The CIB is explained by known galaxies (and their companions) at z < 4

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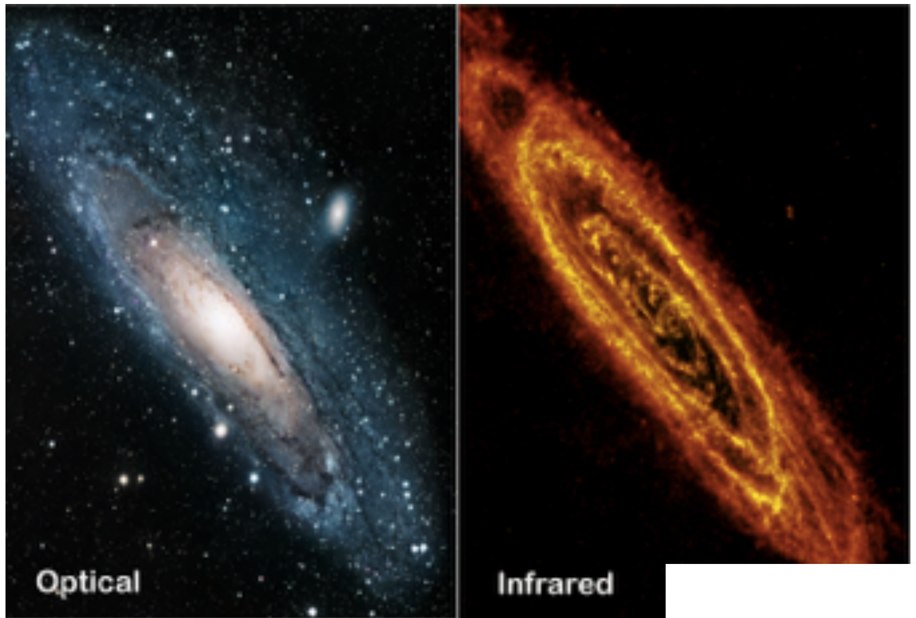
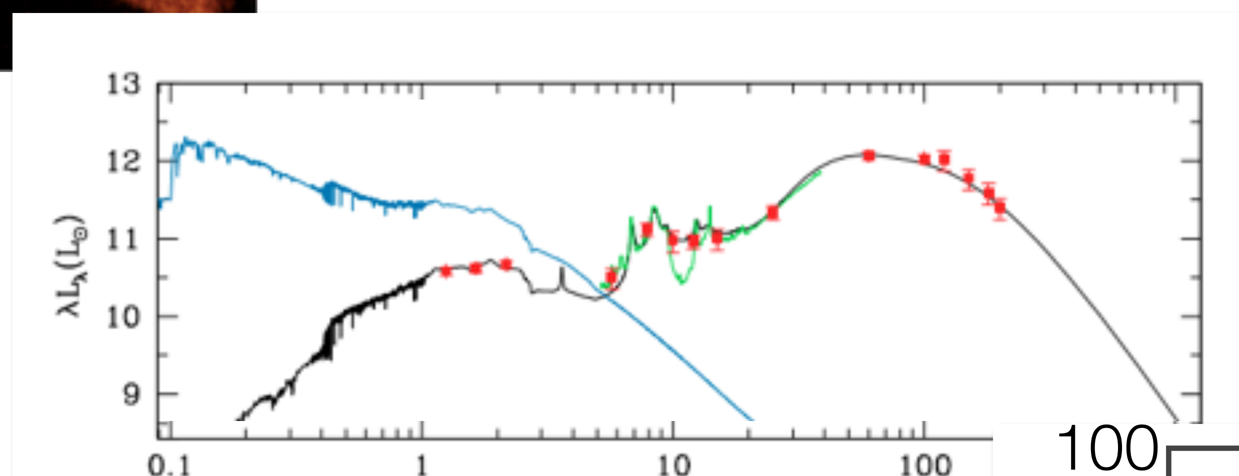
w/
Lorenzo Moncelsi (Caltech), Ryan Quadri (Texas A&M),
and the HerMES Collaboration

Motivation

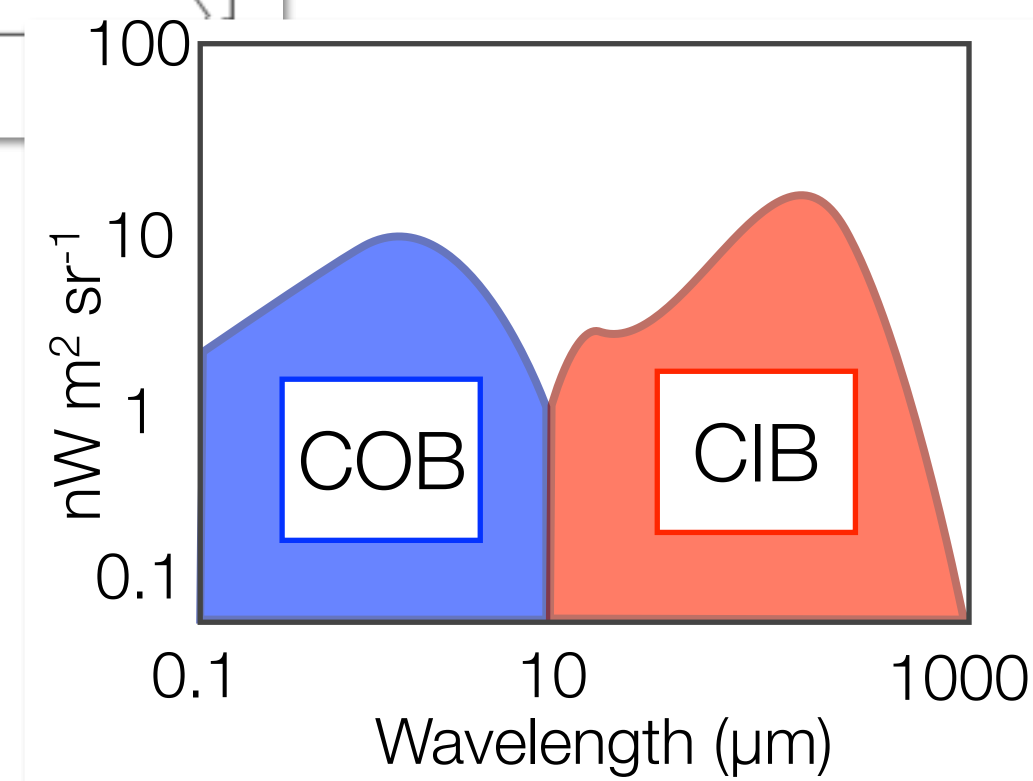


- Infrared/Submillimeter emission reprocessed starlight by dust
- IR/Submm traces star formation
- Half the emission is tied up in dust

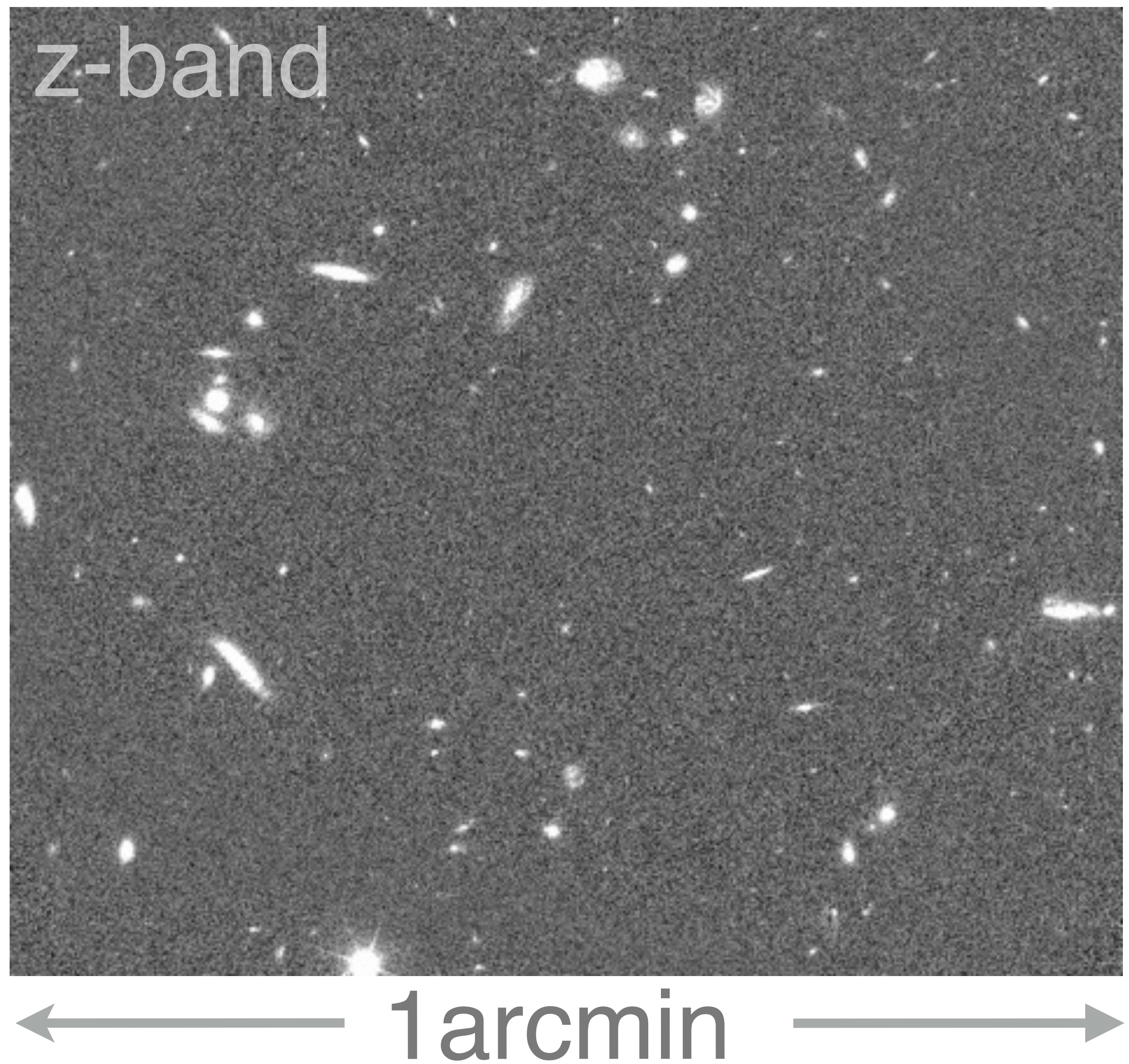


da Cunha+2010

- How do we reconcile COB and CIB?
- Want to know:
  - ➡which galaxies make up CIB?
  - ➡how much of the CIB is accounted for?
  - ➡what limits does this place on models?

