A PAPER-32 Stokes I Sky Catalogue

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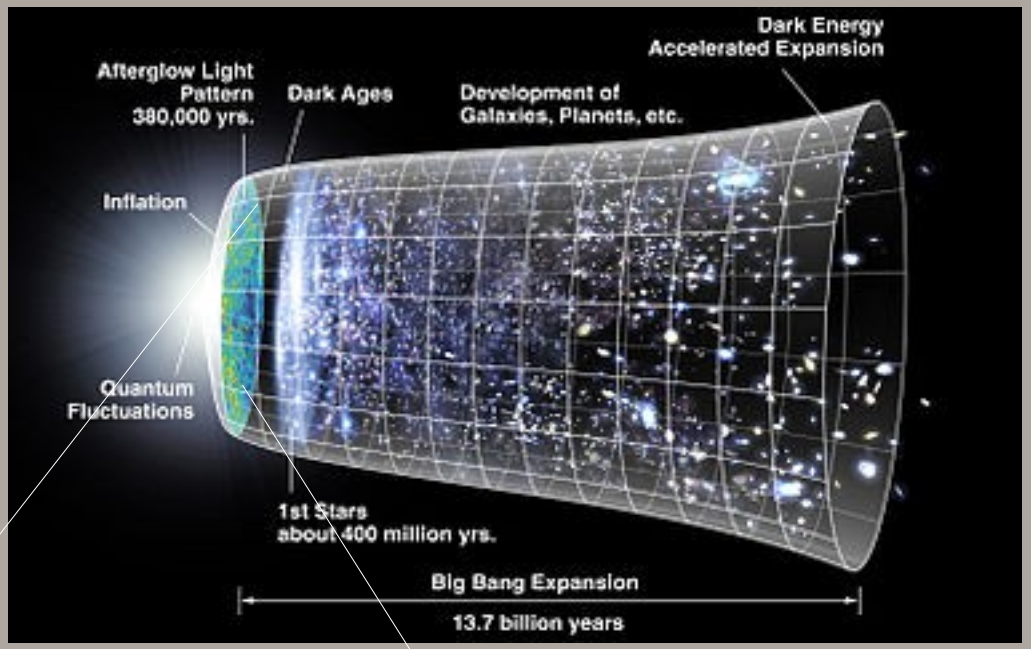
NRF National Research Foundation

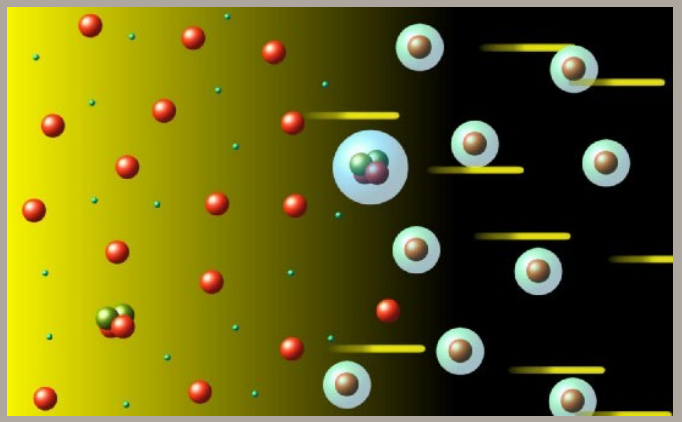
SKA AFRICA
SQUARE KILOMETRE ARRAY

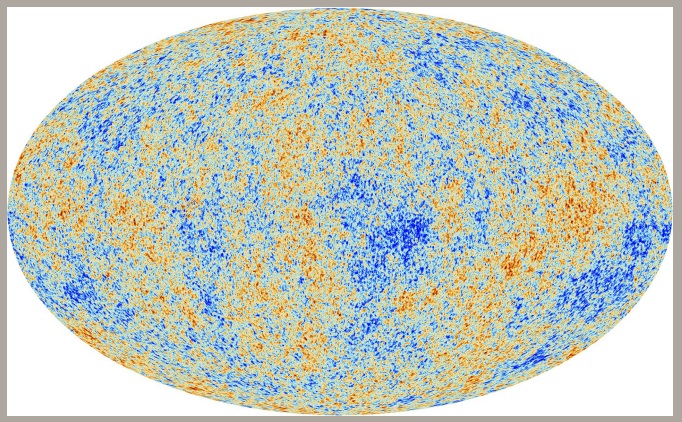
Overview

- Early universe
- Foreground Vs EoR signal
- 21 cm HI emission
- PAPER
- Snapshot imaging
- Direction independent and dependent errors
- Source extraction
- Absolute flux calibration

