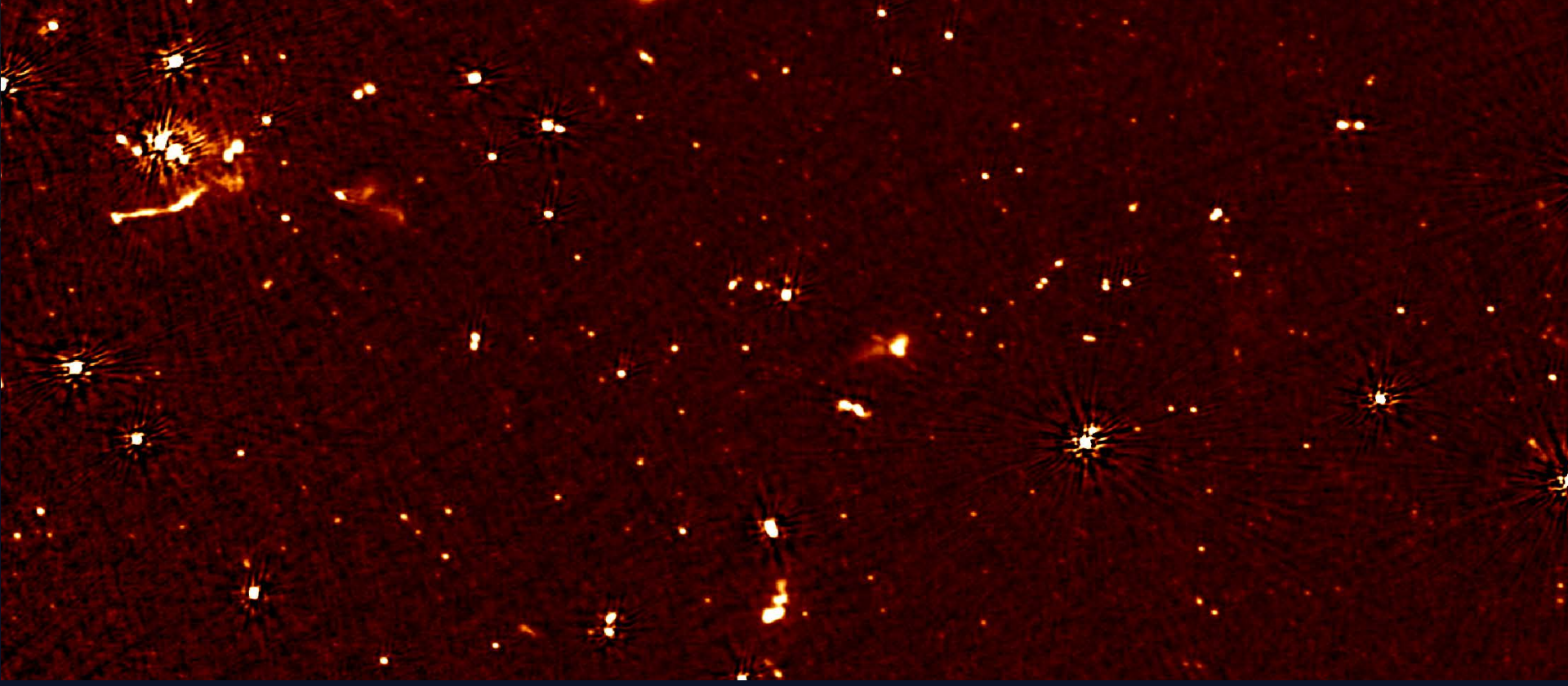

Deep low-frequency surveys with LOFAR:
150 MHz observations of the Lockman Hole Field

Elizabeth Mahony (University of Sydney/CAASTRO)

Raffaella Morganti (ASTRON), Isabella Prandoni (INAF-IRA) + LOFAR Surveys KSP

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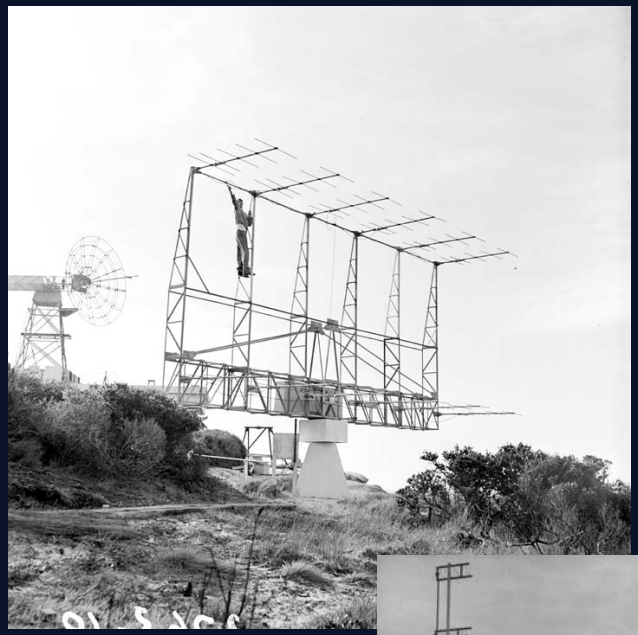
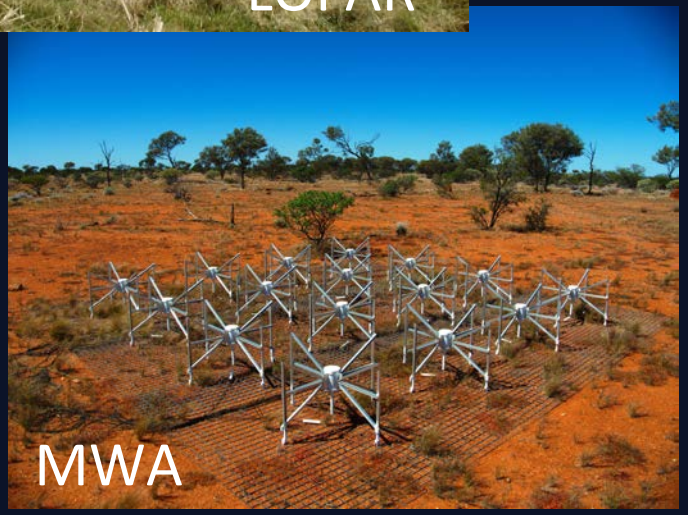
Radio telescopes, then and now…



Dover Heights

LOFAR

Mills cross



MWA

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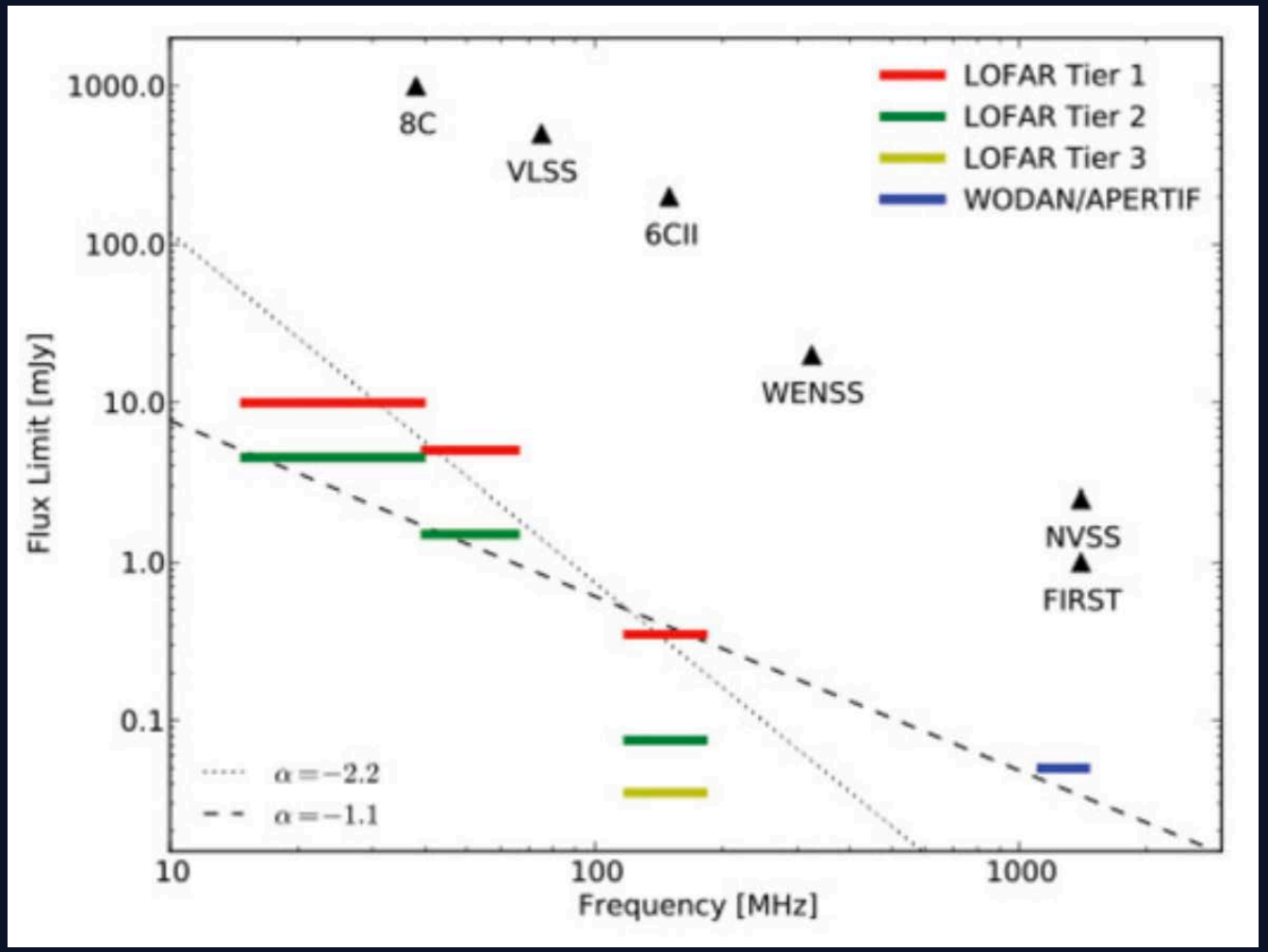
LOFAR surveys 101

