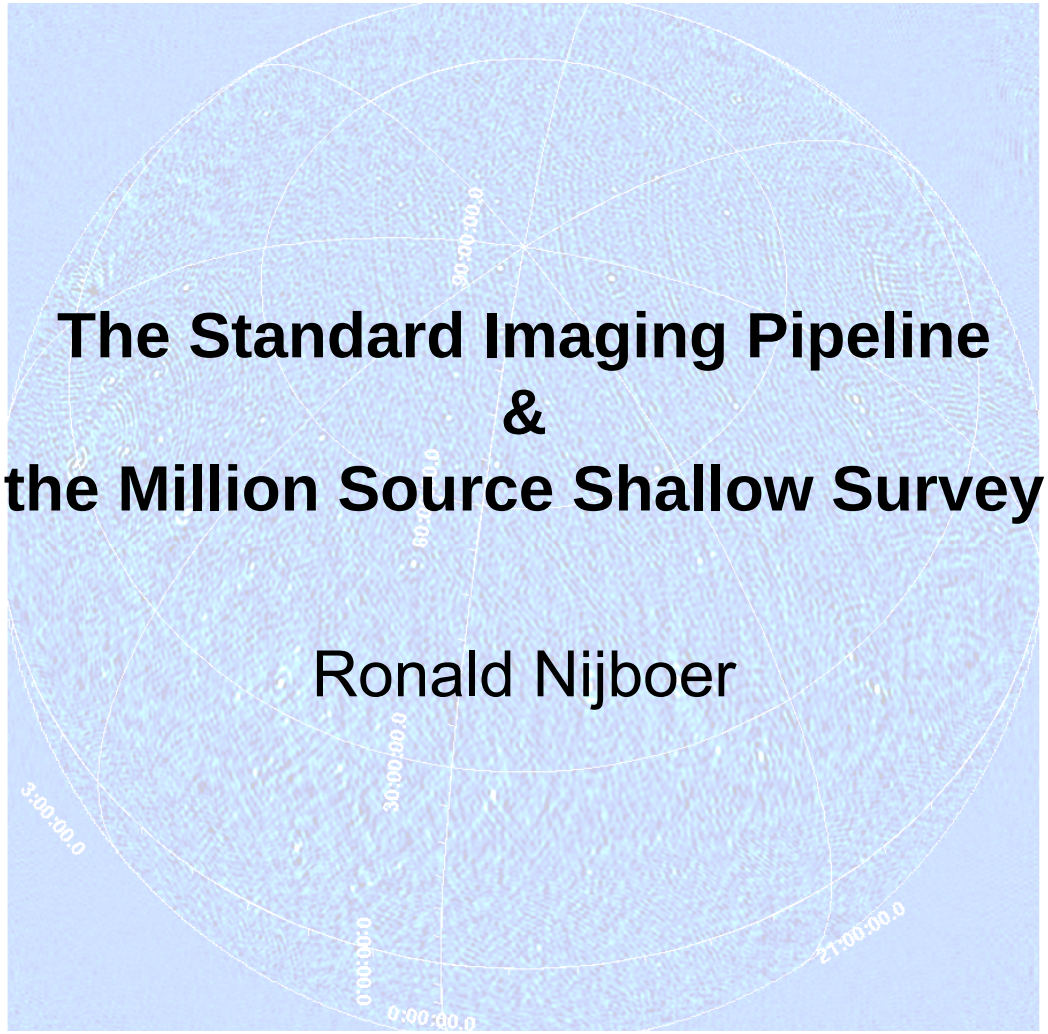


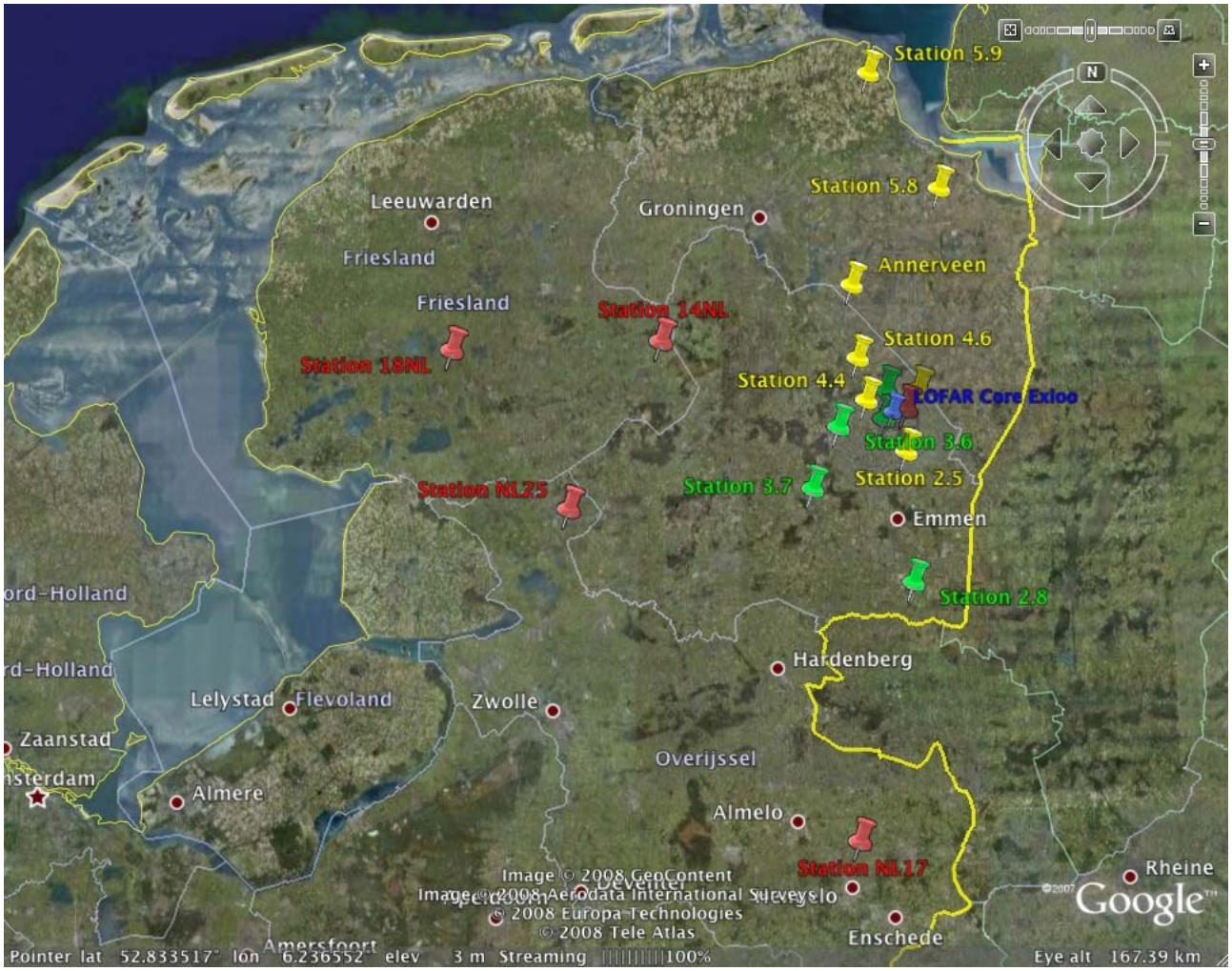
The Standard Imaging Pipeline & the Million Source Shallow Survey