In the beginning…







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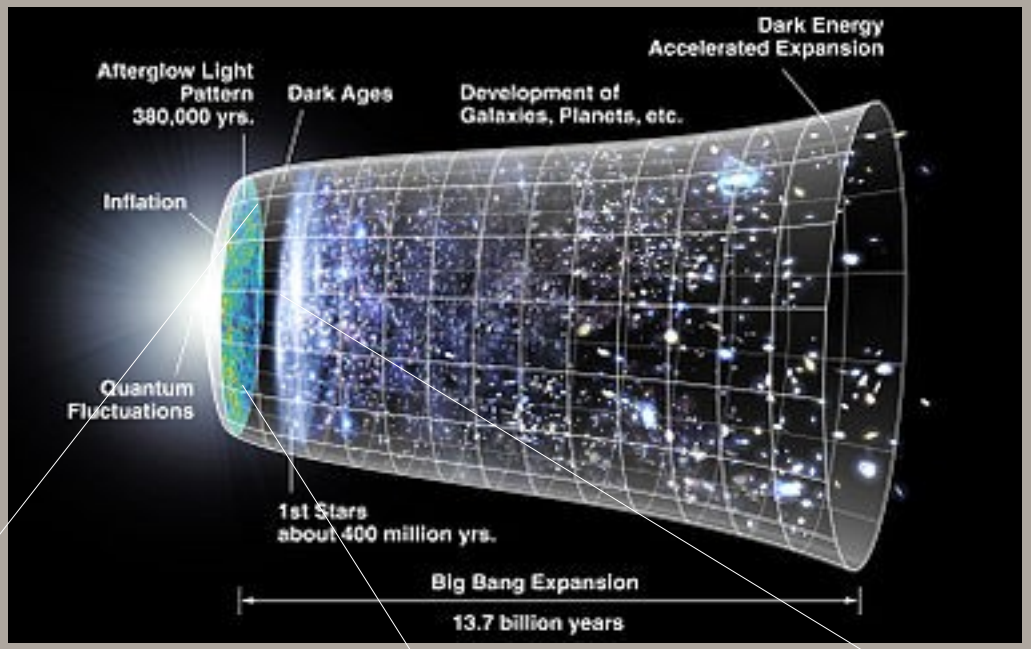
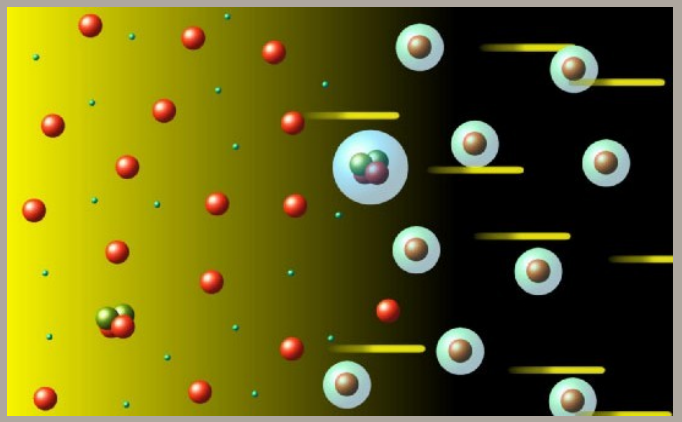
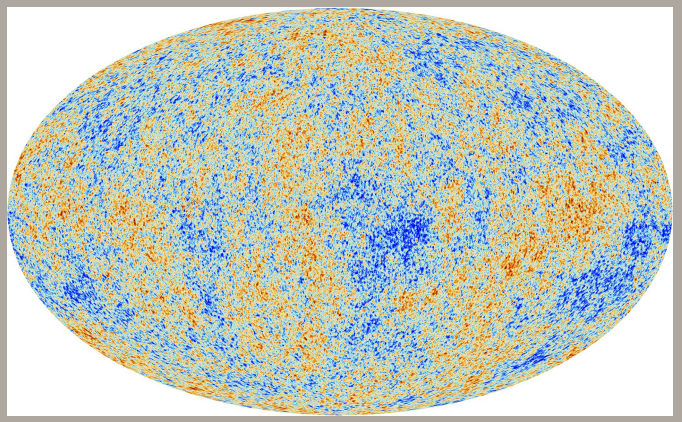
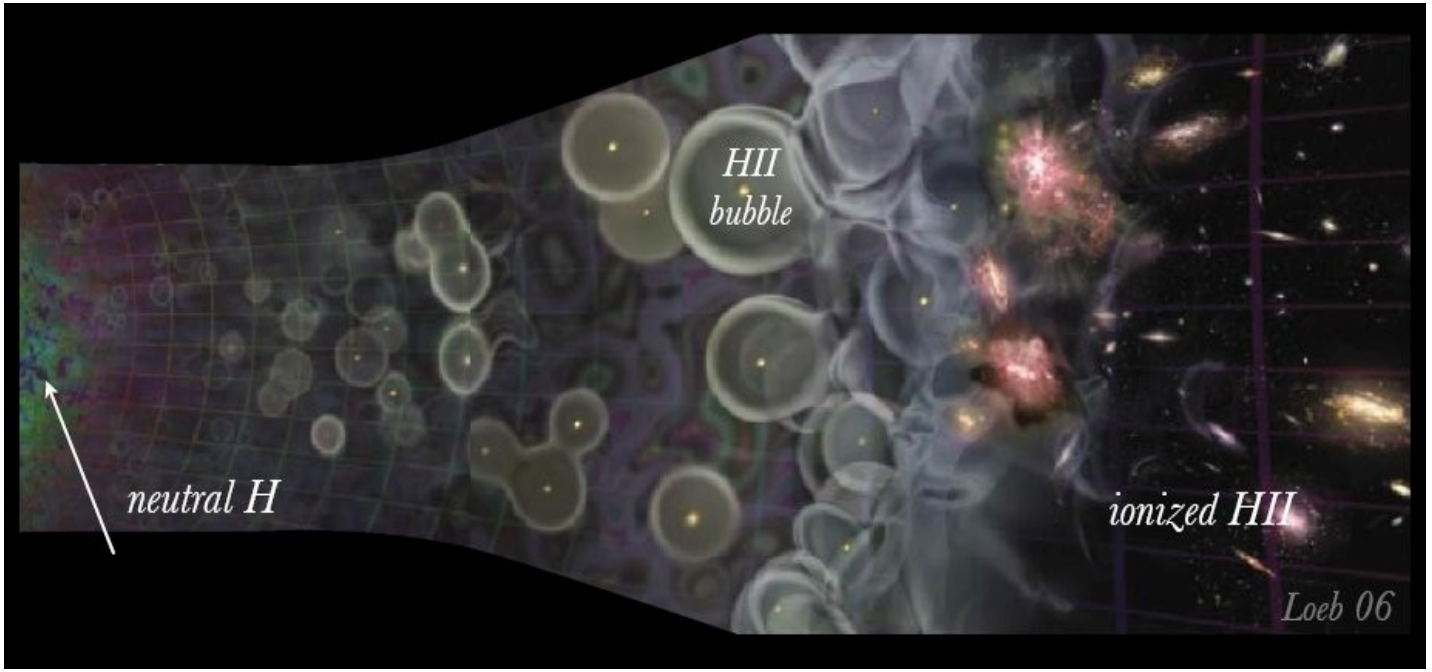


