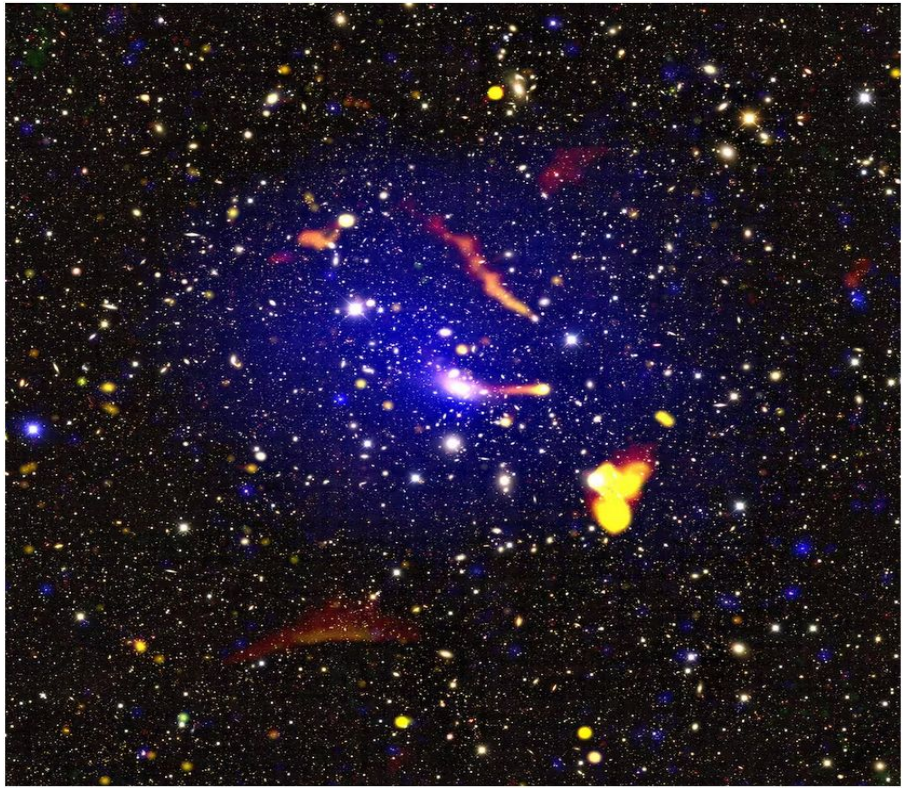
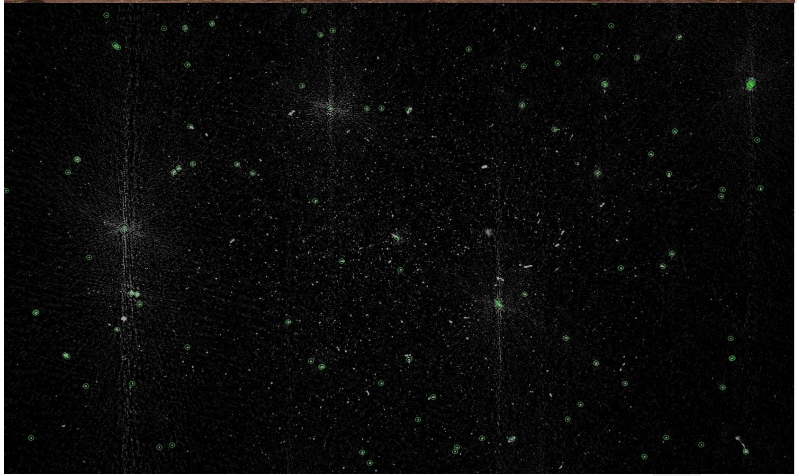
MOSS 2: Mid-Frequency radio catalog of the Saraswati core region

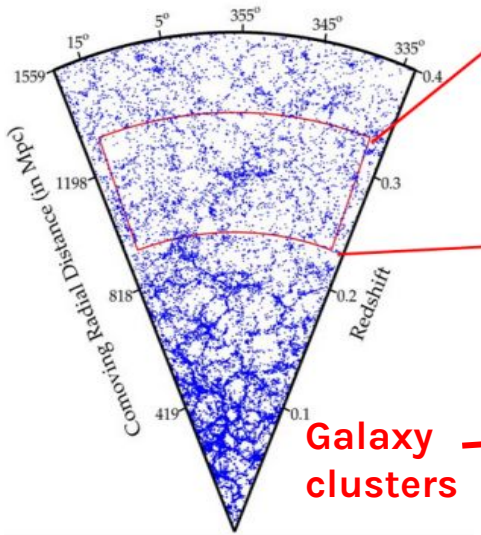
R. Kincaid[1⋆], E. Retana-Montenegro[2,3], B. Šlaus[4], V. Parekh[5], P. Jablonka[1], S. Salunkhe[6], S. Sankhyayan[7], V. Smolčić[8], M. Bondi[9]

