Submillimetre observations of star-forming galaxies

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/me-how me-how-ov-ski/

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Galaxies meet GRBs at Cabo de Gata

Outline

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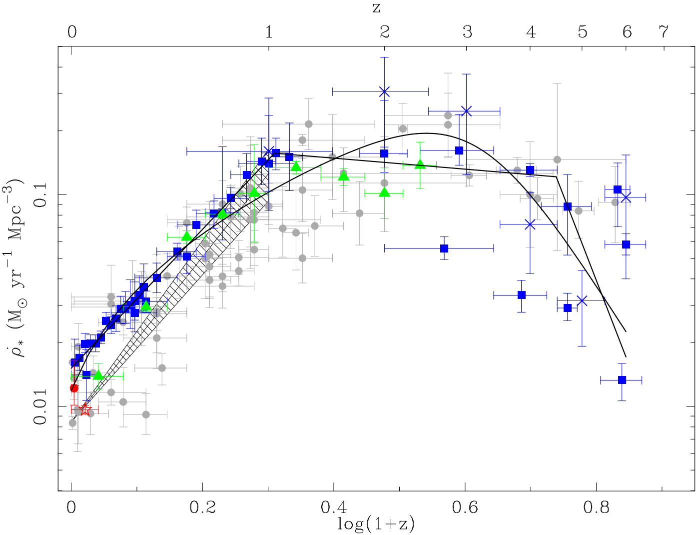
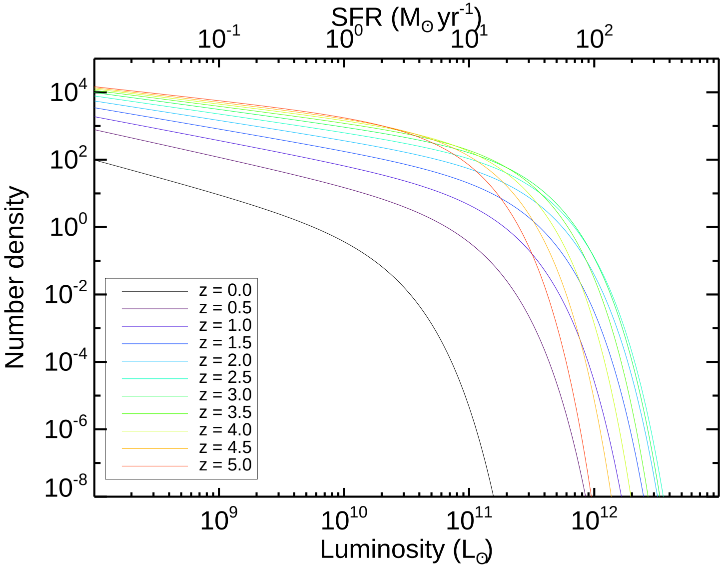
1. Introduction: cosmic star formation history (SFH) and dust
2. Measuring dust-obscured cosmic star formation history (SFH)
   - Bright-end: submm galaxies
   - LIRGs
   - Faint-end including gamma-ray burst hosts
2. Future: towards the full census of dusty galaxies

Star Formation History of the Universe

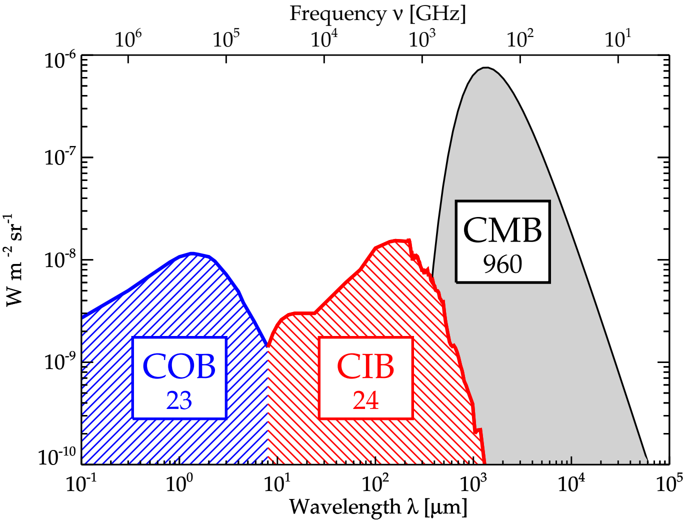


Hopkins & Beacom et al. (2006, ApJ, 651, 142)

Infrared luminosity function

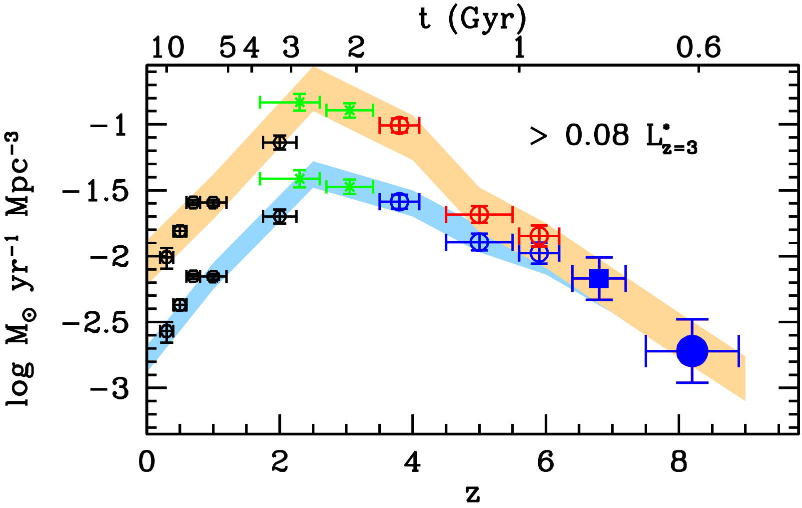


Who cares about dust?



