

# Preparing for the hands-on Tuesday afternoon

- Make sure you have conda
- git clone <https://github.com/crpurcell/friendlyVRI.git>
- go to the downloaded directory
- conda env create -f environment.yml
- conda activate vri
- pip install notebook
- git clone a python notebook <https://github.com/cherryng/teaching/blob/main/PulsarSearchTutorial-ForStudents.ipynb>
- Python notebook solution <https://github.com/cherryng/teaching/blob/main/PulsarSearchTutorial-ForStudents-Solution.ipynb>

# Exercise 1: Playing with interferometer

Pick a source image, play with these settings and see which one gives you the best observations.

```
python vriTk.py
```

The screenshot shows the vriTk.py software interface. It features a central plot of North-South (km) vs East-West (km) with a cluster of points. To the right is a table of telescope and array configurations. Below the plot are fields for antenna diameter, telescope phase, and baseline. At the bottom, there are input fields for model image, source declination, and observing frequency, along with a status bar showing the progress of various tasks.

Telescope	Array
MWA	Extended
MWA	HEX
MeerKAT	AR-1
MeerKAT	AR-2
MeerKAT	AR-3
MeerKAT	KAT-80
PdB	A
PdB	B
PdB	C
PdB	D
SMA	Compact
SMA	Compact_N

Telescope	Array	HA-Start	HA-End	Cadence
MeerKAT	AR-3	0.11	0.11	60

Hour Angle Range (hours): -12.0 to 12.0

Sampling Cadence (s): 60

Model Image: galaxy\_spiral.png

Source Declination (degrees): -20.0

Observing Frequency (MHz): 1240

Pixel Scale (arcsec): 1.0

Robust Weighting Factor: None

Array:  Model:  uv-Coverage:  Model FFT:  Observation:

Calculate & Plot (uv-Coverage) Calculate & Plot (Model FFT) Do Observation Show Plot Window

Telescopes

Integration

Sampling rate

Source image

Declination

Observing freq

# Exercise 1: Playing with interferometer

Pick a source image, play with these settings and see which one gives you the best observations.

The screenshot shows the 'Friendly VRI: Control Window' interface. It features a central plot of 'North-South (km)' vs 'East-West (km)' with a cluster of points. To the right, there are two tables for selecting telescopes and arrays. The first table has 'MeerKAT AR-3' selected. The second table shows 'MeerKAT AR-3' with 'HA-Start' 0.11, 'HA-End' 0.11, and 'Cadence' 60. A blue callout bubble points to the 'Add' button with the text '1. Add selected array'. Below the tables, there are buttons for 'Scan Array Model', 'Clear Selected', and 'Clear All'. At the bottom, there are several checkboxes for 'Array', 'Model', 'uv-Coverage', 'Model FFT', 'uv-Grid', 'Beam', and 'Observation'. A blue callout bubble points to the 'uv-Coverage' checkbox with the text '2. Calculate UV'. Another blue callout bubble points to the 'Do Observation' button with the text '3. Do observation'. The 'Do Observation' button is highlighted in the interface.

Telescope	Array
MWA	Extended
MWA	HEX
MeerKAT	AR-1
MeerKAT	AR-2
MeerKAT	AR-3
MeerKAT	KAT-80
PdB	A
PdB	B
PdB	C
PdB	D
SMA	Compact
SMA	Compact_N

Telescope	Array	HA-Start	HA-End	Cadence
MeerKAT	AR-3	0.11	0.11	60

Antenna  $\Theta$ : 12.0 m      Min Baseline: 0.029 km  
Telescope  $\phi$ : -30.7132°

Model Image: [Source Image]      Source: 1240  
Pixel Scale (arcsec): 1.0      Factor: None

Array       Model       uv-Coverage       Model FFT       uv-Grid       Beam       Observation

INPUTS      Calculate & Plot      Calculate & Plot      Do Observation      Show Plot Window

# Exercise 2: Pulsar Searching and solving for binary

- The provided observational time series from LOFAR contains a pulsar:
  - jupyter notebook
  - Use FFT to detect the spin frequency of this pulsar
  - Check with literature to see if it matches
  - Plot the dynamic spectrum (time vs phase) by folding time series with the period
  - Solve the binary orbit
    - « By hand » take a few spin freq measurements at different epochs
    - Try to guess the orbit
    - Try to fit it with `scipy.optimize.curve_fit`

