

LOFAR

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+ on behalf of the LOFAR collaboration

ASTRON, Dwingeloo & Kapteyn Institute, Groningen

The LOFAR observatory

Array of dipoles grouped in stations

2 types of antennas: isolated (LBA) and tiles (HBA)

Frequency ranges : LBA 10 - 80 MHz
HBA 115 - 240 MHz

Dimensions : 2 km - 100 km - >1000 km

Configuration: NL 36 - 48 stations
Europe ~ 10 stations

Variable station sizes : 24 - 96 antennas
(not intended: effect of rescope !!)

Sensitivity (after 4 h, 4 MHz)

- @ 50 MHz ~ 3 mJy
- @ 150 MHz ~ 0.15 mJy

Up to 8 simultaneous users possible



LOFAR science

The specifications and capabilities of LOFAR are mainly driven by
6 Key Science Projects:

- 1) Surveys of the sky
- 2) Transients and Pulsars
- 3) Epoch of Reionization
- 4) Cosmic Rays (UHECR)
- 5) Cosmic magnetism (- polarimetry)
- 6) Sun and solar system science

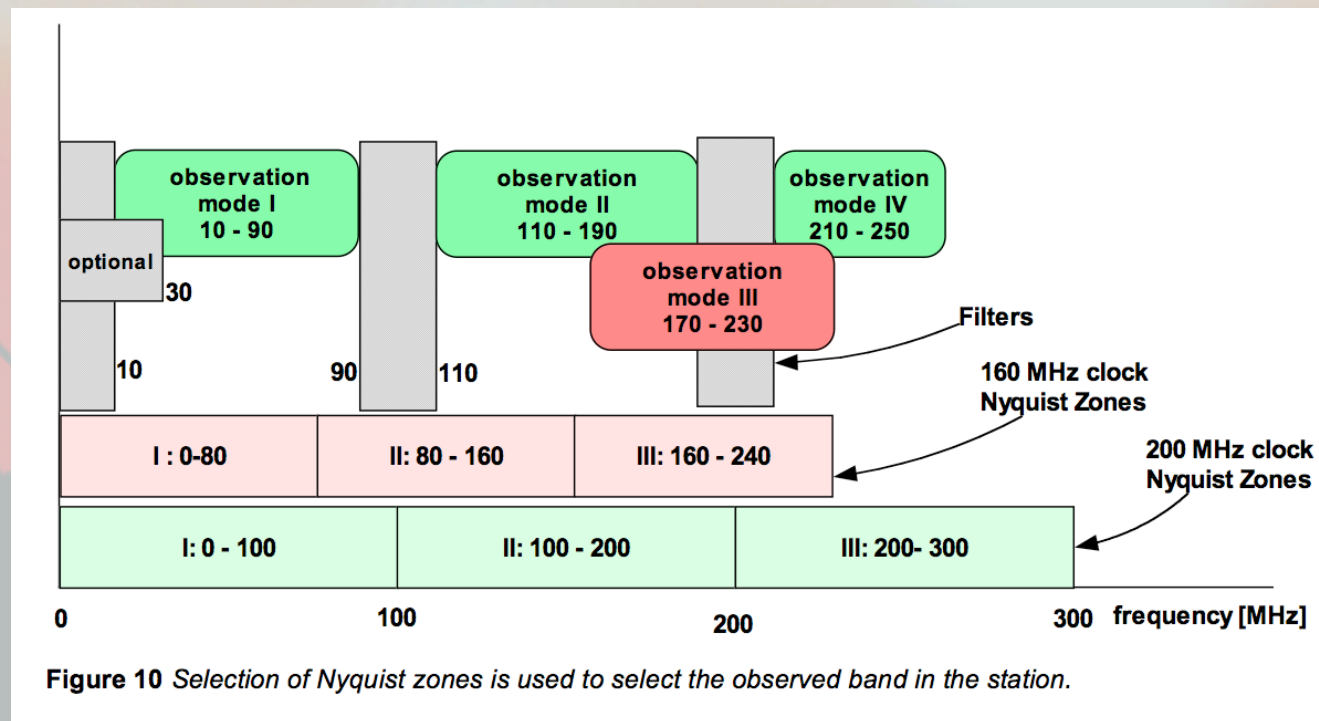
LOFAR frequency selection aspects

Two 12-bit sampling modes: 160 or 200 MHz clock

Frequency filtering done in two (PPF) stages:

- at station \Rightarrow 512 subbands (of 156 or 195 kHz)
- at CEP (BG/P) \Rightarrow 256 channels for \sim 200 subbands \Rightarrow 0.6 - 0.8 kHz

(NB: \sim 1 kHz is required for both RFI excision and very wide-field imaging)



LOFAR pilot facilities/experiments

2004-05 **ITS** 20 - 40 MHz 6.7s

2004-08 **WSRT LFFE** 115 - 175 MHz

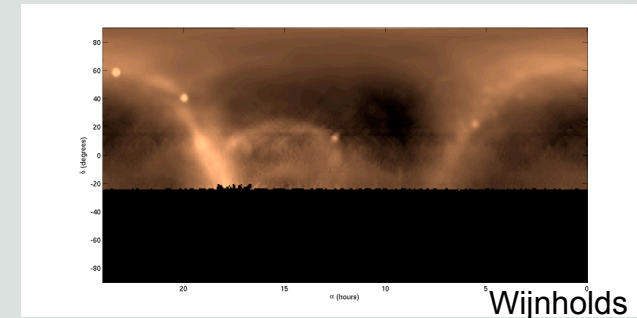
- several deep 6x12=72h syntheses, all-sky imaging !
- 2m - polarimetry (--> [Brentjens, J06, Friday](#))

2006-07 **WSRT 'WHAT'** 115 - 175 MHz (4 prototype tiles)

- combined synthesis --> beampatterns

2007-08 **CS-1** 10 - 80 MHz & 110 - 240 MHz >72h

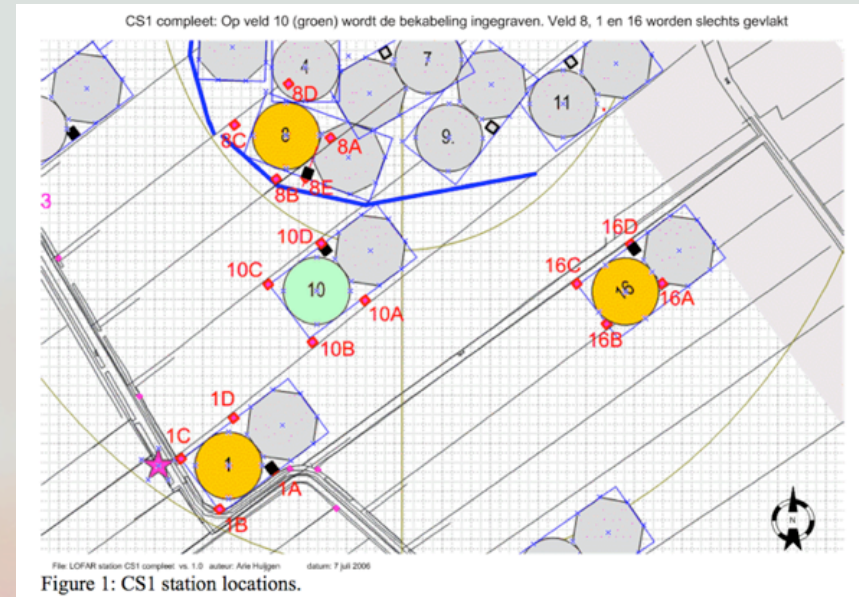
- station calibration, analog/digital beamforming,
- datatransport, tracking, correlation,
- calibration, imaging, ...



CS-1 configuration ('mini'-LOFAR)

Dec 06 --> June 08


- hardware across 4 stations:
 - LBA: 96 dipoles (48 + 3x16)
 - HBA: 32 dipoles + 6 tiles
- per station there are 4 -12 'micro'stations
- digital beamforming (with 4 - 48 dipoles)
- baselines from ~ 10 - 450 meter
- 16 'micro'stations \Rightarrow 120 (~ 60) interferometers
- 24 microstations \Rightarrow 276 (~ 180) interferometers



400 m

SAS 'Navigator' control panel

Hardware Observations Processes Reports Alerts Show TestPanel



Hardware

- CS001
- CS008
- CS010
- CS016

Processes

Processes

Locator

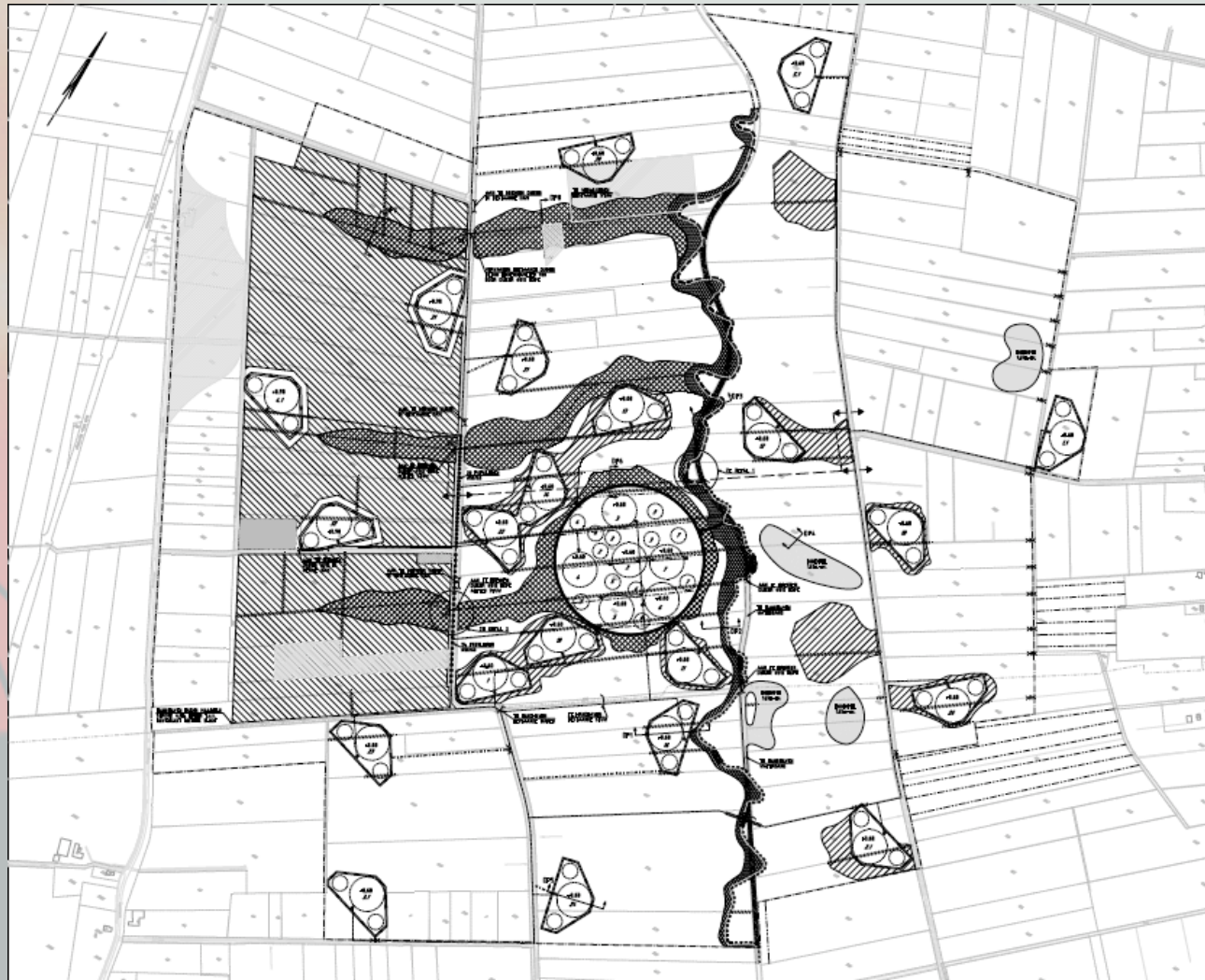
2008.07.29 12:37:43.686 SHM:http://10.230.30.1/shm/data CAME

