The Dusty Universe at low redshift (z<0.4)

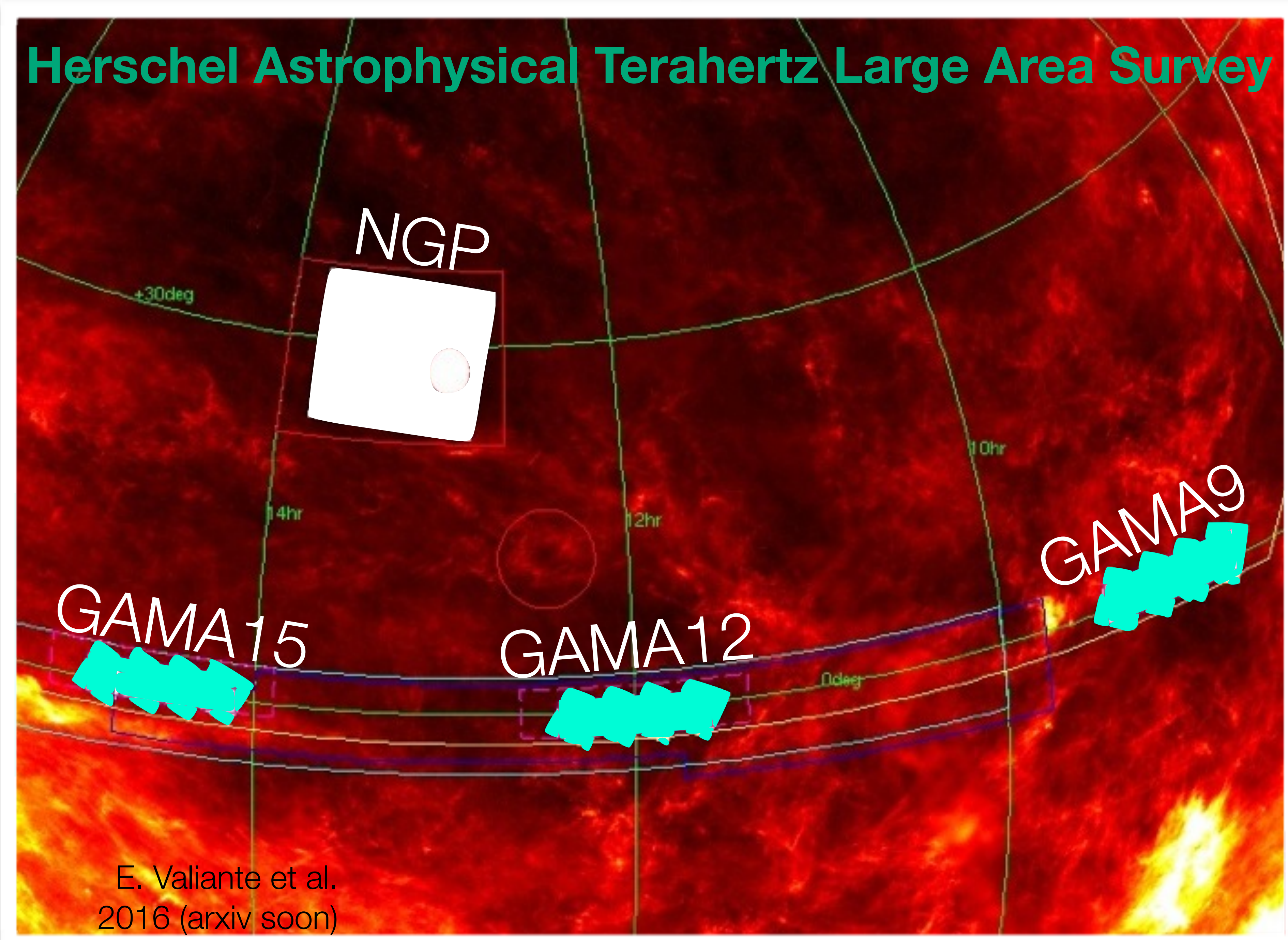
revealed by H-ATLAS & GAMA

Nathan Bourne

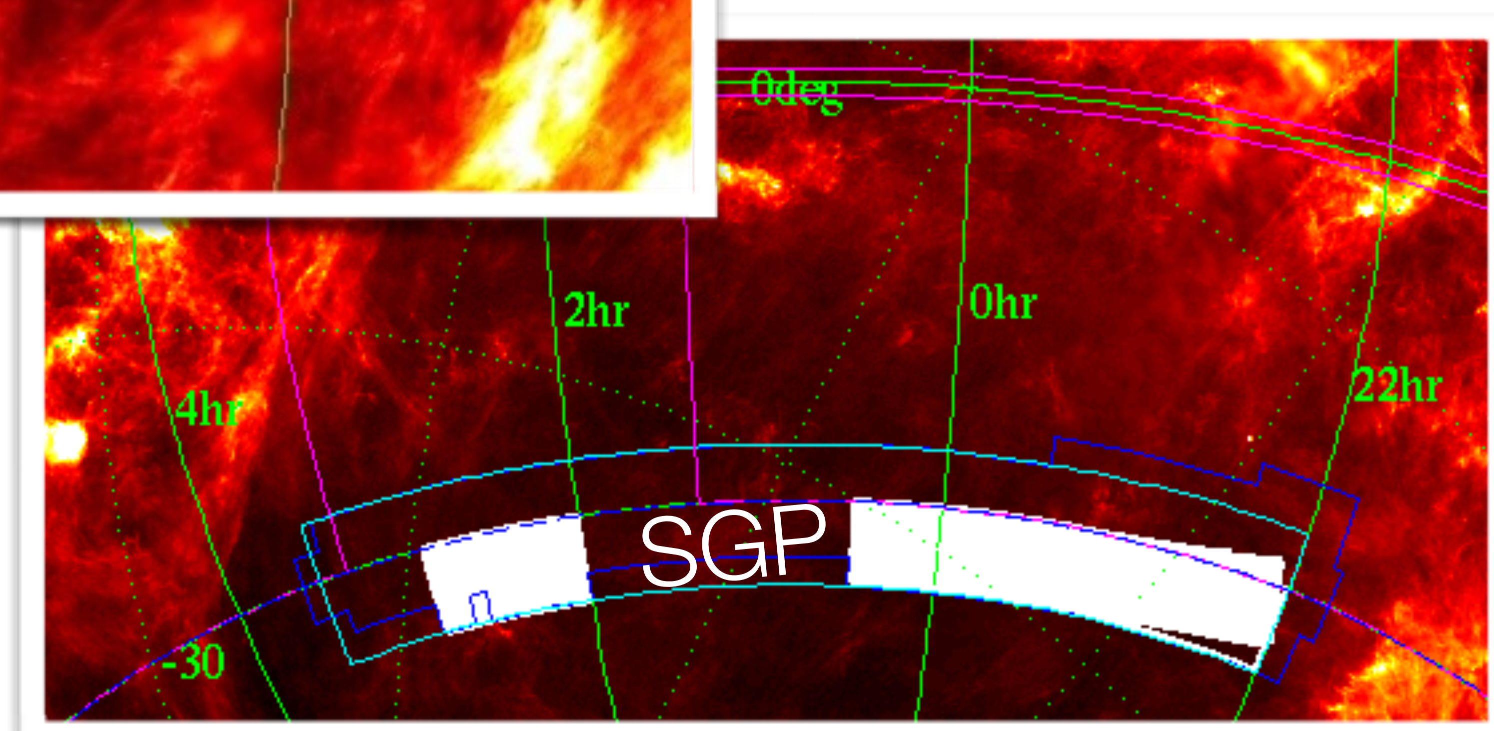
with thanks to the Herschel-ATLAS and GAMA teams

Plan for this talk

- **Herschel-ATLAS cross-IDs:**
  the nature of sources detected in a wide extragalactic sub-mm survey
- **Dust in ordinary galaxies:**
  the sub-mm properties of optically-selected galaxies in the low-z universe
- **The bigger picture:**
  what have we learned about the local universe from large Herschel surveys?
- **Future prospects**
  where can we go from here?



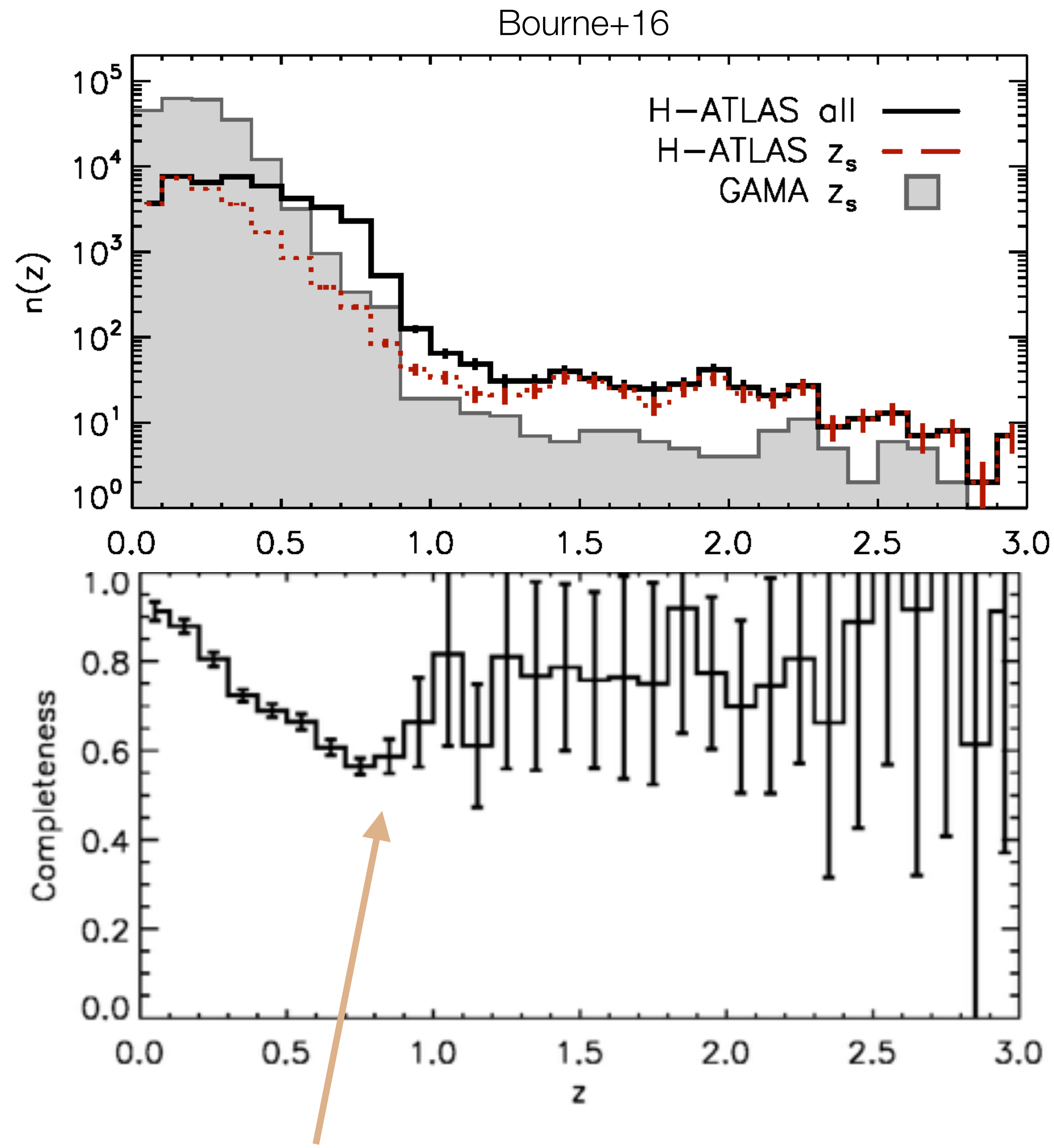
Phase I GAMA fields:
161 sq deg. 100-500μm



- 5 bands 100-500μm
- PSF FWHM 9-36” (18” 250μm)
- In the GAMA fields, 114000 sources detected at 250μm at >28mJy (4sigma)
  - 38%, 9% detected at 350, 500μm
  - 8%, 14% detected at 100, 160μm

Optical IDs in SDSS and GAMA

- Bourne et al. 2016 (submitted)
- IDs assigned based on Likelihood Ratios (Sutherland & Saunders 92) to SDSS r<22.4
- ~45000 (39%) SPIRE 250μm sources have reliable optical ID
- Underlying fraction is Q0 = 54% have a true ID in SDSS: therefore overall ID completeness is 72%
- 1% of these IDs are stars; 2% are quasars; 97% galaxies
- Broad redshift distribution of IDs up to z=0.8; most IDs are at z<0.5 which is due to the limiting depth of SDSS
- However, Herschel is sensitive to sources at both low and high redshifts - the estimated full z distribution has a second peak at z~1.5 (250μm) to 2.5 (500μm)



$$\text{Fraction} = \frac{\text{all reliable IDs as f(z)}}{\text{all submm-bright SDSS galaxies}}$$