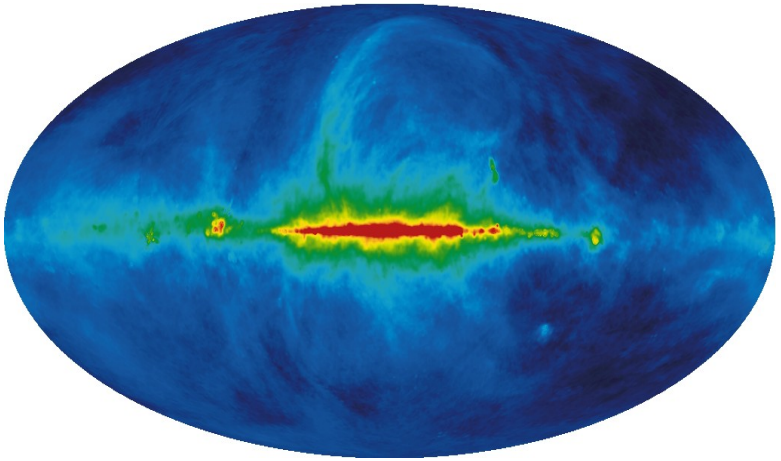




Foreground Vs EoR signal

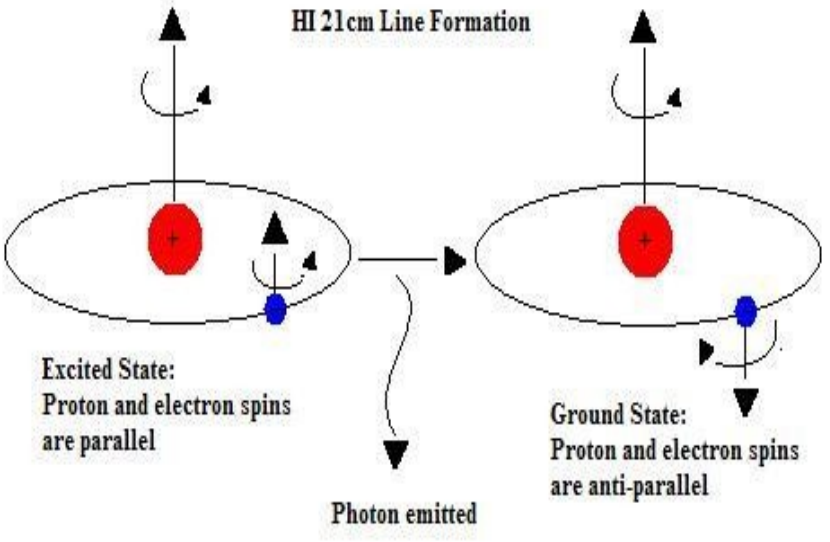
- Presence of foreground emission that is a few orders of magnitude stronger than the 21-cm signal.





- Foreground emission contains galactic and extra galactic emission.

Probing the EoR with redshifted 21 cm HI emission



- This hyperfine transition arises due to the spin-spin interaction between the electron and the proton in hydrogen
- Extremely small transition probability of 10 million years
- Helps us to study the formation of the first structures during the dark ages and the Epoch of Re-ionization

- An experiment aimed towards the detection of the redshifted 21-cm line from the Epoch of Re-ionization.

- To investigate the birth and evolution of first stars and galaxies as well as the thermal history of the intergalactic medium.

Figure: A PAPER dipole

- An array of 128 dipoles sensitive to the 100-200 MHz range, located in the Karoo.
- A collaboration between UCB (lead), UPenn, NRAO, SKA-SA.

