



Netherlands Institute for Radio Astronomy

# LOFAR2.0 Commissioning

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Michiel Brentjens  
Emma van der Wateren  
Manu Orru'

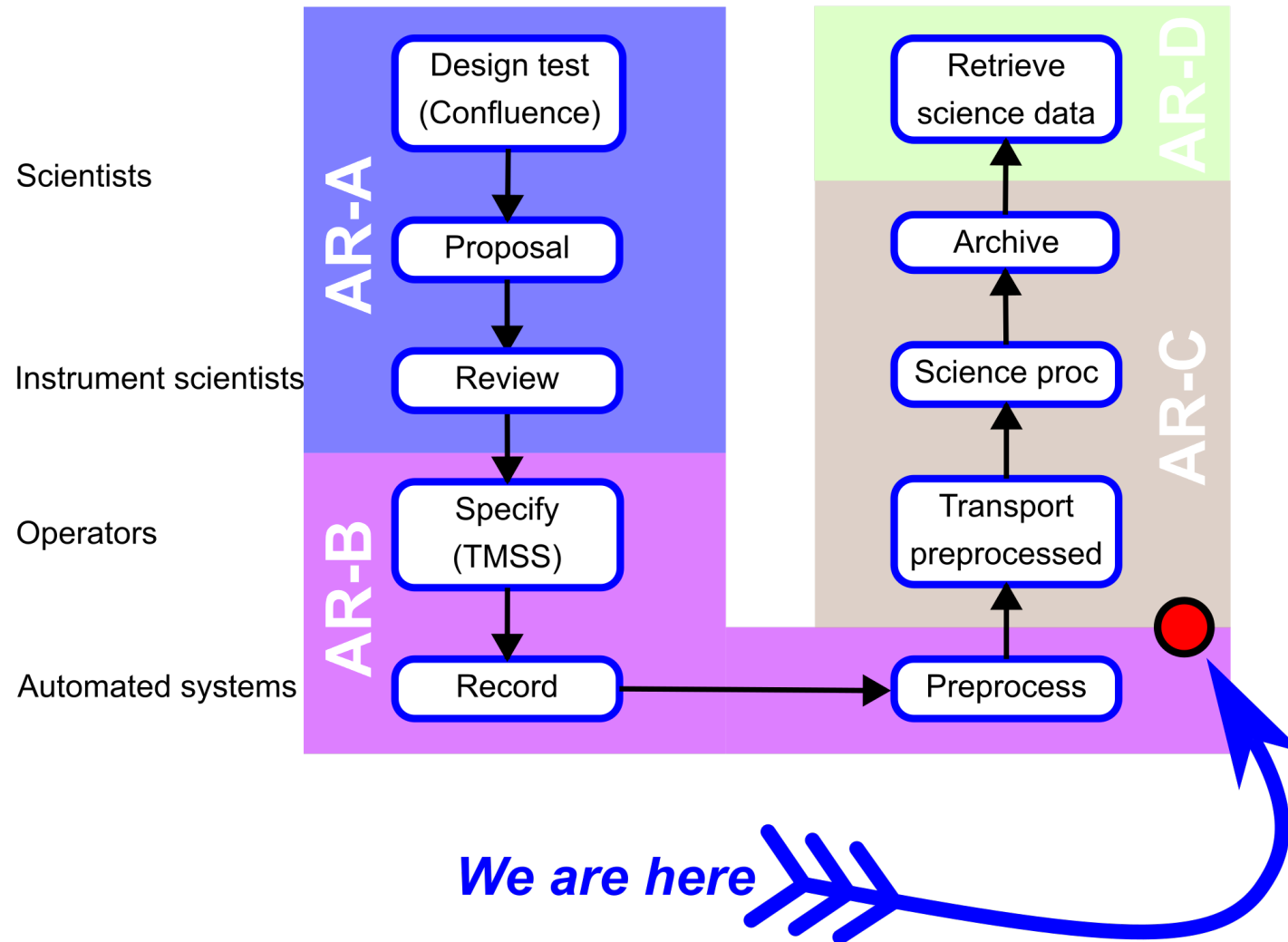
# What *is* commissioning anyway?

AST(RO)N

- **Bridges AIV** and initial **operations** / Science verification
- **Prove** 57 LOFAR2.0 **science requirements** (level 0)
  - ~1500 Levels 1 (system), 2 (sub-system),...5 demonstrated at varying levels of rigour during engineering, (pre-) production, and AIV
- Prove in ***Operational context***

# Observing workflow

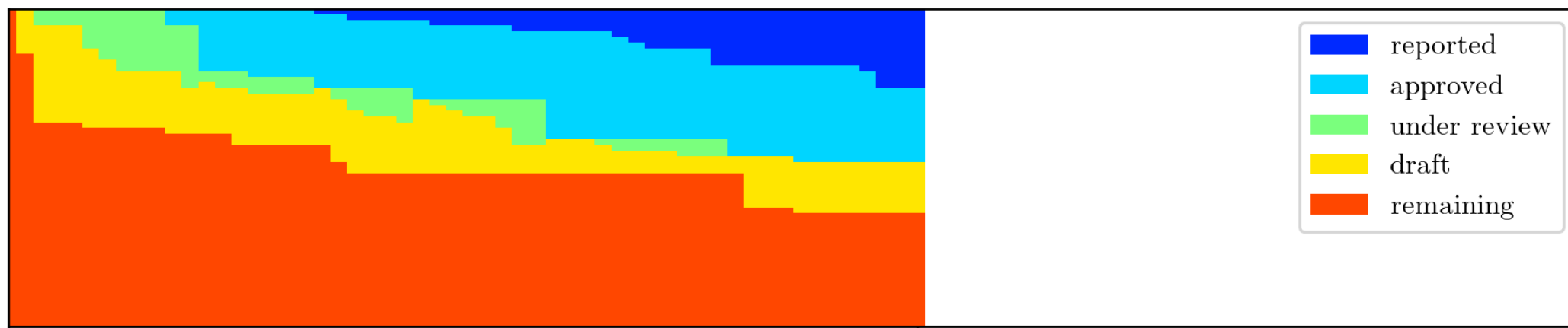
ASTRON



# Current status

ASTRON

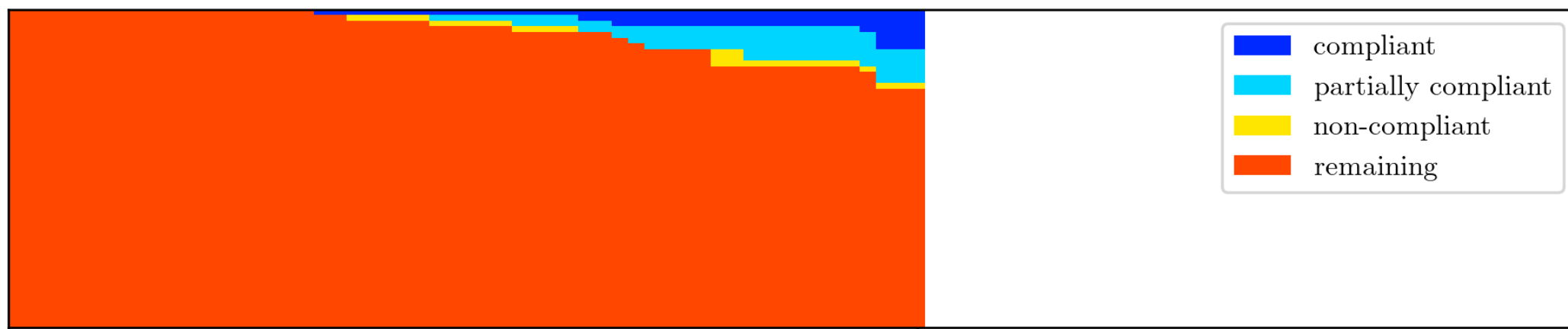
LOFAR-2.0 commissioning progress 2025-09-22



