Re-cap of Week 1 – The Salient Points

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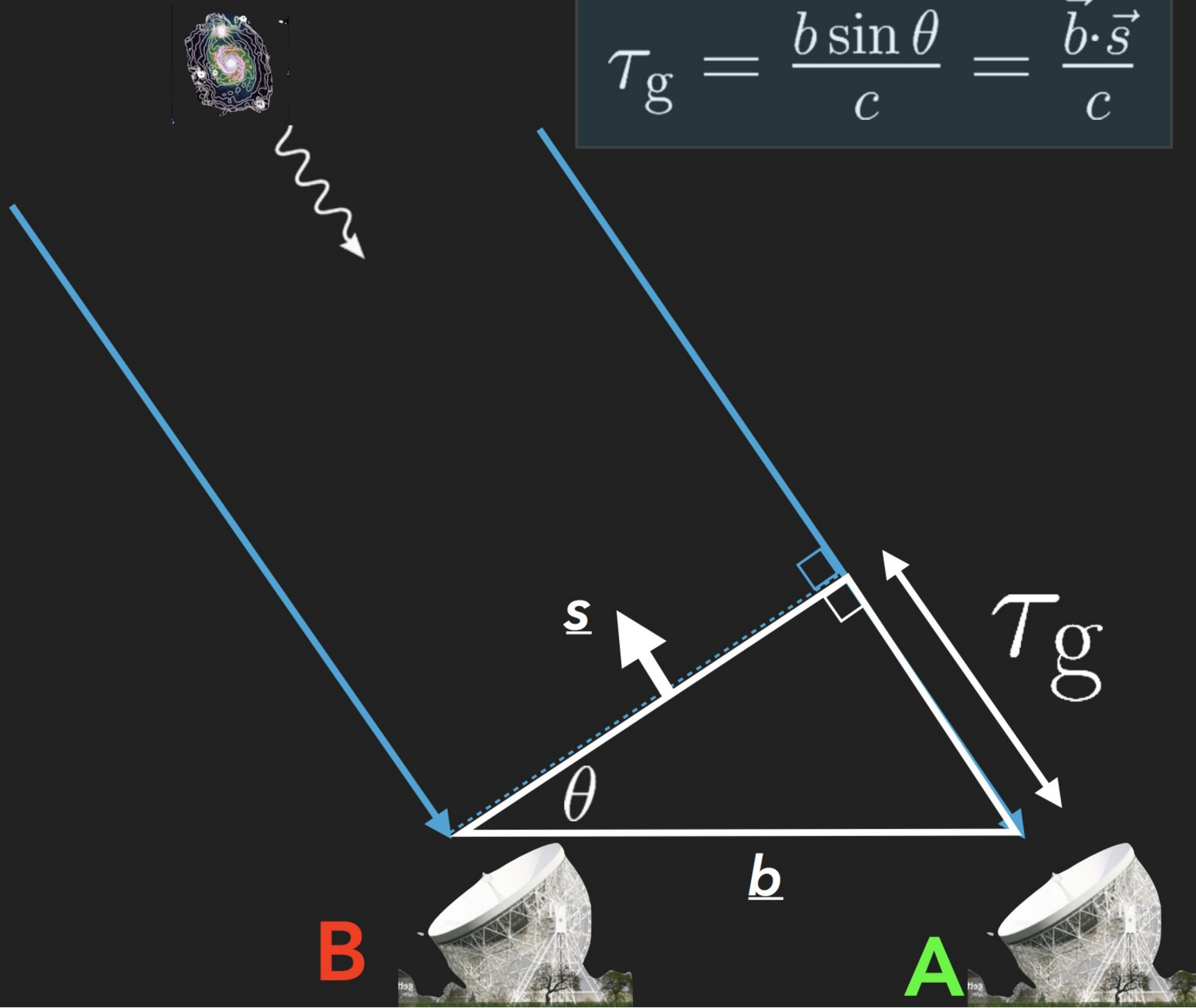
8th of July2018

