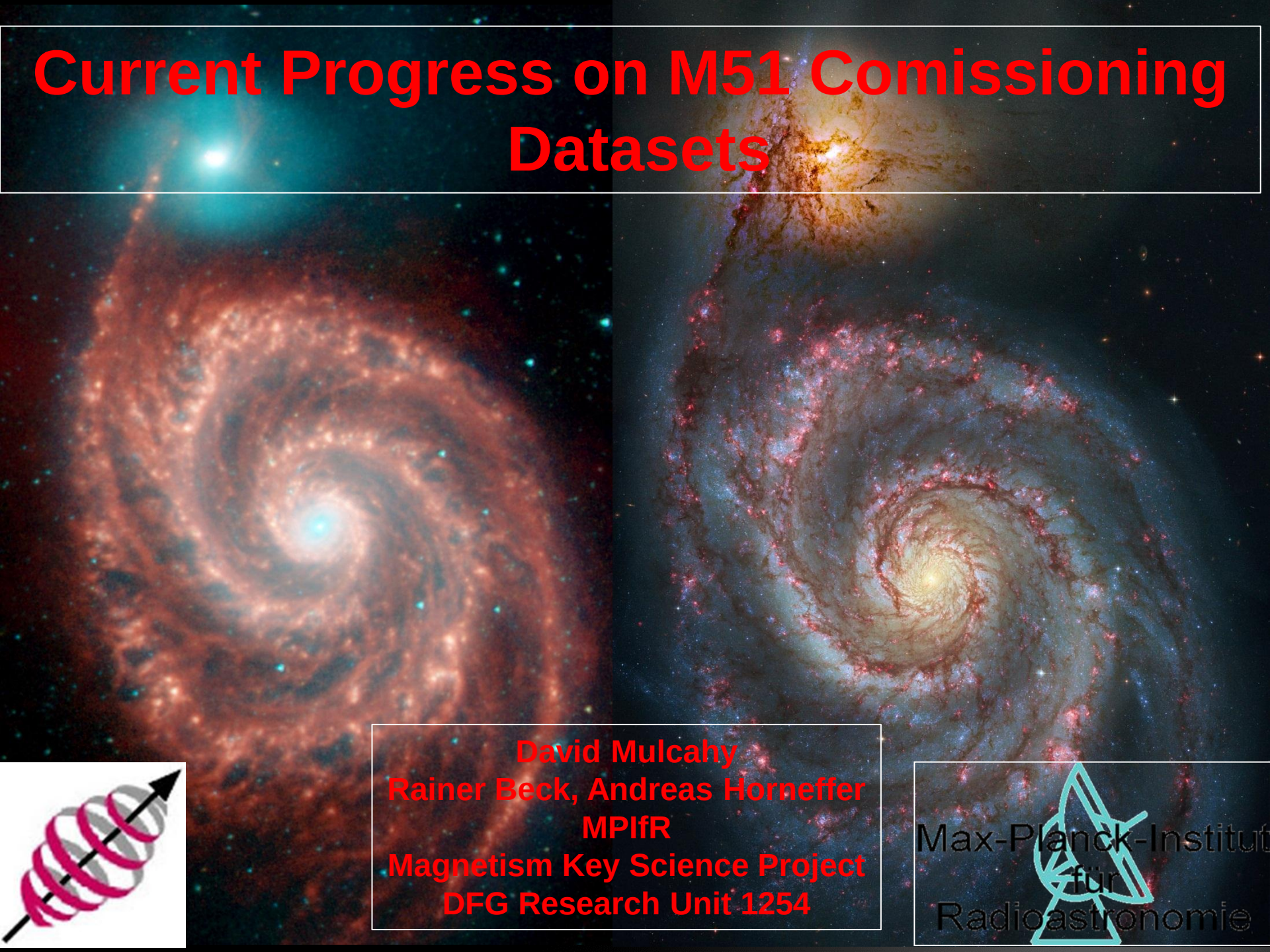
Current Progress on M51 Comissioning Datasets



David Mulcahy
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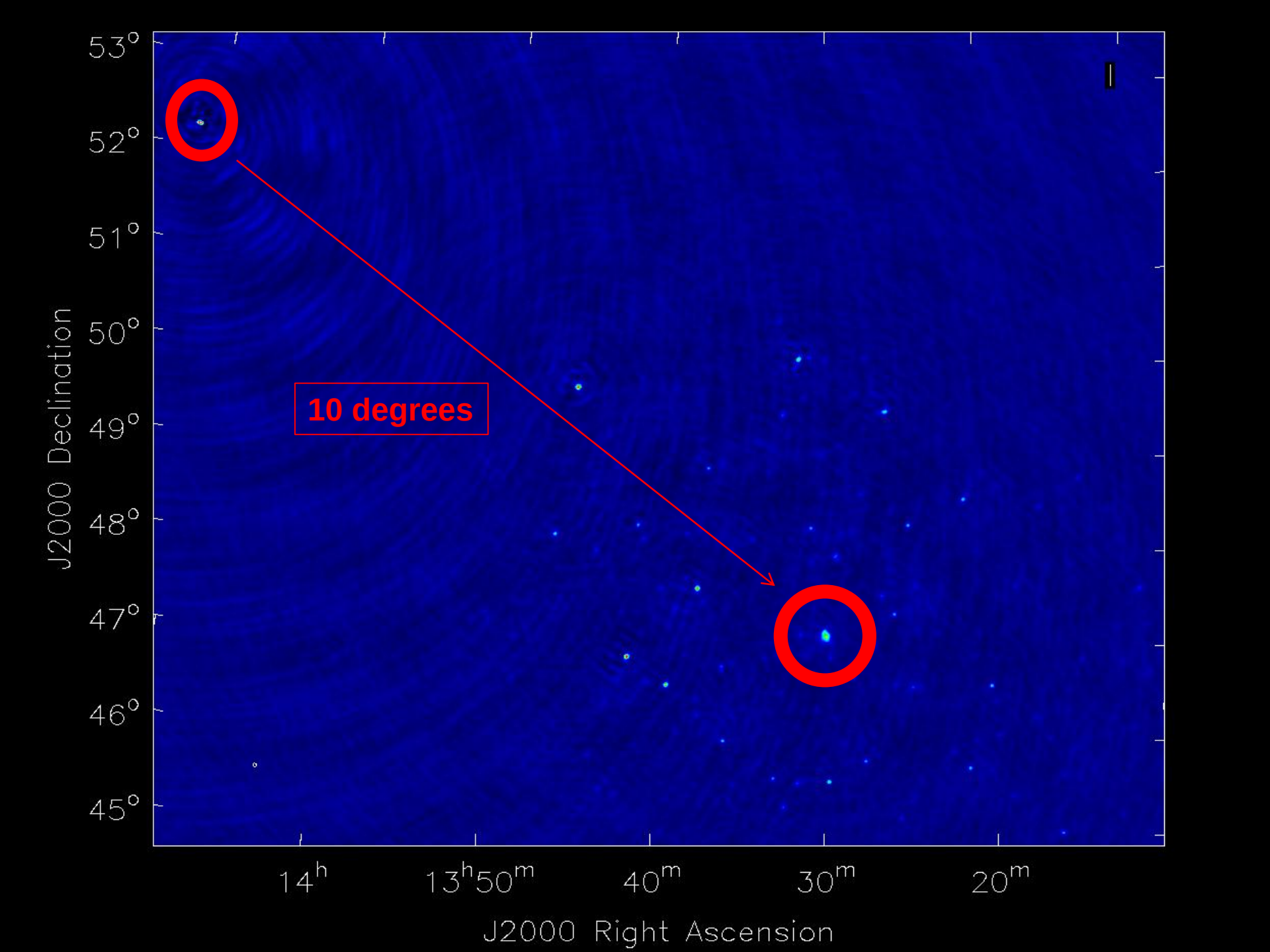
Magnetism Key Science Project
DFG Research Unit 1254

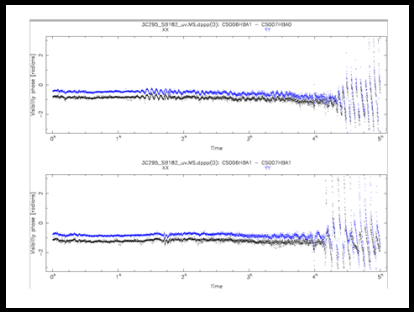
Max-Planck-Institut für Radioastronomie

Outline of Talk

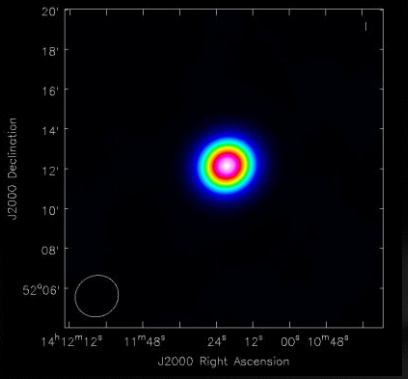
- Commissioning Results from Old Observation
- Using Transfer of Gains from different beams to achieve calibration
- Interpolation of Gain Solutions in Frequency
- Resulting Images from this Observation
- Issues with the old observation
- Commissioning Progress with New Observation
- Identification of bad stations and preprocessing
- First Images
- Future Work


53°
52°
51°
50°
49°
48°
47°
46°
45°
J2000 Declination
10 degrees
14h
13h50m
40m
30m
20m
J2000 Right Ascension

Preprocessing

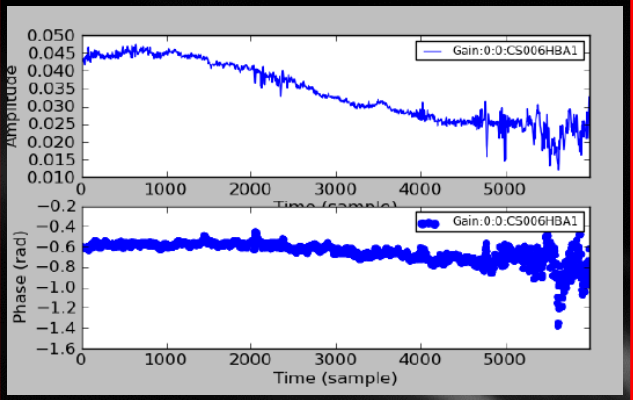


Calibrate the Calibrator



Calibrator: 3C295

Analyze Gains

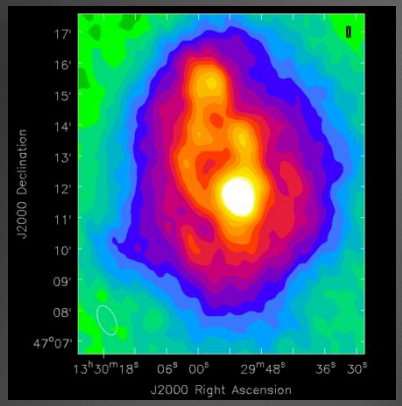


Apply Gains to the target field
--instrument-db
3C295.MS/instrument

uv-plane-cal-transfer.parset
Model.Beam.Enable = T
Solves for all 4 elements in the gain Jones' matrix

Scaife & Heald skymodel
Specifies direction only
for target

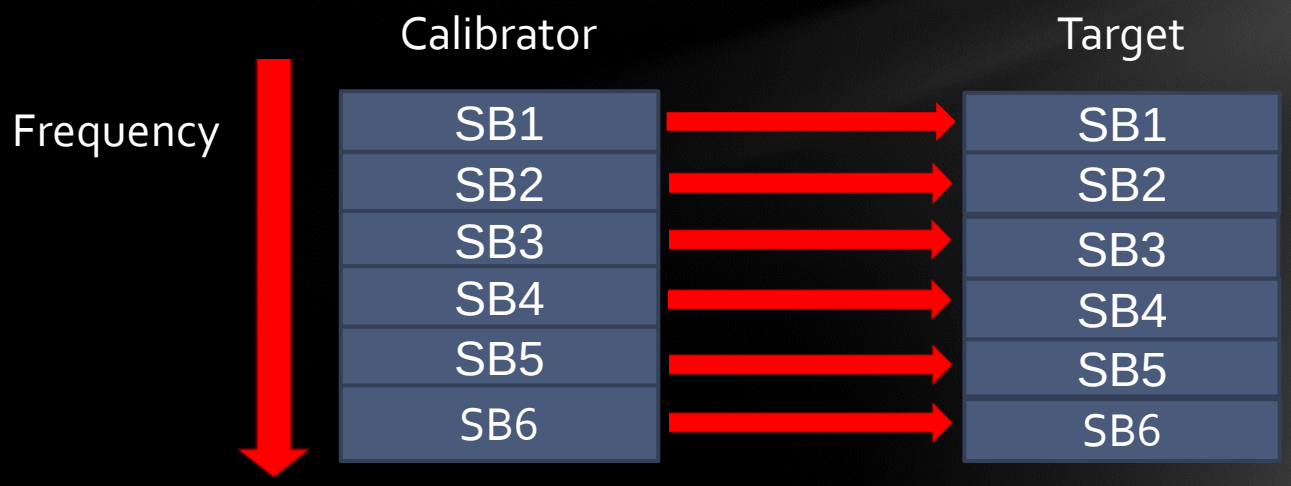
Correct.parset – only solve steps
Model.Beam.Enable = T



Image!!!

Motivation for Gain Interpolation

- At present, an equal amount of subbands must be used on both the calibrator and the target source.
- Therefore, observing bandwidth on the target source is halved.
- Decreasing the number of subbands used for calibration is very desirable.



