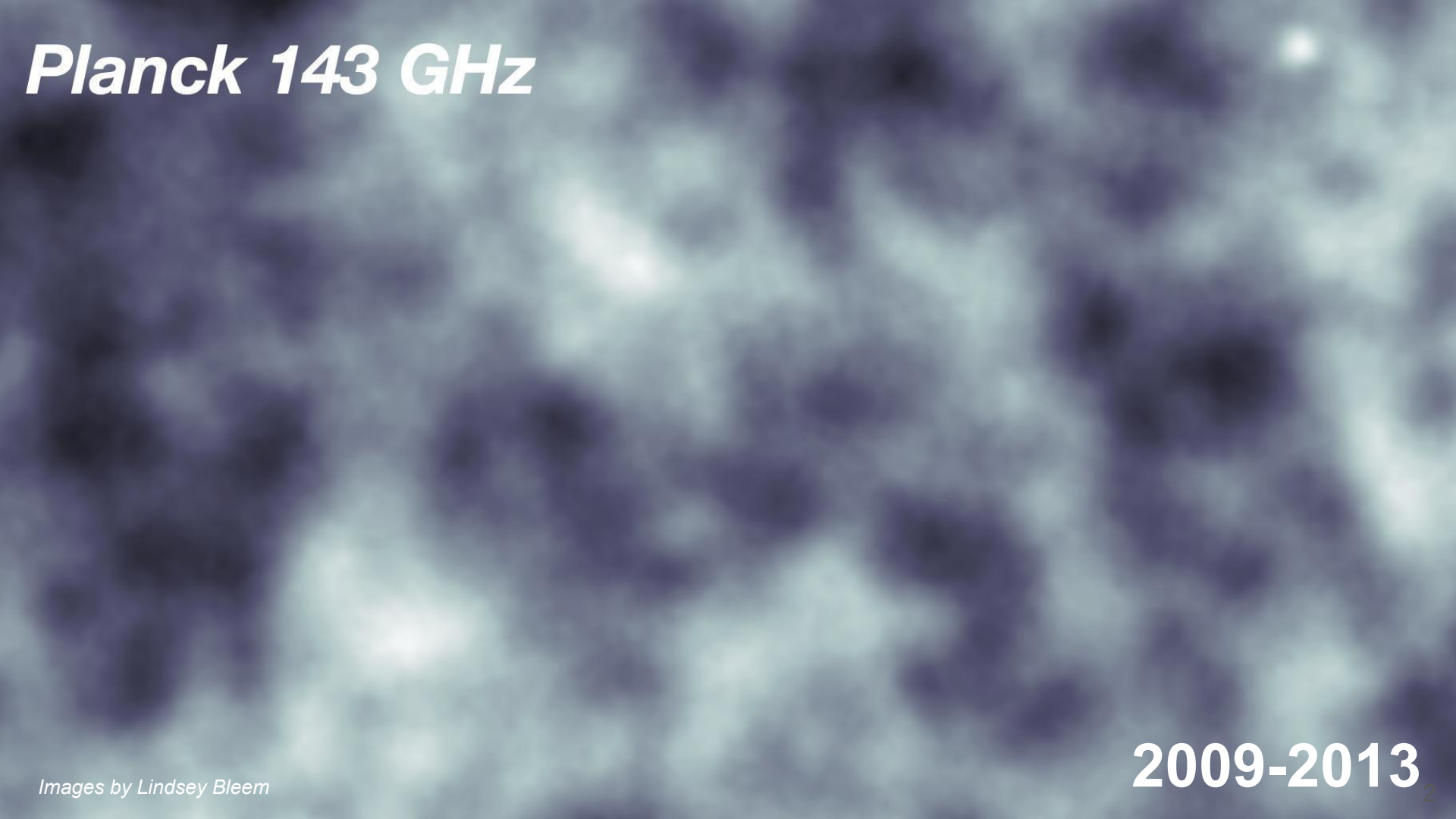
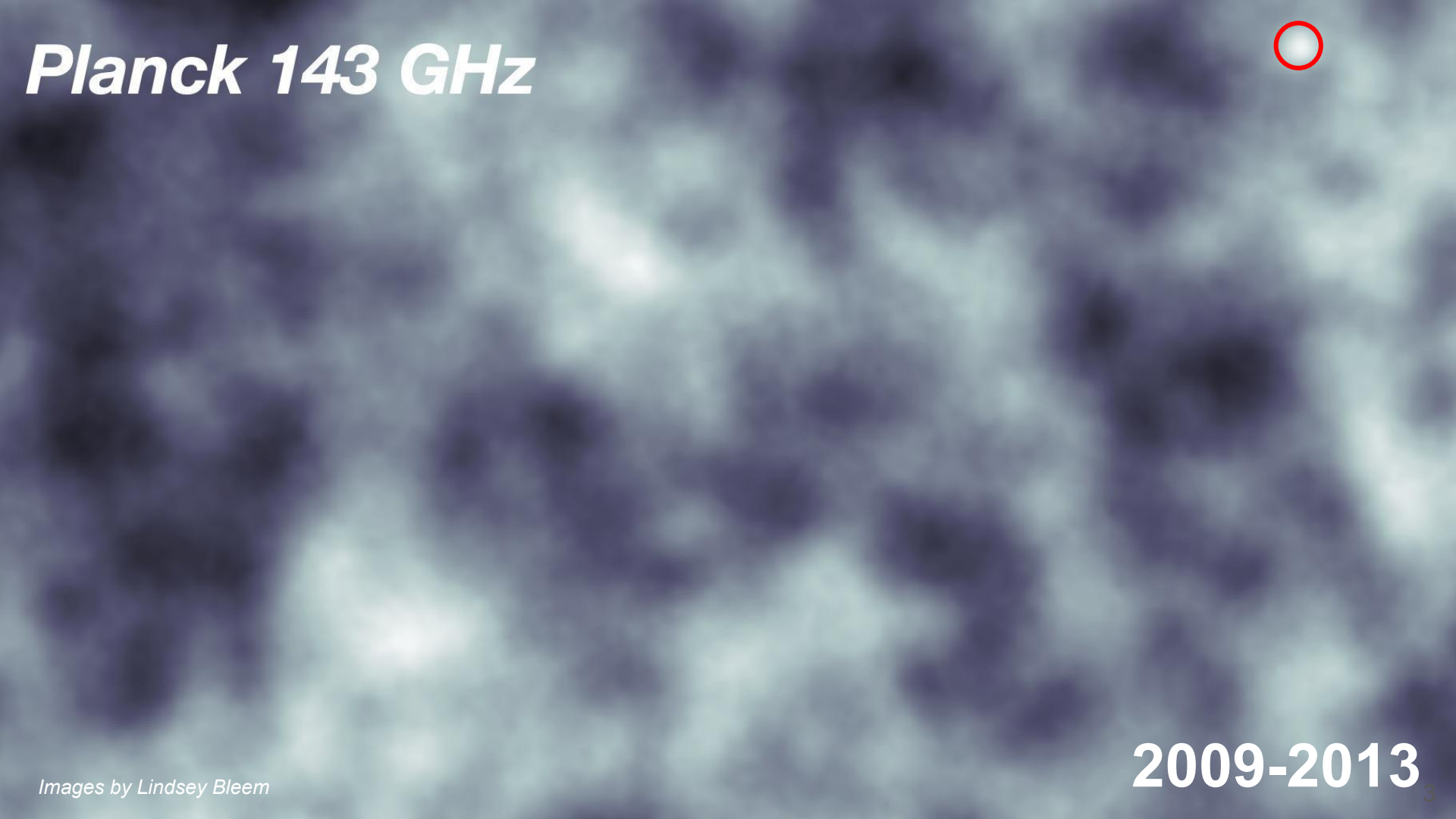
Millimeter-wave emissive static point sources

