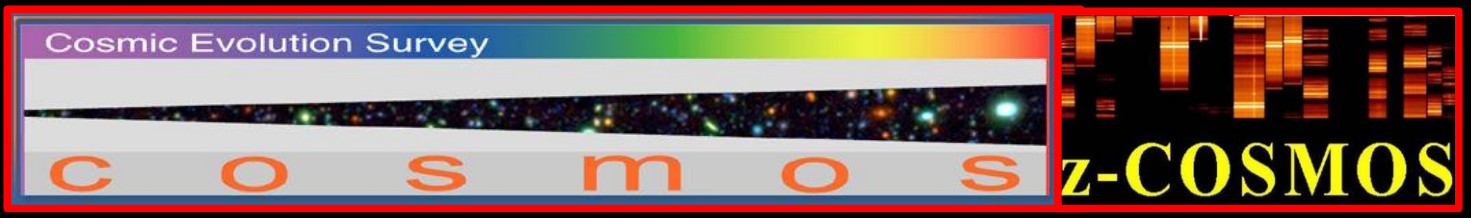
Galaxy Evolution and Environment at high-z

Lessons learned from zCOSMOS

A. Iovino Gee 2009



zCOSMOS in a nutshell:

Large redshift survey using 600hr of VLT+VIMOS

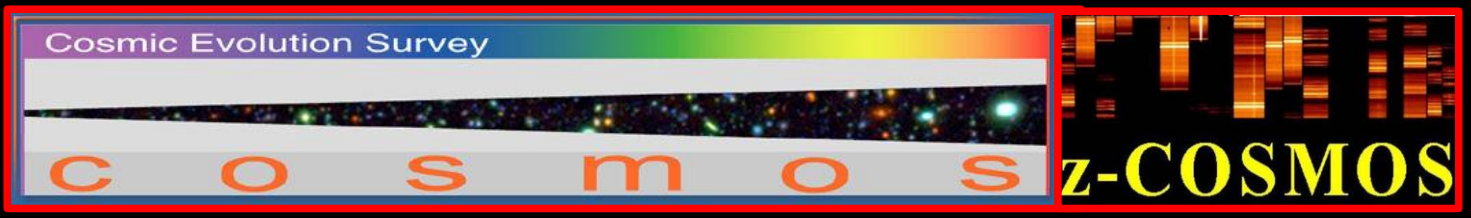
1.7 sq degs

~ 20.000 gals (20K, today 10K)

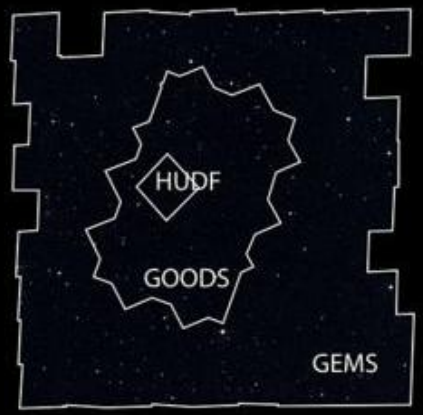
Down to I_{AB} =22.5

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

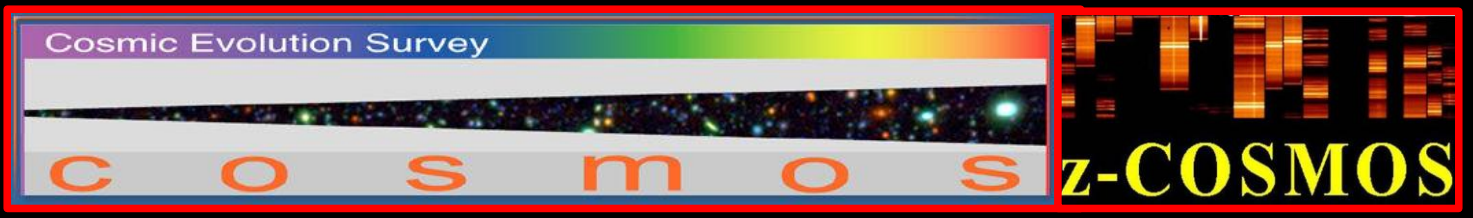
(see **Lilly et al, 2007, *ApJ*** and **Lilly et al., 2009**,for survey details)

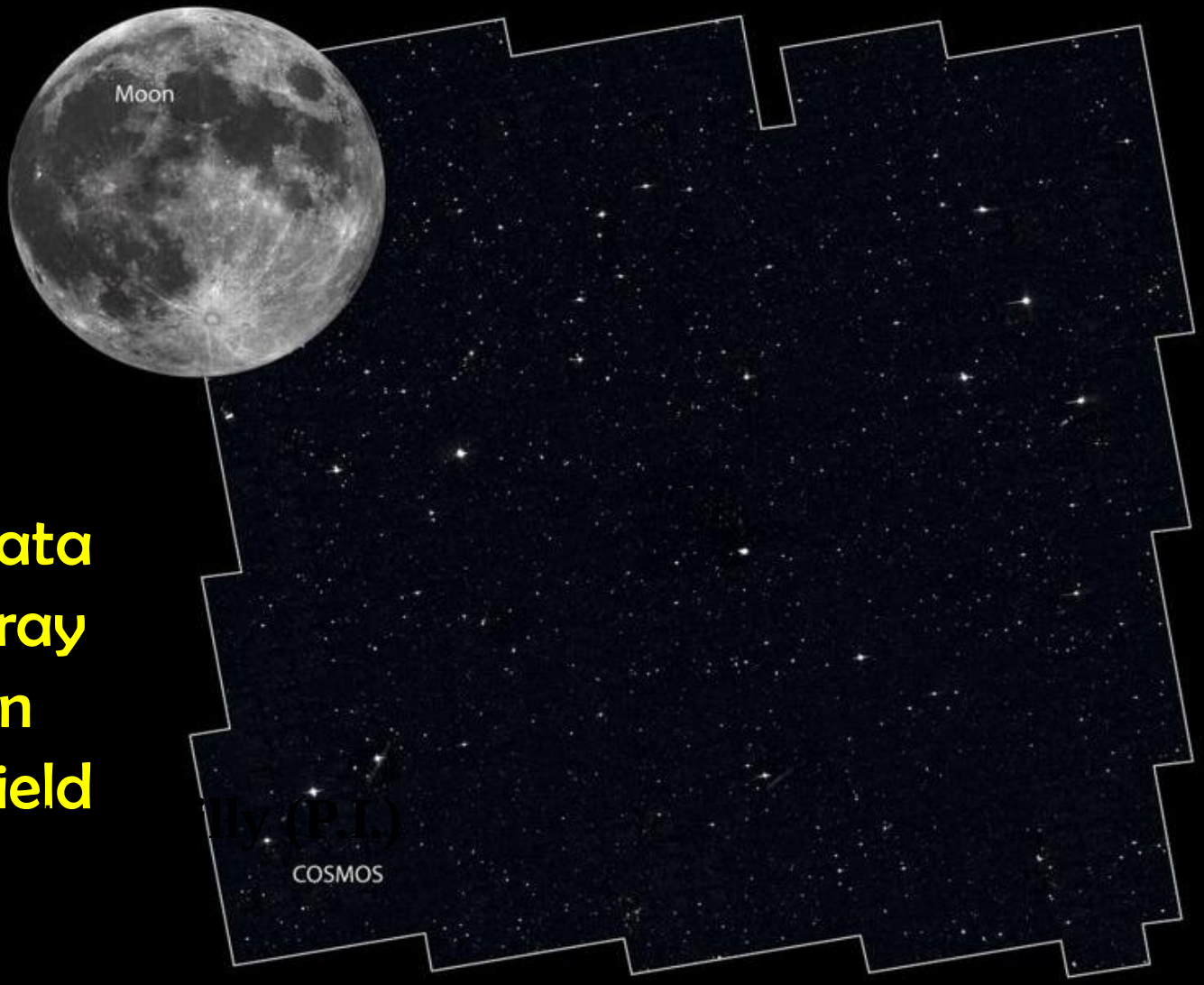


Relative Sizes of *HST* ACS Surveys



1.7 sq degs
~ 20000 gals
Down to I_{AB} =22.5





Ancillary photometric data from FIR to X-ray are available in the COSMOS field

Ancillc
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from F
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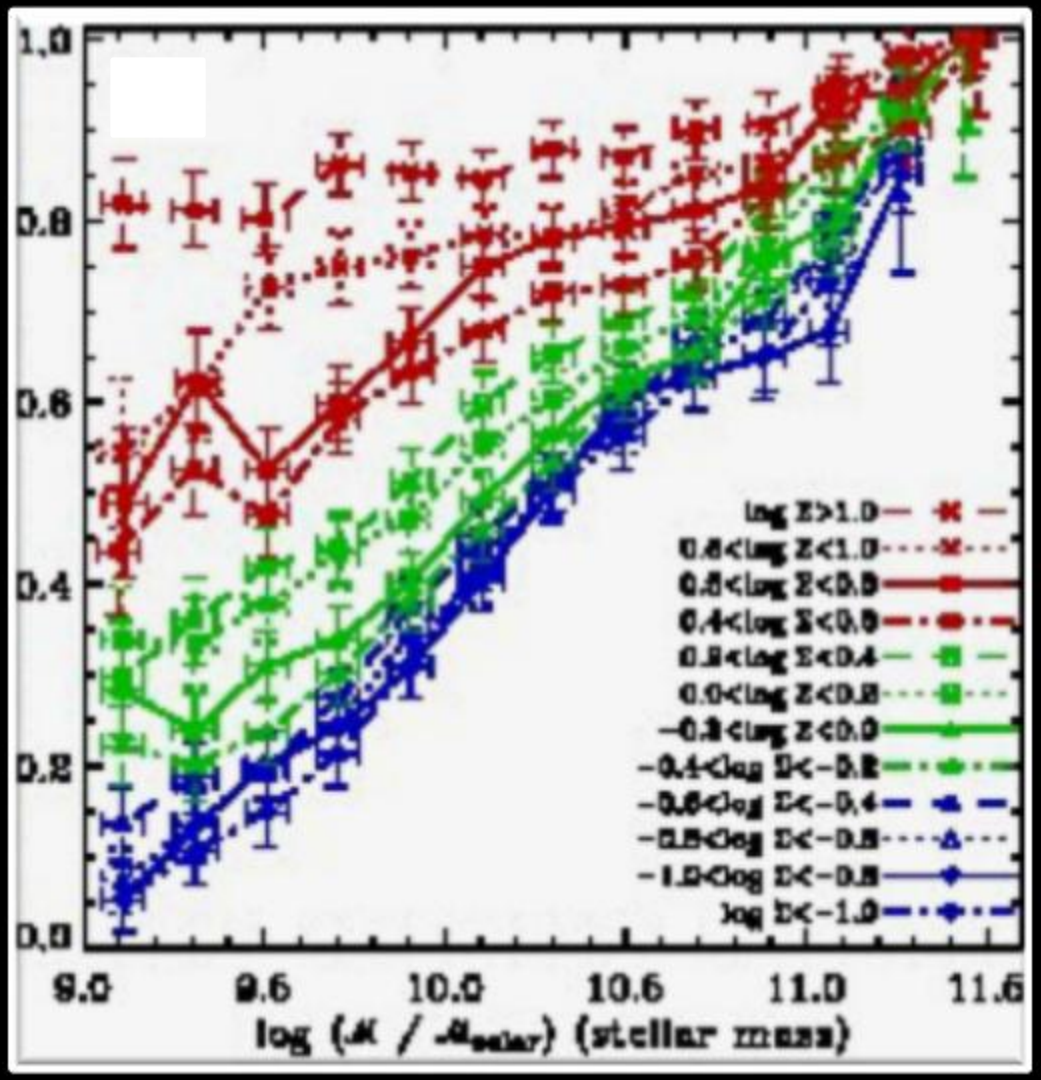
**** zCOSMOS Core Spectral Reduction Team:**

ETH Zurich, INAF Bologna, INAF Milano, LAM Marseille, OAMP Toulouse, MPE/ESO Garching

Bardelli, S., Bolzonella, M., Bongiorno, A., Caputi, K., Carollo, C. M., Contini, T., Coppa, G., Cucciati, O., de la Torre, S., de Ravel, L., Franzetti, P., Garilli, B., Iovino, A., Kampczyk, P., Kneib, J.-P., Knobel, C., Kovac, K., Lamareille, F., Le Borgne , J.-F., Le Brun, V., Le Fevre, O., Maier, C., Mainieri, V., Mignoli, M., Pello, R., Peng, Y., Perez Montero, E., Ricciardelli, E., Scodeggio, M.,Silverman, J., Tanaka, M., Tasca, L., Tresse, L., Vergani, D., Zamorani, G., Zucca, E. + **S. Lilly (P.I.)**

plus about 15 others in these institutions who are not reducing data

Wealth of data available al low z



Baldry et al., ApJ, 2006

Wealth of data available al low z

Need to move to high-z to trace the growth of observed low-z trends and shed light on their origin

