The LOFAR LBA Sky Survey:
problems & solutions

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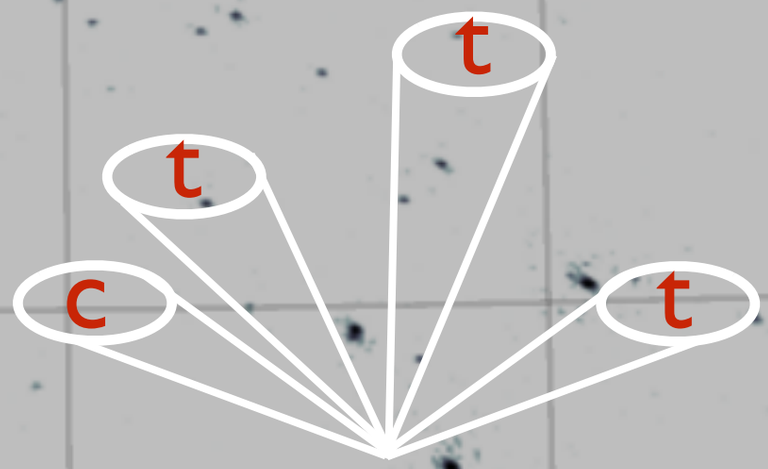
5/4/16 - Zandvoort ann Zee

The LOFAR LBA Survey

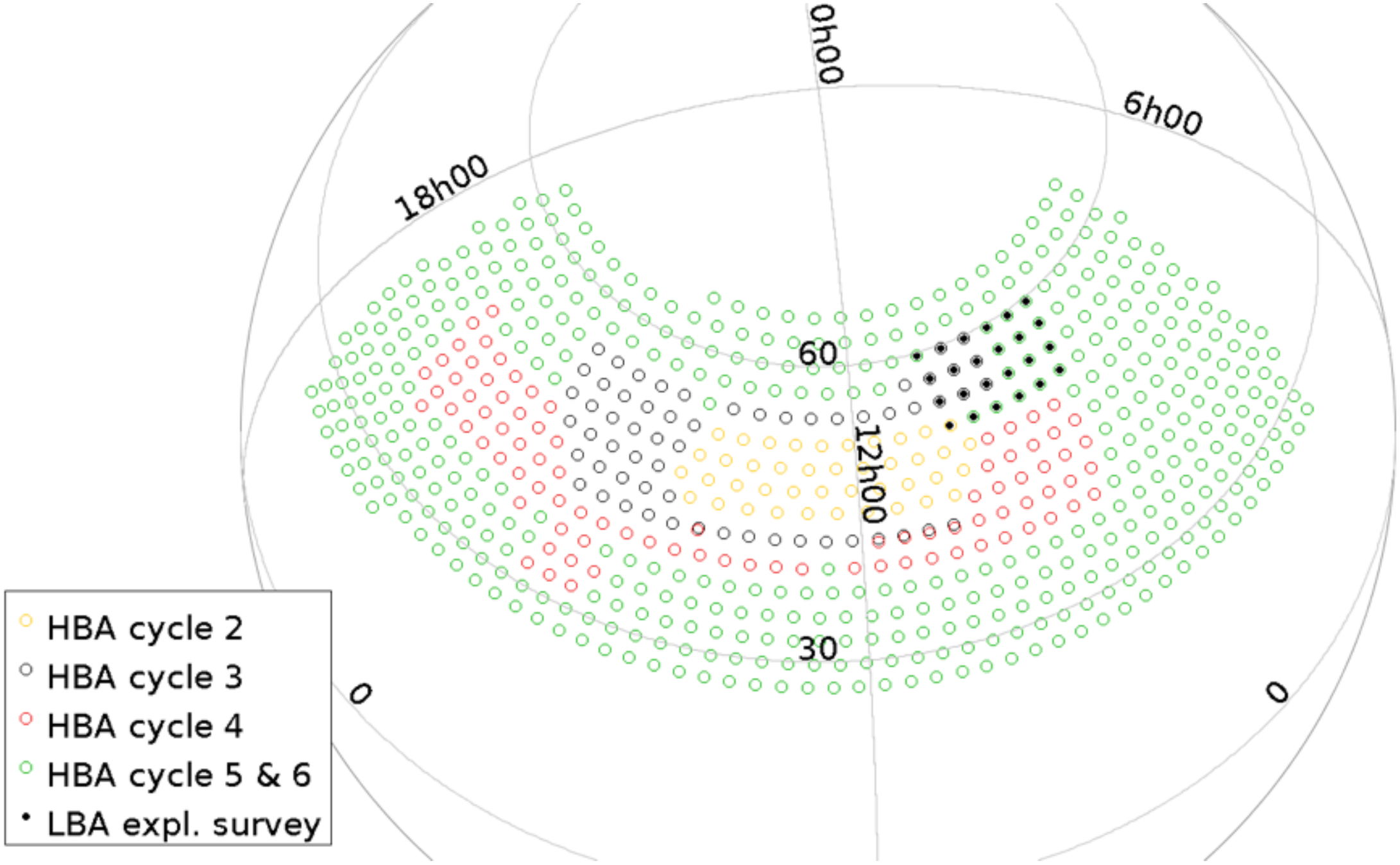
Beams: 4 (1 calibrator + 3 targets)
Mode: LBA_OUTER (4 deg FWHM) - SPARSE?
Obs time: 8 hrs per pointing - total pointings: 3170

Frequency coverage: 42 - 66 MHz
Resolution: 15” to 30”
Noise level: 5-10 mJy (DIE) - 1 mJy (expected DDE)

LoLSS - Vs - VLSS
10 - 20 times better noise
2 - 3 times better resolution



The LOFAR LBA Survey



The LBA Exploratory Survey: 24 pointings (160 sqdeg)

The LOFAR LBA Sky Survey (LoLss)

