Distant Herschel sources revealed with color-deconfusion

Xinwen Shu **(CEA/Saclay)**

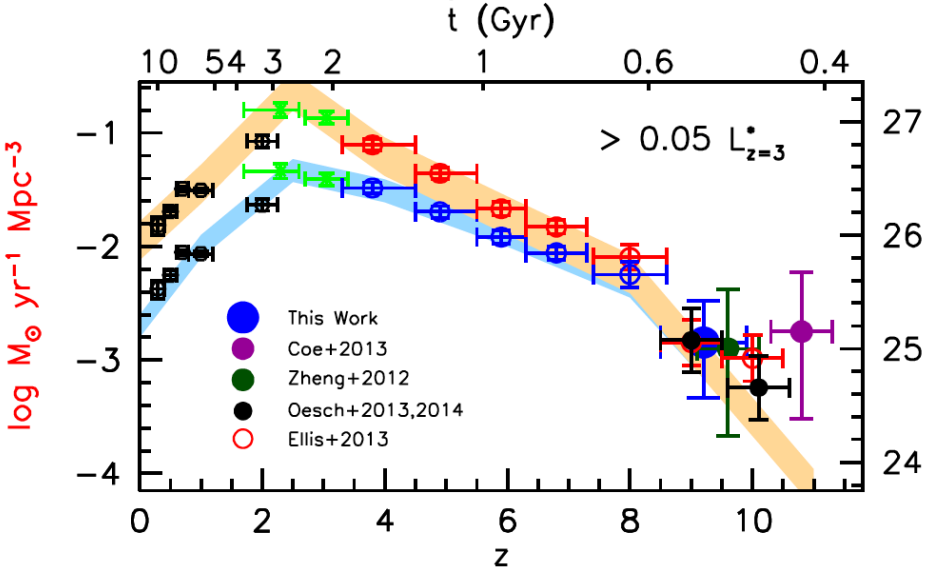
with D. Elbaz, C. Schreiber, T. Wang,
M. Pannella, R. Leiton, E. Daddi
and many Astrodeepers

Sexton meeting, 2015/01/29

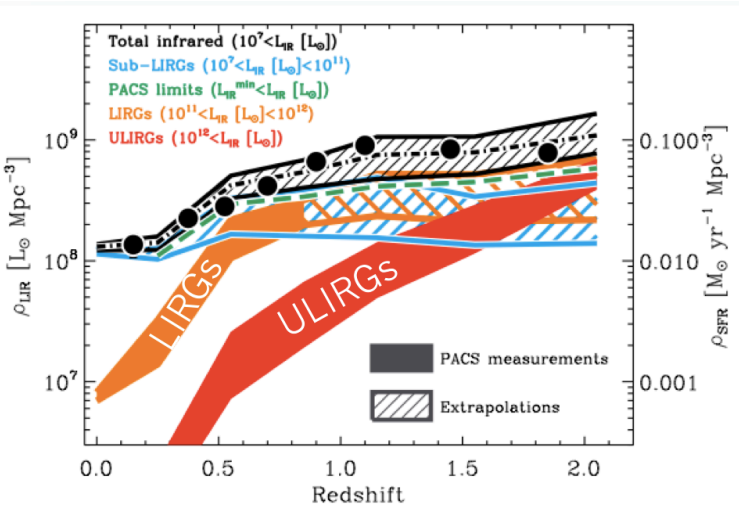
Outline

- The importance of obscured star-formation
- Two “dark clouds” with the current Herschel catalog (worried David Elbaz since 2011 GOODS-Herschel release)
- A new method to identify high-z Herschel sources using color deconfusion
- Results

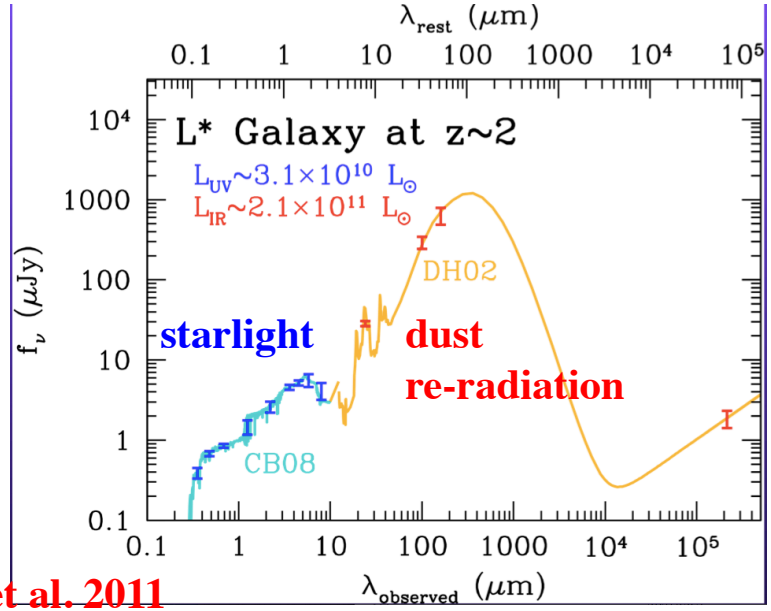
Cosmic Star-formation rate density (SFRD) evolution



Bouwens et al 2014



Magnelli et al. 2013, and Fabian Walter's talk

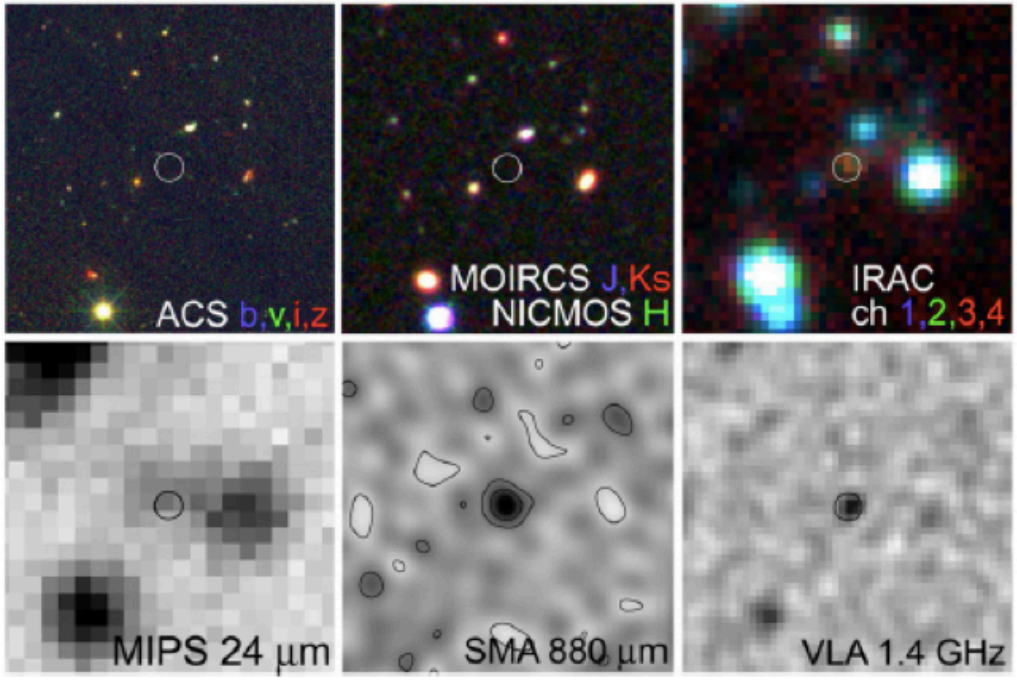


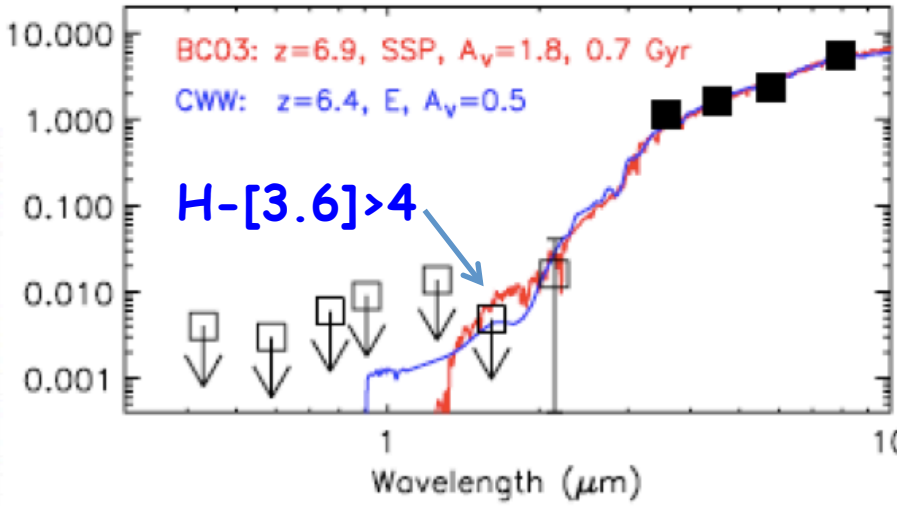
Reddy et al. 2011

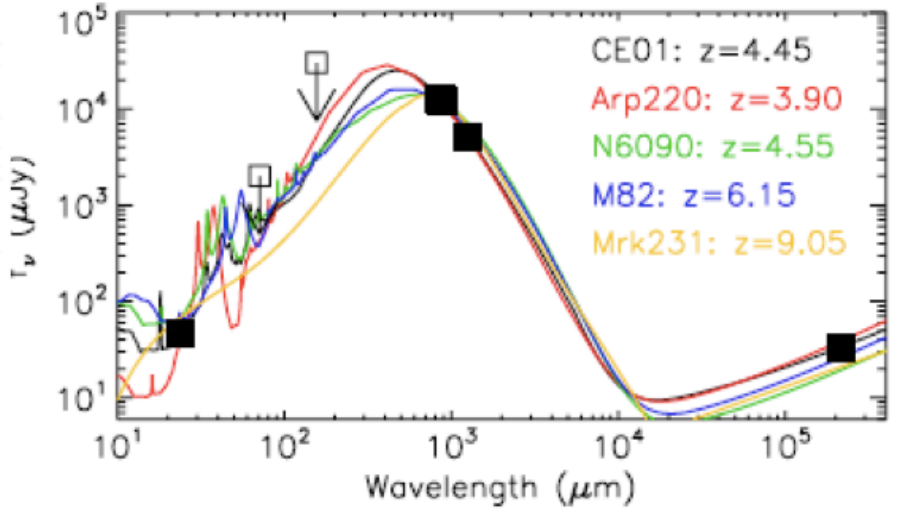
- The peak era of star-formation took place at z~1-3
- SFRD of (U)LIRGs (dusty star-forming galaxies) increase dramatically towards higher redshifts (to z~2 from HERSCHEL/PACS)

z>4 starburst that can only be seen in longer wavelengths

H-dropout? *Not a z=15 LBG*





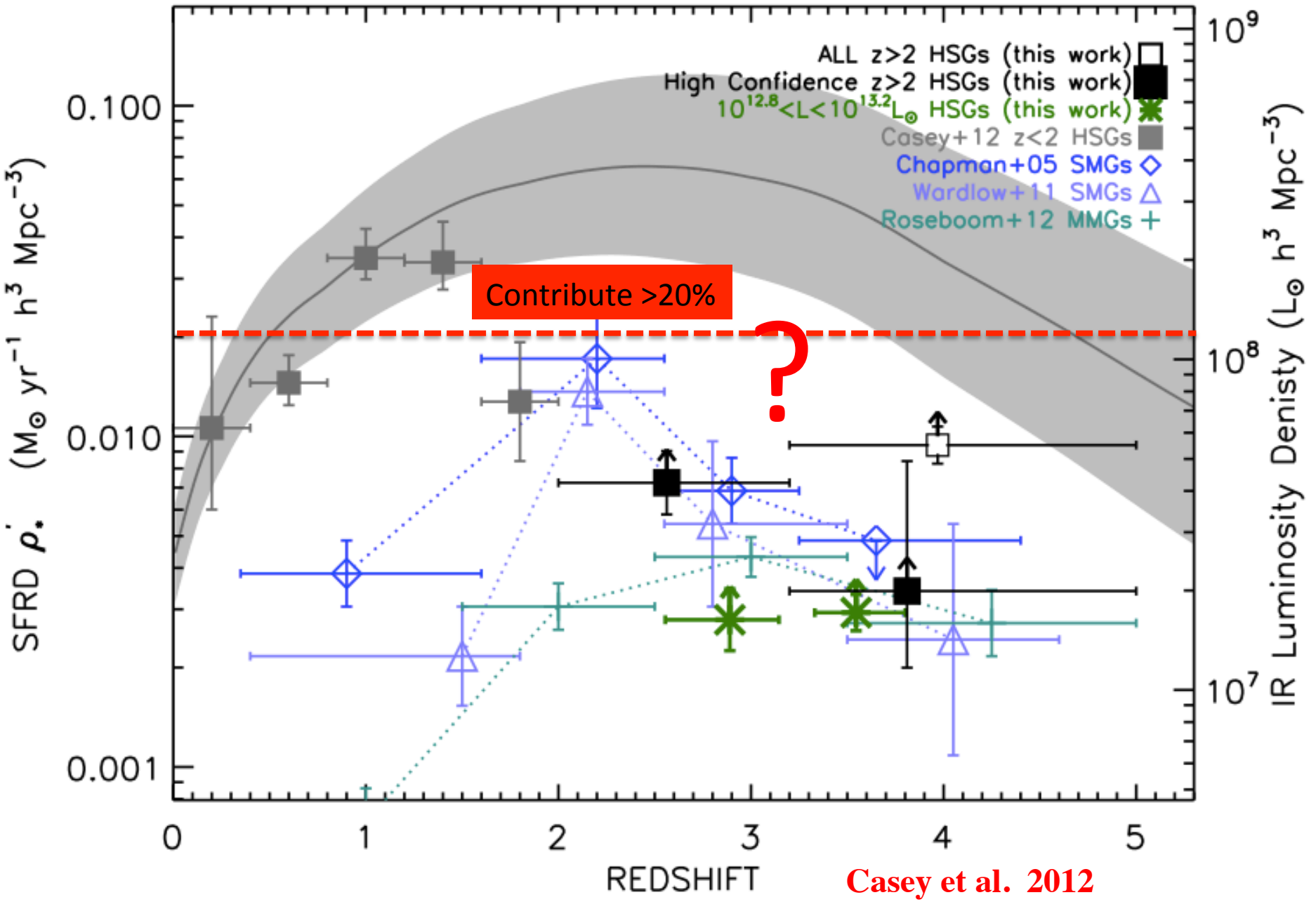


Completing the census of star formation and the assembling history of stellar mass densities

