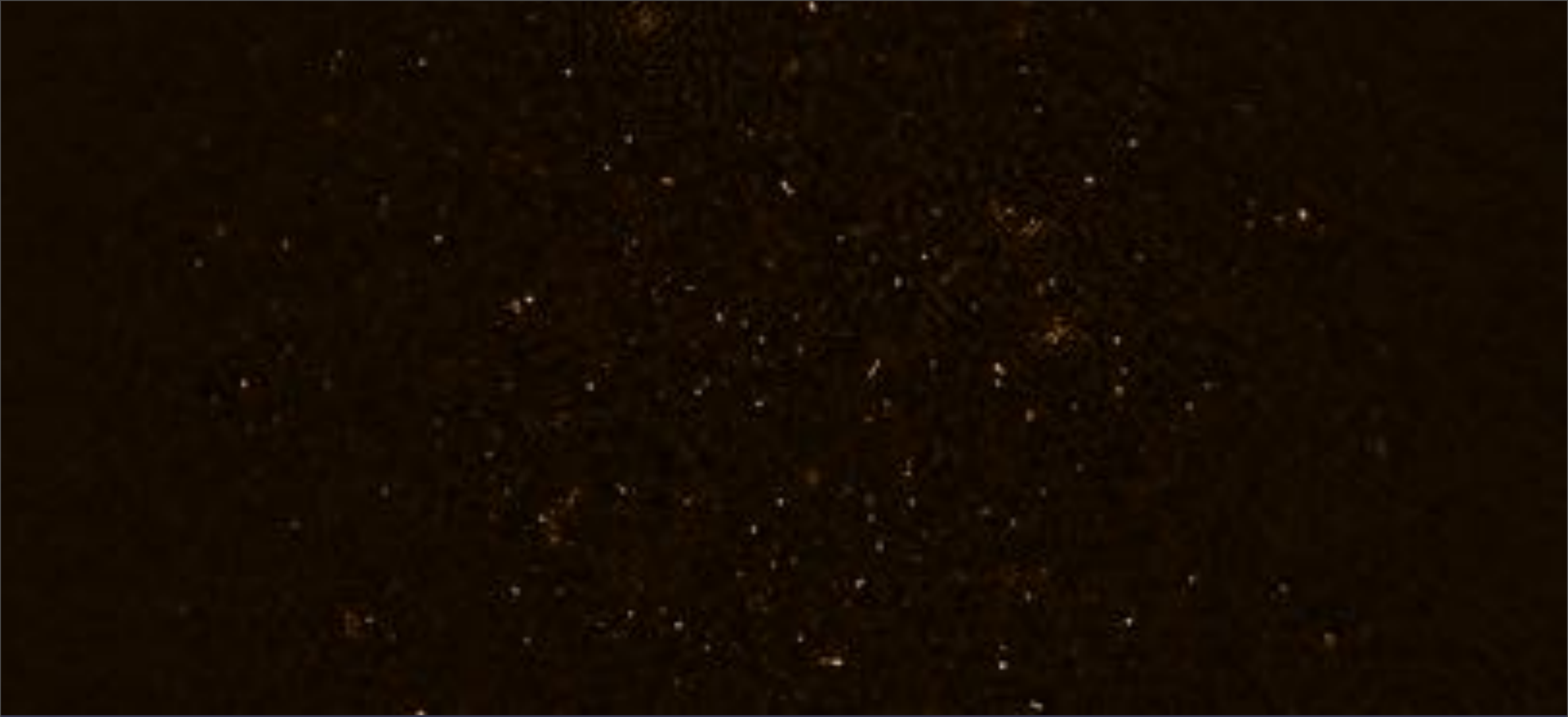
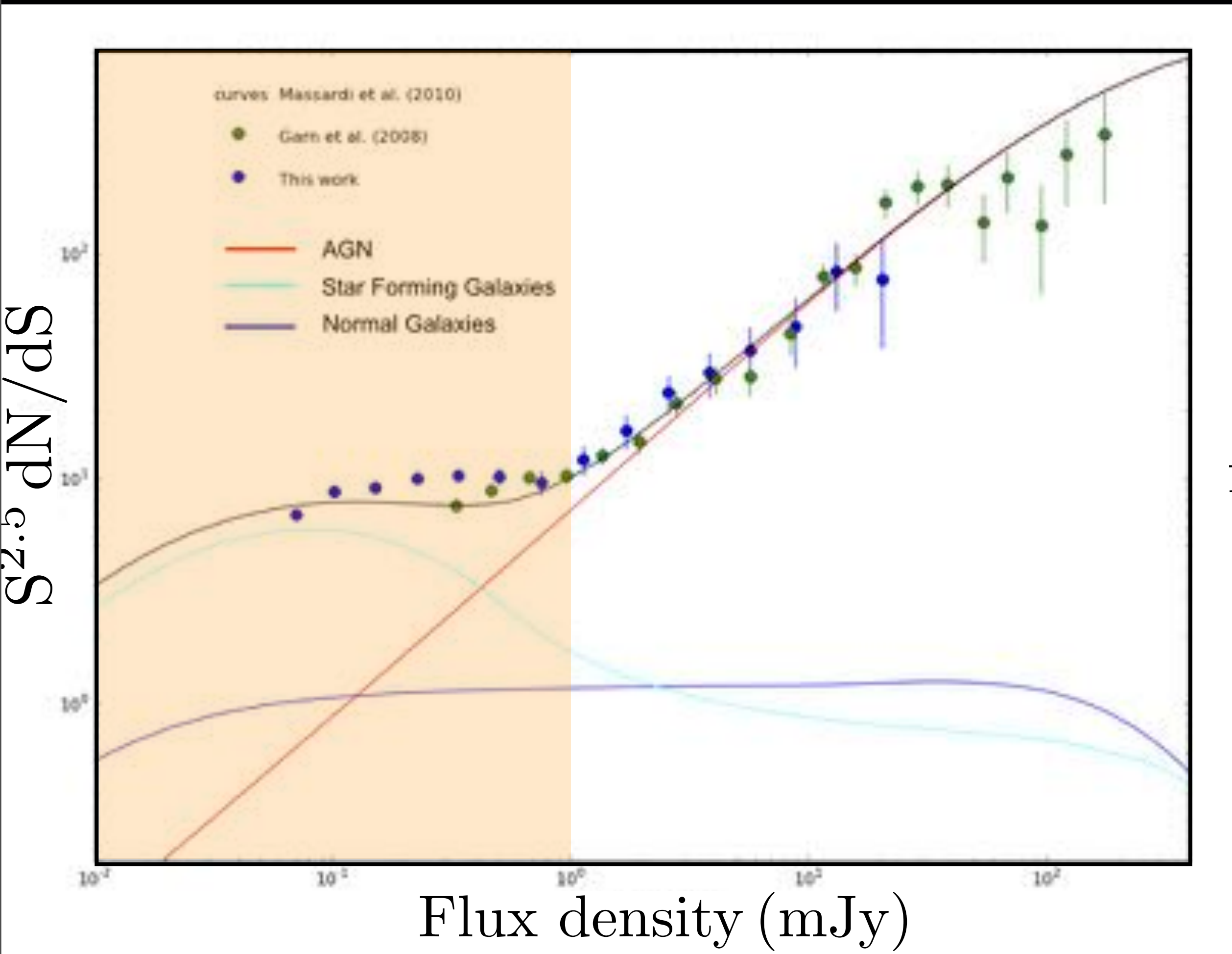


