

# The Lockman Hole Project

## An Update

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# LH: Multi-frequency Coverage

WSRT 1.4 GHz: 6 deg<sup>2</sup>, 11  $\mu$ Jy  
9x11 arcsec res.

WSRT: 345 MHz, 0.7 mJy

GMRT: 610 MHz, 13 deg<sup>2</sup>, 60  $\mu$ Jy

10C: 15 GHz, 4.5 deg<sup>2</sup>, 0.1 mJy

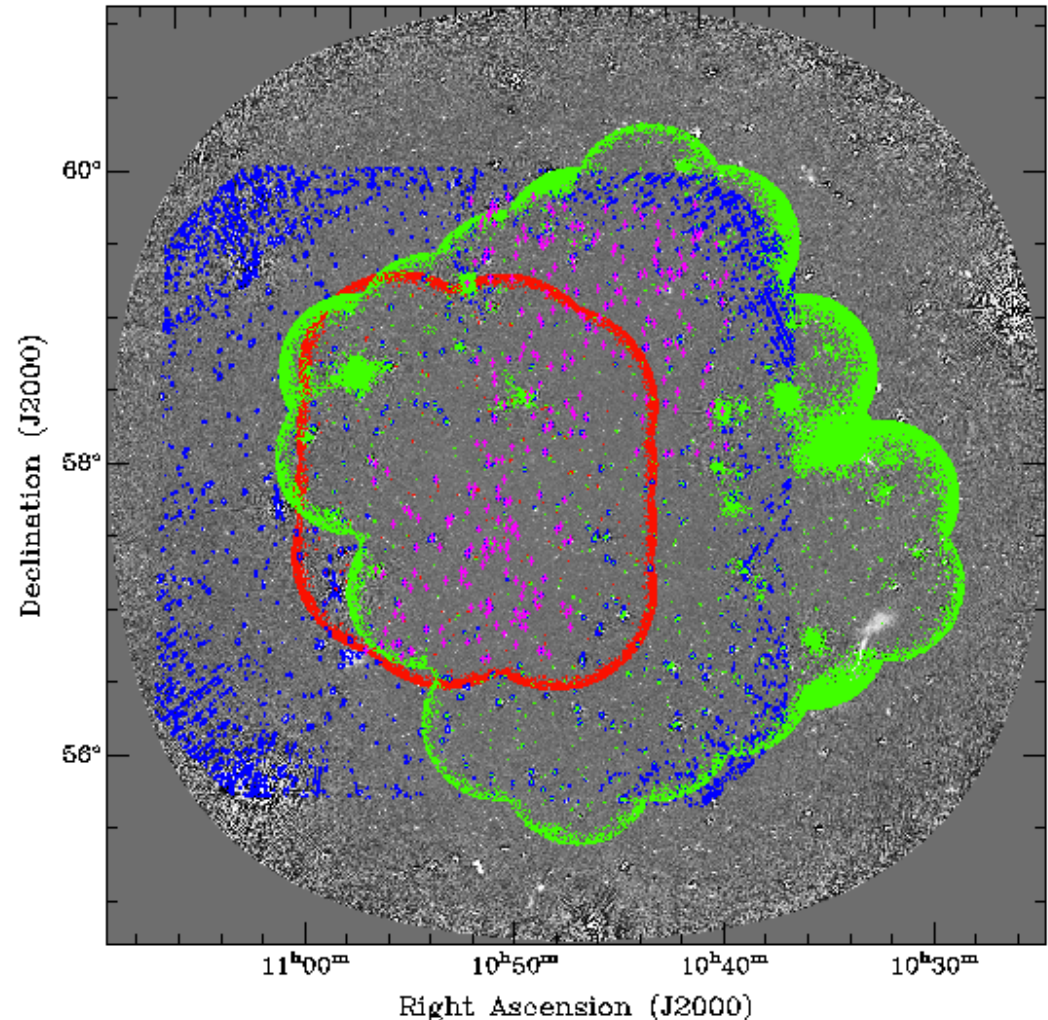
LOFAR 150 MHz (Tier 2)

LOFAR 60 MHz

(Survey KP, PI P. Best)

## Extensive multi-band data:

*PanSTARRS, UKIDSS, SERVS, SWIRE,  
HerMES, VLA, GMRT, WSRT,  
Chandra, SCUBA, SCUBA-2, Galex*



## HBA observations (110-180 MHz)

104 hours so far

- Cycle 0: 10 hours
- 300 sub-bands (58.5 MHz bandwidth)
- direction independent calibration
- 14x18" resolution