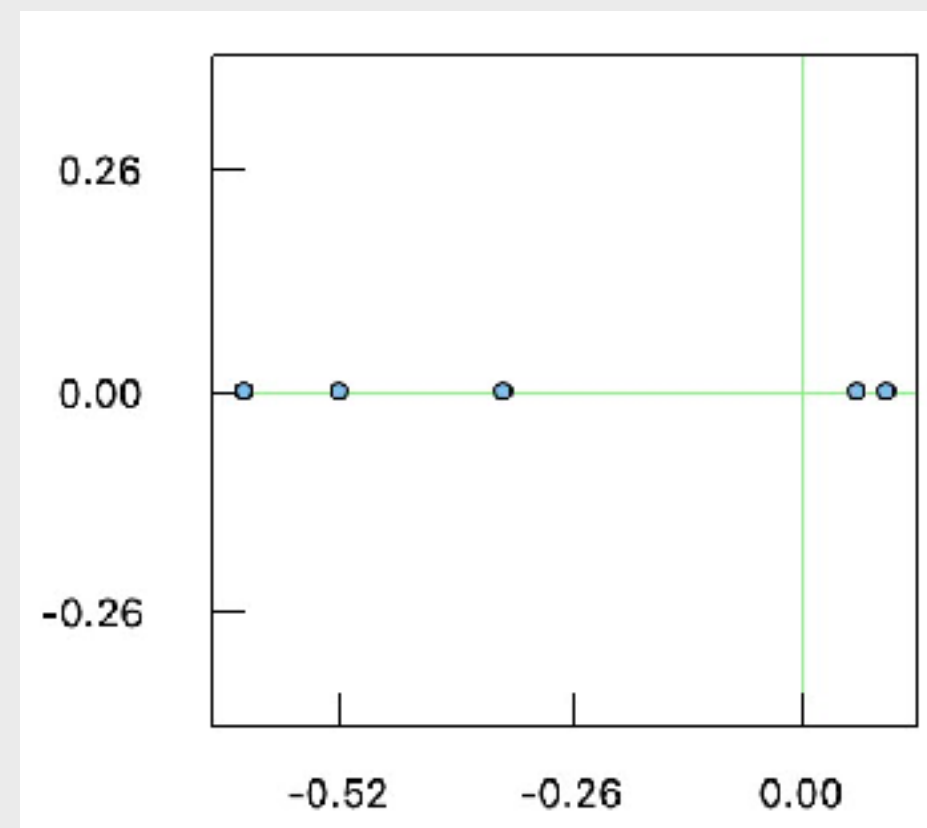
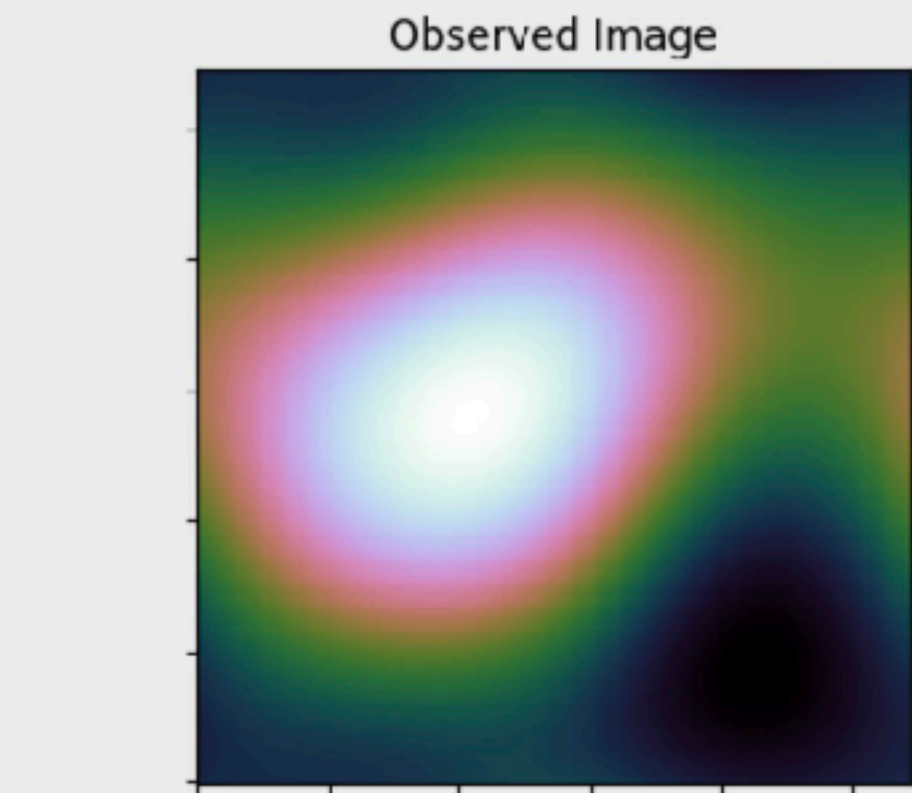
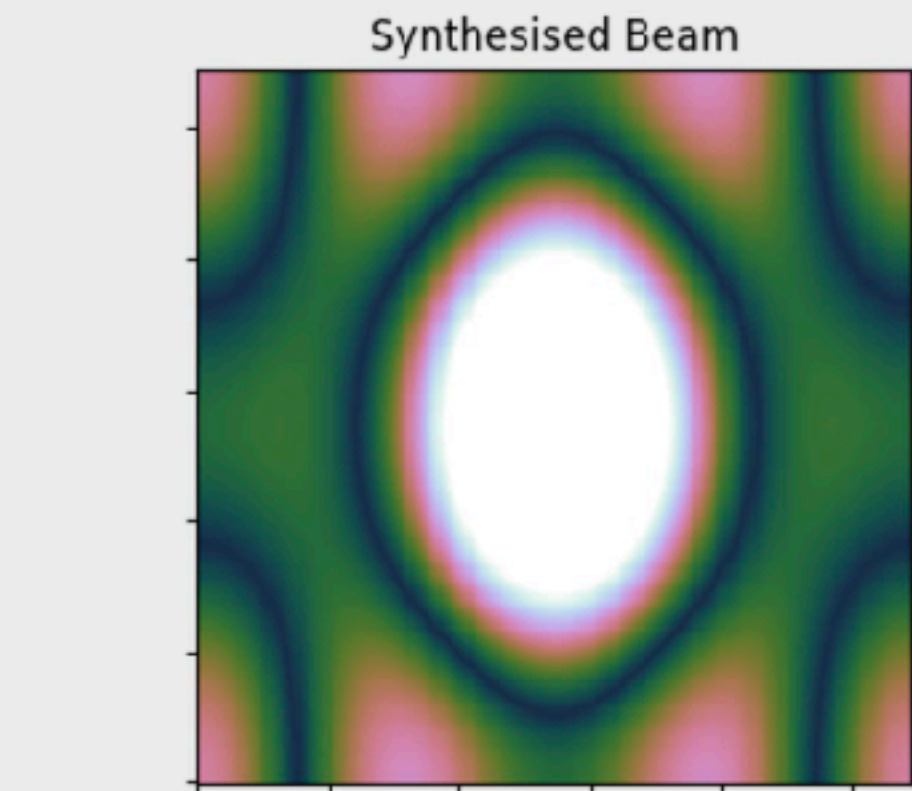
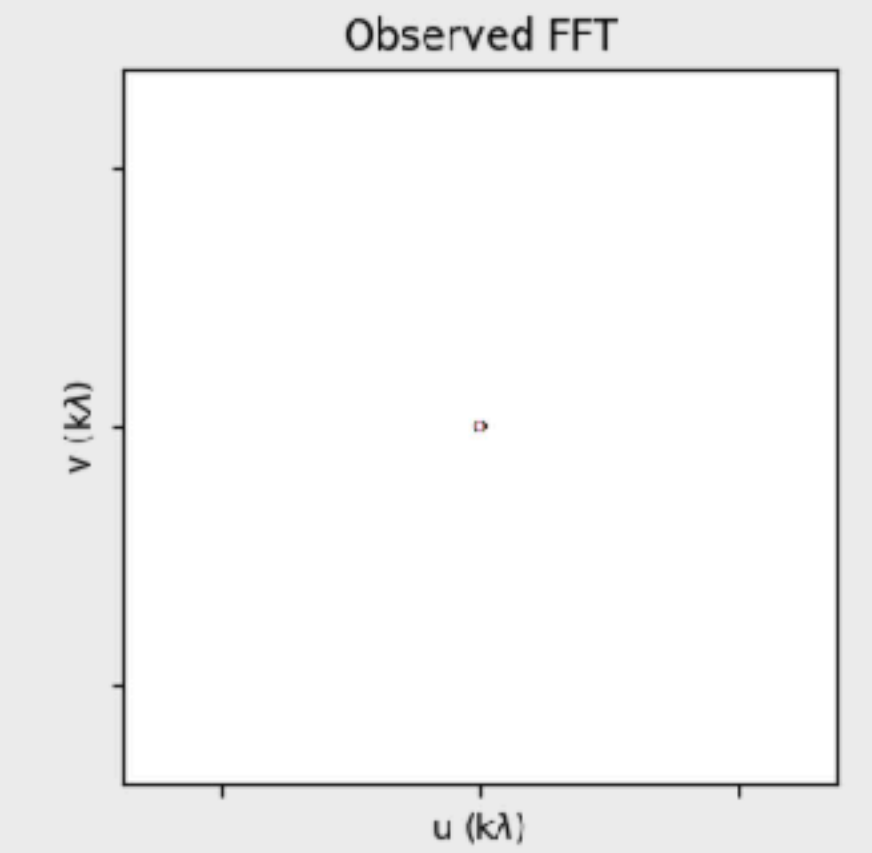
