Galaxy clusters in the Decameter sky

CHRISTIAN GROENEVELD
(LEIDEN OBSERVATORY)

erc

Universiteit Leiden
The Netherlands

Sterrewacht Leiden

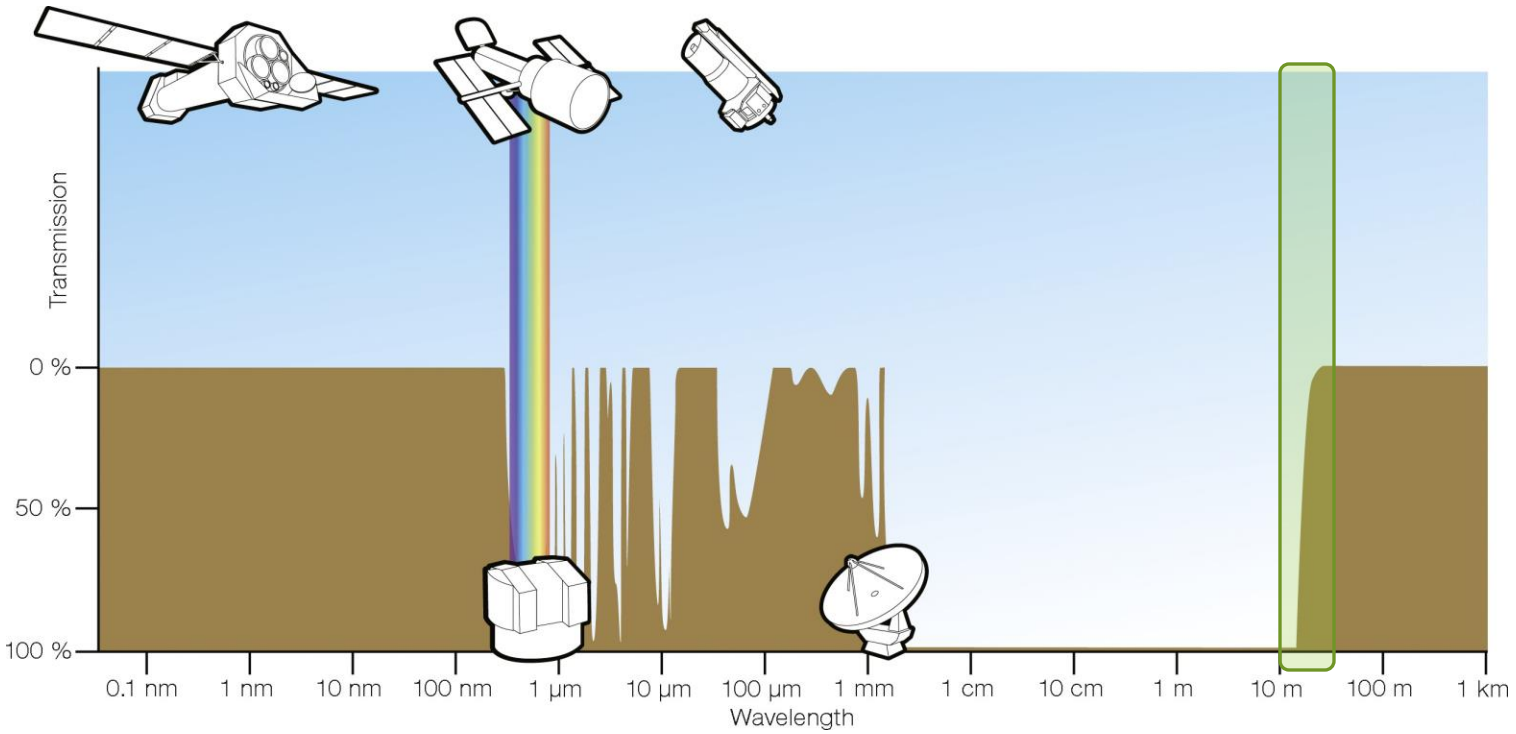
Contents

Recap on Decameter astronomy

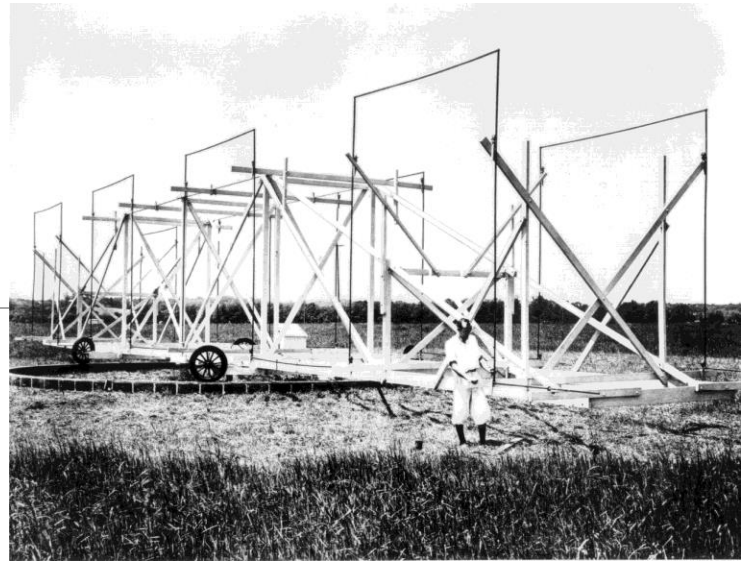
Galaxy clusters in the Decameter wavelength range

Prospects in upcoming surveys

Decameter wavelength band



Source: F. Granato (ESA/Hubble)

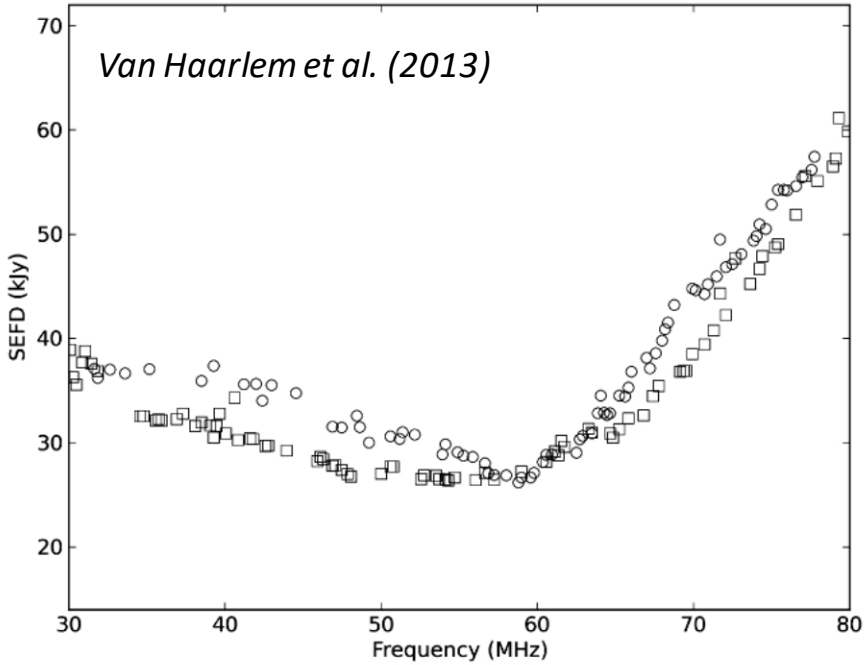


Source: *ukrinform.com*

Why are there no deep surveys?

- Ionosphere changes heavily in time (~second)
- Ionosphere changes heavily in frequency (1/v)
- Faraday rotation (1/v^2)
- Corrections change severely throughout FoV
- Reflected RFI (during daytime)

