
ASTRON
Netherlands Institute for Radio Astronomy
Commissioning lightning talks
LOFAR FAMILY MEETING 2025

Station health

Bernard Asabere

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Netherlands Institute for Radio Astronomy

Station health

Hand-over to Commissioning

- From AIV/Software/TO

TMSS reservation:

- Ensure station(s) not reserved in TMSS

Software/firmware versions:

- Check the latest operational version is running

EC//Timing & Power

- Check the station(s) power connections to all components

Station Test & RTSM

- Check status of antennas and tiles

Signal/Data flow

- Perform IM & BF observations via TMSS

Ensure statistics created

- SSTs, BSTs & XSTs properly created

Station – COBALT – CEP - LTA

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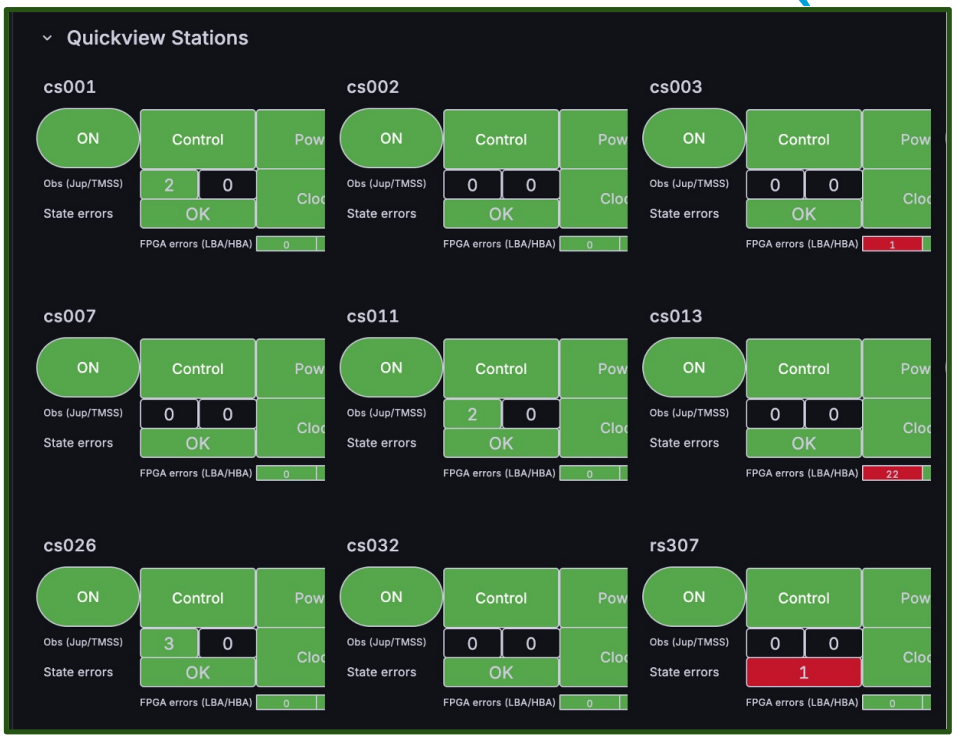
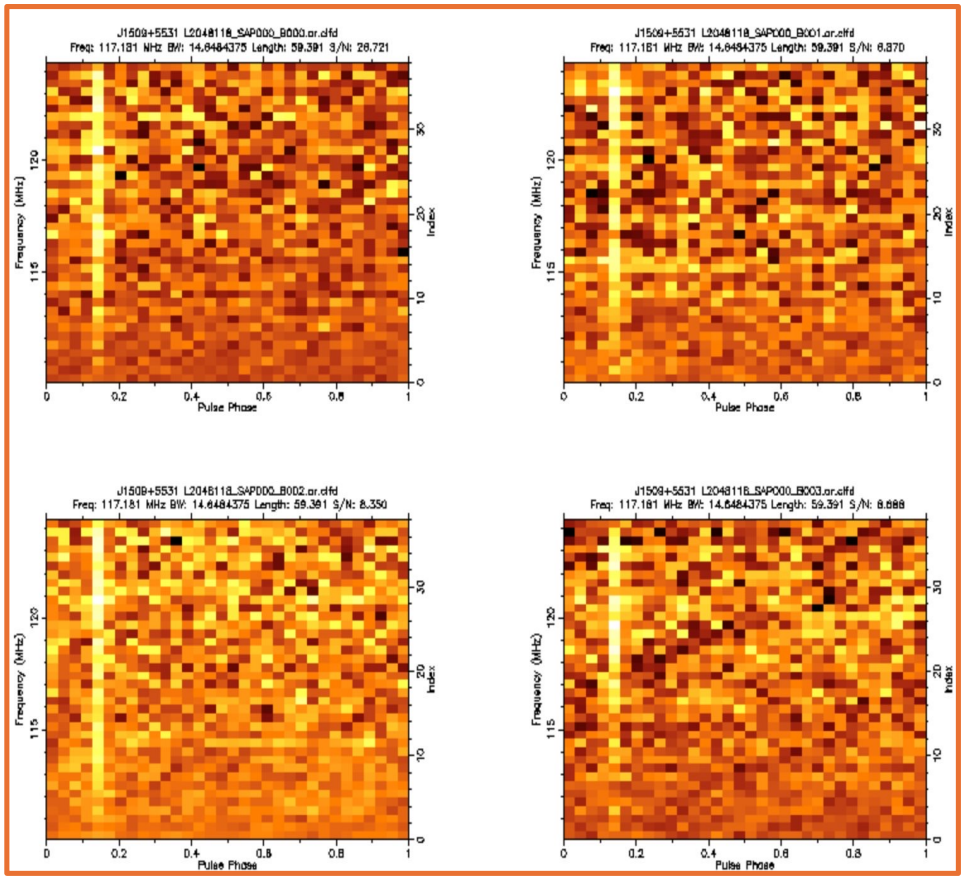


Observations via TMSS
SSTs, BSTs & BSTs → Station(s) → COBALT → CEP → LTA

Station health

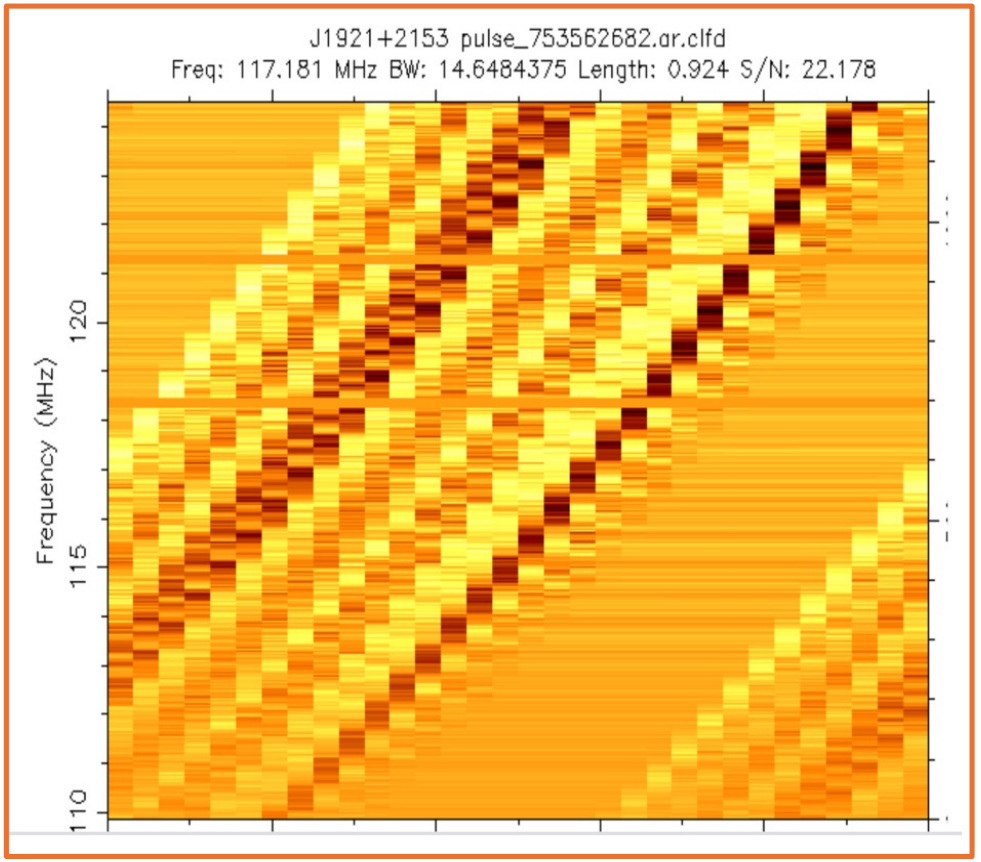
- DUPPLO L0 Requirement: LOFAR2-814:
  - LOFAR2 shall be capable of observations of ≤1 minute
- LOFAR1 limit: 1min
- Test observations 1 min – 1 sec
- With RS307 (CS002 + CS032)
- Target PSR B1919+21
- Pulsar is visible (spectral)
  - 1 min, 45 sec, 30 sec, 15 sec, 10 sec 5 sec & 3 sec
- But observations failed (no data recorded)
  - 2 sec & 1 sec
- Current limit 3 sec.

DUPLLO: the Digital Upgrade for Premier LOFAR Low-band Observing.



Station health

- ✓ LOFAR2-814:
  - LOFAR2 is capable of observations of ≤1 minute
- ✓ The current exposure time limit is 3 sec
- ✓ First successful test observation
- ✓ Starting point to do more of the tests
- ➢ Spectrum of the individual period of the pulsar B1919+21, from the 3-sec observation:
  - Mostly dominated by RFI, but the point of observation was not to get individual pulses.
  - But to show that short observations are possible without data loss with LOFAR2



Station statistics

Aida Ahmadi

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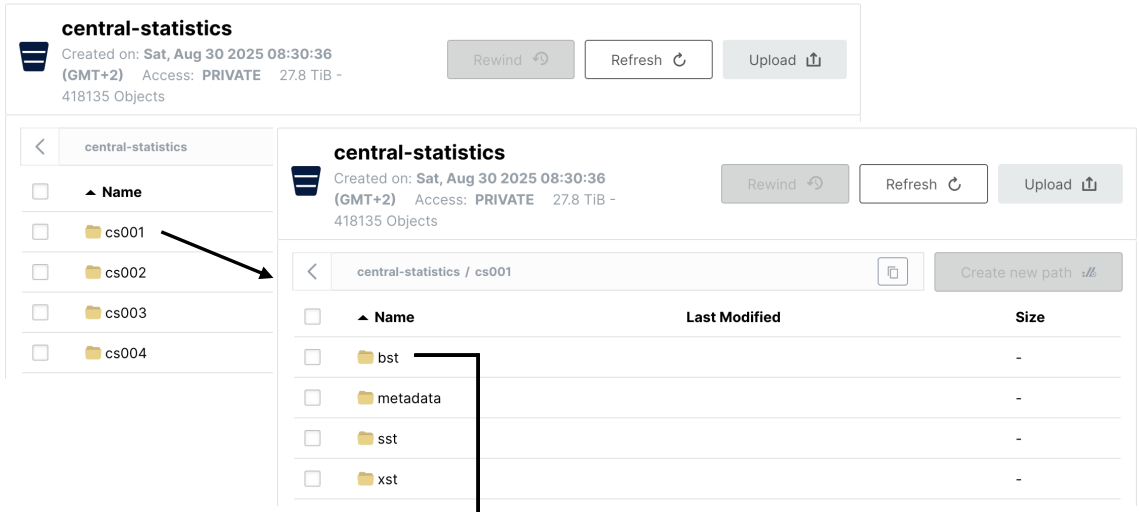
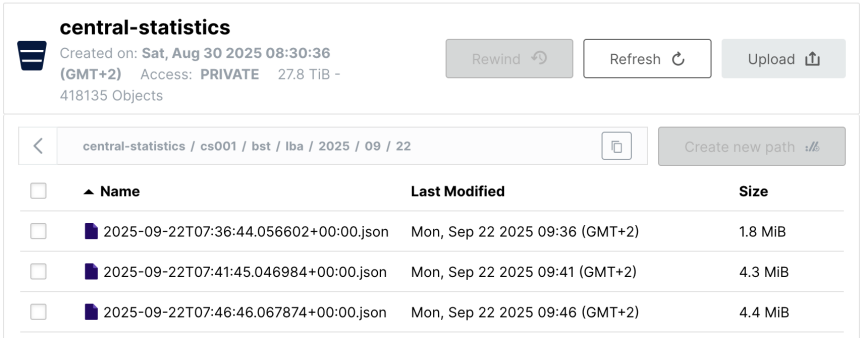
Statistics data products

Station statistics are recorded to an object storage system (minIO) at each station & synced centrally



- BST: Beamlet statistics → average power in each beamlet
- SST: Subband statistics → average power in each subband
- XST: Crosslet statistics → array covariance matrices (ACM) / visibilities



- Saved as JSON files containing 5 minutes of data
- Metadata stored separately
- To make sense of them:
  - Collate metadata + data for desired time range using a Python package developed by David McKenna et al. (`l2json`)
  - Plot the collated dataset using a Python package developed by Cees Bassa et al. (`lofty`)

Continous monitoring of the BSTs to facilitate commissioning

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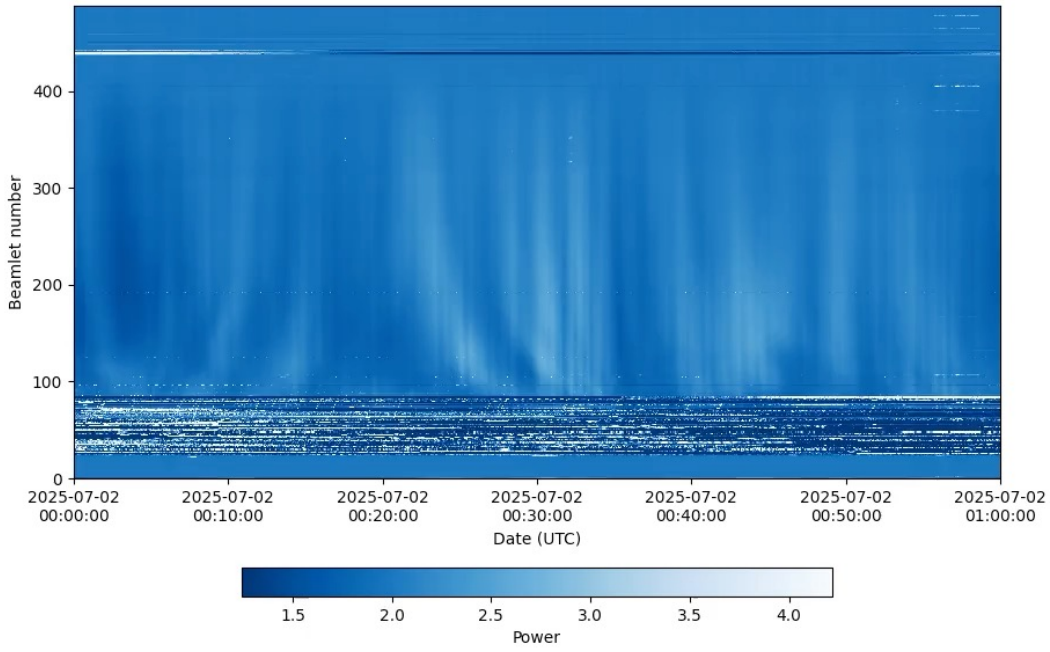
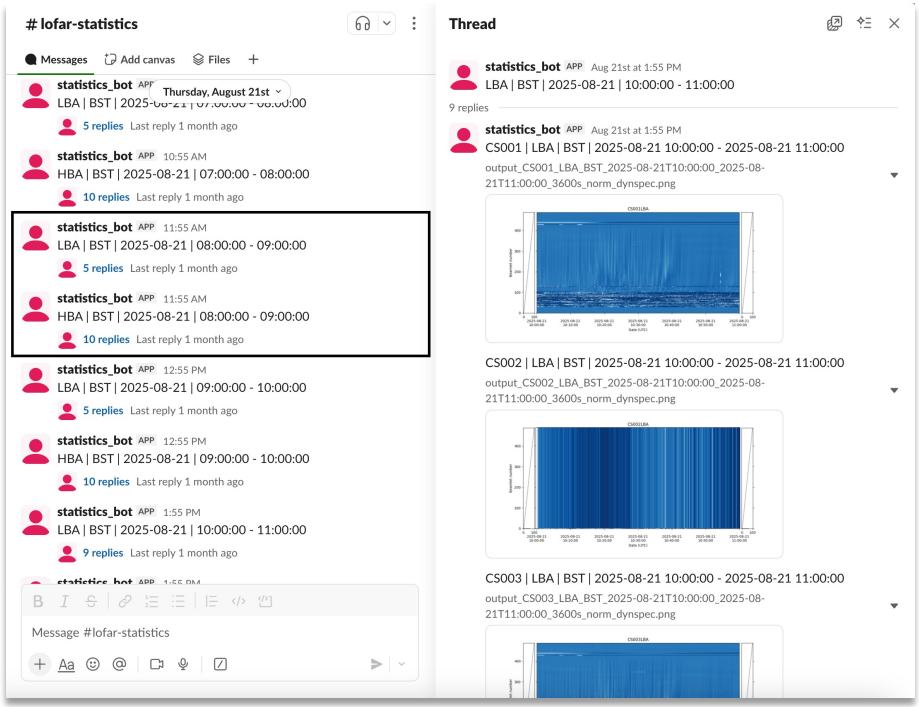
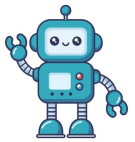
- We continuously and automatically generate dynamic spectra from the BSTs every hour for each station / band
- A bot dumps the plots to a Slack channel for monitoring



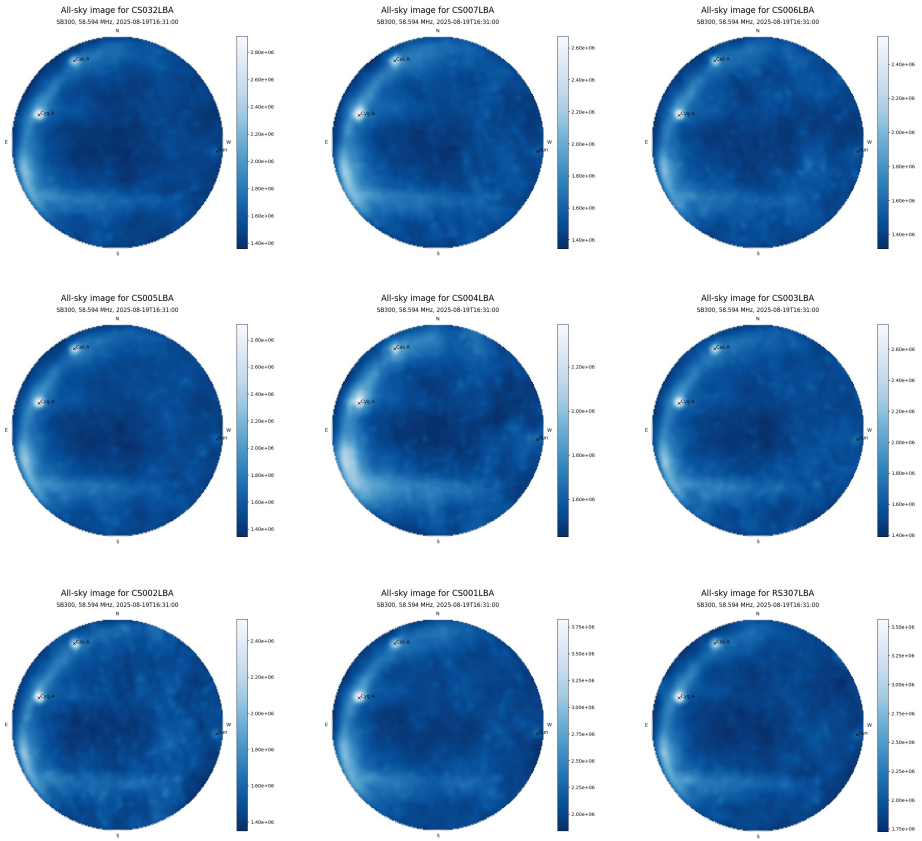


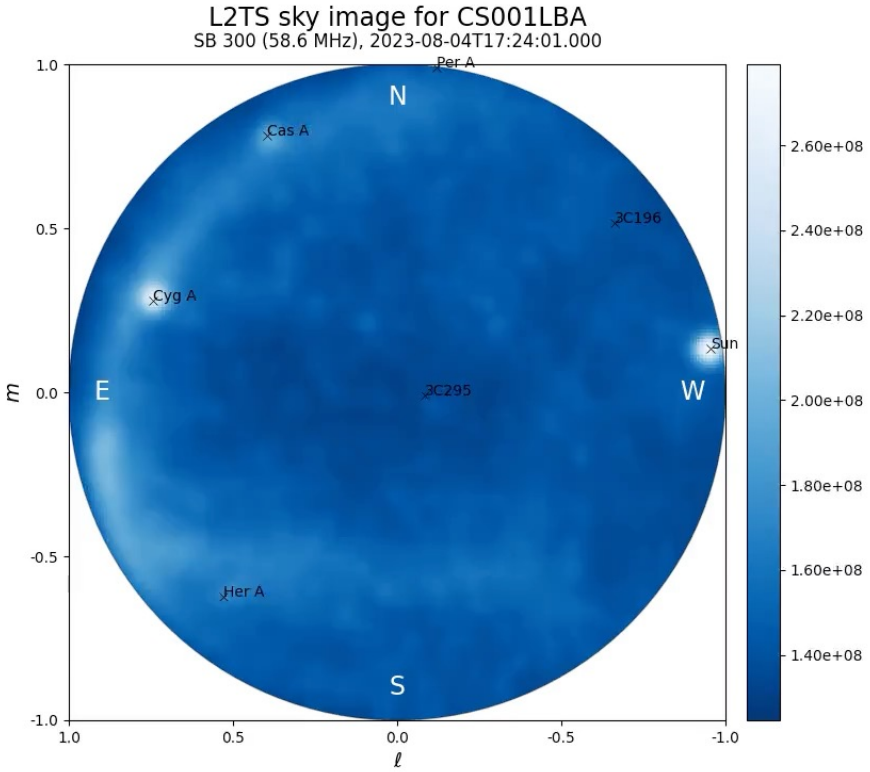
Helps us quickly understand the state of commissioning (e.g. see test observation results, need to reset station after a state transition)



