ASTRON

Netherlands Institute for Radio Astronomy

The LOFAR Multifrequency Snapshot Sky Survey (MSSS)

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ASTRON is part of the Netherlands Organisation for Scientific Research (NWO)

LOFAR

Outline

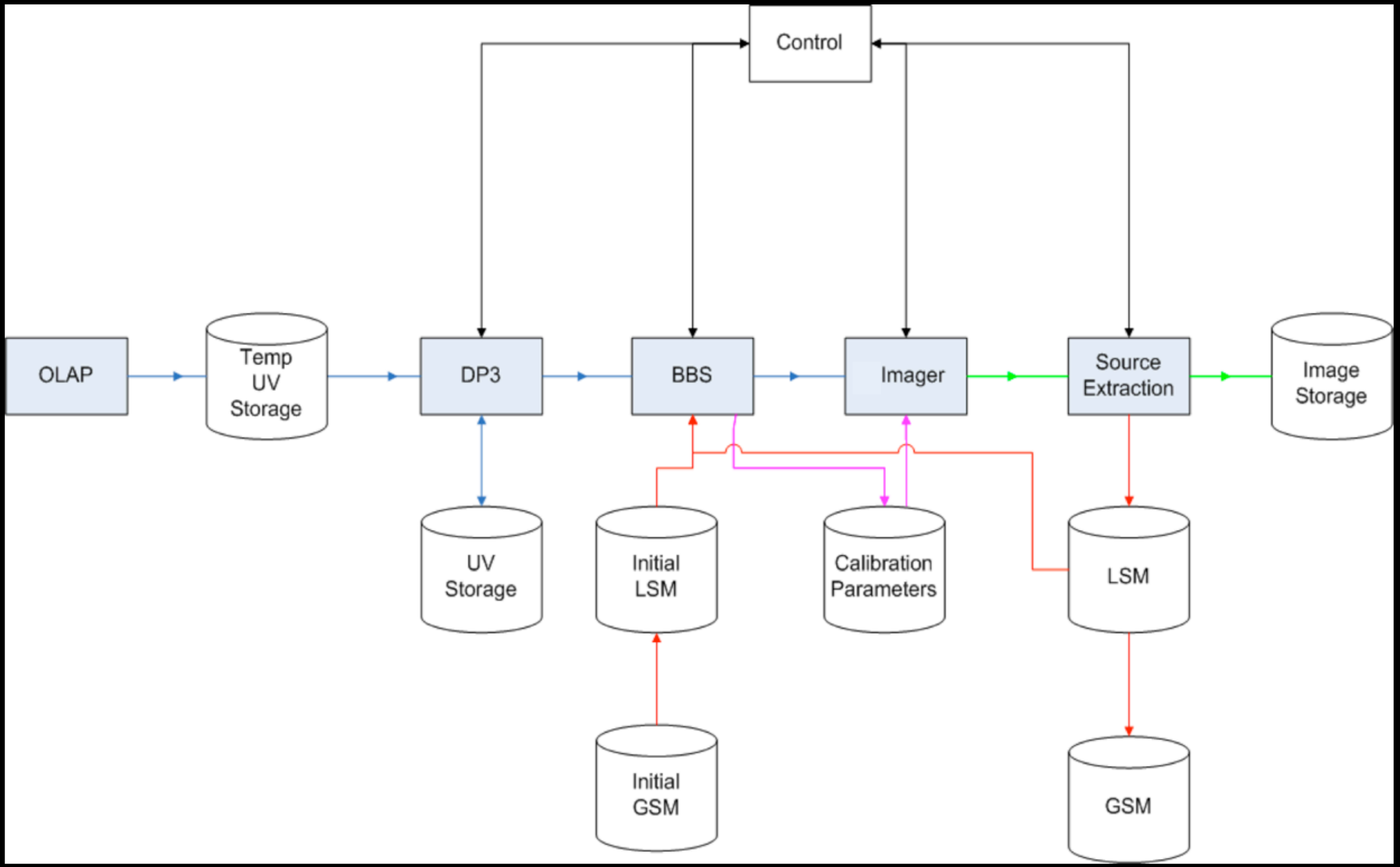
- Standard imaging pipeline: *short* overview
- Why MSSS?
- Survey strategy
- Test observations
- Progress, outlook, and timeline

Standard Imaging Pipeline not covered in much detail...

See Heald et al. (2010,2011), arXiv:1008.4693, arXiv:1106.3195

and also the Imaging Cookbook!

LOFAR standard imaging pipeline



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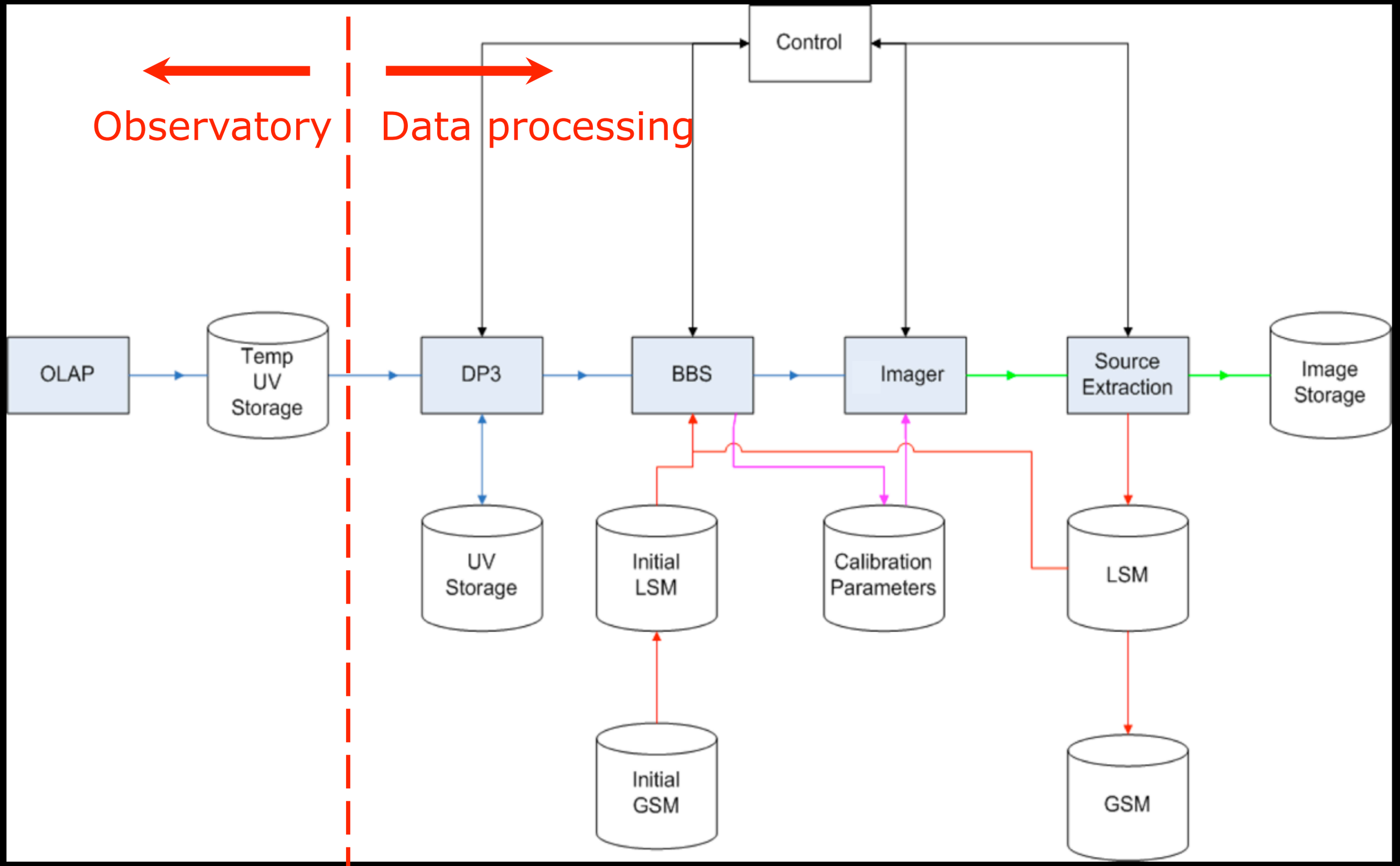

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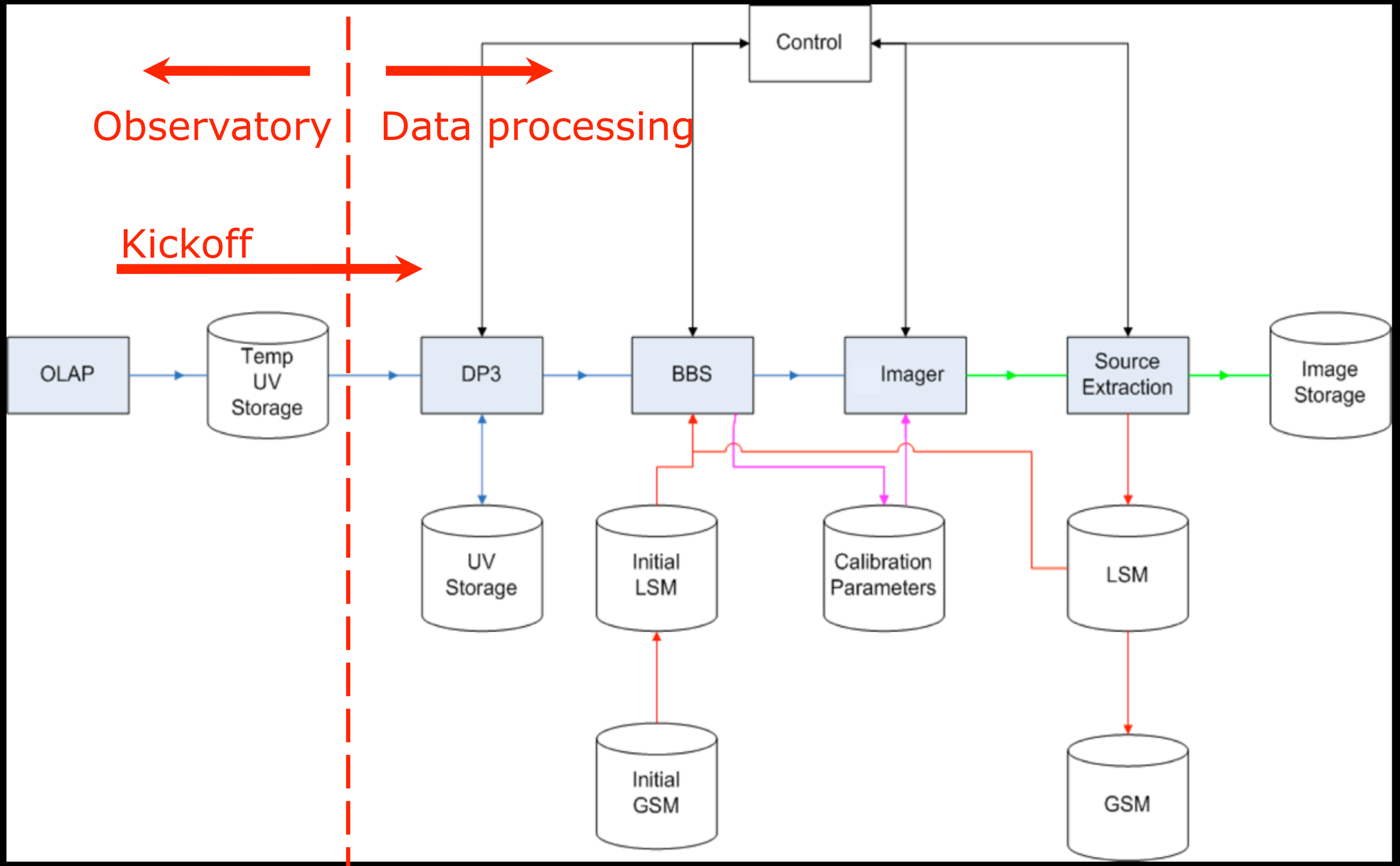