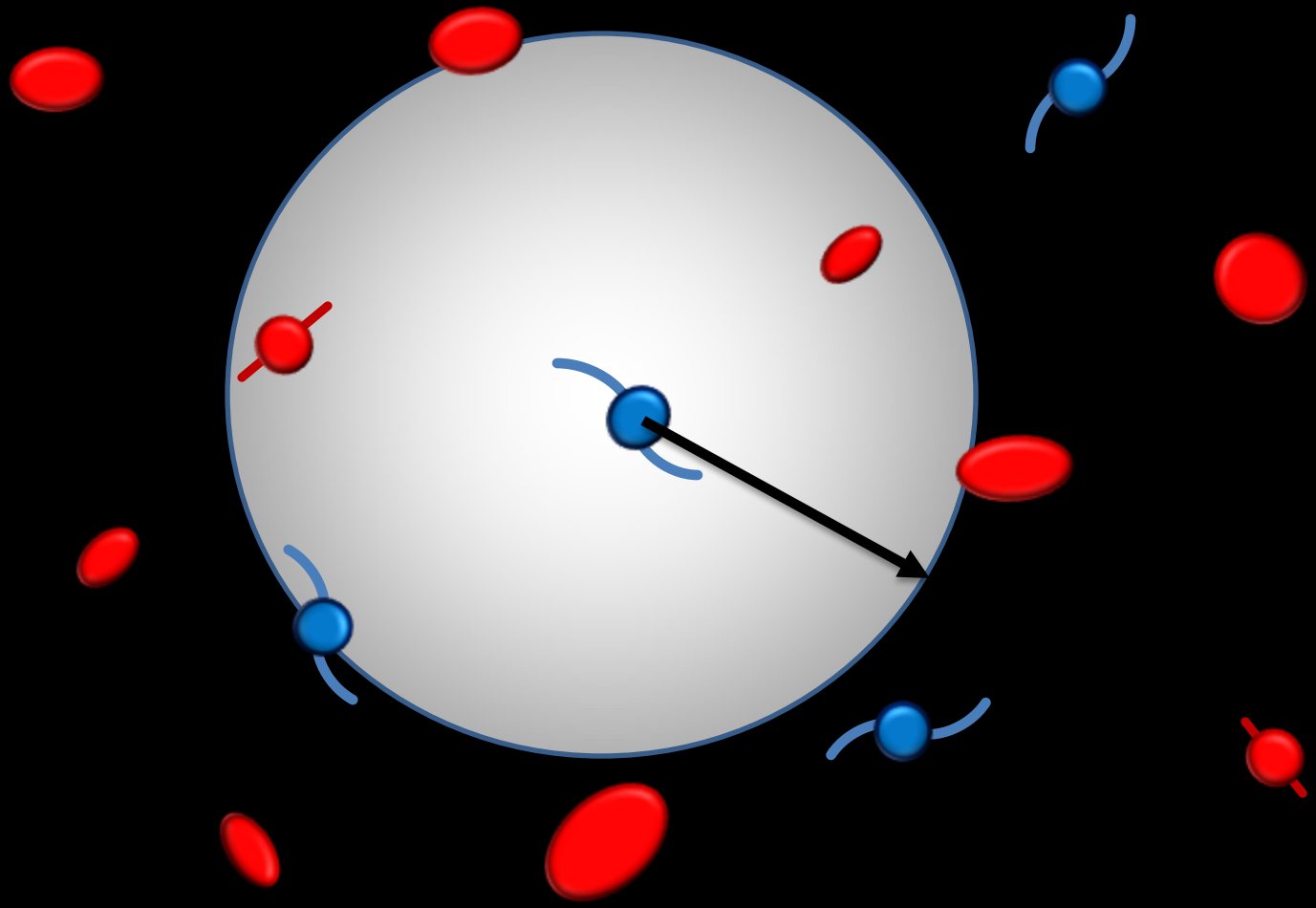
Galaxy Evolution and Environment

How to parametrize environment ?

First strategy:

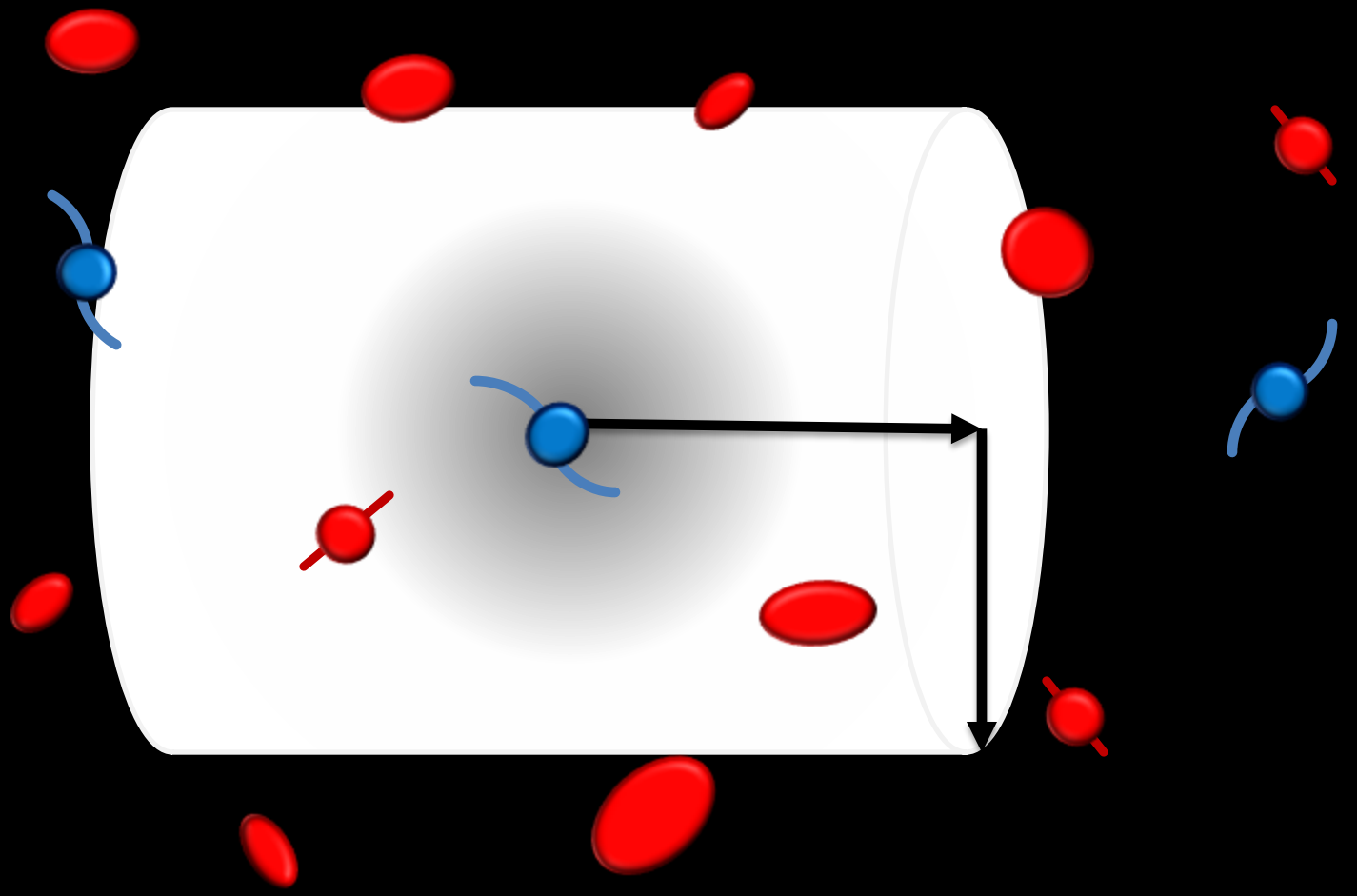
simply counting galaxies ....

3-D comoving spheres/gaussians ...



Cucciati, Iovino, Marinoni et al. 2006

Cilinders, ie in projection ...



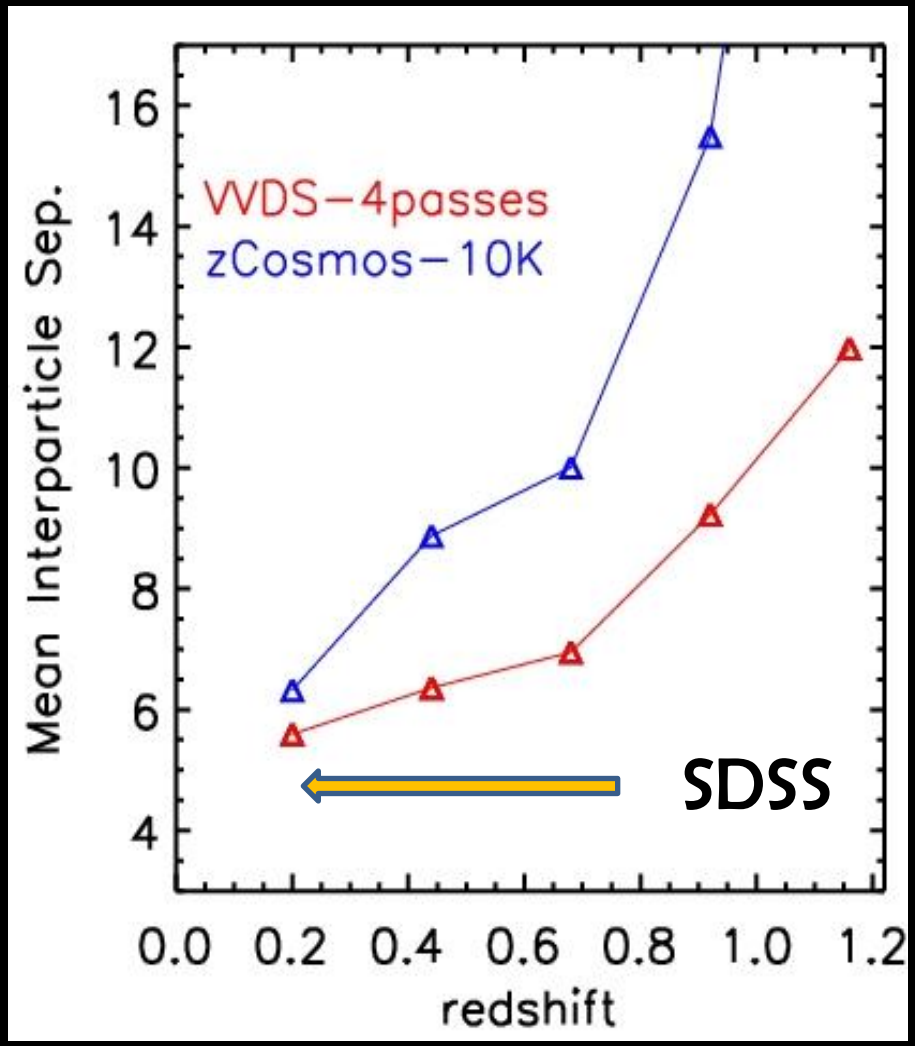
Long enough to account for vel disp in rich structures
(+/- 1000 km/sec)

We used projected counts and the 5th Nearest Neighbour

Advantage: it is adaptive

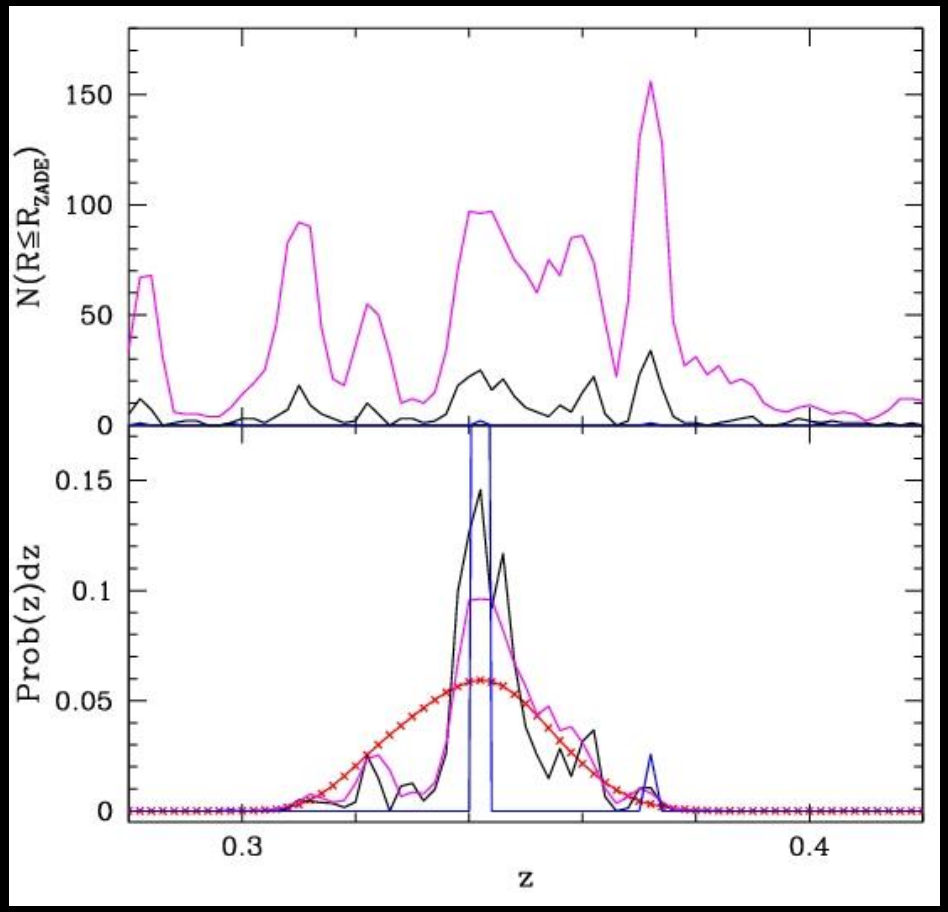
However scales probed are much larger than those of local surveys

Lower sampling rates
+
brighter galaxies



Can we use phot-z info ?

Zade is a novel approach introduced in zCOSMOS



Modify the continuous phot-z probability distribution into a discrete distribution using the high precision spectroscopic redshifts of nearby galaxies .

