

# Extragalactic sources in CMB maps

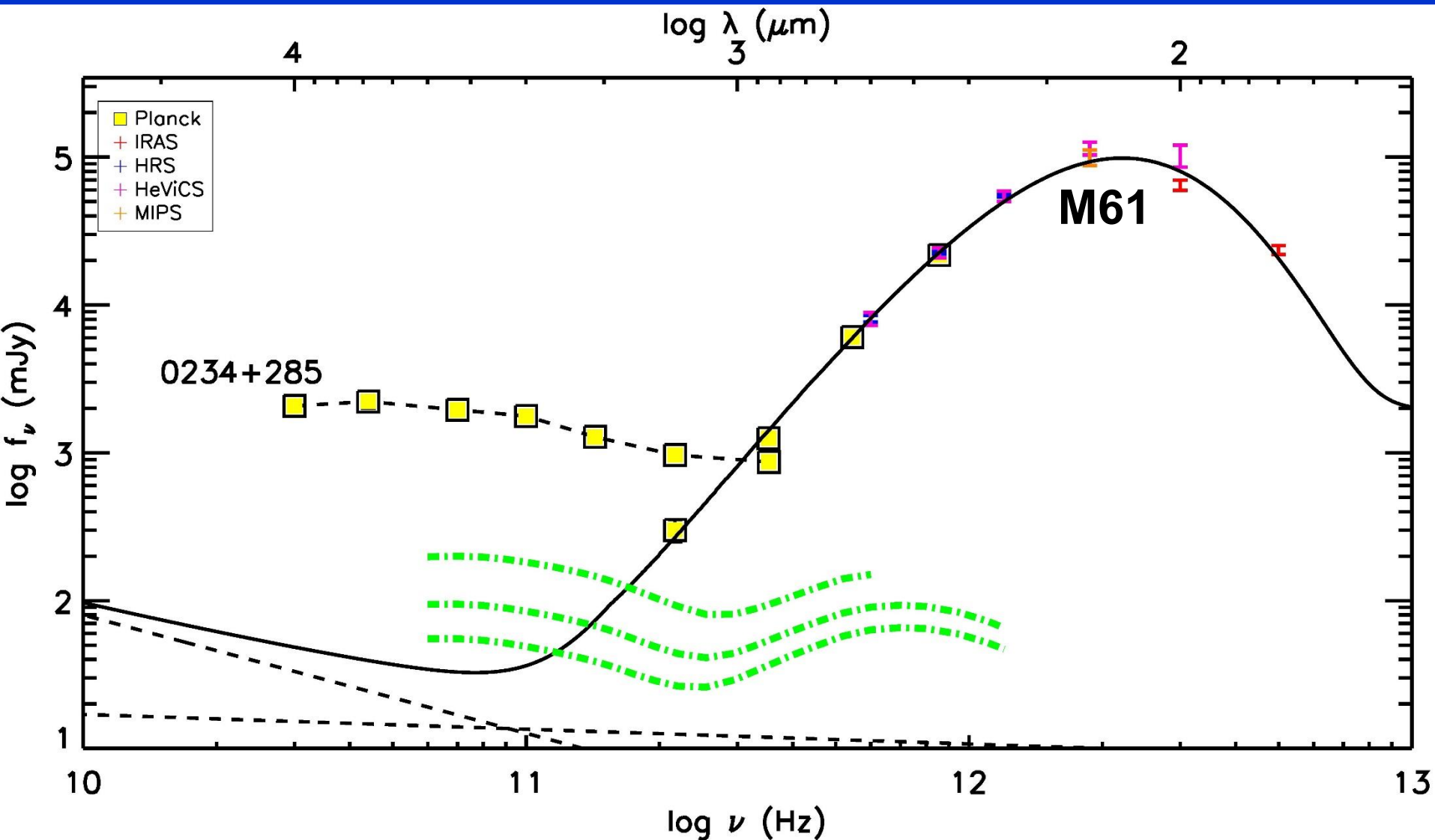
Gianfranco De Zotti (INAF-OAPd & SISSA, Trieste)

Thanks to: J. Gonzalez-Nuevo, Z.-Y. Cai, M. Negrello

# **Extragalactic surveys with space-borne CMB missions - 1**

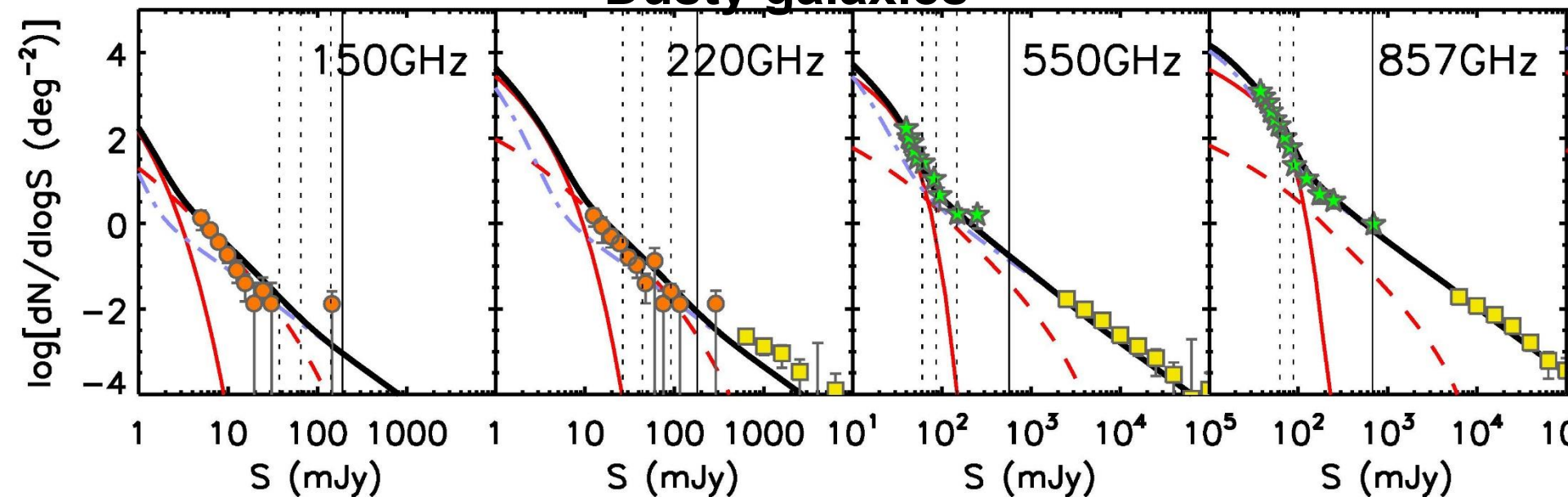
- **Broad spectral range hardly, if at all, accessible from the ground and only lightly covered by other space missions.**
- **All-sky coverage, ideal to look for rare phenomena.**
- **Poor angular resolution that can be both a limitation and a resource.**

# Extragalactic surveys with space-borne CMB missions - 2

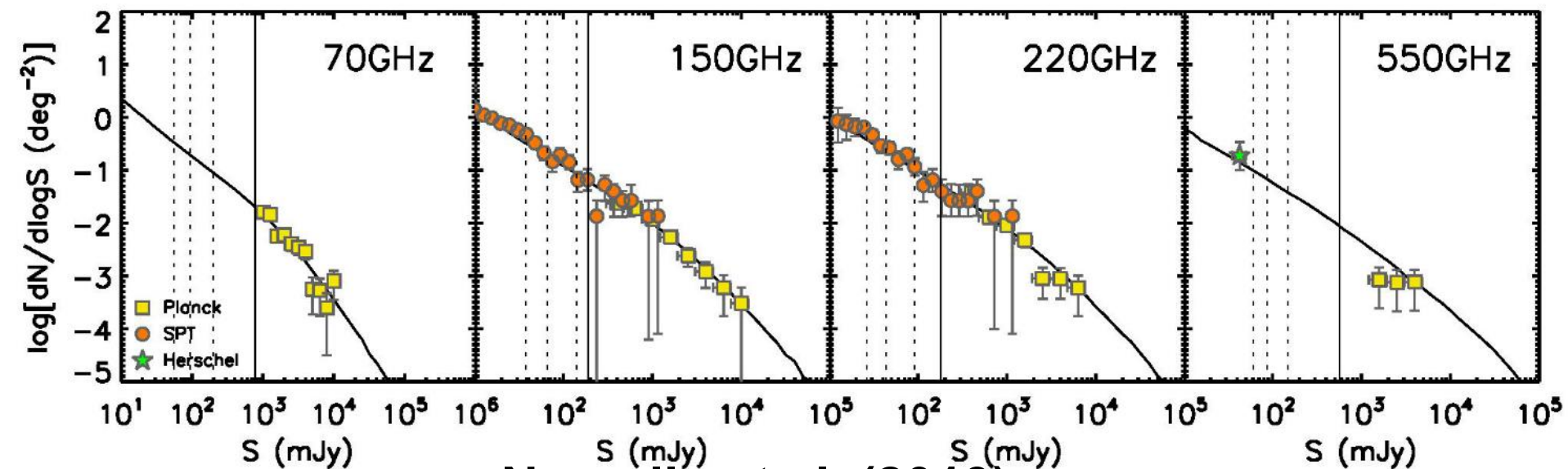


# Source counts

## Dusty galaxies

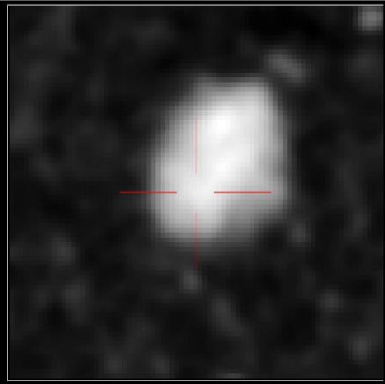


## Radio sources

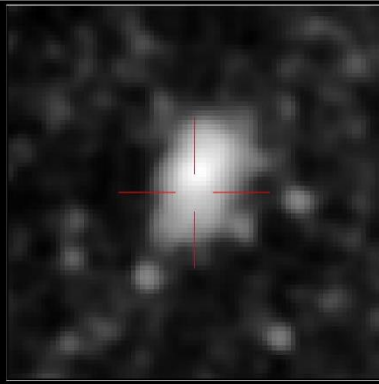


Negrello et al. (2013)