1 / 1

Image © 2008 Aerodata International Surveys
© 2008 Tele Atlas
Google

Nature development in LOFAR core (Exloo)

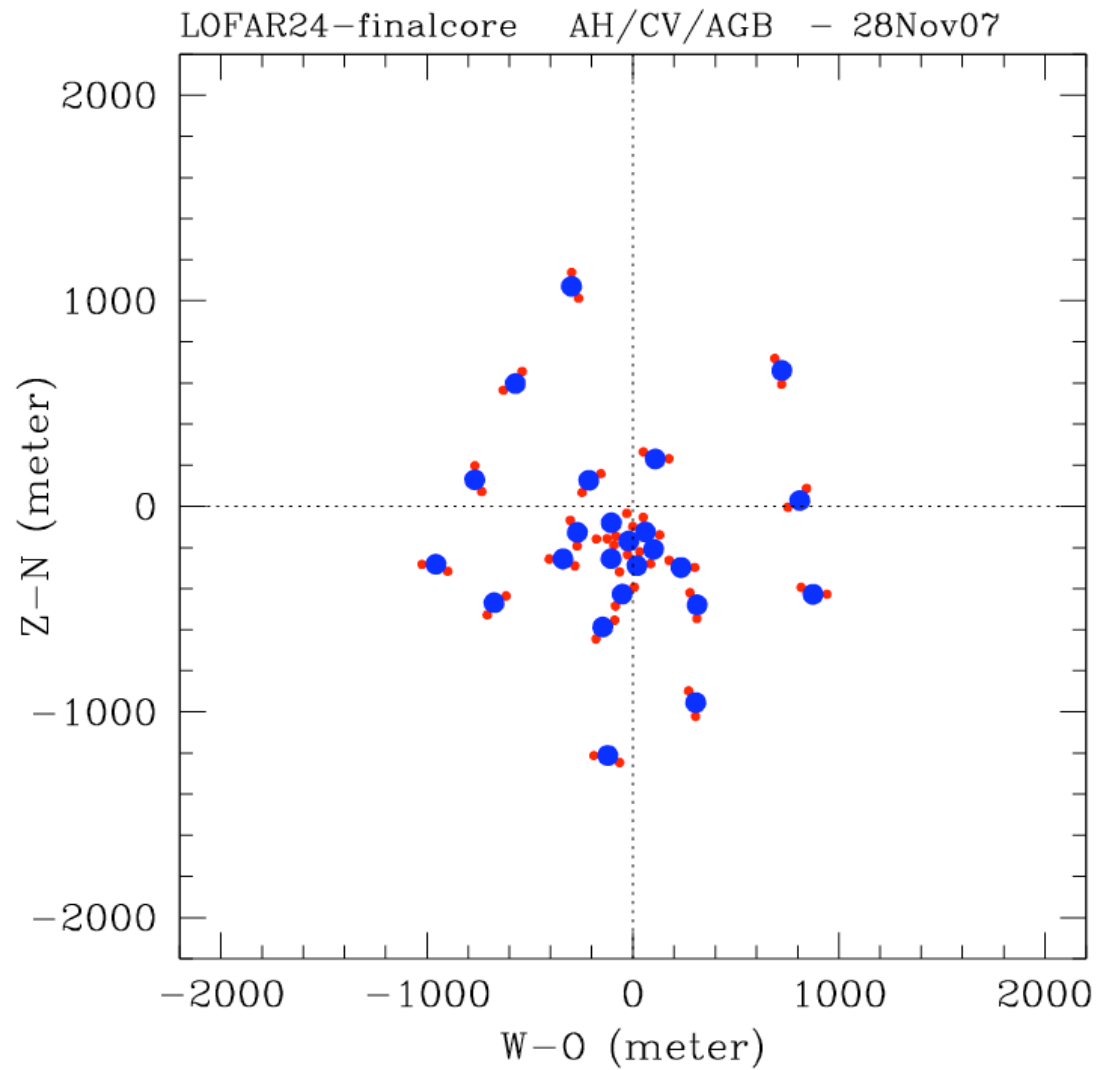
Rather soggy in rainy season \Rightarrow 0.6 m down and 0.6 m up



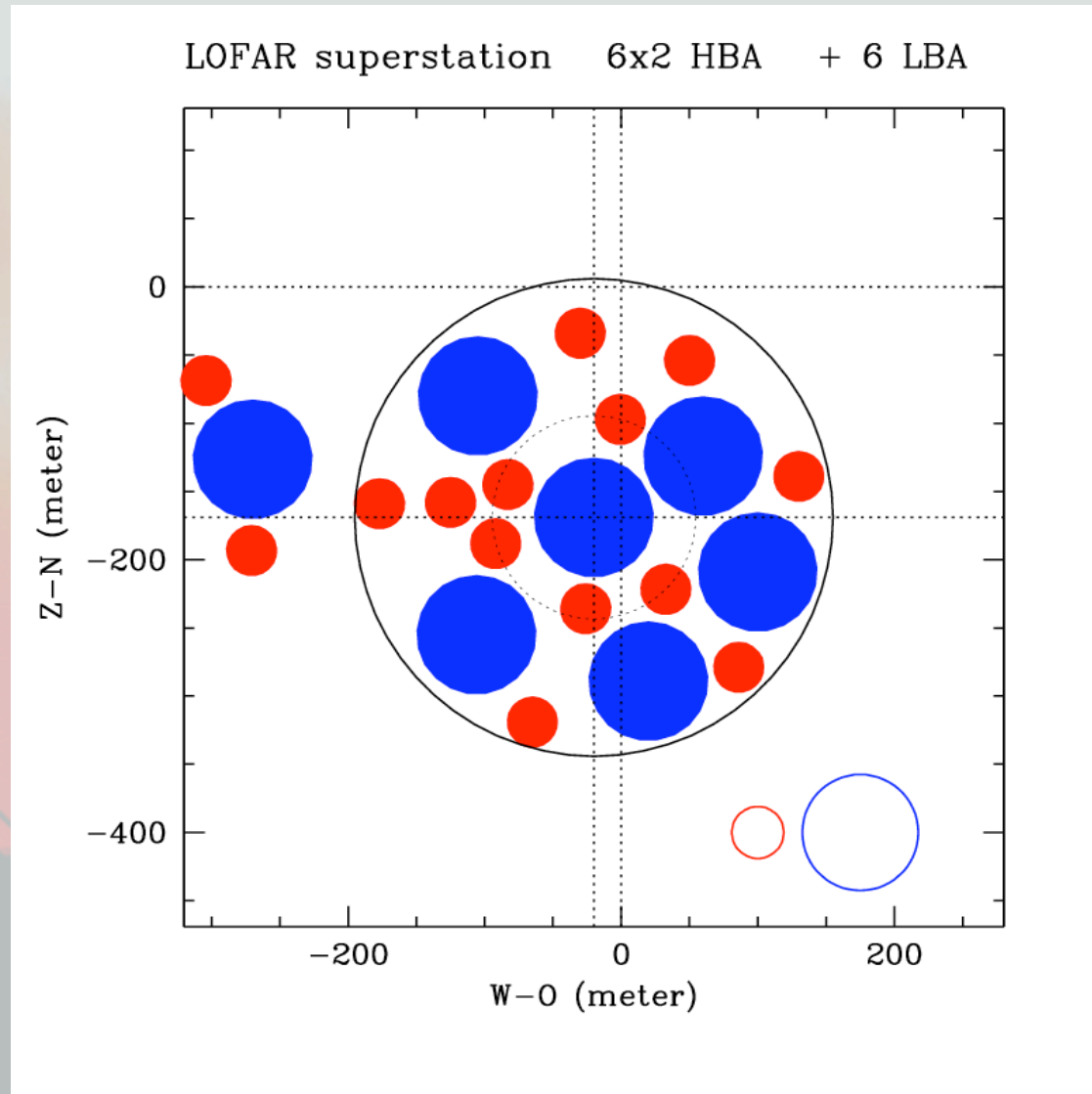
Raising and lowering land in the core (~1 Aug08)



