The role of environment and stellar mass in shaping galaxies

Trying to disentangle among processes which occurred early on the history of the Universe or late in the life of galaxies

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&
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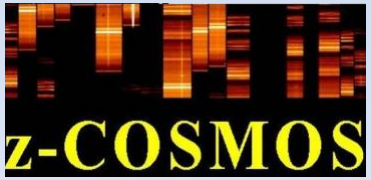
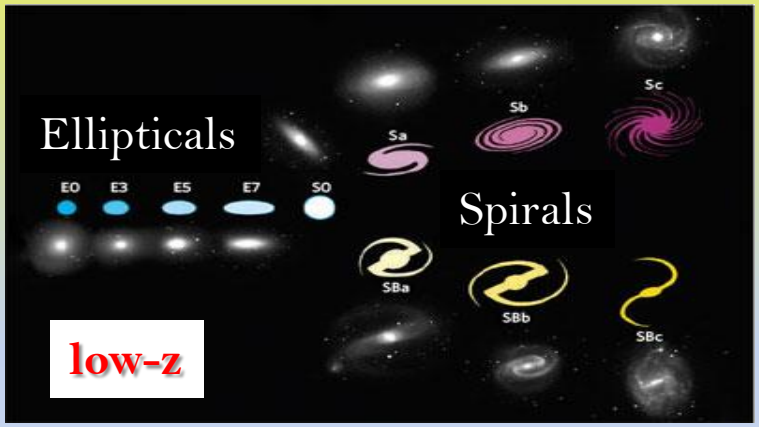


Kuala Lumpur

April 2nd, 2009

How the Hubble sequence took place?



- Which is the role of the environment?
- Which are the main physical mechanisms responsible?

A coherent scenario should be able to explain the morphological and physical properties observed in the local Universe.

Framework

Morphology - density relation:

At low-z the fraction of galaxies with early-type morphologies is higher in clusters than in less dense environments

Observations

Well studied in the local Universe

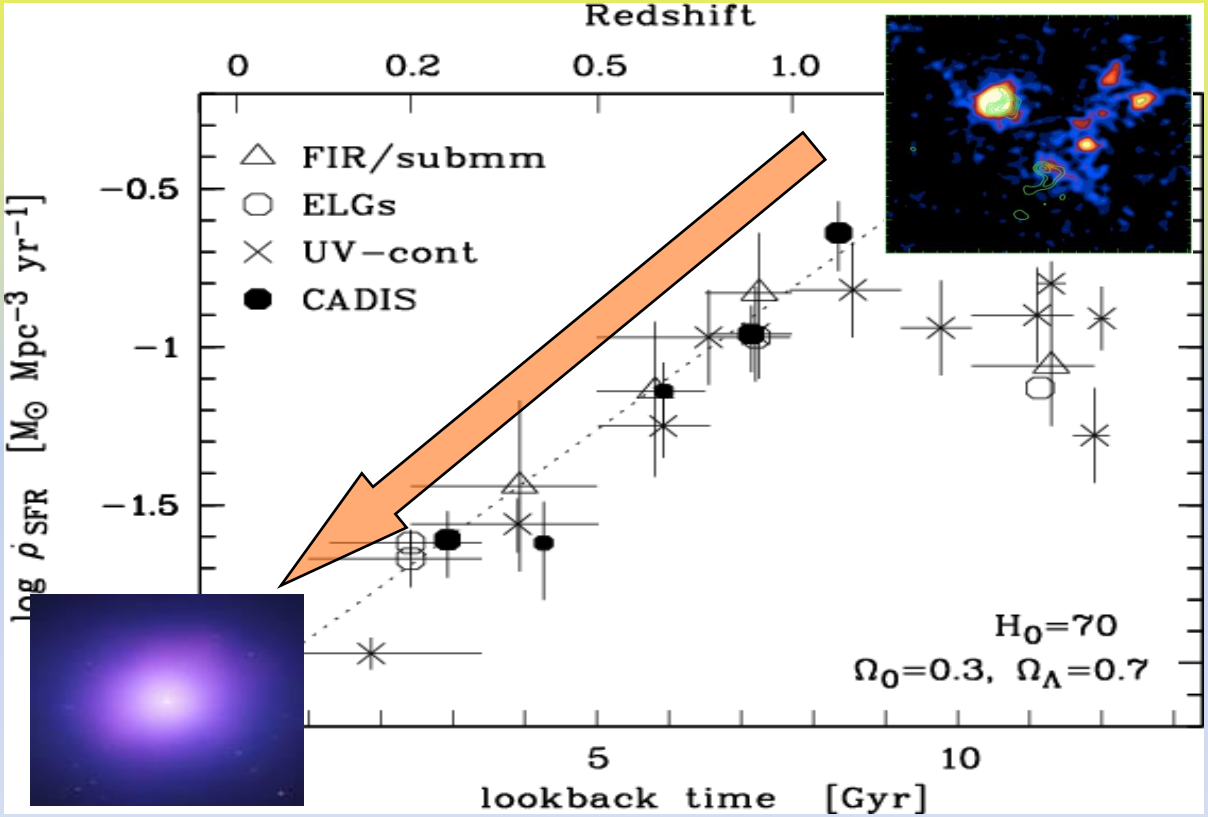
Various studies in clusters up to high-z

Attempts up to z=1 using projected number density

Theory

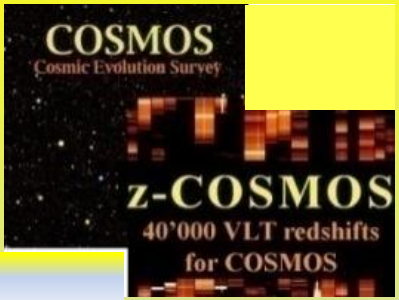
Galaxy segregation is a generic prediction of CDM simulation of LSS formation and semi-analytic galaxy formation models

Why does star formation stop?



