Ruling out barionic mass evolution and mergers in cluster and group galaxies up to z=1.3

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There are many ways to address galaxy evolutions, for example:

- colours, spectra -> stellar age
- counting galaxies vs z -> assembly time
- evolution of the scale relations -> a combination of many things: structural evolution (r_e), stellar age (μ_e), dinamycal evolution (σ_v), etc.

Talk Layout

When galaxies forms, i.e. when they were assembled?
Do high mass galaxies form earlier/later than low mass galaxies?

-> we count galaxies vs redshift in large samples over large redshift ranges, i.e. we explore assembly time.

all galaxies, irrispective of colour:

- barionic mass function: found not to evolve
- Halo Occupation Number: minor role of mergers

dissecting galaxy populations:

- bright red galaxies found not evolve in mass
- red sequence built up at z>> 1.3, including galaxies as faint as 0.05 L*.

Bottom line : mass growth (including mergers) is zero (or near so) for galaxies in (mostly poor) clusters and large groups, in the last 9 Gyr. This holds for all galaxies and for red galaxies. The red sequence is fully populated at z=1.3, hence got populated at z>>1.3.

Stellar mass function for galaxies
of all colours
in 31 low mass clusters/large groups
at $0.20<z<1.22$

[3.6] micron Spitzer band is sampling the 1.8 μm emission at z=1. NIR emission (almost) unaffected by dust or short episodes of star formation

1000 galaxies in 31 clusters, large redshift coverage:

6 above z=0.99

8 above z=0.85

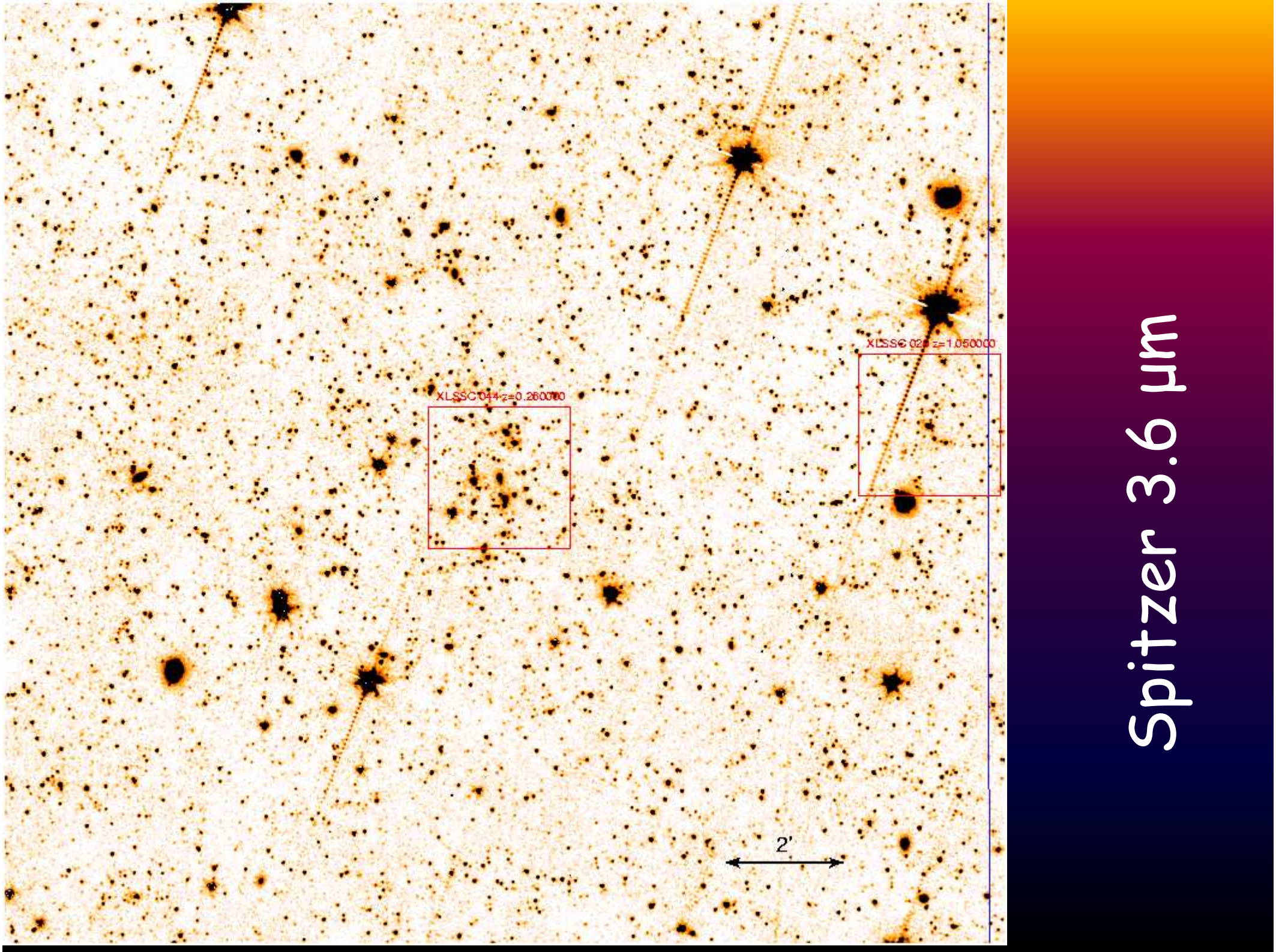
Essential to discriminate among mass assembly histories