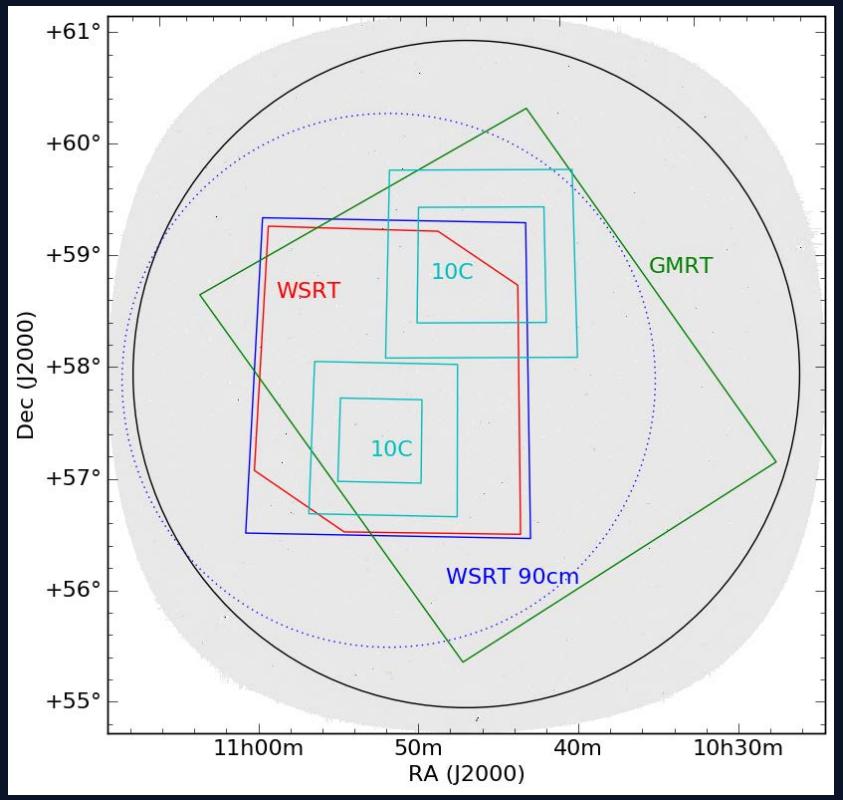


Williams et al., 2013

The Lockman Hole field

- Extensive multiwavelength data:
  - PanSTARRS, UKIDSS, SERVS, SWIRE, HerMES, VLA, GMRT, WSRT, Chandra, SCUBA, SCUBA-2, Galex

- Multiwavelength radio data covering a wide range in frequency:
  - WSRT: 1.4 GHz, 7 deg^2, 11 uJy
  - WSRT: 350 MHz, 0.7 mJy
  - GMRT: 610 MHz, 13 deg^2, 60 uJy
  - 10C: 15 GHz, 4.5 deg^2, 0.1 mJy
  - LOFAR LBA: 60 MHz, 30 deg^2, 24 mJy



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HBA observations (110-180 MHz)

Central freq: 150 MHz

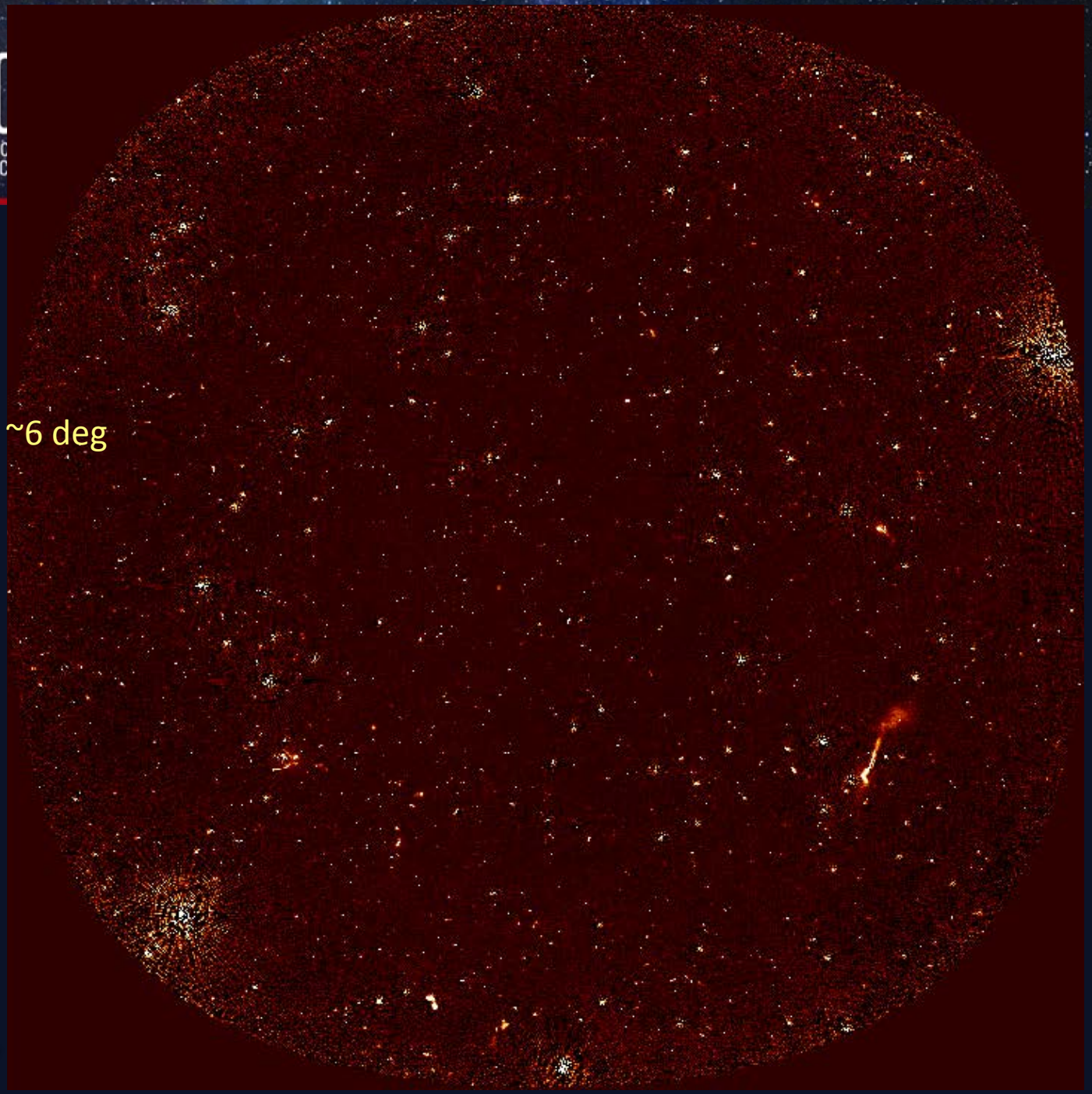
300 subbands (70 MHz bandwidth)