All-sky imaging of the XSTs

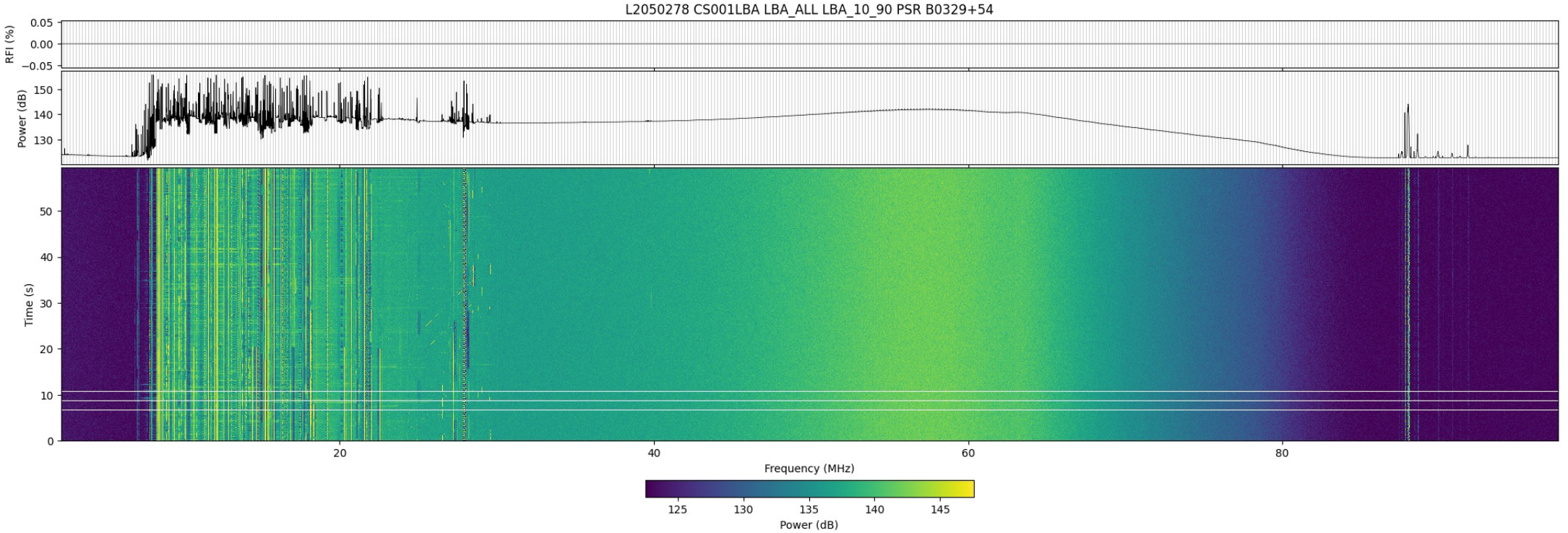
- LBA all-sky images for SB 300 (58.6MHz) for all available L2 stations
- Gives a quick view of the state of the station calibrations



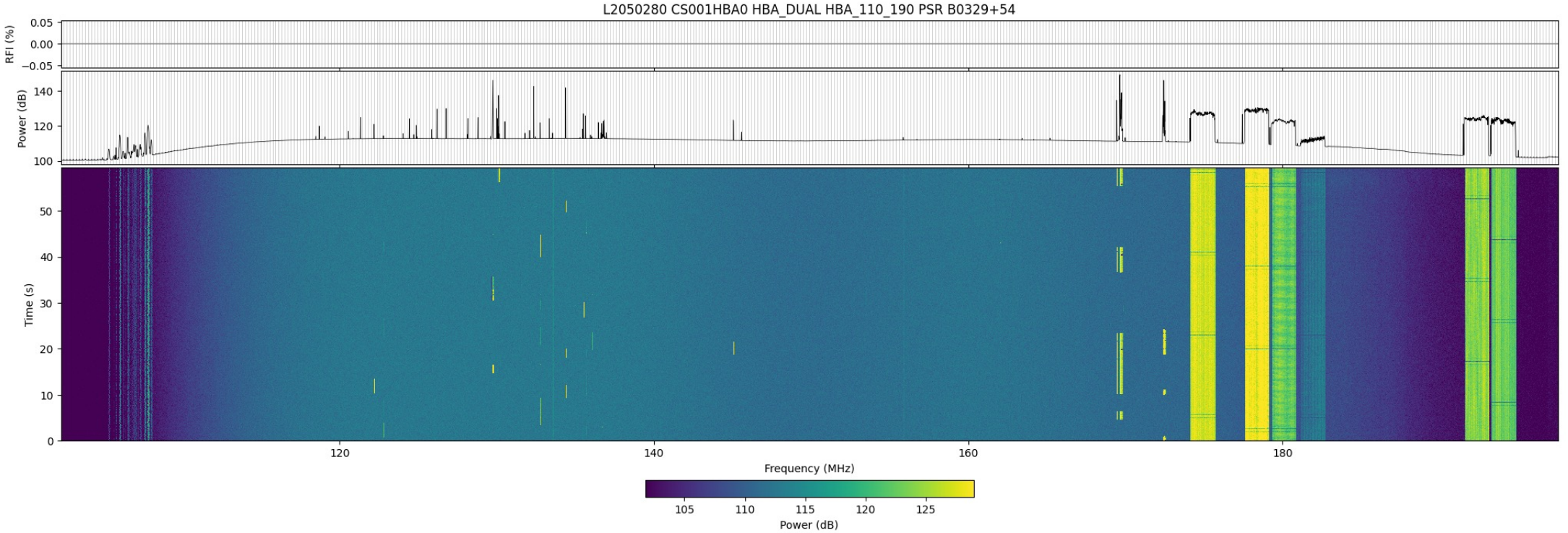


courtesy of Cees Bassa

Fullband LBA *(Cees Bassa)*



Simultaneously: full band HBA! *(Cees Bassa)*



Station calibration

Cristina-Maria Cordun

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LBA (45 MHz)

HBA (140 MHz)

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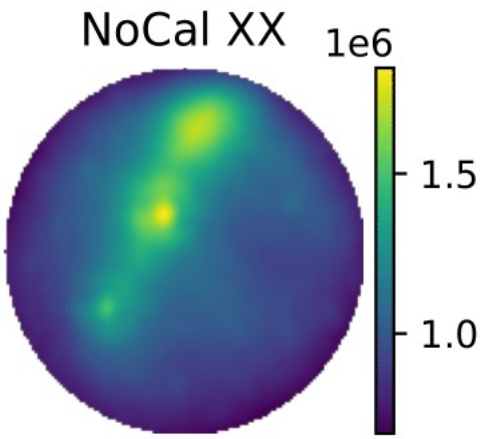
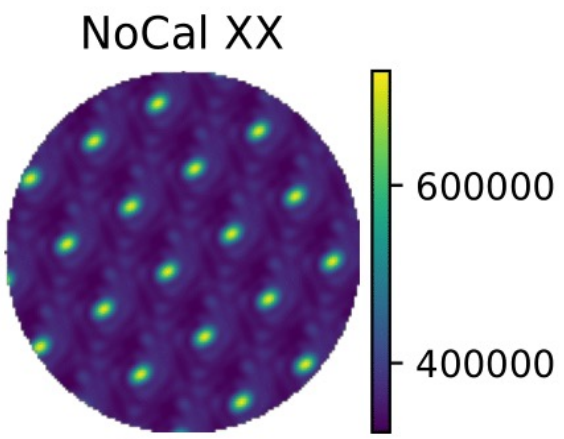
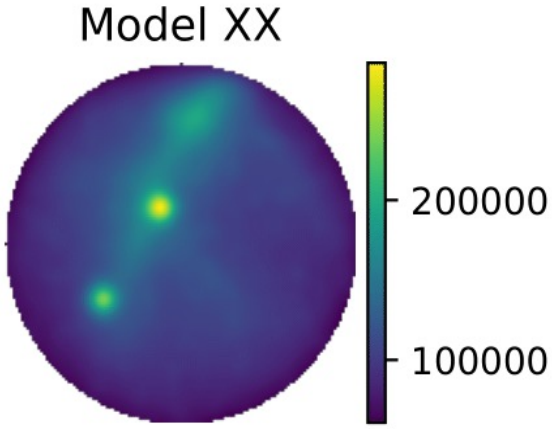
Data

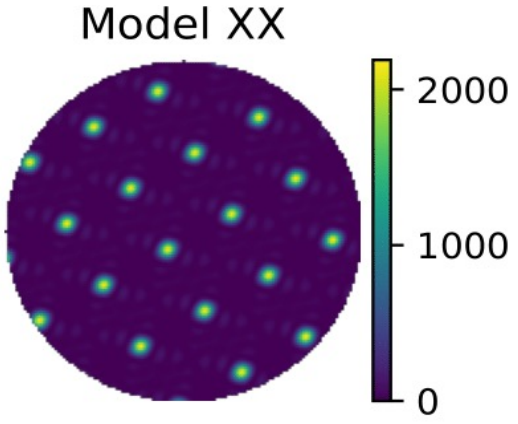




Model

(including EEPs for LBA)





!! Convert to visibilities first !!

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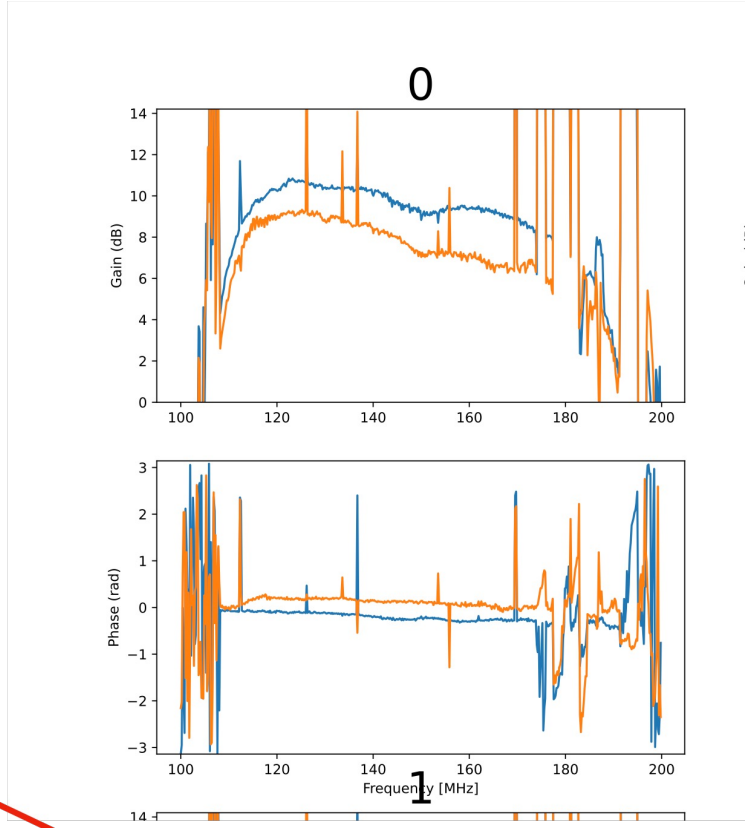
CS001HBA1 2024-12-21T02:23:29.000003
Merged Sky Model consists of: Cas A
Merged Sky Model XX
Merged Sky Model YY
OFF


0
Gain (dB)
Phase (rad)
Frequency [MHz]
1

LBA (45 MHz)

HBA (140 MHz)

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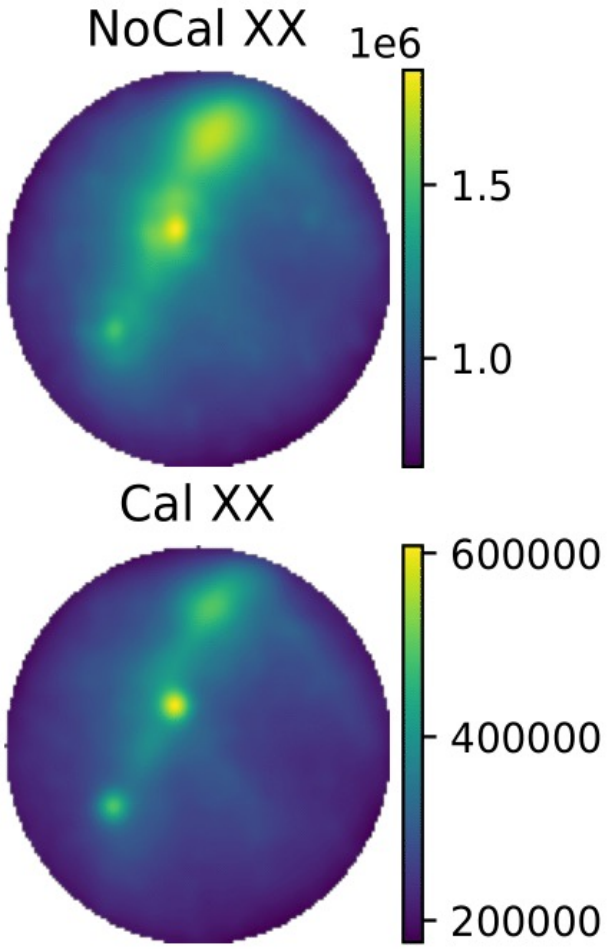
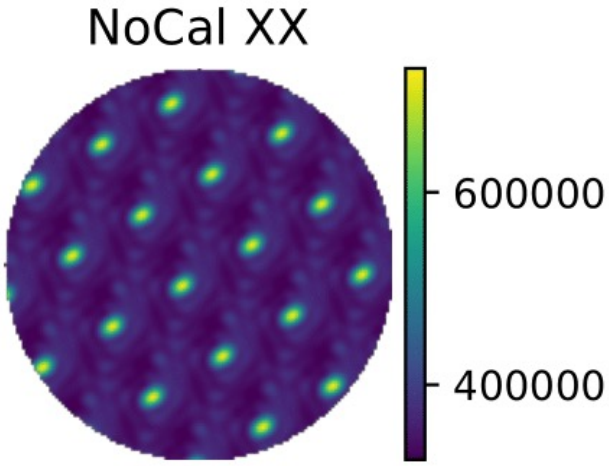
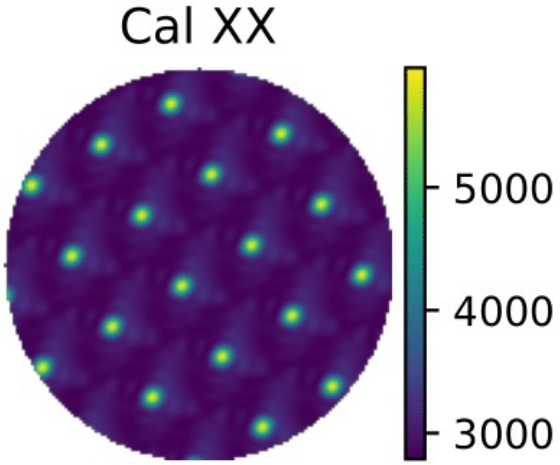
Before





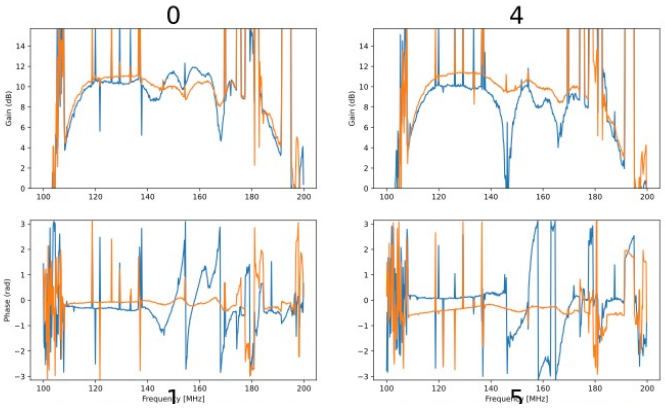
After

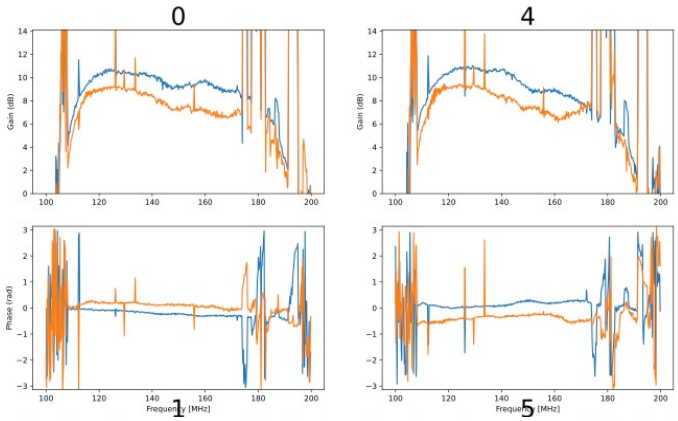


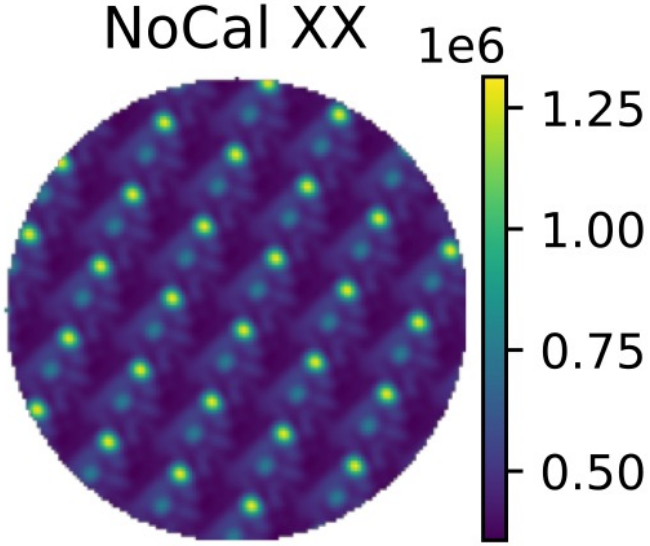
Only a few seconds of data!!

