LOFAR Long Baseline Busy $^{2}/_{5}$-Week

George Heald
on behalf of the LLBWG
31 March 2010

Special thanks to Stefan Wijnholds!

Outline

- What's needed for the long baselines [abridged]
- Ongoing work:
  - X,Y order for LBA_OUTER / LBA_INNER
  - Searching for differential Faraday rotation...
  - Cable length possibly cause of 8 MHz ripple?
  - Clock offsets vs. delays

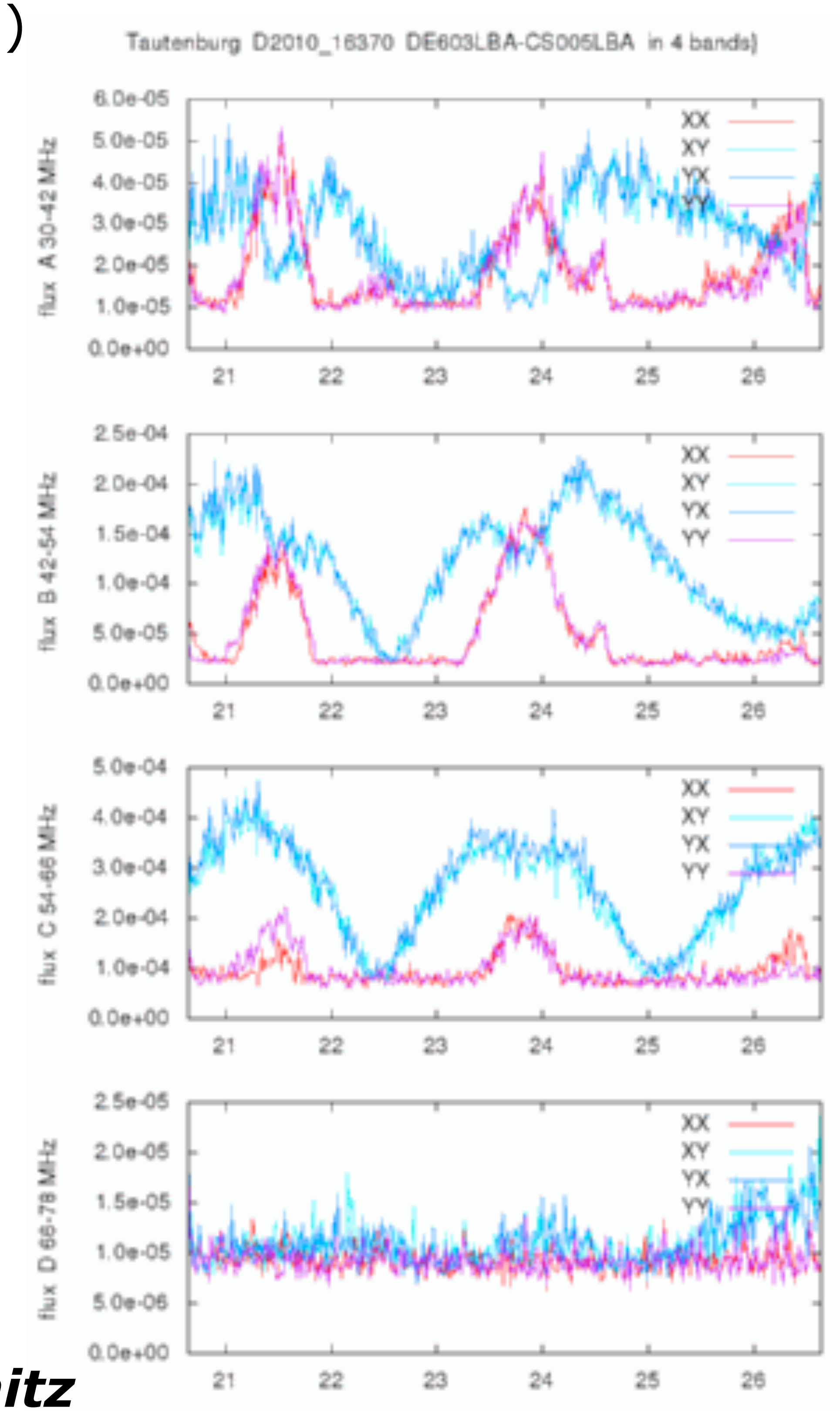
LLBWG:
J. Conway, J. Anderson, V. Tudose, O. Wucknitz, M. Garrett,
J. McKean, N. Jackson, G. Heald, A. Polatidis, N. Pradel

What’s needed

- Prioritization ongoing for several more-or-less long baseline specific items:
  - Fringe fitting in BBS [clock and ionospheric delays over multiple subbands]
  - Faraday rotation [more on this later]
  - Source models for 3C sources [Jackson; using Atlas of DRAGNs]
  - Multiple station beams [one calibration, one science]
  - Calibration transfer between beams [see previous point]
  - Calibrating over multiple beams [later]
  - Imaging with long baselines....
  - Calibrating on several sources per beam
  - Averaging down uv data after phasing up to source locations
  - Check post-calibration noise levels
  - Speed of BBS
  - Speed of imaging

Cable problem?

- Inspection of Dutch-German baselines led to suspicion that X and Y cables were swapped in Tautenburg (or some similar problem)



(note that {XY,YX}/{XX,YY} decreases systematically to higher frequencies, implying that at zero wavelength all correlation would be in the crosshands)

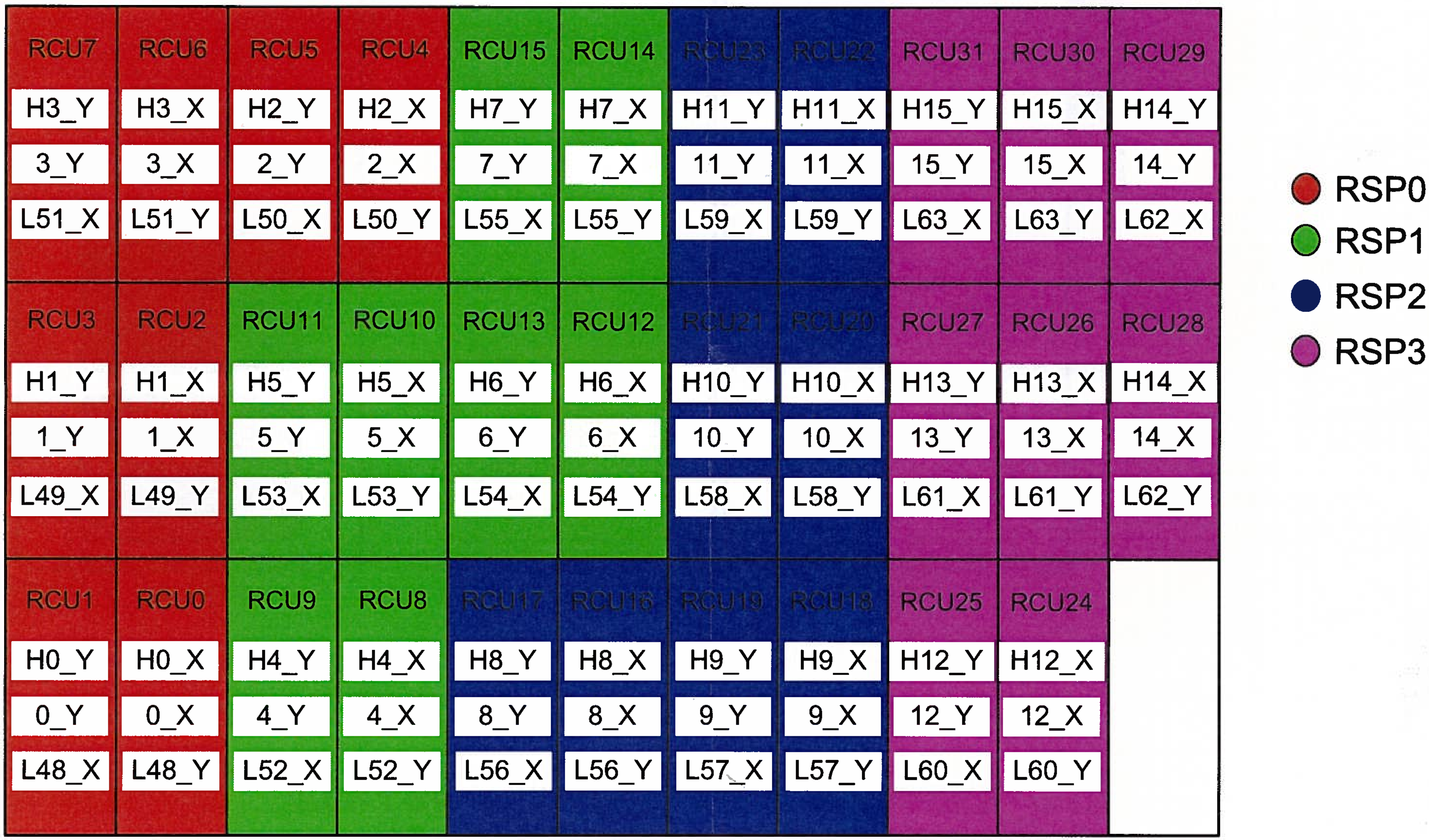
- .... such a cable swap problem seemed to be ruled out by careful inspection at the station

