JIVE

Lessons learned from LOFAR LBA

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Lockman Hole observation

Observations May 2013

- 3C196: 244 subbands
- Field 244 subbands
- Simultaneous
- 4 hours
- 5 second averaging
- 1 or 4 channels
- HBA 150MHz skymodel

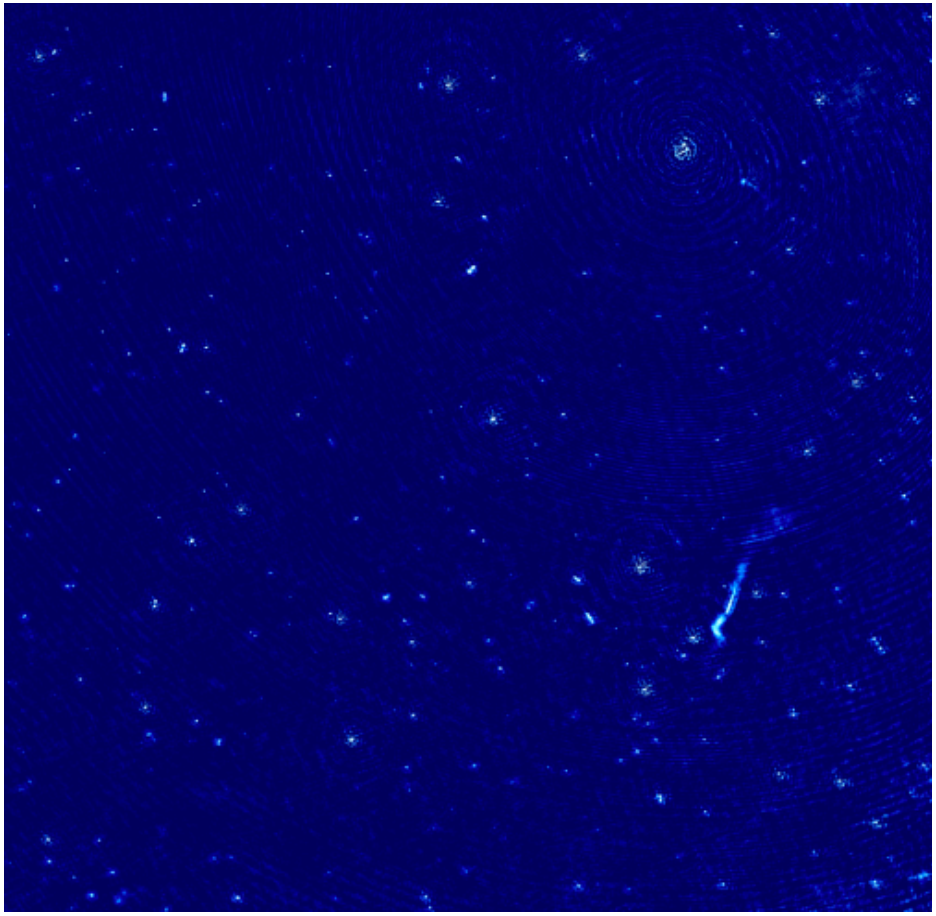
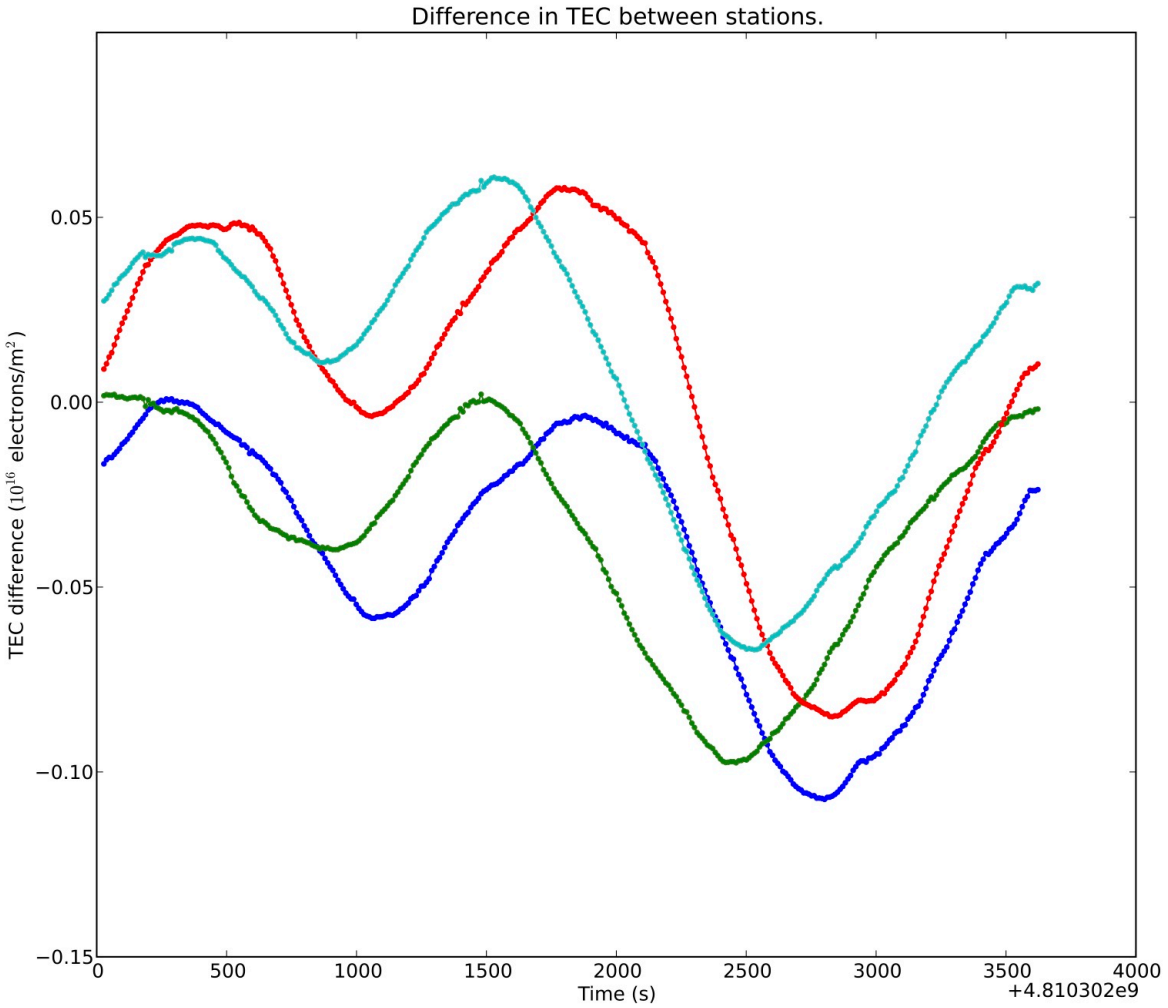


Image courtesy Elizabeth Mahony

Calibration for LBA

- Direction independent effects (DIE)
  - Instrument ga
  - Clock
- Direction depe
  - Ionosphere: t
  - Beam: EM mo



Clock & ionosphere

Phase error on single baseline:

$$\Delta\varphi = 2\pi\,\Delta\nu\,\Delta\tau$$

To maintain coherence:

$$\Delta\varphi < 1\ rad$$

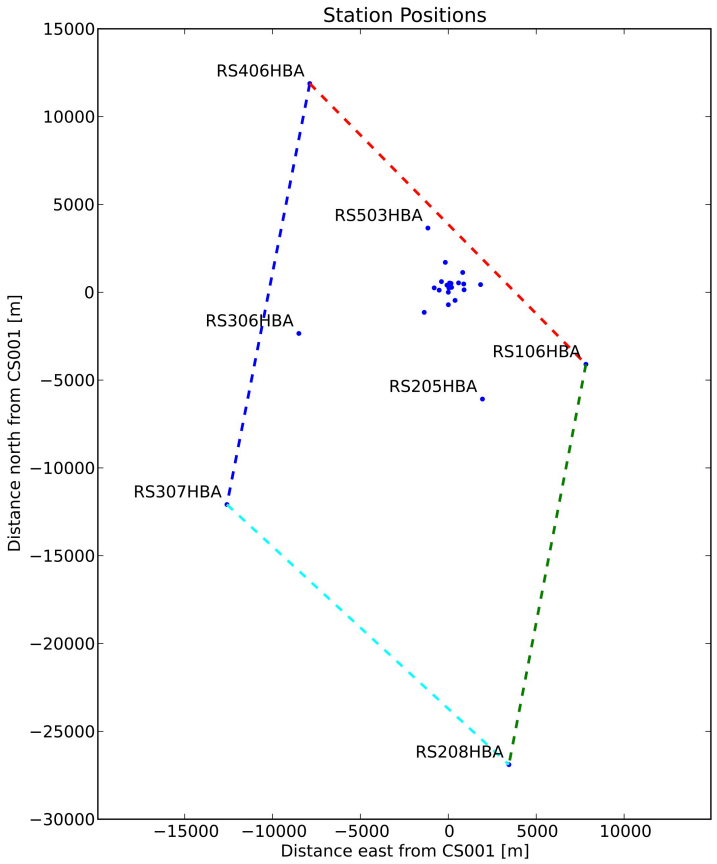
$$\Delta\tau\,(\mathrm{ns}) < 160/\Delta\nu(\mathrm{MHz})$$

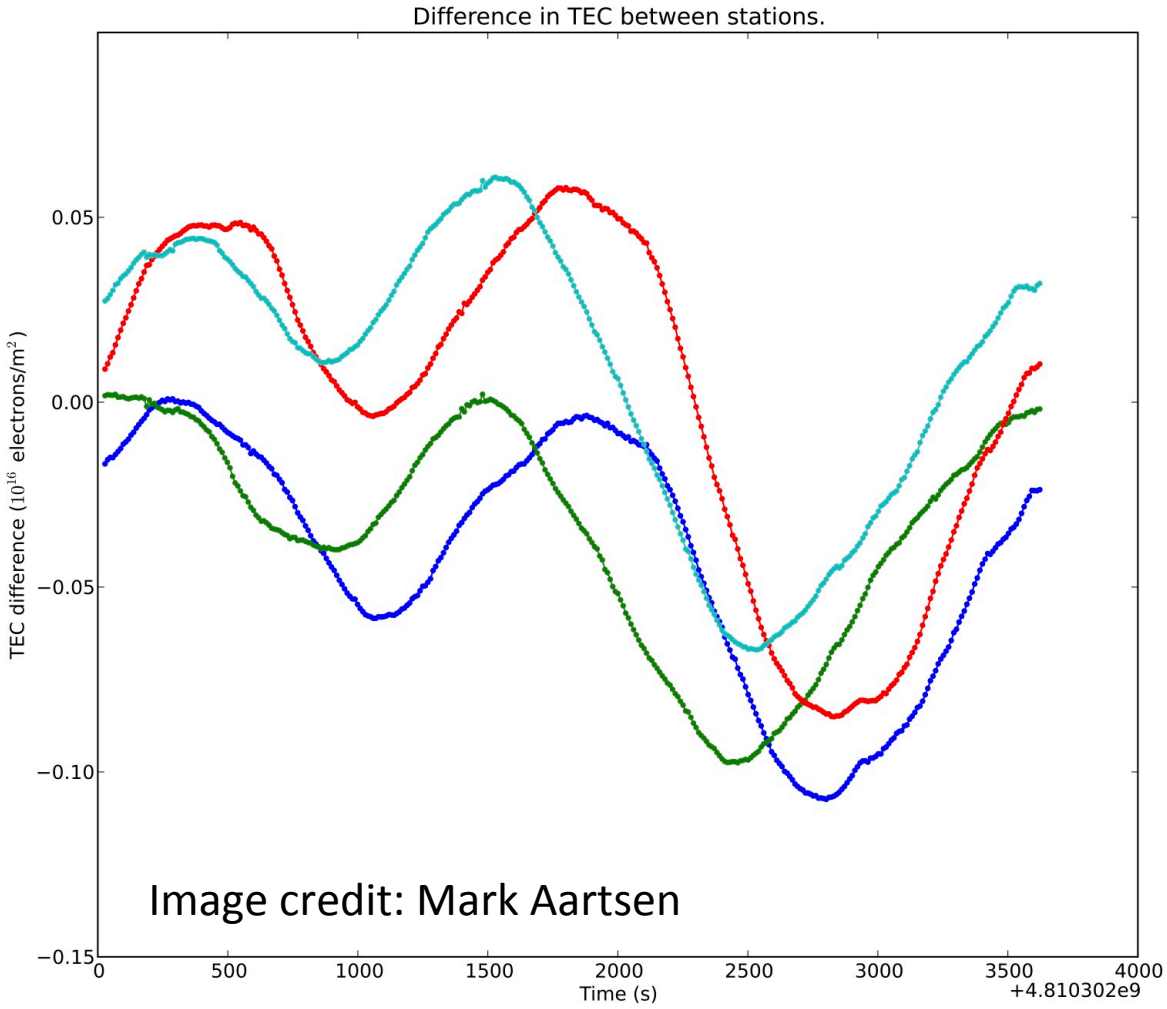
Ionosphere:

$$\Delta\varphi(1\ rad) \approx \lambda(5\mathrm{m})\,\Delta\mathrm{TEC}(0.008)$$