- Stacking of 10 MHz images

$$\Delta\nu = 24 \text{ kHz}$$

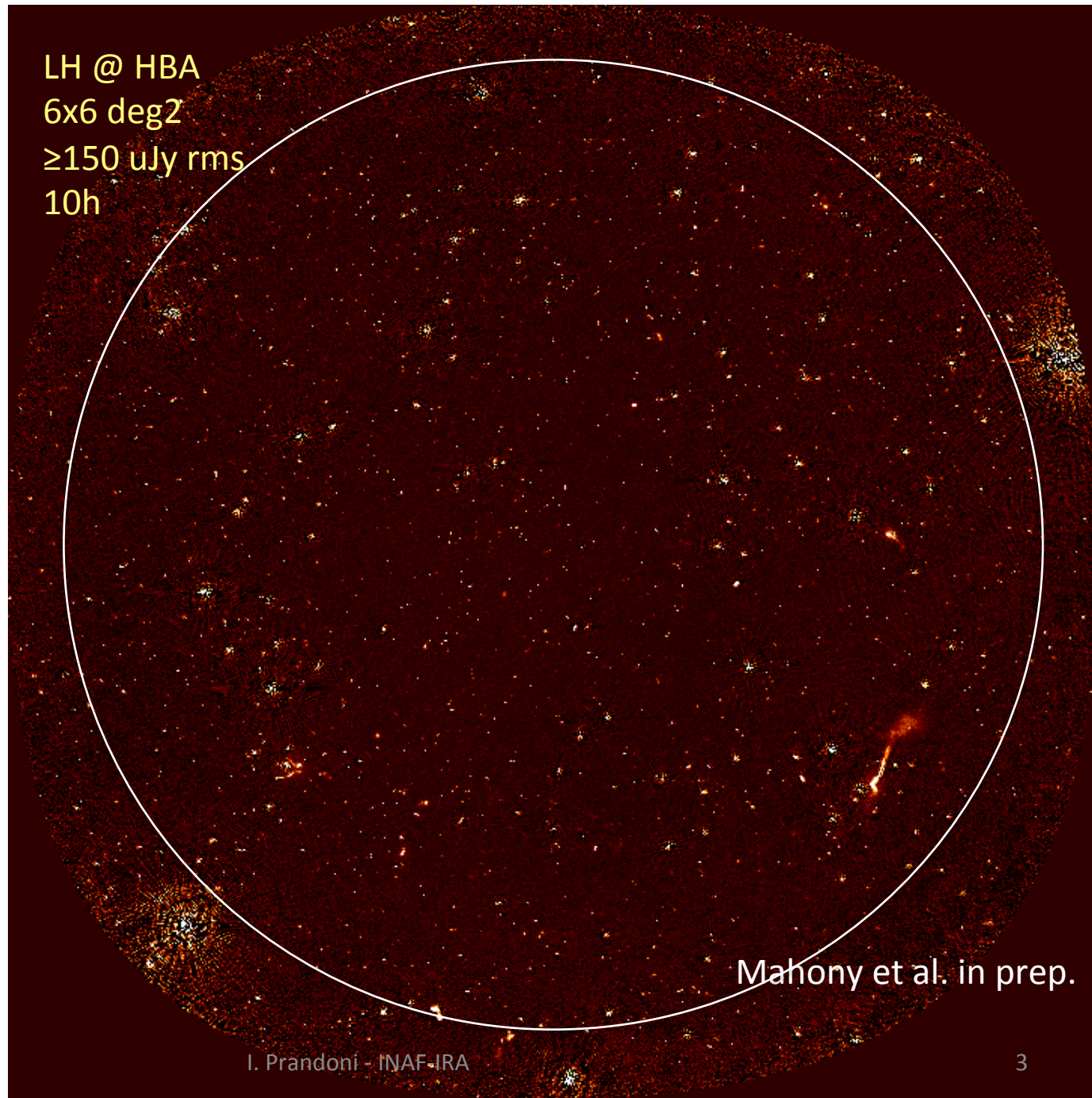
$$\tau_{\text{av}} = 10 \text{ sec}$$

→ smearing < 0.93

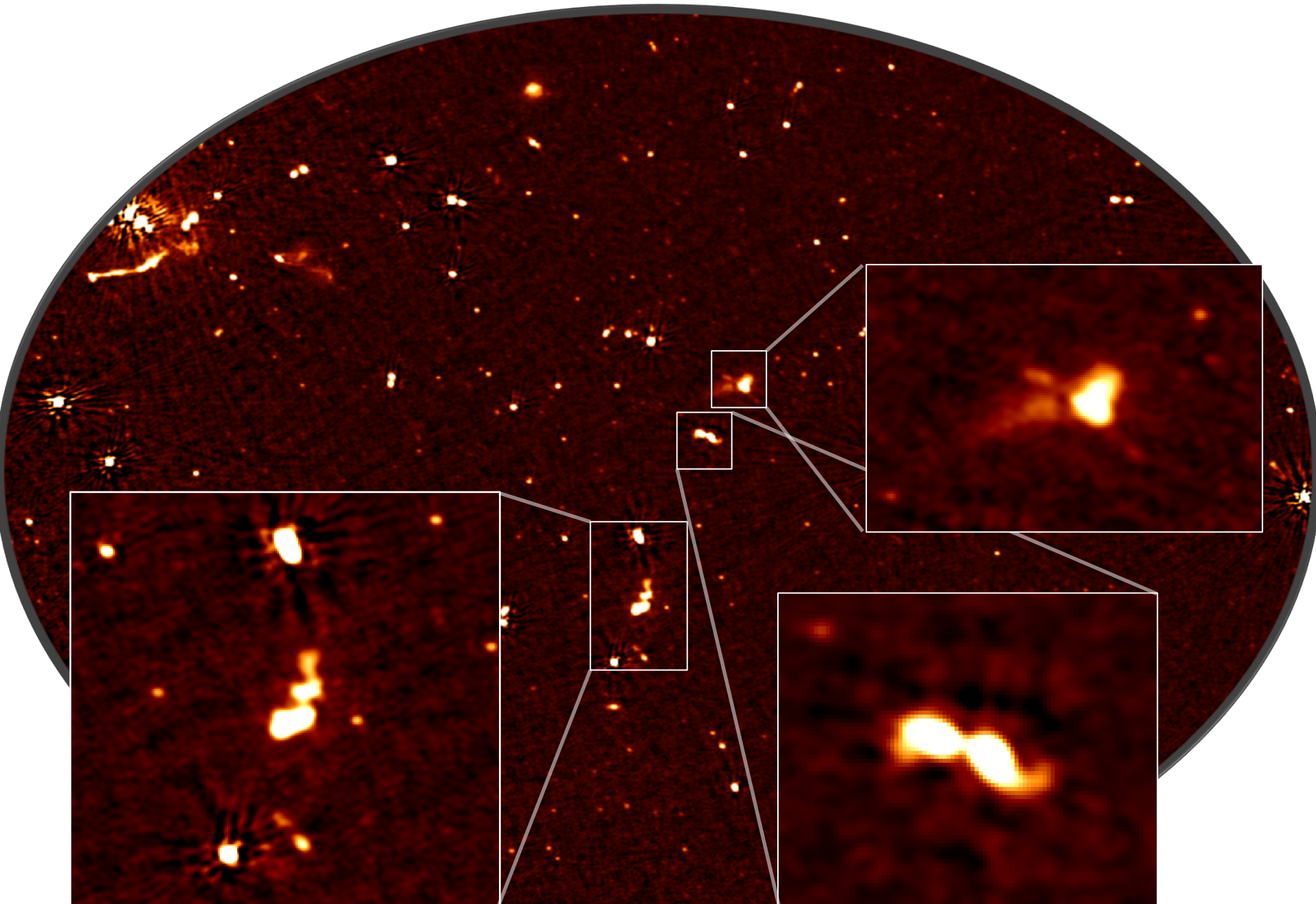
→ rms  $\geq 0.15$  mJy

~5300 sources up to 3  