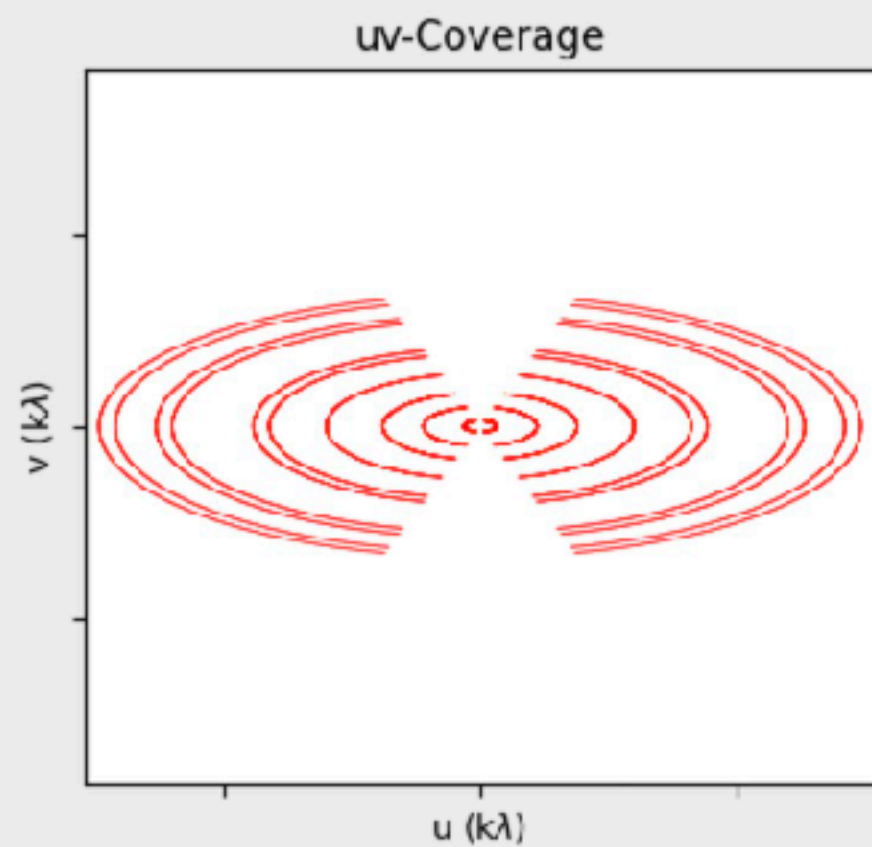
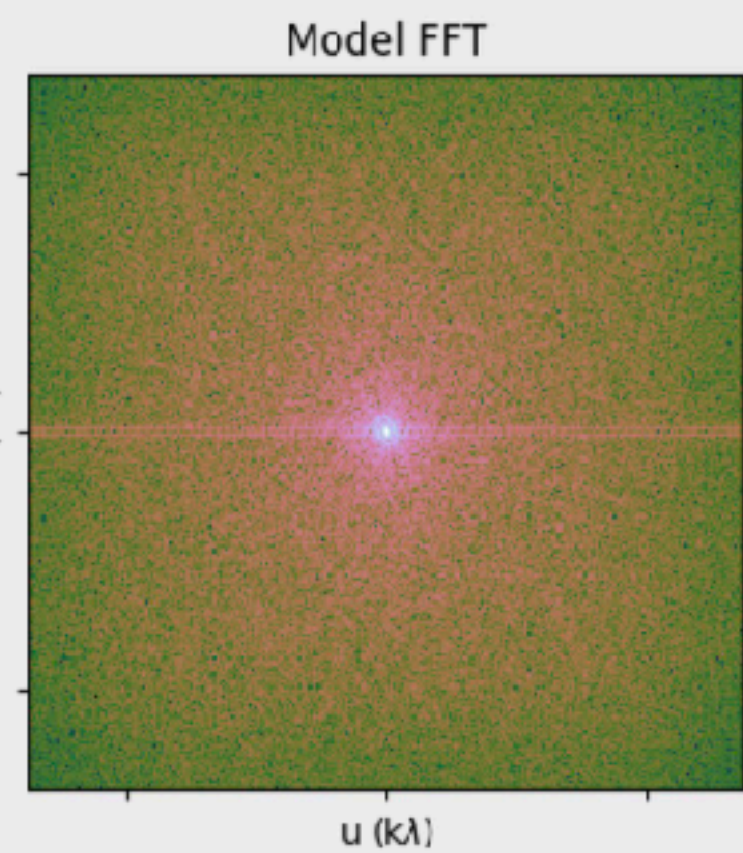
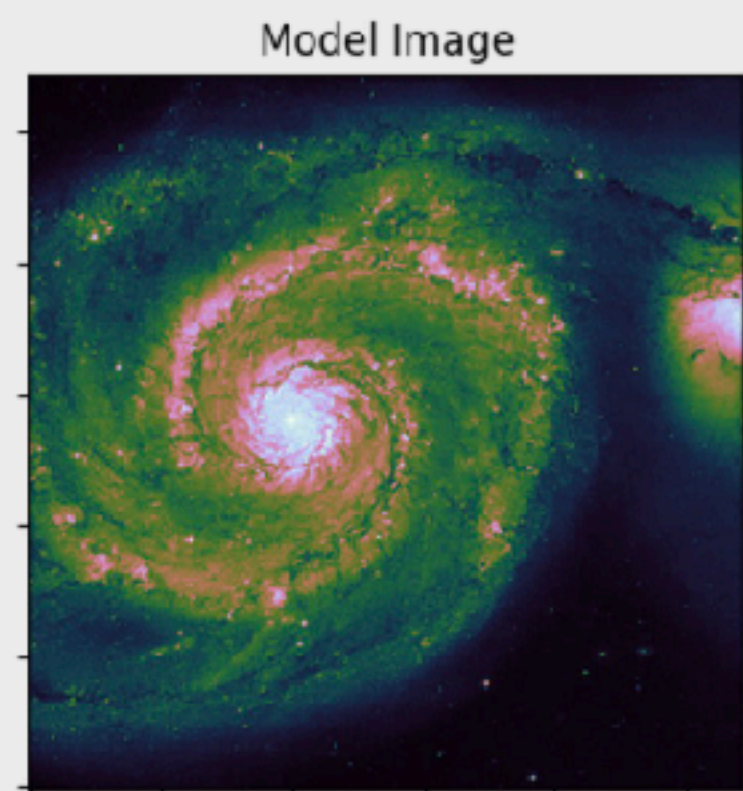
For circular orbit, timing ( $y(t)$ ) is approx. a sinusoid with period equal to the orbital period ( $P_b$ ) and amplitude ( $A$ ) equal to the projected semi-major axis  $y(t) = A \sin(2\pi \frac{t}{P_b} + \phi) + C$