Before

After







CS002 mystery

Cristina-Maria Cordun (representing David McKenna)

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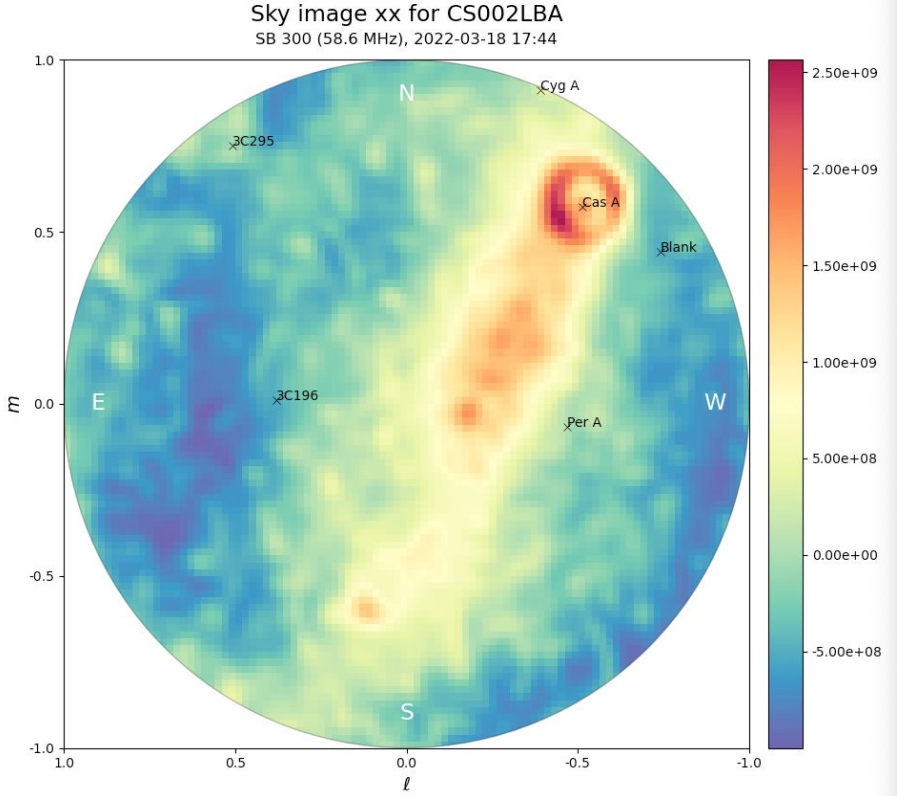
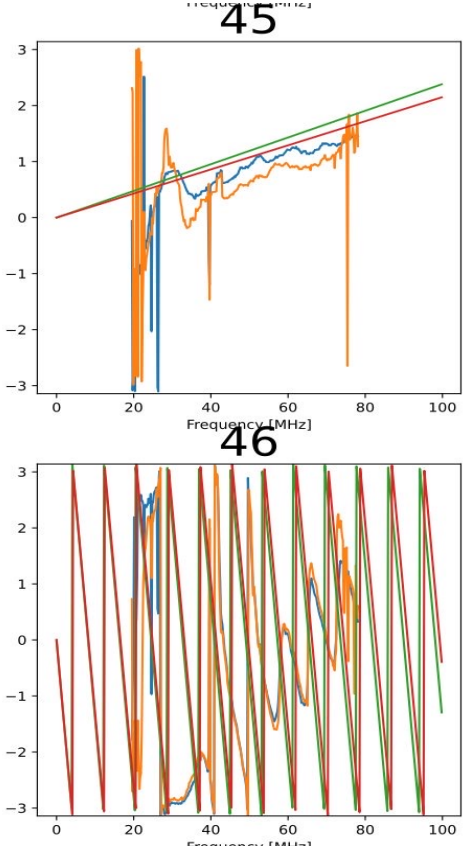
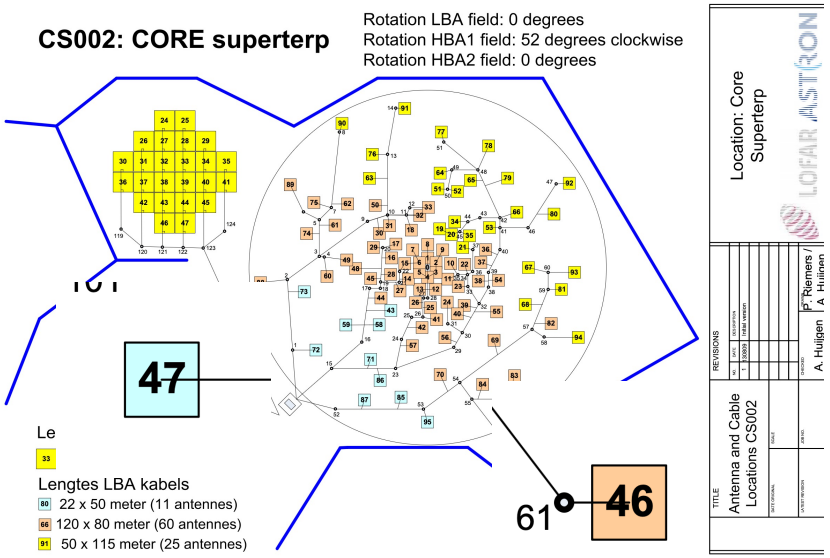
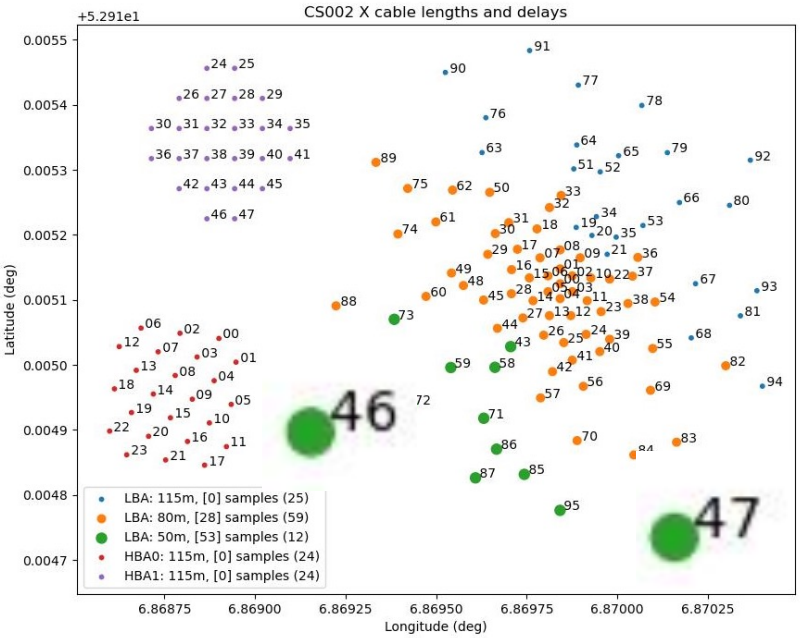
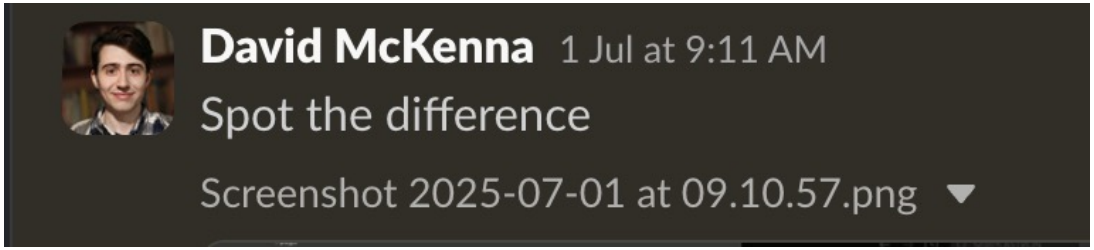
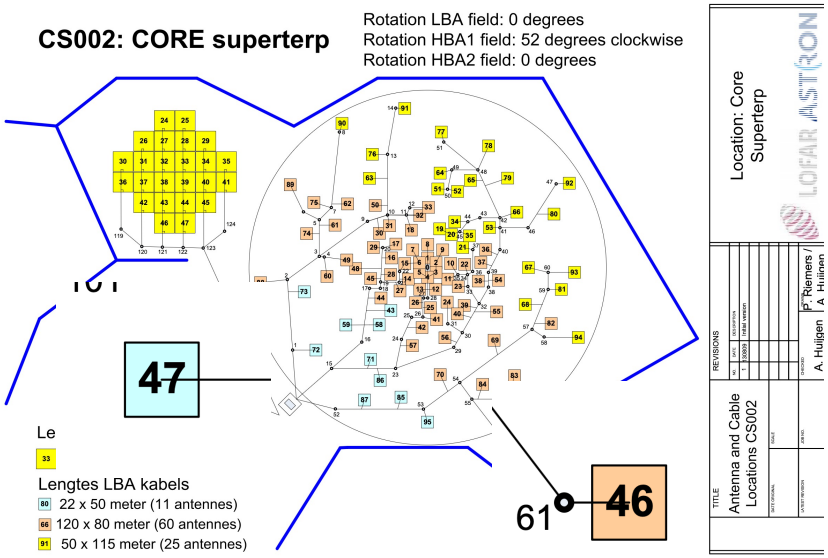

Sky image xx for CS002LBA
SB 300 (58.6 MHz), 2022-03-18 17:44
N
E
S
W
Cyg A
3C295
Cas A
Blank
3C196
Per A
m
ℓ
1.0
0.5
0.0
-0.5
-1.0
2.50e+09
2.00e+09
1.50e+09
1.00e+09
5.00e+08
0.00e+00
-5.00e+08

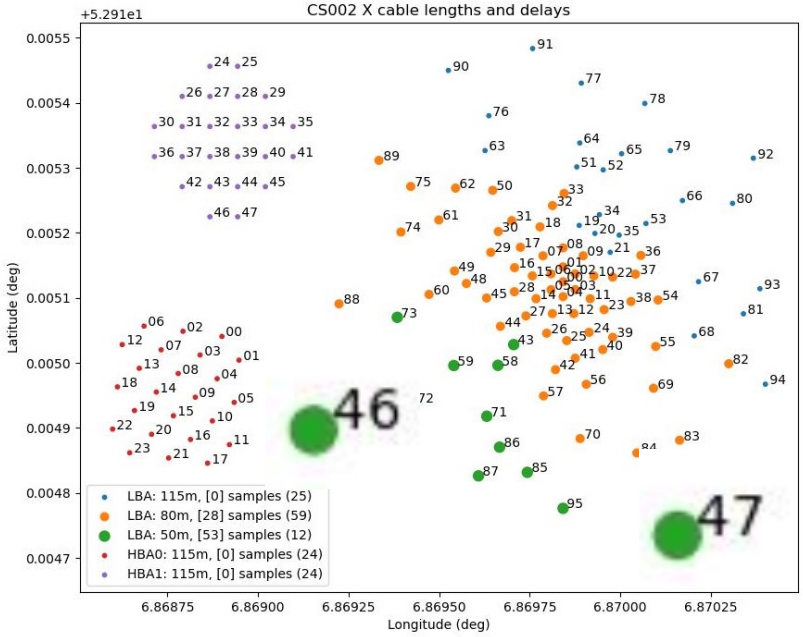

45
Frequency [MHz]
46
Frequency [MHz]
3
2
1
0
−1
−2
−3
0
20
40
60
80
100


CS002: CORE superterp
Rotation LBA field: 0 degrees
Rotation HBA1 field: 52 degrees clockwise
Rotation HBA2 field: 0 degrees
47
46
61
Le
Lengtes LBA kabels
22 x 50 meter (11 antennes)
120 x 80 meter (60 antennes)
50 x 115 meter (25 antennes)
Location: Core
Superterp
LOFAR ASTRON
P. Riemers / A. Huijgen
A. Huijgen
REVISIONS
TITLE
Antenna and Cable
Locations CS002


CS002 X cable lengths and delays
+5.291e1
Latitude (deg)
Longitude (deg)
0.0055
0.0054
0.0053
0.0052
0.0051
0.0050
0.0049
0.0048
0.0047
6.86875
6.86900
6.86925
6.86950
6.86975
6.87000
6.87025
46
47
LBA: 115m, [0] samples (25)
LBA: 80m, [28] samples (59)
LBA: 50m, [53] samples (12)
HBA0: 115m, [0] samples (24)
HBA1: 115m, [0] samples (24)


David McKenna 1 Jul at 9:11 AM
Spot the difference
Screenshot 2025-07-01 at 09.10.57.png


CS002: CORE superterp
Rotation LBA field: 0 degrees
Rotation HBA1 field: 52 degrees clockwise
Rotation HBA2 field: 0 degrees
47
46
61
Lengtes LBA kabels
22 x 50 meter (11 antennes)
120 x 80 meter (60 antennes)
50 x 115 meter (25 antennes)
Location: Core Superterp
Antenna and Cable Locations CS002
P. Riemers / A. Huijgen
A. Huijgen


CS002 X cable lengths and delays
+5.291e1
Latitude (deg)
Longitude (deg)
LBA: 115m, [0] samples (25)
LBA: 80m, [28] samples (59)
LBA: 50m, [53] samples (12)
HBA0: 115m, [0] samples (24)
HBA1: 115m, [0] samples (24)
46
47

SEFDs

Emma van der Wateren, on behalf on Pragya Chawla

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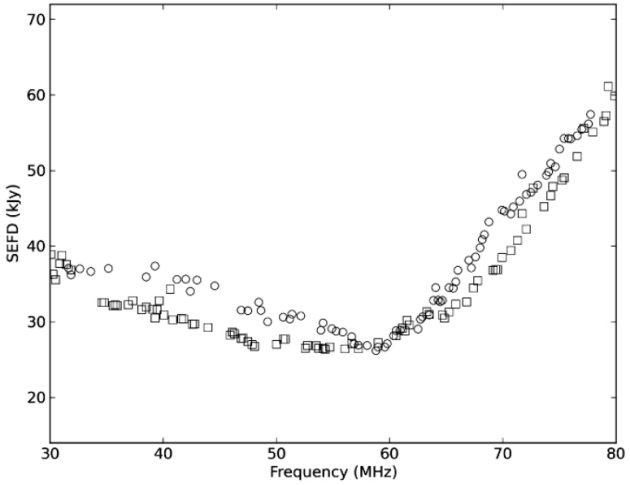
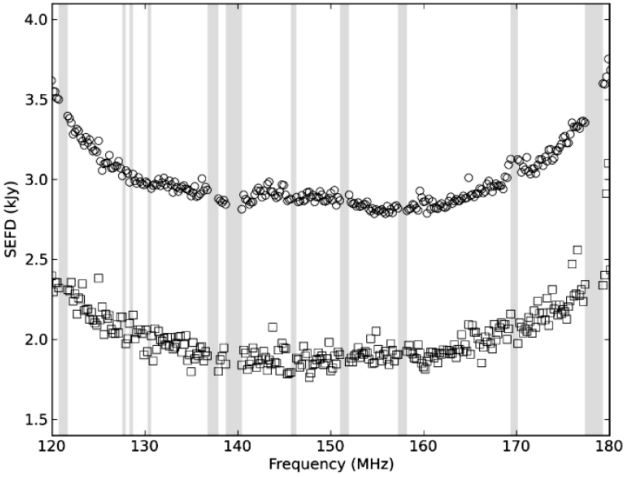
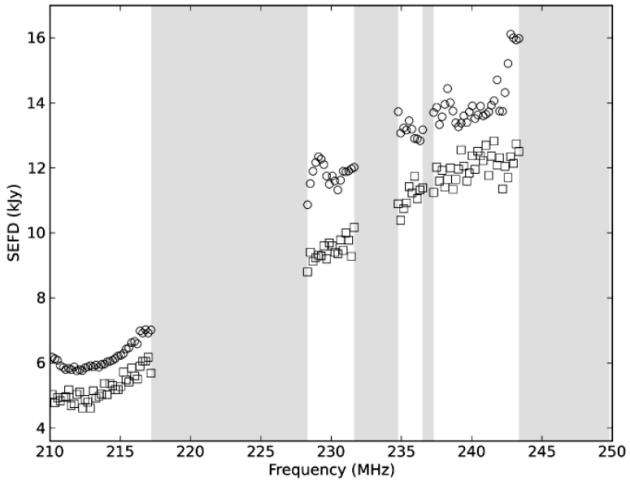
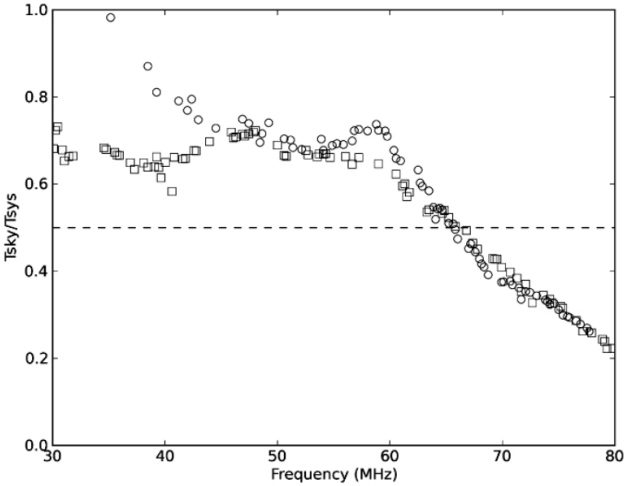
SEFDs

- Previously: interferometric
- Cross-correlations of visibilities on calibrators
- Requires multiple stations



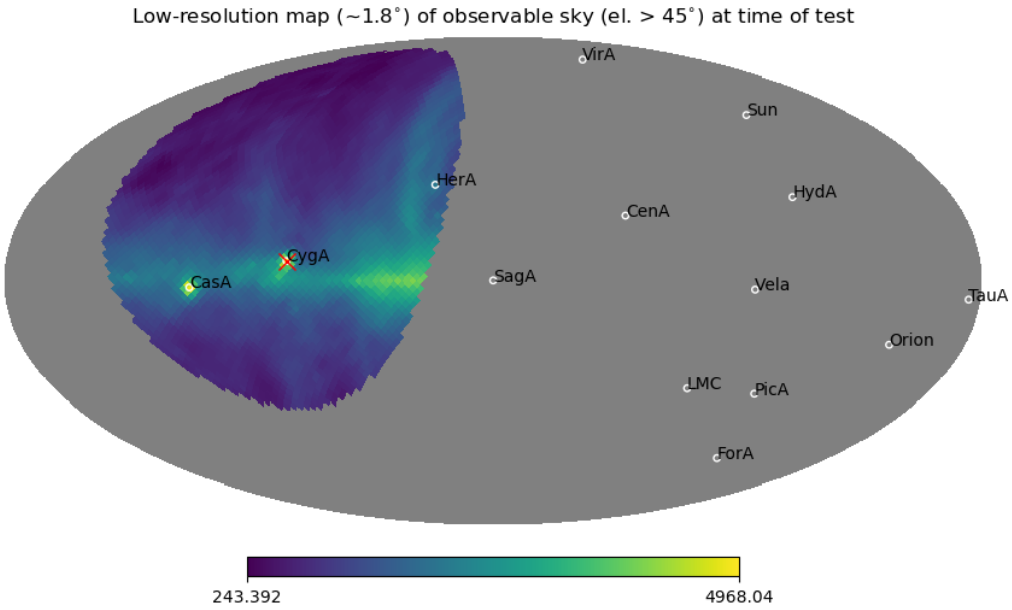


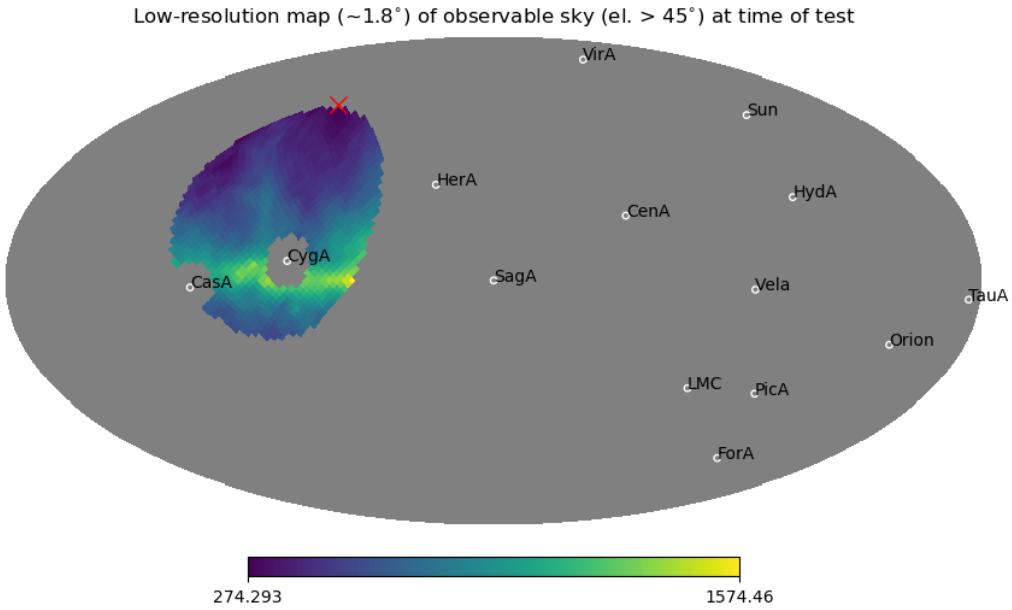




Van Haarlem et al. (2013)

