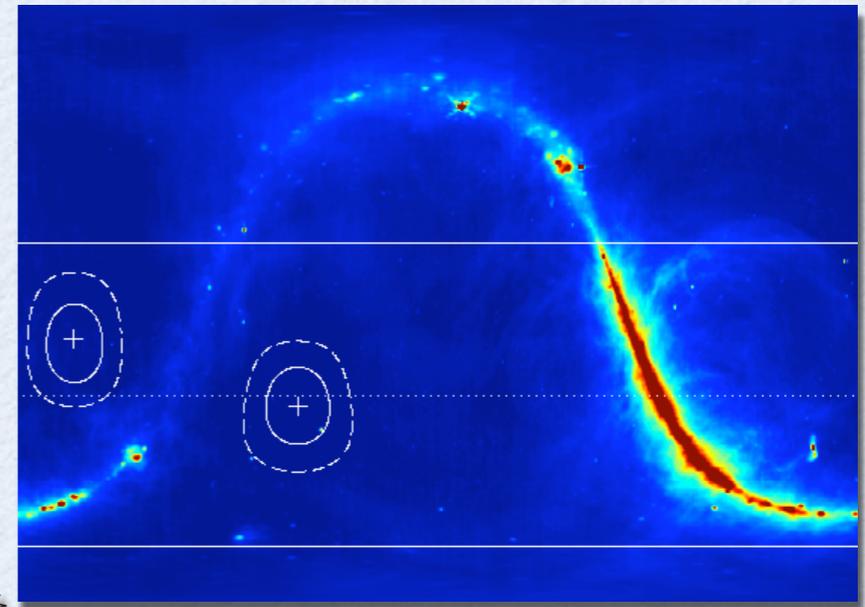
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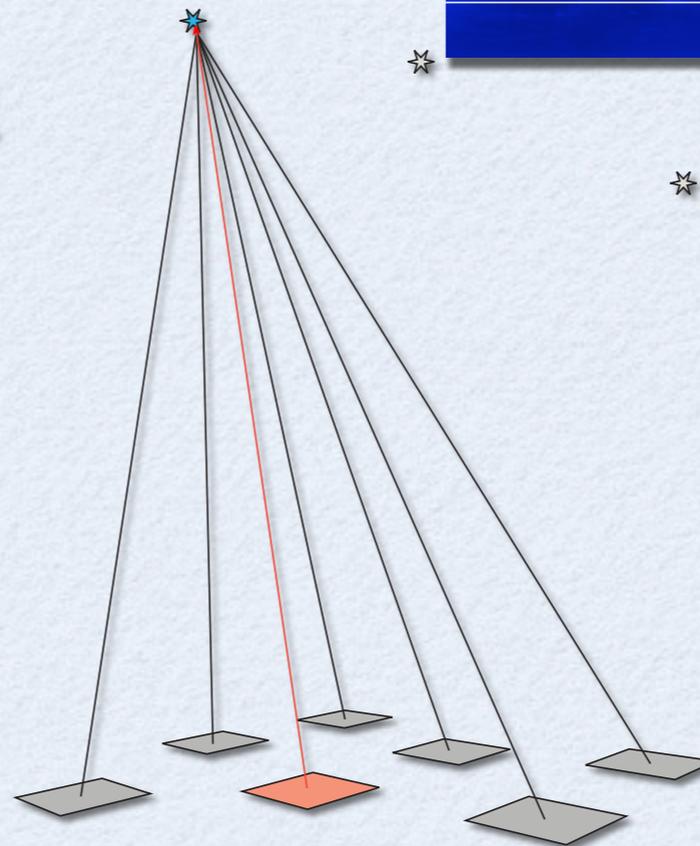
Available next Friday