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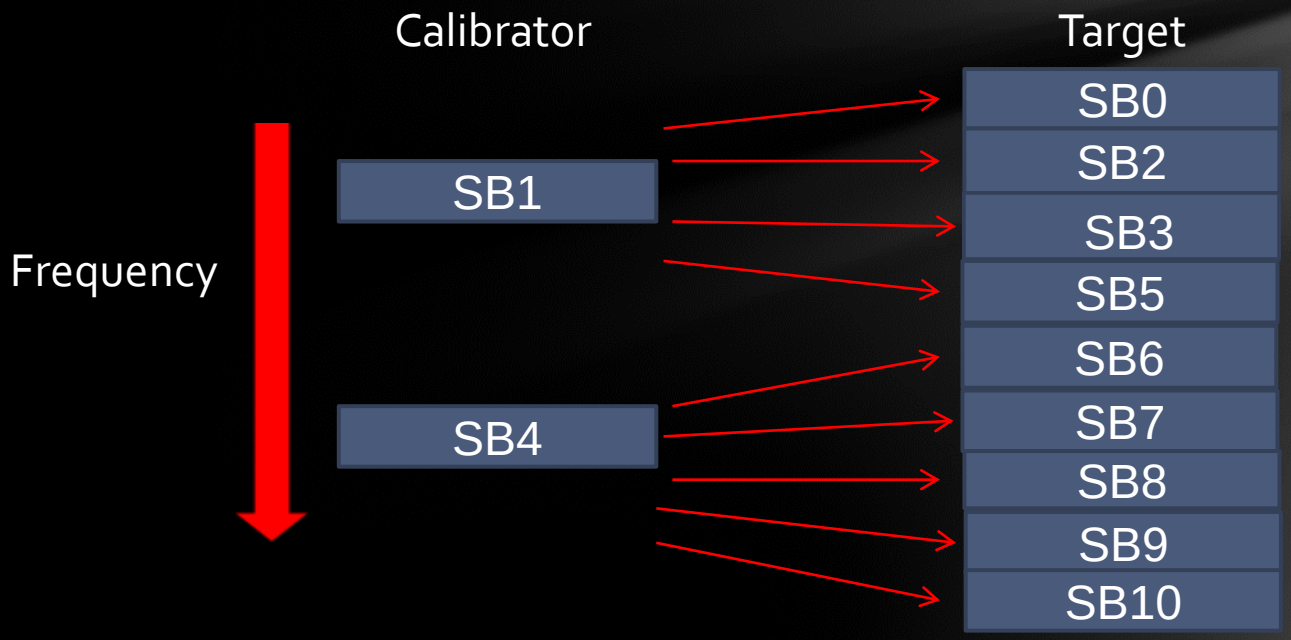
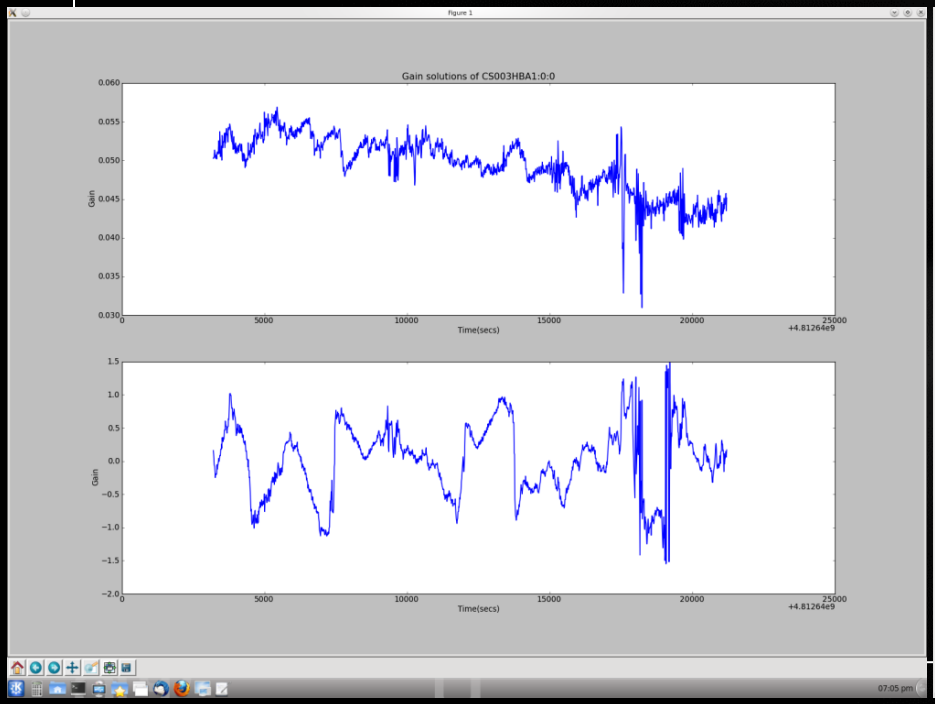
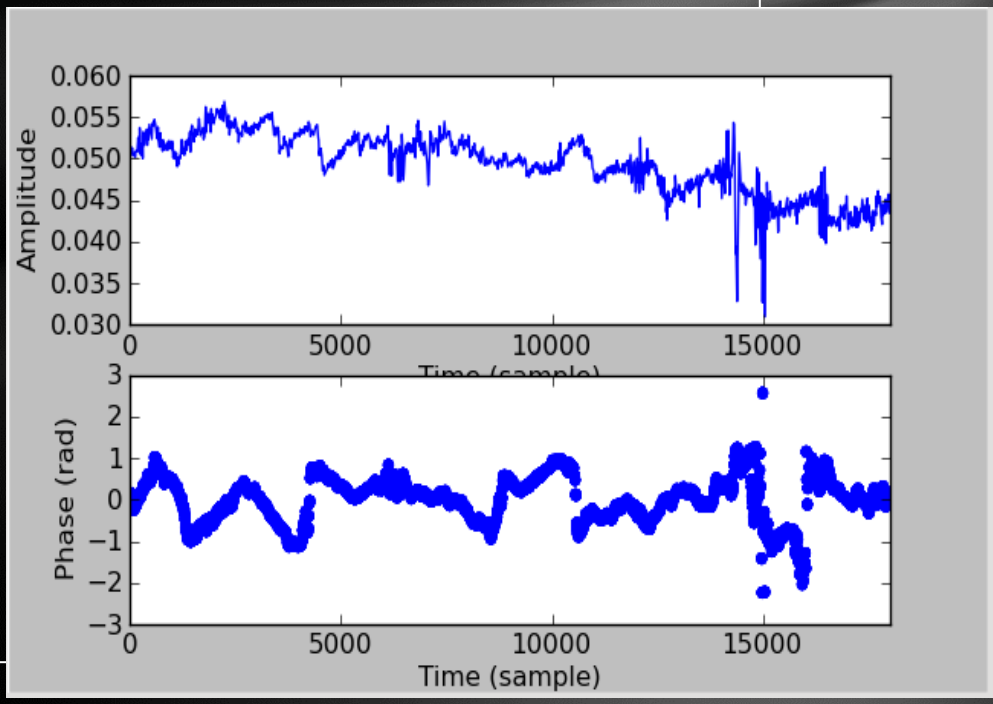


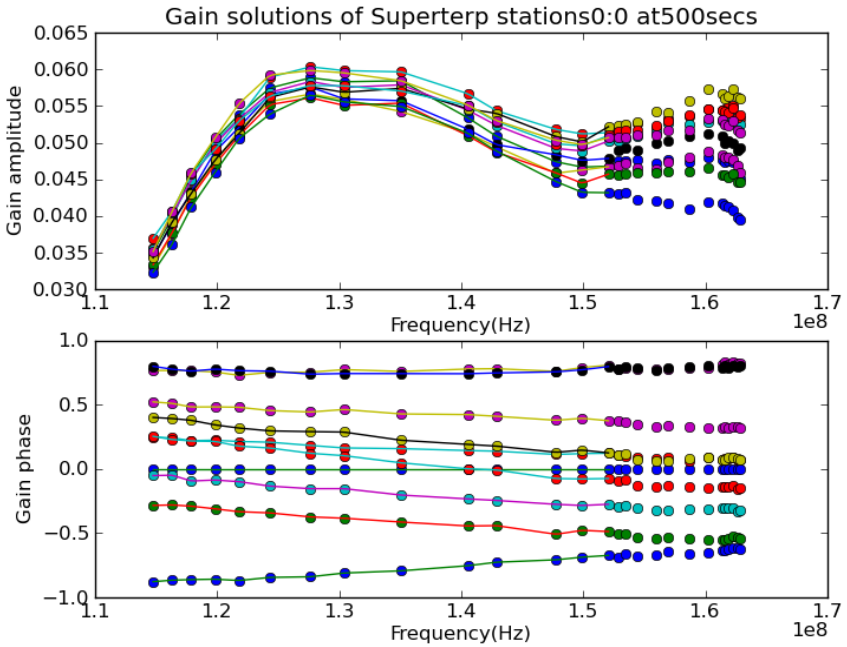
- Study of Gain Solutions of the calibrated 3C295 measurement set through the Python package parmdb package. (import lofar.parmdb as pdb)
- Firstly, program had to retrieve the real & complex values of the gains from the instrument table, calculate the gain amplitude and phase.
- To check I compared program output to parmdbplot output:

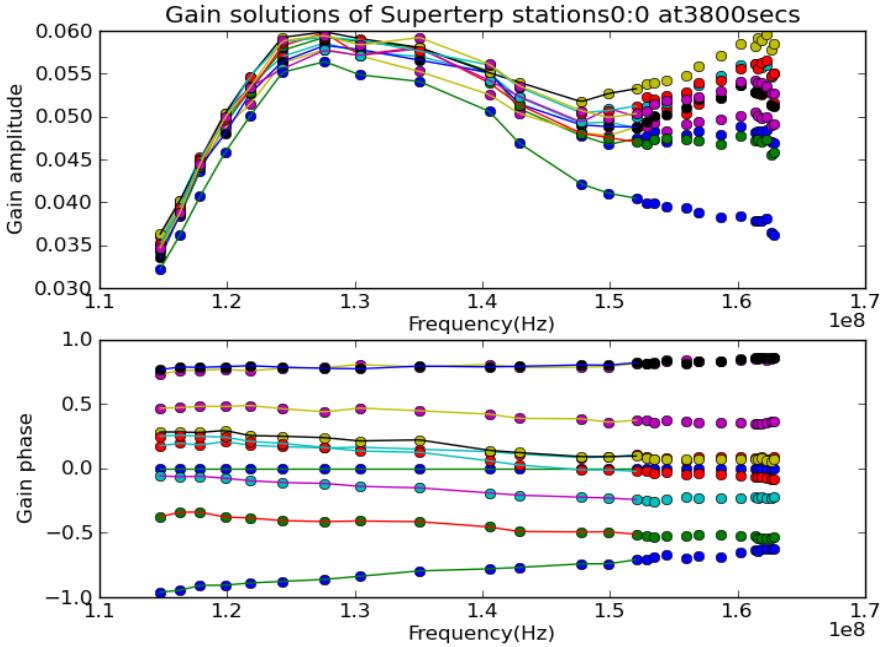
From Program

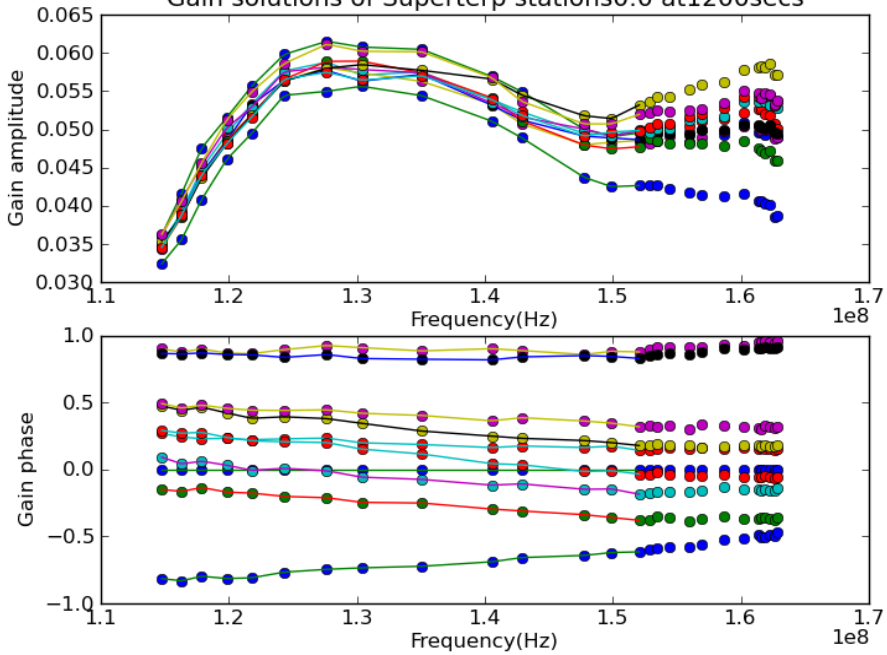


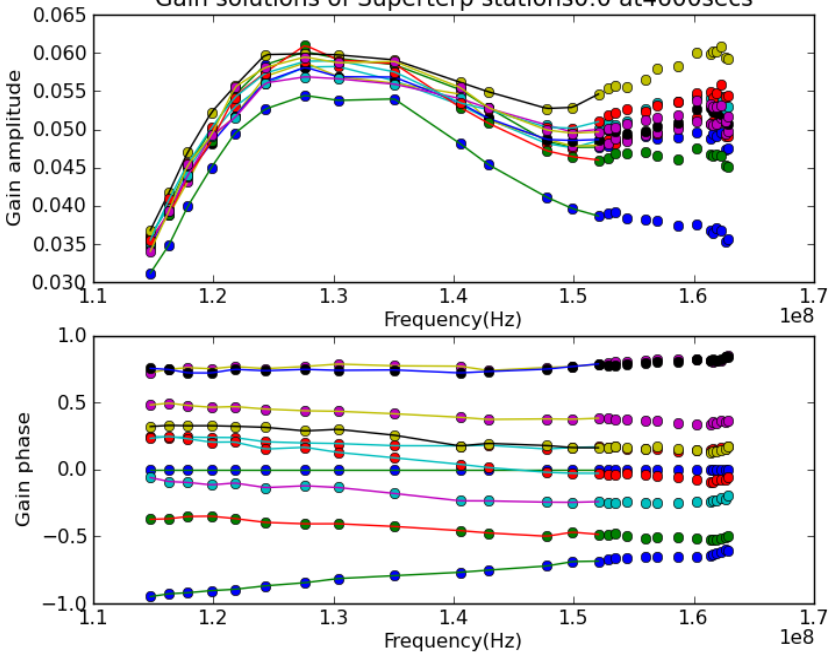
From Parmdbplot

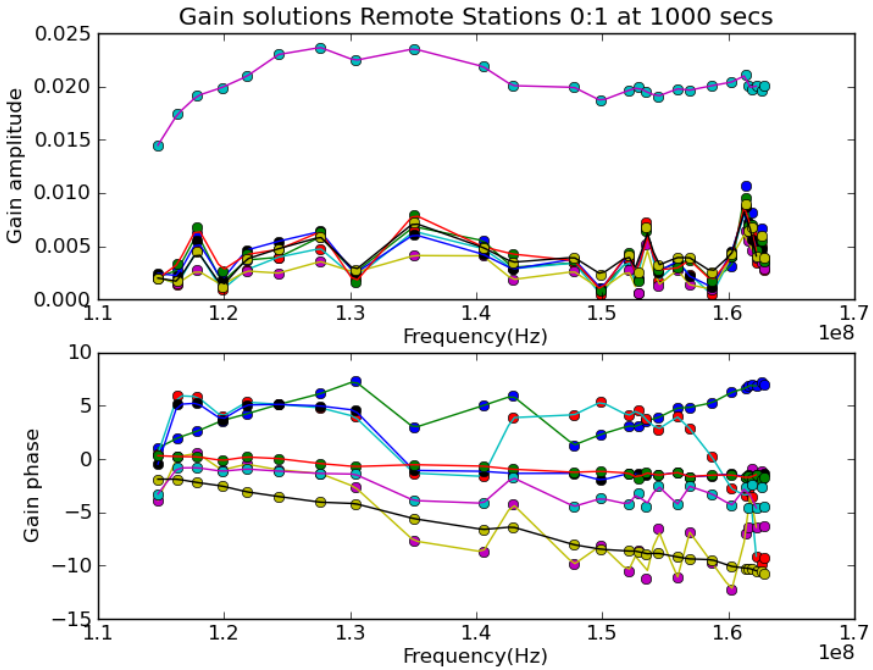


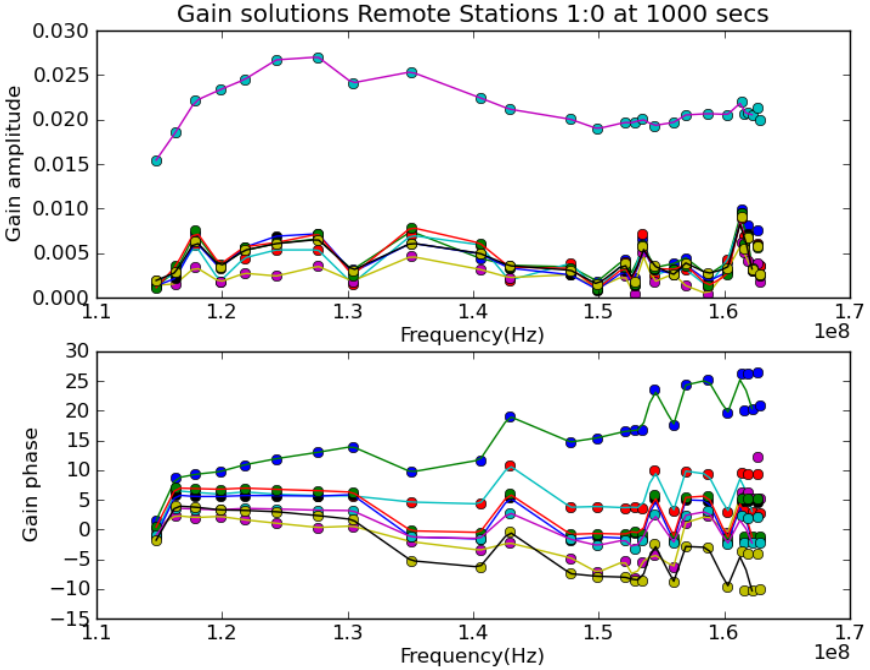

Gain solutions of Superterp stations0:0 at500secs
Gain amplitude
Frequency(Hz)
1e8
Gain phase
Frequency(Hz)
1e8