Ionosphere

- 2010 observations, ~25km baselines



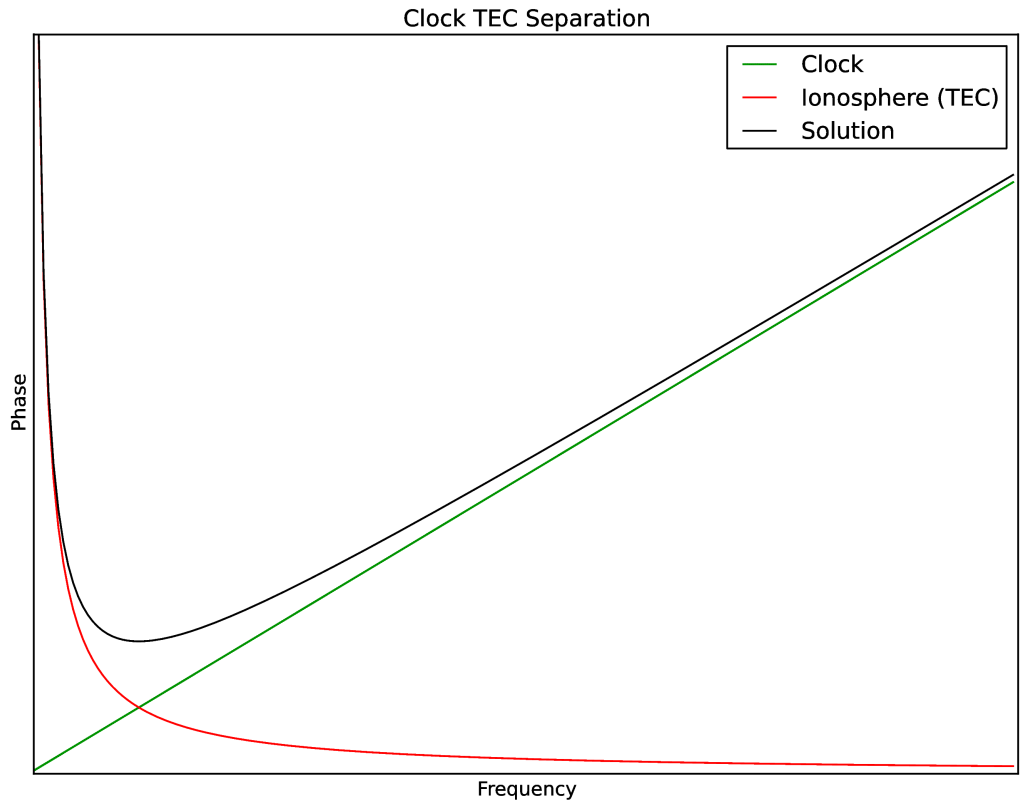


Clock & ionosphere

Phase on a baseline:

$\varphi(\nu) \approx \mathrm{TEC}(\iota$

- Global frin
- Use bandw
- LoSoTo (de



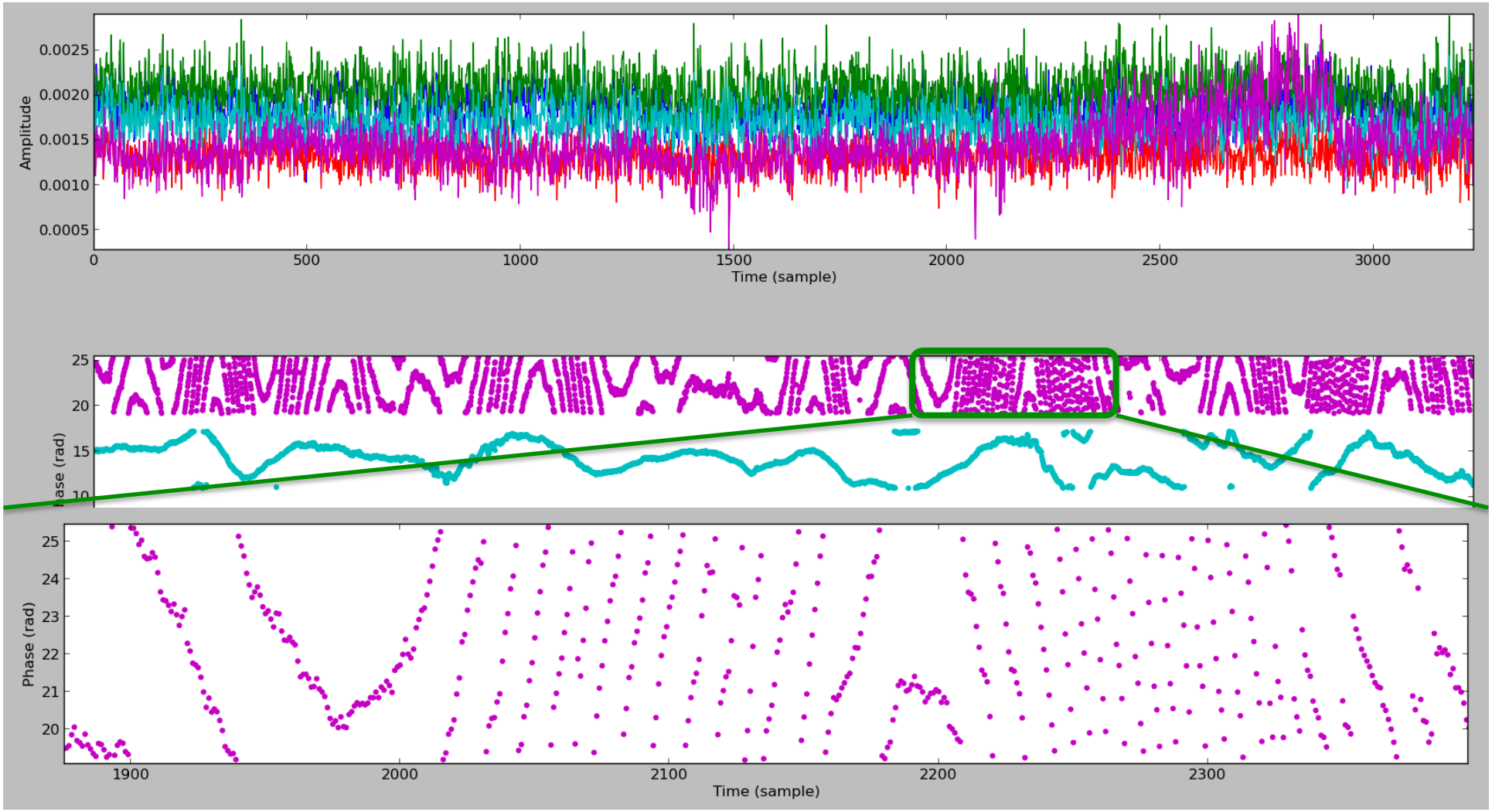
Calibration step plan

- Calibrate 3C196: amplitude & phase, FR
- LoSoTo: fit clock and TEC
- Transfer to target: amplitude and clock
- Average 10 subbands
- Calibrate Lockman Hole: phase only
- Peel the brightest source (3C244.1)

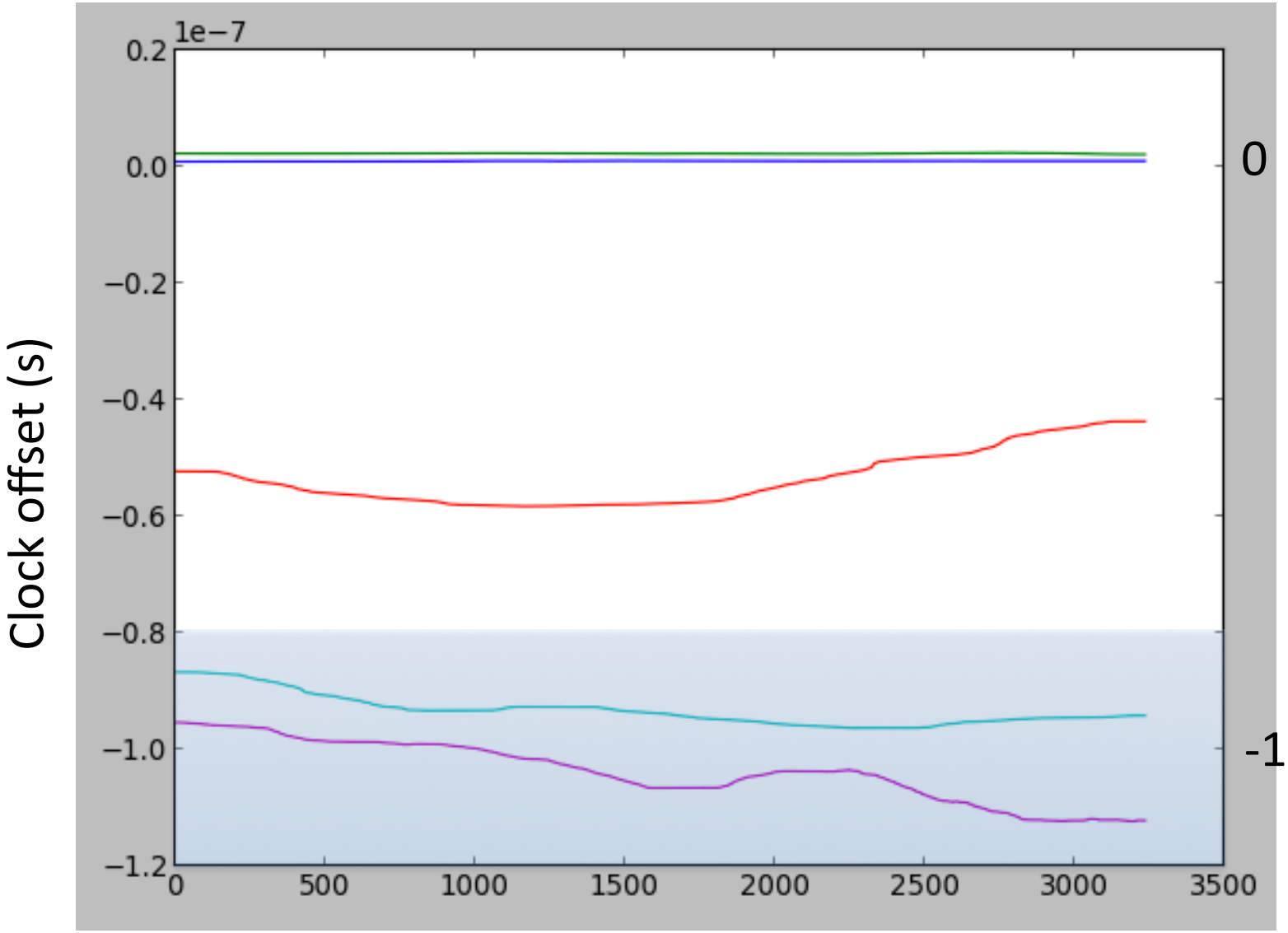
Questions

- Test clock – TEC separation in LoSoTo
- Transfer phases from calibrator to target?
  - Single phase solution in time
  - Phase solutions as function of time
  - Clock solutions as function of time
- Importance of clock offsets
- Importance of clock drifts