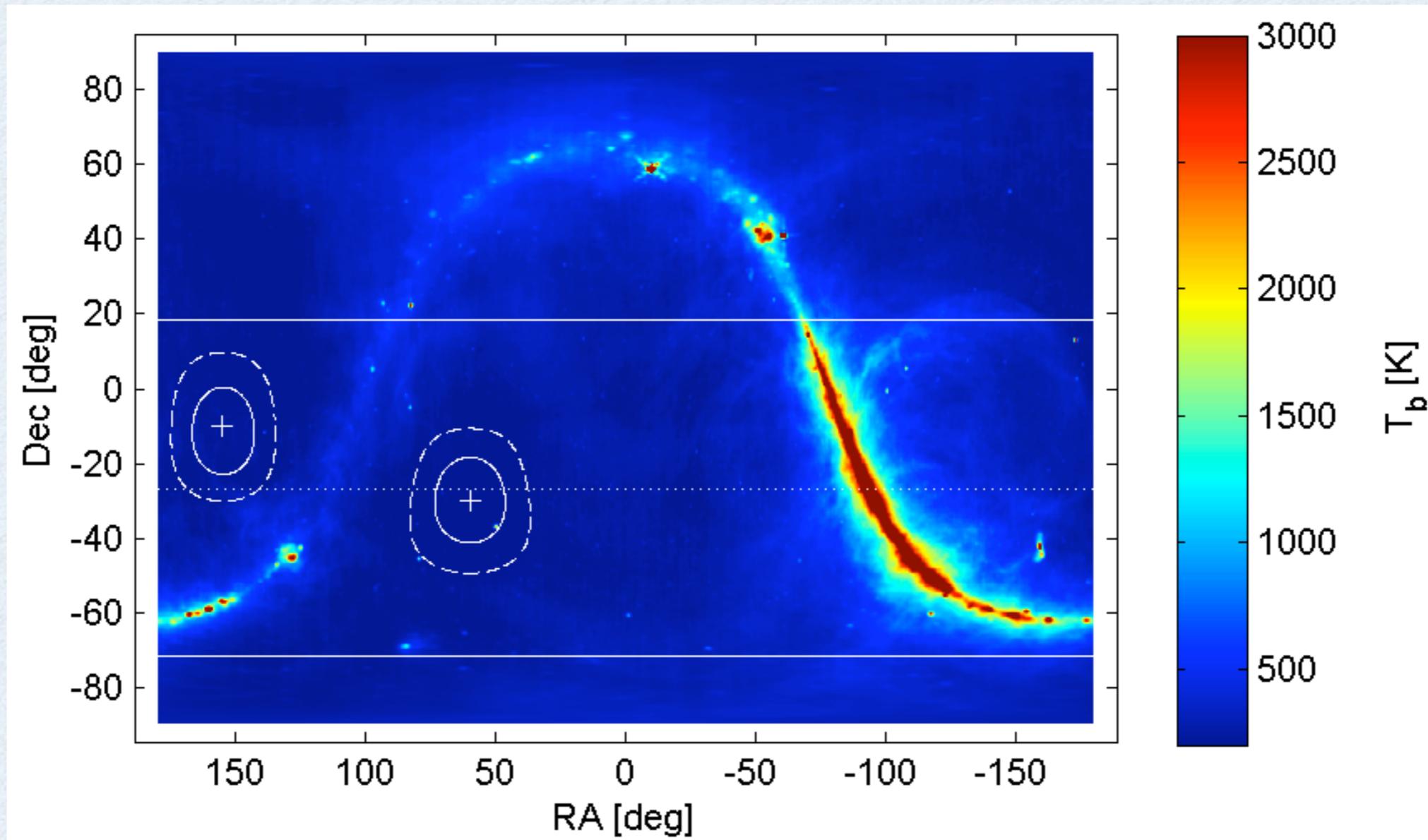
Overview

- Foreground subtraction



- Calibration

