# The MeerKAT Absorption Line Survey
Measuring the cosmic radio dipole

Jonah Wagenveld (Max Planck Institute for Radio Astronomy)
Hans-Rainer Klöckner, Neeraj Gupta, Krishna Sekhar, Preshanth Jagannathan
and the MALS collaboration

The MeerKAT Absorption Line Survey

Observed **391 pointing** s centred on bright (>200 mJy) AGN in a blind search for OH and HI absorption lines, to constrain the evolution of cold gas in the Universe
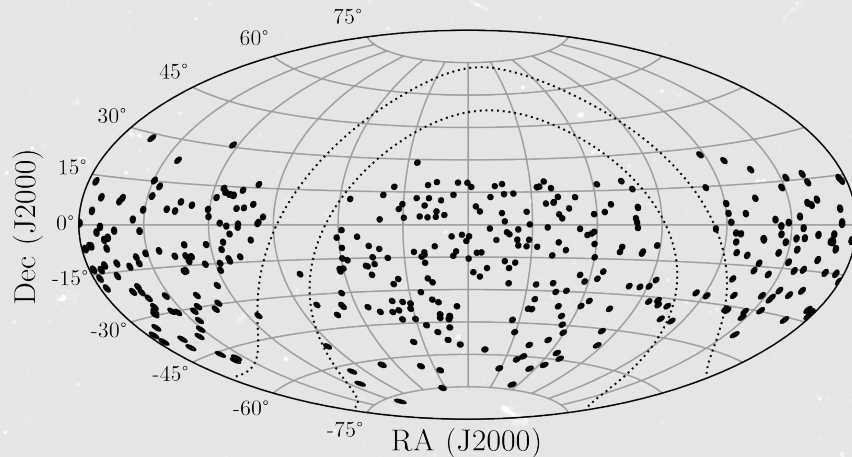
Credit: SARAO

Not only does MeerKAT have excellent sensitivity, it's **wide field of view** promises **thousands of sources per MALS pointing** , enabling a number of potential continuum science cases

MALS continuum

Continuum data are calibrated, self-calibrated and imaged with the **Automated Radio Telescope Imaging Pipeline** (ARTIP, Gupta+ 2021)

Source extraction performed with the **Python Blob Detection and Source Finder** (PyBDSF)

First data release: Catalogues from individual **spectral windows** (15 in total), each covering 60 MHz of 800 MHz bandwidth at L-band (Deka+ 2024), containing 715,760 unique sources

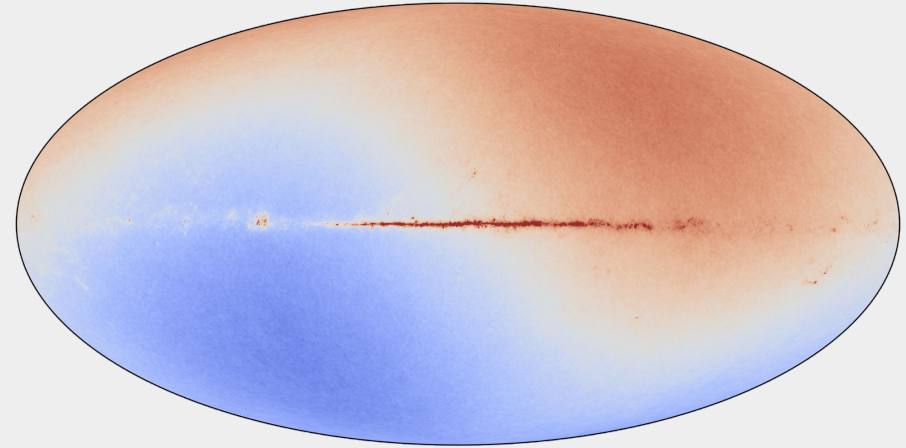Second data release: **full bandwidth!**

Wideband images

The cosmic radio dipole

Analogous to the dipole seen in the CMB, caused by the **movement of the observer**

Kinematic effects cause a dipole in the **number counts** of (extragalactic) radio sources (Ellis & Baldwin 1984)

