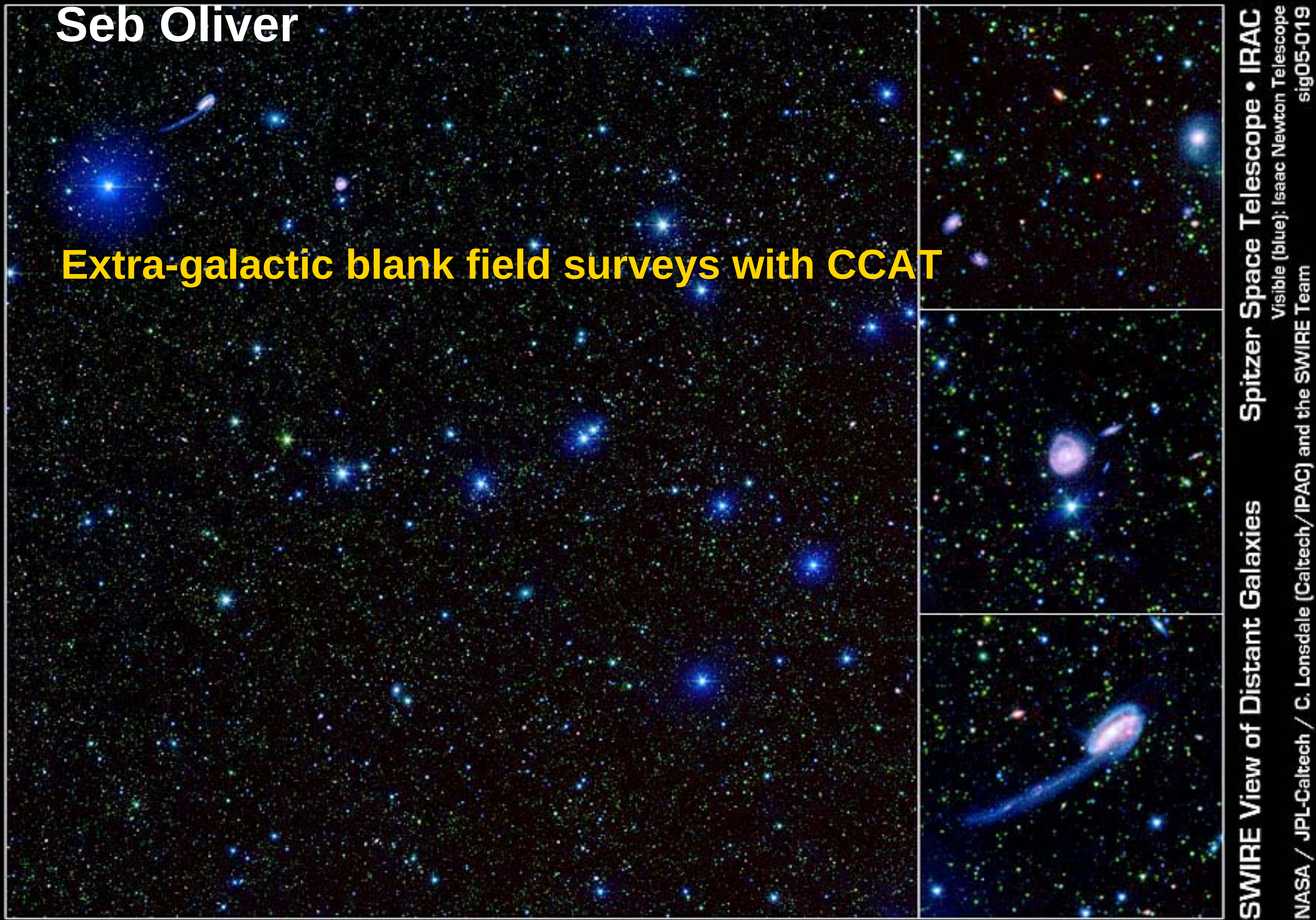
Seb Oliver

Extra-galactic blank field surveys with CCAT



Questions to answer

How did galaxies form & evolve?

What is the feedback process in star-formation?

What is the connection between star-formation and black hole assembly?

When did the stars in the most massive galaxies form? (…)

How did galaxies assemble?

What is IMF at high z?

AGN unification?

Etc…

Why Infrared?