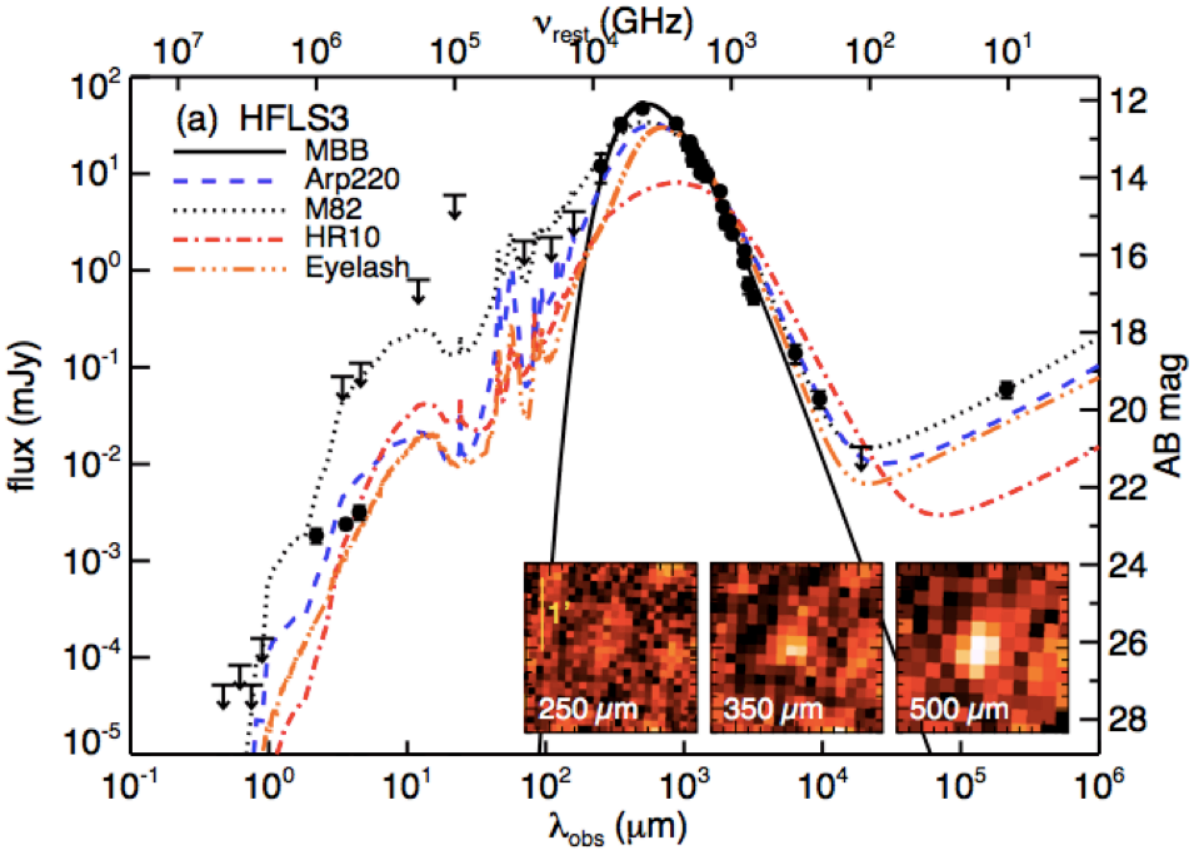
SMG 850-5 by Wang et al. (2009), Daddi+09

See also Tao Wang's talk about this topic

Contribution of SMGs (mostly ULIRGs) to the SFRD



Casey et al. 2012

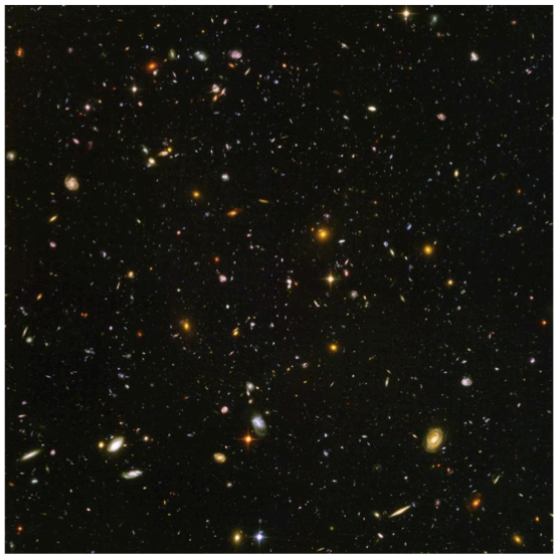


	HFLS3
redshift	6.3369
M_{gas} (M_{sun})[a]	(1.04+/-0.09) x 10^{11}
M_{dust} (M_{sun})[b]	$1.31^{+0.32}_{-0.30}$ x 10^{9}
M_{*} (M_{sun})[c]	~3.7 x 10^{10}
M_{dyn} (M_{sun})[d]	2.7 x 10^{11}
f_{gas}[e]	40%
L_{FIR} (L_{sun})[f]	$2.86^{+0.32}_{-0.31}$ x 10^{13}
SFR ($M_{sun}yr^{-1}$)[g]	2,900
T_{dust} (K)[h]	$55.9^{+9.3}_{-12.0}$

HFLS3: z=6.34
The most distant dusty starburst found with Herschel
Riechers et al. 2013

SFR ~4x all z=5.5-6.5 Galaxies in HUDF

Hubble Ultra Deep Field



A&A 533, A119 (2011)
DOI: 10.1051/0004-6361/201117239

Astronomy & Astrophysics

GOODS–*Herschel*: an infrared main sequence for star-forming galaxies⋆

D. Elbaz[1], M. Dickinson[2], H. S. Hwang[1], T. Díaz-Santos[3], G. Magdis[1], B. Magnelli[4], D. Le Borgne[5], F. Galliano[1],

ABSTRACT

We present the deepest 100 to 500 μm far-infrared observations obtained with the *Herschel* Space Observatory as part of the GOODS-*Herschel* key program, and examine the infrared (IR) 3–500 μm spectral energy distributions (SEDs) of galaxies at $0 < z < 2.5$, supplemented by a local reference sample from IRAS, ISO, *Spitzer*, and AKARI data. We determine the projected star formation densities of local galaxies from their radio and mid-IR continuum sizes.

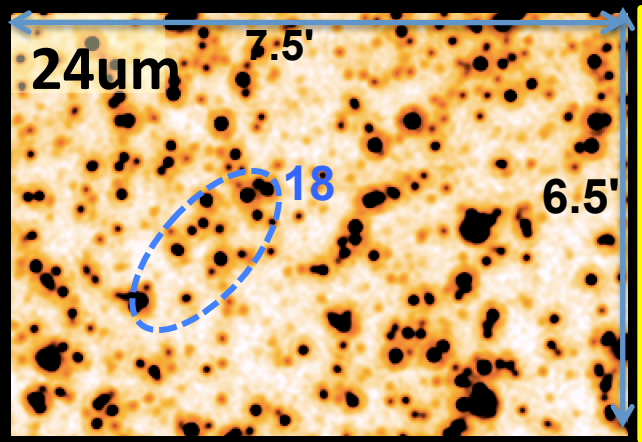
Sexton

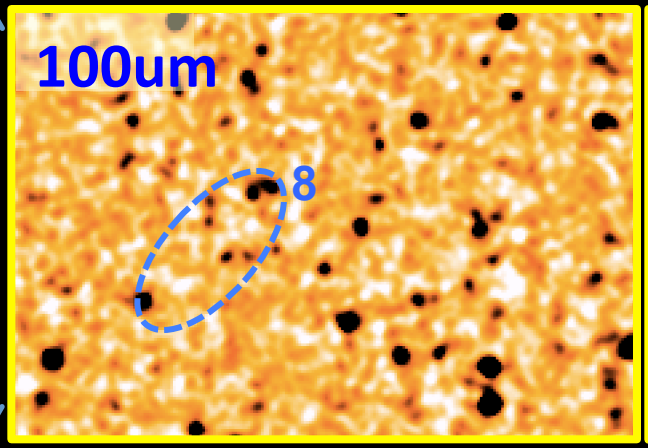

grey clouds
on top of
Herschel cat.

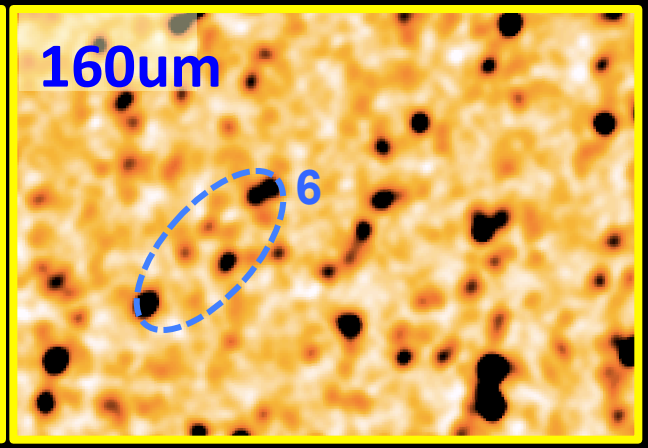
Herschel data are unique, but confusion limited

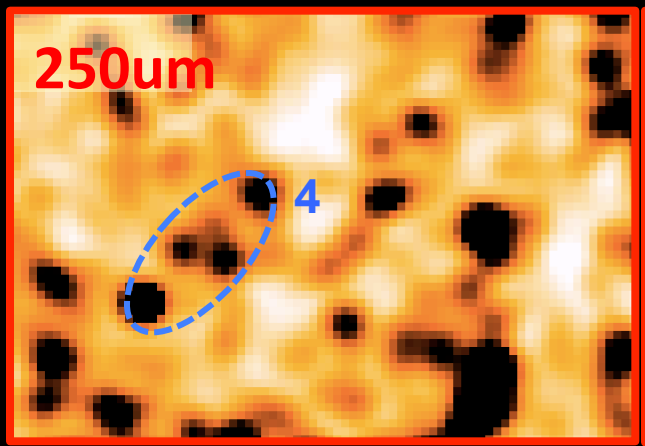
GOODS-N 10' x 15': 44000 optical galaxies (HST)
(From Elbaz et al.)
24476 Spitzer/IRAC (55% have z)
2575 MIPS24um galaxies (91% have z)
1263 ≥ 1 Herschel detection (89% have z)

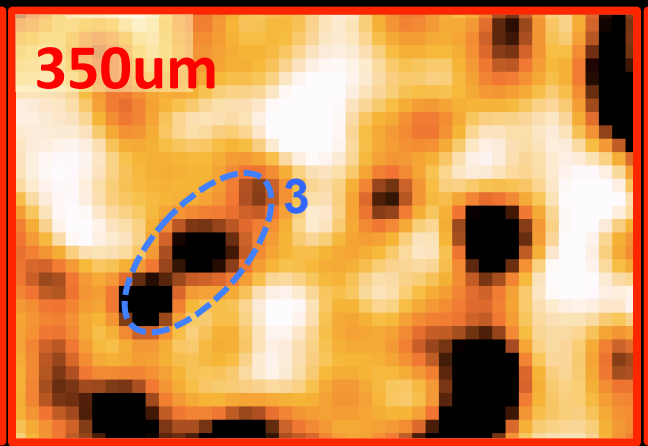
FWHM=	6.7"	11"	18.1"	24.9"	36.9"
λ (μm)=	100	160	250	350	500

