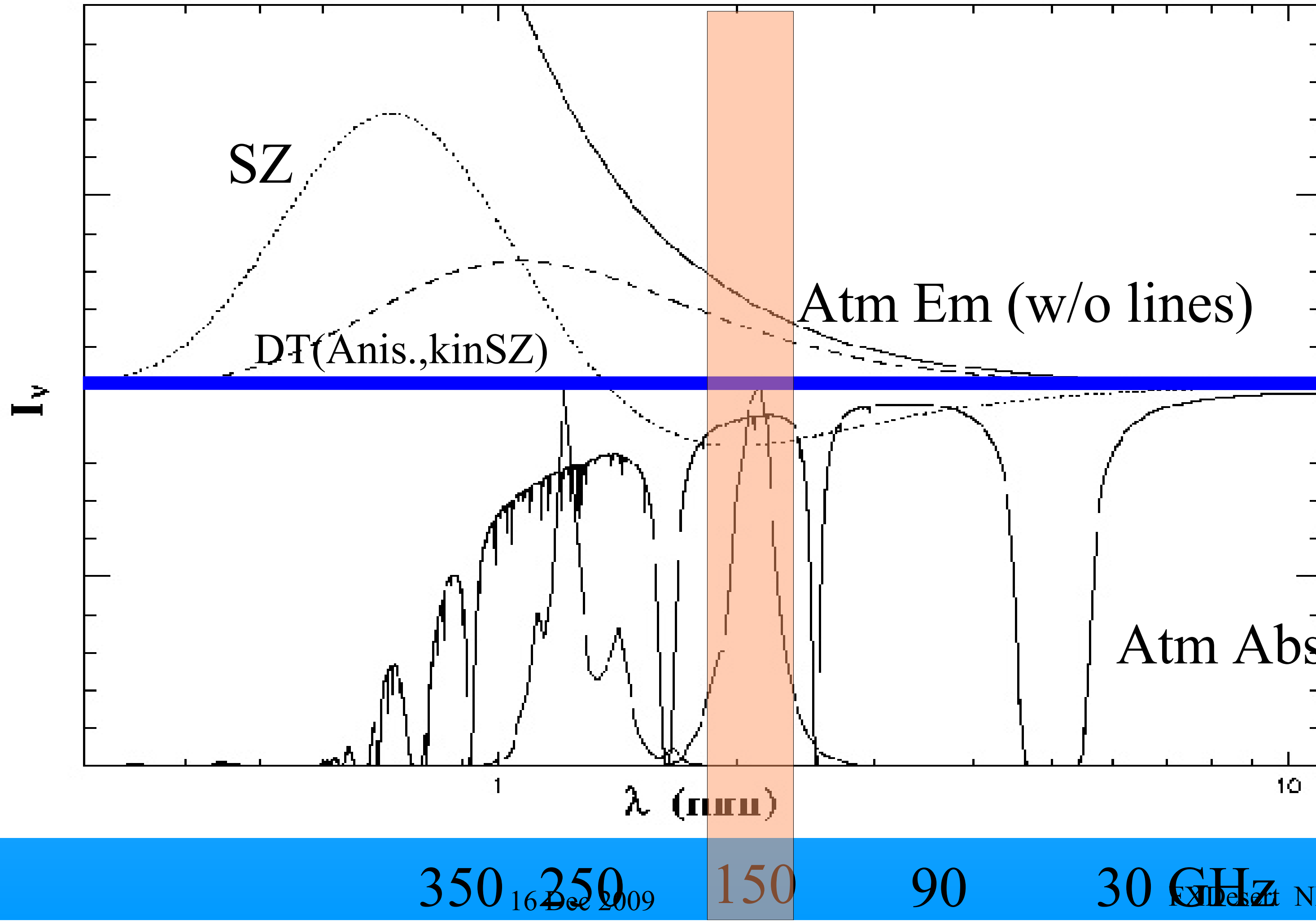
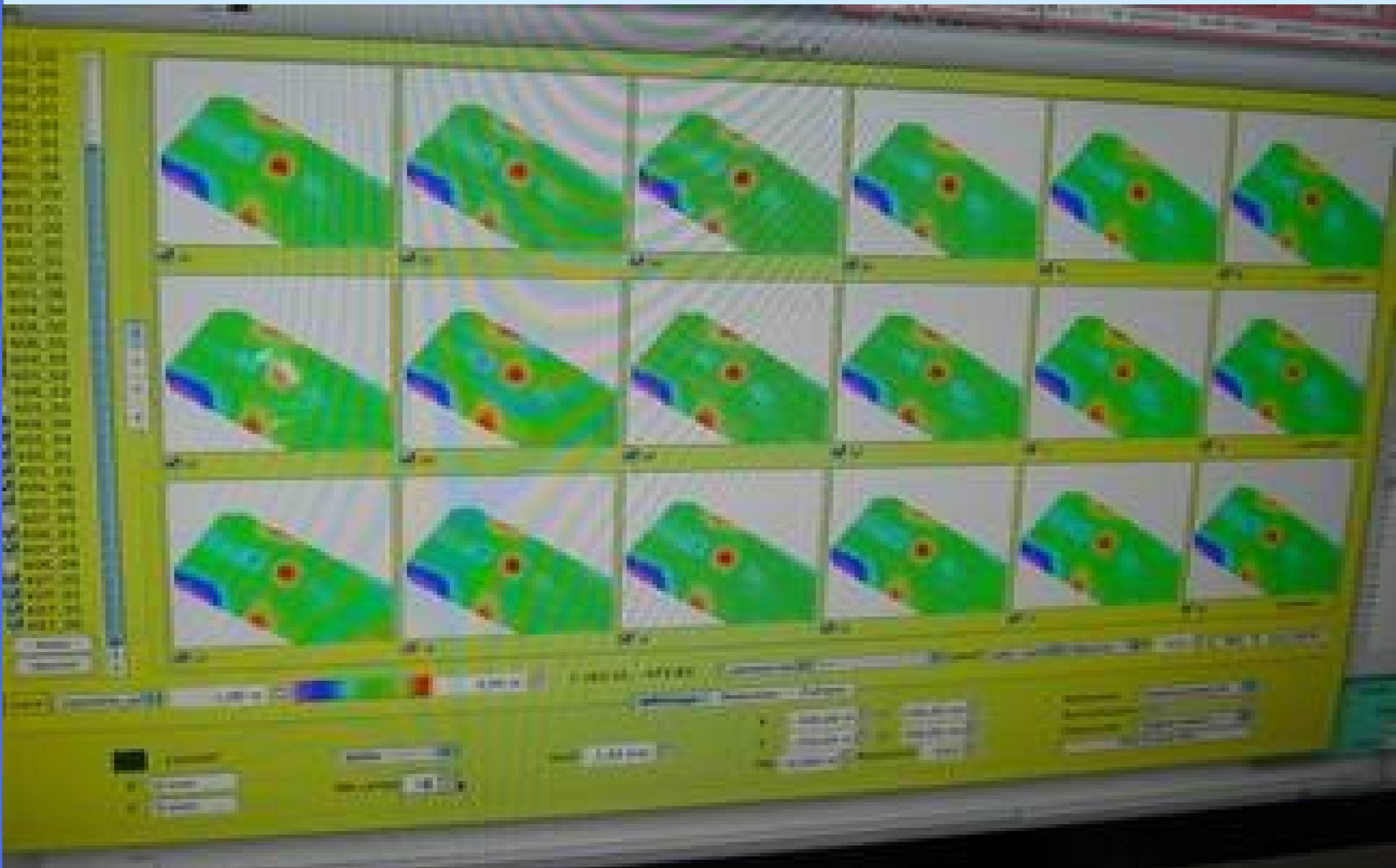
NIKA Oct 2009 Run: Calibration & Sensitivity

F.-Xavier Désert (LAOG/CNRS/UJF)
Aurélien Bideaud, Alain Benoit, Alessandro Monfardini (Institut Néel MCBT)
for the NIKA collaboration