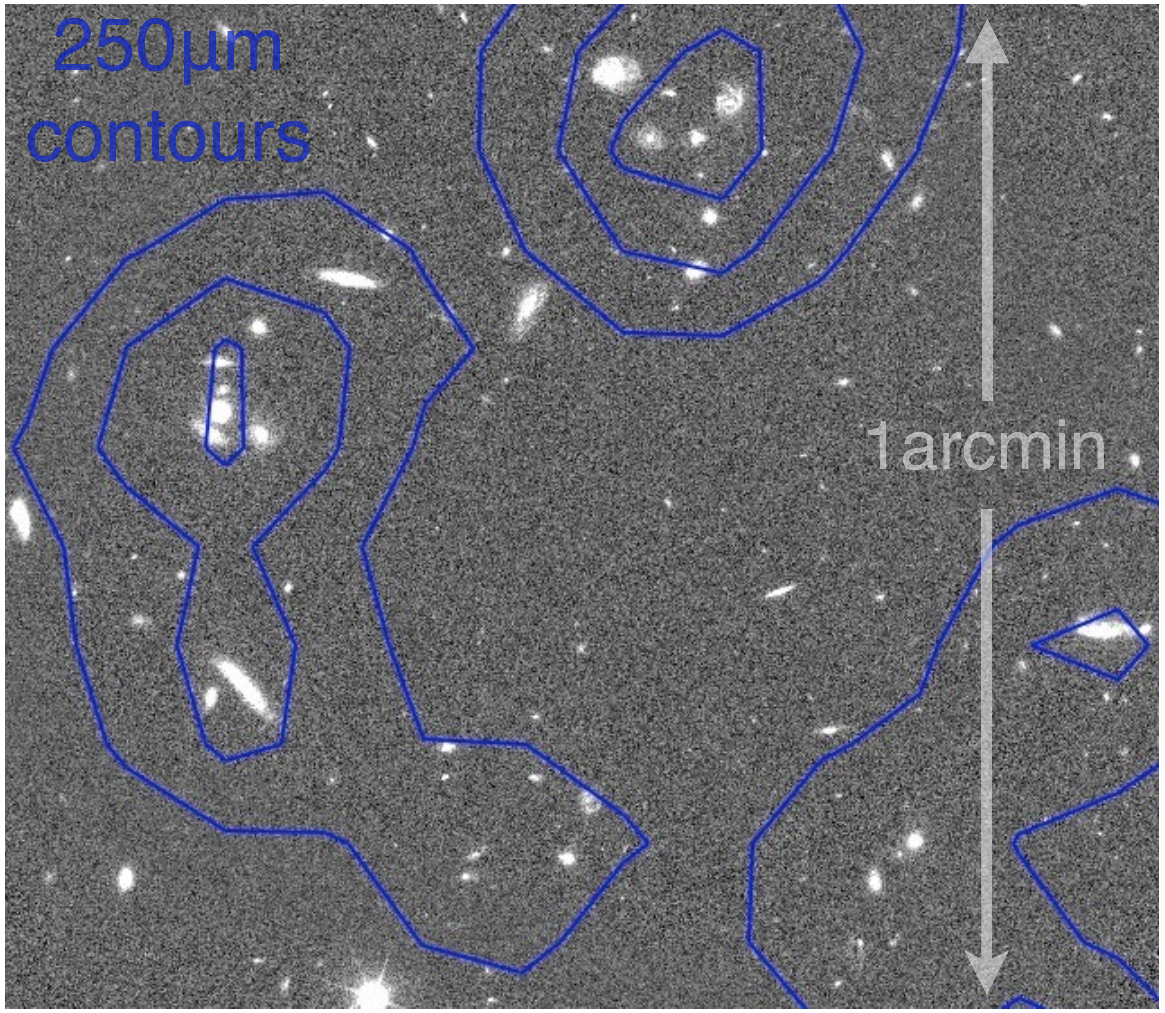


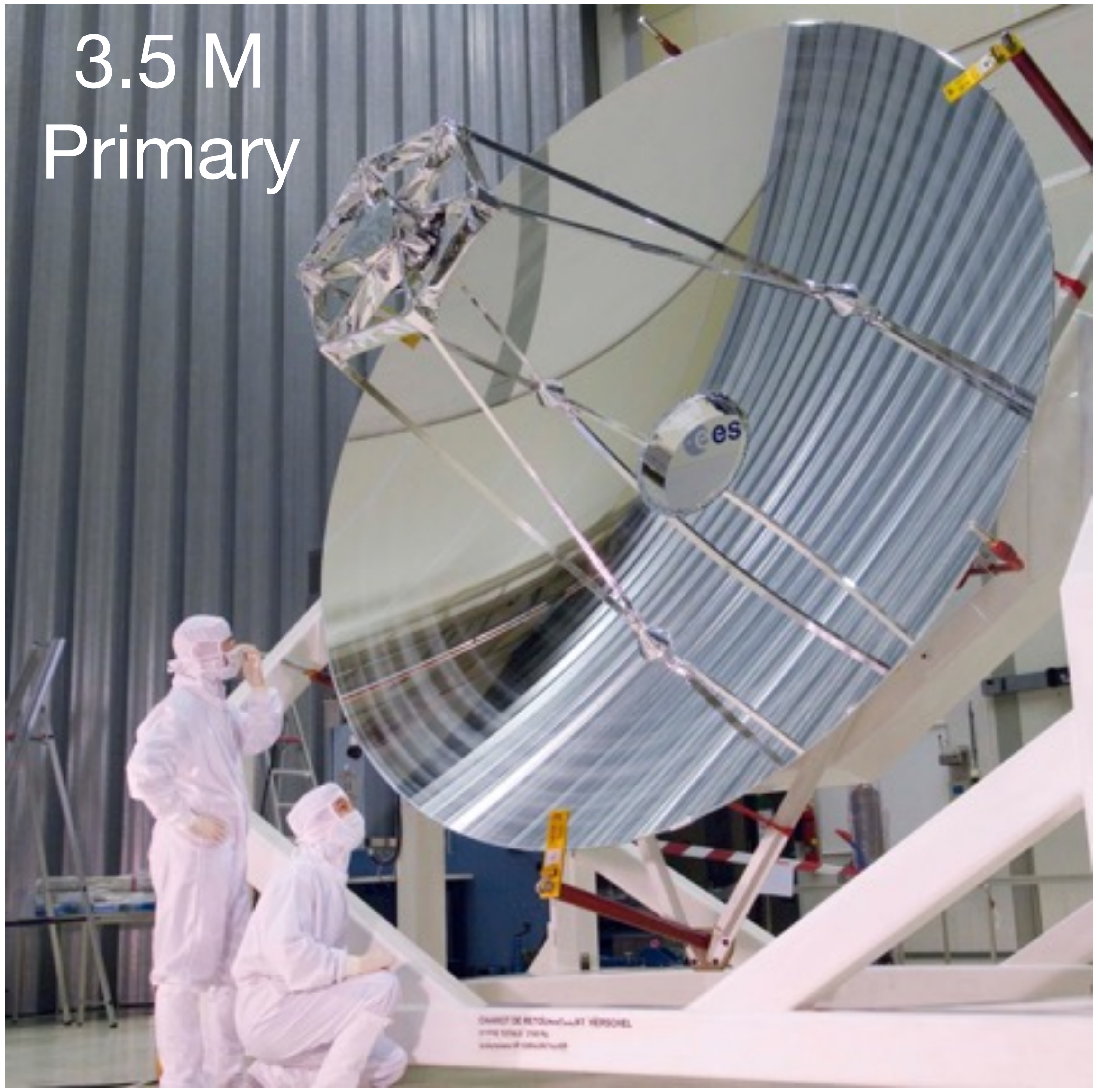
Optical v. Infrared Background



Herschel/SPIRE

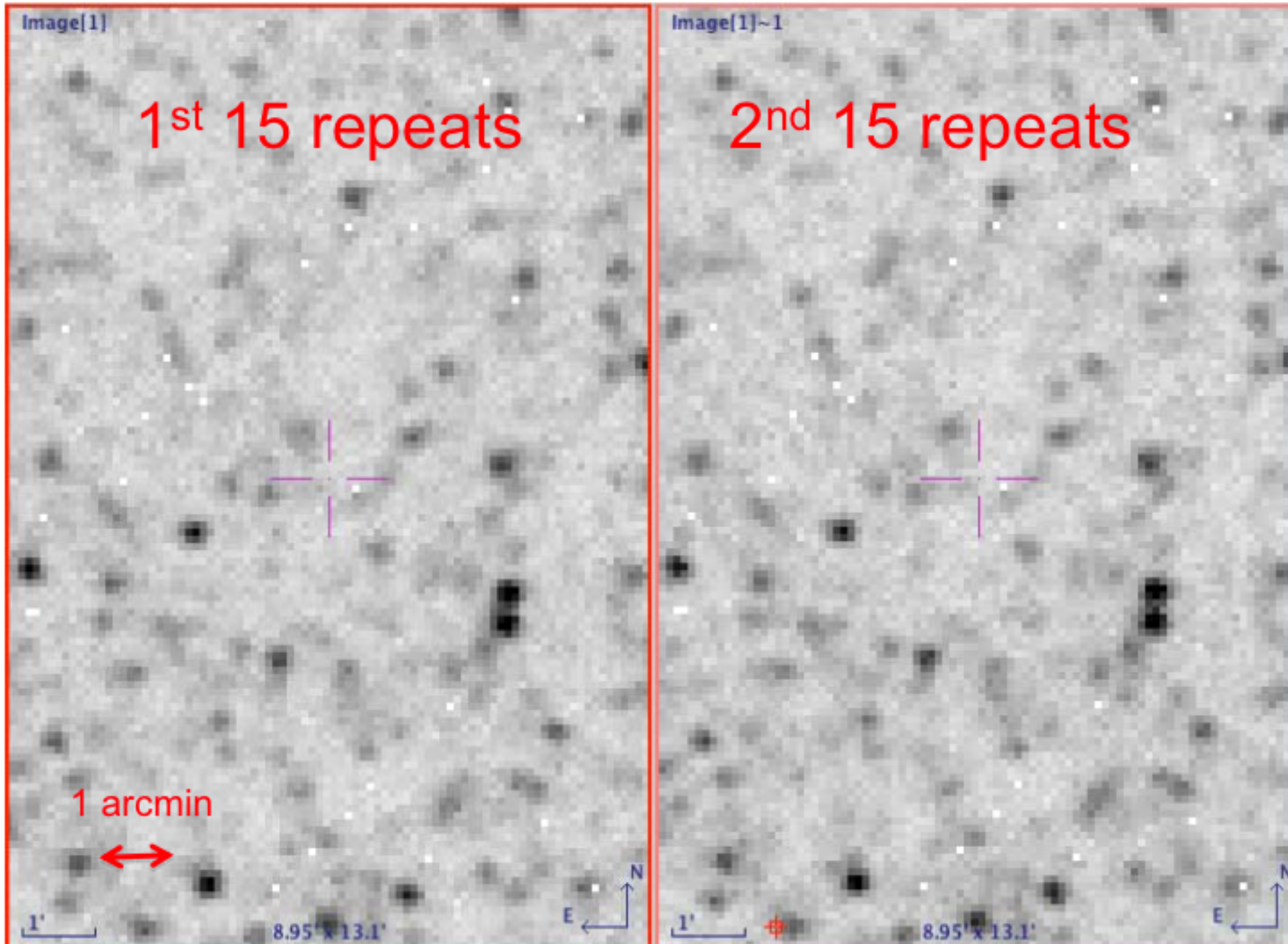
Band	PSF size (FWHM)	Confusion Limit (5σ)
250 μm:	16”	24.0 mJy
350 μm:	25”	27.5 mJy
500 μm:	36”	30.5 mJy





- < 1% of sources resolved at 5σ due to source confusion
- Strength is surveys, with ~1000 deg^2 observed

- Every fluctuation in a deep map is real signal
- Take advantage by modeling based on fitting to the intensities



Near-Infrared Selected Sources at z~1.5

Take advantage of statistics

Split catalog up into groups that are alike, e.g.:

➡**Stellar Mass —** L_{IR} is proportional to SM's (i.e., star-forming main sequence).

➡**Star-Forming / Quiescent —** have vastly different SSFR.

➡**More —** dust/gas mass, SMGs, AGN, UV slope, etc.

SIMSTACK: Measurement Data

Catalogs

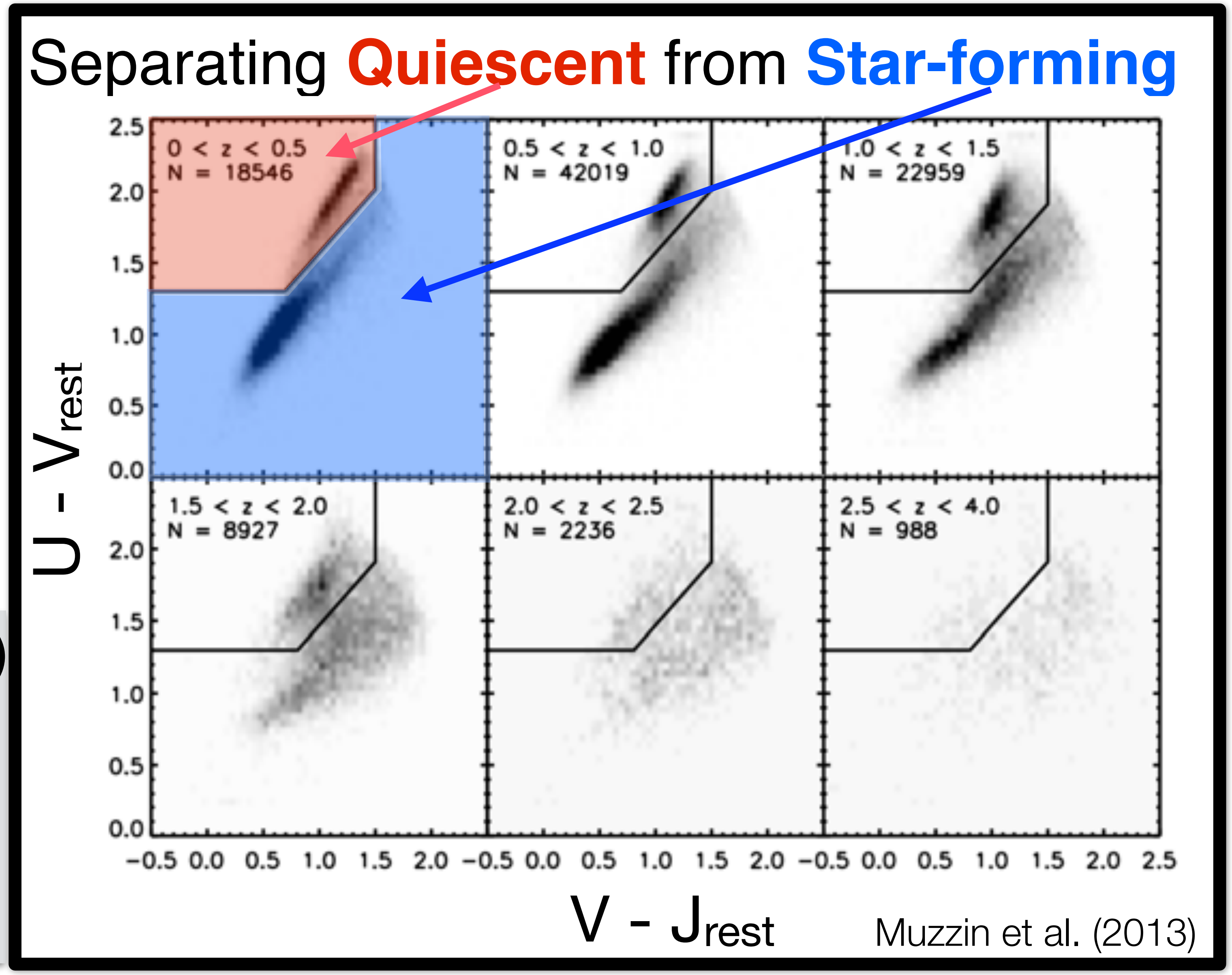
- UKIDSS/UDS [2/3 deg^2] / COSMOS [1.6 deg^2]

  uBVRizJHK + IRAC ch1234

  K-band cut 23.4 / 24 AB

  80,000 / 120,000 sources

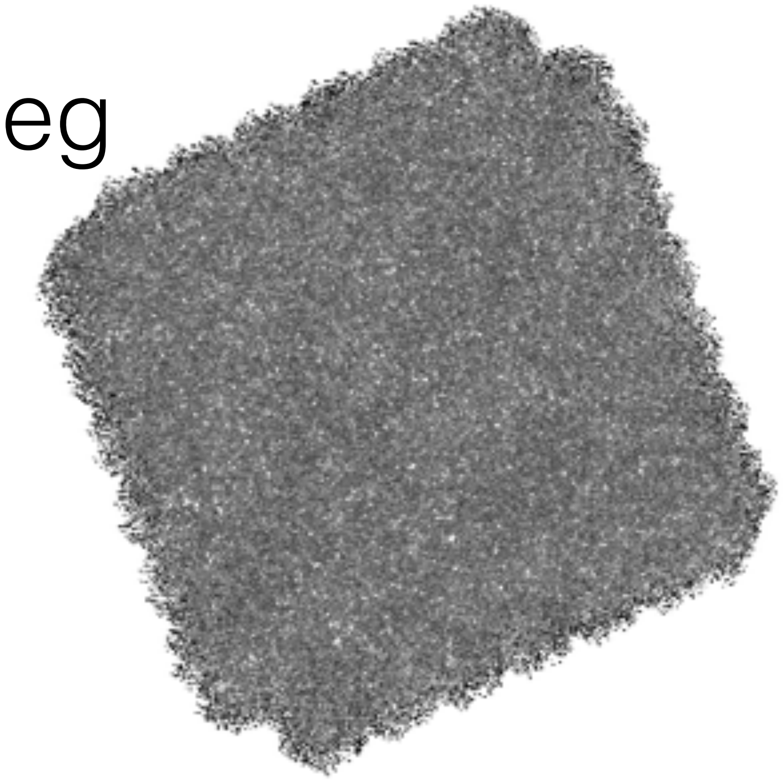
- **Redshifts** - EAZY (Brammer 2008)
- **Masses** - FAST (Kriek 2009)
- **Colors** - UVJ (Williams 2009)

