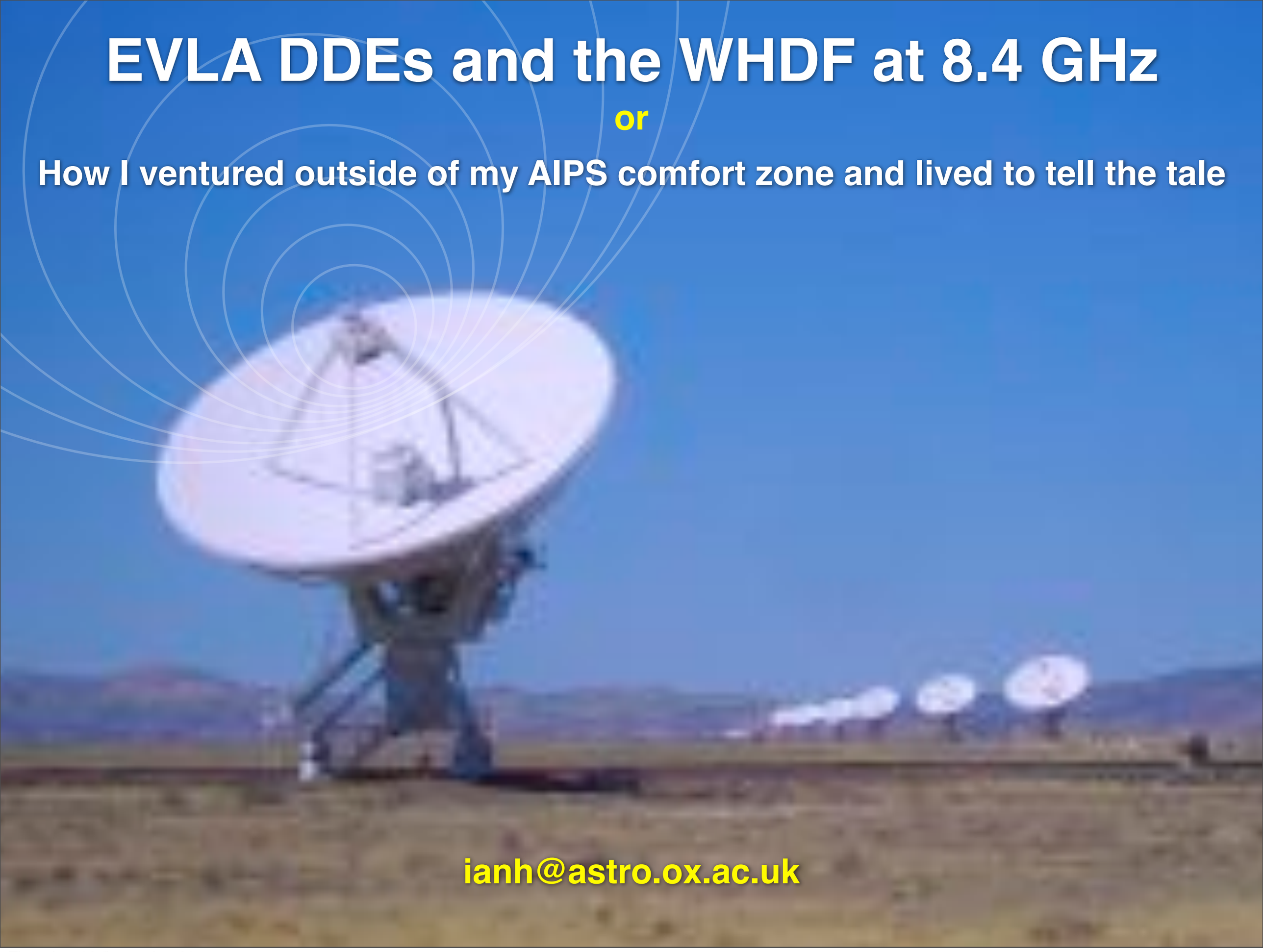
EVLA DDEs and the WHDF at 8.4 GHz

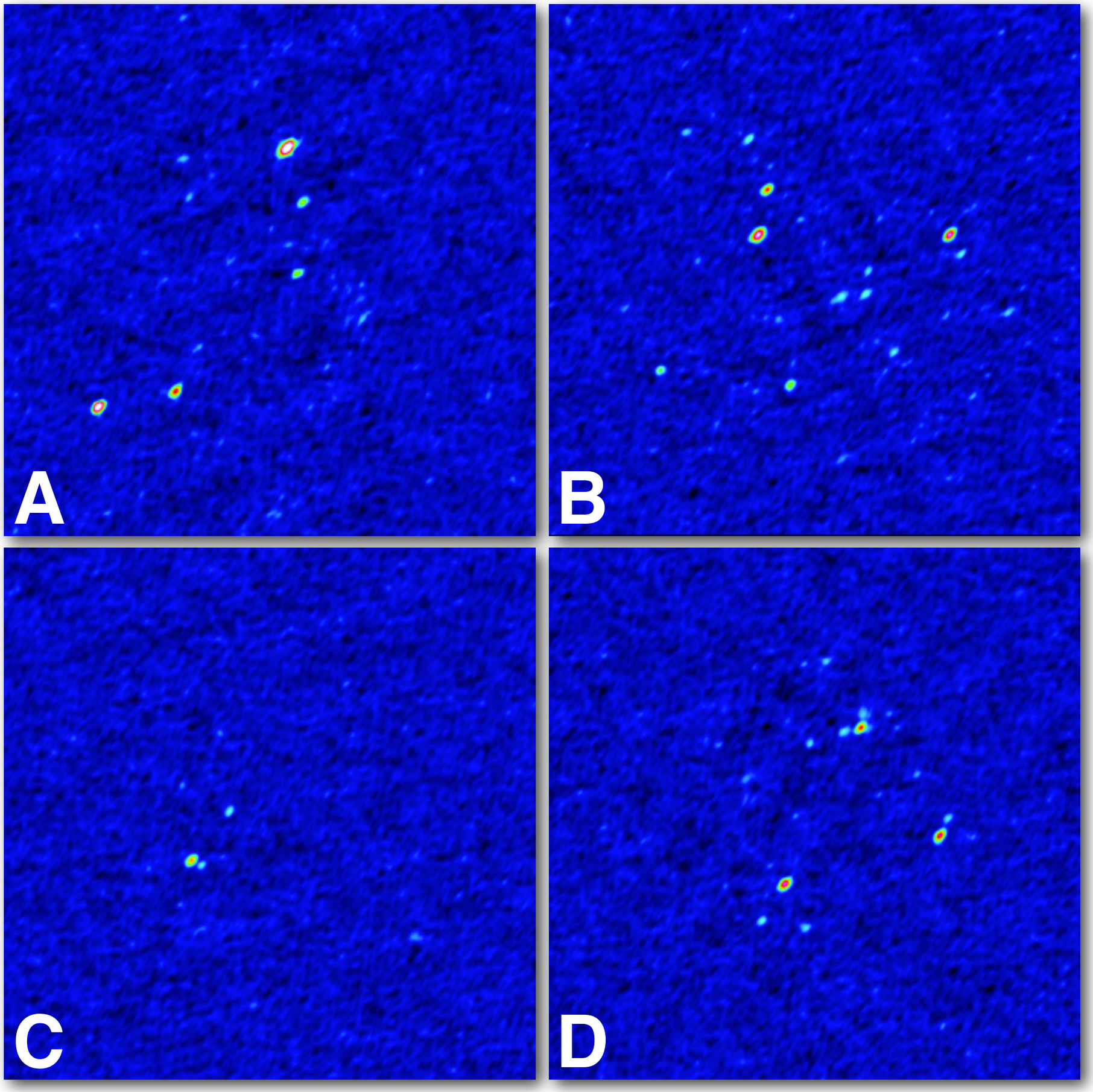
or

How I ventured outside of my AIPS comfort zone and lived to tell the tale



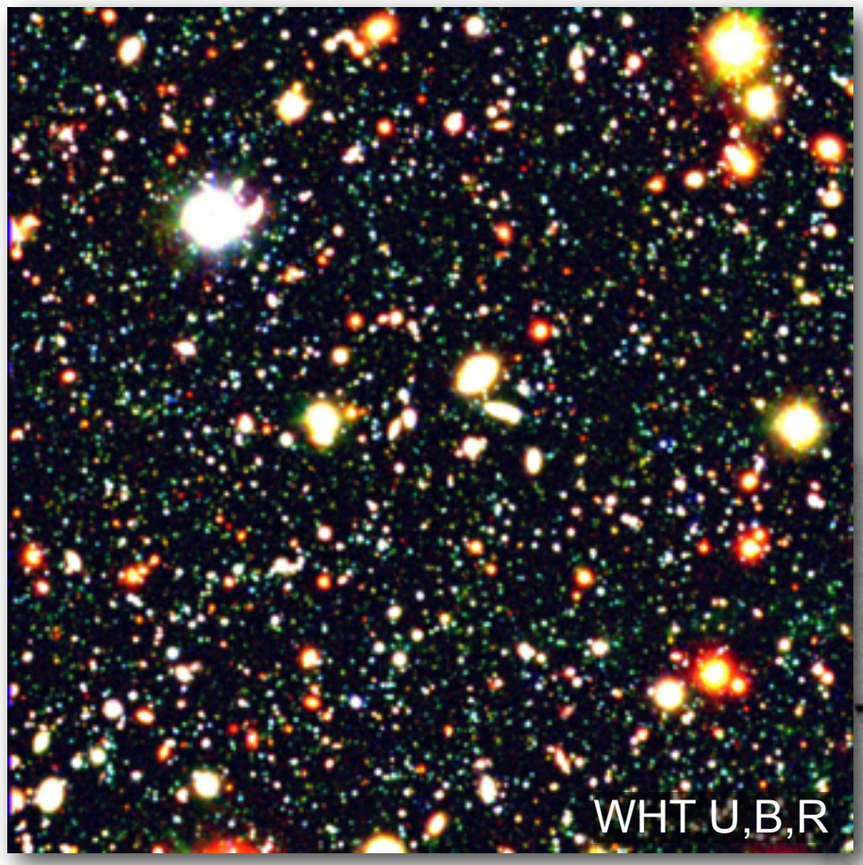
ianh@astro.ox.ac.uk

Yeah, I know what a fugazi is.

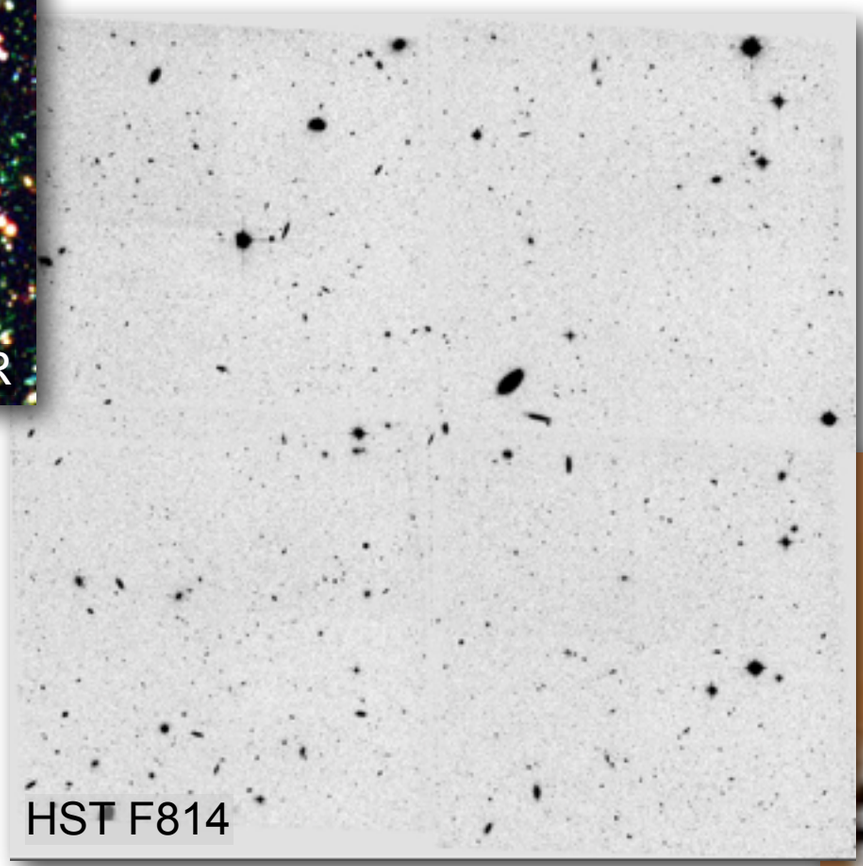


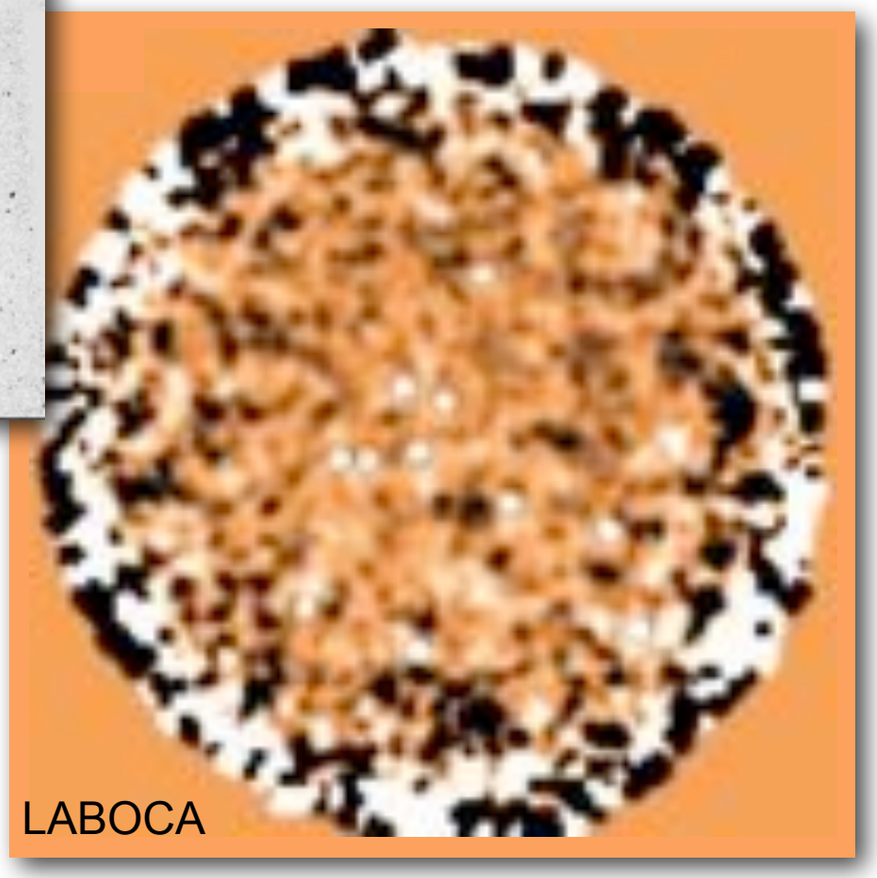
http://bit.ly/n17qCC

Context: sub-mm galaxies and QSOs in the William Herschel Deep Field



WHT	*U B R I Z* imaging (*B* < 27.9 mag)
UKIRT	*H K* imaging
HST ACS	High-resolution *I* band imaging





Chandra	X-ray 10^{-15} erg s^{-1} cm^{-2} (70 ks)
LABOCA	870 μm sub-mm survey (21 h)
EVLA	Deep 8.4 GHz radio (35 h)

EVLA observations of the WHDF

AS1008_sb1094913_1_000.55349.39414662037
AS1008_sb1094913_1.55326.477696724534
AS1008_sb1094913_1.55329.46954527778
AS1008_sb1094913_1.55344.4072031713
AS1008_sb1094913_1.55353.44451736111
AS1008_sb1094913_2.55355.37769755787
AS1008_sb1166741_1.55333.45861159722
AS1008_sb1166741_1.55343.43126916667
AS1008_sb1166809_1_000.55327.47497940972
AS1008_sb1166809_1_001.55328.451462557874
AS1008_sb1166809_1.55283.82364069445
AS1008_sb1166809_1.55311.49789672454
AS1008_sb1166809_1.55320.473294317126
AS1008_sb1166809_1.55324.69096299769
AS1008_sb1349024_1_000.55332.46100375
AS1008_sb1349024_1_000.55337.5100403588
AS1008_sb1349024_1_000.55350.41217465278
AS1008_sb1349024_1_001.55335.45317630787
AS1008_sb1349024_1.55331.464087141205
AS1008_sb1349024_1.55336.5127268287
AS1008_sb1349024_1.55351.47178395833
AS1008_sb1349024_6_000.55358.53580408565
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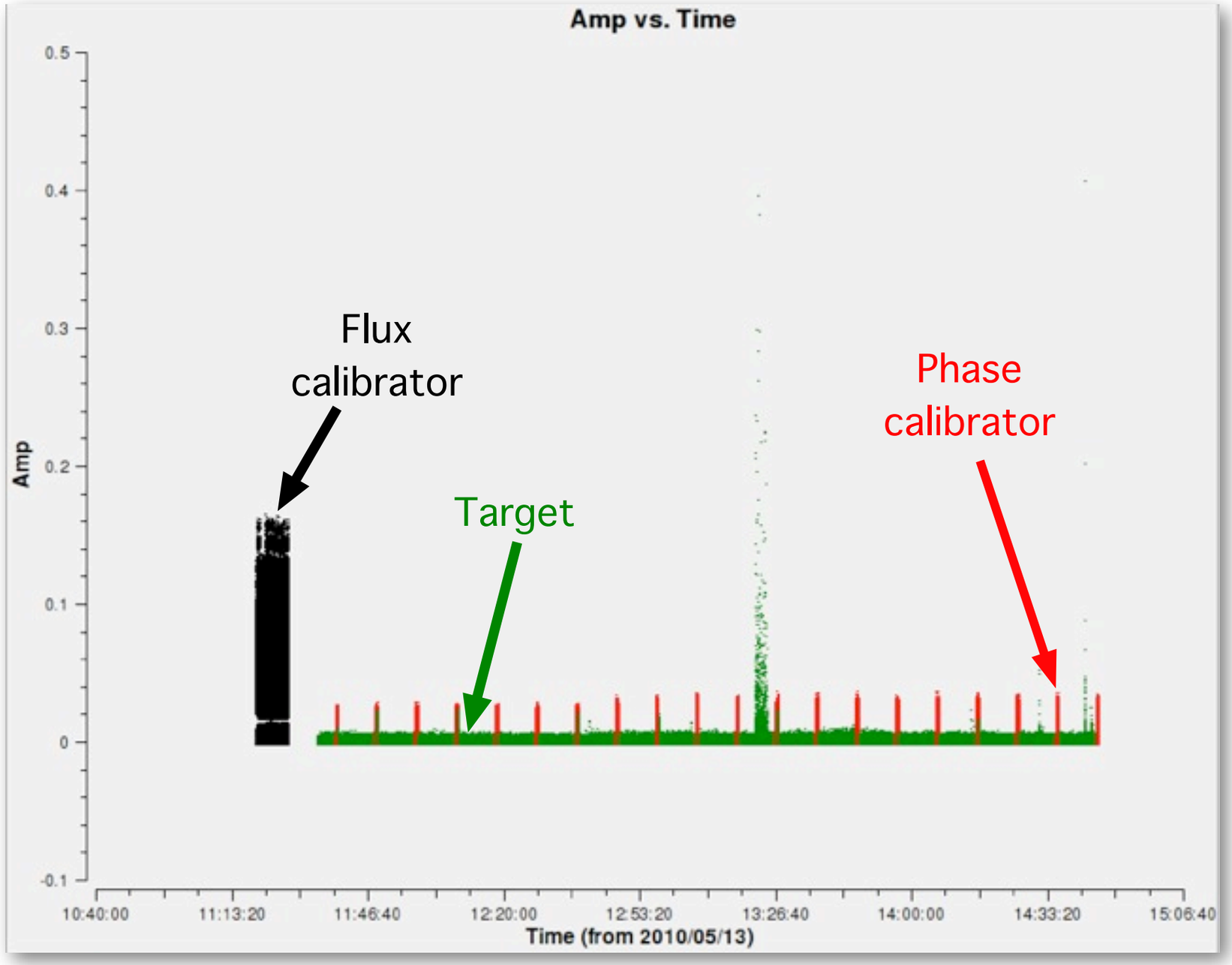
AS1008_sb1349024_8.55362.35865112269
AS1008_sb1349024a_6_000.55357.448393287035