Measurements of the radio dipole show agreement with CMB dipole in terms of direction, but **much larger amplitudes**
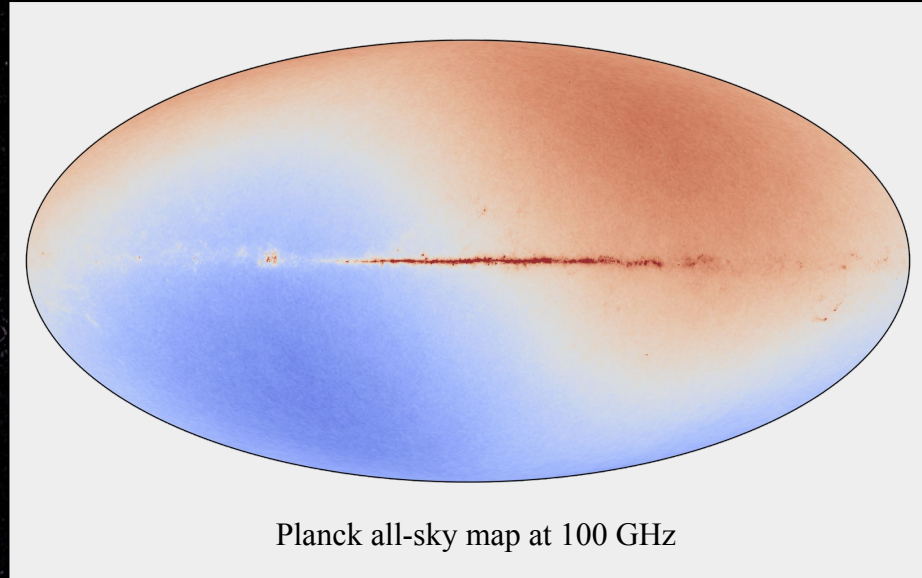

Planck all-sky map at 100 GHz

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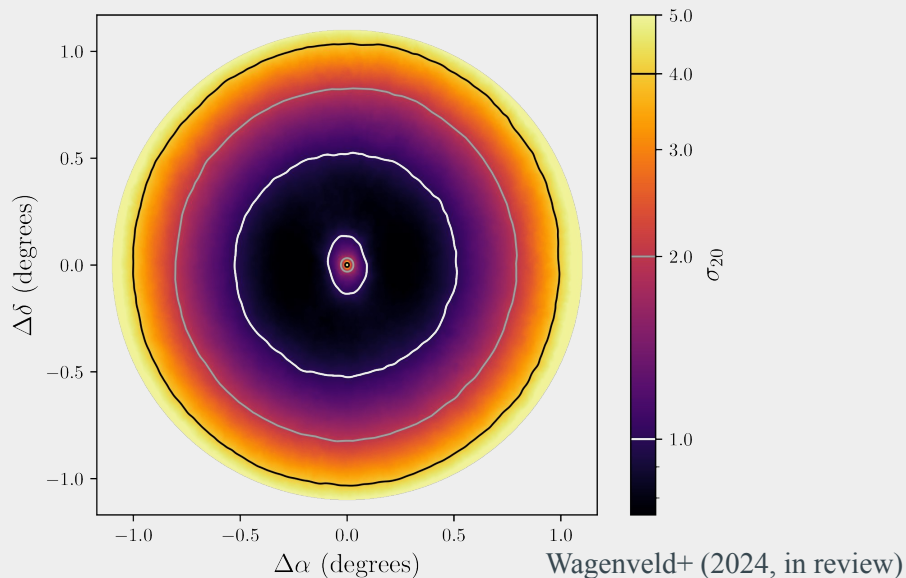
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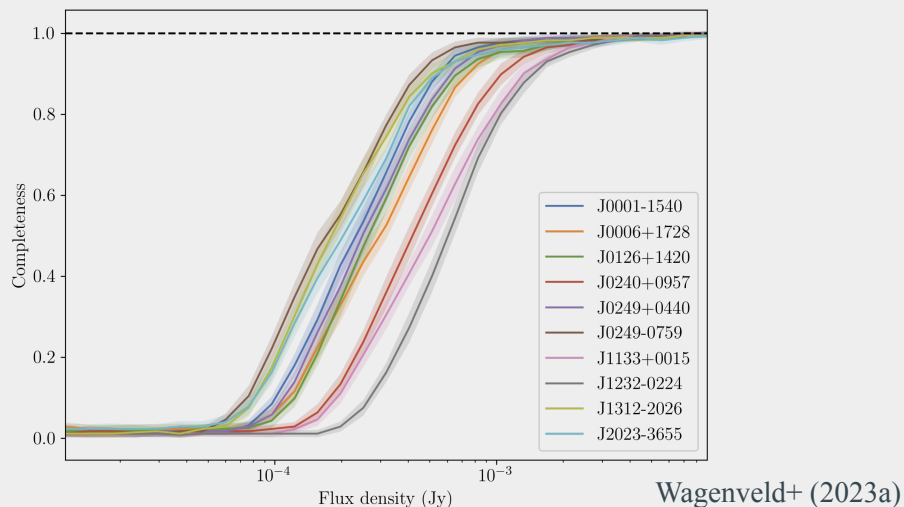