Source: A. R. Offringa



Lowest frequencies with LOFAR LBA

In principle 10-80 MHz

LoLSS: 42-66 MHz

Decameter band: 16-30 MHz

Calibration

LoLSS-like calibration strategy

Direction dependent calibration: Iteratively add directions

- Improves model for subtraction

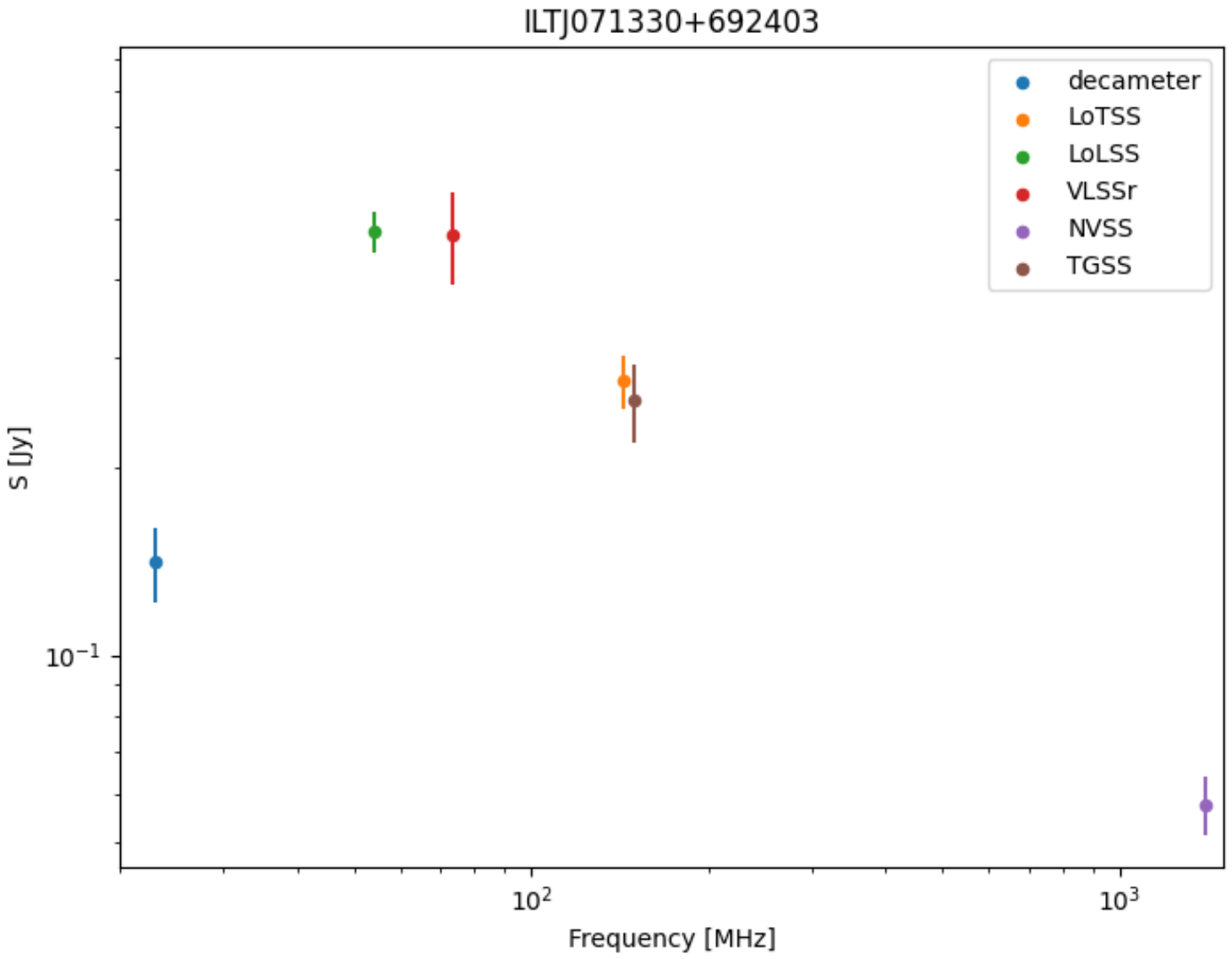
Imaging with WSClean

What can we see?

Decameter sky

Turnovers at low frequencies

- Peaked spectrum sources



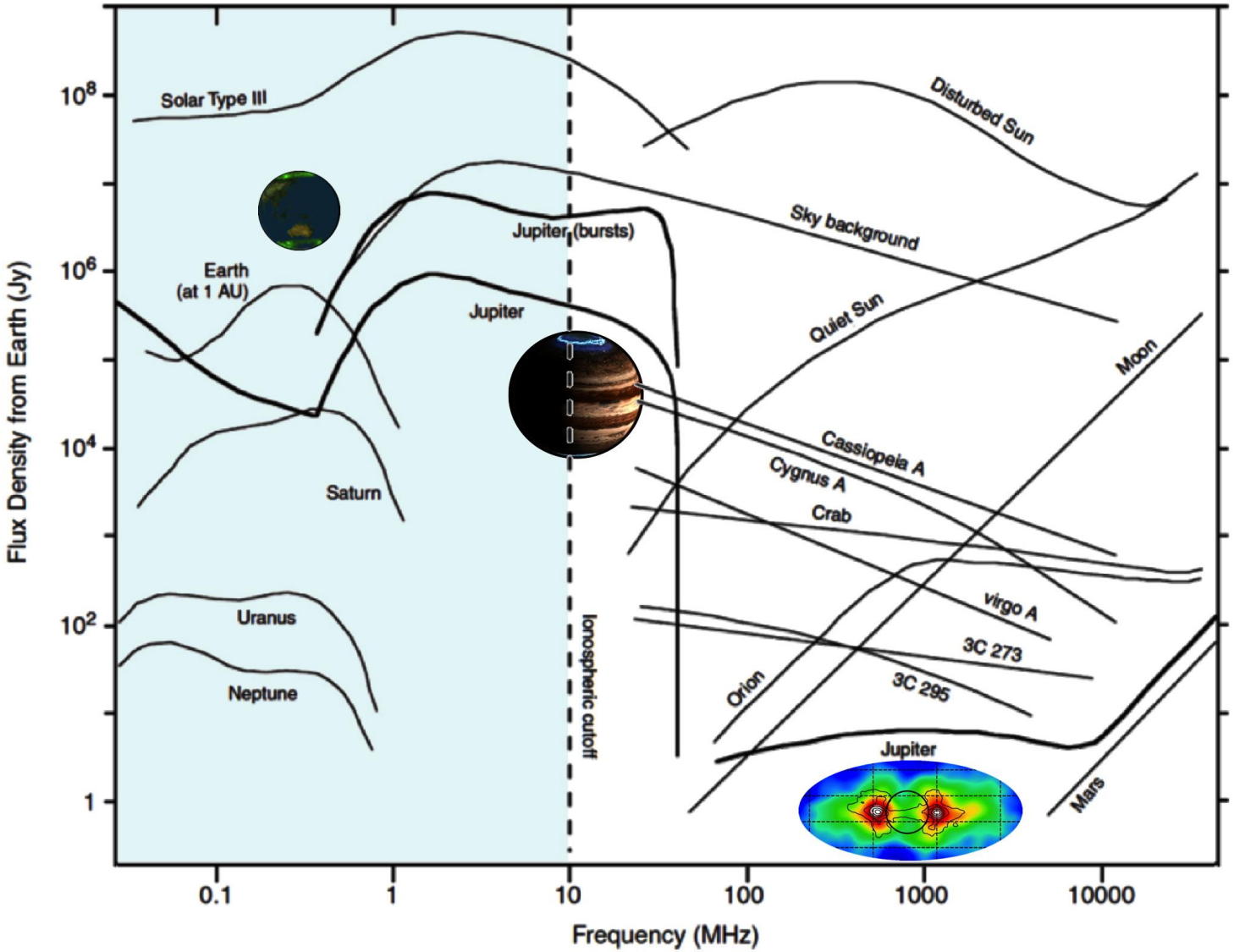
Lotte Jansen

Decameter sky

Turnovers at low frequencies

- Peaked spectrum sources

Unique radiation mechanisms



Source*: P. Zarka*

ECMI emission from Jupiter-Io interaction (e.g. Zarka 1992)

