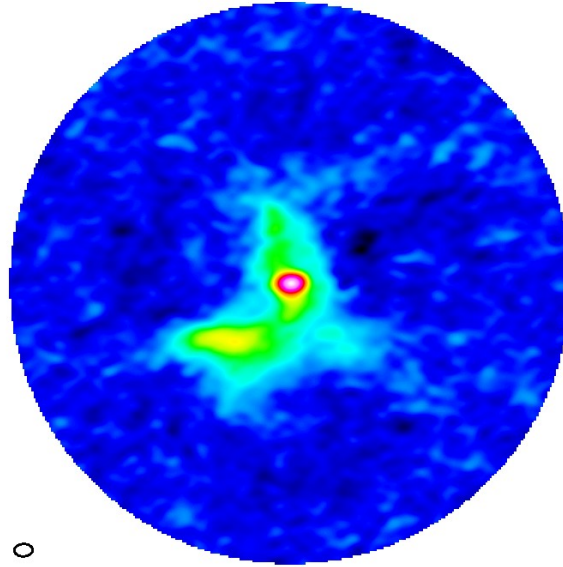


Synthesis Imaging



Ana Karla Díaz-Rodríguez

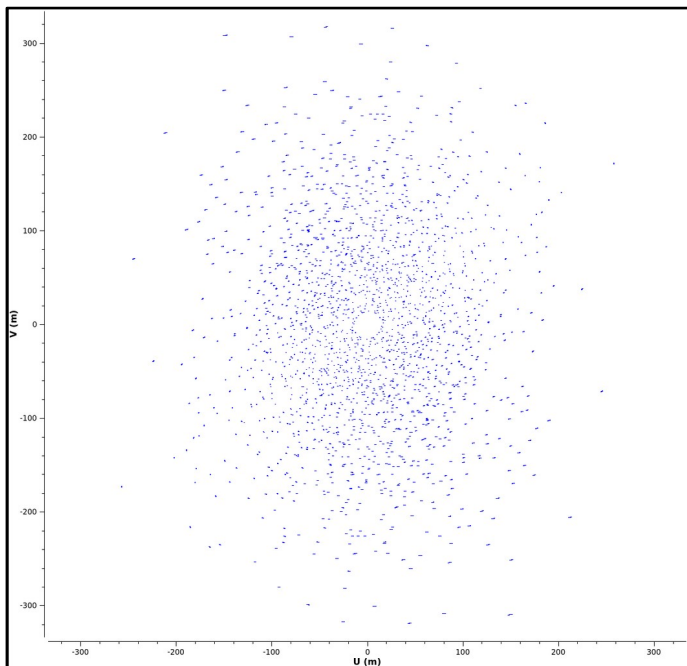


EUROPEAN ARC
ALMA Regional Centre || UK

MANCHESTER
1824

Synthesis Imaging

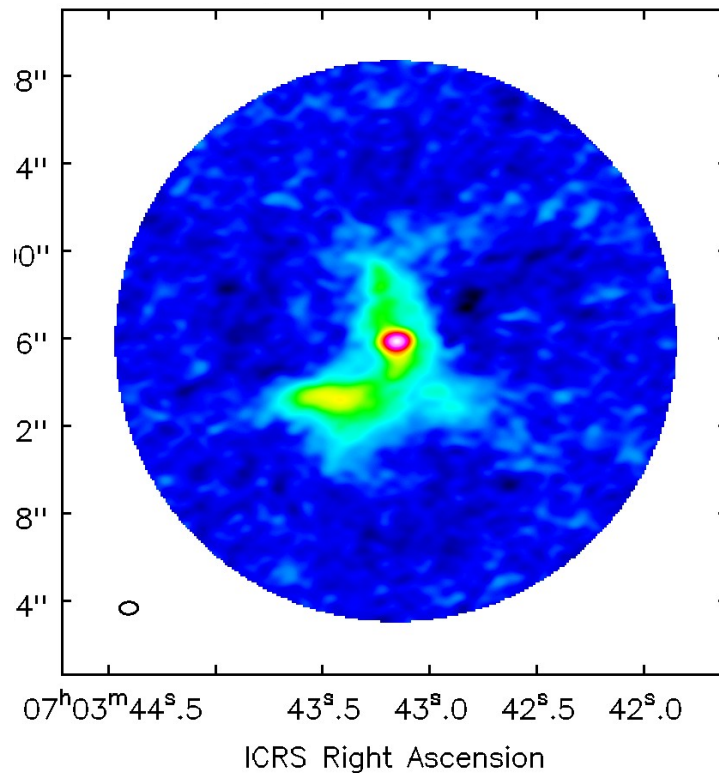
Data



?



