H-ATLAS/GAMA: The evolving dust content of ordinary galaxies at low redshift

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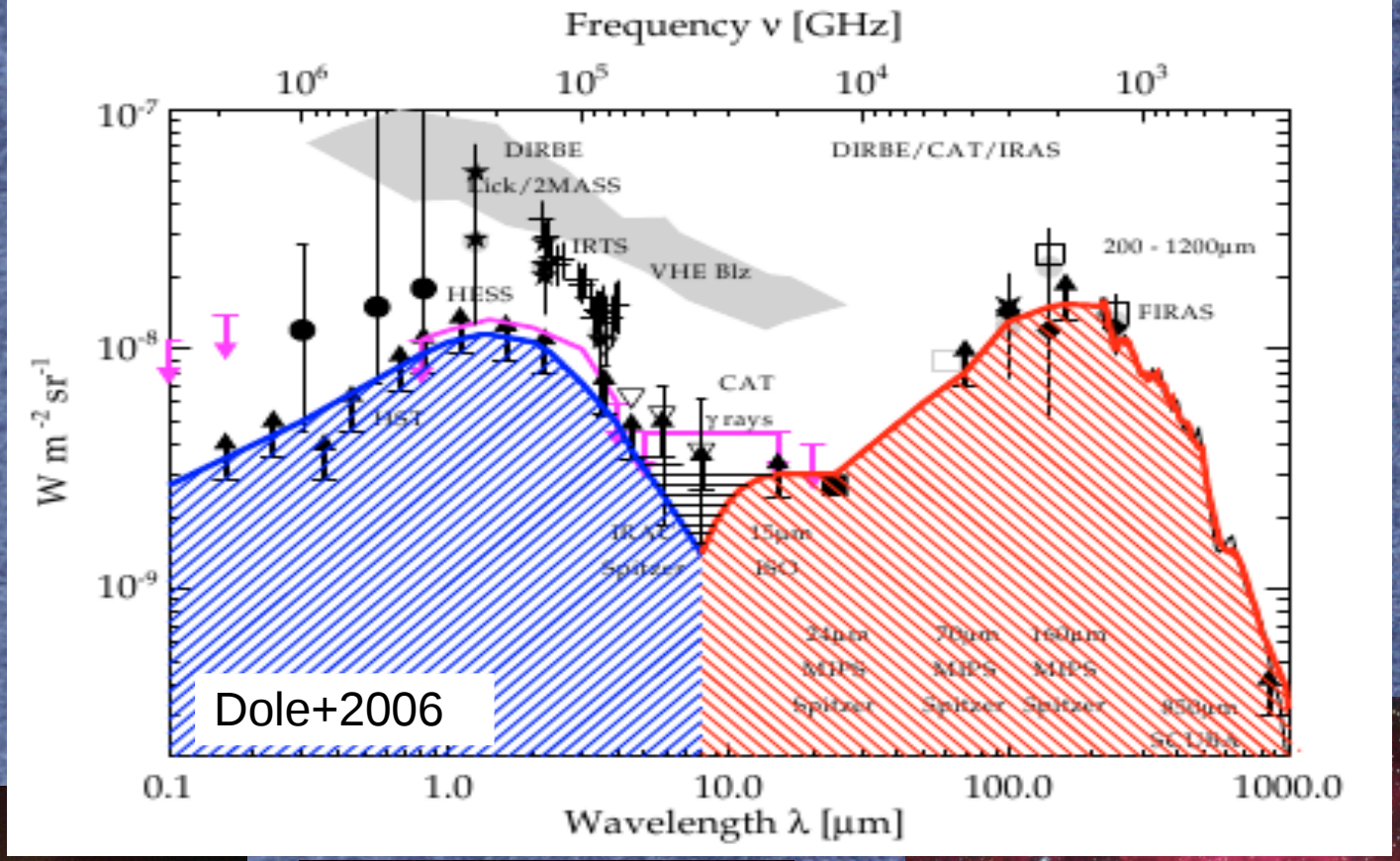
And the Herschel-ATLAS and GAMA Teams


Frequency ν [GHz]
10^6
10^5
10^4
10^3
10^-7
10^-8
10^-9
W m^-2 sr^-1
DIRBE
Lick/2MASS
IRTS
VHE Blz
HESS
HST
DIRBE/CAT/IRAS
200 - 1200μm
FIRAS
CAT
γ rays
IRAC
Spitzer
15μm
ISO
24μm
MIPS
Spitzer
70μm
MIPS
Spitzer
160μm
MIPS
Spitzer
850μm
SCUBA
0.1
1.0
10.0
100.0
1000.0
Wavelength λ [μm]
Dole+2006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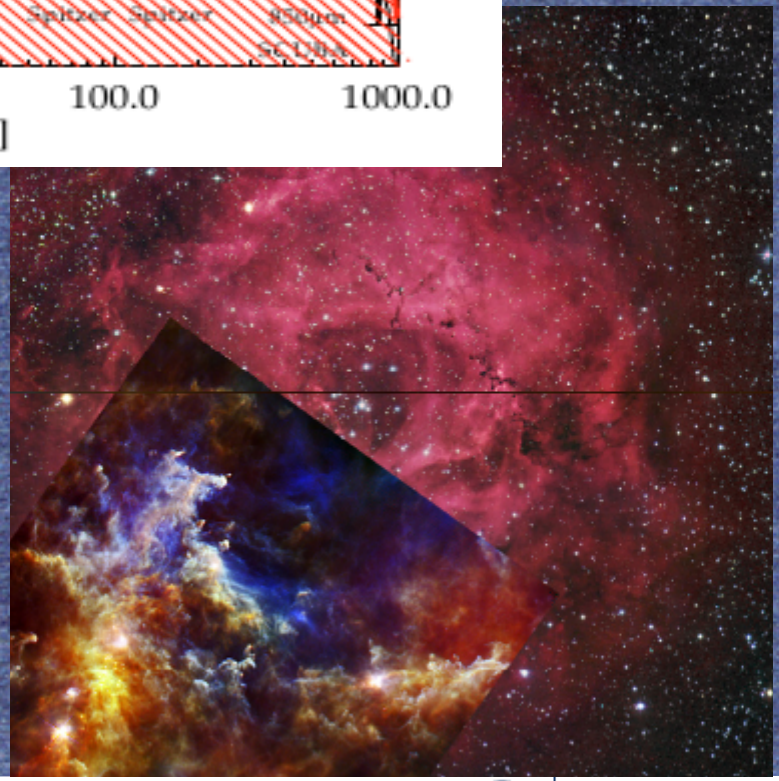
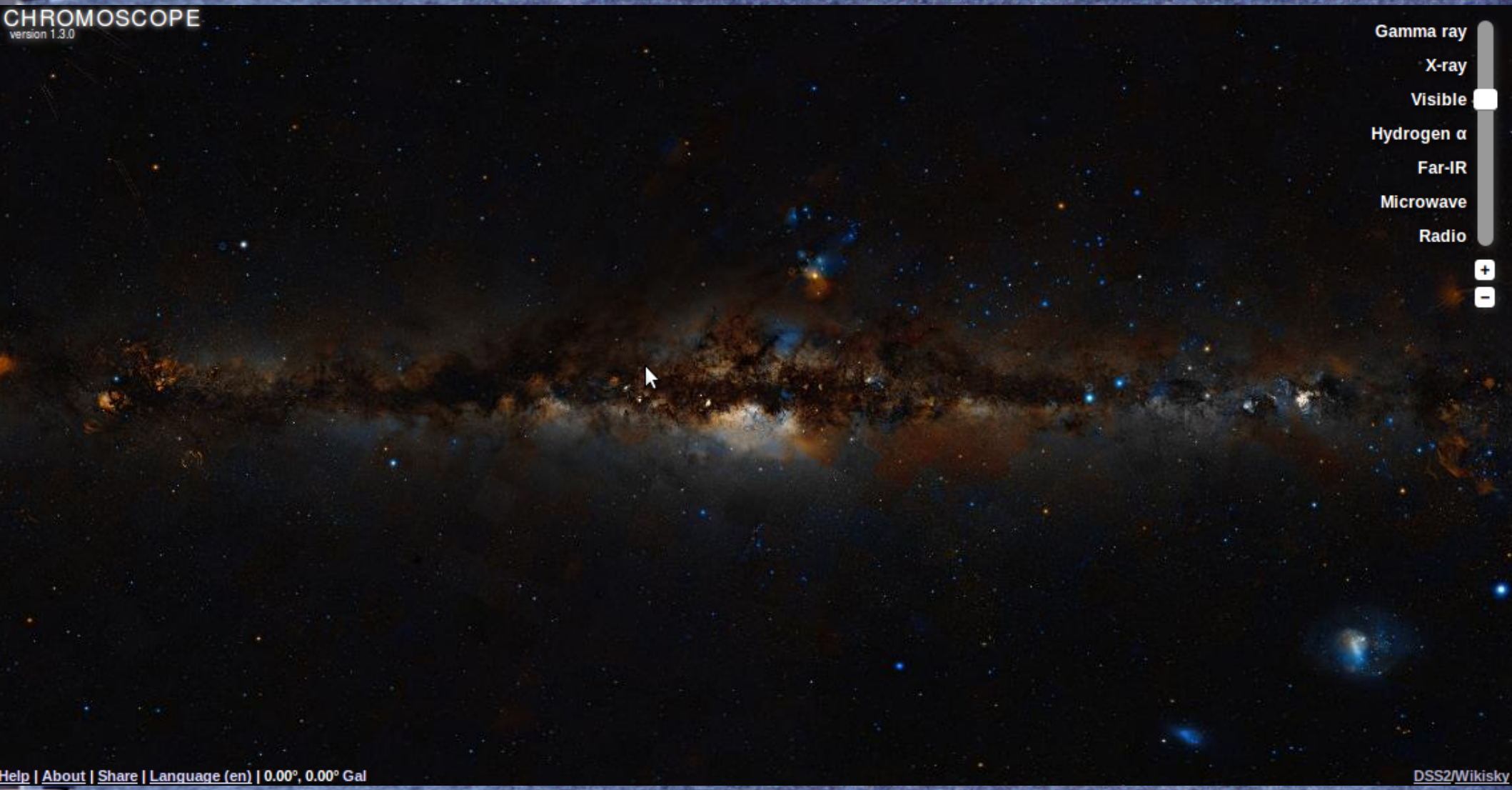


