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!

ianh@astro.ox.ac.uk

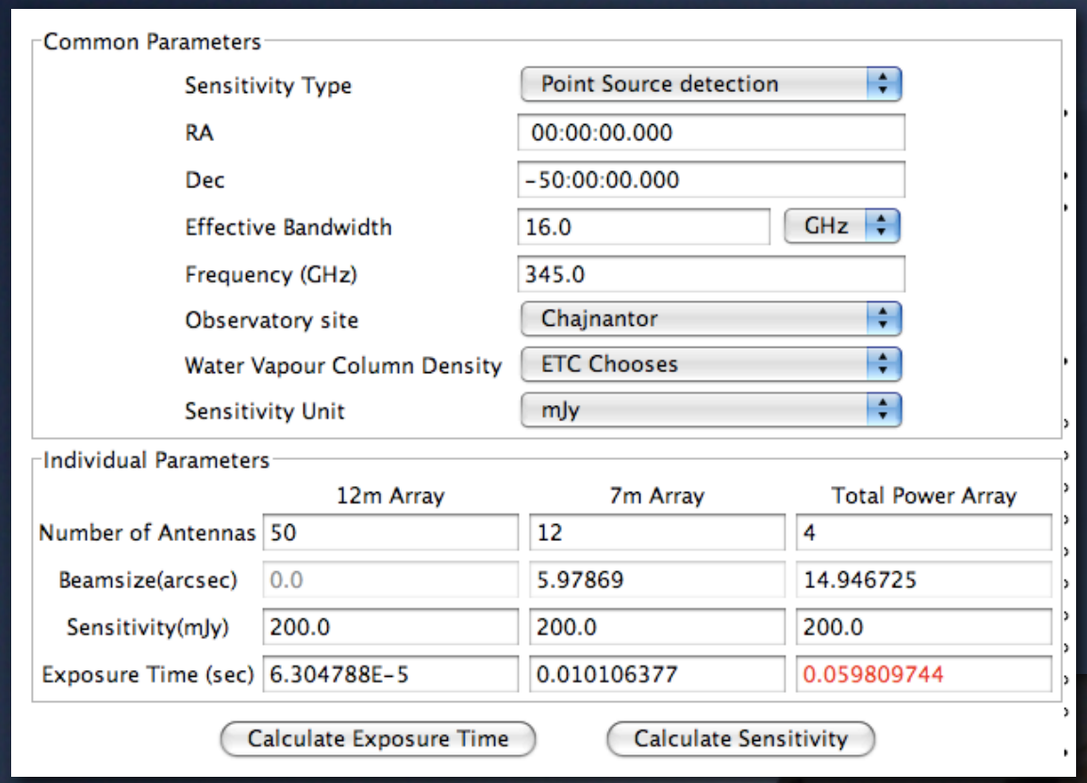
Part One

The ALMA Observation Support Tool

with thanks to:
Chris Williams (OeRC), Eduardo Ibar (Royal Observatory Edinburgh)

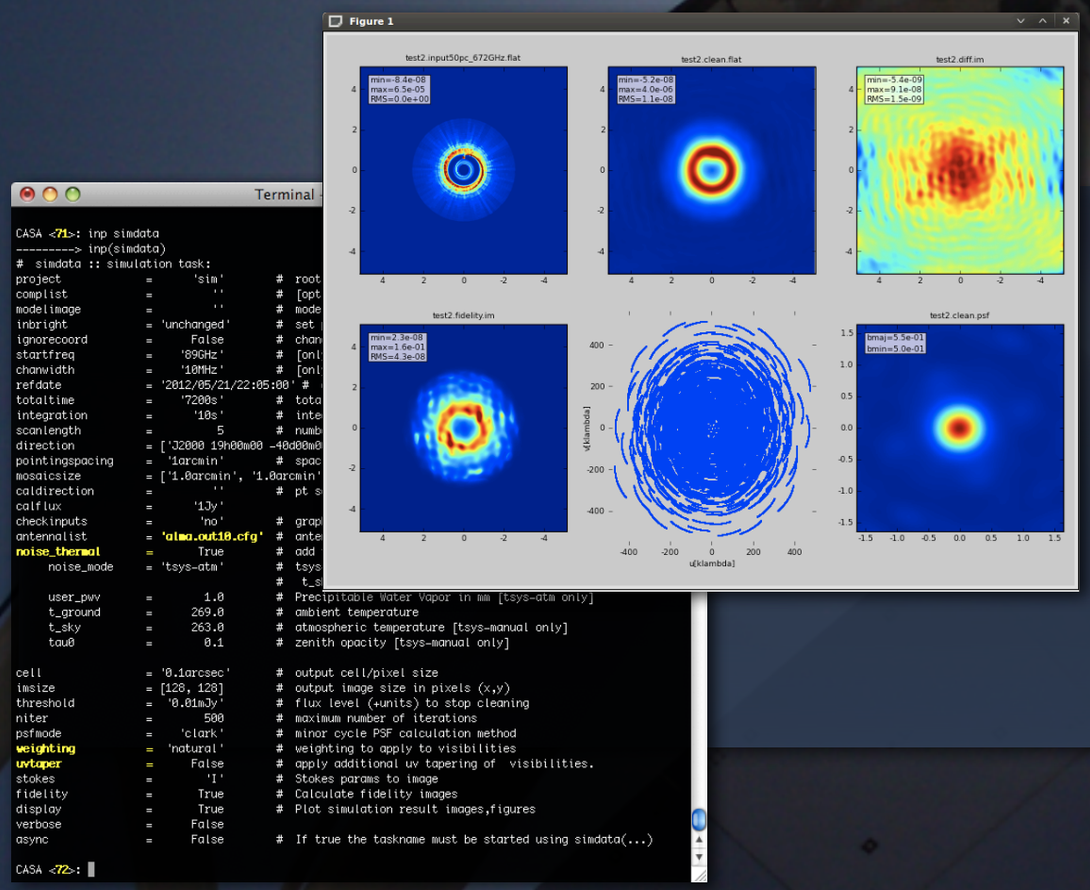
European ARC Nodes are “the interface between ALMA and the European user communities”. Their functions include “making available to users tools for proposal preparation” and the “development and maintenance of new software and techniques”.

From the European ALMA ARC Memorandum of Understanding (ESO)



ALMA Sensitivity Calculator

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



The CASA ‘simdata’ task

BACK END SYSTEM

TEMPORARY 'INCOMING' FOLDER

model.fits

UPLOAD

CLICK

OST webform

Simulation Parameters

model.fits

params.txt

Self-contained CASA script

HTML summary

You've got mail

SEND A MAIL

simulation.fits

TEMPORARY 'OUTGOING' FOLDER

USERS FILES

TEMPORARY FILES ON THE SERVER

SOFTWARE ON THE SERVER

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	Browse...	Leave blank to use central point source model
	Declination	-35d00m00.0s	Ensure correct formatting
	Image peak / point flux in mJy	1.0	Leave blank for no rescaling if uploading sky model
Observation Parameters	Minimum frequency in GHz	90	
	Bandwidth in 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 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	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	Browse...	Leave blank to use central point source model
	Declination	12345 **Not valid!**	Ensure correct formatting
	Image peak / point flux in 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 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 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**	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

Google

ALMA OST - Job ID: 20100820222812

ALMA Observation Support Tool - Result

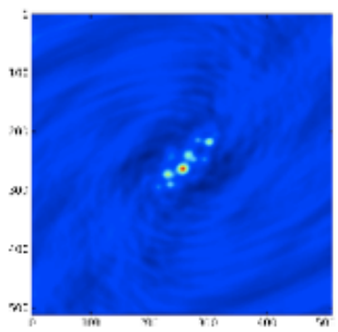
Job ID: 20100820222812 / Submitted by: you@yourdomain.com

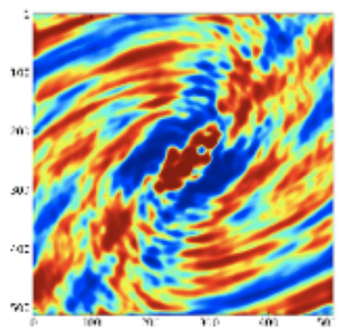
Overview	
Array configuration	ALMA out10
Sky model	cluster.fits
Maximum elevation	77.88 degrees
Minimum frequency	90 GHz = Band 3
Bandwidth	1.0 GHz
Track length	5 hours
System temperature	60.0 K
Theoretical RMS noise	6.08966290416e-06 Jy (in naturally-weighted map)

Data products

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

Your simulated image
Download FITS file





ALMA OST - Job ID: 20...

