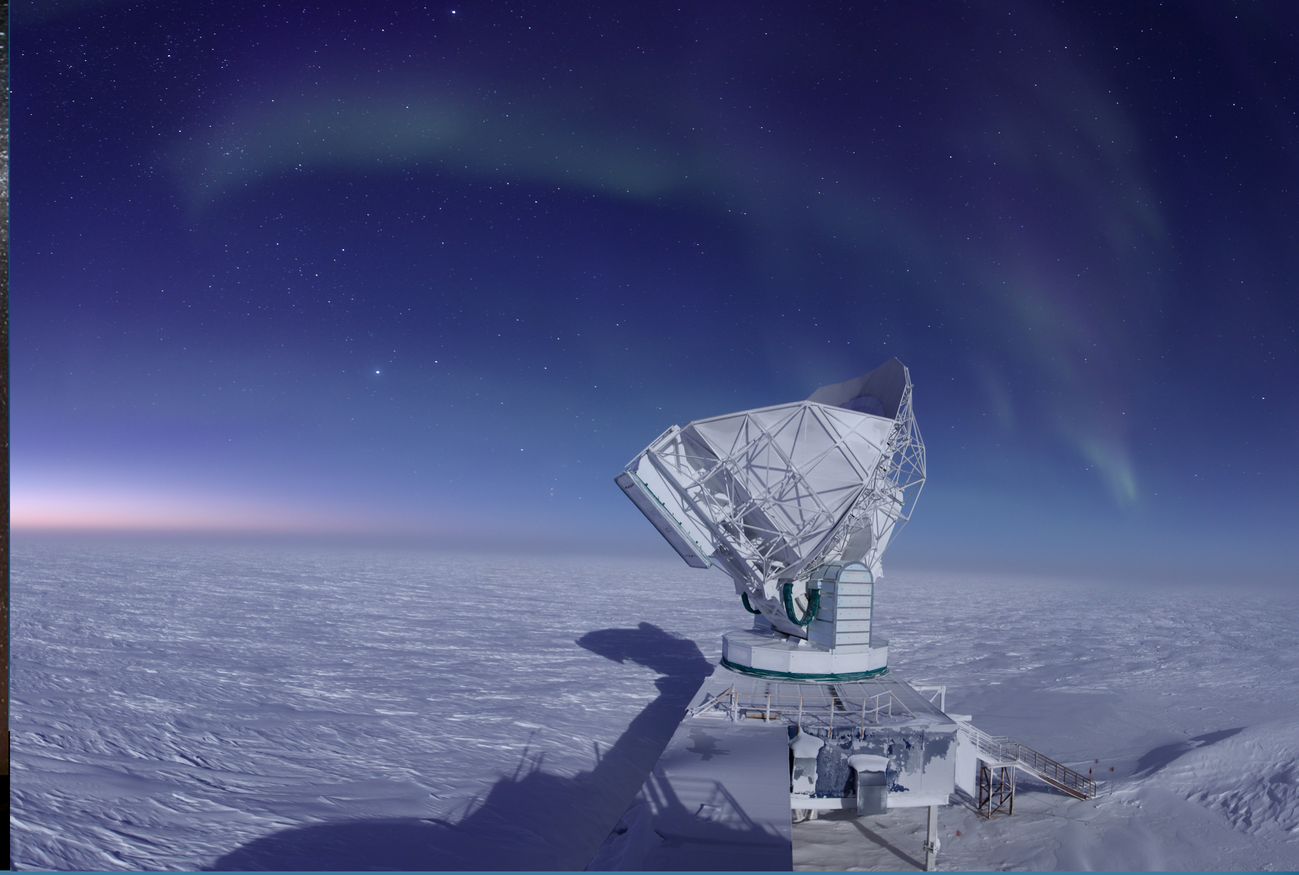




The MeerKAT - South Pole Telescope Survey

Roger Deane - IDIA Director / UCT

IDIA Inter-University Institute for Data Intensive Astronomy



The MeerKAT - South Pole Telescope Survey

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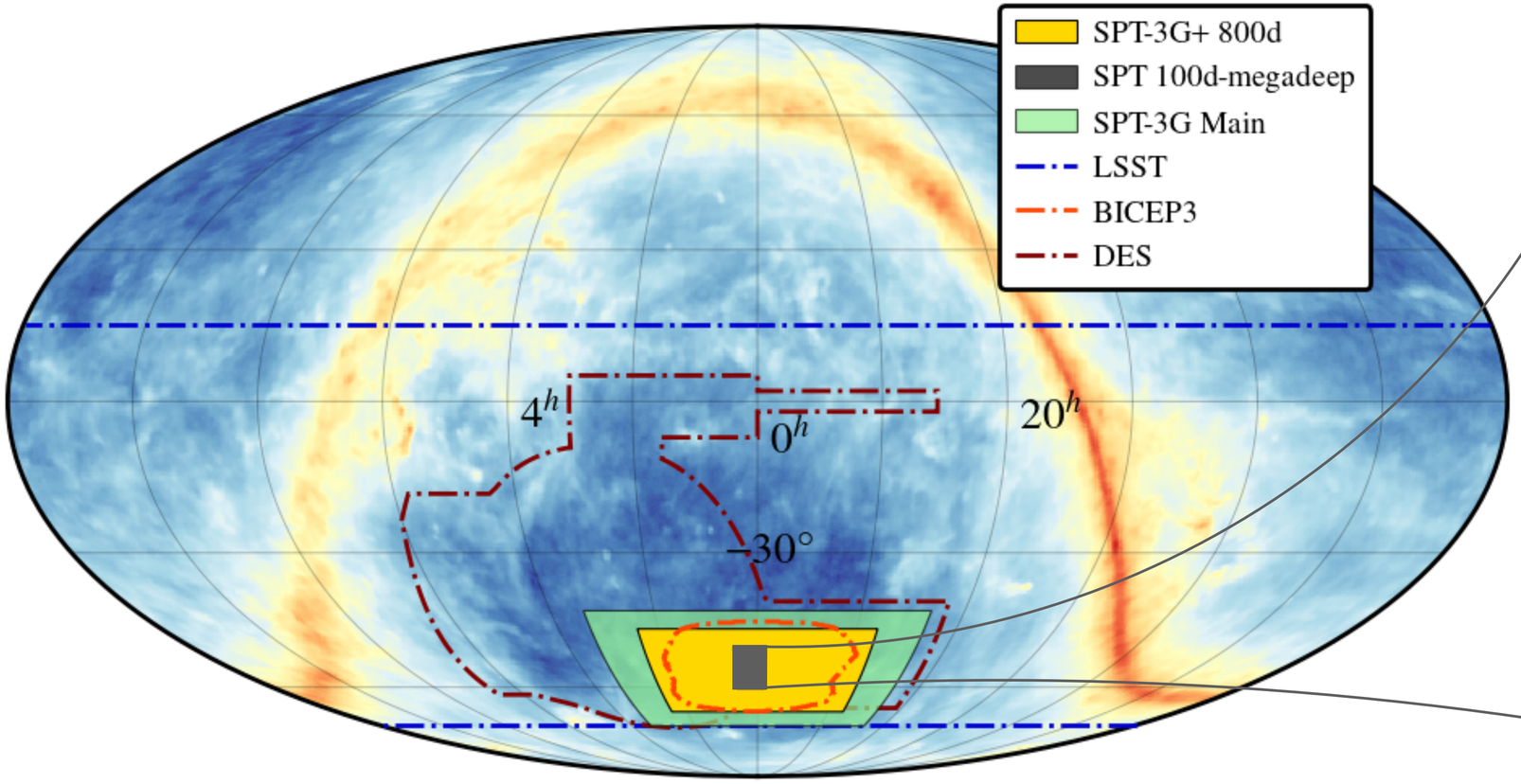
MeerKAT-SPT 800 deg² Survey

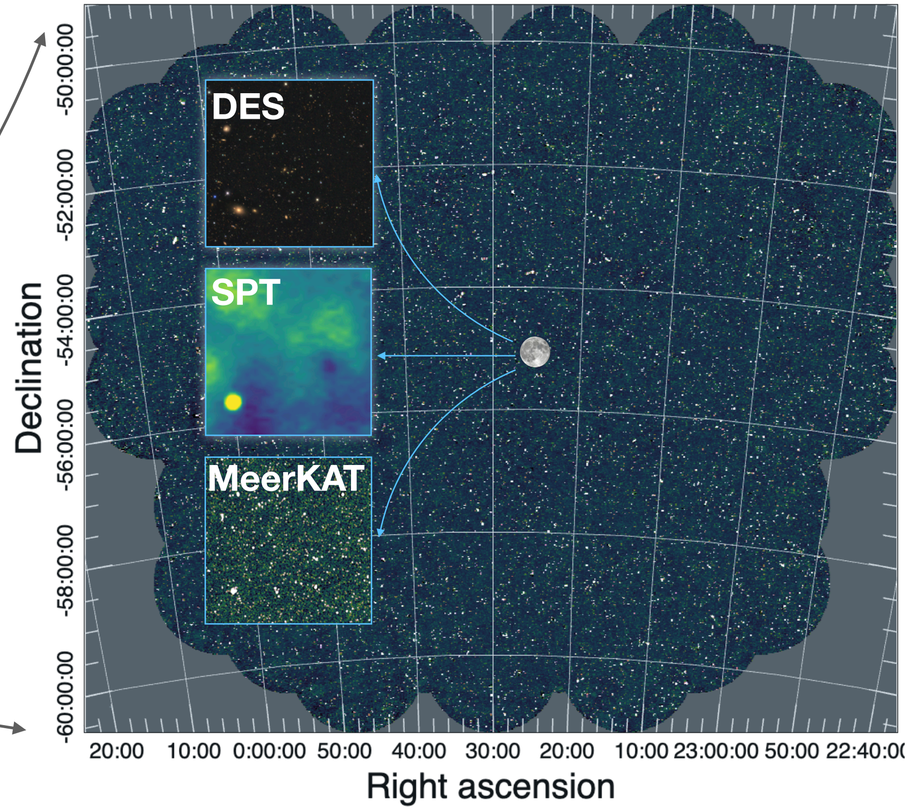
New MeerKAT XLP

8x areal expansion

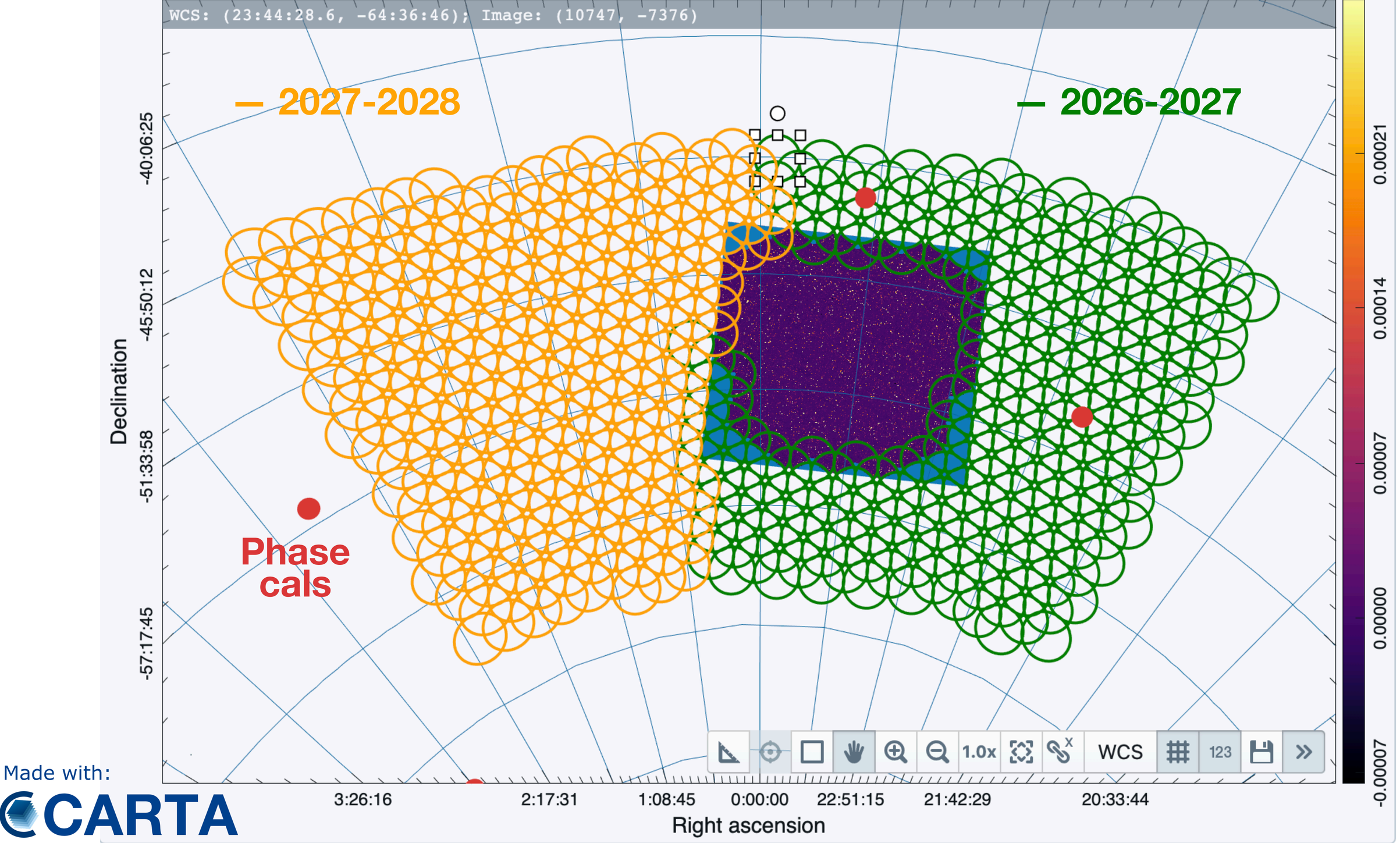
SPT-3G+ field

Legacy Science in the southern radio sky leveraging the deepest CMB fields





PI: Roger Deane (IDIA/UCT)



Made with:
CARTA

Team



SPT-SMG team



Simon Lowry
MSc student
Wits University

South African team @ IDIA, UCT, Wits and Pretoria



Isaac Magolego
Postdoc
University of Pretoria



Thato Manamela
Science Data Processing
SARAO



Jane Mankhubu
PhD student
Wits University



William Rasakanya
Postdoc
University of Pretoria



Fernando Ventura
PhD student
University of Pretoria

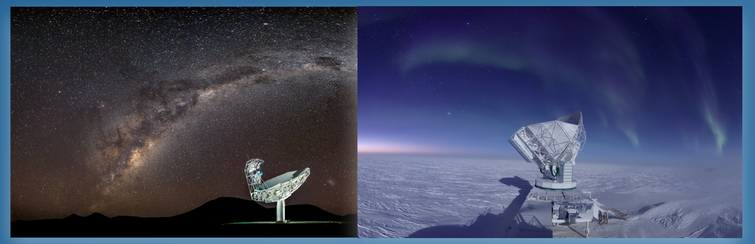


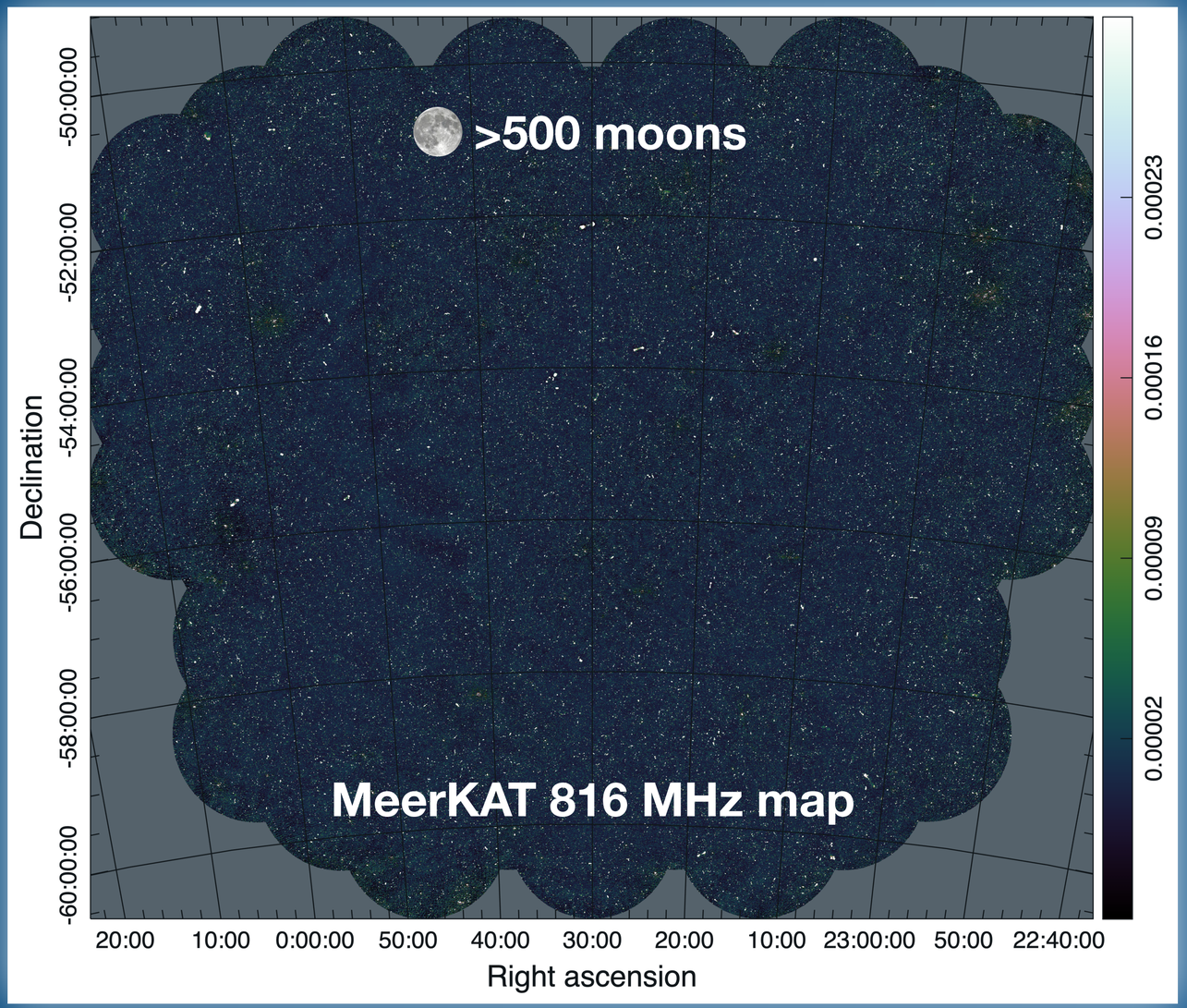
Kshitij Thorat
A/Prof
University of Pretoria

