



Note that these slides are rather different to the slides that were presented. Much has been removed that would not have made sense without the narrative, and I have included screen captures for the OST at the point where the live demo was provided.

I am looking for testers for the OST so please get in touch if you are interested!


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Part One

The ALMA Observation Support Tool

with thanks to:

Chris Williams (OeRC), Eduardo Ibar (Royal Observatory Edinburgh)



European ARC Nodes are “the interface between ALMA and the European user communities”. Their functions include “making available to users tools for proposal preparation” and the “development and maintenance of new software and techniques”.

From the European ALMA ARC Memorandum of Understanding (ESO)

Common Parameters

Sensitivity Type: Point Source detection

RA: 00:00:00.000

Dec: -50:00:00.000

Effective Bandwidth: 16.0 GHz

Frequency (GHz): 345.0

Observatory site: Chajnantor

Water Vapour Column Density: ETC Chooses

Sensitivity Unit: mJy

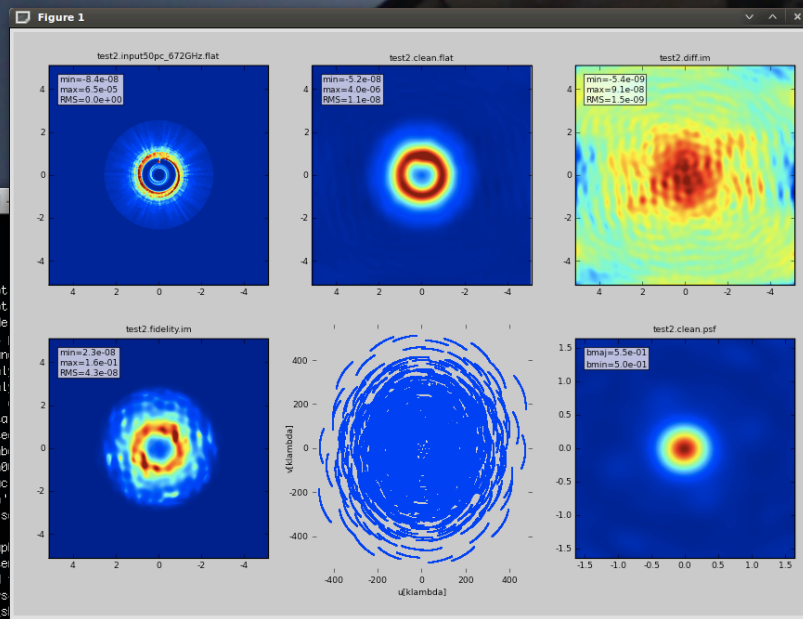
Individual Parameters

	12m Array	7m Array	Total Power Array
Number of Antennas	50	12	4
Beamsize(arcsec)	0.0	5.97869	14.946725
Sensitivity(mJy)	200.0	200.0	200.0
Exposure Time (sec)	6.304788E-5	0.010106377	0.059809744

Calculate Exposure Time Calculate Sensitivity

ALMA Sensitivity Calculator

<http://www.eso.org/sci/facilities/alma/observing/tools/etc>



```

CASA <??: inpsimdata
-----> inpsimdata
# simdata :: simulation task:
project      = 'sim'      # root
complist    = ''         # [opt]
modelimage  = ''         # mode
inbright    = 'unchanged' # set
ignorecoord = False     # chan
startfreq   = '89GHz'   # [onl]
chanwidth   = '10MHz'   # [onl]
refdate     = '2012/05/21/22:05:00' #
totaltime   = '7200s'   # tota
integration = '10s'     # inte
scanlength  = 5         # numb
direction   = ['J2000 19h00m00s -40d00m00s']
pointingspacing = '1arcmin' # spac
mosaicsize  = ['1.0arcmin', '1.0arcmin']
caldirection = ''       # pt s
calflux     = '1Jy'    #
checkinputs = 'no'     # grap
antennalist = 'alma.out18.cfg' # ante
noise_thermal = True   # add
noise_mode  = 'tsys-atm' # tsys
# t_s
user_pwv    = 1.0       # Precipitable Water Vapor in mm [tsys-atm only]
t_ground    = 269.0     # ambient temperature
t_sky       = 263.0     # atmospheric temperature [tsys-manual only]
tau0        = 0.1       # zenith opacity [tsys-manual only]

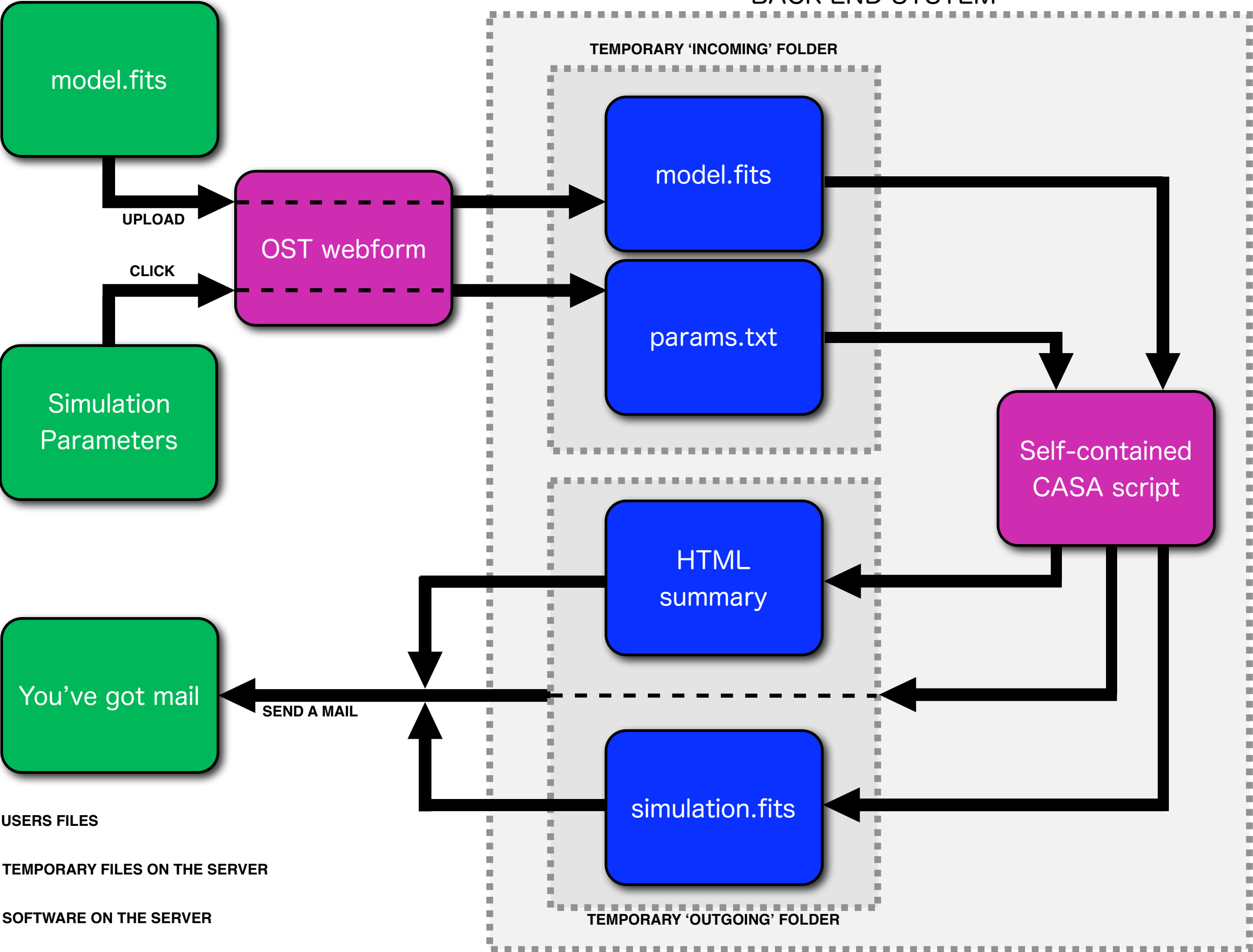
cell        = '0.1arcsec' # output cell/pixel size
imsize     = [128, 128]  # output image size in pixels (x,y)
threshold  = '0.8mJy'   # flux level (+units) to stop cleaning
niter      = 500        # maximum number of iterations
psfmode    = 'clark'    # minor cycle PSF calculation method
weighting  = 'natural'  # weighting to apply to visibilities
uvtaper    = False     # apply additional uv tapering of visibilities.
stokes     = 'I'       # Stokes params to image
fidelity   = True      # Calculate fidelity images
display    = True      # Plot simulation result images,figures
verbose    = False     #
async      = False     # If true the taskname must be started using simdata(...)

CASA <??:

```

The CASA 'simdata' task

BACK END SYSTEM



Front end

Applications Places System Sun 29 Aug, 4:26 AM

ALMA observation support tool - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://localhost/ Google

ALMA observation support tool

ALMA Observation Support Tool

Array	Instrument	ALMA	
Sky	Upload FITS image	<input type="text"/> Browse...	Leave blank to use central point source model
	Declination	-35d00m00.0s	Ensure correct formatting
	Image peak / point flux in <input type="text" value="mJy"/>	1.0	Leave blank for no rescaling if uploading sky model
Observation Parameters	Minimum frequency in GHz	90	
	Bandwidth in <input type="text" value="MHz"/>	32	Use broad for continuum, narrow for single channel
	Desired resolution in arcseconds	0.1	OST will choose config if instrument is set to 'ALMA'
	Start hour angle	0.0	Deviation of start of observation from transit
	Duration in <input type="text" value="hours"/>	3	
	Number of polarizations	2	
Corruption	Atmospheric conditions	Good	Determines level of phase noise due to water vapour
Imaging	Imaging weights	Natural	
	Perform deconvolution?	No (Return dirty image)	
	Your email address	you@yourdomain.com	<input type="button" value="Submit"/>

ALMA observation sup...