Kovac, Lilly, Cucciati et al. 2009

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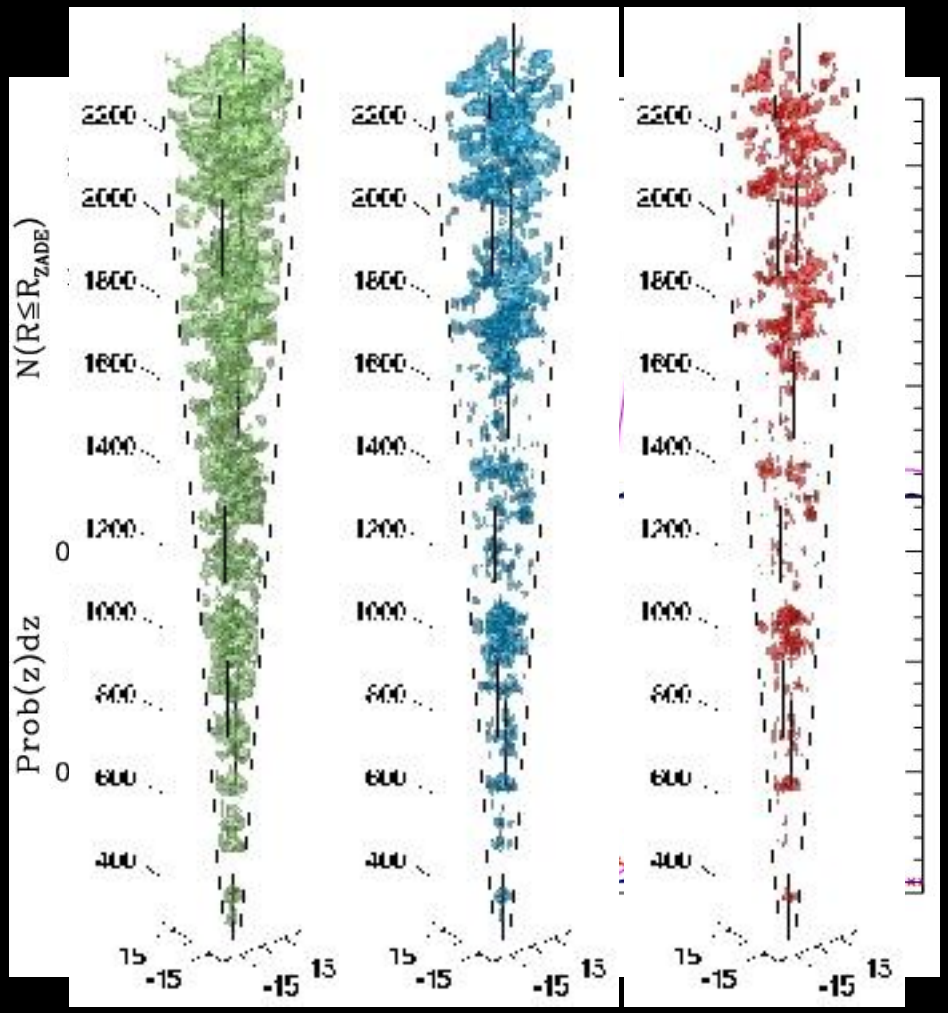


Modify the continuous phot-z probability distribution into a discrete distribution using the high precision spectroscopic redshifts of nearby galaxies .

Kovac, Lilly, Cucciati et al. 2009

Which tracer to use:
Flux limited or Volume Limited?

Weight galaxies using a sensible physical quantity as Mass ?

We explored the different possibilities ...

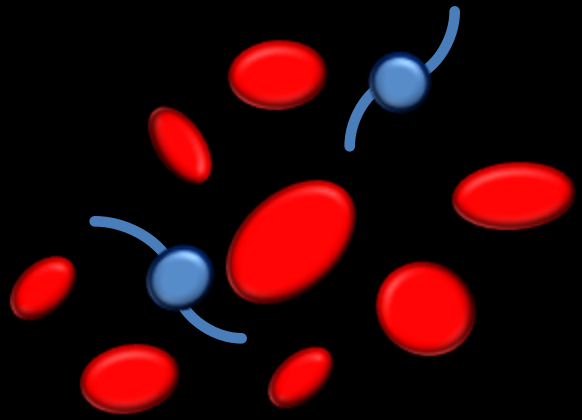
Caution – If the central galaxy is included in density measurements, using mass for weighting may introduce introduce spurious dependencies.

Kovac, Lilly, Cucciati et al. 2009

How to parametrize environment ?

Alternative choice:

Go for (hopefully)
virialized structures :
groups, clusters ...



... and compare with generic field environment
or, better, with isolated galaxies !

Moving to groups/clusters

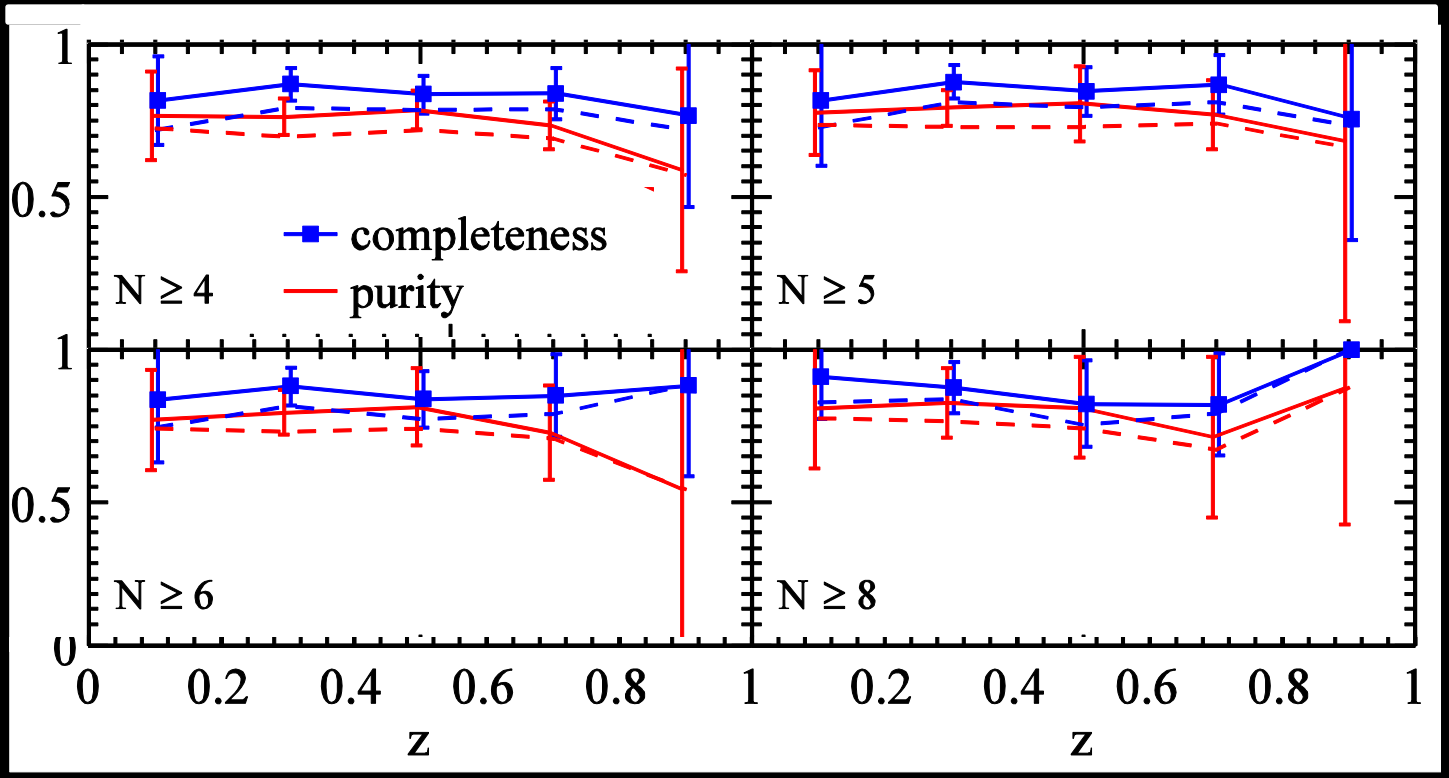
Advantages :

Groups are adaptive by definition, allowing to reach smaller phsyical scales;

Groups are long lived structures (long time-scales involved)

Within groups environmental effects (if any) are expected to take place.

Moving to groups/clusters



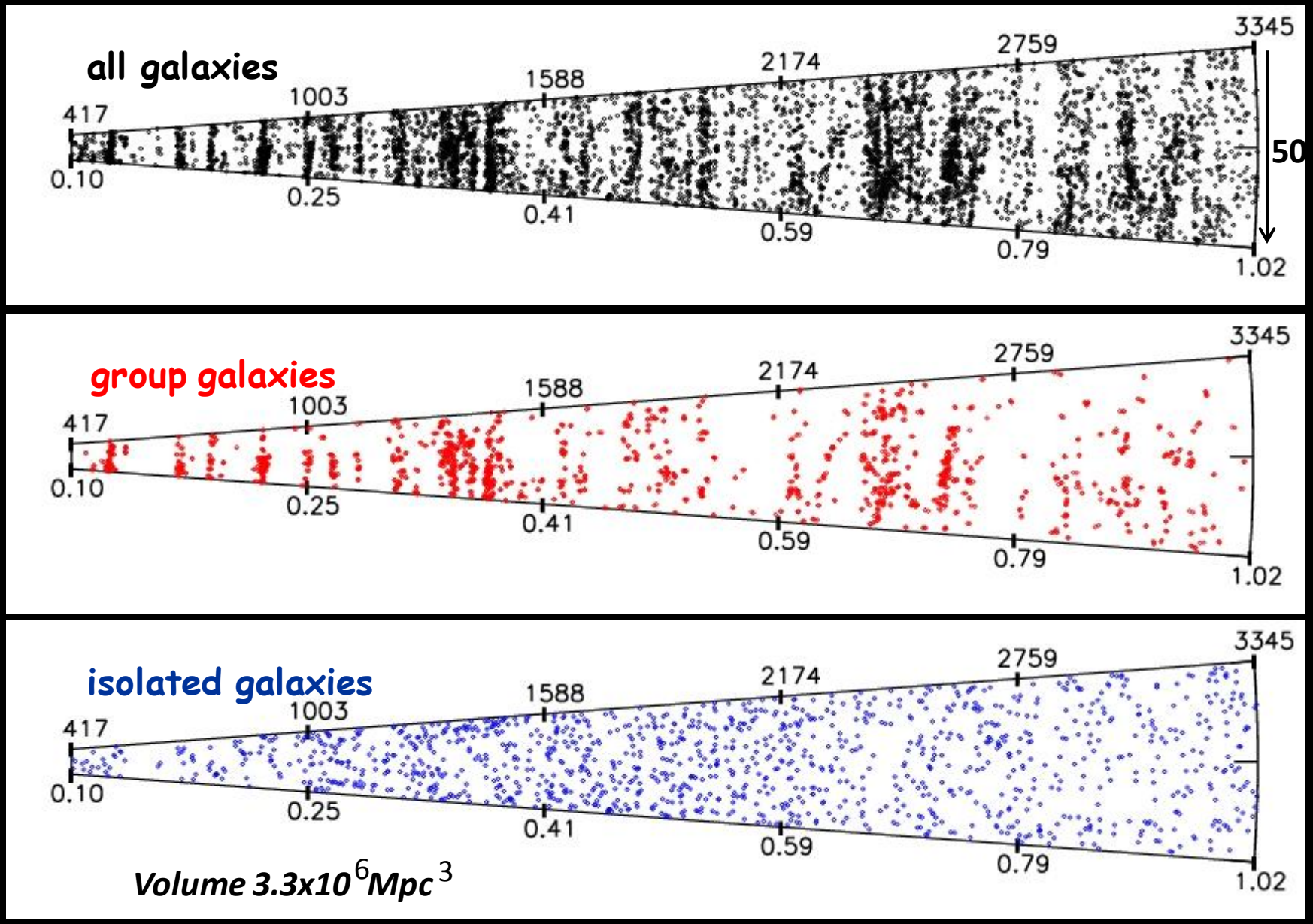
zCOSMOS Group Catalogue

108 groups with N≥5 In 10K sample

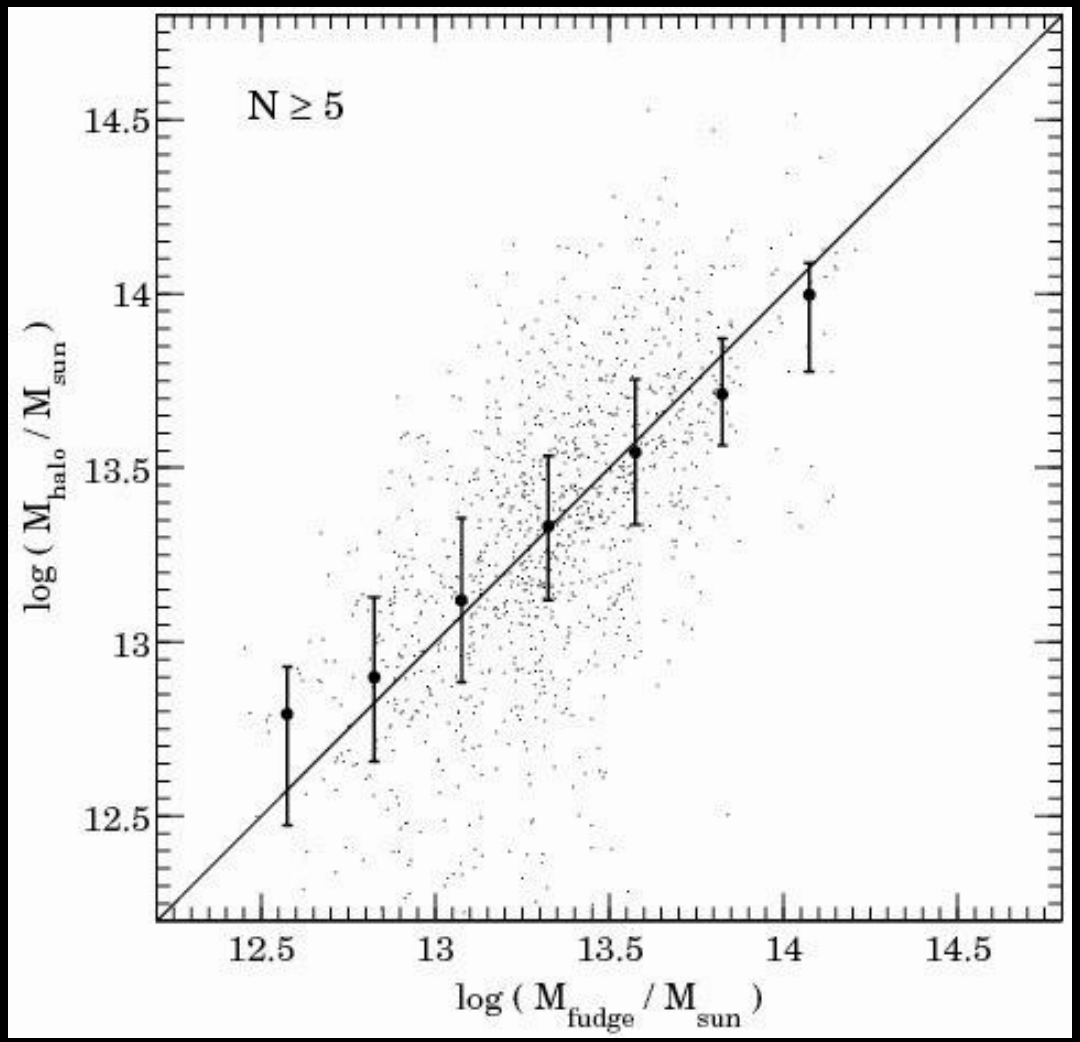
Using FoF +VDM and a multipass approach, purity and completeness values are always abov 80% for N≥5groups, and not substantially worse for N <5.