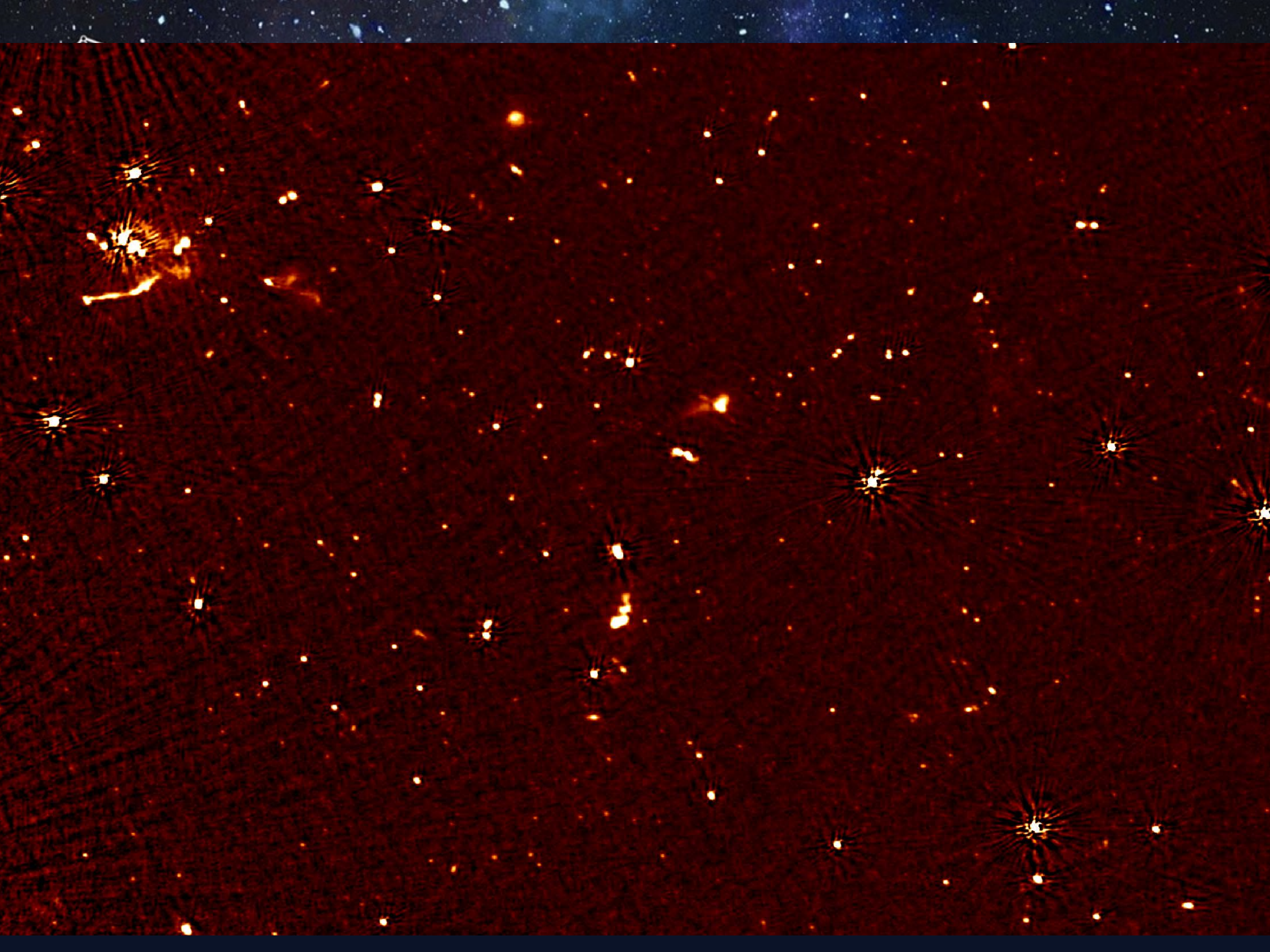
10 hrs int. time

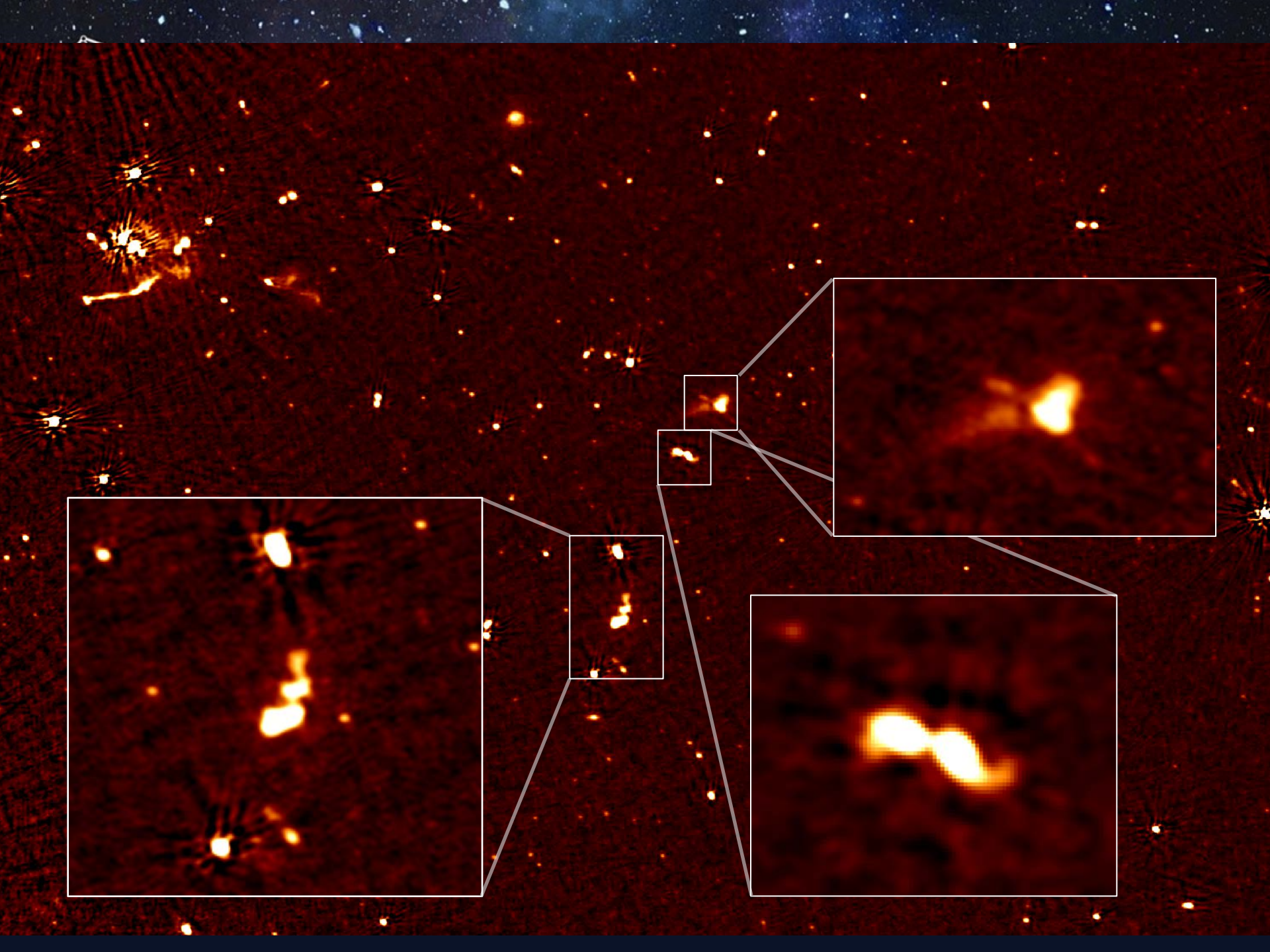
14x18” resolution

rms ~0.16 mJy/bm

~ 5000 sources detected







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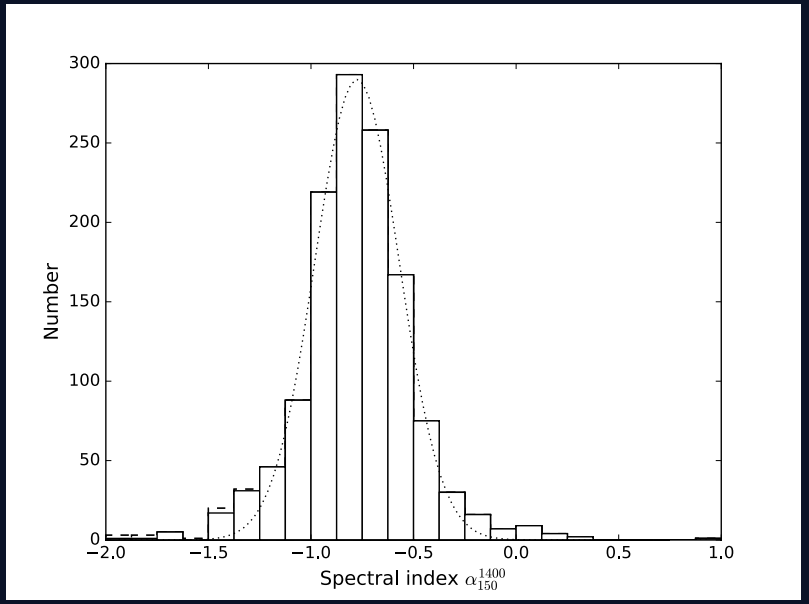
Spectral indices of low-freq. sources

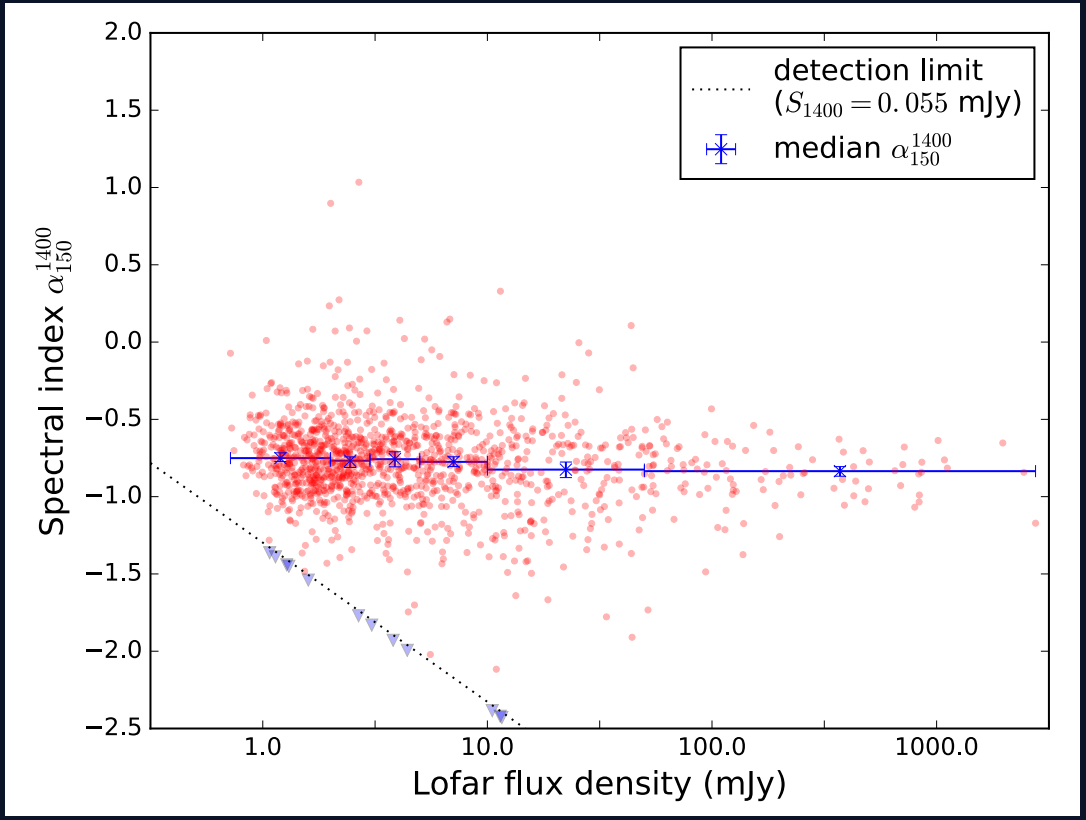
- Crossmatched with deep 1.4 GHz WSRT mosaic
  - 1289 matches
  - Virtually all LOFAR sources have a 1.4 GHz counterpart
  - Median spectral index: α = -0.78



1. Do the average spectral indices change with flux density?
2. Do we see any spectral curvature across such a wide frequency range?
3. Do we learn anything about the Radio-AGN life cycle?
   i.e. can we find large numbers of the youngest and oldest radio sources

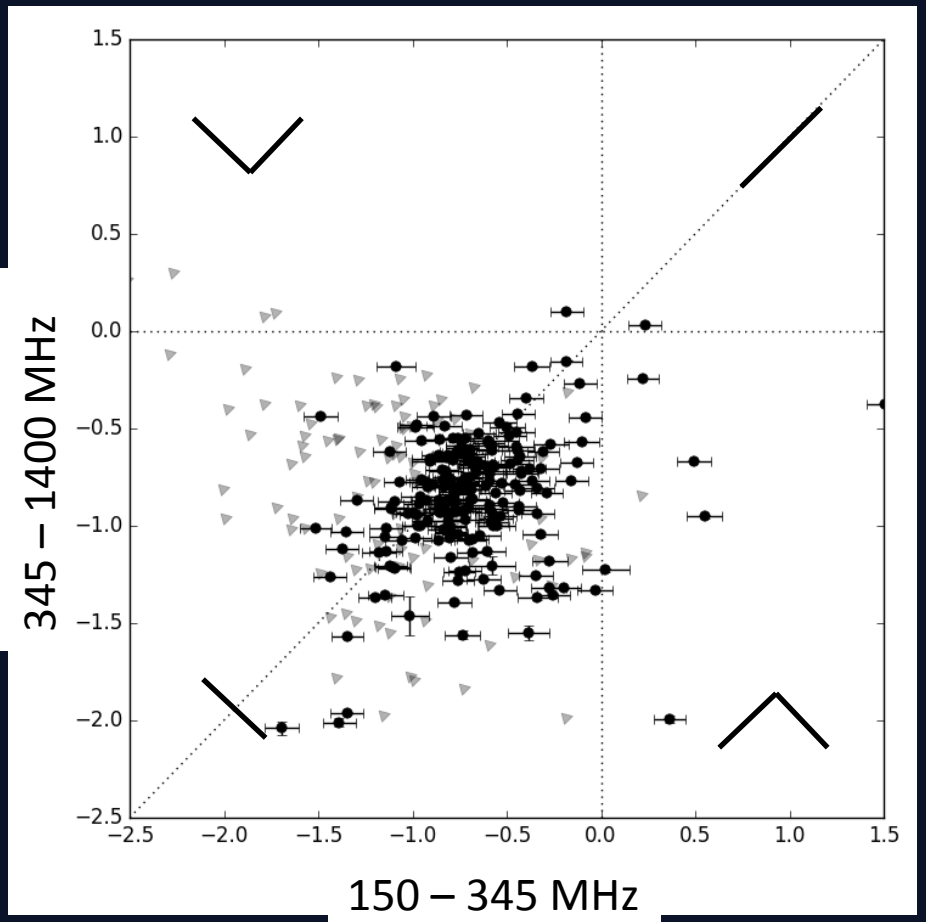
Do the spectral indices change with flux density?