Gain solutions of Superterp stations0:0 at3800secs
Gain amplitude
Frequency(Hz)
1e8
Gain phase
Frequency(Hz)
1e8

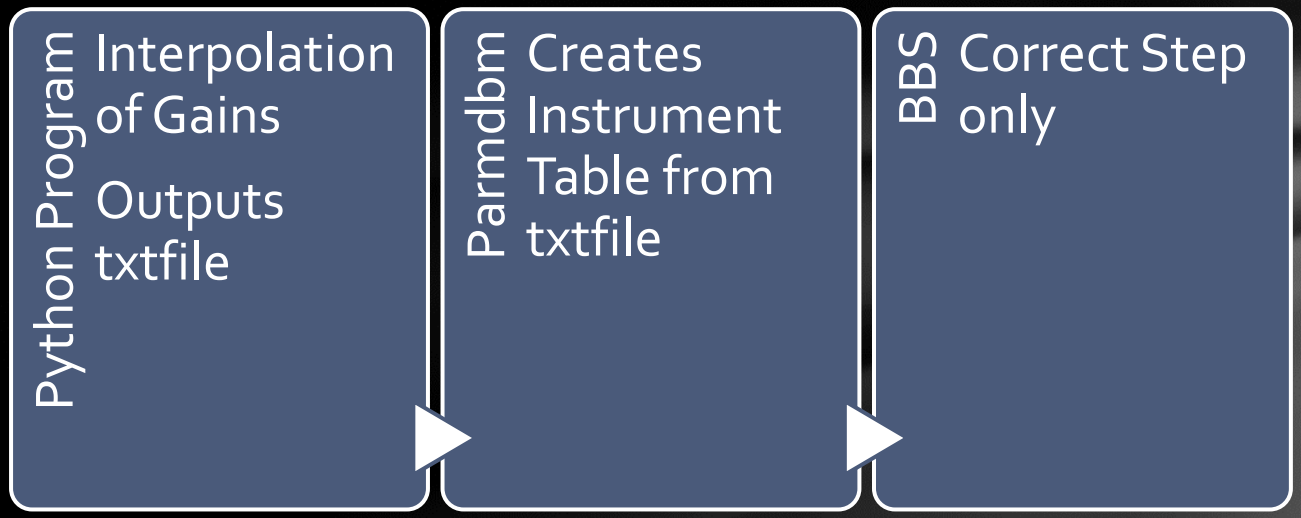

Gain solutions of Superterp stations0:0 at1200secs
Gain amplitude
Frequency(Hz)
1e8
Gain phase
Frequency(Hz)
1e8


Gain solutions of Superterp stations0:0 at4600secs
Gain amplitude
Frequency(Hz)
1e8
Gain phase
Frequency(Hz)
1e8


Gain solutions Remote Stations 0:1 at 1000 secs
Gain amplitude
0.025
0.020
0.015
0.010
0.005
0.000
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1e8
Frequency(Hz)
Gain phase
10
5
0
−5
−10
−15
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1e8
Frequency(Hz)


Gain solutions Remote Stations 1:0 at 1000 secs
Gain amplitude
0.030
0.025
0.020
0.015
0.010
0.005
0.000
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1e8
Frequency(Hz)
Gain phase
30
25
20
15
10
5
0
−5
−10
−15
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1e8
Frequency(Hz)

Entire Gain Interpolation Process

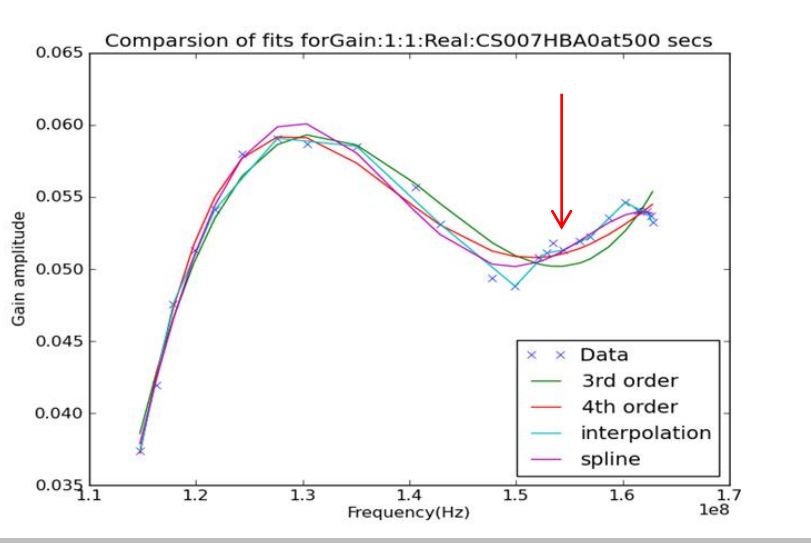


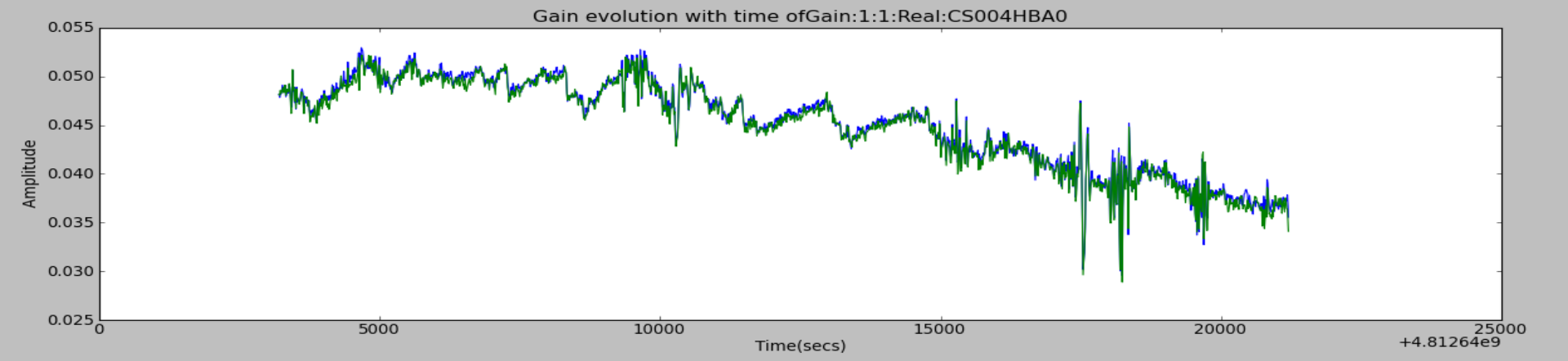
Detailed Description of Software can be found at:

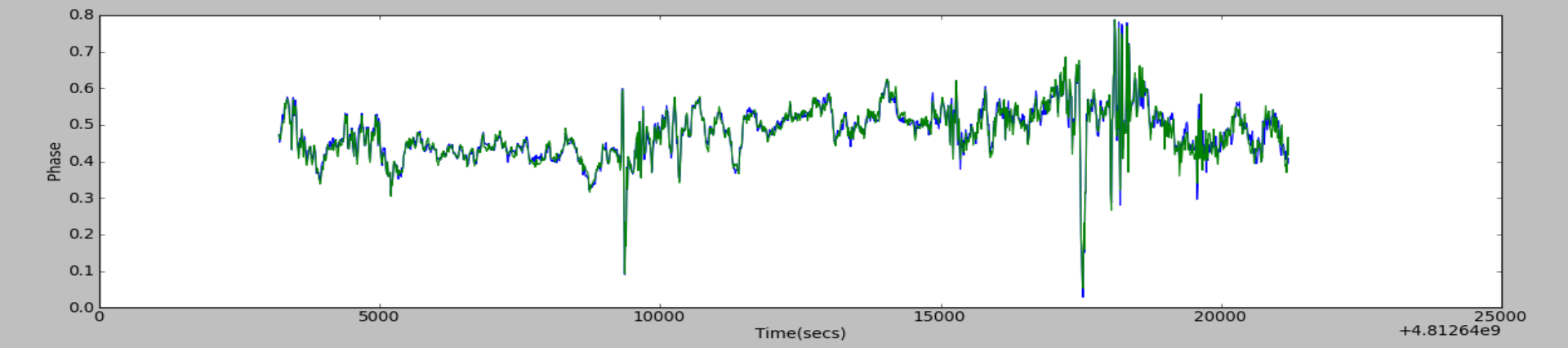
http://www.lofar.org/wiki/doku.php?id=commissioning:pol_commissioning

Testing the model

- Used program to predict and compare with subband (156MHz) not used in creating model.
- Blue is created model, Green are values obtained directly from the subband.

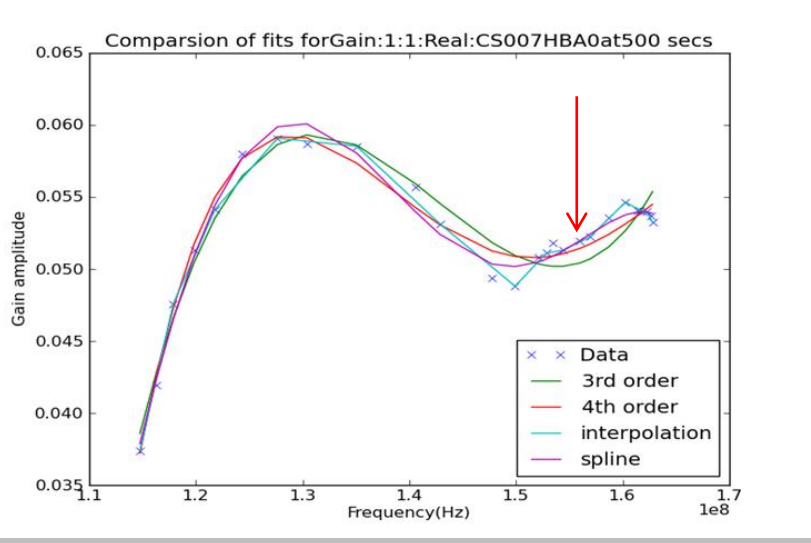


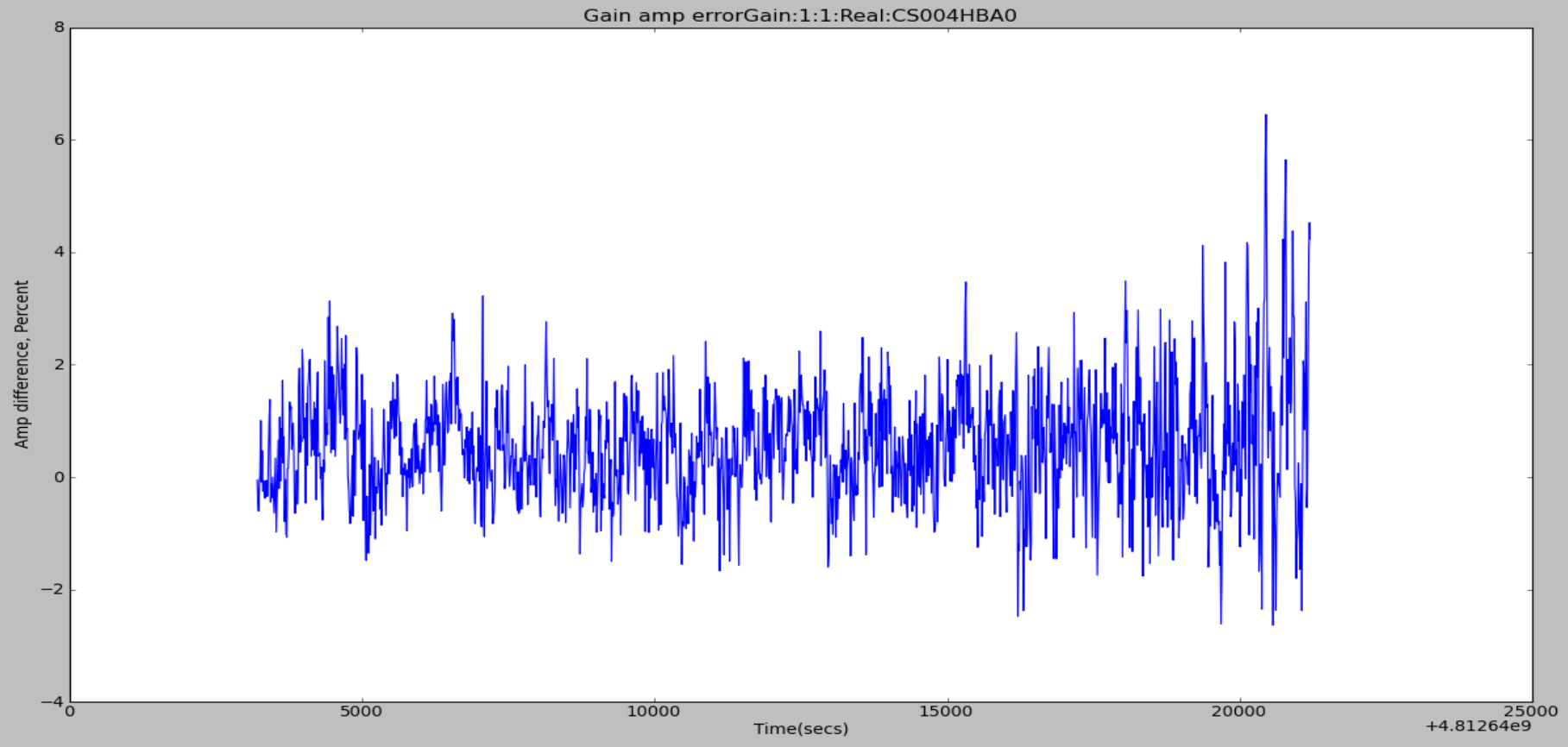




Testing the model

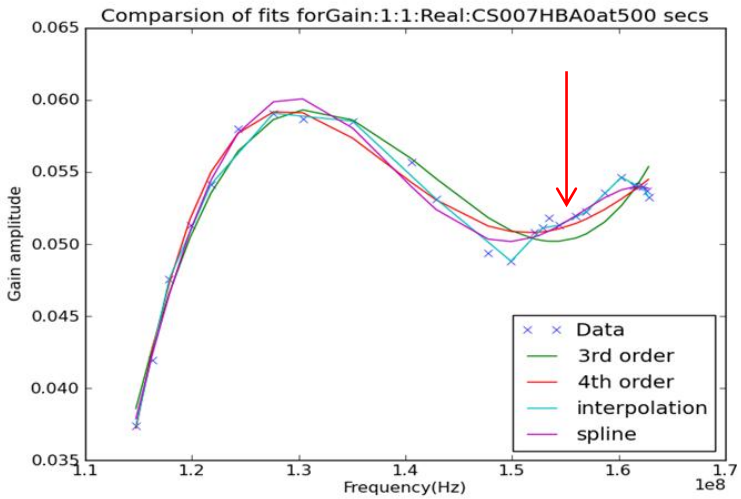
- Used program to predict and compare with subband (156MHz) not used in creating model.
- The difference in amplitude between real and model shows a difference of about 1% until the very end of the observation.