Knobel, Lilly, Iovino et al.,ApJ, 2009

Moving to groups/clusters



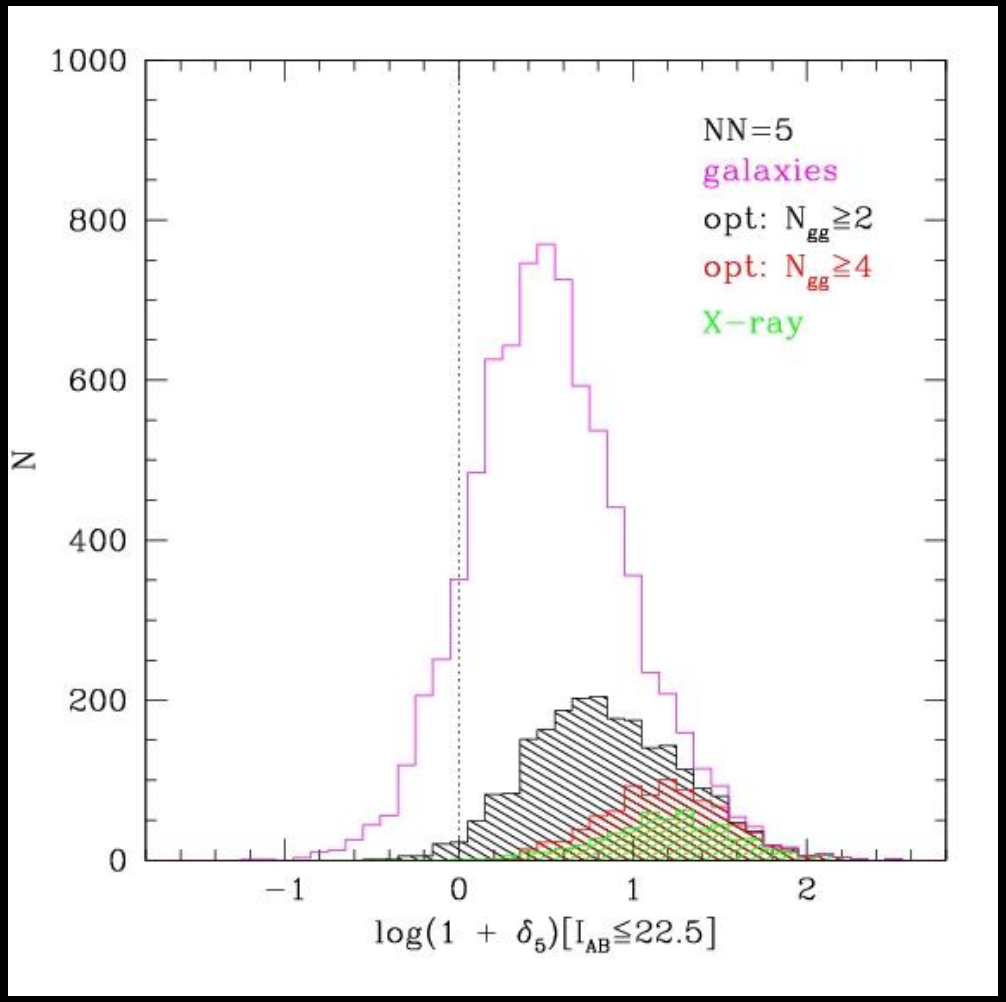
Moving to groups/clusters



Using simulations is is possible to calibrate a reasonably good relationship btween *fudge* mass - estimated using group richness as mass proxy - and group Halo mass.

Knobel, Lilly, Iovino et al.,ApJ, 2009

Moving to groups/clusters



Good agreement between the two estimators ...

... but getting worse at high-z !

Kovac, Lilly, Cucciati et al. 2009

Simulations can help!

We need to explore which of the various choices better correlate with parameters like eg halo mass, expected to influence the properties of hosted galaxies

Galaxy Evolution and Environment

How to parametrize galaxy evolution ?

(U-B) color is the simplest indicator, but morphology, and spectral diagnostics are all equally important alternatives; mass function is another important parameter to consider

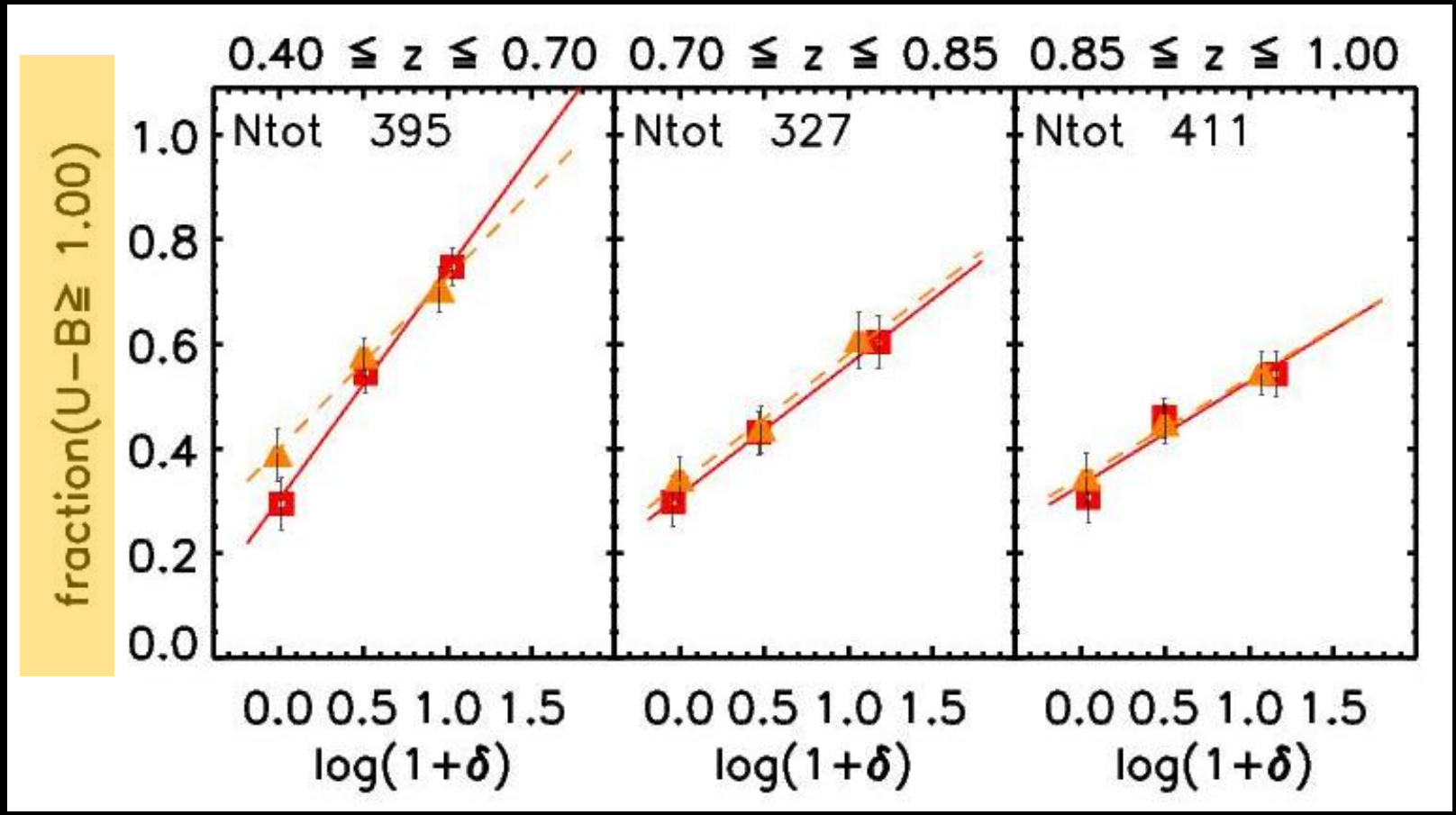
Galaxy Evolution and Environment

Which galaxy samples to use to explore evolution ?

B-band rest frame (evolving) volume limited samples is a classical choice. I-band, K-band and mass limited samples have been used recently.

Galaxy Evolution and Environment

Volume limited luminosity selected sample $M_B < -20.5 - z$



Redshift bins ⟶

Cucciati, Iovino, Kovac et al. , AA, 2009

Galaxy Evolution and Environment

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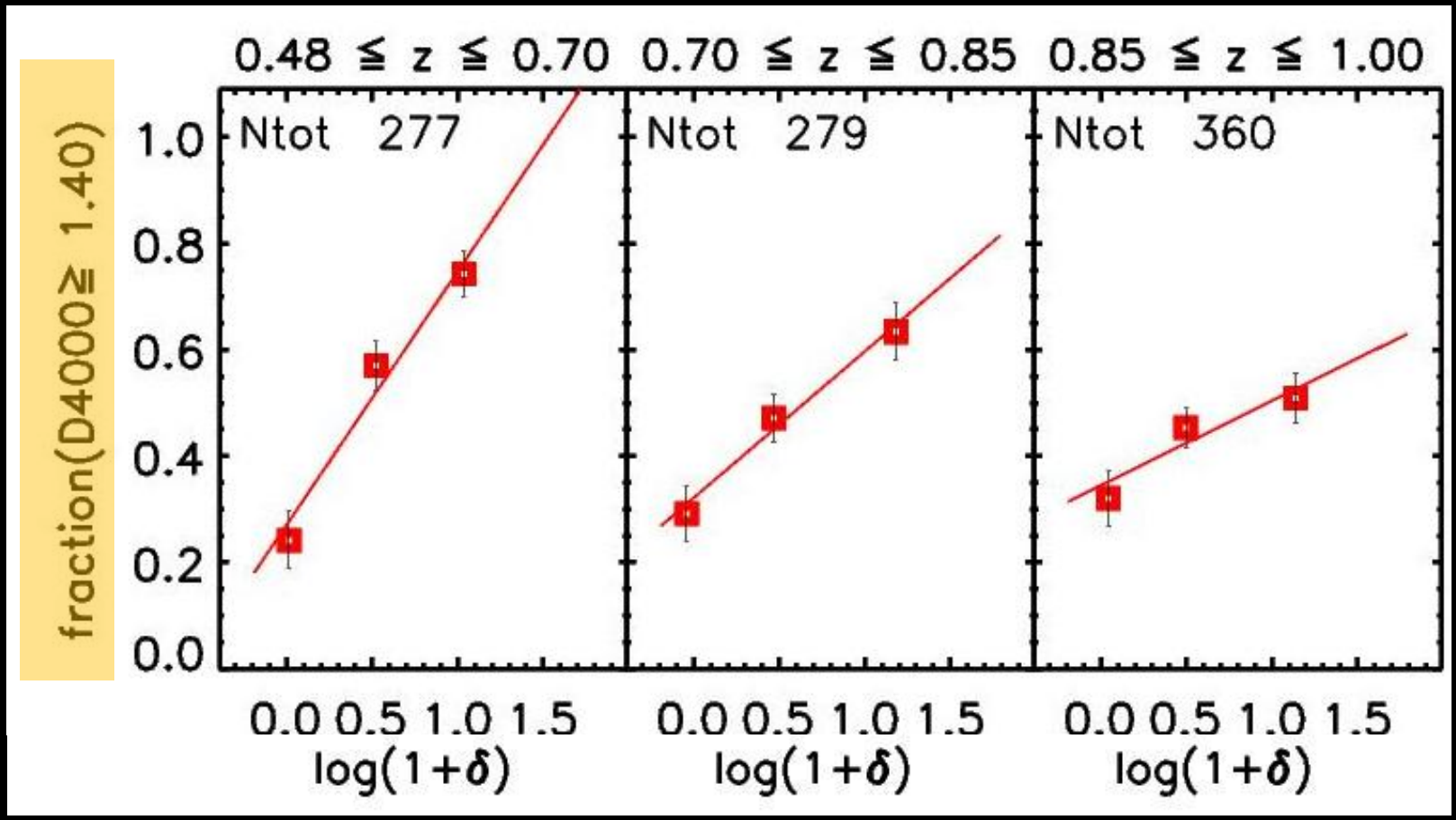