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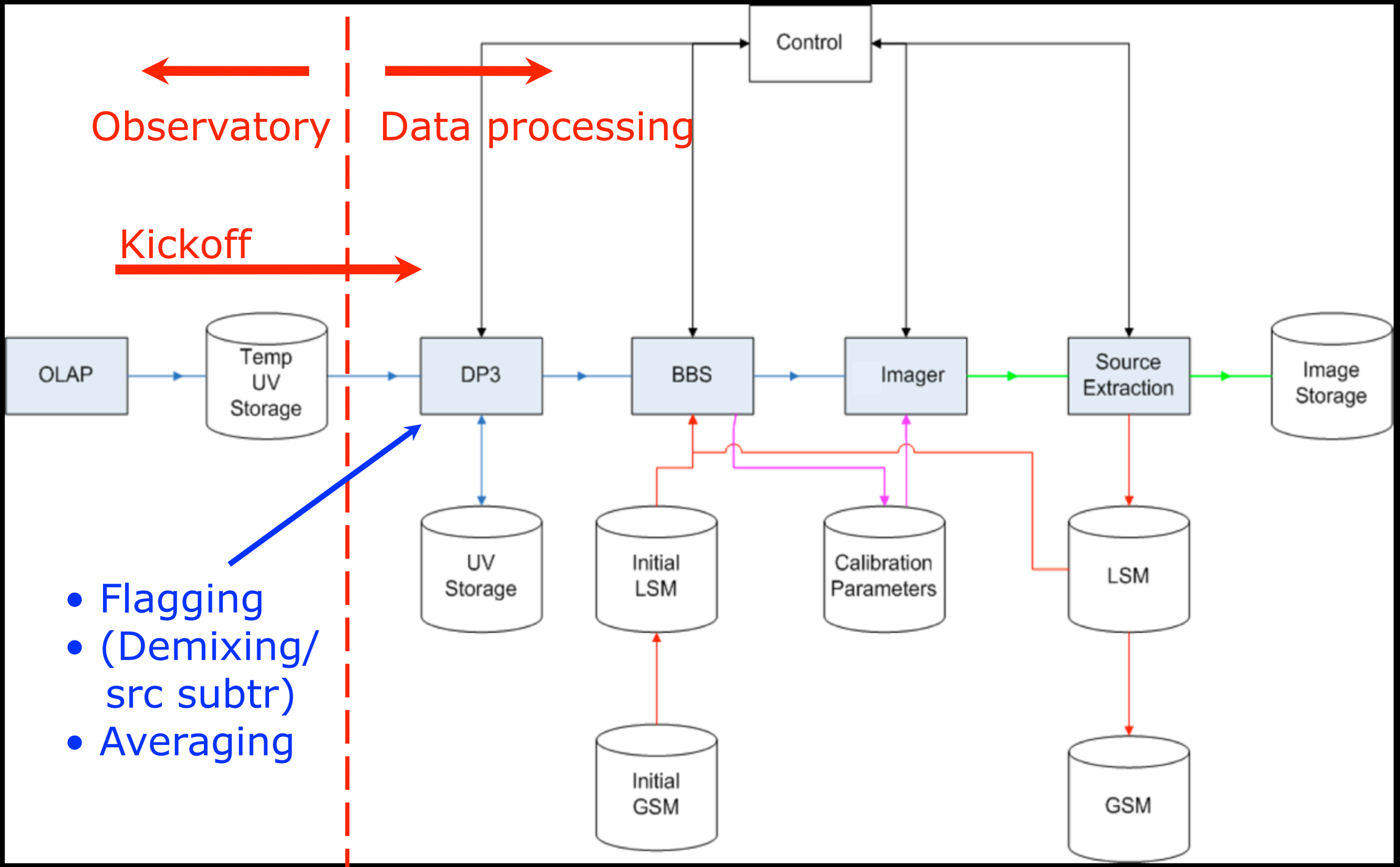

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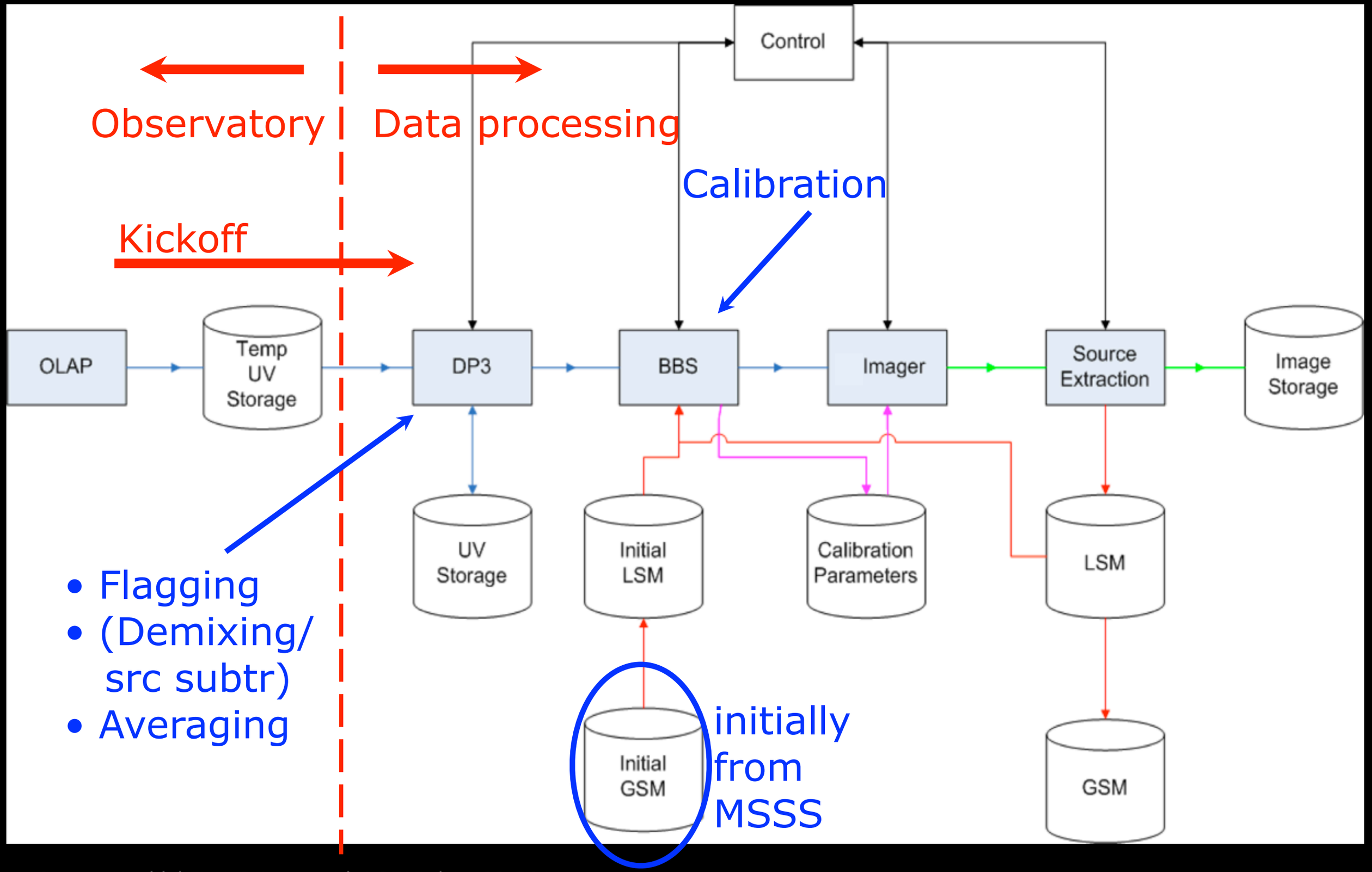