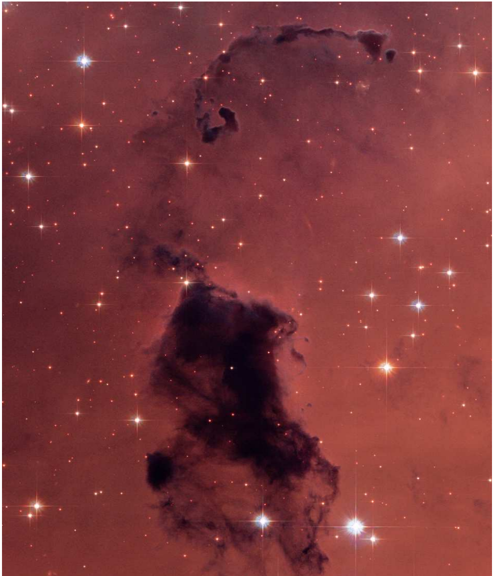
Dole et al. (2006, A&A, 451, 417)

Dust-obscured Star Formation History of the Universe



Bouwens et al. (2010, ApJ, 709, 133)

Long Wavelengths



Optical observations?

- Star formation activity hidden in MCs
- Optical biased towards less-dusty systems
- Extinction correction large, difficult or even impossible

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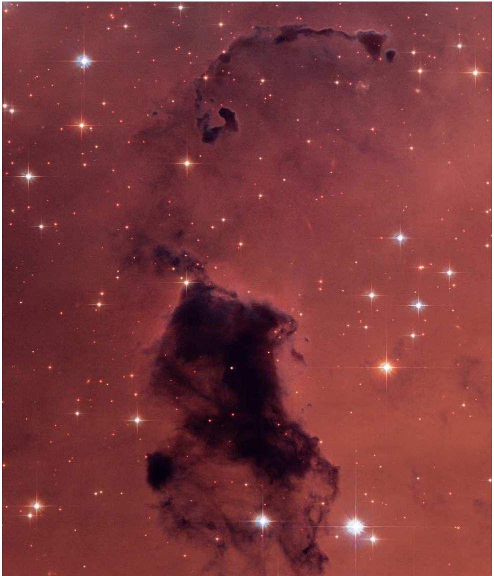

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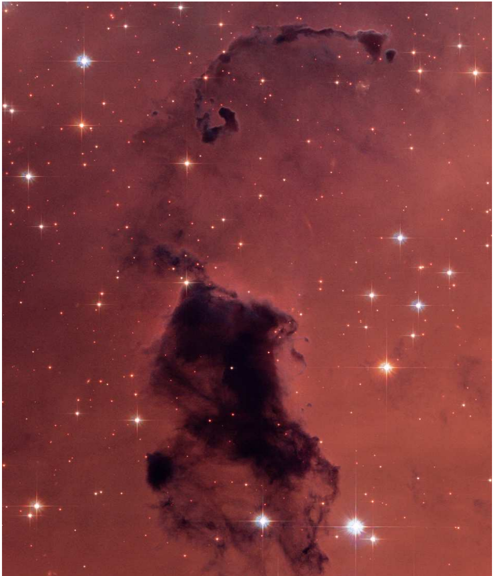

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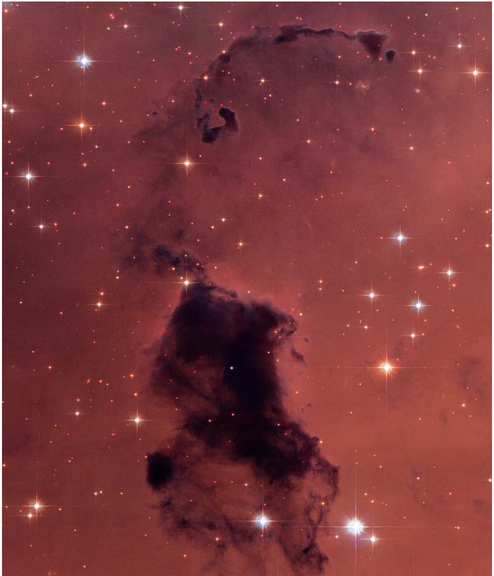

Optical observations?