Results page (2)

Applications Places System — Sun 29 Aug, 4:28 AM

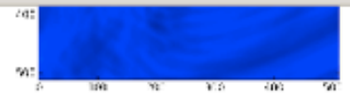
ALMA OST - Job ID: 20100820222812 - Mozilla Firefox

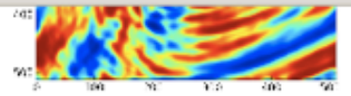
File Edit View History Bookmarks Tools Help

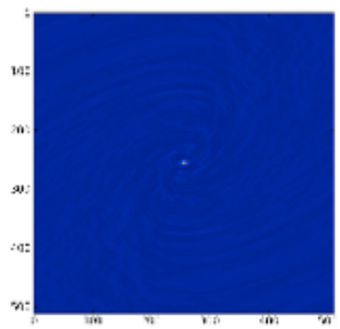
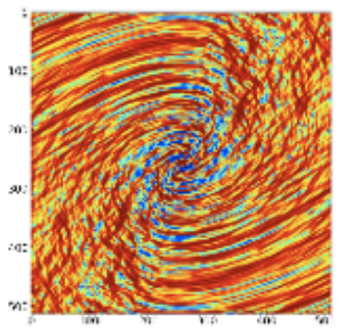
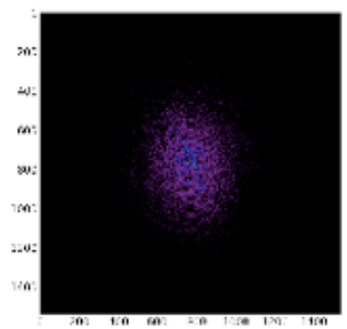
http://localhost/output/20100820222812.html

Google

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

Google

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.

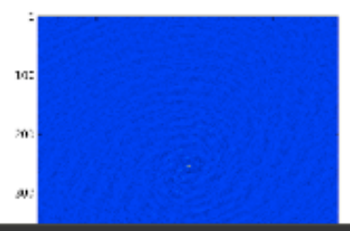
Overview

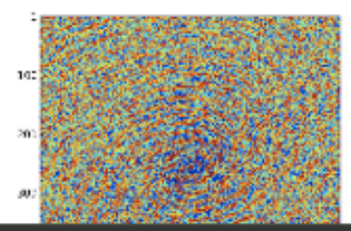
Array configuration	Early Science ALMA (Large)
Sky model	Central point source model 1.0 mJy
Maximum elevation	55.0 degrees
Minimum frequency	115 GHz = Band 3
Bandwidth	1.0 GHz
Track length	3 hours
System temperature	60.0 K
Theoretical RMS noise	2.51185779523e-05 Jy (in naturally-weighted map)

Data products

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

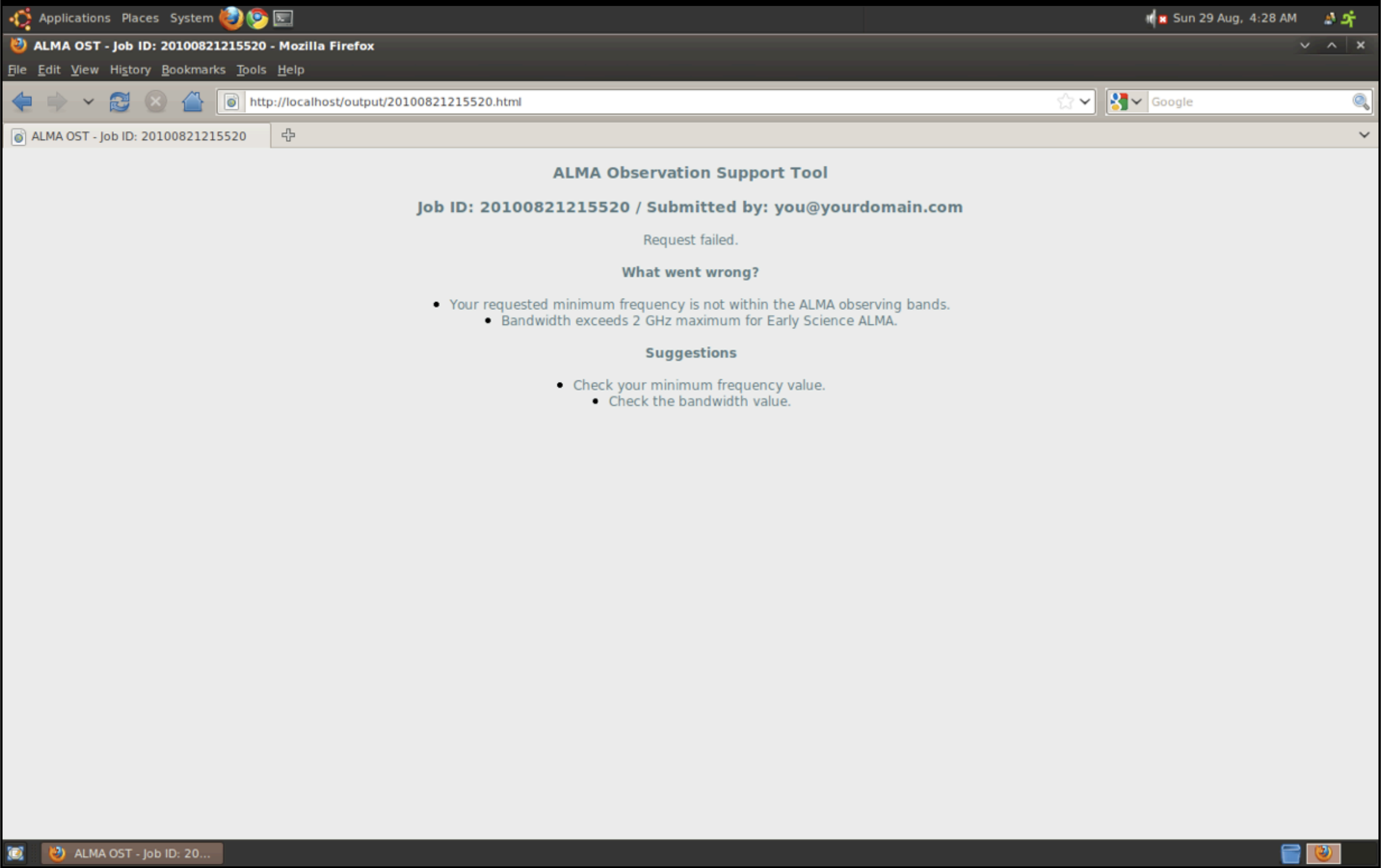
Your simulated image
Download FITS file





ALMA OST - Job ID: 20...

Server-side error checking for more complex problems



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

Part Two

SKA_1 Neutral Hydrogen Simulation

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

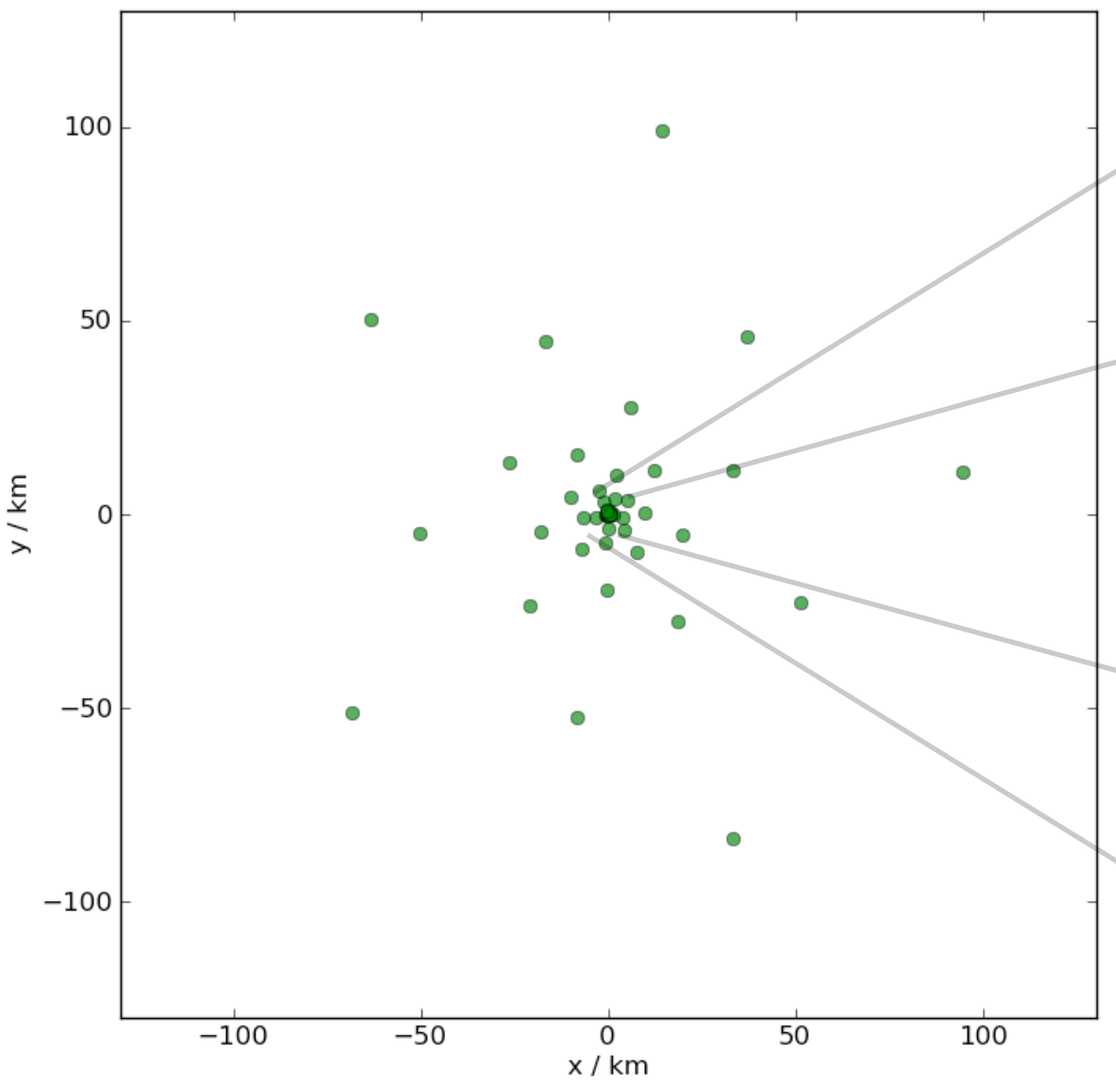
SKA_1 low-frequency sparse aperture array