Deep GMRT observations of the faint radio source population: the case of the ELAIS-N1 field

Zara Randriamanakoto (University of Cape Town)

Russ Taylor (UCT/UWC), Yogesh Wadadekar (NCRA), Dharam Lal (NCRA) et al.

Why study faint radio sources?



Taylor et al. 2015, AASKA14

- Star formation history in the Universe
- Galaxy evolution
- Provide more insights of the far-IR and radio correlation
- Isolate the level of AGN activity in star-forming galaxies
- Almost ~ 90% of the the population composed of star-forming galaxies
- The physics of low SFGs still poorly understood
- Different radio emission mechanisms

Flattening of the source counts at low flux densities attributed to the presence of both starbust galaxies and low luminosity AGN.

Relevance to MeerKAT/SKA

Credit: the MeerKAT team, SA SKA media release

- Early science commissioning of the MIGHTEE deep continuum survey (PI: Jarvis & Taylor)
- MeerKAT/MIGHTEE will map large areas of the sky to unprecedented depths: $0.1 - 1\mu\mathrm{Jy/beam\,rms}$
- => A more detailed studies of faint radio source population

Credit: SA SKA

This work:

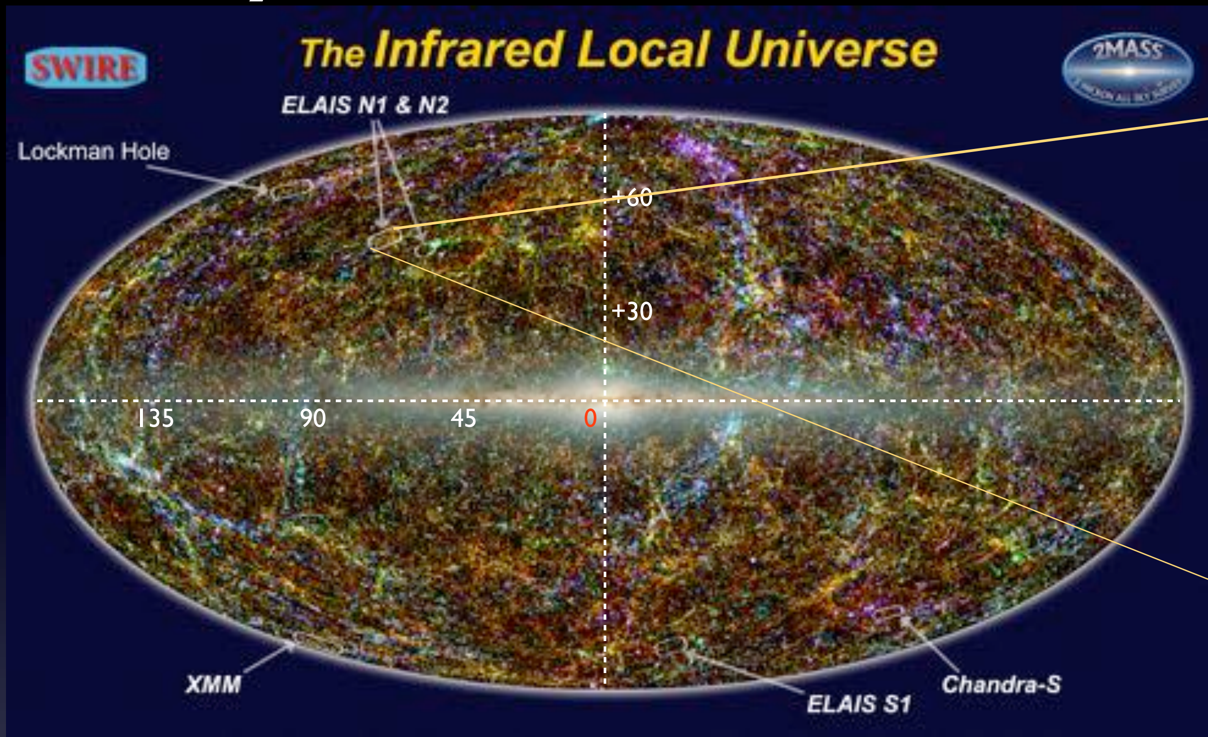
a science commissioning of MIGHTEE

Probe the faint radio source population of ELAIS N1

using deep GMRT observations at 325 & 610 MHz

- Differential source counts
- Spectral index distribution
- Nature of the faint radio sources (AGN/SB)
- Polarization properties
- ...

Why ELAIS-N1?