Aims: check that NIKA detectors can be calibrated evaluate the sensitivity



Going beyong QLA results



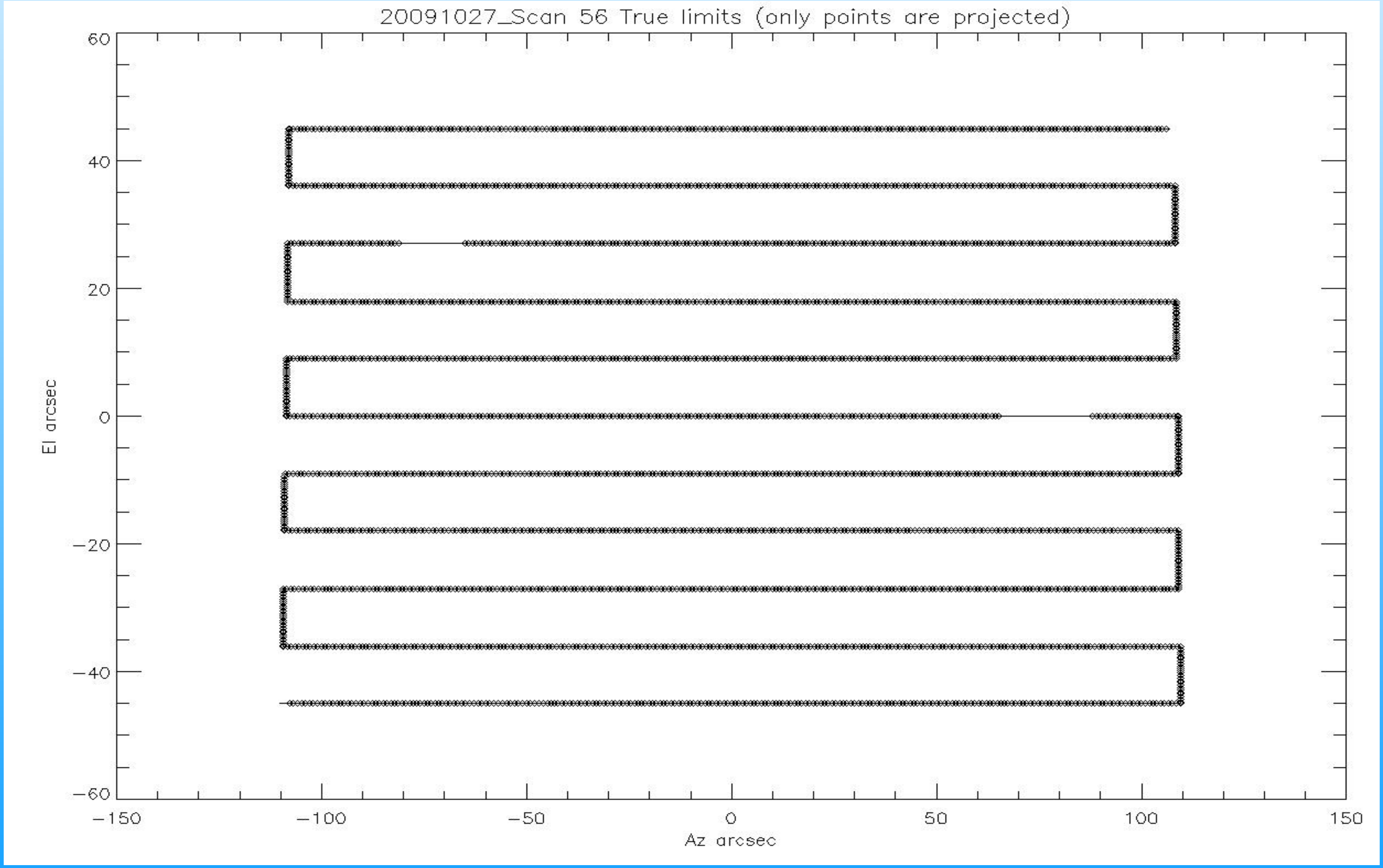
Offline processing

- Read NIKA fits data prepared by QLA (includes pointing info from IRAM telescope data)
- Read Telescope log book
- Truncate data to the analysed scan
- Deglitch and Jump flag the data
- Remove baseline and sky noise
- Get Focal Plane Geometry and Beams
- Correct for opacity
- Project on map
- Calibrate on planets
- Estimate noise
- Coadd (detectors, scans)
- Extract point source photometry

Scan Selection

Read data:

I, Q, Phase, Amplitude Select on speed of scan.



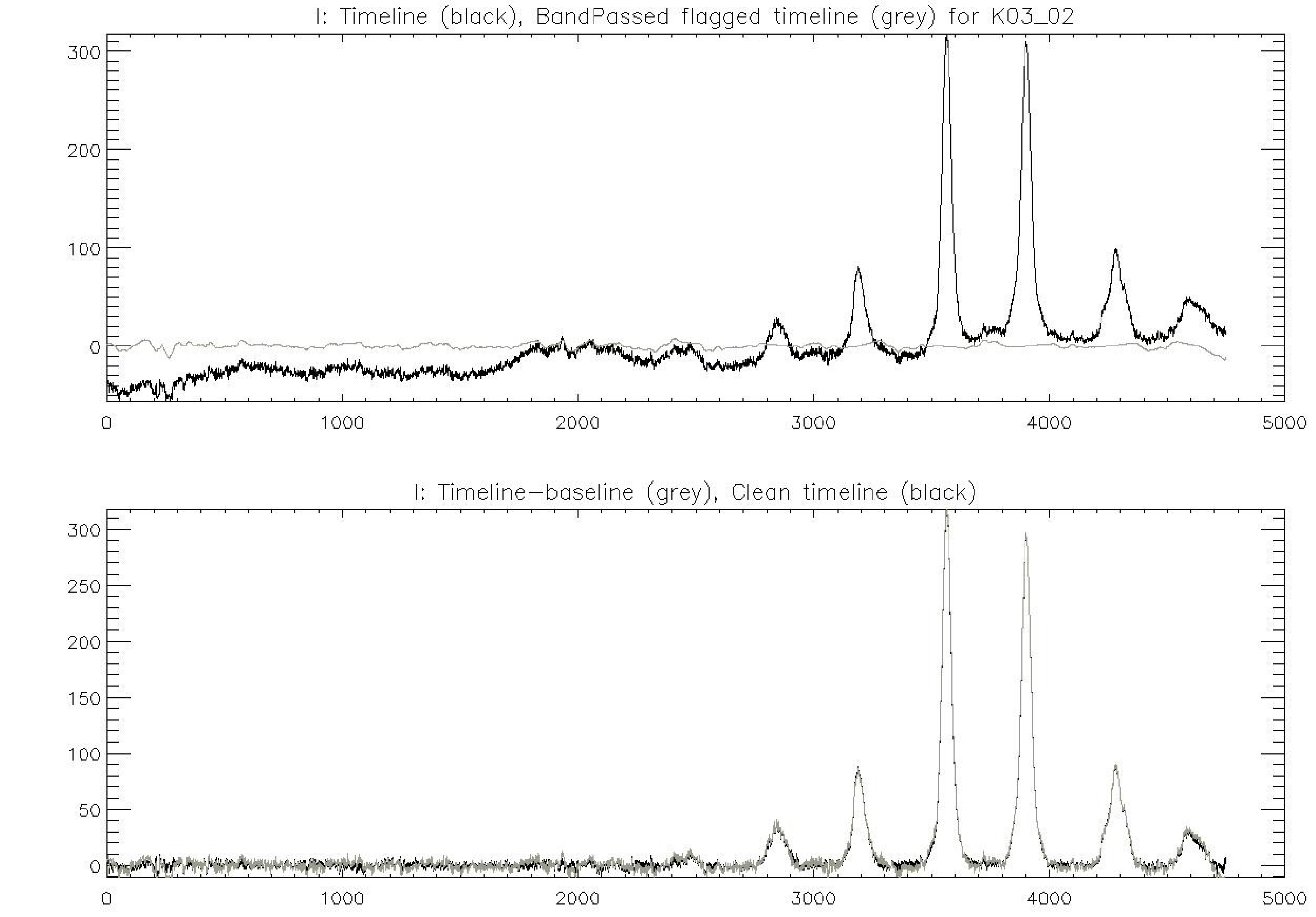
Glitches and Jumps

LEKID example
- 9 glitches per hour per detector in I, Q
- 2 glitches in Phase and Amplitude