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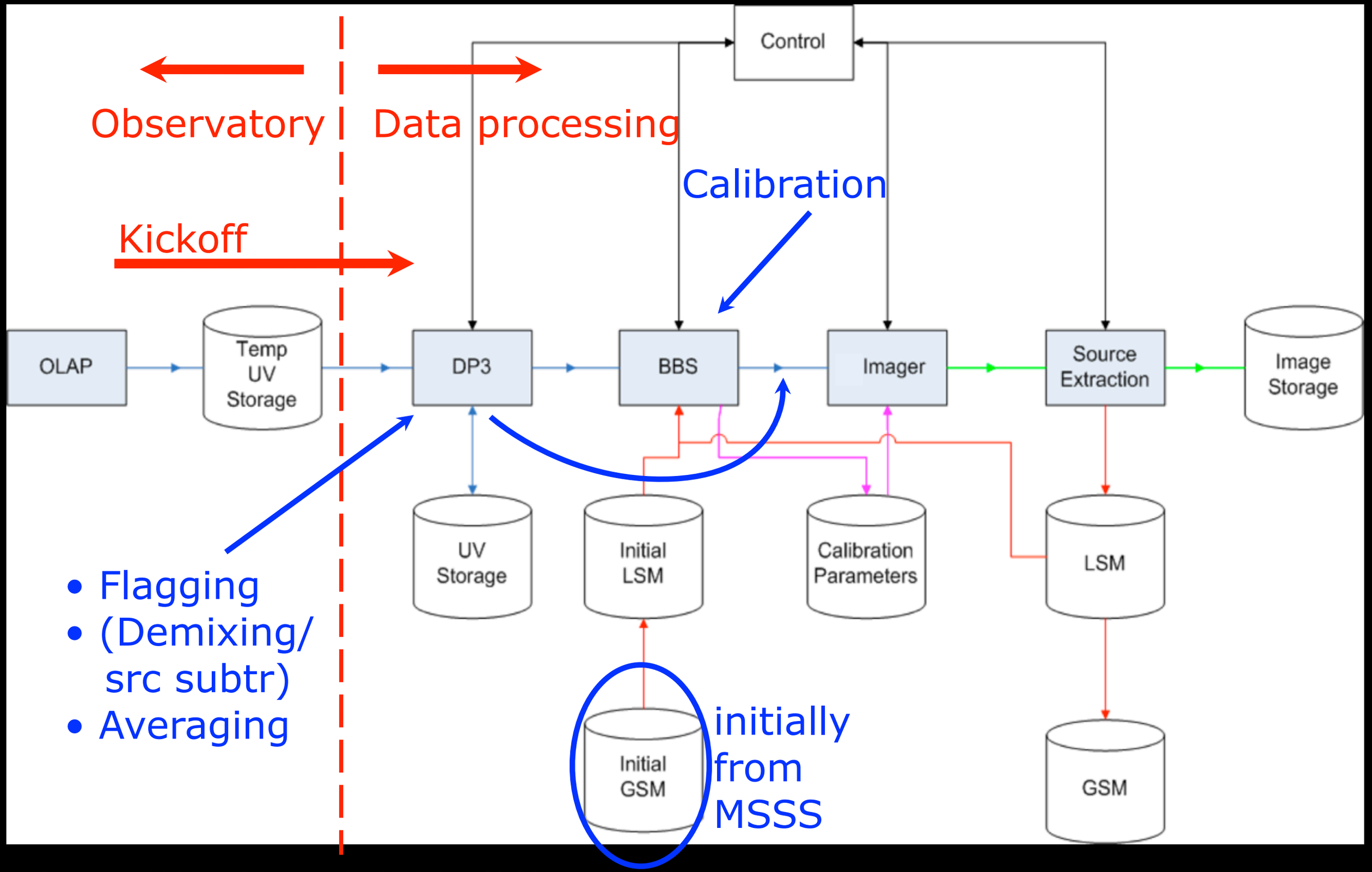

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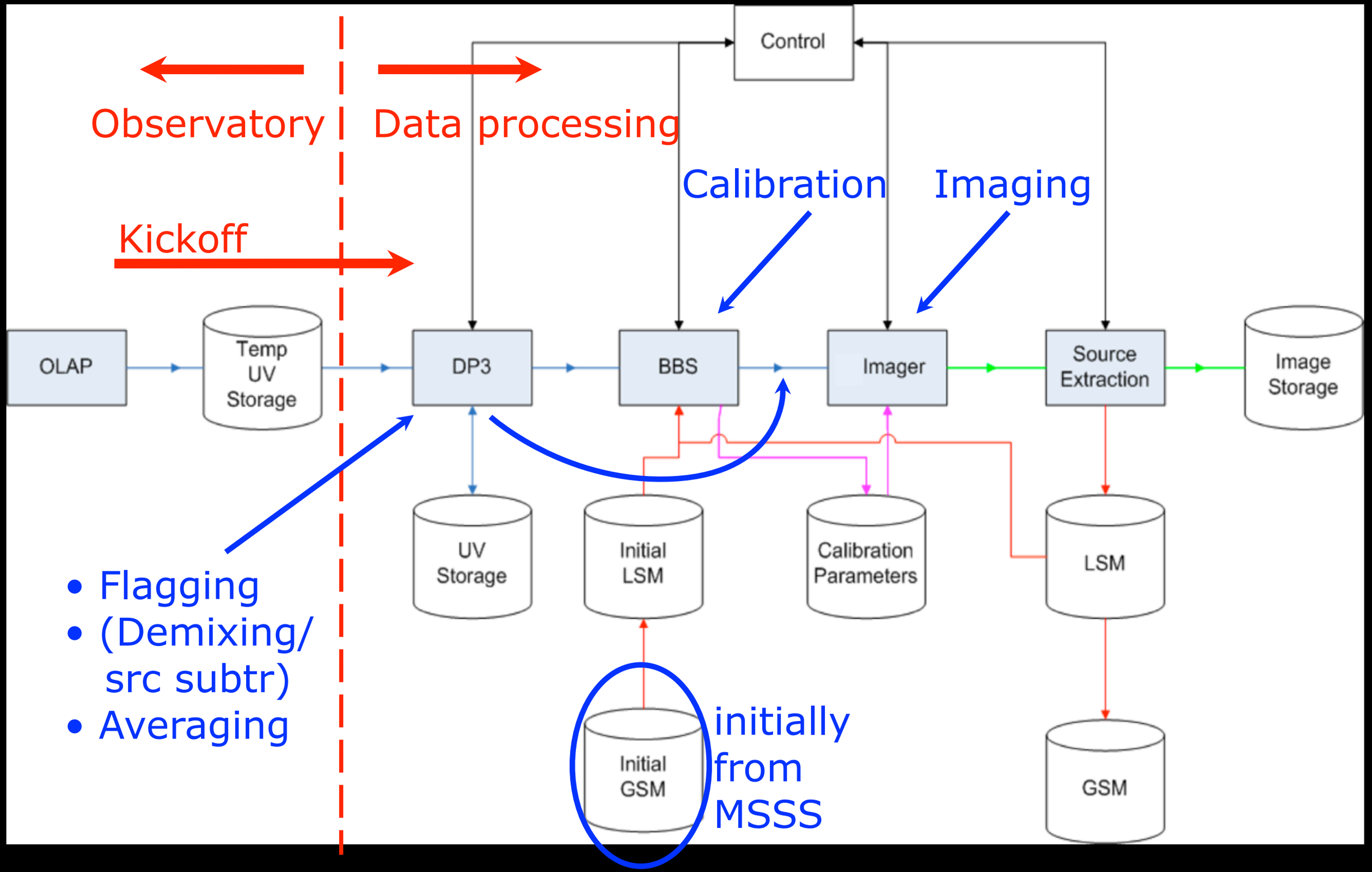