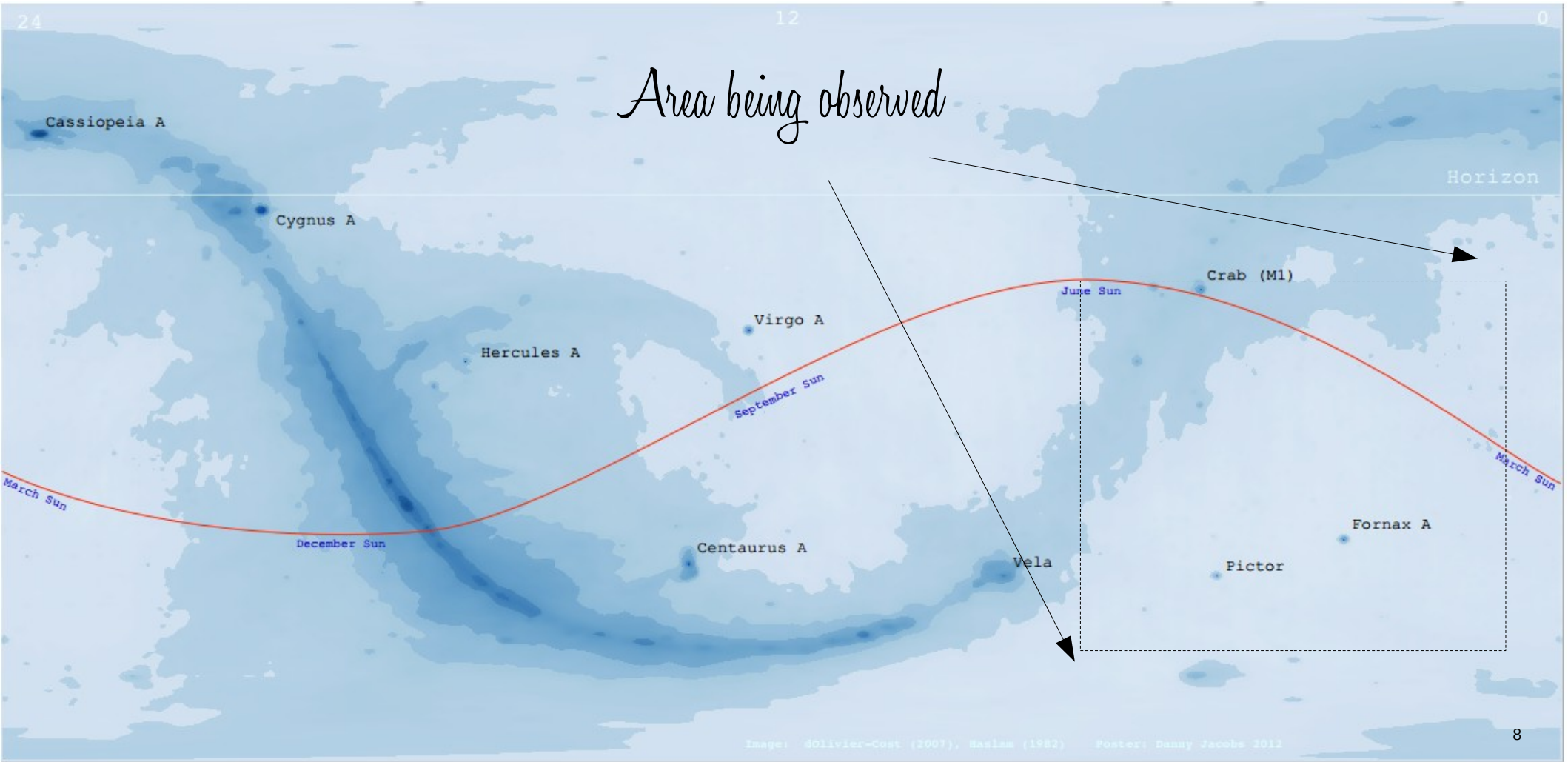
- **PAPER 32**, dipoles distributed pseudo-randomly within a 350 m diameter circle.

- Generate an all-sky catalogue to be used for calibration and foreground subtraction.

Snapshot imaging

- Data recorded on 15th Sept. 2011 from 12:04 hrs to 04:44 hrs [UT]
- 10 minute observation, integration time of 42.85 seconds per snapshot
- A snapshot image have a FoV of 51.2°

Image courtesy: Danny Jacobs



Radio interferometry measurement equation and calibration

(Hamaker et al. 1996; Hamaker 2000, Smirnov 2011a)

Visibility matrix (V) measured by interferometer *pq*

$$\mathsf{V}_{pq} = \boldsymbol{G}_p \left(\iint_{lm} \mathsf{B}_{pq} \mathrm{e}^{-2\pi i(u_{pq}l + v_{pq}m)} \, dl \, dm \right) \boldsymbol{G}_q^H$$