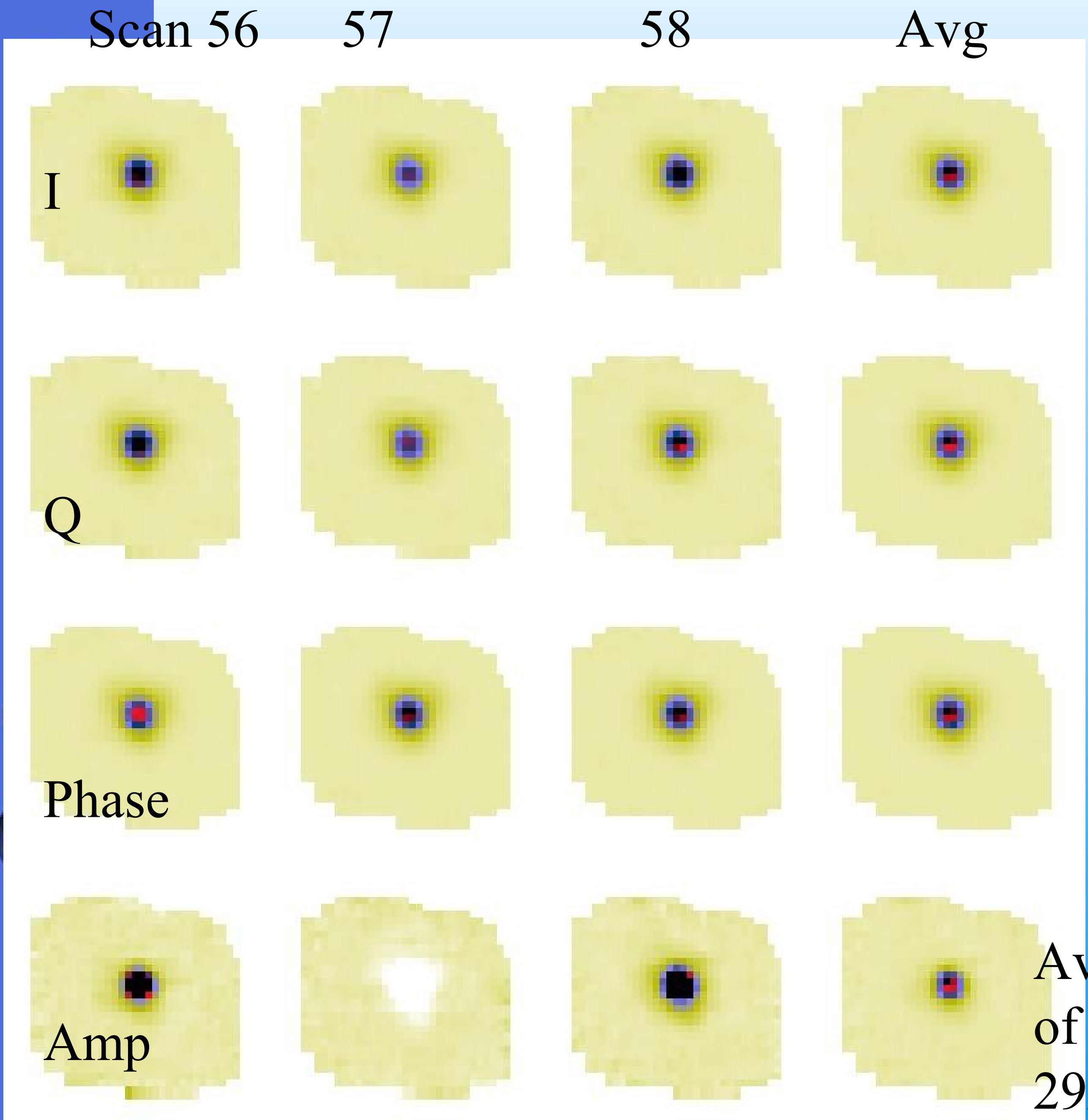
Likely cosmic ray hits with instantaneous relaxation time, i.e. only one sample is affected
- 2 jumps per hour per detector in I, Q (less in phase) usually correlated between several detectors.

Likely magnetic field quantization

Baseline subtraction & Sky noise removal



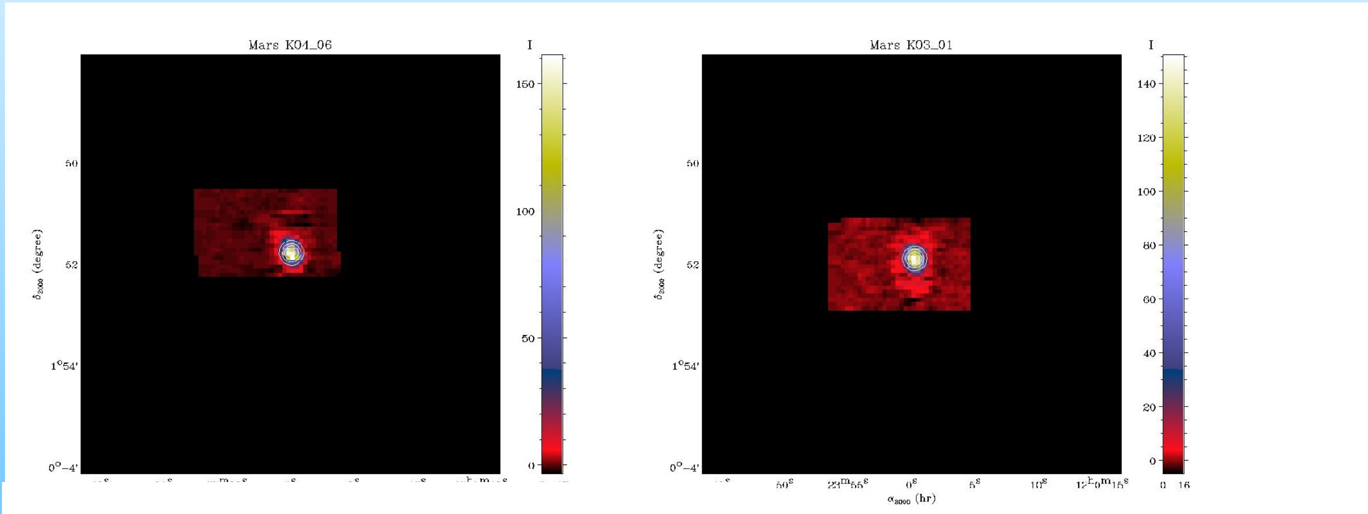
Focal Plane Geometry

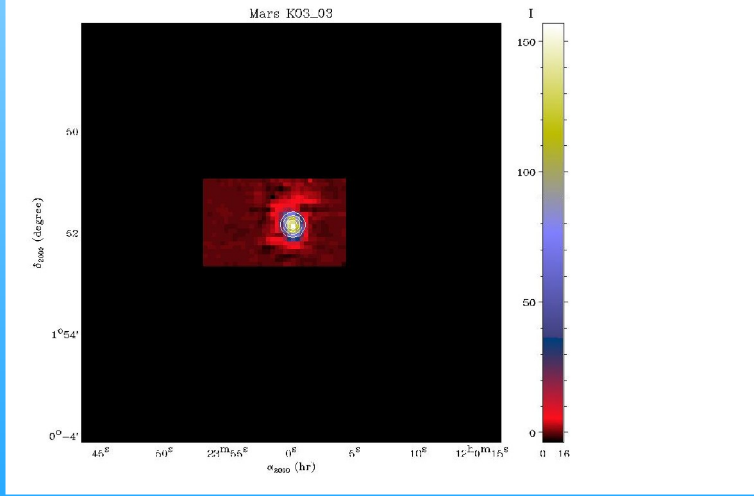


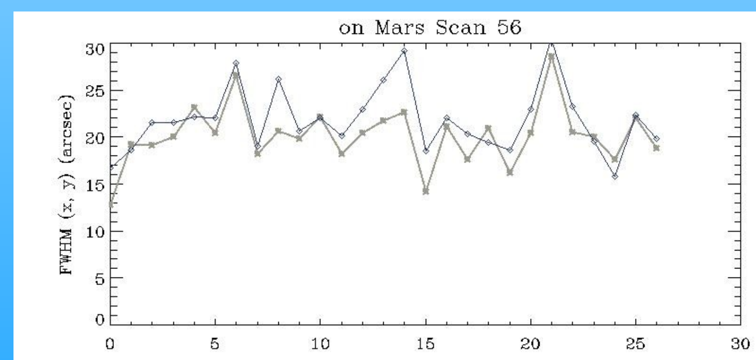
Geometry was found by QLA during the run
Just a Scaling and a Rotation is applied to the array
det-->Nasmyth-->AzEL-->RaDec
Positions are recovered for all detectors at better than the 2 arcsecond level except for some well-identified detectors that have cross-talk
The FPG is not changed here.

Average map of all good kids 29/10/2009.

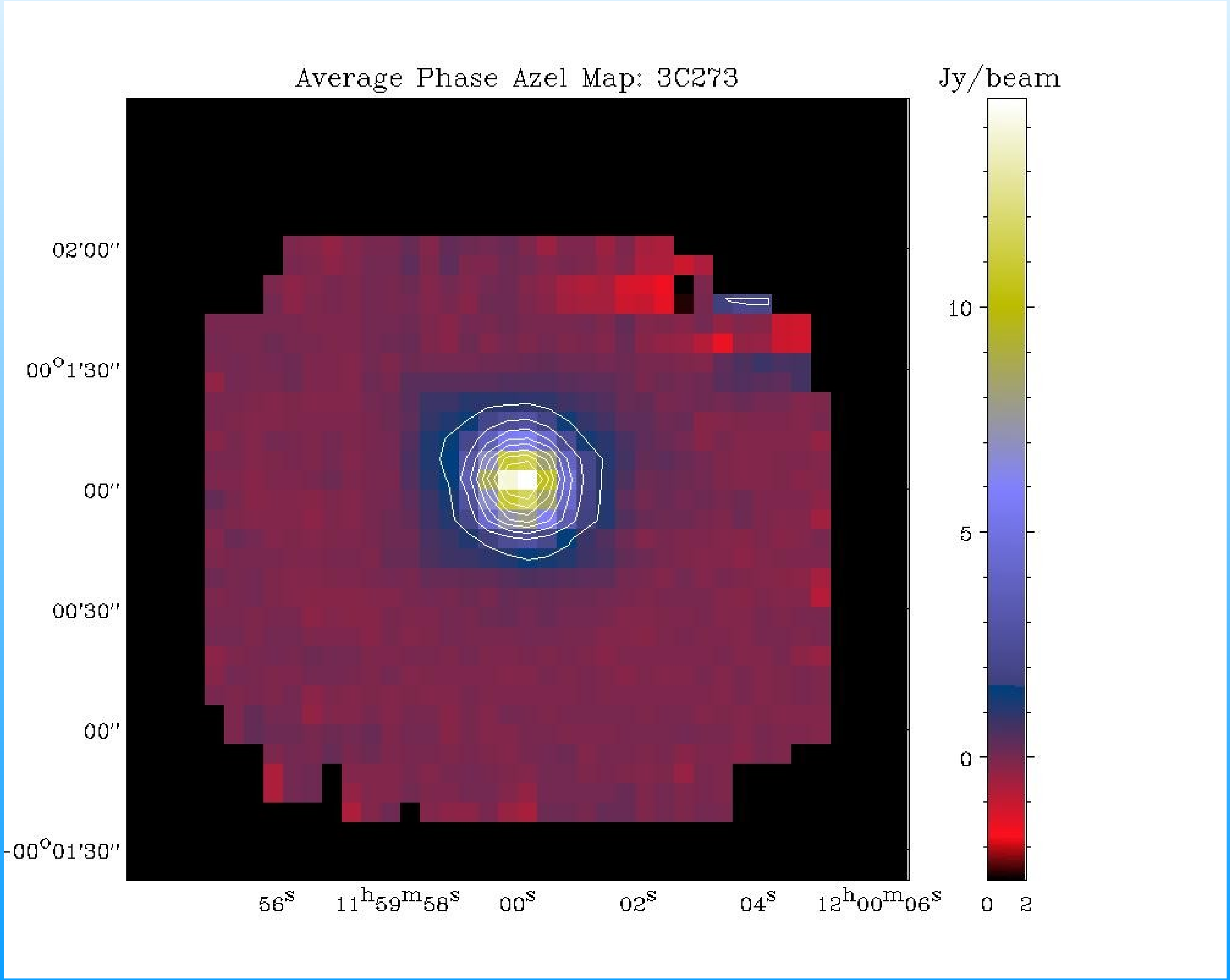
Optical quality (FWHM<~ 19 arcsec)