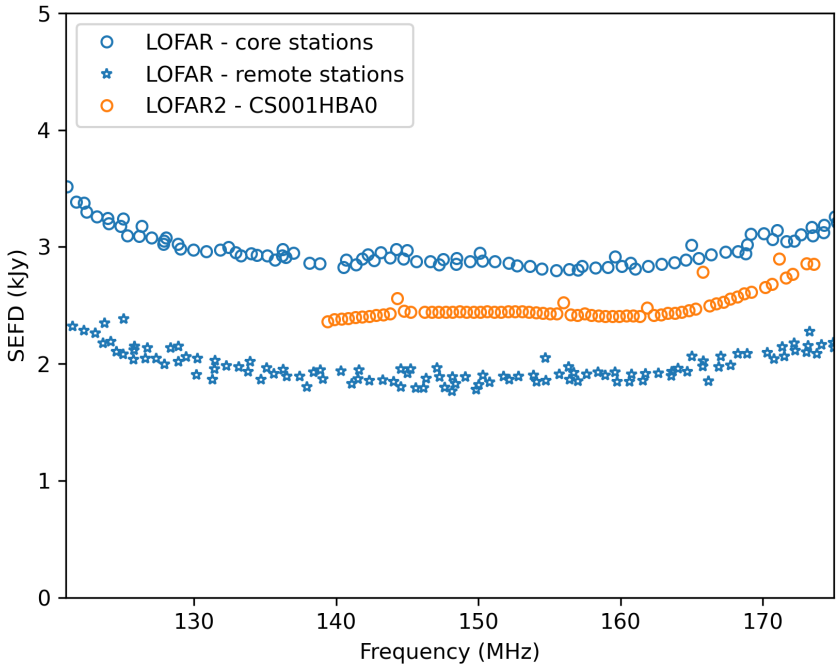
Source selection

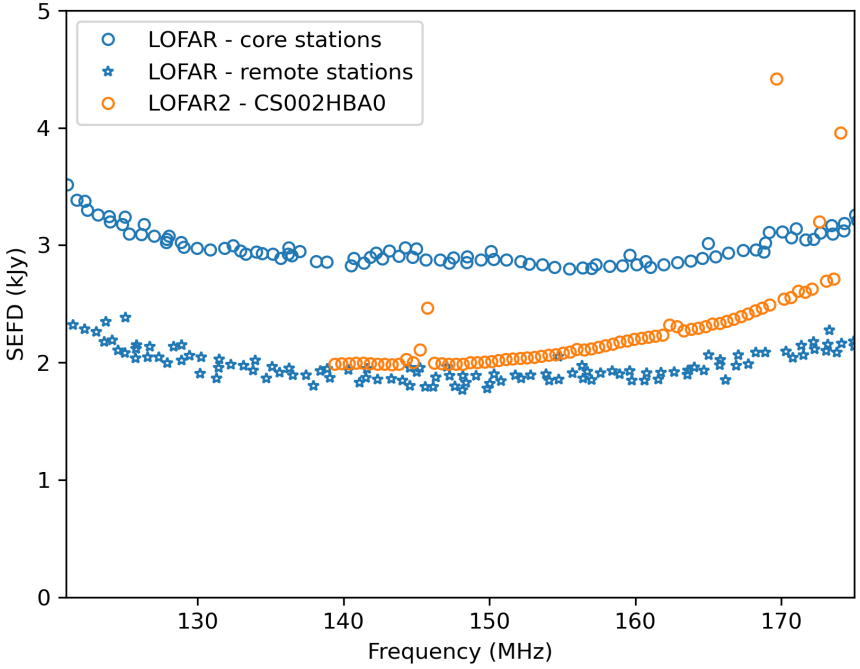




- Convolve beam with sky models
- (T_on – T_off) / T_off
- Use known flux density to get SEFD

HBA 110-190 MHz SEFDs





Monitoring ionospheric scintillation

Aleksandar Shulevski

+ Maaijke Mevius, Pietro Zucca, Henrik Edler

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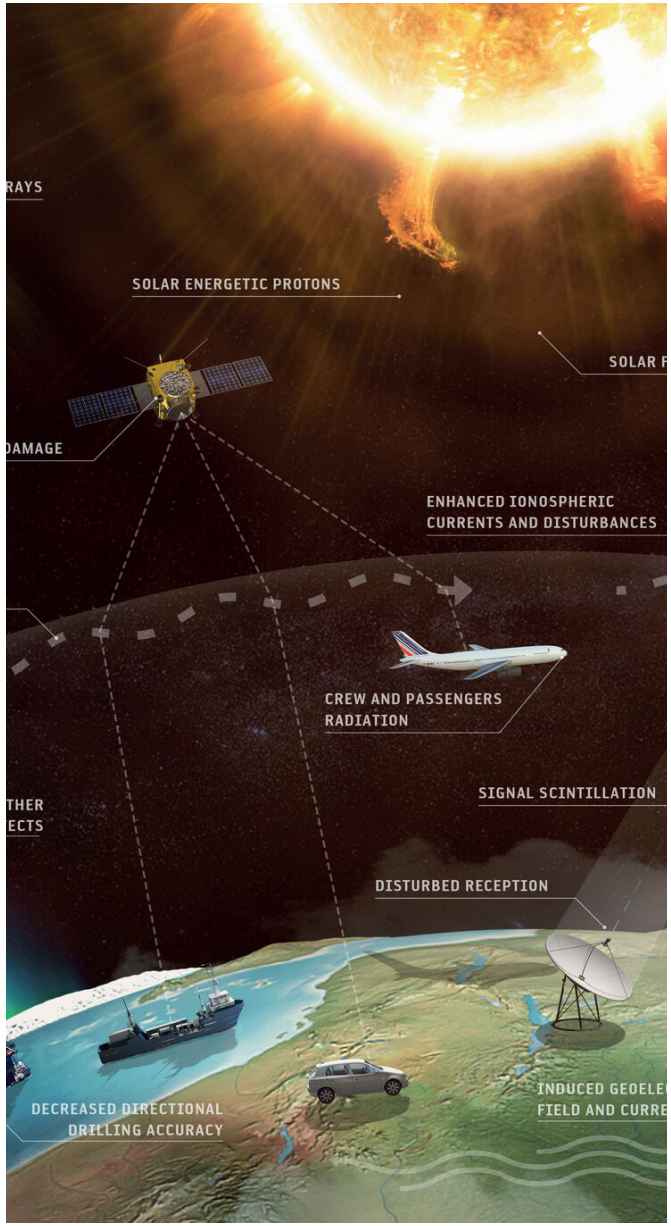
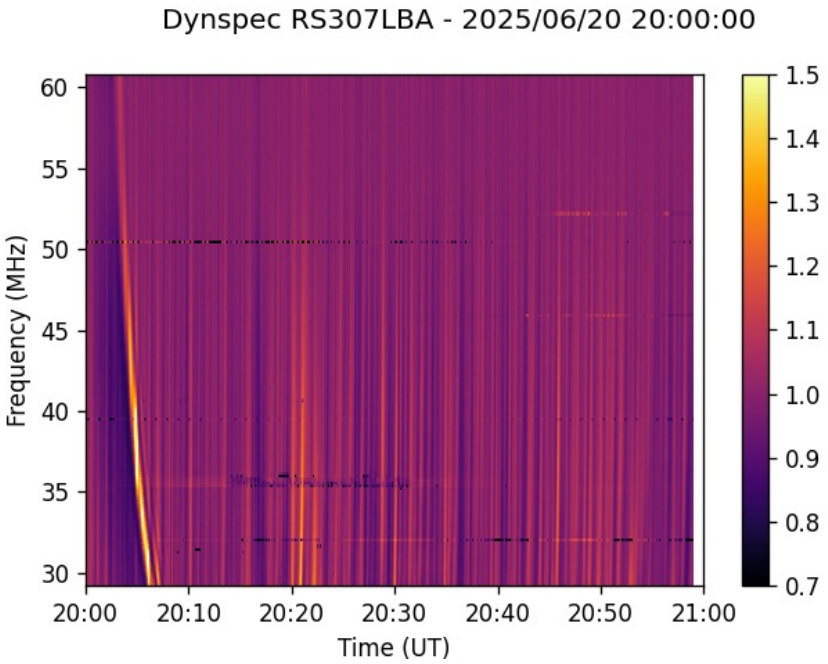
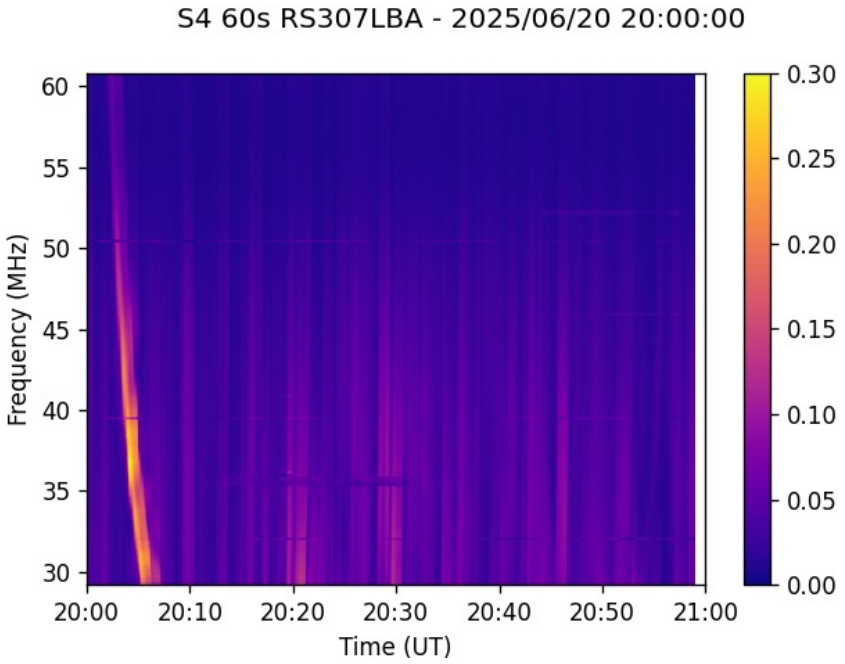


Monitoring ionospheric scintillation

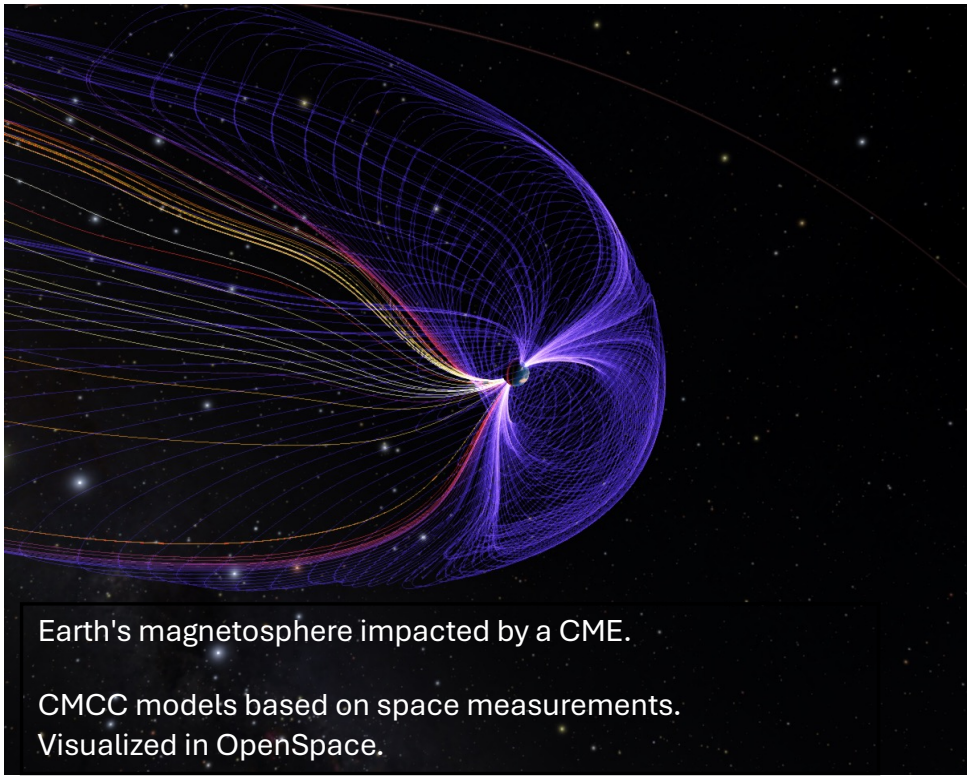
LOFAR2 single station commissioning observation of CasA used to derive the S4 index for the ionosphere. Strong scintillation is detected, most likely originating from a wide-area disturbance moving across the FoV. This would potentially affect production observations, depending on their setup.





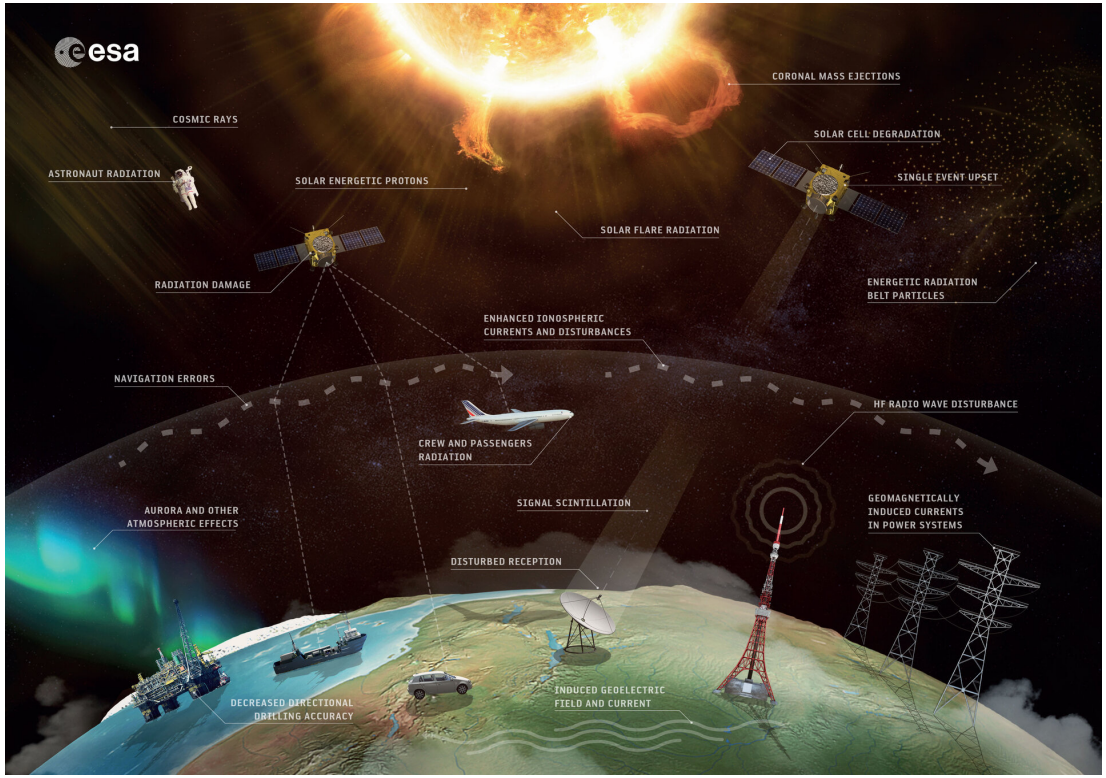
Monitoring ionospheric scintillation

Monitoring the ionosphere and space weather in general can be crucial for proper utilization of the upgraded LOFAR instrument, while generating useful ancillary data.



Earth's magnetosphere impacted by a CME.

CMCC models based on space measurements.
Visualized in OpenSpace.