$A$  = amp\_guess

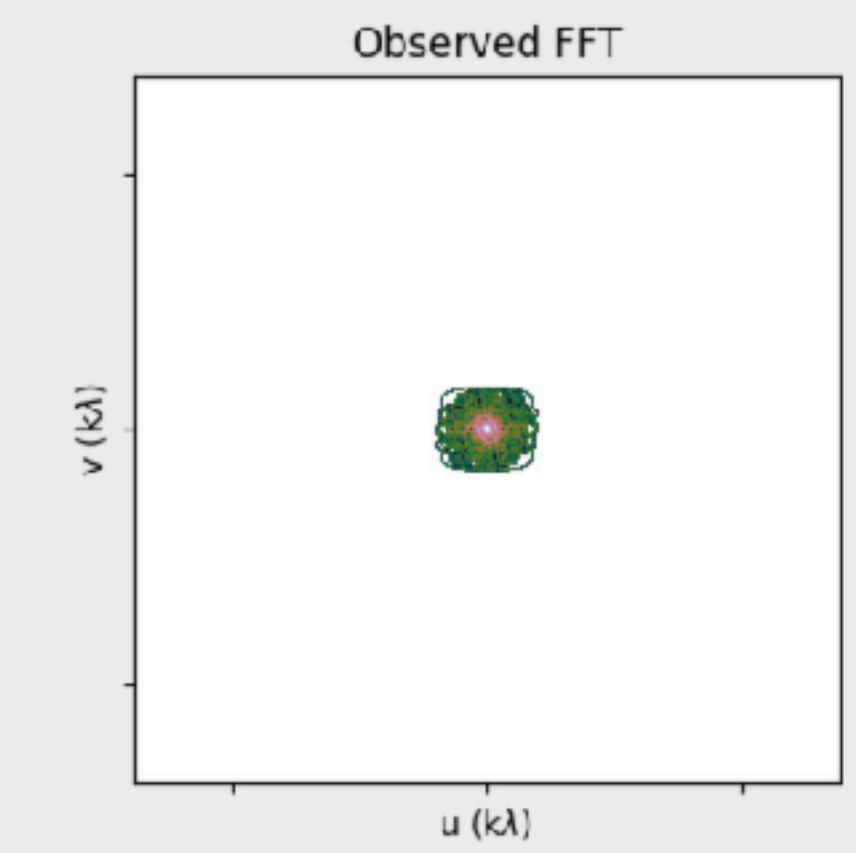
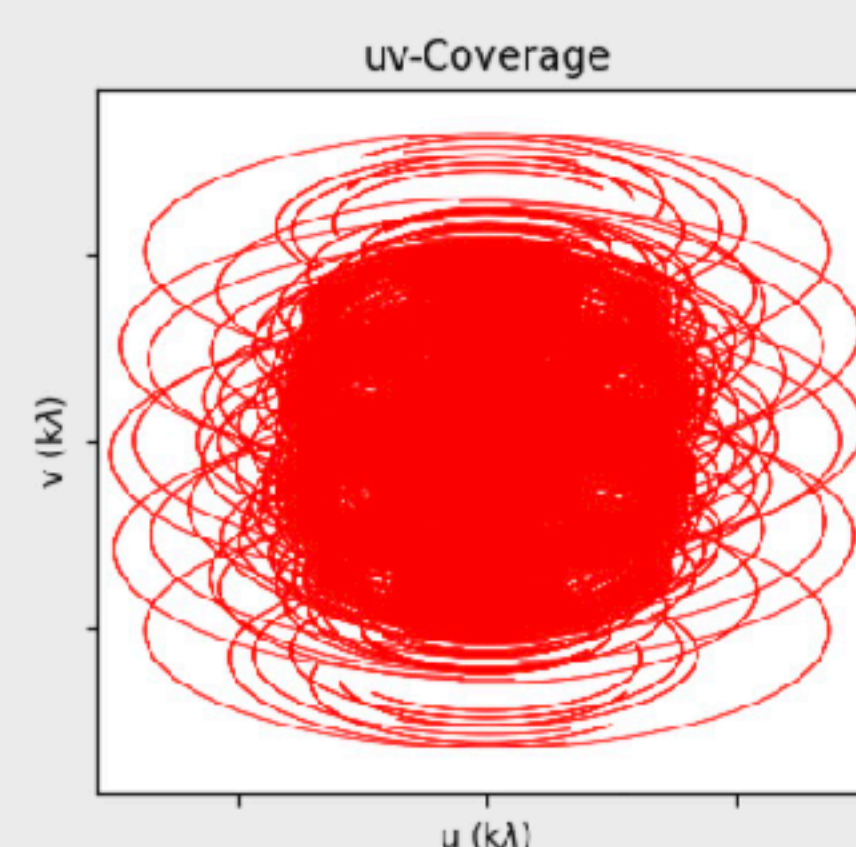
$P_b$  = pb\_guess