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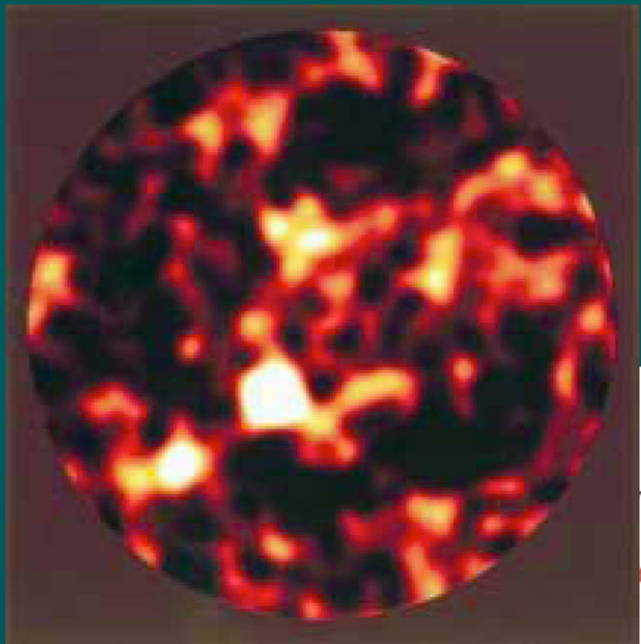
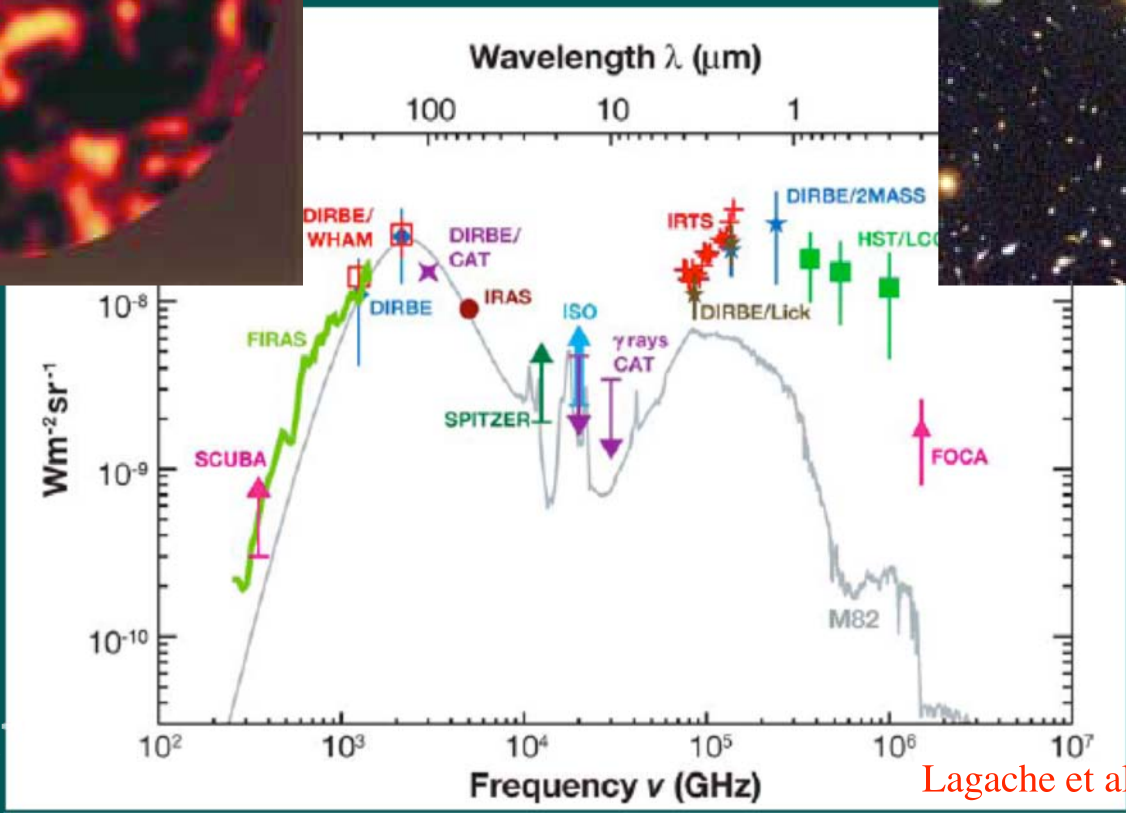
Hughes et al. 1998 Nature 394 241



Williams et al 1996 AJ 112, 1335



Lagache et al 2005 An. Rev. Astro. 43

Cardiff, CCA

Cosmic History of Star formation Down-sizing?

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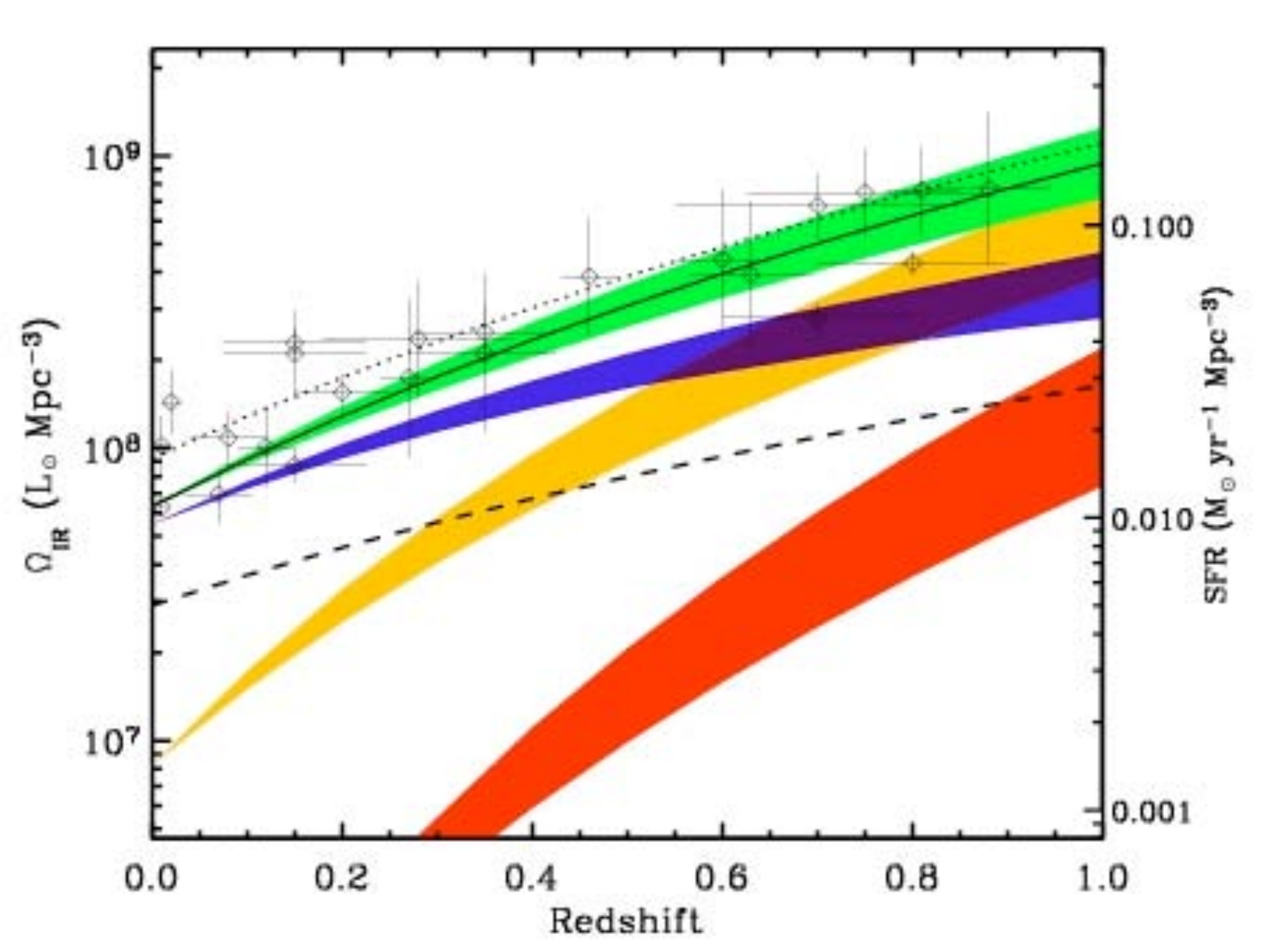
All

