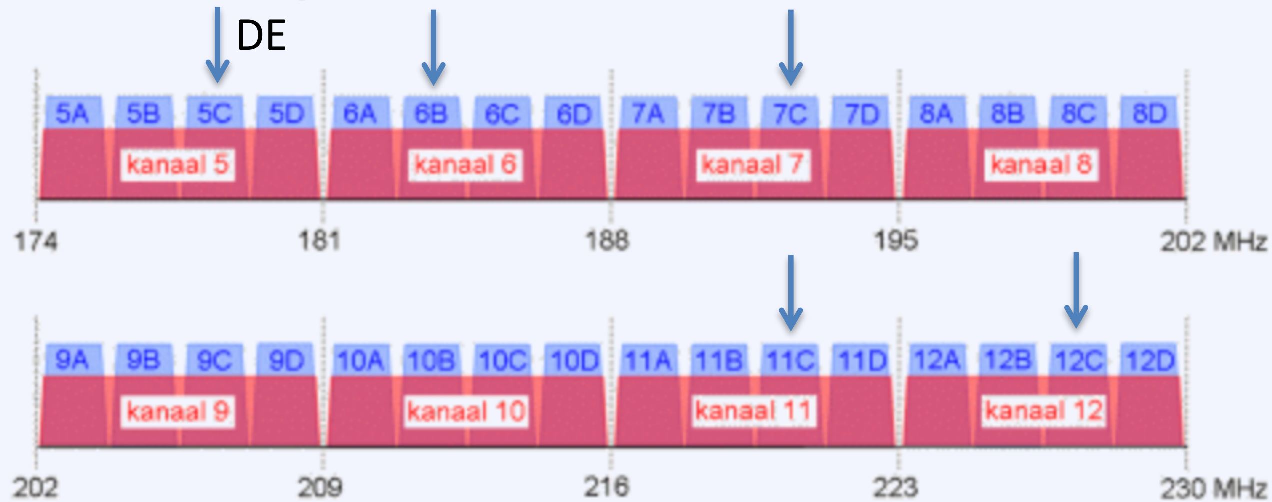
DAB-related RFI in LOFAR and ways to mitigate it

