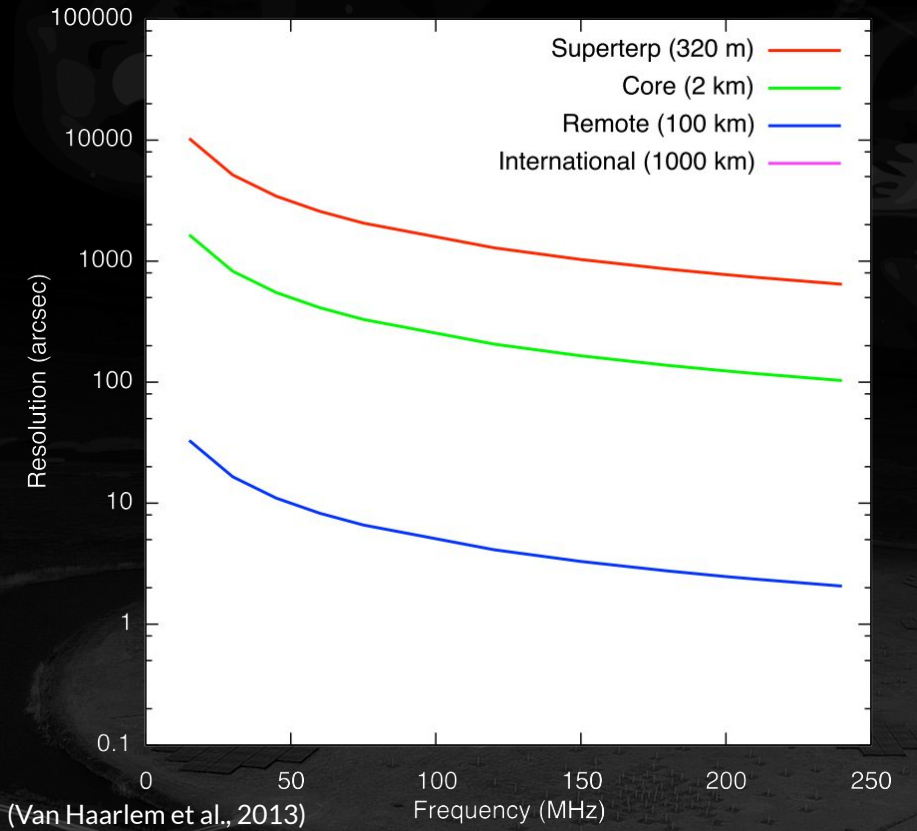
LoTSS-HR

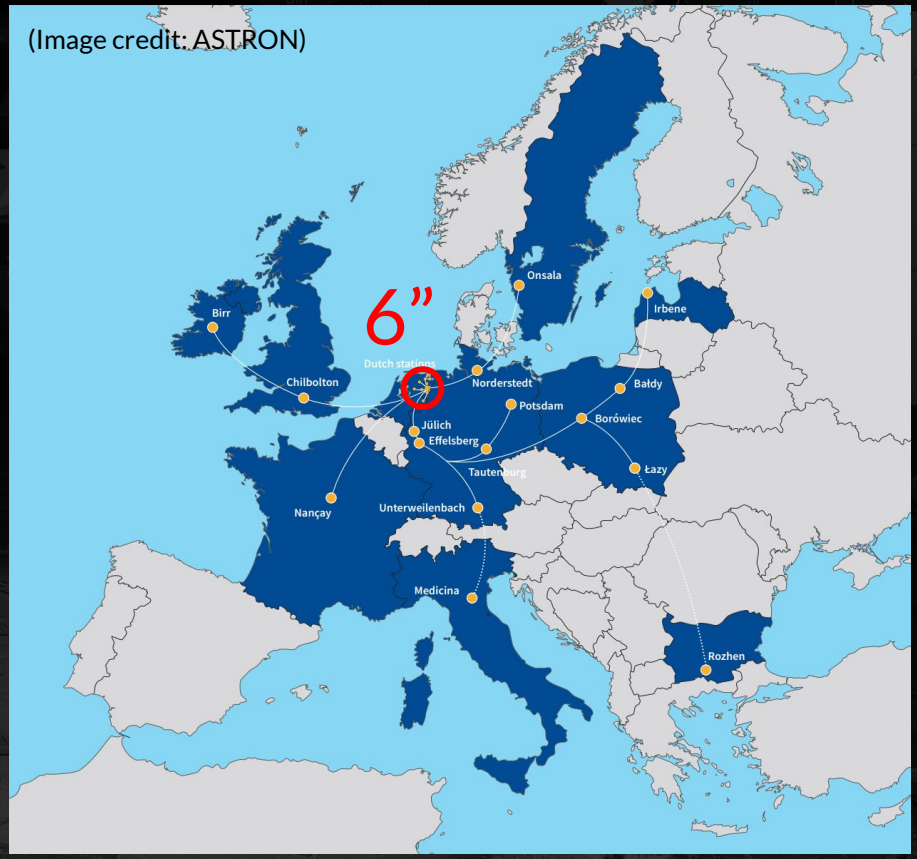
The high-resolution post-processing of the LOFAR Two-Metre Sky Survey

R. Timmerman, L. K. Morabito, N. Jackson,
T. Shimwell, M. Hardcastle, J. W. Petley, F. Sweijen

The International LOFAR Telescope

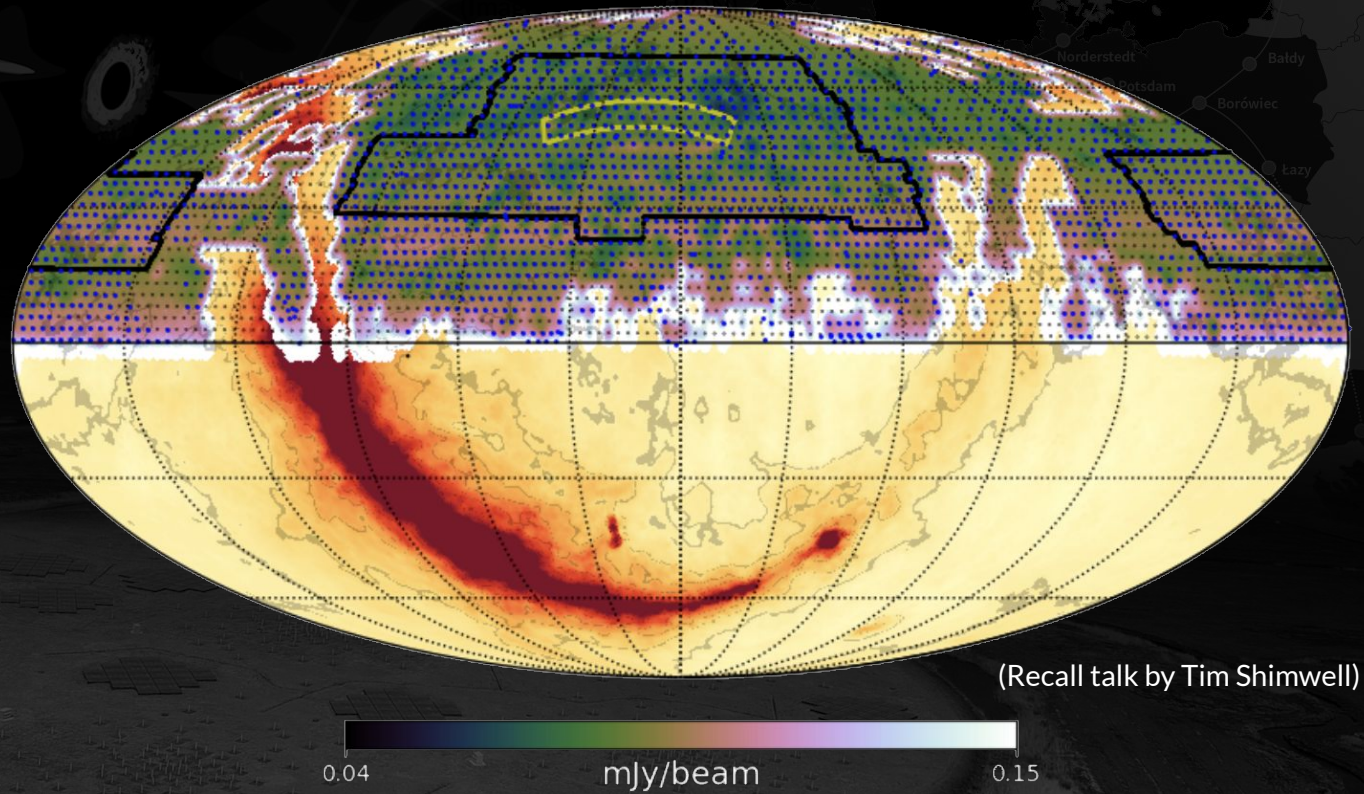


(Van Haarlem et al., 2013)