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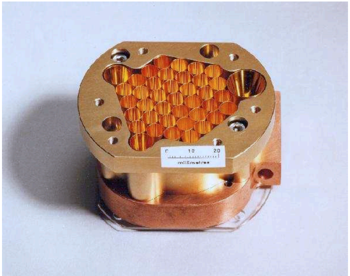
Far-infrared, submm and radio are free of these problems

Outline

The discovery

James Clerk Maxwell Telescope (JCMT)
15 m

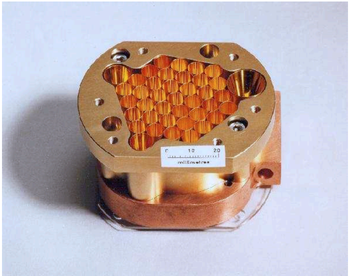


Submillimetre Common User Bolometer Array (SCUBA)
850 μm

beam size: $15''$
confusion limit: 1 mJy

The discovery

James Clerk Maxwell Telescope (JCMT)
15 m $>$ 10.4 m!!



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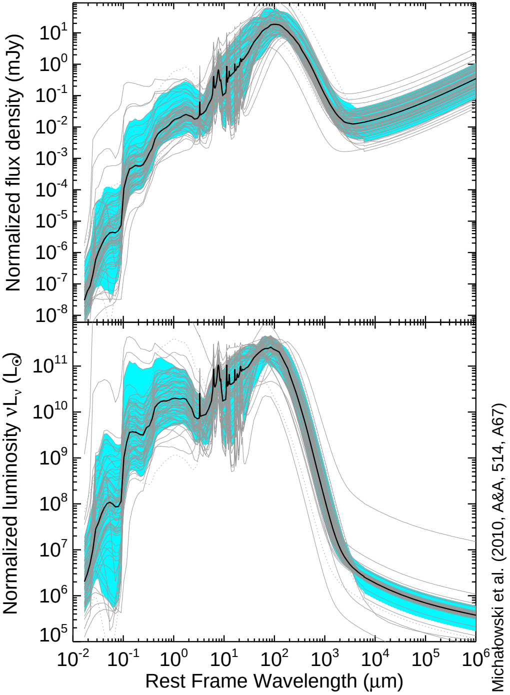
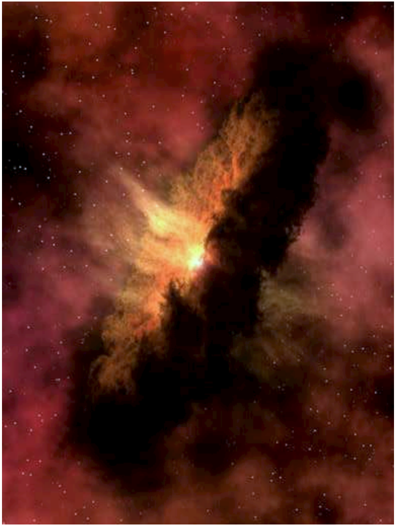
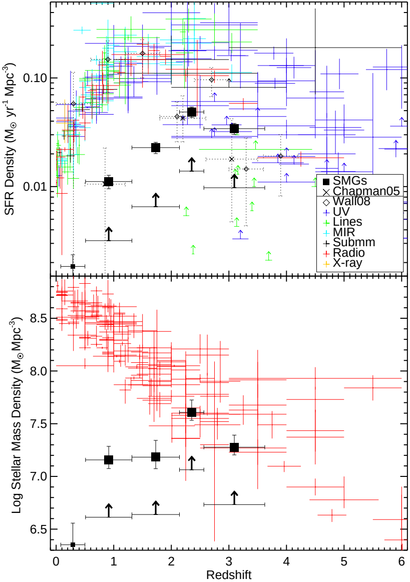

Normalized flux density (mJy)
Normalized luminosity νL$_\nu$ (L$_\odot$)
Rest Frame Wavelength (μm)
Michałowski et al. (2010, A&A, 514, A67)

Basic properties of Submillimeter Galaxies (SMGs)



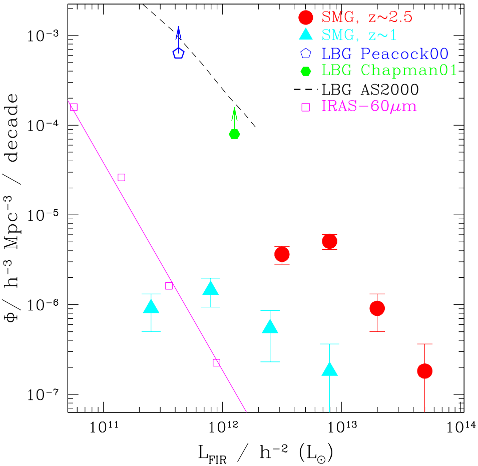
- Selected at submm (typically 850 μm)
- $z = 2$–3
- Luminous, massive, dusty galaxies