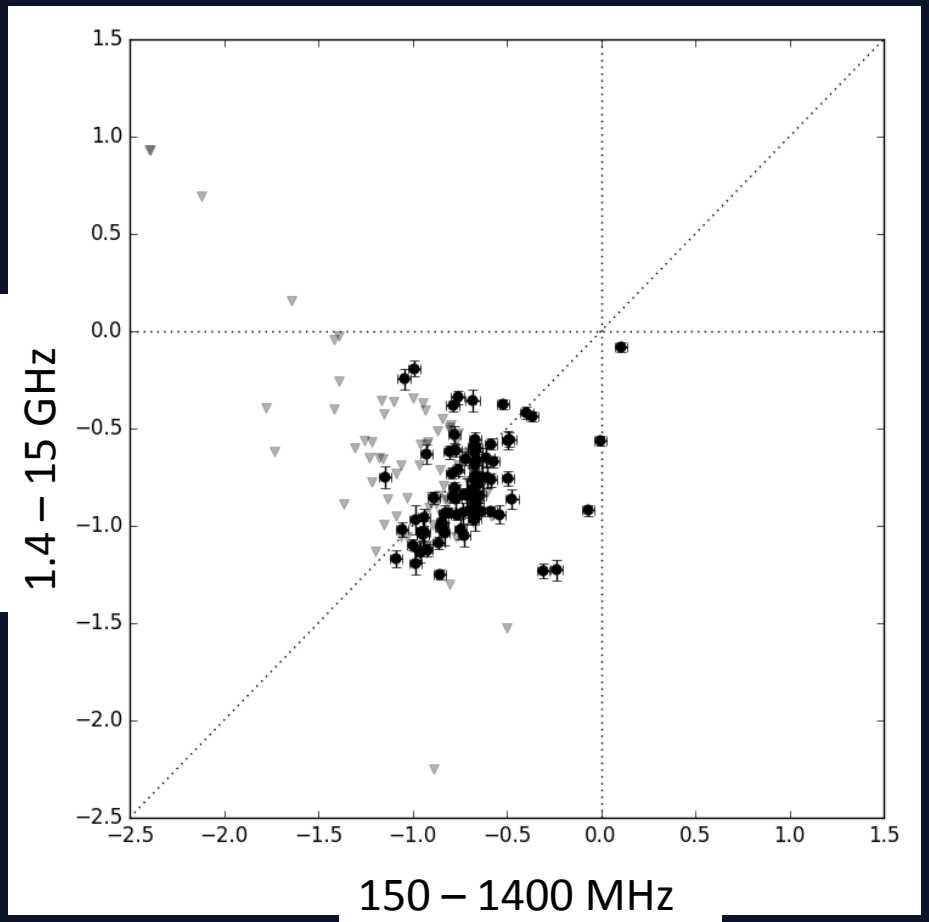
- Previous studies have found a flattening of the spectral indices towards fainter flux density limits (Prandoni+ 2006, Intema+ 2011, Randall+ 2012, Whittam+ 2013, Williams+ 2013)
- Evidence for flattening down to ~5-10 mJy, but median spectral index stays approximately constant below this flux density.



Do we see any spectral curvature?

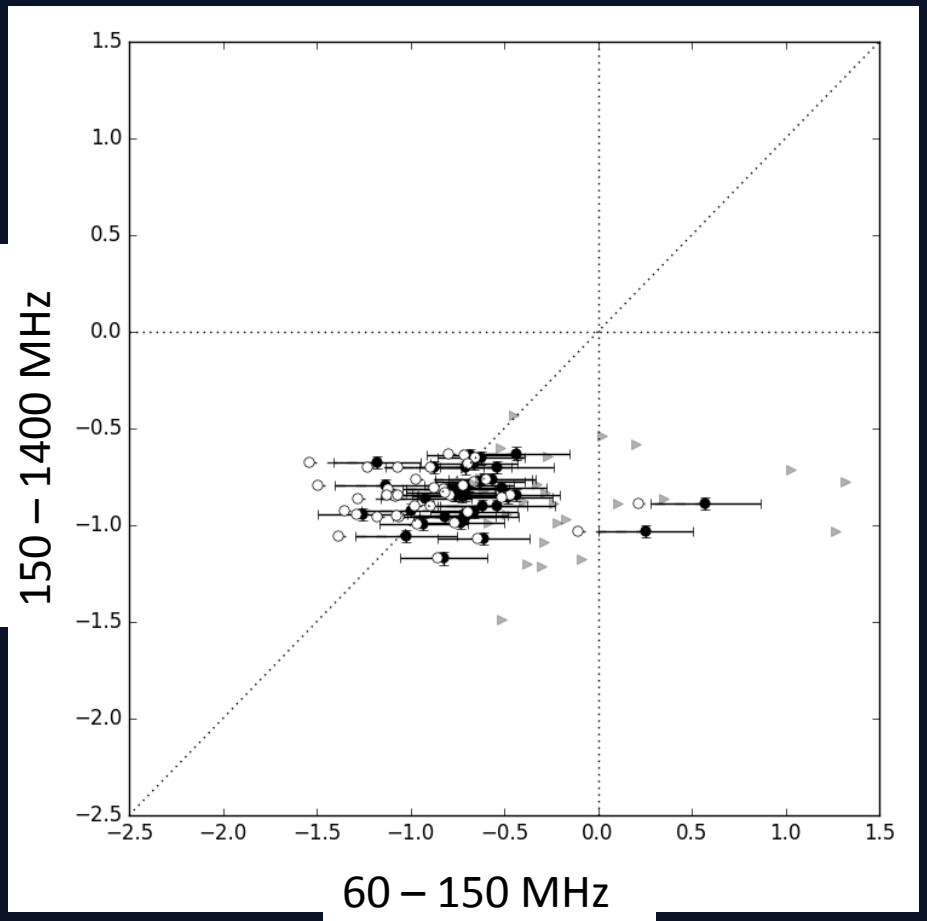
- Use radio colour-colour plots to investigate any change in the spectral indices as a function of frequency

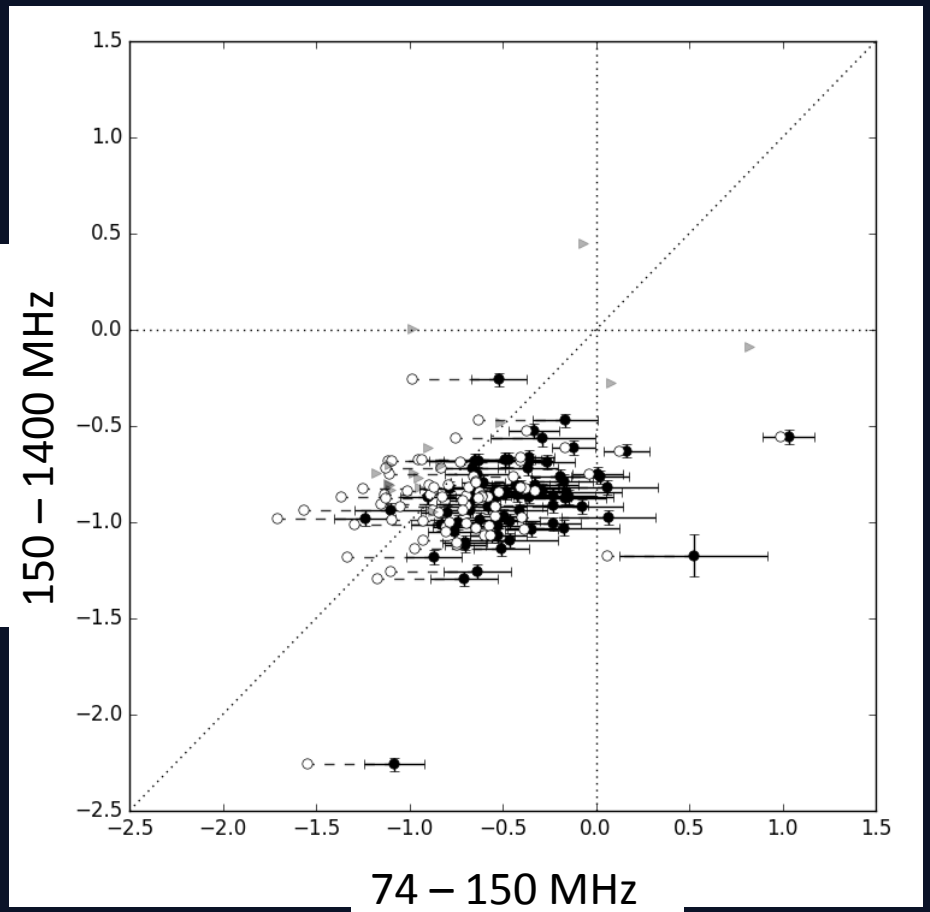




Spectral indices of low-freq. sources

- Tentative evidence for spectral flattening below 150 MHz?





