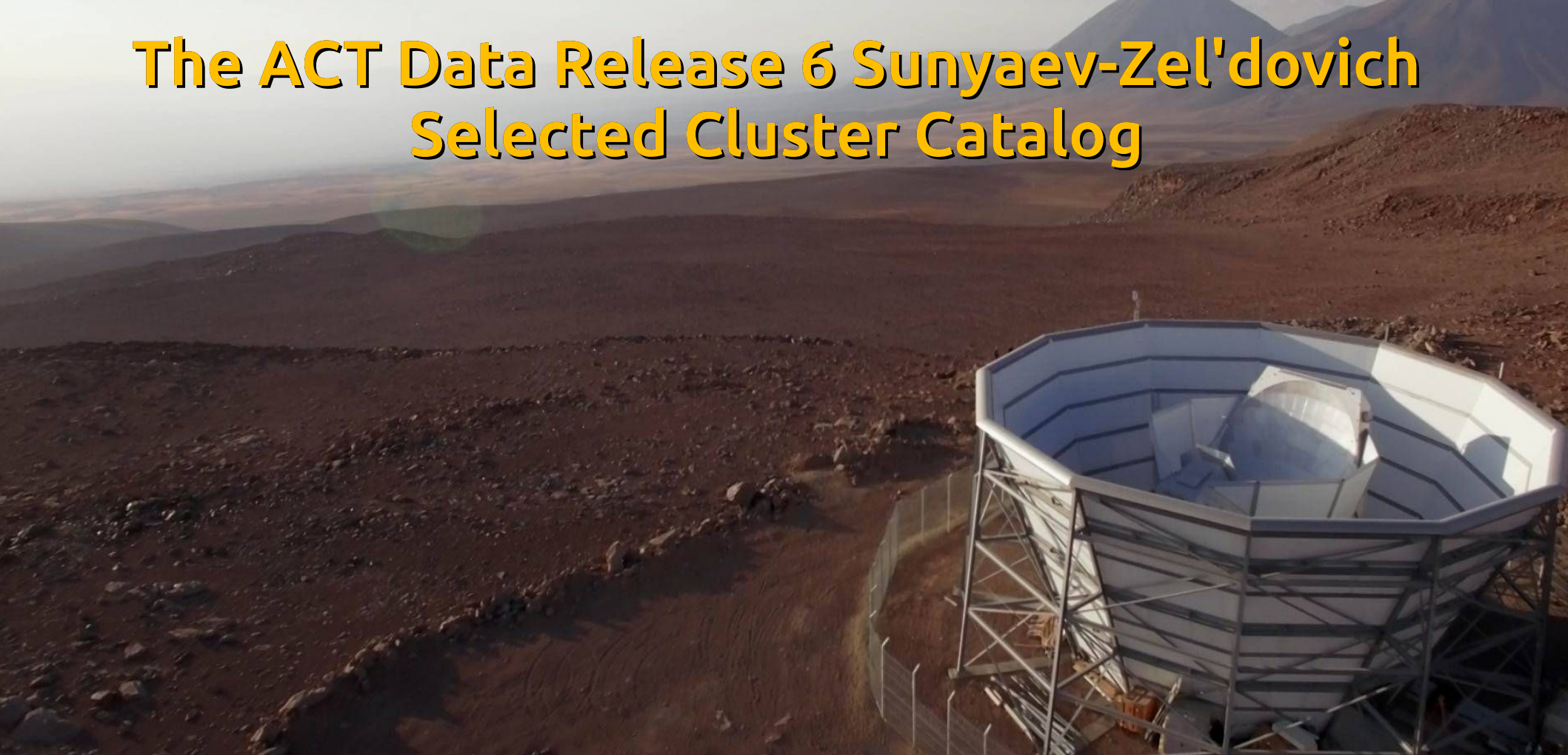


The ACT Data Release 6 Sunyaev-Zel'dovich Selected Cluster Catalog



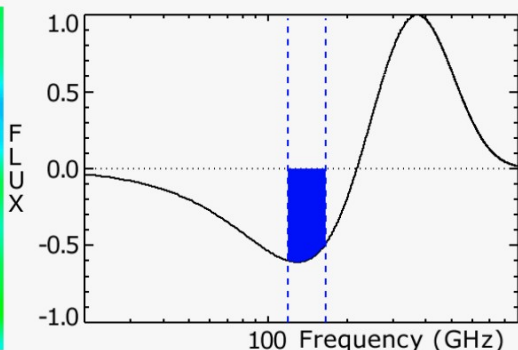
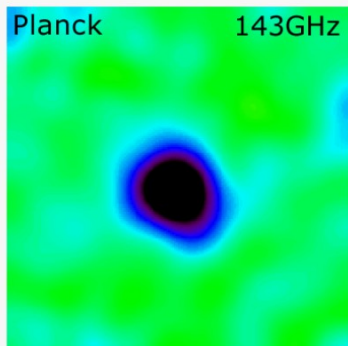
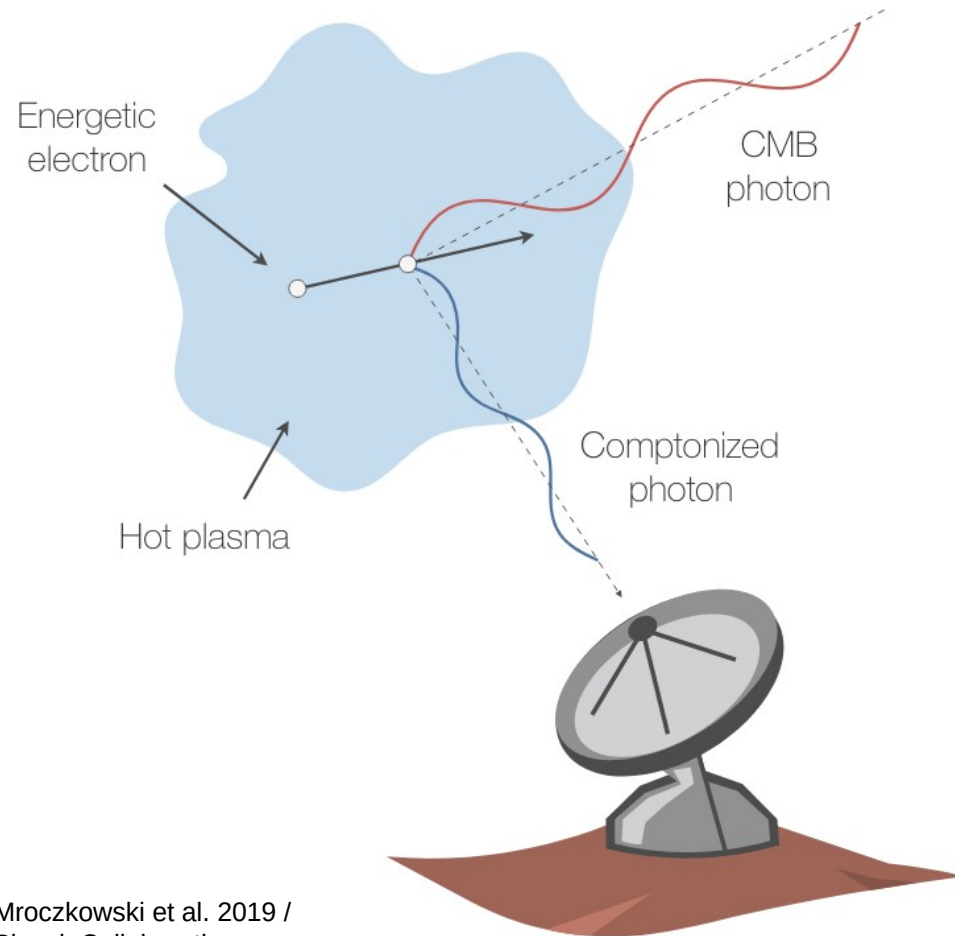
2007-2010: ACT 'MBAC'
2013-2015: ACT 'ACTPoI'
2016-2022: ACT 'AdvACT'

6 m telescope, 1.4' resolution (150 GHz)