ASTRON

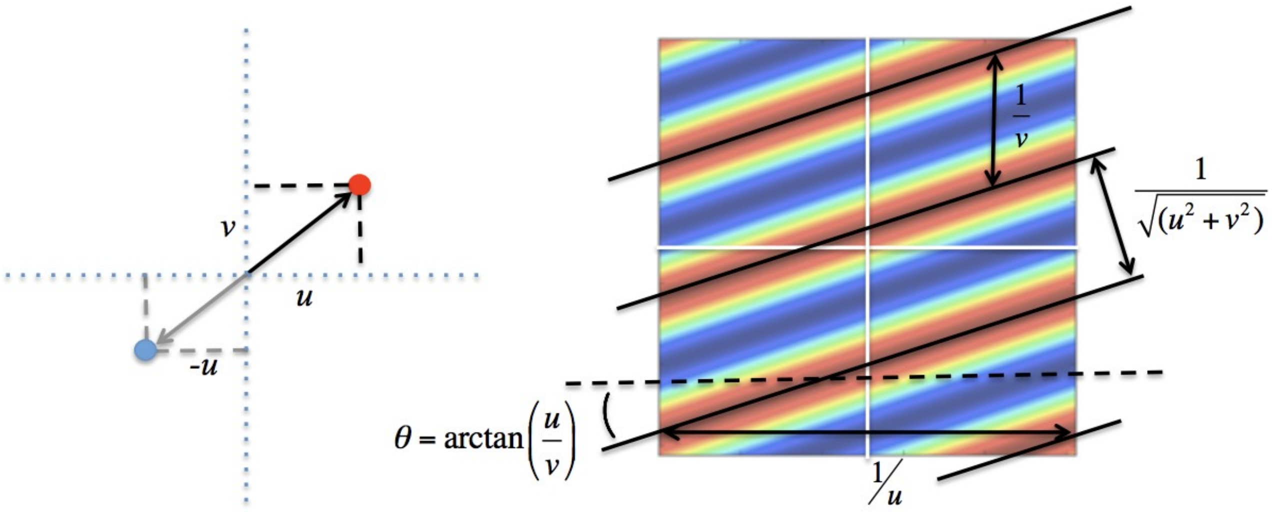
DARA
DEVELOPMENT IN AFRICA WITH RADIO ASTRONOMY