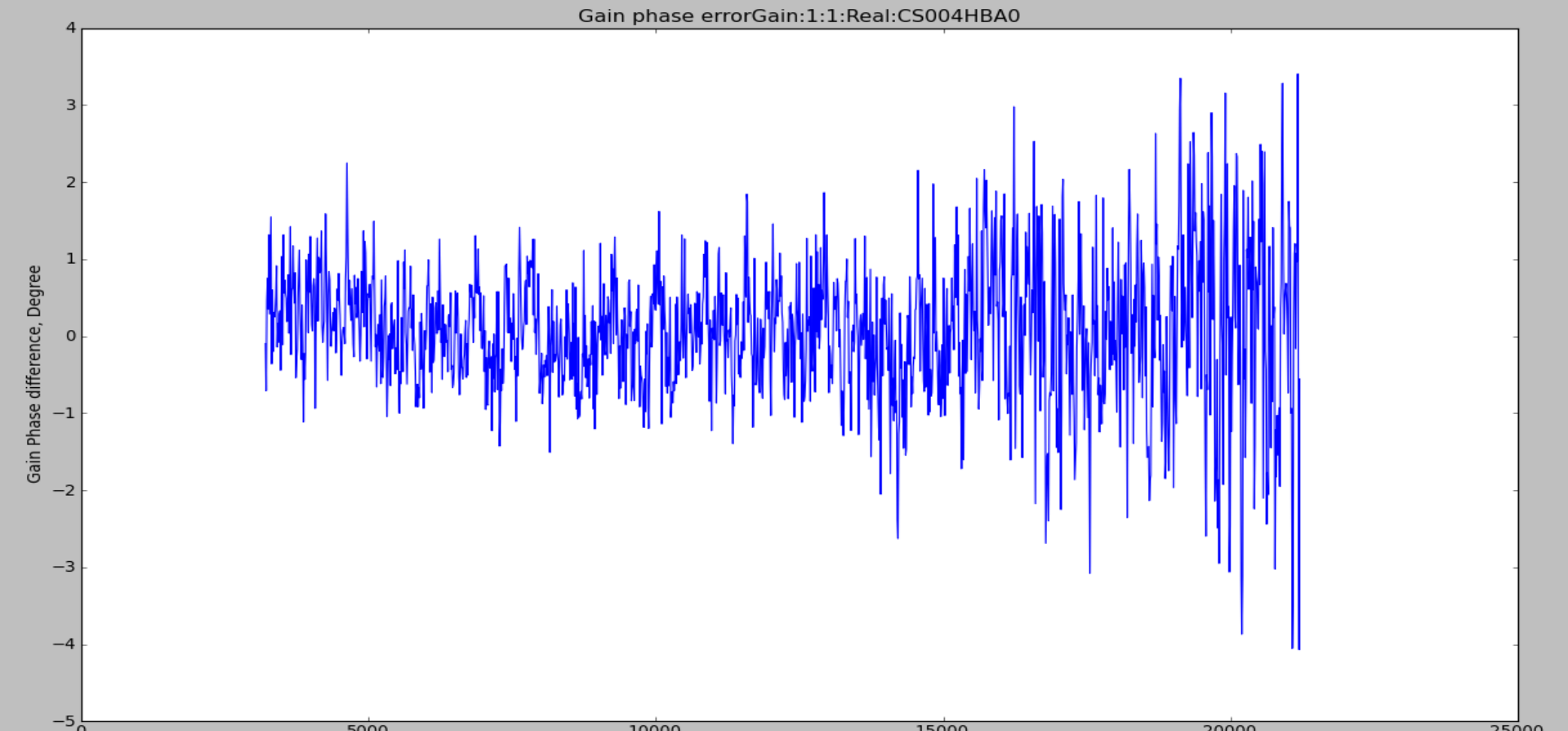




Testing the model

- Used program to predict and compare with subband (156MHz) not used in creating model.
- The difference in amplitude between real and model shows a difference of about 1% until the very end of the observation.
- Difference in phase shows an error of about 1 degree which increases at the end of the observation.





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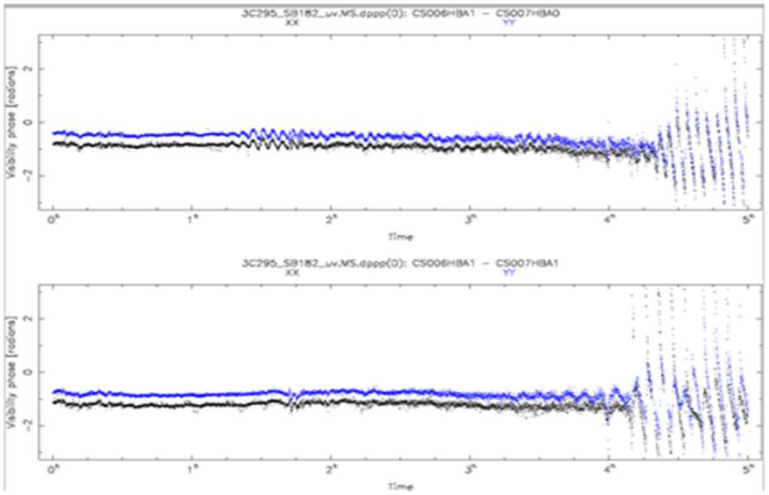
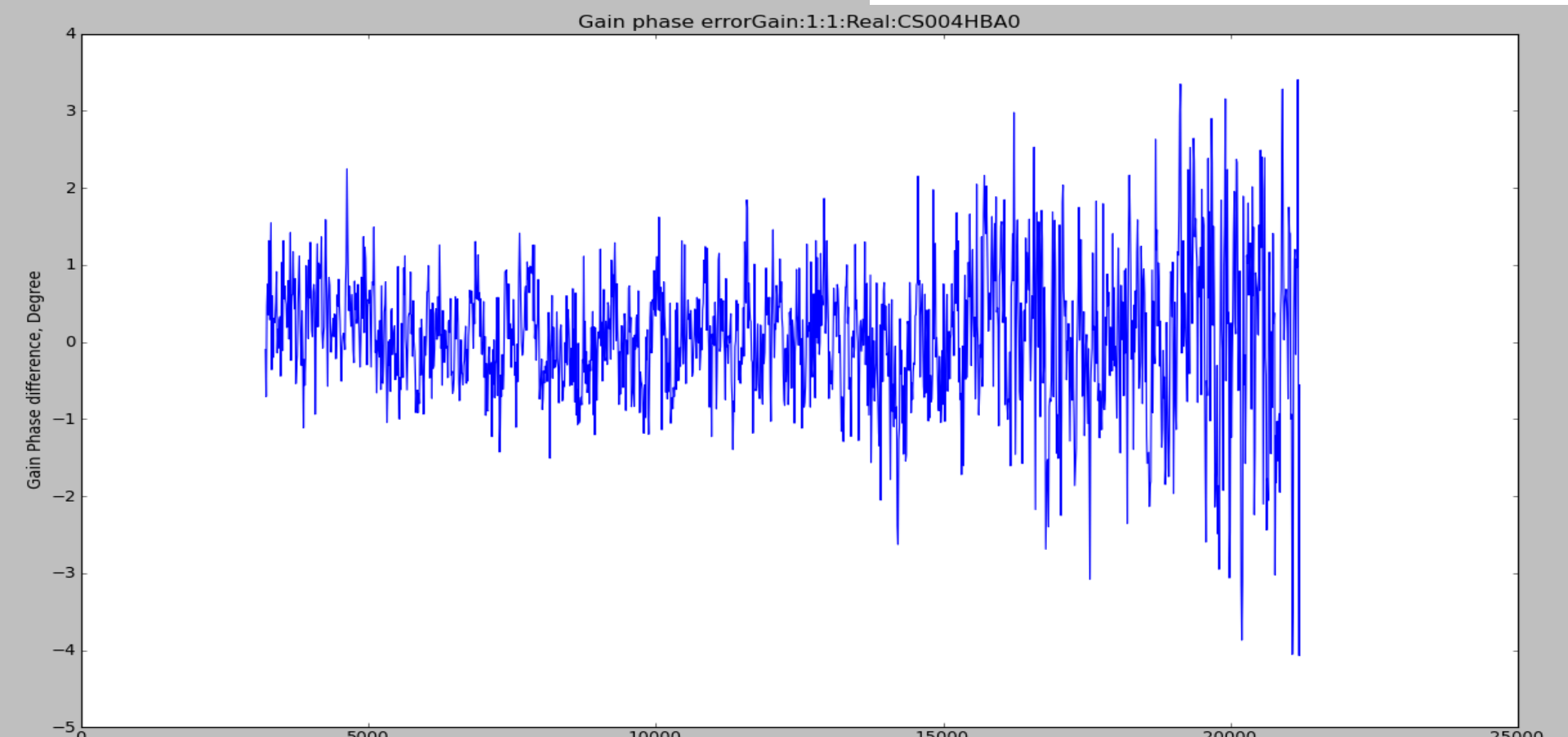
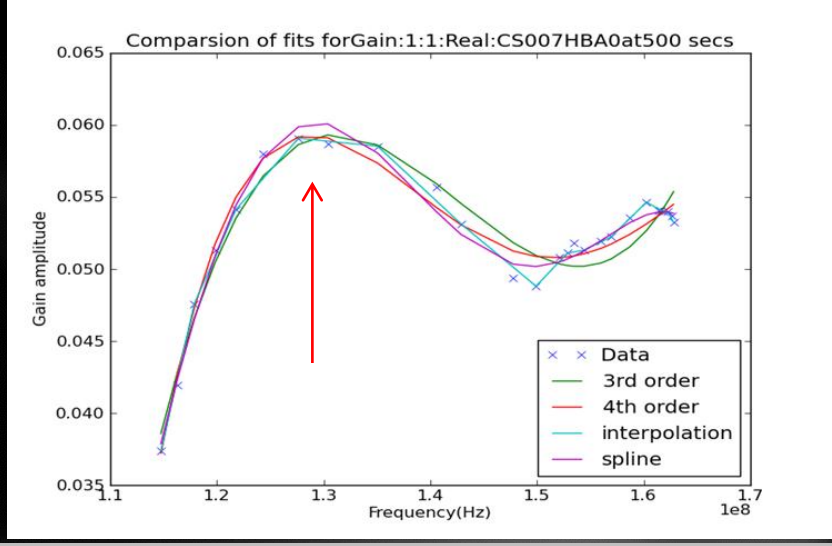
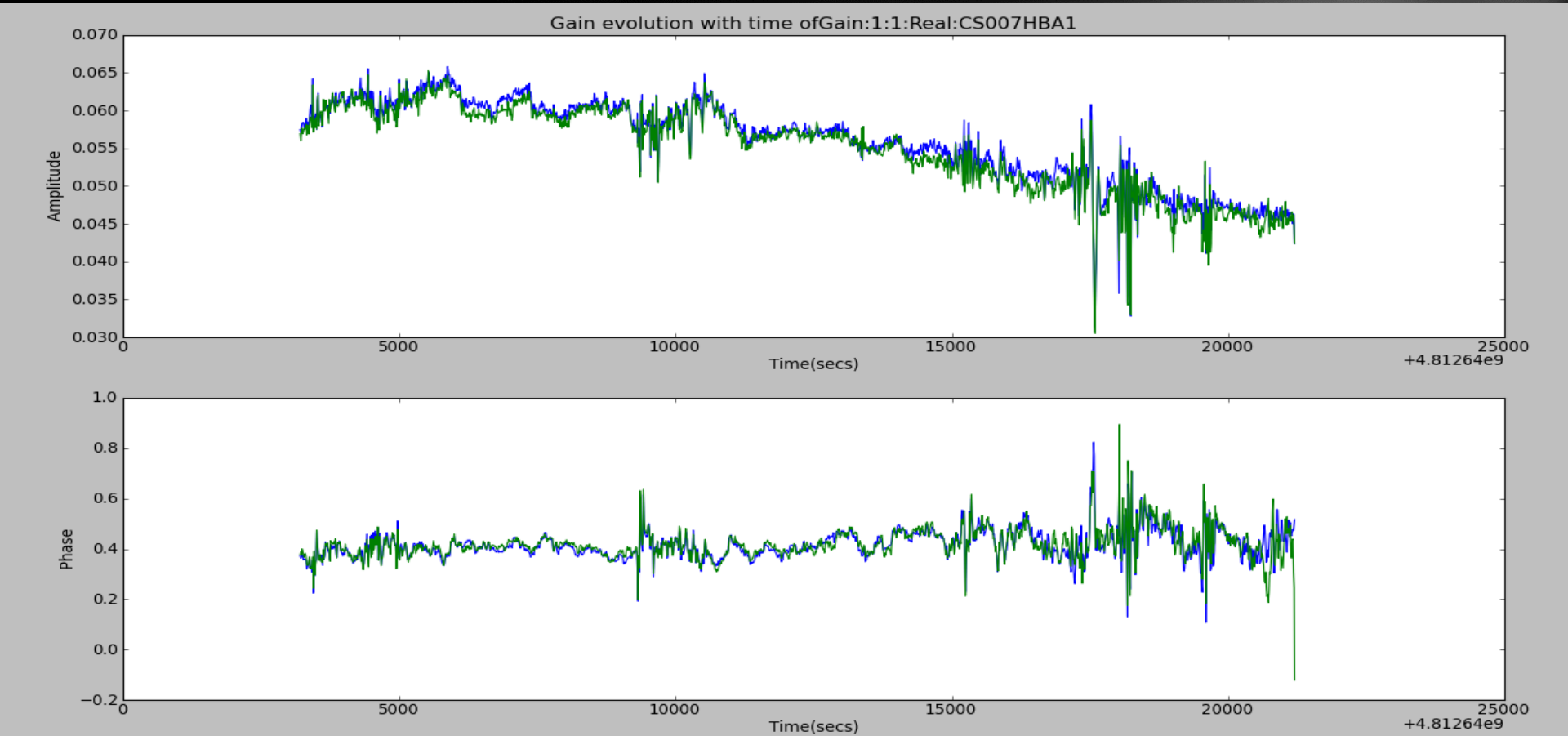




Testing the model

- Used program to predict and compare with subband (approx 130MHz) not used in creating model.
- Model is slightly overestimating gain.