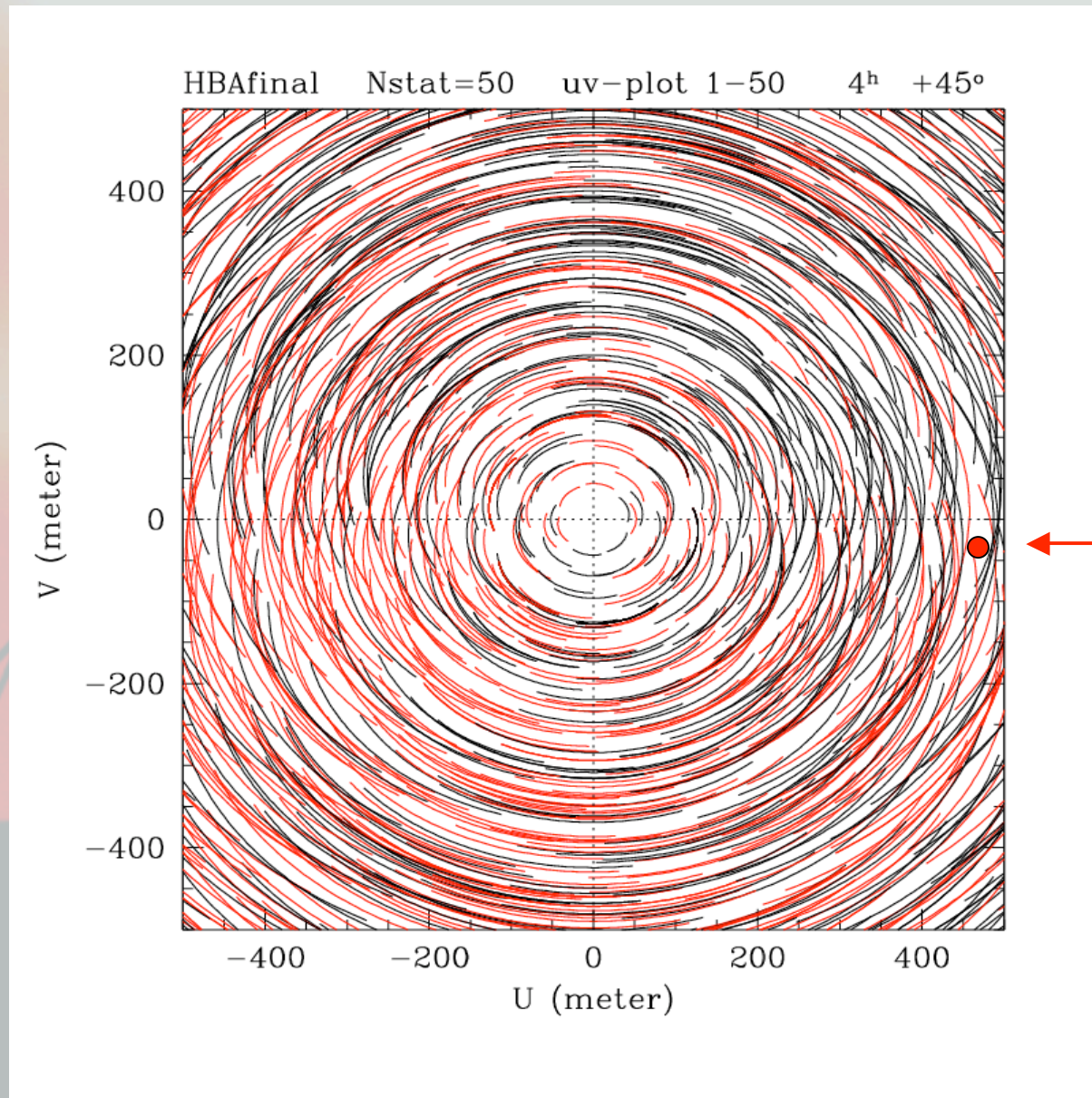
The LOFAR24(x2) core configuration



The 'superstation' in the core: 6 LBA and 6x2 HBA

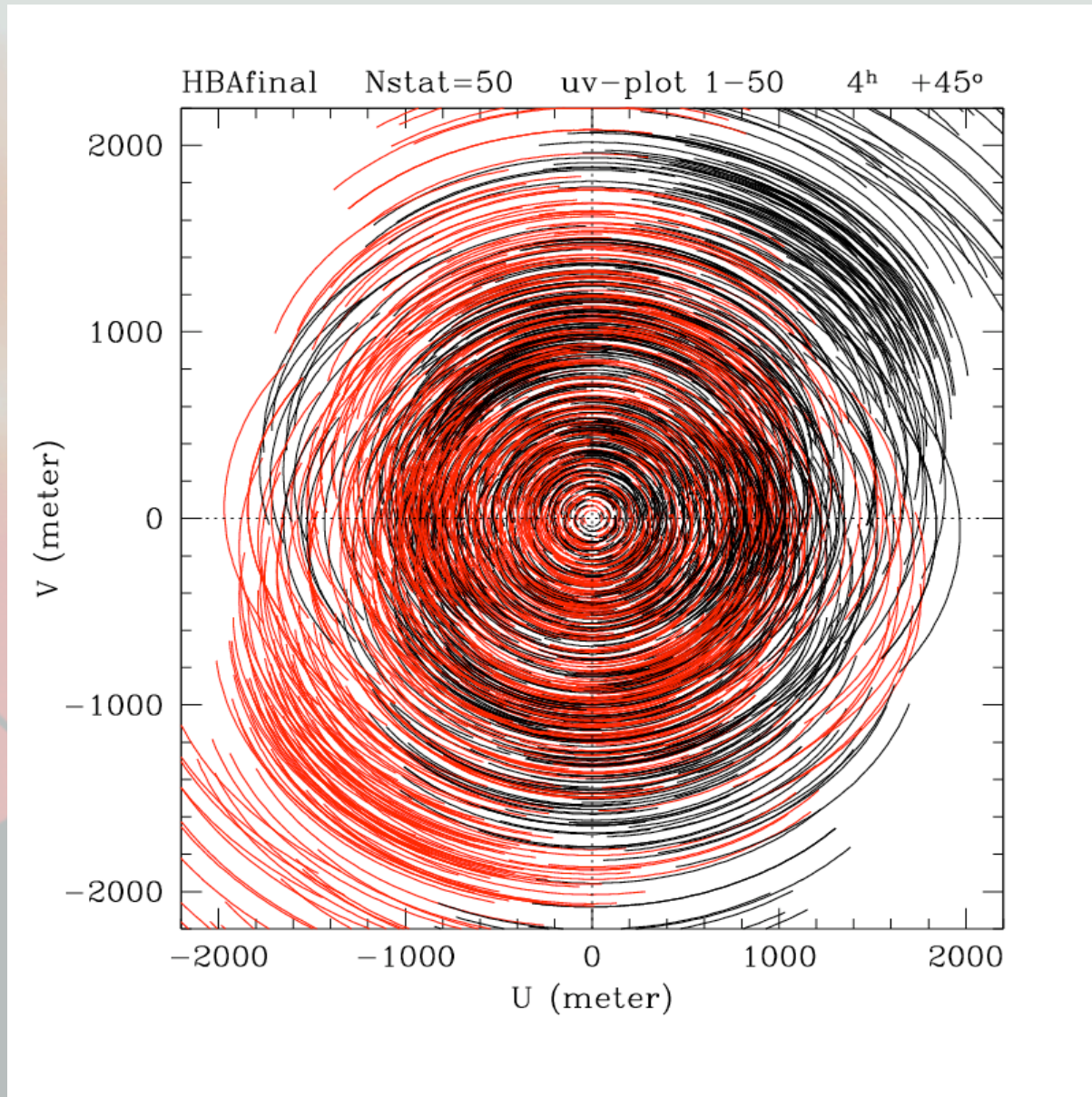


LOFAR24(x2) inner uv-coverage for +45° / 4^h



HBA core station
diameter ~ 25m

LOFAR24(x2) core uv-coverage for $+45^\circ / 4^h$



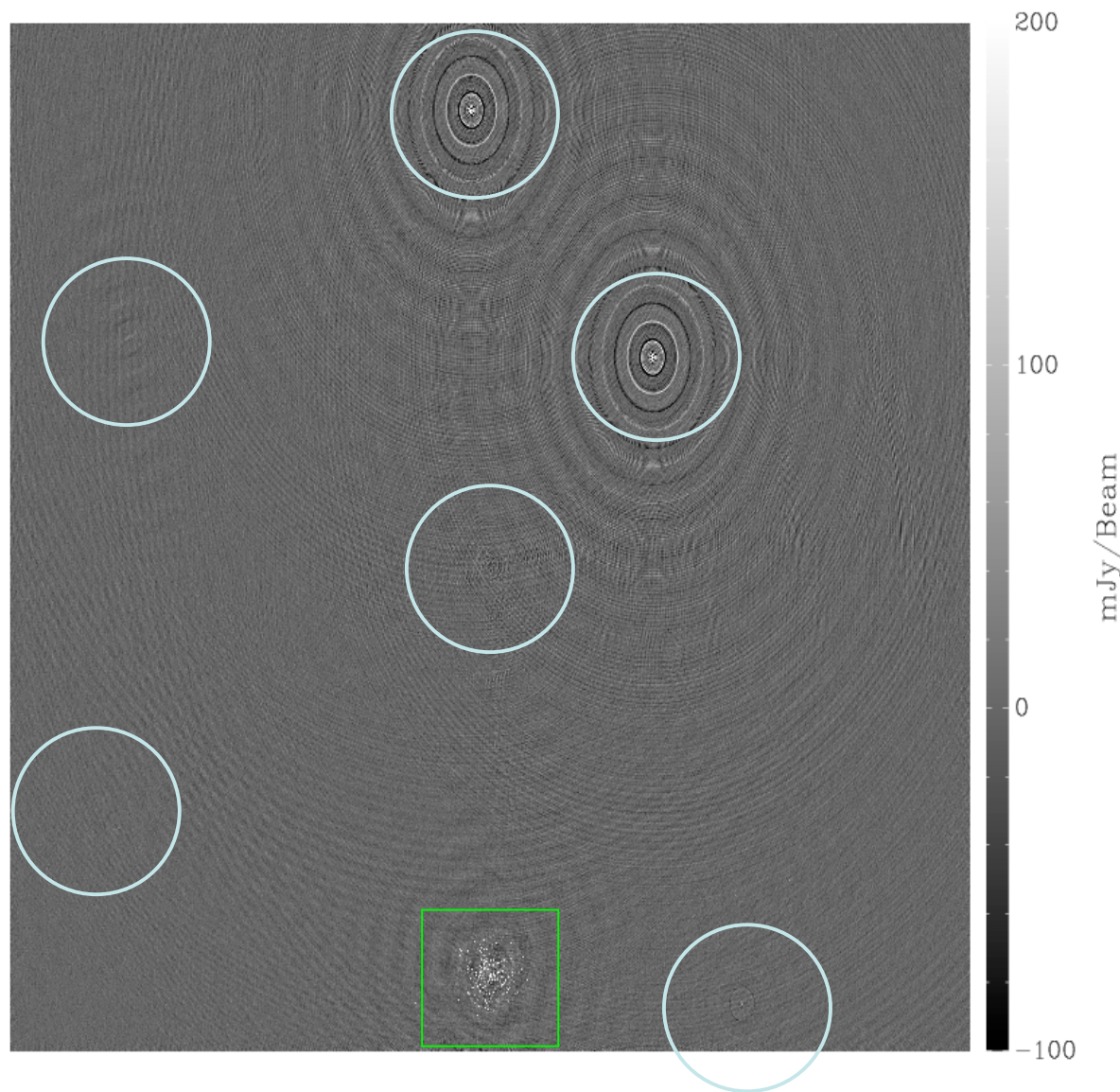


Some results on all-sky imaging with

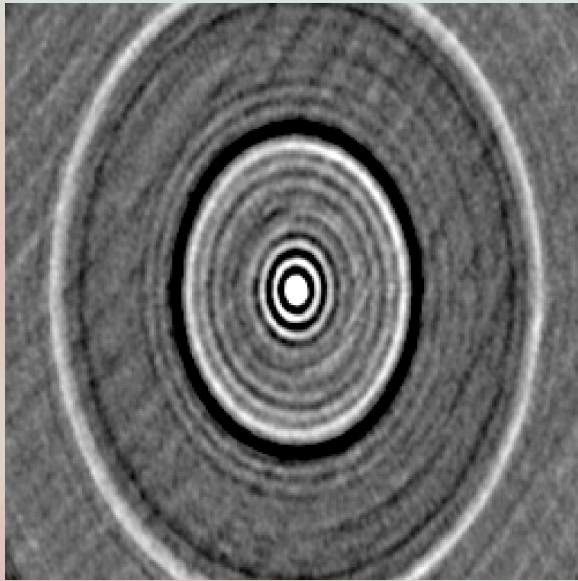
- WSRT at ~ 150 MHz

- LOFAR CS-1 at 50 / 150 MHz

WSRT ~150 MHz image 3C196 and the A-team



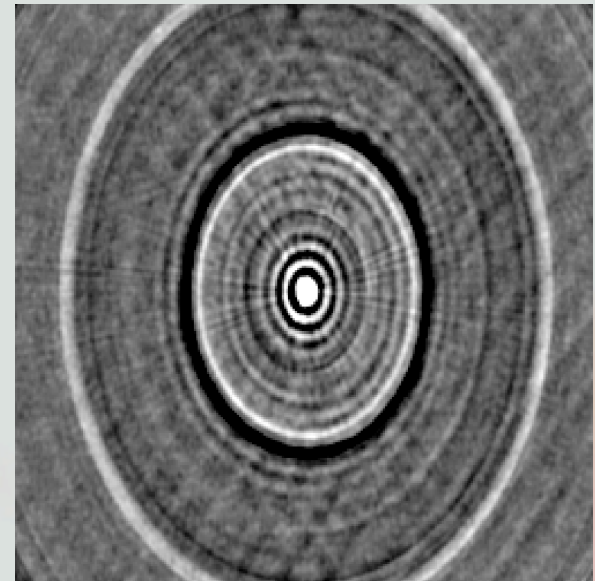
The A-team magnified



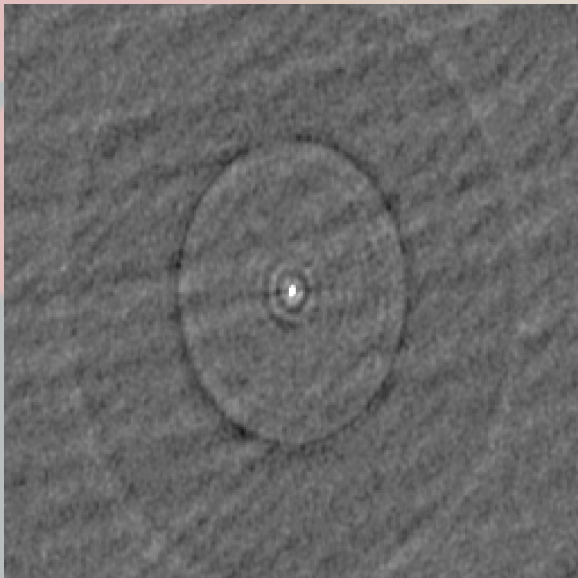
~5' PSF

CasA

CygA

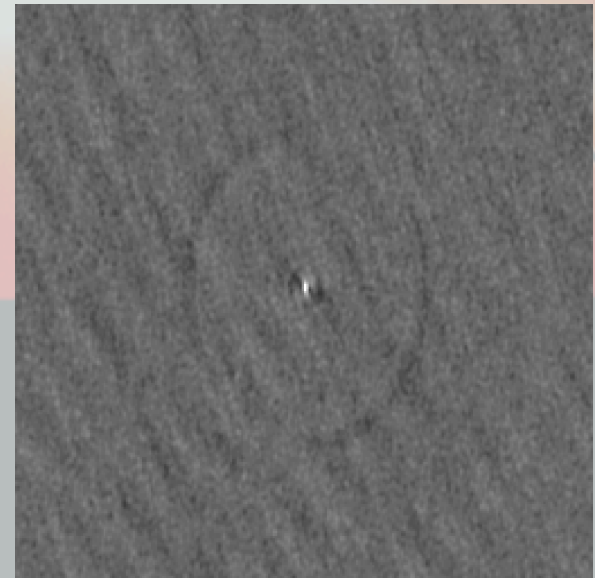


~ 10 Jy peakflux



TauA

VirA



Confusion limited LOFAR CS-1 image at ~ 50 MHz

16 dipoles (only ~ 70 baselines)

3 x 24h

38 - 59 MHz (B=6 MHz)

~ 800 sources !