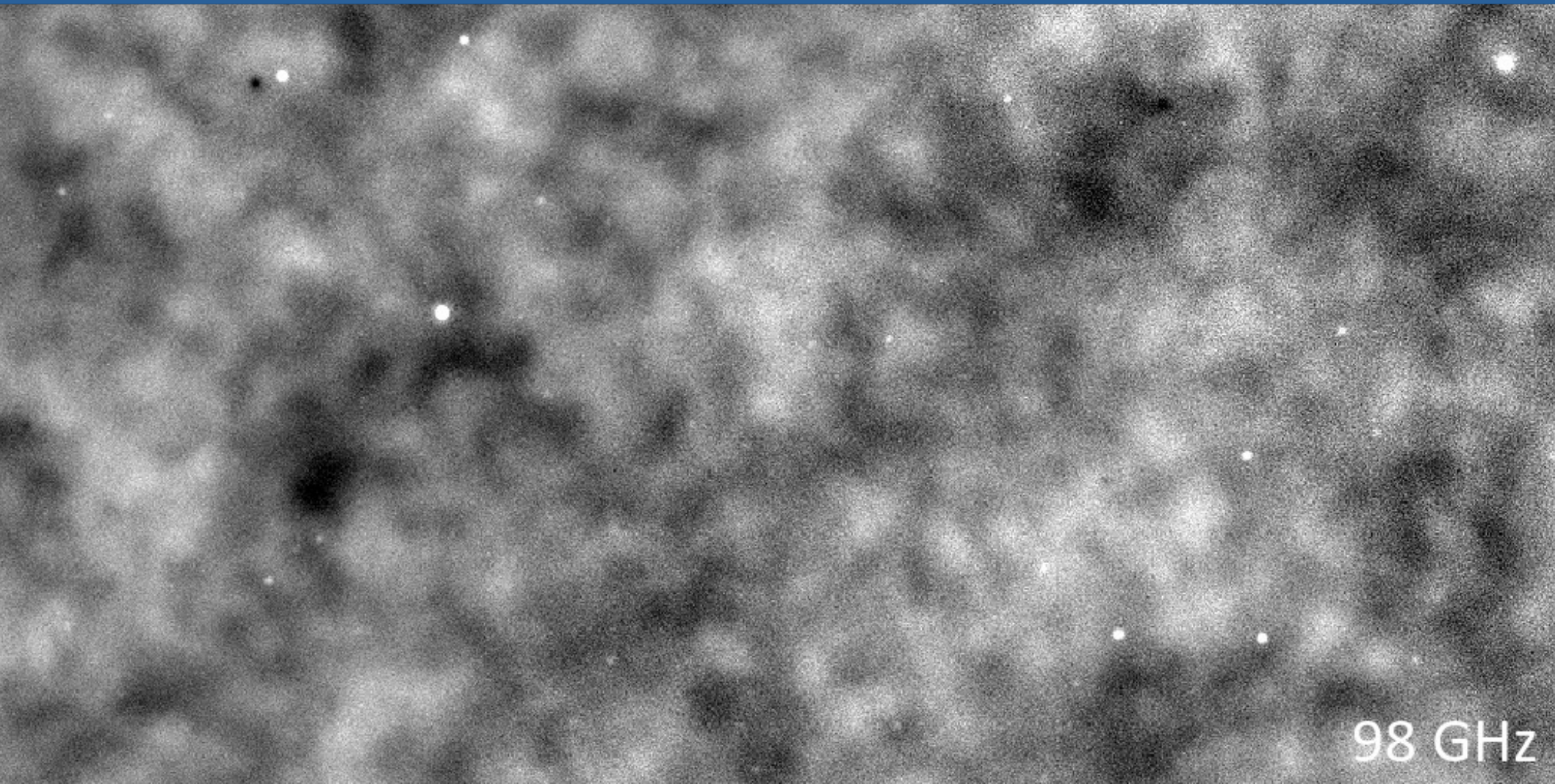
The Sunyaev-Zel'dovich effect

- The SZ effect is the inverse Compton scattering of cosmic microwave background photons by high-energy electrons in the intracluster gas
- Independent of redshift – allows us to find all clusters in the Universe above a mass limit set by the survey noise level
- SZ signal scales with cluster mass
- First blind detections in 2009 by SPT (Staniszewski et al.)



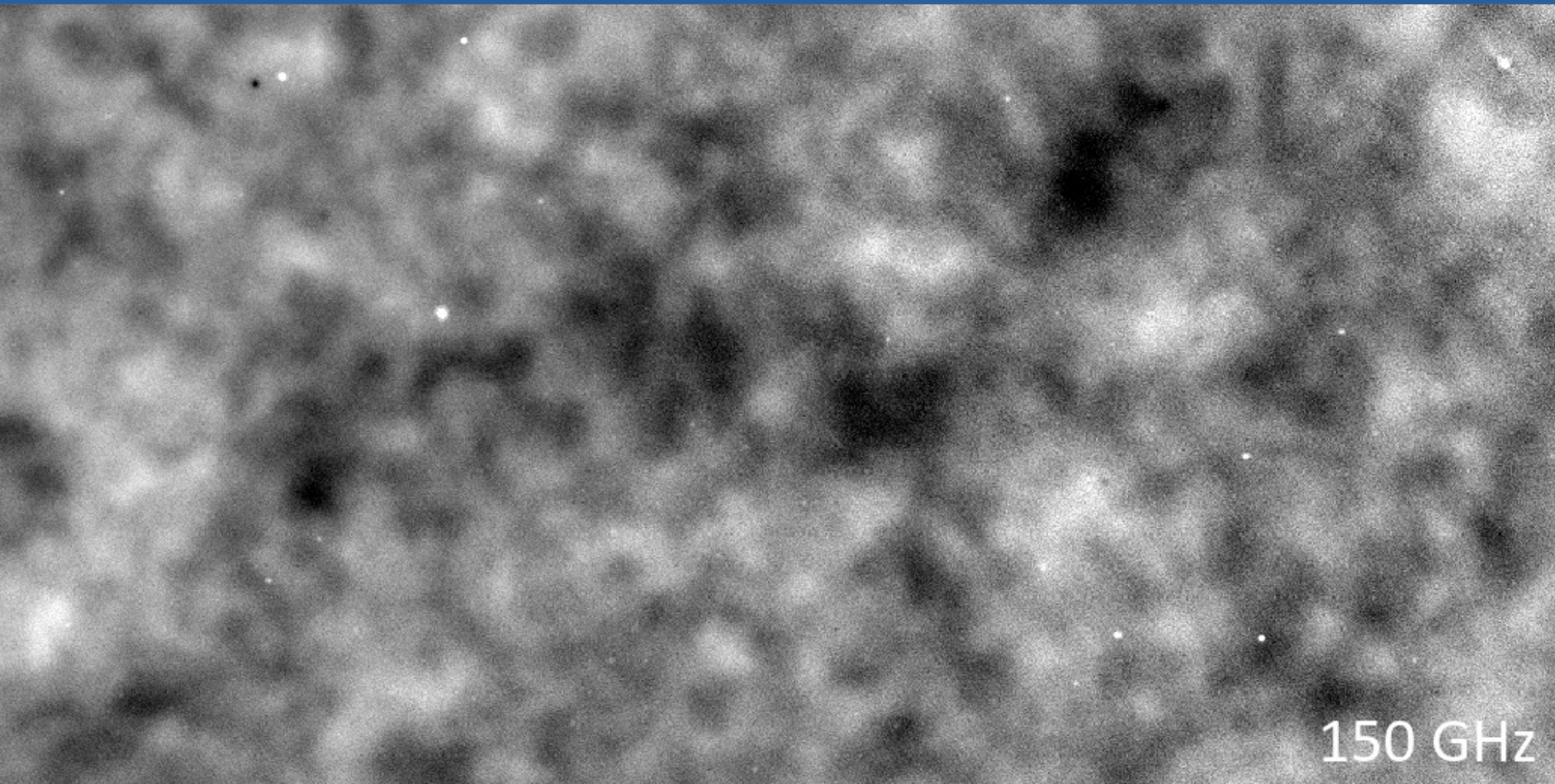
Mroczkowski et al. 2019 /
Planck Collaboration

