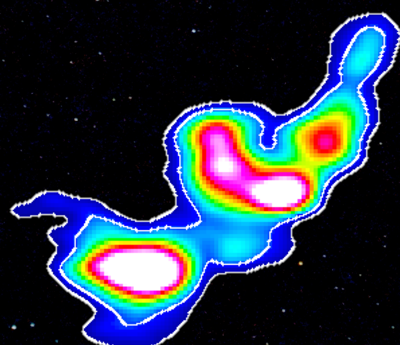
Abell 1682

An Ultra Steep Spectrum Radio Halo



Alex Clarke

MANCHESTER
1824

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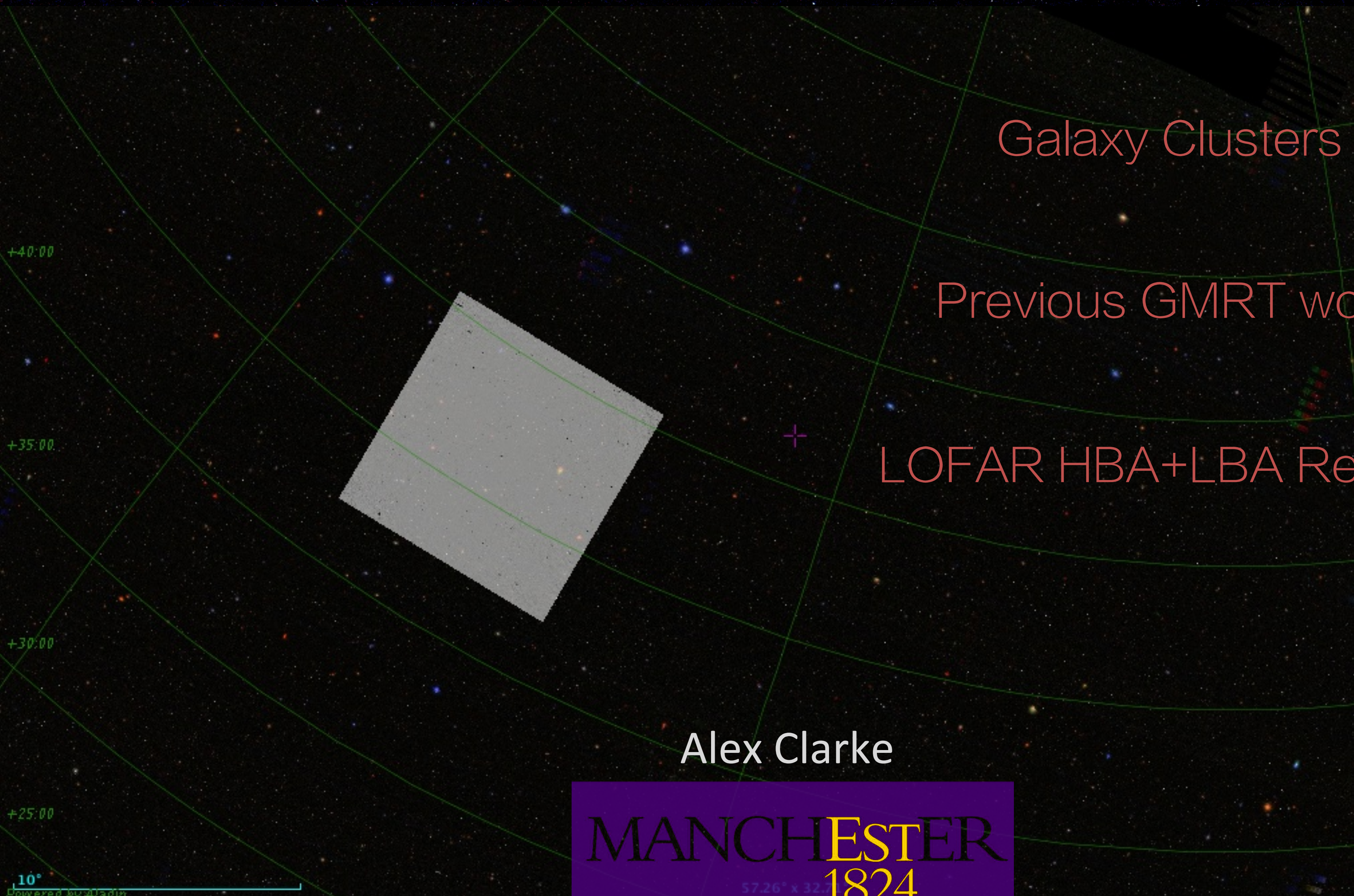


Galaxy Clusters

Previous GMRT work

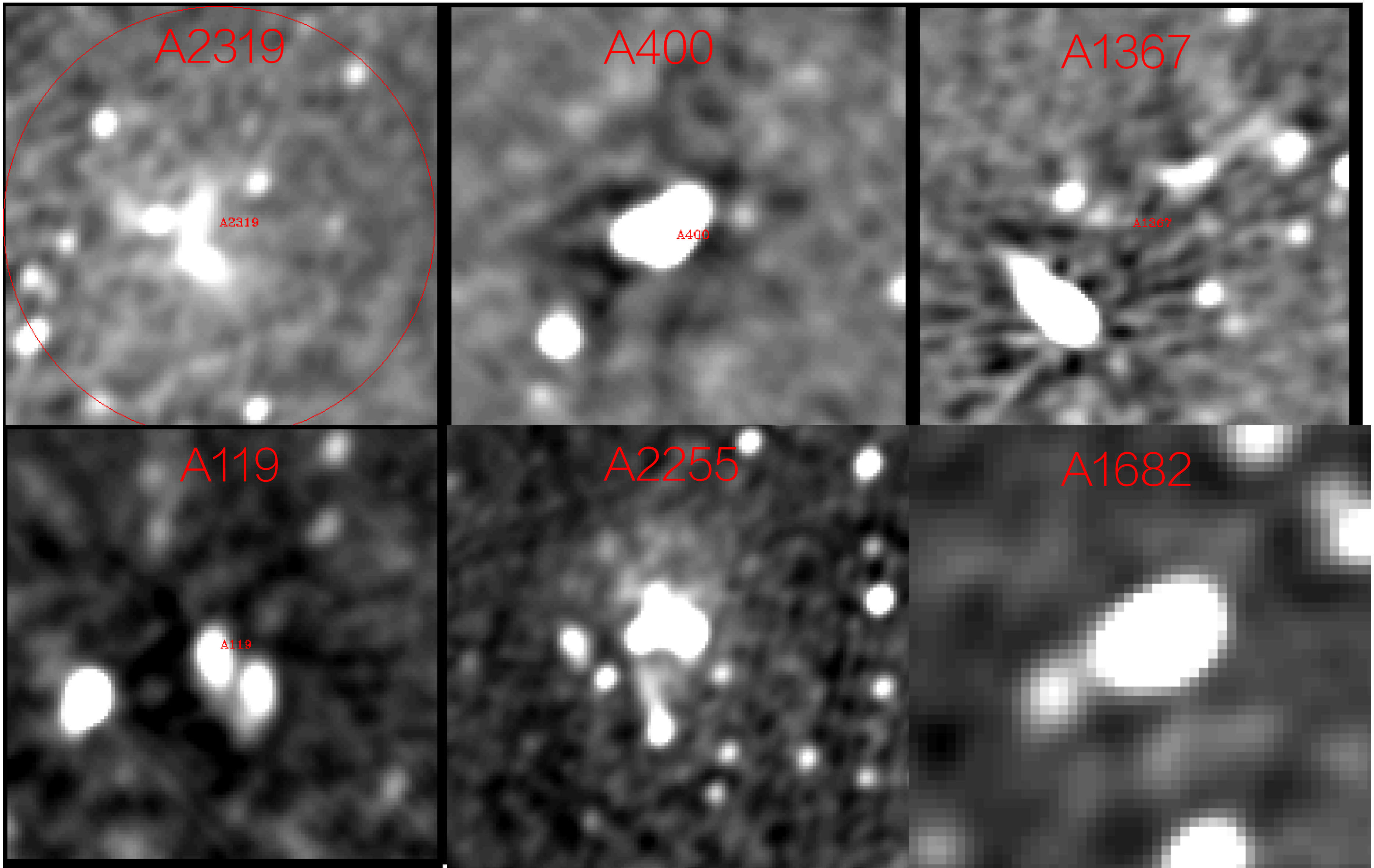
LOFAR HBA+LBA Results

Alex Clarke

MANCHESTER 1824

Galaxy Clusters

MSSS detections



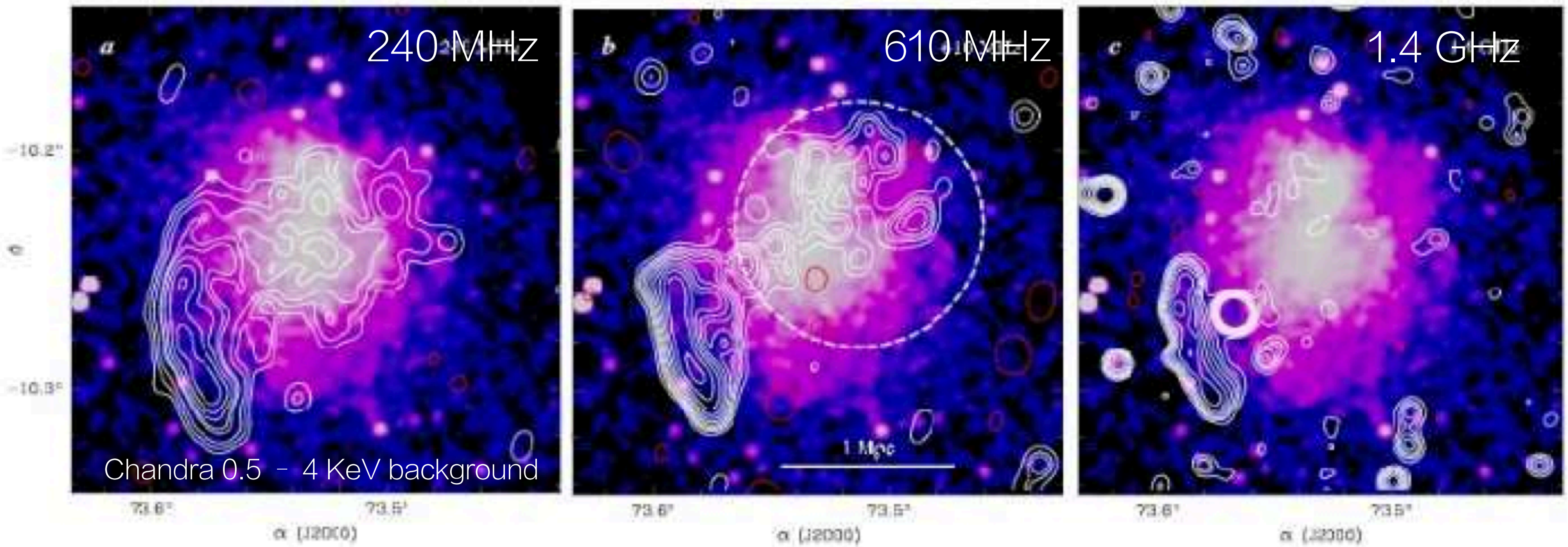
Radio Halos

A) Require that the emitting electrons are accelerated in situ (by turbulence)