1. Understand the systematics
2. Figure out a strategy
3. Reduce the data

Phases RR

Frequency >>

Time >>

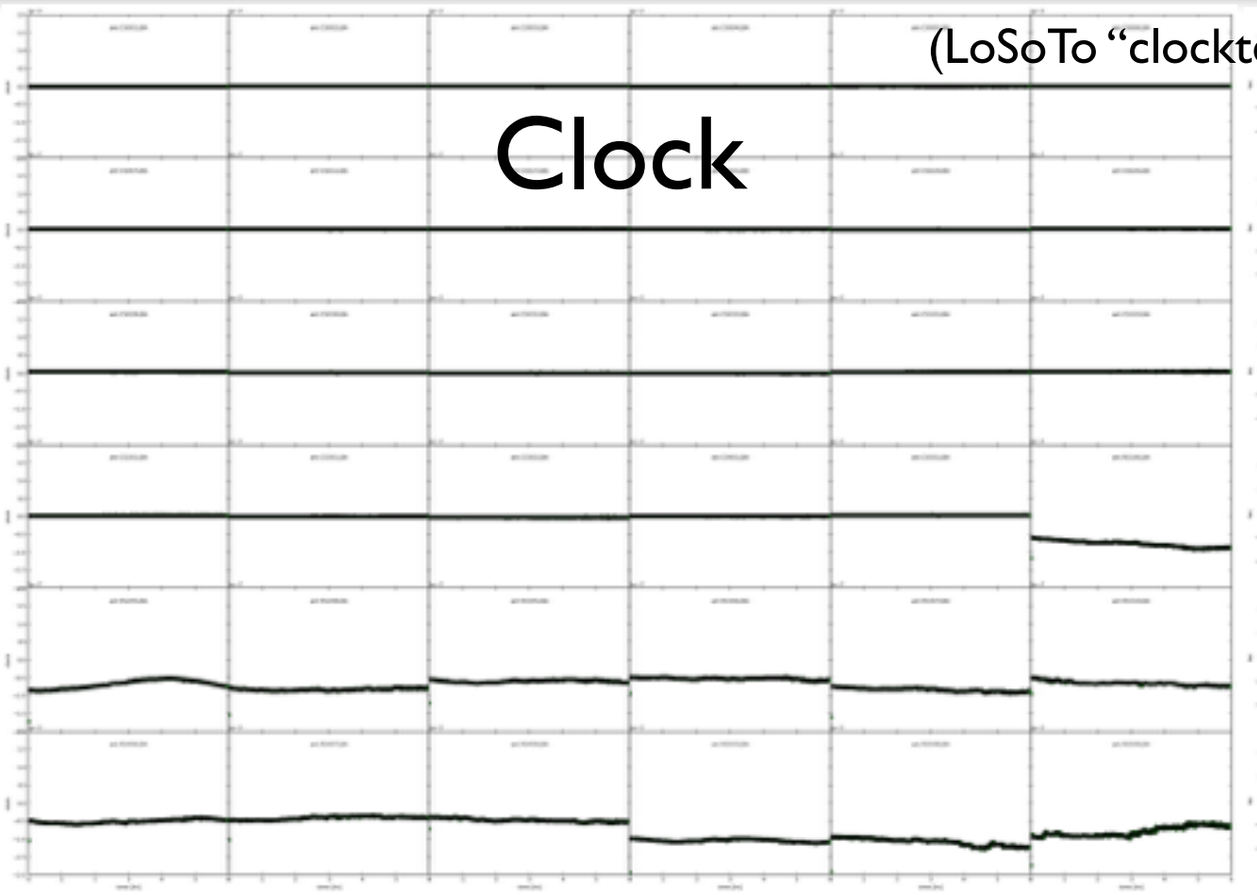
Phases RR

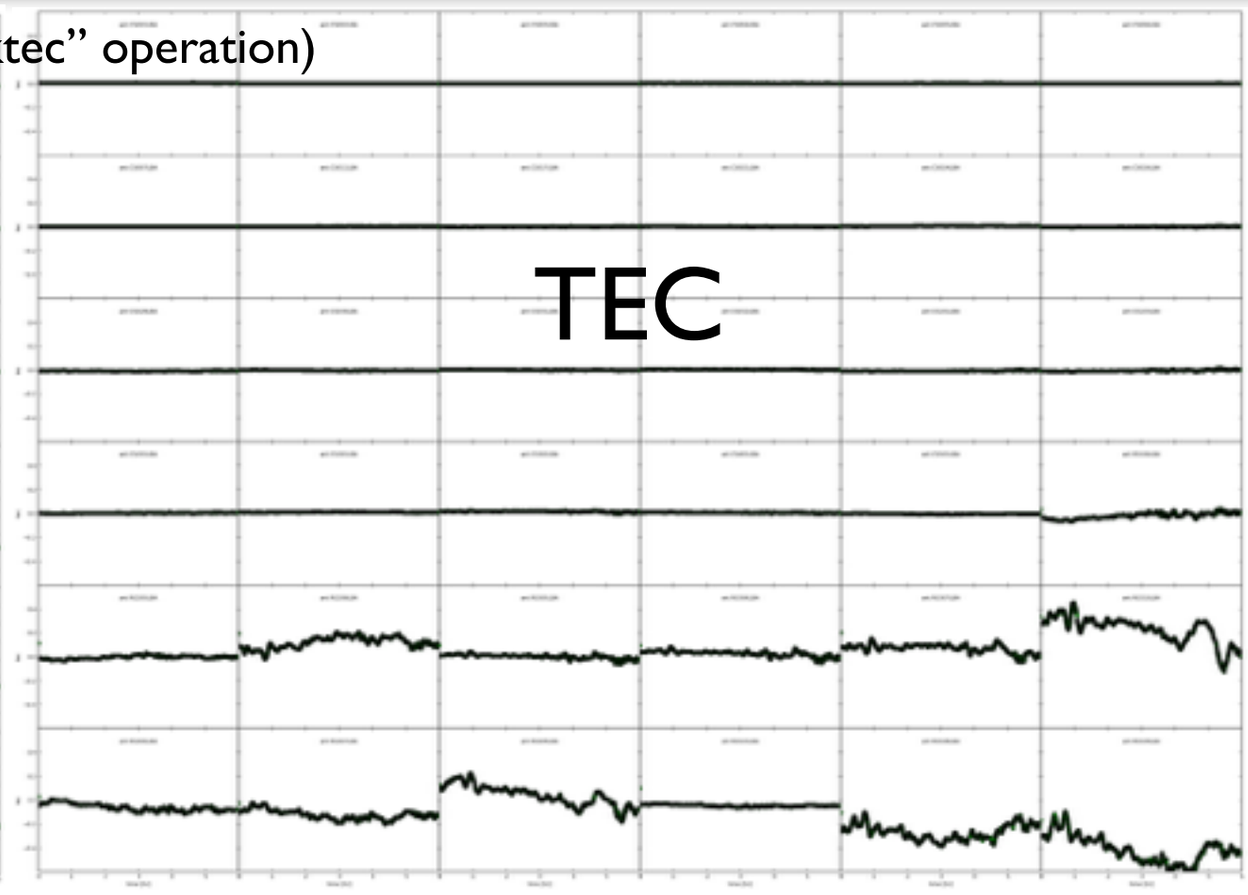
Lesson learned:

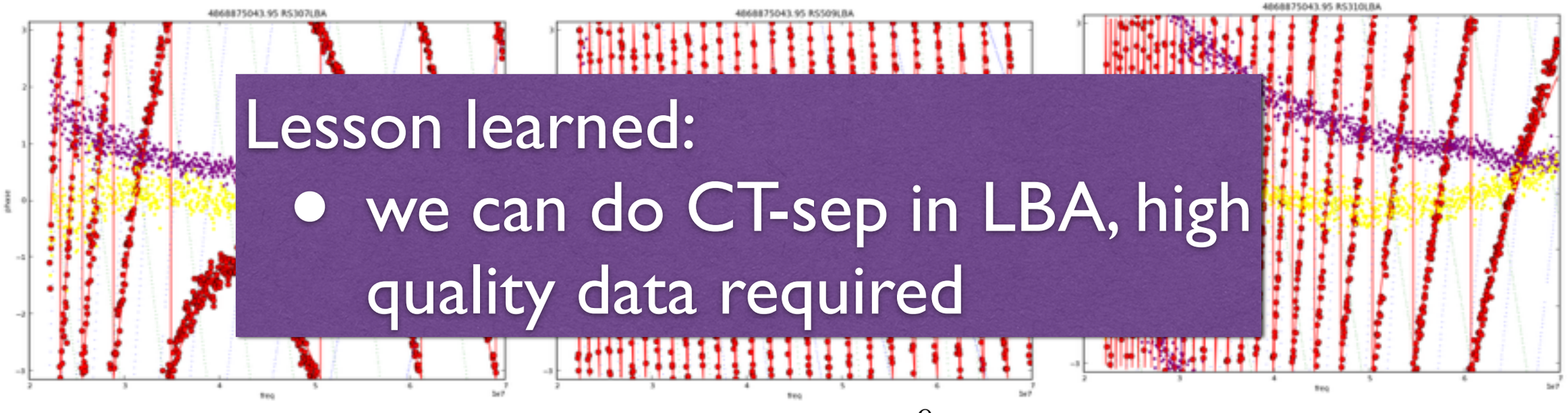
- Min freq res: 4 ch/SB
- Min time res: 5 sec

Clock/TEC separation

(LoSoTo "clocktec" operation)