All clusters are spectroscopically confirmed

All but 3 with detected X-ray emission -> deep potential well

Single mass estimator, homogenous data sample, and dense cluster sample, and largest similar sample overall.

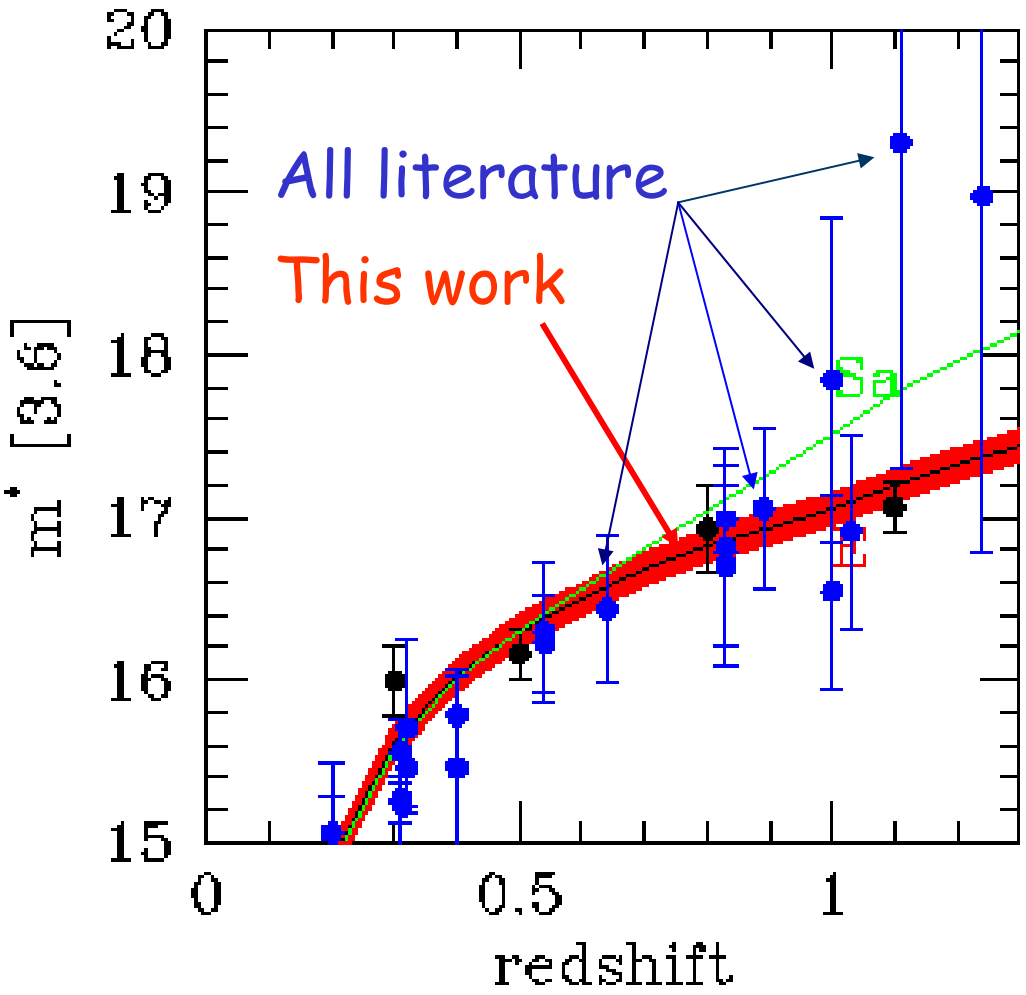
SA (2006, A&A 448,447)