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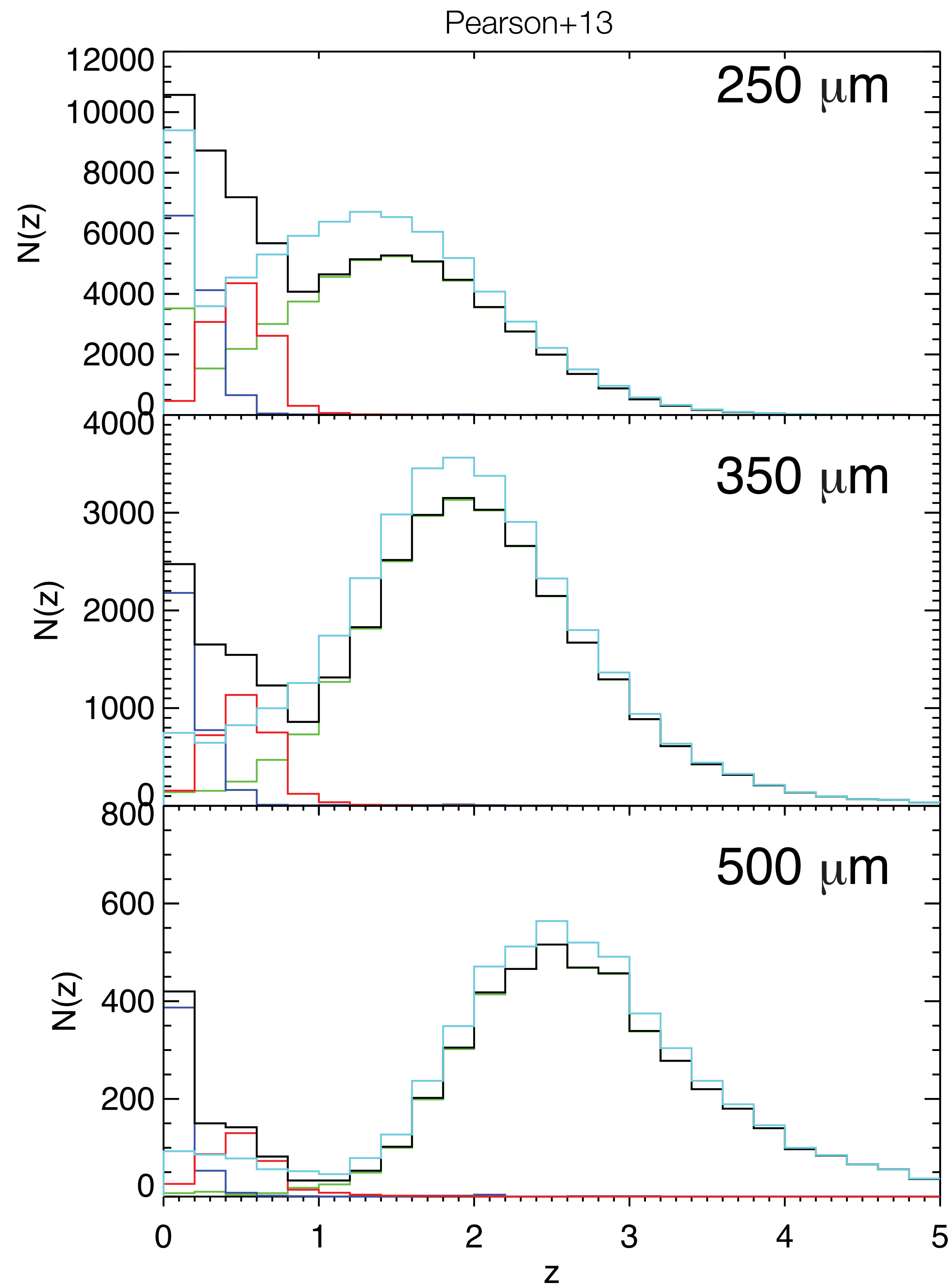
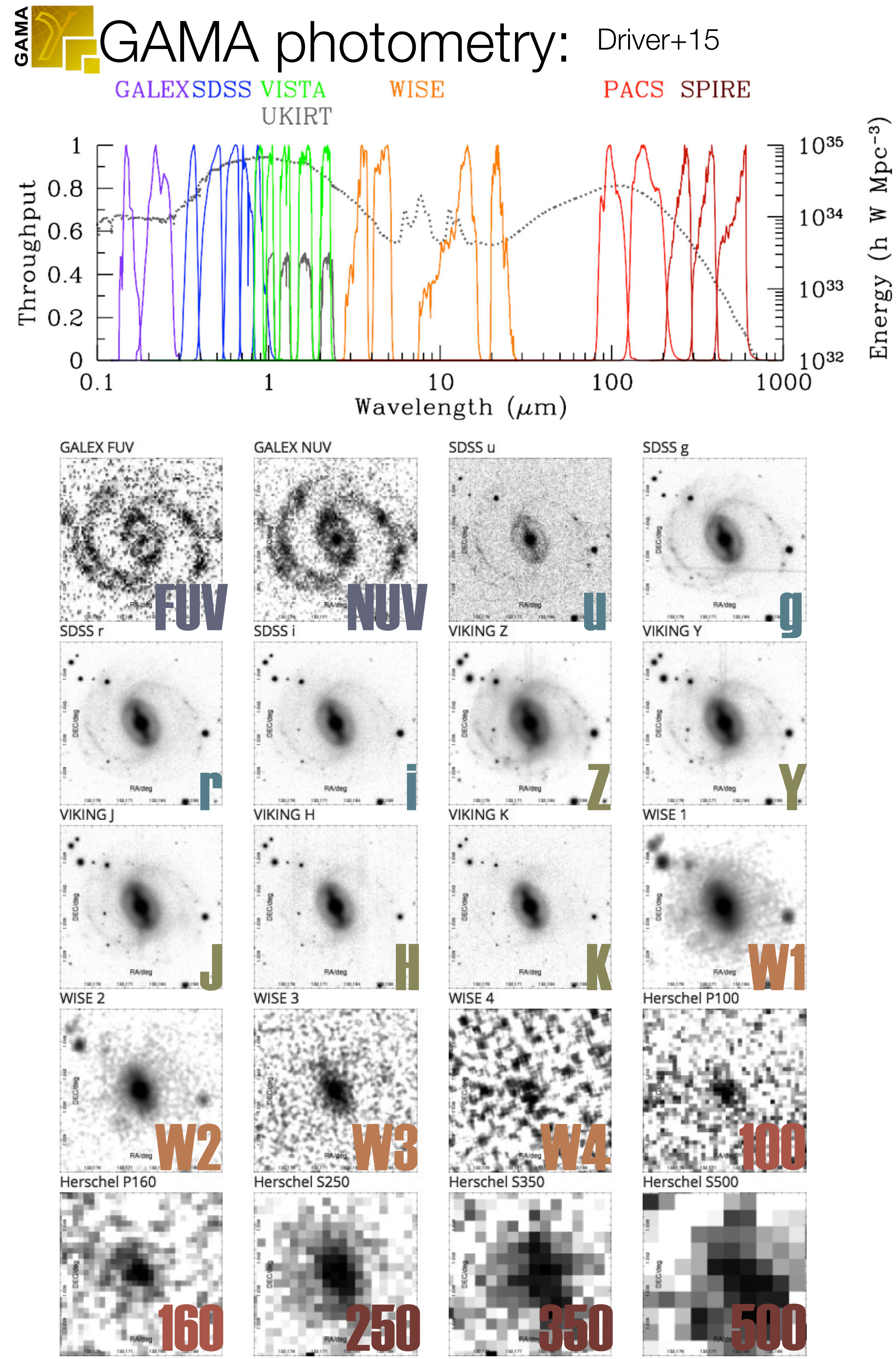


Optical IDs in SDSS and GAMA

- Aperture-matched UV to mid-IR photometry from GAMA allows us to explore the nature of galaxies selected by H-ATLAS
- The main GAMA sample is r<19.8: GAMA contains 52% of our galaxy IDs, but includes most of the galaxies at z<0.4



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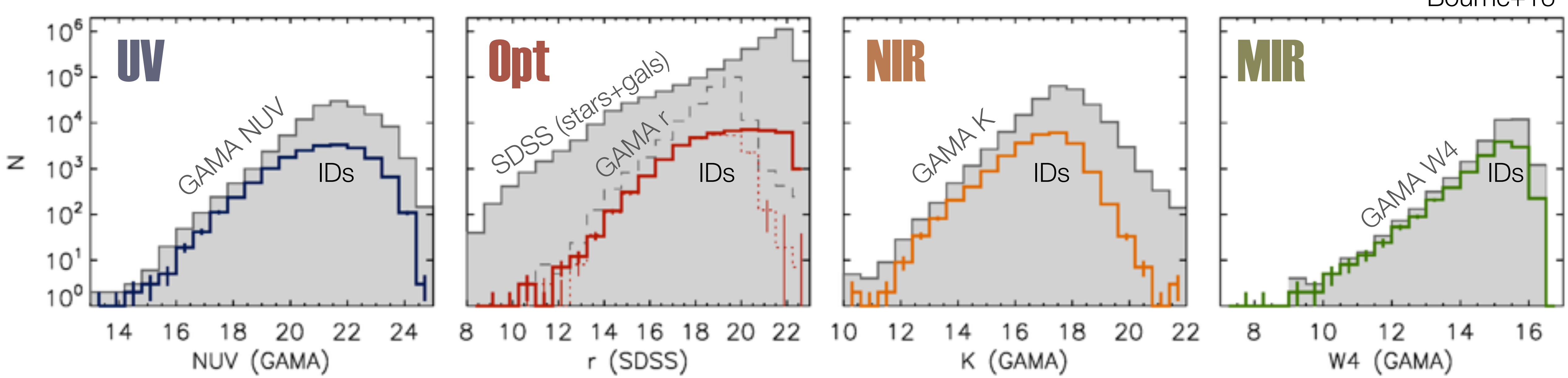
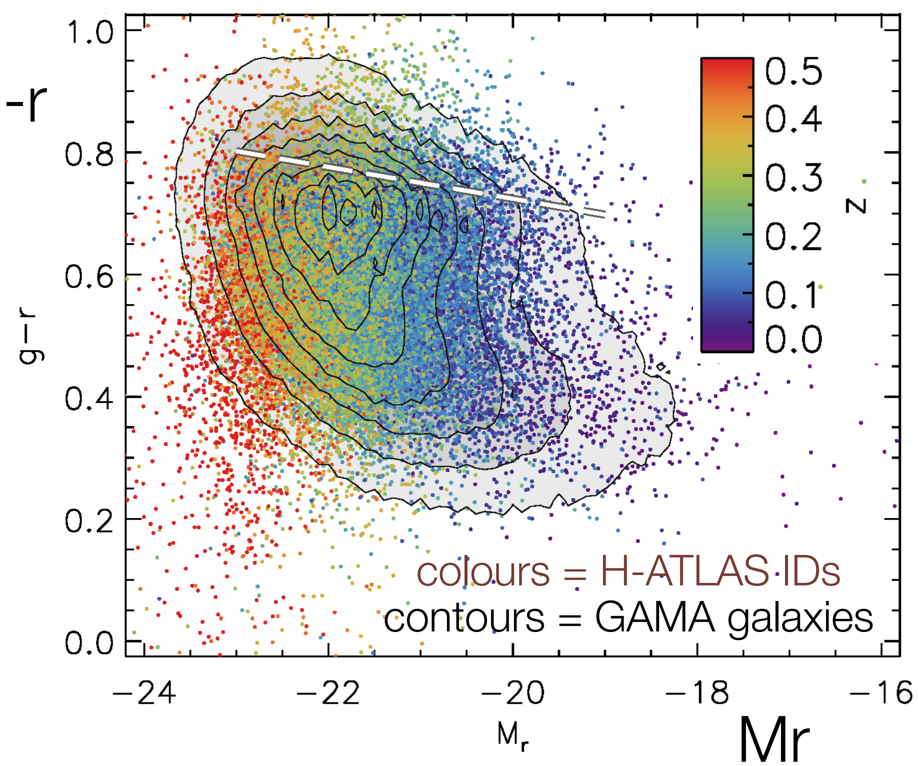
- The main GAMA sample is r<19.8: GAMA contains 52% of our galaxy IDs, but includes most of the galaxies at z<0.4
- IDs sample broad range of magnitudes in UV, optical, NIR, MIR
- Flatter magnitude distribution in the optical and UV compared with GAMA main galaxy sample

