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Netherlands Institute for Radio Astronomy

Imaging with the Low Frequency Array (LOFAR)

John McKean (ASTRON)

on behalf of the LOFAR imaging commissioning team

The Low Frequency Array

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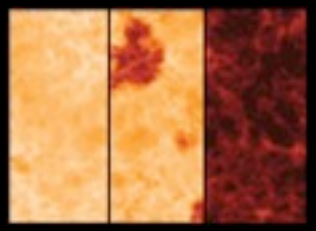
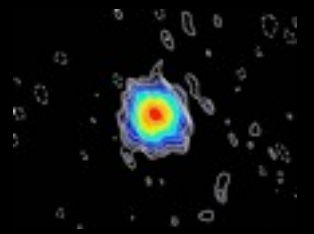
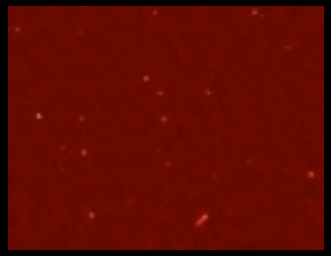
- LOFAR is an Aperture Array system operating between (10-90 MHz and 110-240 MHz).



- Epoch of Reionization

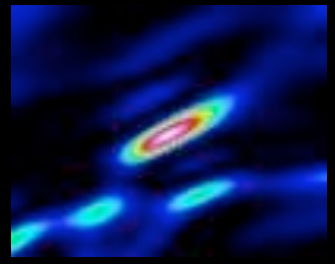
- Transients

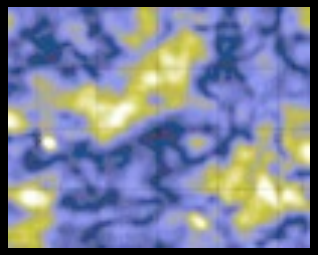




- Extragalactic Surveys

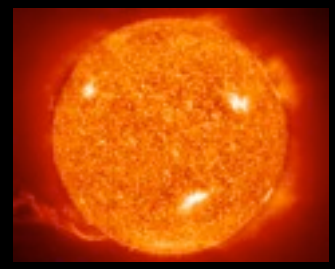
- Cosmic Rays





- Cosmic Magnetism

- Solar Physics



- Open time also (>10 %) - ILT - be creative!

LOFAR - Key Facts

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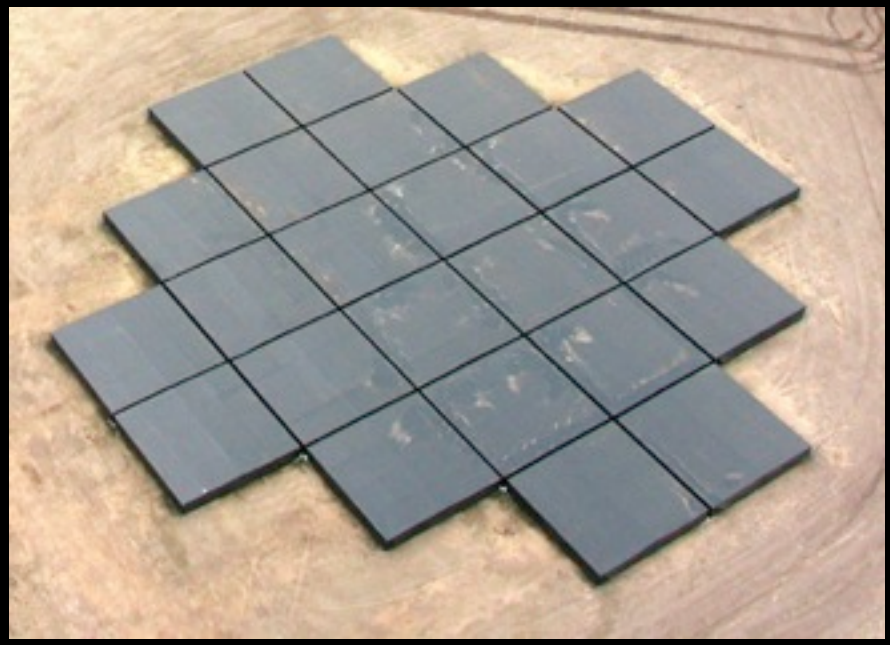
- Low Band Antenna (LBA; 10--90 MHz) - simple dipoles.
- High Band Antenna (110-240 MHz) - tiled array.
- 48 MHz bandwidth (large fractional bandwidth) - single beam
- large fields of view (1700--7 sq deg)
- Sub-mJy sensitivities (1 hr) and sub-arcsec resolution.
- Software telescope - no moving parts
- Automated pipeline to process the data.



Core stations - 20 Dutch

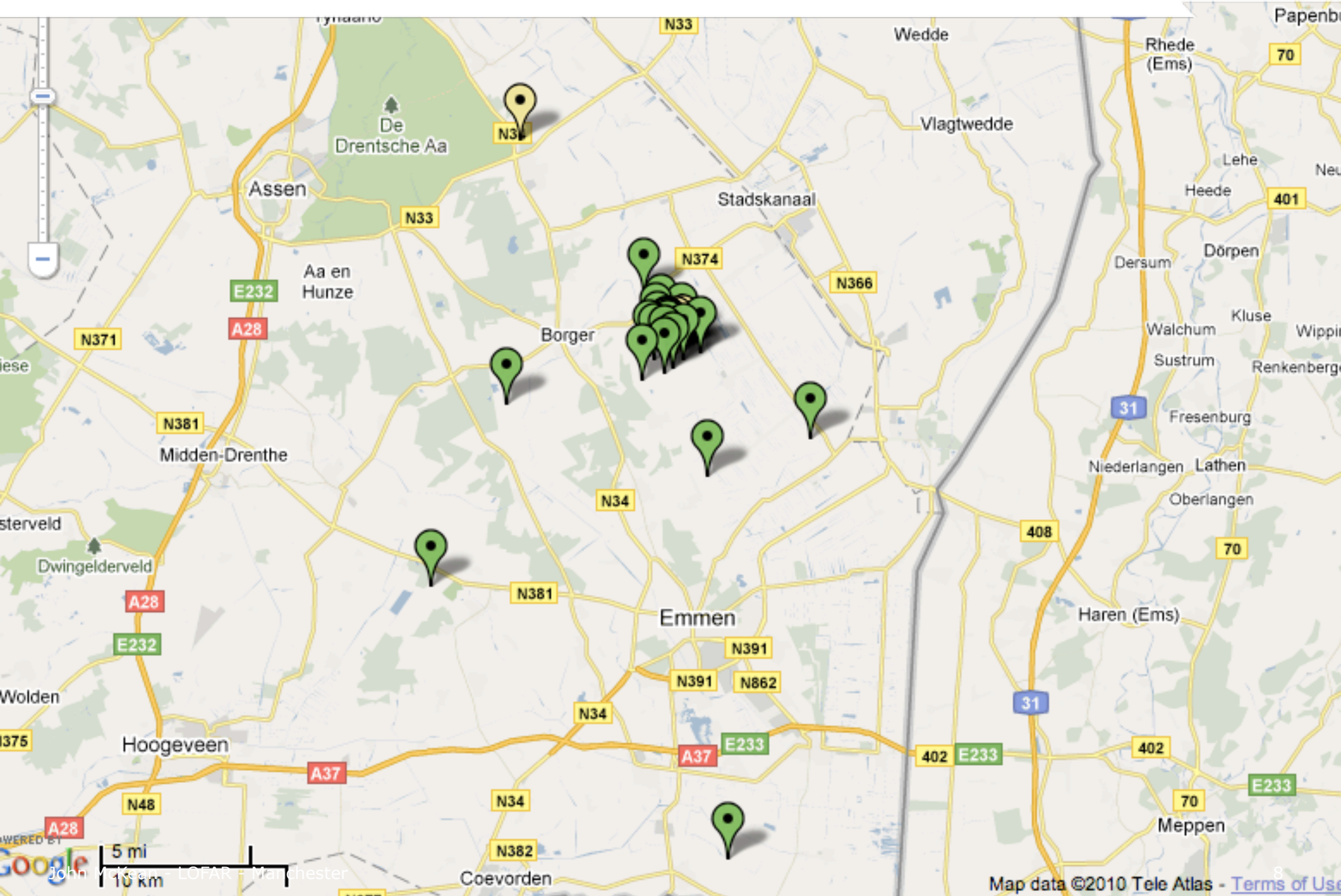
Core stations - 6 station superterp

Remote (16) & International (8) stations

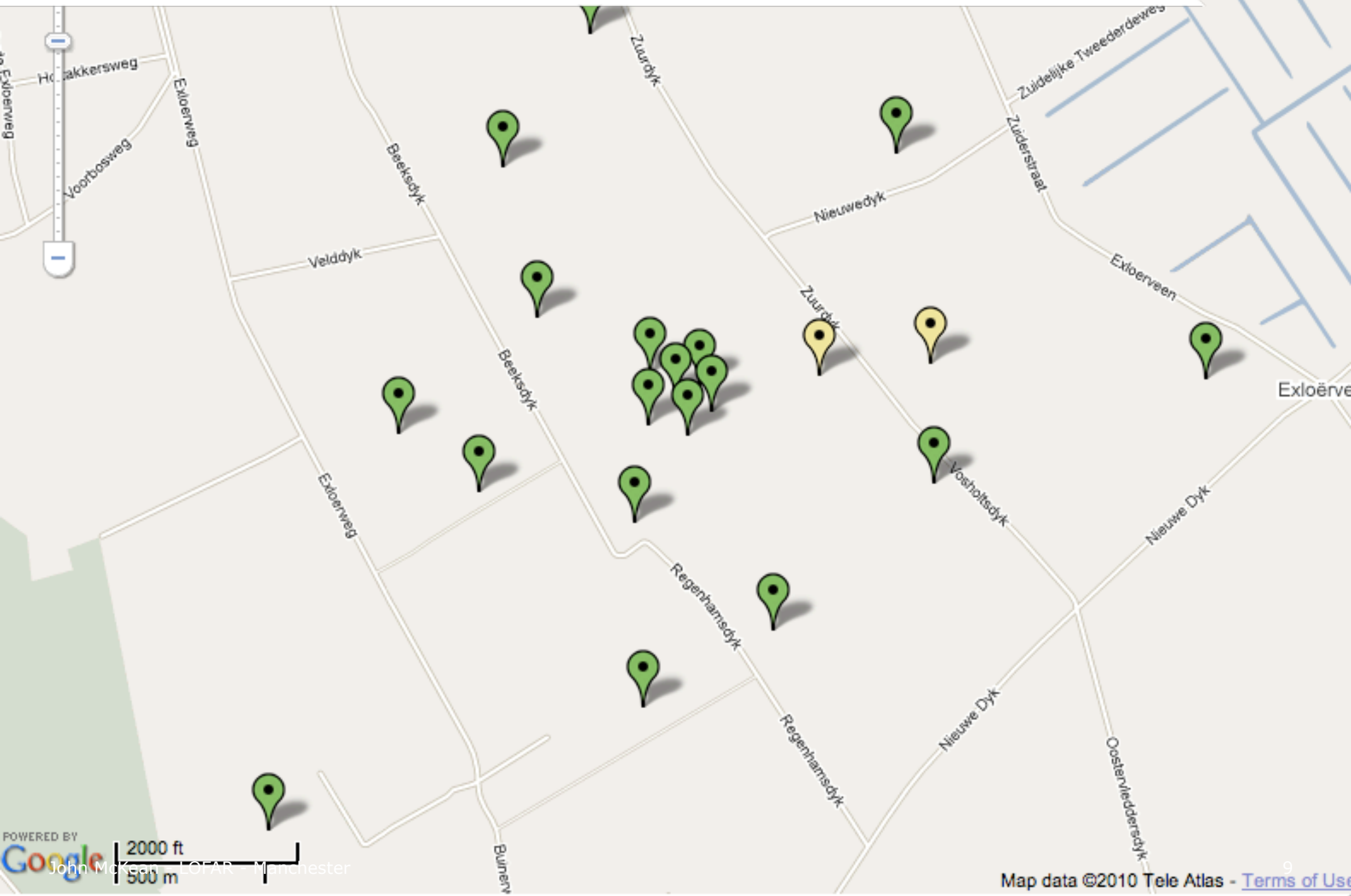
A pan-European array

- 27 stations validated (19 core, 6 remote and 2 International)