Ronald Nijboer

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

Core stations

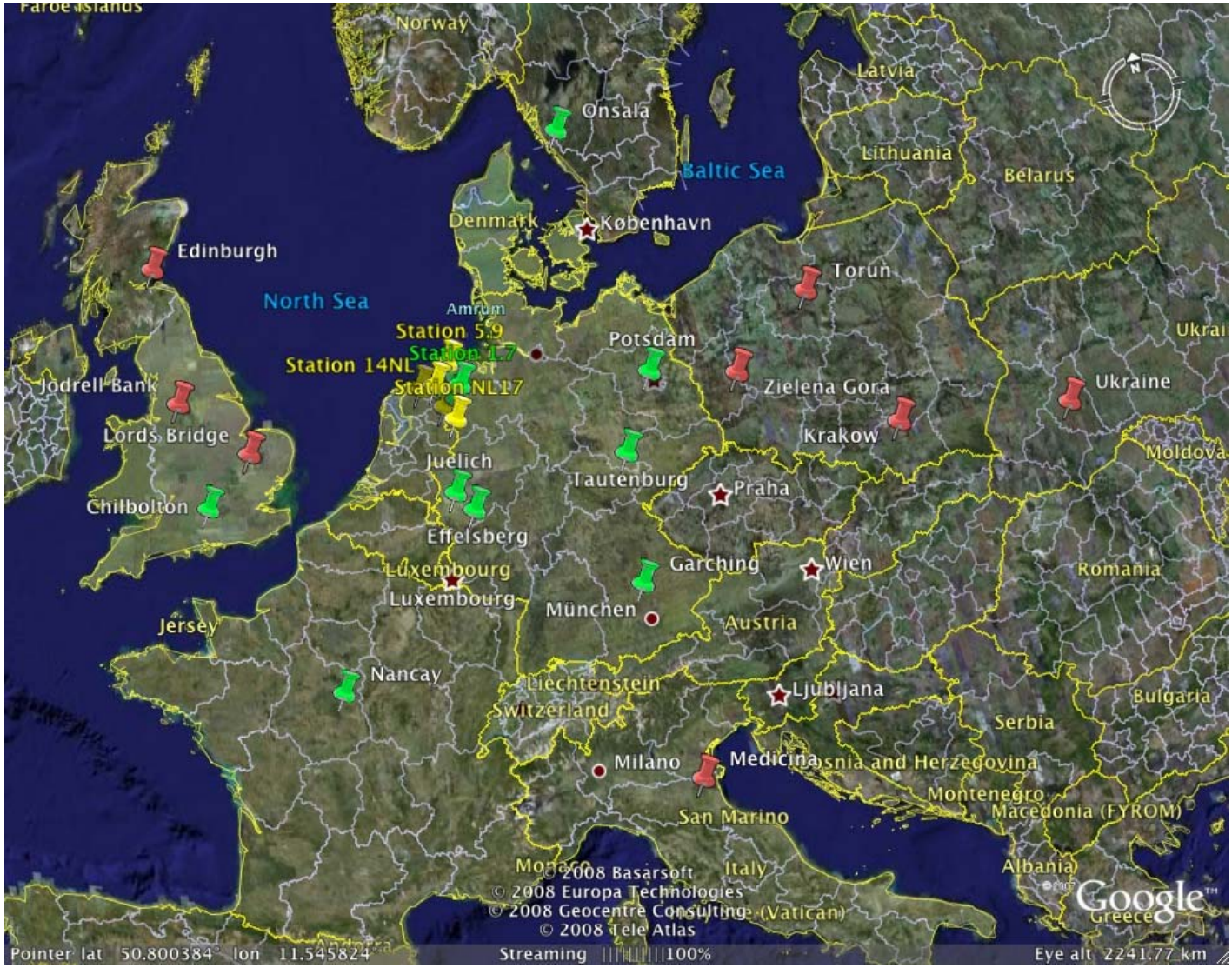
Dutch remote stations

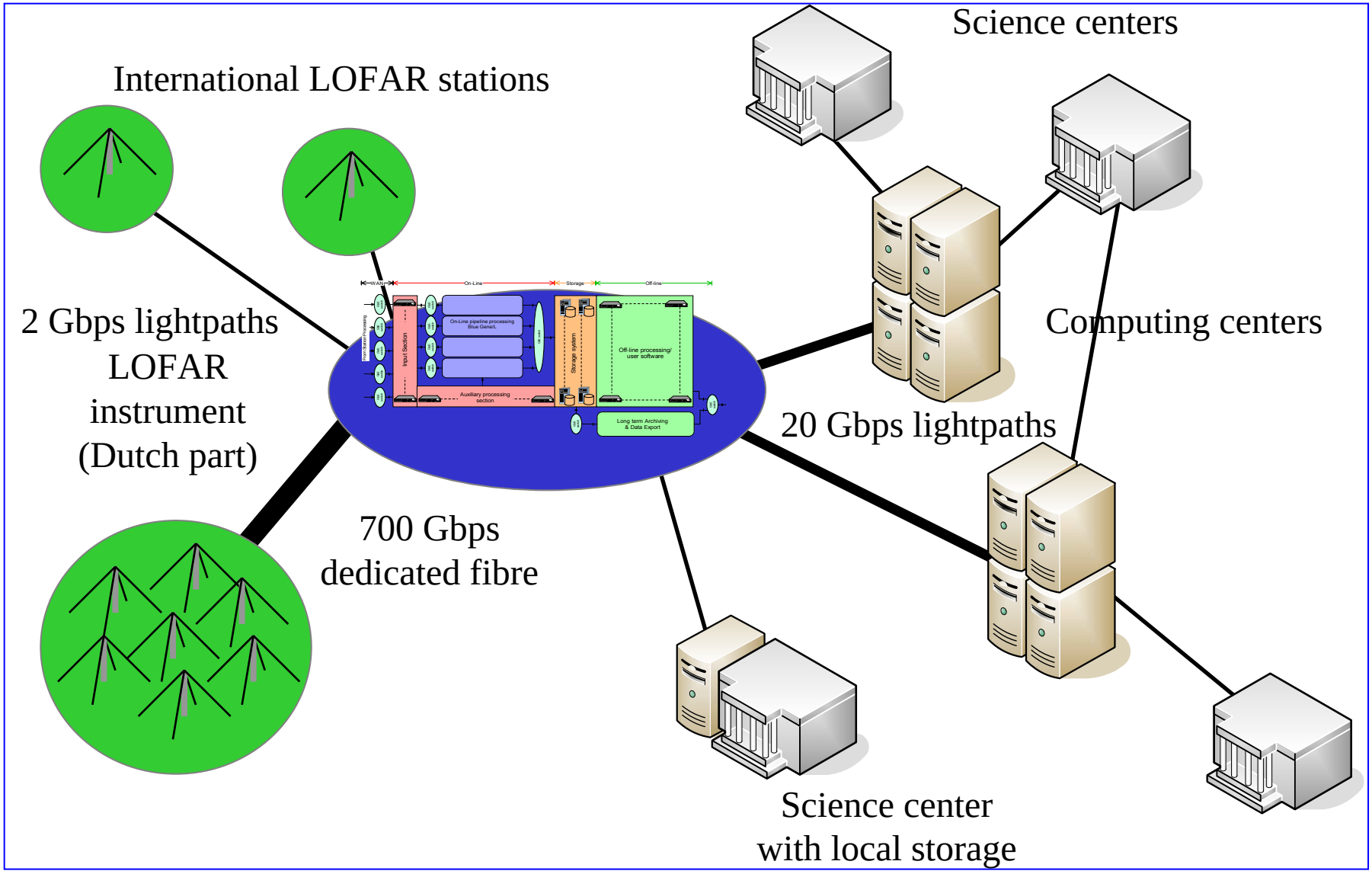


~ 130 km

~ 85 km