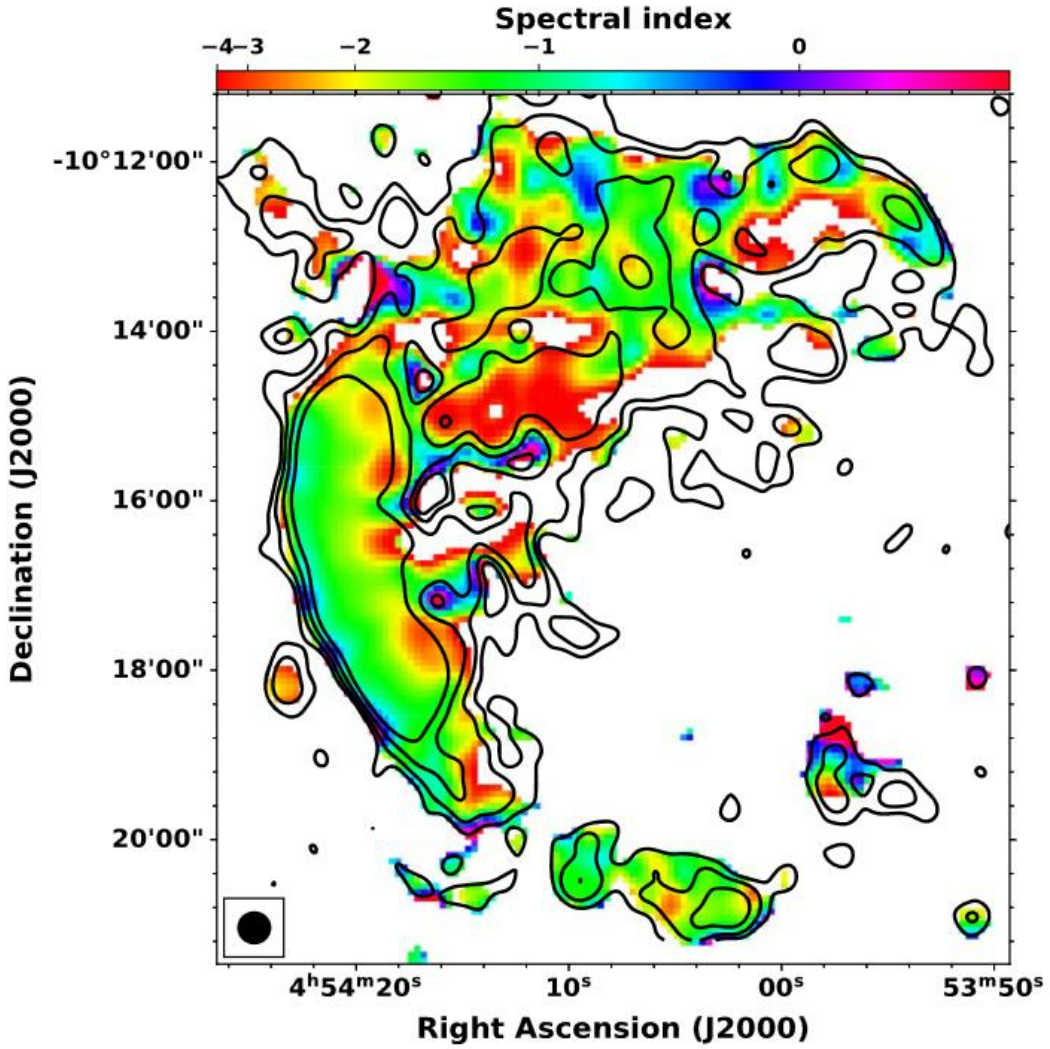
Decameter sky

Turnovers at low frequencies

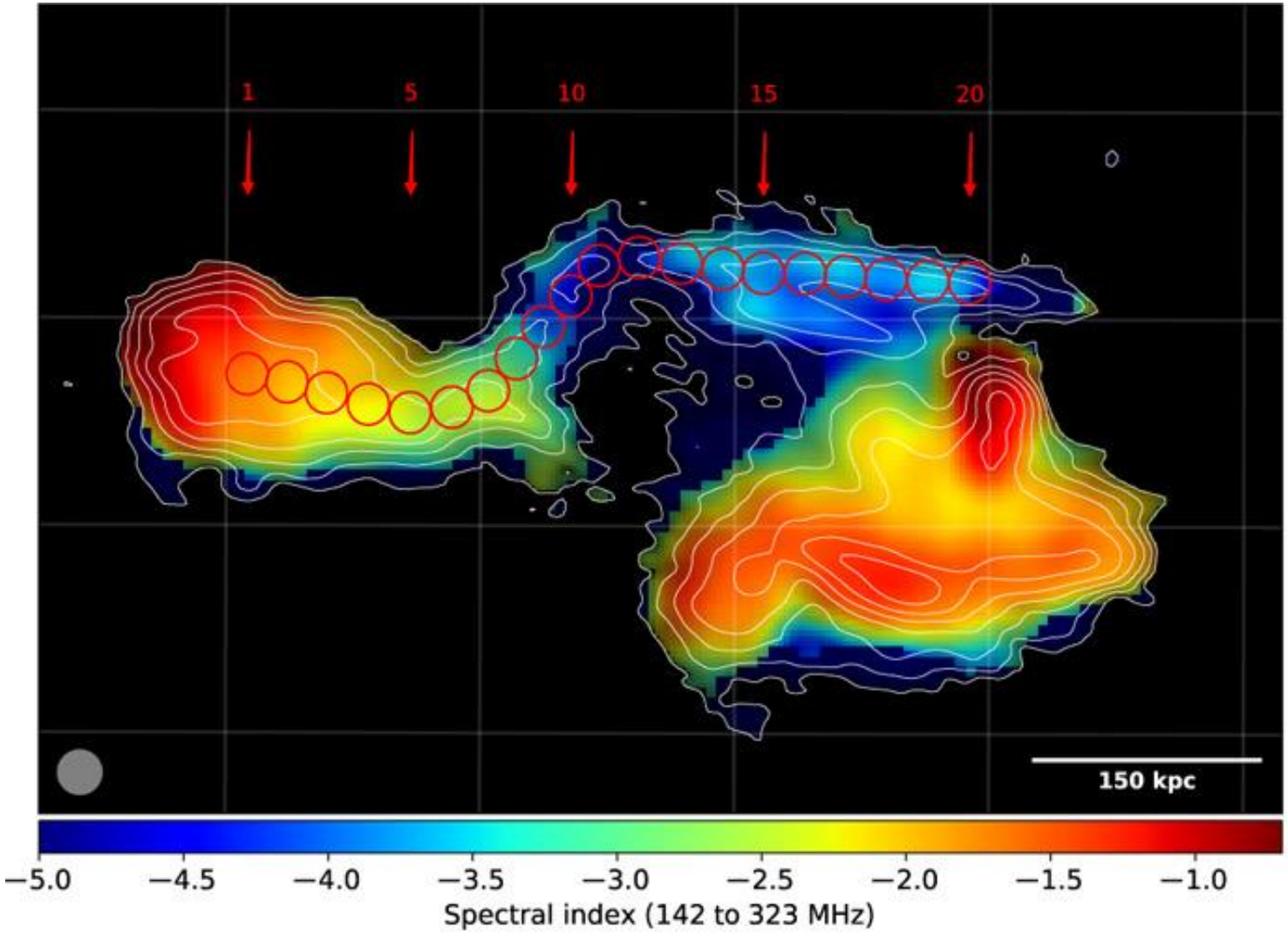
- Peaked spectrum sources

Unique radiation mechanisms

(Ultra) steep spectrum sources