Why are SMGs important



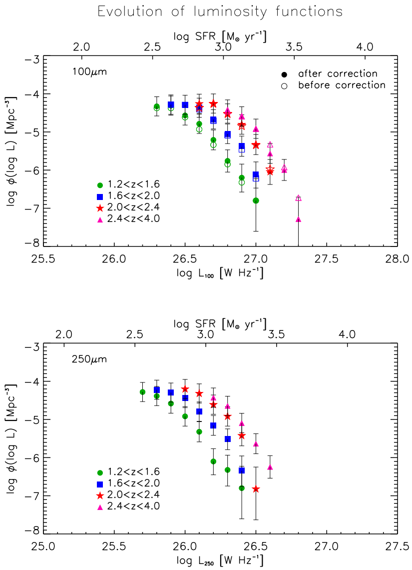
Michałowski et al. (2010, A&A, 514, A67)

SMG luminosity function



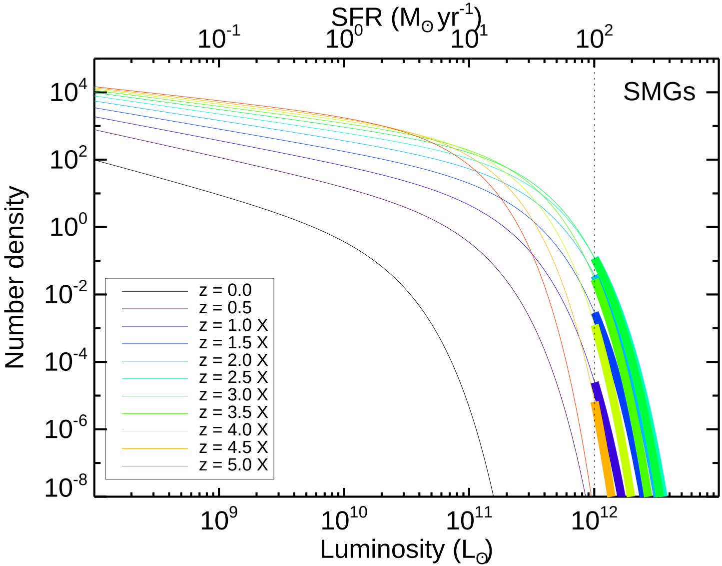
Chapman et al. (2005, ApJ, 622, 772)

SMG luminosity function



Lapi et al. (2011, ApJ, 742, 24)

Infrared luminosity function (SMGs)



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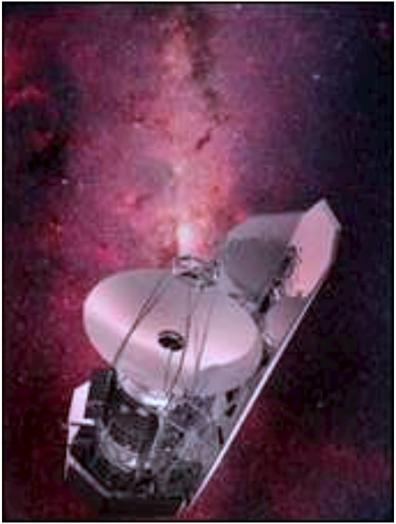
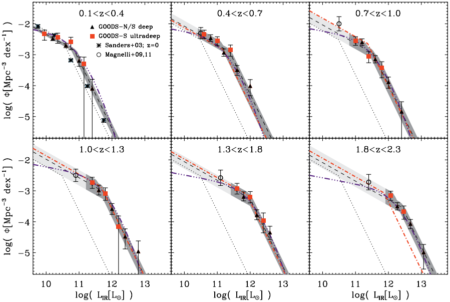
Herschel Space Observatory



- 3.5 m diameter
- 55-671 μm wavelength range
- beam size: 18–35$''$
- second Lagrangian point (L2)
- launched on 14 May 2009
- $\sim$ 1 bln euro

http://news.bbc.co.uk/1/hi/8458203.stm

Herschel deep observations



Magnelli et al. (2013, A&A, 553, 132)

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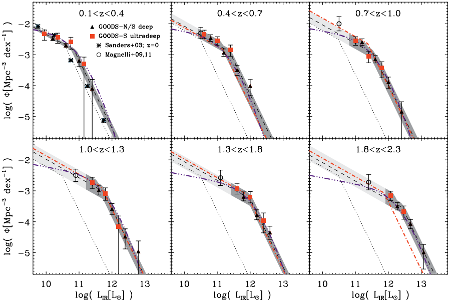
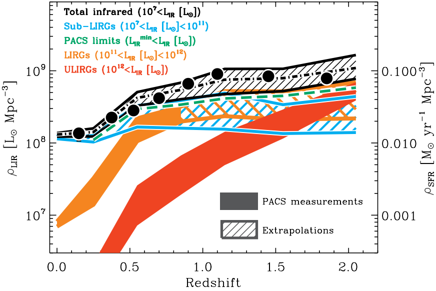
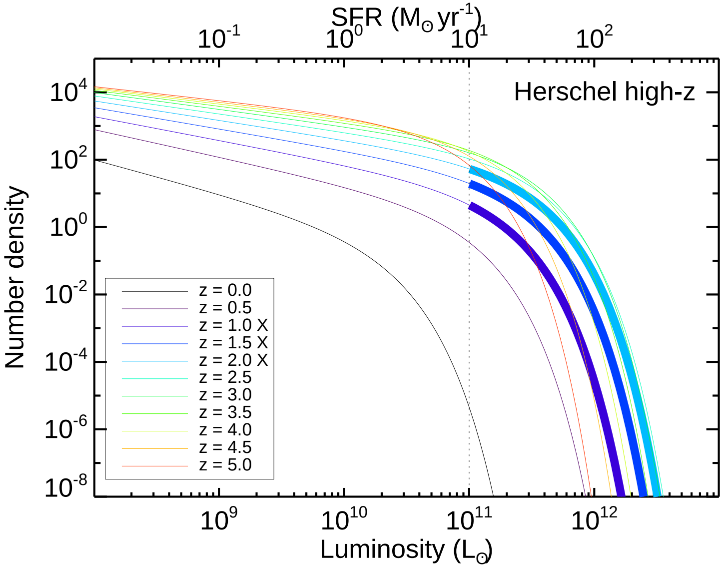




