LOFAR: Recent Imaging Results

Annalisa Bonafede

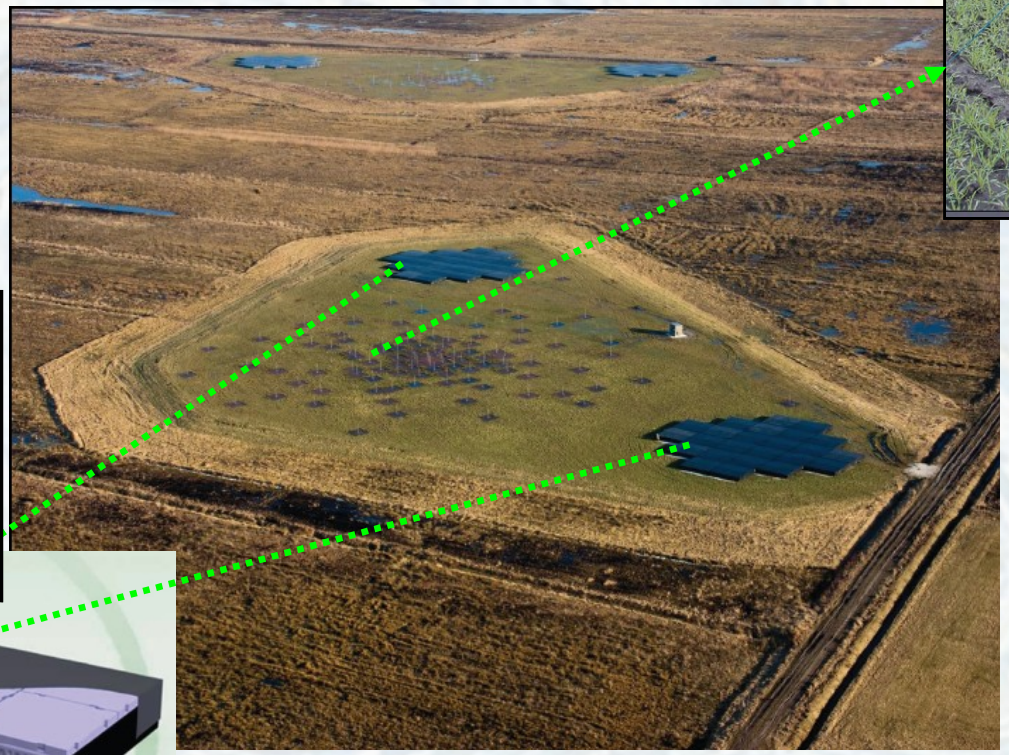
Jacobs University Bremen

LOFAR survey commisioners:

F. Batejat, L. Birzan, J. Conway, F. De Gasperin, C. Ferrari, G. Heald, A. Horneffer, N. Jackson, G. Macario, J. McKean, E Orrù, R. Pizzo, D. Rafferty, A. Shulevski, C. Tasse, M. Trasatti, I. Van Bemmel, B. van der Tol, R. van Weeren, O.Wucknitz, J. van Zwieten

& the LOFAR Collaboration

LOFAR array



2 x 48 antennas

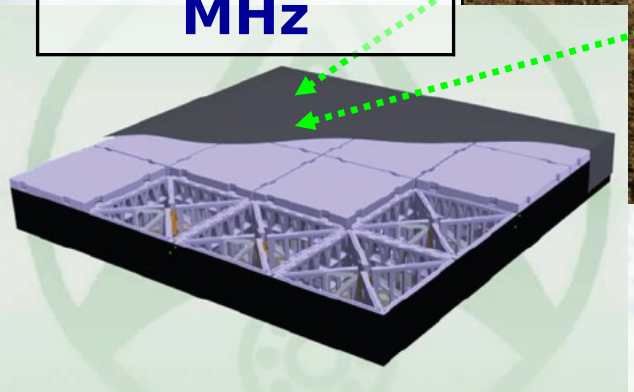
High Band antenna

110-240 MHz

Low Band antenna

10-90 MHz

192 dipoles Per station



A LOFAR Core Station

LOFAR dipoles

- Linear polarization feeds (XX, YY)

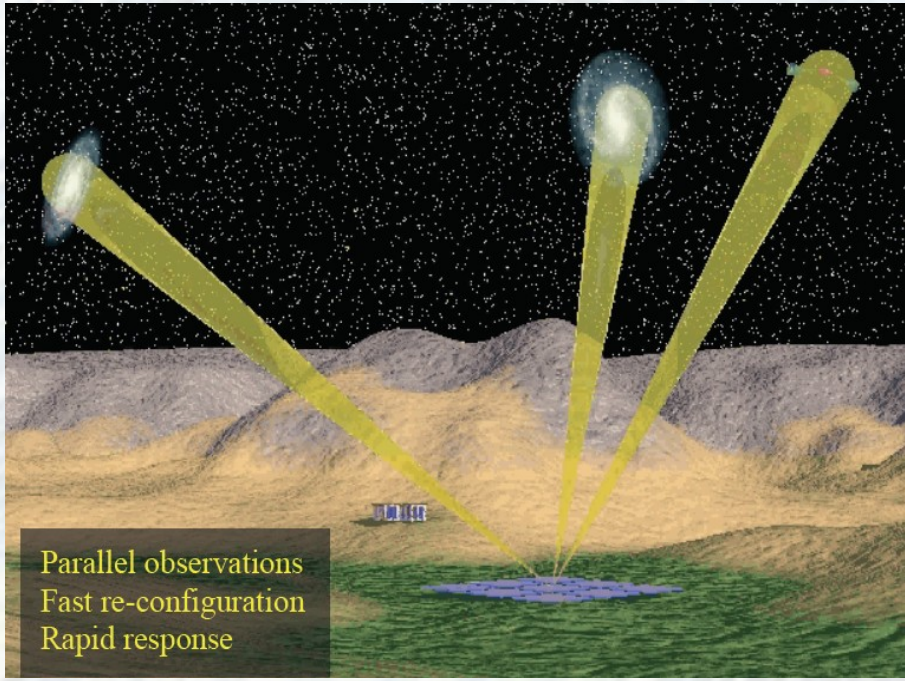
- 48 MHz bandwidth (single beam mode)

- 244 Sub-Bands x 0.2 Mhz (64 or 256 channels)