Credit: Jarrett, the SWIRE Legacy Survey

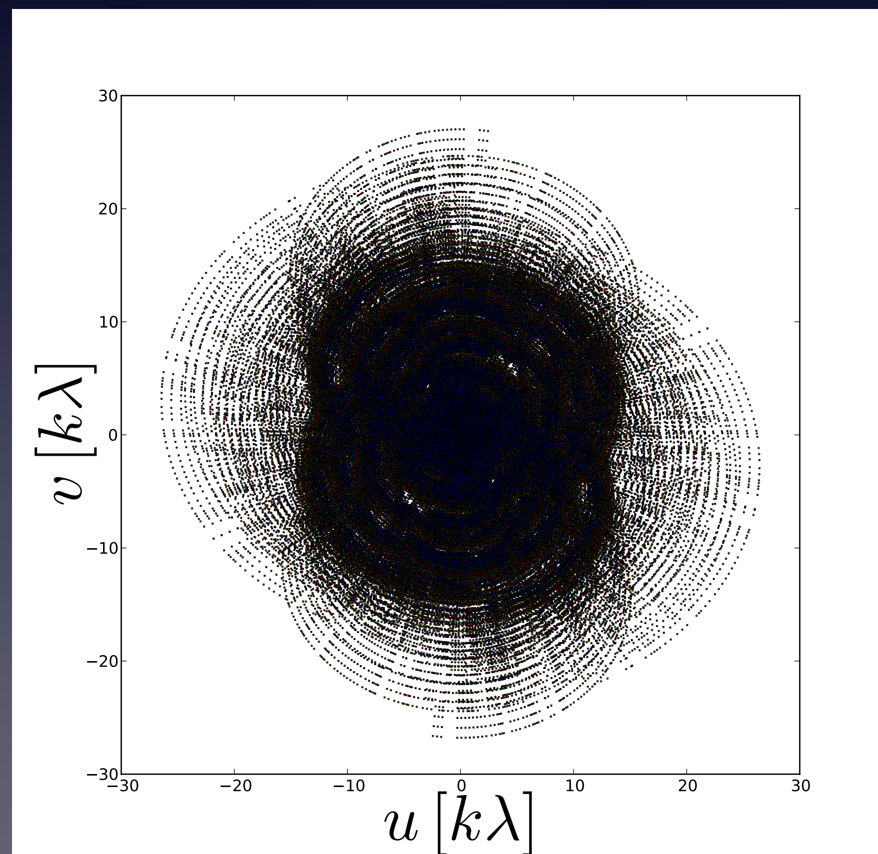
- European Large Area ISO Survey-North 1
- Centred near $\alpha = 16^{\mathrm{h}}10^{\mathrm{m}},\ \delta = +54^{\circ}35'$
- With an area coverage of $2.0^{\circ} \times 1.3^{\circ}$ (Oliver et al. 2000)
- A region of the sky with low-IR foreground emission
- An extensive ancillary multi-wavelength data
- The field hosts thousands of faint radio sources

Data & imaging

325 MHz	610 MHz
$\Delta\nu = 32\,\mathrm{MHz}$	$\Delta\nu = 32\,\mathrm{MHz}$
HPBW: 85 arcmin	HPBW: 44 arcmin
PI: Y. Wadadekar	PI: A. R. Taylor
Single pointing	Mosaic (hexagonal)
Obs.time: 2 x 8.5 hrs	Obs.time: 7 x 30 hrs
Area: 3.2 sq.deg	Area: 1.2 sq.deg
rms ~ 41 microJy/beam	rms ~ 10 microJy/beam
Ang.res: 17.2” x 12.4”	Ang.res: 6.1” x 5.1”

CLEANing ALGORITHM:
a wide-band and wide-field imaging
(MT-MFS with w-term=256)

Credit: GMRT, NCRA-TIFR



Challenges probing faint radio sources

Requires a restored image with a high sensitivity

However, low-frequency wide field surveys prone to severe ionospheric effects

=> Need to correct for direction dependent gain effects (DDE)

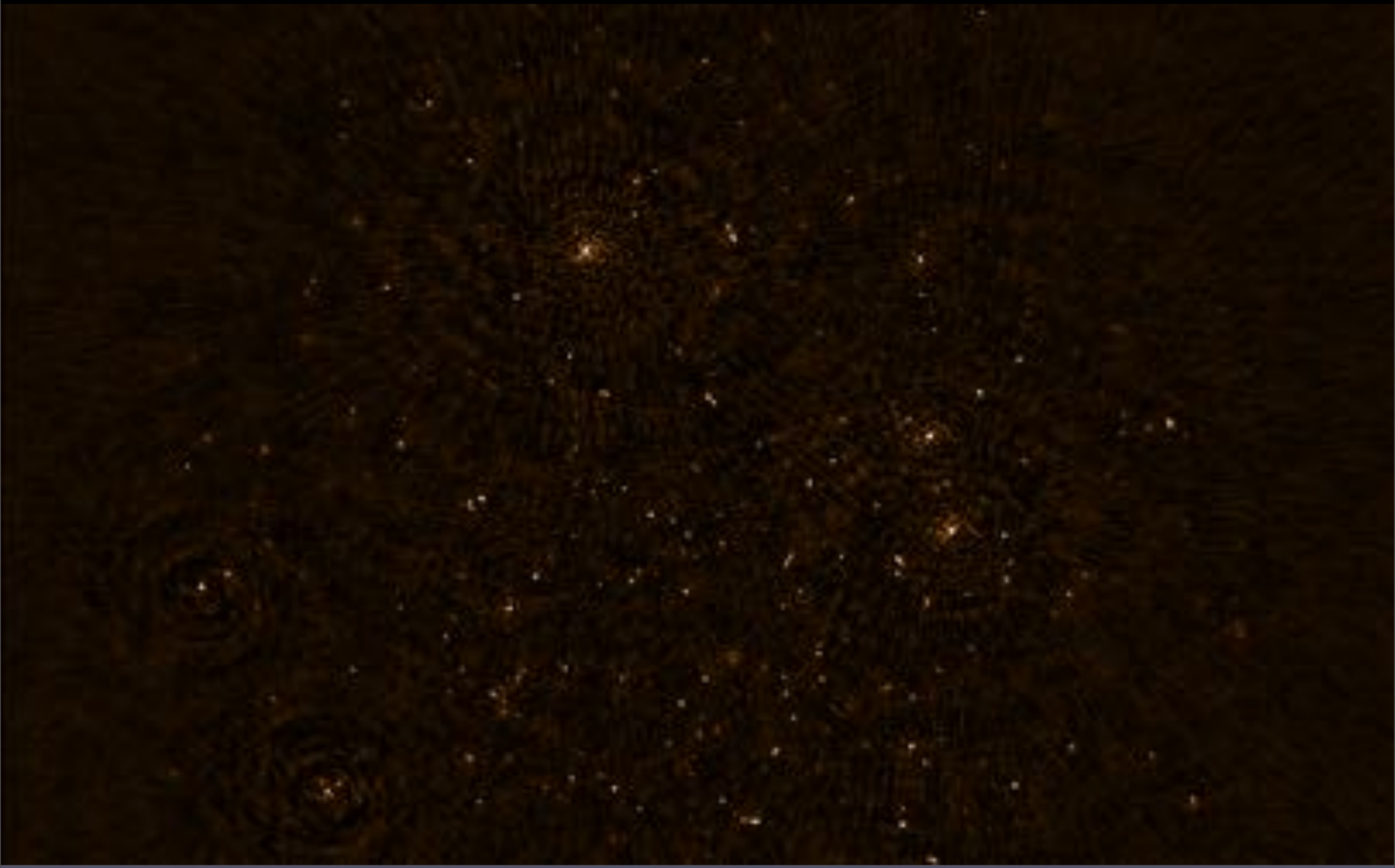
Switch on the A-term in CASA/CLEAN
(Bhatnagar et al. 2008,2013)

(need a primary beam model)