LoTSS: The LOFAR Two-Metre Sky Survey

- 2013 - Present
- 15,000 hours (currently)
- HBA: 120-168 MHz
- Primarily Northern sky
- 20 PB of data
- 6” angular resolution
- 80 μJy/beam sensitivity
- >13 million sources (**92%** unresolved)
- **International stations recorded but not processed**



(Recall talk by Tim Shimwell)

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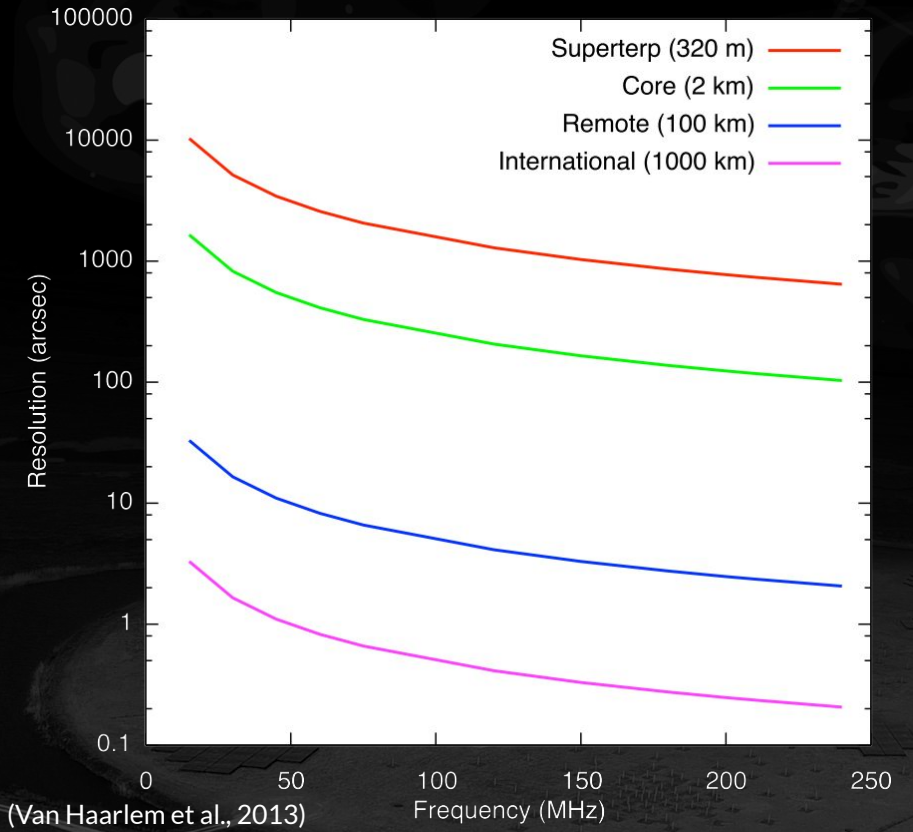

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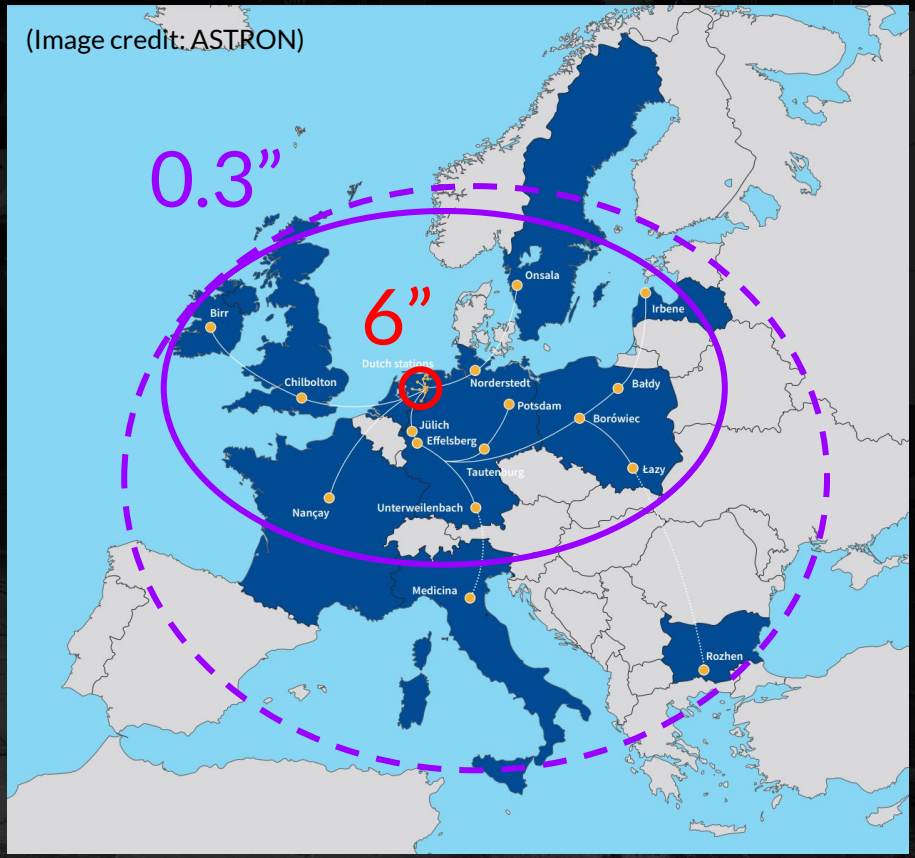
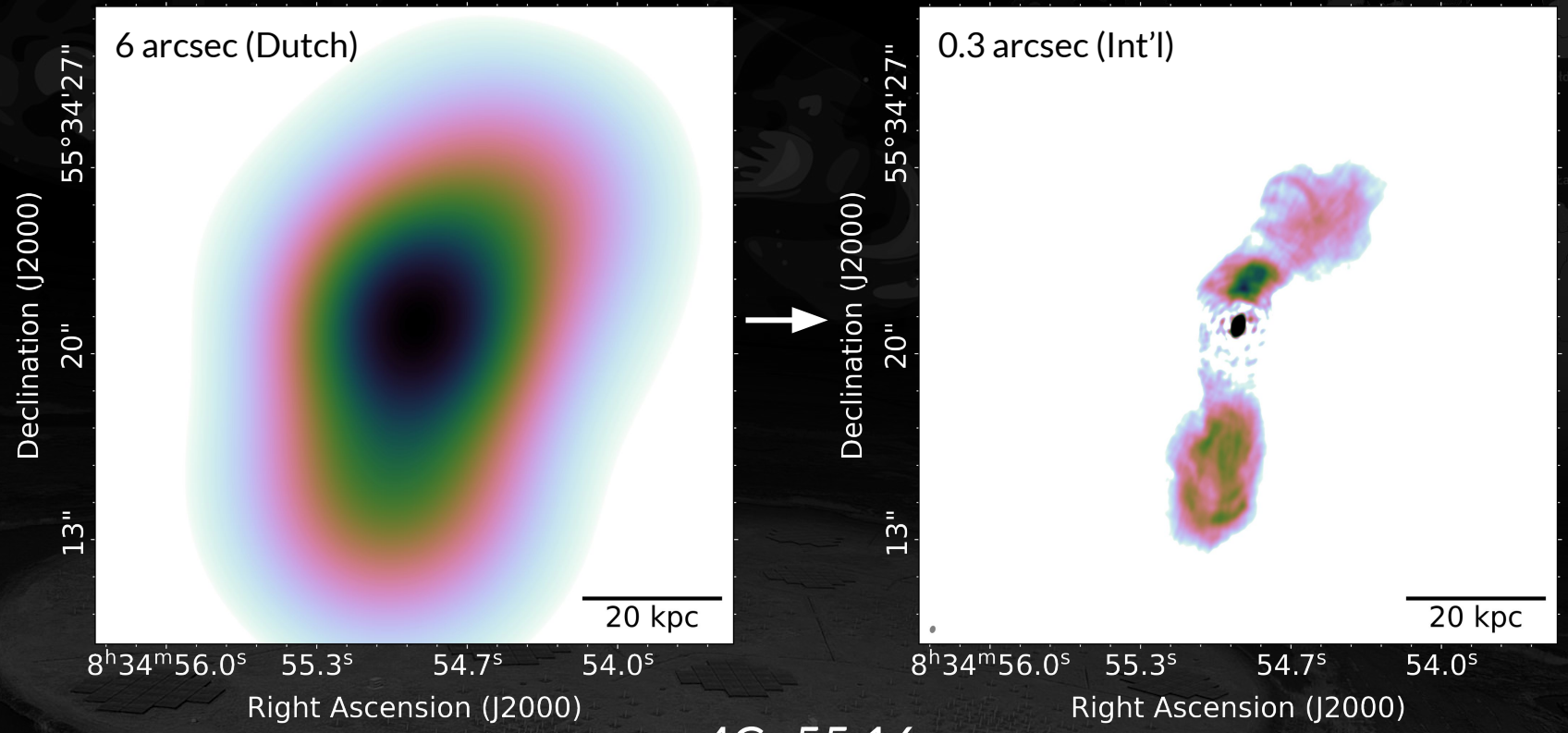