MeerKAT-SPT key science

1. High-redshift dusty star-forming galaxies
2. Galaxy cluster radio halos (and relics)
3. High-redshift hydroxyl megamasers
4. Radio and mm image-plane transients
5. Exotic radio morphologies
6. CMB cross-correlations and radio SZ

MeerKAT-SPT first 100 deg^2





100 deg^2 down to ~10 μJy beam^{-1}

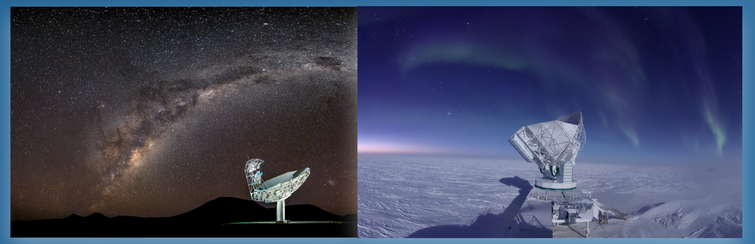
~300,000 sources detected, many rare objects

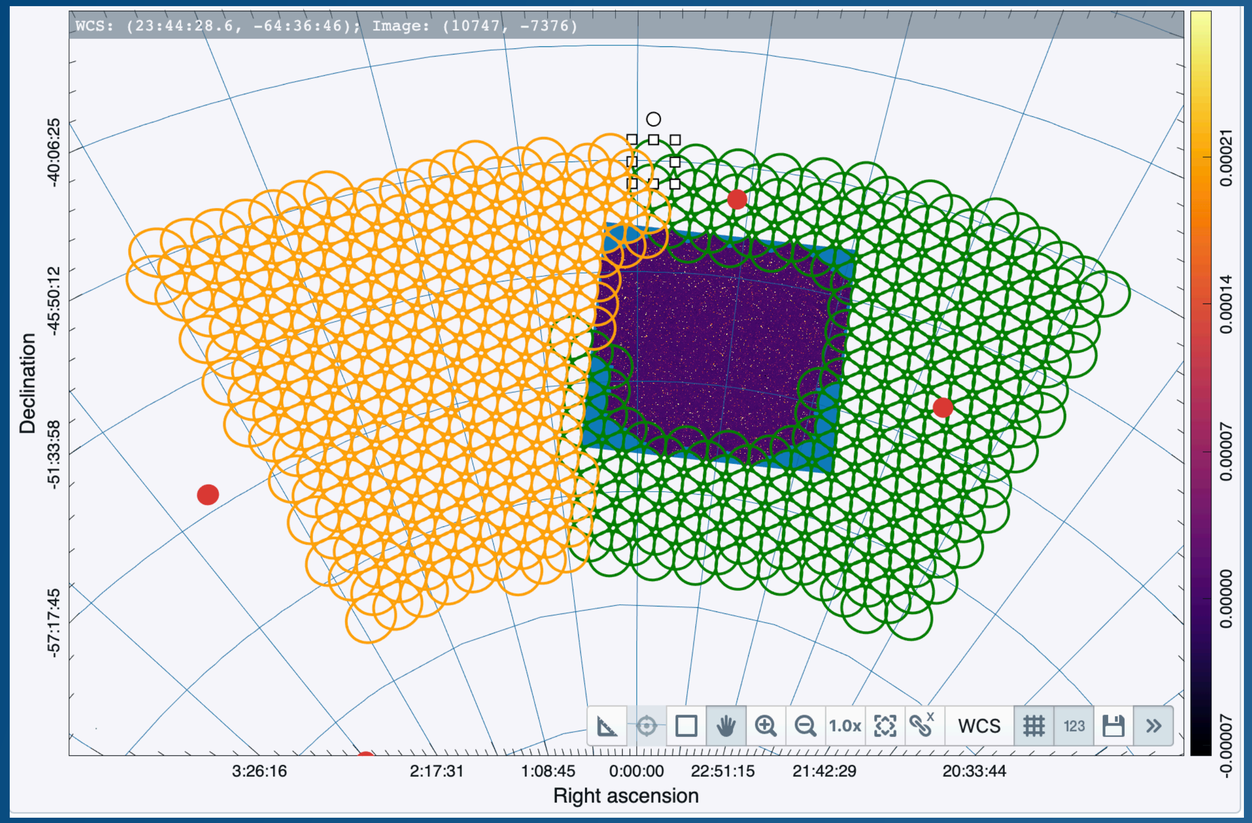
Advanced calibration approaches were essential

Rich synergy with mm sources / SZ-selected clusters

Transient and spectral searches ongoing

MeerKAT-SPT full 800 deg^2





Expansion observations: May 2026 - April 2028

800 deg^2 down to ~10 μJy beam^{-1}

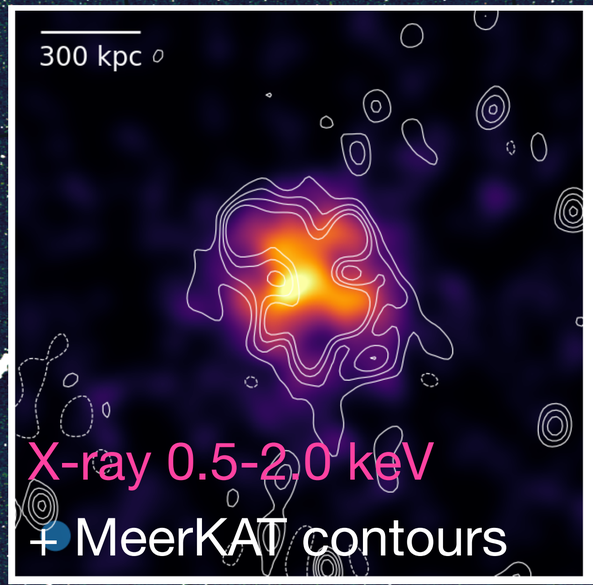
1.4 Petabytes of visibility data

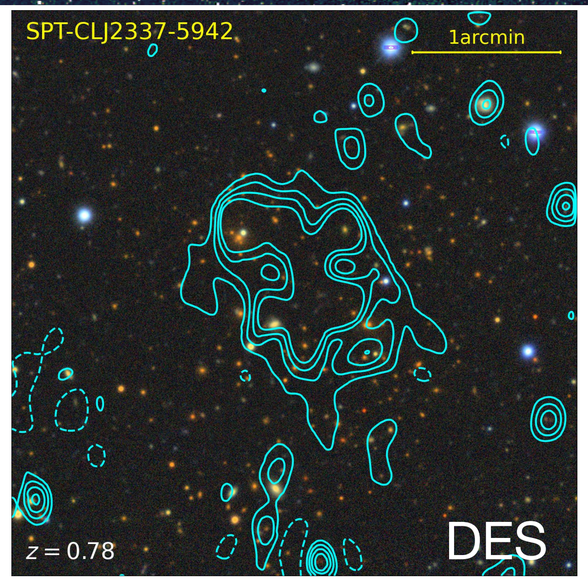
~2,400,000 sources expected, many rare objects

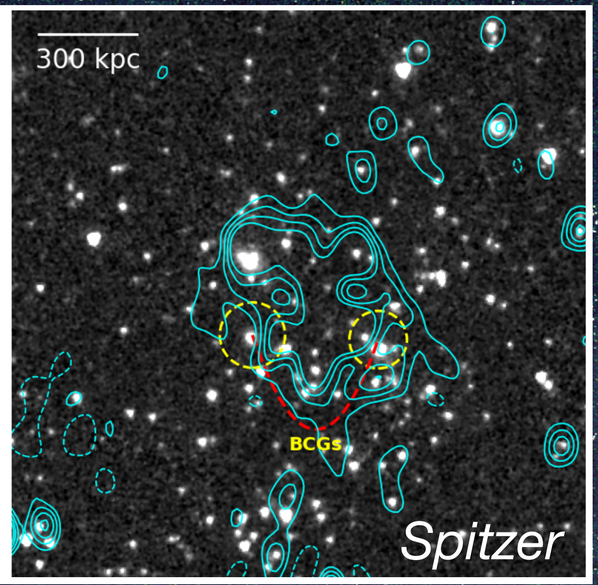


MeerKAT 816 MHz map

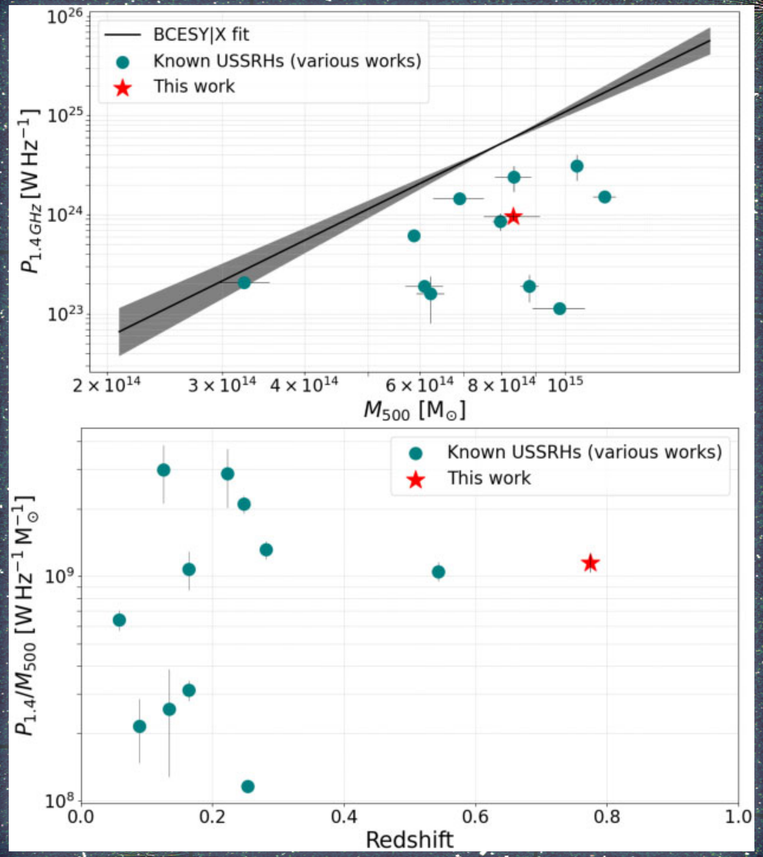
Highest redshift ultra-steep spectrum radio halo







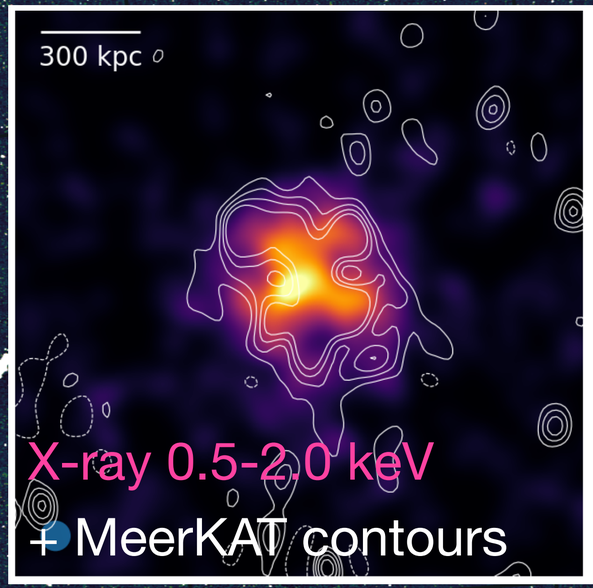
Magolego+2026a

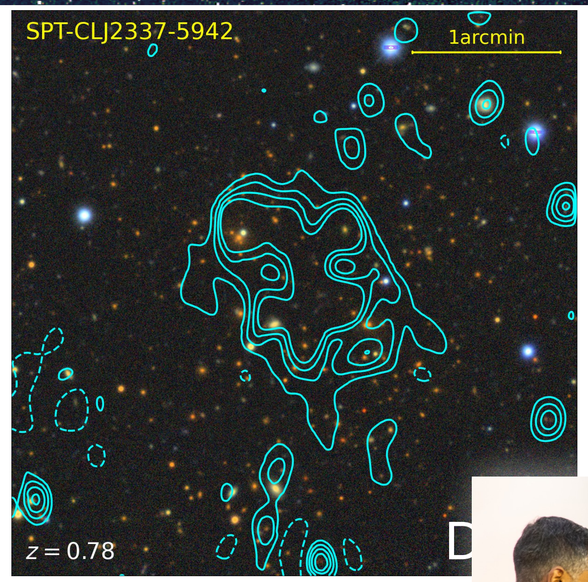


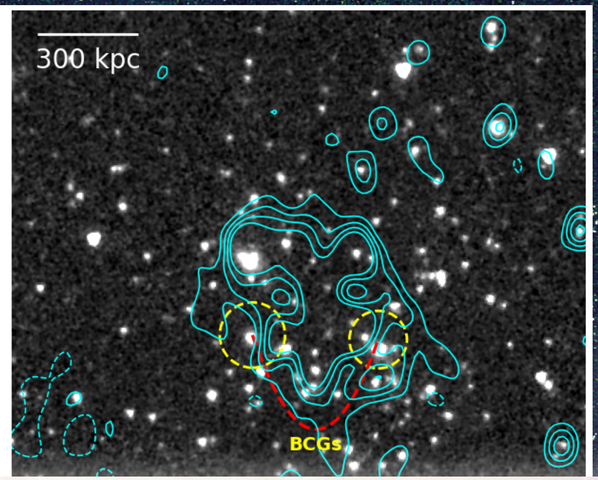
Discovery of a $z \sim 0.8$ Ultra Steep Spectrum Radio Halo in the MeerKAT-South Pole Telescope Survey

Isaac S. Magolego[1]*, Roger P. Deane[1,2], Kshitij Thorat[2], Ian Heywood[3,4,5], William Rasakanya[1], Manuel Aravena[6,7], Lindsey E. Bleem[8,9,10], Maria G. Campitiello[8], Kedar A. Phadke[11,12,13], Justin Spilker[14], Joaquin D. Vieira[11,12], Dazhi Zhou[15], Bradford A. Benson[9,10,16], Scott Chapman[17,18,19], Ana Posses[14], Tim Schrabback[20], Antony Stark[21], David Vizgan[11]

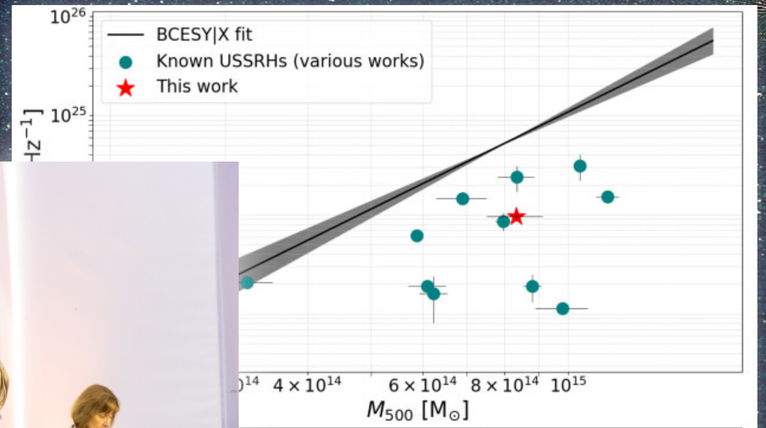
Highest redshift ultra-steep spectrum radio halo