Internal: gas consumption, "normal" aging, AGN/SN feedback

External: hierarchical build-up of structures inhibits star formation



zCOSMOS Redshift Survey

540 hours (guaranteed clear) awarded on VLT (VIMOS)

20,000 objects with $0.2 < z < 1.2$ "bright sample"

&

10,000 objects with $1.4 < z < 3$ "deep sample"

zCOSMOS-bright 10k current sample:

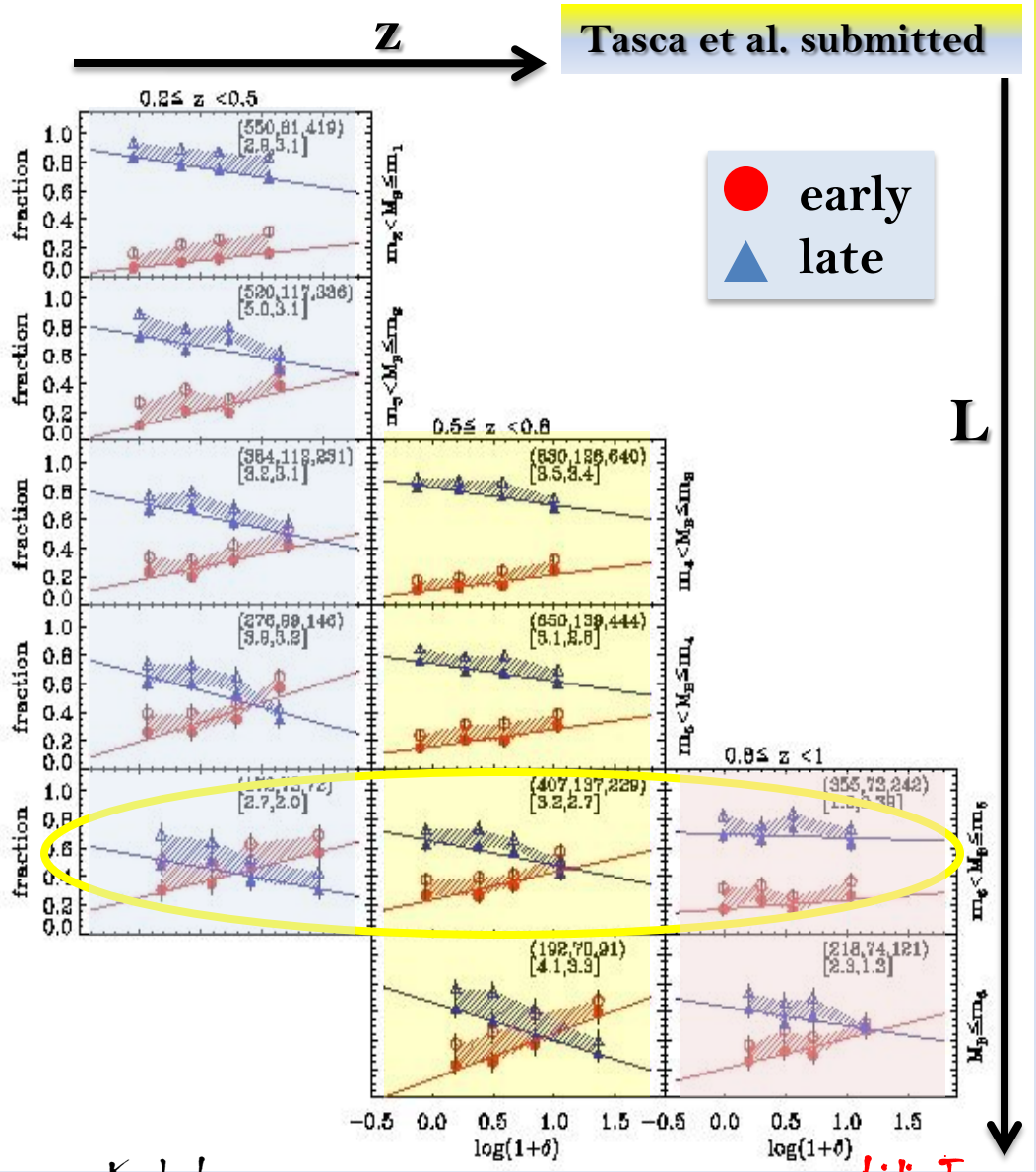
~ 10,000 galaxies, with spectroscopic z: $0 < z < 1.2$

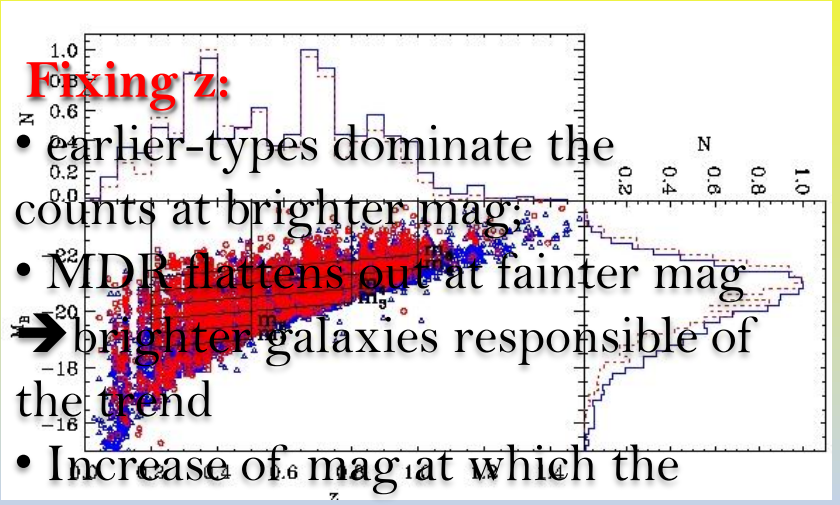
- 3D density field (Kovac et al.)
- Group catalogue (Knobel et al.)
- HST/ACS morphology (Tasca et al.)
- multi-wavelength photometry:
  galaxy luminosity (Zucca et al.; Oesch et al.)
  galaxy stellar mass (Bolzonella et al.)