Optical sky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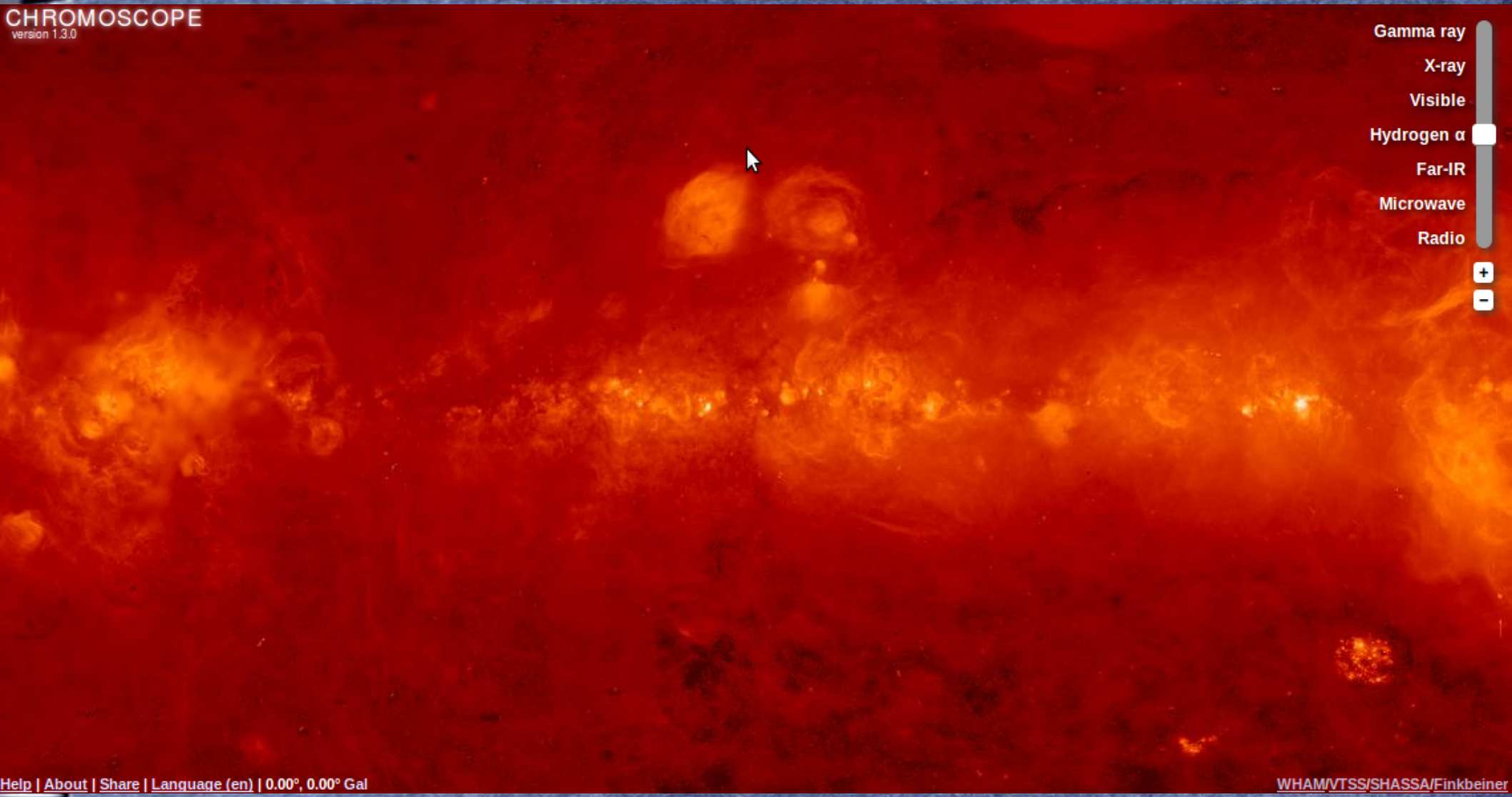
version 1.3.0
Gamma ray
X-ray
Visible
Hydrogen α
Far-IR
Microwave
Radio
Help | About | Share | Language (en) | 0.00°, 0.00° Gal
DSS2/Wikisky

Hα sky


CHROMOSCOPE
version 1.3.0
Gamma ray
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Visible
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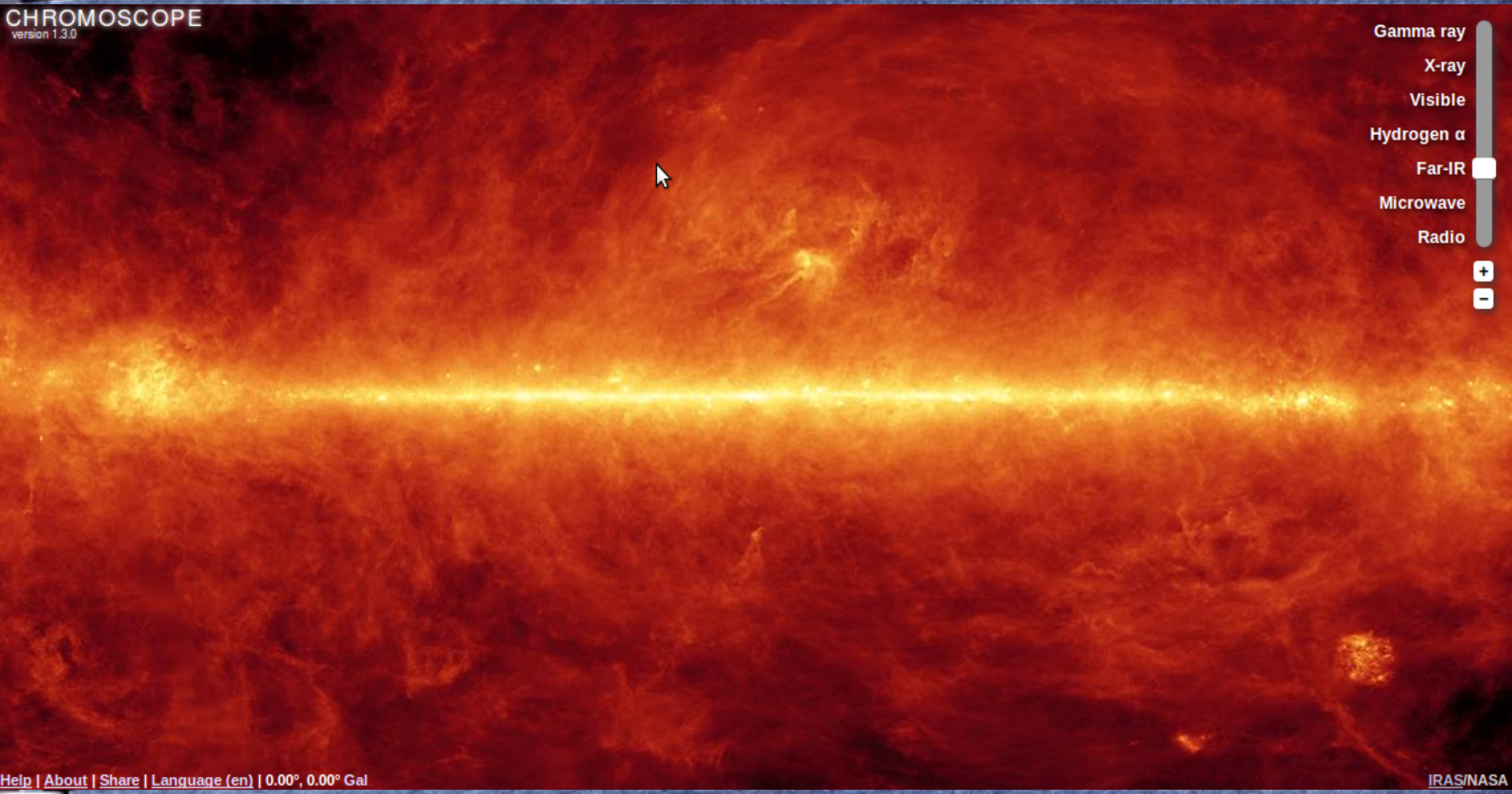
WHAM/VTSS/SHASSA/Finkbeiner