Low luminosity

LIRGS

ULIRGS



Le Floch et al. 2005

Clustering of ‘bump’ sources (ULIRGS)

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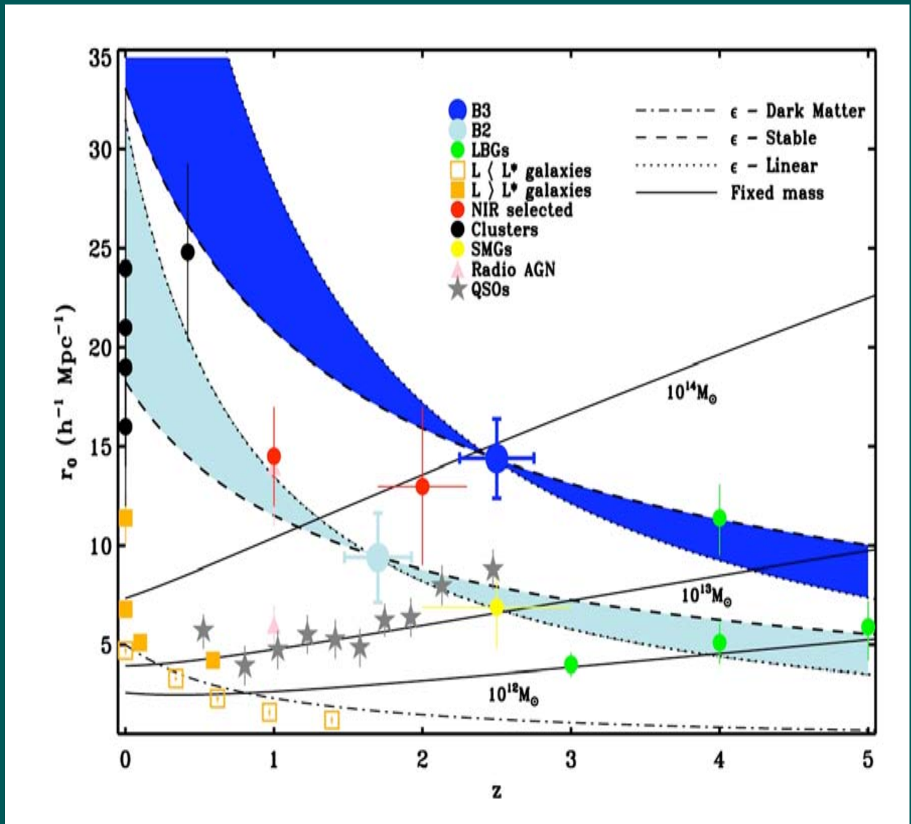


Farrah et al 2006

High mass (>10^{11}Mo), high star formation rate (>200Mo/yr) ultra-luminous infrared galaxies

Photo-z selection at z~1.7 and z~2.5

Clustering strength => dark matter halo masses ~7x10^{12}Mo

Evolve into clusters/groups

ULIRGS at high z are in massive Halos

But...?