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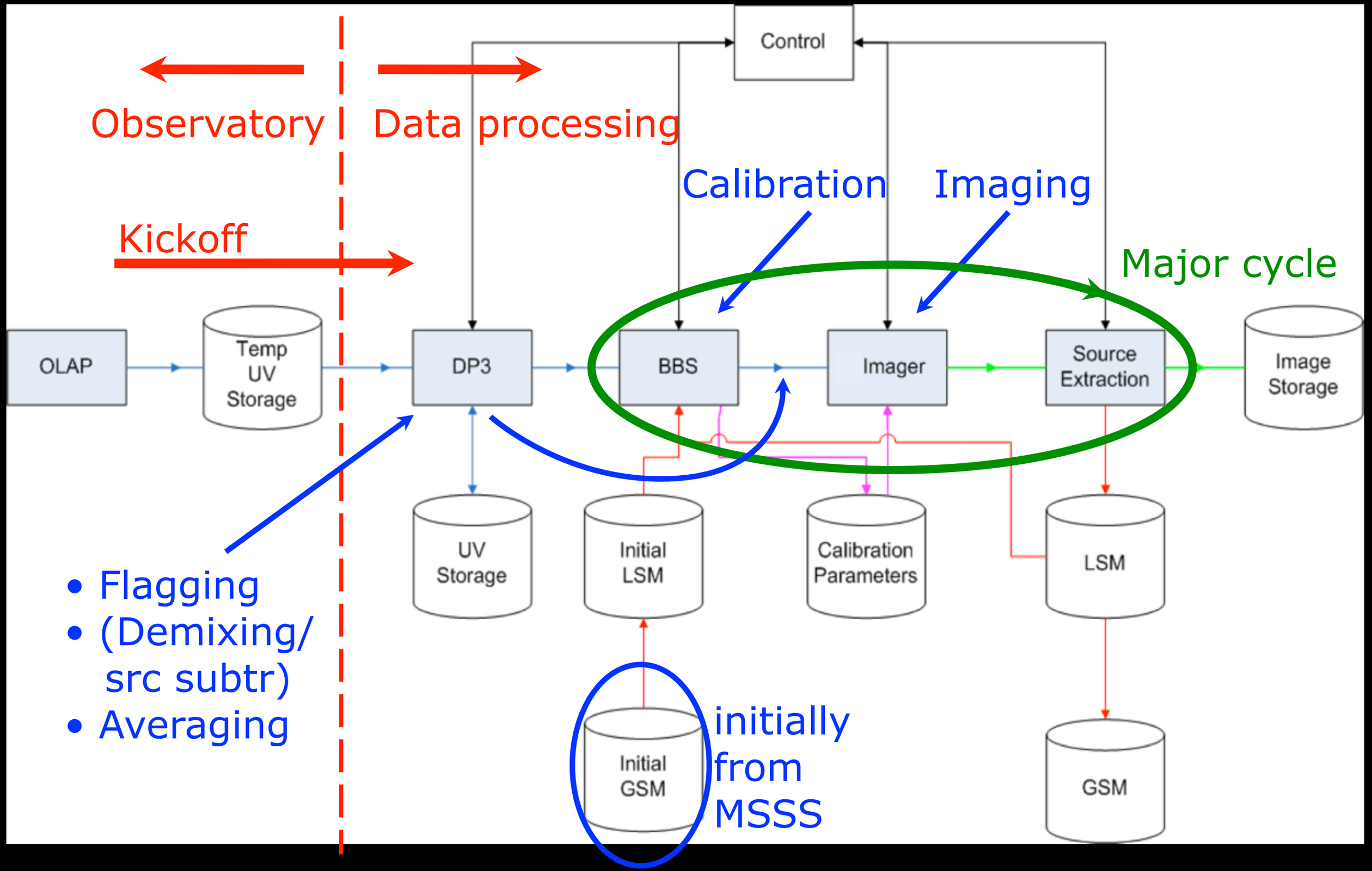
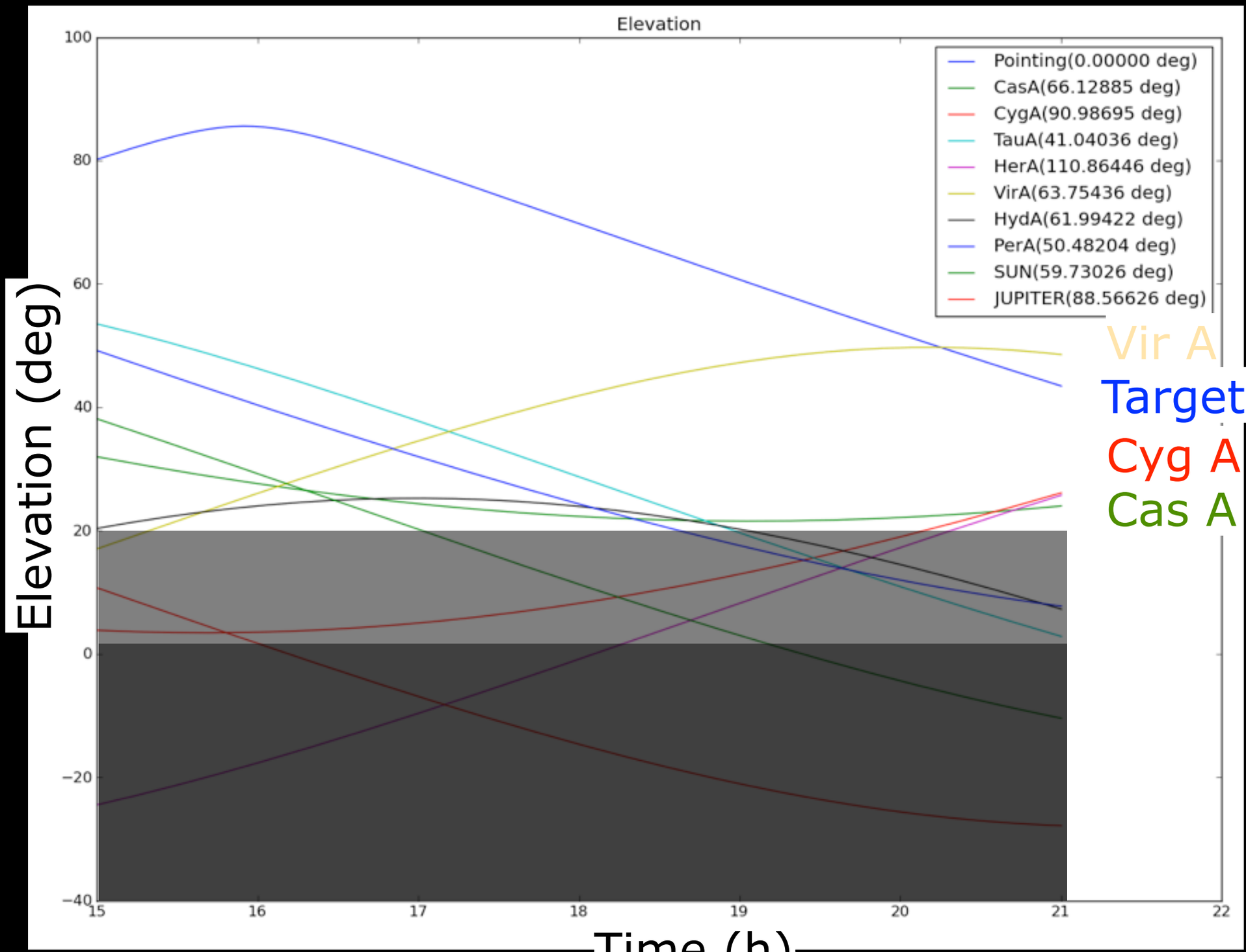
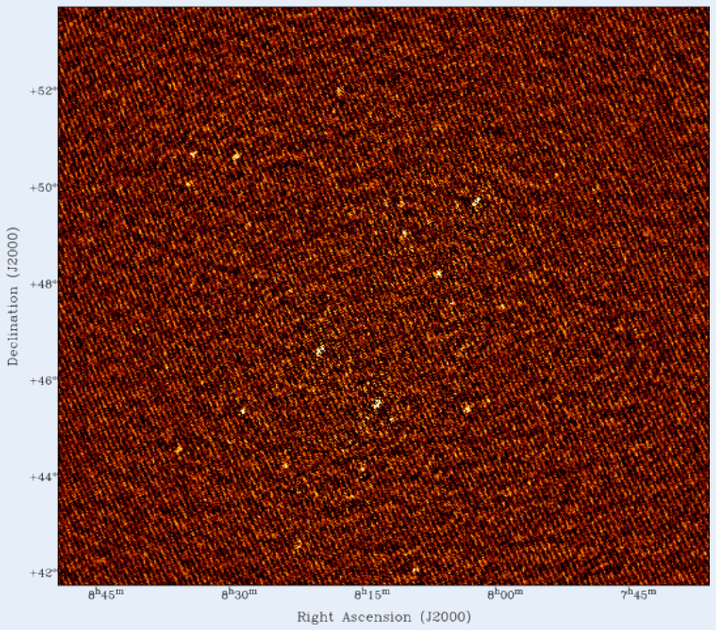


Demixing: 3C196 LBA_INNER

- Demixed CygA, CasA, VirA (latter not necessary in hindsight)



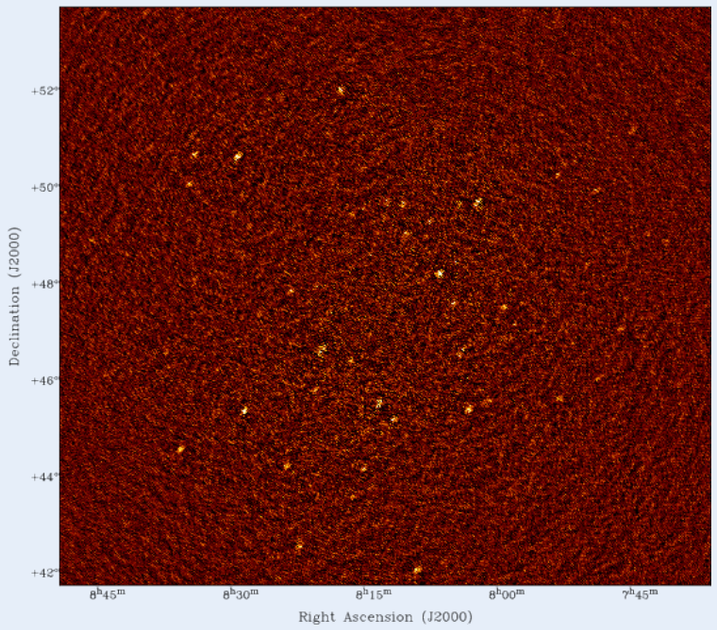
3C196 LBA_INNER: images



no demixing
(but using gains obtained post-demixing)

no cleaning

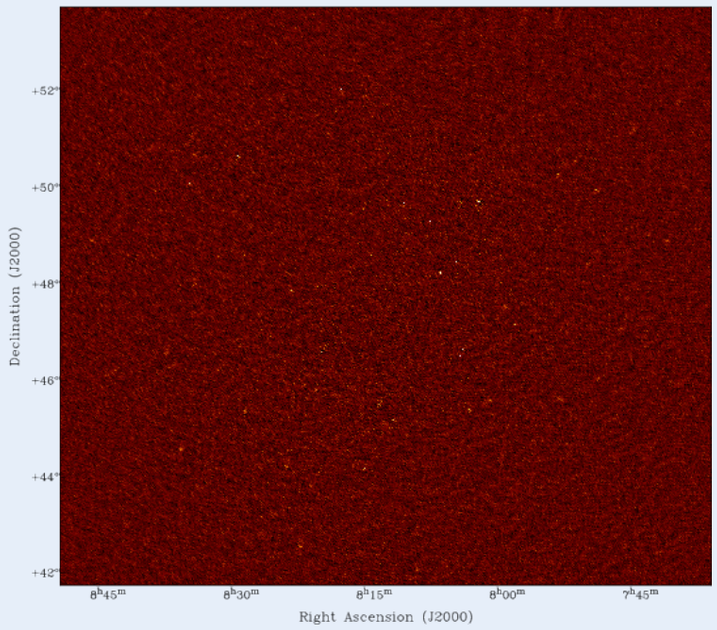
image rms
122 mJy



with demixing
(using gains obtained post-demixing)

no cleaning

image rms
66 mJy

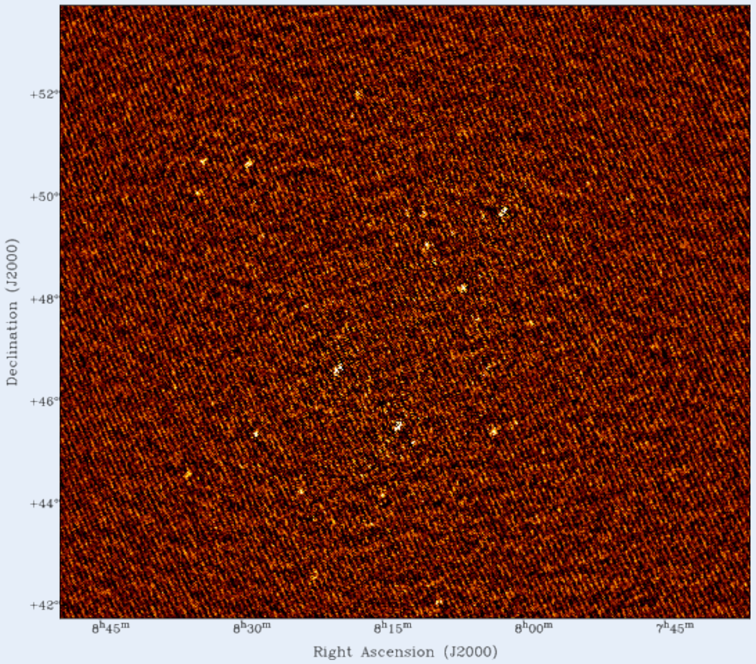


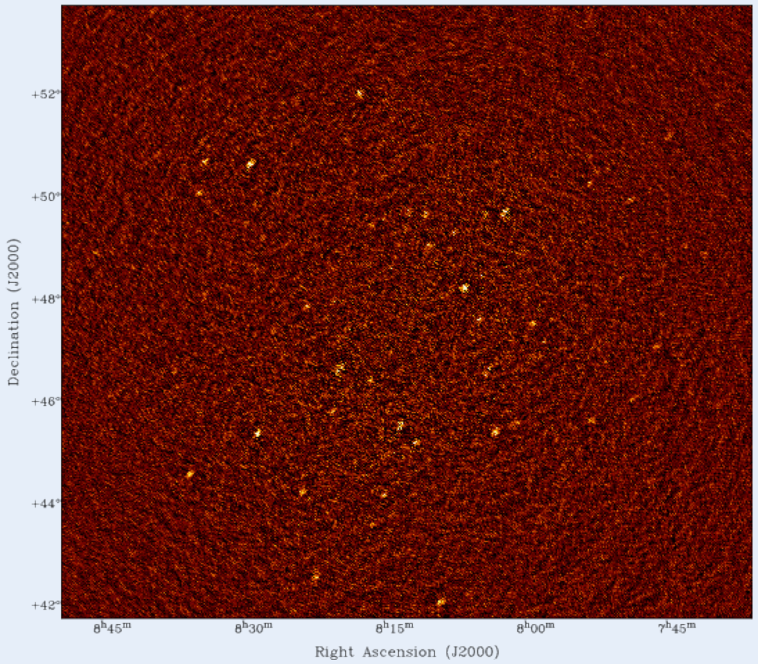
with demixing
(using gains obtained post-demixing)