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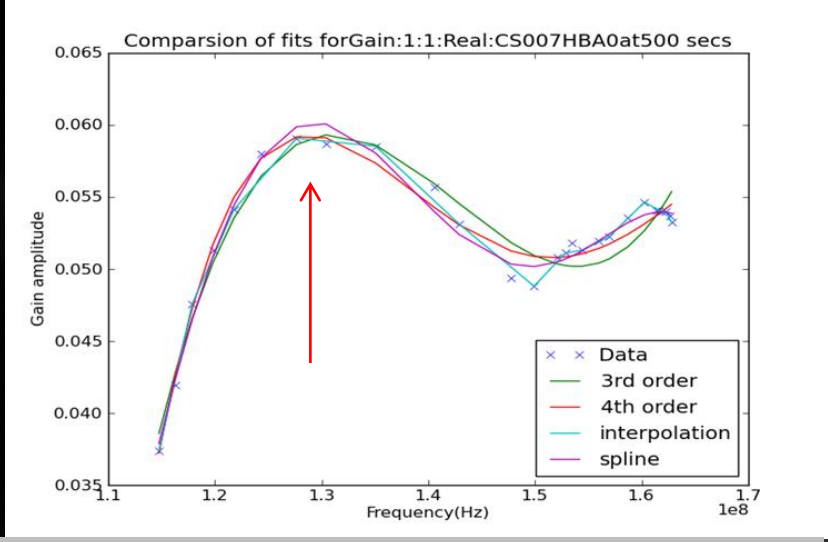
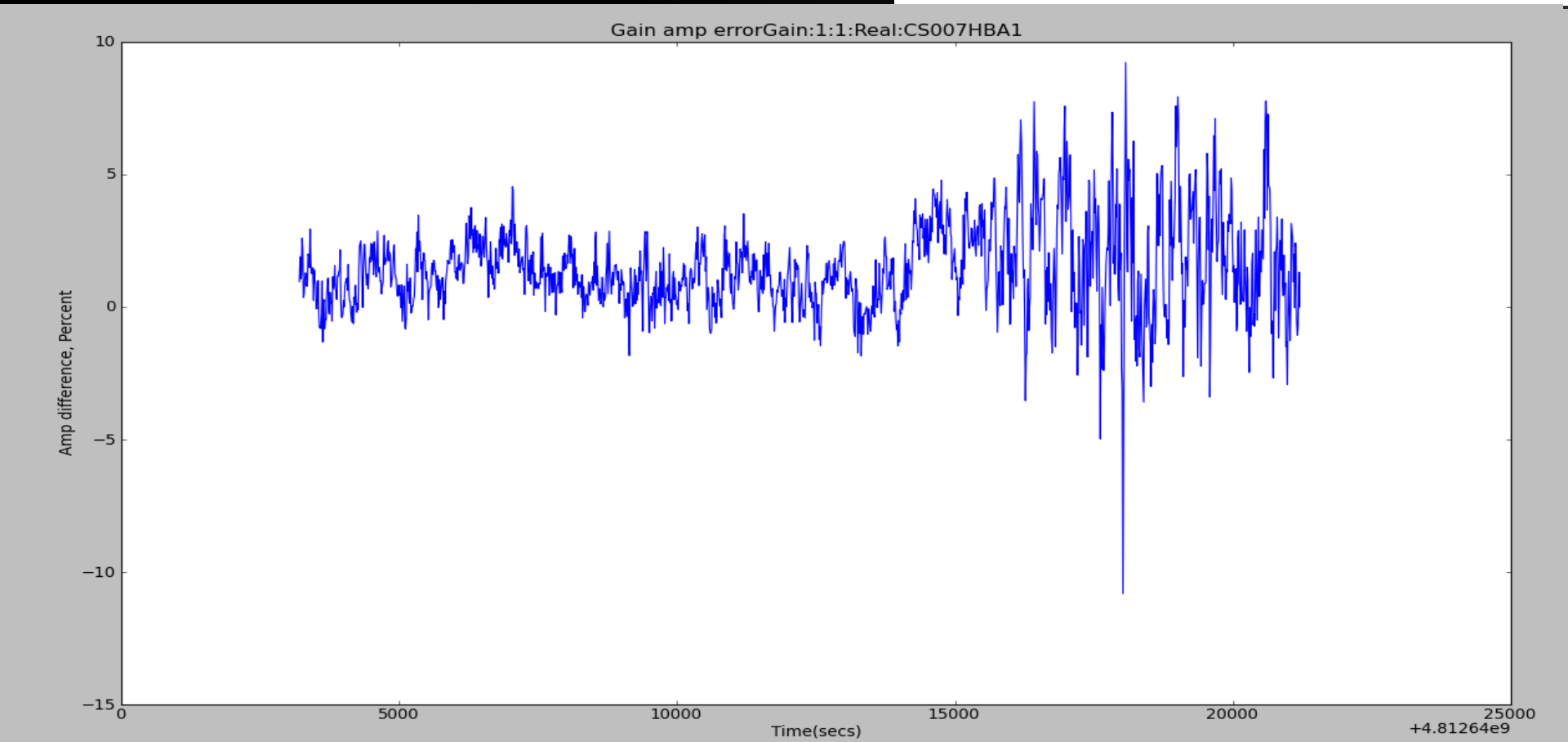




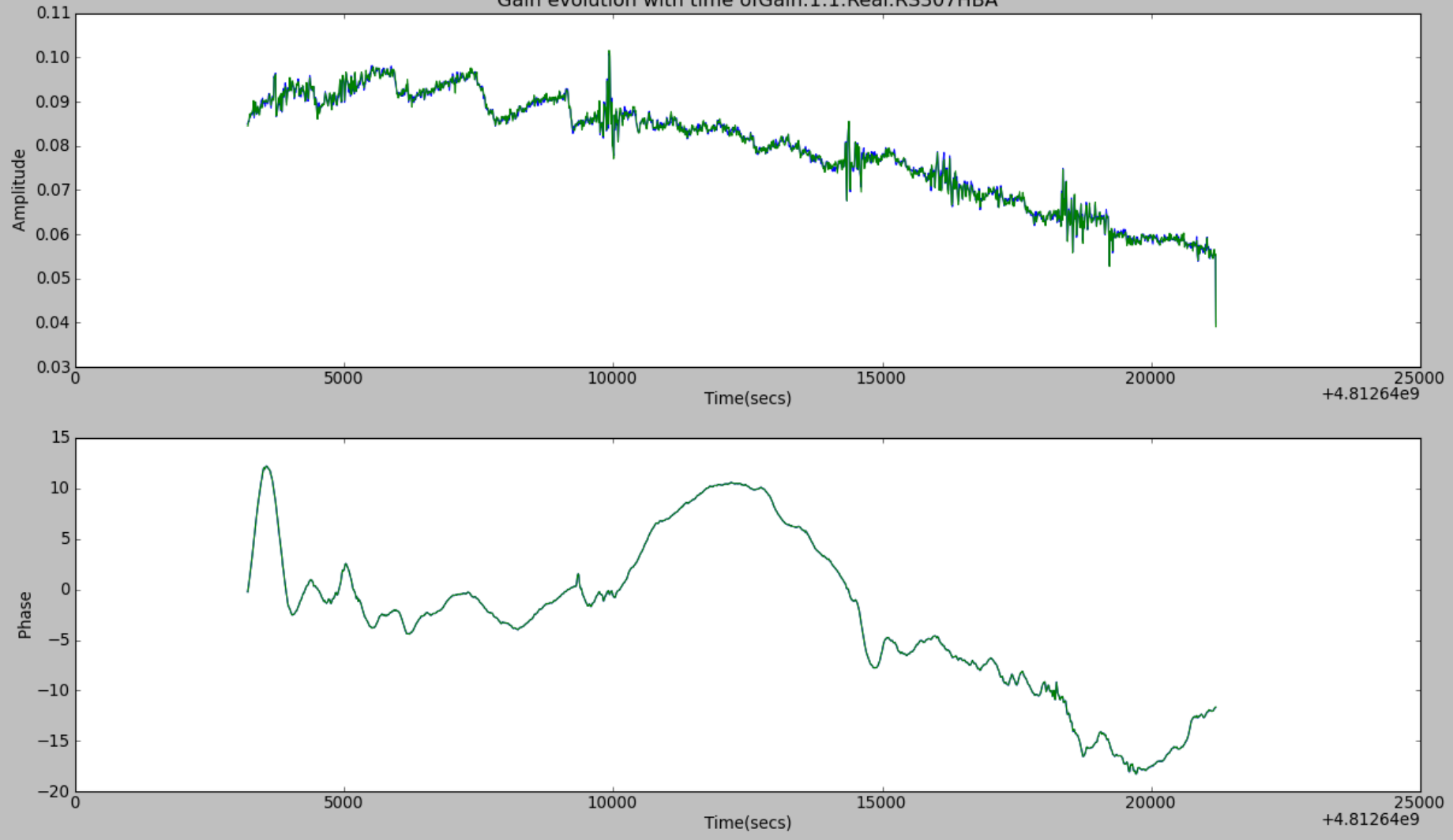
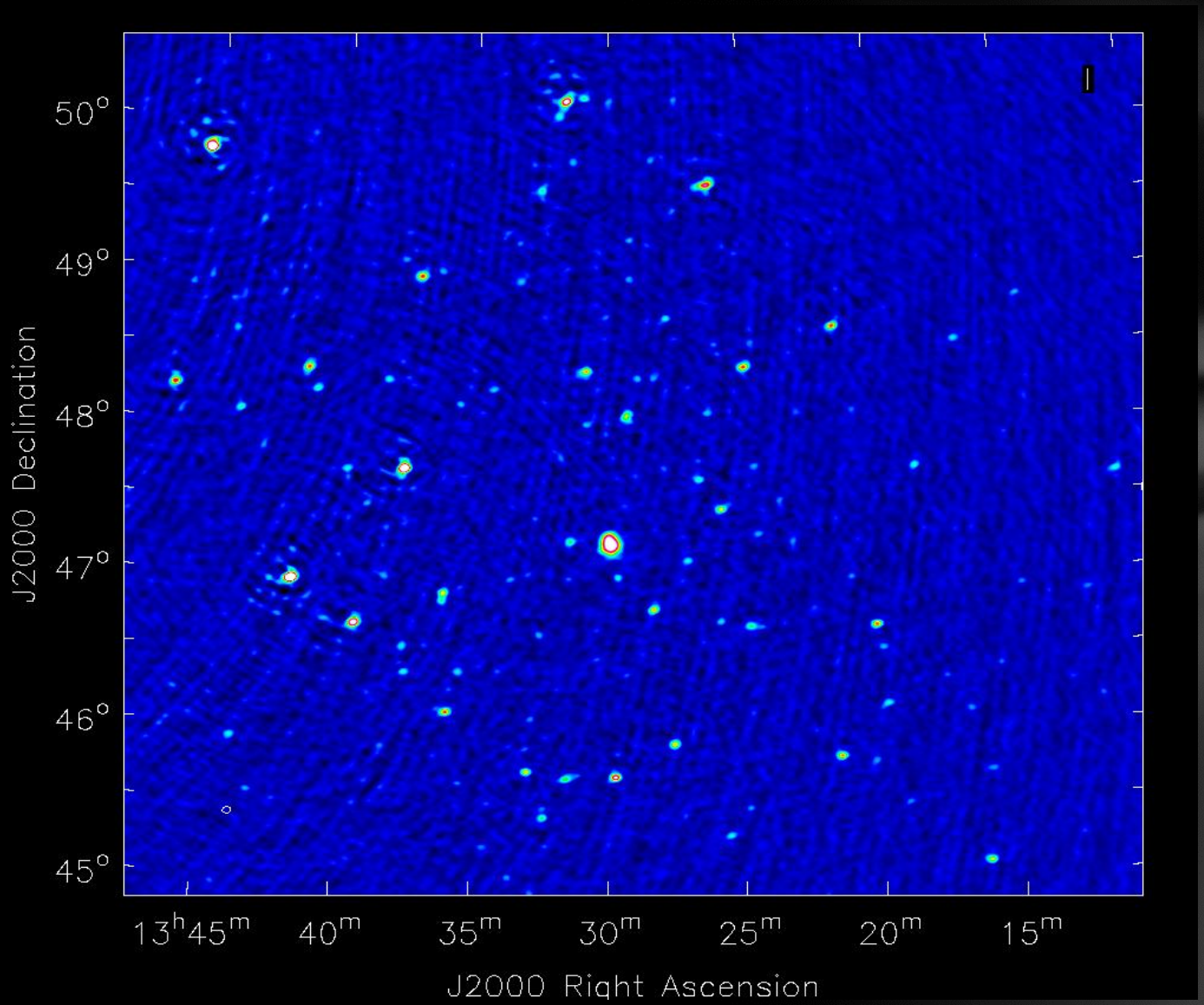
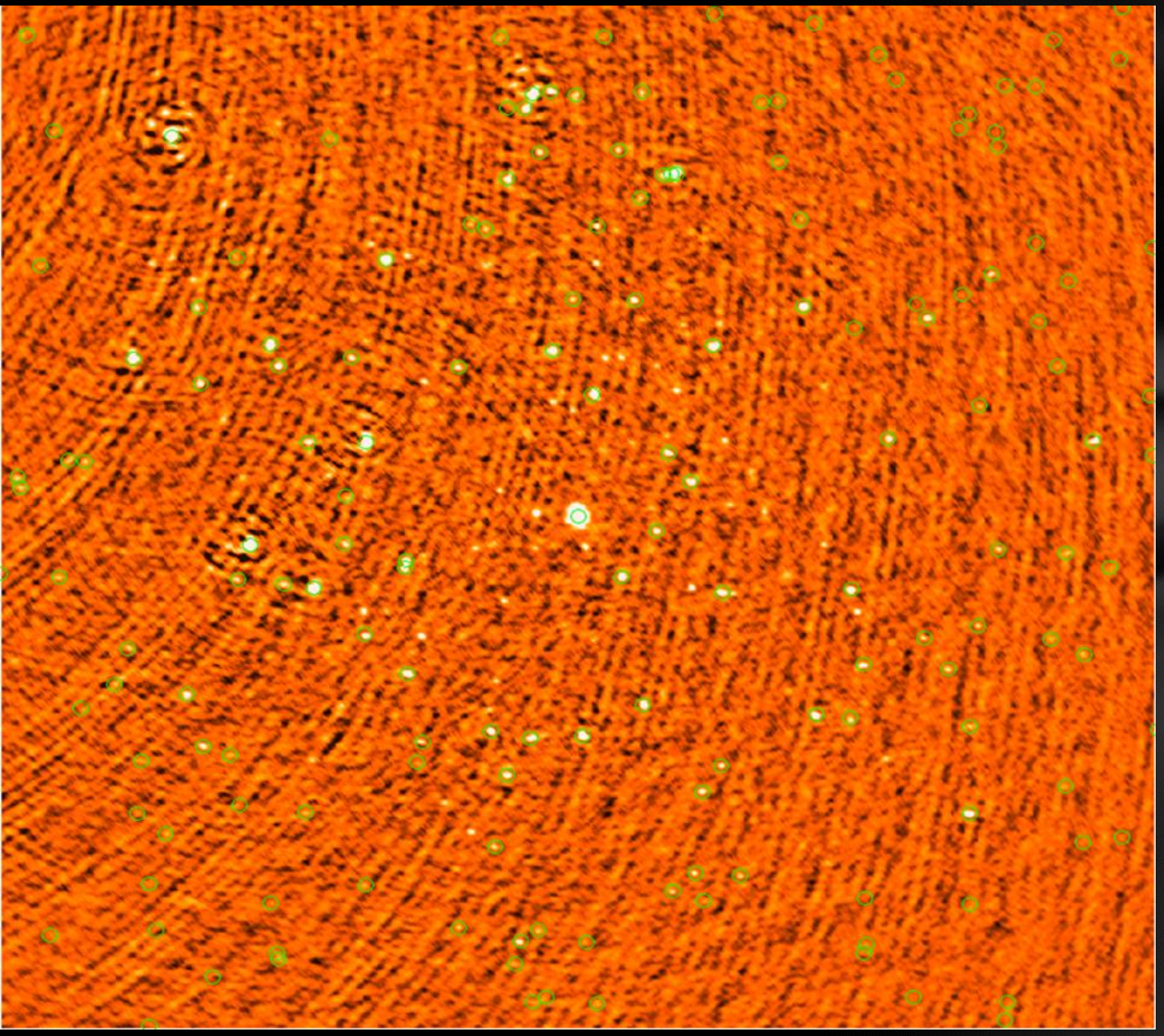