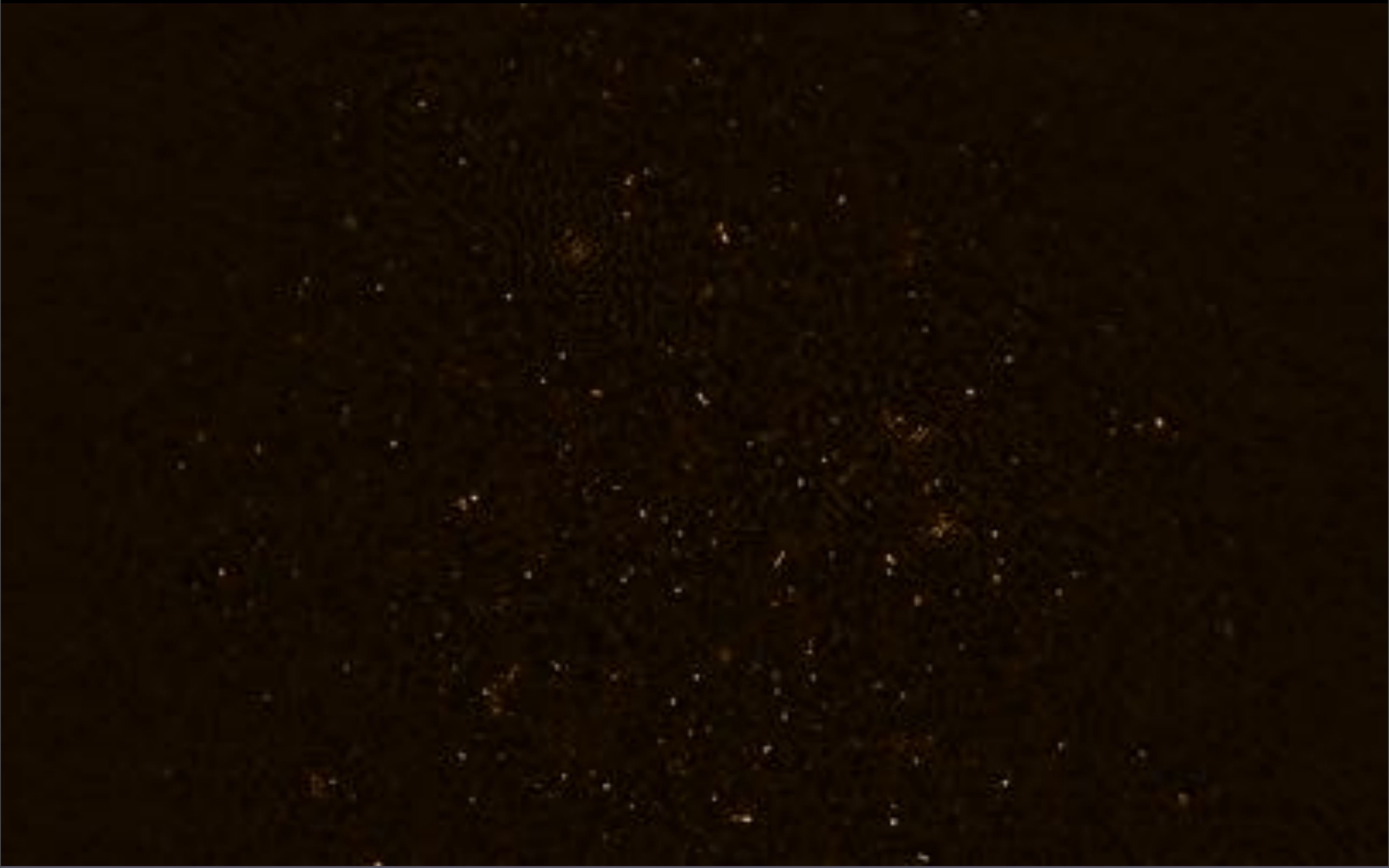
Adopt a DD calibration pipeline

Peeling (only the very bright sources)