Aims:

- study the evolution of the morphology-density relation up to z~1
- study the luminosity, mass and spectral properties dependence of the MDR
- study the impact of the environment on the evolution of galaxies

MDR in luminosity bins as f(z)





Fixing z:

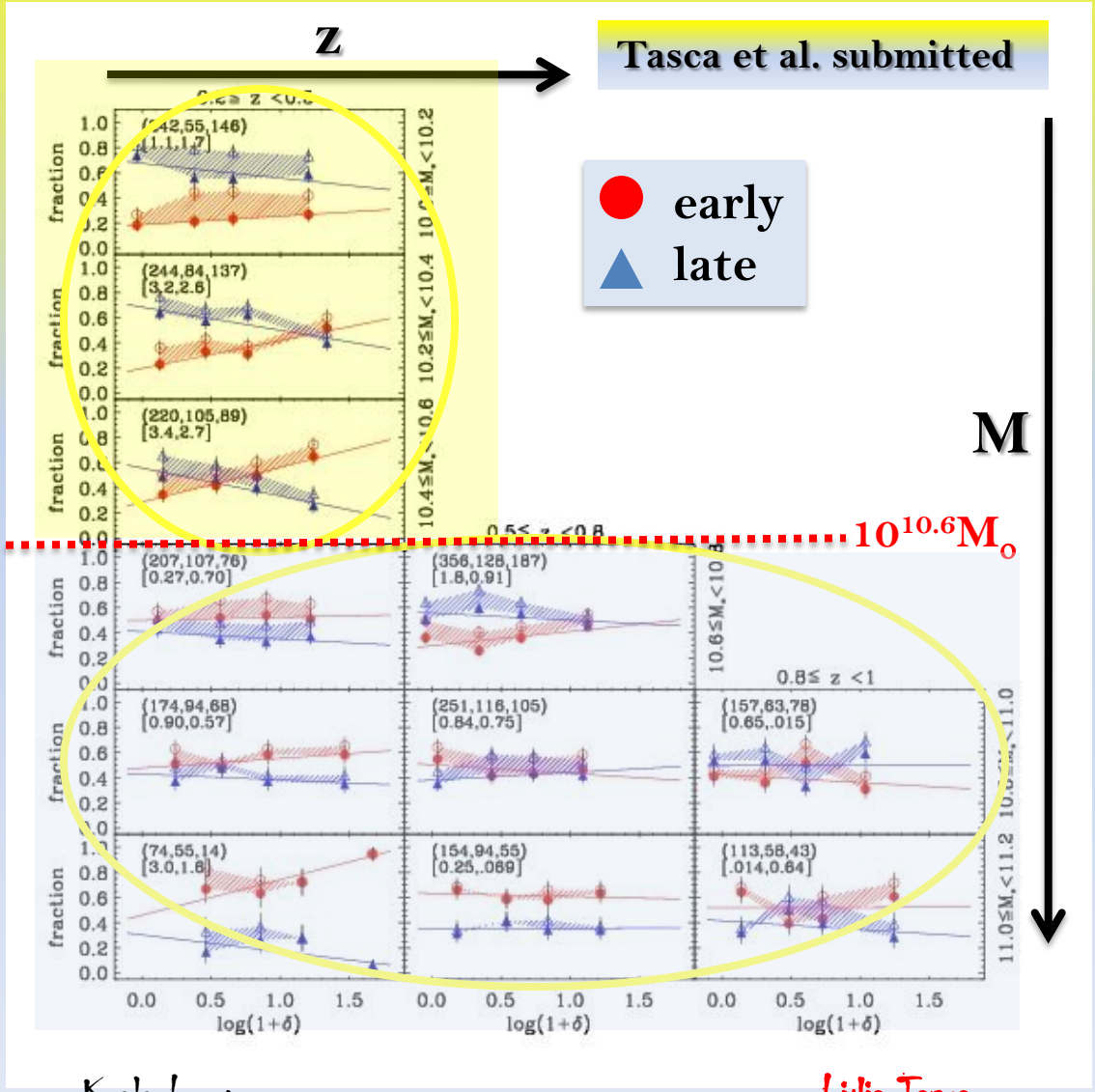
- earlier-types dominate the counts at brighter mag;
- MDR flattens out at fainter mag ➔ brighter galaxies responsible of the trend
- Increase of mag at which the MDR flattens

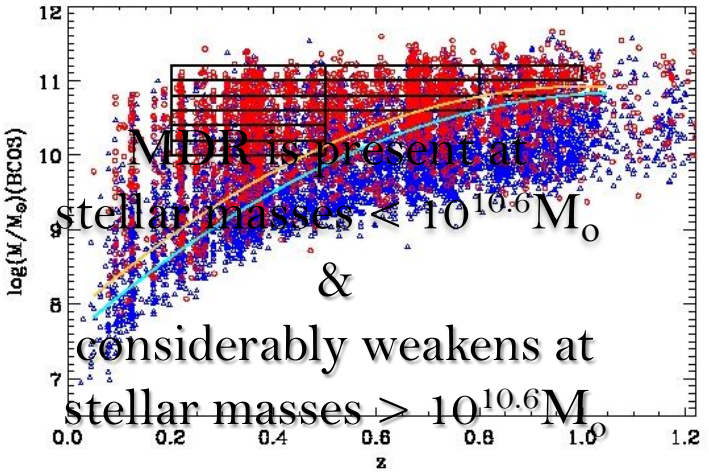
Fixing the magnitude:

- MDR at local z at expected;
- MDR less steep at intermediate z but still present;
- MDR getting flatter at high z

- Build up of early-types can be observed

MDR in mass bins as f(z)