$$\tau_{\mathrm{g}} = \frac{b \sin\theta}{c} = \frac{\vec{b} \cdot \vec{s}}{c}$$



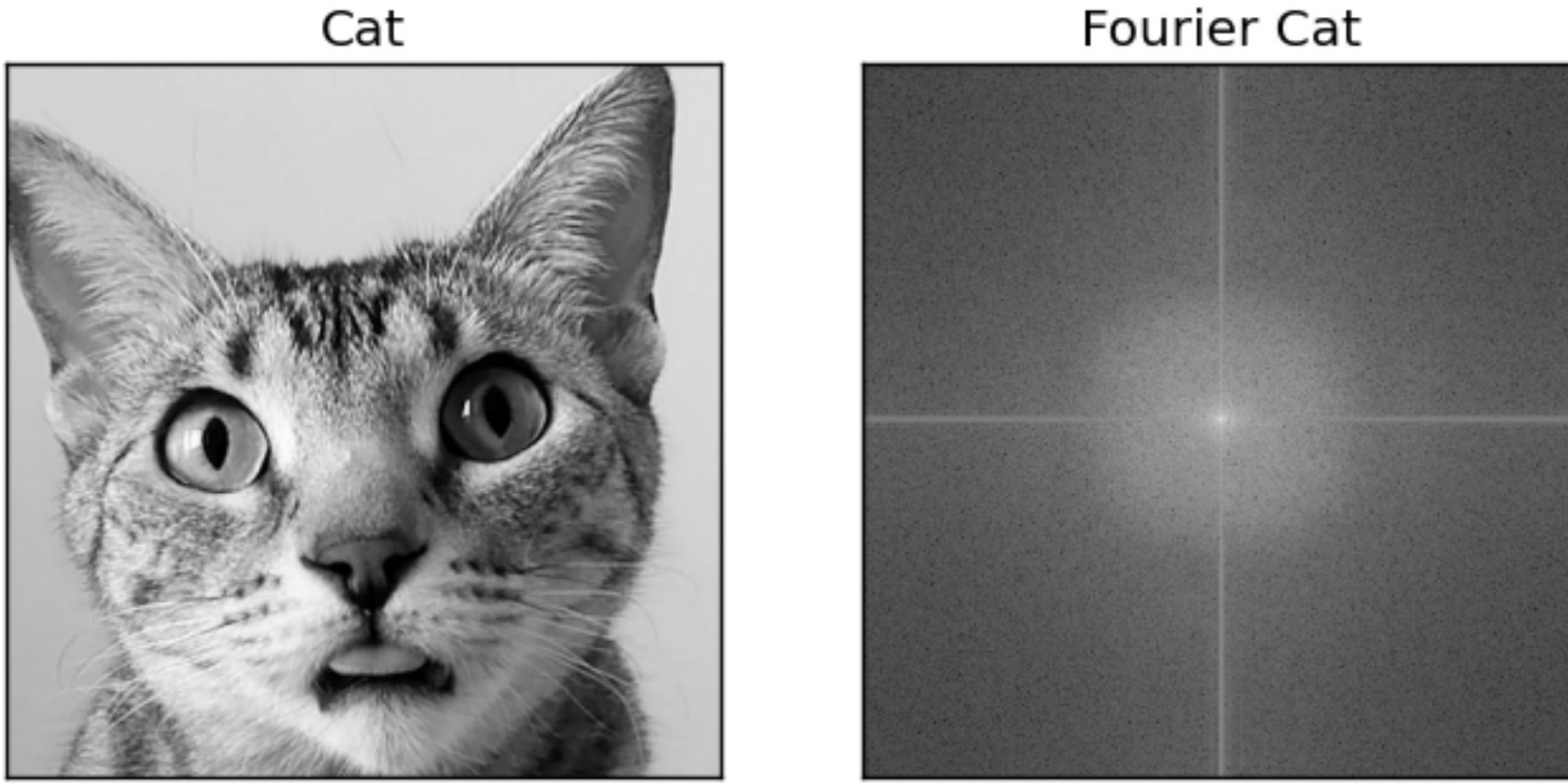
Visibilities

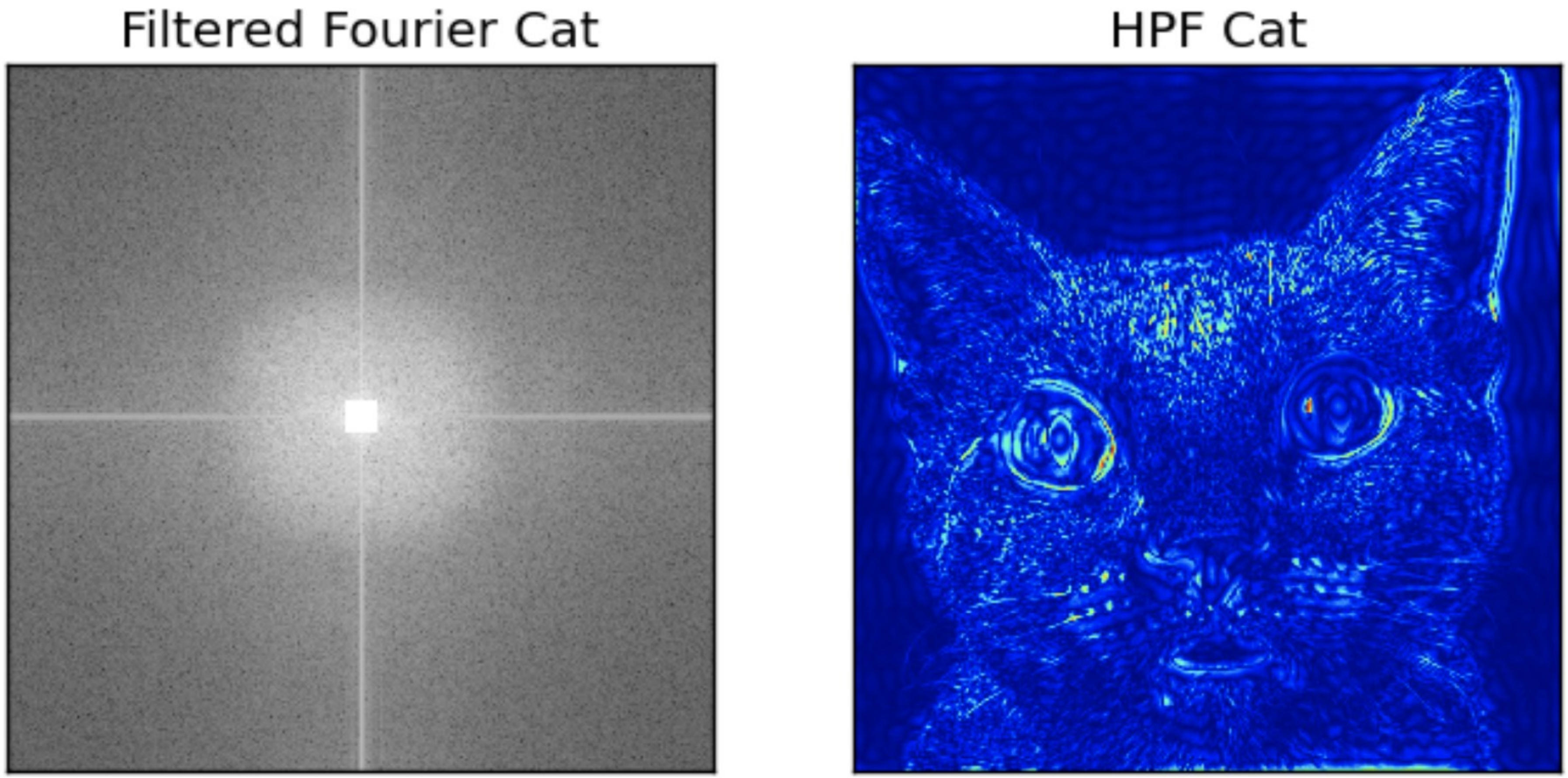
FOURIER COMPONENTS