A pan-European array



A pan-European array



uv Coverage

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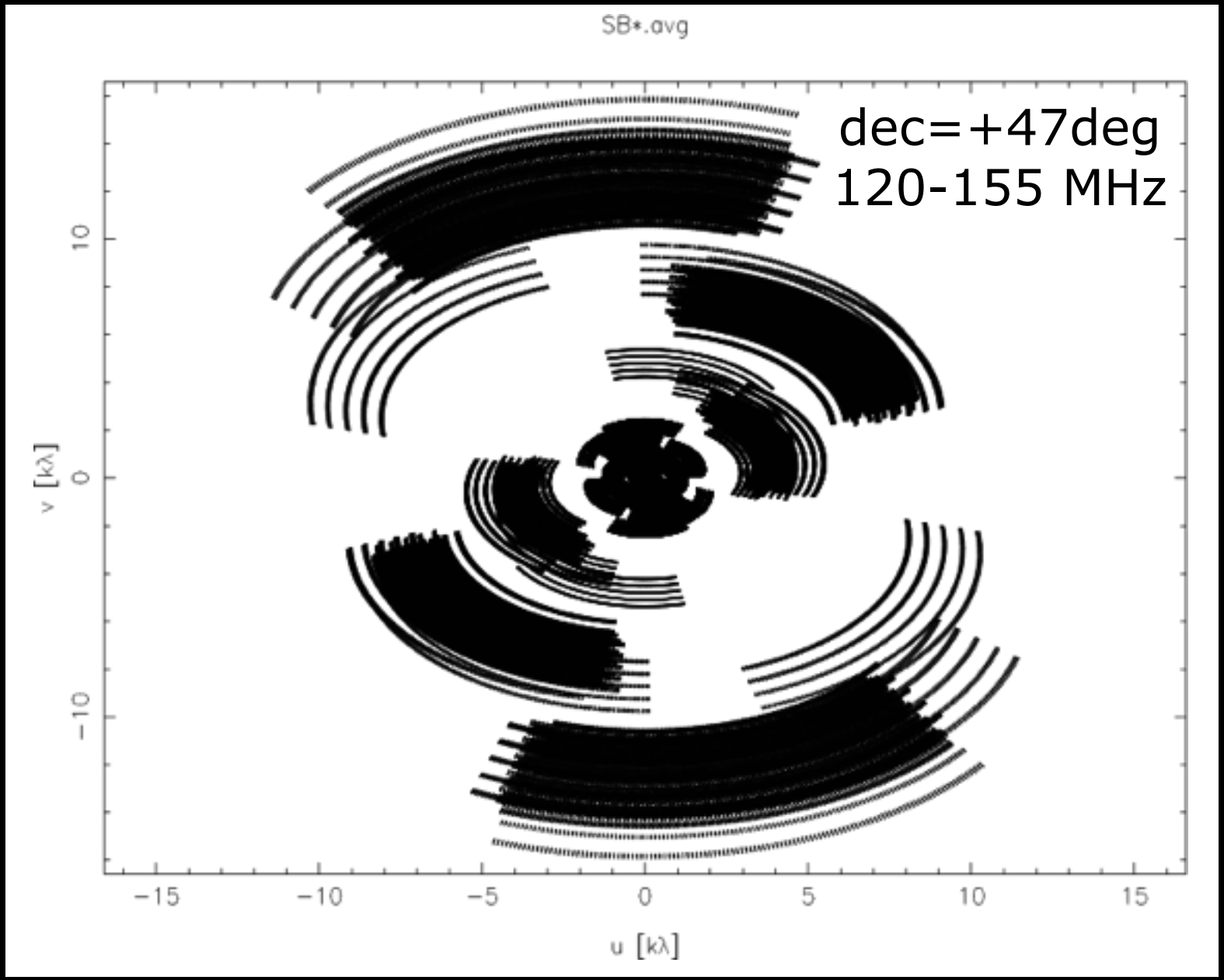
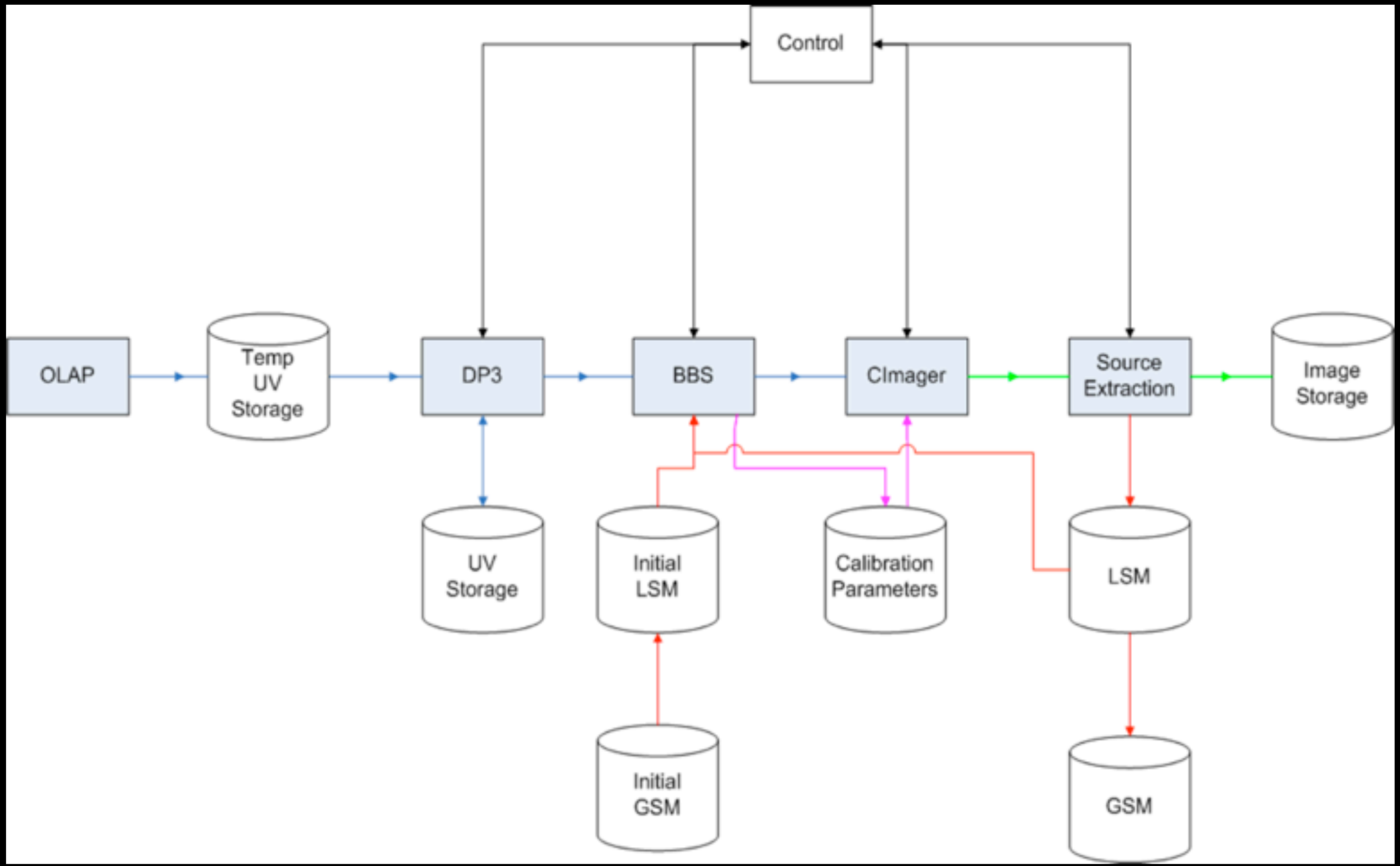
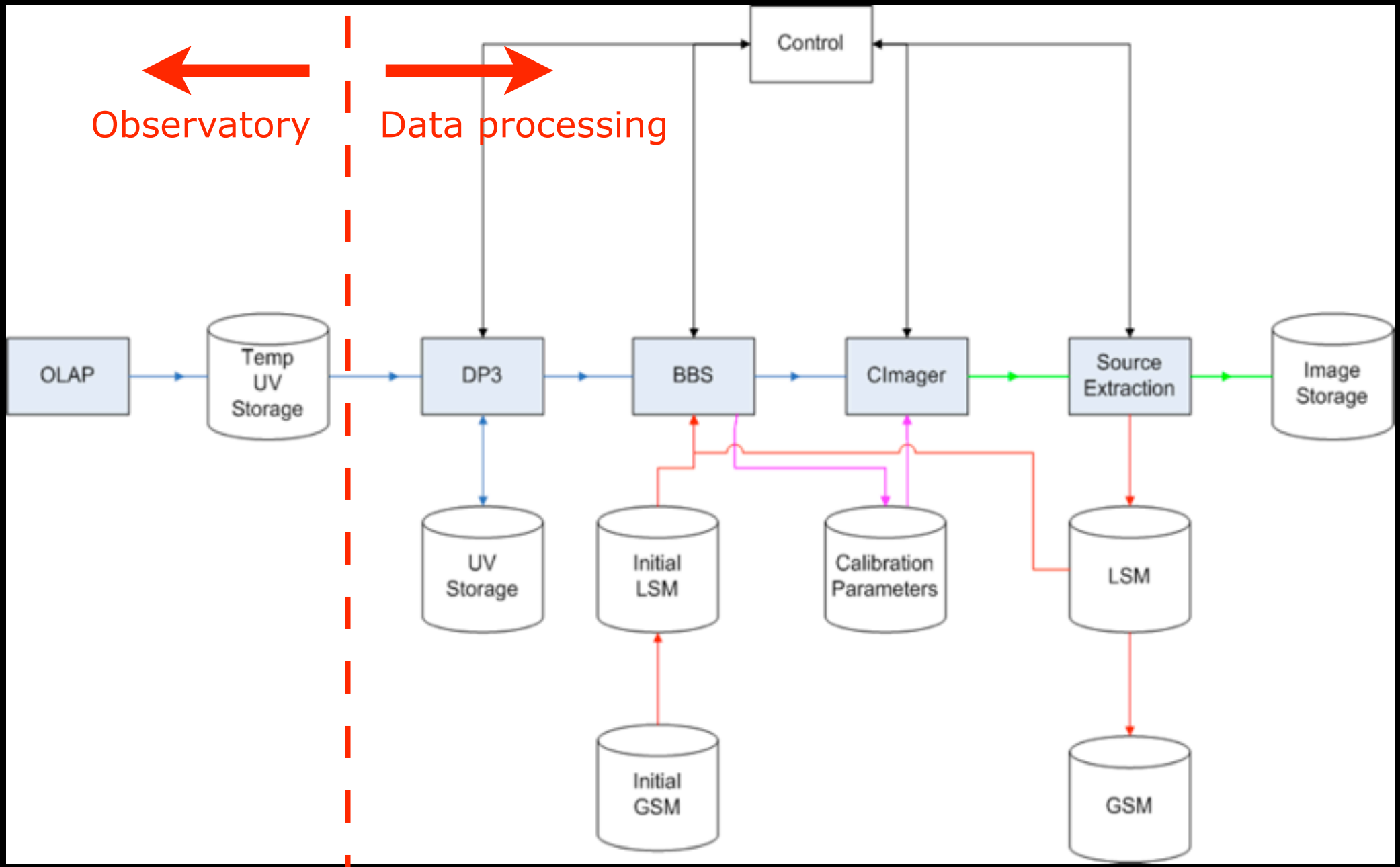