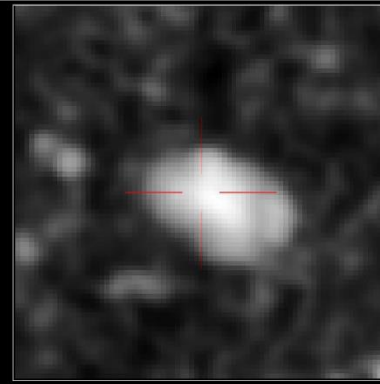
# Herschel/SPIRE images of Planck sources



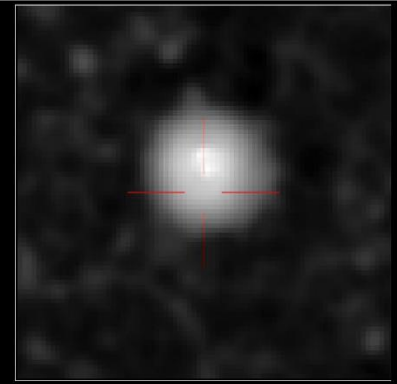
(a) ID#21



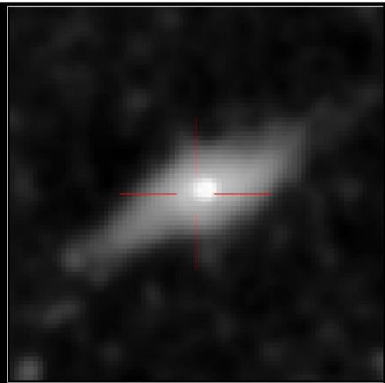
(b) ID#22



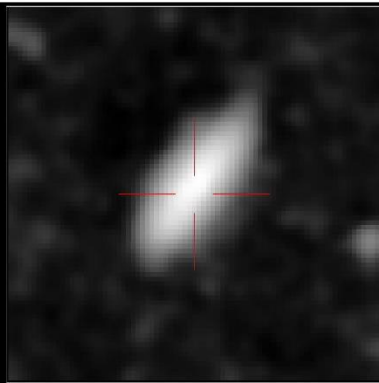
(c) ID#23



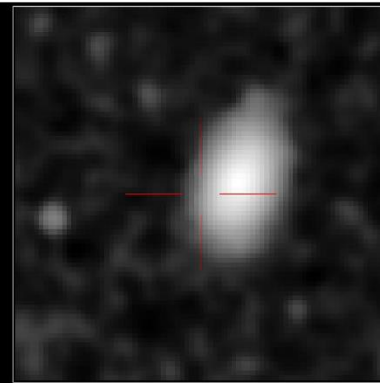
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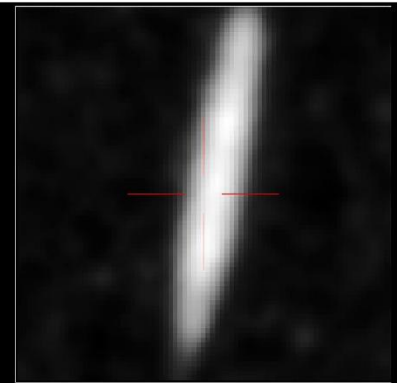
(e) ID#25



(f) ID#26

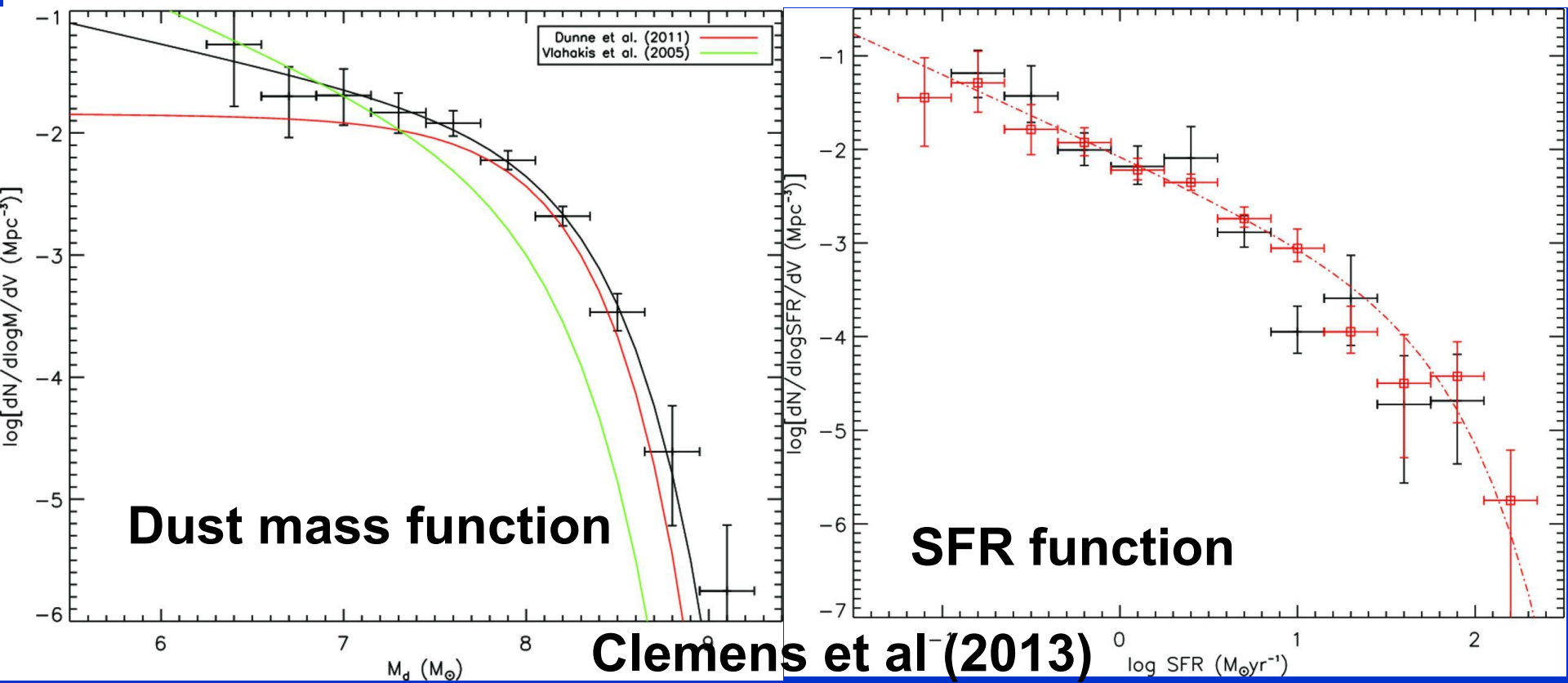
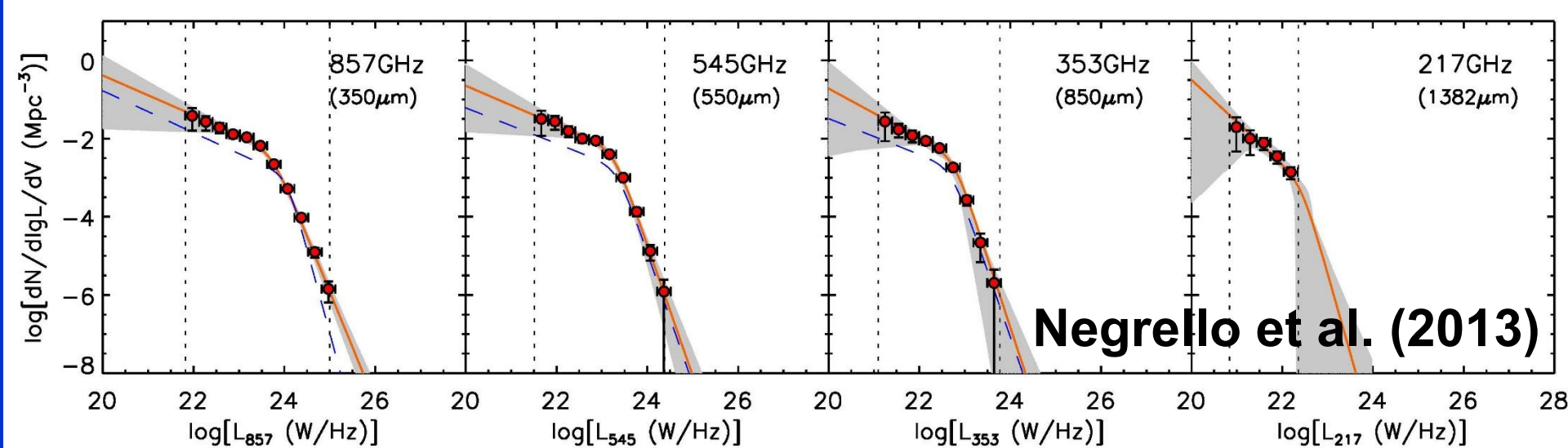


(g) ID#27



(h) ID#28

Herranz et al. (2013)



