THE GALAXY STELLAR MASS FUNCTION IN DIFFERENT ENVIRONMENTS AND ITS TIME EVOLUTION

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January, 12th 2012 - INAF-Bologna

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in collaboration with:

- Bianca M. Poggianti
- Giovanni Fasano
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- Alan Dressler
- EDisCS, ICBS and WINGS teams

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Outline

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- Samples used
- The mass function in different global environments
- The evolution of the mass function in different global environments
- The mass function in different local environments
- Summary
- + SFR-Mass relation in clusters

Samples used @ low-z

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WIde field Nearby Galaxy-cluster Survey (WINGS - Fasano+ 2006):

- 0.04<z<0.07
- Spectroscopic data of 21 clusters
- Morphologies determined on V images, automatic classification with MORPHOT (Fasano+ 2011)
- Stellar masses determined using the relation between L_B and B-V color (Bell & De Jong 2001), Kroupa (2001) IMF adopted
- Mass limited sample, limit: $\log(M/M_{sun})>9.8$
- Local density computed from the circular area containing the 10 nearest projected neighbors, for members with $M_V<=-19.5$

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Padova Millennium Galaxy Group Catalog (PM2GC - Calvi+ 2011):

- $0.04<z<0.1$
- Spectroscopic data of ~$38deg^2$ from the Millennium Galaxy Catalog
- Rich sample of groups, binary systems and isolated galaxies
- Stellar masses determined using the relation between L_B and B-V color (Bell & De Jong 2001), Kroupa (2001) IMF adopted
- Mass limited sample, limit: $\log(M/M_{sun})>10.25$
- Local density computed from the circular area containing the 5 nearest projected neighbors within +/- 1000 km/s, for galaxies with $M_V<=-19.85$

Samples used @ higher-z

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IMACS Cluster Building Survey (ICBS - Oemler+ 2012):

- 0.25<z<0.5
- Spectroscopic data of clusters, groups and field
- Stellar masses determined using the relation between L_B and B-V color (Bell & De Jong 2001), Kroupa (2001) IMF adopted
- Mass limited sample, limit: $\log(M/M_{sun})>10.5$
- Local density computed from the rectangular area containing the 5 nearest projected neighbors, for members with r<=22.5. For field galaxies, neighbors within +/- 1000 km/s have been considered.

Samples used @ higher-z

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- Local density computed from the rectangular area containing the 5 nearest projected neighbors, for members with r<=22.5. For field galaxies, neighbors within +/- 1000 km/s have been considered.

ESO Distant Cluster Survey (EDisCS - White+ 2005):

- $0.5<z<0.8$
- Spetroscopic and photo-z data of clusters and groups
- Morphologies determined using HST images, visual classification
- Stellar masses determined using the relation between L_B and B-V color (Bell & De Jong 2001), Kroupa (2001) IMF adopted
- Mass limited sample, limit: $\log(M/M_{sun})>10.2$
- Local density computed from the circular area containing the 10 nearest projected neighbors, for members with $M_V<=-20$

WHICH IS THE RELATION BETWEEN MASS AND ENVIRONMENT?