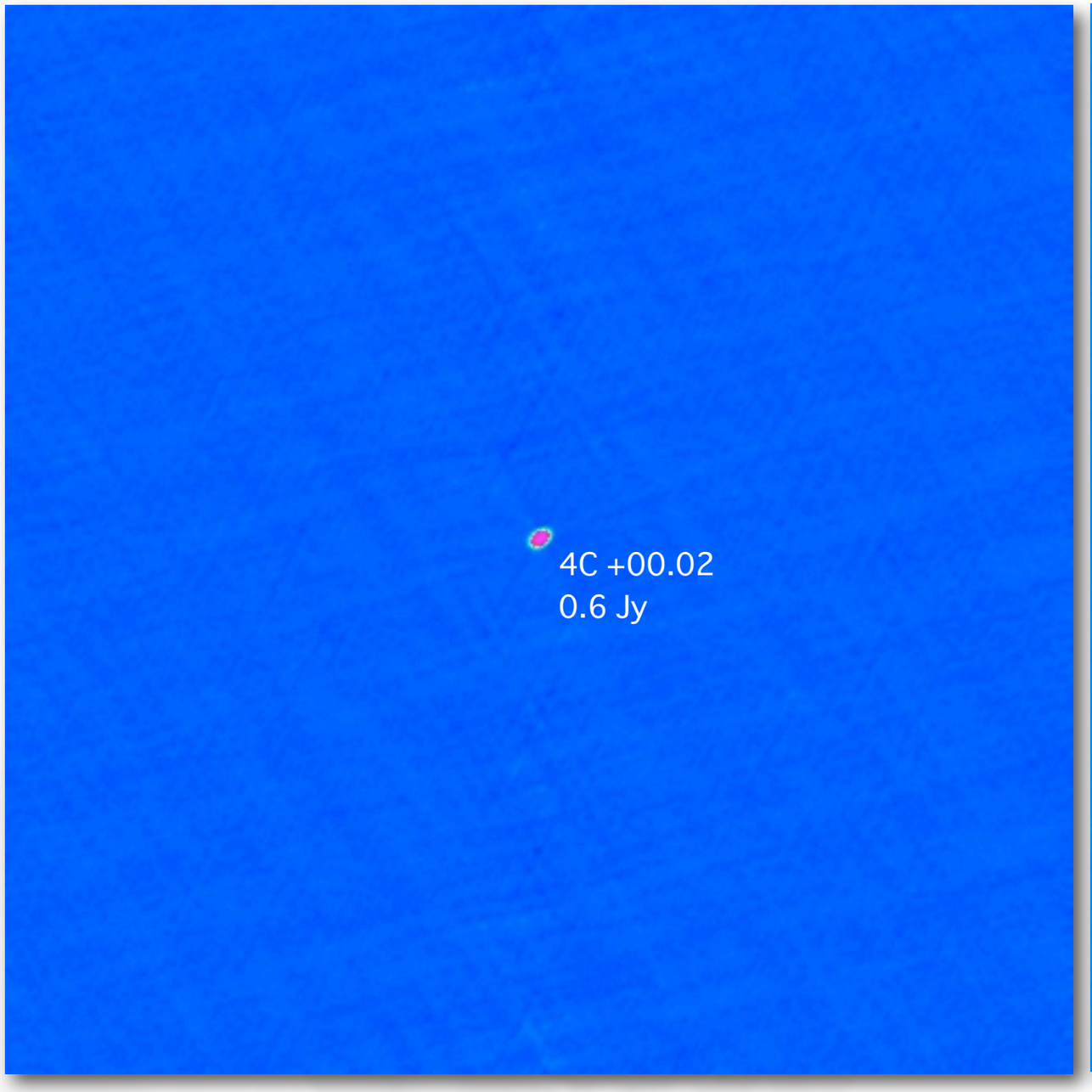


Post-flagging, post-averaging gain calibration performed with CASA

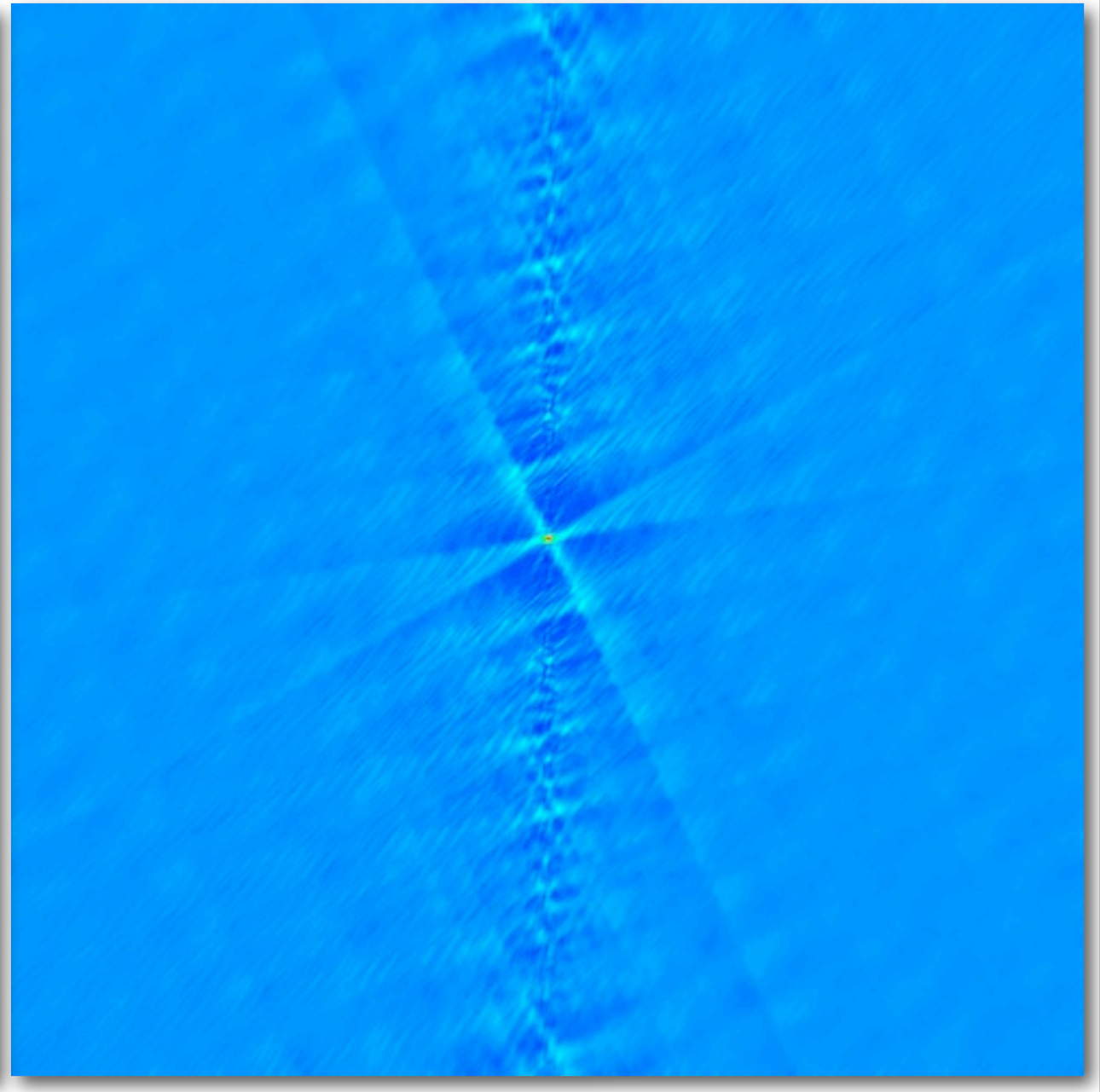
flux scale → bandpass → complex gain

Two features of this target field that an estate agent would describe as ‘quirky’