Magnelli et al. (2013, A&A, 553, 132)

Infrared luminosity function (*Herschel* high-*z*)



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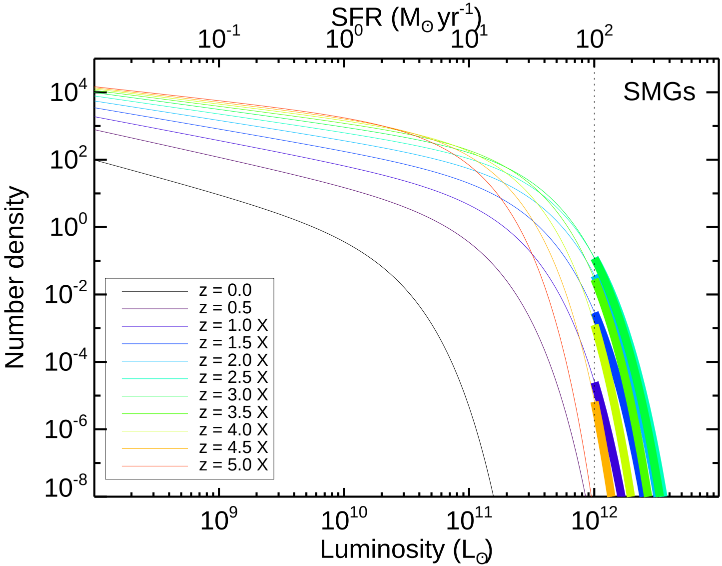

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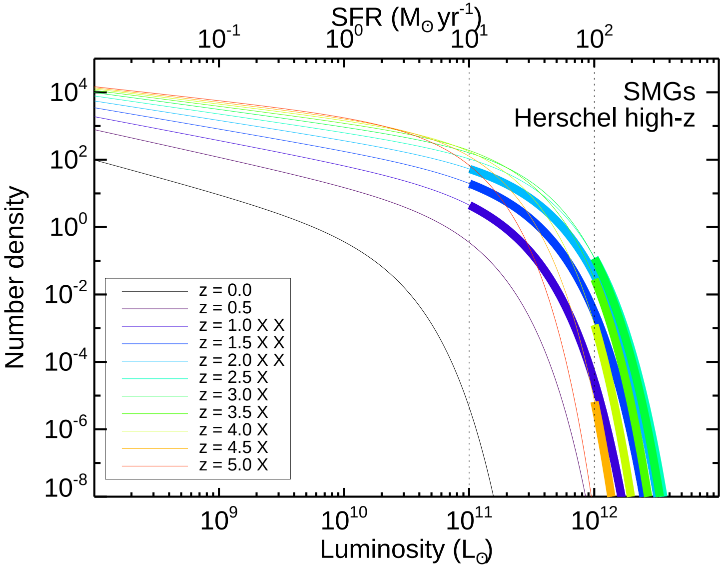

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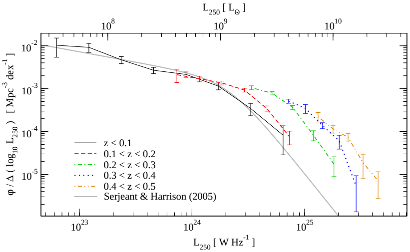
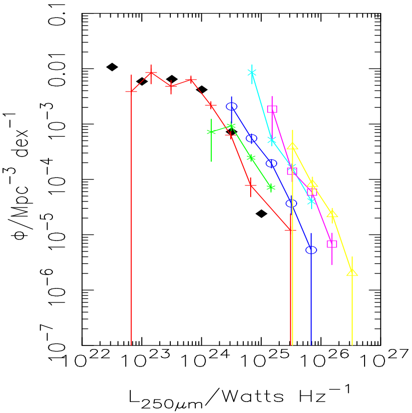
Infrared luminosity function at $z < 1.5$