- No moving parts

- Beams formed in software – multiple beams can be formed

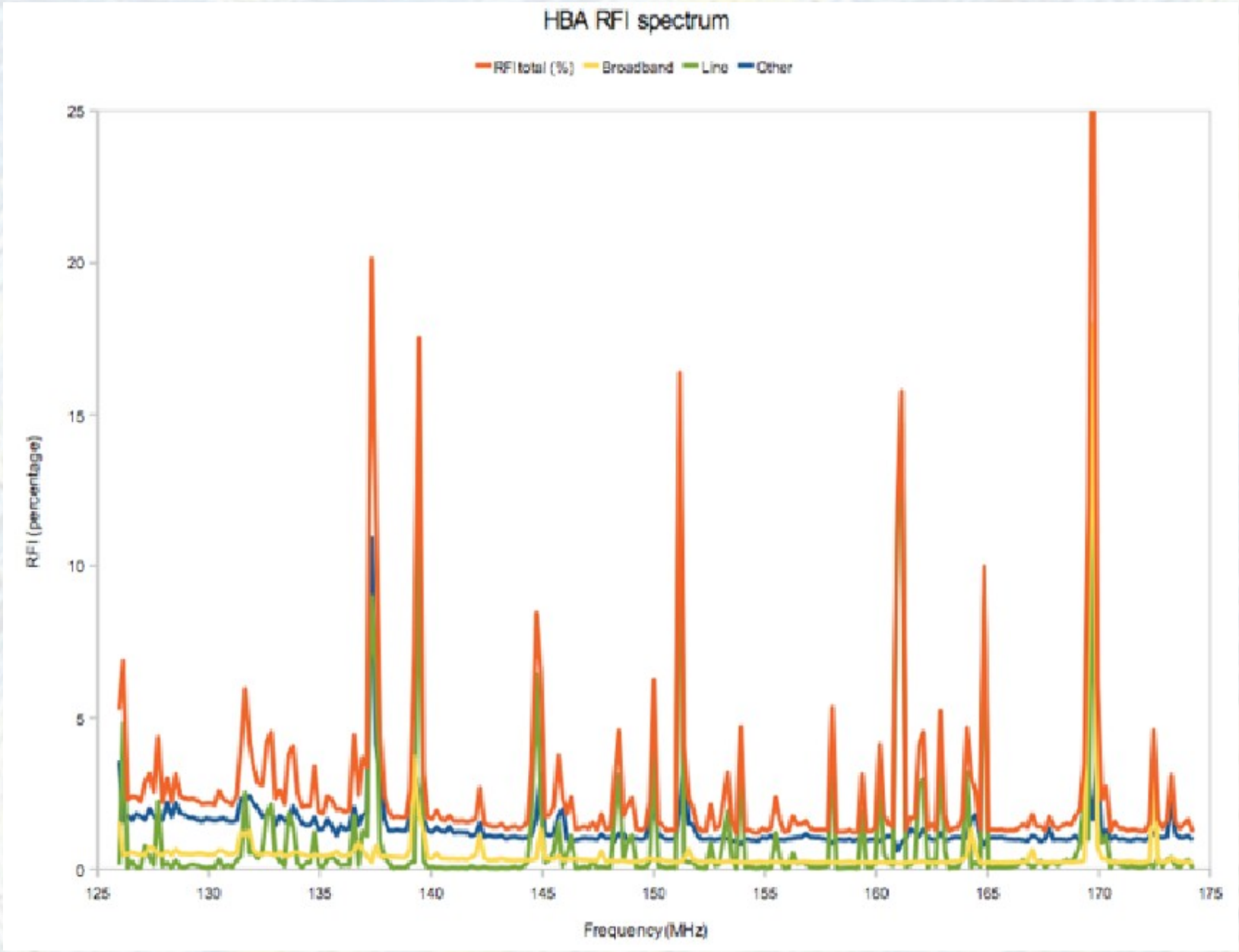
- Commissioning aiming at an authomated pipeline to reduce the data



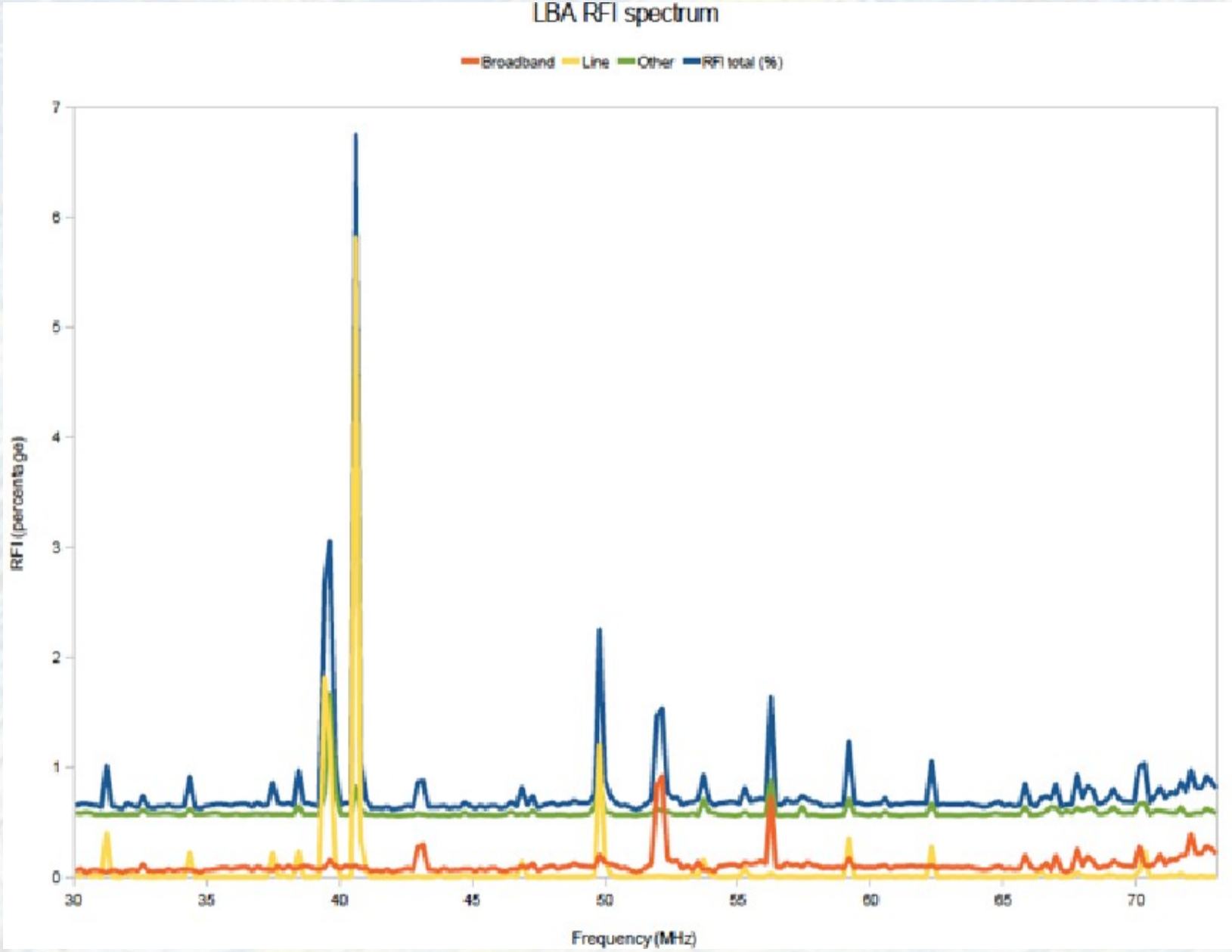
The imaging pipeline

1) Radio Frequency Interferences

Radio Frequency Interference



Radio Frequency Interference



Radio Frequency Interference

Different softwares inmplemented in the pipeline for RFI removal
AOflagger by A. Offringa is usually used

- *Frequency resolution of 3-4 KHz*

- *Time resolution of 1-3 sec*

Less than 10% of data lost

The imaging pipeline

1) Radio Frequency Interferences

2) Removal of strong off-axis sources

Removal of strong off-axis sources

" A-Team" _*Cygnus A, Cassiopeia A*, Virgo A, Hercules A and Taurus A

LBA dipoles see the entire sky
CasA and CygA always dominate the visibility function whenever they are above the horizon.