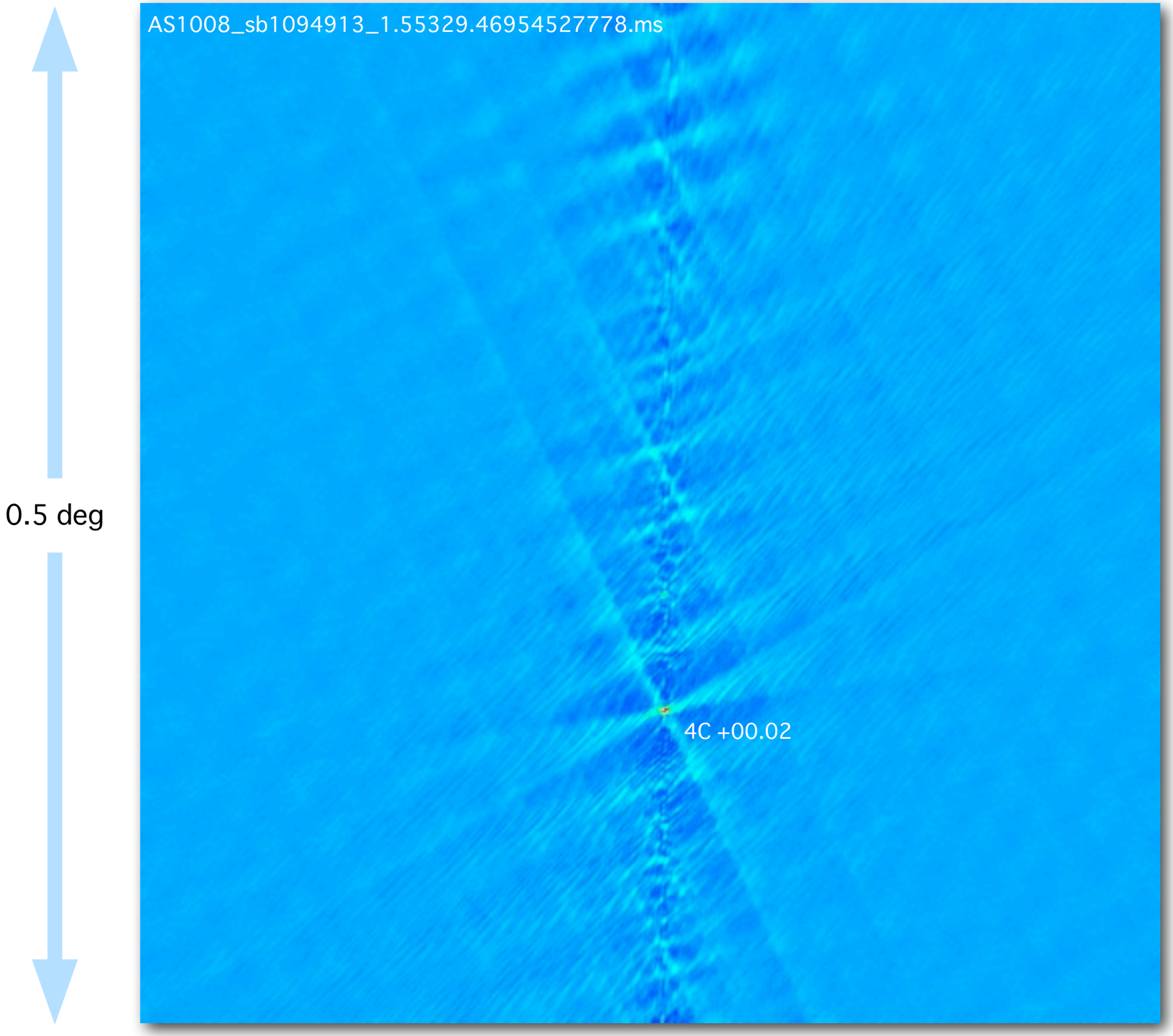
The phase calibrator



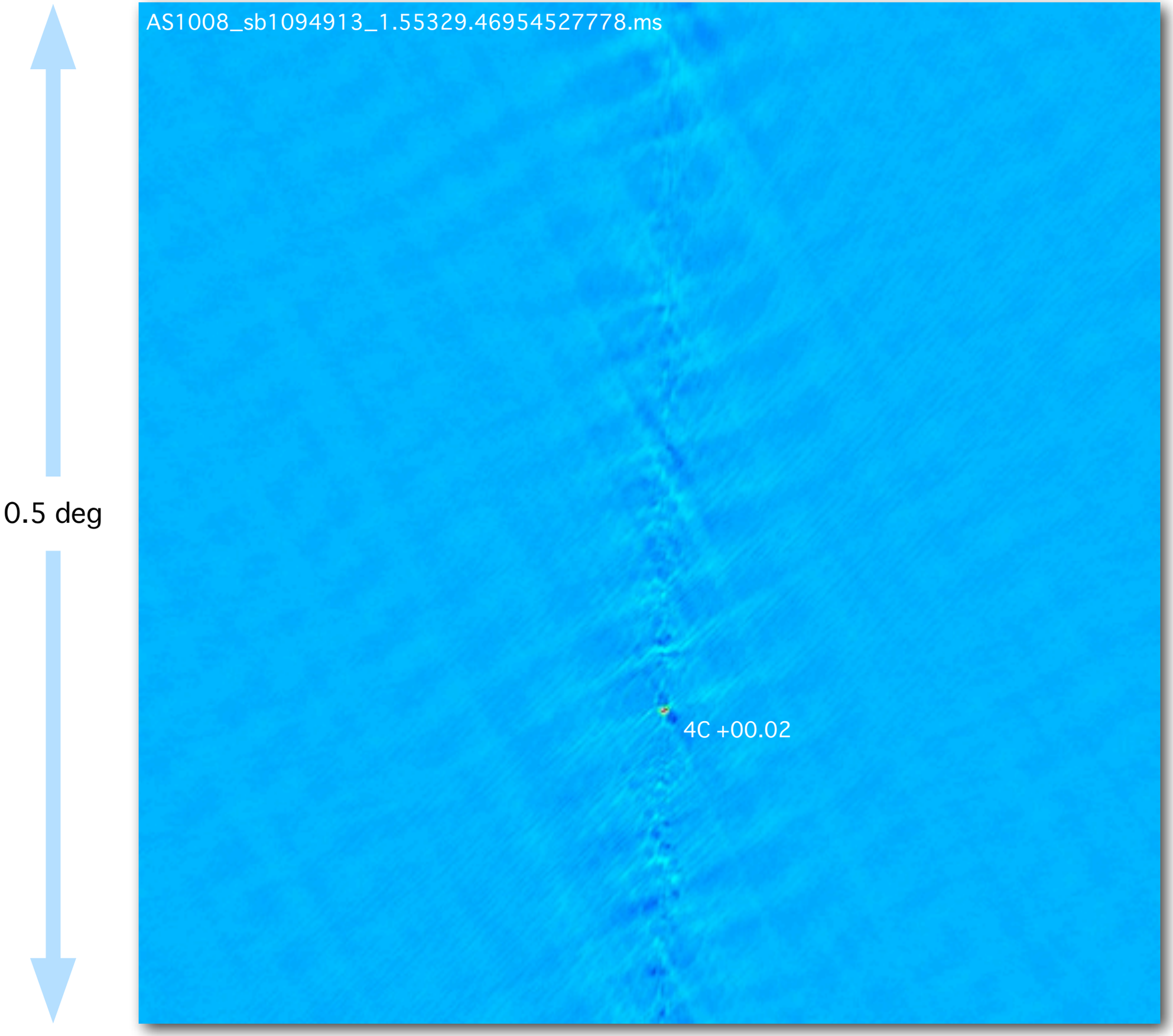
The point-spread function



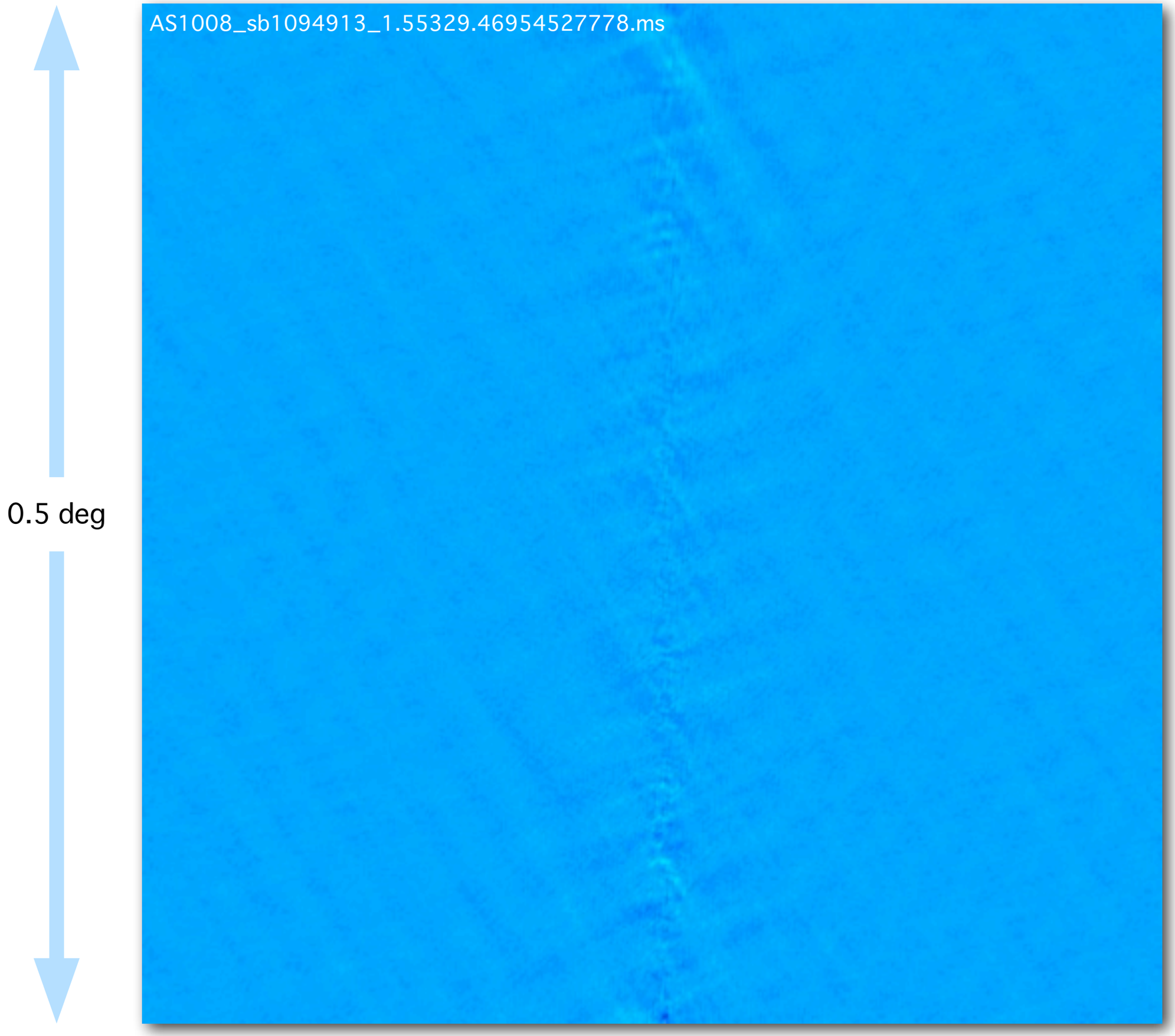
Wide-field dirty image of target



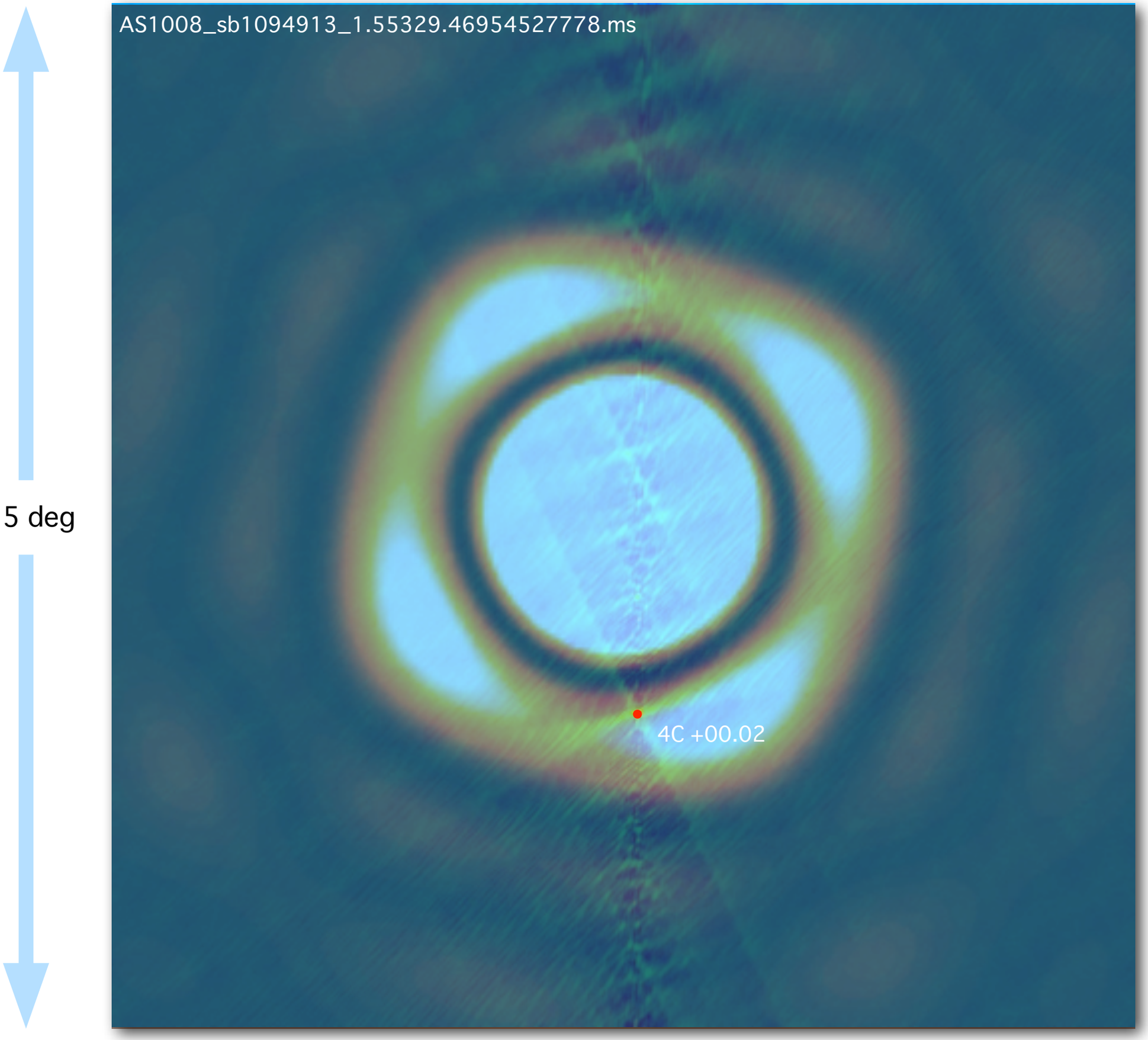
Deconvolved image



Subtract MODEL_DATA column and image residuals

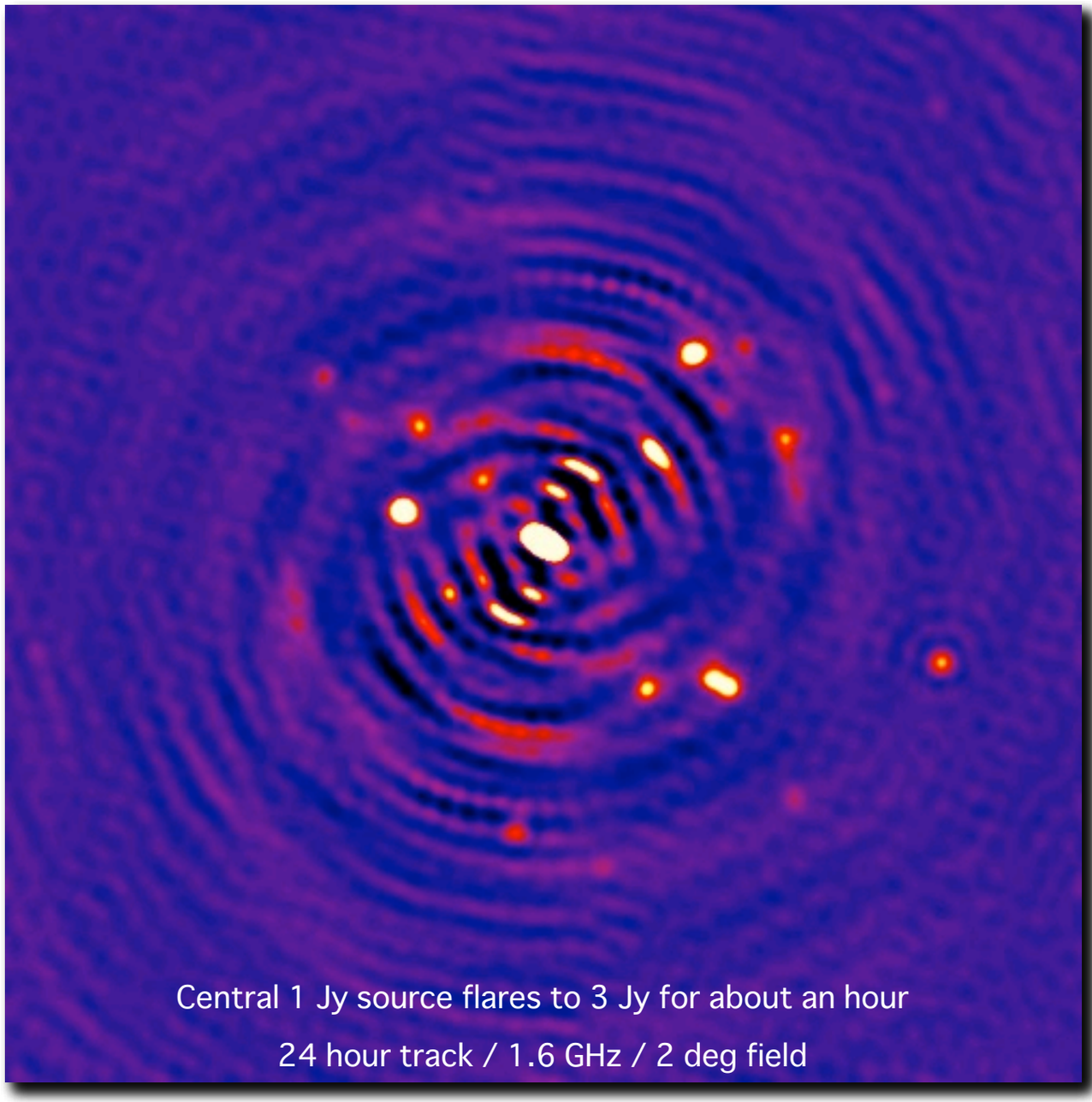


The EVLA primary beam: NOT a luxury problem!



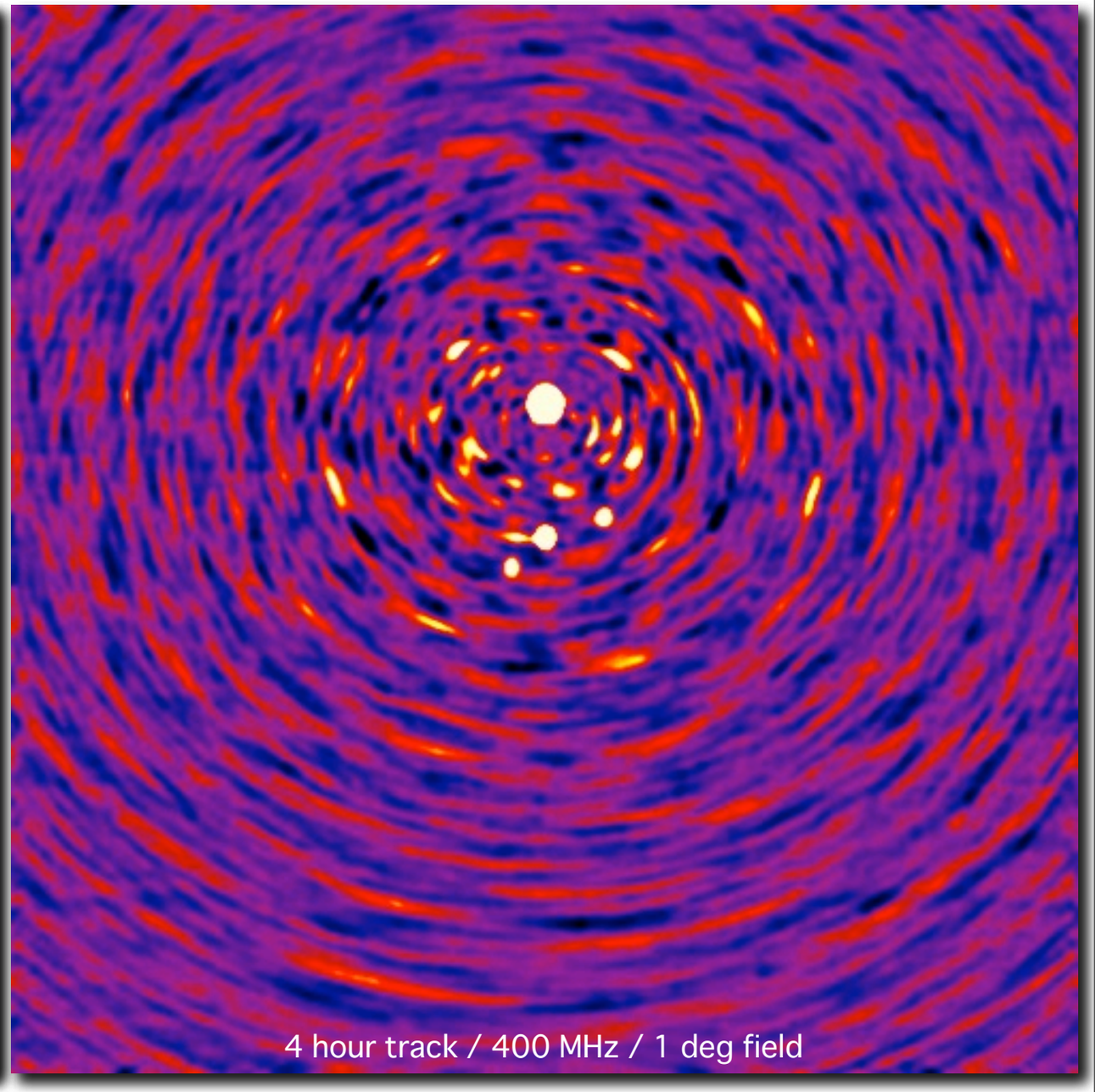
Intrinsic or apparent transients? Either way your continuum map is a mess

MeqTrees KAT-7 simulation



Deconvolved image, Briggs weighting

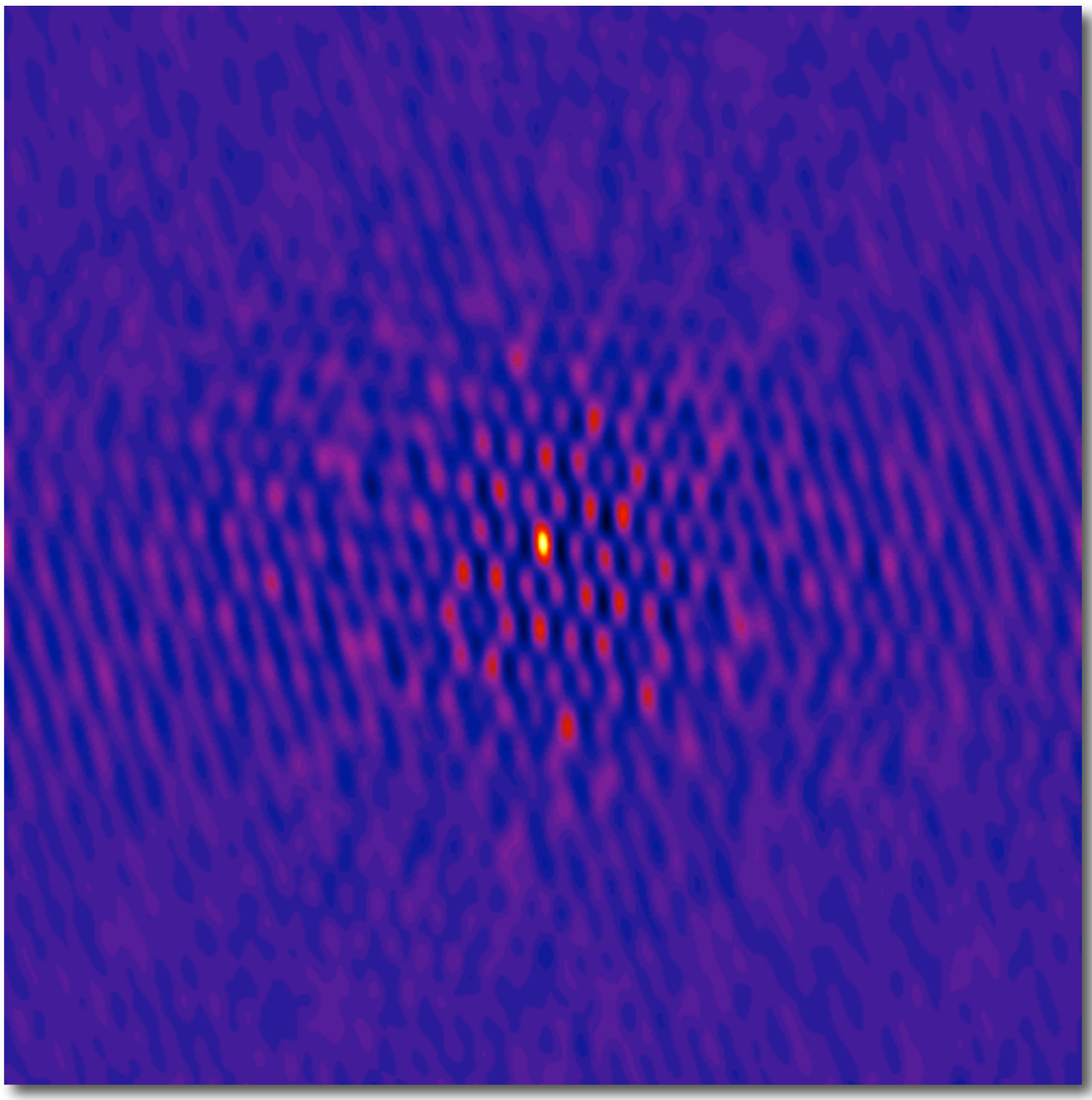
OSKAR simulation (Dulwich, Mort, Salvini)