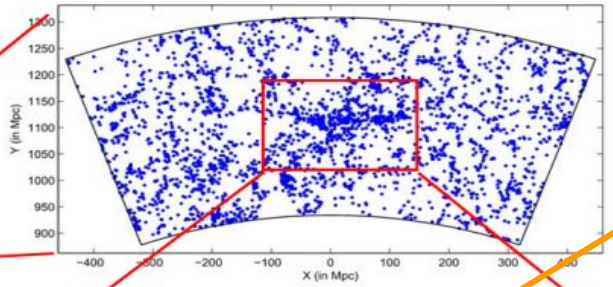


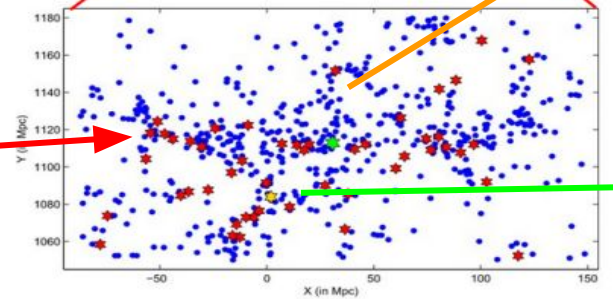


Saraswati supercluster

- One of the most significant density enhancements found at medium-to-high redshifts (z ~ 0.27, universe ~ 10 billion years old).
- Mass and density comparable to nearby superclusters like Virgo and Lanaeka.
- Contains over 40 galaxy cluster and groups. The 2 largest galaxy clusters comprise 20% of its total mass (4x10^15 solar mass).
- The largest and 2nd largest galaxy clusters situated at the core are A2631 and Zwcl2341.

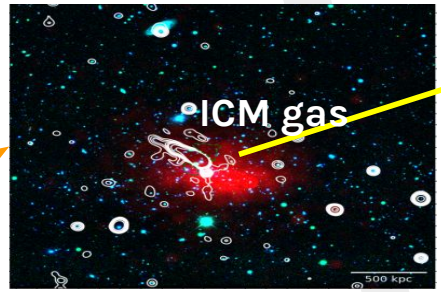






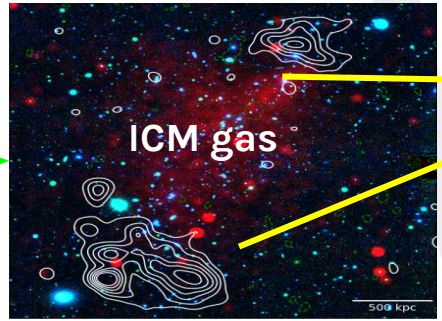
Galaxy clusters

Abell2631



AGN

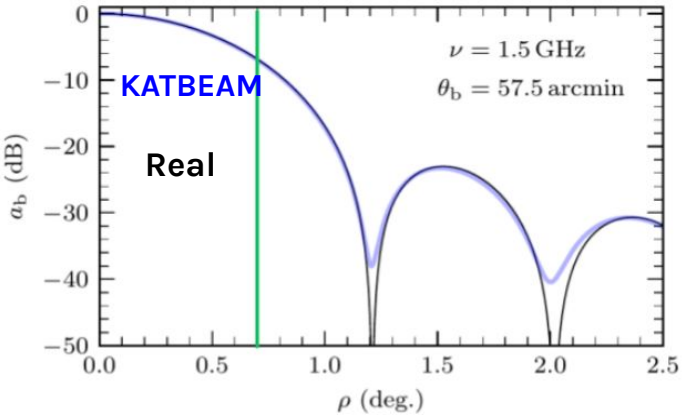
Zwcl2341



Radio Relics

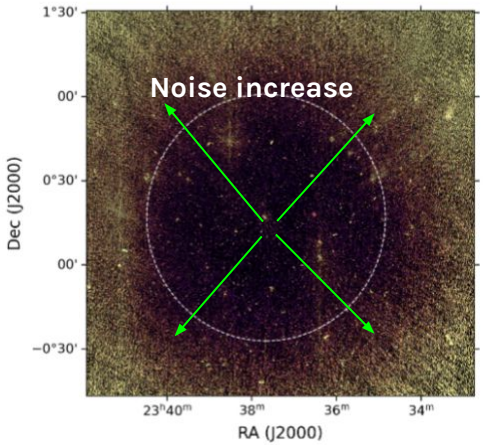
MeerKAT observations

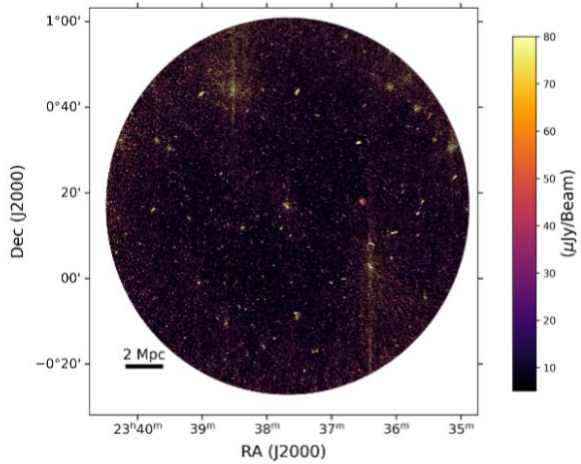
- Each cluster observed for 8 hour observations (4096 channels, 16s int time) with MeerKAT.
- 8 arcsec resolution and 10uJy noise.
- Primary beam pattern -> noise increase with increasing distance to edges.
- Apply a cutoff where primary beam attenuation > 30%
- Simplified beam model of KATBEAM -> cosine aperture taper