Image

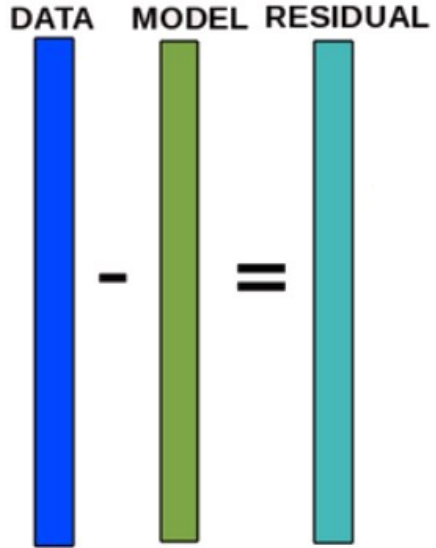


Synthesis Imaging

DATA

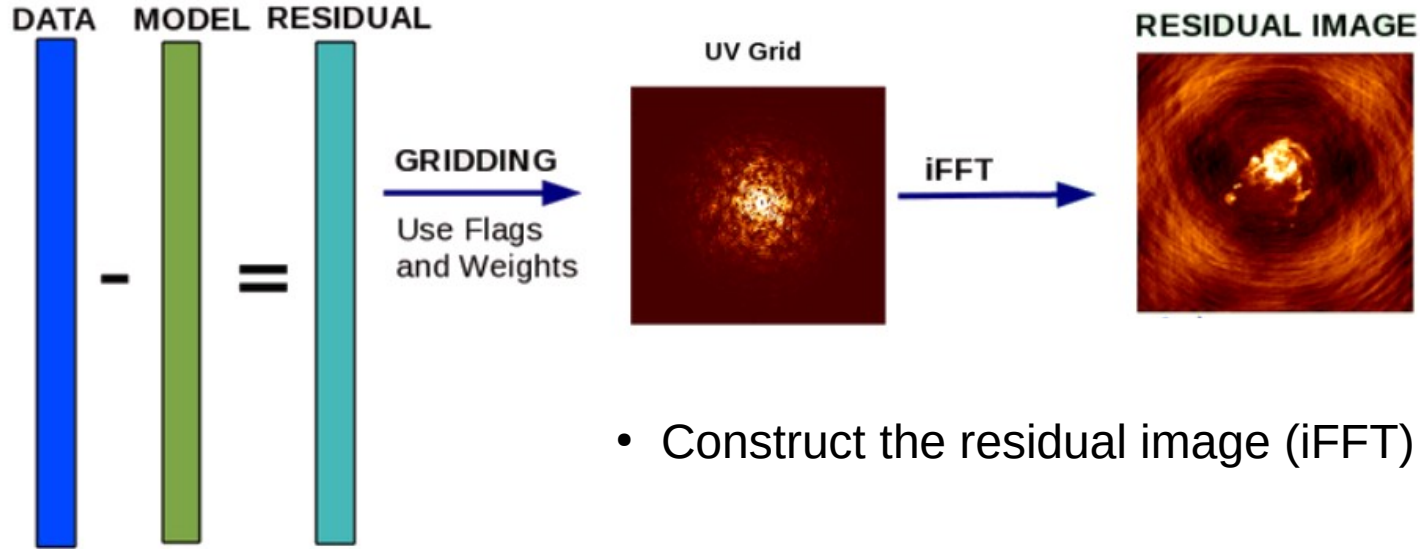


Synthesis Imaging

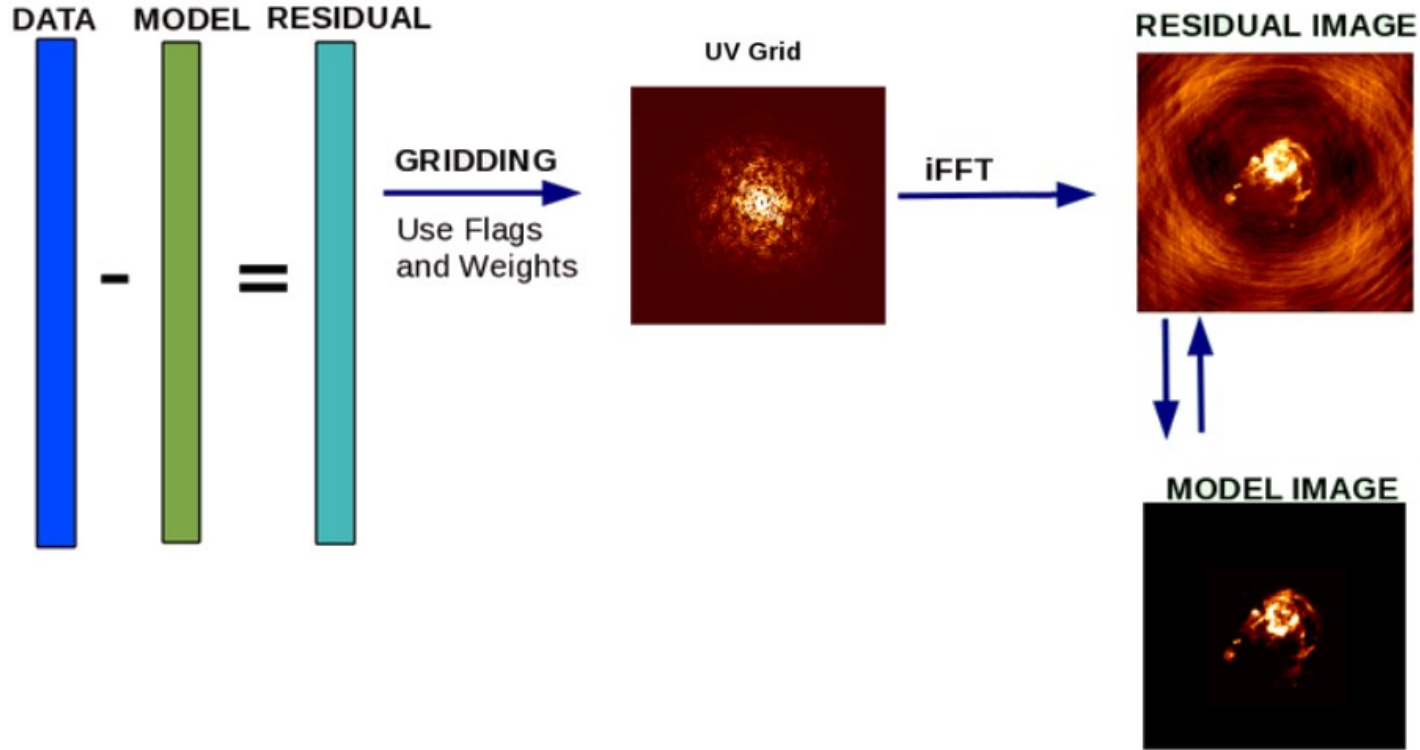


- Predict a model for the data visibilities
- Obtain the residual visibilities (data - model)