Frequency range:	$70 \leq \nu \leq 450$ MHz
Instantaneous bandwidth:	380 MHz
Stations:	50×180 m diam.
Nyquist frequency:	100 MHz
Maximal A_{eff} / T_{sys}:	~2000 m^2 / K

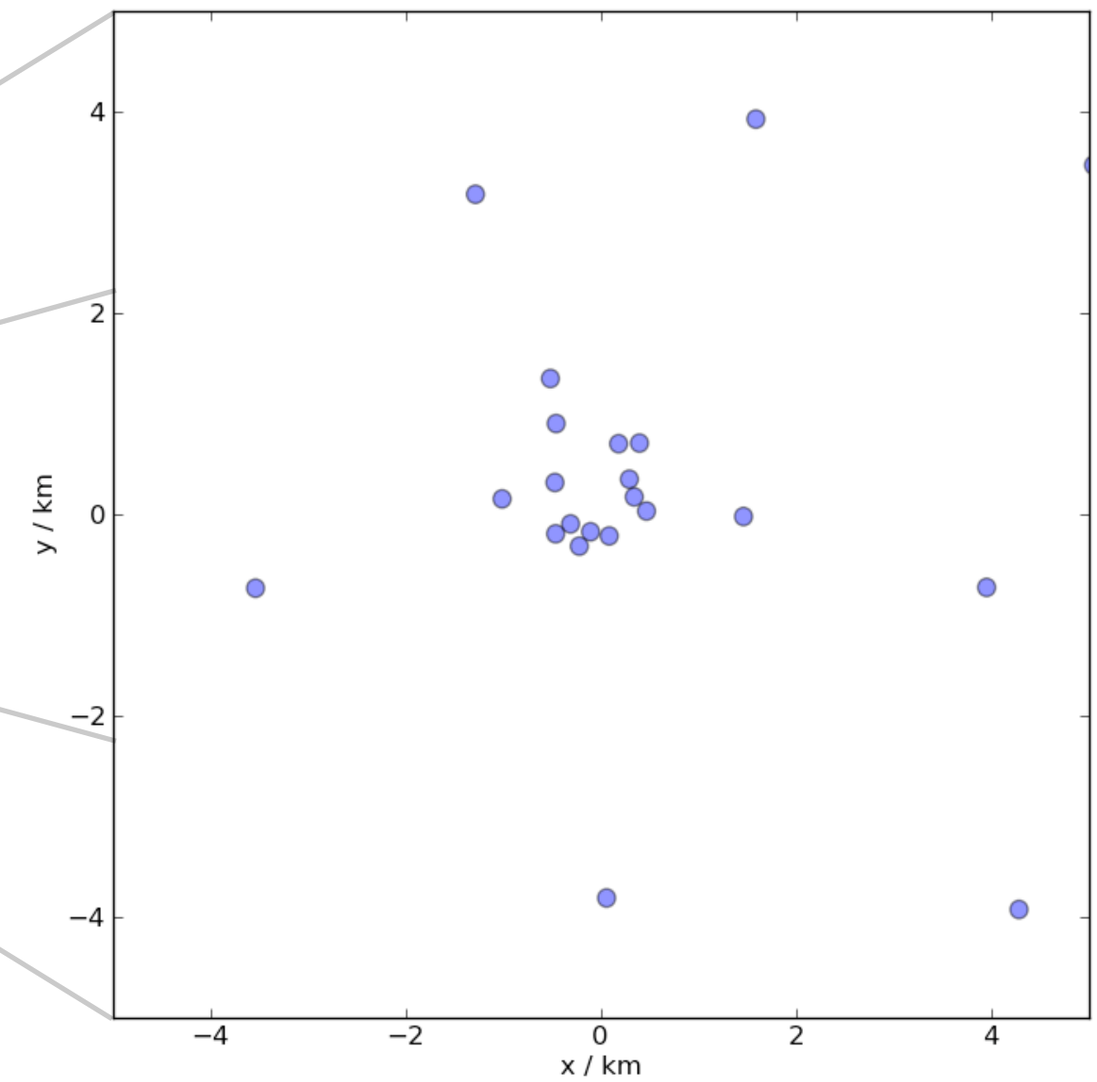
(See e.g. Garrett et al., 2010, arXiv 1008.2871)

SKA_1 aperture array: assumed 50-station layout

(with thanks to Rosie Bolton)