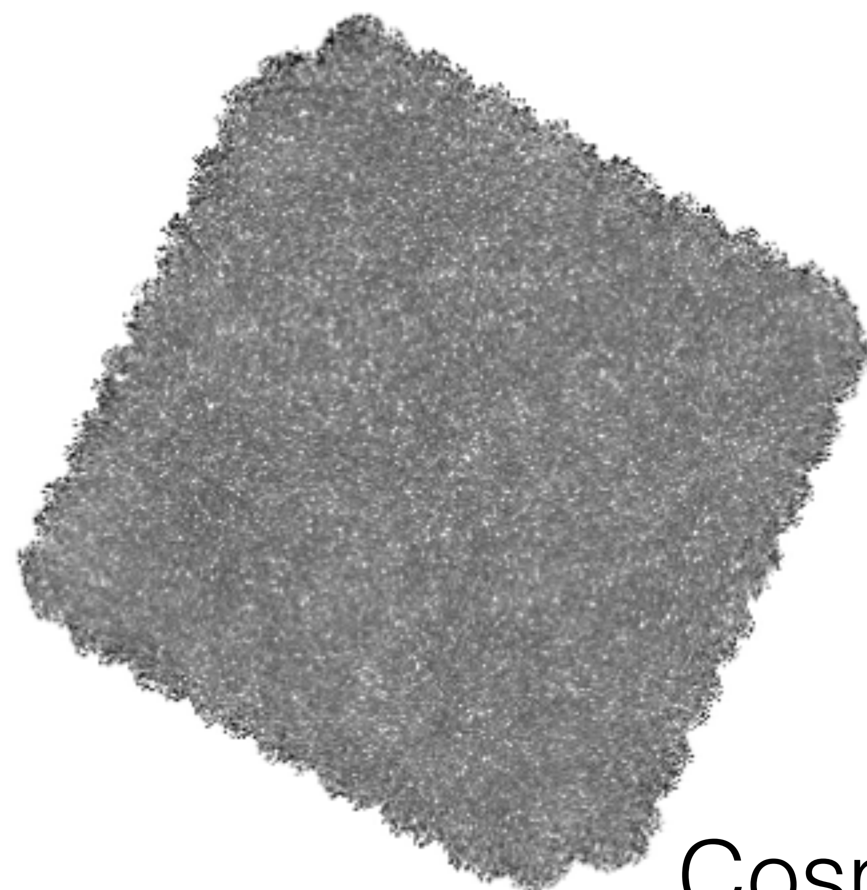


Maps

- *Spitzer*/MIPS
  - 24, 70μm
- *Herschel*/PACS
  - 100, 160μm
- *Herschel*/SPIRE
  - 250, 350, 500μm
- ASTE/AzTEC
  - 1100μm

UDS - 1.4 x 1.4 deg





Cosmos - 1.8 x 1.8 deg

Simplest Intensity Fitting

RA	DEC
149.853	2.608
149.854	2.258
149.752	2.584
149.832	2.724
149.275	2.196
149.262	2.966
149.915	2.206
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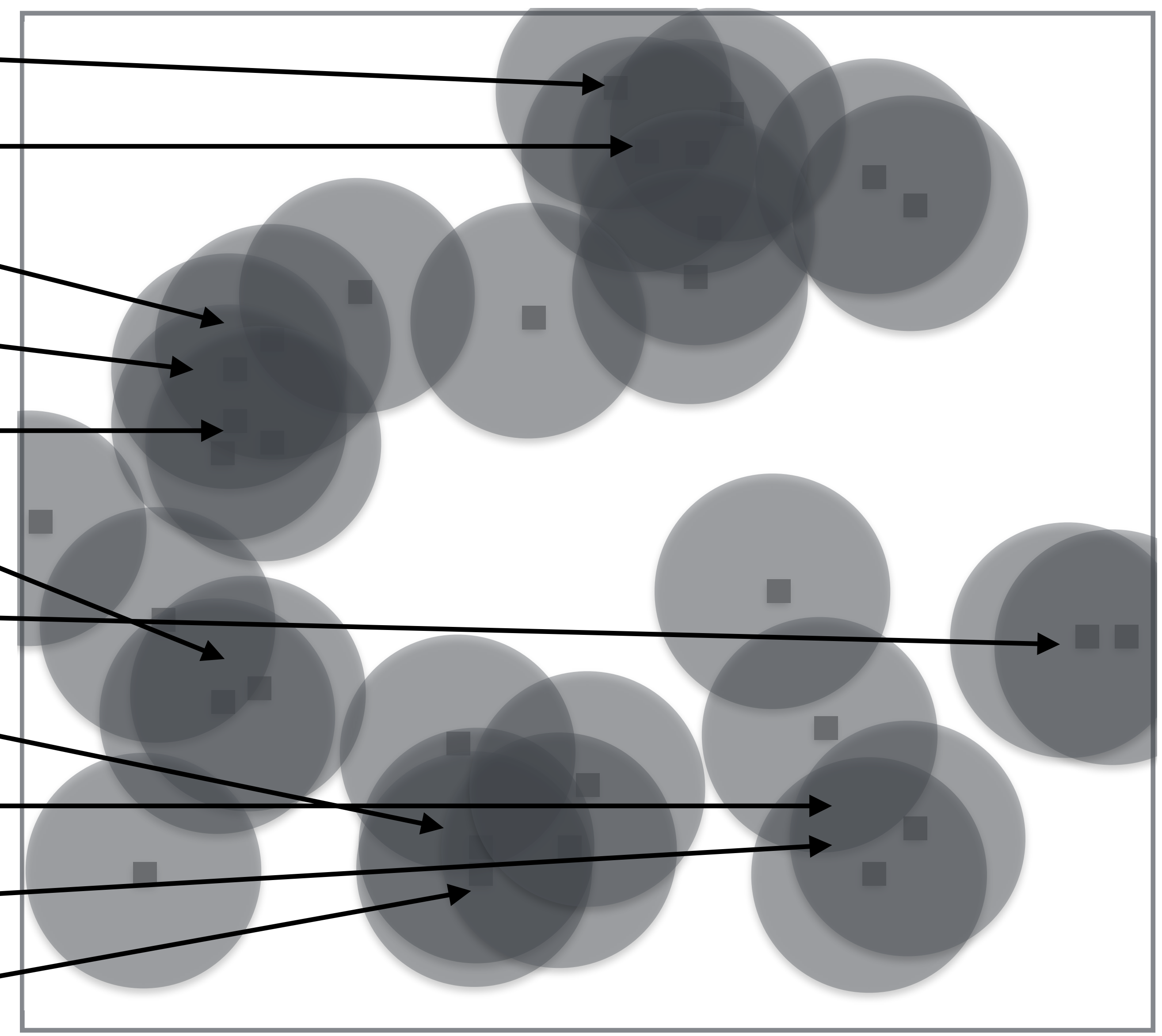
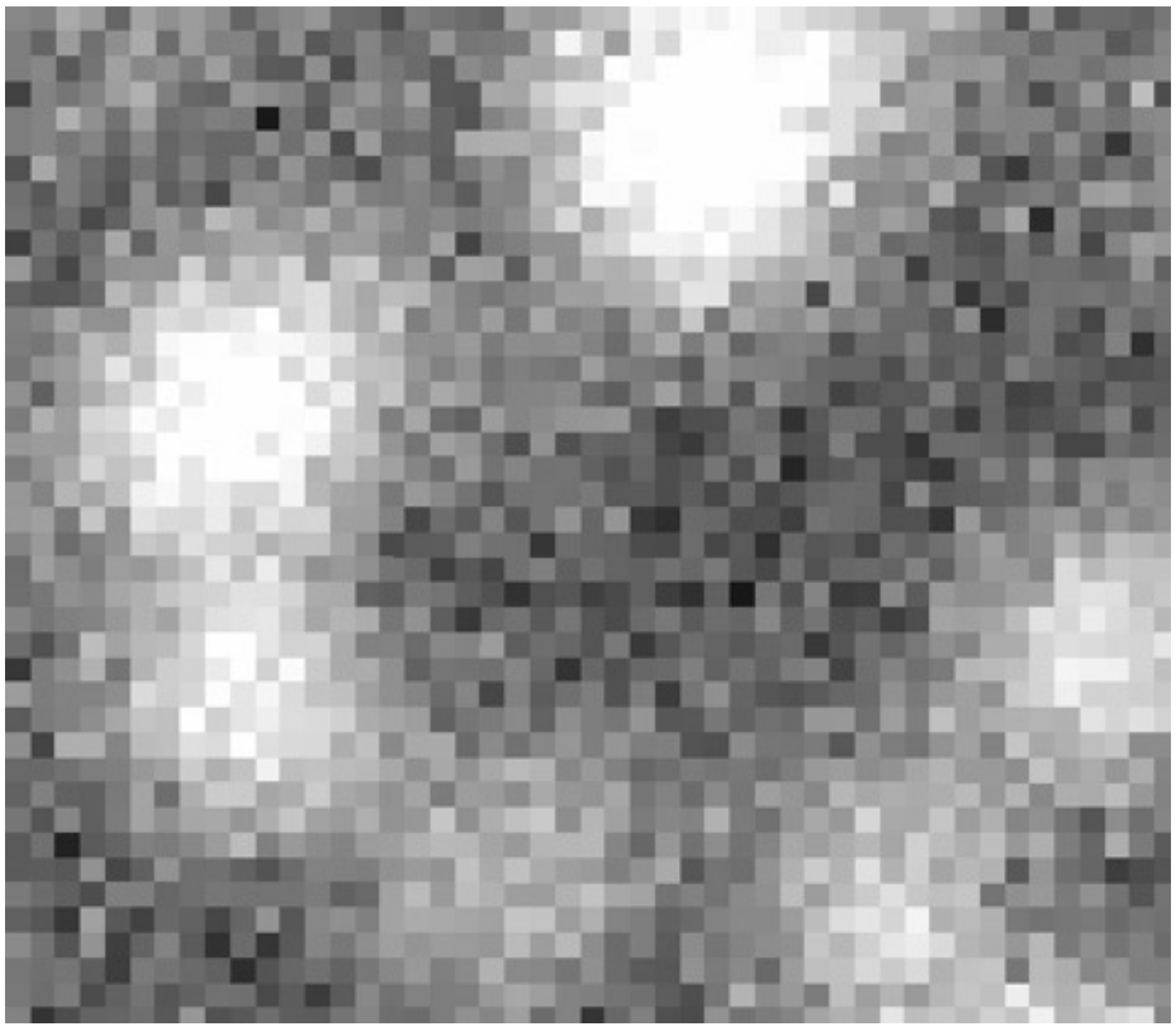
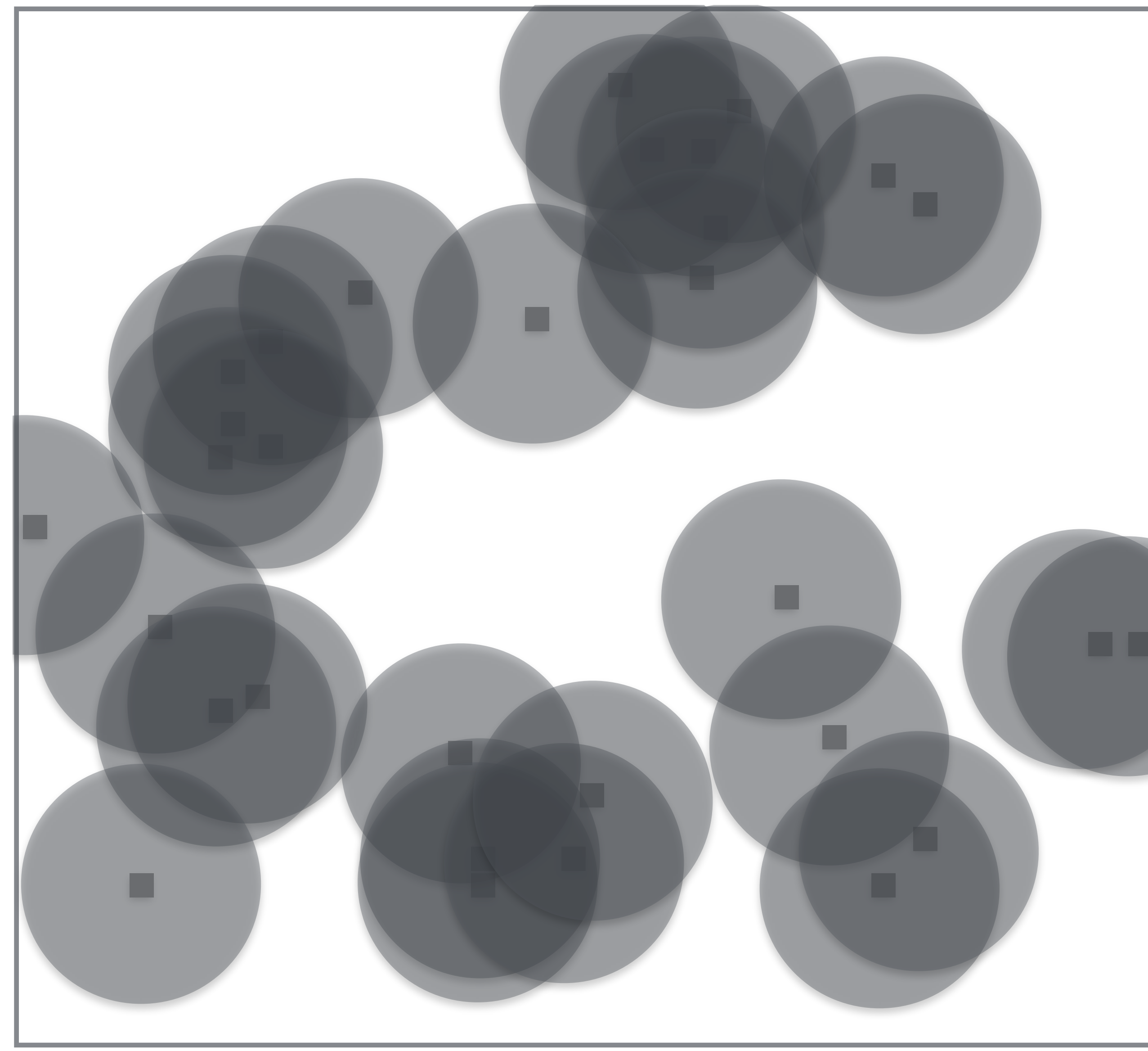
149.453	2.278
149.863	2.788
…	…