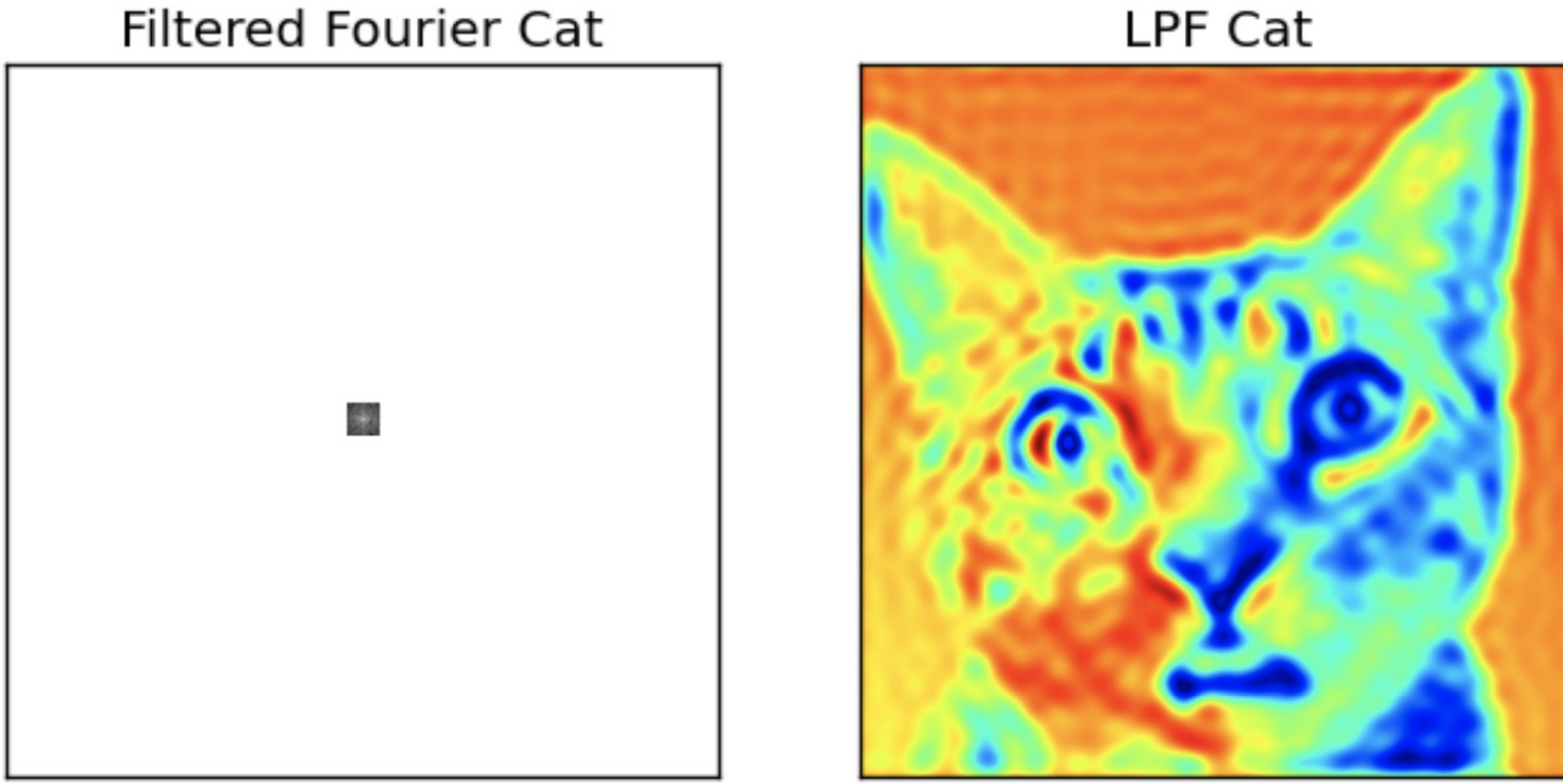


Writing the equation in this way allows us to visualise how our image is composed.

$$I_{meas}(l,m) = \frac{1}{M}\sum_{i=1}^{M} A(u_i,v_i)\cos[2\pi(u_i l + v_i m) + \phi_i]$$