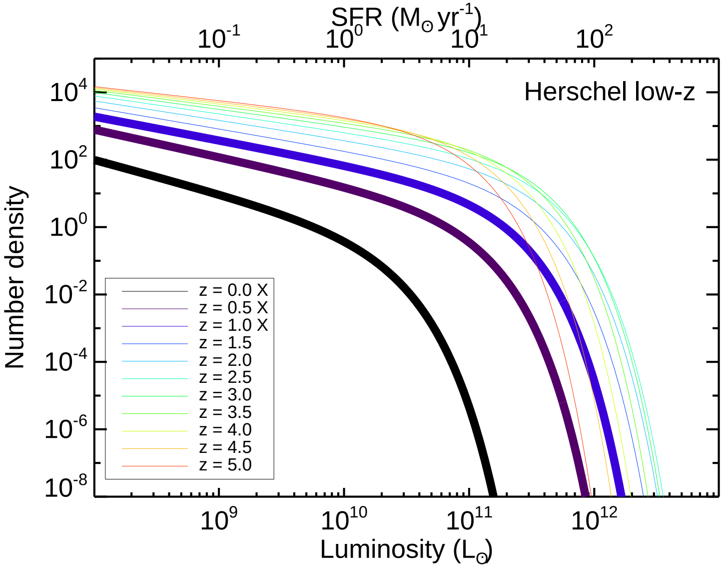


Dye et al. (2010 A&A, 518, 10)



Eales et al. (2010, A&A, 518, 23)

Infrared luminosity function (*Herschel* low-*z*)



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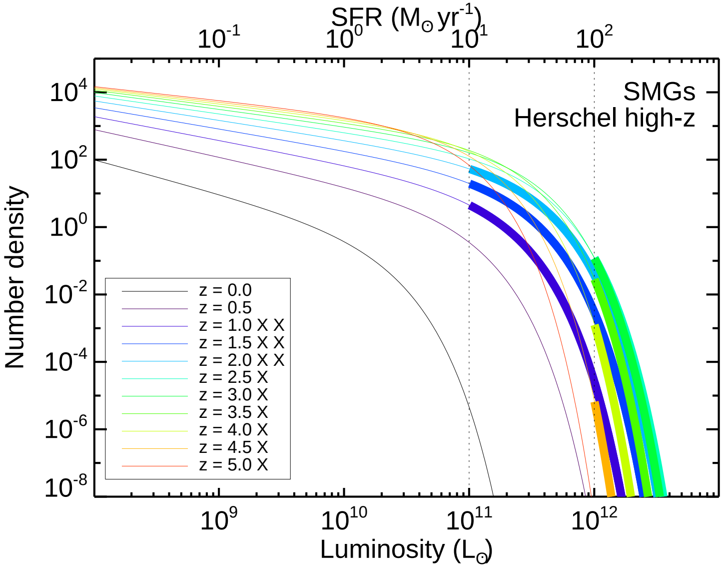
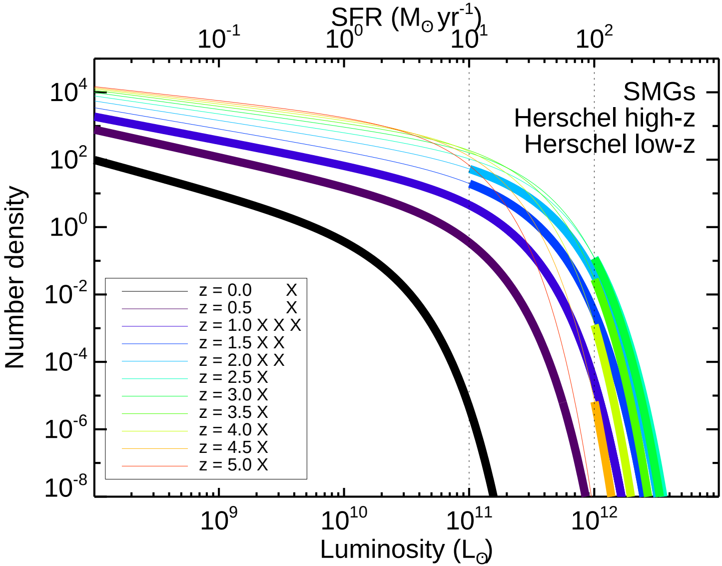
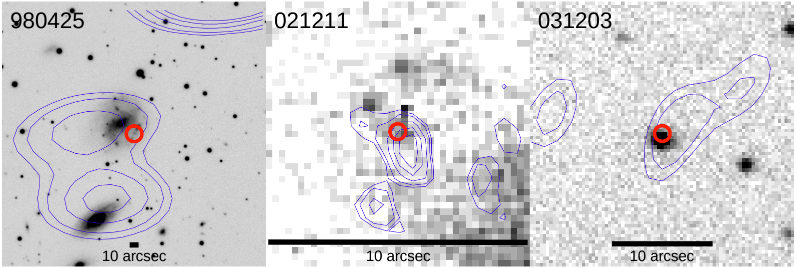


Infrared luminosity function (*Herschel* low-*z*)



Distribution of star formation rates of GRB hosts



Michałowski et al. (2012, ApJ, 755, 85)