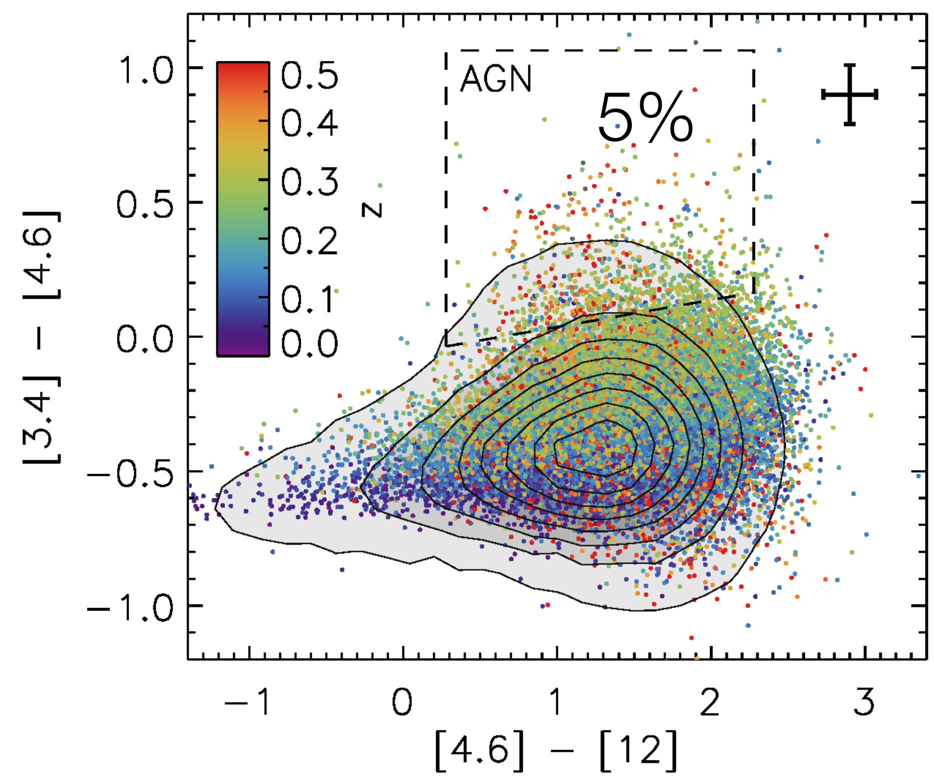
Bourne+16



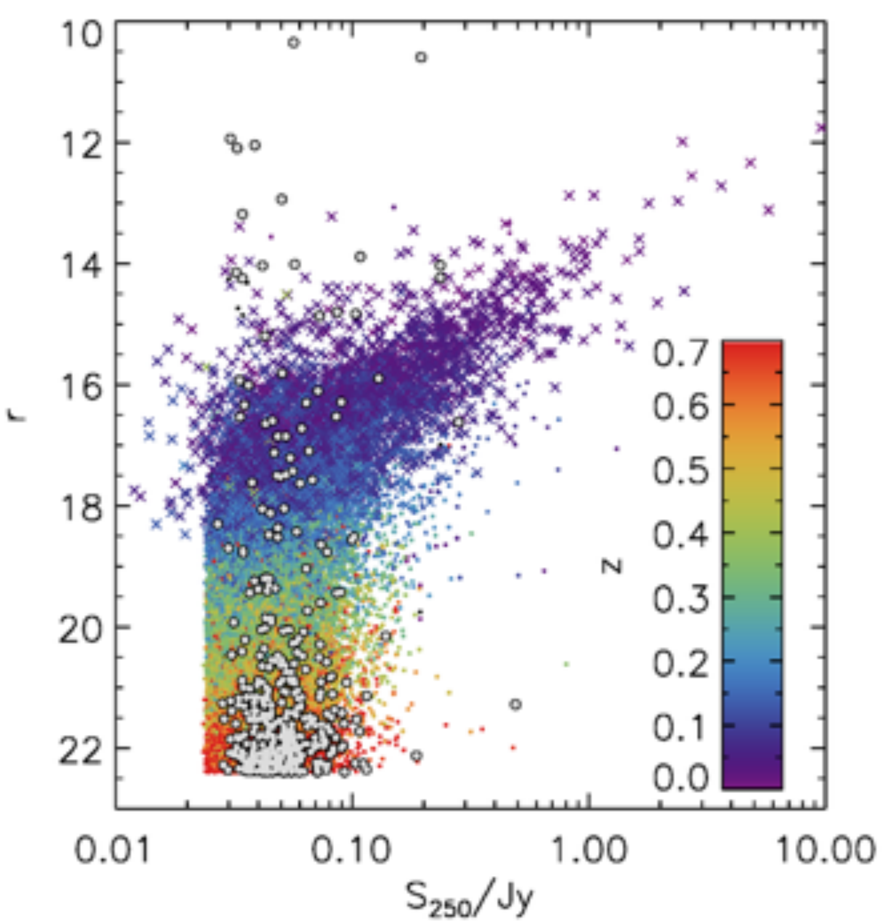
Diversity of galaxies detected in H-ATLAS

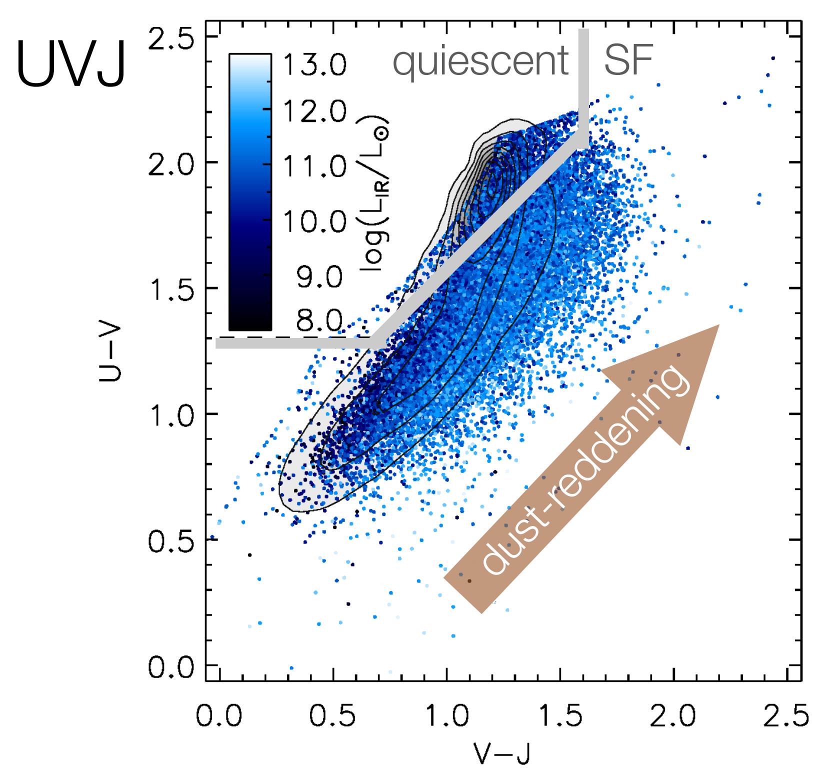
- Multi-wavelength properties of galaxies selected at 250μm at z<0.5





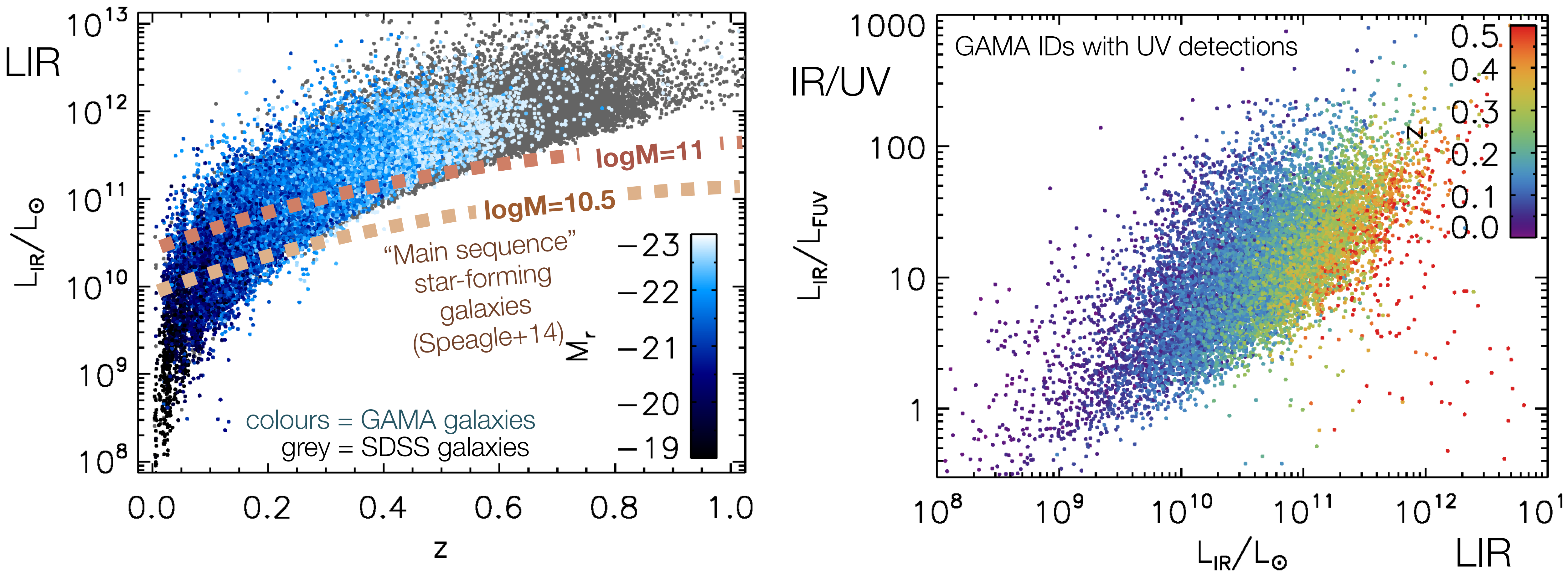
Bourne+16





Diversity of galaxies detected in H-ATLAS

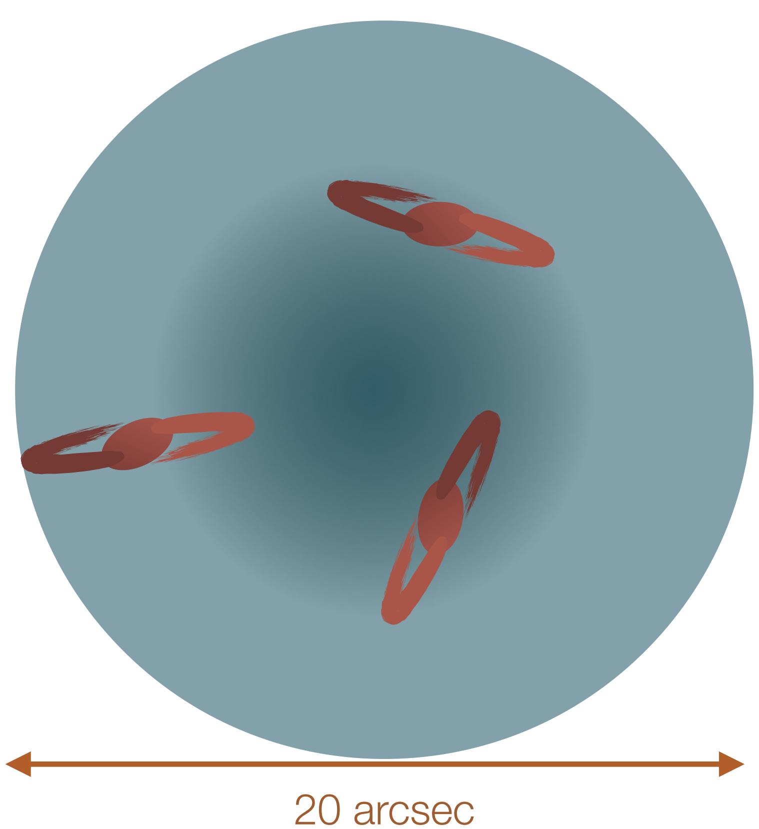
- IR luminosities and obscuration of Star-formation



Multiplicity of H-ATLAS IDs

- Reliability threshold assumes single counterparts
- Multiple real IDs will not be identified and will lead to incompleteness

	With p xgal candidates:	
p	$N_{\rm SPIRE}$	$N_{\rm rel}$
0	41018	0 (0%)
1	50054	30716 (61%)
2	18029	11049 (61%)
3	4115	2251 (55%)
4	723	367 (51%)
5	96	41 (43%)
6	12	5 (42%)
7	2	1 (50%)
8	3	1 (33%)
9	0	0 (–)