Melanie Archipley
University of Illinois Urbana-Champaign

CMB-S4 Spring Collaboration 2024



Images by Lindsey Bleem



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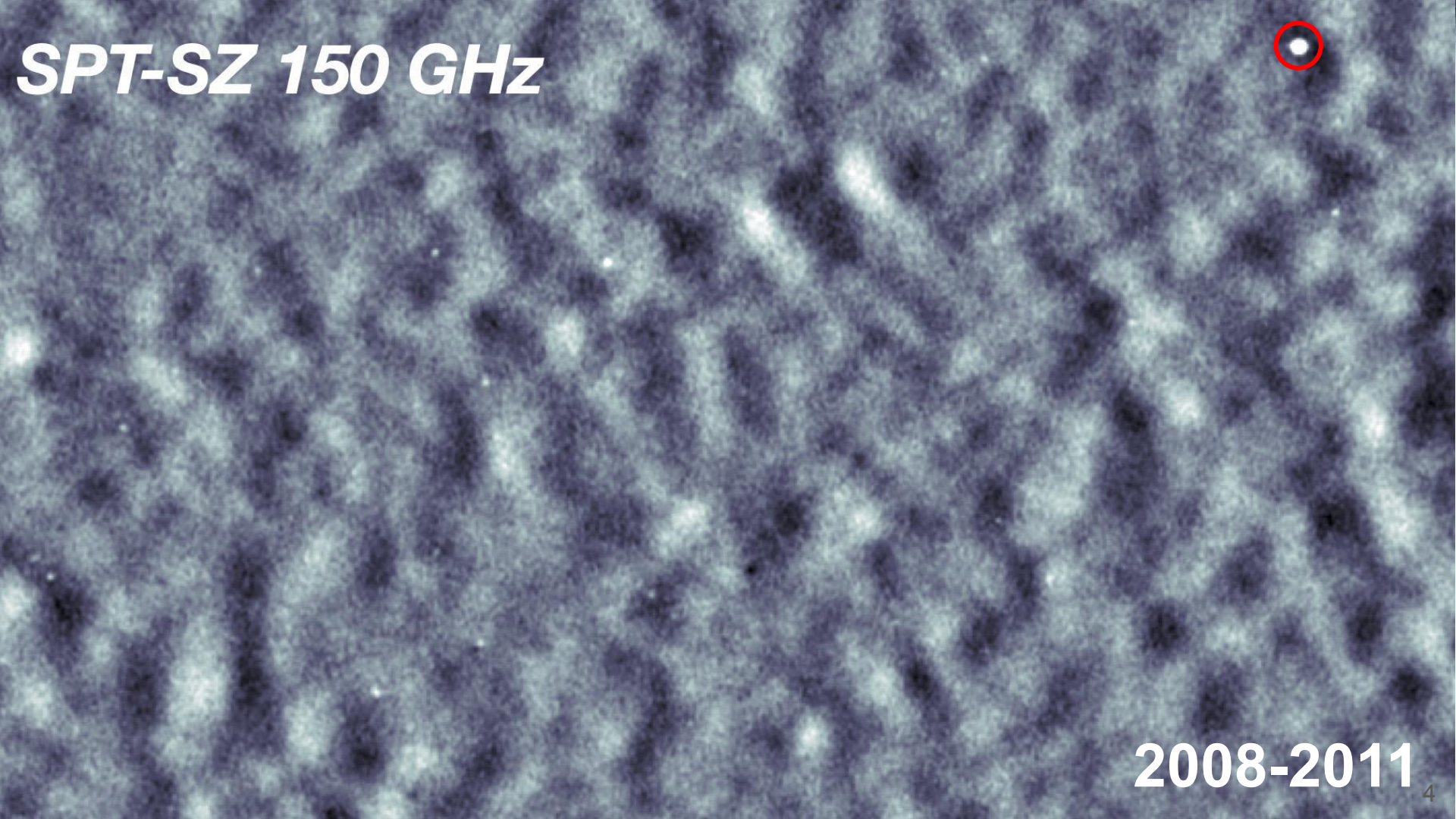
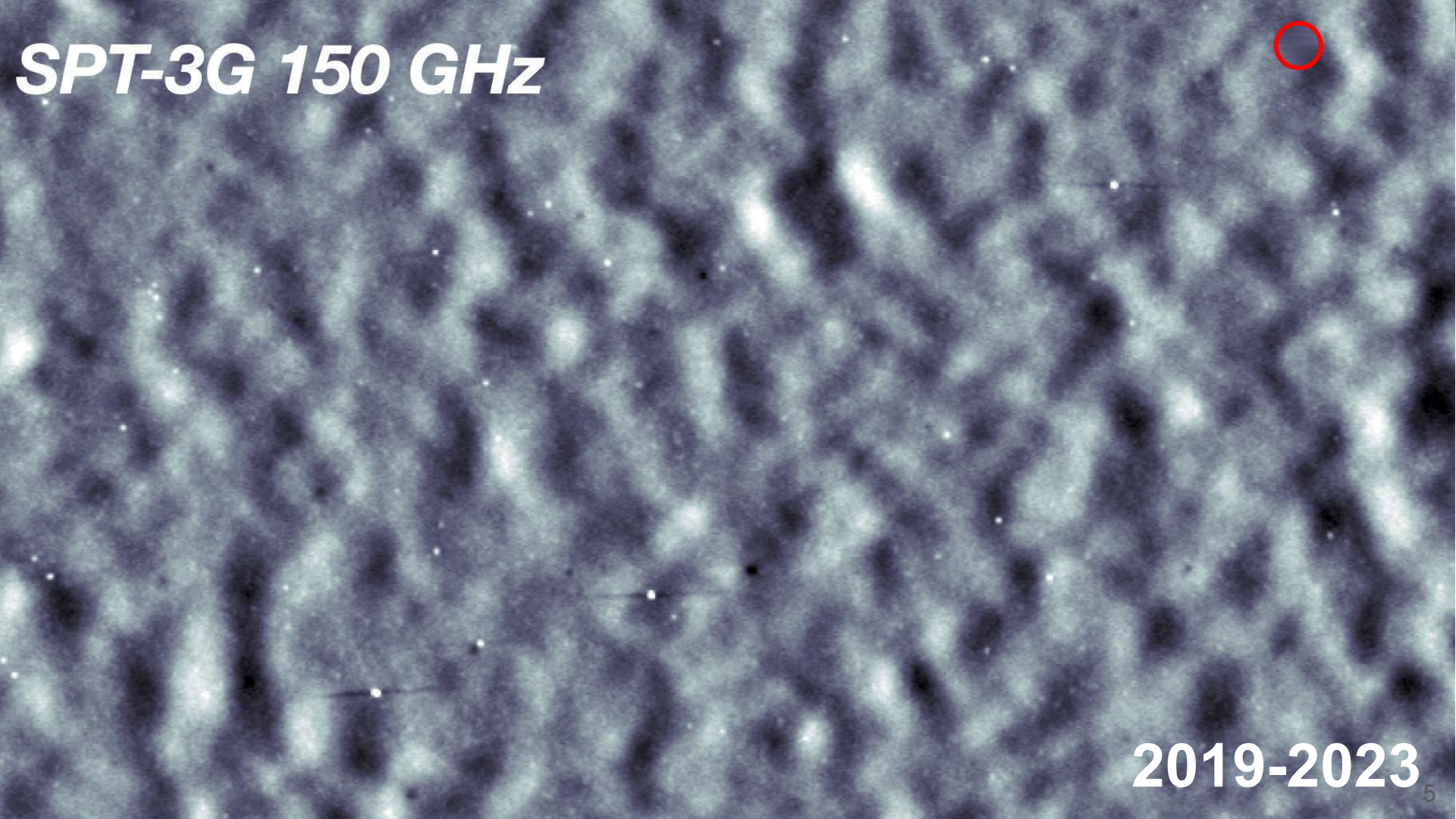