High-resolution imaging at low frequencies



4C+55.16

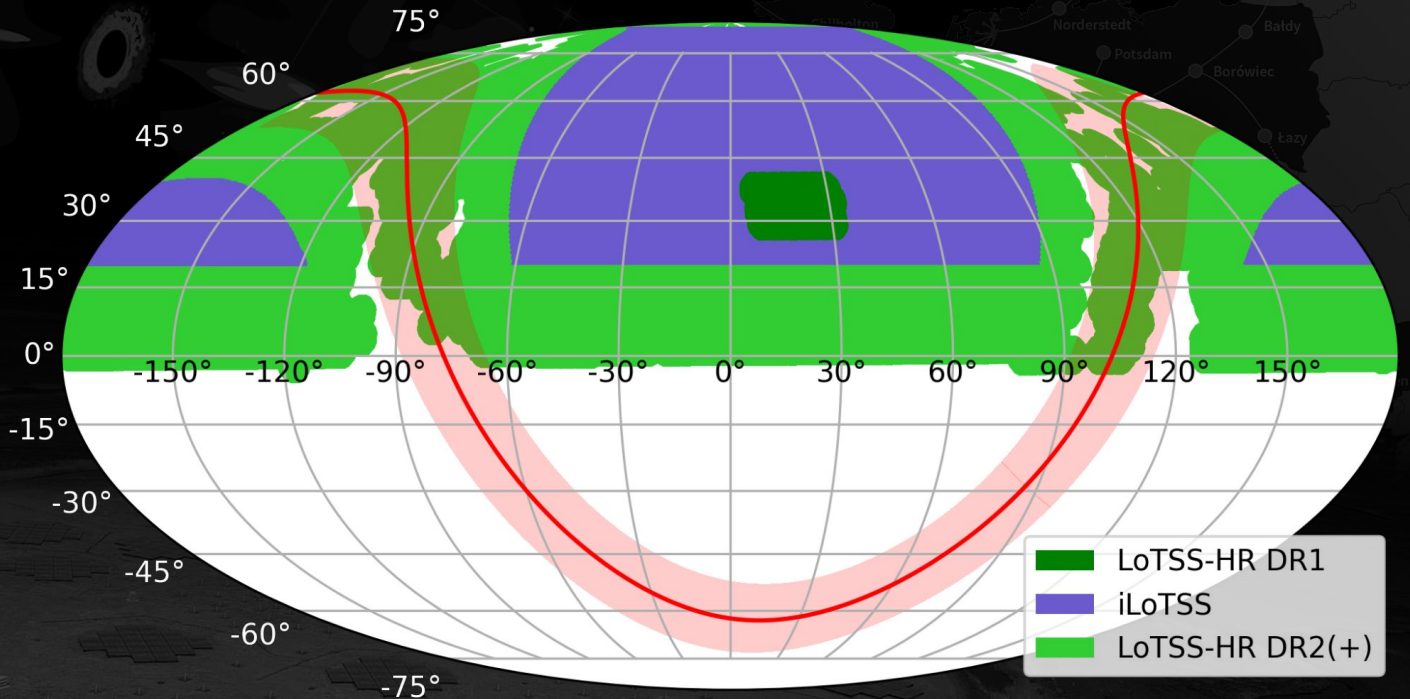
LoTSS-HR: The High Resolution LoTSS

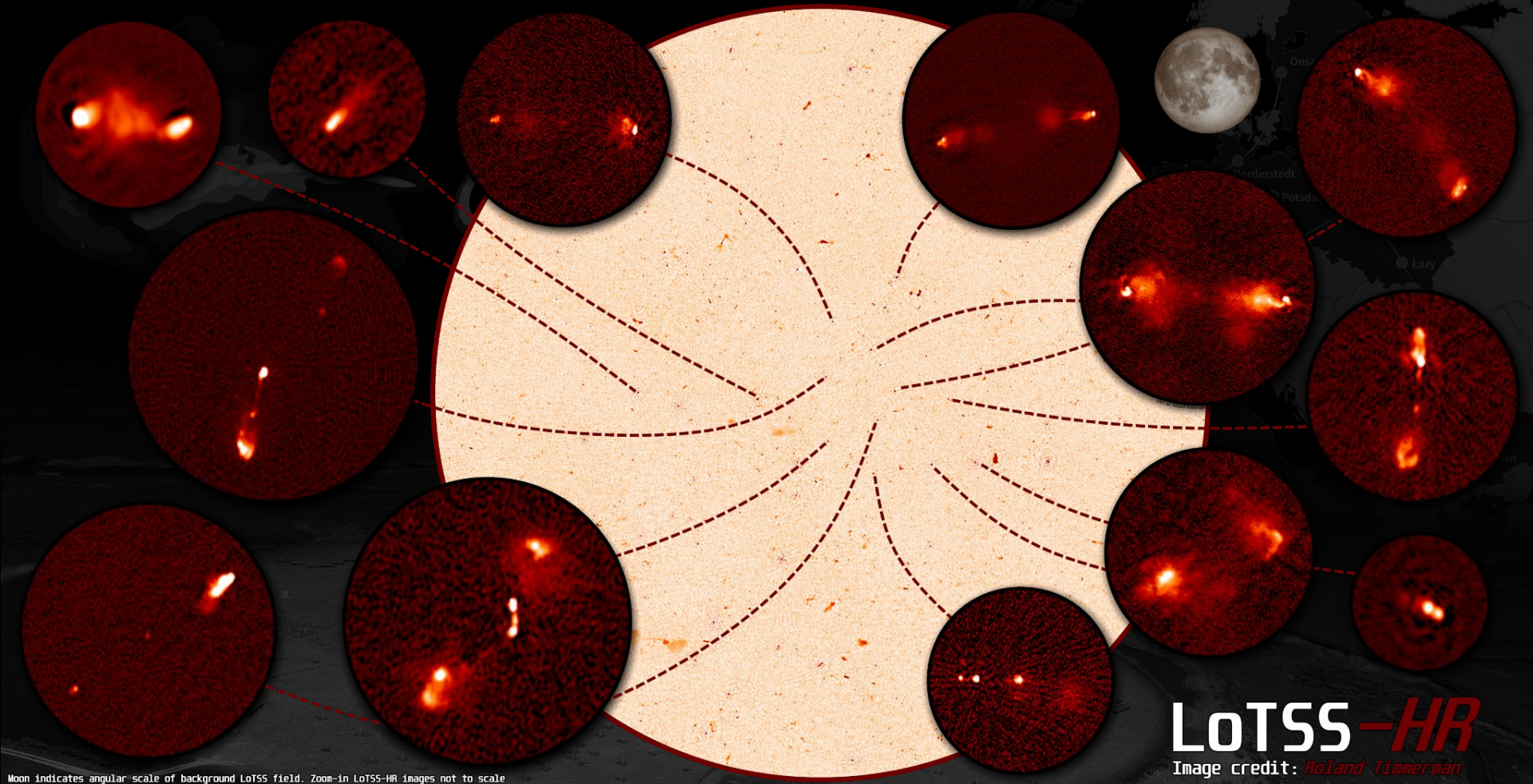
Reprocessing of LoTSS using the **full international array**