Array calibration

Cristina-Maria Cordun

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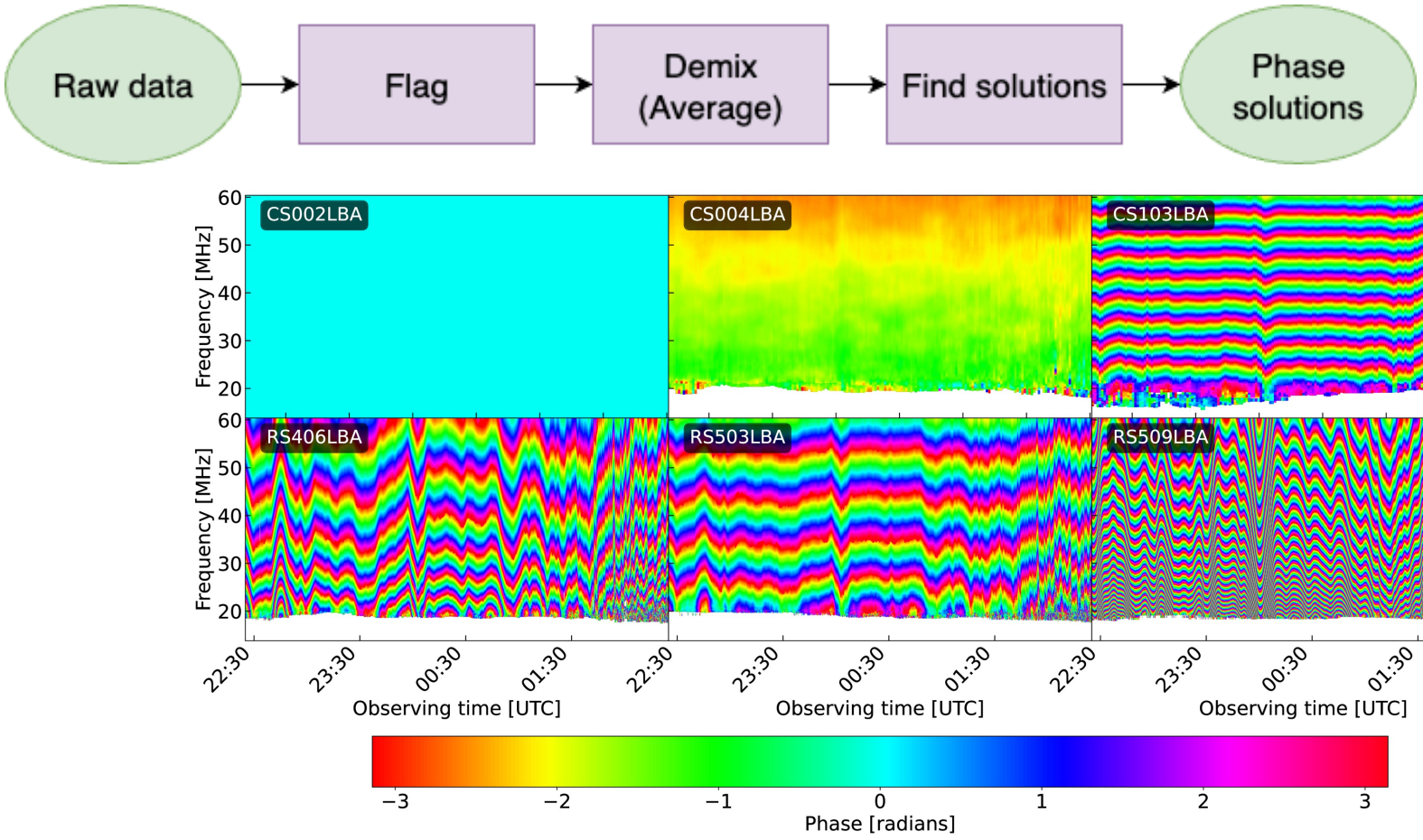
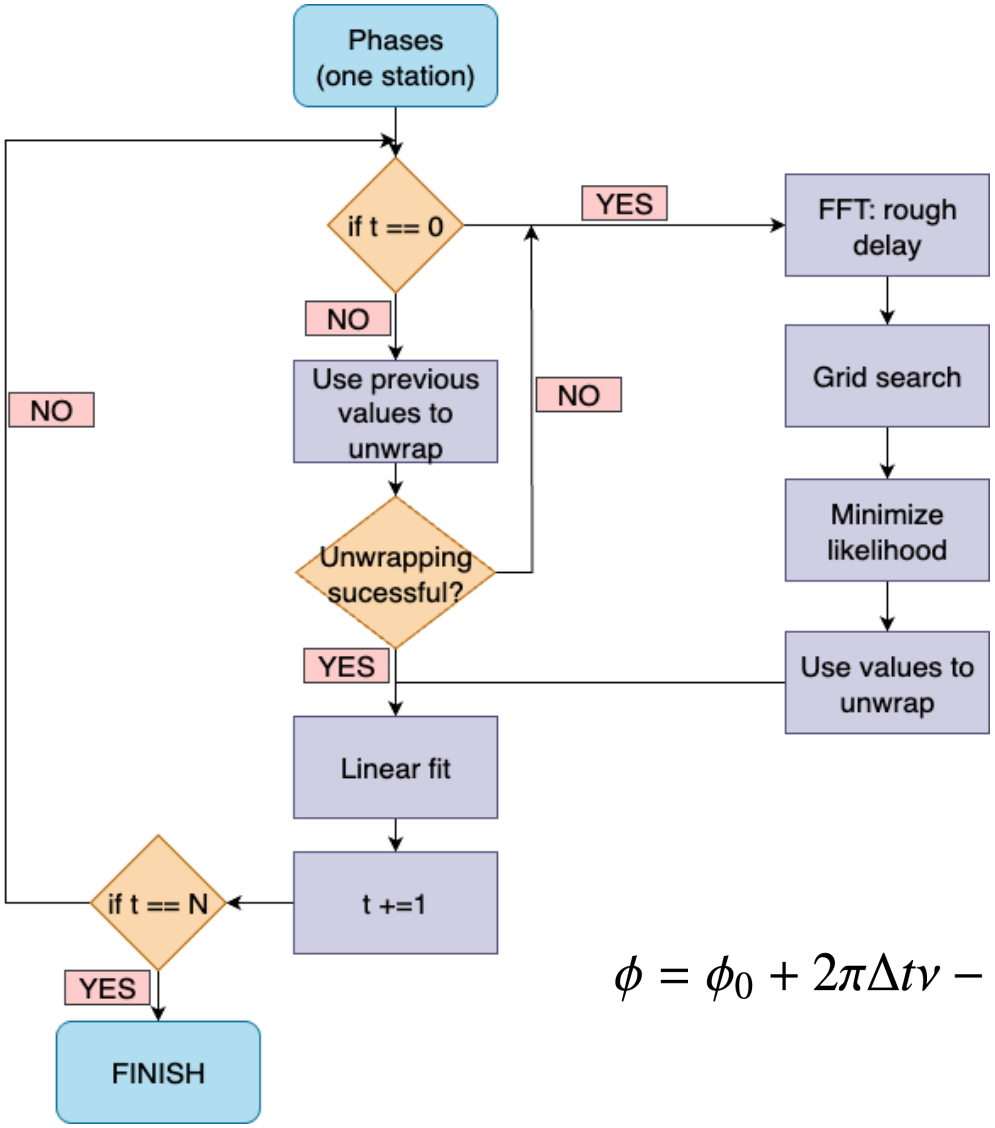


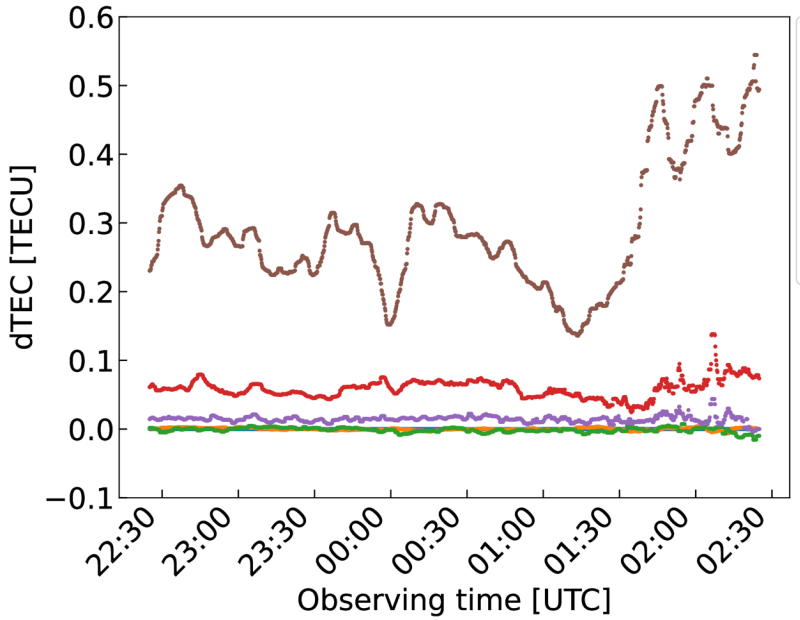
Cordun et. al (2025)

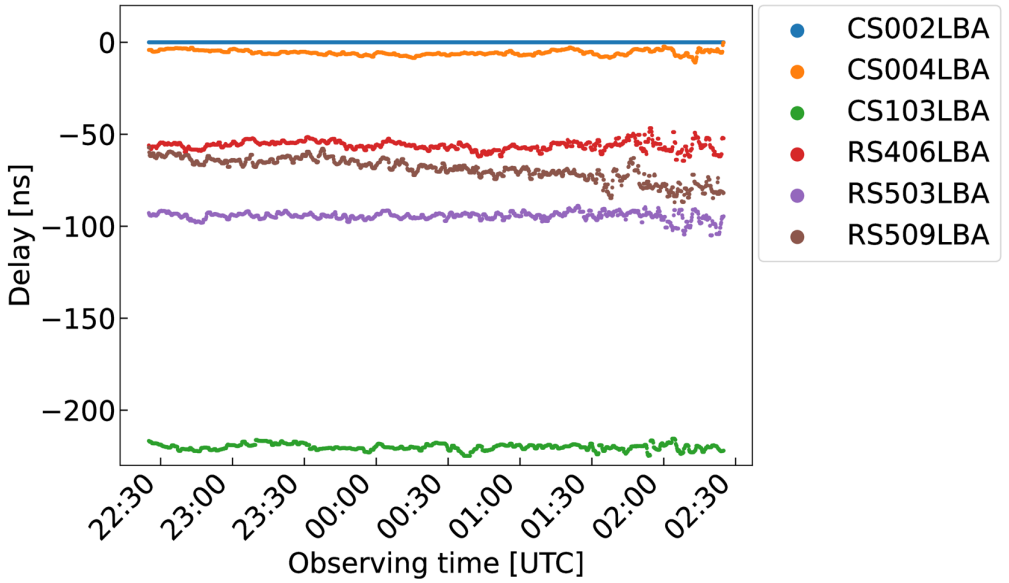
HBA worked before, so we focus on LBA

$$\phi = \phi_0 + 2\pi\Delta t\nu - 8.4479745 \cdot 10^9 \frac{\tau_1}{\nu}$$

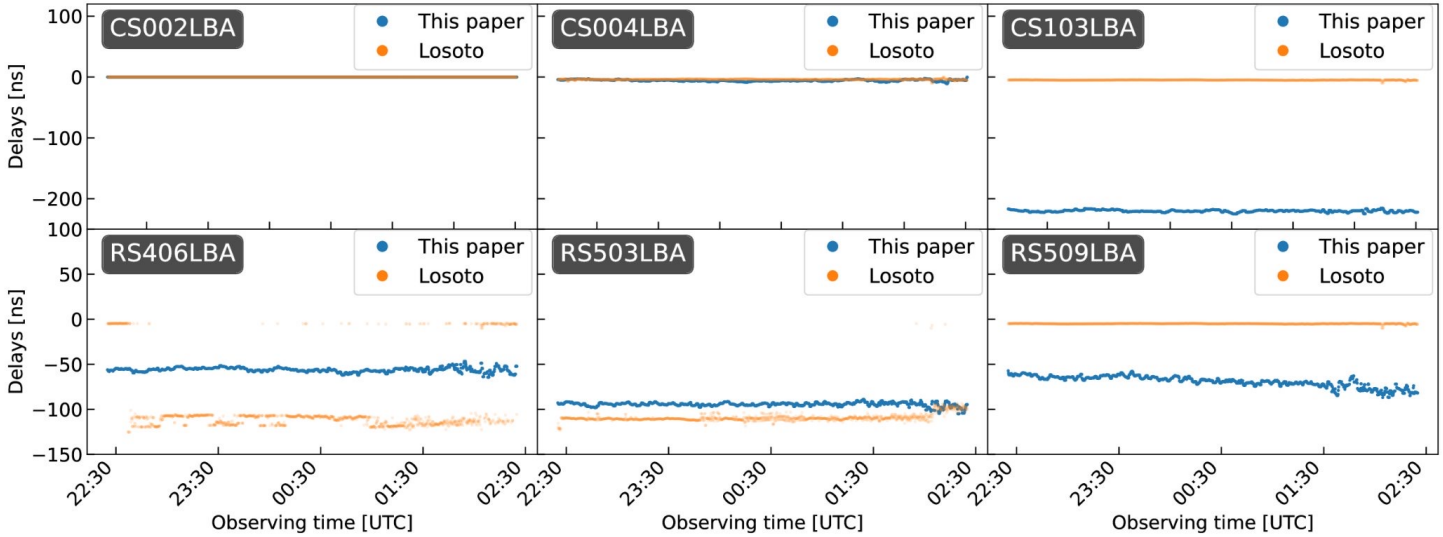


$$\phi = \phi_0 + 2\pi\Delta t\nu - 8.4479745 \cdot 10^9 \frac{\tau_1}{\nu}$$





ON



Cordun et. al (2025)

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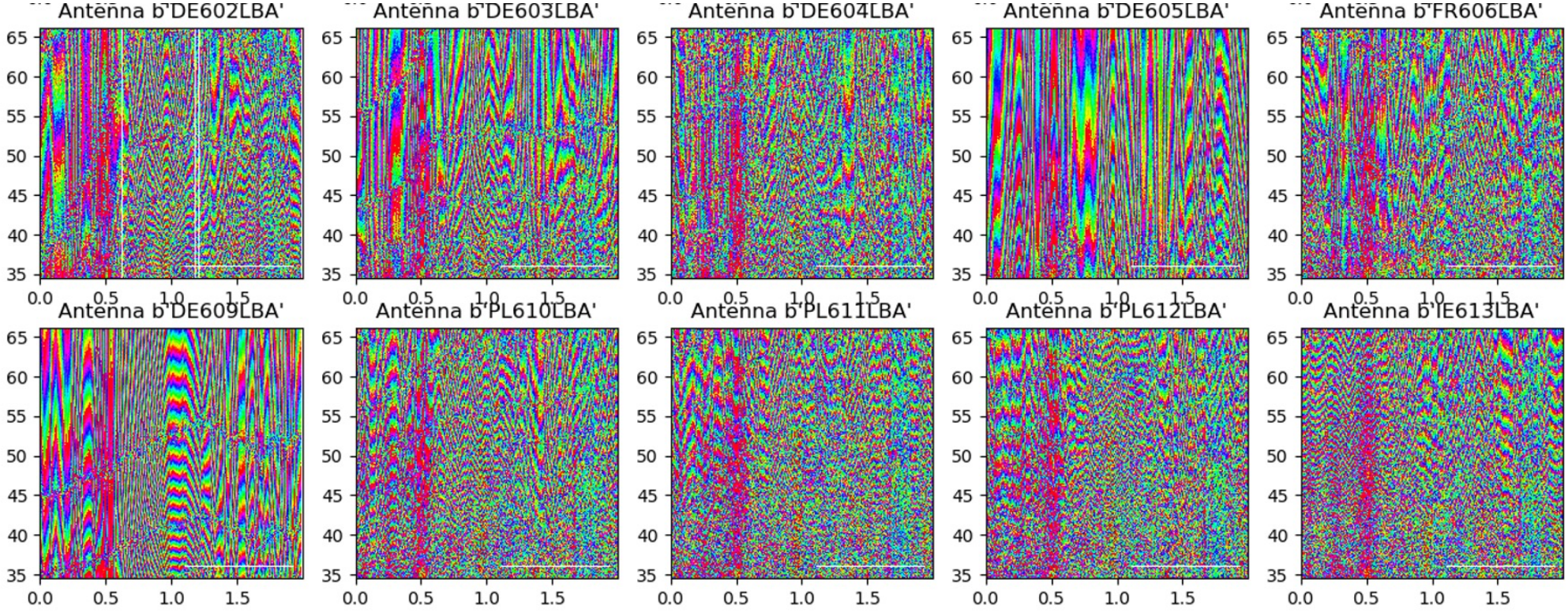
Antenna b'DE602LBA'
Antenna b'DE603LBA'
Antenna b'DE604LBA'
Antenna b'DE605LBA'
Antenna b'FR606LBA'
Antenna b'DE609LBA'
Antenna b'PL610LBA'
Antenna b'PL611LBA'
Antenna b'PL612LBA'
Antenna b'IE613LBA'
65
60
55
50
45
40
35
0.0
0.5
1.0
1.5


dTEC (TECU)
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
−2.5
26 05:30
26 05:35
26 05:40
26 05:45
26 05:50
DE601LBA
DE602LBA
DE603LBA
DE604LBA
DE605LBA
FR606LBA
SE607LBA
UK608LBA
DE609LBA
PL610LBA
PL611LBA
PL612LBA
IE613LBA
LV614LBA
SuperSt

Tuning LOFAR2.0 in phase

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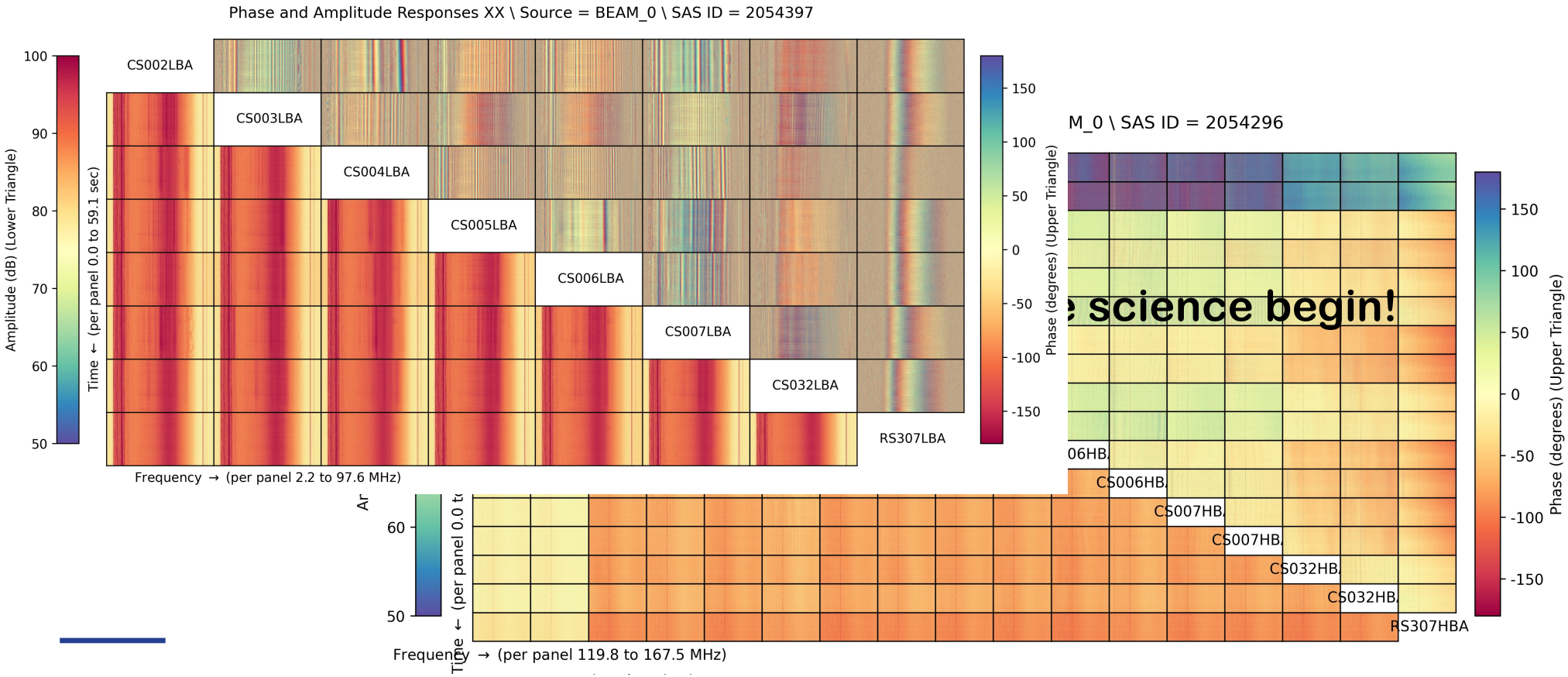

Raw, uncalibrated images

a.k.a. how well can LOFAR2 stay on source?

