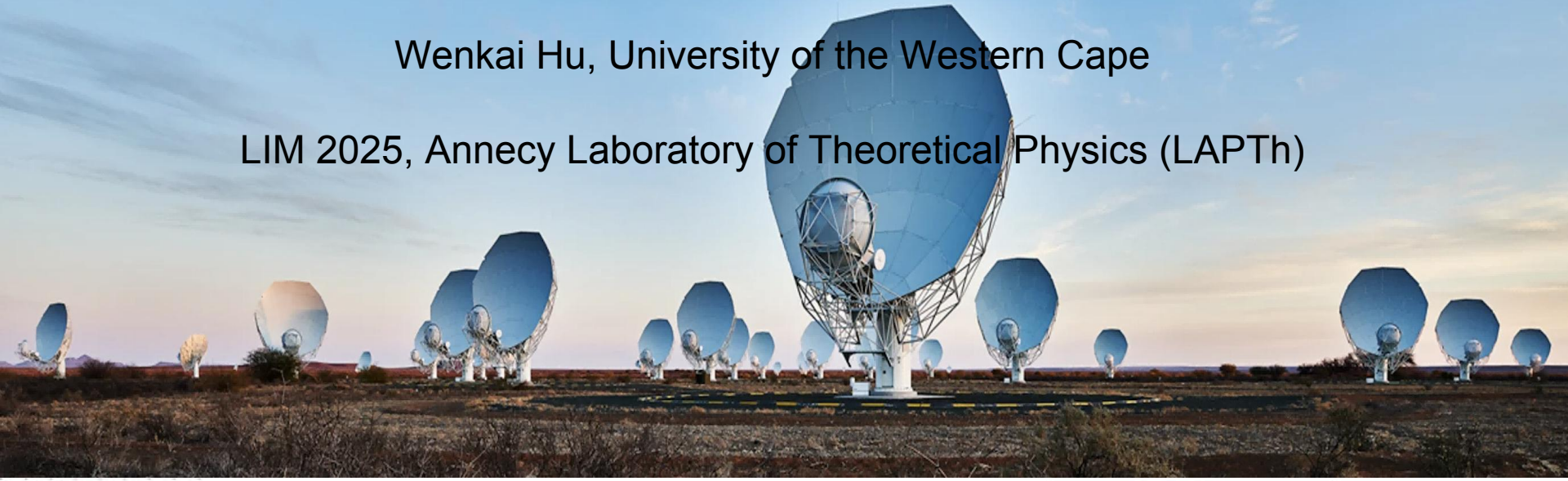
MeerKLASS:
MeerKAT Large Area Synoptic Survey

Wenkai Hu, University of the Western Cape

LIM 2025, Annecy Laboratory of Theoretical Physics (LAPTh)



CRC

UNIVERSITY of the WESTERN CAPE

UWC ASTROPHYSICS

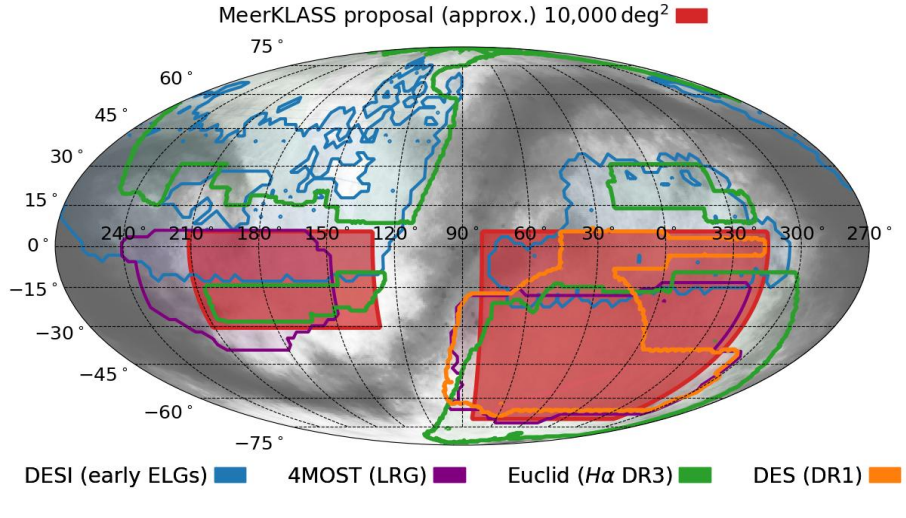
NRF National Research Foundation

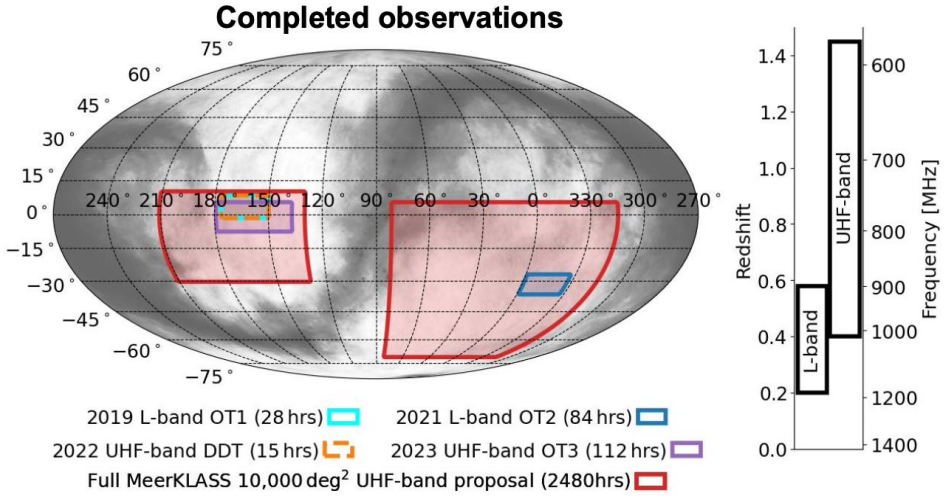
SARAO South African Radio Astronomy Observatory

MeerKLASS: MeerKAT Large Area Synoptic Survey

- Aim: Cosmology (HI intensity mapping) but commensal with lots of other science (continuum survey)
- Covering L-band (900-1670MHz, z<0.57) and UHF band (580-1015MHz, z ~ 0.4-1.45)
- Focus on sky patches with multi-wavelength data for cross-correlation
- Goal: 2,500 hours over 10,000 deg2 within next 4 years
- The leading radio Cosmology survey in preparation towards SKA1-MID
- International collaboration