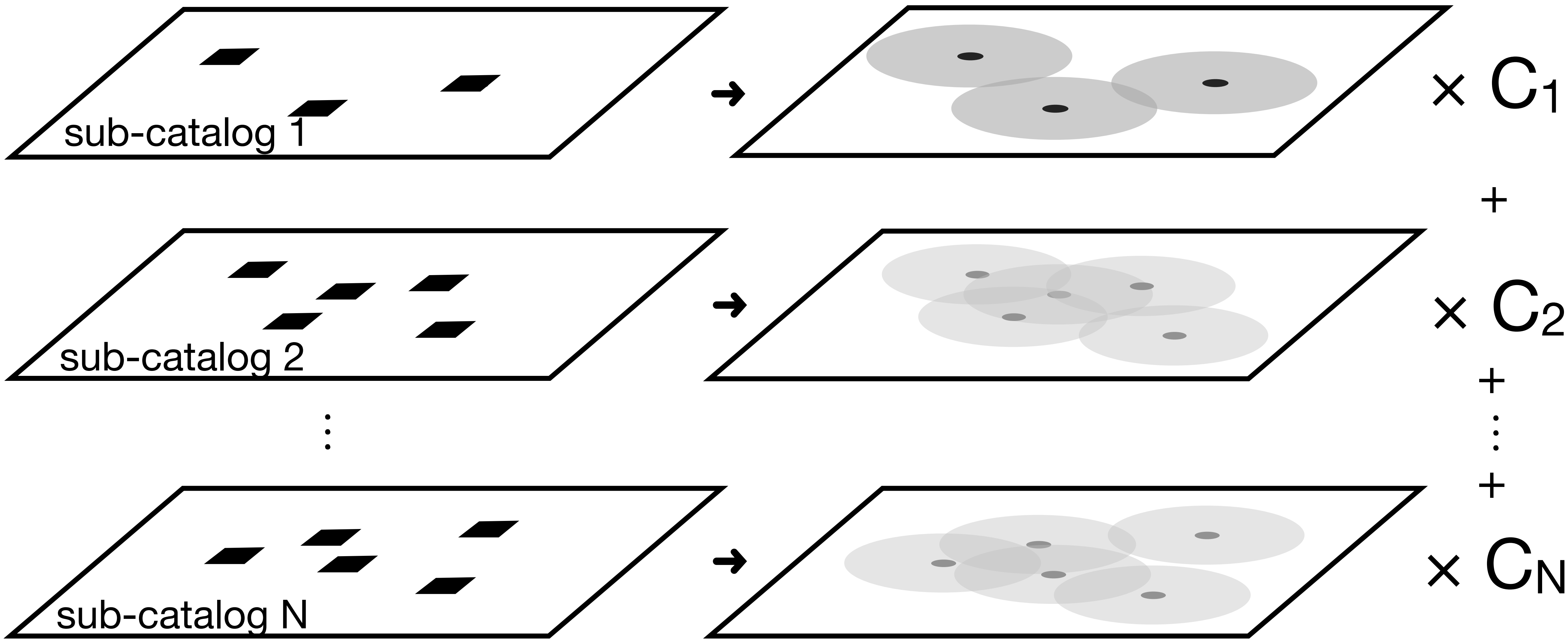


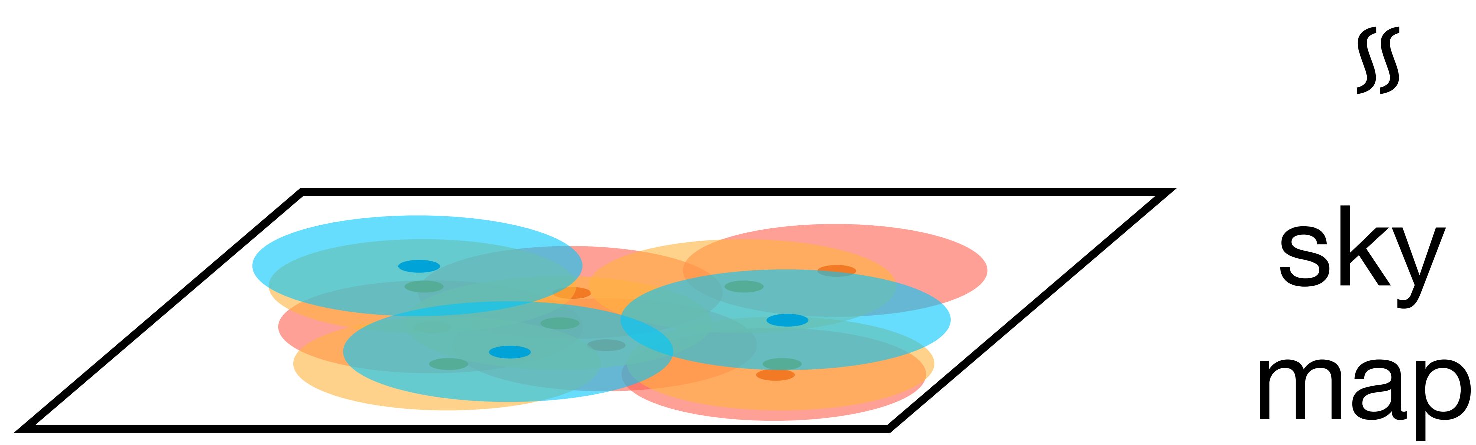
Simplest Intensity Fitting





SIMSTACK: Synthetic Image Fitting Algorithm

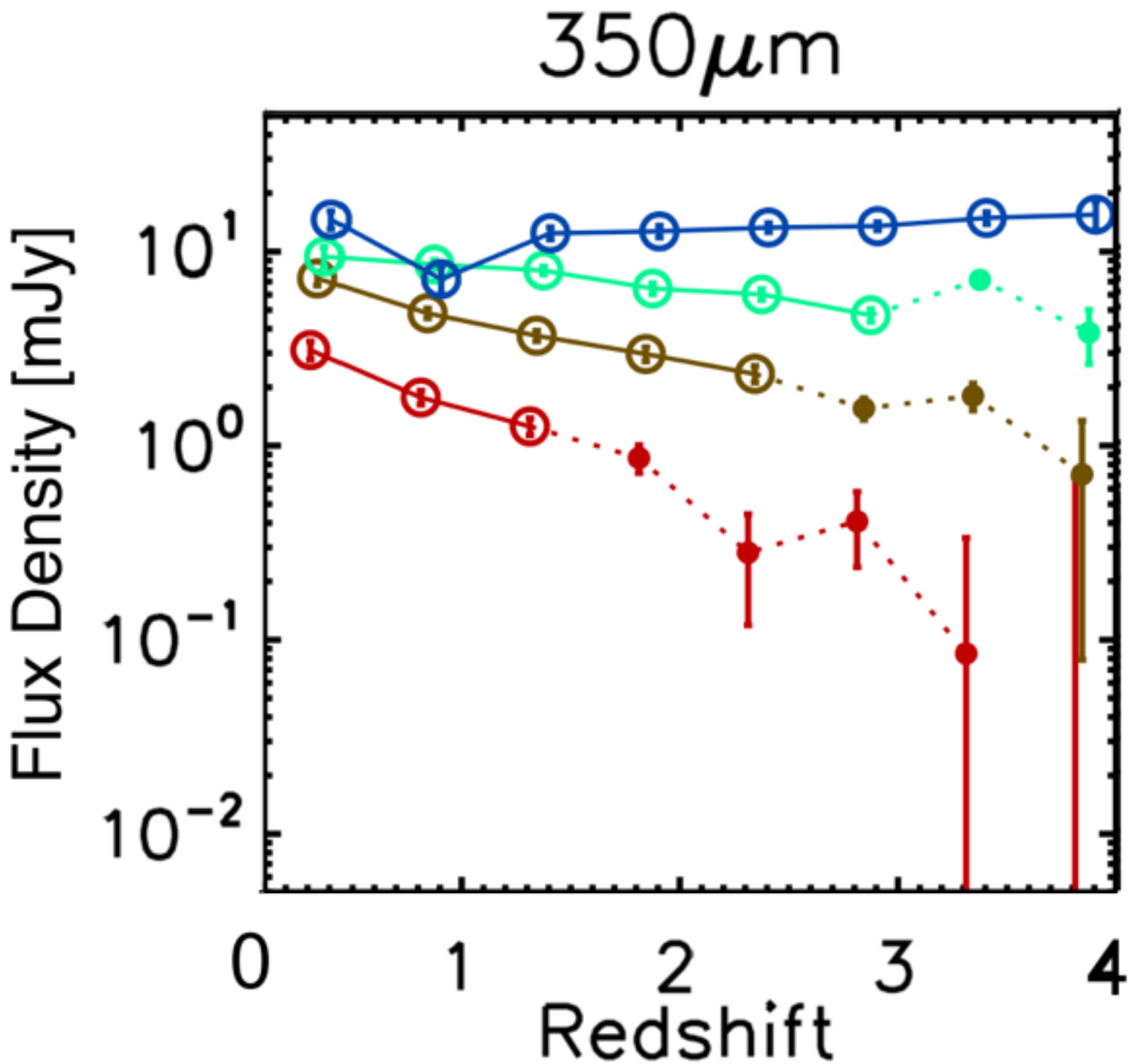




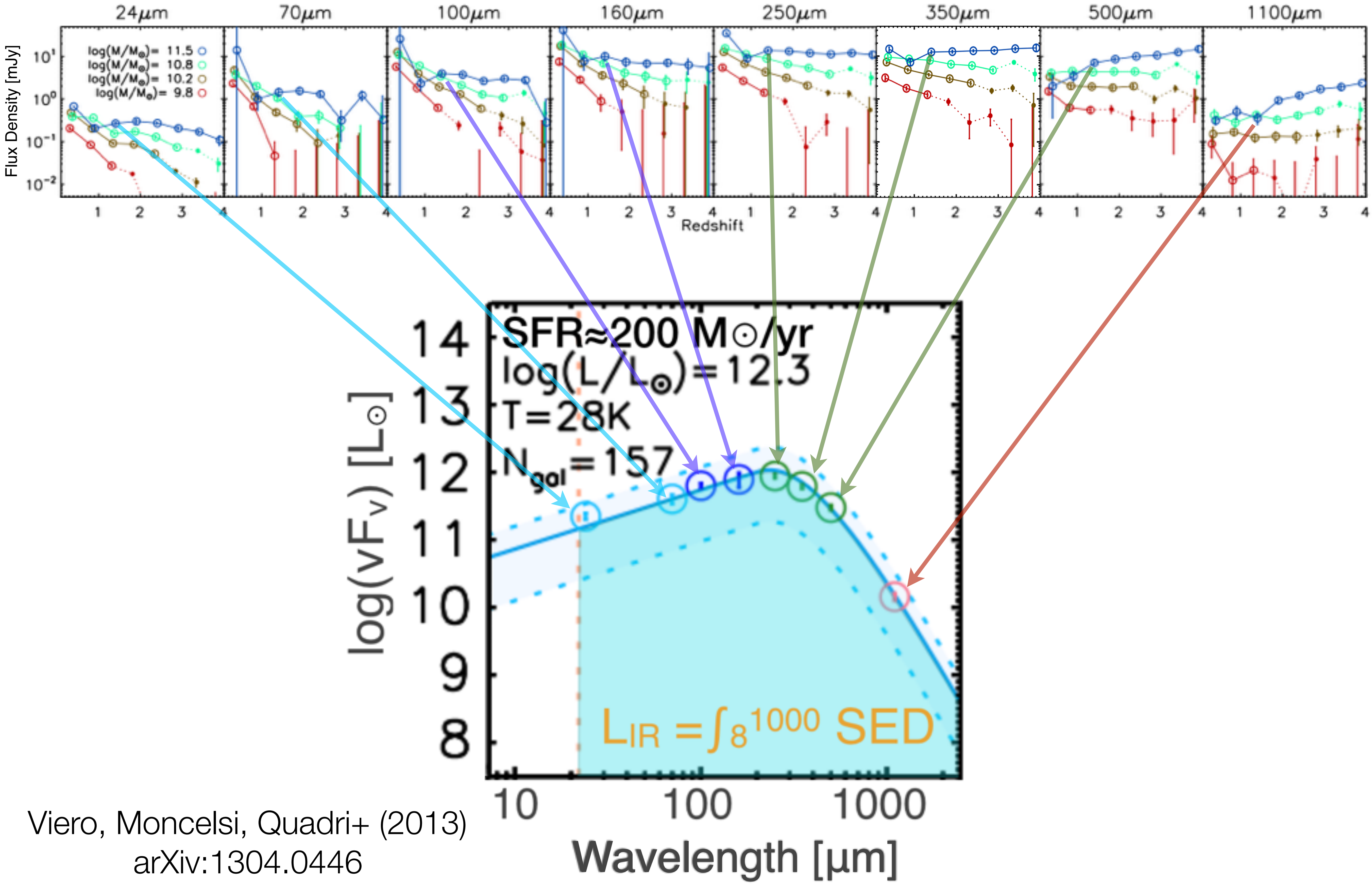
Formalism developed w/ Lorenzo Moncelsi (Caltech)

SIMSTACK code publicly available
see arXiv:1304.0446

SIMSTACK: Flux Densities (M,z)