Wucknitz

LBA_INNER vs. LBA_OUTER

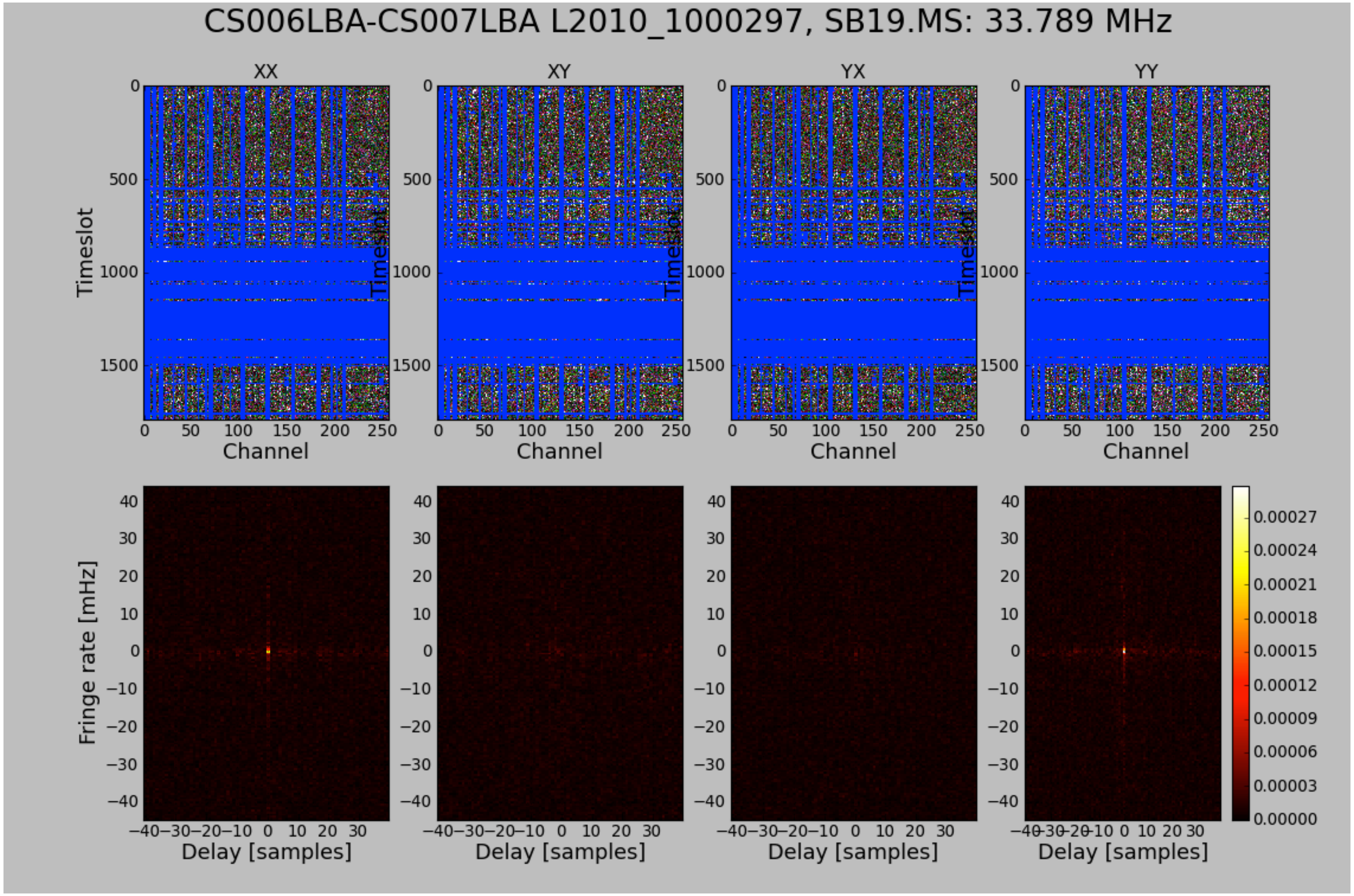
- X,Y inputs swapped (*on purpose*) between LBA-high and LBA-low on RCU boards