B) Electrons injected (as secondary particles) by proton collisions

Found in clusters with complex dynamics

Ultra Steep Halos



Abell 521 was the 1st ultra steep spectrum halo: $\alpha = -2.1$

(Brunetti et al 2008 – Nature)

Rule out injection from secondary particles by energy arguments for the protons

Strongly favor relativistic particle re – acceleration by turbulence

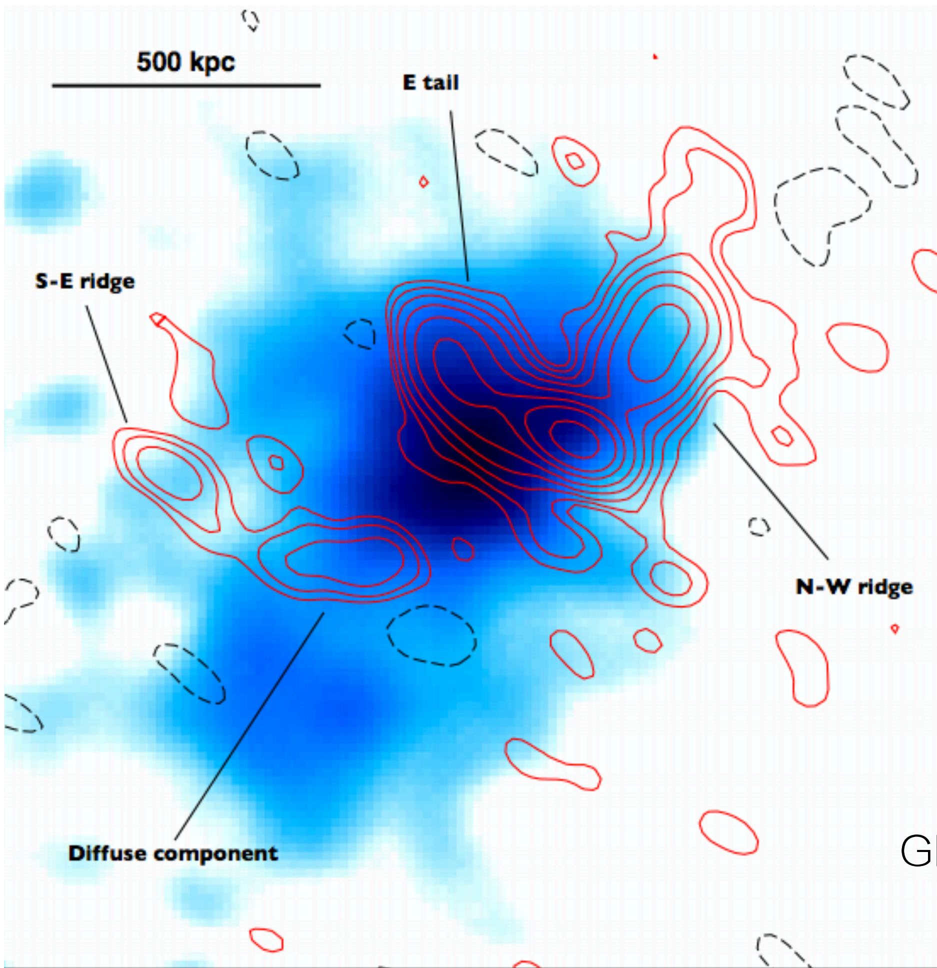
Occurs on timescales of ~100 MYears

What is Abell 1682?

A massive merging galaxy cluster

(z=0.226, LX[0.2 – 2.4keV] = 7.02 × 10^{44} erg s^{-1})