In-browser sanity checks

Applications Places System Sun 29 Aug, 4:27 AM

ALMA observation support tool - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://localhost/ Google

ALMA observation support tool

ALMA Observation Support Tool

Array	Instrument	ALMA	
Sky	Upload FITS image	<input type="text"/> Browse...	Leave blank to use central point source model
	Declination	12345 Not valid!	Ensure correct formatting
	Image peak / point flux in <input type="text" value="mJy"/>	1.0 OK	Leave blank for no rescaling if uploading sky model
Observation Parameters	Minimum frequency in GHz	hello Must be a number!	
	Bandwidth in <input type="text" value="MHz"/>	32 OK	Use broad for continuum, narrow for single channel
	Desired resolution in arcseconds	0.1 OK	OST will choose config if instrument is set to 'ALMA'
	Start hour angle	-100 Minimum value: -12	Deviation of start of observation from transit
	Duration in <input type="text" value="hours"/>	3 OK	
	Number of polarizations	2	
Corruption	Atmospheric conditions	Good	Determines level of phase noise due to water vapour
Imaging	Imaging weights	Natural	
	Perform deconvolution?	No (Return dirty image)	
	Your email address	testing Please check	<input type="button" value="Submit"/>

ALMA observation sup...

Uses open-source Javascript library from <http://livevalidation.com>

Results page (1)

Applications Places System Sun 29 Aug, 4:28 AM

ALMA OST - Job ID: 20100820222812 - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://localhost/output/20100820222812.html

ALMA OST - Job ID: 20100820222812

ALMA Observation Support Tool - Result

Job ID: 20100820222812 / Submitted by: you@yourdomain.com

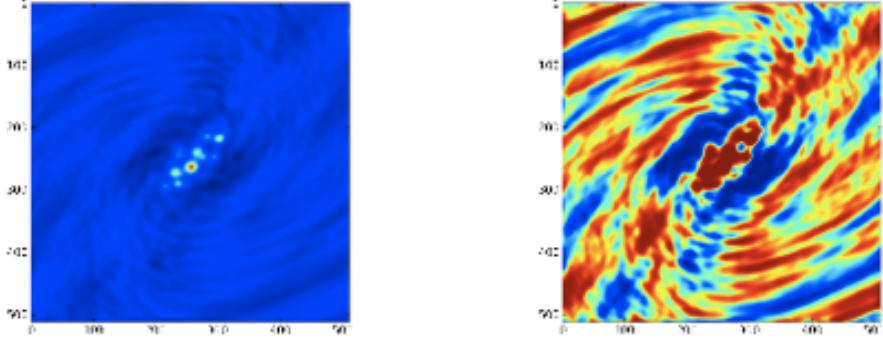
Overview

Array configuration	ALMA out10
Sky model	cluster.fits
Maximum elevation	77.88 degrees
Minimum frequency	90 GHz = Band 3
Bandwidth	1.0 GHz
Track length	5 hours
System temperature	60.0 K
Theoretical RMS noise	6.08966290416e-06 Jy (in naturally-weighted map)

Data products

Click thumbnails to view full-size images. Left: linear colour scale, right: with histogram equalization.

Your simulated image
[Download FITS file](#)



Results page (2)


Applications Places System Sun 29 Aug, 4:28 AM

ALMA OST - Job ID: 20100820222812 - Mozilla Firefox

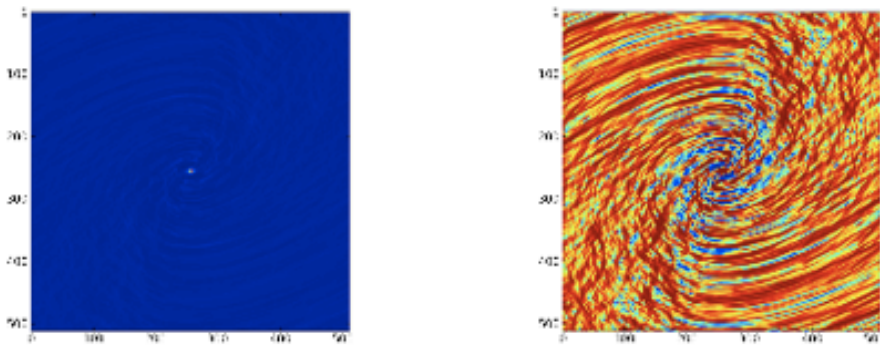
File Edit View History Bookmarks Tools Help

http://localhost/output/20100820222812.html

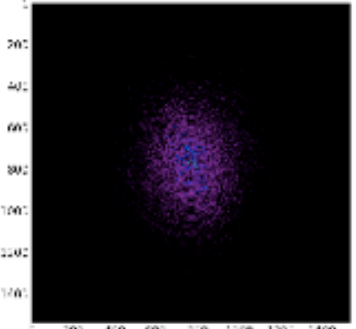
ALMA OST - Job ID: 20100820222812



Point Spread Function



Coverage in the uv-plane



Diagnostics

Processing time	507 seconds
Log file	Click here
Parameter file	Click here

ALMA OST - Job ID: 20...

Results page with message window

Applications Places System Sun 29 Aug, 4:28 AM

ALMA OST - Job ID: 20100820185515 - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://localhost/output/20100820185515.html

ALMA OST - Job ID: 20100820185515

ALMA Observation Support Tool - Result

Job ID: 20100820185515 / Submitted by: you@yourdomain.com

Messages

- Your requested bandwidth and minimum frequency push the maximum frequency out of the top of the band. The bandwidth has therefore been truncated.

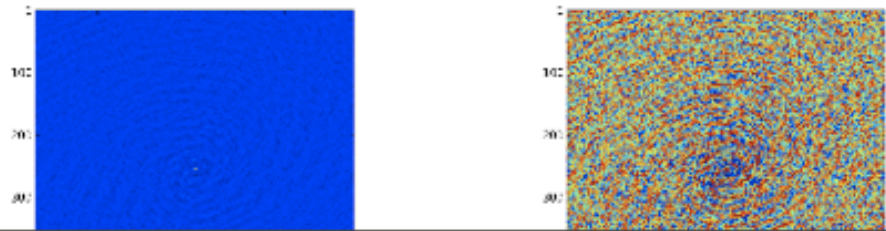
Overview

Array configuration	Early Science ALMA (Large)
Sky model	Central point source model 1.0 mJy
Maximum elevation	55.0 degrees
Minimum frequency	115 GHz = Band 3
Bandwidth	1.0 GHz
Track length	3 hours
System temperature	60.0 K
Theoretical RMS noise	2.51185779523e-05 Jy (in naturally-weighted map)

Data products

Click thumbnails to view full-size images. Left: linear colour scale, right: with histogram equalization.

Your simulated image
[Download FITS file](#)



Server-side error checking for more complex problems

The screenshot shows a Mozilla Firefox browser window with the following details:

- System tray: Applications, Places, System, Sun 29 Aug, 4:28 AM
- Browser title bar: ALMA OST - Job ID: 20100821215520 - Mozilla Firefox
- Menu bar: File, Edit, View, History, Bookmarks, Tools, Help
- Address bar: http://localhost/output/20100821215520.html
- Search bar: Google
- Tab: ALMA OST - Job ID: 20100821215520

The main content of the page is an error message from the ALMA Observation Support Tool:

ALMA Observation Support Tool

Job ID: 20100821215520 / Submitted by: you@yourdomain.com

Request failed.

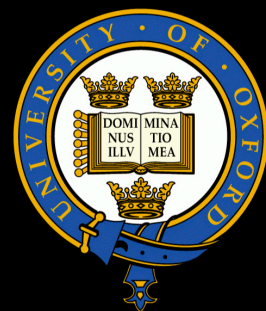
What went wrong?

- Your requested minimum frequency is not within the ALMA observing bands.
 - Bandwidth exceeds 2 GHz maximum for Early Science ALMA.

Suggestions

- Check your minimum frequency value.
 - Check the bandwidth value.

(or for users who do not have Javascript enabled.)



Part Two

SKA₁ Neutral Hydrogen Simulation

with contributions from:

Danail Obreschkow (TWT GmbH), François Levrier (ENS, Paris),
Oleg Smirnov (ASTRON), Steve Rawlings (Oxford)

SKA₁ low-frequency sparse aperture array

Frequency range: $70 \leq \nu \leq 450$ MHz

Instantaneous bandwidth: 380 MHz

Stations: 50×180 m diam.