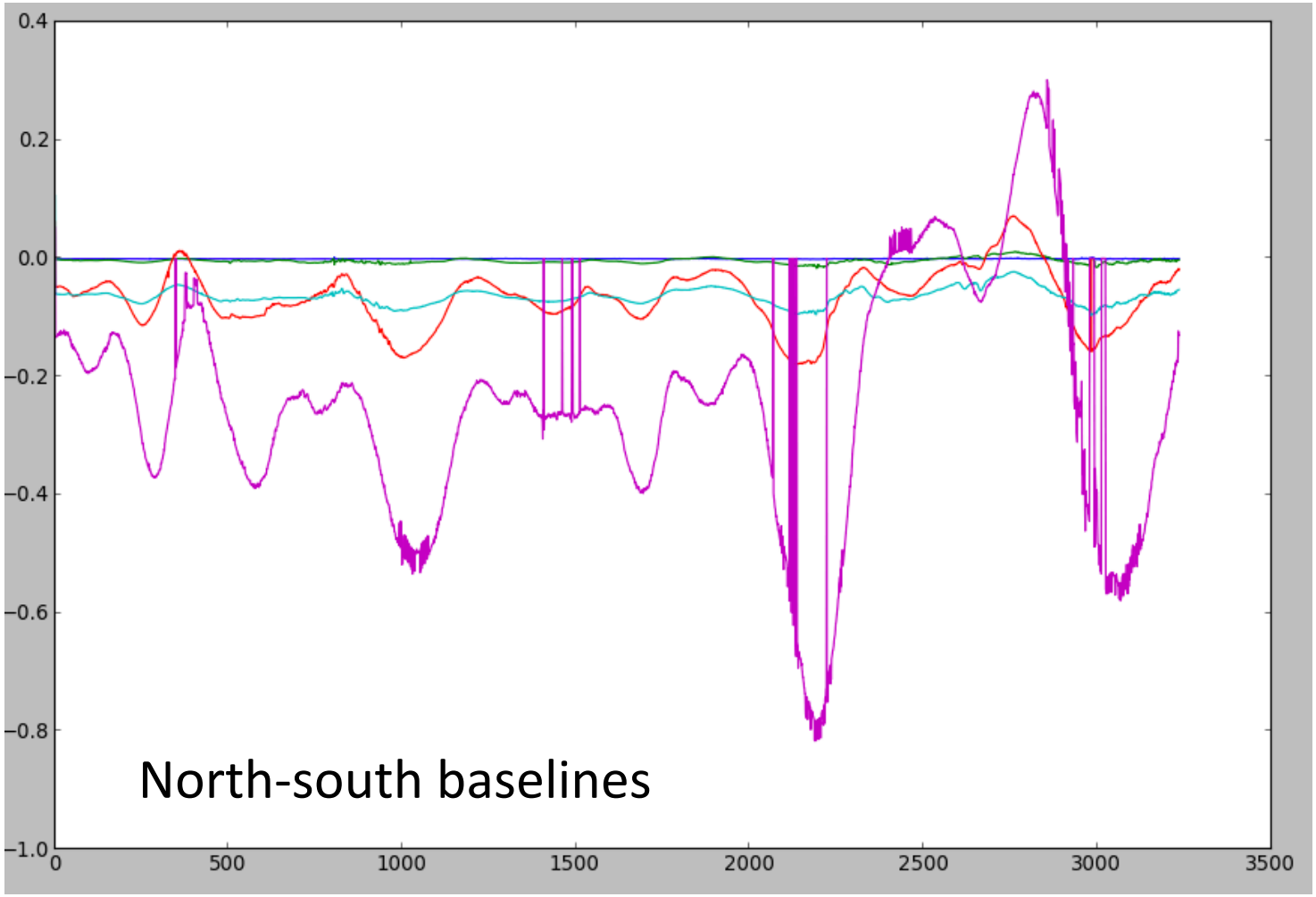
3C196 solutions



Clock offsets



Ionospheric effects

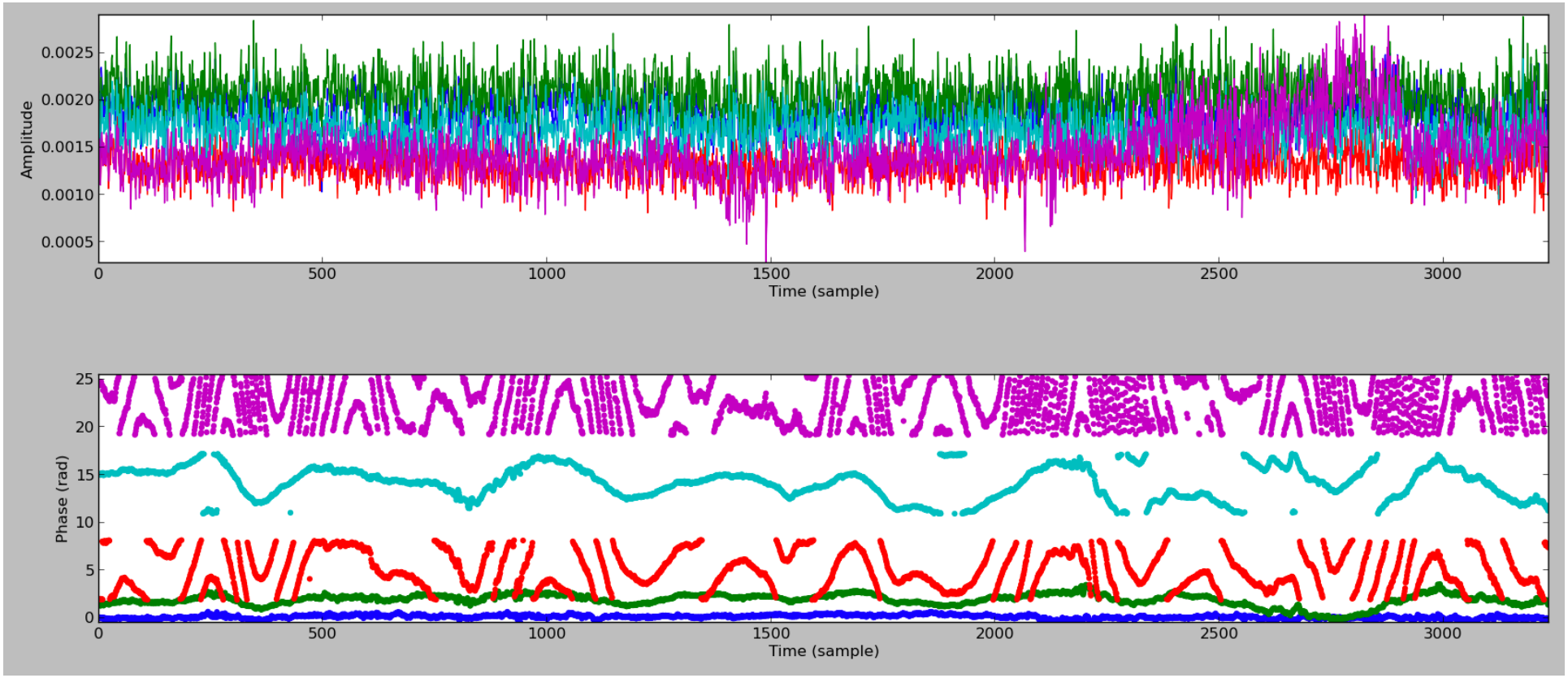


TEC

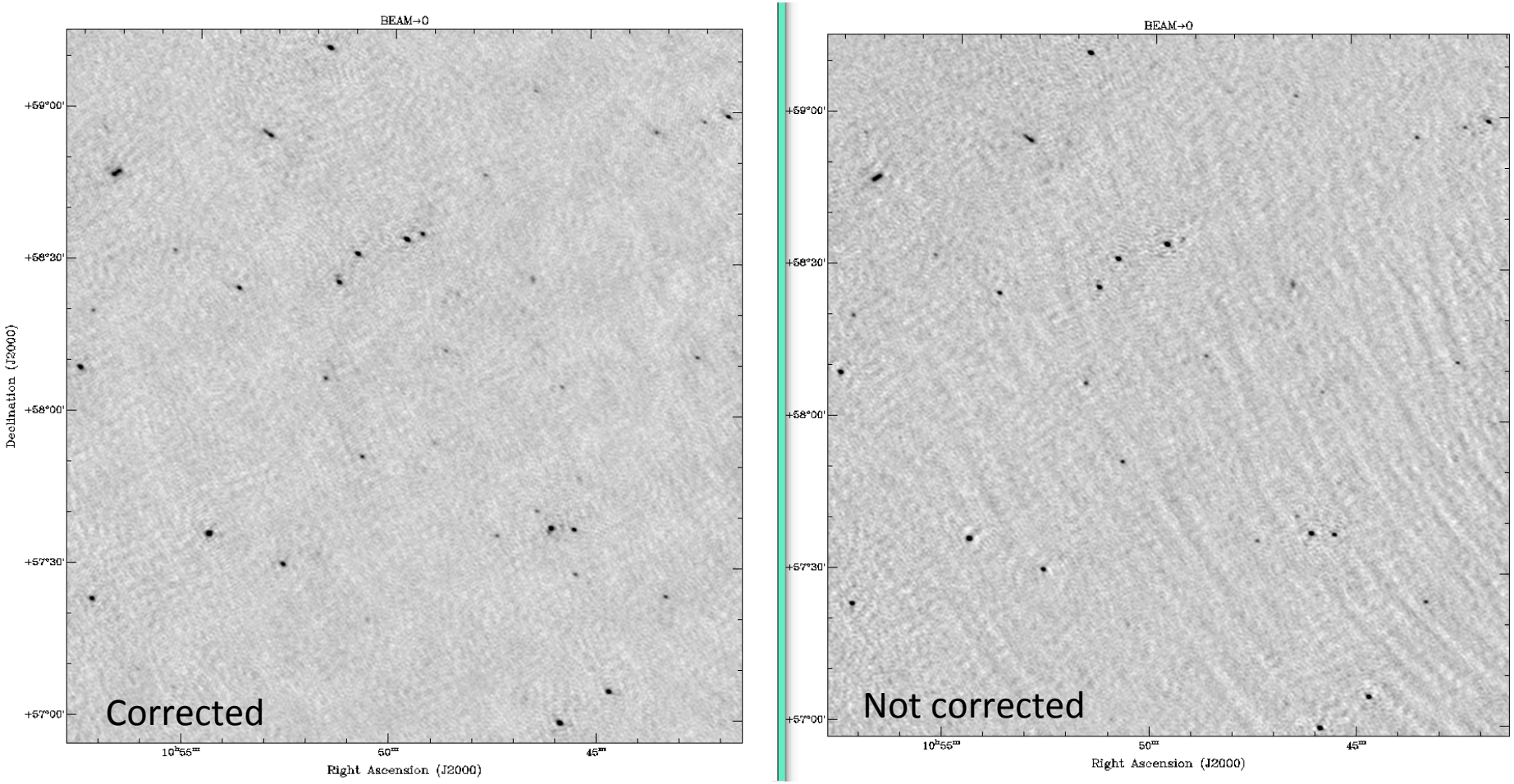
Time

Thanks to Maaijke Mevius