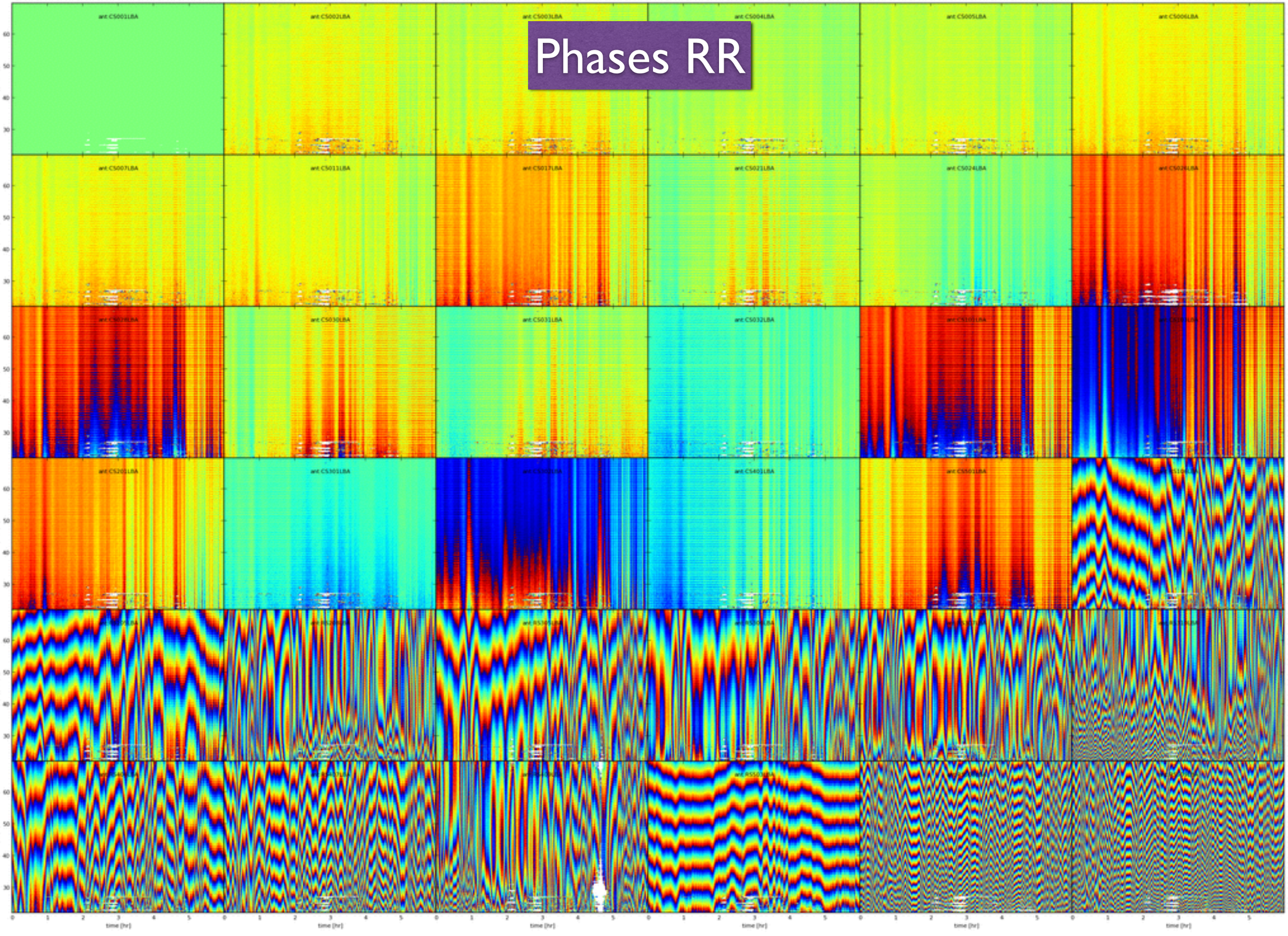


Lesson learned:

- we can do CT-sep in LBA, high quality data required

$$\Delta\theta = 2\pi f \Delta t + 8.44797245 \times 10^9 \Delta TEC/f + \Delta\theta_0$$

Phases RR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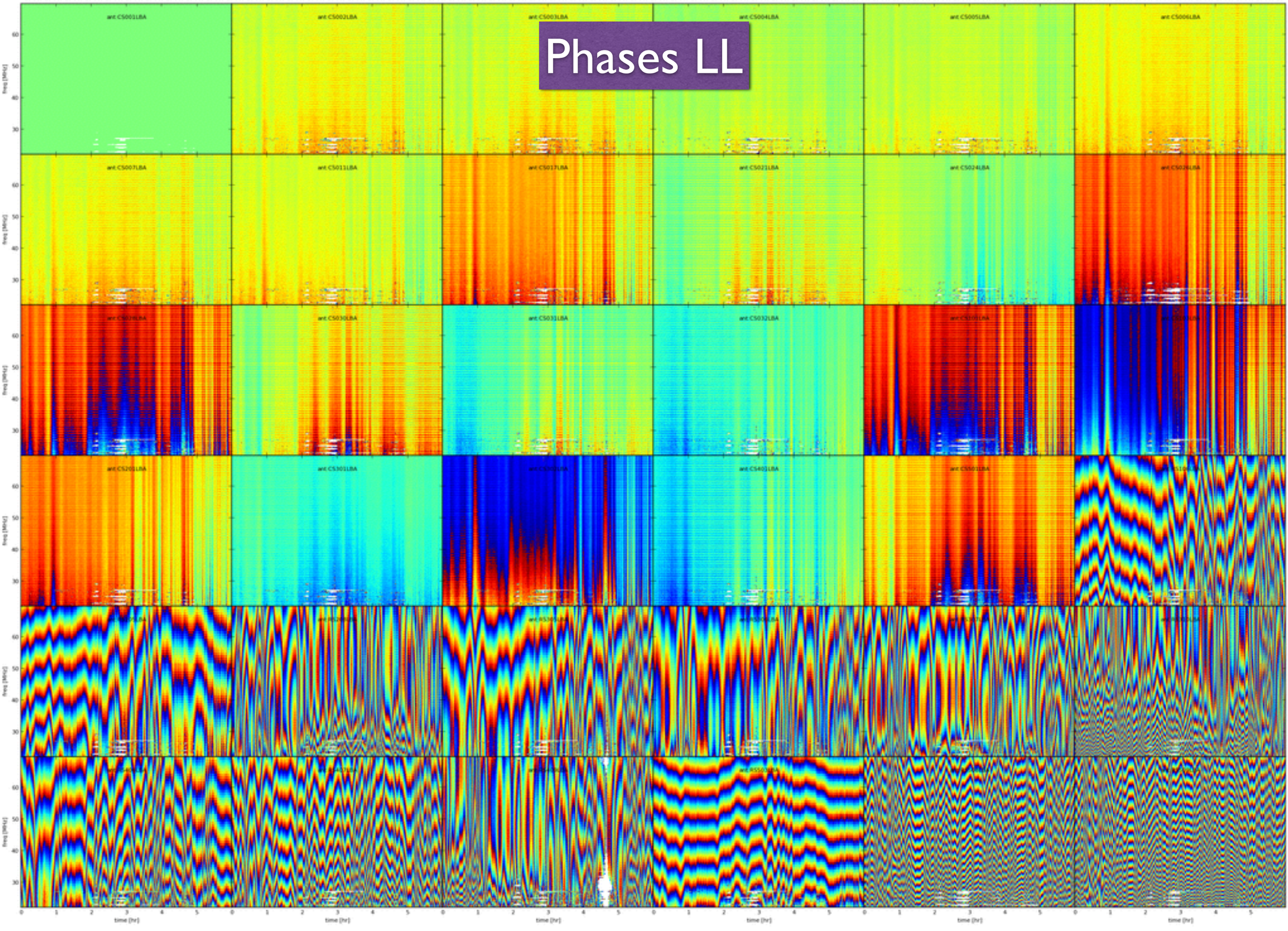
freq [MHz]
time [hr]