Postage stamp imaging of all sources **>10 mJy** in the field of view (~150 sources per field)

DR1: 30 fields within H-ATLAS

Complete high-resolution **0.3”** imaging products to be published




LoTSS-HR
Image credit: Roland Timmerman
Moon indicates angular scale of background LoTSS field. Zoom-in LoTSS-HR images not to scale

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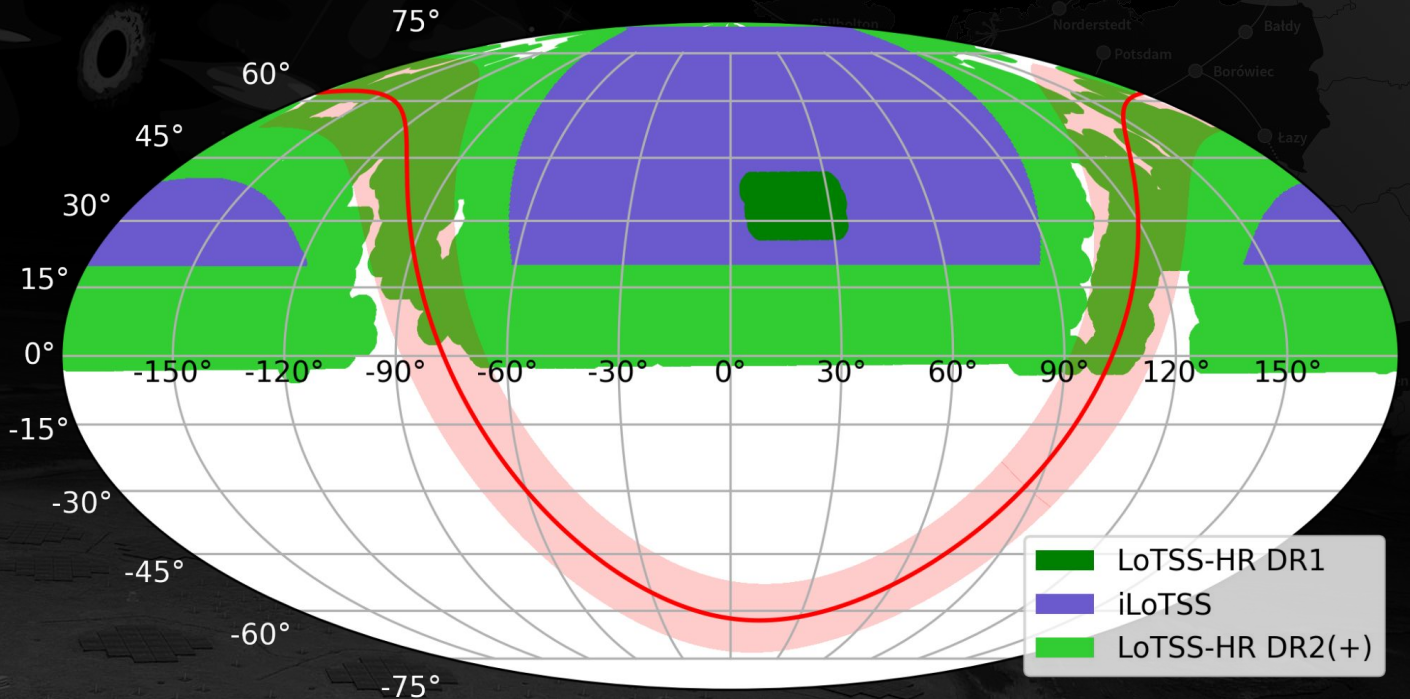

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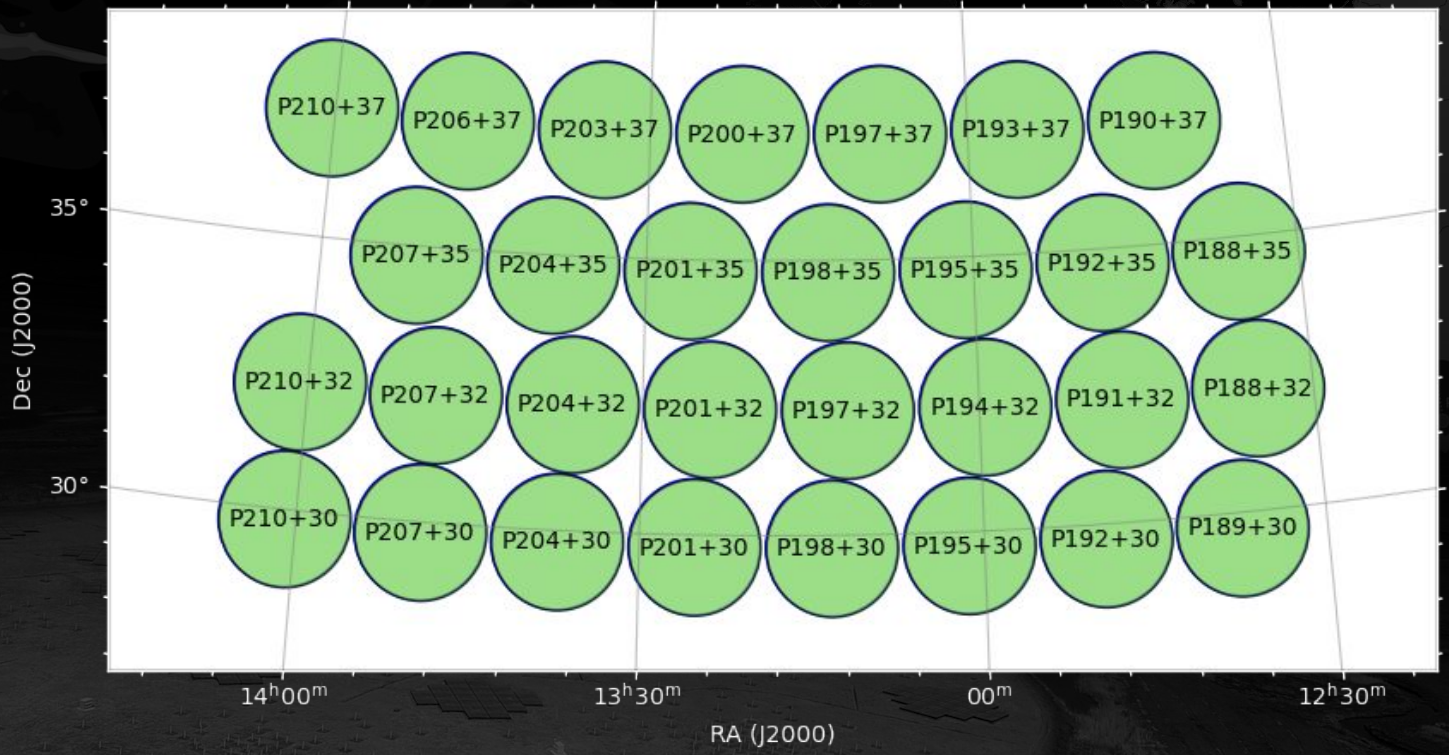