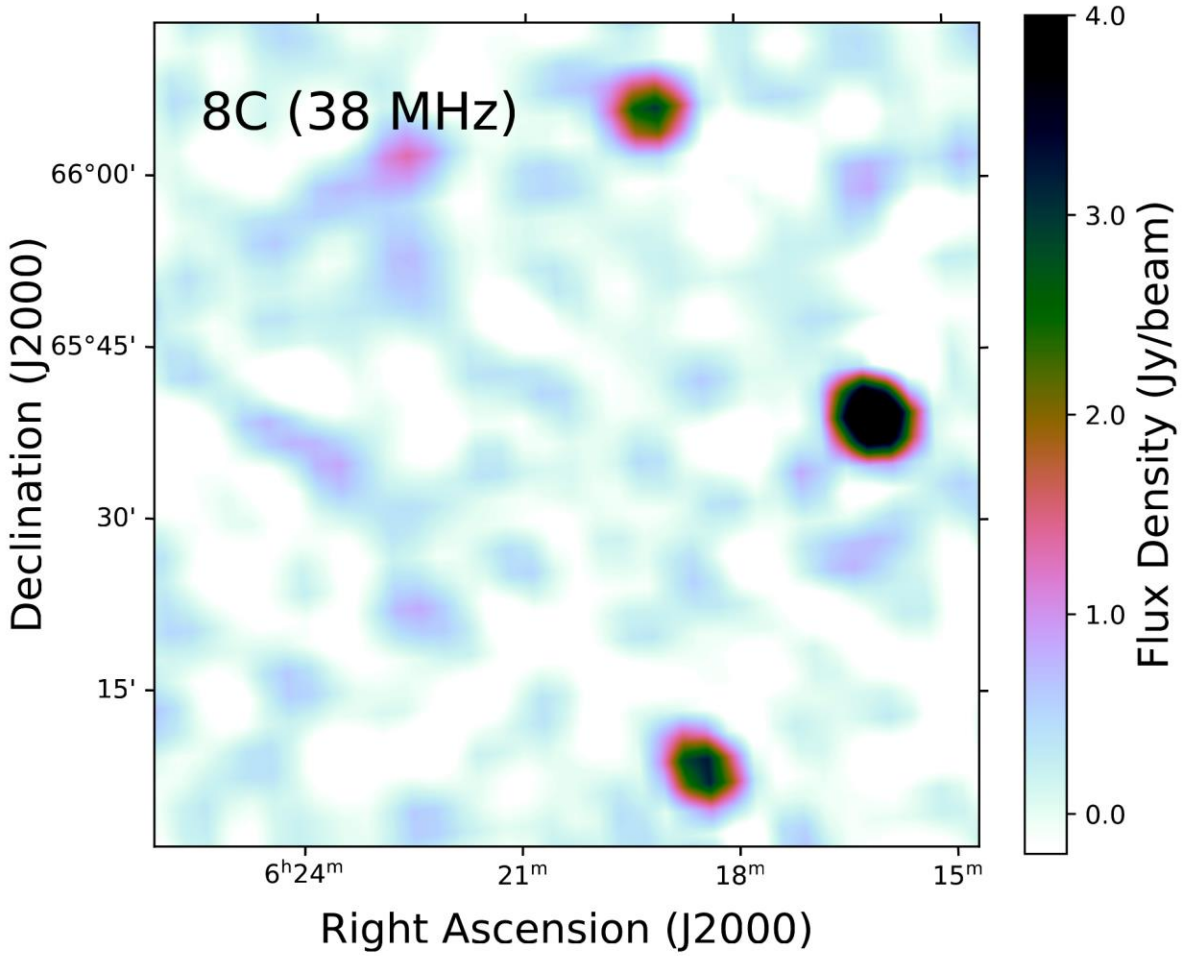
Source: *Santra et al. 2024*

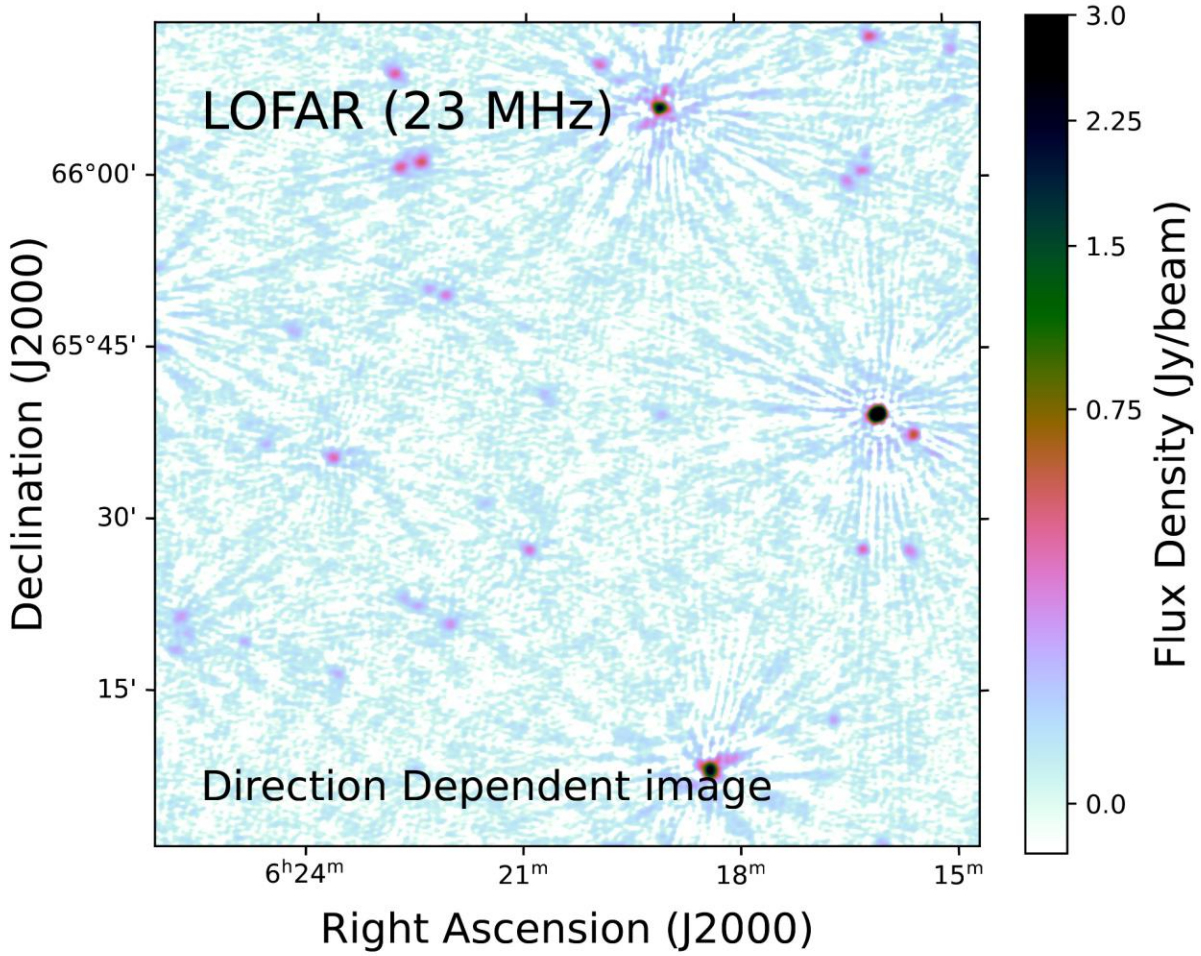


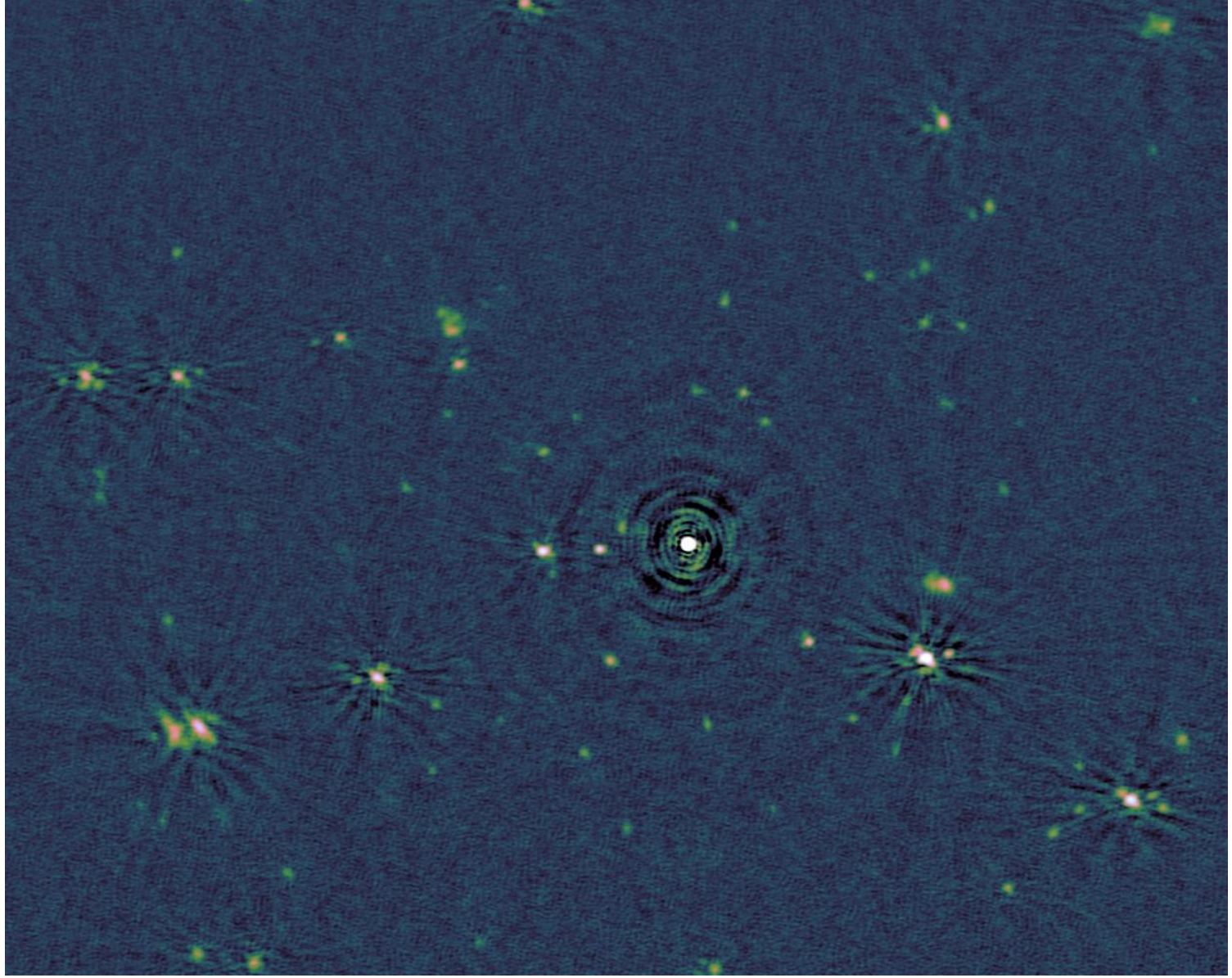
Source: de Gasperin et al. (2017)

Your science!

