SPT-3G: The emissive extragalactic source catalog with 2019-2023 data

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mm Universe conference
Wednesday, June 25, 2025

Photograph: Kevin Zagorski

Outline

- Introduction to mm static point source catalogs
- Observations with SPT-3G
- Signal extraction and catalog generation
- Catalog results and source counts
- Concurrent and future work

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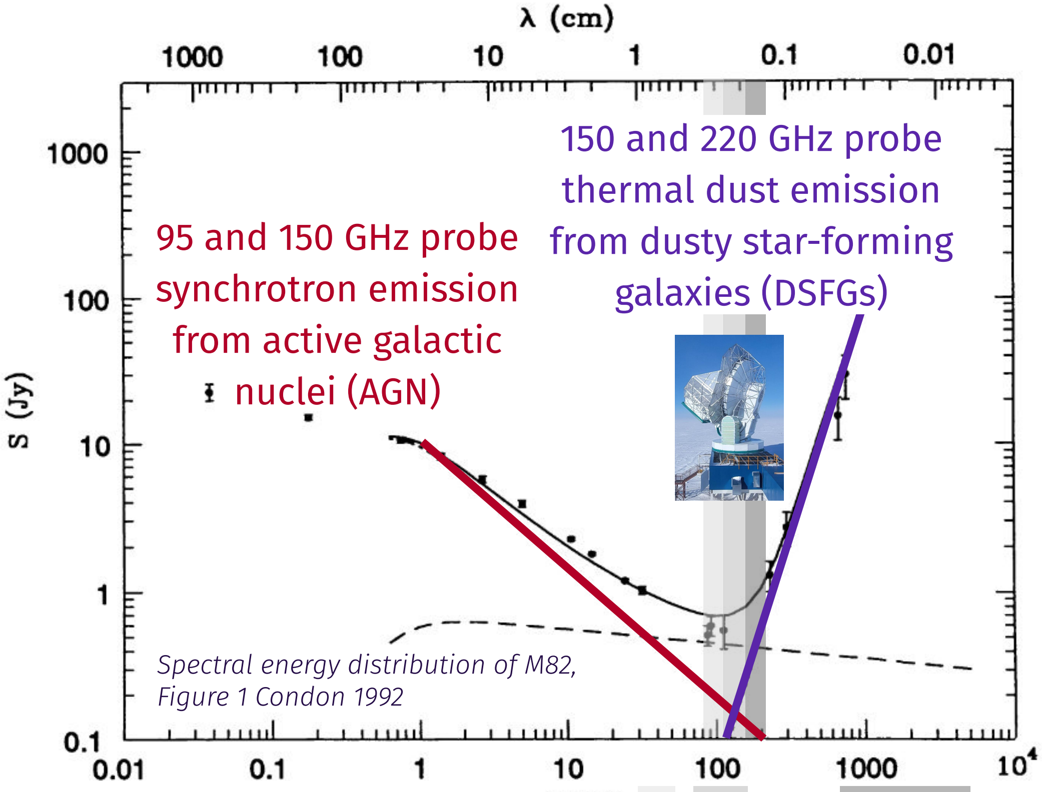
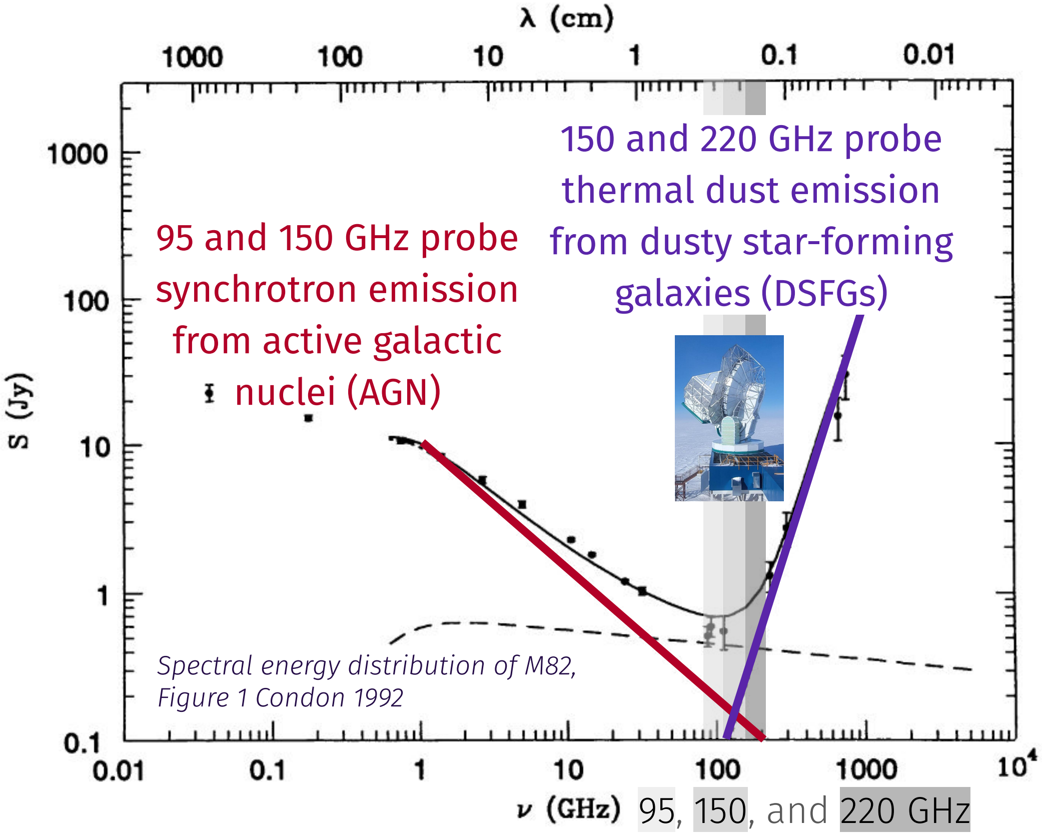
Introduction to mm static point source catalogs



95, 150, and 220 GHz
(3.3, 2.0, and 1.4 mm)

Introduction to mm static point source catalogs



Spectral energy distribution of M82, Figure 1 Condon 1992

95, 150, and 220 GHz
(3.3, 2.0, and 1.4 mm)

Why make a mm catalog?

- **Contamination** in cosmic microwave background (CMB) survey data. Point sources can be contamination by distorting the CMB signal in power spectrum and lensing studies.

  Similarly, cluster and transient analyses want to detect point-like signals, but need the catalog to ignore static point source locations.

- **Science**. Millimeter-selected source populations worthy of study in their own right – keep listening!

This presentation is mostly about galaxies and galaxy populations.