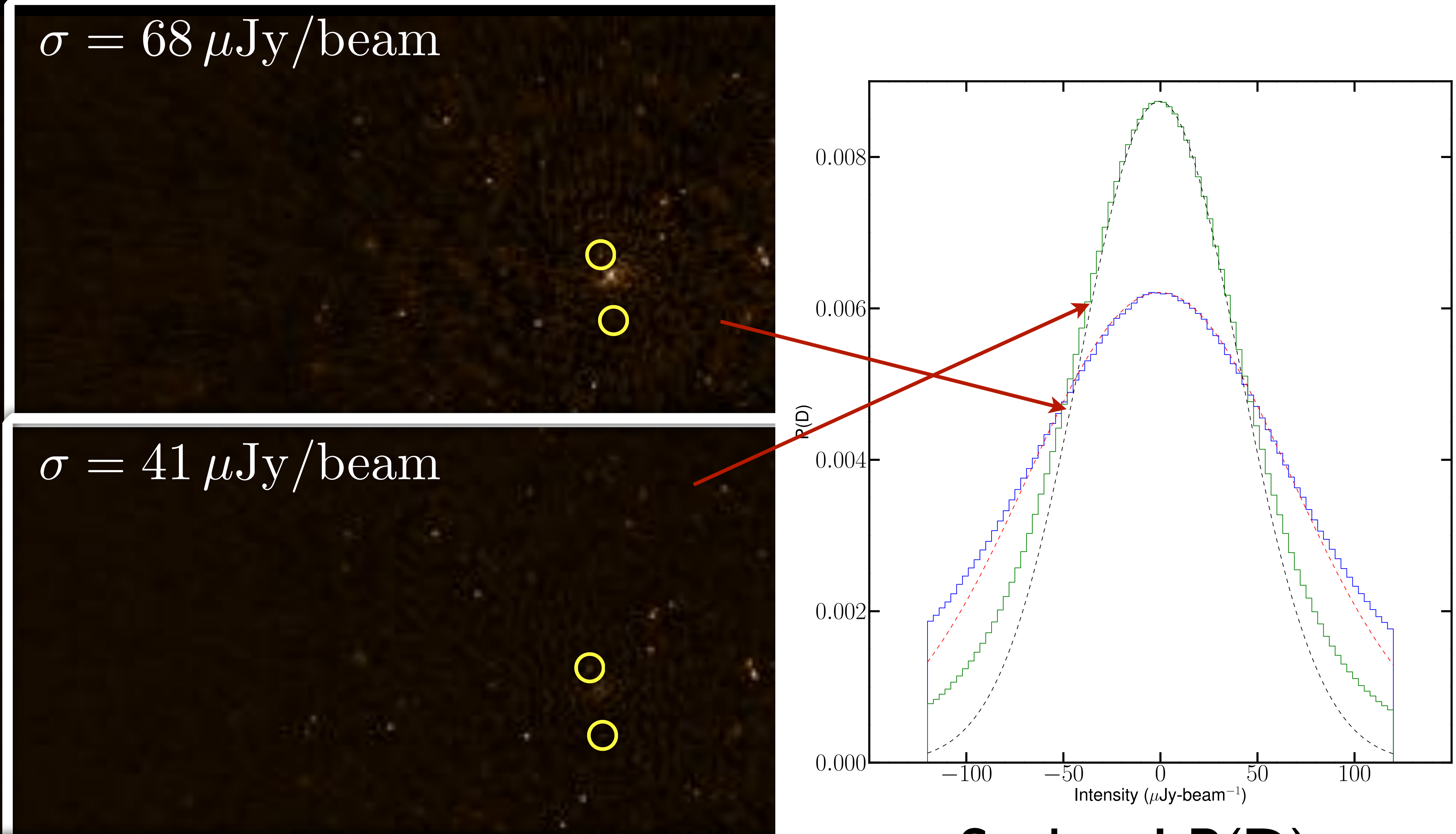

Self-calibration +
direction-independent calibration only



Self-calibrated but without a direction-dependent calibration
median noise level of ~ 68 microJy/beam



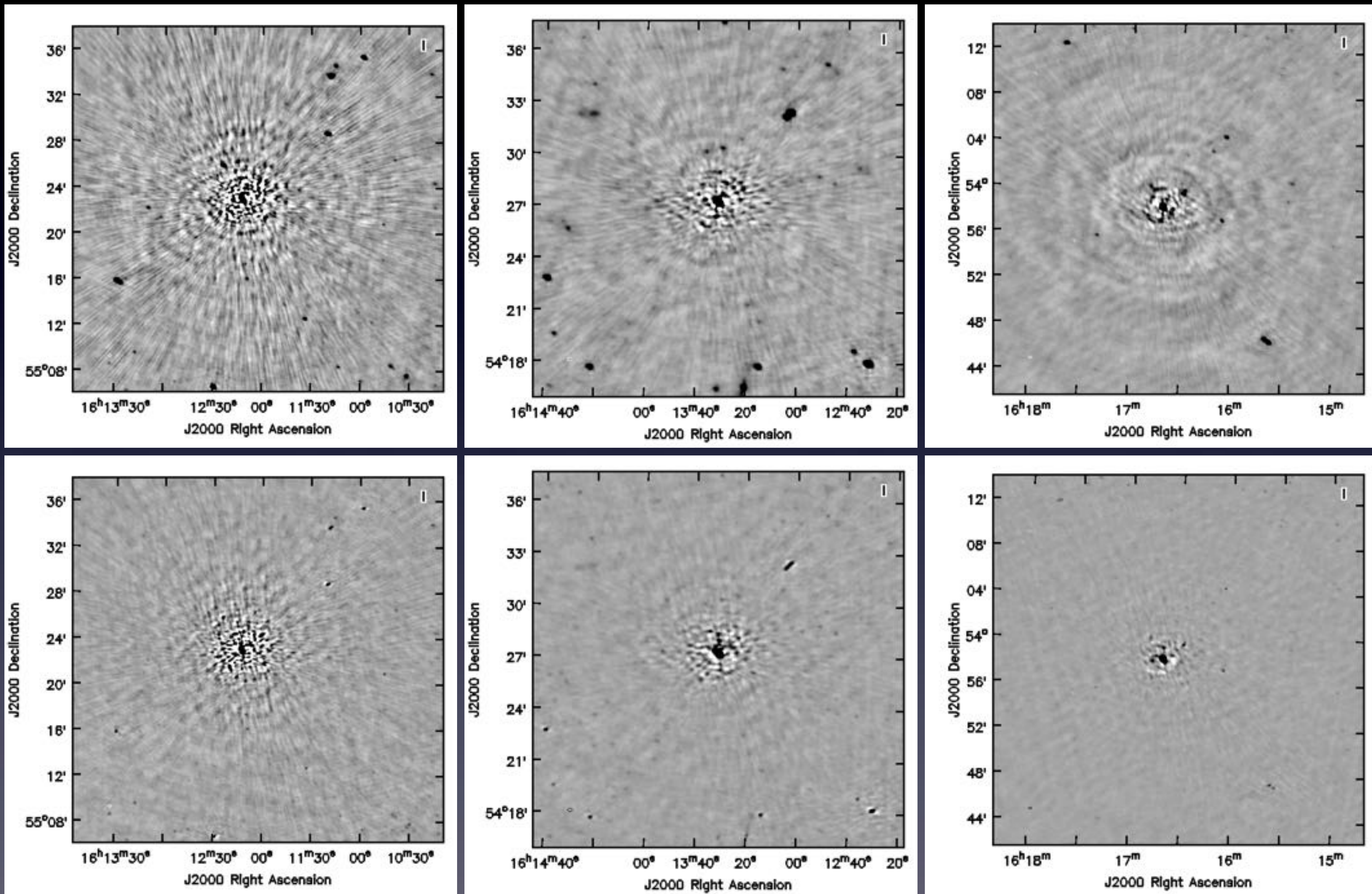
Self-calibrated + direction-dependent calibration via PEELING
Image noise level of 41 microJy/beam (improved by 40%)



Stokes I P(D)

- Improve the detection of faint radio sources near bright off axis sources
- And to provide a more accurate value of their flux densities