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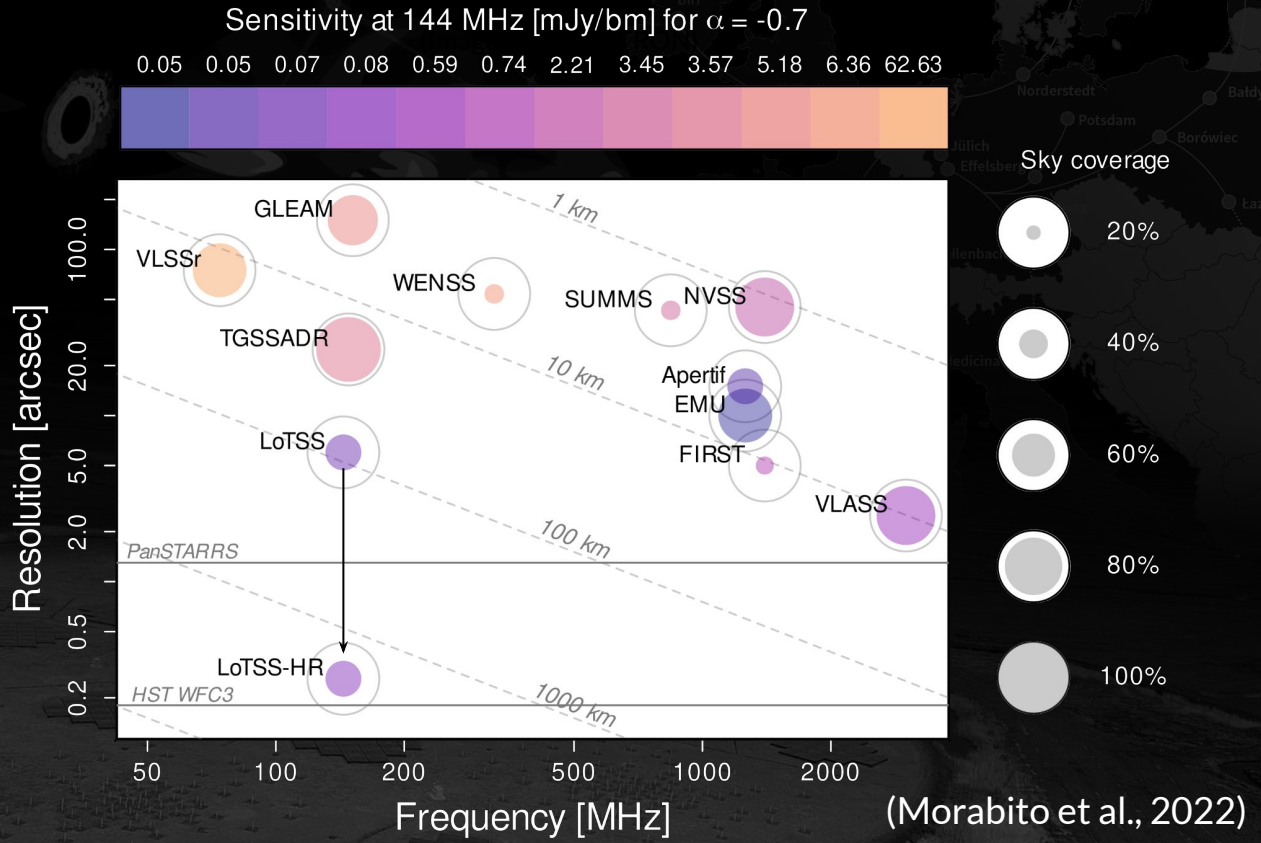
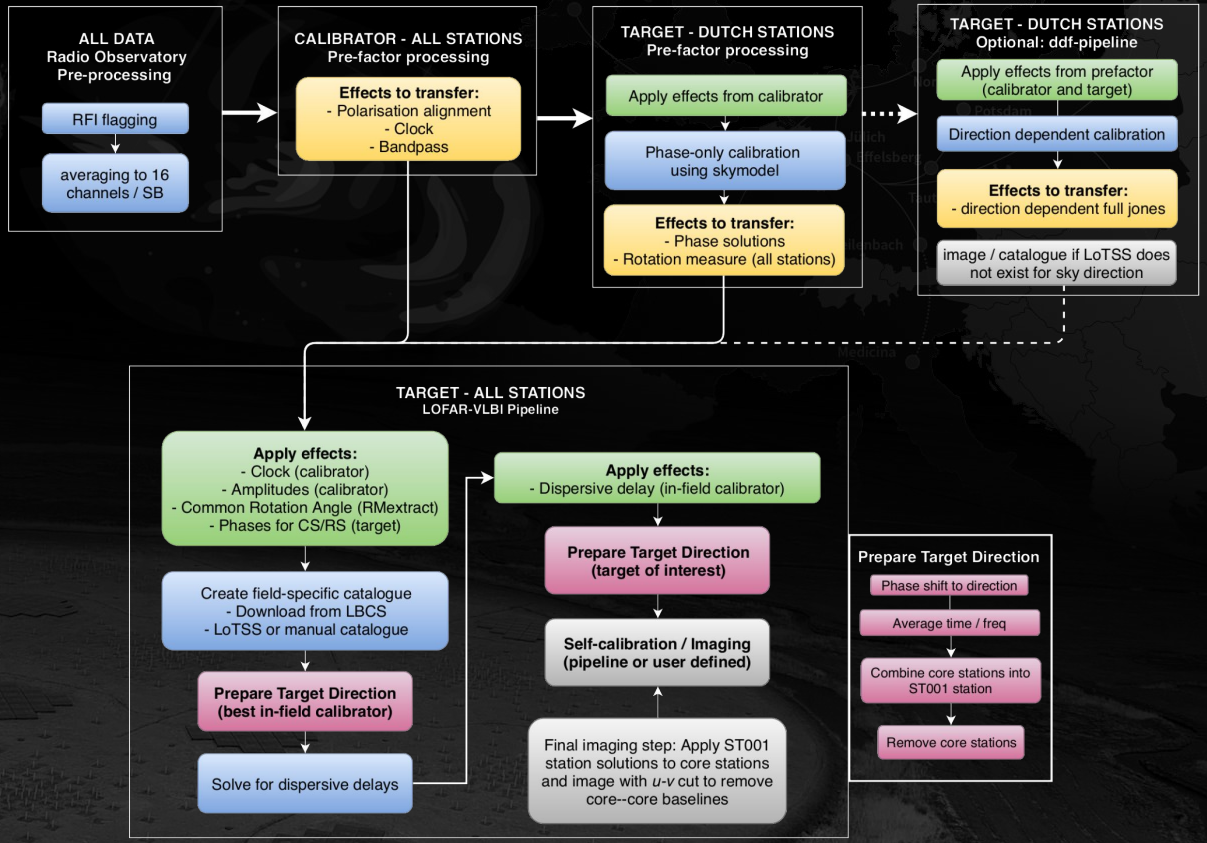