Hard for theory to explain e.g. modified IMF

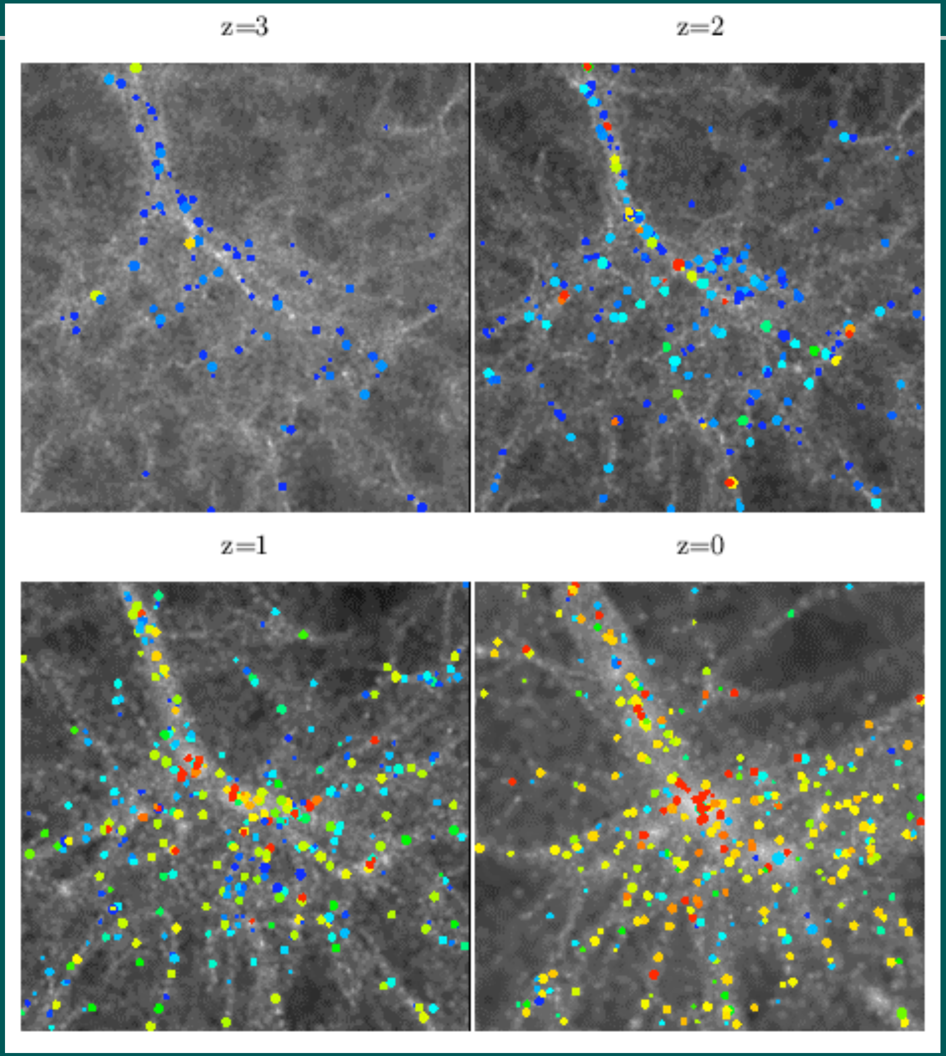
Testing Theories of Structure formation

Requires full sampling of environments & scales --> Large volumes

Rare objects --> Large volumes

Sampling to low masses star-formation rates --> drives depth

Variety of galaxies --> requires large numbers



Kauffmann et al. (1999) 21x21x8 (Mpc/h)^3

red → blue increasing SFR

Counts at 24 μm

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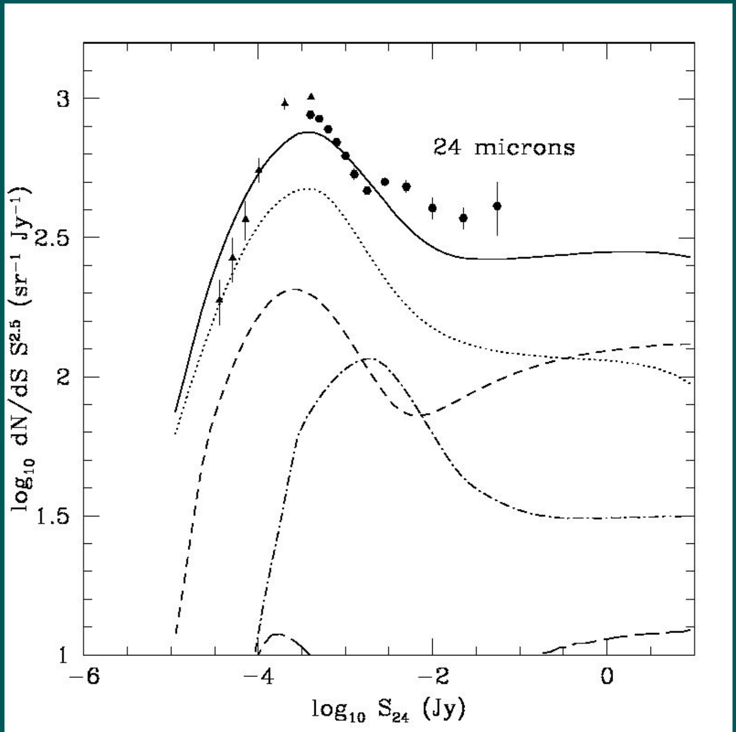
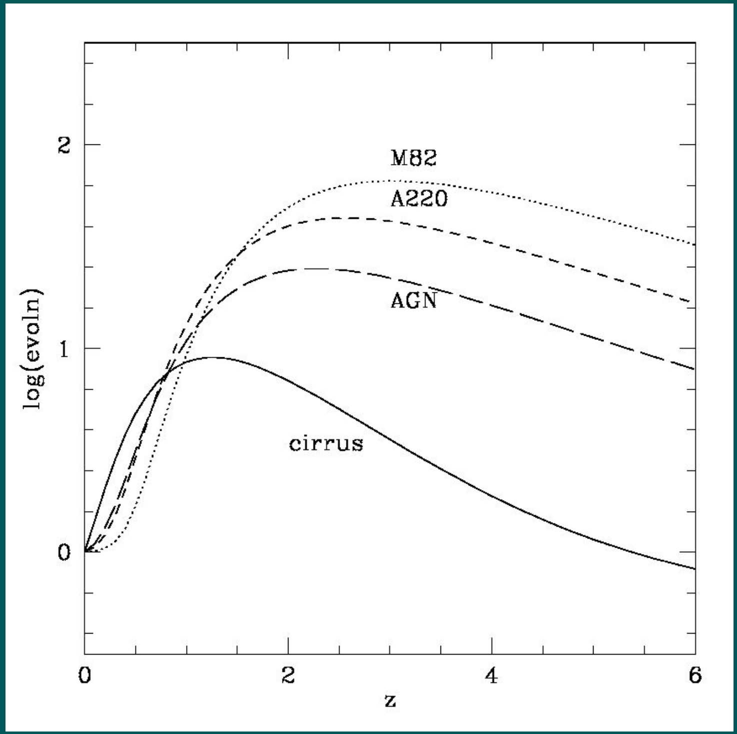
Sharp peak in counts

Requires cool cirrus ?





model for ir counts (developed from RR 2001)
independent evolution for each component