degrees from phase  
center

LH @ HBA  
6x6 deg<sup>2</sup>  
 $\geq 150$   $\mu$ Jy rms  
10h

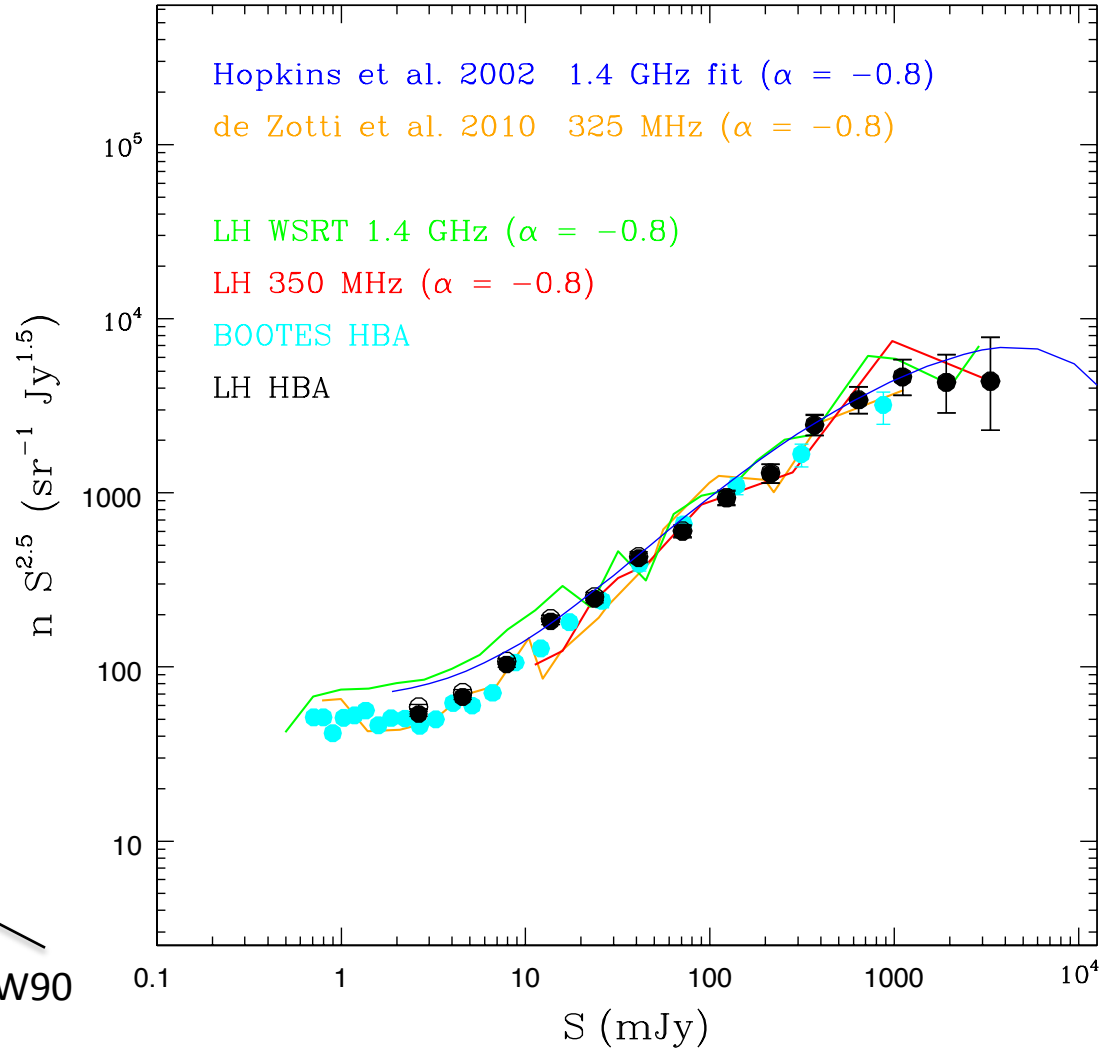
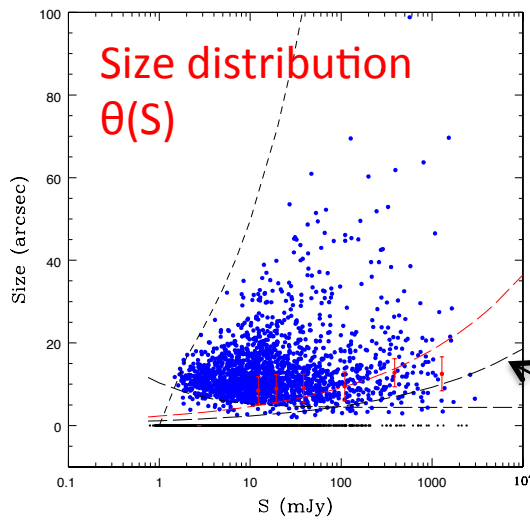
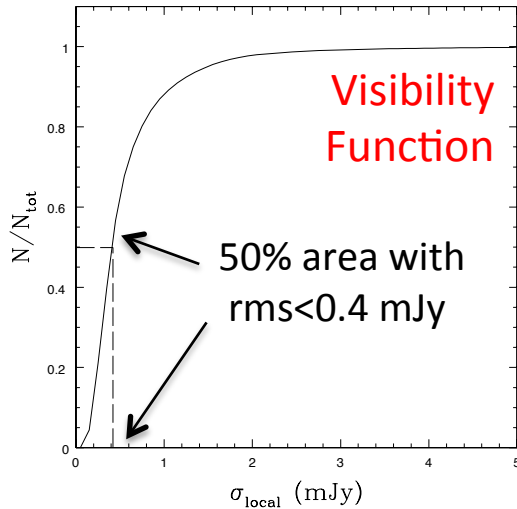








