# Groups vs. isolated galaxies: exploring the factors that shape galaxy evolution

**Environment matters!**

A. Iovino,
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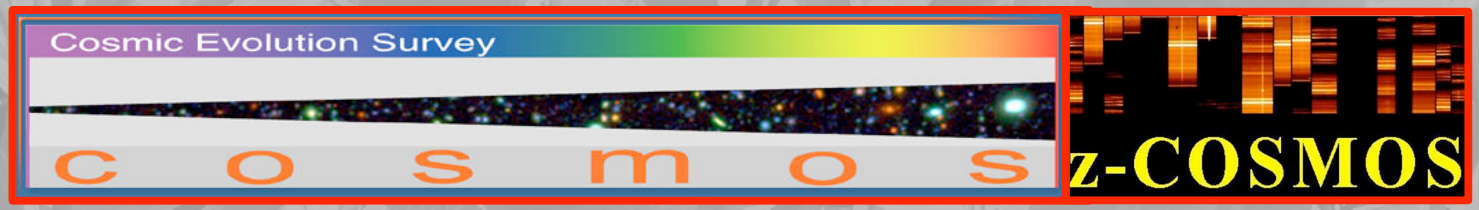
& ZCOSMOS team

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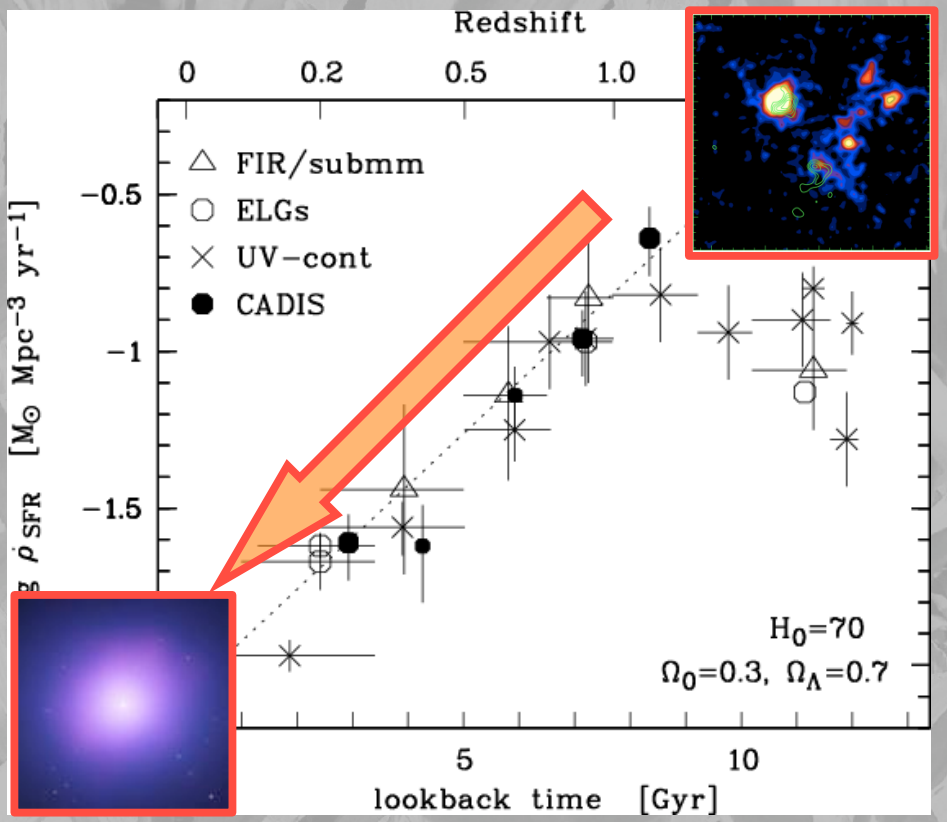
# Context of our analysis

## 1 - Why Does Star Formation Stop?




## 2 - Why red and dead are found preferentially in denser environments ?

Hippelein et al. 2003

- **Internal?** Gas consumption, "normal" aging, AGN/SN feedbacks
- **External?** Specific mechanisms taking place in denser structures inhibit star formation

In over-dense environments dark matter halos assembled their mass more rapidly and at higher redshifts than halos of the same mass in low density environments

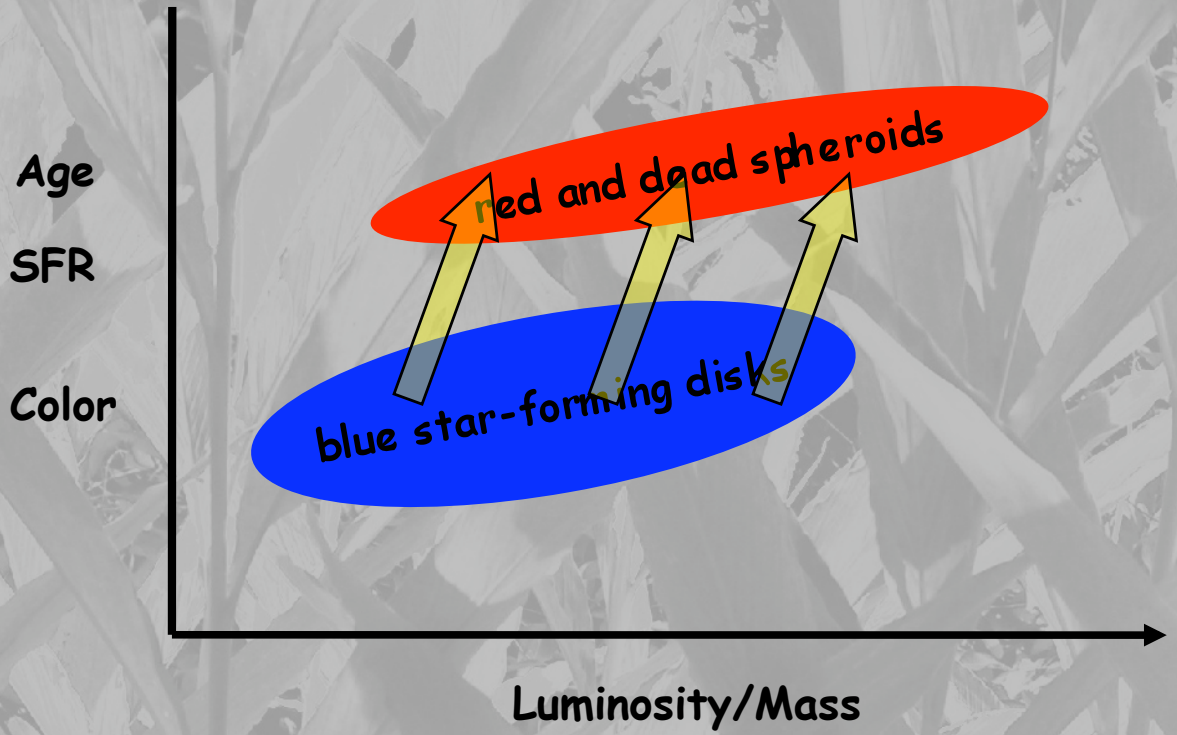
**NATURE**

and/or

Local interactions between galaxies and their environment are responsible for what we see

**NURTURE**

## Galaxies follow a strong bi-modal distribution for many of their properties …




**How does Fb vary with cosmic time ?**

Galaxy (U-B) rest-frame color is a simple indicator of the age of the stellar population.

We used a classical diagnostic tool:

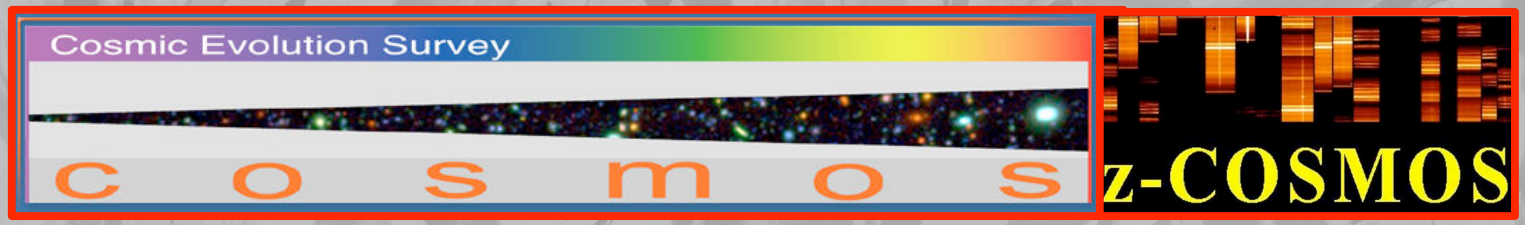
**Fb** = fraction of blue galaxies, i.e. at (U-B) <= 1, over total.

# Our Questions

How **Fb** changes as a function of

- galaxy properties (luminosity&mass) ?
- galaxy environment ?
- cosmic time ?

# Ingredients of our analysis



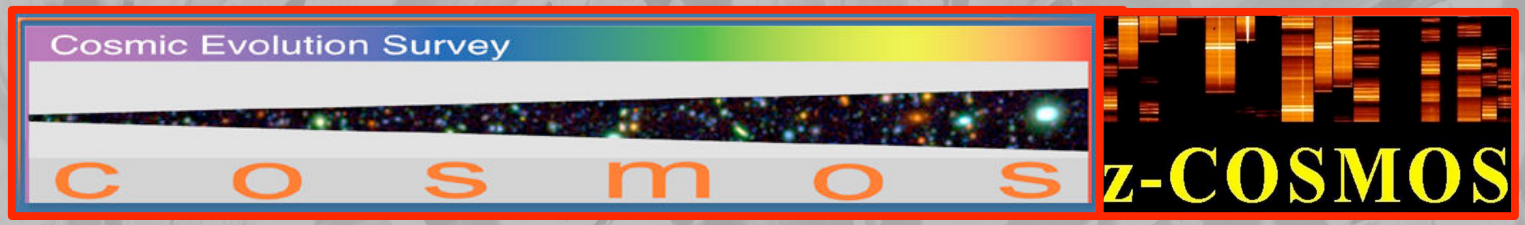

Large redshift survey using 600hr of VLT+VIMOS

zCOSMOS-bright: approx 20.000 galaxies purely flux selected down to $I_{AB}$ = 22.5 to cover the 1.7 sq deg

Institutes involved: Zurich (P.I. S. Lilly), Bologna, Marseille, Milano, Munich, Toulouse.

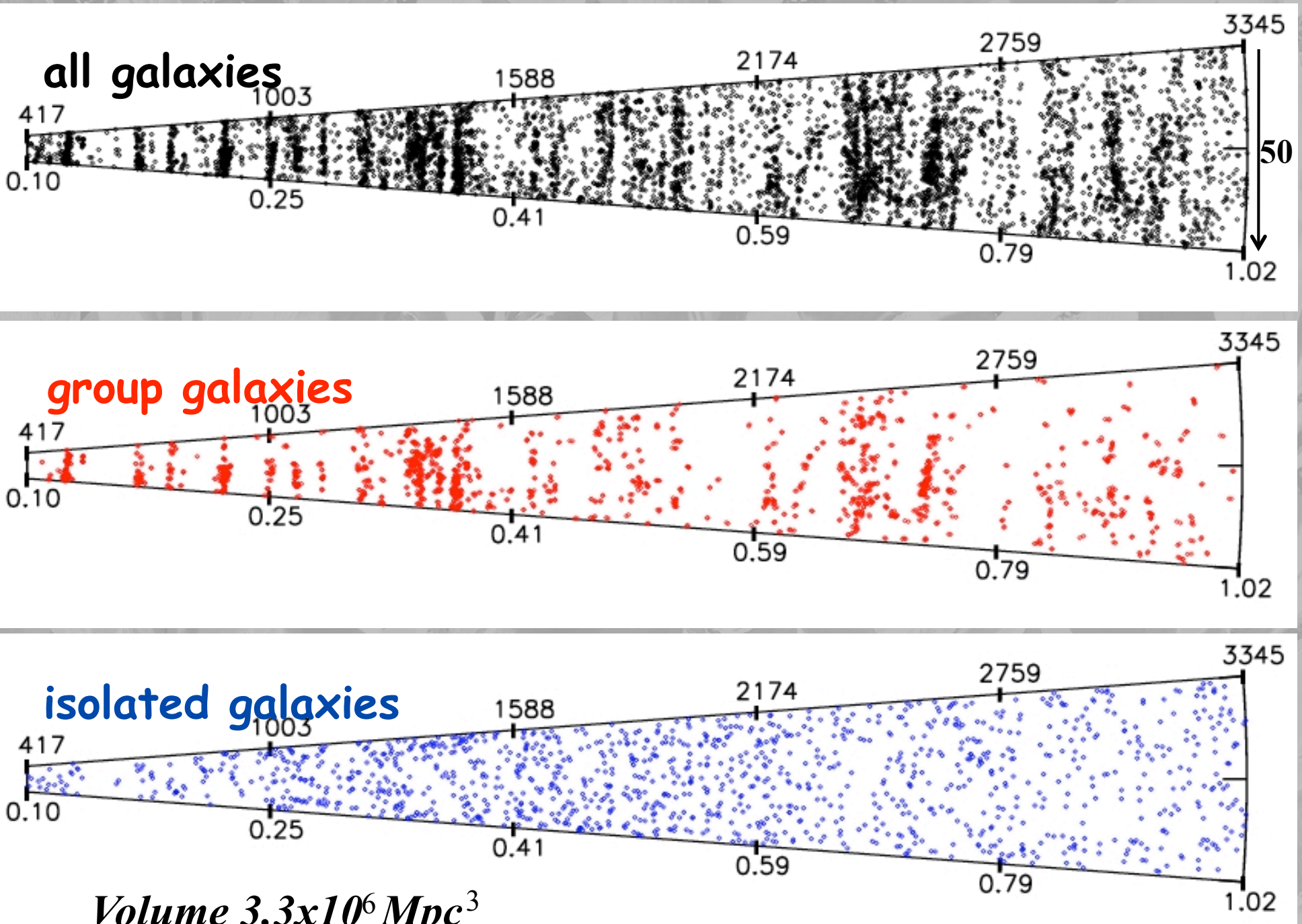
(see Lilly et al, 2007, **ApJ**, Lilly et al., 2009,for survey details)