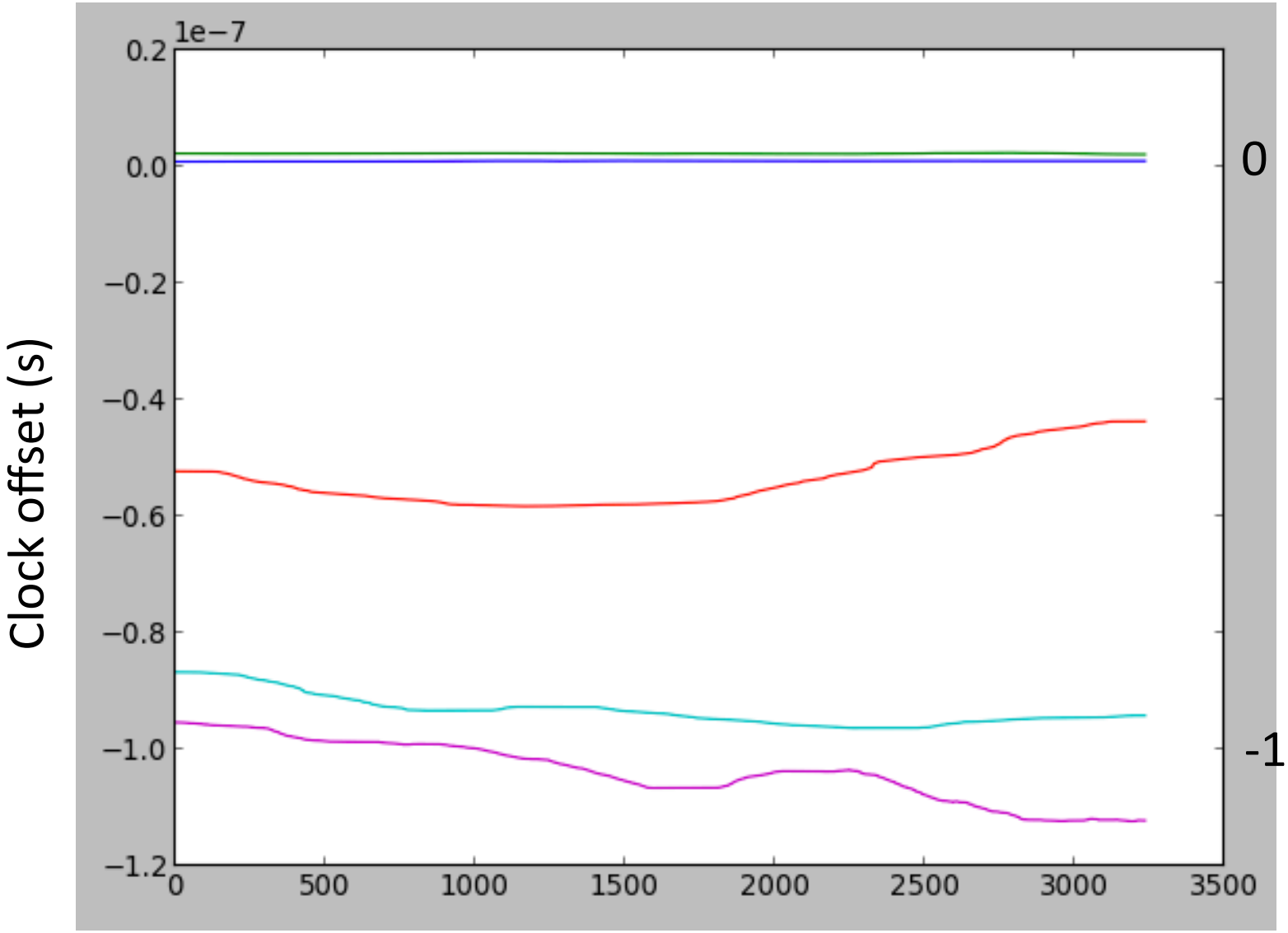
3C196 solutions



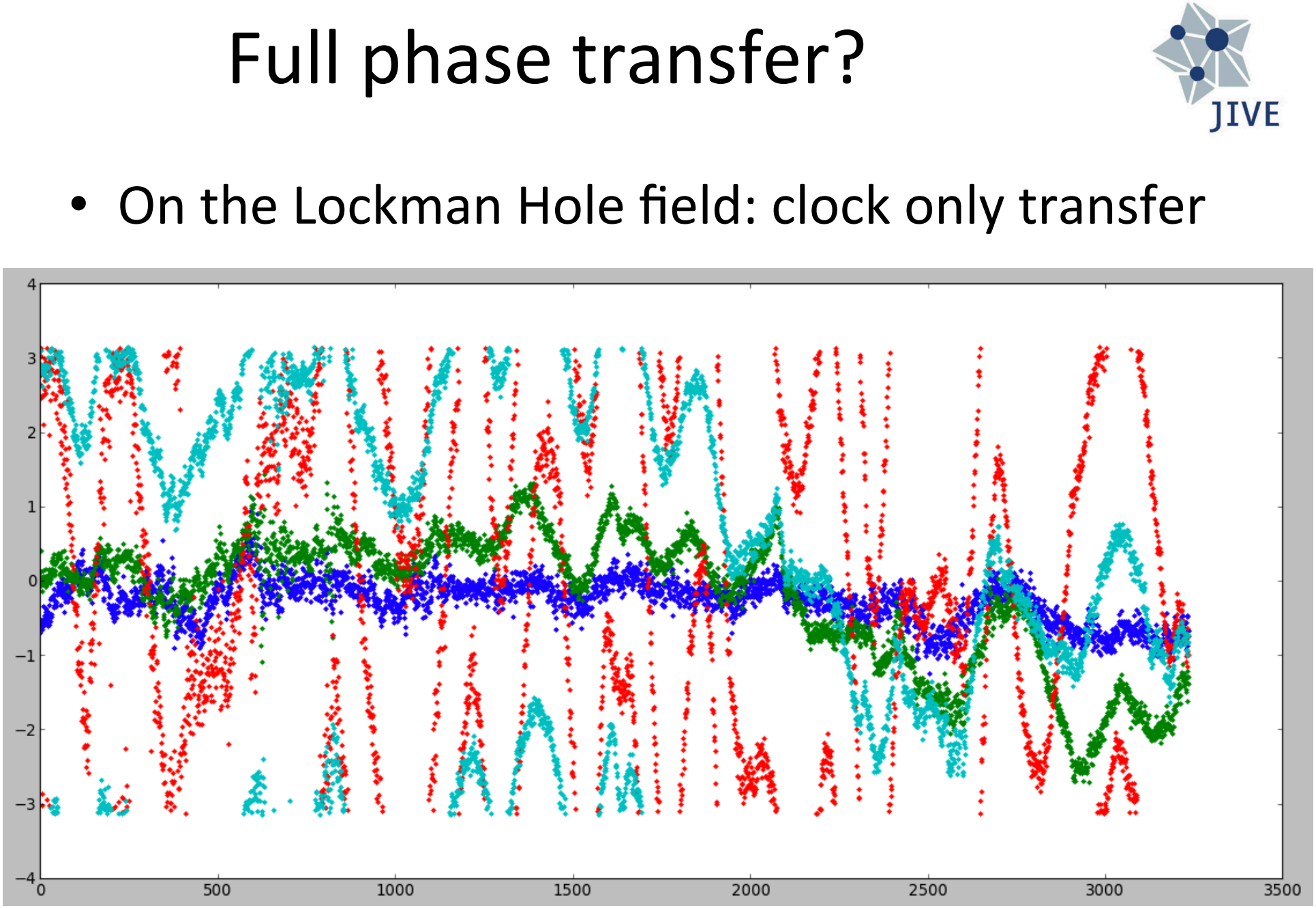
Single solution transfer



Clock drifts

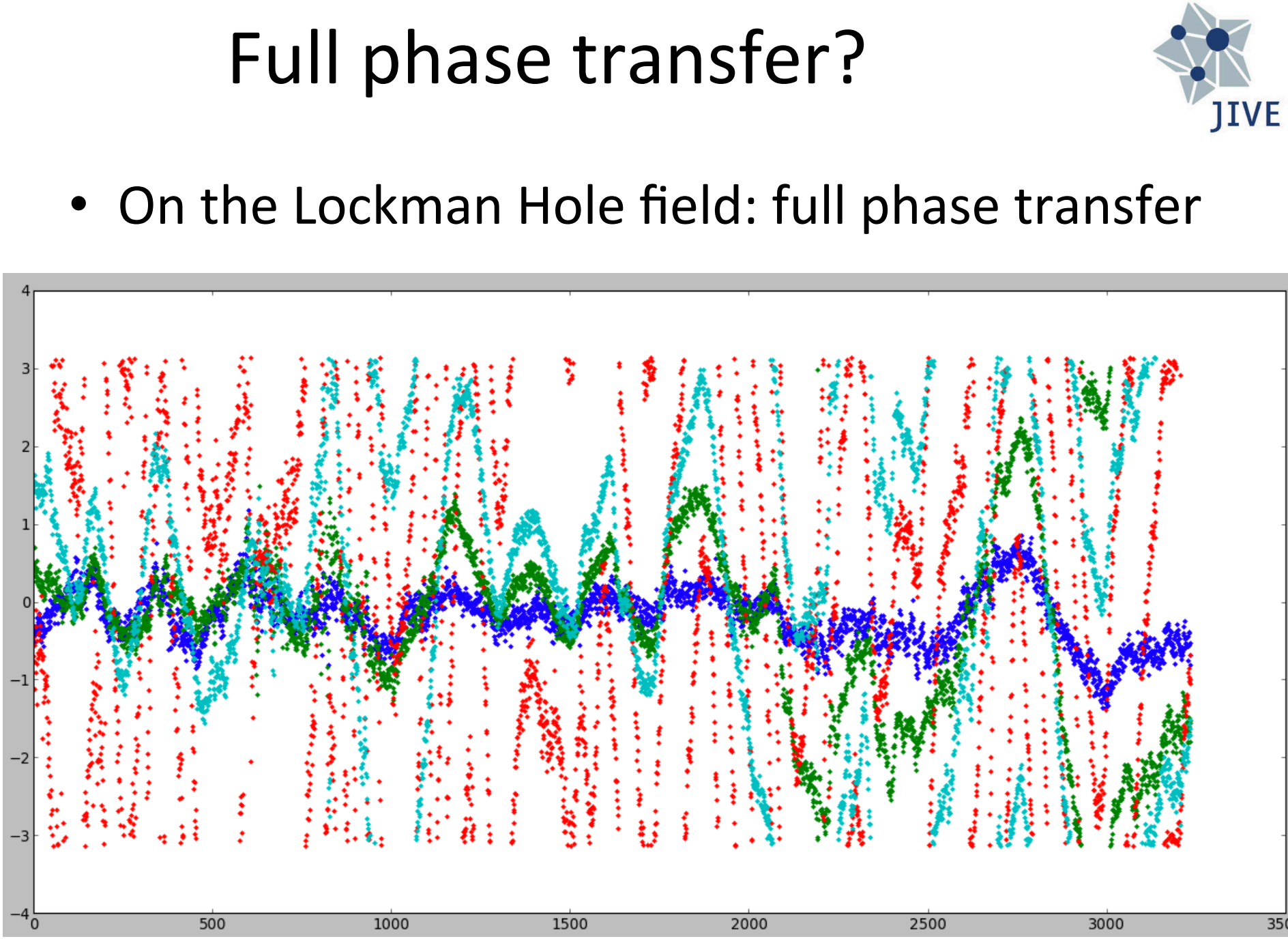


Full phase transfer?