Observations with SPT-3G

- Over 10,000 square degrees observed using SPT-3G since 2018 to a range of noise levels
- SPT-3G Main 1500 deg^2 field 5σ flux and beam size:

95 GHz/ 3.3 mm	150 GHz/ 2.0 mm	220 GHz/ 1.4 mm
1.3 mJy	1.5 mJy	5.0 mJy
1.6 arcmin	1.2 arcmin	1.0 arcmin

SPT photo: Alex Pollack, background photograph: Kevin Zagorski

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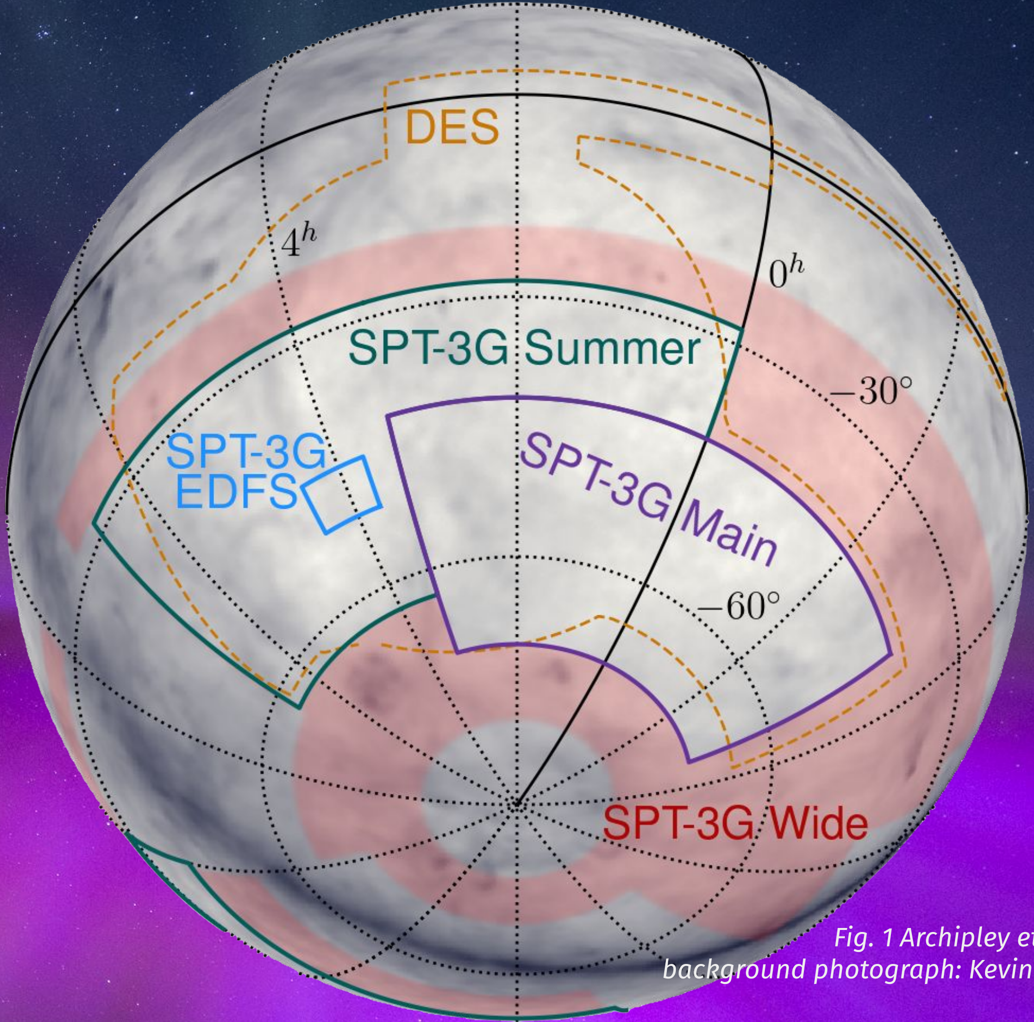
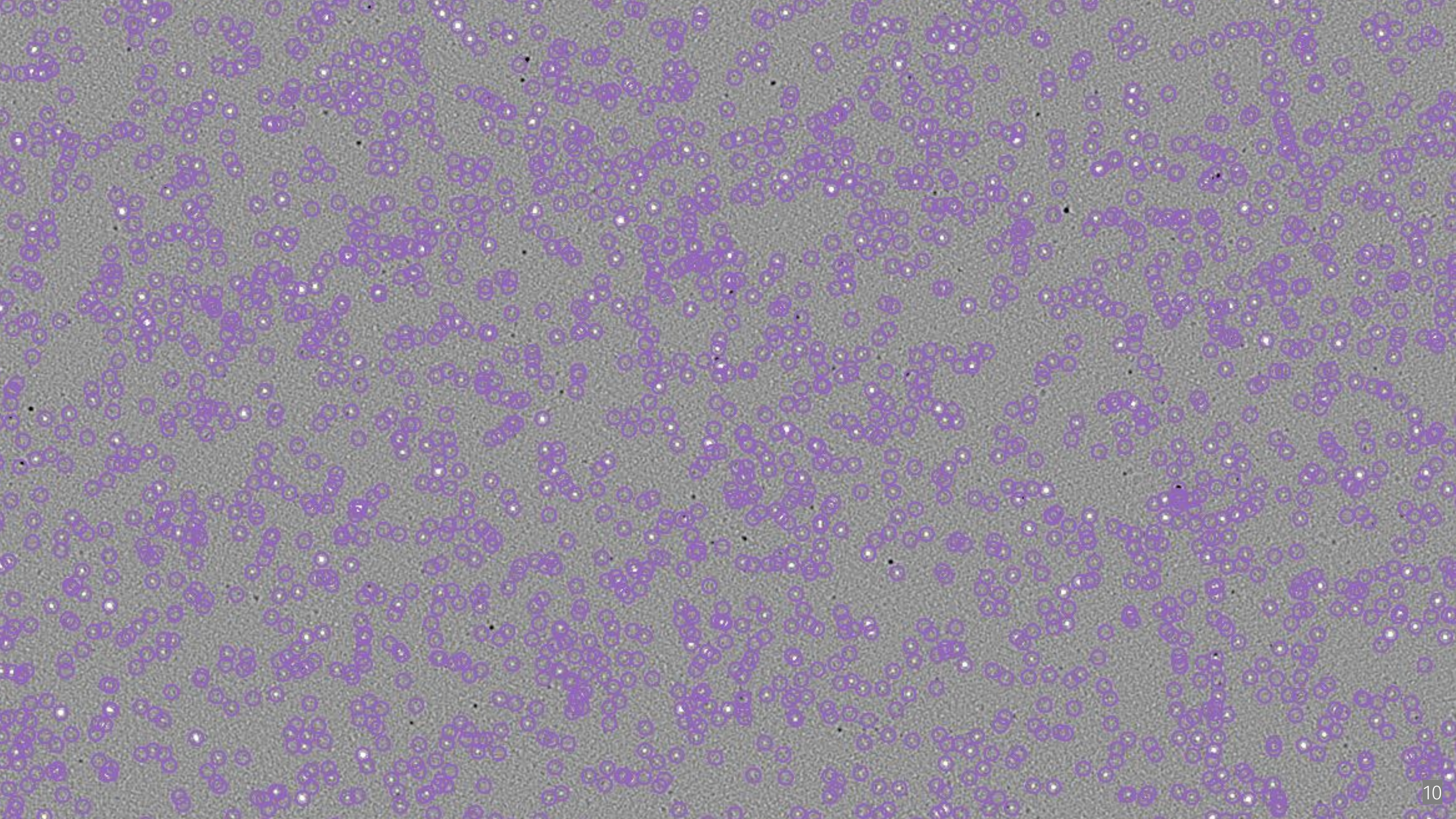


Fig. 1 Archipley et al. 2025, background photograph: Kevin Zagorski

Signal extraction and catalog generation

The missing slides: how to turn CMB survey data into maps – see **Wei Quan**'s talk "SPT-3G: Maps of the Millimeter-wave Sky from 2019-2020 Data" @ **tomorrow 9am in ERC 161**