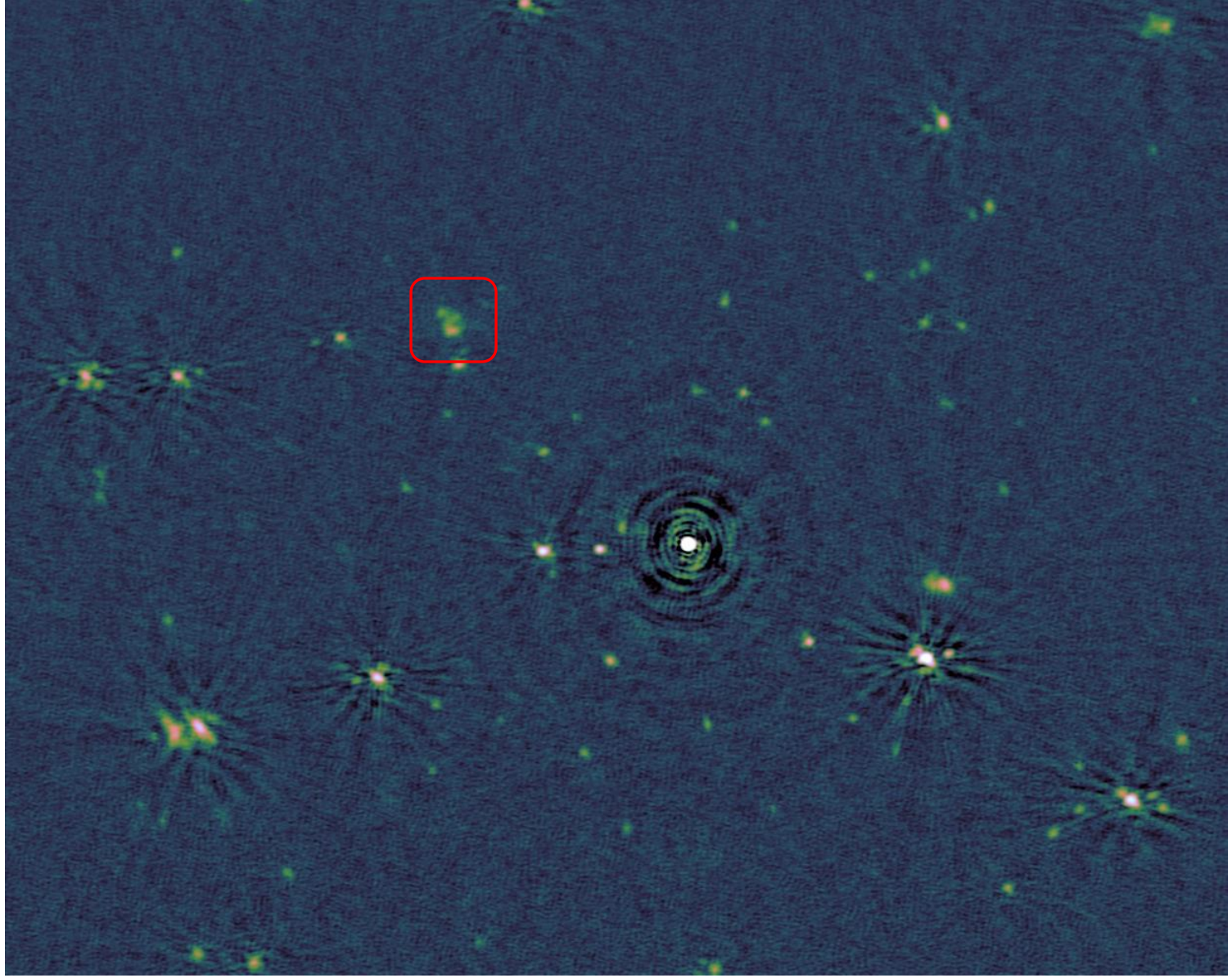
Decameter observations


8C (38 MHz)
66°00'
65°45'
30'
15'
Declination (J2000)
6h24m
21m
18m
15m
Right Ascension (J2000)
4.0
3.0
2.0
1.0
0.0
Flux Density (Jy/beam)


LOFAR (23 MHz)
66°00'
65°45'
30'
15'
Declination (J2000)
Direction Dependent image
6h24m
21m
18m
15m
Right Ascension (J2000)
3.0
2.25
1.5
0.75
0.0
Flux Density (Jy/beam)