Synthesis Imaging

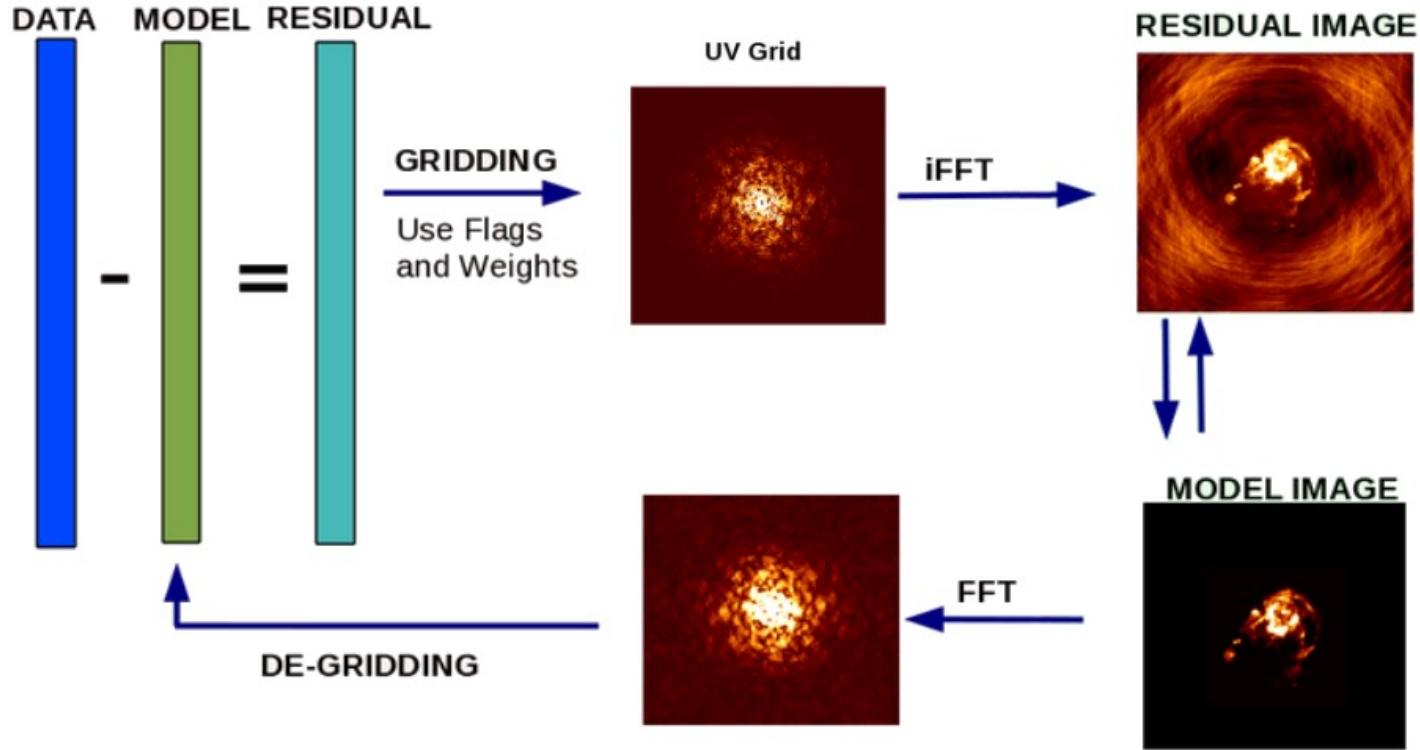


Synthesis Imaging



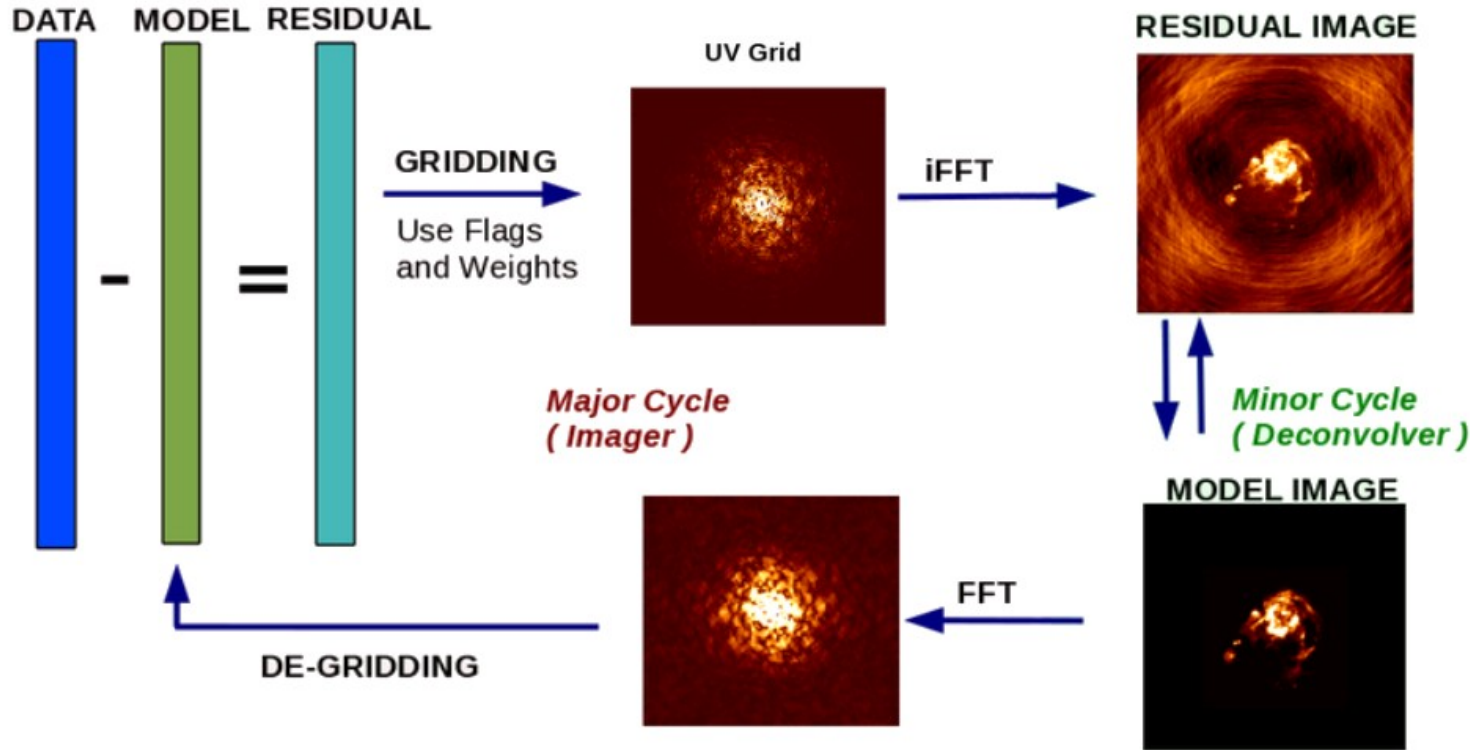
- Iteratively improve your model image

Synthesis Imaging



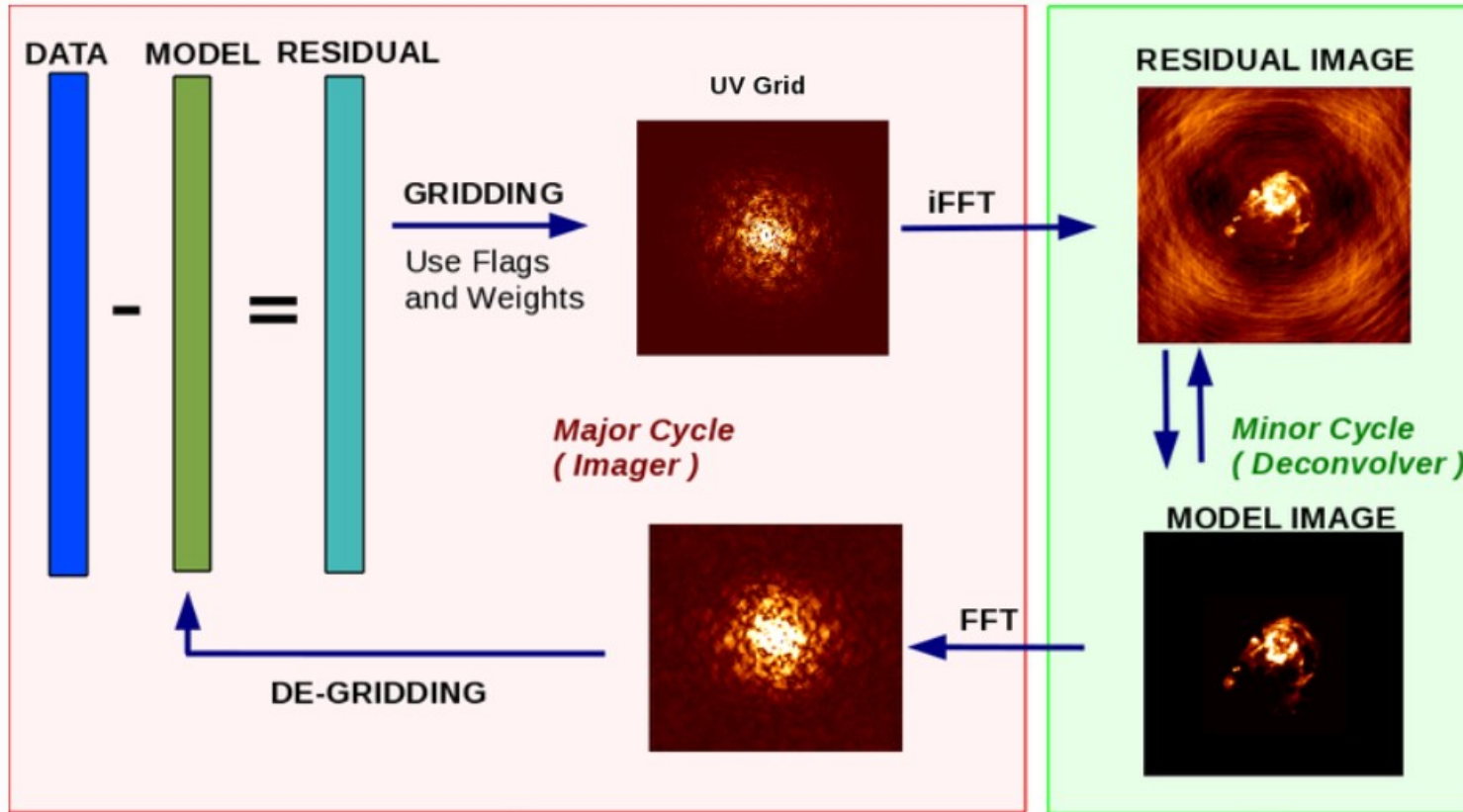
- Construct the visibilities of your improved model

Synthesis Imaging



- Start again by calculating the new residuals
- Goal: obtain the model that better reproduce our data (minimize residuals)

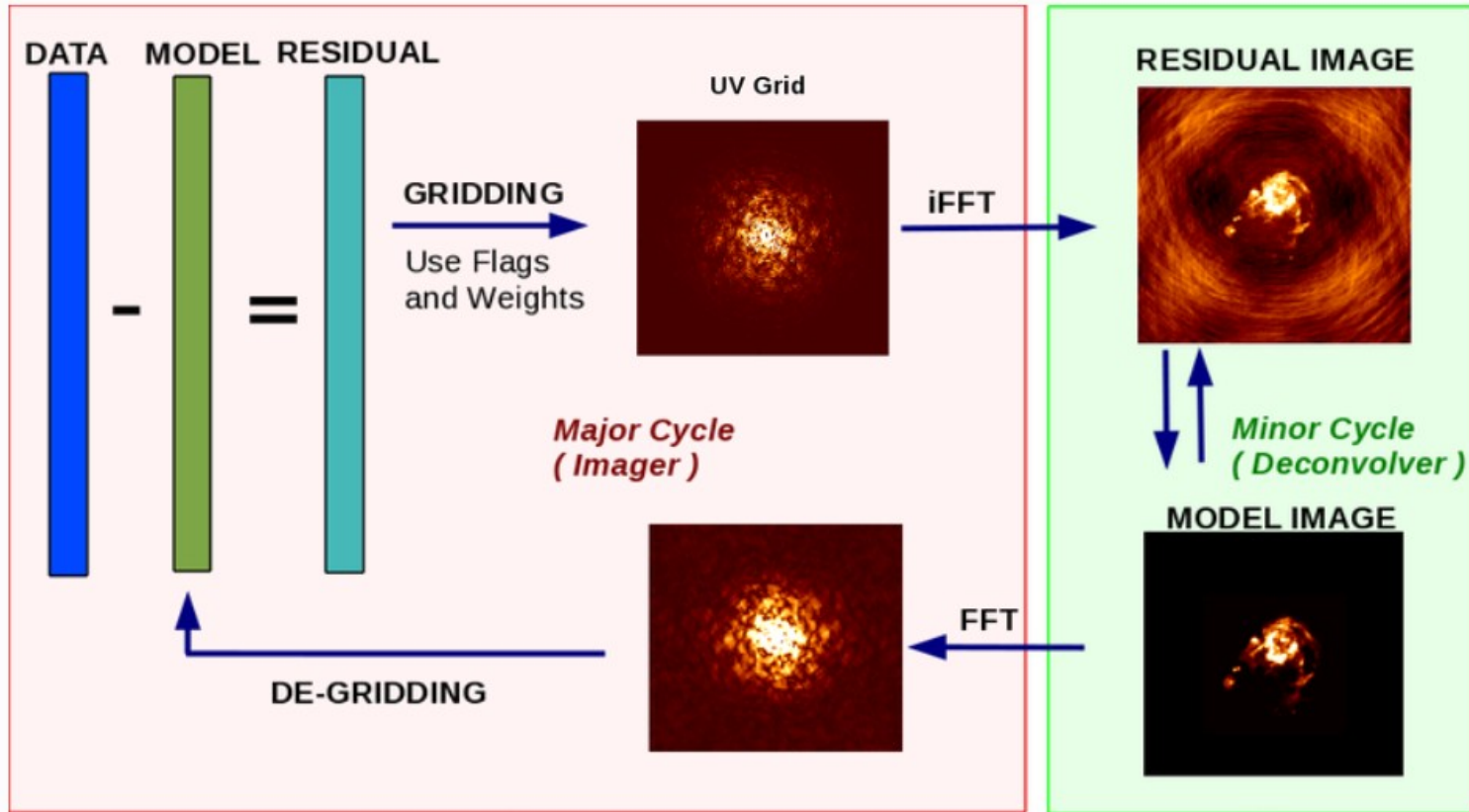
Synthesis Imaging



- Start again by calculating the new residuals
- Goal: obtain the model that better reproduce our data (minimize residuals)