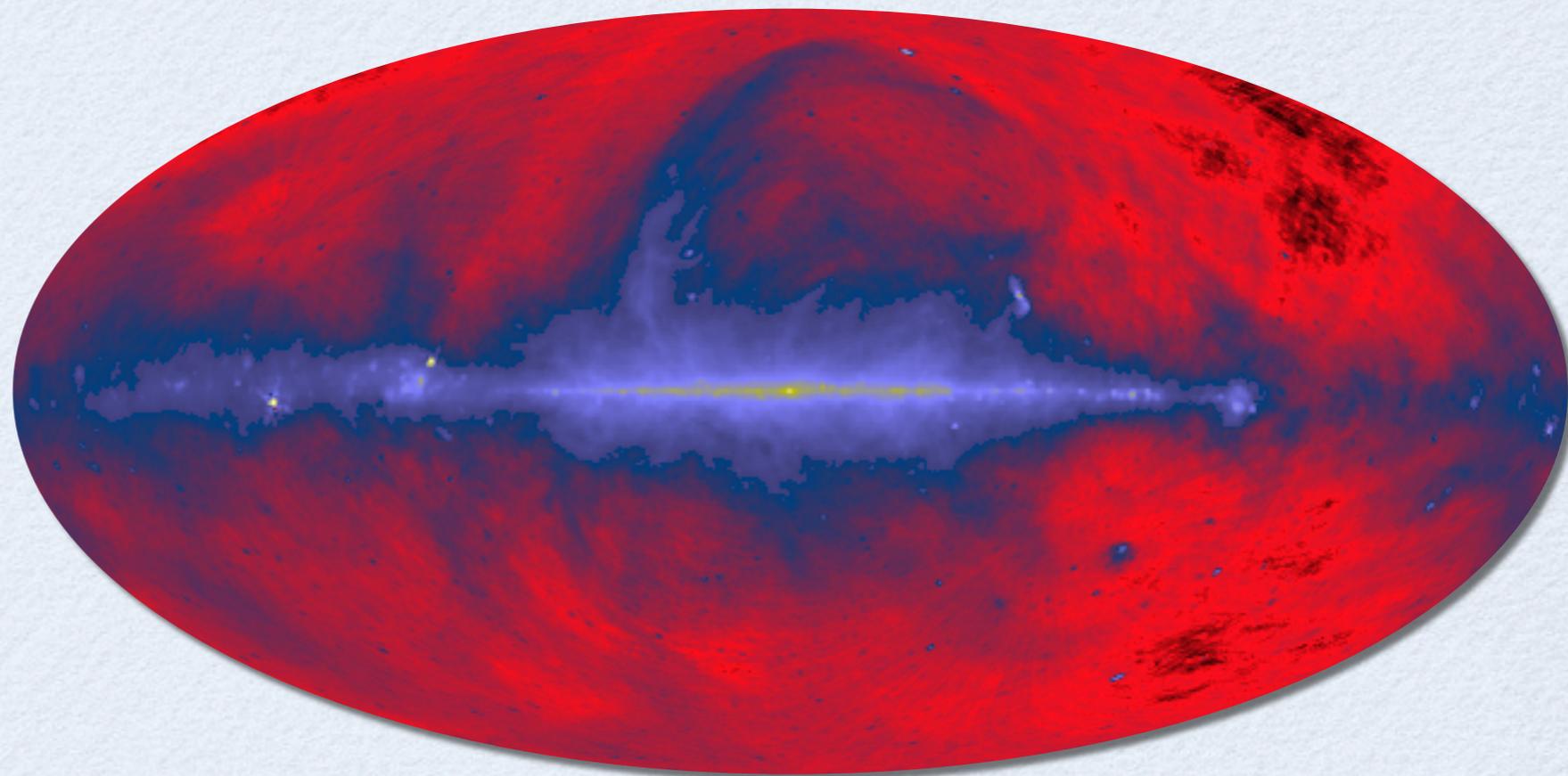




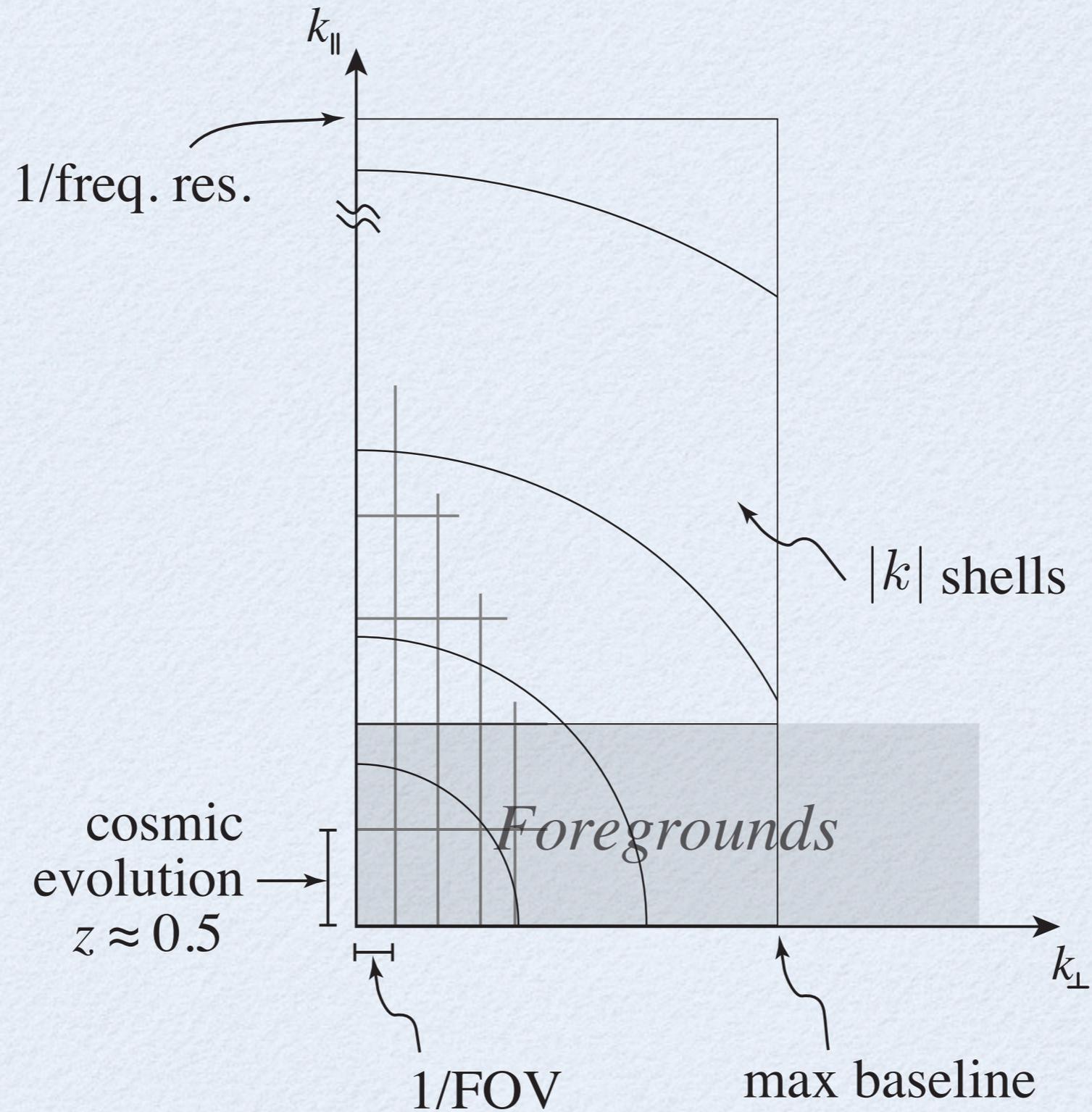
Foreground subtraction

Foregrounds