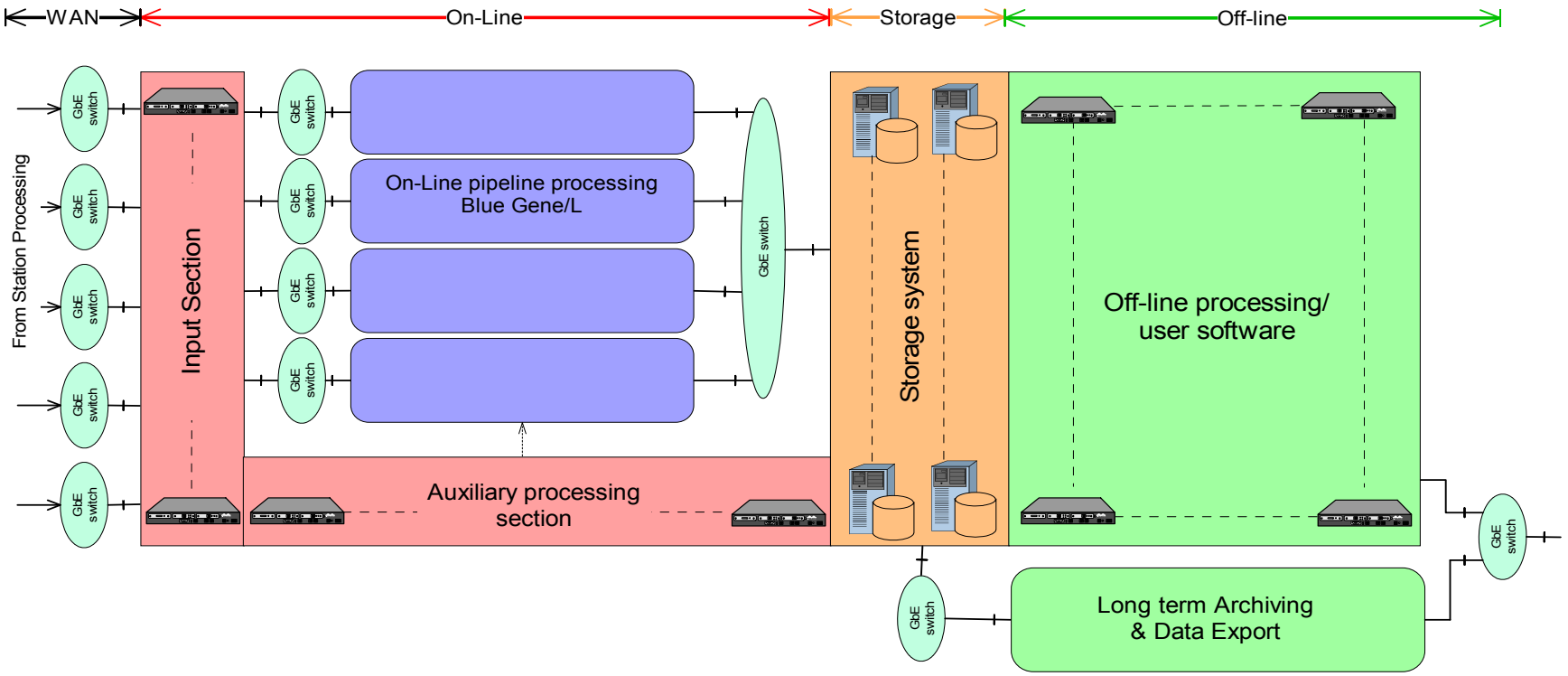
European stations




Science centers
International LOFAR stations
2 Gbps lightpaths
LOFAR
instrument
(Dutch part)
Computing centers
20 Gbps lightpaths
700 Gbps
dedicated fibre
Science center
with local storage