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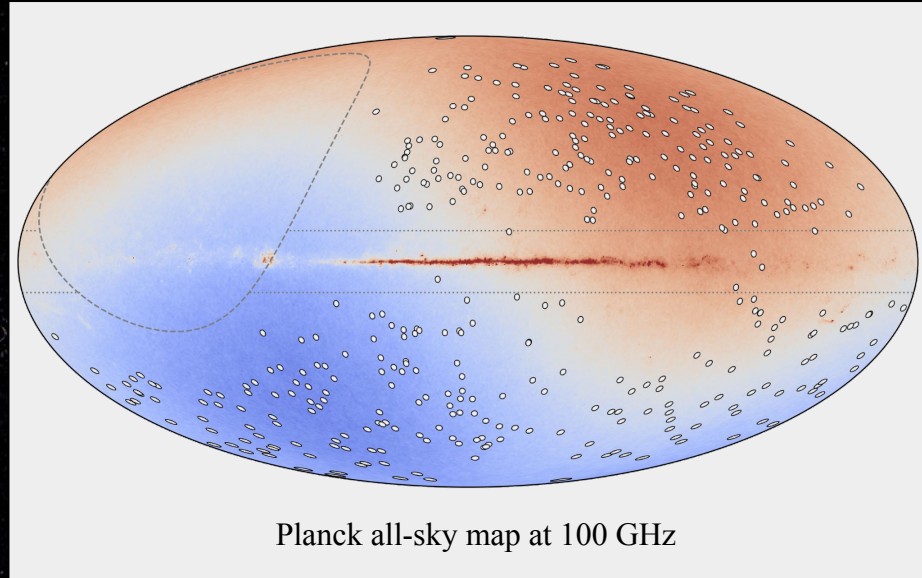
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Assuring homogeneity of the sample

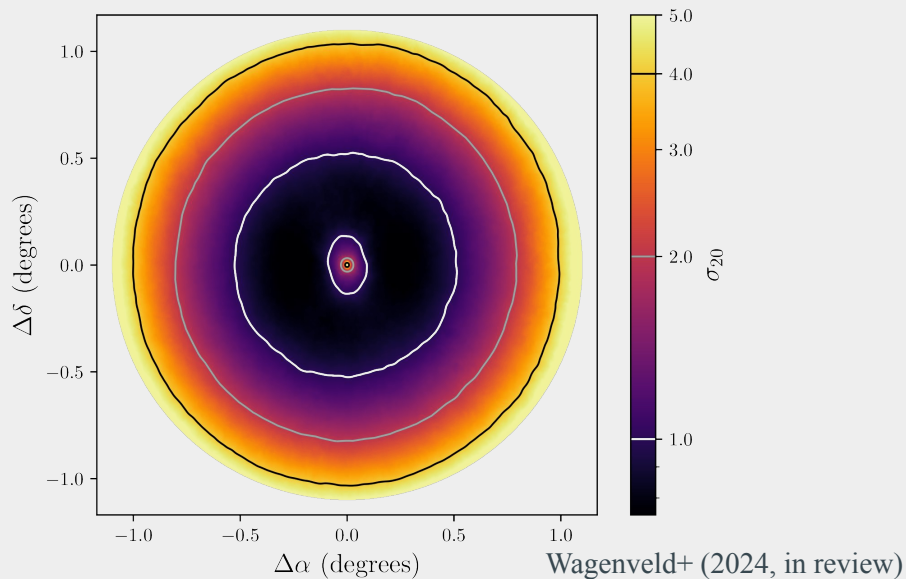Median stacking the rms maps of all pointings reveals their overall noise structure

Wagenveld+ (2024, in review)