Phases LL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freq [MHz]
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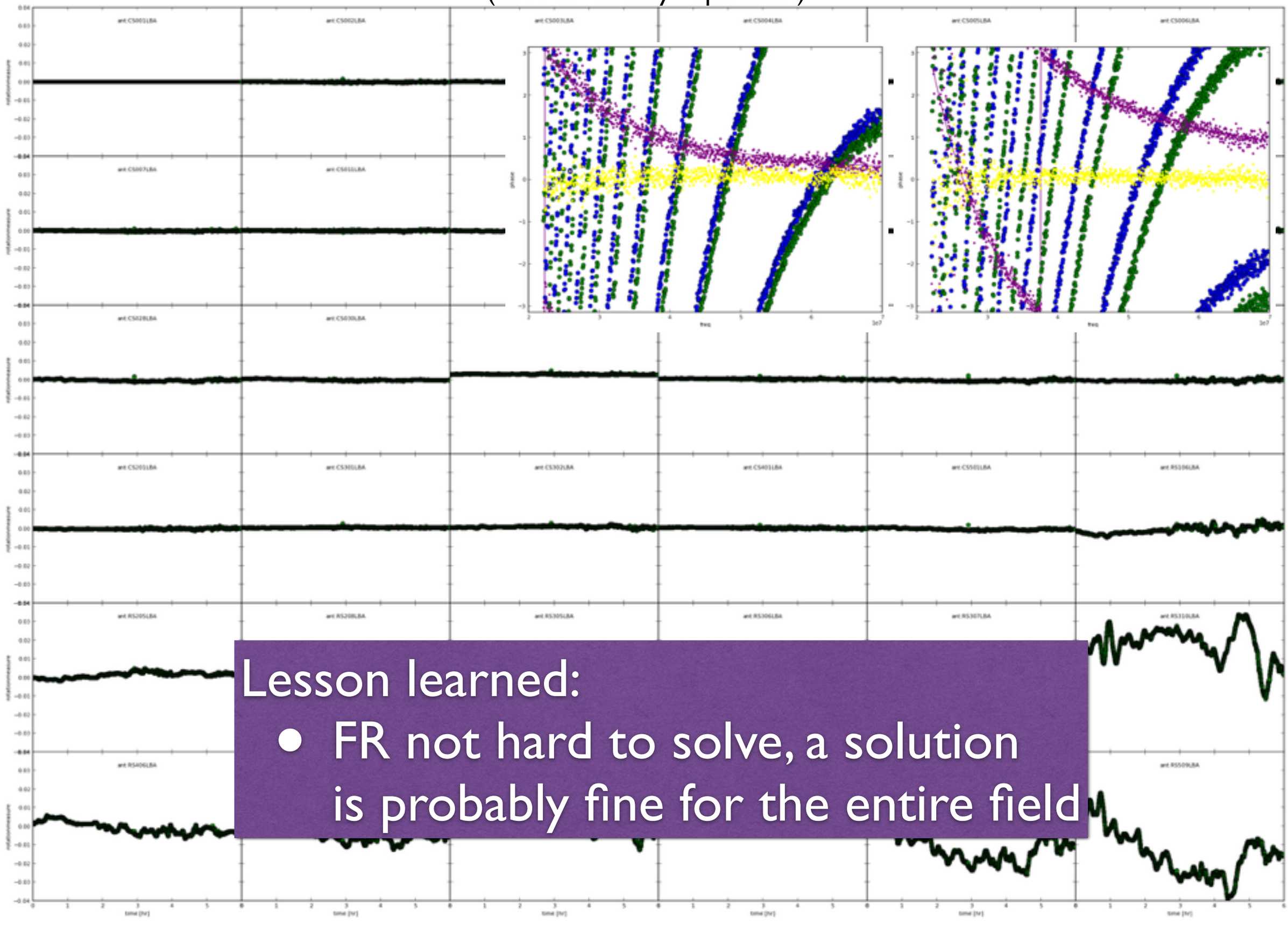
Rotation Measure

(LoSoTo "faraday" operation)



Lesson learned:

- FR not hard to solve, a solution is probably fine for the entire field

RR

- clock

↓ - TEC - FR

↓ - FR

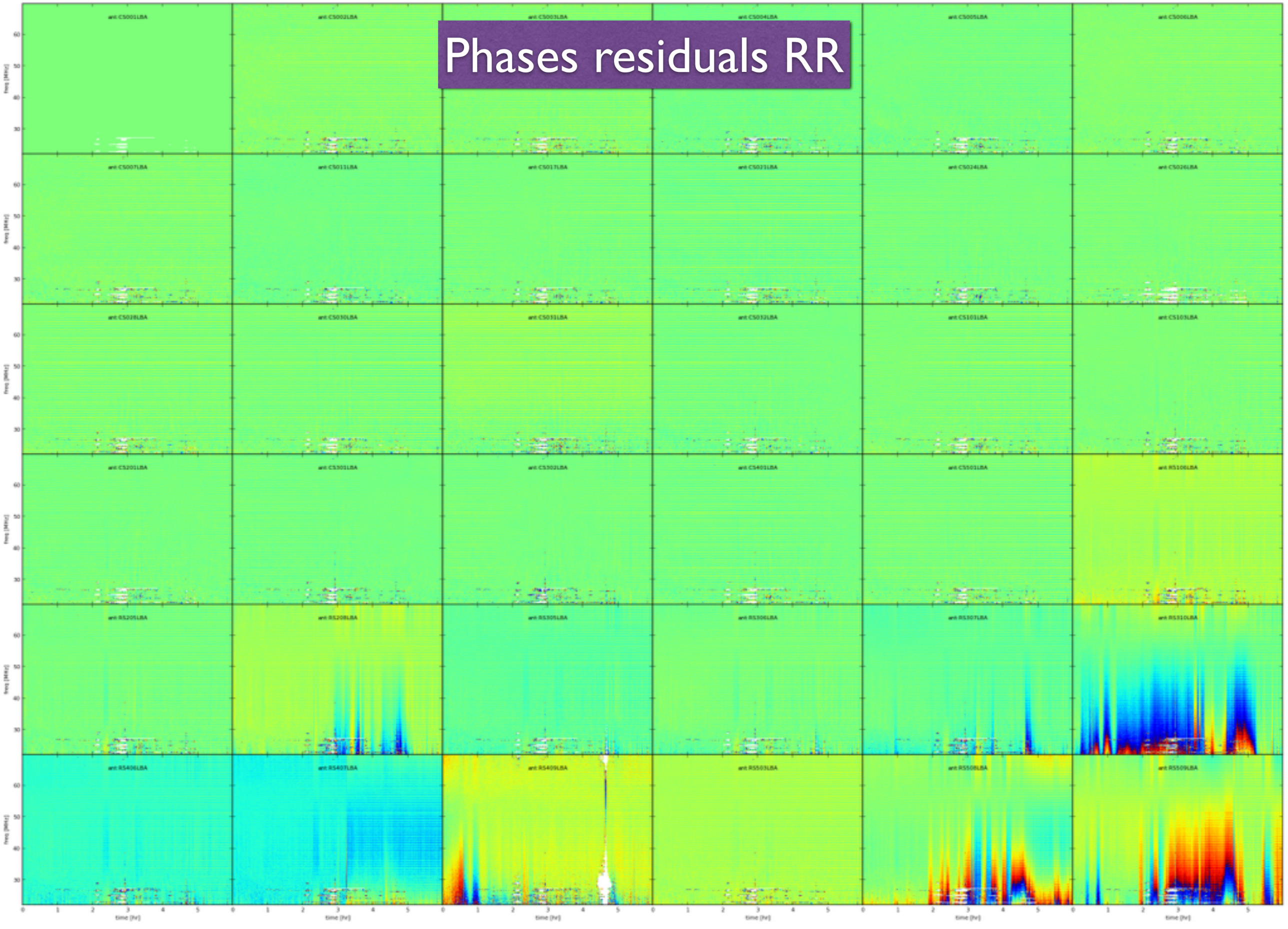
LL

→ - clock

↓ - TEC - FR

↓ - FR

Phases residuals RR



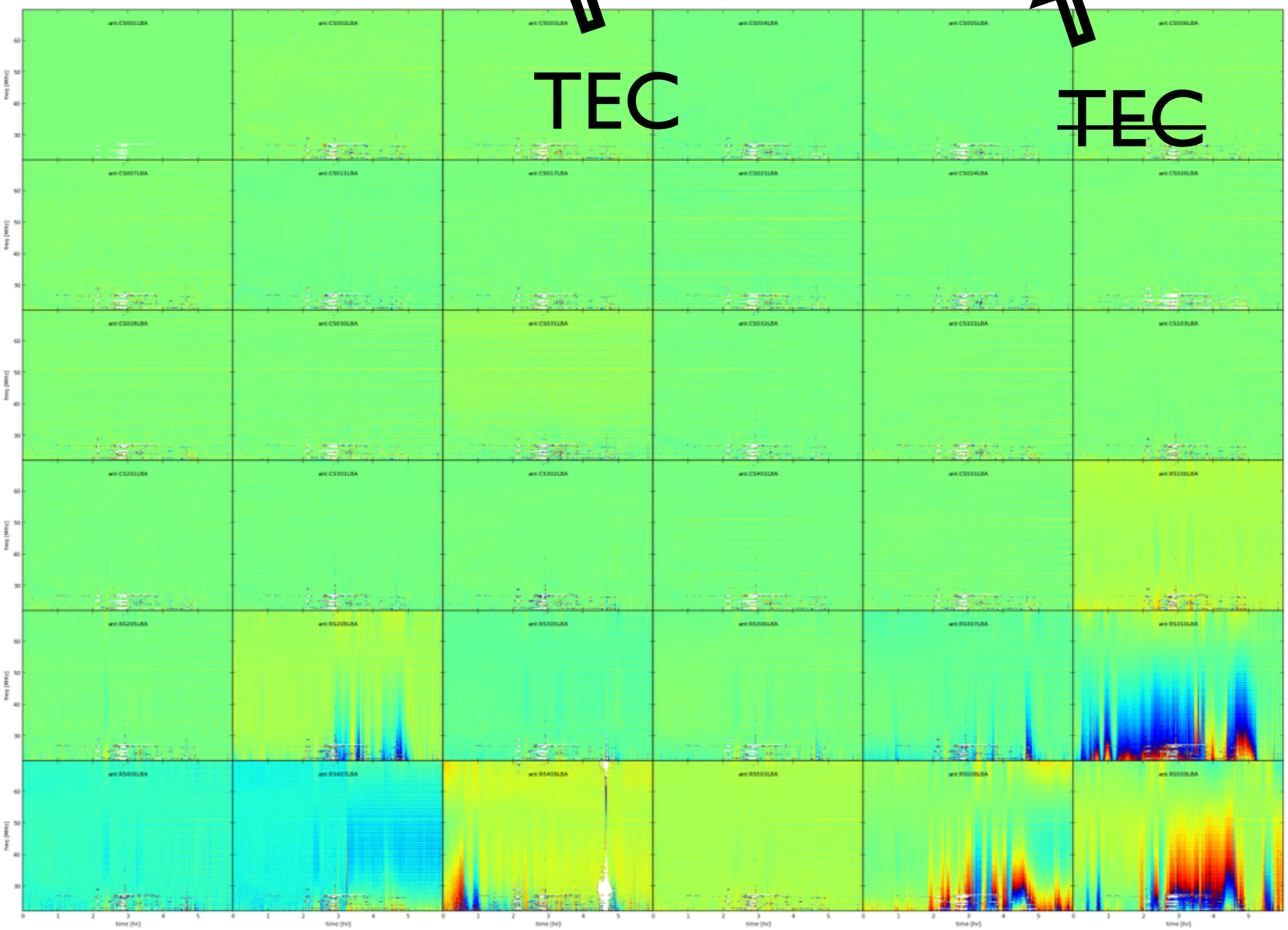
Higher orders

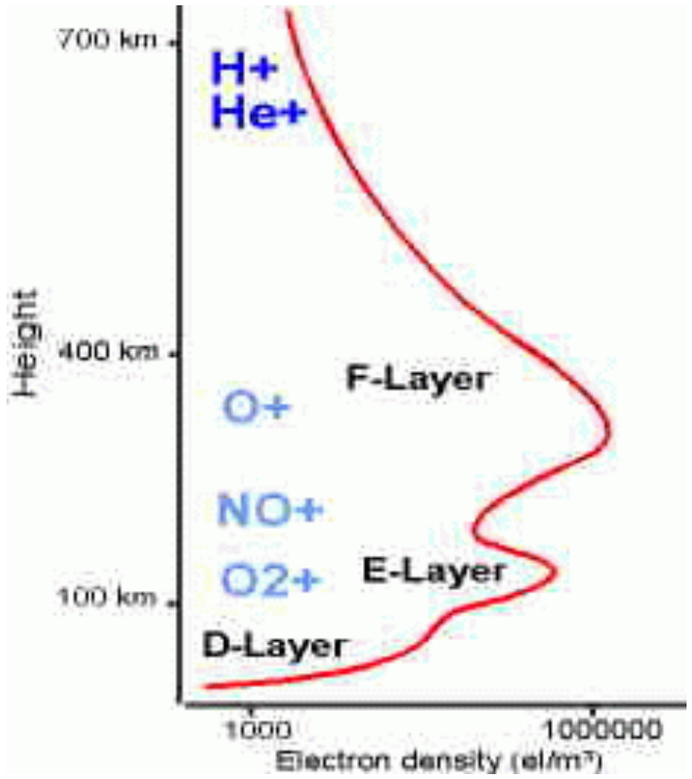
I order II order III order

$$\iota \approx \frac{\kappa}{c\nu^2}\int_0^d n_{\mathrm{e}}(x)\,\mathrm{d}x. + \frac{3\kappa^2}{2c\nu^4}\int_0^d n_{\mathrm{e}}^2(x)\,\mathrm{d}x. + \frac{5\kappa^3}{2c\nu^6}\int_0^d n_{\mathrm{e}}^3(x)\,\mathrm{d}x. + \cdots.$$