Gain evolution with time ofGain:1:1:Real:RS307HBA
Amplitude
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0
5000
10000
15000
20000
25000
Time(secs)
+4.81264e9
Phase
15
10
5
0
−5
−10
−15
−20
0
5000
10000
15000
20000
25000
Time(secs)
+4.81264e9

Image of a target Subband with Gain solutions transferred (Interpolation of 1.96MHz)

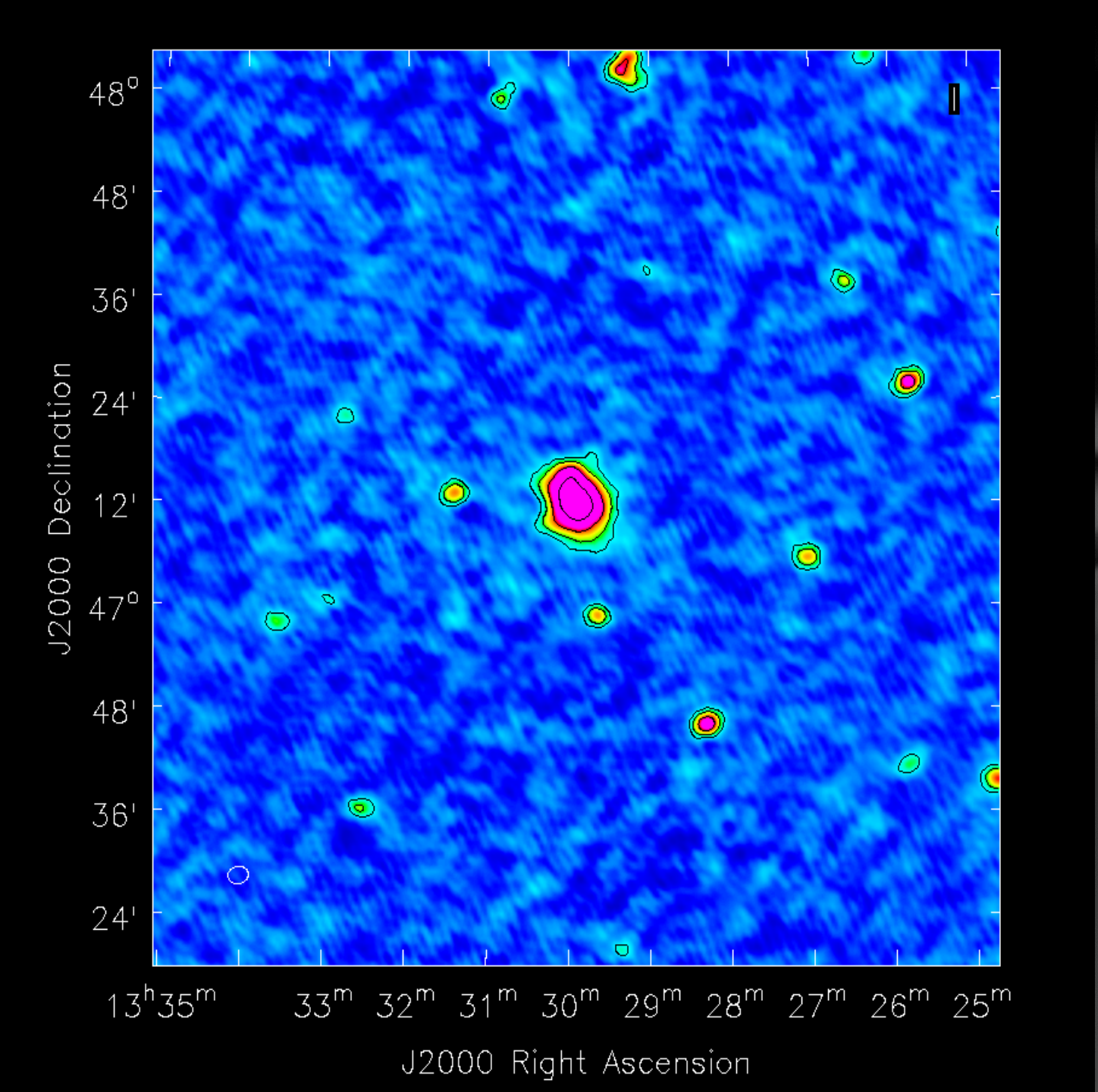


- Image of a target Subband (138.67MHz) with Gain solutions transferred.
- Interpolation of 1.96MHz.
- Only the core stations are imaged.

Image of a target Subband (145.12MHz) with Gain solutions transferred (Interpolation of 2.73MHz)



- Image of a target Subband (145.12MHz) with Gain solutions transferred (Interpolation of 2.73MHz)
- Visibilities less than 6km uvrange are imaged.
- Green circles indicate sources in the VLSS catalogue.
- As one can see, there is a strong source located outside the image in the north west producing many ripples.



Close up of M51

145.12 MHz

1 subband
Of 200 kHz

Baselines up to 6km

2 rounds of phase calibration and subtraction of 3C295

Noise is around 7.5mJy

Lowest contour is 5 sigma level

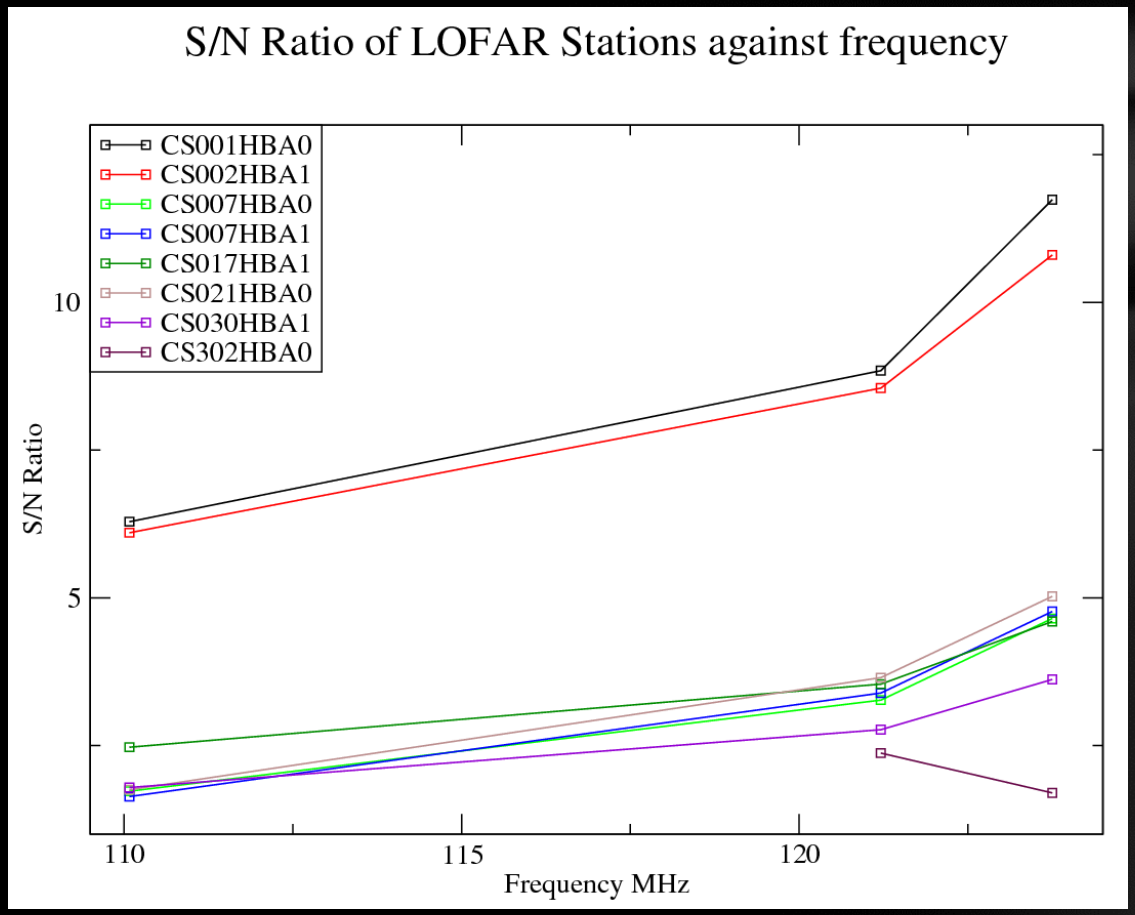
New Observation of 3C295 & M51

- Main motivation: To further develop Gain Interpolation and learn to calibrate Total Flux properly
- Polarization work is secondary but will be attempted
- 6 hour nighttime observation was taken when M51 was at high elevation.
- 9 chunks of 20 subands (of 200KHz) spread evenly from 120 to 181MHz; 10 subbands placed near HBA-low filters; 54 subbands on calibrator.

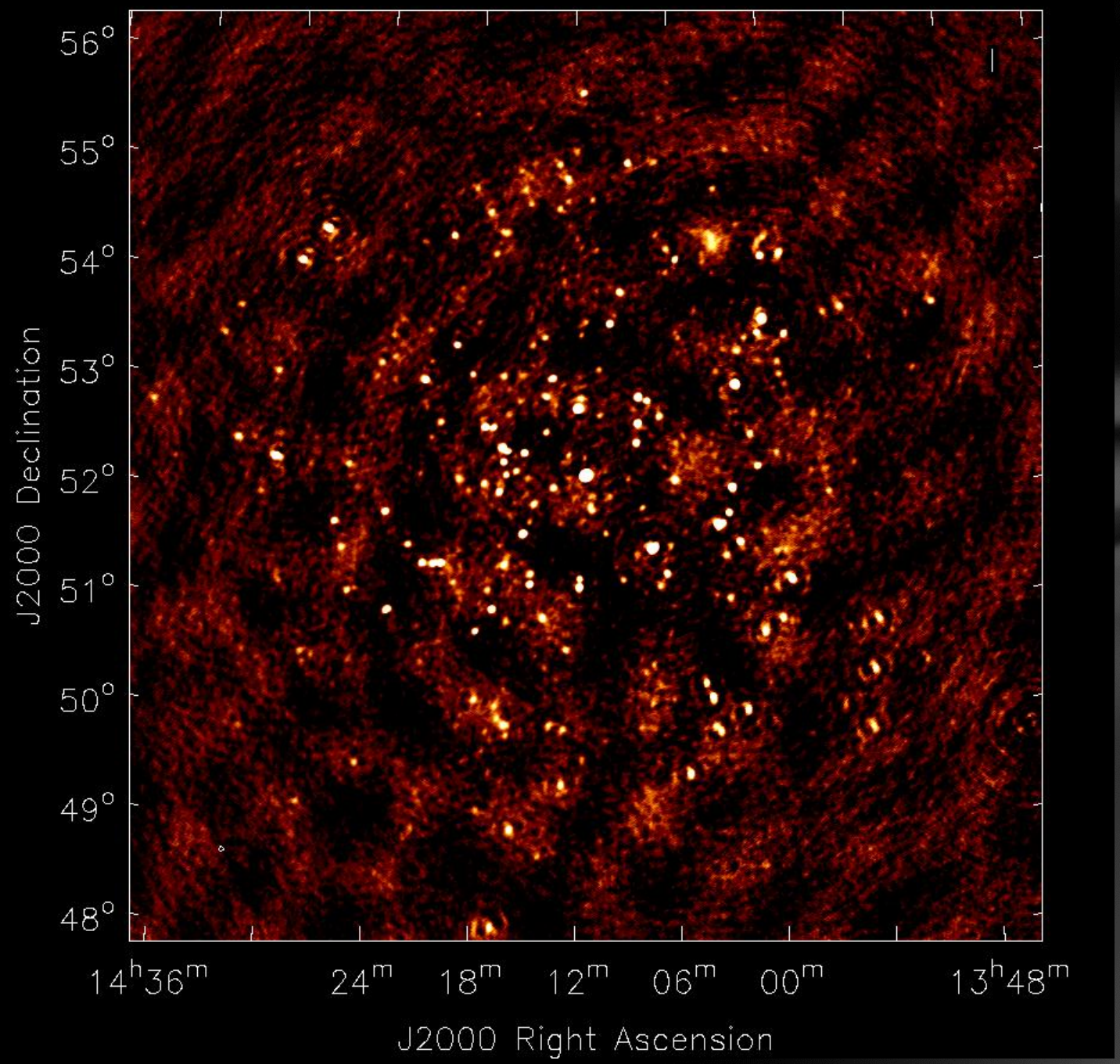
Over **50%** increase of Subbands on the target!

Preprocessing the Data

5ns offset in RSP boards is a very serious problem, stations need to be identified and flagged.
Demixing was tested with NDPPP so 3 channels per subband can be used for Polarization. Results seemed promising, also see Andreas Busy Thursday Report given last week on this matter.



7 stations in total were found to suffer from this problem due to their low S/N and low gains compared to the median.