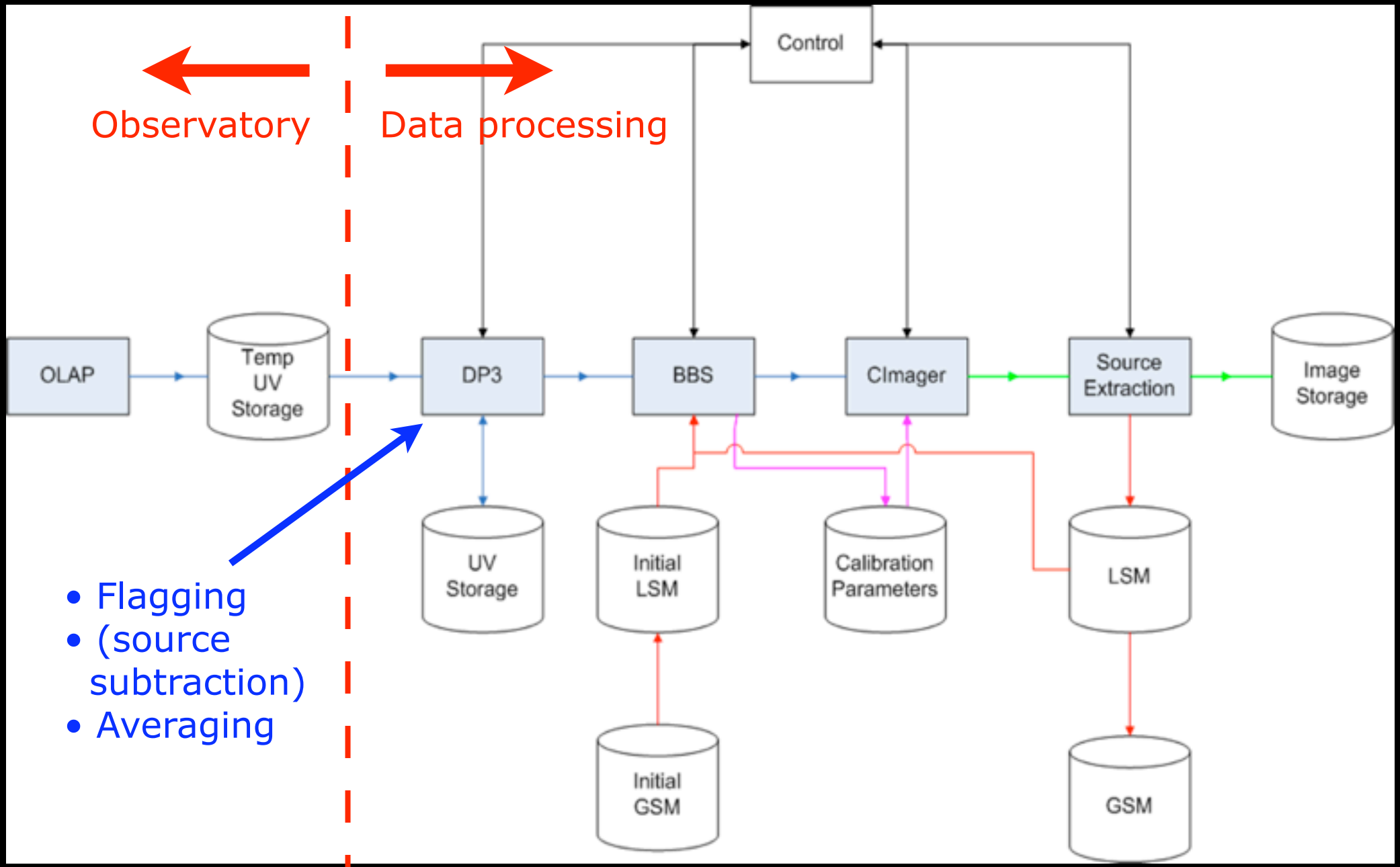
LOFAR imaging pipeline



LOFAR imaging pipeline



LOFAR imaging pipeline



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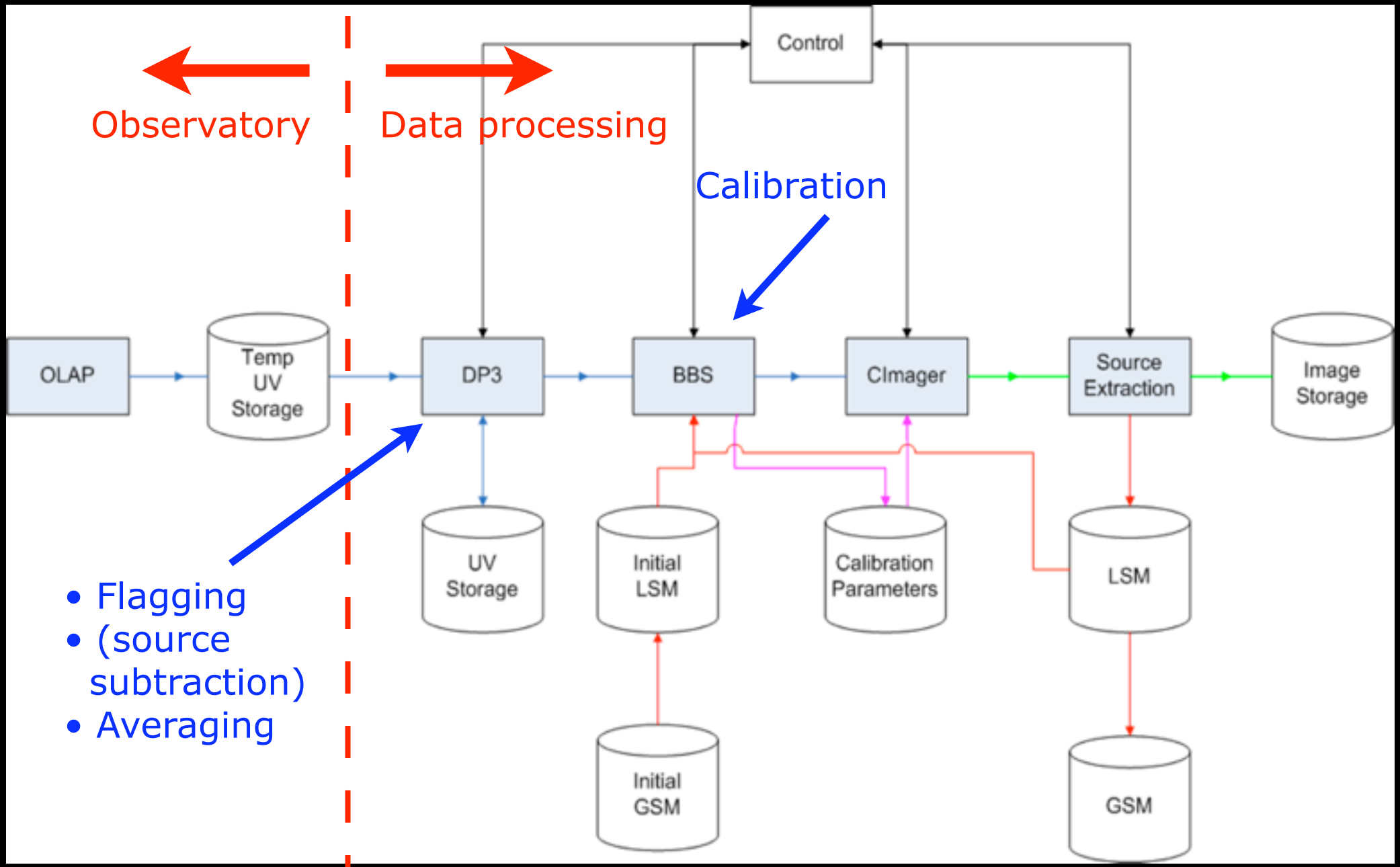

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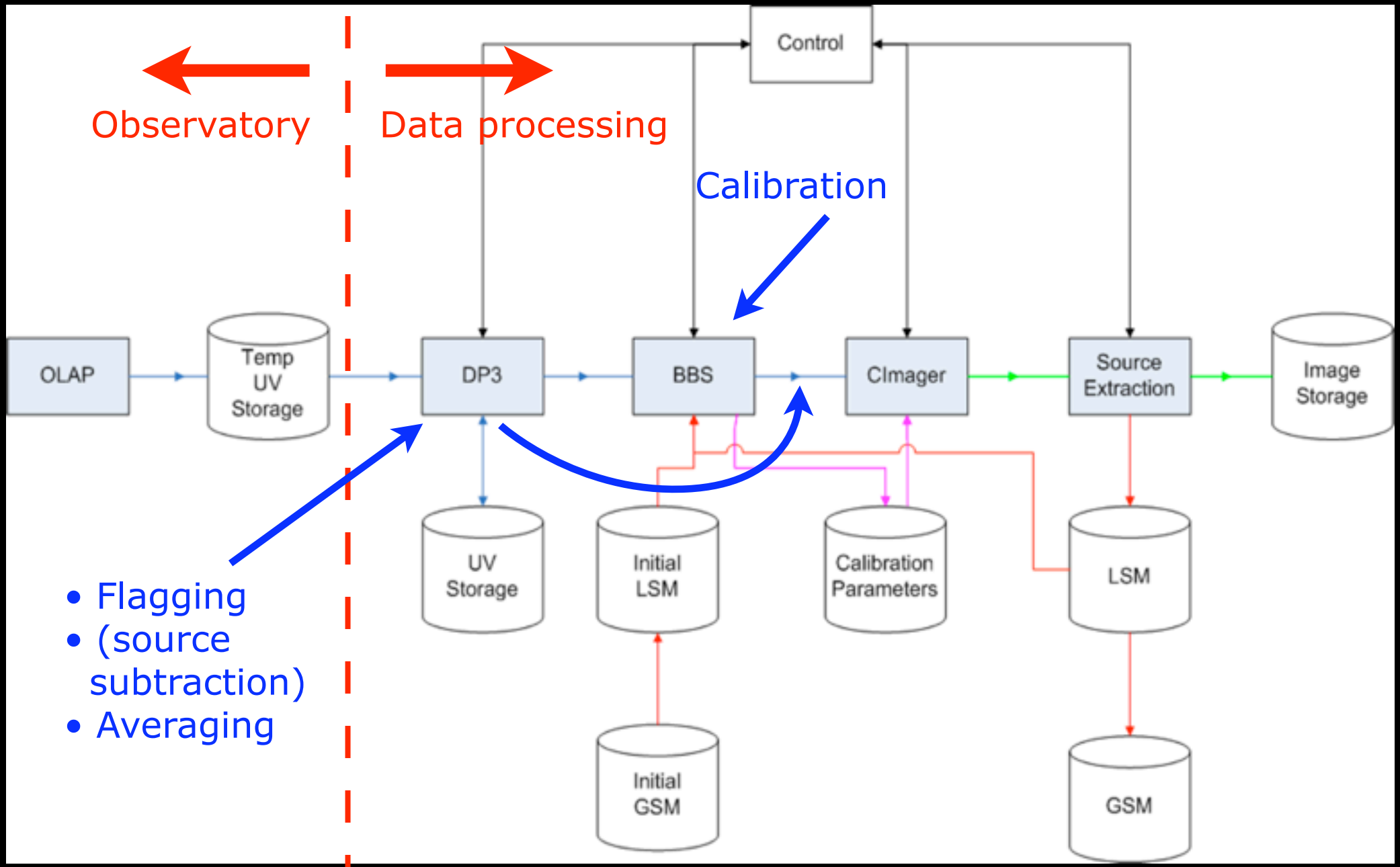