Shupe et al, 2006, Papovich et al 2004

Cardiff, CCAT September 2006, Seb Oliver

Rowan-Robinson et al 06

C.f. Optical

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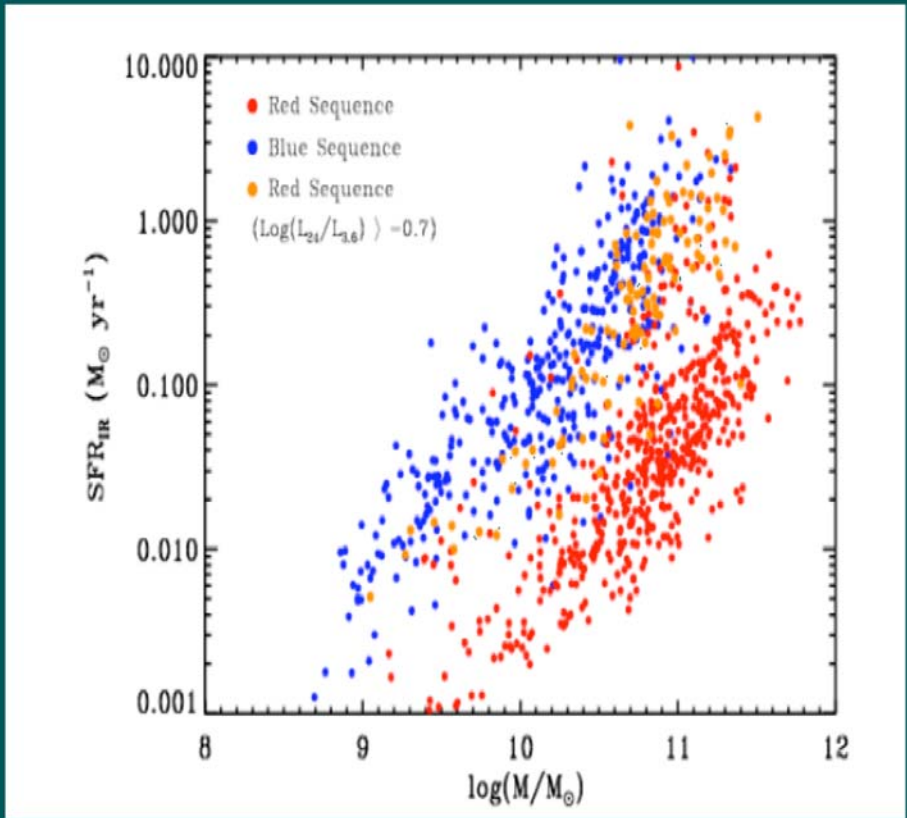

47% of observed 24micron Luminosity is in red galaxies

28% of which is in star-forming galaxies

19% in AGN

N.B. massive galaxies not just reddening

Davoodi et al., 2006, PhD

(cf Wolf et al 2005 - dusty red sequence galaxies)

Census of the Universe

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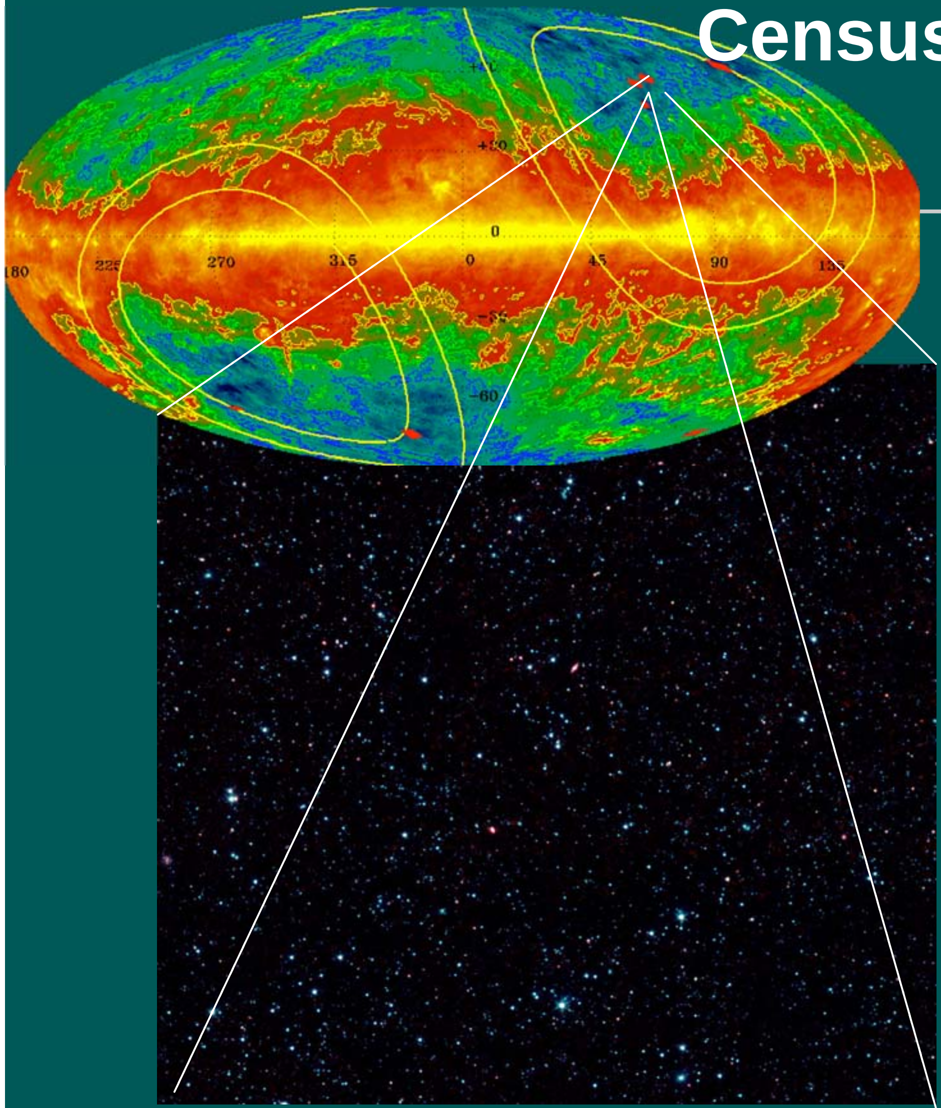

Needs full FIR SED coverage

Need to sample low luminosity systems

Need to cover a fair sample of environments

Linking star-formation, stellar assembly and black-hole accretion to the dark matter halo histories