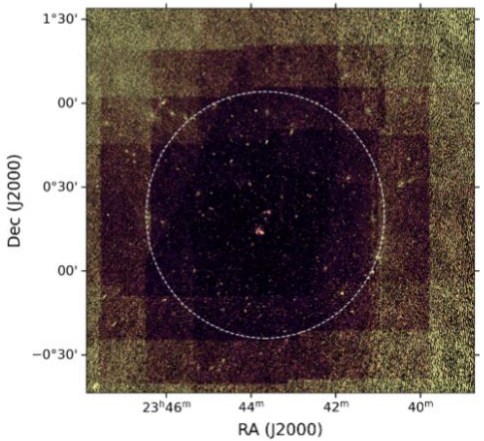


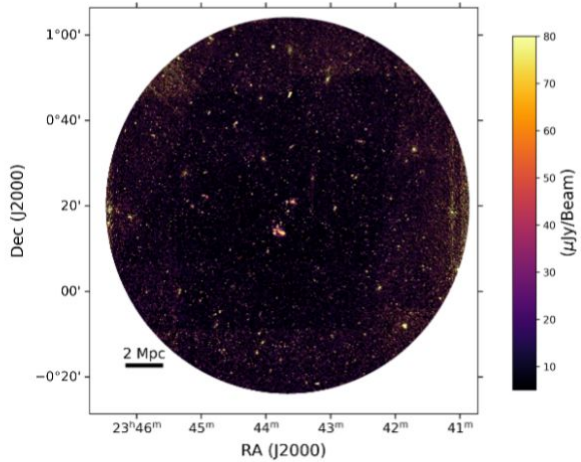
Primary beam corrected maps

30% cutoff images



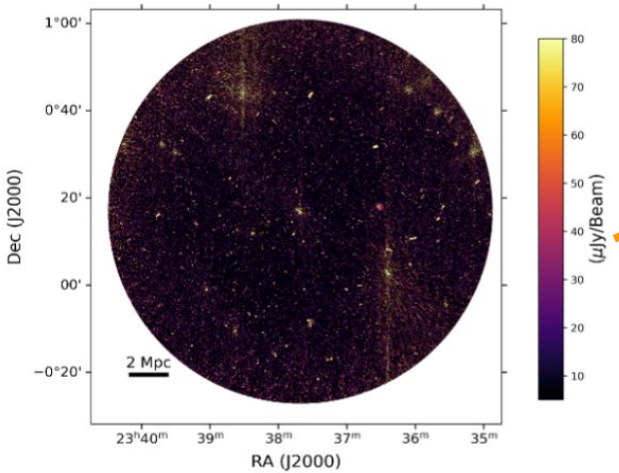


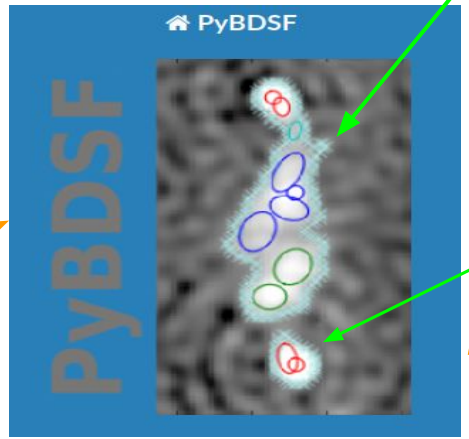




Catalog creation

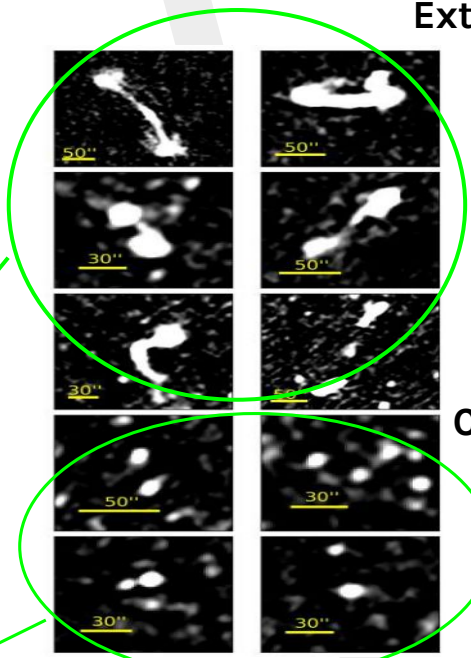
- Run the PyBDSF source finder to fit regions of emission with gaussians.
- PyBDSF -> island threshold = 3, Pixel threshold = 5.
- Sample of ~ 3000 radio sources with flux density 10uJy to 10mJy.
- Resolved and unresolved sources existing in catalog.