SPT-SZ 150 GHz
2008-2011


SPT-3G 150 GHz
2019-2023

Current and changing landscape of facilities

← 2010

Surveys

- Optical: DSS (S), SDSS (N)
- IR: *IRAS* (from 1983)
- Radio: SUMSS (843 MHz from 1999), NVSS (N)
- X-ray: RASS (from 1990)

Follow-up facilities

- Optical: Keck (N), VLT (S)
- IR: *Spitzer*
- Submm: CSO, APEX, SMA (N), PdBI (N)
- Radio: VLA (N), ATCA (S)
- X-ray: *Chandra*

2010-2020s

Surveys

- Optical: **DES** (S), HSC (N)
- IR: ***Planck***, ***WISE***
- Radio: SUMSS (843 MHz from 1999), NVSS (N)
- X-ray: RASS (from 1990)

Follow-up facilities

- Optical: Keck (N), VLT (S)
- IR: ***Herschel***, *Spitzer*
- Submm: **ALMA**, SMA (N), NOEMA (N)
- Radio: VLA (N), ATCA (S)
- X-ray: *Chandra*

2030s →

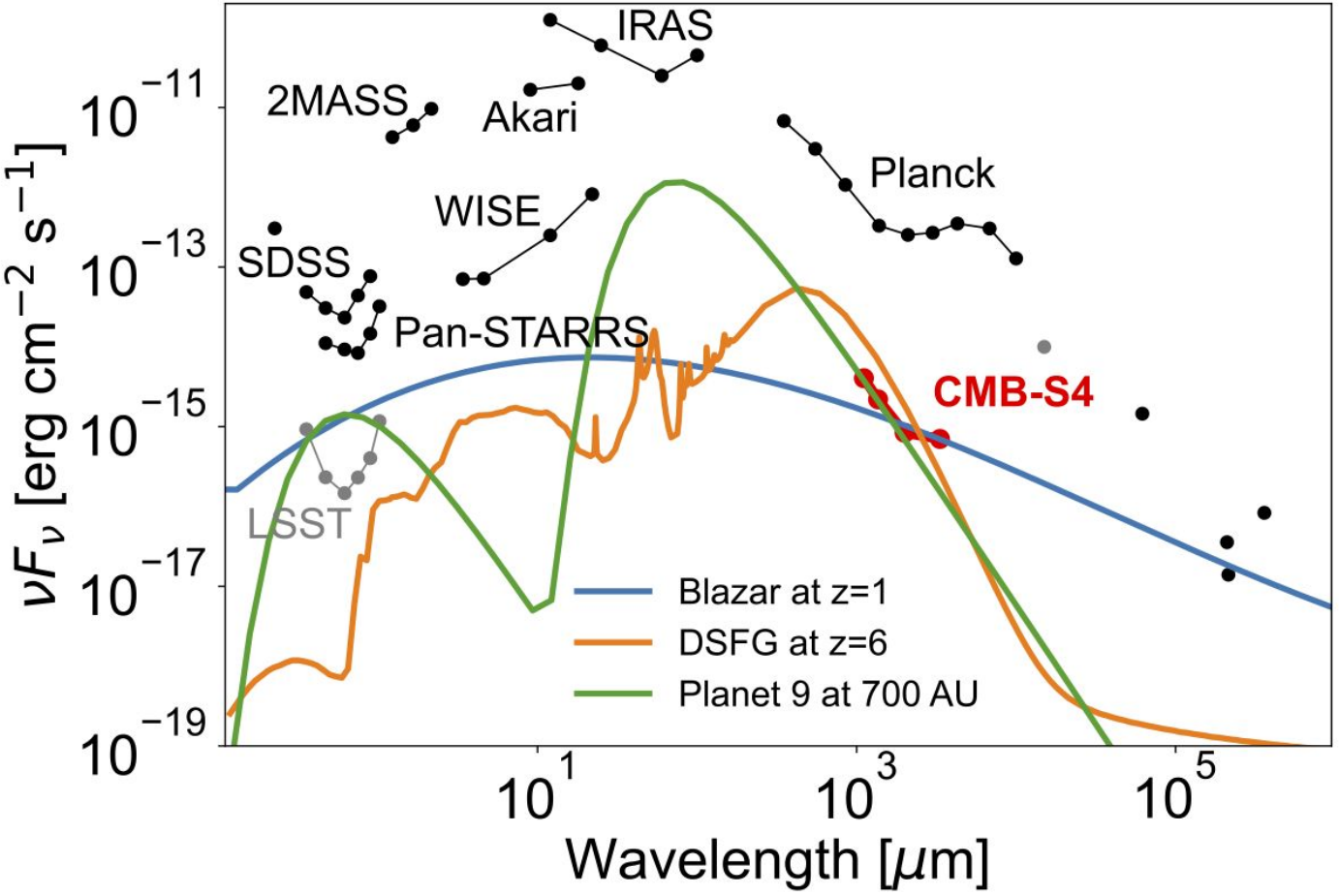
Surveys

- Optical: **Rubin**, *Euclid*, *Roman*, *SPHEREx*
- IR: *Planck, WISE*
- Radio: SKA
- X-ray: *eROSITA*

Follow-up facilities

- Optical: ELTs
- IR: ***JWST***
- Submm: ALMA, LMT
- Radio: ngVLA (N), SKA
- X-ray: *ATHENA*