RCU-LBA connection scheme SUBRACK 0   P 2/4



LBA_INNER vs. LBA_OUTER

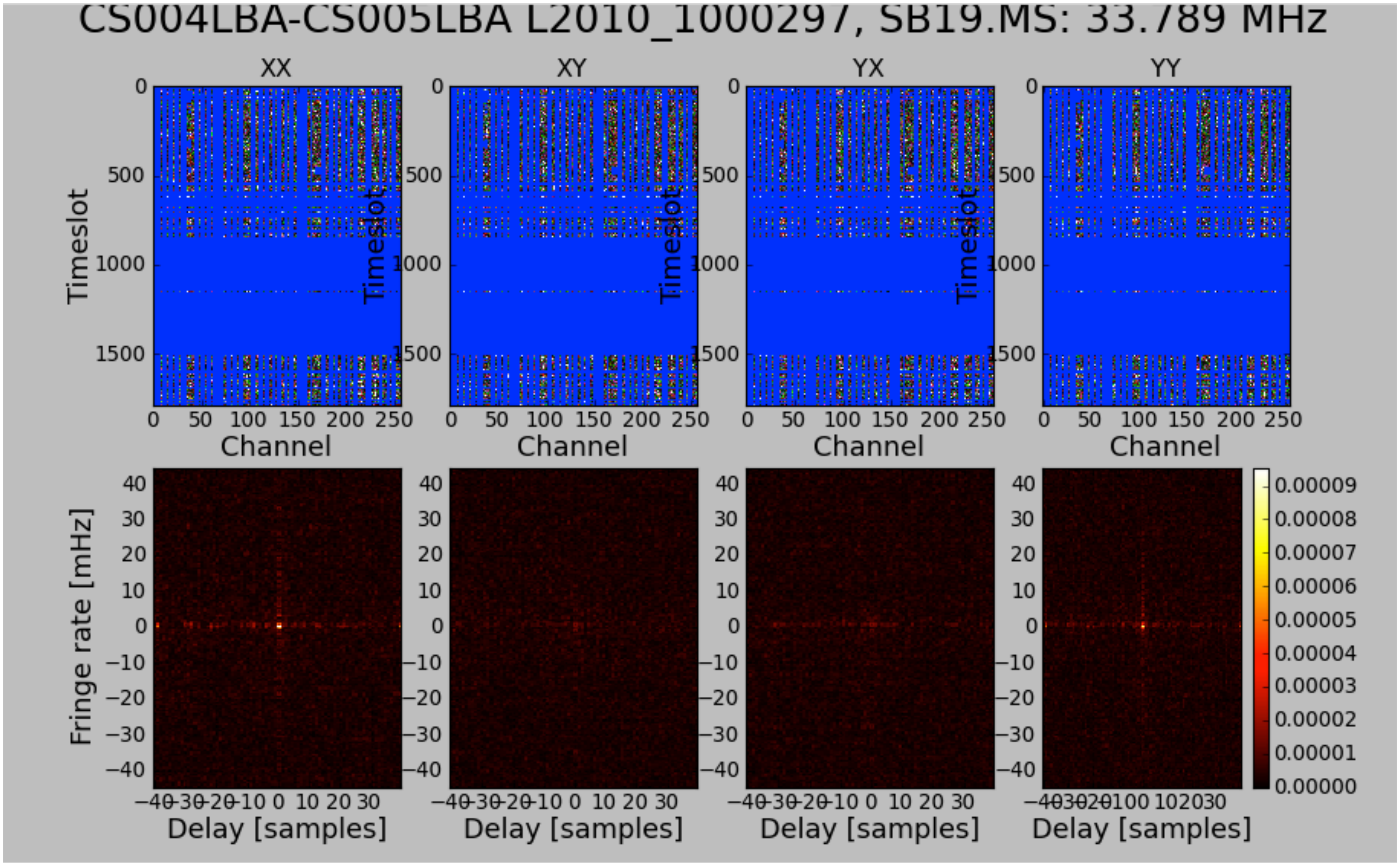
- Test experiment: several superterp stations, some in LBA_INNER and some in LBA_OUTER, correlated together in same experiment.



Two LBA_INNER stations...

LBA_INNER vs. LBA_OUTER

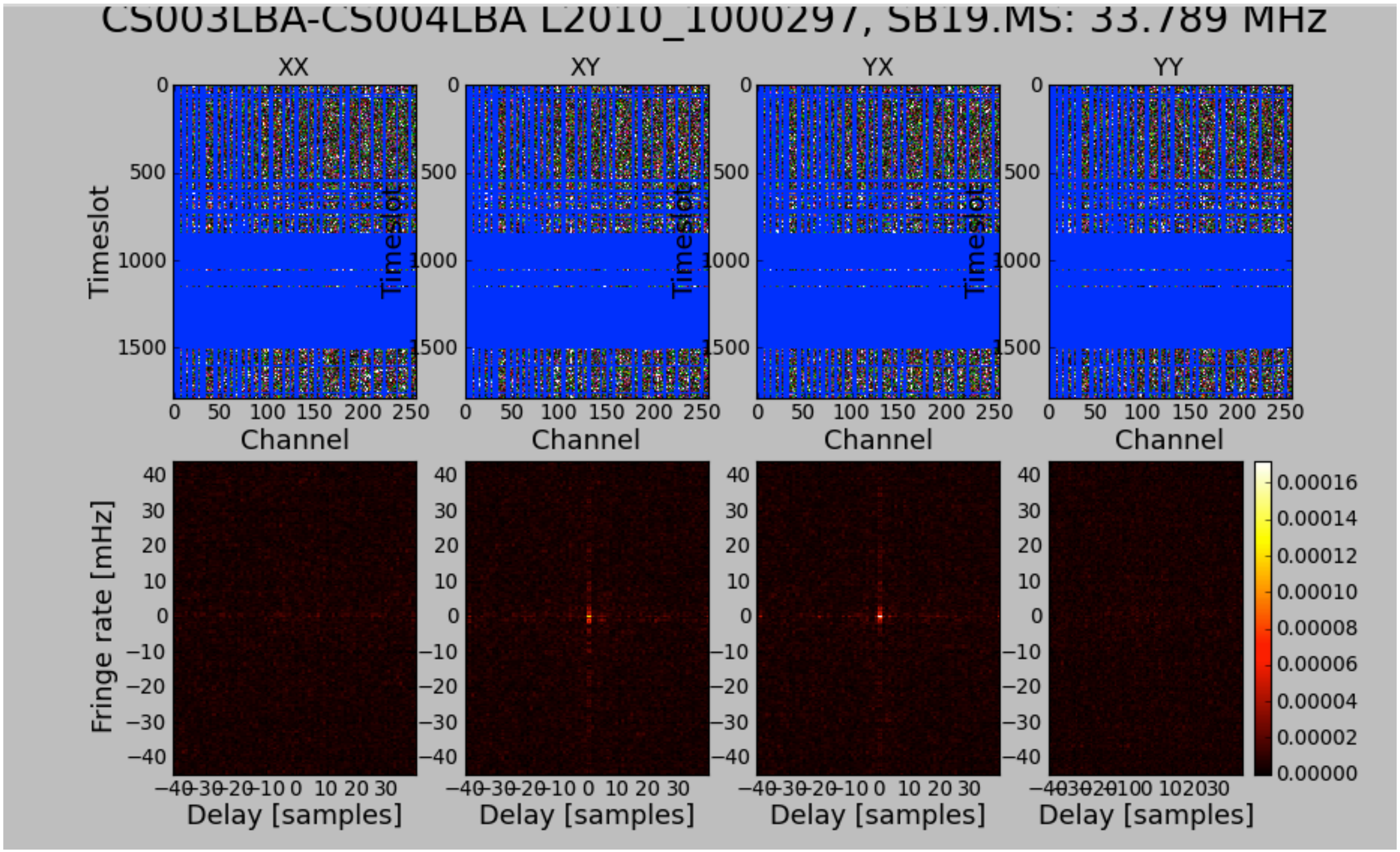
- Test experiment: several superterp stations, some in LBA_INNER and some in LBA_OUTER, correlated together in same experiment.



Two LBA_OUTER stations...

LBA_INNER vs. LBA_OUTER

- Test experiment: several superterp stations, some in LBA_INNER and some in LBA_OUTER, correlated together in same experiment.



One LBA_INNER and one LBA_OUTER station!