# Ingredients of our analysis



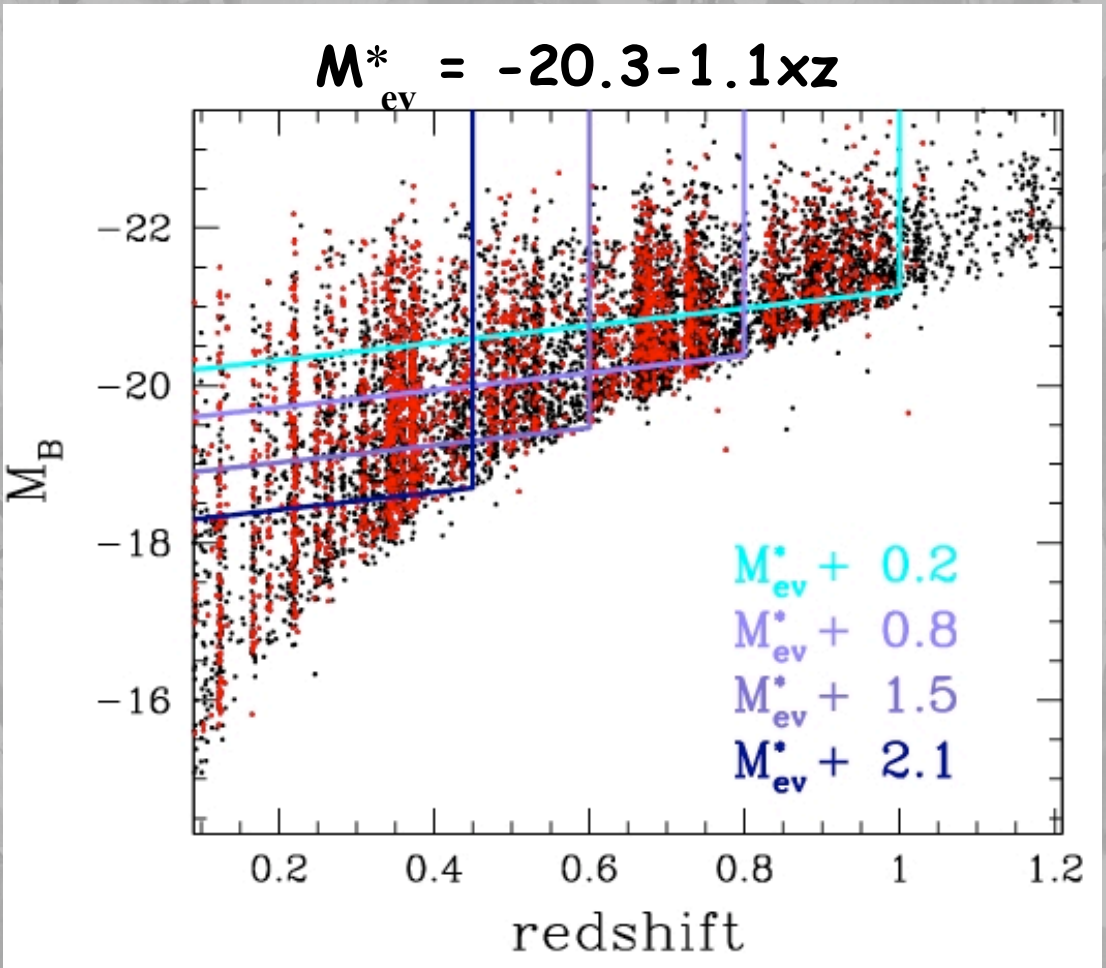

Galaxy group catalogue from the 10K sample (**Knobel, et al., 2009**) and isolated galaxies sample.

Galaxy luminosities and masses from SED fitting of the large available database of photometric data (**Oesch et al. in prep., and Bolzonella et al., 2009**).


all galaxies
group galaxies
isolated galaxies
417
1003
1588
2174
2759
3345
0.10
0.25
0.41
0.59
0.79
1.02
50
Volume 3.3x10^6 Mpc^3

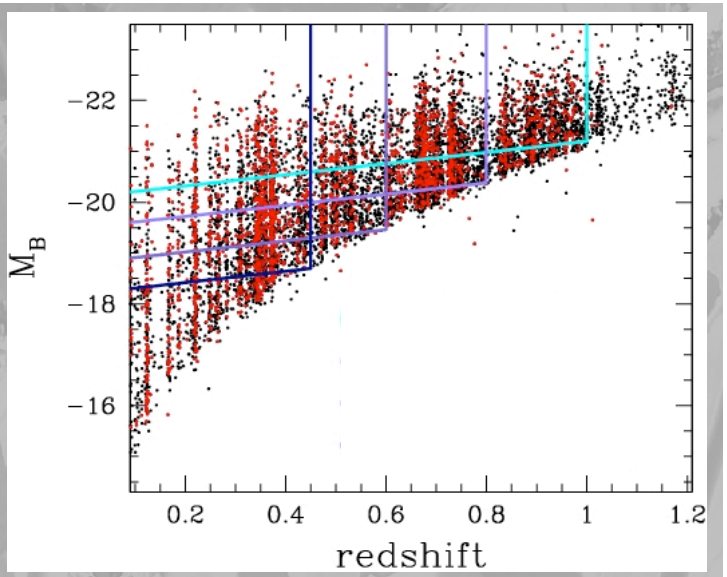
# Ingredients of our analysis

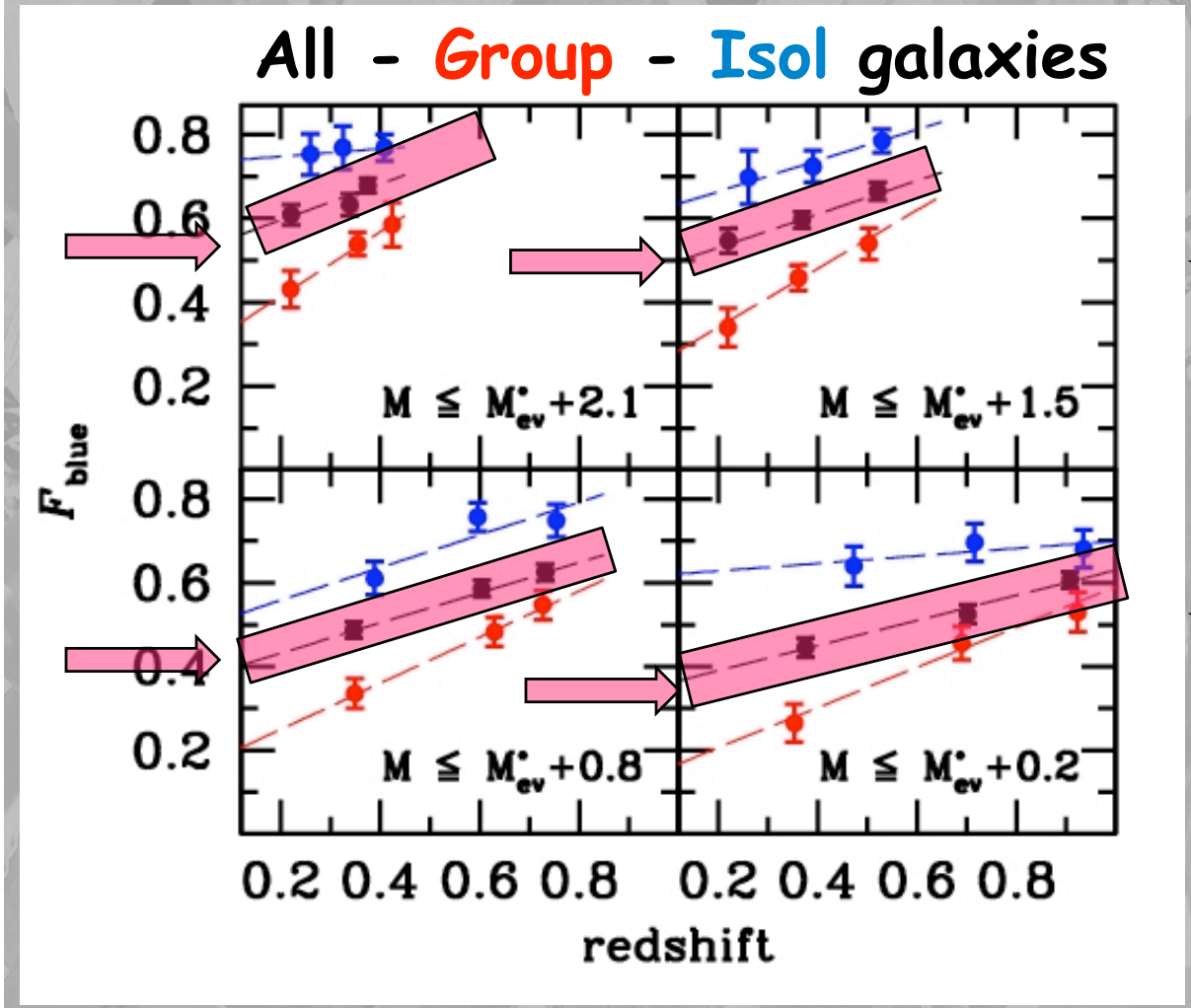
We selected four volume limited samples to probe an **homogeneous** population of galaxies at different redshifts:




In each volume limited sample we considered *only* groups with 2 or more members brighter than $M_B$ cut-off …

# Results



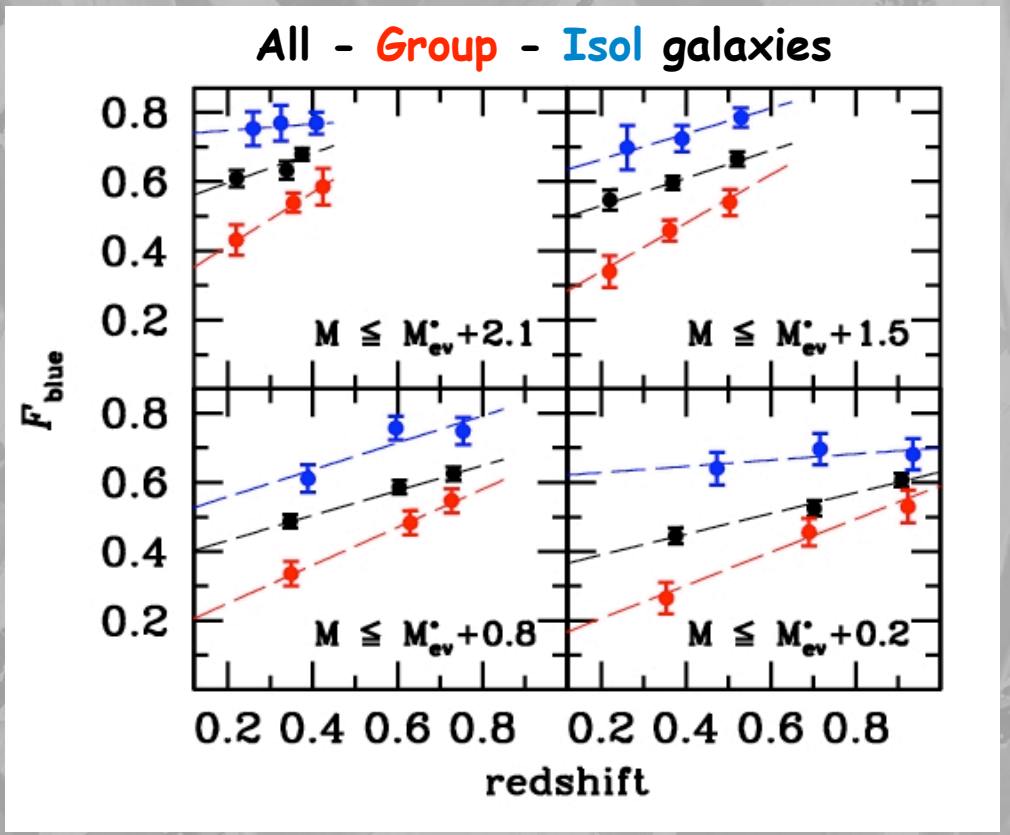

★ Up to z~1 and at all magnitudes galaxy colors depend quite strongly on environment

★ Galaxy colors become redder going to brighter magnitudes irrespective of environment

# Results

➡ Lines have different slopes in different environments

Which are the mechanisms responsible for these different environmental trends ?




**Faster quenching of star formation in dense environments** ⟺ **Delayed replenishing of blue cloud in lower density environments**