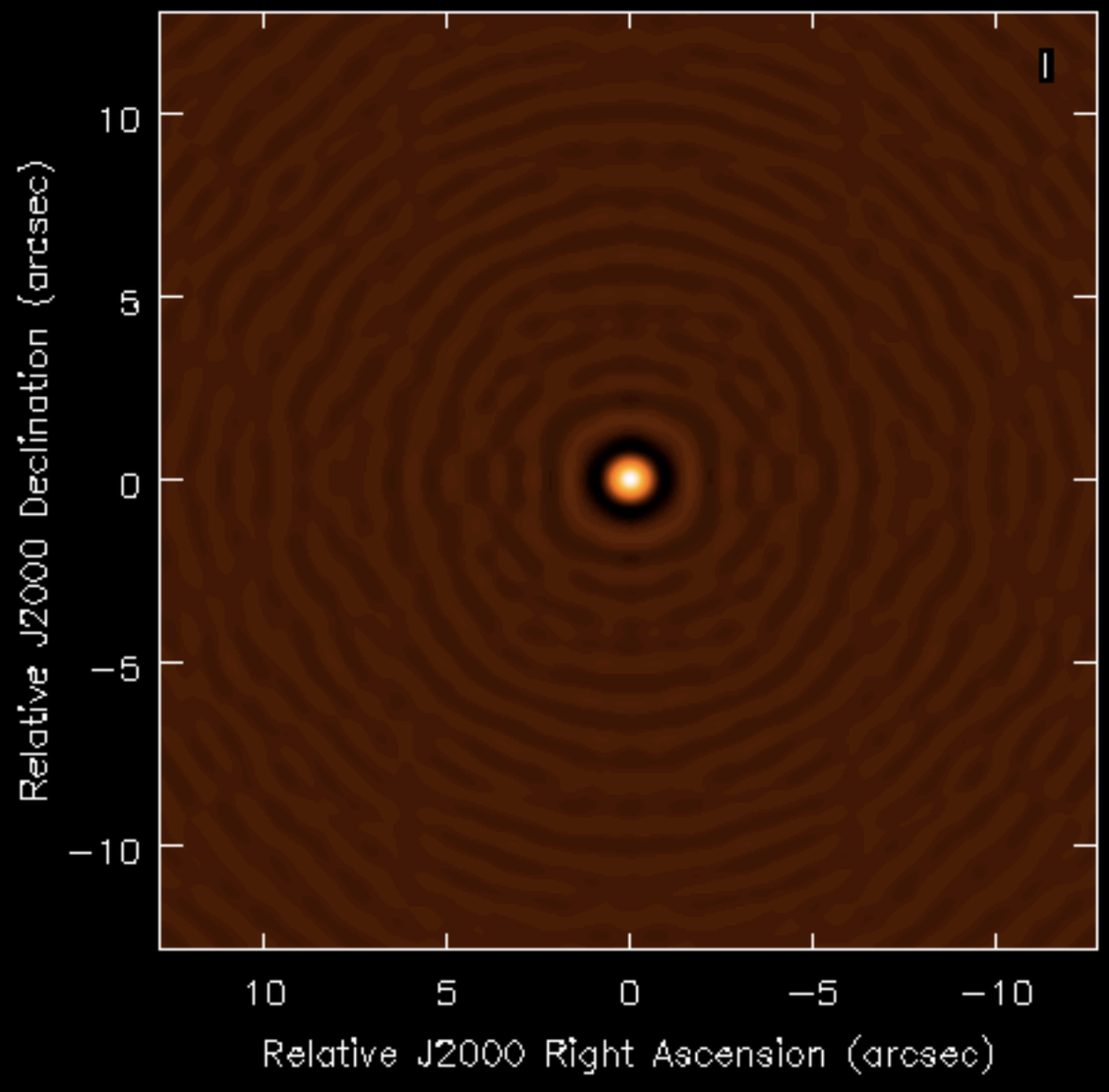
All stations

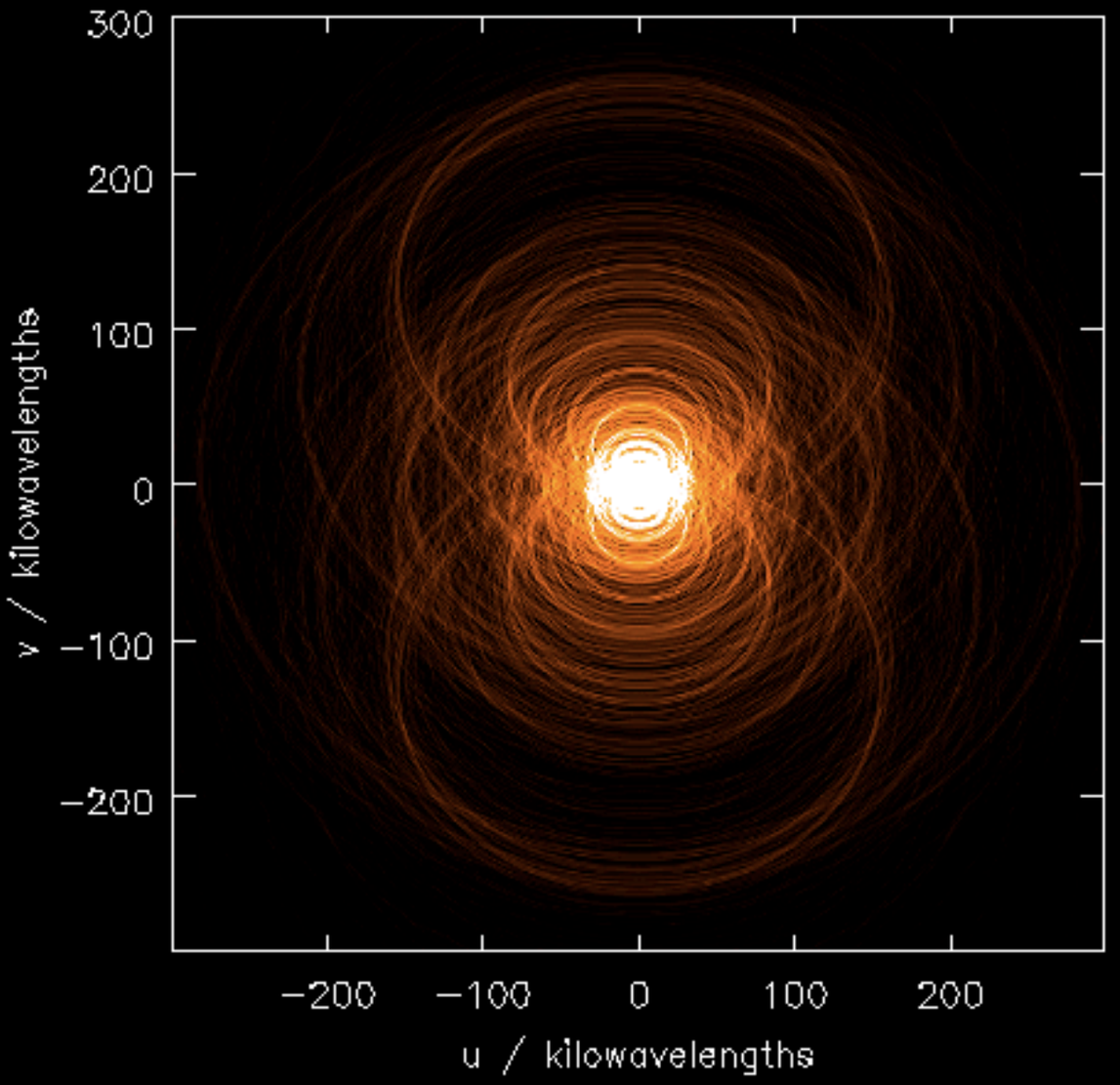


Inner 10km

SKA_1 aperture array: PSF and *uv* coverage

Dec = -60°, 450 MHz





SPDO / Swinburne Astronomy Productions

SKA_1 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 $\Delta v = 250$ km s^{-1}.

SKA_1 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

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

Generate sky model

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

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

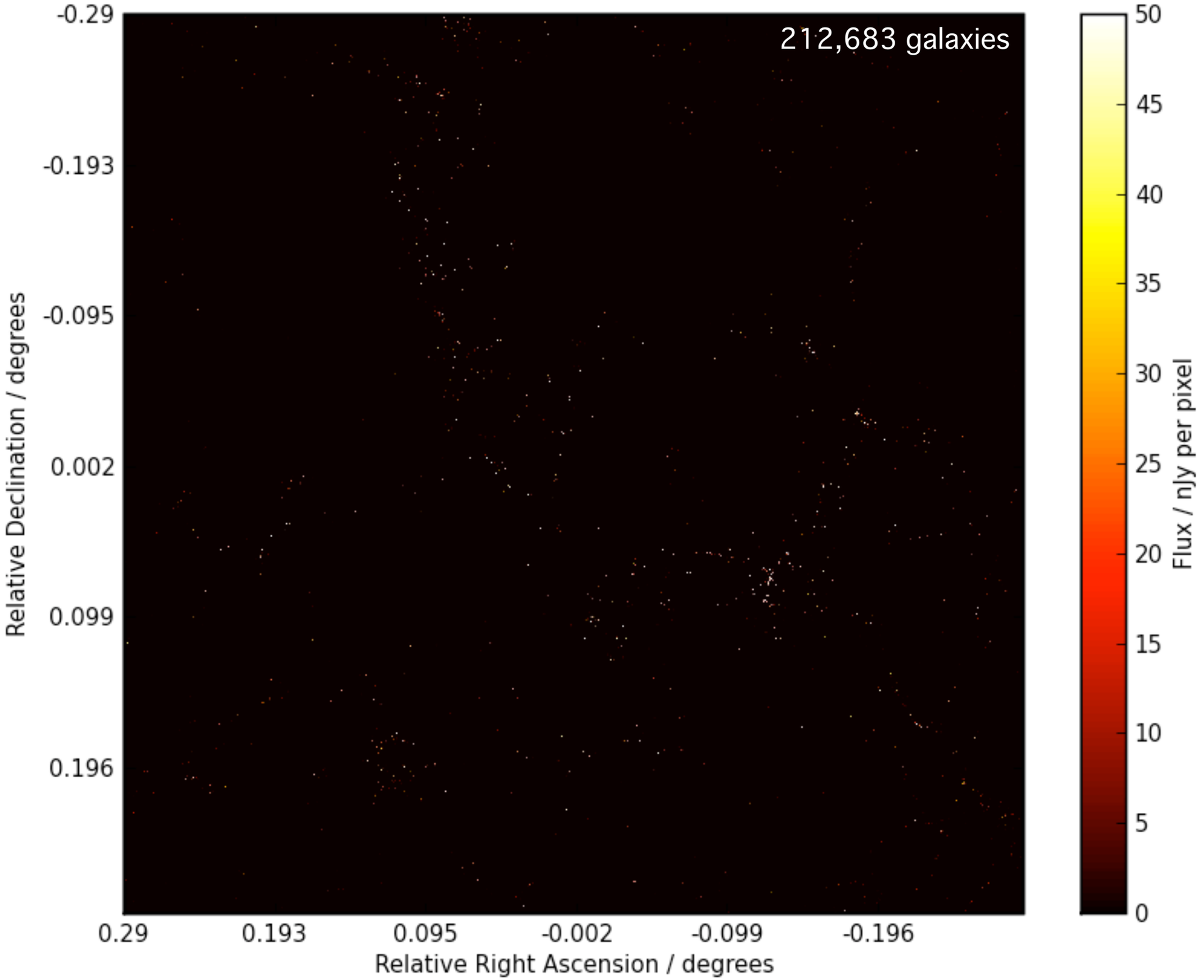
Invert visibilities to produce ‘observed’ image cube.