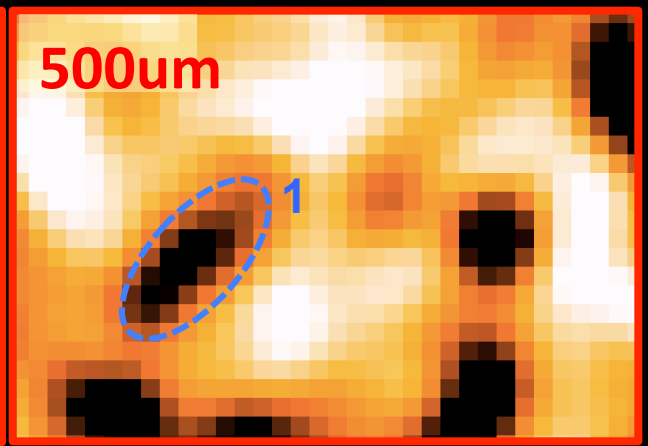






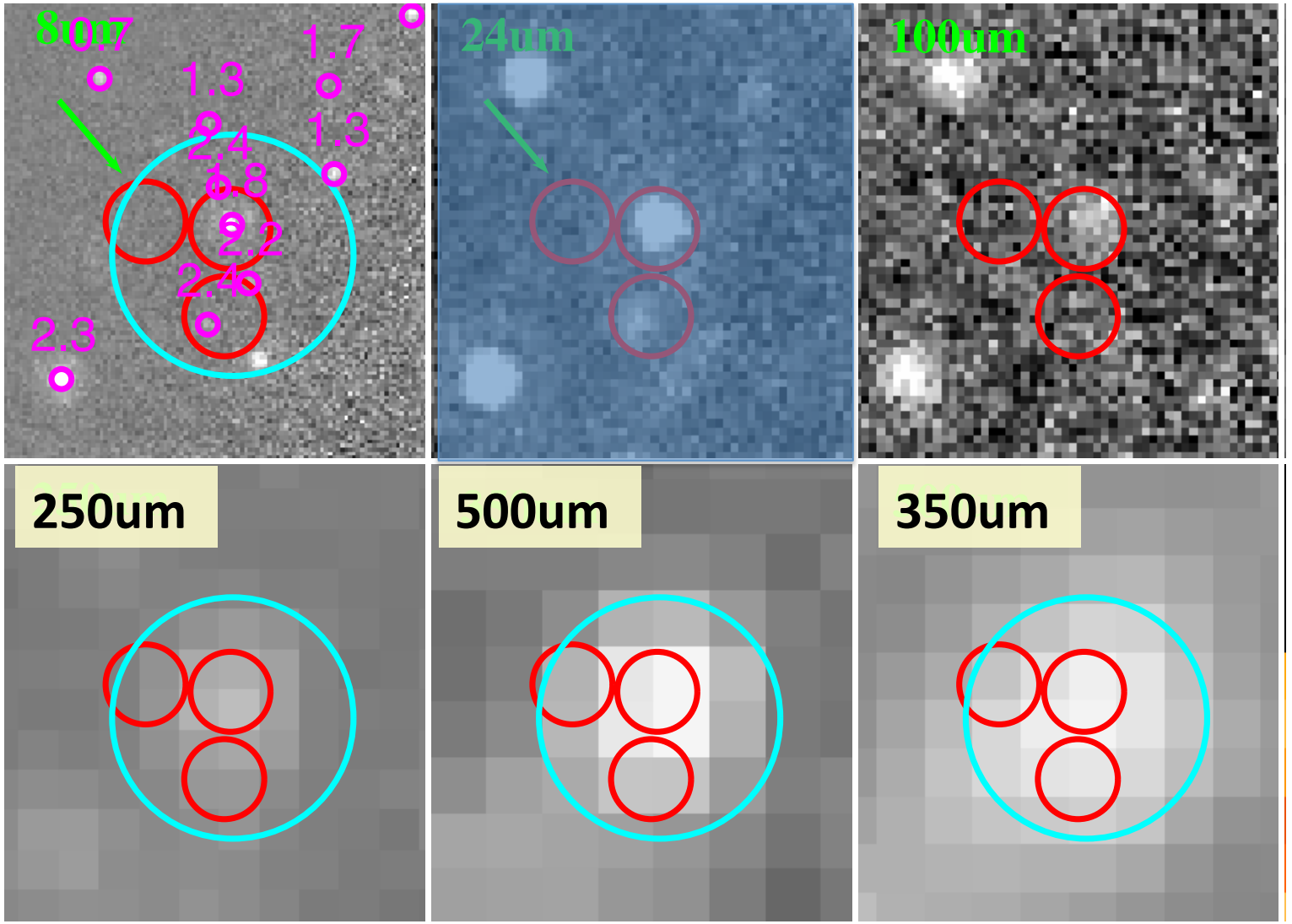






Herschel photometry catalog: using positions of source >3sigma in the deep 24um image

Grey cloud (1): bias against 24um non-detections



FWHM=	5.7”	6.7"	11"	18.1"	24.9"	36.9"
λ (μm)=	24	100	160	250	350	500

herschel — idl — 174×26

```
IDL> mkdata
% X windows protocol error: GLXBadContext.
% Compiled module: GCIRC.
ZPHOT_MP        FLOAT     = Array[44429]
AA              LONG      = Array[14]
% Compiled module: RADEC.
      189.18985       62.327573       26.372999      104.380       1156.19       5601.44       10900.0       14600.0       14900.0      0.276700      0.277000
      189.18345       62.327344       10.549000      34.9300      -99000.0      -99000.0       3170.00      -99000.0      -99000.0     -1.00000       3.45000
sum of f8um       36.921999       139.310       1156.19       5601.44       14070.0       14600.0       14900.0
     0.160000       4.38000       0.00000       0.00000       0.00000       0.00000       0.00000       0.00000       0.00000       0.00000       0.00000       0.00000       0.00000
     0.00000
```

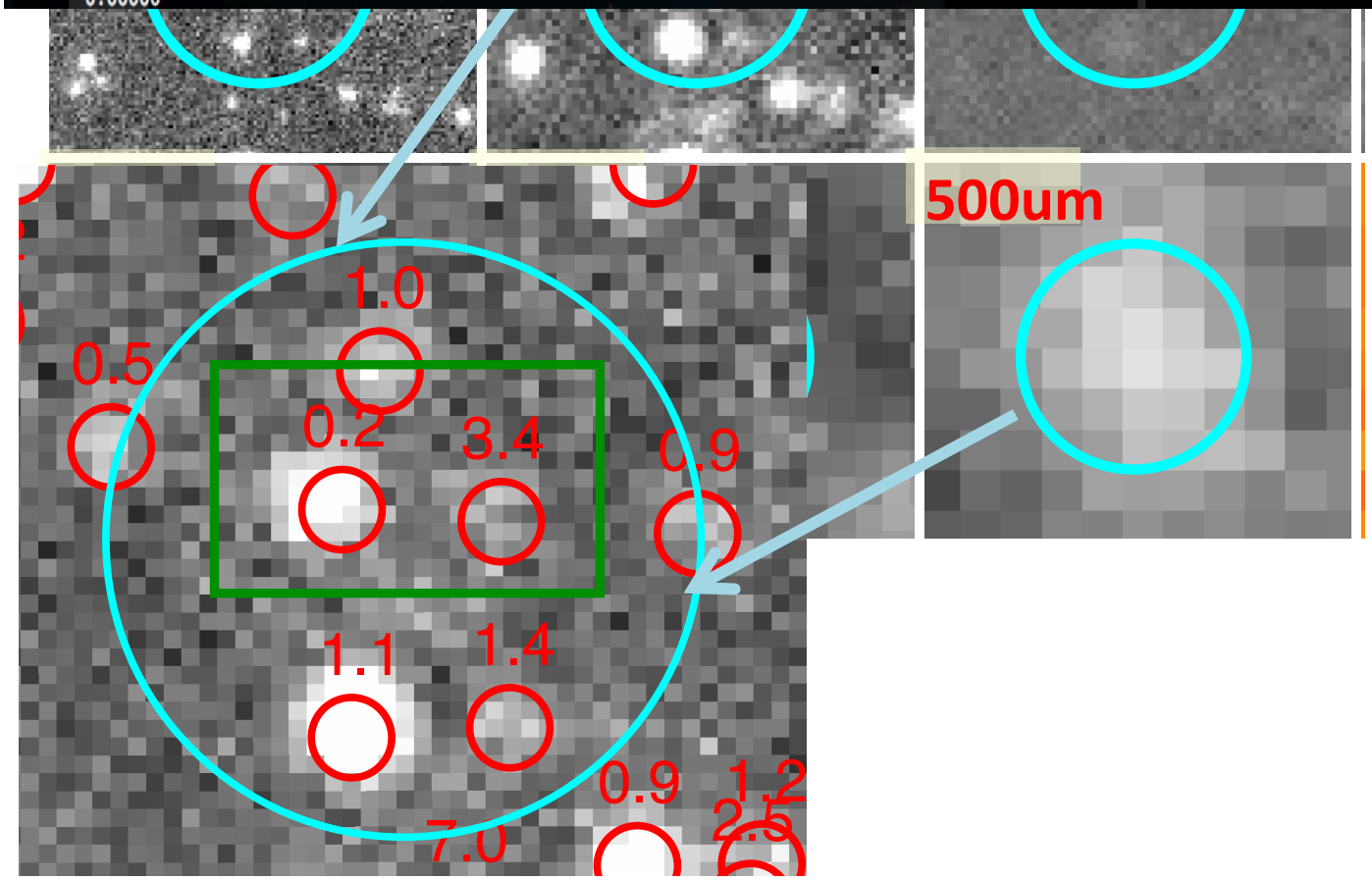
24um (uJy)