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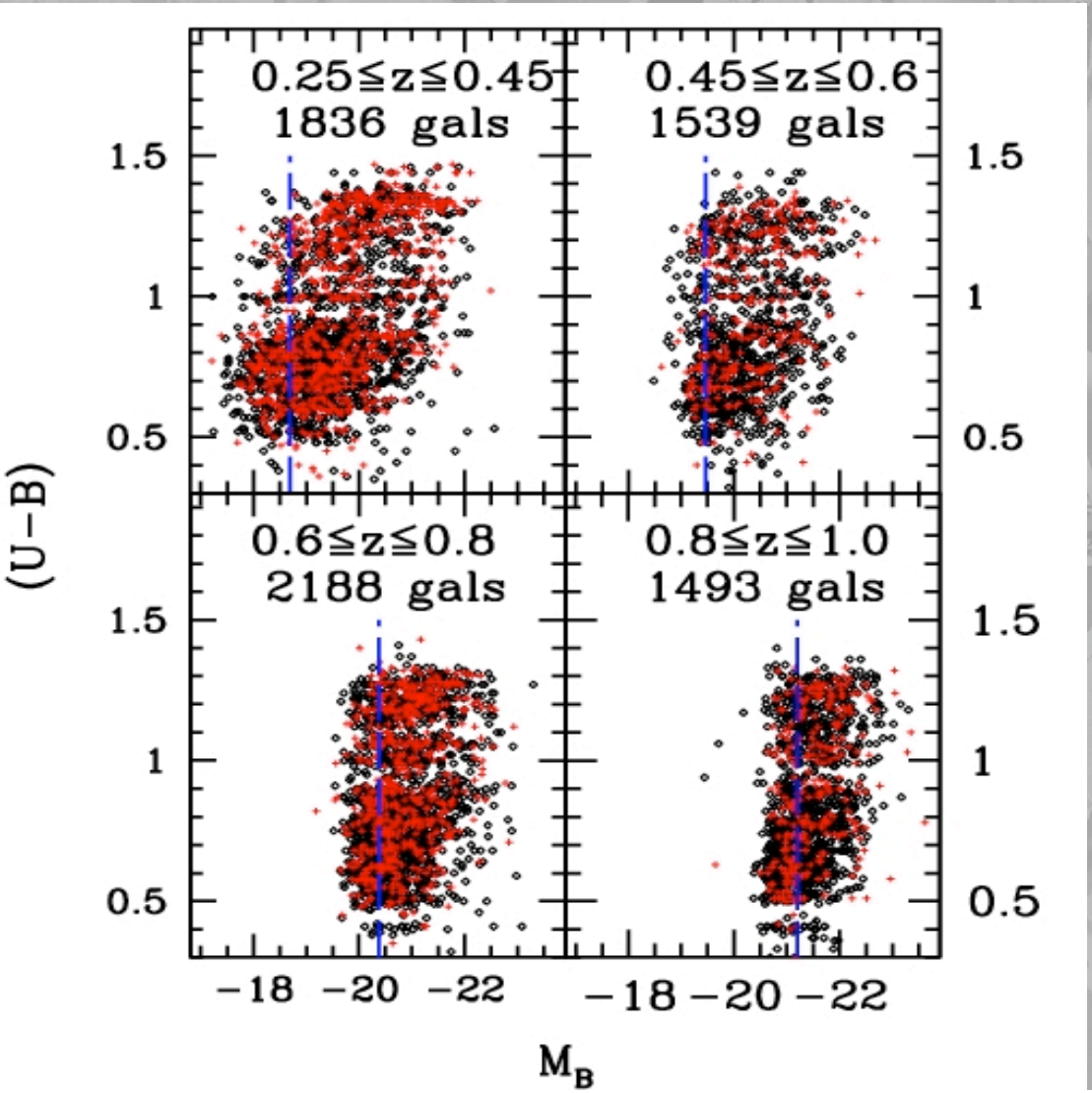
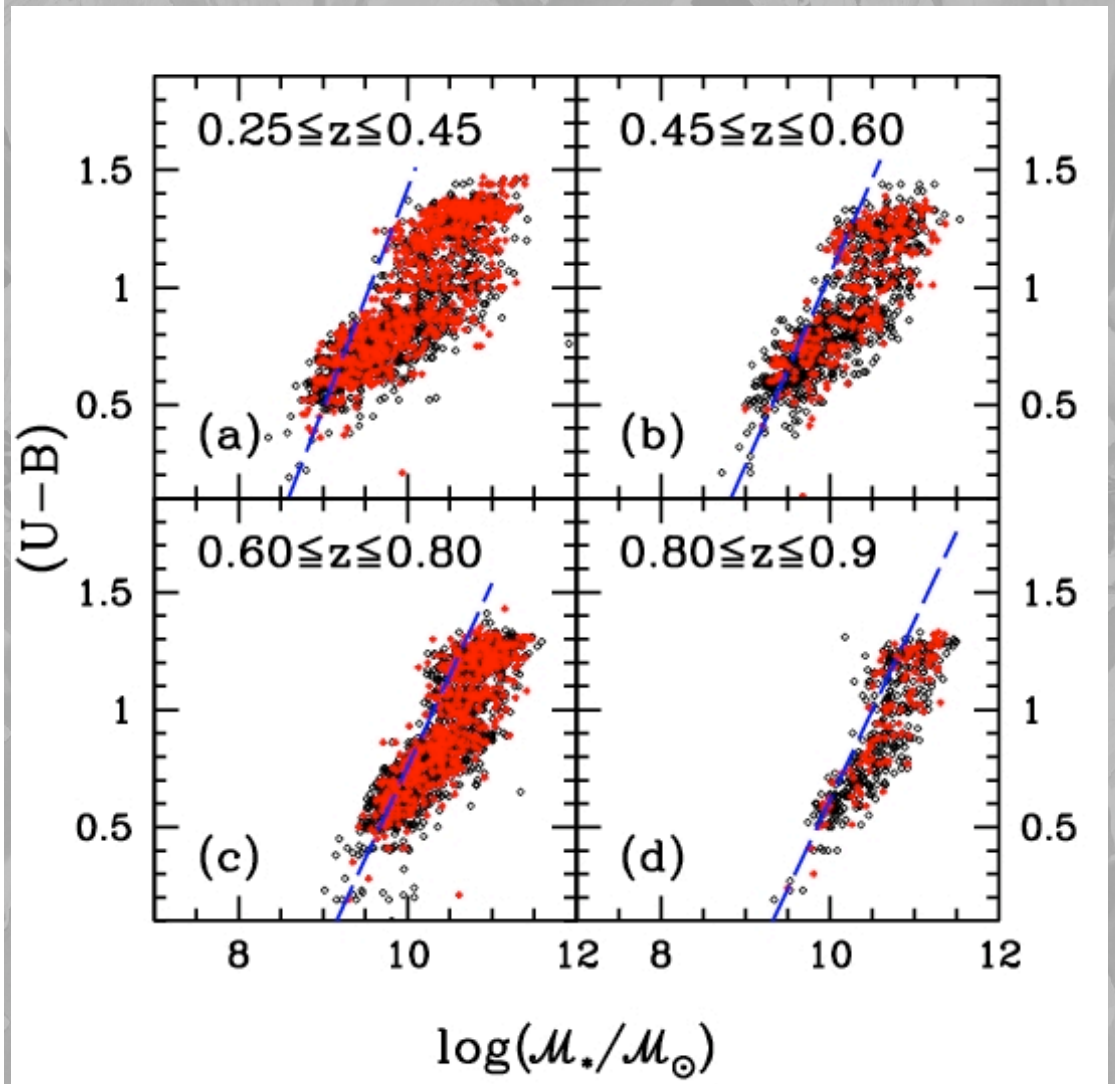
# Need to enter galaxy mass information

What happens of the strong trends observed in luminosity selected samples when moving to mass selected samples?



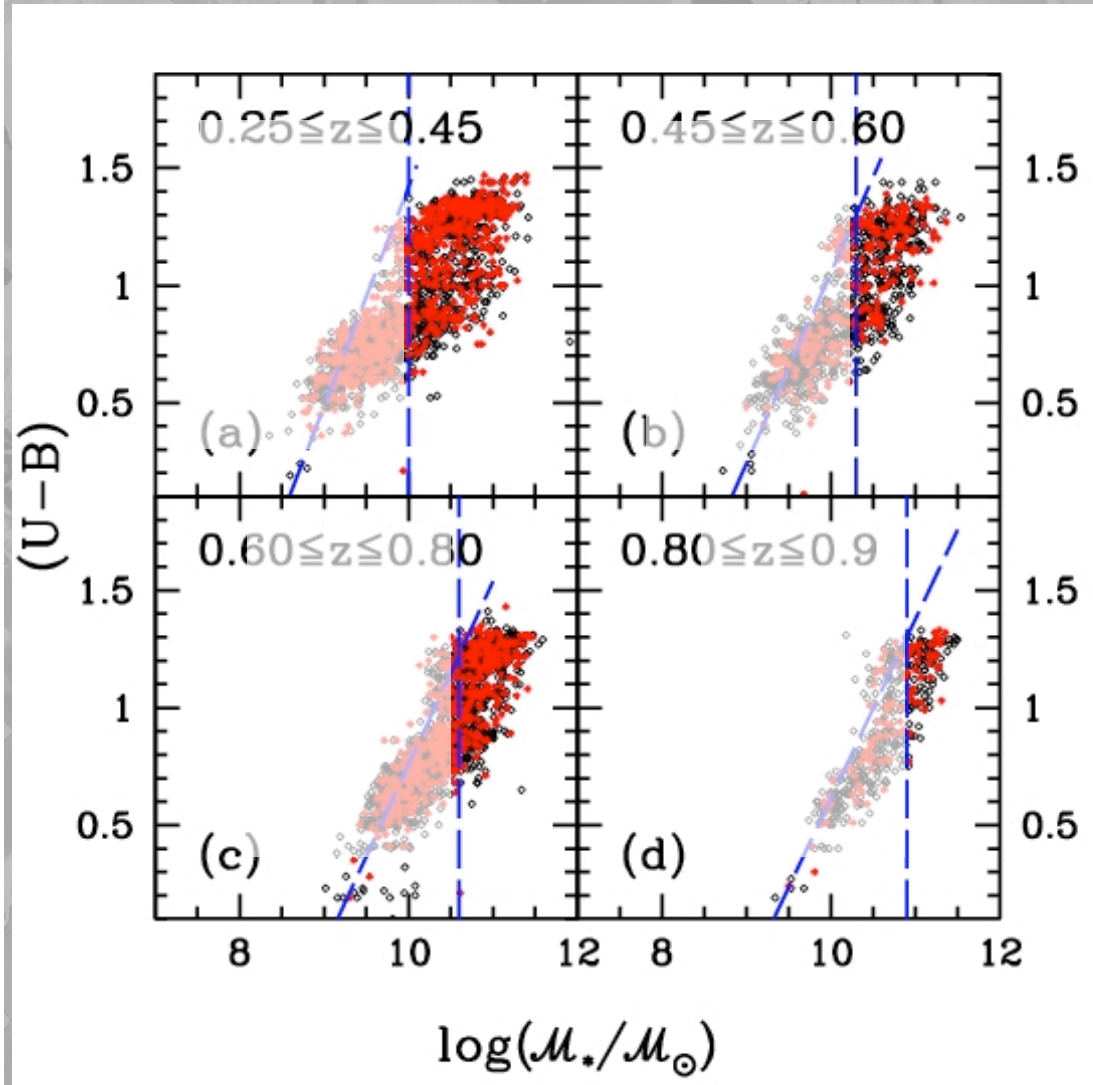

The B-band volume limited sample does not shows color dependent selection biases.

# Enter galaxy mass information




But moving to color-mass space there is a strong selection bias in color!

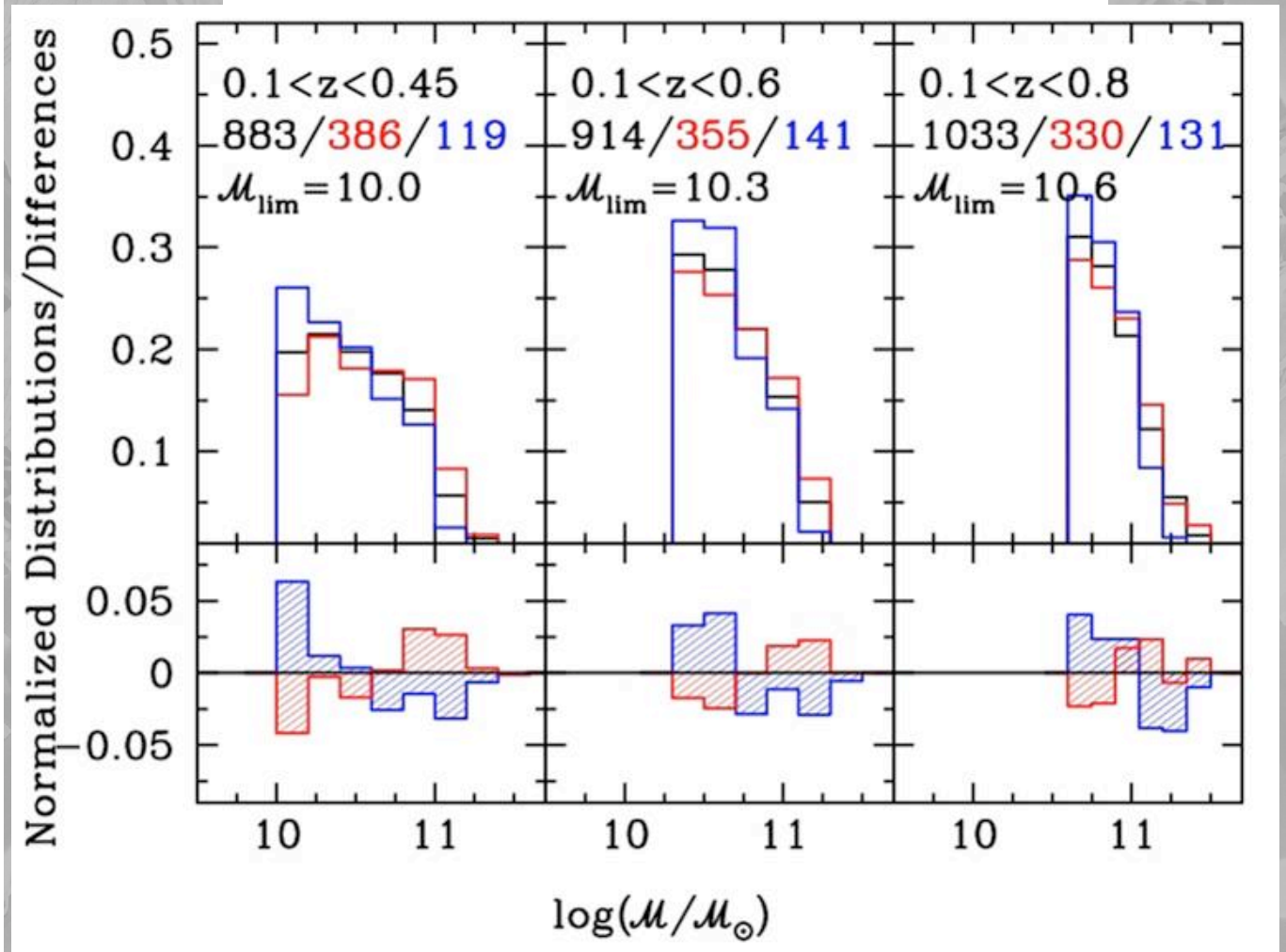
# Enter galaxy mass information




But moving to color-mass space there is a strong selection bias in color!