Image MS

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

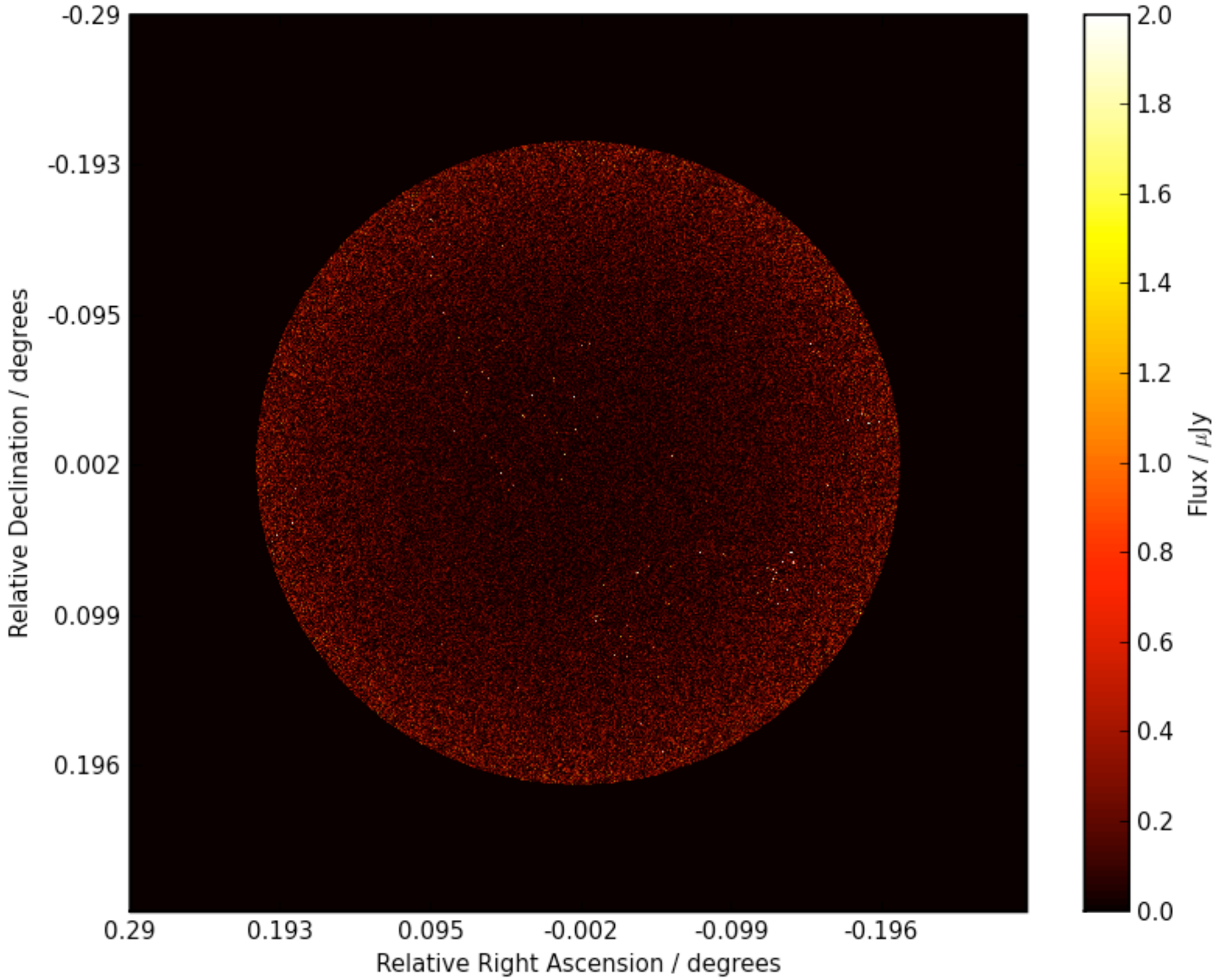
PB correction

Simulated neutral hydrogen cube: 2.1491 ≤ z ≤ 2.8989



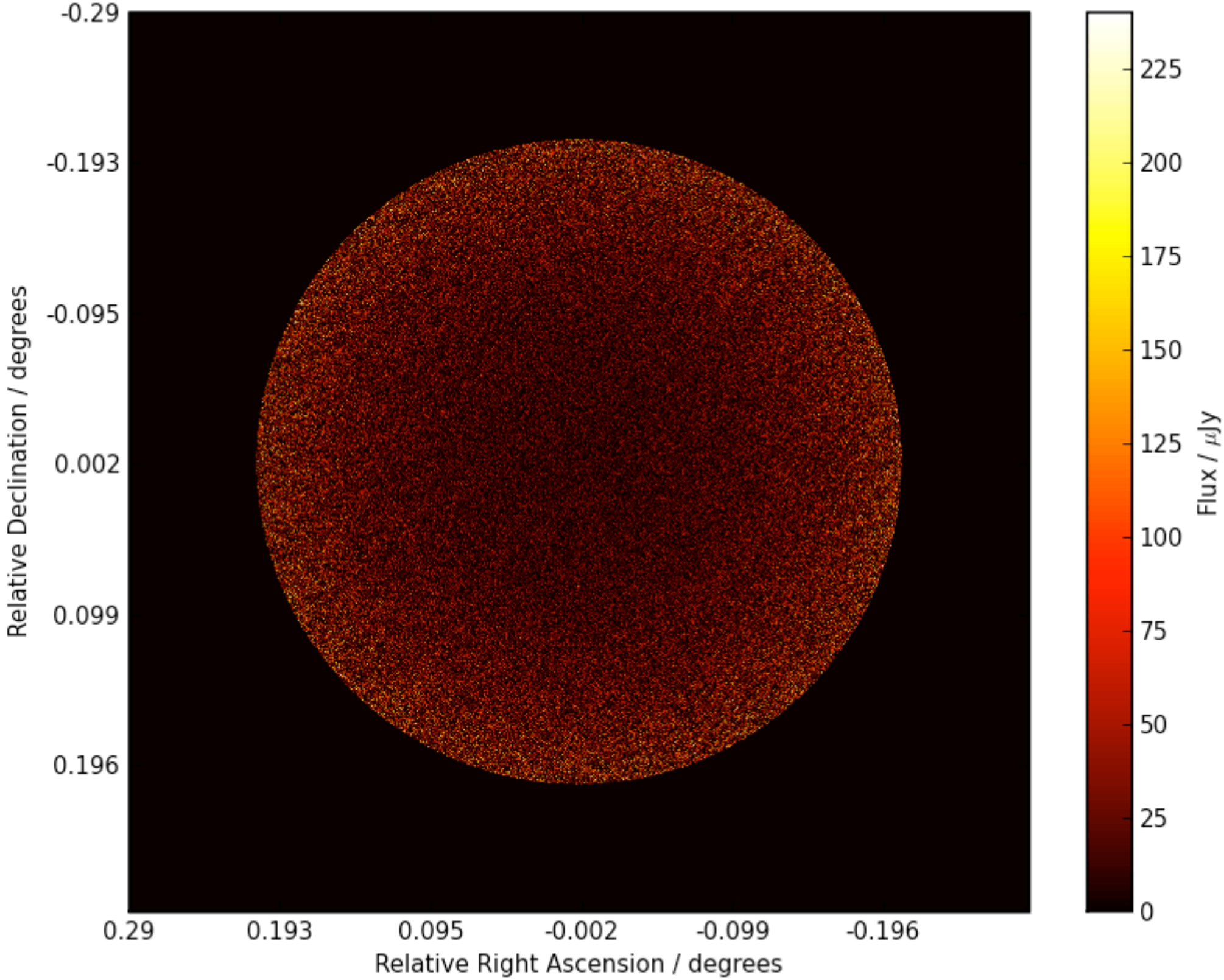
256 channel input model

SKA_1 Aperture Array single beam: $364.2 \leq \nu \leq 450.9$ MHz



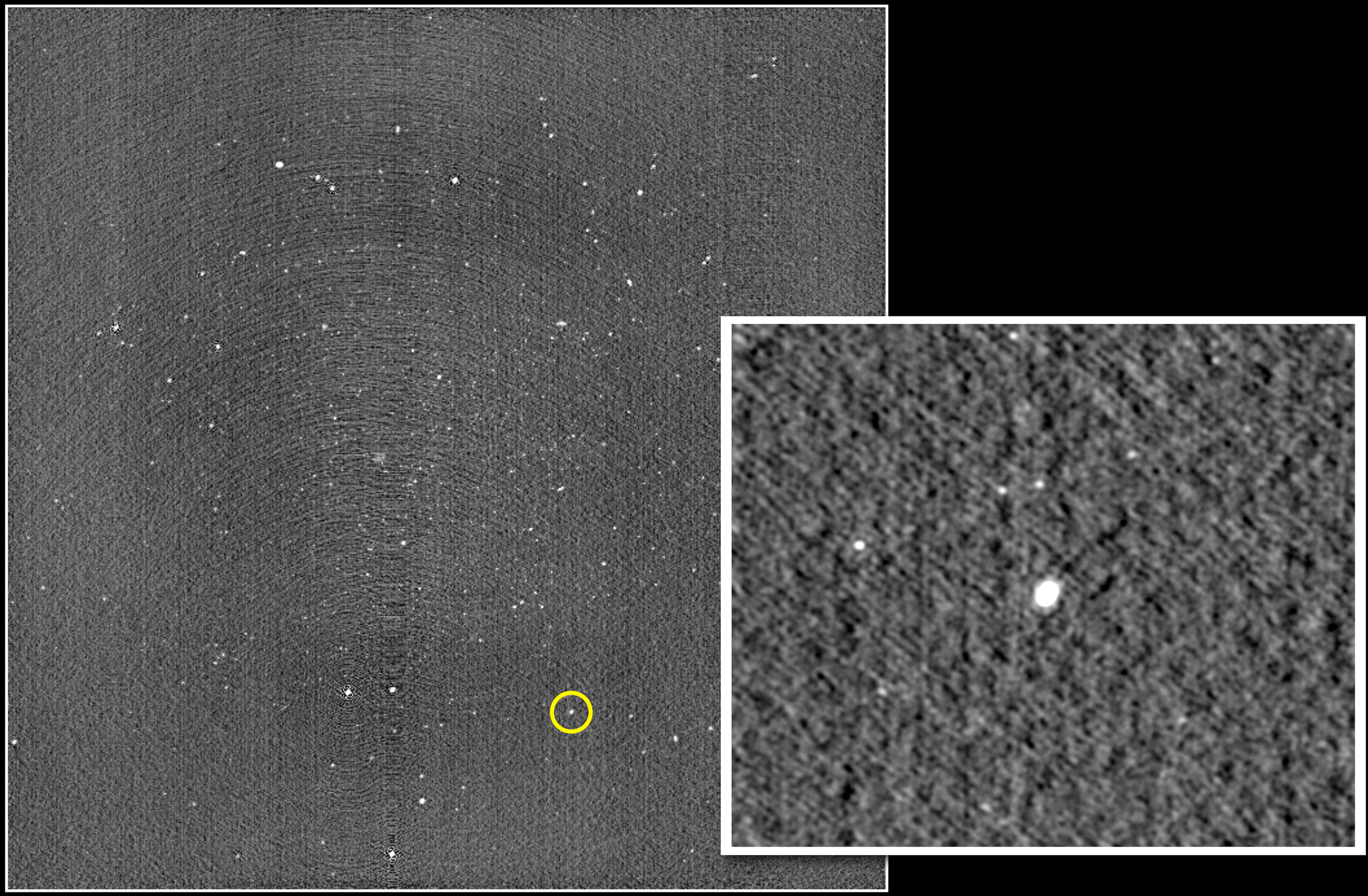
256 channel cube with an arbitrary low noise floor