Ger de Bruyn

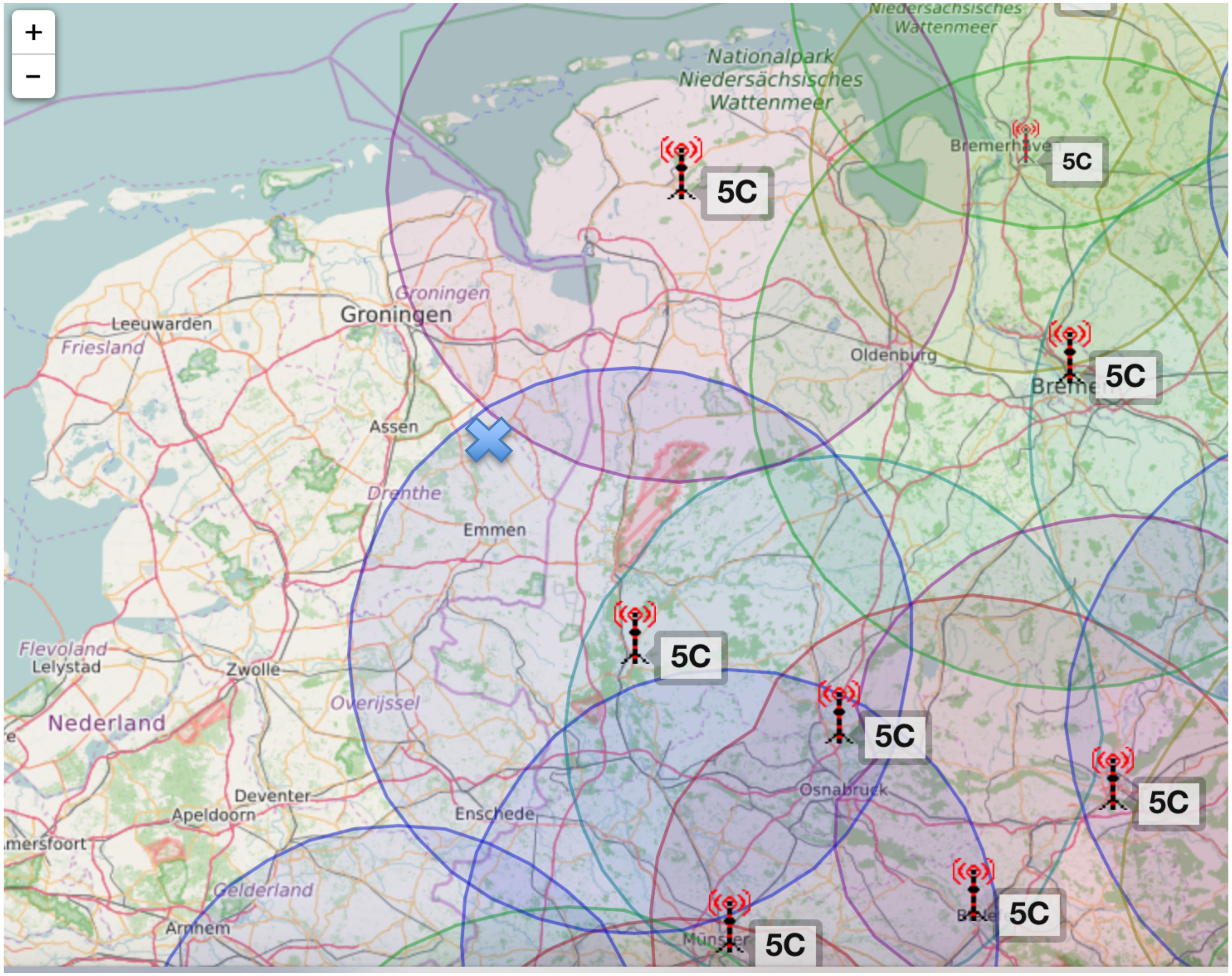
T-DAB kanalen in Band III

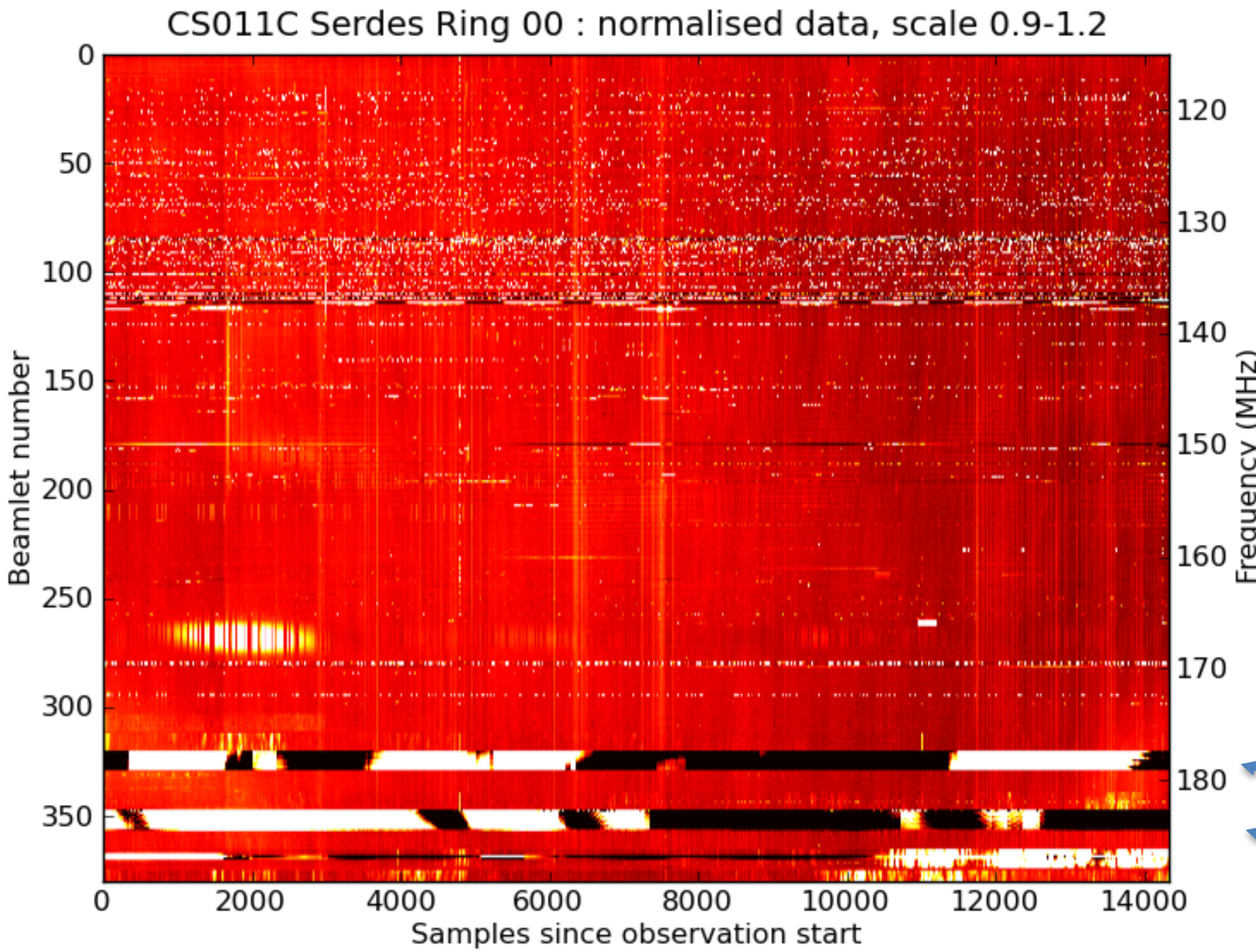
In internationaal verband zijn er tijdens de Regionale Radio Conferentie 2006 (ook wel Geneve 2006) afspraken gemaakt over de TV-banden III, IV en V. T-DAB kan worden gebruikt in Band III (174 - 230 MHz). De TV-kanalen 5 tot en met 12 zijn ieder 7 MHz breed. Een dergelijk TV-kanaal kan worden opgesplits in 4 subkanalen (kanaal A tot en met D) van ieder 1,75 MHz. Binnen een dergelijk subkanaal kan een T-DAB signaal worden uitgezonden. Een T-DAB signaal neemt ongeveer 1,5 MHz in beslag. De onderverdeling van de TV-kanalen in de T-DAB subkanalen is gegeven in onderstaande figuur.