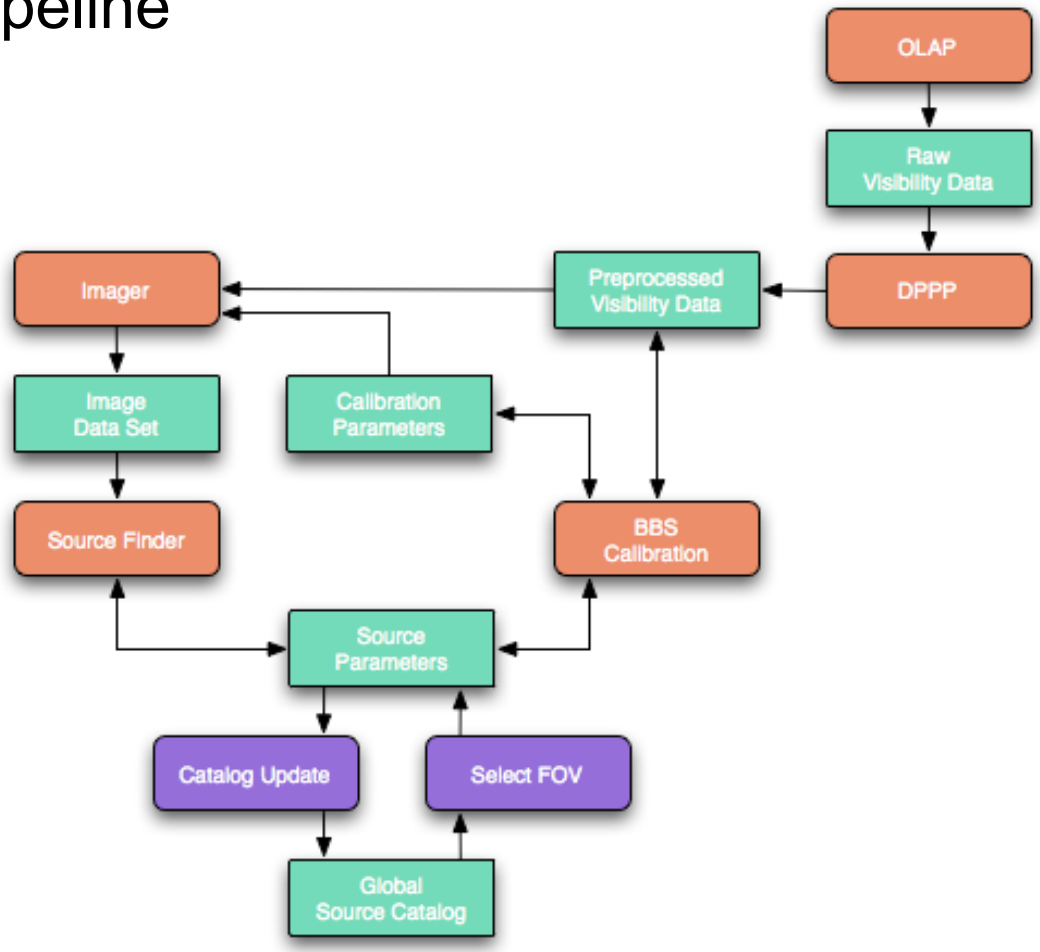
LOFAR CEP @ Groningen

CEP Systems

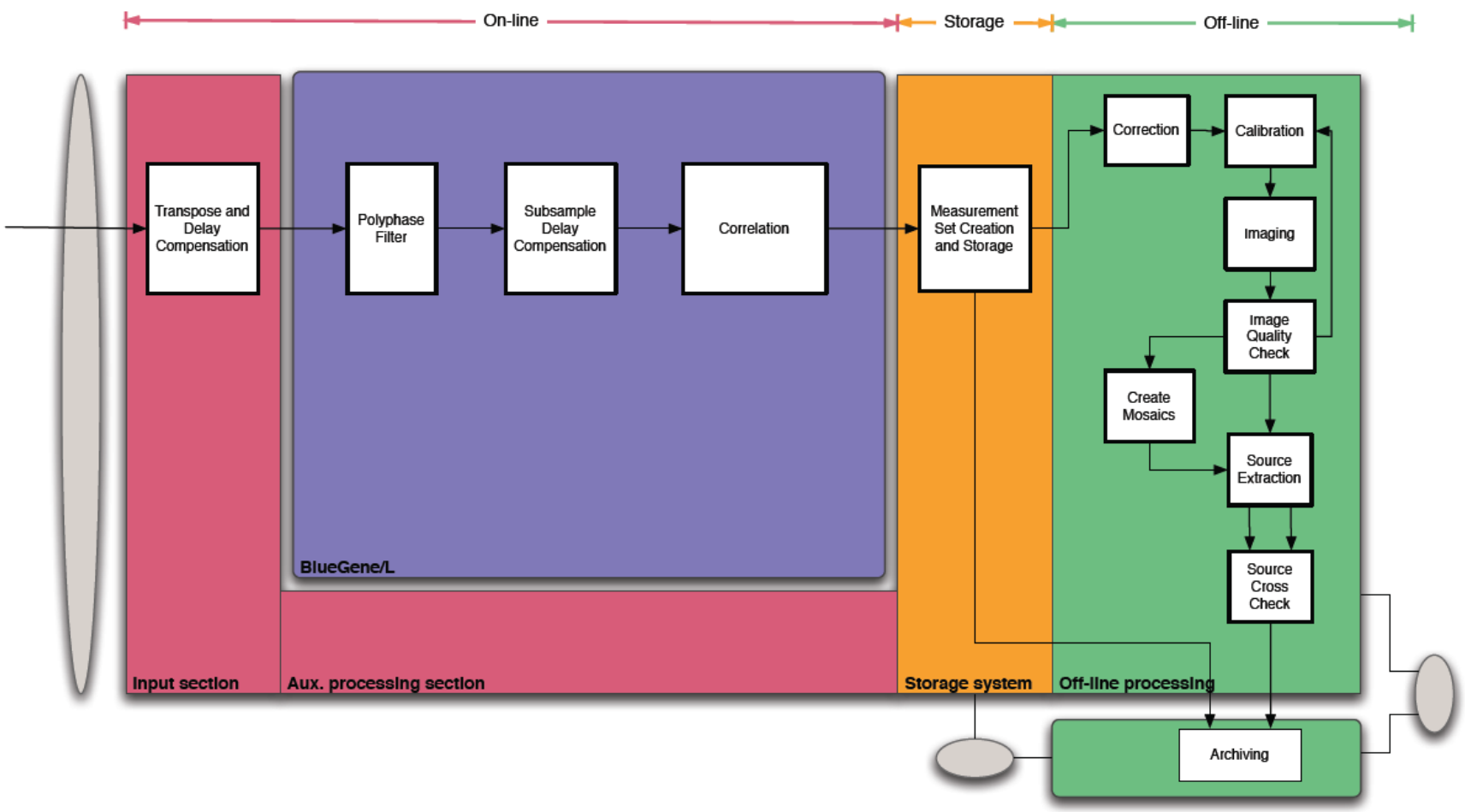

WAN
On-Line
Storage
Off-line
From Station Processing
GbE switch
Input Section
On-Line pipeline processing
Blue Gene/L
Auxiliary processing
section
Storage system
Off-line processing/
user software
Long term Archiving
& Data Export