Pictured: SPT-3G 95 GHz data taken 2019-2023



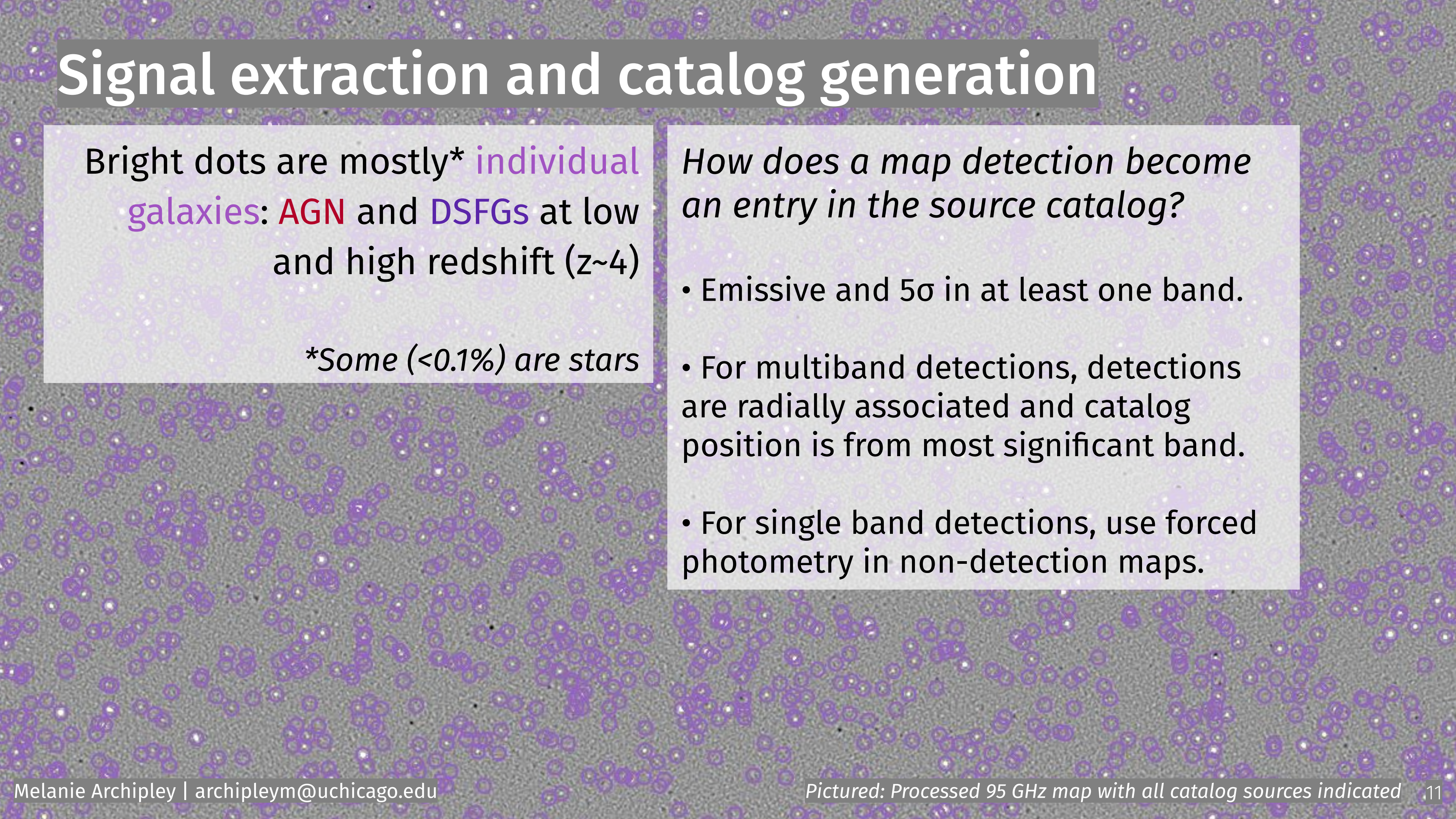
Signal extraction and catalog generation

Bright dots are mostly* individual galaxies: AGN and DSFGs at low and high redshift (z~4)

**Some (<0.1%) are stars*

How does a map detection become an entry in the source catalog?

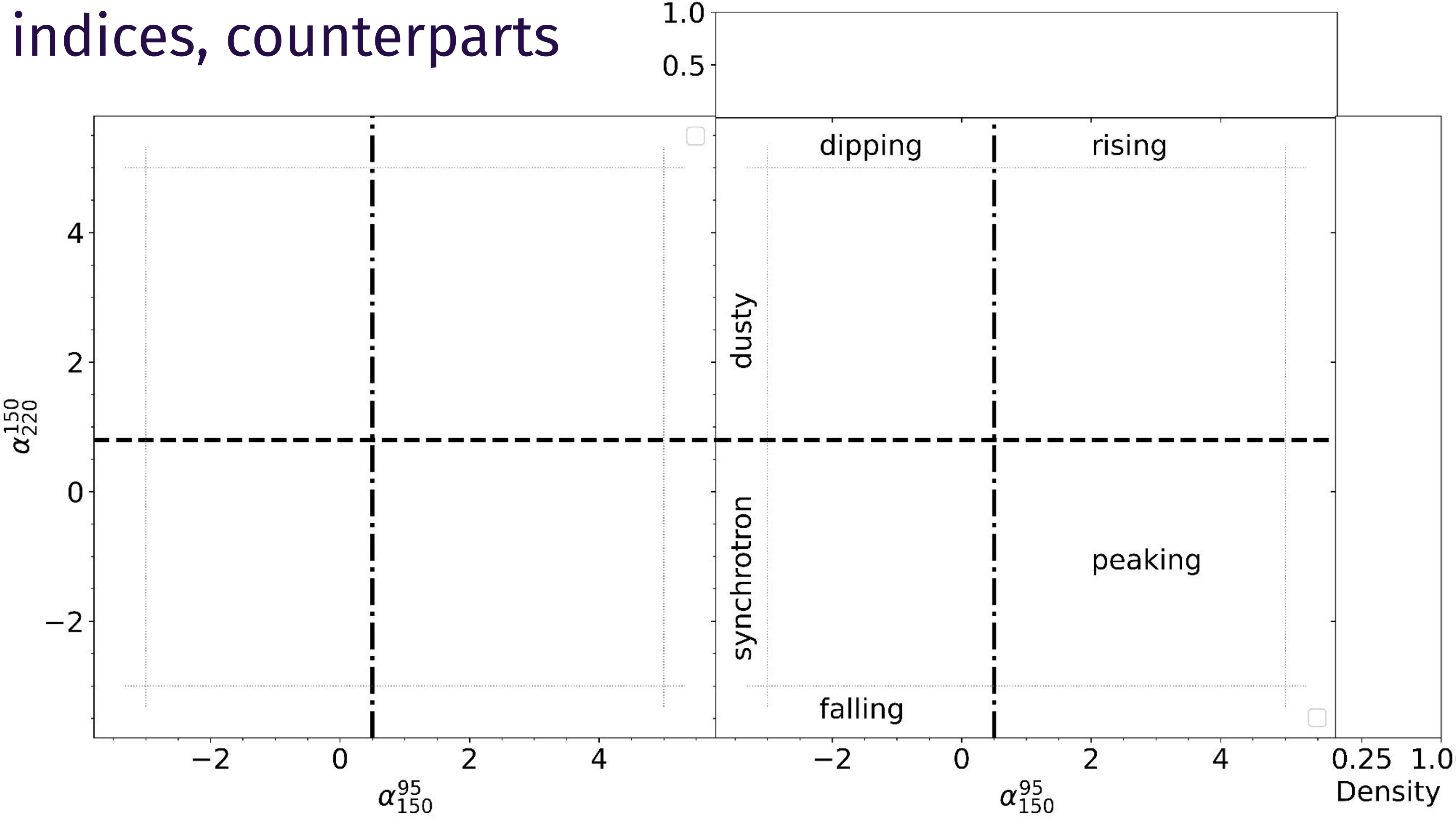
- Emissive and 5σ in at least one band.
- For multiband detections, detections are radially associated and catalog position is from most significant band.
- For single band detections, use forced photometry in non-detection maps.