SZ cluster finding



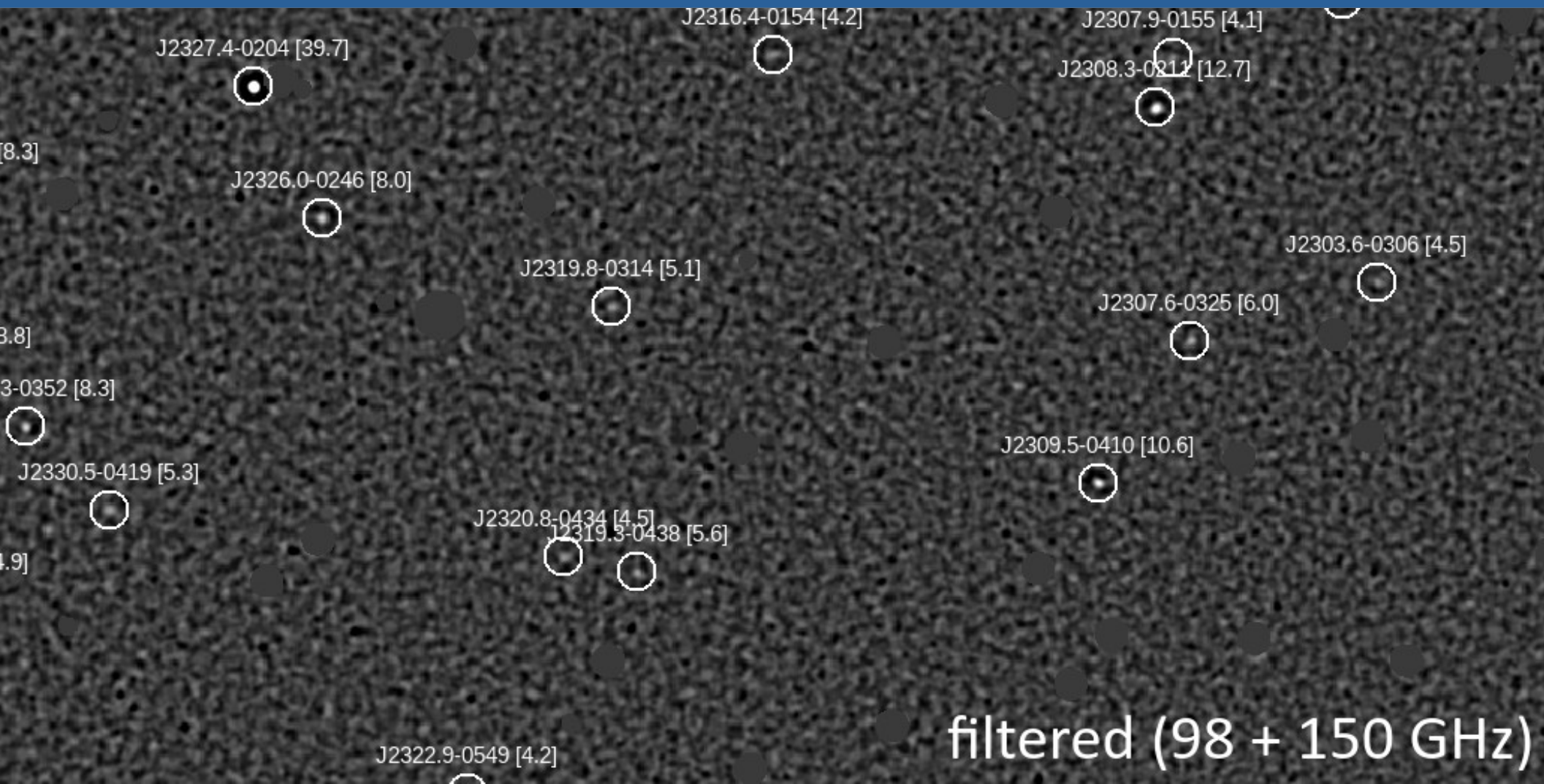
98 GHz

SZ cluster finding

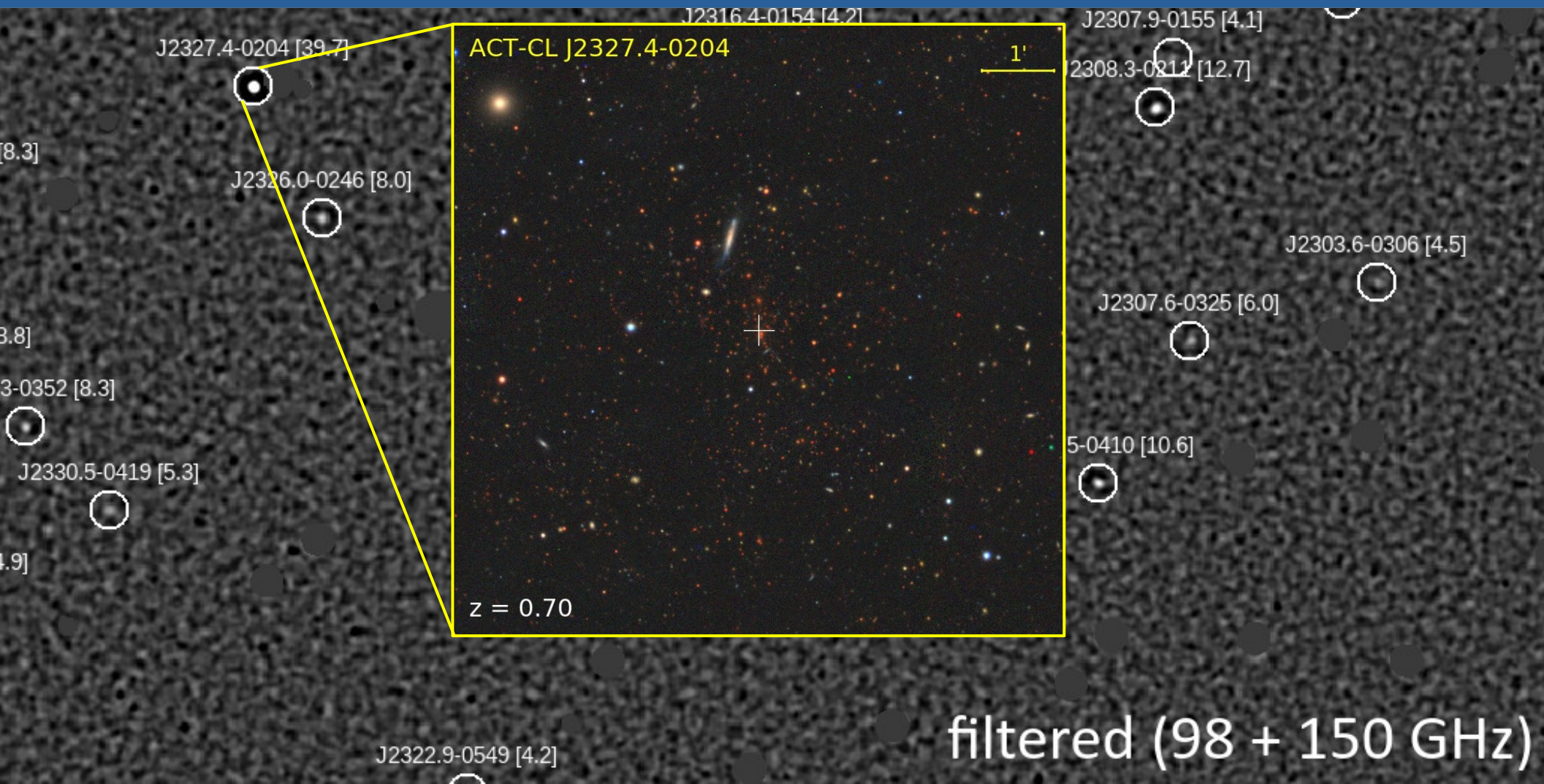


150 GHz

SZ cluster finding

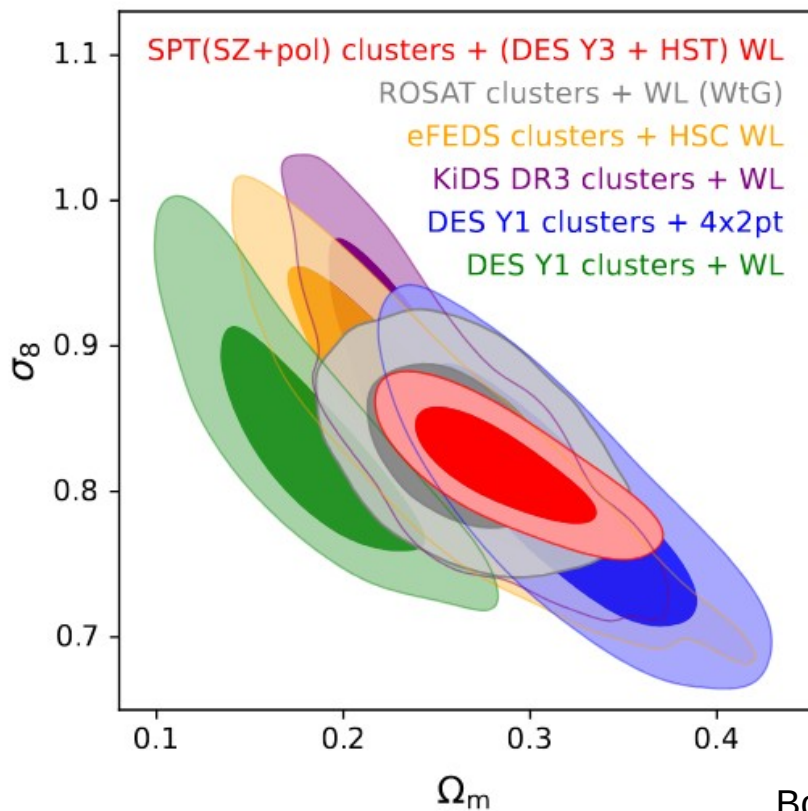


SZ cluster finding

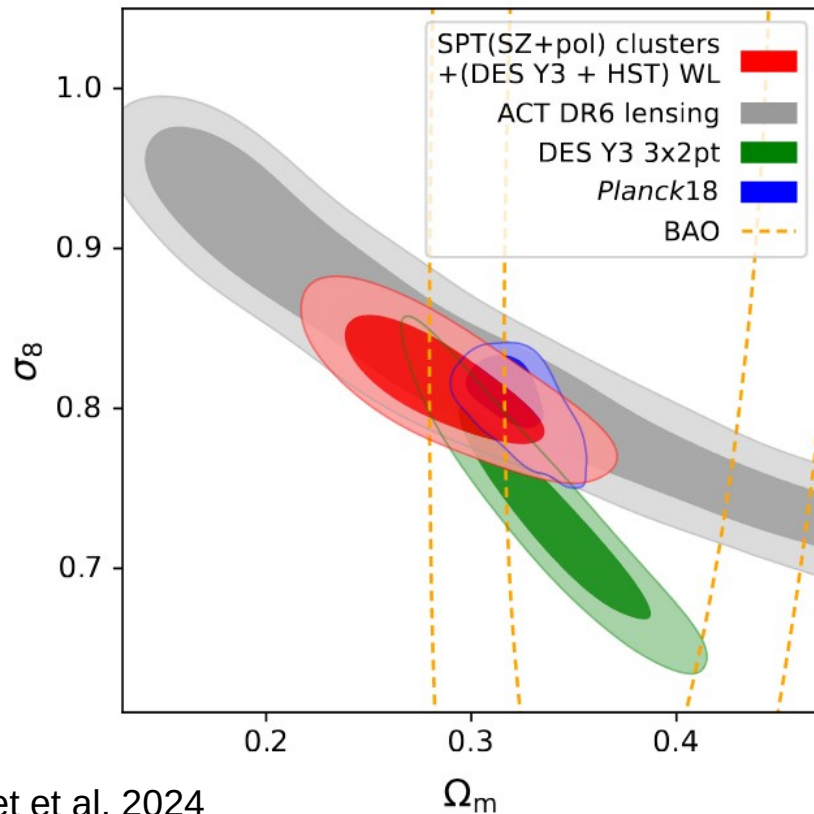


Cosmology with clusters

- Recent results using clusters from the South Pole