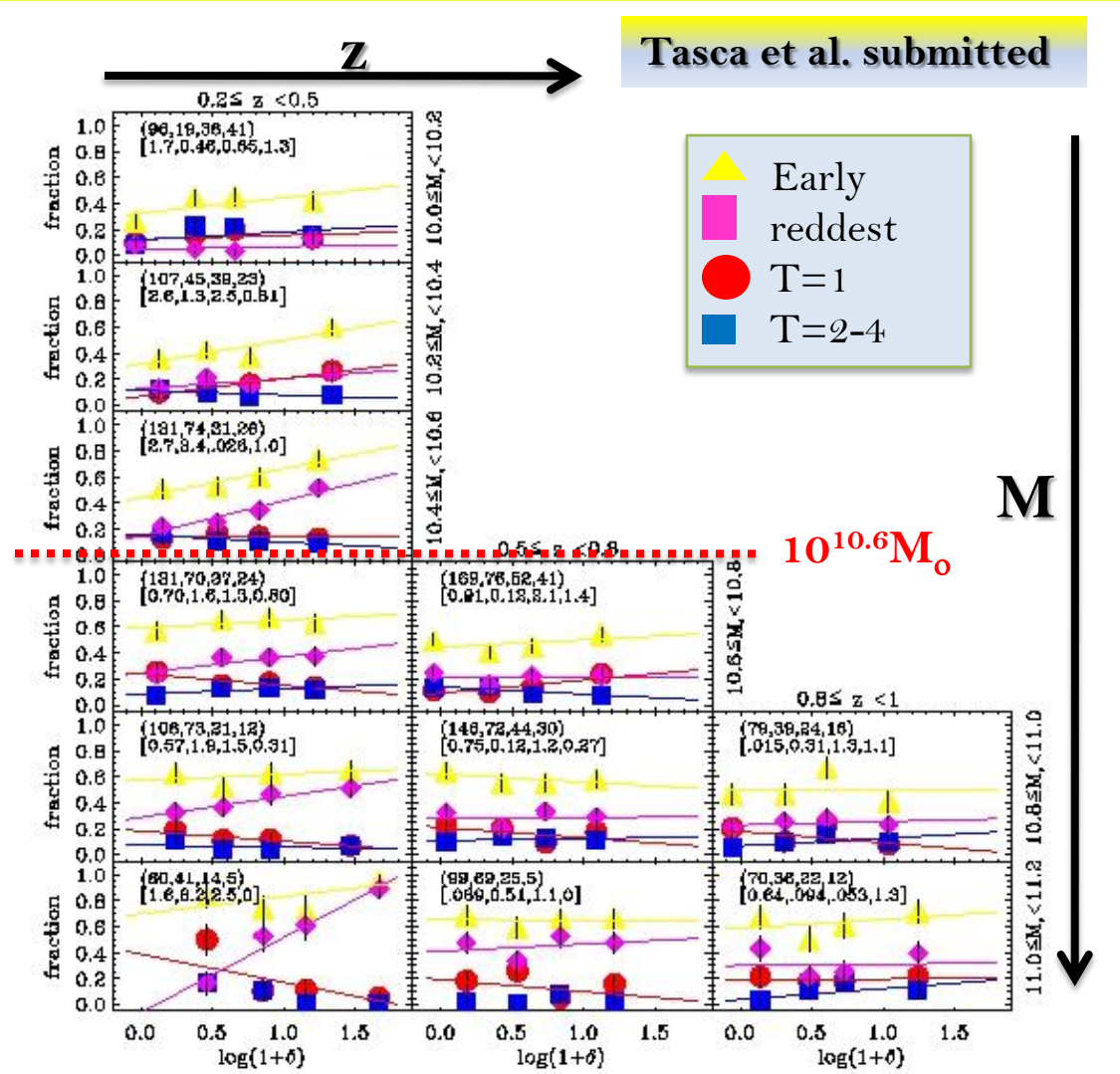


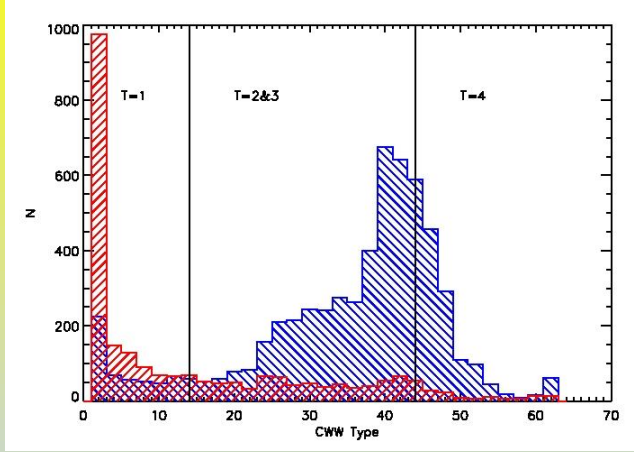


Existence of a critical mass?

Is stellar mass a more "fundamental" parameter than environment?

Spectral type of morpho Es as f(δ)