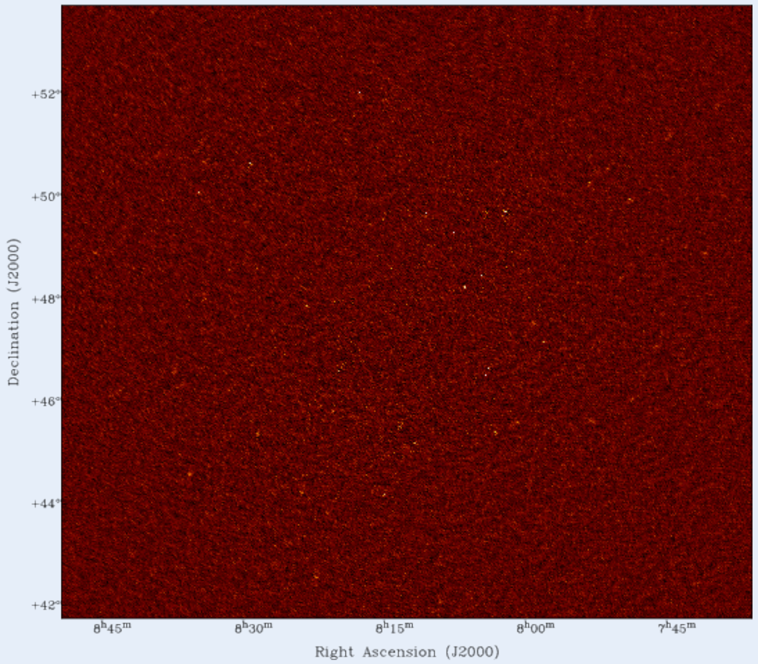
(unguided) cleaning

image rms
40 mJy

3C196 LBA_INNER: images







Each image (single beam!) has size: 100 square degrees
Following demixing, ~thermal noise is reached
(6h observation,0.2 MHz bandwidth)

Required MSSS depth is not much beyond this
(but note that uv coverage will be different)

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66 mJy

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- Matching resolution in the model is crucial to jumpstarting the calibration cycle on remote baselines

MSSS

- MSSS fundamentally a commissioning survey
- Key roles:
  - Fill the initial GSM for calibration of arbitrary fields at arbitrary frequency in LOFAR bands

Multifrequency - need fluxes over wide LOFAR bands

Snapshot - spend little time to image the sky

Sky - cover the full LOFAR sky (dec ≳ 0 degrees)

Survey - provides output catalog of sources in the sky

  - Guide development of, and exercise observatory operations, processing software, imaging pipeline, (and commensal applications?)

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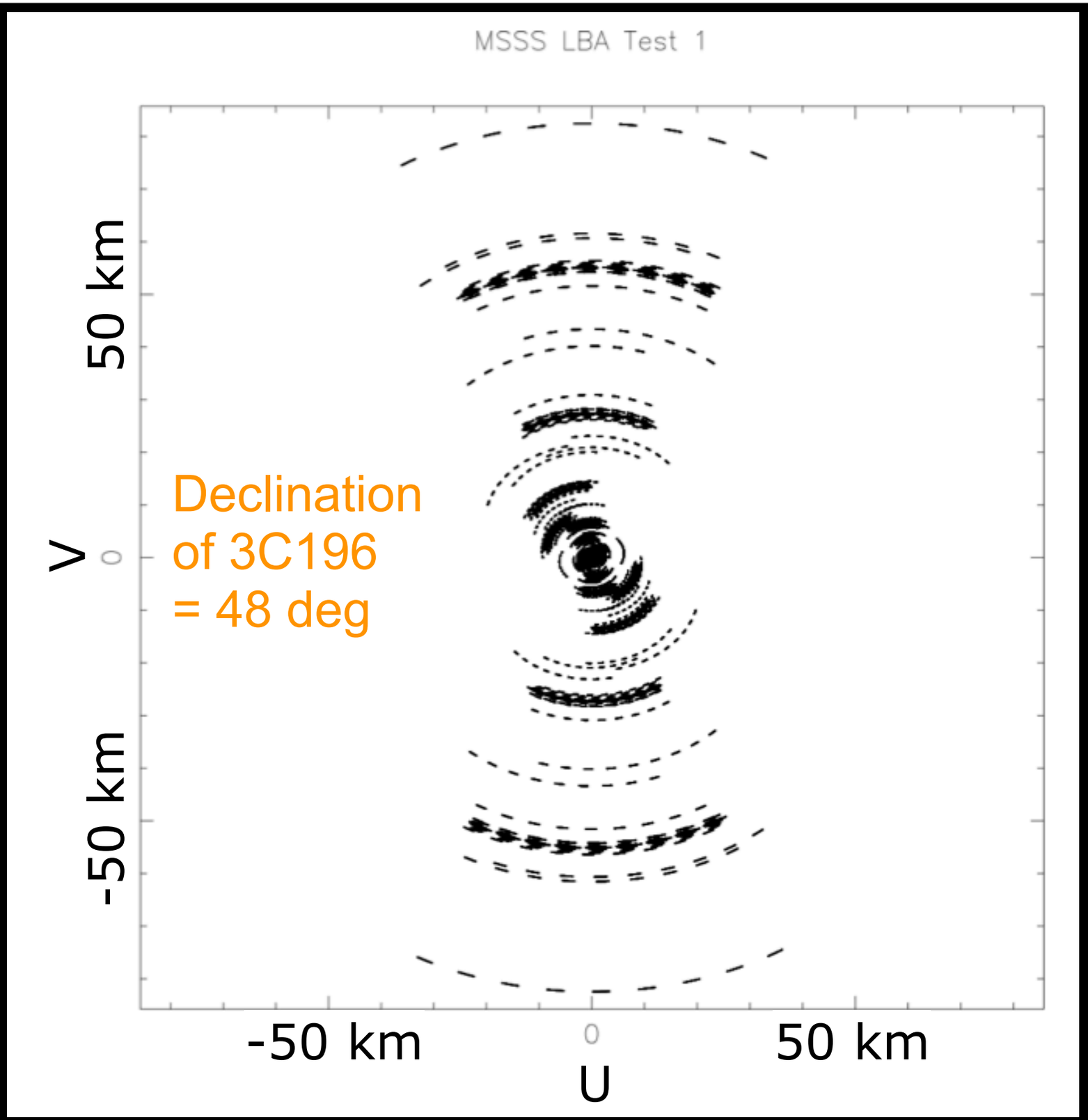
- Note that this refers to the *processing* rather than to the observations - the idea is to use all available stations
- Key reasons:
  - Beam information is not available (yet) in the imager, so differing HBA station sizes could not be taken into account (this may be a moot point in the near future...)
  - Processing time increases with baseline length, so using a compact array makes ~real-time processing more realistic

MSSS Specifications

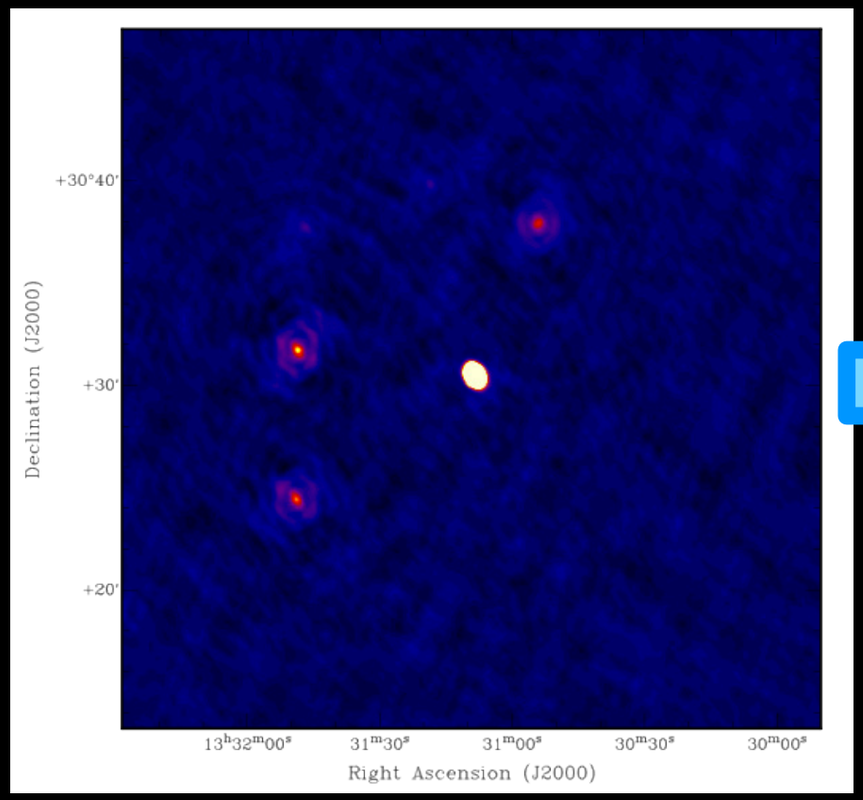
	MSSS-LBA	MSSS-HBA
Array configuration (observed)	full	full
Array configuration (processed)	≤10km baselines	core baselines
Bandwidth	16 MHz/beam	16 MHz/beam
Number of beams	3	3
Time per field	9x10 min	2x7 min
Final sensitivity	15 mJy/beam	5 mJy/beam
Number of fields	619	3522
On-source time	309.5 hr	293,5
Total time (with overheads)	6 weekends	6 weekends