Spectral energy distribution (SED) sensitivity



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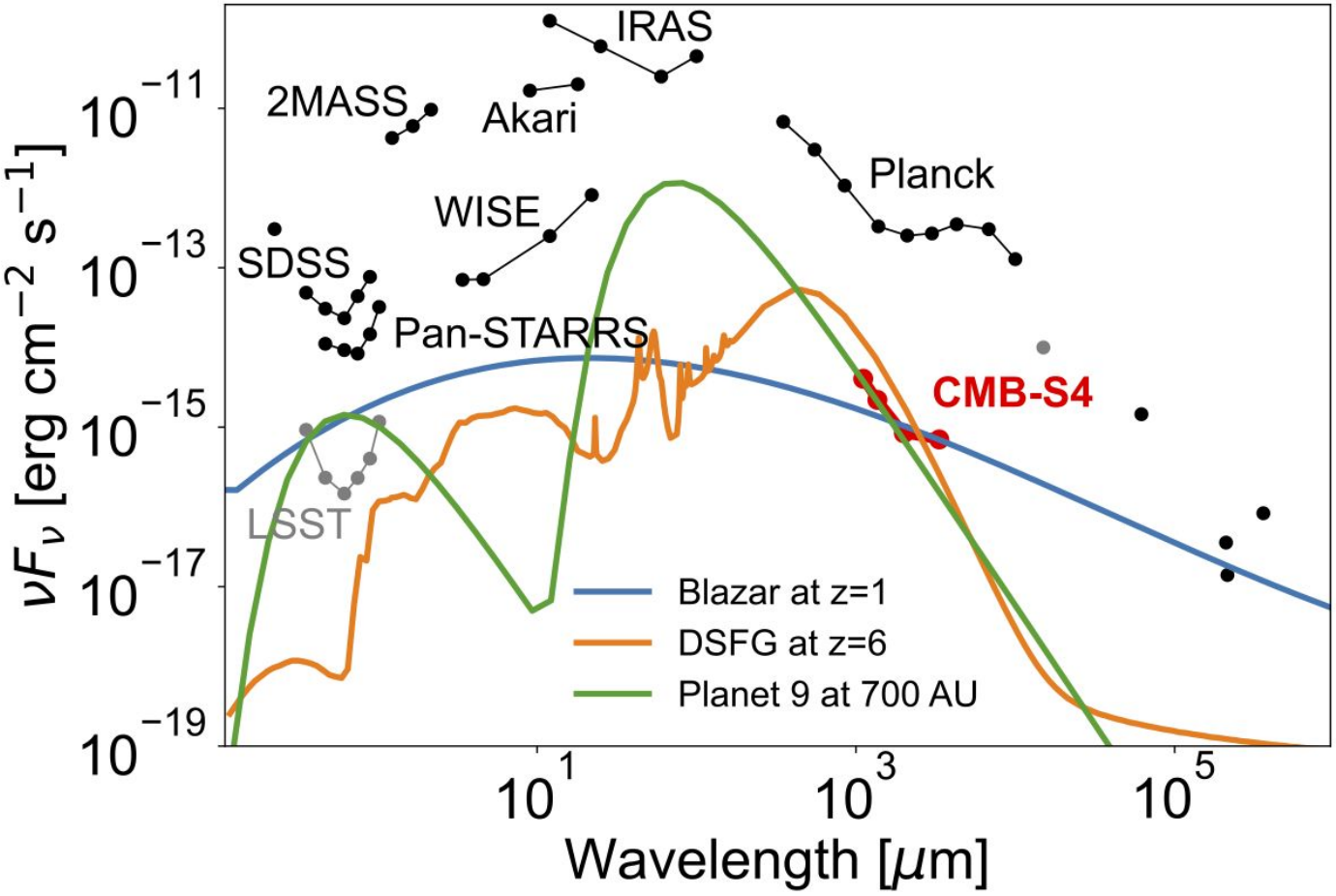
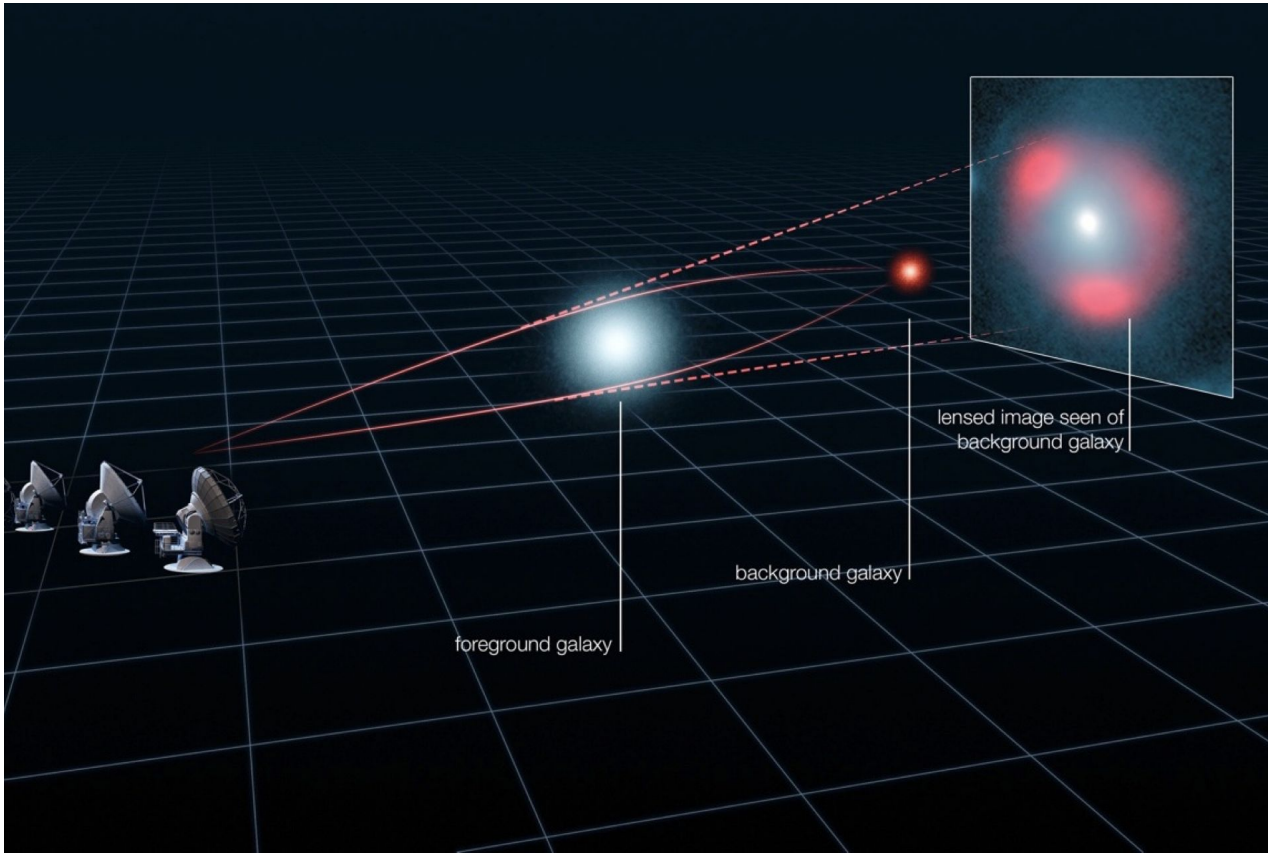
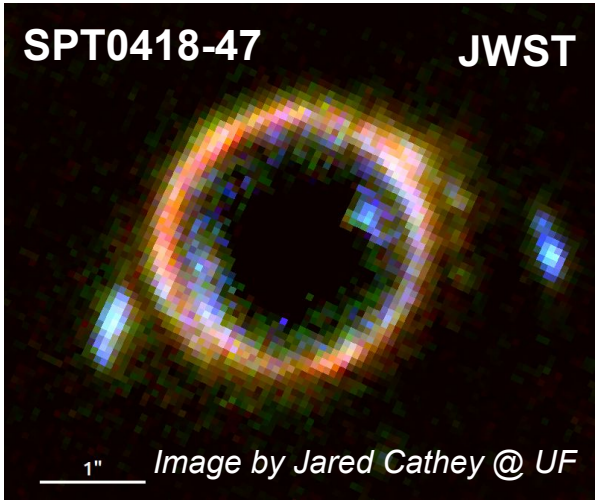


CMB-S4 will have an unprecedented combination of depth and sky coverage

Object types from high to low redshift

Lensed submillimeter galaxies (SMGs)