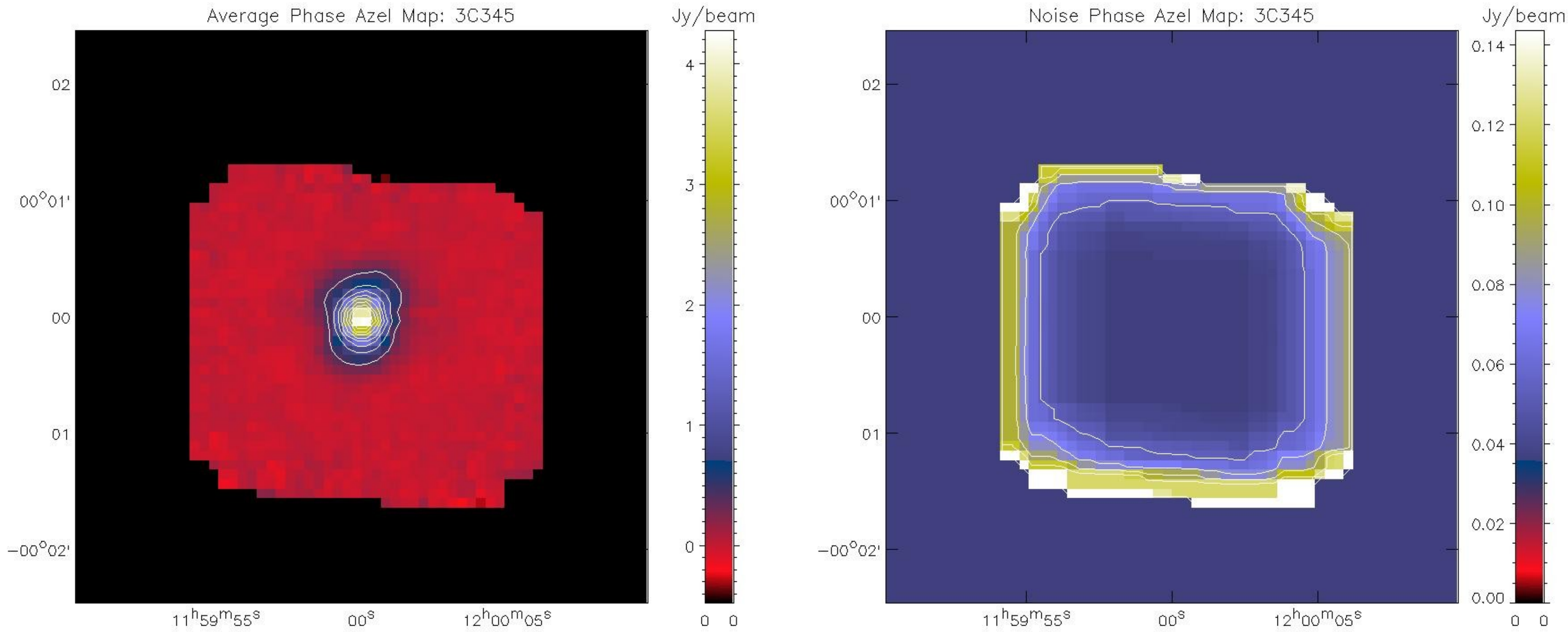


Mapping



Average Phase Azel Map: 3C273
Jy/beam
02'00''
00°1'30''
00''
00'30''
00''
-00°01'30''
56s
11h59m58s
00s
02s
04s
12h00m06s
10
5
0
0 2

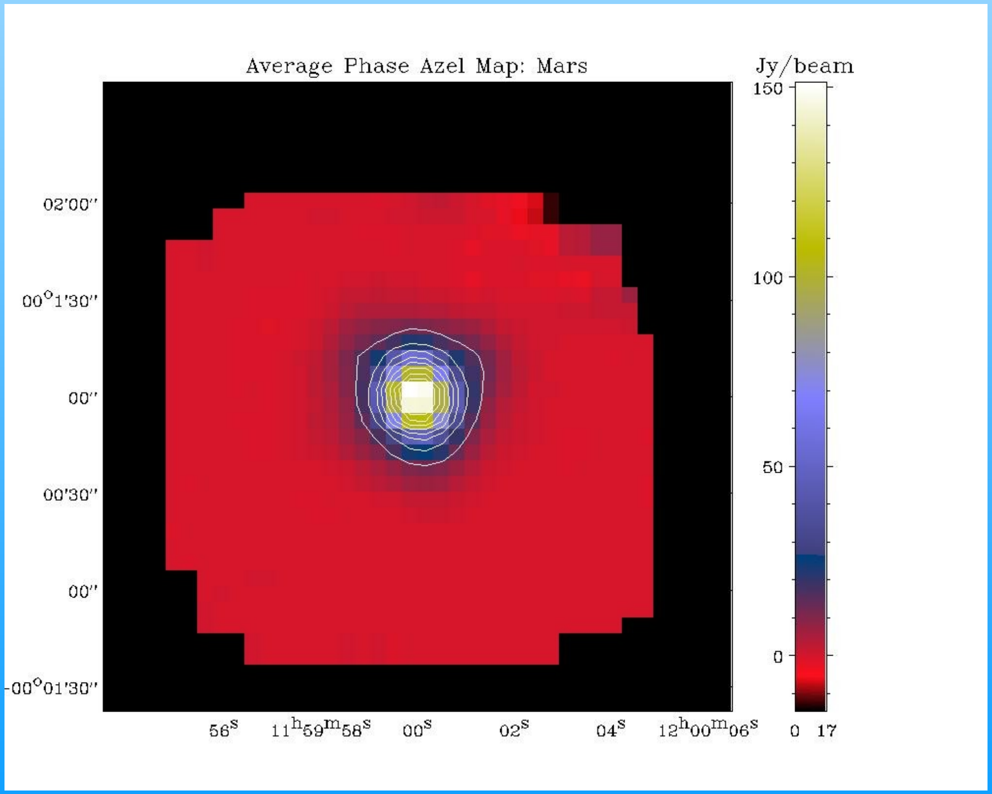
Mapping 2



Average Phase Azel Map: 3C345
Jy/beam
02
00°01'
00
01
−00°02'
11h59m55s
00s
12h00m05s
4
3
2
1
0
0 0
Noise Phase Azel Map: 3C345
Jy/beam
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00

Calibration

Mars: 205 K, 7.47 arcsec diameter, 166 Jy
S/N ~ 440 one second one detector
32 K in a beam of 19 arsecond (190 mK/ Jy)