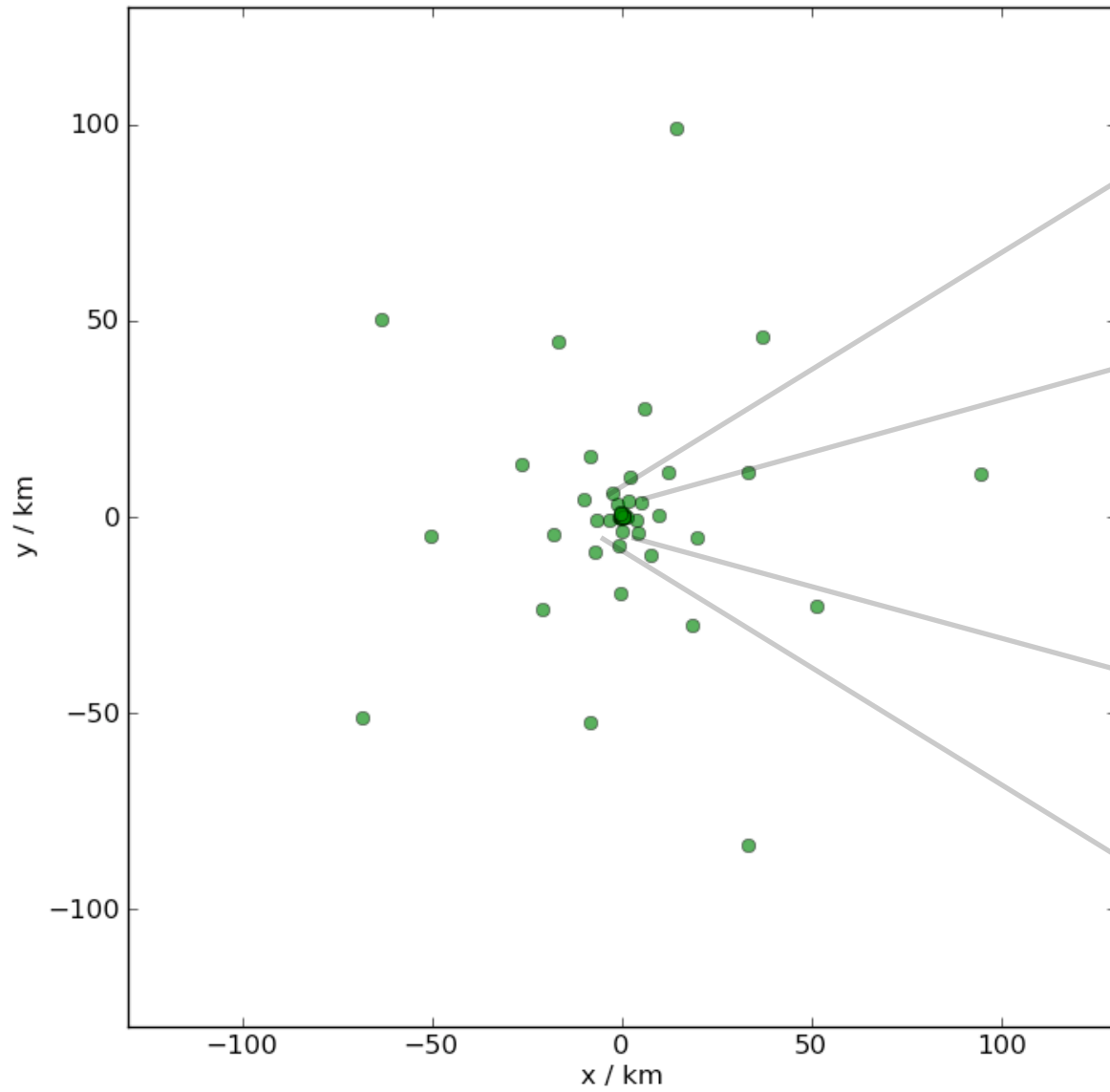
Nyquist frequency: 100 MHz

Maximal $A_{\text{eff}} / T_{\text{sys}}$: ~ 2000 m² / K

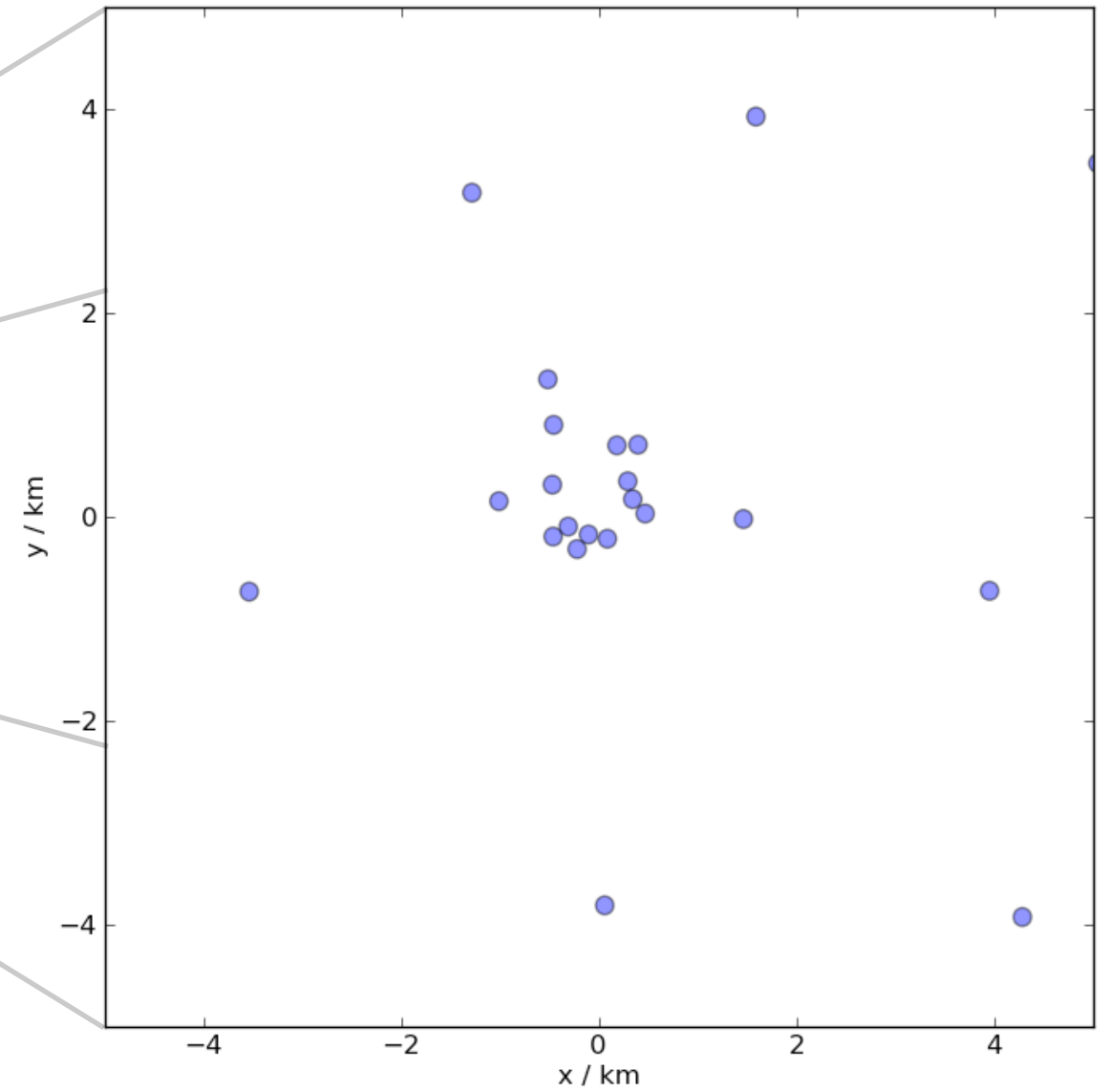
(See e.g. Garrett et al., 2010, arXiv 1008.2871)

SKA₁ aperture array: assumed 50-station layout

(with thanks to Rosie Bolton)