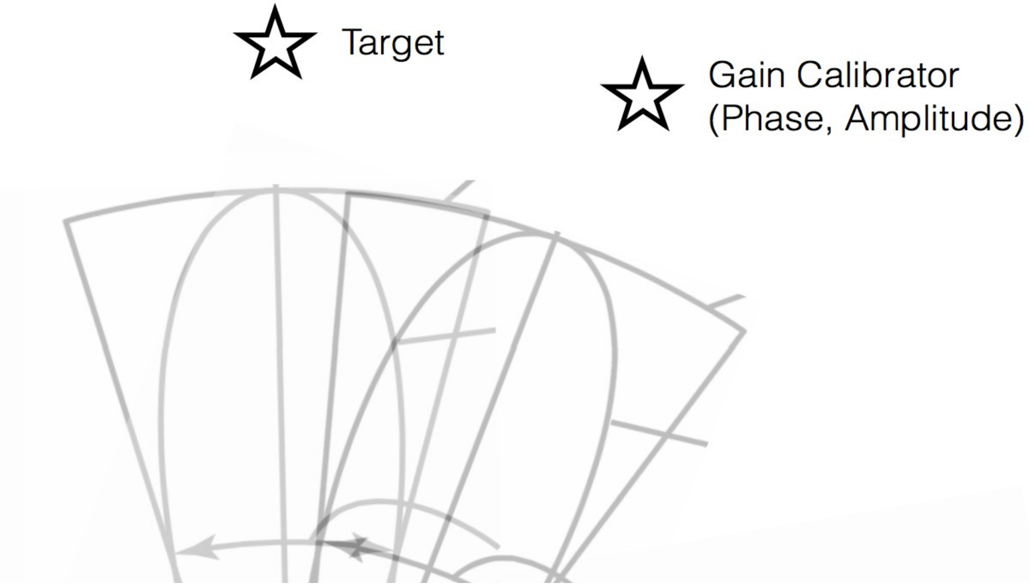

Cat
Fourier Cat


Filtered Fourier Cat
HPF Cat


Filtered Fourier Cat
LPF Cat

a Priori Calibration

Phase Referencing Recap



1. Observe **source**
2. Observe **calibrator** to measure gains (amplitude and phase) as a function of time.
3. Observe **bright calibrator** of known flux-density and spectrum to measure absolute flux calibration, band-pass and residual delays

Jones matrix for antenna *i*

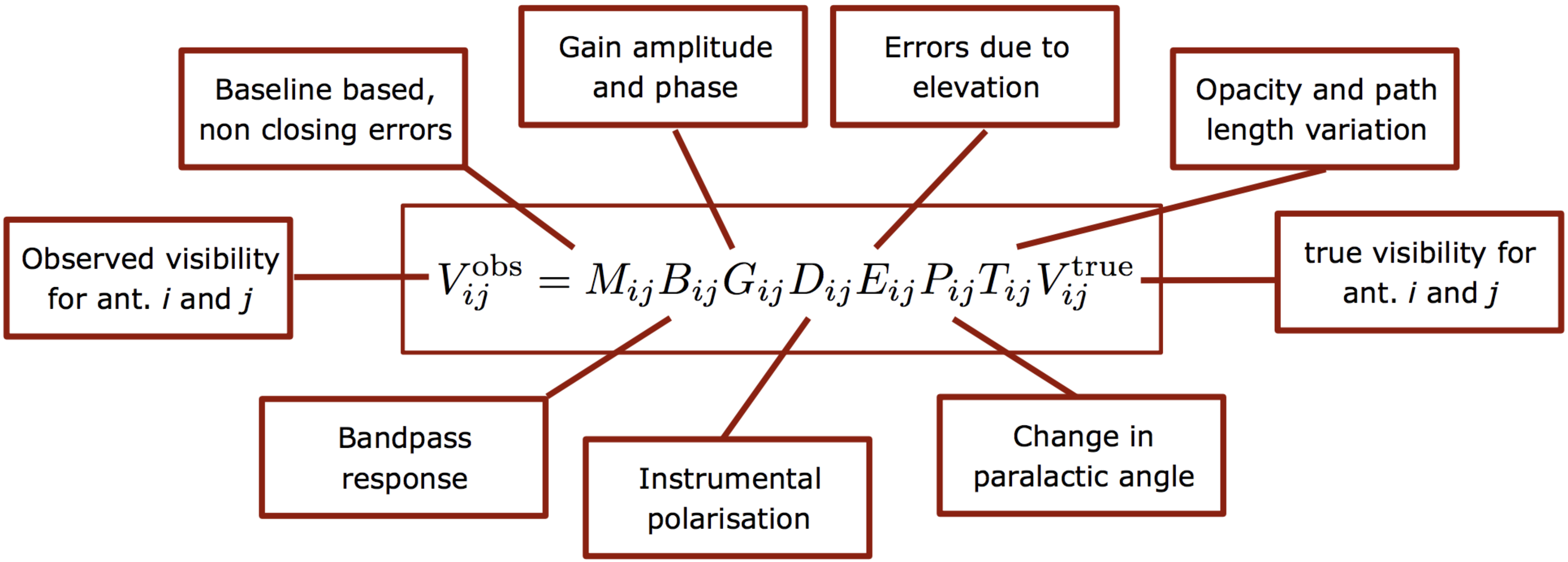
$$\vec{V}_{ij} = J_{ij}\vec{V}_{ij}^{\mathrm{IDEAL}} \quad \text{where} \quad J_{ij} = J_i \times J_j^*$$

observed visibility

Combined Jones matrix

ideal visibility

CASA’s formalisation of RIME



Calibration solves for each Jones matrix (when required) given a **model** for the sky.

How to fringe-fit?

$$\vec{V}_{ij}^{\text{obs}} = M_{ij} B_{ij} F_{ij} G_{ij} D_{ij} E_{ij} P_{ij} T_{ij} \vec{V}_{ij}^{\text{true}}$$

- Need to solve for phase errors in time (rate) and frequency (delay) space
- Remember the interferometer phase: $\phi = 2\pi\nu\tau_{\text{obs}}$

→ phase error depends on delay (i.e. against frequency)

- Fringe fitting solves these errors assuming a linear model of the phase error for each antenna i.e.

$$\Delta\phi_i(t,\nu) = \phi_{i,0} + \frac{\partial\phi_i}{\partial\nu}\Delta\nu + \frac{\partial\phi_i}{\partial t}\Delta t$$