TEC

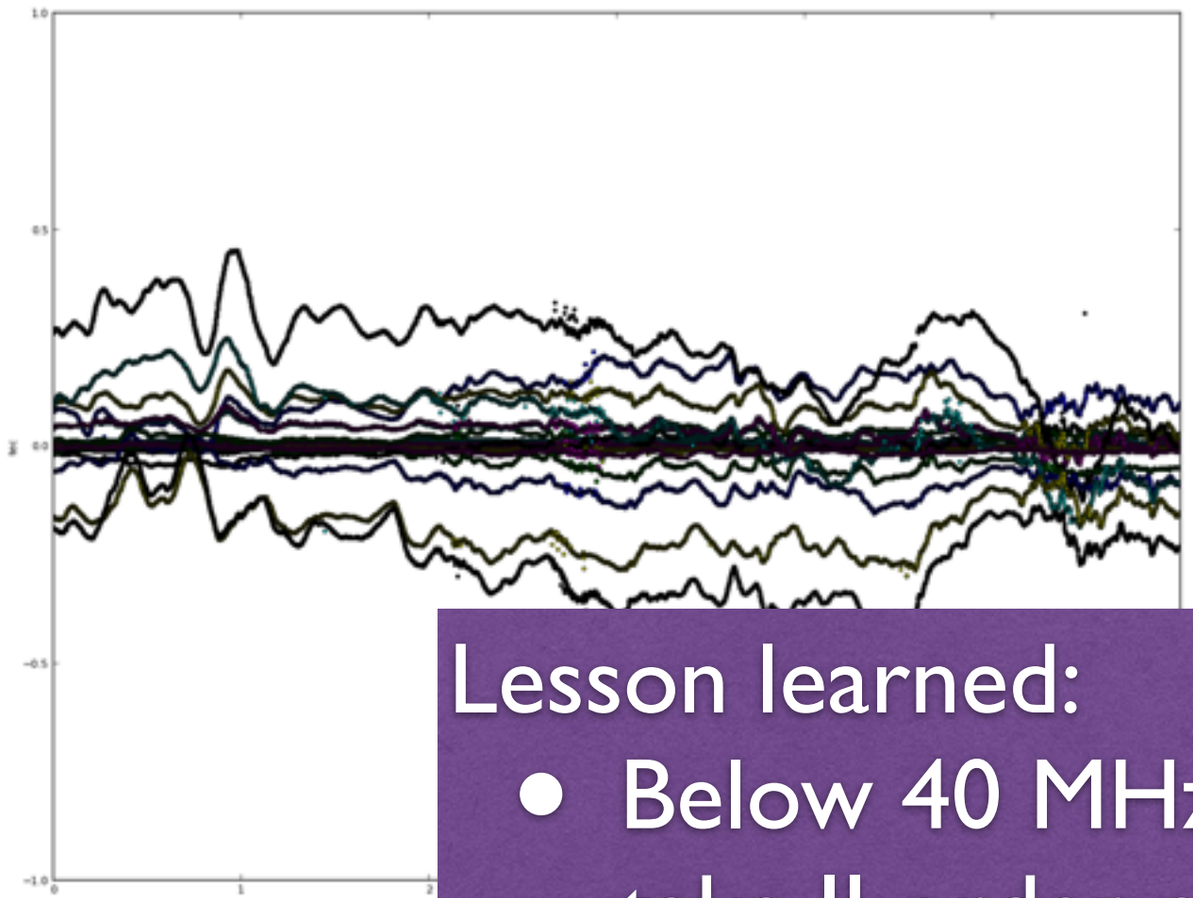
~~TEC~~



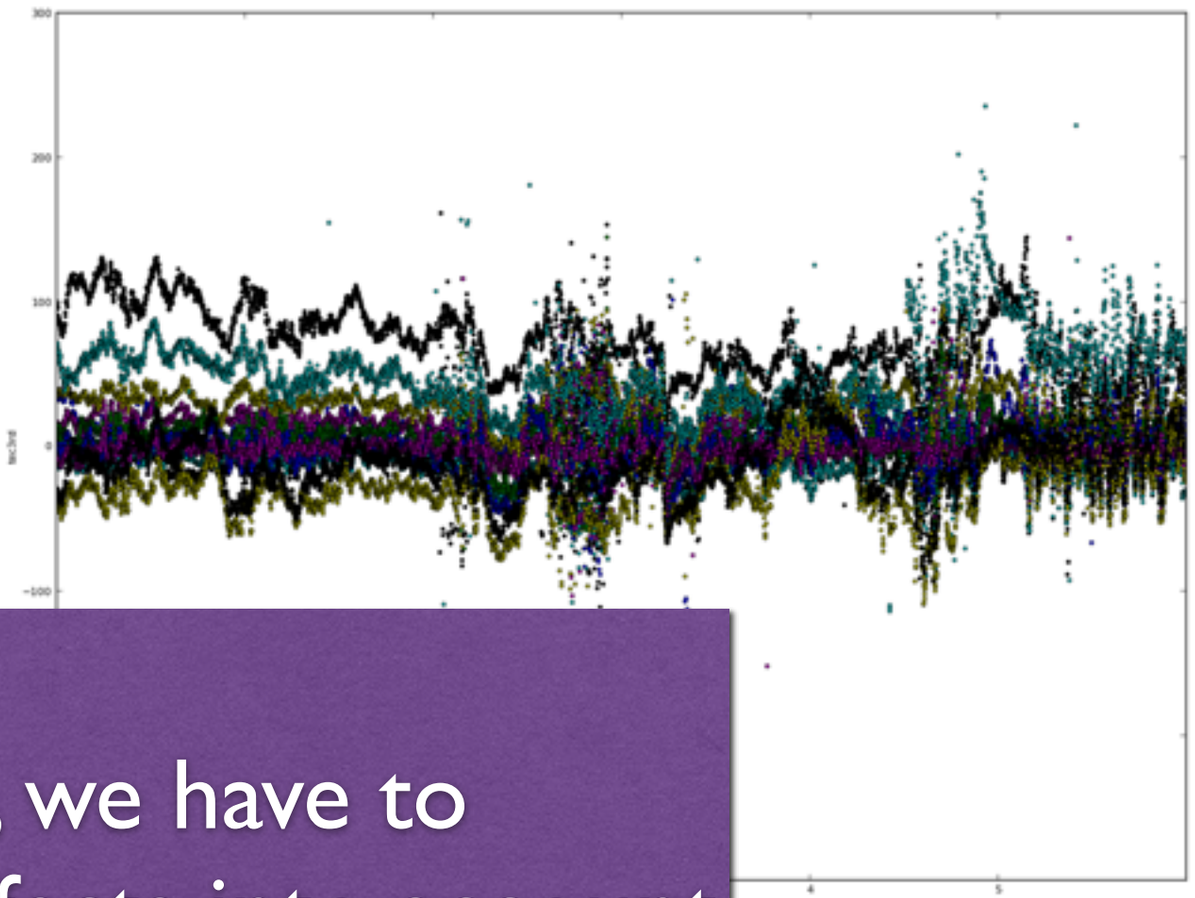


Higher order terms

$$\iota \approx \frac{\kappa}{c\nu^2}\int_0^d n_{\mathrm{e}}(x)\ \mathrm{d}x. + \frac{3\kappa^2}{2c\nu^4}\int_0^d n_{\mathrm{e}}^2(x)\ \mathrm{d}x. + \frac{5\kappa^3}{2c\nu^6}\int_0^d n_{\mathrm{e}}^3(x)\ \mathrm{d}x. + \cdots.$$



TEC (1/f)



EC2 (1/f^3)

Lesson learned:

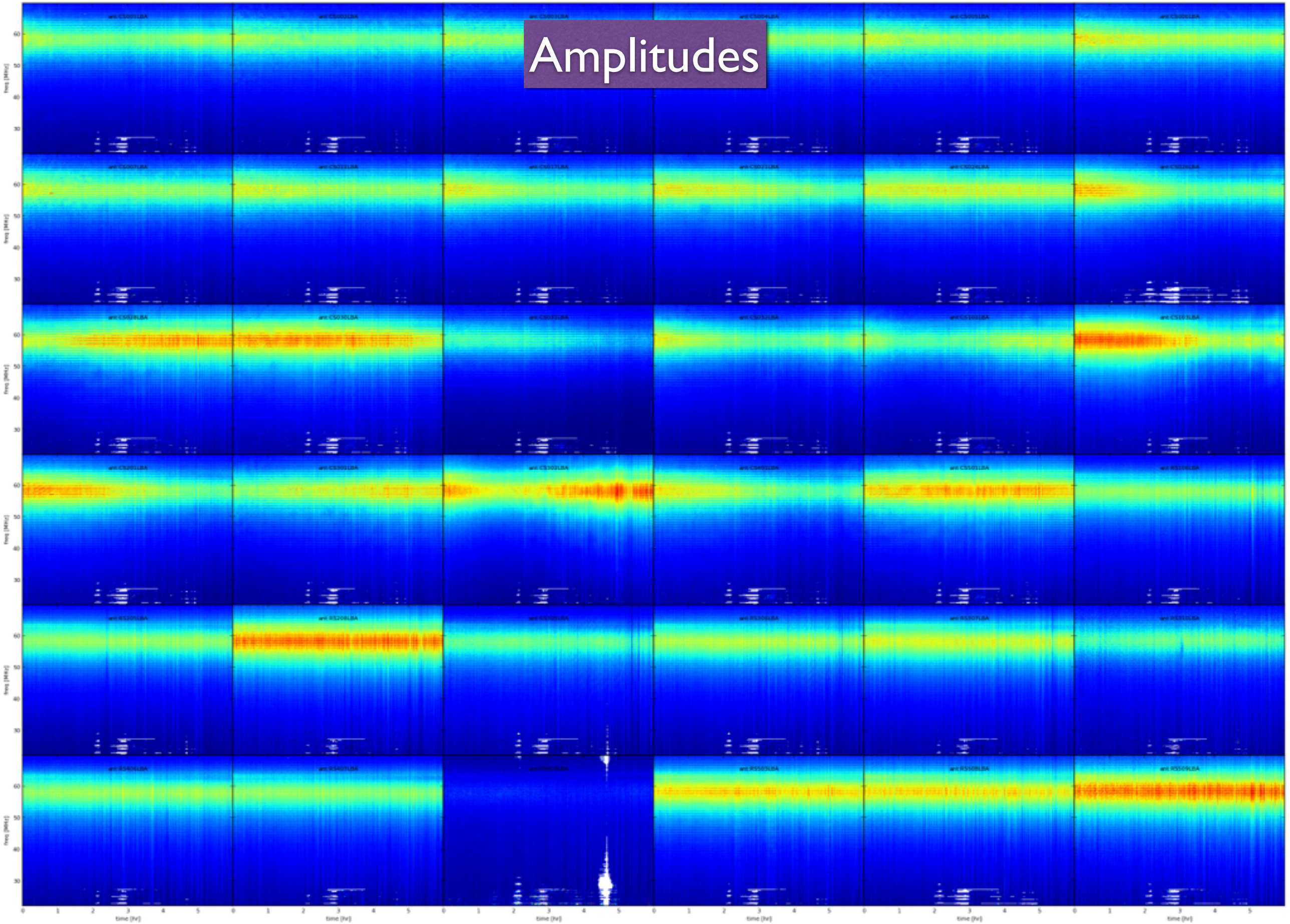
- Below 40 MHz, we have to take II order effects into account

Phases residuals RR

Lesson learned:

- LOFAR phases can be described with just Clock, TEC, FR

Amplitudes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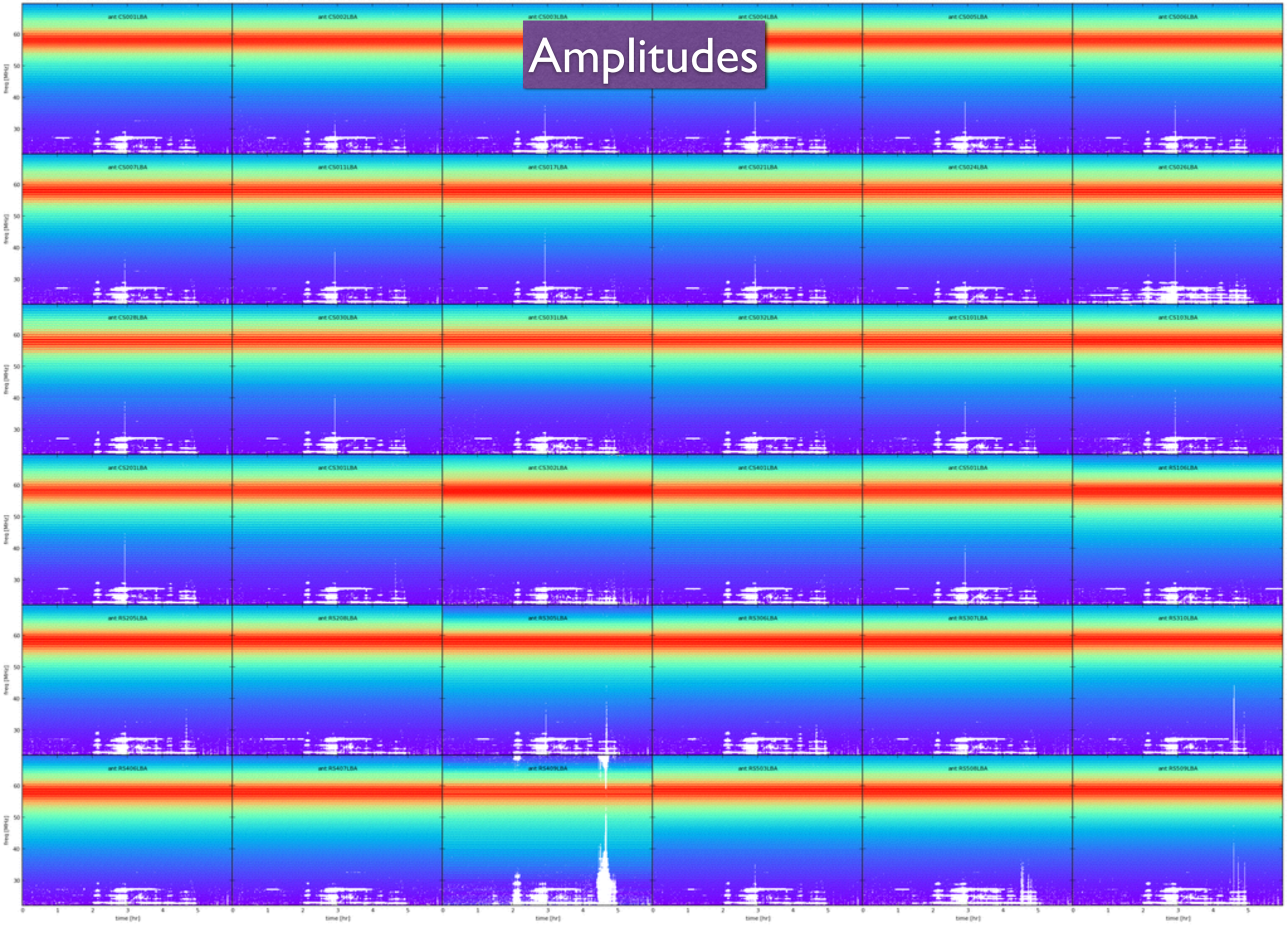
freq [MHz]
time [hr]