FIR sky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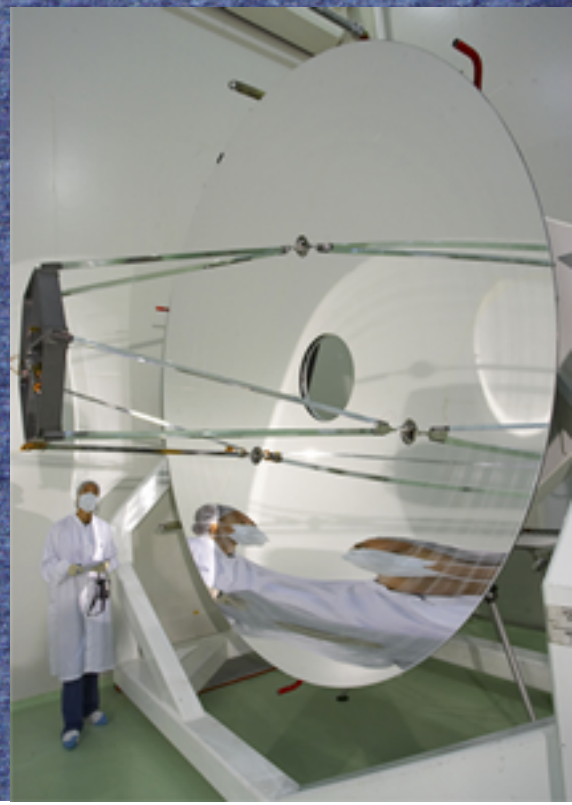
version 1.3.0
Gamma ray
X-ray
Visible
Hydrogen α
Far-IR
Microwave
Radio
Help | About | Share | Language (en) | 0.00°, 0.00° Gal
IRAS/NASA

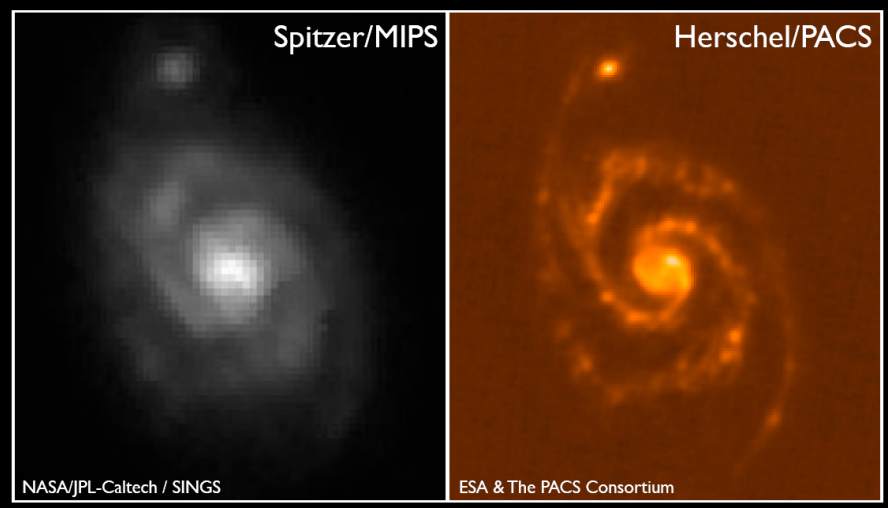
Herschel

- Space telescope avoids atmospheric transmission problems, means observations can be carried out much more efficiently than previously
- Largest mirror in space offers relatively good angular resolution at long wavelengths

  res. ~ 1.22 λ / D

- Long wavelengths ~100-500μm sensitive to cold dust at ~20K

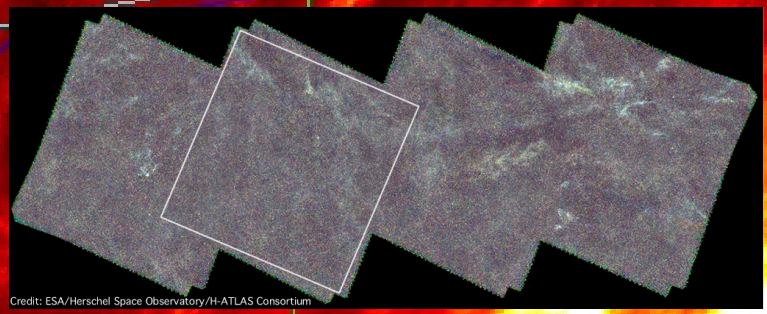




Spiral Galaxy M51 ("Whirlpool Galaxy") in the Far Infrared (160μm)

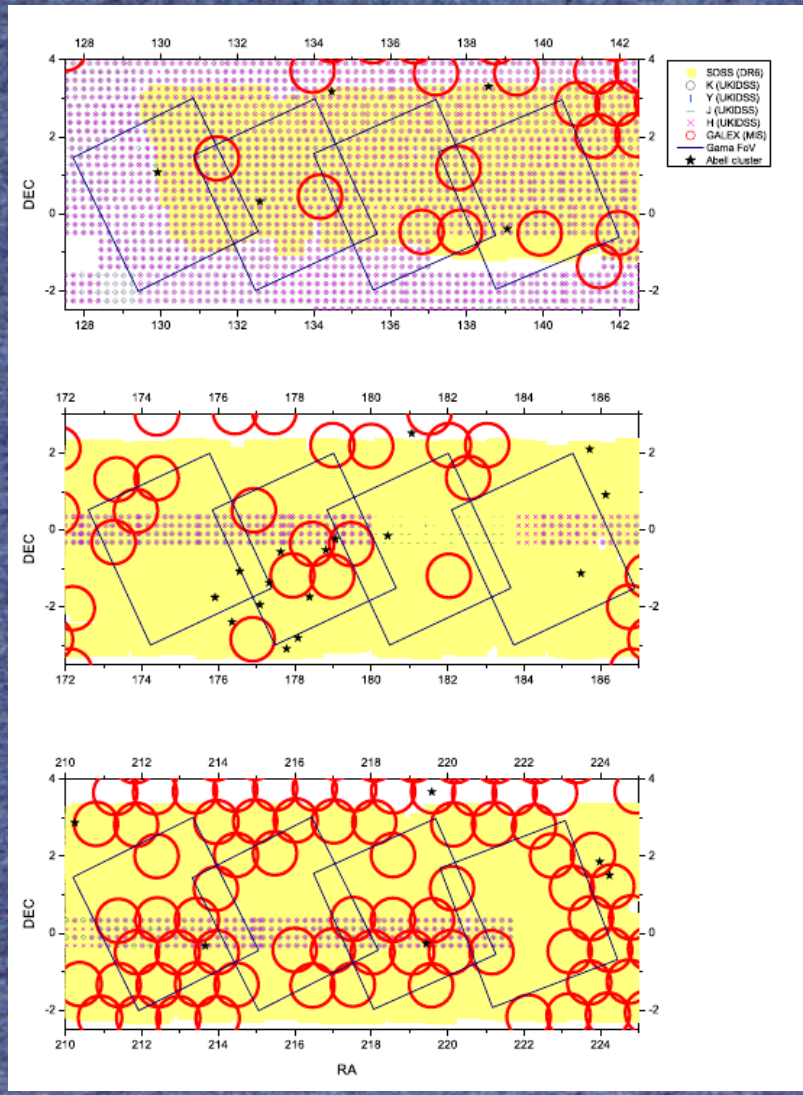
The Herschel-ATLAS Survey

- 550 deg^2 imaging at 100, 160, 250, 350, 500μm with PACS and SPIRE instruments
- 3 equatorial fields crossover with GAMA for multiλ coverage
- 1400 reliable ID's in 16 deg^2 SDP field
- Coverage of many many more galaxies not detected/reliably ID'd