SIMSTACK: Flux Densities (M,z)

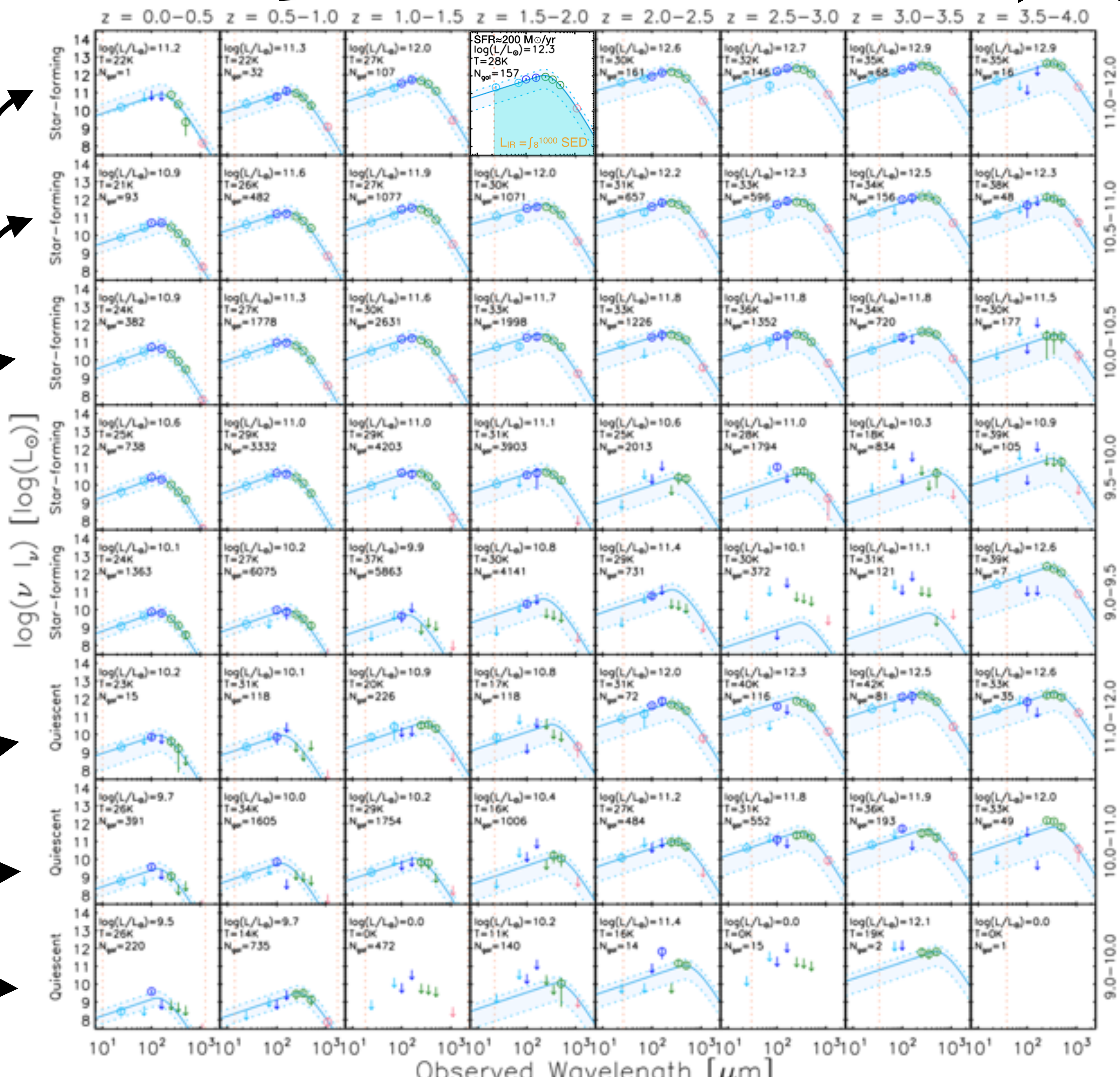


Viero, Moncelsi, Quadri+ (2013)
arXiv:1304.0446

SIMSTACK: SEDs

redshift slices

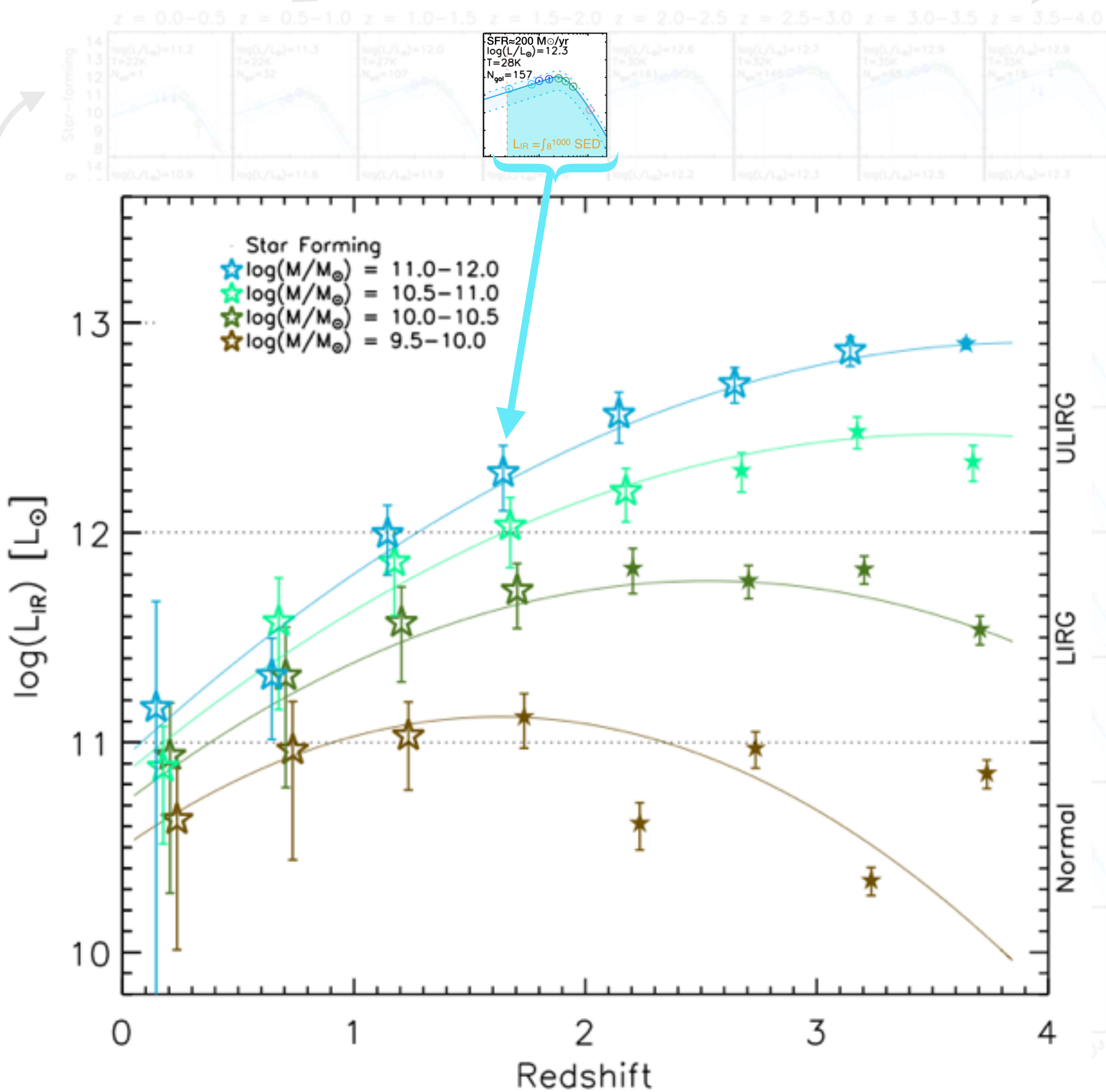
stellar mass slices



SIMSTACK: $L_{IR}(M,z)$

redshift slices

stellar mass slices



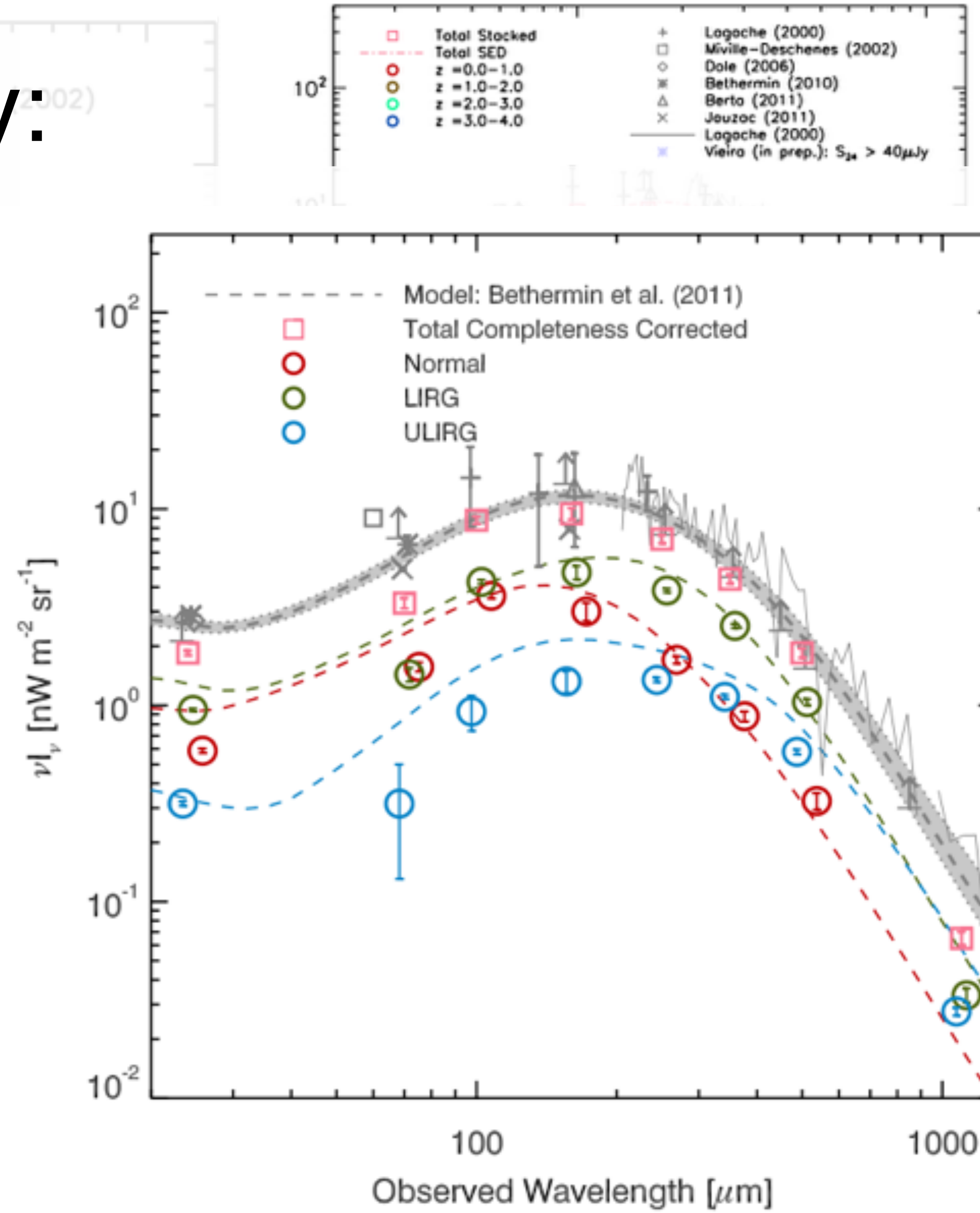
CIB Breakdown

Split Sample by:

ULIRGS

LIRGS

Normal



Viero, Moncelsi, Quadri et al. (2013)
arXiv:1304.0446

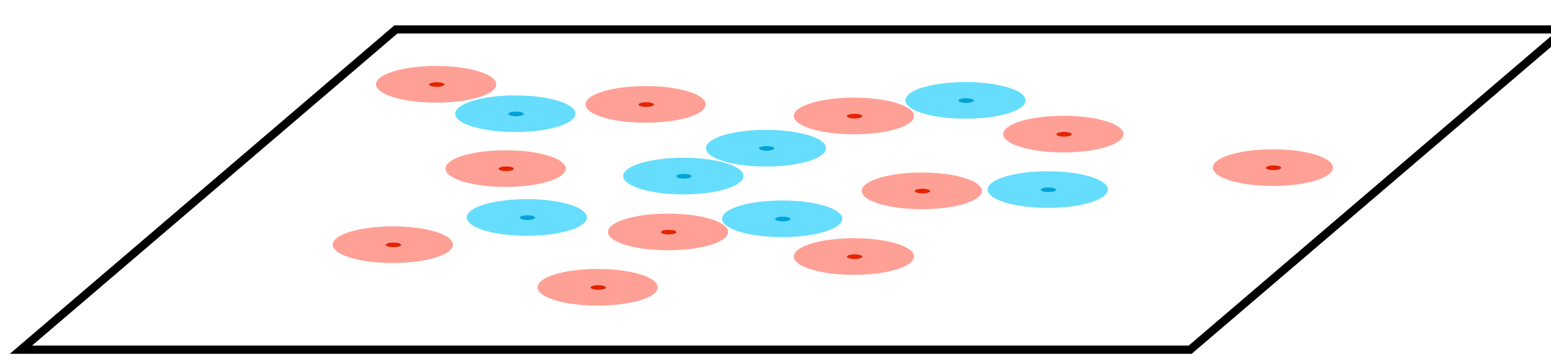
What about the rest?

A New Accounting of the CIB

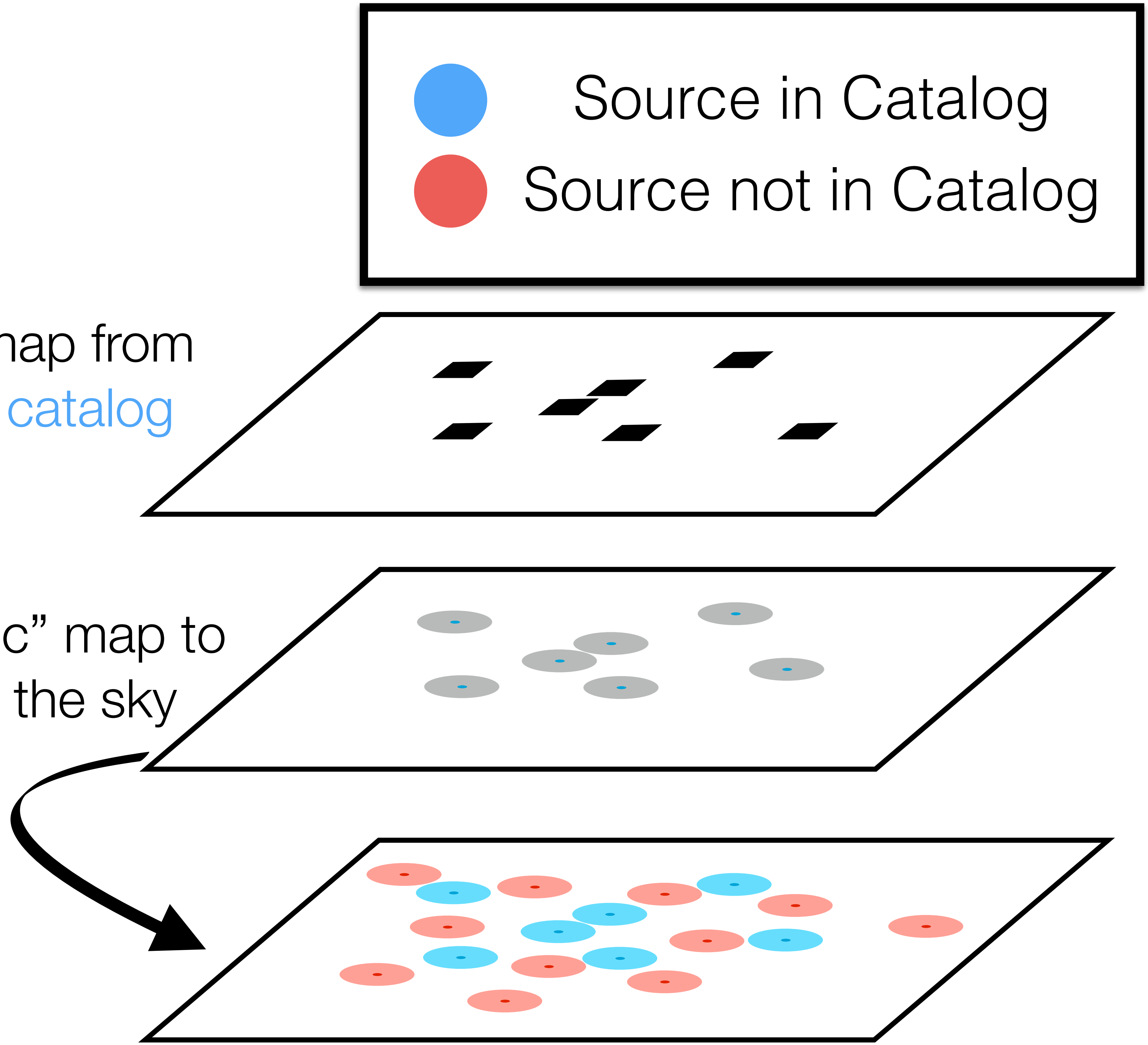
Source in Catalog

Source not in Catalog

Imagine this is a SKY MAP



A New Accounting of the CIB



make synthetic "hits" map from positions of sources in catalog

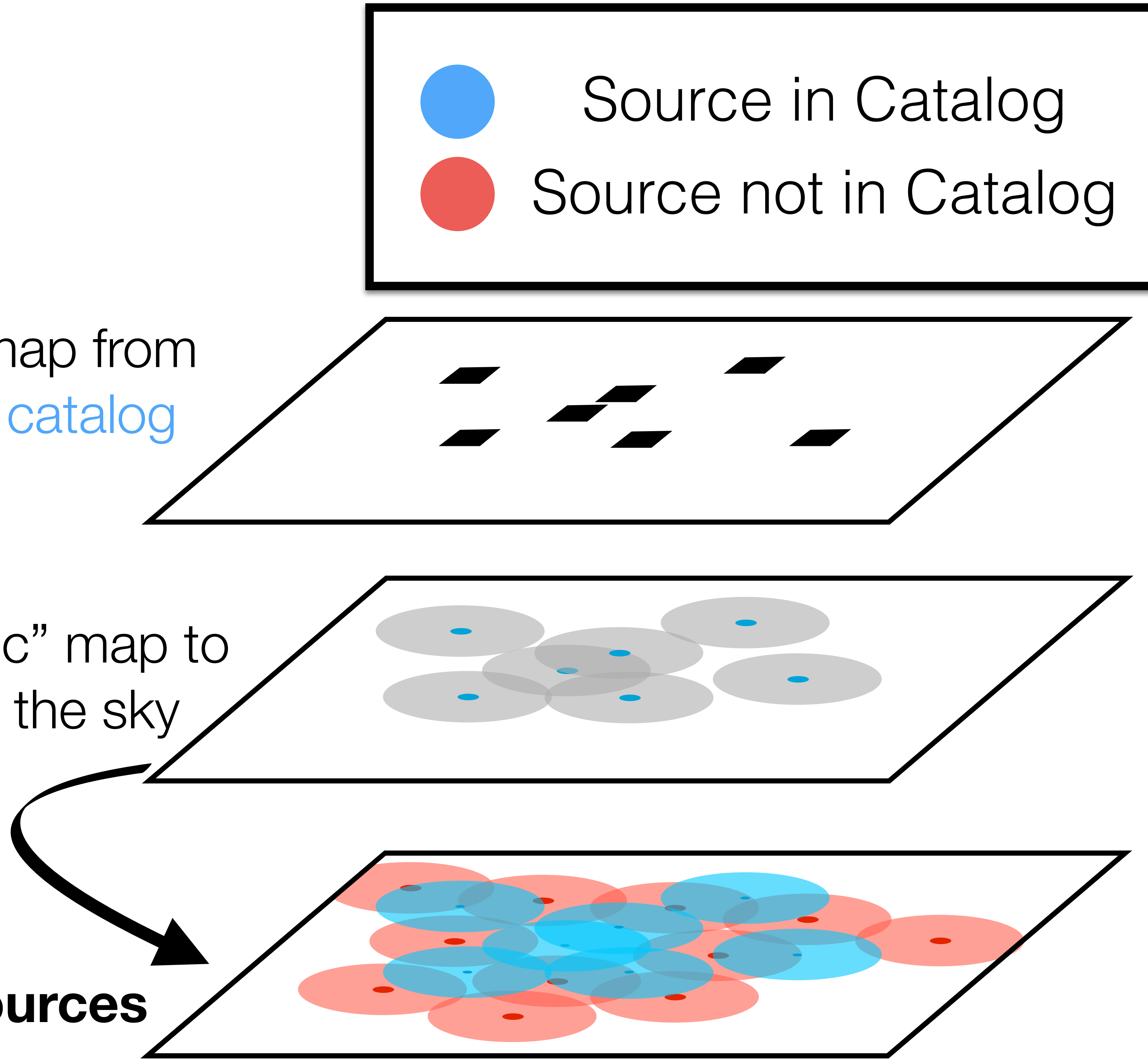
fit "synthetic" map to the map of the sky