Therefore ...

$$\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$$

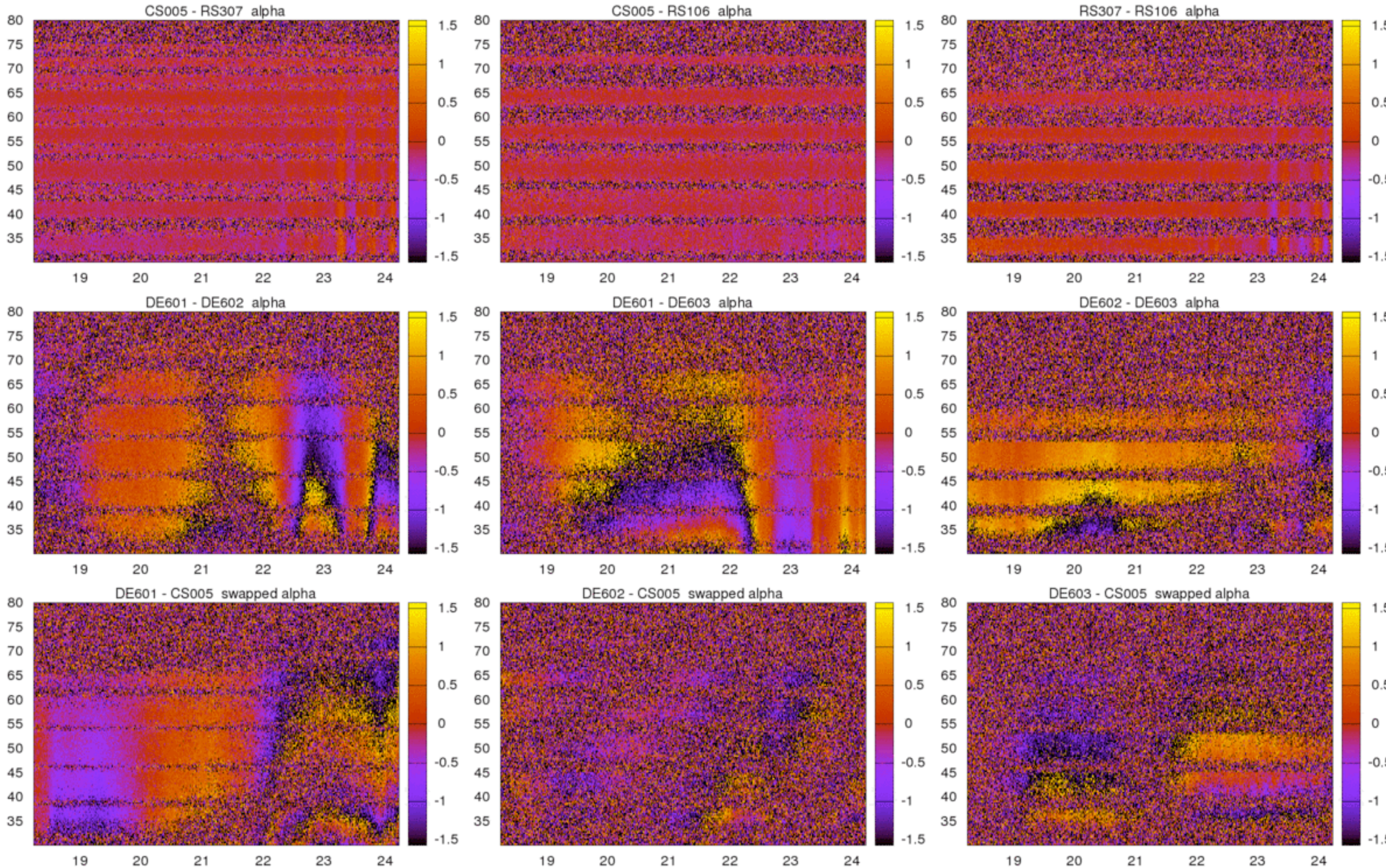
Therefore ...

... we apologize for blaming Tautenburg

$$\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$$

… but wait, there's more!

- The X,Y flip is not the only effect. There is still differential Faraday rotation:



Wucknitz

Differential Faraday rotation

- Joris has implemented a Faraday rotation Jones matrix in BBS
- To verify the need for solving F-Jones in this case, look to the data!

- Solve for all 4 elements of Gain (G) in BBS

$$V = G_i C G_j^\dagger$$

- Ansatz: Faraday rotation part is separable, and remainder is diagonal:

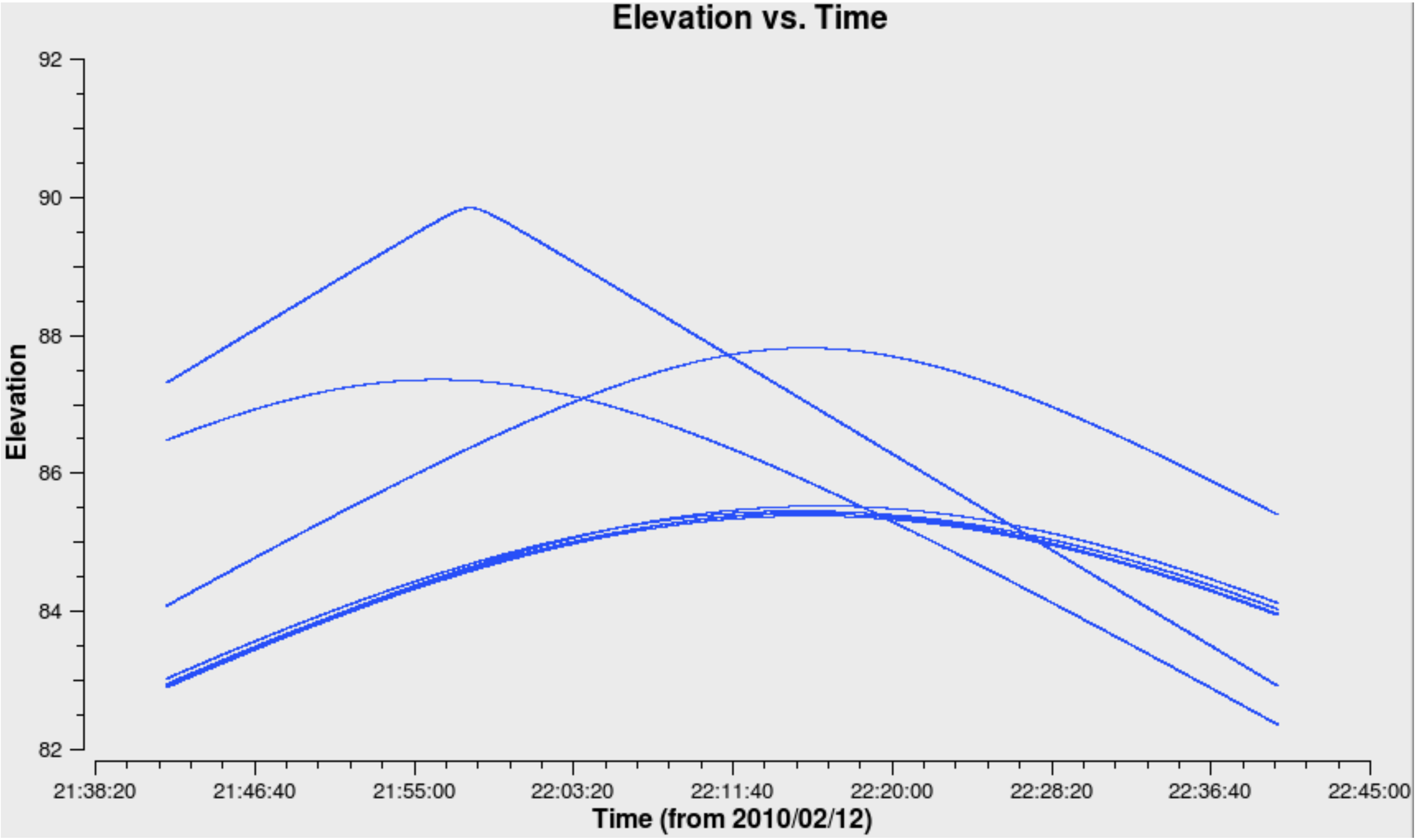
$$G = \begin{pmatrix} G_{00} & G_{01} \\ G_{10} & G_{11} \end{pmatrix} = \begin{pmatrix} G'_{00} & 0 \\ 0 & G'_{11} \end{pmatrix} \begin{pmatrix} \cos(\phi\lambda^2) & -\sin(\phi\lambda^2) \\ \sin(\phi\lambda^2) & \cos(\phi\lambda^2) \end{pmatrix}$$