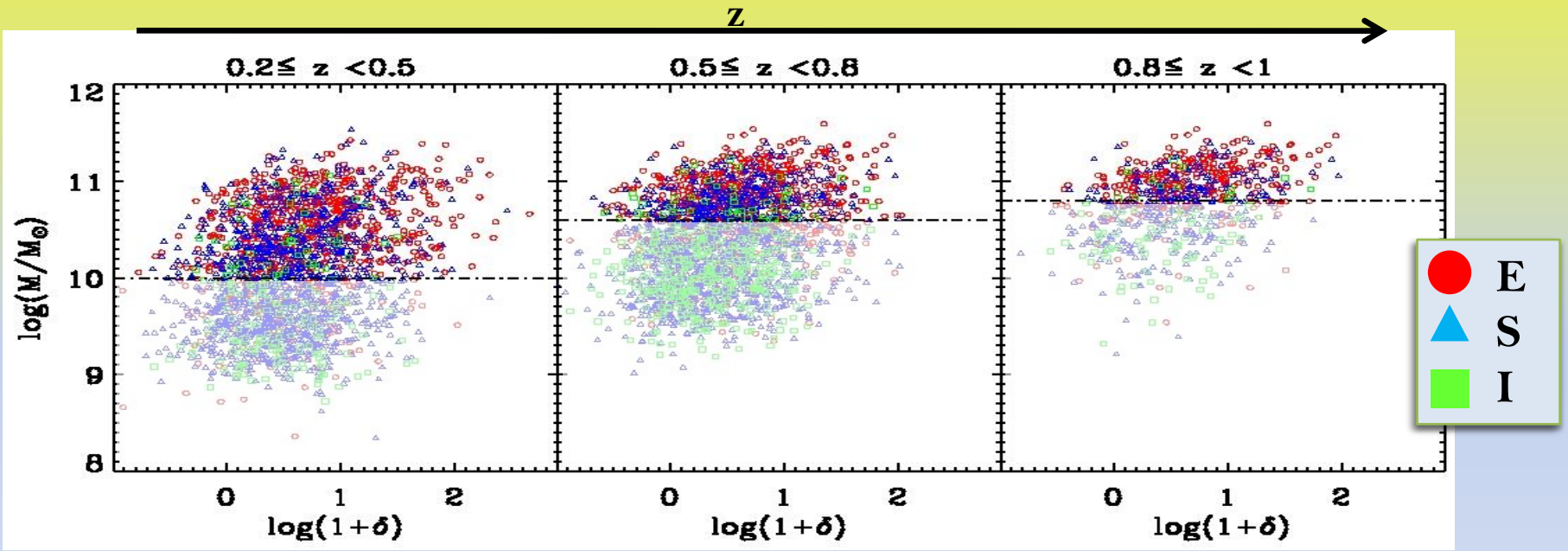




Morpho Es have a wide spread of spectral types

There is an environmental dependence for color beyond that for morphology

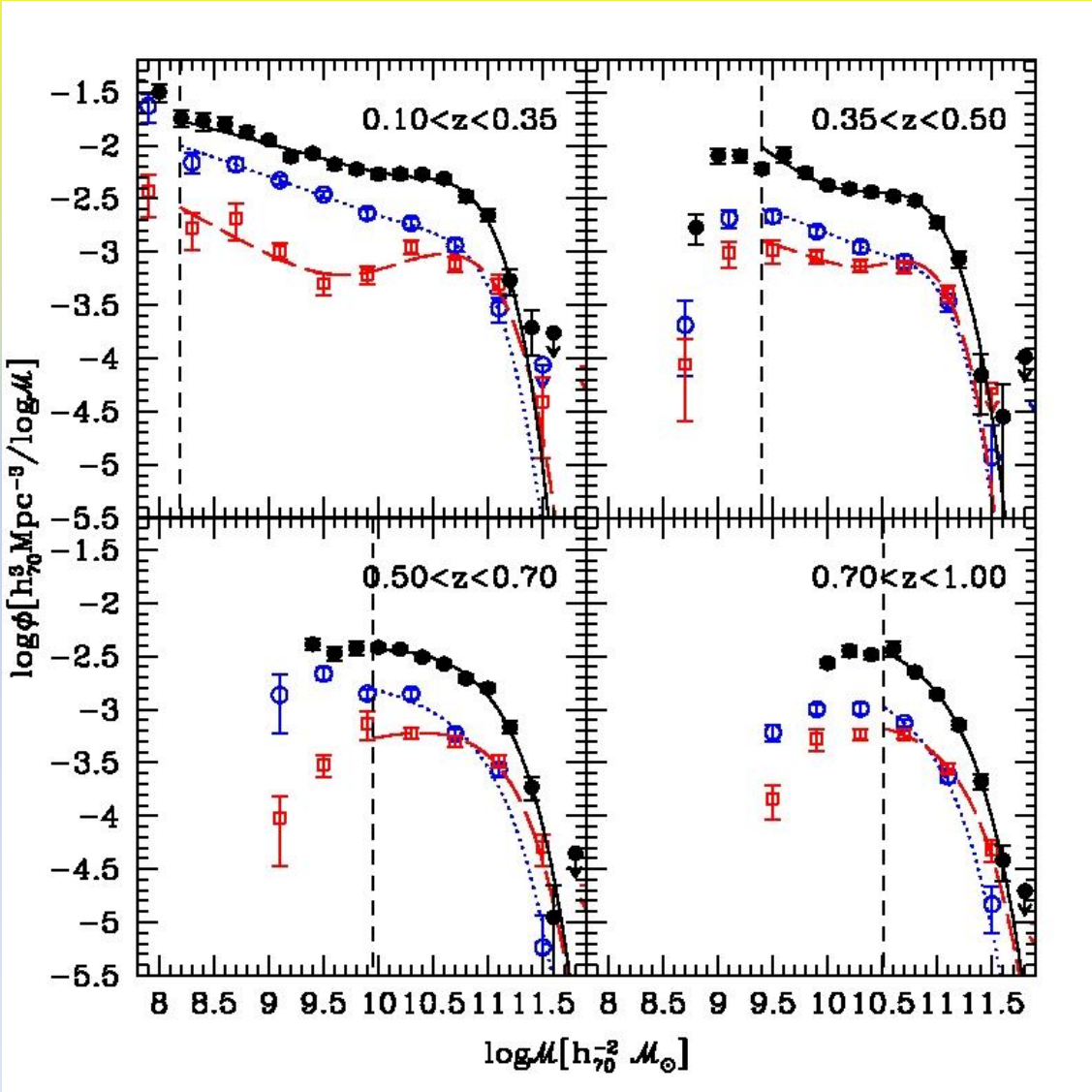
Luminosity vs mass selected



Standard view: bias in B-band magnitude volume limited sample against red, low mass galaxies, too faint to be included by the luminosity cut-off

⇨ The trends seen in luminosity volume limited samples are due to "selection effects"

Galaxy Stellar Mass Function as f(δ)



Global GSMF bimodality:
upturn of the lower mass end (Pozzetti et al.)

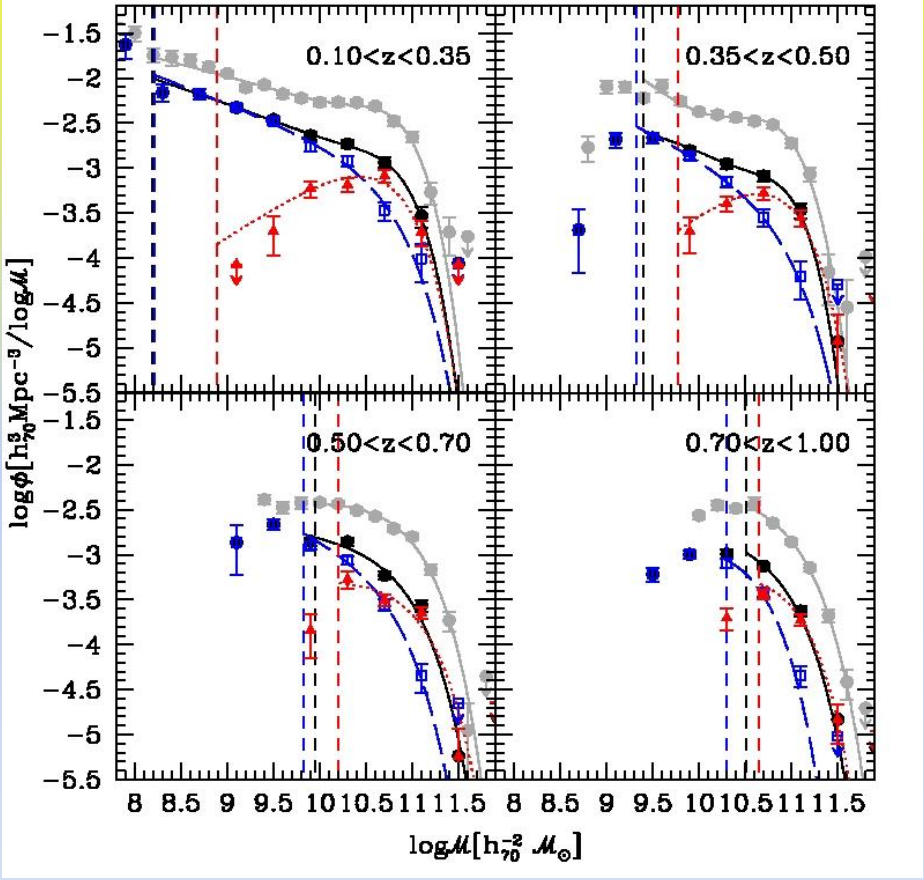
Stronger bimodality in high δ regions

GSMF depends on the environment:
more low mass galaxies are present in low δ environments