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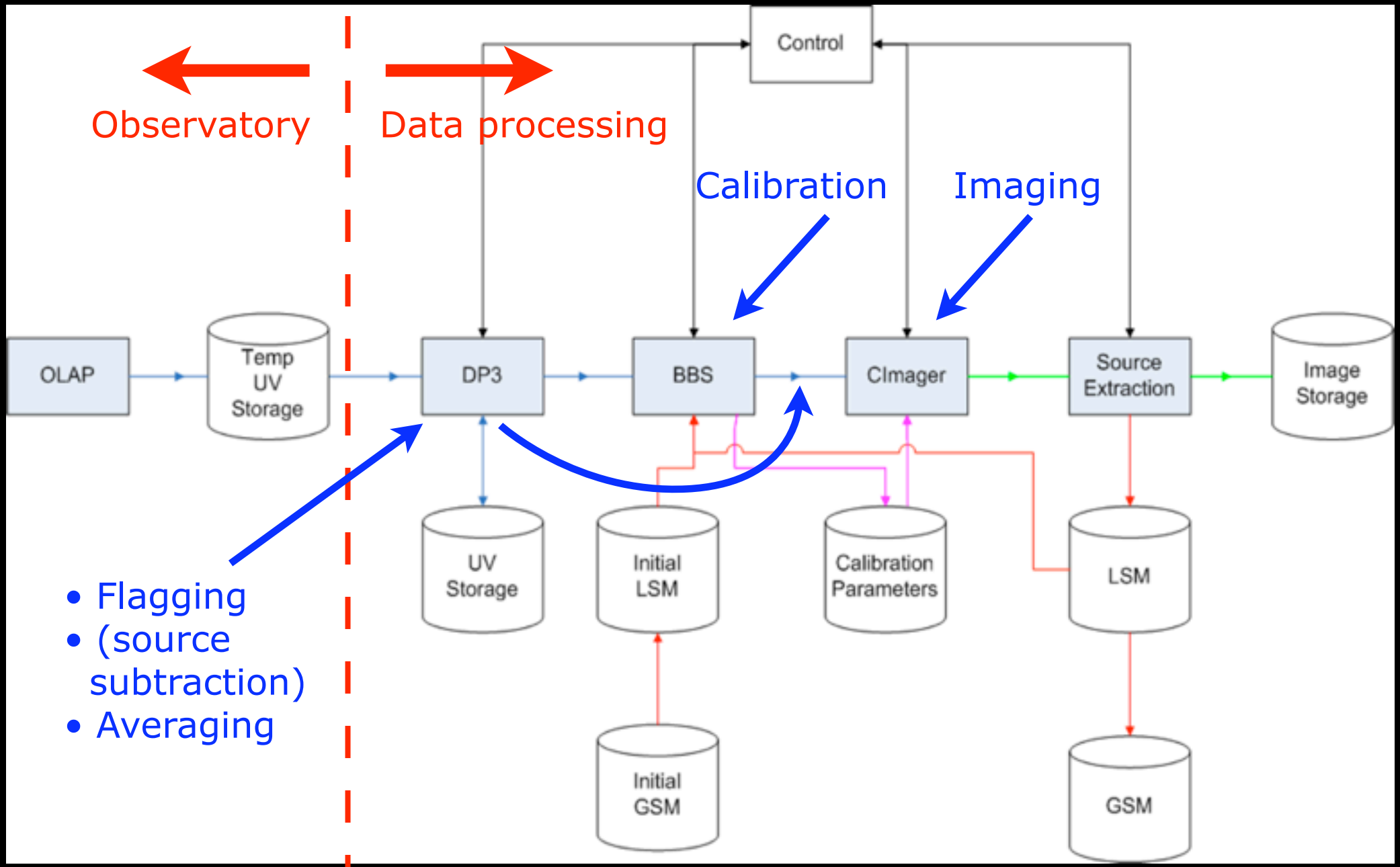
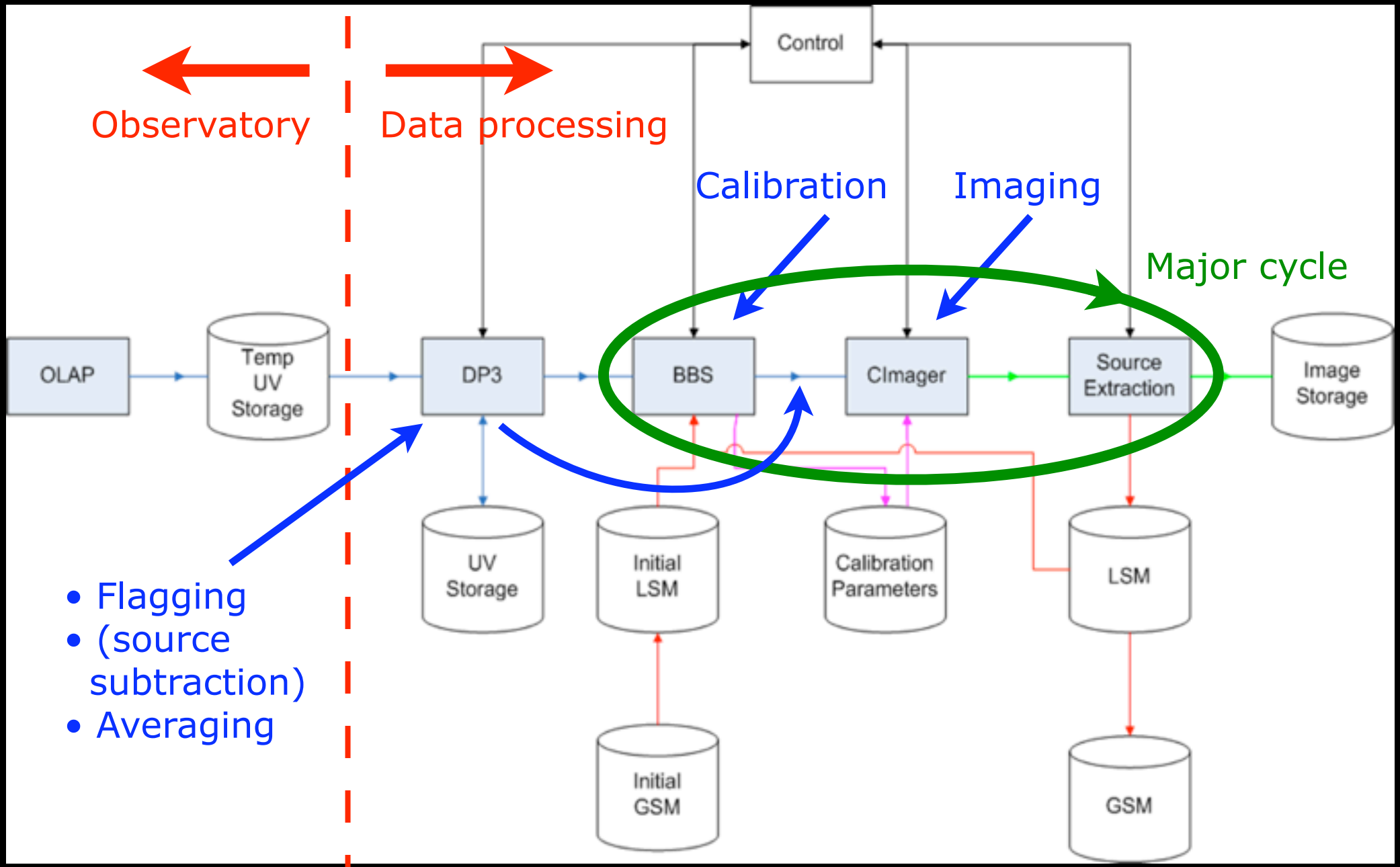
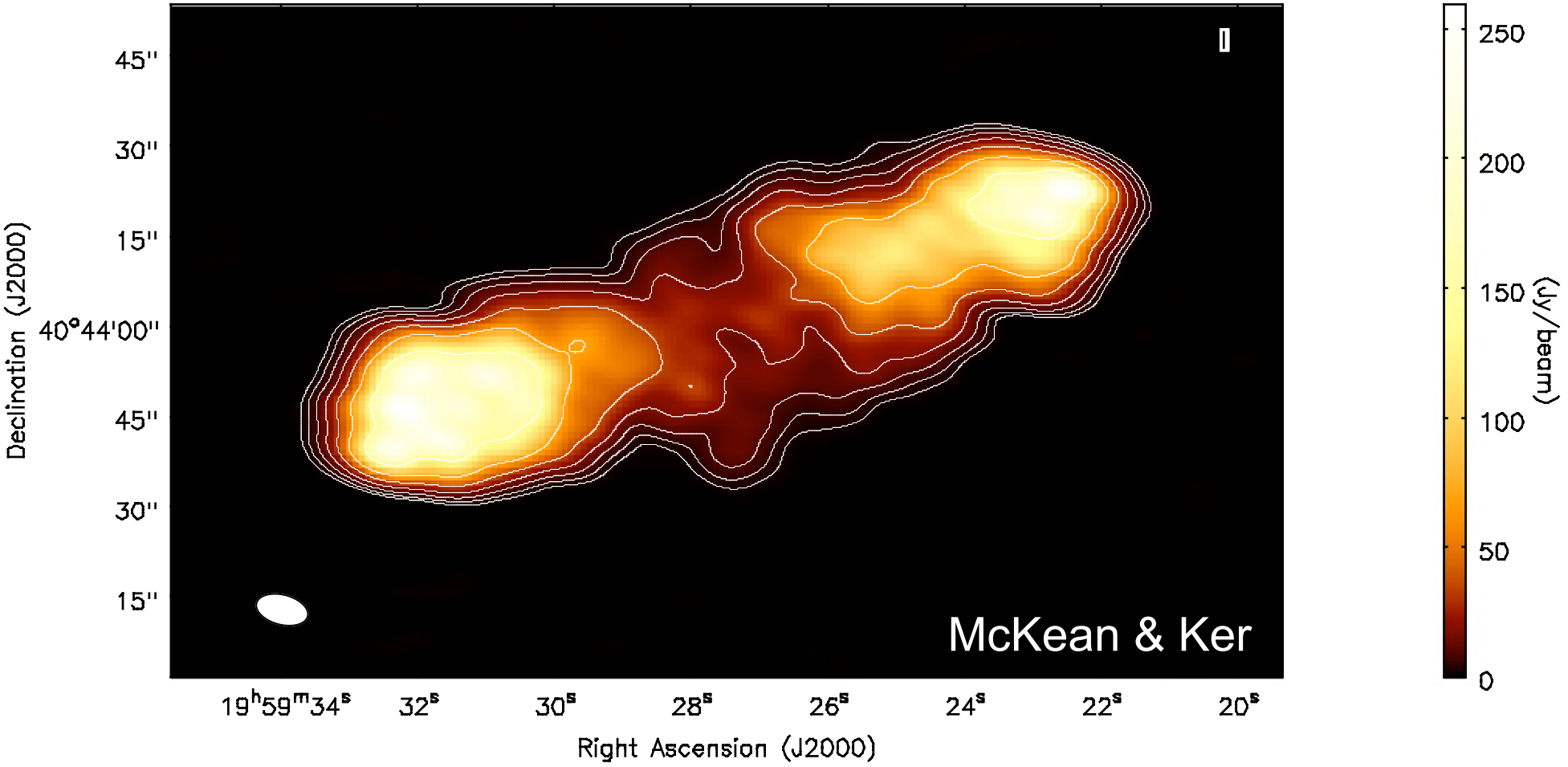