Radio emission is dominated by a strong central radio galaxy

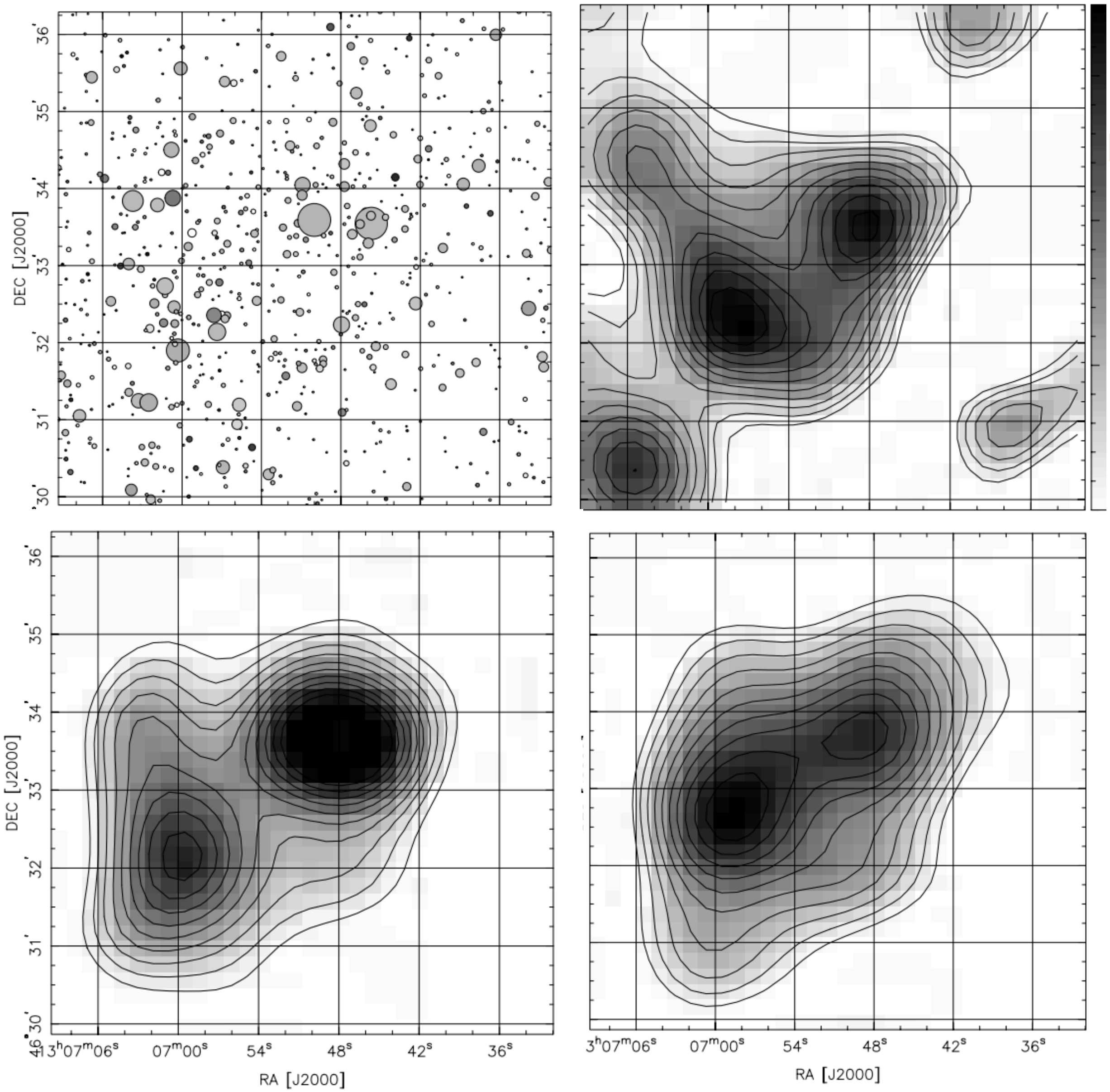


G. Macario et al 2013:
GMRT 150 MHz contours
overlaid on Chandra

Bimodal mass distribution

Galaxy Distribution

Projected mass density from lensing

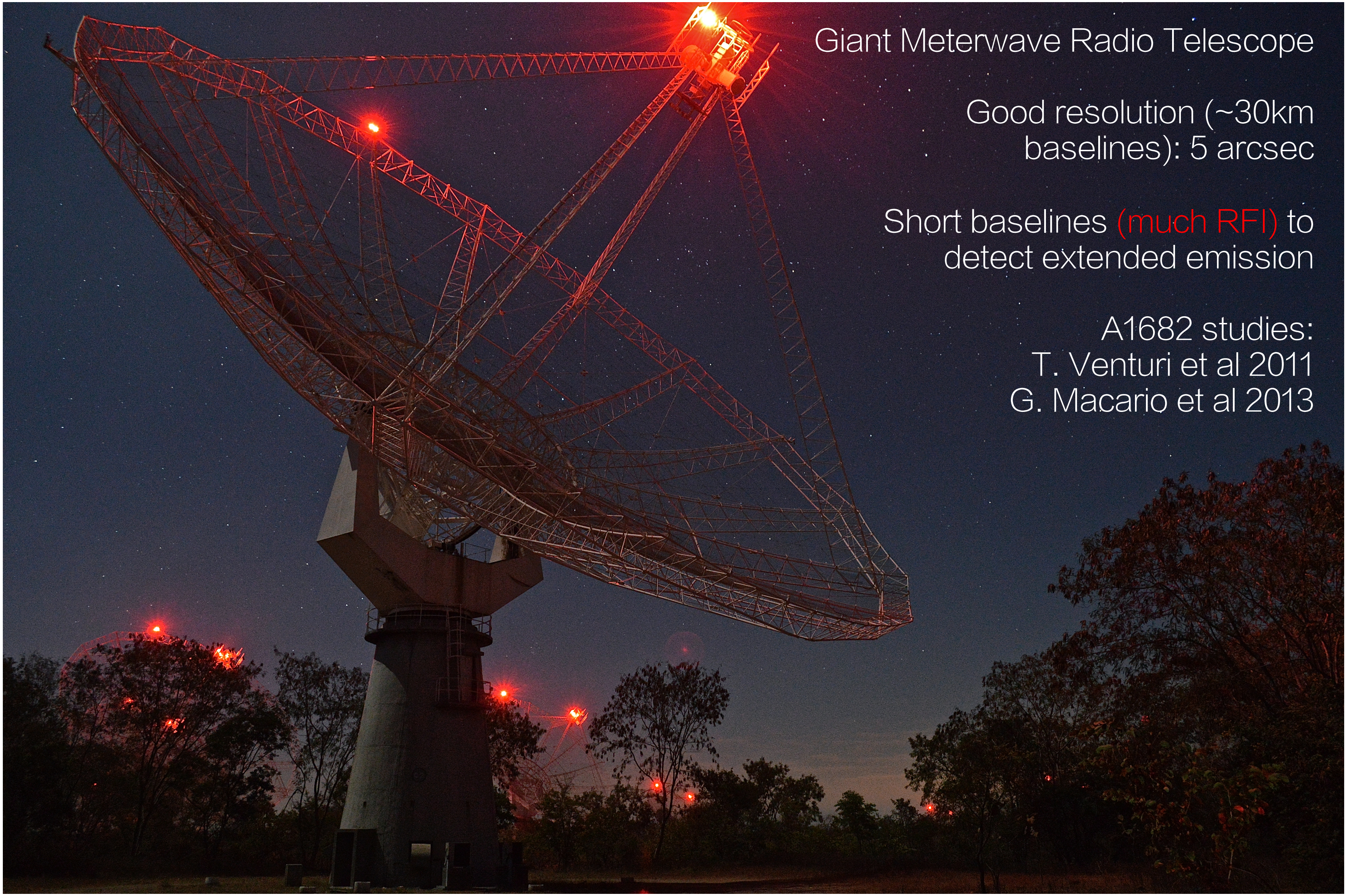


Projected mass density from galaxies

Galaxy number density

Dahle et al. 2002

Previous GMRT work



Giant Meterwave Radio Telescope

Good resolution (~30km baselines): 5 arcsec

Short baselines (much RFI) to detect extended emission

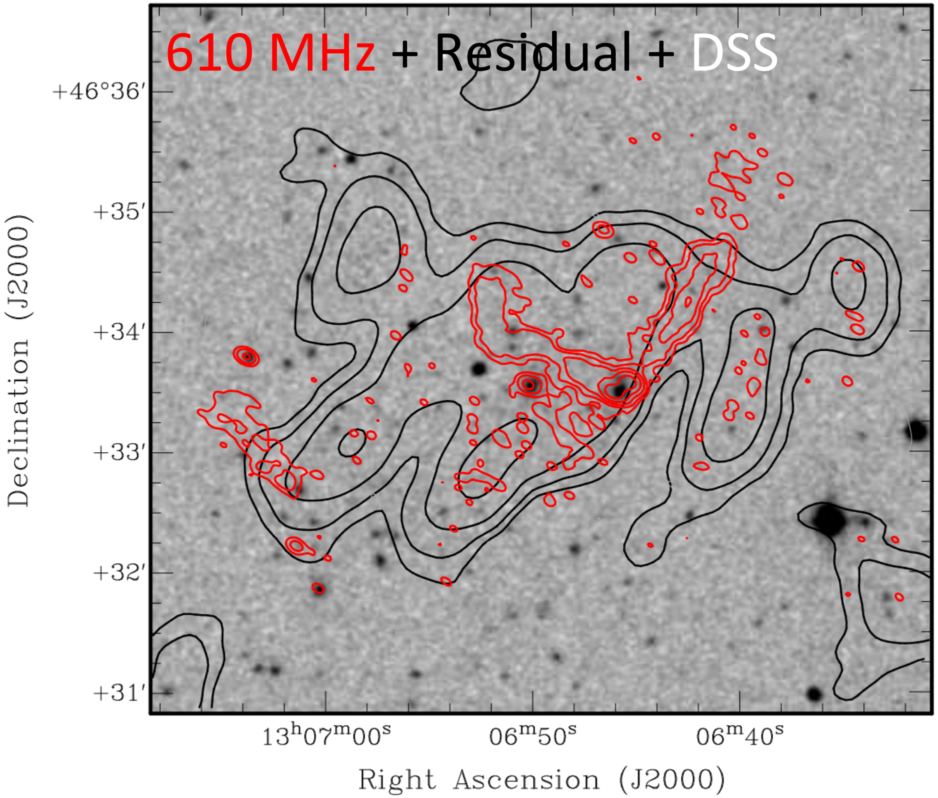
A1682 studies:
T. Venturi et al 2011
G. Macario et al 2013

Previous GMRT work

High resolution GMRT maps enabled them to subtract the radio galaxy and relics

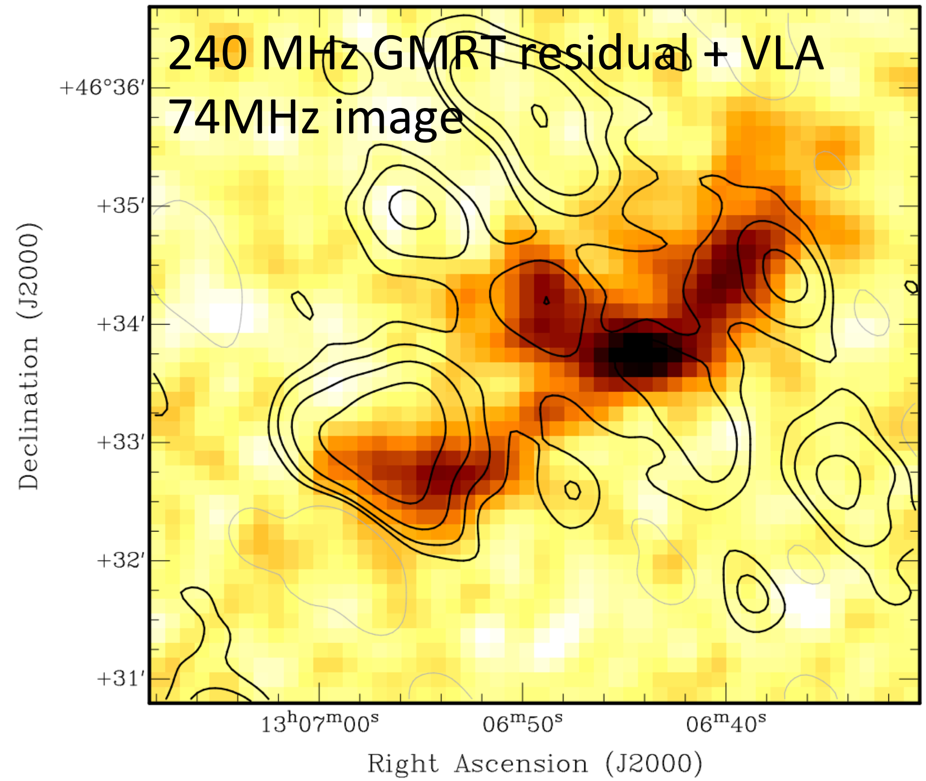
Leaves behind a radio halo?

T. Venturi et al 2011



610 MHz: Red contours ±0.15,0.6,2.4 mJy/b

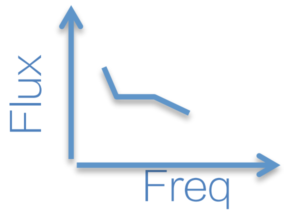
Black: residual image: ±0.3, 0.6, 1.2, 2.4 mJy/b, (1σ ~ 0.1)



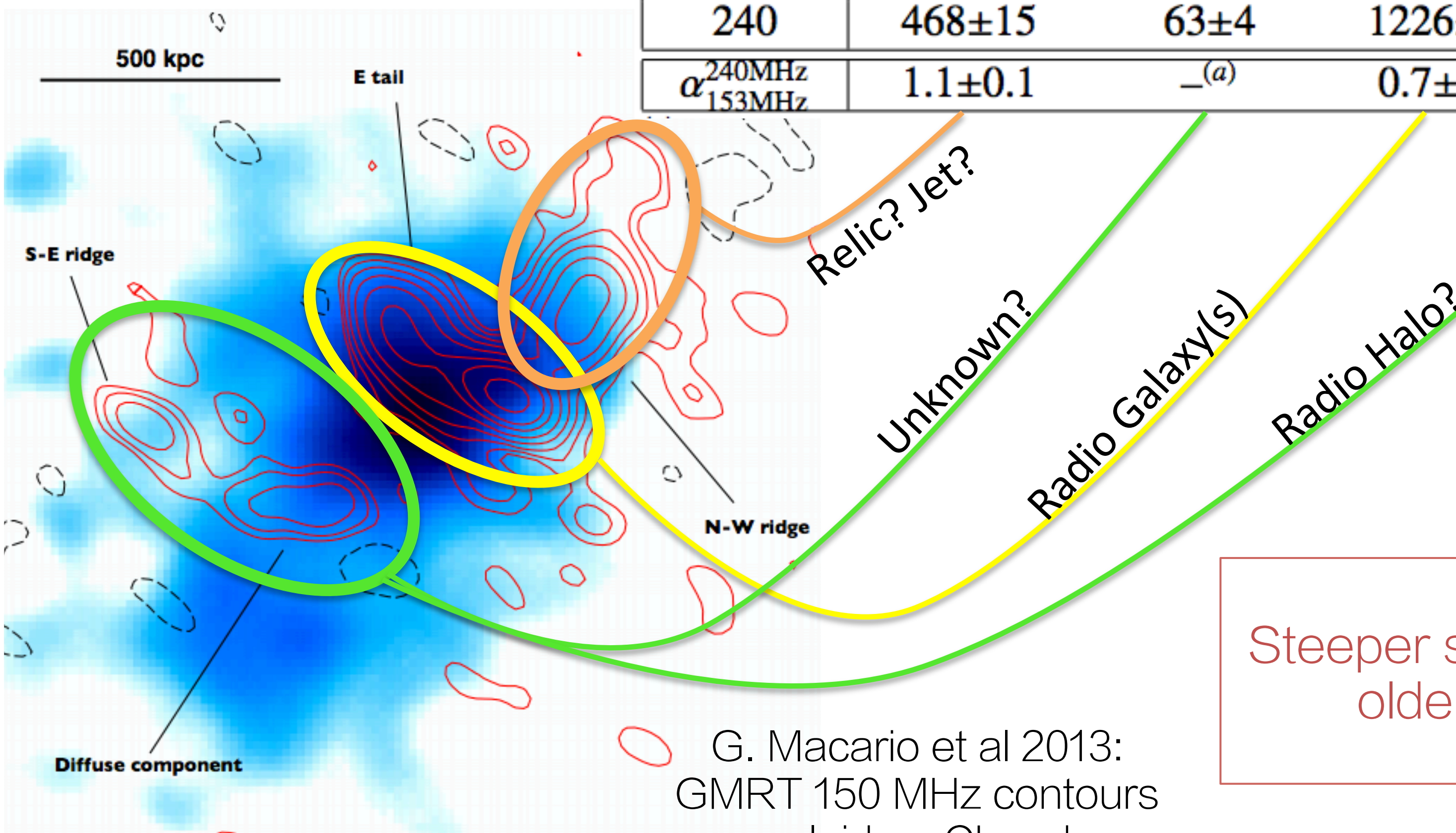
240 MHz: Black contours ±0.6,1.2,2.4,4.8 mJy/b, (1σ ~ 0.3 mJy/b)

Previous GMRT work

- Spectral index maps help tell us the nature of the radio emission



ν [MHz]	$S(\nu)$ [mJy]			
	N-W ridge	S-E Ridge	E Tail	Diff. Comp.
153	746 ±149	62±12	1710±342	98±20
240	468±15	63±4	1226±40	46±4
α_{153MHz}^{240MHz}	1.1±0.1	–[(a)]	0.7±0.1	1.7±0.1



G. Macario et al 2013:
GMRT 150 MHz contours
overlaid on Chandra

Steeper spectral index = older electrons

LOFAR Observational Setup

HBA

- 2013 dual beam observation
  (calibrated from infield calibrator)