Pictured: Processed 95 GHz map with all catalog sources indicated

Catalog results: compare to SPT-SZ, spectral indices, counterparts

Archipley et al. in prep



Catalog results: compare to SPT-SZ, spectral indices, counterparts

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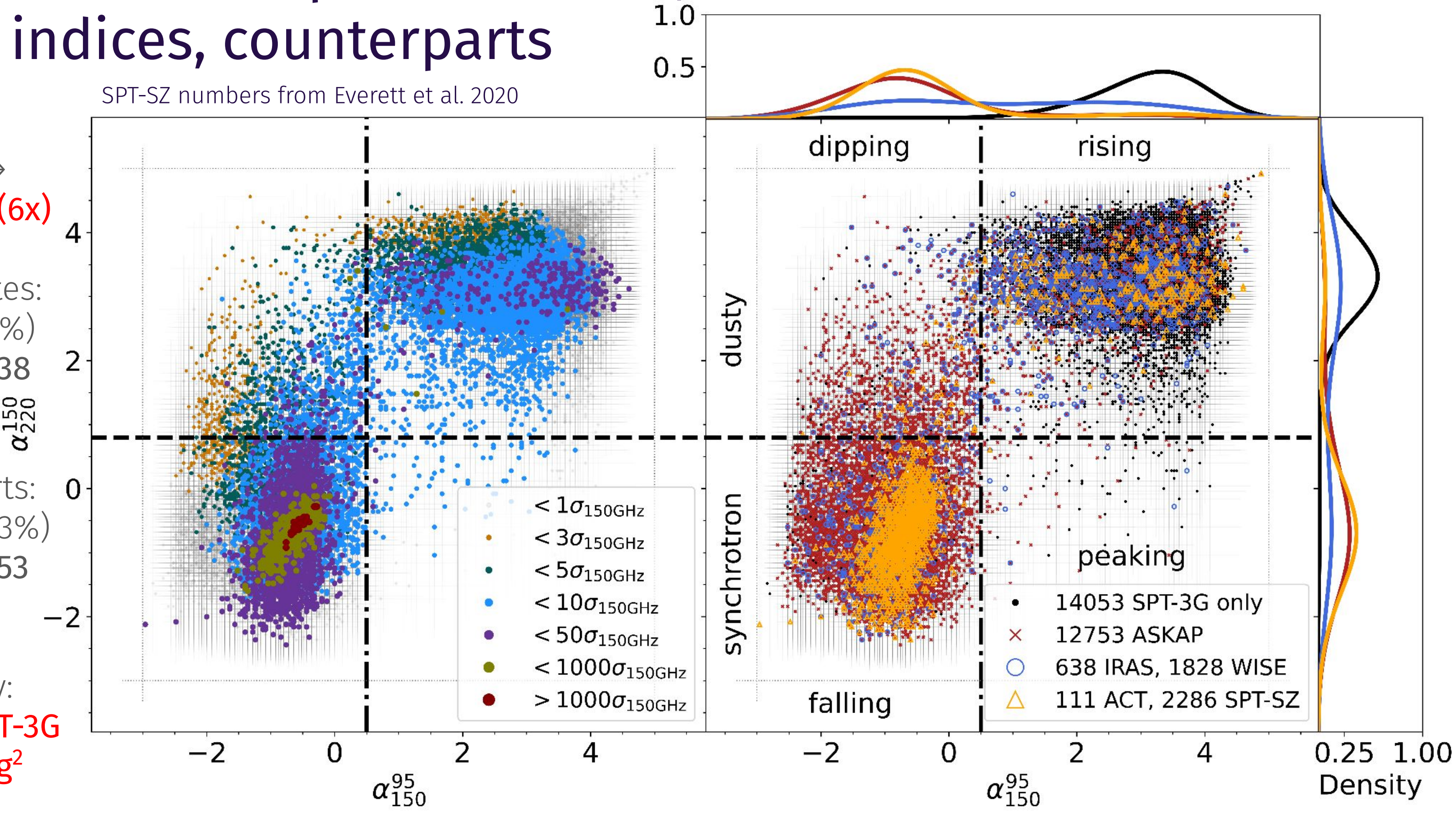
SPT-SZ numbers from Everett et al. 2020

Total sources:
SPT-SZ 4,845 →
SPT-3G 27,883 (6x)

DSFG candidates:
SPT-SZ 506 (10%)
→ **SPT-3G 14,838** (53%) (29x)

No counterparts:
SPT-SZ 1,109 (23%)
→ **SPT-3G 14,053** (50%) (13x)