375
0.1%

>28mJy 250μm

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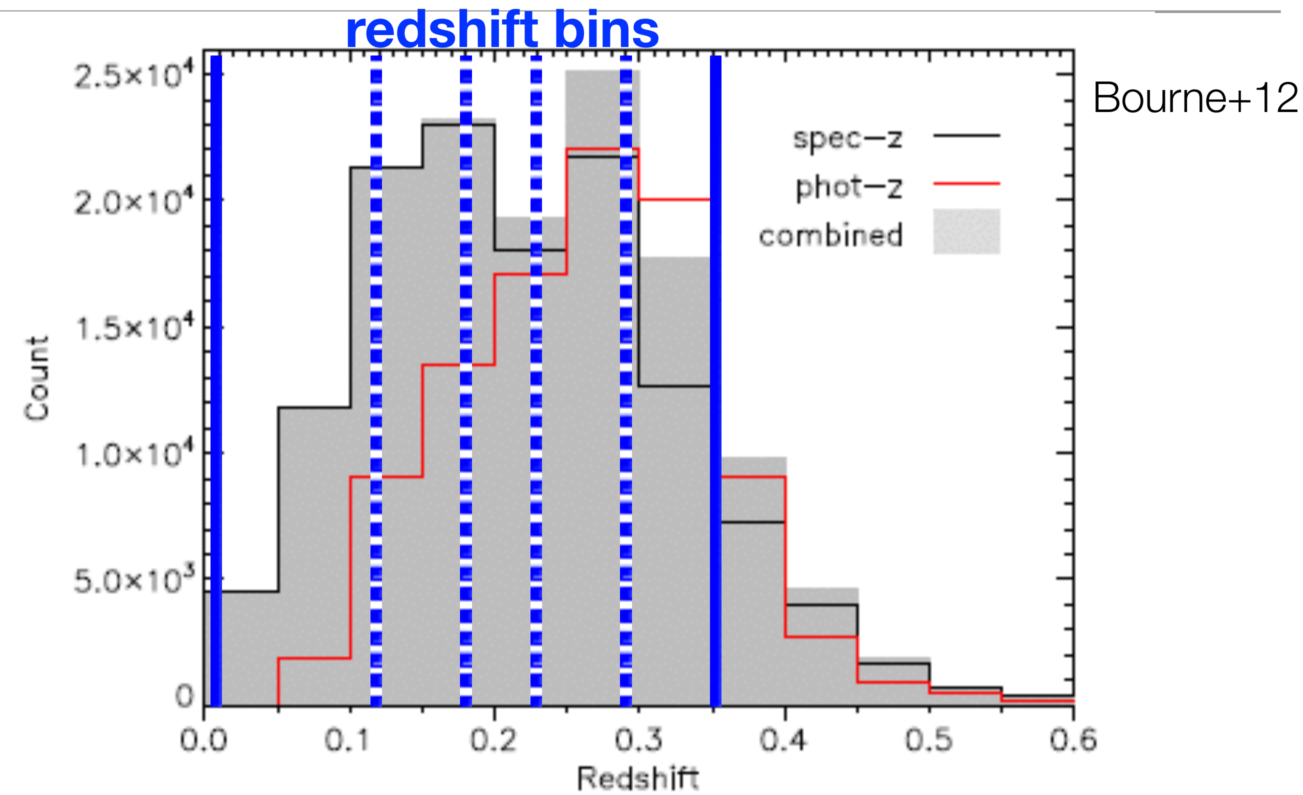
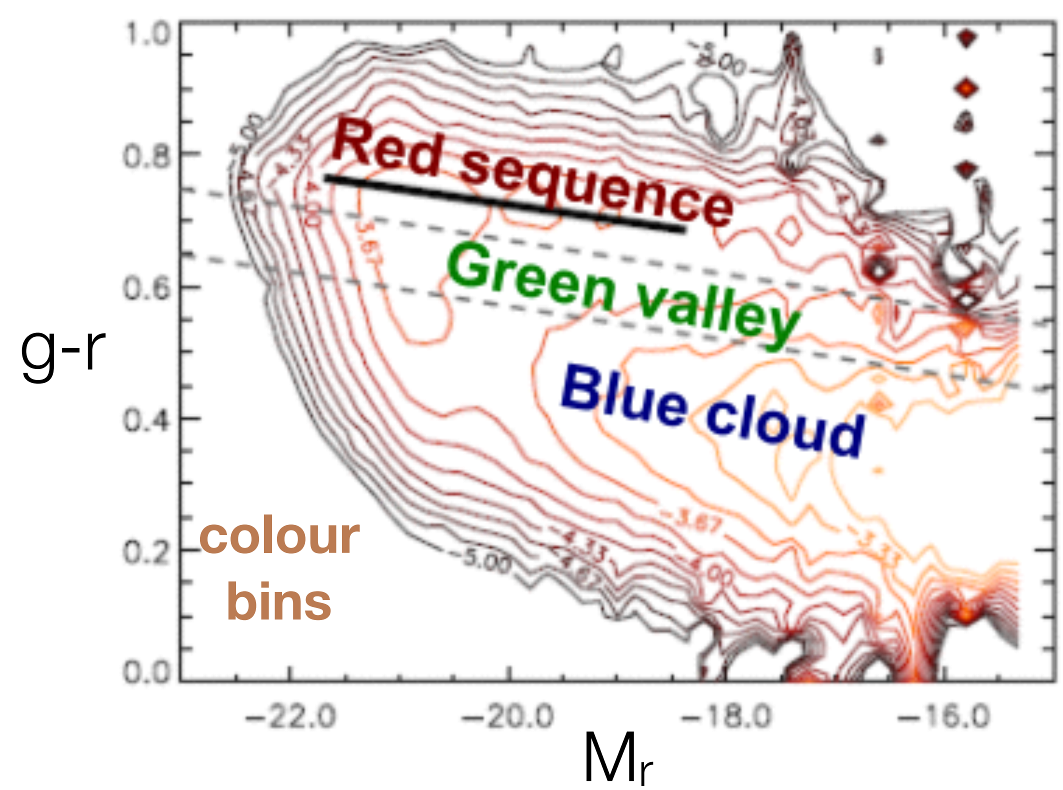
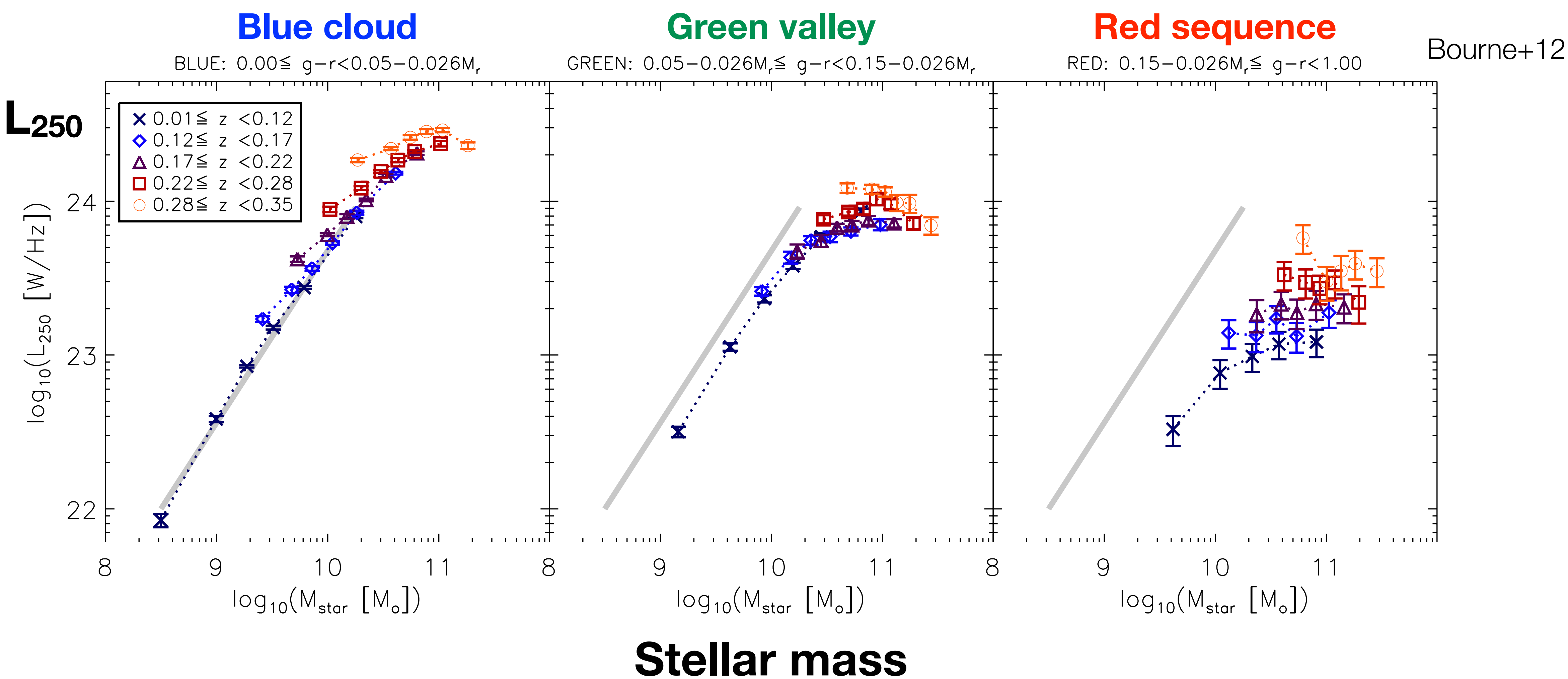
Stacking GAMA galaxies in H-ATLAS

- GAMA provides a rich multi-wavelength catalogue and a complete redshift survey at low redshifts
- This makes it an ideal sample for investigating the galaxy population through statistical analysis
- Select sample based on optical properties: stellar population
- Stack into submm: probe dependence of dust emission on stellar population



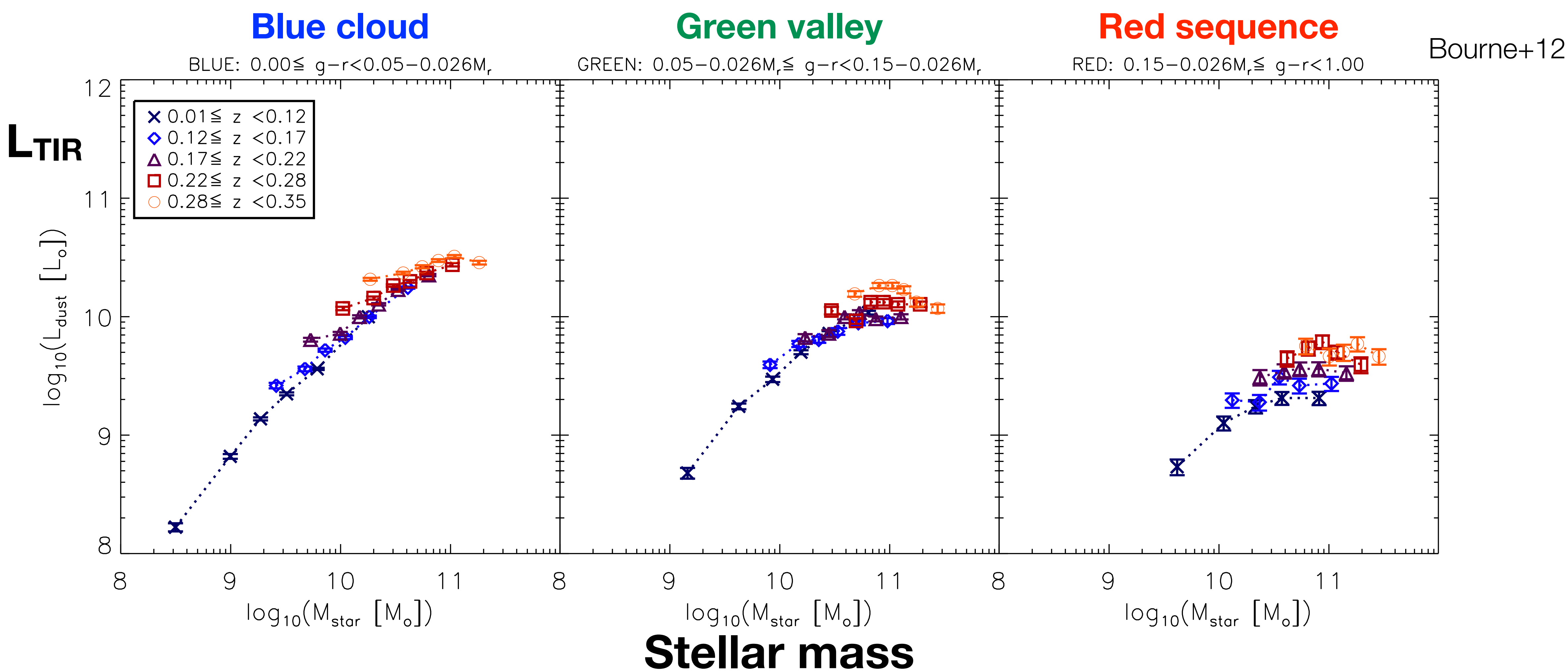


FIR luminosities of optically-selected galaxies



- Rest-frame L_{250} of stacked GAMA galaxies
- Evolution: (1+z)^4 (blue) (1+z)^3 (green) (1+z)^6 (red)

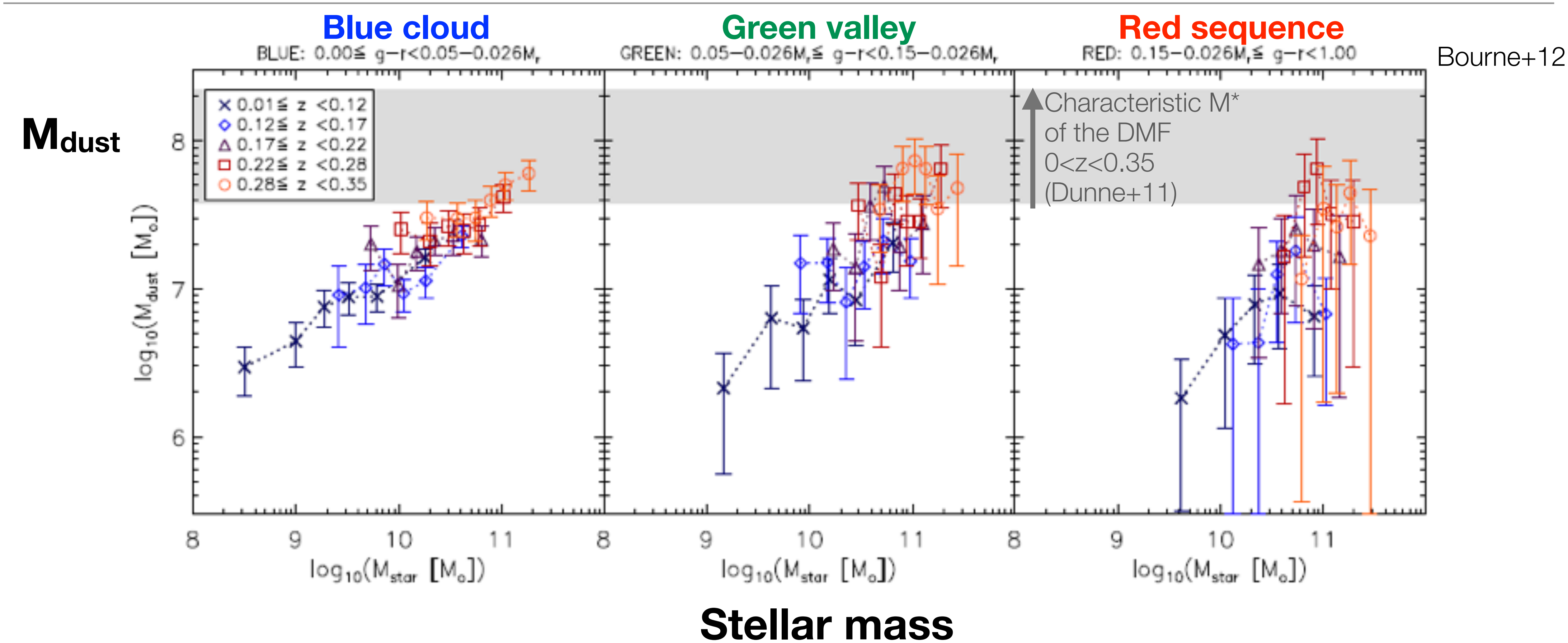
FIR luminosities of optically-selected galaxies



- L_{TIR} estimated by fitting the SPIRE data with templates from H-ATLAS (Smith et al. 2012)