# Enter galaxy mass information

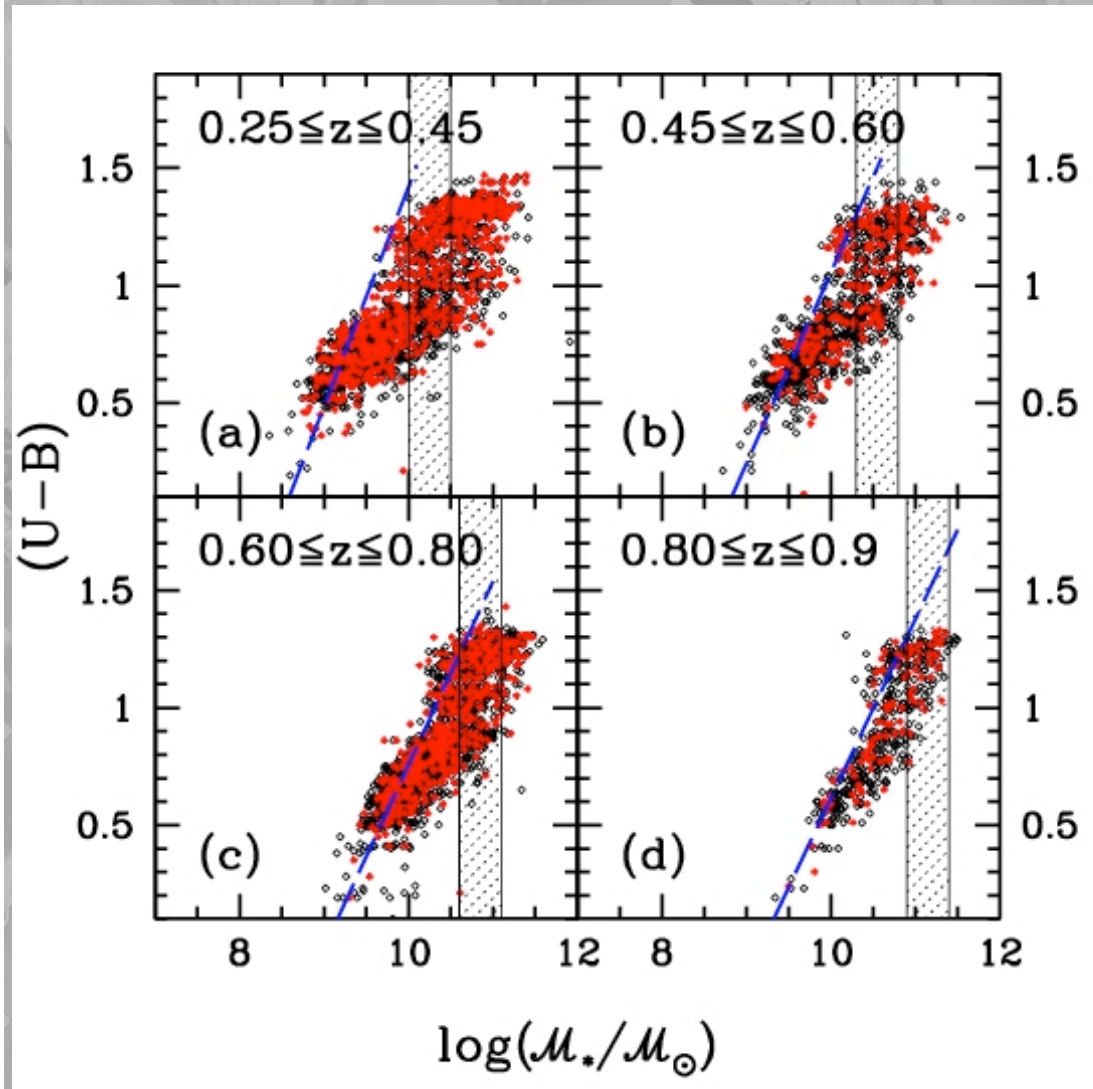
## All - Group - Isol galaxies




The mass limited samples display non negligible mass segregation

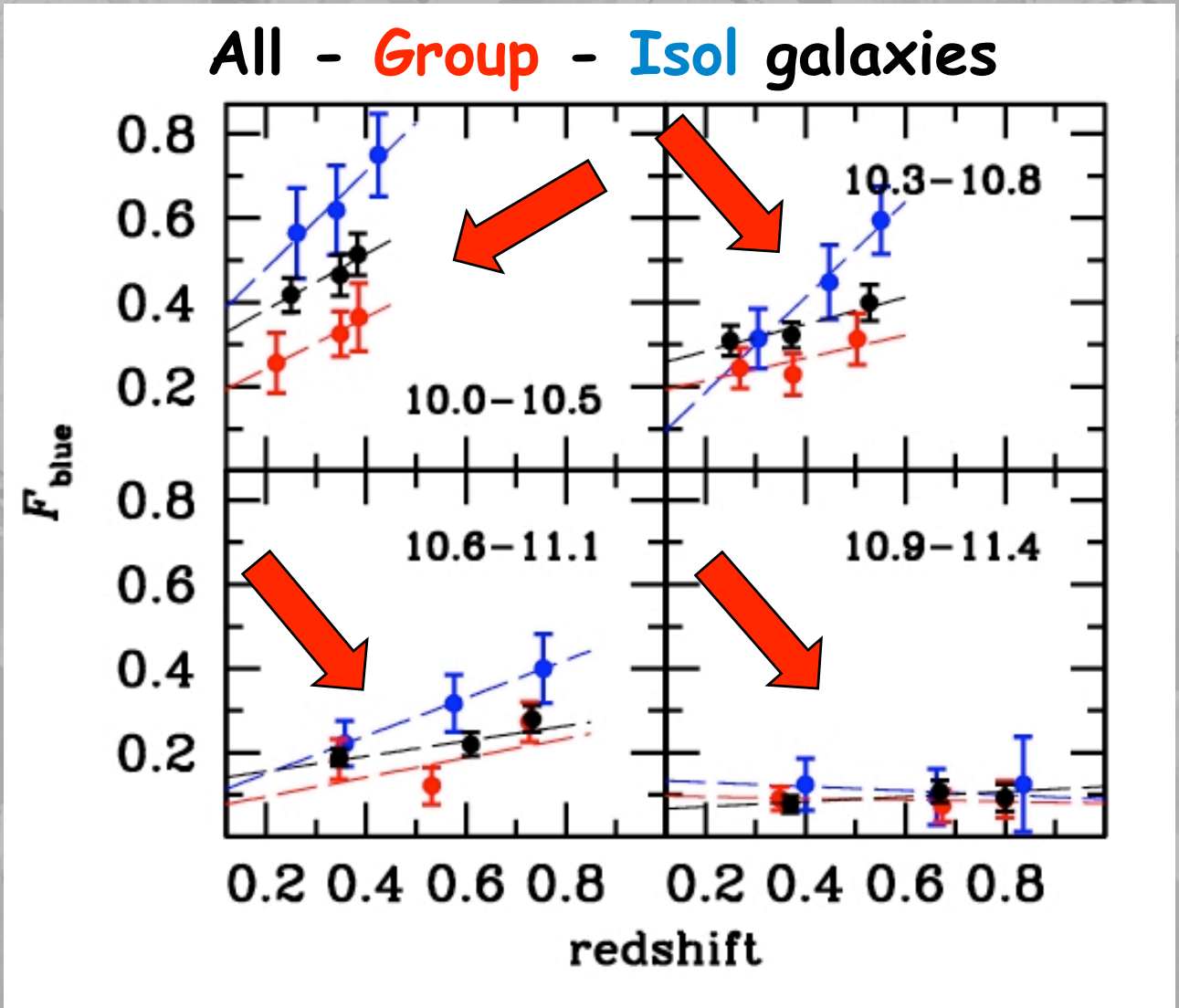
See also **Scodeggio et al. 2009** and **Bolzonella et al. 2009.**

# Enter galaxy mass information




We need to do our analysis in mass bins, **narrow enough** to neglect mass segregation …

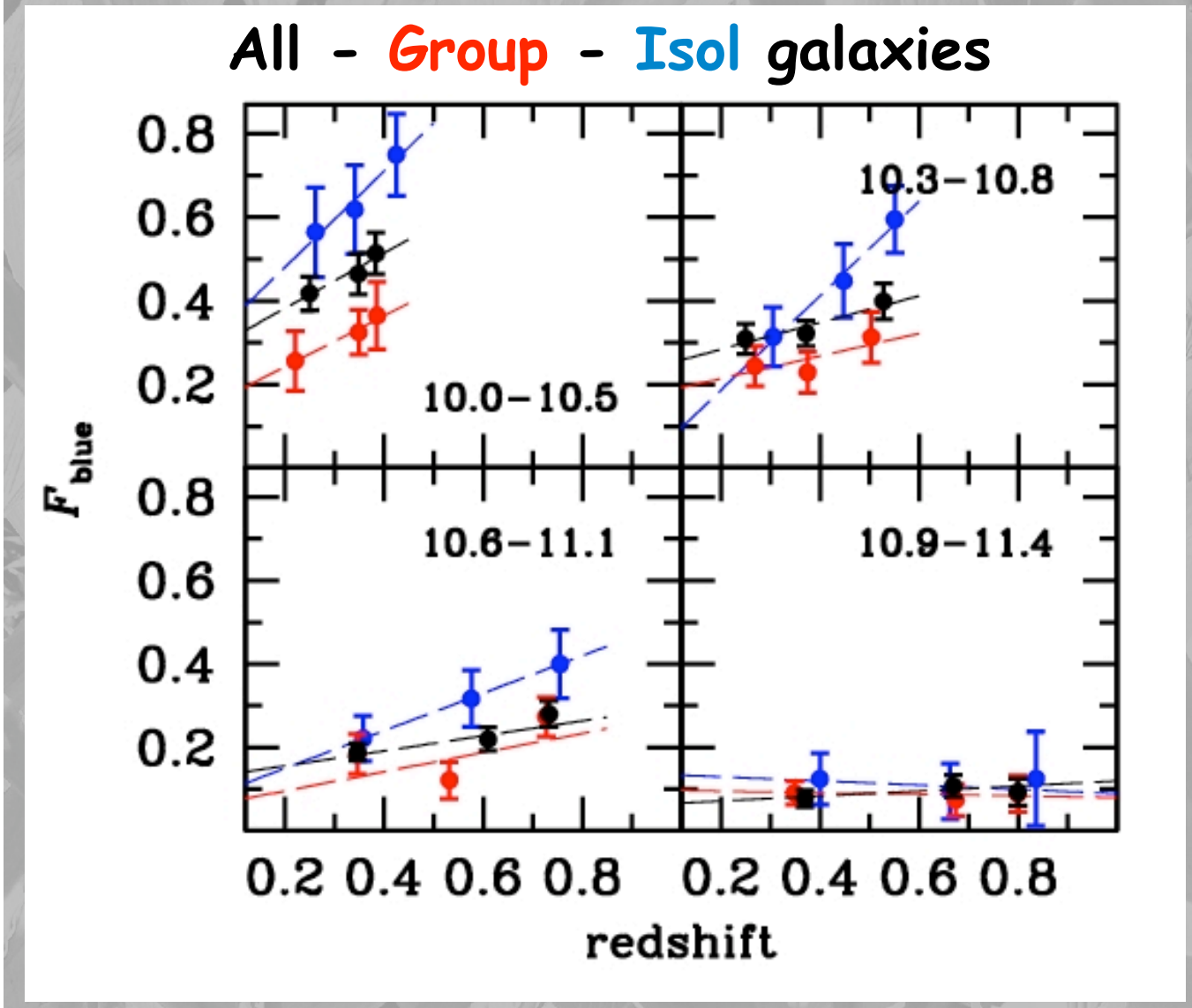
# Results




★ Higher mass galaxies show nearly constant Fb since redshift ~ 1 and little dependence on environment

★ Lower mass galaxies show stronger trends with redshift and environment

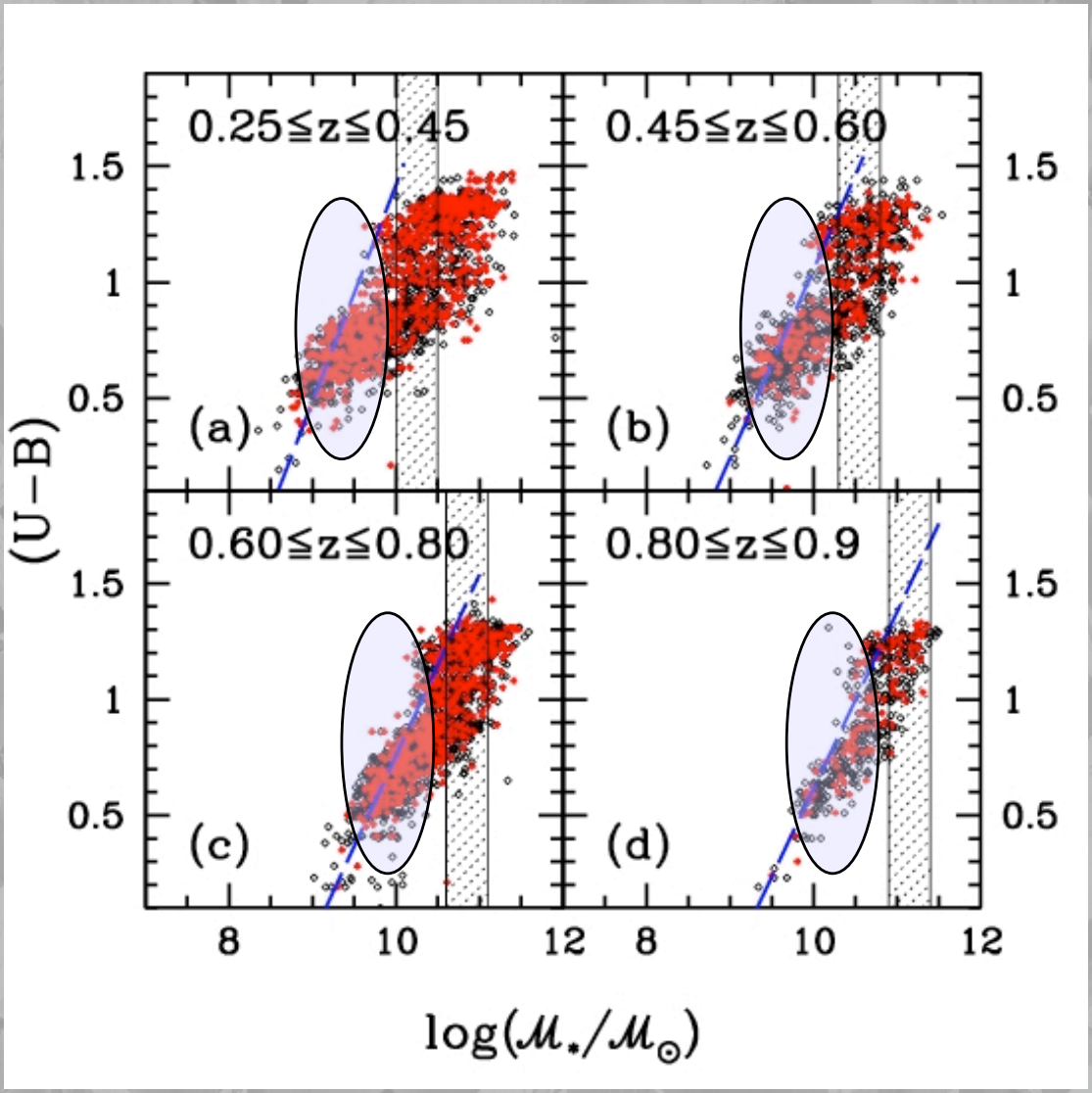
# Results




Comparison with volume limited samples:

★ Fraction of blue galaxies is lower at all redshifts and environments considered.