Imaging pipelines

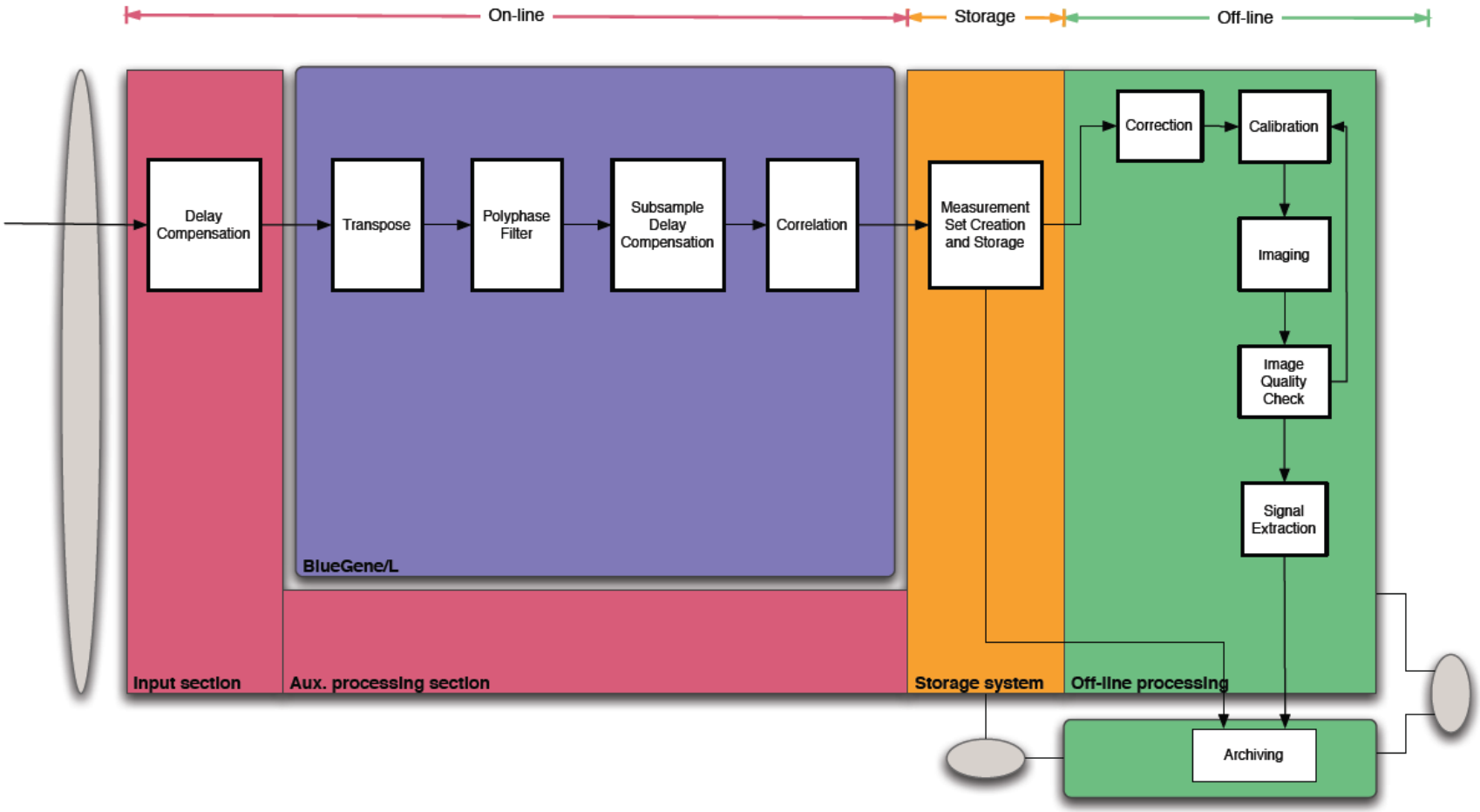
- Standard Imaging Pipeline
- Precursor for
  - Surveys pipeline
  - EoR pipeline
  - Transients pipeline
  - Magnetism pipeline
  - Solar pipeline