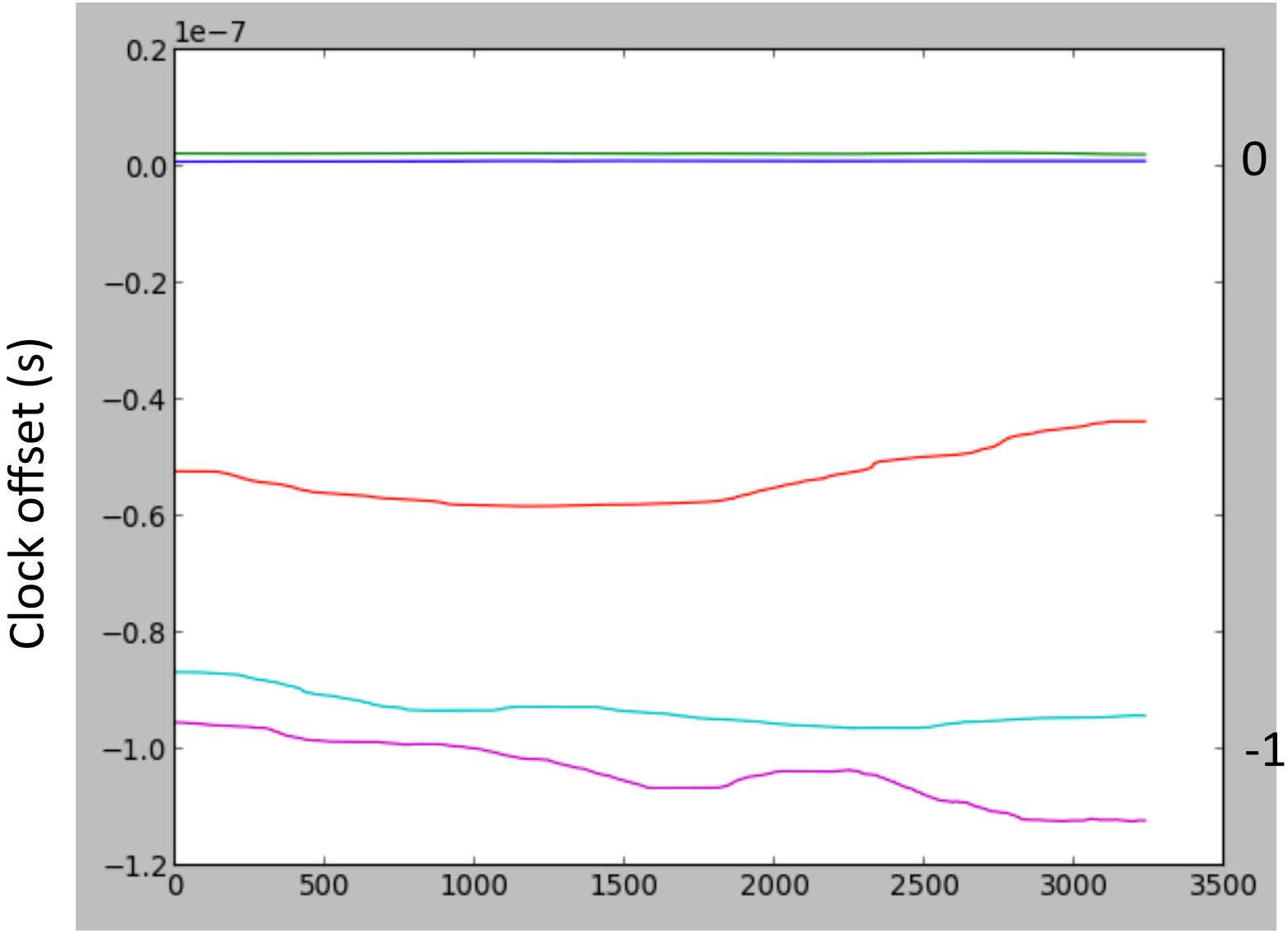
- On the Lockman Hole field: clock only transfer

Full phase transfer?