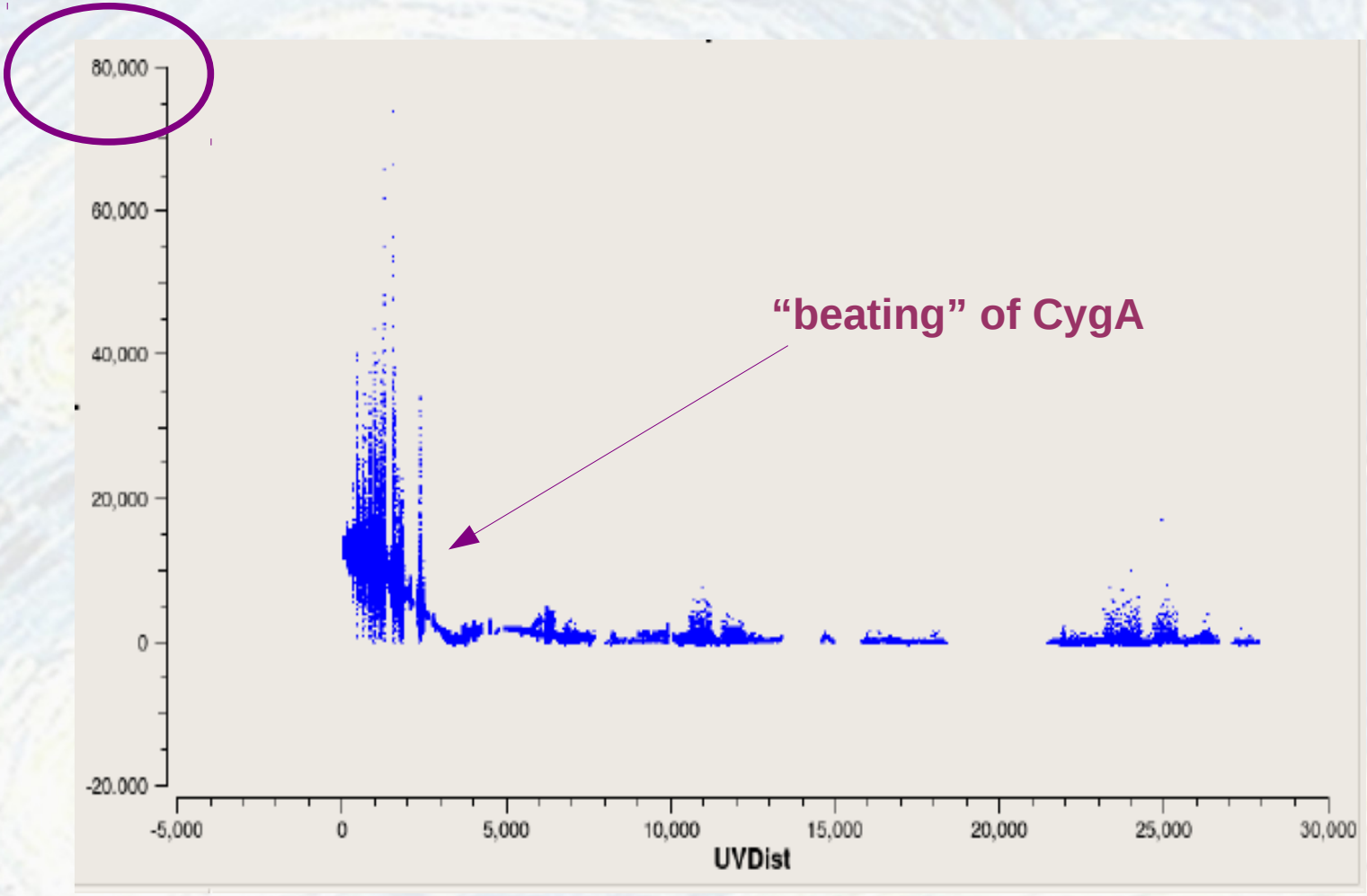
Brute calibration and Subtraction time and computig expensive

New strategies
- no universal solution yet
- "demixing method" by vdTol

HBA: situation less problematic (smaller field of view)

Removal of strong off-axis sources

Observation of CasA at 67 MHz
Cyg A is 35 deg far away



Courtesy of N. Jackson

Removal of strong off-axis sources

Observation of CasA at 67 MHz
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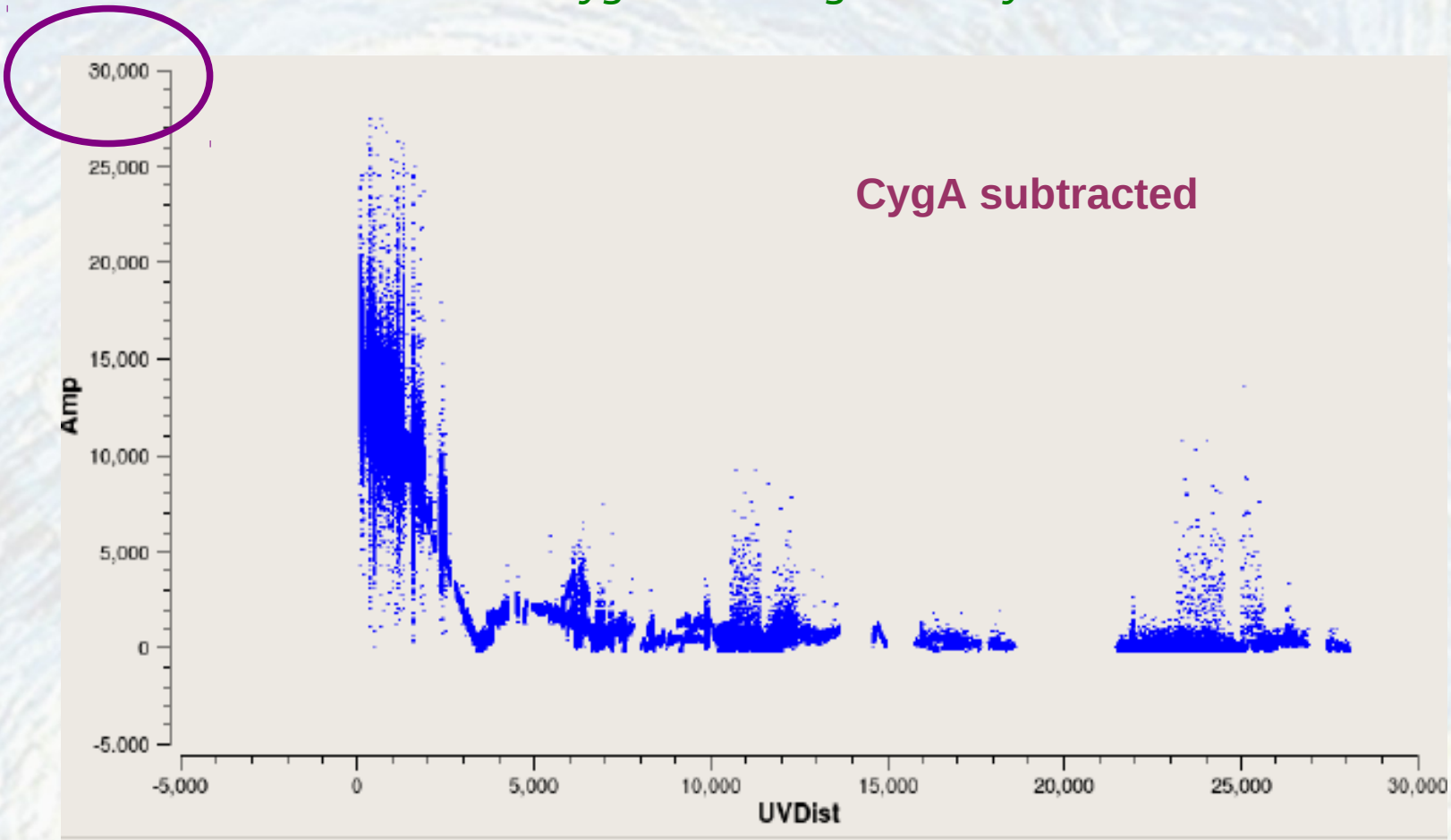


Courtesy of N. Jackson

The imaging pipeline

1) Radio Frequency Interferences

2) Removal of strong off-axis sources

3) Calibration

Calibration

- Initial Model

  - *For LBA: VLSS 74 MHz*
  - *For HBA: WSRT 300 Mhz*

- Calibration with BBS (BlackBoard SelfCal)