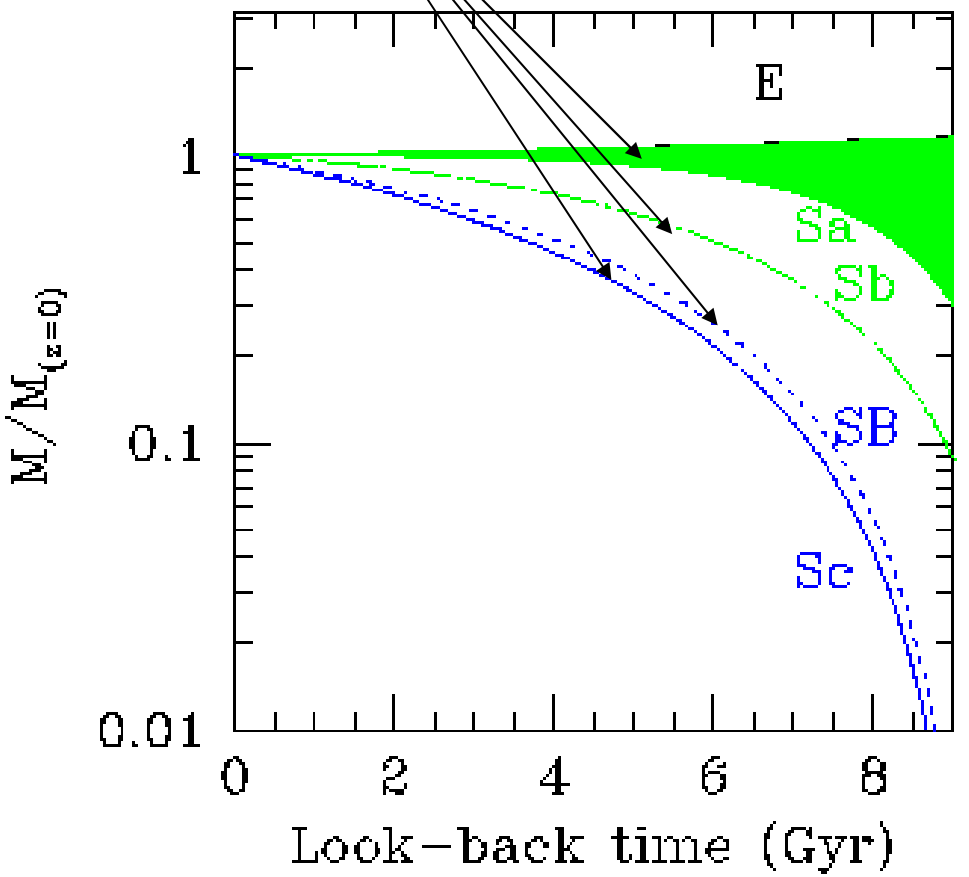

XLSSC044 z=0.260700
XLSSC 029 z=1.050000
2'
Spitzer 3.6 μm

My data (red shading) alone discard all but one model: no mass growth (or, assembly time z>1.3). The novelty is that the integrated effort of all literature (blue points) still allows doubling the mass in the last 8 Gyr (Sa model) my data reject at 5 σ.