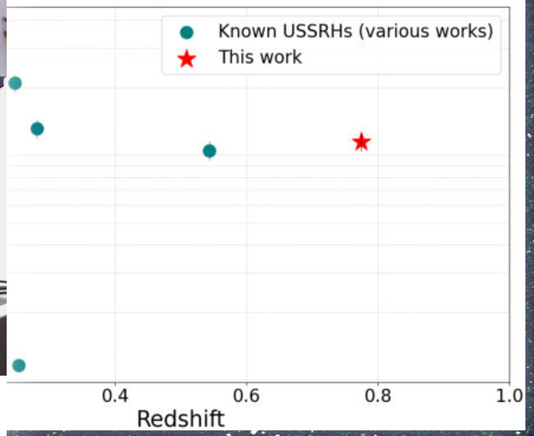




Magolego+2026a





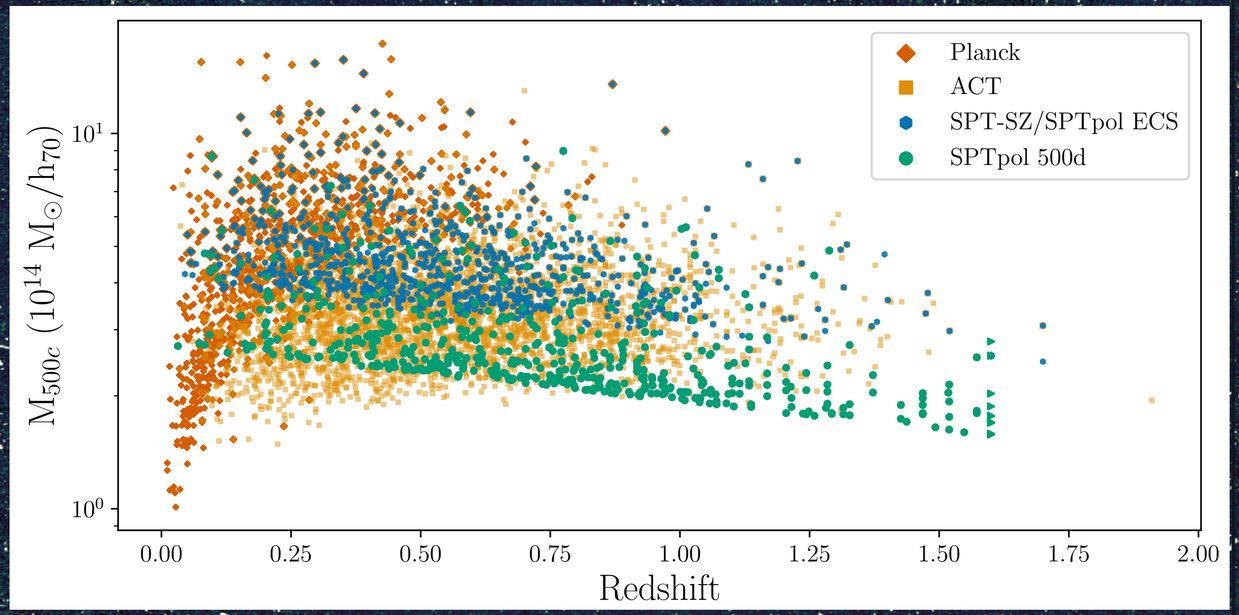


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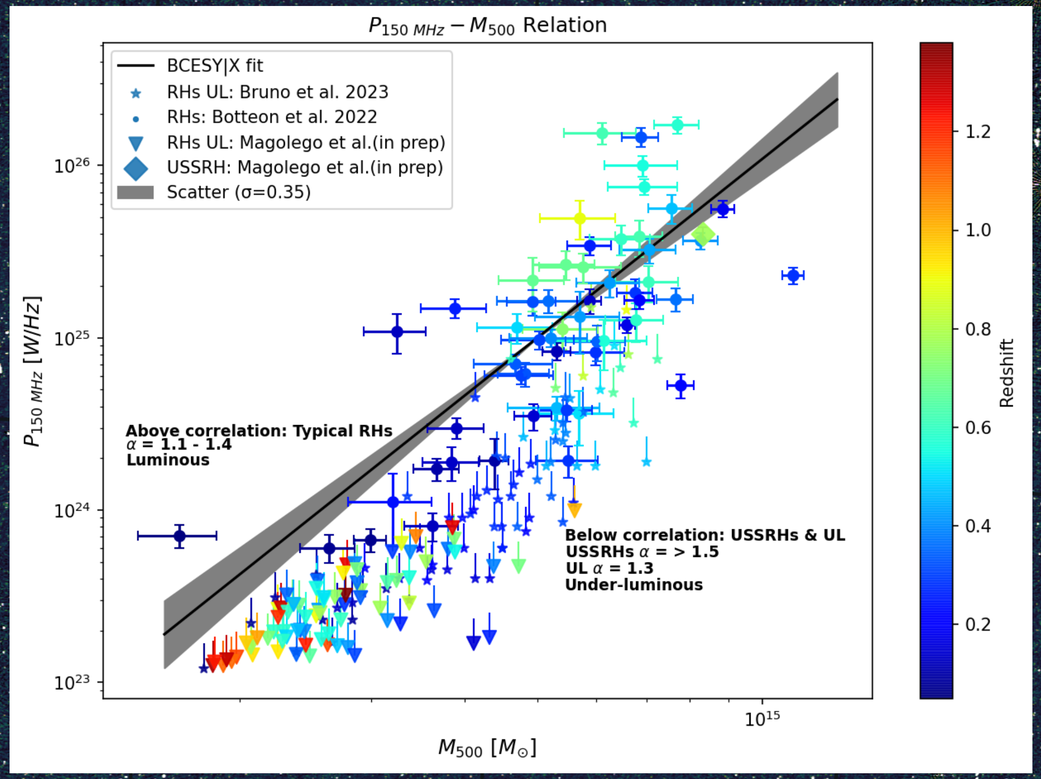
Radio halos in MK-SPT

SZ-selected clusters



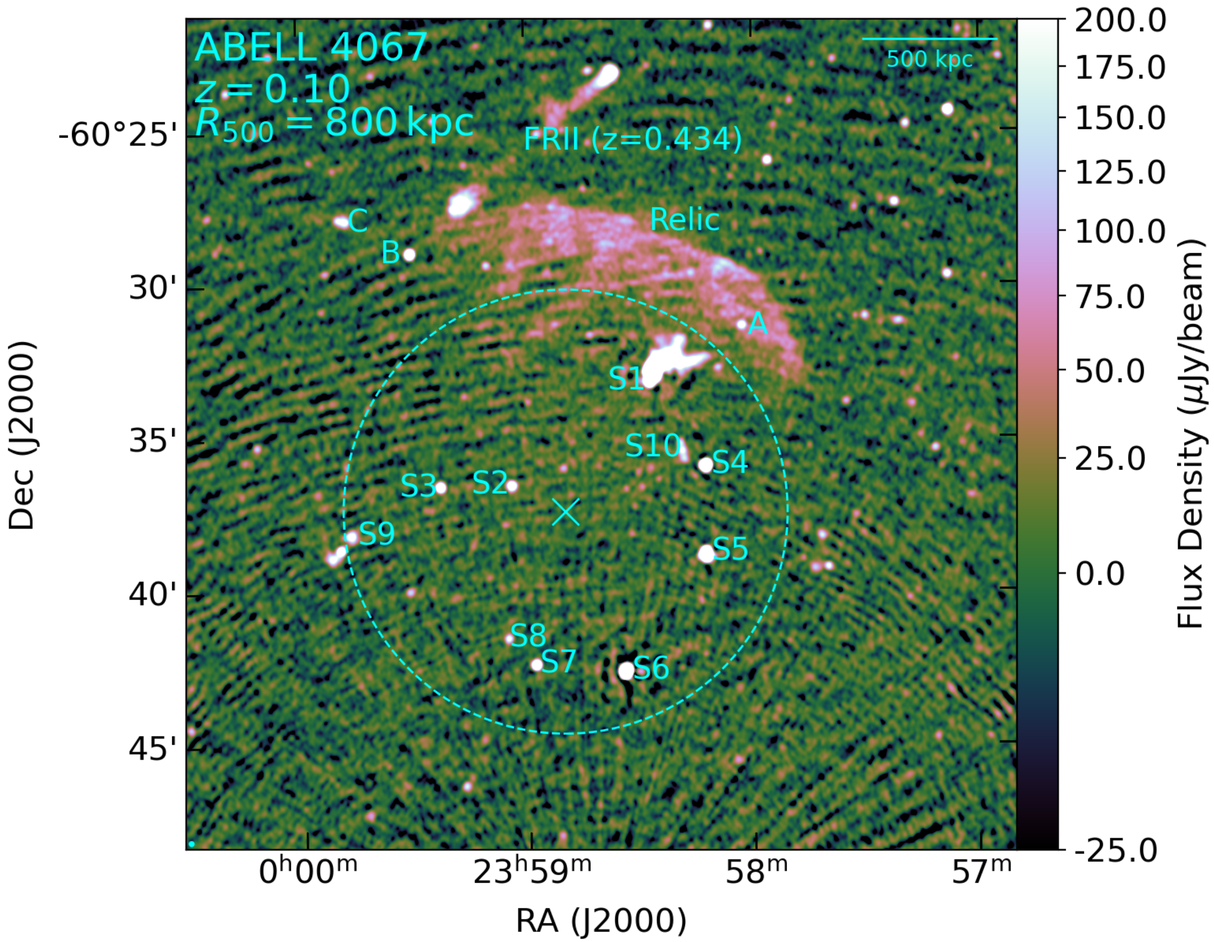
Bleem+2024

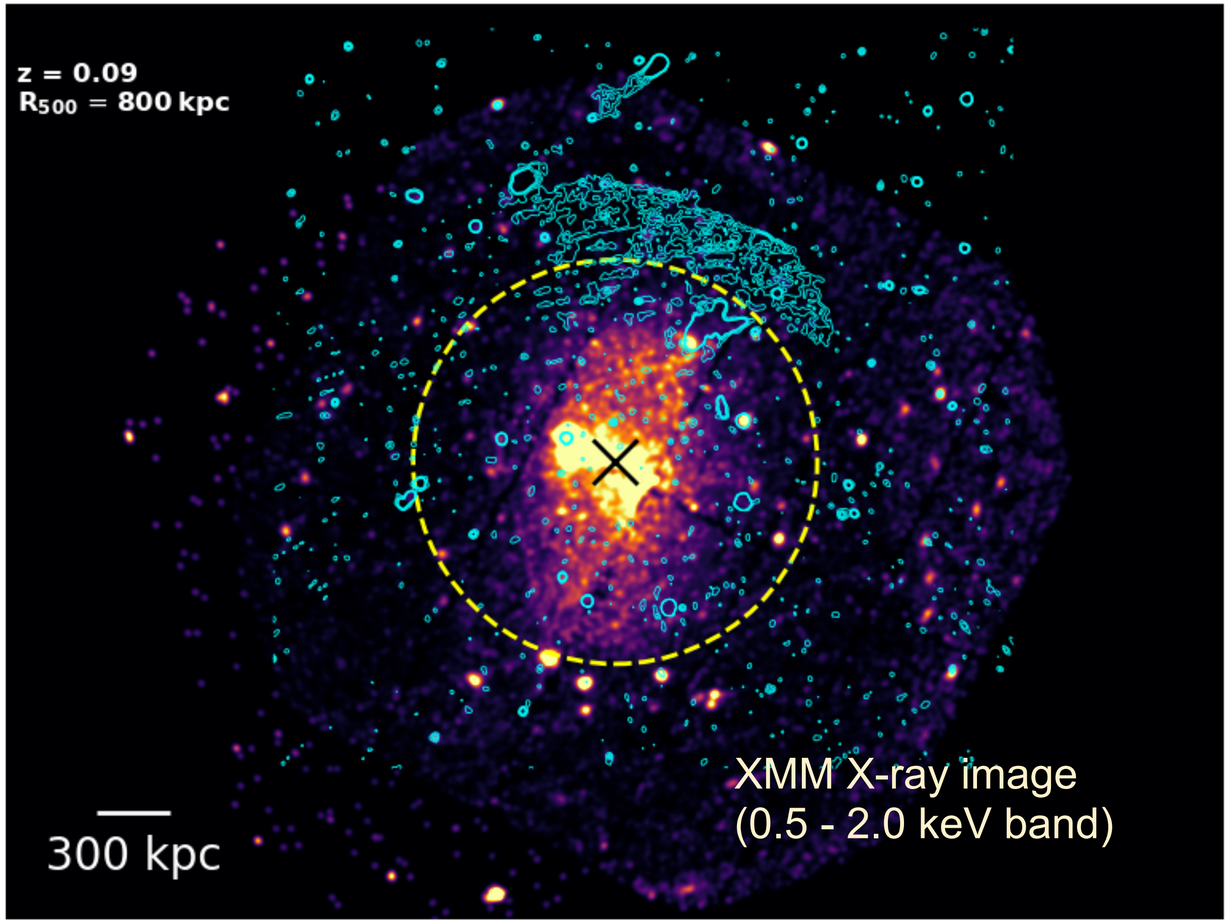
Radio halo power-mass relation



Magolego+(in prep.)

Discovery of a radio relic in a low-mass, merging cluster



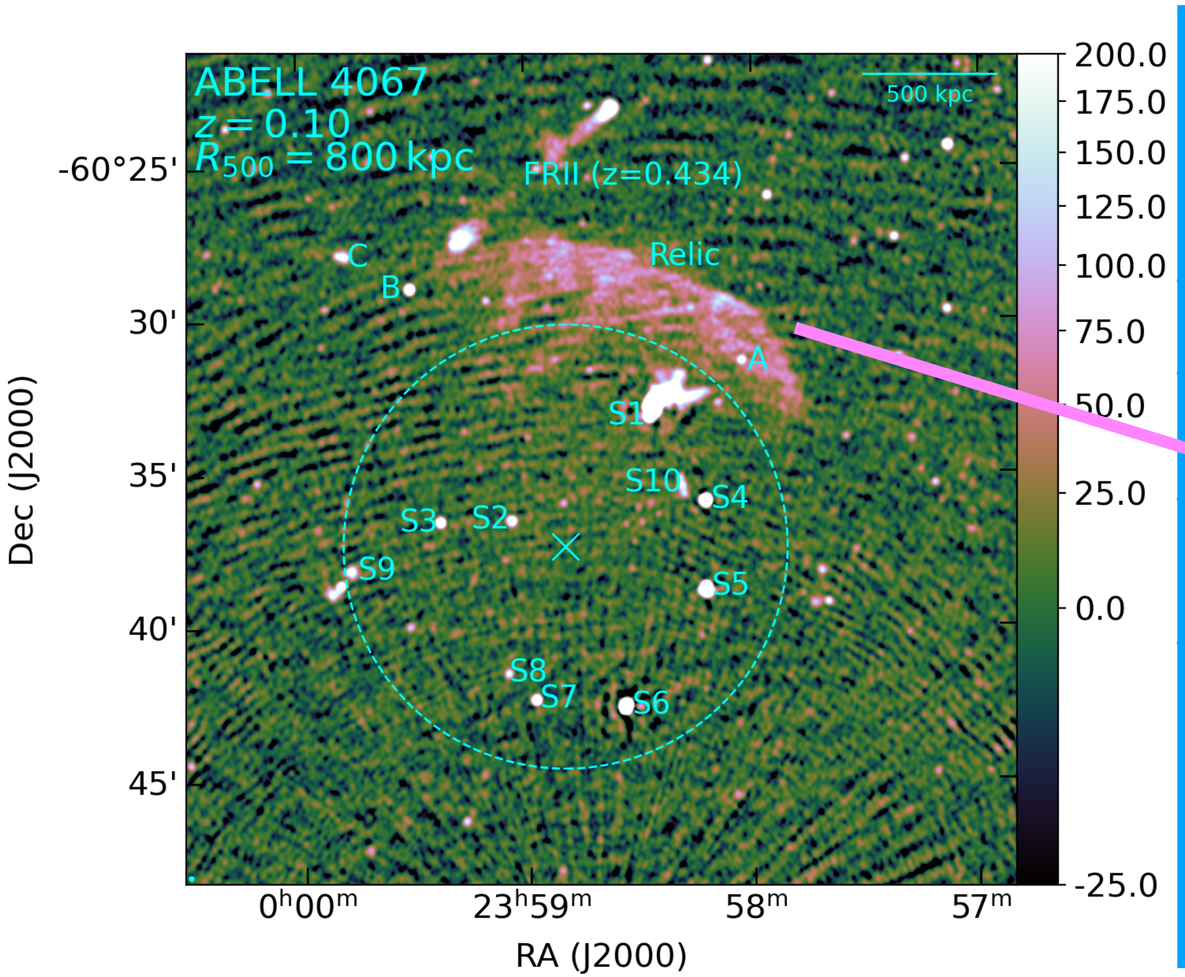


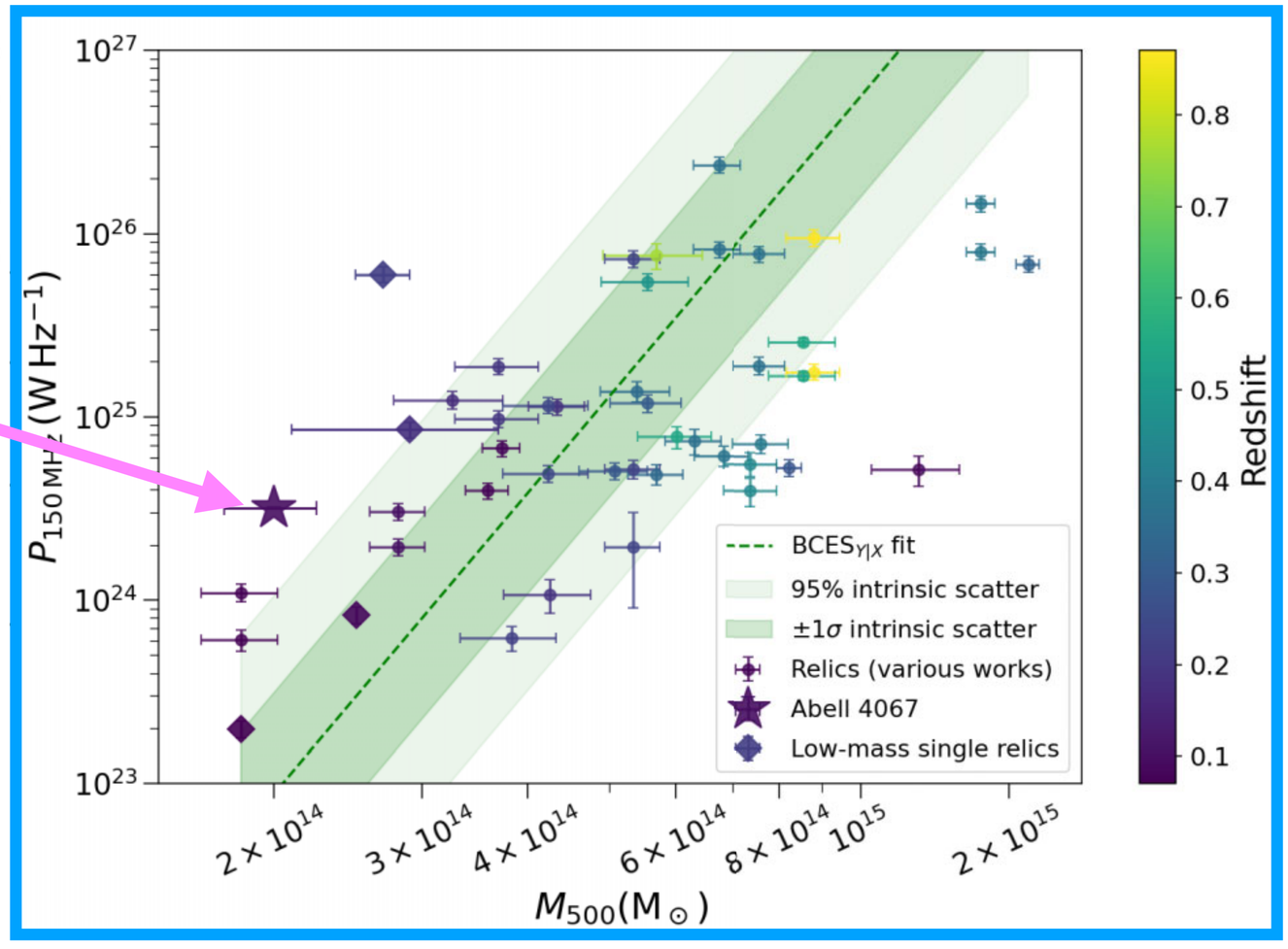
Relic's orientation supported by the X-ray image:

- Perpendicular to the major axis of the X-ray emission from the ICM
- Only relic found within the 100 deg^2 survey
- One of the lowest halo masses known to host a radio relic

Magolego et al. (2026b), *MNRAS* Letters

Discovery of a radio relic in a low-mass, merging cluster





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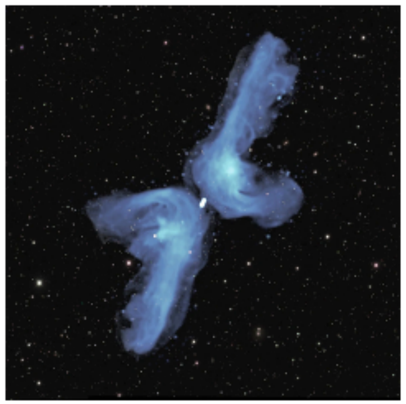
Magolego et al. (2026b), *MNRAS* Letters

A uniformly selected X-shaped radio galaxy (XRG) sample

The New York Times

A Black Hole's Boomerangs

Astronomers dissect the energy flow in a distant galaxy.