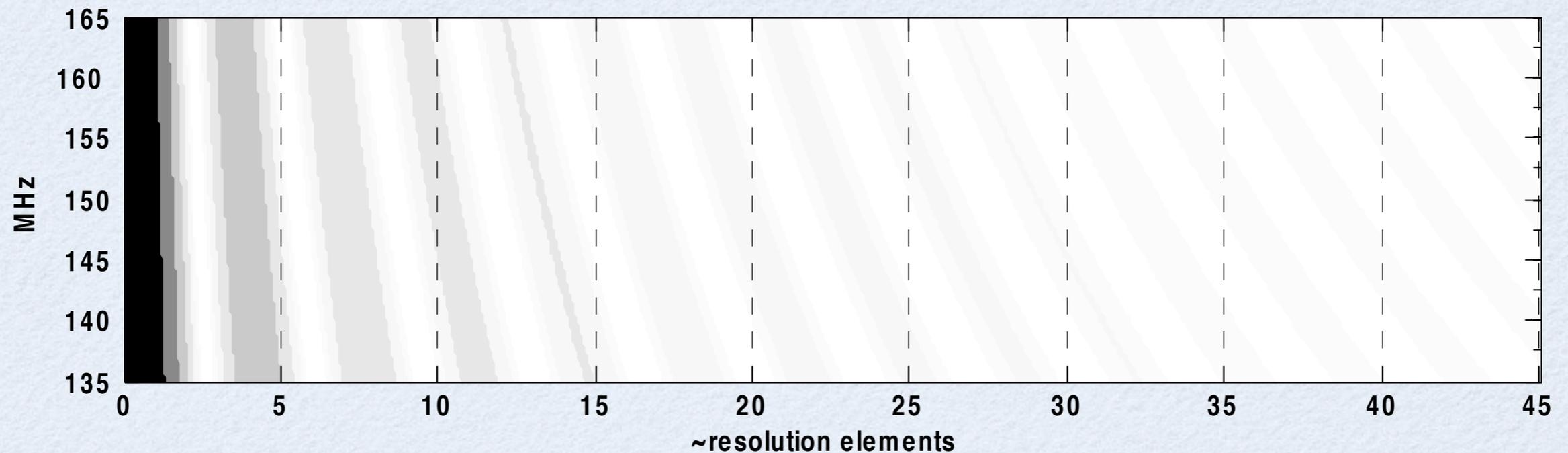
- Faint point sources
- Galactic emission (polarized)
- RFI
- Others!