Deconvolved image, natural weighting

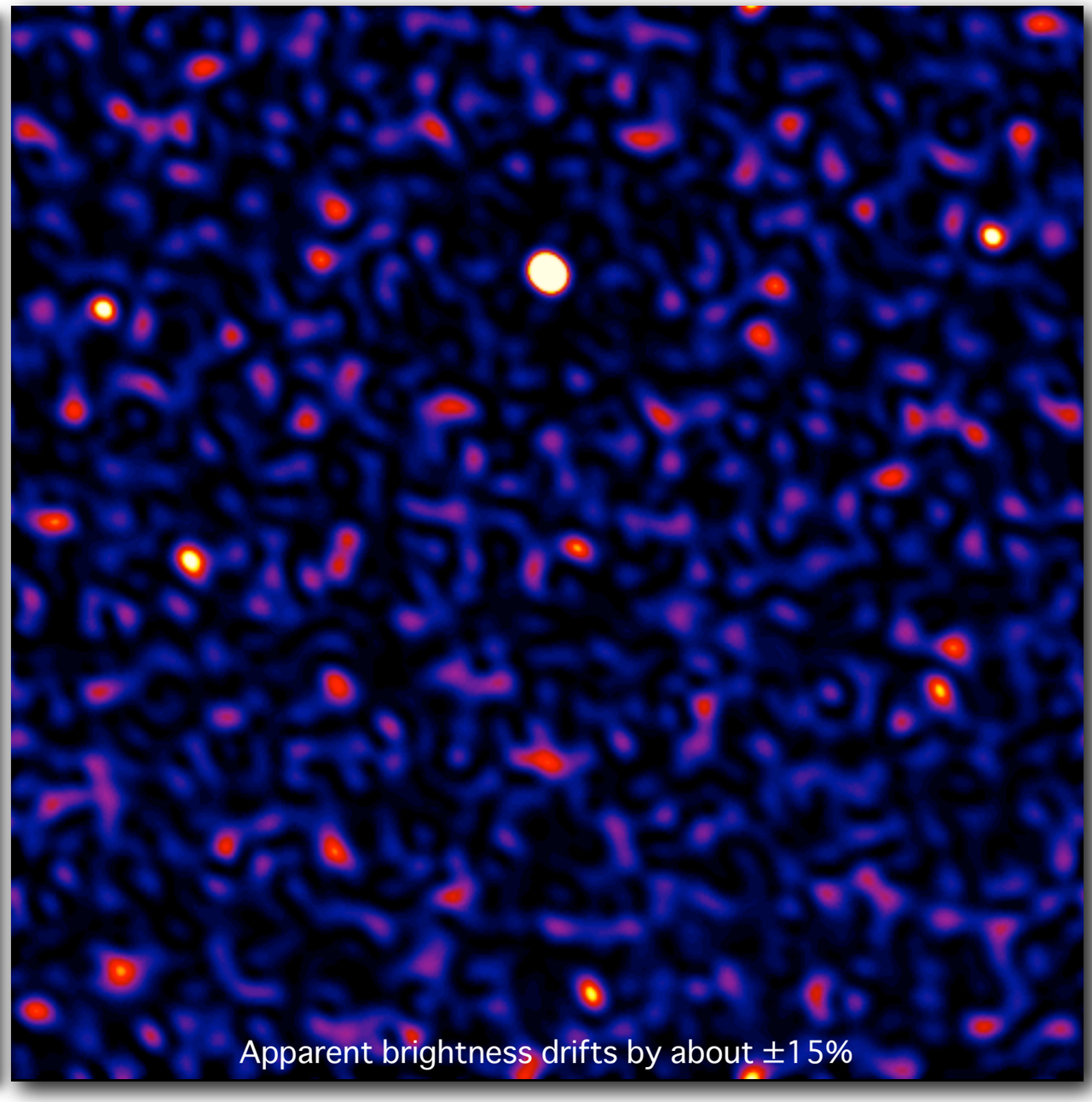
Intrinsic or apparent transients? Either way your continuum map is a mess

MeqTrees KAT-7 simulation



48 × 30-minute snapshot dirty images

OSKAR simulation (Dulwich, Mort, Salvini)



48 × 5-minute snapshot dirty images

Direction-dependent calibration to the rescue

Peeling

AIPS HELP file (version 31DEC) | peel

www.aips.nrao.edu/cgi-bin/ZXHLP2.PL?PEELR

AIPS HELP file for PEELR in 31DEC11

As of Mon Jul 25 5:08:21 2011

PEELR: RUN PEELR for proc to calibrate interfering sources

INPUTS

INNAME			Input UV file name (name)
INCLASS			Input UV file name (class)
INSEQ	0.0	9999.0	Input UV file name (seq. #)
INDISK	0.0	9.0	Input UV file disk unit #
IN2NAME			Input image name (name)
IN2CLASS			Input image name (class)
IN2SEQ	0.0	9999.0	Input image name (seq. #)
IN2DISK	0.0	9.0	Input image disk unit #
OUTNAME			Output UV file name (name)
OUTCLASS			Output UV file name (class)
OUTSEQ	-1.0	9999.0	Output UV file name (seq. #)
OUTDISK	0.0	9.0	Output UV file disk unit #.
NFIELD	1.0	4096.0	Number facets in IN2NAME
NGAUSS	1.0	10.0	Number resolutions in IN2NAME
PPARM	0.0		List of <= 100 facets to peel
BCHAN	0.0	16384.0	Lowest channel number 0=>all
ECHAN	0.0	16384.0	Highest channel number
SOLINT			CALIB solution interval (min)
SOLTYPE			Soln type,' ','L1','GCON', 'R', 'L1R', 'GCOR'
SOLMODE			'P' phase only, else 'A&P'
WEIGHTIT	0.0	3.0	Modify data weights function
APARM			General CALIB parameters 1=min. no. antennas 2 > 0 => data divided 3 > 0 => avg. RR,LL

AIPS HELP file (version 31DE | peel

casa.nrao.edu/docs/taskref/peel-task.html

National Radio Astronomy Observatory

Search NRAO

Monday, July 25, 2011

NRAO Home > CASA > TaskRef

Search

[next] [prev] [prev-tail] [tail] [up]

0.1.57 peel

Requires:

Synopsis Do direction dependent selfcal(s) and optionally remove annoying sources. **Description**

Arguments

Inputs	
vis	Name of the input visibility set. allowed: string Default:
dirs	List of directions to peel. allowed: any Default: variant ""
remove	Subtract the selfcalibrated source(s) from the data. allowed: bool Default: True
calmode	Type of selfcal to do. (p: Phase only, a: Ampl only. ap: both allowed: string Default: p

Example

Peeling

$$\mathsf{D}_{pq}^{(1)} = \mathsf{D}_{pq} - \tilde{\boldsymbol{G}}_p \mathsf{X}_{s_0 pq} \tilde{\boldsymbol{G}}_q^H$$

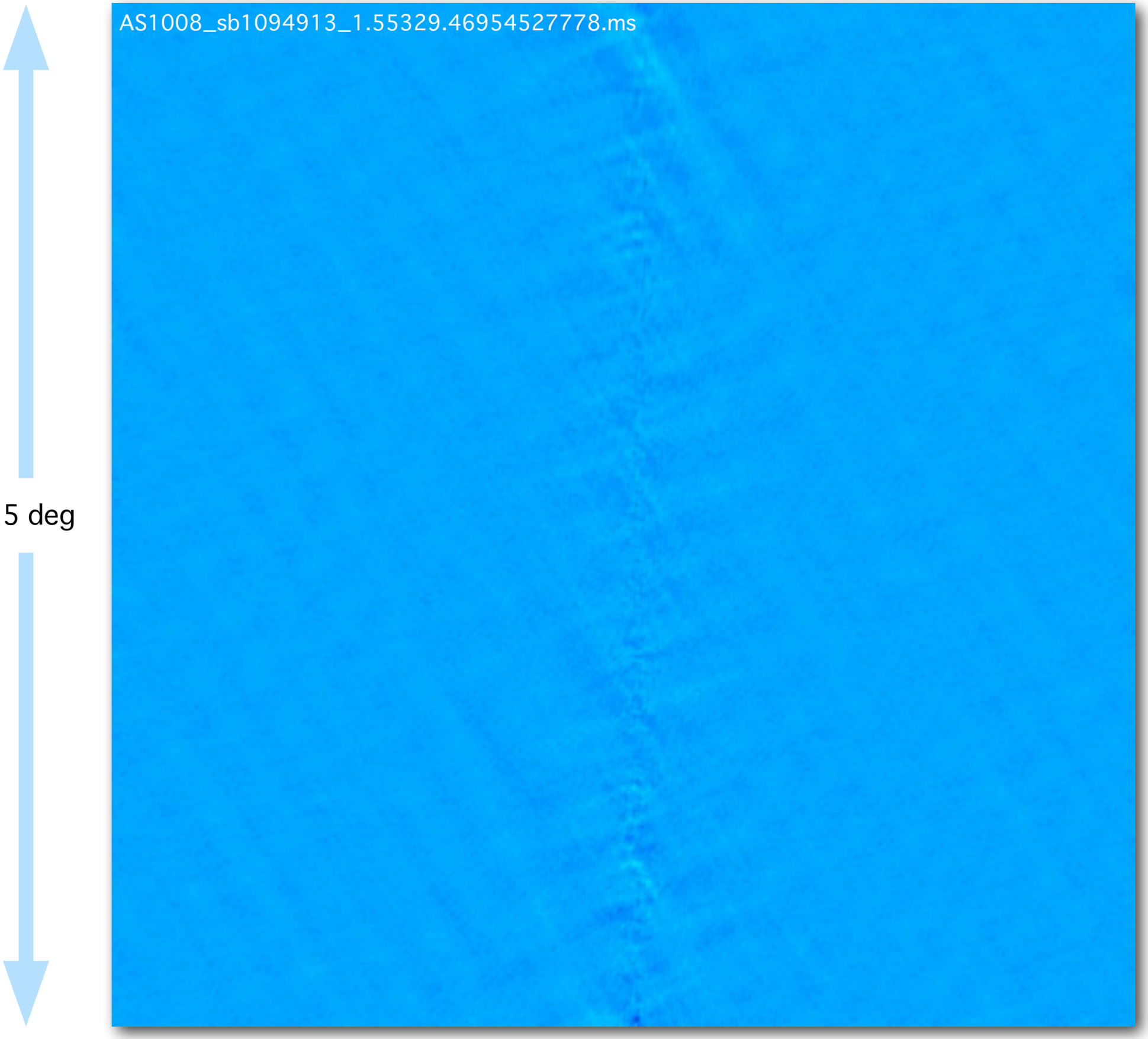
Smirnov, A&A, 572, 107, 2011 following Noordam, SPIE, 5489, 817, 2004

Solve for differential gains

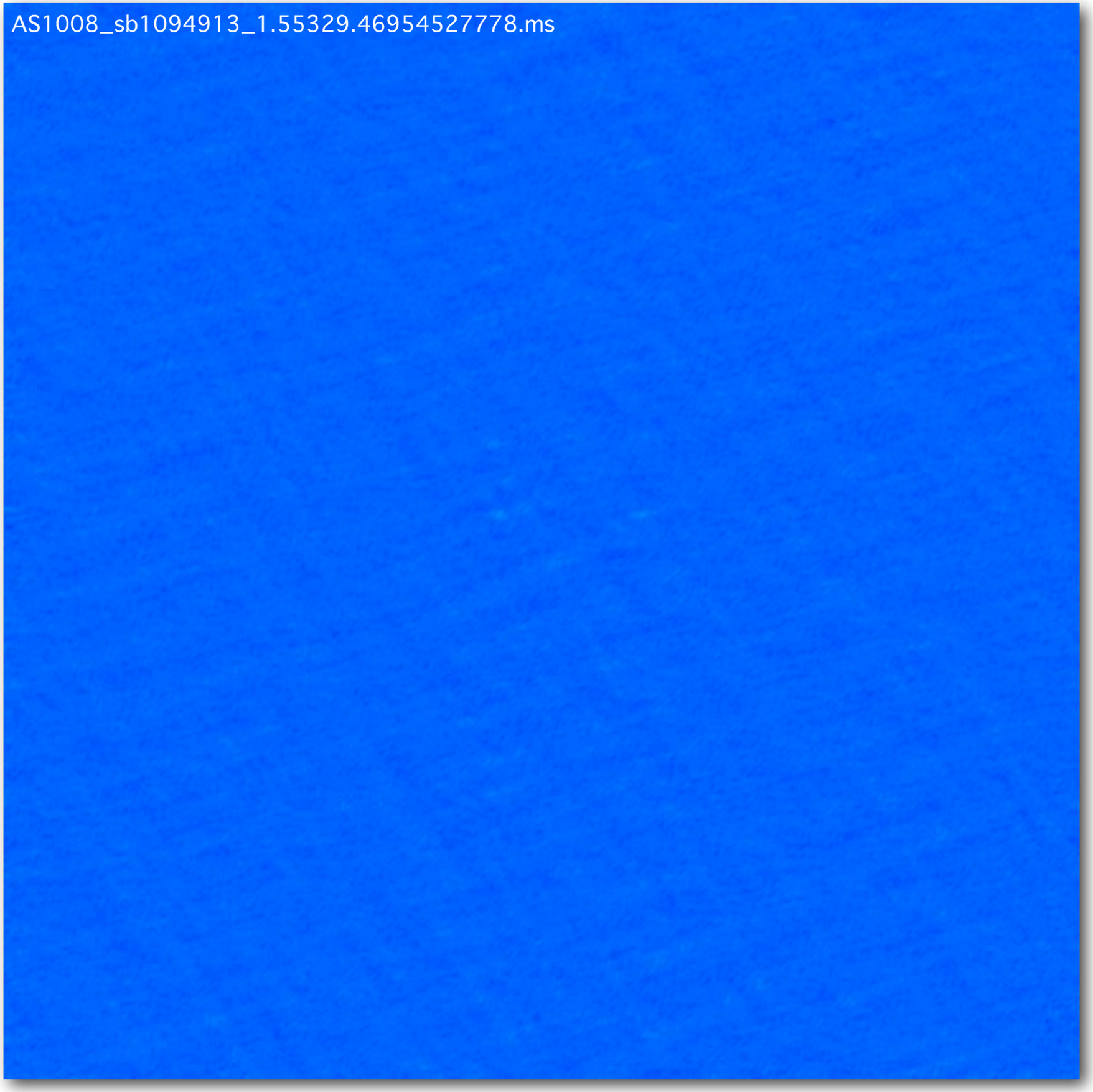
$$\mathbf{V}_{pq} = \boldsymbol{G}_p \left(\sum_s \Delta \boldsymbol{E}_{sp} \mathbf{X}_{spq} \Delta \boldsymbol{E}^H_{sq} \right) \boldsymbol{G}^H_q$$