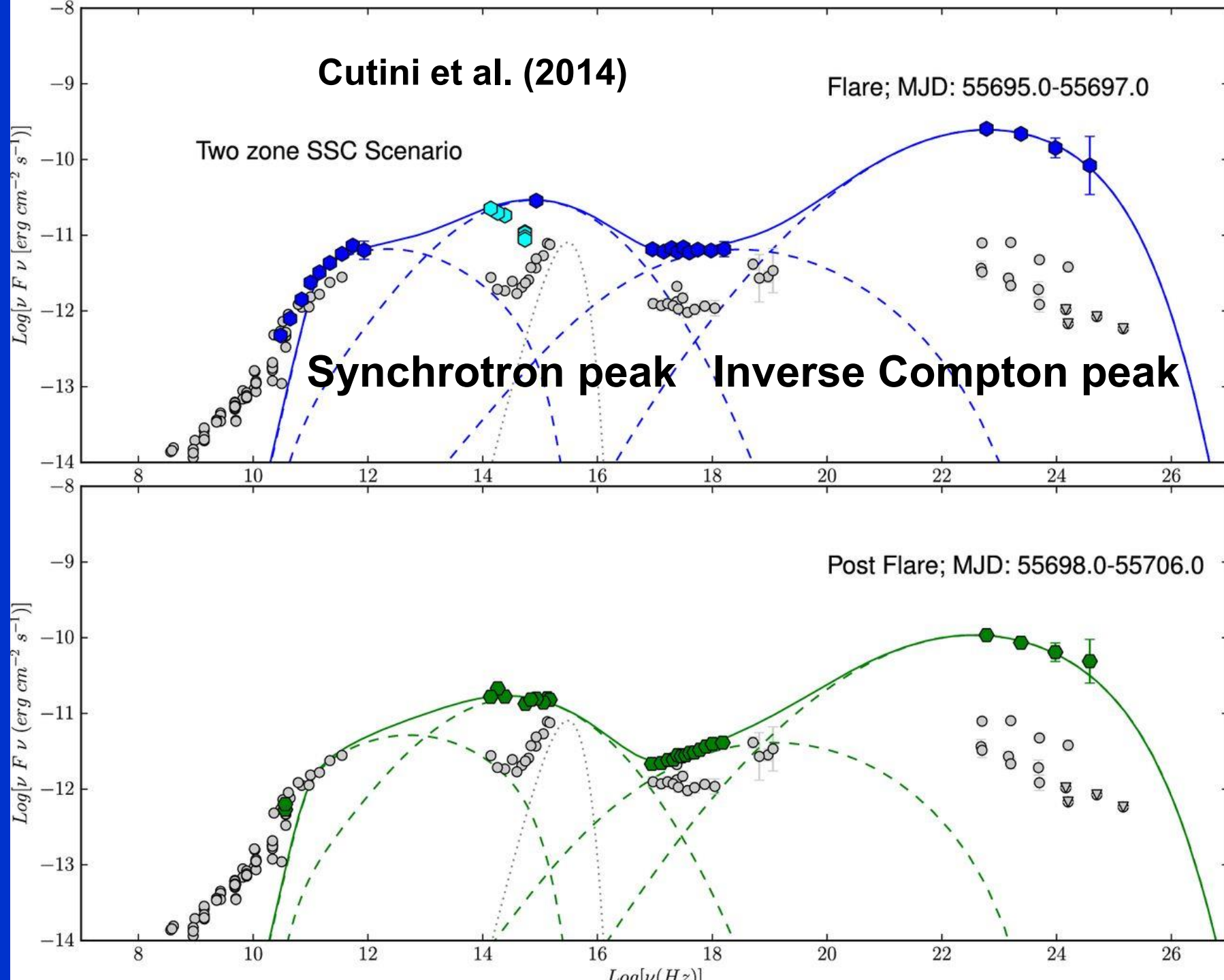


# Cutini et al. (2014)

Flare; MJD: 55695.0-55697.0

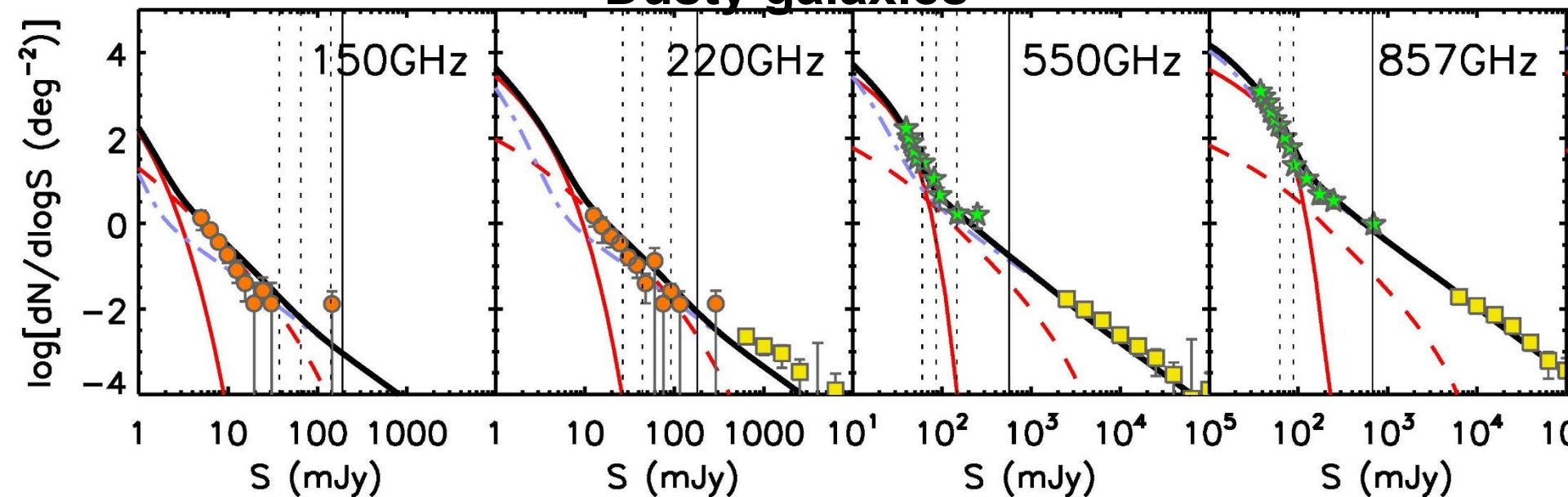
Two zone SSC Scenario

Synchrotron peak      Inverse Compton peak