S.Cunnington



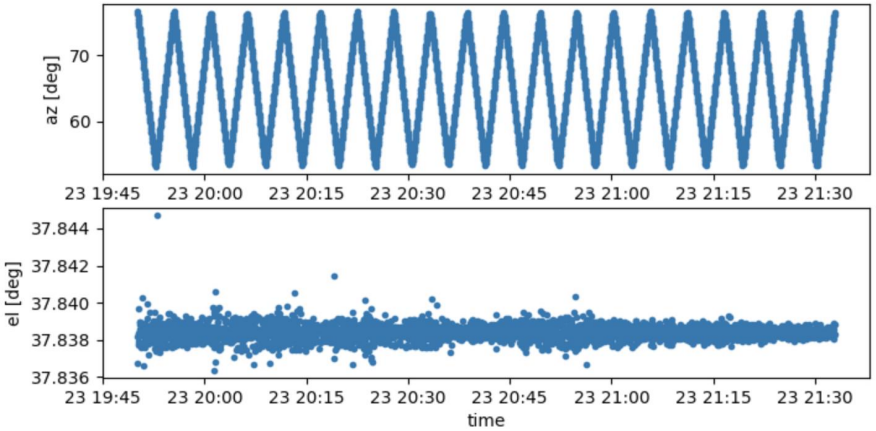


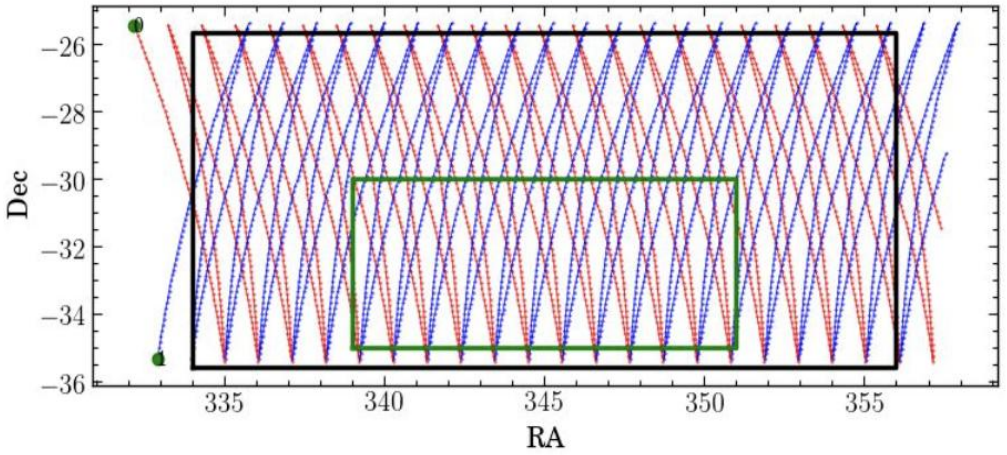
Survey Strategy

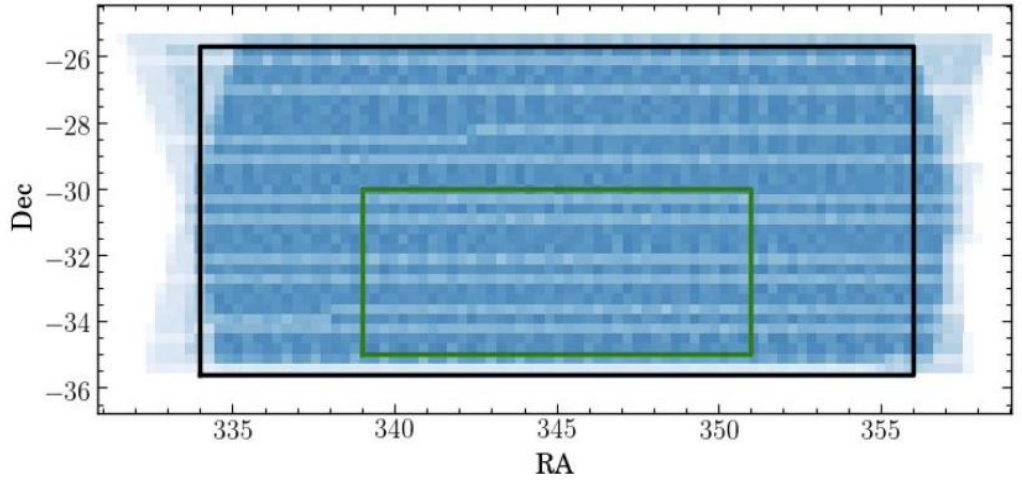
Resonable fast scanning strategy (5 arcmin/s): maximize the stability of the telescope, keep gain fluctuations (1/f noise) to a minimum

Scan the sky back and forth at constant elevation: minimise any time-varying effects due to ground pickup

2 sec resolution, ~2 hour per scan: pointing centre moves only by ~ 1/5th of the primary beam

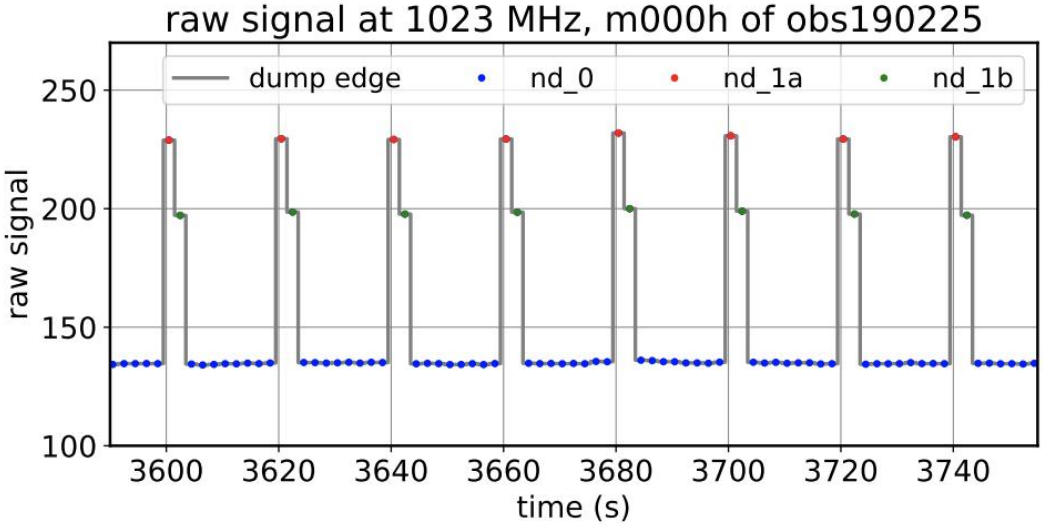


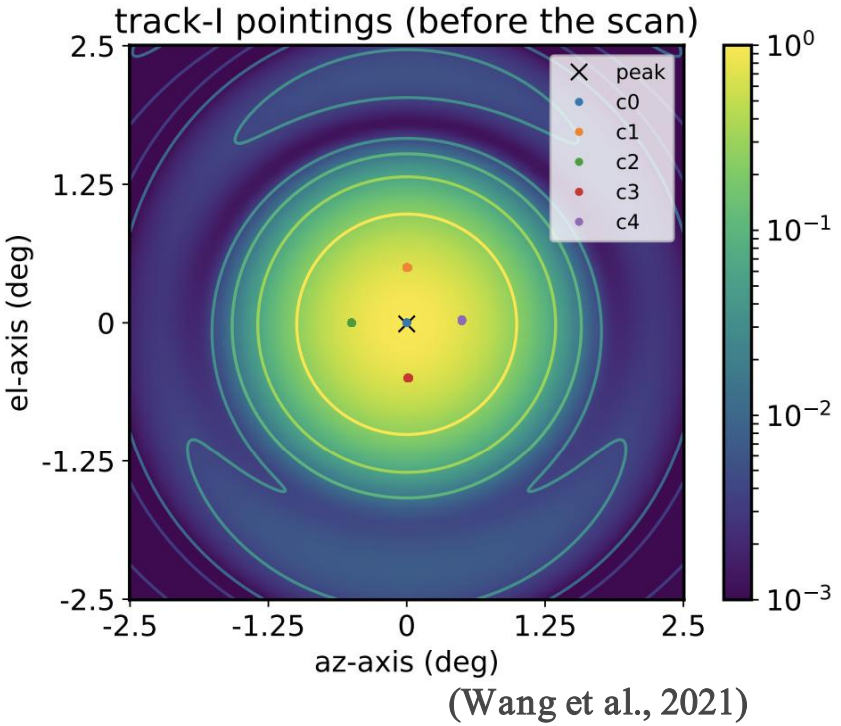




Calibrator Calibration

Observe a calibrator before and after each scan (right)
Noise diode injection every 20 sec during scan (Below)
Using Synch model





(Wang et al., 2021)

nd_0 (time dumps without diode injection), nd_1a (the first dump with injection) and nd_1b (the second dump with injection).