The IR background and CCAT role

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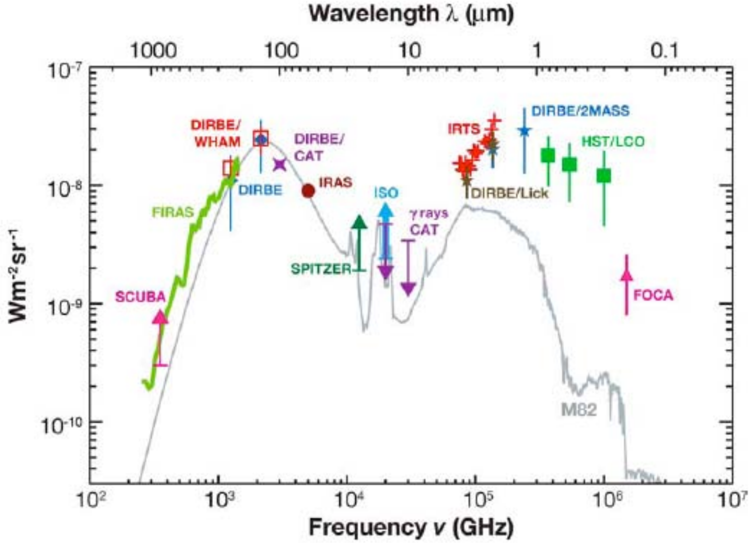
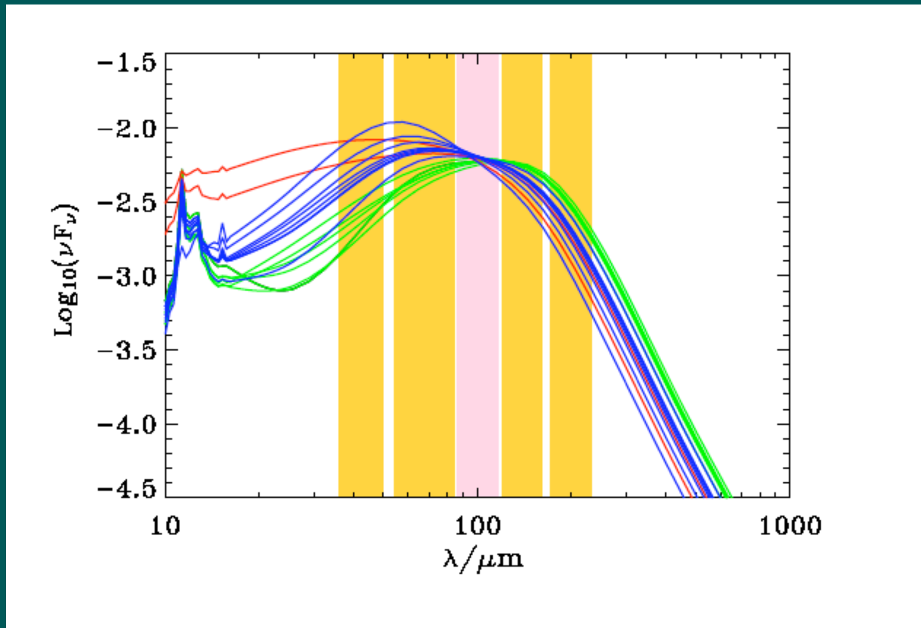


Figure 2 The extragalactic background over three decades in frequency from the near UV to millimeter wavelengths. Only strongly constraining measurements have been reported. We show for comparison in gray an SED of M82 (Chanial 2003)—a starburst galaxy at $L = 3 \times 10^{10} L_\odot$—normalized to the peak of the CIB at 140 μm. References for data points are given in Table 1.



CCAT will resolve the peak of FIR background

& probe emission at higher z at shorter rest-frame wavelengths

Same patch of Galics (Guiderdoni et al.) catalogue sky, viewed with 0.85m, 3.5m, 10m, 30m apertures @ 250 microns. 16x8 arcminute field of view.

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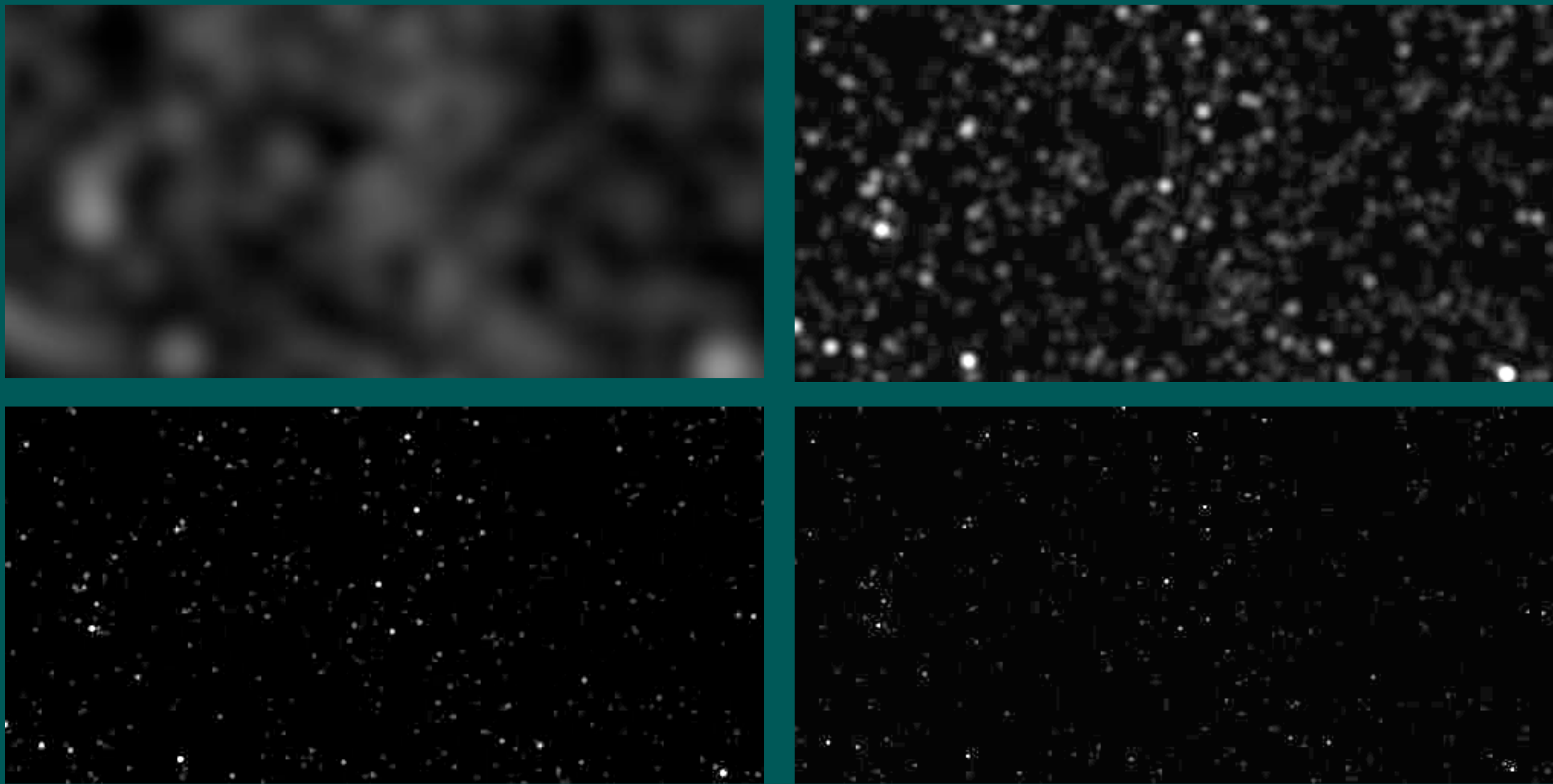