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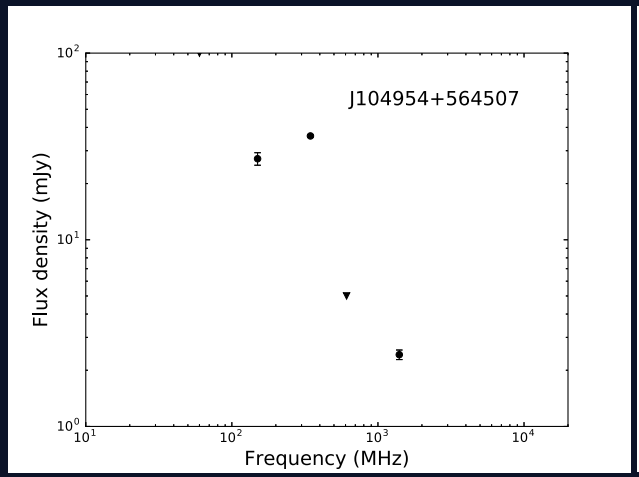
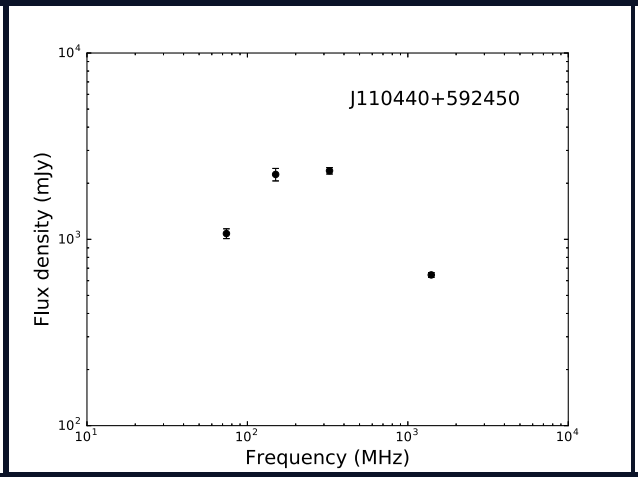
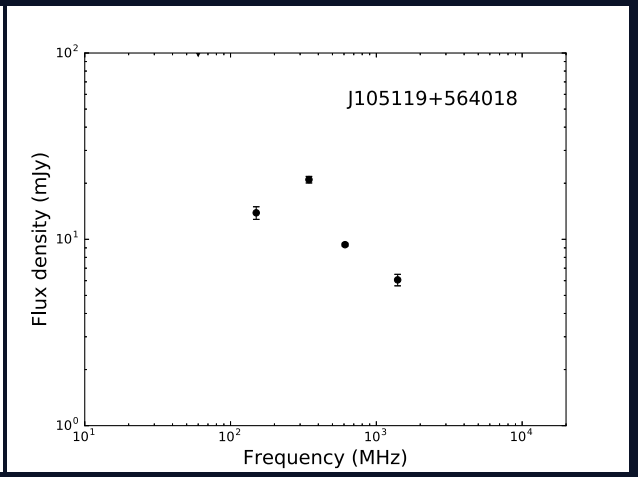
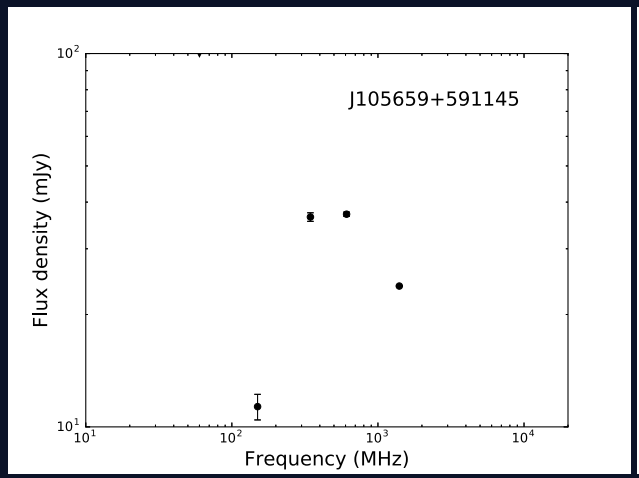
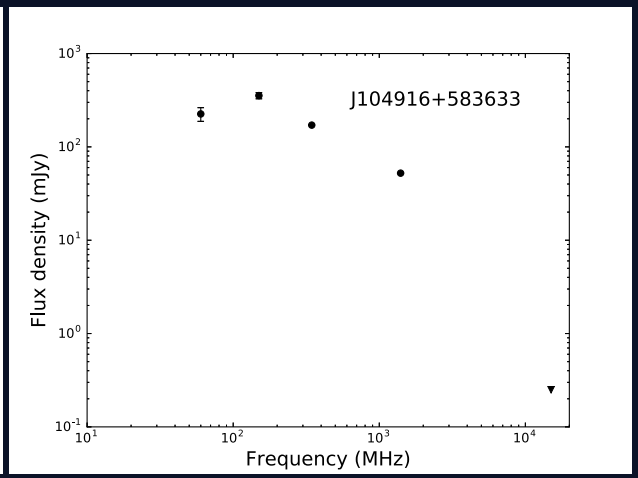
Peaked spectrum sources in the Lockman Hole field

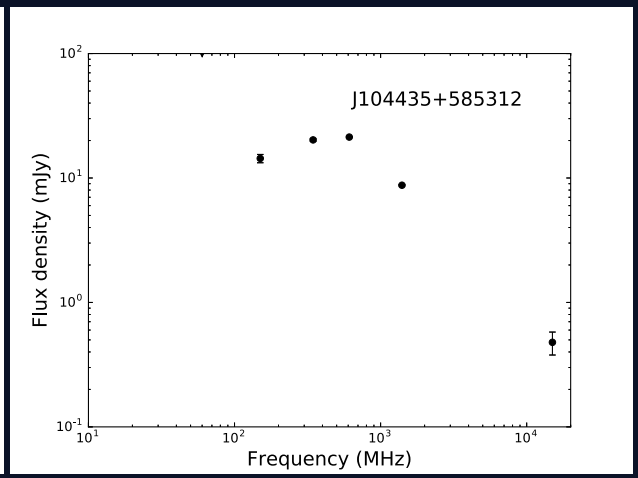












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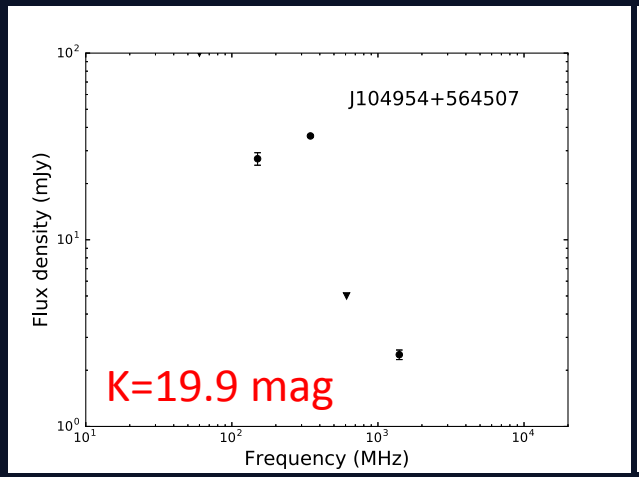
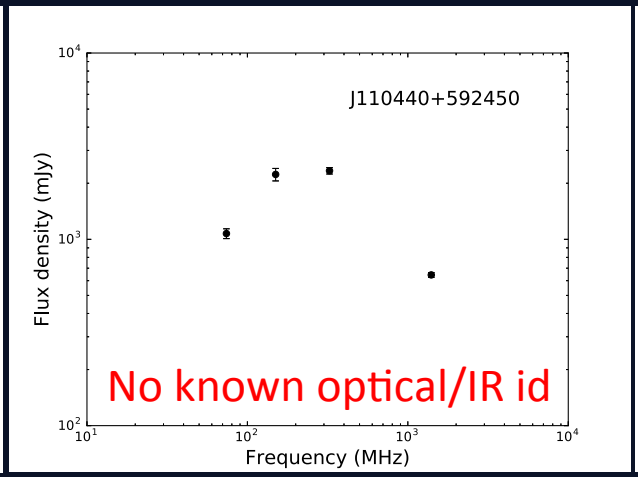
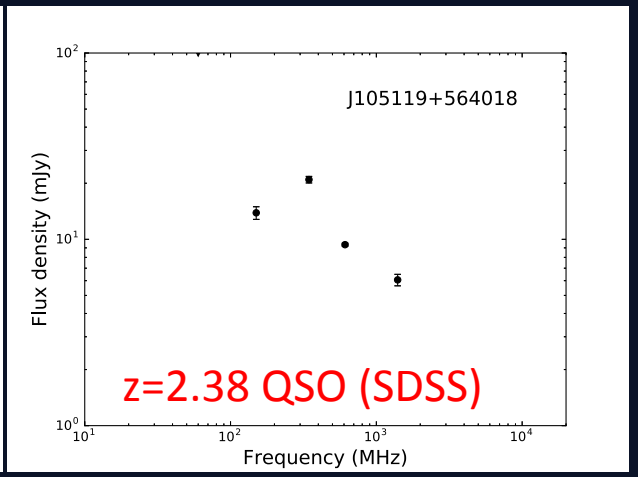
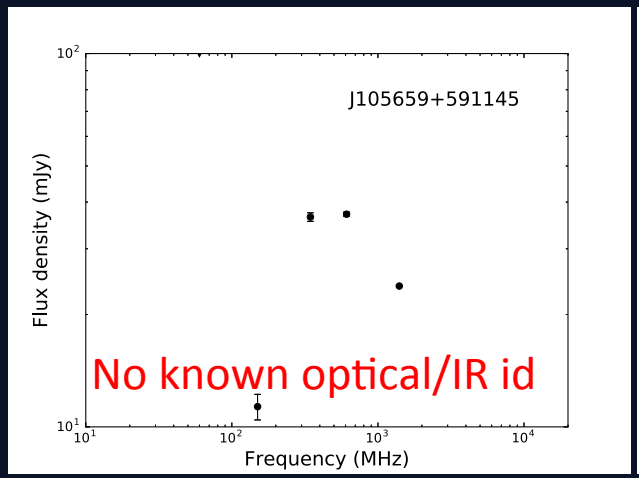
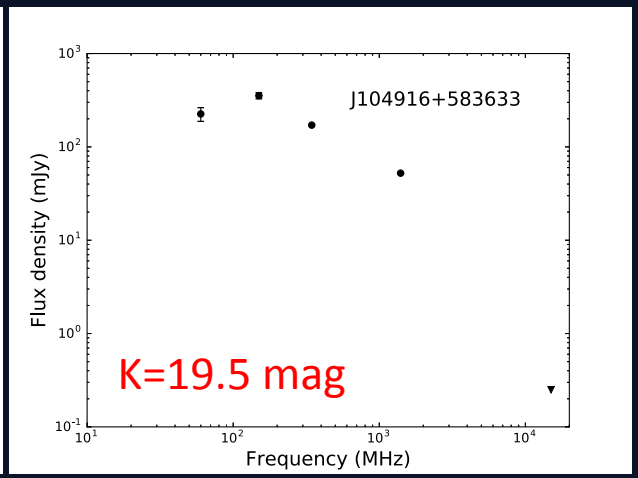
Peaked spectrum sources in the Lockman Hole field