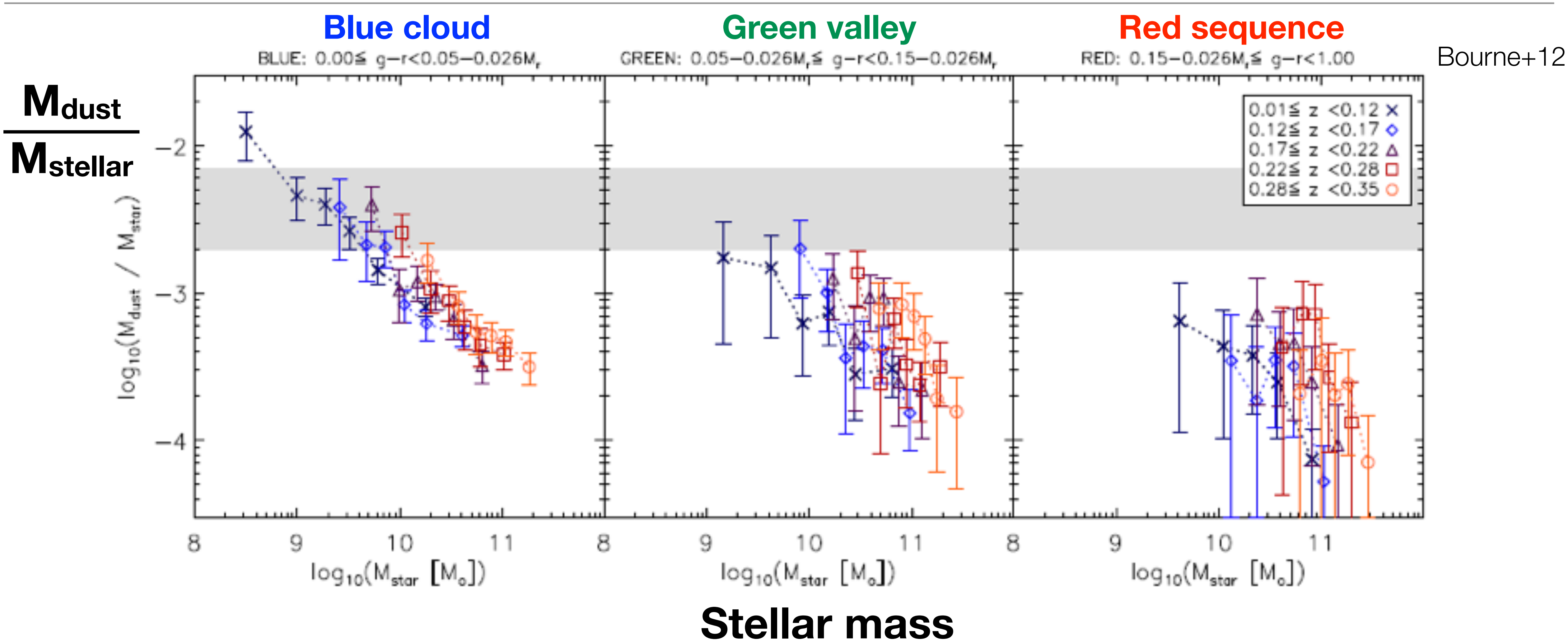
- In total, GAMA galaxies with r<19.8 at z<0.35 contribute 4% of the 250μm CIB (60% from blue cloud galaxies)

Dust mass vs Stellar mass



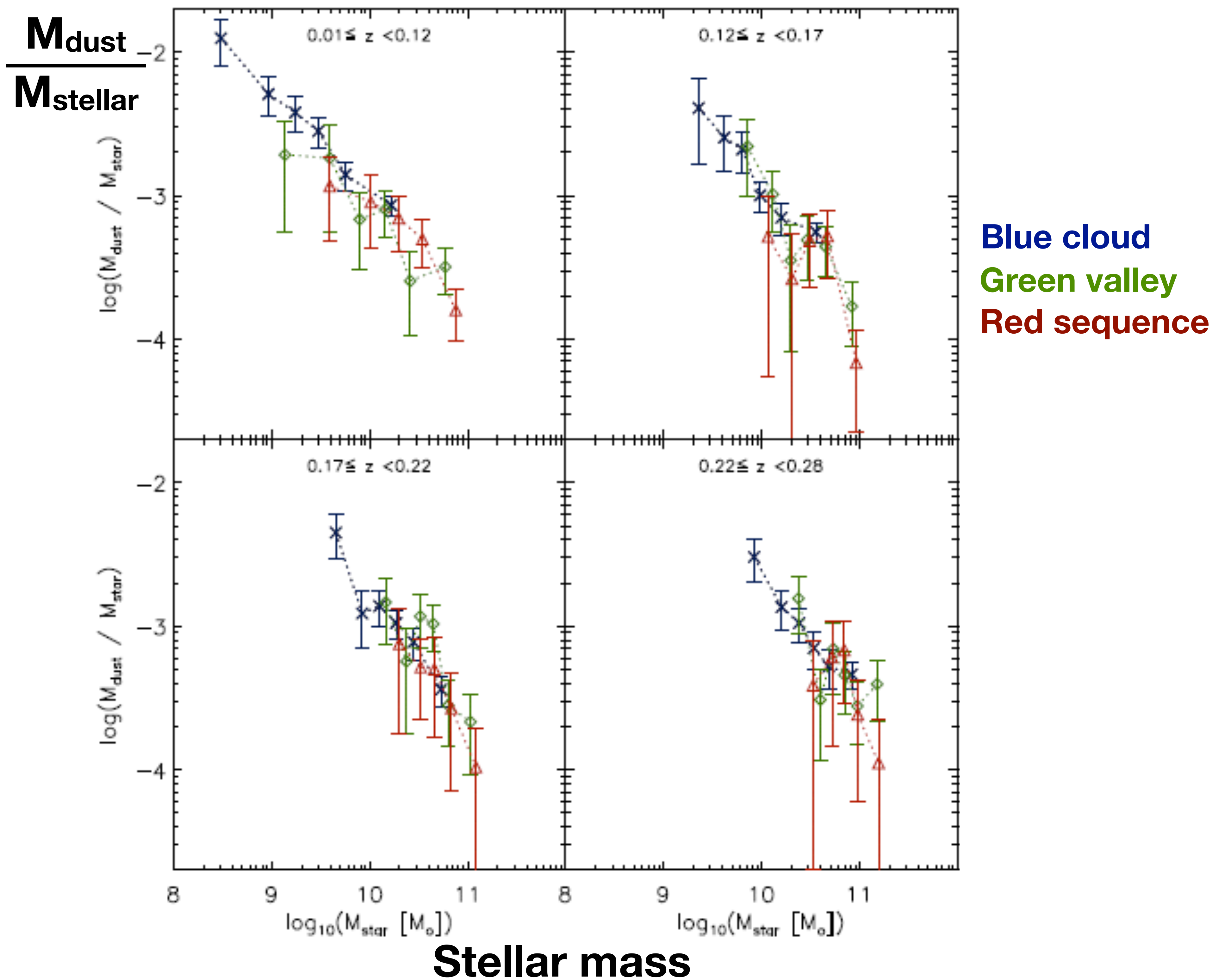
- M_{dust} estimated from a single-component modified blackbody, β=2 (T free)
- Evolution ~ (1+z)^4 - similar to evolution in dust mass function

Dust/stellar mass ratio

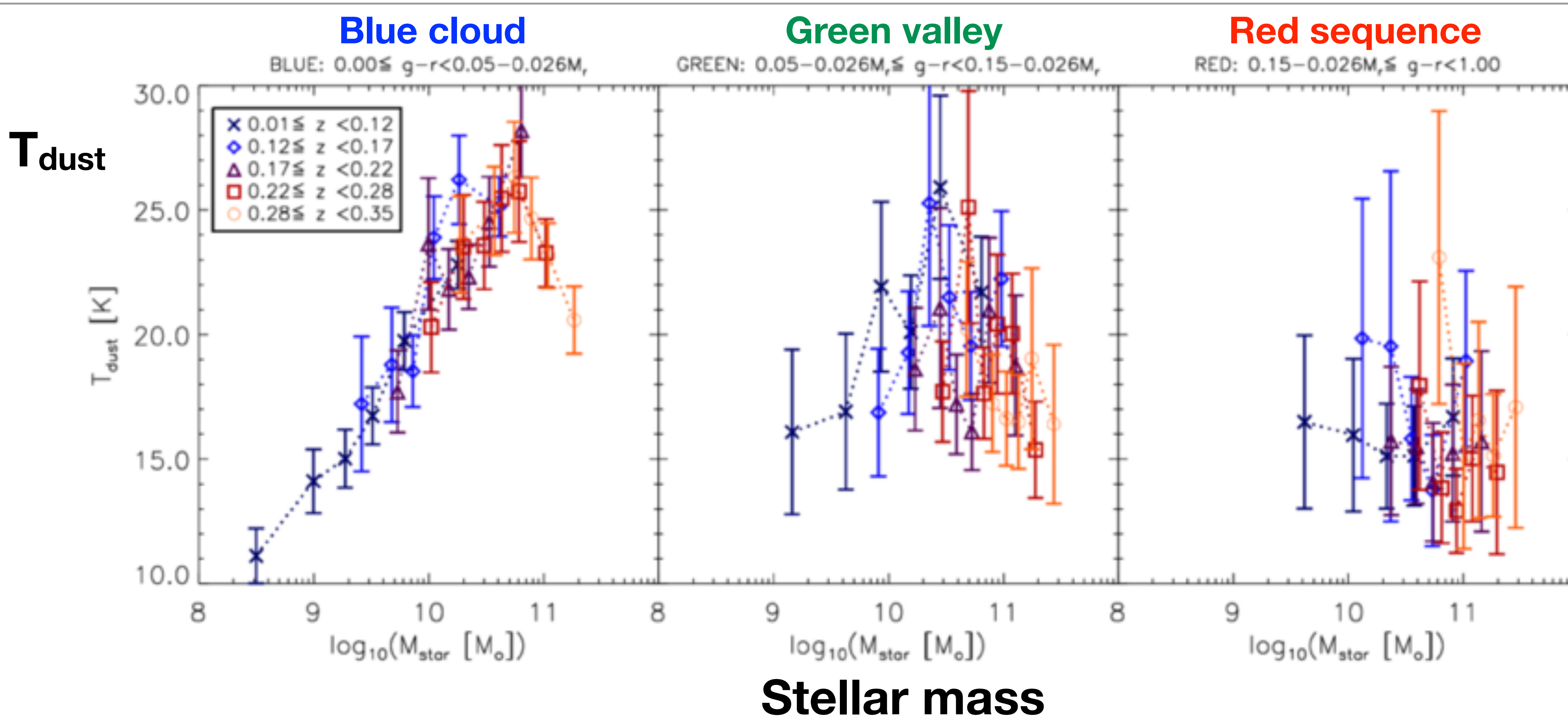


- Dust/stellar mass ratio strongly dependent on stellar mass and redshift; weakly dependent on colour

Dust/stellar mass ratio and optical colour



Dust temperature



- Dust temperature varies with stellar mass and optical colour
- Red sequence galaxies colder hence less luminous for the same dust mass

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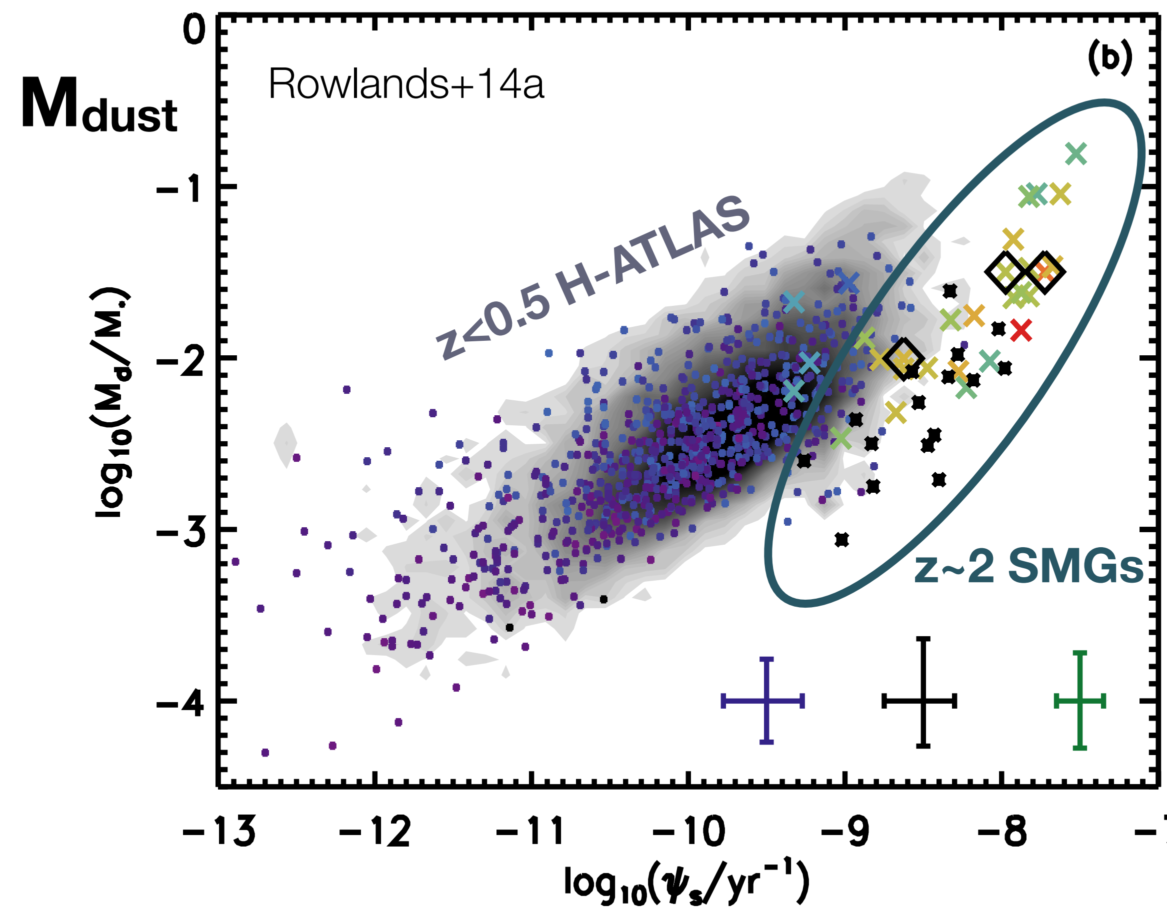
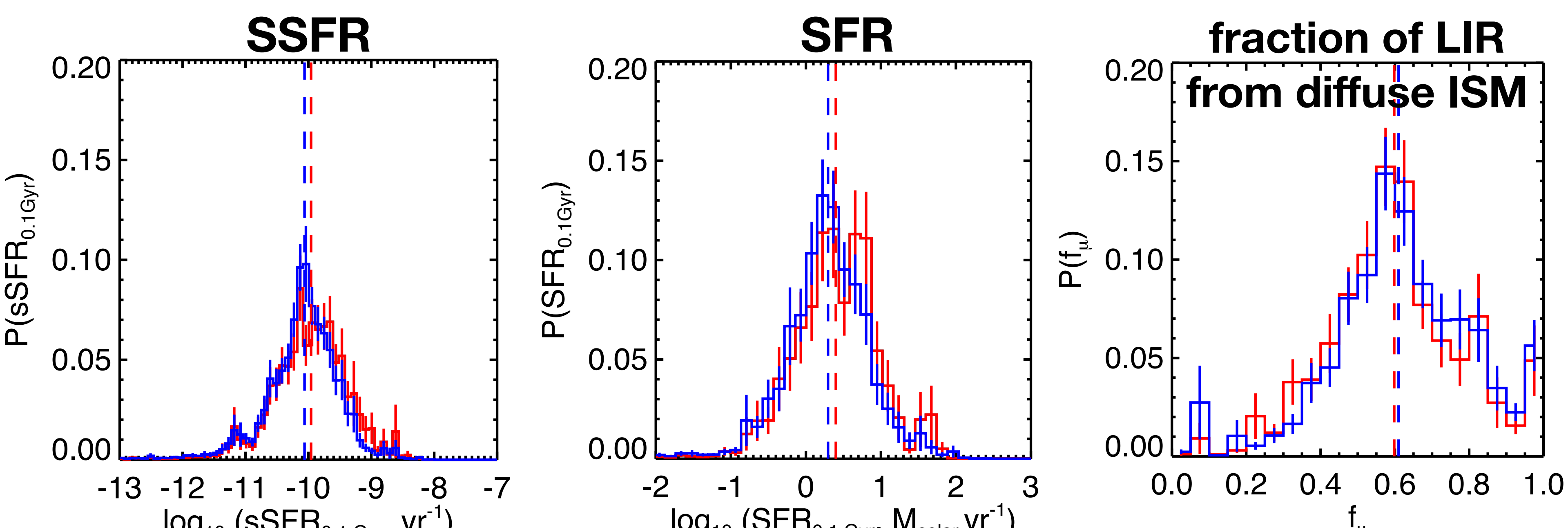
The H-ATLAS sample in context