Rich Savage

Resolving the CIRB into galaxies

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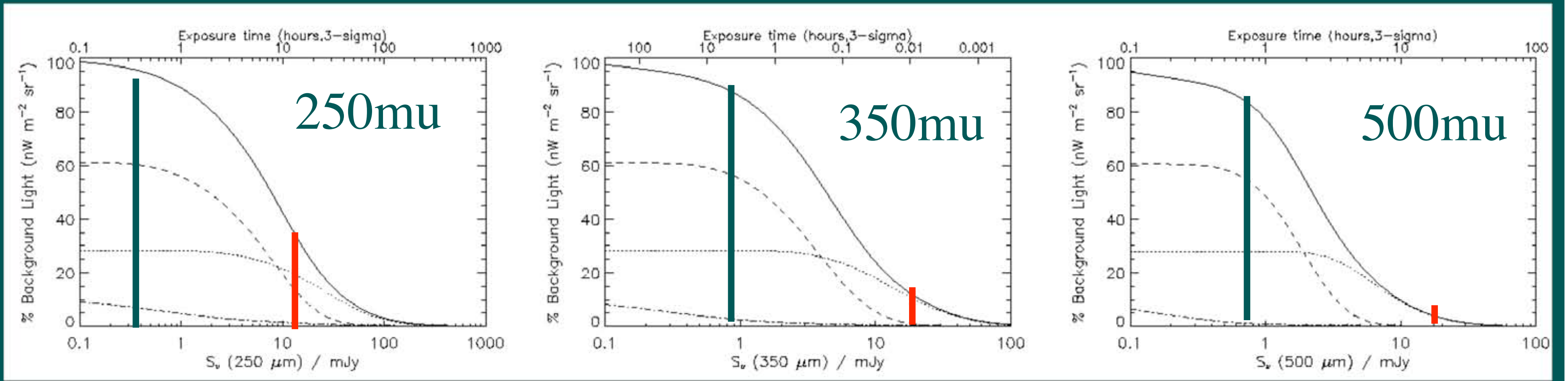

Fraction of the Extragalactic Background Light resolved at 3 Herschel's Bands, down to the confusion limit (Elbaz).

Confusion limits/mJy

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Still uncertainties within factor 2-3

	250	350	500	
10 Beams per source	0.04	0.19	0.41	Lagache
	0.11	0.42	0.62	Franceschini
	0.03	0.29		Rowan-Robinson
30 Beams per source	0.32	1.02	1.47	Lagache
	0.99	2.17	2.15	Franceschini
	0.56	1.26		Rowan-Robinson

What volume / area do we need?

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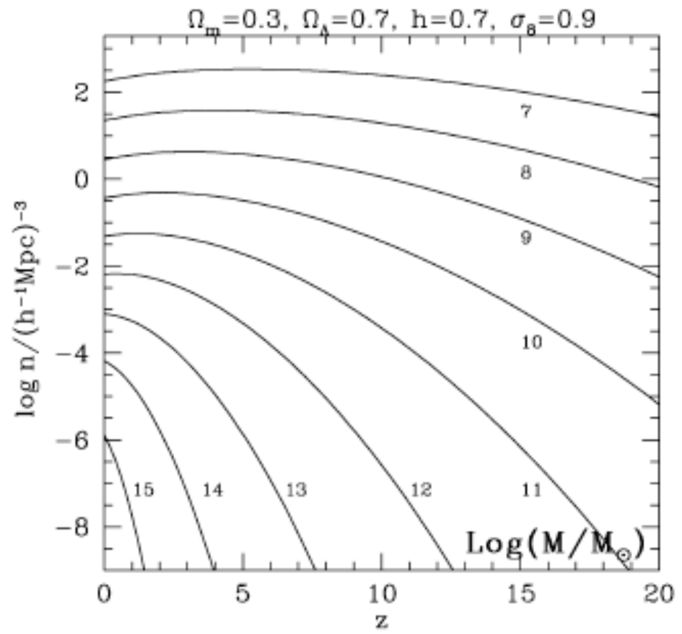
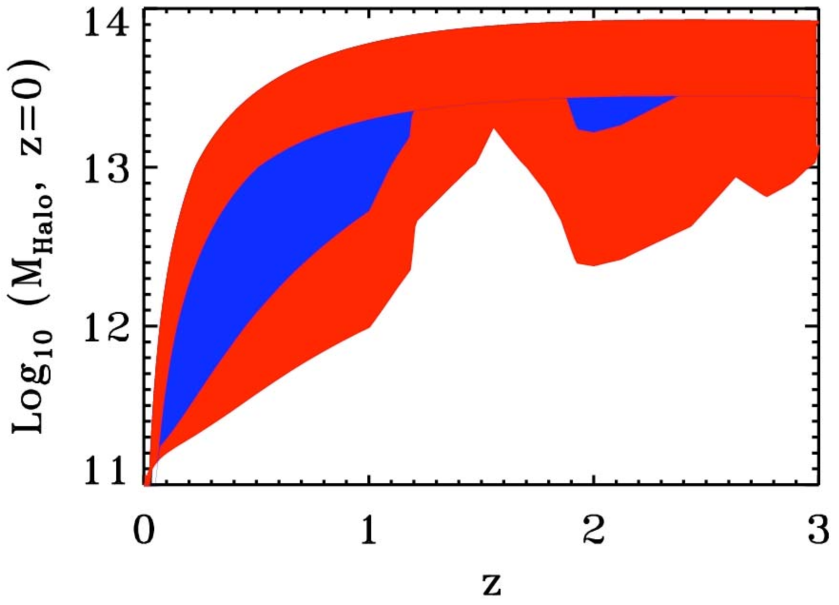