2024-09-02

2025-09-22

LOFAR-2.0 L0 compliance 2025-09-22



2024-09-02

2025-09-22



## Next months of *COMMISSIONING*

ASTRON

	SEP	OCT	NOV	DEC	2026
#stations	6	12	24	38	54
Tied-array	Superterp		Core		
Imaging	Test planning		Core	NL	VLBI
Transient buffer			Test planning		Core
All-sky imaging				Test planning	
Pipelines	PULP PreProcessing		LINC	Full-beam imaging	

# Three teams (themes?)

AST(RO)N

## Telescope Bassa, Kondratiev

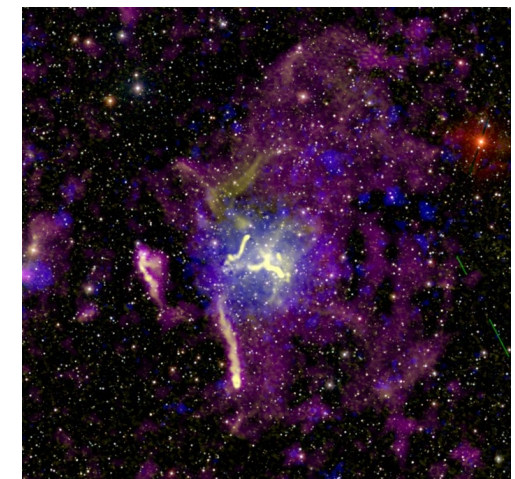
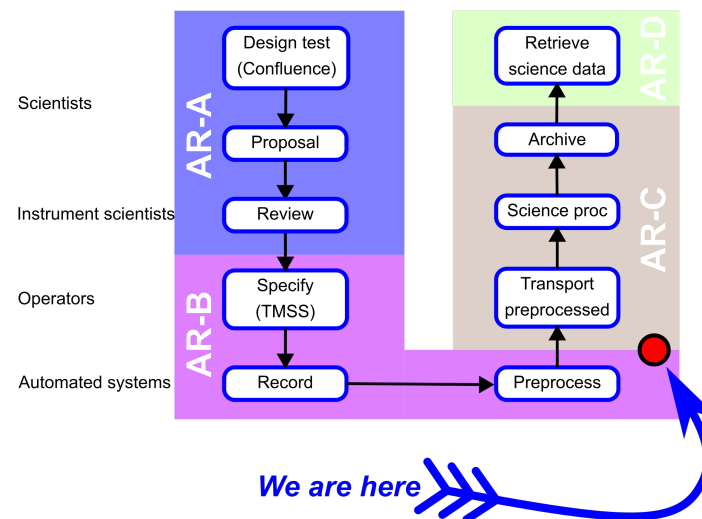
- Antennas
- Stations
- Timing
- Real-time processing

## Operations Orru', Asabere

- Proposal management
- Specification
- Observing workflow
- Archiving

## Pipelines Shimwell, Iacobelli

- Commissioning *with* pipelines
- Resource measurement
- Operations manuals



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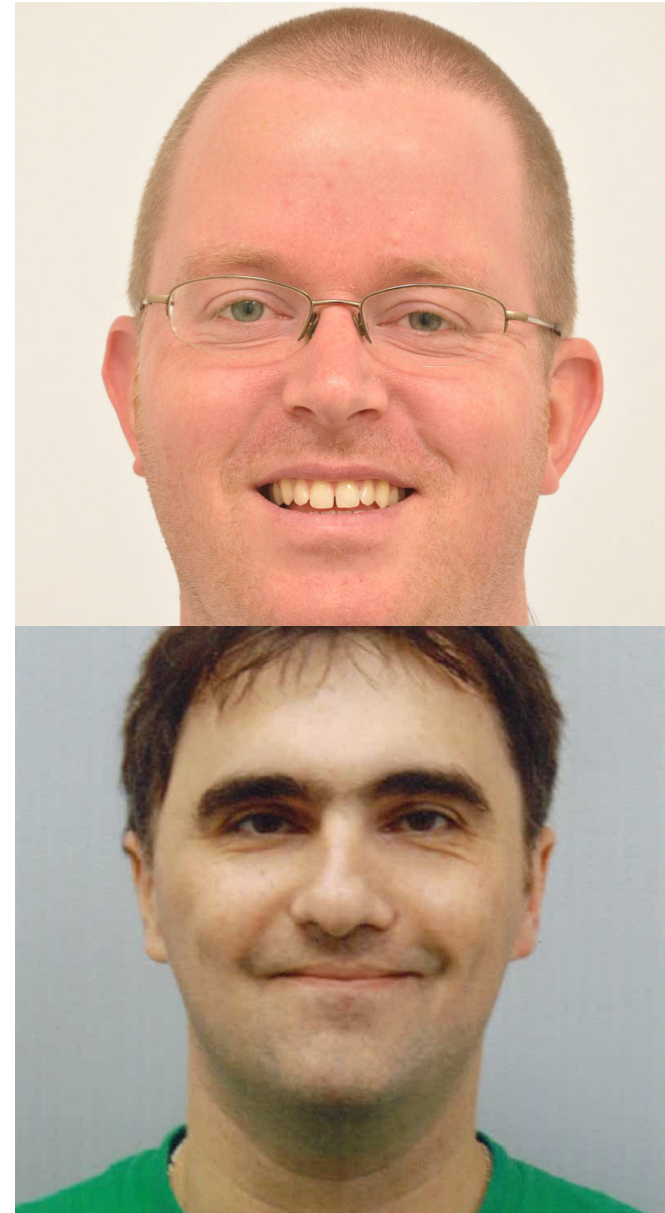
# Station commissioning