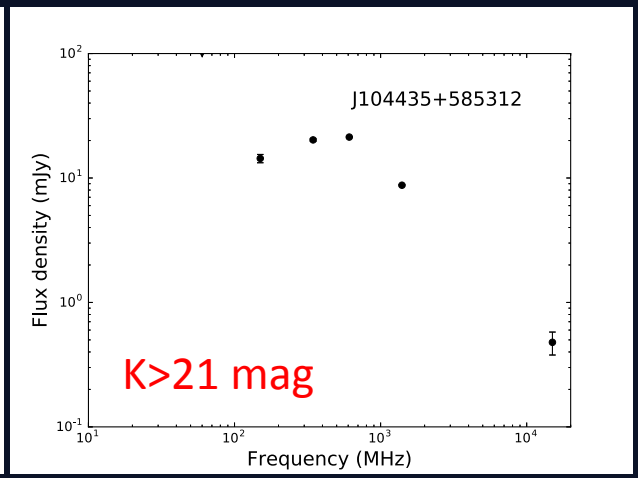




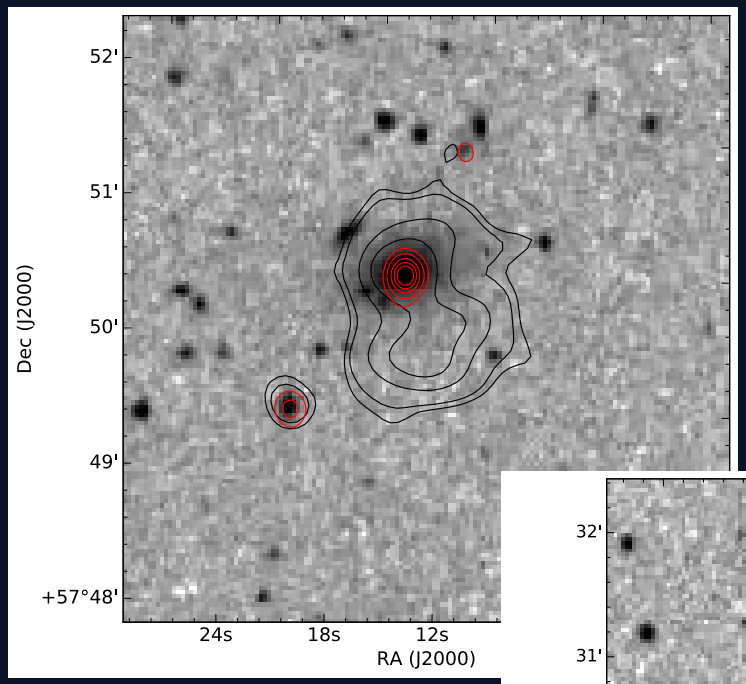




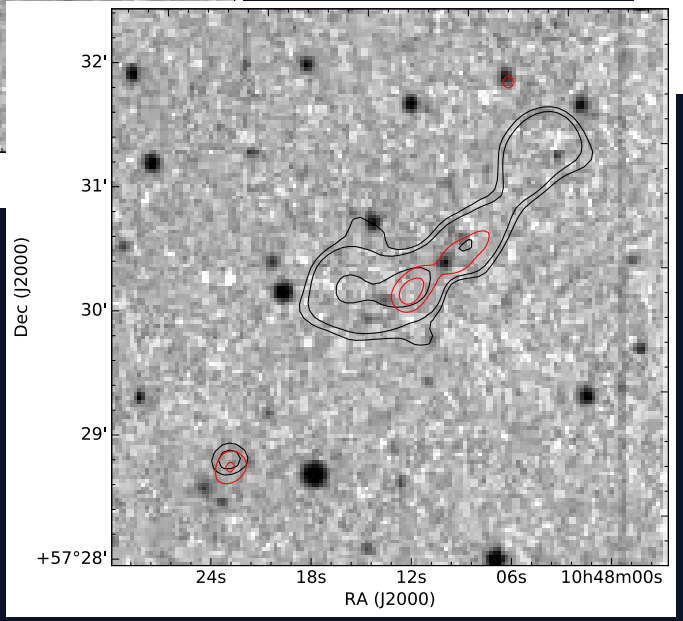


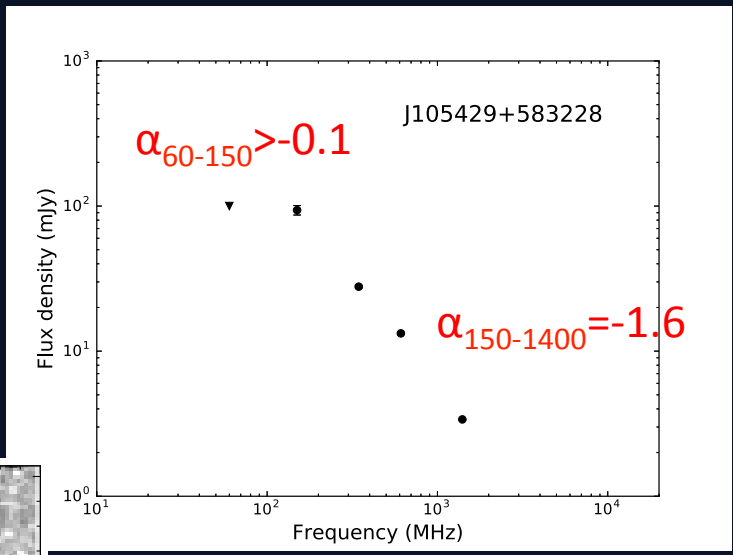


Ultra-steep spectrum sources in the LH



Red contours: WSRT 1.4 GHz
Black contours: LOFAR 150 MHz





Peaked spectrum source with very sharp turnover – similar to B0008-421?

Low frequency source counts

MSH survey (85 MHz; Mills, Slee & Hill 1958)

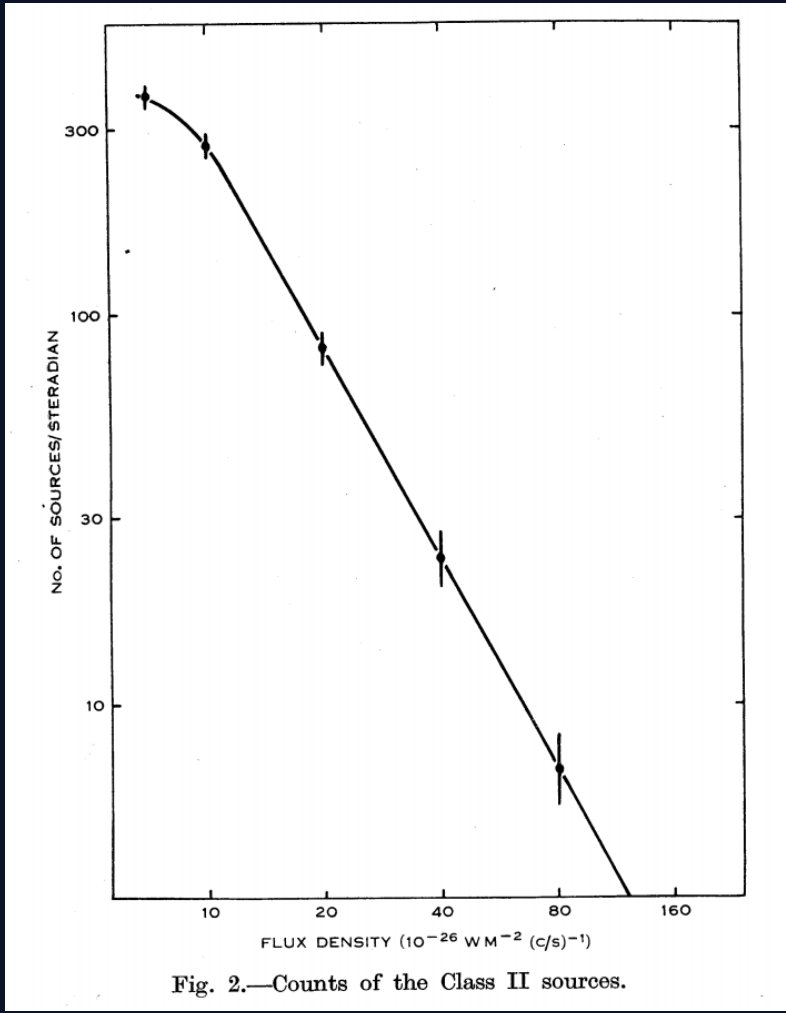
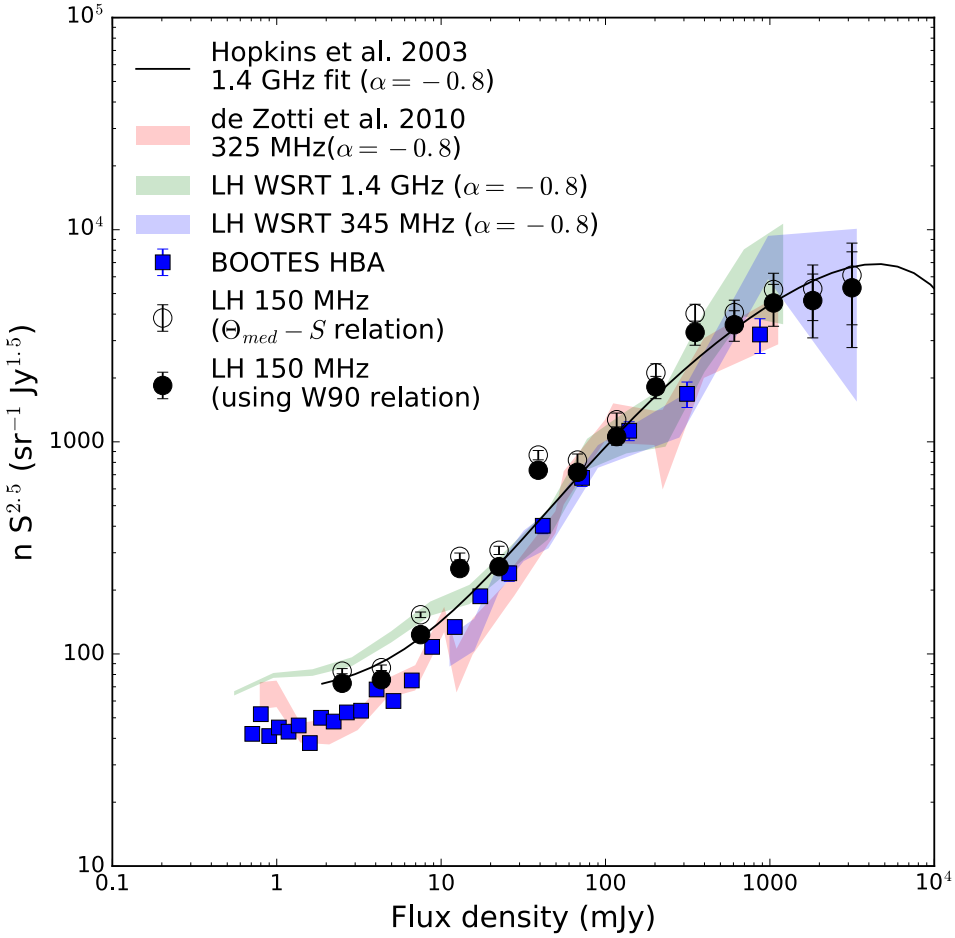


Fig. 2.—Counts of the Class II sources.