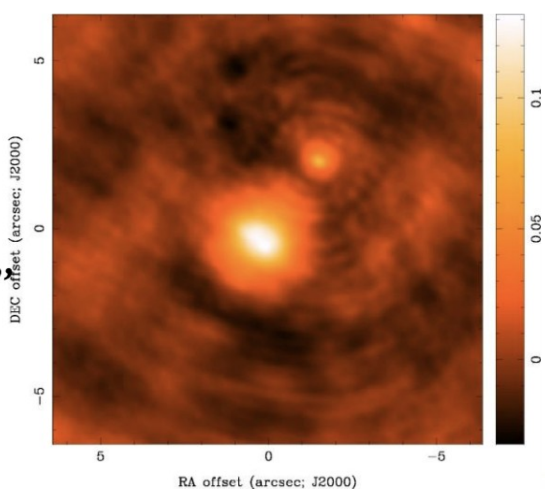
Phase error at time t and ν

Delay term

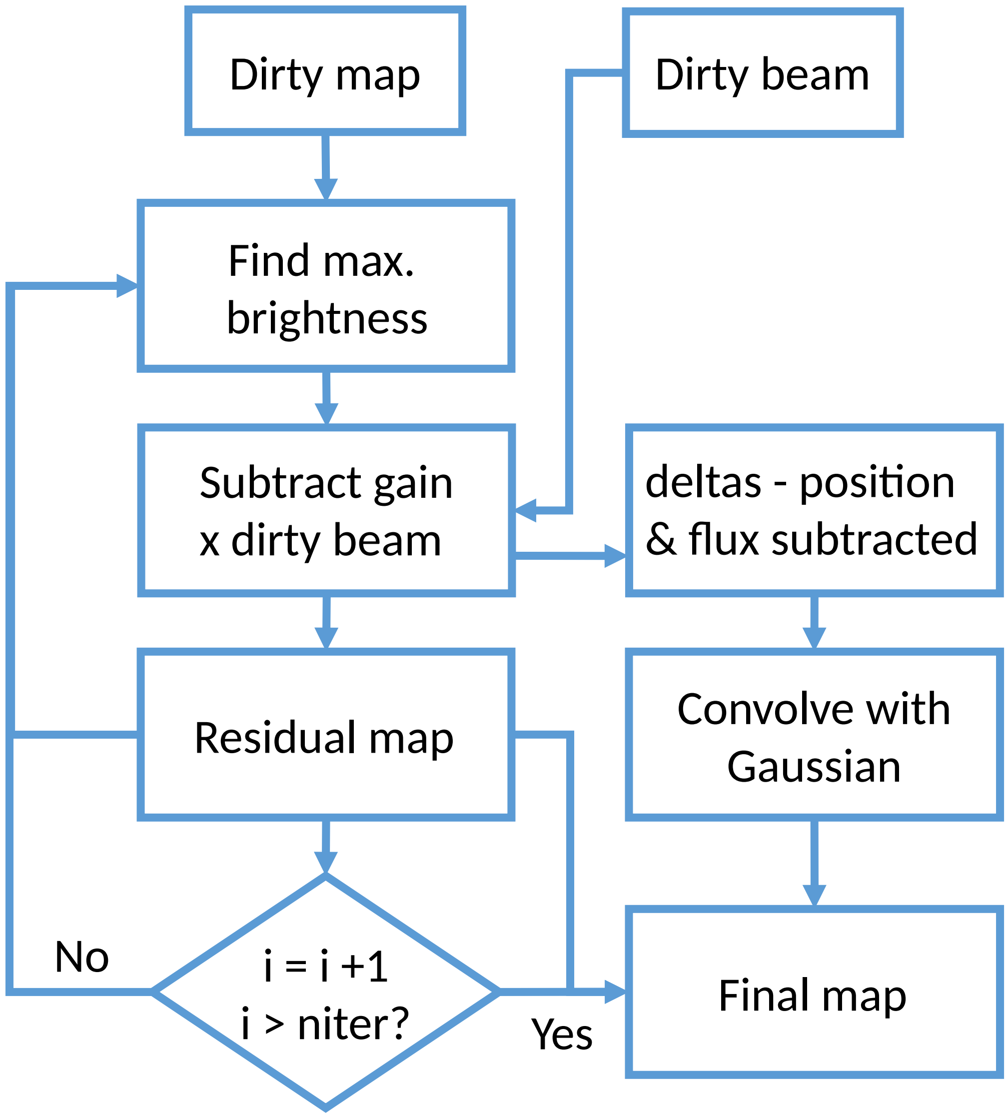
Rate term

- Some cases (e.g. space, mm-, low-frequency VLBI) need require higher orders e.g. dispersive delays - $\mathcal{O}\frac{\partial^2\phi}{\partial\nu^2}\Delta\nu$

$T^D(l,m)$
"dirty image"