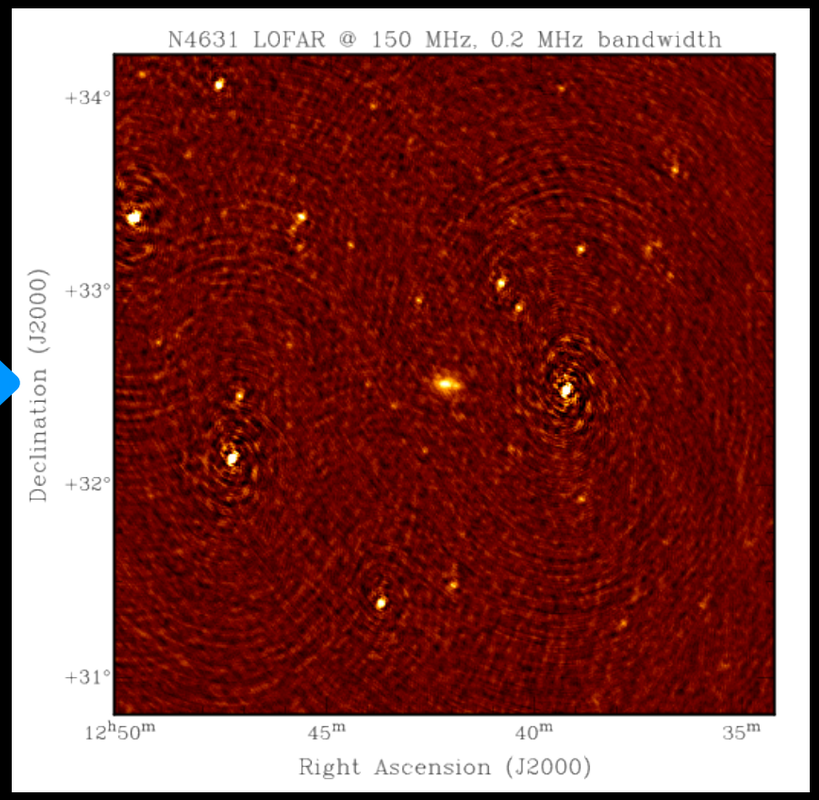
MSSS uv coverage: LBA



MSSS Calibration Strategy

- Determination of instrumental gain solutions from known calibrator field, and transfer those to target MSSS fields

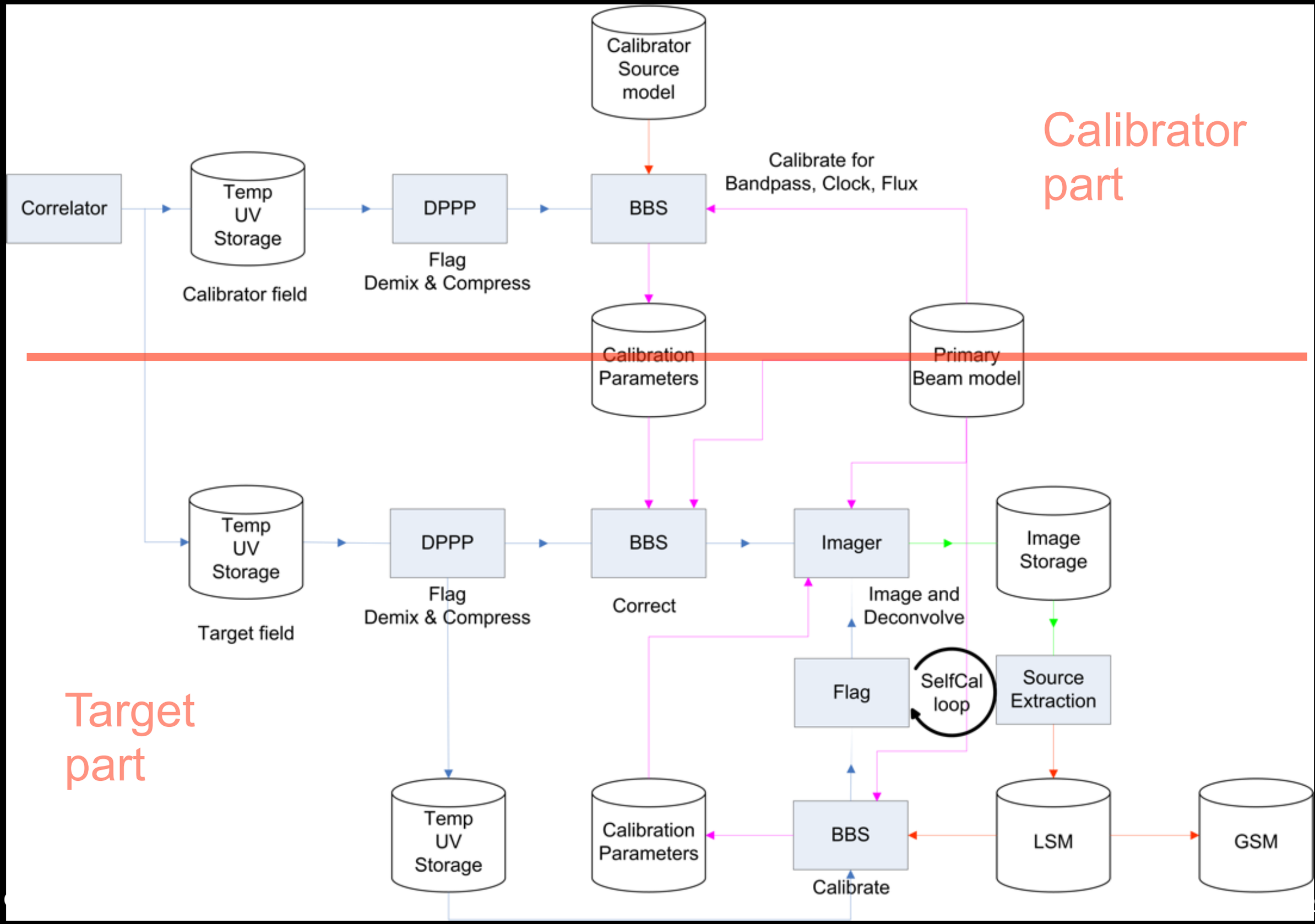




See talk by David Mulcahy

- Individual fields observed in ≥1 snapshots, primarily for uv-coverage (but maximizing usefulness for transient searches...)
- Broad frequency span in both LBA and HBA (Low)
- Self-calibration loop (to be specified once awimager is available)