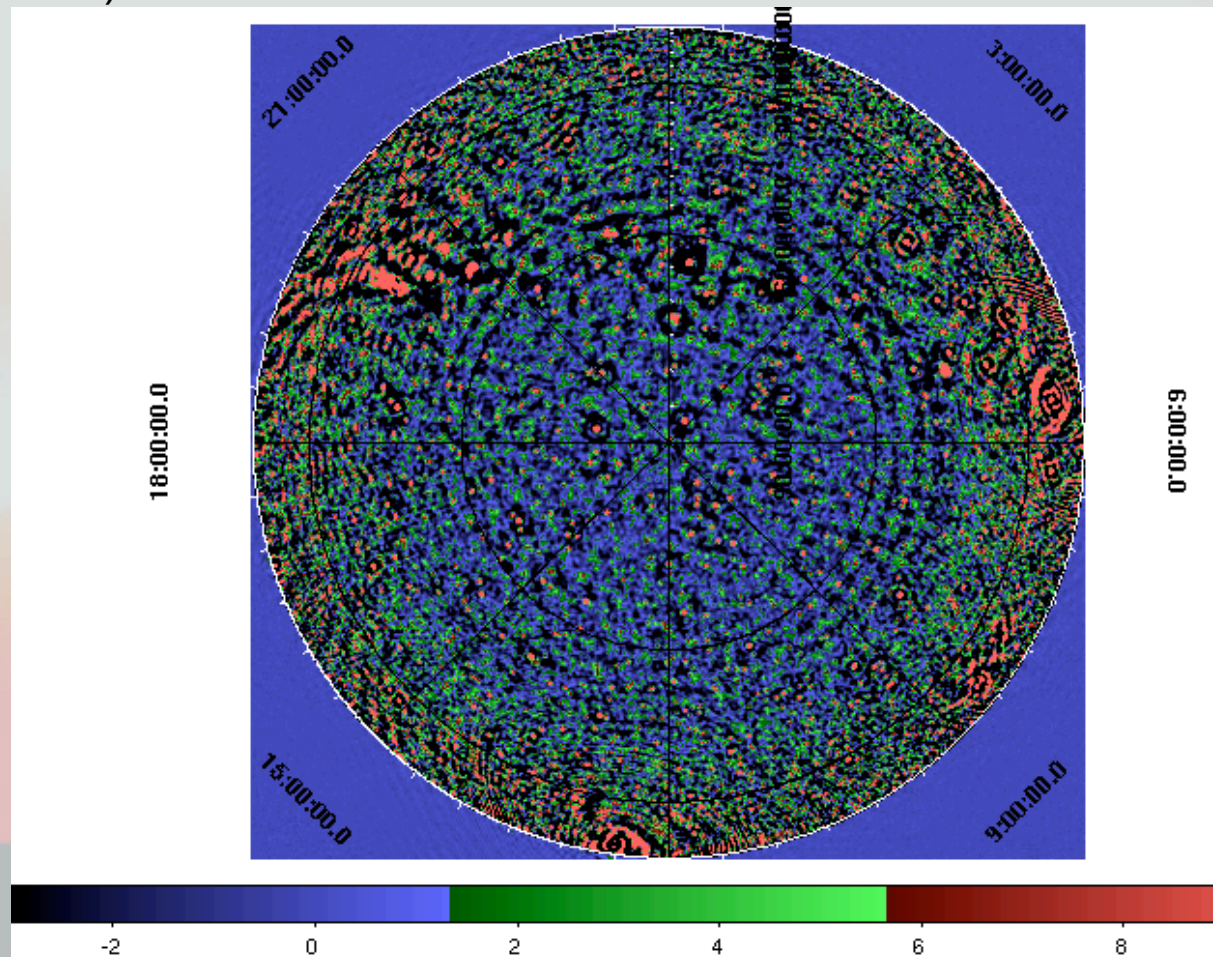
PSF $\sim 0.5^\circ$

noise $\sim 0.5 - 1$ Jy

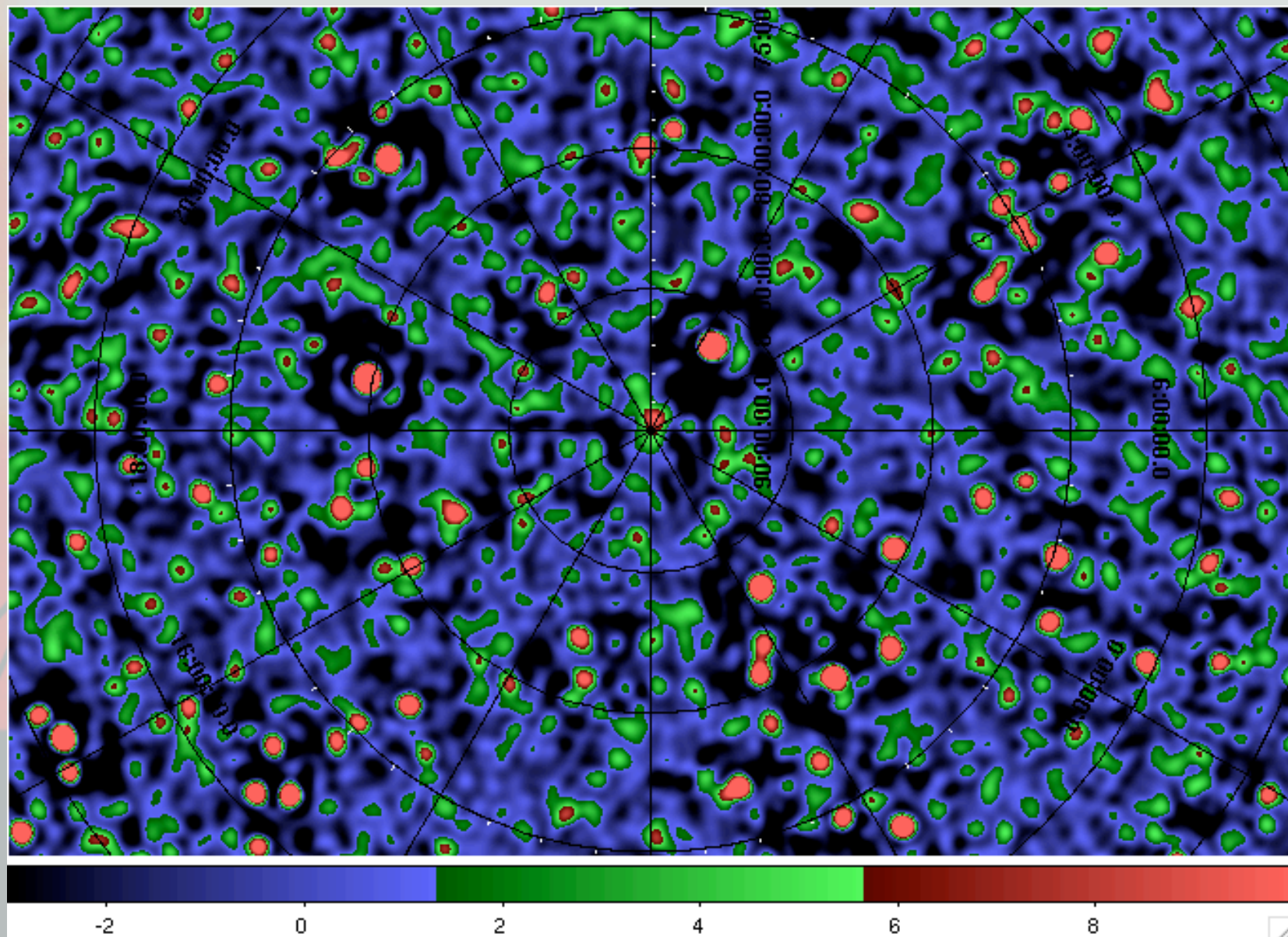
CasA/CygA ($\sim 20,000$ Jy)
subtracted

- dipole beam corrected
- no deconvolution

Sarod Yatawatta

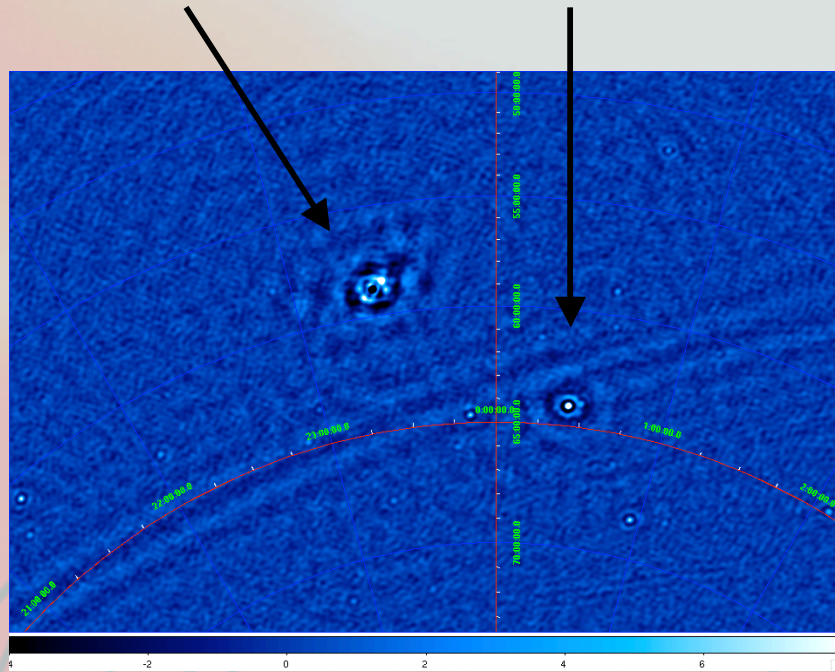


ASTRONs 2007 Xmas card

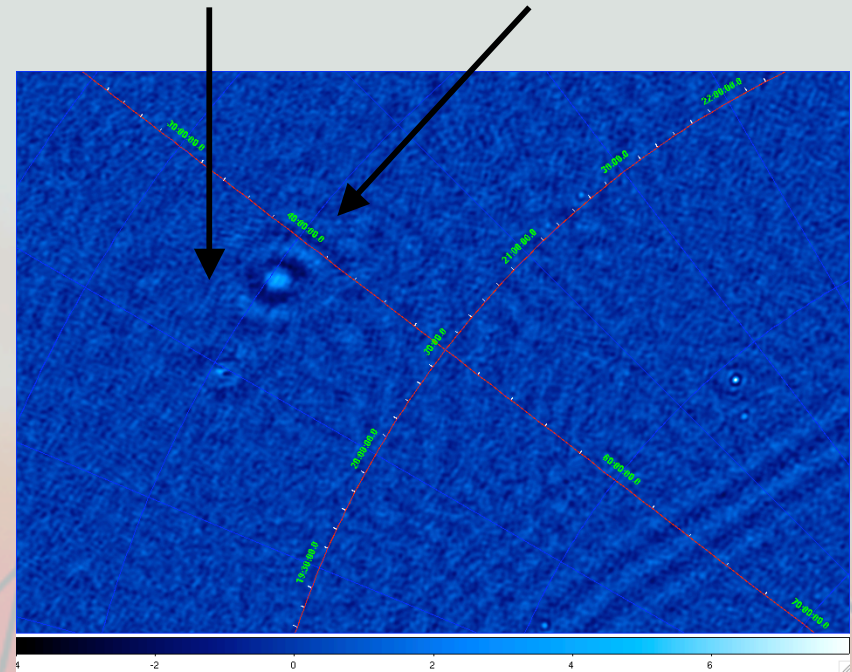


Zooming in on HBA ~ 150 MHz images

CasA & Tycho's SNR



CygA & HB20