Onderverdeling van de TV-kanalen in T-DAB kanalen voor Band III

Powerful channel 5C (177.5-179.25 MHz) transmitters in Lingen and Aurich





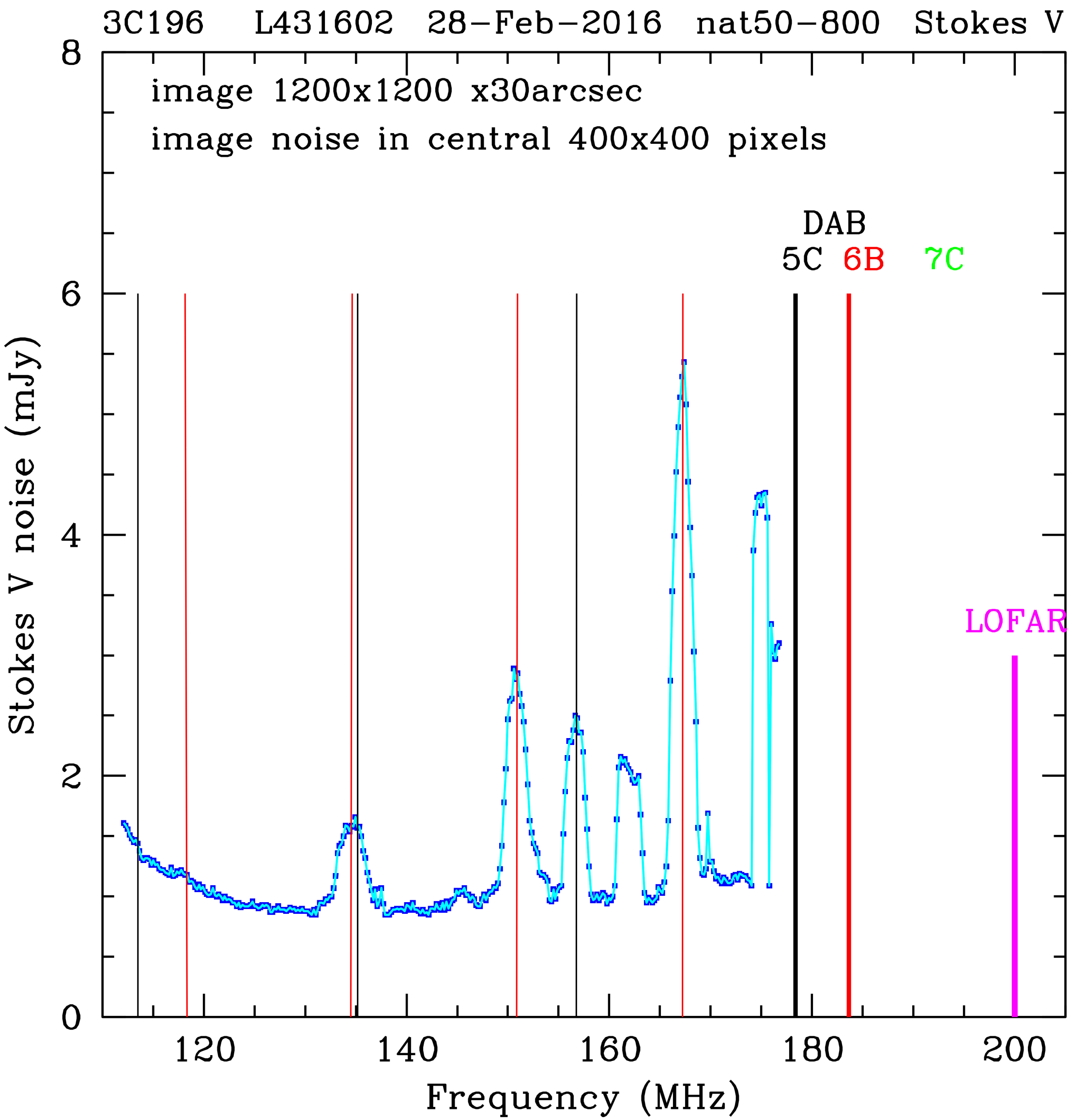
A recent 3C196 observation in RCU mode 5:

(23 Aug 2016)

Normalized station power levels

5C 178 MHz
6B 183 MHz

In-band DAB !!