Smirnov, A&A, 572, 107, 2011

Best ‘traditional-cal’ residual image, 21 μJy RMS

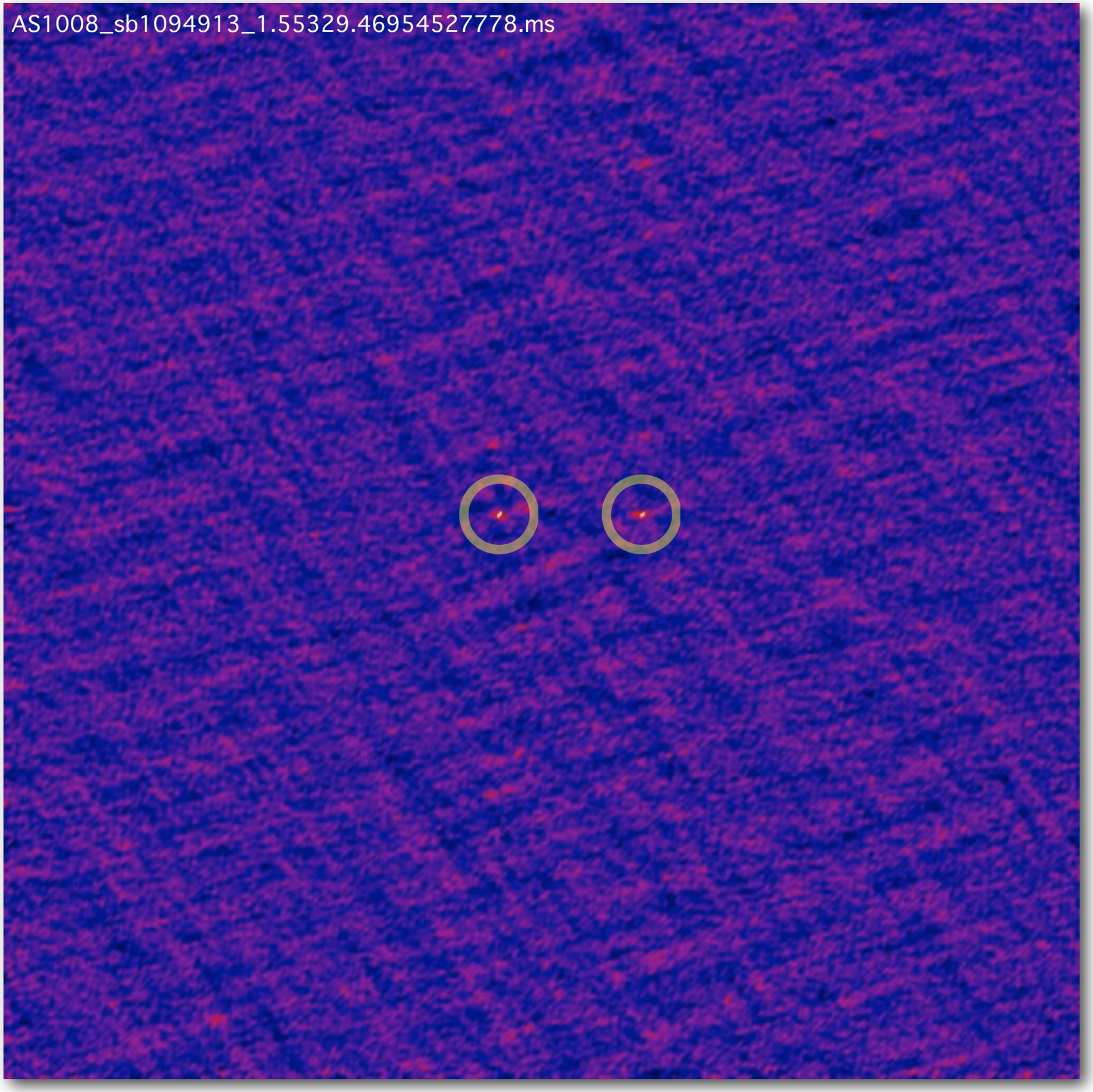


Solve for differential gains with MeqTrees and subtract model, 12μJy RMS



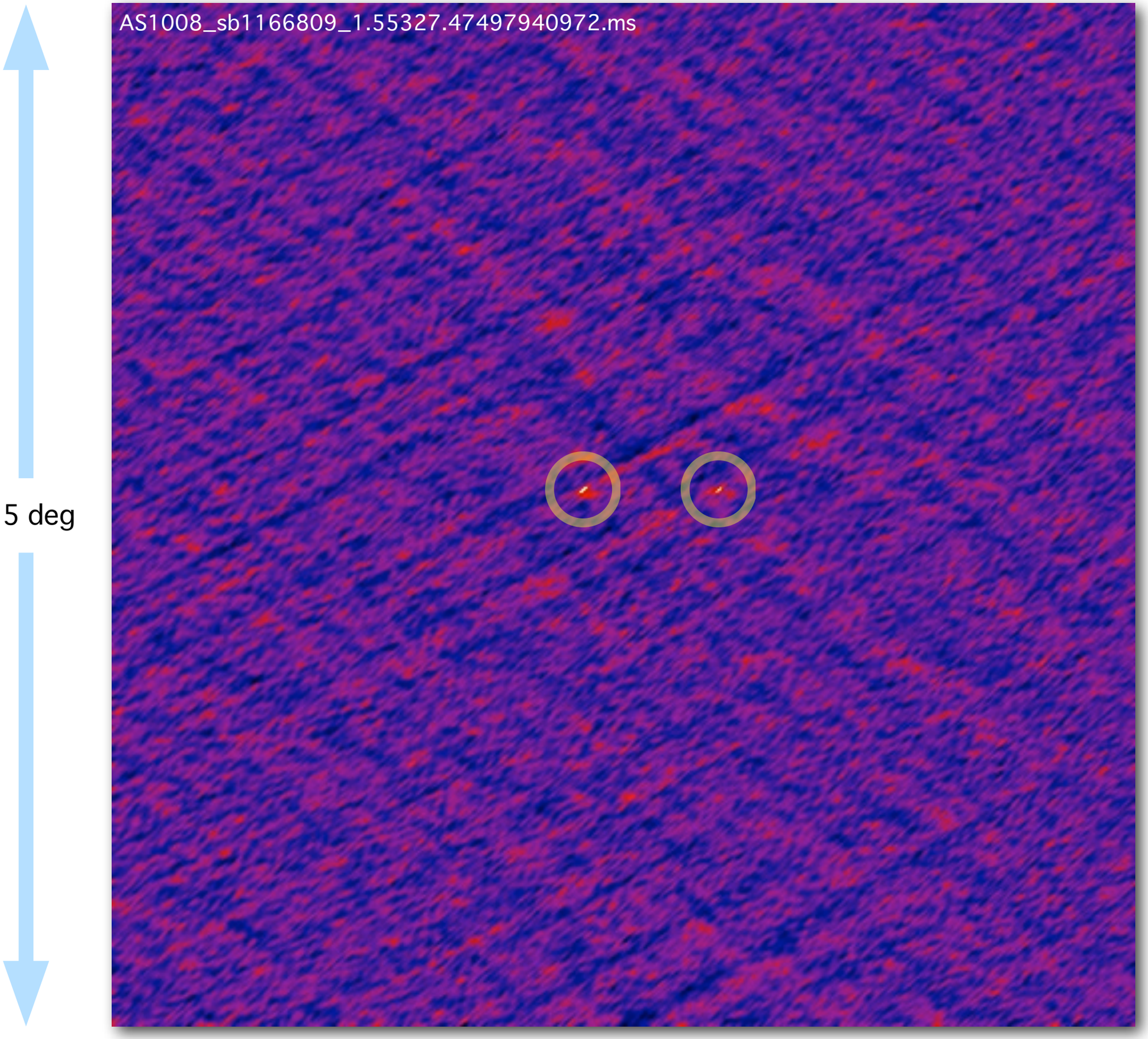
Smirnov, A&A, 572, 107, 2011
Noordam & Smirnov, ApJ, 524, 61, 2011

Solve for differential gains with MeqTrees and subtract model, 12μJy RMS



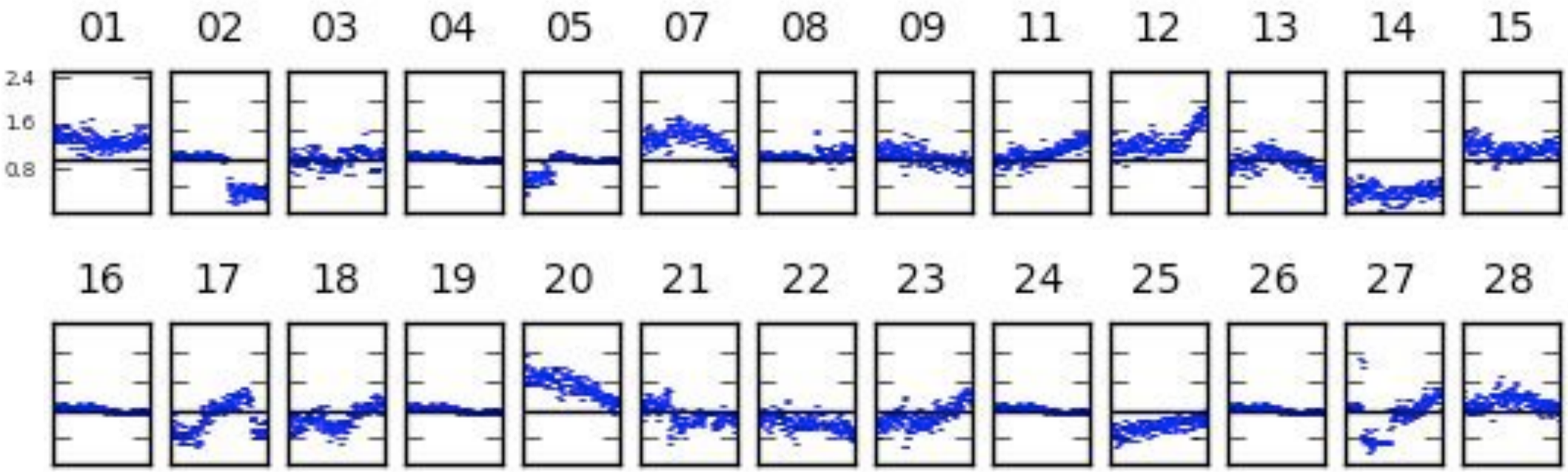
Smirnov, A&A, 572, 107, 2011
Noordam & Smirnov, ApJ, 524, 61, 2011

Solve for differential gains with MeqTrees and subtract model, 12μJy RMS

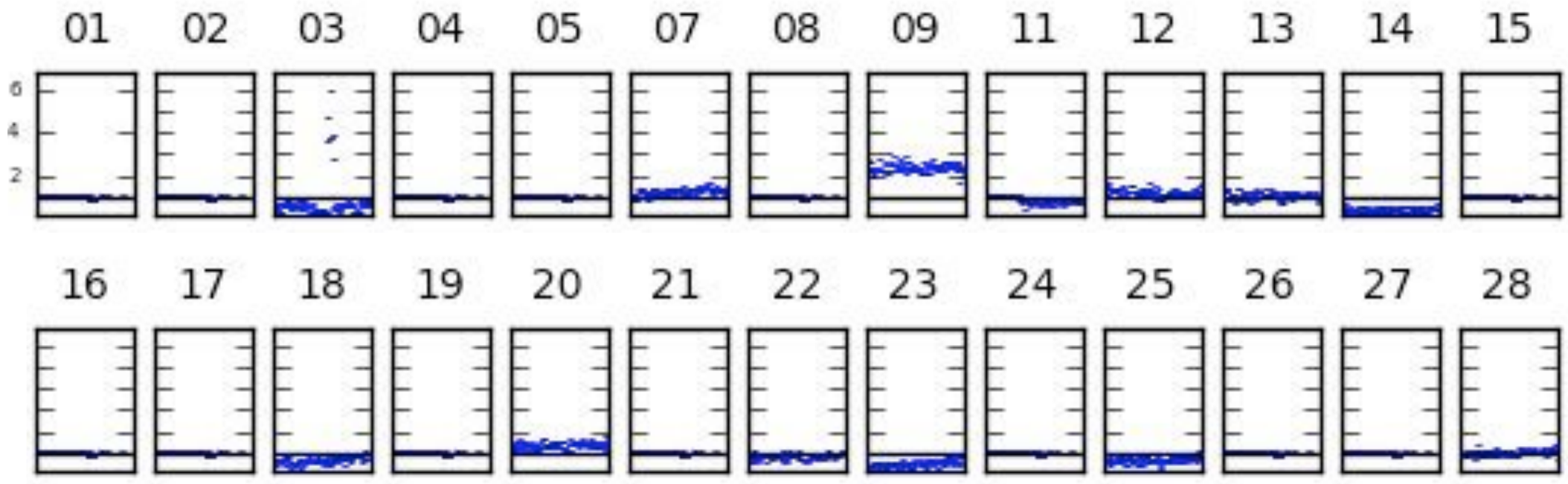


Smirnov, A&A, 572, 107, 2011
Noordam & Smirnov, ApJ, 524, 61, 2011

dE solutions per antenna for two Measurement Sets

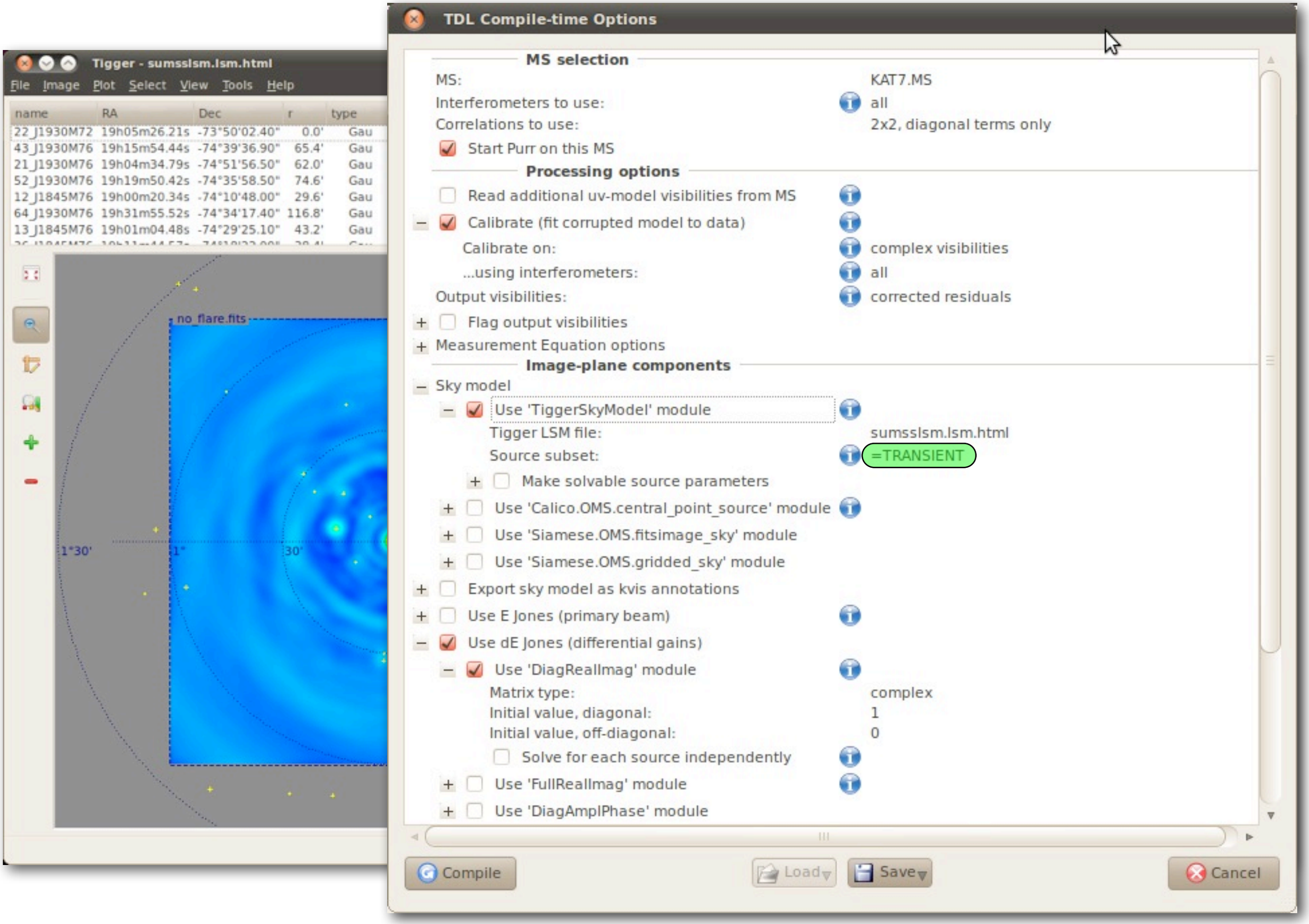


55329_55327_CONCAT.ms



AS1008_sb1166809_1.55311.49789672454.ms.SPLIT.WHDF1.ms

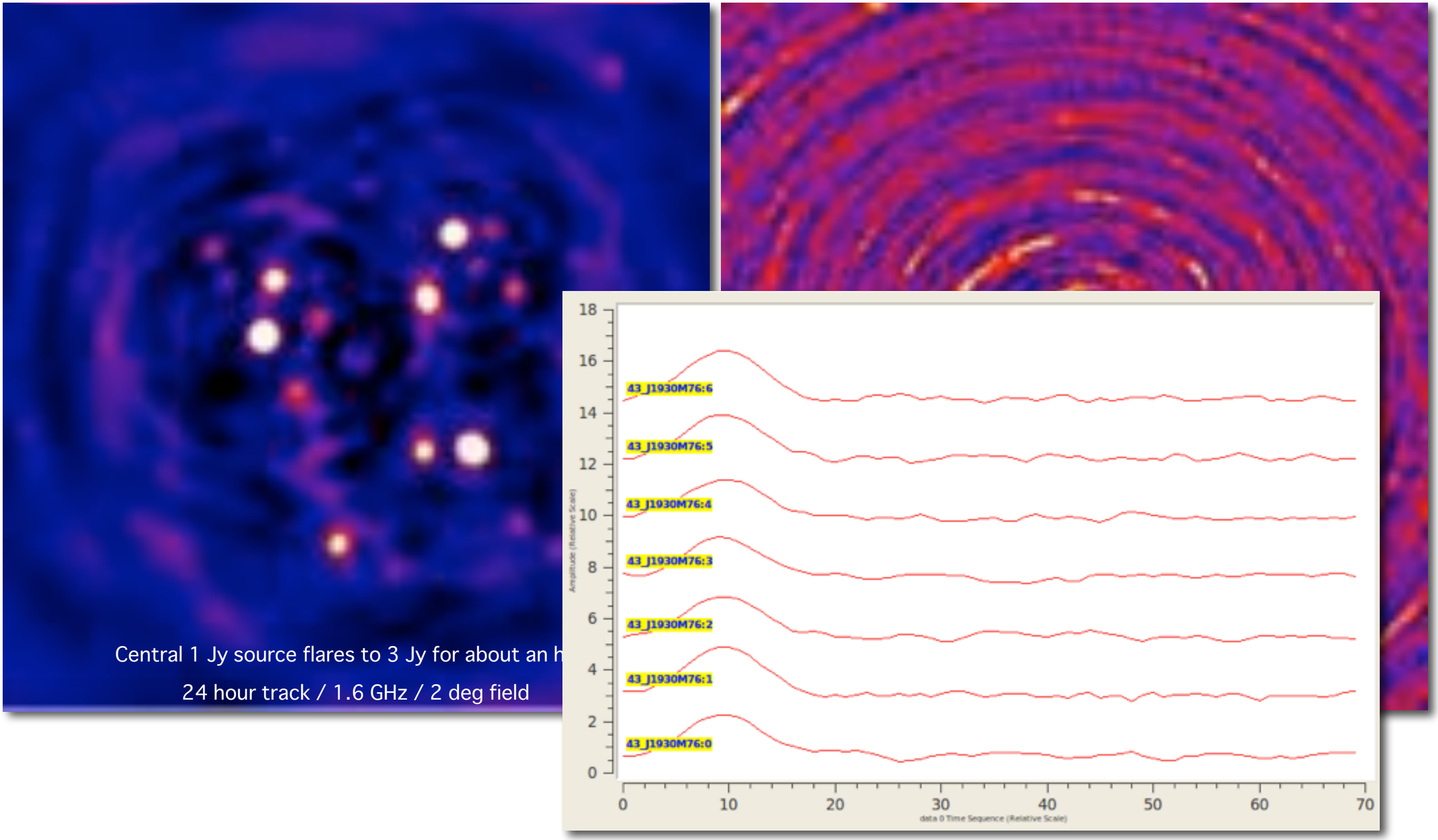
Solving for the ‘variable’ sources in our simulations