Telescope SZ surveys compared to several other cosmological measurements

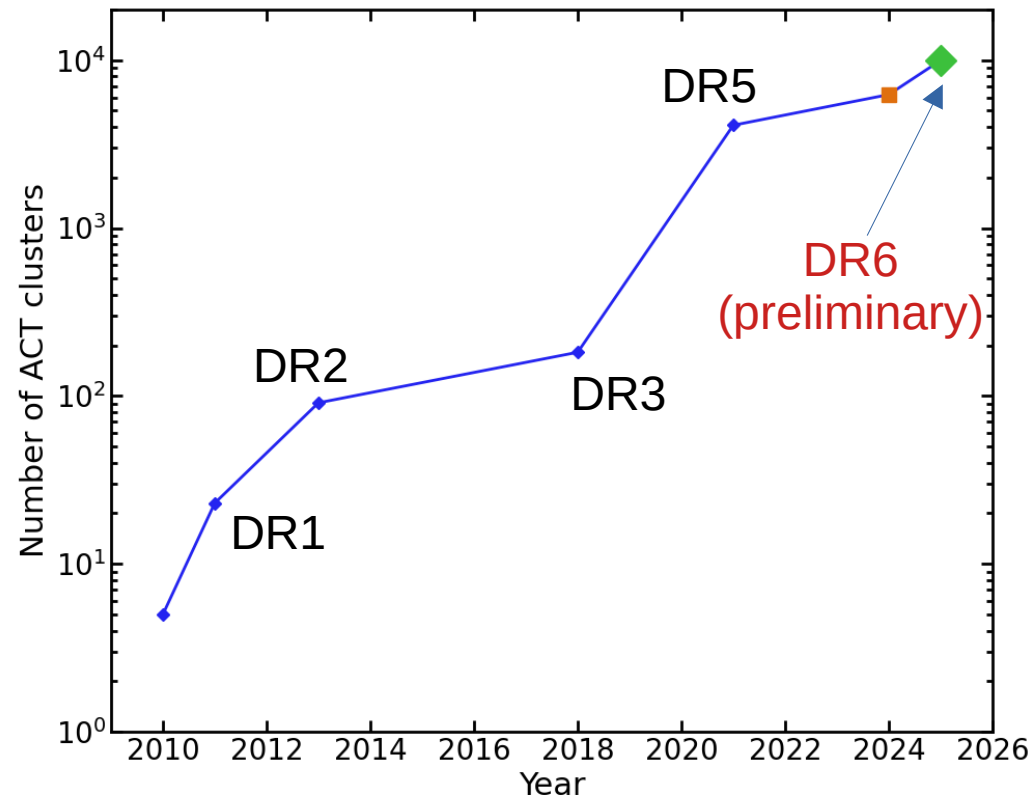
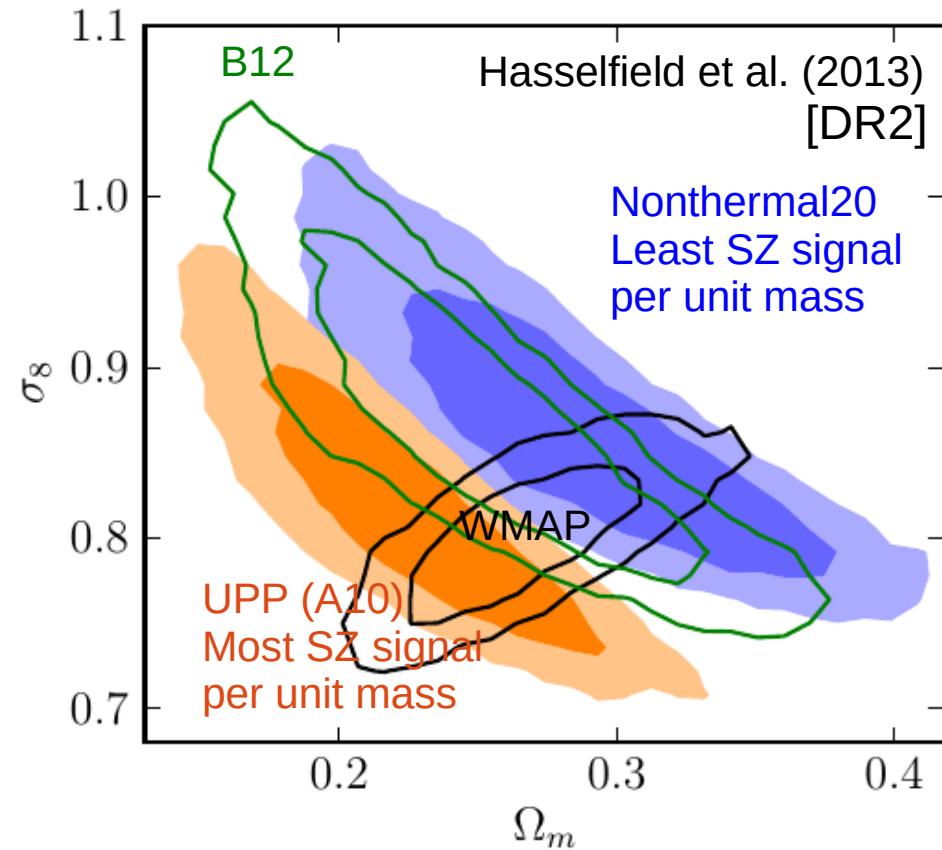


Bocquet et al. 2024



The ACT cluster search

- It's 12 years since the last ACT cluster cosmology paper
- In that time the cluster sample has increased by a couple of orders of magnitude