- In this case, combinations of the parameters that BBS solves for should give an estimate of the rotation measure:

$$\frac{G_{01} - G_{10}}{G_{00} + G_{11}} = \tan(\phi\lambda^2)$$

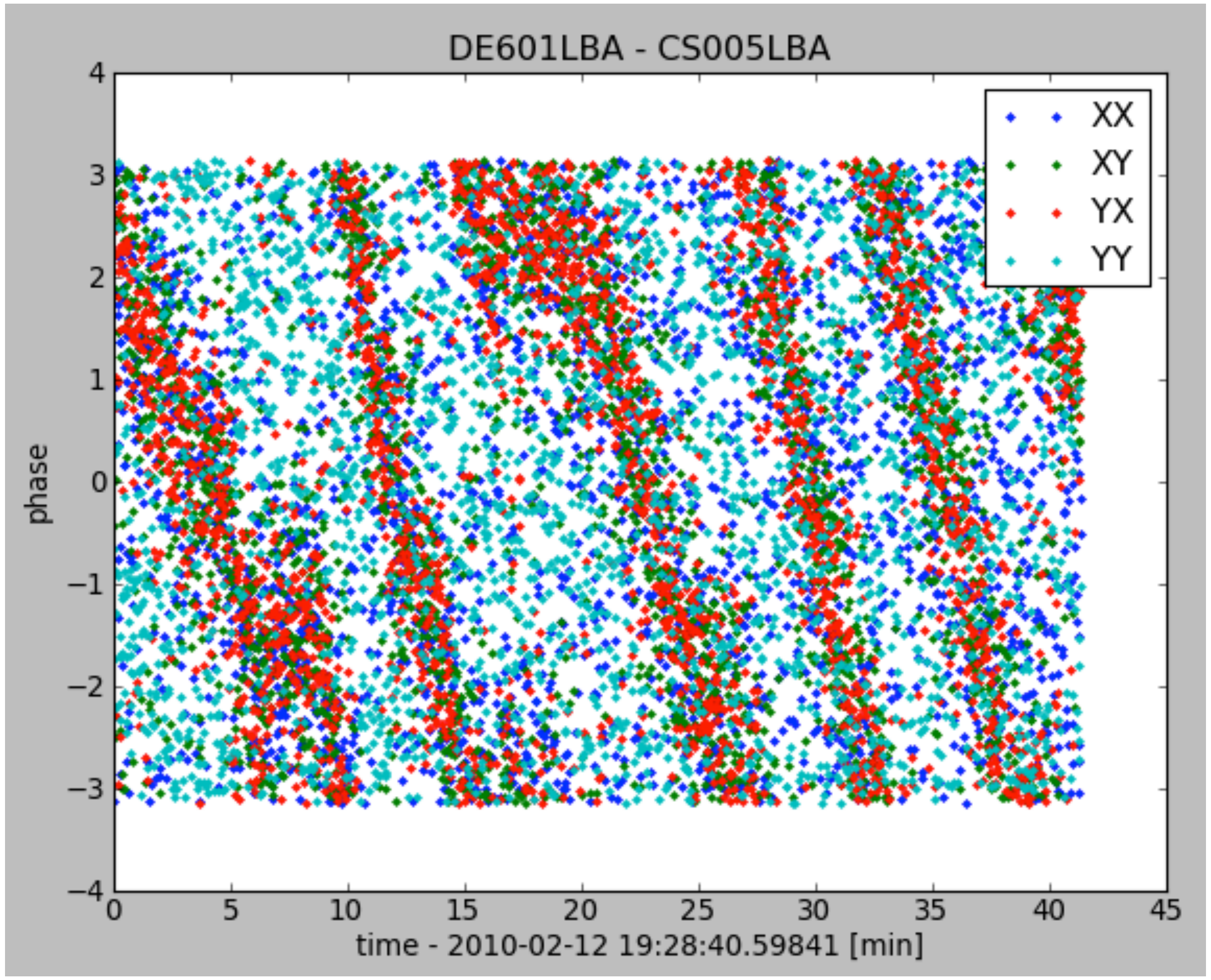
3C196

- L2010_16704 (Tautenburg test)