LOFAR SIP: MSSS implementation

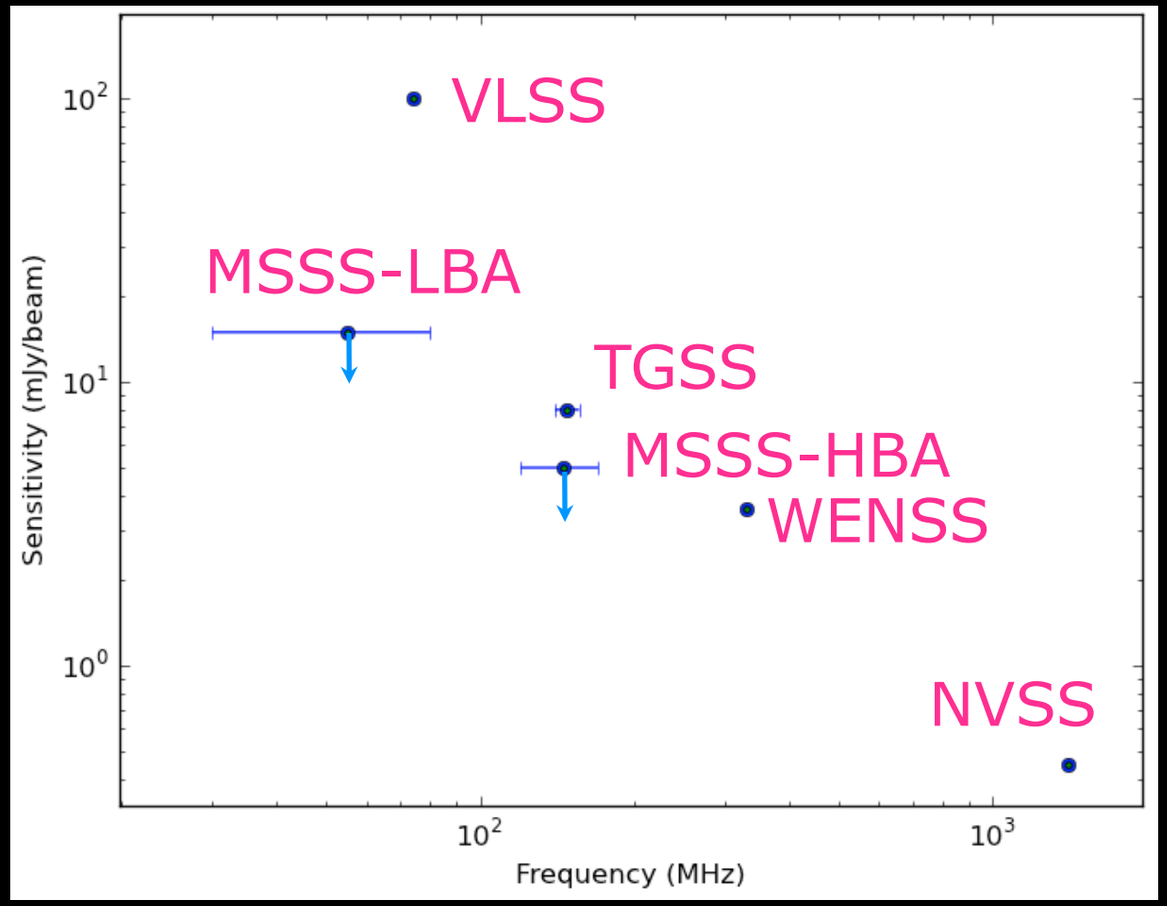


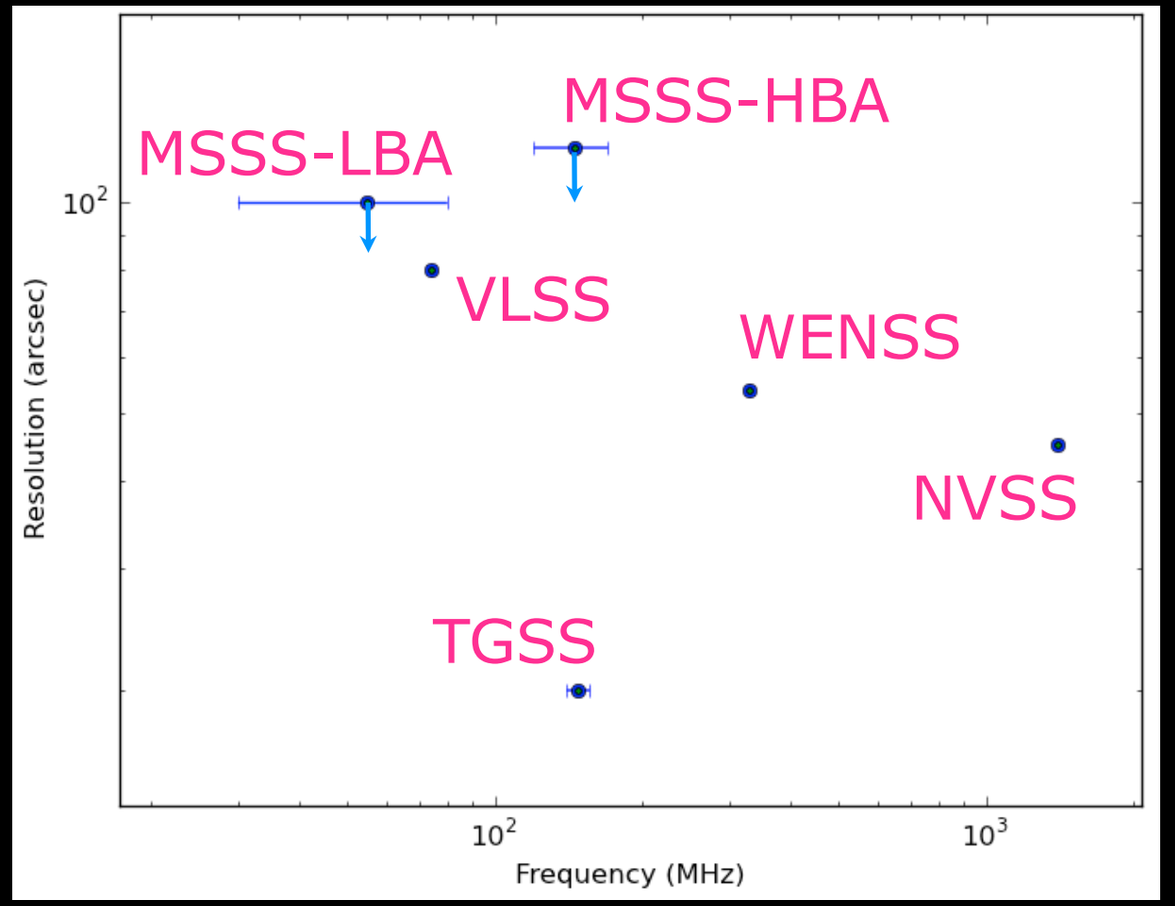
Comparison of relevant surveys

Table 2: Parameters of default MSSS and comparison with other surveys

Survey	Frequency	Sensitivity	Resolution	Area
MSSS-LBA	30 – 78 MHz	$\lesssim 15$ mJy beam^{-1}	$\lesssim 100''$	20,000 □° ($\delta > 0°$)
VLSS	74 MHz	100 mJy beam^{-1}	$80''$	30,000 □° ($\delta > -30°$)
MSSS-HBA	120 – 170 MHz	$\lesssim 5$ mJy beam^{-1}	$\lesssim 120''$	20,000 □° ($\delta > 0°$)
TGSS	140 – 156 MHz	7 – 9 mJy beam^{-1}	$20''$	32,000 □° ($\delta > -30°$)
WENSS	330 MHz	3.6 mJy beam^{-1}	$54''$	10,000 □° ($\delta > +30°$)
NVSS	1400 MHz	0.45 mJy beam^{-1}	$45''$	35,000 □° ($\delta > -40°$)

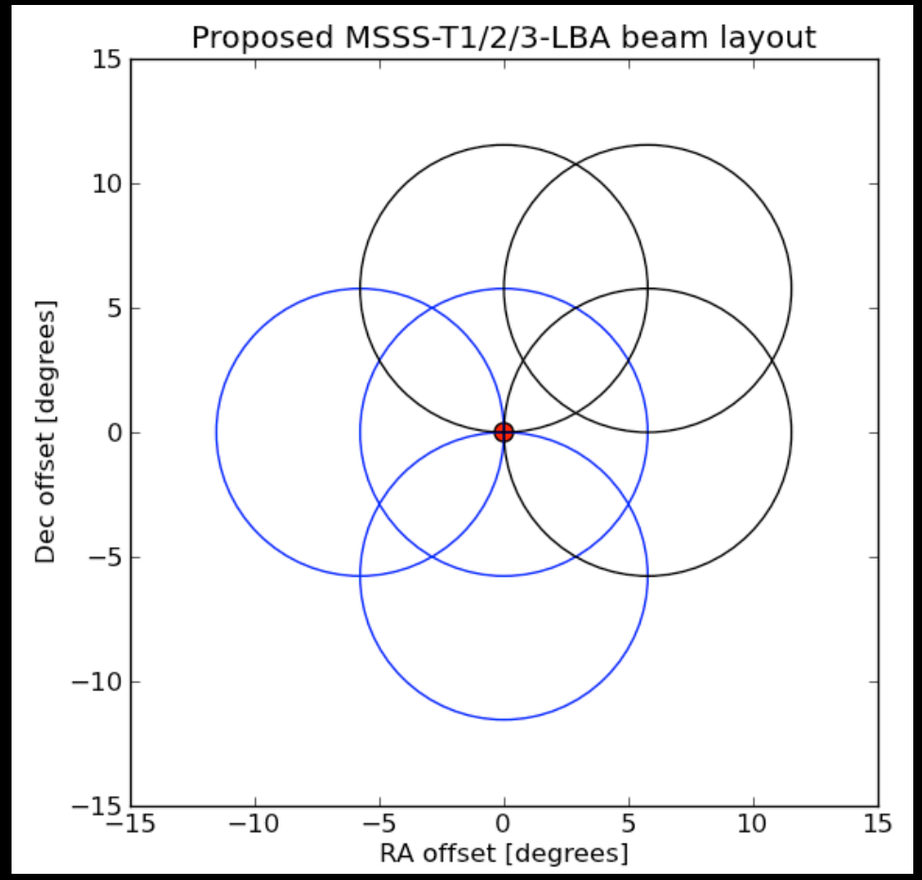
Note. Sensitivity and resolution values for the MSSS surveys are upper limits corresponding to core-only (HBA) and 10-km (LBA) surveys. Full array observations will be taken; final sensitivity and resolution values are likely to improve (provided that the new imager is fully functional, and that sufficient compute resources are available).