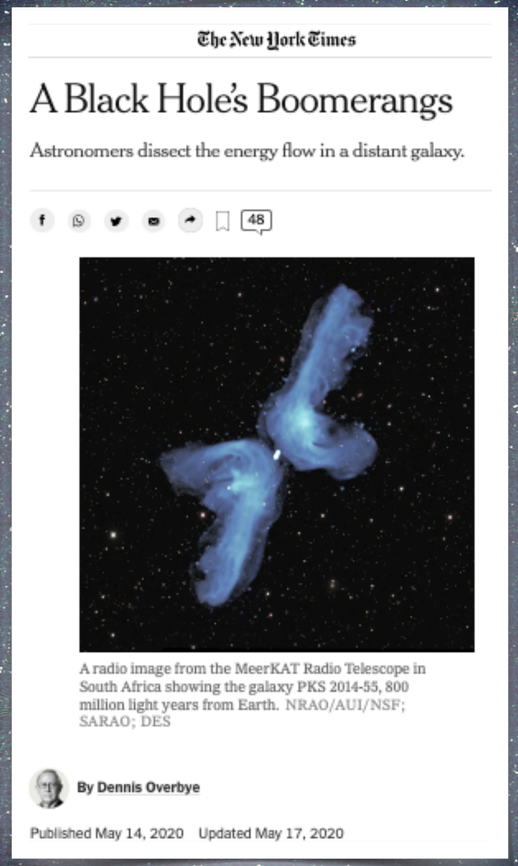
A radio image from the MeerKAT Radio Telescope in South Africa showing the galaxy PKS 2014-55, 800 million light years from Earth. NRAO/AUI/NSF; SARAO; DES

By Dennis Overbye

Published May 14, 2020 Updated May 17, 2020

Cotton+2020

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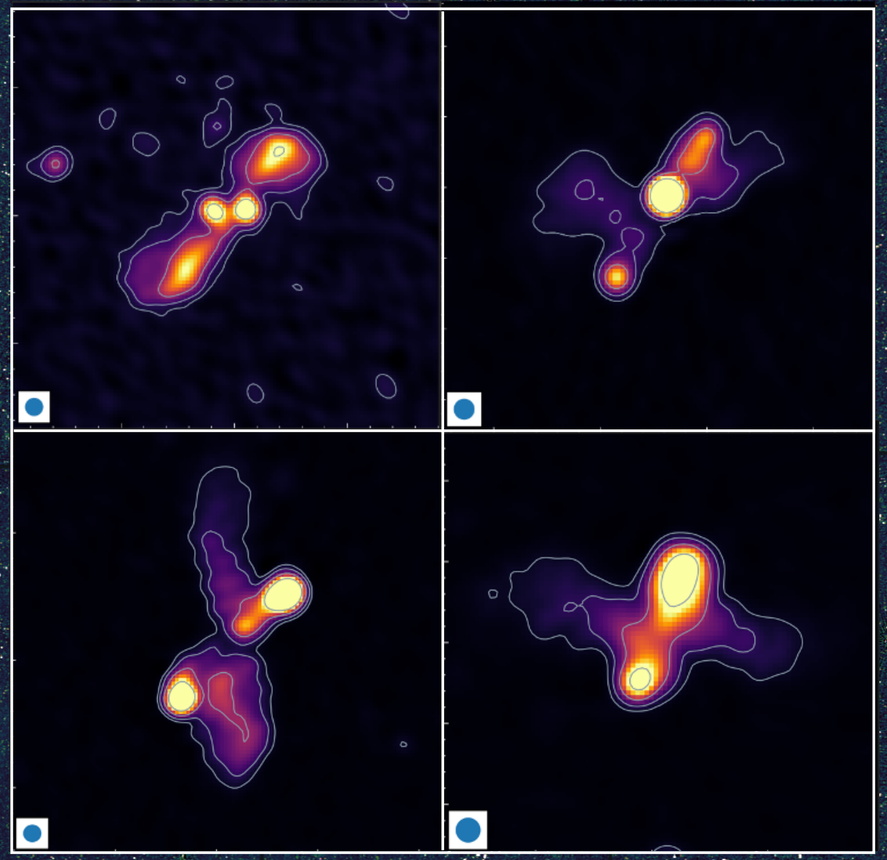
48

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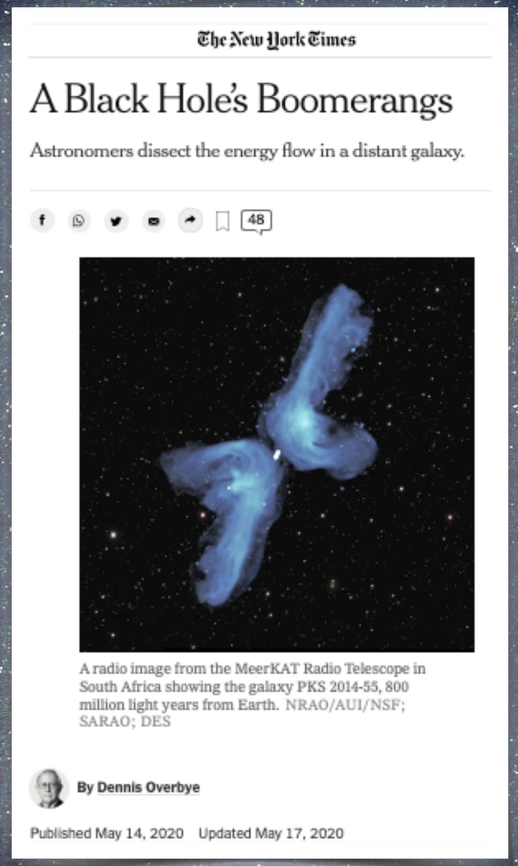
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Rasakanya+(in press)

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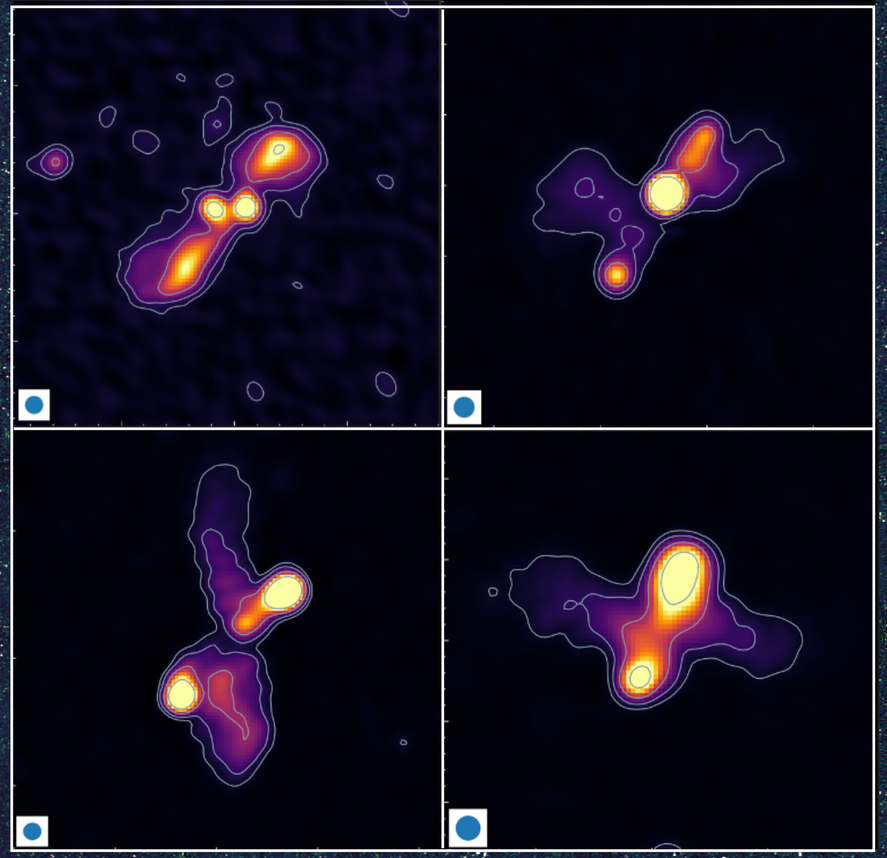
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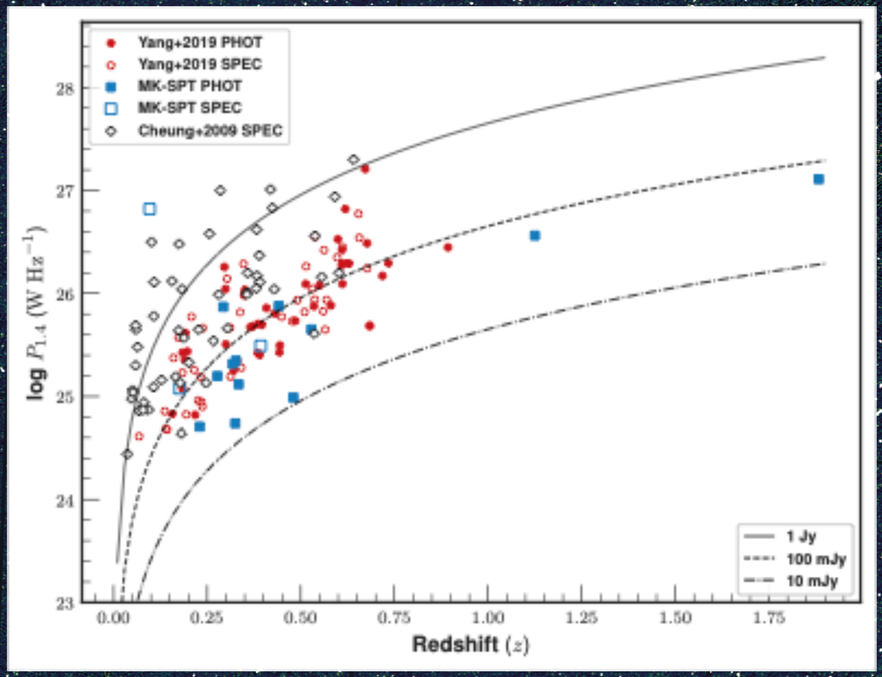
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Cotton+2020



Rasakanya+(in press)

11 new XRGs!

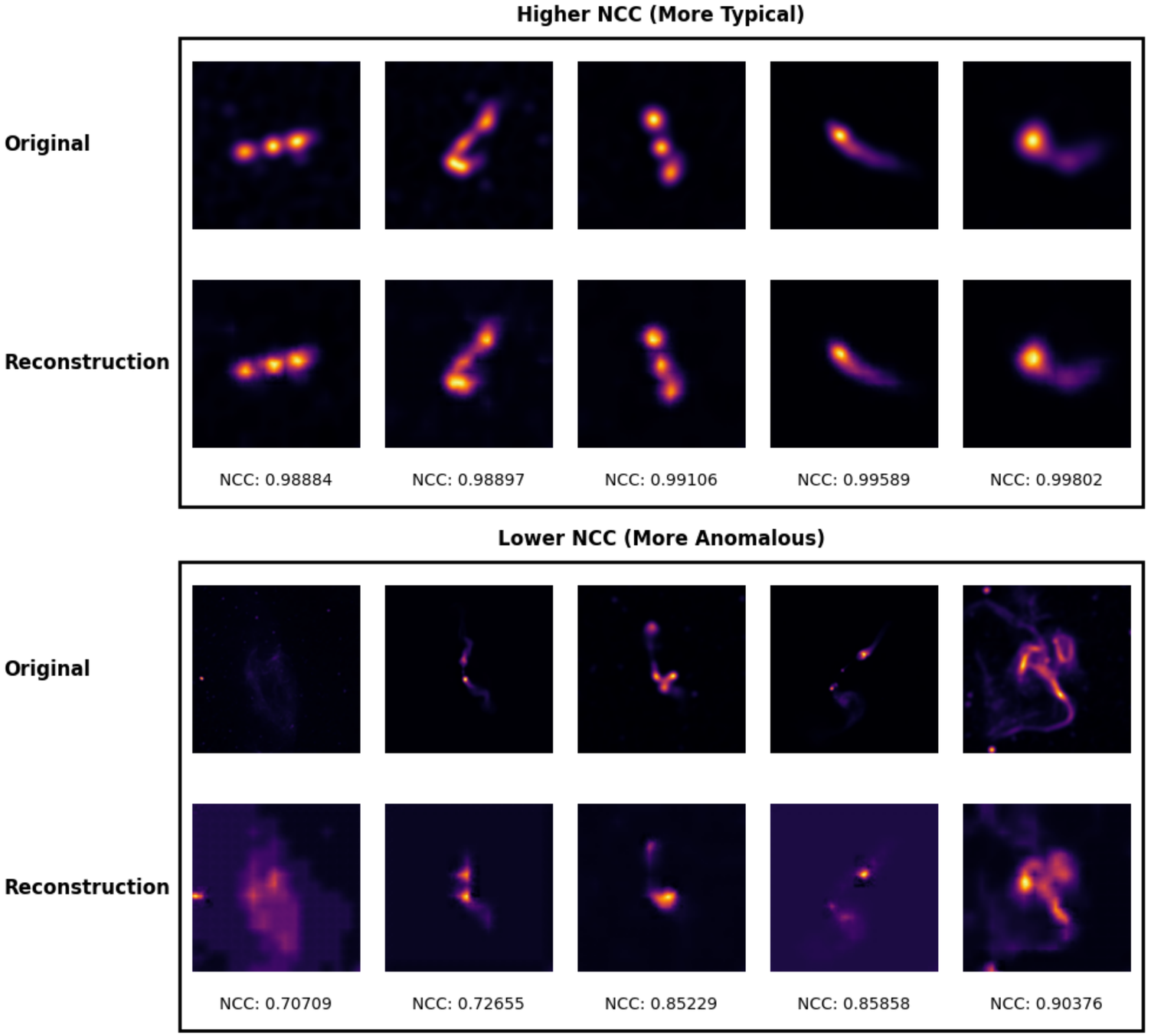


Uniform sensitivity and selection

Sample appears systematically lower power

DES imaging enriches host analysis

Using VQ-VAEs search through MGCLS



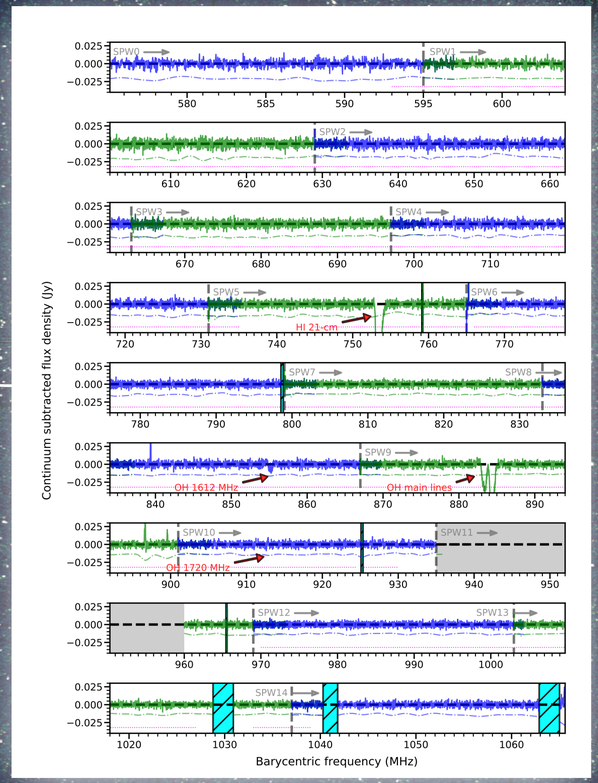
A selection of unlabelled sources as reconstructed by a type C VQ-VAE