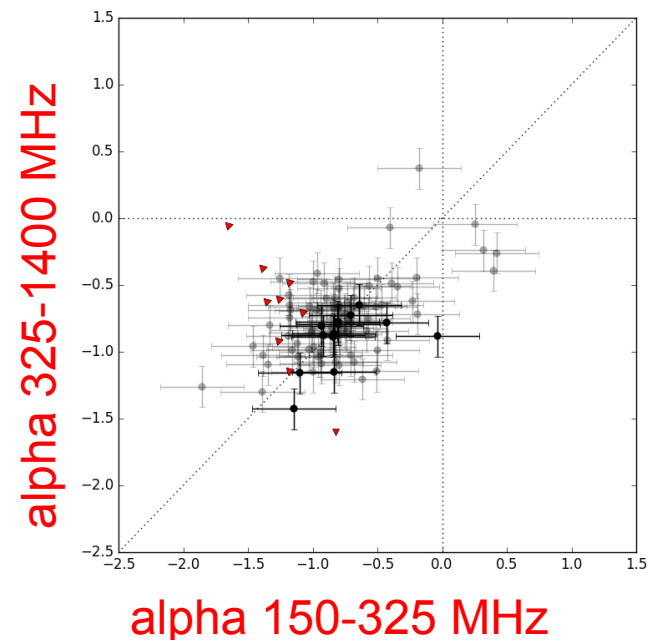
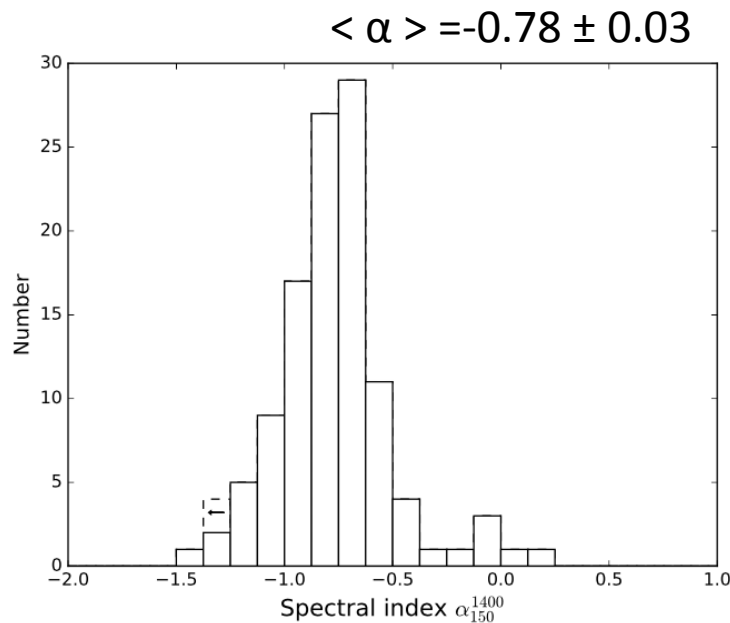
# Lockman Hole: Source counts at 150 MHz



# Spectral index Analysis – LH WIDE

**WENSS, NVSS:  $S(150 \text{ MHz}) > 40 \text{ mJy}$ : 104 point sources**

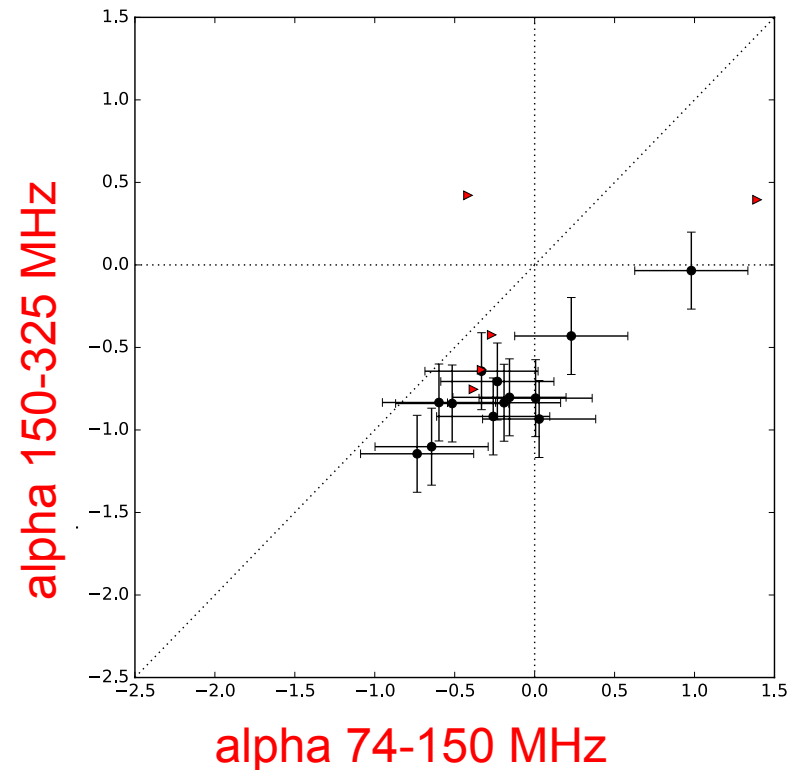
- 94 sources, NVSS & WENSS
- 8 sources, NVSS only
- 1 source, WENSS only
- 1 source, no match