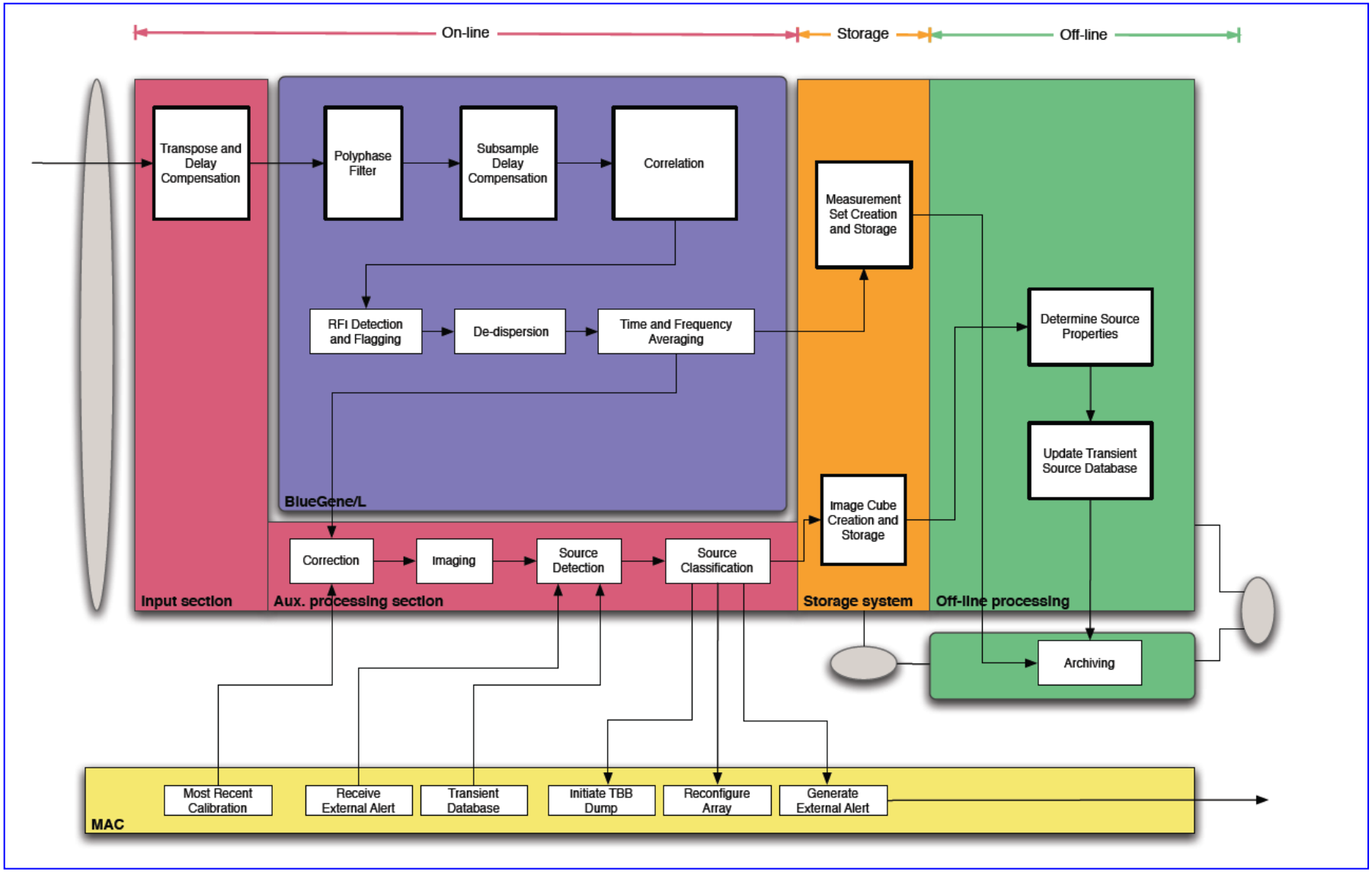
Surveys pipeline



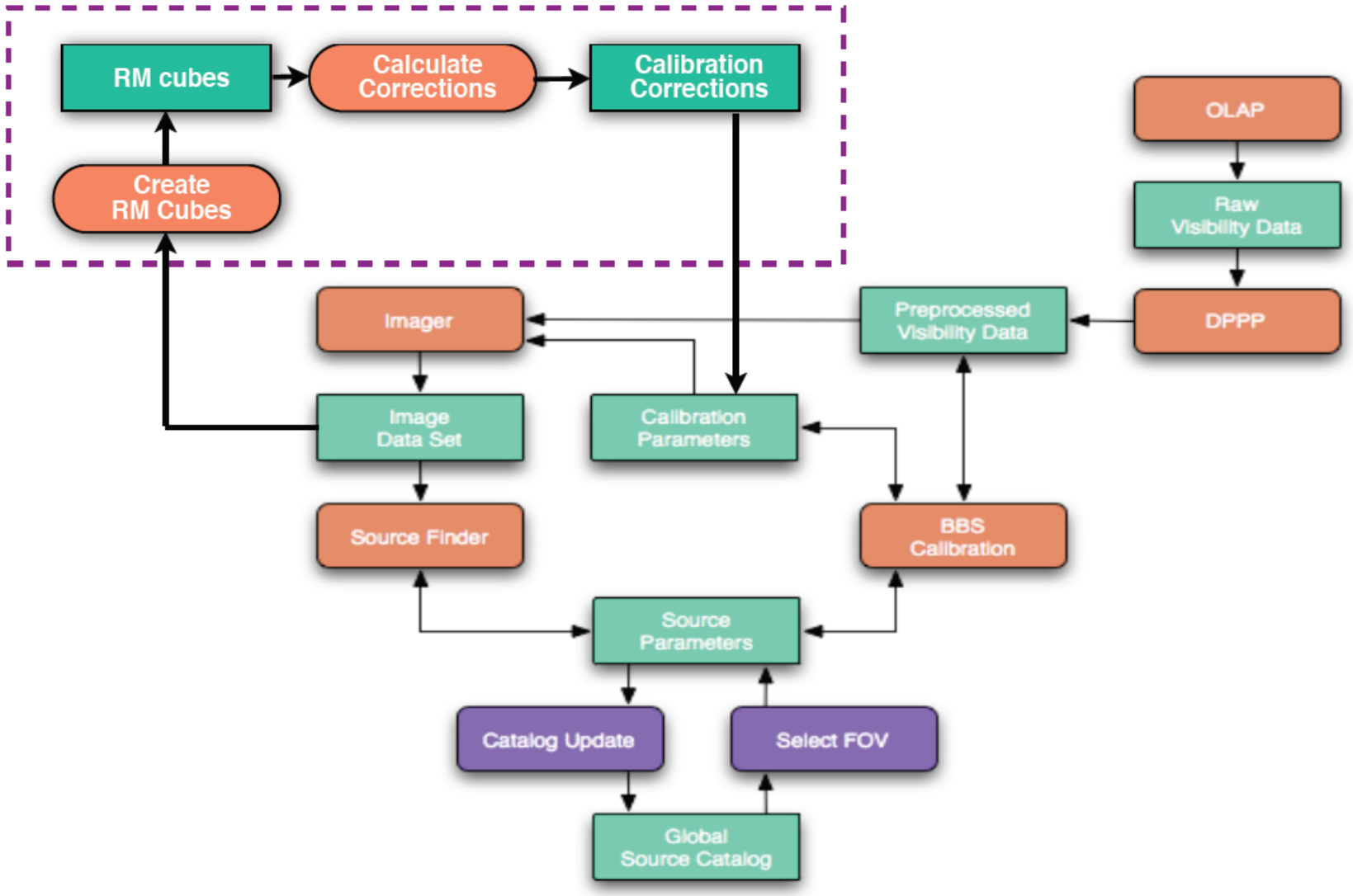
EoR pipeline



Transients Pipeline



Magnetism Pipeline



Million Source Shallow Survey (MSSS)

- Purpose: fill initial GSM + testing of software
- “All” sky survey: Dec > 0; using 13 core + 7 remote stations
- Minimize “challenges”, currently:
  - Beams
  - Ionosphere
  - Wide FoV
  - Wide freq band
- Total Intensity only
- 4 beams of 8 MHz BW each
  - 16 bit mode
  - Processed independently
- Observe fields in several short observations to improve uv-coverage
  - 60 MHz: 36 times 5 minutes
  - 150 MHz: 12 times 5 minutes