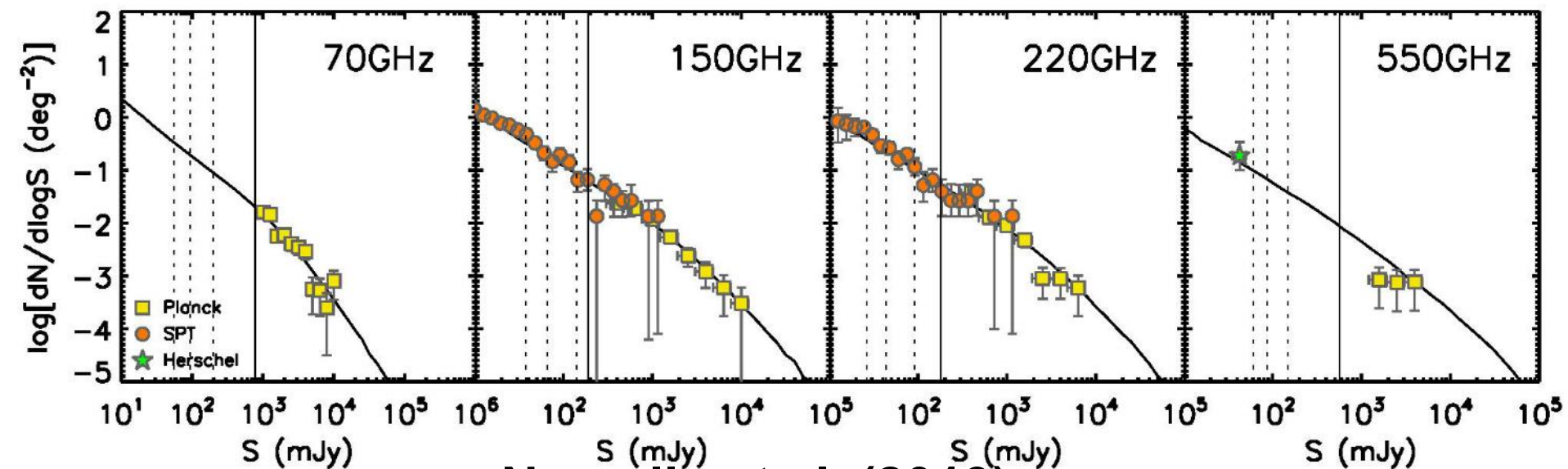


# Source counts

## Dusty galaxies

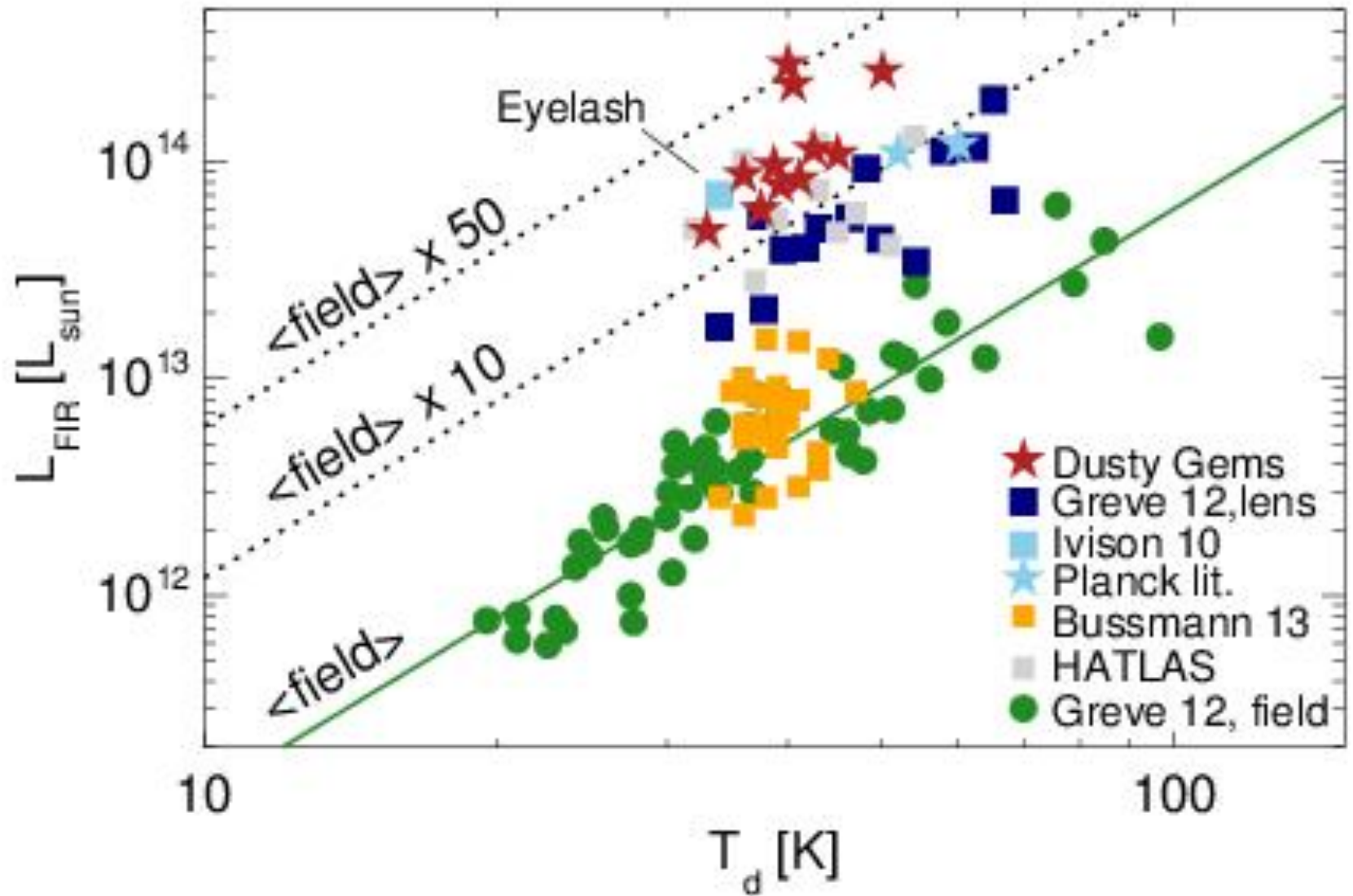


## Radio sources

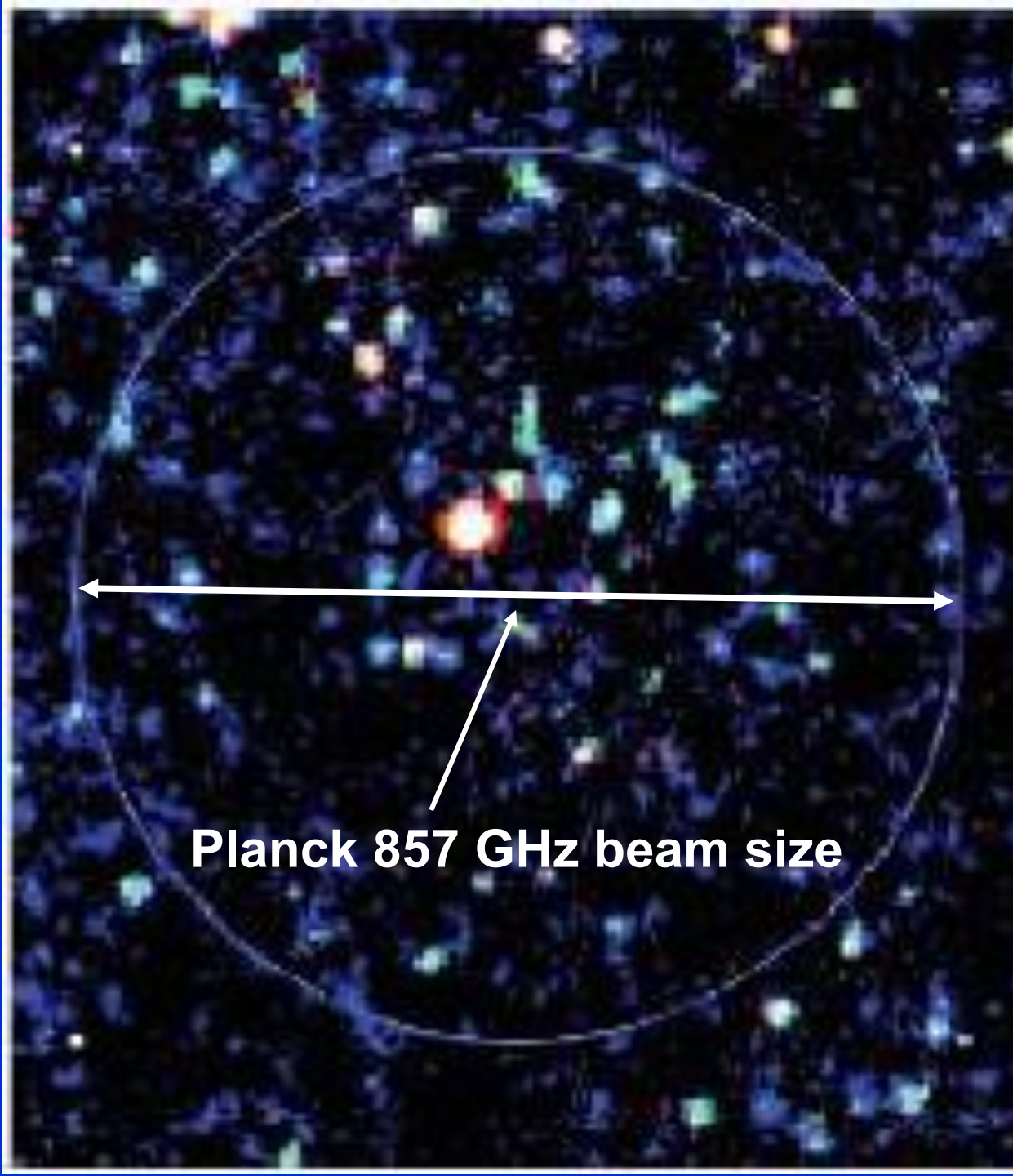


Negrello et al. (2013)