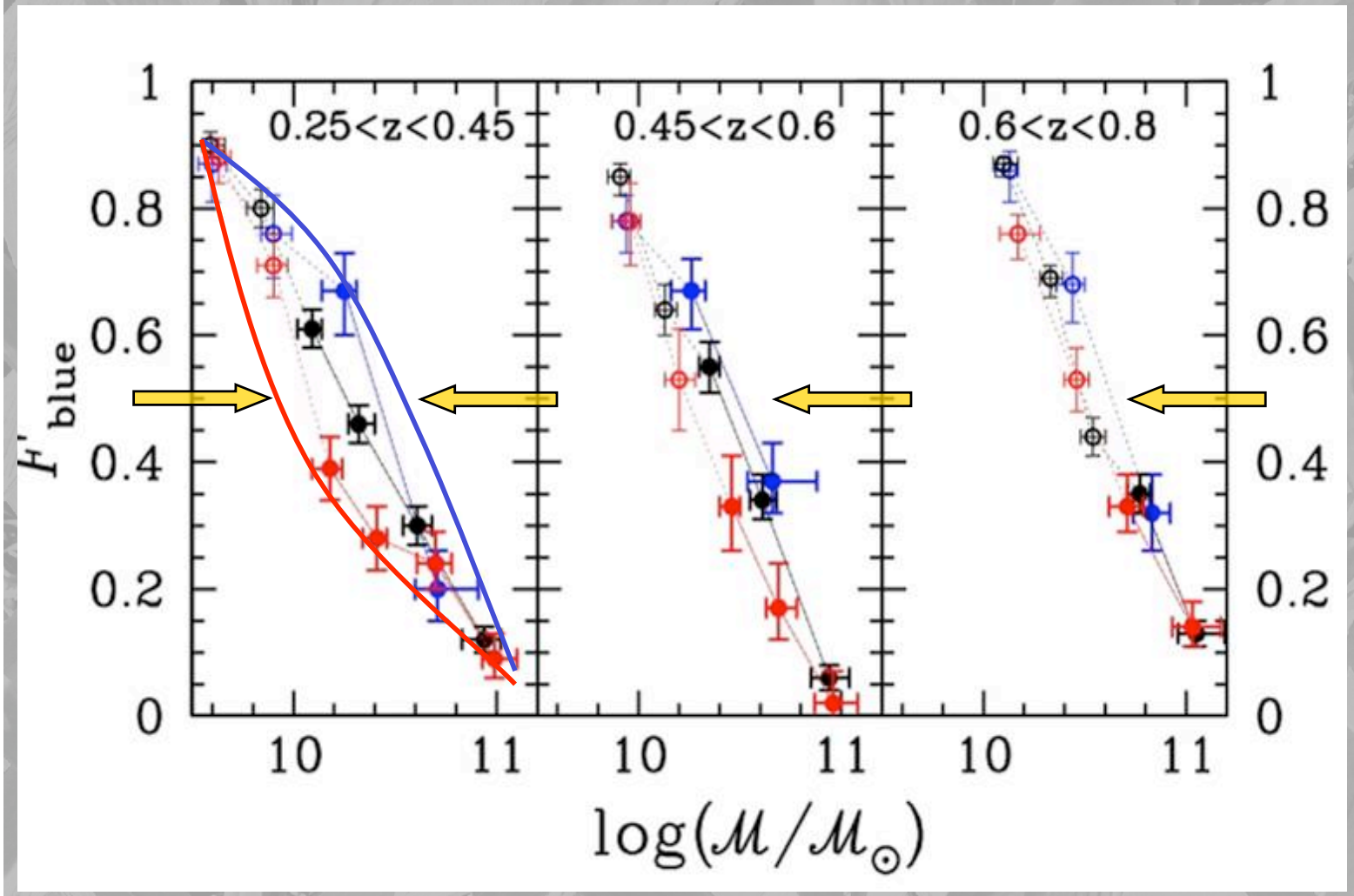
# Results




… suggesting that blue, lower mass galaxies are responsible for the stronger trends seen in luminosity selected samples.

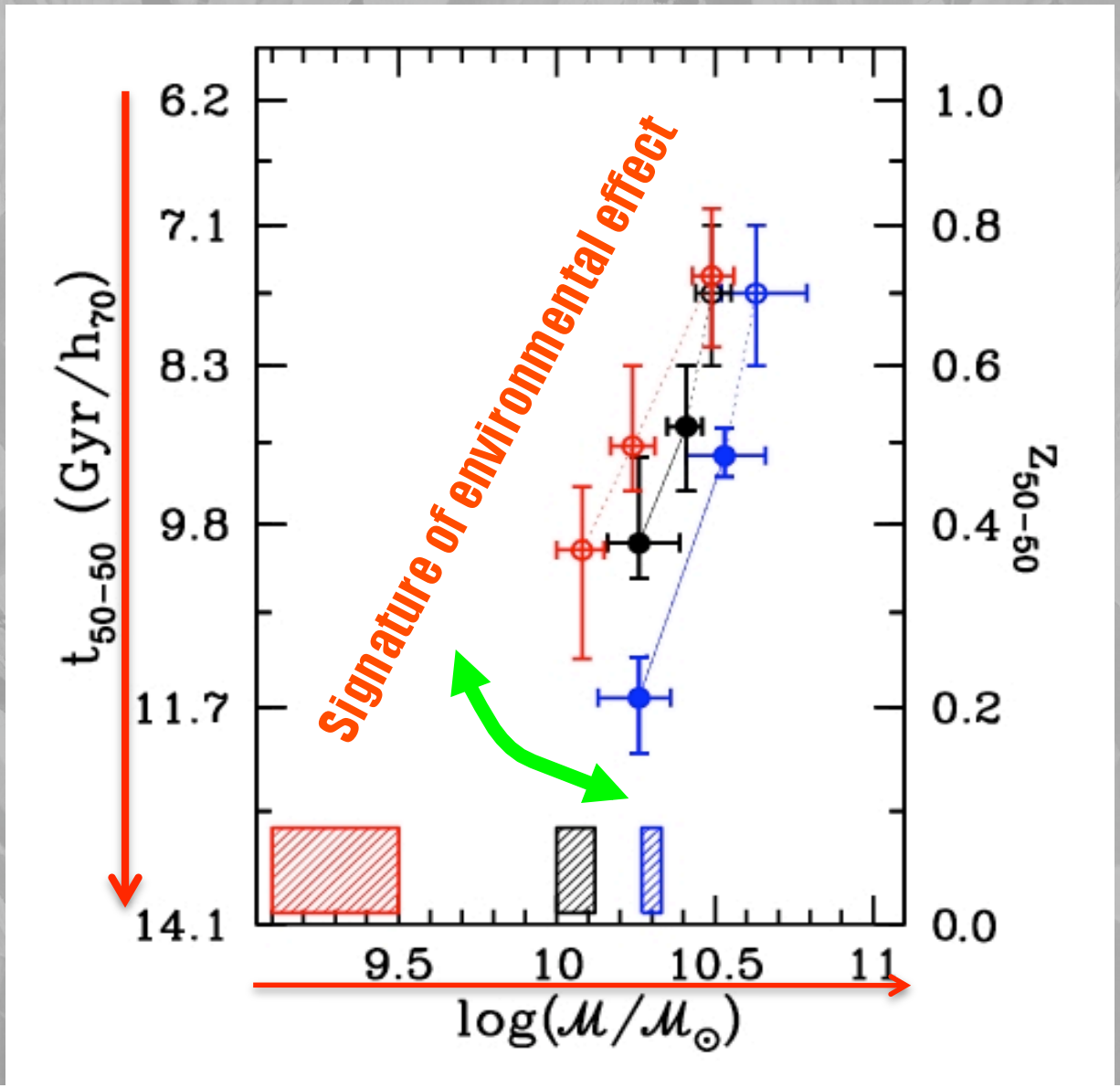
**Biased view resulting from the B luminosity selection!**

★ At fixed redshift: Fb →1 for more massive galaxies while Fb → 0 for lower mass galaxies irrespective of environment.




★ There is a restricted range of masses where colors show dependence on environment.

# The emerging picture in consistent with 'downsizing' scenario modulated by environment.




The progressive speeding up in group environment of the color transition from red to blue galaxies cannot be interpreted using only nature mechanisms!

Local points from Baldry et al. 2006

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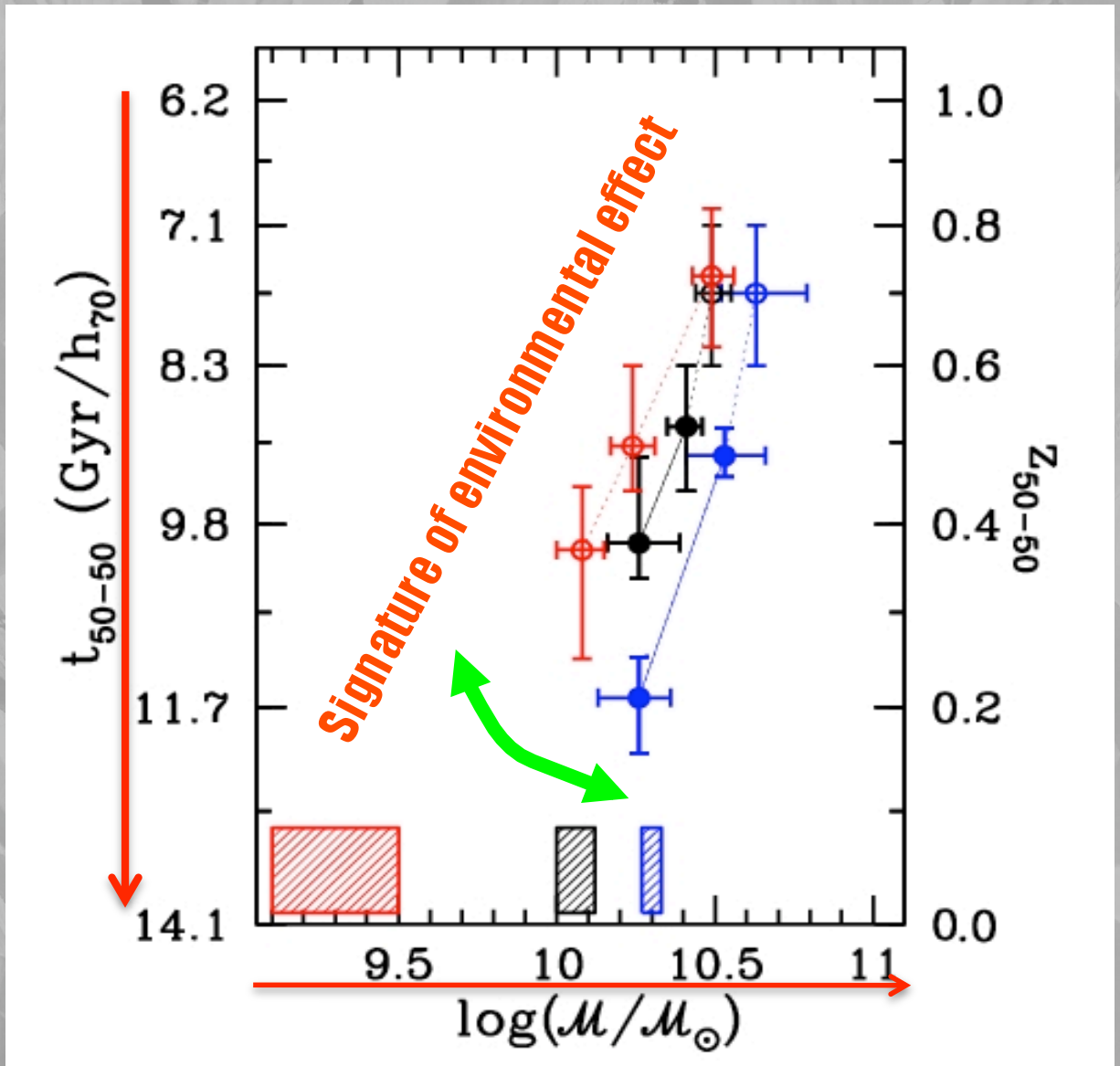
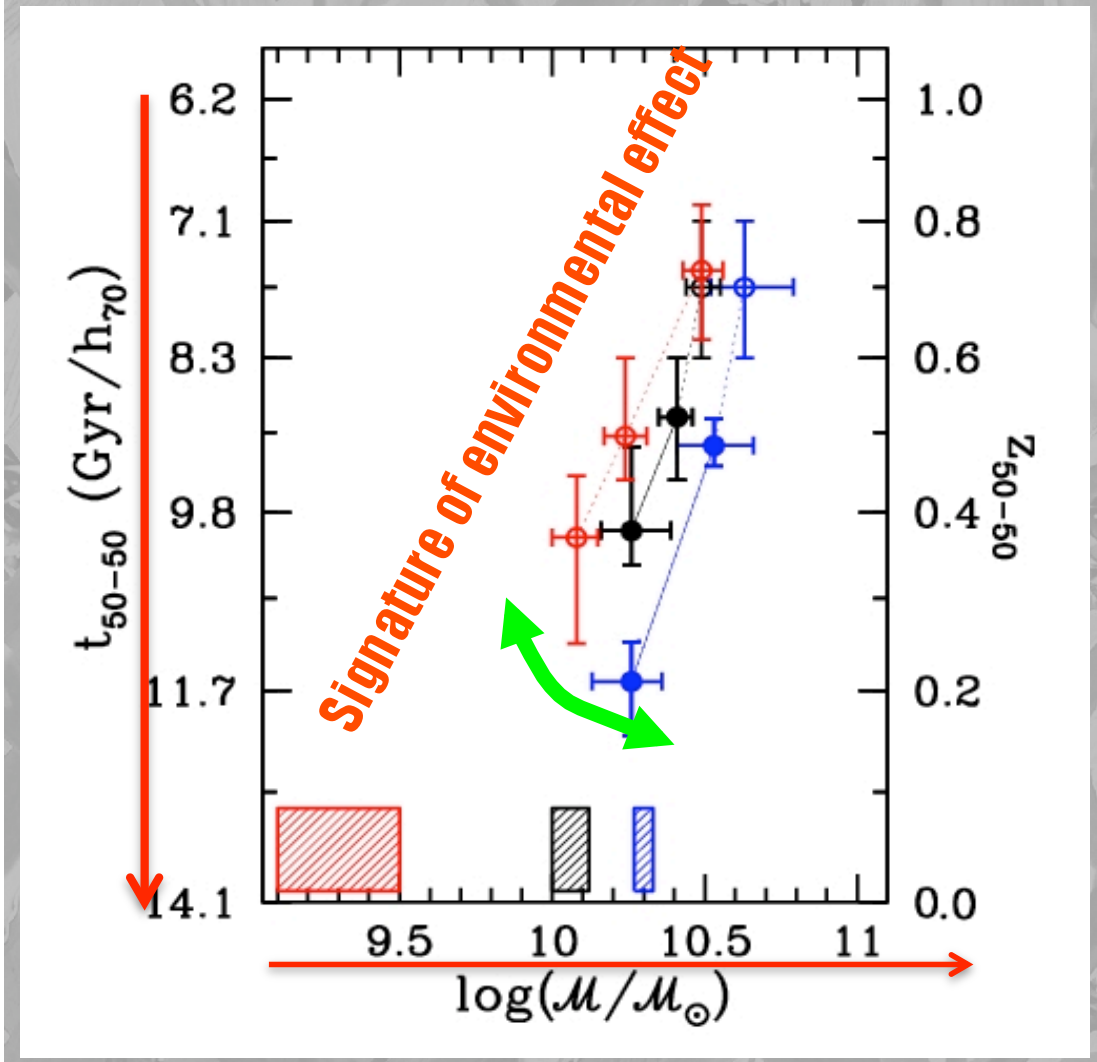



Natural mechanisms to explain such trends are those taking place in groups: more efficient for less massive galaxies and with a timing that mirrors the emergence of structures.

Local points from Baldry et al. 2006

# The emerging picture in consistent with 'downsizing' scenario modulated by environment.




1 – massive galaxies already in place at z -1

2 –at lower redshifts nurture red galaxies emerge, bearing signs of environmental effects

3 – their timing mirrors the progressive emergence of structures where such mechanisms take place.