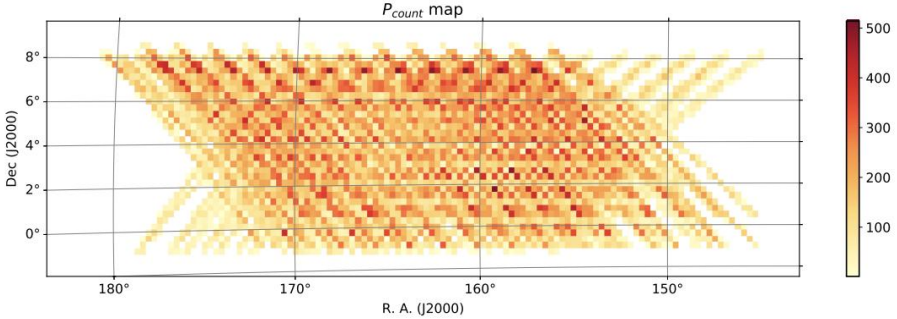
Pipeline and Some Results

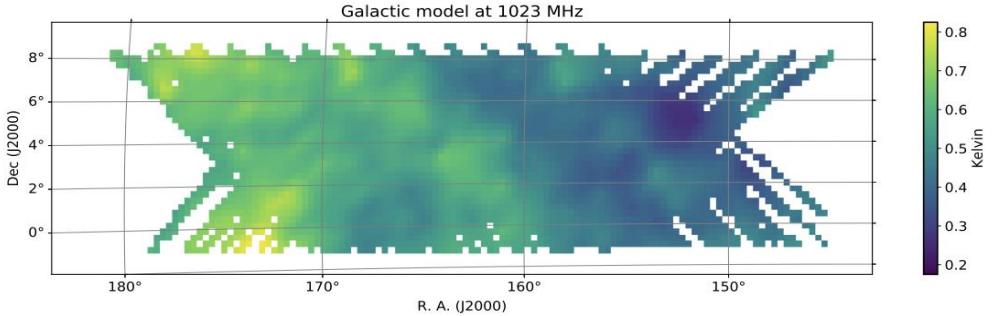
KATcali

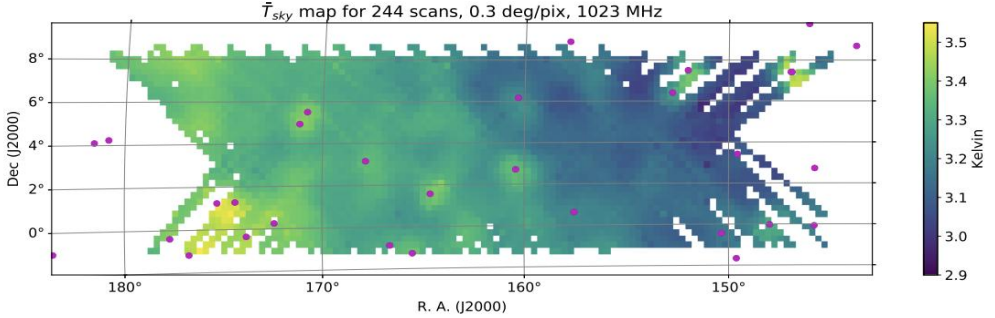
1. use the flux model of a strong **point source** during tracking observations to calibrate the bandpass and absolute flux, as well as the **injection power of the noise diode**.

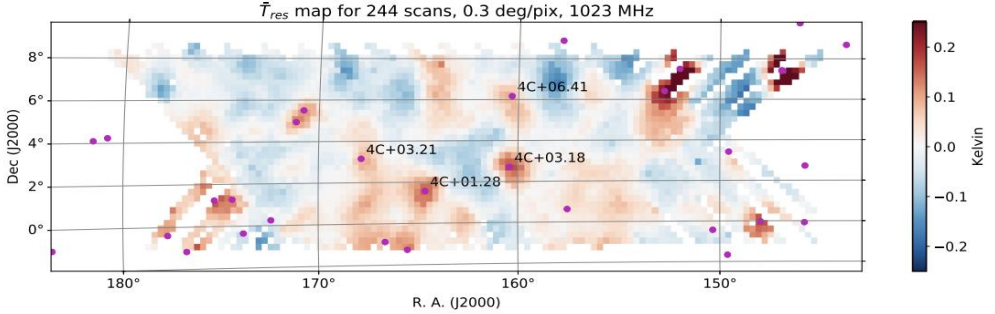
2. uses the **noise diode injections** to calibrate the **time ordered data** during the constant-elevation scanning phase. This is done per frequency, per dish per polarisation and for each individual scan.

calibration results for 2019 data (Wang et al., 2021)