First Images

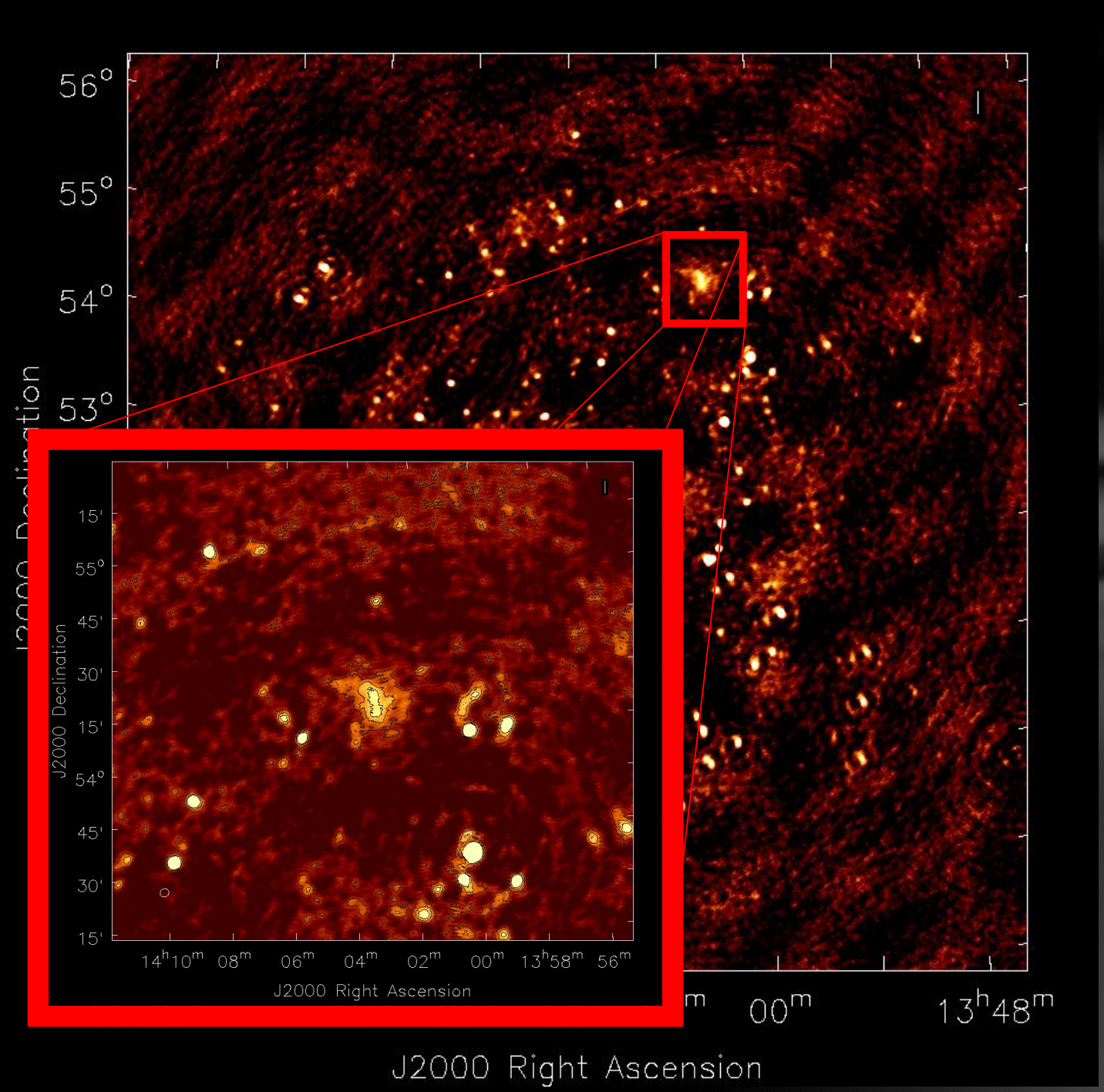
3C295 field

200kHz subband at 142MHz

200 kHz subband

Natural weighting

Many more point sources detected



First Images

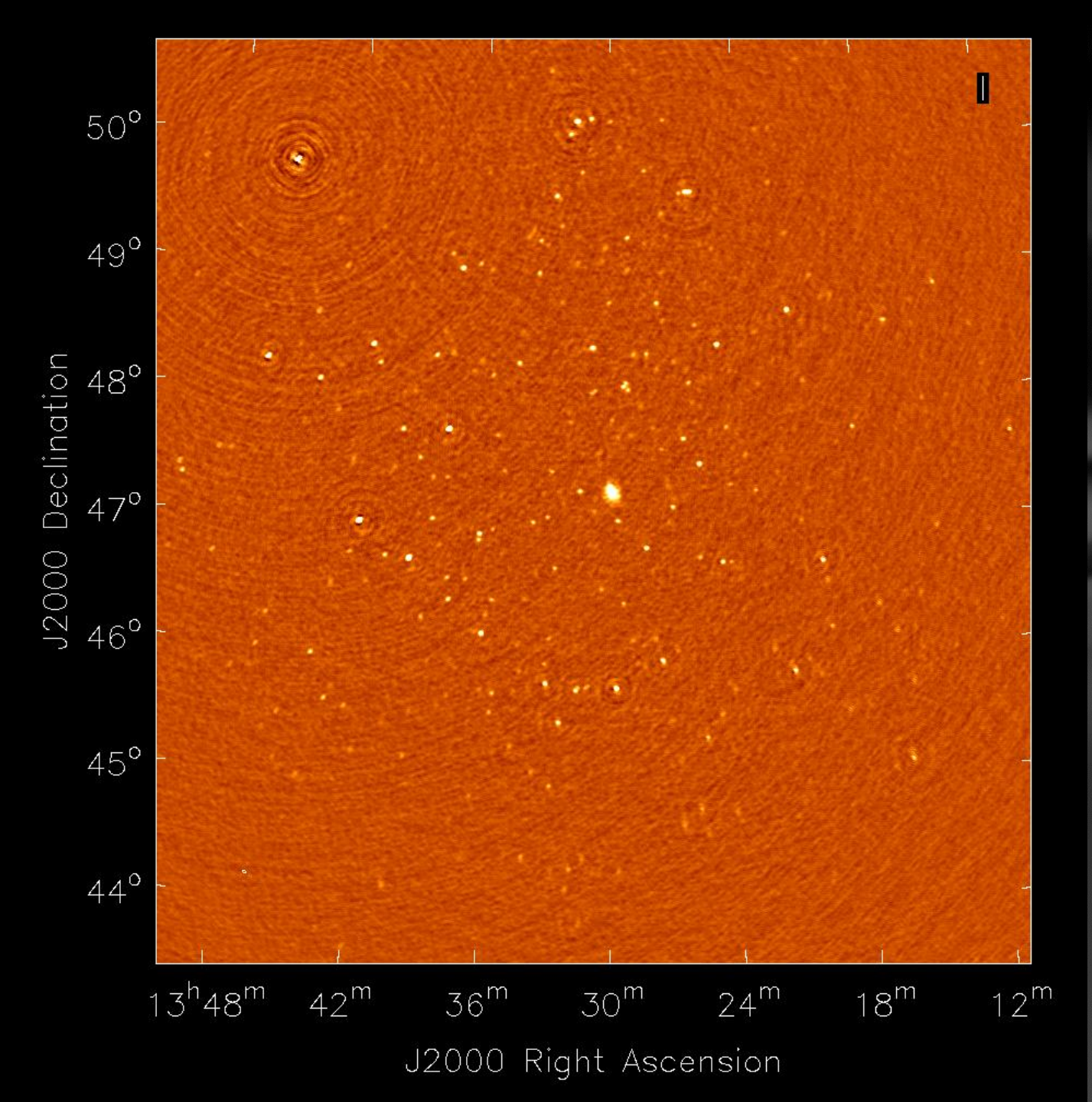
3C295 field

200 kHz subband at 142MHz

Natural weighting

Lot more point sources detected

M101 can be detected with only 1 subband.



First Images

M51 field

1 subband of 200KHz at 142.7MHz

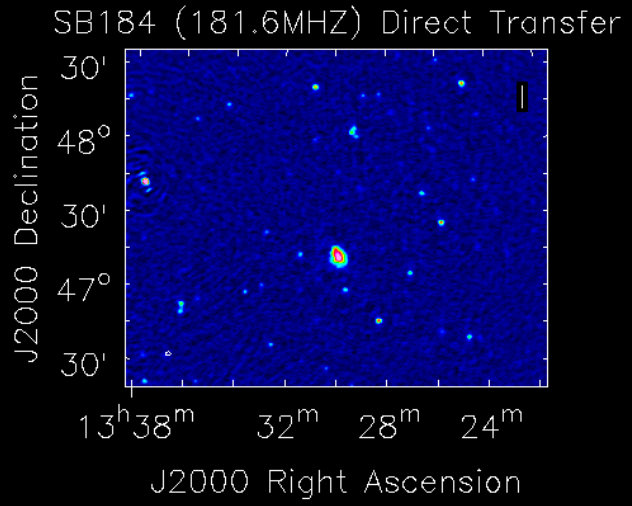
Robust weighting

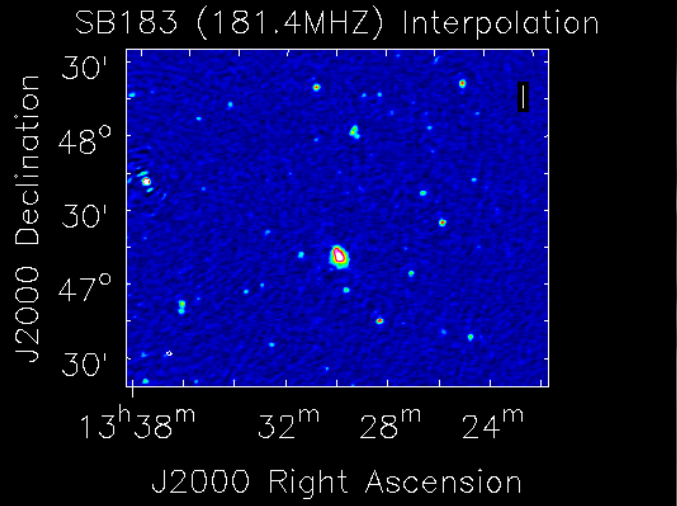
UV taper of 6km used

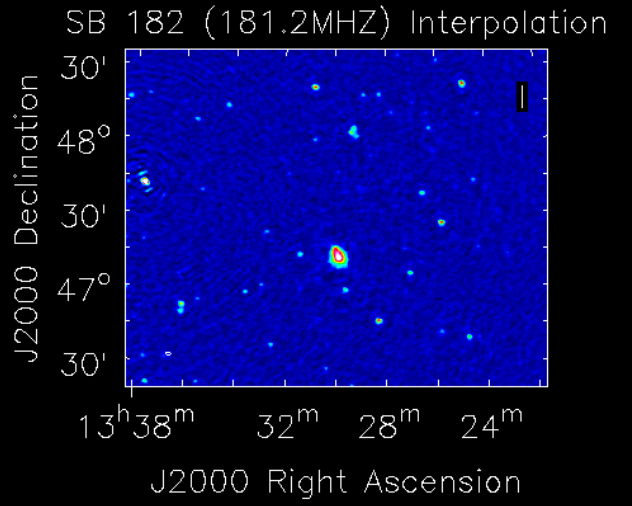
3C295 is not a problem anymore

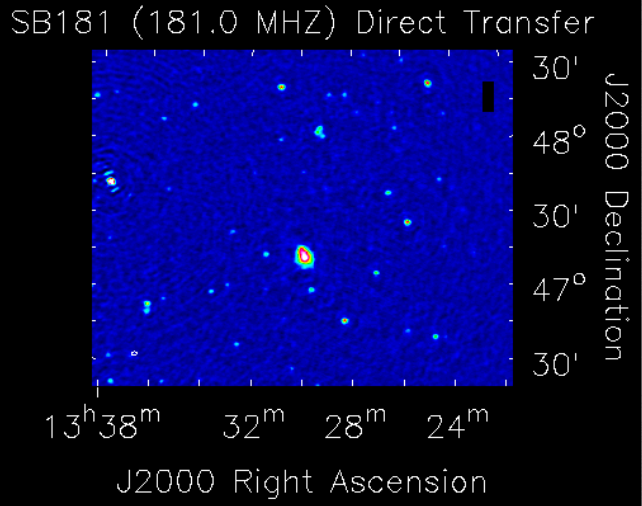
Preliminary work done on interpolation in new observation

- Stokes I images look good compared to direct transfer, noise is more or less the same



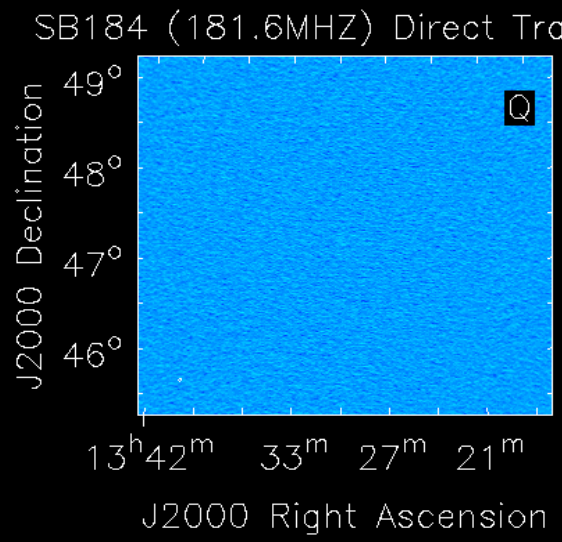


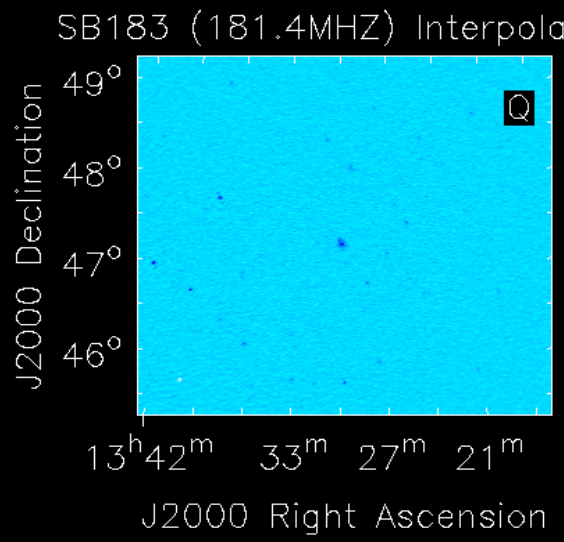


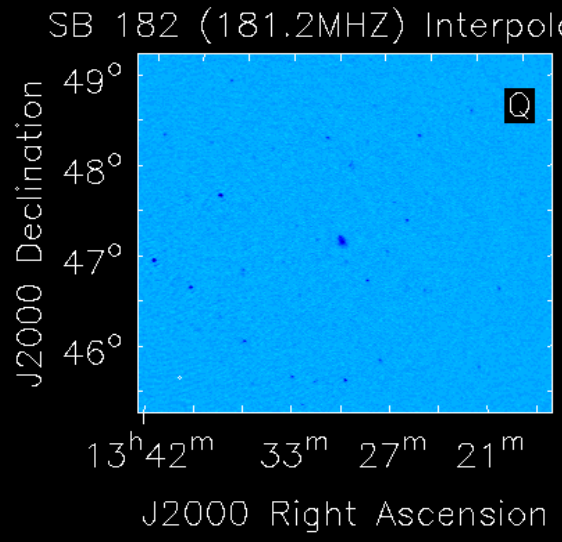


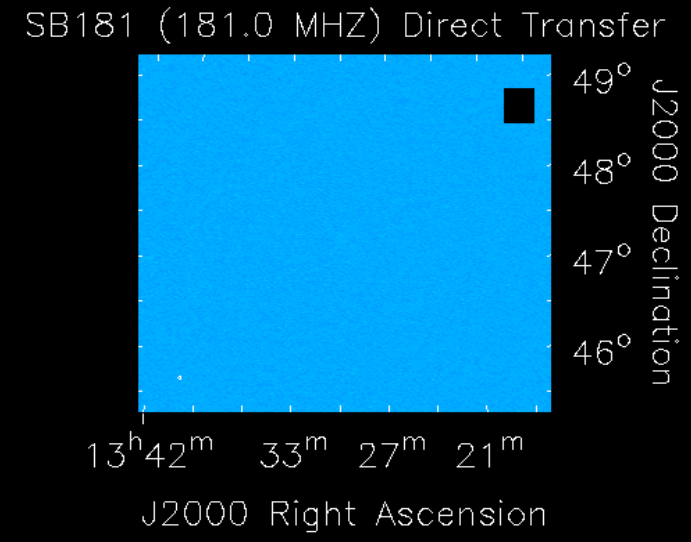
Preliminary work done on interpolation in new observation

- However, high instrumental polarization is seen in Q and U!