Source peeling - some examples



160 to 73 muJy/b
Sint = 0.804 Jy

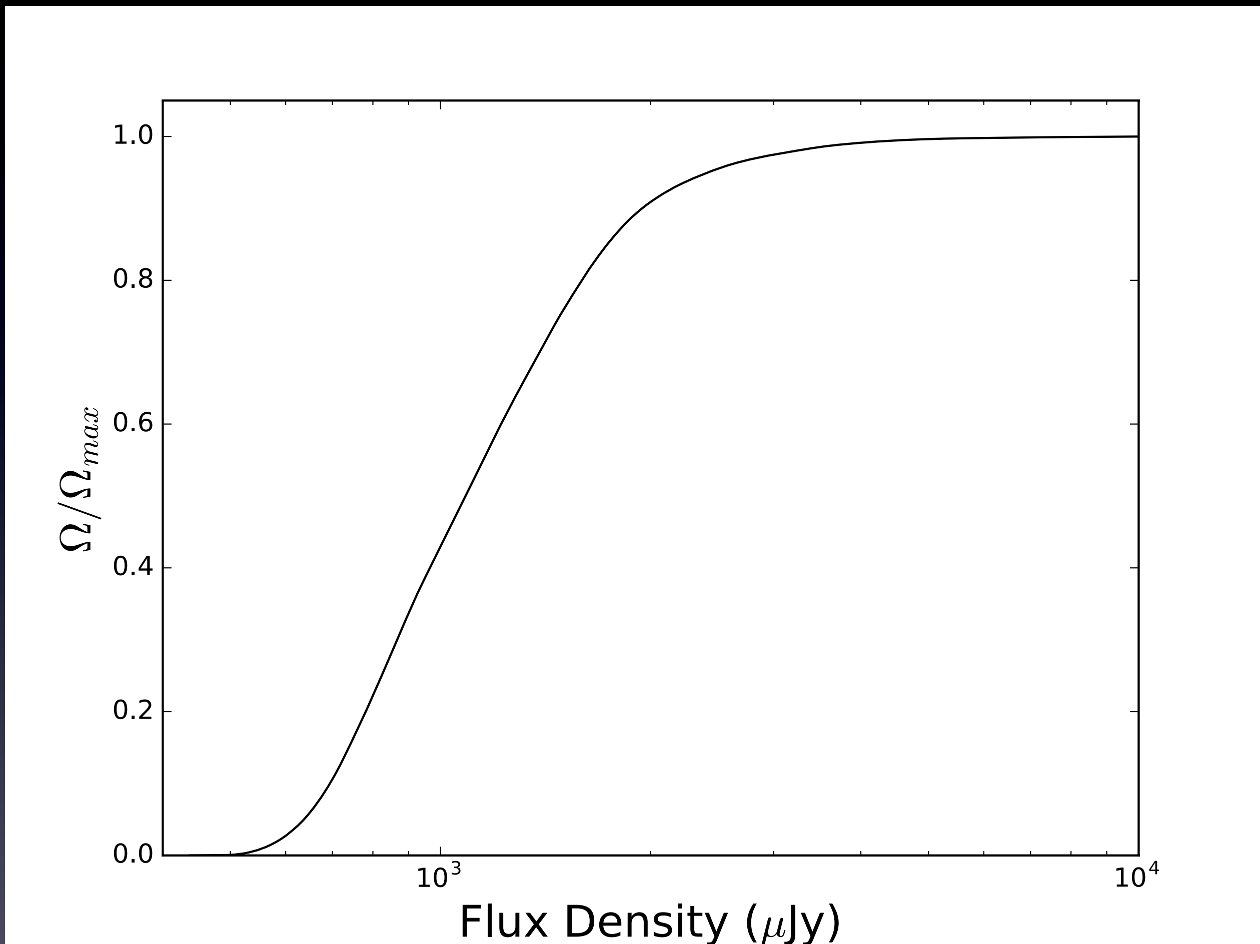
154 to 98 muJy/b
Sint = 0.213 Jy

110 to 54 muJy/b
Sint = 0.197 Jy

Source catalogue

- Compiled with PyBDSM above $4.5\,\sigma_{loc}$ local noise level
- Use of an RMS map during the source extraction
- Around 1300 sources detected with flux densities between 165 muJy and 0.804 Jy within 4.9 sq degree area of the field (and 1550 sources considering the entire field)
- Compile another catalogue based on a reference field: EN1 observed with GMRT at 610 MHz with a noise level of 10 microJy/beam (around 2800 sources detected)

Effective areal coverage



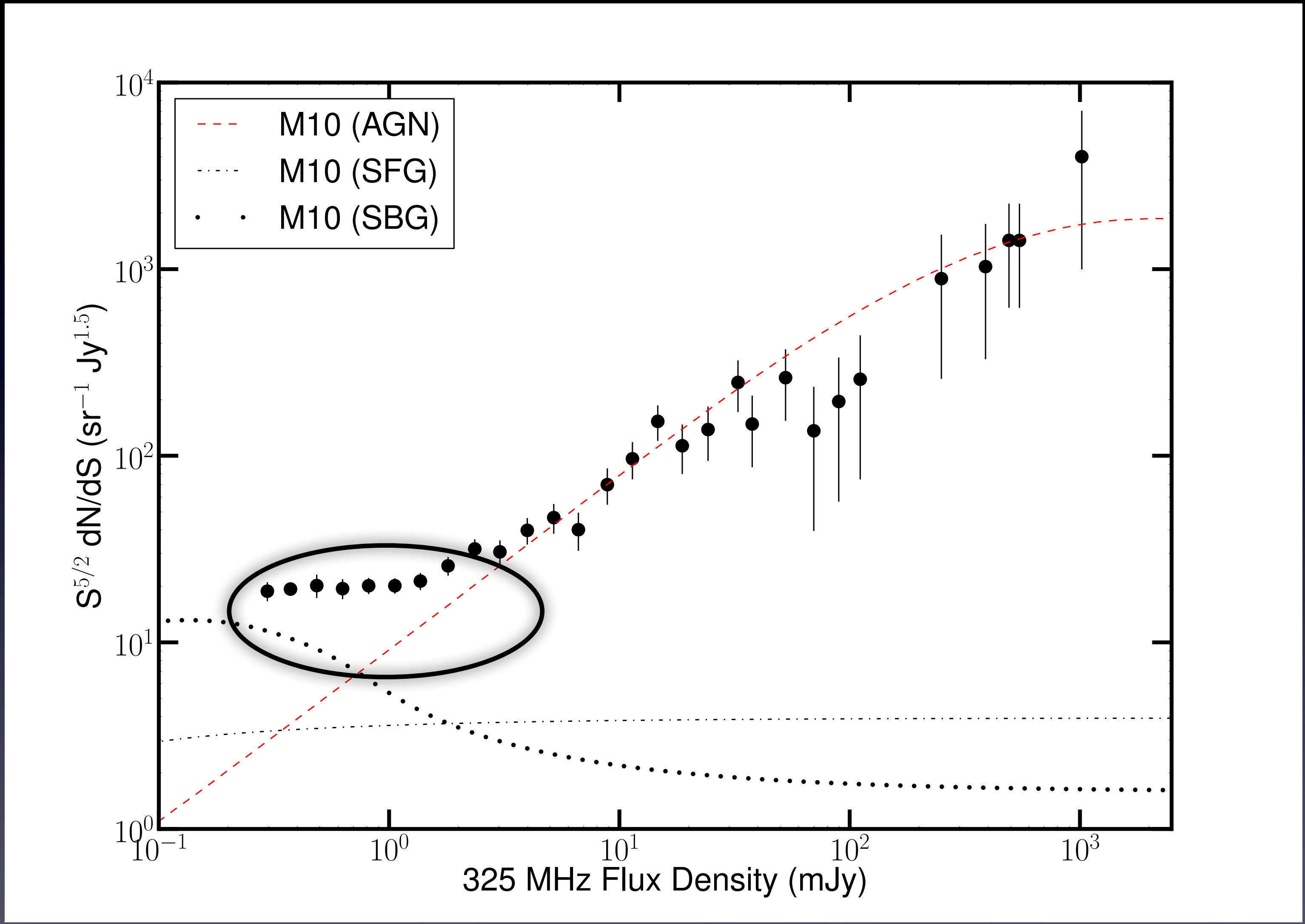
$$\Omega_{max} = 3.34\,\mathrm{sq.deg}$$