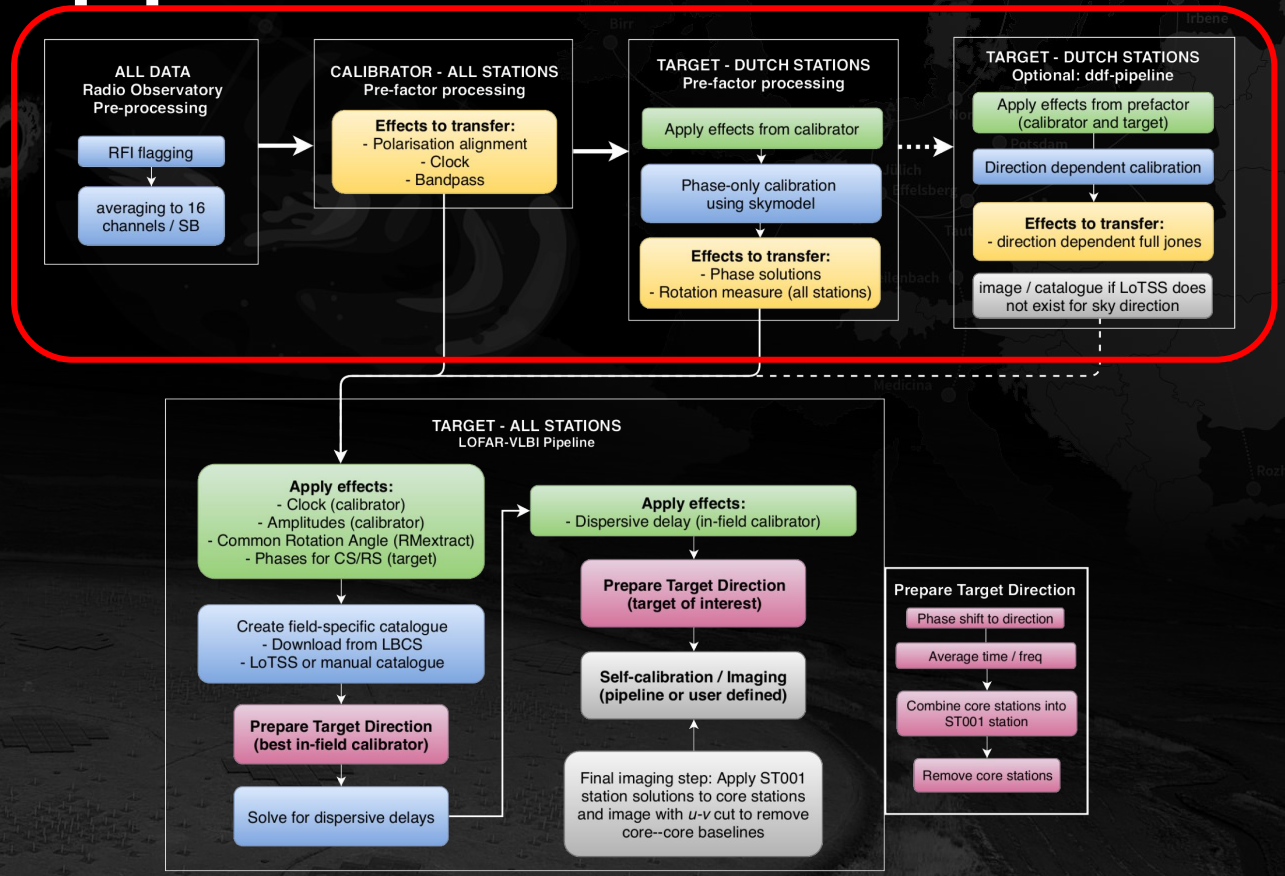
(Morabito et al., 2022)

The LOFAR-VLBI pipeline



The LOFAR-VLBI pipeline

Standard Dutch array processing



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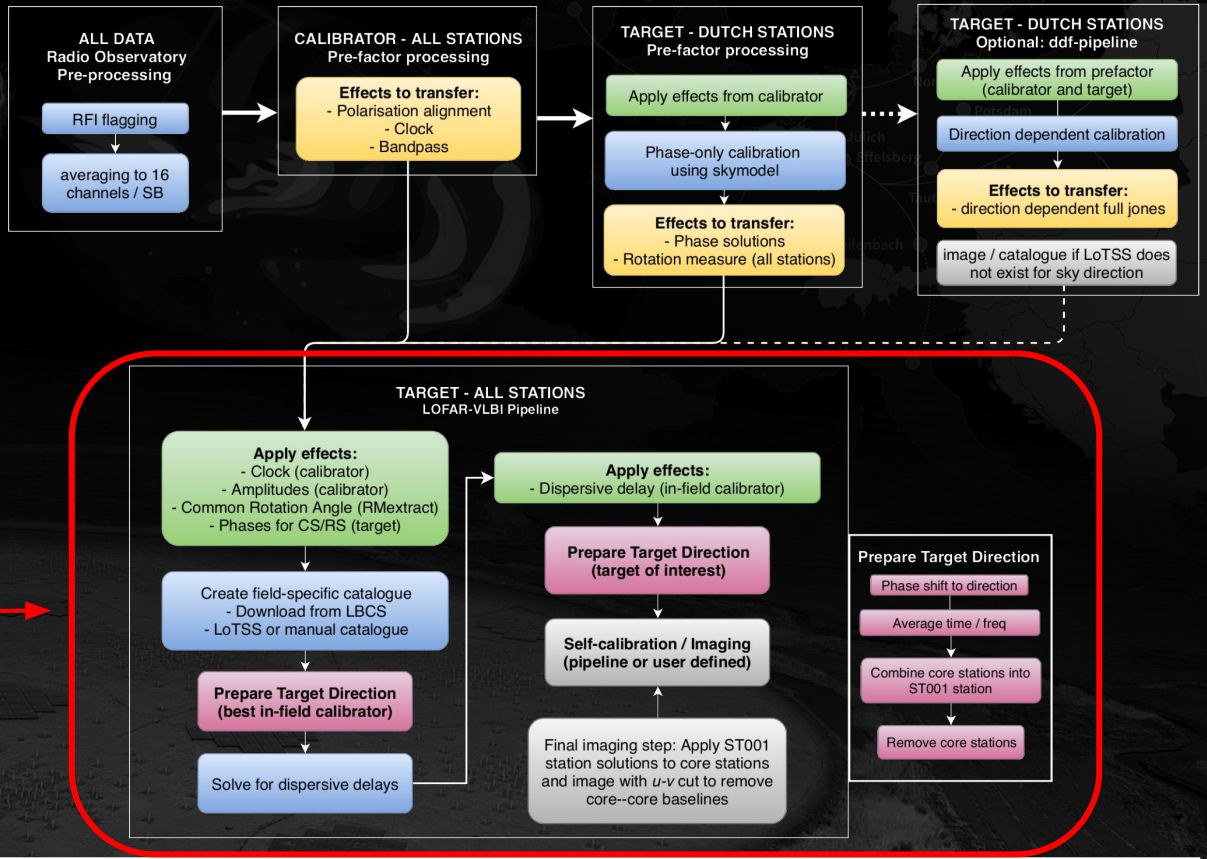
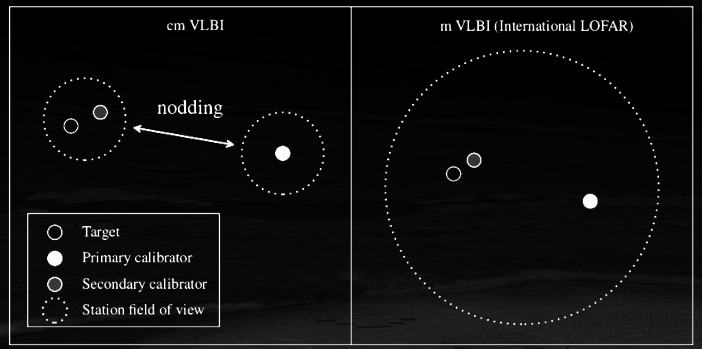


LOFAR-VLBI Pipeline →

Available on GitHub:
github.com/lofar-vlbi

The LOFAR-VLBI pipeline

(J. Moldon)



ALL DATA
Radio Observatory Pre-processing
- RFI flagging
- averaging to 16 channels / SB

CALIBRATOR - ALL STATIONS
Pre-factor processing
- **Effects to transfer:** - Polarisation alignment - Clock - Bandpass

TARGET - DUTCH STATIONS
Pre-factor processing
- Apply effects from calibrator
- Phase-only calibration using skymodel
- **Effects to transfer:** - Phase solutions - Rotation measure (all stations)