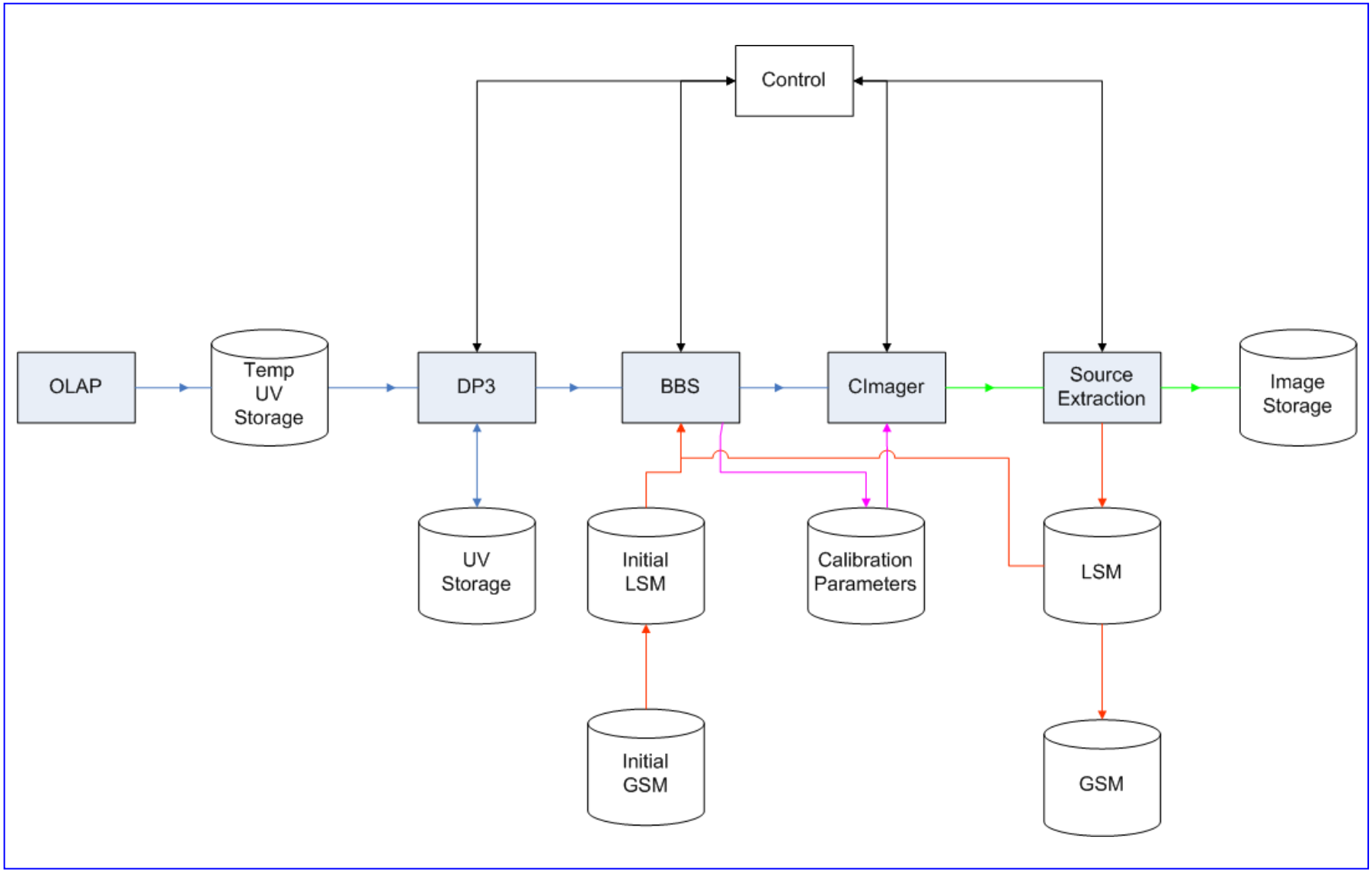
MSSS (cont.)

Frequency (MHz)	Area (sq. deg.)	Rms (mJy)	BW (MHz)	Sources / FoV	Int. time (hrs)	# pointings	Tot. obs. (days)	Tot. sources
60	20262	5.37	8	6062	3	609.1	19.0	1.18e+6
150	20262	0.499	8	5768	1	3346	34.9	6.14e+6

- # sources @ 5 σ thermal noise
  - Multiple freq. planes & 30 σ: few times1e+5
- Total obs. Time (100% eff.): 53.9 days or 7.7 weeks
- At 50% eff.: 15.4 weeks or 3.4 months

- Not taken into account:
  - Nyquist sampling yields another factor 1.5 in sensitivity
    - (or 2.25 in observing time)
  - Tapering of HBA stations for near sidelobe reduction

Standard Imaging Pipeline for MSSS



MSSS Processing steps

- Pre-processing of the data
  - Flagging of RFI, …
  - Correction for global bandpass
  - Correction for clock drifts
  - Solving for and subtraction of the A-Team
  - Compression of data
- Uv-plane calibration
  - Phases
  - Gains
- Direction dependent calibration
  - Total Intensity calibration (using Cat I sources)
    - Ionospheric phase: SPAM based
    - Beams
- Cat II subtraction
- Imaging in facets
  - Correction per facet
- Image combining
- Source finding
  - Sky model update

MSSS Summary

	60 MHz	150 MHz
Bandwidth	8 MHz	8 MHz
Observing time per FoV	36 times 5 minutes	12 times 5 minutes
FoV	106 deg^2	19.4 deg^2
FWHM	11.6 deg	4.97 deg
PSF resolution (10 km)	82.5 arcsec	33.0 arcsec
Correlator time resolution	1 s	1 s
Correlator freq resolution	0.76 kHz	0.76 kHz
Uv data size	762 Gbyte	678 Gbyte
Post DP^3 time res.	5 s	5 s
Post DP^3 freq res.	21.3 kHz	42.6 kHz
Post DP^3 uv data size	~ 4.76 Gbyte	~ 2.12 Gbyte
# channels per image cube	Tbd	Tbd
# pixels per image plane	2048 x 2048 ?	2048 x 2048 ?
Total image size	Tbd	Tbd

Table 1: Specifications per pointing / FoV

- 2048 squared plane ~ 16.8 MByte

MSSS Summary (cont.)

	60 MHz	150 MHz
Total # fields (2 pi steradian)	609	3346
Total observing time (100% eff., using 4 beams)	456.75 hr	836.5 hr
Total # sources	Tbd	Tbd
Total uv data size	466 Tbyte	2.27 Pbyte
Total post DP^3 uv data size	~ 2.9 Tbyte	~ 7.1 Tbyte
Total image data size	Tbd	Tbd

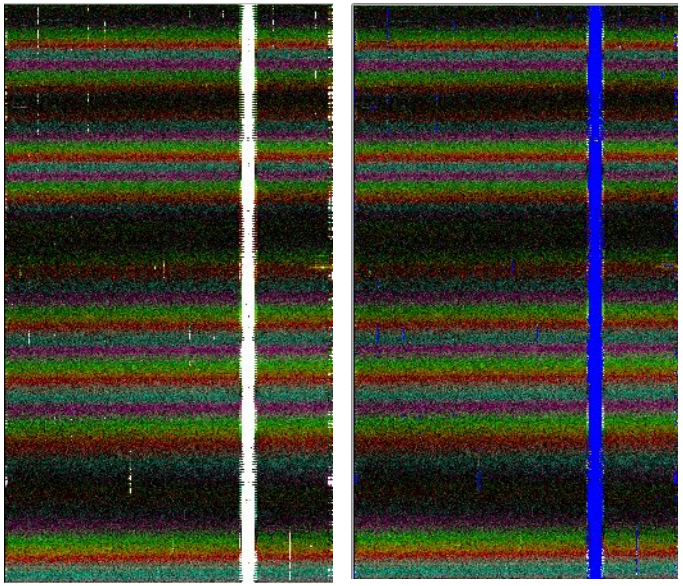
Table 2: "All sky" specifications

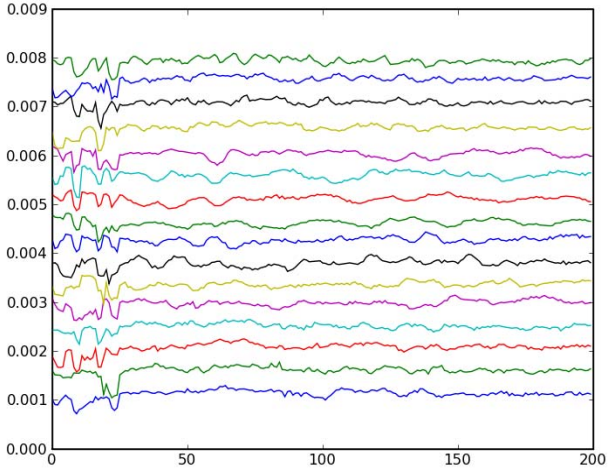
- 1 freq. plane: 16.8 MByte x 3955 = 66.4 GByte