An increase in noise near the bright sources

=> Correct for the fraction over which the source could be detected

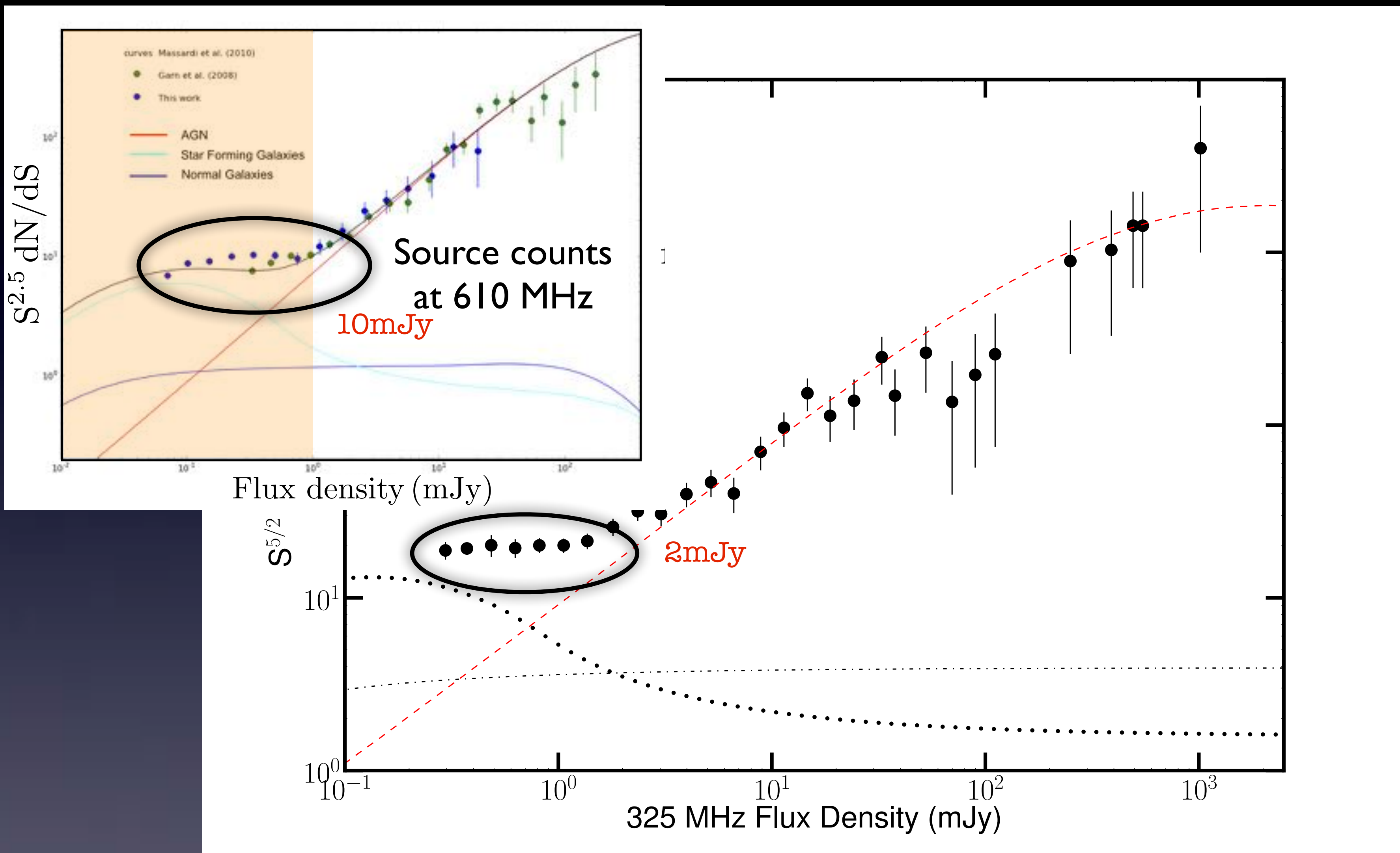
=> A theoretical completeness curve from an RMS image

The 325 MHz source counts (preliminary)



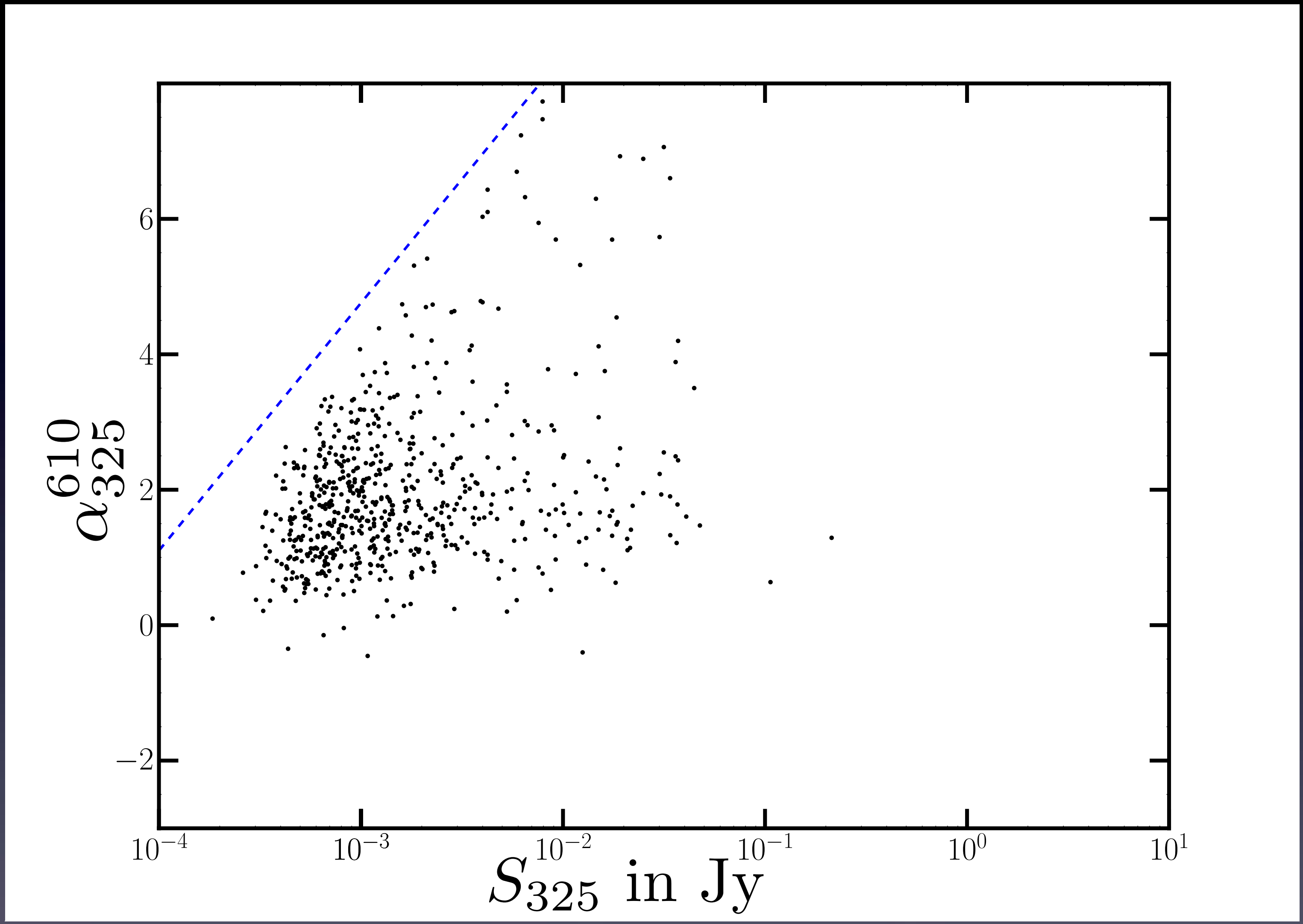
- Models from Massardi et al. (2010, MNRAS, 404, 532)
- Evidence of a flattening around ~ 2mJy due to the presence of low-luminosity AGN and SF galaxies
- Consistent with higher frequency studies (e.g. Taylor et al 2015)