A series of papers further investigating such findings using zCosmos sample:

1- Cucciati et al. (see also poster)
2- Kovac et al. & Tasca et al → morphologies in groups and different environments
3- Knobel et al. → group catalogue in zCosmos
4 - Kovac et al. → density field in zCosmos
5- Bolzonella et al. → mass function in different environments
6- Zucca et al. → luminosity function in different environments
7- Iovino et al. → what I presented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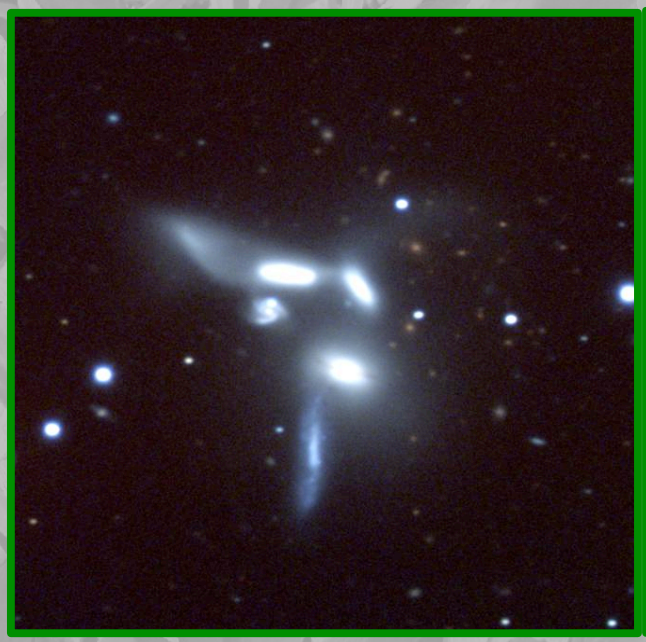
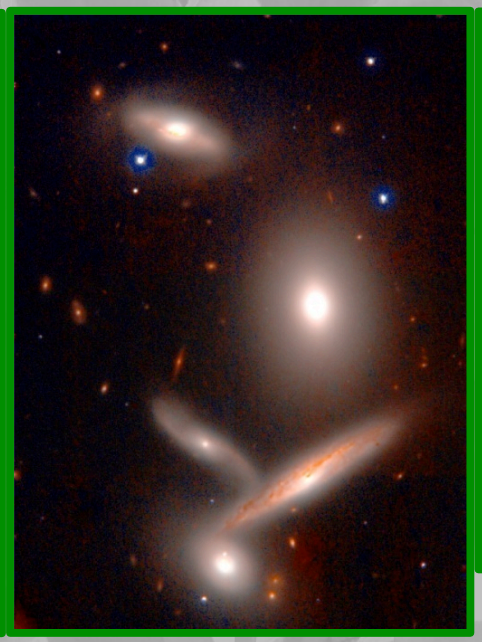
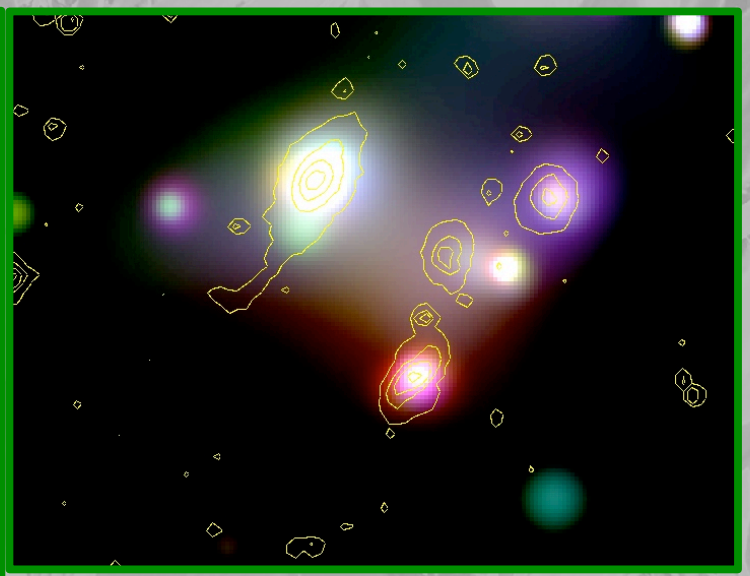
Future: detailed comparisons with simulations predictions and the new 20K group sample to confirm and better explain these trends.

*Thank you*

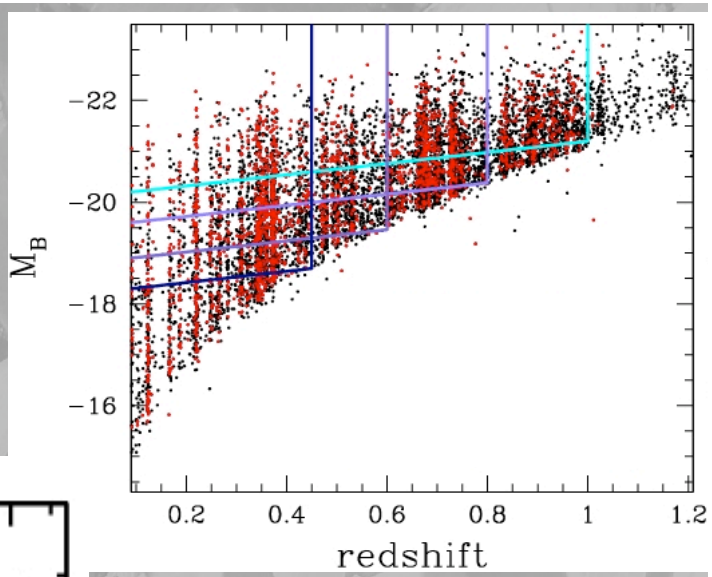
# Context of our analysis

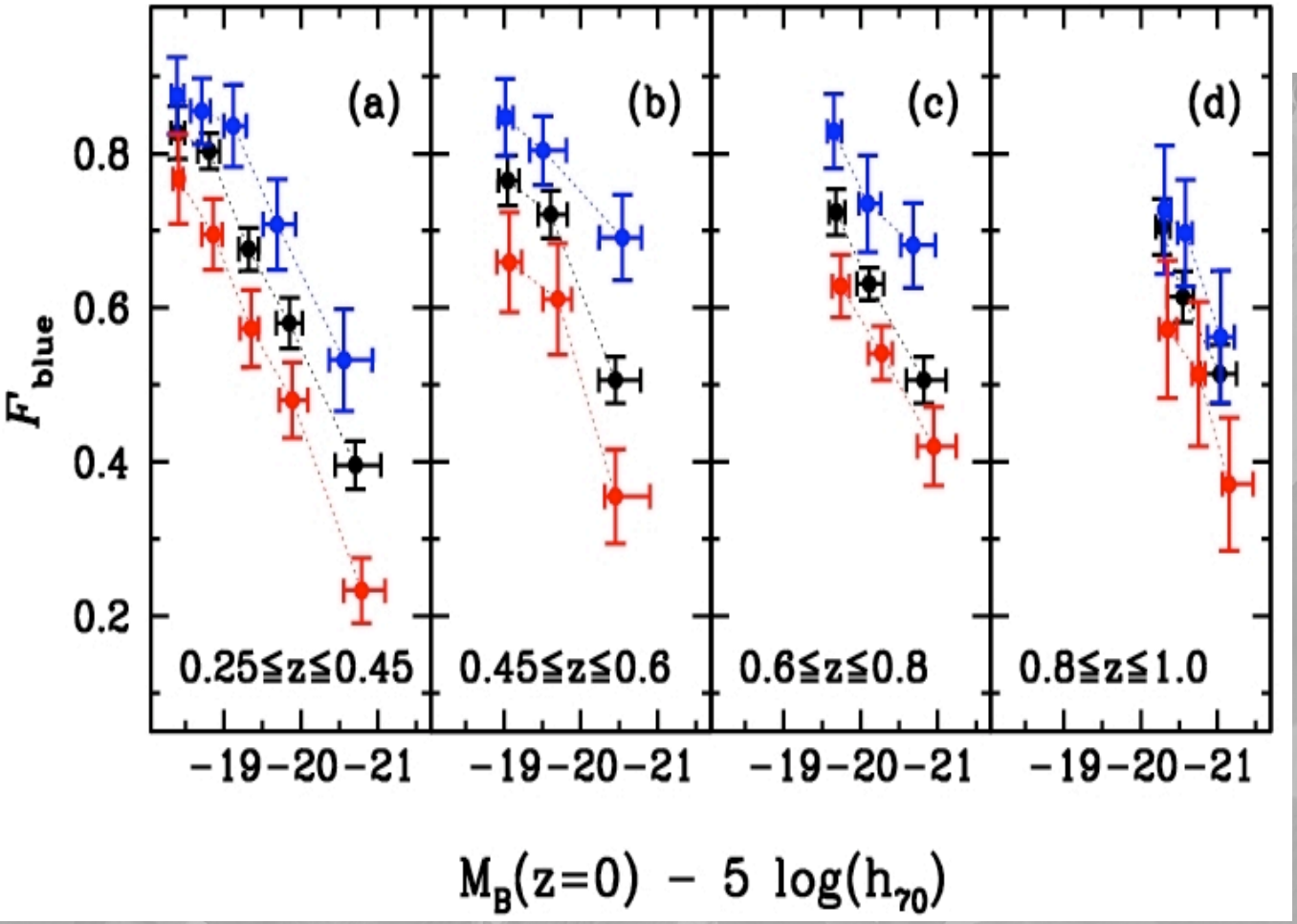
## Groups as powerhouse of Galaxy evolution ?

Groups of galaxies are a common environment at z~0.
Probing dependence of galaxy properties on group environment will allow to understand the evolutionary processes taking place in groups and to assess their importance in driving global trends.

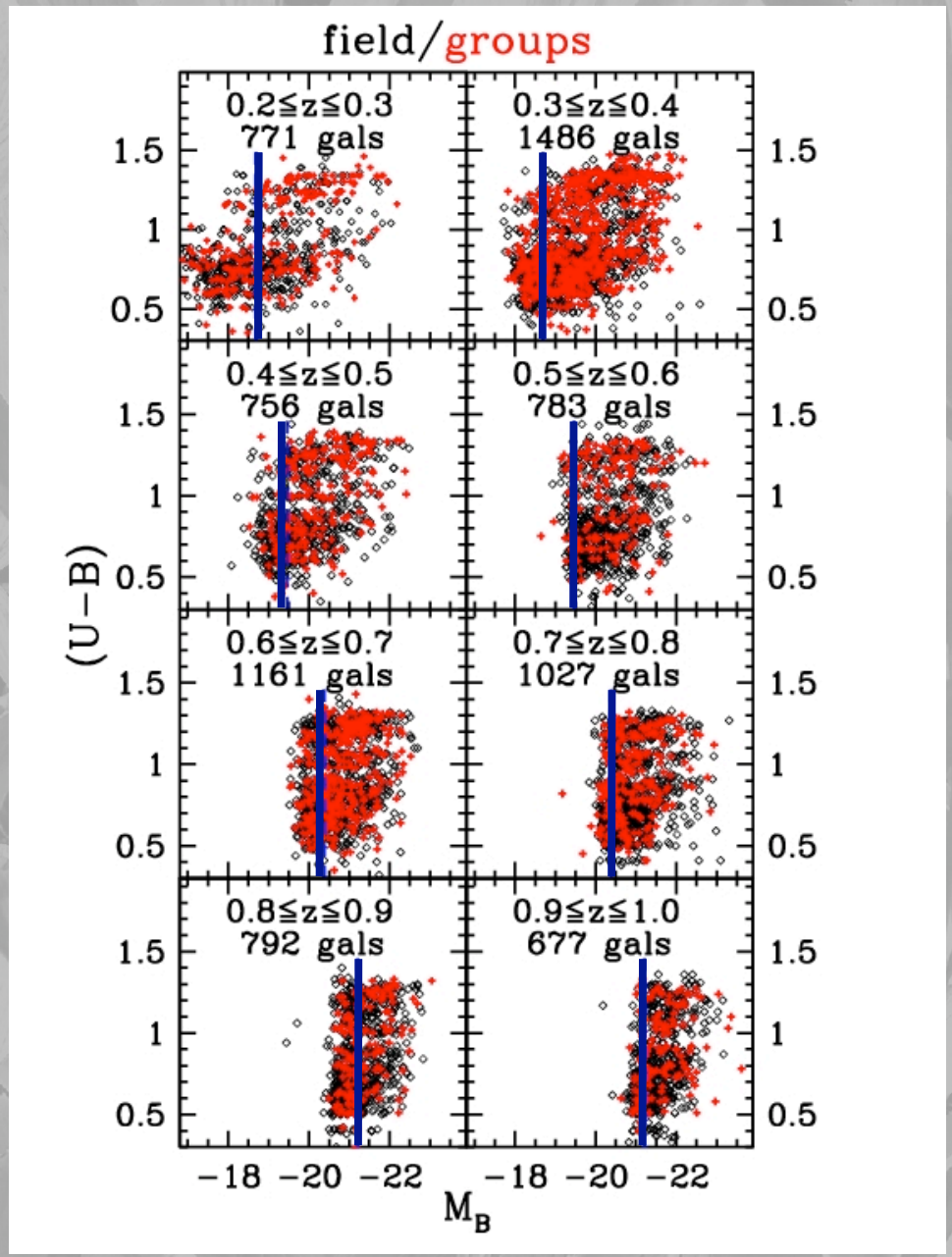
# Results




★ At all redshifts and environments galaxy colors become bluer going to fainter magnitudes …
$F_b$ is always higher in lower density environments.