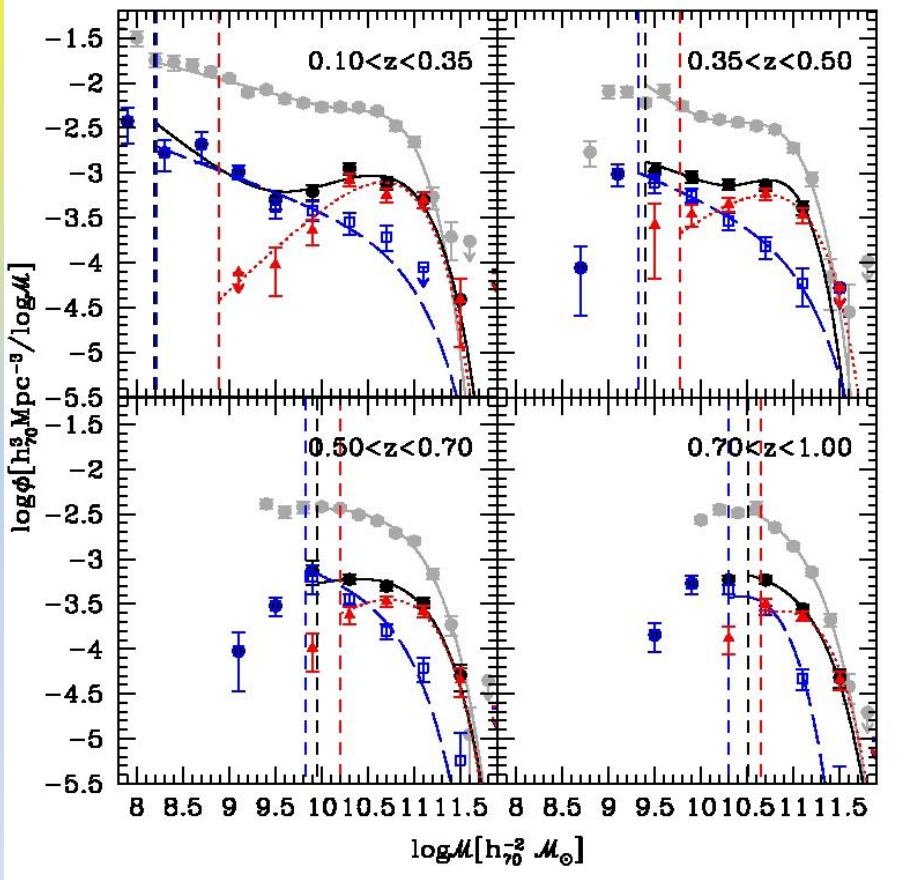
Bolzonella et al. to be submitted

Galaxy types contribution to the GSMF

low density environment



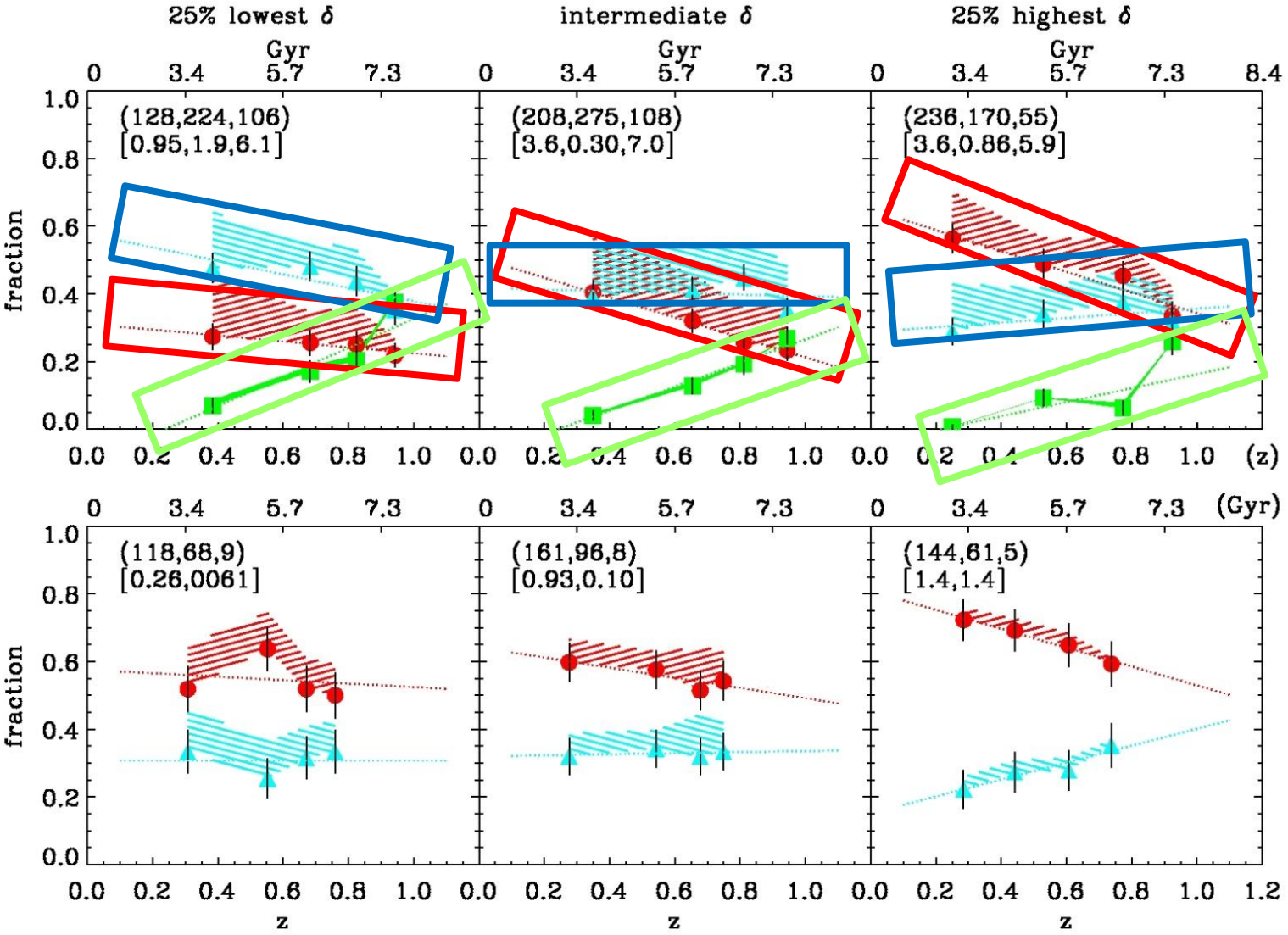
high density environment



Bolzonella et al. to be submitted

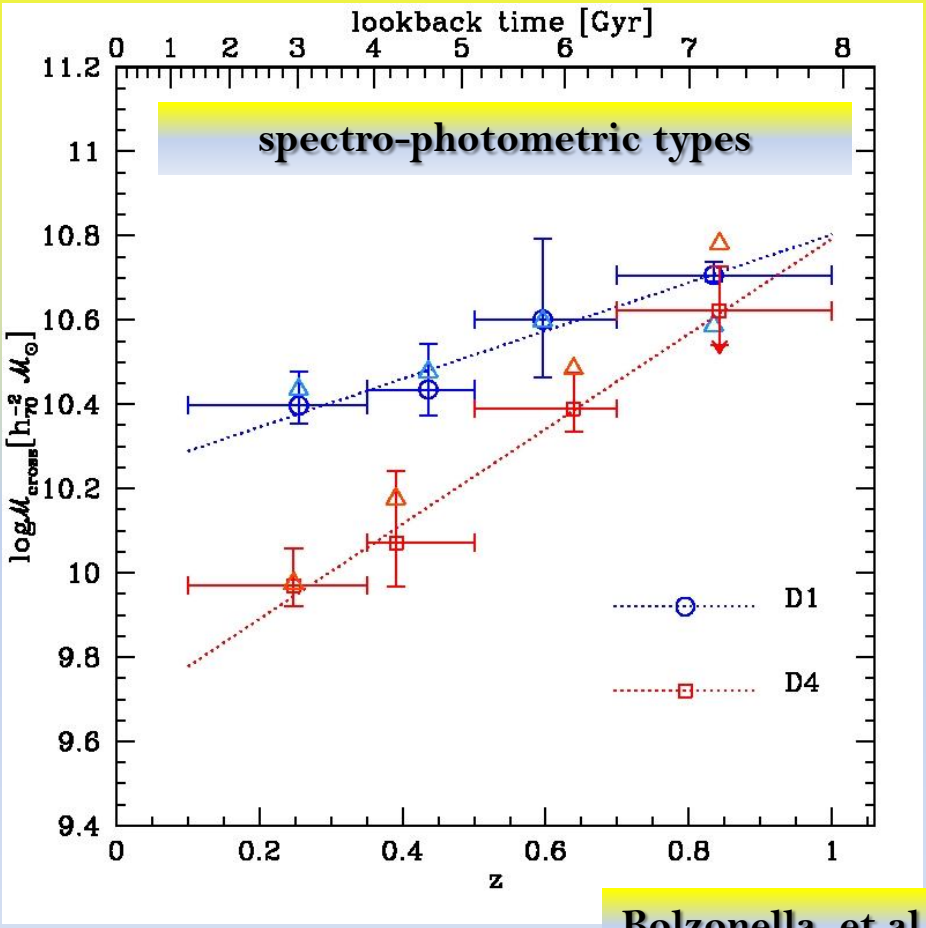