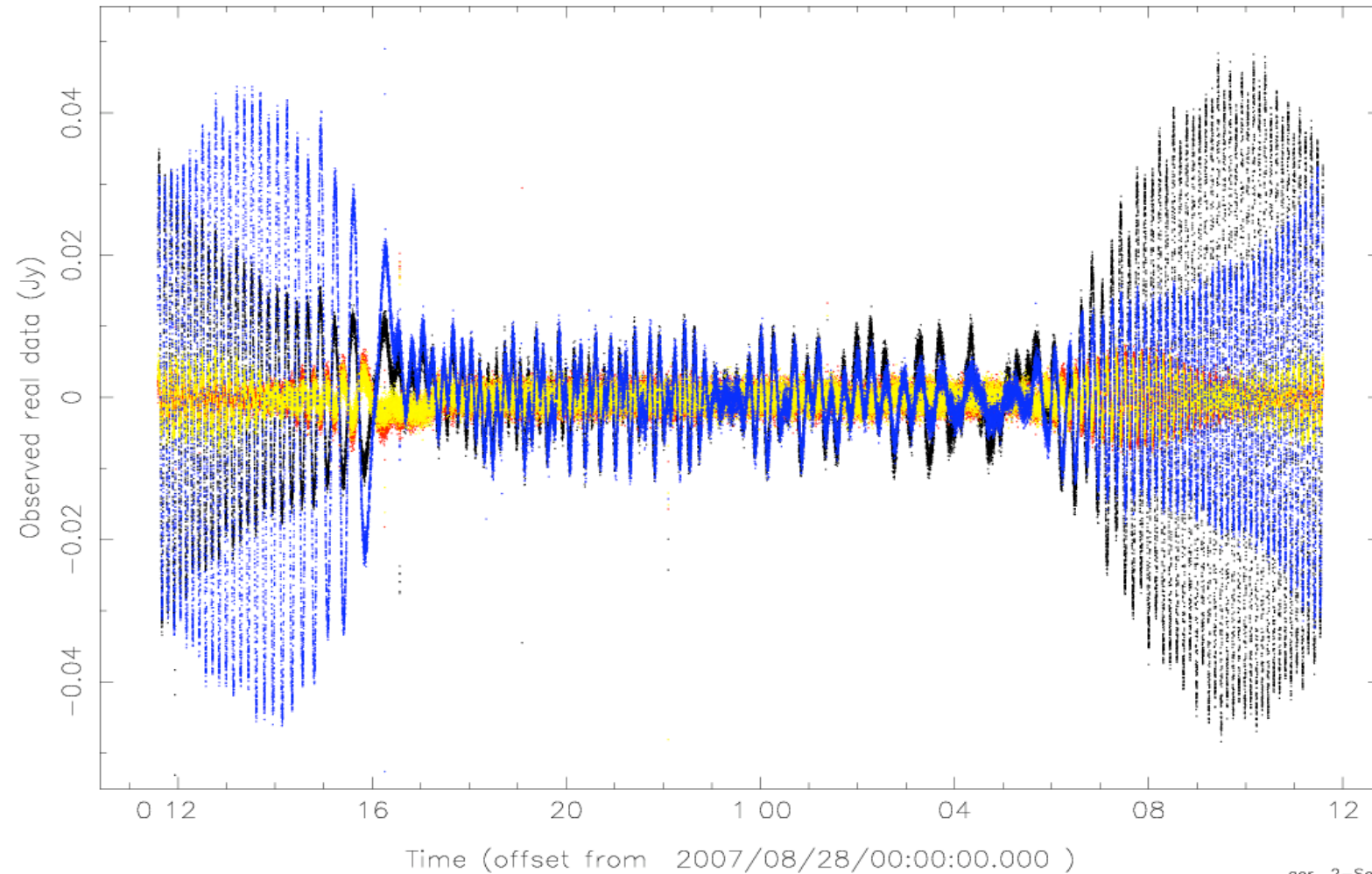


NOTE:

- CasA resolved (no deconvolution)
- sidelobes from Sun

The difference between day and night at 220 MHz

me: /dop64_2/ger/LOFAR/CS1/data/28aug07-L3743/SB10.MS Spectral Window: 1 Polarization: 1 Fields: B
XX XY YX YY
Antenna1 = 13 Antenna2 = 15

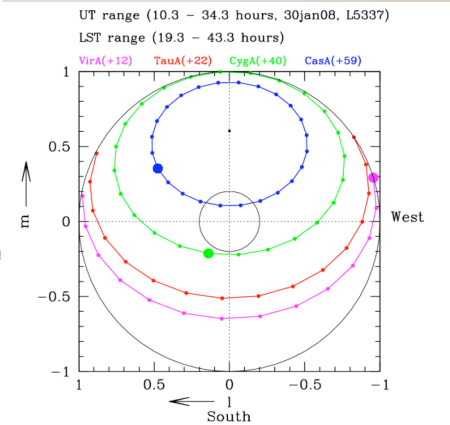
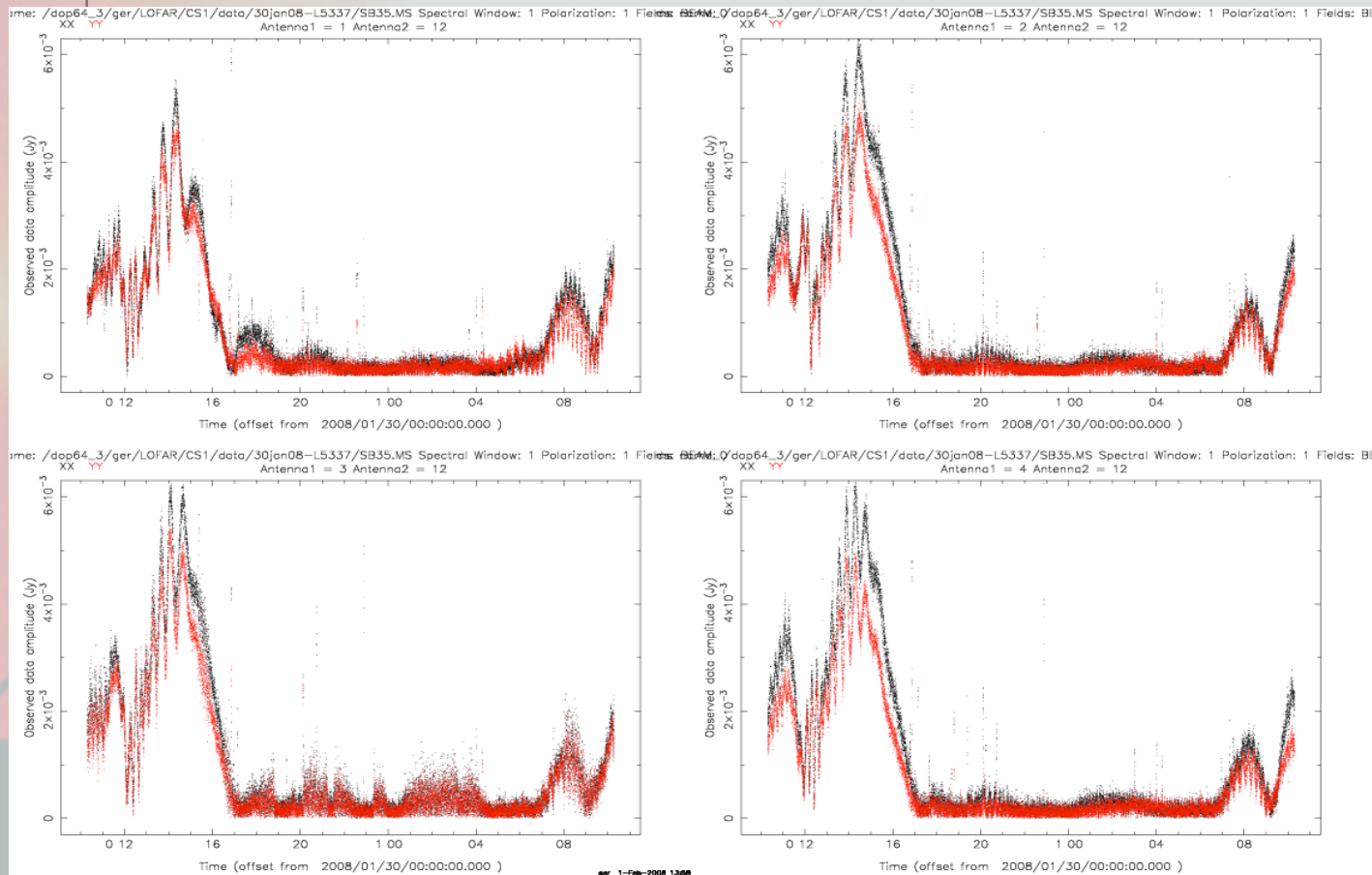


ger 2-Sep-2007 21:07

and this is the quiet Sun ...