250um

350um

500um

z



herschel — idl — 174×26

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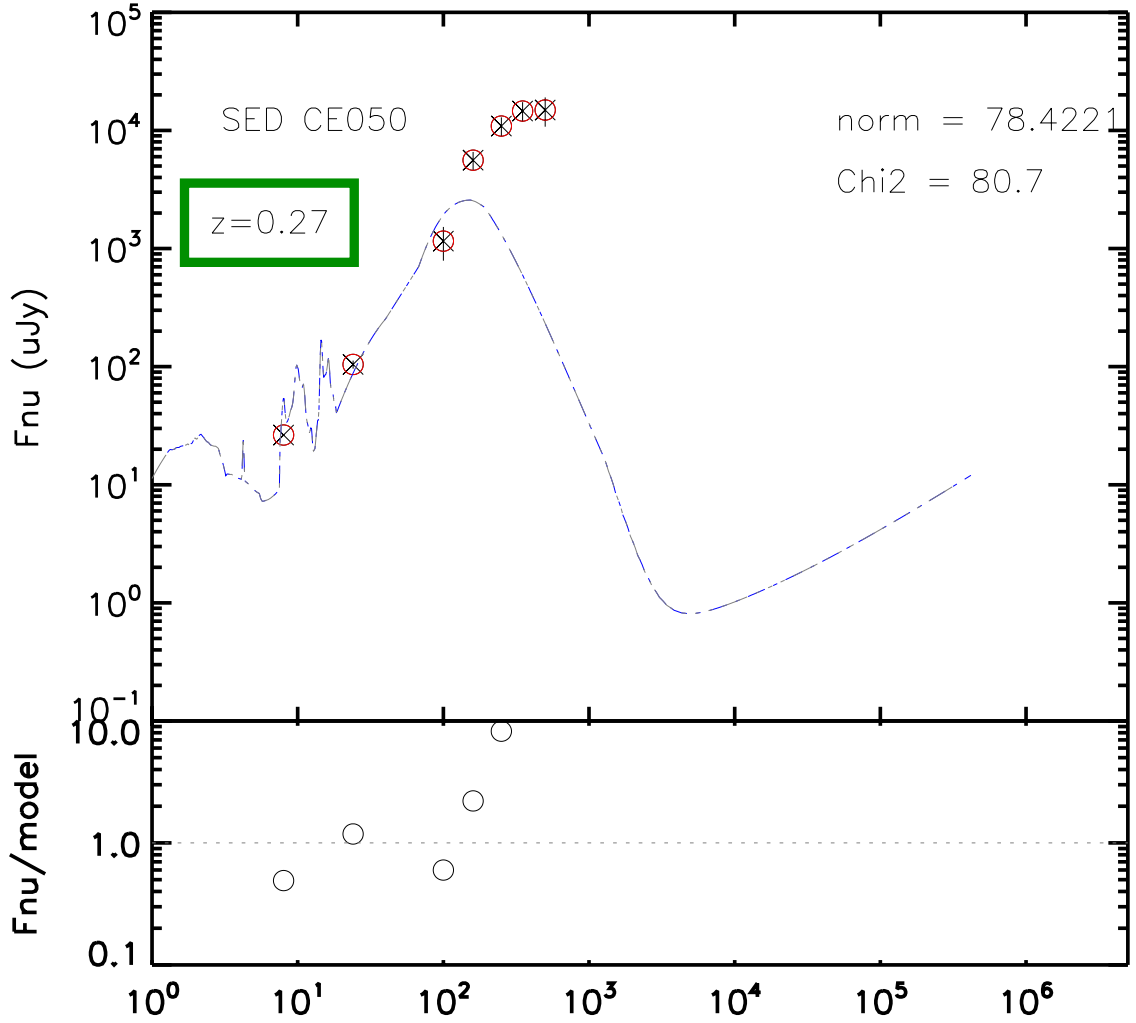
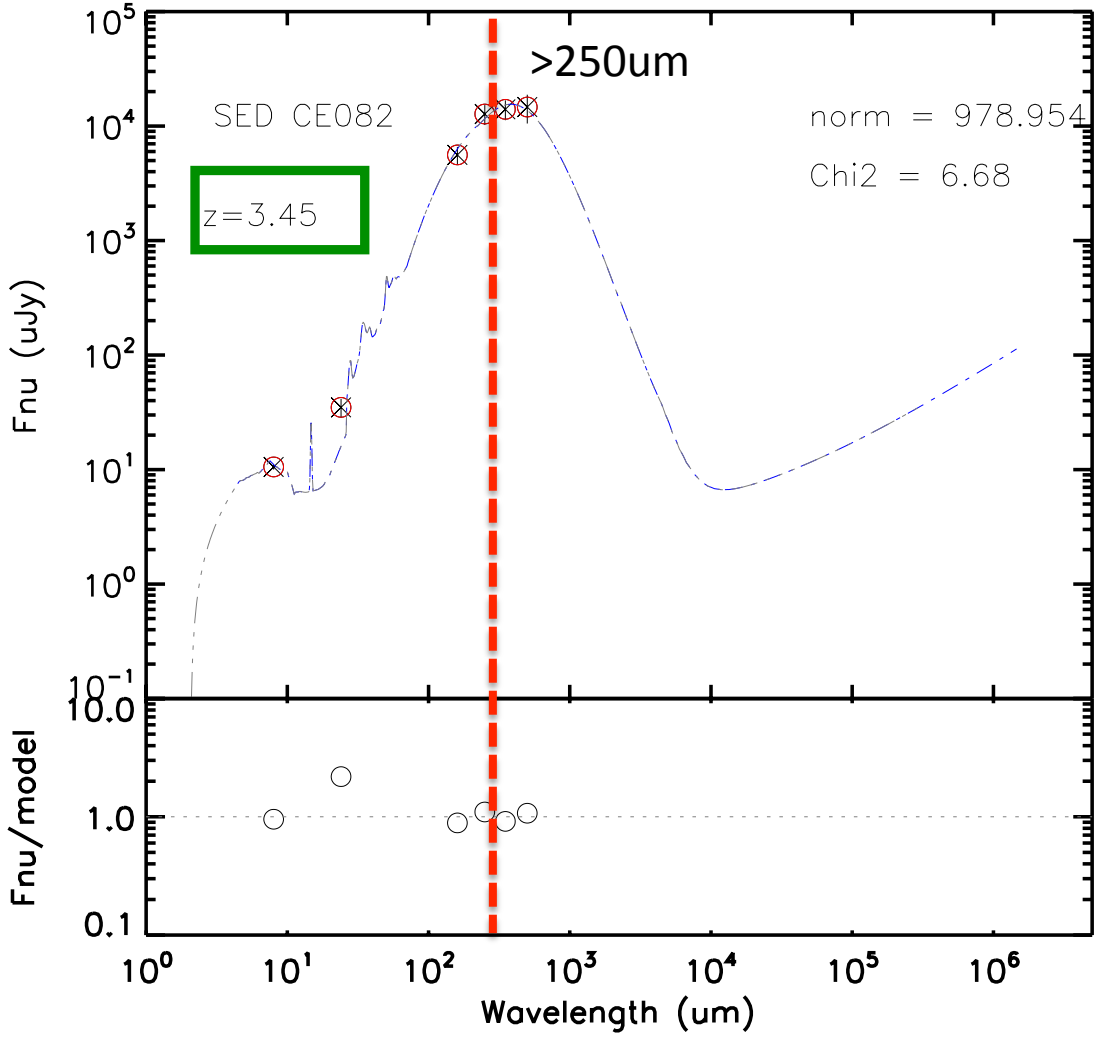
sum of f8um       36.921999       139.310         1156.19         5601.44         14070.0         14600.0         14900.0
     0.160000        4.38000         0.00000         0.00000         0.00000         0.00000         0.00000         0.00000         0.00000         0.00000         0.00000         0.00000         0.00000
     0.00000
```

24um

500 um

z

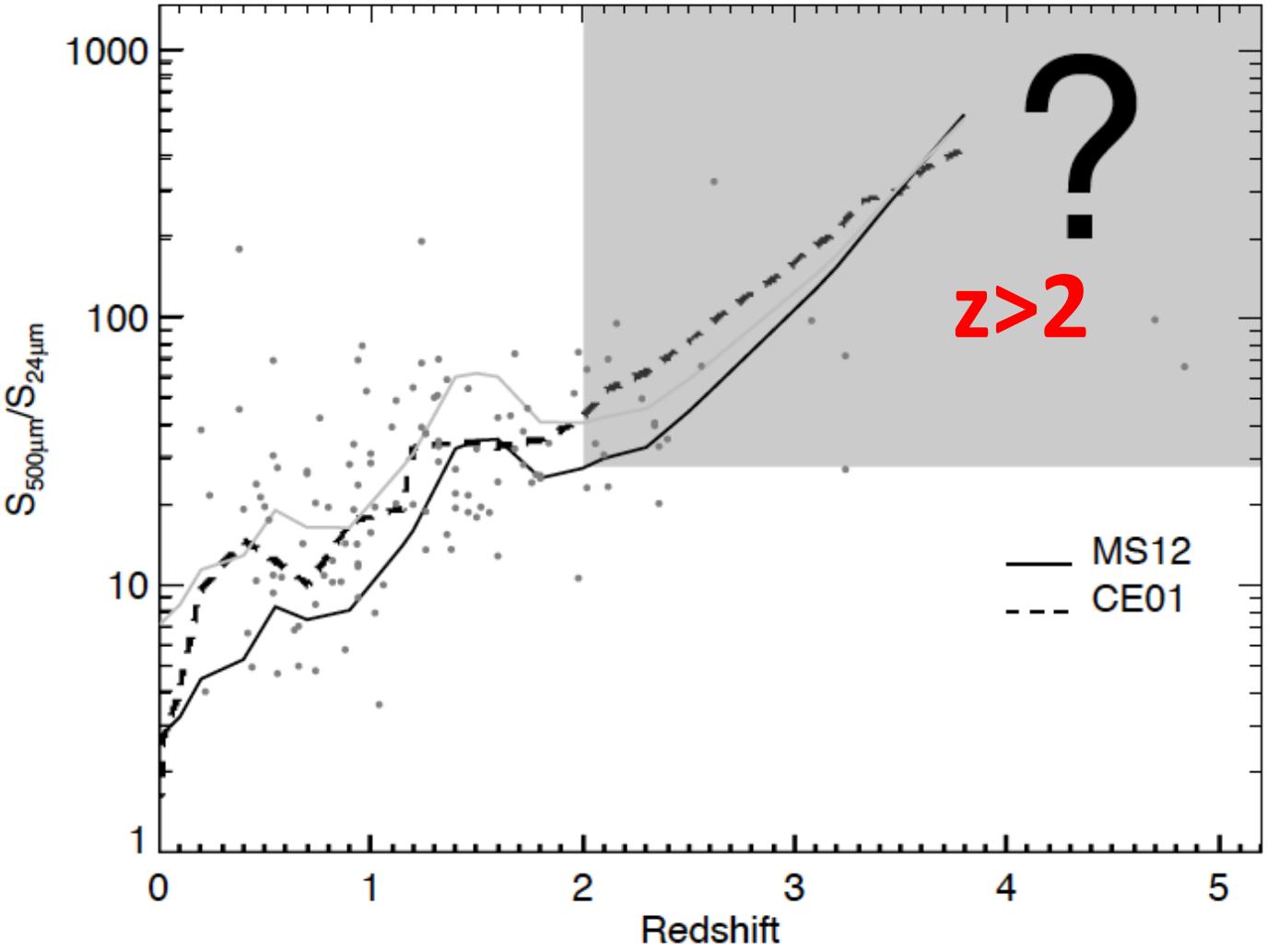


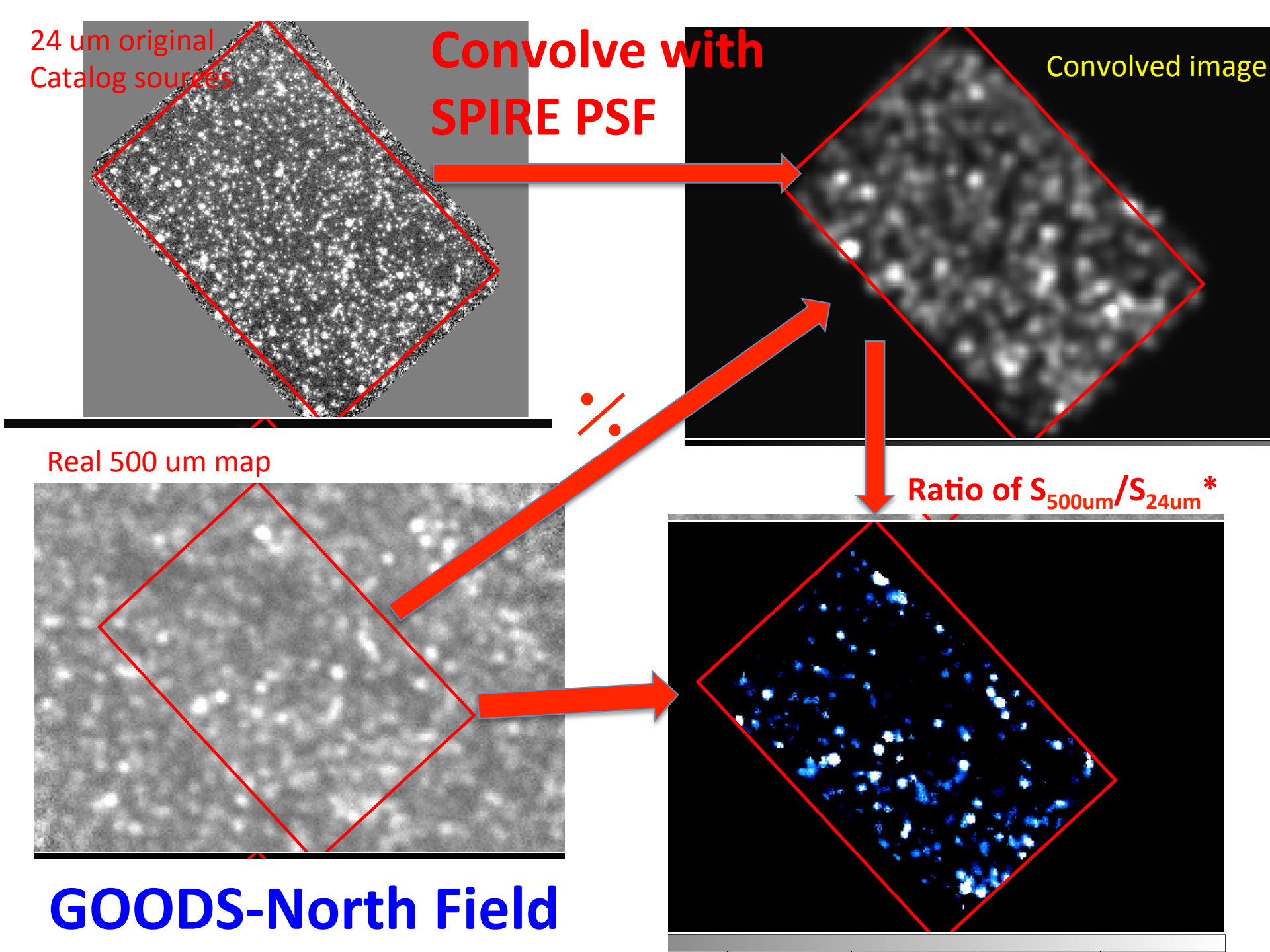


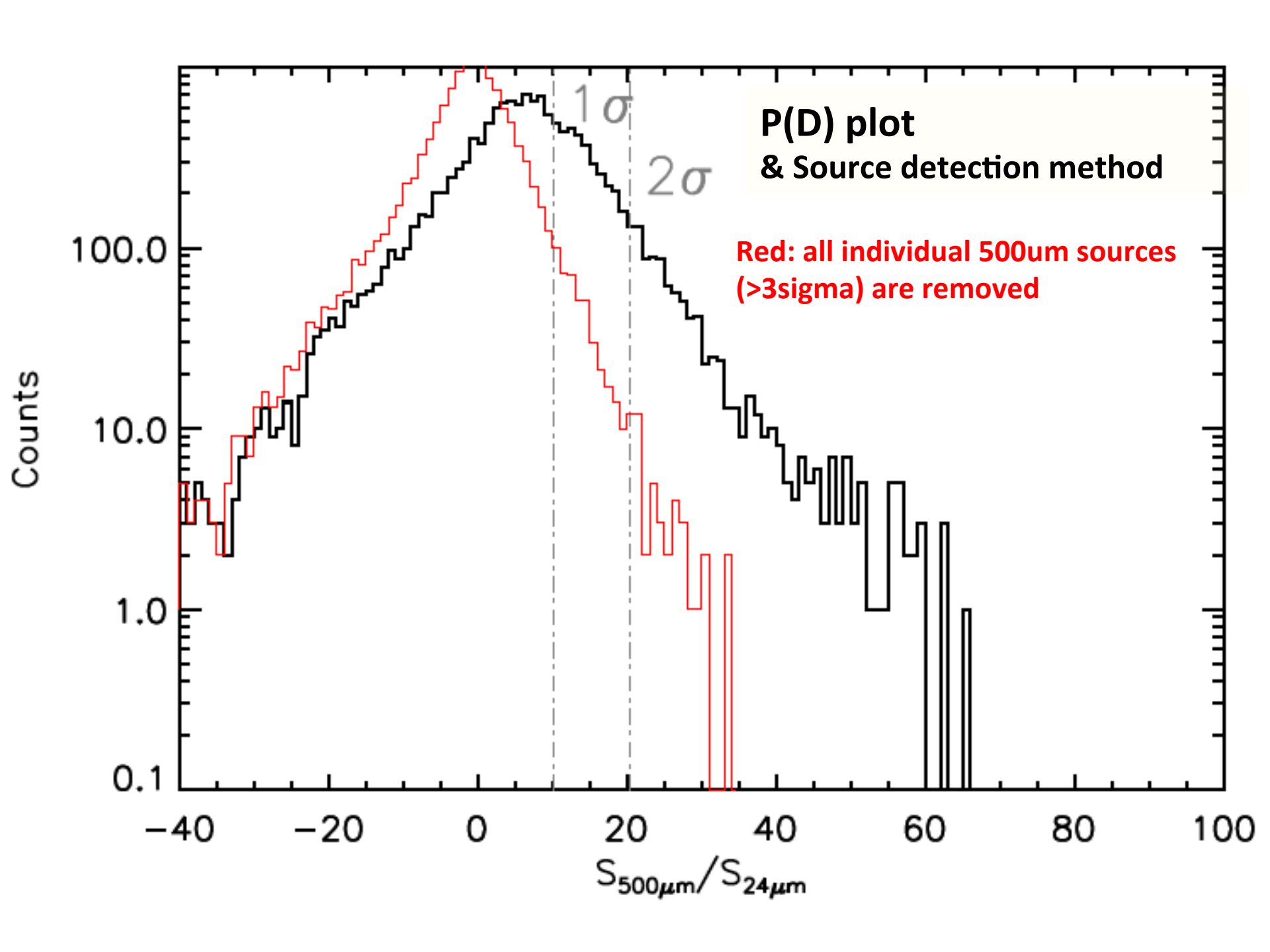
1. By **“Spectral” deconfusion:** (i.e., . Iteratively subtract the flux in SPIRE 350 and 500um of low-z sources based on redshift and best-fit templates,
