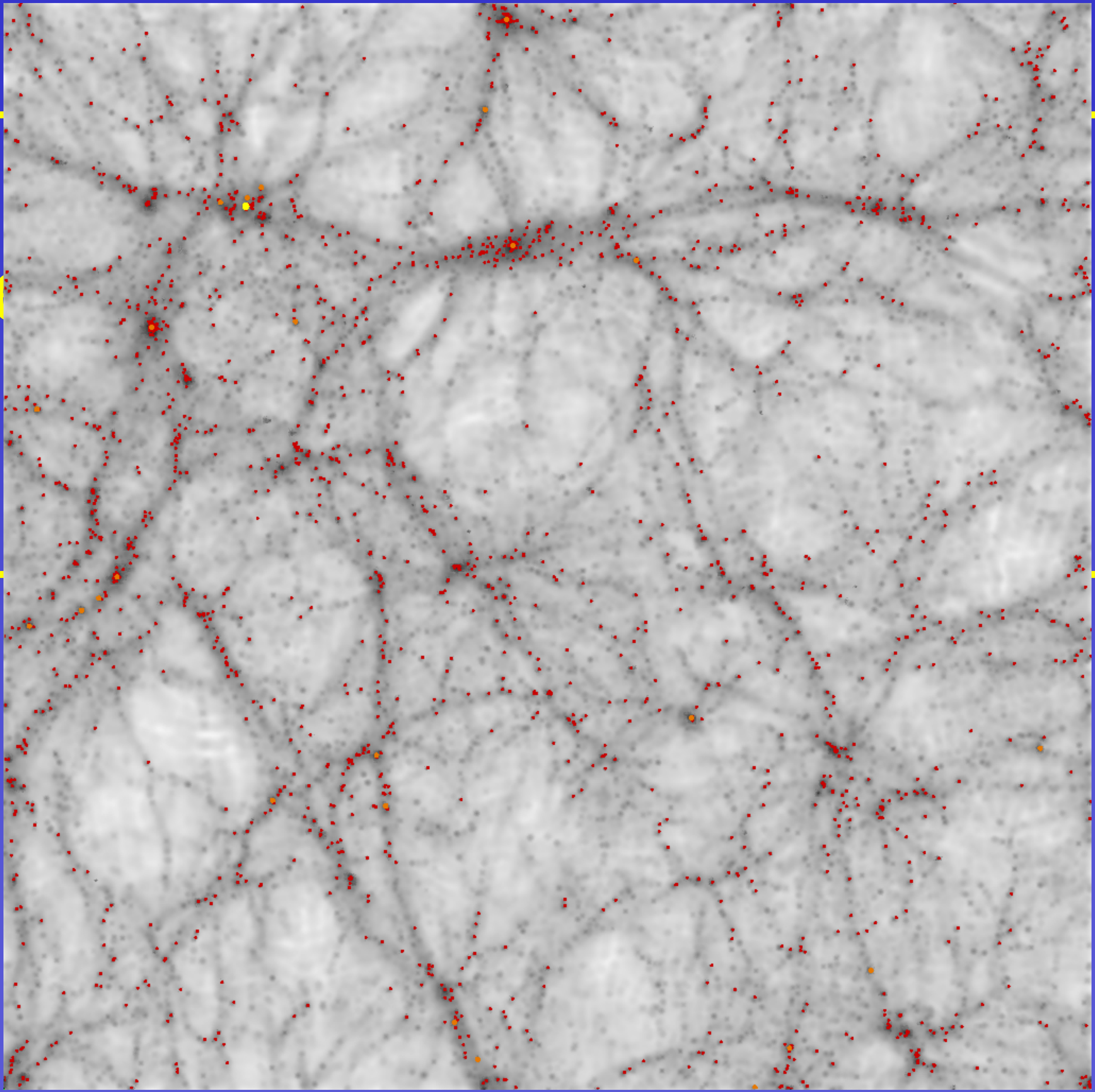
The ... of



The Background/Foreground of Infrared Galaxies

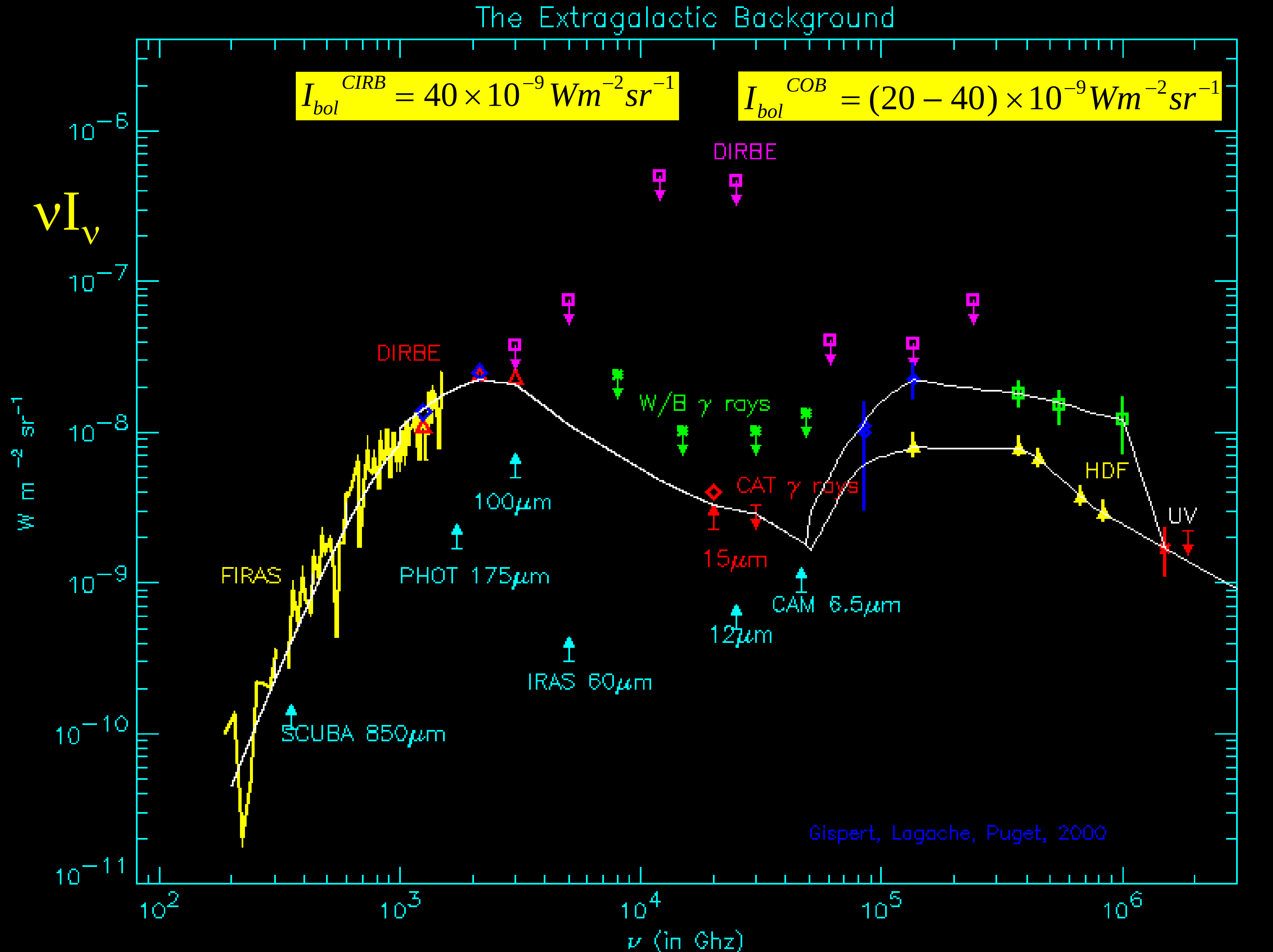
Outline of Talk

- The Cosmic Infrared Background
- Breaking the CIRB into sources : counts with ISOCAM & ISOPHOT (ISO), SCUBA (JC MT), MAMBO (IRAM)
- Properties of IR/submm galaxies : redshift distributions, luminosities, SFR, clustering, etc.
- A word on SPITZER
- Models: phenomenological and Hierarchical Galaxy Formation
- Forthcoming observational landscape with PLANCK and HERSCHEL

Observation of IR/submm Galaxies and Cosmology ?

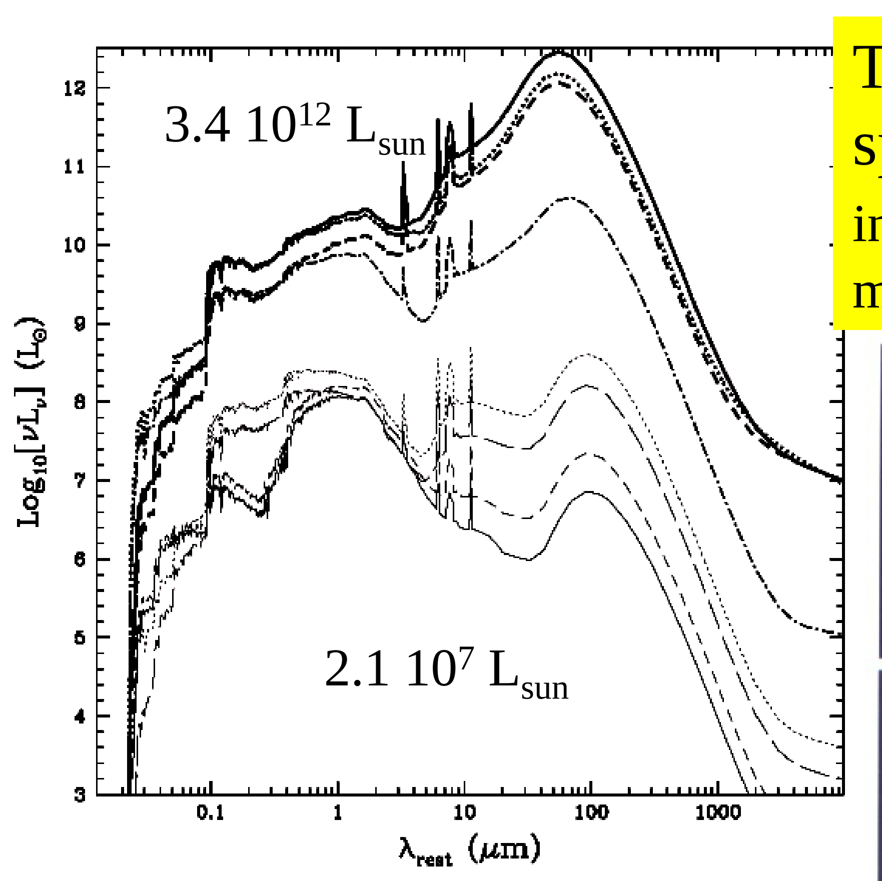
- The observation of the Cosmic IR Background is necessary for the complete test of Olbers' paradox.
- The objects that contribute to the CIRB may be the progenitors of local elliptical galaxies (test Hierarchical Galaxy Formation).
- The *background* due to dusty galaxies is a *foreground* for the observation of CMB anisotropies.
- Early phenomena (e.g. the formation of Pop III stars) are observed in the IR (redshifts z=10-30).

The CIRB

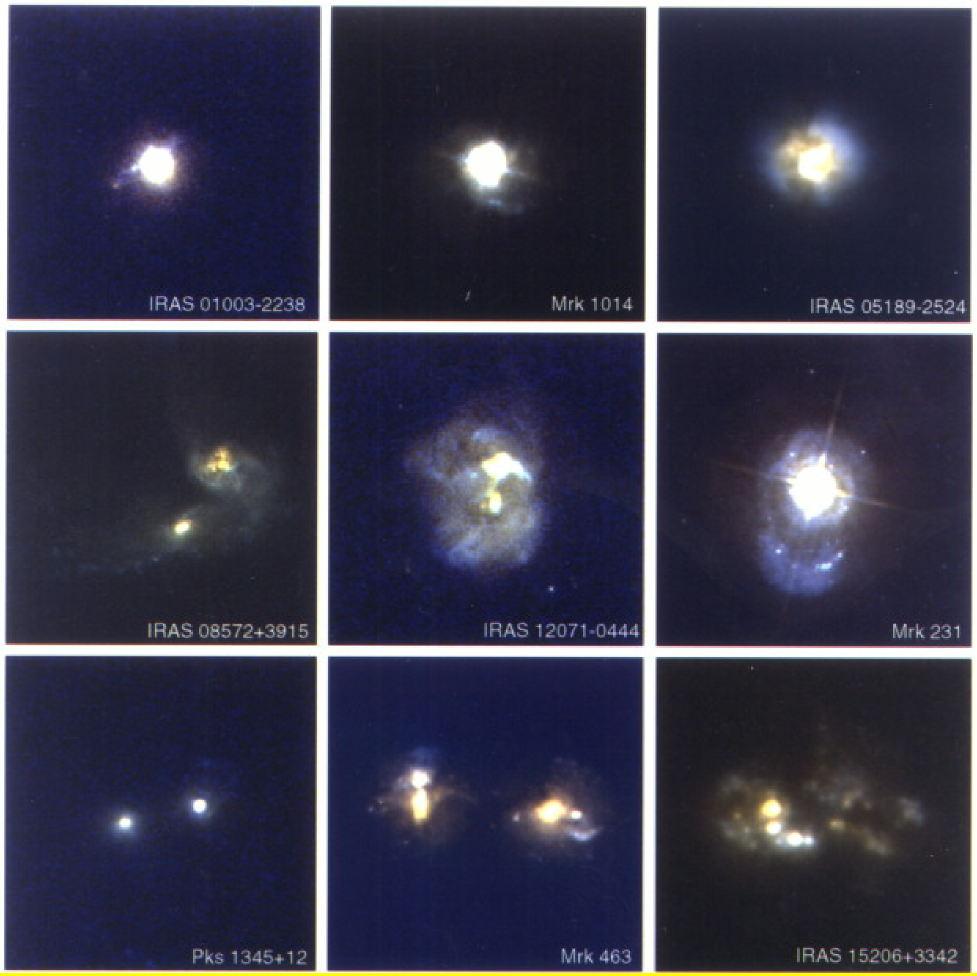


The Extragalactic Background
$I_{bol}^{CIRB} = 40 \times 10^{-9} Wm^{-2} sr^{-1}$
$I_{bol}^{COB} = (20 - 40) \times 10^{-9} Wm^{-2} sr^{-1}$
νI_ν
W m^{-2} sr^{-1}
DIRBE
DIRBE
W/B γ rays
CAT γ rays
HDF
UV
FIRAS
100μm
PHOT 175μm
15μm
CAM 6.5μm
12μm
IRAS 60μm
SCUBA 850μm
Gispert, Lagache, Puget, 2000
ν (in Ghz)

The IR luminosity sequence from spirals to LIRGs (10^{11} —10^{12} L_{sun}, interacting) and ULIRGs (>10^{12} L_{sun} mergers, starburst powered for < 3 10^{12} L_{sun})



Locally, 30 % of bolometric luminosity emitted in IR. ULIRGs contribute only 2 % of local IR luminosity density



Morphologies of ULIRGs (Surace et al. 1998)

Black Hole Growth and the Cosmic Background

$$I_{bol} = \frac{c}{4\pi}\eta_{BH}\int\frac{\dot{\rho}_{BH}c^2}{1+z}dt = \frac{c}{4\pi}\frac{0.1\rho_{BH}(0)c^2}{1+z_{eff}}$$

Census of BH mass density from the local luminosity density :

$$\rho_B(0) = (9.0 \pm 1.4)10^7\, L_{Bsun}\, Mpc^{-3}$$

1/3 from E ; $\frac{M}{L_B} = 6\frac{M_{sun}}{L_{Bsun}}$ and $M_{BH} = 0.005M$ Magorrian et al. 1998

$$\rho_{BH}(0) = 9 \times 10^5\, M_{sun} Mpc^{-3}$$

$$I_{bol} = \frac{14}{1+z_{eff}}10^{-9}\, Wm^{-2}sr^{-1}$$

$z_{eff} \approx 2.5$ → $I_{bol} = 4 \times 10^{-9}\, Wm^{-2}sr^{-1}$

Stellar Nucleosynthesis and the Cosmic Background

$$I_{bol} = \frac{c}{4\pi}\left(\frac{\Delta Y}{\Delta Z}\eta_Y + \eta_Z\right)\int \frac{\dot{\rho}_Z c^2}{1+z}dt = \frac{c}{4\pi}\frac{0.03\rho_Z(0)c^2}{1+z_{eff}}$$

Census of local metal density from the local luminosity density :

$$\rho_B(0) = (9.0 \pm 1.4)10^7\, L_{Bsun}\, Mpc^{-3}$$

2/3 from Sp ; $\frac{M}{L_B} = 2\frac{M_{sun}}{L_{Bsun}}$ and $Z \approx 0.02$

1/3 from E ; $\frac{M}{L_B} = 6\frac{M_{sun}}{L_{Bsun}}$ and $Z \approx 0.03$ +0.02 for metals in IGM

$\frac{M_Z}{L_B} = 0.3\frac{M_{sun}}{L_{Bsun}}$ (Mushotzky & Loewenstein 1997)

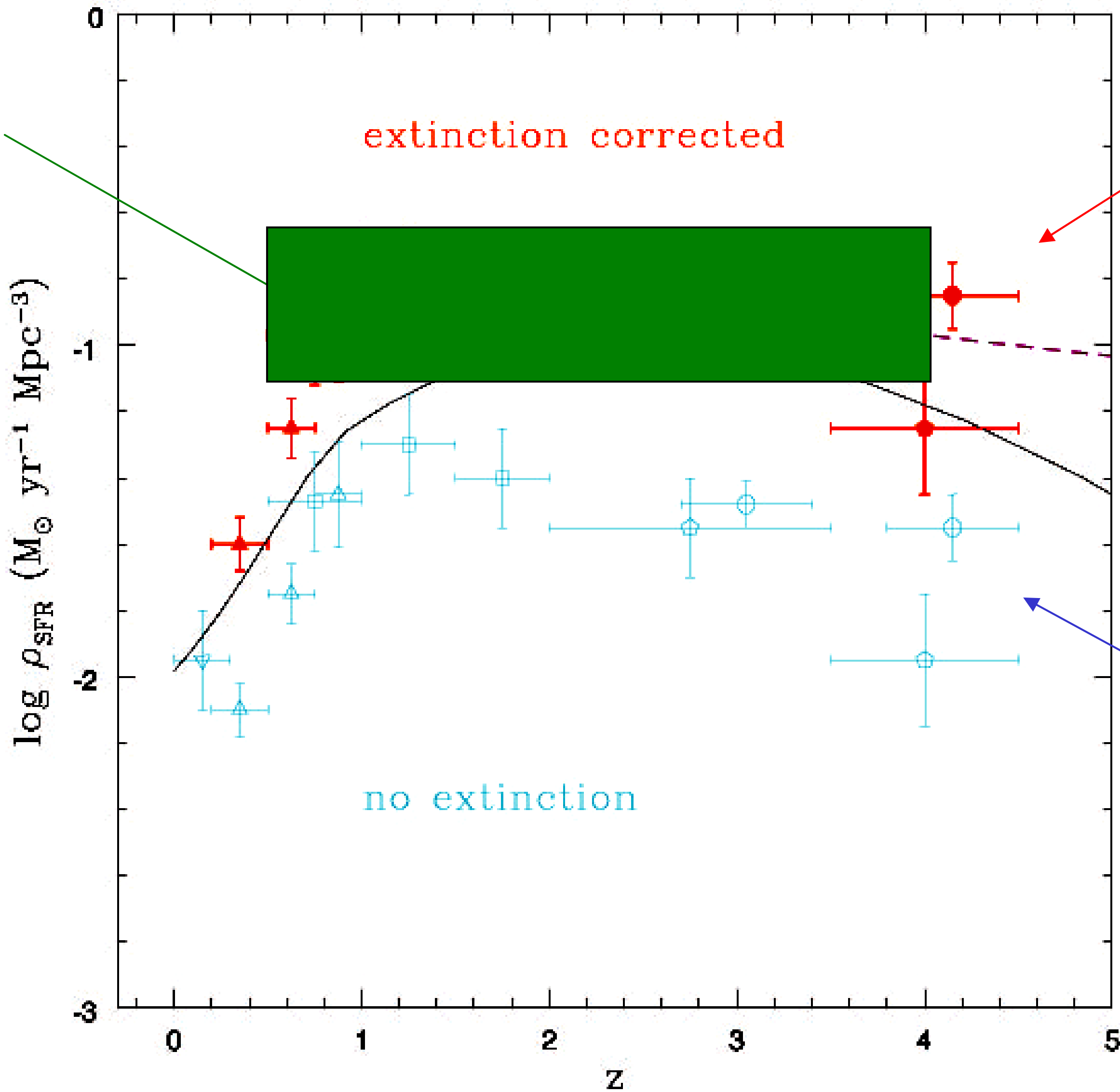
$\Rightarrow$ $\rho_Z(0) = 1.1 \times 10^7\, M_{sun} Mpc^{-3}$

$\Rightarrow$ $I_{bol} = \frac{50}{1+z_{eff}} 10^{-9} Wm^{-2} sr^{-1}$

$z_{eff} \approx 1.5$ $\Rightarrow$ $I_{bol} = 20 \times 10^{-9}\, Wm^{-2} sr^{-1}$

The Cosmic Star Formation History

IR and submm counts sources



LBGs corrected for dust

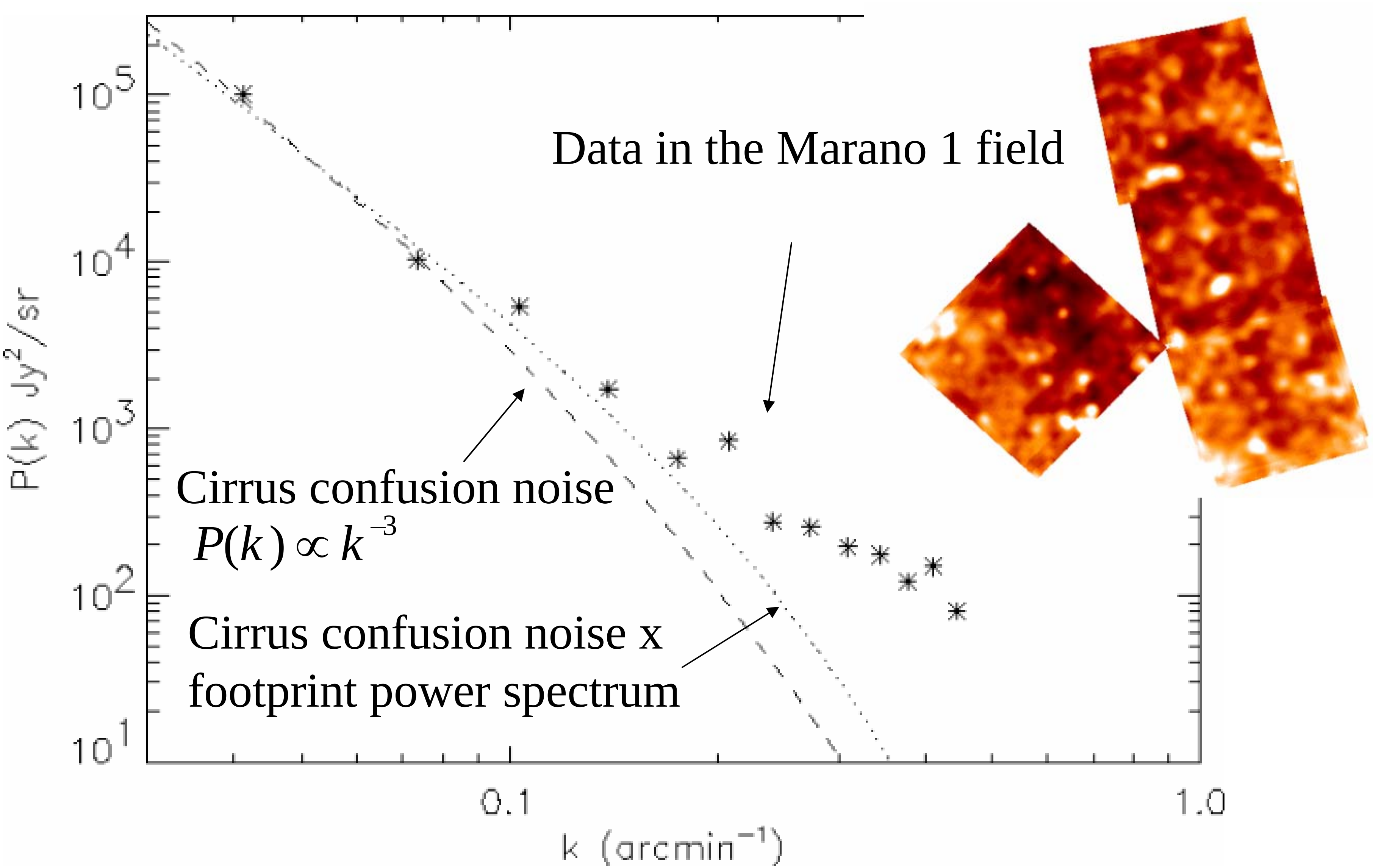
Deconvolved CIRB

SAM

Uncorrected LBGs

Gispert et al. 2000, Chary & Elbaz 2001, etc.