HOGBOM CLEAN & VARIANTS



- initialize
  - a *residual map* to the dirty map
  - a *Clean Component* list

1. identify the highest peak in the residual map as a point source
2. subtract a fraction of this peak from the *residual map* using a scaled dirty beam, *s(l,m)* x gain
3. add this point source location and amplitude to the *Clean Component* list
4. goto step 1 (an iteration) unless stopping criterion reached

Self Calibration

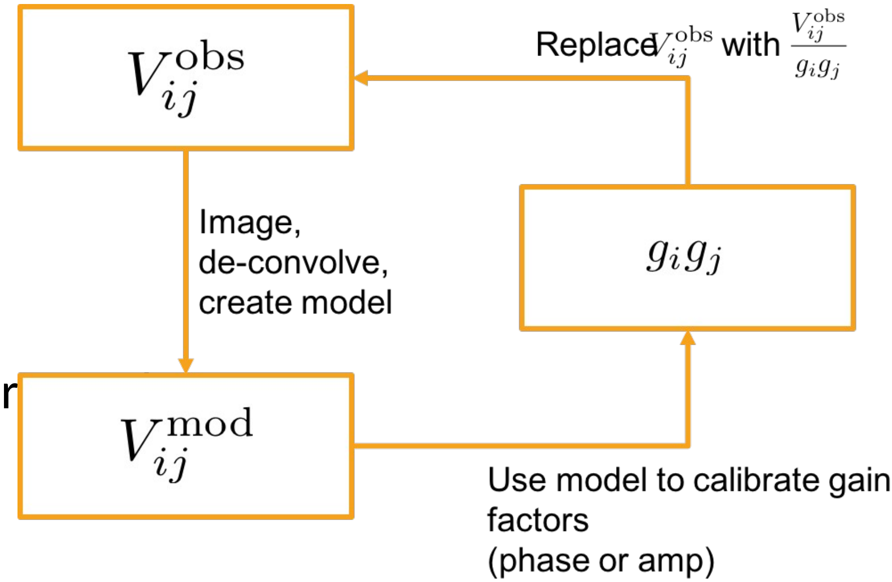
The Self Calibration Method

1. Create an initial source model, typically from an initial image (or else a point source)
   - Use full resolution information from the model image NOT the restored image (ie. CLEAN +residuals)

2. Find antenna gains
   - Using “least squares” fit to visibility data

3. Apply gains to correct the observed data

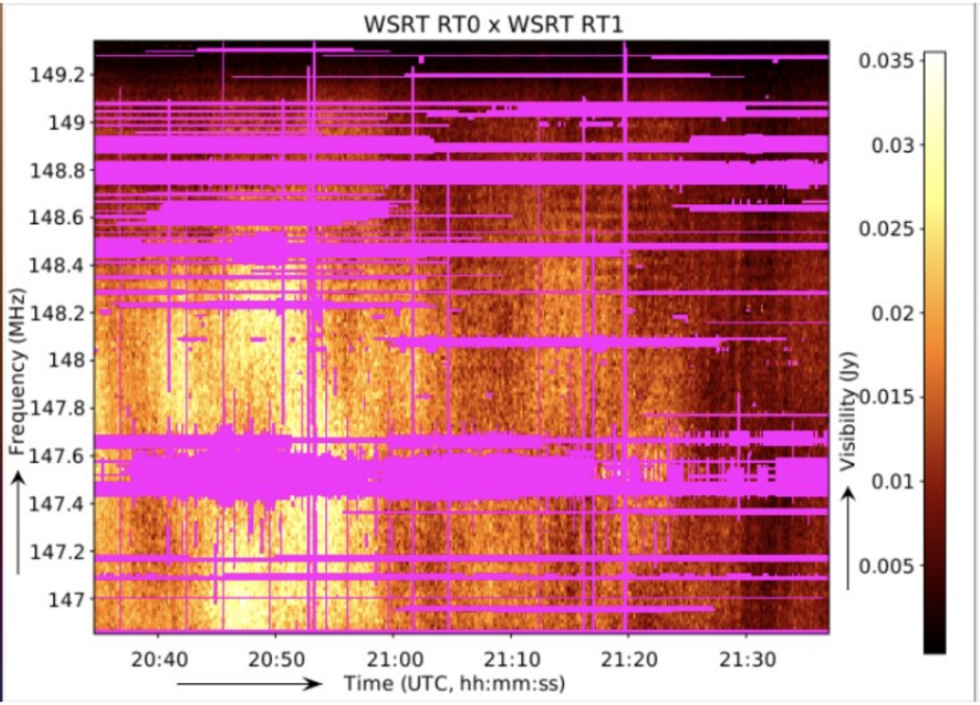
4. Create new model visibilities () from the cor data