Ventura+2026

Spectral searches in the MK+SPT Survey

- Similar depth to MALS (MeerKAT LSP)
- HI absorption / stacking between $0.4 < z < 1.45$
- OH absorption between $0.67 < z < 1.87$
- Lensed OH megamaser emission
- Validation with MALS overlapping targets
- Expect of order 40-80 new associated HI absorbers

32,000 spectral channels
to search for HI/OH absorption



MALS/Combes+2021

Manamela+2026

Lensed Gigamaser at z = 1

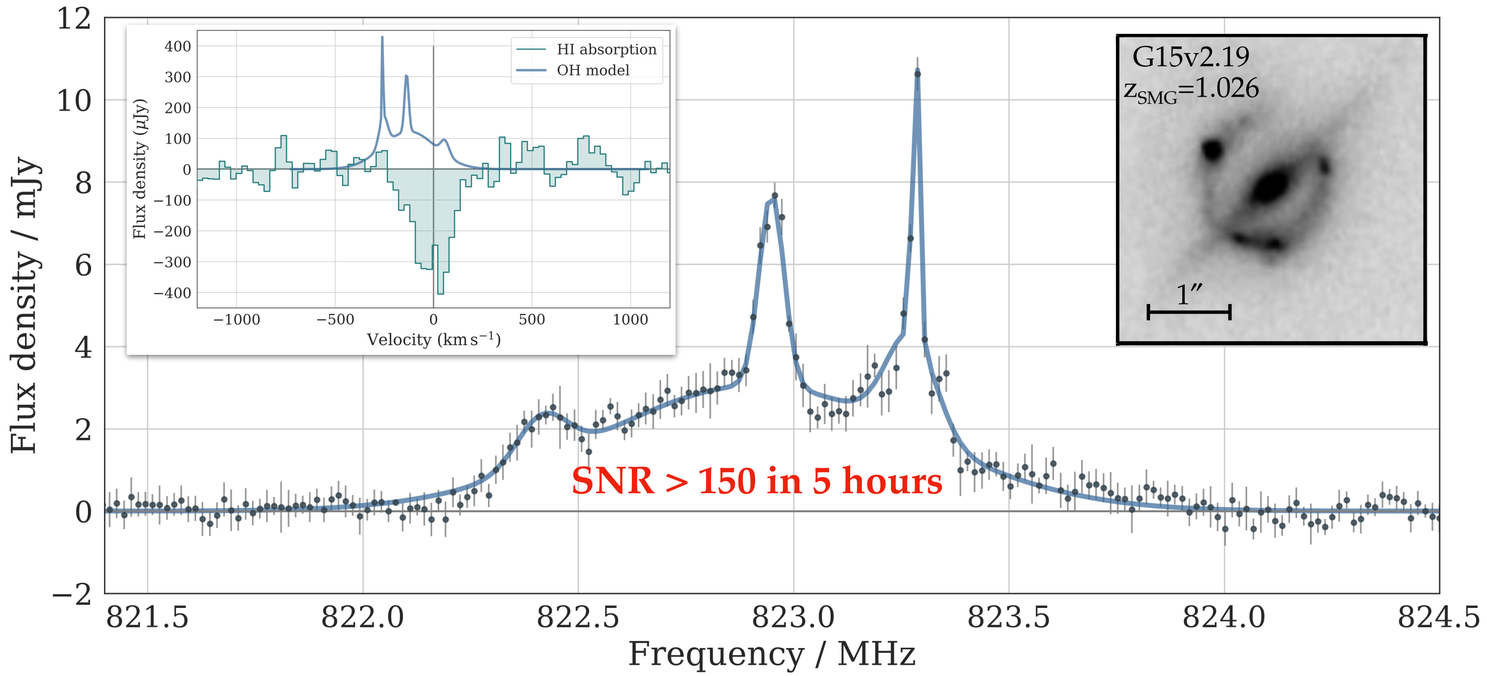


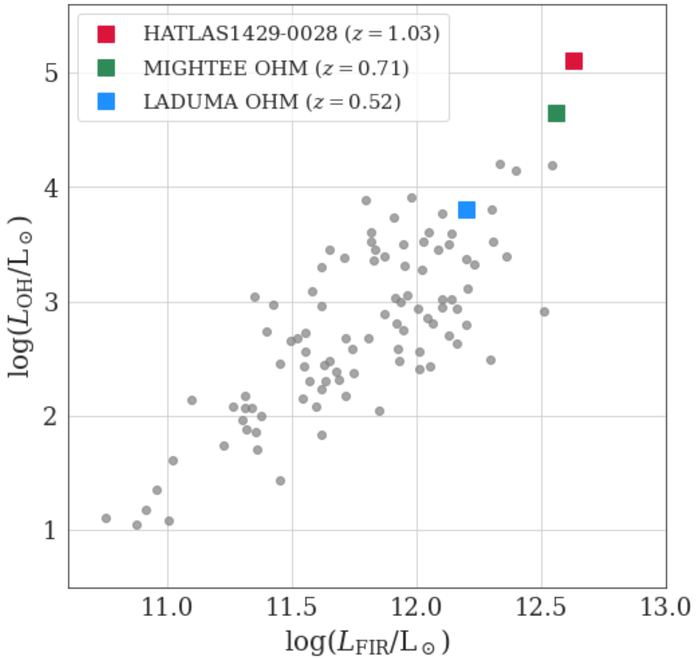
Hydroxyl megamasers are signposts for galaxy major mergers and potentially dual AGN systems

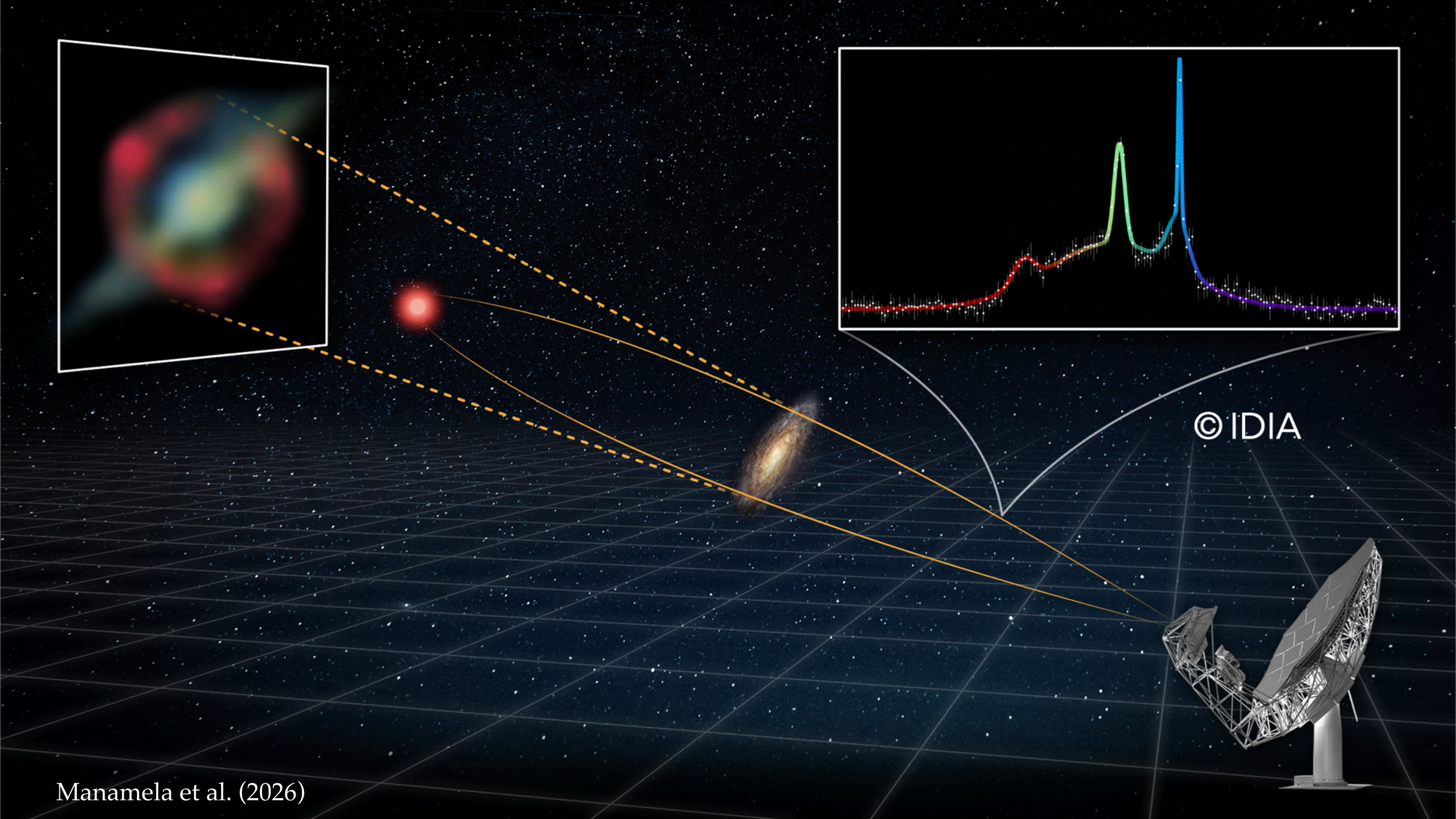
Limited to z < 0.25 for ~20 years until MeerKAT

LADUMA, MIGHTEE, and this lensed system have **doubled**, **tripled**, **quadrapuled** redshift record

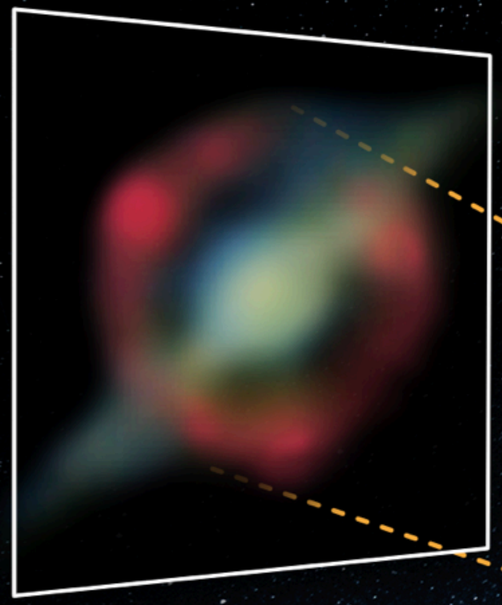
HI absorption discovered in the same datasets for some, molecular outflows suggested

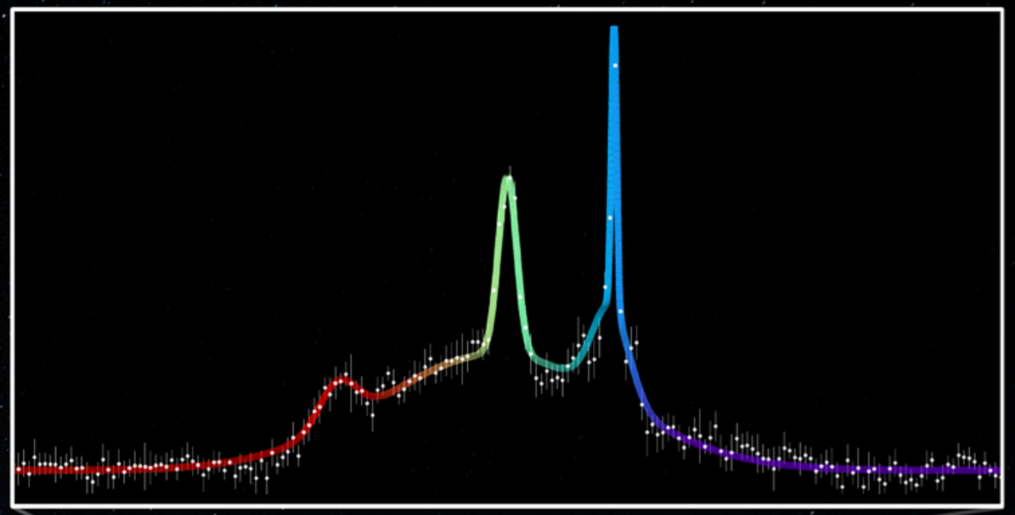




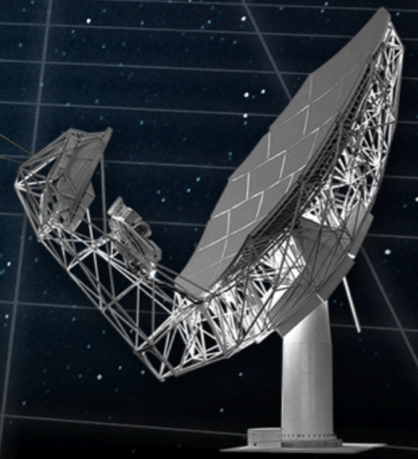


Manamela et al. (2026)





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FEATURE | 05 March 2026

Rare cosmic ‘gigamaser’ spotted by South African astronomers

The discovery highlights MeerKAT’s power to probe hidden galaxy mergers across cosmic time.

By Paul Adepoju

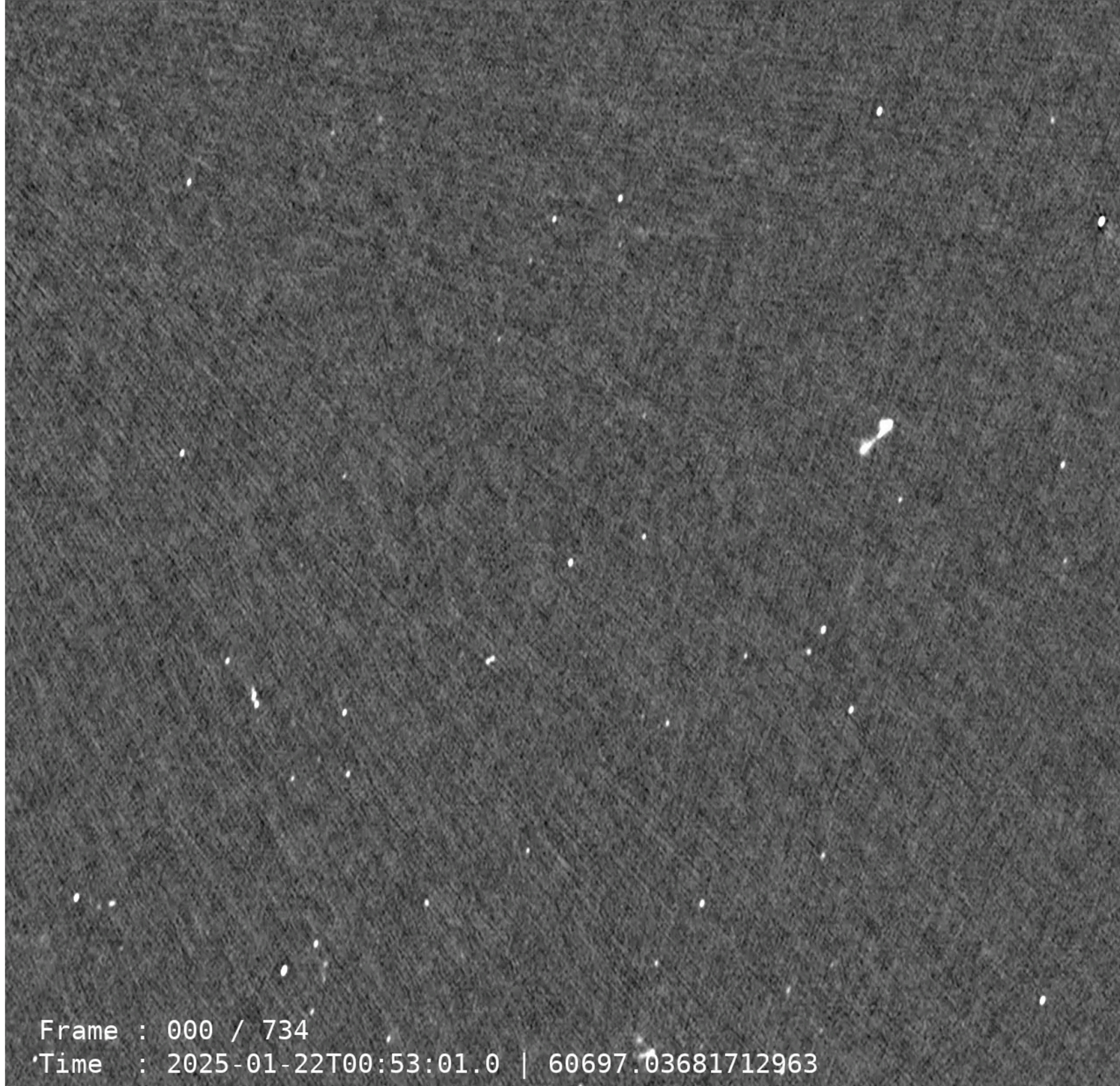
Manamela et al. (2026)

Transients

Making movies

- 8 second snapshot imaging
- ~450 individual images per pointing
- each image has ~1.5x FIRST sensitivity