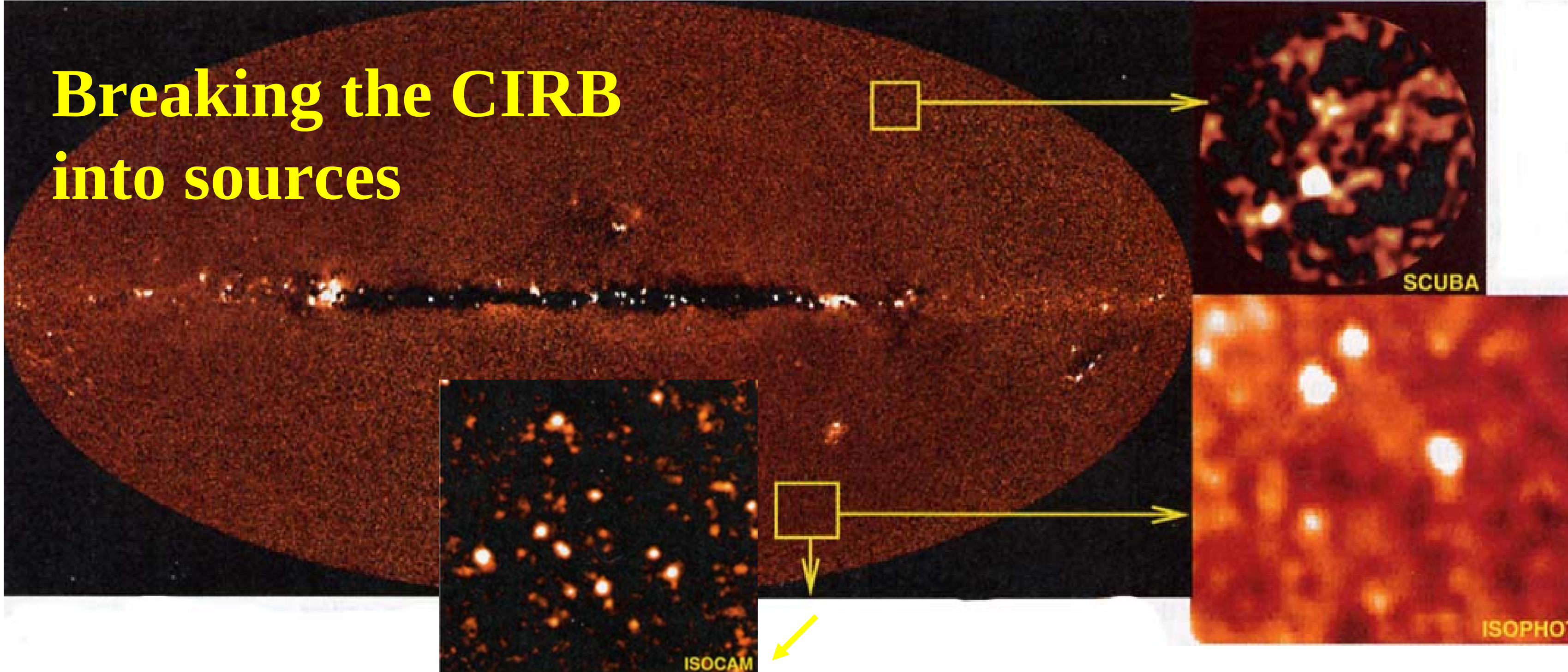
CIRB fluctuations in ISO (170 μm) and IRAS (60 & 100 μm) surveys



Lagache & Puget 2000, Matsuhara et al. 2000, Miville-Deschenes et al. 2003

Faint Galaxy Counts

Breaking the CIRB into sources

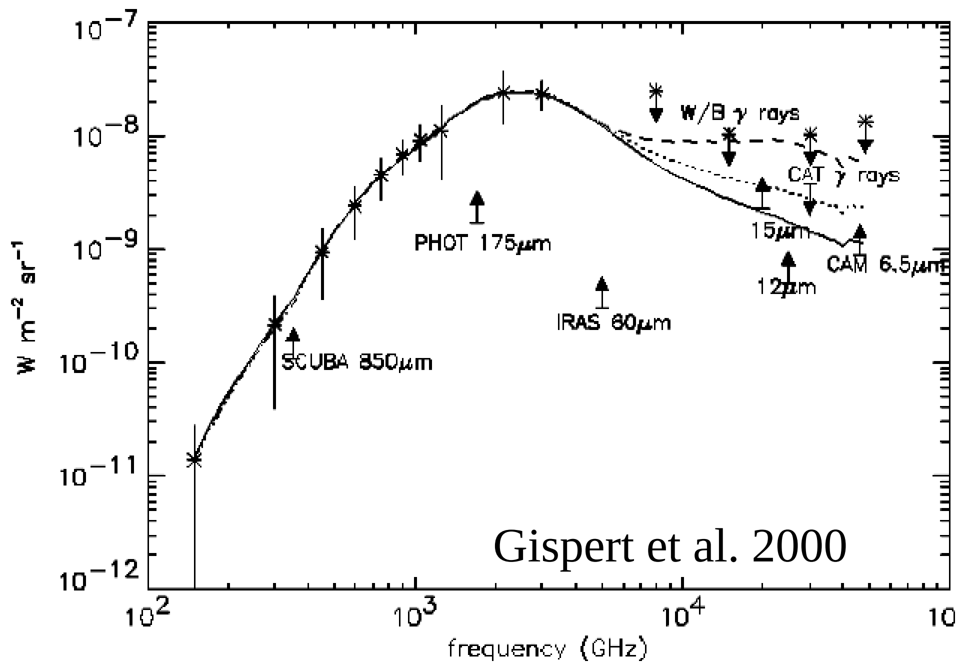


•ISOCAM (15 μm) : 70 % @ S_ν>30 μJy

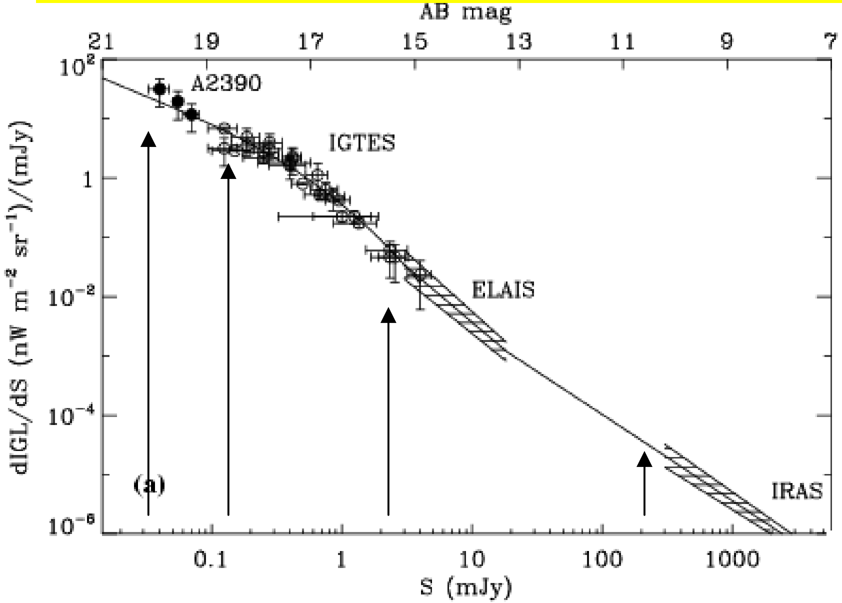
•ISOPHOT (175 μm) : 5 % @ S_ν>200 mJy (Puget et al. 1999, Dole et al. 2000)

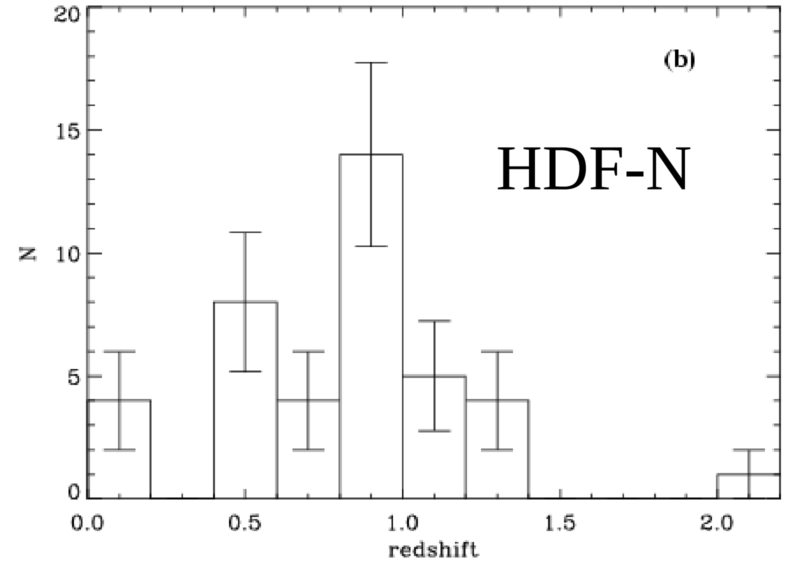
•JCMT/SCUBA (850 μm) : 40 to 80 % @ S_ν>2 mJy to 0.3 mJy (Smail et al. 1997, Hughes et al. 1998, Eales et al. 1998, Cowie et al. 2002, etc.)

•IRAM/MAMBO (1200 μm) : 30 % @ S_ν>2 mJy (Carilli et al. 2000, Bertoldi et al. 2000)

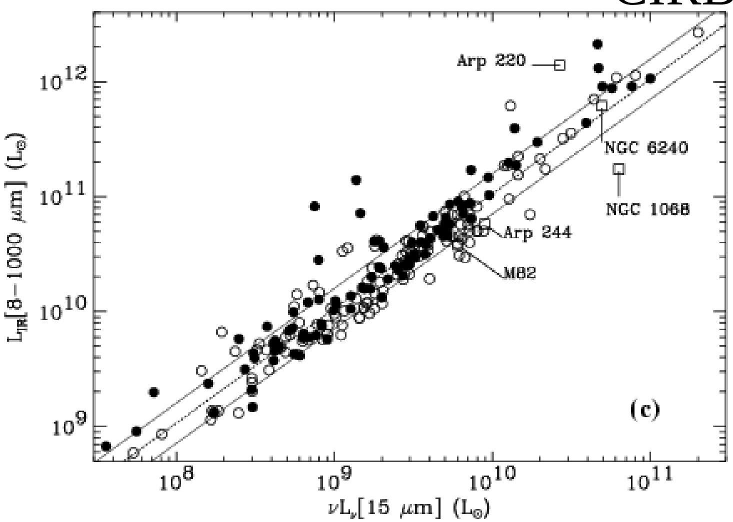


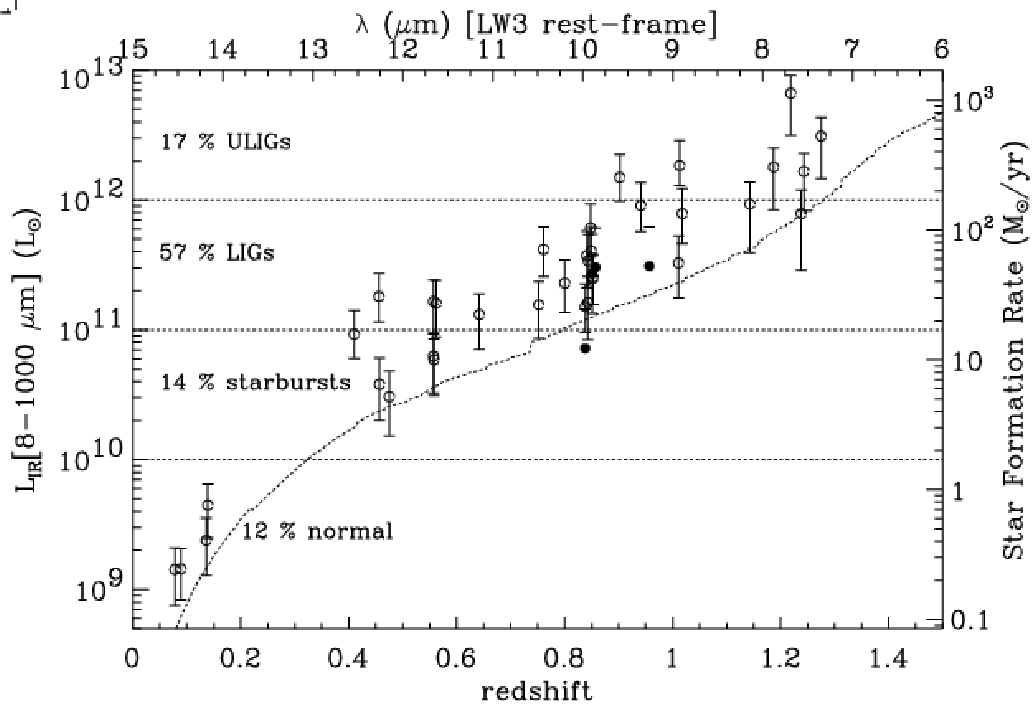
ISOCAM 15 μm Galaxies
(Elbaz et al. 2002)





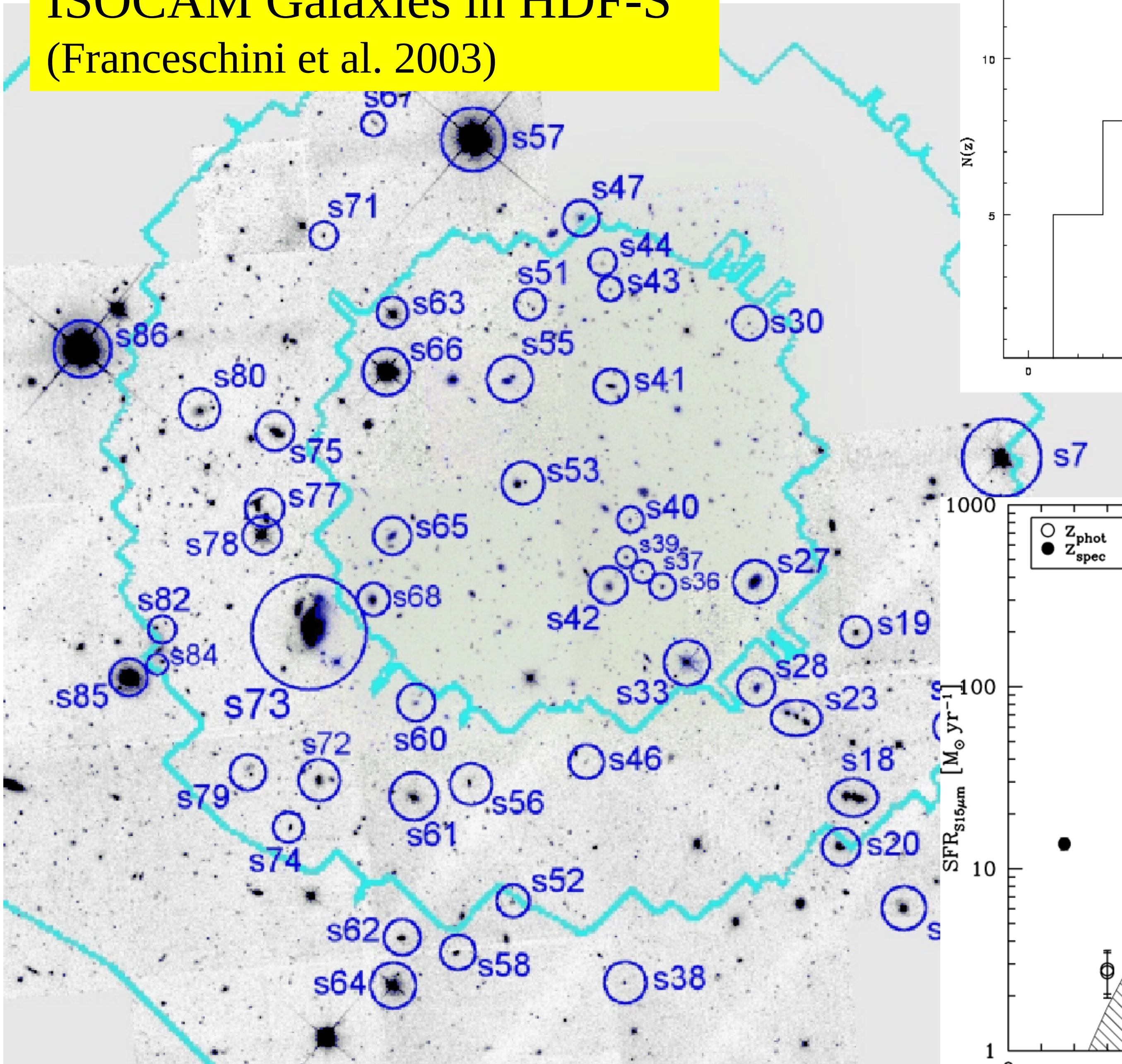
77 % 54 % 6 % 0.5 % of CIRB

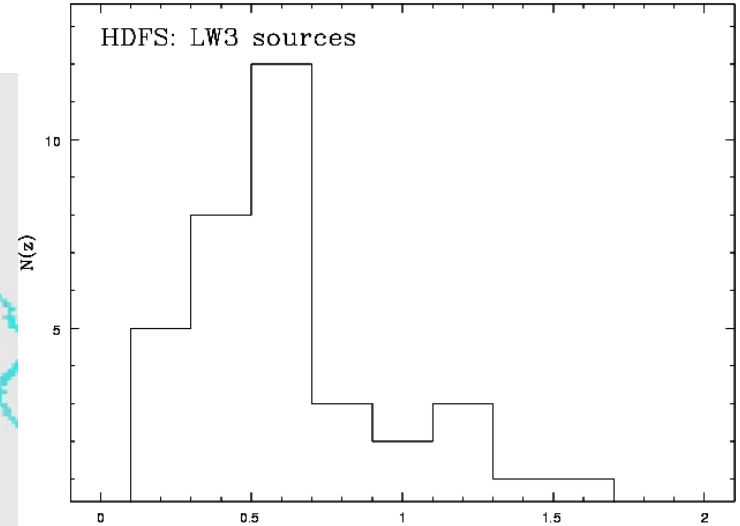




ISOCAM Galaxies in HDF-S

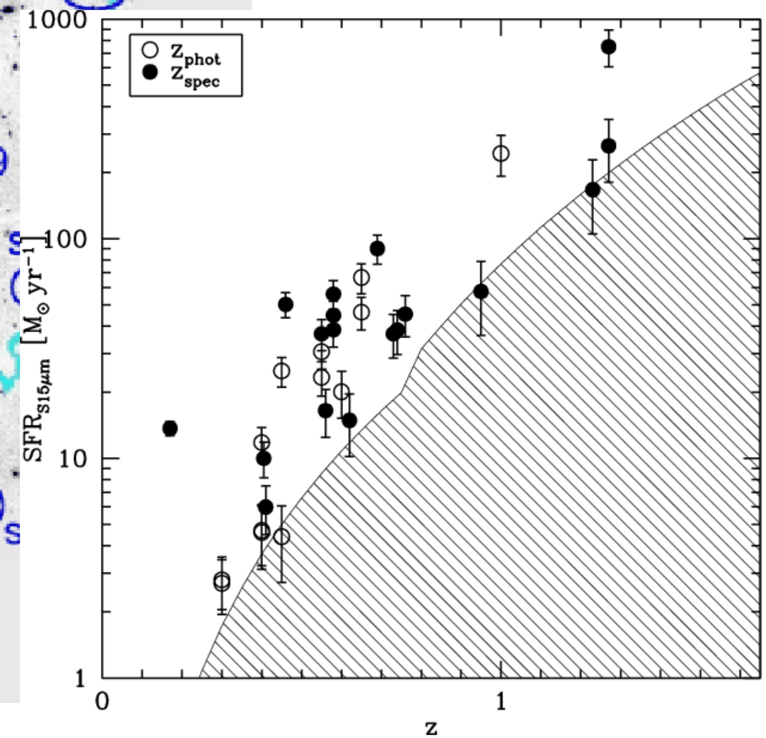
(Franceschini et al. 2003)

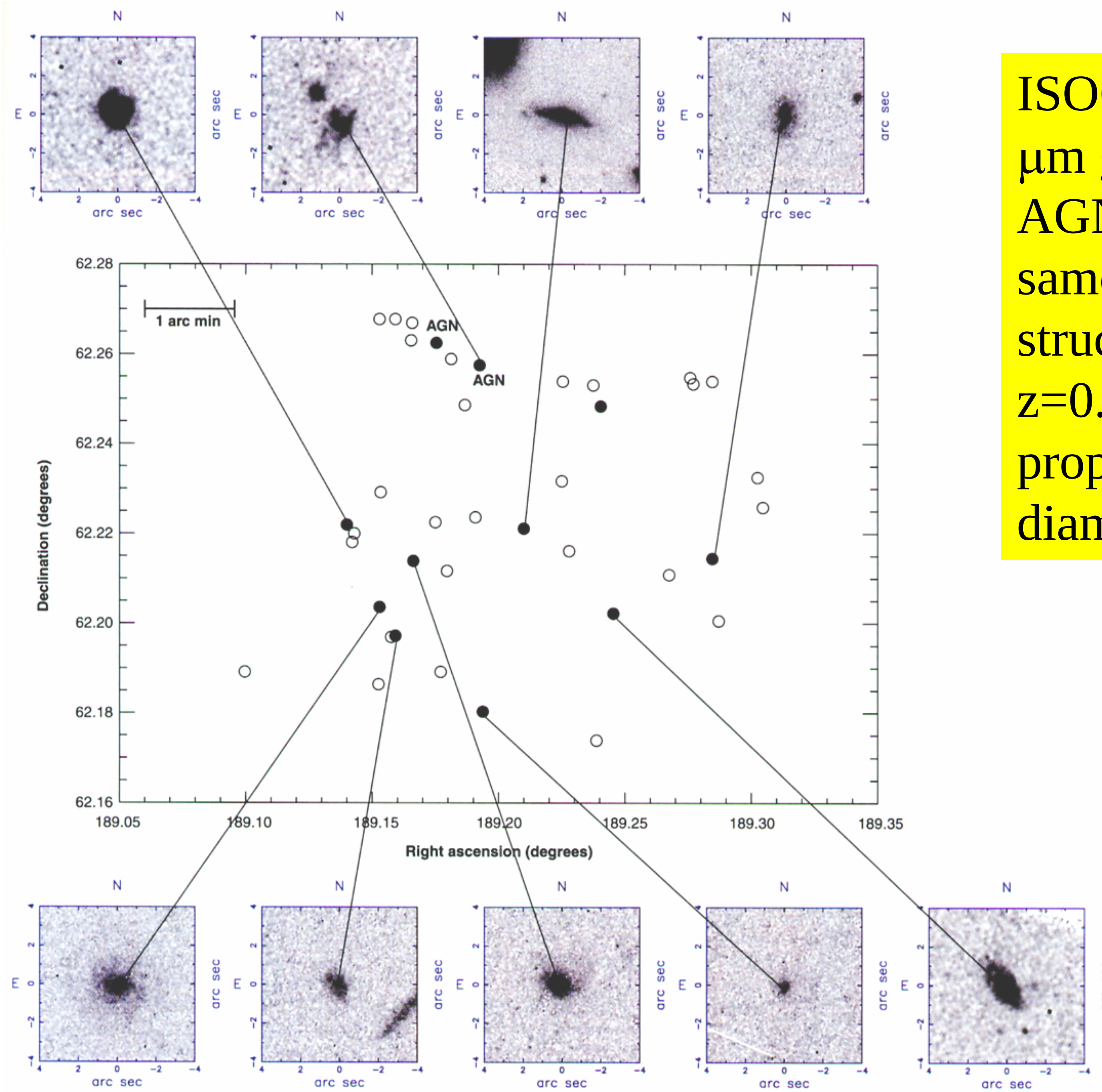




1

z



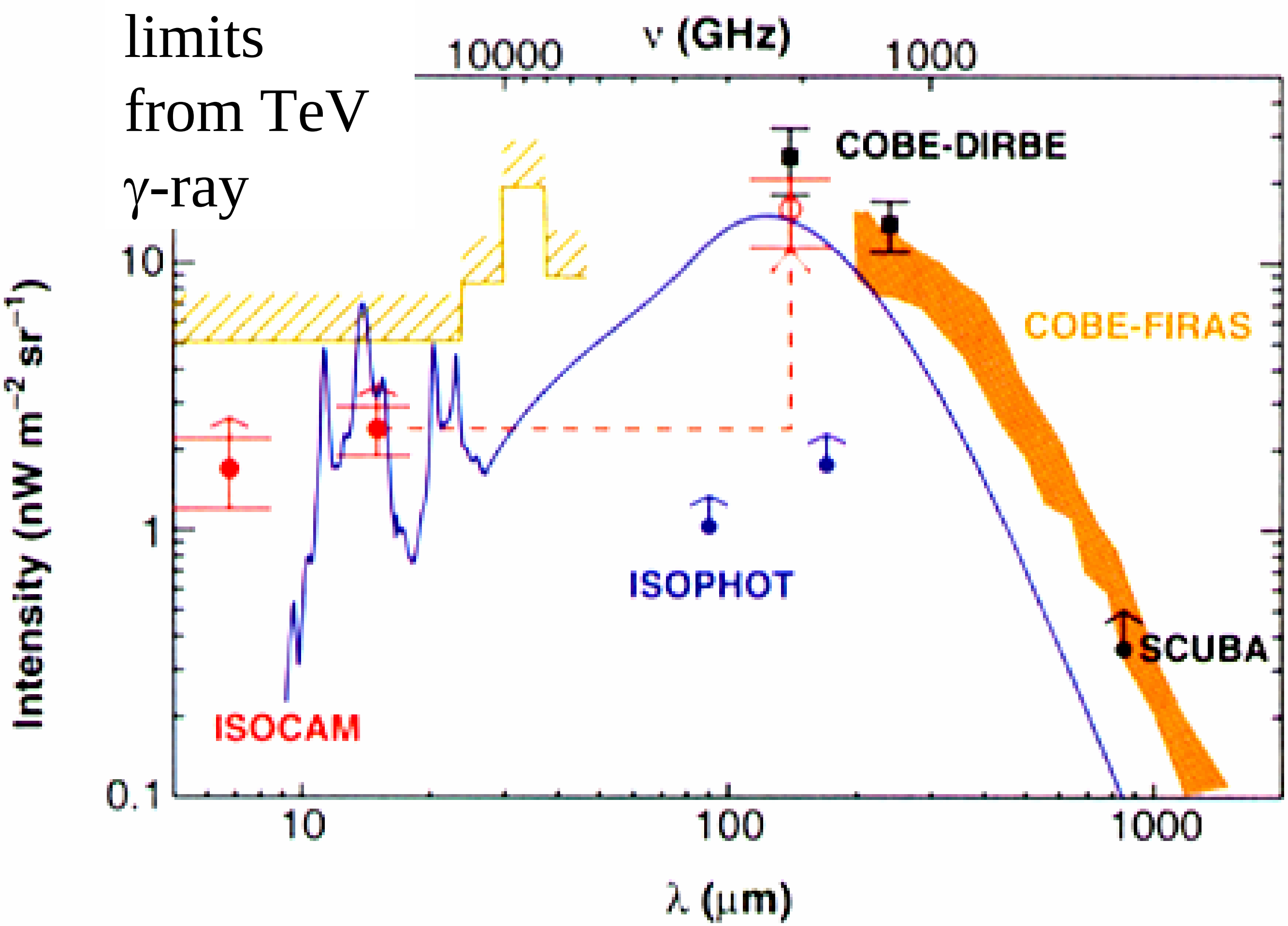


ISOCAM 15 μm galaxies and AGNs share the same large-scale structure @ z=0.848 (3 Mpc proper diameter)

Elbaz and Cesarsky 2003

Galaxies detected by ISOCAM at 15 μm (> 30 μJy) at z ~ 0.8 should contribute significantly to the CIRB at 140 μm