k -space contamination



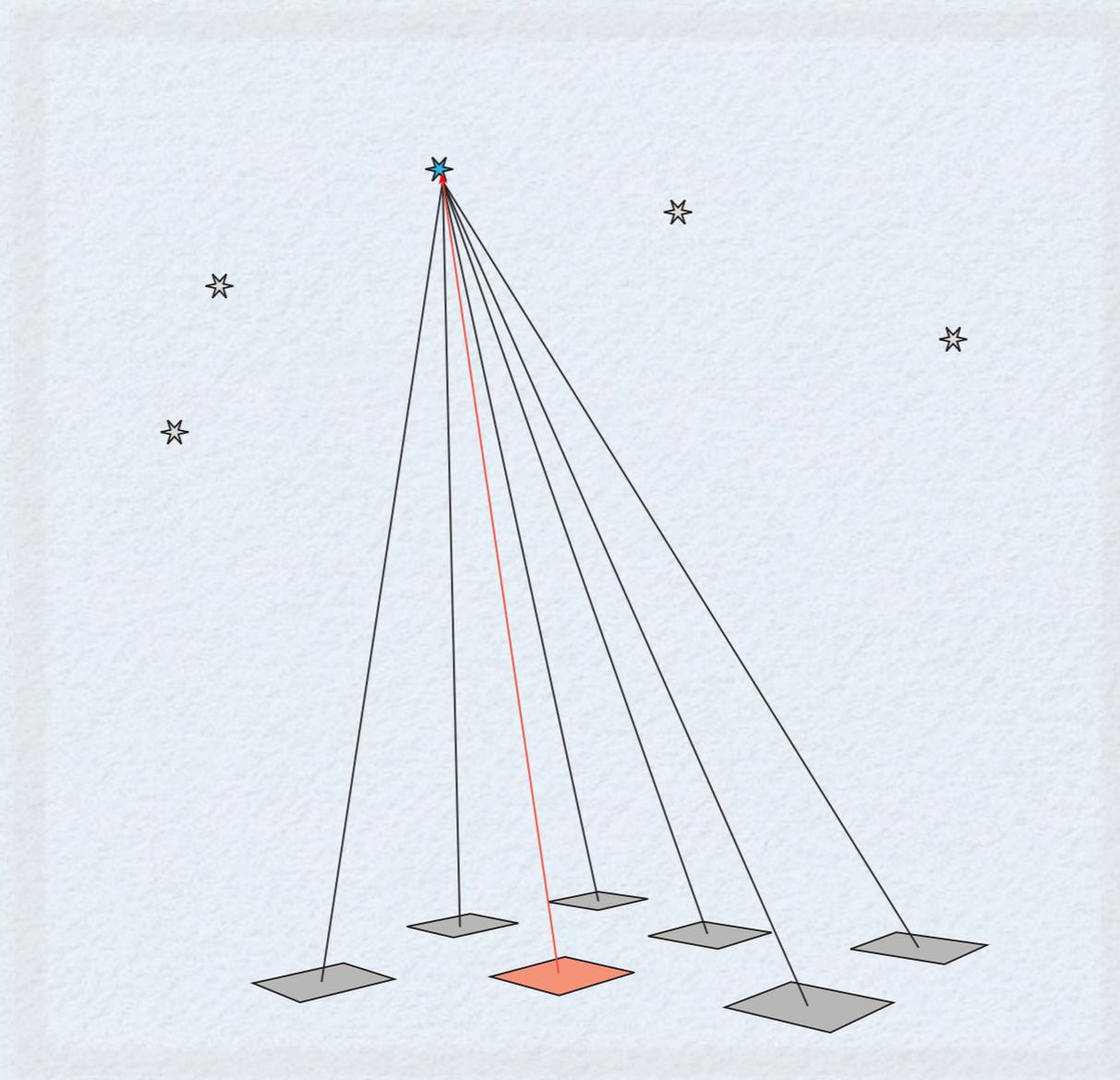
Mode-mixing



- Chromatic array beam (PSF) & residual source flux, residual frequency ripple
- Polarized foreground & polarization mis-calibration, flux leakage from Q & U \rightarrow I
- Antenna beam dependence & point sources, decorrelation of visibilities at different frequencies

Mode mixing

- Frontier of foreground subtraction is interactions between calibration and foregrounds
- Need measurement fidelity of $10^{-4} - 10^{-6}$
- Effectively a product of the calibration errors and foreground uncertainty