The First Large-Scale Census of Dust in Normal Galaxies at Low Redshift

- Optical selection unbiased by dust properties
- Unprecedented sub-mm sky coverage providing large number statistics at low redshift
- UV-NIR photometry aids classification of sample to explore dependencies

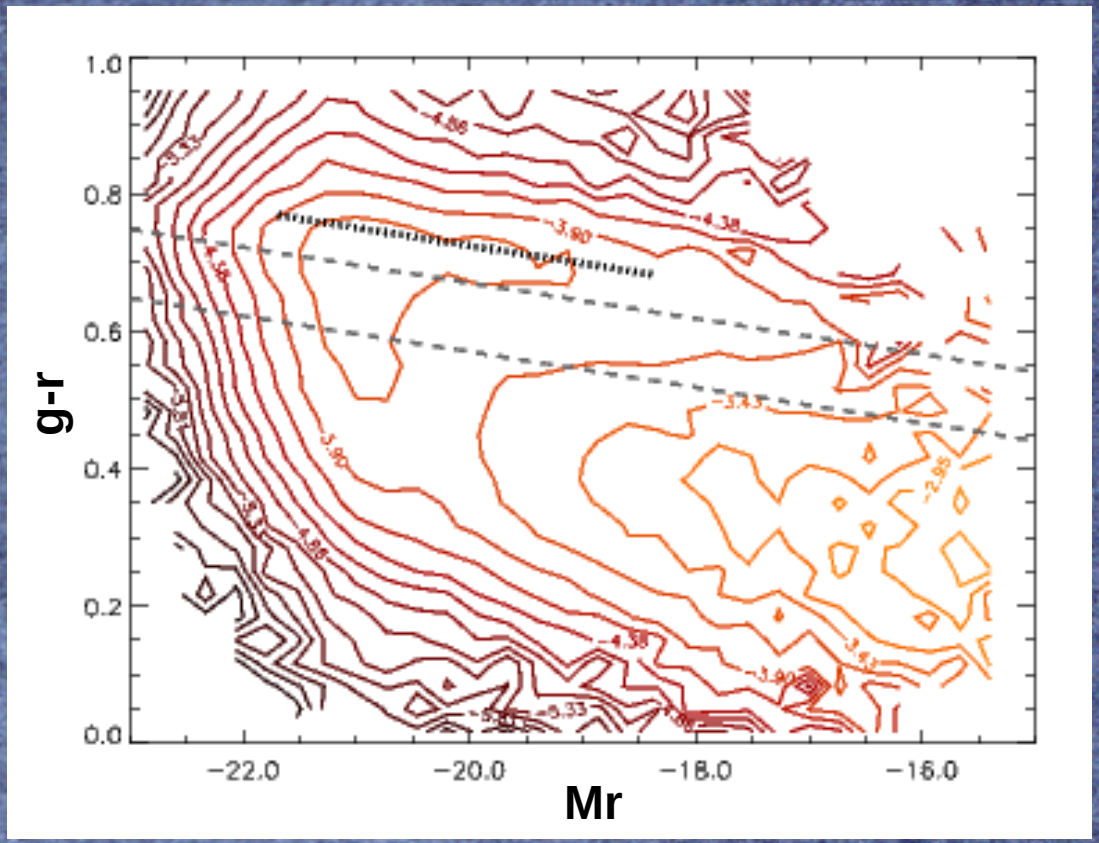


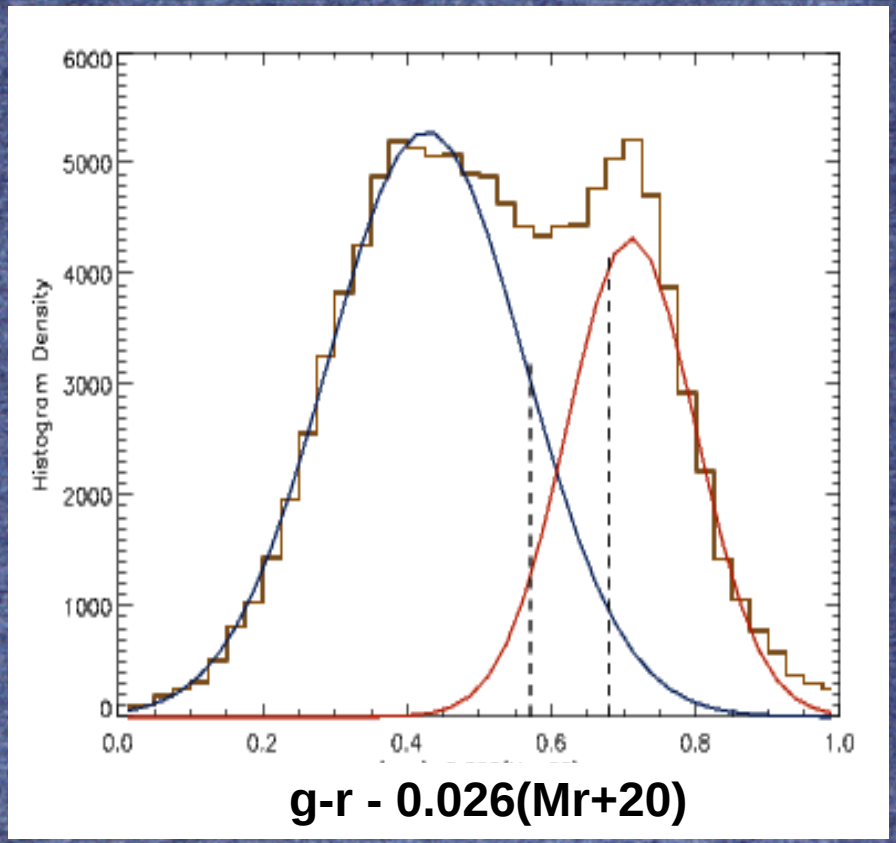
The GAMA Galaxy Catalogue

- Photometry: *ugriz* (SDSS) *YJHK* (UKIDSS LAS) *FUV+NUV* (GALEX)
- K-corrections with KCORRECT
- ~150,000 galaxies with r_{petro}<19.8
- Spectroscopic redshifts for ~90%
- Photometric redshifts for the rest
- Stellar Masses from *ugriz* SED fits (Ned Taylor et al., in preparation)
- 86,000 galaxies with SPIRE coverage in H-ATLAS (250, 350, 500μm)

Dividing the Galaxy Catalogue: Optical Sample

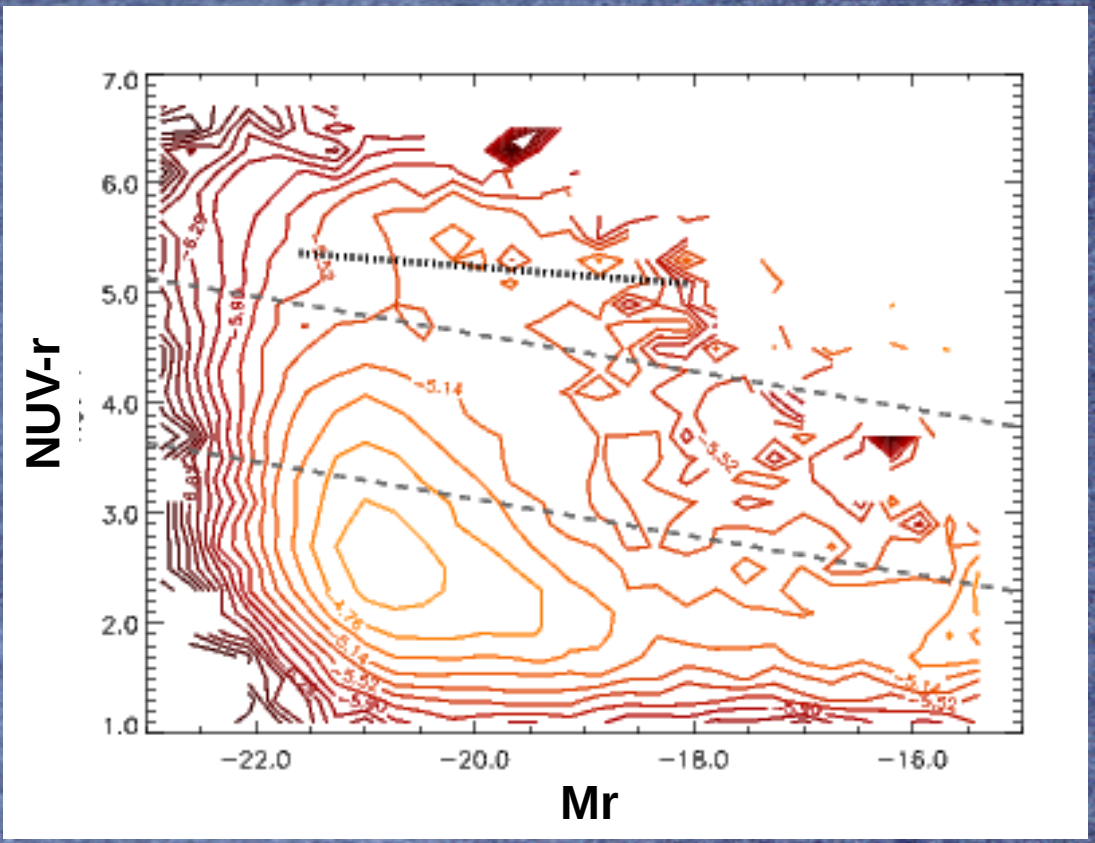
- Split data first by optical colours, using the CMD to define Red, Green and Blue subsets