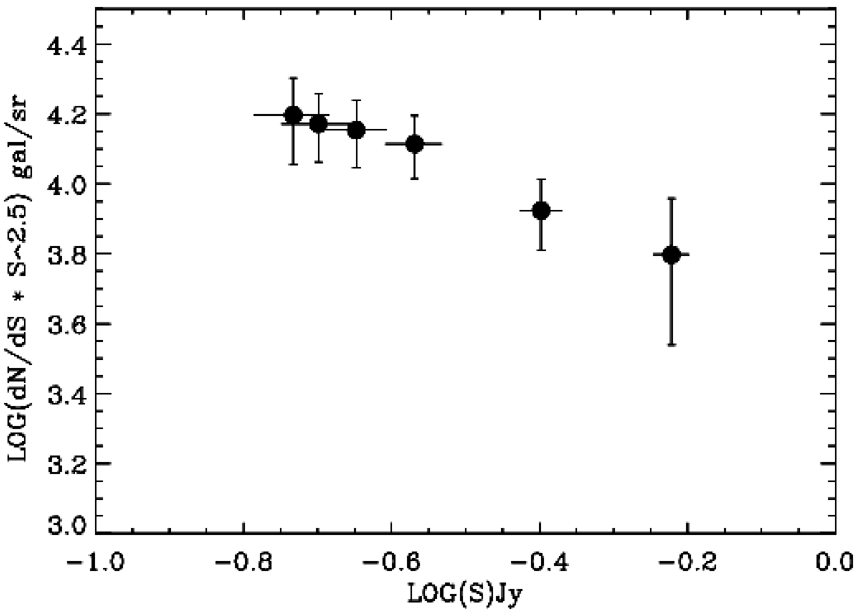
Upper limits from TeV γ-ray

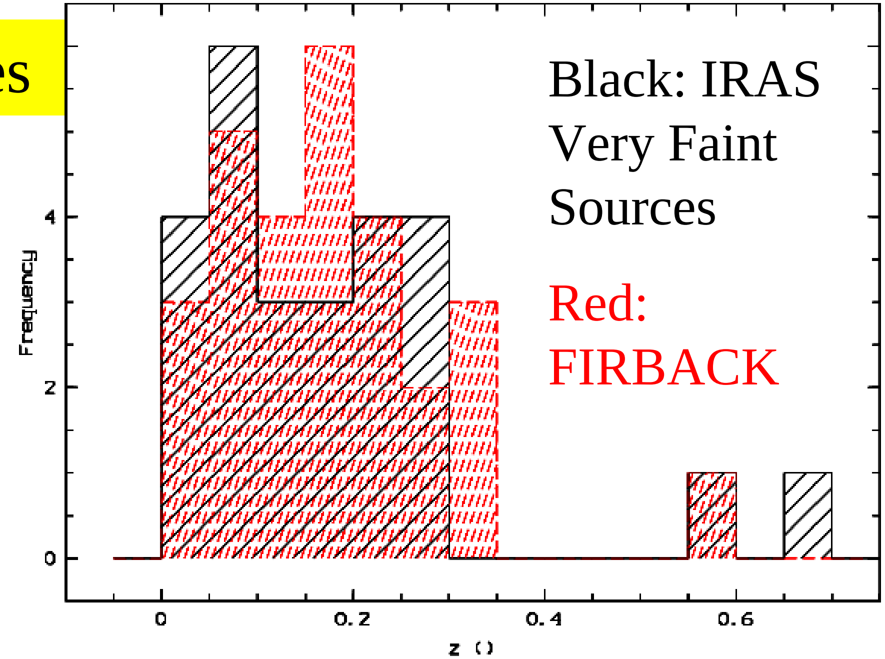


Slope of CIRB is shallower than β=2: higher-redshift sources

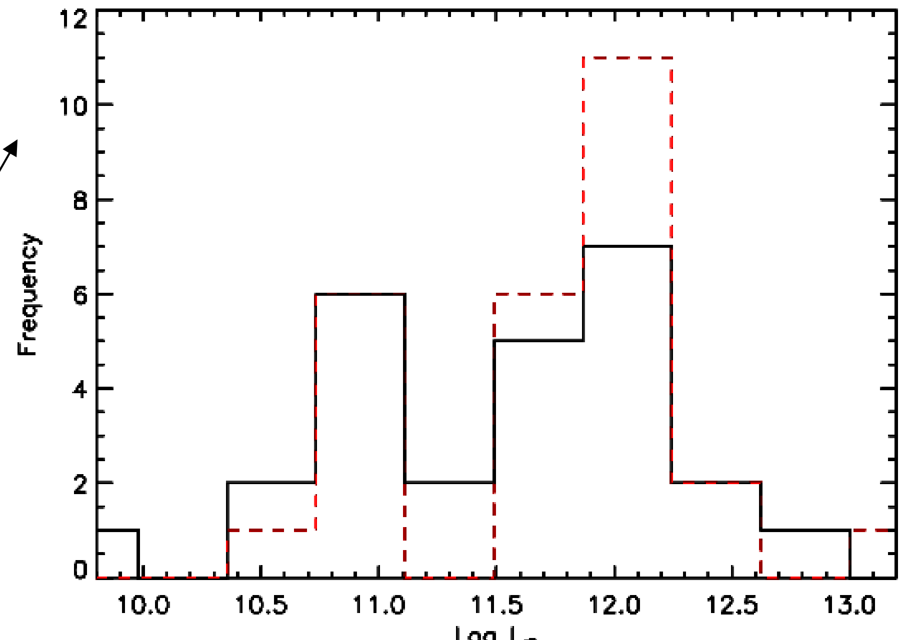
From Elbaz and Cesarsky 2003

ISOPHOT FIRBACK 170 μm sources





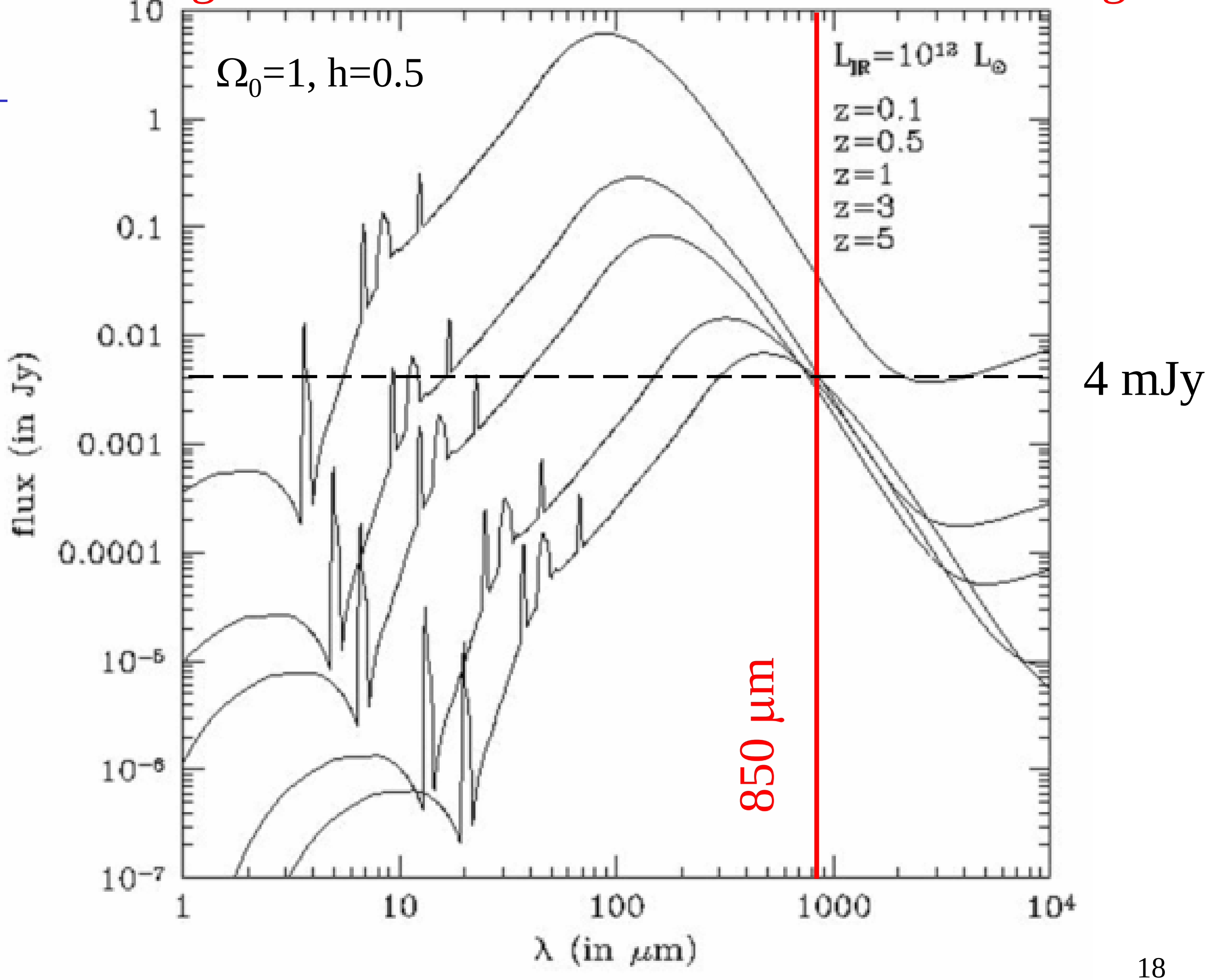
Puget et al. 1999, Dole et al. 2001, 106 sources at > 180 mJy in 3.89 deg^2



Patris et al. 2003: 22 sources > 200 mJy in South Marano

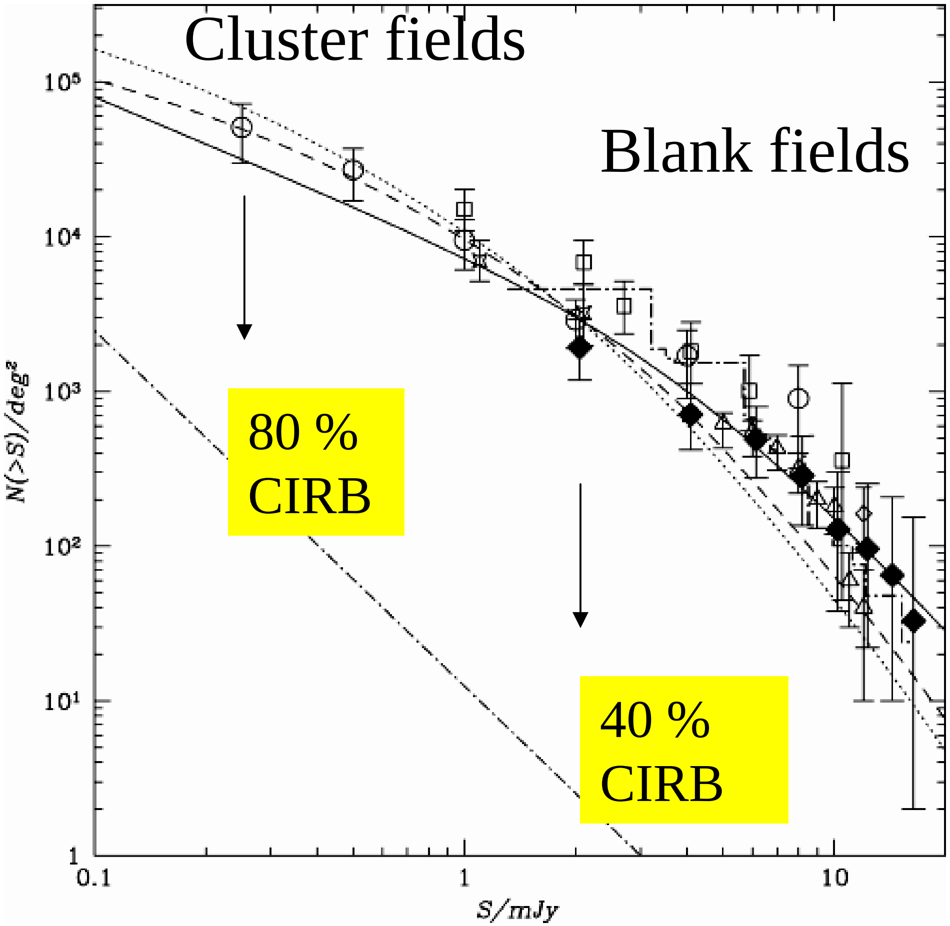
The « negative K-correction » at submm/mm wavelengths

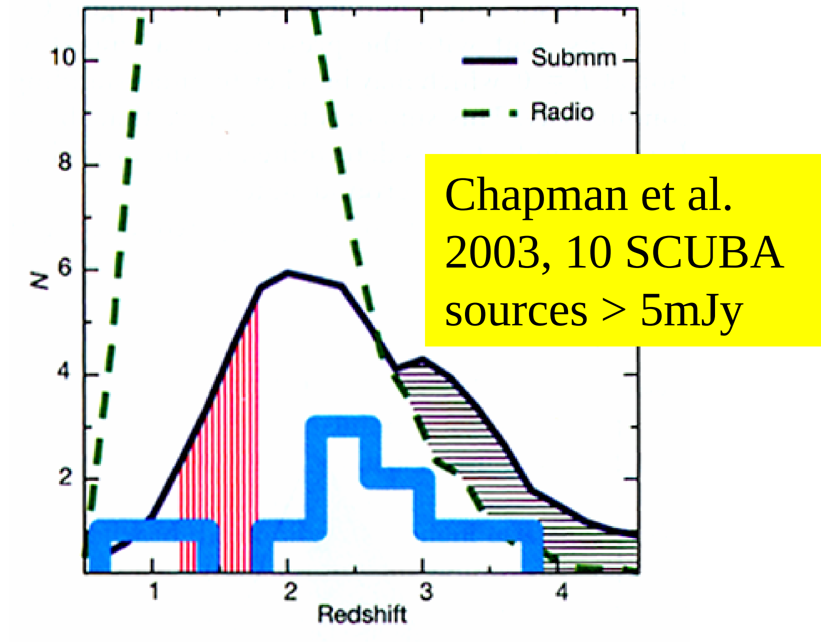
The 600—2000 µm flux directly measures L_{IR} provided z>0.5

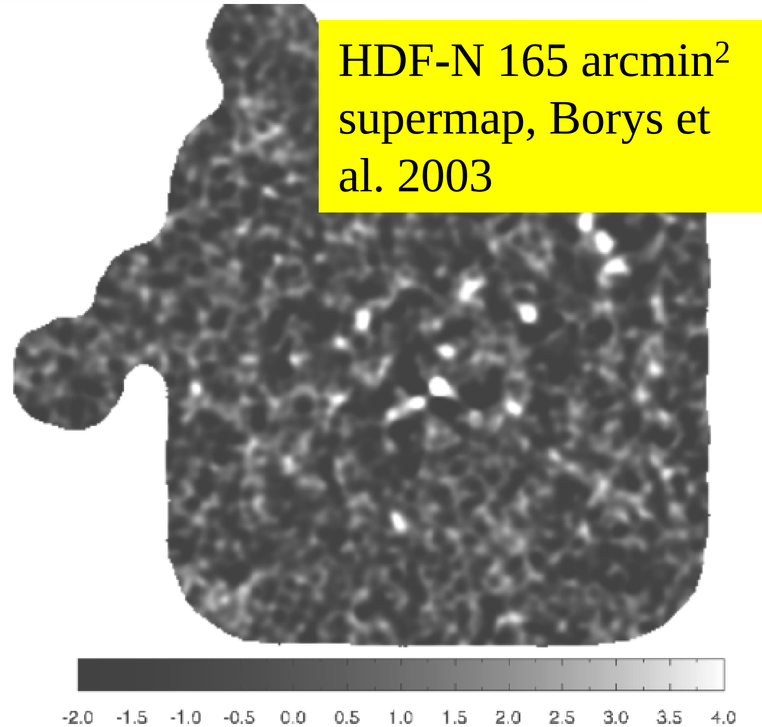


Guiderdoni et al. 1998

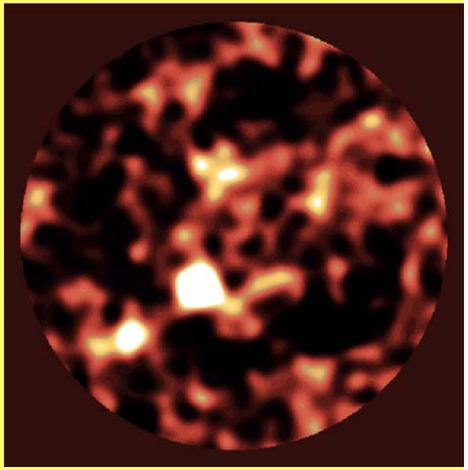
SCUBA 850 μm counts



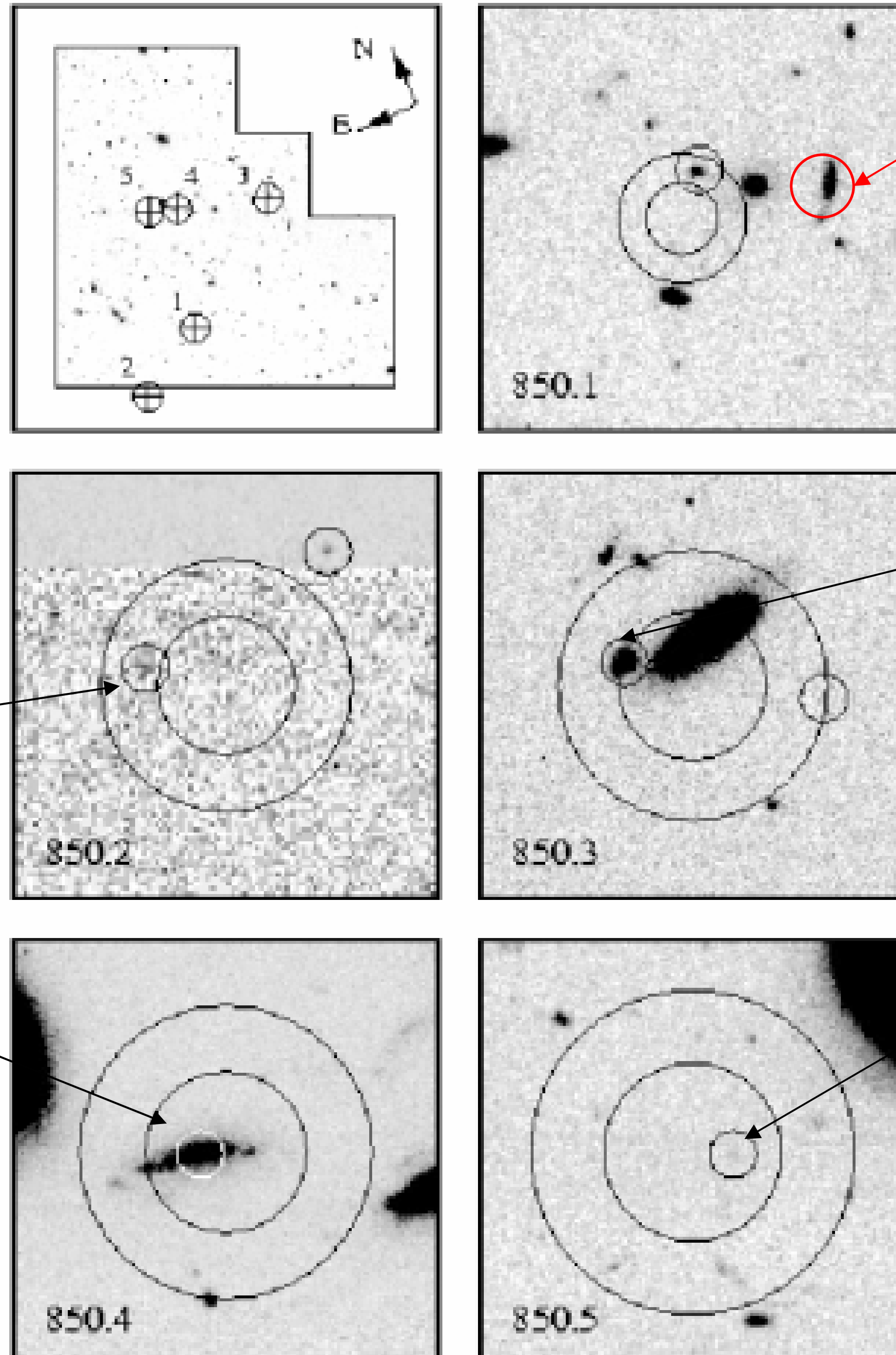




Clusters: Chapman et al. 2002, Smail et al. 2002, Cowie et al. 2002, *UK 8-mJy survey:* Scott et al. 2002, *HDF-N:* Borys et al. 2003. *Brightest upper limit:* 2.9 deg^{-2} @ 100 mJy, Barnard et al. 2004



8.7 arcmin^2, σ=0.45 mJy, FWHM=14.7 arcsec



This is the actual optical ID (lensed)

~~z=3.4~~

z=2.0

$\log L_{IR}$=11.8

z=3.8

$\log L_{IR}$=11.9

z=0.9

$\log L_{IR}$=11.8

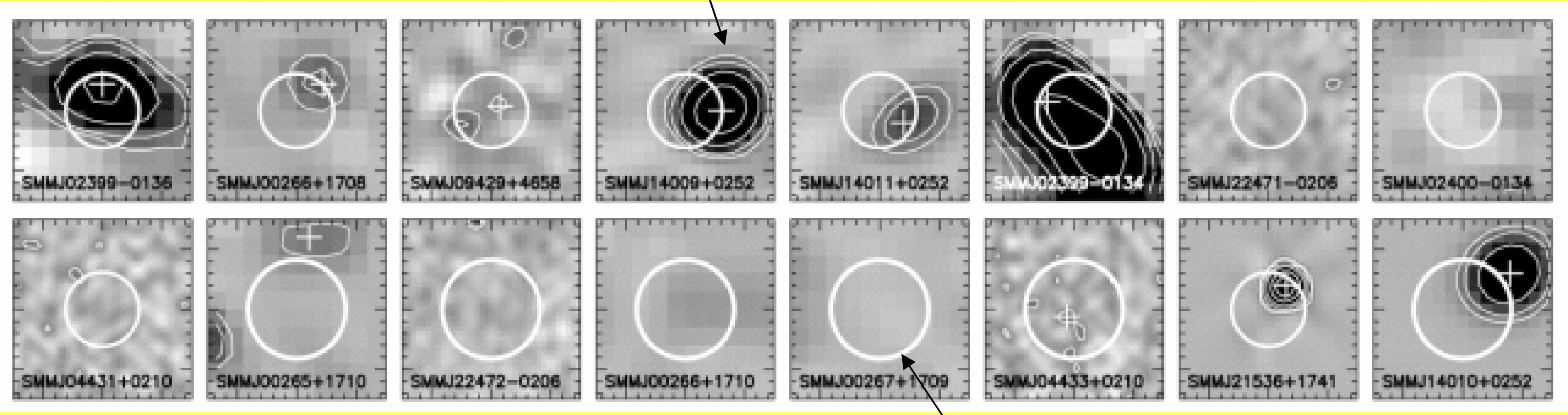
z=3.2 ?

$\log L_{IR}$=11.6

ID of SCUBA sources: optical

ID of SCUBA sources : radio continuum

VLA 1.4 GHz contours



SCUBA error box

Smail et al. 2000

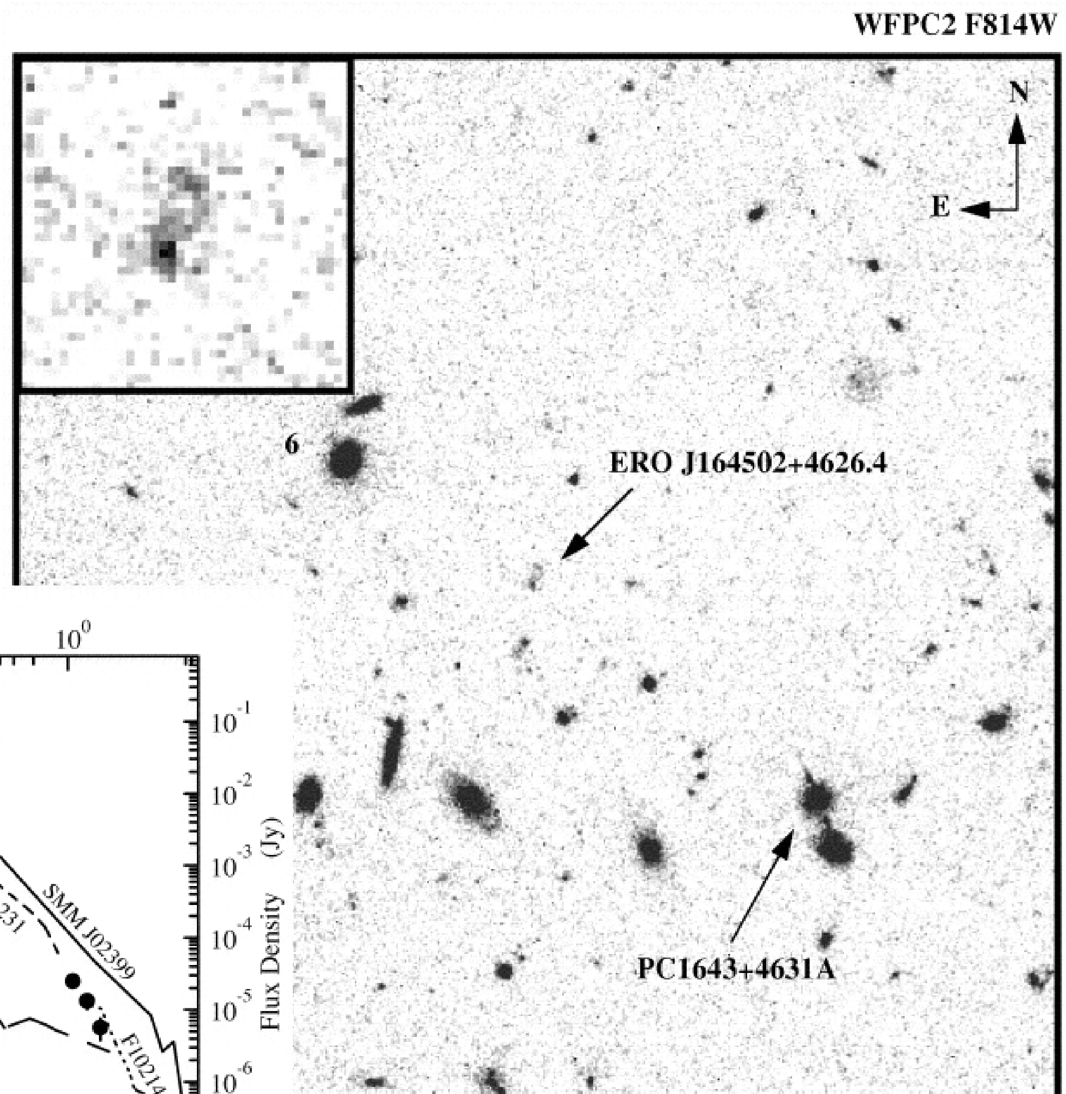
Radio/submm « photometric » redshifts (Carilli & Yun 1999) give <z> > 2

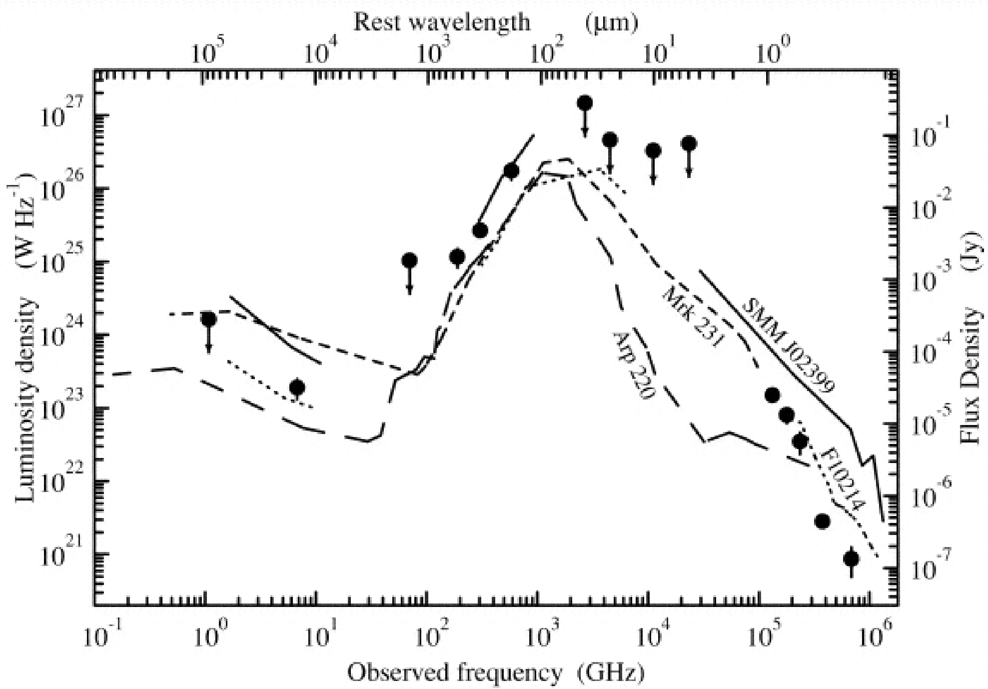
Typical SEDs

HR 10, z=1.44

I_c-K=5.8 (ERO)