- H-ATLAS samples typical star-forming disc galaxies at low-z — in contrast to high SSFRs selected at rest-frame 250μm at high-z (Rowlands+14a; Smith+12)



SSFR

Smith+12



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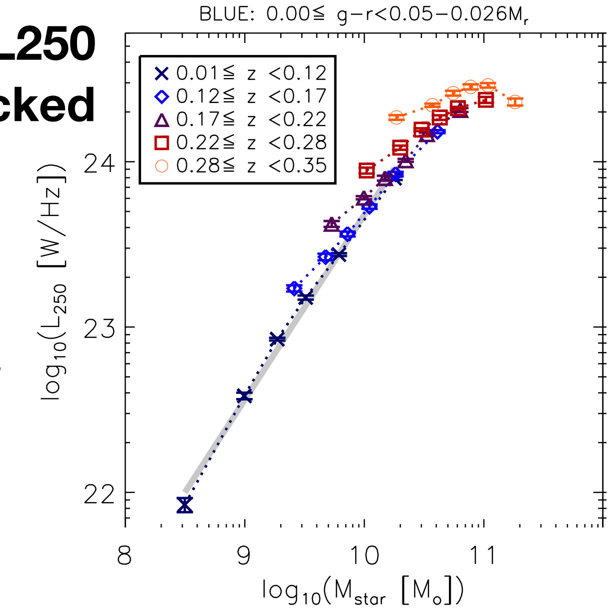
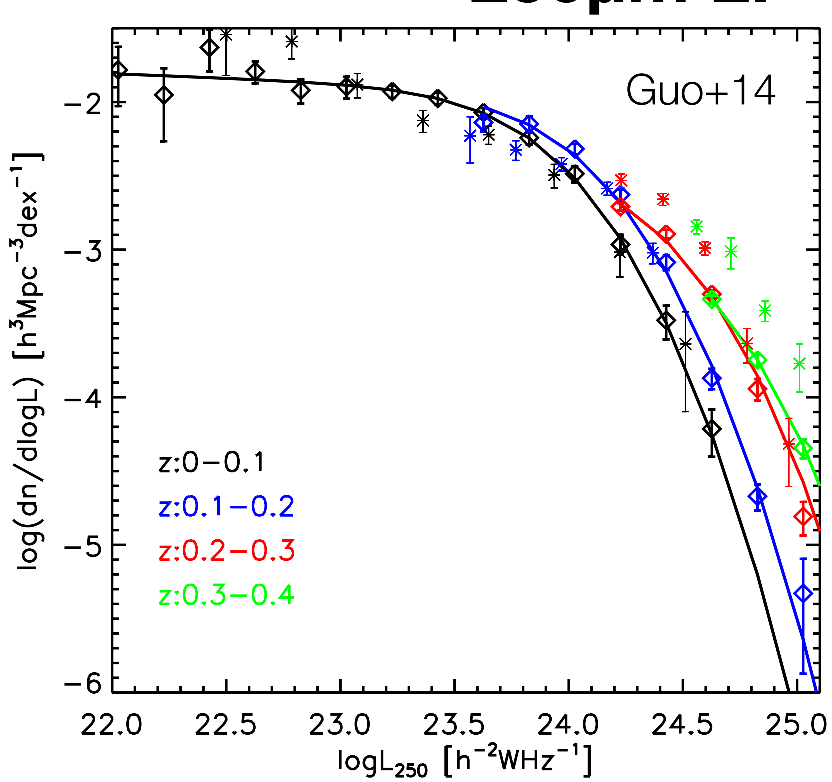
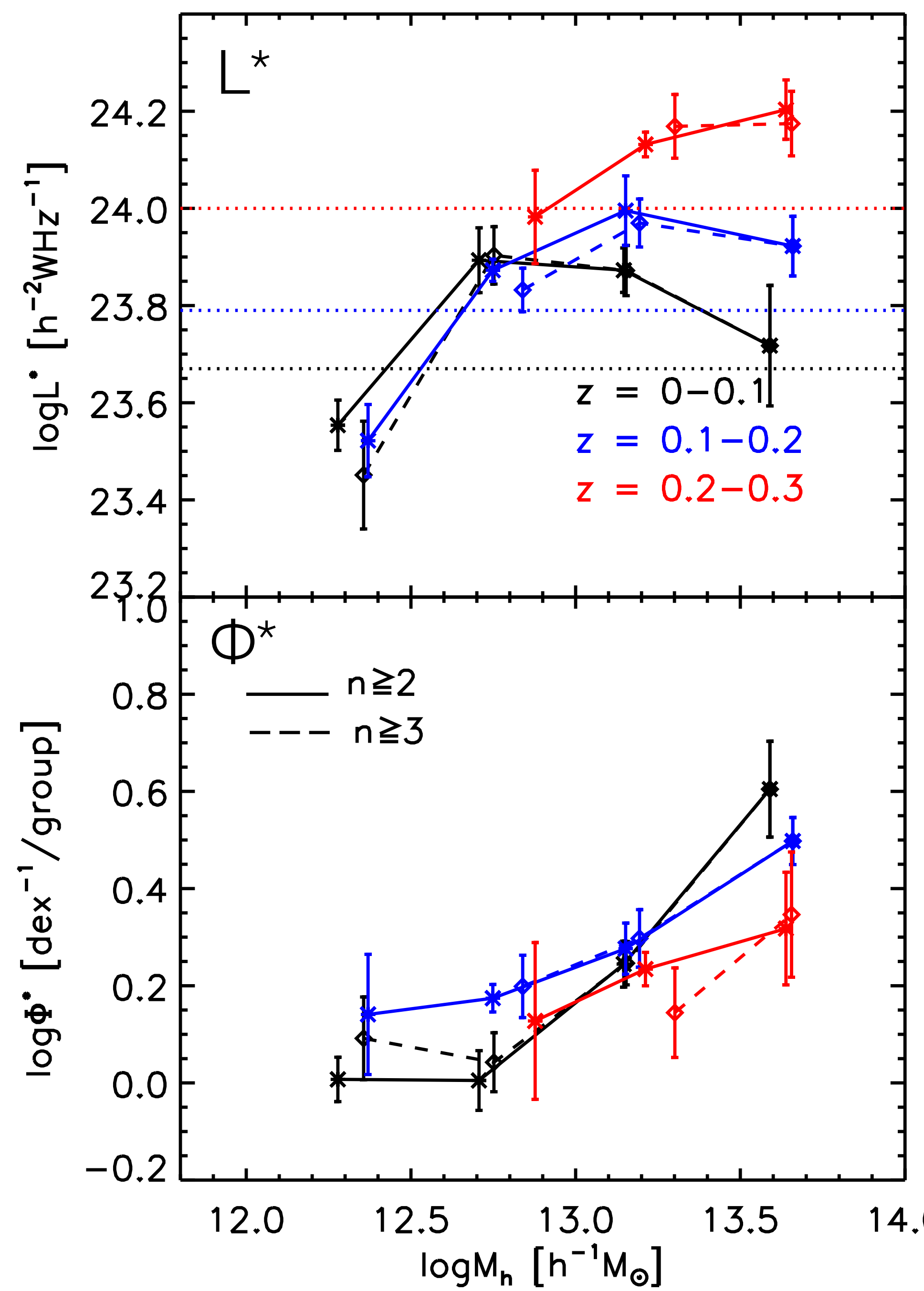
- H-ATLAS samples typical star-forming disc galaxies at low-z — in contrast to high SSFRs selected at rest-frame 250µm at high-z (Rowlands+14a; Smith+12)
- FIR/sub-mm luminosities of star-forming galaxies evolve strongly with redshift (Dunne+11, Guo+14)
- Linking evolution in SFR with dark matter halo mass (Guo+14)