$$\mathsf{B}_{pq} = \boldsymbol{E}_p \mathsf{B} \boldsymbol{E}_q$$

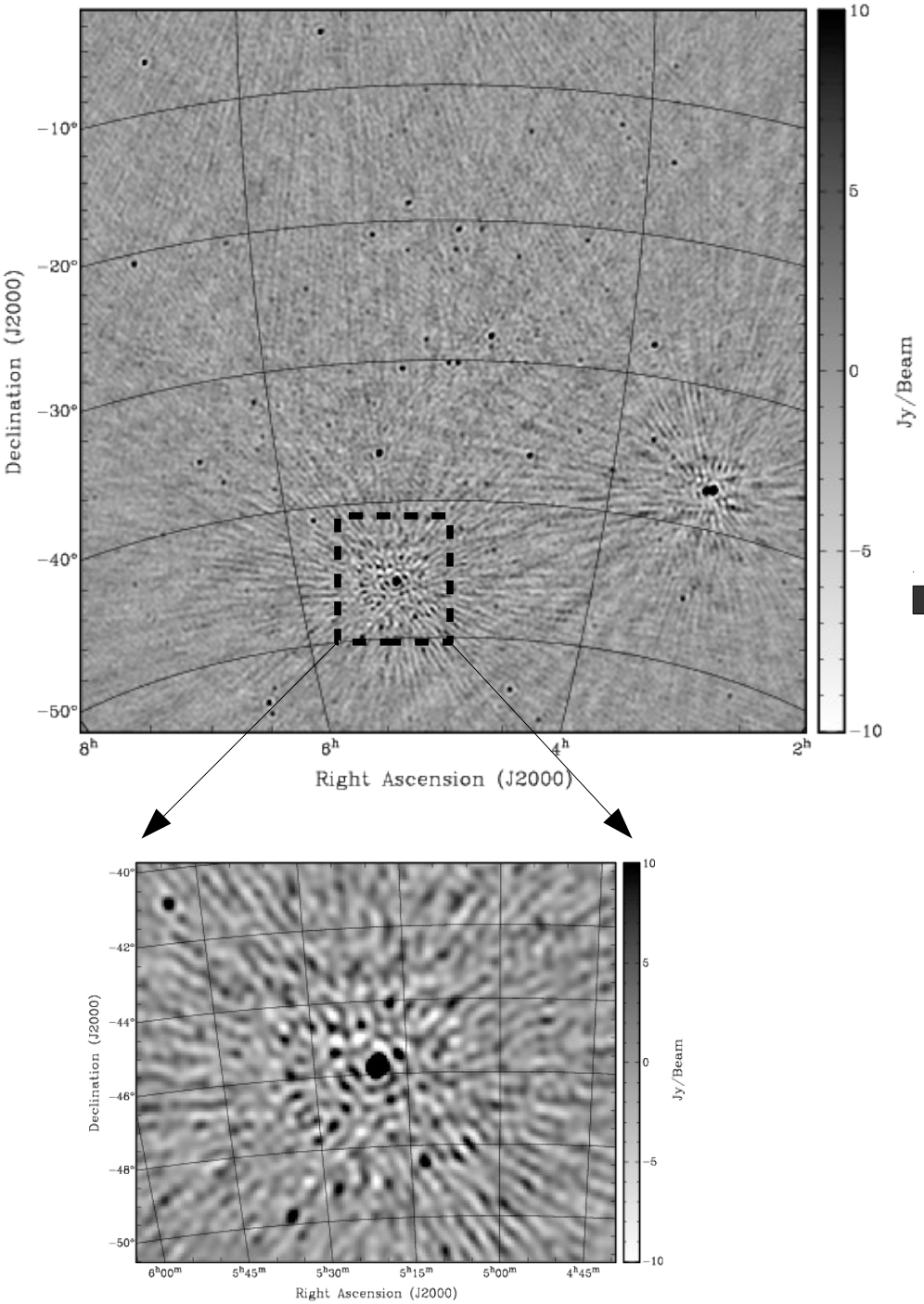
B term → a 2 × 2 brightness matrix

G*p* → Jones matrices represent the per-antenna direction-independent effects (DIEs)

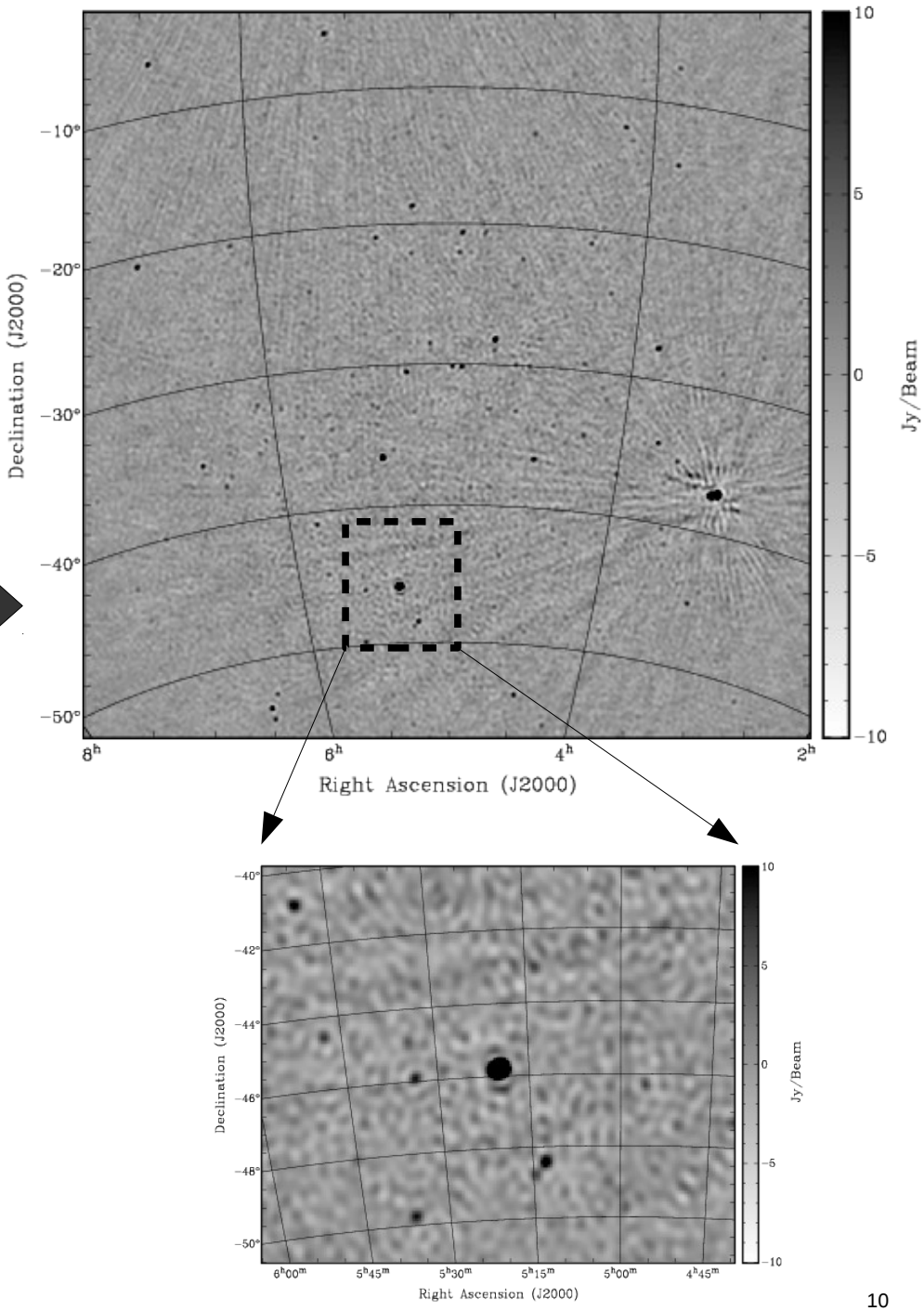
E*p* → Jones matrices represent the direction-dependent effects (DDEs)