L_{IR}=7 10^{12} h_{50}^{-2} L_{sun}



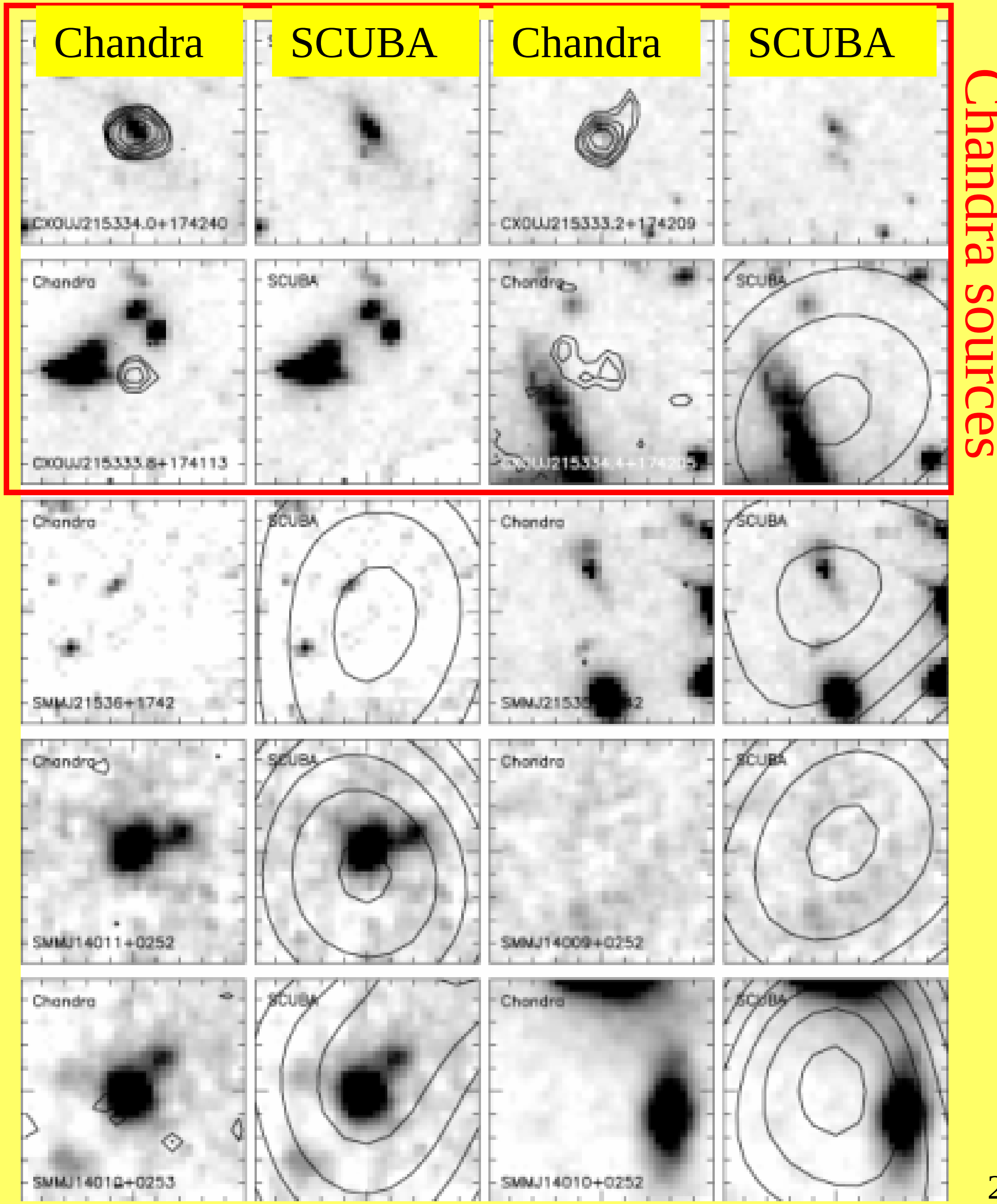


Dey et al. 1999

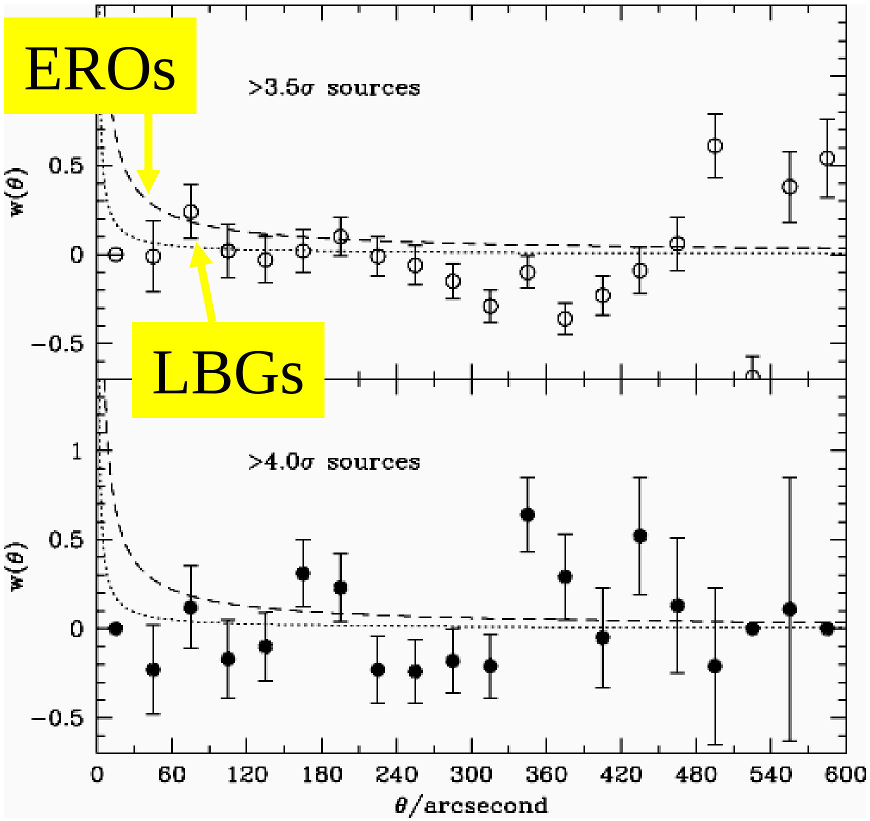
No connection between the SCUBA and Chandra sources at S_{850mm}>2 mJy & $F_{0.5—2keV}$>1—3 10^{-15} erg cm^{-2} s^{-1}

Most natural interpretation : SCUBA sources are powered by starbursts

Fabian et al. 2000, Severgnini et al. 2000, Almaini et al. 2003, Waskett et al. 2003

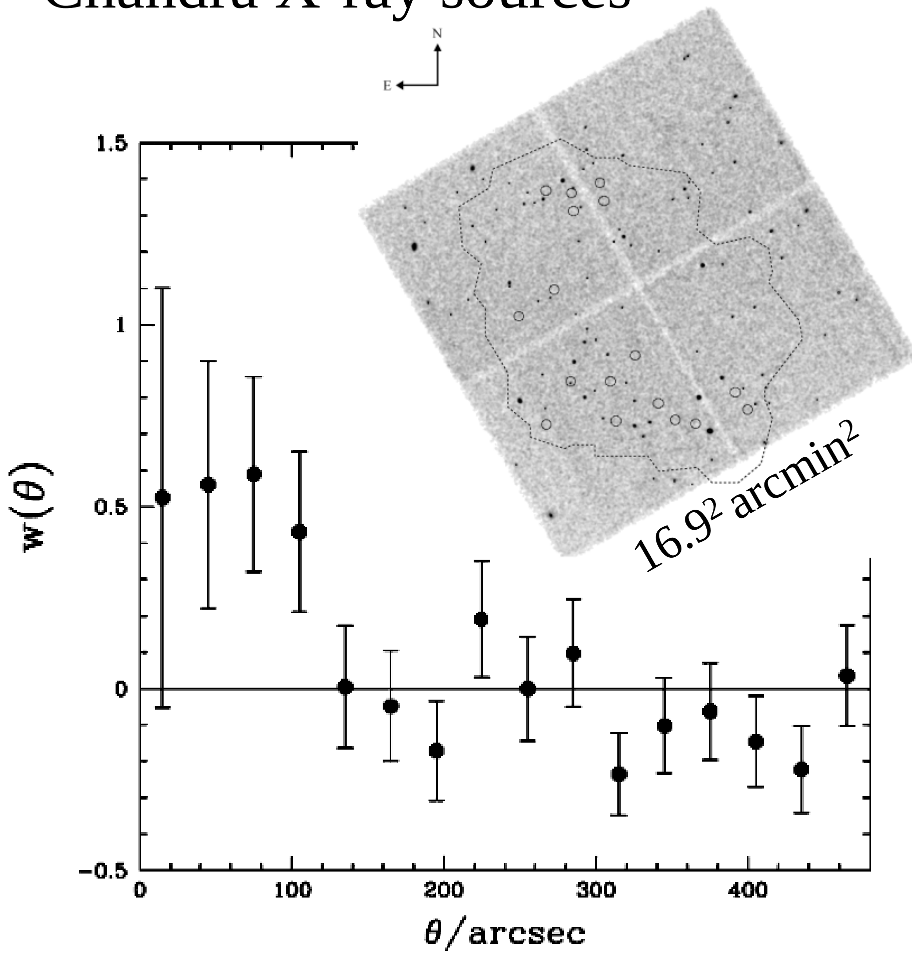


The clustering of SCUBA sources is not detected



HDF-North supermap,
Borys et al. 2003

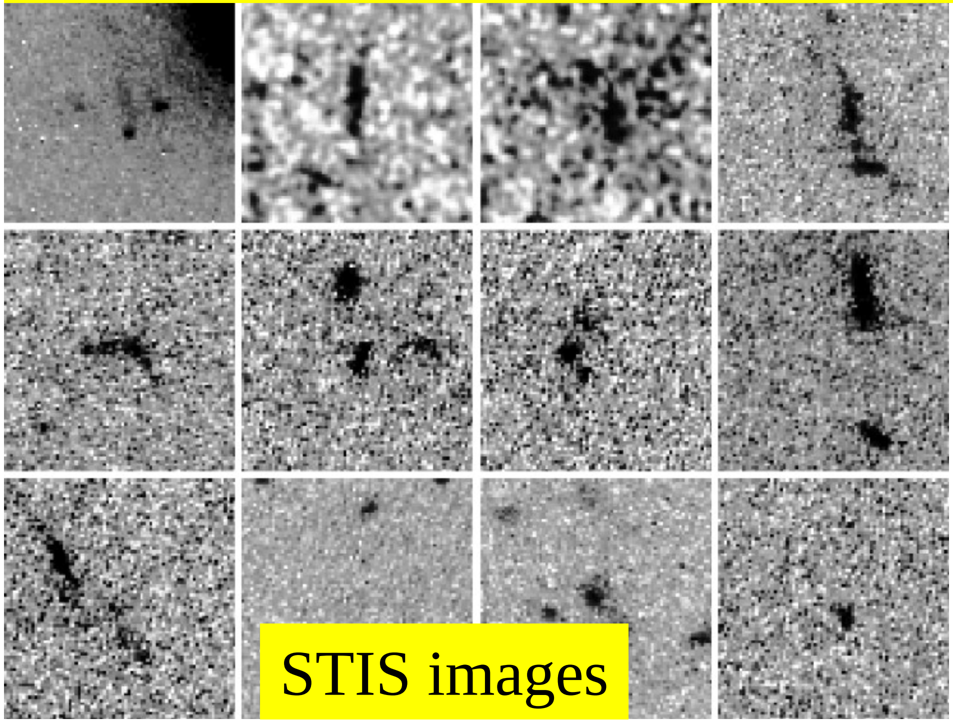
But SCUBA sources are located in same structures as Chandra X-ray sources



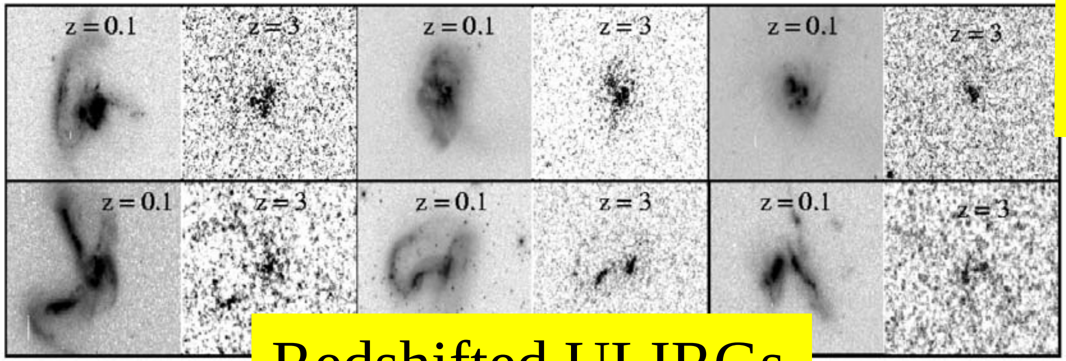
UK 8-mJy survey + Chandra,
Almaini et al. 2003

Morphologies of optical counterparts of submm sources

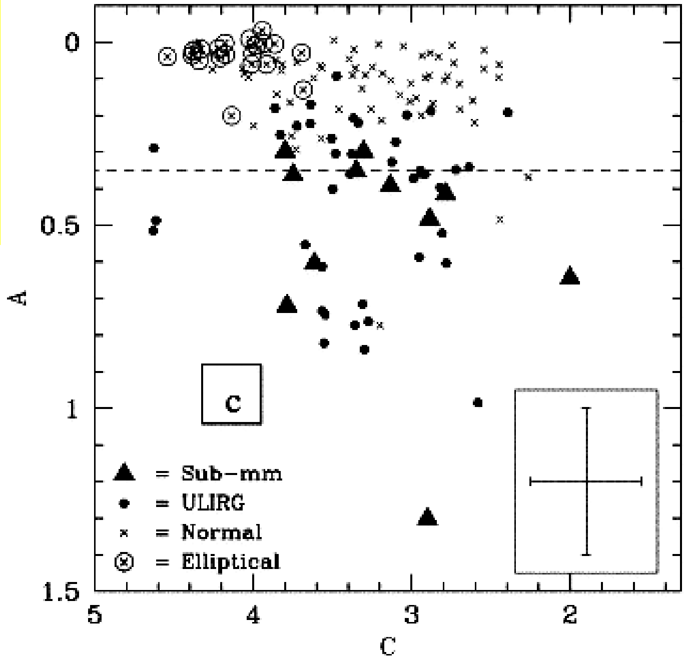
(Chapman et al. 2003, Conselice et al. 2003, etc.)



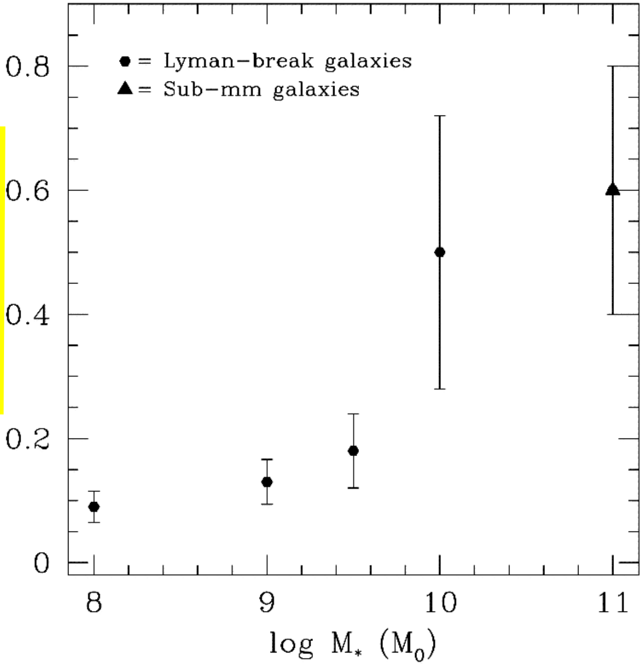
STIS images



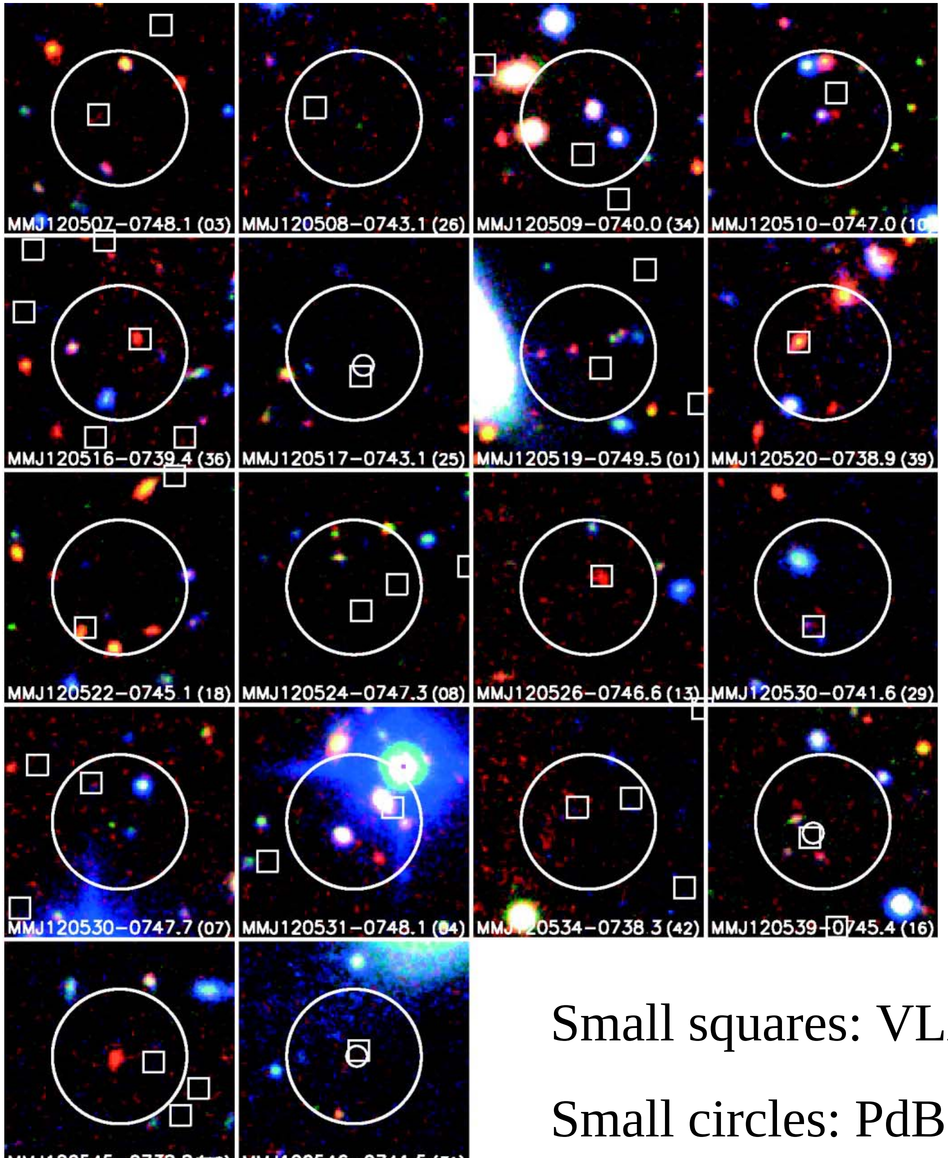
Redshifted ULIRGs



Merger fraction

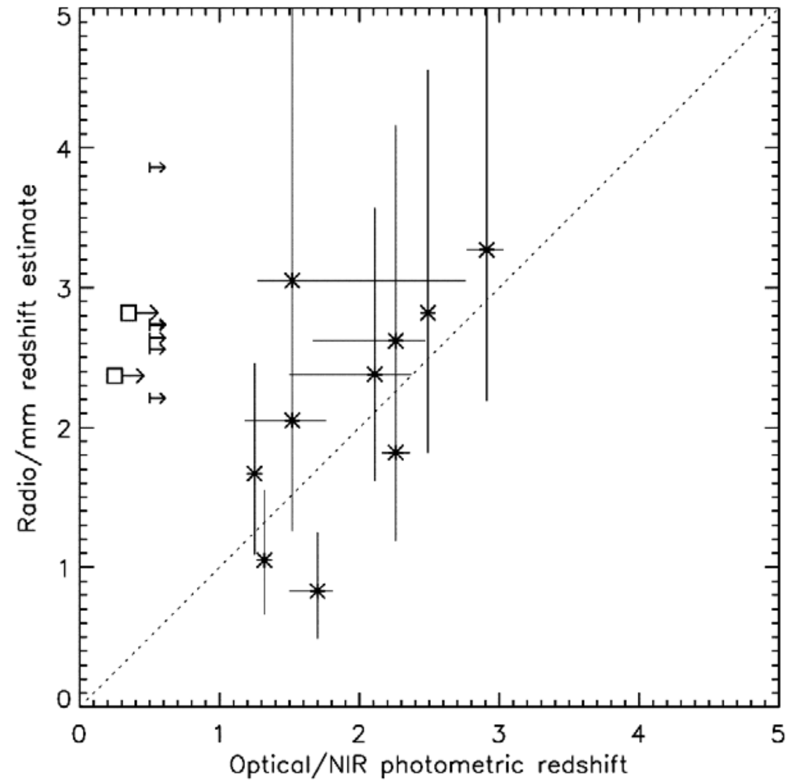


Optical counterparts of 18 MAMBO 1.2mm sources (Dannerbauer et al. 2004)



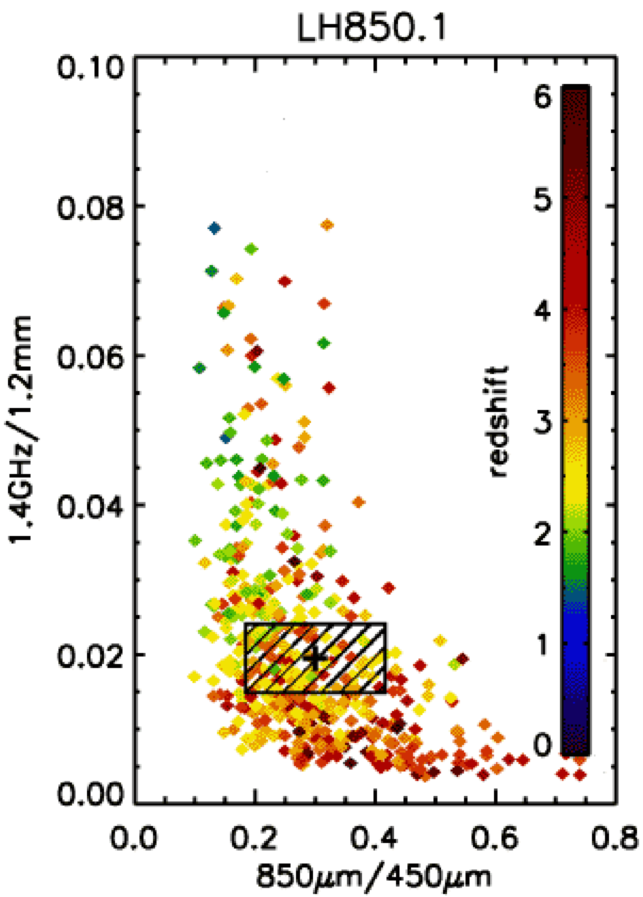
Small squares: VLA

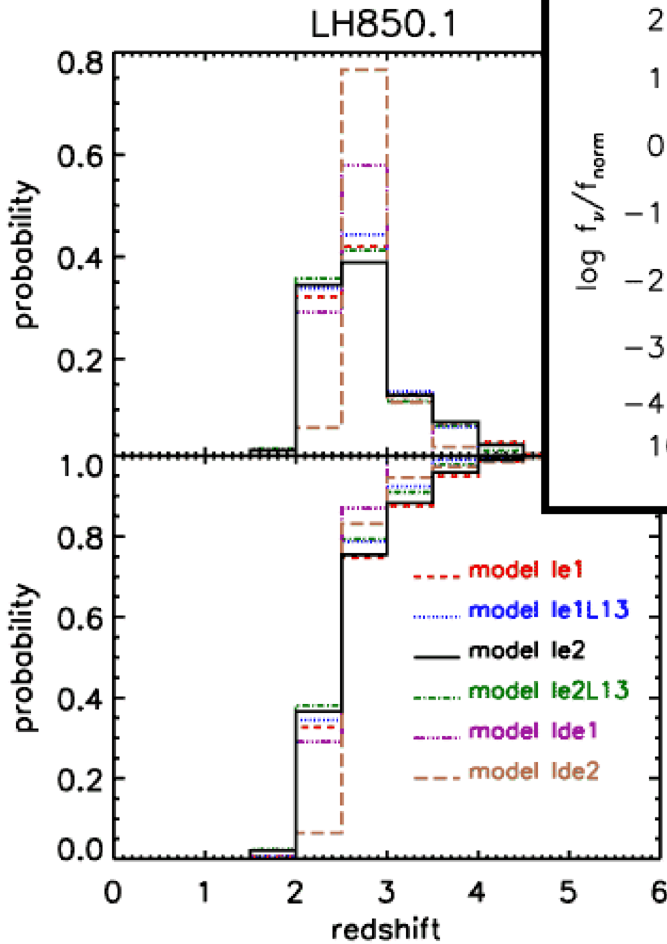
Small circles: PdB

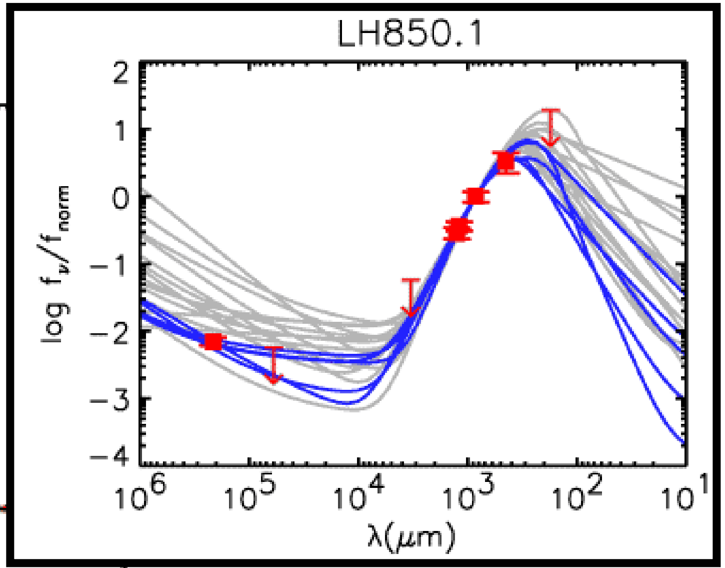


2/3 of sample at z>2.5

Low values of 850/1200 μm ratio suggest sources are even at z>3, or that β=1 rather than 2 (Eales et al. 2003)

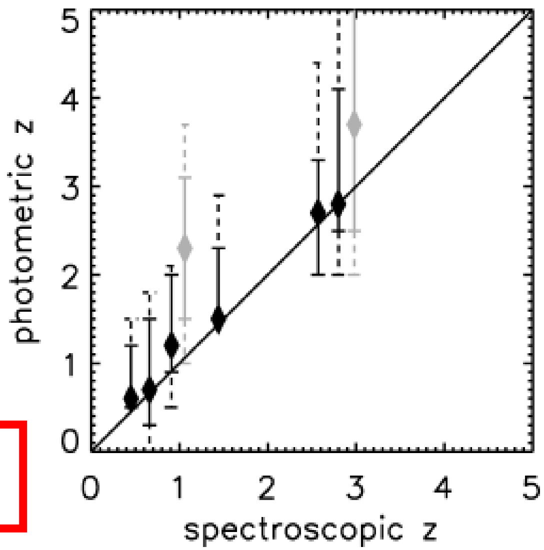






Hughes et al. 2002, Aretxaga et al. 2003

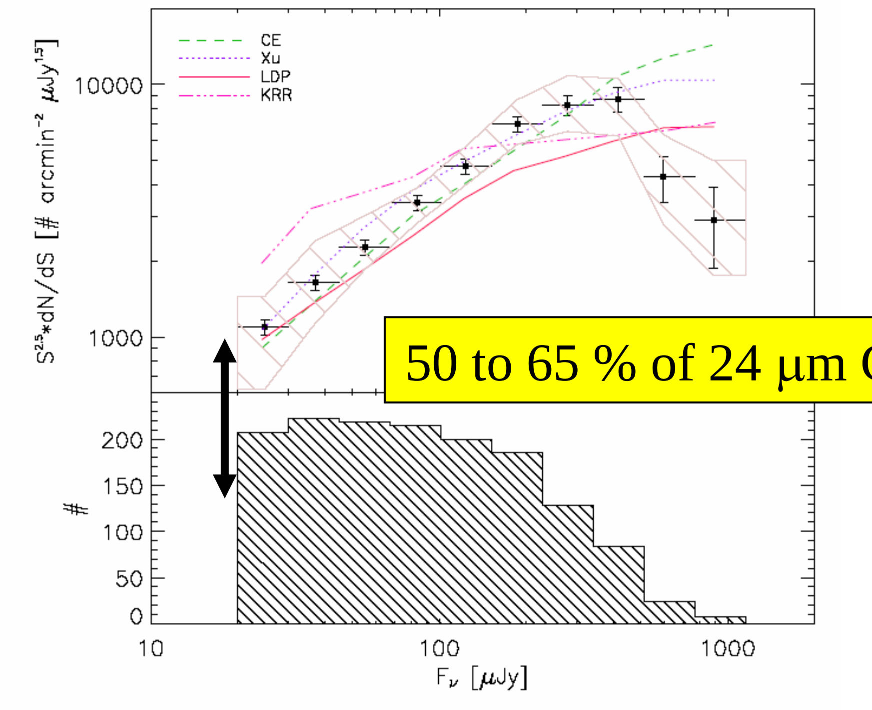
But see Blain et al. 2003



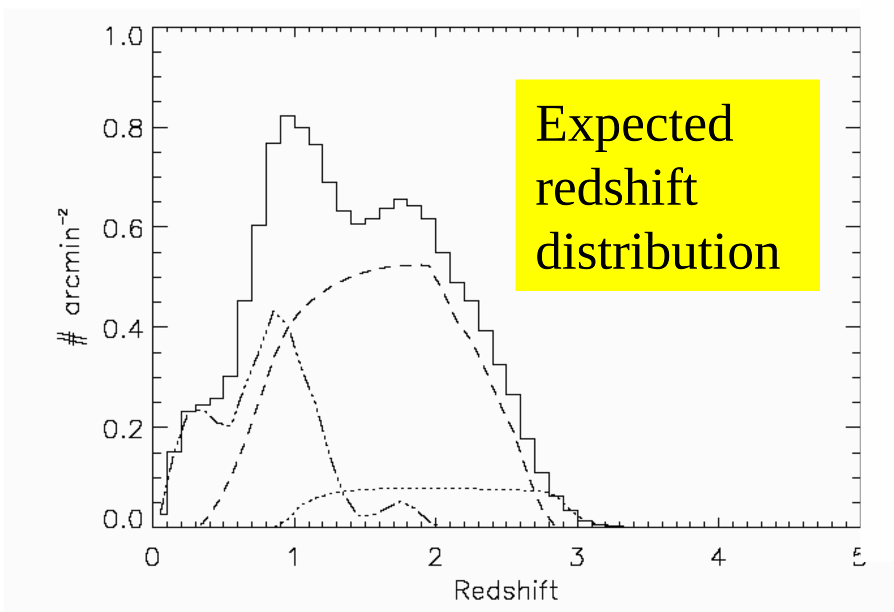
Photometric redshifts in the submm/radio range ?