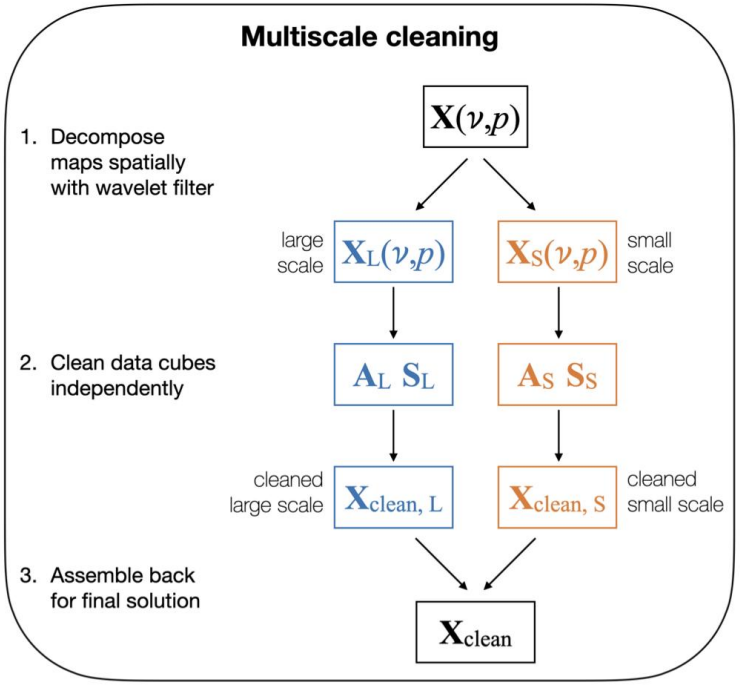


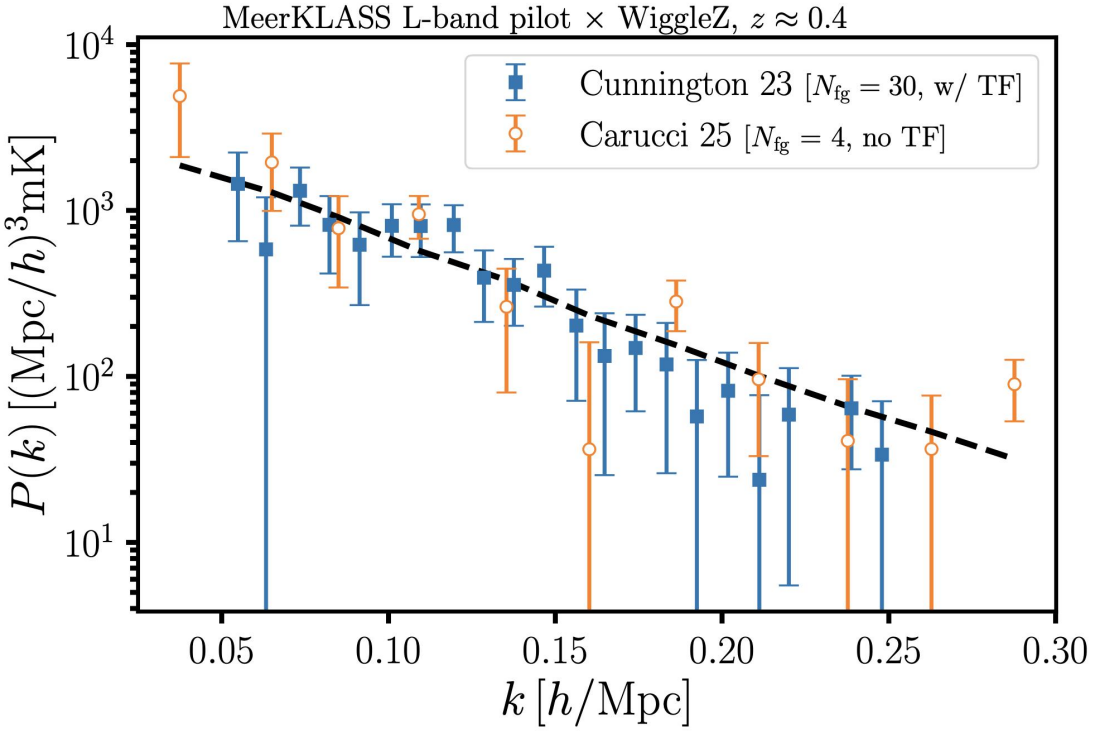






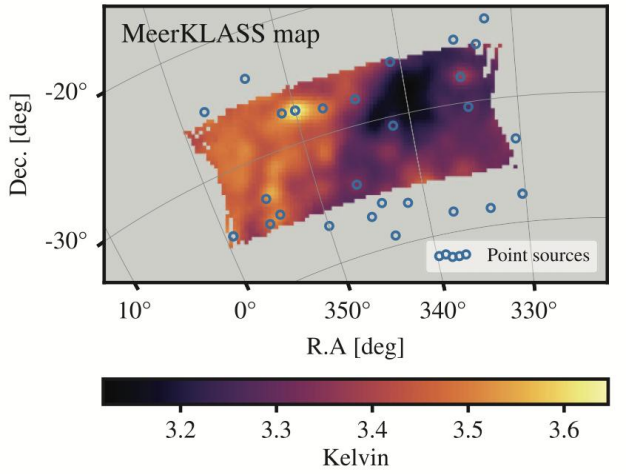
MeerKLASS studies

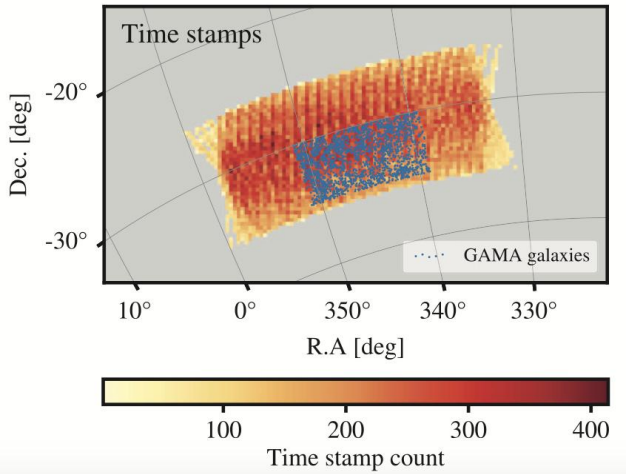


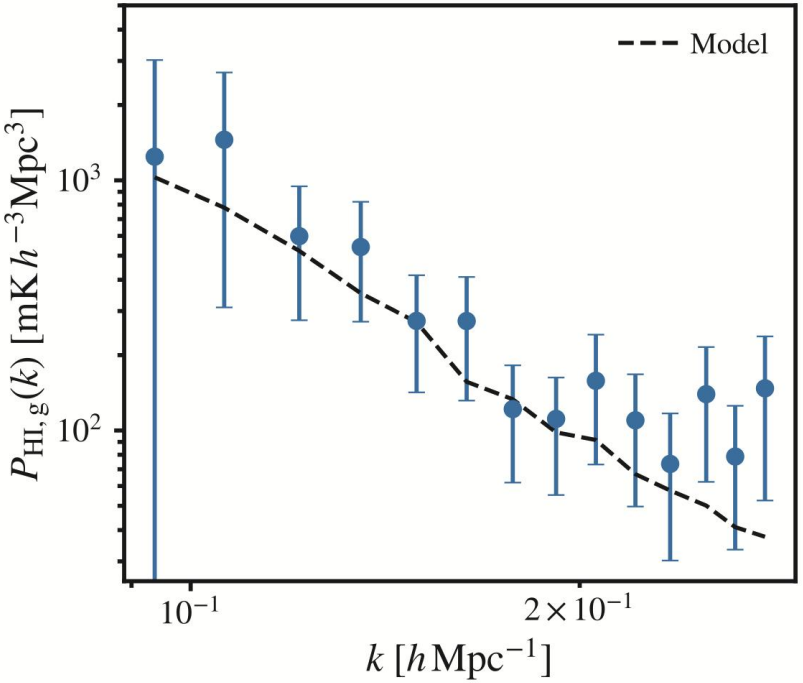


Carucci 25 100 deg2 at redshift $z \approx 0.4$ collected by the MeerKAT, with a combined 10.5-hour observation