Dividing the Galaxy Catalogue: UV Sample

- Can do a similar thing with UV-optical colours (following Wyder+07)

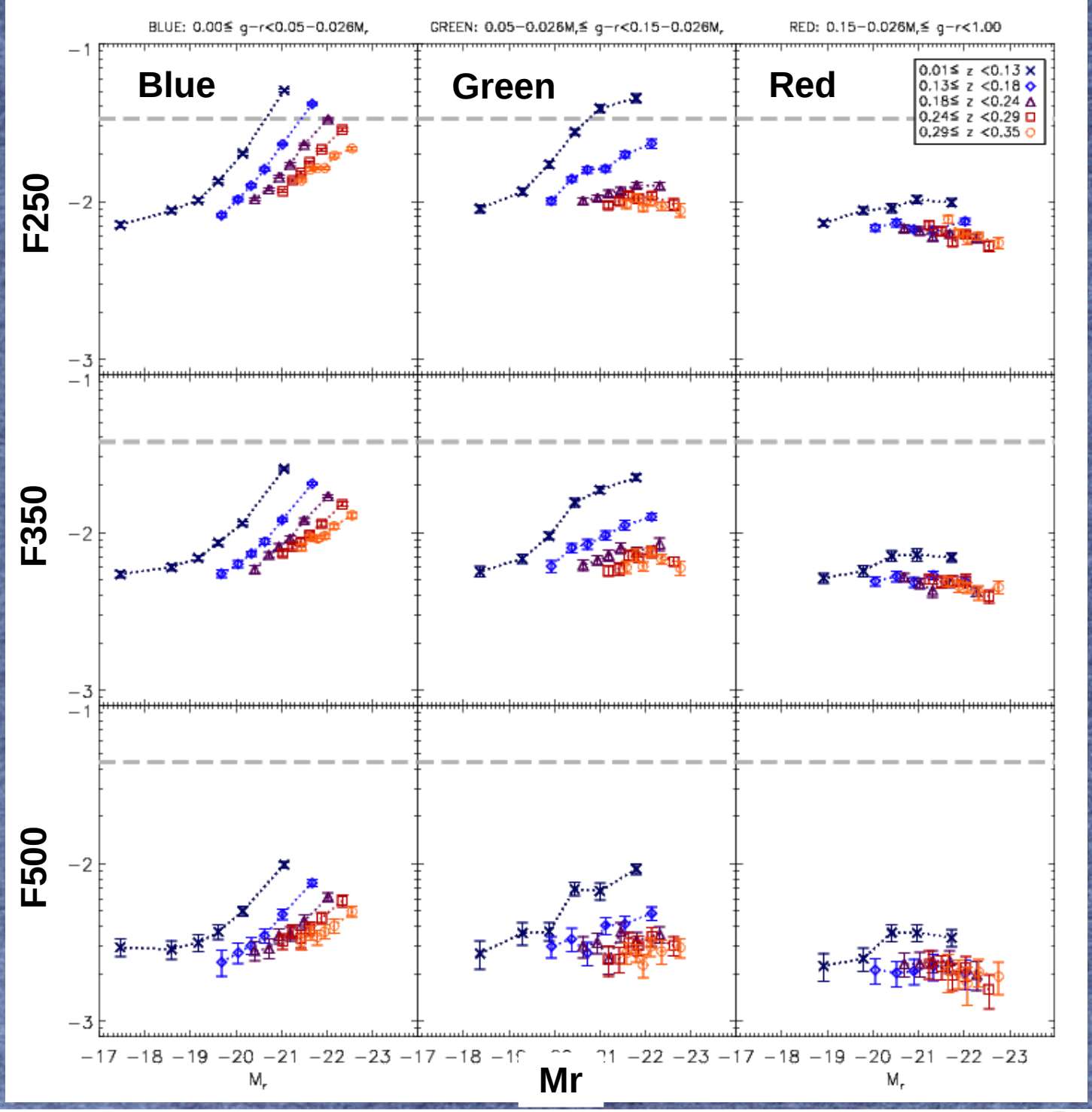


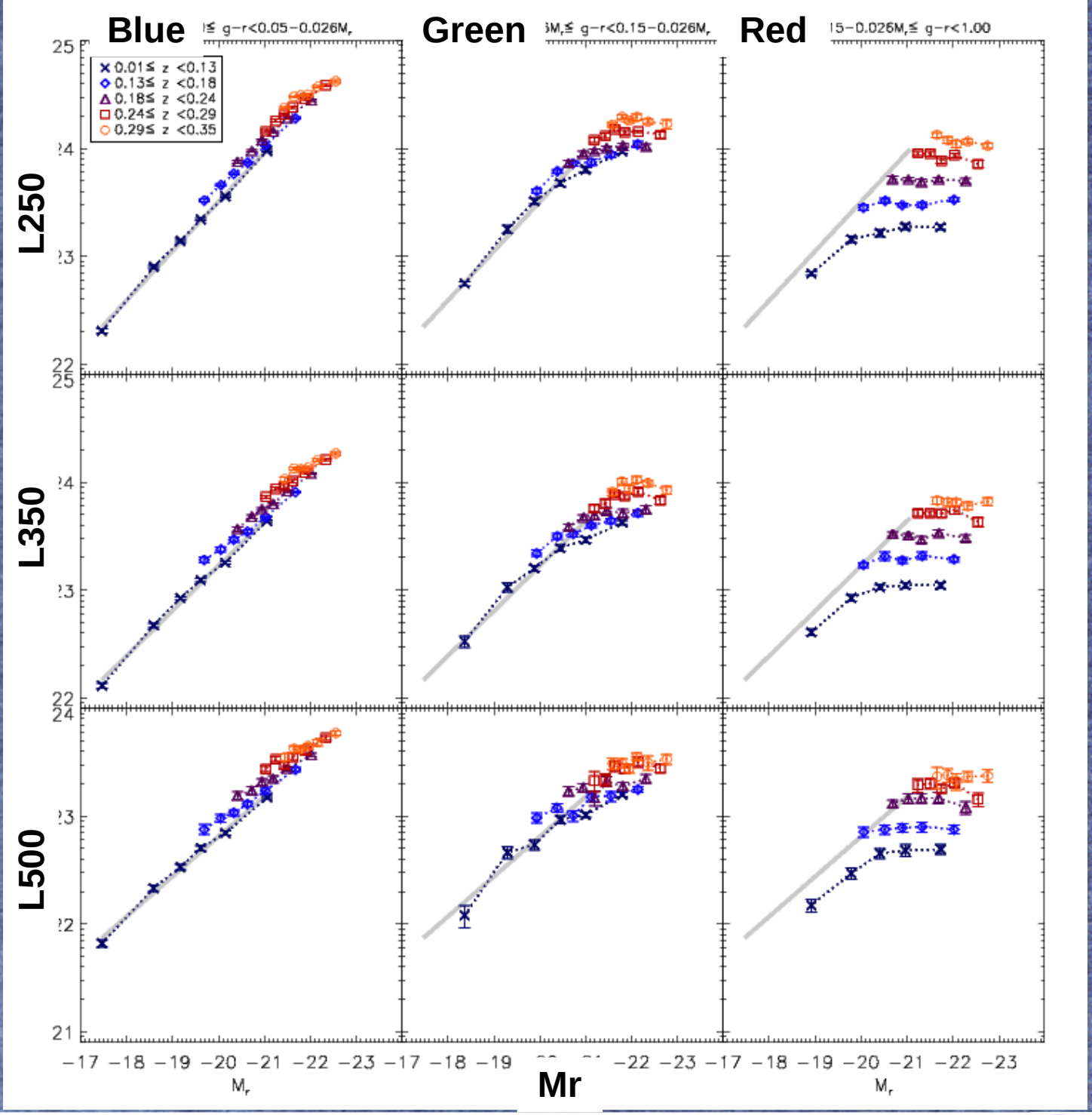
- **Cannot fit in same way as optical**
- **But can use a fit based on morphological selection (Yi+05)**
- **UV-optical colour bins likely to be less contaminated**