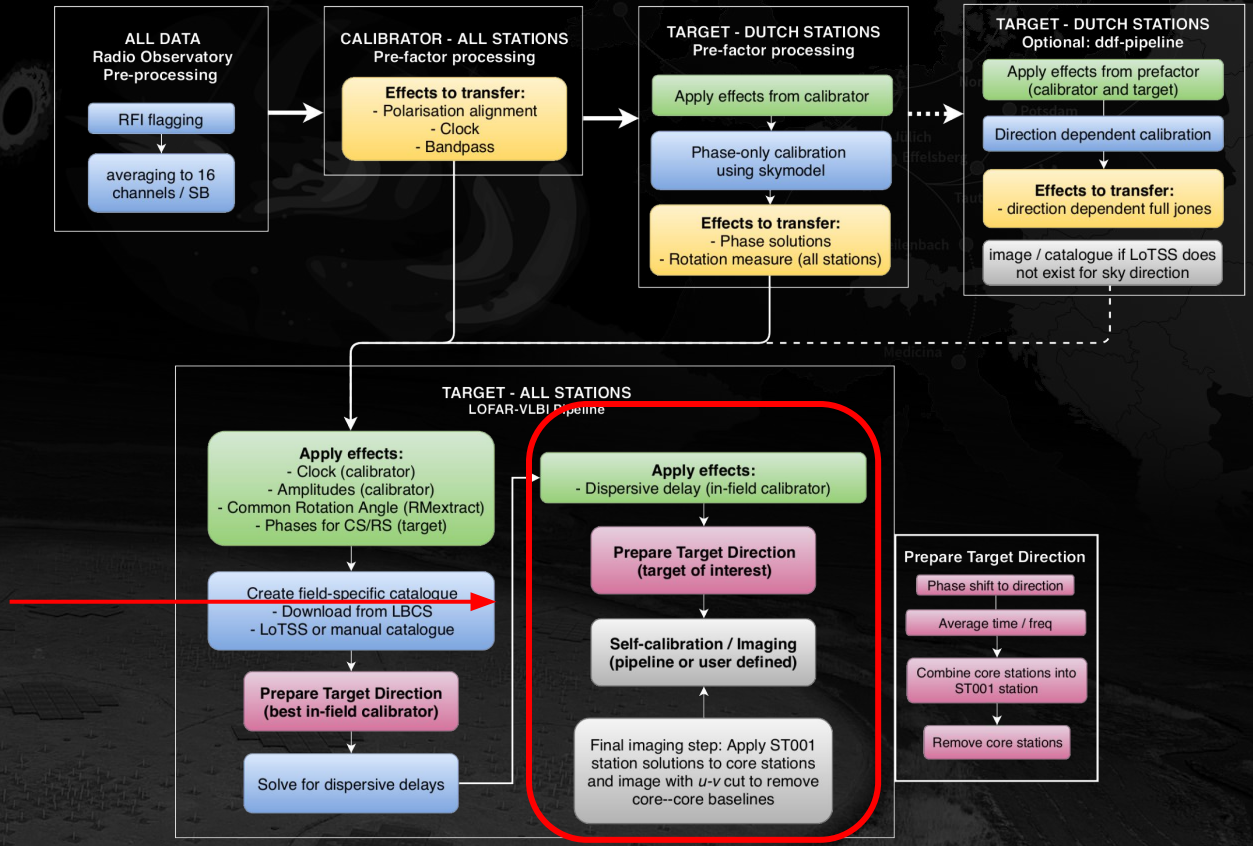
TARGET - DUTCH STATIONS
Optional: ddf-pipeline
- Apply effects from prefactor (calibrator and target)
- Direction dependent calibration
- **Effects to transfer:** - direction dependent full jones
- image / catalogue if LoTSS does not exist for sky direction

TARGET - ALL STATIONS
LOFAR-VLBI Pipeline
- **Apply effects:** - Clock (calibrator) - Amplitudes (calibrator) - Common Rotation Angle (RMextract) - Phases for CS/RS (target)
- Create field-specific catalogue - Download from LBCS - LoTSS or manual catalogue
- **Prepare Target Direction (best in-field calibrator)**
- Solve for dispersive delays
- **Apply effects:** - Dispersive delay (in-field calibrator)
- **Prepare Target Direction (target of interest)**
- **Self-calibration / Imaging (pipeline or user defined)**
- Final imaging step: Apply ST001 station solutions to core stations and image with *u-v* cut to remove core--core baselines

Prepare Target Direction
- Phase shift to direction
- Average time / freq
- Combine core stations into ST001 station
- Remove core stations

Solve for dispersive delays using in-field calibrator source

The LOFAR-VLBI pipeline



1. Apply DI solutions and perform self-calibration on target postage stamp
2. Find DD calibrators and apply those solutions to poorest targets

The LOFAR-VLBI pipeline

Current status:

Primary calibrators: ✅

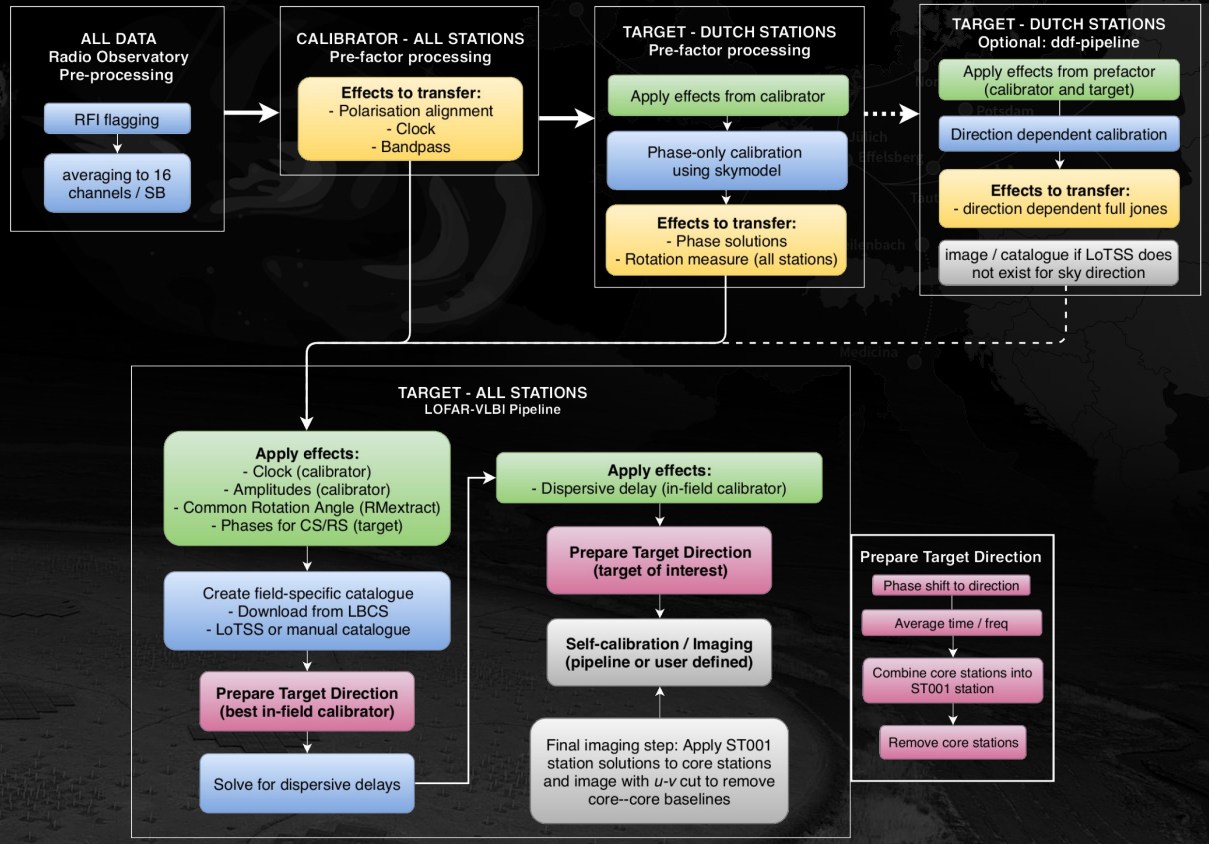
LINC-VLBI: ✅

In-field calibrators: ✅

Target field imaging: ✅

DD selection and re-run:
About halfway

Post-processing and cataloguing:
Testing on one field
Quick to apply on rest



Scientific prospects

(Credit: Morabito)