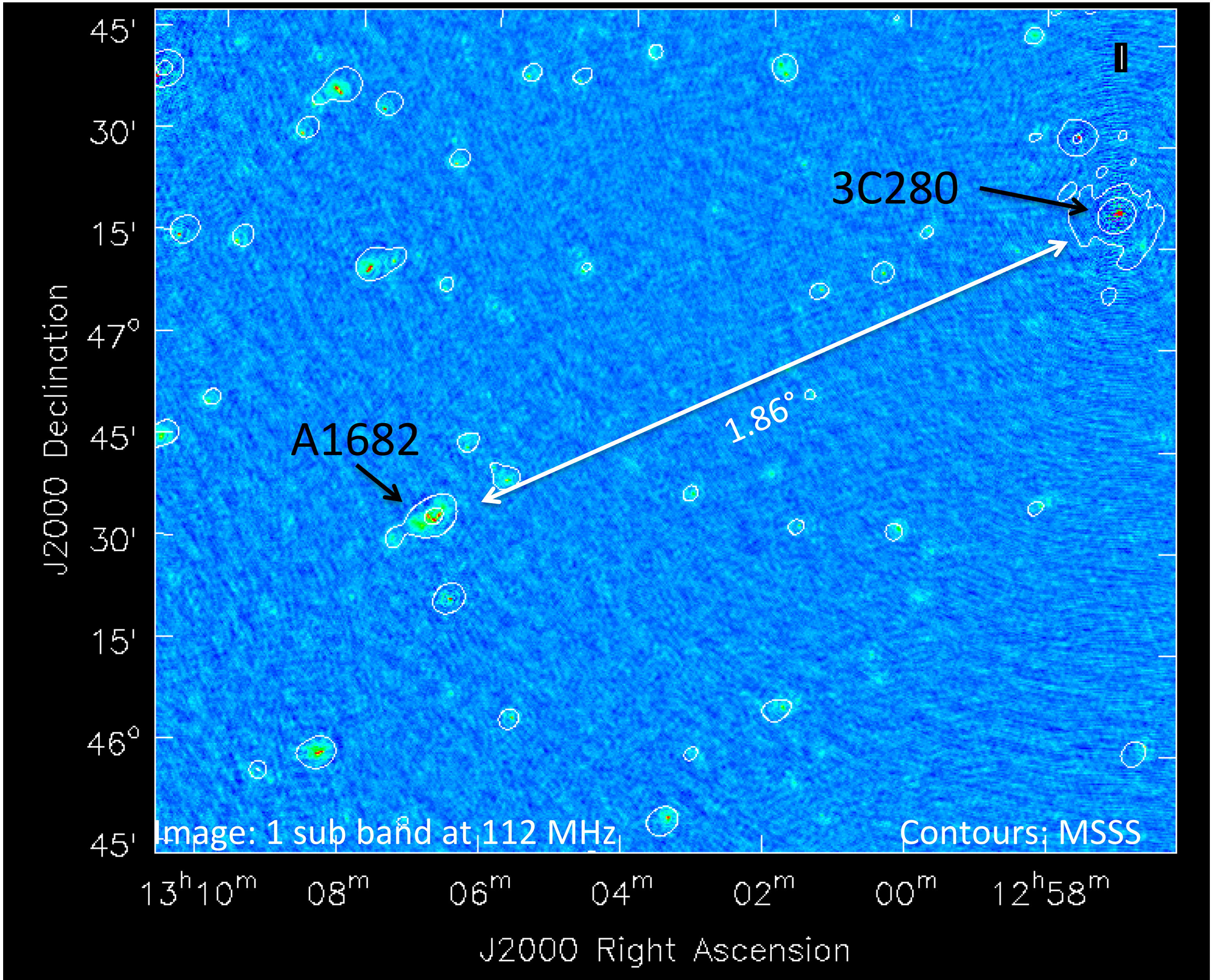
- Calibrator: 3C 280
  (created my own model from VLA snapshots)

- Calibrator−Target separation: 1.86°
  (useful for self−calibration and potentially mosaicking)

LBA

- Observation in 2014
  (10 subbands processed at 45 MHz & using infield calibrator)

3C 280: Non standard calibrator

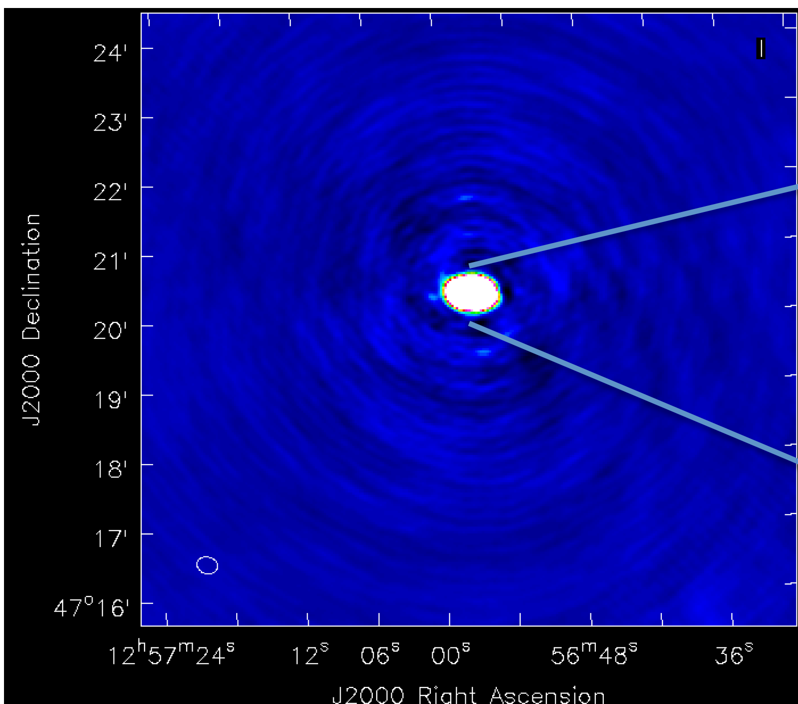


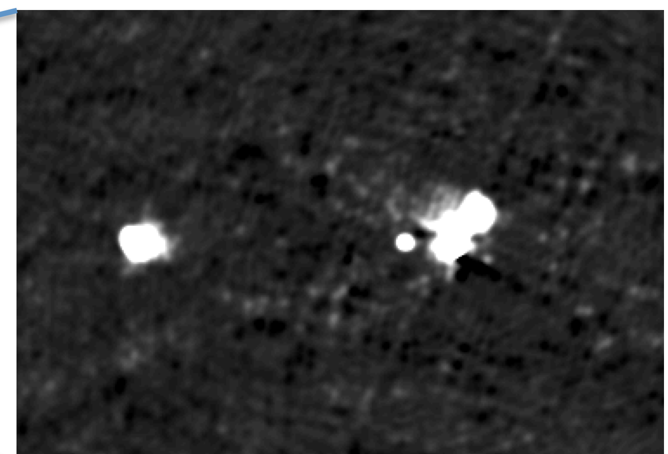
3C 280: Non standard calibrator

- Spatial model created using 5GHz VLA snapshots
- Spectral model built up using the 3C catalogue

K. I. Kellerman and I. I. K Pauliny-Toth (1968)

Source	S_{38}	S_{178}	S_{750}	S_{1400}	S_{2695}	S_{5000}	Notes
3C 280	62 b	23.7 a	7.7 a	4.9 a	2.83 a	1.53 a	