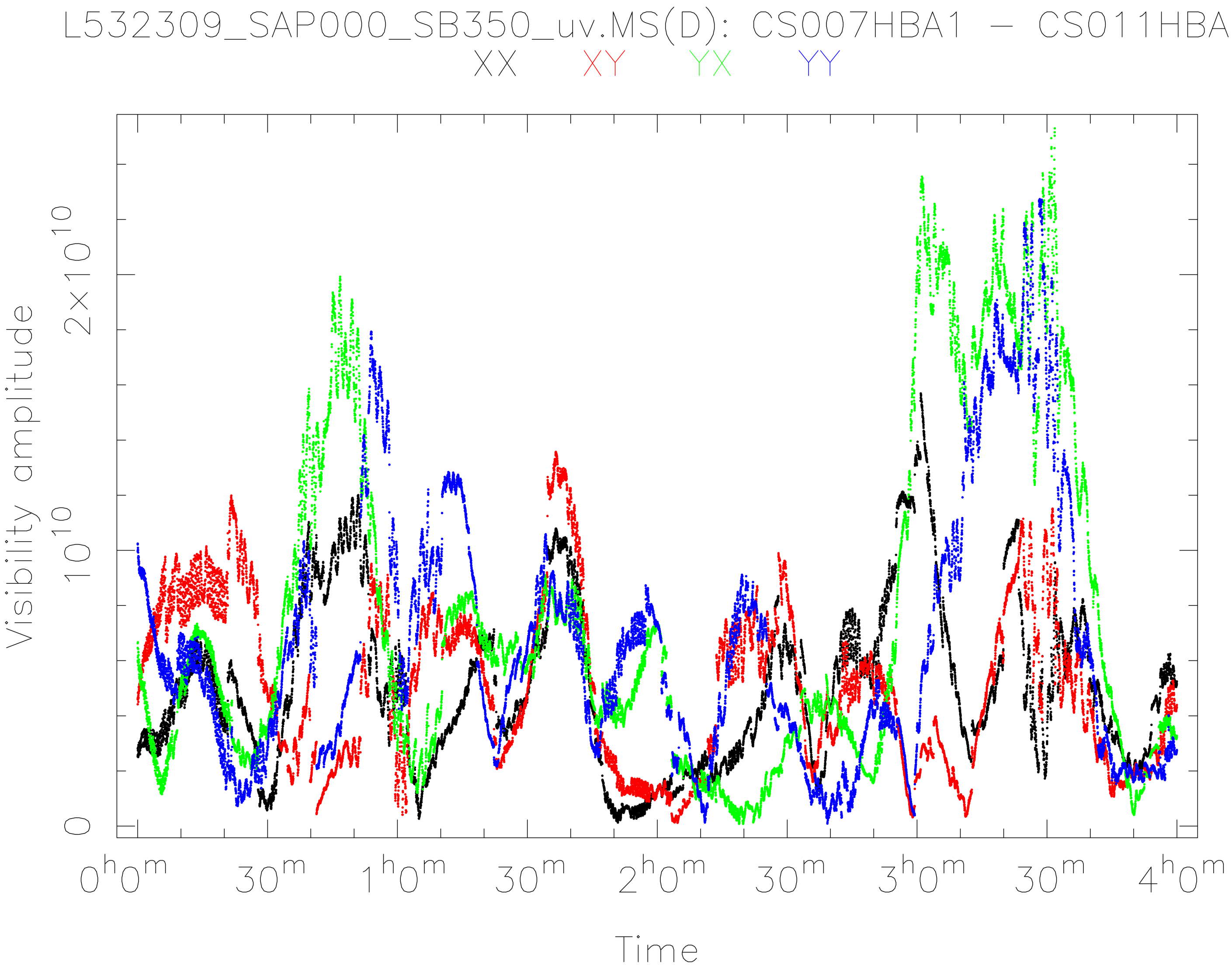


An intriguing relation of the new RFI to the in-band DAB-signals

....

and LOFAR's 200 MHz sampling clock

Still not understood ...