***Un*biased if :**
-beam is small

A New Accounting of the CIB

make synthetic “hits” map from positions of sources in catalog

fit “synthetic” map to the map of the sky



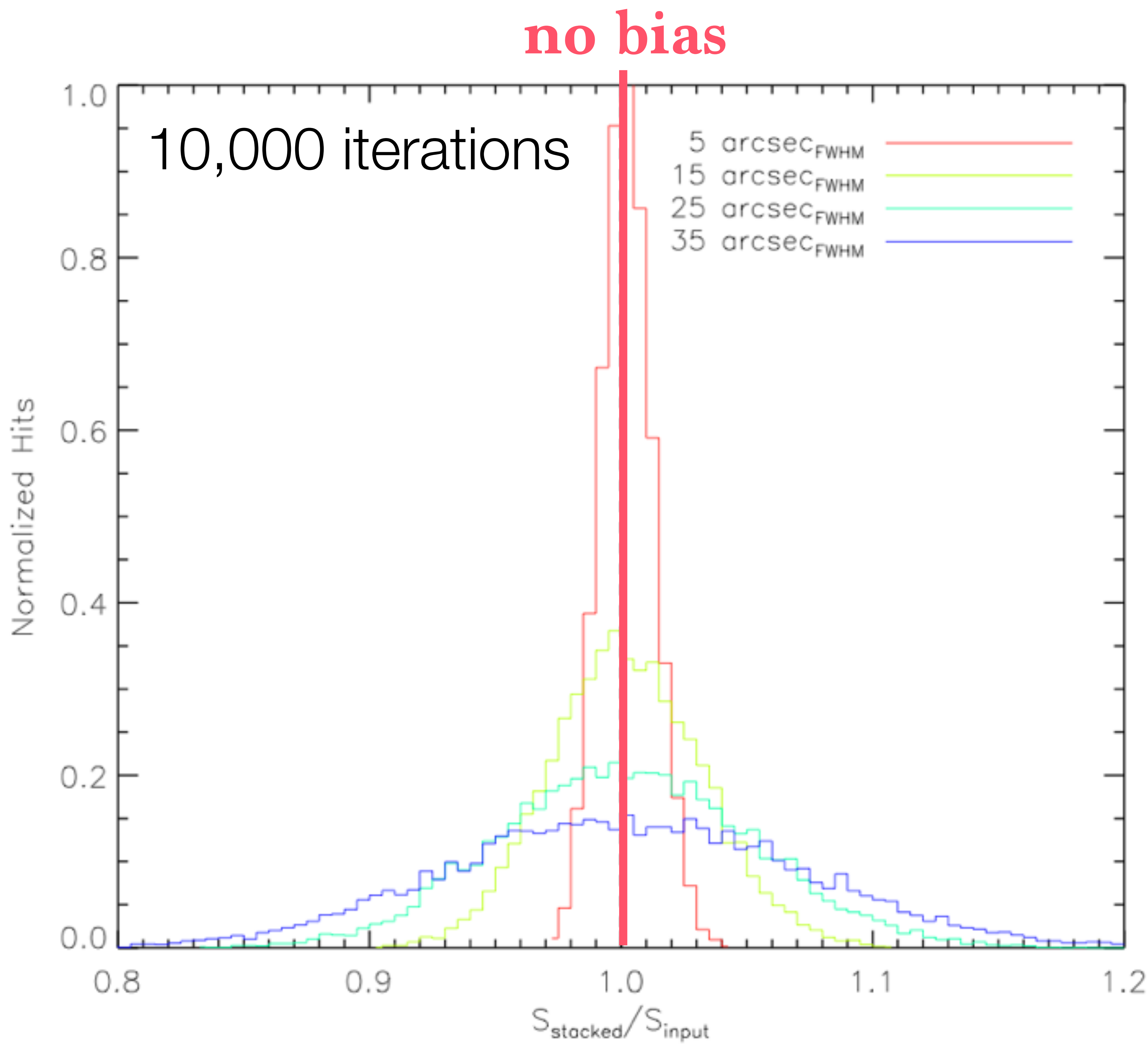
Biased **if :**

-beam is big

-missing a lot of sources

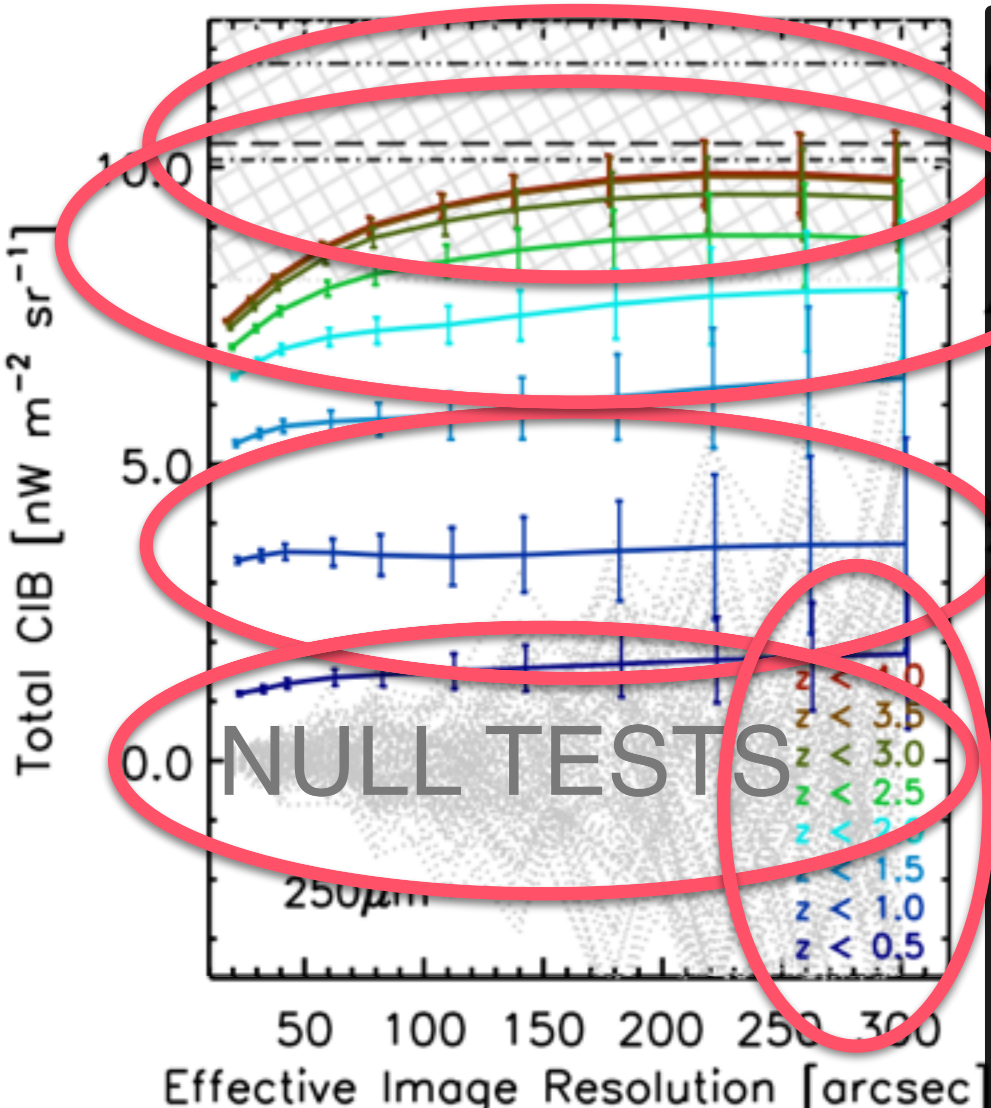
A New Accounting of the CIB

- Uncorrelated emission does not bias result, only increases noise



A New Accounting of the CIB

COBE: Fixsen 1998 -----------------



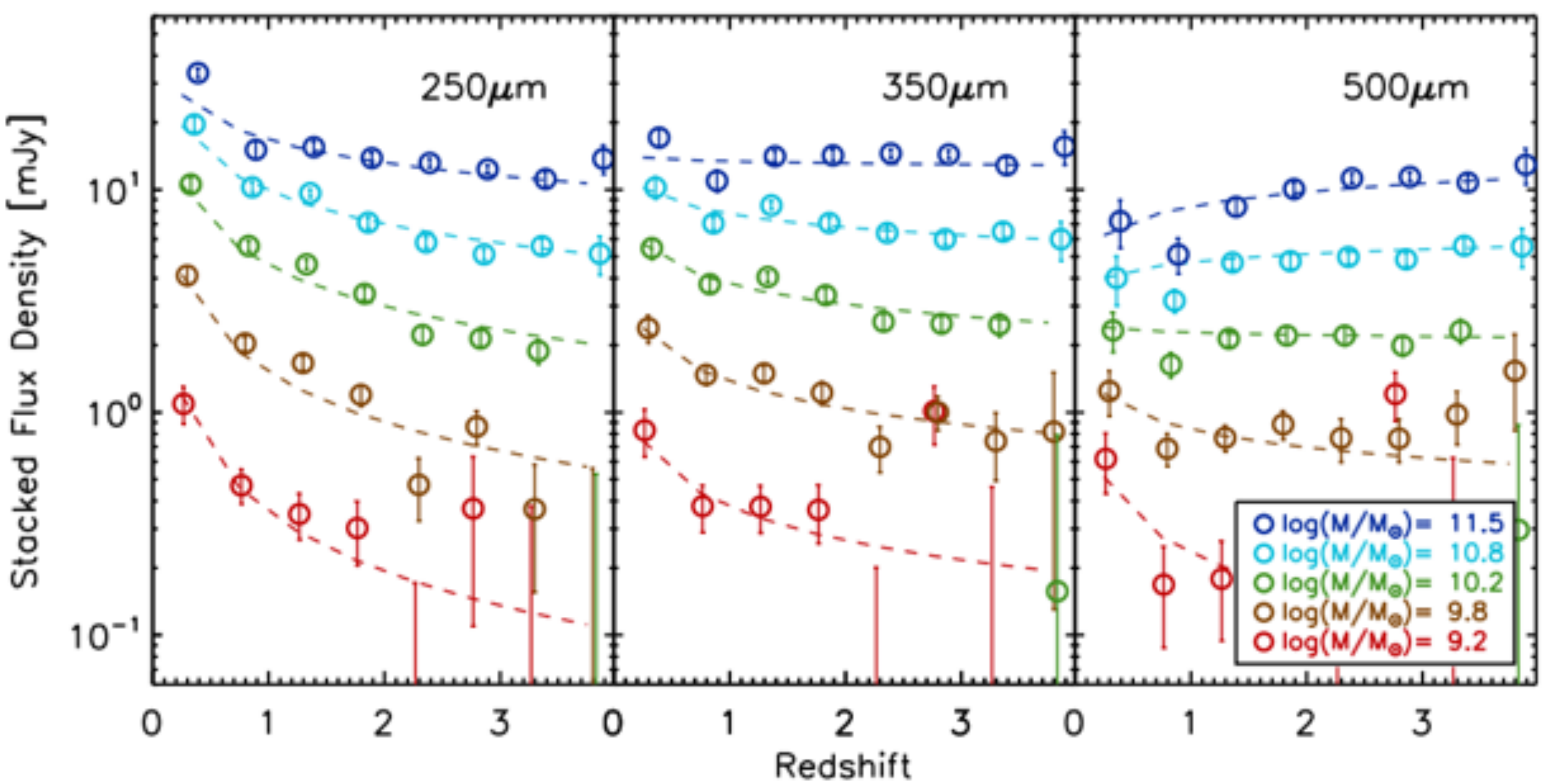
- x-axis increasing beam
- y-axis cumulative Intensity below z
- FIRAS Direct measurement ~30% errors
- Null tests on random positions
- Flat because Catalog is ~100% complete to log(M/Msun) = 9 - 11.5
- Nearly all of the CIB is accounted for by emission correlated with known, cataloged, galaxies. ***But is it necessarily originating from galaxies?***

Smooth with bigger beam

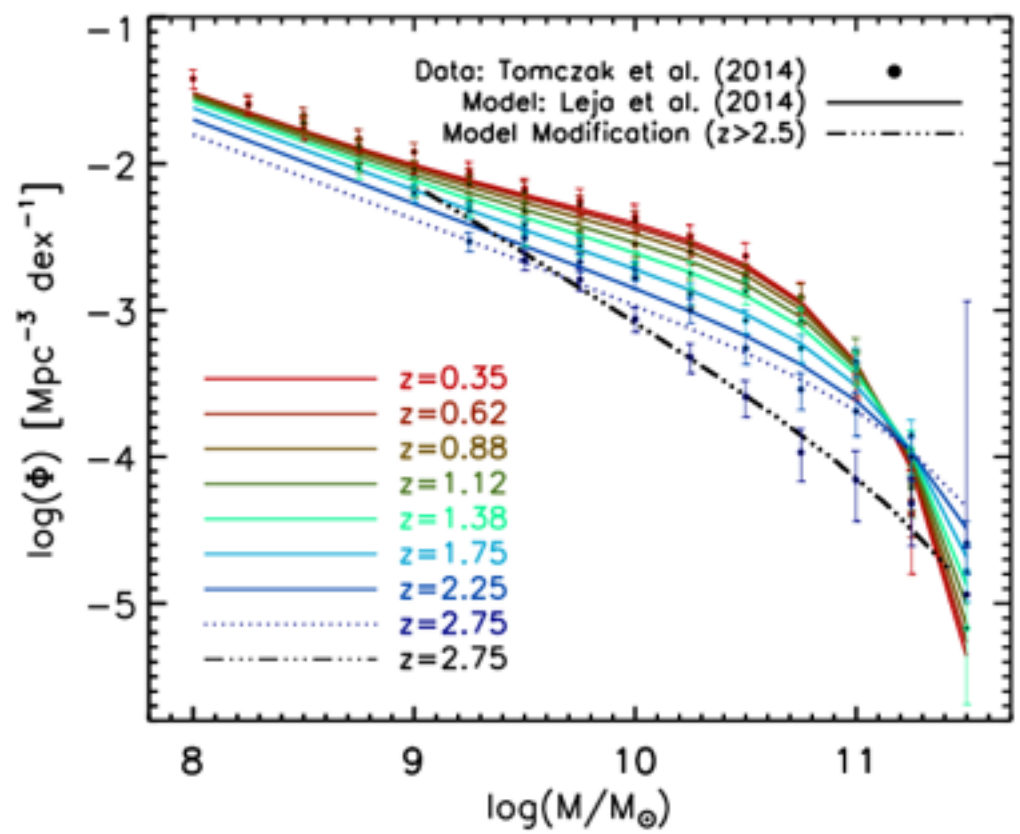
Viero, Moncelsi, Quadri et al. (2015)
arXiv:1505.06242

A New Accounting of the CIB

Submillimeter Flux Densities

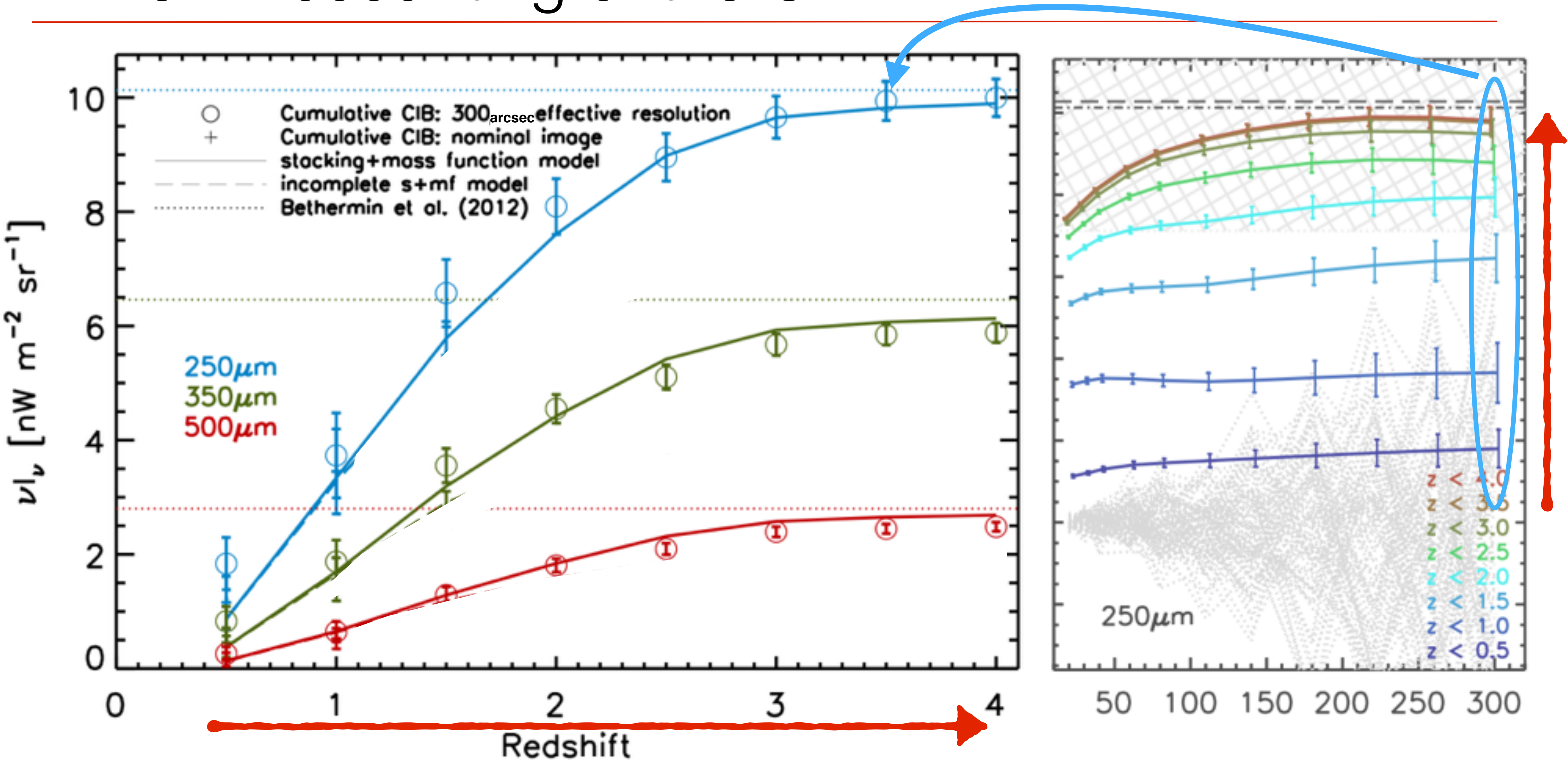


Stellar Mass Functions



- Parametric fit to the (nominally) stacked flux densities (dashed lines)
- Parametric fit to the stellar mass functions from Leja et al. 2014 (solid lines)