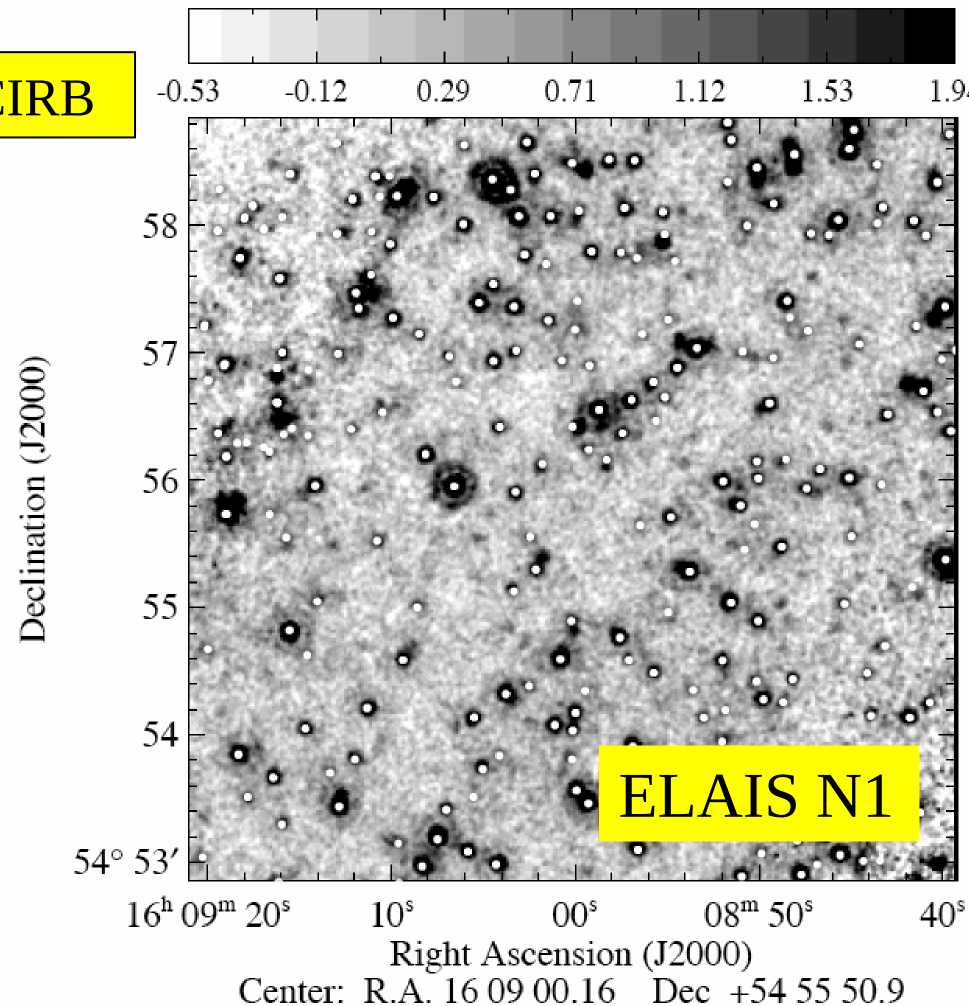
And now SPITZER…

(Chary et al. 2004)



50 to 65 % of 24 μm CIRB





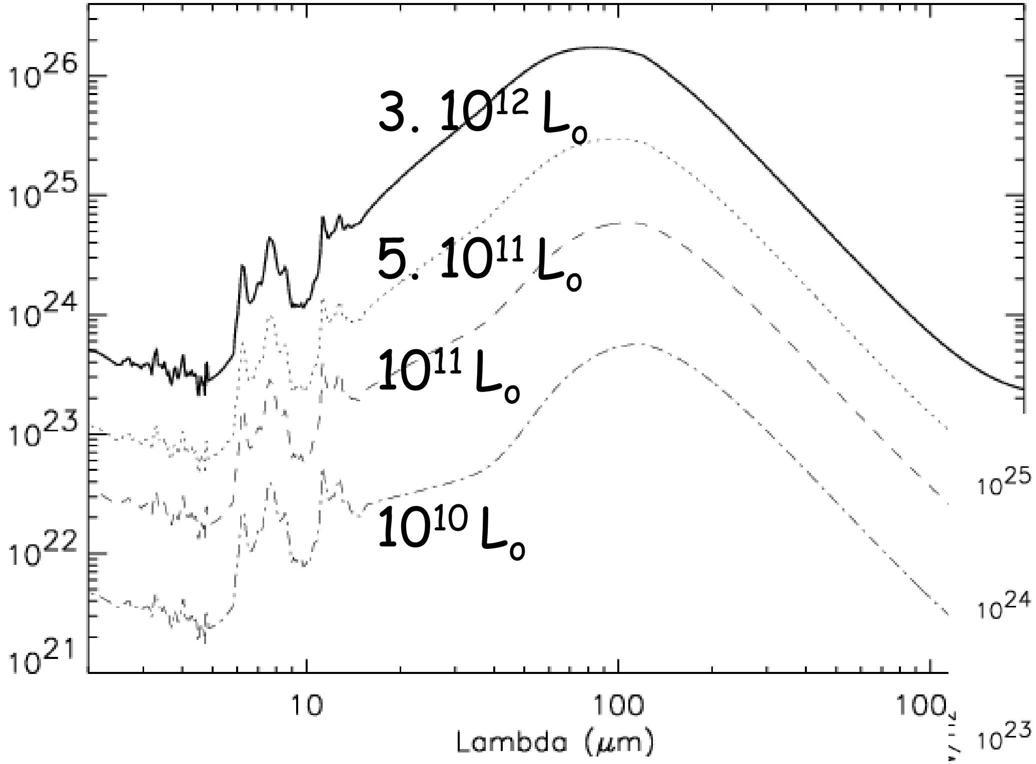
Models

Recent models of faint counts in the IR/submm

- Phenomenological models: Chary & Elbaz 2001, Rowan-Robinson 2001, Serjeant & Harrison 2002, Lagache et al. 2003, King & Rowan-Robinson 2003, etc.
- Spectrophotometric evolution of stellar populations: Toffolatti et al. 1998, Franceschini et al. 1998, 2001, etc.
- Hierarchical Galaxy Formation: Guiderdoni et al. 1997, 1998, Devriendt & Guiderdoni 2000, Lacey et al. 2003, Devriendt et al. 2003, Hatton et al. 2003, Baugh et al. 2004, etc.

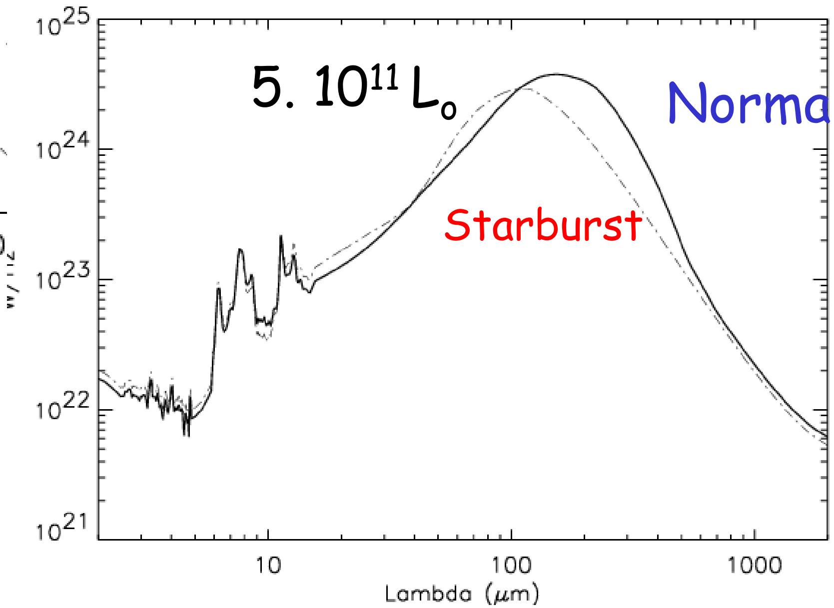
Galaxy SEDs

SEDs for Starburst Galaxies



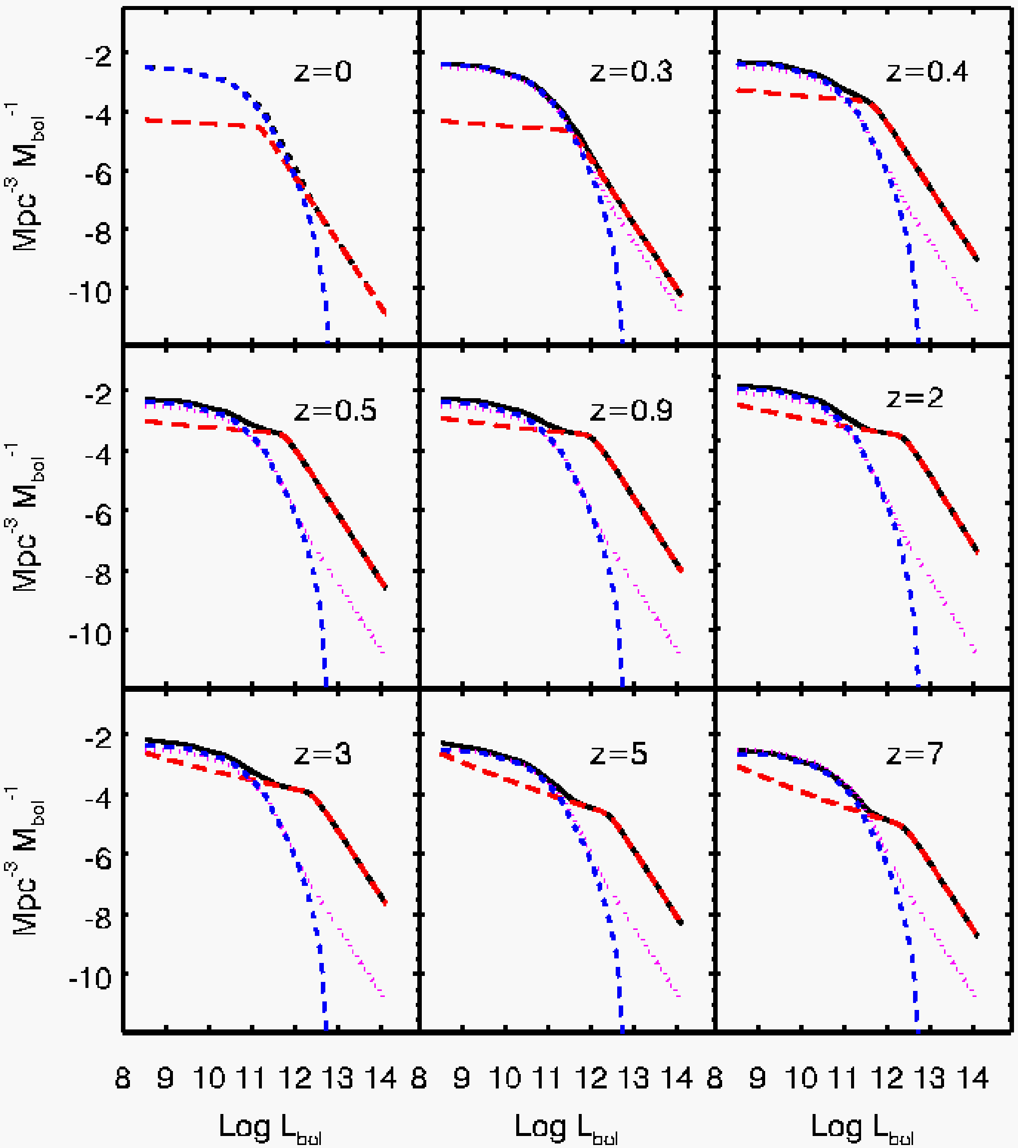
"IAS", Lagache, Dole, Puget, 2003, MNRAS

Comparison of SEDs: Starburst & Normal Galaxies



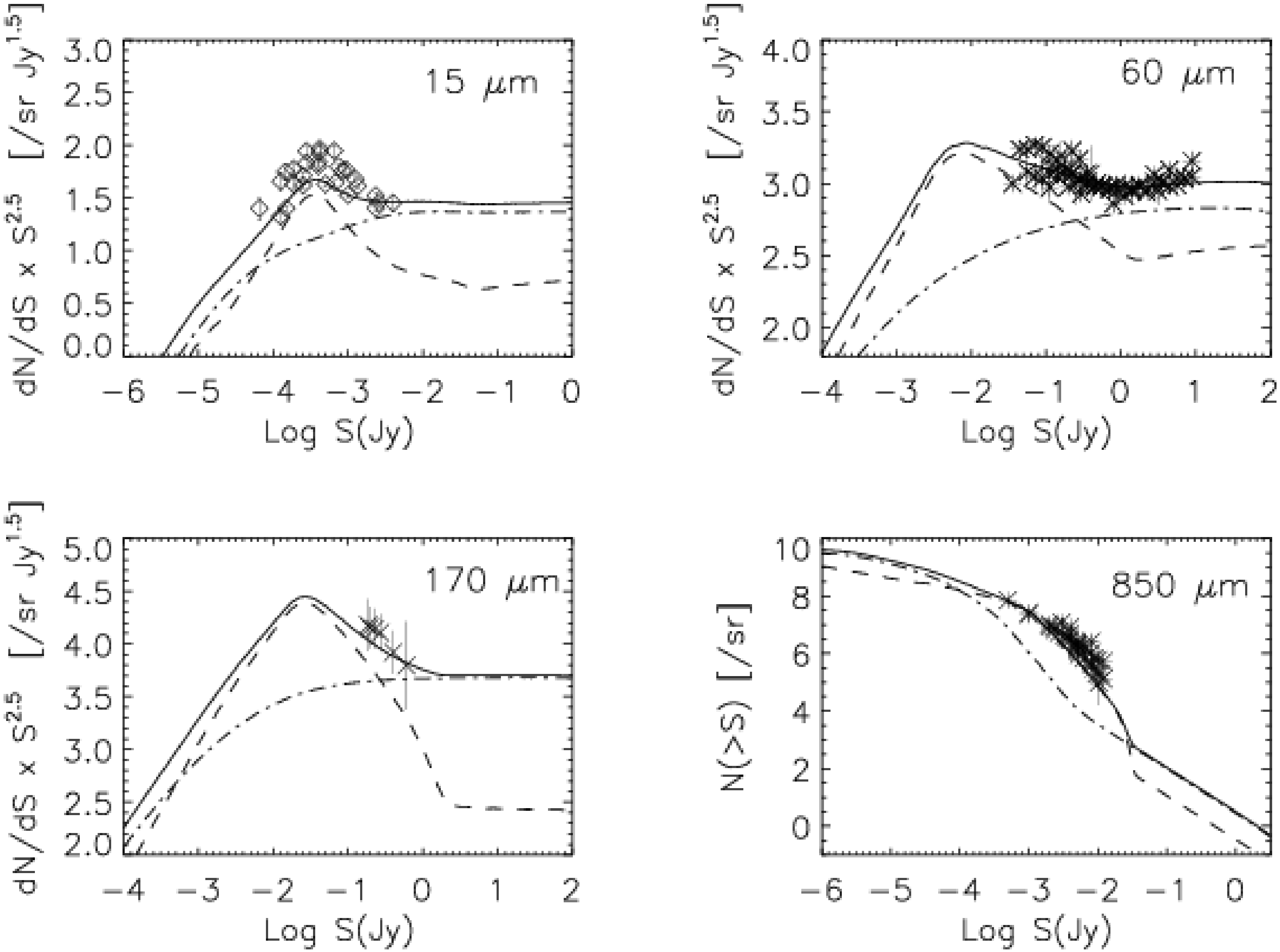
Evolving LF to Fit Data

Normal
Starburst
Total LF
Local LF



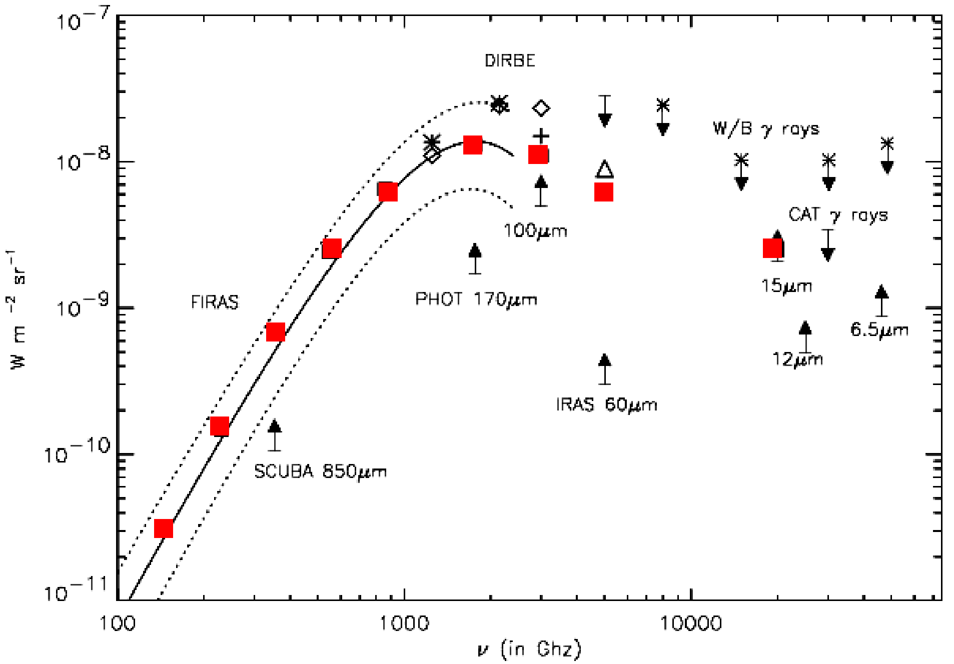
"IAS", Lagache, Dole, Puget, 2003, MNRAS

Source Counts



"IAS", Lagache, Dole, Puget, 2003, MNRAS

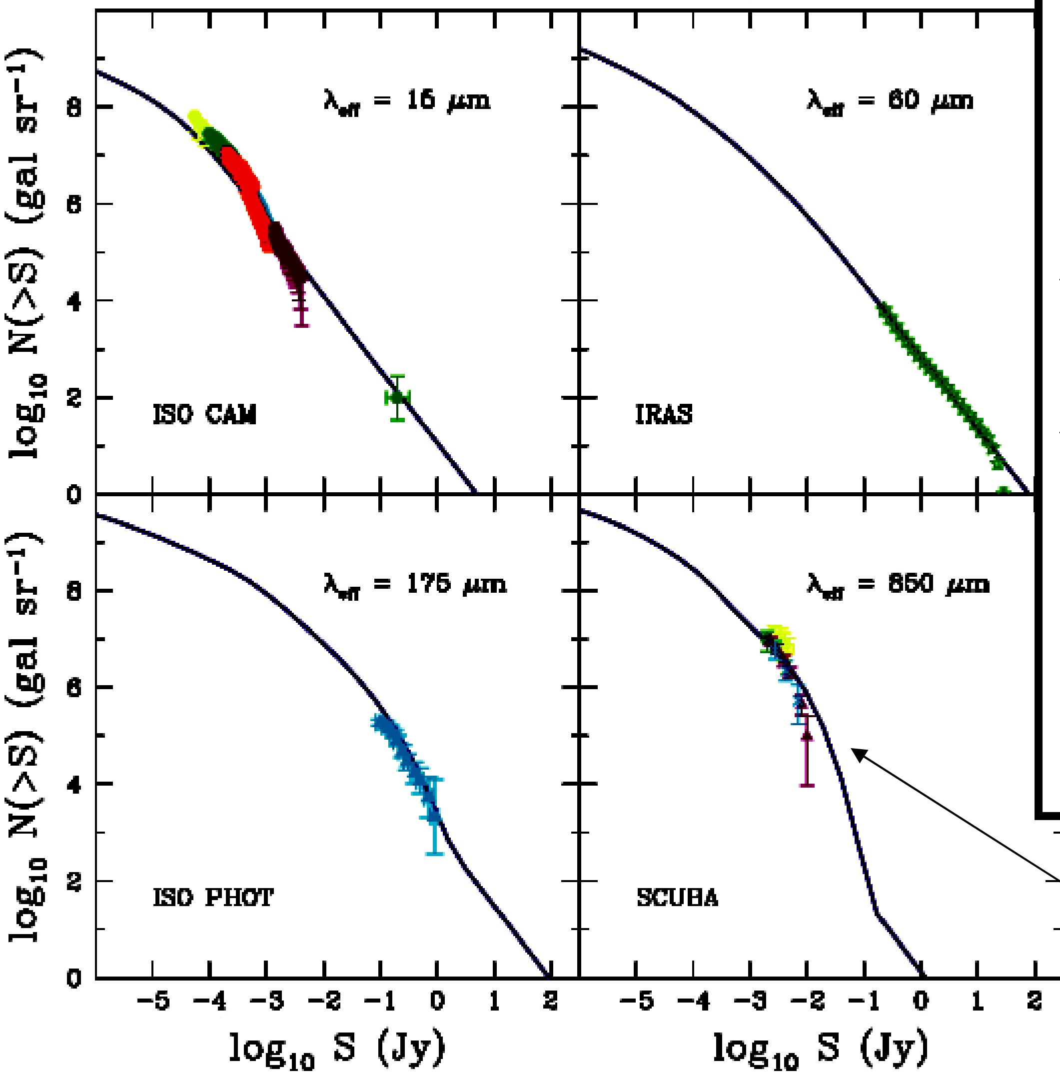
CIRB Intensity & Fluctuations

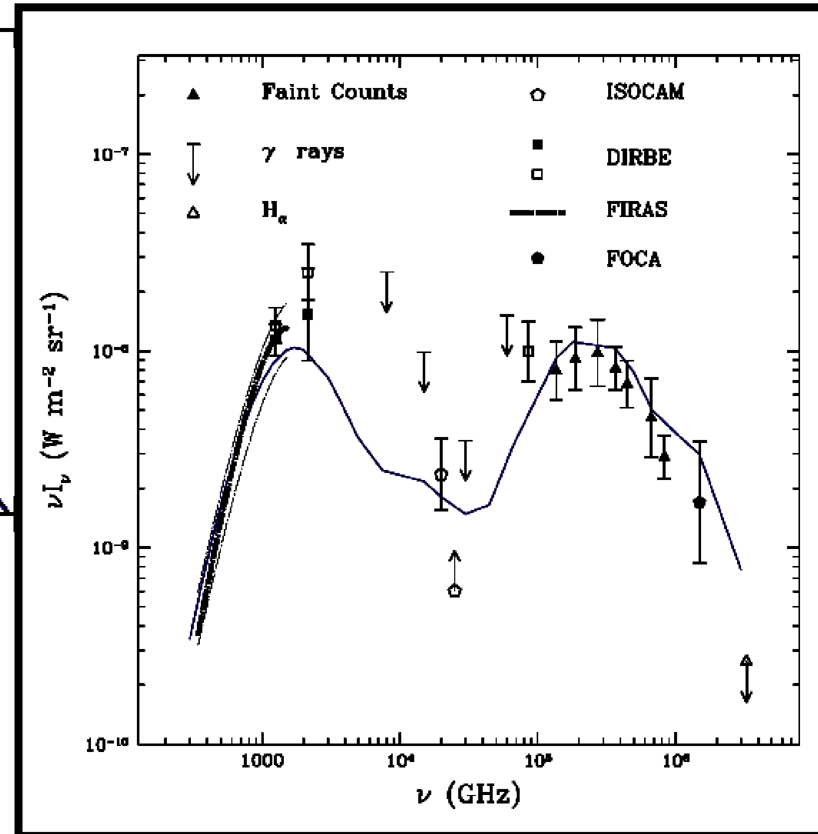


λ (µm)	S_{max} (mJy)	Observations (Jy^2/sr)	References	Model (Jy^2/sr)
170	1000	∼25000	Sorel et al., in prep	23694
170	250	13000±3000	Matsuhara et al. 2000	15644
170	100	7400	Lagache & Puget 2000	11629
100	700*	5800±1000	Miville-Deschênes et al. 2002	10307
90	150	12000±2000	Matsuhara et al. 2000	5290
60	1000	1600±300	Miville-Deschênes et al. 2002	2507