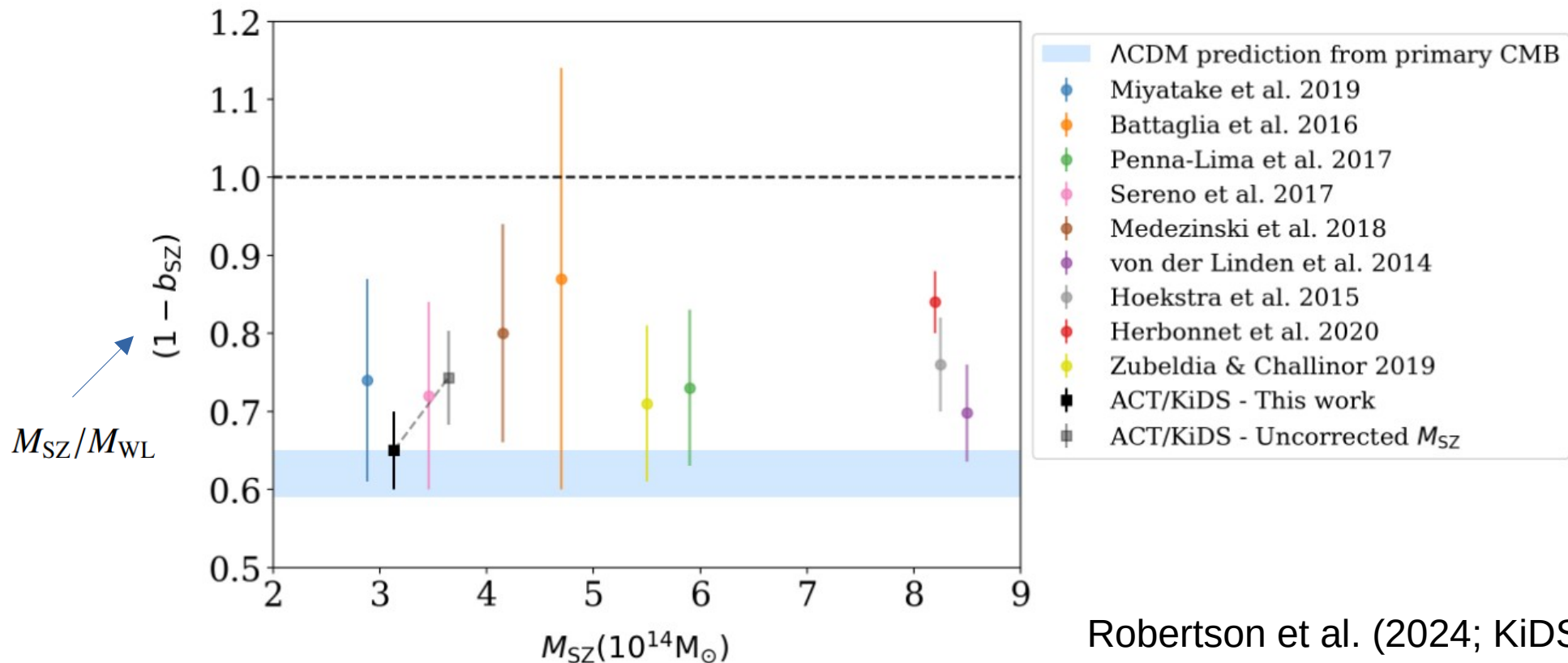


Differences between DR6 and DR5

- 3 frequencies (f090, f150, f220) using as much data as possible from 2008 – 2022
- Multipass filtering + source detection:
 1. Find brightest sources ($S/N > 50$) in each frequency and mask / infill
 2. Find other sources ($S/N > 5$) in each frequency and subtract (flag affected regions)
 3. Find clusters and subtract from maps when estimating noise in the matched filter
 4. Final cluster finding run to extract $S/N > 4$ clusters
- Flagging:
 - Finder flags (regions containing subtracted point sources)
 - Dusty regions (thresholded Planck 353 GHz map)
 - Extended objects (nearby galaxies, nebulae, etc.)
 - Regions near bright stars (harder to get photo-zs etc.)
- Redshifts:
 - Updated DES (redMaPPer + WaZP Y6) and HSC (CAMIRA S23B) cluster catalogs
 - DECaLS DR9/10 catalogs (Klein+2024 MCMF ; MaDCoWS2 ; eRASS ; our own photo-zs; etc.)
- Mass calibration:
 - Report masses using scaling relation consistent with weak-lensing measurements
 - We still report Arnaud+2010 scaling relation masses for comparison with previous work

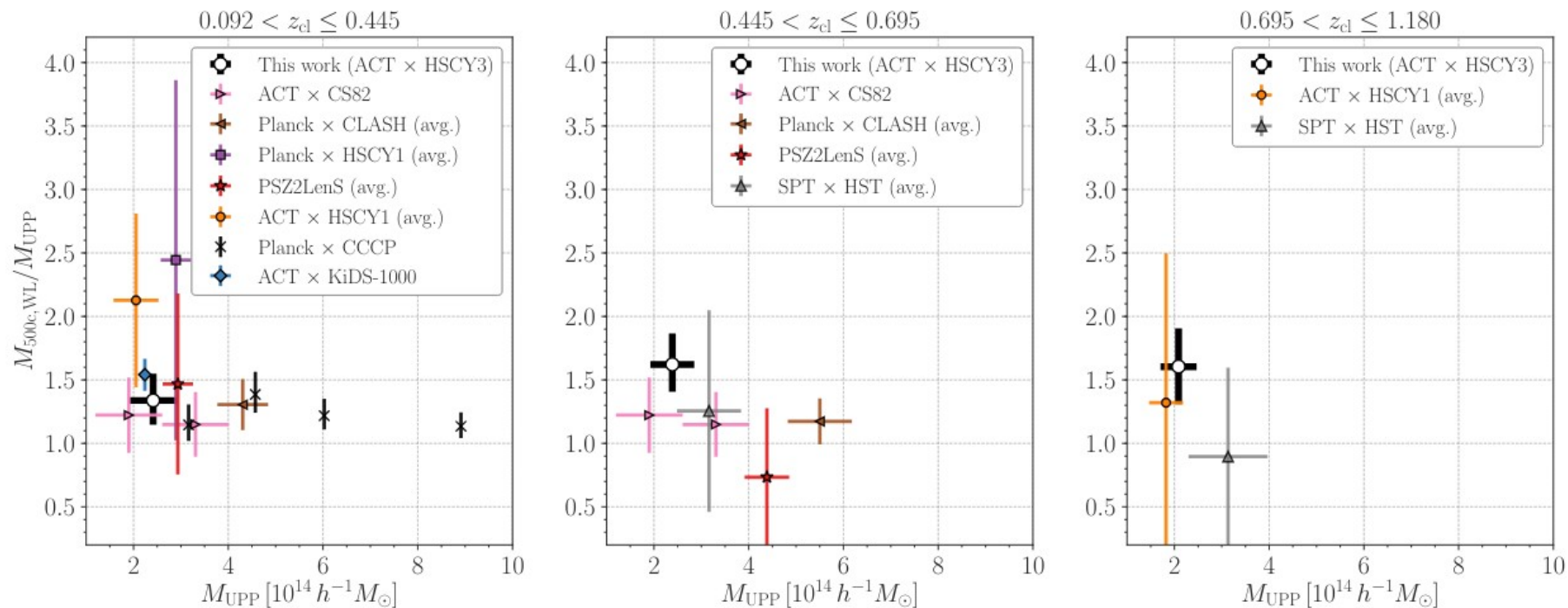
Mass calibration in ACT DR5

- Weak lensing mass calibration on stacks of ~ 100 clusters using the Kilo Degree Survey (KiDS) and the Subaru Hyper Suprime Cam (HSC) survey



Mass calibration in ACT DR5

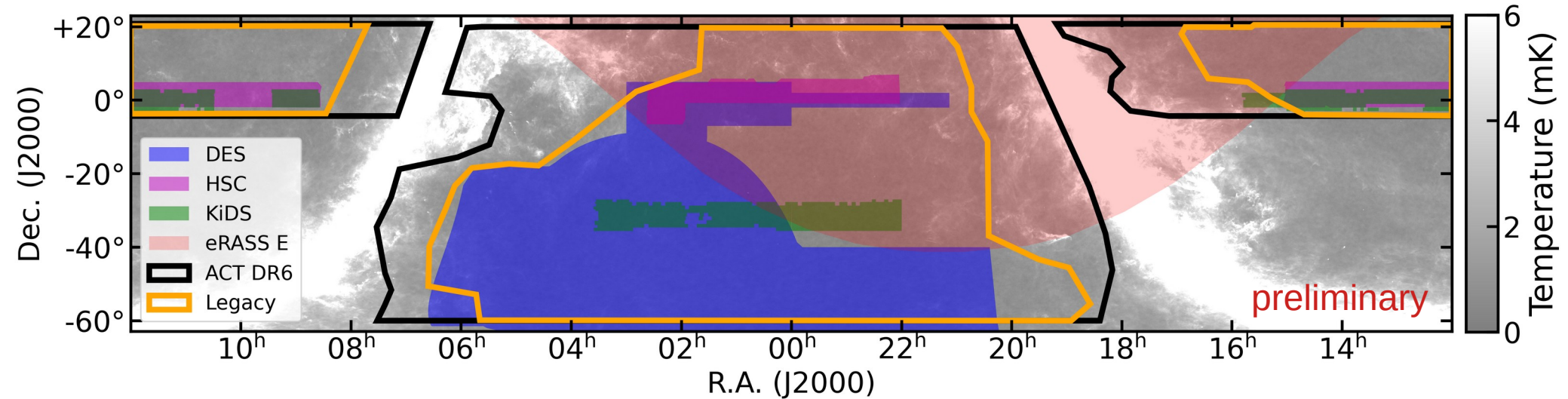
- Weak lensing mass calibration on stacks of ~ 100 clusters using the Kilo Degree Survey (KiDS) and the Subaru Hyper Suprime Cam (HSC) survey