1. Earl-types dominate at high mass, their contribution decrease at intermediate mass
2. The typical GSMF of a specific class is not universal but depends on the environment

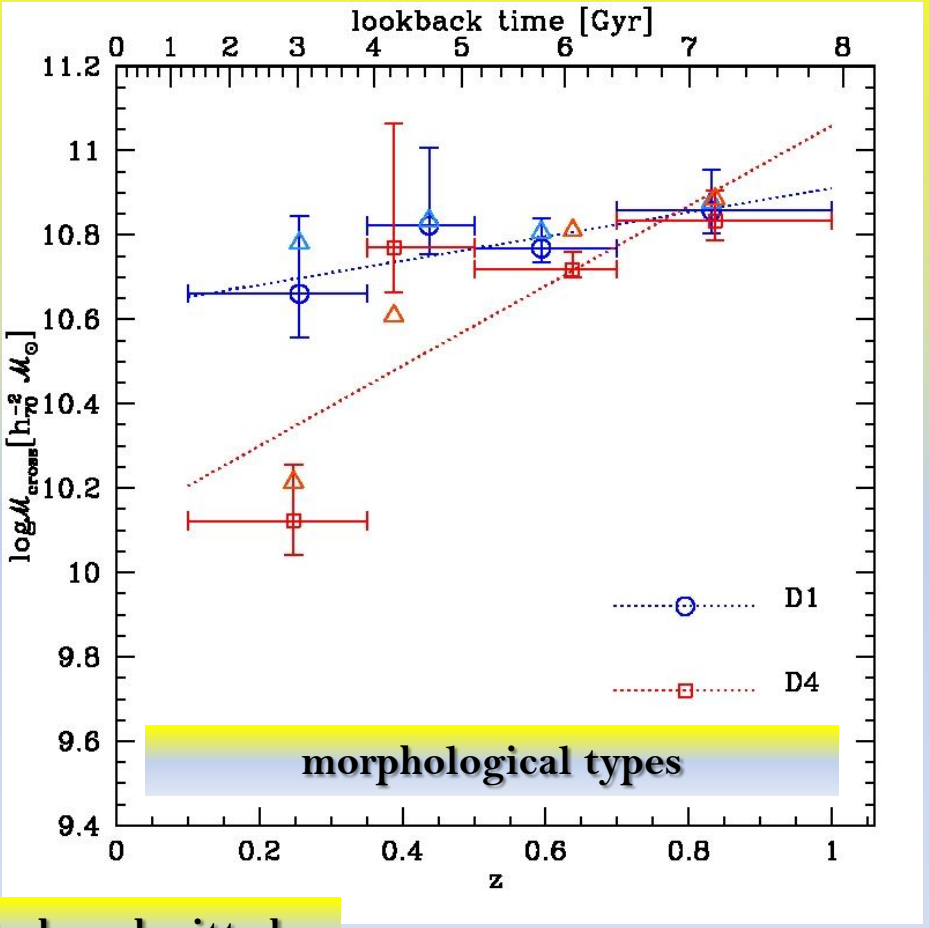
Evolution of the MDR as f(δ)