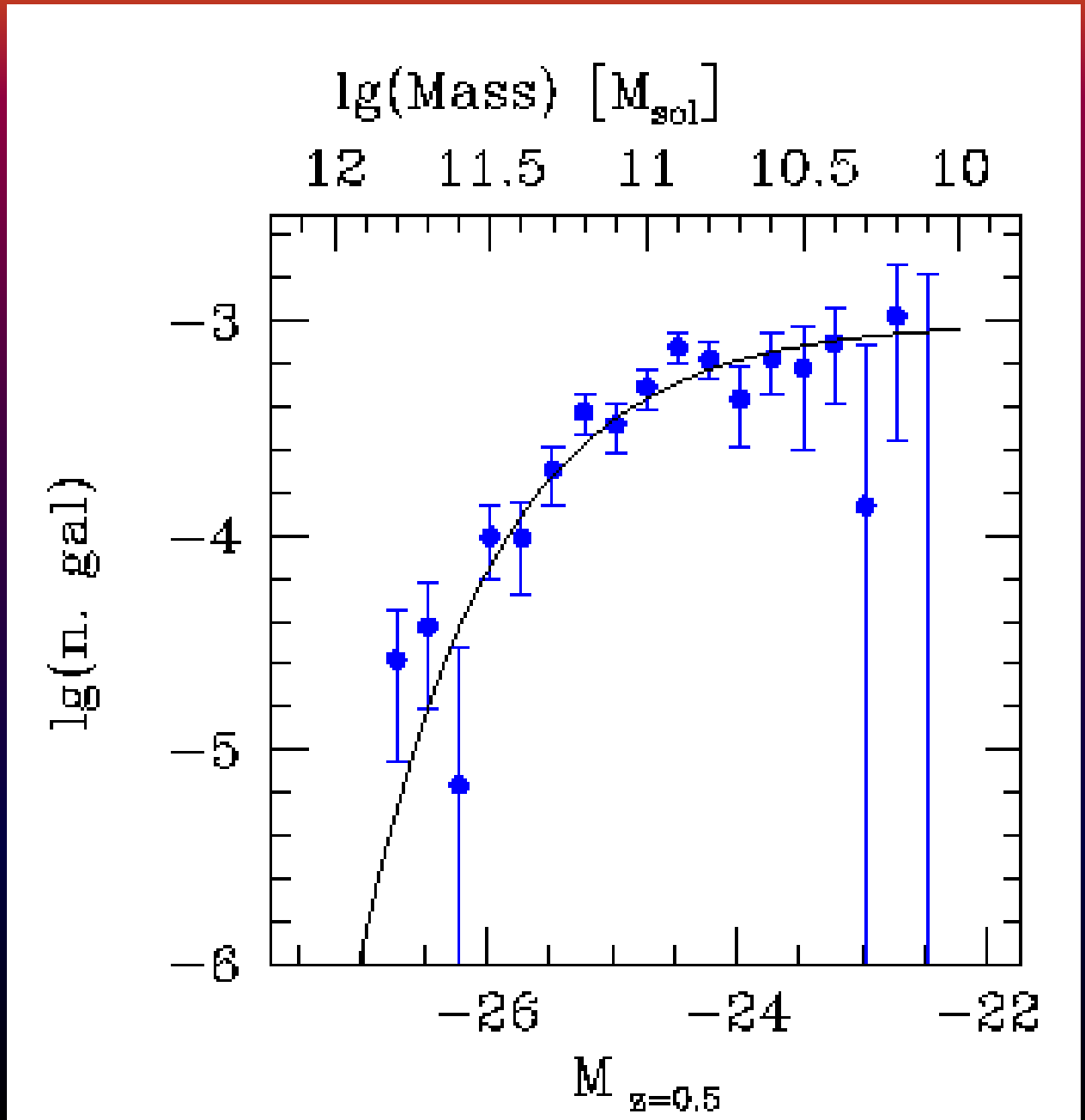
Grasil is used to convert mass in [3.6] micron flux