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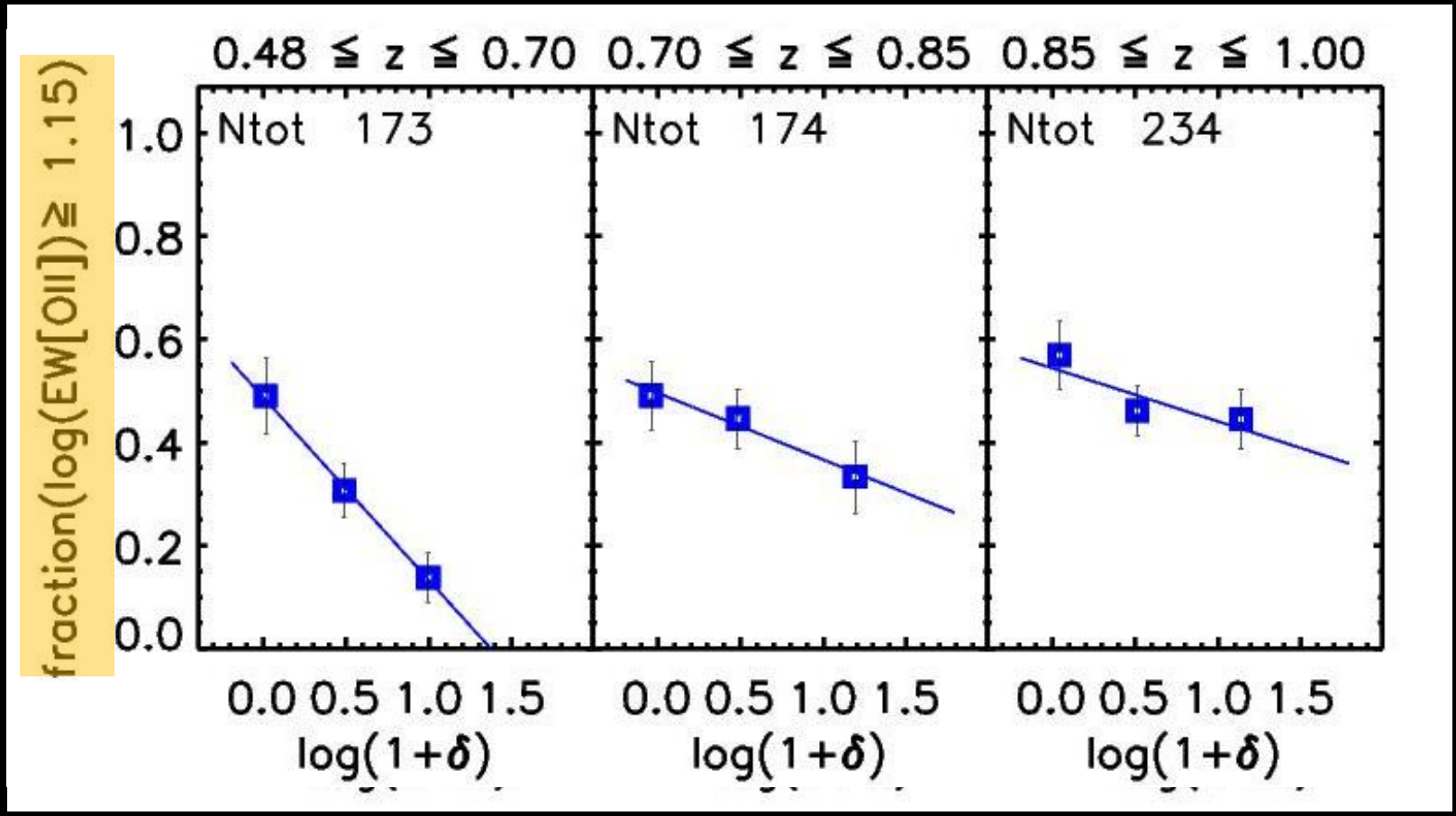
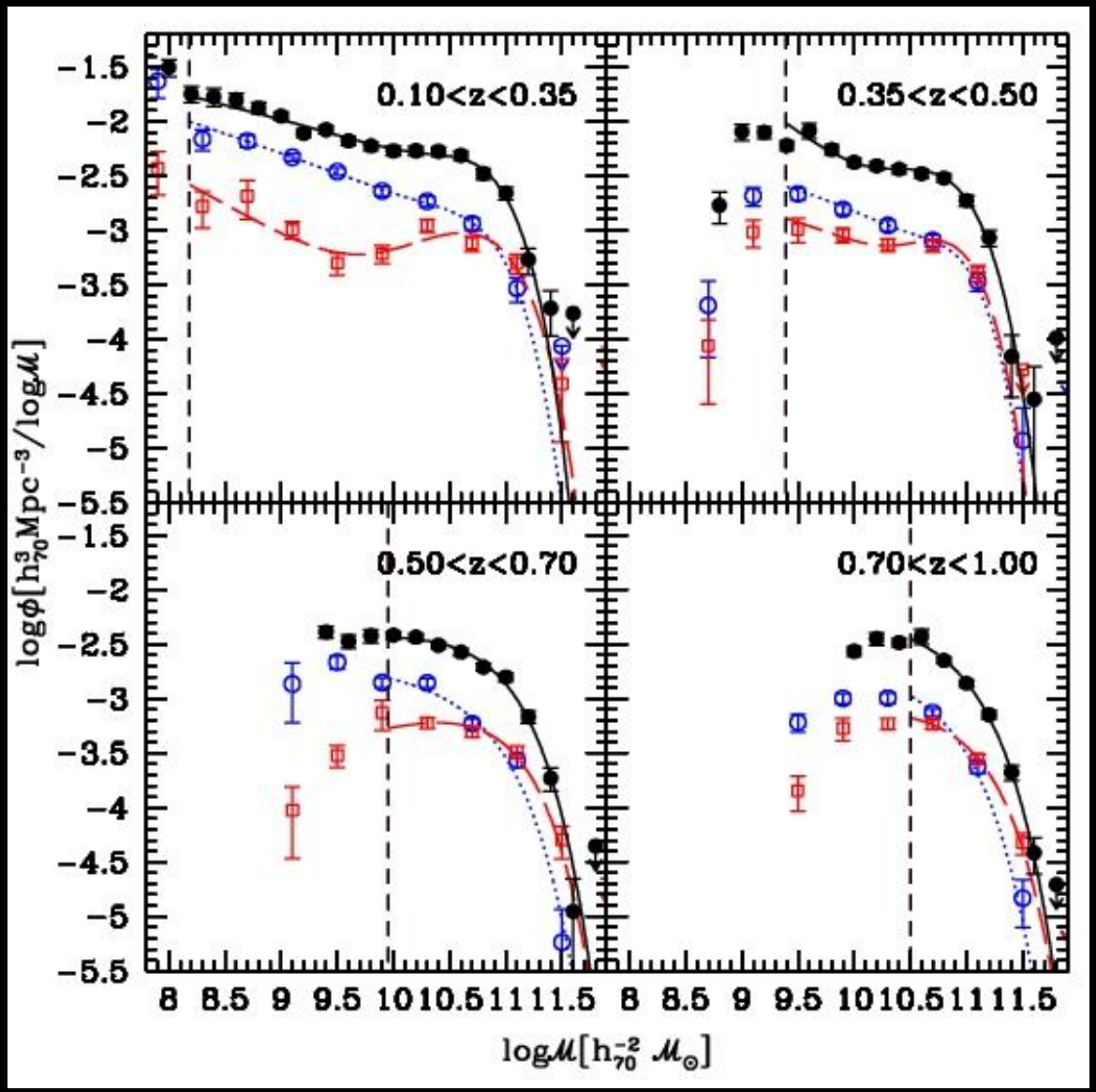


Cucciati, Iovino, Kovac et al. , AA, 2009

Galaxy Evolution and Environment



Galaxy stellar mass function in lowest and highest density quartiles

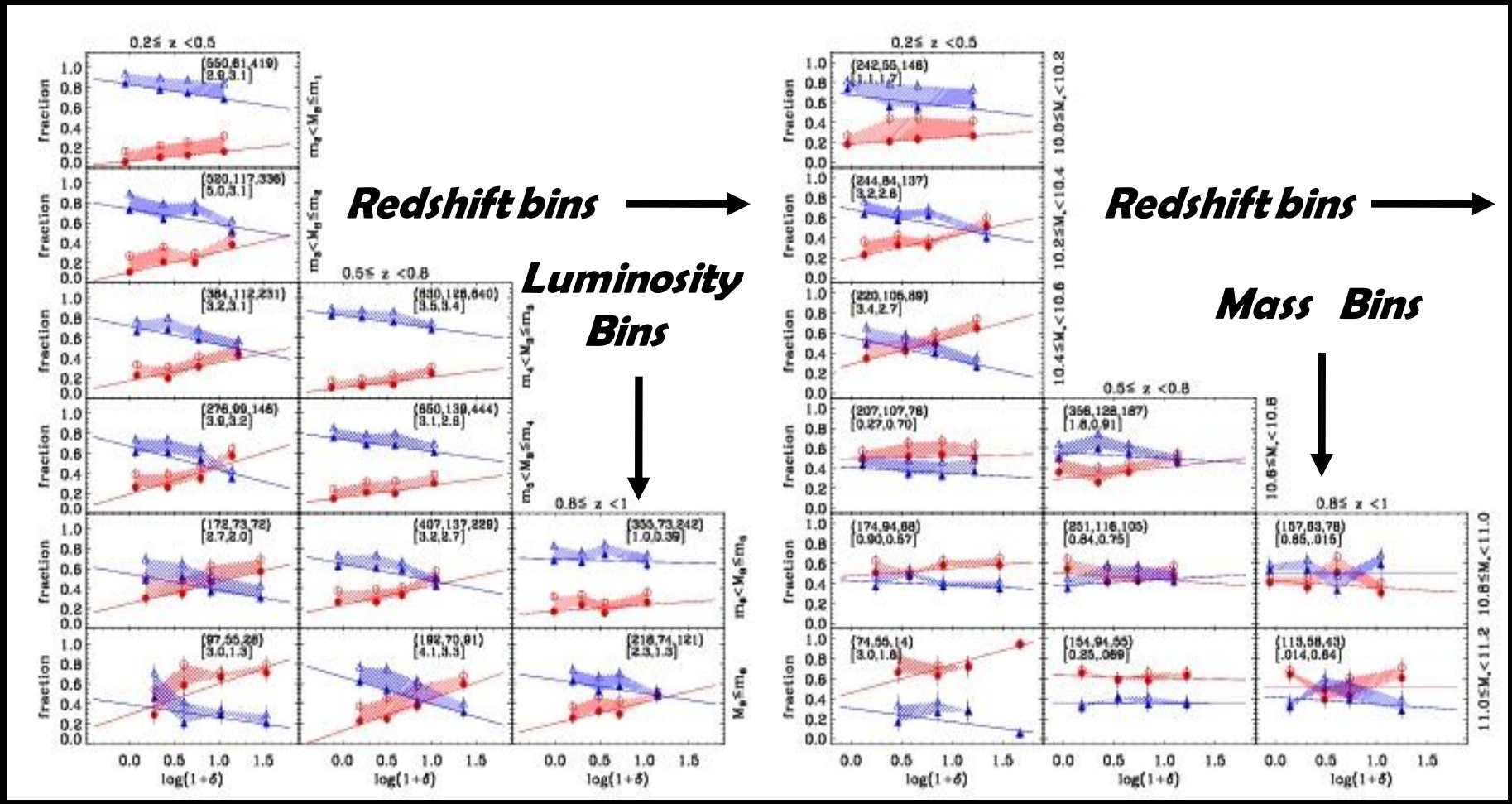
Bolzonella, Kovac, Pozzetti et al. , AA, 2009
Pozzetti, Bolzonella, Zucca et al., AA, 2009

Different mass distribution of galaxies with environment

Caution – subtle biases can affect the analysis whenever there is a sample of galaxies that contains a range of stellar masses !

It is difficult to distinguish between environment dependent trends and environment driven trends !

Moving from luminosity bins to mass bins ... one sees a different picture!



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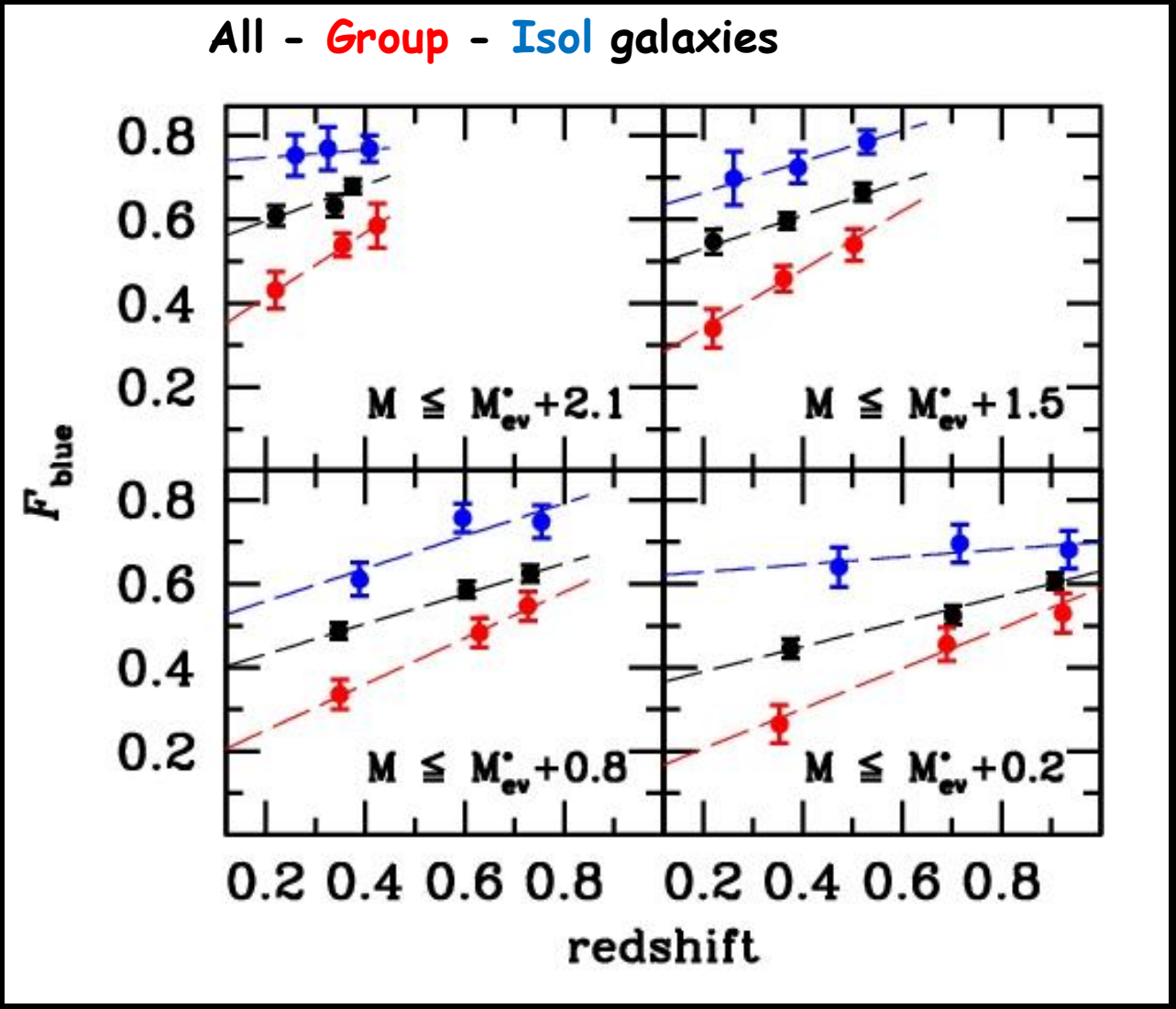