Direction independent errors

Before

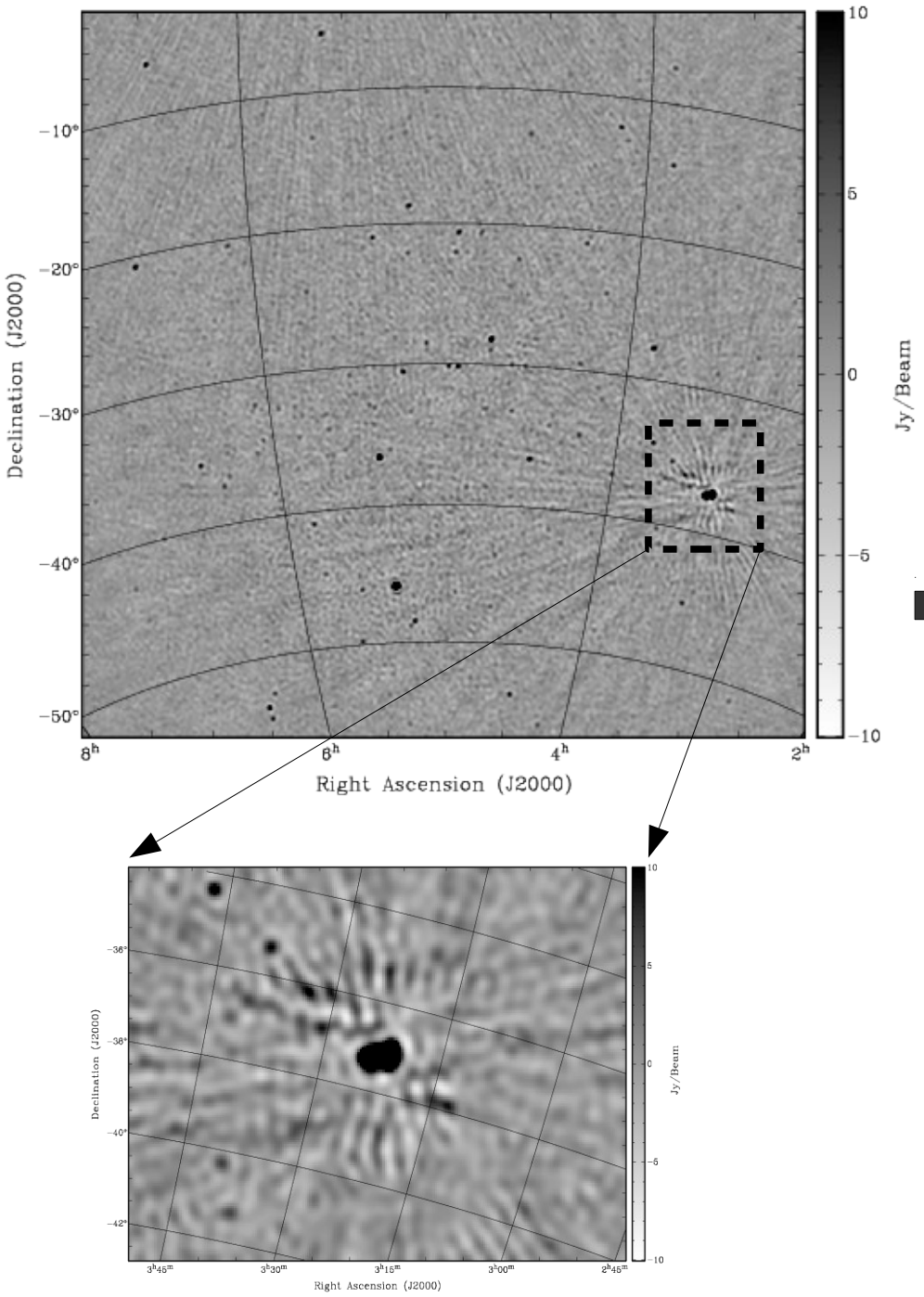


After

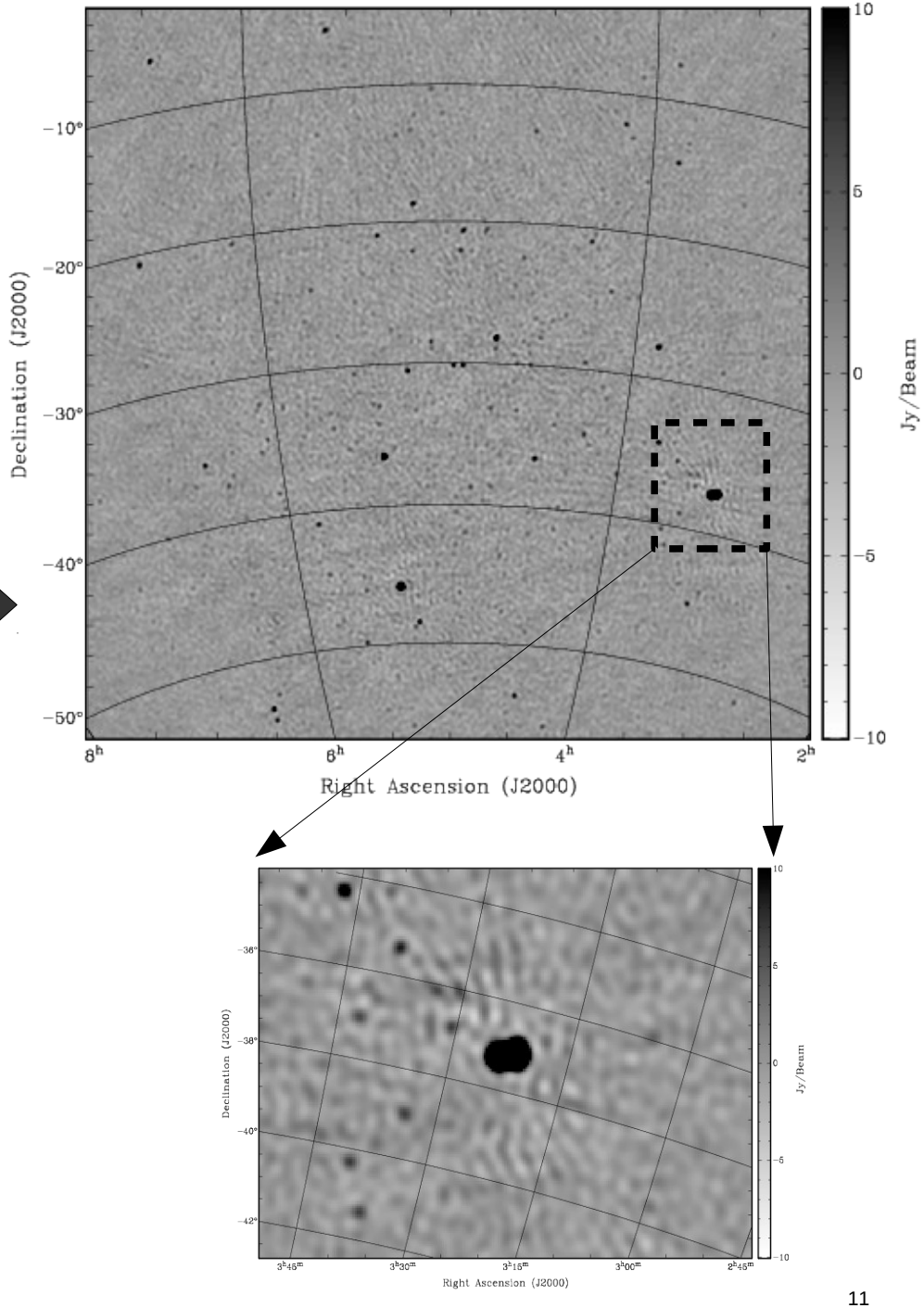


Direction dependent errors

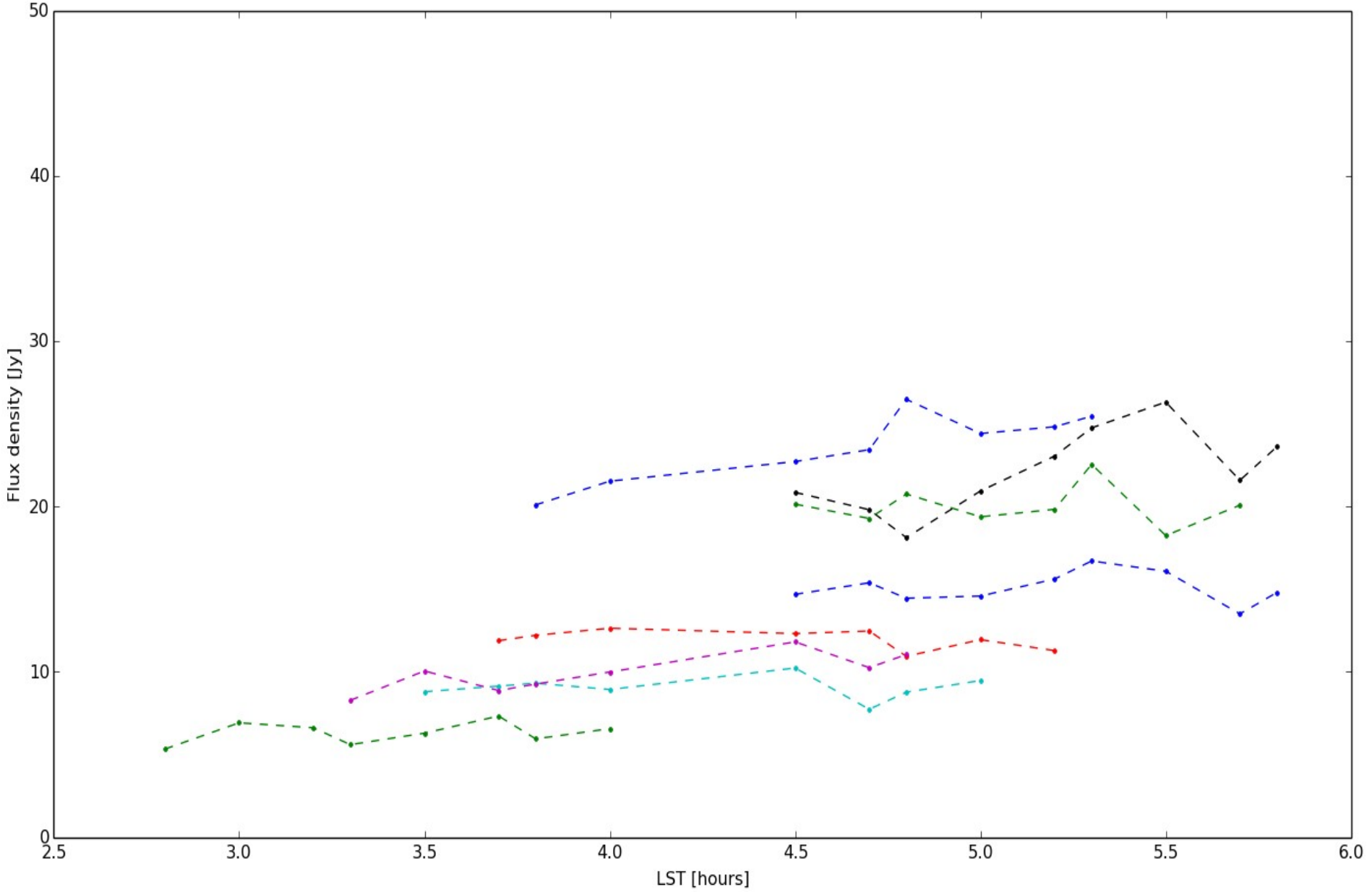