"IAS", Lagache, Dole, Puget, 2003, MNRAS

Predicted IR/submm counts with simple SAM

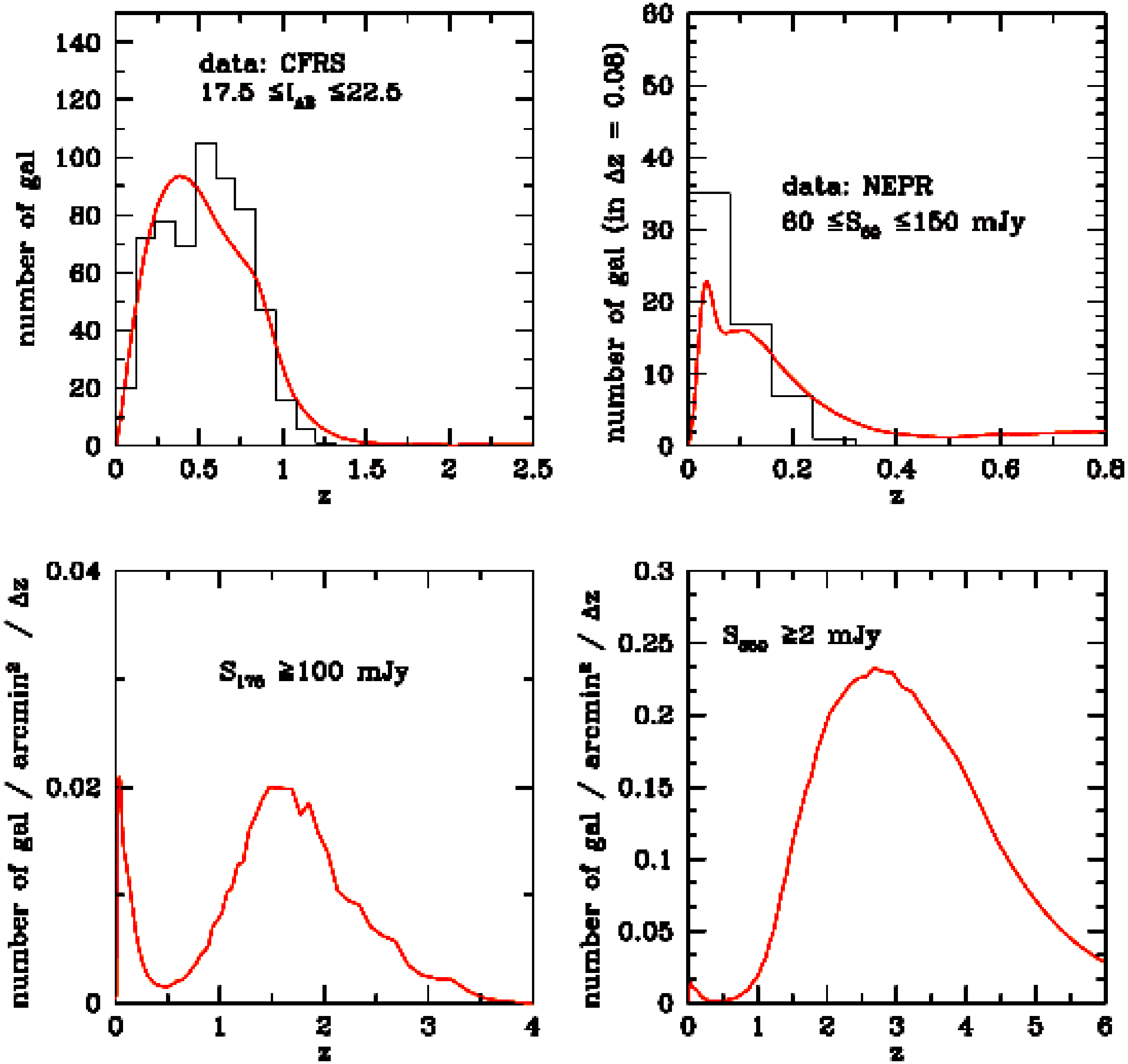




Fit submm counts with ad hoc top-heavy IMF extinguished starbursts (see also Somerville et al. 2003, Baugh et al. 2004, etc.)

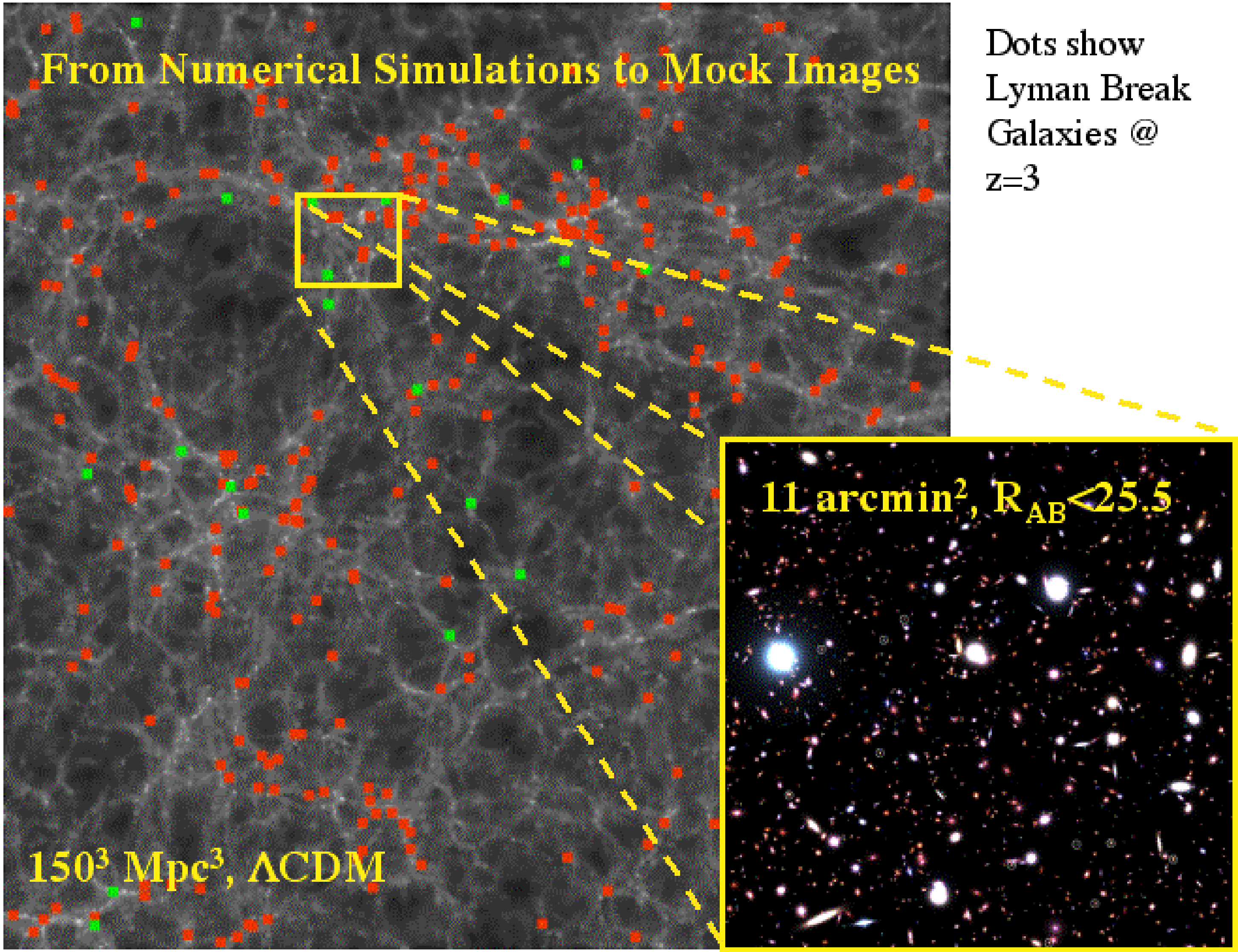
Devriendt & Guiderdoni 2000

Predicted z distribution with simple SAM

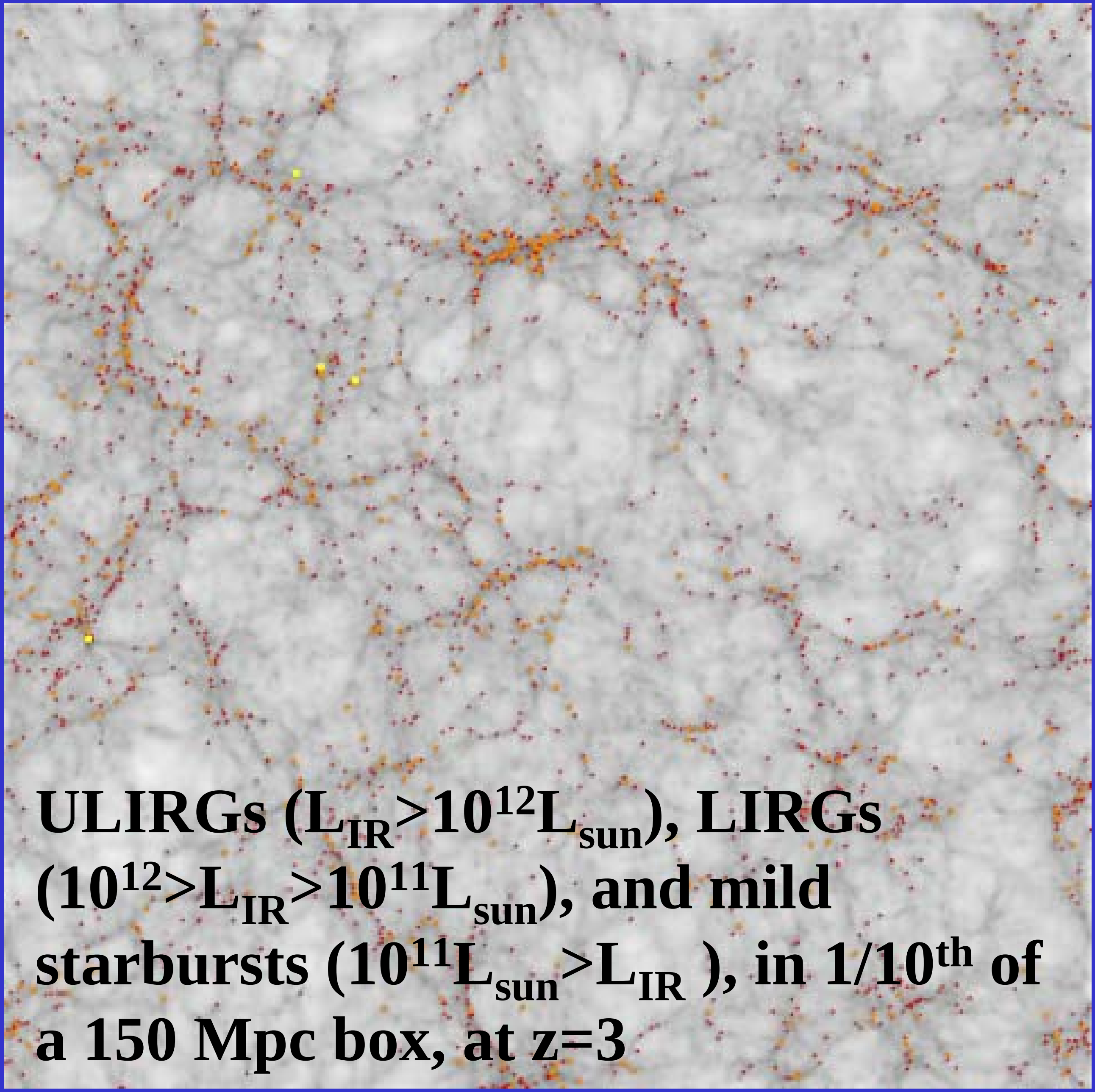


Devriendt & Guiderdoni 2000

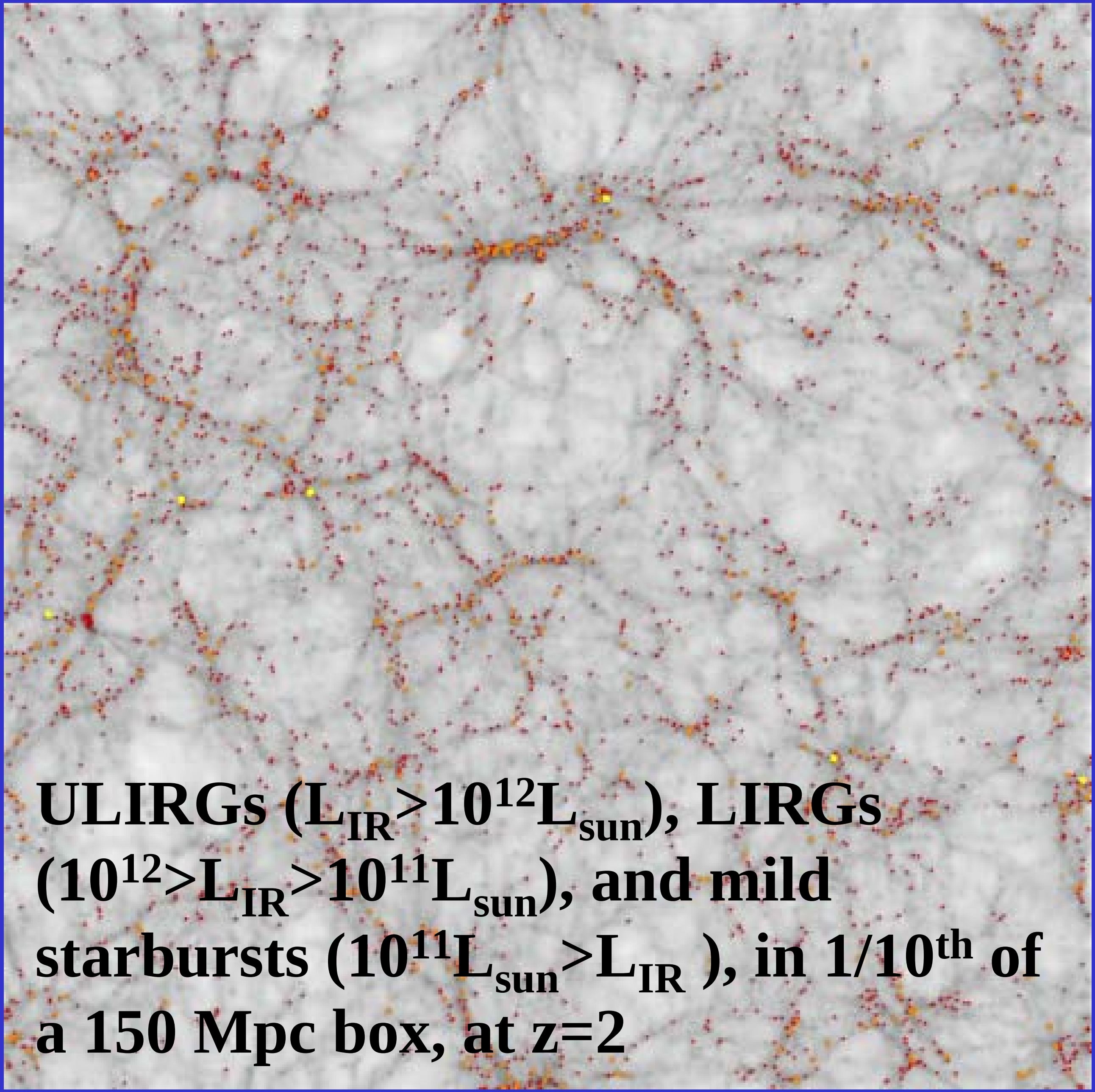
The “hybrid” approach : GalICS (*Galaxies in Cosmological Simulations*); see http://galics.iap.fr



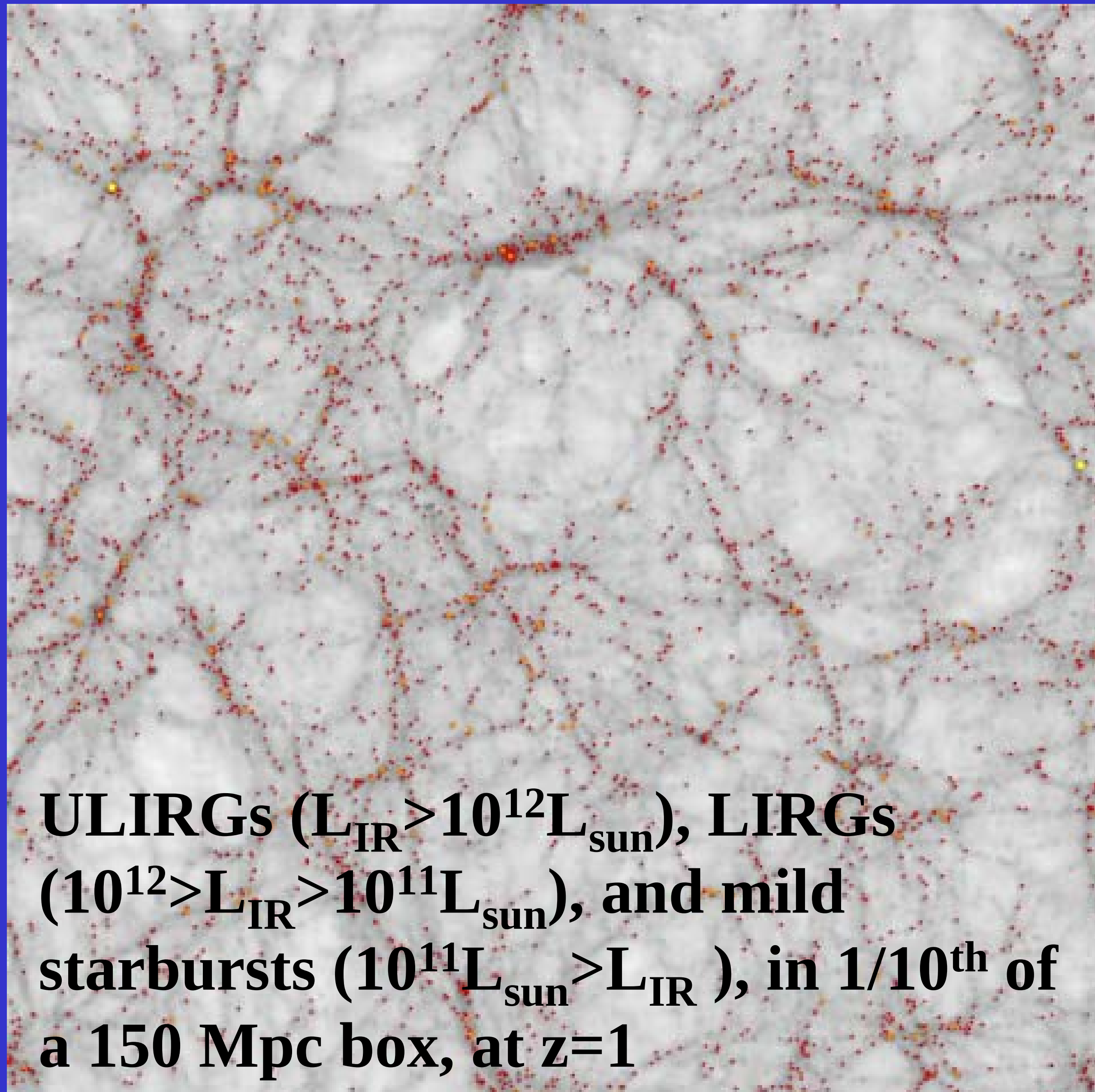
Dots show Lyman Break Galaxies @ z=3



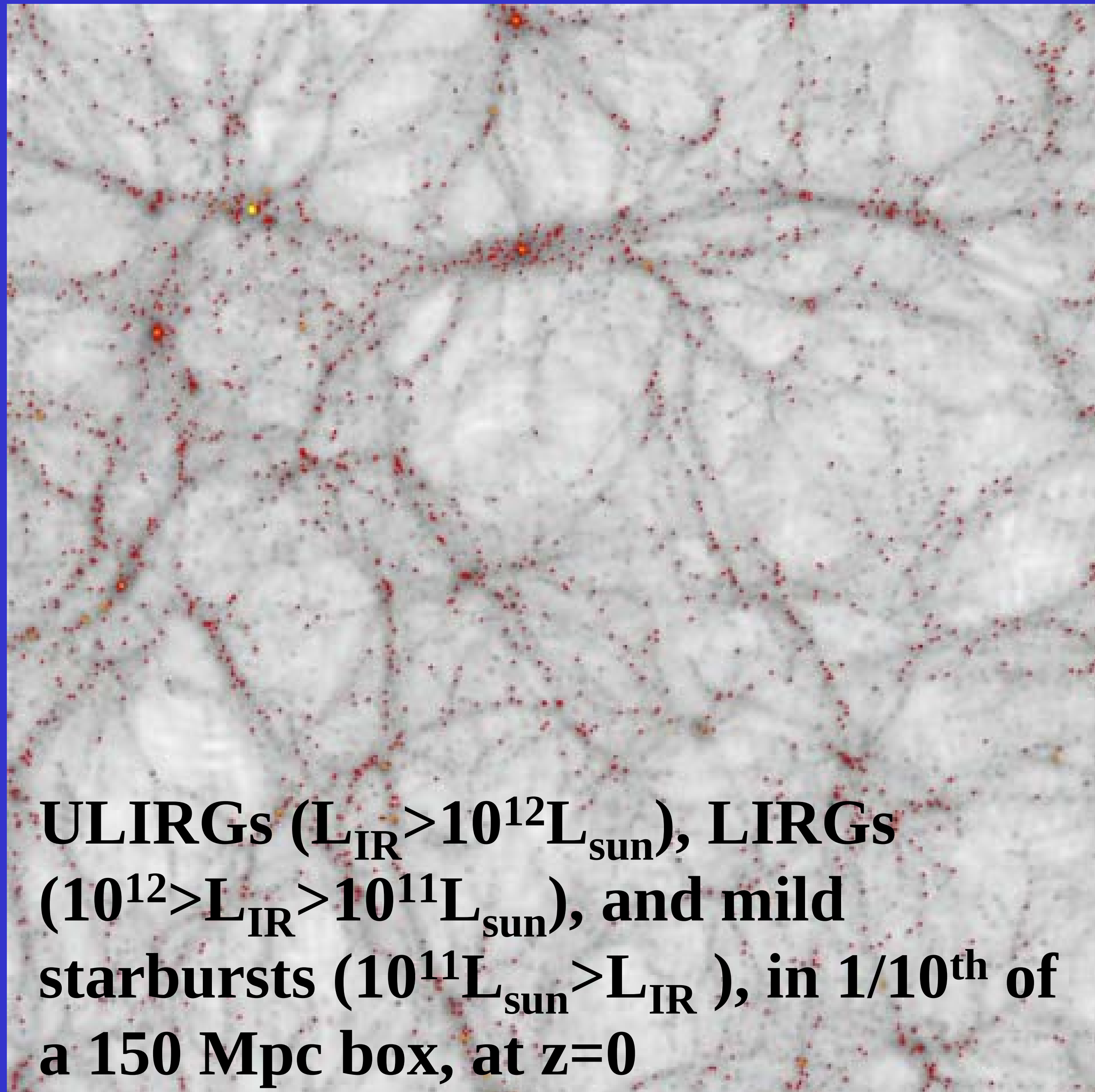
ULIRGs ($L_{IR}>10^{12}L_{sun}$), LIRGs ($10^{12}>L_{IR}>10^{11}L_{sun}$), and mild starbursts ($10^{11}L_{sun}>L_{IR}$), in 1/10th of a 150 Mpc box, at $z=3$



ULIRGs (L_{IR}>$10^{12}L_{sun}$), LIRGs (10^{12}>L_{IR}>$10^{11}L_{sun}$), and mild starbursts ($10^{11}L_{sun}$>L_{IR}), in 1/10th of a 150 Mpc box, at z=2

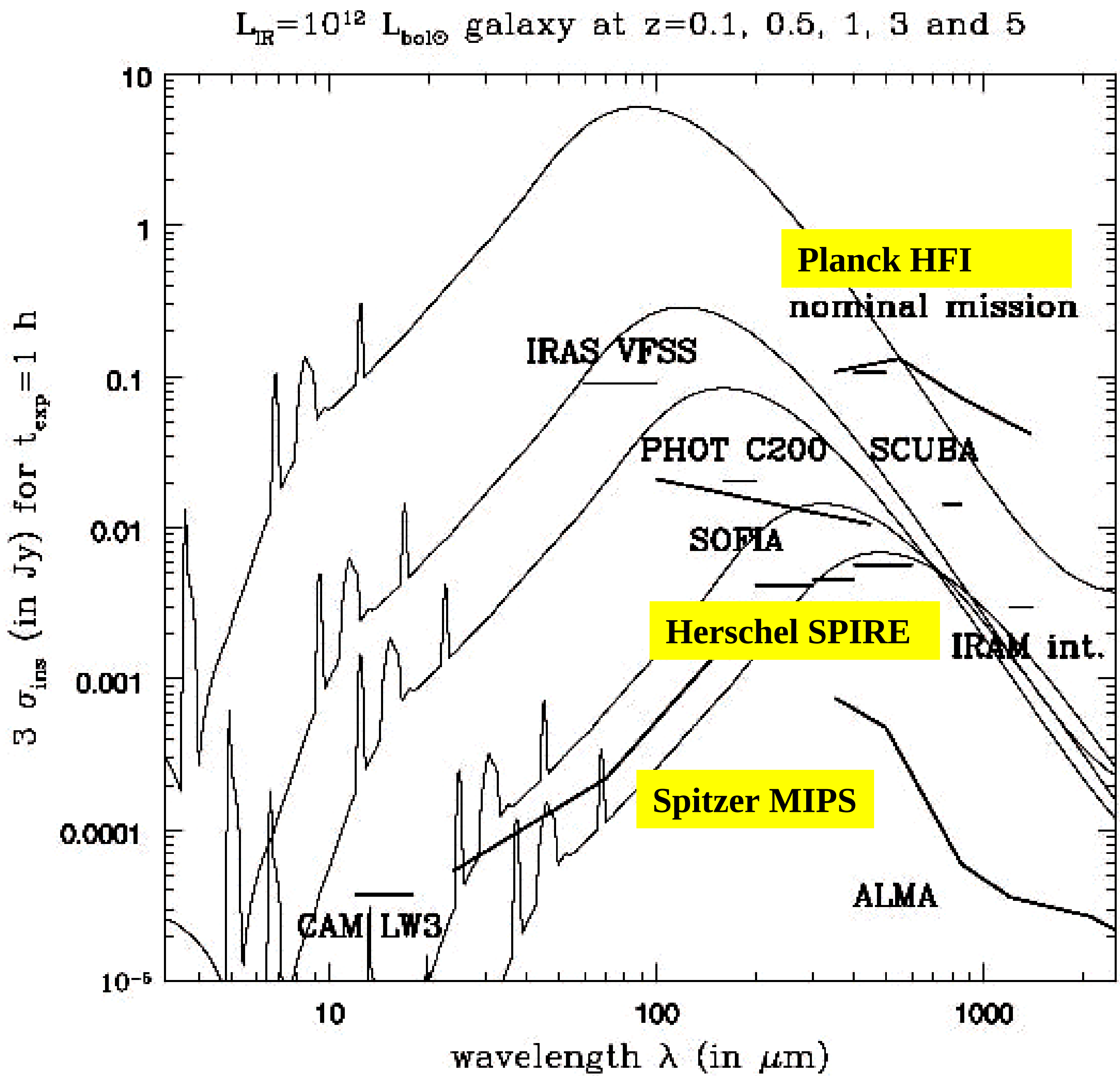


ULIRGs ($L_{IR}>10^{12}L_{sun}$), LIRGs ($10^{12}>L_{IR}>10^{11}L_{sun}$), and mild starbursts ($10^{11}L_{sun}>L_{IR}$), in 1/10th of a 150 Mpc box, at z=1