Some example of models from the library





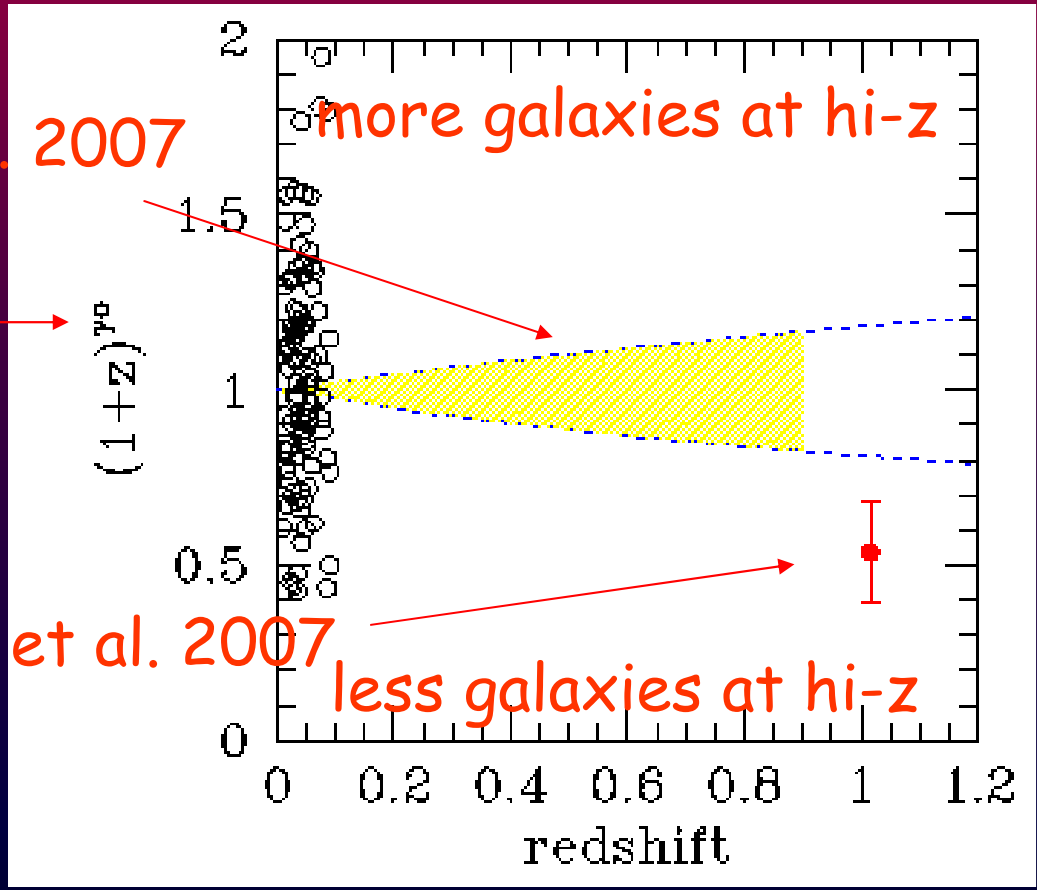
Mass Function



Alternative way of counting:
per unit cluster mass,
i.e. HON

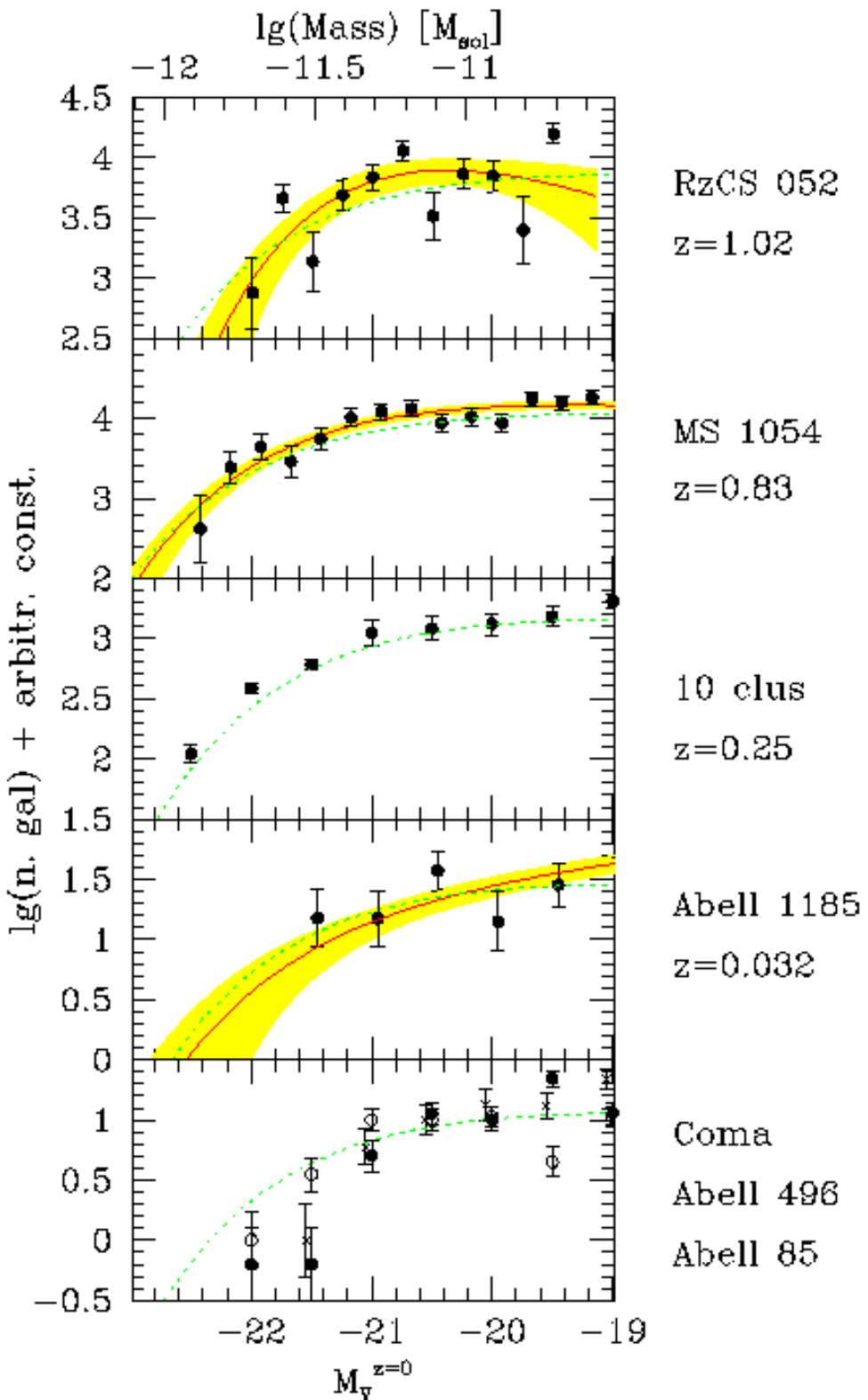
- indirectly measured cluster mass and reference radius (from T), assuming a redshift dependent scaling: Lin et al. 2007
- directly measured cluster mass and reference radius: SA, de Propris et al. (2007, MNRAS, submitted). One cluster only, but carrying similar information content (size of the error bar)