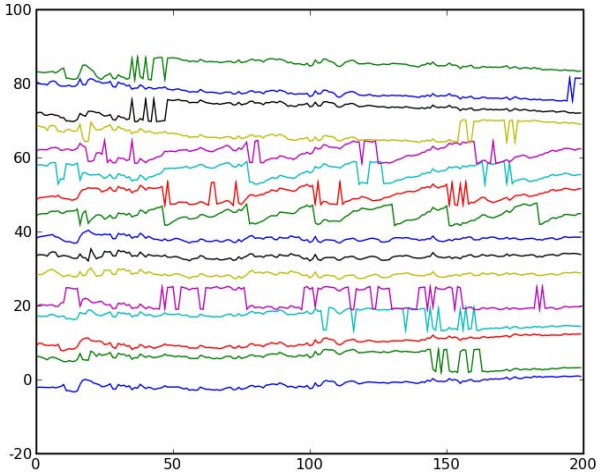
Data Products

- Uv-data sets
- Image cubes
- RM cubes
- LSM / GSM
- Meta data
  - Calibration solutions

Uv-data: before and after Flagging

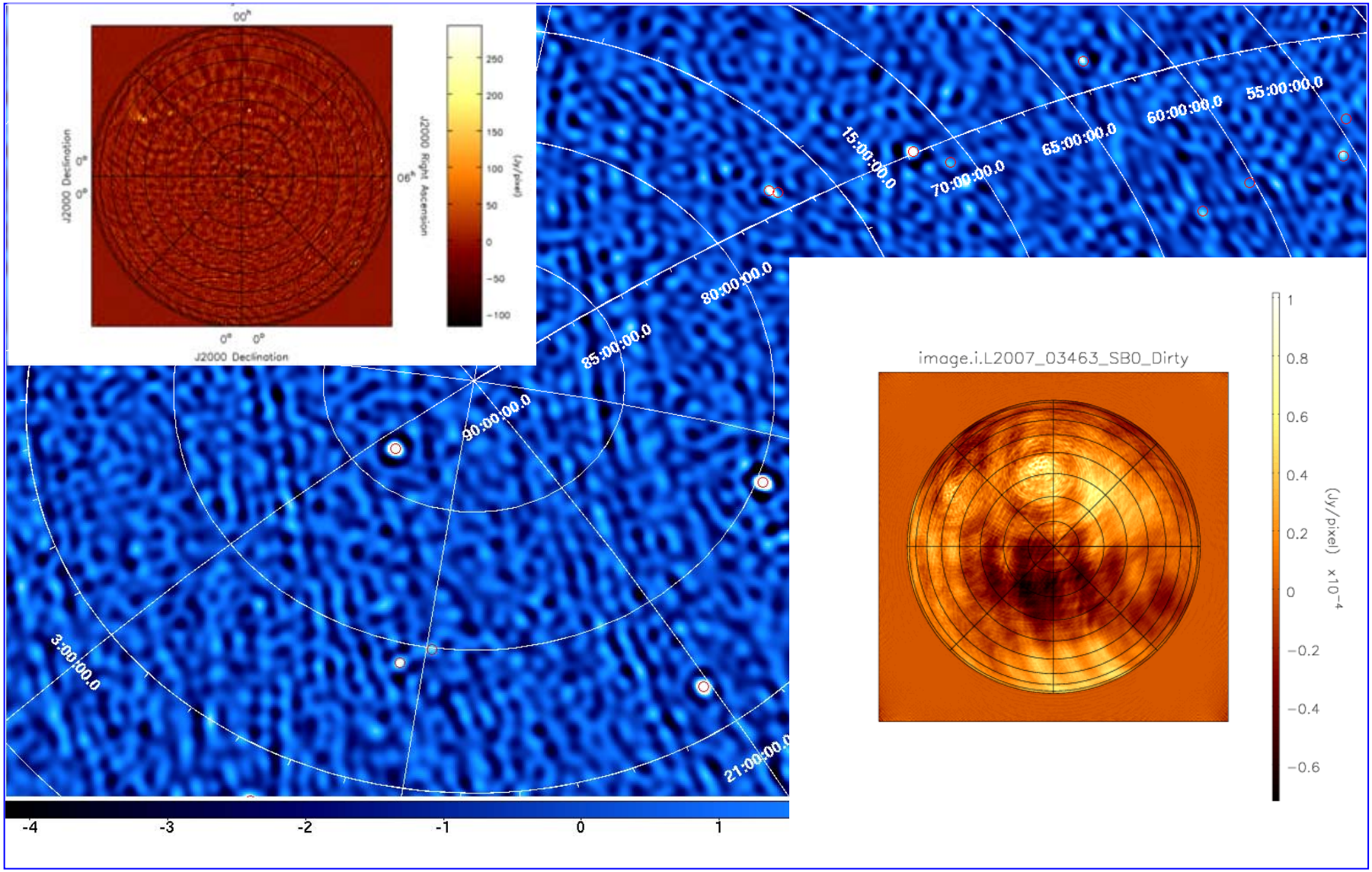






Gain and phase solutions from BBS

Images & cubes



MSSS Data storage

- What do we store?
  - Raw uv – data: ~ 2.7 Pbyte 
  - Compressed uv – data: ~ 10 Tbyte 
  - Images: ~ 325 Gbyte??? 
  - GSM 
  - Calibration parameters

Development and commissioning team

- DPPP
  - Adriaan Renting
  - V.N. Pandey

- BBS
  - Joris van Zwieten
  - Marcel Loose
  - Maaijke Mevius
  - V.N. Pandey

MM

- Imager
  - Ger van Diepen
  - ASKAP team
  - Evert Rol

ER

- Source Finding
  - John Swinbank

- RM Synthesis
  - Sven Duscha

- LSM / GSM
  - Ger van Diepen
  - Bart Scheers

- Pipeline Integration
  - Marcel Loose

- Calibration Project Scientist
  - Ger de Bruyn

- Calibration Project Manager
  - Ronald Nijboer