ULIRGs ($L_{IR}>10^{12}L_{sun}$), LIRGs ($10^{12}>L_{IR}>10^{11}L_{sun}$), and mild starbursts ($10^{11}L_{sun}>L_{IR}$), in 1/10th of a 150 Mpc box, at z=0

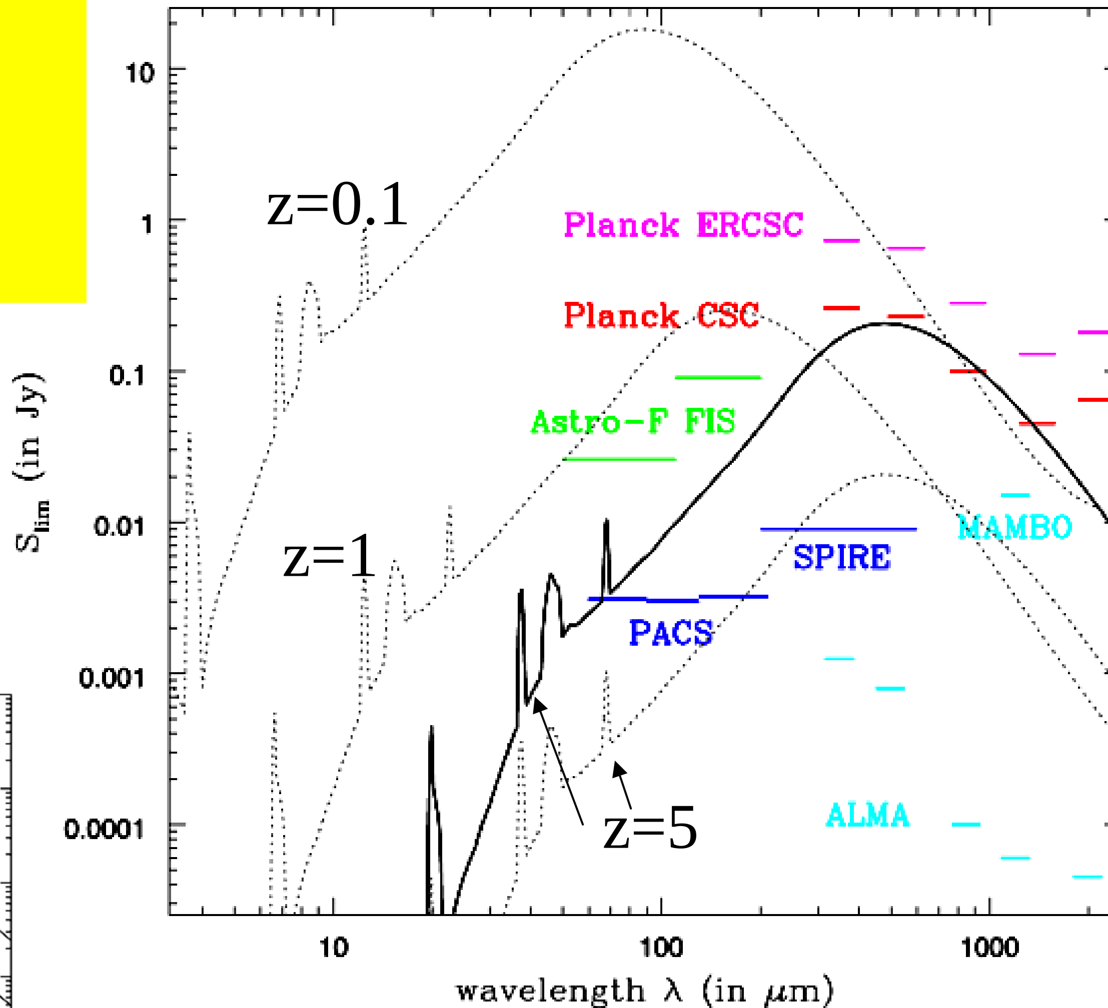
Planck and Herschel

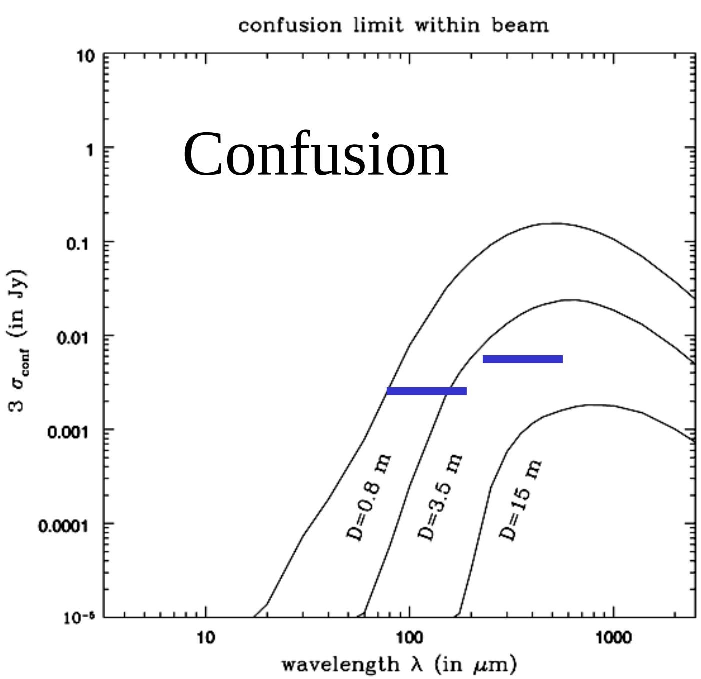


$L_{IR}=10^{12}$ $L_{bol\odot}$ galaxy at z=0.1, 0.5, 1, 3 and 5
Planck HFI
nominal mission
IRAS VFSS
PHOT C200
SCUBA
SOFIA
Herschel SPIRE
IRAM int.
Spitzer MIPS
ALMA
CAM LW3
$3\ \sigma_{ins}$ (in Jy) for $t_{exp}=1$ h
wavelength λ (in μm)
10
1
0.1
0.01
0.001
0.0001
10^{-5}
100
1000

Planck CSC will get local (z~0.1) LIRGs/ULIRGs sources, and rare HyLIRG (if any).

Herschel Deep Surveys will get ULIRGs up to z ~3.





Dots: L_{IR}=3 10^{12} L_{sun} galaxy

Solid line: L_{IR}=3 10^{13} L_{sun} galaxy

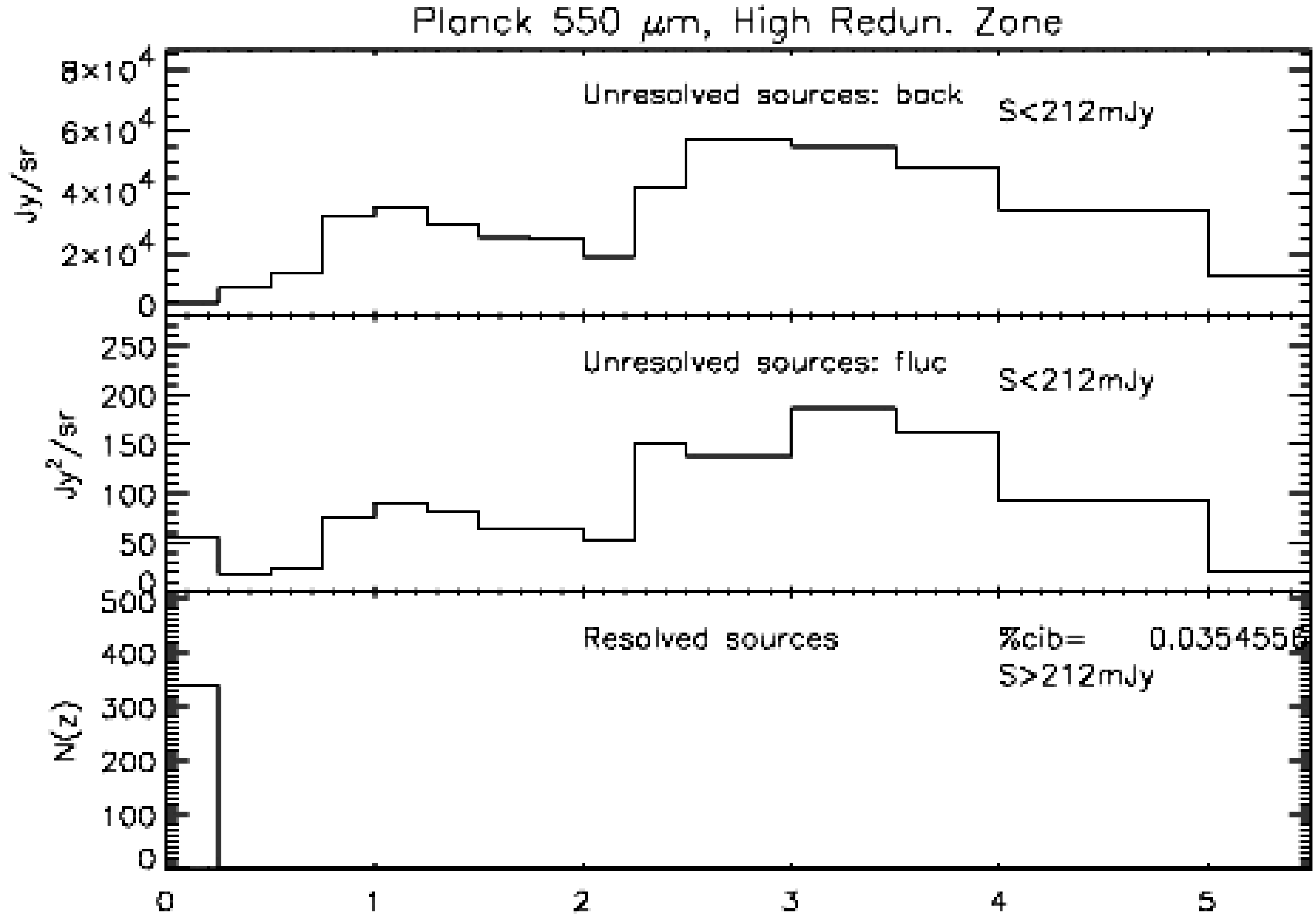
Planck HFI number counts

λ (μm)	$5\sigma_{inst}$ (mJy)	$5\sigma_{conf}$ (mJy)	$5\sigma_{add}$ (mJy)	$5\sigma_{tot}$ (mJy)	$N_{cold}(S > 5\sigma_{tot})$ (/sr)	$N_{SB}(S > 5\sigma_{tot})$ (/sr)	$N(S > 5\sigma_{tot})$ (/sr)
350	216.5	447	0	497	1342	40	1382
550	219	200	7.9	297	187	15	202
850	97	79.4	3.2	125	72	8	80
1380	57.5	22.4	2.6	62	35	4	39
2097	41.5	11.2	2.4	43	23	3	26

Herschel SPIRE Survey @ 350 mm

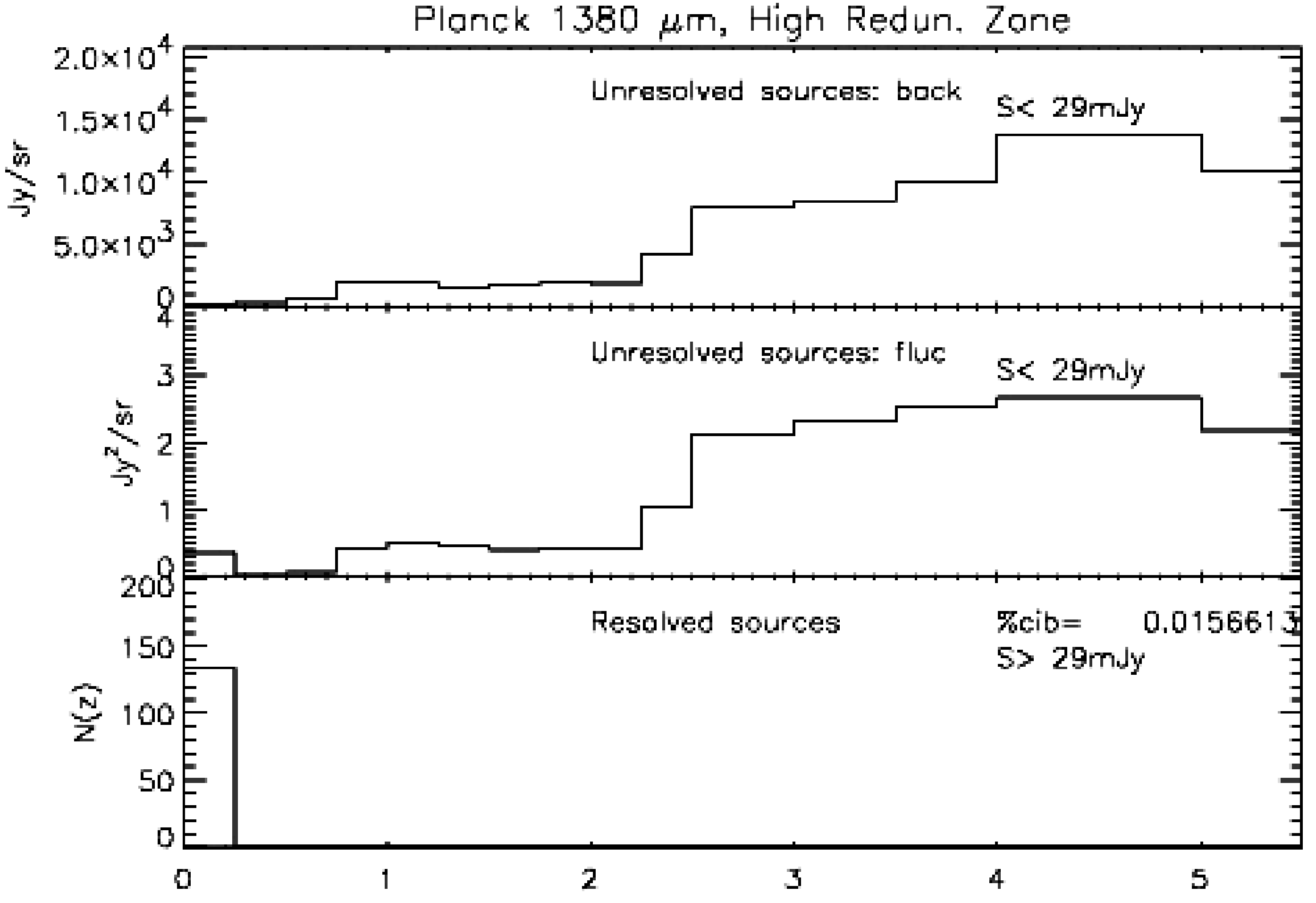
Surface (Sq. Deg.)	$5\sigma_{inst}$ (mJy)	$5\sigma_{conf}$ (mJy)	$5\sigma_{tot}$ (mJy)	Days	Number of sources	% resolved CIB
400	100	28.2[1]	103.9	18	4768	1
100	15.3	22.4	27.1	192	33451	6.7
8	7.5	22.4	23.6	64	3533	7.8

IAS model, Lagache et al.



High-redshift sources contribute Planck IR Foreground intensity and fluctuations

Lagache et al.



Higher wavelengths probe higher redshifts

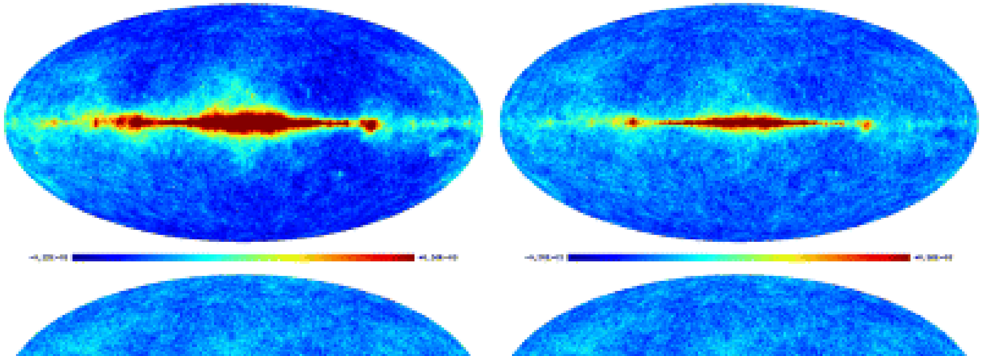
Lagache et al.

Predicted Planck CSC

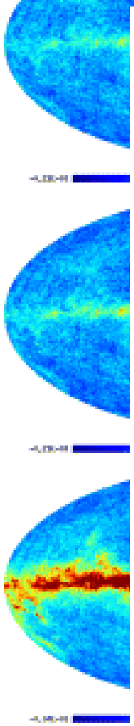
λ In μm	S_{lim}(Mexican Hat Wavelet) In mJy	N(> S_{lim}) 4π sr Toffolatti et al.	N(> S_{lim}) 4π sr IAP GalICS	N(> S_{lim}) 4π sr IAS model
350	480	67,485	61,049	18,304
550	490	9,358	9,266	1,198
850	180	7,255	7,791	582
1380	120	4,442 (+RG)	1,180	182
2097	130	4,003 (+RG)	289	62

Simulations of Planck Fields

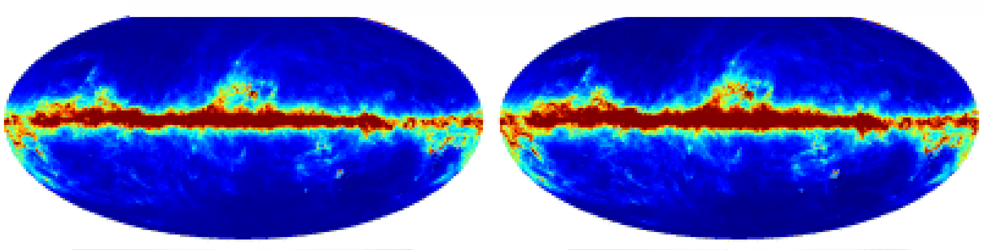
- “Cavendish Lab.” (Hobson et al. 1998 from Toffolatti et al. 1998). *Include radiogalaxies*.
- “Santander/Oviedo” (Vielva et al. 2003, from Toffolatti et al. 1998). *Include radiogalaxies*.
- “IAS” (Dole et al. 2003, from Lagache et al. 2003).
- “IAP/GalICS” (Blaizot et al. 2003, and Devriendt et al. 2003 from GalICS, Hatton et al. 2003). *Include clustering*.



Point Source Extraction with Mexican Hat Wavelet (Vielva et al. 2001, 2003)

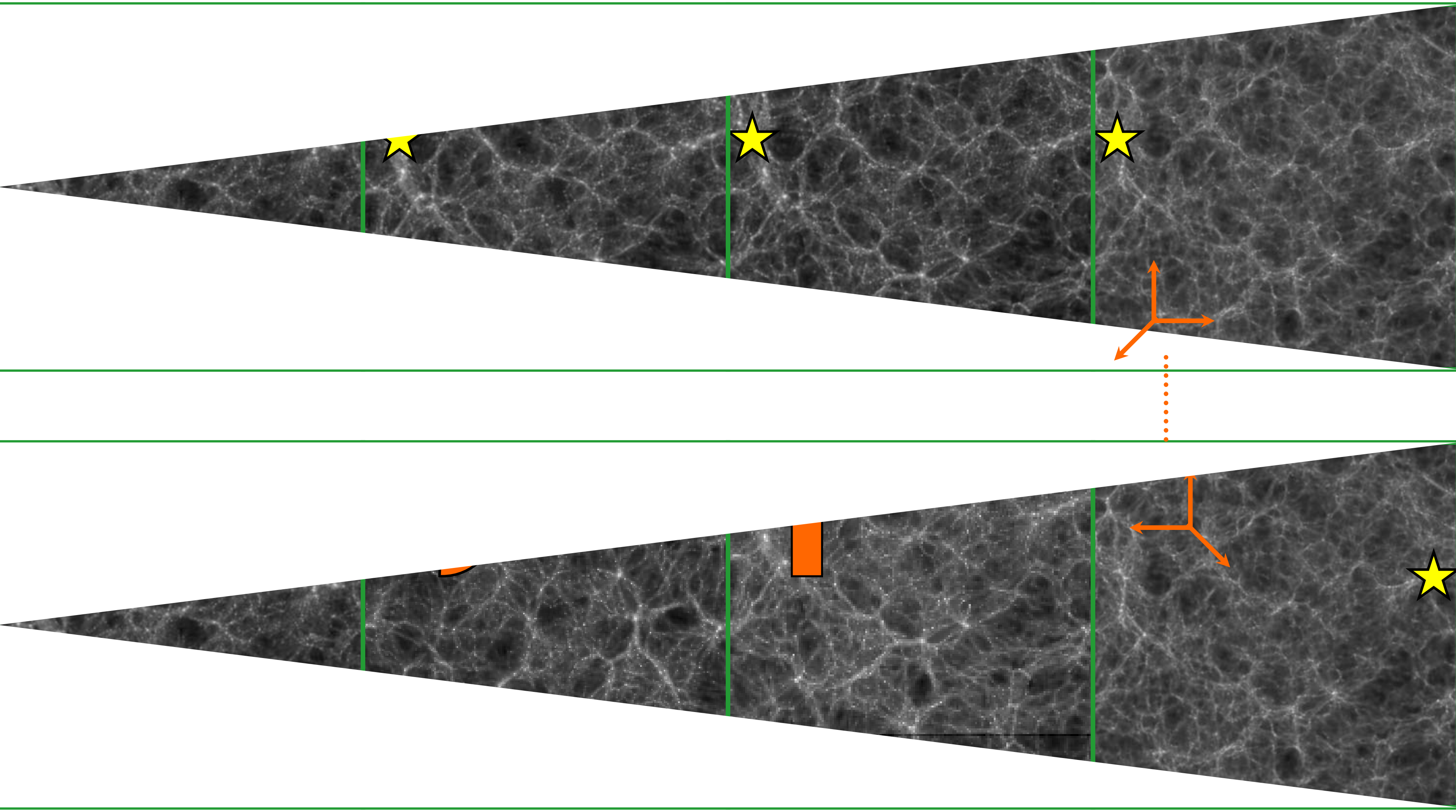


Frequency (GHz)	#	Min flux (Jy)	$\bar{E}$ (per cent)	$\bar{b}$ (per cent)	Galactic cut (°)	N_{R_o}	Completeness (per cent)
857	27257	0.48	17.7	−4.4	25	17	70
545	5201	0.49	18.7	4.0	15	15	75
353	4195	0.18	17.7	1.4	10	10	70
217	2935	0.12	17.0	−2.5	7.5	4	80
143	3444	0.13	17.5	−4.3	2.5	2	90
100 (HFI)	3342	0.16	16.3	−7.0	0	4	85
100 (LFI)	2728	0.19	17.0	−2.4	0	4	80
70	2172	0.24	17.1	−6.7	0	6	80
44	1987	0.25	16.4	−6.4	0	9	85
30	2907	0.21	18.7	1.2	0	7	85

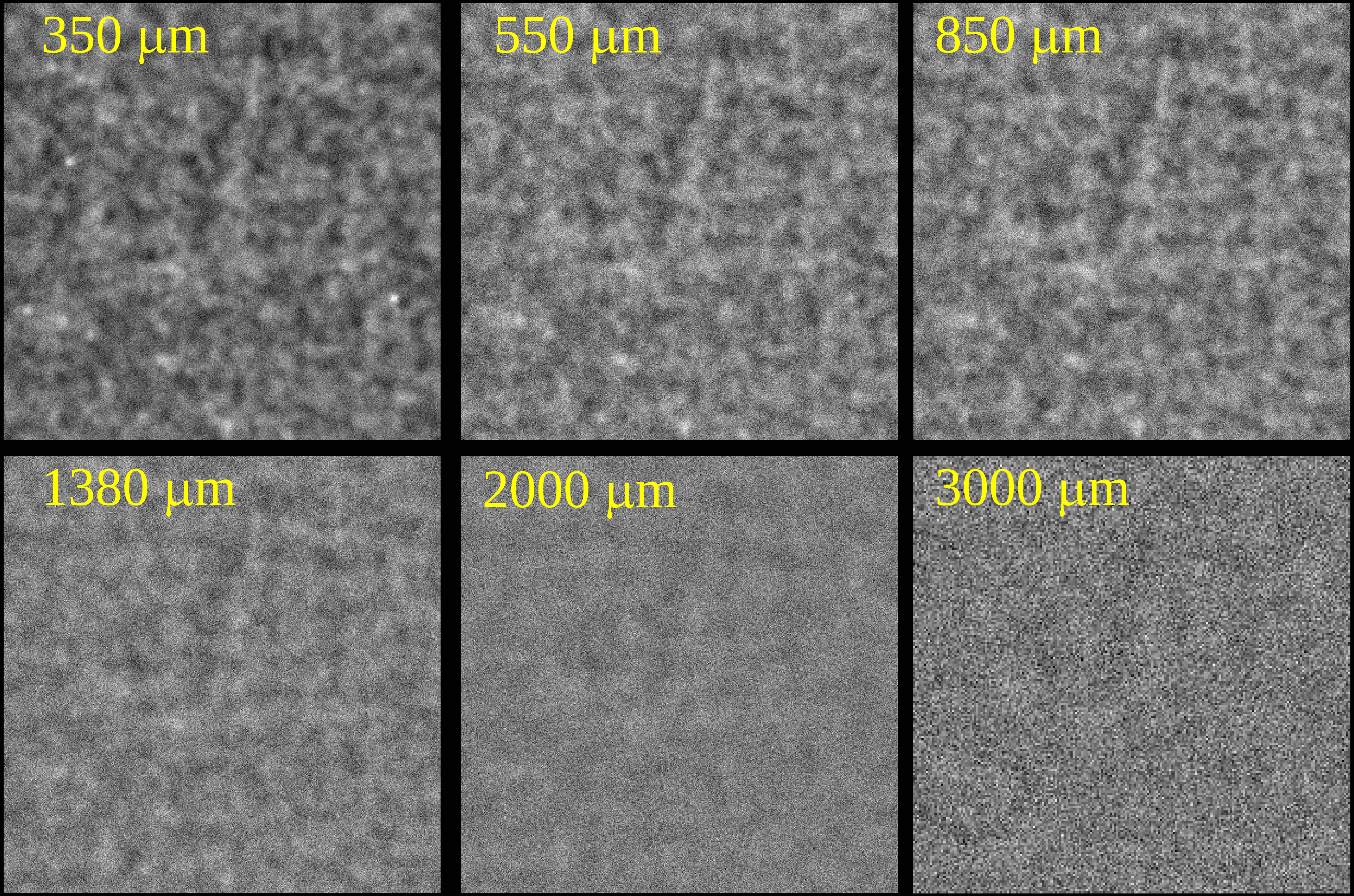


Replication effects

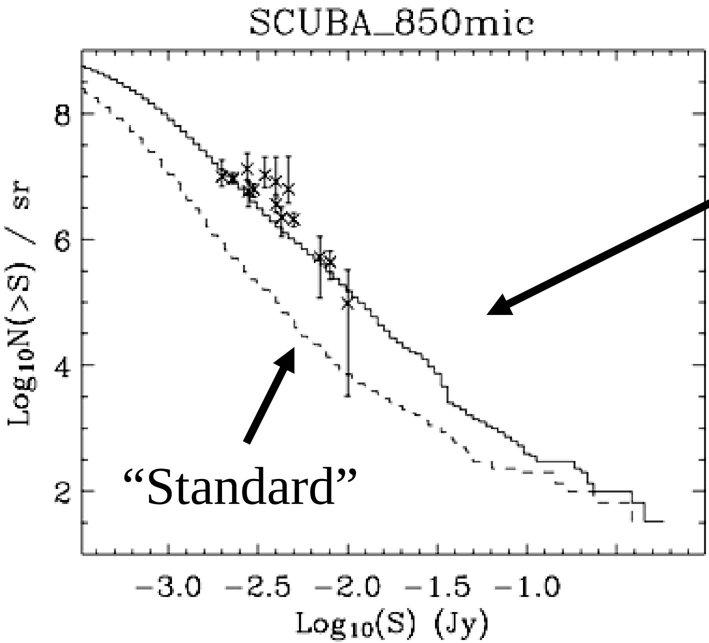
« Random tiling »