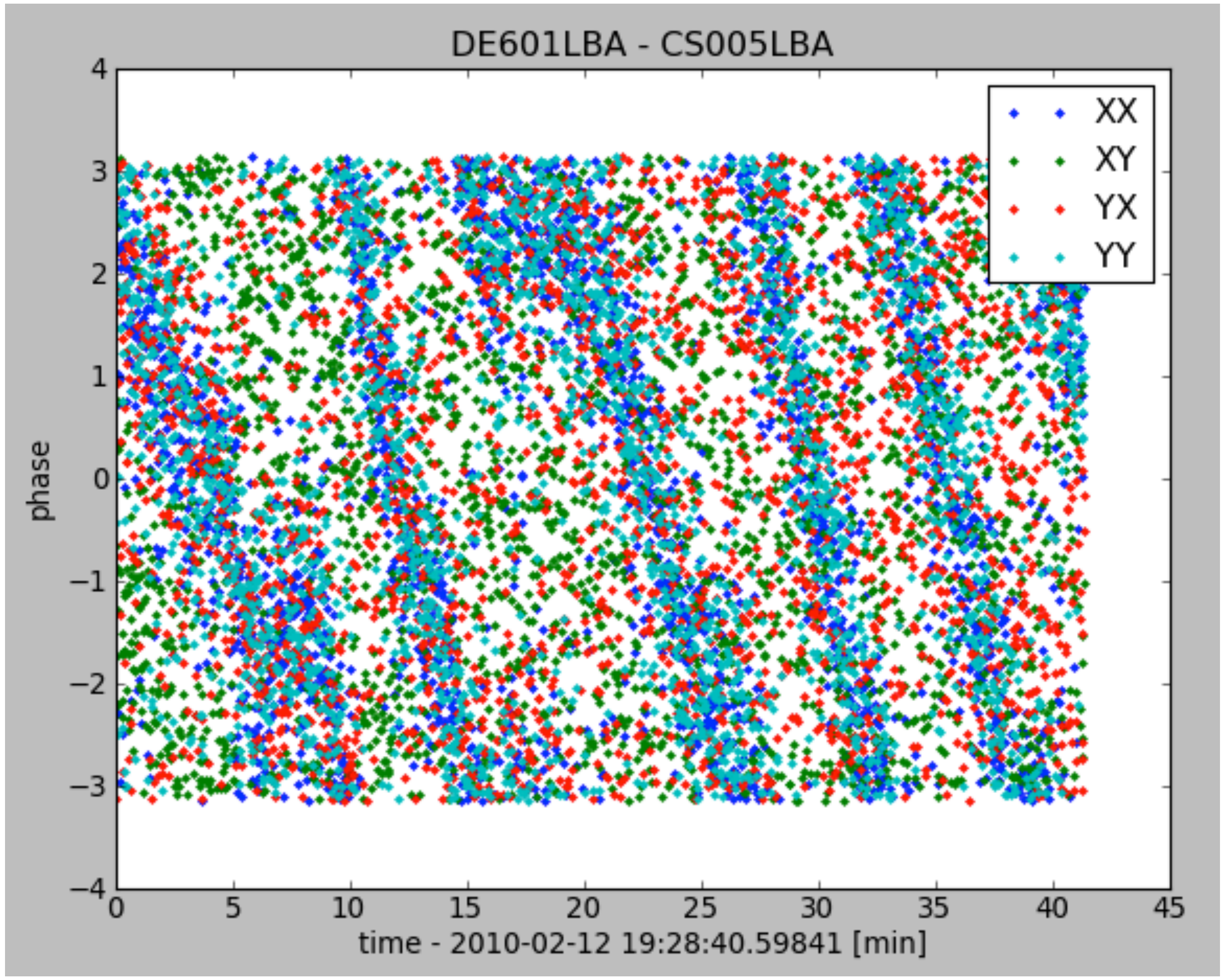


Faraday rotation?

- Calibrated using BBS, after:
  - running NDPPP to flag, and then compress in frequency
  - splitting out a small (~40 min) time range
  - eliminating DE603LBA and RS503LBA
  - flipping X,Y for DE601 - (CS*/RS*): ~seven lines of python, using pyrap!



BEFORE



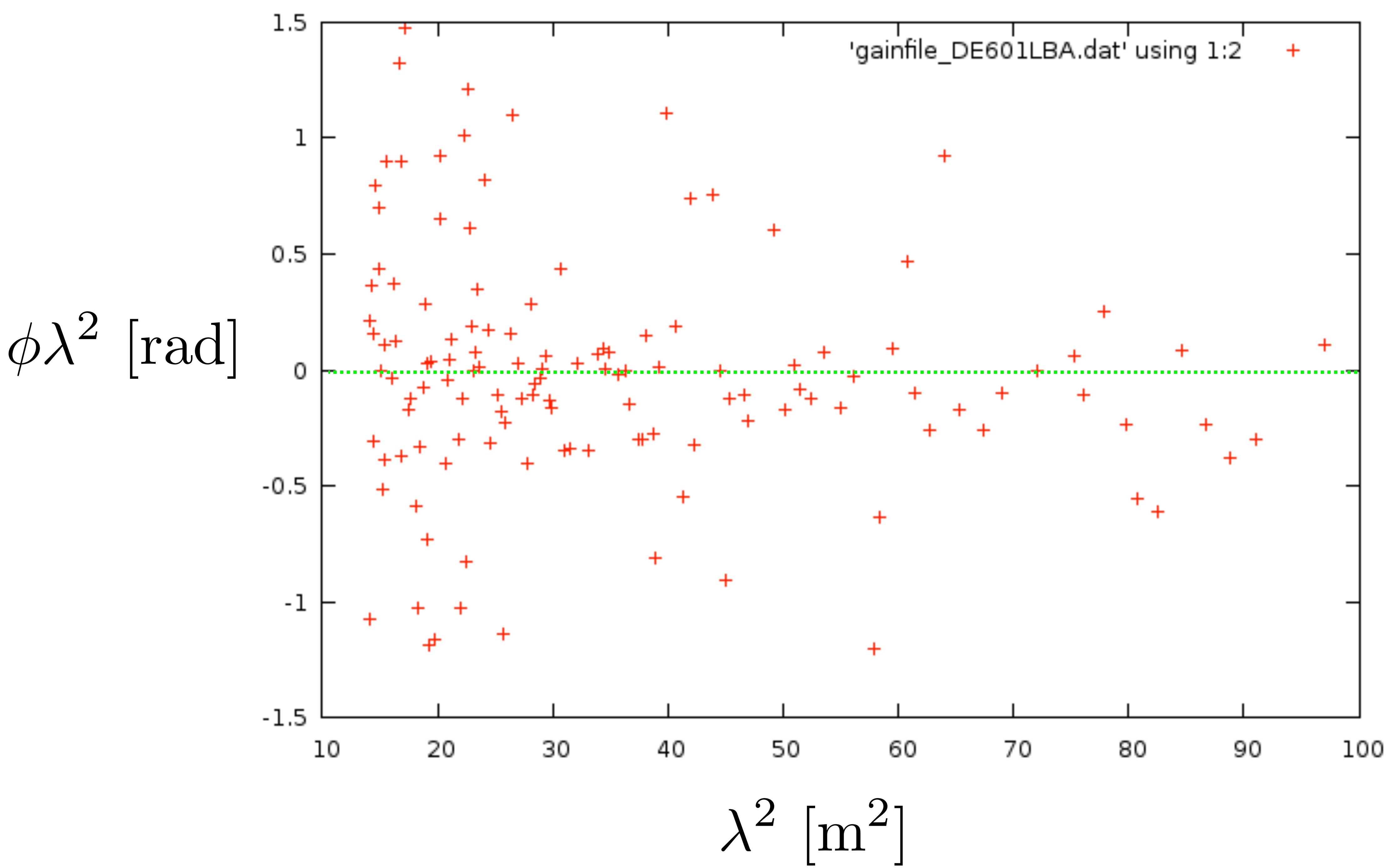
AFTER

Faraday rotation?

- Calibrated using BBS, after:
  - running NDPPP to flag, and then compress in frequency
  - splitting out a small (~40 min) time range
  - eliminating DE603LBA and RS503LBA
  - flipping X,Y for DE601 - (CS*/RS*): ~seven lines of python, using pyrap
- Used following strategy:
  - use CS005LBA as the reference station
  - hold reference phase fixed to 0 for diagonal G terms
  - hold offdiagonal G terms fixed to 0
  - fit all four terms of G for every other station, using a 20sec time interval, and an independent solution for each (compressed) subband
  - inspect fitted gains as function of frequency