Shirasaki et al. (2024; HSC)

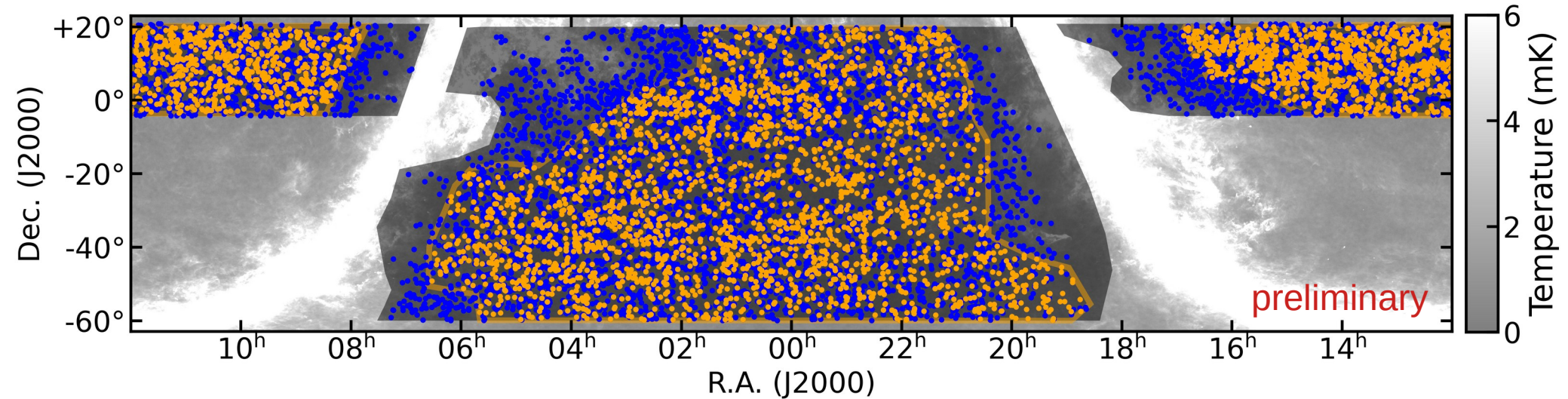
ACT DR6 clusters

- Using f090, f150, f220 ACT data from 2008 – 2022
- > 9900 optically confirmed clusters with redshifts and mass estimates
- > 3700 clusters in the S/N > 5.5 redshift complete “legacy sample”



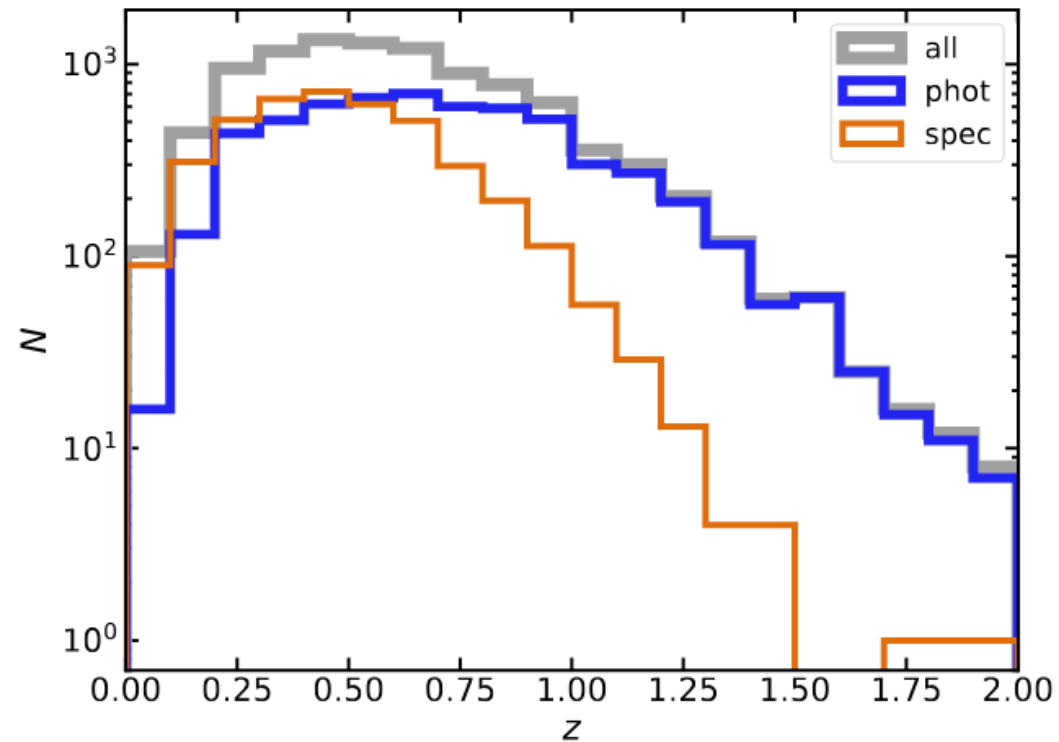
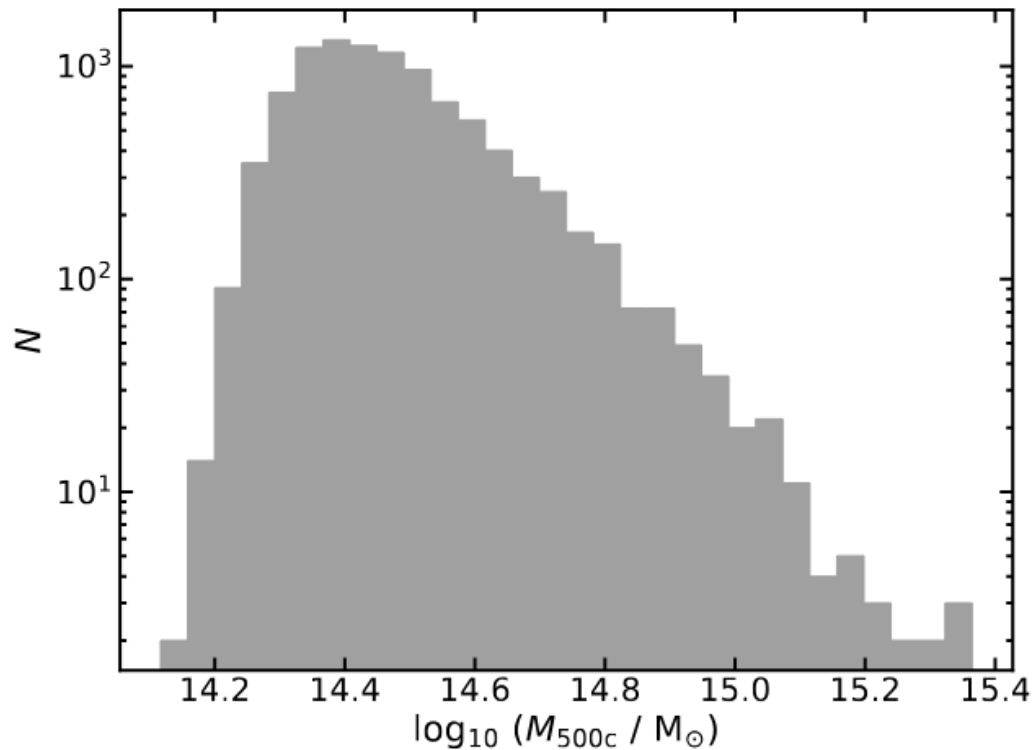
ACT DR6 clusters

- Using f090, f150, f220 ACT data from 2008 – 2022
- > 9900 optically confirmed clusters with redshifts and mass estimates
- > 3700 clusters in the S/N > 5.5 redshift complete “legacy sample”