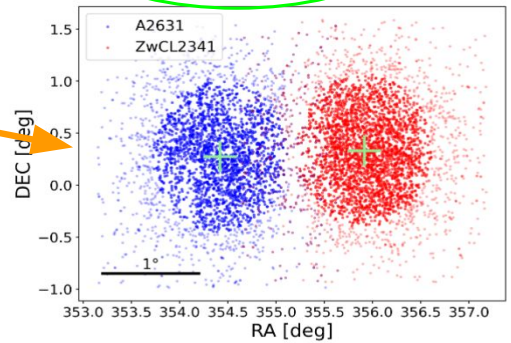




Extended

Compact

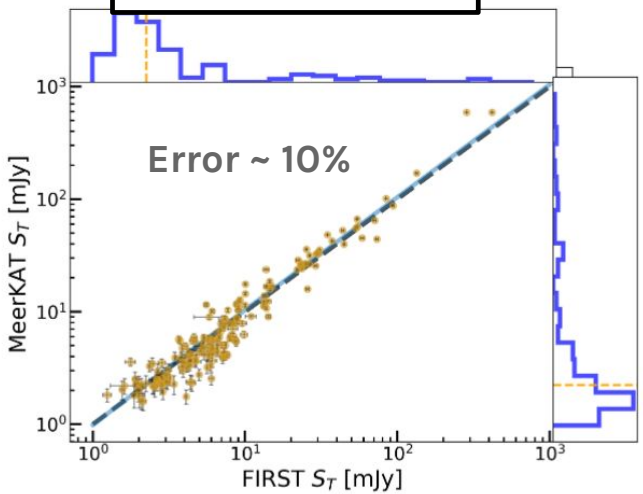




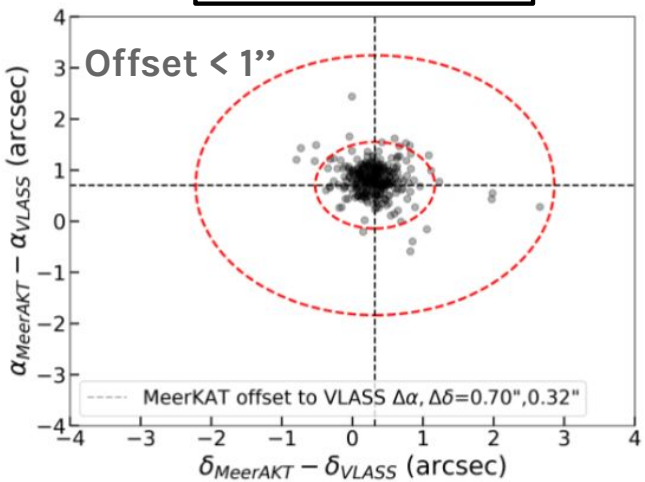
Systematic checks

- Consistency check with existing radio surveys such as FIRST (VLA), VLA all sky survey (VLASS), TGSS(uGMRT).
- Due to similar beam size (~5”) and frequency (1.4GHz) we chose to compare flux with FIRST.
- Due to large number of sources in VLASS we used this for astrometry check.
- Bright unresolved well-separated sources are used for comparison.