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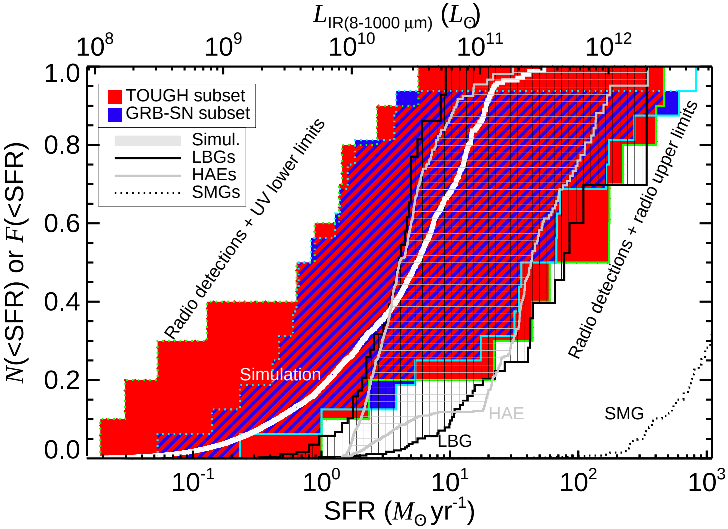
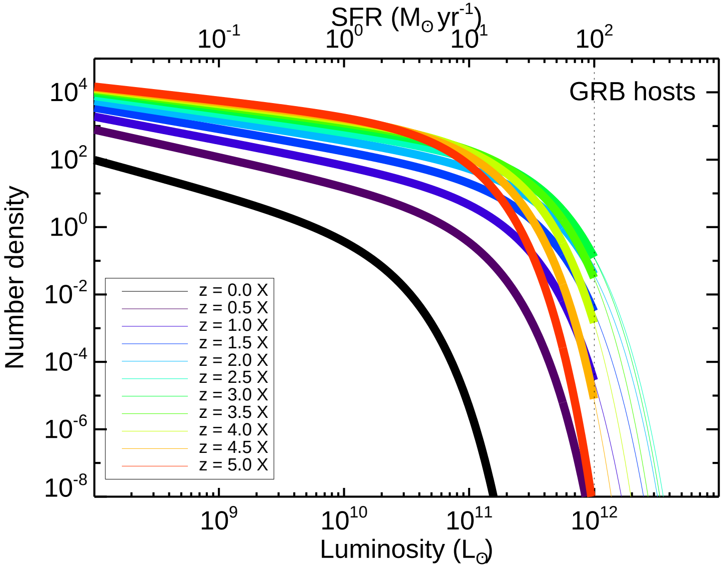


Michałowski et al. (2012, ApJ, 755, 85)

Infrared luminosity function (GRB hosts)



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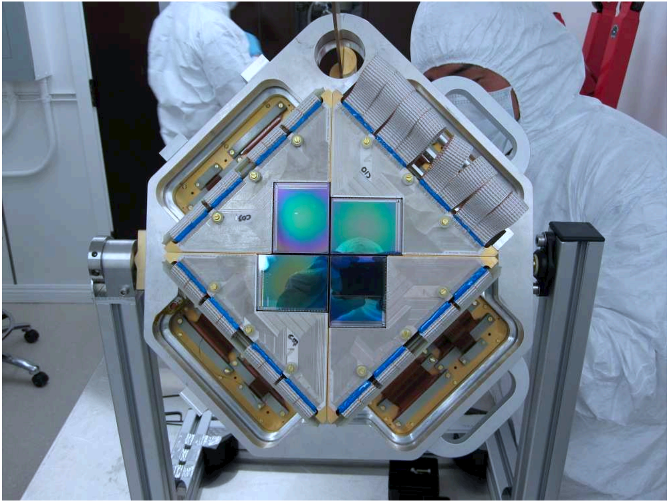
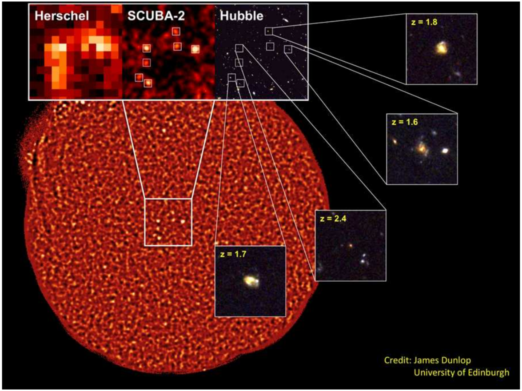
Submillimetre Common-User Bolometer Array 2

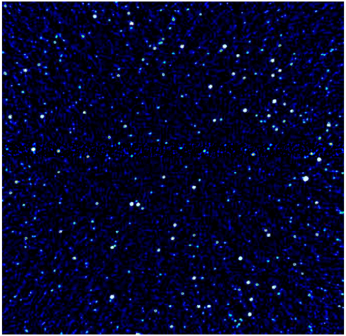


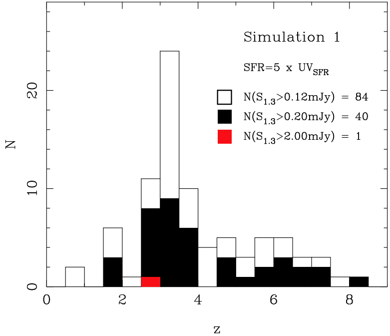
SCUBA2 Cosmology Legacy Survey: basics



- 10 deg^2 with rms of 1.2 mJy at 850 μm ($\sim$ 2 deg^2 done)
- 0.25 deg^2 with rms of 1.2 mJy at 450 μm
- 4000 hr, 5000 sources, 2011-2014