MeerKLASS studies







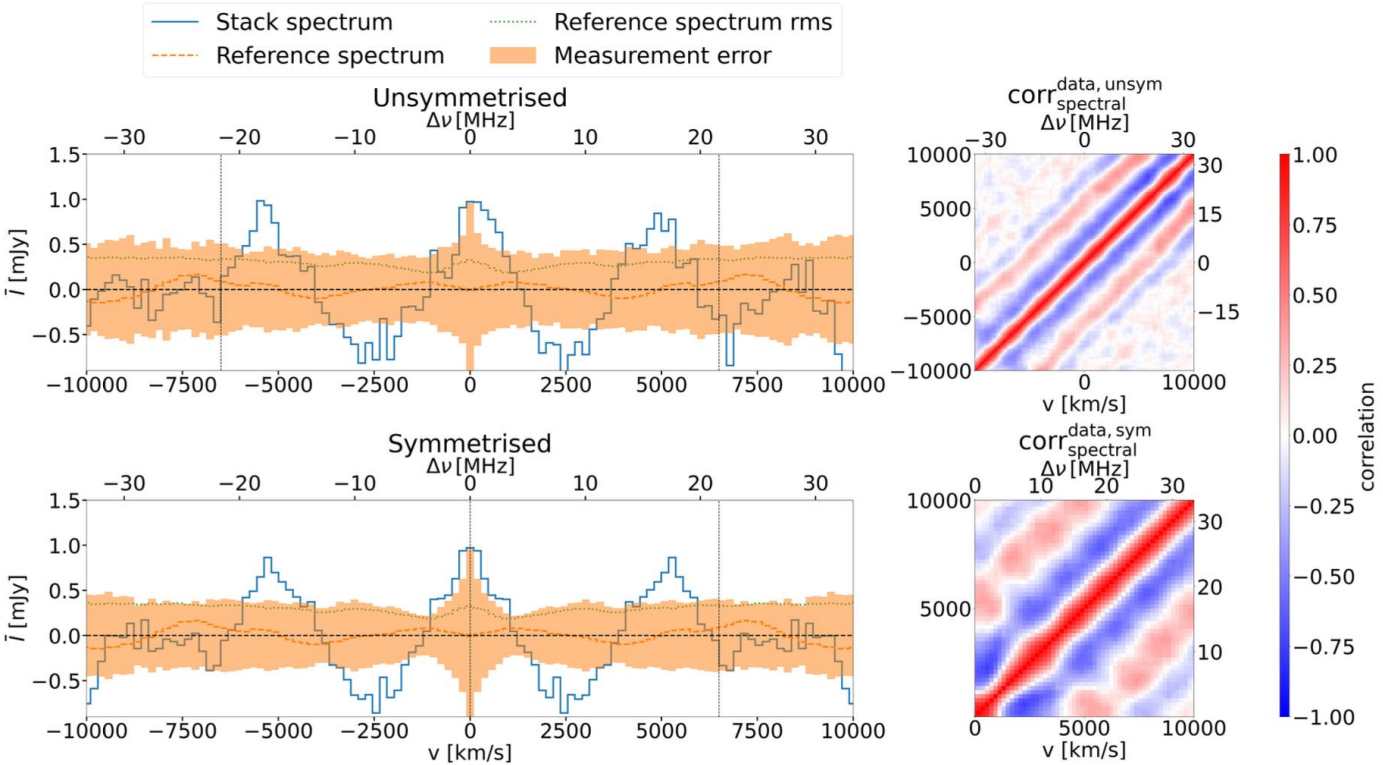
MeerKLASS Collaboration 2025

41 repeated scans over 236 deg2,

62 h of observation for each of the 64 dishes before flagging.

$0.39 < z < 0.46$ ($971\ \mathrm{MHz} < \nu < 1023\ \mathrm{MHz}$)

MeerKLASS studies



Zhaoting Chen 25

stacked spectrum exhibits an oscillating component of systematics

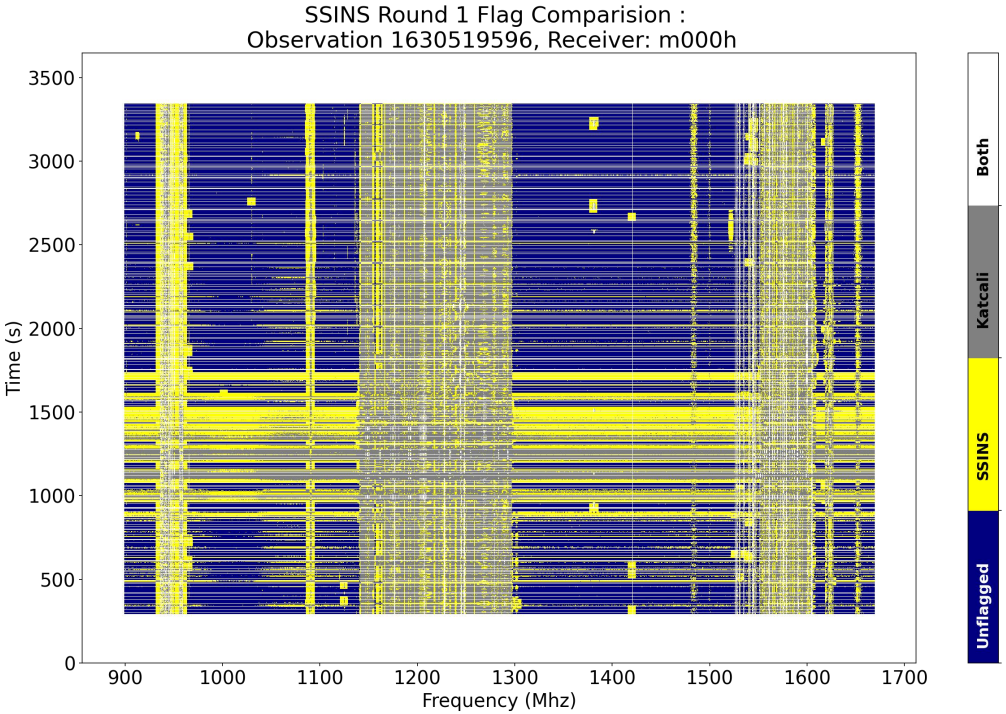
Upper left panel: The measurement of the stacked spectrum of the MeerKLASS L-band deep-field data over the GAMA galaxies (“Stacked spectrum”).

Upper right panel: The estimated correlation matrix.

Lower left panel: The same as the upper left panel, but the stacked spectrum is symmetrised.

Lower right panel: The estimated correlation matrix for the symmetrised spectrum.