# Spectral index Analysis – LH WIDE

**NVSS, WENSS, VLSS:  $S(150 \text{ MHz}) > 350 \text{ mJy}$ : 18 point sources**

- all sources, NVSS & WENSS
- 13 sources, VLSS



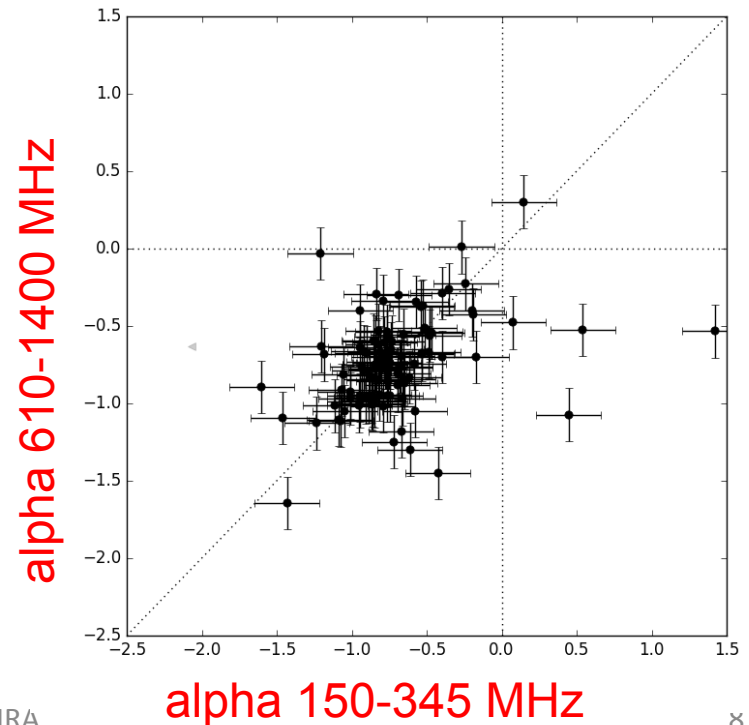
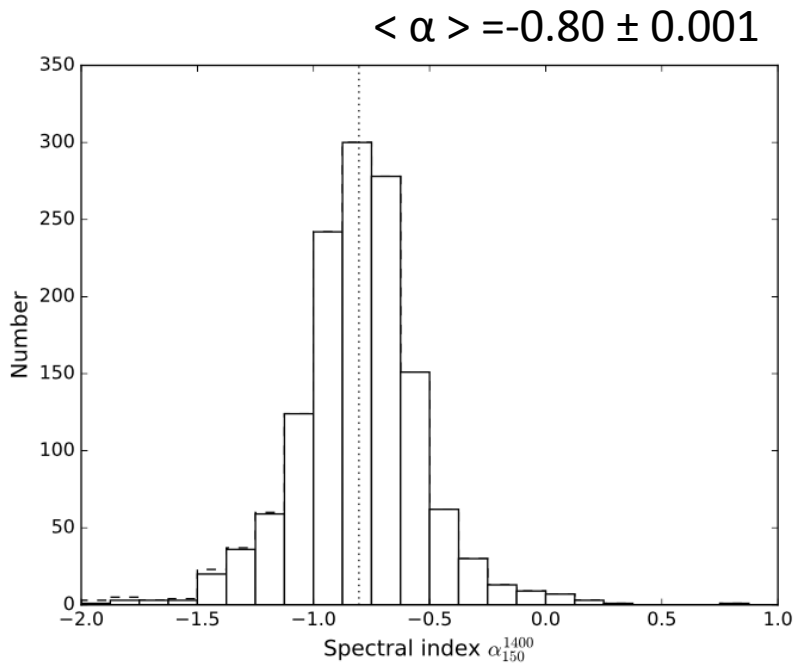


# Spectral index Analysis – LH DEEP

**WSRT 1.4 GHz mosaic = 6 sq.degr. → 1379 LOFAR HBA sources**

– all matched at 1.4 GHz [S(1.4 GHz)>55  $\mu$ Jy]

**WSRT 345MHz, 1.4GHz; GMRT 610 MHz: S(150 MHz)>8 mJy: 363 sources**



# Spectral index Analysis – LH DEEP

**WSRT 1.4GHz; LOFAR LBA 60 MHz:**

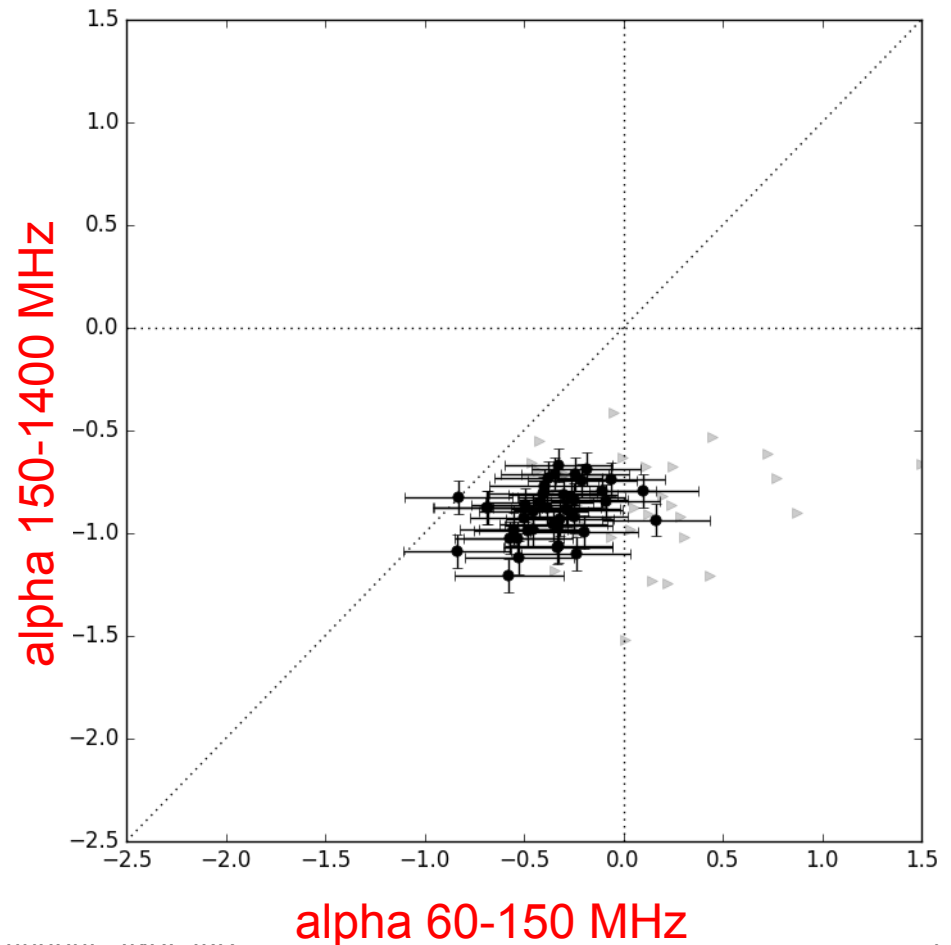
**S(150 MHz)>65mJy: 68 sources**

– 42 detection @60MHz

**Peaked sources:**

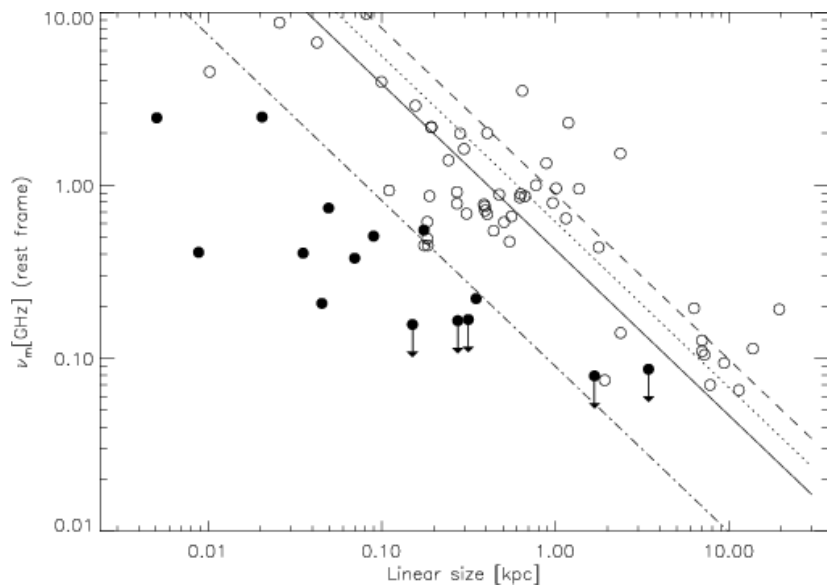
– required at least 4 points in radio SED