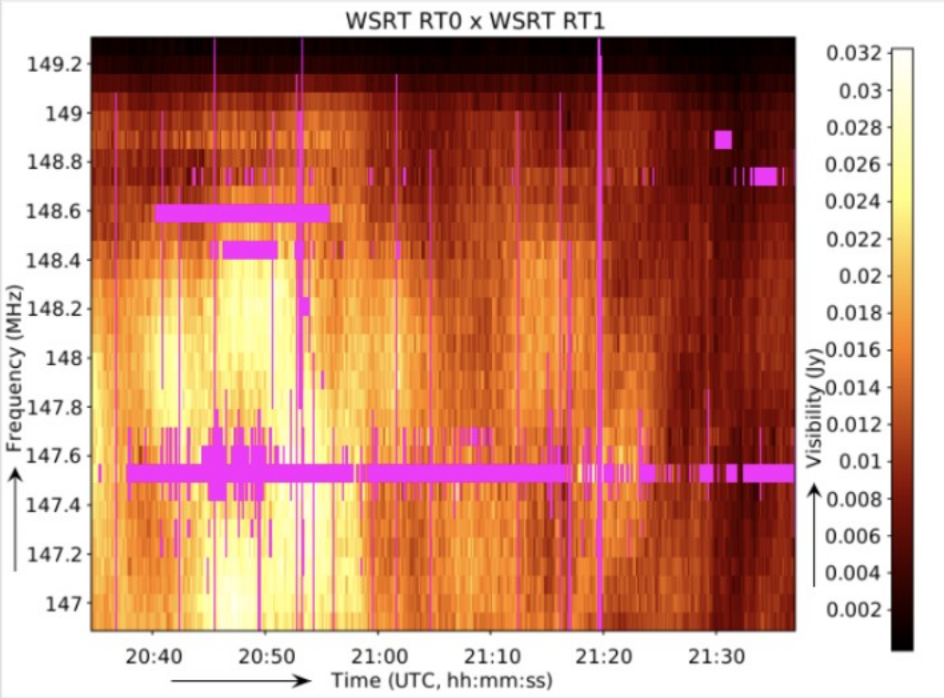
5. Go to (2), unless current model is satisfactory
   - shorter solution interval, different uv limits/weighting
   - phase → amplitude & phase

Flagging

Original resolution:

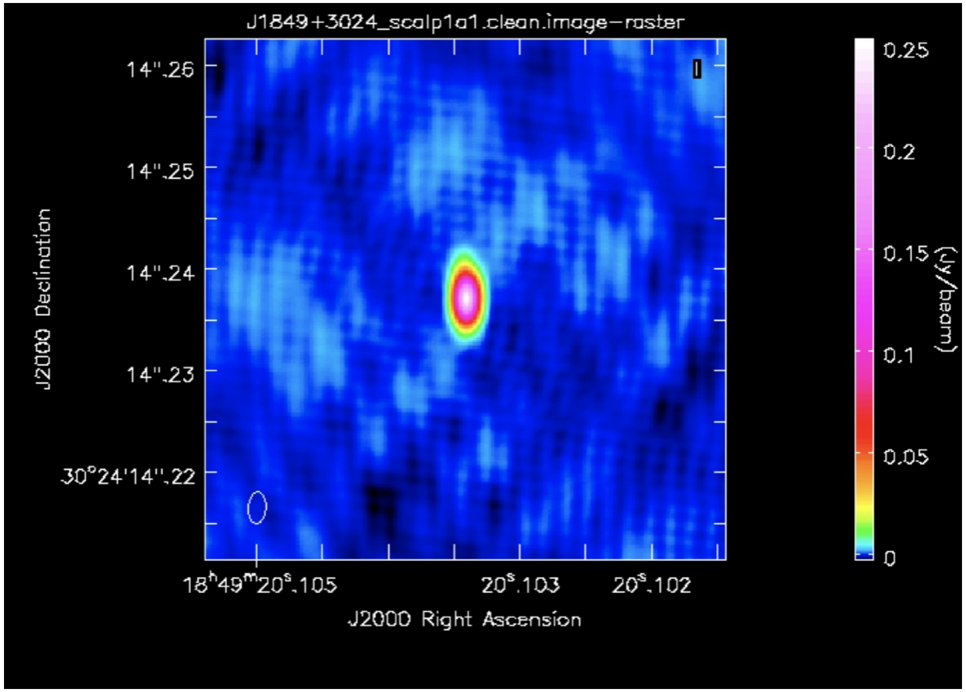


After averaging



Tutorials

- Through all this theory you were working towards a practical understanding too.
- Have experience with interacting with CASA manually and via a script
- Can perform VLBI calibration for the EVN and image source.



Next few days

Today

		W7: EVN continuum p.3 - refine calibration	Jack/Joe
		W7: EVN continuum p.3 - imaging & self-cal	Jack/Joe

6	09:00-10:45	Recap of week 1 W8: 3C277.1 calibration	Joe/Jack Joe/Jack
	11:15-12:30	W8: 3C277.1 calibration	Joe/Jack
	14:00-15:30	W8: 3C277.1 calibration	Joe/Jack
	16:00-17:00	Science talk 2	Jack
7	09:00-10:45	L11: Advanced imaging	Jack
	11:15-12:30	W8: 3C277.1 imaging	Joe/Jack
	14:00-15:30	W8: 3C277.1 imaging	Joe/Jack
	16:00-17:00	L12: Life cycle of a project and archives	Jack/Joe