Phi = phase\_guess

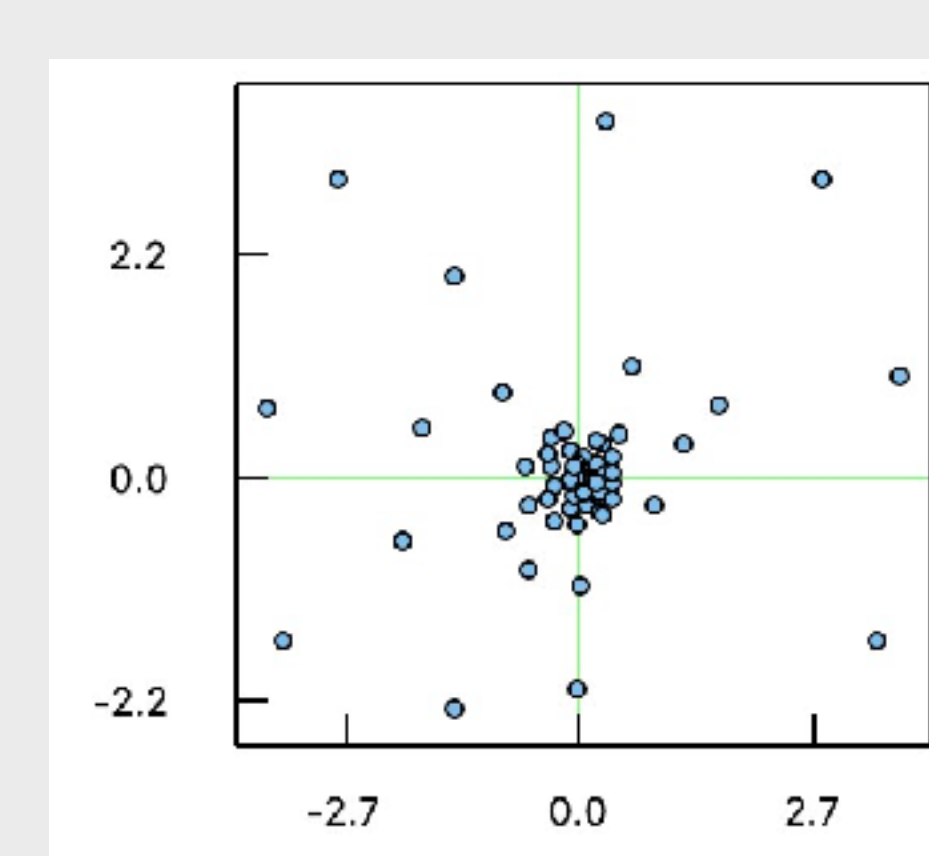
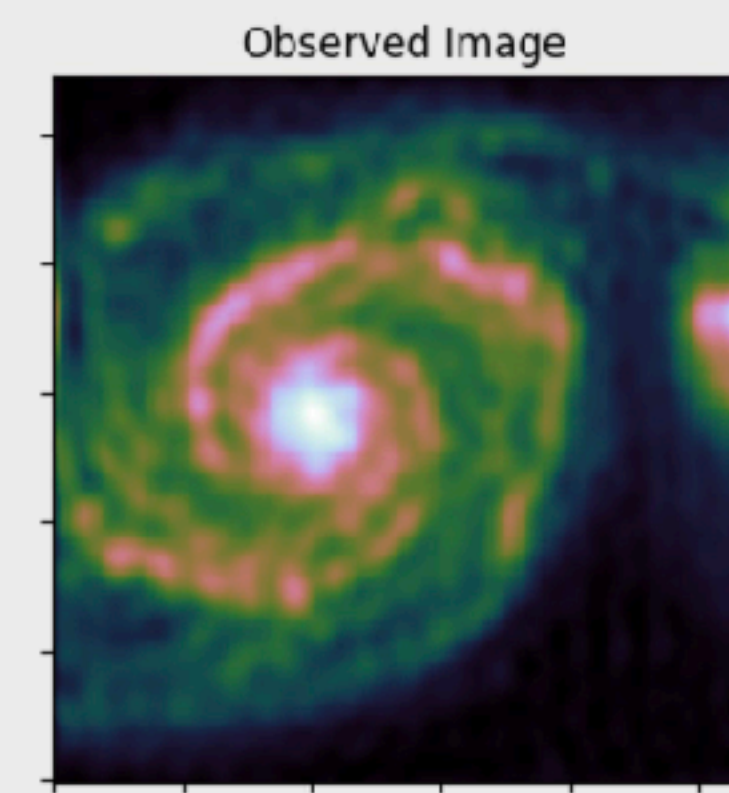
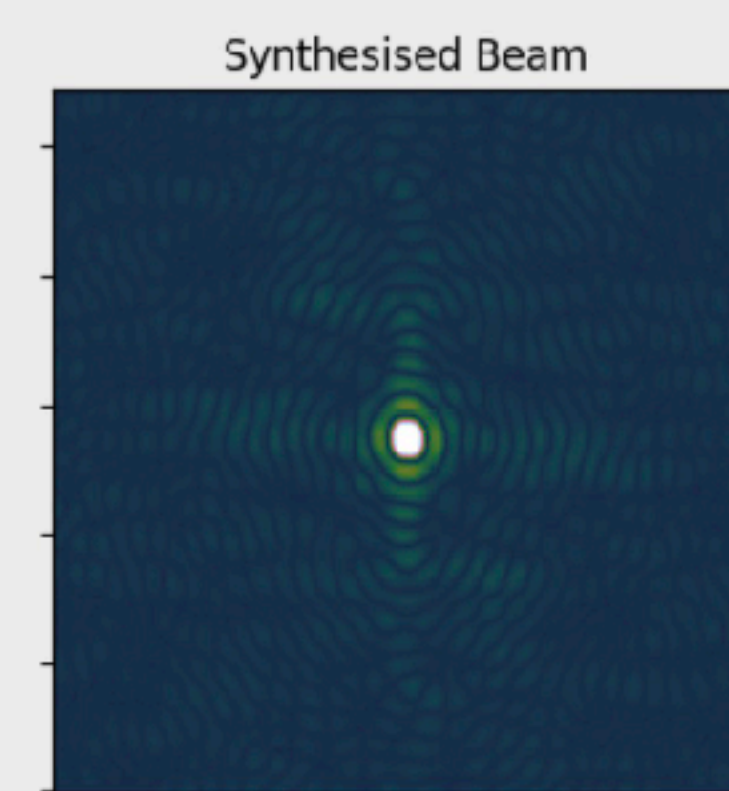
$C$  = offset\_guess