Dipole - tile correlations (zenith centered)

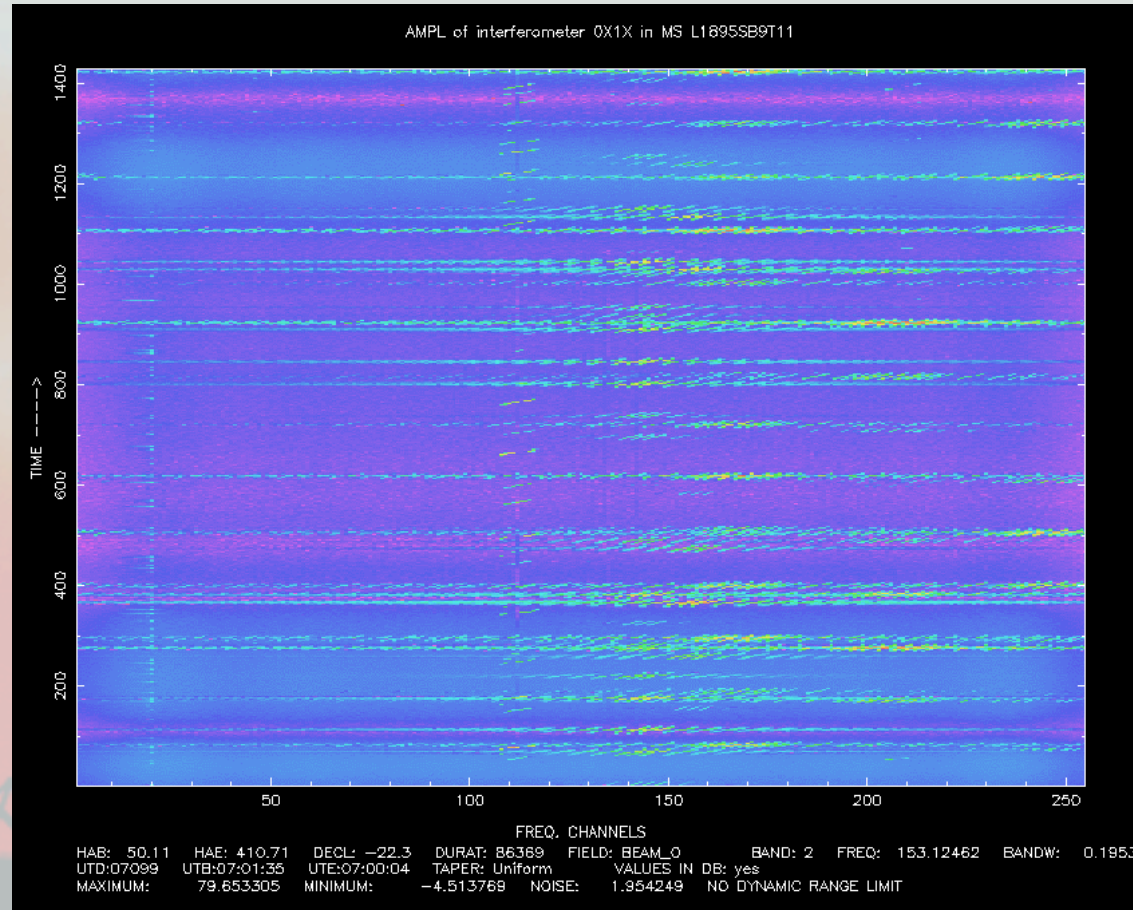
(L5337, 30 jan08)



Dynamic spectrum at ~147 MHz

9apr07

24h



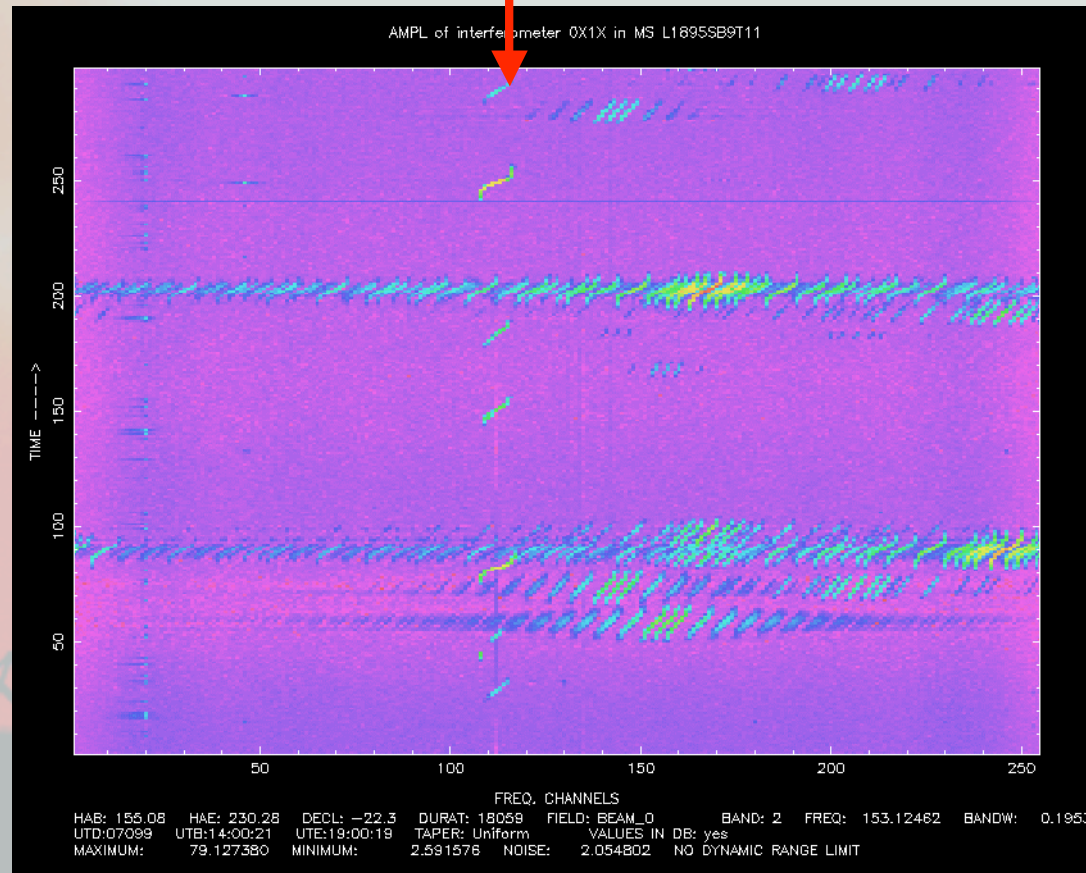
~ 84 dB
intensity
range !!