2. The SED is in agreement with the high-z source’s
3. The SPIRE flux is not correctly measured in the catalog
4. **Missed a population of candidates of high-z SPIRE sources?**

A new method to identify high-z Herschel 500um sources using ***color-deconfusion***

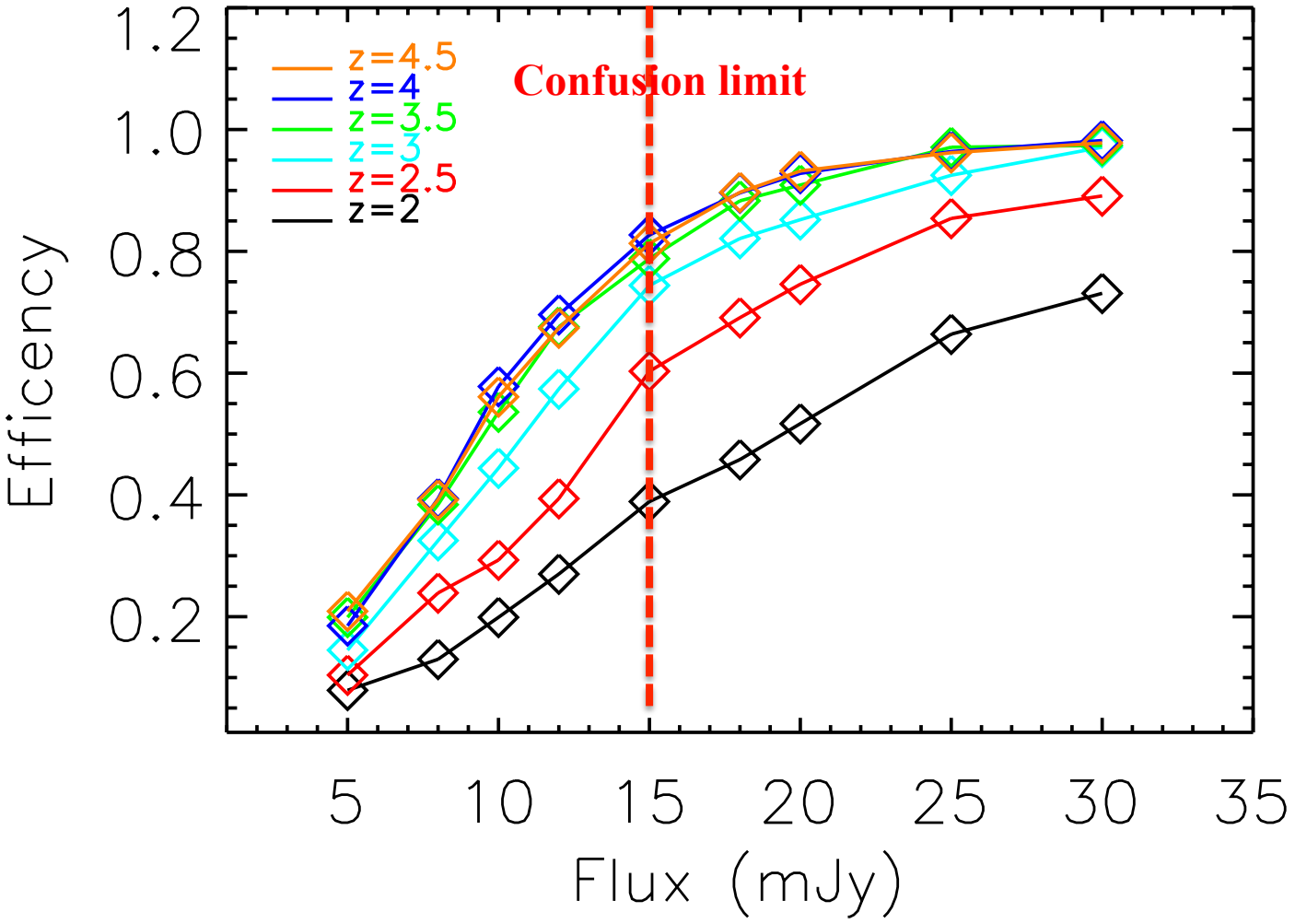
Shu et al. 2015, almost ready

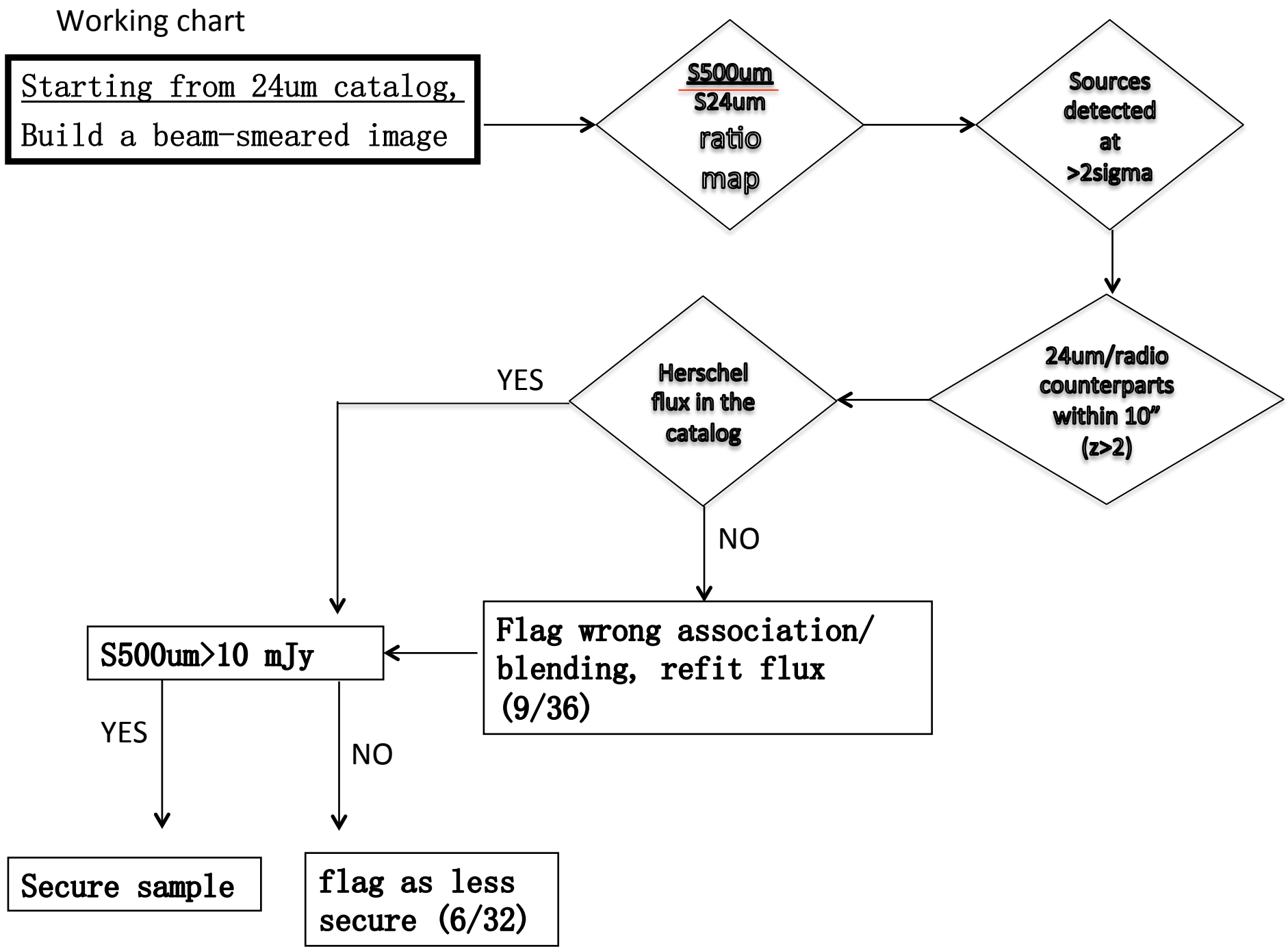


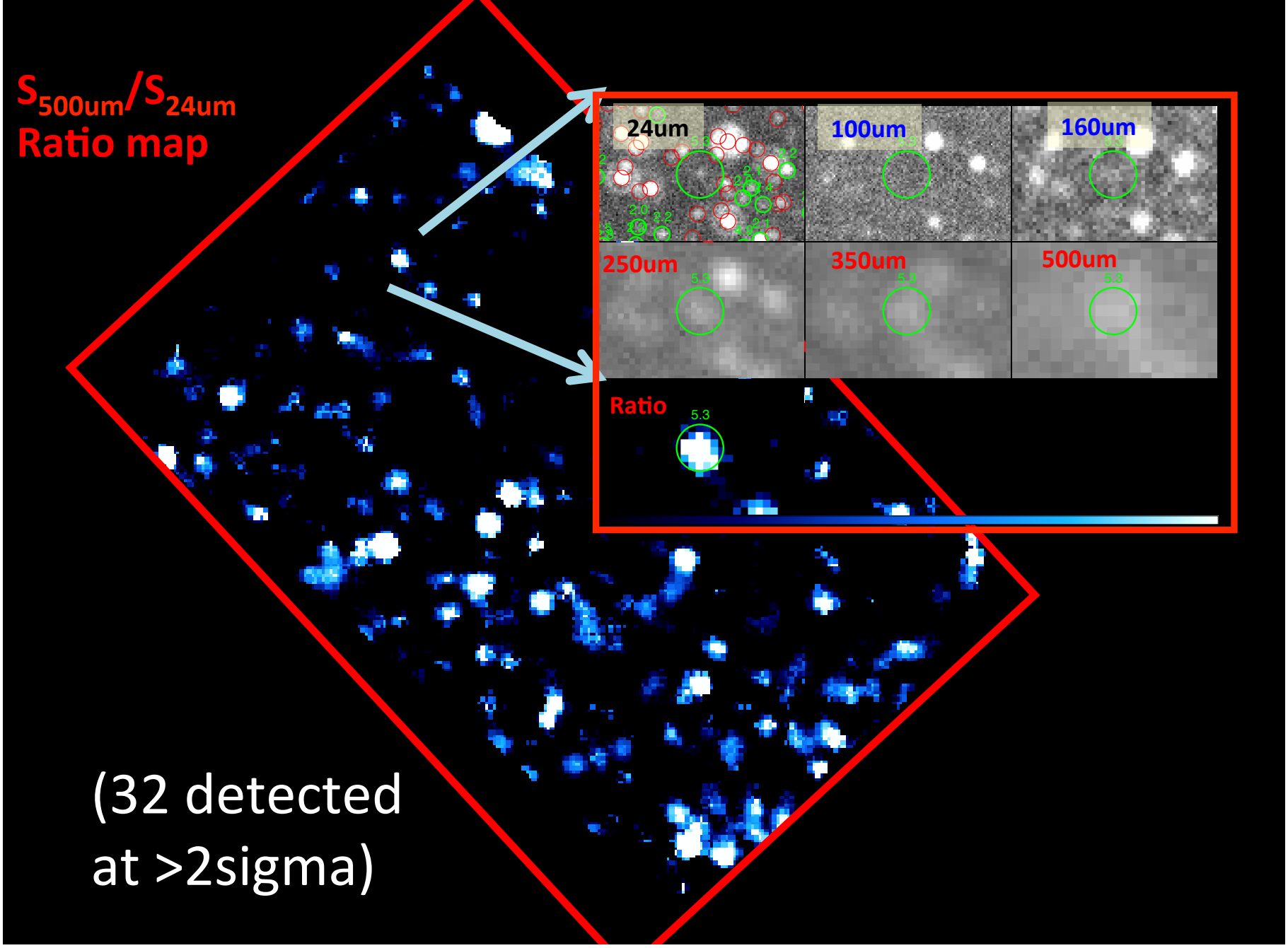

24 um original
Catalog sources
Convolve with
SPIRE PSF
Convolved image
Real 500 um map
Ratio of S_{500um}/S_{24um}*
GOODS-North Field

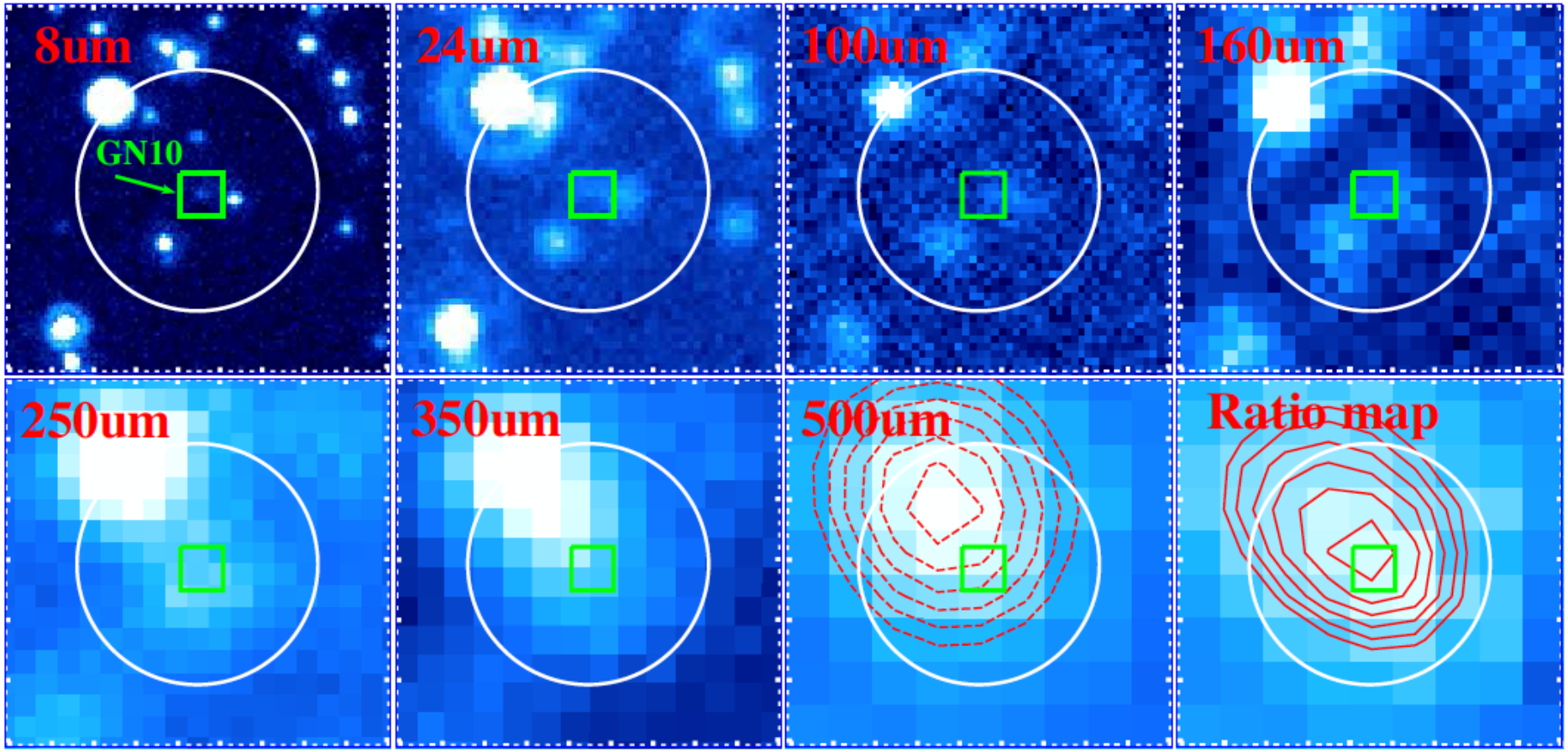

P(D) plot
& Source detection method
Red: all individual 500um sources
(>3sigma) are removed
1σ
2σ
100.0
10.0
1.0
0.1
Counts
−40
−20