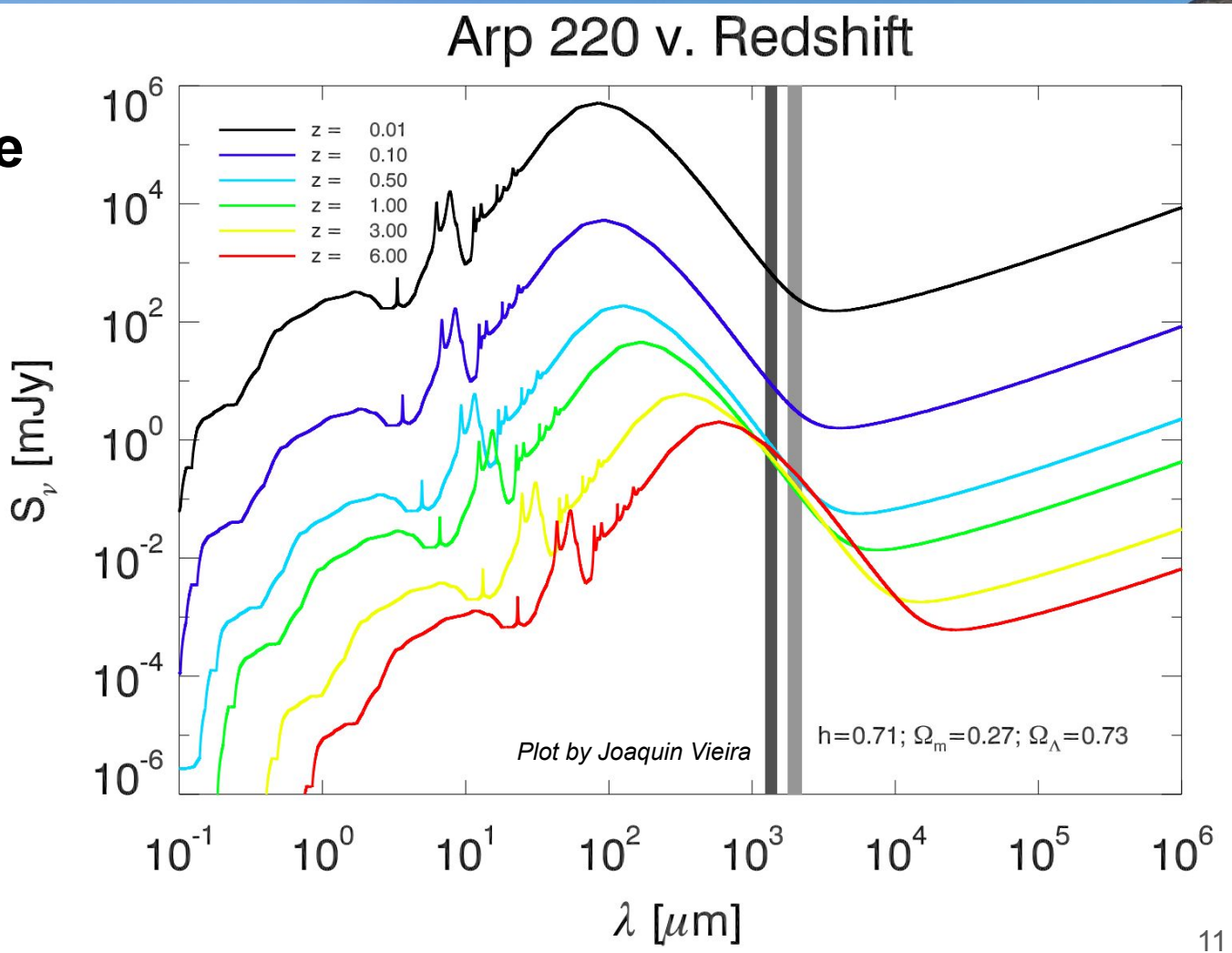


Many are lensed, dusty star forming galaxies (DSFGs), lacking multiwavelength counterparts, and are at high (z>4) redshift.

How can we see distant dusty galaxies?

On Rayleigh-Jeans tail of spectrum at submm and mm wavelengths, flux loss from distance "cancels out"
→ dusty galaxies detected independent of redshift

SPT bands shown are 150 GHz and 220 GHz



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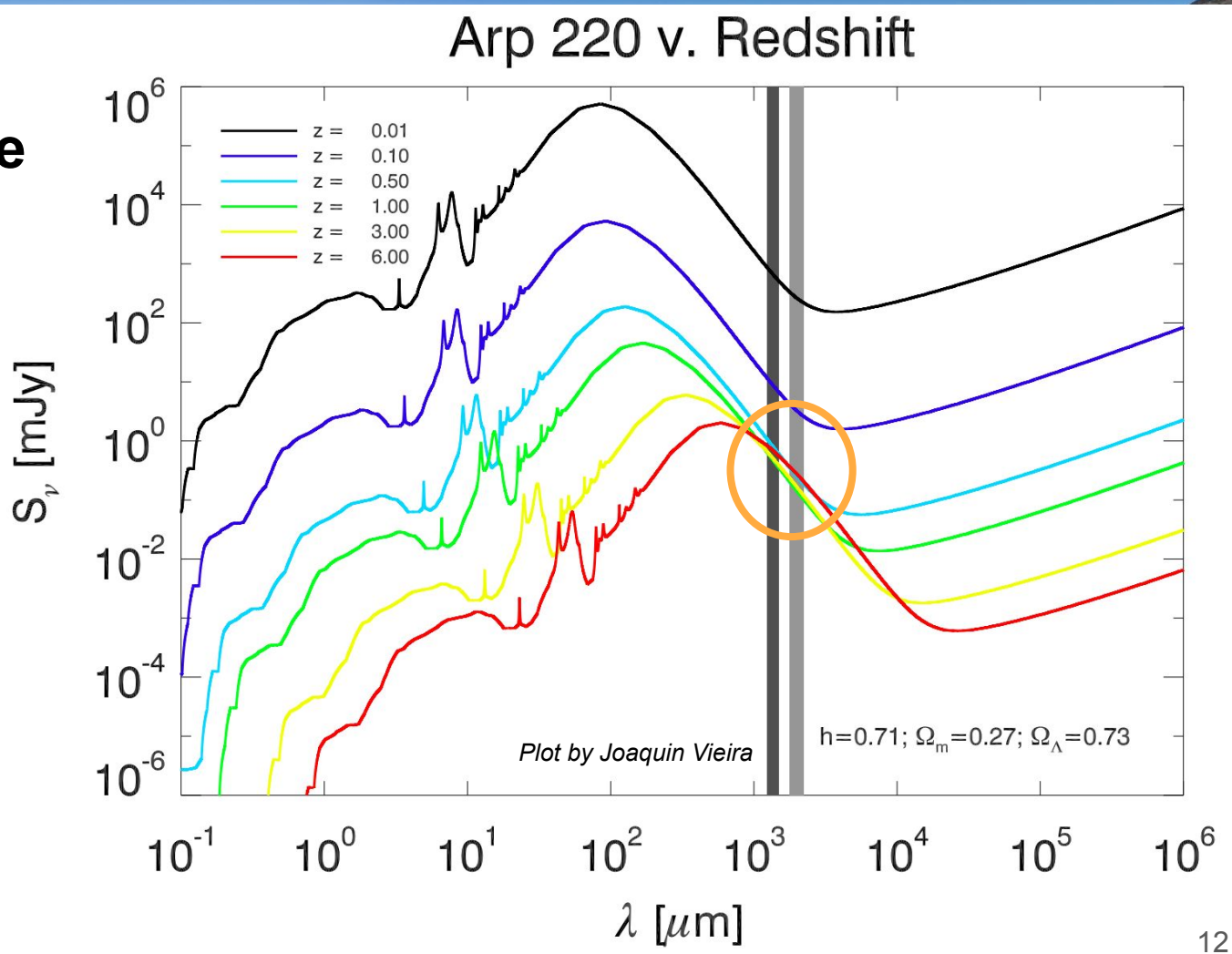
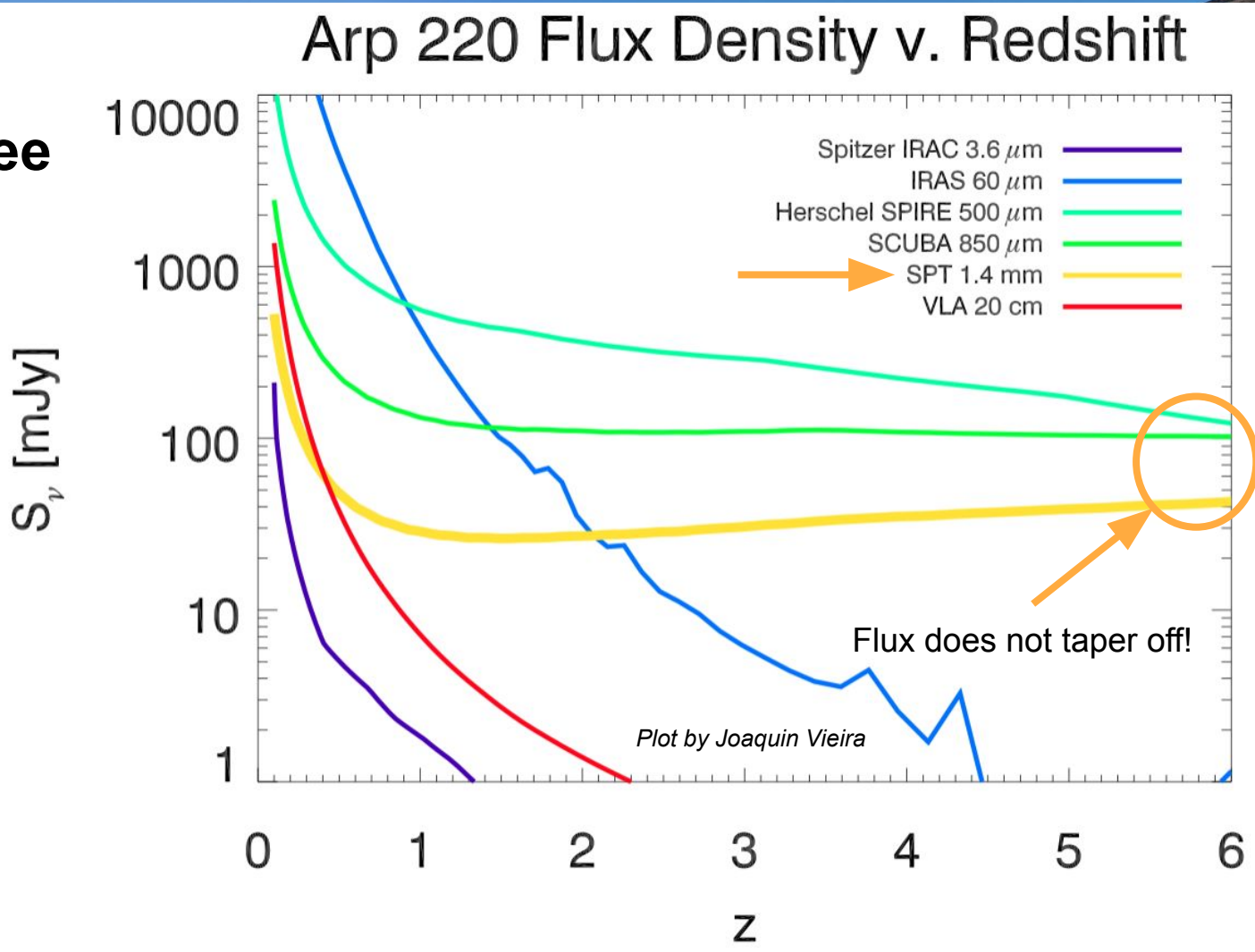