SKA_1 Aperture Array single beam: $364.2 \leq \nu \leq 450.9$ MHz



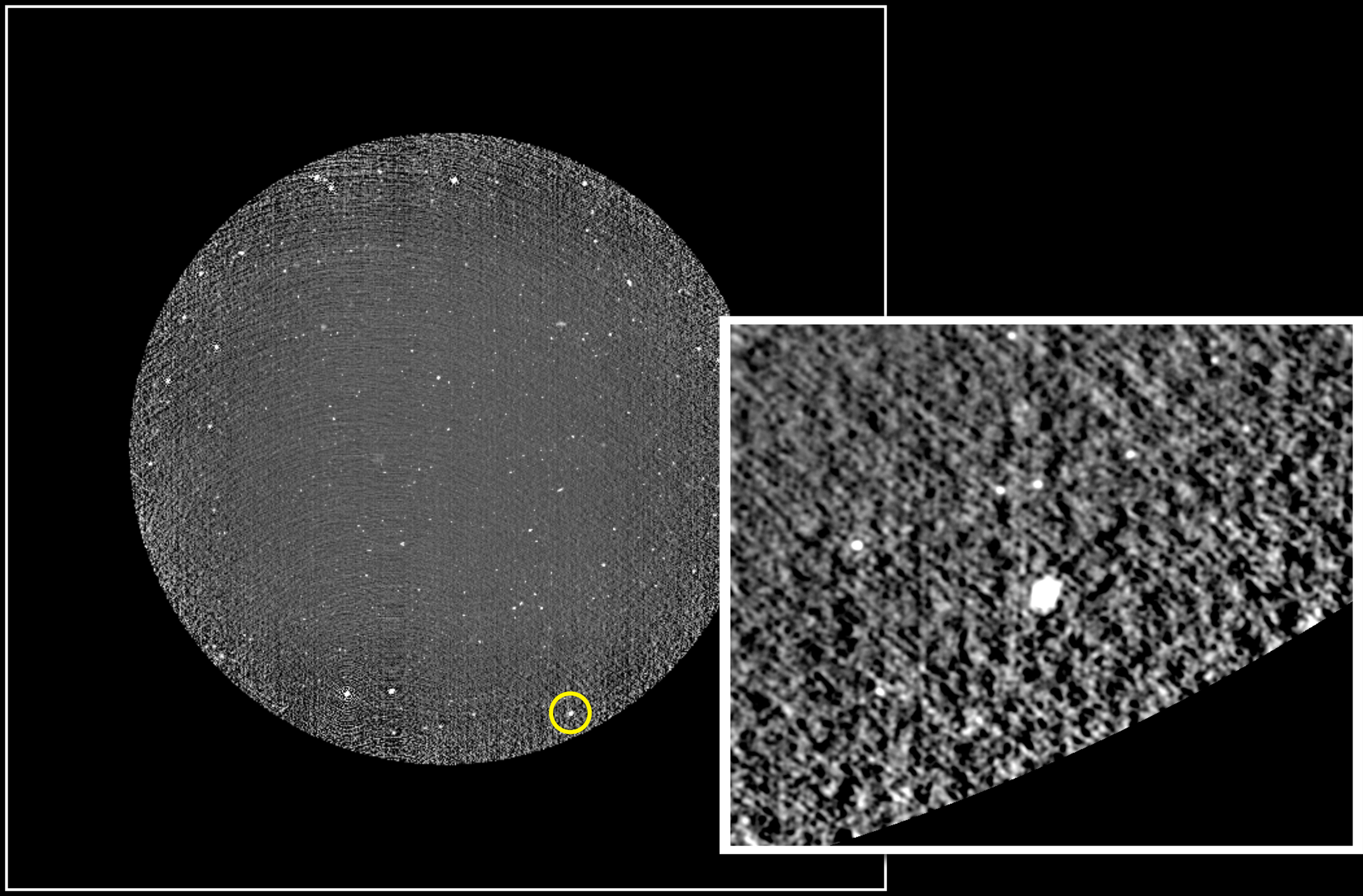
256 channel output cube

Spatial noise variation - primary beam correction



MeerKAT deep continuum simulation - sky model from S^3-SAX (Wilman et al., 2008)

Spatial noise variation - primary beam correction



MeerKAT deep continuum simulation - sky model from S^3-SAX (Wilman et al., 2008)

Spectral and temporal noise model

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

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

$T_{sky} = 5\times10^{8}\ \nu_{\mathrm{MHz}}^{-2.861} + 4$ (Medellin, SKA Memo 95)

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

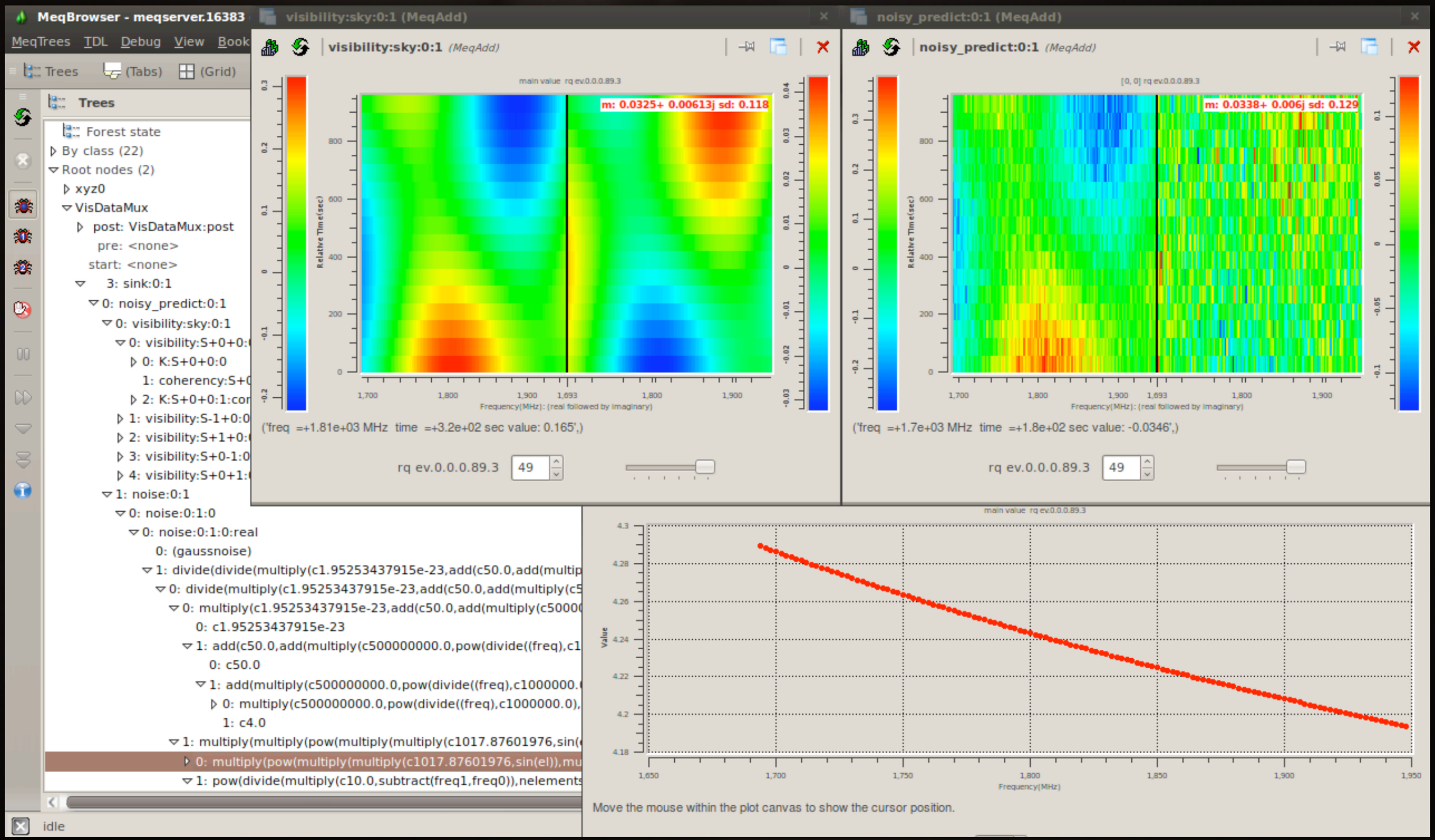
$A_p = A_{geom}\ \eta_A\ \sin(\lambda_p)$

(Generalised from Eq. 6.43, Thompson, Moran and Swenson, 2nd Ed.)