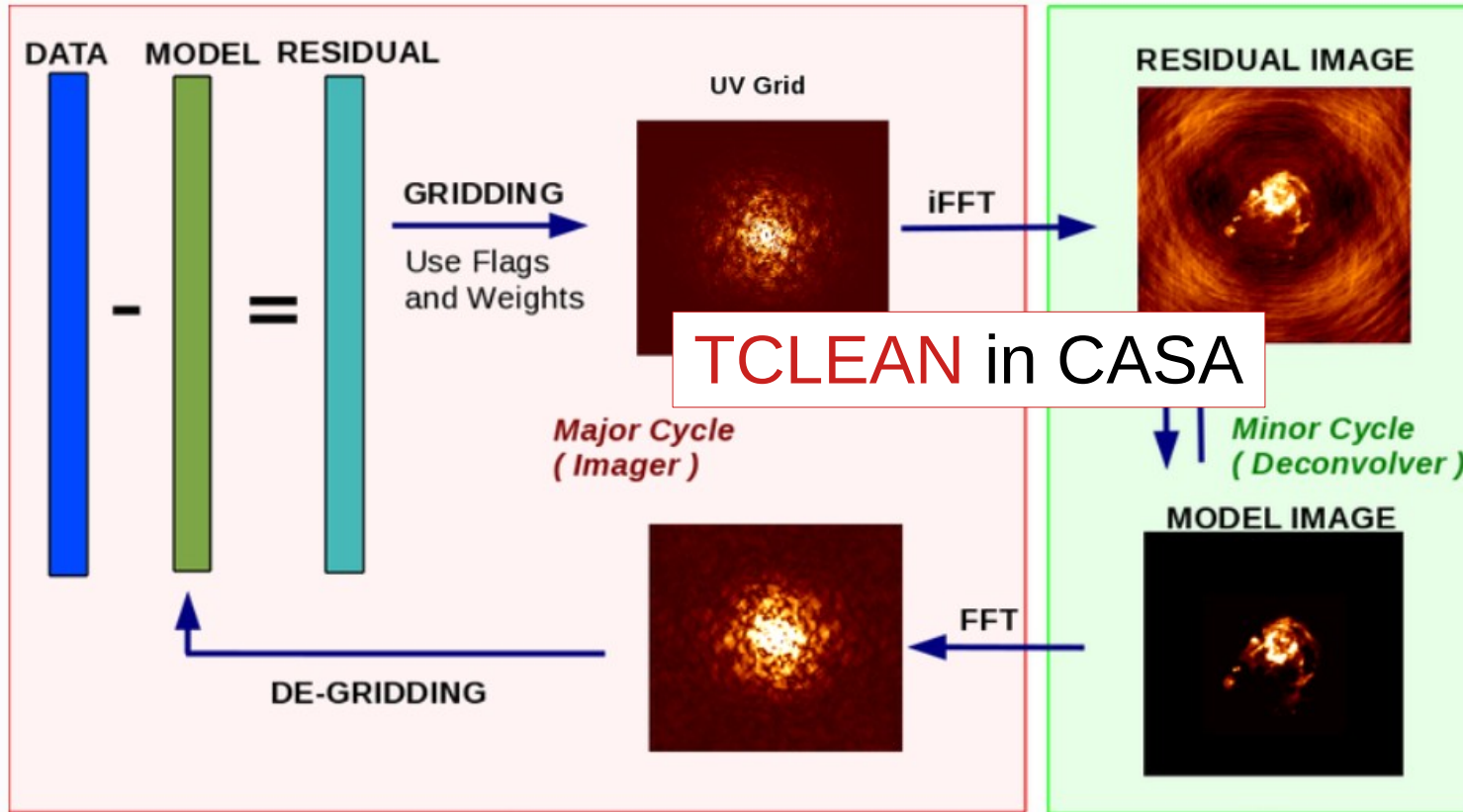
uv space \longleftrightarrow image space

Synthesis Imaging



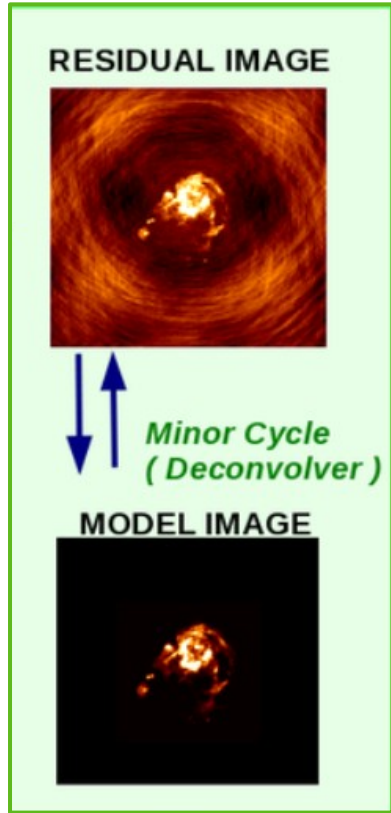
- Start again by calculating the new residuals
- Goal: obtain the model that better reproduce our data (minimize residuals)
- Control the total number of iterations or a cleaning threshold

Synthesis Imaging

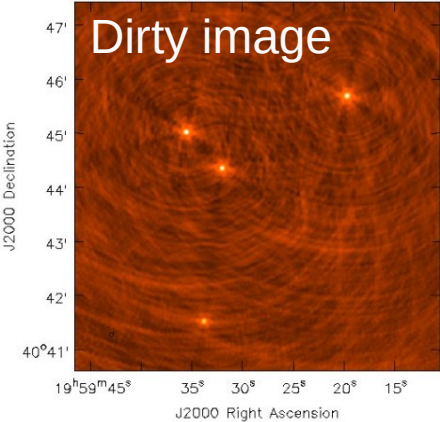
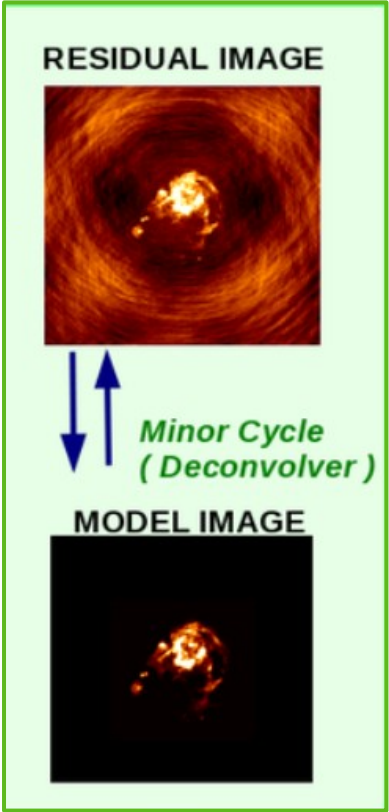


- Start again by calculating the new residuals
- Goal: obtain the model that better reproduce our data (minimize residuals)
- Control the total number of iterations or a cleaning threshold

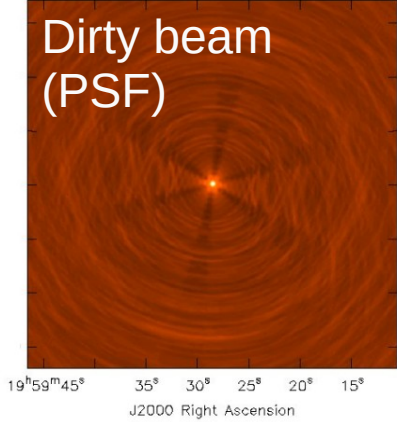
Deconvolution



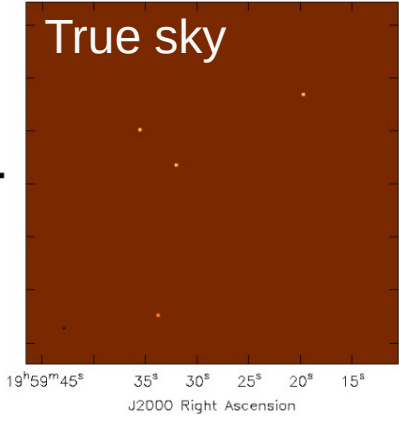
Deconvolution



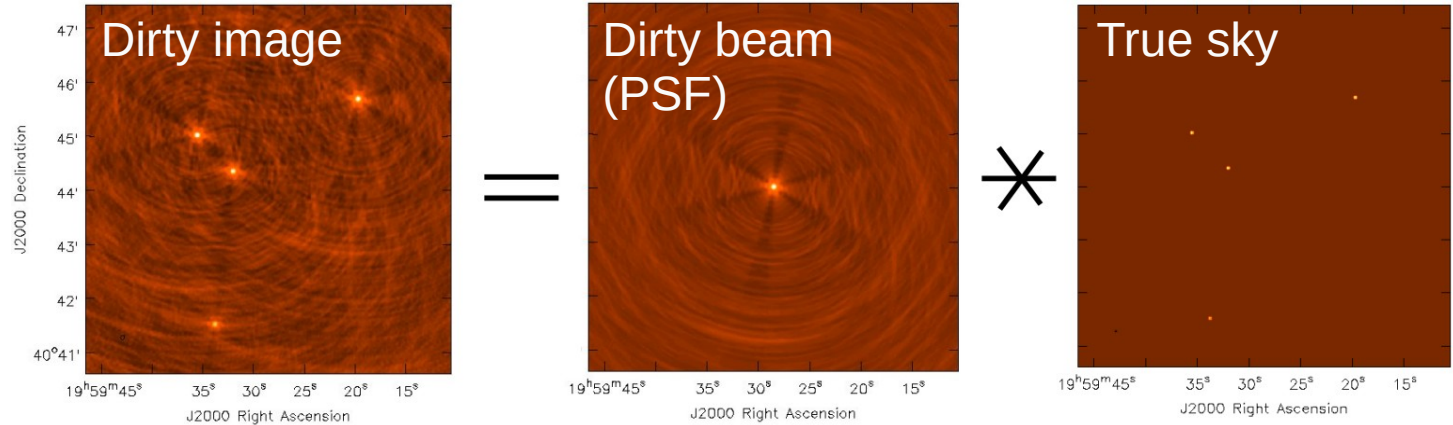
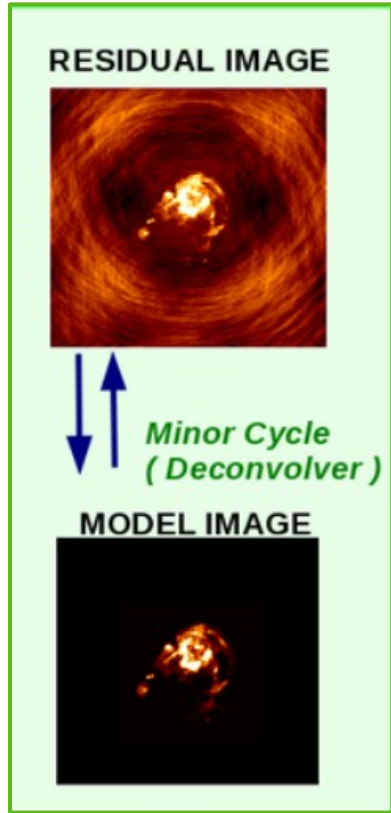
=



*



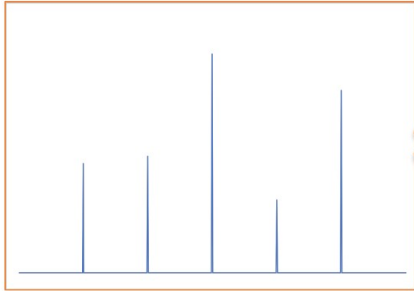
Deconvolution



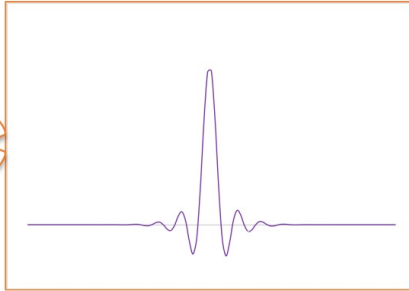
Process of reconstructing a model of the sky brightness distribution, given a dirty/residual image and the point-spread-function (PSF) of the instrument.