78 ptgs x 10240^2 pixel images x 450 timeslots
$\approx 10^{13}$ pixels

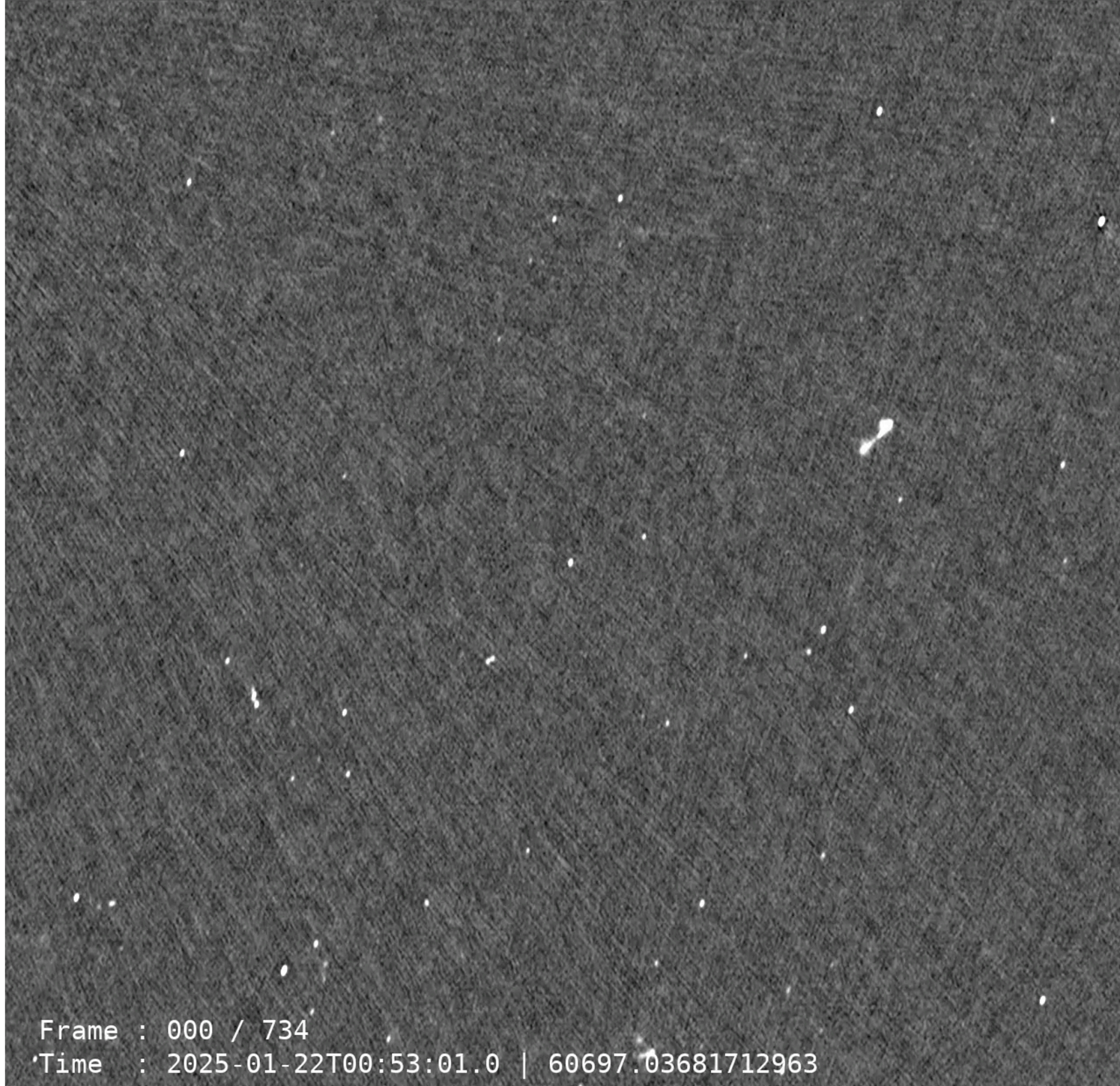


Simon Lowry MSc

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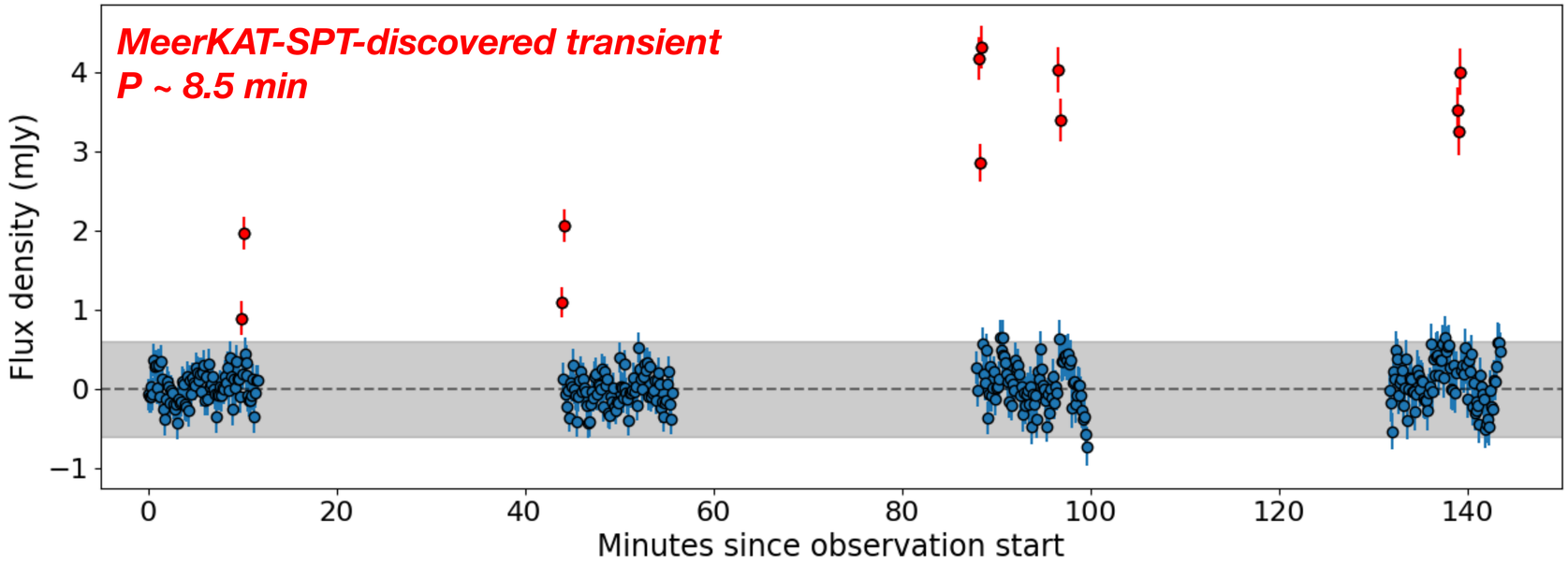
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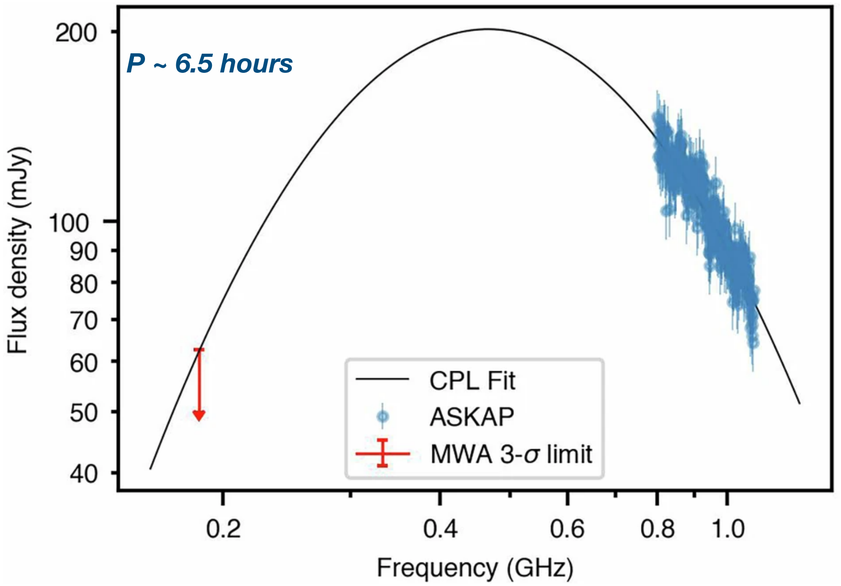
Simon Lowry MSc

MK-SPT-discovered Long Period radio Transient:

Bright+(in prep.)



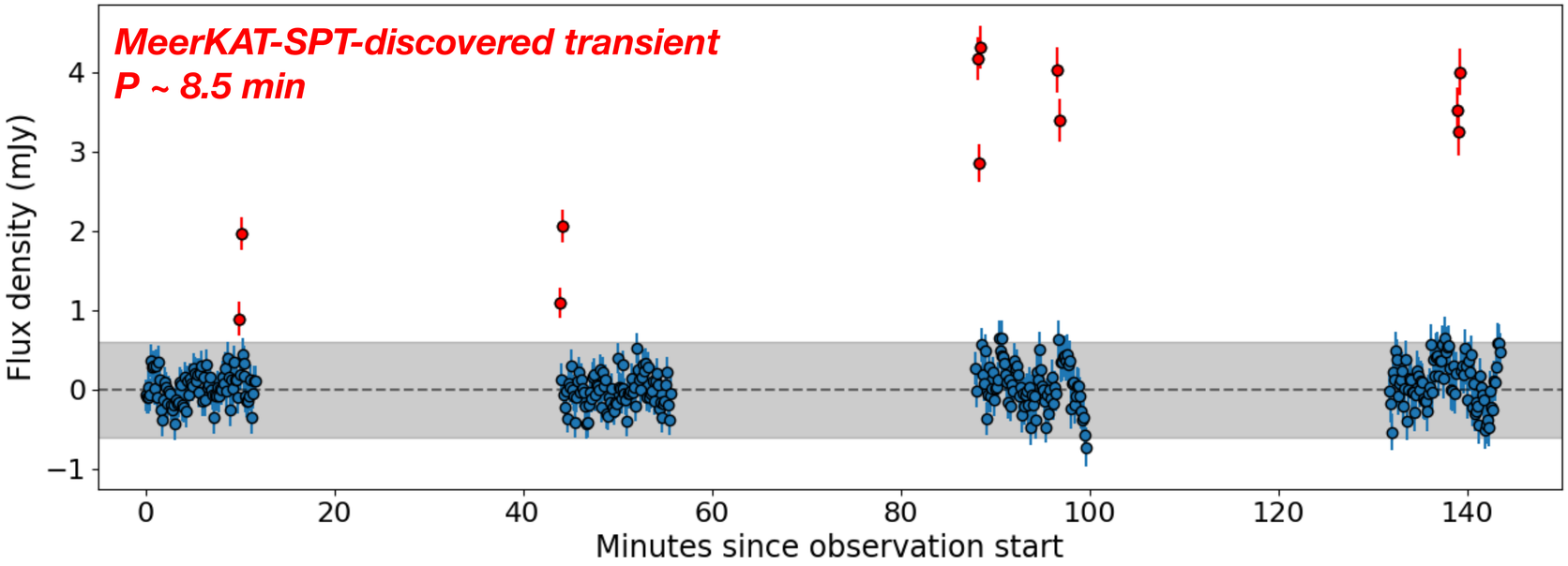
Lee+2025, Nature Ast.



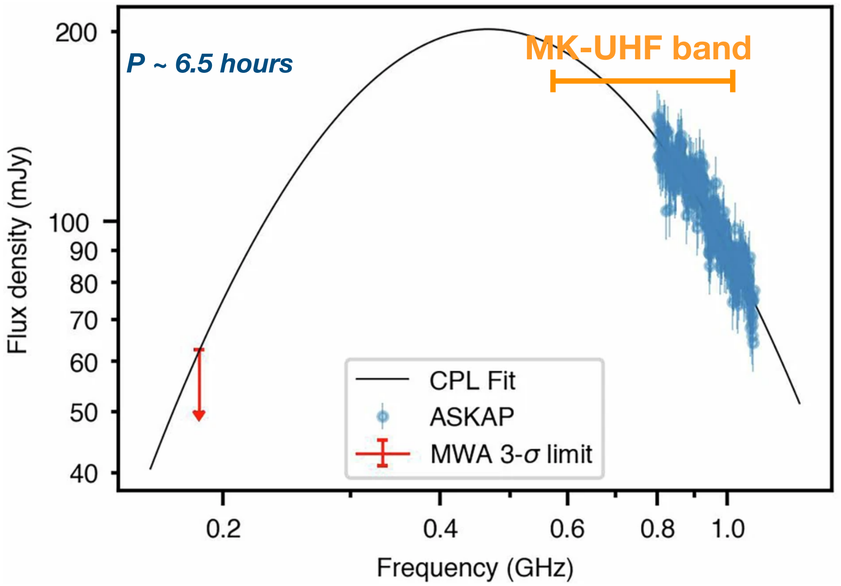
DDT follow-up confirms discovery

MK-SPT-discovered Long Period radio Transient:

Bright+(in prep.)



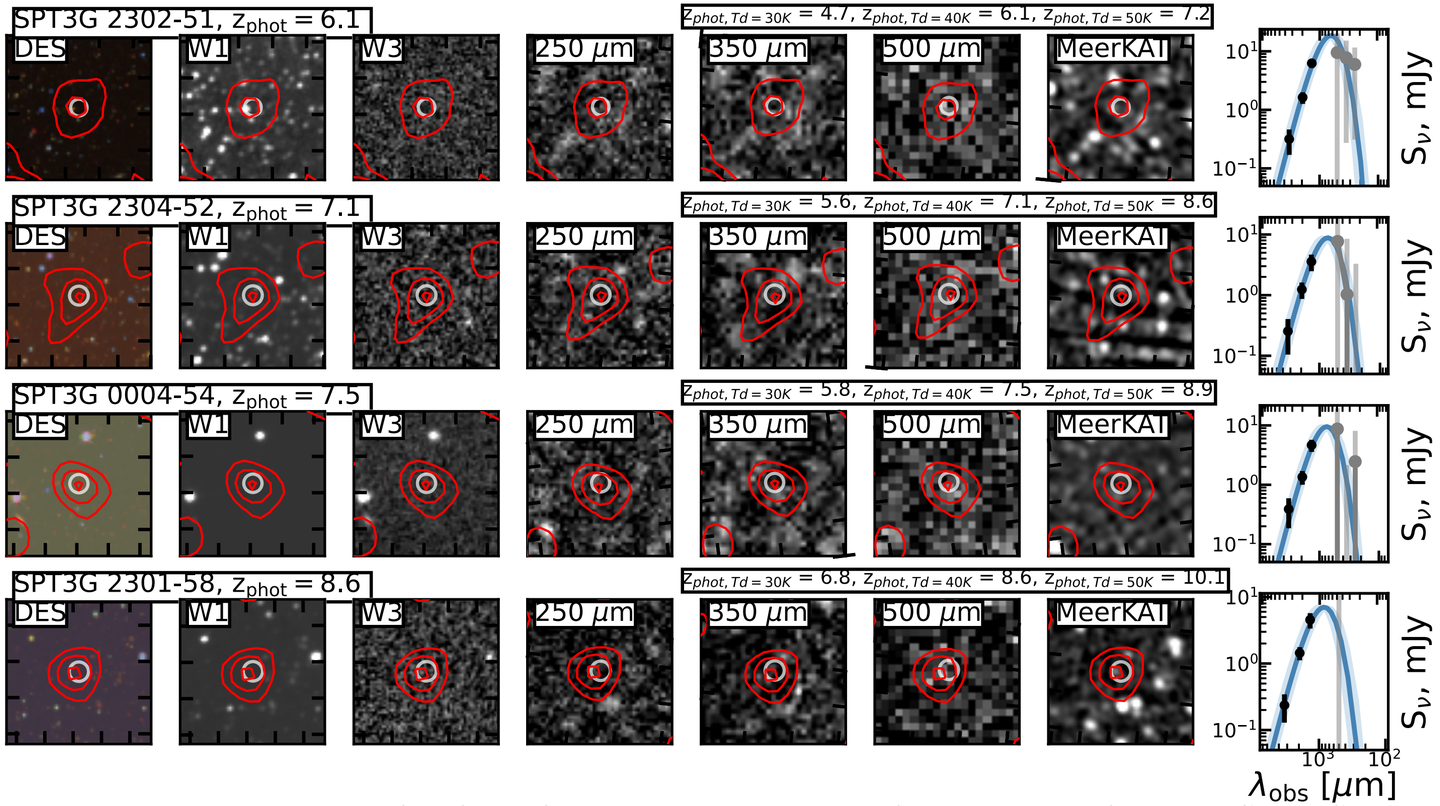
Lee+2025, Nature Ast.