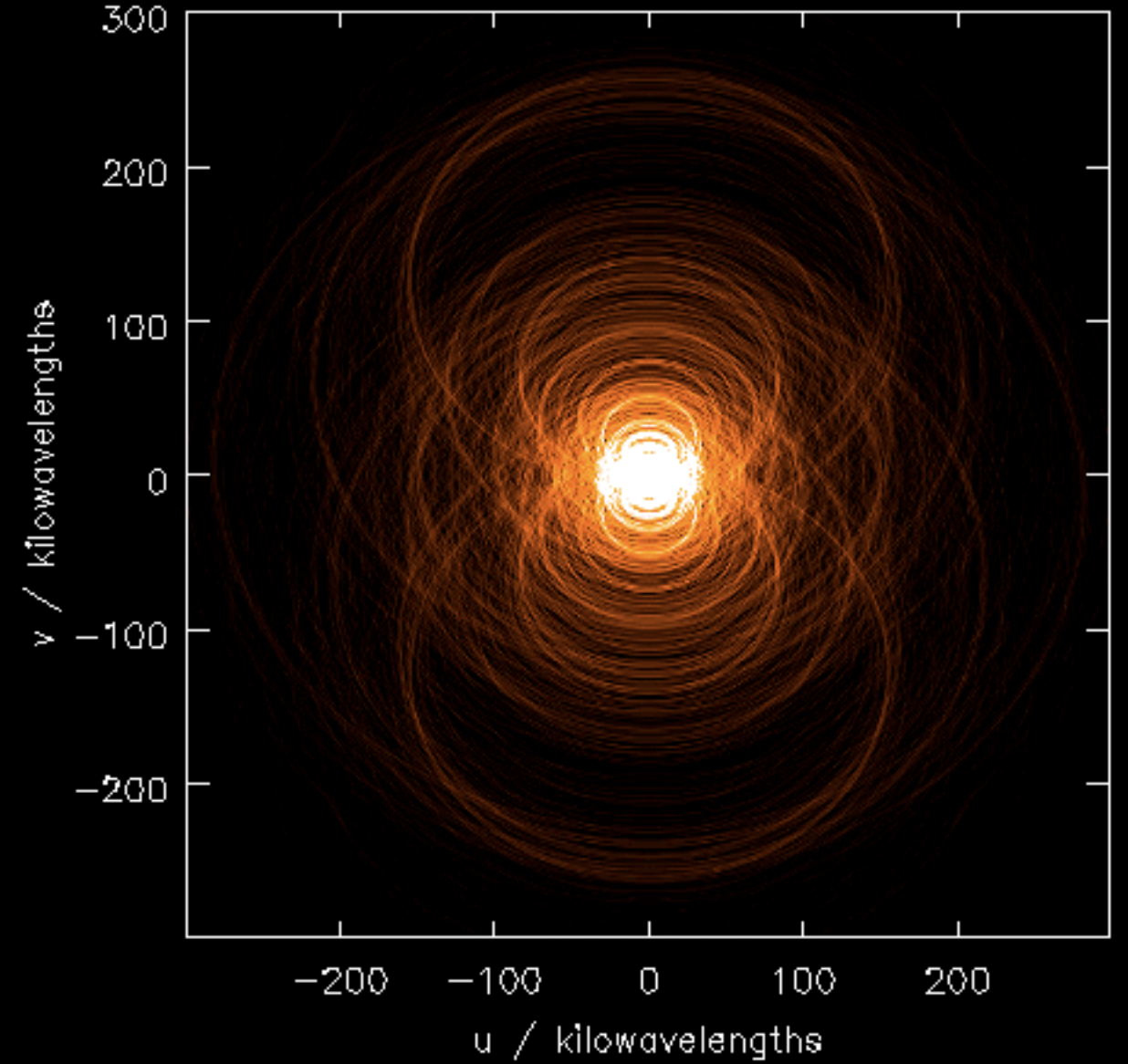
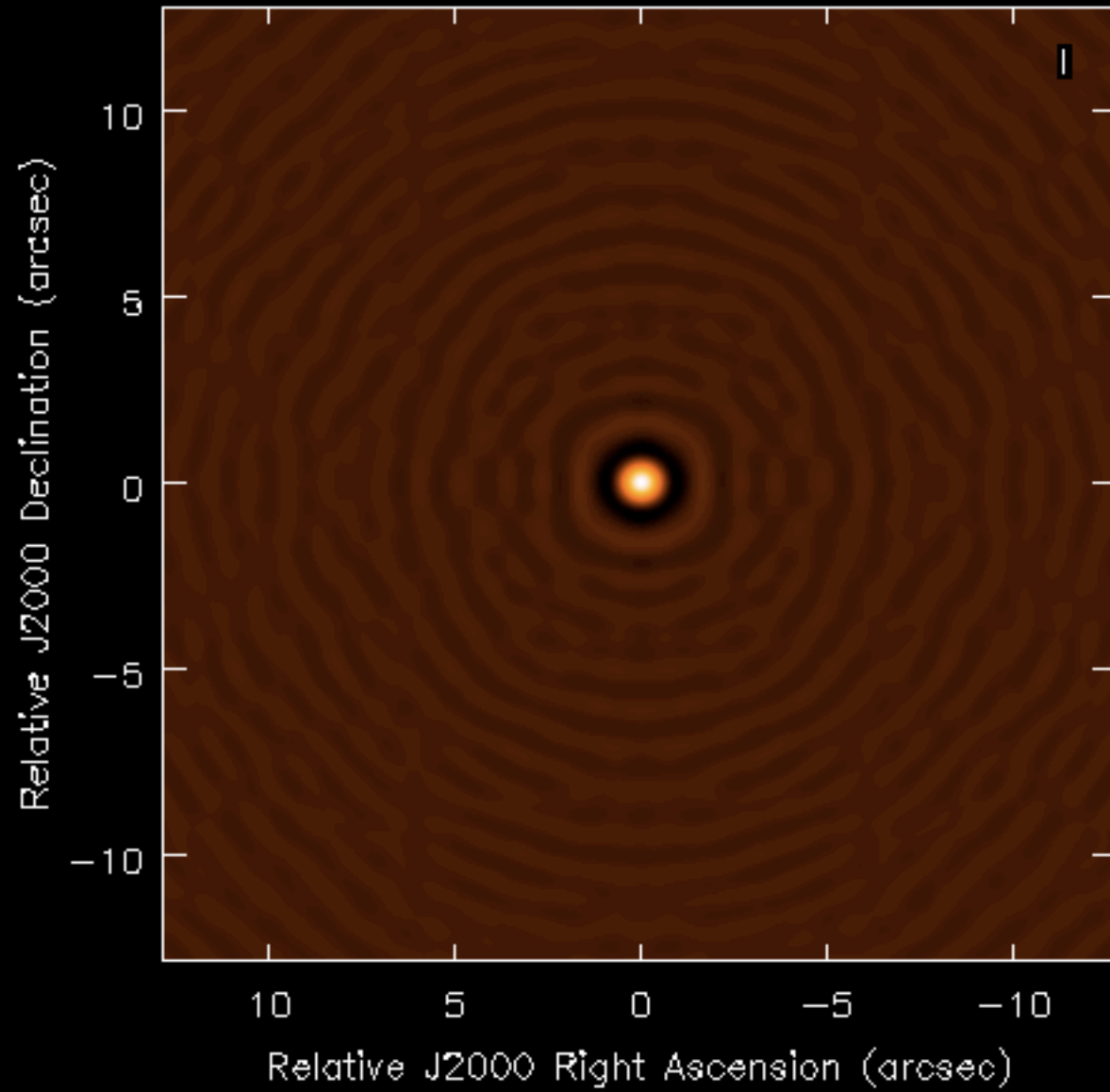
All stations



Inner 10km

SKA₁ aperture array: PSF and *uv* coverage

Dec = -60° , 450 MHz



SKA₁ aperture array simulation

Simulate multiple beams with 1000-hours on-source
with $180 \leq \nu \leq 450$ MHz, corresponding to $2.16 \leq z \leq 6.89$ for neutral hydrogen.

To make this more digestible...

Sub-band	Redshift range	Max. resolution at ν_{centre}	FoV (FWHM) at ν_{centre}
180 - 270 MHz	$6.89 > z > 4.25$	1.83 arcsec	0.52 deg
270 - 360 MHz	$4.25 > z > 2.94$	1.30 arcsec	0.37 deg
360 - 450 MHz	$2.94 > z > 2.16$	1.01 arcsec	0.29 deg

Assume 256 channels for now, giving $\Delta\nu = 250 \text{ km s}^{-1}$.

SKA₁ aperture array simulation

“What we put into the simulation is what we get out.”

Two (big) assumptions:

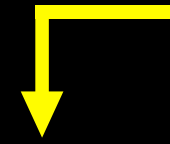
1. Calibration problems such as ionospheric corruptions and variable station beams are tractable.
2. The SKA will actually work.

Simulation steps

Generate sky model

Extract sample of galaxies from S^3 -SAX within relevant volume of space.
Generate model sky cube in FITS format.

Many papers by Obreschkow et al.
<http://s-cubed.physics.ox.ac.uk>



Process sky model

Attenuate image cube with simple PB model.

Generate MS 'crates' with CASA sm tool.
Fill visibilities with MeqTrees.

Generate and fill MS

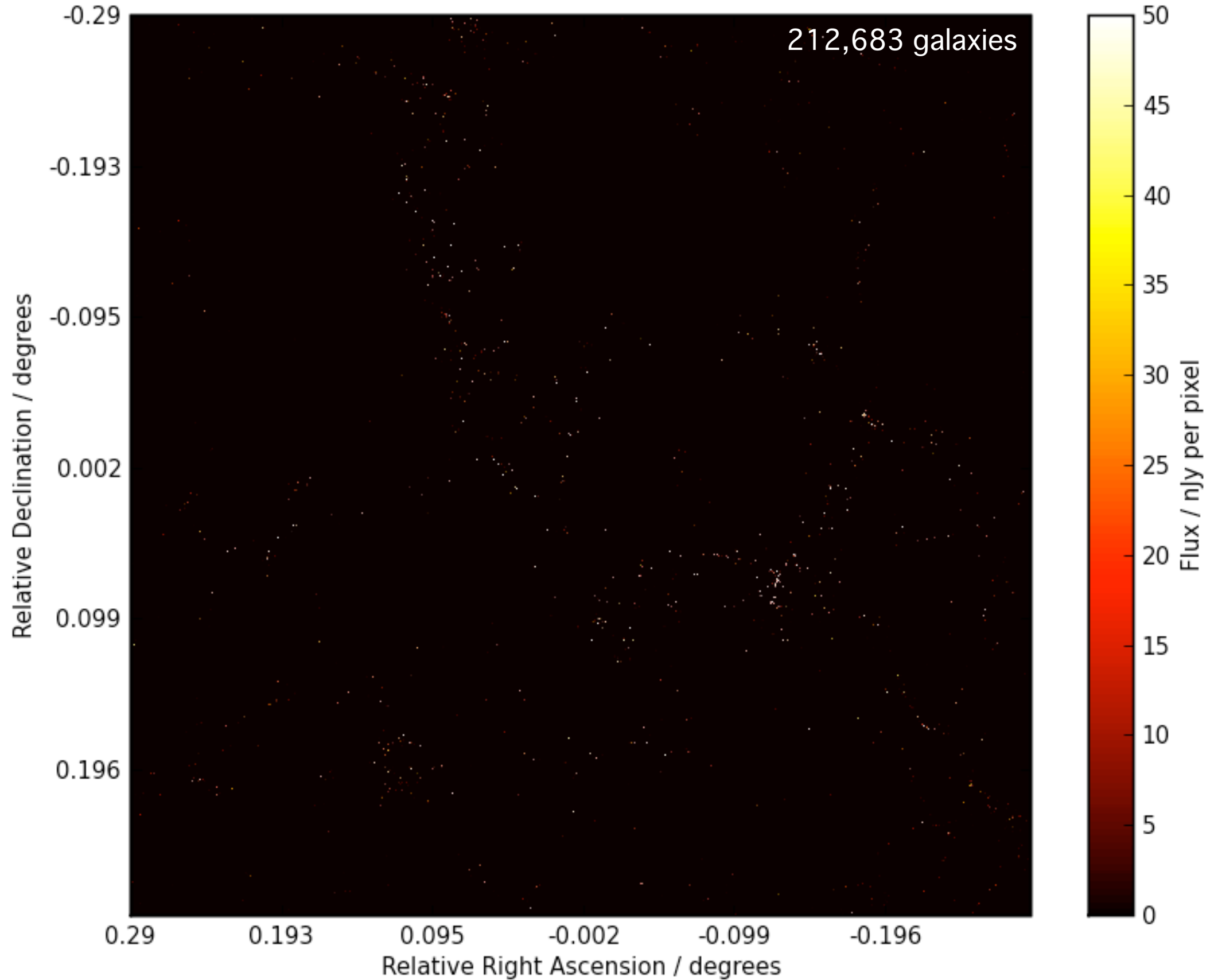
Invert visibilities to produce 'observed' image cube.