MeerKLASS studies



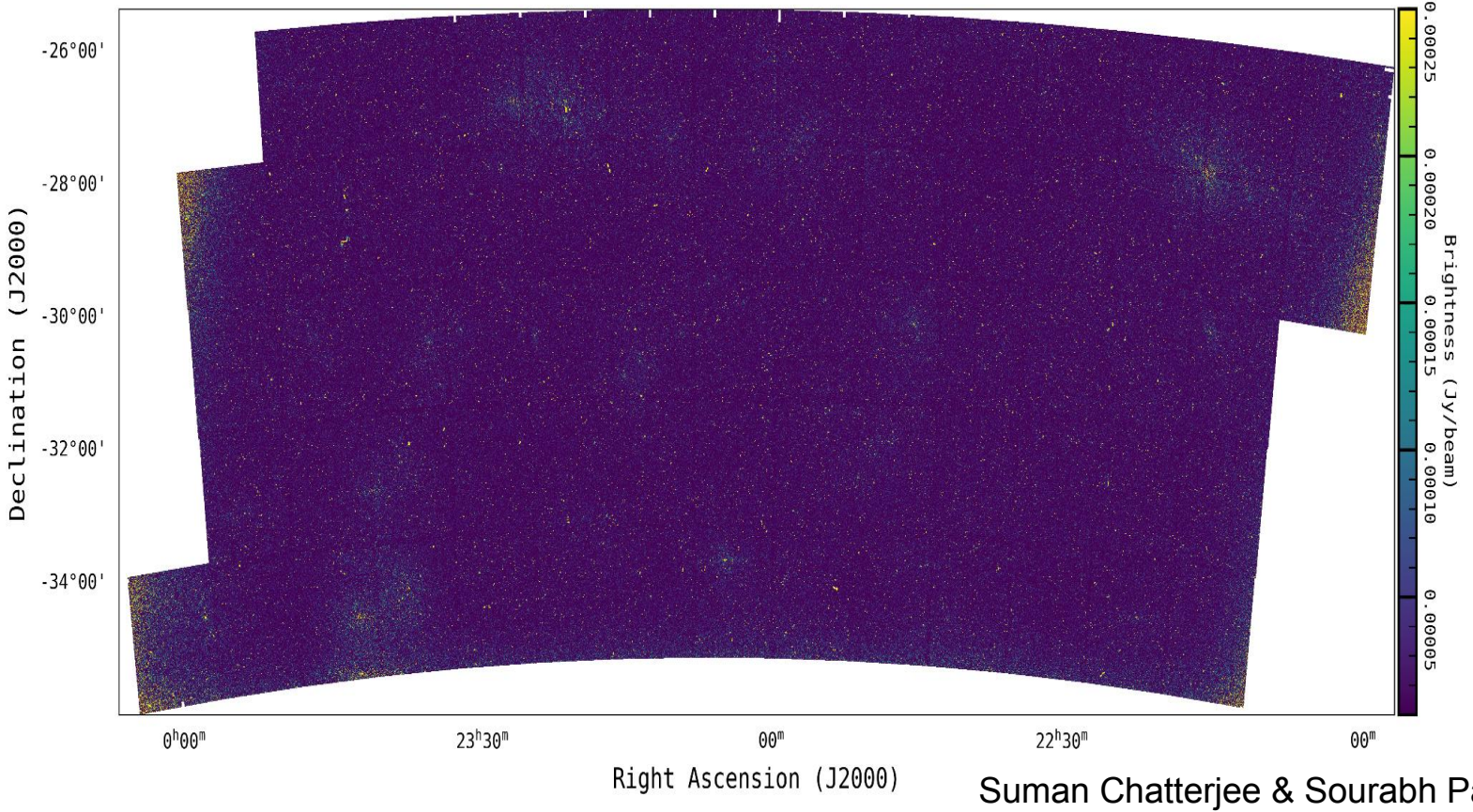
TAmera Kassie

the detection and mitigation of faint RFI in MeerKLASS datasets using a statistics-based algorithm known as the **Sky-Subtracted Incoherent Averaged Spectrum** (*SSINS*).

When applied to MeerKLASS L-band data, the algorithm has demonstrated the ability to flag both well-known RFI regions and potential undetected low-level RFI in the visibilities.

MeerKLASS studies

268 square degree



53215 Sources with SNR> 5

18313 Sources with RACS-UHF

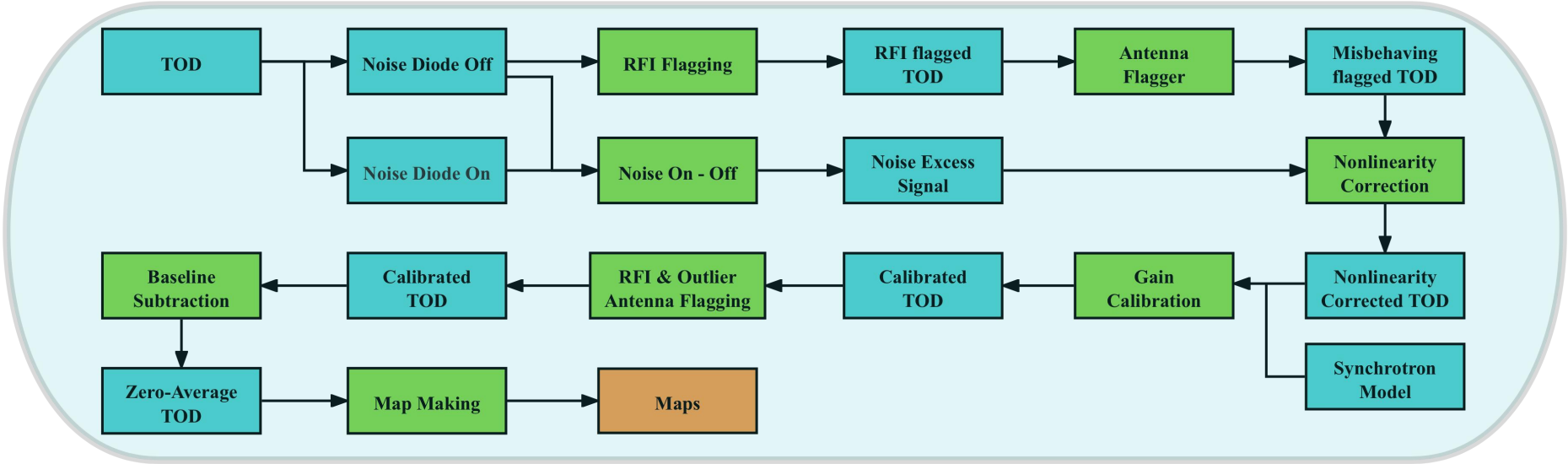
20589 Sources with RACS-MID

6835 Sources with NVSS

Suman Chatterjee & Sourabh Paul

Pipeline for UHF band

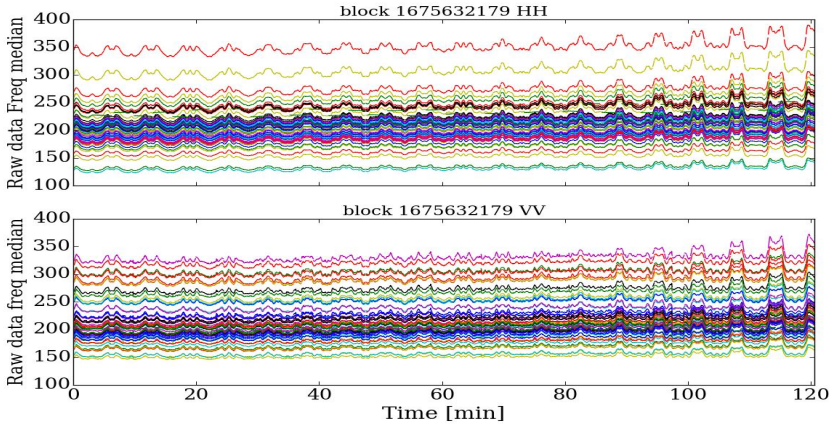
Museek (Multi-dish Signal Extraction and Emission Kartographer) :
a flexible, modular and easy-to-extend data processing pipeline for multi-instrument autocorrelation radio telescopes.