Flux scale

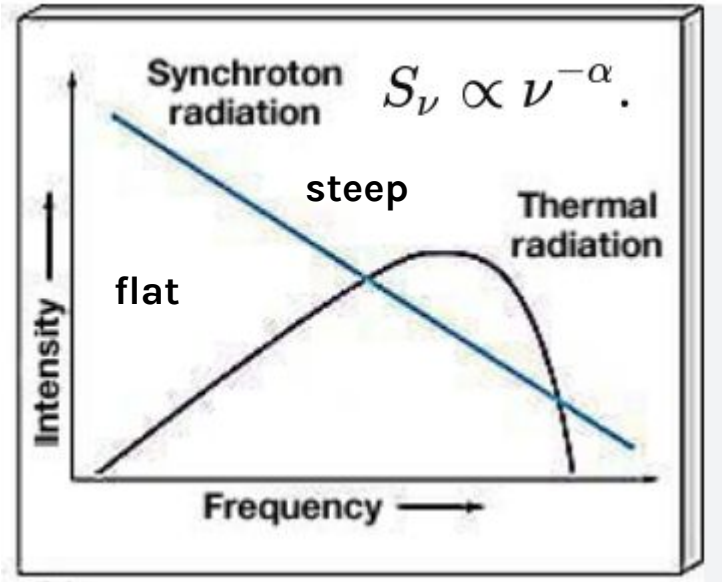


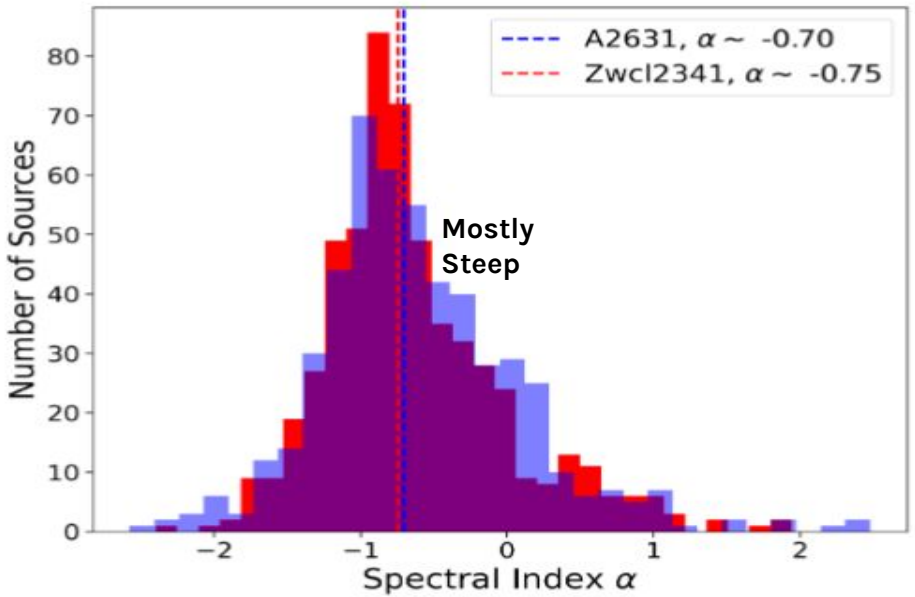
Astrometry



Spectral index distribution

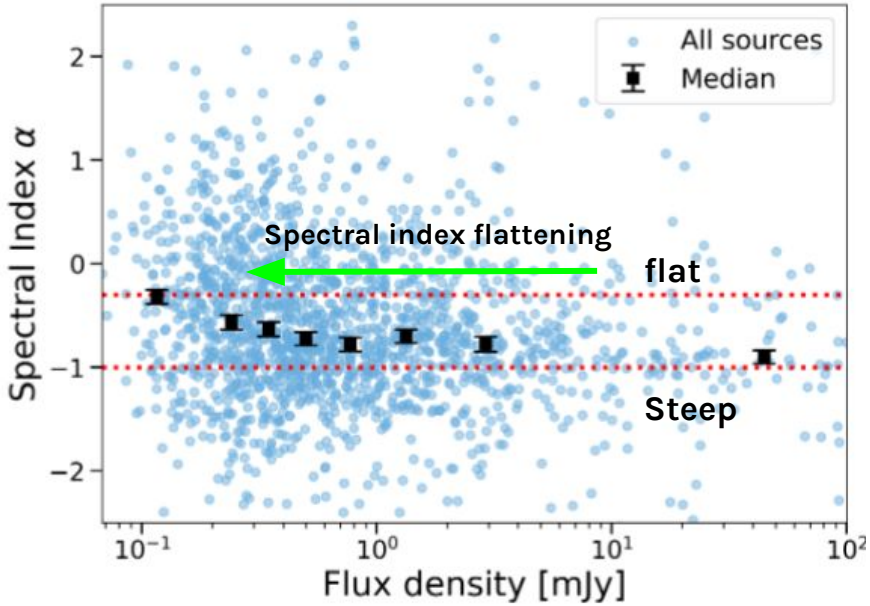
- Image cubes split into 3 at v1, v2, v3 = 0.8, 1.2, 1.6GHz to measure spectral index value.
- Steep (α~0.7/0.8) and flat (α~0.3/0.4) spectrum source classifications. Steep -> Synchrotron dominated emission. Flat -> Free-free emission mechanisms.
- At GHz frequencies sky is dominated by steep spectrum sources.

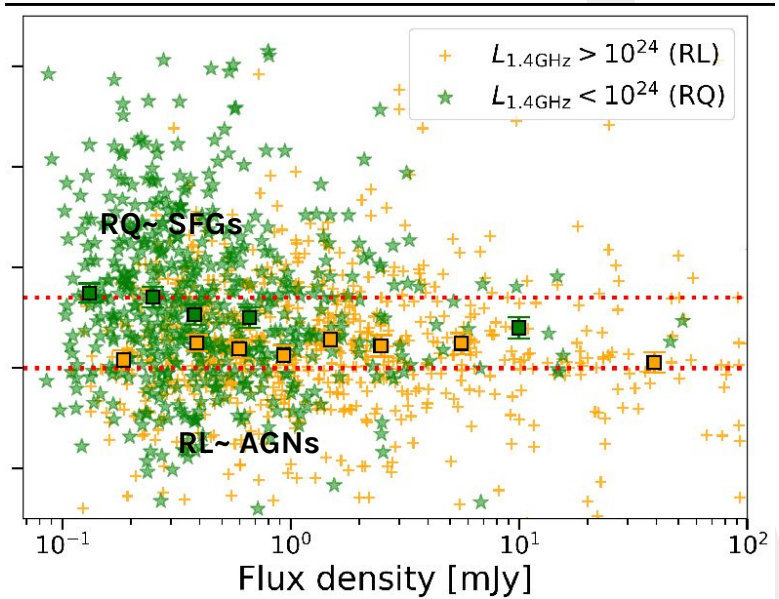




Spectral index as a function of flux density

- A trend of spectral index flattening towards brighter fluxes is observed.
- Clear seperation between radio loud (RL) and radio quiet (RQ) sources is observed.
- High luminosity sources are associated with AGN sources while low luminosity sources are associated with SF galaxies.