- *enables solving for gain solutions in multiple directions simultaneously.*

- *Global solver enables solving using more Subbands together*

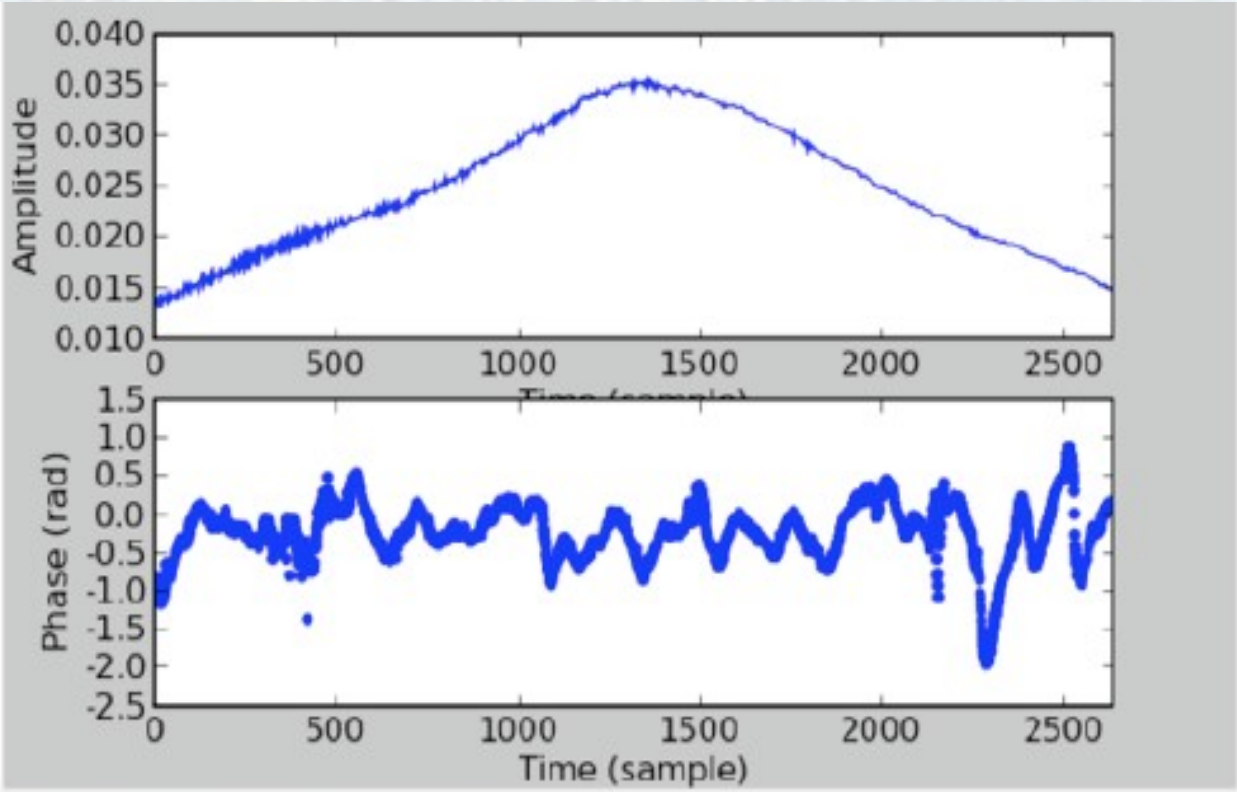
- *ionospheric modeling algorithm (Intema et al. 2009) will be implemented*

Imaging

difficult task for LOFAR

- dipoles have fixed orientation on the ground
- The sensitivity pattern of the telescope is a function of

- angular position
-observing frequency
-Time

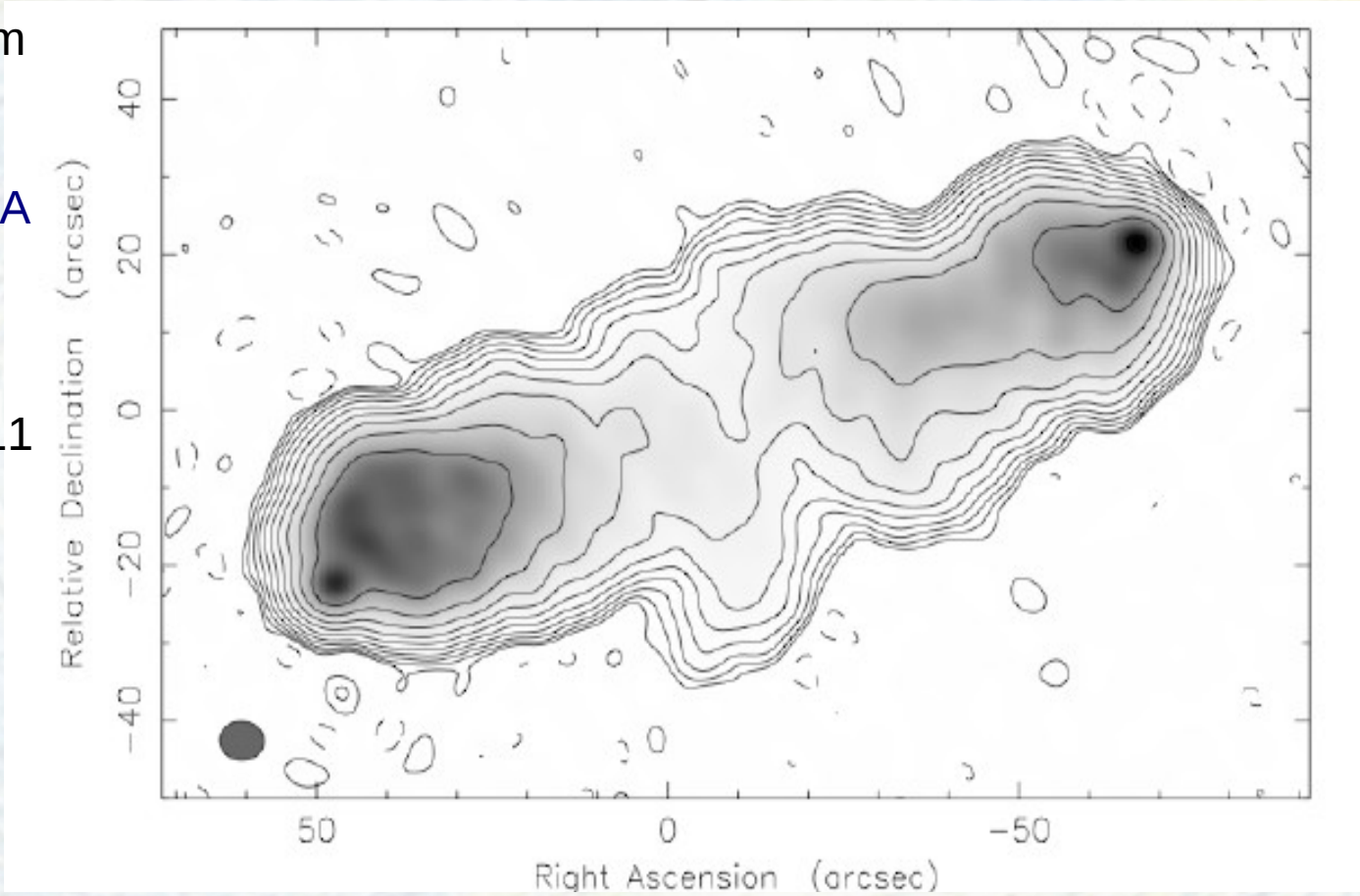


Courtesy of J. McKean

Imaging results: HBA CygnusA

15h observations
v ~ 239 Mhz
Rms noise 78 mJy/beam
Dynamic range 3340
c.f. With 4700
obtained at 325 MHz VLA