A New Accounting of the CIB



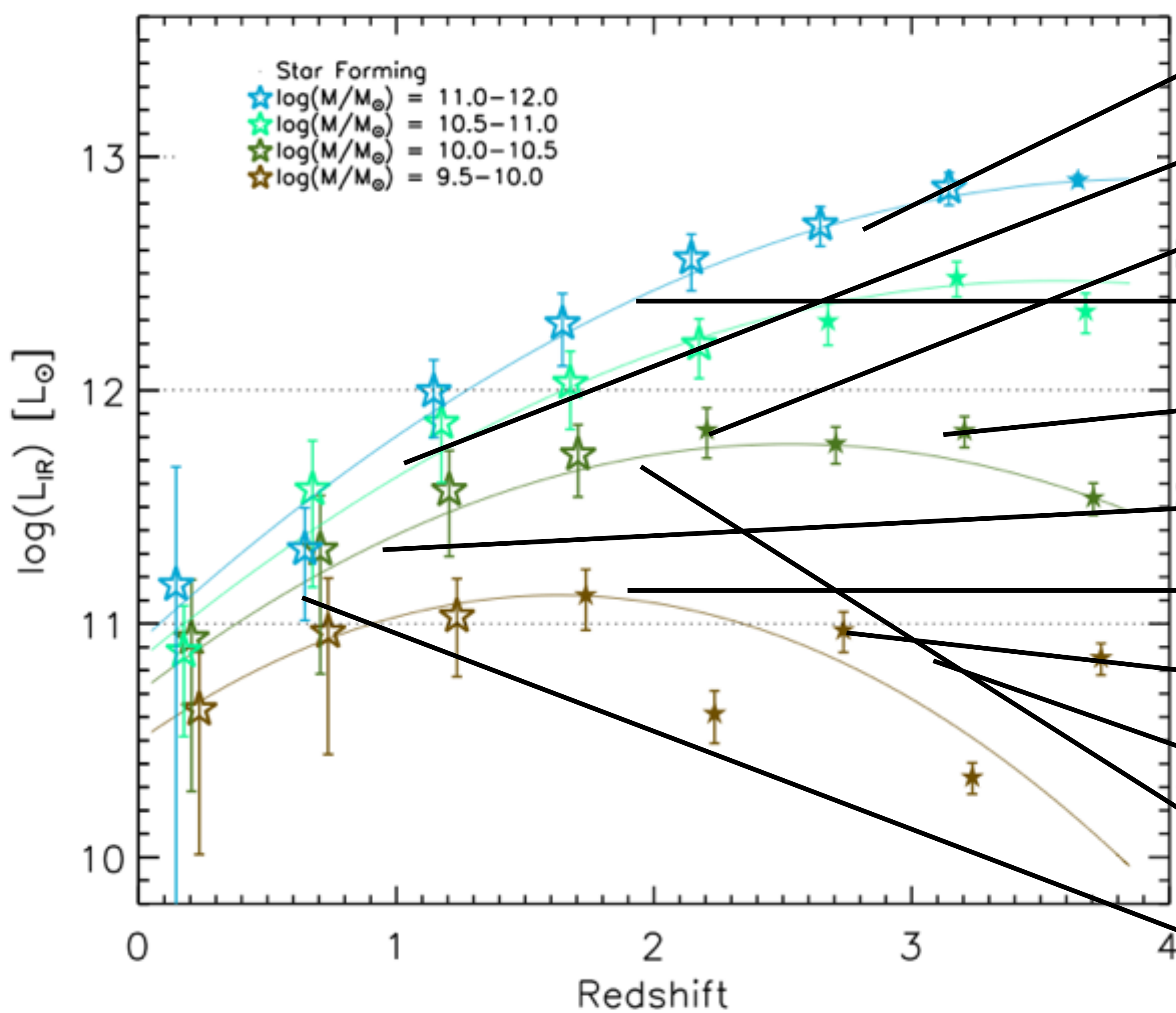
Viero, Moncelsi, Quadri et al. (2015)
arXiv:1505.06242

- Circles/Solid lines: Model compared to total CIB after smoothing to 300 arcsec FWHM.

The total CIB places limits on, e.g.,:

- ➡Low-Mass end of the Stellar mass function
  - Any stellar mass model cannot have to many/few IR emitters
- ➡Star-Formation Rate Density (to z = 4 for now)
  - Limits on total obscured star formation

SIMSTACK: coming full circle



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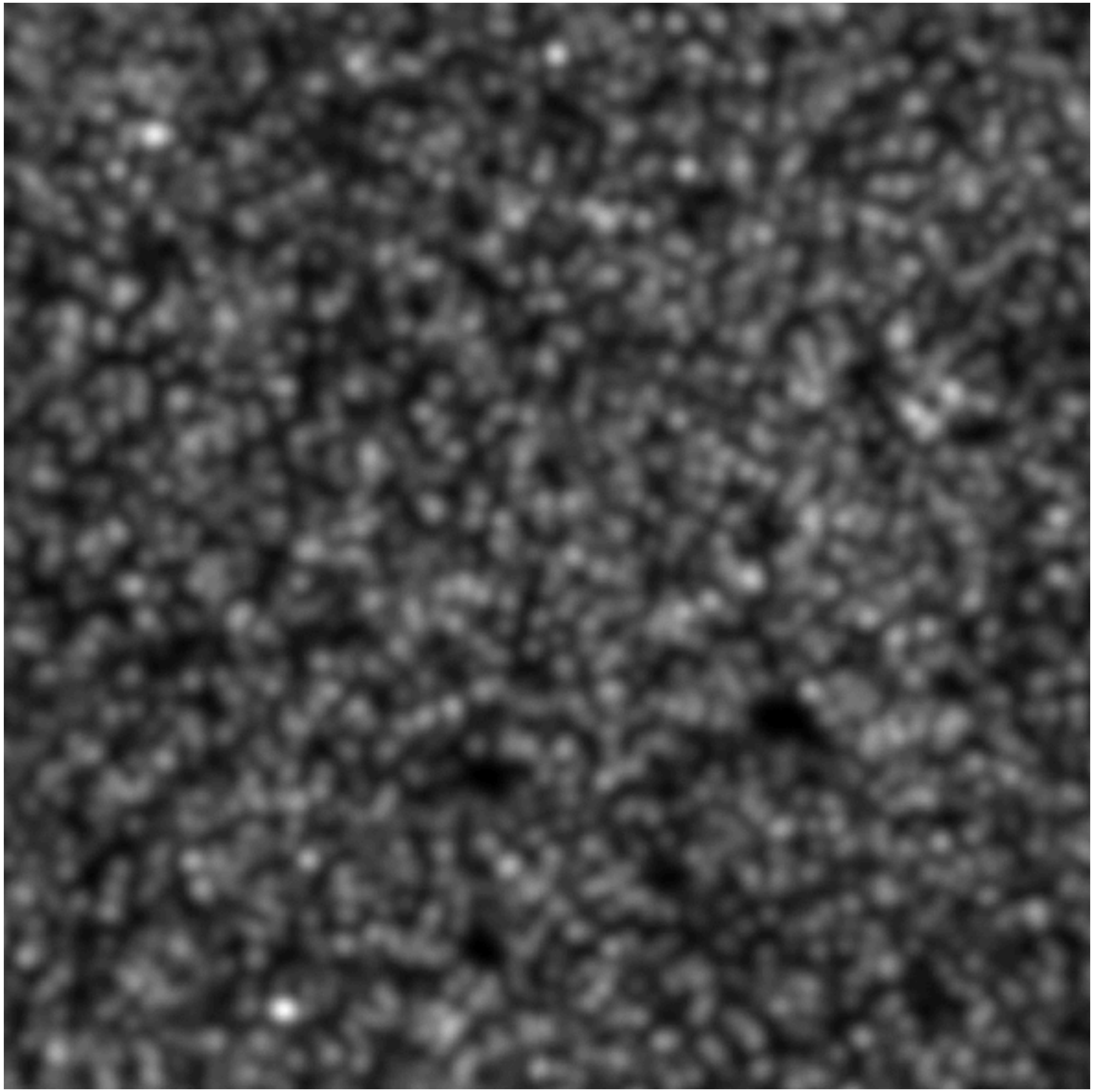

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2.1	149.863	2.788
…	…	…

A New Accounting of the CIB: Summary

- Current Estimates of the total CIB can be explained by known galaxies, and their correlated companions, at z < 4
- This technique is not limited to submillimeter maps or CIB studies
  - ➡ as we push to higher redshifts, intensities will be powerful probes of first galaxies, which will be faint, numerous, and highly correlated

Viero et al. (2015) — arXiv:1505.06242

DRAFT VERSION MAY 26, 2015
Preprint typeset using LaTeX style emulateapj v. 08/29/06

HERMES: CURRENT COSMIC INFRARED BACKGROUND ESTIMATES ARE CONSISTENT WITH CORRELATED EMISSION FROM KNOWN GALAXIES AT $Z < 4$[†]

M.P. VIERO[1,2], L. MONCELSI[2], R.F. QUADRI[3], M. BÉTHERMIN[4,5], J. BOCK[2,6], D. BURGARELLA[7], S.C. CHAPMAN[8], D.L. CLEMENTS[9], A. CONLEY[10], L. CONVERSI[11], S. DUIVENVOORDEN[12], J.S. DUNLOP[13], D. FARRAH[14], A. FRANCESCHINI[15], R.J. IVISON[16,13], G. LAGACHE[7], G. MAGDIS[17], L. MARCHETTI[15], J. ÁLVAREZ-MÁRQUEZ[7], G. MARSDEN[18], S.J. OLIVER[12], M.J. PAGE[19], I. PÉREZ-FOURNON[20,21], B. SCHULZ[2,22], DOUGLAS SCOTT[18], I. VALTCHANOV[11], J.D. VIEIRA[23,24], L. WANG[25,26], J. WARDLOW[27], M. ZEMCOV[2,6]

Draft version May 26, 2015

ABSTRACT

We report contributions to cosmic infrared background (CIB) intensities originating from known galaxies, and their companions, at submillimeter wavelengths. Using the publicly-available UltraVISTA catalog, and maps at 250, 350, and 500 µm from *Herschel*/SPIRE, we perform a novel measurement that exploits the fact that correlated sources will bias stacked flux densities if the resolution of the image is poor; i.e., we intentionally smooth the image — in effect degrading the angular resolution — before stacking and summing intensities. By smoothing the maps we are capturing the contribution of faint (undetected in $K_S \sim 23.4$) sources that are physically associated with the detected sources. We find that the cumulative CIB increases with increased smoothing, reaching 9.82 ± 0.78, 5.77 ± 0.43, and $2.32 \pm 0.19\,\mathrm{nWm^{-2}sr^{-1}}$ at 250, 350, and 500 µm at 300 arcsec full width half maximum. This corresponds to a fraction of the fiducial CIB of 0.94 ± 0.23, 1.07 ± 0.31, and 0.97 ± 0.26 at 250, 350, and 500 µm, where the uncertainties are dominated by those of the absolute CIB. We then propose, with a simple model combining parametric descriptions for stacked flux densities and stellar mass functions, that emission from galaxies with $\log(M/M_\odot) > 8.5$ can account for the entire measured total intensities, and argue against contributions from extended, diffuse emission. Finally, we discuss prospects for future survey instruments to improve the estimates of the absolute CIB levels, and observe any potentially remaining emission at $z > 4$.
Subject headings: cosmology: observations, submillimeter: galaxies – infrared: galaxies – galaxies: evolution – large-scale structure of universe

1. INTRODUCTION

Since the cosmic infrared background (CIB; Hauser & Dwek 2001) was first detected spectroscopically (Puget et al. 1996) with the Far Infrared Absolute

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[2] California Institute of Technology, 1200 E. California Blvd.,