Dusty sources in a 100 deg^2 HFI field (+noise)



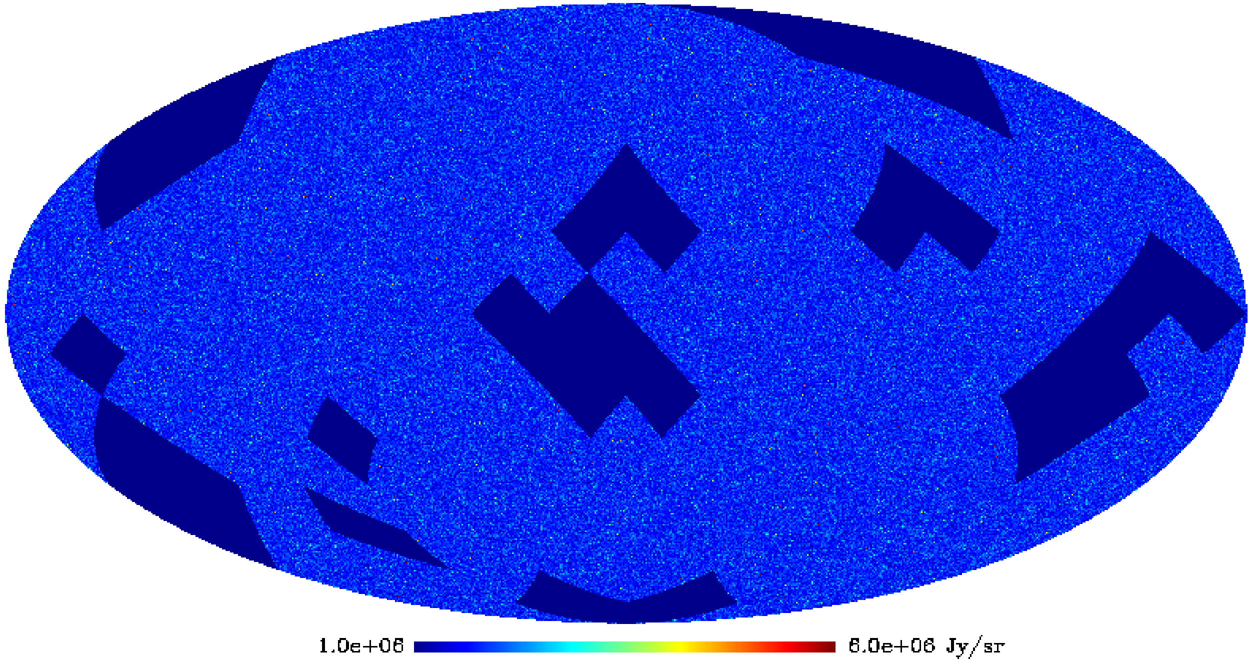
All-sky Templates for Point Sources (Thermal Emission)



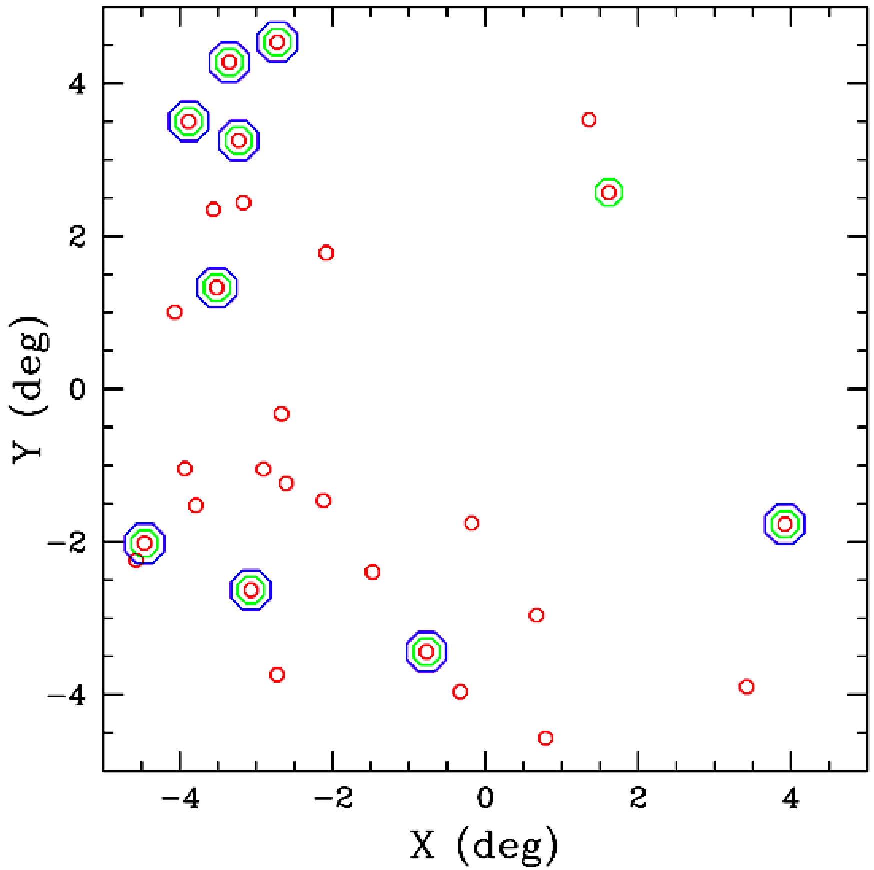
+ Top-heavy IMF ($>4M_{sun}$) in starbursts

From models of faint galaxy counts to mock sky templates (HEALpix $n_{side}=2048$)

All-sky maps achieved through connection of 192 patches. Hubble volume is paved by using the **MoMaF** random tiling method with a 150^3 Mpc^3 box simulation



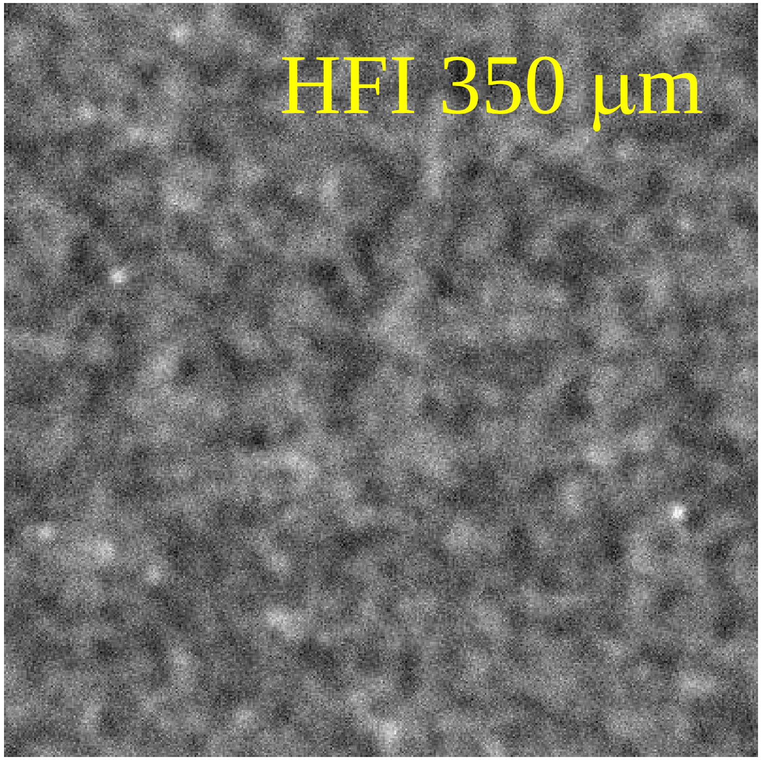
Dusty sources in a 100 deg^2 field: The effect of large-scale structures



Red dots S_{350} > 1.03 Jy

Green dots S_{550} > 0.53 Jy

Blue dots S_{850} > 0.28 Jy



29 dusty sources @ 350 μm, z < 0.1

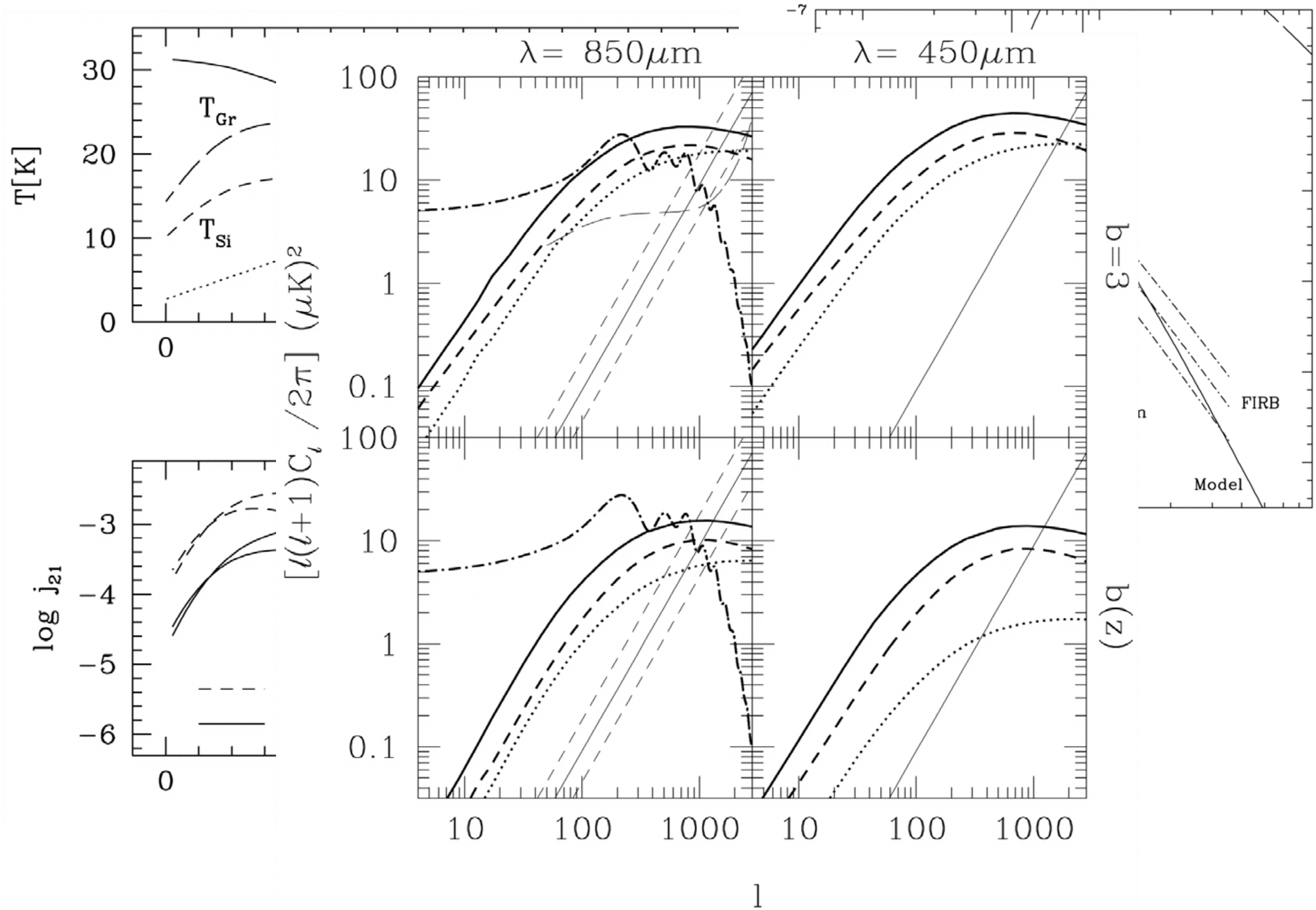
Mean sky density: 41 sources / 100 deg^2

Summary and Conclusions

- Extinction is important in the high-redshift universe. CIRB = (1—2)xCOB
- About 80 % of the CIRB has been broken into sources (thanks to gravitational lensing in cluster fields) at 15 μm and 850 μm. Only 10 % at 170 μm, but most sources contributing at 170 μm should have already been seen at 15 μm.
- Sources are predominantly powered by starbursts. At 15 μm, mostly interacting LIRGs @z~0.8; At 850 μm, mostly merging ULIRGs @z~2.4 (1000 x more numerous than in local universe). MAMBO sources (1.2 mm) even more distant (z>2.5—3 ?). SFR from a few 10 to a few 100 M_{sun}/yr (up to 1000 M_{sun}/yr). IR/submm sources seem to share the same structures as AGNs.
- Link with other high-redshift objects (EROs, LBGs, LAEs) unclear (some submm sources are EROs, LBGs and/or LAEs)

Summary and Conclusions (continued)

- Spitzer is breaking up the CIRB at 3—8 μm (IRAC) and 24 μm (MIPS). Will improve IDs (especially for SCUBA/MAMBO sources), determine SEDs, detect and discriminate AGNs ("warm SEDs"), follow-up optically-detected sources (EROs—LBGs—LAEs connection), etc.
- Phenomenological models do quite well in reproducing counts, CIRB, fluctuations). More sophisticated models with physics of Hierarchical Galaxy Formation reproduce submm counts only if extra ingredients included (e.g. top-heavy IMF).
- Herschel will see ULIRG sources up to z=4 (counts, SEDs, clustering, etc…)
- Planck will see 10,000—30,000 sources at 857 GHz (mostly local sources with possible high-z monsters). Background intensity and fluctuations probe sources at $z>1$.


λ= 850μm
λ= 450μm
[ℓ(ℓ+1)C_ℓ /2π] (μK)²
l
T[K]
T_Gr
T_Si
log j_21
b=3
b(z)
FIRB
Model

Dusty sources in a 1 deg^2 HFI and SPIRE field (+noise)

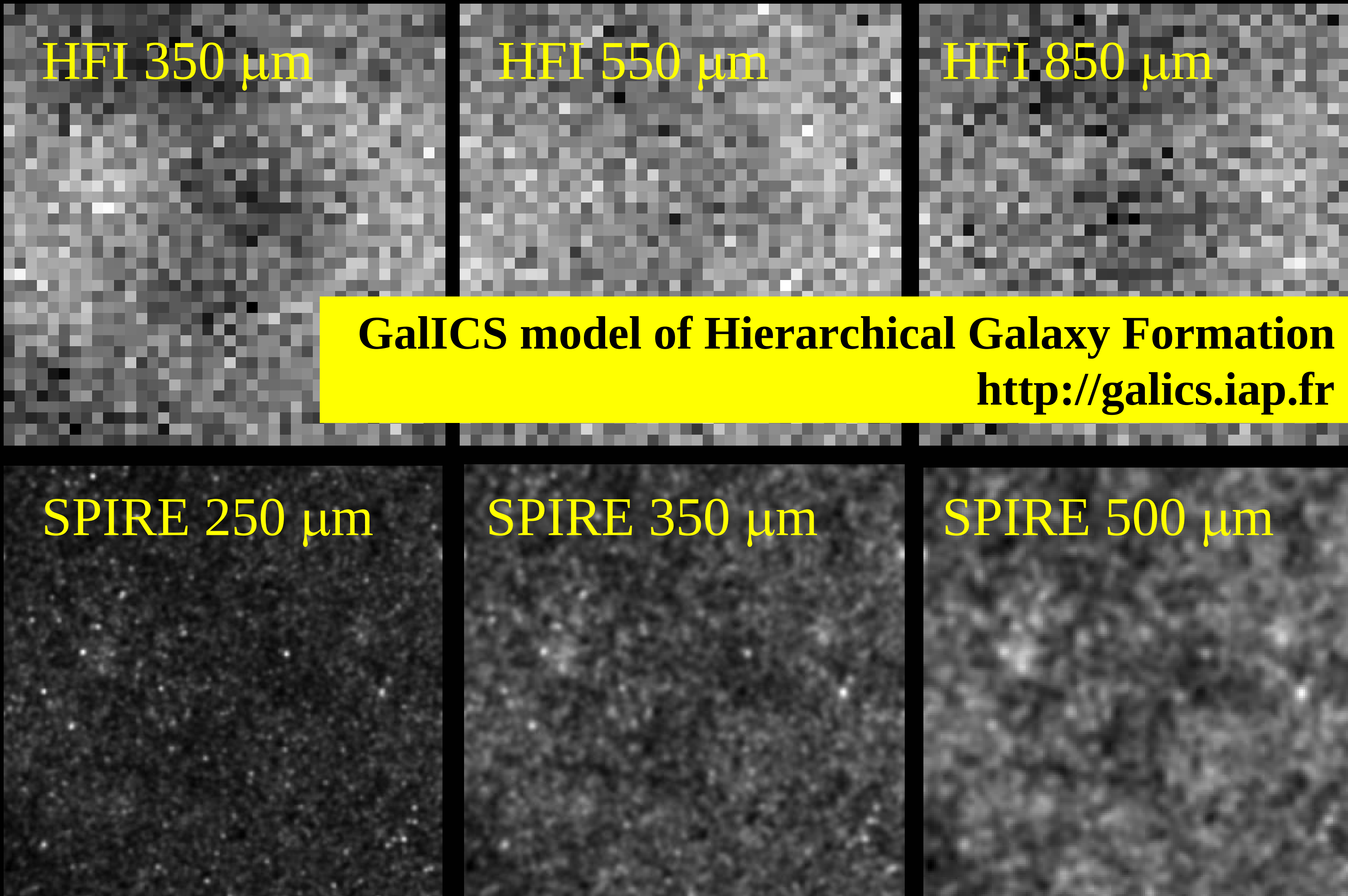


Table 5. Designed surveys that could be done with *SPIRE* (Numbers are from the 350 μm channel).

Surface (Sq. Deg.)	$5\sigma_{inst}$ (mJy)	$5\sigma_{conf}$ (mJy)	$5\sigma_{tot}$ (mJy)	Days	Number of sources	% resolved CIB
400	100	28.2[1]	103.9	18	4768	1
100	15.3	22.4	27.1	192	33451	6.7
8	7.5	22.4	23.6	64	3533	7.8

[1] Unresolved sources below $5\sigma_{inst}$= 100 mJy induce a confusion noise of σ_{conf}=5.63 mJy.

Table 6. Designed surveys that could be done with *PACS*.

Surface	λ (μm)	Days[a]	$5\sigma_{inst}$ (mJy)	S_{min}[b] (mjy)	Number of sources	% resolved CIB
20 Sq. Deg.	170	88	7.08	10.01	87 322	48.7
625 Sq. Arcmin	110	67	0.89	1.26	1955	77
25 Sq. Arcmin	75	96	0.13	0.18	192	87

[a] Depending on the scanning/chopping/beam switching strategy, there may be some overhead of about 20%

[b] $S_{min} = \sqrt{(5\sigma_{inst})^2 + S_{lim}^2} = \sqrt{2} \times S_{lim}$

Forthcoming IR/submm Observations

A golden era for high-z submm sources

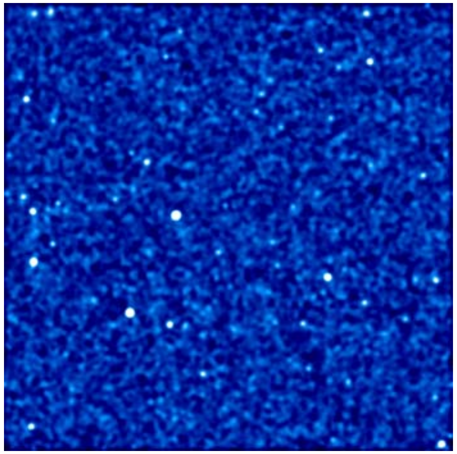
- **SIRTF** (launch in 2003) : MIPS (24, 70, 170 μm) : rest-frame MIR for z<3.
- **HERSCHEL** (launch in 2007) : PACS (60-90, 90-130, 130-210 μm) and SPIRE (200-350, 350-450, 450-670 μm)
  - Deep fields (S_{lim}=15 mJy @ 350 μm) : a few 10^4 sources. Expected 1<z<3. Confusion limited
  - *Will study the SEDs of a large sample of high-z ULIRGs*
- **PLANCK** (launch in 2007) : HFI (350, 550, 850 μm, 1.3, 2 mm)
  - All-sky Compact Source Catalogue (S_{lim}=260 mJy @ 350 μm) : a few 10^4 to 10^5 sources. Expected <z>=0.2.Confusion limited
  - *Will study the rarest/most luminous ULIRGs*
- **ALMA** (full operation 2010) : (850 μm, 1.3, 2 mm)
  - 5σ = 30 μJy/beam in t_{exp}=1h. With 0.1 arcsec resolution : ID, morphology
  - Spectroscopic measures of z with CO lines
  - *Will follow-up blank fields and optically selected high-z sources (LBGs)*

ID of IR/submm sources

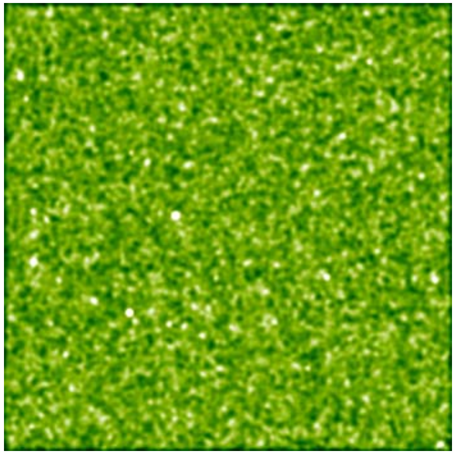
- ISOCAM @ 15 μm, S_ν>30 μJy : ID z = 0.5-1 (~ dusty, luminous galaxies of the CFRS)
- ISOPHOT @ 175 μm, S_ν>200 mJy : ID z < 0.5, + some sources à z ~1 ? (FIRBACK)
- SCUBA @ 850 μm, S_ν>2 mJy : 1 source arcmin^{-2}, IDs are diffficult; many « blank fields »; majority of source IDs at 1<z<4
  - some AGNs (10 % of CIRB ?)
  - some EROs (10 % du C IRB ?)
  - L_{IR} luminosities : a few 10^{11} to a few 10^{12} $L_\odot$ **provided z>1**
  - $\rho_{SFR}(z>1) = 10^{-1}\ M_\odot yr^{-1} Mpc^{-3}$ (Hughes et al. 1998)

IR & Submm Panchromatic Sky

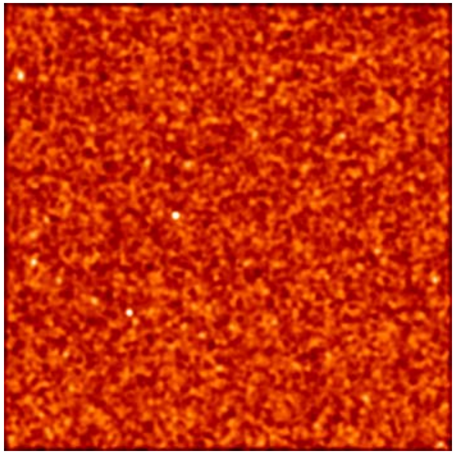
Planck HFI
350 μm

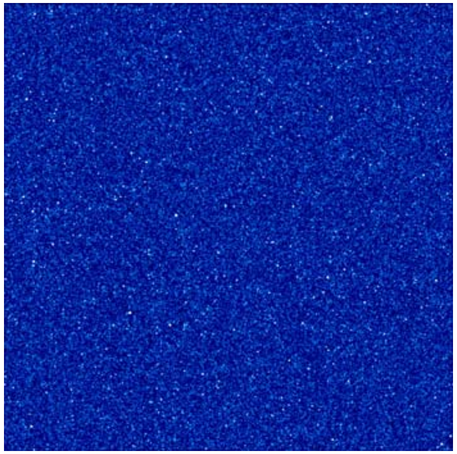


Planck HFI
550 μm

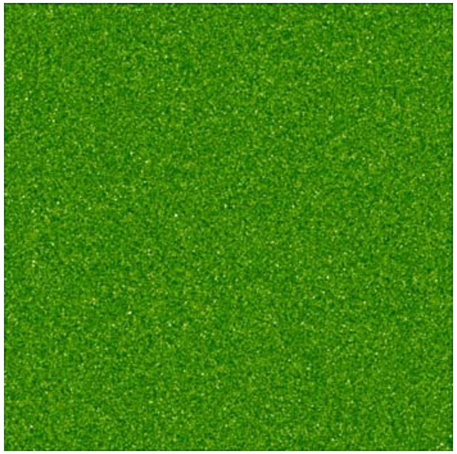


Planck HFI
850 μm

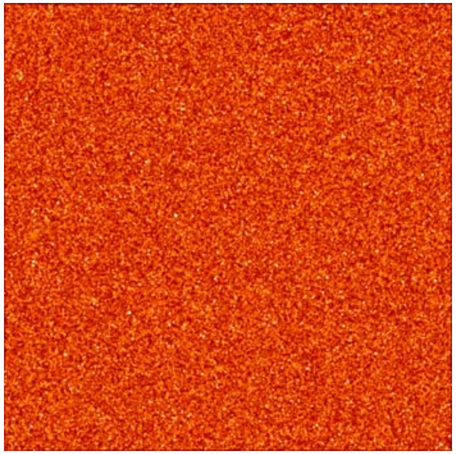




Herschel SPIRE
250 μm



Herschel SPIRE
350 μm



Herschel SPIRE
500 μm

Surface: 50.6$^{\circ 2}$

Sims from Dole, Lagache, Puget, 2003, ApJ

Possible Herschel Key Projects

GT KP: 50-60 d per instrument consortium

- HIFI Spectral Survey (60 d?)
- SPIRE/PACS Molecular Cloud Survey
  - Gal. Conf. Limit 10 mJy (1σ), 100 deg^2, 30 d.
- SPIRE Galactic Plane Survey |b|<2.5°
  - 30 mJy (1σ), 1800 deg^2, 54 d.
- SPIRE/PACS Extragalactic "Wedding-cake" Surveys from wide field to confusion limit
  - 4 surveys from 90 deg^2, 20 mJy (1σ) @ 250 μm to 0.25 deg^2, 0.54 mJy (1σ) @ 120 μm, 24 d. SWIRE fields ?
- SPIRE/PACS Targeted Proposals:clusters as lenses, cluster evolution, SZ clusters, high-z AGNs, galaxies and radiosources, rich environments, etc. 30 d ?

Planck/Herschel Synergy

- Complementary wavelength coverage (esp. 850 μm, 1380 μm) to bright sources found in Herschel Projects.
- Polarization.
- All-sky detection of «new», «rare» sources for Herschel follow-up.
- Cross-calibration of bright point sources, and diffuse background.
-