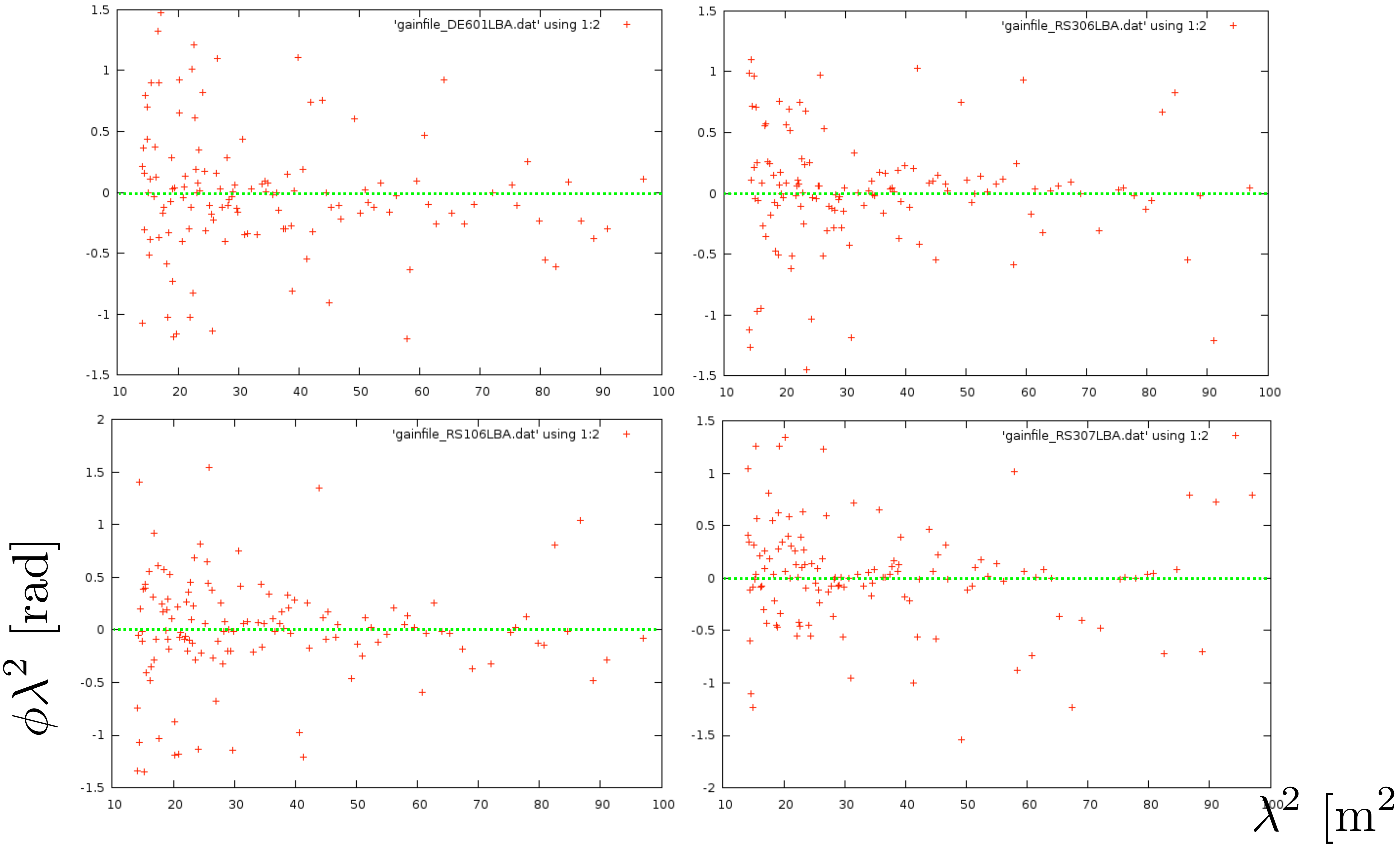
Faraday rotation?

- The time range that I picked seems to have little to no differential Faraday rotation between Effelsberg and Exloo:



Faraday rotation?

- and also none between Dutch stations

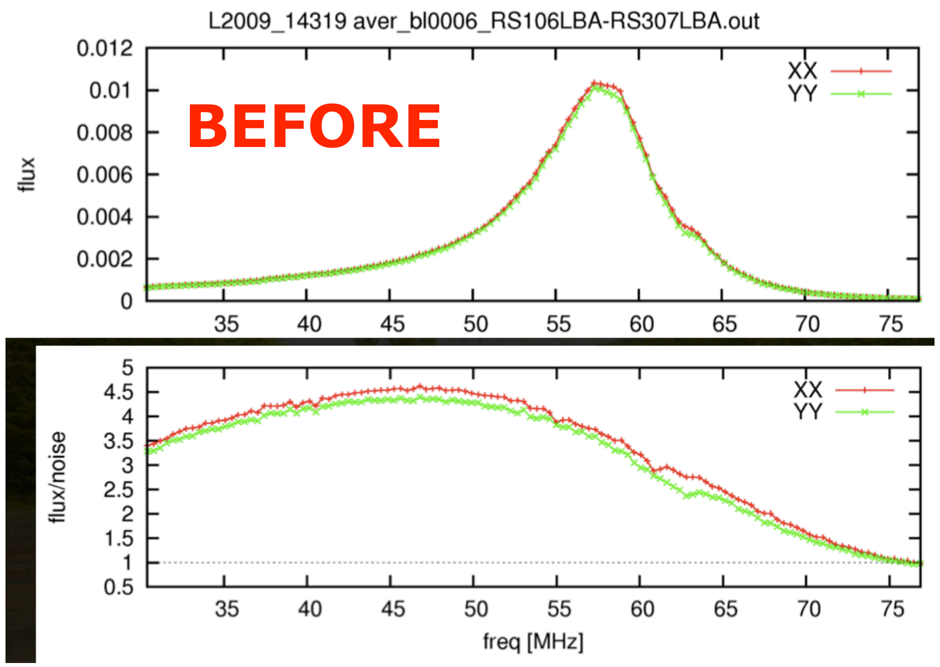


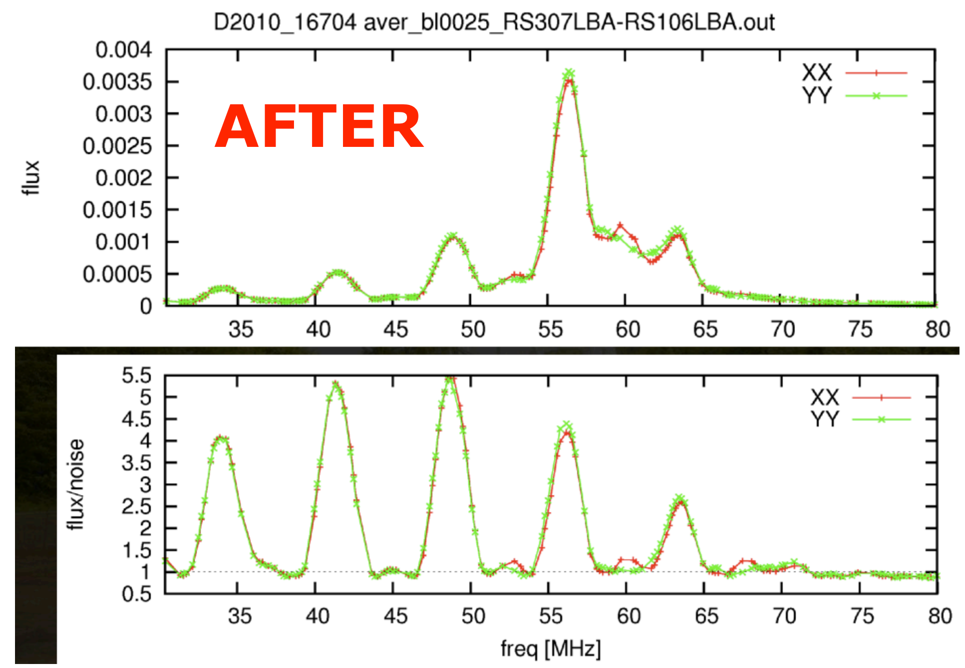
Faraday rotation?