Source density:
SPT-SZ 2 → SPT-3G
17 sources/deg^2



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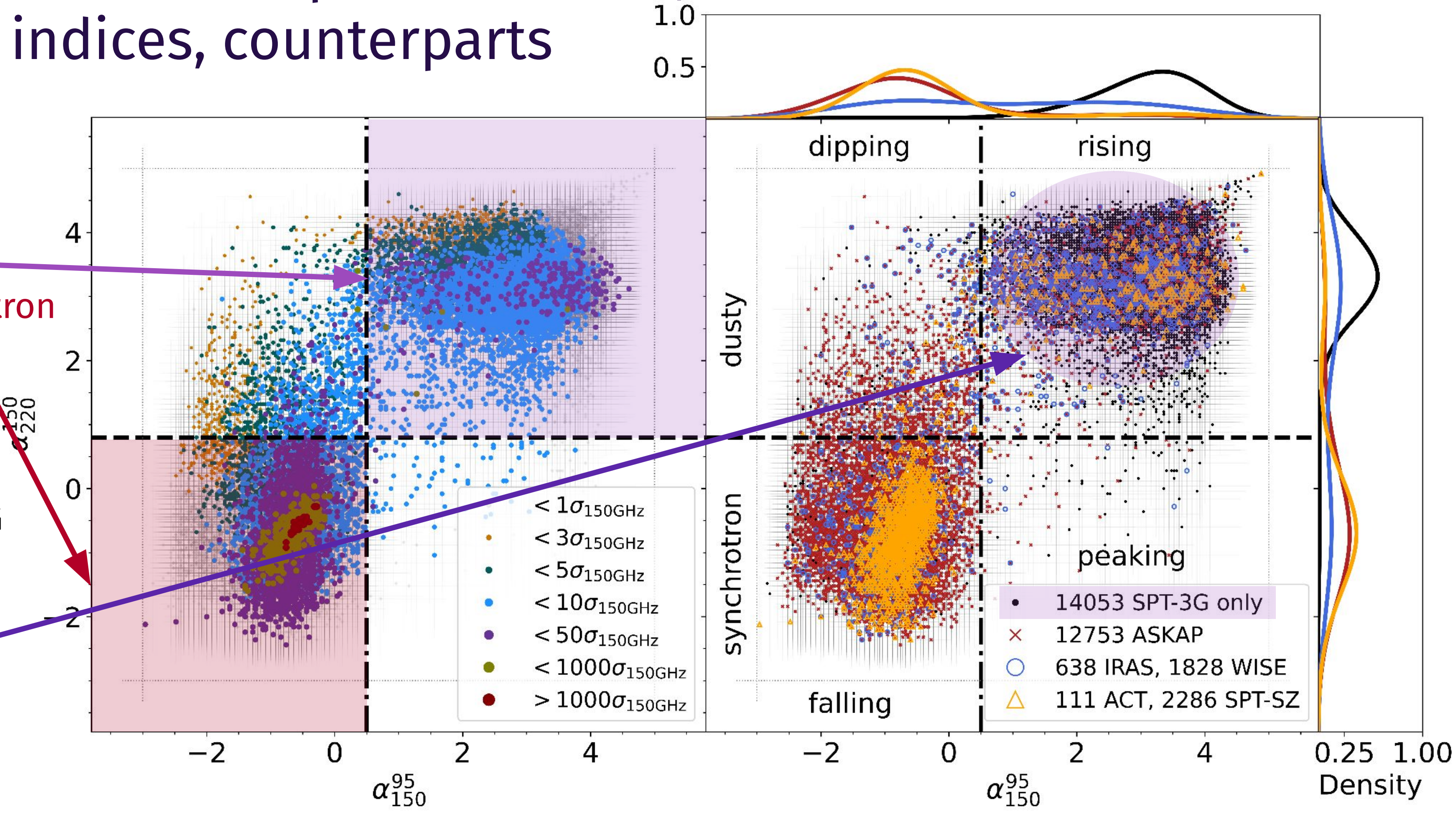
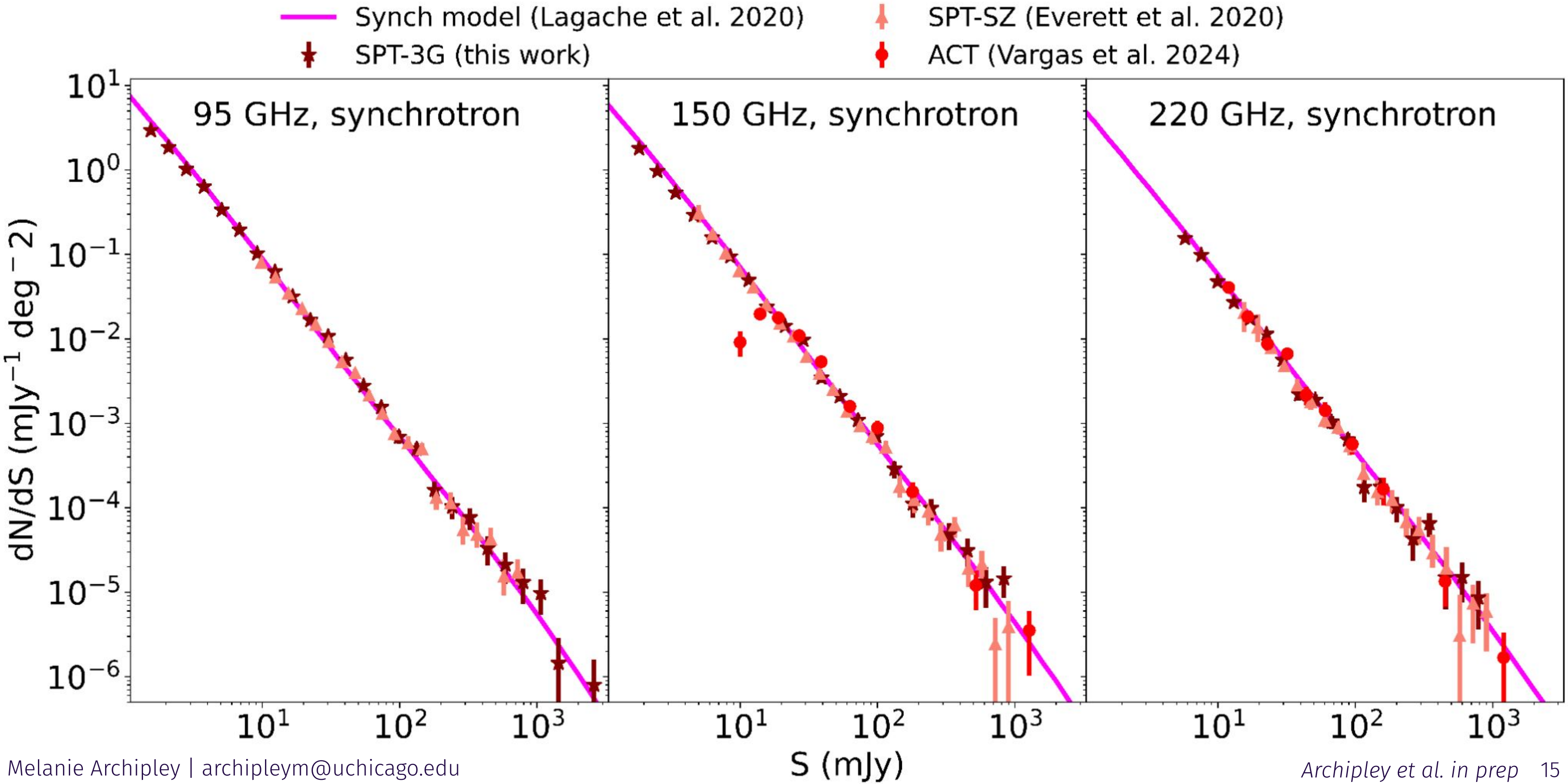
Archipley et al. in prep