→ sample of 117 sources to search for peaked spectra

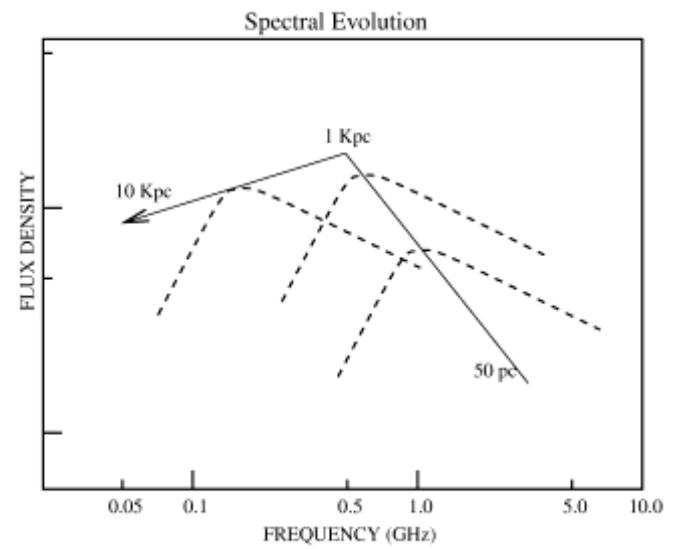


# Searching high-z GPS sources

- ‘nearby’ CSS sources
  - Correlation between spectral peak and linear size



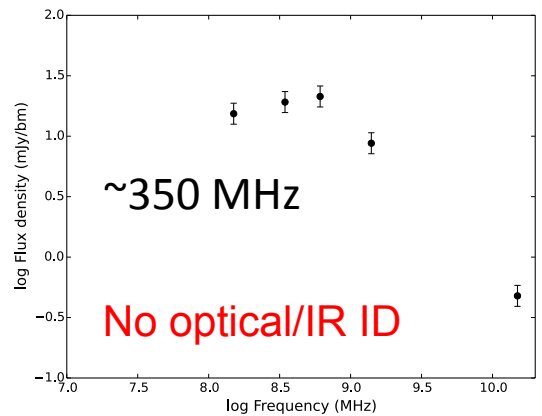
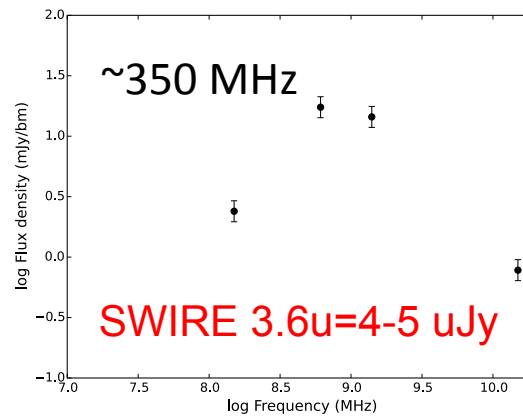
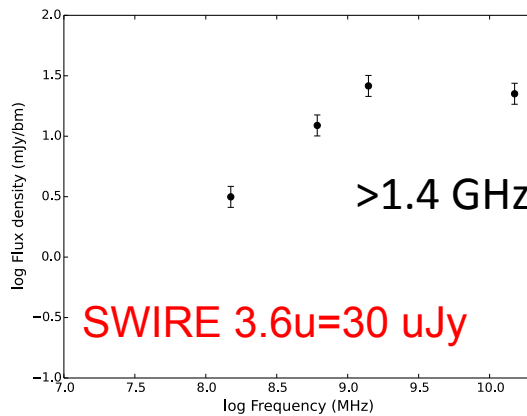
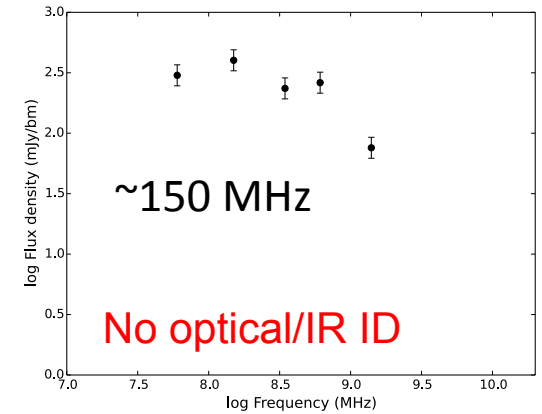
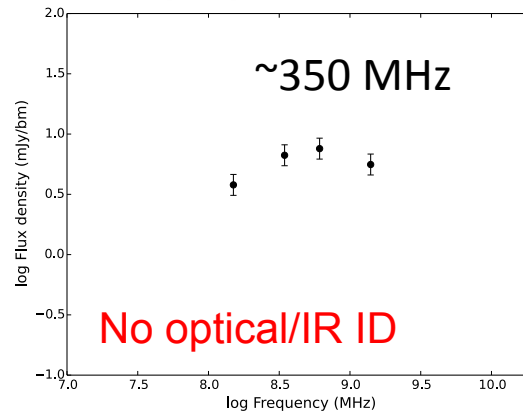
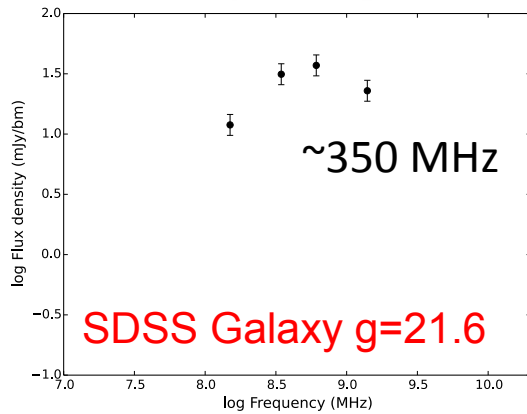
- High-z GPS sources
  - Correlation between spectral peak and source age -> redshifted to low frequencies