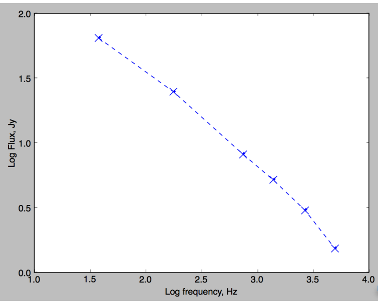




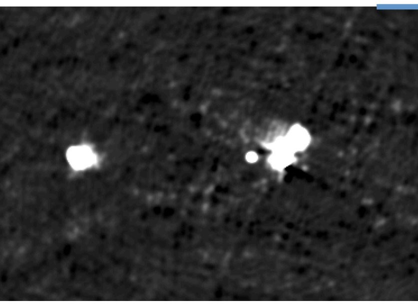
15 arc seconds

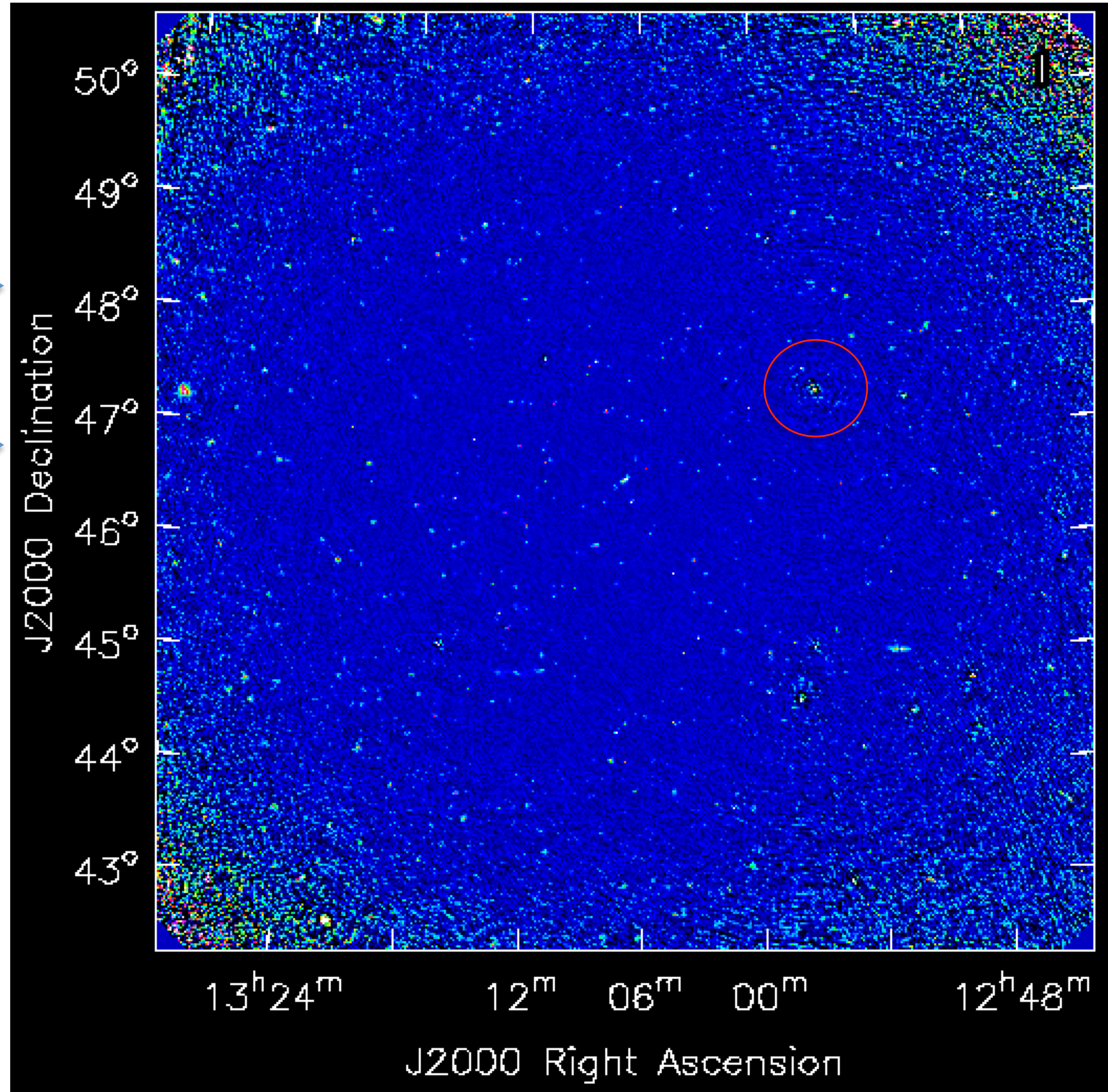
HBA & LBA Calibration

Calibrate target beam using 3C280 model



Amp + phase calibration





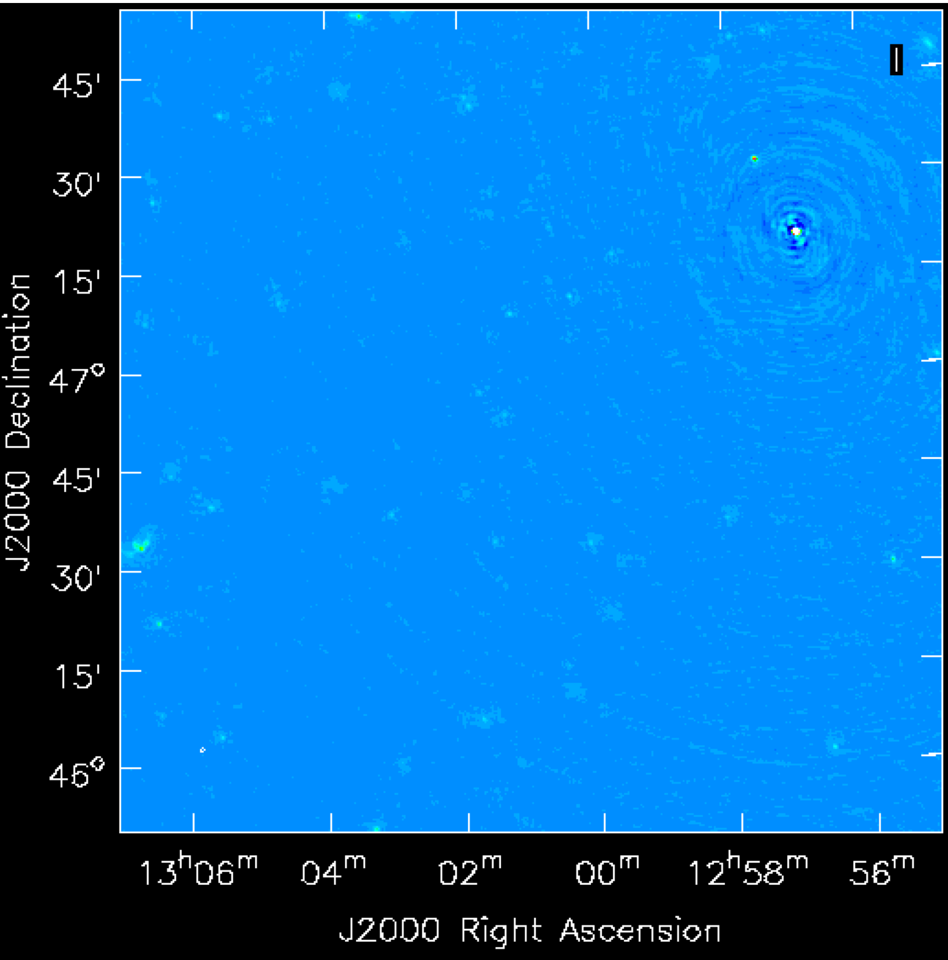
Initial tests show 5% fluctuation in fluxes, as compared to transferring amplitude gain solutions from calibrator beam

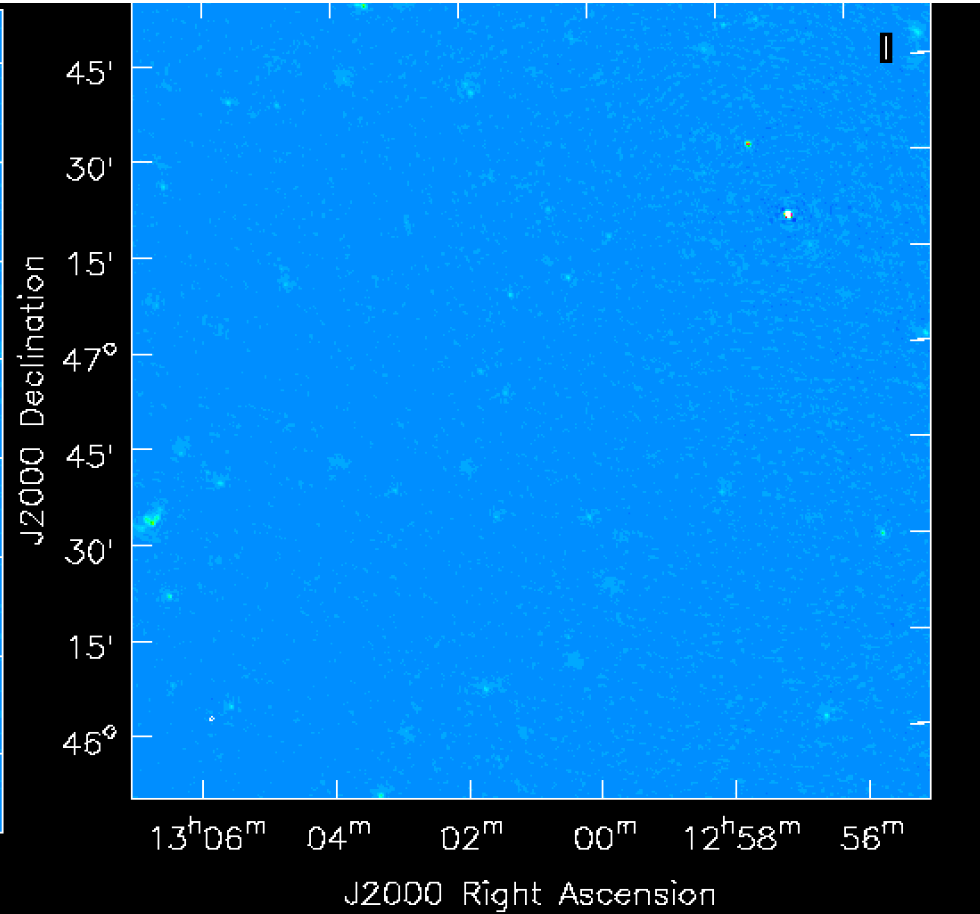
HBA & LBA Calibration

Calibrate target beam using 3C280 model

- Gain amp transfer from cal beam
- Phase cal on 3C280

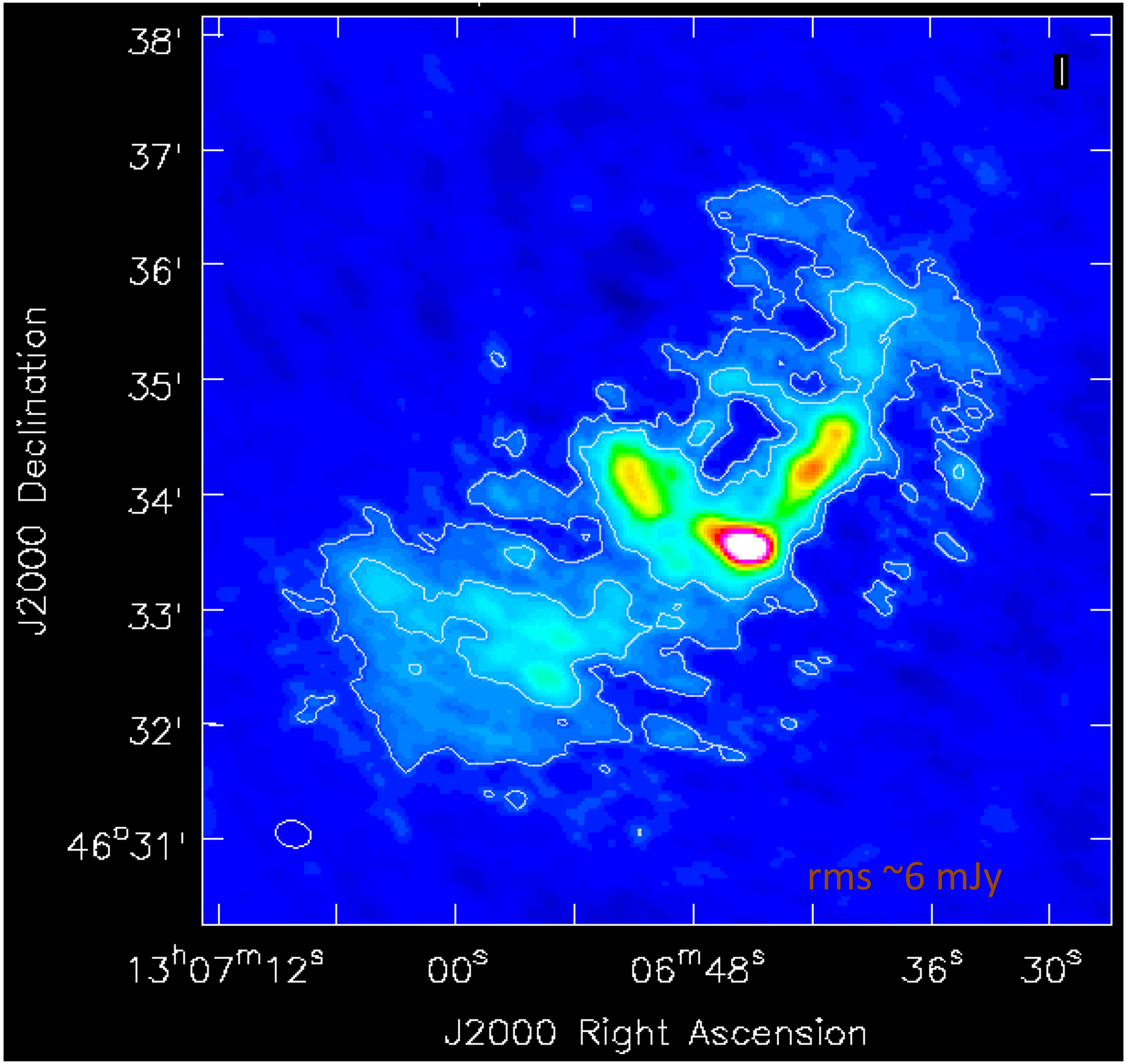
- Direct Amp+Phase solve for target beam