Similarly, the completeness of pointings shows all pointings have **similar structure**, once **overall noise level** has been accounted for
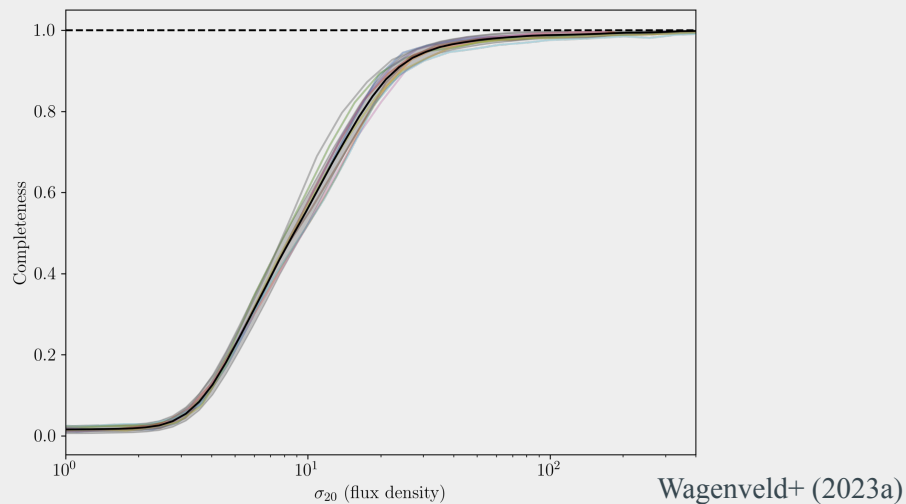

Wagenveld+ (2023a)

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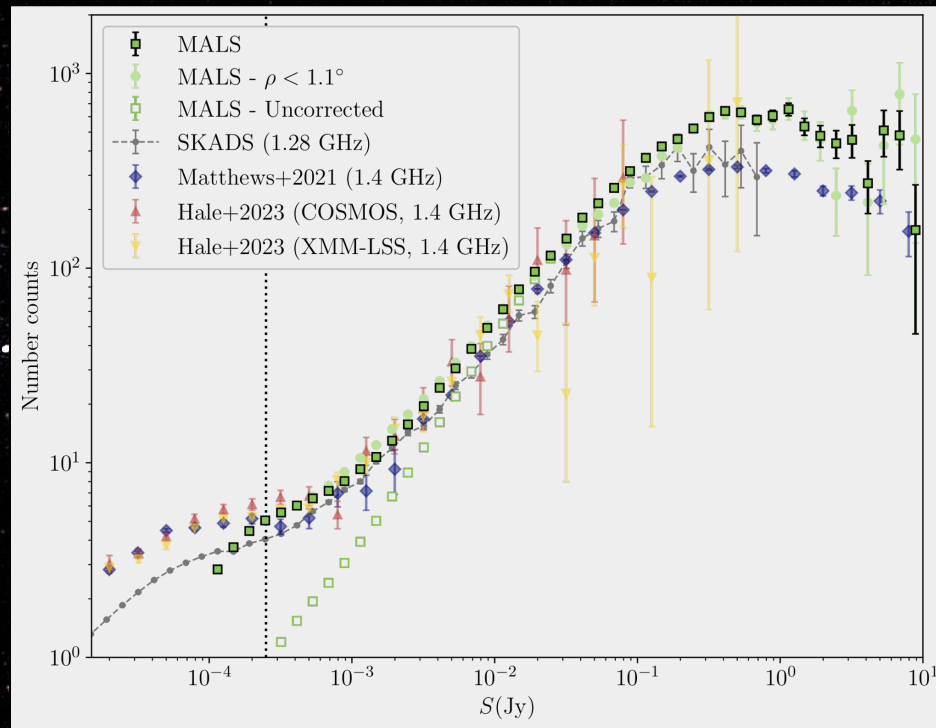

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Wagenveld+ (2023a)

MALS DR2 - wideband catalogues

➢ First ten full bandwidth pointings analysed in Wagenveld+ (2023a)

➢ MALS DR2 contains the wideband catalogues of all 391 pointings in L-band
  ○ Containing 971,980 sources
  ○ Covering 4344 square degrees
  ○ Down to 10 μJy/beam rms

➢ Largest continuum catalogue of any MeerKAT survey, robustly covering the radio source population down to 250 μJy.