CLEAN Algorithm

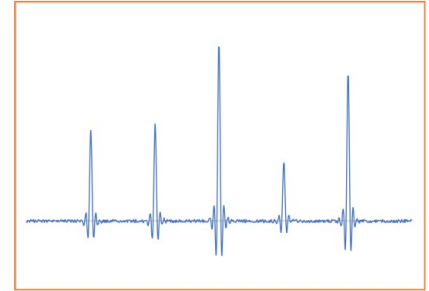
2D
Example



True sky of 5 point sources



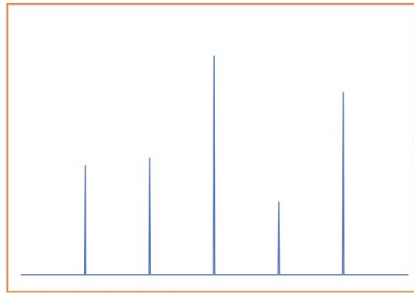
Dirty Beam (DB)



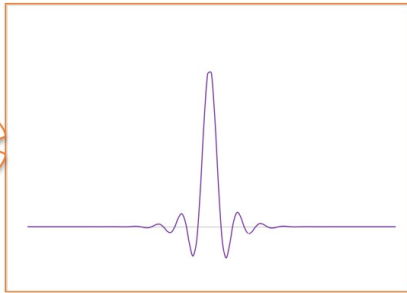
Dirty Image + noise, (DI)

CLEAN Algorithm

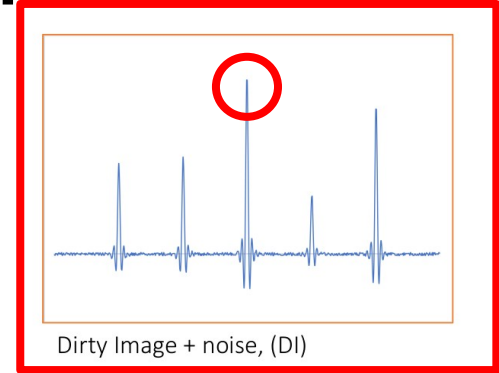
2D
Example



True sky of 5 point sources

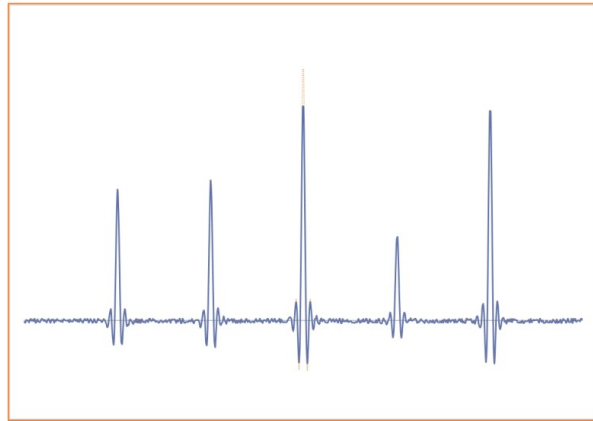


Dirty Beam (DB)



Dirty Image + noise, (DI)

Iteration 1



Residual Image after subtracting DB from peak in DI



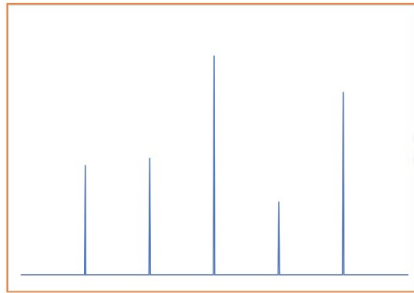
CLEAN components in Model Image

(this can be
guided by
drawing a
mask)

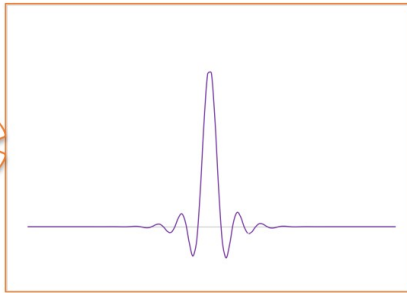
1. Find the magnitude and position of peak emission in the dirty image.

CLEAN Algorithm

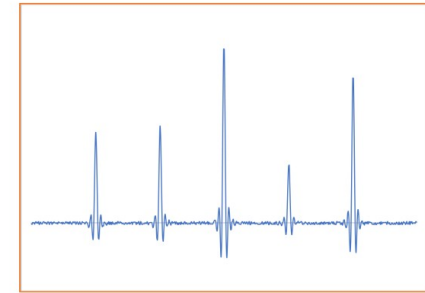
2D
Example



True sky of 5 point sources

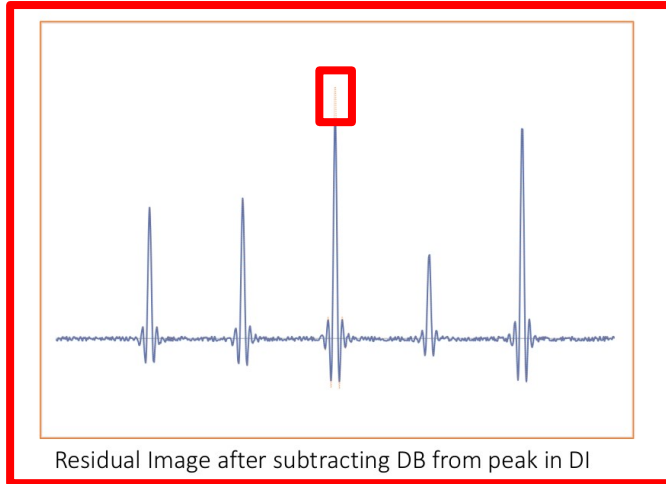


Dirty Beam (DB)

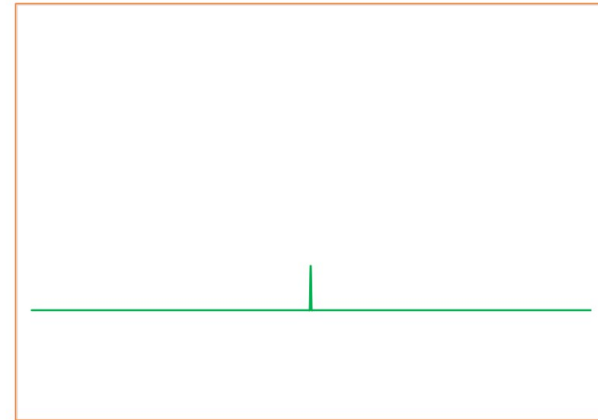


Dirty Image + noise, (DI)

Iteration 1



Residual Image after subtracting DB from peak in DI

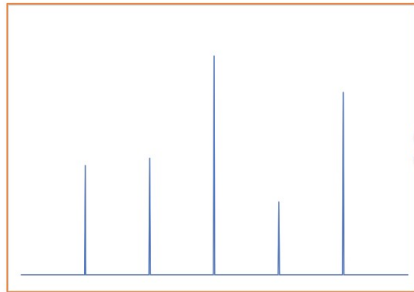


CLEAN components in Model Image

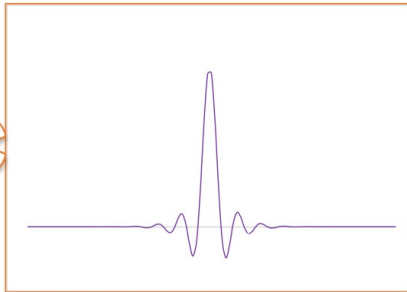
2. Subtract from the dirty image the dirty beam, DB, at the peak position and scaled by some gain value (i.e. 0.1), creating a 'residual' image.