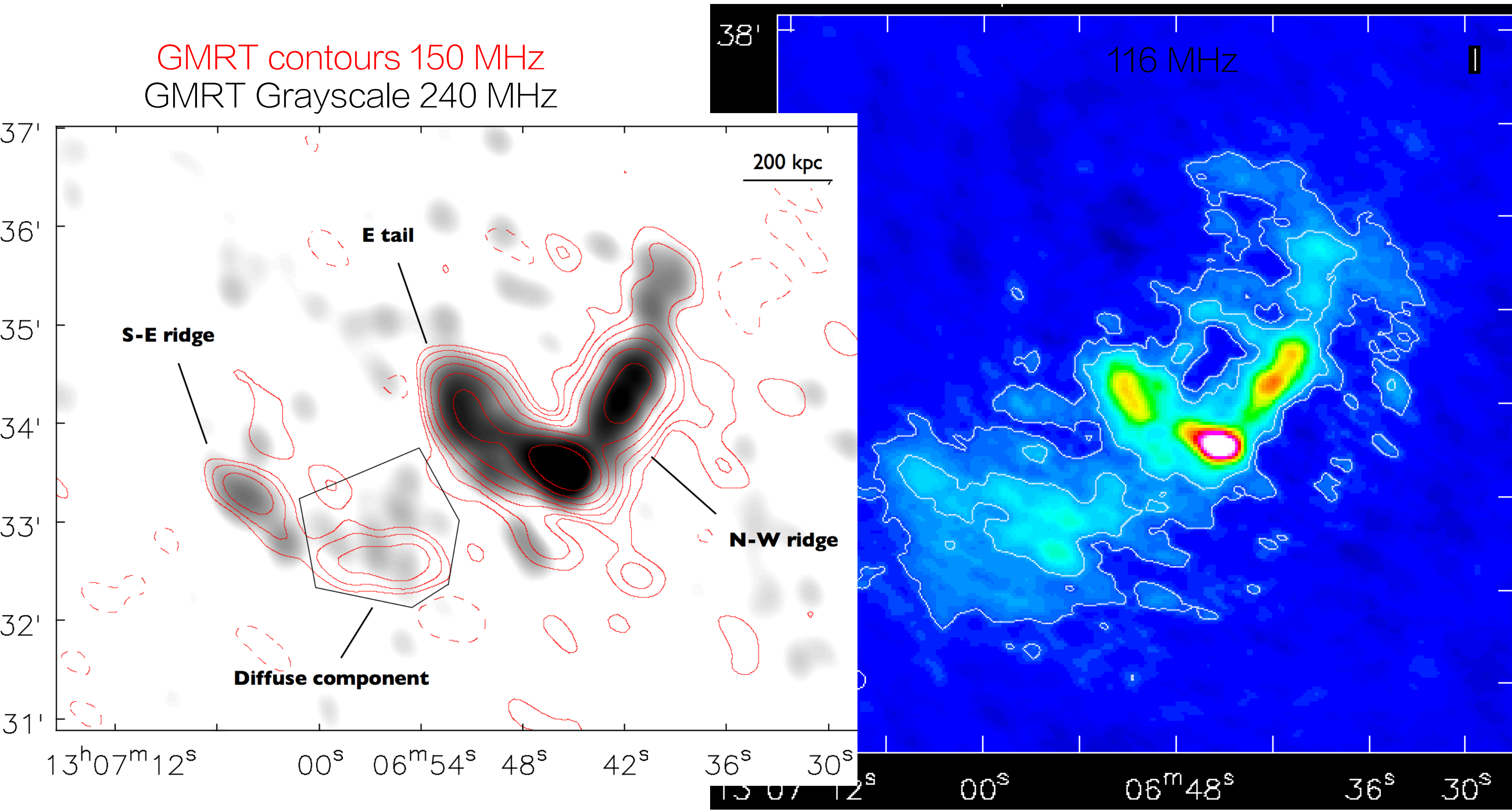
LOFAR HBA Results

116 MHz, robust 0, contours at 5 & 10 σ , 15” beam

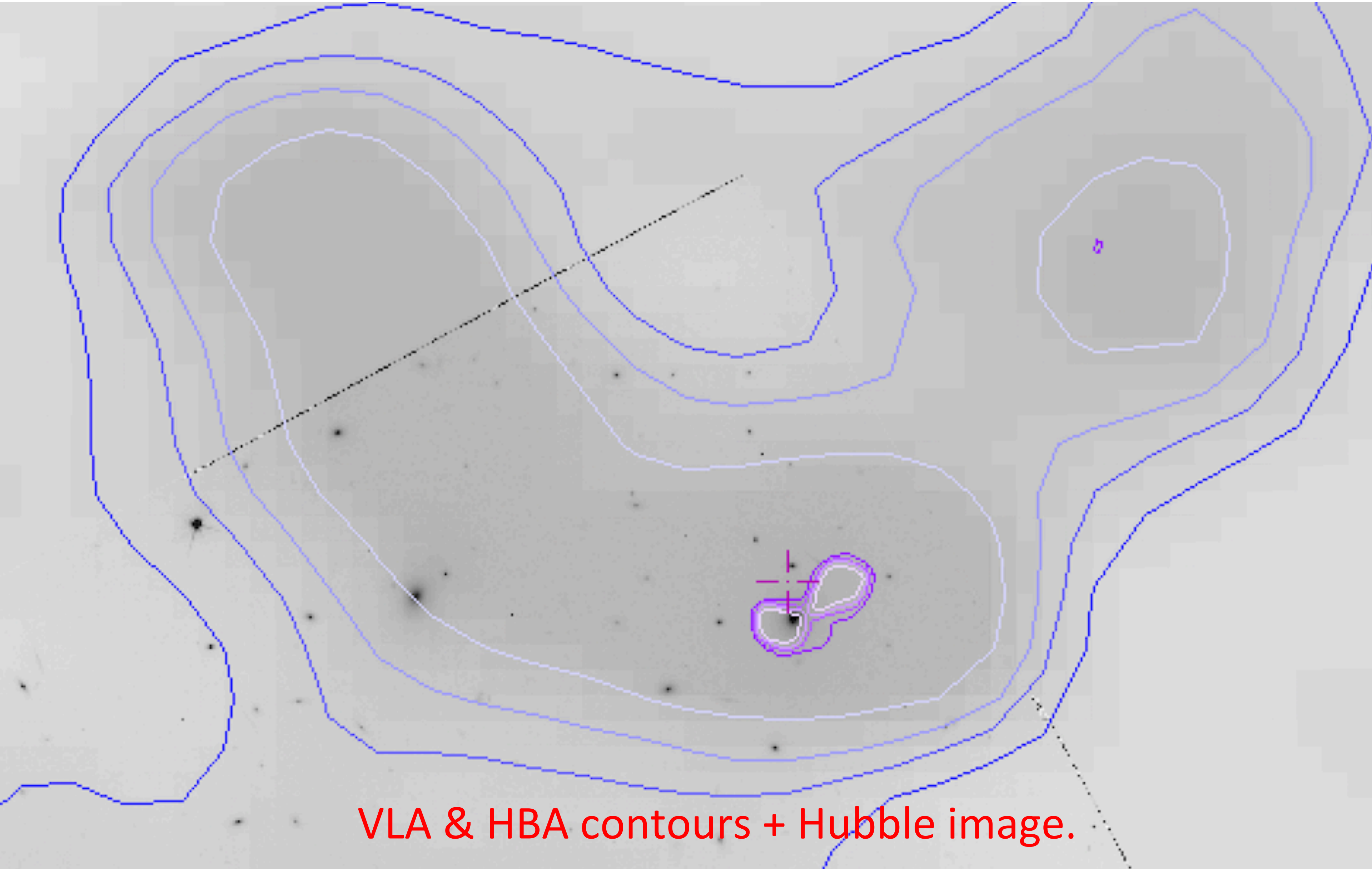


LOFAR HBA Results

+ GMRT



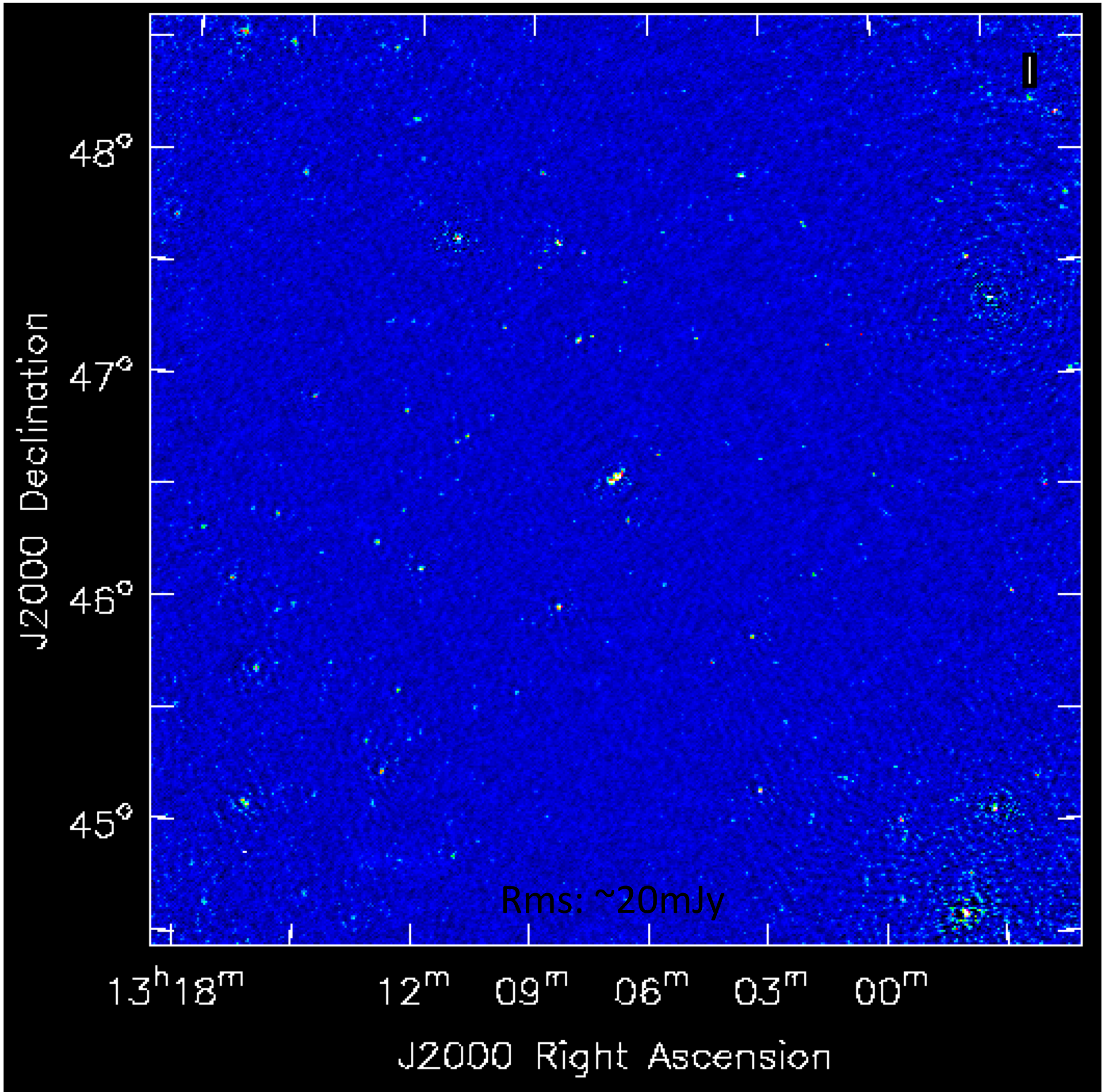
Jet resolved with VLA



VLA & HBA contours + Hubble image.