Noa Peters

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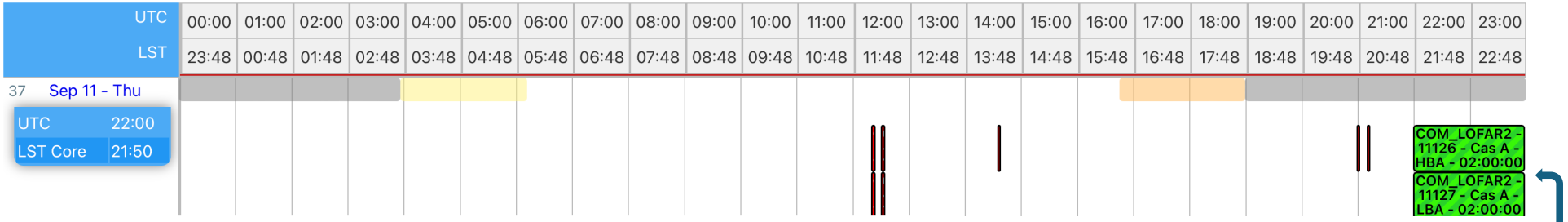
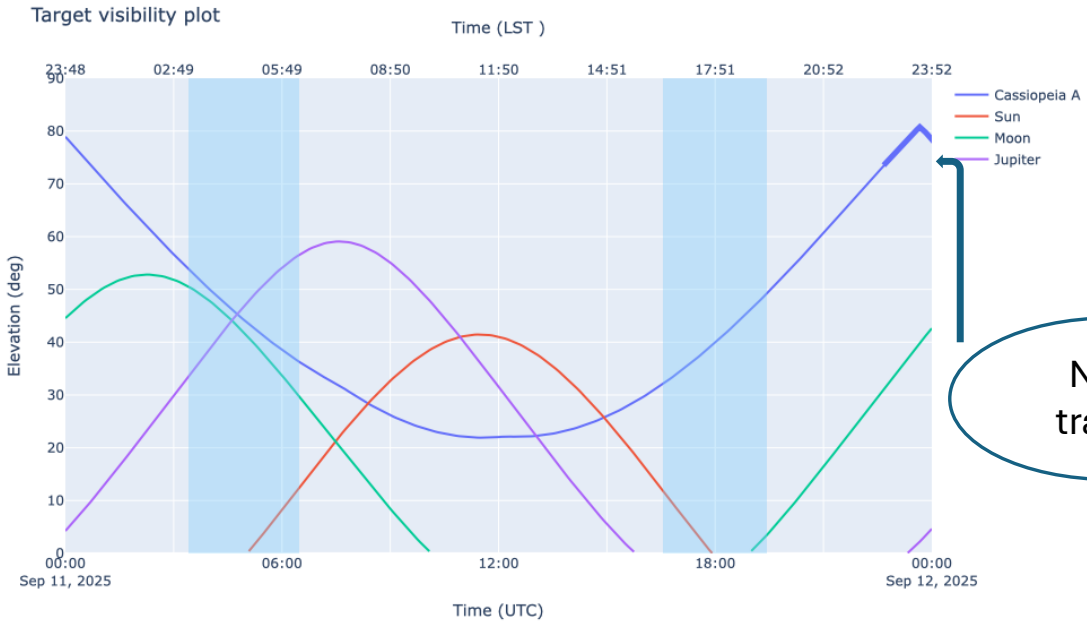
Cassiopeia A observation



HBA+LBA



Near transit

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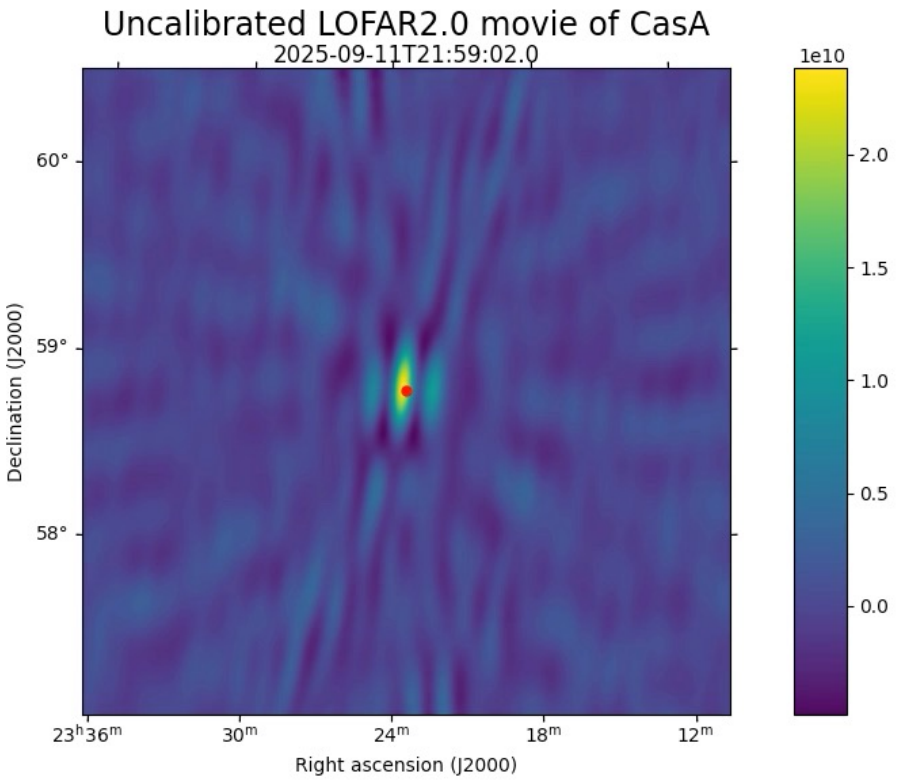
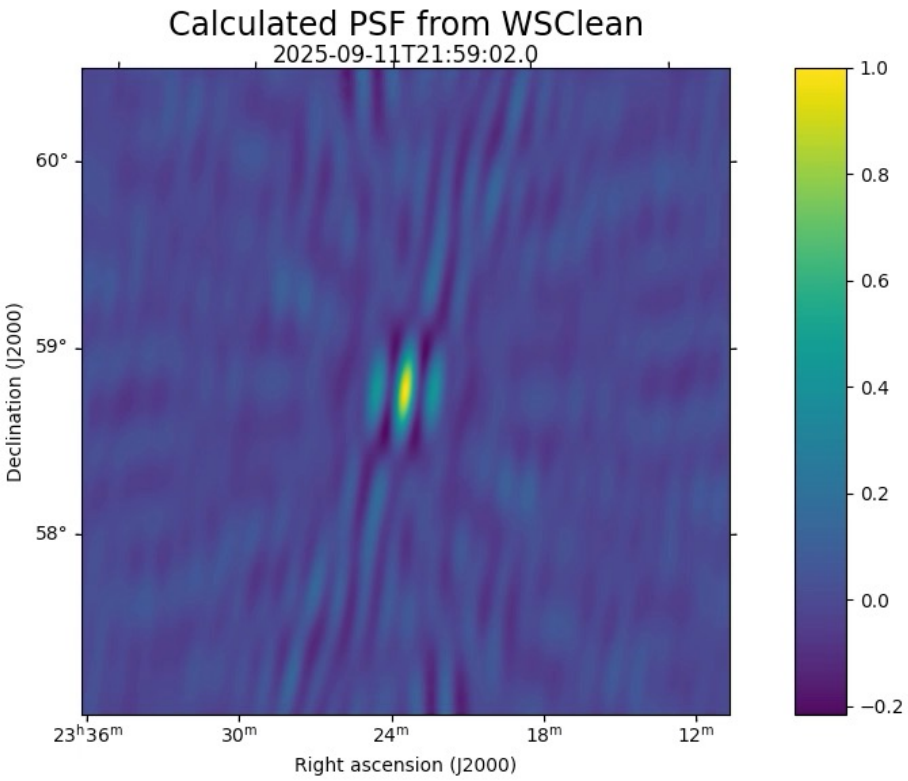
UNCALIBRATED dirty images + PSF

HBA



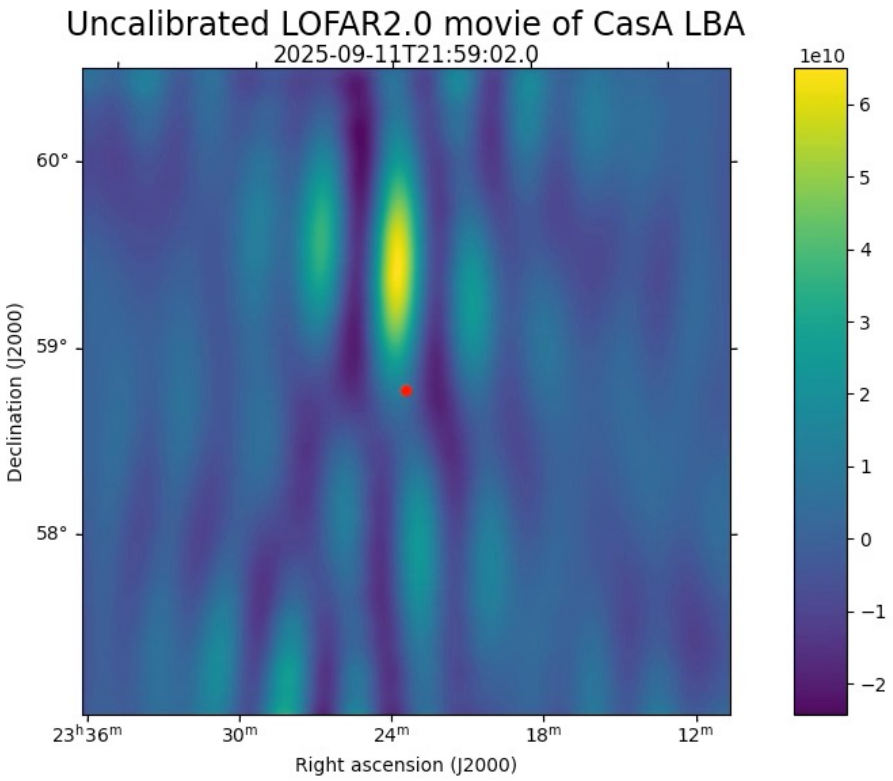


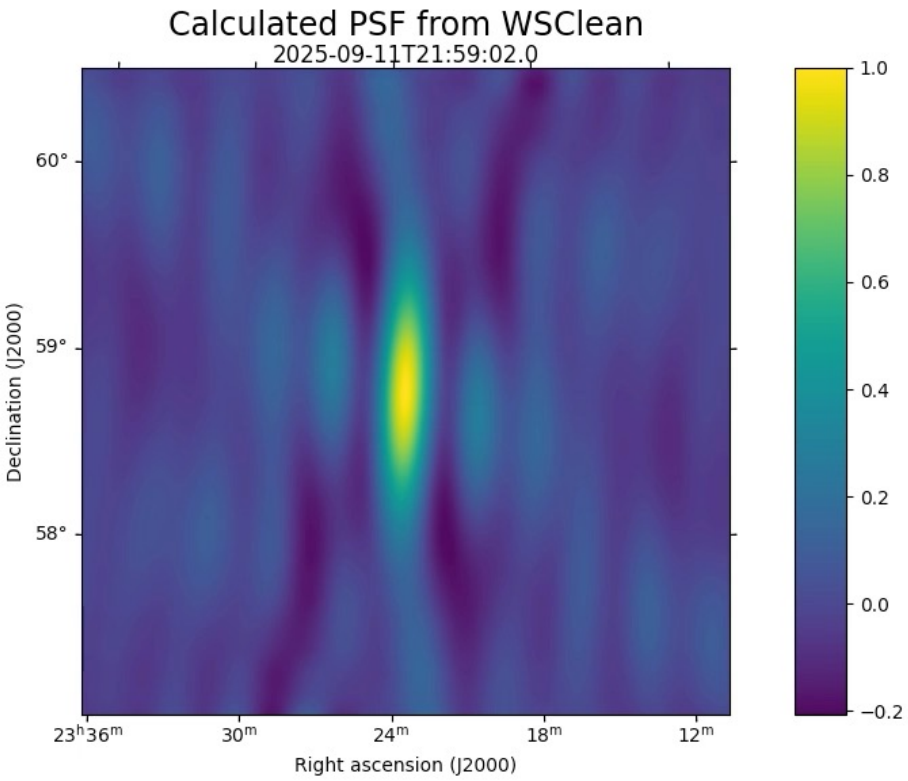
7 stations (CS002, CS003, CS004, CS005, CS006, CS007, CS032), 2 hrs, HBA 120-168 MHz, briggs -0.5

- White rabbit ✅
- (some) station calibration tables ✅

UNCALIBRATED dirty images + PSF

LBA





7 stations (CS002, CS003, CS004, CS005, CS006, CS007, CS032), 2 hrs, LBA 20-68 MHz, briggs -0.5

- Offset ❓
  - Correlator tracking problem? Station calibration tables? Ionosphere?
  - **Commissioning** ❗👷

PULP2

Emma van der Wateren, on behalf of Vlad Kondratiev

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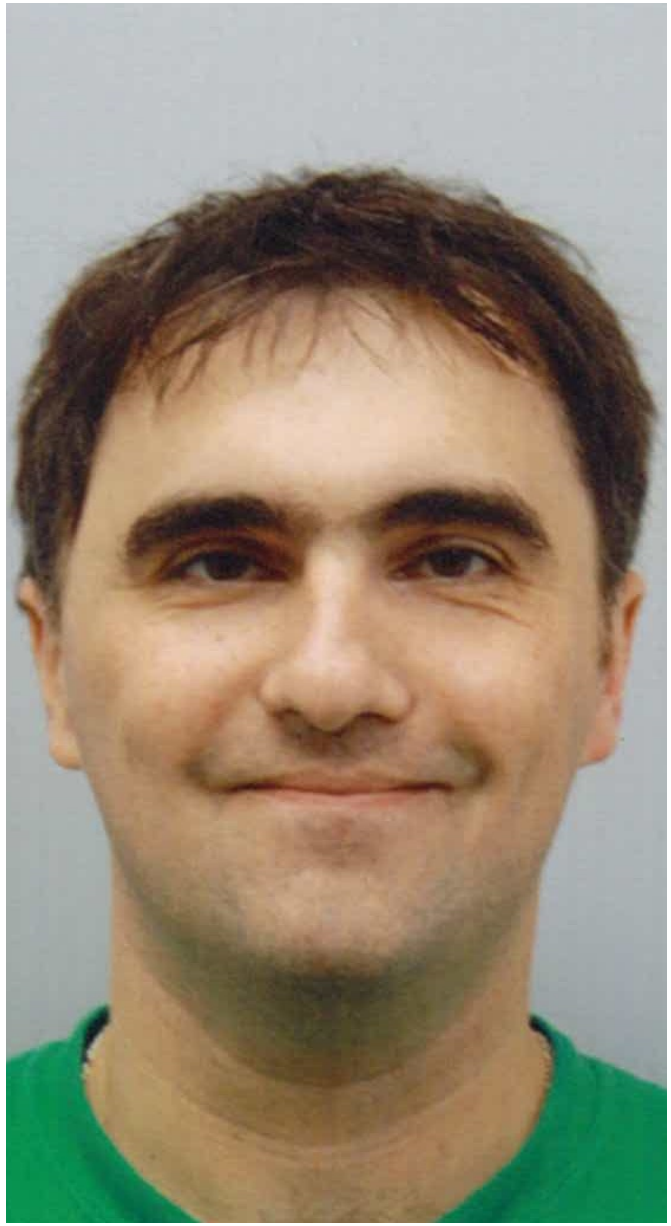
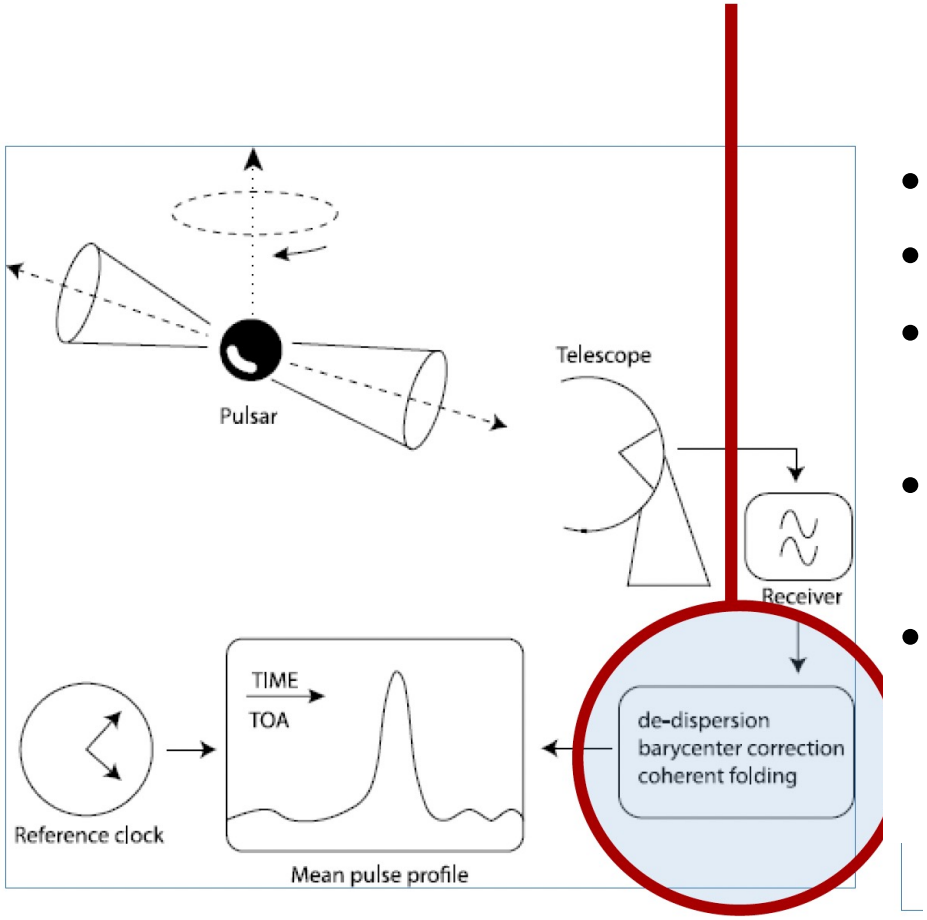


LOFAR2 Beamformed **Pulsar Folding**



(from Lorimer & Kramer "Handbook of Pulsar Astronomy")

- CWL reimplementation
- Modular, portable, maintainable
- Overarching suite, specialised pipelines
- Works manually on CEP4, and CEP6
- Implementation into TMSS will come this year

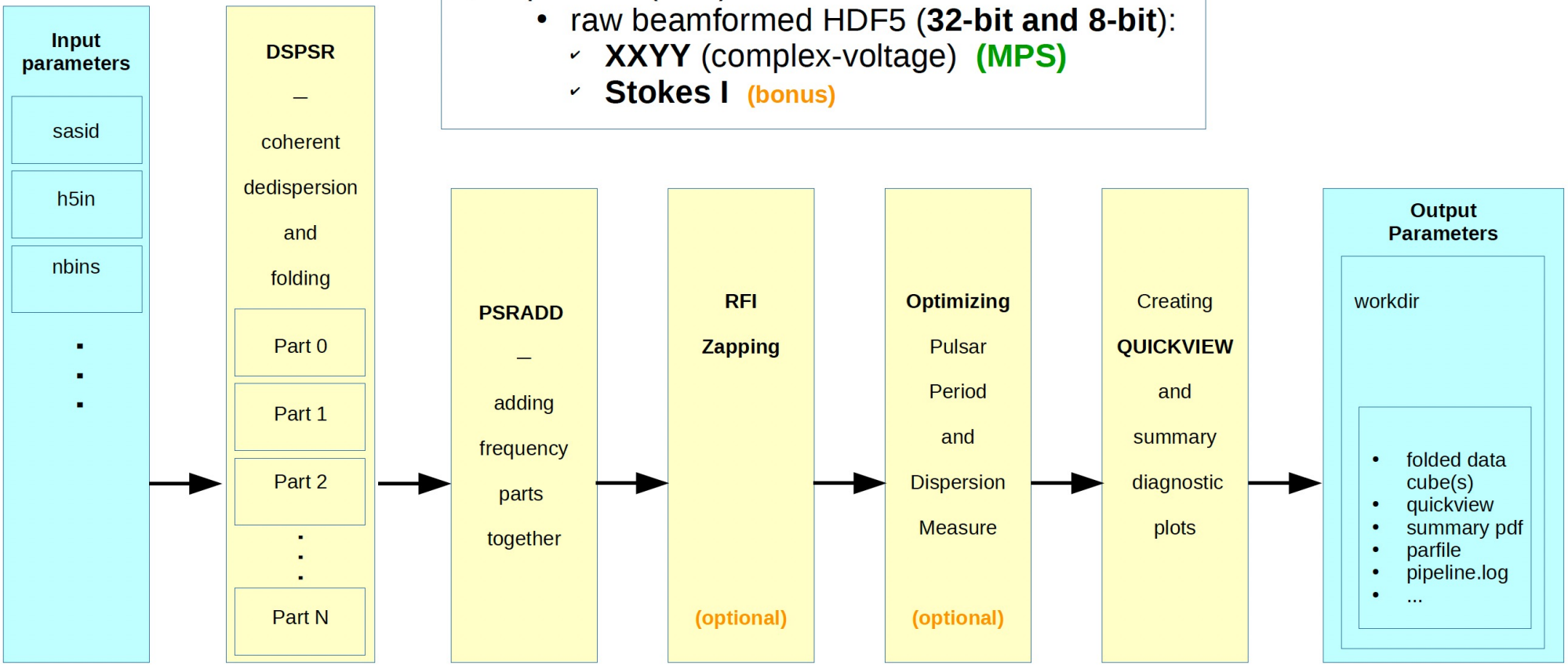
Main CWL pipeline steps:

demo

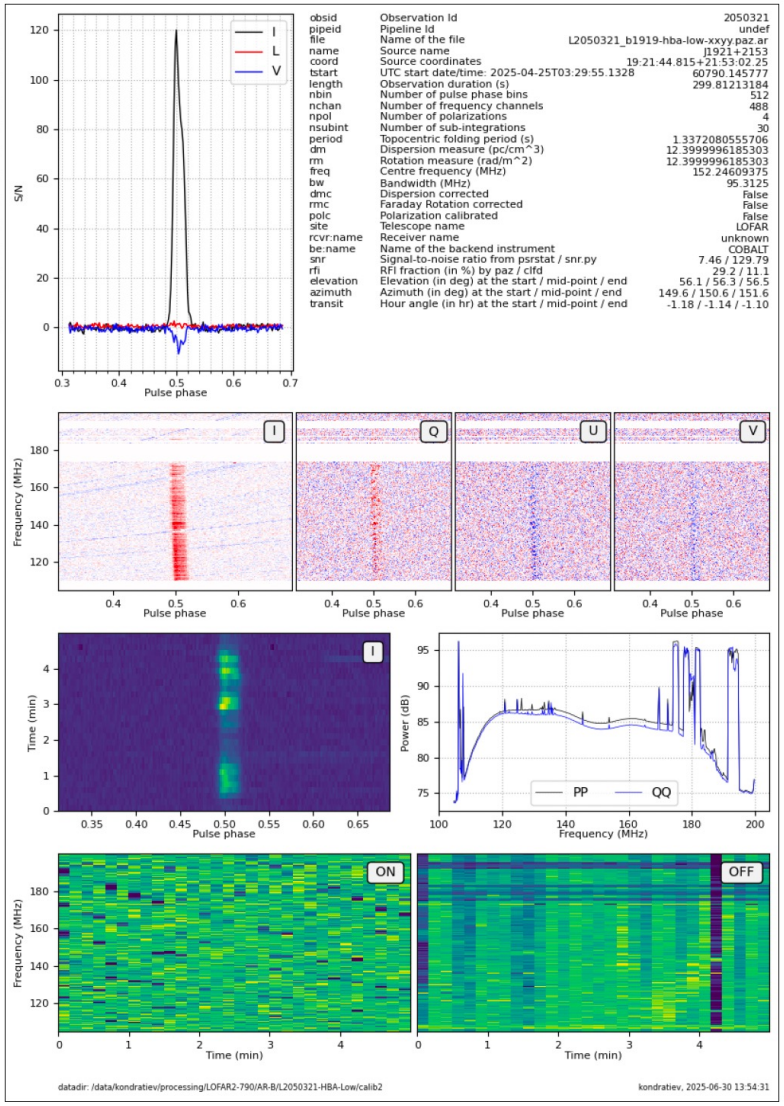
ⓘ pipeline runs per TAB

COMMON WORKFLOW LANGUAGE

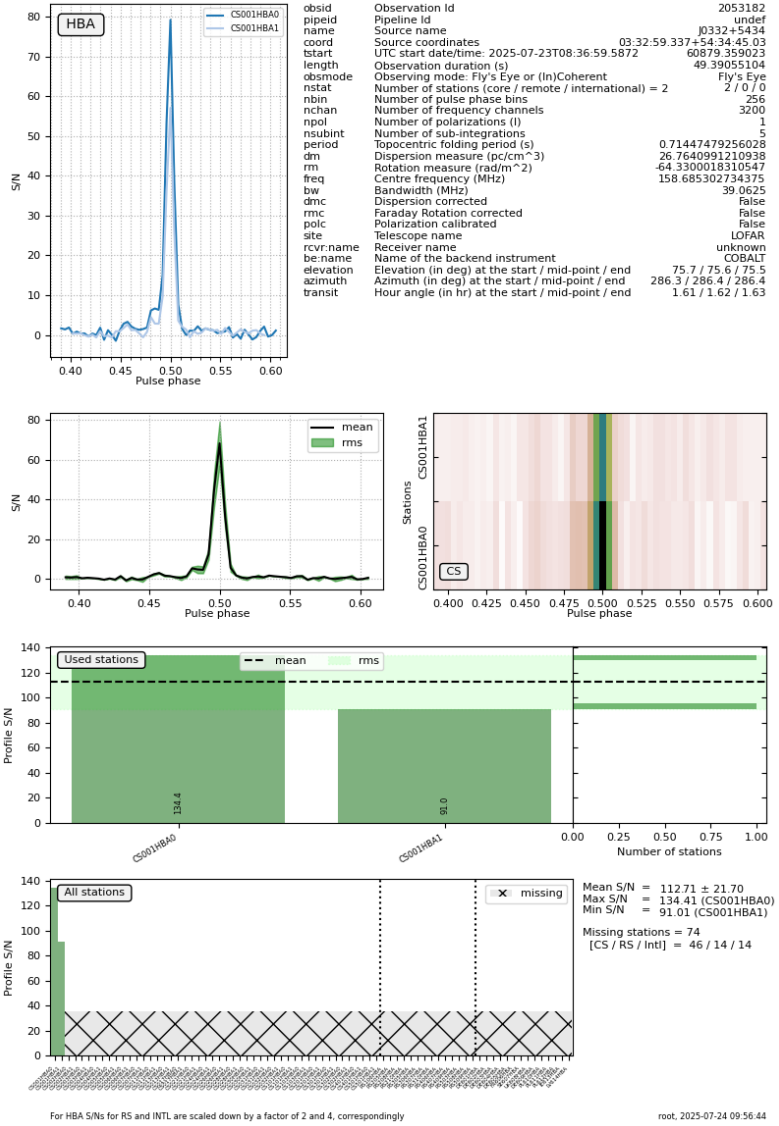
ⓘ input files (h5in):
- raw beamformed HDF5 (**32-bit and 8-bit**):
  - ✔ **XXYY** (complex-voltage) **(MPS)**
  - ✔ **Stokes I** **(bonus)**



Quickview diagnostic plot



obsid	Observation Id	2050321
pipeid	Pipeline Id	undef
file	Name of the file	L2050321_b1919-hba-low-xyy.paz.ar
name	Source name	J1921+2153
coord	Source coordinates	19:21:44.815+21:53:02.25
tstart	UTC start date/time: 2025-04-25T03:29:55.1328	60790.145777
length	Observation duration (s)	299.81213184
nbin	Number of pulse phase bins	512
nchan	Number of frequency channels	488
npol	Number of polarizations	4
nsubint	Number of sub-integrations	30
period	Topocentric folding period (s)	1.3372080555706
dm	Dispersion measure (pc/cm^3)	12.3999996185303
rm	Rotation measure (rad/m^2)	12.3999996185303
freq	Centre frequency (MHz)	152.24609375
bw	Bandwidth (MHz)	95.3125
dmc	Dispersion corrected	False
rmc	Faraday Rotation corrected	False
polc	Polarization calibrated	False
site	Telescope name	LOFAR
rcvr:name	Receiver name	unknown
be:name	Name of the backend instrument	COBALT
snr	Signal-to-noise ratio from psrstat / snr.py	7.46 / 129.79
rfi	RFI fraction (in %) by paz / clfd	29.2 / 11.1
elevation	Elevation (in deg) at the start / mid-point / end	56.1 / 56.3 / 56.5
azimuth	Azimuth (in deg) at the start / mid-point / end	149.6 / 150.6 / 151.6
transit	Hour angle (in hr) at the start / mid-point / end	-1.18 / -1.14 / -1.10



obsid	Observation Id	2053182
pipeid	Pipeline Id	undef
name	Source name	J0332+5434
coord	Source coordinates	03:32:59.337+54:34:45.03
tstart	UTC start date/time: 2025-07-23T08:36:59.5872	60879.359023
length	Observation duration (s)	49.39055104
obsmode	Observing mode: Fly's Eye or (In)Coherent	Fly's Eye
nstat	Number of stations (core / remote / international) = 2	2 / 0 / 0
nbin	Number of pulse phase bins	256
nchan	Number of frequency channels	3200
npol	Number of polarizations (I)	1
nsubint	Number of sub-integrations	5
period	Topocentric folding period (s)	0.71447479256028
dm	Dispersion measure (pc/cm^3)	26.7640991210938
rm	Rotation measure (rad/m^2)	-64.3300018310547
freq	Centre frequency (MHz)	158.685302734375
bw	Bandwidth (MHz)	39.0625
dmc	Dispersion corrected	False
rmc	Faraday Rotation corrected	False
polc	Polarization calibrated	False
site	Telescope name	LOFAR
rcvr:name	Receiver name	unknown
be:name	Name of the backend instrument	COBALT
elevation	Elevation (in deg) at the start / mid-point / end	75.7 / 75.6 / 75.5
azimuth	Azimuth (in deg) at the start / mid-point / end	286.3 / 286.4 / 286.4
transit	Hour angle (in hr) at the start / mid-point / end	1.61 / 1.62 / 1.63

Can we detect a pulsar?

Emma van der Wateren

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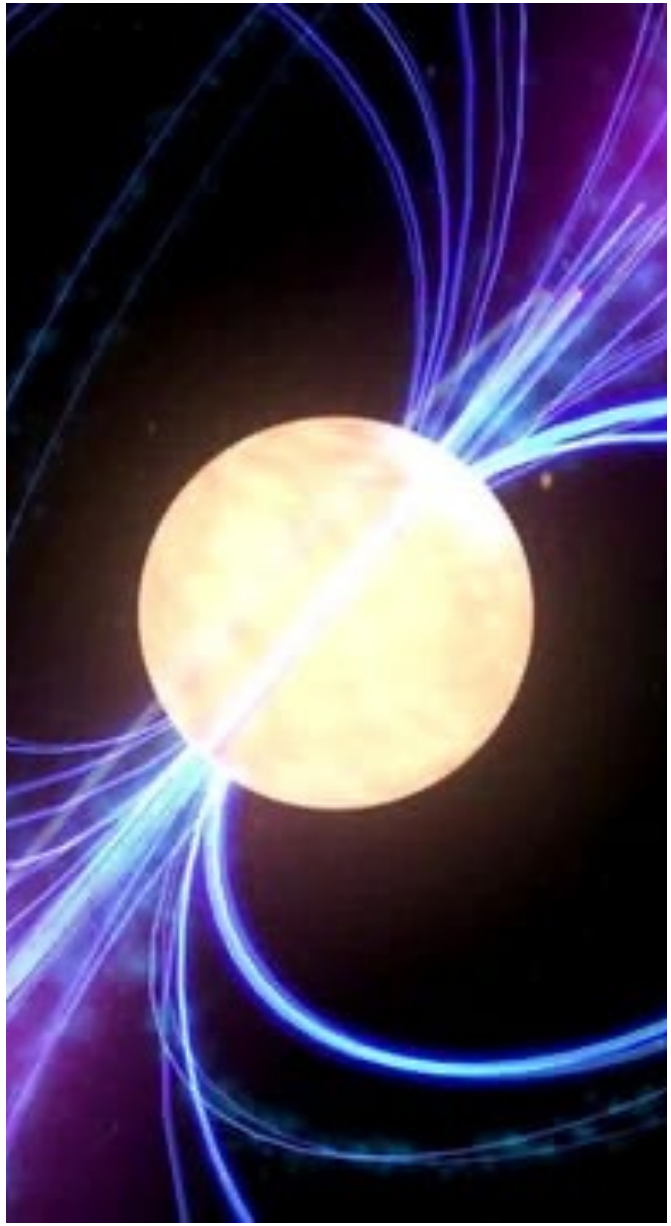


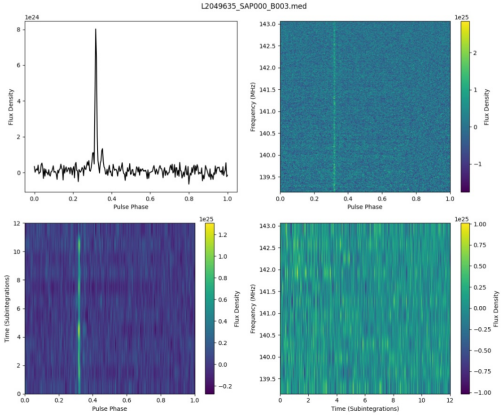


Figure 7: Diagnostic plots for the CS032HBA1 observation recording stokes IQUV data.

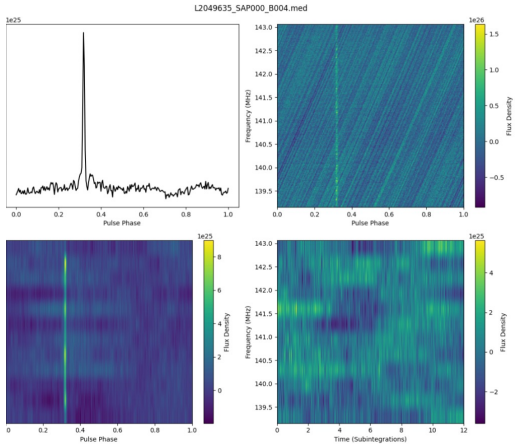


Figure 8: Diagnostic plots for the RS307HBA observation recording stokes IQUV da

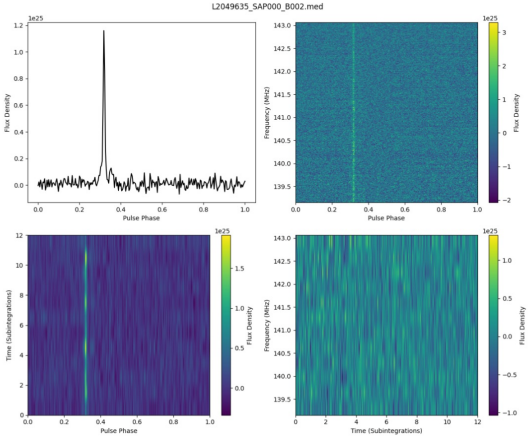


Figure 6: Diagnostic plots for the CS032HBA0 observation recording stokes IQUV data.

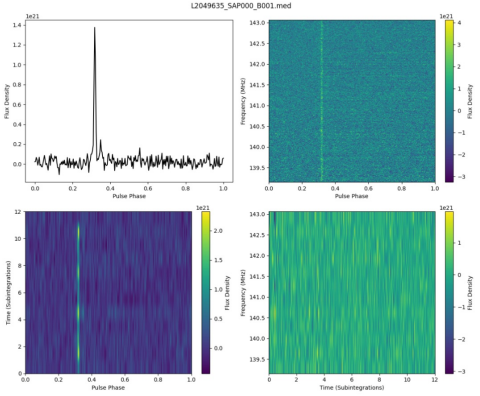


Figure 5: Diagnostic plots for the CS001HBA1 observation recording stokes IQUV data.

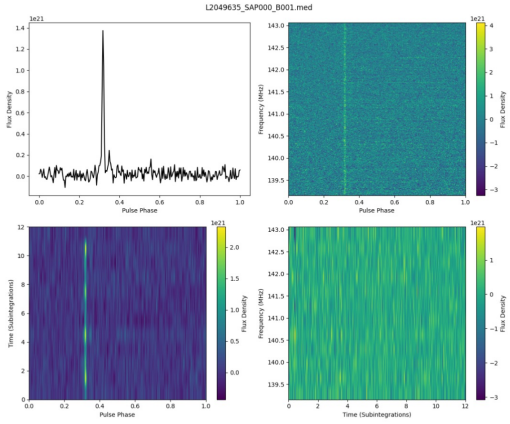


Figure 5: Diagnostic plots for the CS001HBA1 observation recording stokes IQUV data.

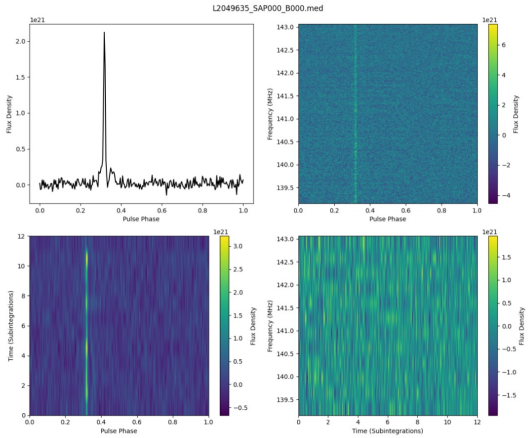
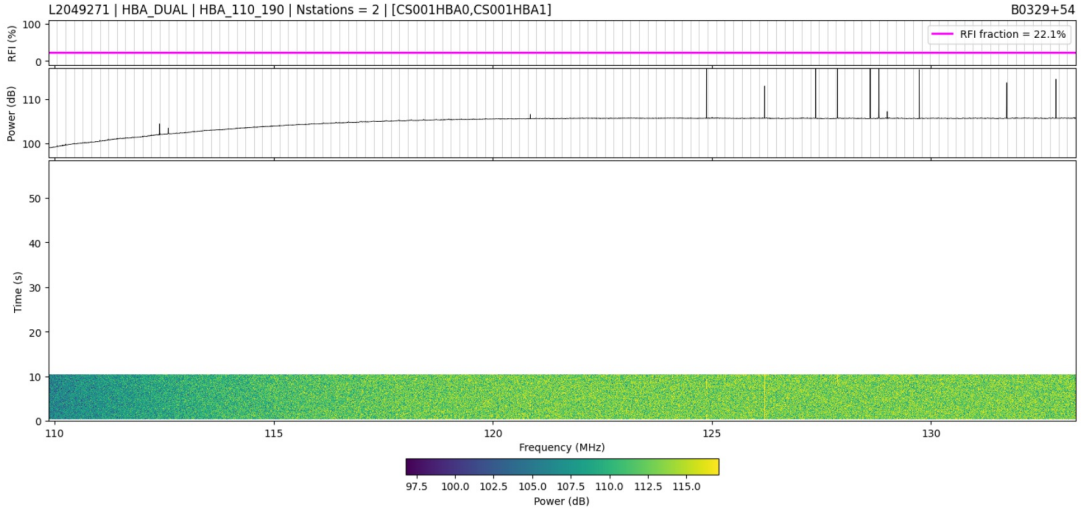
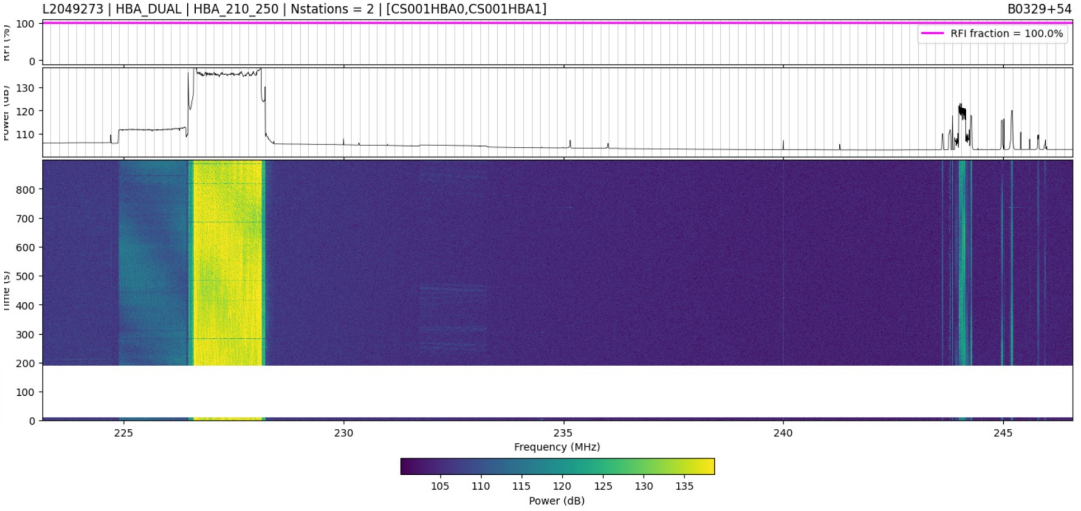
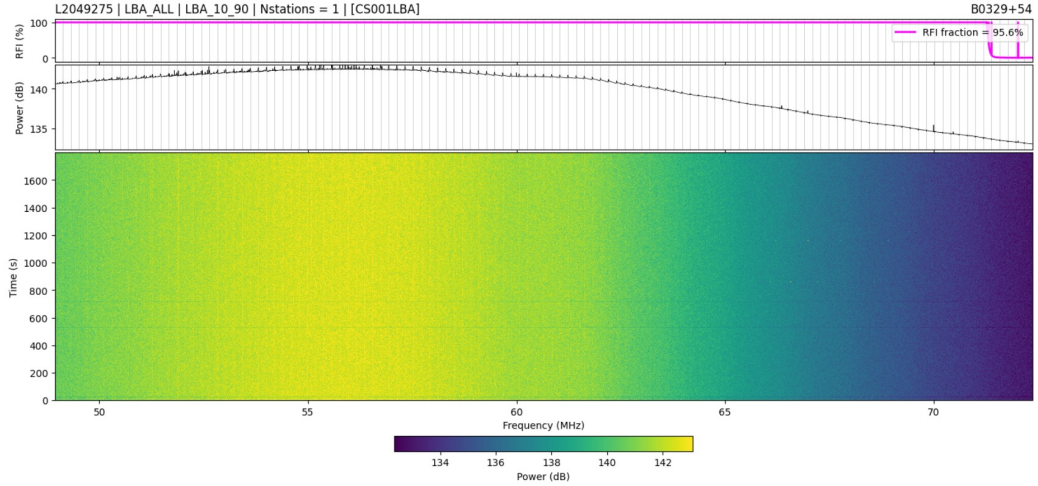
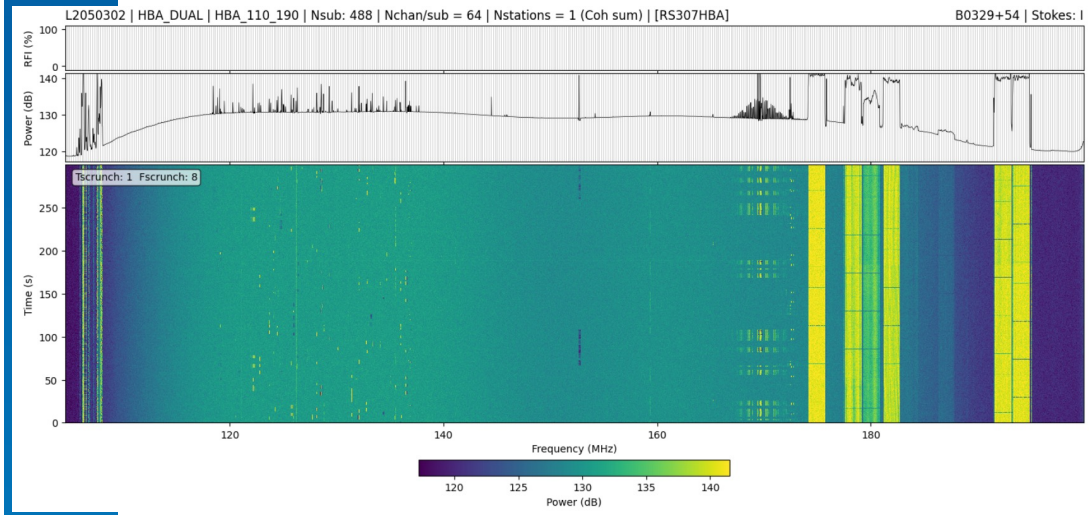