Comparing colors in volume limited and mass limited samples

Iovino, Cucciati, Scodeggio et al, 2009

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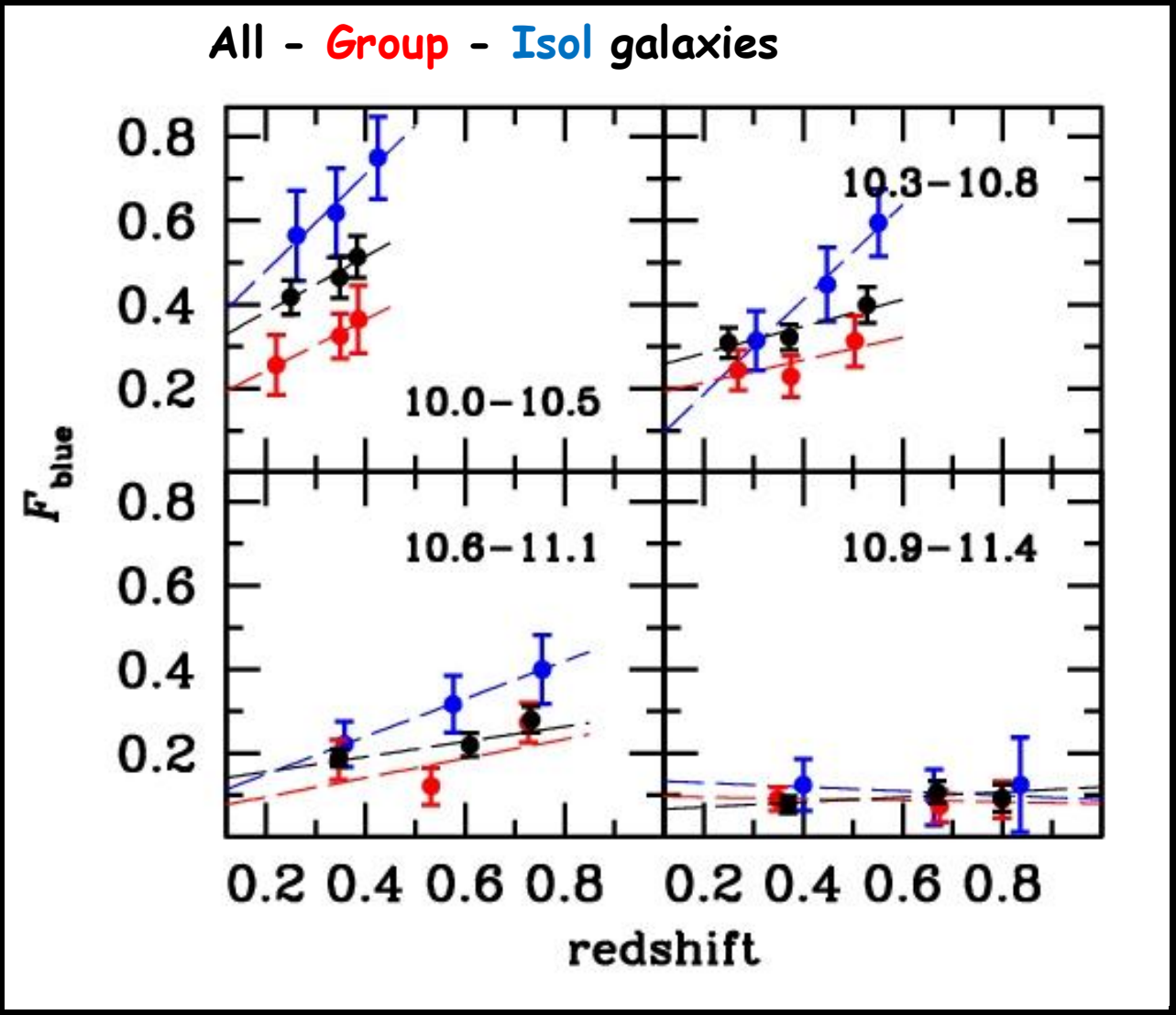
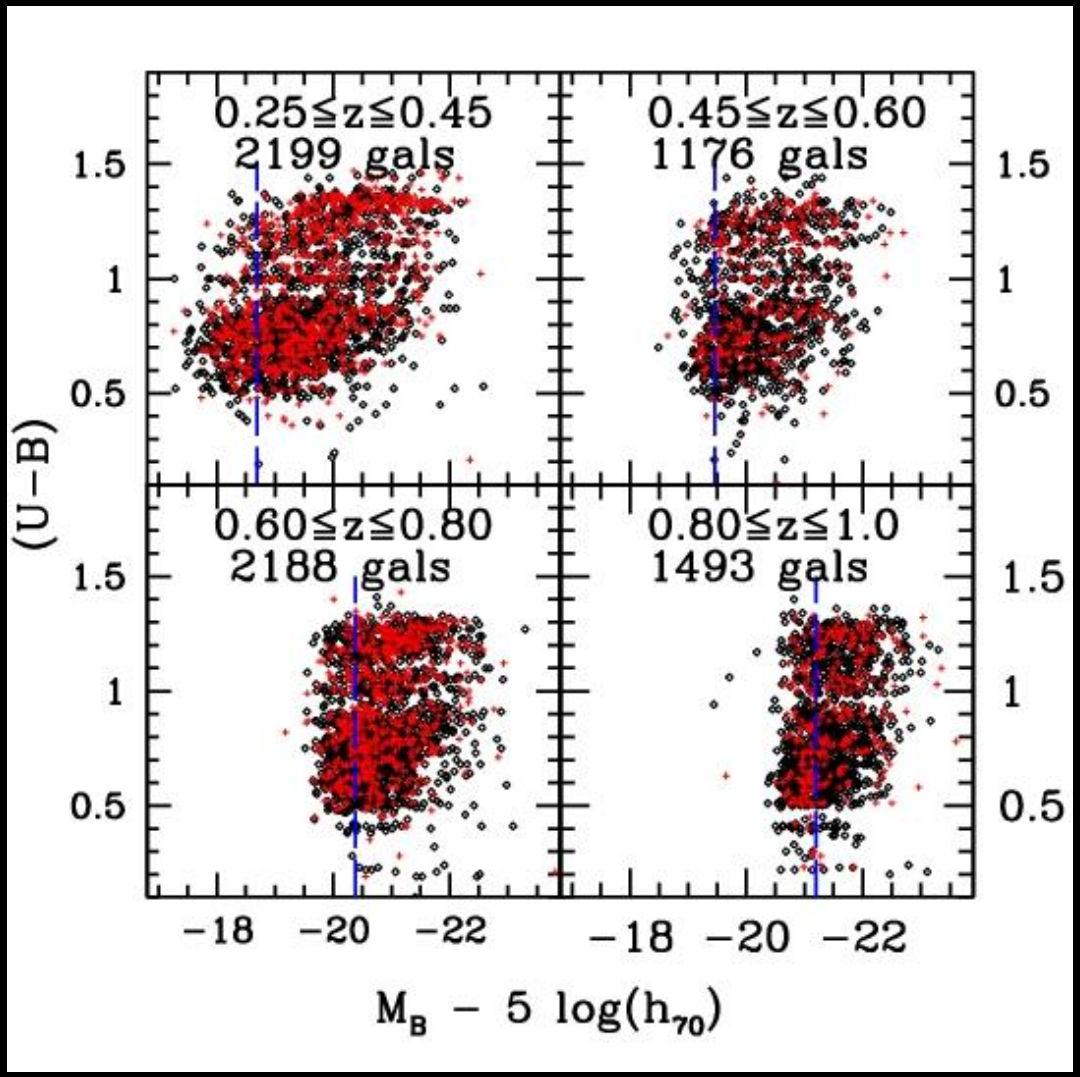


Comparing colors in volume limited and mass limited samples

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

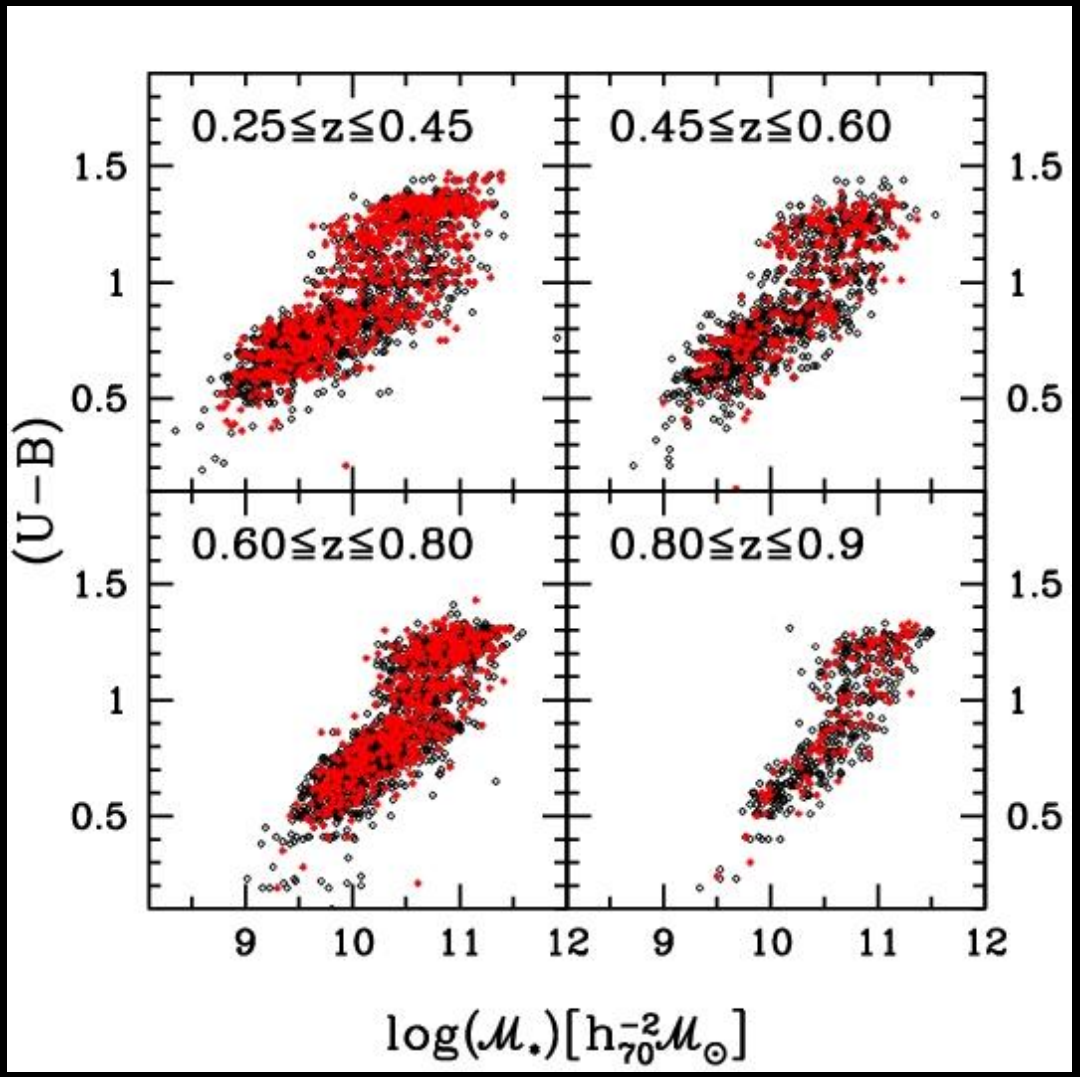
Iovino, Cucciati, Scodeggio et al, 2009

Moving from luminosity bins to mass bins ... one sees a different picture!



Moving from B-band selection ...

Moving from luminosity bins to mass bins ... one sees a different picture!



Moving from B-band selection to mass selection ...