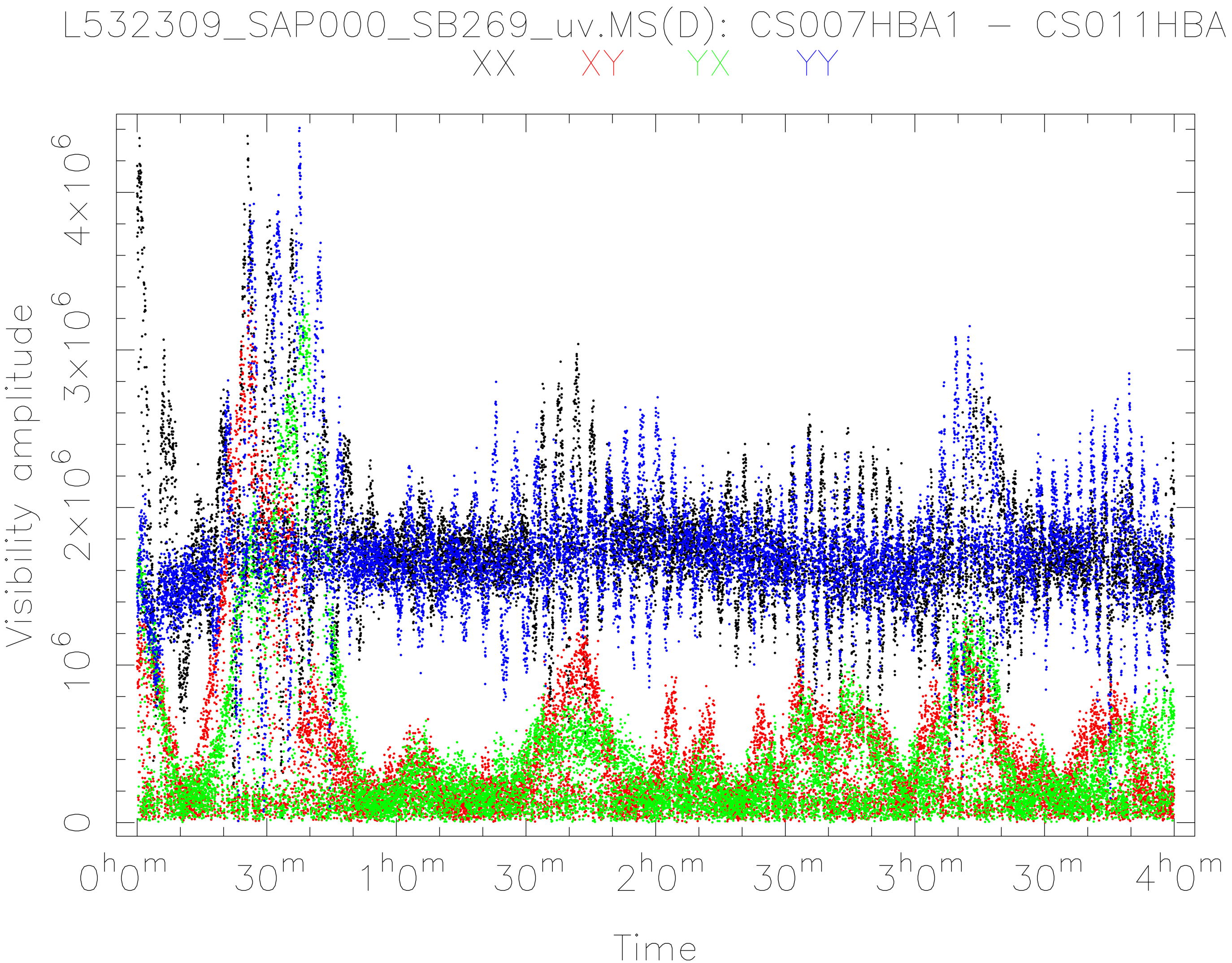


Correlated signals at 183.4 MHz

DAB band 6B

Note the intensities

10^{10} units !!



Observed raw 3C196 visibilities on a core baseline at 167.6 MHz

~ 10^6 units

This signal should be related to the strength of the 6B signal

However, there is a beamformer inbetween so a linear relation might not be expected

A method to mitigate/remove these signals was recently developed by Sarod Yatawatta and is available for testing

It is based on an idea presented in the following paper:

IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, VOL. 31, NO. 3, MARCH 2013 379

Spectrum Sensing for Cognitive Radios Based on Directional Statistics of Polarization Vectors

Caili Guo, *Member, IEEE,* Xiaobin Wu, Chunyan Feng, and Zhimin Zeng

In a nutshell:

Polarization vectors can be represented on the Poincare sphere.
If you have pure noise the polarization vectors have a random orientation.

RFI is usually highly intrinsically polarized (but will be changed by instrumental effects)
The stronger the RFI signal the more **aligned** the polarization vectors will be

The correction method computes the alignment per baseline, averaged over some specified time interval, and corrects the data. The more aligned, the stronger the RFI !!

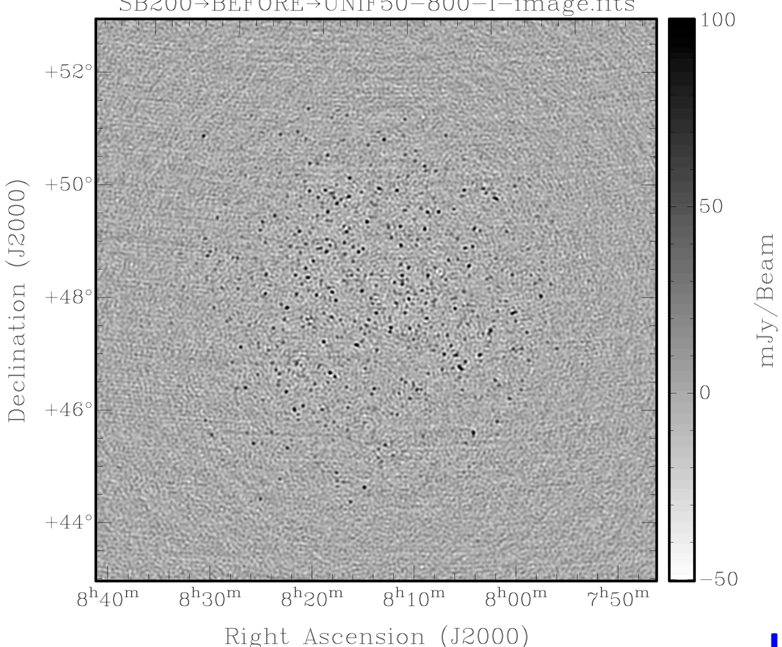
A python script to correct signals has been tested by me with reasonable success on the 3C196 field. It is somewhat less succesful on the LOFAR EoR NCP data and more research is needed.

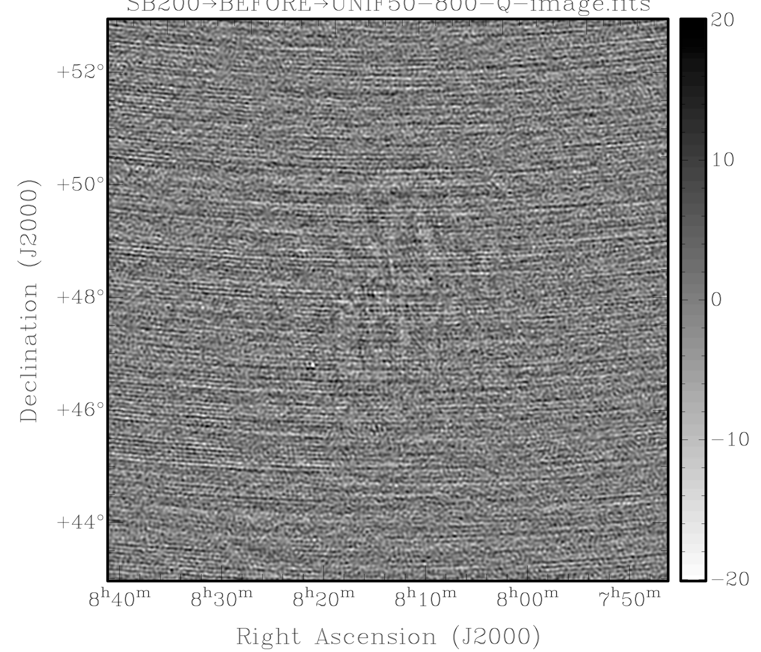
Important steps, per effected subband, are:

- Clean your image → residual visibility data column (plus RFI)
- Phase-rotate this column to dec 90 at relatively high resolution (e.g. 5ch/sb and 4s)
- Apply the directional statistics script and store corrected data in a new column
- Phase-rotate the data in this column back to the original phase-centre
- Continue with processing……. (e.g. restore the subtracted model)

Removing these 'quasi-stationary' signals is easier when your target is far from dec 90. This is because the fringe rates are different enough to separate RFI from celestial signals

For some more background on post-correlation filtering techniques see also Offringa etal, 2012 (MNRAS, 422, 563)





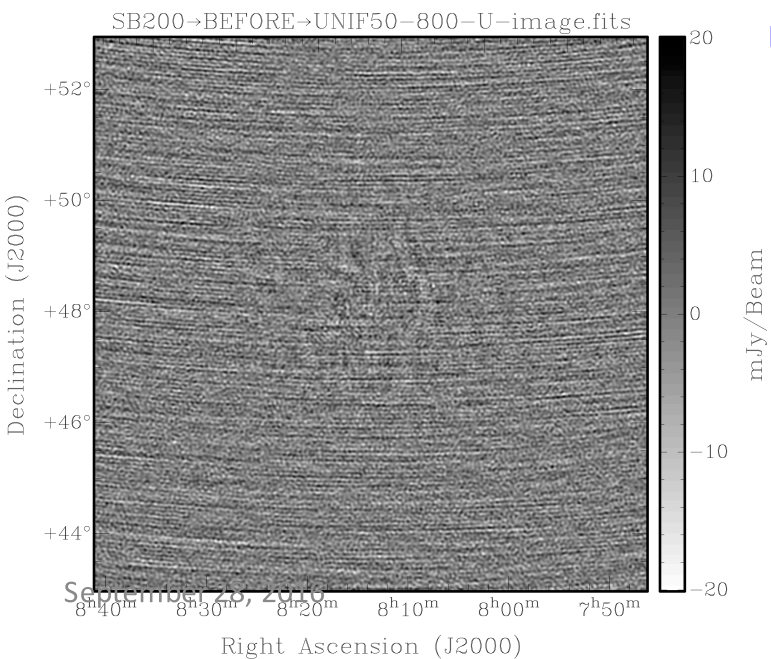