Correct for the atmospheric opacity Using the 225GHz taumeter and the elevation of the telescope

$$g \cdot s = f_\nu \cdot \exp(-\tau_0 / \sin e)$$

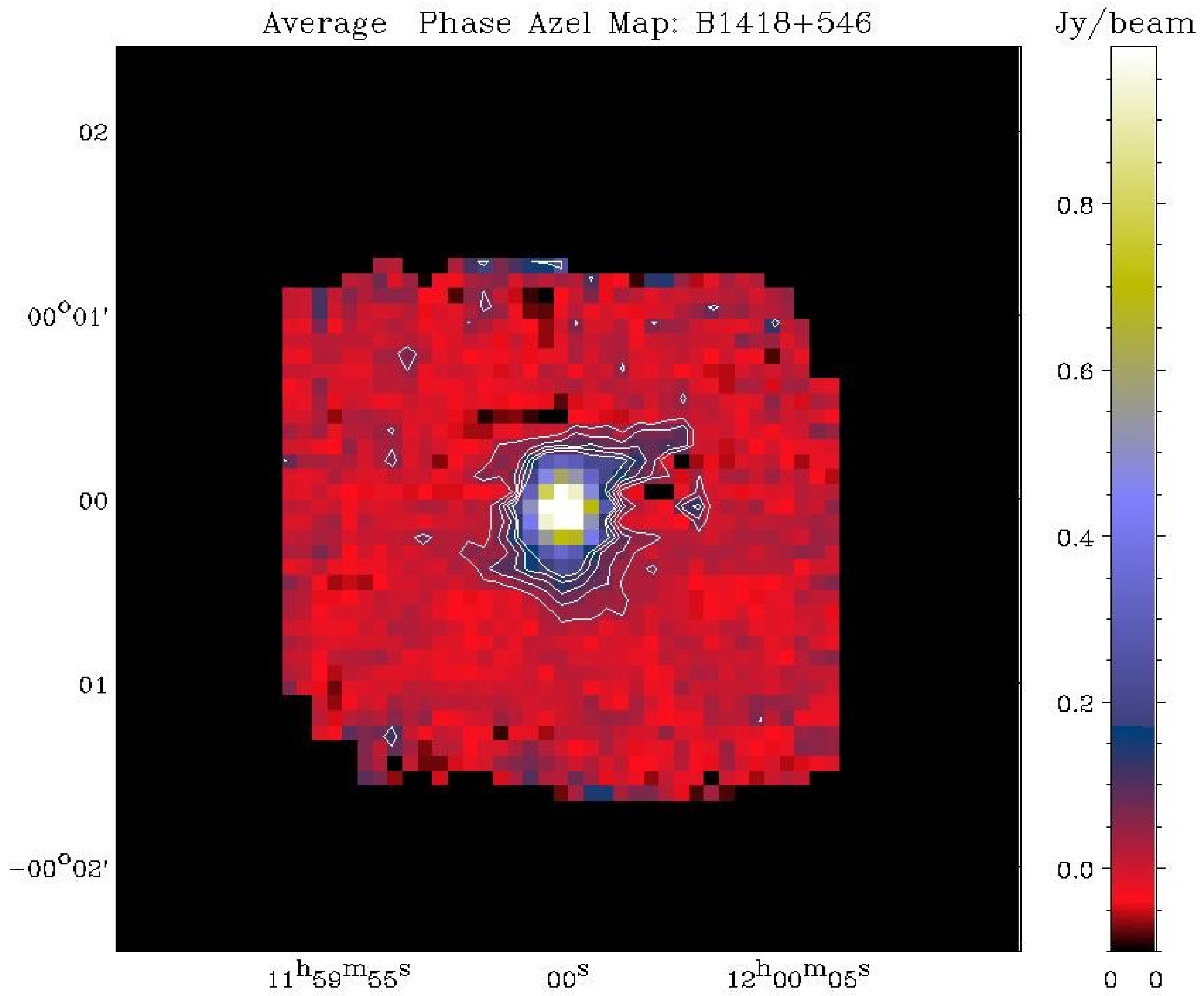
Calibration 2

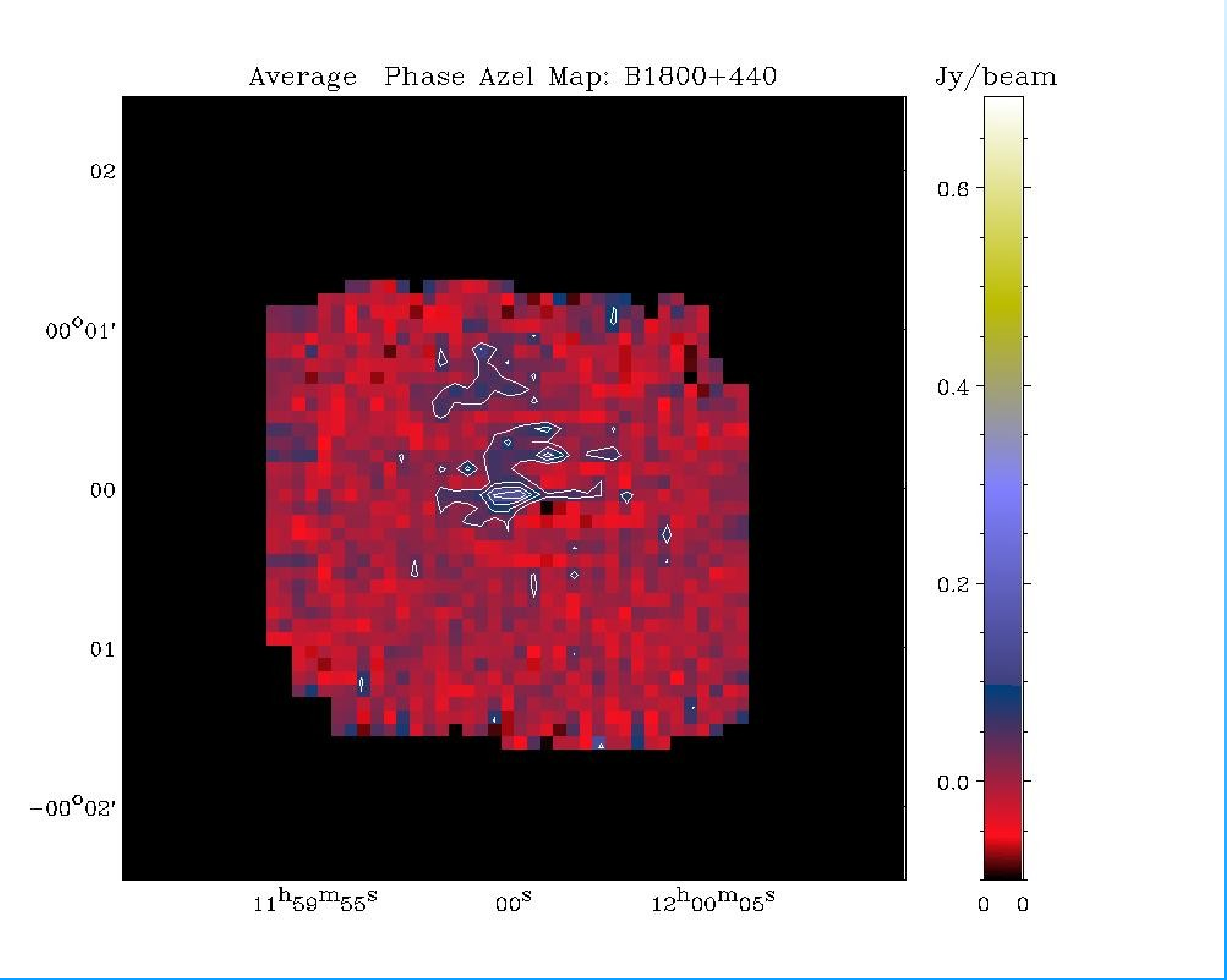
- Try to work with small signals only. No circle method used yet.
- Phase calibration seems to work.

  From 150 to 1.5 Jy, linearity is OK

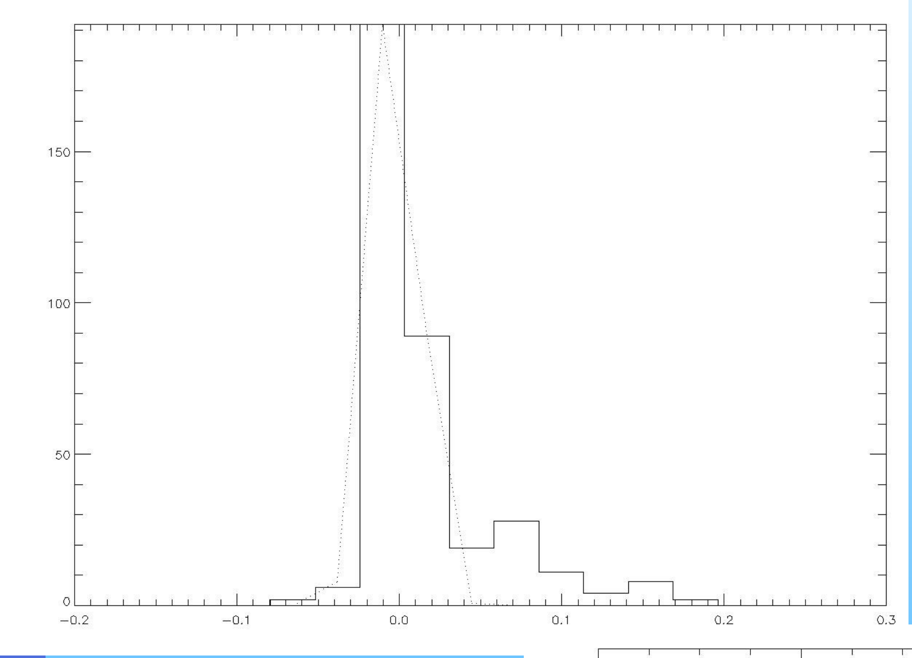
  More difficult for I, Q, Amplitude (factor 2 uncertainty). Understood.
- Need new procedure to ease