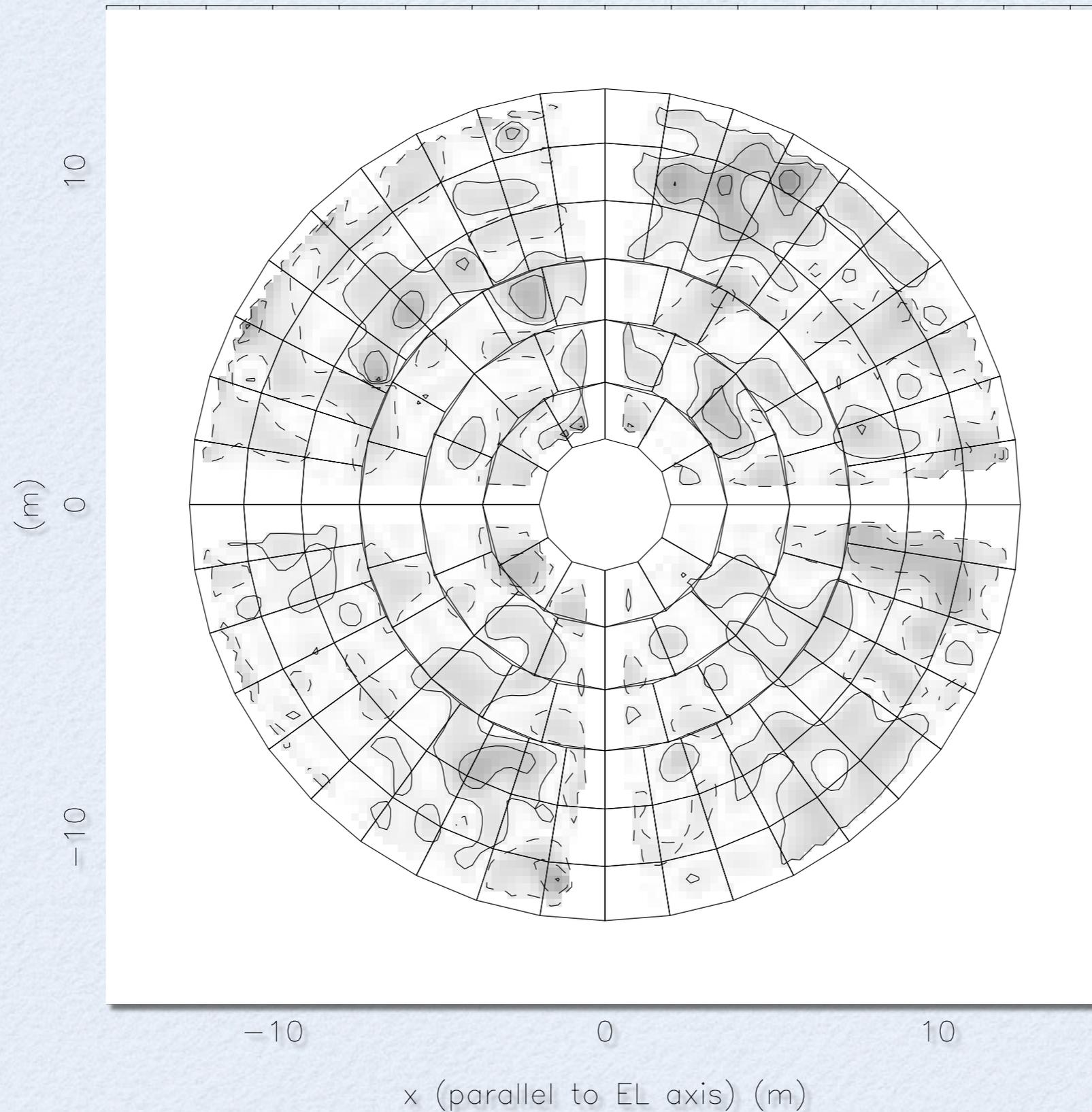


Calibration

What does calibration mean?

- It does *not* mean gain & phase (one complex number) per receiving element / antenna
- For high dynamic range need the direction-dependent complex gain

Holographic antenna maps



Calibration sources

- If there are sufficient (truly) independent calibrators, can fit the parameters to obtain instrumental calibration
- Unfortunately, no good artificial calibrators
- EoR machines relying on astrophysical sources, issue is source isolation