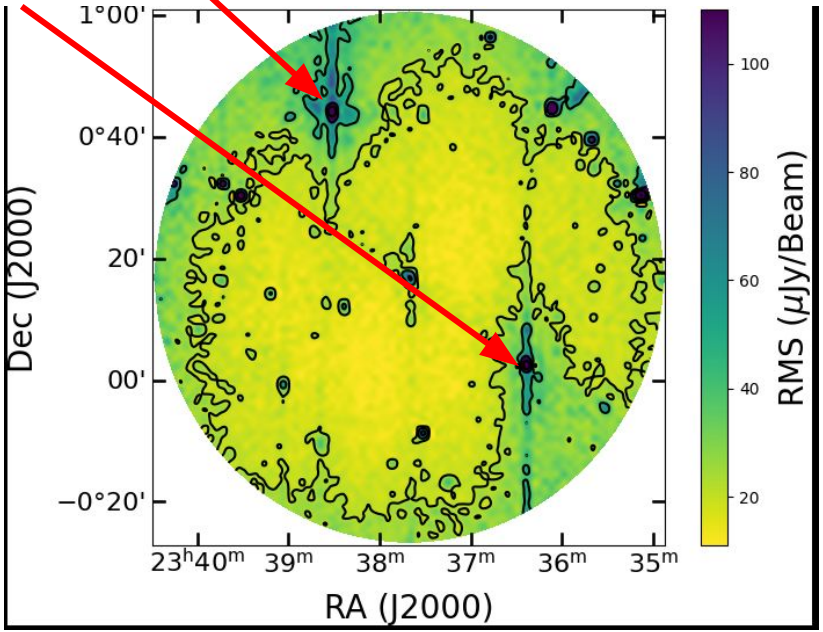


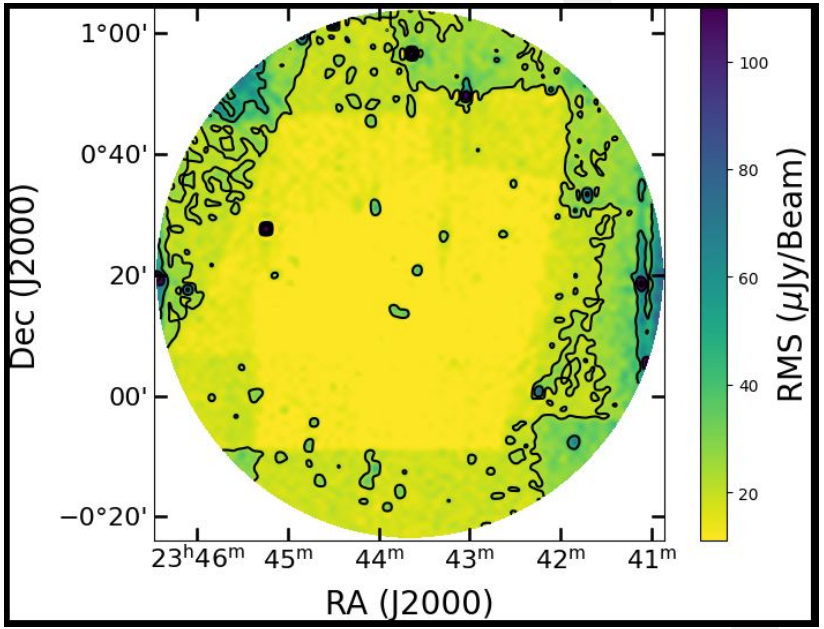


Completeness of radio catalog

- Radio catalogs contains several biases due to different instrument, source finding procedures, etc
- Sources in regions of high noise are more biased than sources in regions of lower noise.
- Faint sources near noise peaks can have their flux density dip below detection threshold.

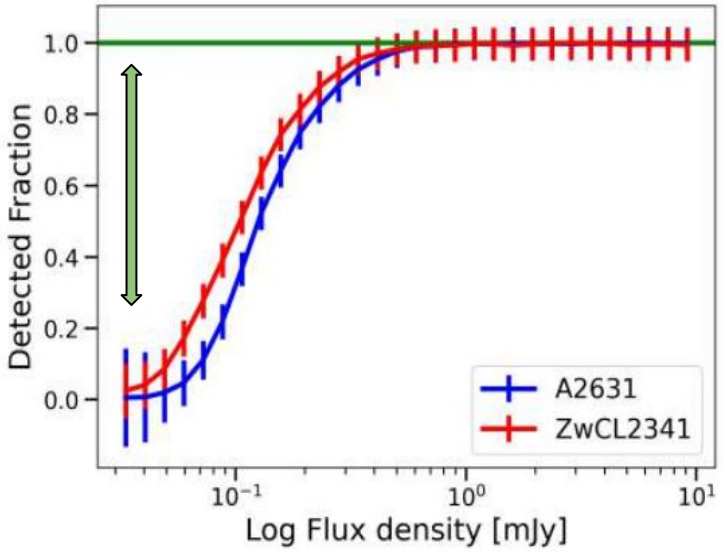
Noise peaks



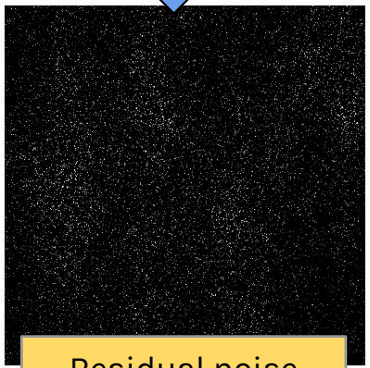


Estimation of correction factors

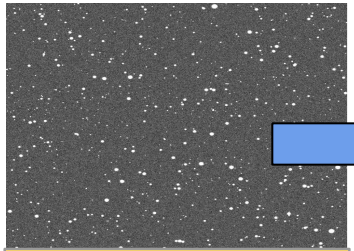
- Use radio simulations we can estimate the correction needed as a function of flux.
- Inject sources of known properties onto residual noise map.
- Find the ratio of injected sources with recovered.