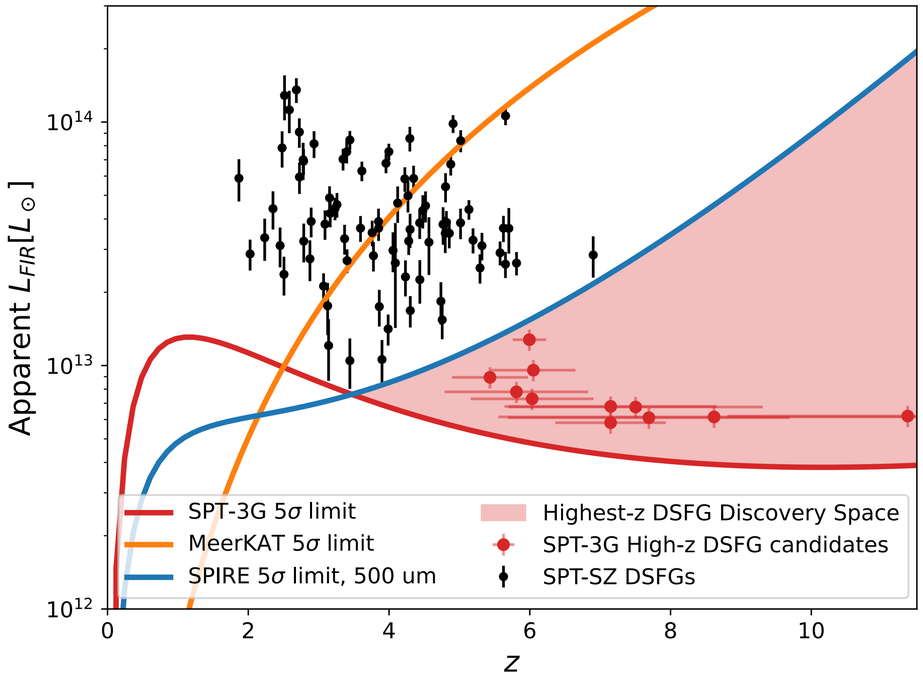


DDT follow-up confirms discovery

High-z galaxy selection

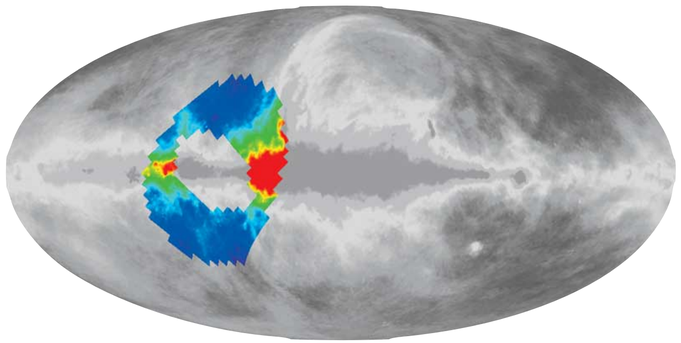
radio as a veto with SPT emission detections





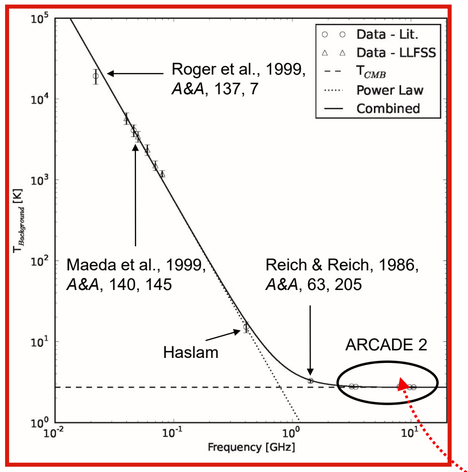
Understanding the cosmological radio background

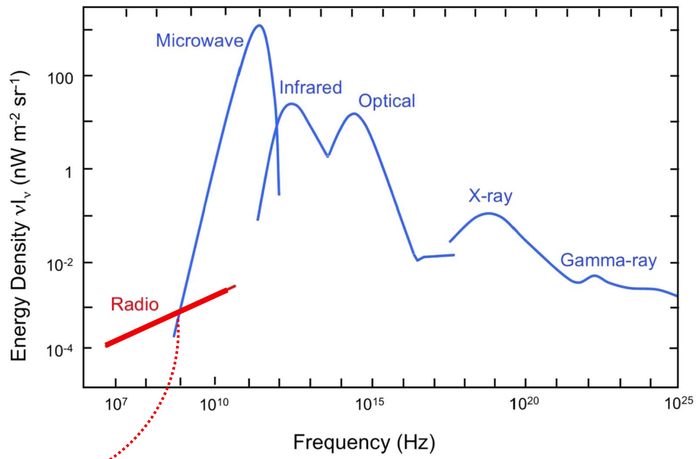




ARCADE: Absolute Radiometer for Cosmology, Astrophysics, and Diffuse Emission

Fixen+2011; Seiffert+2011

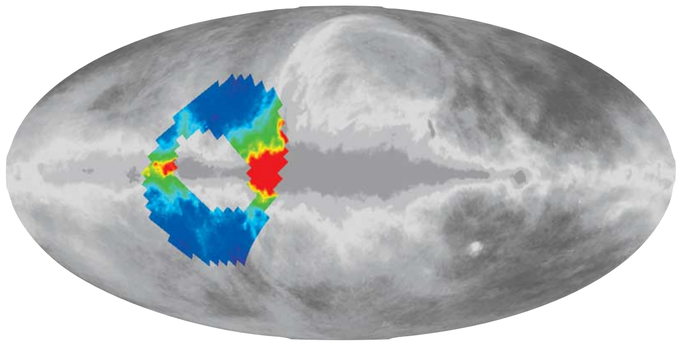




Singal+2018

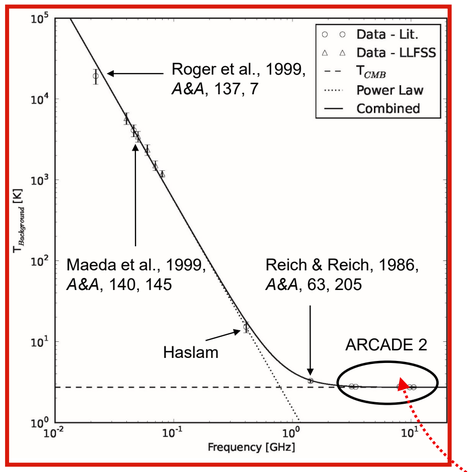
Understanding the cosmological radio background

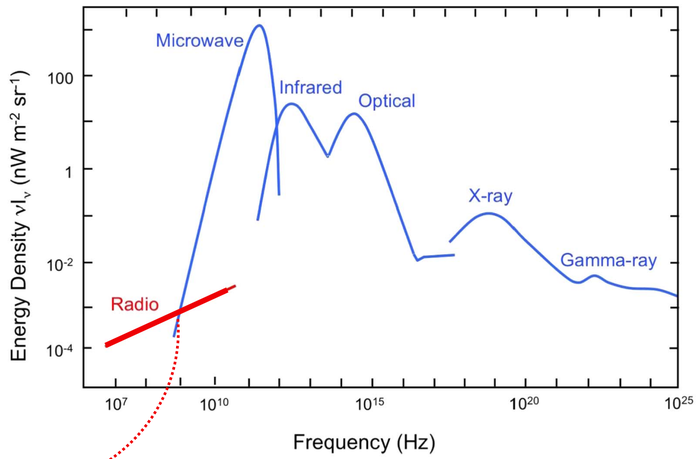




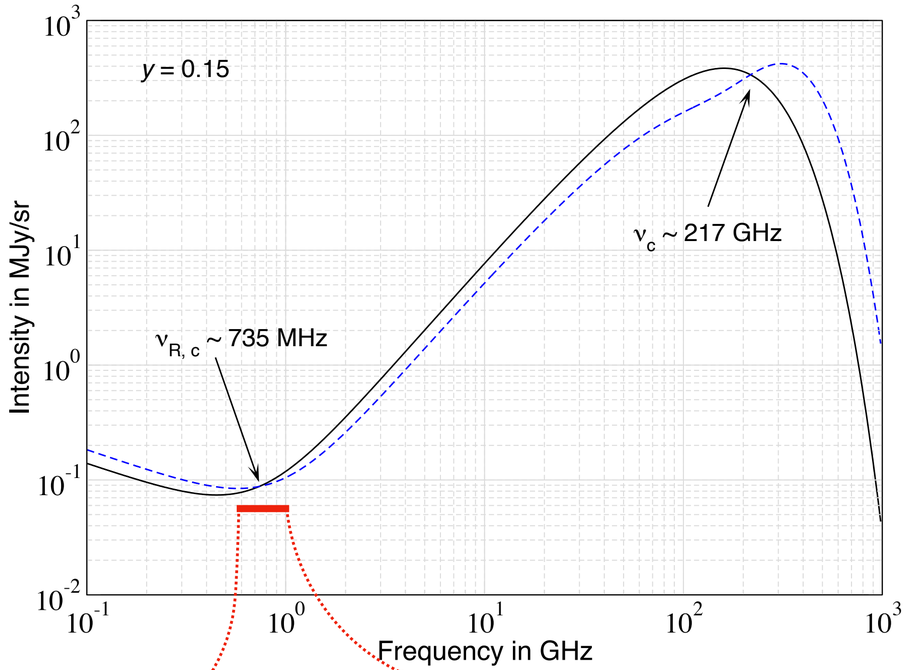
ARCADE: Absolute Radiometer for Cosmology, Astrophysics, and Diffuse Emission

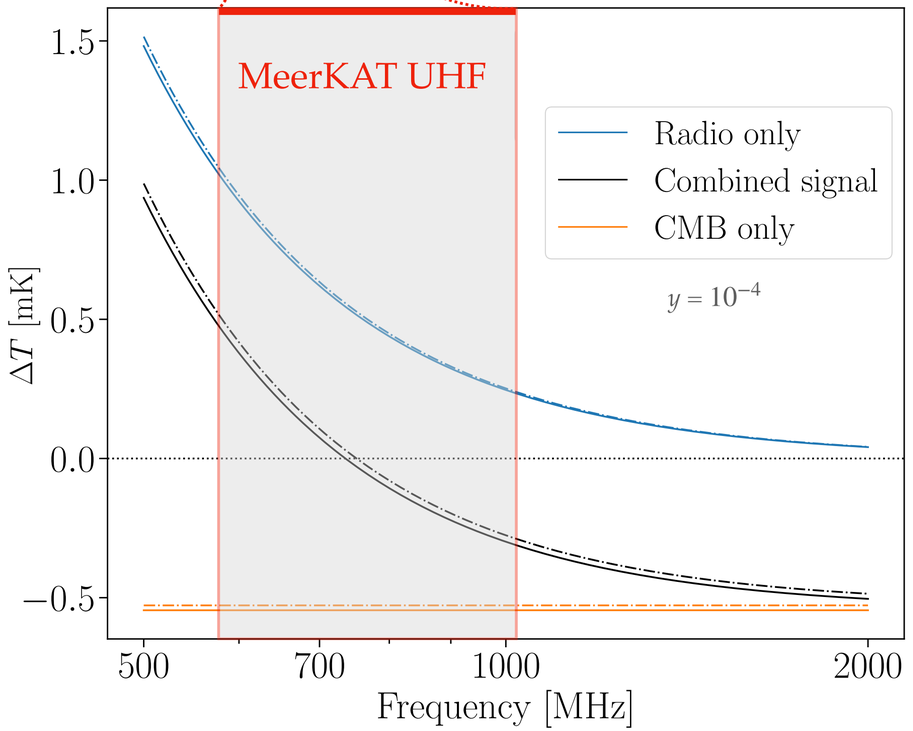
Fixen+2011; Seiffert+2011

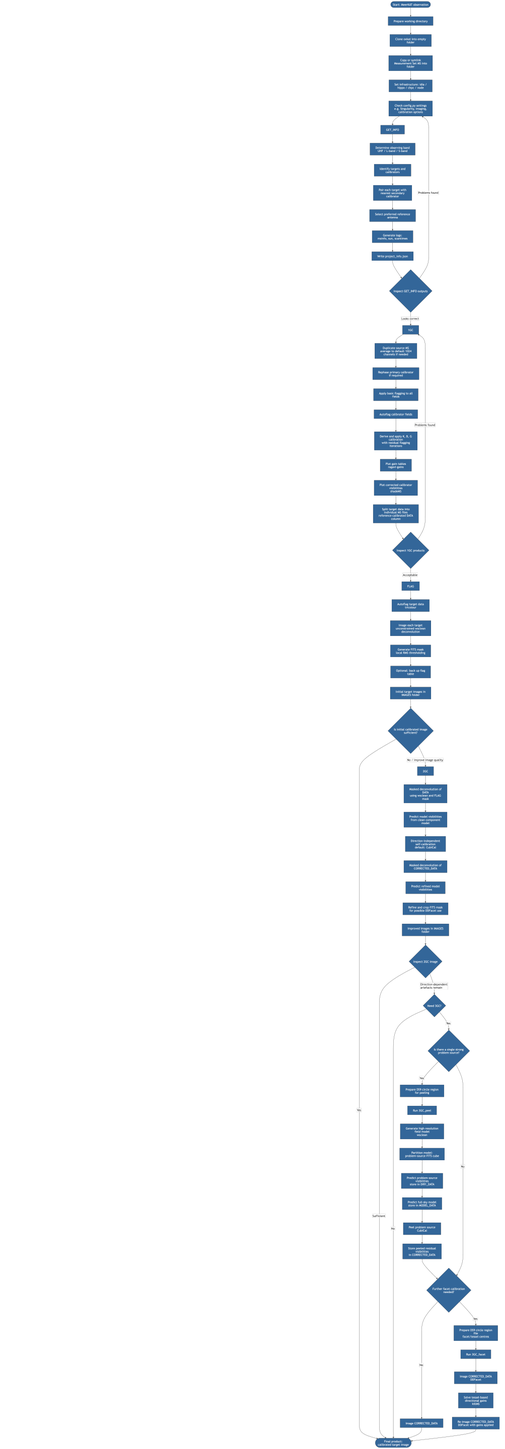


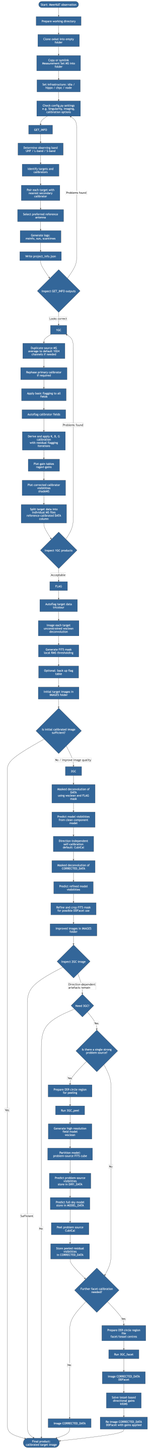


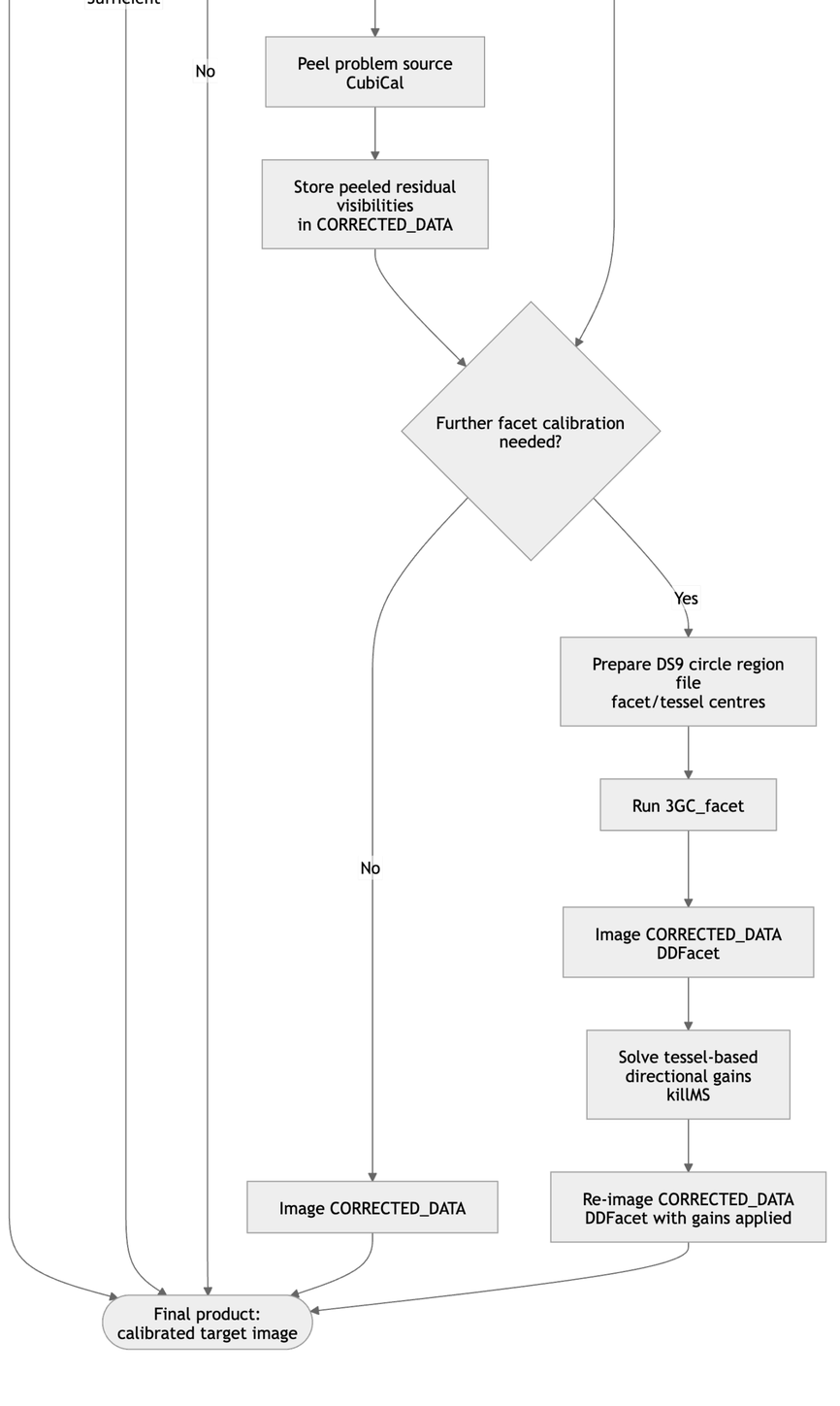
Singal+2018





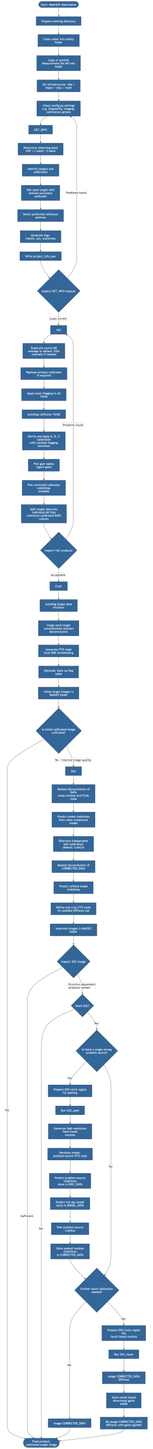

Run 'AutoSIF' observation
Prepare working directory
Clean raw turn-times folder
Clean up stale observation files in raw folder
Set environment for this night / start a log
Clear config for archive e.g. snapshots, images, and known targets
GET_INFO
Determine observing band (BP / B-band / Clear)
Identify targets and exposures
Set main target name, nearby, and reference catalogue
Problems found
Select preferred reference antenna
Generate new nearby_ref_refAnt.txt
Write project_info.json
Check GET_INFO Outputs
Looks correct
OK
Duplicate source dir to image to archive, then rename to original
Replace project_refAnt.txt if needed
Apply fant_flagging to all data
Anything calibrator fields
Problems found
Derive pol angle, R, Q, U, and fractional linear polarization
Plot gain table against time
Plot polarization calibrator results in standard
Open target data from measurement set, and inspect visibilities
Inspect ISF products
Acceptable
Flag
Autoflag target data tvchannel
Image and target average each antenna individually (bluemarble)
Summarize RFI mask check RFI terminating
Remove .bpol.ms file later
Close target images in AIPS/CASA open
Is RMS calibrated image sufficient?
No - Improve image quality
SELF
Restart documentation of calibrated data in AIPS and FUGE image
Model-model relationship between unpolarized image
Generate unpolarized image with the new refined Tutorial
Restart documentation of CLEANED.fits_data
Model refined model relationship
Refine and log CTG model for baseline SEF/LAB set
Improved image in AIPS/CASA image
Inspect SEF image
Directory dependent, previous known
Image SEF
Is there a high SEF or problematic data set?
Prepare SEF-only region for imaging
Run SEF_clean
Converge SEF calibration for refined tvchannel
Remove project product source RFI_Case
Predict product source data in SEF_data
Model CLEAN model source in AIPS_data
Plot polarized source images
Save product output to CLEANED.fits_data
Is image SEF calibrated enough?
Prepare SEF-only region for the Sgr* source
Run SEC_clean
Image CLEANED.fits_data_SEFcase
Save input image and image data source
Image CLEANED.fits_data
Re-image CLEANED.fits_data and save to archive
Save calibrated image final
Yes
No
Sufficient
Problems found