0
20
40
60
80
100
S500μm/S24μm

Test on the selection efficiency, using M-C Simulations




Working chart
Starting from 24um catalog,
Build a beam-smeared image
S500um / S24um ratio map
Sources detected at >2sigma
24um/radio counterparts within 10" (z>2)
Herschel flux in the catalog
YES
NO
Flag wrong association/ blending, refit flux (9/36)
S500um>10 mJy
YES
NO
Secure sample
flag as less secure (6/32)

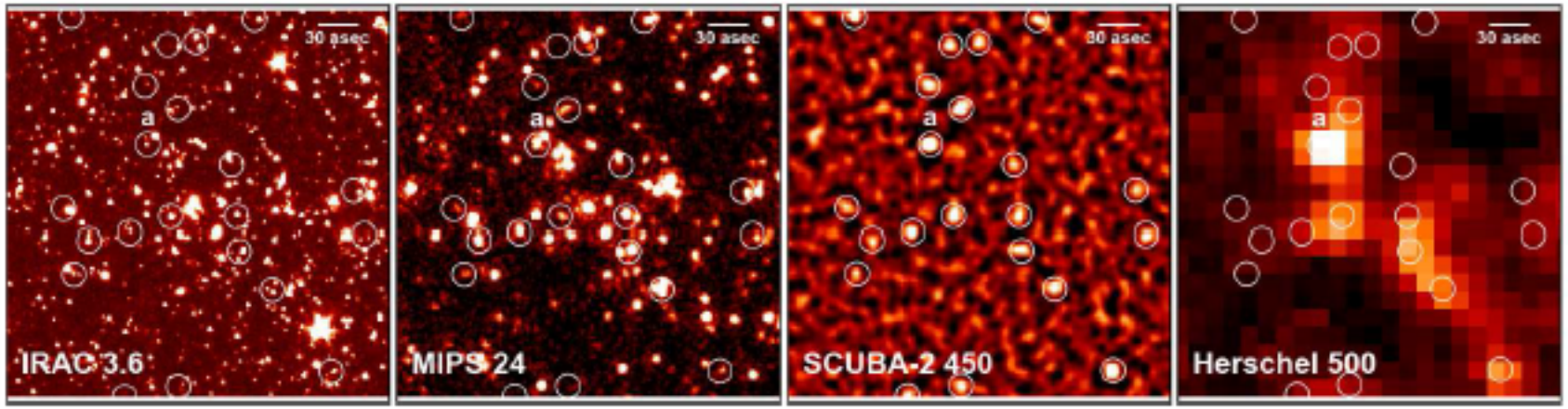

S_{500um}/S_{24um}
Ratio map
24um
100um
160um
250um
350um
500um
Ratio
5.3
(32 detected
at >2sigma)



A spectroscopically-confirmed z=4 SMG (Daddi+09),
Wrong Herschel flux association with a z=1.4 source

Validation of the method with SCUBA2 (JCMT) at 450um

Identify and study individual Herschel 500 sources at other wavelengths