The 325 MHz source counts (preliminary)



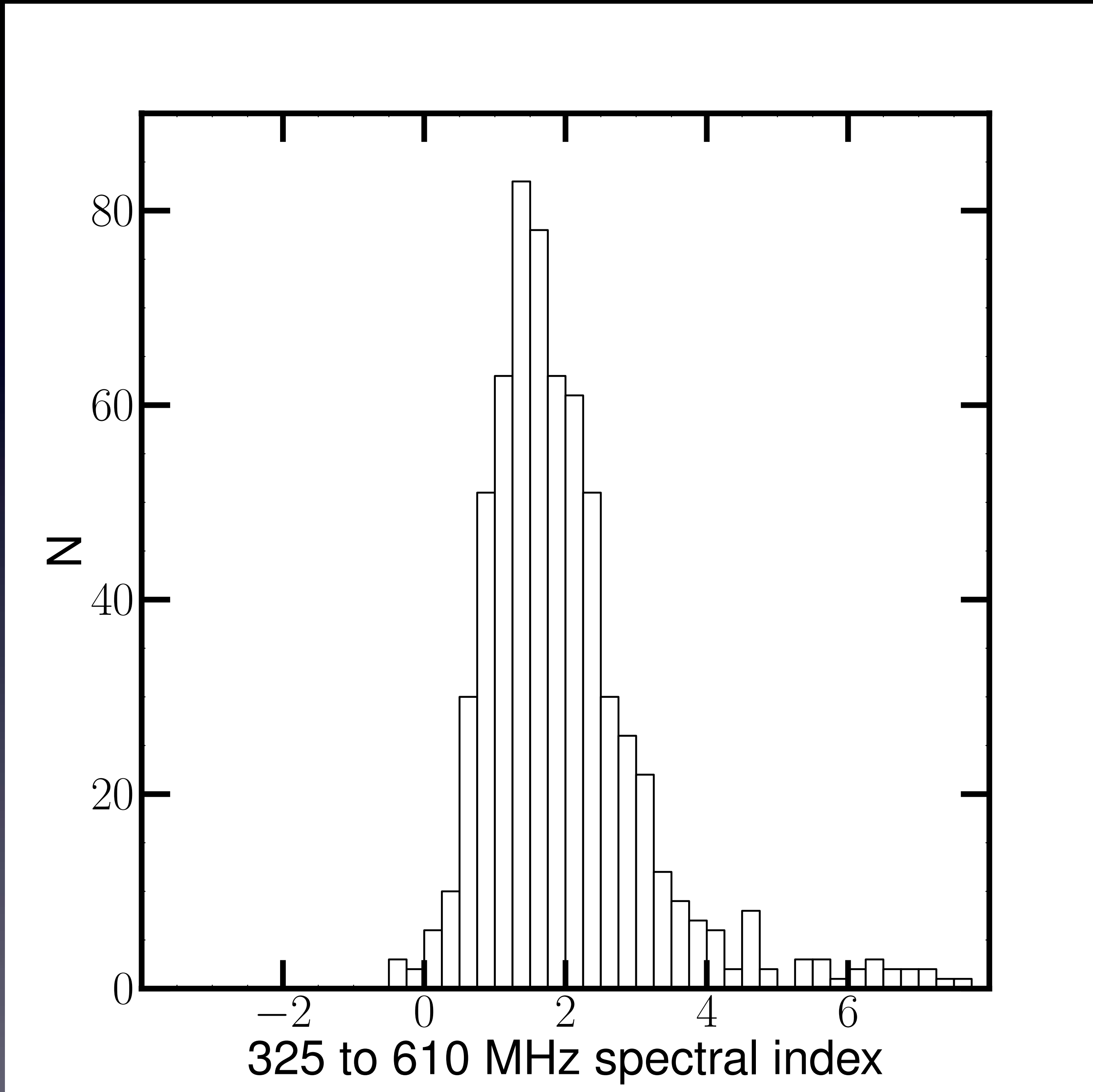
- Models from Massardi et al. (2010, MNRAS, 404, 532)
- Evidence of a flattening starting around ~ 2mJy
- Consistent with higher frequency studies (e.g. Taylor et al 2015)
- Presence of low-luminosity AGN and starbust galaxies

Spectral index distribution



- A cross-match with the GMRT 610 MHz catalogue (~2800 sources with rms =10muJy/beam)
- Matched 650 sources within a 1.2 sq.deg area and a 10 arcsec radius of the source centroid
- Median value of the spectral index: 1.64

Spectral index distribution



Summary & way forward

- Deep GMRT 325 MHz observations of ELAIS N1
- Sensitivity down to 41 microJy/beam
- Source peeling to correct for DDE
- A flattening of the 325 MHz source counts at low flux densities
- Spectral index distribution with a median value of α_{325}^{610} = 1.64

- Comparison of the 325 MHz source counts with previous works
- Nature (AGN/SB) and evolution of the faint radio sources
- Any correlation between α and the nature of the source