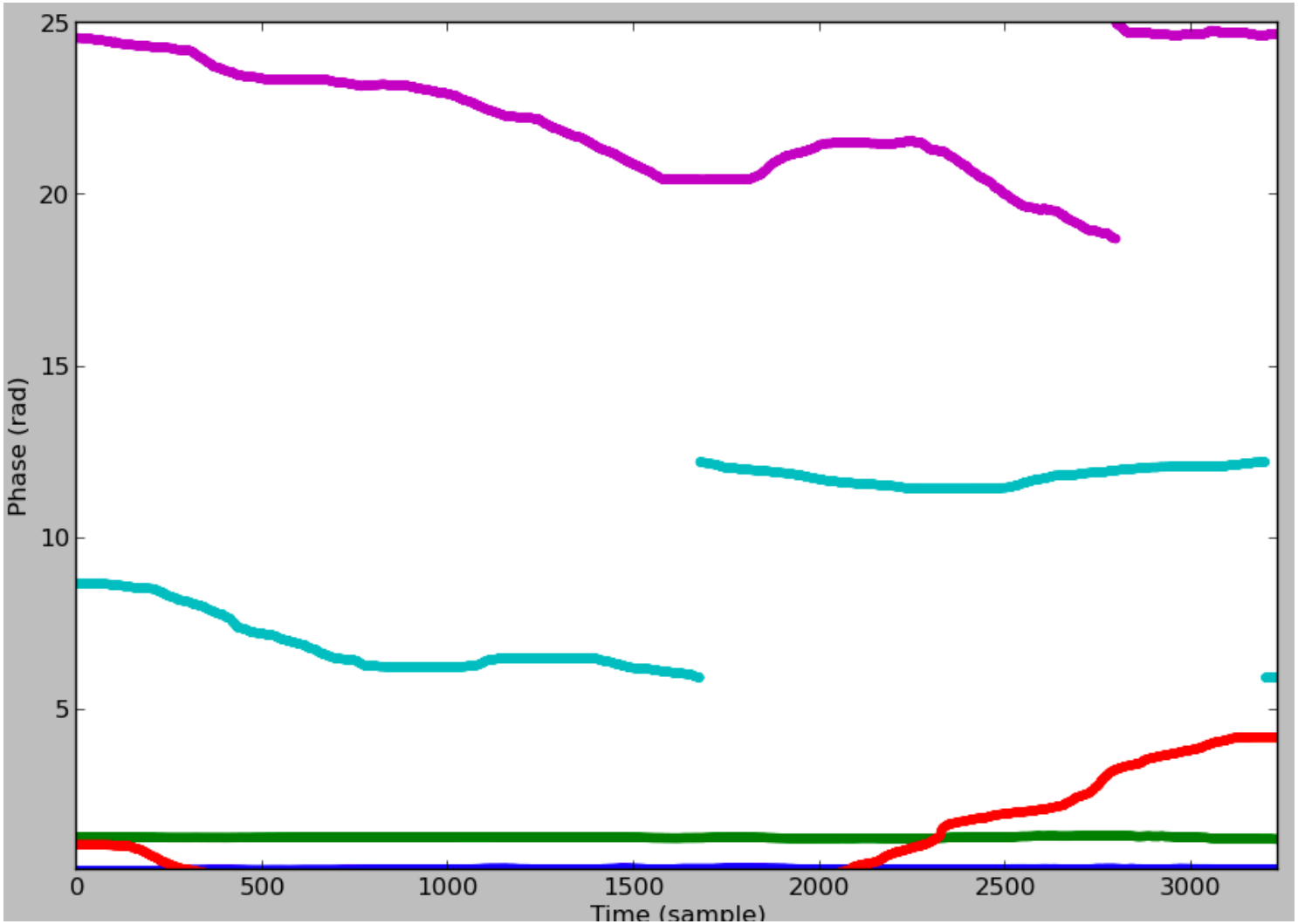


- On the Lockman Hole field: full phase transfer

Clock drifts



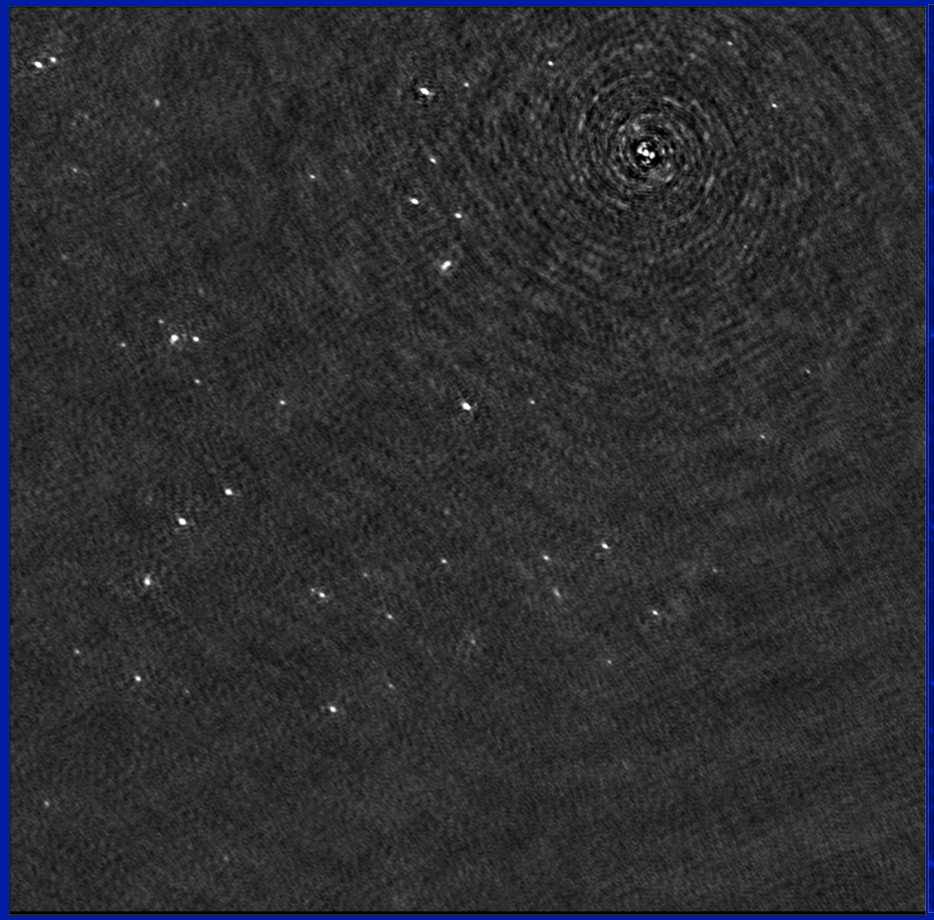
Clock drifts

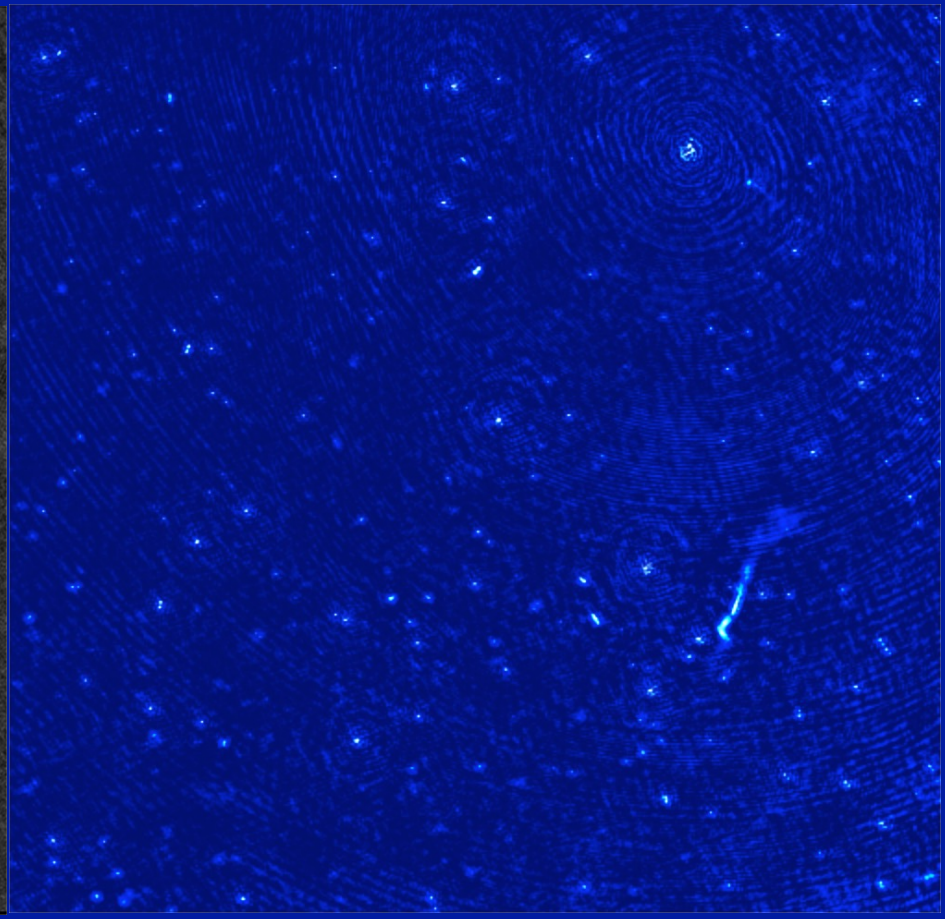


Questions

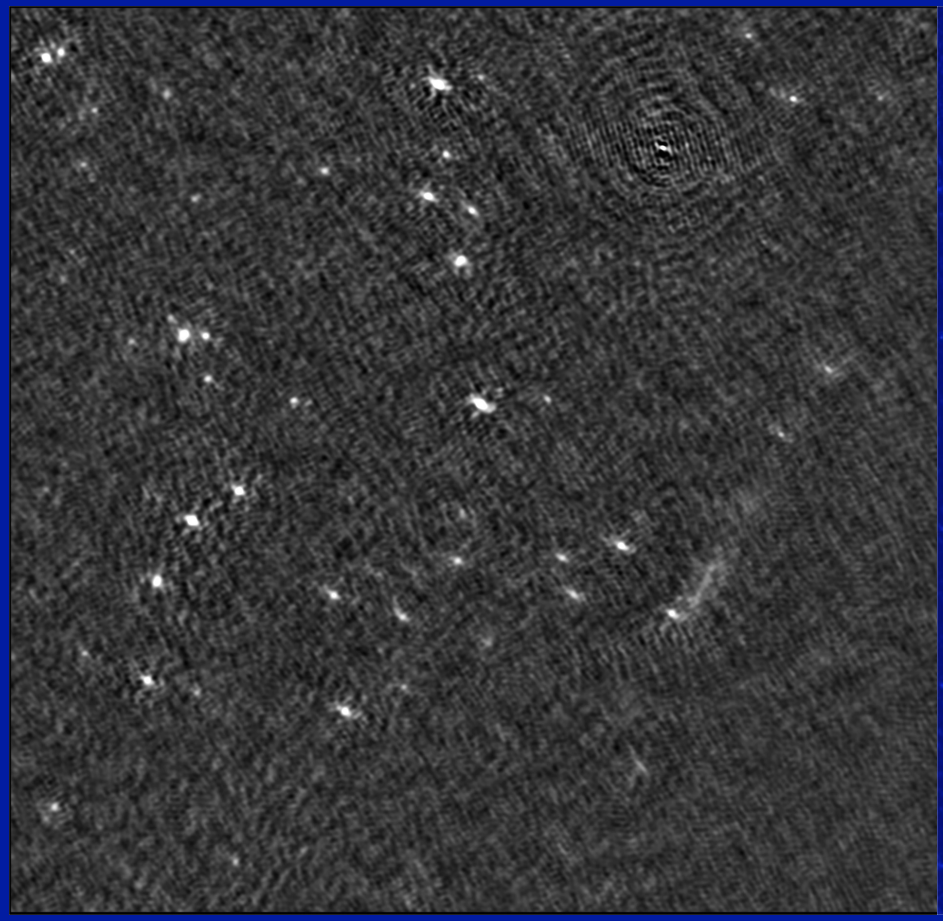
- Test clock – TEC separation ✔
- Transfer phases from calibrator to target?
  - Single phase solution: clock offset ✔
  - Phase solutions: offsets & drifts ✗
  - Clock solutions only: **TBD**
- Importance of clock offsets ✔
  - Coherence loss over large bandwidth
- Importance of clock drifts ✔
  - Coherence loss over long times

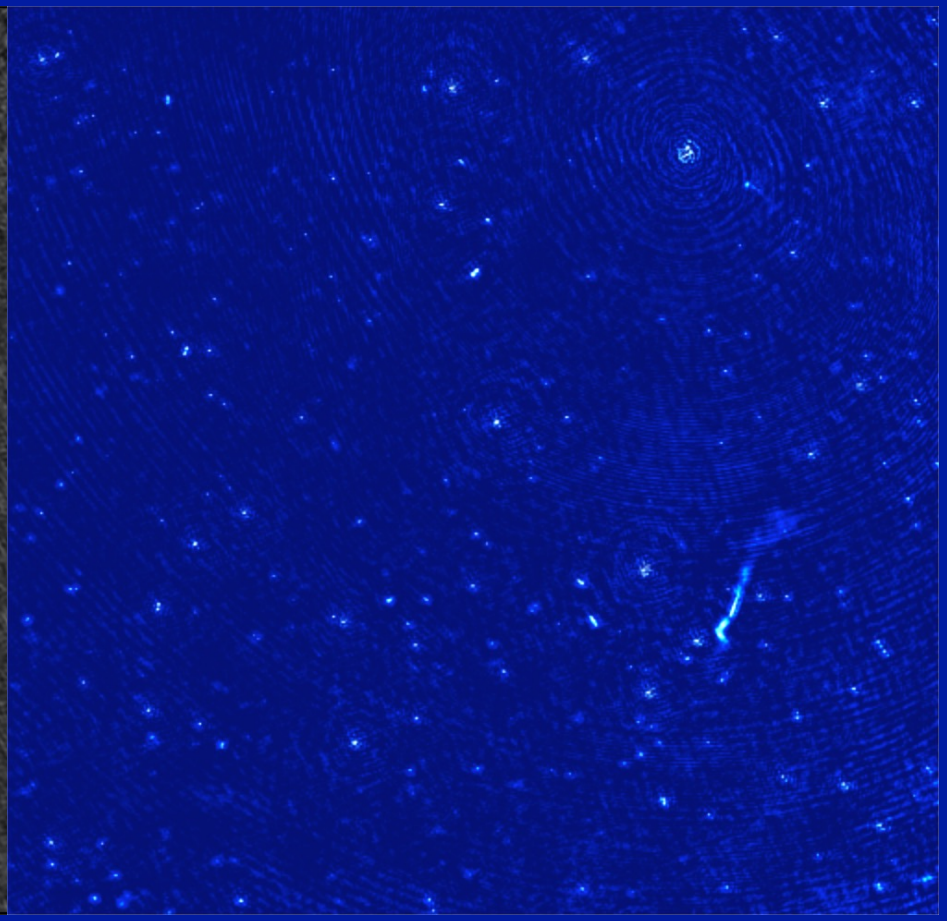
LBA 60MHz HBA 150MHz





LBA 45MHz HBA 150MHz





Next steps

- Full clock correction
- Fringe fitting
- SageCal
- Facet based cleaning
- Ionospheric phase screen (SPAM)
- MeqTrees & Bayesian methods:

  “anything you can parametrize”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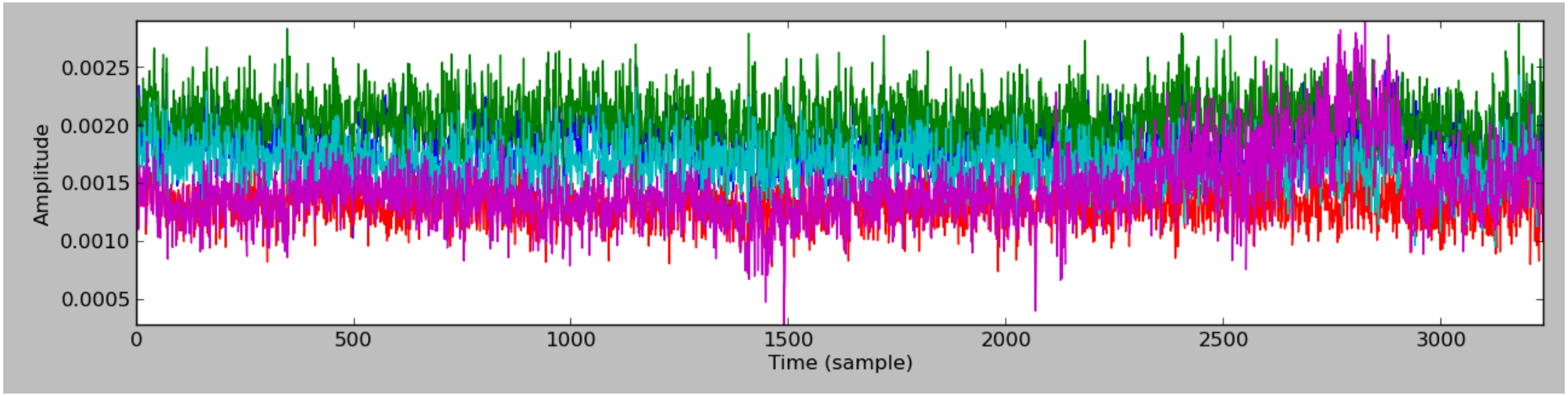
Wishlist