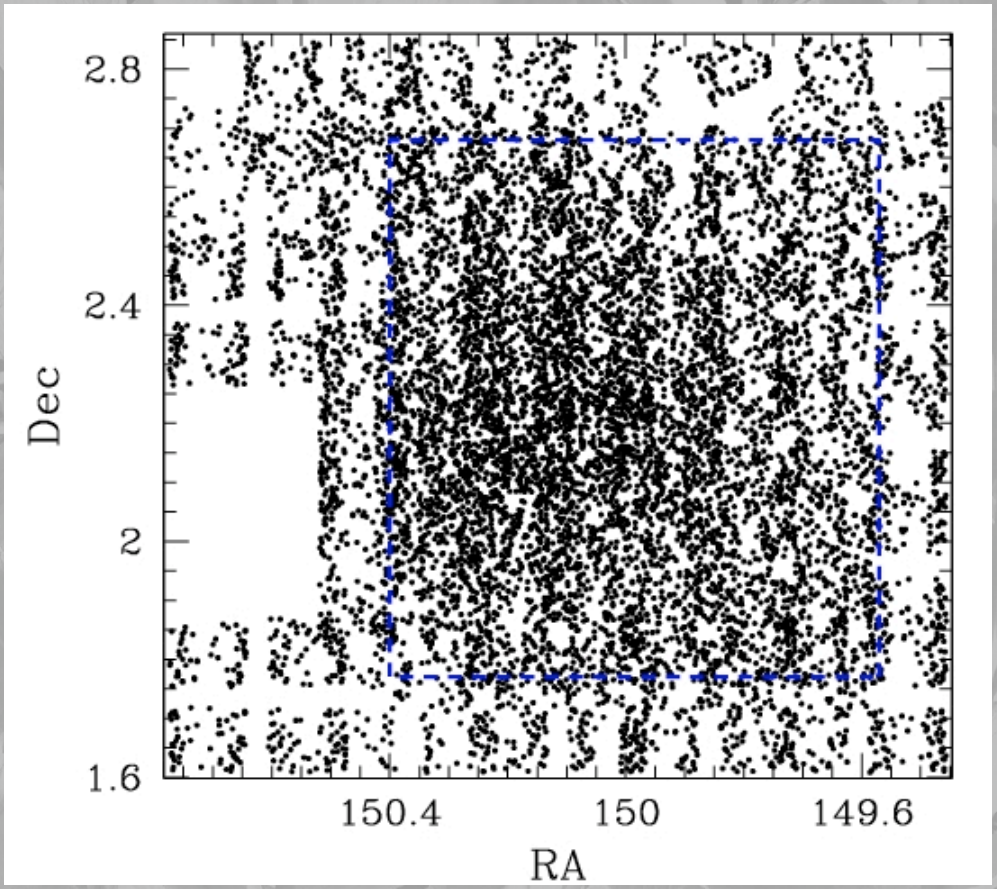
# Ingredients of our analysis




zCosmos survey is ideal for this investigation being free from redshift dependent selection biases in color-magnitude space up to z ~ 1

# zCOSMOS

As of today we have already collected approx 10.000 spectra: the so-called **10K** sample



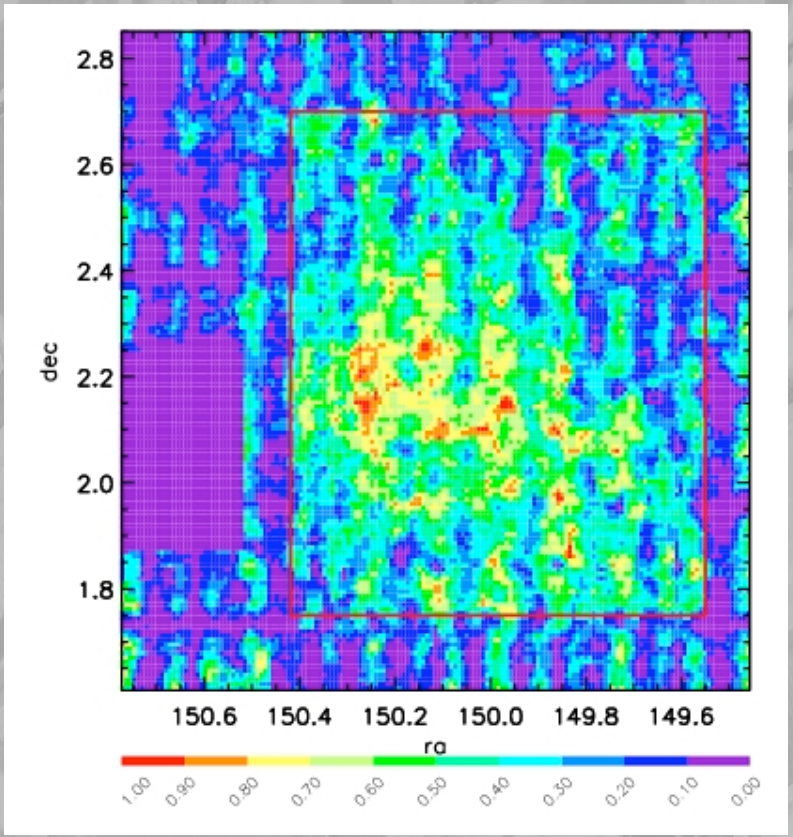

## 10K field layout

The central part (~0.9 sq deg) has a relatively uniform spectroscopic coverage: approx 1 out of 3 gals with reliable redshift measurement (typical error in v ~ 100 k/s)

# zCOSMOS - groups catalogue

Problems related to the **uneven sampling rate** of the survey: before performing our analysis we introduced a weighting scheme to correct both for **alpha-delta uneven coverage** and for luminosity dependence of **success rate** in redshift measurements.

$$Wi = 1/(TSR*SSR*\varphi(\alpha,\delta))$$




We used this weighting scheme to correctly estimate group richness and other measured quantities …

# Context of our analysis

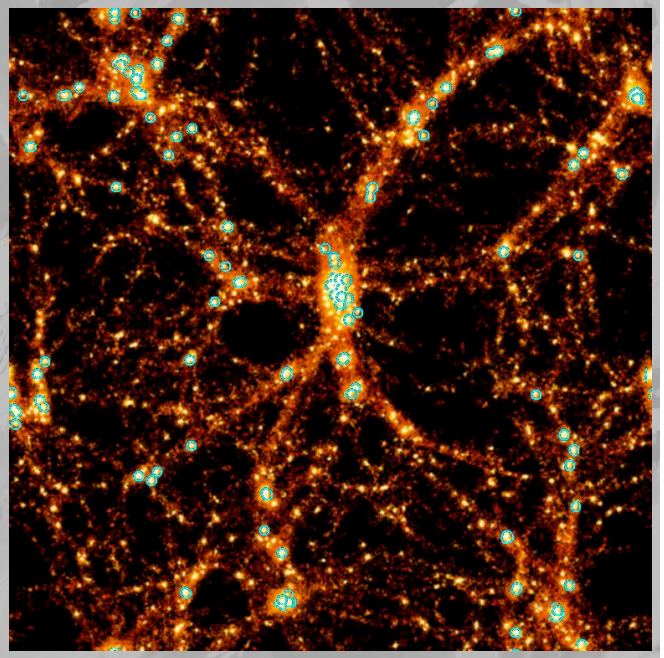
## Why Does Star Formation Stop?

Possible External Mechanisms

- ~~Ram-pressure stripping~~
  - ✓ ~~Needs dense ICM and high velocities clusters~~
- Collisions / harassment
  - ✓ Groups are preferred place
- Strangulation
  - ✓ Slow removal of the gas halo
  - ✓ Similar to ram-pressure stripping but much easier

# Context of our analysis

## Why Does Star Formation Stop?



❖ **Just structure growth:**

- In over-dense environments dark matter halos start to assemble their mass at higher redshifts and more rapidly + internal mechanisms, like AGN/SN feedbacks, to shutdown star formation

Offers a possible alternative explanation for the most evolved population of galaxy groups and clusters without appealing to local interactions between galaxies and their environment.

## zCOSMOS - groups catalogue

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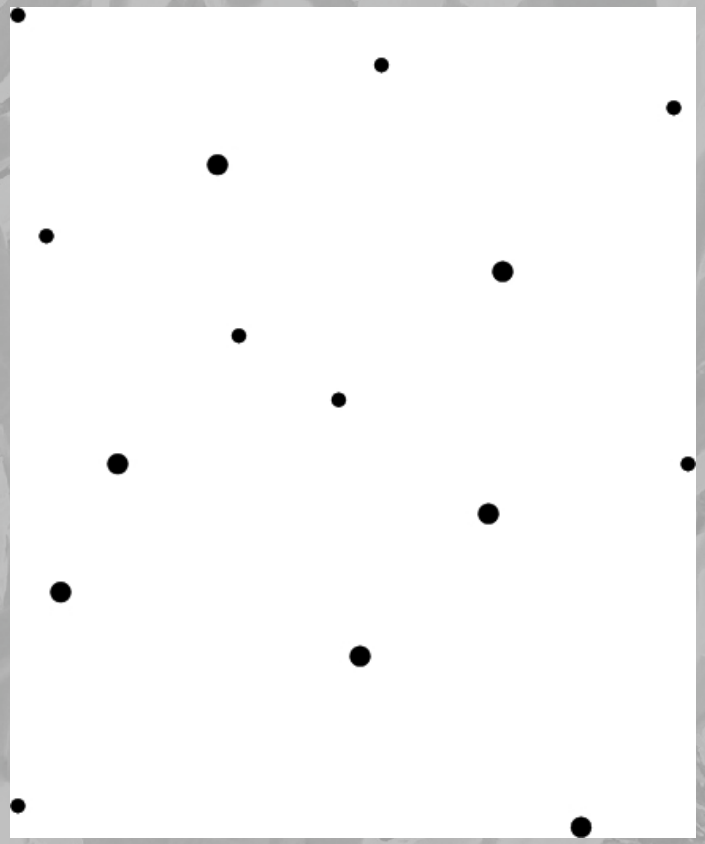
## zCOSMOS - groups catalogue

Problems related to the **uneven sampling rate** of the survey:

$$Wi = 1/(TSR*SSR*\varphi(\alpha,\delta))$$

$$TSR = Nspec/Nphot$$



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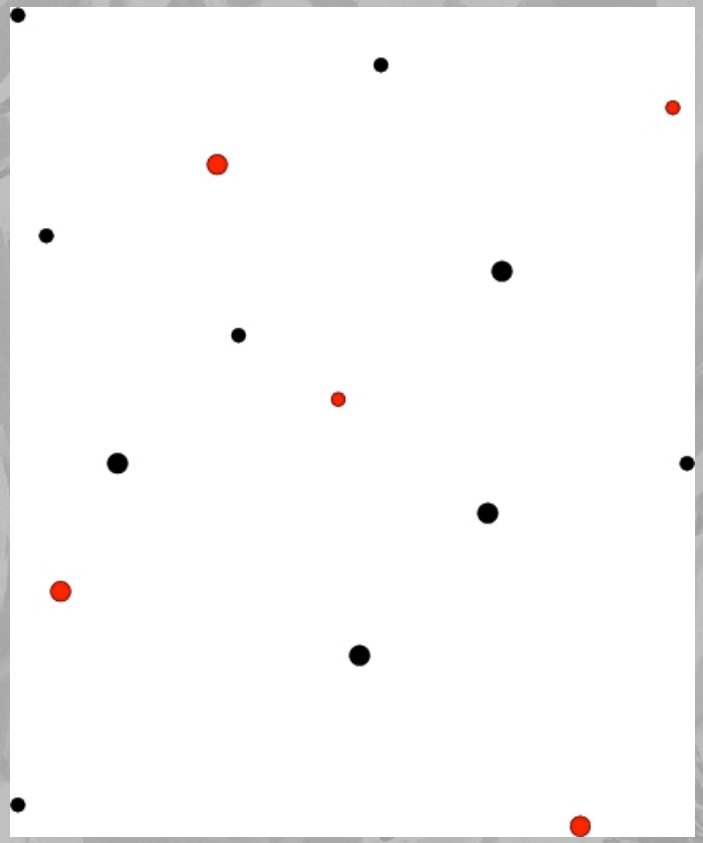

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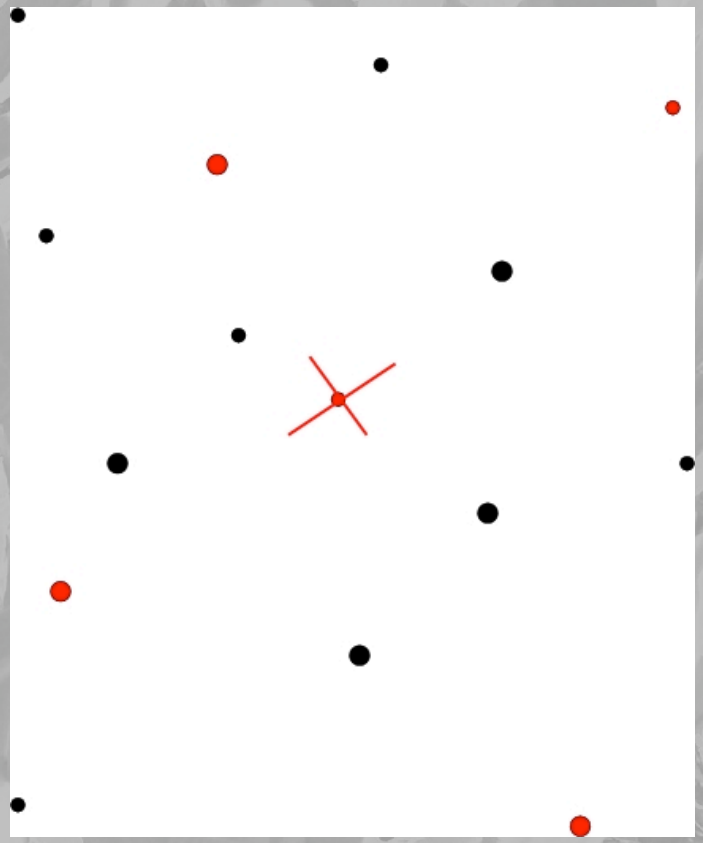

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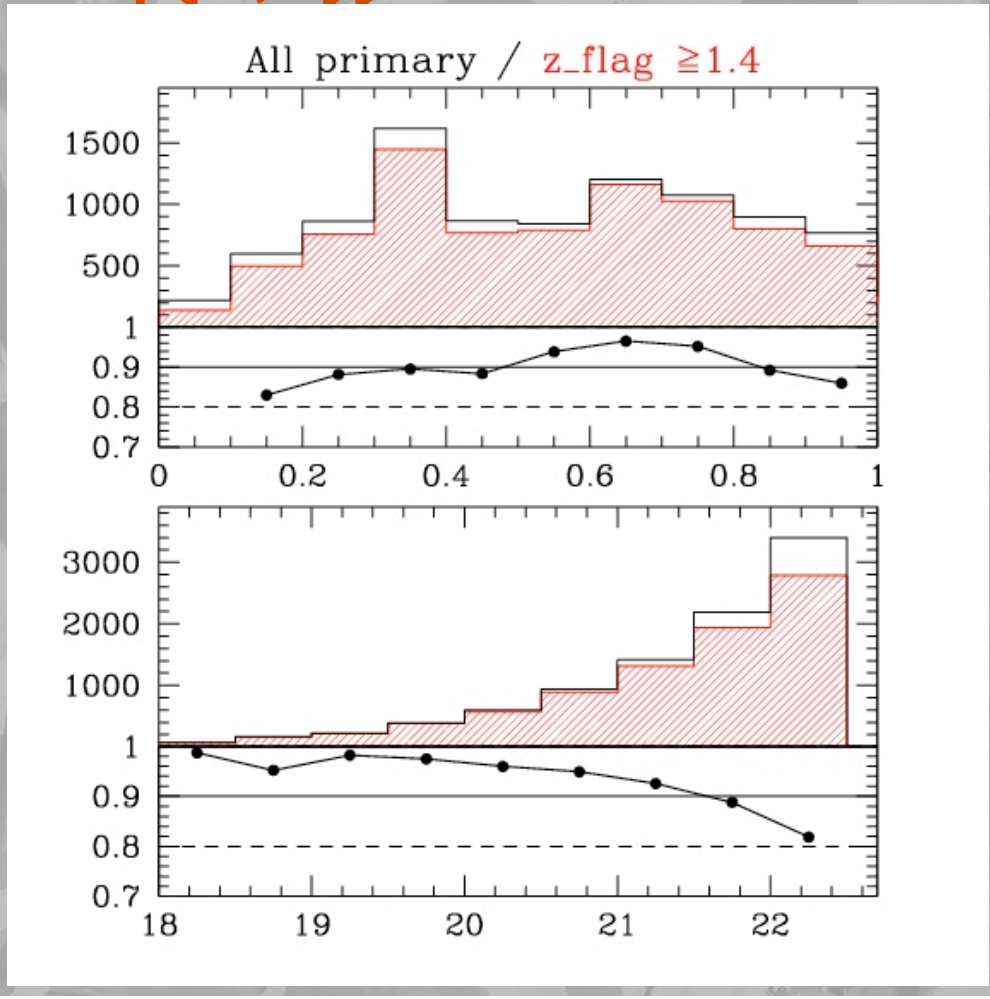