Redshift dependency of HON



minor role of mergers in building (bright) galaxies

Lets consider now galaxy population sub-samples:
assembly time of red galaxies from mass function evolution



Stellar mass function of red galaxies in 16 clusters. A reference un-evolving mass function is plotted as dotted green line. Do data move to the left going from hi-z (top) to low-z (bottom)?

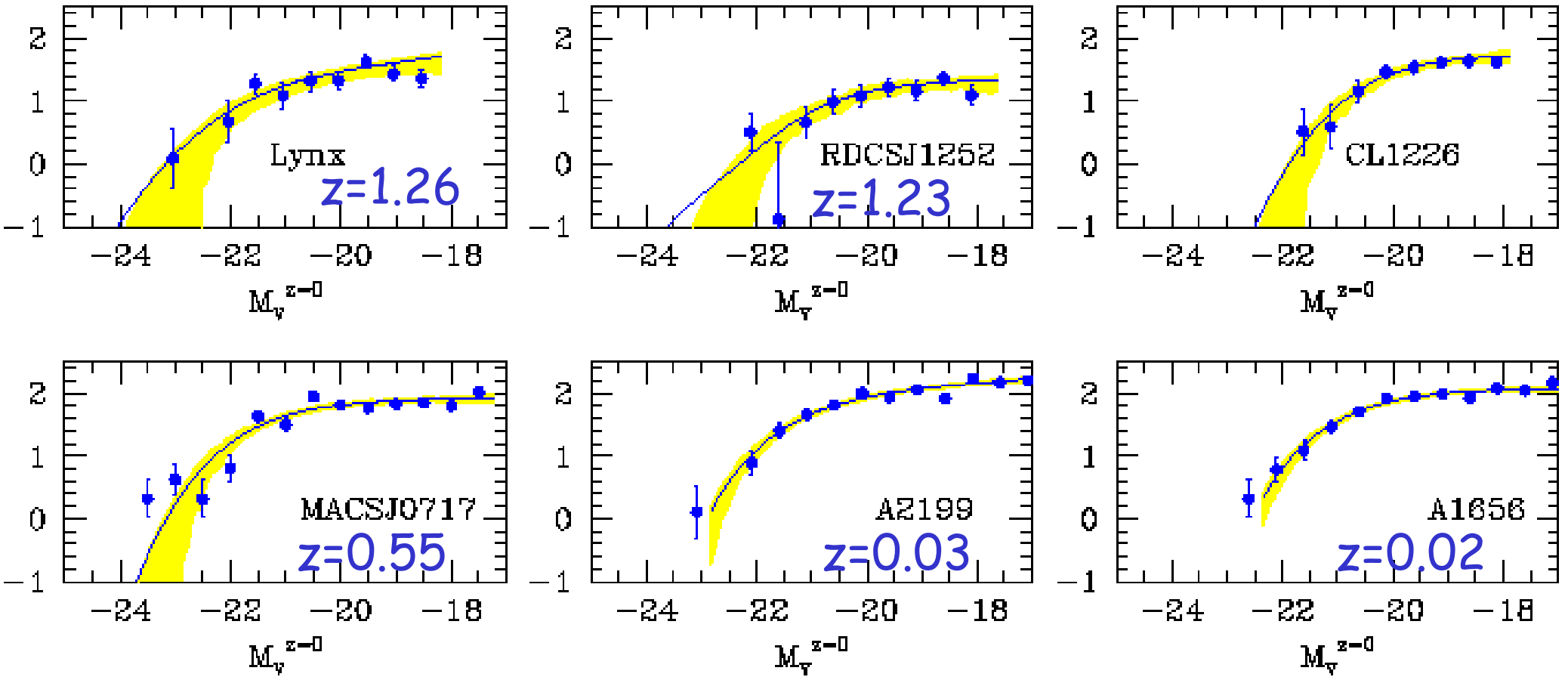
->Assembly time z>1, as for "all" galaxies.

SA, Puddu et al. 2007, MNRAS, submitted

An highly debated topic:
the build up of the red sequence.
Does faint red galaxies arrive on the red sequence at low (i.e. $z<0.8$) redshift, as claimed?