Emma van der Wateren

TEAM: **Cees Bassa**, **Vlad Kondratiev**, Boudewijn Hut, Aleksandar Shulevski, Harish Vedantham, Cristina Cordun, Tammo Jan Dijkema, Emma van der Wateren, Jason Hessels, Michiel Brentjens, Pragya Chawla, Xiaoxi Song, Paulus Kruger, Sander ter Veen, Betsey Adams, Joe Callingham, Aditya Parthasarathy Madapusi, Bernard Asabere, David McKenna, Gemma Janssen, Menno Norden, Ilse van Bommel, Maaijke Mevius, Caterina Tiburzi, Richard Fallows, Vergil Yotov, Jean-Mathias Griessmeier, Eleni Vardoulaki, Jun Wang, Ben Stappers, Kamen Kozarev, Hariharan Krishnan

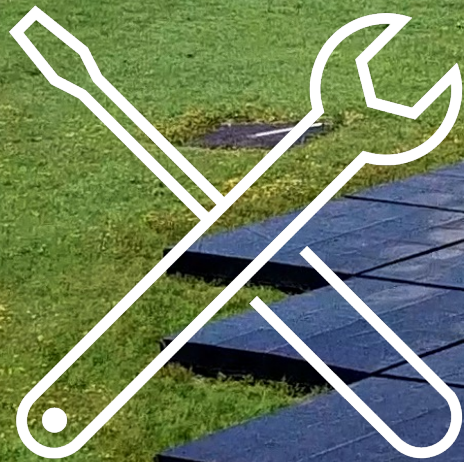
**ASTRON**

Netherlands Institute for Radio Astronomy



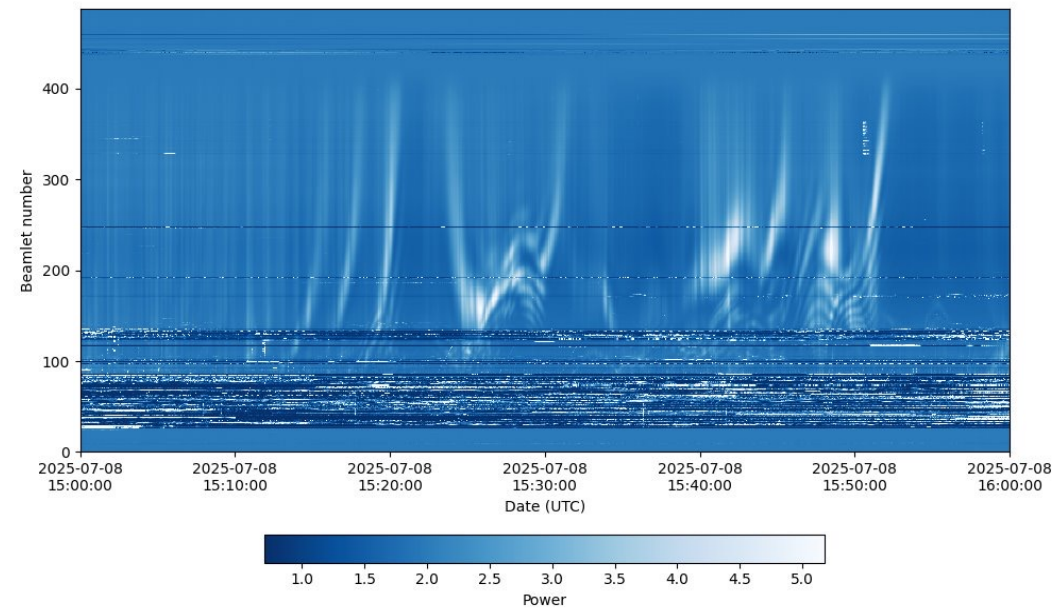
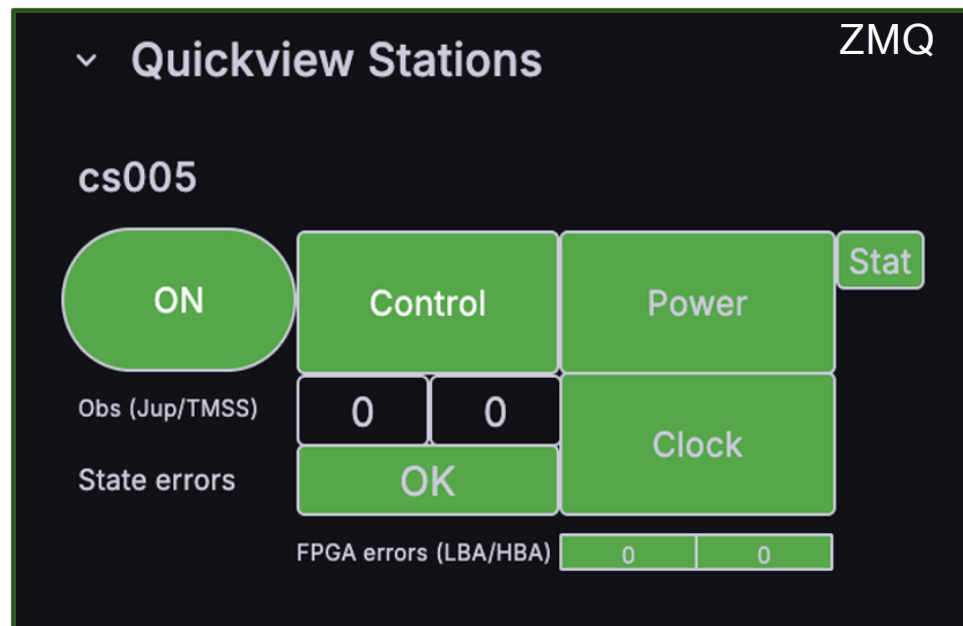


# Station commissioning



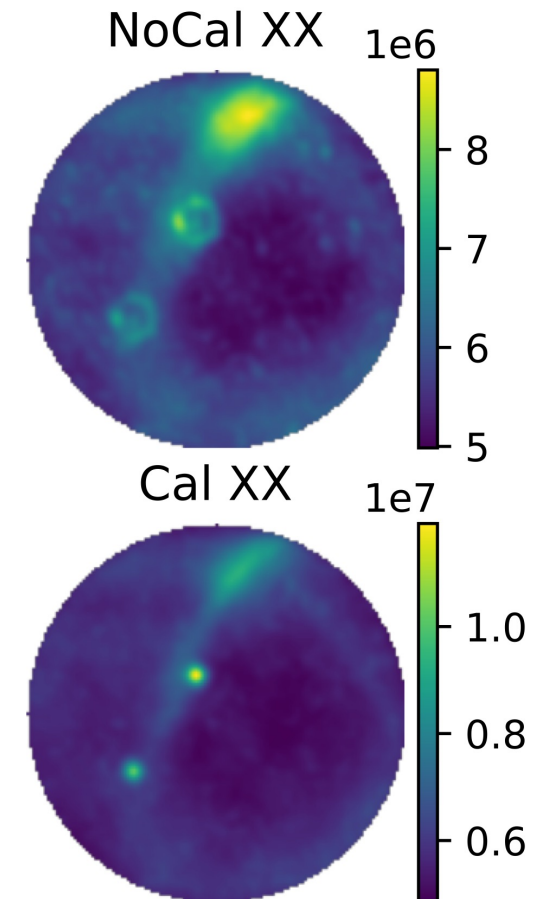


# Station health and station statistics



# Station calibration

- All dipoles within a station MUST add coherently
- Well-defined station beam, required for accurate imaging
- Without it, array calibration fails → loss of sensitivity, artifacts, and unusable images