LOFAR imaging pipeline

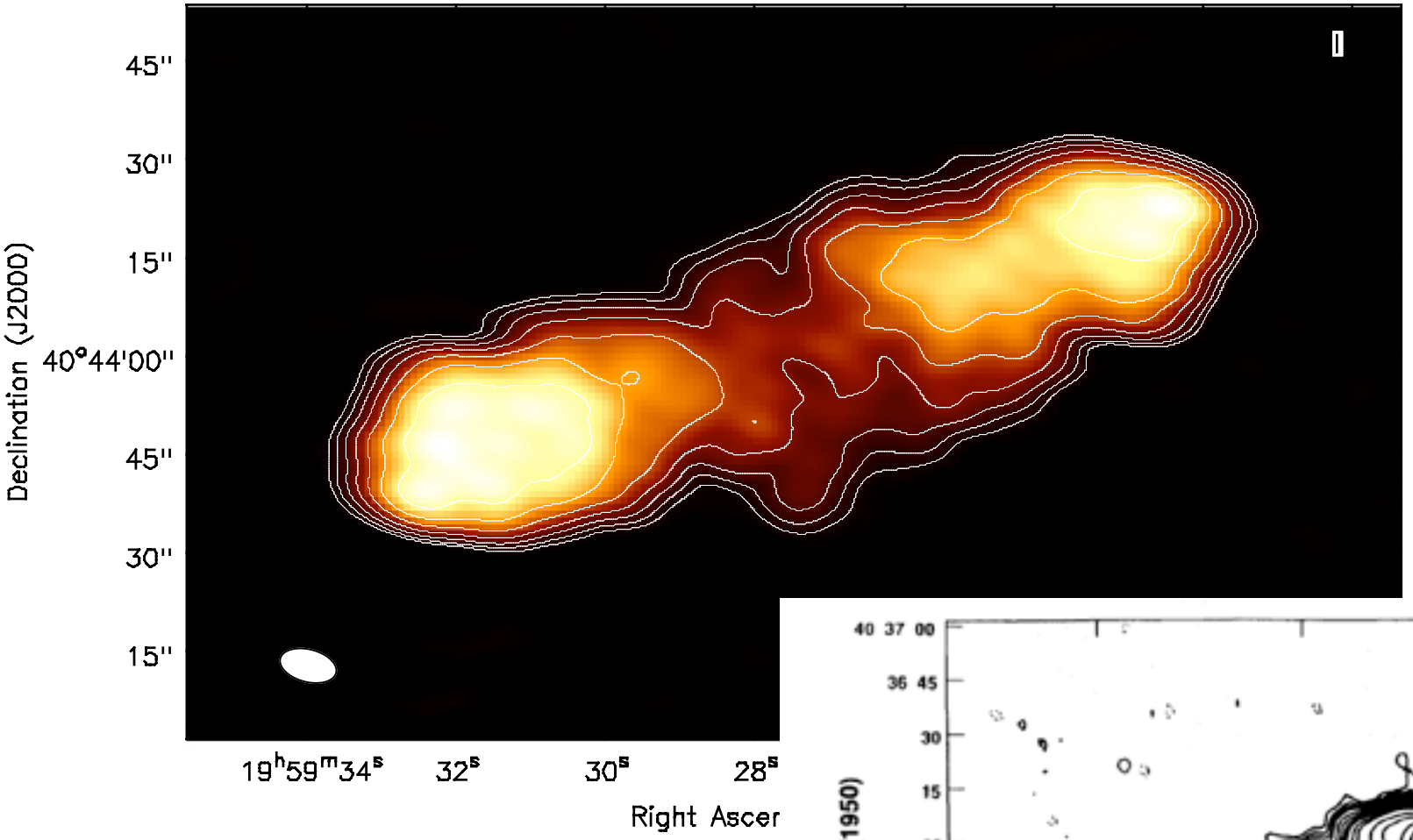


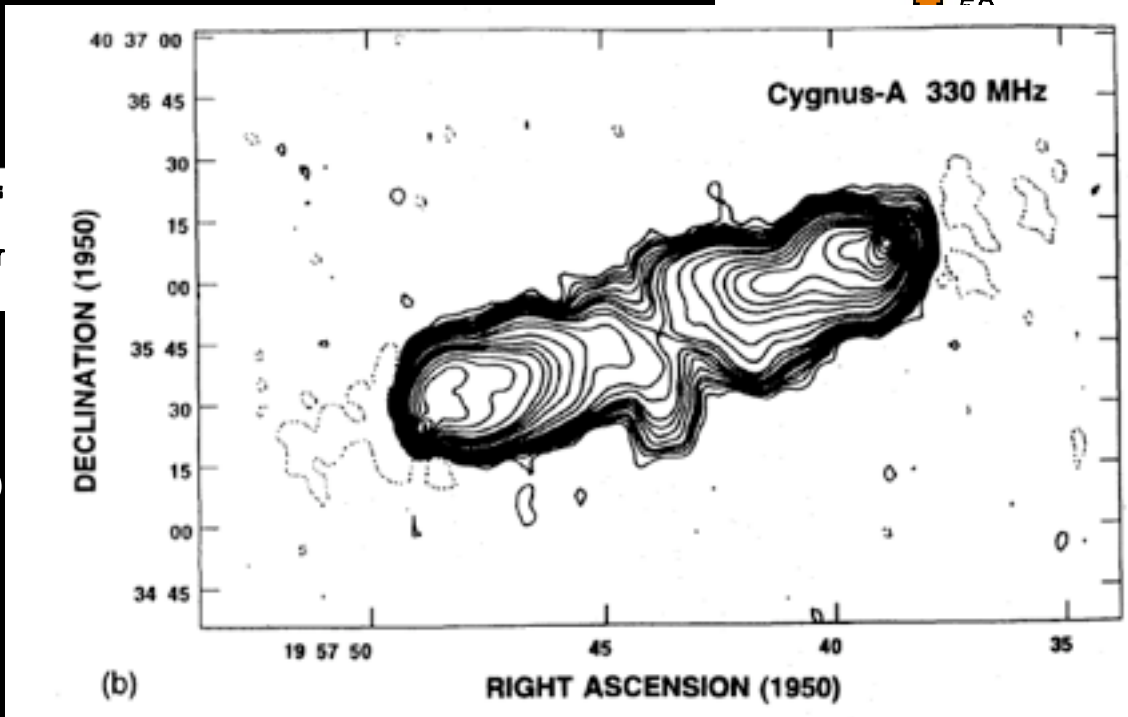
HBA at 240 MHz image Cygnus A



- 220-240 MHz (230 MHz)
- 16 stations (120 Gb x 240 subbands)
- 6 hr observation

HBA at 240 MHz image Cygnus A





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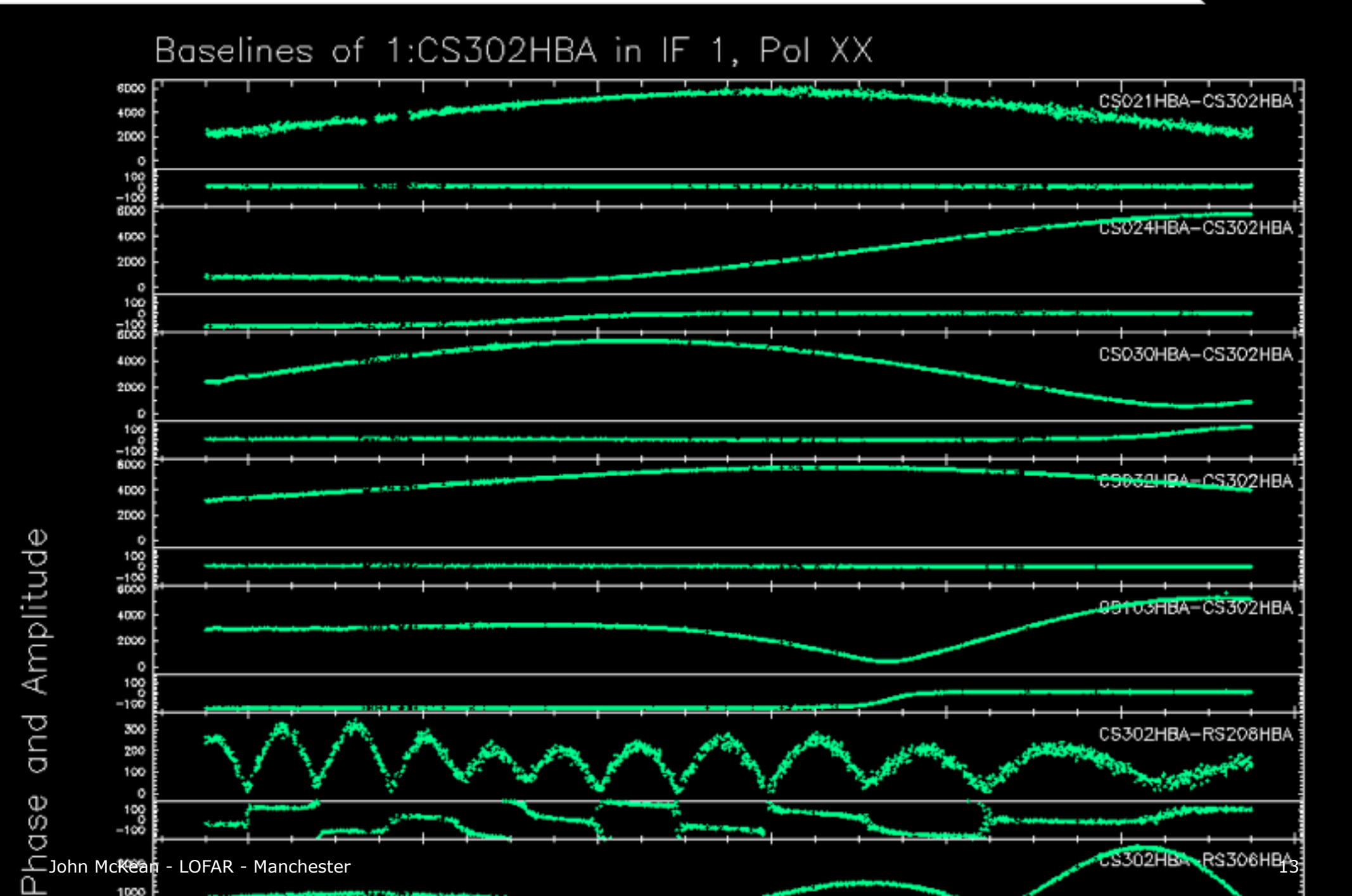
Data quality