Figure 1. Each curve indicates the variation with redshift of the comoving number density of dark matter haloes with masses exceeding a specific value M in the standard ΛCDM model with $\Omega_{m,0} = 0.3$, $\Omega_{\Lambda,0} = 0.7$, $h = 0.7$ and $\sigma_8 = 0.9$. The label on each curve indicates the corresponding value of $\log(M/M_\odot)$.

Mo & White 2002



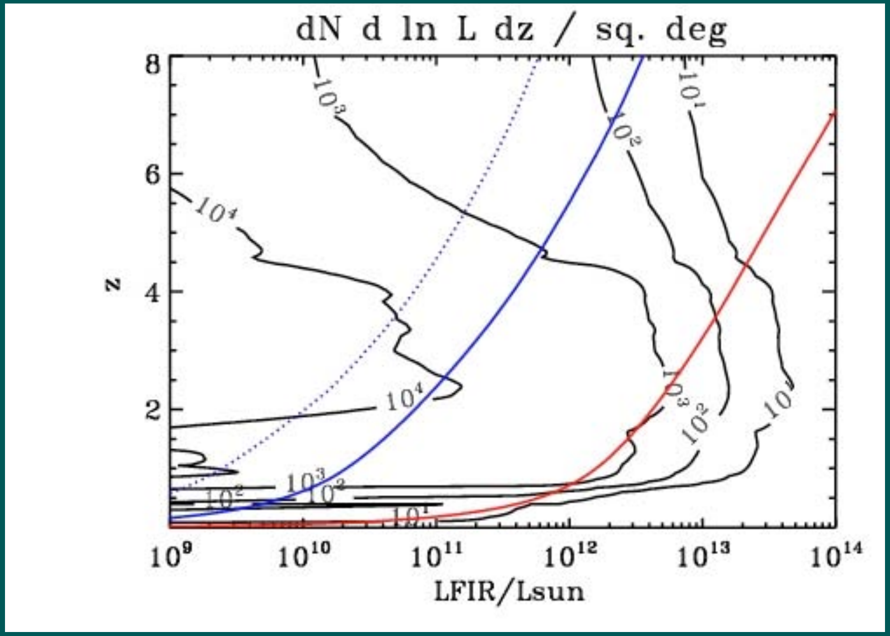
Nhalos=400, Dz=0.2 Area=2 or 7 sq. deg.

V(10^15Msun)=10^6 (h-1Mpc)^3

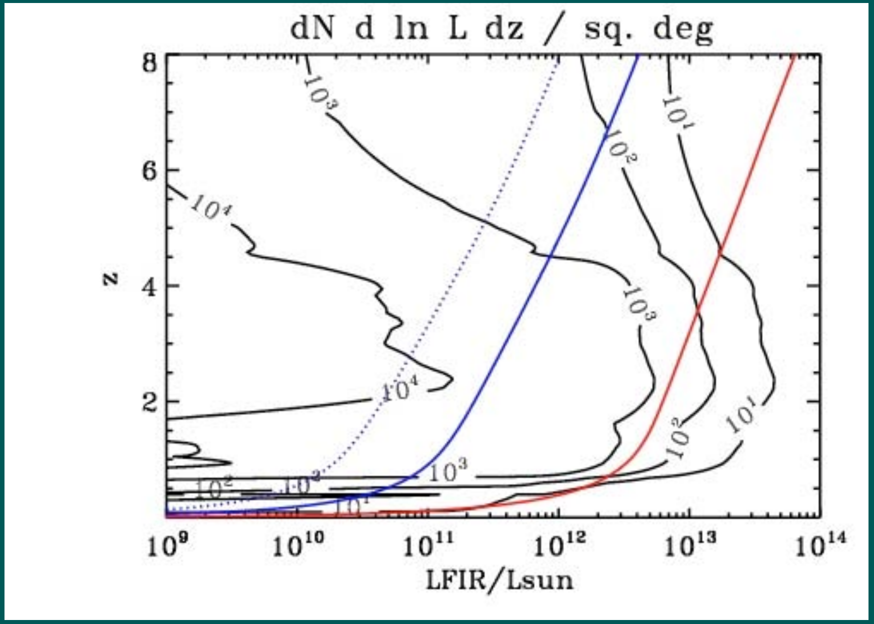
N/sq.deg./dz=0.1 At z=1, 0.28 ==> 10

What could we se?

Number density as function of FIR luminosity density
Confusion limits from SPIRE & CCAT



250 micron



350 micron

Lagache Model

Options

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Finding very high-z galaxies from PAH emission
---GOOODS 0.2 sq. deg. 0.3mJy @ 200 (30BPS confusion limit) 300 nights

Formation of L* galaxies -- star formation in low mass systems
--- COSMOS 2 sq. deg. 0.3mJy @350 (10BPS confusion limit) 300 nights

Star-formation in full range of environments
---SWIRE 20 sq. deg. 1mJy@350 (30BPS confusion limit) 300nights

Wider/shallower surveys possible but less obvious niche

Conclusions

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Spitzer, SCUBA & CIRB underline importance of IR studies

Raise more questions -

modified IMF? Cool objects? IR emission from ellipticals

Requires samples across peak of FIR SED to faintest possible L and over wide areas

Herschel / Scuba-2 etc. will only partly address these

Needs high resolution lambda <= 300