Image MS

Divide out PB model from output images, and cut at 30% level.

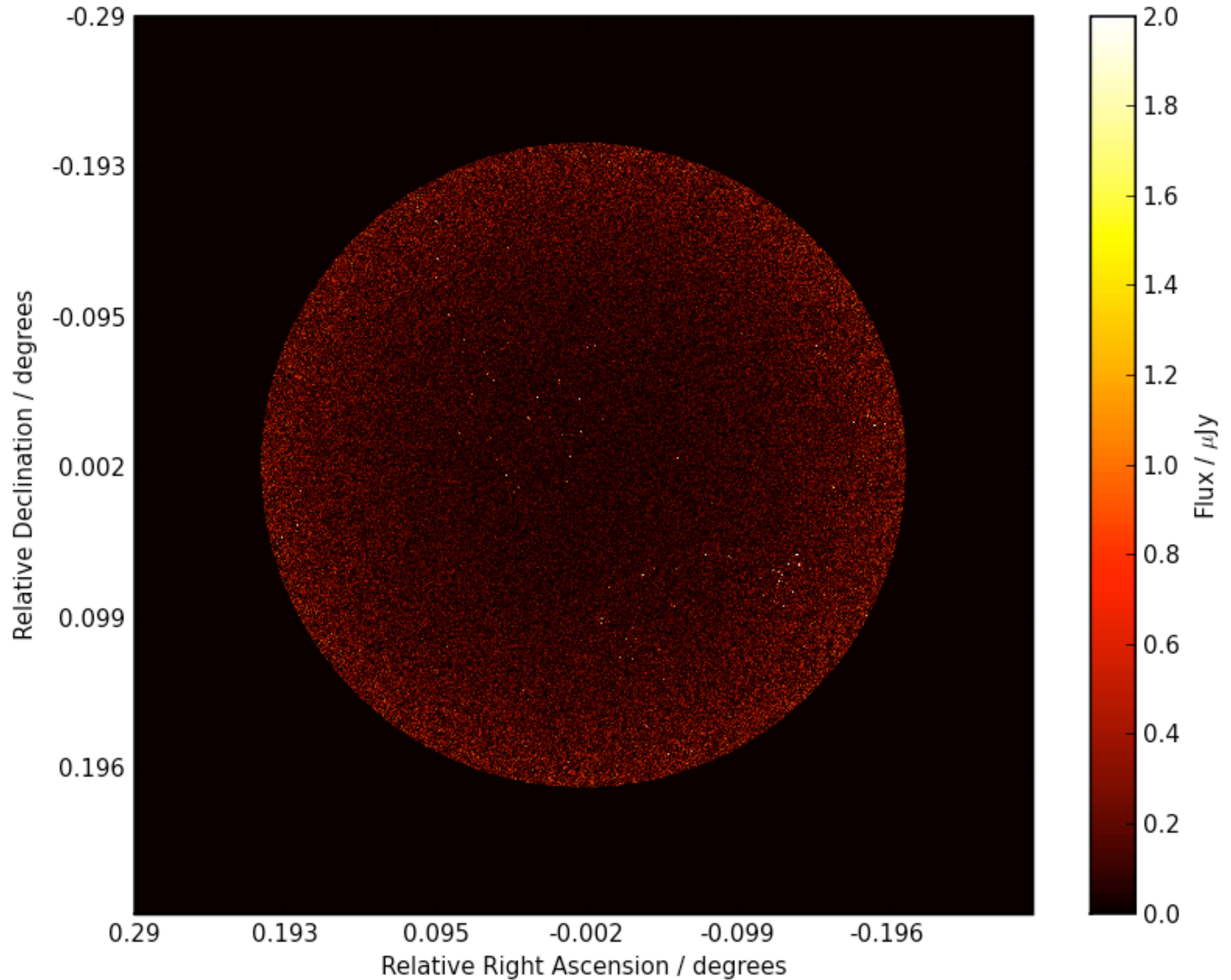
PB correction

Simulated neutral hydrogen cube: $2.1491 \leq z \leq 2.8989$



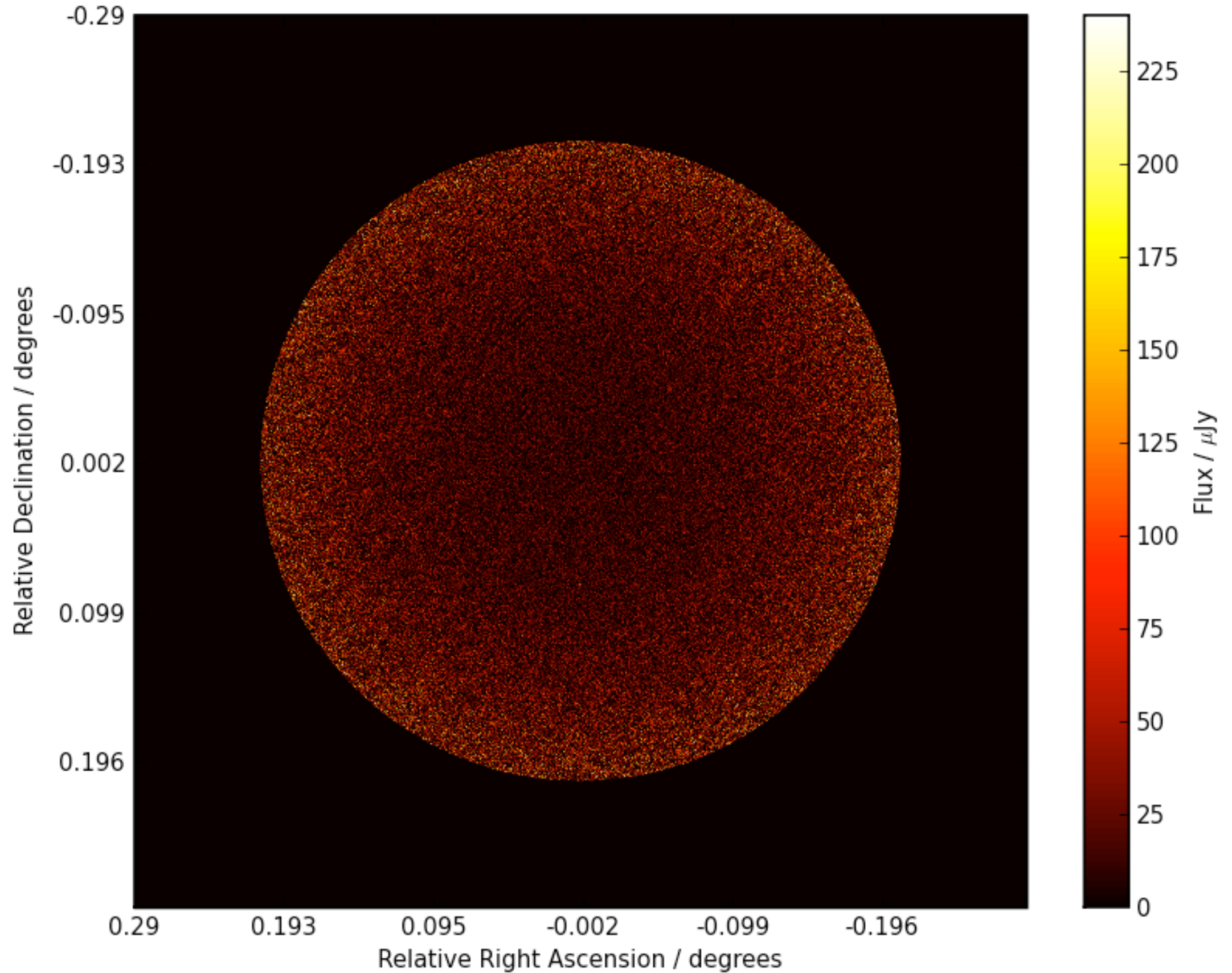
256 channel input model

SKA₁ Aperture Array single beam: $364.2 \leq \nu \leq 450.9$ MHz