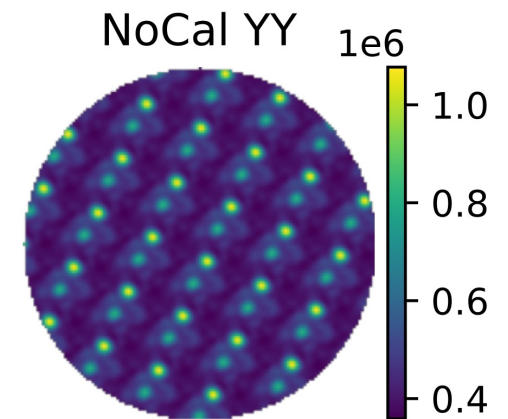


Example of before and after  
for CS004 at 53 MHz



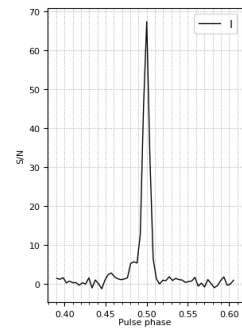
# Calibration improvements from LOFAR1

BEFORE	AFTER	Which band?
24h-observation to average the beam	Few seconds-observation - dipole beams simulated in full station configuration	LBA
Simple point source model	Point sources and diffuse emission from the Milky Way	LBA
Independent solver for XX and YY	Full Jones solver	LBA, HBA
Bright sources in grating lobes → failed calibration	Grating-lobe sources included in model → stable calibration	HBA

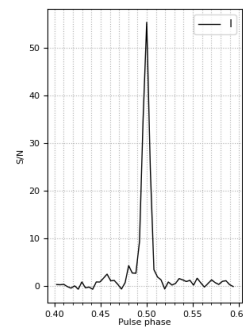


Example of HBA image with the Sun in the grating lobe

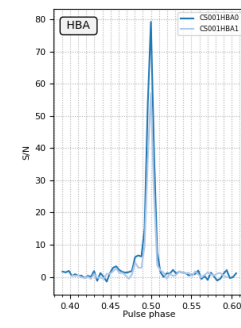
# Single station



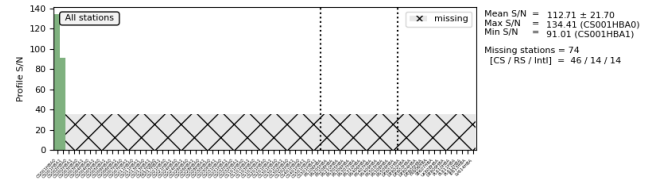
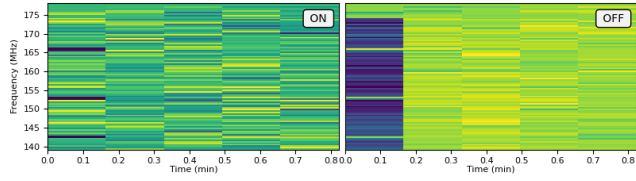
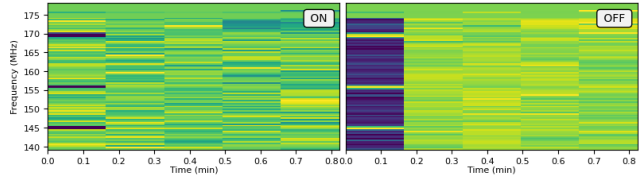
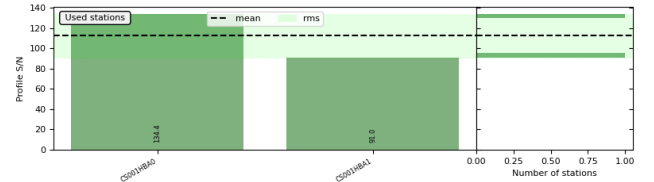
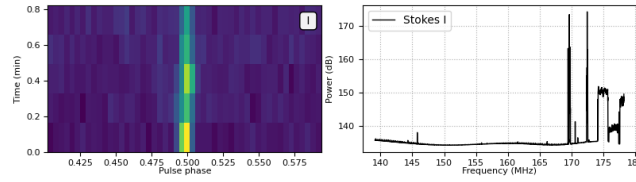
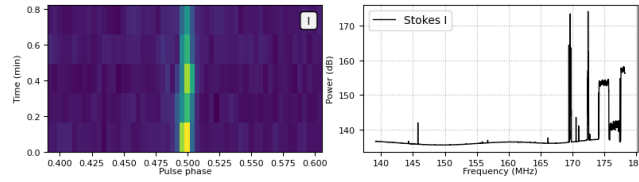
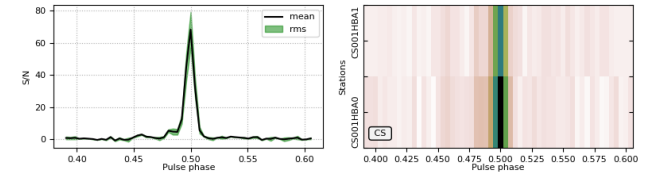
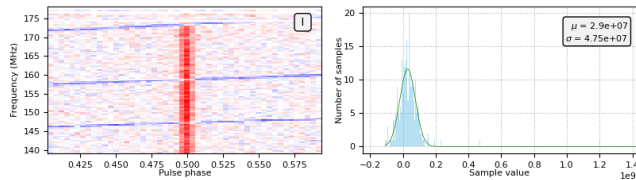
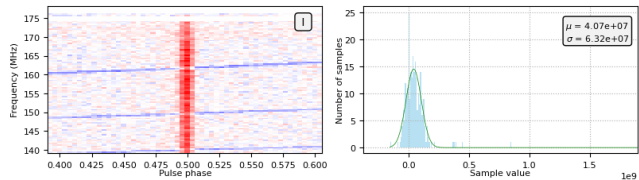
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 UTC start date/time 2025-07-23T08:36:59.5872  
 Observation duration (s) 60879.359023  
 Observing mode: Fly's Eye or (In)Coherent 49.39055104  
 Station for this beam CS001HBA0  
 Number of pulse phase bins 256  
 Number of frequency channels 3200  
 Number of polarizations (I) 1  
 Number of sub-integrations 5  
 Topocentric folding period (s) 0.71447479256028  
 Dispersion measure (pc/cm<sup>3</sup>) 26.7640991210938  
 Rotation measure (rad/m<sup>2</sup>) -64.3300018310547  
 Centre frequency (MHz) 158.685302734375  
 Bandwidth (MHz) 39.0625  
 Dispersion corrected false  
 Faraday Rotation corrected false  
 Polarization calibrated false  
 Telescope name LOFAR  
 Receiver name unknown  
 Name of the backend instrument COBALT  
 Signal-to-noise ratio from poststat / snr.py 5.10 / 134.41  
 RFI fraction (in %) by paz / cild 13.2625 / 11.35  
 Elevation (in deg) at the start / mid-point / end 75.7 / 75.6 / 75.5  
 Azimuth (in deg) at the start / mid-point / end 286.3 / 286.4 / 286.4  
 Hour angle (in hr) at the start / mid-point / end 1.61 / 1.62 / 1.63