Obtain precise host identifications of radio sources

Scientific prospects

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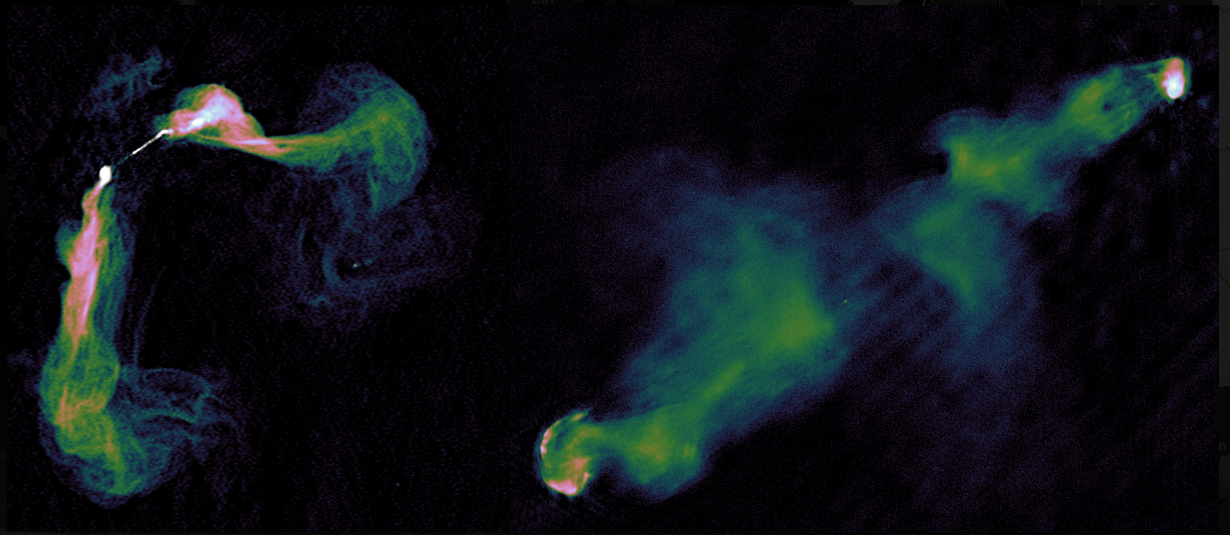
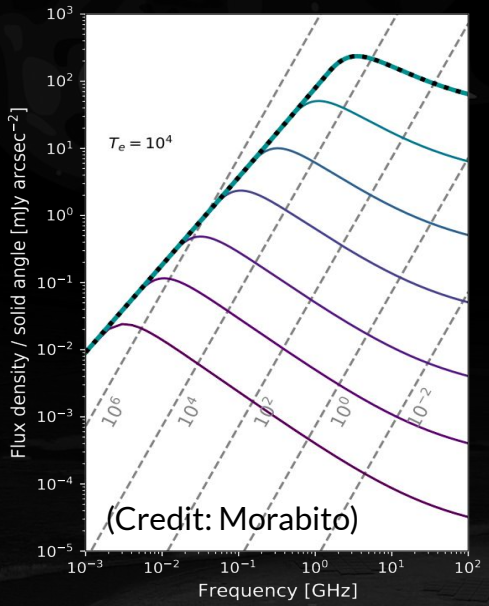


Obtain precise host identifications of radio sources

Reveal detailed (sub)structure in radio jets, lobes, SF regions, gravitational lenses, etc…

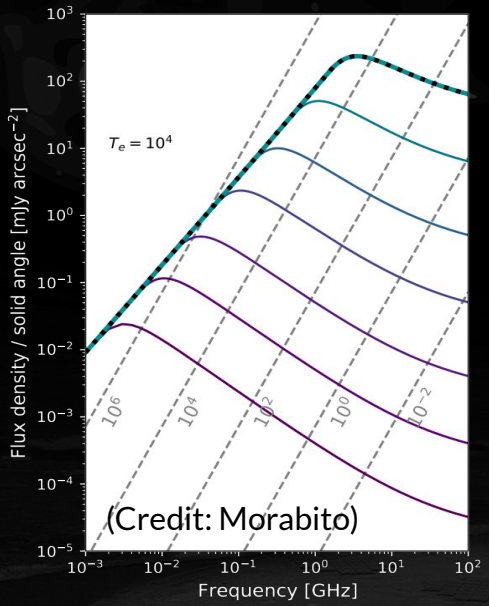
Scientific prospects



(Credit: Morabito)

Differentiate between AGN activity and SF through brightness temps

Scientific prospects



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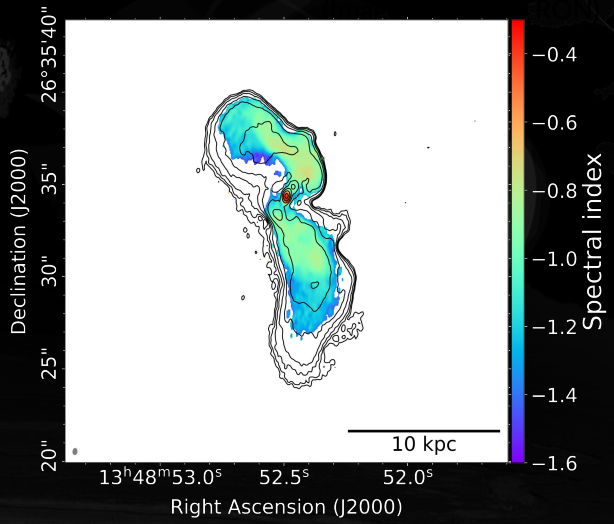
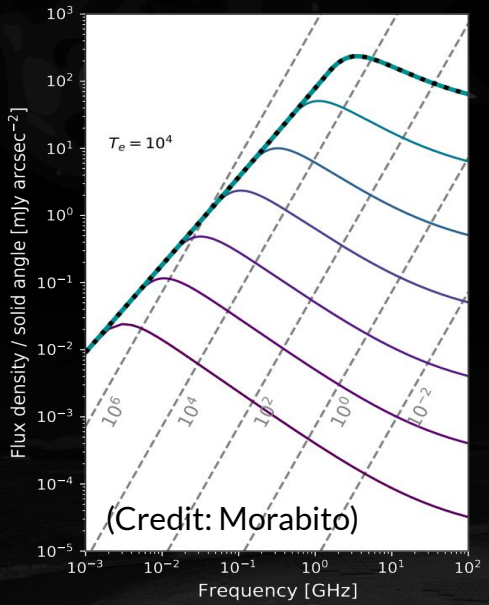


Enable high-resolution spectral index mapping at low frequencies

Scientific prospects



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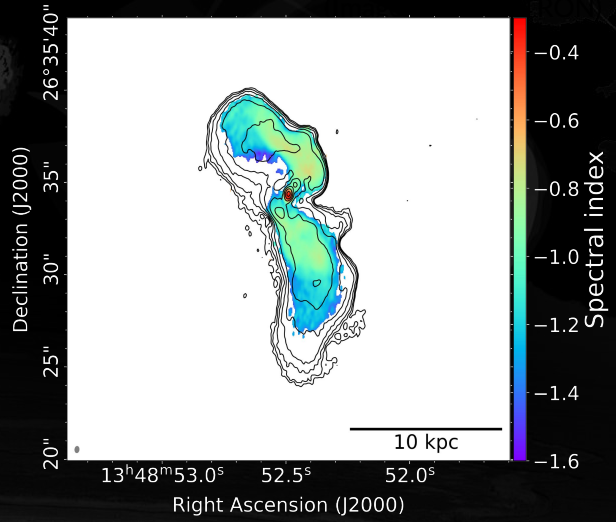

Enable high-resolution spectral index mapping at low frequencies

Your science case here

Take-home messages

1. The LoTSS-HR project expands upon LoTSS by post-processing all data including the international LOFAR stations

2. The LoTSS-HR project is currently working towards imaging all reasonably bright (>10 mJy) sources in the Northern hemisphere at 0.3” resolution at 144 MHz

3. DR1 will contain the first 30 LoTSS fields, containing 4000-5000 sources. After that, DR2 will continue with a larger sample of field outside of iLoTSS.

4. DR1 is almost here!