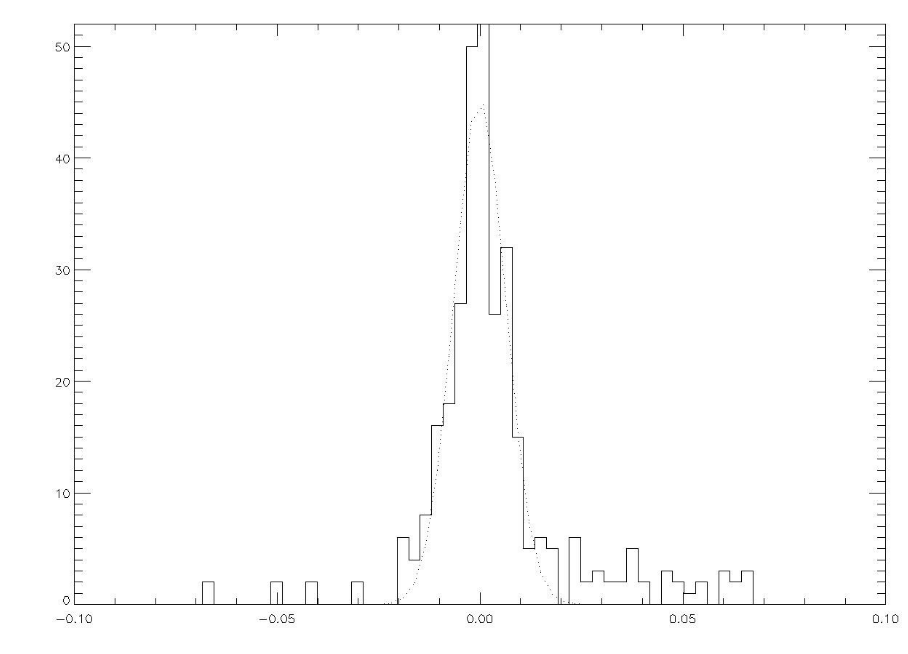
  Frequency Sweep and Tuning between scans

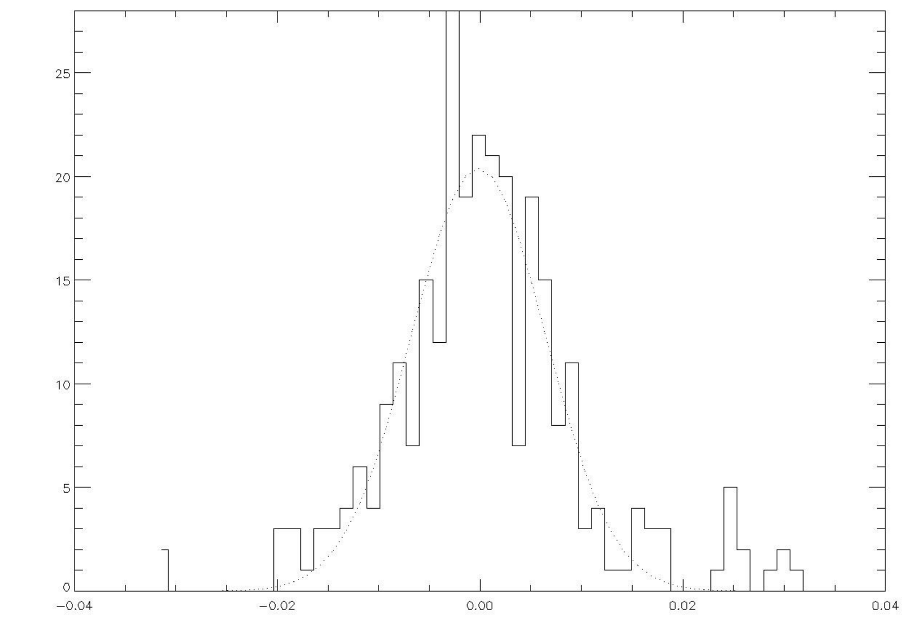

Average Phase Azel Map: B1418+546
Jy/beam
02
00°01′
00
01
−00°02′
11h59m55s
00s
12h00m05s
0.8
0.6
0.4
0.2
0.0
0 0

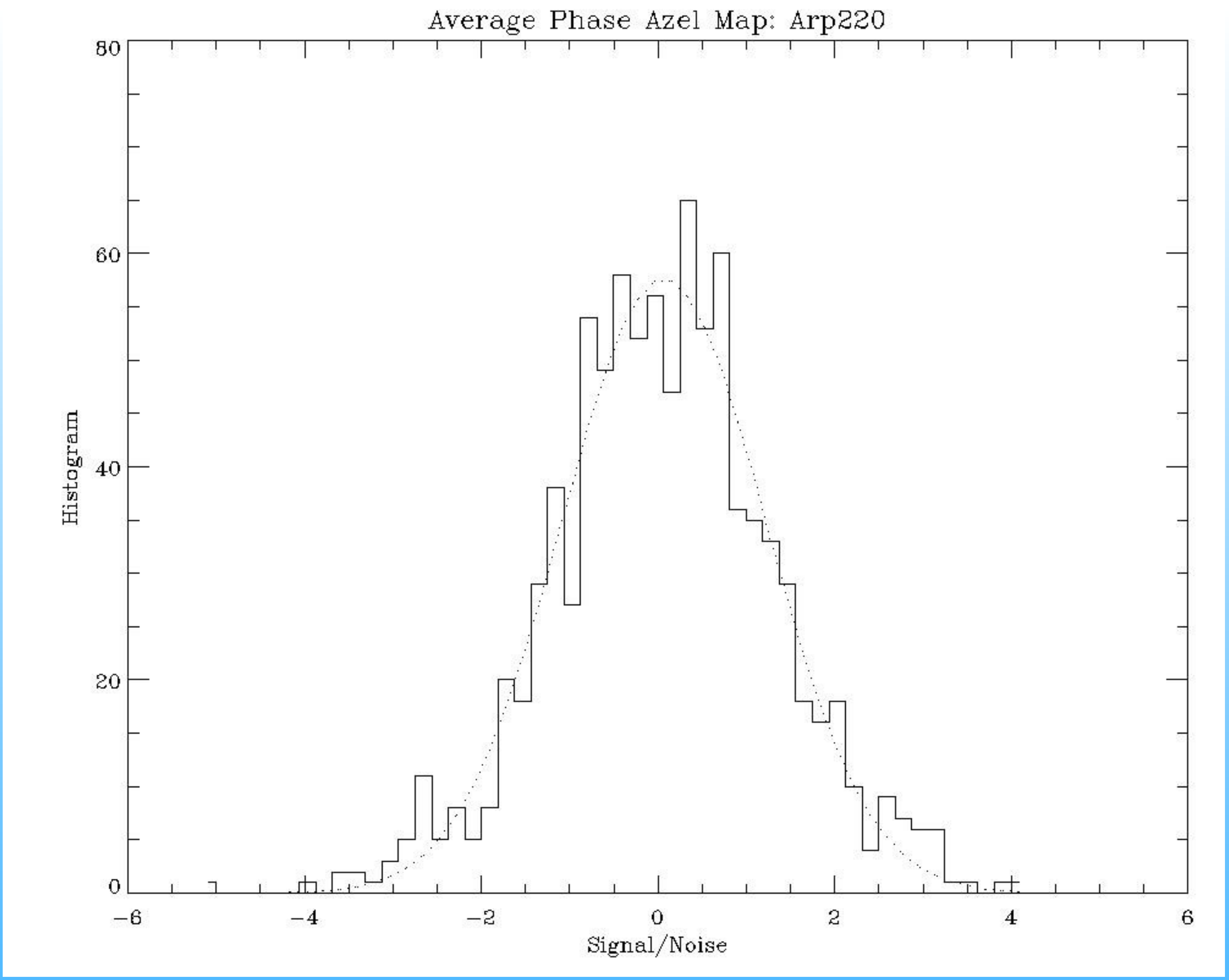

Average Phase Azel Map: B1800+440
Jy/beam
02
00°01′
00
01
−00°02′
11h59m55s
00s
12h00m05s
0.6
0.4
0.2
0.0
0
0