Wagenveld+ (2024, in review)

Catalogue preparation for a dipole measurement

Make cuts in the full catalogue:

- Restrict sources to the 1.1 degrees from the pointing centre, minimising impact of direction dependent effects
- Exclude false detections
- Exclude pointings close to Galactic plane
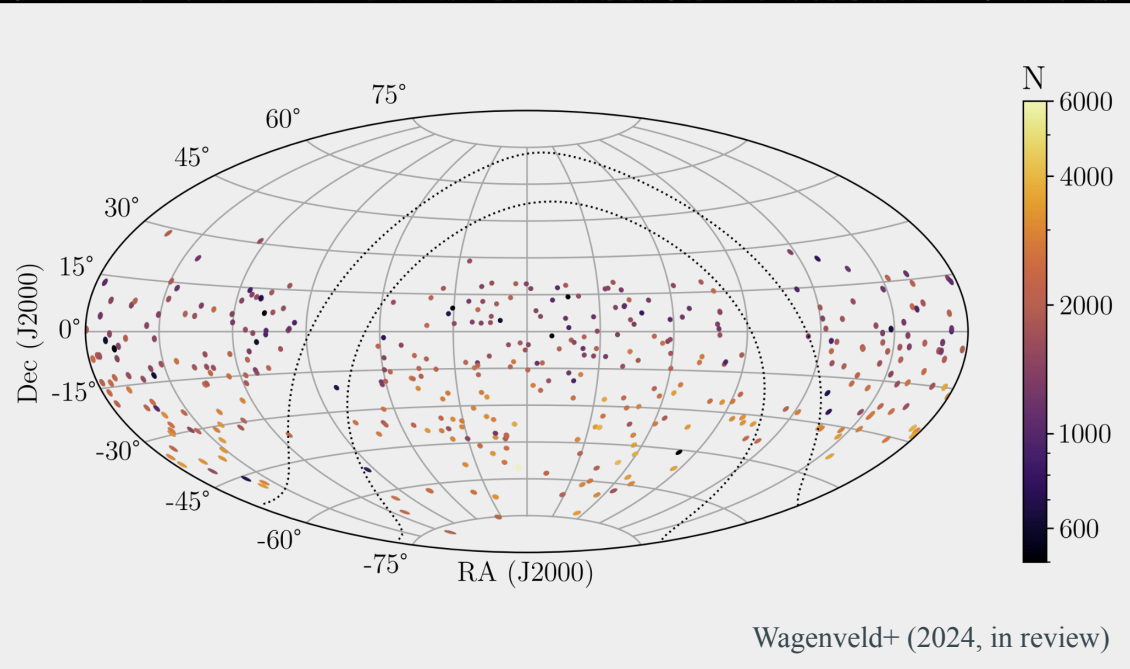- Exclude pointings with very high rms noise