- 62% dusty
38% synchrotron

- Most **SPT-3G** *only* sources are dust dominated

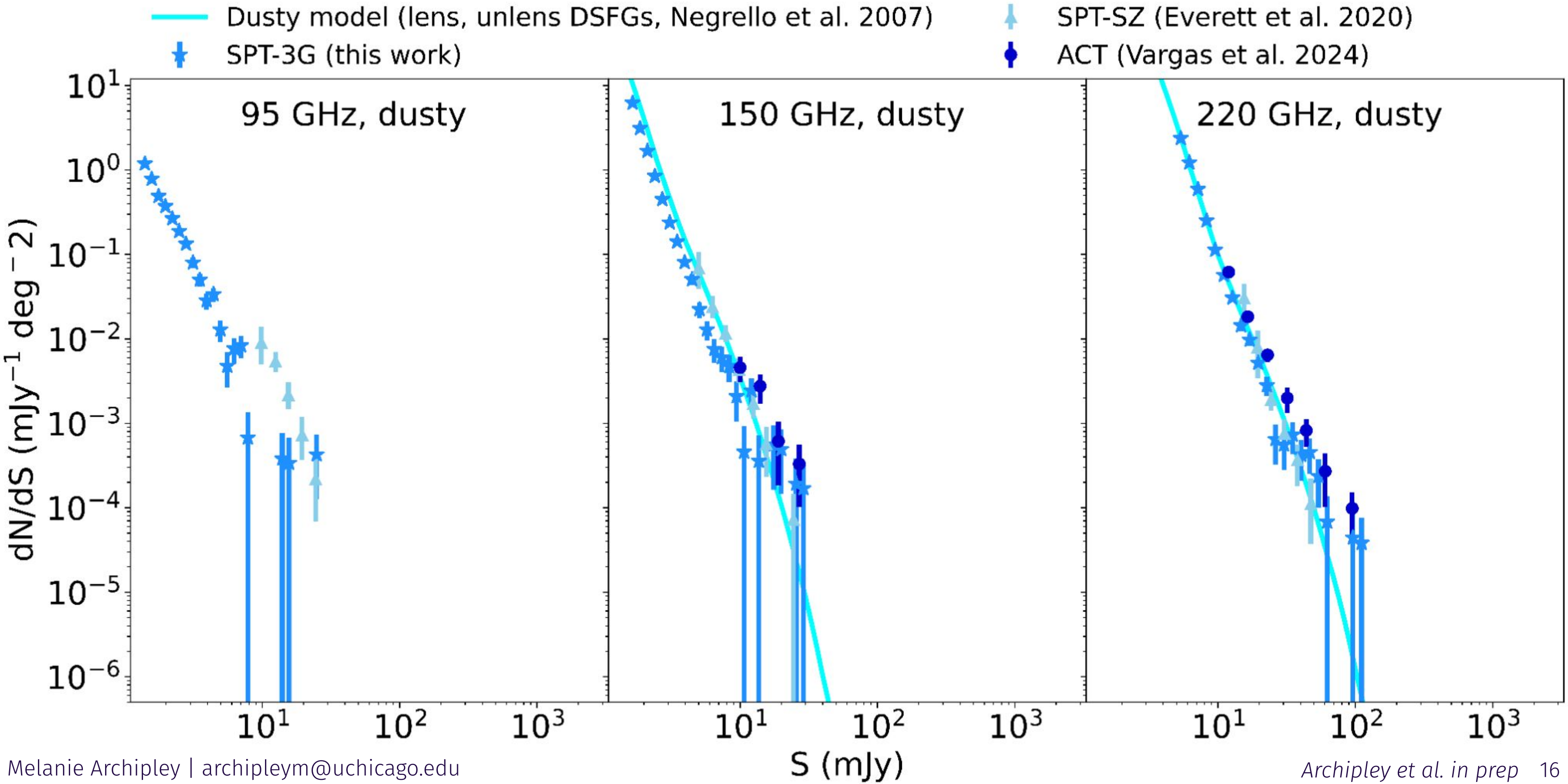


Catalog results: synchrotron-dominated source counts



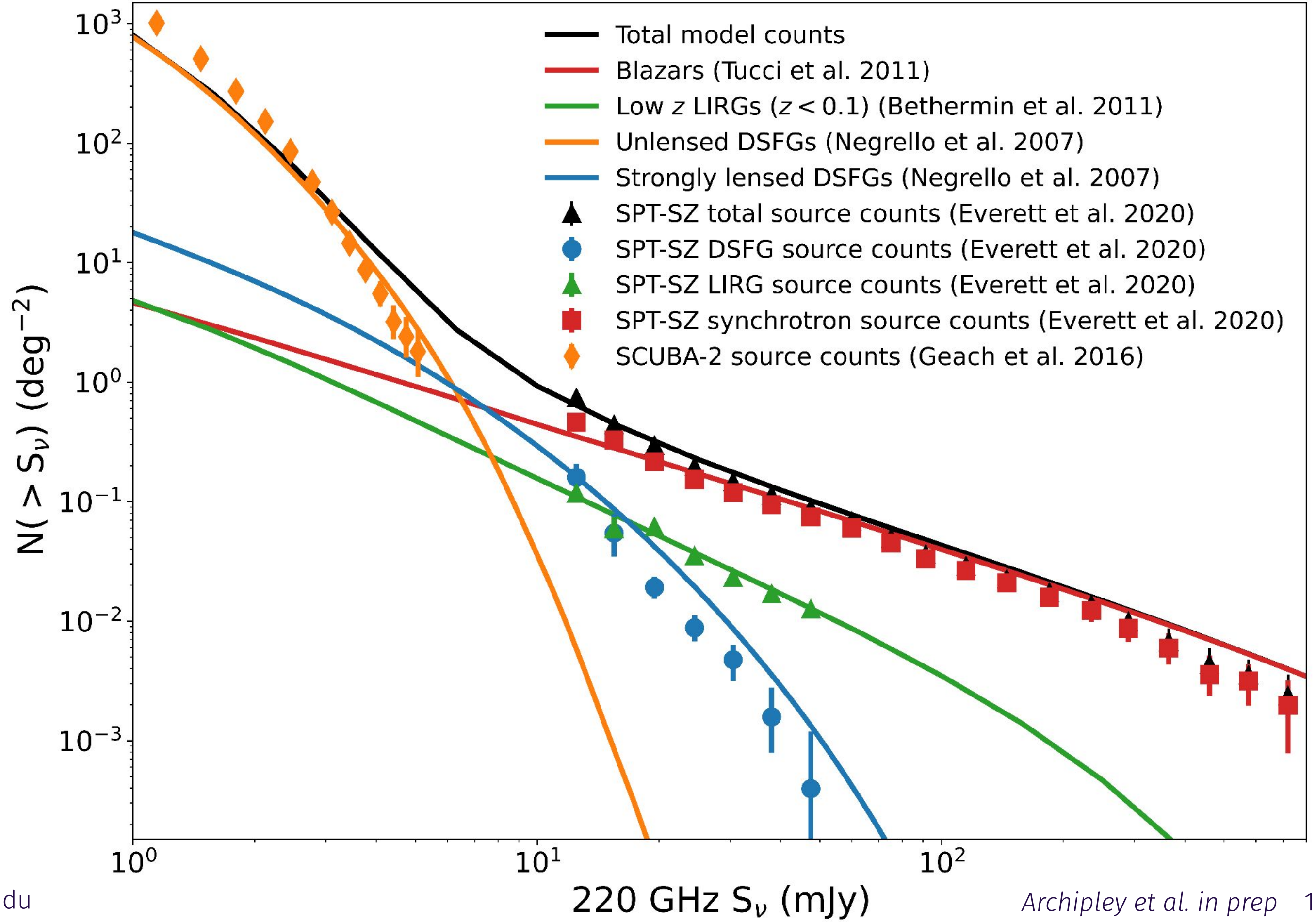
Archipley et al. in prep

Catalog results: dust-dominated source counts



Catalog results: cumulative total source counts

Pictured: cumulative source counts separated by source population from observations (SPT-SZ and SCUBA-2, points) are in agreement with models (lines)



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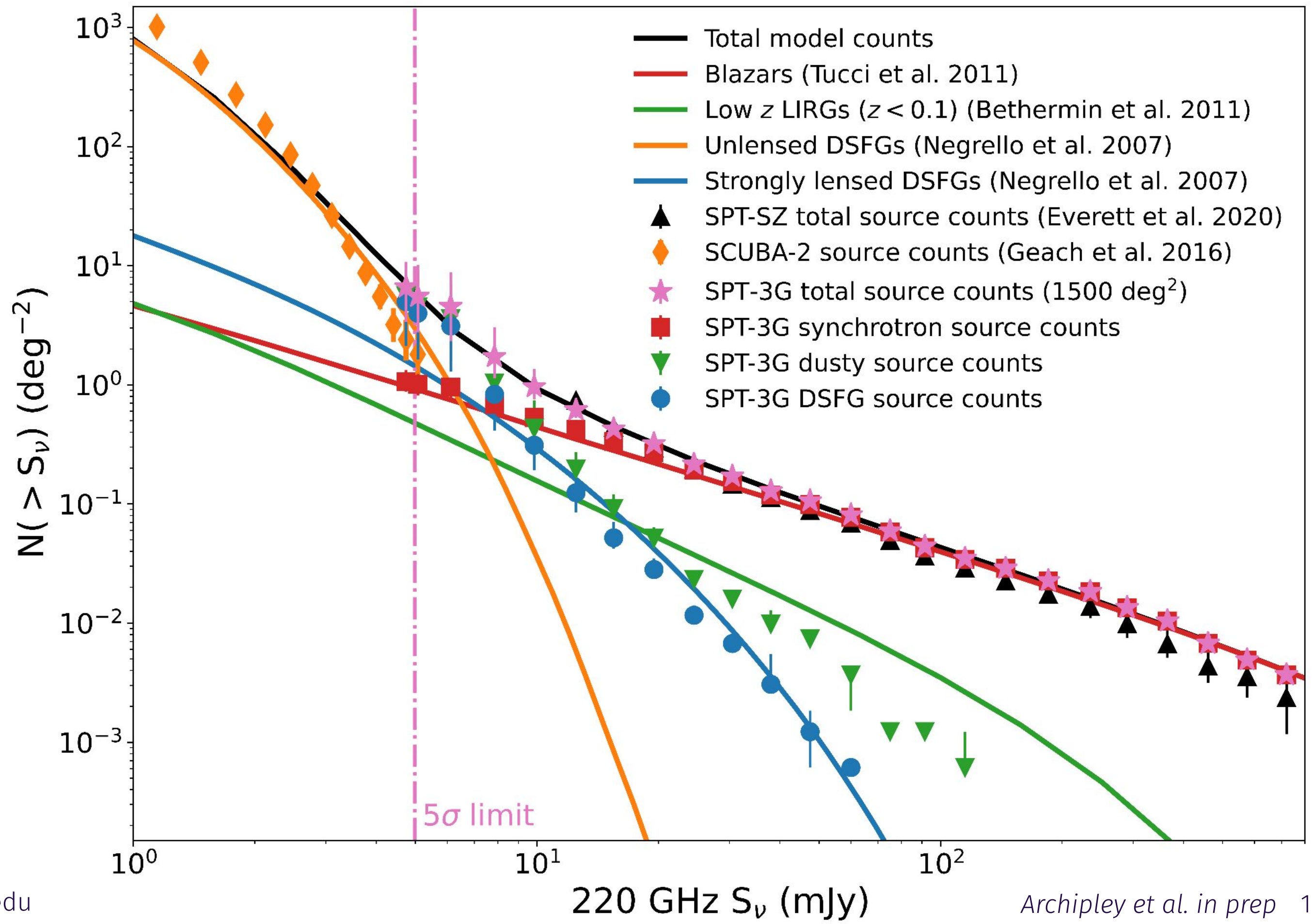
Catalog results: cumulative total source counts