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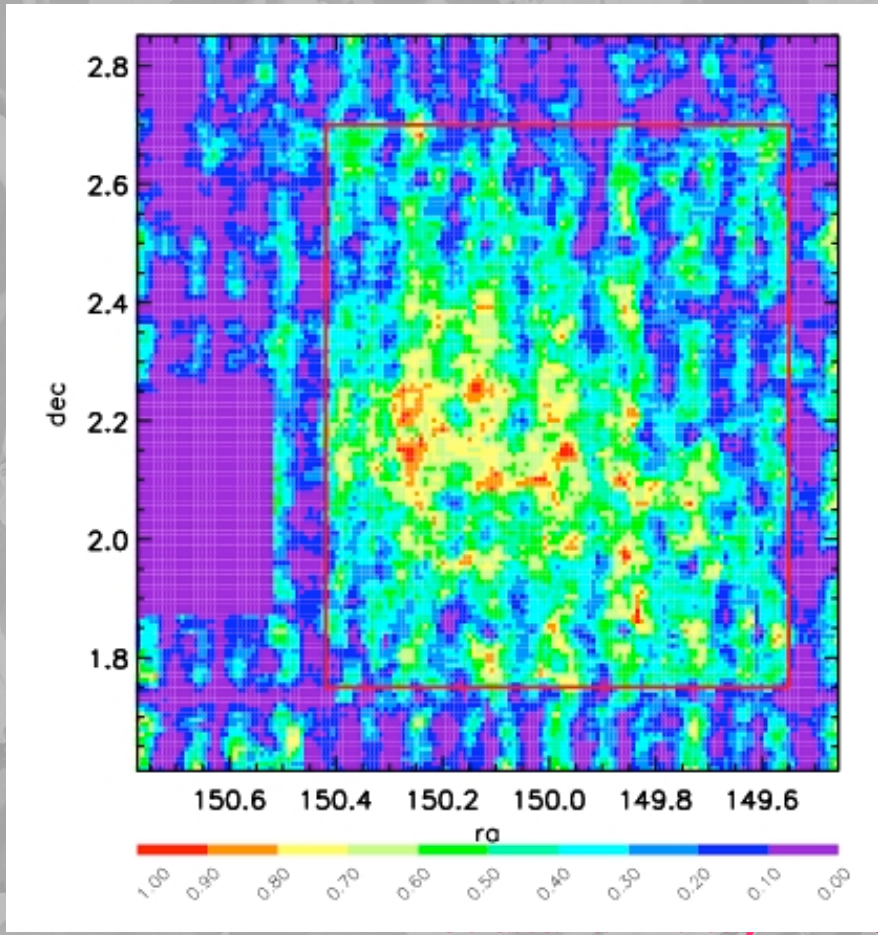
$$\varphi(\alpha,\delta)$$



## zCOSMOS - groups catalogue

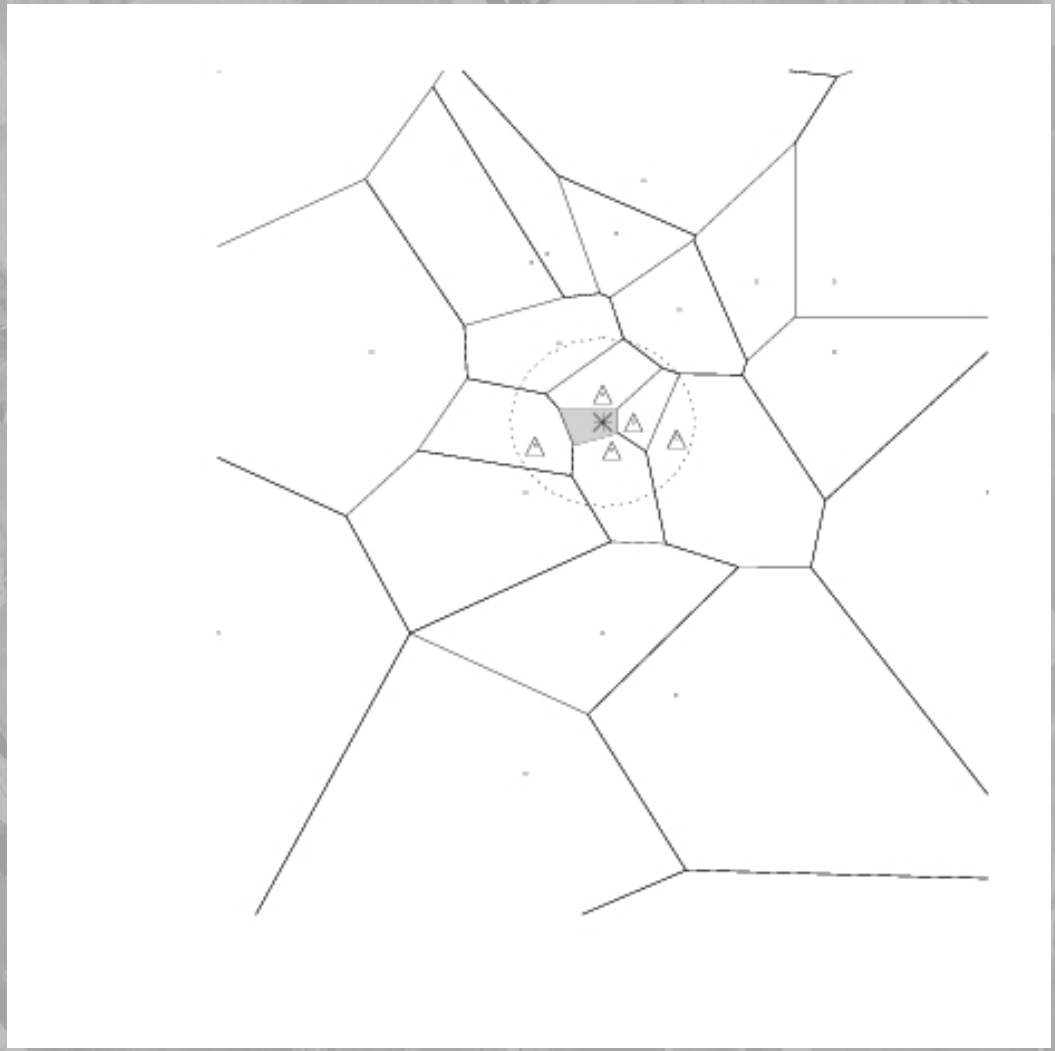
Problems related to the **uneven sampling rate** of the survey:

$$Wi = 1/(TSR*SSR*\varphi(\alpha,\delta))$$

We used this weighting scheme to correct for group richness and all our group quantities estimates.

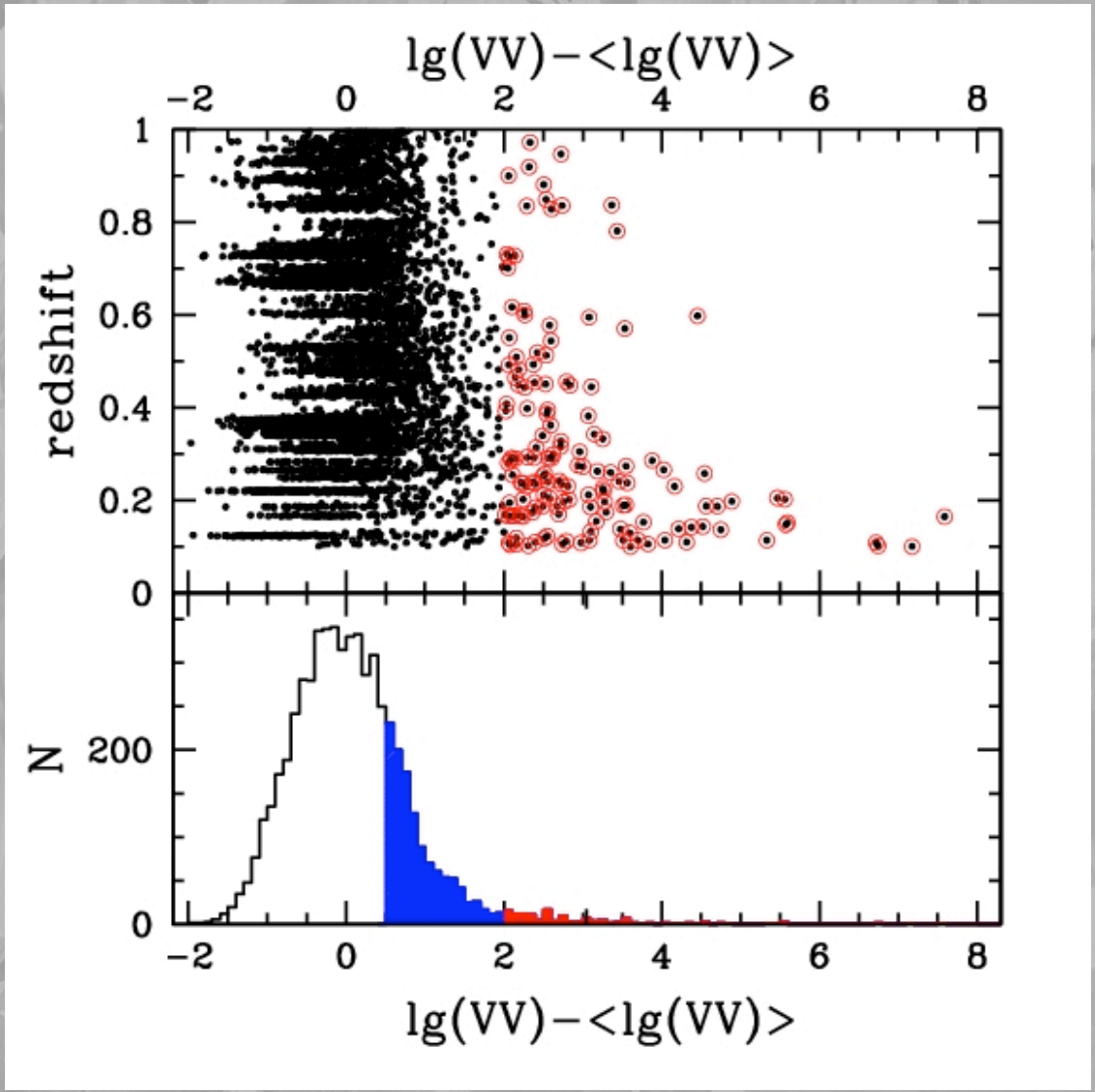
★How to define a sample of isolated galaxies?

Use Voronoi Volumes

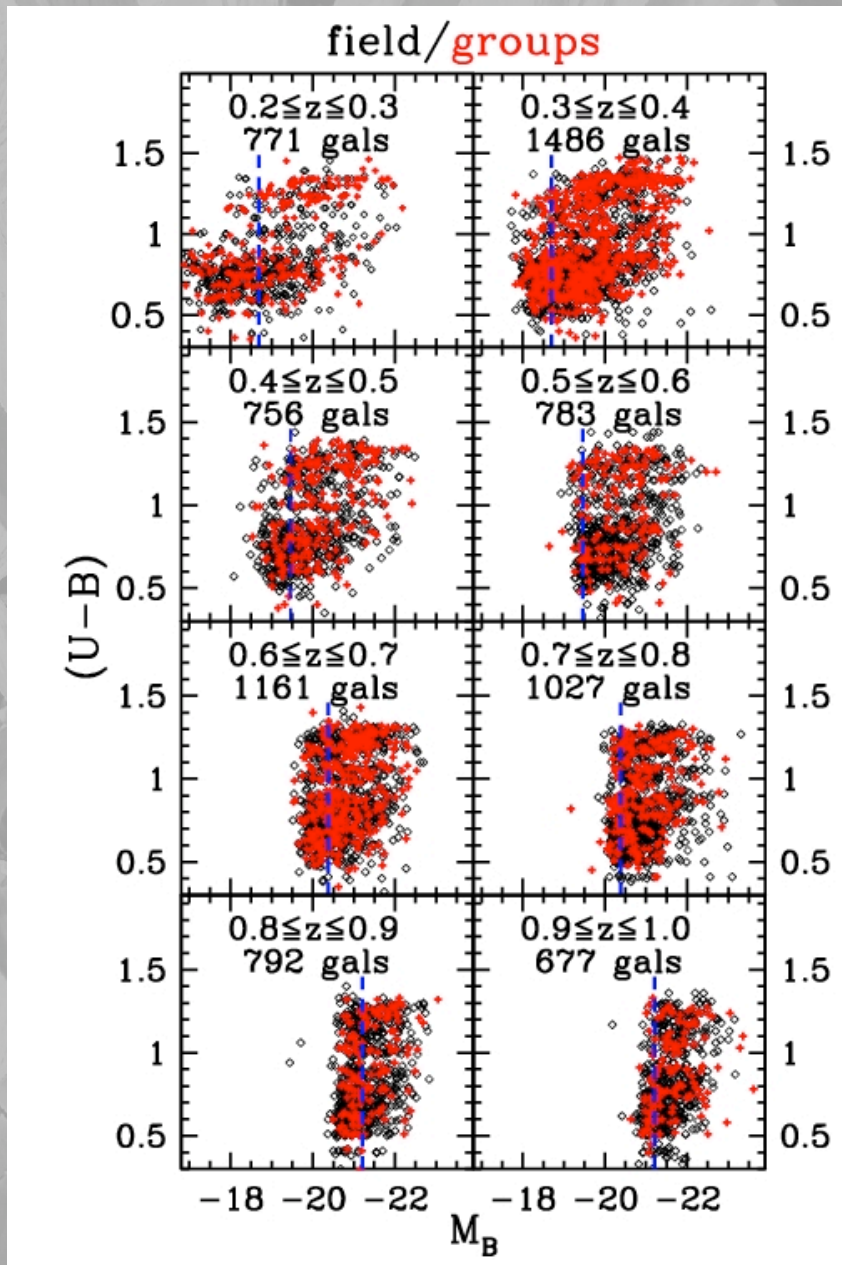


# zCOSMOS - Isolated galaxies - definition

★How to define a sample of isolated galaxies?



# Ingredients of our analysis …




The same plot for DEEP2 !