156 kHz in 256 channels

Drifting signals from LEO satellites at 147 MHz

exquisite spectral resolution !
8 kHz Doppler shift in 5-10m

time

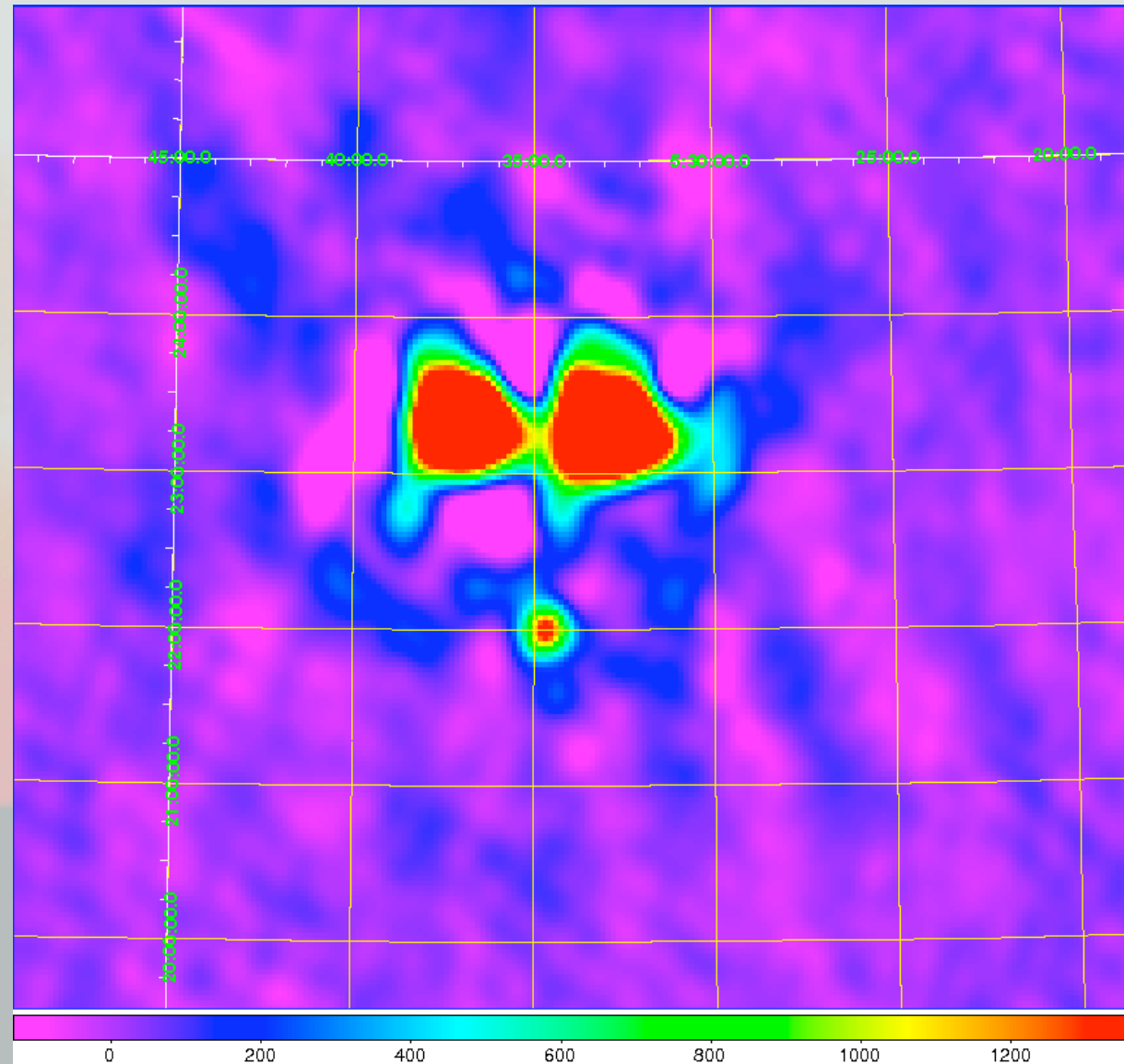


frequency

The Sun and Tau A on 14+15 June 2008

HBA

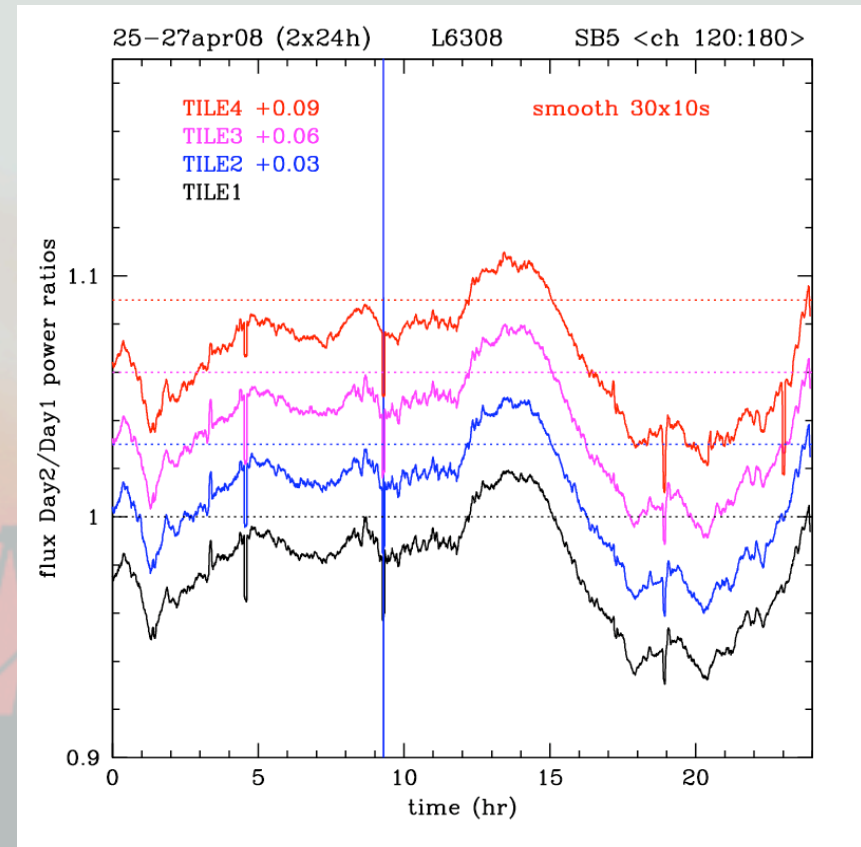
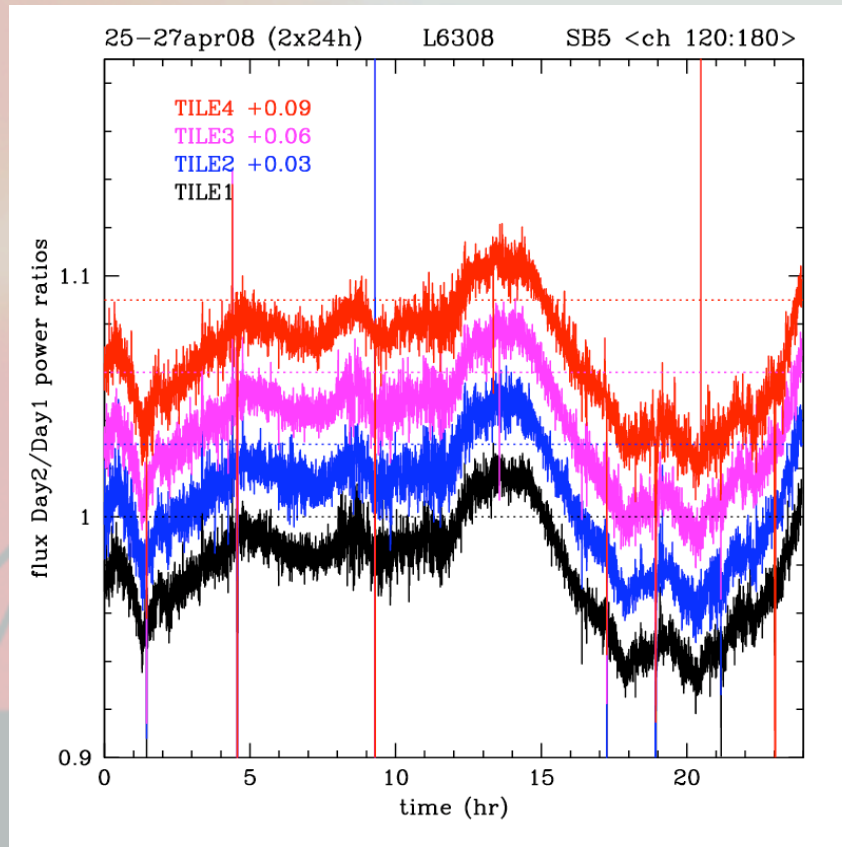
~150 MHz



Tile power ratios: 2x24h L6308 - 26apr08

10s

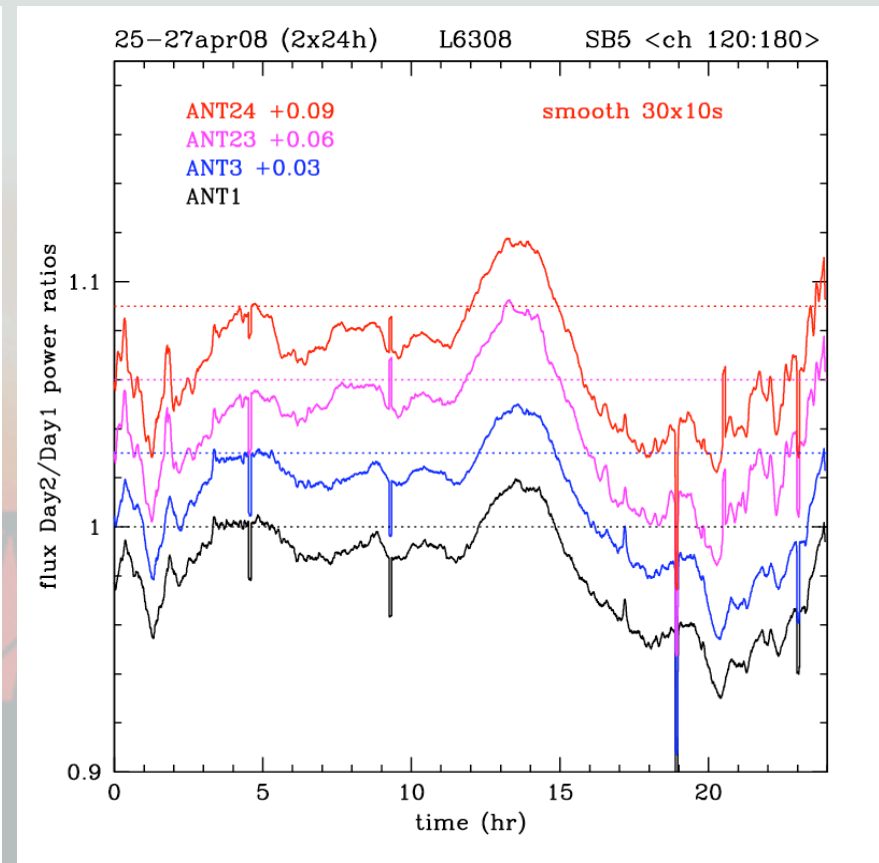
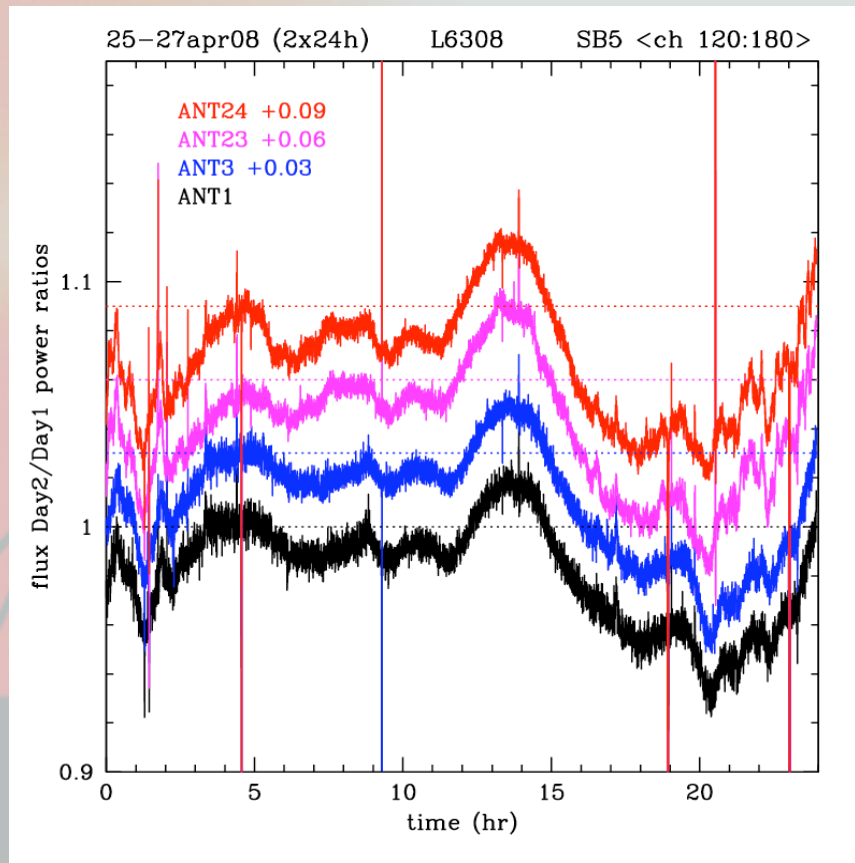
smoothed 5m



Dipole power ratios: L6308 - 26apr08

10s

smoothed (5m)



Roll-out and Planning

Stations:

- Oct 08 2 stations
- Dec 08 4 + 6 ('superstation')
- Apr 09 20 stations + (2 - 7) in Europe

Central processor (BG/L -> BG/P transition)

Off line cluster + storage by Dec08

Technical/Software commissioning: Oct08 - Apr09

Integration SAS / MAC / SHM / OLAP /Off-line processing

Construction of a Global Sky Model (GSM): Summer 2009

The MS³-project:

Spring 2009: LOFAR should have 13 (core) + 7 (NL) + 2+ Eu- stations

Calibration & Imaging requires a Global Sky Model (GSM) in place

Sensitivity in ~ 45m (LBA) and 15m (HBA) in multiple 5m 'snapshots' sufficient to detect ~ 0.5 - 2.5 million sources $> 20\sigma$ (thermal noise)

hence MSSS = the Million Source Shallow Survey

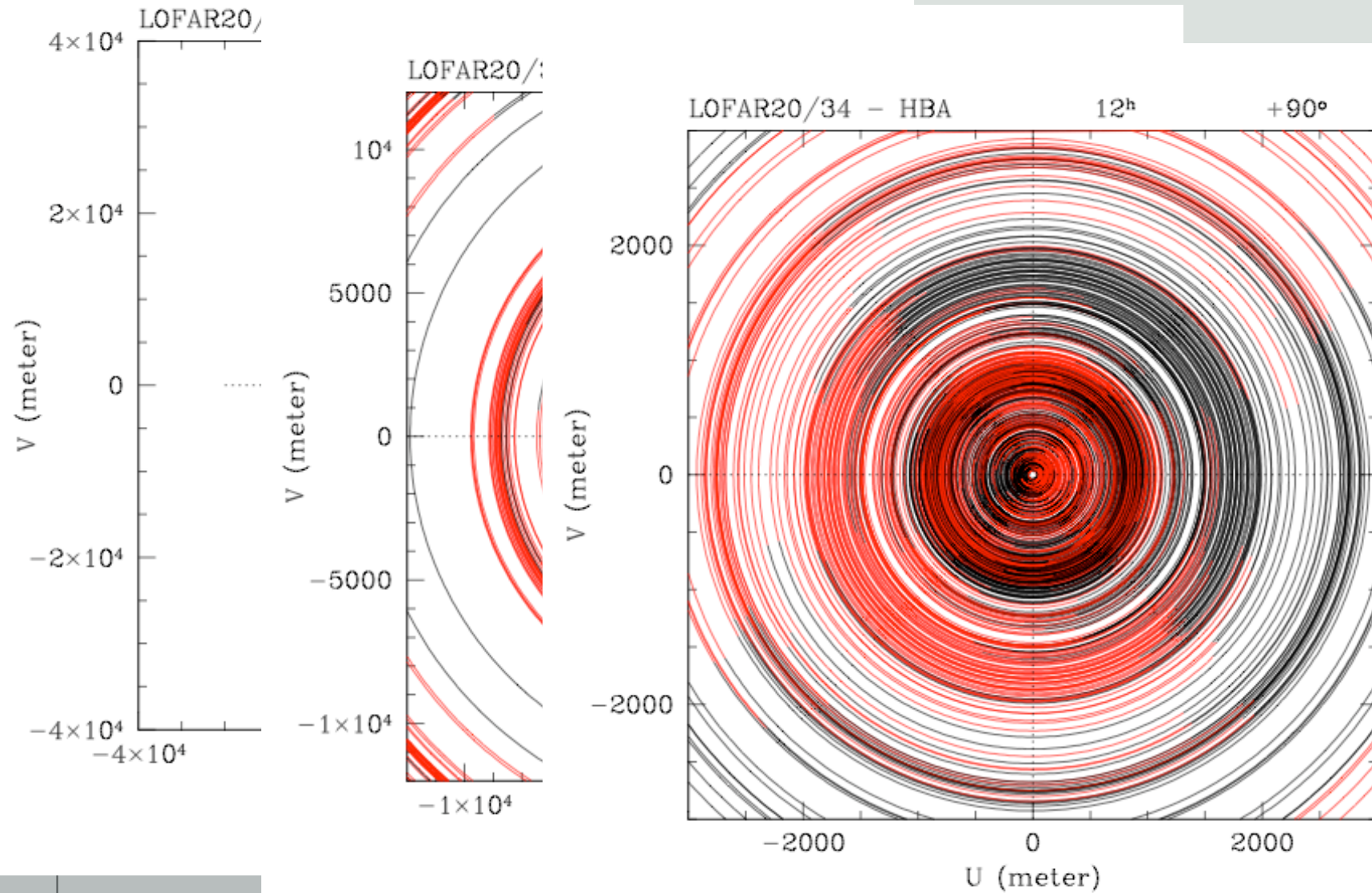
Meetings in March 08 and August 08

The project should be completed within 3 months over summer 2009

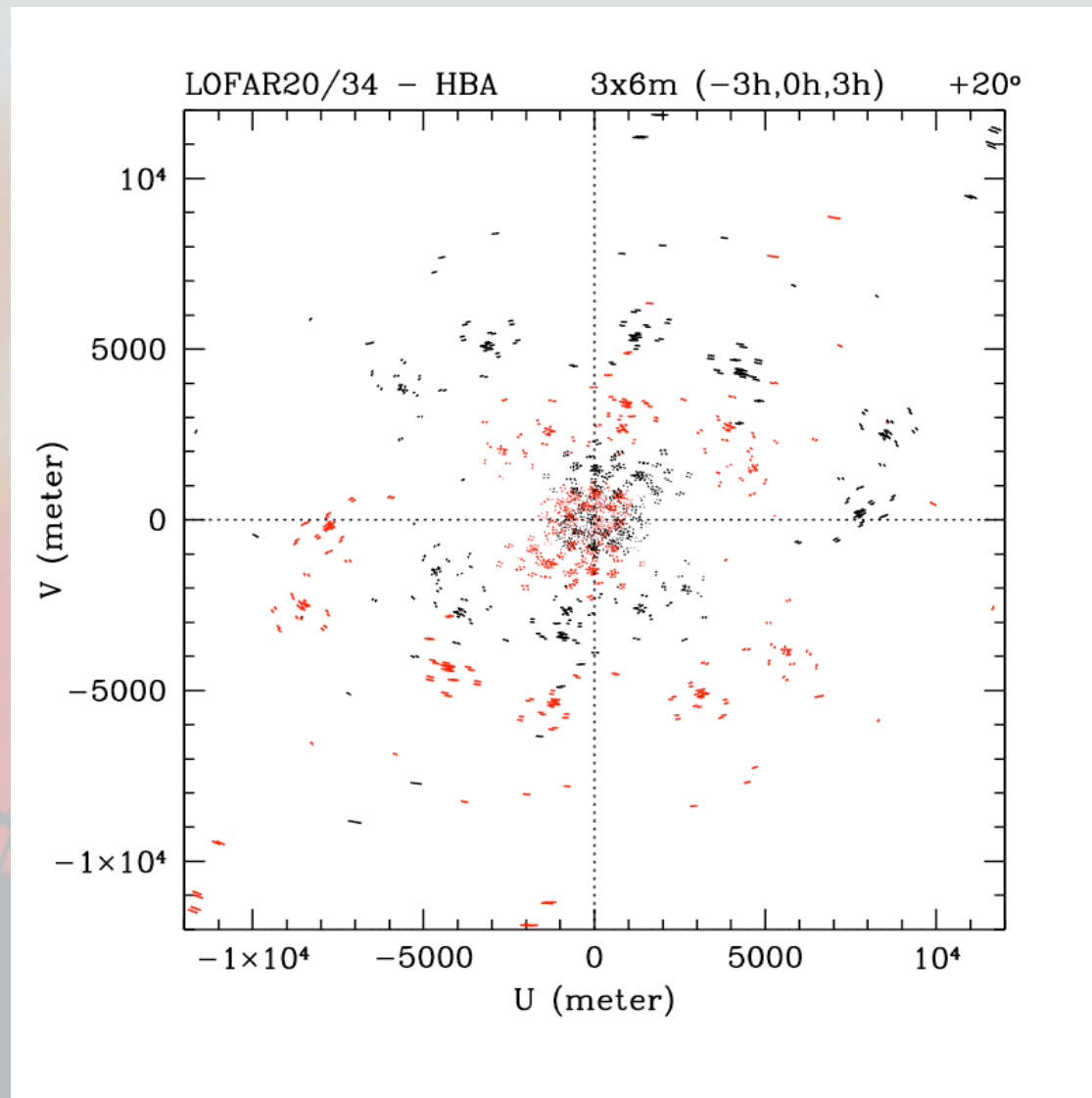
Main goals of MS³ project:

- Focus for activities, priorities for hardware/software
- Getting some 'hard' numbers on requirements & efforts needed
- Plan scheduling cal/imaging -->DP³ --> processing --> Catalog +source parameters
- Testing 'readiness' of 'basic' LOFAR calibration+imaging mode/pipeline
- Early science

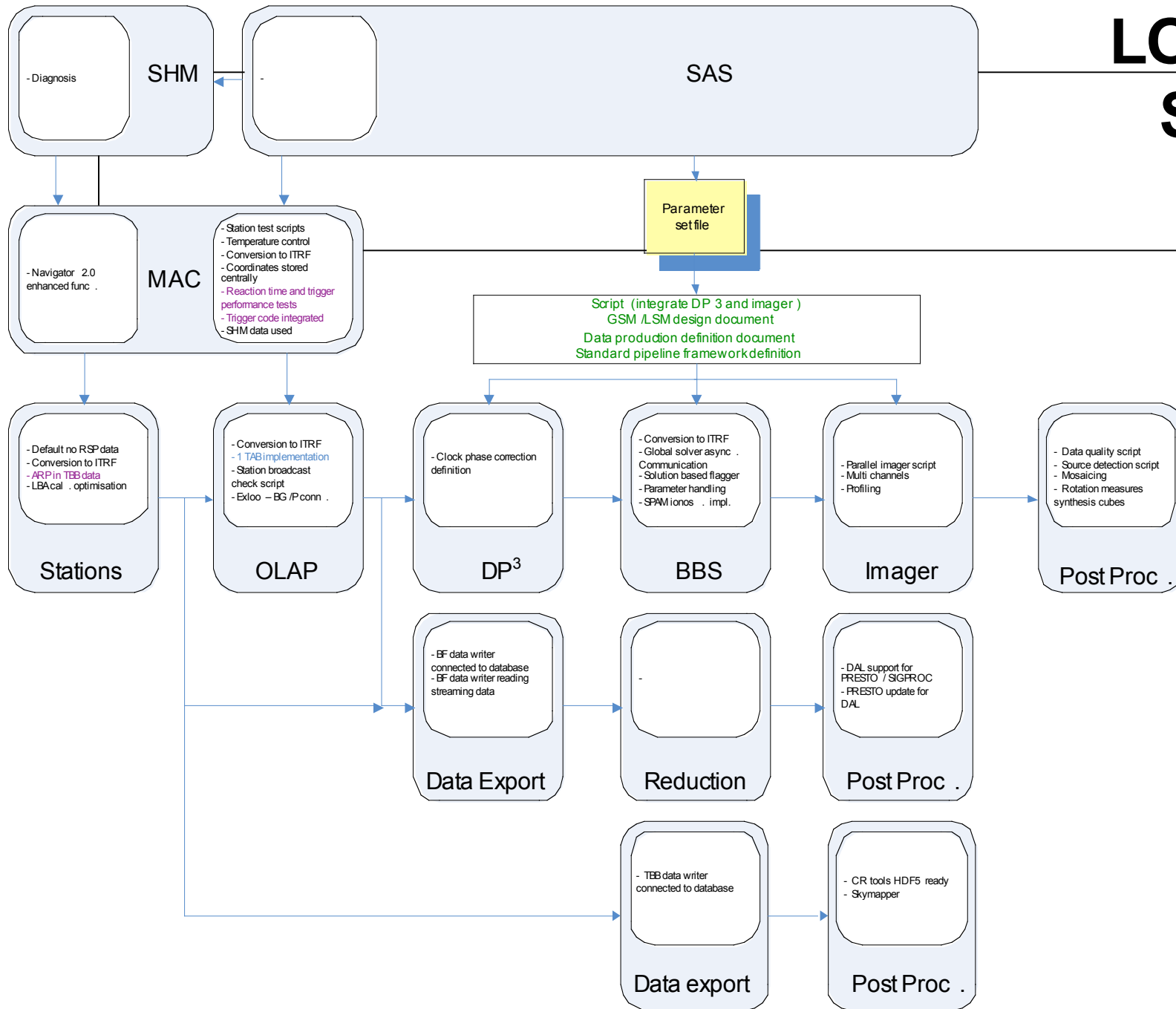
LOFAR20/34 uv-coverages HBA (monochr. NCP)



Typical uv-coverage with LOFAR20/34 in MSSS



LOFAR 20 Step 1



Standard
Imaging
Mode

Known
Pulsar
Mode

VHECR
Mode