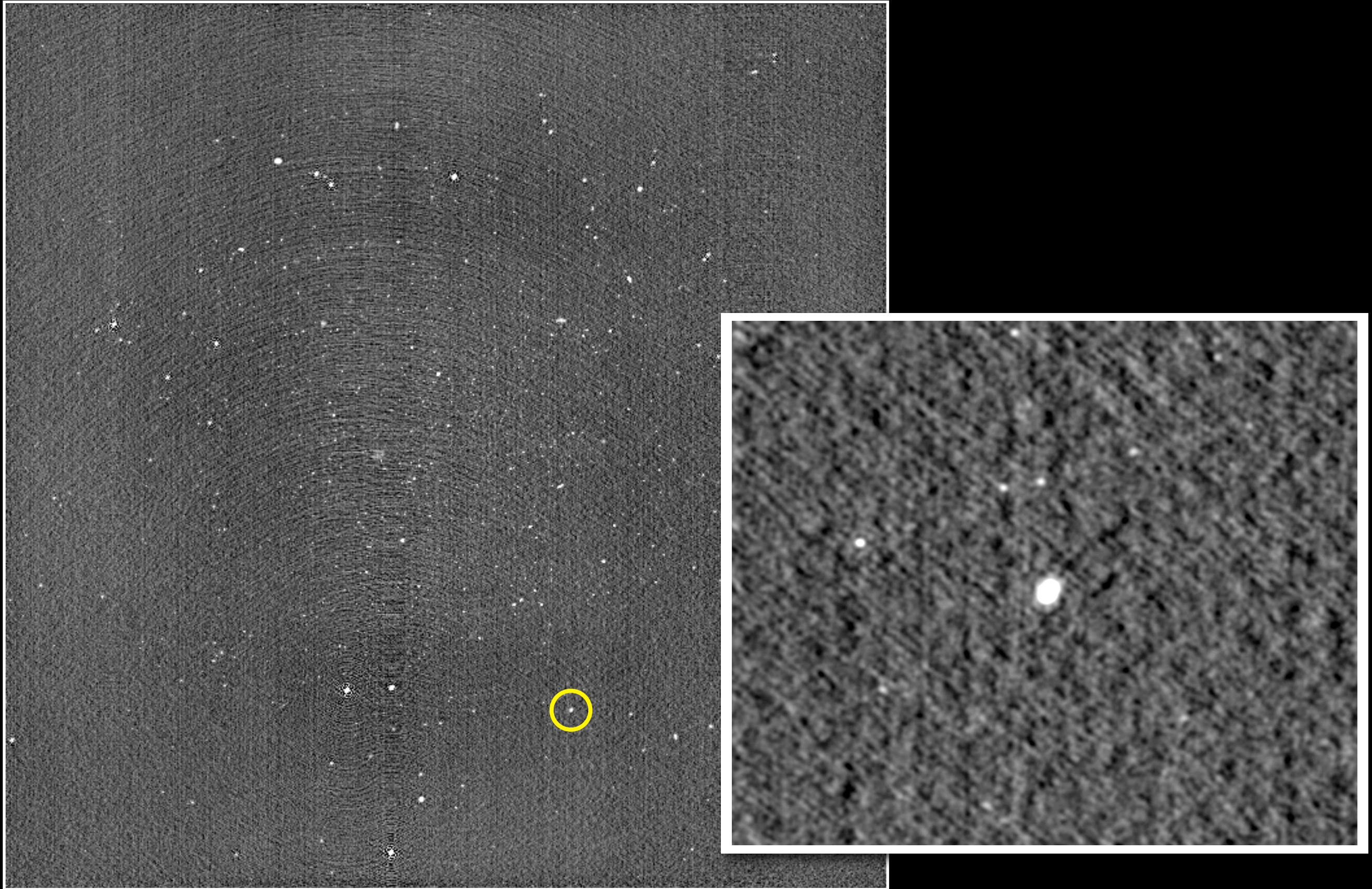
256 channel cube with an arbitrary low noise floor

SKA₁ Aperture Array single beam: $364.2 \leq \nu \leq 450.9$ MHz



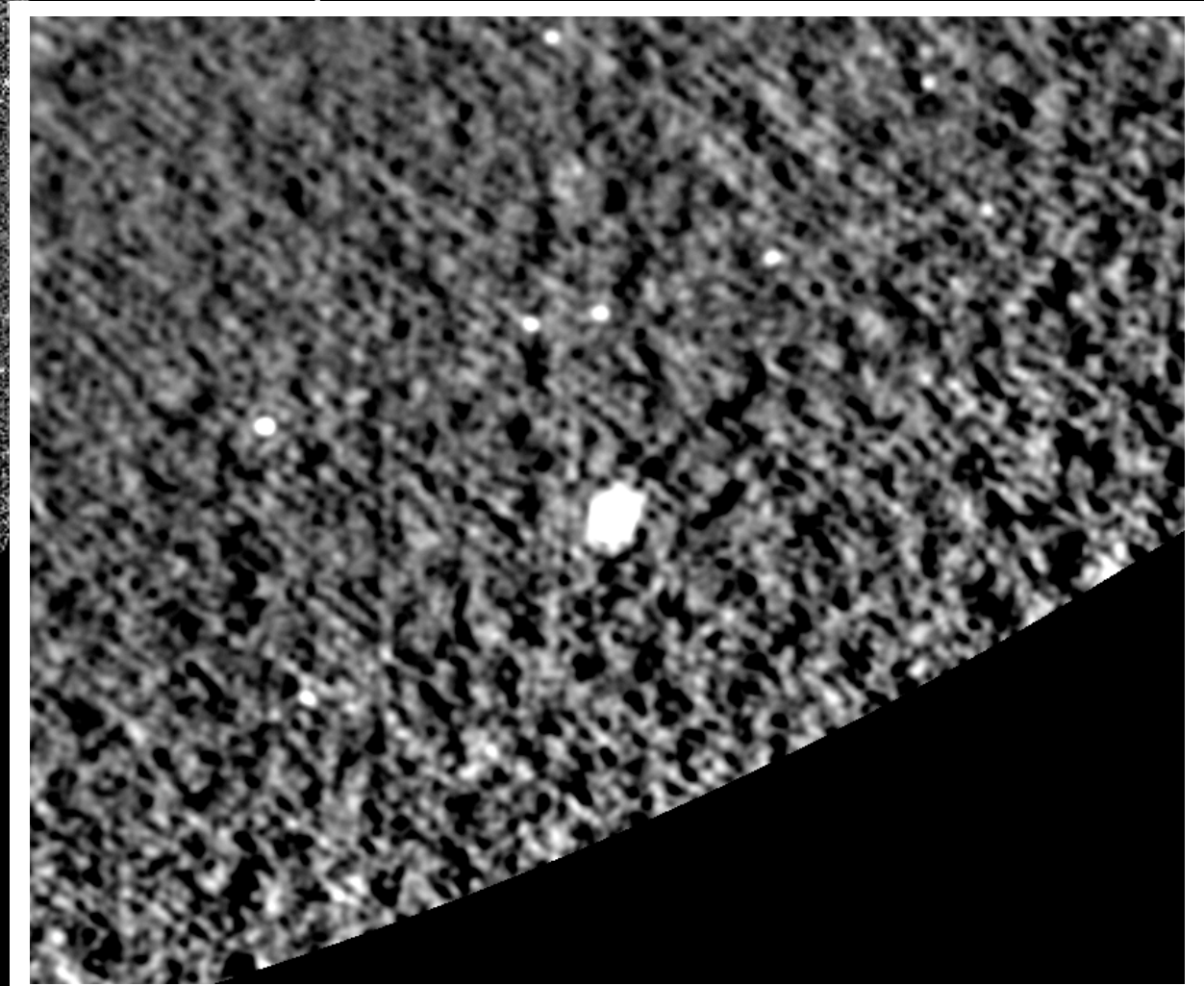
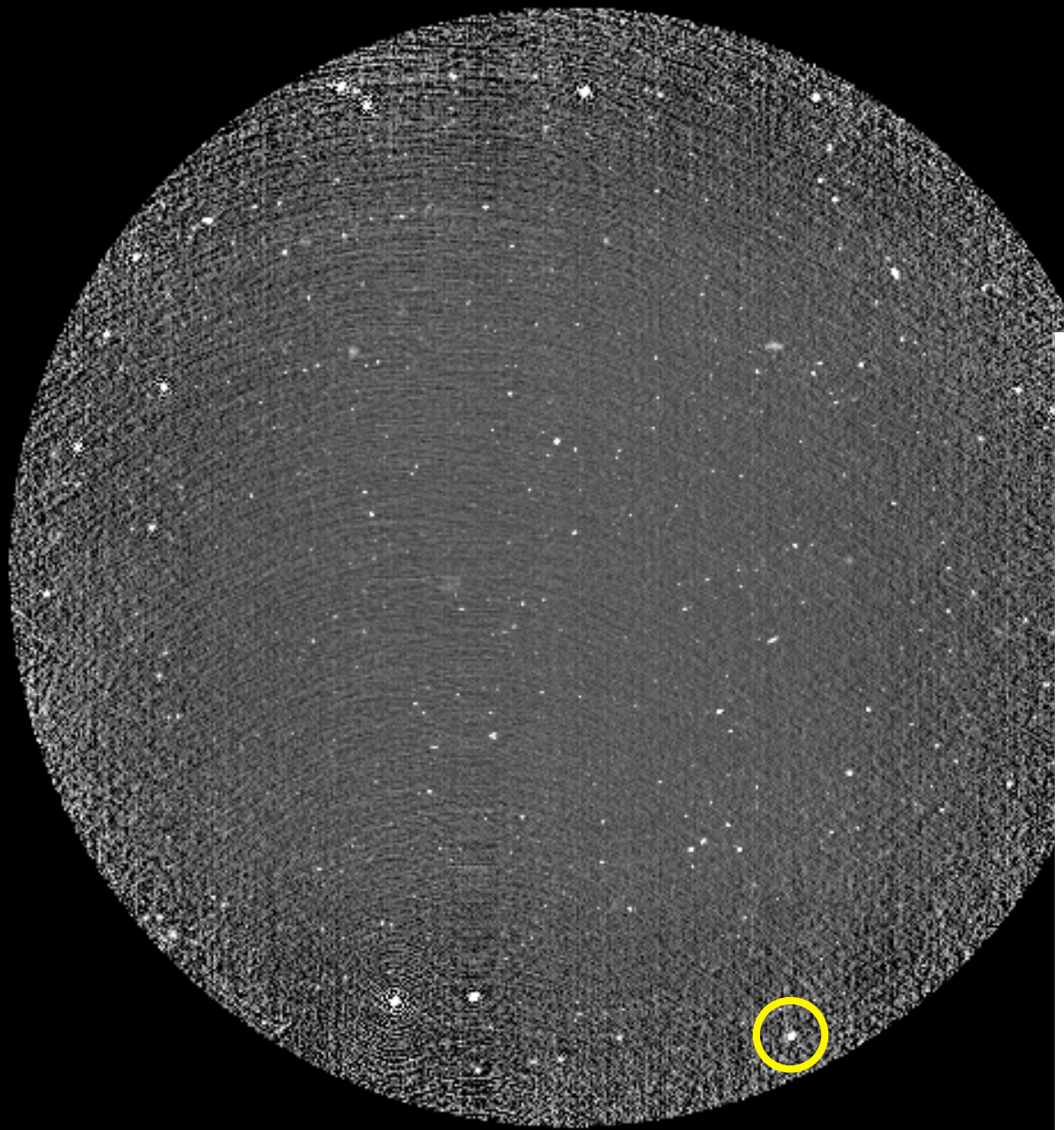
256 channel output cube