Observation Id 2053182  
 Pipeline Id underf  
 Name of the file L2053182\_SAP000\_B001\_paz.ar  
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 Observation duration (s) 60879.359023  
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 Number of frequency channels 3200  
 Number of polarizations (I) 1  
 Number of sub-integrations 5  
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 Dispersion measure (pc/cm<sup>3</sup>) 26.7640991210938  
 Rotation measure (rad/m<sup>2</sup>) -64.3300018310547  
 Centre frequency (MHz) 158.685302734375  
 Bandwidth (MHz) 39.0625  
 Dispersion corrected false  
 Faraday Rotation corrected false  
 Polarization calibrated false  
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 Azimuth (in deg) at the start / mid-point / end 286.3 / 286.4 / 286.4  
 Hour angle (in hr) at the start / mid-point / end 1.61 / 1.62 / 1.63



Observation Id 2053182  
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 Name of the file L2053182\_SAP000\_B001\_paz.ar  
 Source name 70332+5434  
 Source coordinates 03:32:59.337+54:34:45.03  
 UTC start date/time 2025-07-23T08:36:59.5872  
 Observation duration (s) 60879.359023  
 Observing mode: Fly's Eye or (In)Coherent 49.39055104  
 Station for this beam CS001HBA0  
 Number of pulse phase bins 256  
 Number of frequency channels 3200  
 Number of polarizations (I) 1  
 Number of sub-integrations 5  
 Topocentric folding period (s) 0.71447479256028  
 Dispersion measure (pc/cm<sup>3</sup>) 26.7640991210938  
 Rotation measure (rad/m<sup>2</sup>) -64.3300018310547  
 Centre frequency (MHz) 158.685302734375  
 Bandwidth (MHz) 39.0625  
 Dispersion corrected false  
 Faraday Rotation corrected false  
 Polarization calibrated false  
 Telescope name LOFAR  
 Receiver name unknown  
 Name of the backend instrument COBALT  
 Signal-to-noise ratio from poststat / snr.py 5.10 / 134.41  
 RFI fraction (in %) by paz / cild 13.2625 / 11.35  
 Elevation (in deg) at the start / mid-point / end 75.7 / 75.6 / 75.5  
 Azimuth (in deg) at the start / mid-point / end 286.3 / 286.4 / 286.4  
 Hour angle (in hr) at the start / mid-point / end 1.61 / 1.62 / 1.63



datadir: /data/projects/COM\_LOFAR/2053182/csl

root: 2025-07-24 09:56:22

datadir: /data/projects/COM\_LOFAR/2053182/csl

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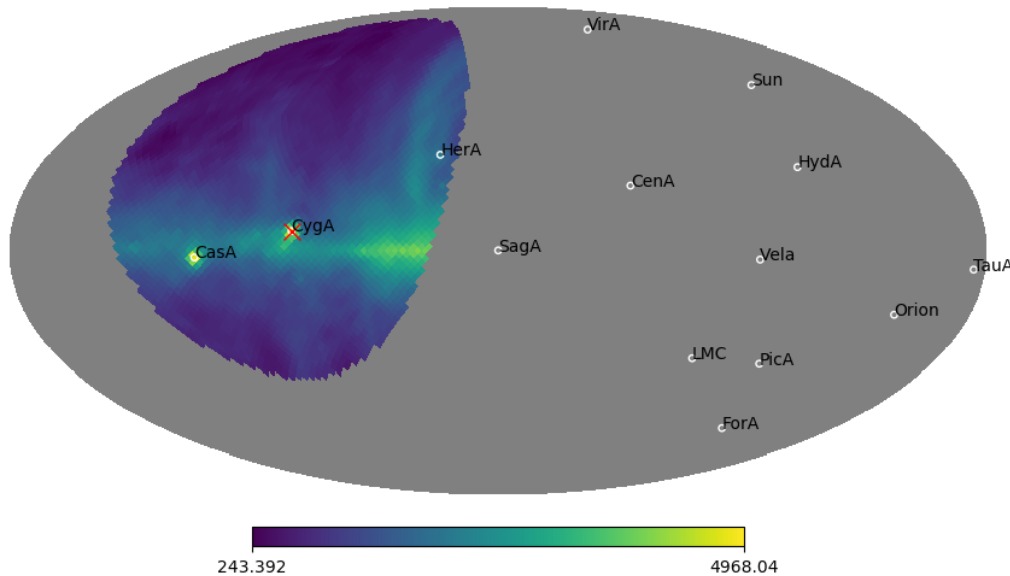
For HBA SNs for RS and INTL are scaled down by a factor of 2 and 4, correspondingly

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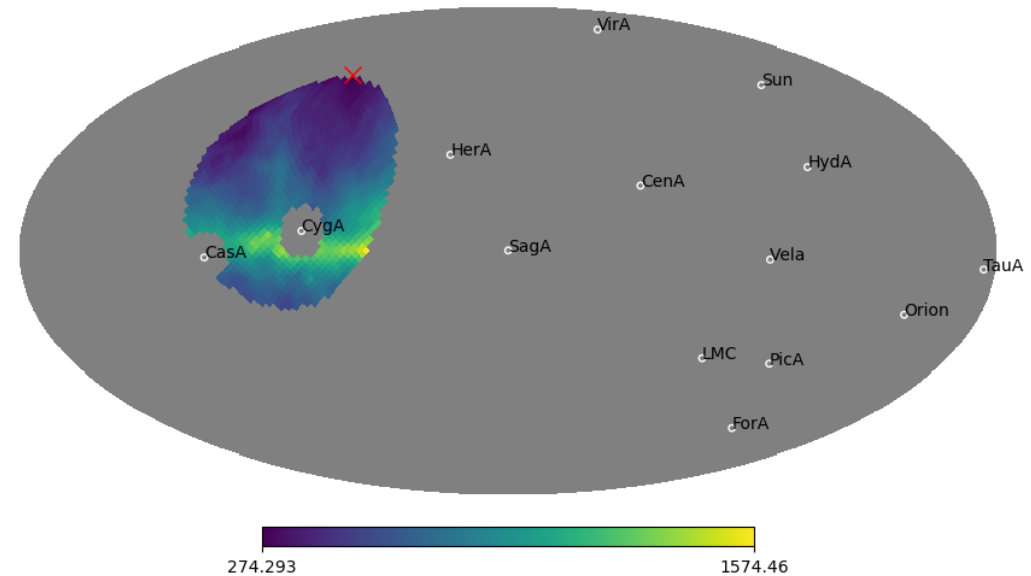
# SEFDs (more later!)