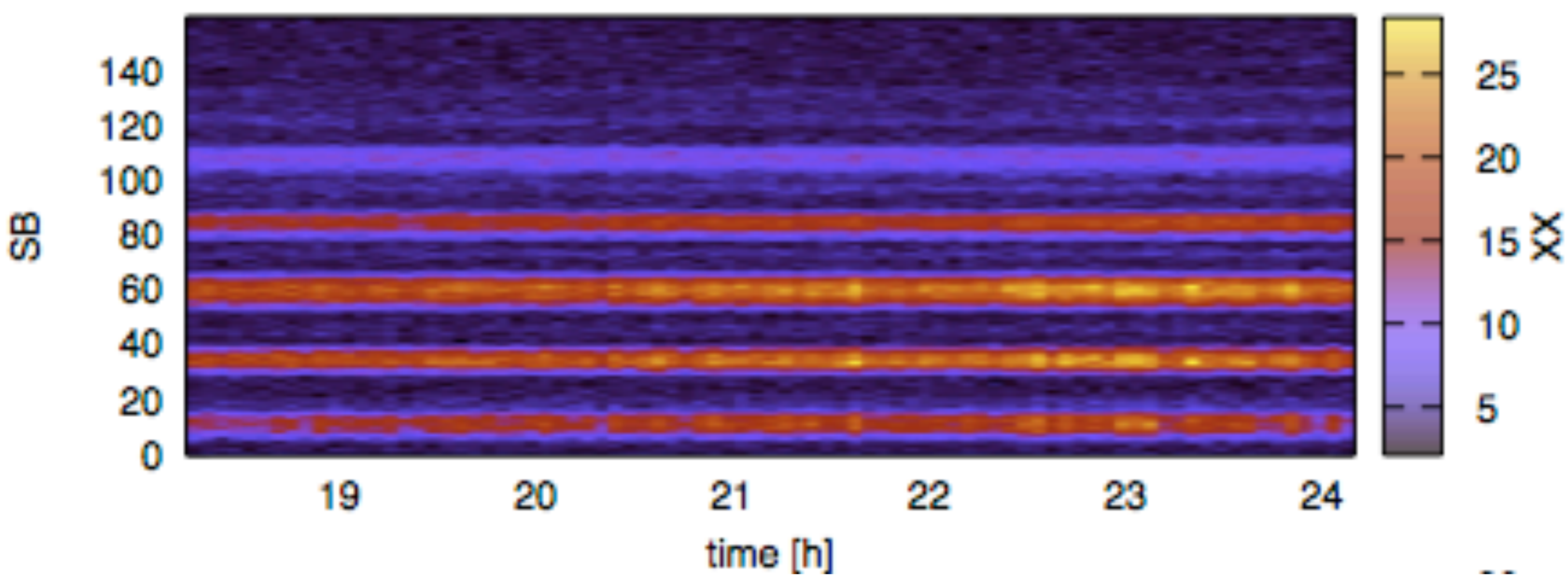
- To do:
  - Find a more appropriate dataset / time range. Which data set did Sarod use to extract differential Faraday rotation in MeqTrees?
  - Use a strong polarized source

8 MHz "ripple"

- Olaf detected a strong sensitivity variation with frequency, period ~8 MHz.





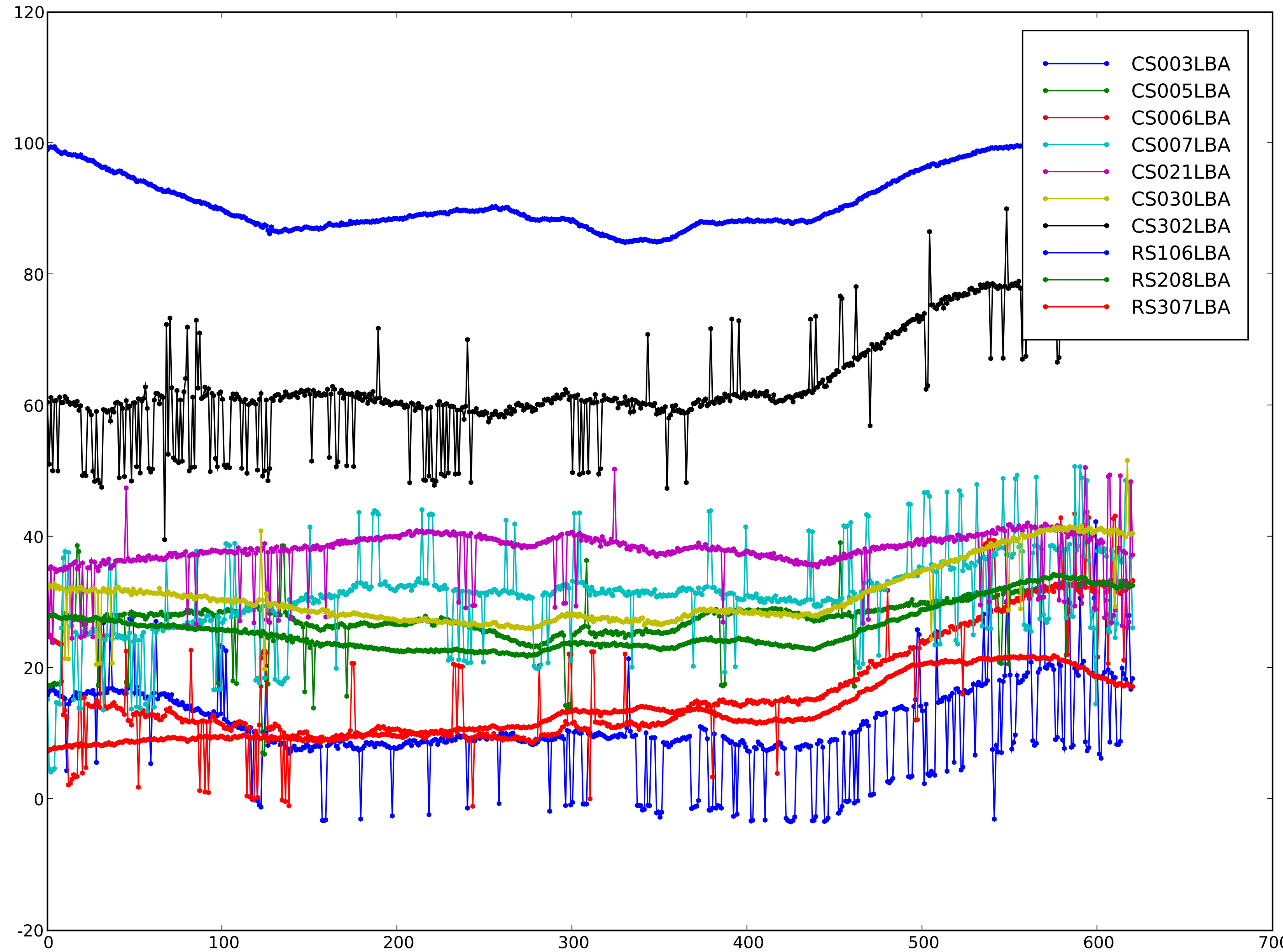


Wucknitz

- Problem began mid-January, and is roughly consistent with different cable lengths in the stations. ***Did we stop correcting for cable length?***

Clock offsets

- Are observed ~100ns - 1us "clock errors" really due to clock problems, or are they delays?



van der Tol

- Future observation strategy under development to
  - find out if "clock errors" are constant with time, or variable
  - compare their values with properties of individual stations e.g. cable lengths