CLEAN Algorithm

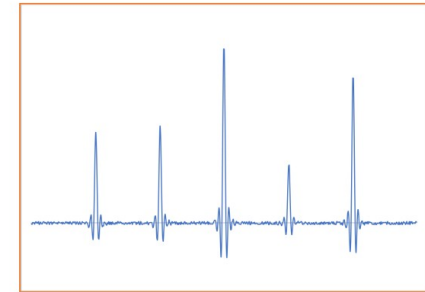
2D
Example



True sky of 5 point sources

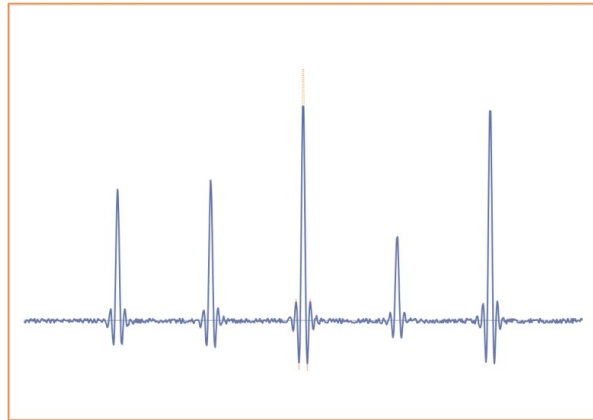


Dirty Beam (DB)

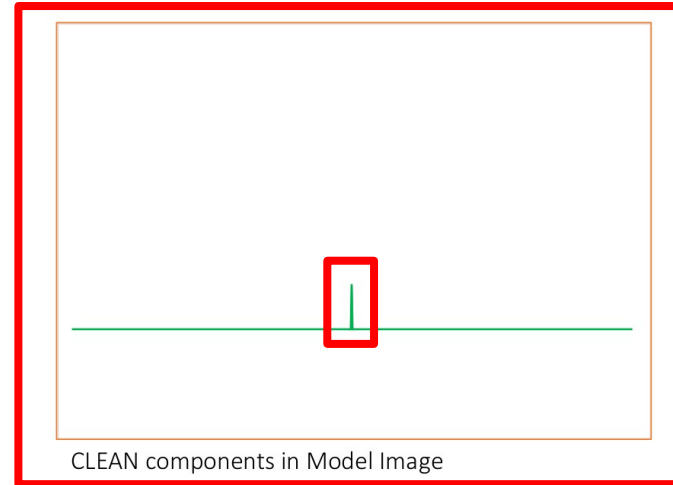


Dirty Image + noise, (DI)

Iteration 1



Residual Image after subtracting DB from peak in DI

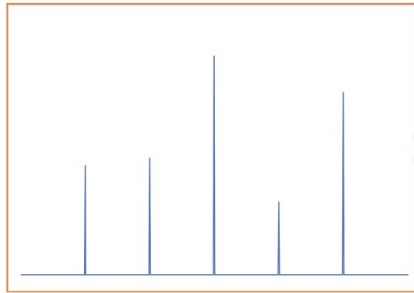


CLEAN components in Model Image

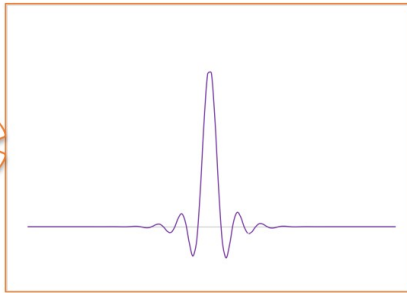
3. Put the position and magnitude subtracted as a point source in the model image.

CLEAN Algorithm

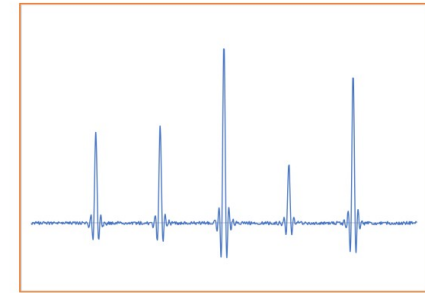
2D
Example



True sky of 5 point sources

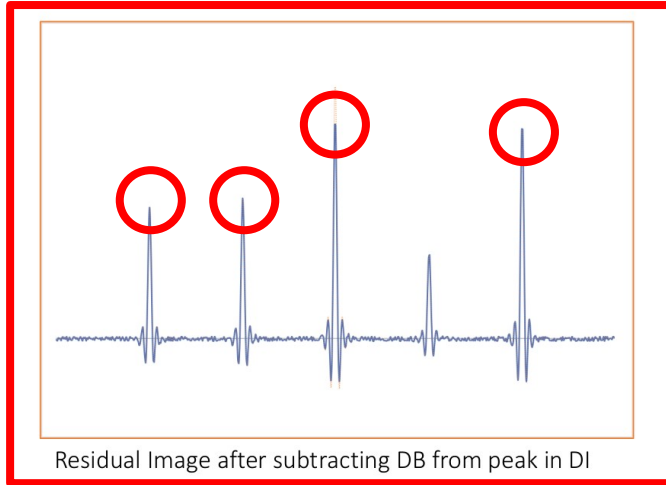


Dirty Beam (DB)

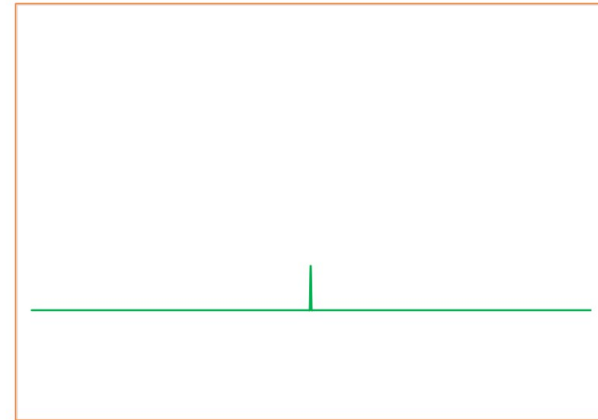


Dirty Image + noise, (DI)

Iteration 1



Residual Image after subtracting DB from peak in DI

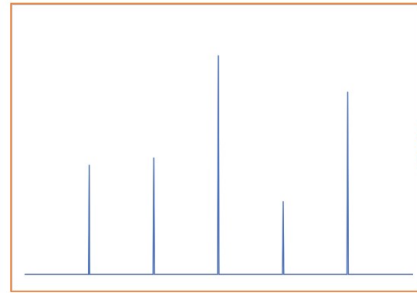


CLEAN components in Model Image

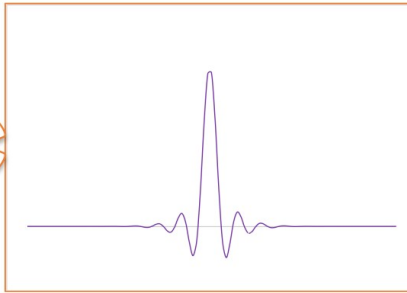
4. Repeat steps 1-3 in the residual image until a user defined threshold is reached, either some noise limit (in the residual) or a given number of iterations.

CLEAN Algorithm

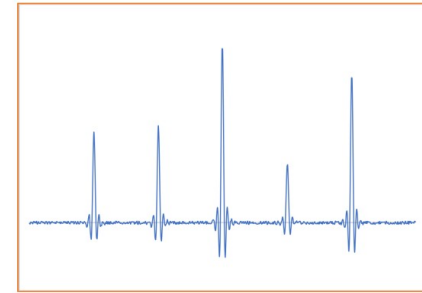
2D
Example



True sky of 5 point sources

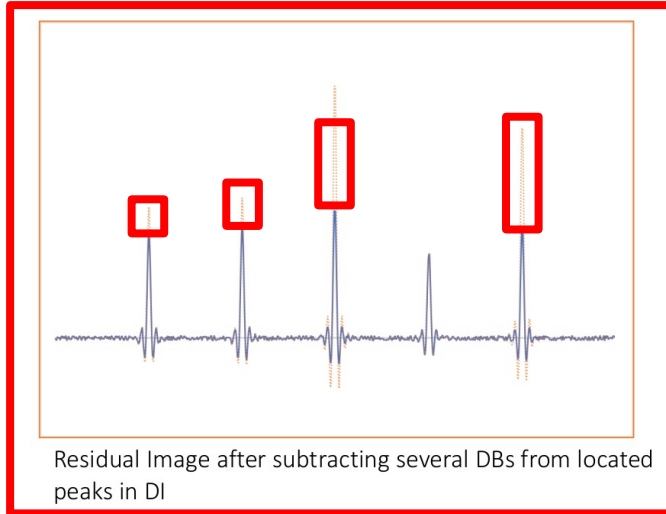


Dirty Beam (DB)

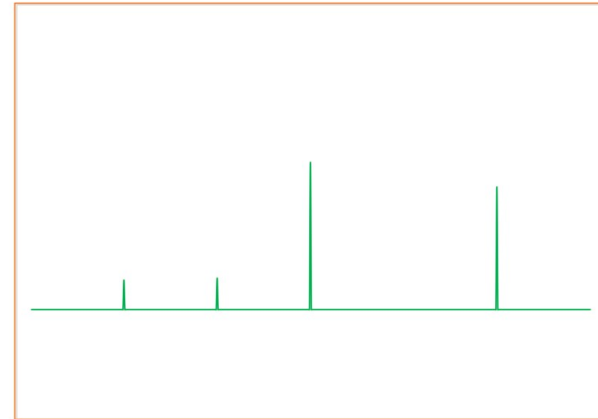


Dirty Image + noise, (DI)

Iteration n



Residual Image after subtracting several DBs from located peaks in DI

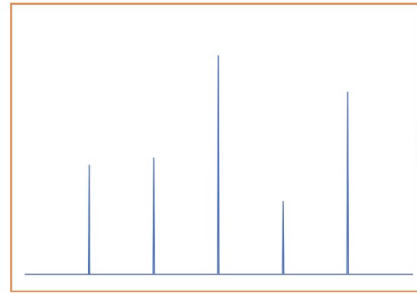


CLEAN components in Model Image

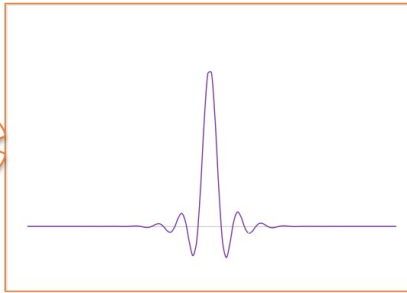
4. Repeat steps 1-3 in the residual image until a user defined threshold is reached, either some noise limit (in the residual) or a given number of iterations.