16-30 MHz image



16-30 MHz image

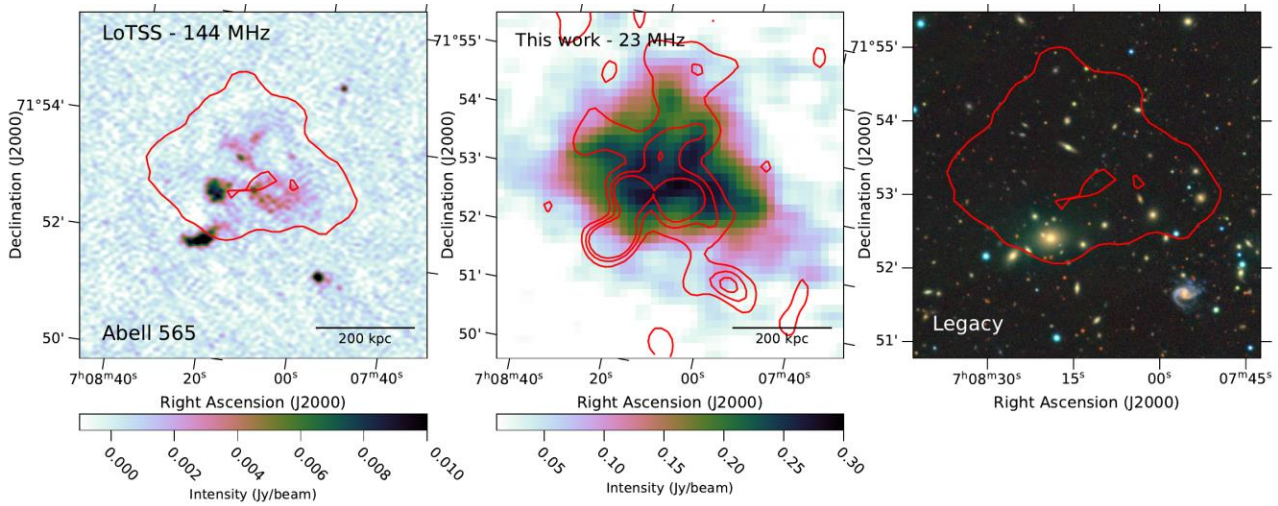
Galaxy clusters in the Decameter sky

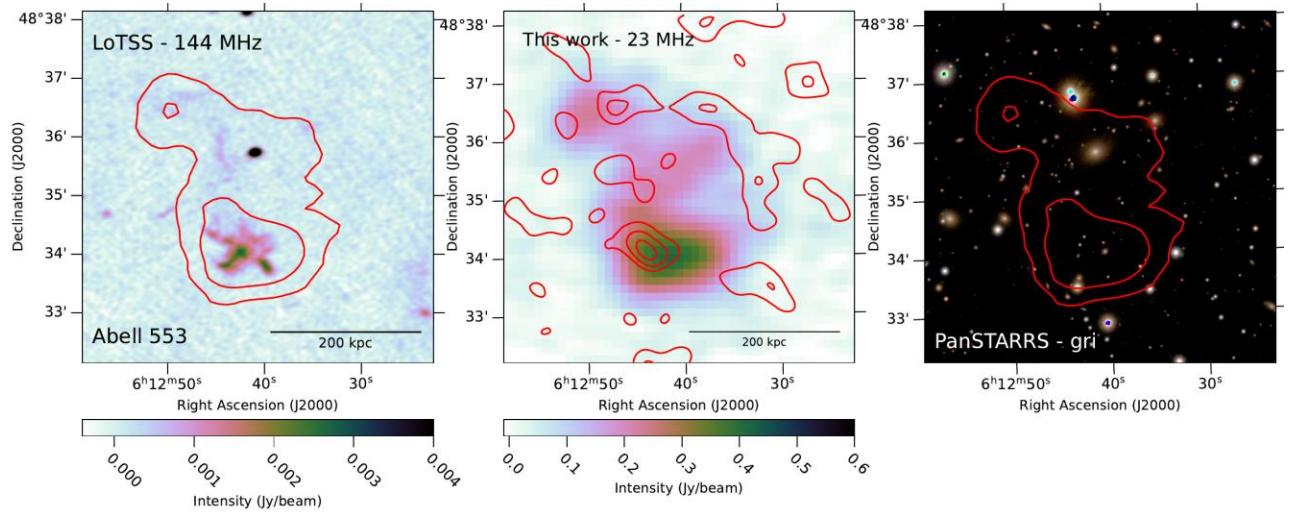
A565: α ~ -1.28

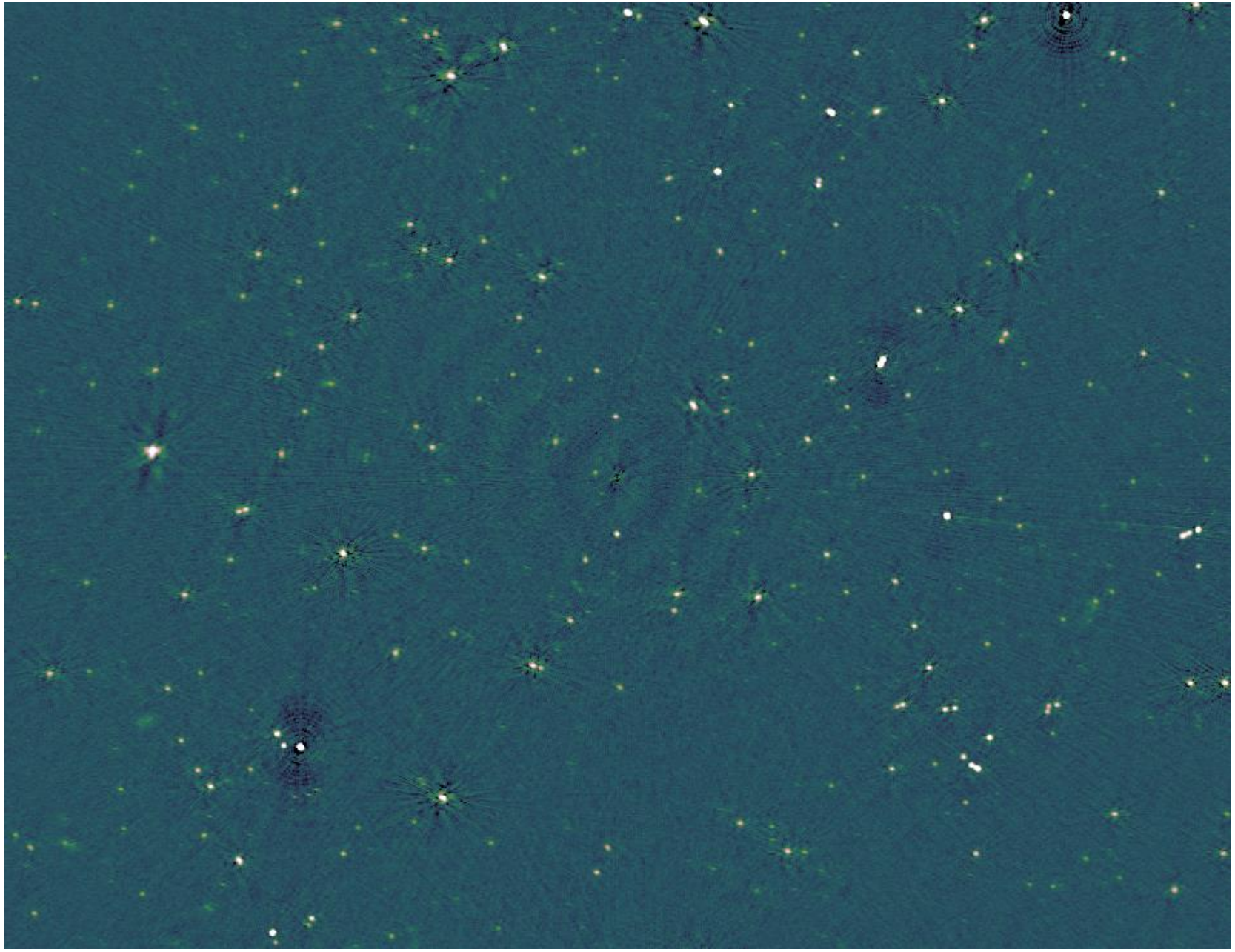
A553: α ~ -1.82

Both low-mass galaxy clusters