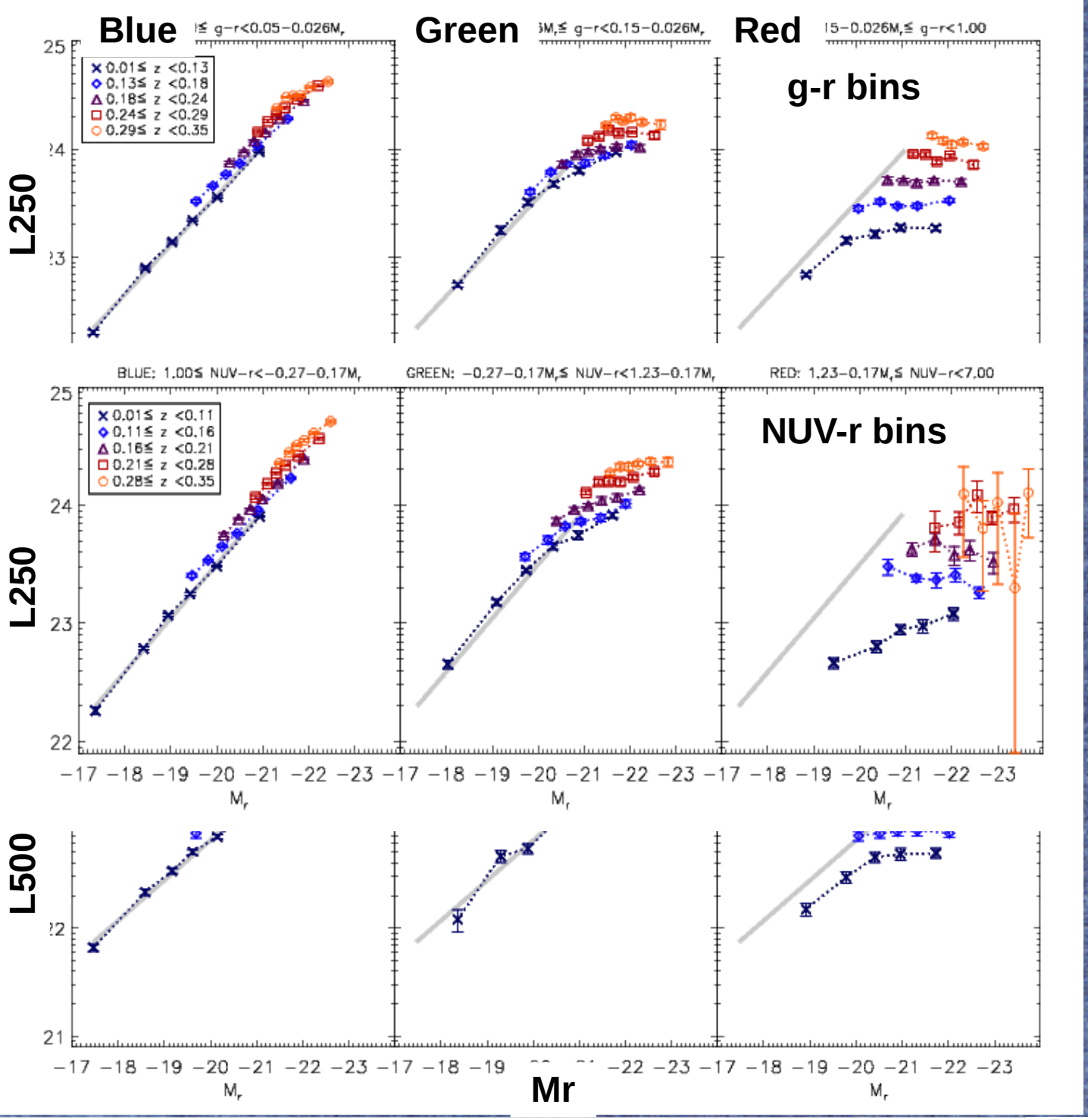
Stacking

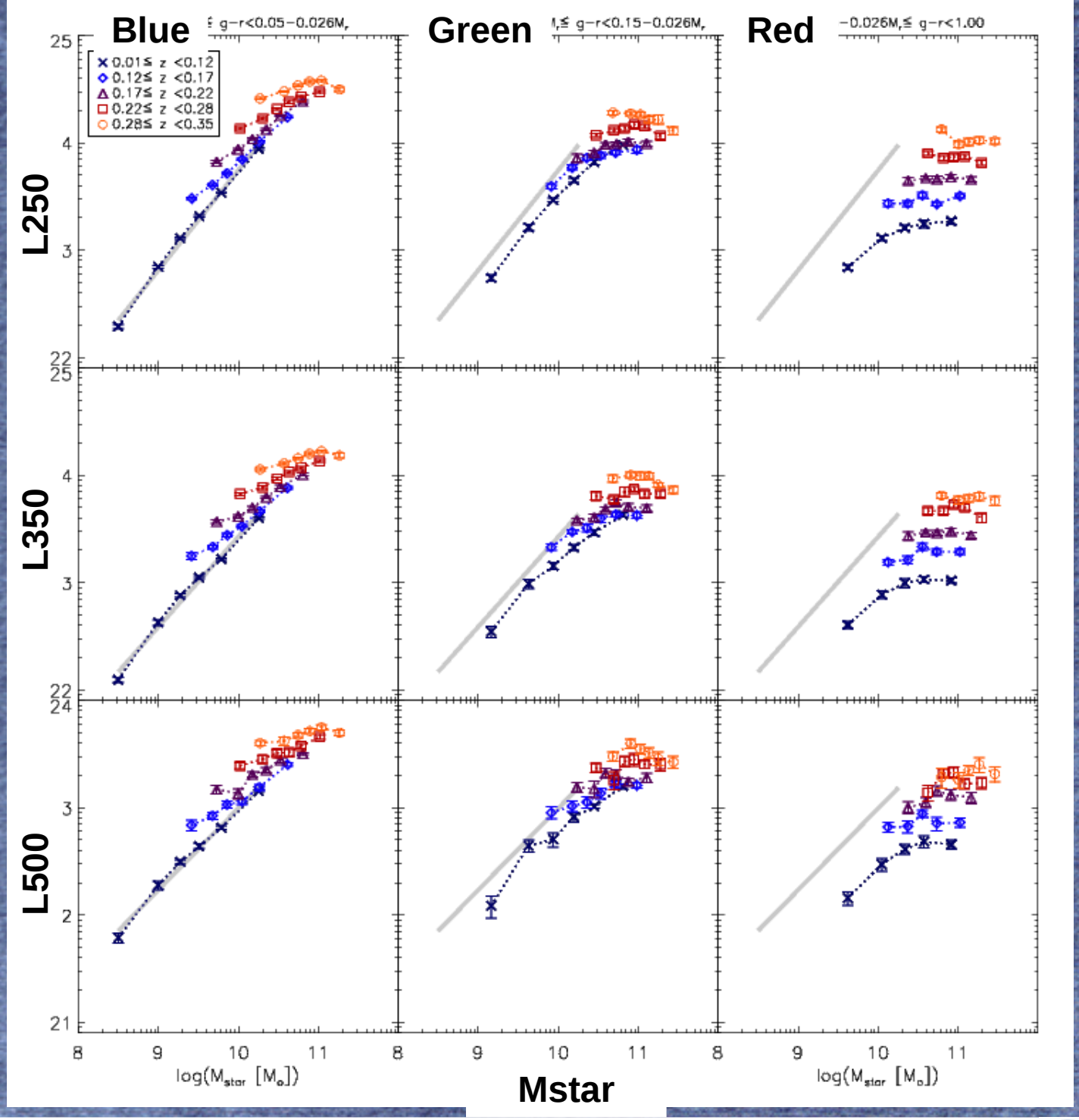
- 3 colour bins (either g-r or NUV-r), 5 redshift bins, 6 bins of either *Mr* or *Mstar*
- Confusion a problem: in fact 3 problems to consider:
  - Unresolved background (faint high z sources): simple subtraction of a flat sky background
  - Blending between sources in the GAMA catalogue: divide flux in map between the blended sources
  - Blending with resolved sources *not* in GAMA (mostly bright high z sources): fit & subtract