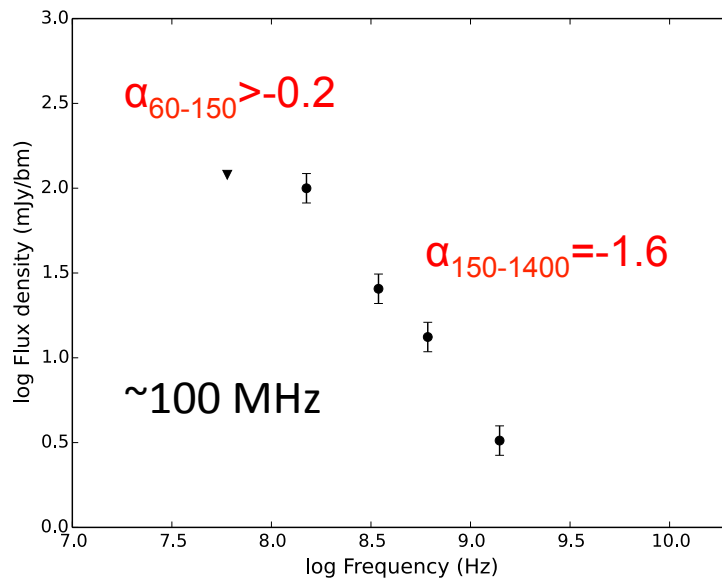


# MHz-peaked spectrum sources in the LH

*Mahony, Morganti, IP et al 2015, in prep.*



# MHz-peaked spectrum sources in the LH



- Ultra Steep Spectrum (USS) source
  - 100 mJy at 150 MHz, very steep ( $\alpha = -1.6$ ) up to 1.4 GHz
  - No detection at 60 MHz (< 120 mJy)
  - Possible spectral peak @ 100 MHz?
  - opt. counterpart,  $K_{\text{mag}} = 20.1$

*Mahony, Morganti, IP et al 2015, in prep.*

# Lockman Hole @150 MHz: Facet Calibration

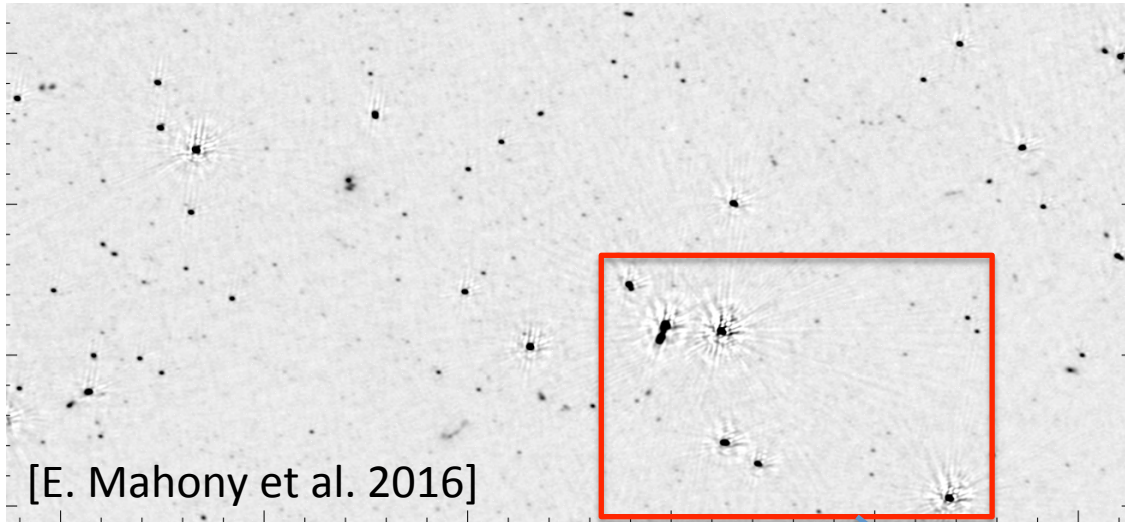
- rms noise: 170-190  $\mu\text{Jy}/\text{beam}$
- resolution: 5''
- only 8 MHz bandwidth out of 48 MHz!
- only 8 hours out of  $\sim 110$  hours!
- including everything  $\sim 9/10$  times deeper

[S. Mandal, PhD Thesis]