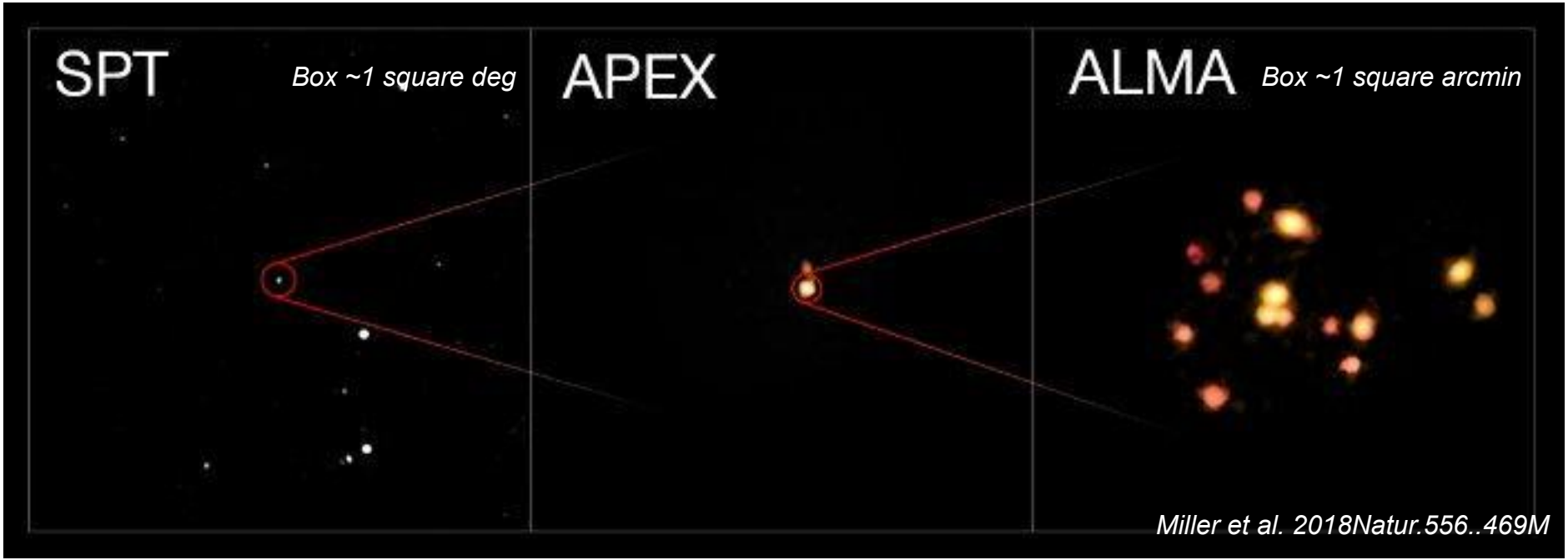
How can we see distant dusty galaxies?

→ **dusty galaxies detected independent of redshift**

CMB surveys provide unique discovery space for these types of galaxies: we anticipate detecting thousands of z > 6 dusty sources with CMB-S4