Results


BLUE: 0.00≤ g−r<0.05−0.026M,
GREEN: 0.05−0.026M,≤ g−r<0.15−0.026M,
RED: 0.15−0.026M,≤ g−r<1.00
Blue
Green
Red
0.01≤ z <0.13
0.13≤ z <0.18
0.18≤ z <0.24
0.24≤ z <0.29
0.29≤ z <0.35
F250
F350
F500
−1
−2
−3
−17 −18 −19 −20 −21 −22 −23
M_r
Mr


Blue
Green
Red
0.01≤ z <0.13
0.13≤ z <0.18
0.18≤ z <0.24
0.24≤ z <0.29
0.29≤ z <0.35
L250
L350
L500
Mr
M_r

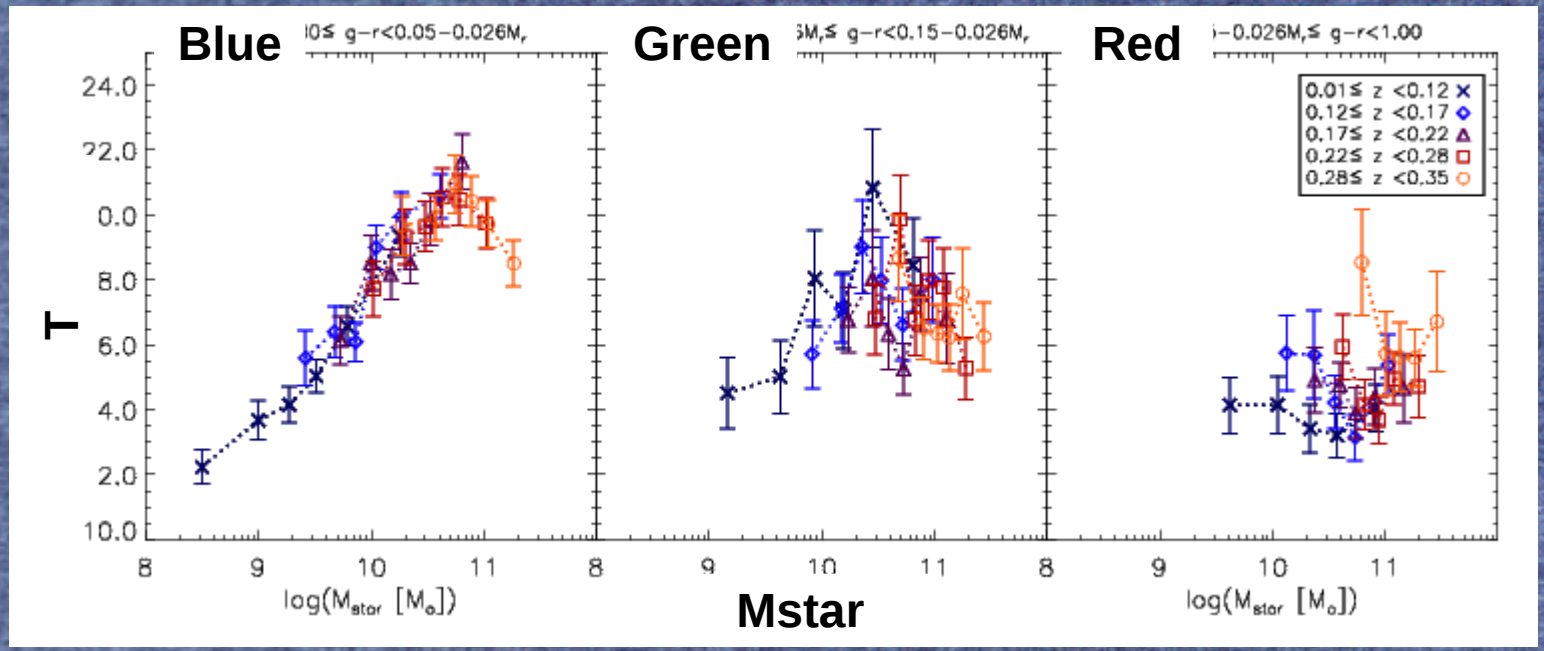



Blue
Green
Red
0.01≤ z <0.12
0.12≤ z <0.17
0.17≤ z <0.22
0.22≤ z <0.28
0.28≤ z <0.35
L250
L350
L500
log(M_star [M_o])
Mstar

Results: SPIRE Luminosities

- Blue galaxies: strong correlation between optical and SPIRE lum.
- Red: Very little correlation with Mr or Mstar
- Green: properties intermediate between red/blue – probably a mixed population
- Strong evolution with redshift (especially red)
- These results virtually independent of model used for K-corrections (used single-compt T=17K, β=2)