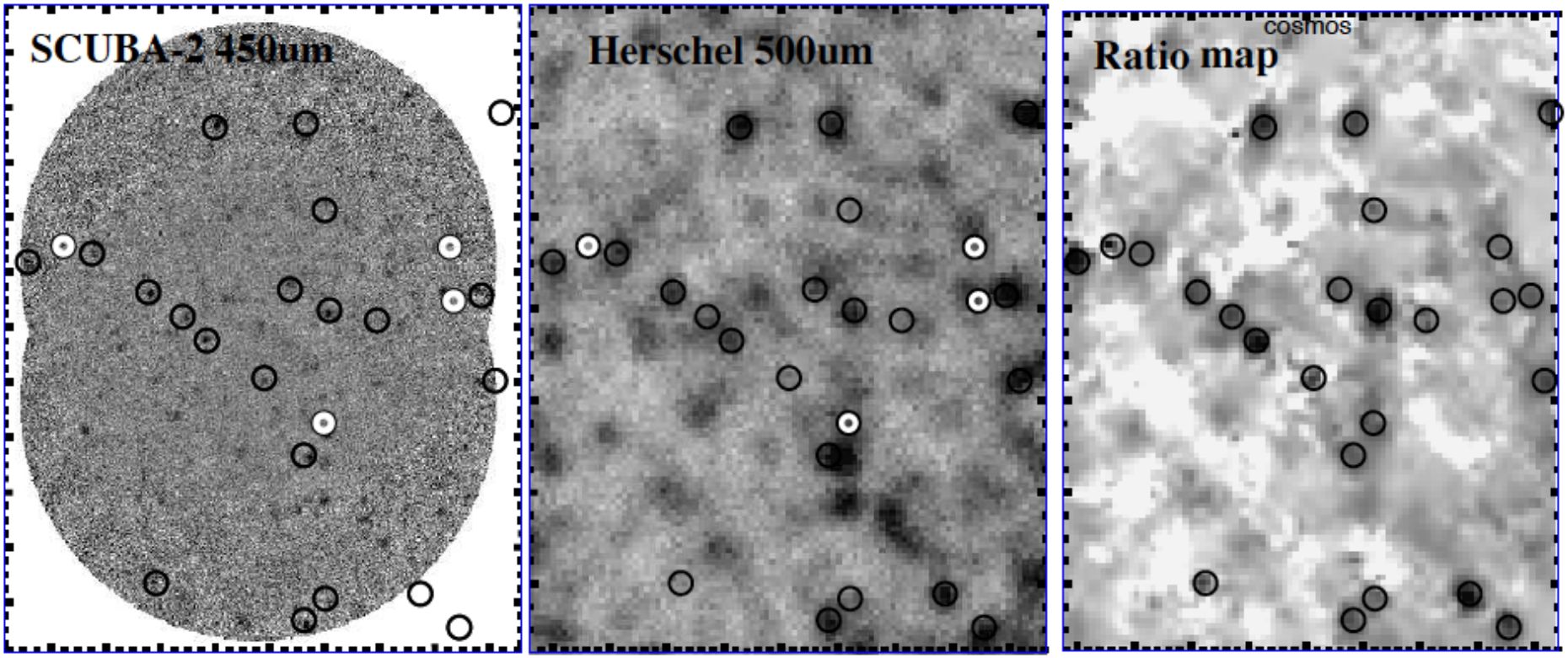


Images from J. Dunlop's talk

SCUBA2 450um: FWHM~7”

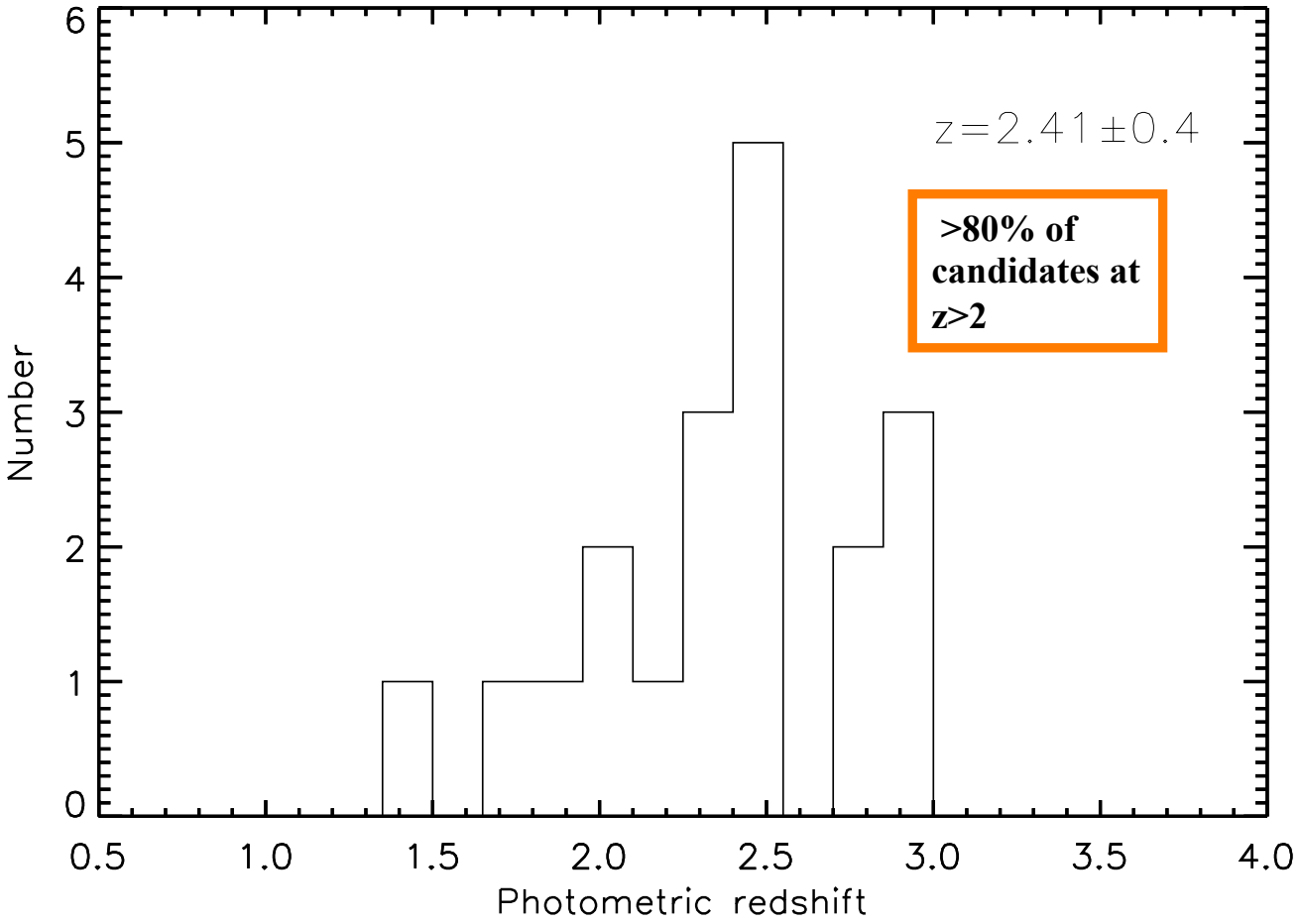
SPIRE 500um: FWHM~36”

Validation of the method with the SCUBA2 data of COSMOS



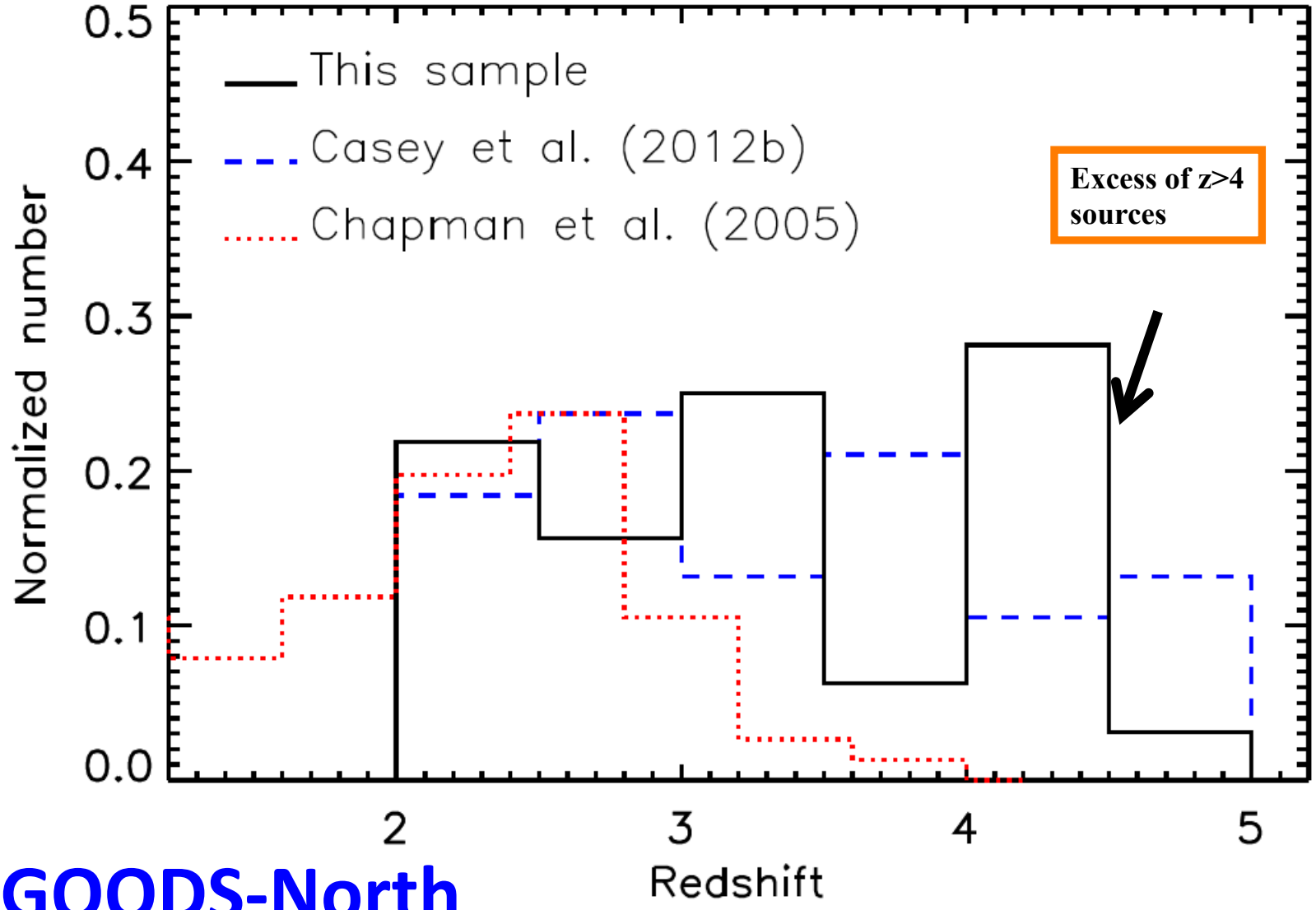
COSMOS (central field)

Validation of the method with SCUBA2

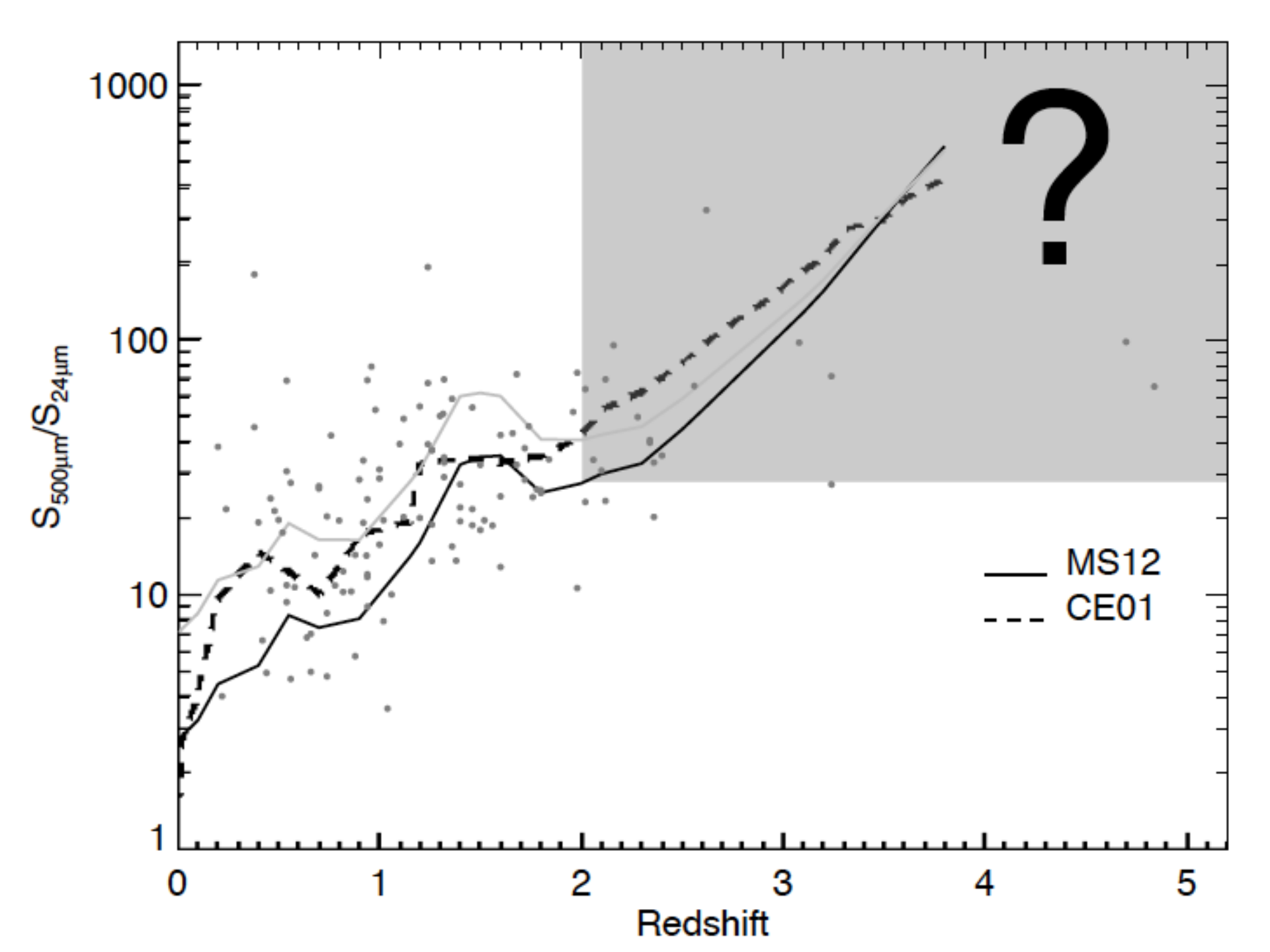


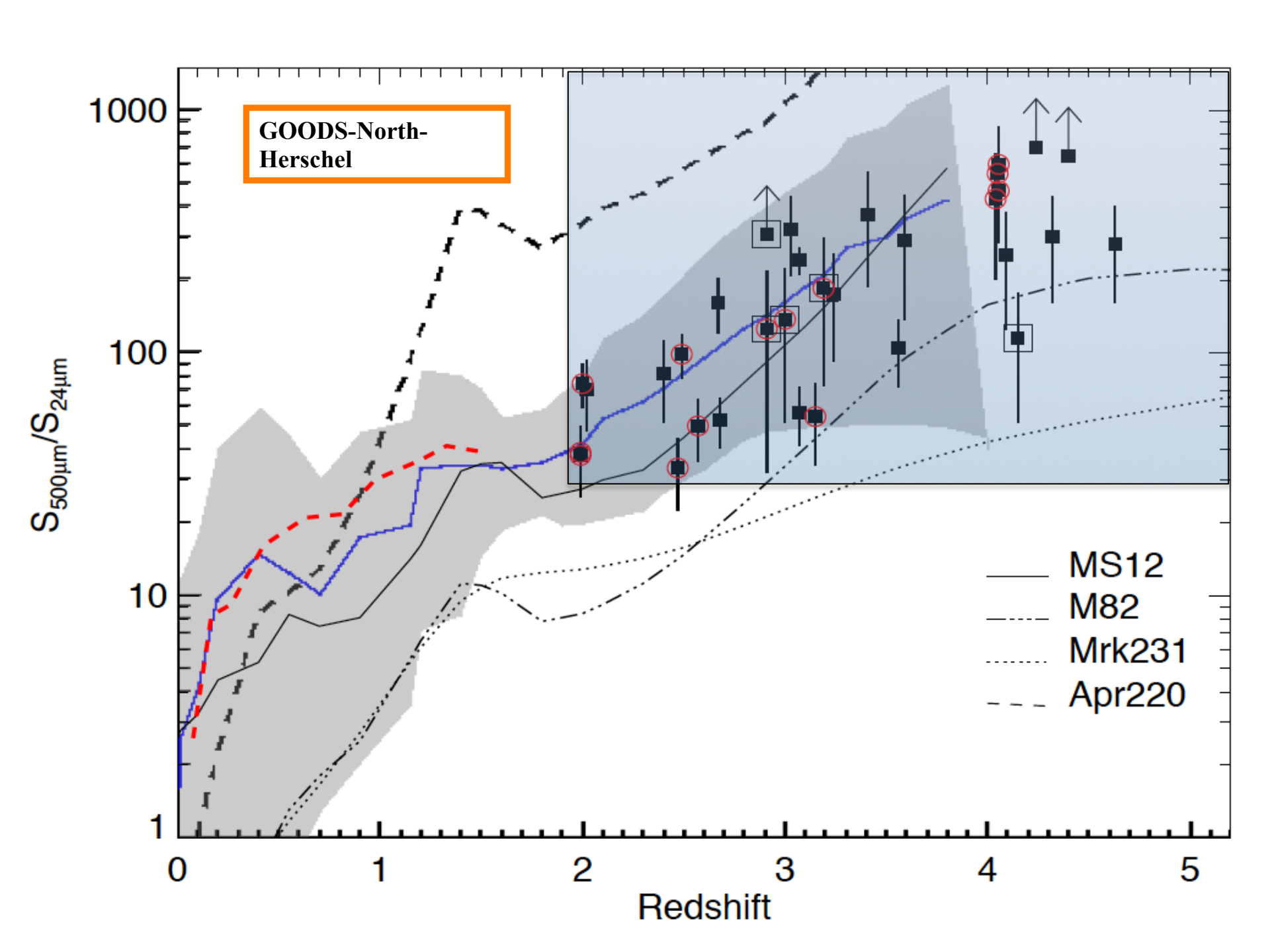
Redshift distribution of the selected candidates

Redshift distribution of z>2 galaxies selected using ***color-deconfusion***

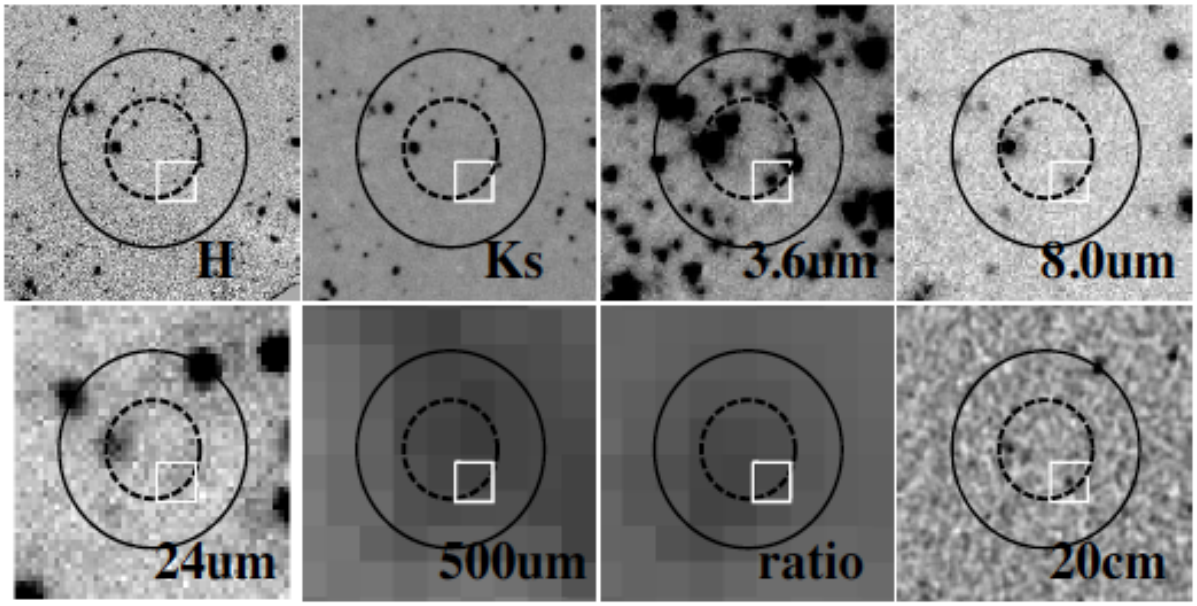


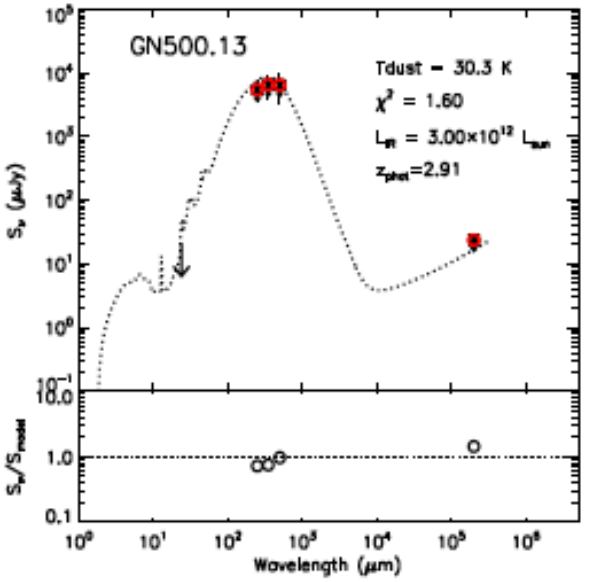
GOODS-North

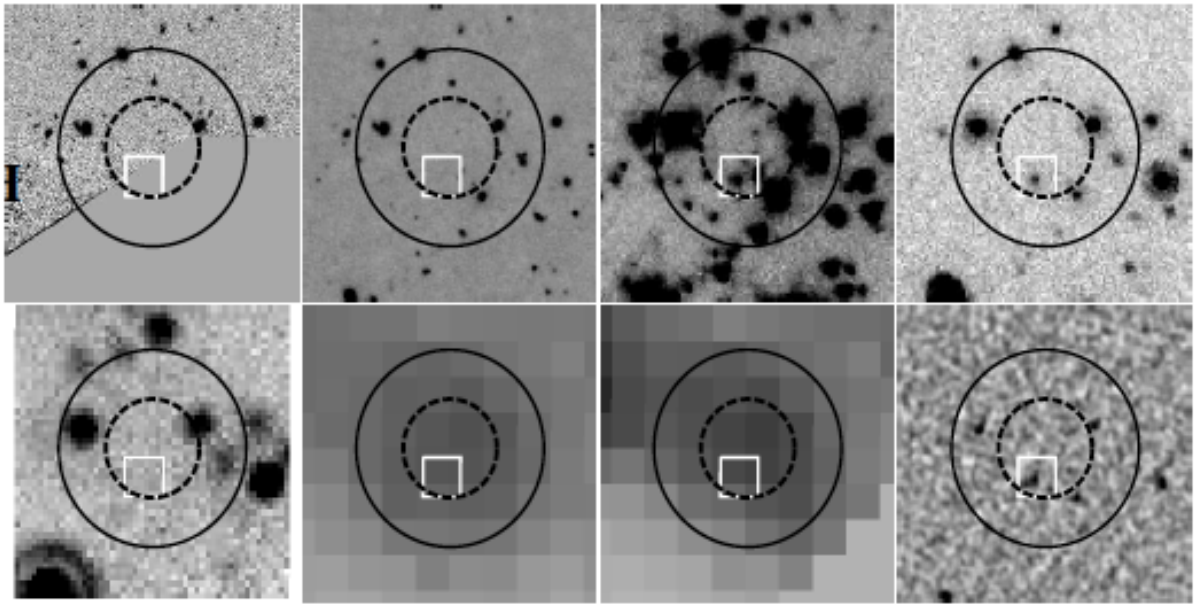

1000
100
10
1
0
1
2
3
4
5
$S_{500\mu m}/S_{24\mu m}$
Redshift
?
MS12
CE01

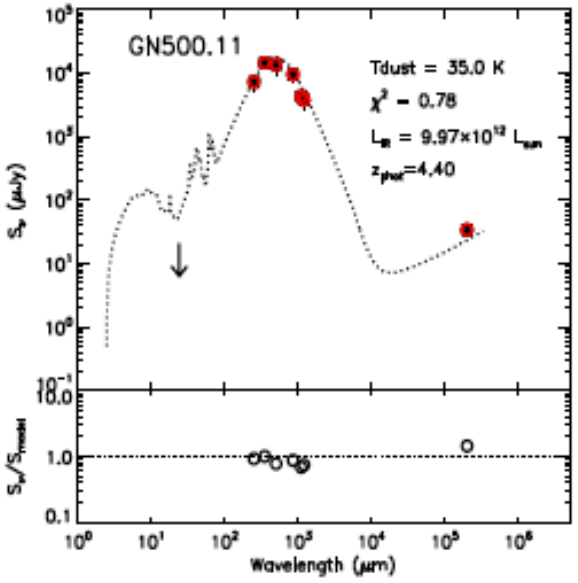