Noise estimation on individual maps (outside sources) by iteration

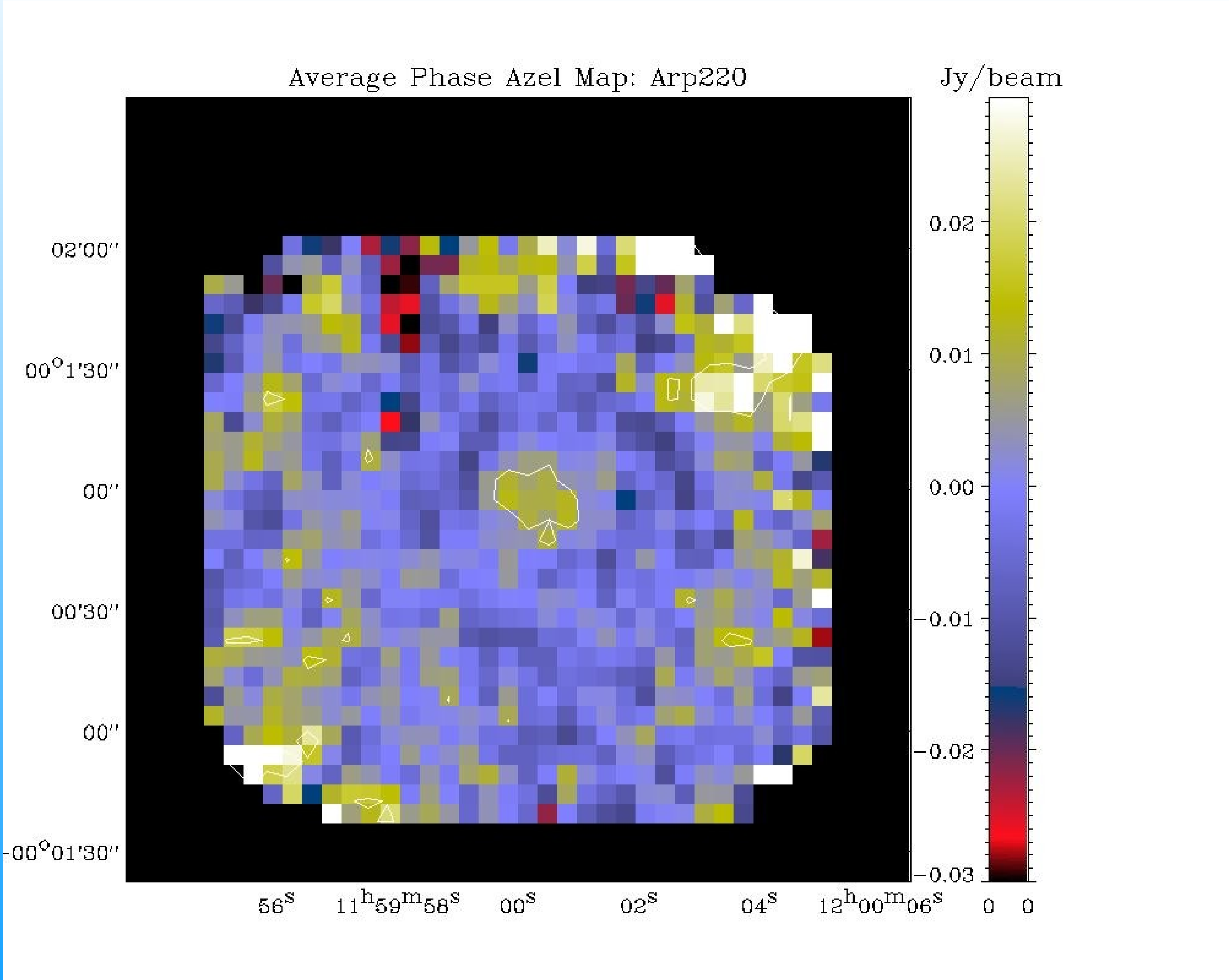




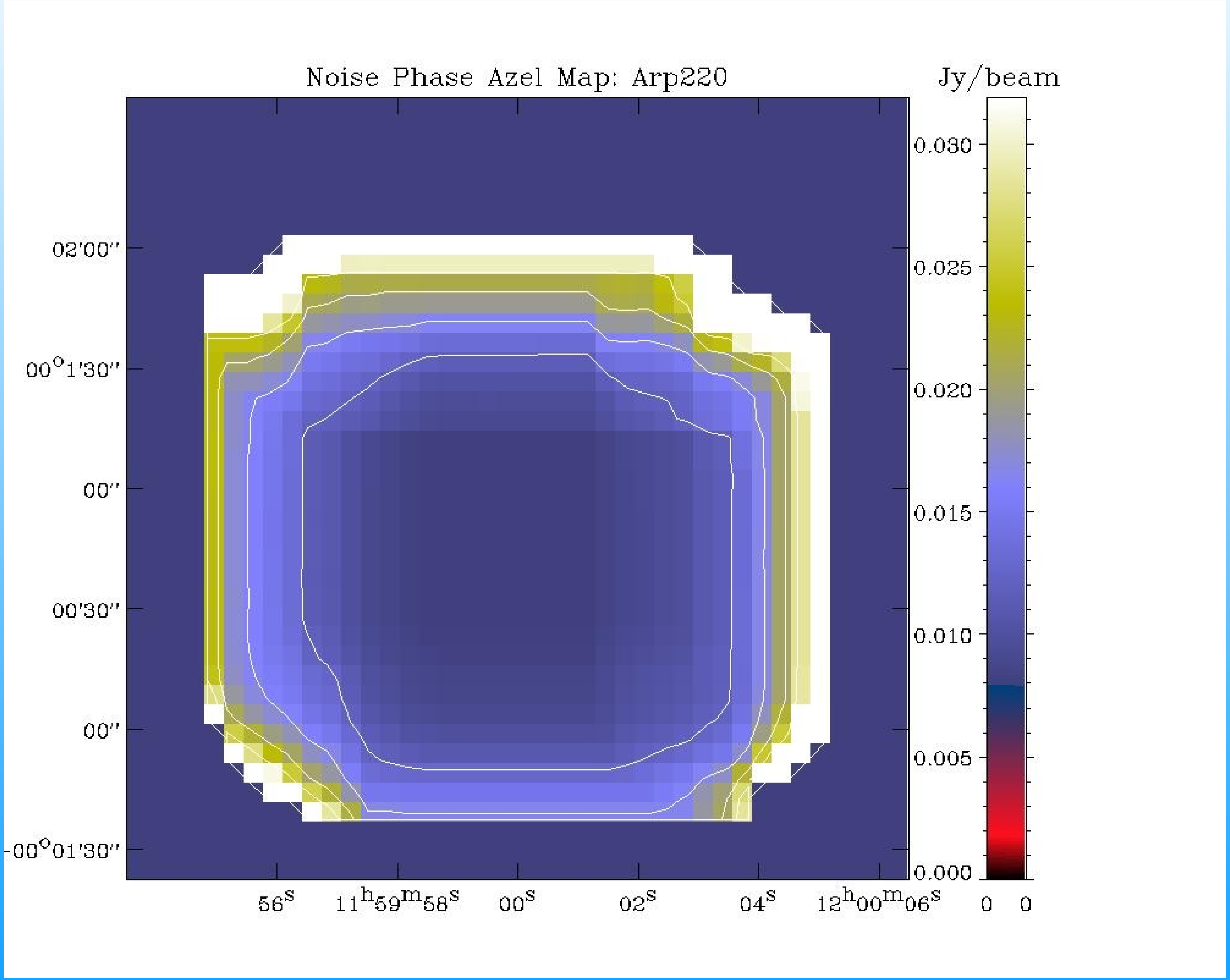




Histogram of signal/noise over the map-->
Noise evaluation and propagation is OK
We check that on sourceless map, the source flux measurement has a correct chi2 statistics (5% precision)



Average Phase Azel Map: Arp220
Jy/beam
02'00"
00°1'30"
00"
00'30"
00"
-00°01'30"
56s
11h59m58s
00s
02s
04s
12h00m06s
0.02
0.01
0.00
−0.01
−0.02
−0.03
0
0


Noise Phase Azel Map: Arp220
Jy/beam
0.030
0.025
0.020
0.015
0.010
0.005
0.000
02'00"
00°1'30"
00"
00'30"
00"
-00°01'30"
56s
11h59m58s
00s
02s
04s
12h00m06s
0 0

Log Observations 24/10/2009
Lekid – Bonn electronics

Source	Scans Dim (arcsec)	Integration time (s) x Nscan	Expected Flux (Jy)	Measured Flux (Phase)	I Q Amp	
Mars	67	210	160			
3C345	69 – 73 90 x 90	210 s x 5	~6.5 @ 100GHz	4.348 ± 0.013	2.851±0.011 4.410±0.015 1.623±0.014	
B1418+546	75 - 82	210 s x 8	~0.5	1.167 ± 0.013	+0.935 ± 0.012 +0.707 ± 0.012 +0.521 ± 0.013	
MWC349	94 – 96	210 s x 3	1.550	1.471 ± 0.029	+1.332 ± 0.027 +0.771 ± 0.026 +1.694 ± 0.032	
B1800+440	98 – 99	210 s x 2	0.5	0.095 ± 0.012	+0.059 ± 0.018 +0.151 ± 0.019 +0.205 ± 0.027	

Log Observations 29/10/2009
Lekid – FPGA electronics

Source	Scans Dim (arcsec)	Integration time (s) x Nscan	Expected Flux (Jy)	Measured Flux (Phase)	I Q Amp	
Mars	56 – 58		160			
3C273	66 – 67 90 x 90	110 s x 2	~15	14.784 ± 0.038	15.539±0.045 15.966±0.048 31.240±0.138	
Arp220	125 - 166	110 s x 32	~0.020	0.007 ± 0.003	-0.001±0.004 +0.006 ± 0.005 +0.038 ±0.015	