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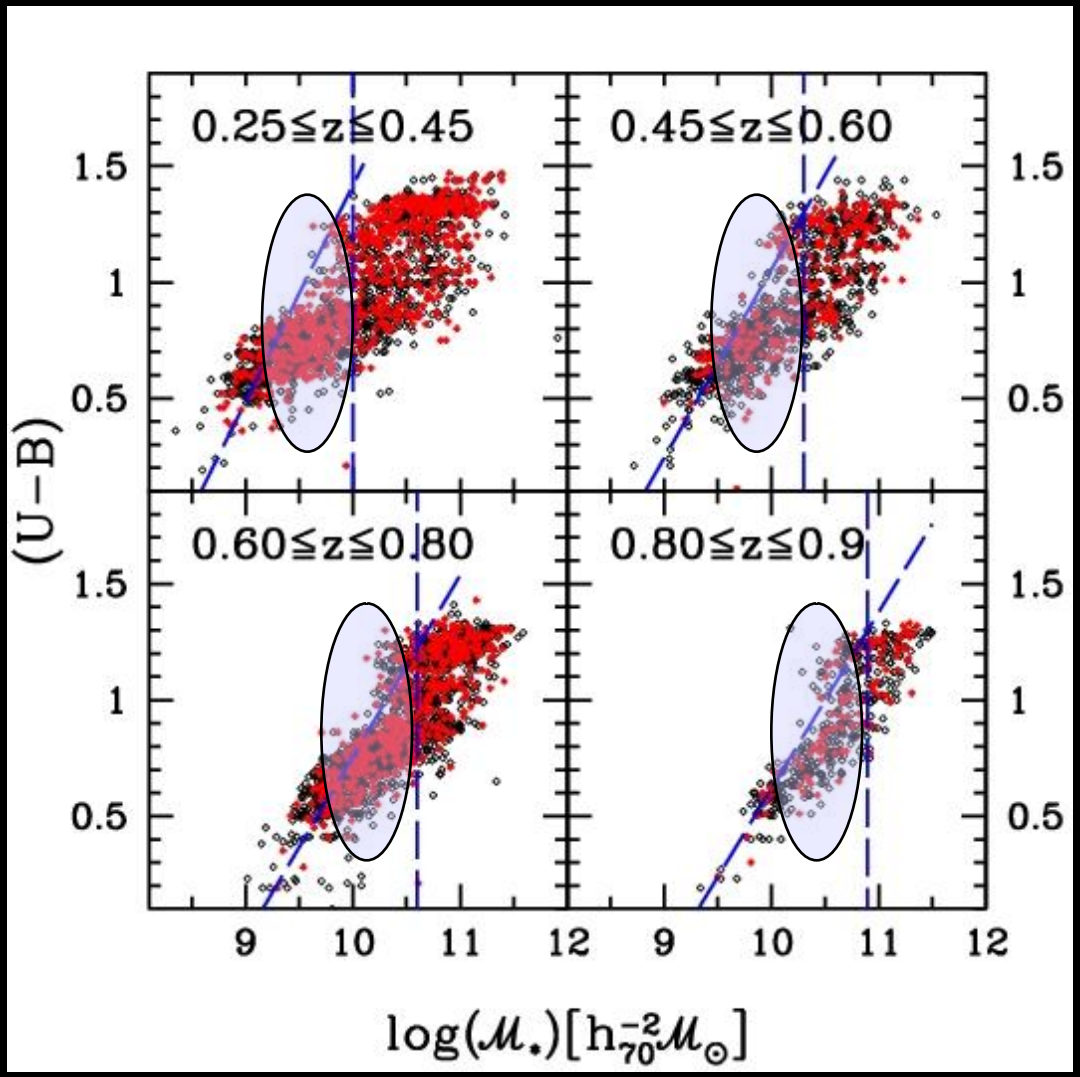
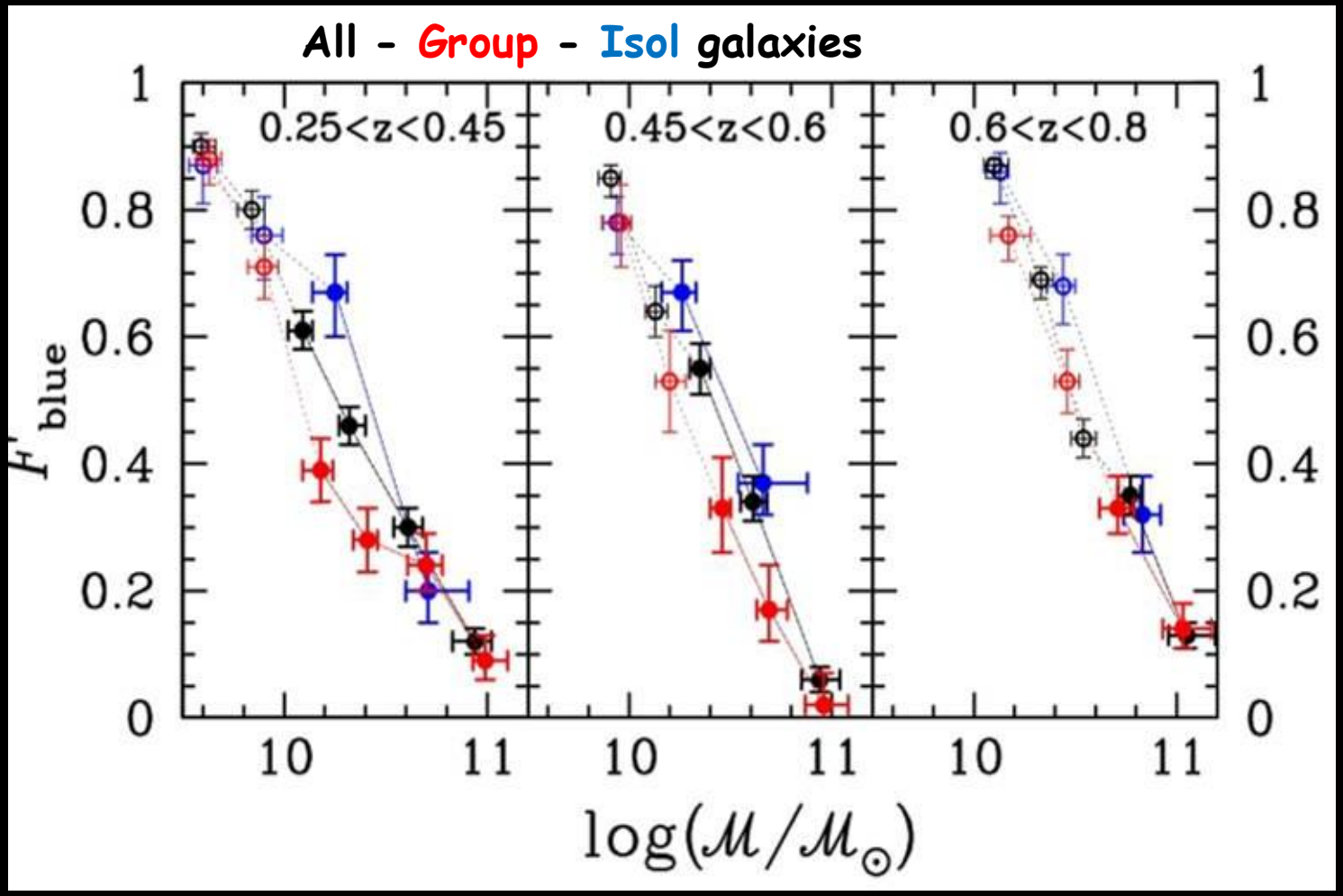


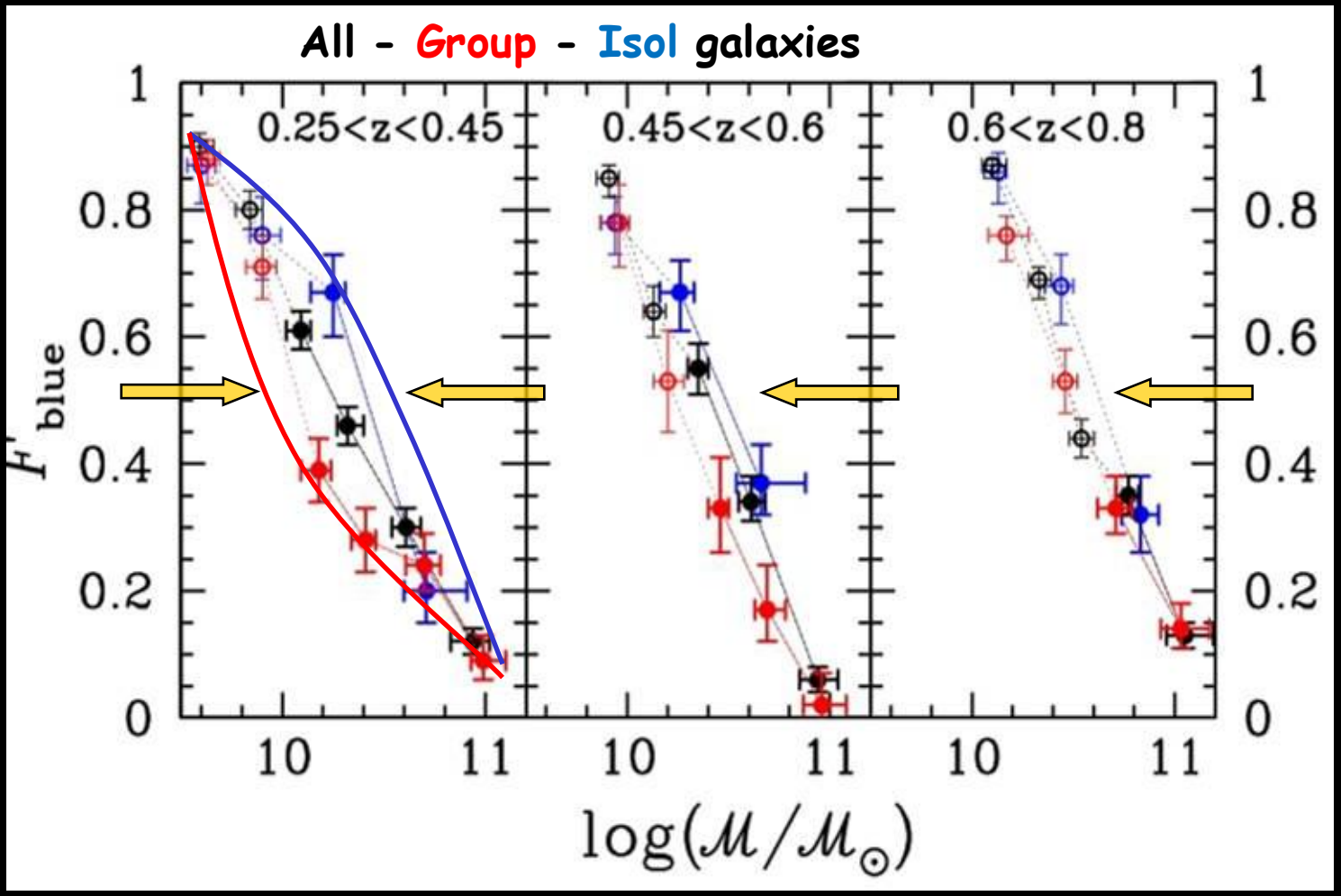
... suggesting that blue, lower mass galaxies are responsible for the stronger trends seen in luminosity selected samples.

Biased view resulting from the B luminosity selection!

Working in restricted mass bins

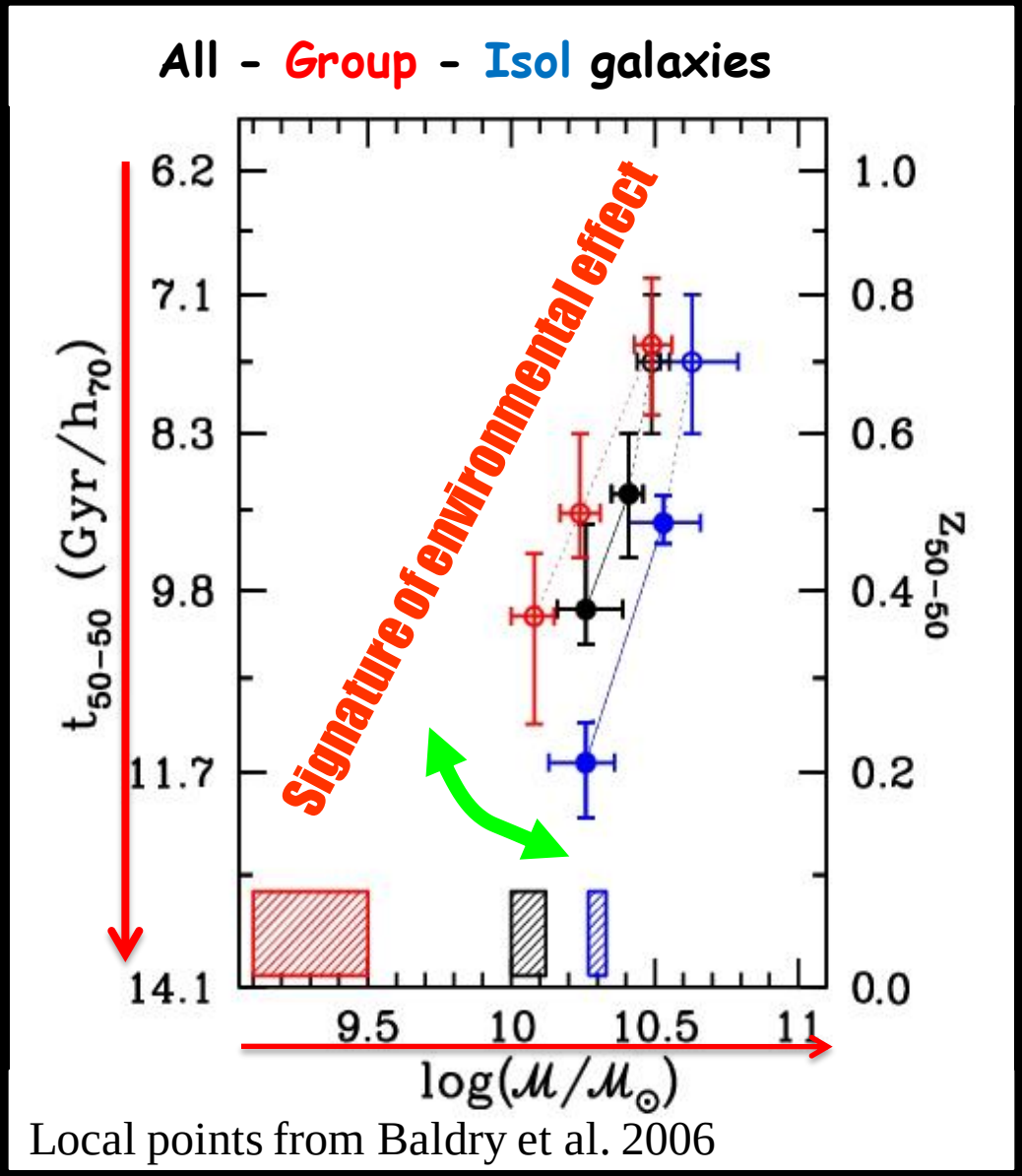


At fixed redshift: Fb →1 for more massive galaxies while Fb → 0 for lower mass galaxies irrespective of environment.



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

The emerging picture ...

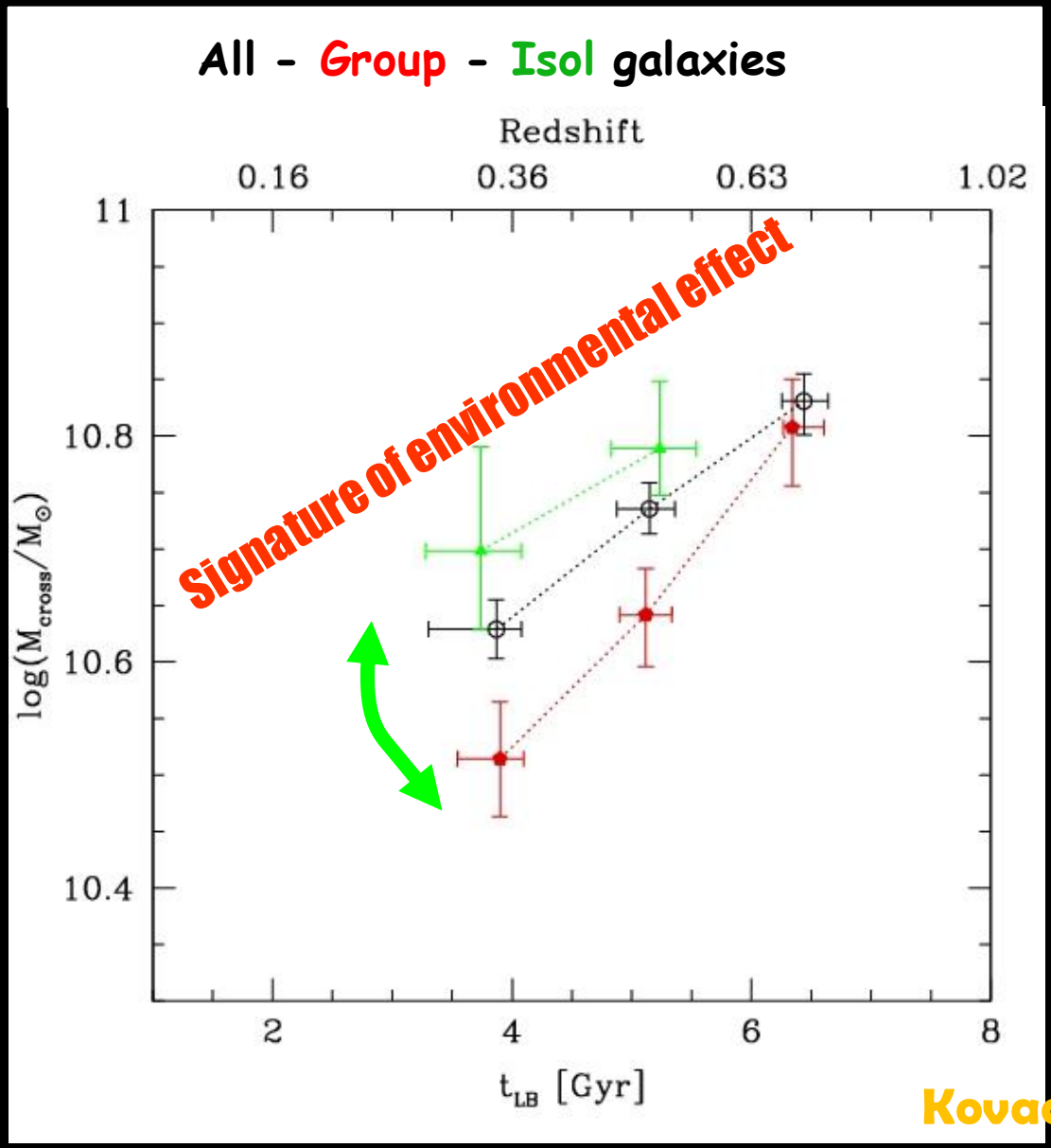


Local points from Baldry et al. 2006

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

Iovino, Cucciati, Scodeggio et al, 2009

The emerging picture ...