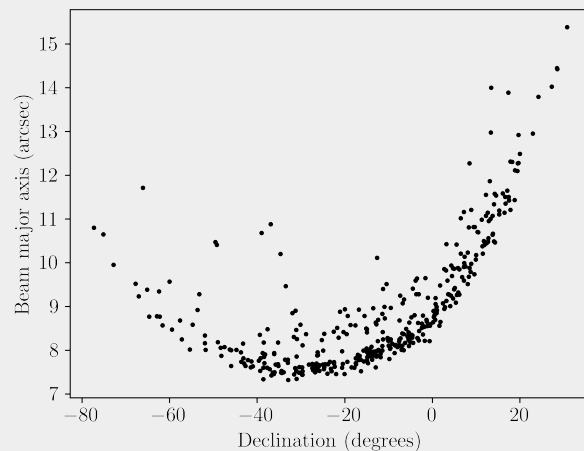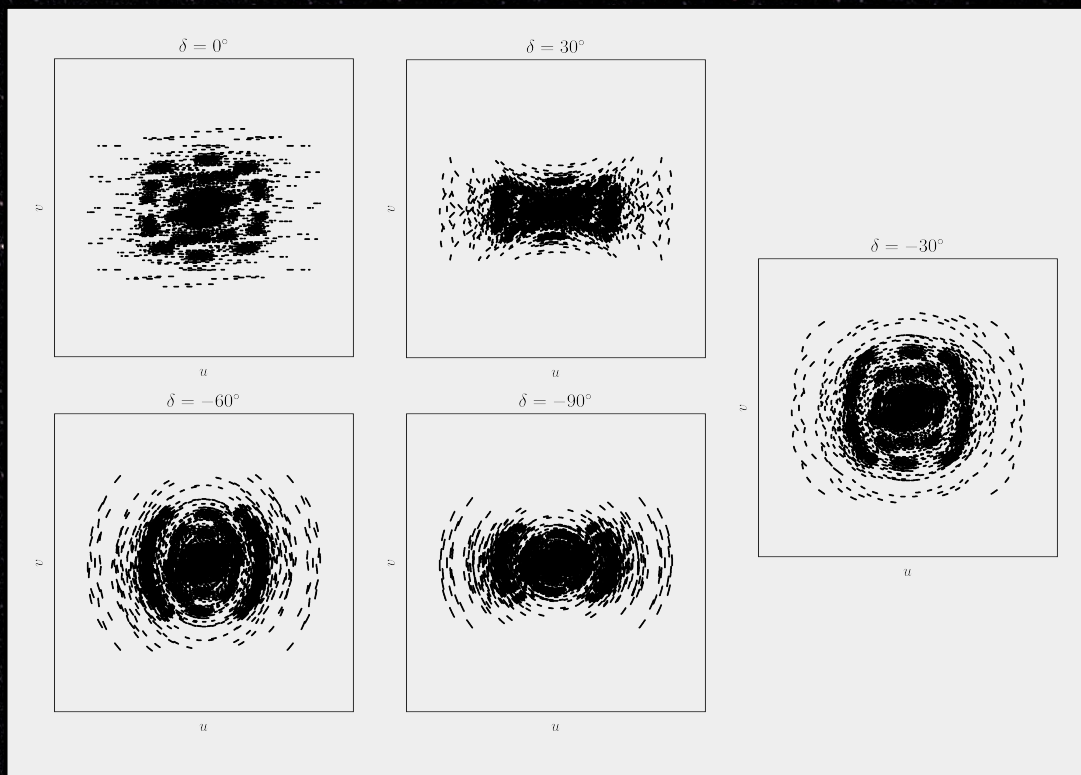This leaves 750,000 sources in 345 pointings
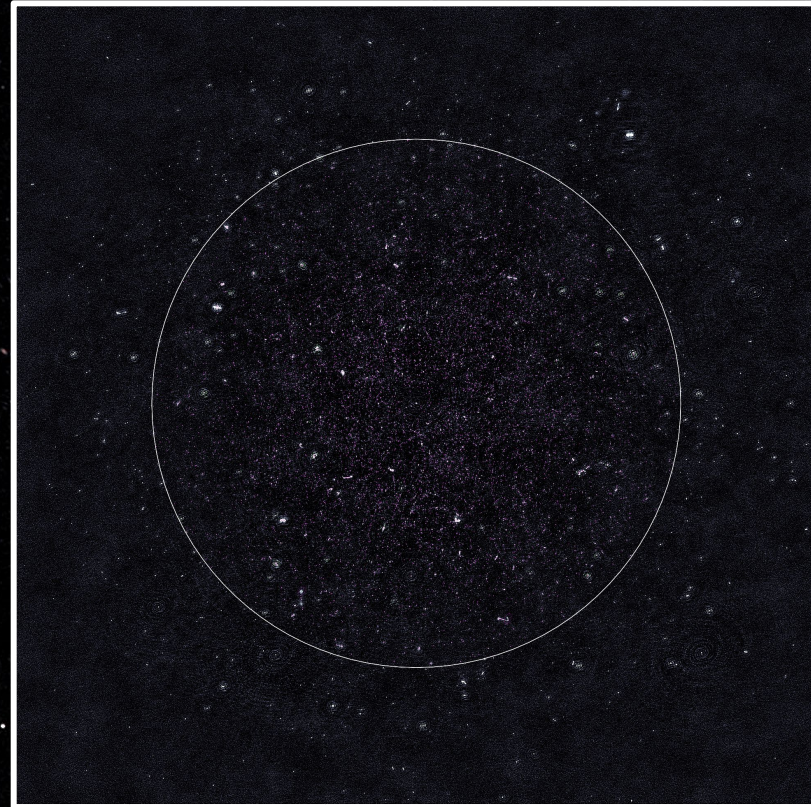
Pointing counts

Source counts per pointing show a **systematic variation in source density** as a function of declination, persisting above the completeness limit

This has to be taken into account during dipole estimation to **avoid biased estimates**