ATCA linear array  
 $0.03 < \text{baseline km} < 0.7$

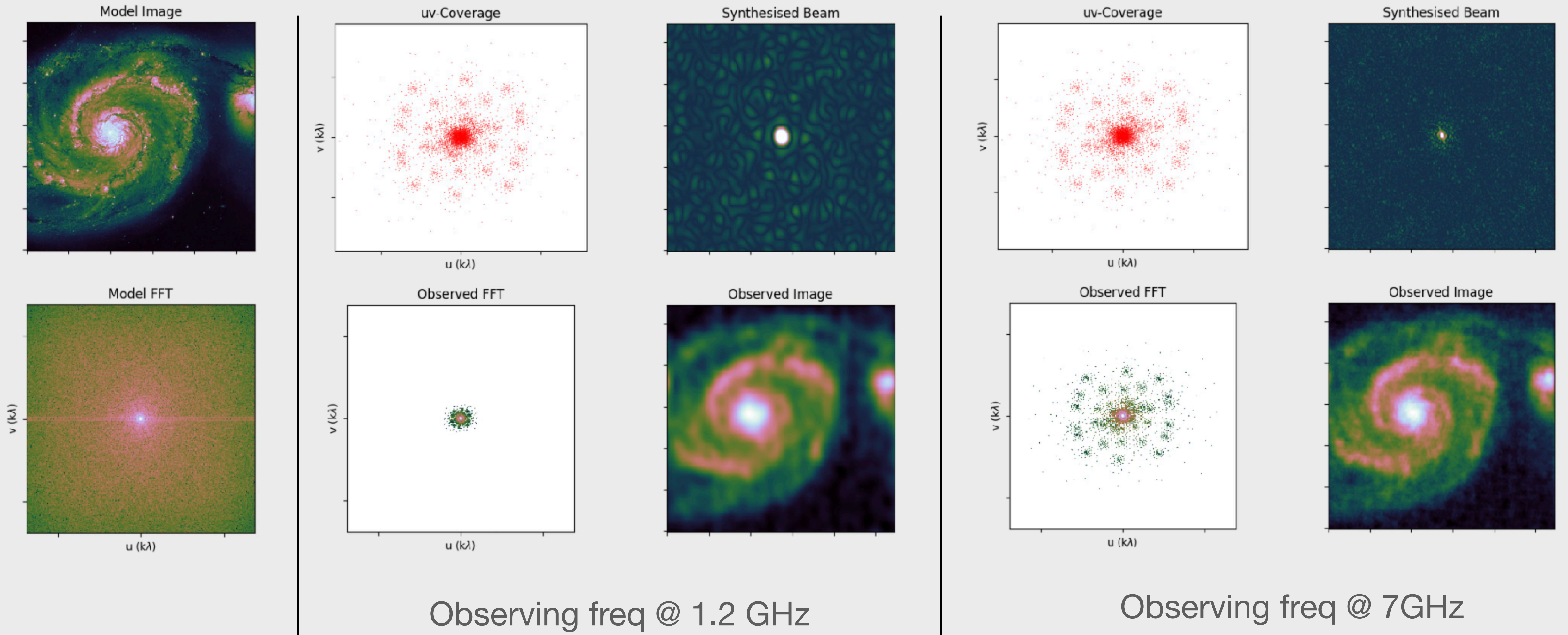


MeerKAT AR3  
 $0.03 < \text{baseline km} < 7.7$



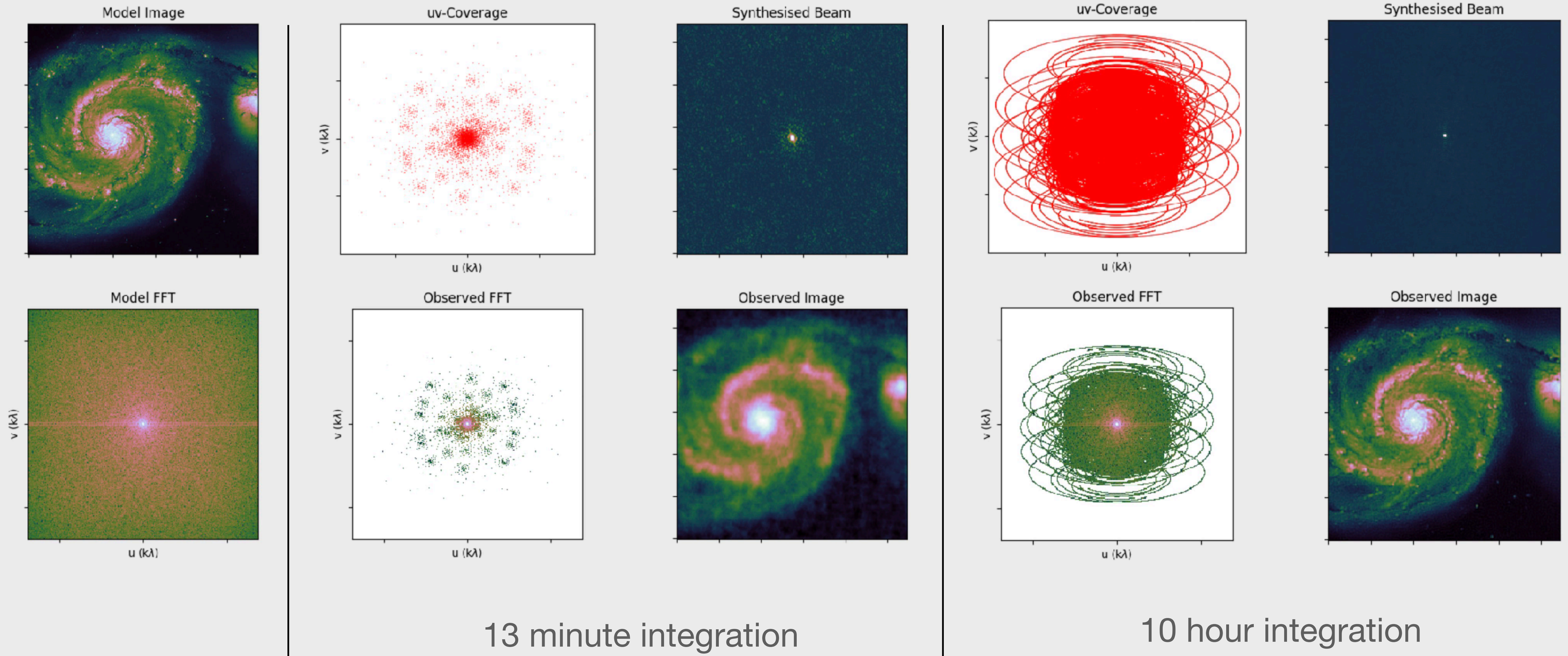
**More baseline lengths  $\rightarrow$  better filled UV plane**

# MeerKAT AR3, || 0.03 km < baseline < 7.7 km || 13 min obs



**Higher obs freq → finer synthesized beam → higher angular resolution**

# MeerKAT AR3, || 0.03 km < baseline < 7.7 km || Obs freq @7GHz



**Longer obs → Earth rotation fills UV plane → less sidelobe → high fidelity**