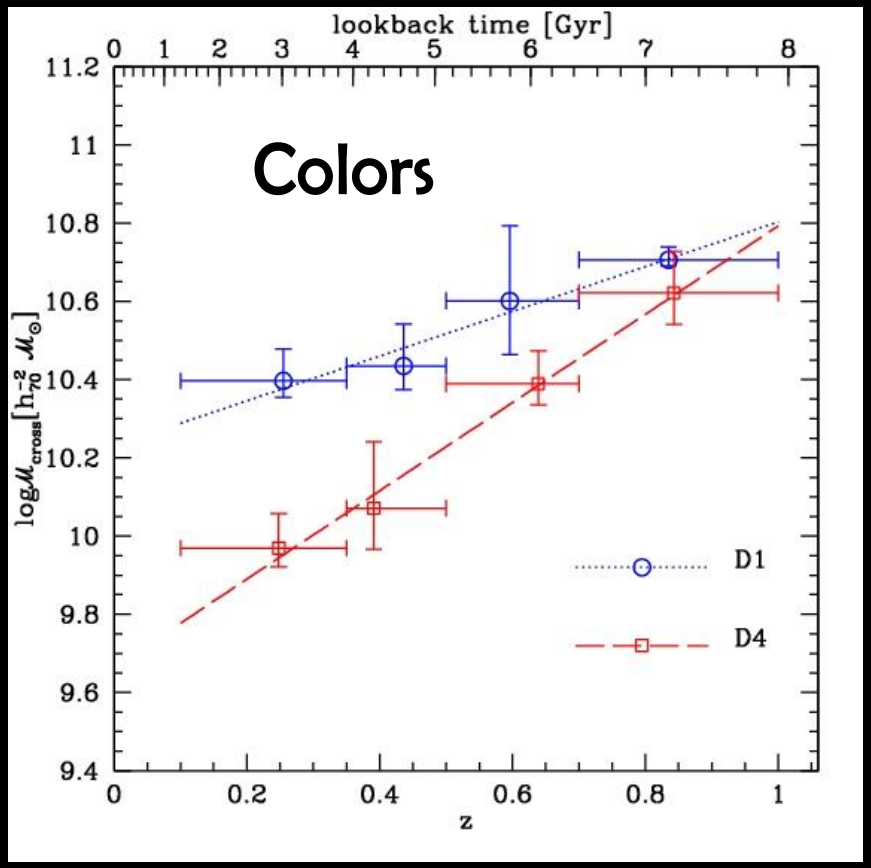


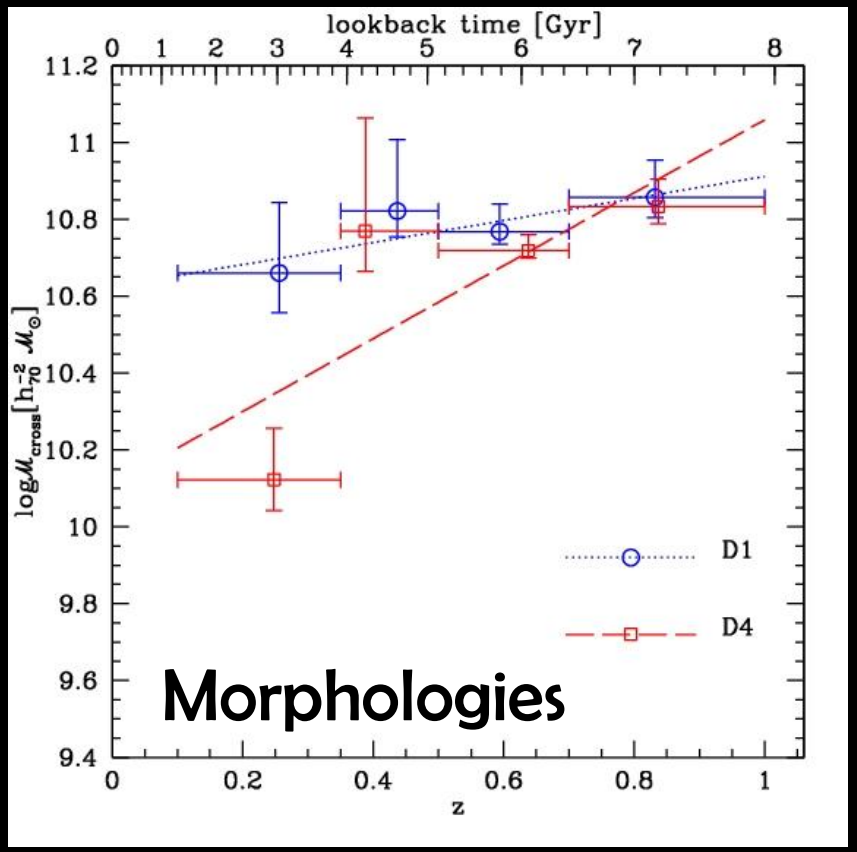
The same holds for the morphological transition from late to early galaxies

But the timescales for morphological transformations are longer with respect to those for color transformations

Kovac, Lilly, Knobel et al, ApJ, 2009

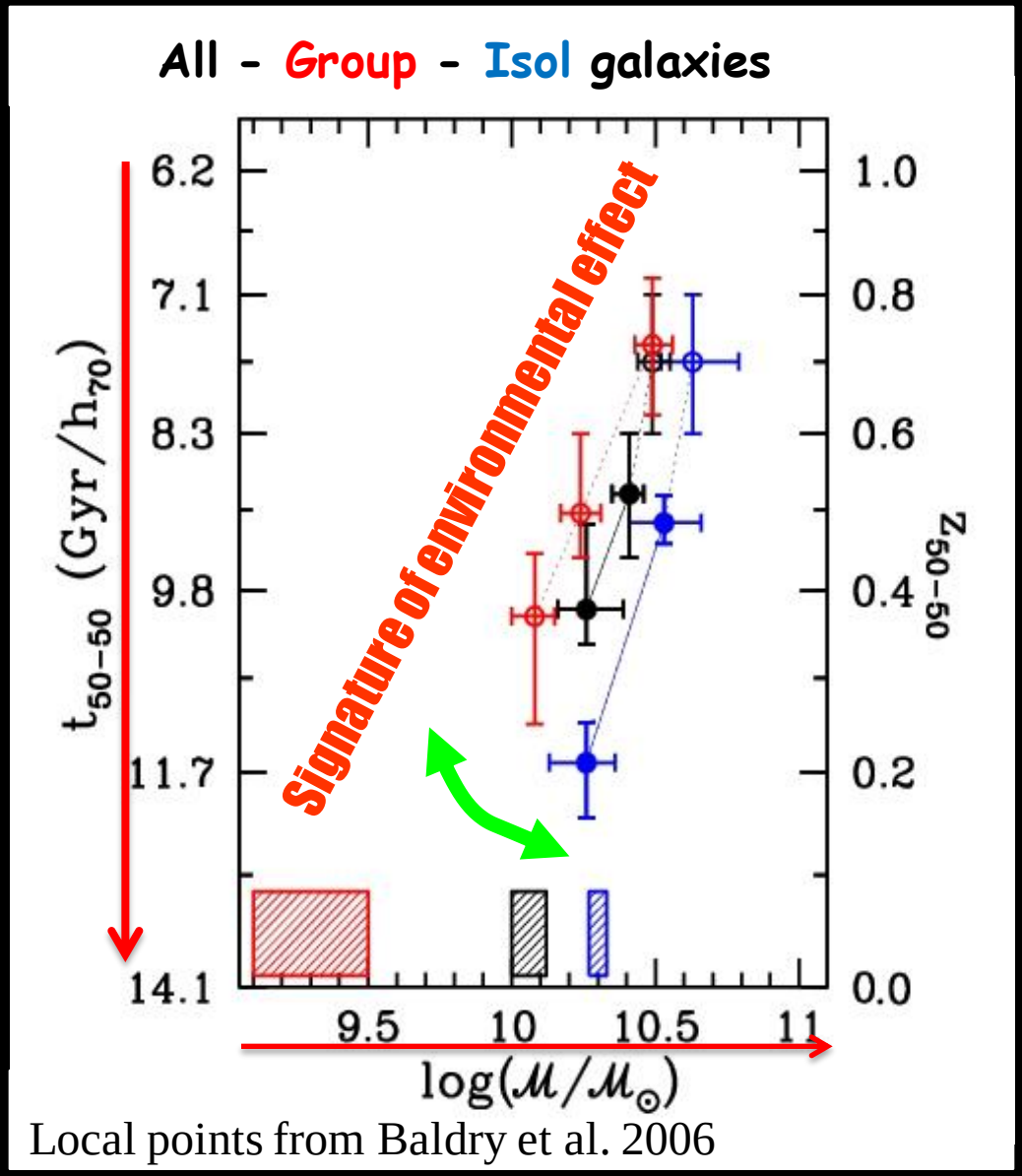
Identical results are obtained using mass function formalism and the extreme quartiles in the density distribution





Bolzonella, Pozzetti, Zucca et al, AA, 2009

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



Local points from Baldry et al. 2006

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.

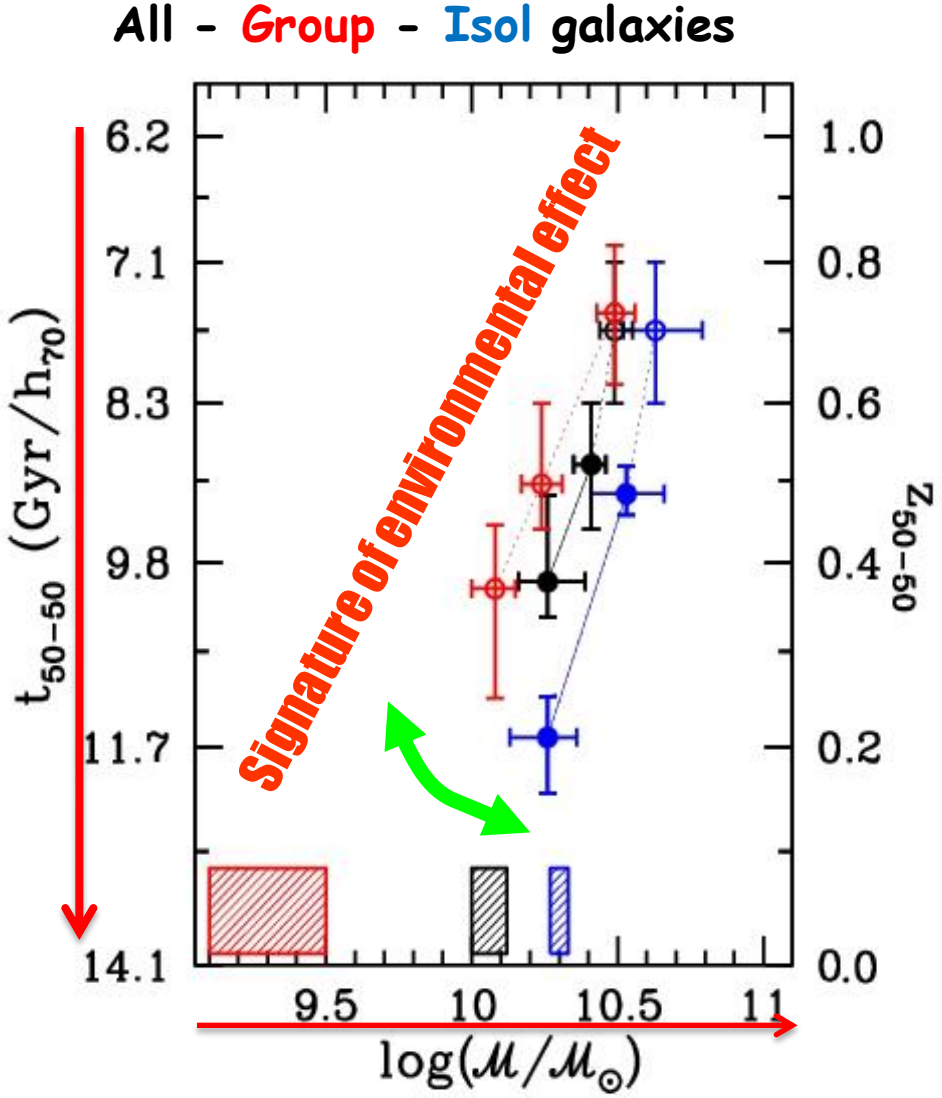
Summary of main results

1 - need to move to mass selected samples in order to avoid the biased view imposed by the luminosity selection

2 - need to work in mass bins in order to avoid the further complication due to mass environment relations that can create artificial trends with environment

3 - the emerging picture in consistent with 'downsizing' scenario modulated by environment.

Summary of main results



Local points from Baldry et al. 2006

1 – massive galaxies already in place at z ~1 and do not show dependence on environment

2 –at z<1 *nurture* red galaxies emerge, showing the signature of environmental effects

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