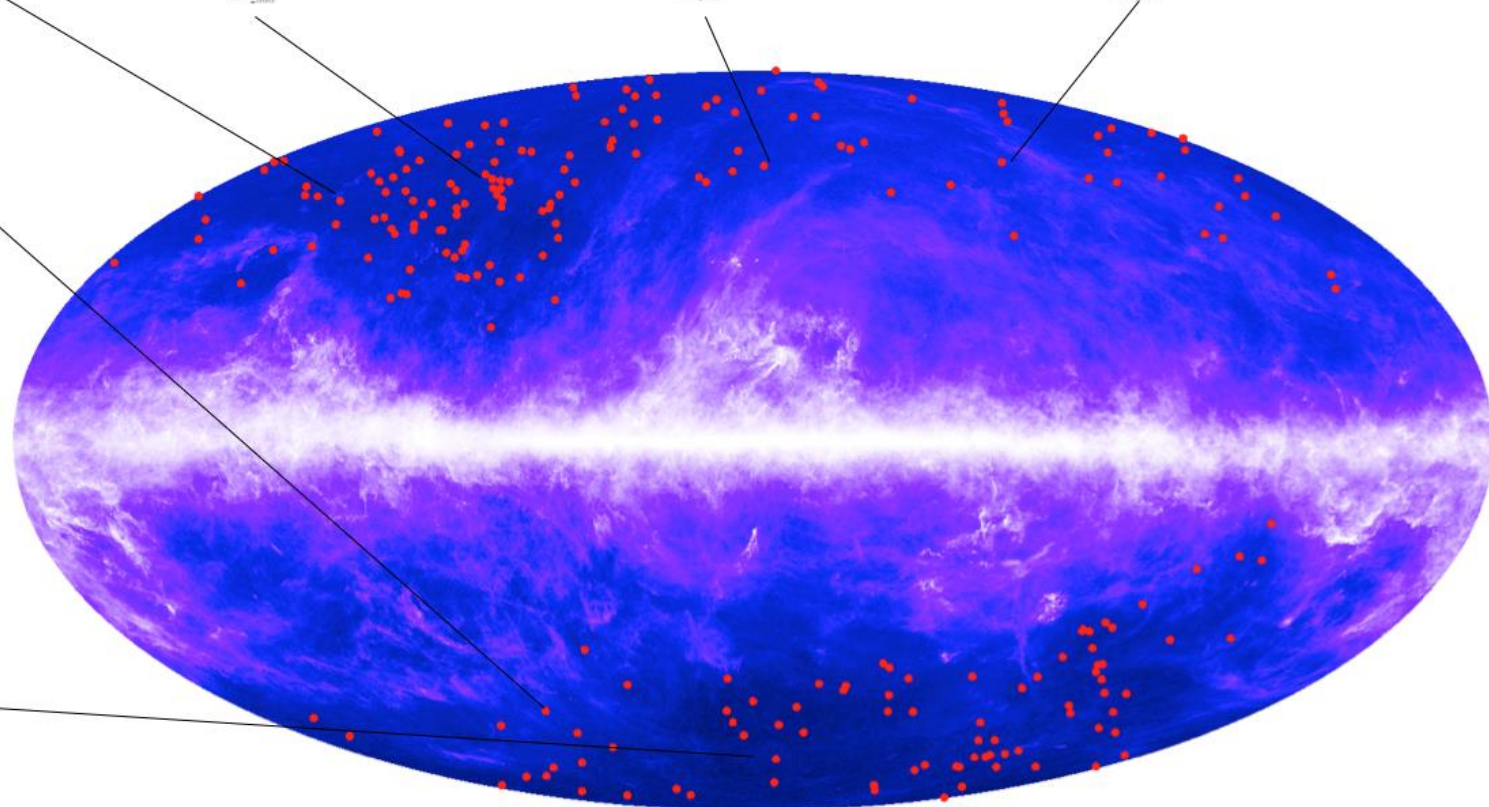
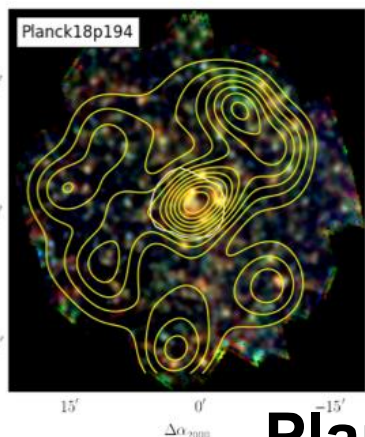
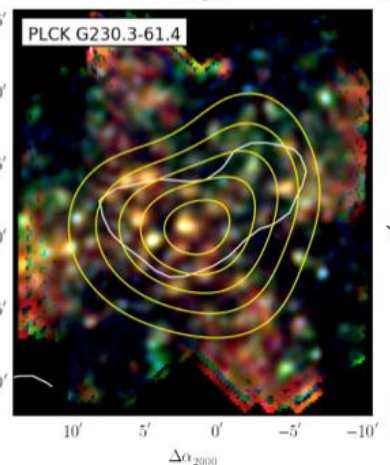
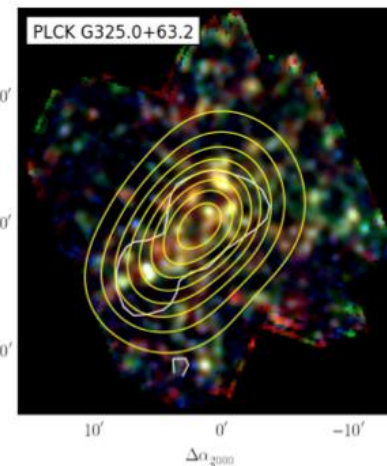
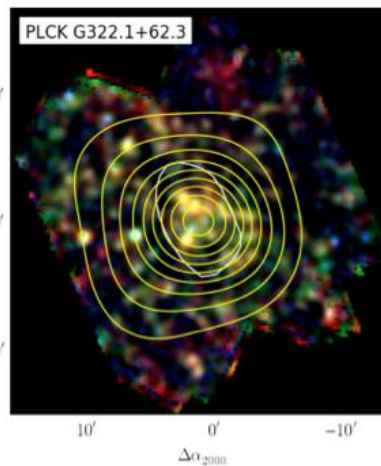
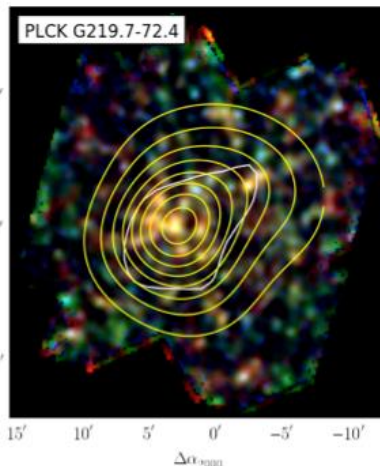
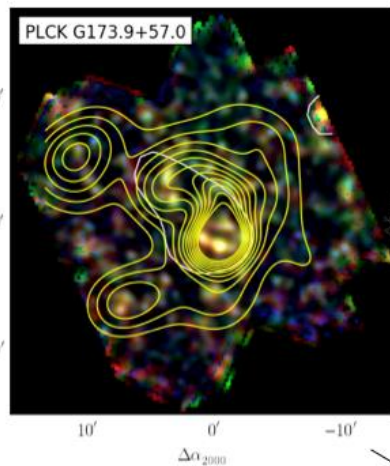
**Dusty Gems: 11 strongly gravitationally lensed galaxies at  $z = 2.2 - 3.6$  detected by Planck (Cañameras et al. 2015)**



**Planck 857 GHz beam size**

**A Planck source resolved by Herschel as a clump of galaxies surrounding a bright strongly gravitationally lensed galaxy at  $z=3.26$  which accounts for  $\sim 1/3$  of the Planck flux density. The light circle represents the Planck beam. From Herranz et al. (2013)**

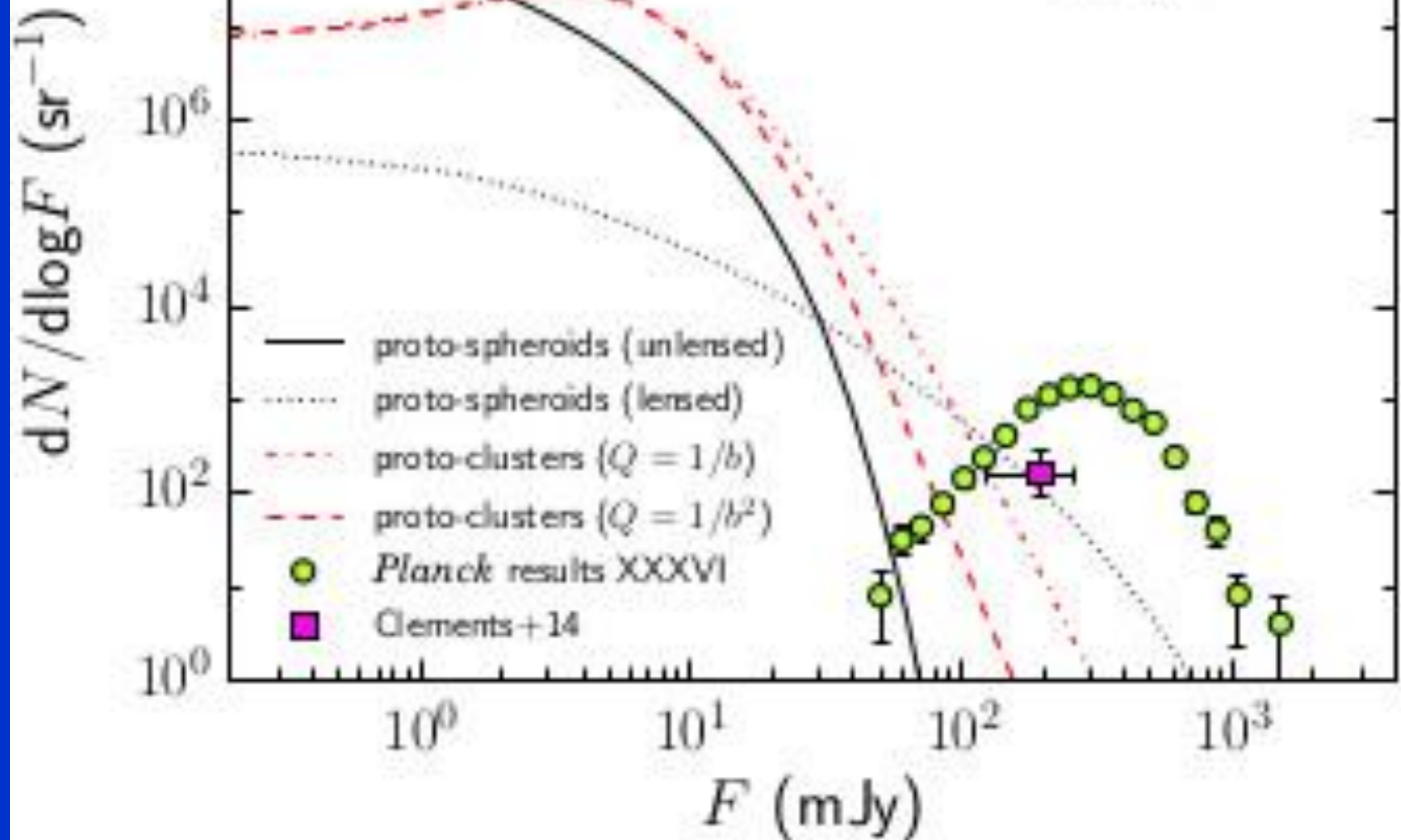




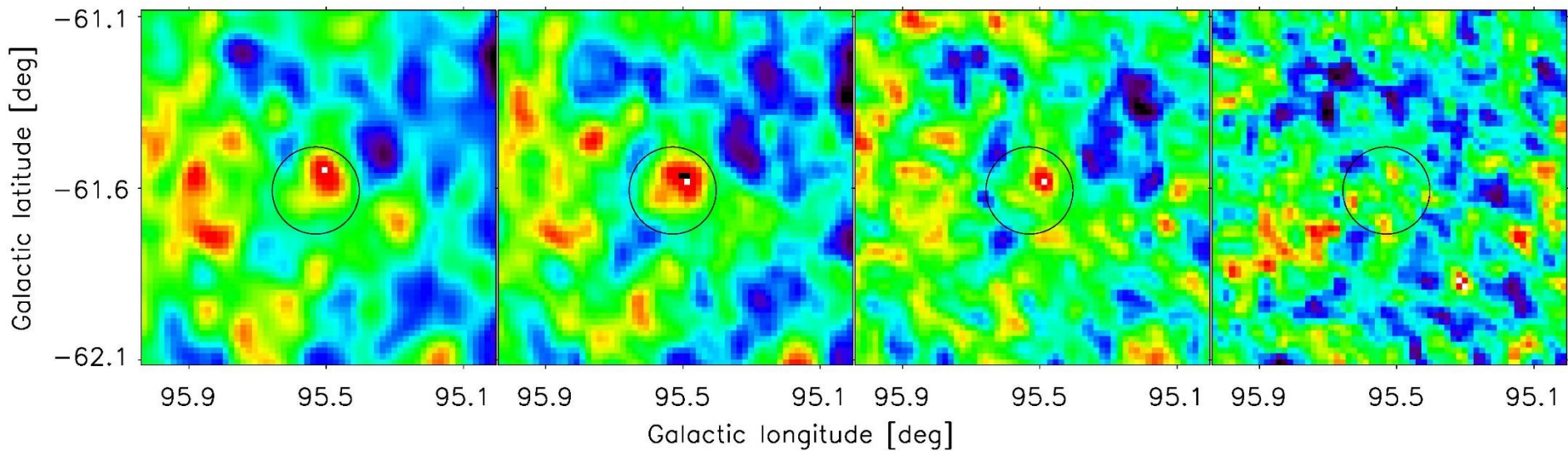
Planck intermediate results. XXVII (2015)