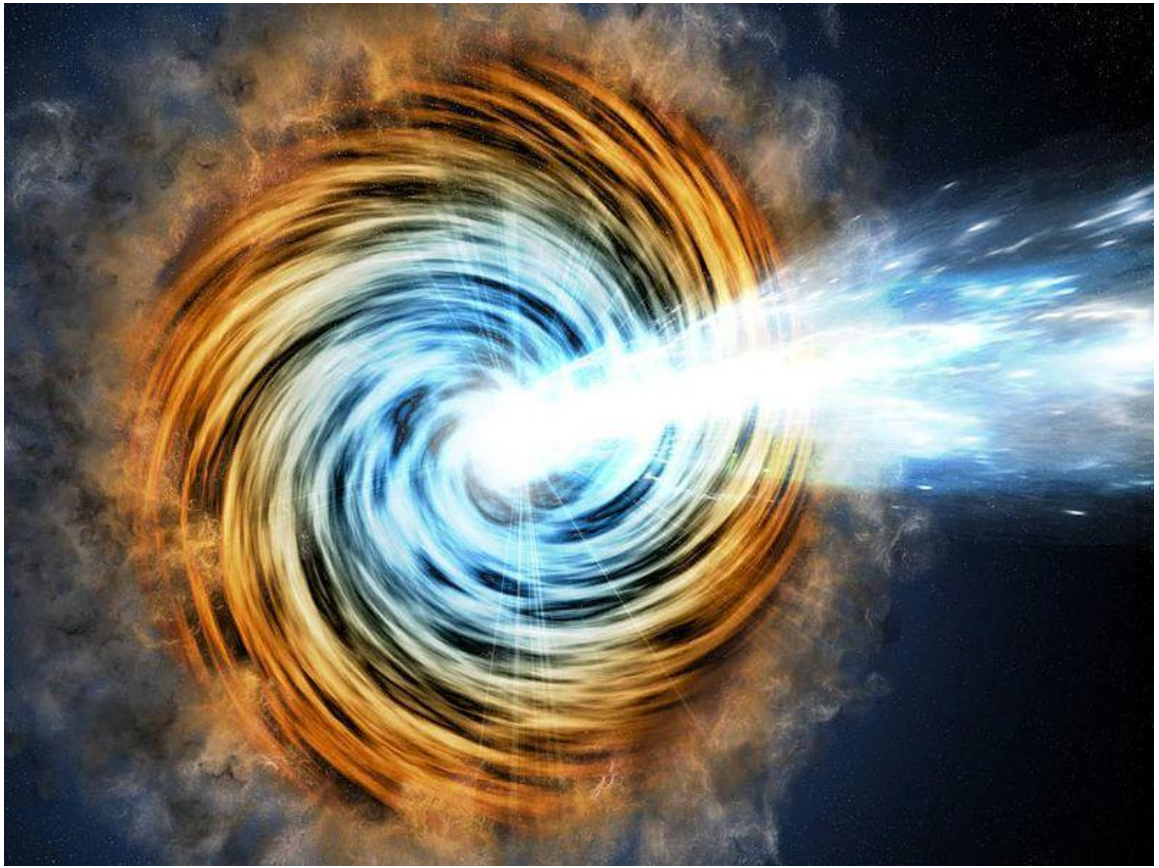
Galaxy protoclusters



Wide view in CMB survey (SPT) shows just a bright point. Follow-up observations reveal 14 merging galaxies in the process of forming a galaxy cluster. SPT2349-56 is at redshift 4.3, when the universe was only 1.4 billion years old.

Image credit: (ALMA (ESO/NAOJ/NRAO); B. Saxton (NRAO/AUI/NSF)).

Active Galactic Nuclei (AGN)

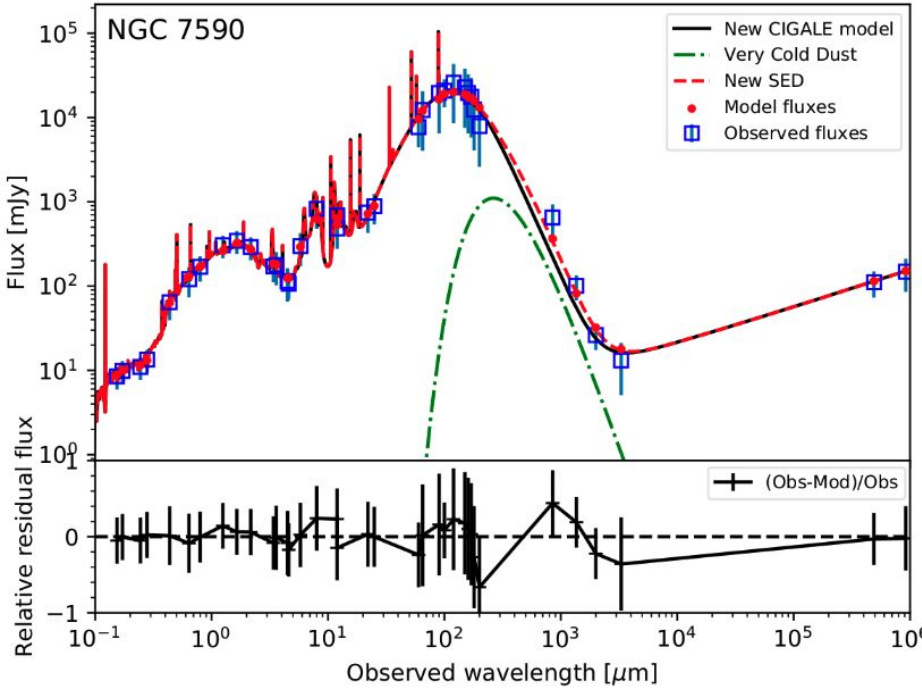


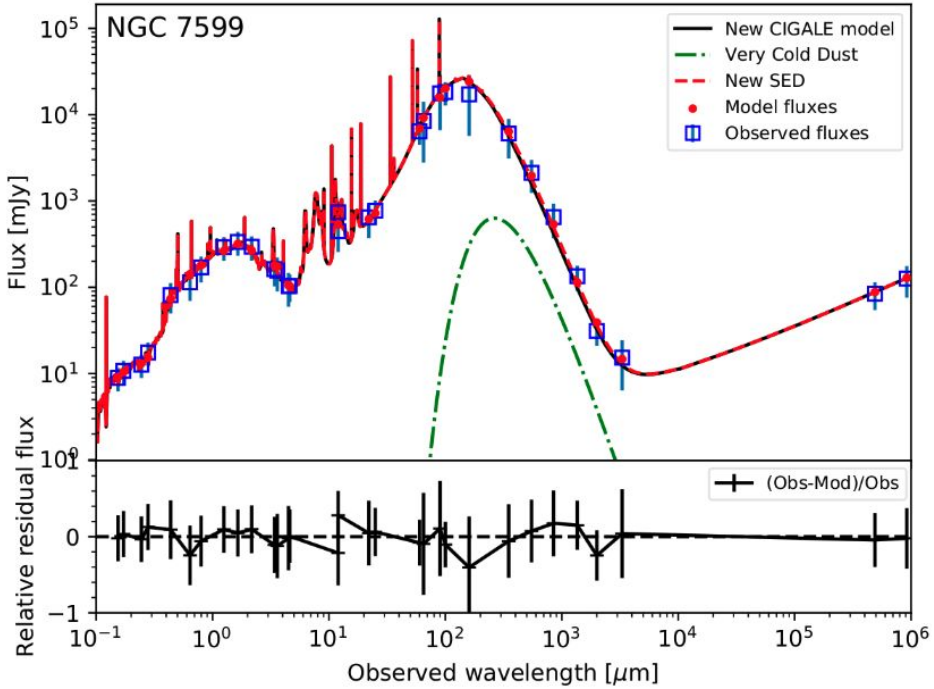
The brightest mm sources are blazars (AGN with jet pointed towards us). Almost all mm AGN have multiwavelength counterparts with z<3.