Solving for the ‘variable’ sources in our simulations

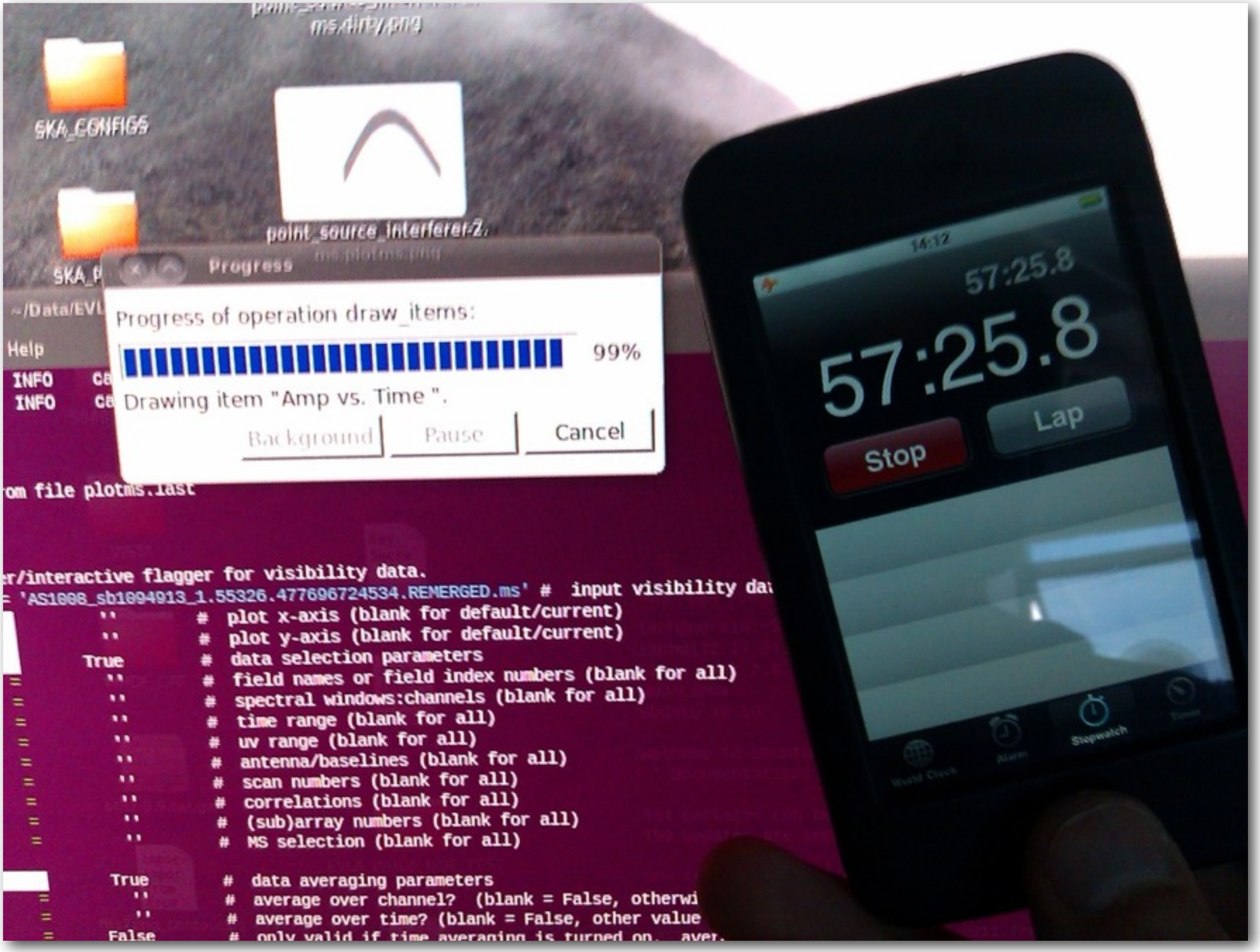
MeqTrees KAT-7 simulation

OSKAR simulation (Dulwich, Mort, Salvini)

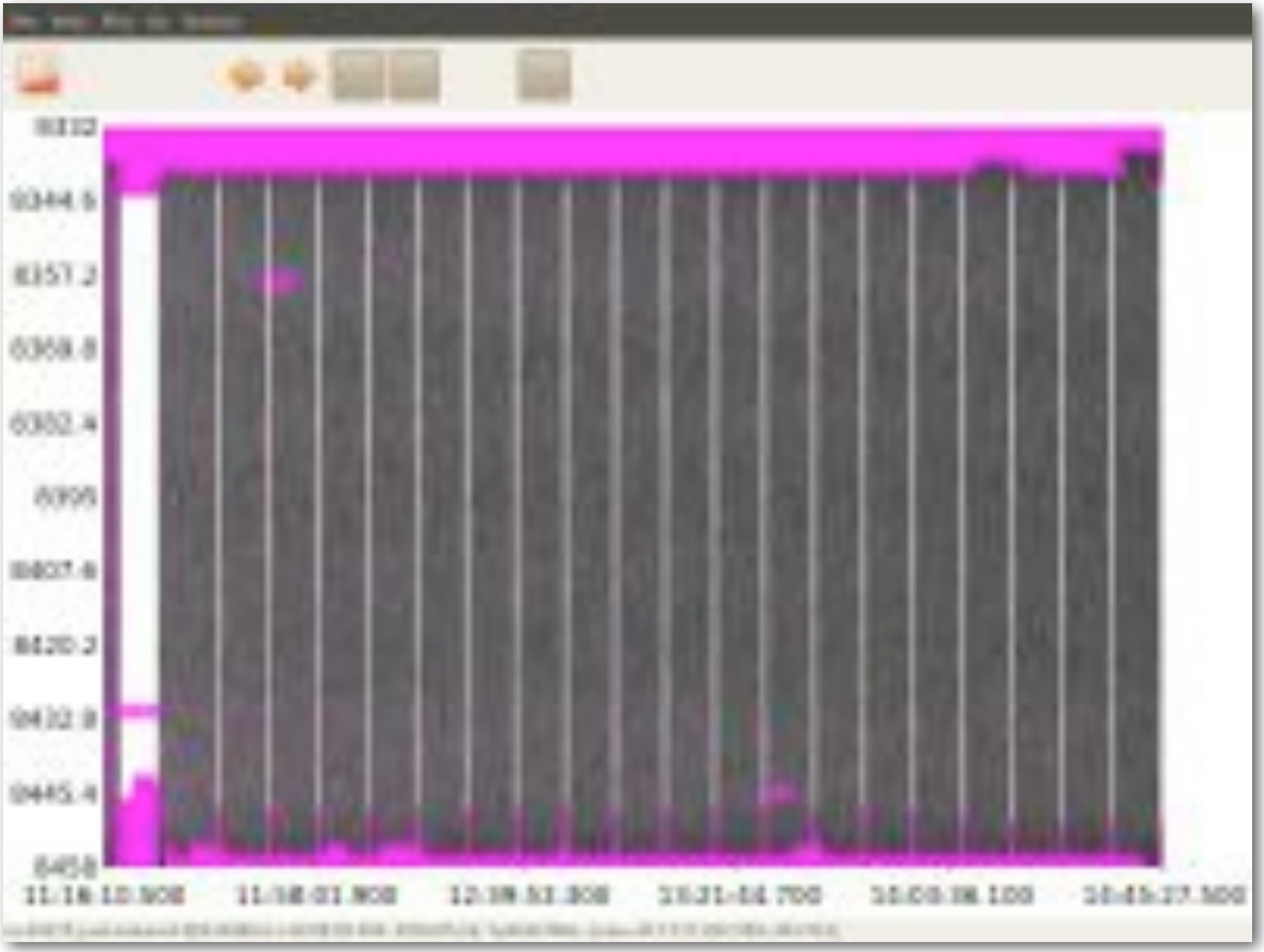


Automating everything

Flagging full spectral resolution data



Automatic flagging of full-resolution data with rficonsole



Offringa et al., MNRAS, 405, 155, 2010

Automated calibration scheme / software inventory

Software

Intermediate / final visibility product

Diagnostic product

uncalibrated scheduling block ms

split by field (CASA)

flux cal ms

phase cal ms

target ms

flagging reports

auto flag (rficonsole)

concatenate (CASA)

FLAGGING

phase solutions

flux, bandpass, gain calibration (CASA)

split target field (CASA)

calibrated target ms

flagged multi-source ms

GAIN CALIBRATION

residual visibilities (Owlcat)

dE solutions (Owlcat)

solve dE, subtract confusing source (MeqTrees)

calibrated residual ms

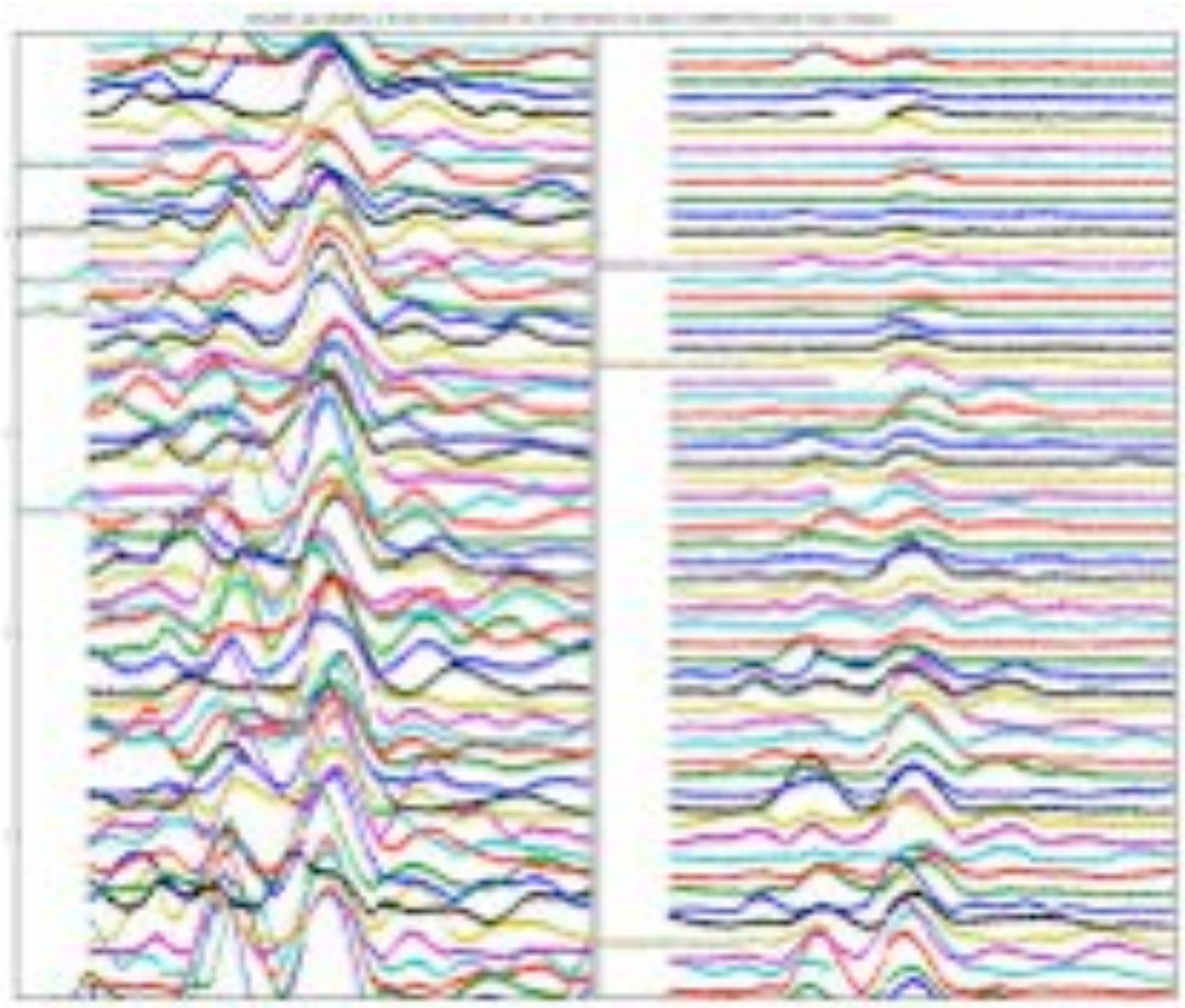
image (lwimager)

calibrated map

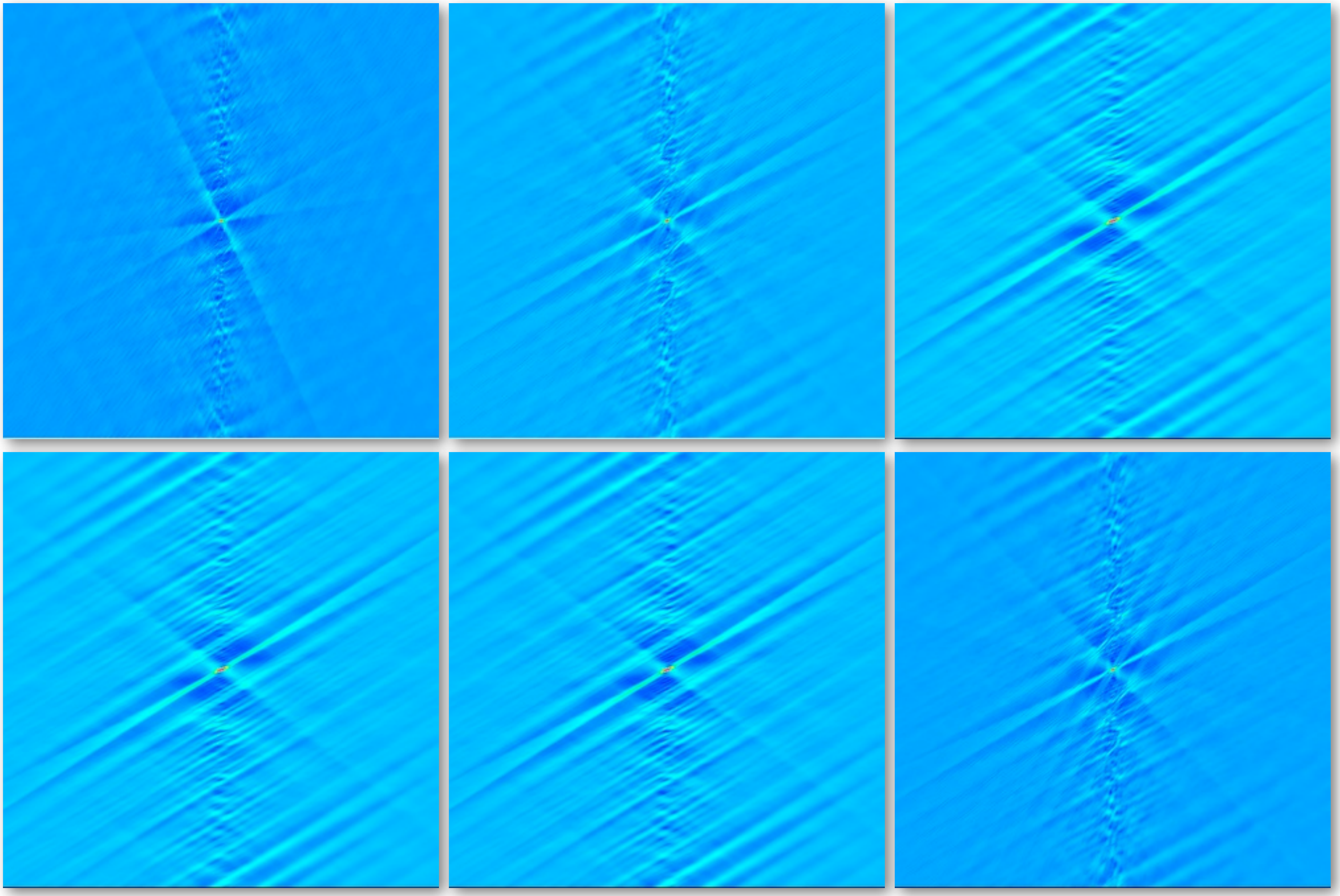
concatenate and image

SUBTRACT CONFUSING SOURCE

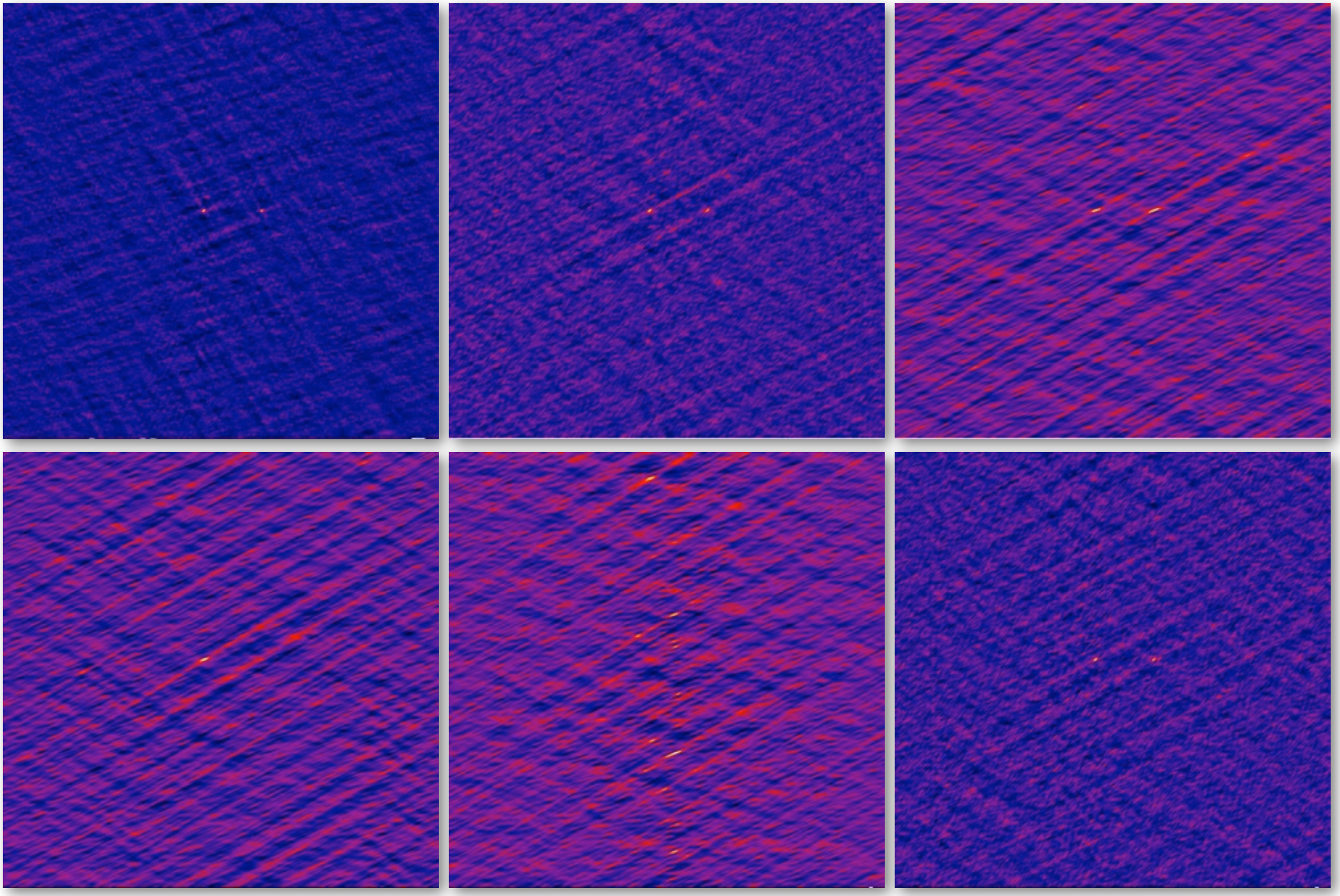
The importance of diagnostic data products: UFOs over New Mexico?