3C 196

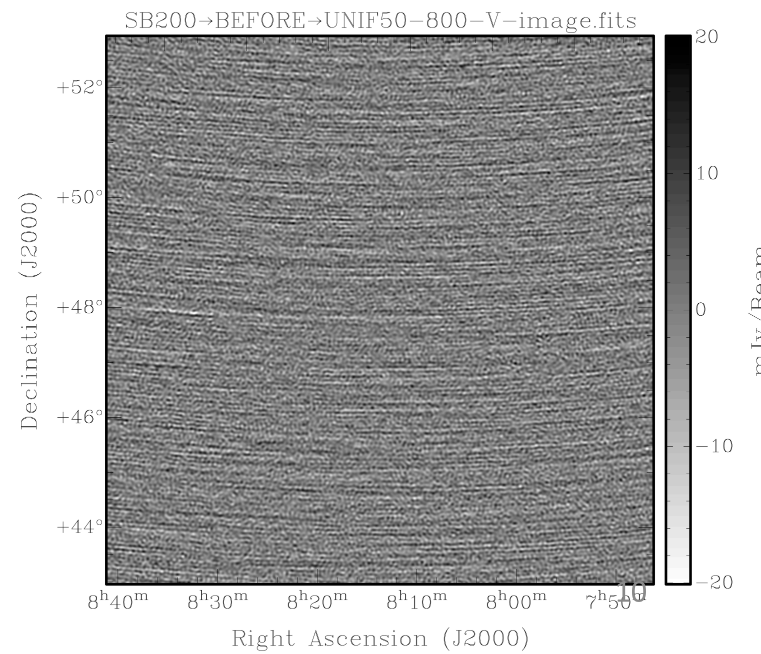
I **Q**

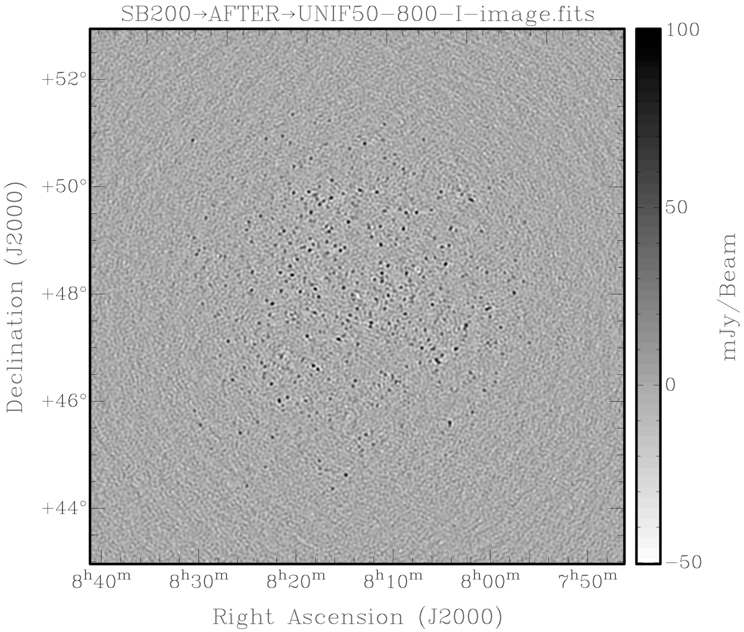
151.17 MHz

before

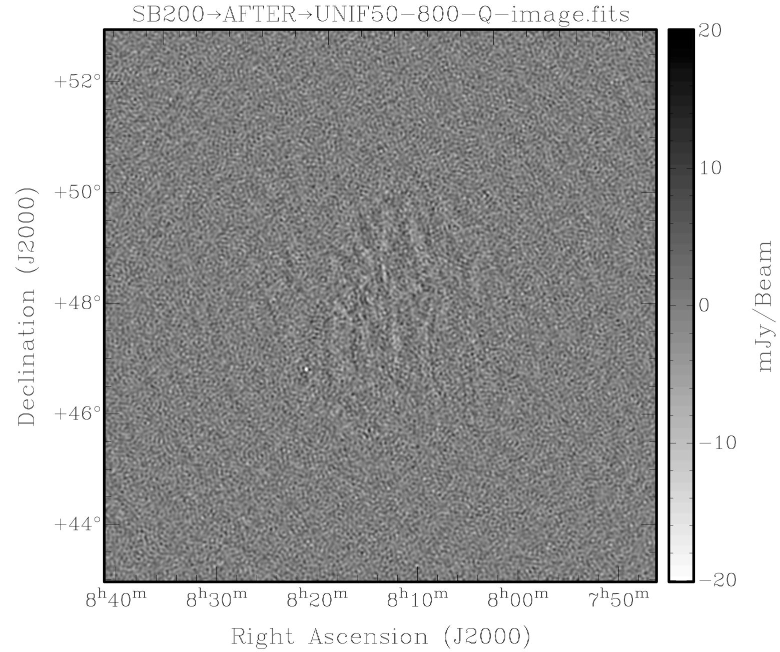
U **V**







3C 196

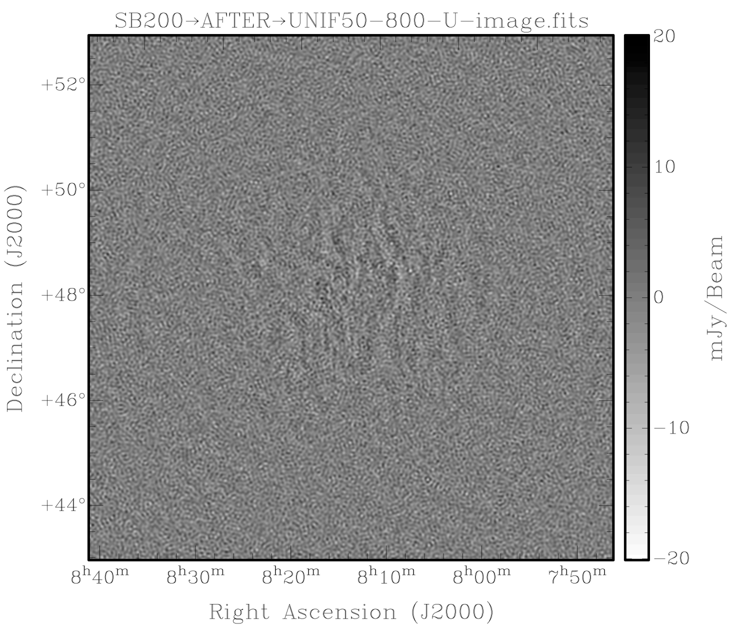


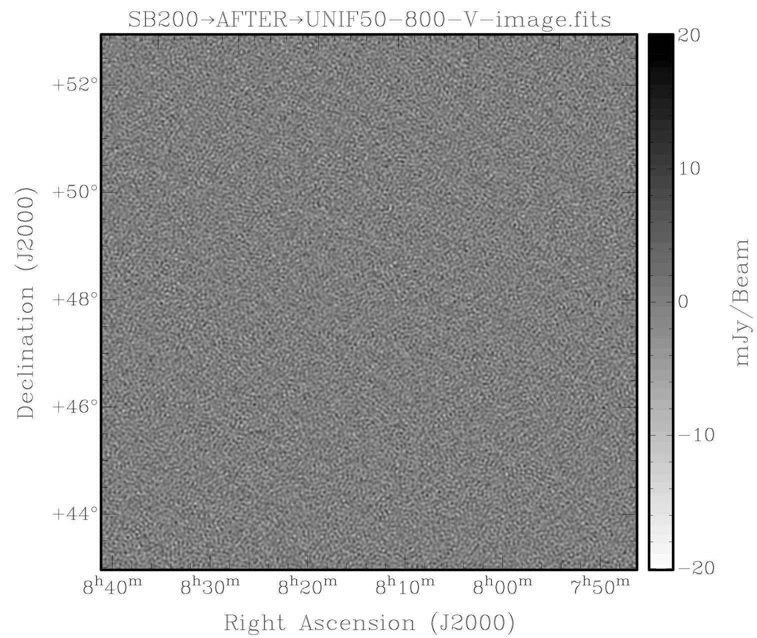
I **Q**

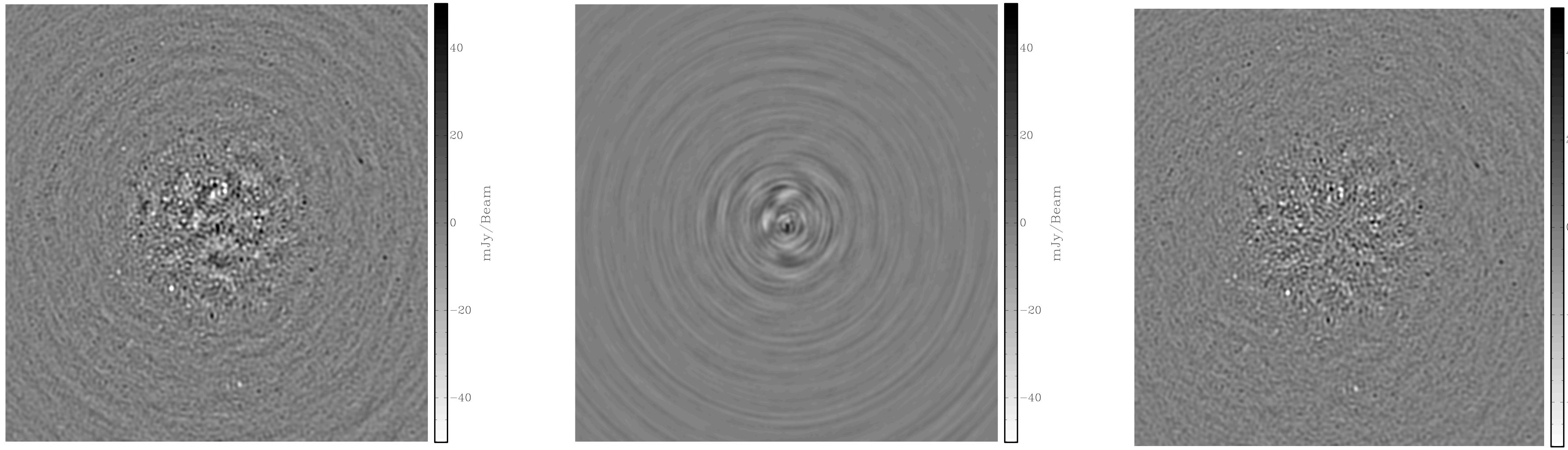
151.17 MHz

after

U **V**



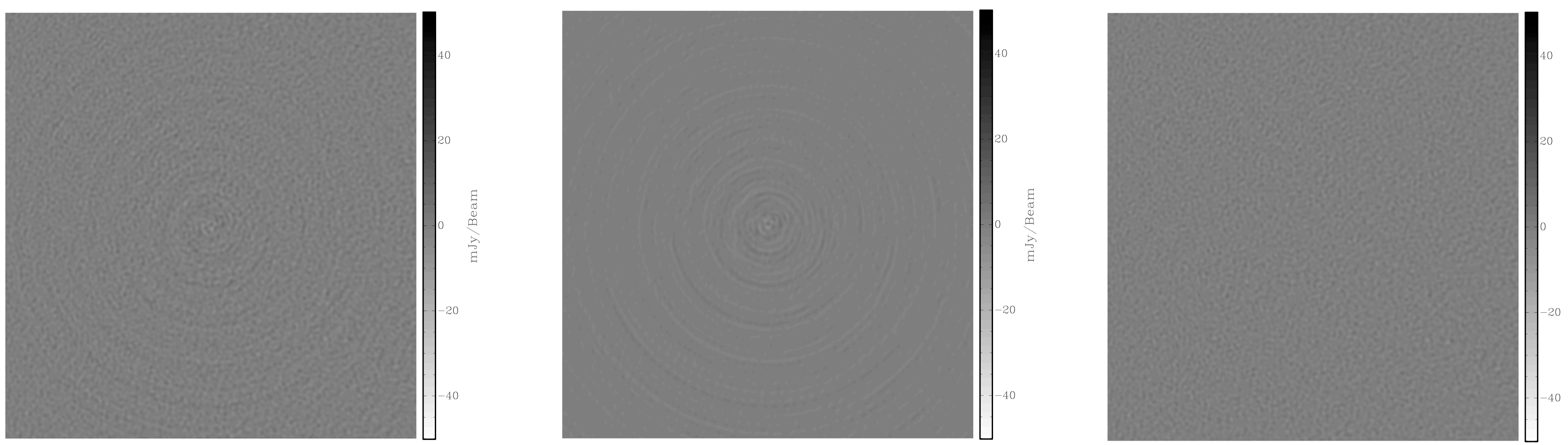




Stokes I: before, difference, after
Stokes V: before , difference, after

L412370 (Jan '16)
sb090-099
unif30-250

NCP



Conclusions:

- The appearance of strong DAB signals inside 110-190 MHz band has led to spurious signals affecting mostly signals above 150 MHz
- These signals appear to have a constant geometrical phase and hence (their sidelobes) will accumulate near the NCP (dec +90)
- They are strongest on core baselines but can be seen up to 5 km

A python script to correct with them has been developed by Sarod Yatawatta. and has been tested with reasonable success.

Important steps are:

- Clean your image → residual visibility data
- Phase-rotate the data to dec 90 at relatively high resolution (e.g. 5ch/sb and 4s)
- Apply the directional statistics script
- Phase-rotate the data back
- Continue with processing… (e.g. restore the subtracted model)

Removing these ‘quasi-stationary’ signals is easier, i.e. less dangerous, when your target is far from the North pole.