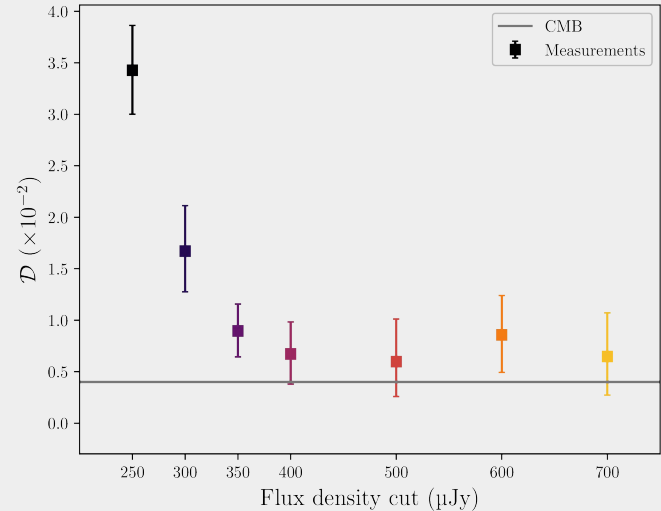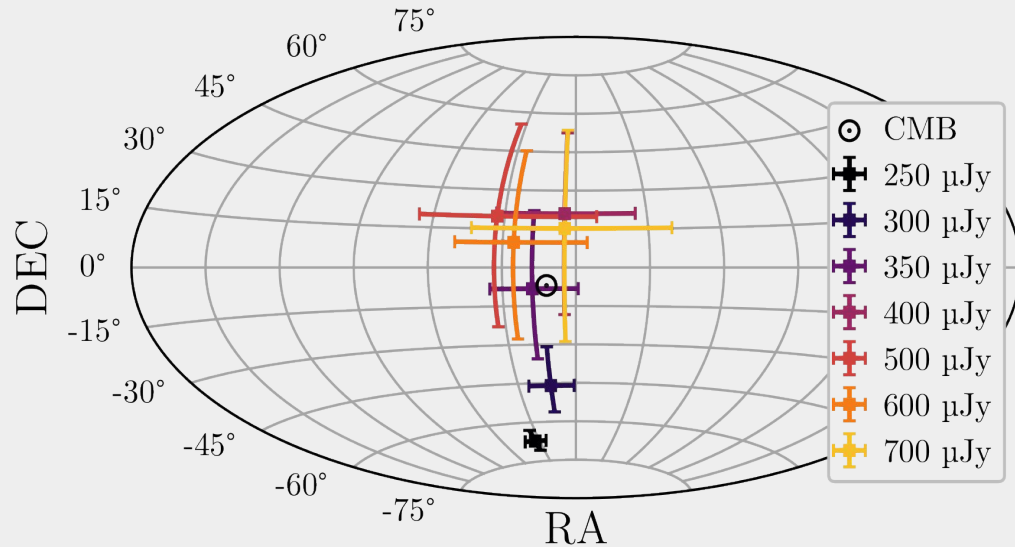Wagenveld+ (2024, in review)

UV-coverage and the beam

Major axis of the beam of the images follows a similar **relation** that we already saw in our source counts - only **inverted**

Results

Fit for a linear relation between the **major axis of the synthesised beam** and source counts. The new measurements are **consistent for different cuts** in the data. The direction converges towards the direction of the CMB dipole, and unlike previous findings, the **amplitude as well!**