Before



After



Flux density of sources before absolute flux calibration



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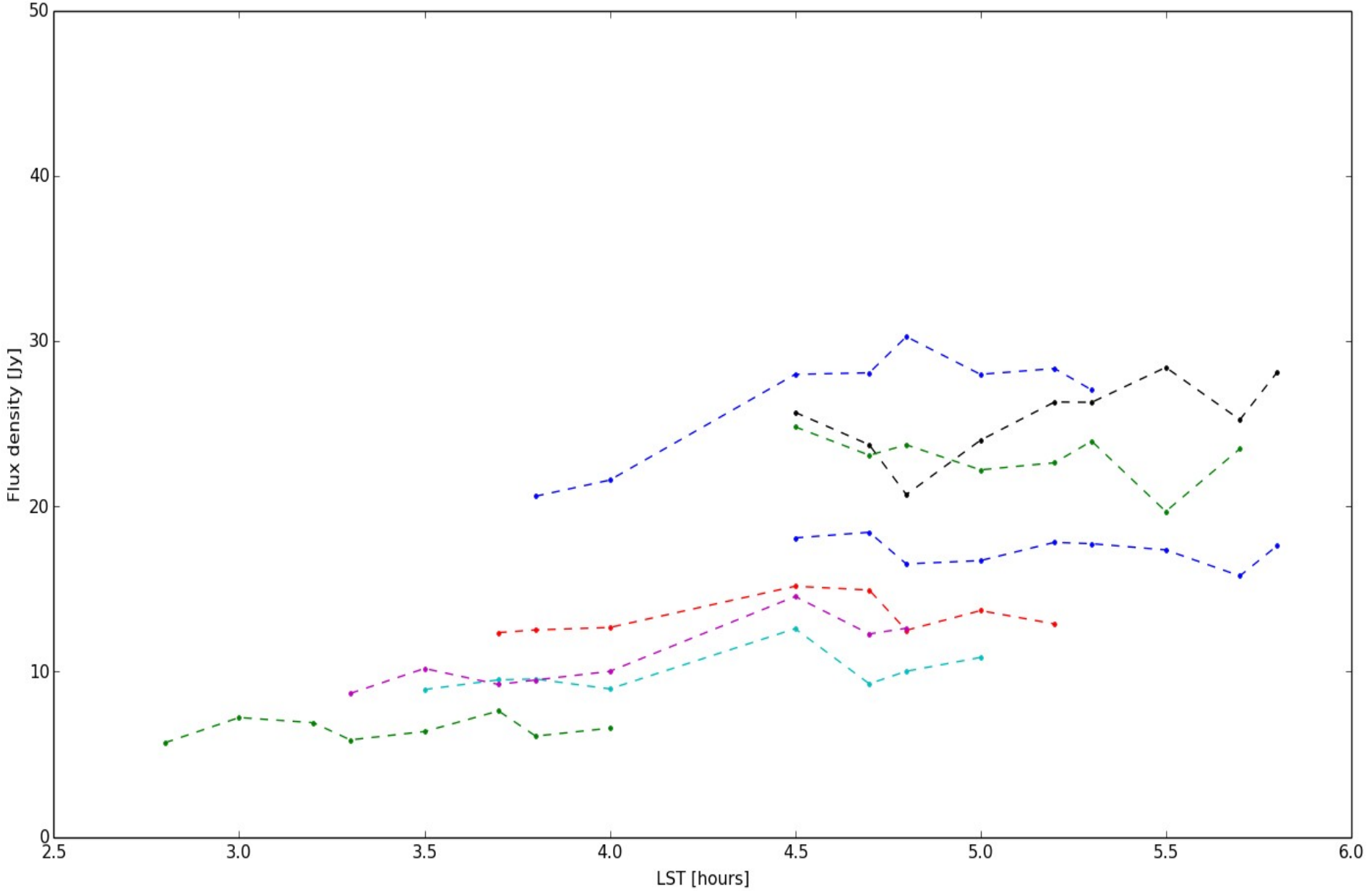

Summary

- Snapshot imaging
- Direction independent calibration
- Direction dependent calibration
- Absolute flux calibration
- Source extraction

Future work

- Catalogue preparation

Thank You