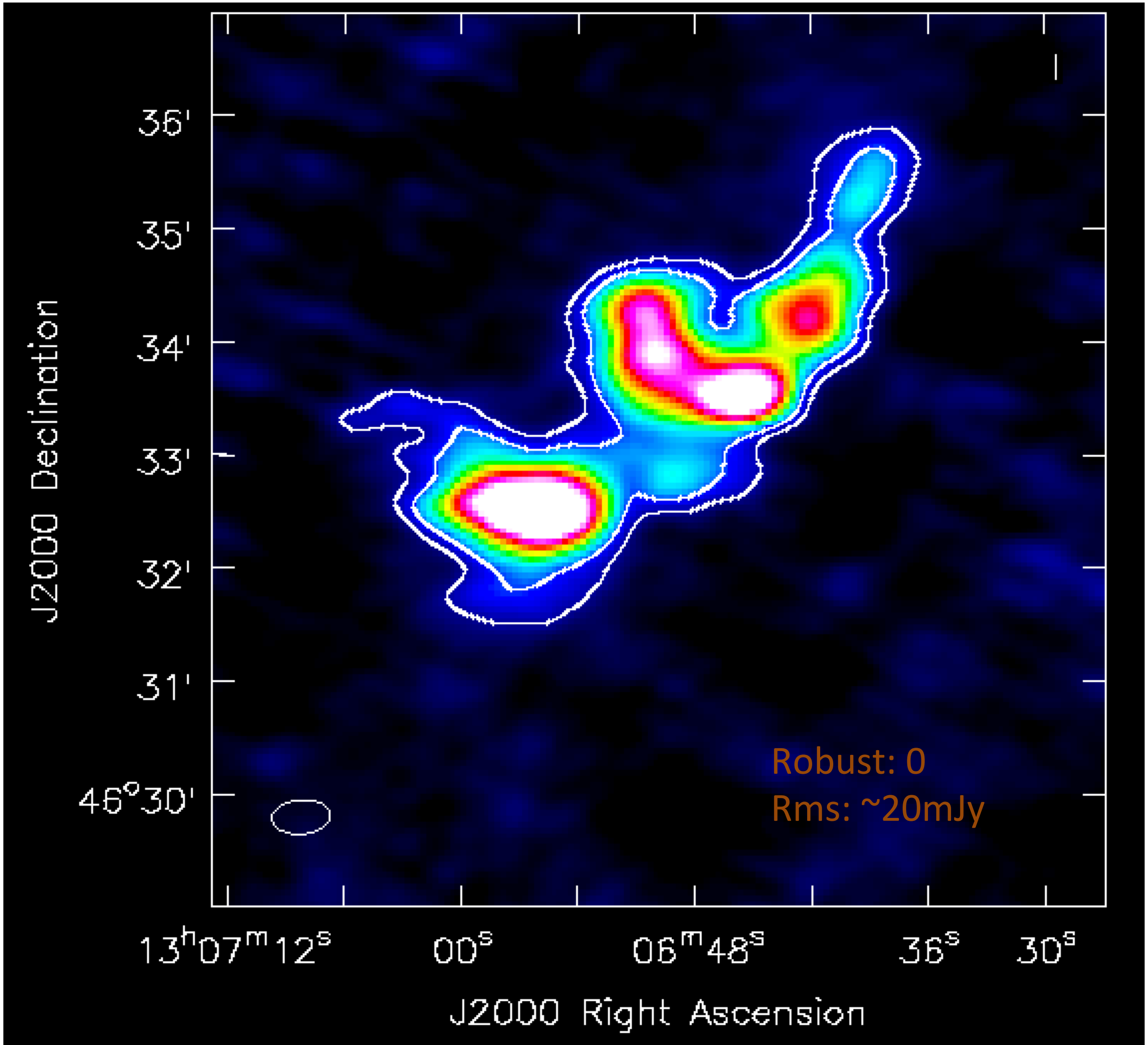
LOFAR LBA Results

44 MHz, robust 0, contours at 5 & 10 σ , 20”x30” beam



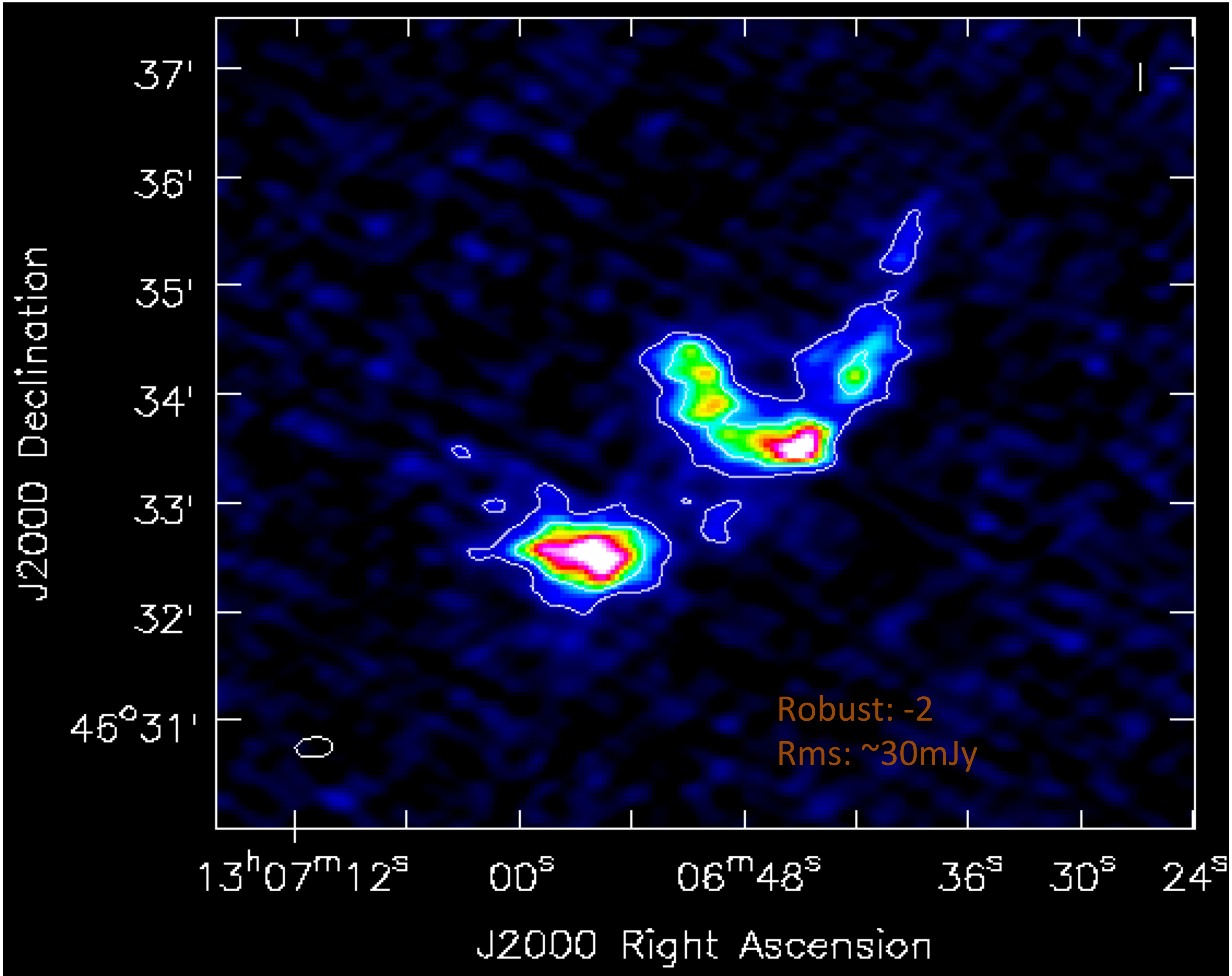
LOFAR LBA Results

44 MHz, robust 0, contours at 5 & 10 σ , 20”x30” beam

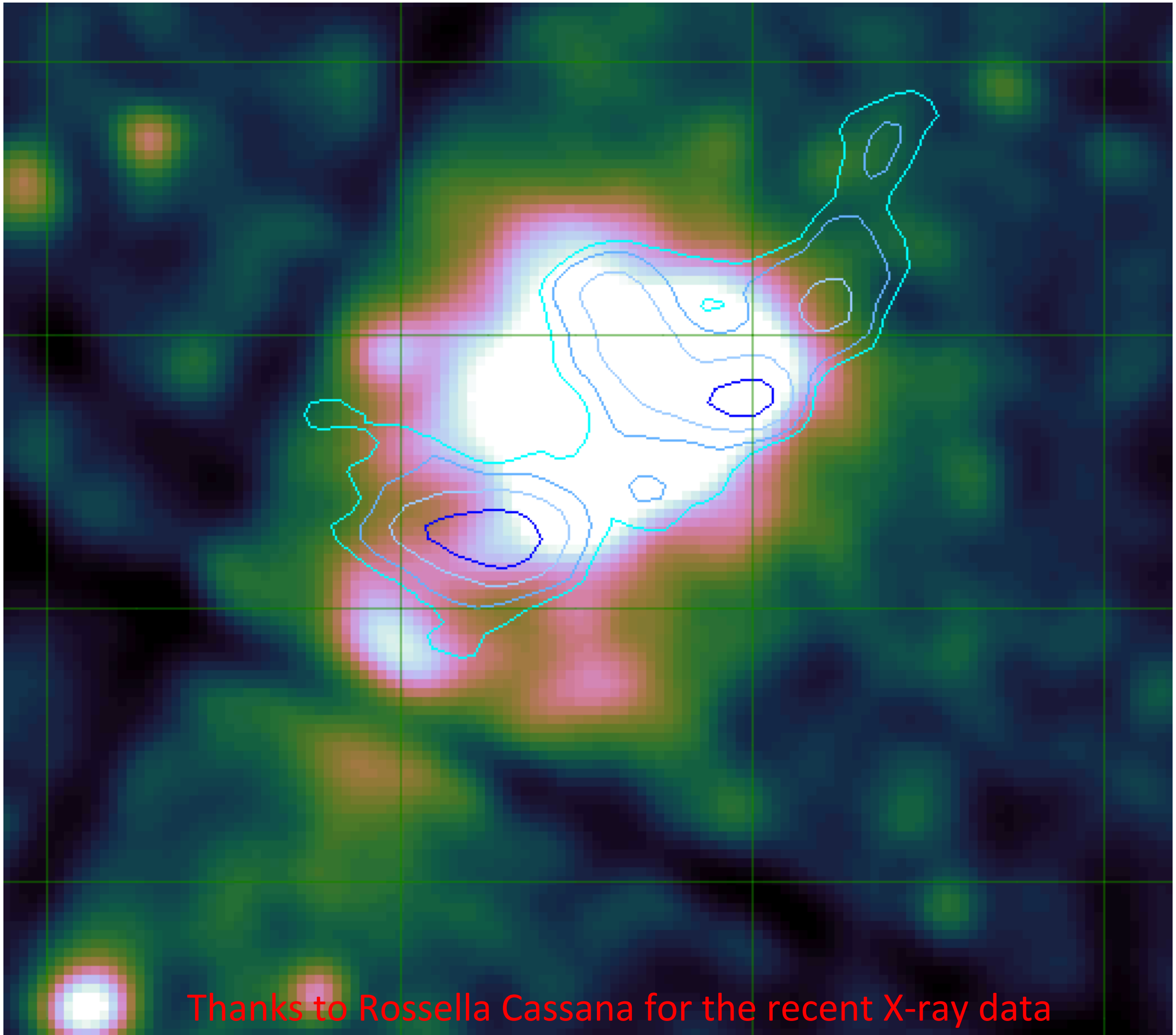


LOFAR LBA Results

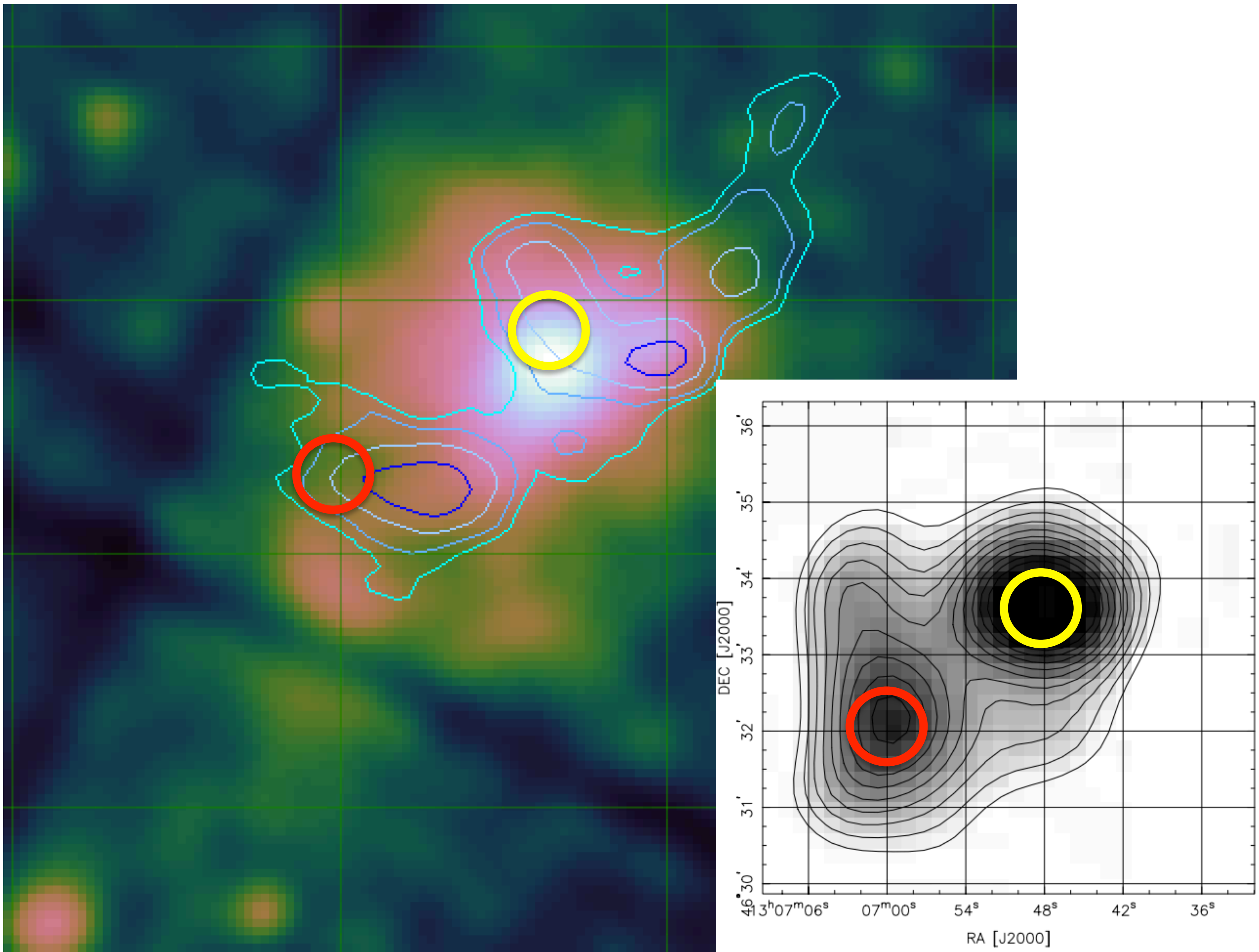
44 MHz, robust 0, contours at 5 & 10 σ , 10”x20” beam



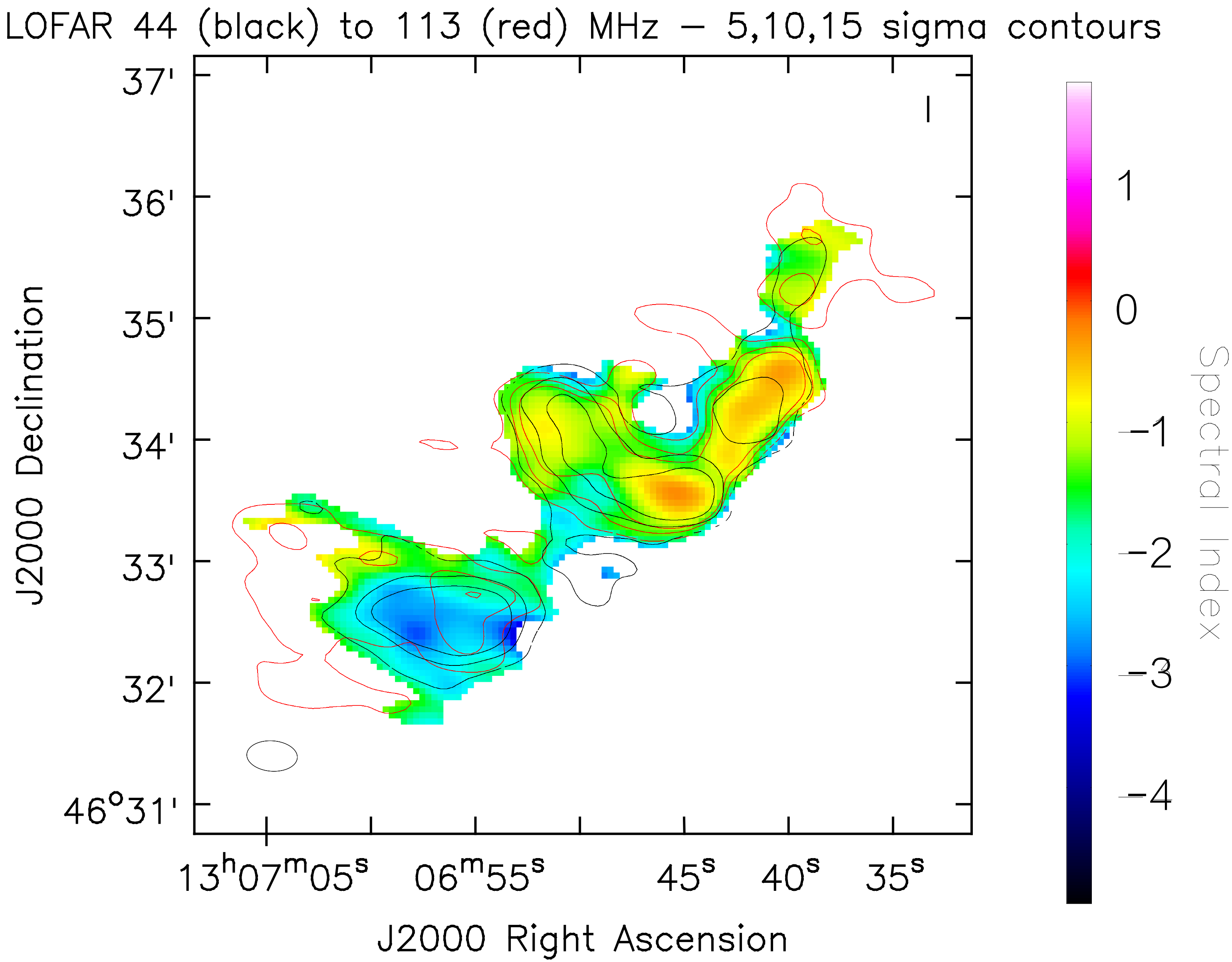
LOFAR LBA + 20 ksec Chandra X-ray