- More LBA data
- More people

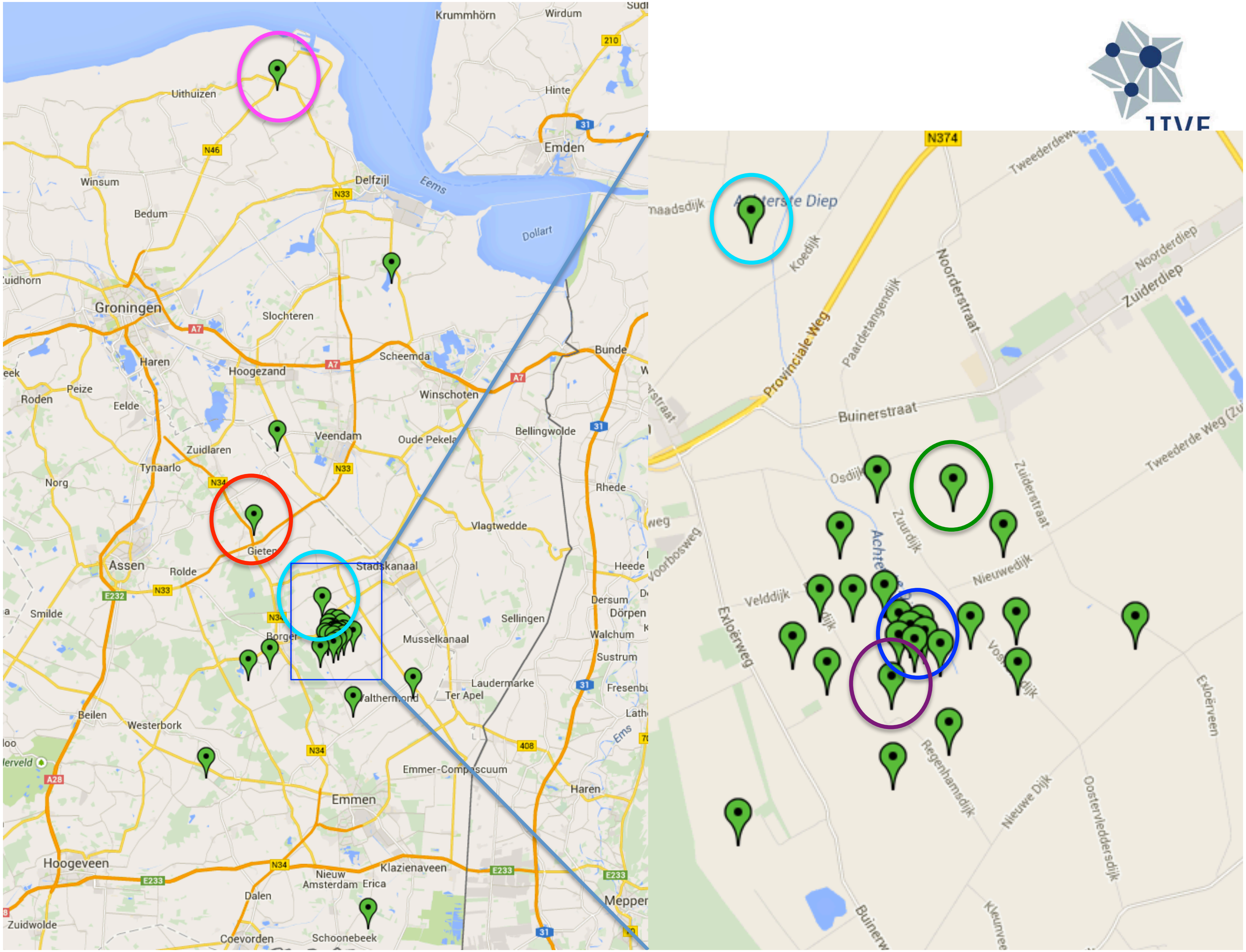
LBA amplitude stability



60MHz

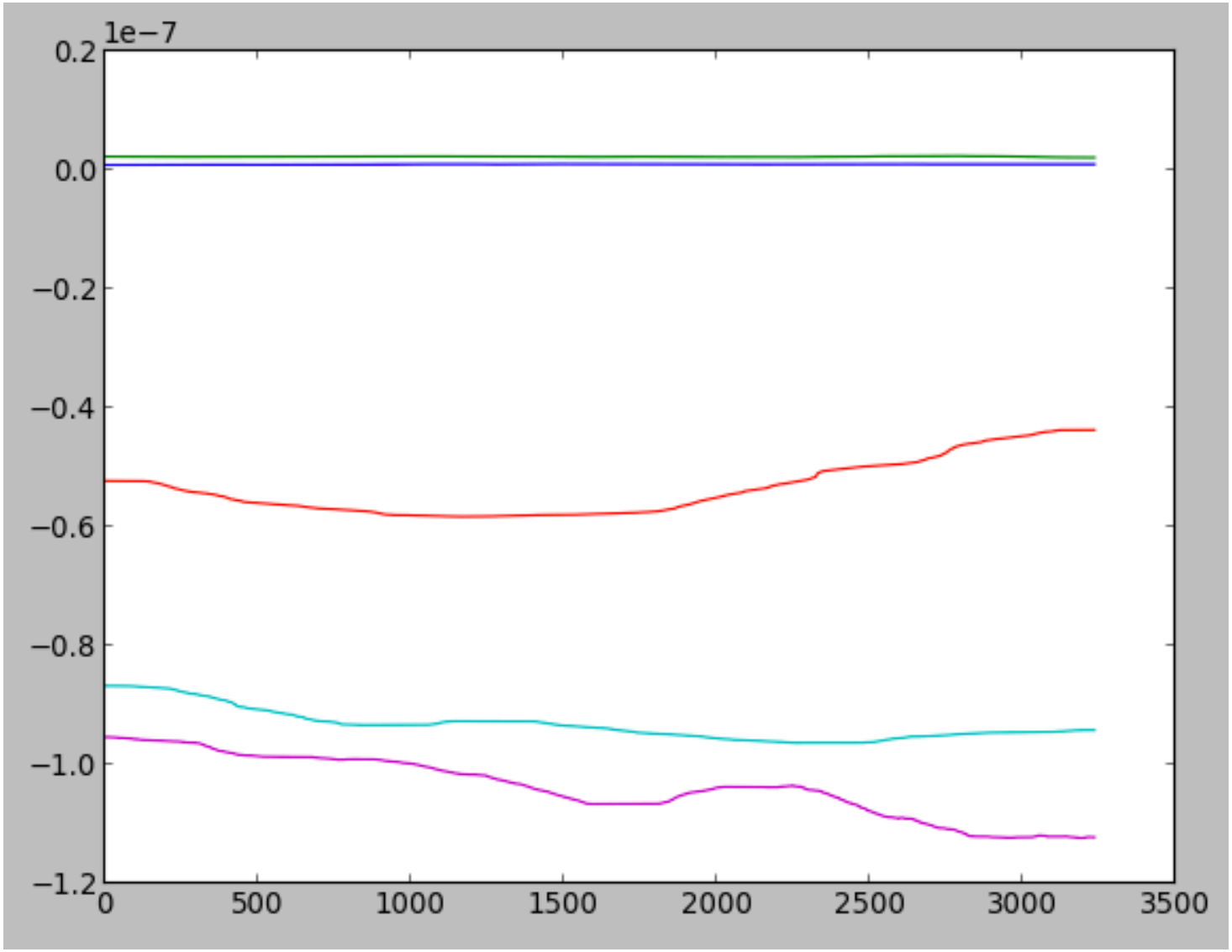
1 subband

Solve per channel, per timestep

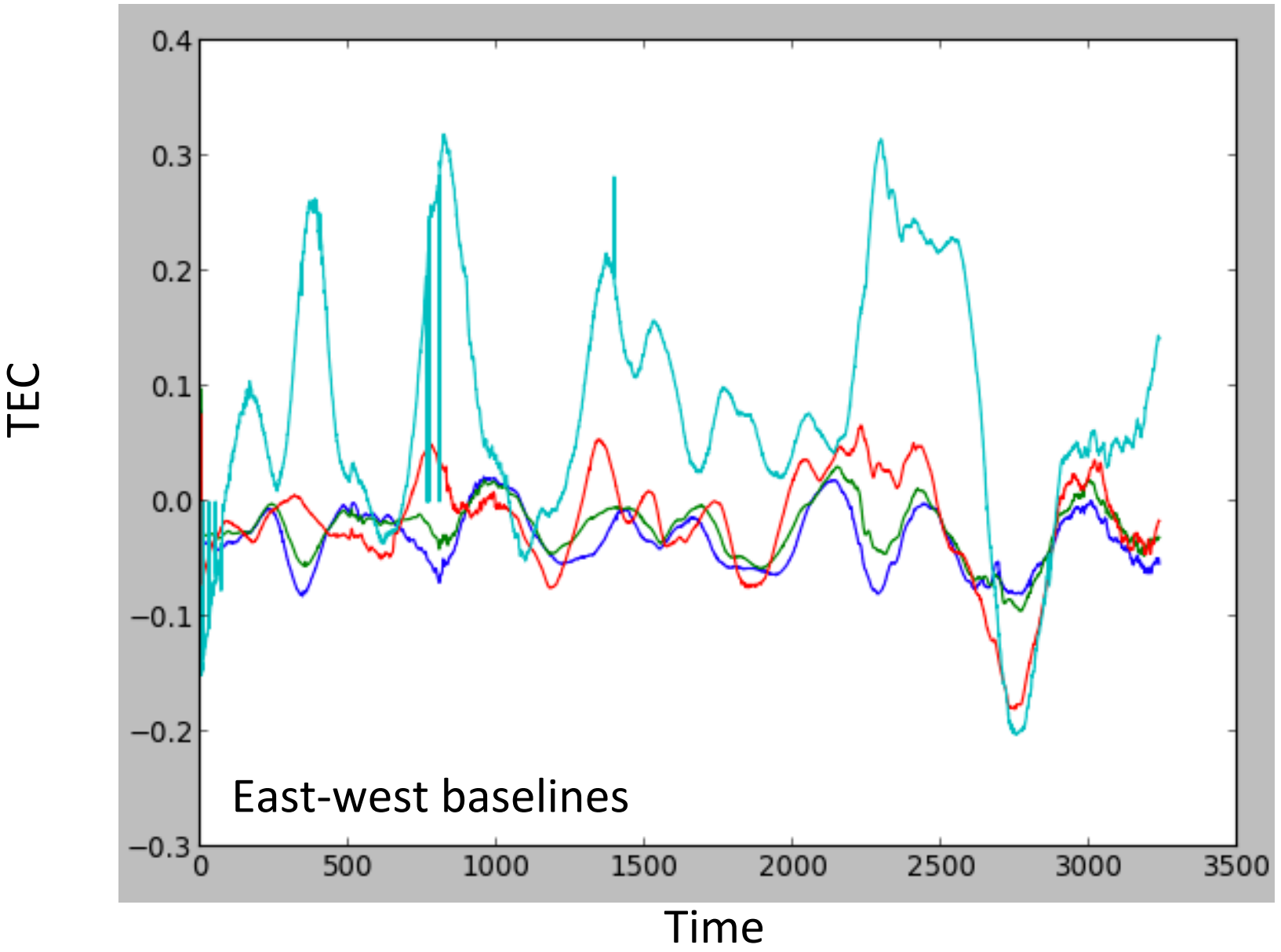


Krummhörn
Wirdum
210
Uithuizen
Hinte
31
Emden
N46
Winsum
Delfzijl
N33
Eems
Bedum
Dollart
Groningen
A7
Slochteren
Haren
Hoogezand
Scheemda
Bunde
Peize
Roden
Eelde
Winschoten
Veendam
Oude Pekela
Bellingwolde
Zuidlaren
Tynaarlo
Norg
N34
Rhede
Vlagtwedde
Gieten
Assen
Rolde
Stadskanaal
Heede
E232
Smilde
Dersum
Dörpen
Sellingen
Borger
Musselkanaal
Walchum
Sustrum
Laudermarke
Ter Apel
Beilen
Westerbork
408
Emmer-Compascuum
A28
Haren
Emmen
Hoogeveen
Klazienaveen
E233
Nieuw Amsterdam
Erica
Dalen
Zuidwolde
Coevorden
Schoonebeek
Meppen
N374
Koedijk
Noorderstraat
Noorderdiep
Zuiderdiep
Paardetangendijk
Provinciale Weg
Buinerstraat
Osdijk
Zuurdijk
Zuiderstraat
Velddijk
Nieuwedijk
Exloërweg
Voorbosweg
Regenhamsdijk
Nieuwe Dijk
Oostervleddersdijk
Exloërveen