Amplitudes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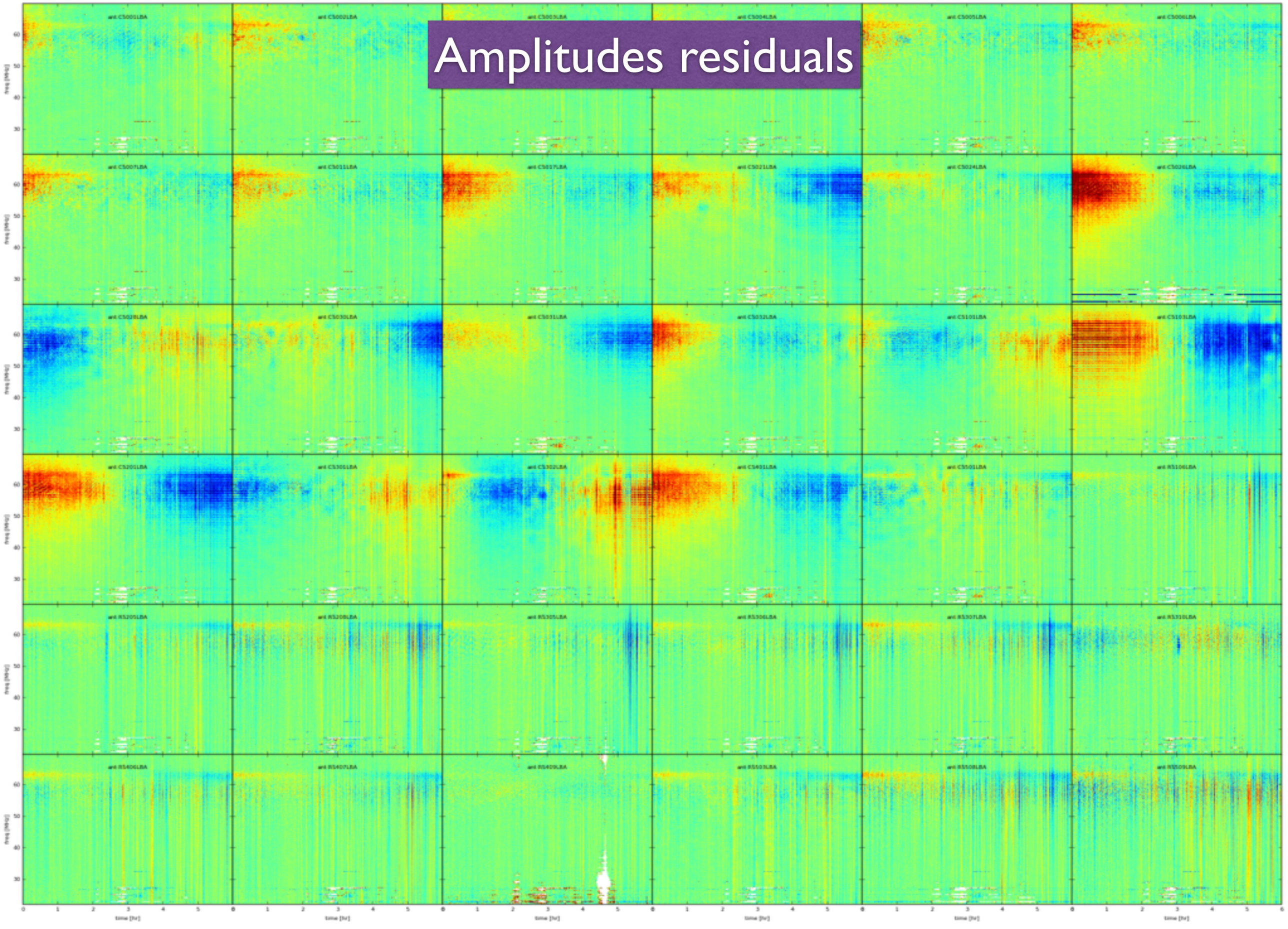
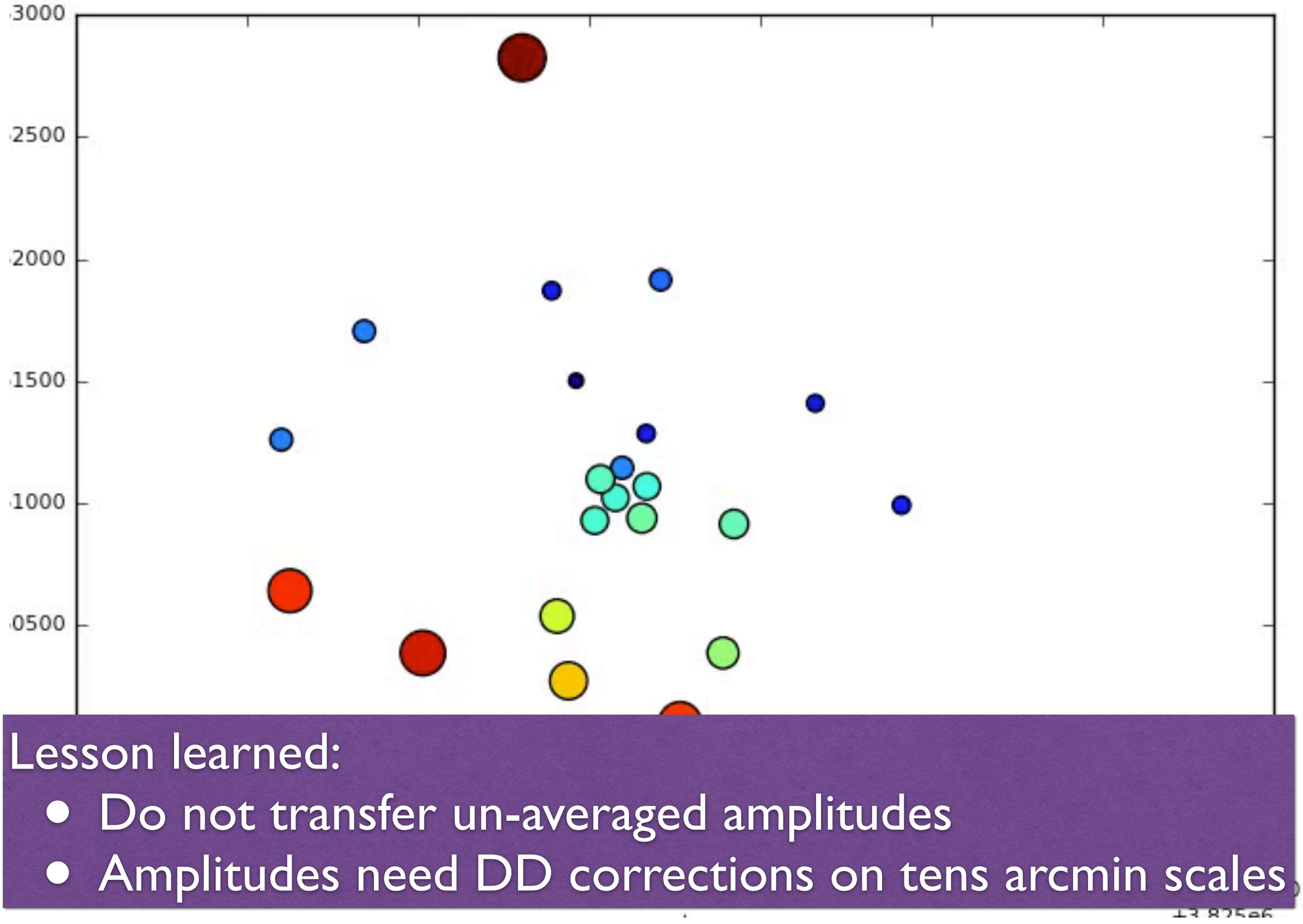
Amplitudes residuals





Lesson learned:

- Do not transfer un-averaged amplitudes
- Amplitudes need DD corrections on tens arcmin scales

The LOFAR LBA Sky Survey (LoLss)

✔ 1. Understand the systematics

2. Figure out a strategy

3. Reduce the data

What is still missing:

- solver capable to solve **freq-dependent effects** (TEC, FR)
  >> call for developers
- solver capable to handle **multiple directions**
  >> killMS promising
- ultimately **Signal/Noise** will be a problem
  >> LOFAR 2.0 (upgrade LBA antennas)

	Clock drift	Ionospheric delay	Faraday rotation	Scintillations
Affects	Phase	Phase	Phase (circ) Amp+Ph (lin)	Amplitudes
Type	Scalar	Scalar	Diag (circ) Rot (lin)	Scalar?
Freq. dep.	$\propto f$	$\propto 1/f$; $\propto 1/f^3$	$\propto 1/f^2$	some
Dir. dep.	No	Yes (tens arcmin)	Yes (degrees)	Yes (tens arcmin)

KillMS

DIE selfcal