- ON/OFF scan
- S/N comparison, convolving station beam response with sky models
- $T_{\text{source}}/T_{\text{sys}}$

Low-resolution map ( $\sim 1.8^\circ$ ) of observable sky (el.  $> 45^\circ$ ) at time of test



Low-resolution map ( $\sim 1.8^\circ$ ) of observable sky (el.  $> 45^\circ$ ) at time of test



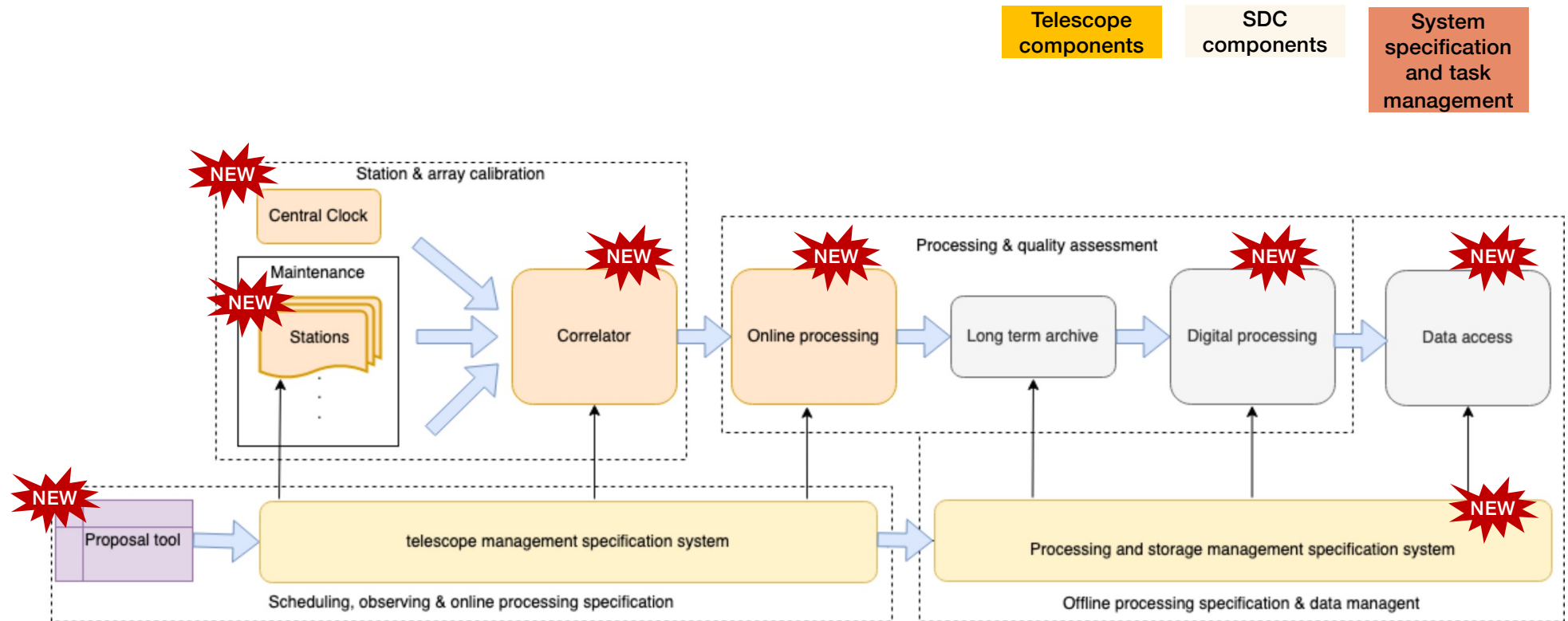


# Commissioning LOFAR2.0 Operations

**Emanuela Orru'**

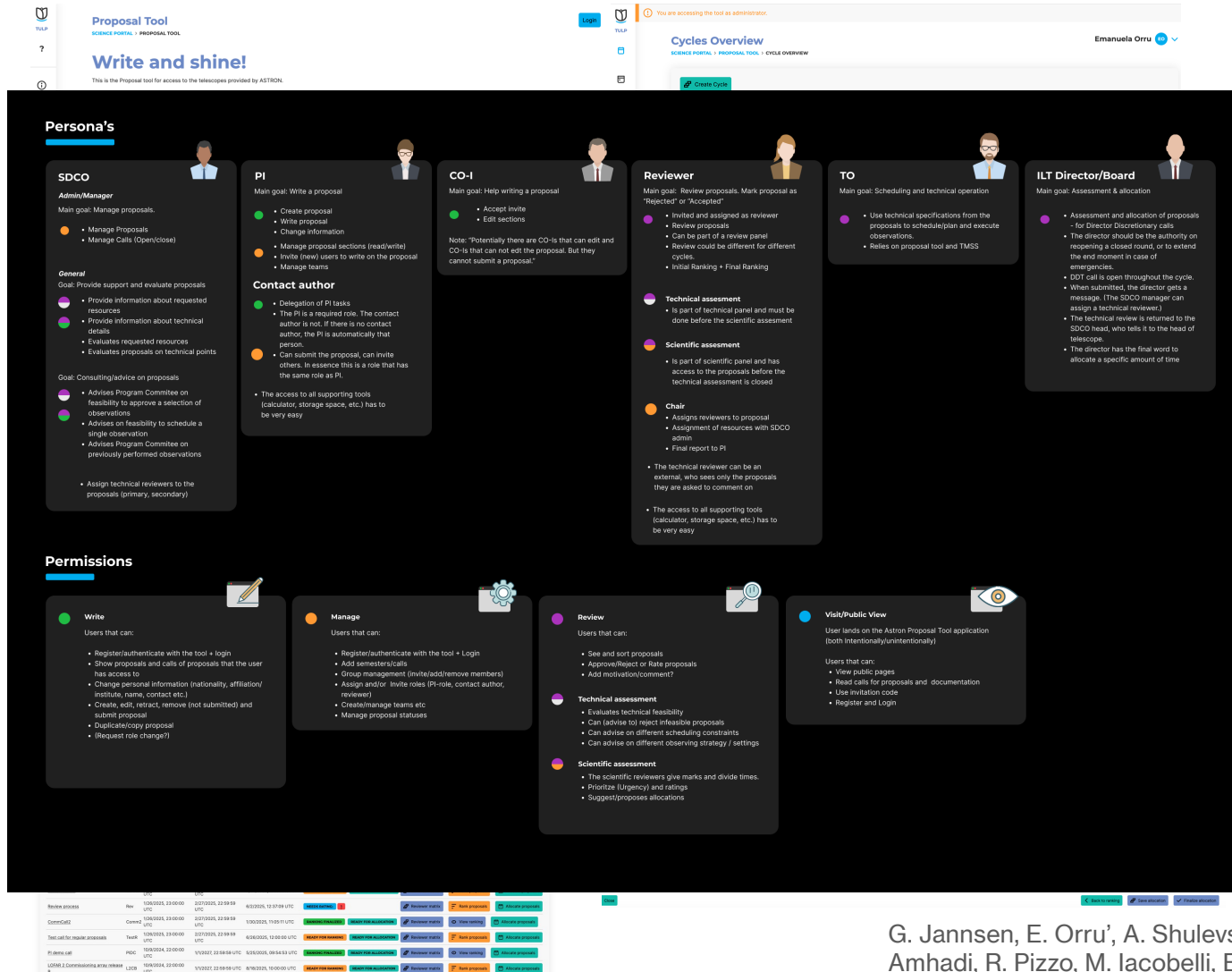
Lead of Commissioning of Operations on behalf of the commissioning team

# LOFAR2.0:Data flow



# TULP

MVP is ready needs to be tested.