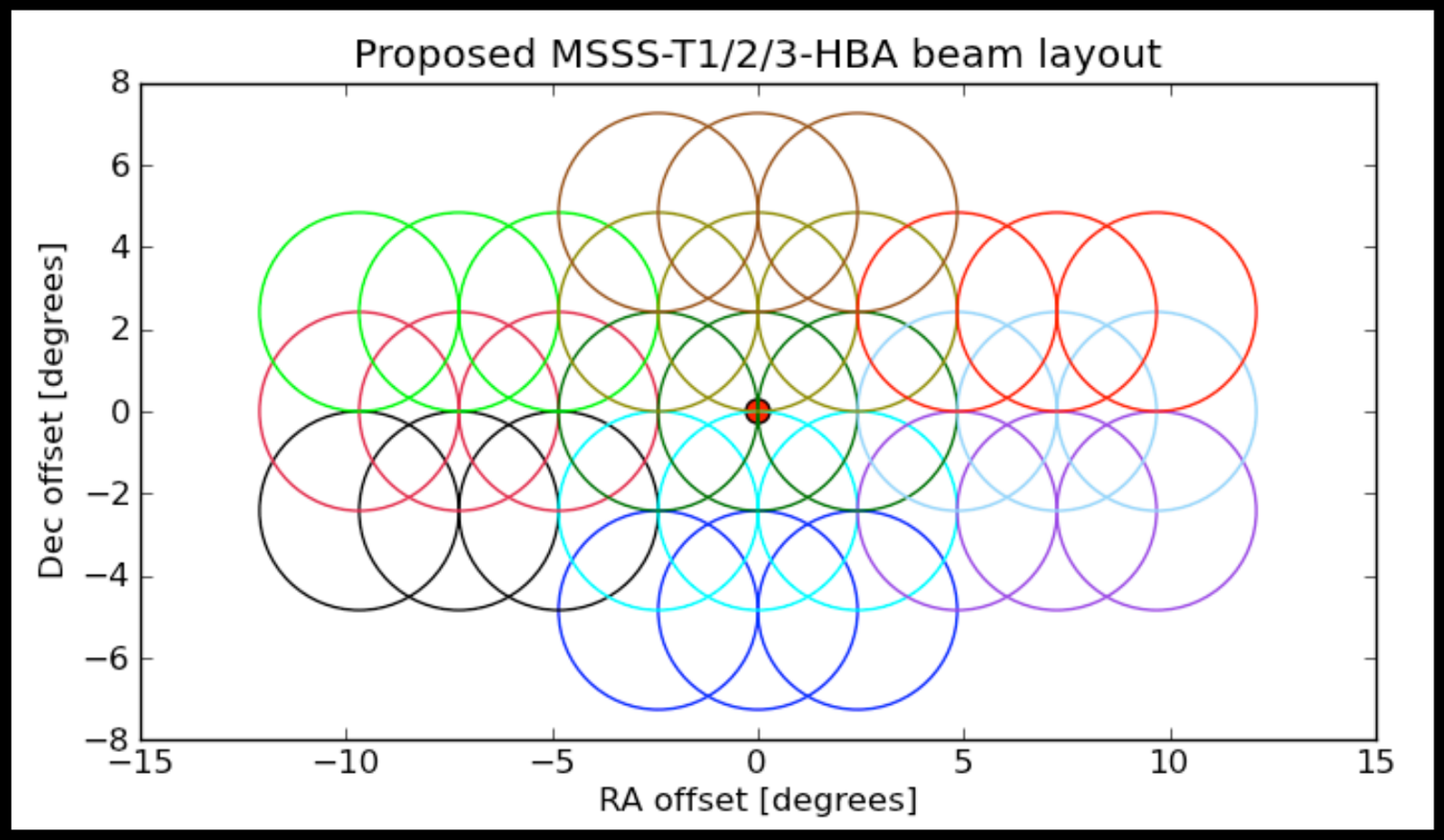




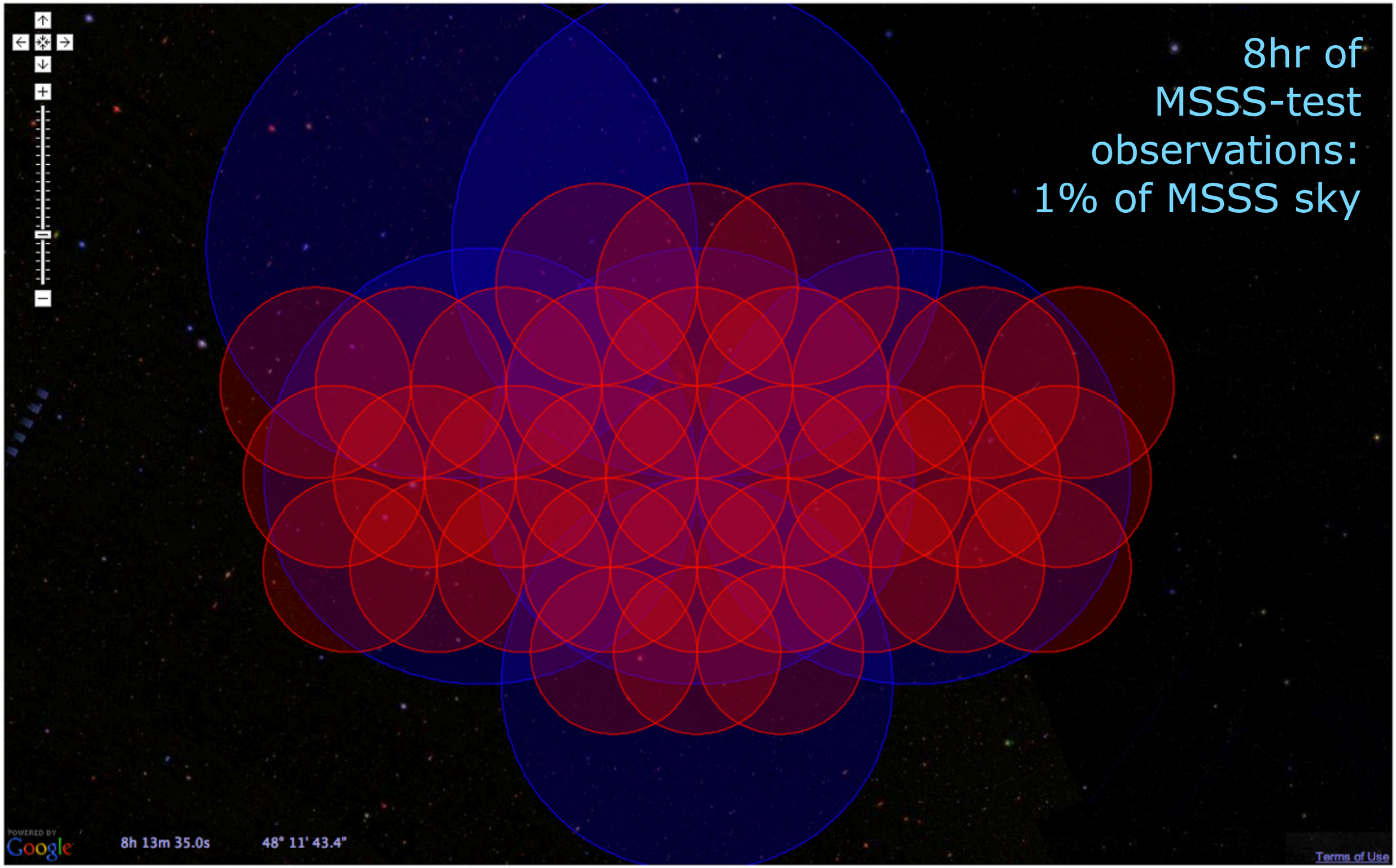
First MSSS test pointings

- Each set of pointings covers approx 200 square degrees
- Key is to make these as realistic as possible
  - test, understand, and optimize: data taking, handling, processing, major cycle algorithm, pipeline runtime, catalog creation, etc etc etc





Tracking MSSS observations



Tracking MSSS observations

M81/82

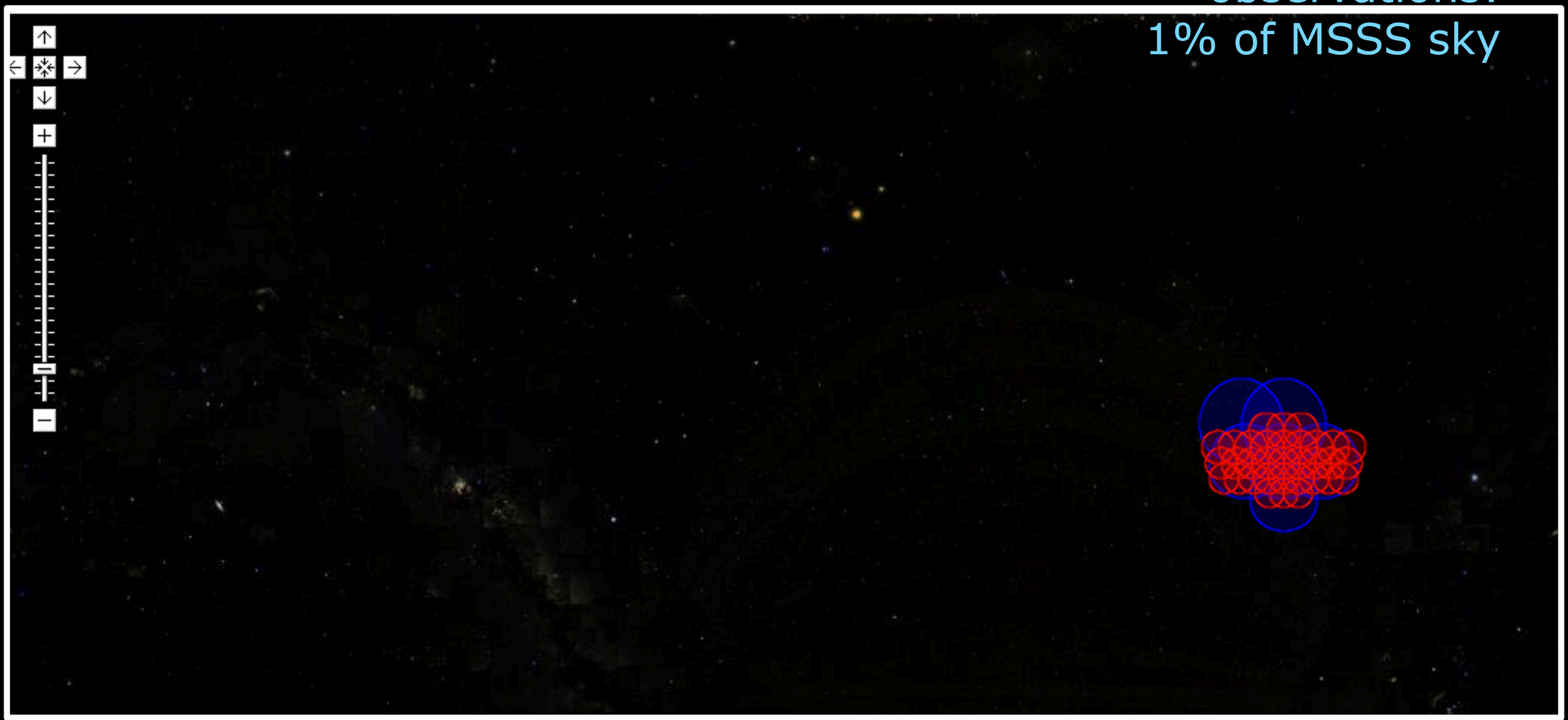
8hr of MSSS-test observations: 1% of MSSS sky

California Nebula

M31

Tracking MSSS observations

8hr of MSSS-test observations:
1% of MSSS sky

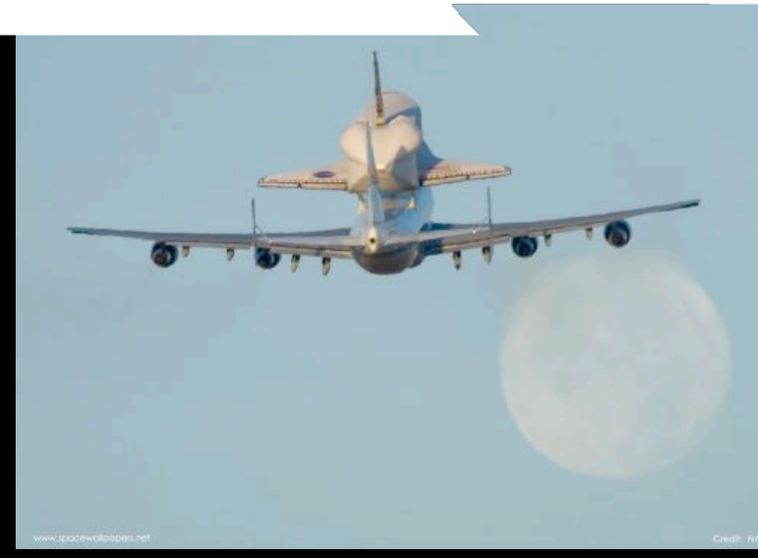


MSSS scheduling

- MSSS observations can be specified semi-automatically but with no dynamic re-shuffling of snapshots for maximum efficiency (This is coming with the observatory's new scheduler...)
- Observatory measurement management system is being updated to include all of the metadata needed for processing

...and so on...

Science applications



- Science teams are defining projects that can run in parallel with MSSS, or use its data products to generate additional output:
  - Cosmic ray triggering
  - International-baseline observations
    - finding compact calibrators for future long baseline observations
    - first high-resolution images of bright sources
  - Search for polarization calibrators
  - Search for (slow) transient sources on hour - week(?) timescales
    - intelligent scheduling of individual snapshots....

MSSS test data

- MSSS test data are being run through the preliminary pipeline (starting last week, proceeding now.....!)
- The calibration part seems to be functioning properly but there are still some problems to be sorted out
- The next step is applying solutions to the target fields (well understood from the procedural perspective), and then imaging the data and combing the MSSS desert!
- So, test data are in hand and we have done some first processing, but there are no results from the test fields yet
- We will be tabulating statistics as the analysis proceeds

Combing the desert

MSSS Timeline

- Now - Sept 2011: test observations and pipeline runthroughs
  - First test (observed, in processing): 200 sq deg near 3C196
  - Second: 3C465 - including piggybacking applications
  - Third: a “blank field” (TBD)
- Oct 2011: begin MSSS
  - Start with LBA part, during HBA tile repair process
  - continue to HBA when possible
- Priority:
  - A-team
  - 3C catalog
  - Rest of northern (dec>=0) sky
  - Southern sky as time/resource allocation permits

Playing a role in MSSS

- We will be seeking out assistance in running (and inspecting the output of!) MSSS via the KSPs ... including things like:
  - Source detection in MSSS test fields
  - Algorithm for major cycle stop criteria
  - Identification of final survey pointing grids in LBA and HBA
  - Identification of calibration (& astrometric) reference grid(s)
  - Assistance to Radio Observatory in setting up and performing observations
  - Assistance in data handling
  - Inspection of pipeline output and identification of fields that require follow-up post-processing
  - ... !