Images from Wikimedia commons, above: artist impression of a blazar

Nearby galaxies

Singh et al. 2021MNRAS.504.4143S

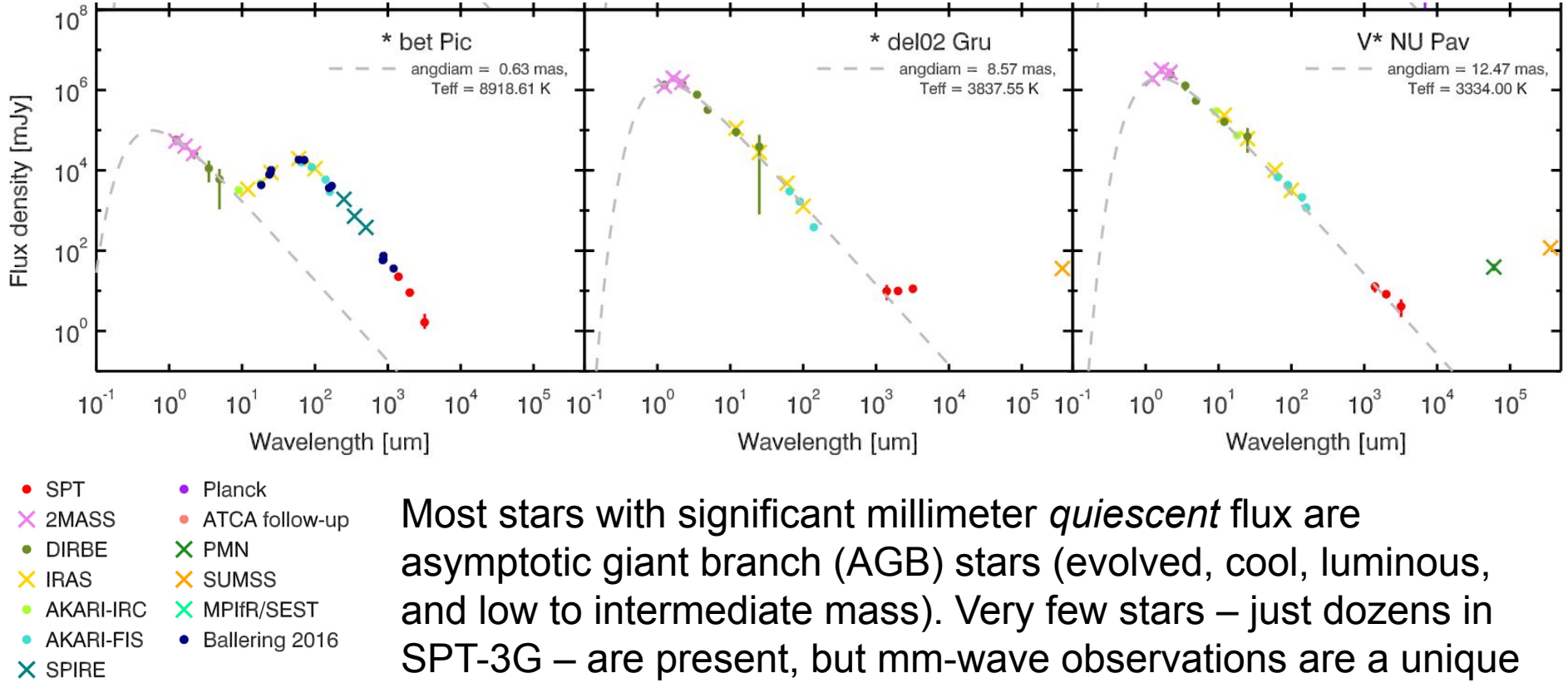




Mm observations of low redshift (z<0.1) galaxies deepen understanding of dust properties in galaxies and, therefore, star formation and galaxy evolution as a whole. Multiwavelength counterparts enable detailed studies of separate galaxy components.

Stars

Everett et al. 2020ApJ...900...55E



Most stars with significant millimeter *quiescent* flux are asymptotic giant branch (AGB) stars (evolved, cool, luminous, and low to intermediate mass). Very few stars – just dozens in SPT-3G – are present, but mm-wave observations are a unique insight into their nature.

Science book chapters for millimeter-wavelength emissive sources

- Extragalactic
  - Active Galactic Nuclei (AGN)
  - Phase calibrators for ngVLA
  - Dusty Star Forming Galaxies (DSFGs)
  - Lensed sources
  - Protoclusters
- Galactic
  - Evolved low mass stars
  - Massive stars
  - Exo-Oort clouds
  - Debris disks
  - Planetary nebulae
  - Symbiotic stars
  - Supernova (SN) remnants
  - Pulsar wind nebulae
  - Magellanic clouds

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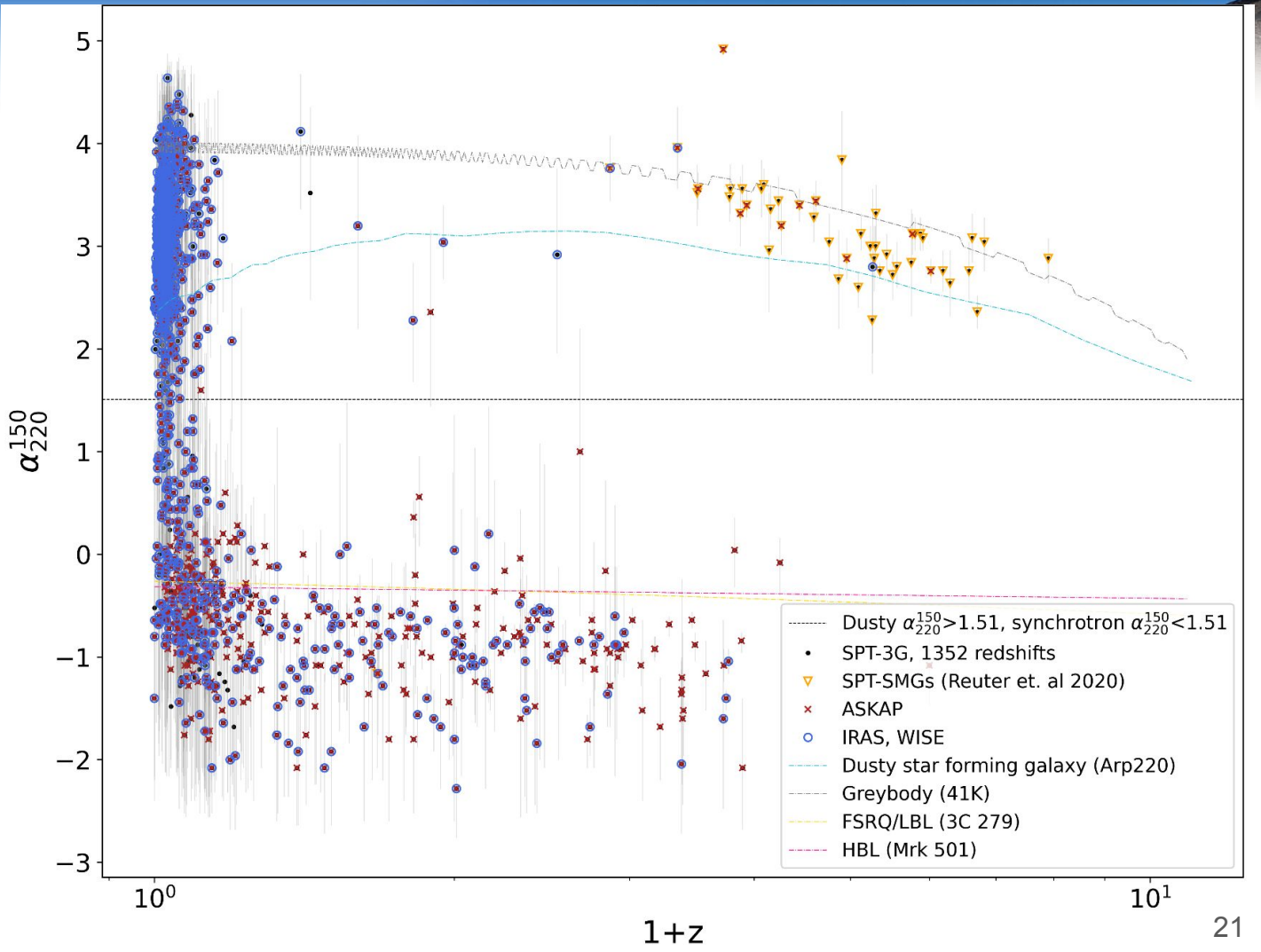
Extra

CMB-detected extragalactic sources, external counterparts, and redshifts

Showing SPT-3G point sources with redshifts in NED and spectral index (α) from SPT bands



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