GOODS-North-
Herschel
1000
100
10
1
$S_{500\mu m}/S_{24\mu m}$
0
1
2
3
4
5
Redshift
MS12
M82
Mrk231
Apr220

24um dropouts (at z>3?)

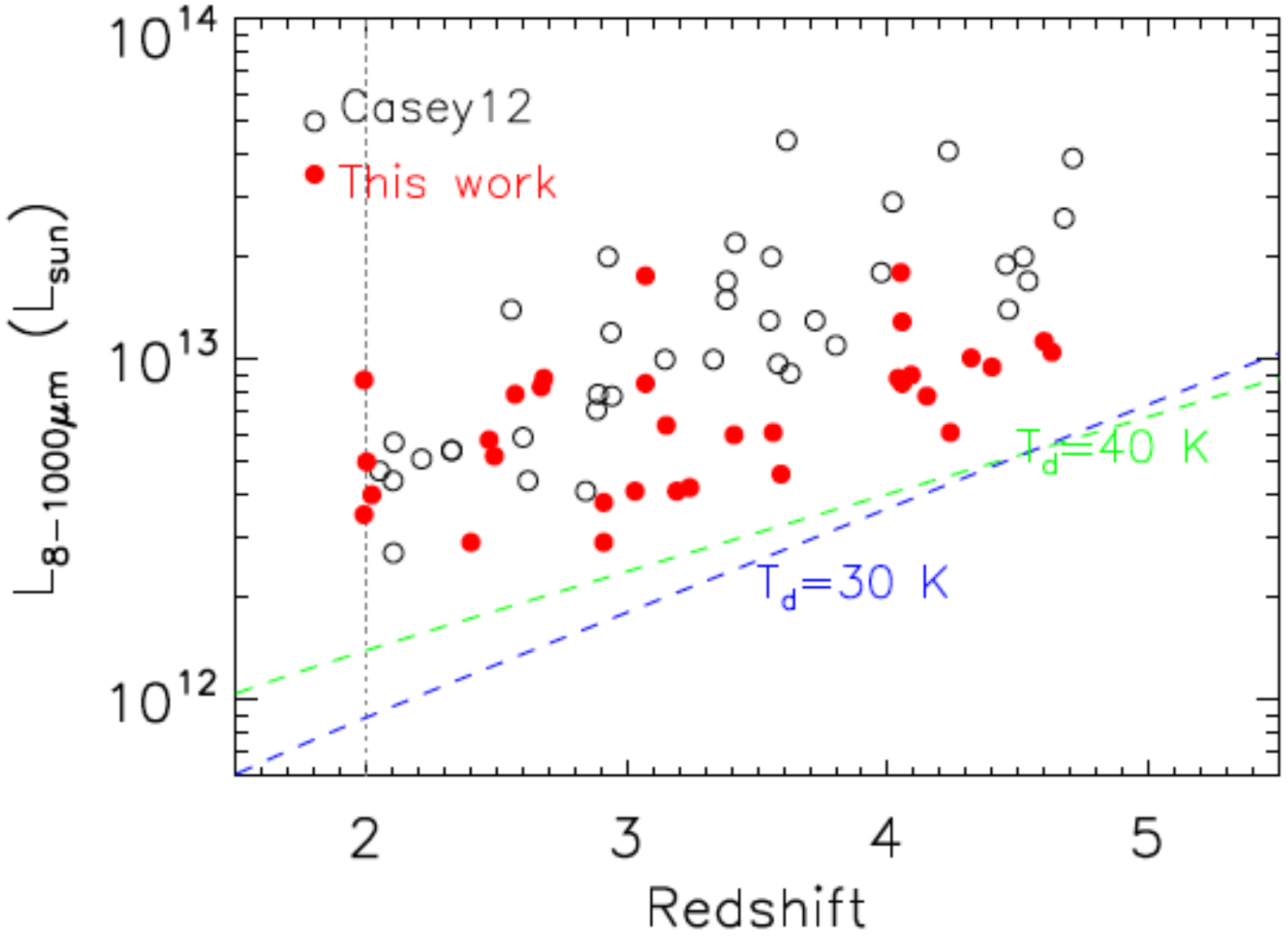




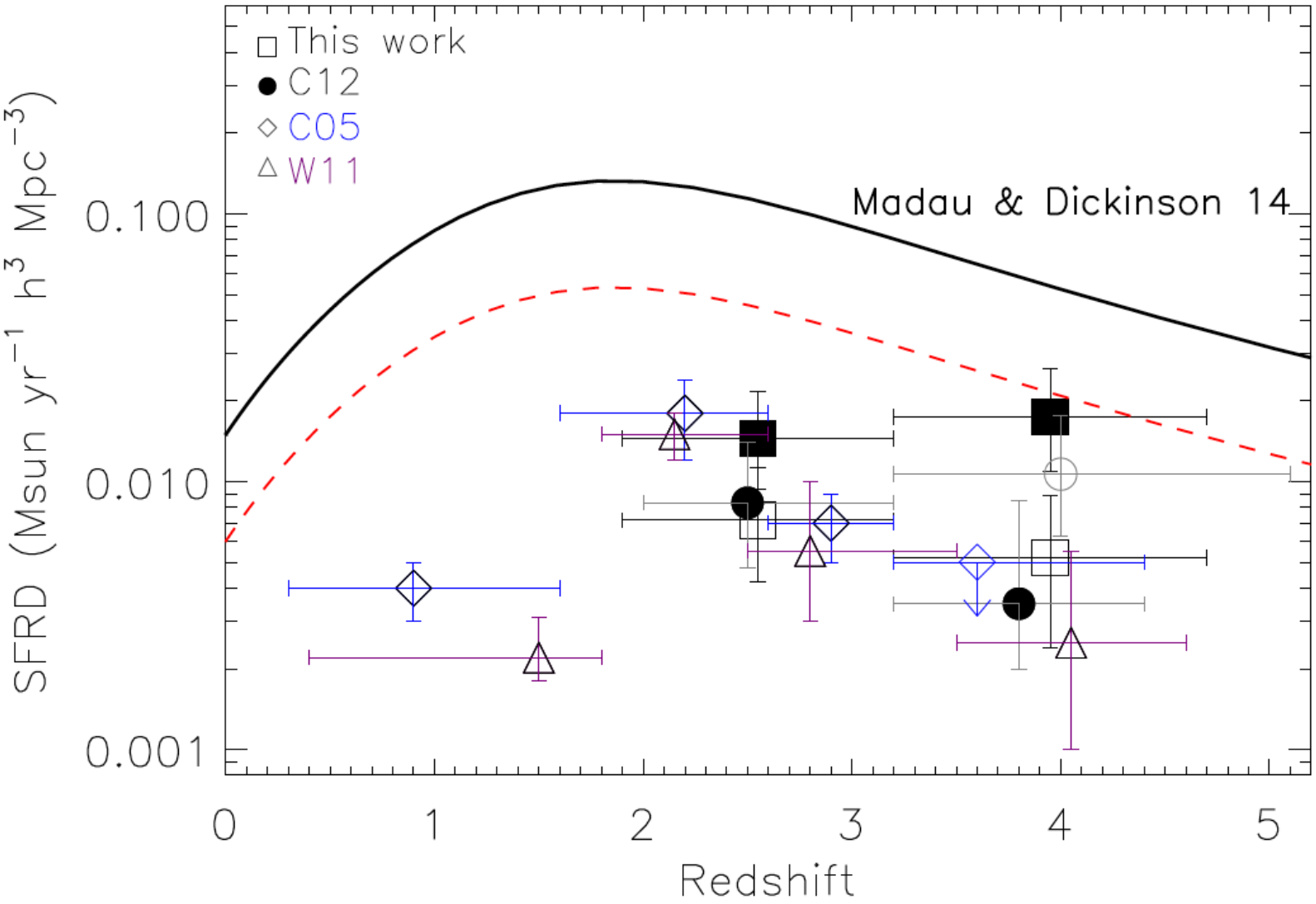




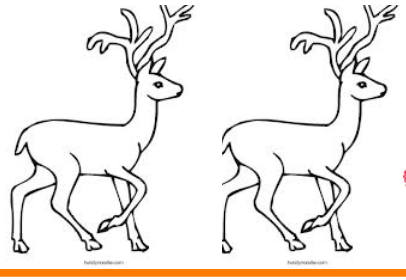
Lower FIR luminosity (0.3 dex) compared to the brighter SPIRE sources in HerMes fields, more complete?.



SFRD contribution: rising at z~4?



Take away messages to coffee-break



(1) A new method to identify Herschel counterparts using color-deconfusion

(2) Efficiency is tested with simulations and validated with SCUBA2-450um map

(3) New *high-z* Herschel sources (ULIRGs) are found, follow-up studies are on-going

(4) A less expensive approach to pin down *high-z* Herschel sources in deep fields