Some example LFs of red galaxies

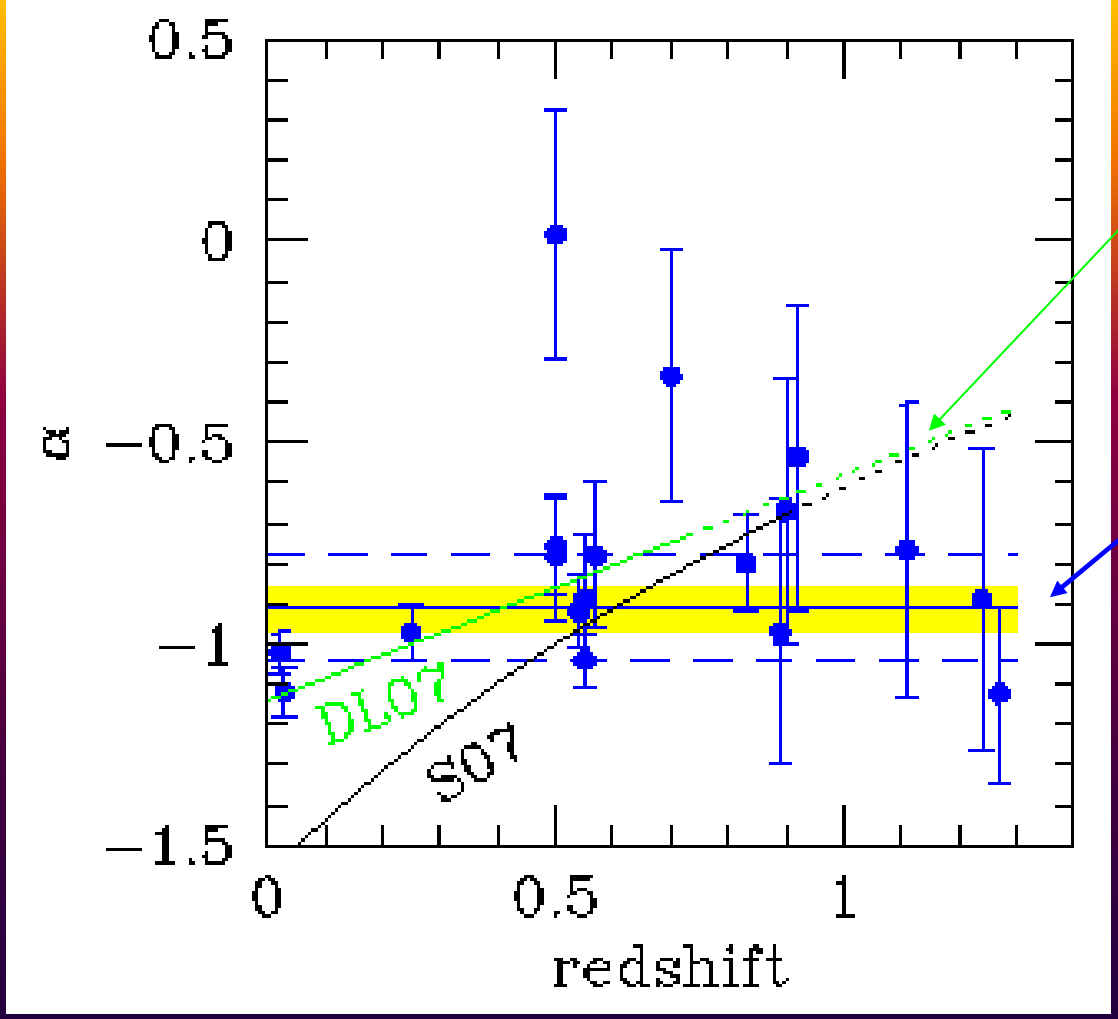
HST (hi-z) or SDSS (low-z) images uniformely sampling the 4000 A break.