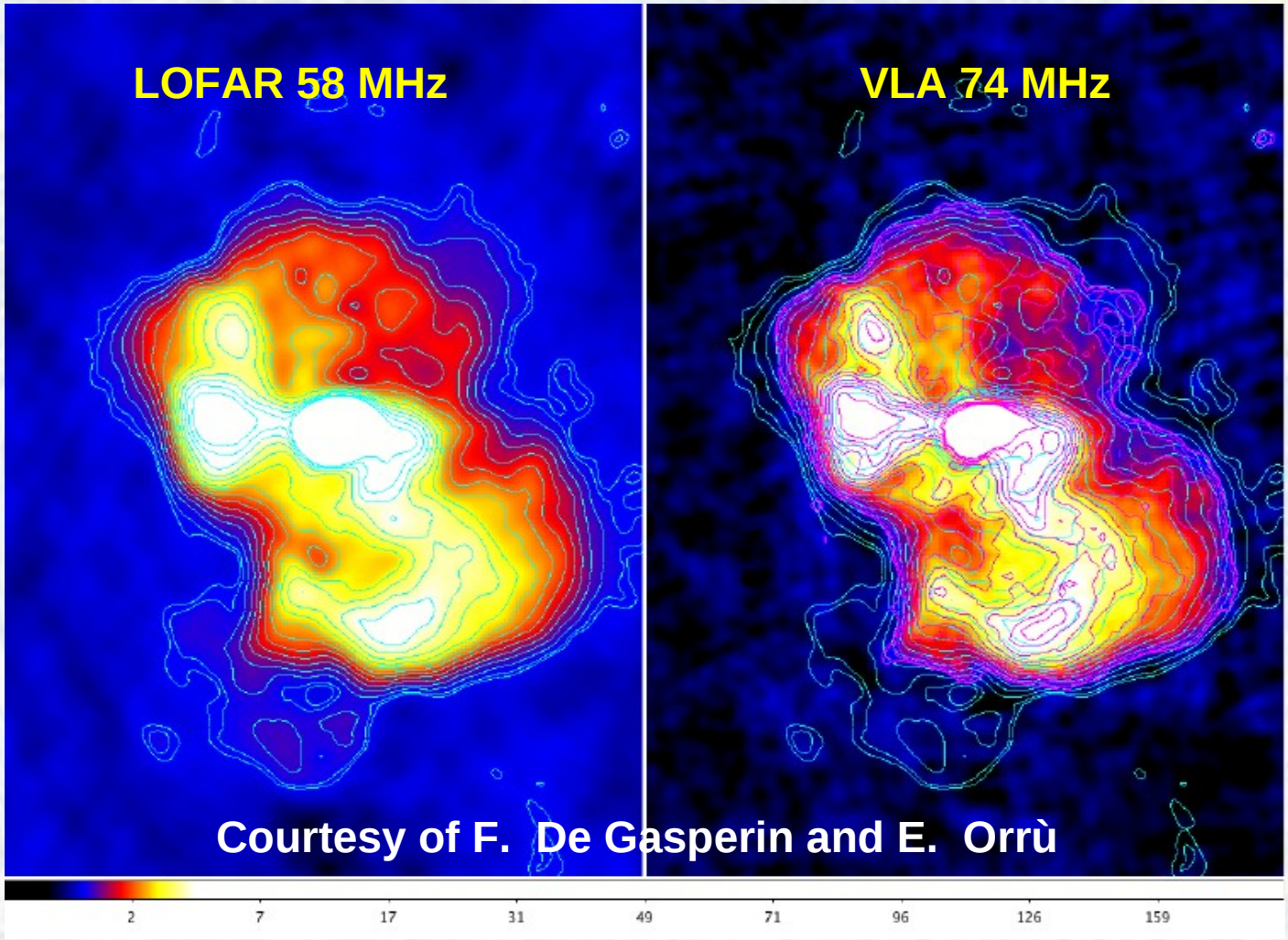
Data taken in March 2011
- 19 Core Stations,
- 7 remote stations



Mc Kean et al. 2011

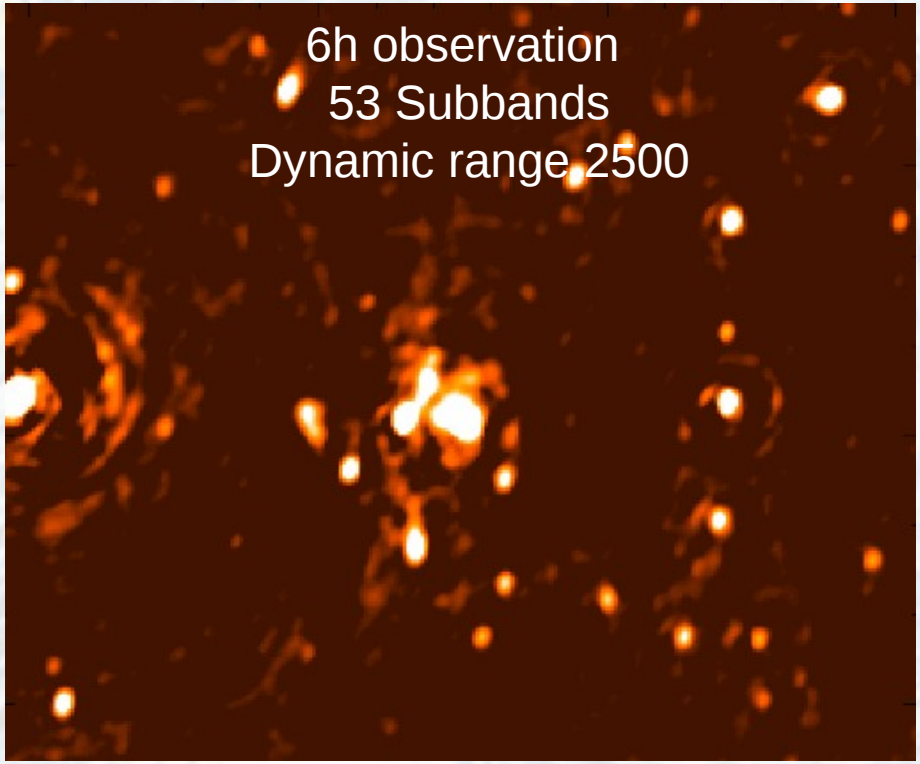
Imaging results: LBA VirgoA

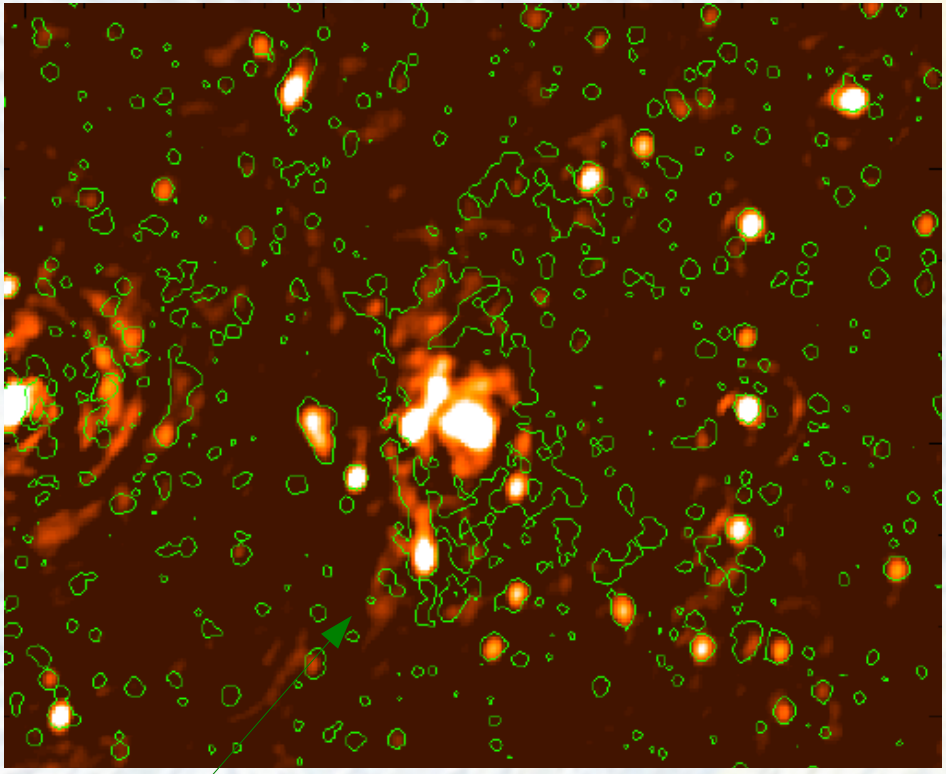
- 8h observation
- Image of 5 Sub-bands
- dyn range> 2000