Spatial noise variation - primary beam correction



MeerKAT deep continuum simulation - sky model from S³-SAX (Wilman et al., 2008)

Spatial noise variation - primary beam correction



MeerKAT deep continuum simulation - sky model from S³-SAX (Wilman et al., 2008)

Spectral and temporal noise model

$$T_{\text{sys}} = T_{\text{rec}} + T_{\text{sky}}$$

$$T_{\text{rec}} = 50 \text{ K}$$

$$T_{\text{sky}} = 5 \times 10^8 \nu_{\text{MHz}}^{-2.861} + 4 \quad (\text{Medellin, SKA Memo 95})$$

T_{sys}

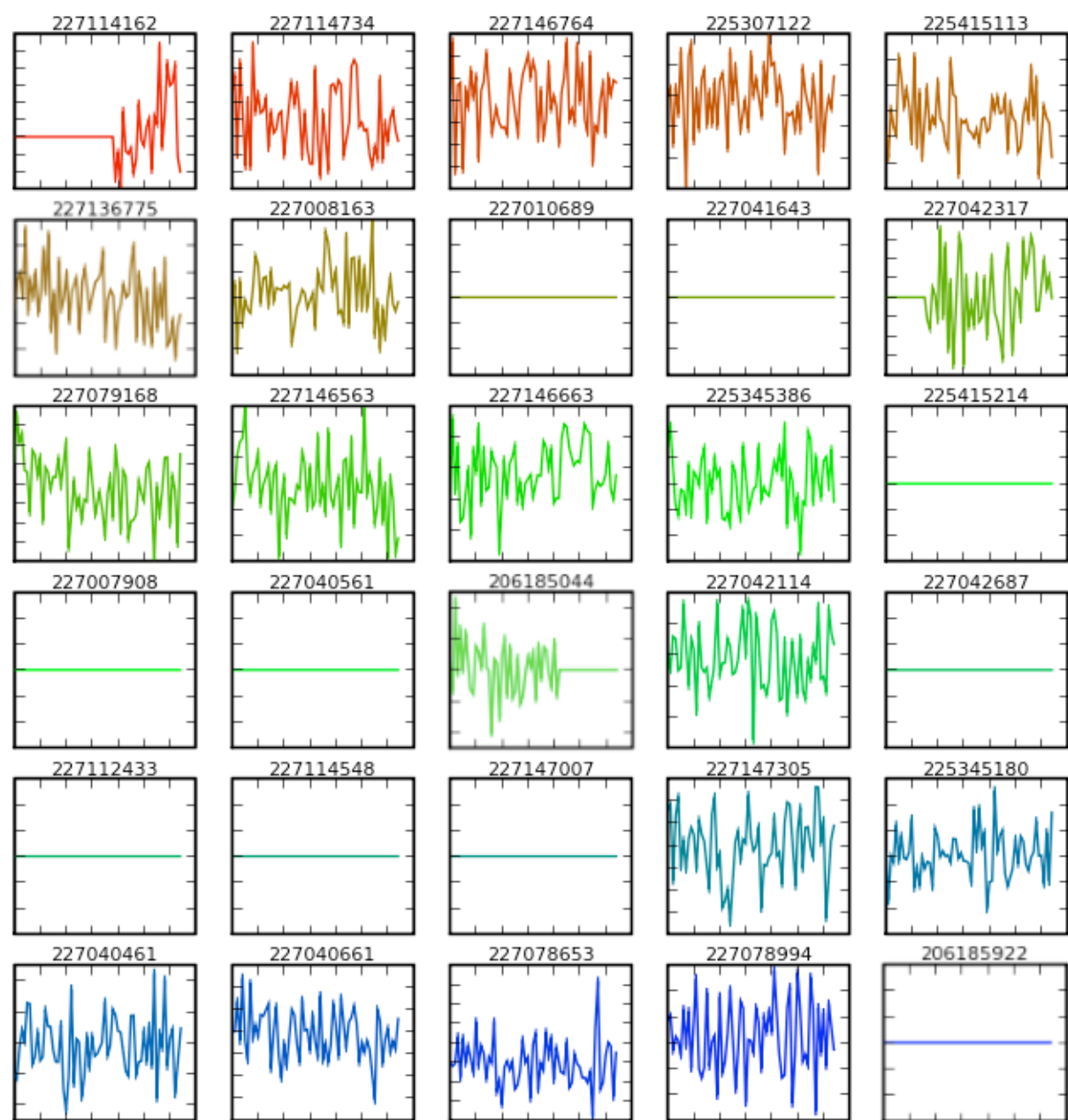
$$\sigma_{pq} = \frac{\sqrt{2} k_B}{\eta_Q} \cdot \frac{T_{\text{sys}}}{\sqrt{A_p A_q \Delta t \Delta \nu}}$$

$$A_p = A_{\text{geom}} \eta_A \sin(\lambda_p)$$

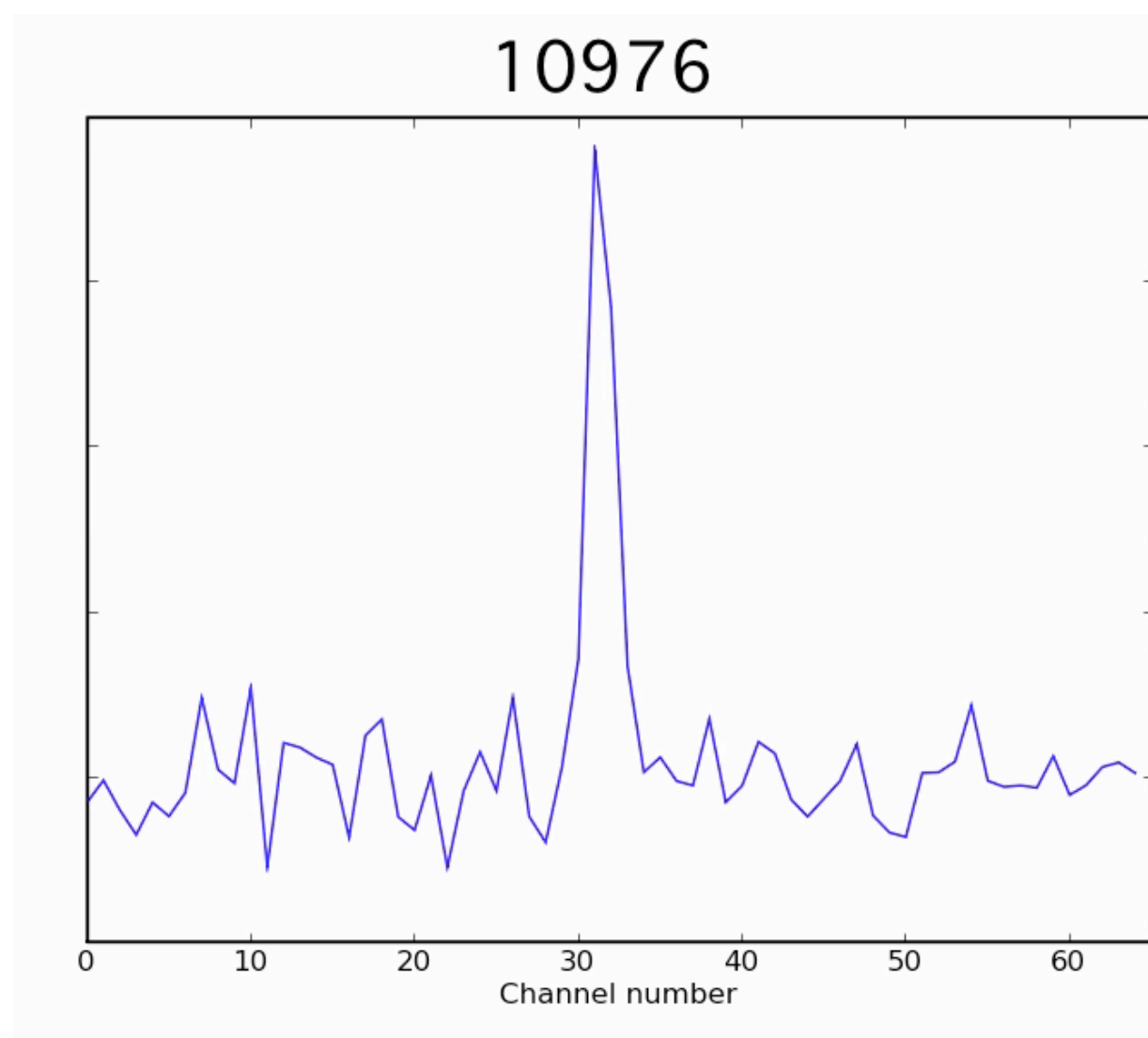
The spectral line stacking technique

(signal from the noise!)