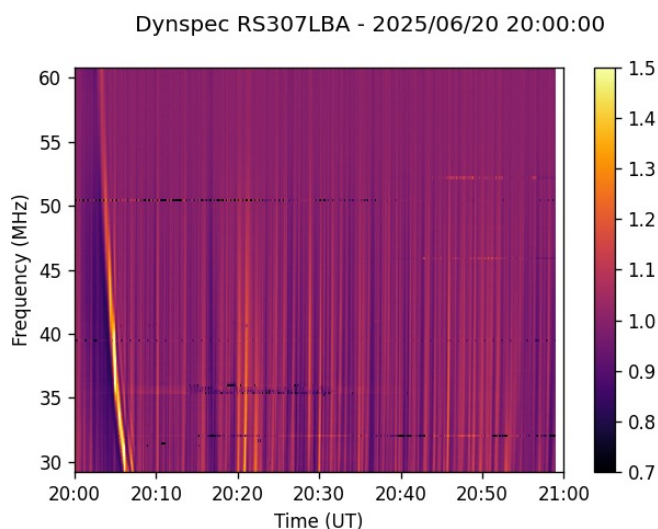
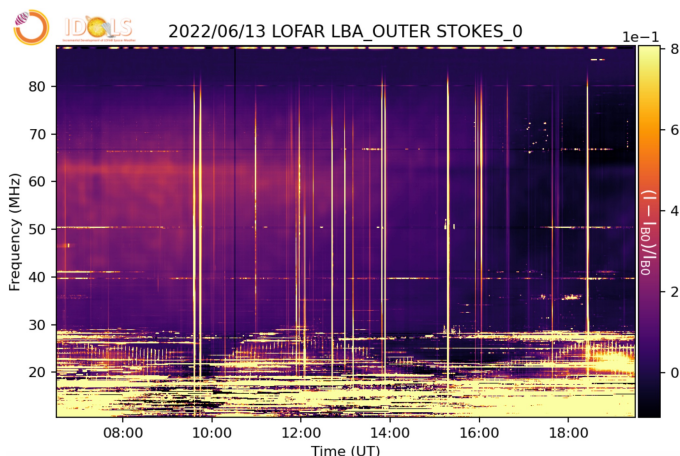
# Proposing

# Reviewing

G. Jannsen, E. Orru', A. Shulevski, V. Kondratiev, N. Peters, E. van der Wateren, A. Amhadi, R. Pizzo, M. Iacobelli, B. Asebere, M. Brentijens& more



# Scheduling



DINOS see A. Wood's talk given by **G. Dorian**

Scheduling. See **A. Shulevski's** poster

Solar monitoring. See **P. Zucca's** talk

Multi disciplinary approach

700 LBA observations

Solar activity scores

Ionospheric analysis based on solutions

Implementing this in operations and testing it on real observation is our next goal.

A. Shulevski, M. Mevius, P. Zucca, A. Wood, H. Edler, G. Dorian, E. Orru' & more

# Observing

## System monitoring

- ✓ Monitoring & Control on station hardware, FMW versioning, environmental conditions, WR-clock
- ✓ Missing monitoring points Network, Cobalt & CEP6

## CEP commissioning

- ✓ Cobalt2.1 (new OS, multicast)
- ✓ CEP6 functionality: observing and processing
- ✓ CEP6 Implementing ingest functionality
- ✓ Need to increase the load
- ✓ Need to monitor the stability

## Operational automated procedures

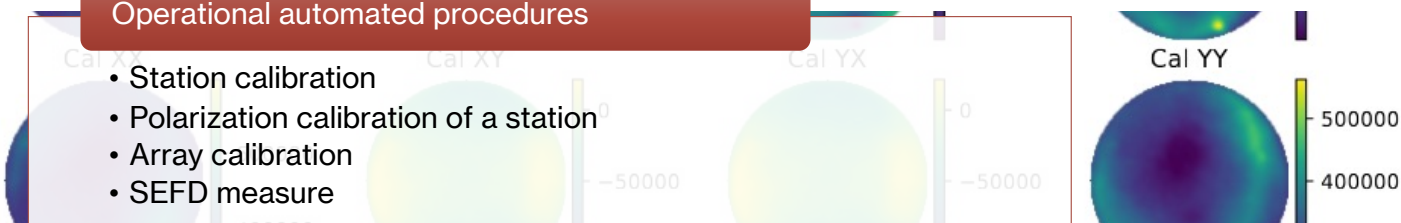
- Station calibration
- Polarization calibration of a station
- Array calibration
- SEFD measure



```

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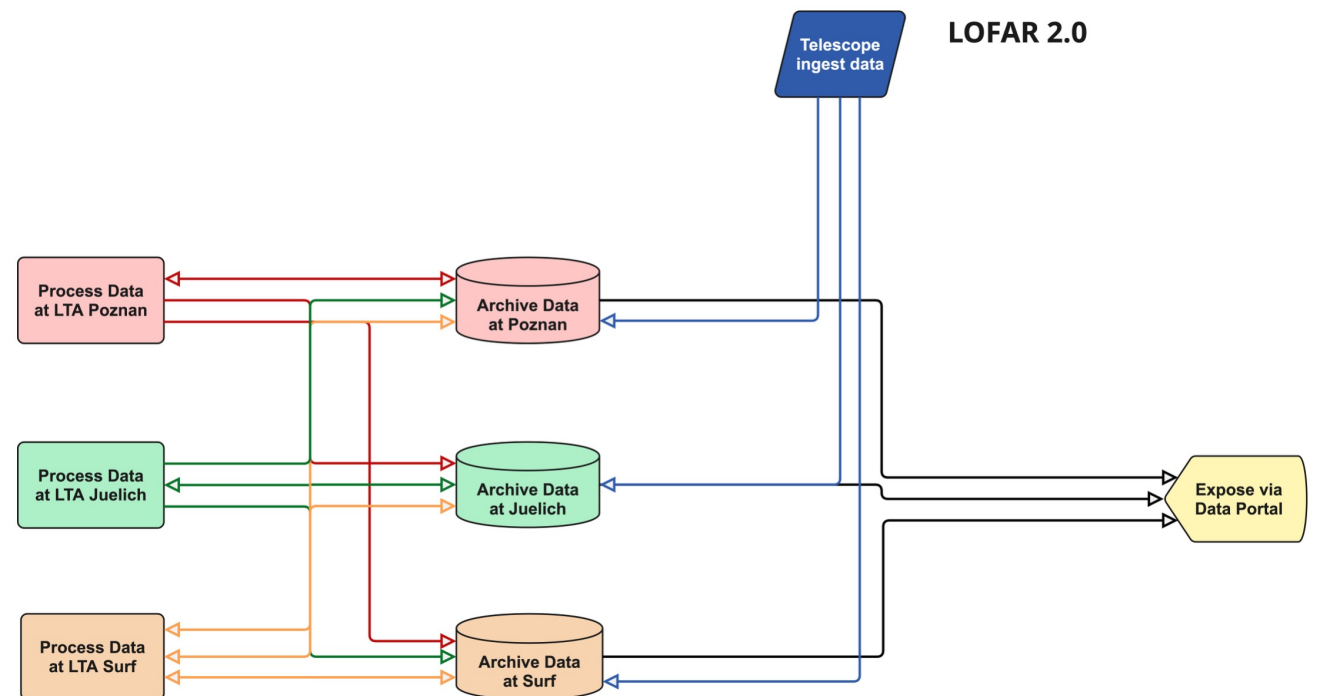
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Load average: 0.00 0.00 0.00
CPU: 0K/926M
Uptime: 16:46:37
    
```