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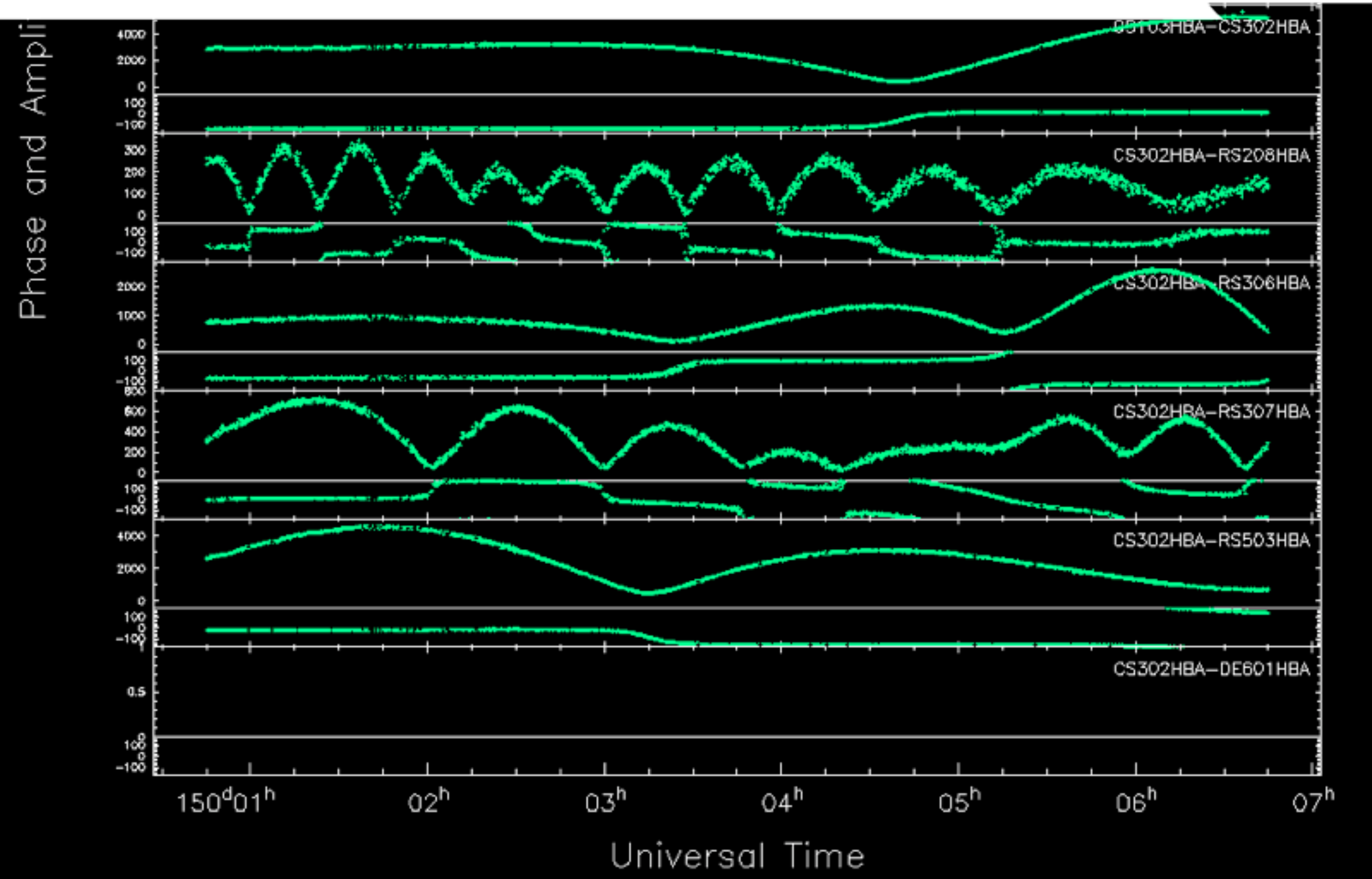
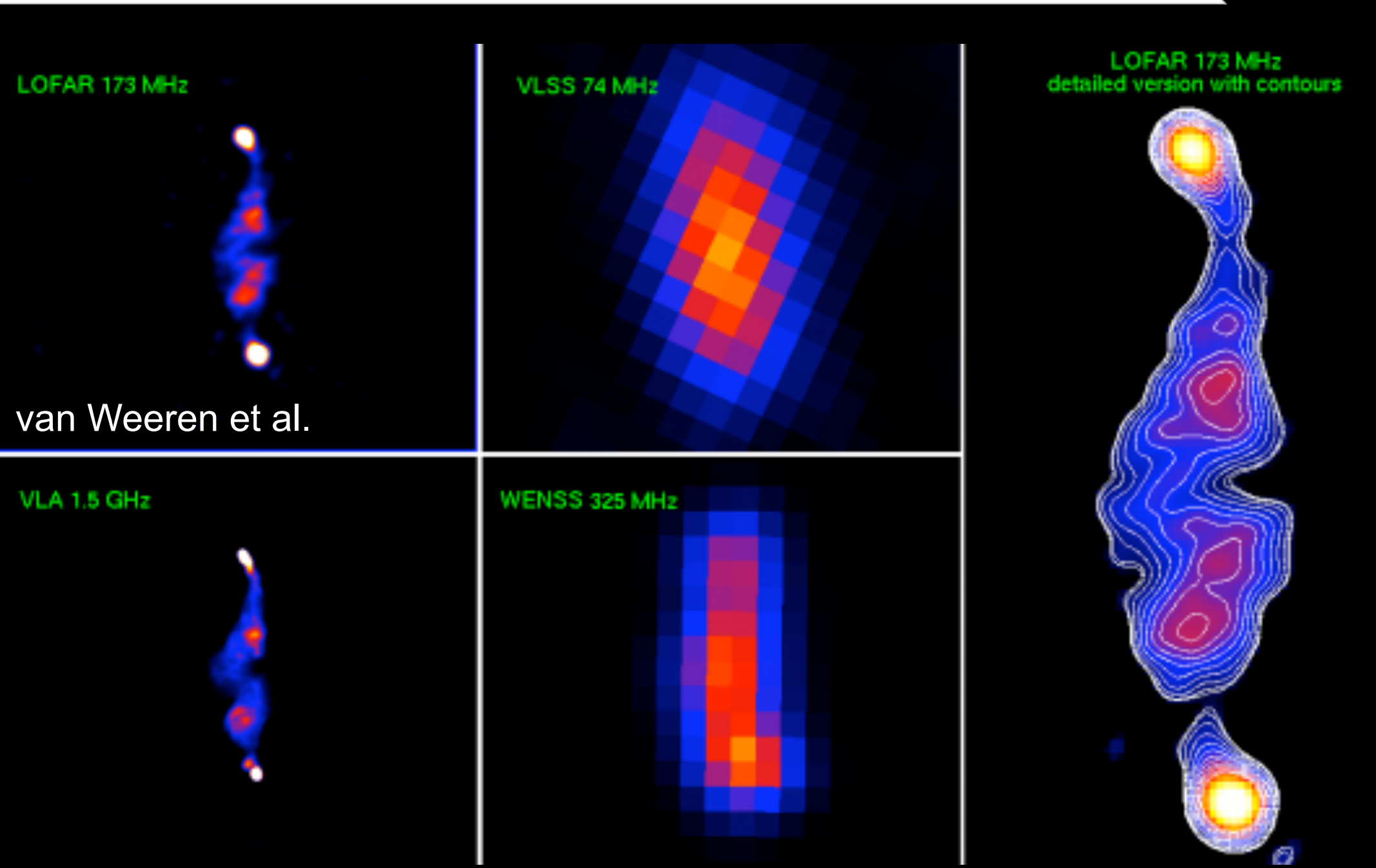
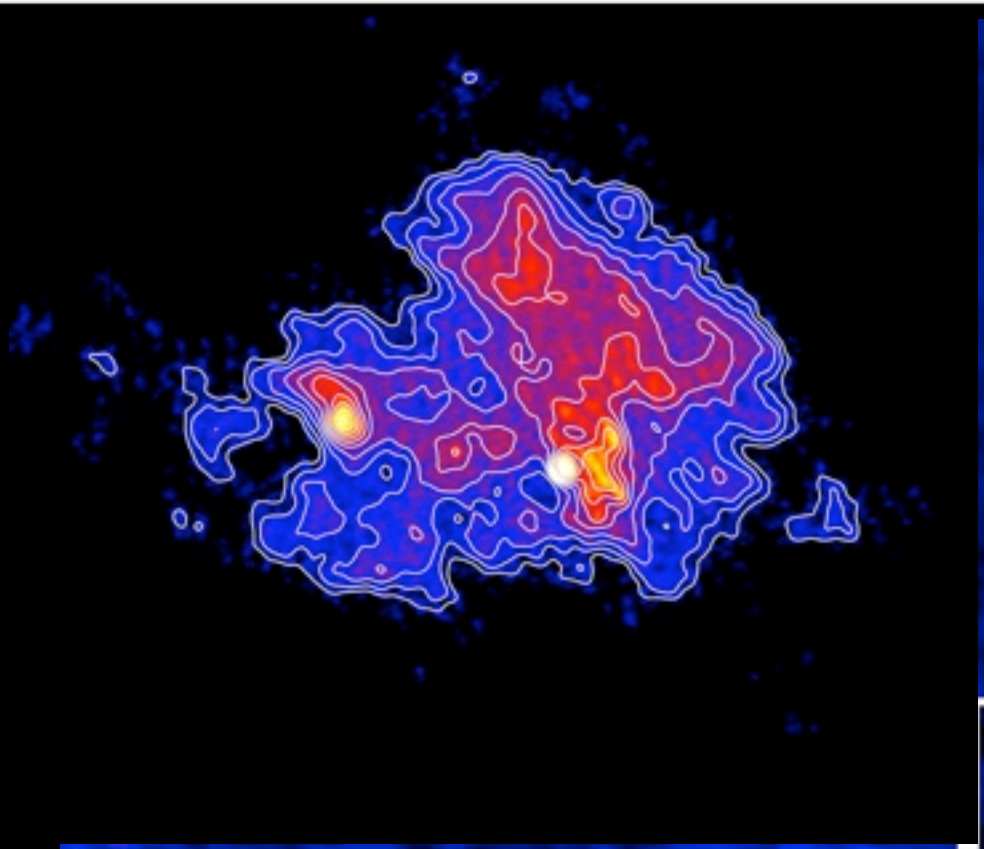
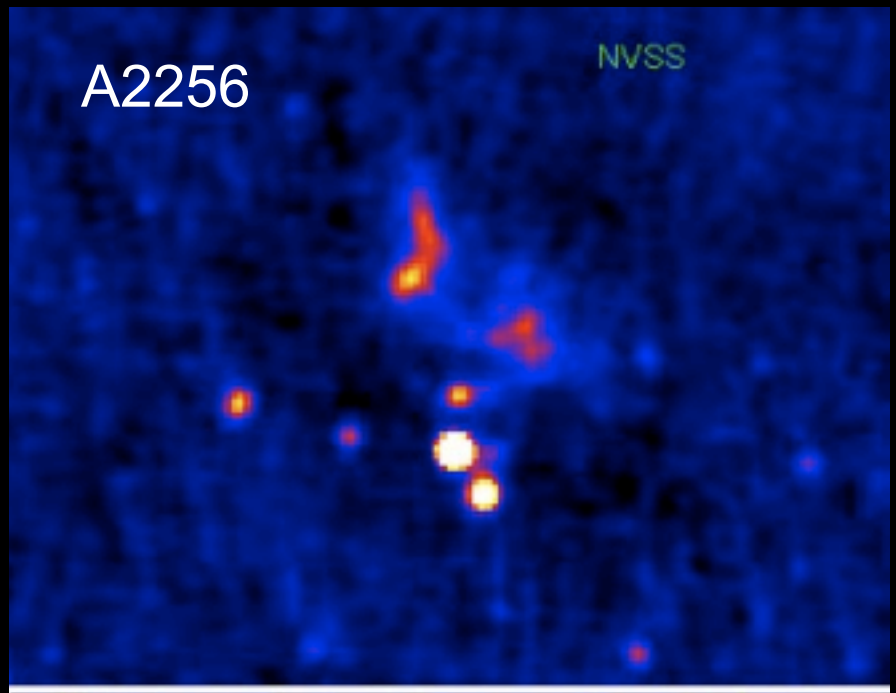