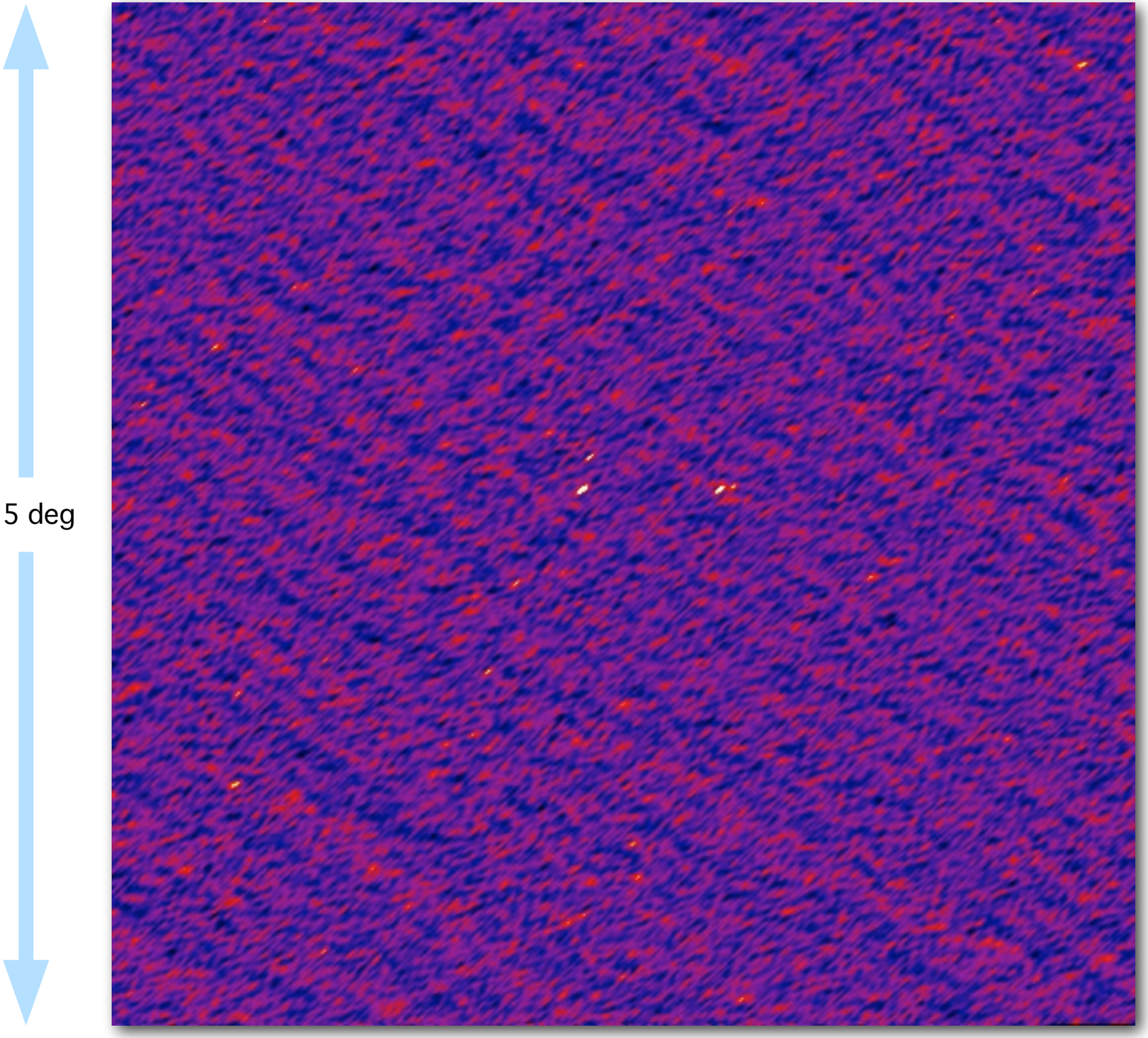
Automatically generate PSF images



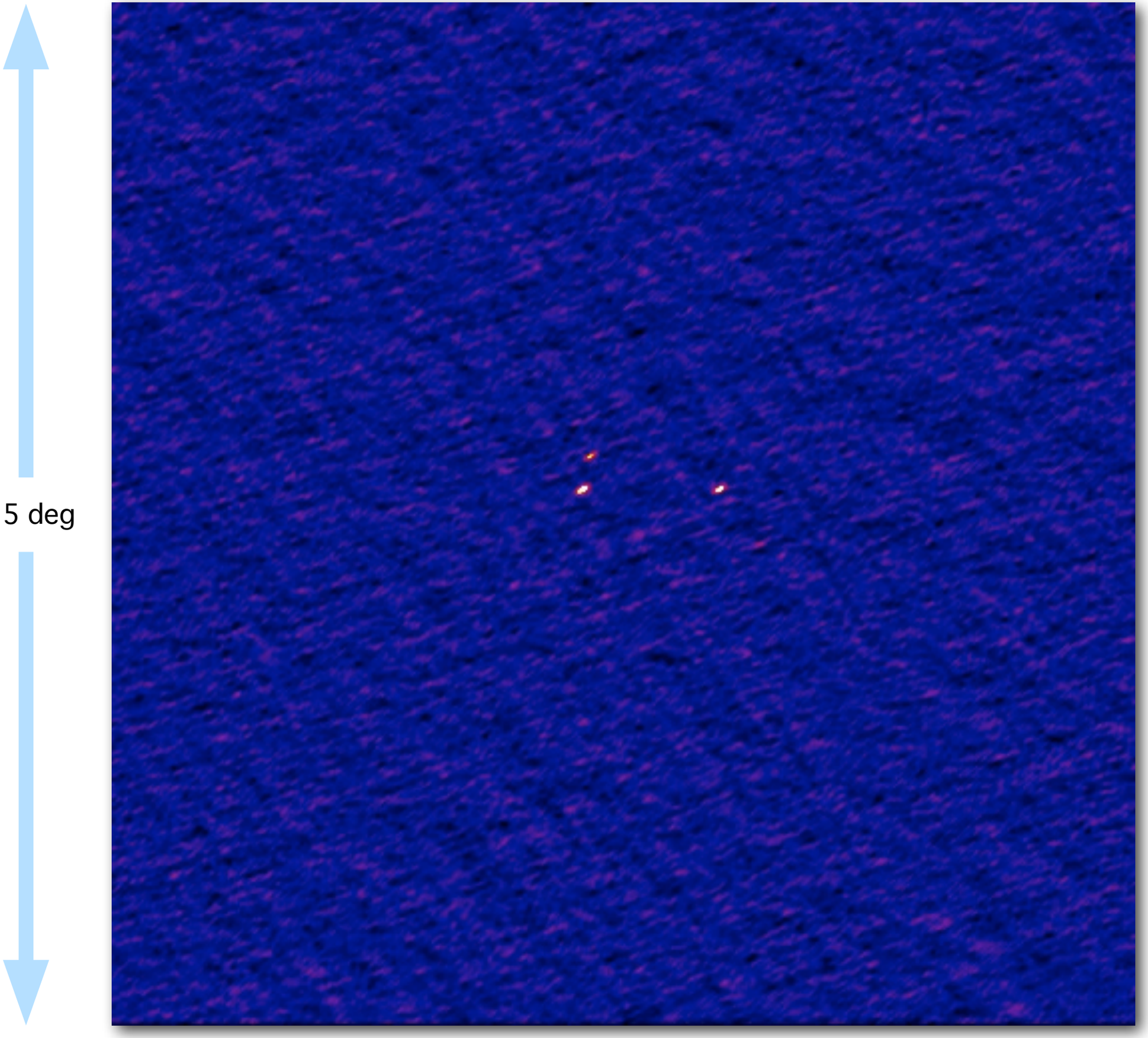
Automatically generate dirty maps



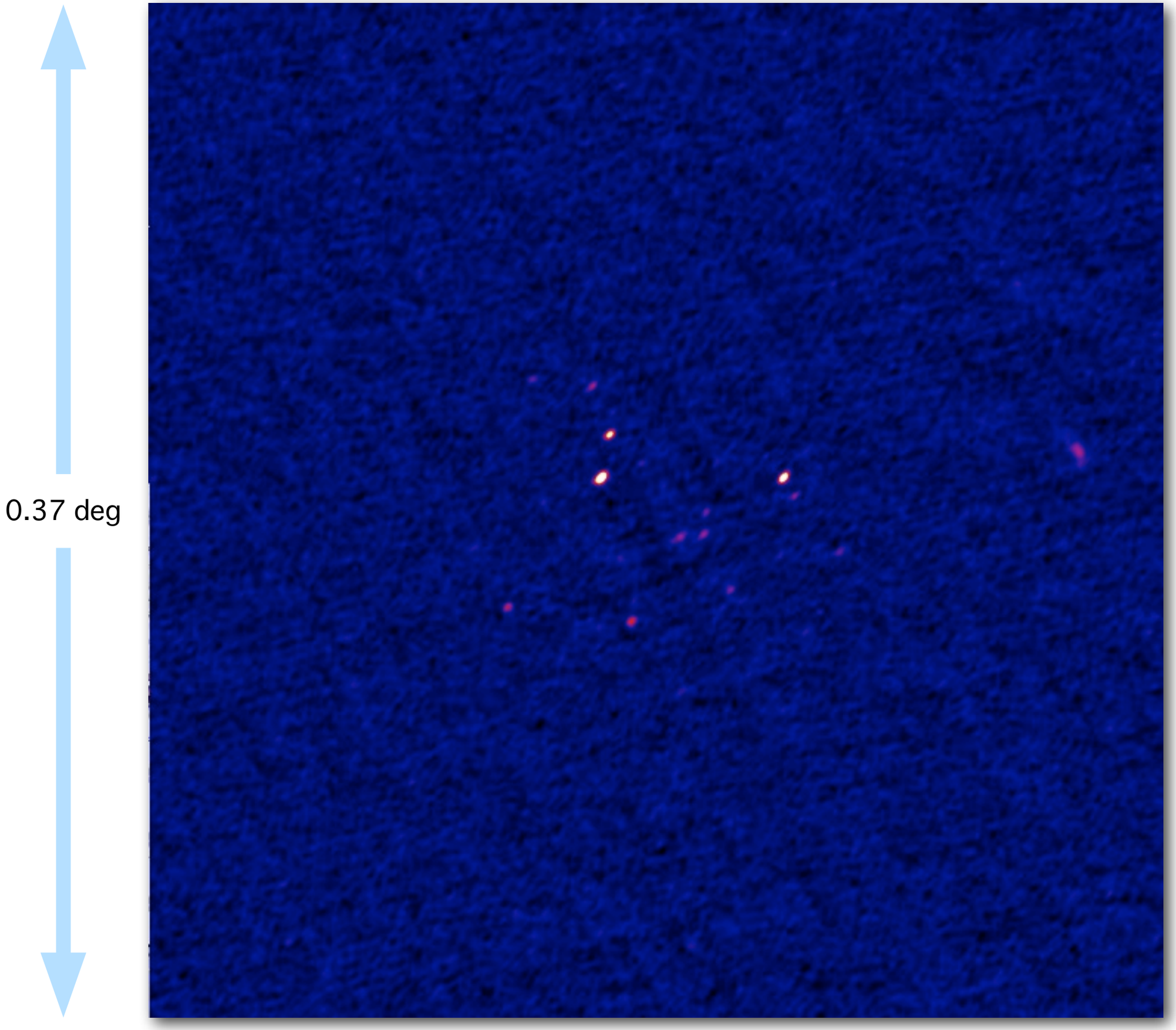
Map from 6 MS × 2 SPW, 13μJy RMS



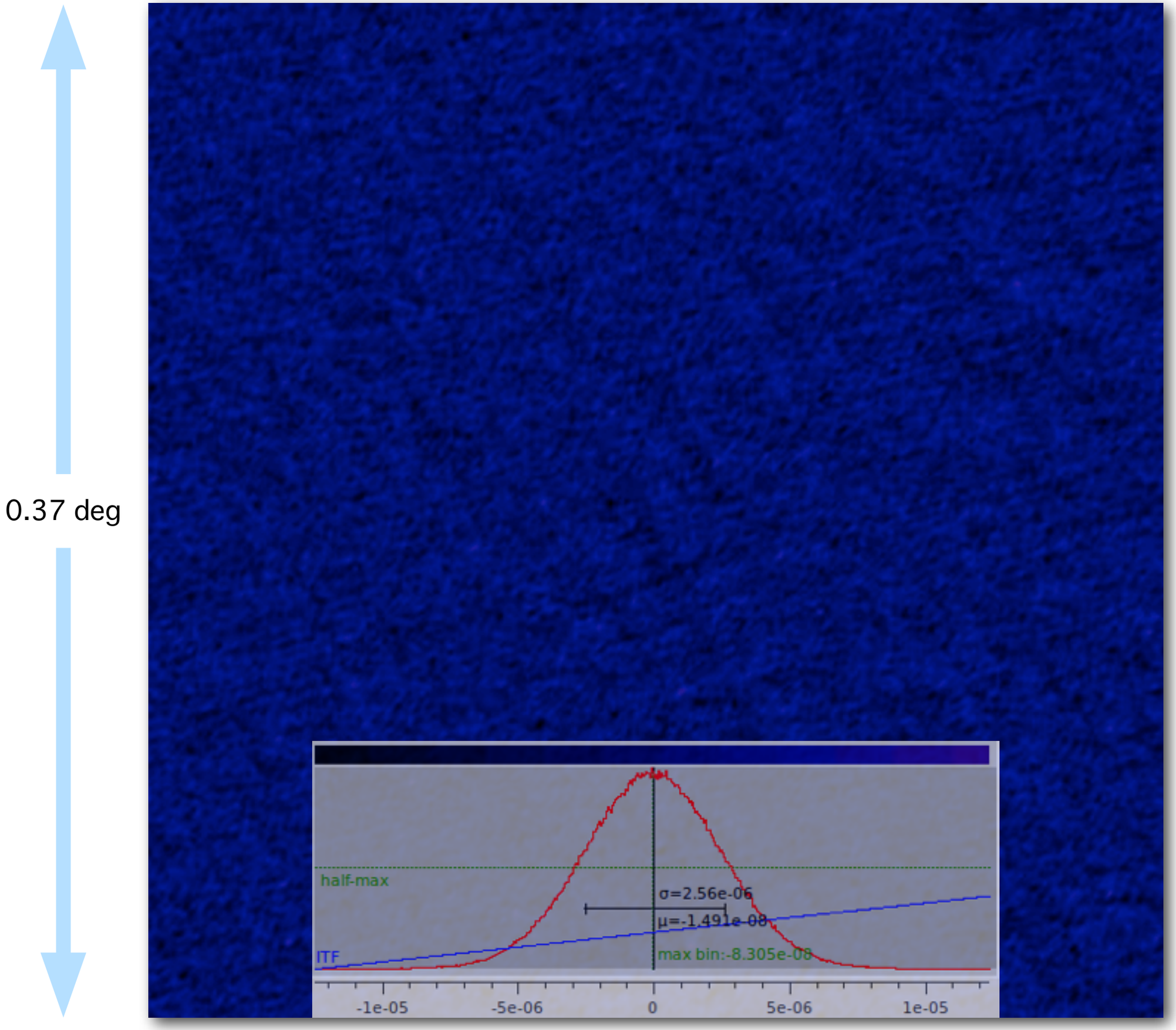
Less is more: 5 MS × 2 SPW, 6μJy RMS



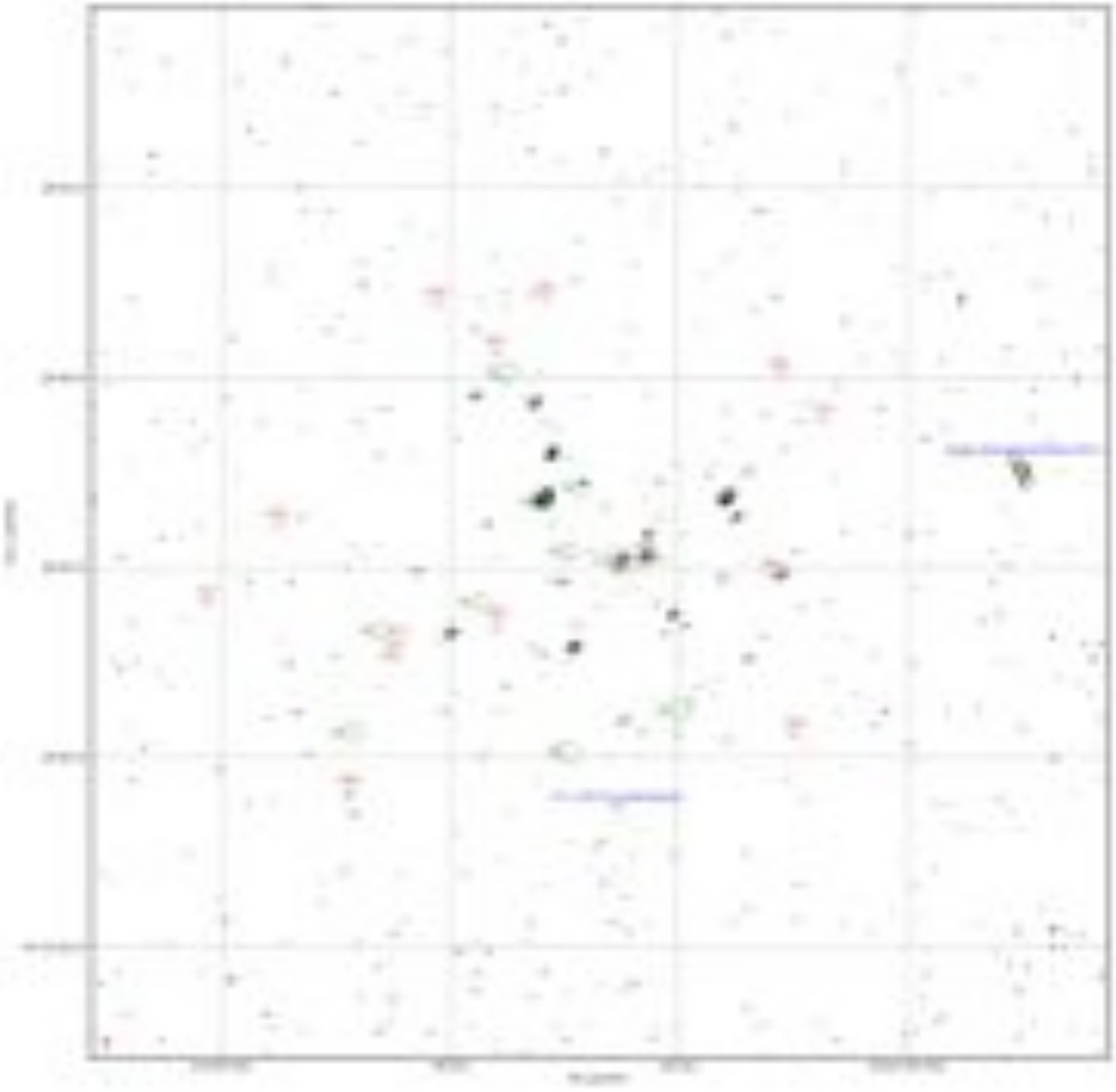
Final map: 2.5μJy RMS



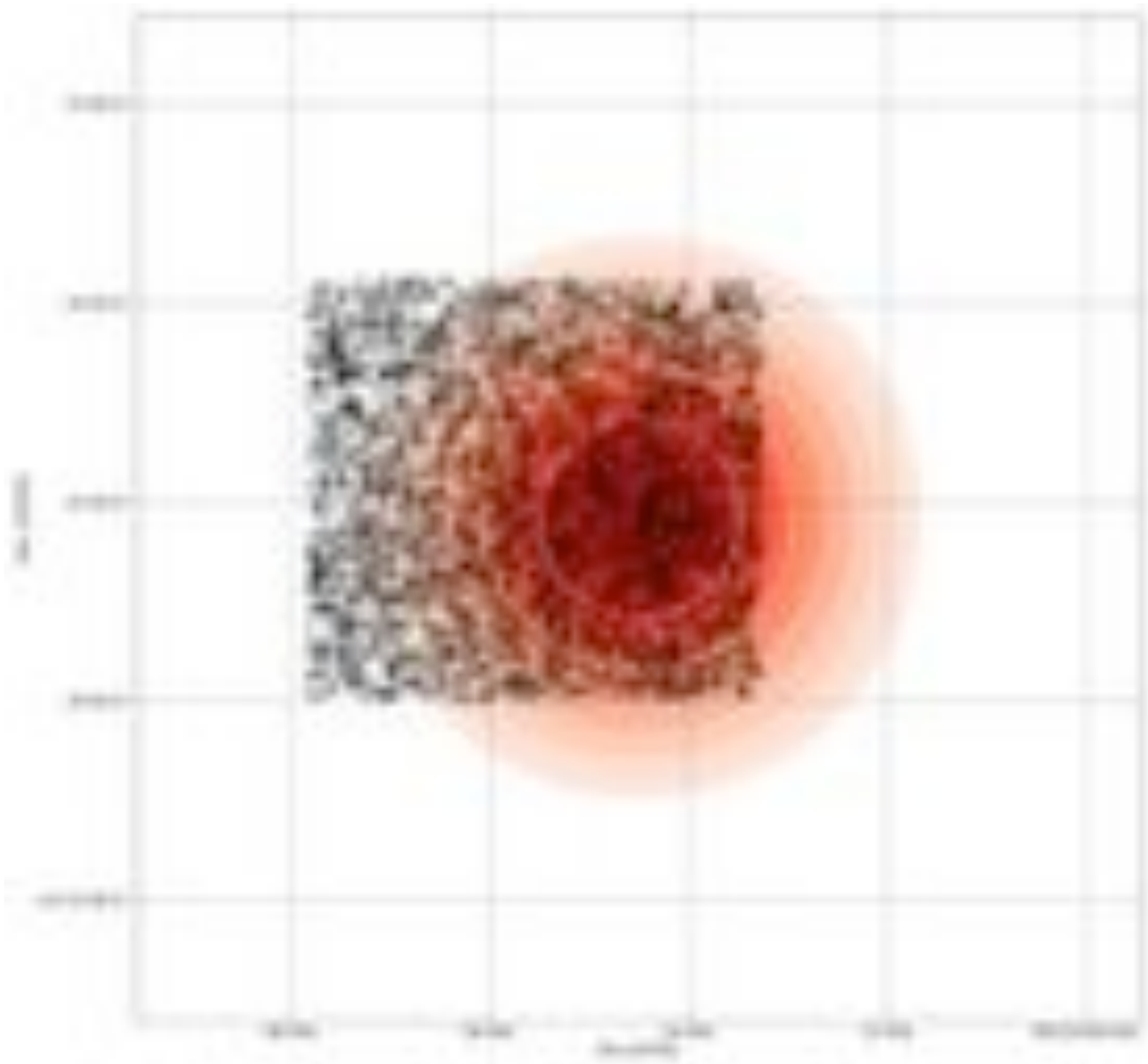
Subtraction of 17 sources > 5σ

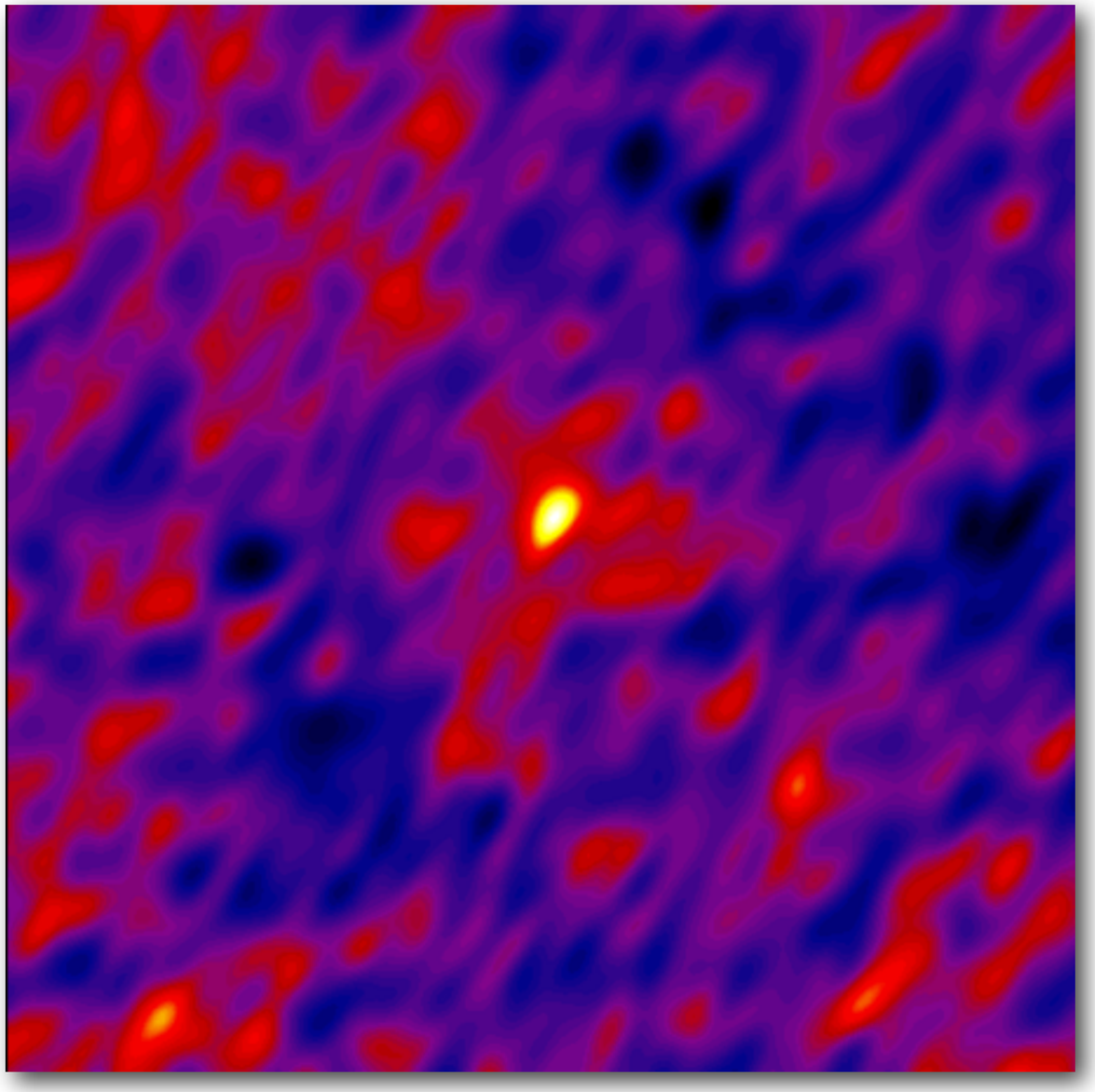


Quasars, sub-mm sources and radio contours (lowest contour = 3σ)



Stacked 3σ continuum detection from 2673 optical positions