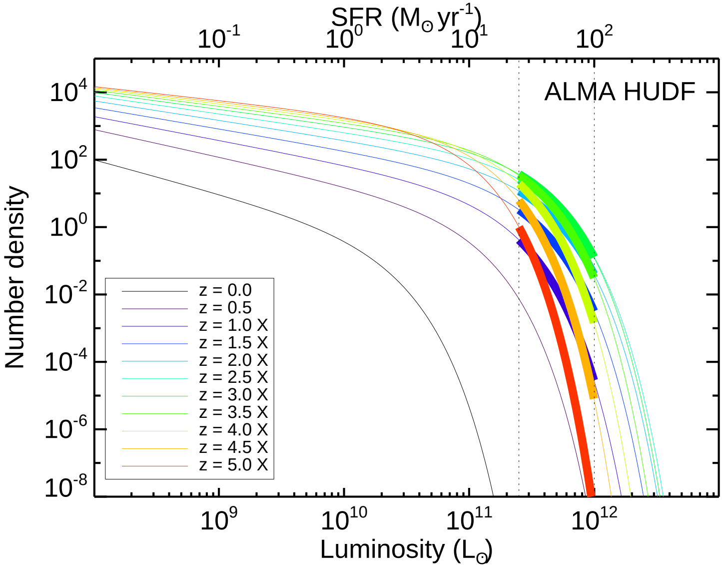
Future: ALMA blank field





- Dunlop, Michałowski, Ivison et al.
- 5 arcmin^2 Hubble Ultra Deep Field at 1.3 mm
- 50 pointings, 0.7$''$ resolution
- 19.2 hr, 0.03 mJy rms, 25 $M_\odot$ yr^{-1}

Infrared luminosity function (ALMA HUDF)



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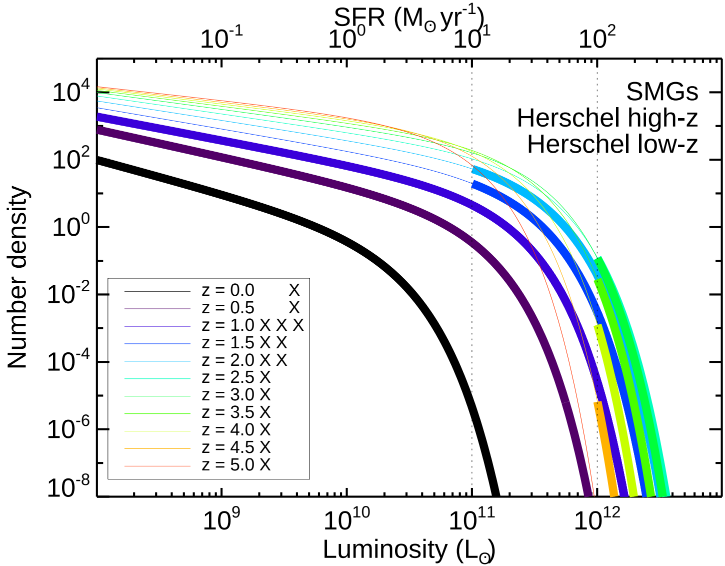

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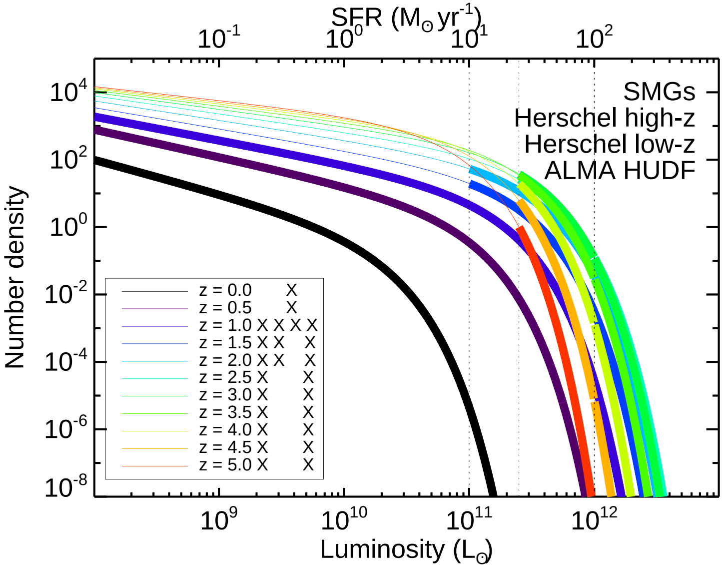

Conclusions