Negrello et al. (2016)

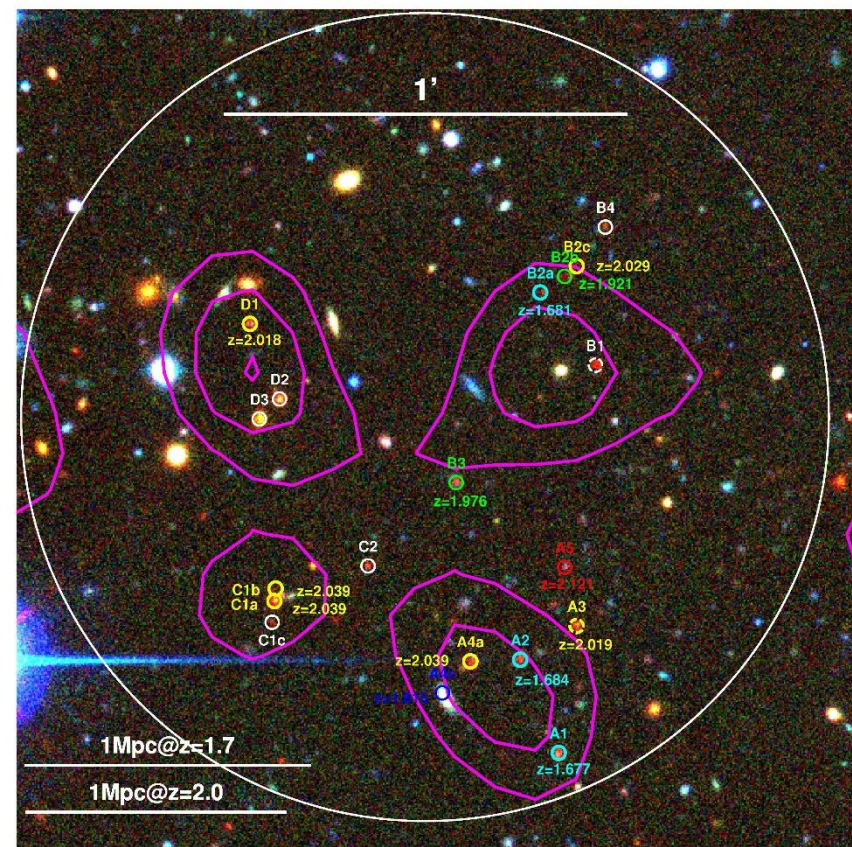
FWHM=5'  
850 $\mu$ m



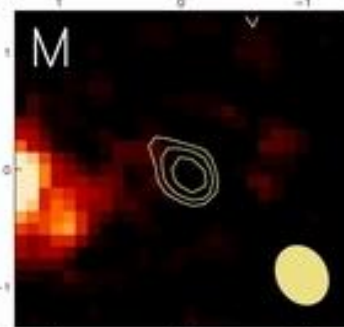
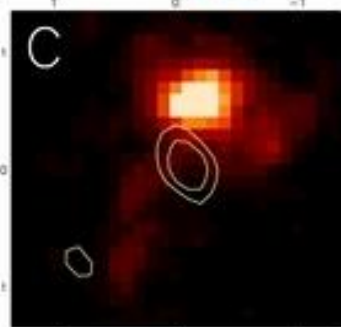
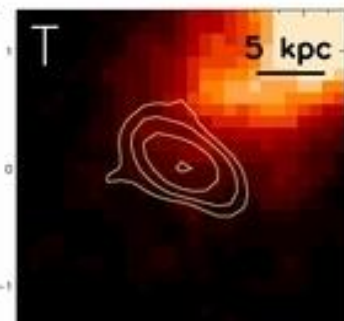
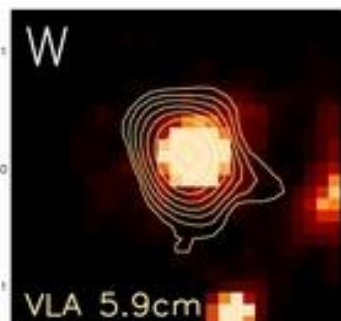
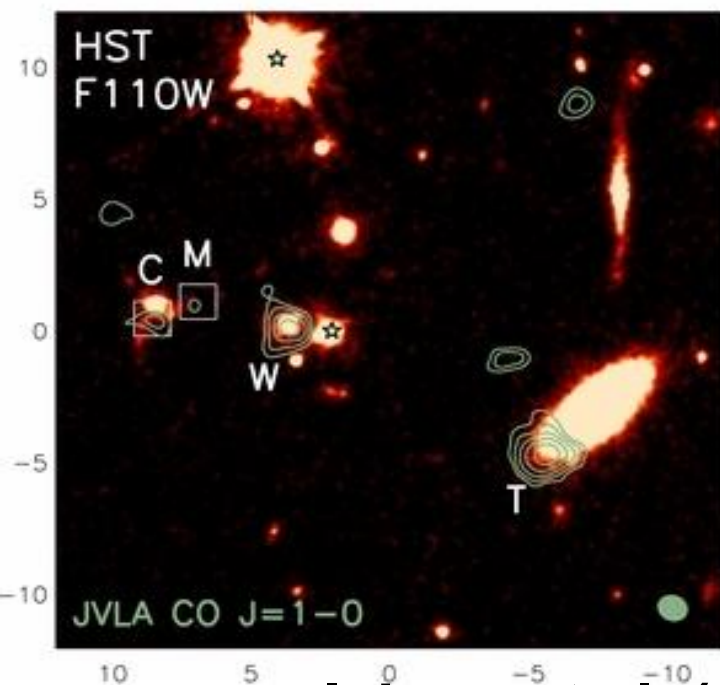
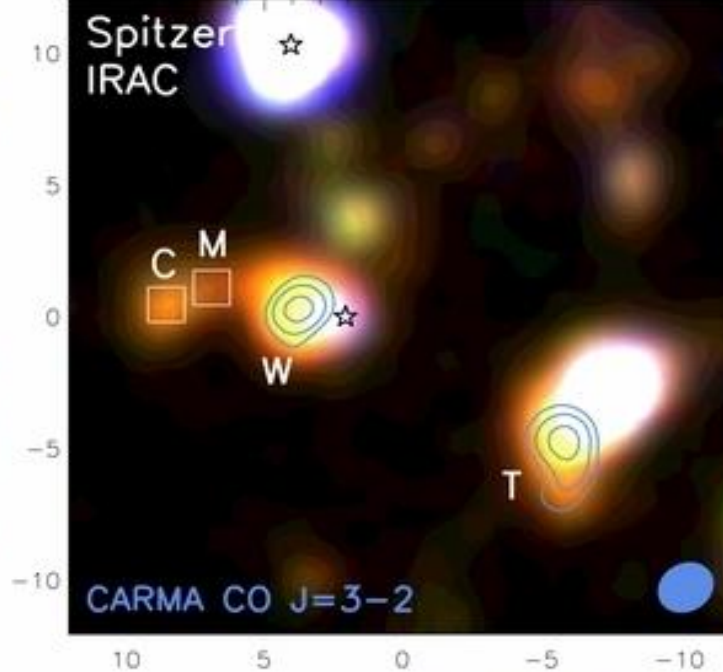
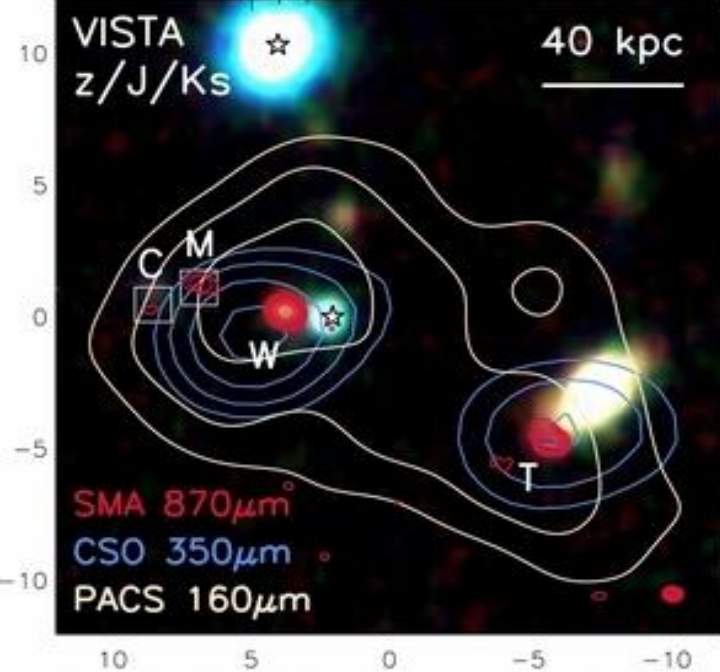




**Multi-frequency follow up of a Planck candidate proto-cluster (Flores-Cacho et al. 2016) has revealed that it is made of two structures at  $z \simeq 1.7$  and at  $z \simeq 2.0$ . Both structures occupy a circular region of comoving radius smaller than 1 Mpc, consistent with being physically bound.**