Imaging results: HBA Abell2255

225 - 250 MHz



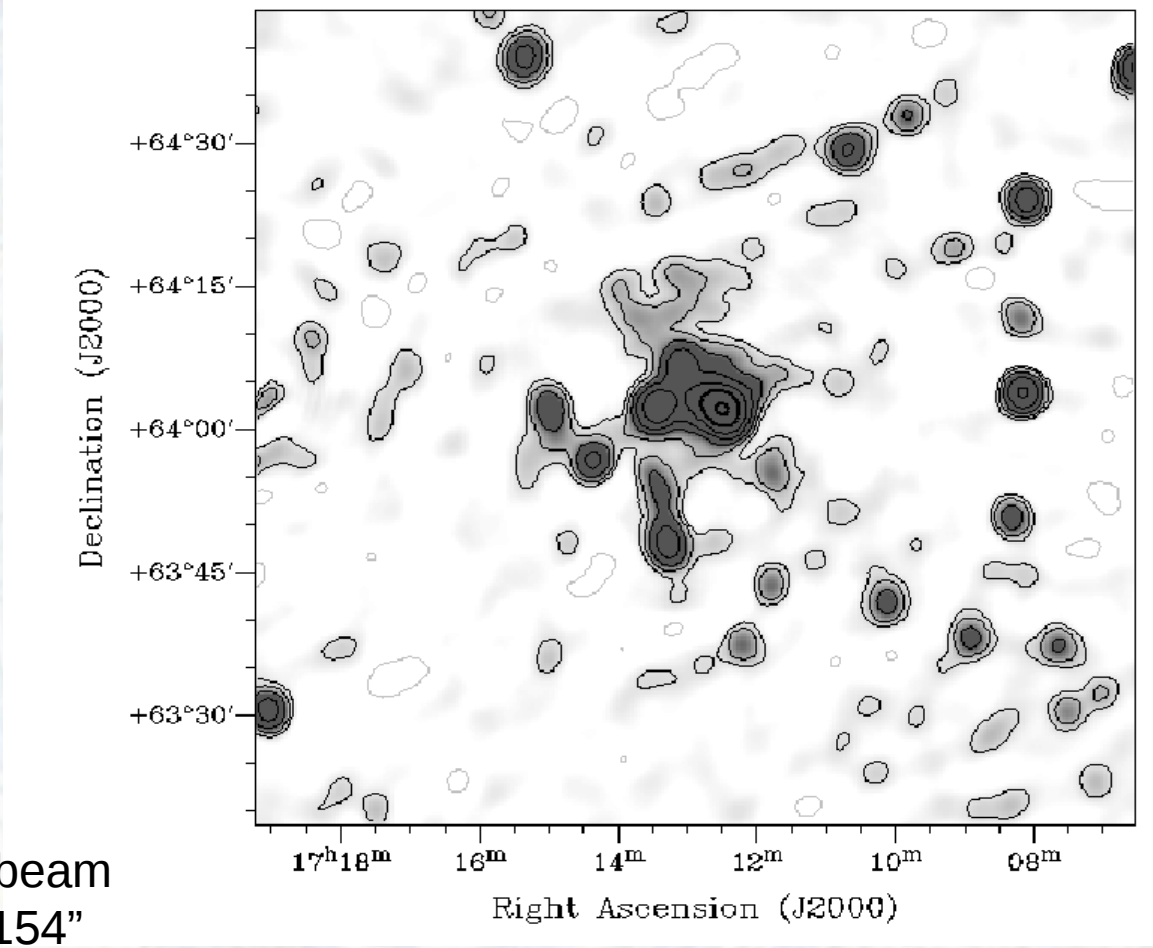


Pizzo, VanWeeren, Bonafede, Ferrari

Observations taken in March 2011

WSRT 85cm contours (Pizzo et al. 2008)

Imaging results: HBA Abell2255



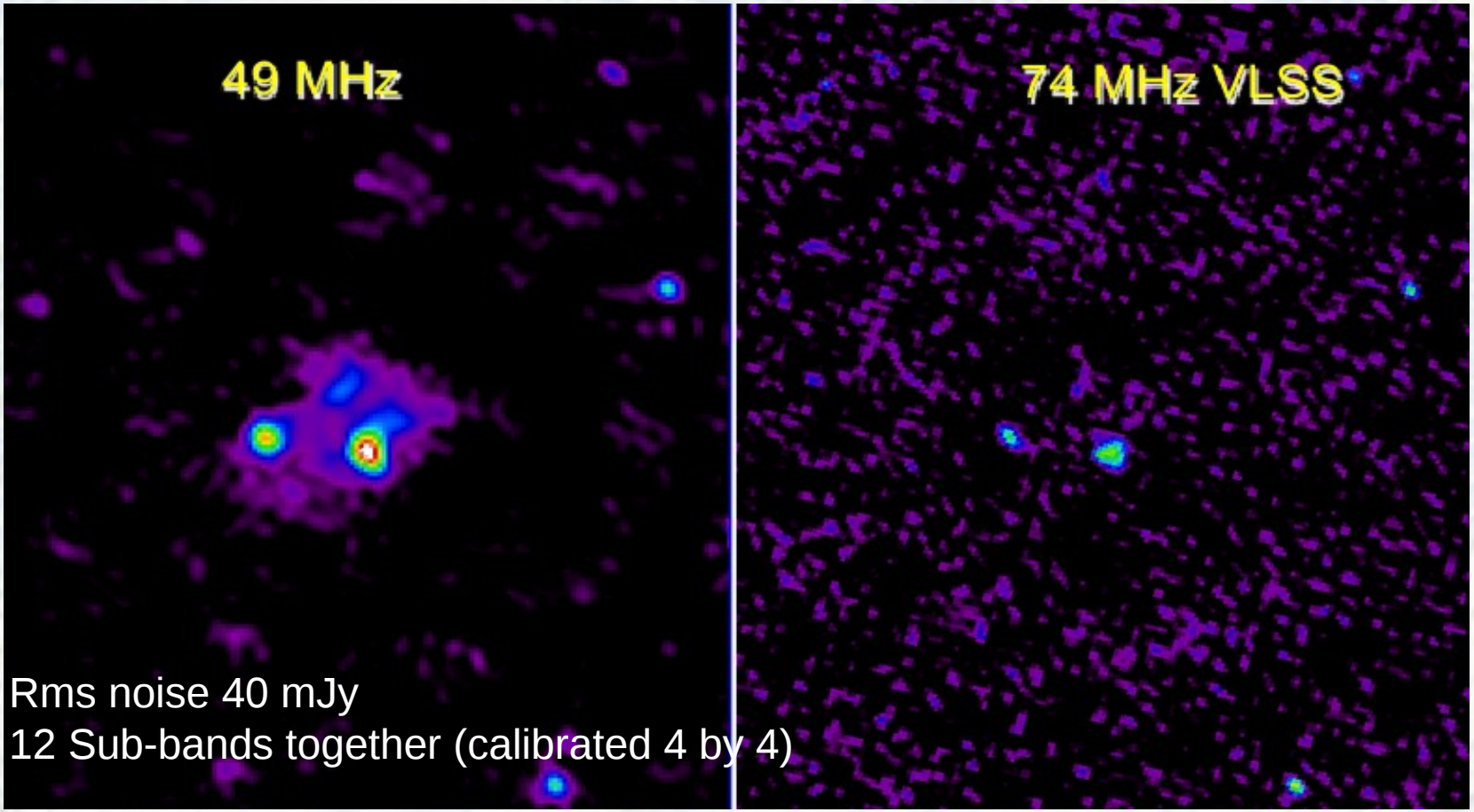
Noise ~10 mJy/beam
Beam = 163” x 154”
12 SB Stacked in the image plane