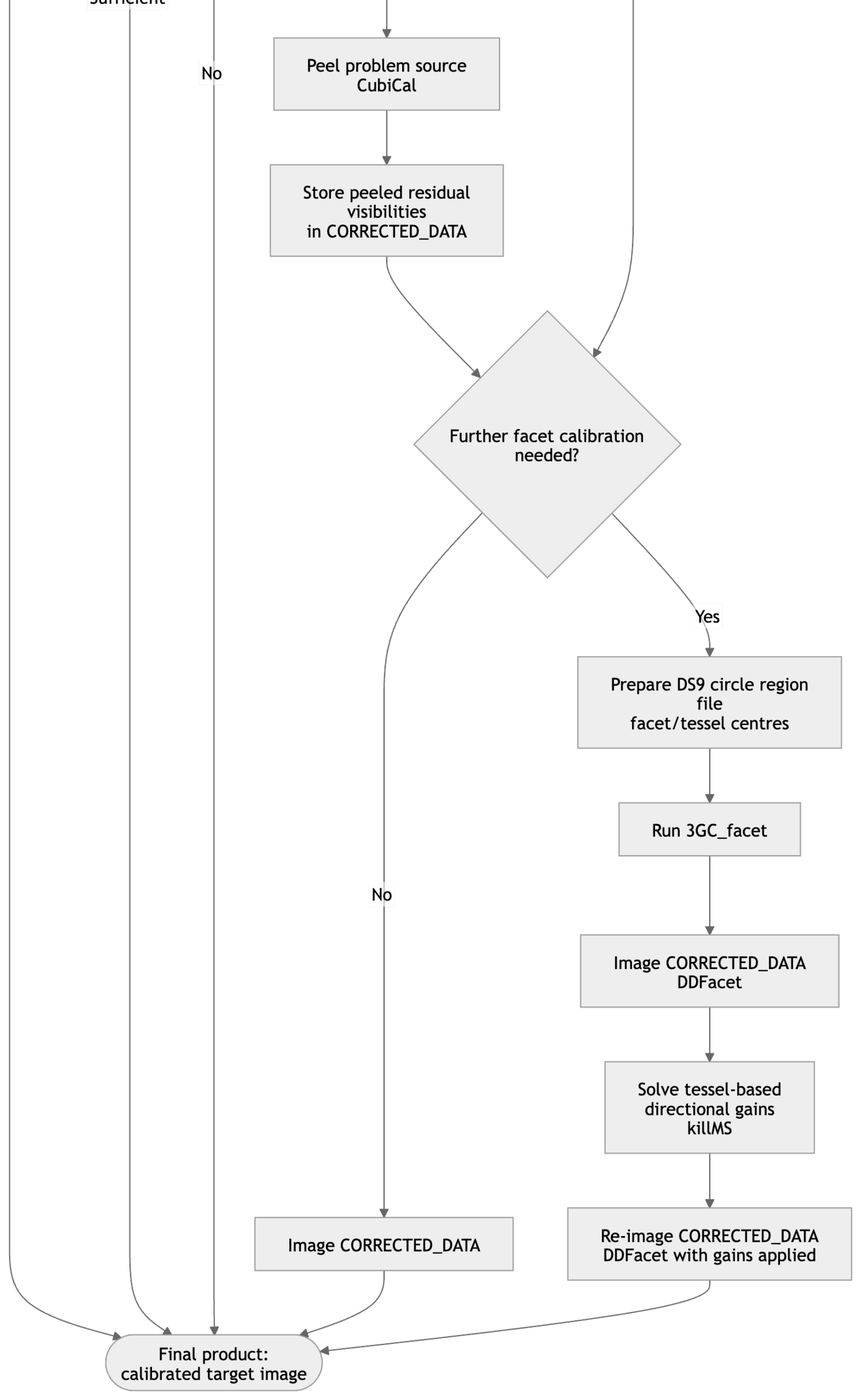

Run 'makeMS' observation
Prepare working directory
Clone code from Github master
Copy in custom meqtrees-cattery MS.py, Meow.py
Add pipeline scripts to $PATH / start X -nolo
Check config for workingdir, e.g. Singularity, killMS, DDFacet, QuartiCal, etc.
GET_INFO
Documented observing band (UHF / L-band / S-band)
Identify imagers and calibrators
Run init script with observing band and calibrator
Problems found
Select preferred reference antenna
Generate make_mask.py, rad_indirect.py
Write project_info.json
Inspect GET_INFO products
Looks correct
GET
Read and source MS, re-image to confirm field centre and calibrator
Rephase primary calibrator if required
Apply band flagging to all MS
Identify calibrator fields
Problems found
Extract and apply K, B, G solutions from calibrator, flagging outliers
Plot gain solutions
Plot amplitude-calibrator data vs. model, pre-solution
Spot-image data from calibrator fields to check calibrator flux is correct
Inspect CAL products
Acceptable
CAL
Autoflag target data (optional)
Image and target average data, initial dirty/residual
Generate RFI mask from CASA TB0 terminating
Rephase, split to the field
Image target averages in WSCMS mode
Is initial calibrated image sufficient?
No – improve image quality
IMG
Restart deconvolution of calibrated data with CASA, wsclean, or DDFacet
Predict mask-validation model from improved image
Generate subtracted/corrected data with default DDFacet
Restart deconvolution of CORRECTED_DATA
Predict refined model visibilities
Refine and tag CTIO mask for sensitive DDFacet use
Improved image in WSCMS mode
Inspect IDG image
Direction-dependent products known
Make RFI
Is there a high degree of confusion/ RFI in the primary beam?
Prepare RFI mask region for plotting
Run RFI_plot
Coverage-type exploration for RFI mask retrieval
Examine extent, position angle of RFI cone
Predict problem source data to CORR_DATA
Predict full sky model data to MODEL_DATA
Plot amplitude against uv-distance
Form passive residual data in CORRECTED_DATA
Further facet calibration needed?
Prepare DDF mask region for facet-based cleaning
Run IDG_recon
Image CORRECTED_DATA, DDFacet
Store facet-based direct-cross gains
Re-image CORRECTED_DATA, DDFacet with gains applied
Image CORRECTED_DATA
Final product: calibrated target image


Sufficient
No
Peel problem source CubiCal
Store peeled residual visibilities in CORRECTED_DATA
Further facet calibration needed?
Yes
Prepare DS9 circle region file facet/tessel centres
Run 3GC_facet
No
Image CORRECTED_DATA DDFacet
Solve tessel-based directional gains killMS
Image CORRECTED_DATA
Re-image CORRECTED_DATA DDFacet with gains applied
Final product: calibrated target image

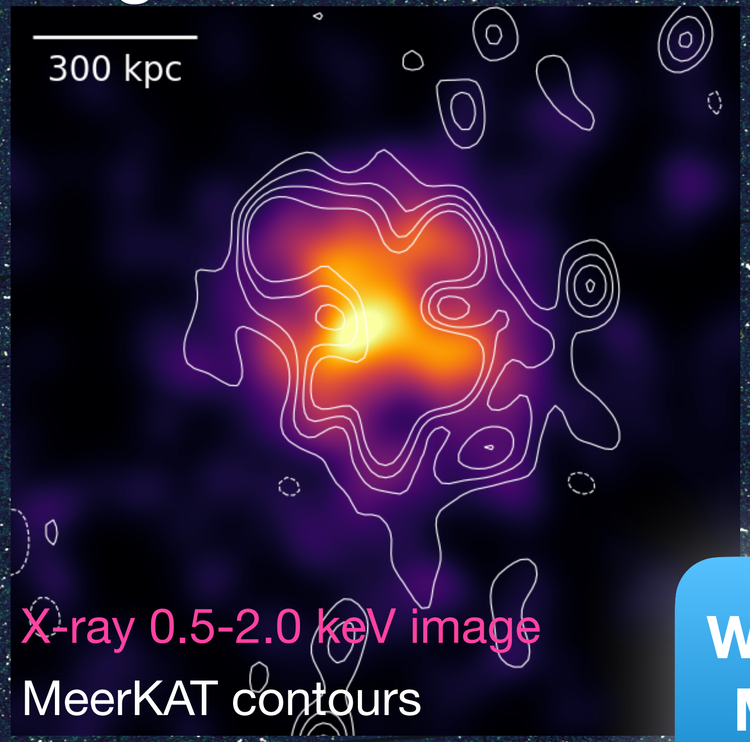
IceKAT pipeline



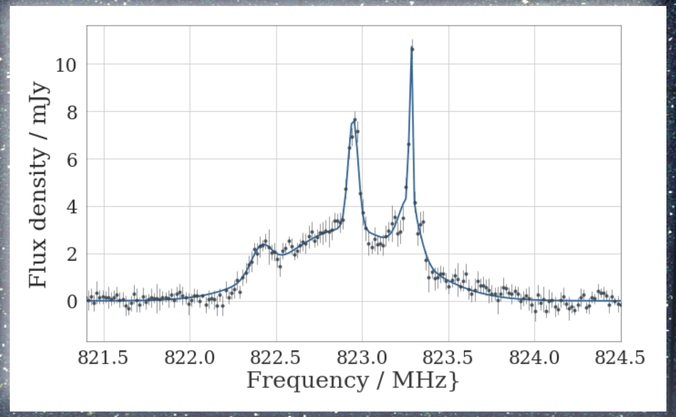




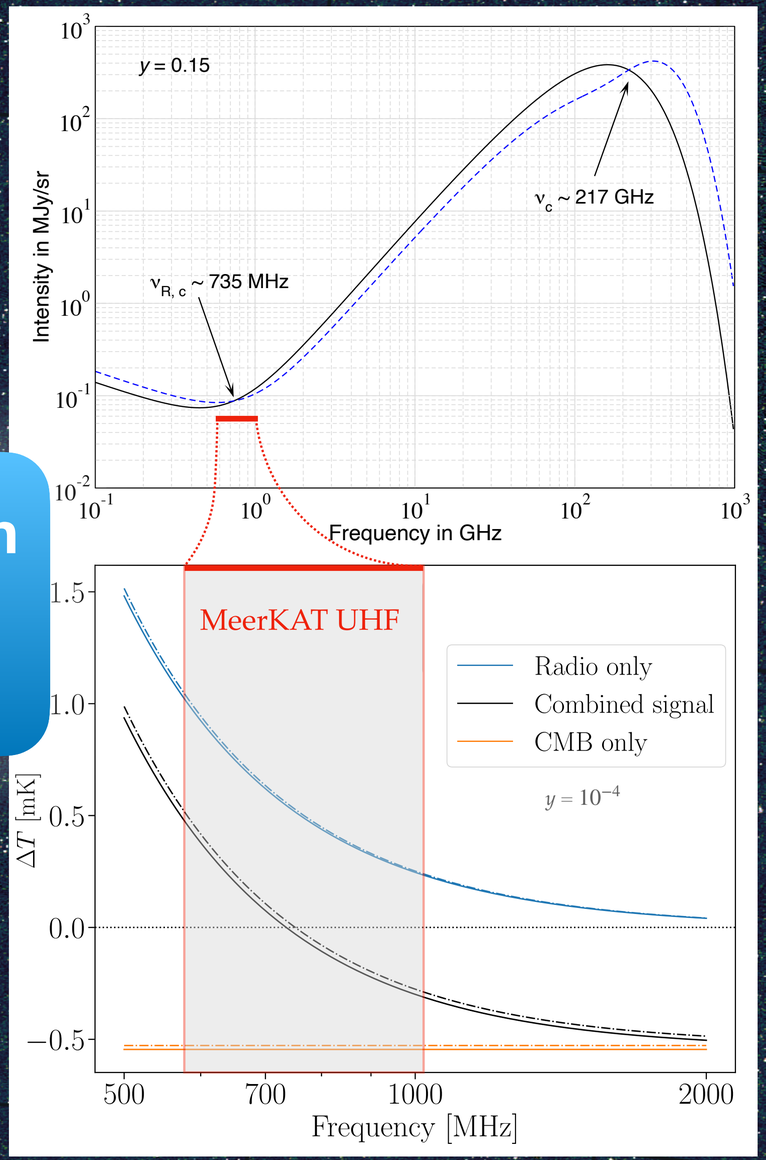
High-z radio haloes



Lensed OHMs

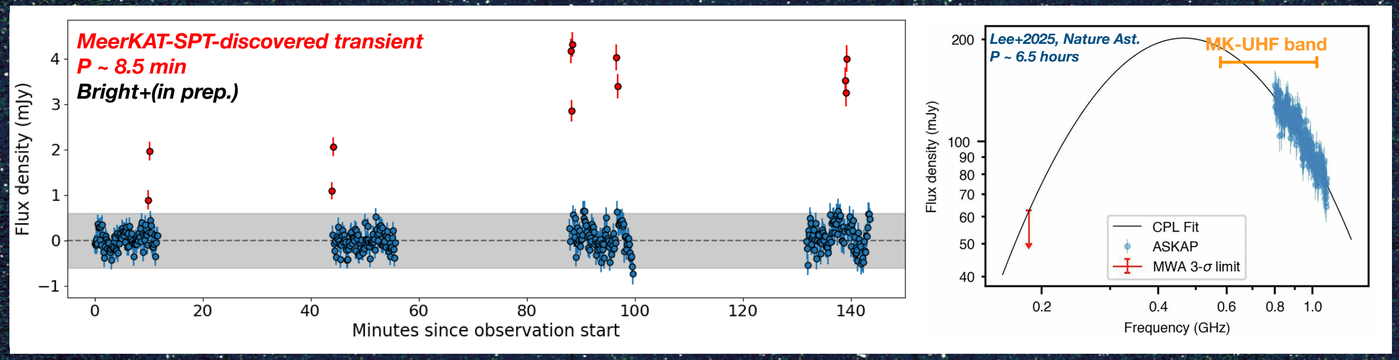


Radio SZ effect



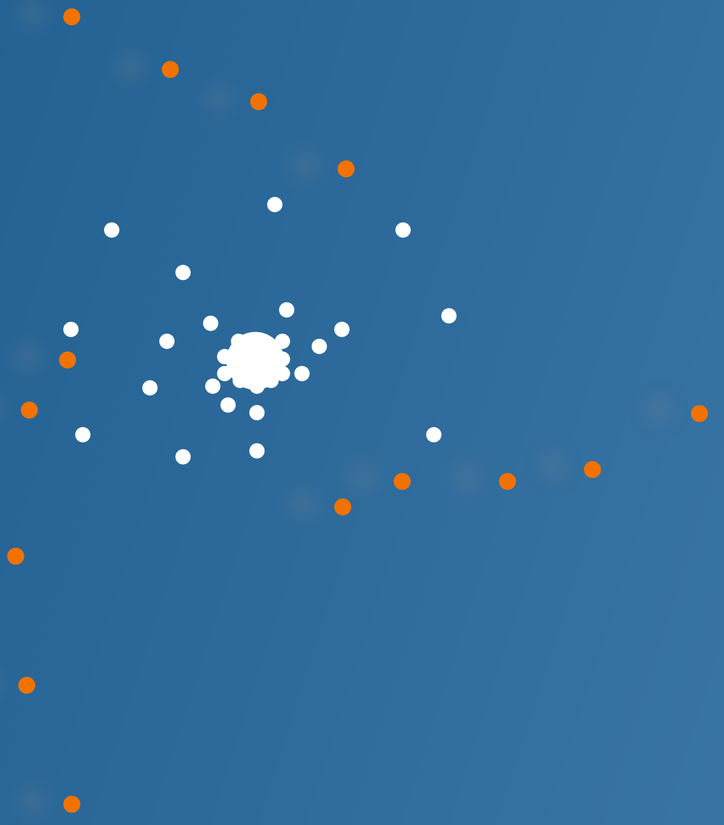
Well positioned for >8x increase in MK-SPT science, but need more input with science input

Transient / variable sources





Expansion to MeerKAT+



NRF National Research Foundation | SARAO South African Radio Astronomy Observatory

MAX PLANCK GESELLSCHAFT

INAF ISTITUTO NAZIONALE DI ASTROFISICA

Summary

New MeerKAT XLP: 800 deg^2 sub-10 μJy/beam UHF survey over SPT deep fields, leveraging mm and cm-wave synergies to explore a discovery-rich parameter space.

Survey provides a unique combination of area, depth, angular resolution, imaging fidelity.

Wide range of commensal science (clusters, high-z galaxies, radio transients, OHMs) as well as cosmological applications.