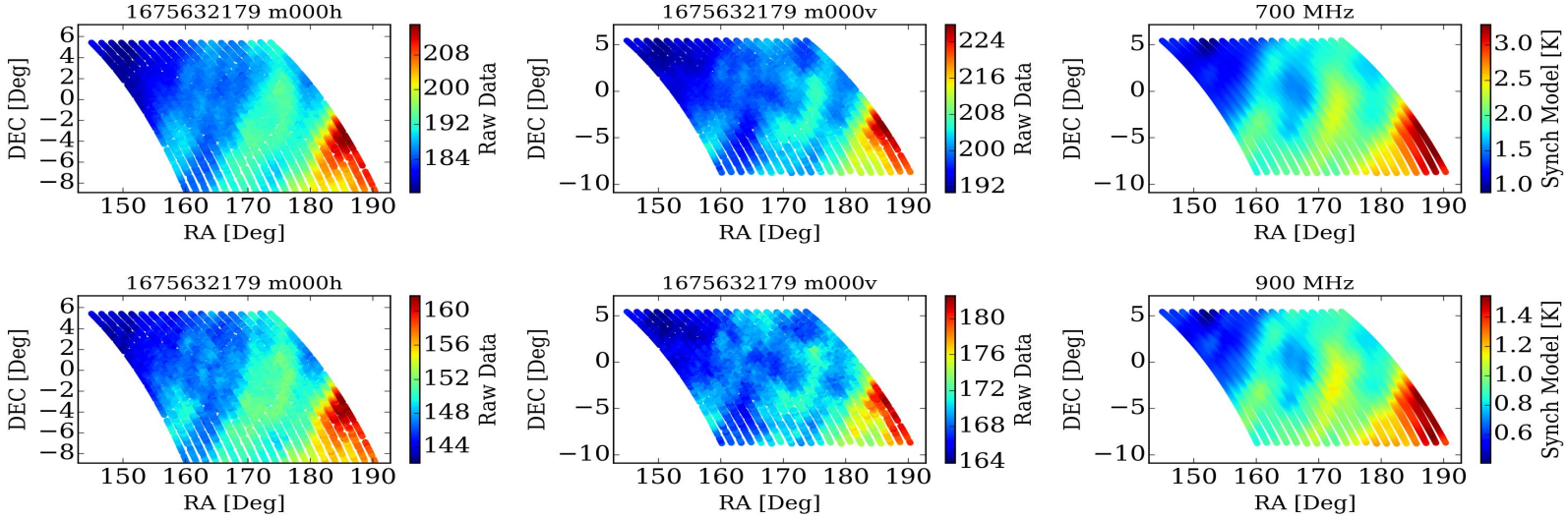


Calibration for UHF band

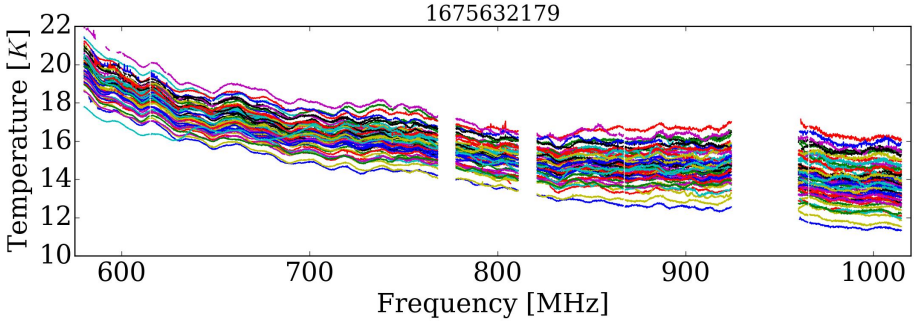
MuSEEK adopts a model-driven approach wherein calibration is performed using a physically motivated synchrotron emission template derived from the re-processed Haslam 408 MHz map and WMAP 23 GHz data.

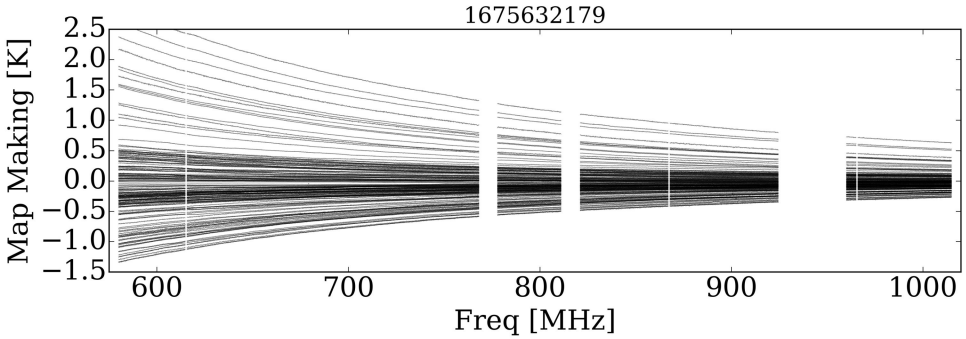
$$g(\nu) = \frac{\Sigma_t \left[(d(t,\nu) - \overline{d}(\nu)) \times (Syn(t,\nu) - \overline{Syn}(\nu)) \right]}{\Sigma_t (Syn(t,\nu) - \overline{Syn}(\nu))^2}$$