Observational gap filled by SPT-3G catalog at transition from domination of strongly gravitationally lensed DSFGs to unlensed DSFGs



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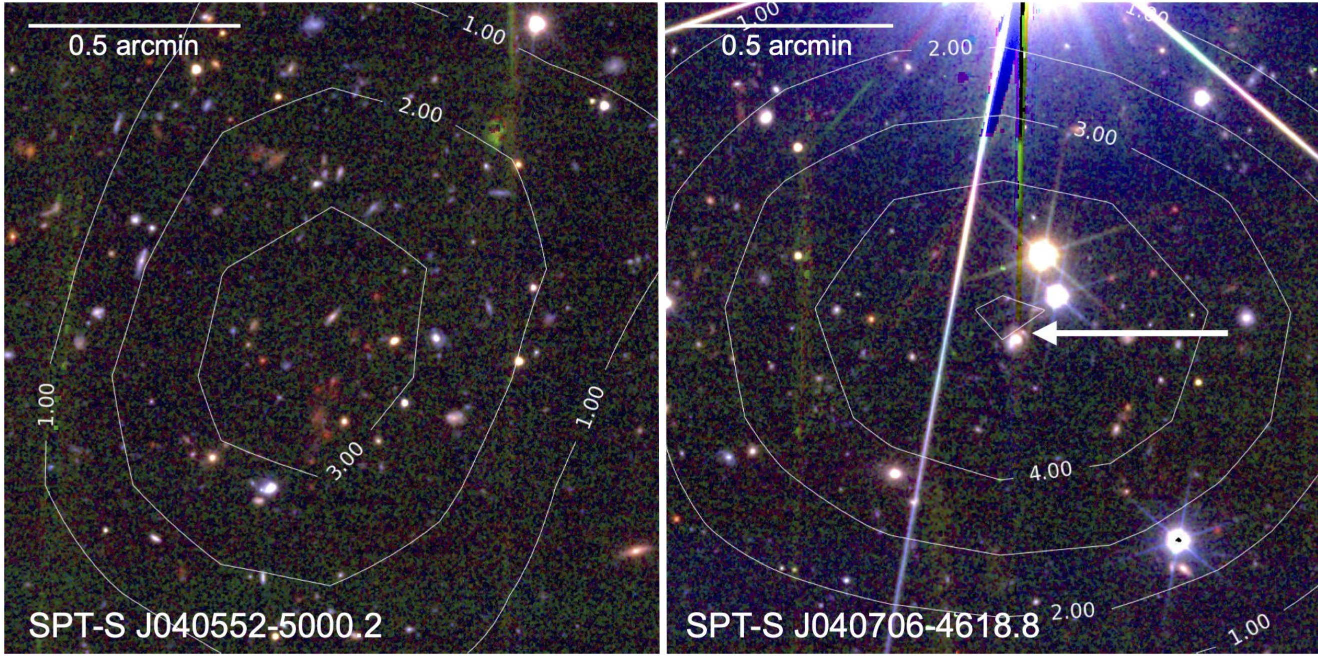
Concurrent and future work: *Euclid*, ALMA, MeerKAT

- Leveraging *Euclid* Q1 data to select objects for ALMA follow-up in Euclid Deep Field South, e.g. Fig 7 in arXiv:2506.00298

- Accepted ALMA proposal (2024, PI Cassie Reuter) for blind spectral scans of SPT-3G DSFG candidates in a small pilot patch of SPT-3G Main field, confirming z>3 for 3 DSFGs



Euclid VIS, Y, H with SPT 220 GHz contours of two DSFG-flagged sources from SPT-3G, Fig. 7 Archipley et al. 2025

- Currently working with MeerKAT (radio) observations over pilot patch and proposing for more

Summary

- mm wavelengths are uniquely tuned to DSFG selection, which probe some of the most extreme environments and epochs in the Universe's history

- The SPT-3G Main 1500 square degree point source catalog, as well as the SPT-3G source-finding pipeline, is state-of-the-art for wide, deep mm surveys

- The catalog comprises almost 28,000 objects with 53% of these being DSFG candidates (29x more than SPT-SZ) down to 5.0 mJy at 220 GHz

- The SPT team is looking forward to complementary multiwavelength data to characterize sources

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See **David Vizgan's** poster for high spectral and spatial resolution of some SPT-SZ DSFGs!

Thank you to colleagues **Joaquin Vieira, Tom Crawford,** and members of the **SPG-3G collaboration** for all their efforts!

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EXTRA

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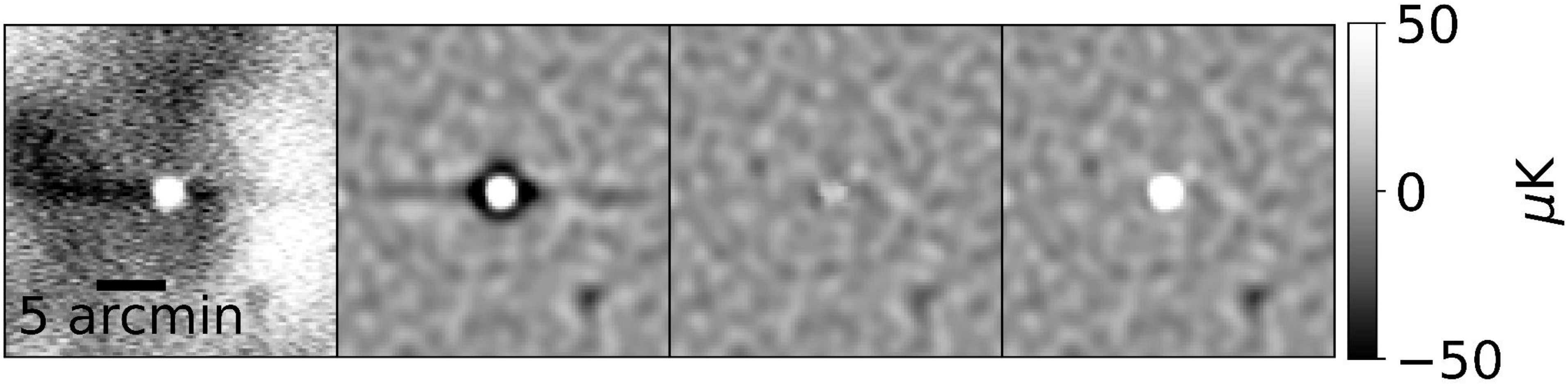
Processing of CMB maps for point source extraction



1. *Raw* **maps** only after processing the telescope data into maps with 0.25 arcmin pixels. Signal from the CMB is significantly present.