CLEAN Algorithm

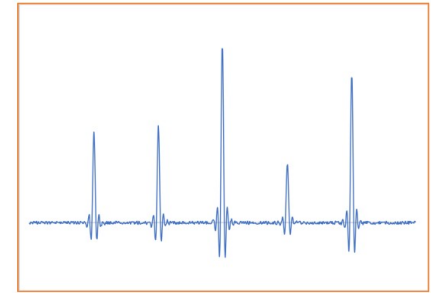
2D
Example



True sky of 5 point sources

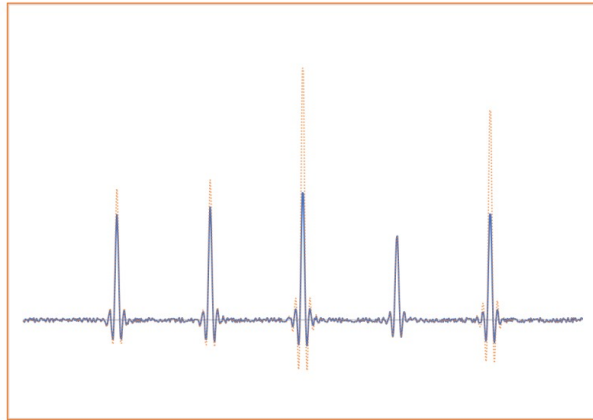


Dirty Beam (DB)

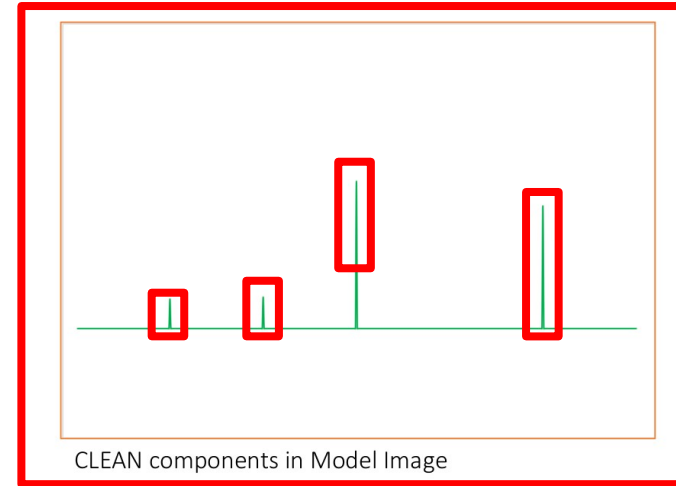


Dirty Image + noise, (DI)

Iteration n



Residual Image after subtracting several DBs from located peaks in DI

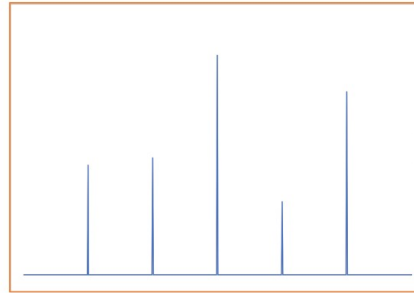


CLEAN components in Model Image

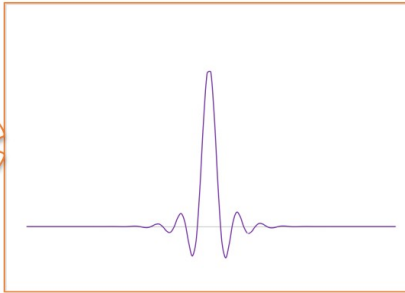
4. Repeat steps 1-3 in the residual image until a user defined threshold is reached, either some noise limit (in the residual) or a given number of iterations.

CLEAN Algorithm

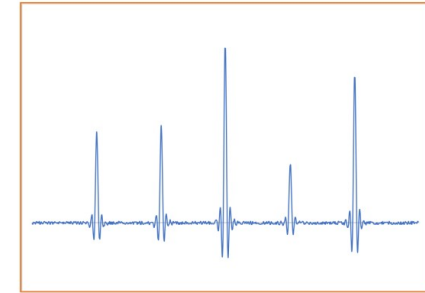
2D
Example



True sky of 5 point sources

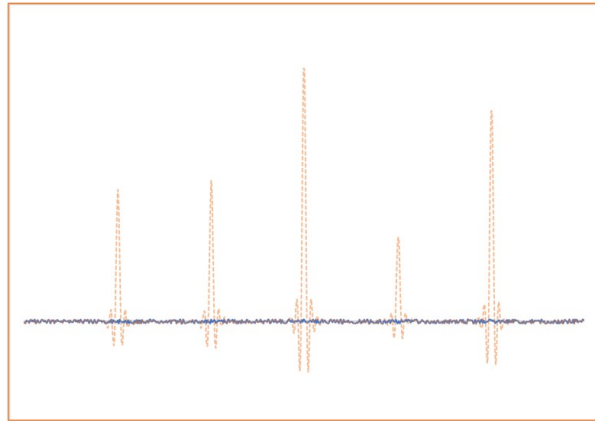


Dirty Beam (DB)

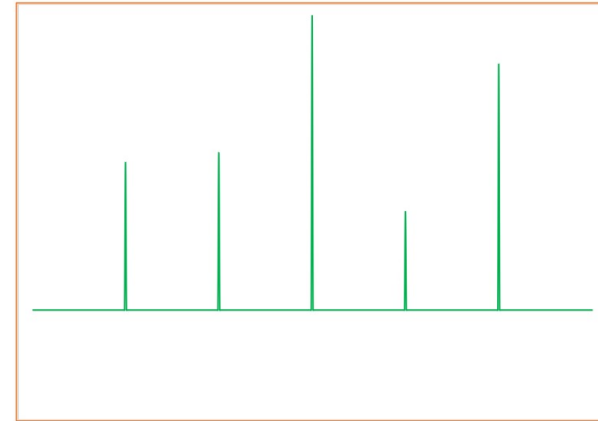


Dirty Image + noise, (DI)

Iteration *FINAL*



Residual Image after subtracting enough DBs from located peaks in DI until threshold met.

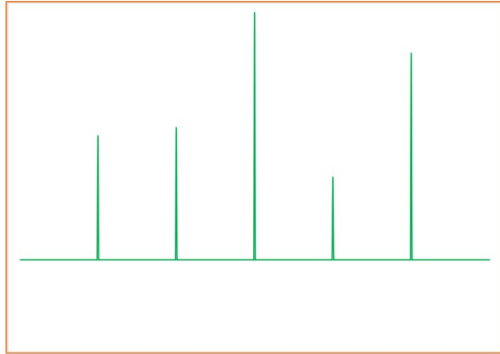


CLEAN components in model Image after final CLEAN loop

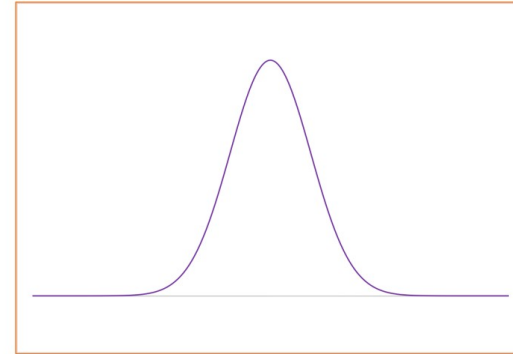
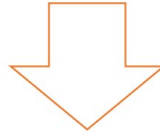
4. Repeat steps 1-3 in the residual image until a user defined threshold is reached, either some **noise limit** (in the residual) or a **given number of iterations**.

CLEAN Algorithm

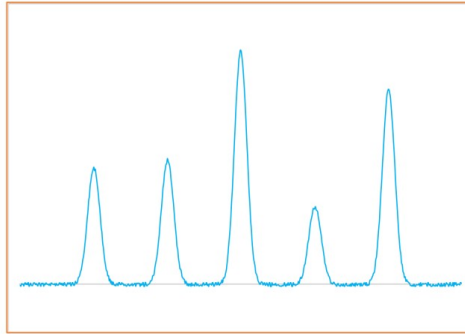
2D
Example



CLEAN components in model Image after final CLEAN loop



Idealized beam

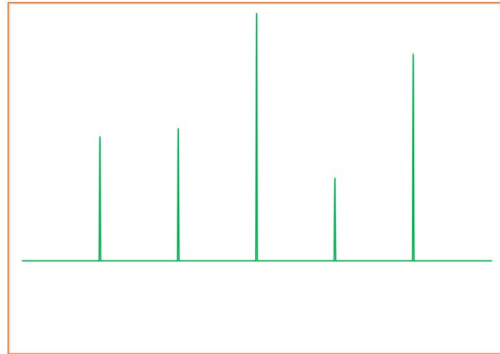


Final reconstructed image

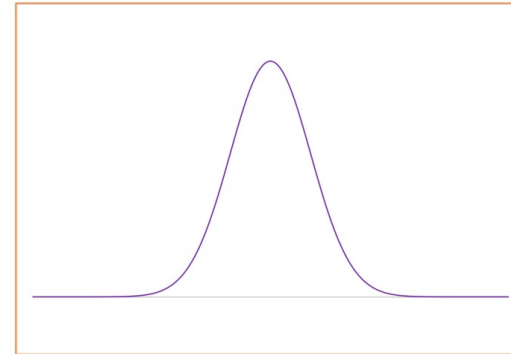
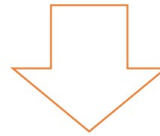
5. Convolve the final model with an idealised beam. I.e. a beam based on the interferometer if it was a huge single dish.