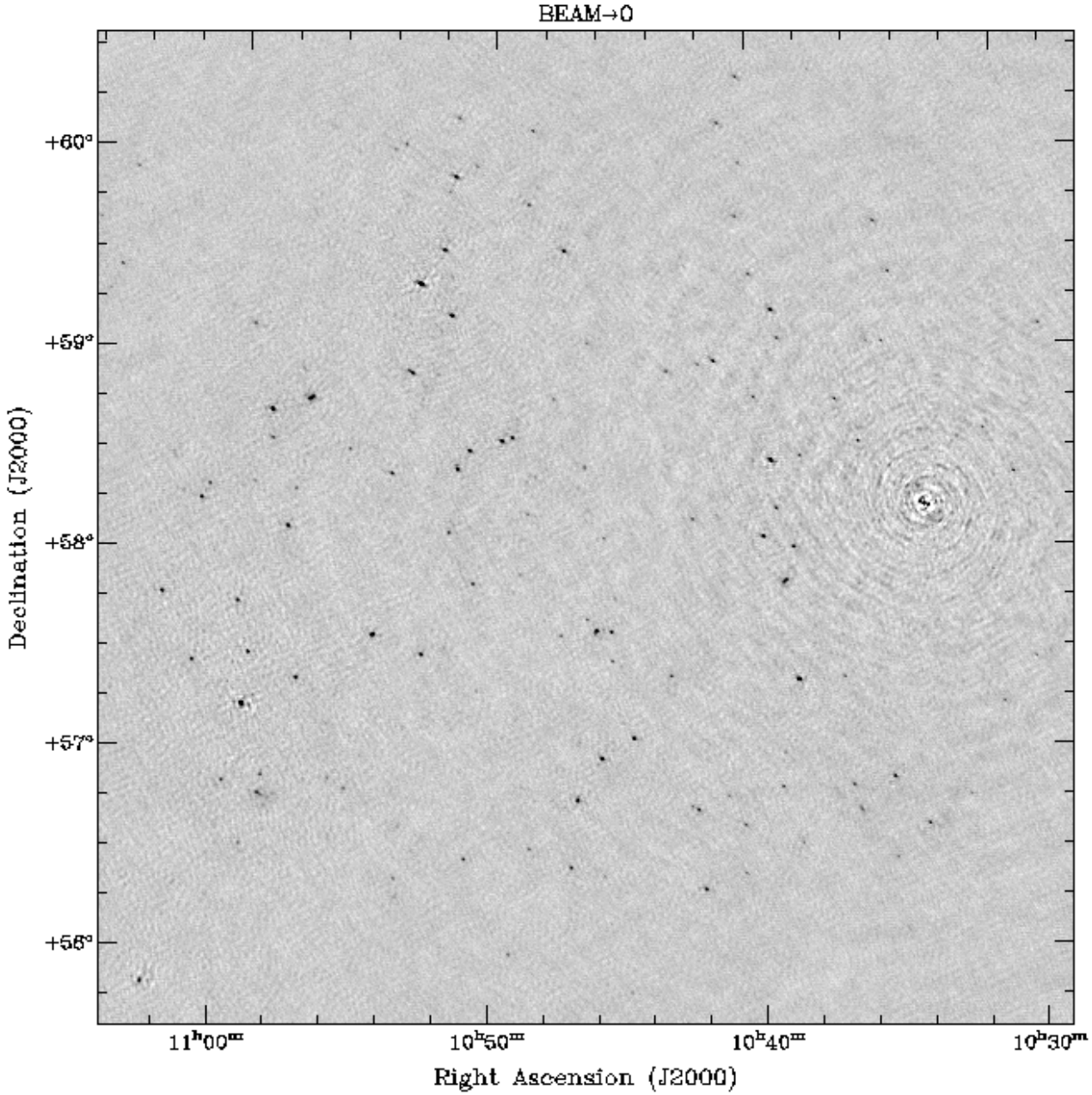
3C196 clock & TEC



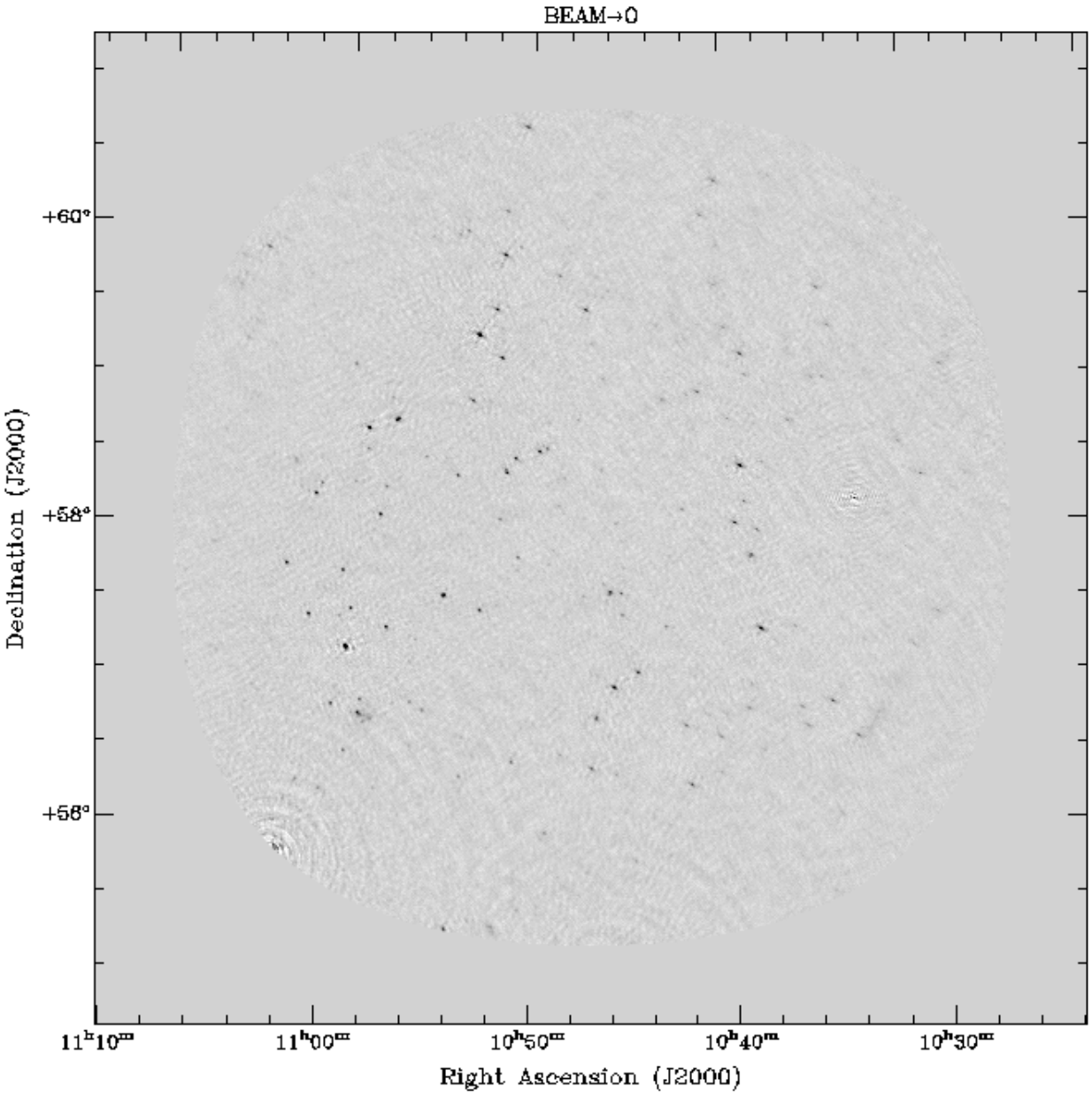
3C196 clock & TEC

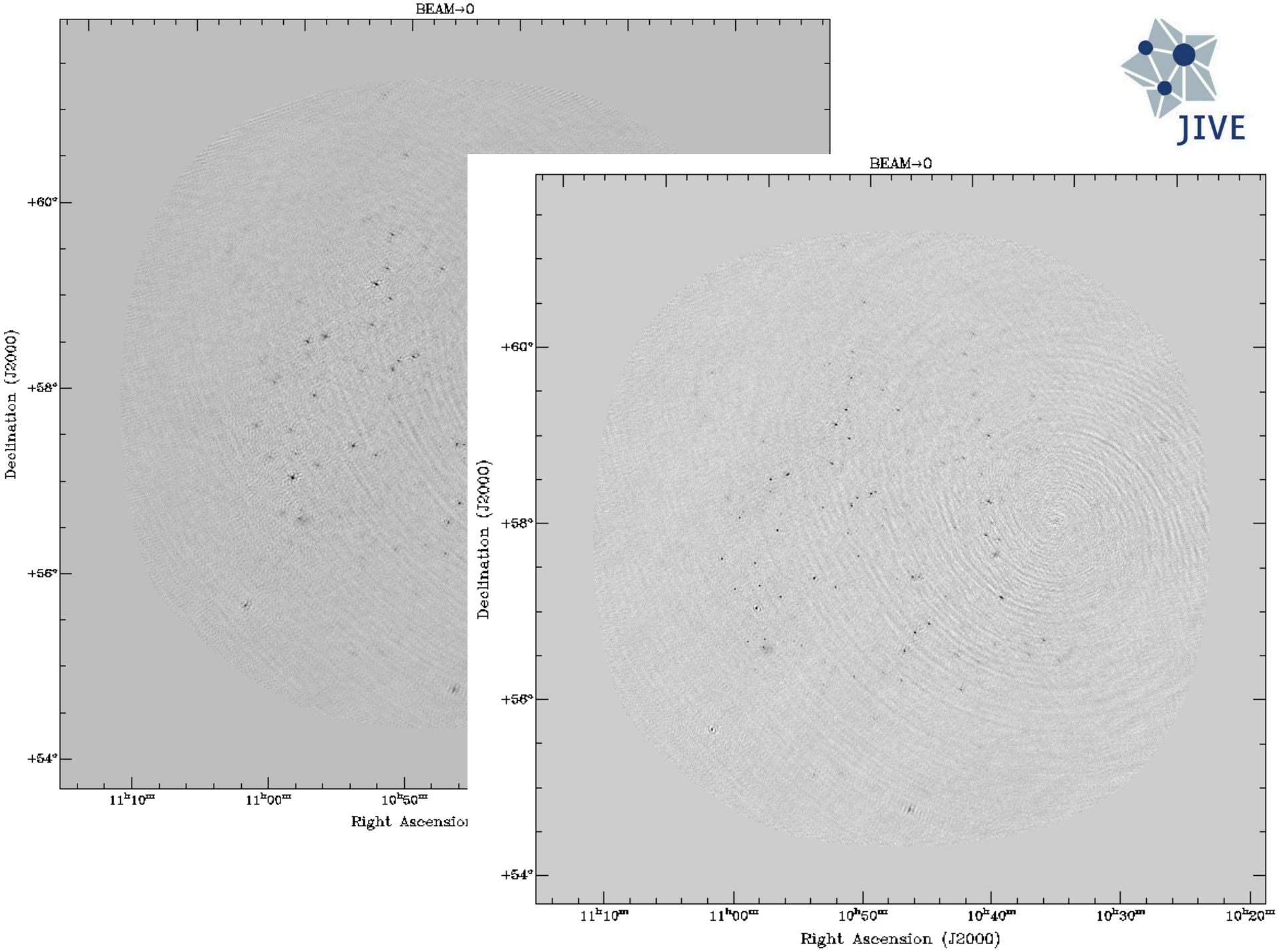


Best so far…


BEAM→0
+60°
+59°
+58°
+57°
+56°
Declination (J2000)
11h00m
10h50m
10h40m
10h30m
Right Ascension (J2000)

Best so far…


BEAM→0
+60°
+58°
+56°
Declination (J2000)
11h10m
11h00m
10h50m
10h40m
10h30m
Right Ascension (J2000)


BEAM→0
+60°
+58°
+56°
+54°
Declination (J2000)
11h10m
11h00m
10h50m
Right Ascensio
BEAM→0
+60°
+58°
+56°
+54°
Declination (J2000)
11h10m
11h00m
10h50m
10h40m
10h30m
10h20m
Right Ascension (J2000)

Lessons learned

- Amplitudes are stable
- Sky model is important
- Clock offsets need to be corrected
- Clock drifts should be corrected
- Transfer phases between calibrator and target: probably not
- Ionospheric errors need more attention

Conclusions

- Transfer phase solutions
- Clock offsets are important!
- Clock drifts are present
- Correction TBD

LoSoTo

- LOFAR Solutions Tool (de Gasperin)
- HDF5 format
- Smooth, flag, fit, etc

clockTEC fitting

- Clock: function of frequency
- TEC: function of inverse frequency

- Large bandwidth: separate effects