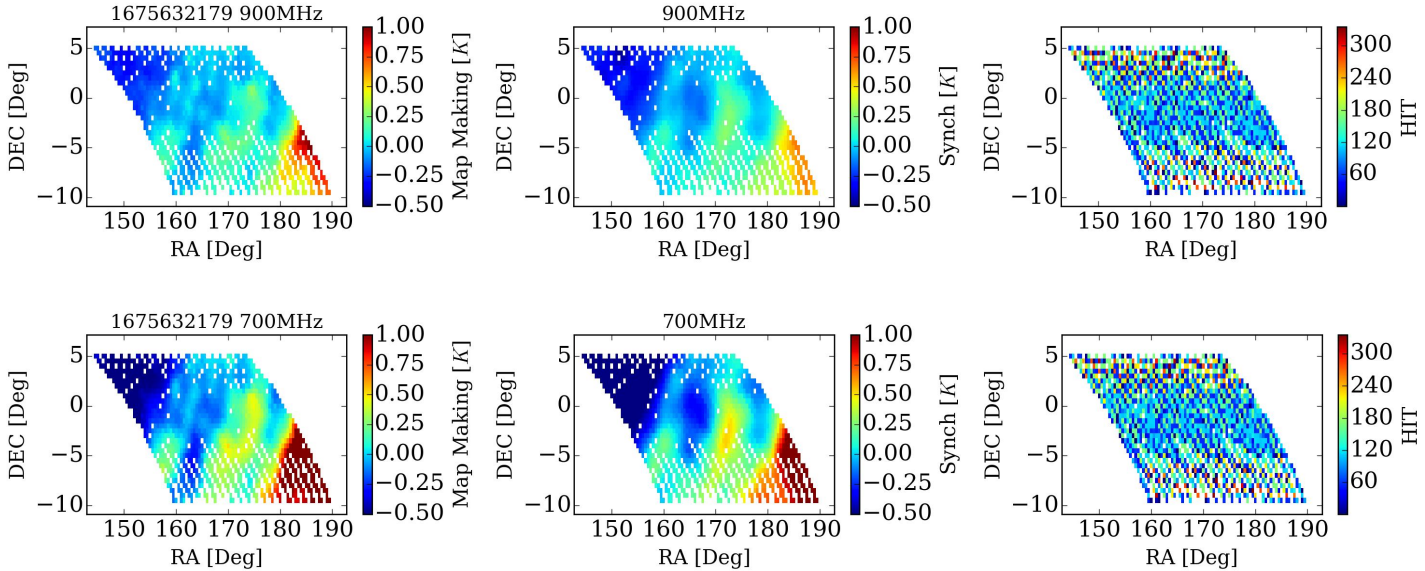




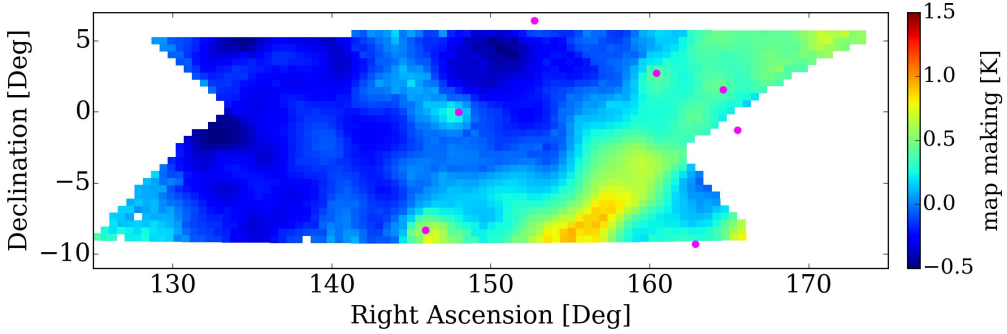
Mapmaking for UHF band

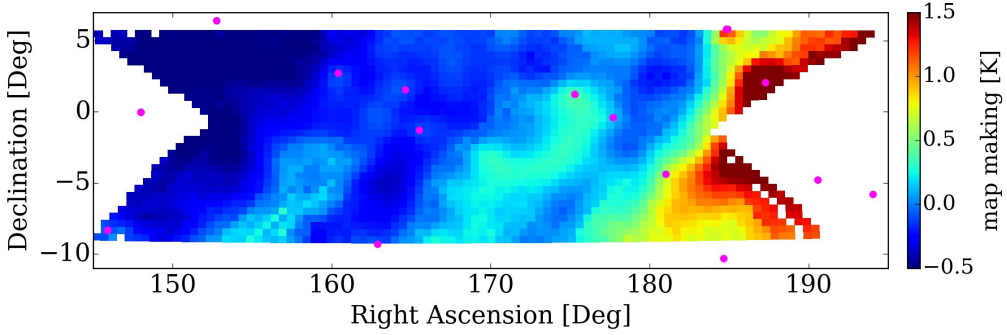


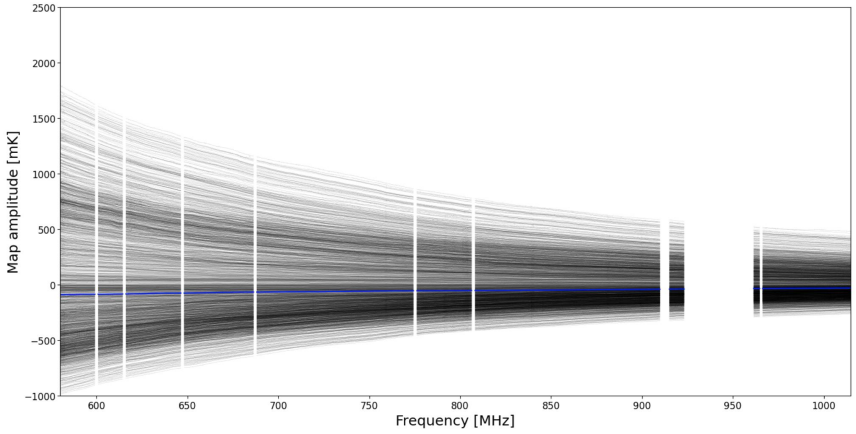


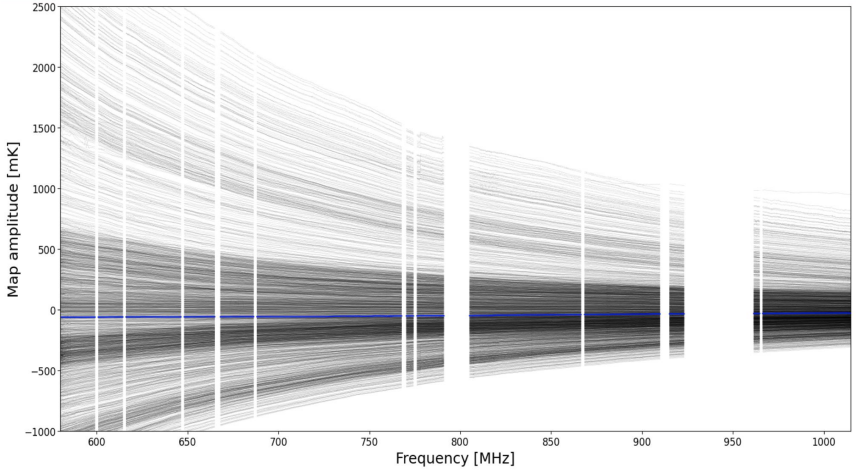


Maps





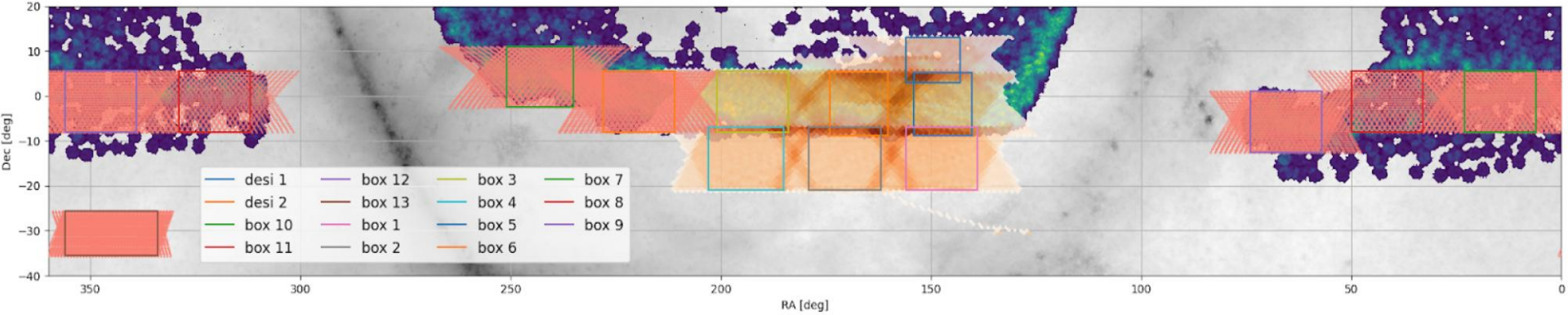




23 scans conbined, ~40 hours for each antenna

Ongoing Surveys

By the end of 2024, MeerKLASS has accumulated over 400 hours of observations across approximately 2,000 deg²



(Piyanat)

More is coming !

Thanks to collaborators!

PI: Mario G. Santos[1]
Co: Matilde Barberi Squarotti[7], Chris Blake[8], José Luis Bernal[9], Philip Bull[6], Isabella P. Carucci[5], Stefano Camera[14], Zhaoting Chen[2], Tianyue Chen[17], Suman Chatterjee[1], Steven Cunnington[2], Brandon Engelbrecht[1], José Fonseca[11], Karin Fornazier[15], Keith Grainge[2], Stuart E. Harper[2], Wenkai Hu[1], Melis O. Irfan[1], Tamera Kassie[1], Piyanat Kittiwisit[1], Yichao Li[13], Yin-Zhe Ma[16], Sifiso Mahlalela[1], Siyambonga Matshawule[1], Aishrila Mazumder[2], Mosima Masipa[1], Geoff Murphy[1], Sourabh Paul[10], Alkistis Pourtsidou[3], Felicia Setshabe[1], Paula S. Soares[6], Marta Spinelli[12], Junaid Townsend[1], Laura Wolz[2], Amadeus Wild[1], Jingying Wang[4], Jinglan Zheng[18] ...

[1] U. of Western Cape, SA
[2] U. of Manchester, UK
[3] U. of Edinburgh, UK
[4] Shanghai Astronomical Obs, CHN
[5] Istituto Nazionale di Fisica Nucleare, Italy
[6] Queen Mary U. of London, UK
[7] U. of Milan, Italy
[8] Swinburne U. of Technology, Australia
[9] U.of Cantabria, Spain
[10] U. of McGill, Can
[11] Universidade do Porto CAUP,Portugal
[12] Observatoire de la Côte d'Azur Laboratoire Lagrange, France
[13] Northeastern U., CHN
[14] Università degli Studi di Torino, Italy
[15] Universidade de São Paulo, Brazil
[16] Stellenbosch U., SA
[17] UK SKA Regional Centre
[18] U. of Portsmouth, UK