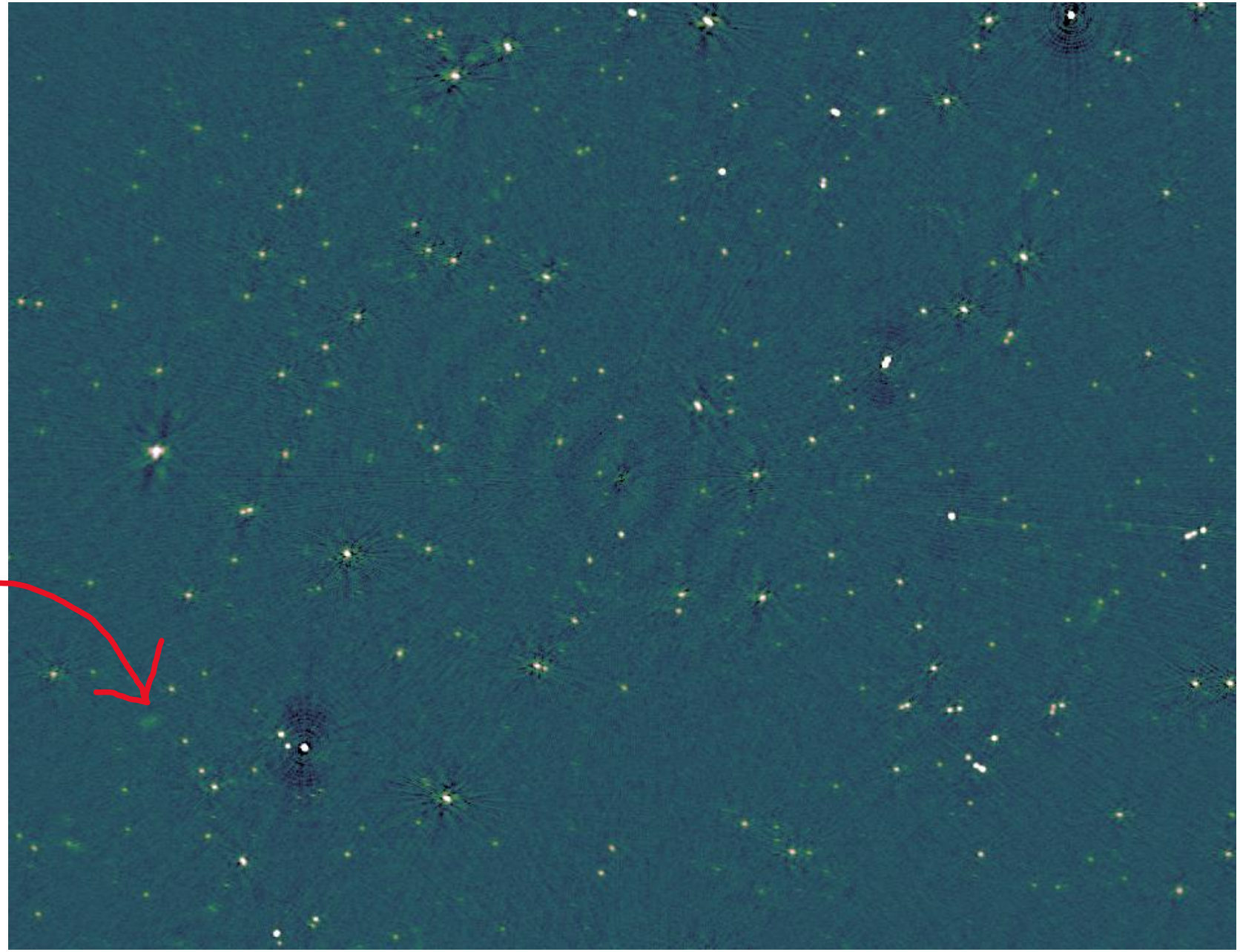
Irregular morphology: Radio phoenix





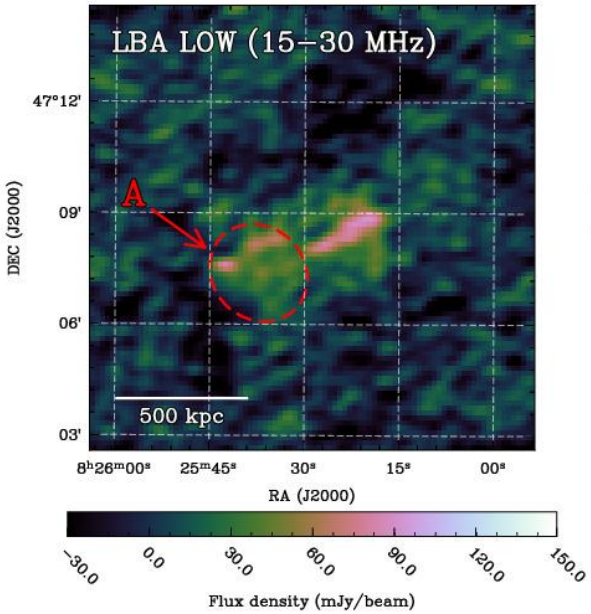


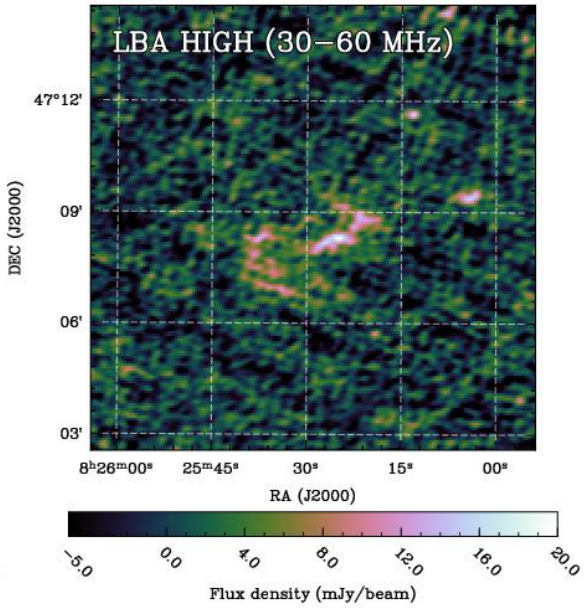
12-36 MHz image

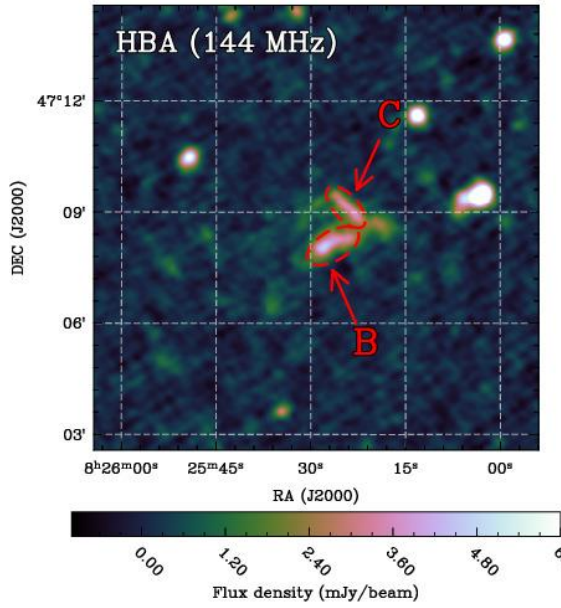


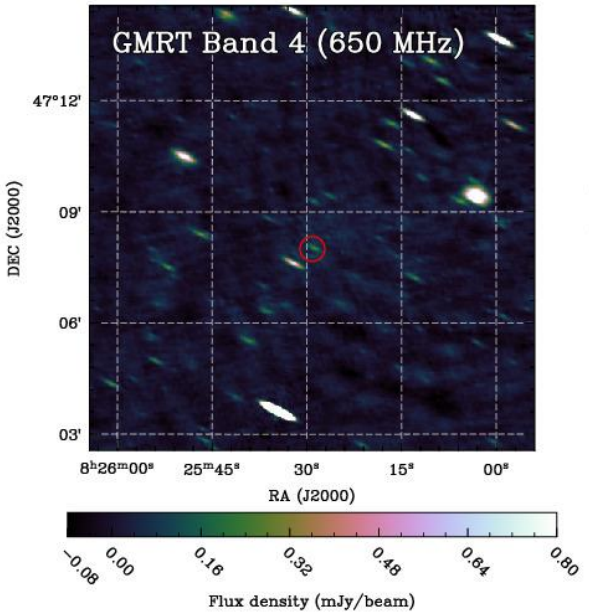
Abell 655!