Sensitivity

$$rms_{det}\,(1\,\sigma) = \frac{NEFD_{det}}{\sqrt{t}}$$

$$T = \frac{\Omega_{map}}{\omega_{Airy}}\,t_{Airy}$$

$$\Omega_{array} = N_{det}\,\frac{\omega_{Airy}}{K_{overs}}$$

Allows comparison of different arrays

$$rms_{scan} = \frac{NEFD}{\sqrt{T\,N_{det}}}\sqrt{\frac{\Omega_{map}}{\omega_A}} = \frac{NEFD_{Airy}}{\sqrt{T}}\sqrt{\frac{\Omega_{map}}{\Omega_{array}}}$$

$$NEFD_{Airy} = \frac{NEFD_{det}}{\sqrt{K_{overs}}}$$

Choice of observing strategy

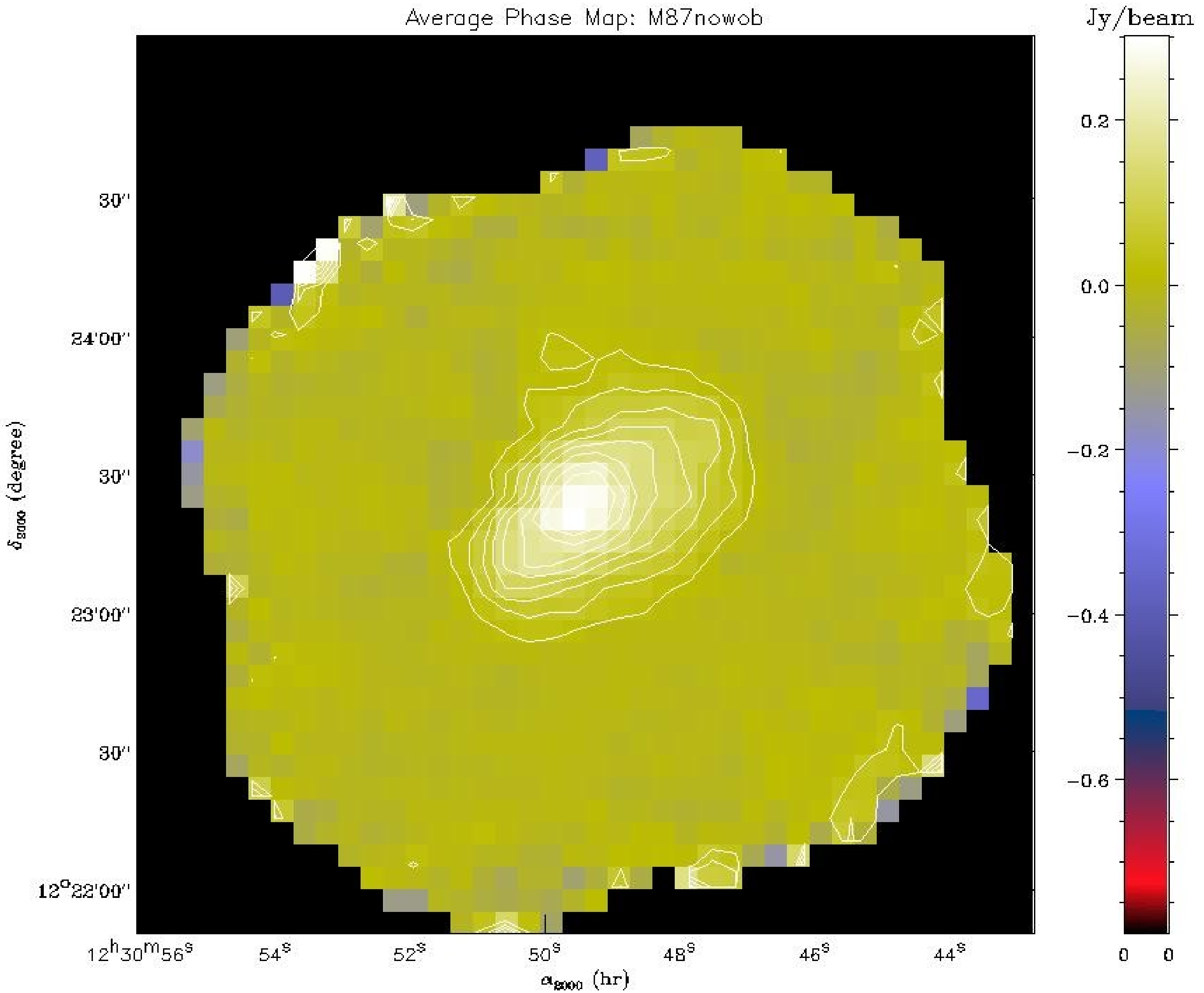
Sensitivity 2 : Lekid example

- K_overs= $(0.63)^{-2}$ = 2.5 [4 for Ant. Kid]
- Omega_map= (120x120)=14400 arcsec^2
  Omega_array = (25*284/2.5)=2840

  rms = 37 mJy for all det., one scan of 210 sec.
- $\text{NEFD}_{\text{Airy}}$=240 mJy $s^{1/2}$ (+- 50)
- Arp220 long integration (90x90 map)

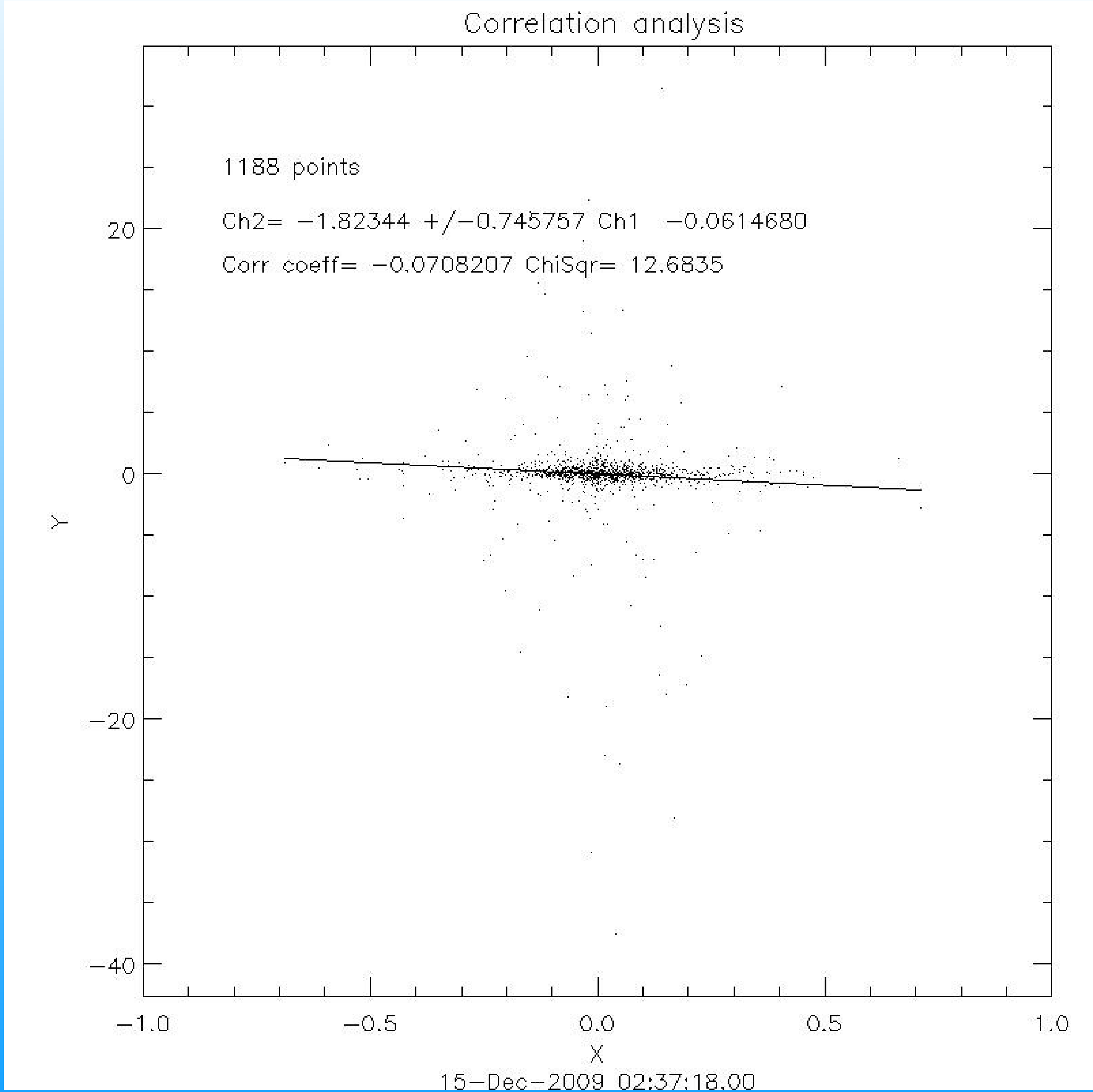
  2.9 mJy, all det., all scans (44) of 110 s
- NET_{Airy} = 46 $\text{mK.s}^{1/2}$
- NEP_{Det} = 2.5 10^{-15} W. $\text{Hz}^{-1/2}$

Mapping capability on M87



Perspective

- Not all scans looked at
- Use true pointing
- Compare with other processing methods
- Wobbler observations
- Find the optimal S/N variable


Correlation analysis
1188 points
Ch2= −1.82344 +/−0.745757 Ch1 −0.0614680
Corr coeff= −0.0708207 ChiSqr= 12.6835
20
0
−20
−40
Y
−1.0
−0.5
0.0
0.5
1.0
X
15−Dec−2009 02:37:18.00