studied 22 more clusters …

Many faint red galaxies

few



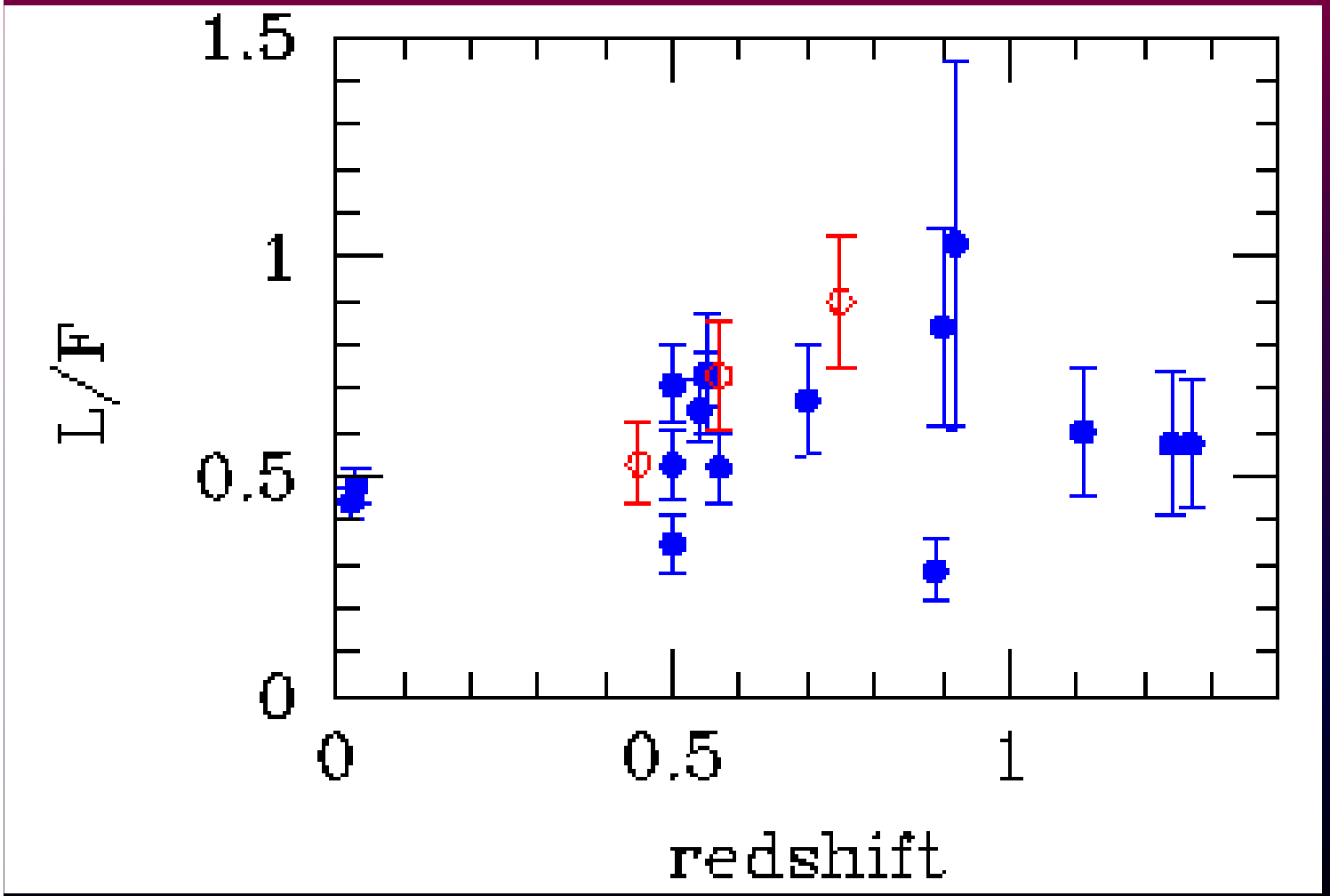
Previously suggested trends on small samples with heterogeneous data

28 clusters, uniform data (rest-frame sampling the 4000 A break), minimizing systematics and putting care in the statistical analysis

SA (2007, MNRAS, submitted).

The built-up of the red sequence occurred at z>>1.3 not at z<0.8, for galaxies as faint as 0.05 L*.

For those of you who don't trust a



Red: De Lucia et al. (2006)

Blue: 28 clusters in SA (2007)

Summary

all galaxies:

- ✓ the mass function does not evolves in 31 clusters/groups up to z=1.22. Upper limit to the mass growth: 5 % per Gyr^{-1}.
- ✓ Seen constant (Lin et al) or too few (myself) galaxies at hi-z from HON analysis -> minor role of mergers among bright galaxies.

red galaxies:

- ✓ No shift of the mass function is seen in 16 clusters up to z=1.02
- ✓ 28 clusters up to z=1.27 show constant relative aboundance of faint to bright galaxies. The red sequence is fully built up by z=1.3.

All lines addressed above, all consistently give the same answer:

Galaxies are fully assembled at z>>1.3 and un-evolving mass fit all observations, of bright, faint (0.05 L*), red or all galaxies, in clusters (mostly of low richness) or groups. No space is left for mergers, given the 5 % per Gyr^{-1} upper limit. The red sequence is fully in place at z=1.3, indistinguishable from present day red sequence.

Thank you