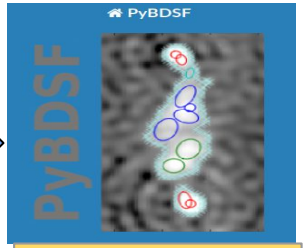
Injected sources



Residual noise



Simulated Image



Source finder parameters

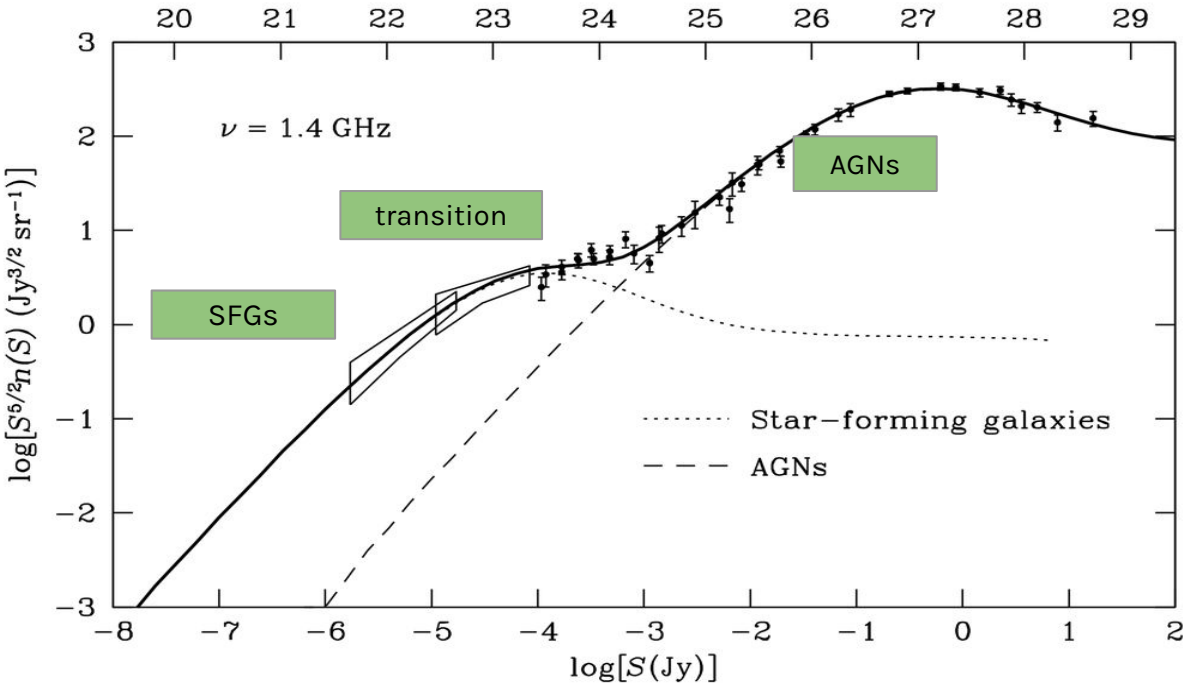
N Simulated catalog

N Injected catalog

EPFL SKACH

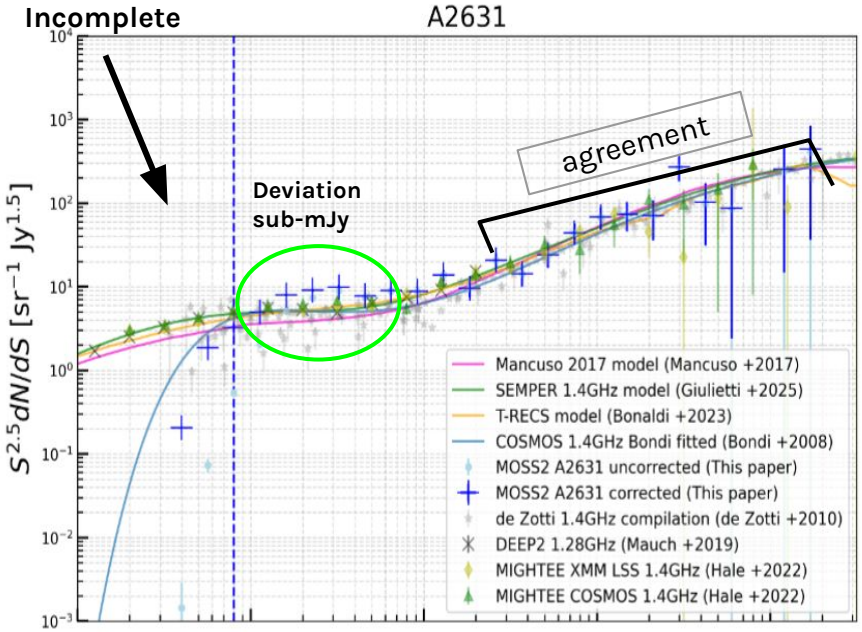
Radio source counts

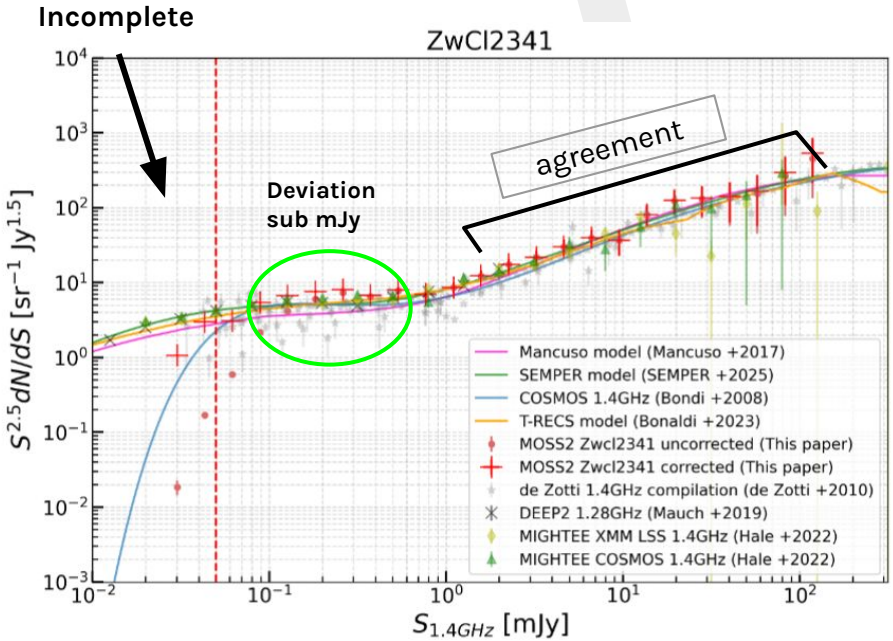
- Number of radio sources per unit area as a function of flux density -> source counts.
  - Gives information regarding relative galaxy populations existing in Universe.
- Inflection point ~ 1mJy signalling the emergence of a new population of SF galaxies.



Radio source counts for cluster observations

- Radio source counts plotted together with other MeerKAt data and simulated radio sky models.
- The counts show a good agreement for the bright end.