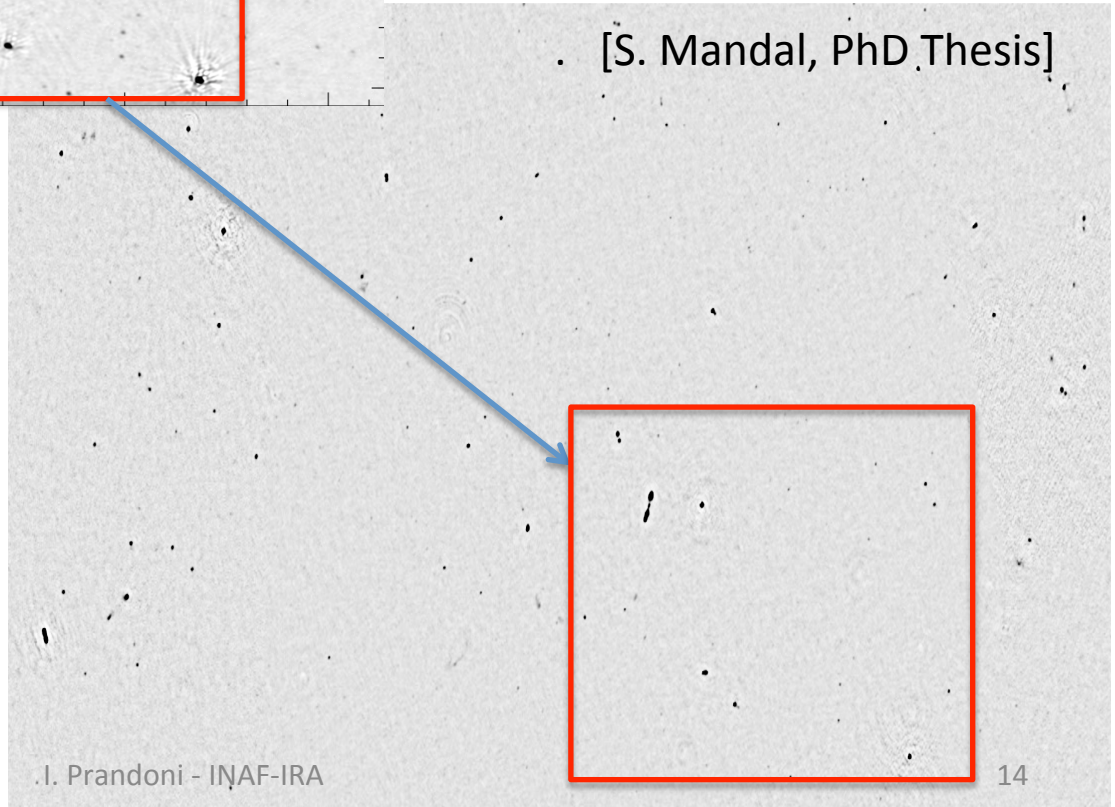
**Direction independent calibration:**

10h; BW~60 MHz → ~150 uJy rms; 15"x18" res.



[E. Mahony et al. 2016]

**Lockman Hole  
@150 MHz**



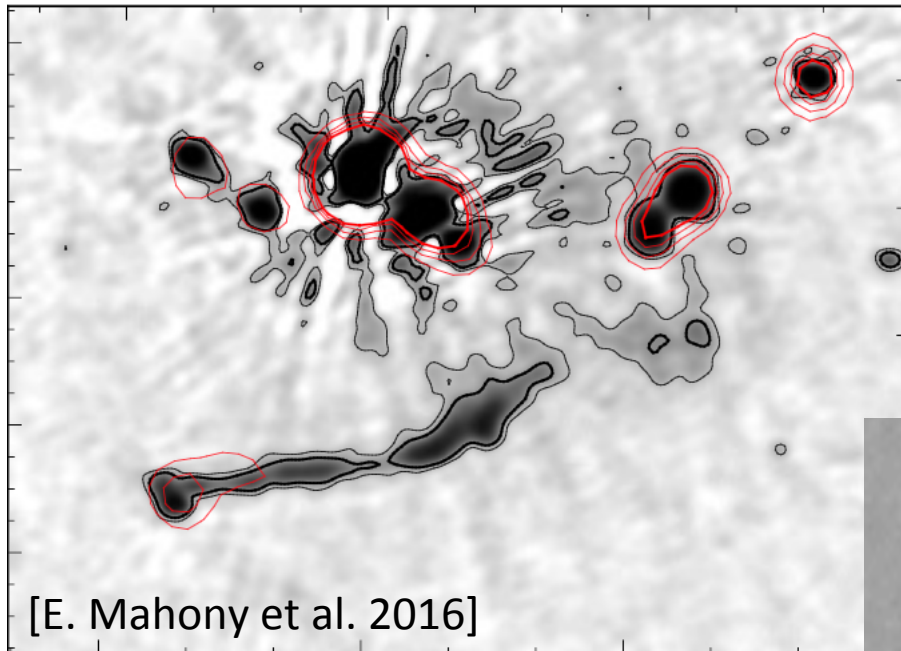
[S. Mandal, PhD Thesis]

**Facet calibration:**

8h; BW=8 MHz  
170-190 uJy rms  
~5"x5" res.

## Direction independent calibration:

10h; BW=60 MHz  $\rightarrow$   $\sim 150$   $\mu$ Jy rms;  $15'' \times 18''$  res.

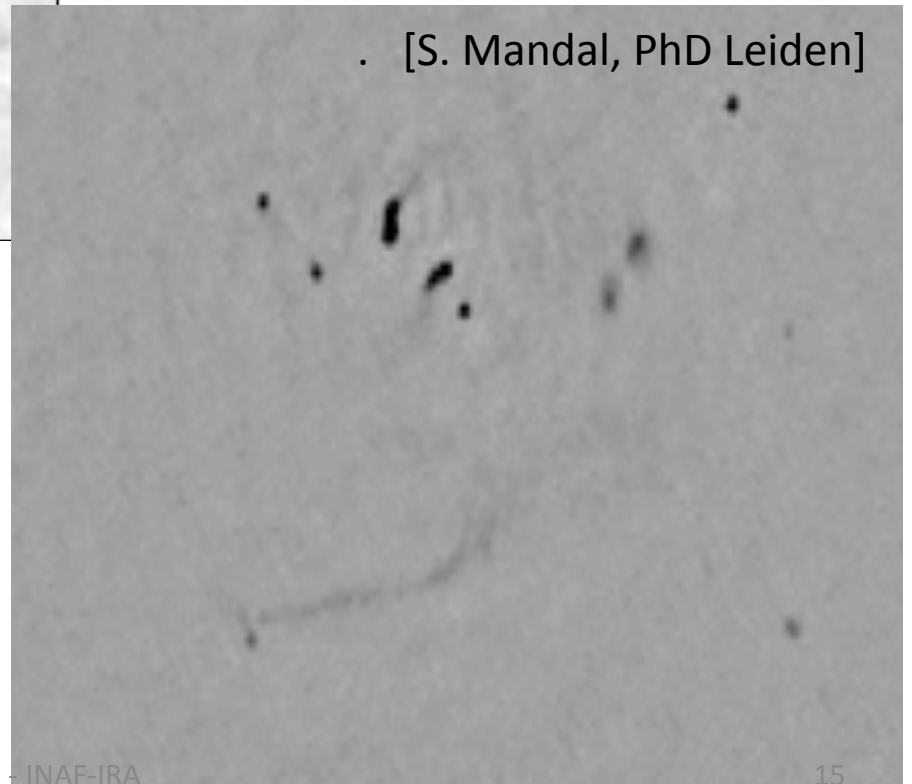


[E. Mahony et al. 2016]

Red contours: NVSS

Complex sources:  
Abell 1132

[S. Mandal, PhD Leiden]



## Facet calibration:

8h; BW=8 MHz  
170-190  $\mu$ Jy rms  
 $\sim 5'' \times 5''$  res.

LH @ HBA: 104 hours obtained  
goal: 15-20  $\mu\text{Jy}$  rms

Stay tuned...