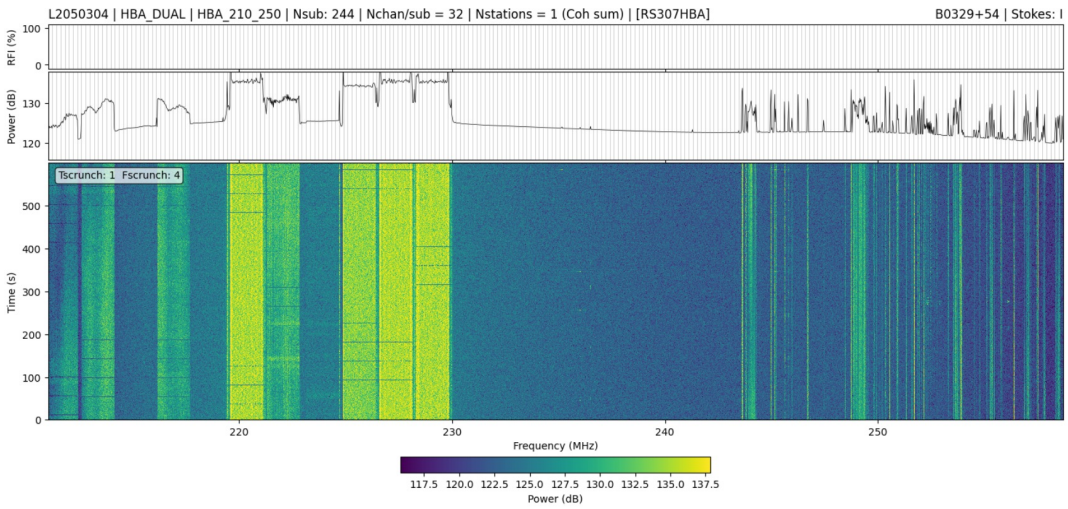
Figure 4: Diagnostic plots for the CS001HBA0 observation recording stokes IQUV data.

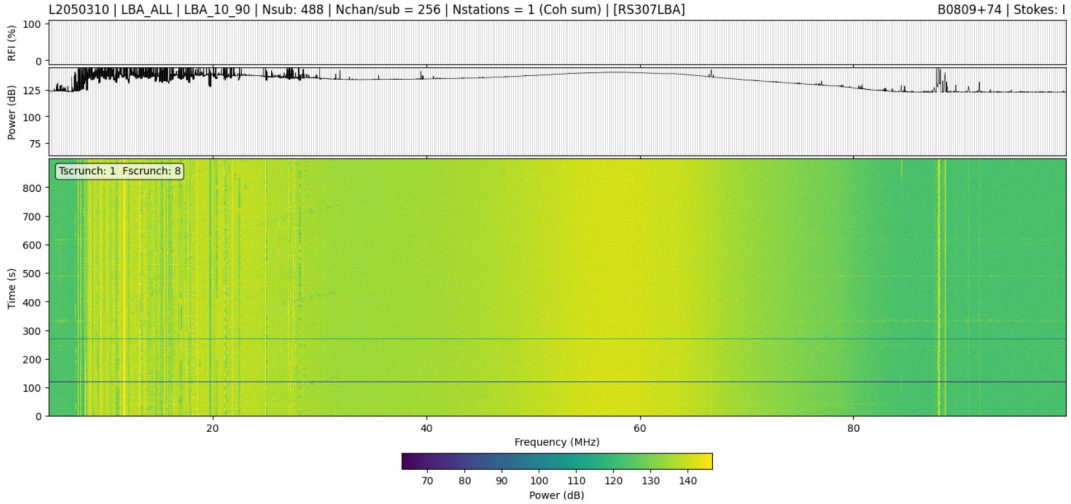

L2049271 | HBA_DUAL | HBA_110_190 | Nstations = 2 | [CS001HBA0,CS001HBA1]
B0329+54
RFI (%)
RFI fraction = 22.1%
Power (dB)
Time (s)
Frequency (MHz)
Power (dB)

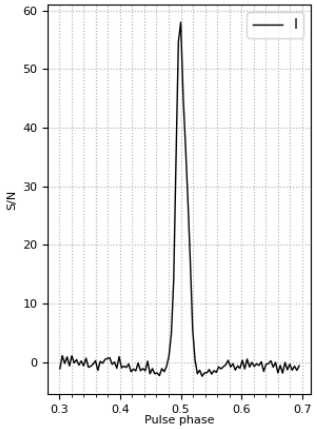

L2049273 | HBA_DUAL | HBA_210_250 | Nstations = 2 | [CS001HBA0,CS001HBA1]
B0329+54
RFI fraction = 100.0%
Frequency (MHz)
Power (dB)


L2049275 | LBA_ALL | LBA_10_90 | Nstations = 1 | [CS001LBA]
B0329+54
RFI (%)
RFI fraction = 95.6%
Power (dB)
Time (s)
Frequency (MHz)
Power (dB)


L2050302 | HBA_DUAL | HBA_110_190 | Nsub: 488 | Nchan/sub = 64 | Nstations = 1 (Coh sum) | [RS307HBA]
B0329+54 | Stokes: I
RFI (%)
Power (dB)
Tscrunch: 1 Fscrunch: 8
Time (s)
Frequency (MHz)
Power (dB)


L2050304 | HBA_DUAL | HBA_210_250 | Nsub: 244 | Nchan/sub = 32 | Nstations = 1 (Coh sum) | [RS307HBA]
B0329+54 | Stokes: I
RFI (%)
Power (dB)
Tscrunch: 1 Fscrunch: 4
Time (s)
Frequency (MHz)
Power (dB)


L2050310 | LBA_ALL | LBA_10_90 | Nsub: 488 | Nchan/sub = 256 | Nstations = 1 (Coh sum) | [RS307LBA]
B0809+74 | Stokes: I
RFI (%)
Power (dB)
Tscrunch: 1 Fscrunch: 8
Time (s)
Frequency (MHz)
Power (dB)



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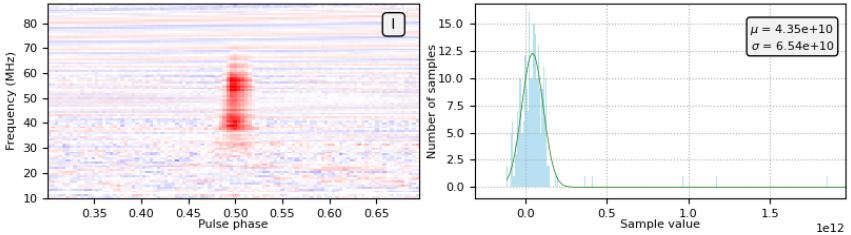
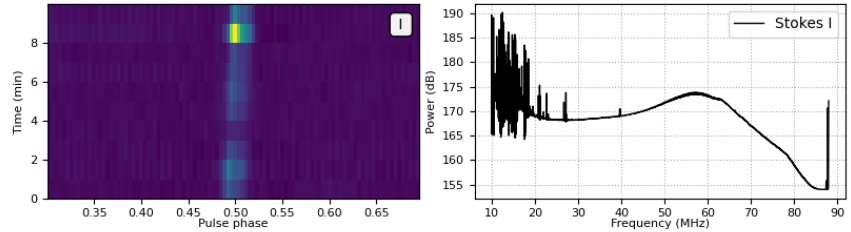
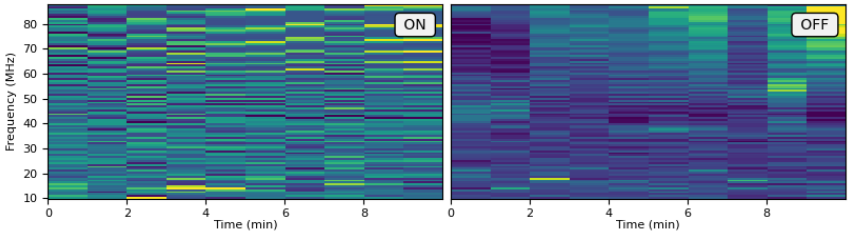
pipeid	Pipeline Id	undef
file	Name of the file	L2054150_SAP000_B000.paz.pdmp.ar
name	Source name	J1921+2153
coord	Source coordinates	19:21:44.815+21:53:02.25
tstart	UTC start date/time: 2025-09-03T19:04:59.5776	60921.795134
length	Observation duration (s)	599.95324416
obsmode	Observing mode: Fly's Eye or (In)Coherent	Coherent
nstat	Number of stations (core / remote / international) = 6	6 / 0 / 0
nbin	Number of pulse phase bins	256
nchan	Number of frequency channels	6400
npol	Number of polarizations (I)	1
nsubint	Number of sub-integrations	10
period	Topocentric folding period (s)	1.337348169
dm	Dispersion measure (pc/cm^3)	12.4405002593994
rm	Rotation measure (rad/m^2)	-15.3999996185303
freq	Centre frequency (MHz)	48.919677734375
bw	Bandwidth (MHz)	78.125
dmc	Dispersion corrected	False
rmc	Faraday Rotation corrected	False
polc	Polarization calibrated	False
site	Telescope name	LOFAR
rcvr:name	Receiver name	unknown
be:name	Name of the backend instrument	COBALT
snr	Signal-to-noise ratio from psrstat / snr.py	19.26 / 145.54
rfi	RFI fraction (in %) by paz / clfd	15.4703 / 6.10625
elevation	Elevation (in deg) at the start / mid-point / end	57.1 / 57.4 / 57.7
azimuth	Azimuth (in deg) at the start / mid-point / end	155.3 / 157.4 / 159.5
transit	Hour angle (in min) at the start / mid-point / end	-56.61 / -51.59 / -46.58







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root, 2025-09-04 07:04:18

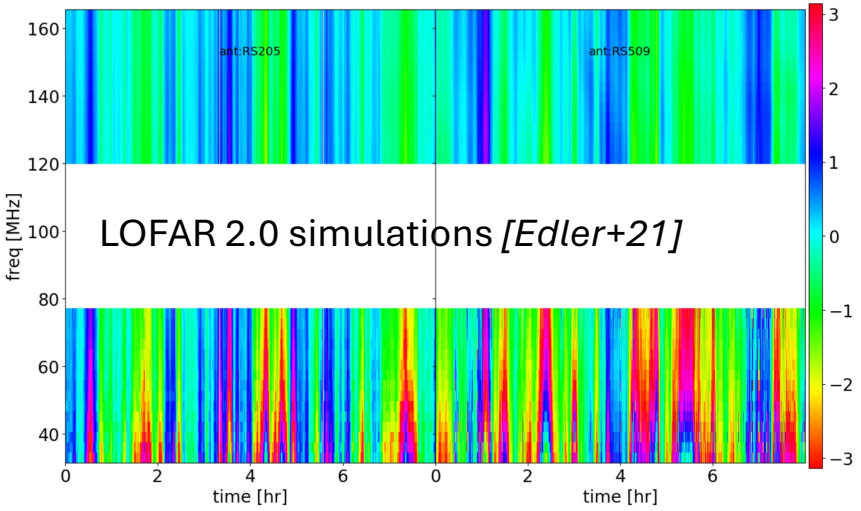
The first calibrated LOFAR 2.0 image

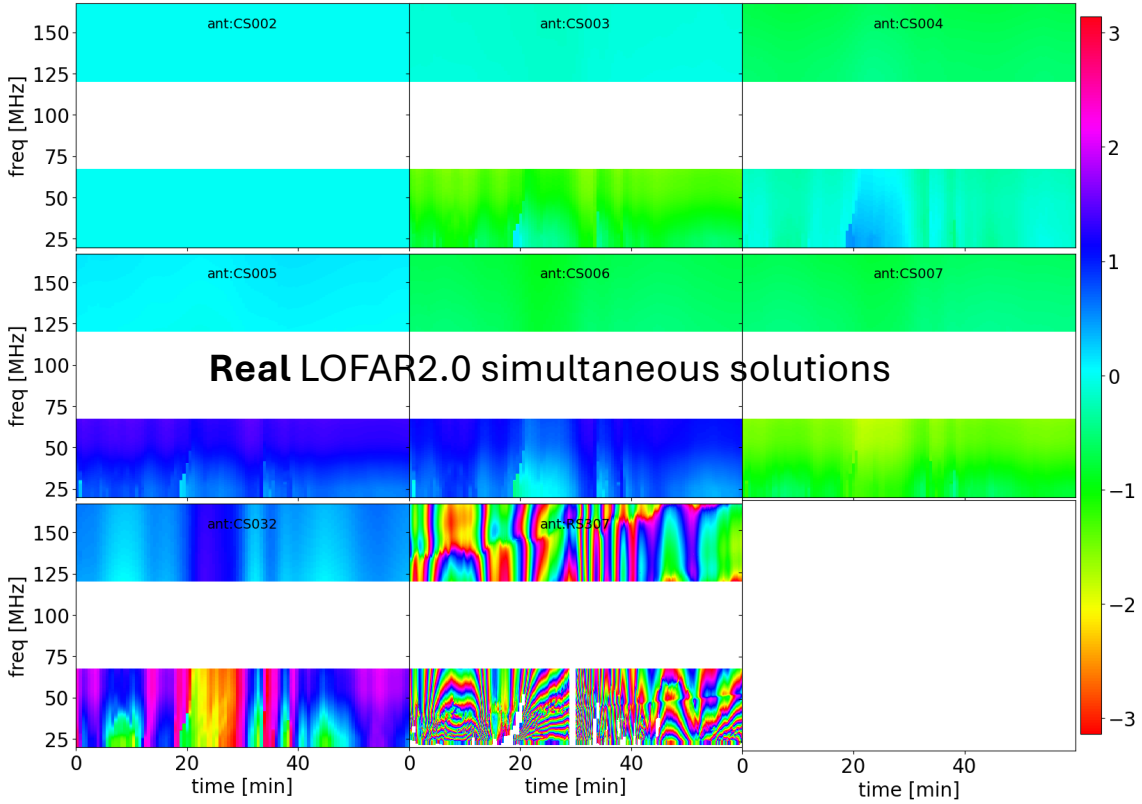
Henrik Edler

ASTRON
Netherlands Institute for Radio Astronomy

The first calibrated interferometric observation

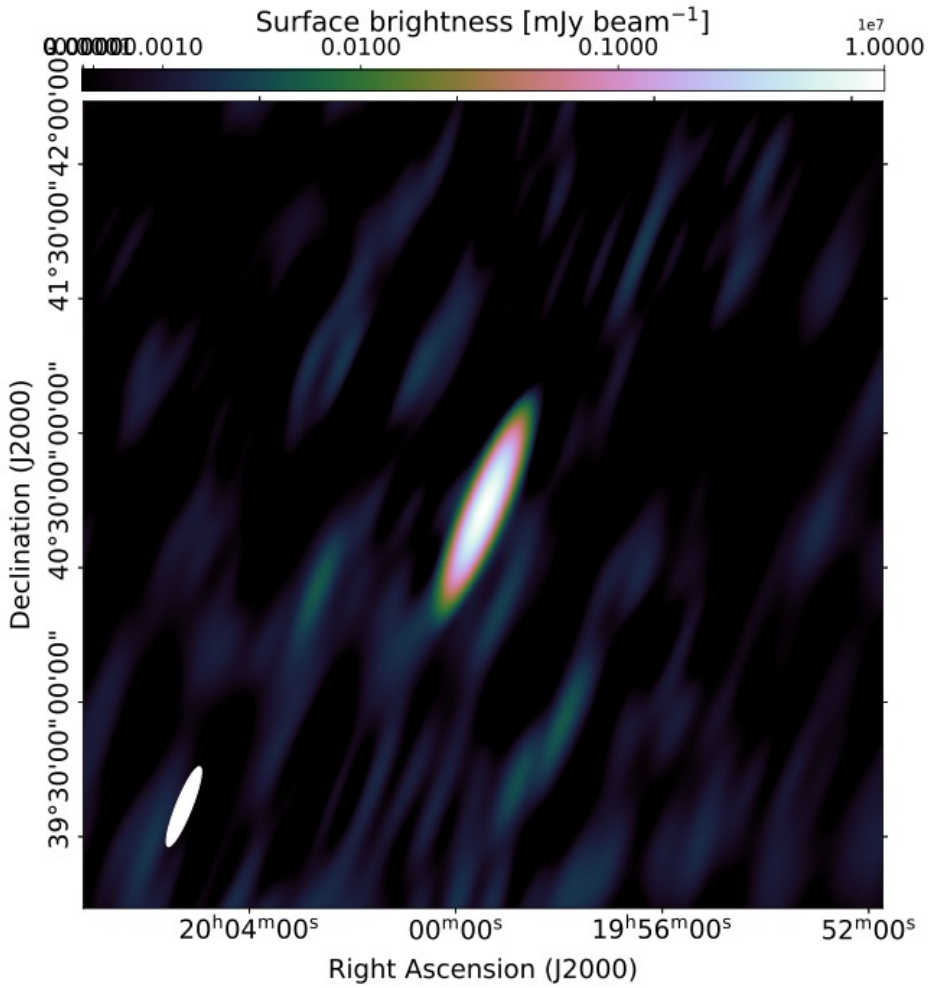
- 1h parallel LBA + HBA observation of Cyg A
- 8 Stations: Superterp + CS032 + RS307





The first calibrated LOFAR 2.0 image

- 8 stations
- Joint LBA+HBA 120 – 168 MHz
- Resolution: 18' x 4'
- Noise level ~ 5 Jy/beam



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