Timing in the evolution: M_{cross}

(M_{cross}= mass above which GSMF is dominated by early-type galaxies)



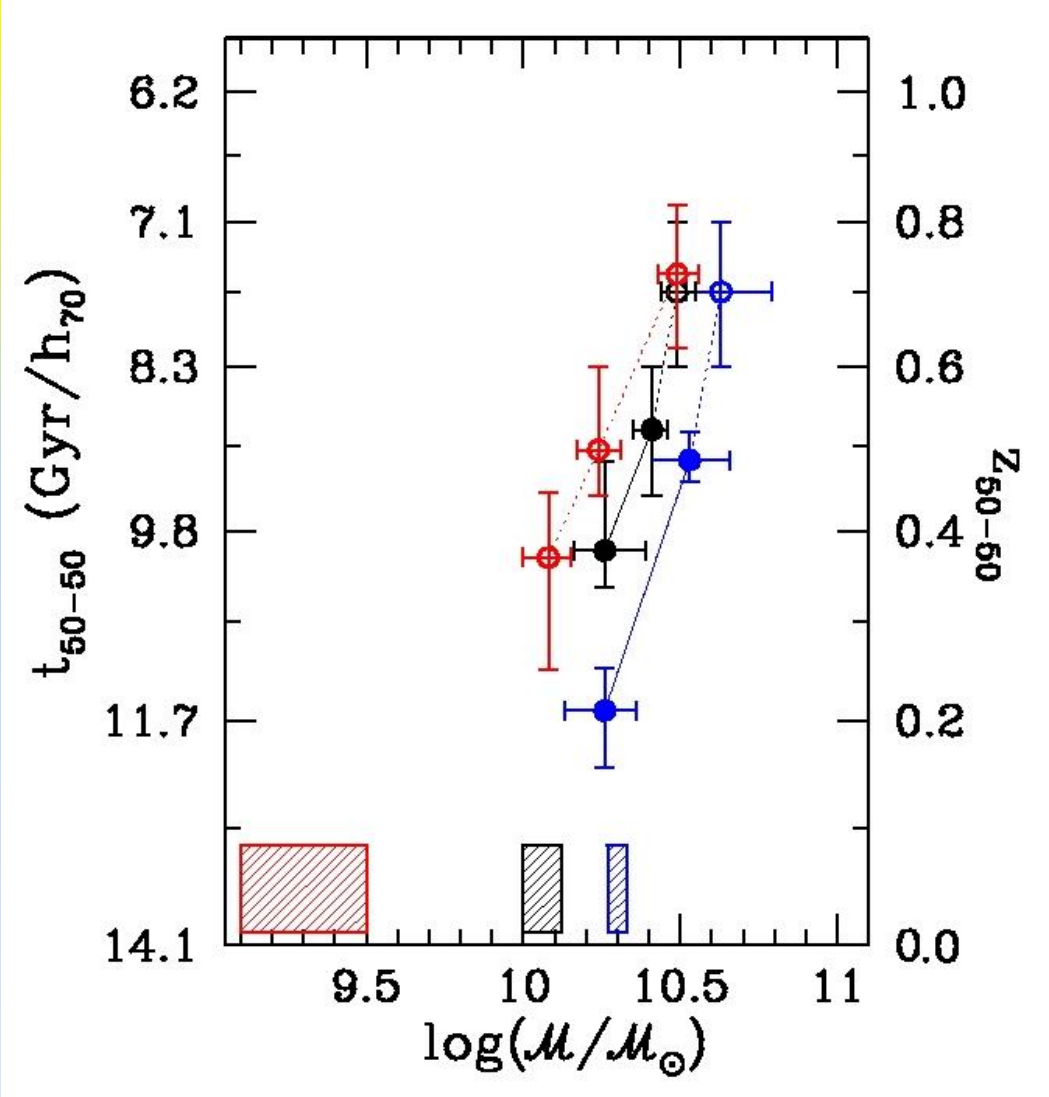


Bolzonella et al. to be submitted

1. The timescales for quenching of star formation and for morphological transformation depends on the environment
2. After z~0.5 the environment acts on the morphological transformation

What about galaxy groups?

(t_{50-50}= time when galaxies in the mass and environment bins considered were equally partitioned among red and blue colors)



1. signature of downsizing: as cosmic time goes by the mass at which galaxies are equally partitioned move progressively to lower values

2. signature of environmental effect: for each mass considered t_{50-50} is progressively delayed moving from groups to the field.

3. The modulation shows itself a downsizing behavior: galaxies in groups become red earlier

Iovino et al. to be submitted

Emerging scenario

- First signature of environmental influence on galaxy evolution at z~1
- As cosmic time passes star formation moves from higher to lower masses: intermediate mass blue galaxies are transformed in more massive red galaxies after quenching of SF, more efficiently in over-densities.
- In higher δ regions SF stops at increasingly early times:
  what seen in high δ happens ~2Gyr later in low δ.
- Morphological transformation is then delayed of ~2Gyr

Emerging picture consistent with a downsizing scenario modulated by environment

Summary

Looking at the morphology-density relation:

- Morphological segregation is in place up to intermediate z and flattens at high-z;
- At $M>10^{10.6}$ M_o galaxies of specific morphological types do not show environmental dependencies;
- There is a residual environmental dependence for color beyond that for morphology.

Looking at morphological evolution in different environment:

- Environmental dependence of the evolution of different morphological types;
- Early-type galaxies build up more rapidly in dense than sparse regions;
- Very massive galaxies ($M>10^{10.8}$ M_o) stopped their evolution at least at $z=1$;
- At $z<1$ evolution moved to low mass galaxies → downsizing scenario .

NATURE + NURTURE scenario