LOFAR 150 MHz observations



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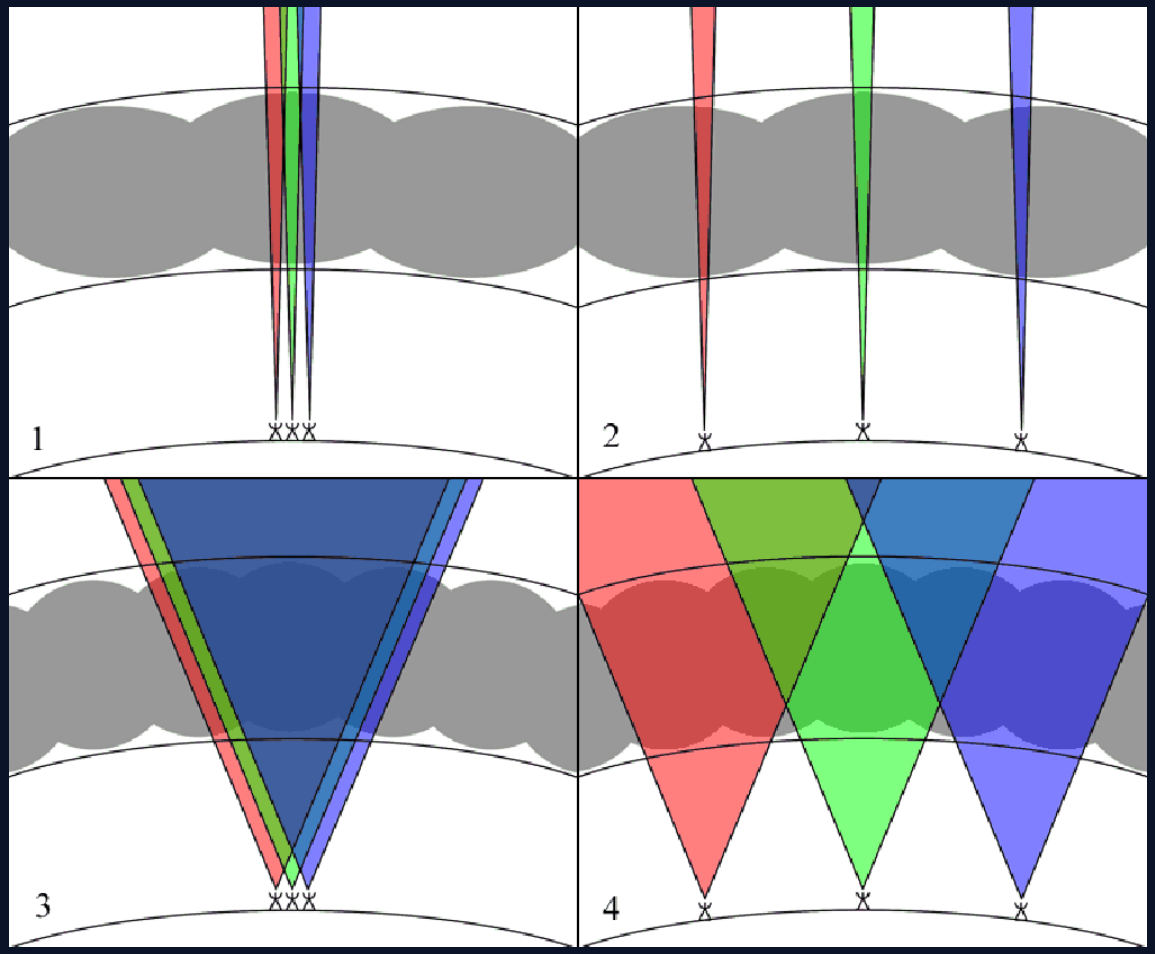
Going deeper and to higher resolution



Aim of the LOFAR surveys is to get to 100 uJy noise at 5 arcsec resolution

BUT, calibrating ionospheric effects is hard!

Intema et al., 2009

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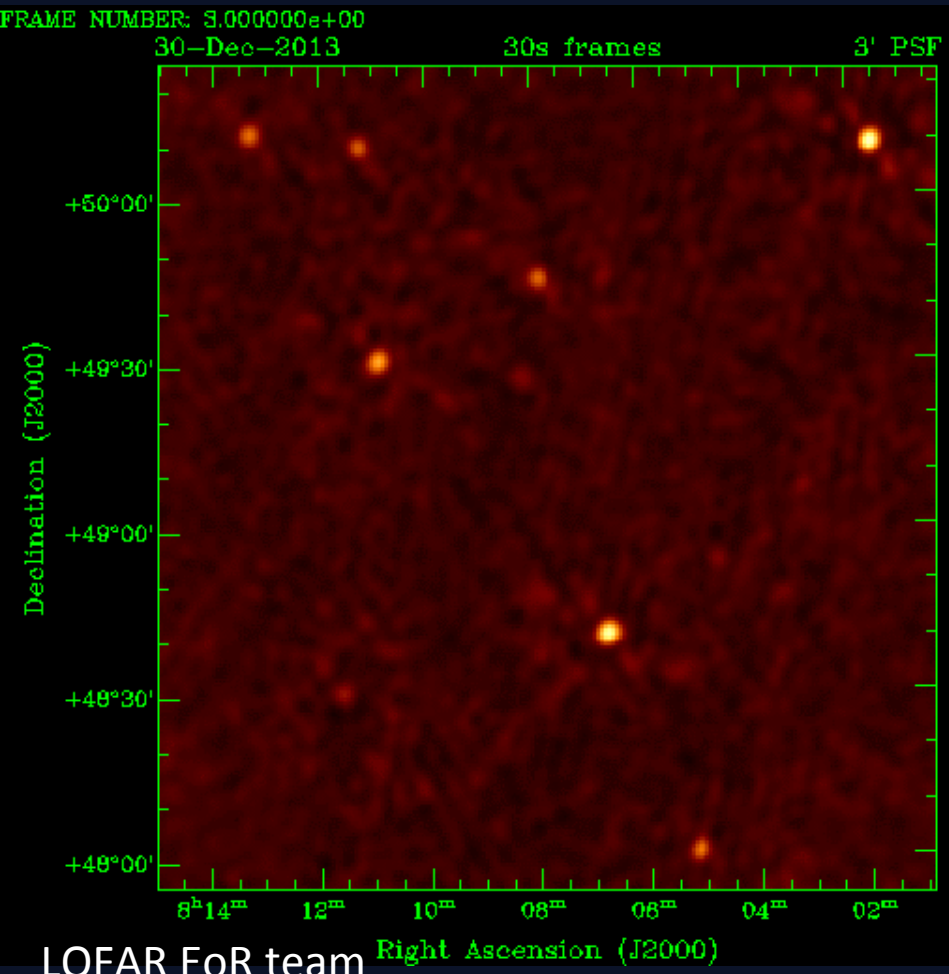
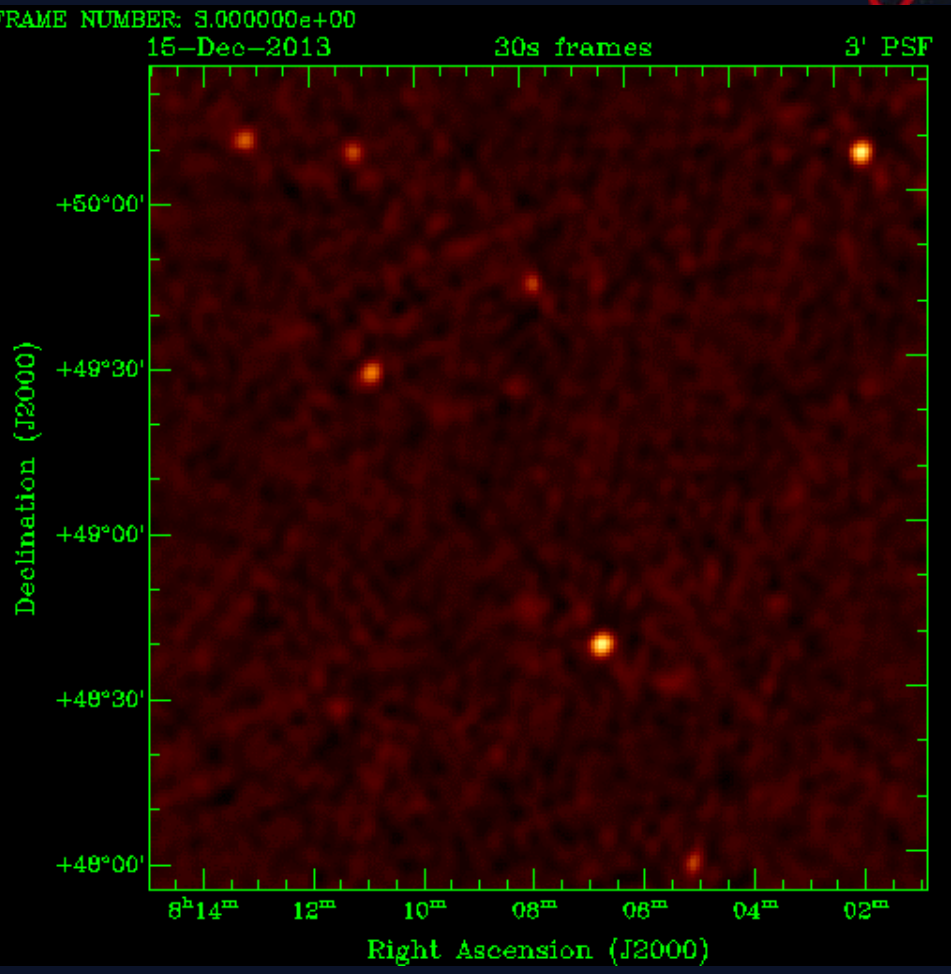
LOFAR enemy no. 1: The Ionosphere