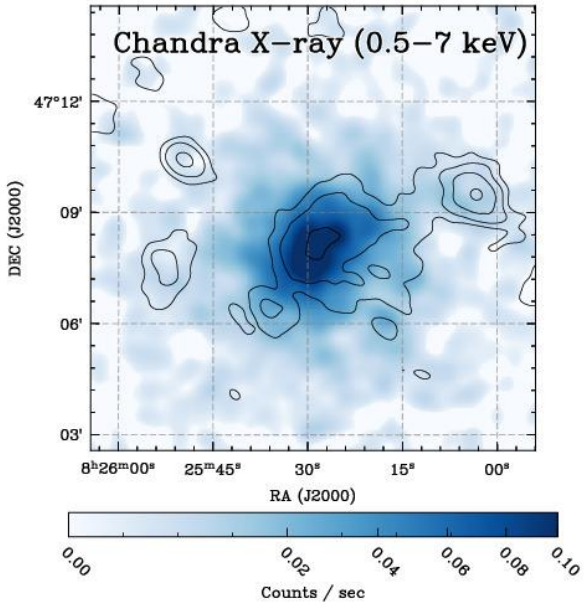
Galaxy clusters in the Decameter sky

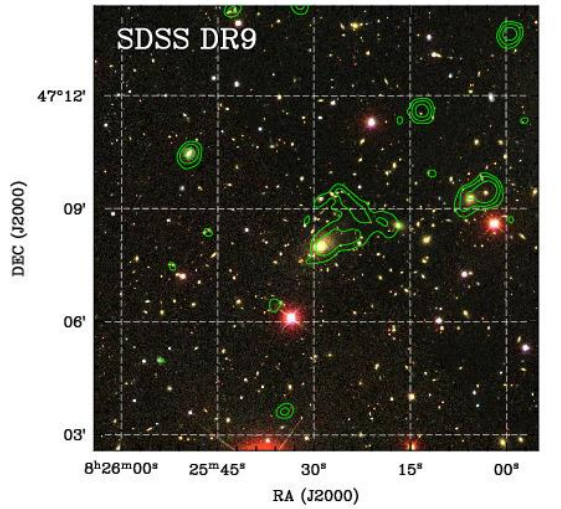






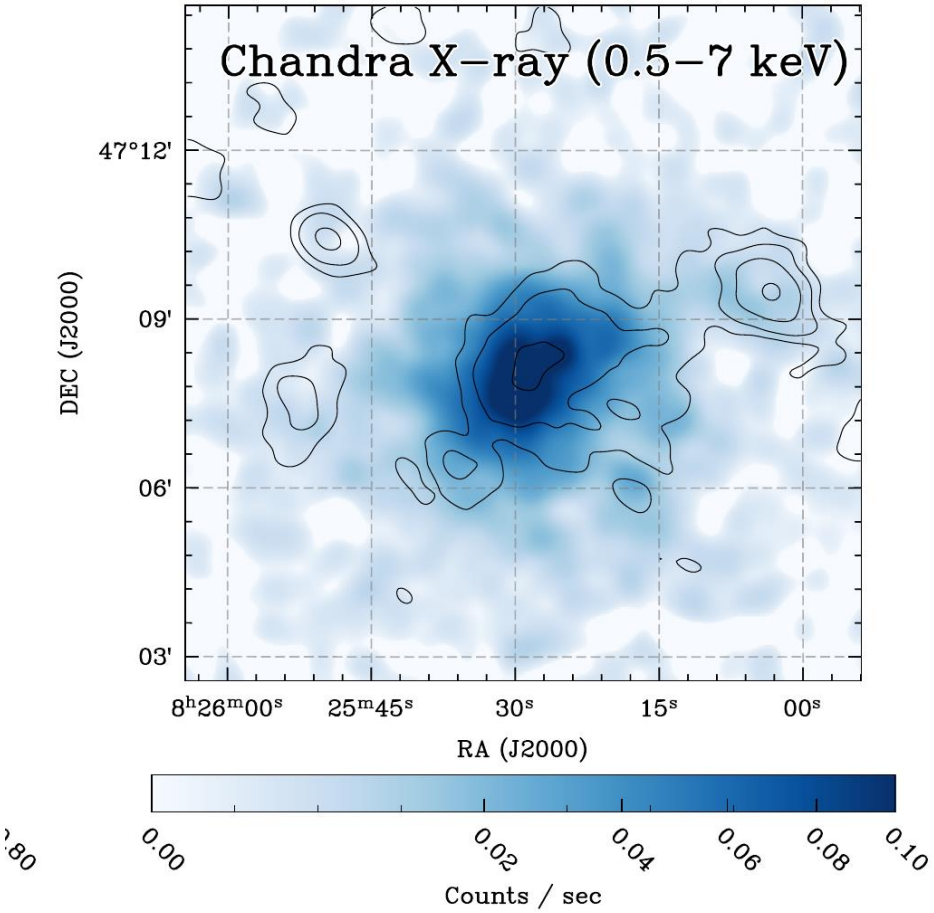






Galaxy clusters in the Decameter sky

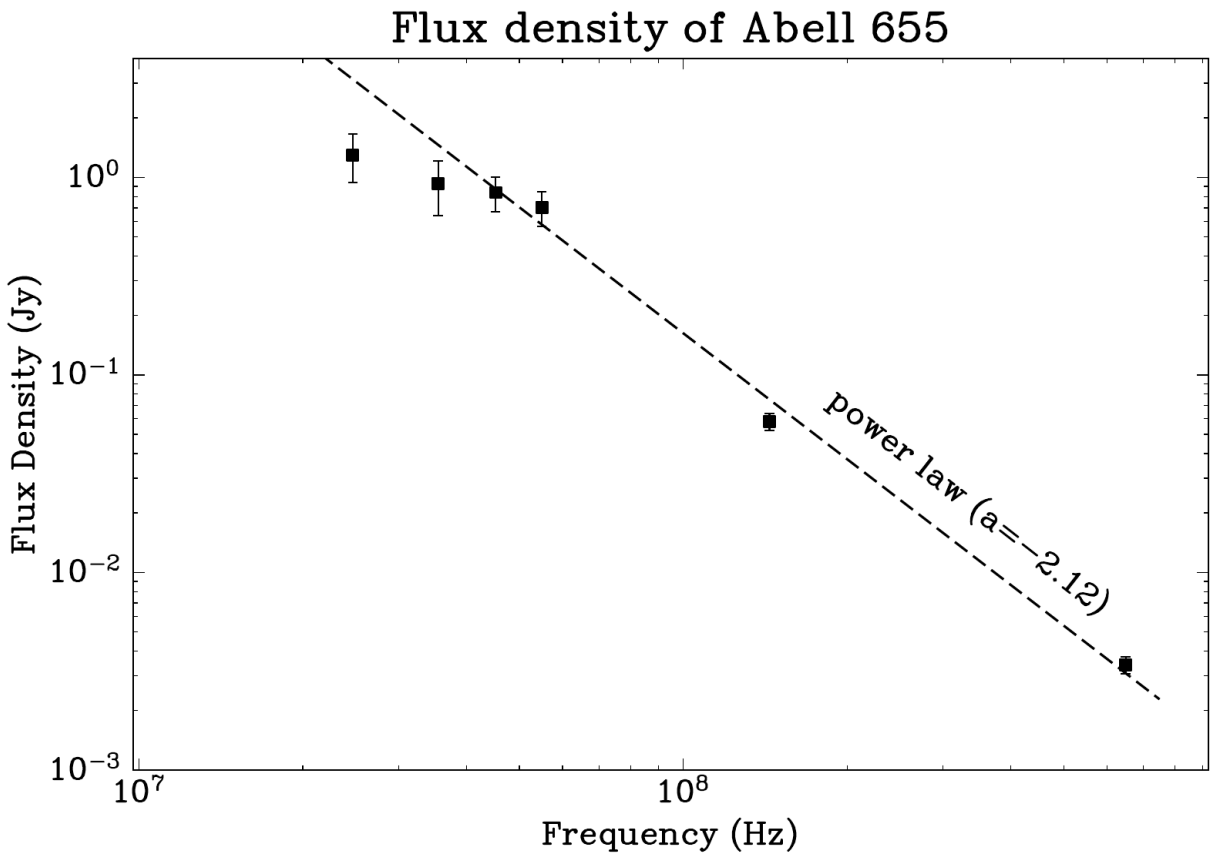
X-ray + 650 MHz GMRT
Diffuse radio emission follows X-ray morphology – Radio halo



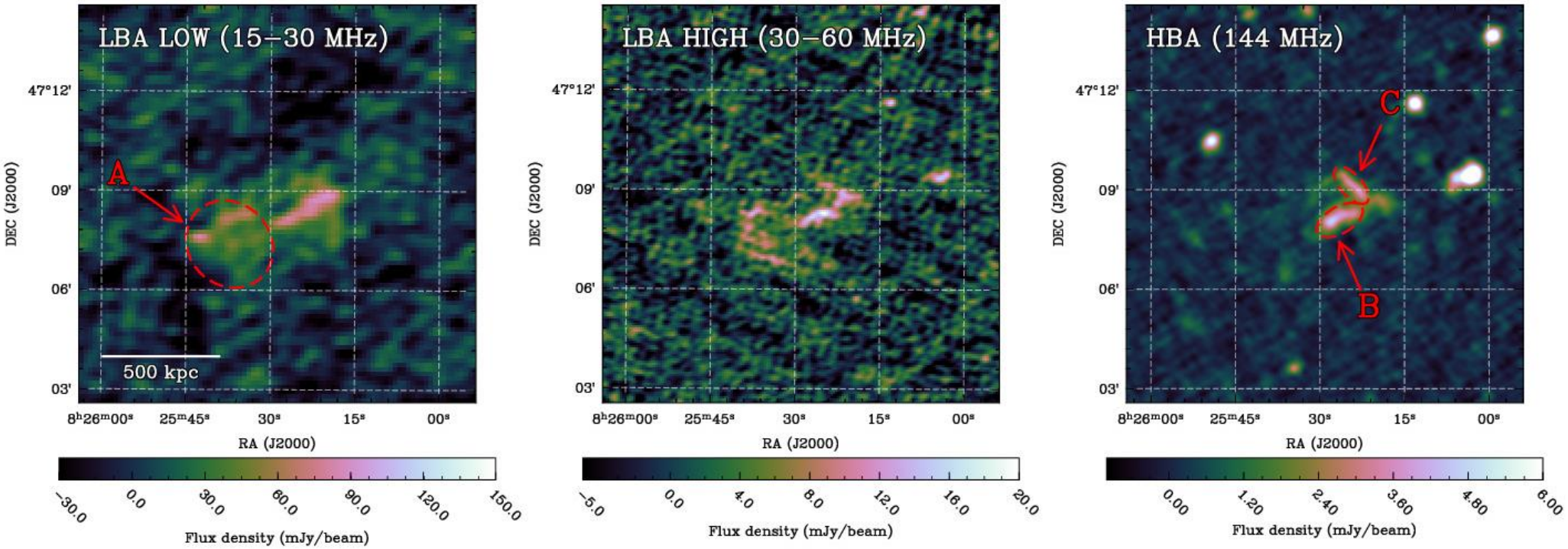
Integrated spectrum: $\alpha \sim -2.1$

Not a single component...

Large spectral coverage

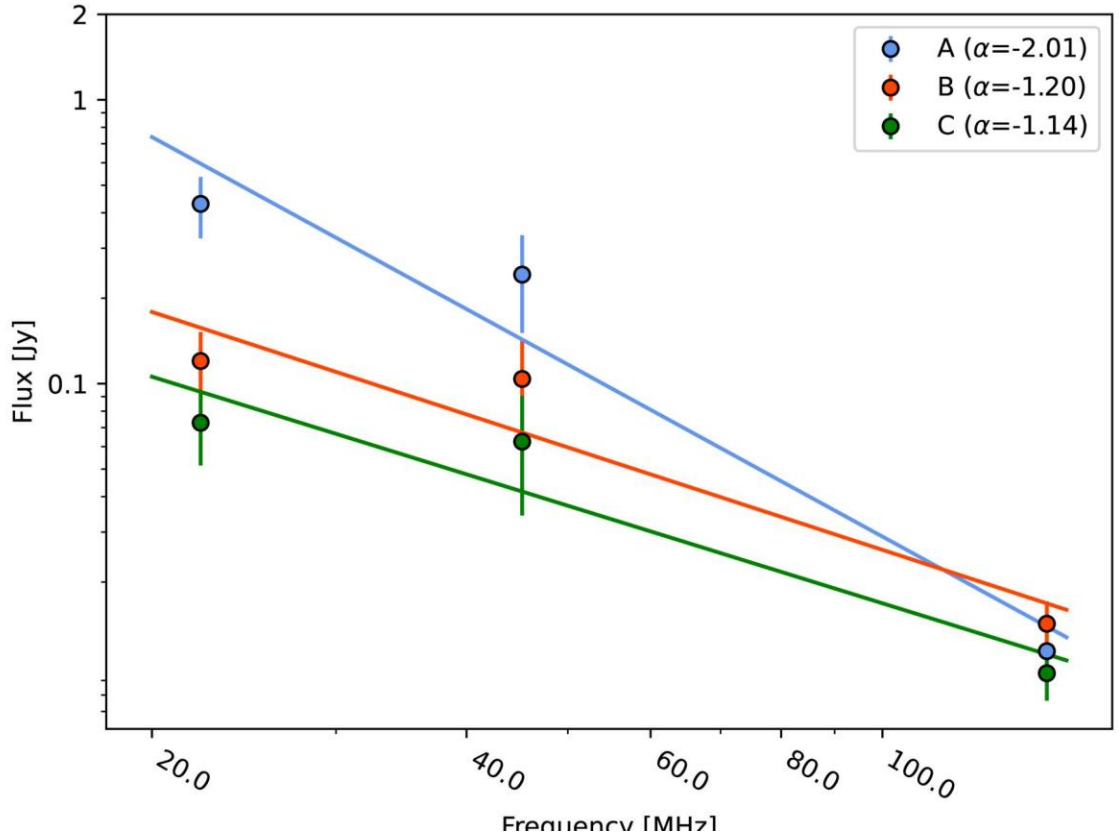


Galaxy clusters in the Decameter sky



Different component, and steep spectrum (A)
Connection to AGN emission (B+C)

Radio Phoenix (irregular shape)



Different component, and steep spectrum (A)
Connection to AGN emission (B+C)

Radio Phoenix (irregular shape)

Progress of LOFAR Decameter Sky Survey

- Full sky survey: five target beams + Calibrator beam
- Calibrators all done – allows for selection of 'easy' targets

- Ionosphere potentially severe...
- 2/362 pointings succesfully reduced
- Focus on interesting fields

Future potential

- LOFAR 2.0
- Stokes V
- Science:
  - Radio halos (galaxy clusters)
  - Peaked-spectrum sources
  - Re-energised fossil plasma
  - Exoplanets (Cristina Cordun)
  - Ionosphere
  - Other sources... (any suggestions?)

Conclusion

- LOFAR is capable of observing below 30 MHz
- Particular interest: Radio phoenices
- Survey under way