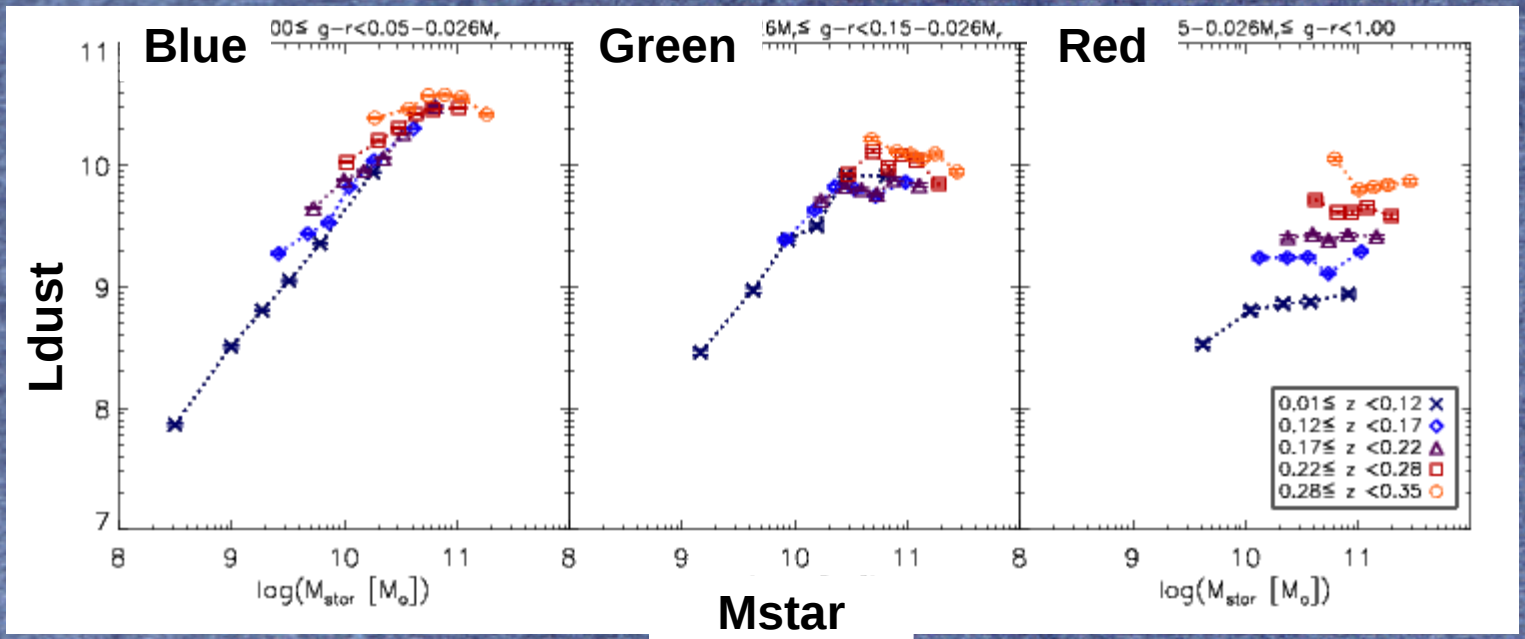
Infrared SEDs and Dust Temperatures



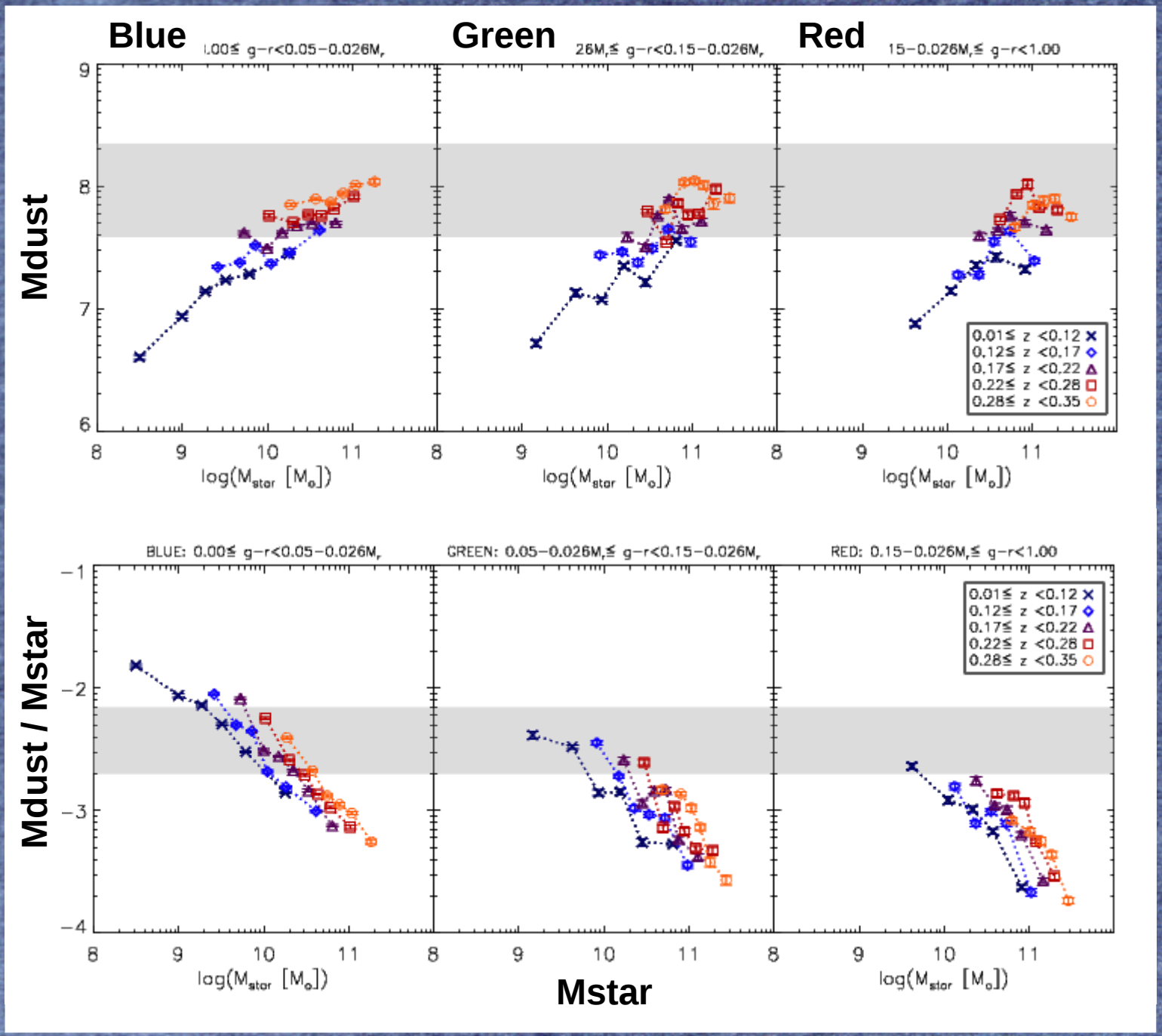
- Fitting single component greybodies to the SPIRE fluxes
- β=2 fixed from analysis of SPIRE colours
- T correlates with Mstar, and colour, and z?

Infrared SEDs and Dust Temperatures

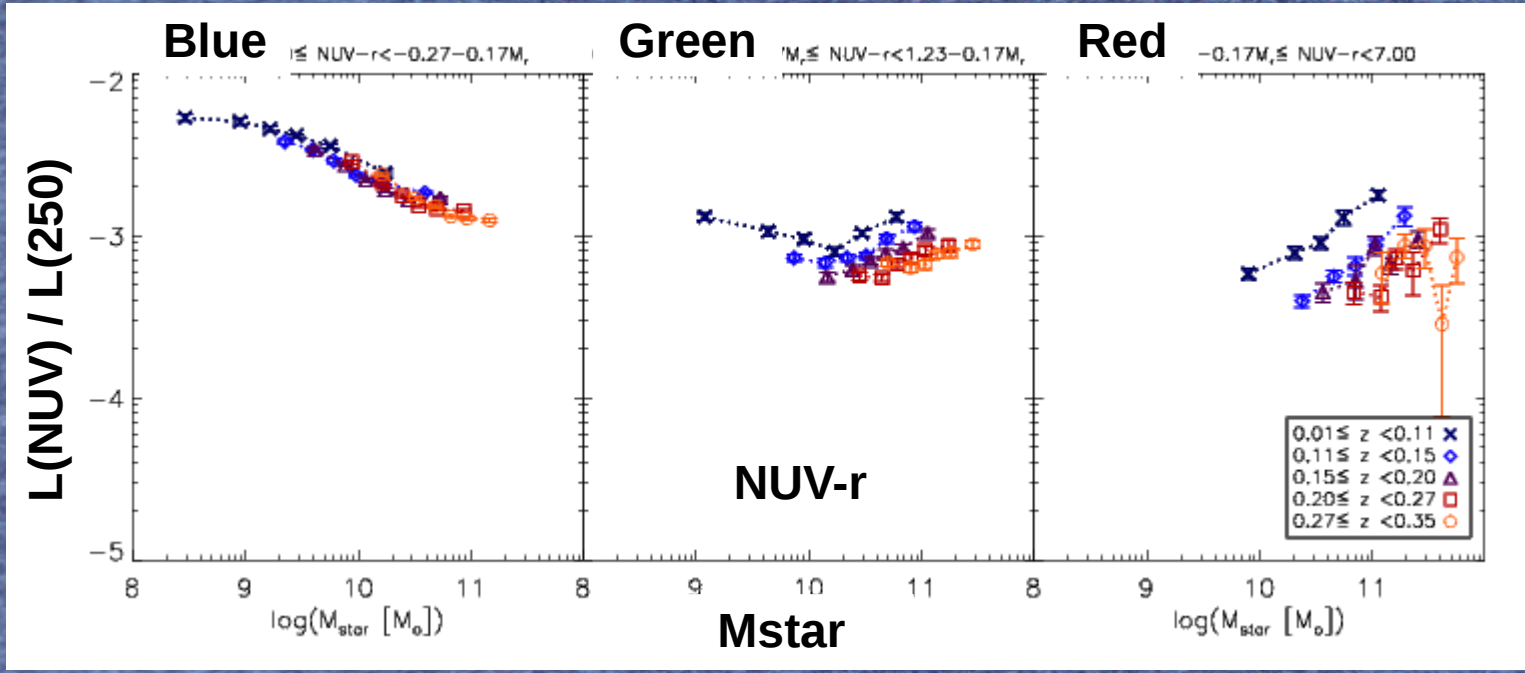
- Total IR luminosity of SED fitted to SPIRE fluxes
- Low luminosities at all Mstar: <LIRGs
- Red galaxies least luminous but evolve strongly
- Similar correlations to monochromatic L250 etc.



What about dust mass?


Blue
Green
Red
Mdust
Mdust / Mstar
Mstar
log(M_star [M_o])
0.01≤ z <0.12
0.12≤ z <0.17
0.17≤ z <0.22
0.22≤ z <0.28
0.28≤ z <0.35

Obscured Star Formation



- NUV-selected sample
- Blue galaxies are more obscured at higher Mstar
- Red galaxies are more obscured at *lower* Mstar
- Obscuration of massive red galaxies increases at higher redshift

Conclusions

- We have conducted the first large-scale survey of dust in optically-selected normal galaxies in the low redshift universe
- Excellent number statistics provide meaningful constraints on the dependence of dust content on the stellar properties of galaxies
- Sub-mm luminosity depends strongly on stellar mass and colour, and evolves rapidly with redshift
- Difference between red and blue galaxies appears to be largely due to different dust temperatures
- Dust mass appears to be similar between red and blue galaxies
- Dust fraction (Md/Ms) is much higher for less massive galaxies
- Dust content of all galaxies evolves with redshift $0.01<z<0.35$