LOFAR EoR team

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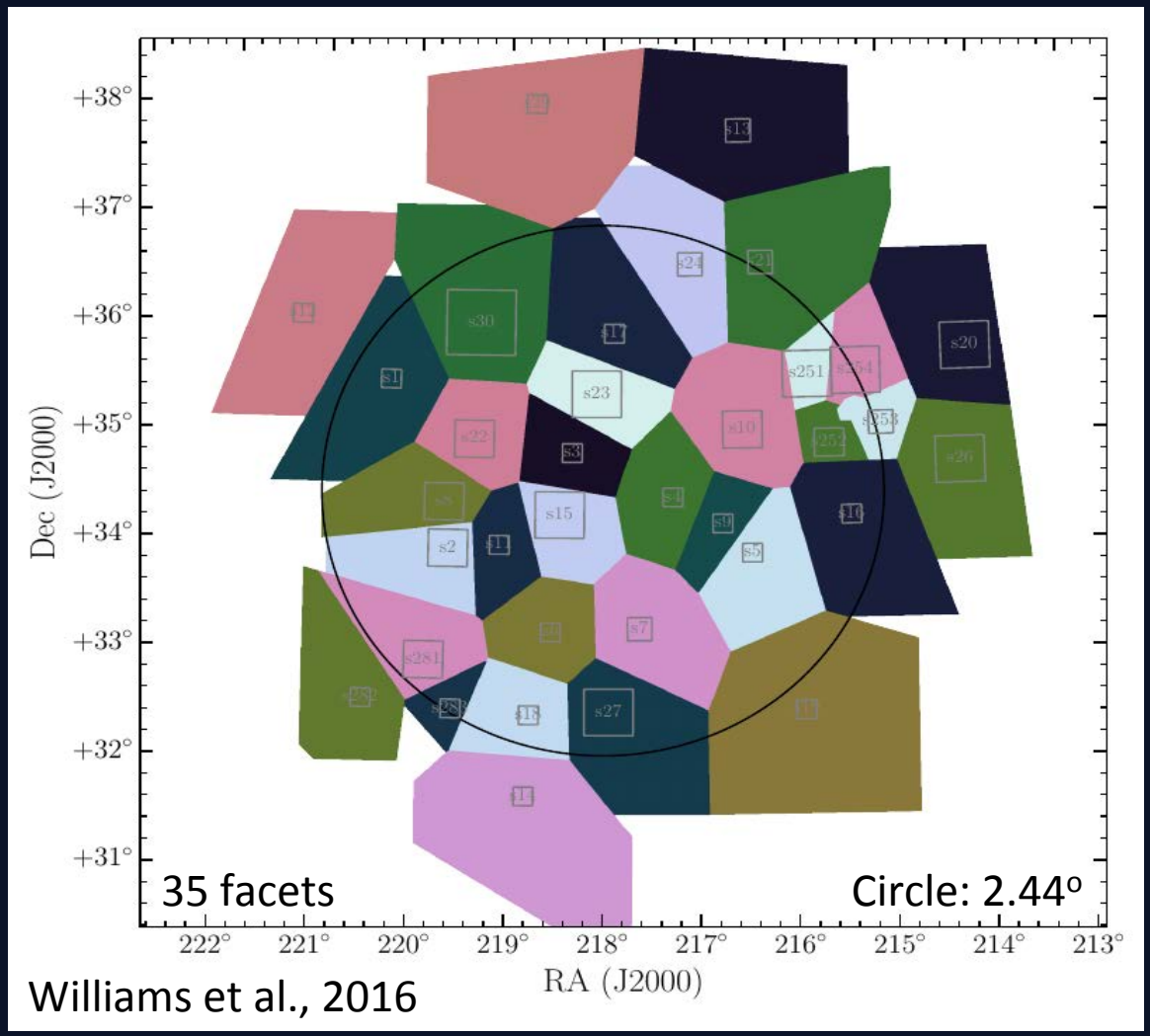
Direction-dependent calibration of LOFAR data

Need to apply different phase calibration to different areas of the field

Do this using the 'Facet-calibration' technique (van Weeran et al. 2016, Williams et al. 2016)

Following images show the technique carried out on the Boötes field (Wendy Williams, Leiden Univ.)



Williams et al., 2016

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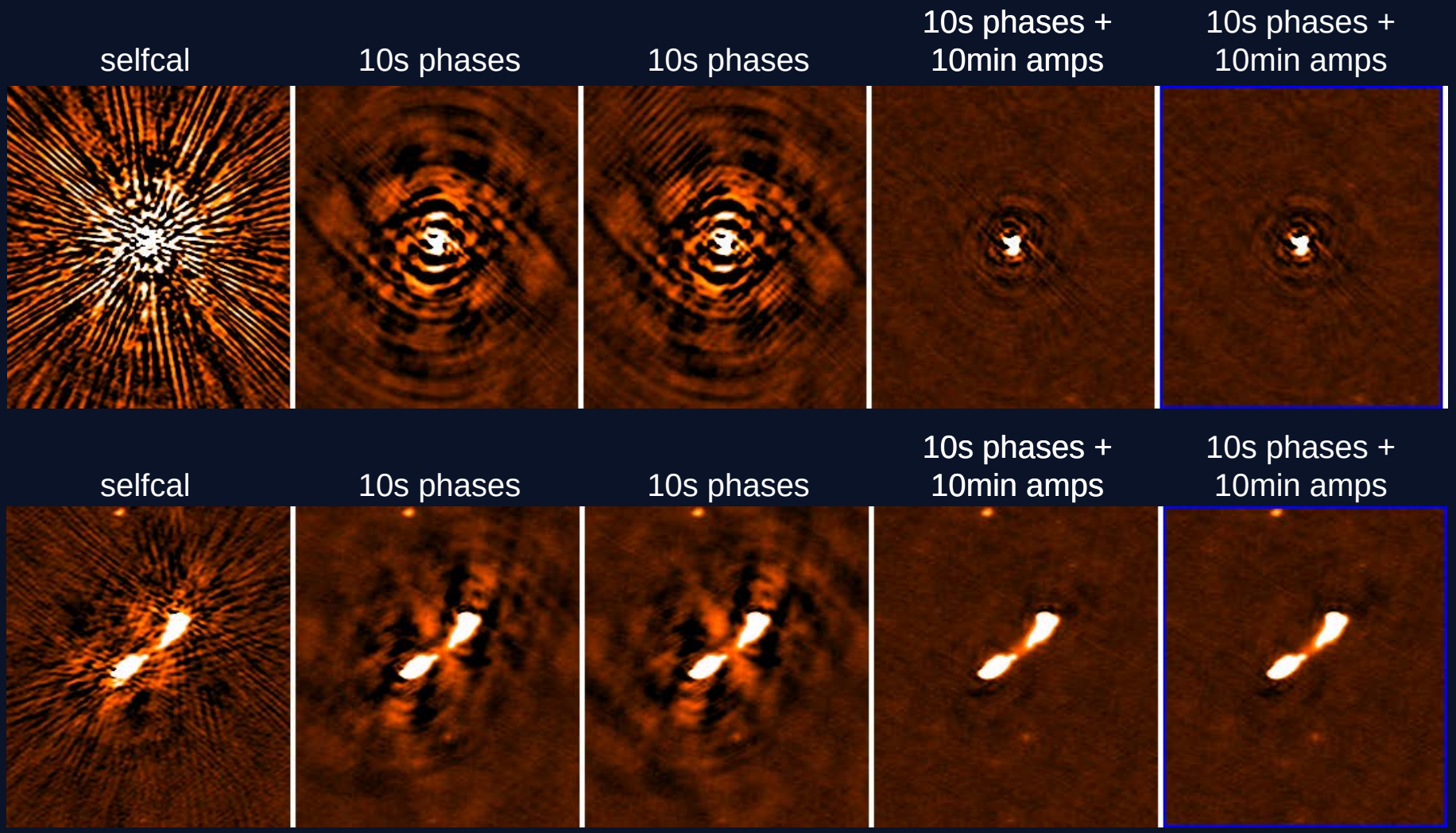
Direction-dependent calibration of LOFAR data



Williams et al., 2016

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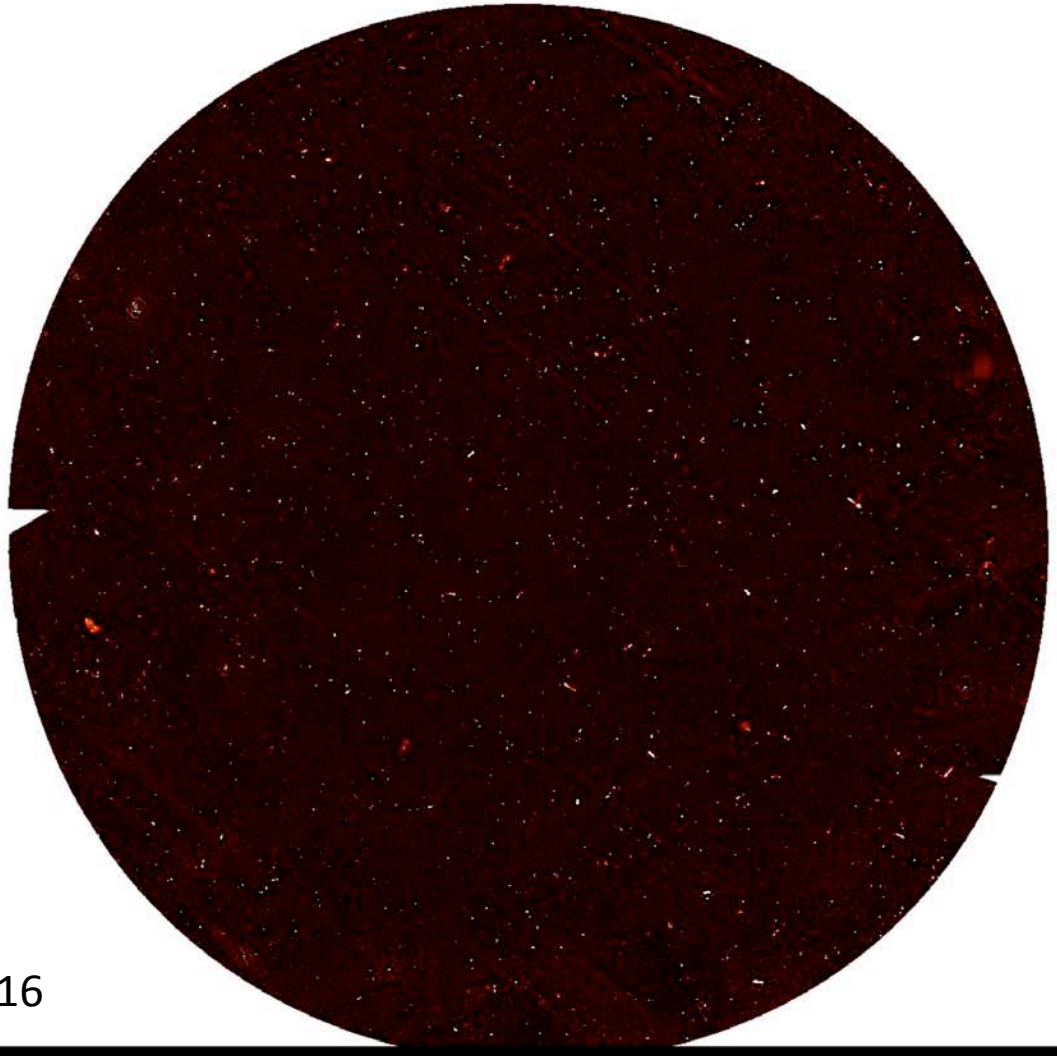
Direction-dependent calibration of LOFAR data



5x7” resolution
120 uJy noise

Williams et al., 2016

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