GMRT



Unique pulsar calibration with custom correlator

PAPER



PAPER collaboration

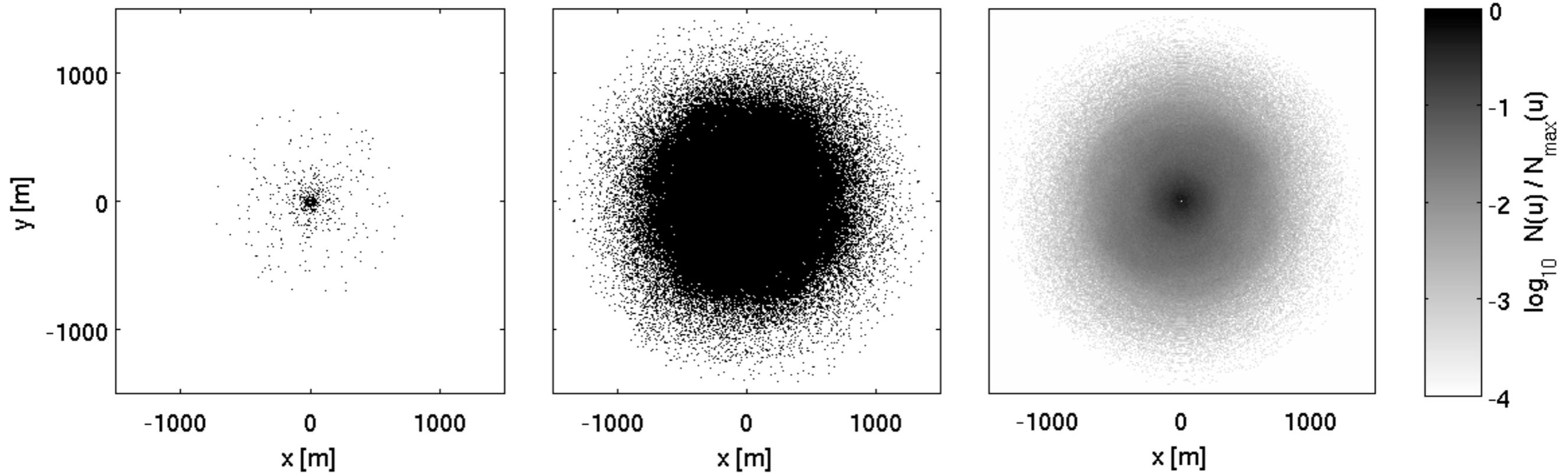
Very stable antenna

LOFAR



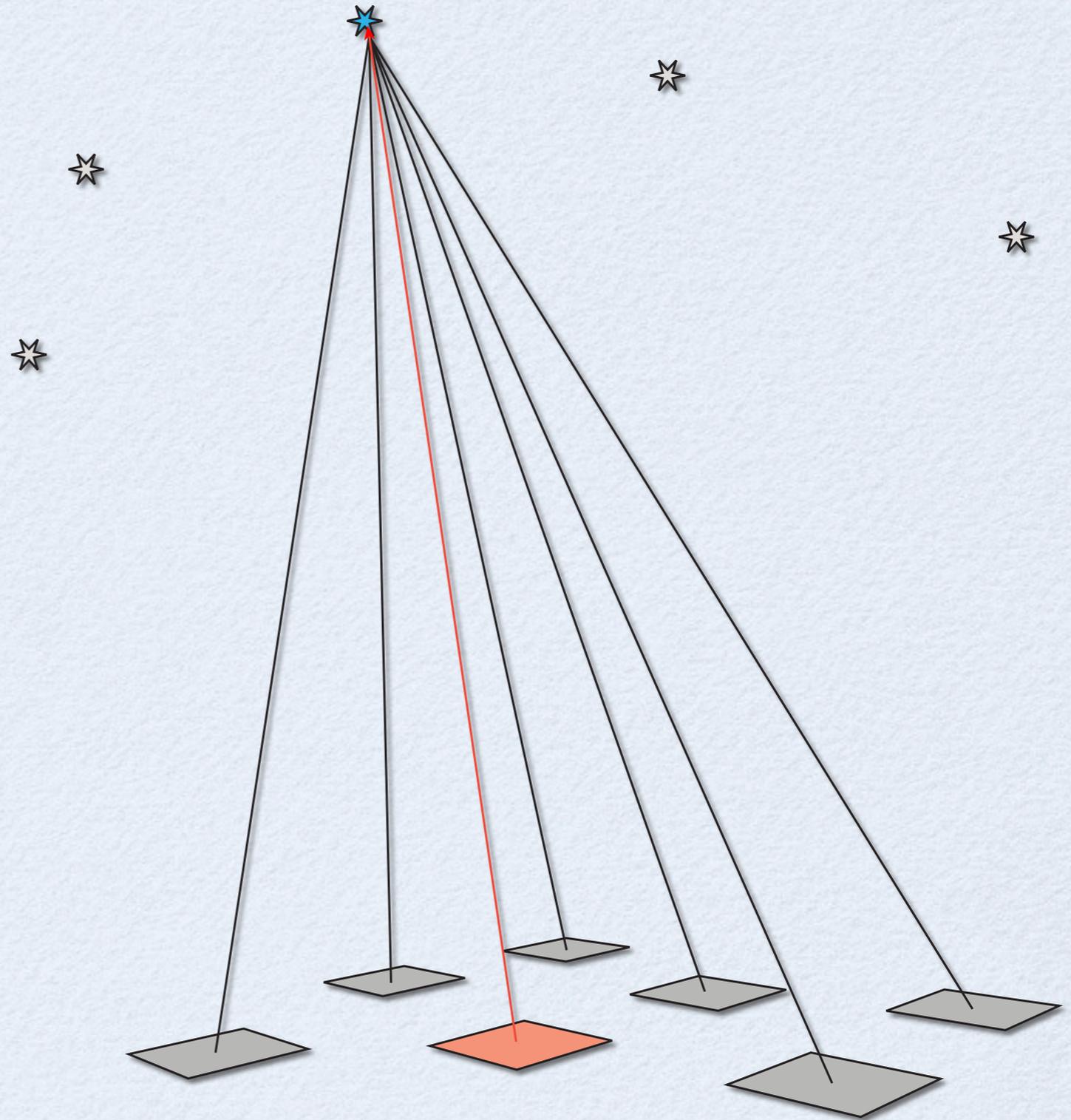
Petabyte storage & integrated likelihood calibration and foreground subtraction

MWA antenna distribution



MWA calibration

- Gain from one antenna to rest of array, simultaneously for all antennas & 100 sources