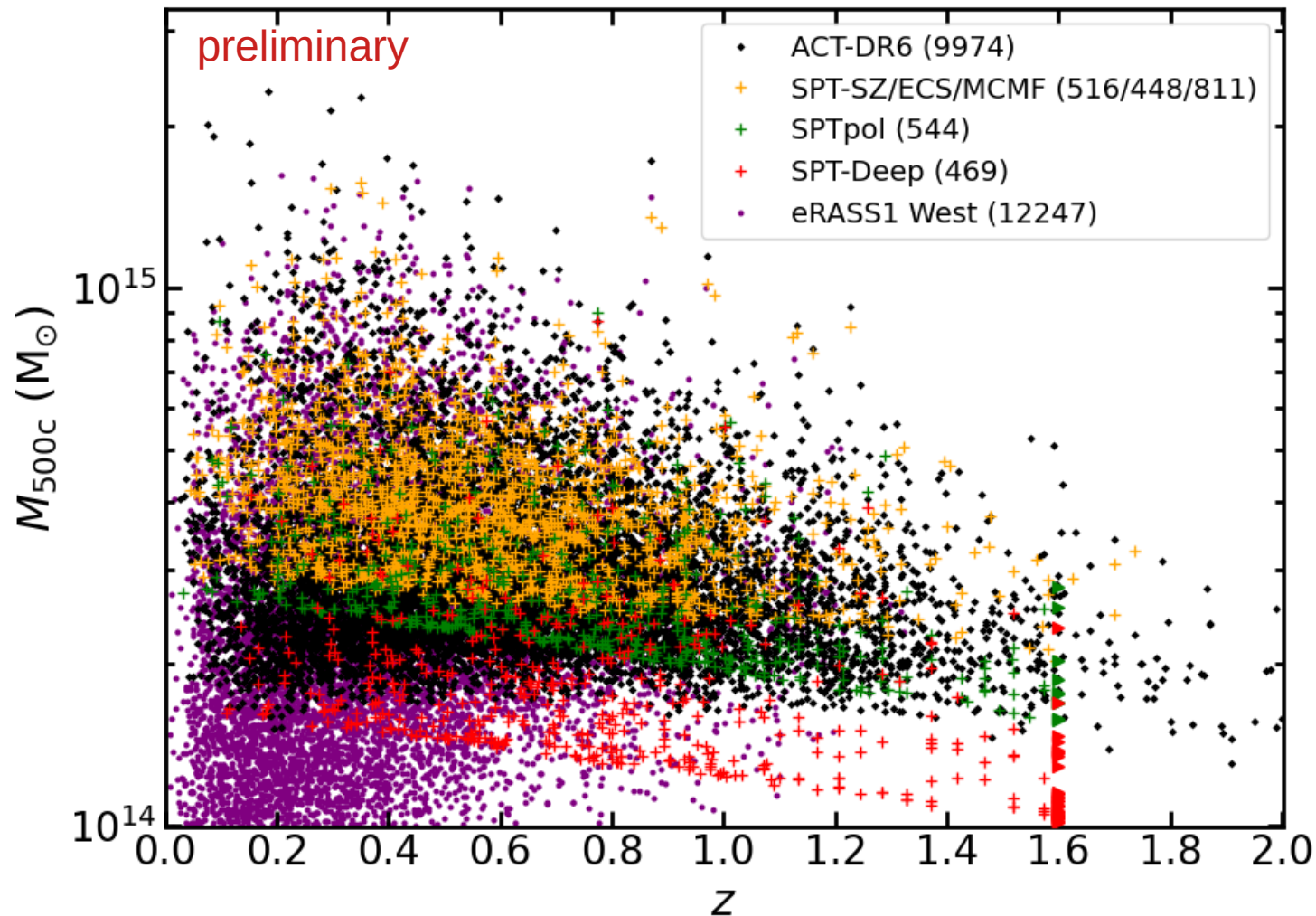


ACT DR6 clusters

- Median mass $M_{500c} = 2.8 \times 10^{14} \text{ M}_{\odot}$; median $z = 0.59$
- > 1000 $z > 1$ clusters
- > 100 $z > 1.5$ clusters



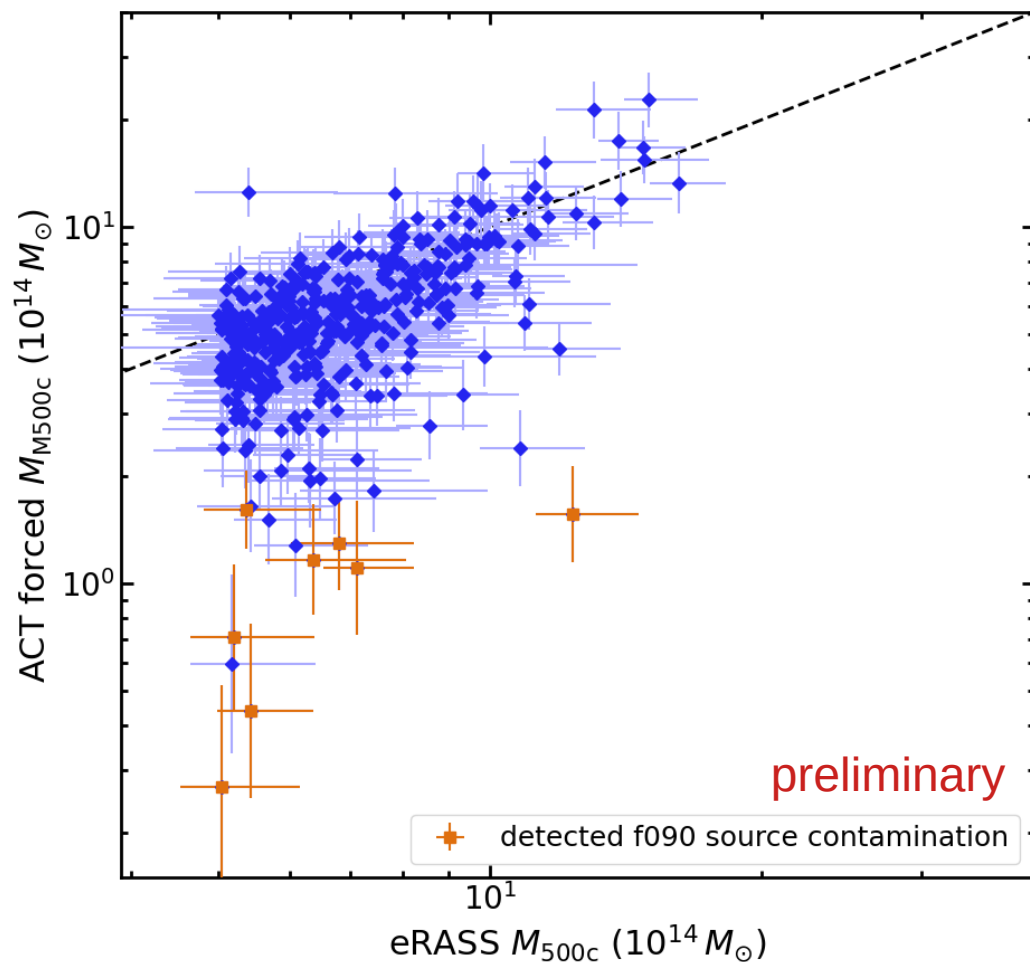
ACT DR6 clusters



- Median mass:
 $M_{500c} = 2.8 \times 10^{14} M_\odot$
- Median $z = 0.59$
> 1000 $z > 1$ clusters
> 100 $z > 1.5$ clusters