Testing the noise model in the MeqTrees browser

Uncorrupted visibilities (L: real, R: imaginary)

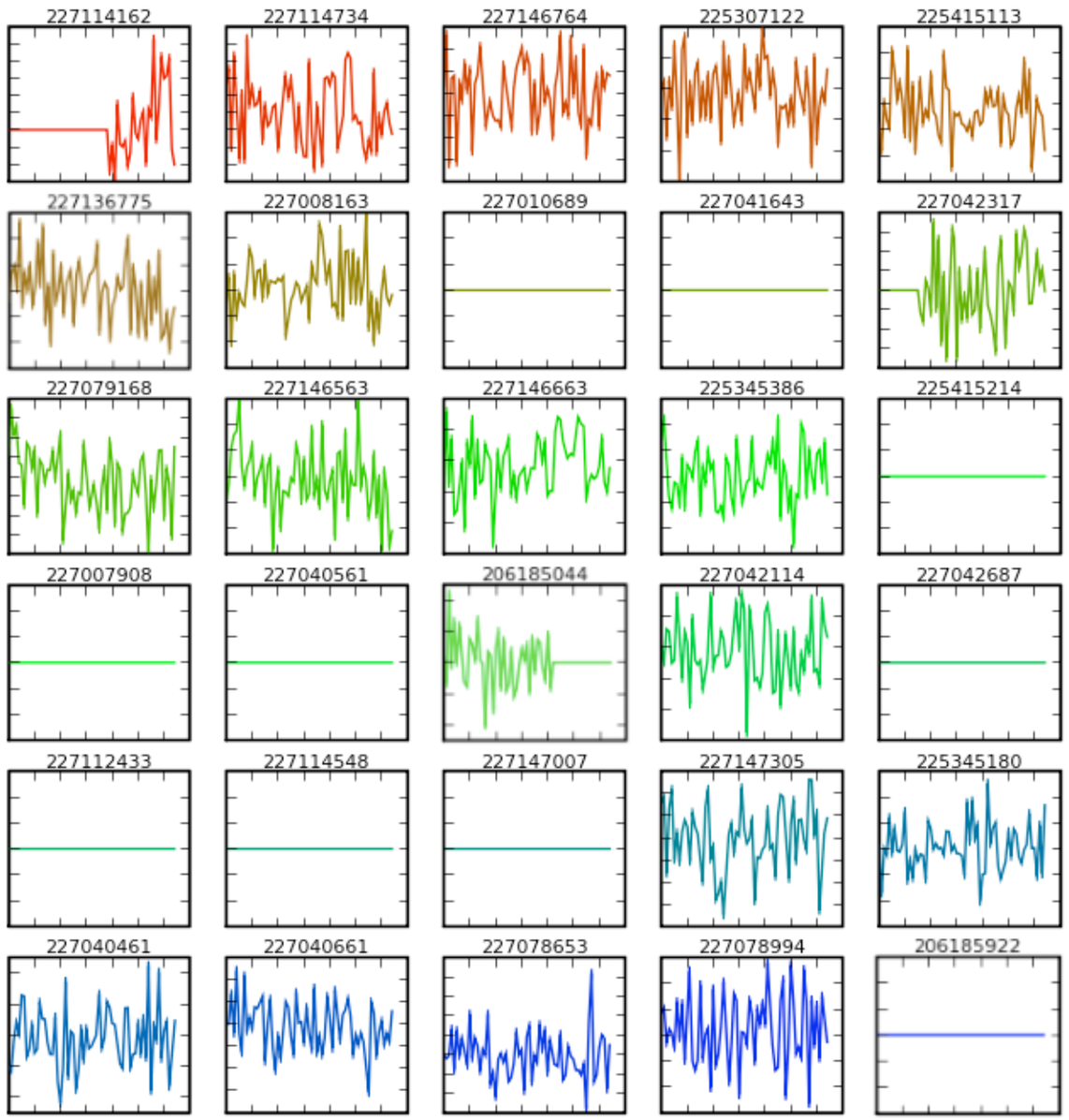
Corrupted visibilities



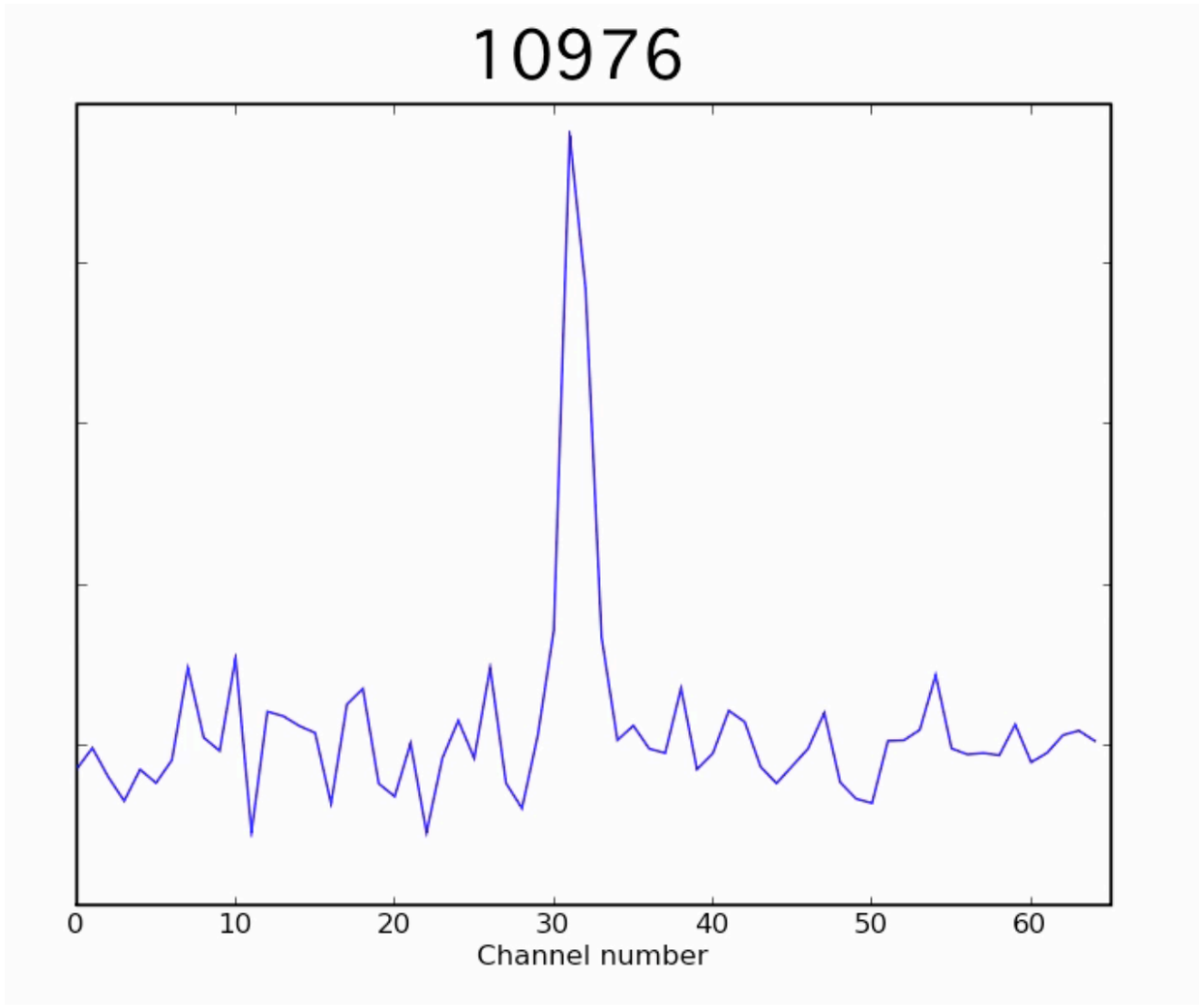
Sky temperature node

The spectral line stacking technique (signal from the noise!)