L250 stacked



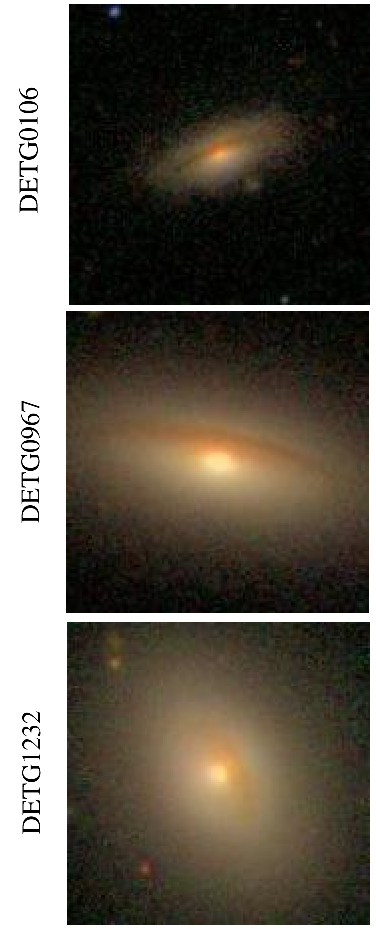
250µm LF

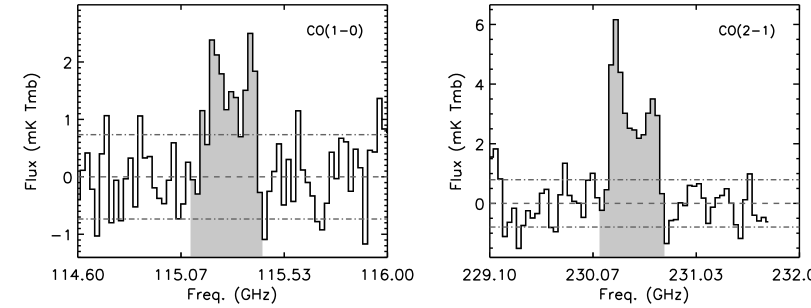


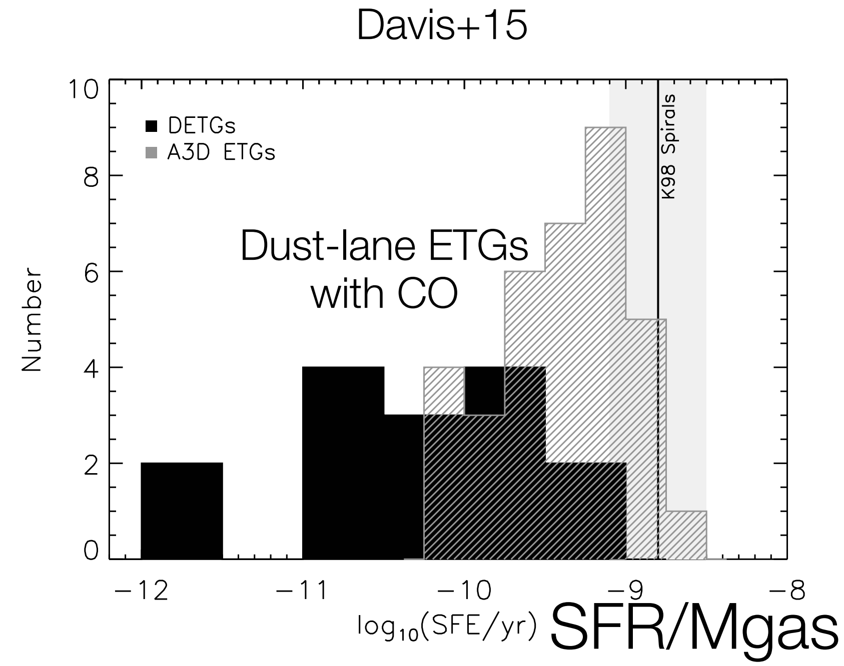


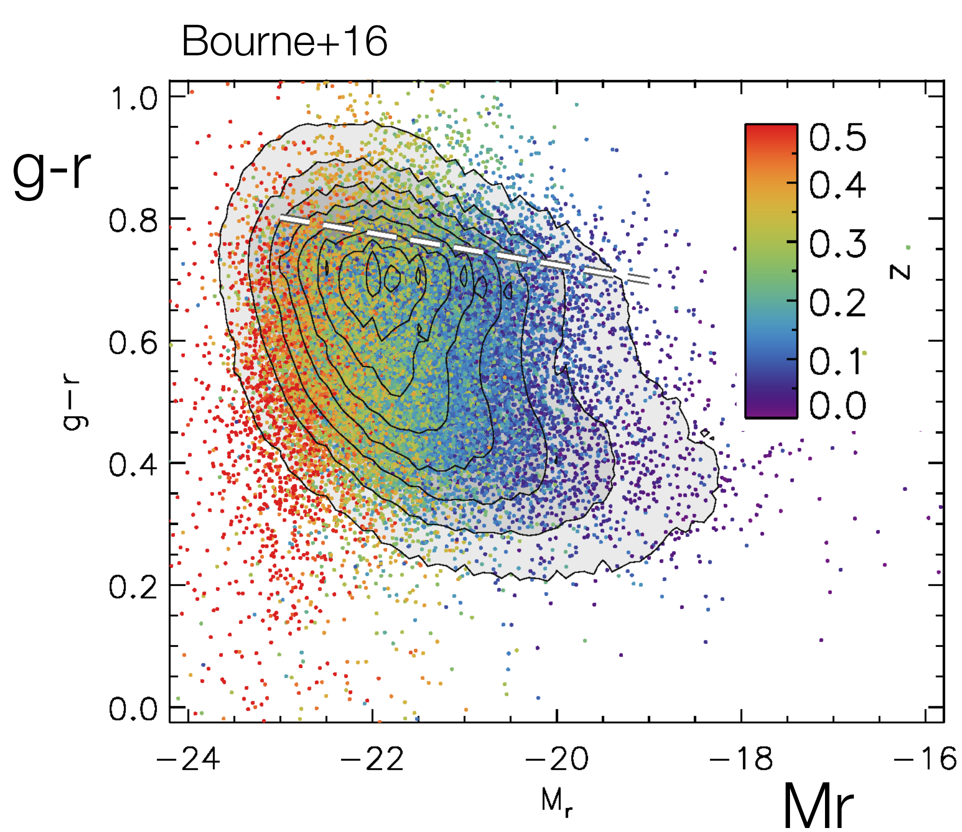
Dust across the galaxy population

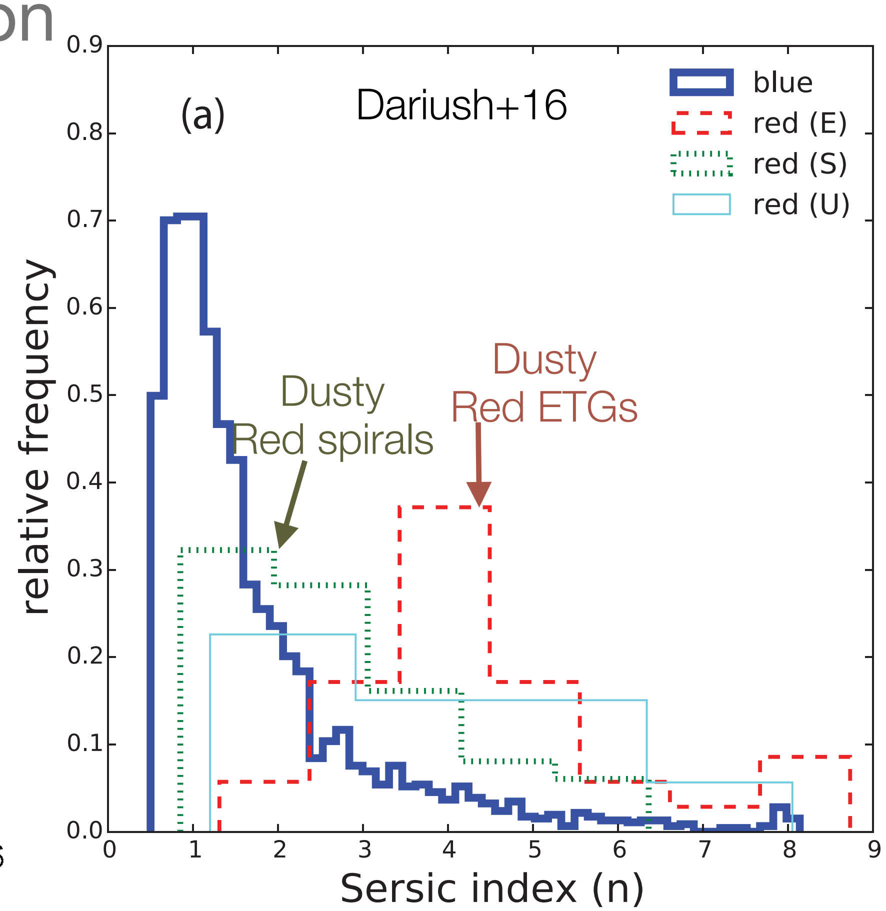
- Dusty galaxies with old stellar populations and early-type morphologies
- Dust and gas acquired in mergers
- Dust growth & destruction