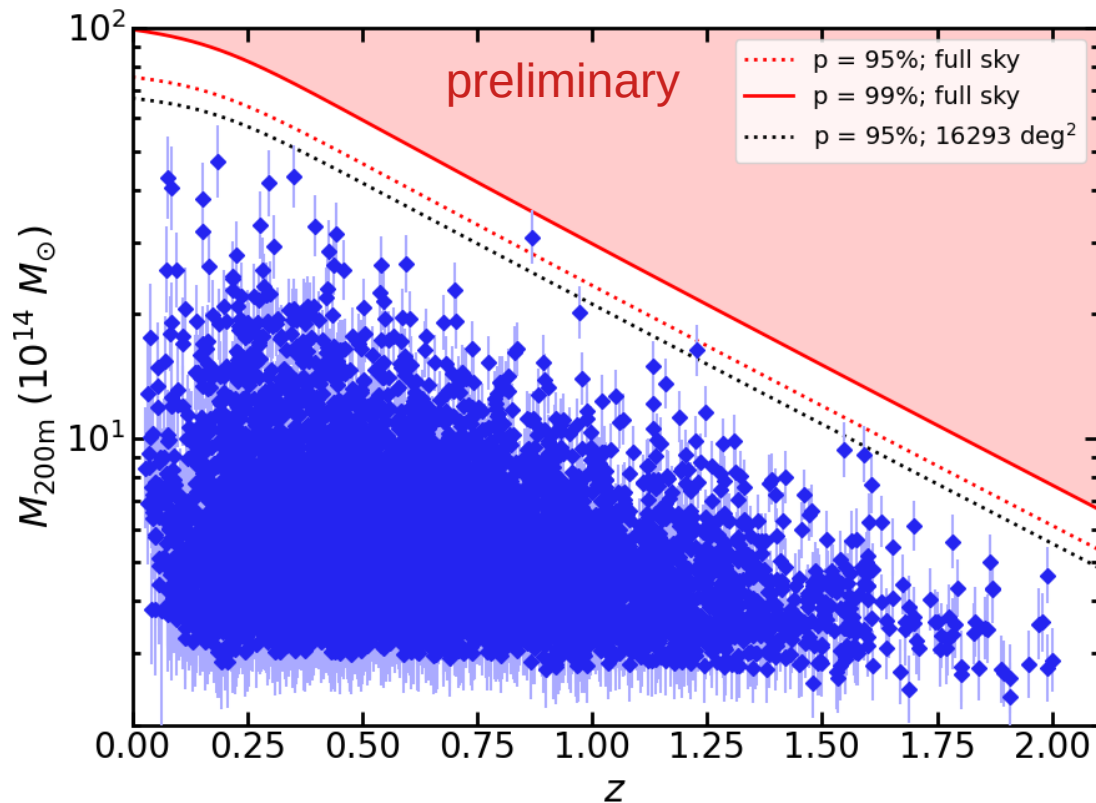
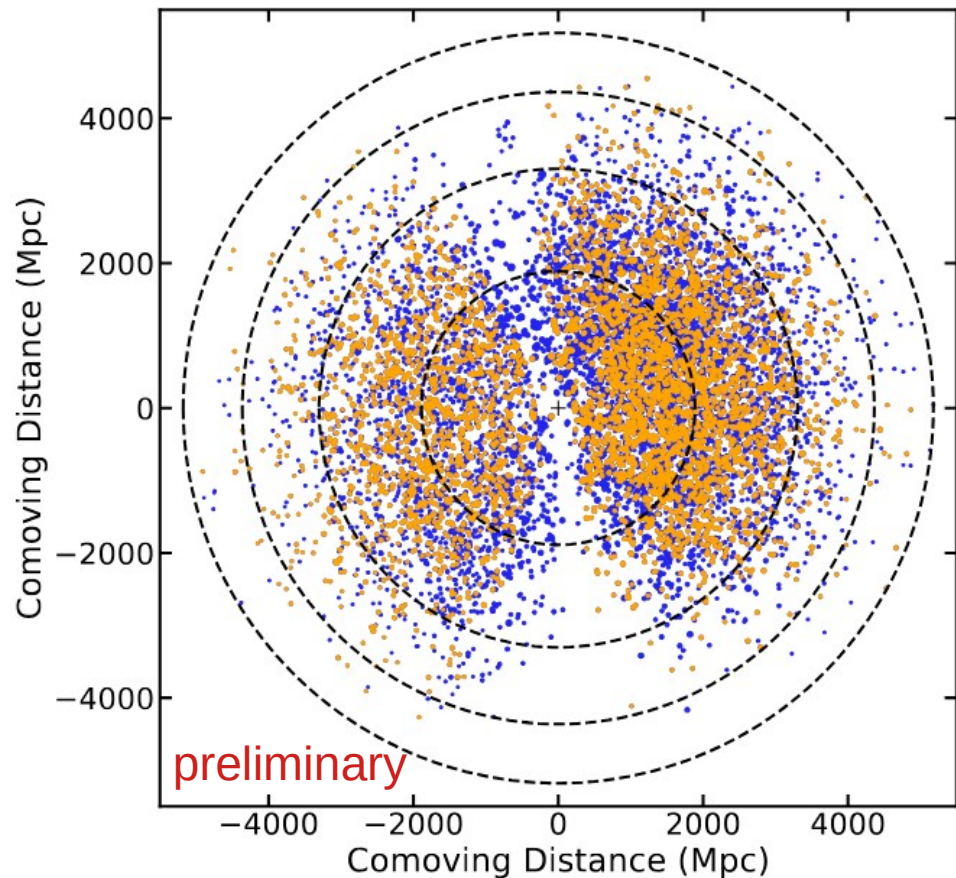
Are we missing any massive clusters?

- Radio sources in BCGs (brightest central galaxies) can wipe out SZ cluster signal...
- X-ray clusters are not affected by this (but L_x can be boosted by AGN contamination)
- Forced photometry in ACT maps at eRASS positions for clusters with:
 - eRASS $M_{500c} > 5 \times 10^{14} M_{\odot}$
 - $z > 0.2$
- 34/428 (8%) clusters have ACT S/N < 5:
 - 4/34 affected by X-ray AGN
 - 17/34 with position offsets
 - 9/34 within 1.2 arcmin of f090 source
- So: at least 2-3% of massive clusters have SZ signal suppressed by radio sources (see also Dicker+2021, 2024)



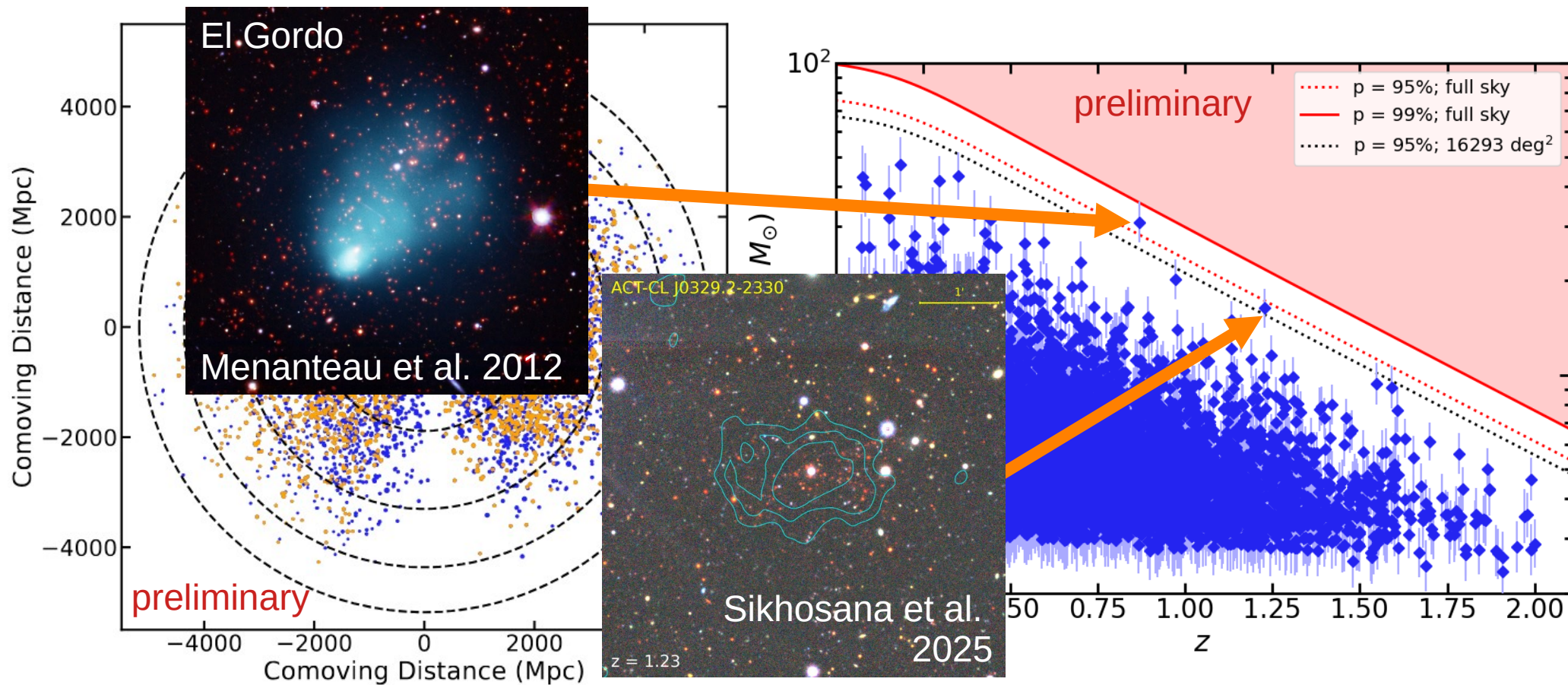
Extreme clusters?

- No Λ CDM-breaking clusters found within ~ 5 Gpc comoving distance
- El Gordo is still the most extreme cluster found by ACT



Extreme clusters?

- No Λ CDM-breaking clusters found within ~ 5 Gpc comoving distance
- El Gordo is still the most extreme cluster found by ACT



Summary

- ACT DR6 is out! Papers related to the CMB power spectrum analysis are on the arXiv, maps and likelihood are on LAMBDA:

https://lambda.gsfc.nasa.gov/product/act/act_dr6.02/

cluster and source catalogs will follow soon...

- The SZ effect provides approximately mass limited galaxy clusters samples with no redshift limit – ideal for measuring the growth of massive structures over cosmic time
- With ACT, we have gone from samples of ~10 SZ-detected clusters to ~10,000 over the lifetime of the project (2008 – 2022)
- We do not see any cluster at high redshift that is sufficiently massive to falsify Λ CDM
- Full ACT cluster cosmology analysis to follow later...
- Our cluster detection pipeline code is public:
 - <https://github.com/simonsobs/nemo/> (source code)
 - <https://nemo-sz.readthedocs.io/en/latest/> (docs)

and we will provide instructions for reproducing most of the DR6 cluster data products