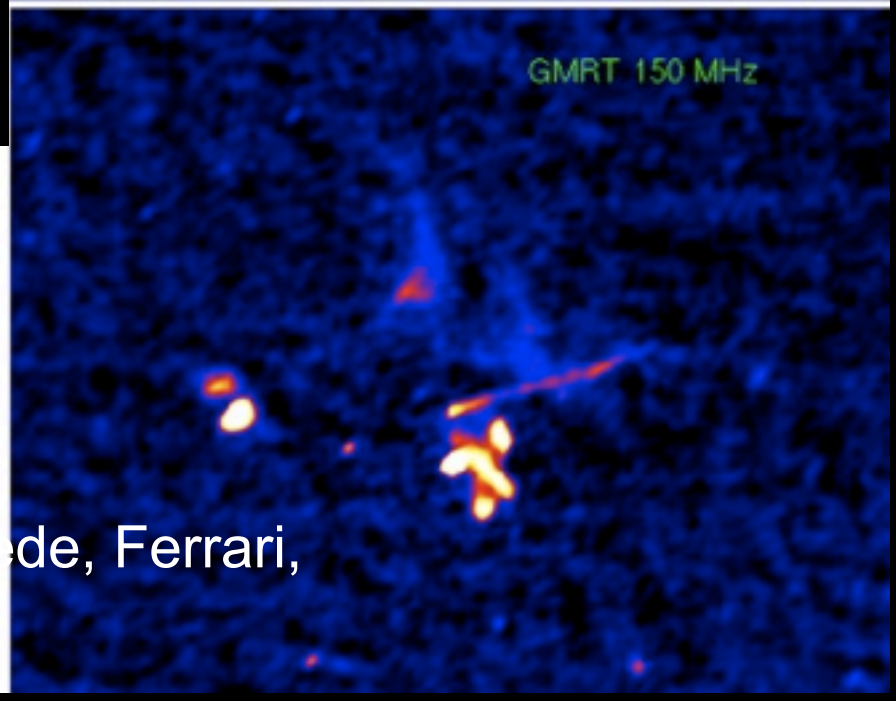
3C61.1 at 173 MHz with LOFAR



Cluster relics and haloes

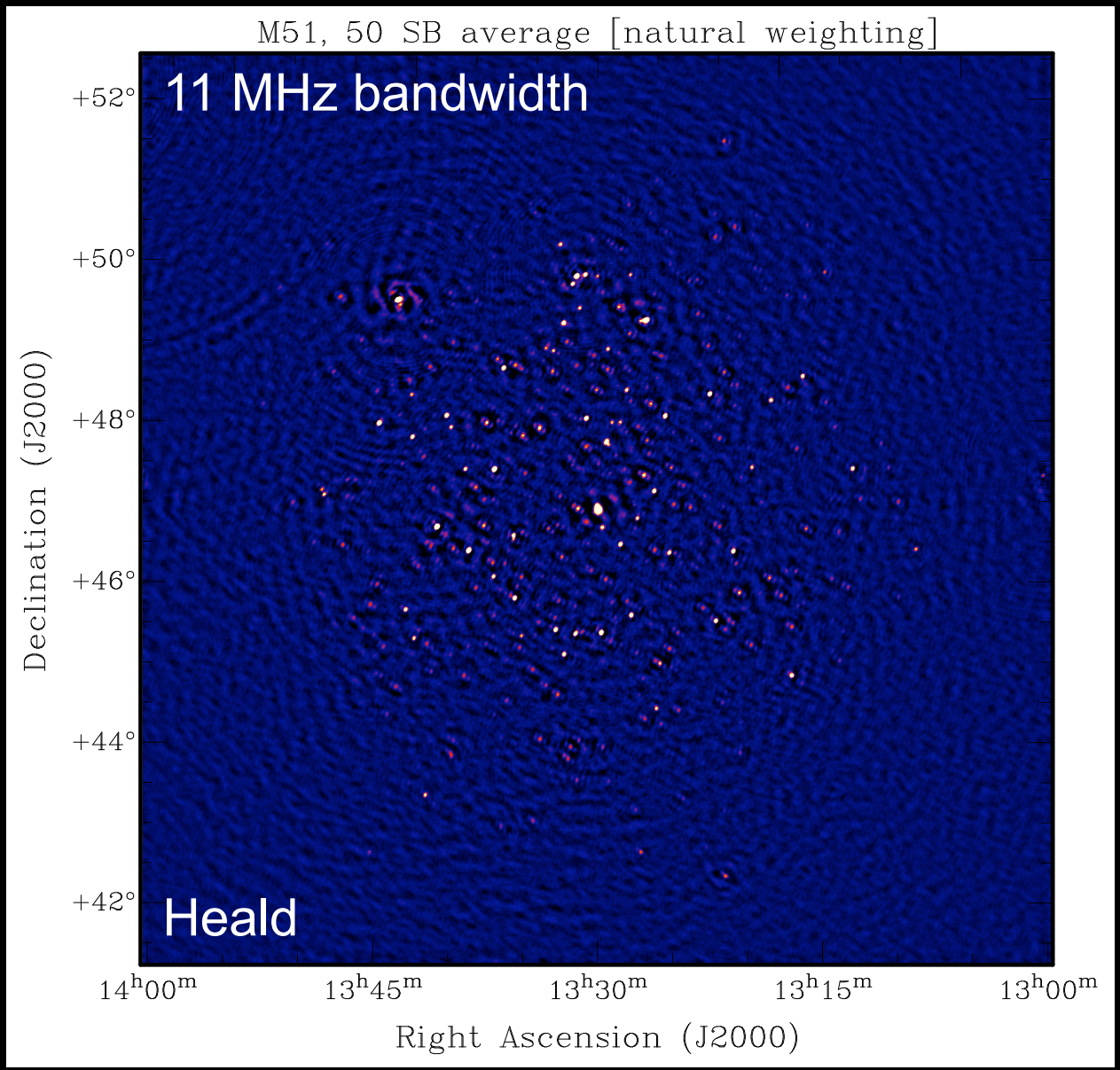




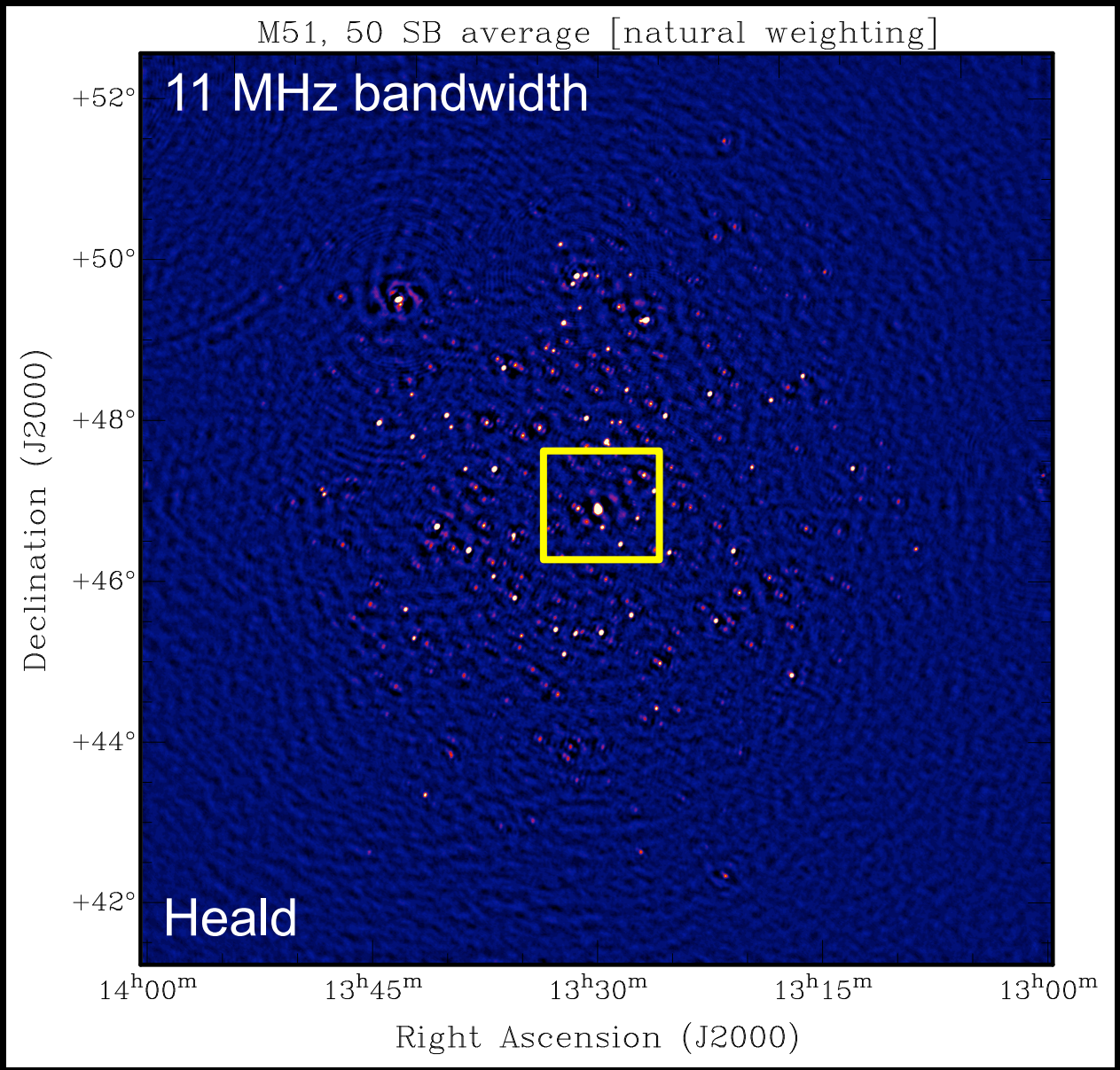


van Weeren, Orru, Pizzo, Bonafede, Ferrari, Macario, Shulebski, van der Tol

M51


M51, 50 SB average [natural weighting]
11 MHz bandwidth
Heald
+52°
+50°
+48°
+46°
+44°
+42°
Declination (J2000)
14h00m
13h45m
13h30m
13h15m
13h00m
Right Ascension (J2000)

M51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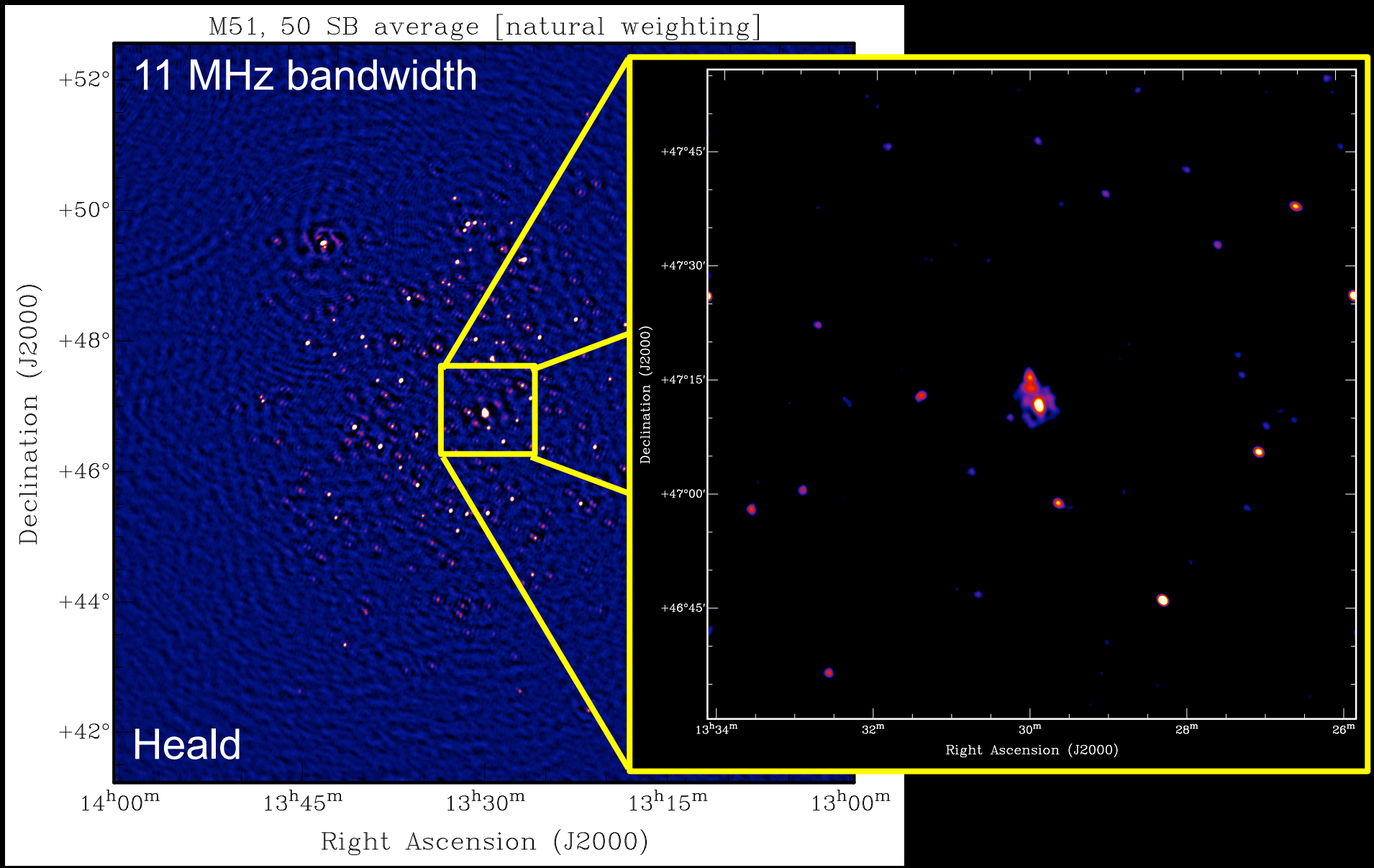
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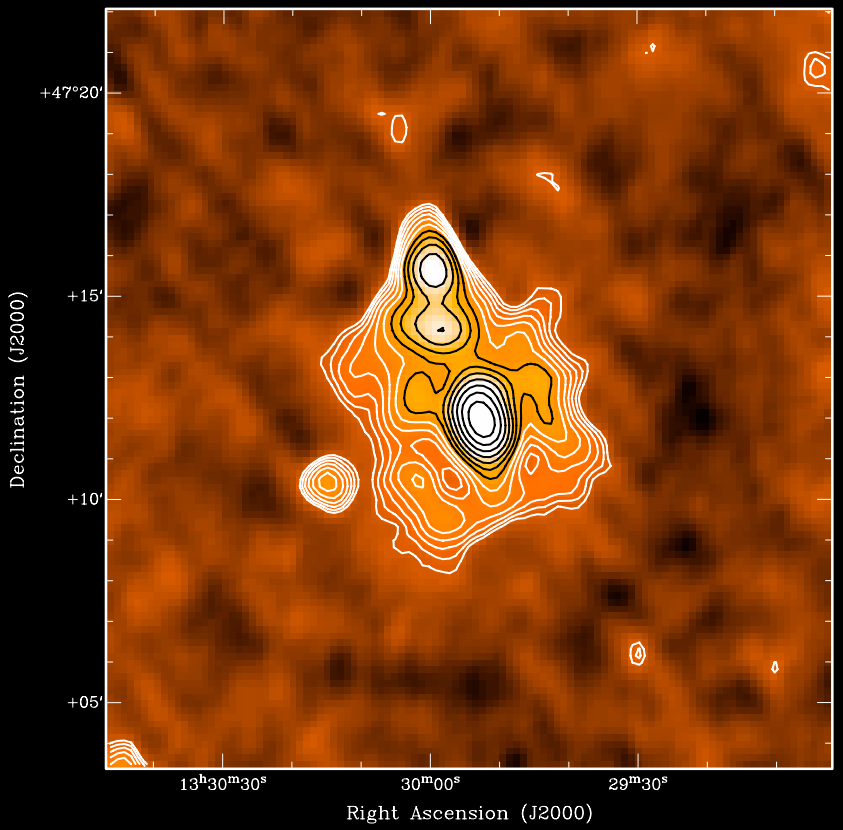
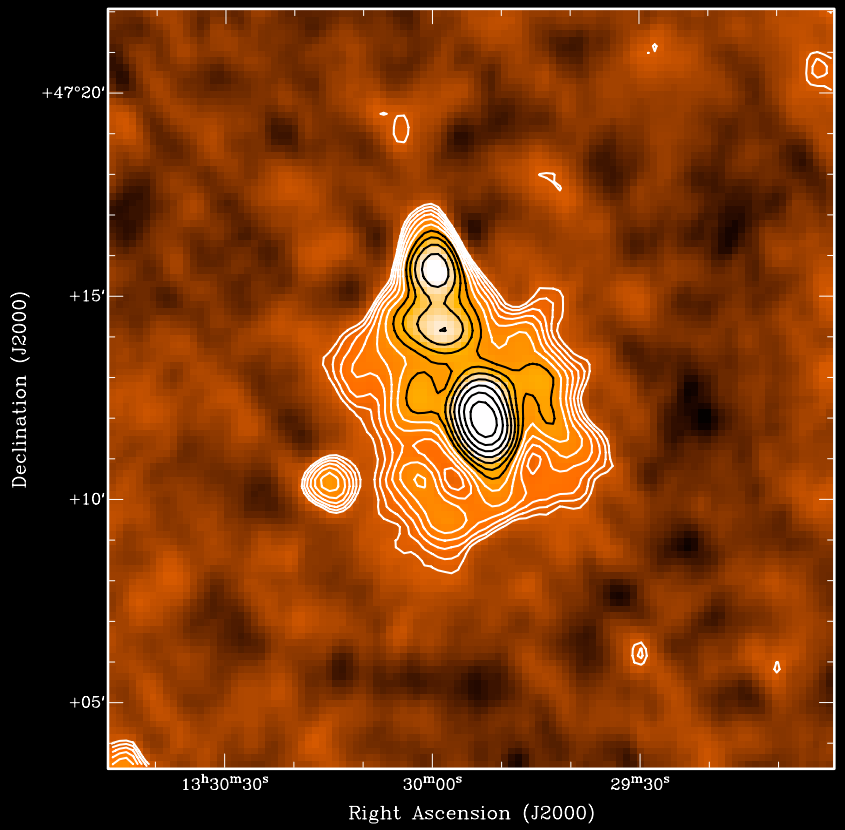
13h45m
13h30m
13h15m
13h00m
Right Ascension (J2000)
+47°45'
+47°30'
+47°15'
+47°00'
+46°45'
Declination (J2000)
13h34m
32m
30m
28m
26m
Right Ascension (J2000)