- Observed counts lie slightly higher at the transition region (0.1-1mJy) compared tothe other data.





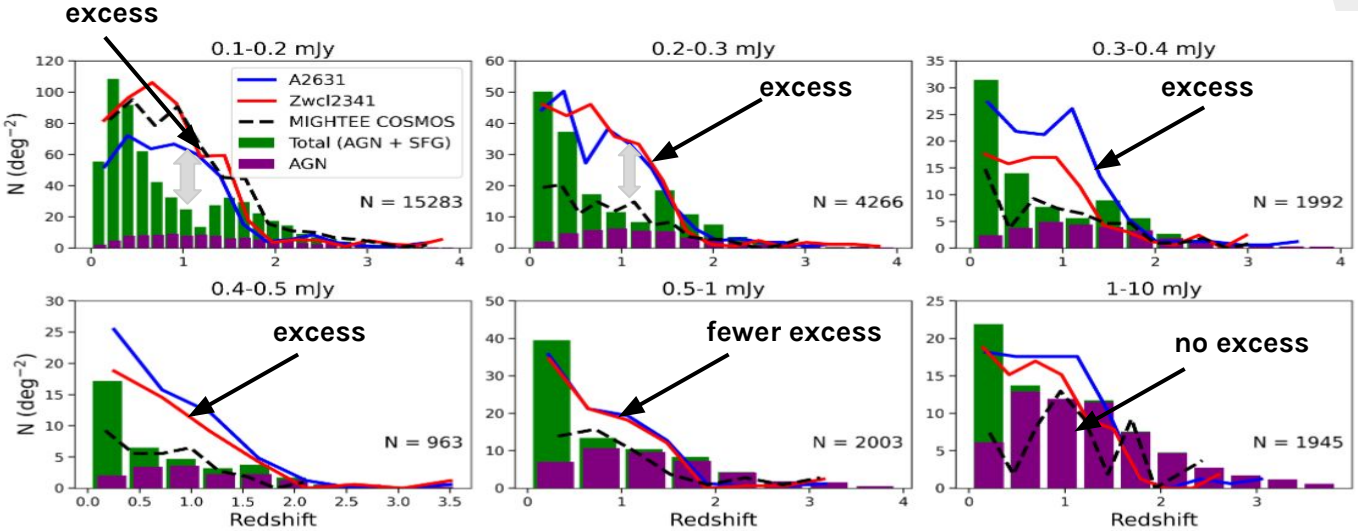
Redshift distribution comparison with evolutionary models

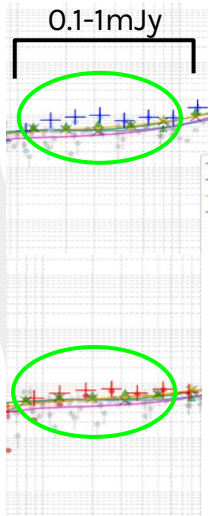
- Compare the redshift distribution of our sources with that of extragalactic radio simulations to probe deviation.
- Our radio data shows an excess of sources as compared with the extragalactic simulation and other MeerKAT data (of COSMOS).
- This is due to Cosmic variance -> non-uniform distribution of sources in the universe.
- Supercluster region contains different source population as compared to that of radio simulations and other data.

Simulated AGN+SF

Our data: A2631, Zwcl2341

MIGHTEE COSMOS ---





Thank you!