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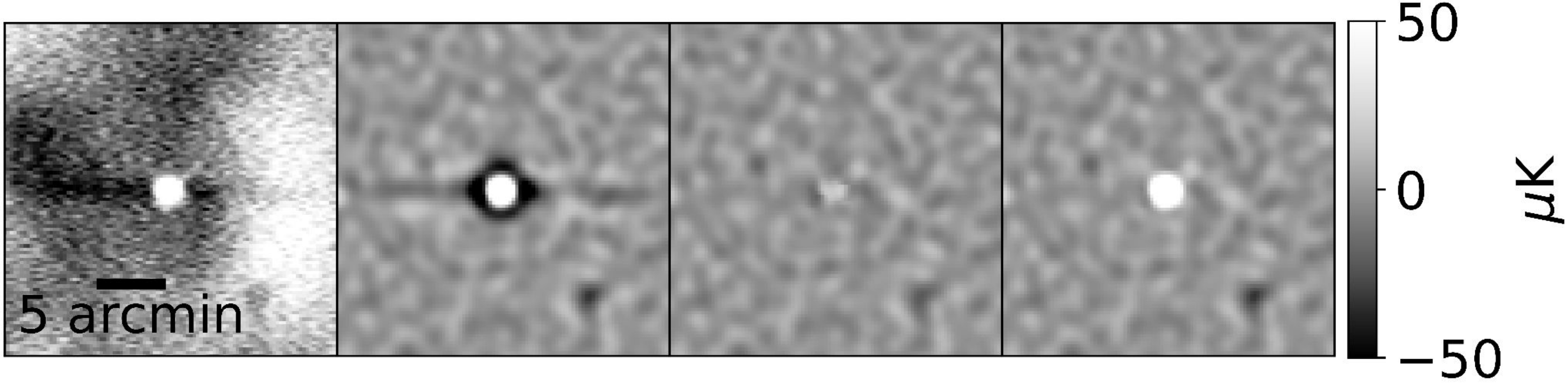

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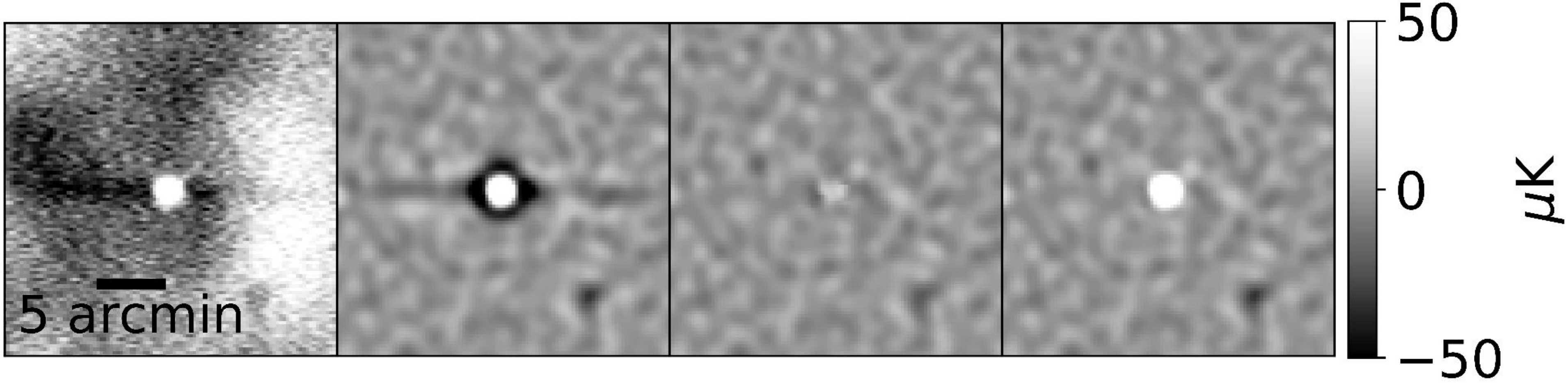

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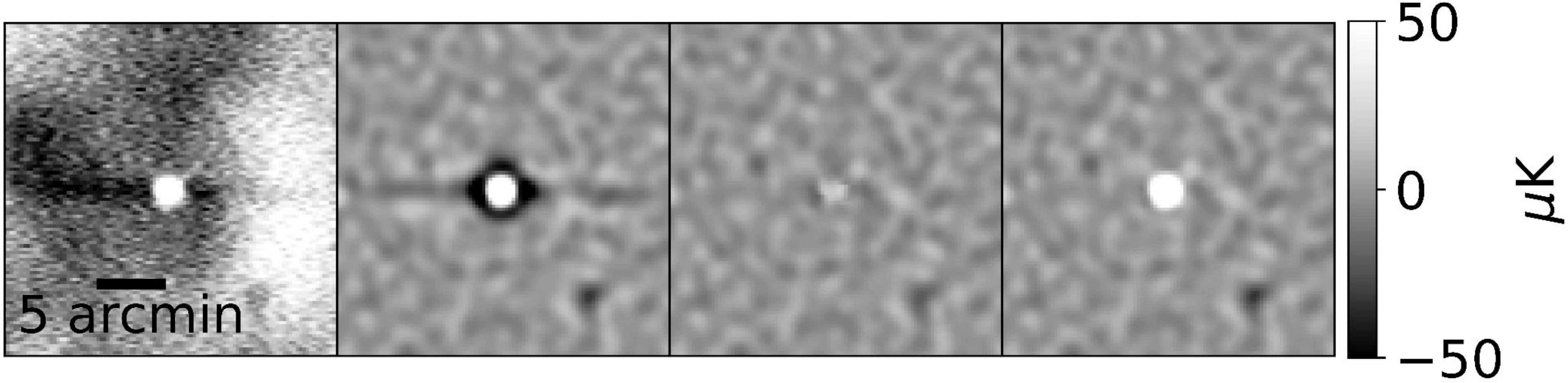

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4. *Clean beam* maps after replacing a beam shape *without* filtering wings at the pixel locations of sources from the previous step.

Catalog results: census compared to SPT-SZ (2500deg^2)

Characteristic	SPT-SZ → SPT-3G Number	SPT-SZ → SPT-3G Fraction
Synchrotron dominated	3,980 → **10,650** (2.7x)	**82%** → 38%
Dust dominated	865 → **17,233** (20x)	18% → **62%**
DSFG candidate	506 → **14,838** (29x)	10% → **53%**
Extended	131 → **909** (7x)	**2.7 → 3.3%**
Total	4,845 → **27,883** (6x)	100%

External data	SPT-SZ → SPT-3G Number	SPT-SZ → SPT-3G Fraction
Radio (SUMSS → ASKAP)	3,437 → **13,138** (4x)	**71%** → 47%
Infrared (IRAS → WISE)	813 → **1,881** (2.3x)	6.6% → 6.7%
Millimeter (ACT or SPT-SZ)	2,313 (3G only)	8.3% (3G only)
No counterpart	1,109 → **14,053** (13x)	23% → **50%**

SPT-SZ numbers from Everett et al. 2020, SPT-3G from Archipley in prep.

SPT-SZ → SPT-3G source density
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