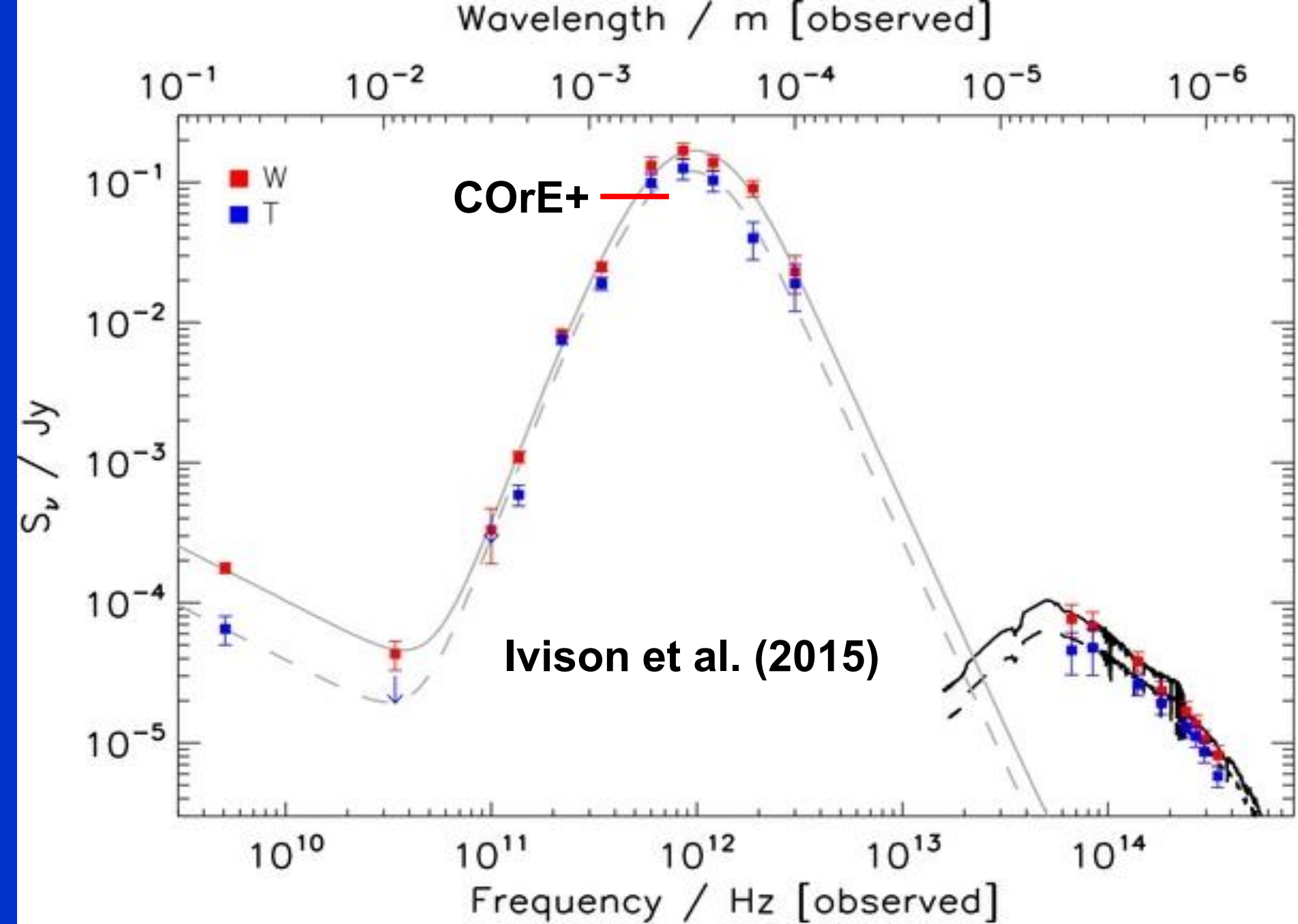


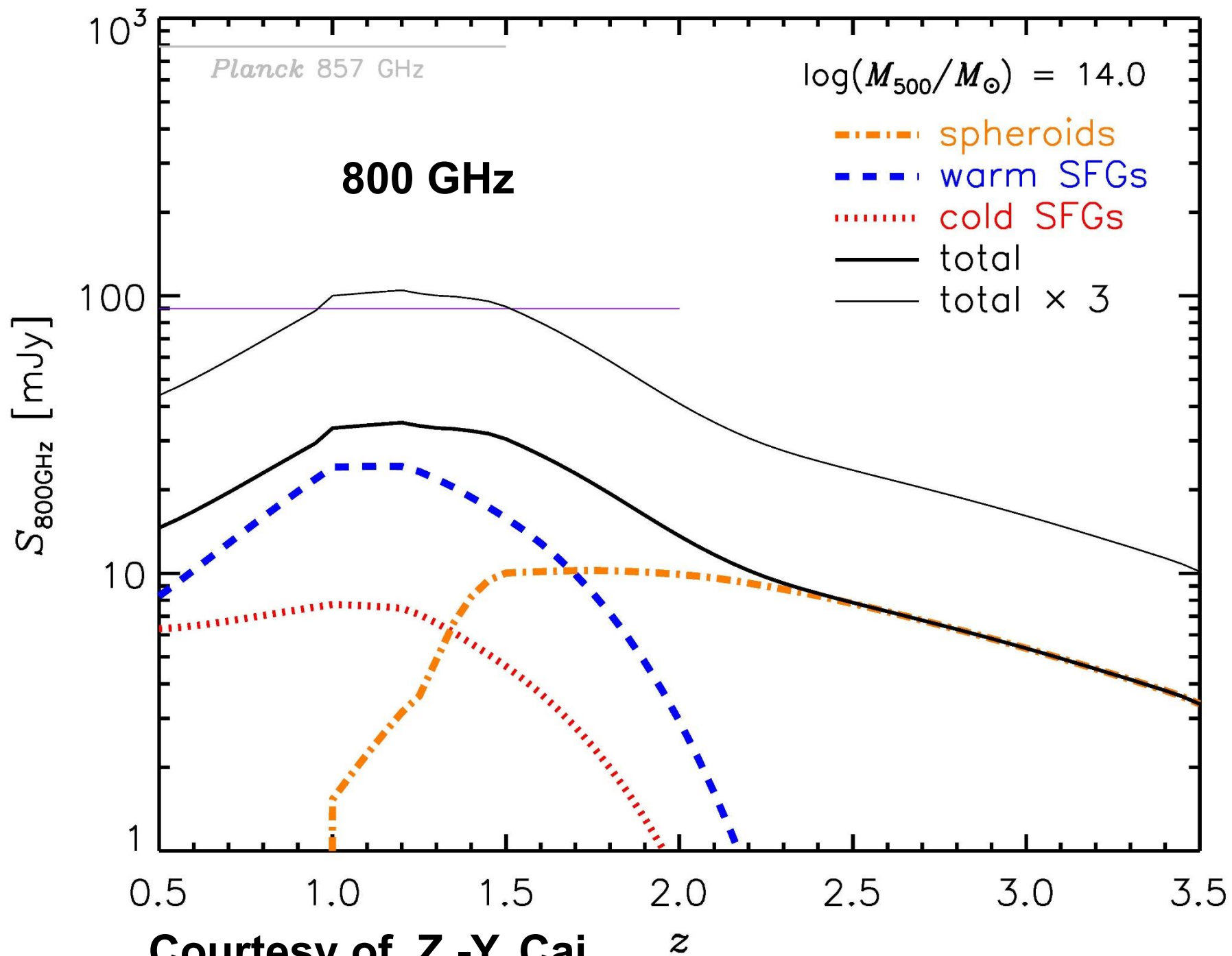


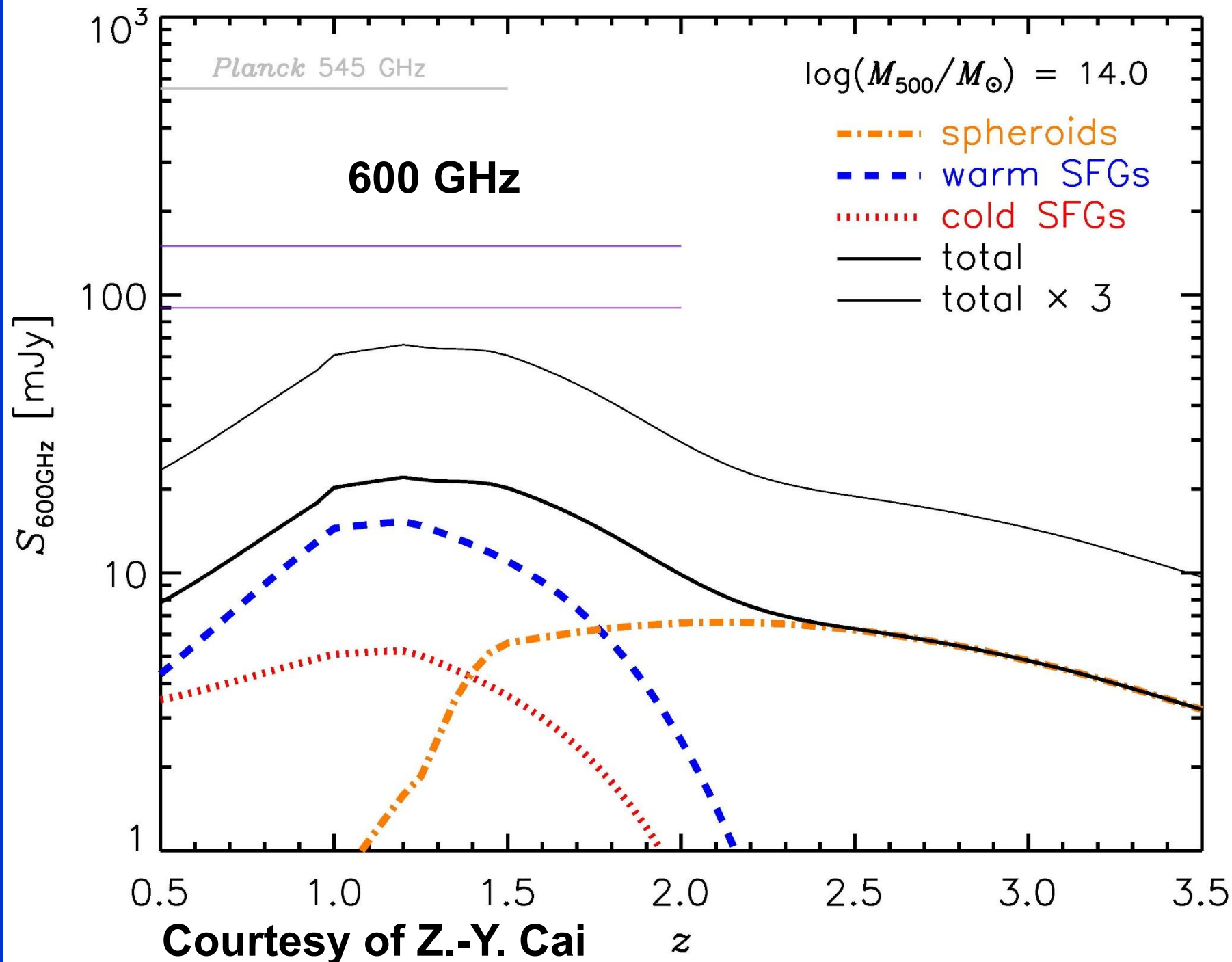


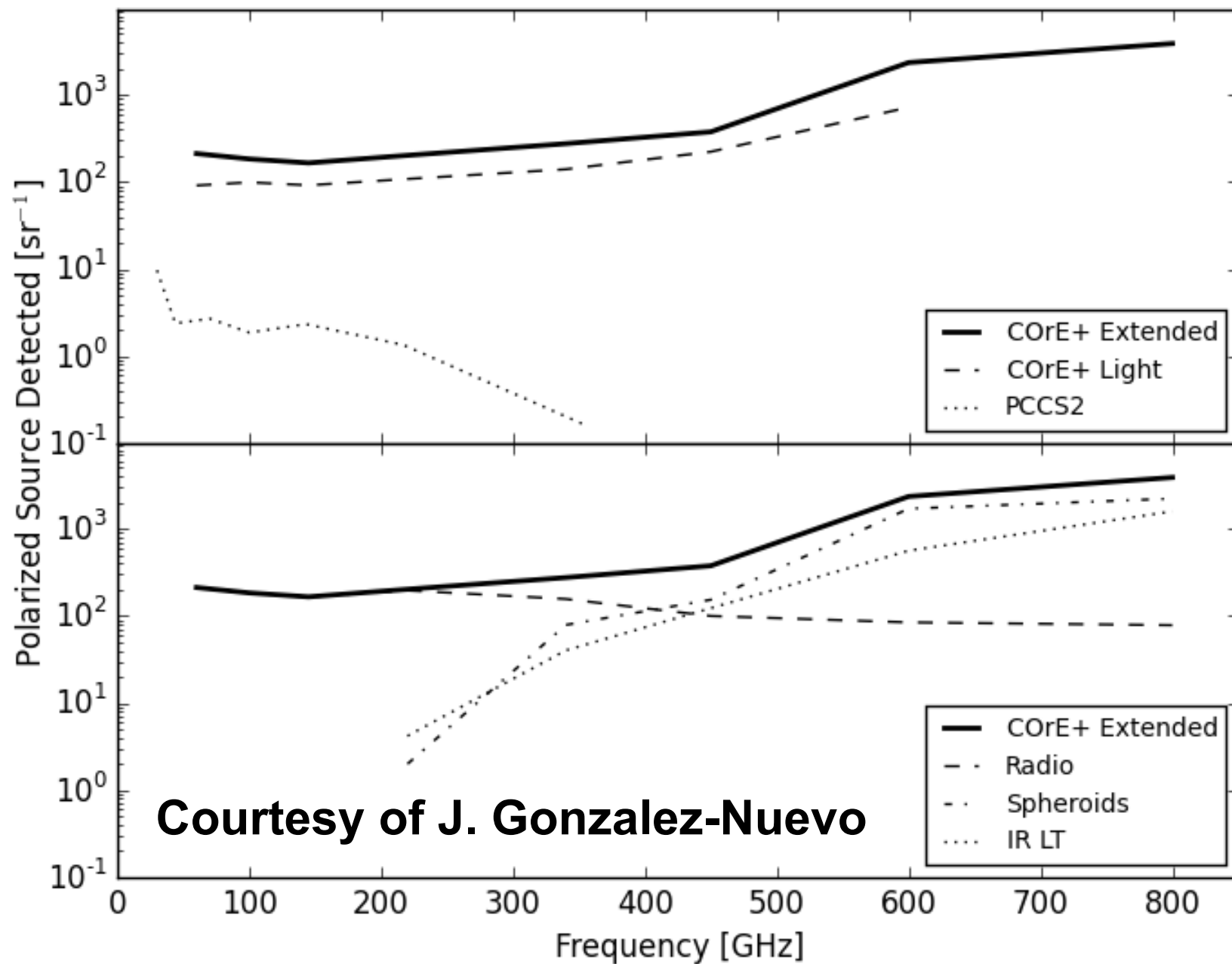
**Proto-  
cluster of  
starbursting  
proto-  
elliptical  
galaxies  
across an  
 $\approx 100$  kpc  
region at  
 $z = 2.41$**

**Ivison et al. (2013)**



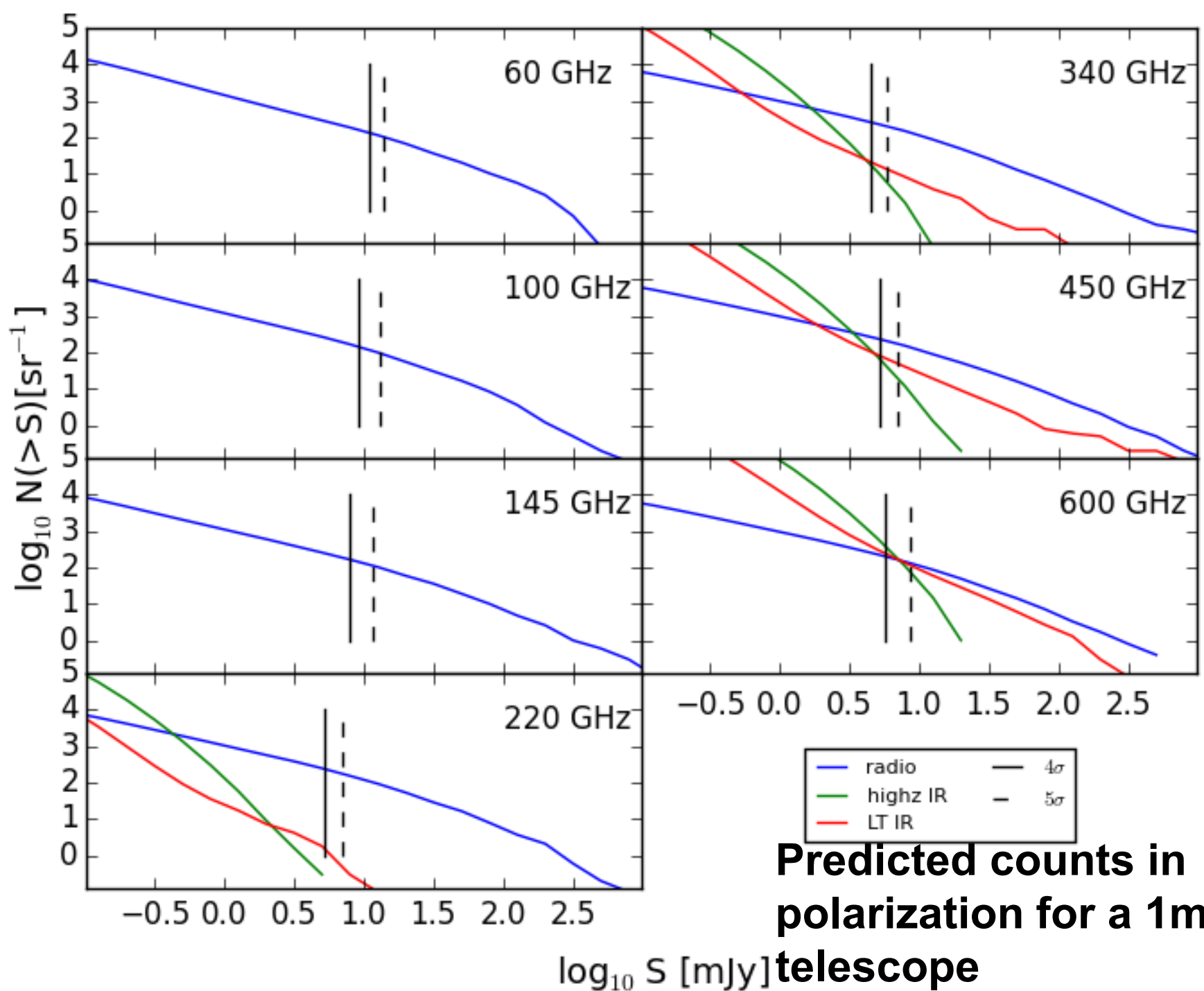






Courtesy of J. Gonzalez-Nuevo





# Conclusions - 1

**As amply demonstrated by Planck, space-borne CMB experiments thanks to their all-sky coverage and broad frequency range hardly or not accessible from the ground, provide unique information of great astrophysical interest on extragalactic sources.**

**Examples are:**

- Population properties and SEDs of blazars and of star-forming galaxies**
- Discovery of extreme strongly lensed galaxies at high- $z$**
- Discovery of candidate proto-clusters of galaxies, caught in the pre-virialization phase, when their member galaxies were forming most of their stars**

## Conclusions - 2

**The substantially better angular resolution of the planned next generation experiment, COrE+, even with the same telescope size as Planck, will boost by large factors the number of detections.**

**But it will also make possible entirely new science such as:**

- The direct detection of large proto-cluster samples**
- The study of the evolution of the star-formation in virialized groups and cluster of galaxies**
- The study of the polarization properties of large samples of radio sources and of dusty galaxies at mm and sub-mm wavelengths**