CLEAN Algorithm

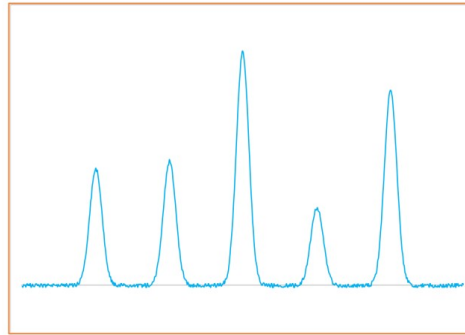
2D
Example



CLEAN components in model Image after final CLEAN loop



Idealized beam

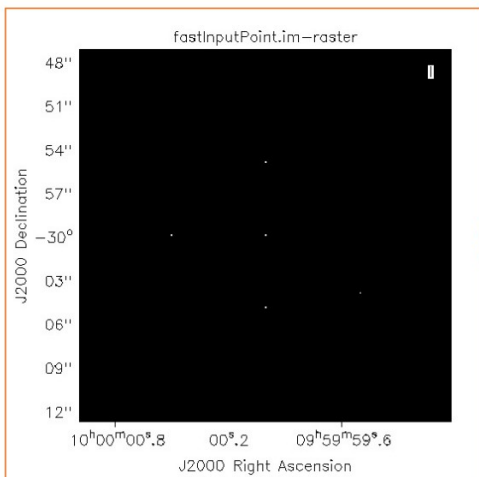


Final reconstructed image

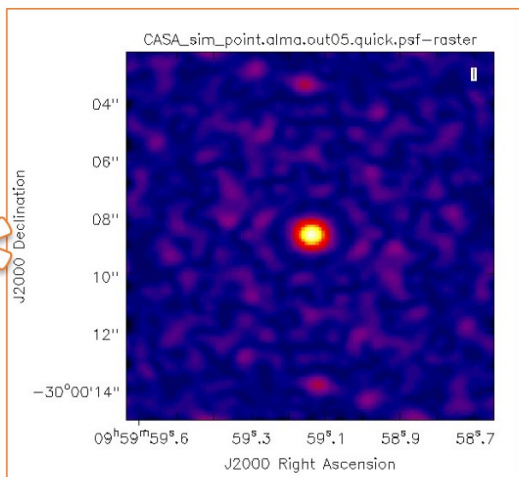
← (improved model that you take back to the major cycle)

5. Convolve the final model with an idealised beam. I.e. a beam based on the interferometer if it was a huge single dish.

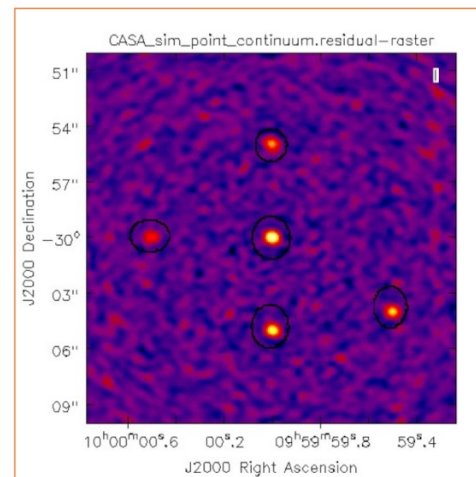
3D example



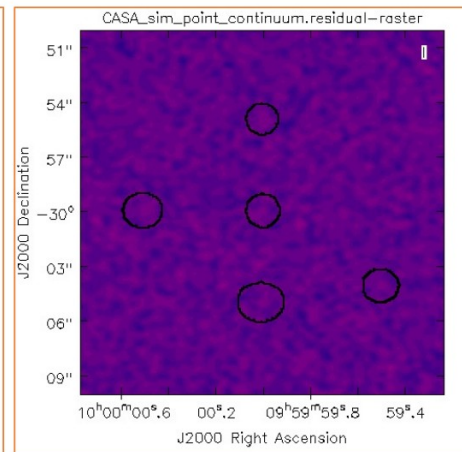
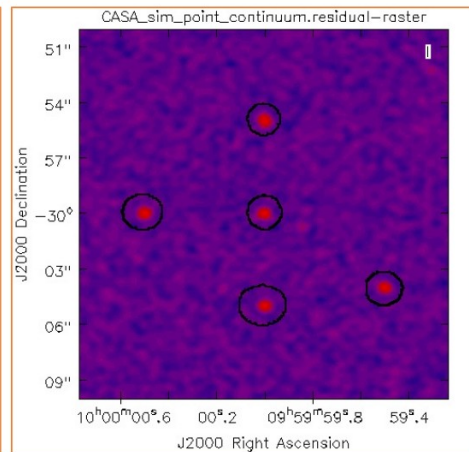
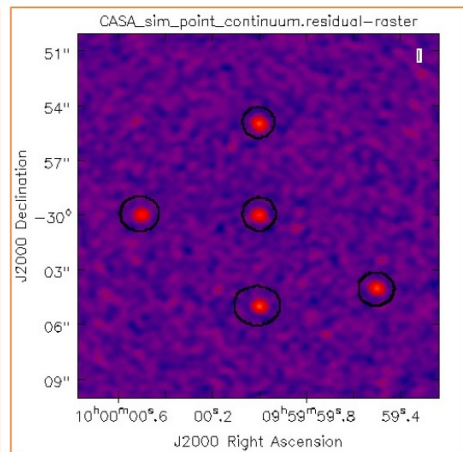
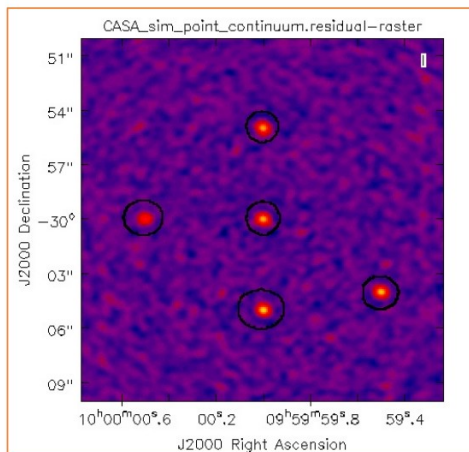
True sky of 5 point sources



Dirty Beam (DB)



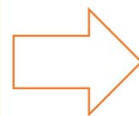
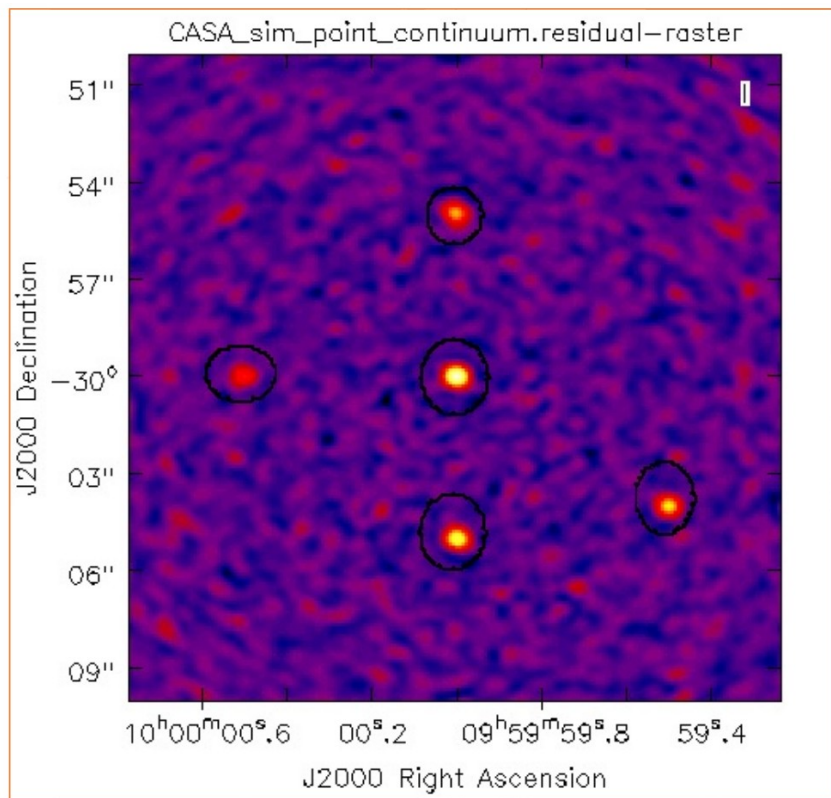
Dirty Image + noise, (DI)



→ Increasing CLEAN cycles →

3D example

Dirty image



Clean image