LOFAR LBA + 20 ksec Chandra X-ray



HBA-LBA Spectral Index Map



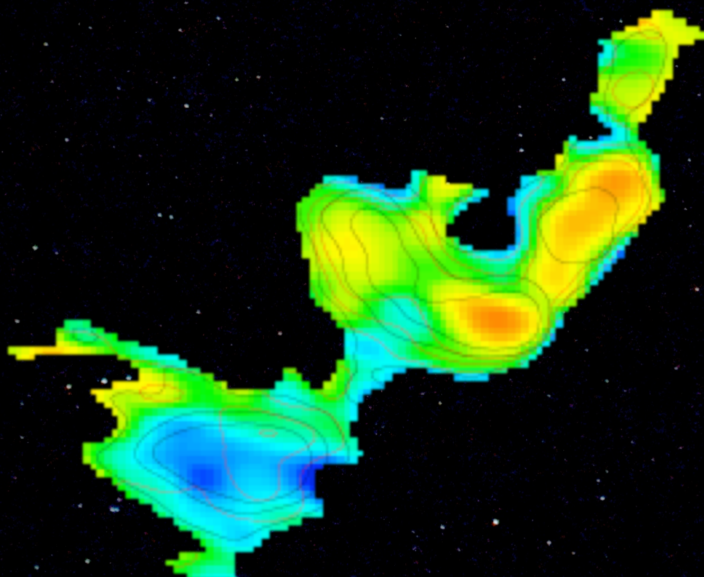
Conclusions

Need rigorous calibration to achieve very low noise

(direction dependent/facet calibration)

- This would confirm it`s giant size
  - As the largest and steepest spectrum halo discovered
- Confirms the re−acceleration model for halo formation

Thanks for listening!



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