Sample of individual spectra



Average line profile



Investment per simulated 256-channel beam

Intel Core 2 Duo @ 3 GHz / 8 GB RAM

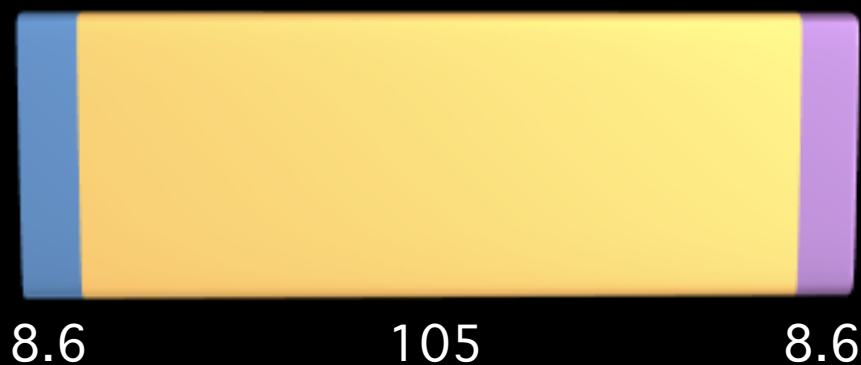
Approx. CPU time / hours



Data volume / GB



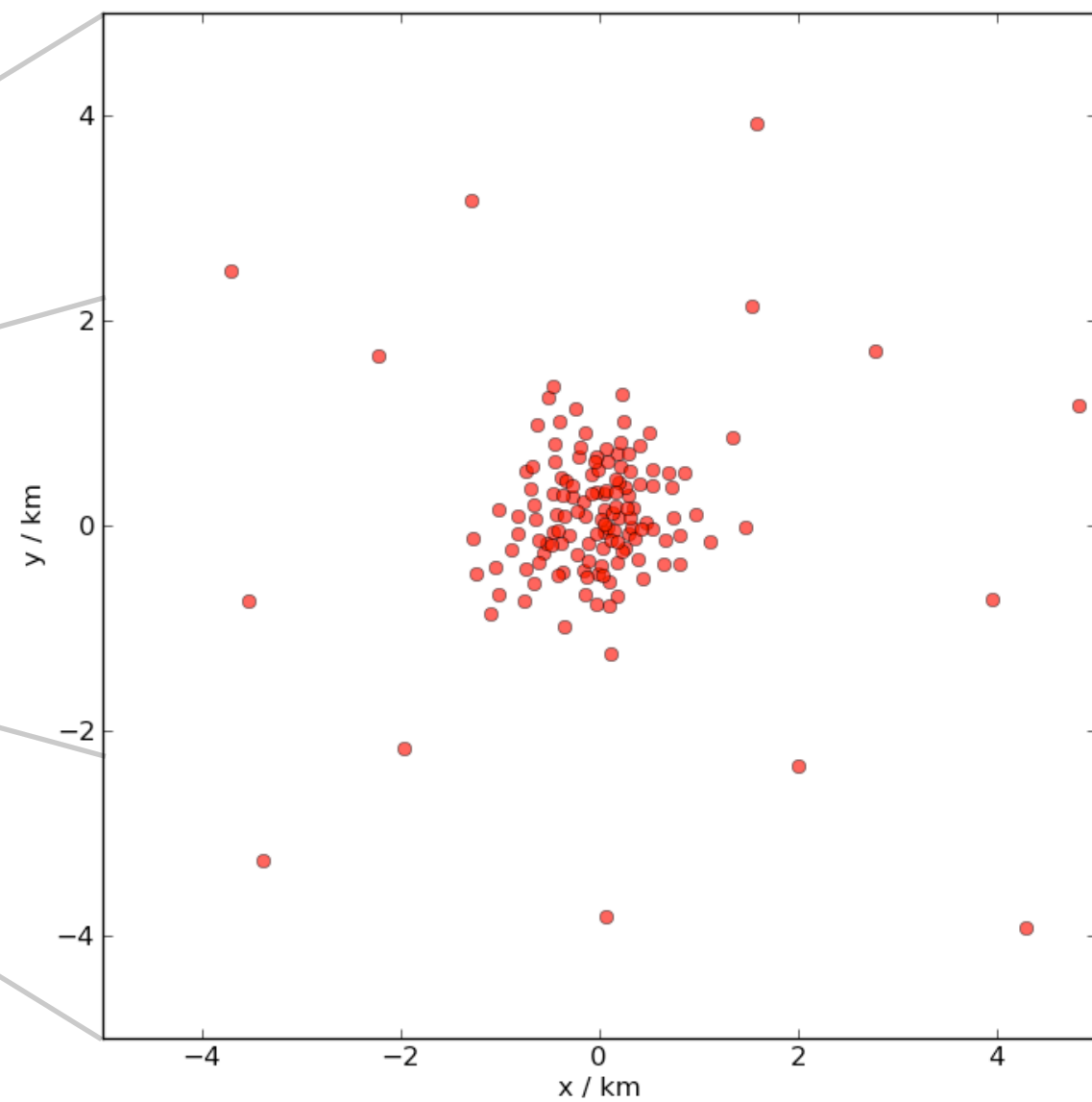
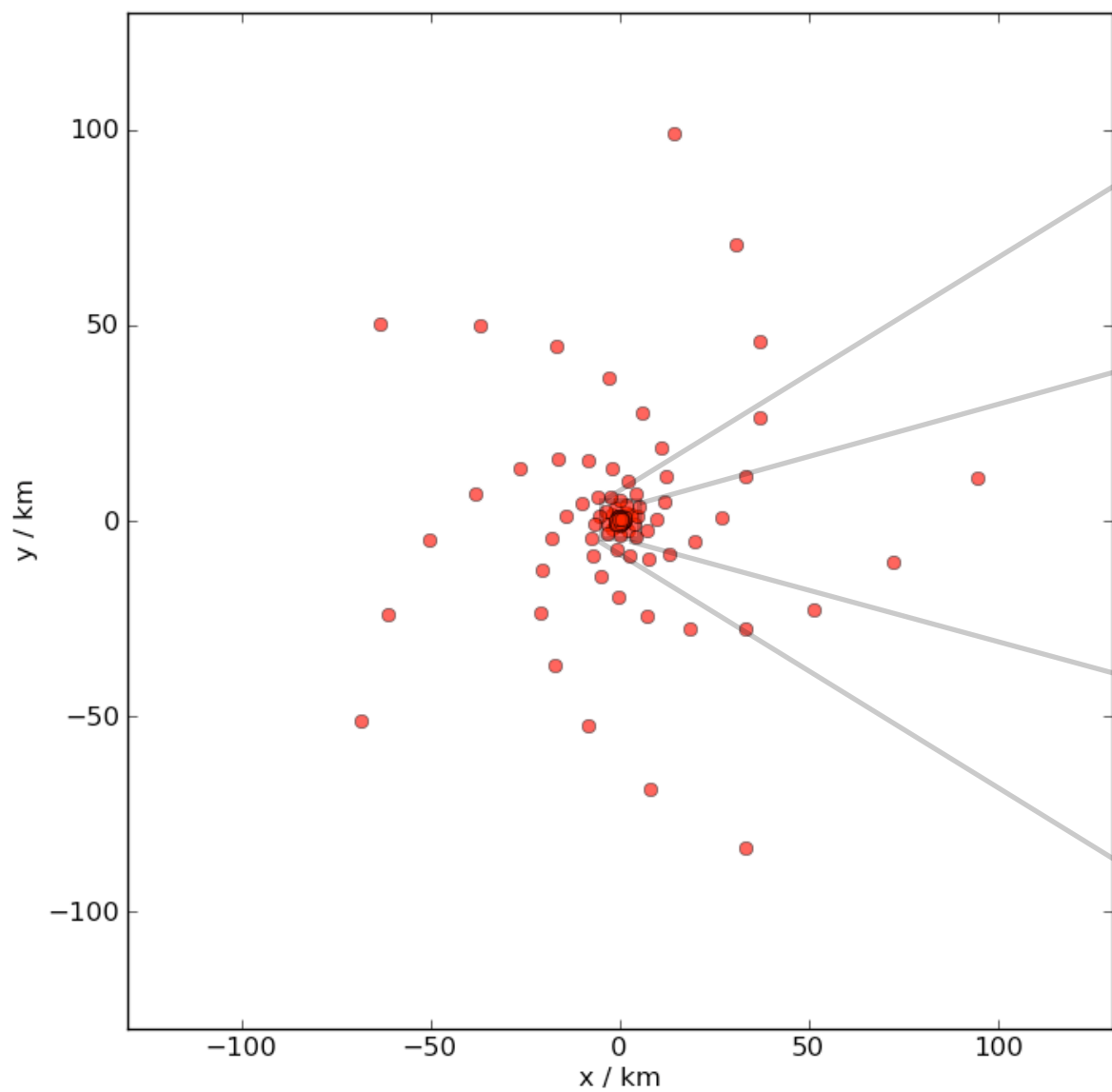
Reduces to about 122 GB (Including hard removal of flagged MS rows)



- Ideal sky input cube
- Attenuated sky cube
- Generate and fill Measurement Sets
- Image Measurement Sets
- PB-corrected output cube

SKA₁: 250 dishes

(with further thanks to Rosie Bolton)



All stations

Inner 10km

SKA₁ dish array: nothing ventured, nothing gained...

Time to generate Measurement Set for one channel:

~6 hours

Size of single channel Measurement Set:

~25 GB

Time to produce 16384^2 -pixel image from single channel Measurement Set:

?