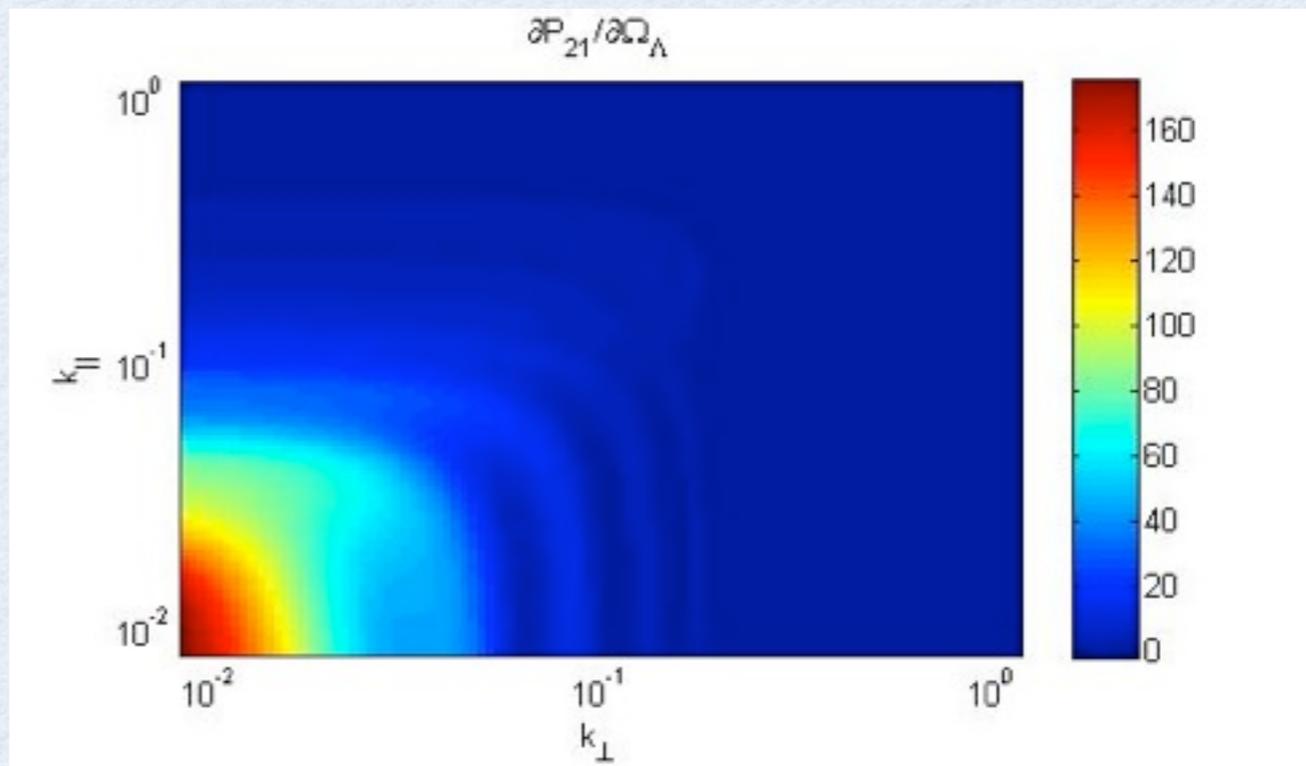
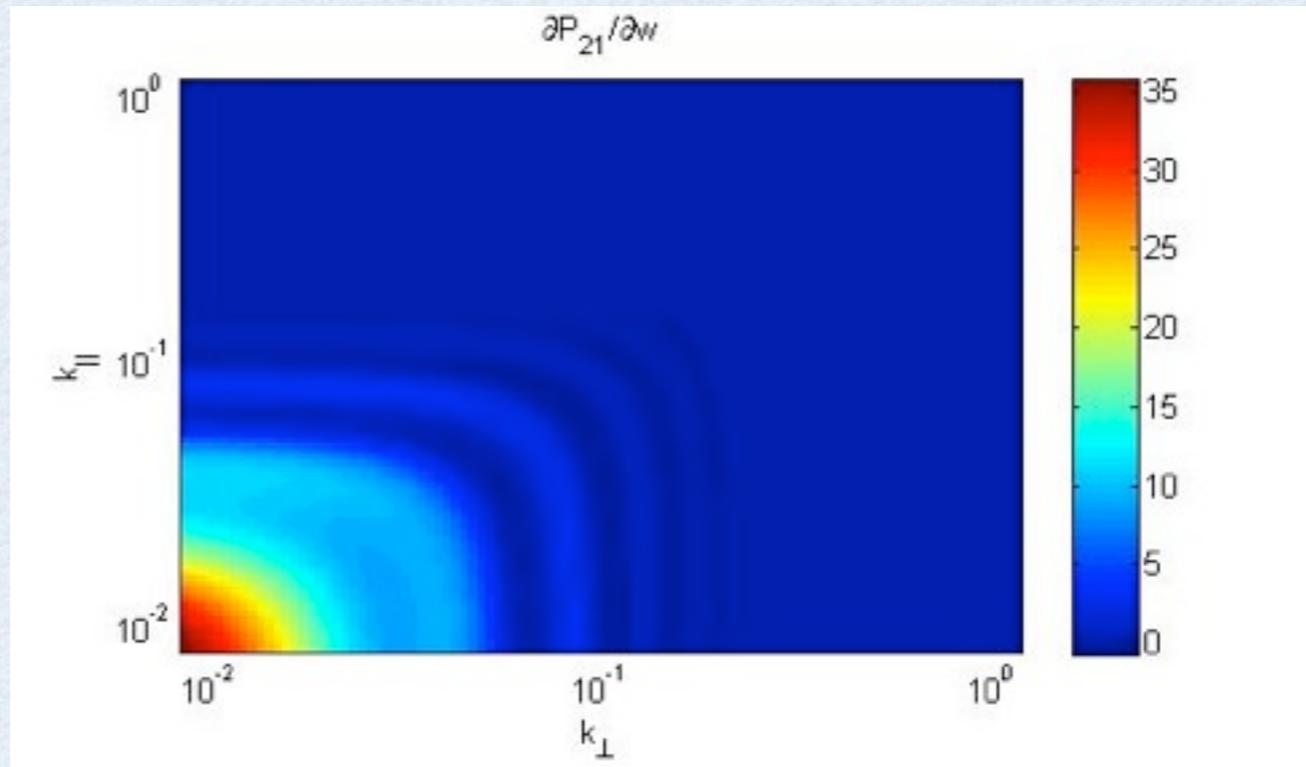


Conclusion

- Foregrounds and calibration will be a real issue for intensity mapping
- Must have a robust calibration strategy

k -space Fisher matrixes

Tuning parameter
sensitivity



Visbal, in prep.