M51 closeup


+47°20′
+15′
+10′
+05′
Declination (J2000)
13h30m30s
30m00s
29m30s
Right Ascension (J2000)

M51 closeup


+47°20′
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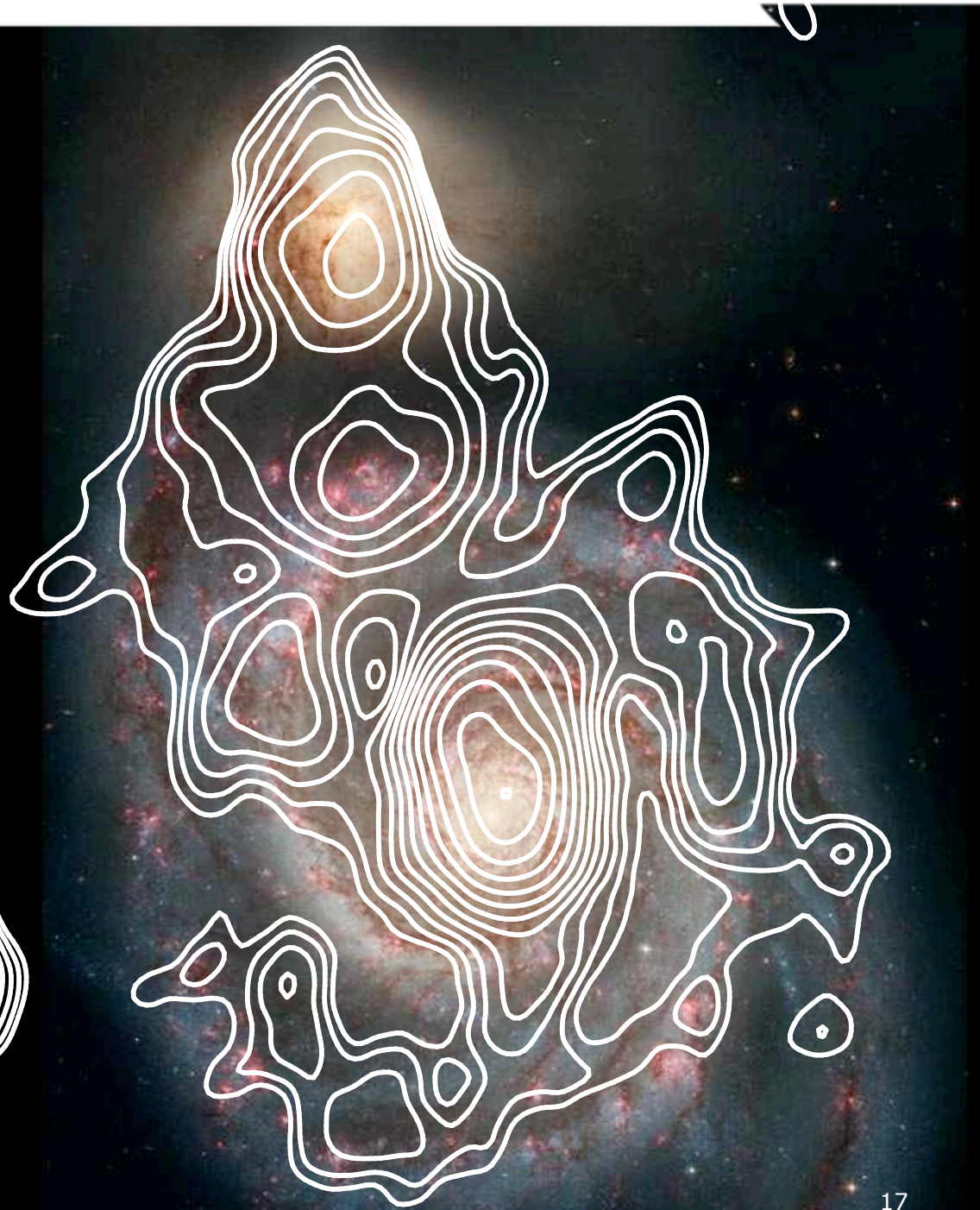
+10′
+05′
Declination (J2000)
13h30m30s
30m00s
29m30s
Right Ascension (J2000)



Current Status and Issues

ASTRON

- The Observatory is testing new hardware (Beamformer) and station calibration => Science Observations
- Wide-field imaging (w-projections and facets).
- Direction dependent gains.
- Removal of the bright radio sources (A-team).
- Computing limitations (we can only just keep up).
- Dynamic range of ~10^4, but we will need much better for EoR.

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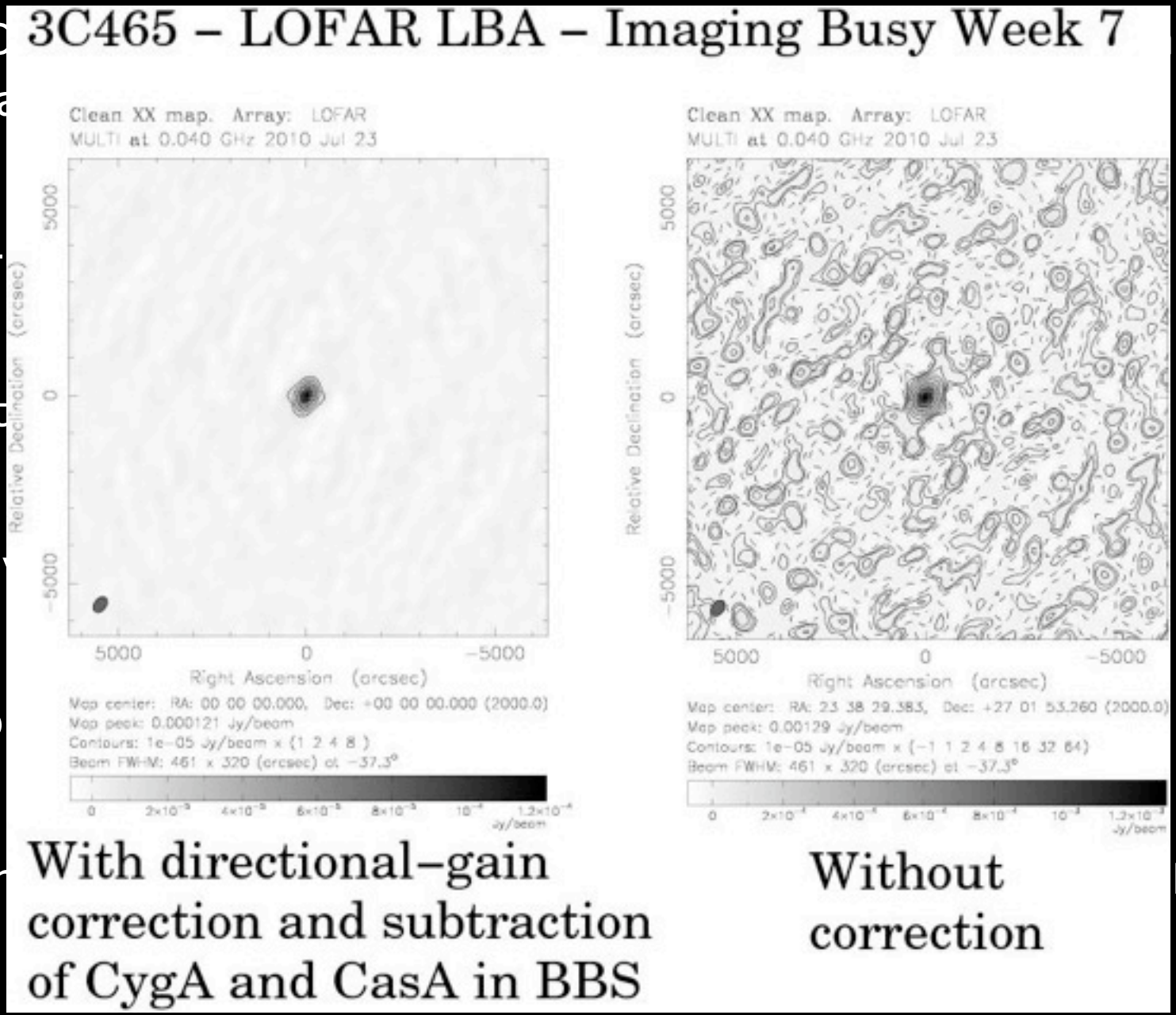
- Wide-…
- Direct…
- Remov…
- Comp…
- Dynar… R.



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Summary

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- LOFAR works as an interferometer, and produces excellent data in both low (30-80 MHz) and high (120-240 MHz) frequency ranges
  - Fringes detected on baseline lengths up to 600 km, even at the lowest frequencies (See Olaf's talk)!
  - First interferometric images made.

- Data flagging, calibration and imaging done as a pipeline and step-by-step manually.

- LOFAR-UK is up and running (See Rob's talk).

- A test site for aperture array technology, LOFAR is a crucial step towards a full (low-frequency) SKA and new science on the way.