Courtesy of R. Pizzo, G. Macario

Imaging results: LBA Abell2256

CasA and CygA subtracted – they were at 20 and 40 deg from the phase center

Model from vlss 12 sq degrees



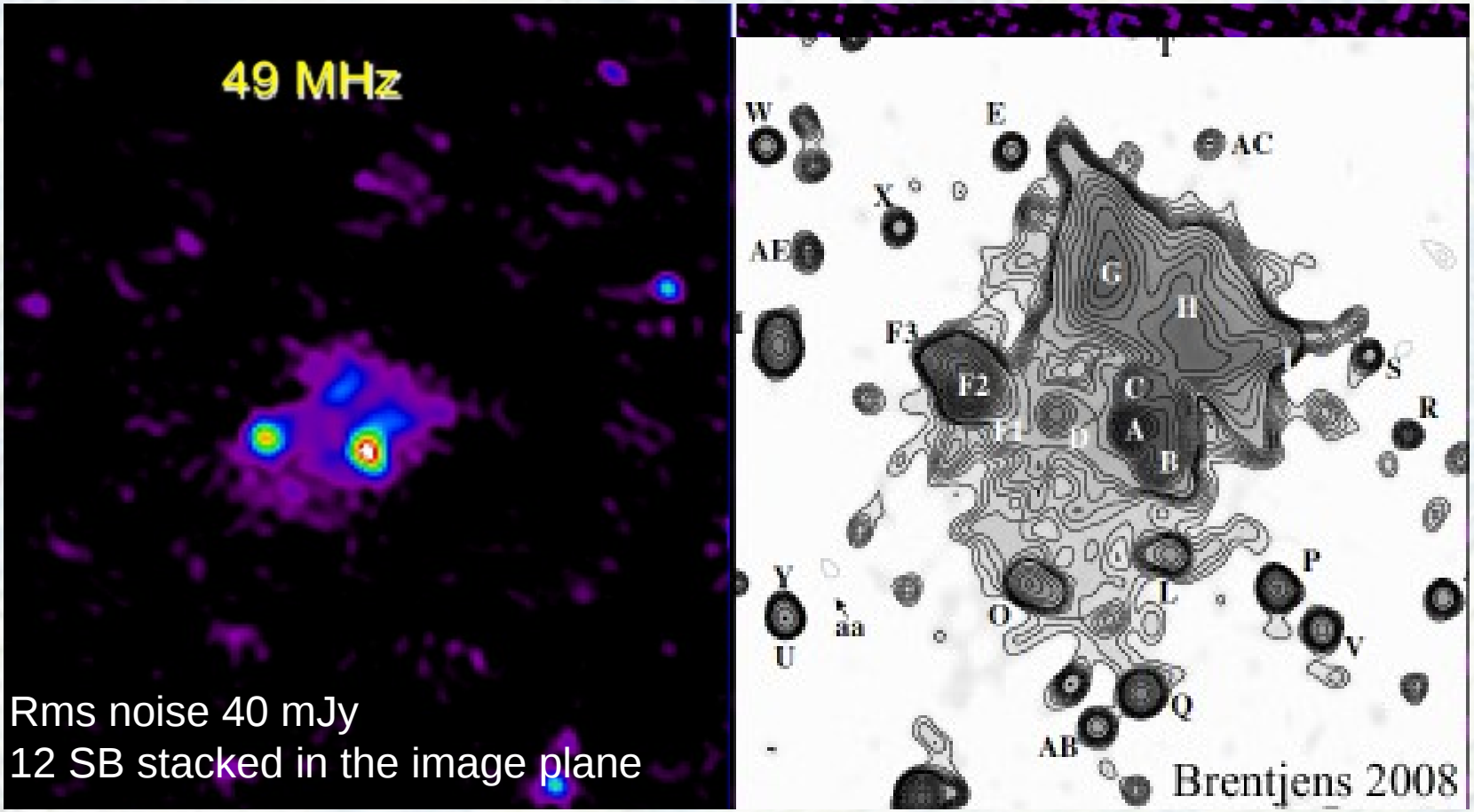
Rms noise 40 mJy
12 Sub-bands together (calibrated 4 by 4)

VanWeeren, Bonafede, Pizzo, Ferrari

Imaging results: LBA Abell2256

CasA and CygA subtracted – they were at 20 and 40 deg from the phase center

Model from vlss 12 sq degrees



VanWeeren, Bonafede, Pizzo, Ferrari

Imaging results

- Fields with strong sources (3C sources) and far from the “A-team”