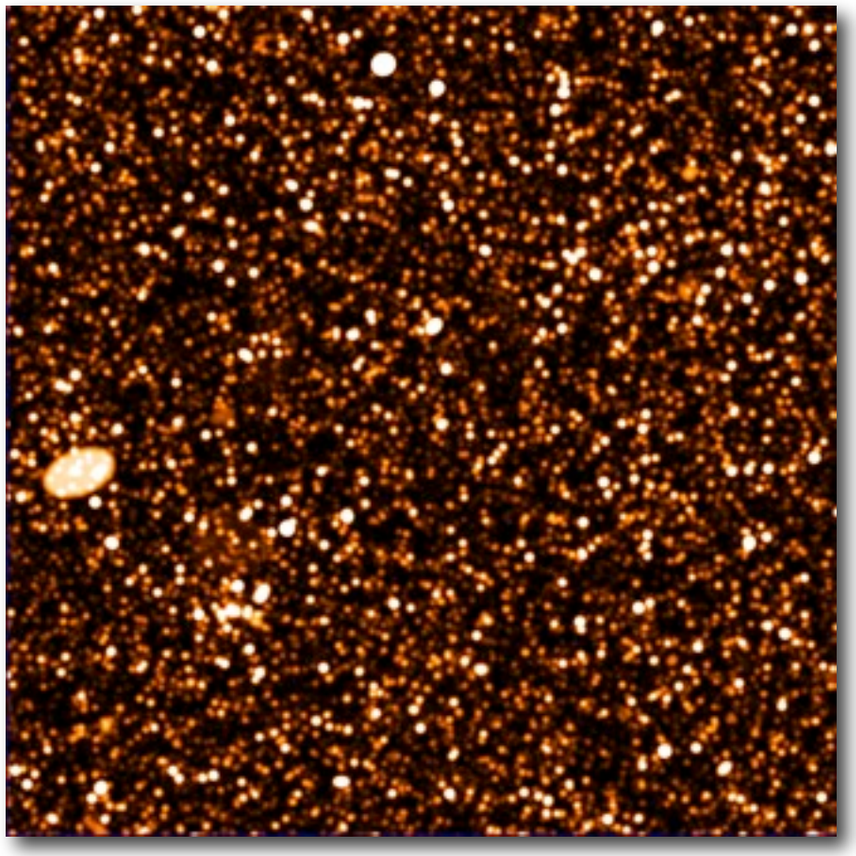




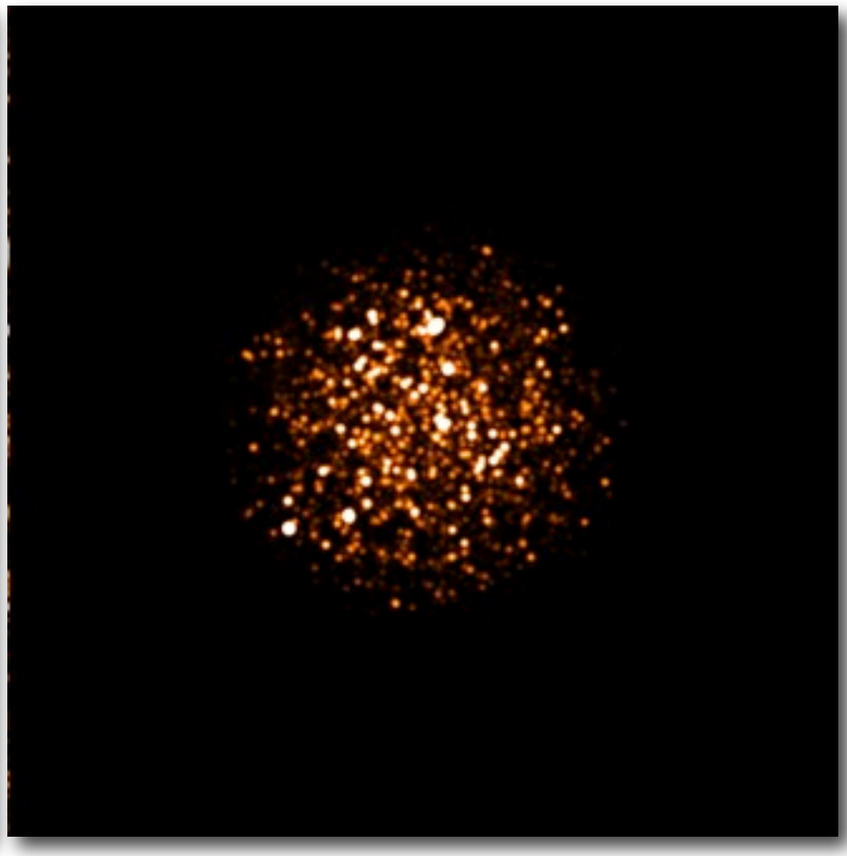
Effective RMS noise in stacked map = 95 nJy

Simulating benchmark maps with MeqTrees and S^3

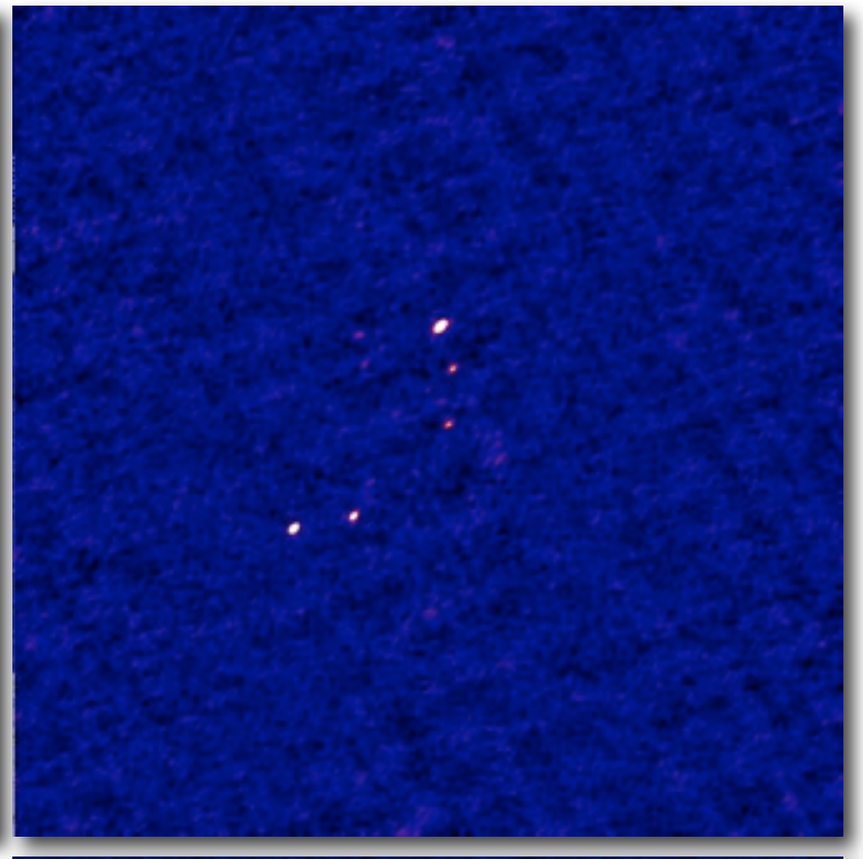
Ideal simulated sky at 8.4 GHz



Applied primary beam attenuation

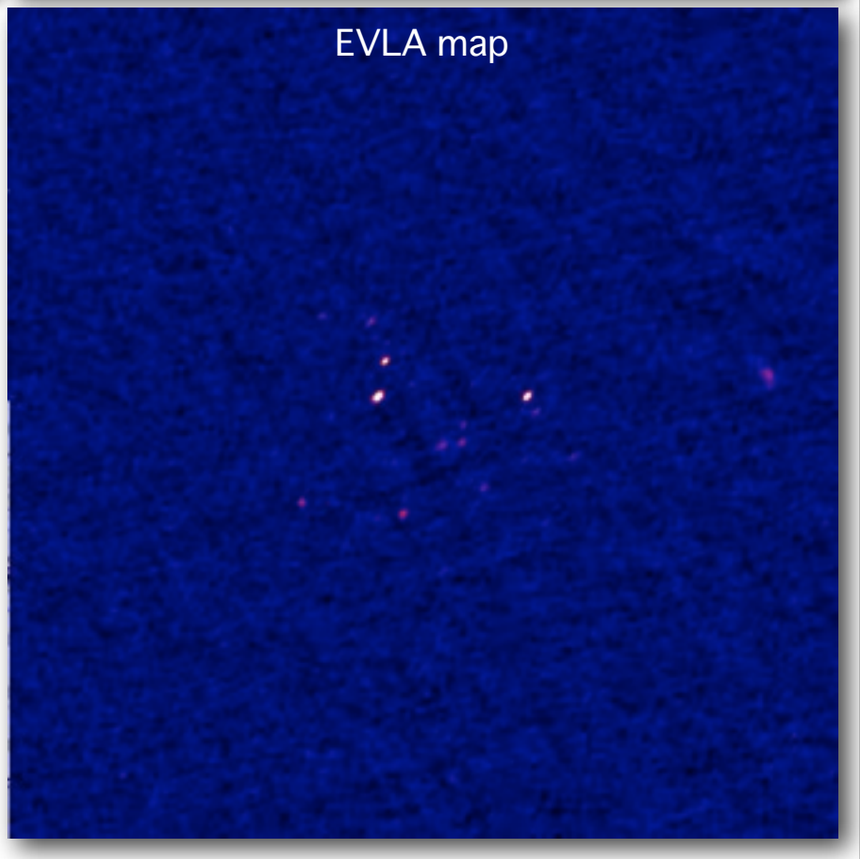


Generate perturbed visibilities and image



$$\sigma = \frac{\sqrt{2}\,kT_S}{A\eta_Q} \Big/ \sqrt{\Delta\nu_{\mathrm{IF}}\,\tau_a},$$

EVLA map



http://s-cubed.physics.ox.ac.uk

The two-step programme to being a contented radio astronomer

1. Observe at X-band

2. Do not spatially resolve anything