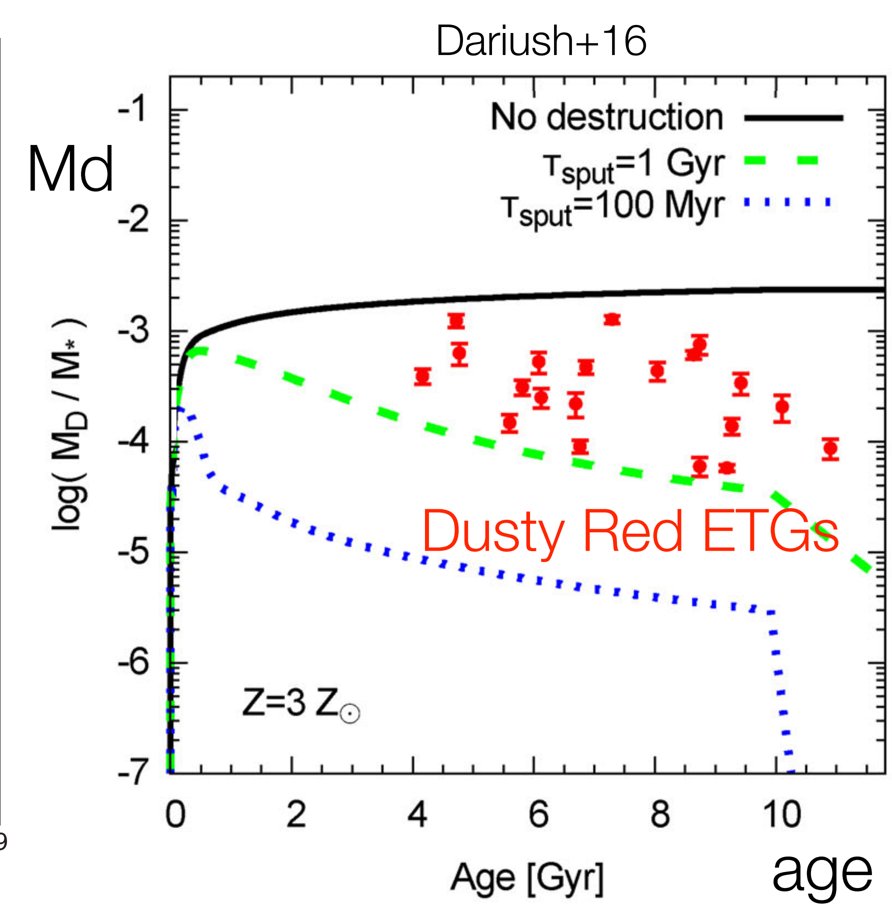






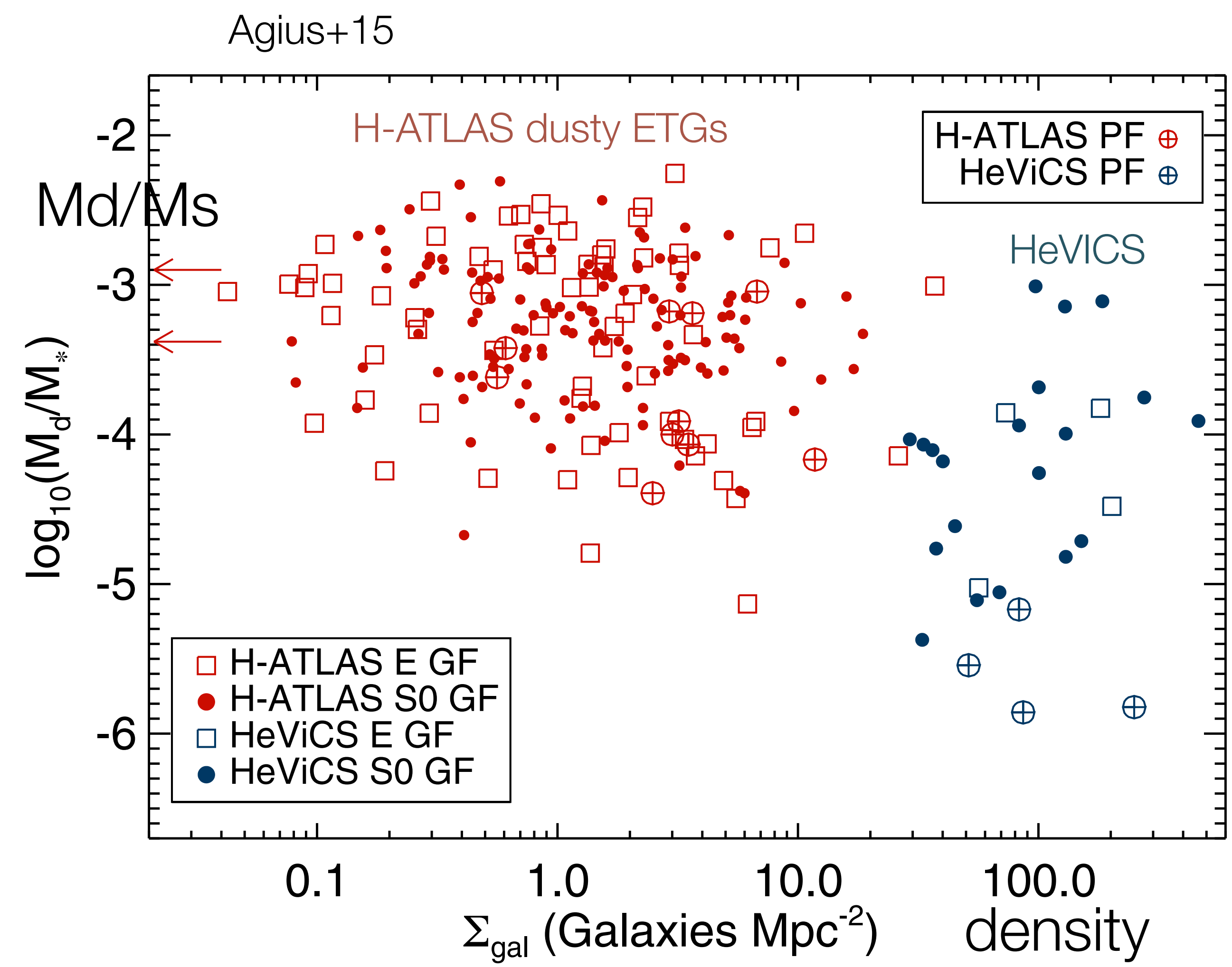






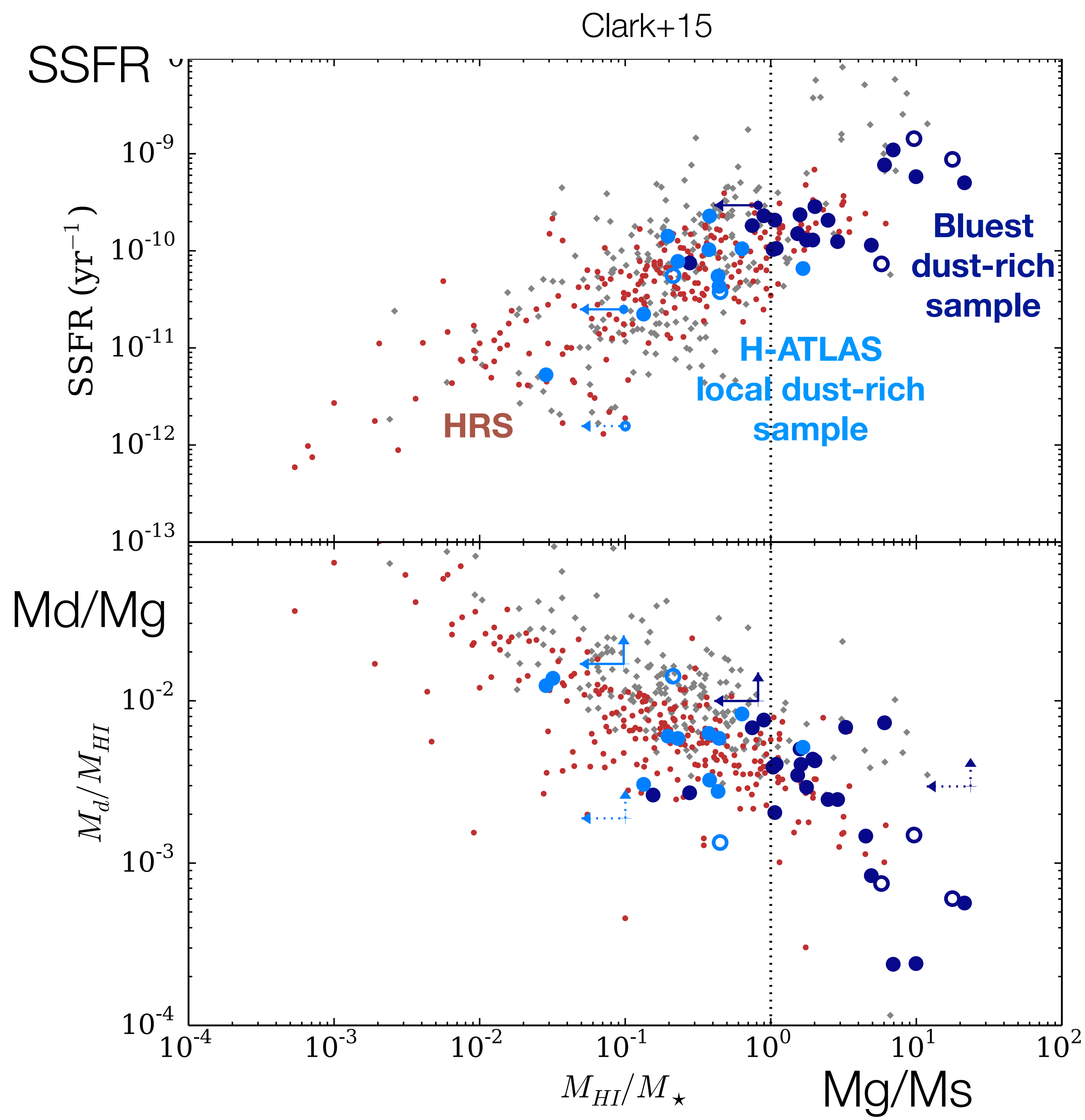
Dust across the galaxy population

- Dusty galaxies with old stellar populations and early-type morphologies
- Dust and gas acquired in mergers
- Dust growth & destruction
- Role of environment - fewer Virgo-cluster ETGs have high dust masses (Agius+15)



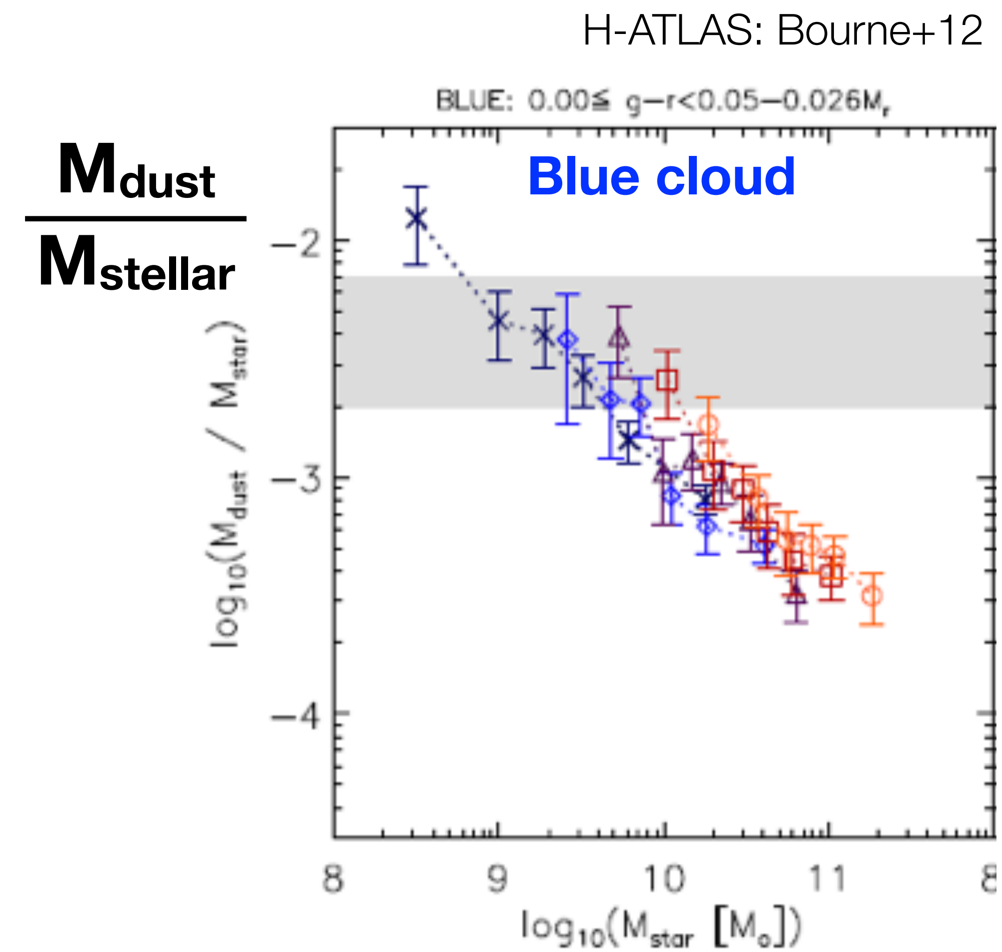
Dust across the galaxy population

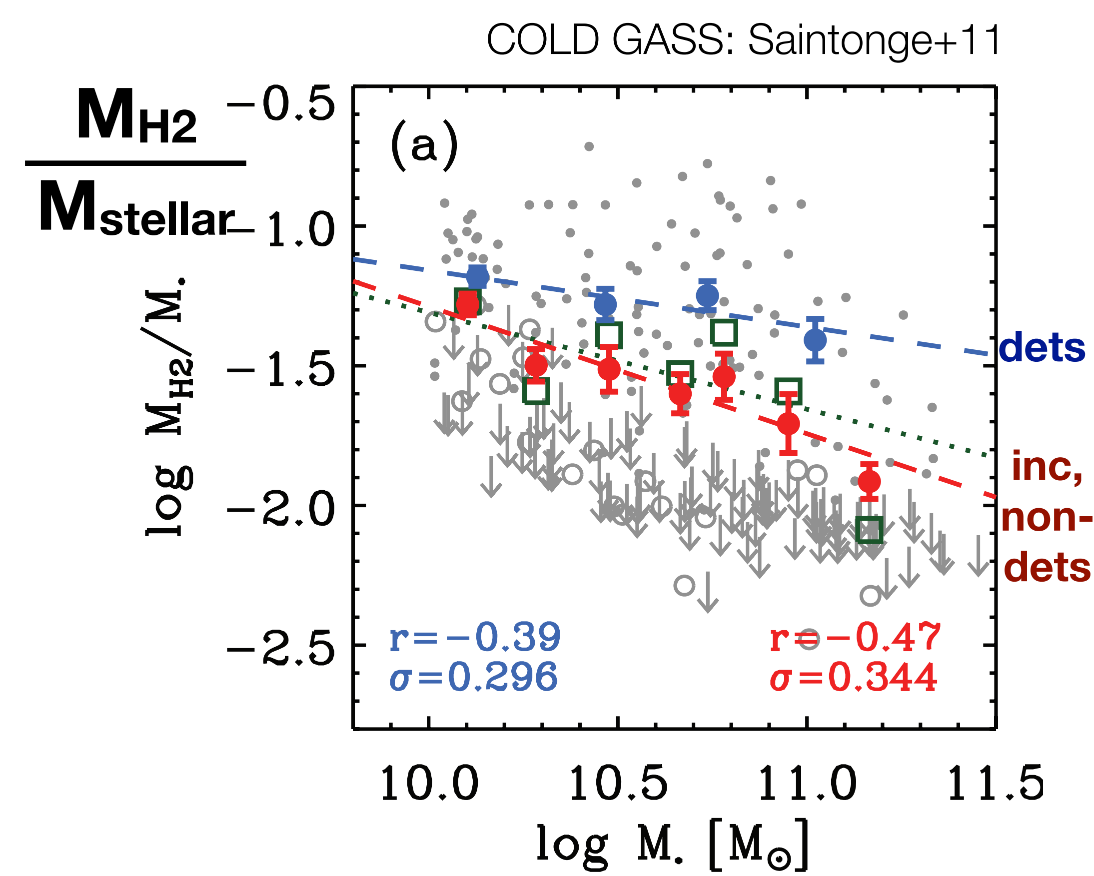
- Dustiest galaxies in the local volume (Clark et al. 2015)
- Very late-type morphologies, blue UV/optical colours, low dust extinction
- High dust mass but very high gas mass and specific SFR:
- Early evolutionary stage



Dust tracing gas

- Mass-dependence of dust/stellar mass ratio (Bourne+12) indicates similar dependence of gas/stellar mass ratio
- This is supported by a comparison with COLD GASS CO survey (Saintonge+11)
- Can we use dust to trace gas in large surveys like H-ATLAS?
- Would have to control for the metallicity dependence, and need good calibrations, e.g. from [CI]





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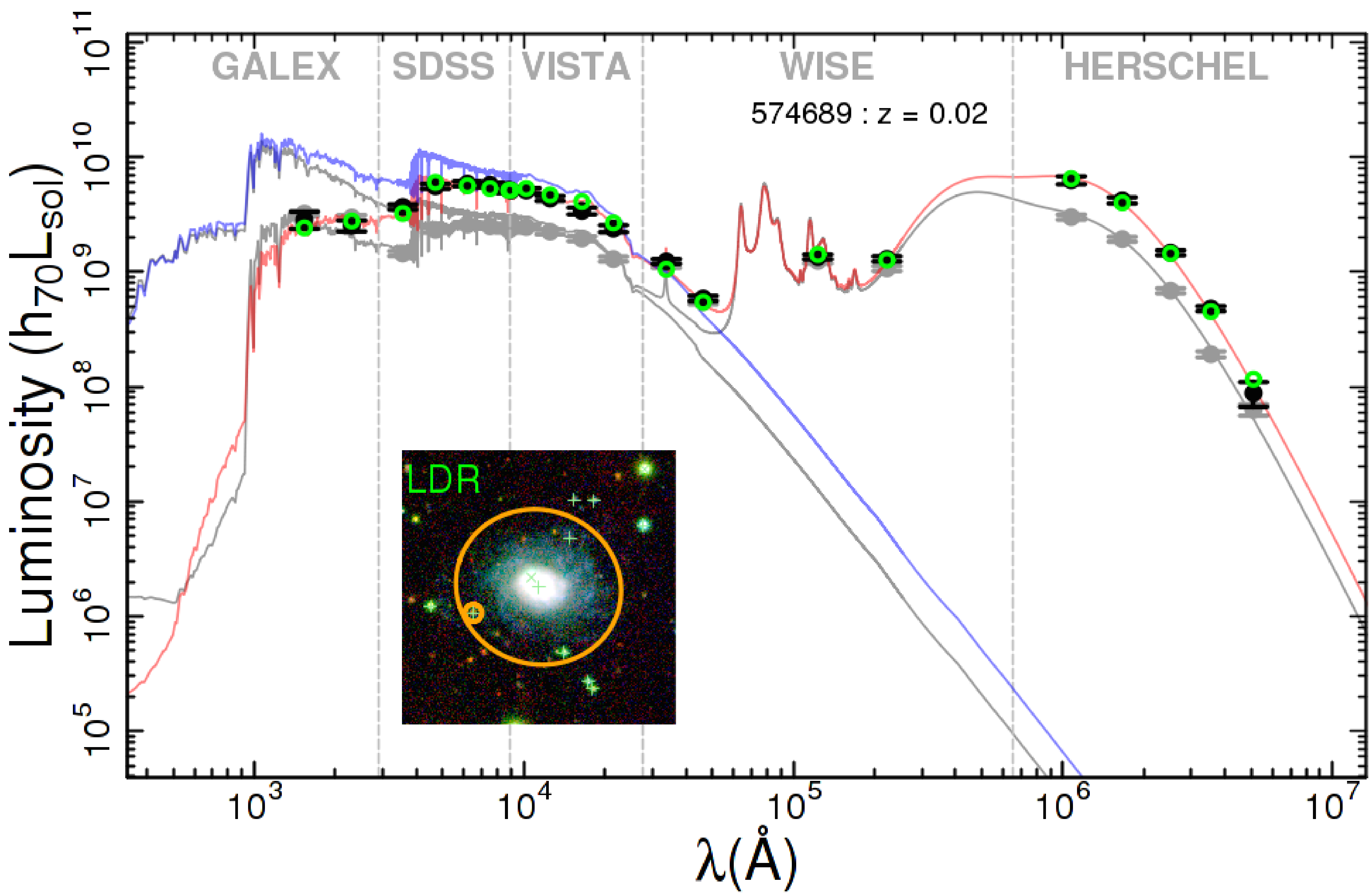
Prospects

- The GAMA fields of H-ATLAS currently offer the best opportunity for exploring the low-z Universe with current data (both photometric and spectroscopic) from GAMA and other multi-wavelength surveys
- Still plenty of scope for further exploration and mining of existing data-sets, e.g.
  - Environment studies using GAMA's complete redshift database and group catalogue
  - Exploiting WISE overlap for studies of obscured AGN
  - Using dust mass measurements to trace gas mass in galaxies
  - Benefits of GAMA pan-chromatic photometry…

Optimised matched photometry across all wavelengths and resolution regimes: LAMBDAR

- Wright et al. 2016



In conclusion

- H-ATLAS probes dust across a diverse range of low-z galaxies
- Sensitive to star-forming galaxies over a wide redshift range
- Synergy with GAMA and multi-wavelength surveys to study galaxy evolution in detail over $0<z<0.4$

- Bourne et al. 2016: Optical IDs to all H-ATLAS 250um sources: redshifts and multi-wavelength properties for wide-field Herschel-selected sample
- Wright et al. 2016: optimised UV-submm photometry for all GAMA galaxies