Sample of individual spectra



Average line profile



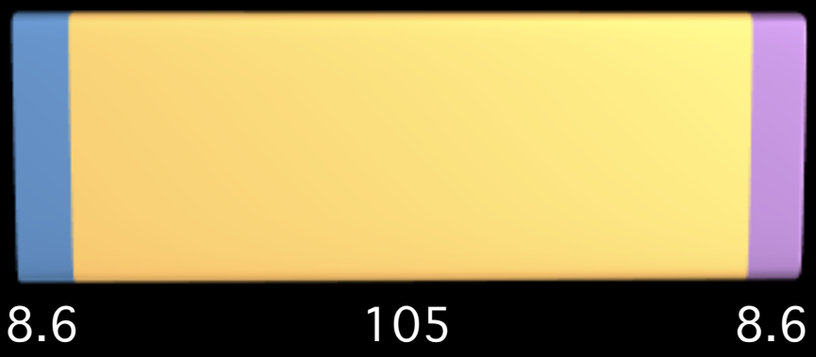
Investment per simulated 256-channel beam

Intel Core 2 Duo @ 3 GHz / 8 GB RAM

Approx. CPU time / hours

Data volume / GB

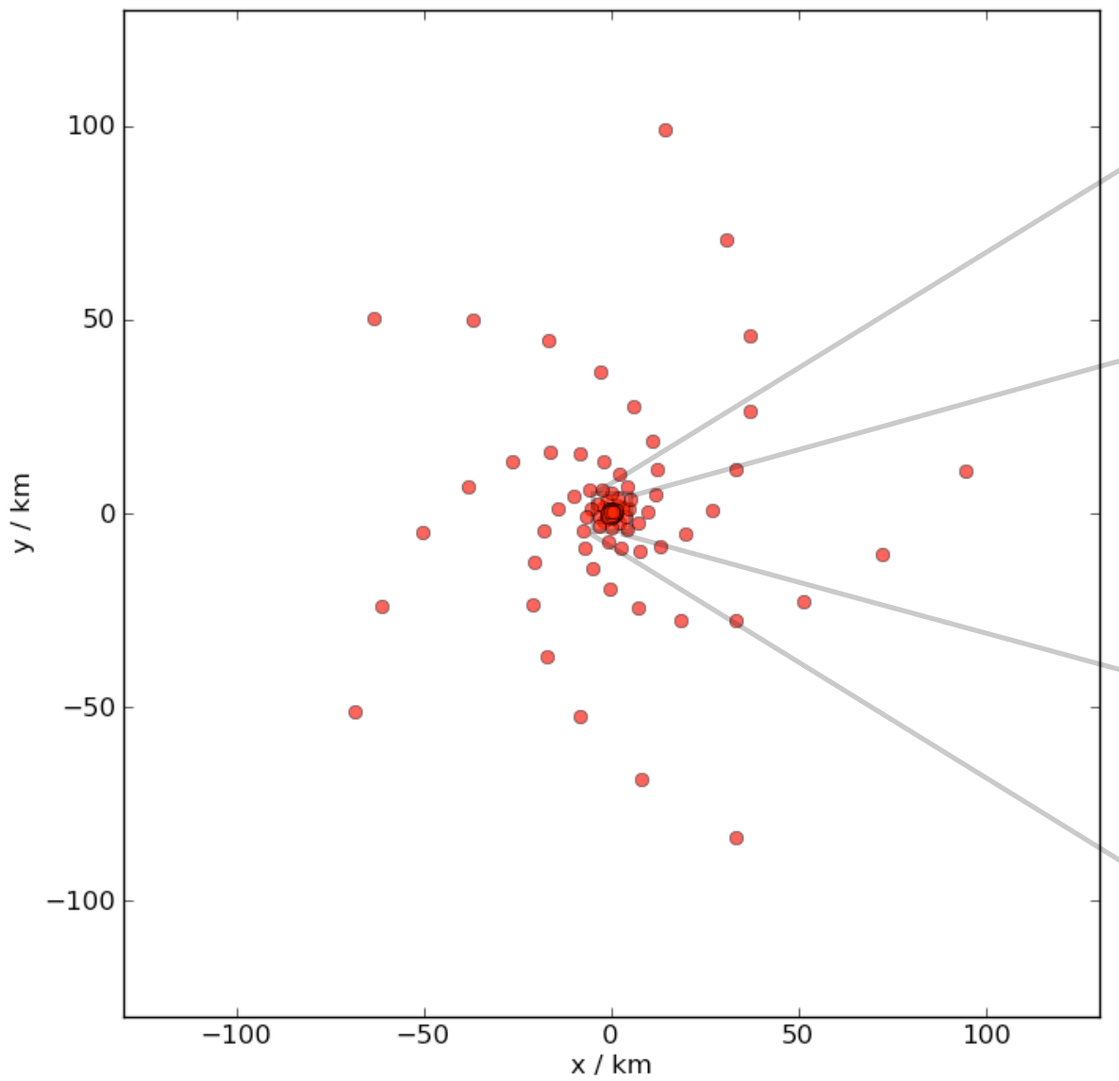
Reduces to about 122 GB (Including hard removal of flagged MS rows)

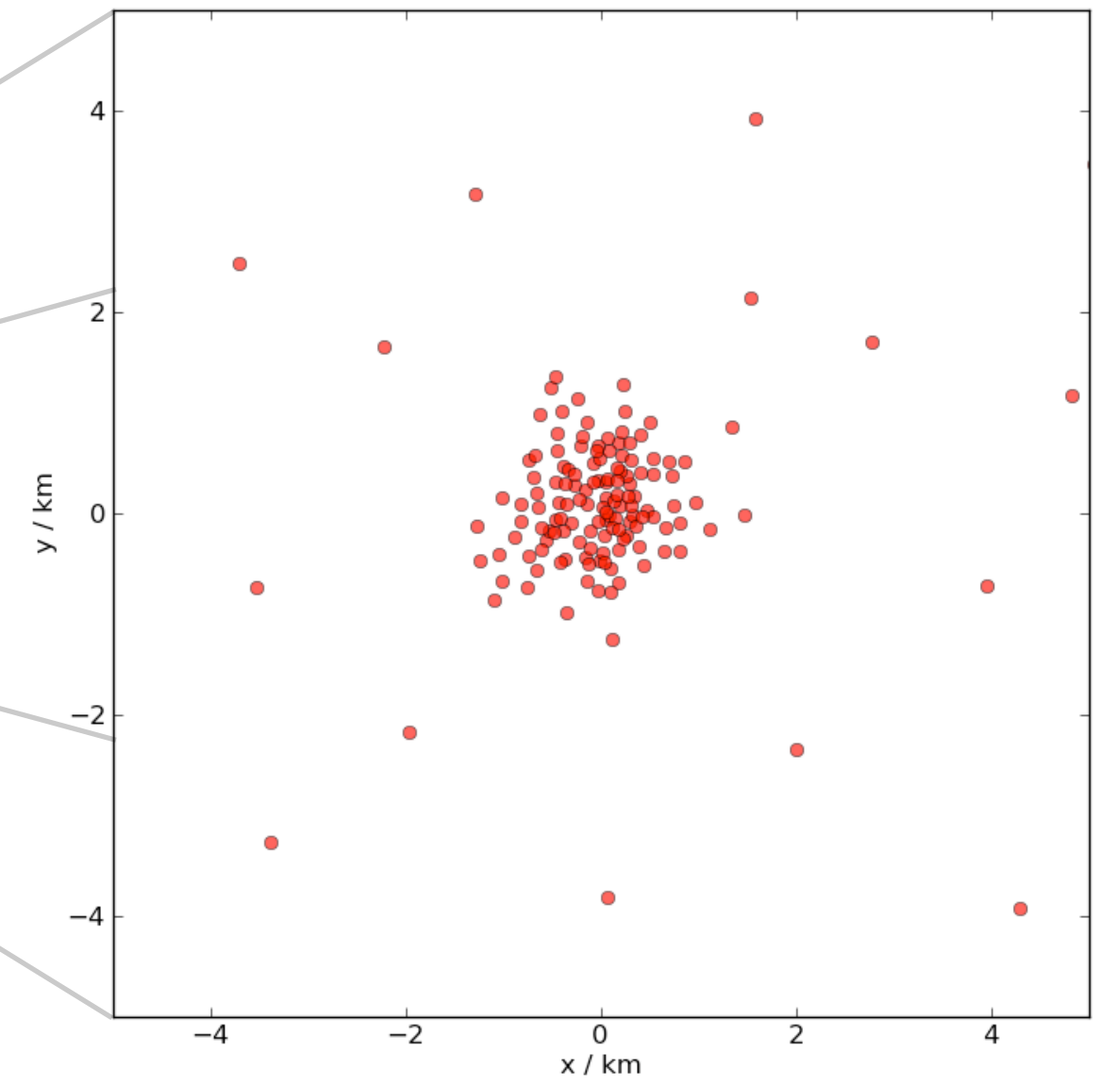


- Ideal sky input cube
- Attenuated sky cube
- Generate and fill Measurement Sets
- Image Measurement Sets
- PB-corrected output cube

SKA_1: 250 dishes

(with further thanks to Rosie Bolton)





All stations

Inner 10km

SKA_1 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:

?