The sub-mJy source population

Star-forming galaxies **contribute significantly** the dipole signal at our sampled flux densities. The consequence of this is not clear, but it might explain our results.
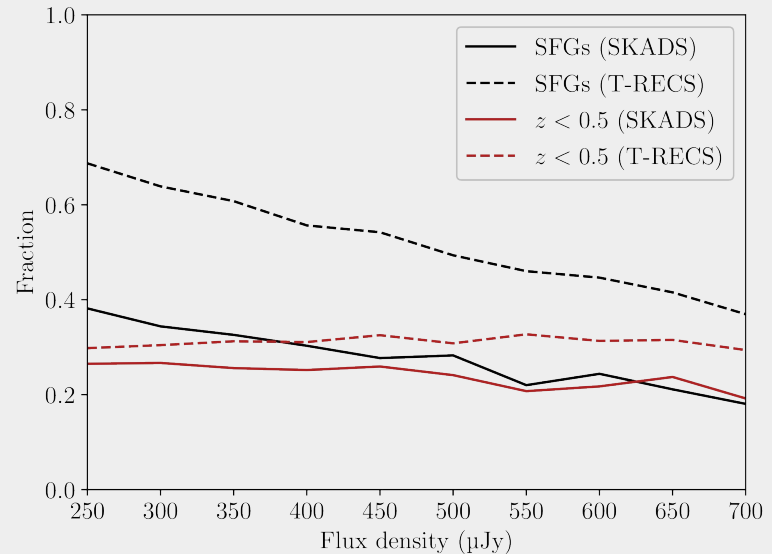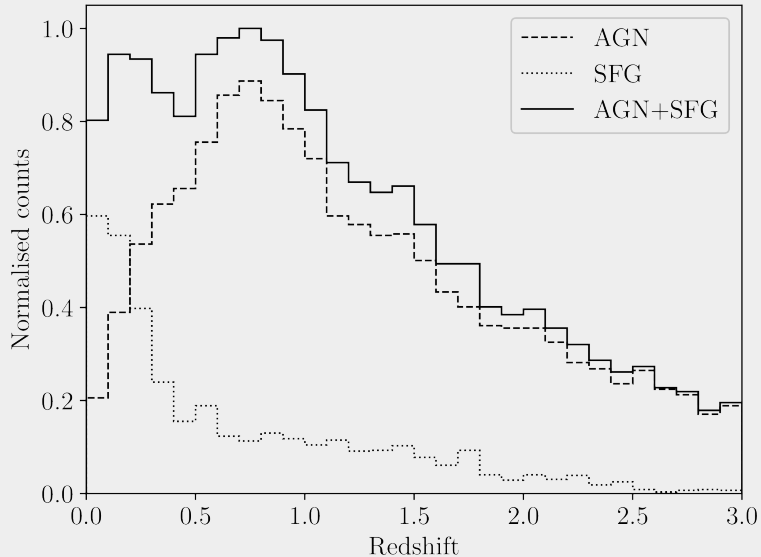
Summary

➢ MALS DR2 is the largest catalogue of radio sources produced by MeerKAT survey, containing nearly a million sources in 391 pointings
➢ With it, we perform a dipole measurement
➢ Accounting for systematic effects, we measure a dipole with both direction and amplitude **consistent with the CMB expectation**
➢ This unexpected result could be caused by the population of **faint SFGs** in the survey
➢ Demonstrates possibilities of MALS continuum in statistical populations studies
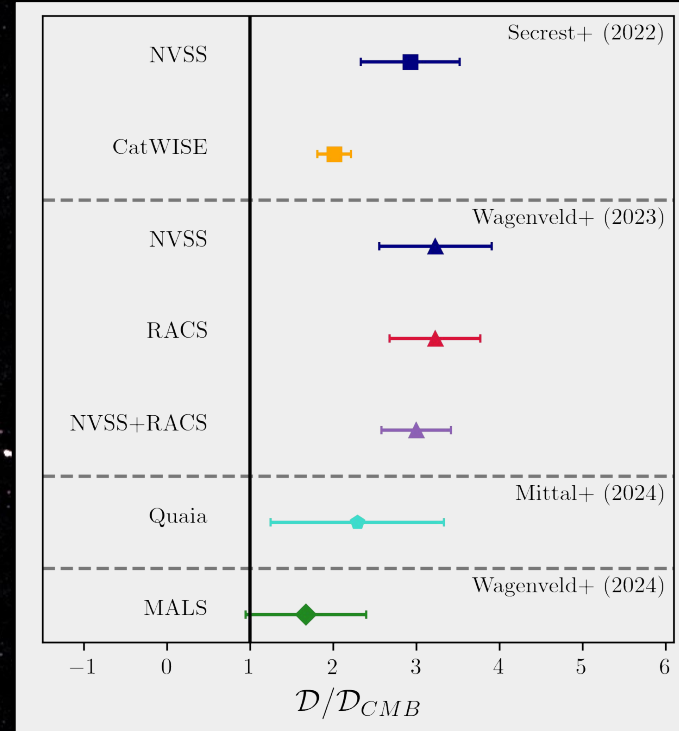
Try MALS for your science!

A beta release of MALS DR2 is now available!
Full release along with publication of Wagenveld+(2024)

- Catalogue and image search
- Full catalogues
  - Sources
  - Gaussian components
- Images of individual pointings
  - Stokes I
  - Spectral index

mals.iucaa.in