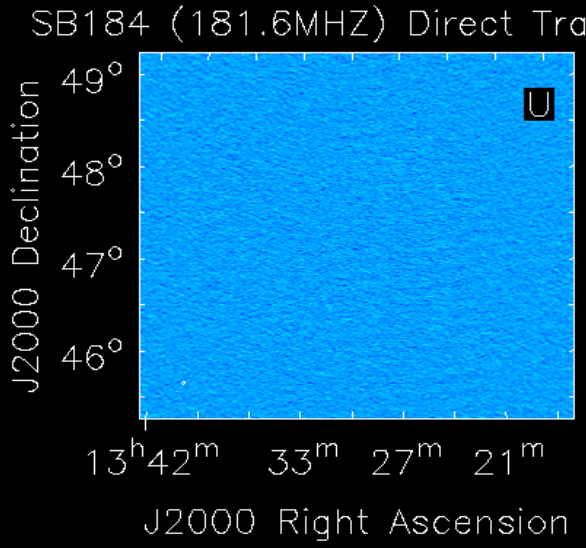


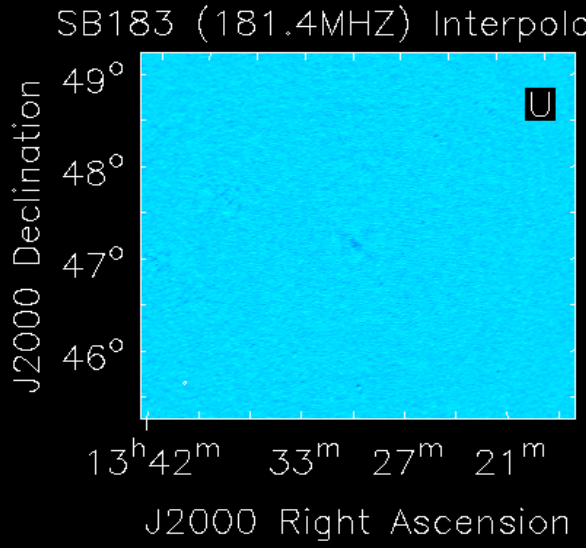


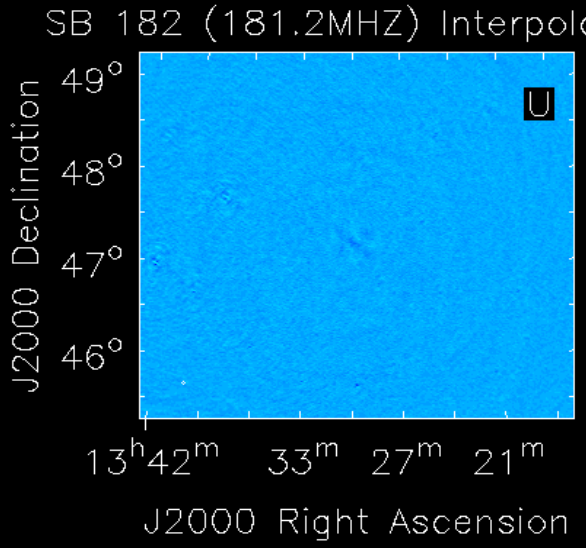


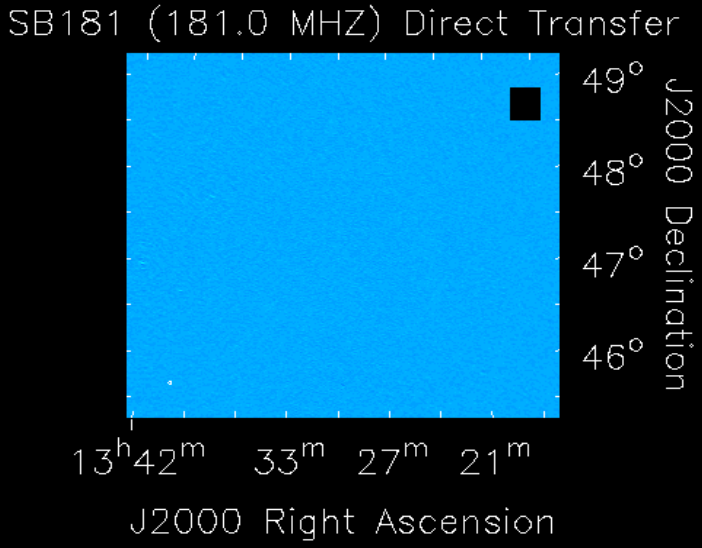
Preliminary work done on interpolation in new observation

- However, high instrumental polarization is seen in Q and U!









Preliminary work done on interpolation in new observation

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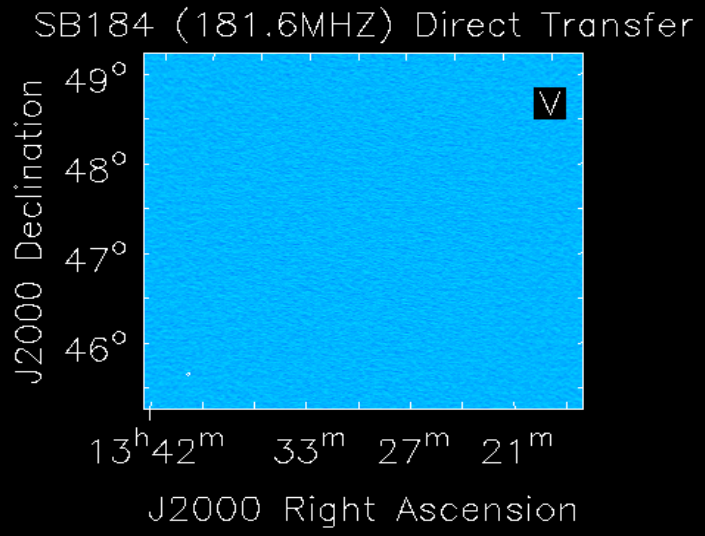

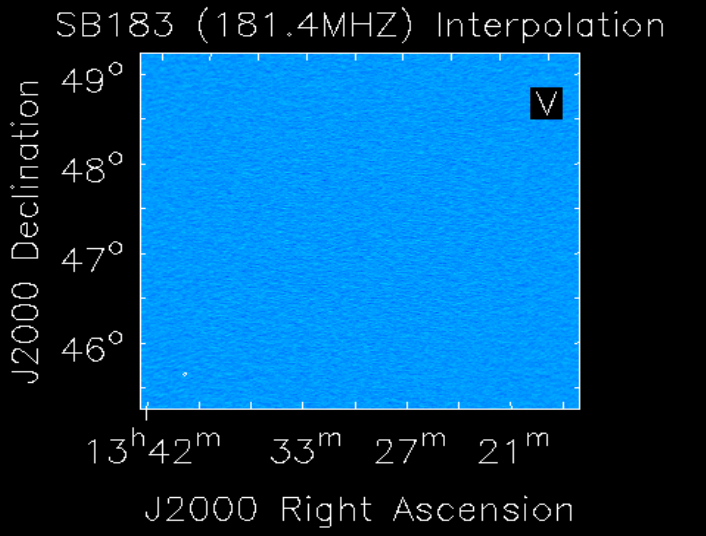

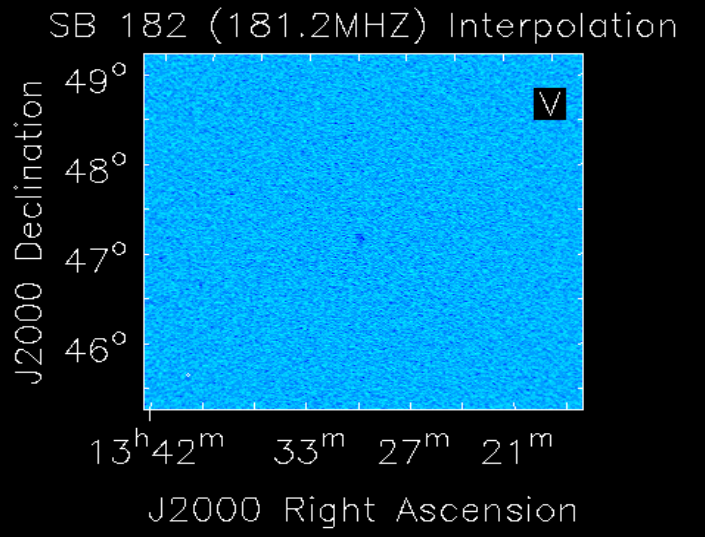

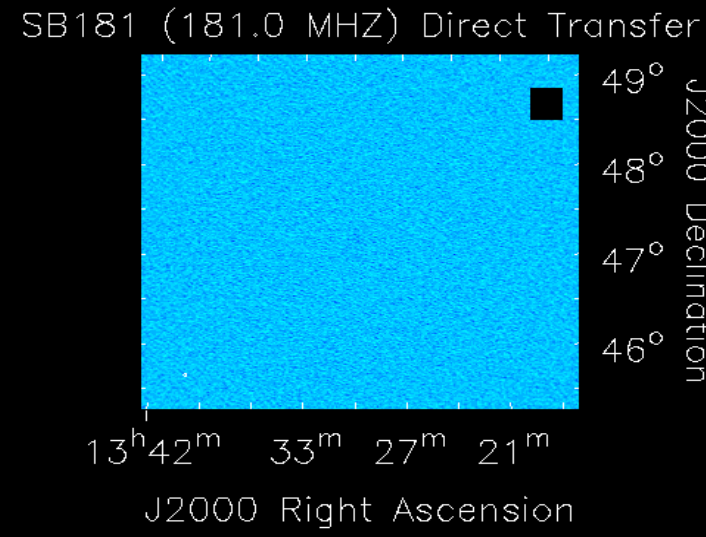

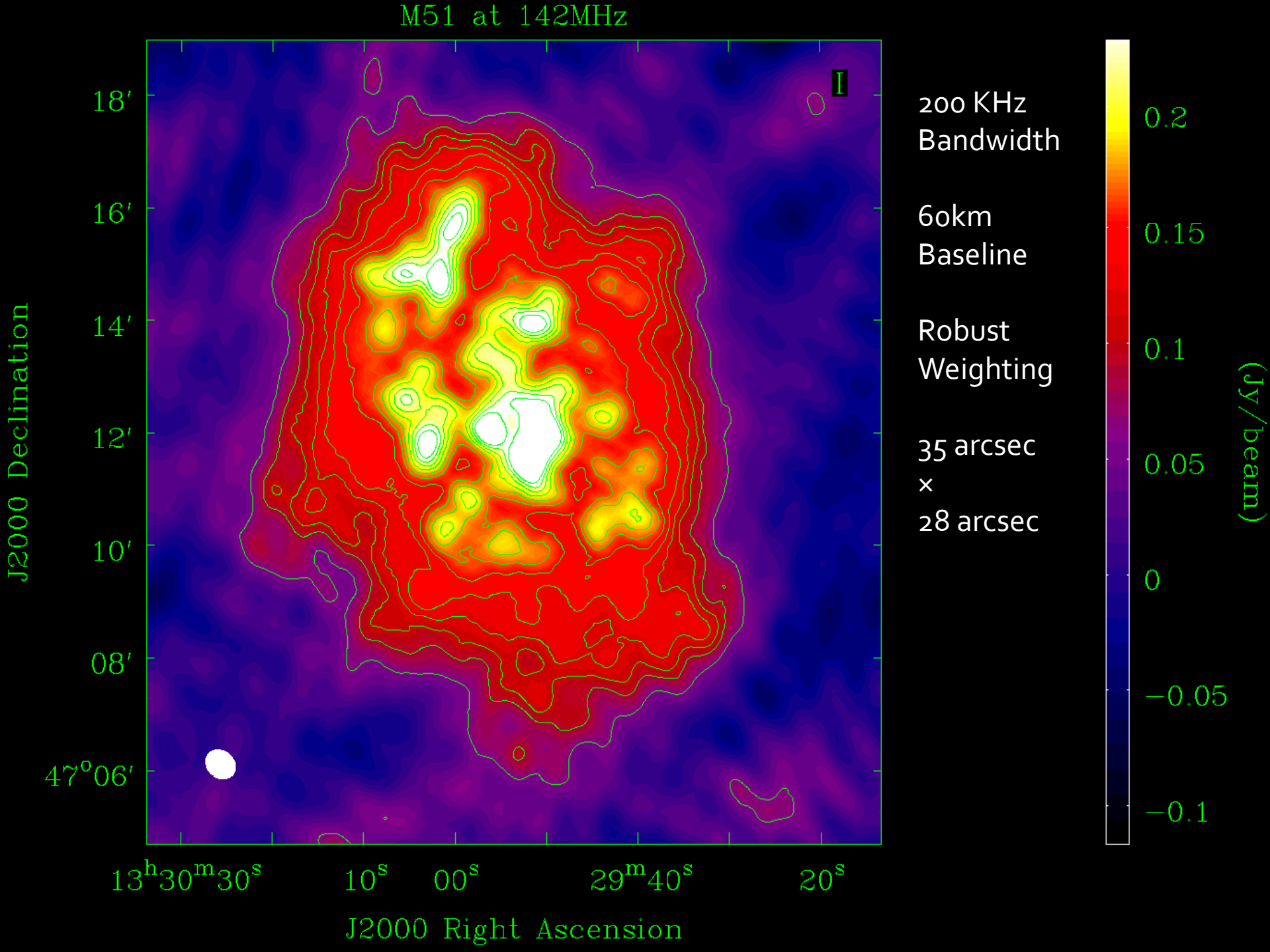
M51 at 142MHz
I
200 KHz
Bandwidth
60km
Baseline
Robust
Weighting
35 arcsec
×
28 arcsec
0.2
0.15
0.1
0.05
0
−0.05
−0.1
(Jy/beam)
18′
16′
14′
12′
10′
08′
47°06′
J2000 Declination
13h30m30s
10s
00s
29m40s
20s
J2000 Right Ascension

Main Issues to be worked on

- XY & YZ gain interpolation at the moment works very badly…. Will need to investigate
- Also flux transfer needs to be looked at due to problems discovered by MSSS Team (see reports by Breton, Pietka and Sabater Montes) and the report of Croston & Scaife.
- Expand software to interpolate multi-channel subbands.
- Further comparison studies between self-cal, direct transfer and interpolation gain transfer are to be done.
- Examining subbands near HBA-Low filters , important to know for upcoming surveys

Conclusions

- Transfer of Gains Solution from calibrator to target source can be interpolated in frequency to give well calibrated results.
- More tests being done on this especially with regards to flux calibration
- More work to be done to make it useable for other users.
- The M51 disk is seen to extend further out than other low frequency observations for only one subband.
- Data quality of the new observation is much better than before.

-> For updates, please check LOFAR Wiki!