see talks given by  
**C. M Cordun**

# LOFAR data processing system

- Processing system from LOFAR1 towards LOFAR2.0.
- Complexity increases needs scalability to be sustainable
- Growth of the breadth of data products types hosted in the LTA



# LOFAR data processing system

POPPY

SpecificationsTasksTask DetailsDashboardFilterQualityValidationIngestQFailuresDiscardedFinishedMonitoringDiagramConfigurationAdmin

Sign Out marco

Specifications

New SpecificationClear Filter

Search for...

FirstPrevious12345NextLast

ID	Type	Status	Pre	WF	Project	SAS_ID	Processing	Ingest policy	Filter	Inputs	Batch	Tasks	Error	Actions
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20	regular	discarded	-	29	ddt2_001	239952	same-as-inputs	default-lta	nv-surf-no-dysco	3	-	-	-	Remove Tasks
21	regular	defining	-	12	lc10_013	1440060	-	-	nv-linc-test2	11	-	-	-	EditLTA InputsCreate Tasks
26	regular	defining	-	29	lt5_008	559793	-	-	lt5_008-as-comp	240	9	-	-	EditLTA InputsCreate Tasks
27	regular	defining	-	12	lc10_013	1440060	-	-	mi-linc-cal-test	243	-	-	-	EditLTA InputsCreate Tasks

POPPY

SpecificationsTasksTask DetailsDashboardFilterQualityValidationIngestQFailuresDiscardedFinishedMonitoringDiagramConfigurationAdmin

Sign Out marco

Click to Filter

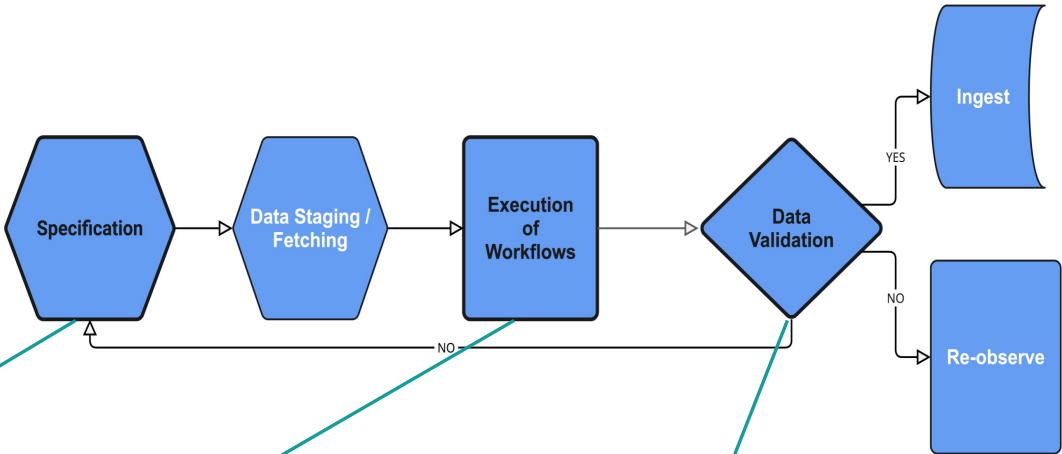
Clear FilterActiveFailedOn Hold

definingdefinedstagingstagedfetchedprocessingprocessedstoredvalidatedscrubbedpre archivingprel archived

Search for...

FirstPrevious12345678910111213141516171819...NextLast

ID	type	Spec	Details	WF	Status	Project	SAS_ID	Processing	Ingest Policy	Filter	Size	Actions
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406696	regular	84	Details	31	staged	lc4_008	346150	srm.grid.sara.nl	srm.grid.sara.nl	lc4_008_surf-mi-comp	3.3 GB	hold
406695	regular	84	Details	31	staged	lc4_008	346150	srm.grid.sara.nl	srm.grid.sara.nl	lc4_008_surf-mi-comp	3.3 GB	hold
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406693	regular	84	Details	31	staged	lc4_008	346150	srm.grid.sara.nl	srm.grid.sara.nl	lc4_008_surf-mi-comp	3.3 GB	hold
406692	regular	83	Details	31	fetched	lc4_008	369526	srm.grid.sara.nl	srm.grid.sara.nl	lc4_008_surf-mi-comp	2.1 GB	hold
406691	regular	83	Details	31	fetched	lc4_008	369526	srm.grid.sara.nl	srm.grid.sara.nl	lc4_008_surf-mi-comp	3.4 GB	hold
406690	regular	83	Details	31	fetched	lc4_008	369526	srm.grid.sara.nl	srm.grid.sara.nl	lc4_008_surf-mi-comp	3.4 GB	hold
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POPPY

SpecificationsTasksTask DetailsDashboardFilterQualityValidationIngestQFailuresDiscardedFinishedMonitoringDiagramConfigurationAdmin

Sign Out ma

Validation

These are the SAS\_ID's in status **stored** that can be validated. Click one of the quality buttons to validate.

Clear Filter

Search for...

FirstPrevious123456789101111NextLast

SAS_ID	Workflow	Project	Filter	Plots	Summary	Annotate	Calc Q	Quality	Validate (choose a Q)	Discard
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847244	30	ltt6_004	nv-juelich	Plots	SUM		moderate	-	<div><div>✓P</div><div>✓M</div><div>✓G</div><div>✓Validate</div></div>	
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1503394	35	ltt0_010	nv-debug-141	Plots	SUM		-	-	<div><div>✓P</div><div>✓M</div><div>✓G</div><div>✓Validate</div></div>	