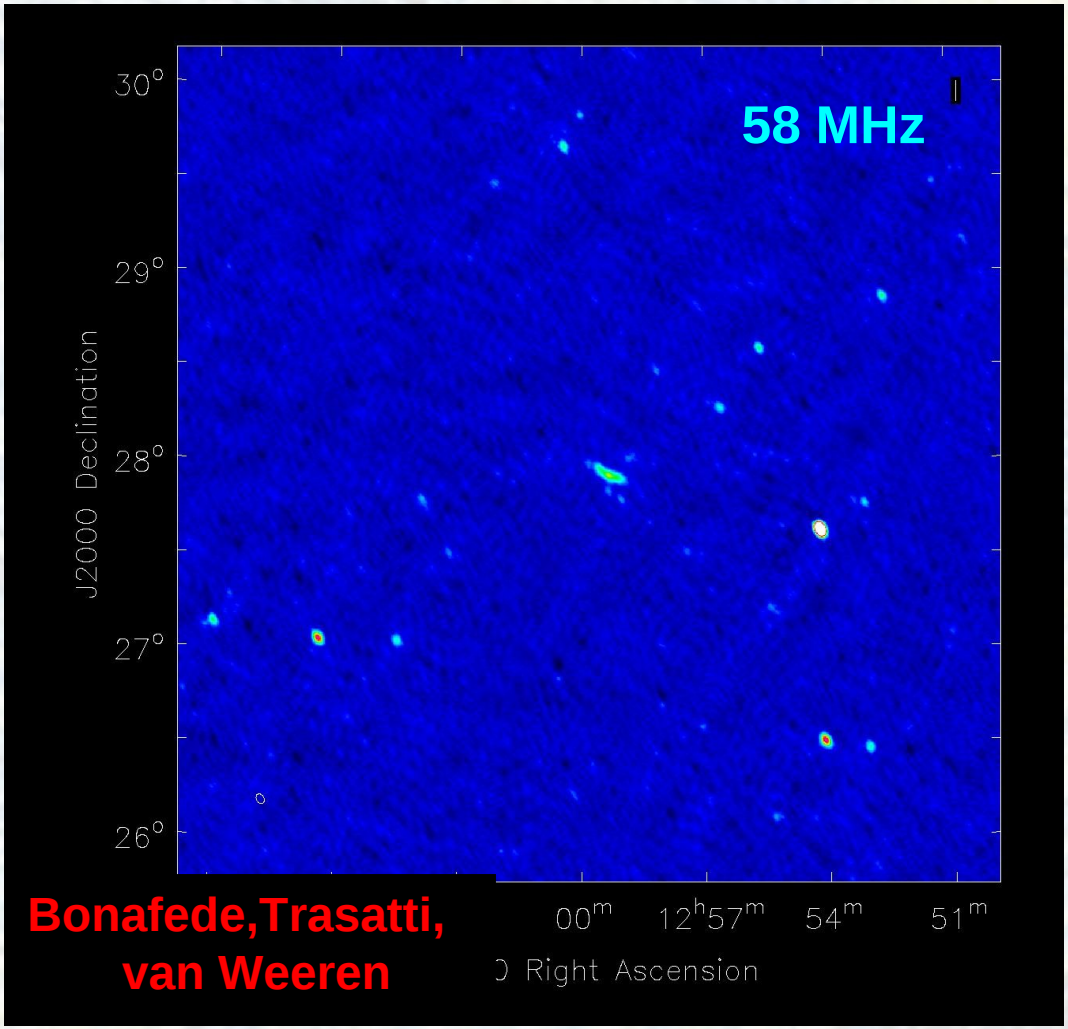
More problematic

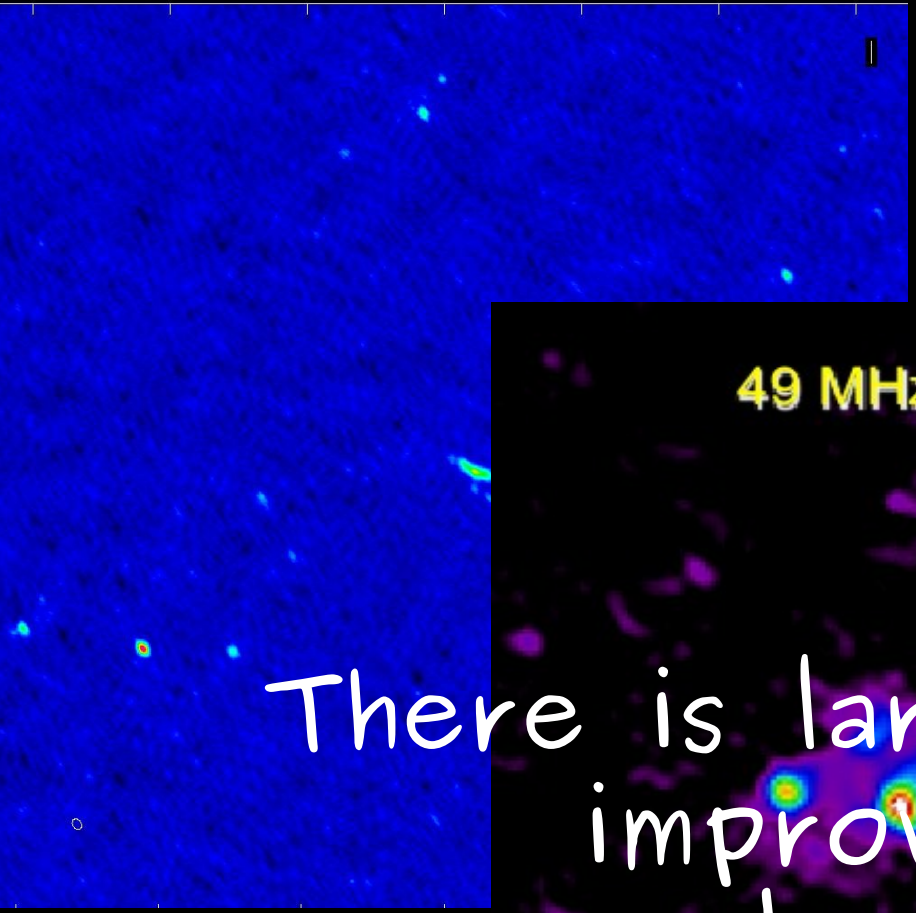
- LBA: fields with sources of ~20-30 Jy/beam (peak)
- LBA: targets close to “A team” sources (less than 25 deg at 50 MHz)

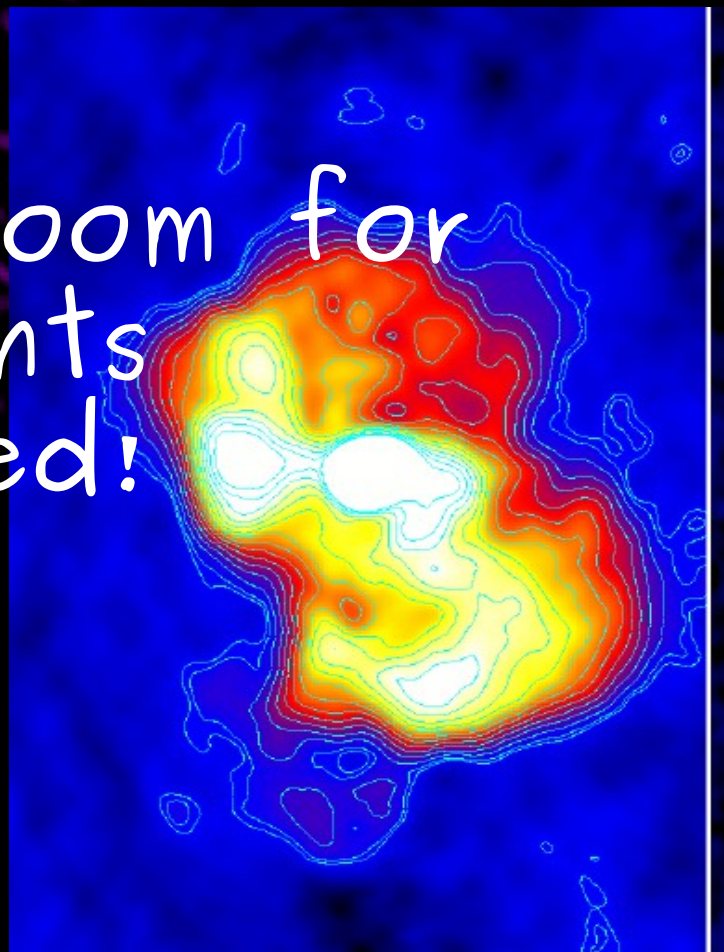
Example of more problematic field: the Coma cluster

Coma: VirA too close to be subtracted with the demixing method (17° from the phase center)

Dynamic range only 200
Noise rms ~ 0.1 Jy/beam
Beam ~ 130”







There is large room for improvements ..stay tuned!

RFI not the major problem

Main present issues:

- "A team" CygA, CasA are always inside the beam of LBA obs

- Model for calibration

Current approach:

- "demixing" method to subtract "A team" – full resolution in frequency – time expensive

- Averaging in time and frequency

- Calibration for the target
  Model from vlss for LBA obs
  Model from WSRT for HBS obs

Current approach:

- “Demixing method” developed by B. van der Tol to subtract Cas and Cyg

-

$$\hat{v}(t,f) = a_1(t,f)v_1 + a_2(t,f)v_2 + a_3(t,f)v_3$$

Observed data

Fields: Target + sources to subtract

$$\mathbf{v} = \mathbf{a}_1 v_1 + \mathbf{a}_2 v_2 + \mathbf{a}_3 v_3$$

$$\hat{\mathbf{v}} = \mathbf{a}_1 v_1 + \mathbf{a}_2 v_2 + \mathbf{a}_3 v_3 = \begin{bmatrix} \mathbf{a}_1 & \mathbf{a}_2 & \mathbf{a}_3 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix} = \mathbf{A}\mathbf{v}$$