The MF in different global environments

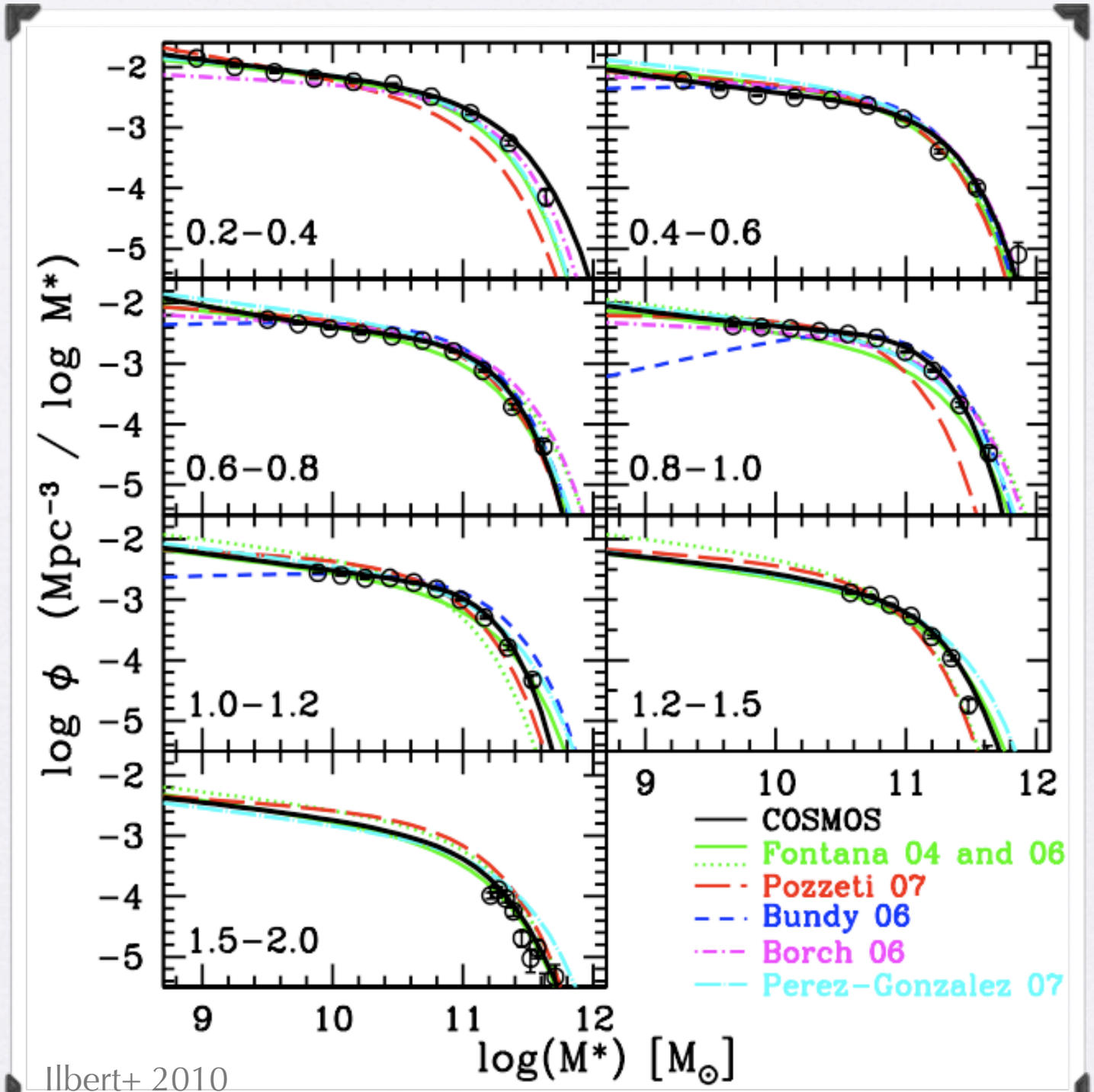
The MF in the field

The MF in the field

(e.g. Fontana+ 2006, Bundy+ 2006, Franceschini+ 2006, Borch+ 2006, Vergani+ 2008, Pozzetti+ 2009, Bolzonella+ 2010)

For high mass galaxies, the evolution of the total mass function from $z = 1$ to $z = 0$ is relatively modest

Low mass galaxies evolve more then high mass galaxies



Ilbert+ 2010

The MF in the field

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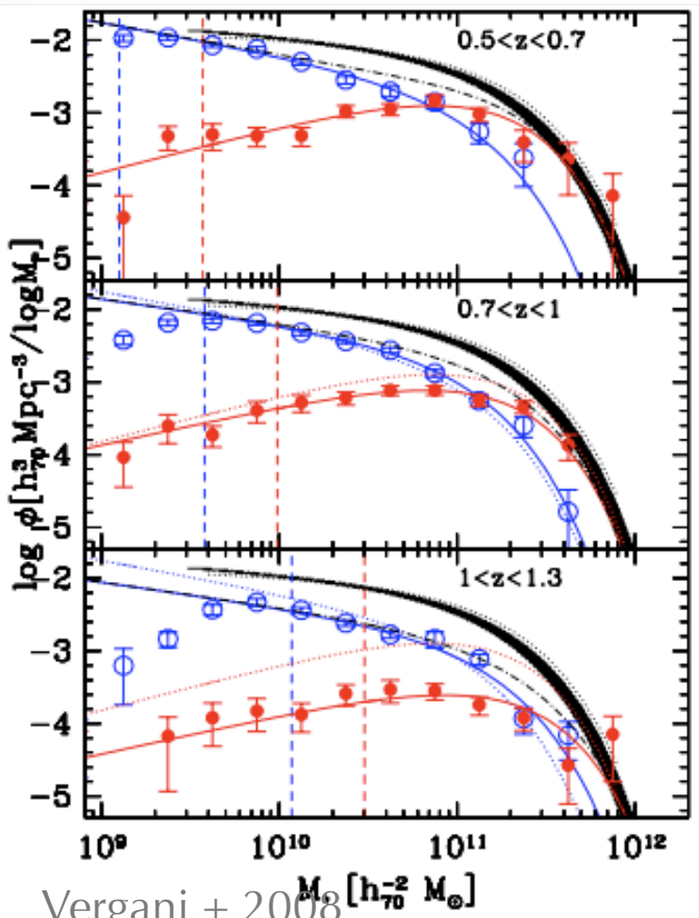
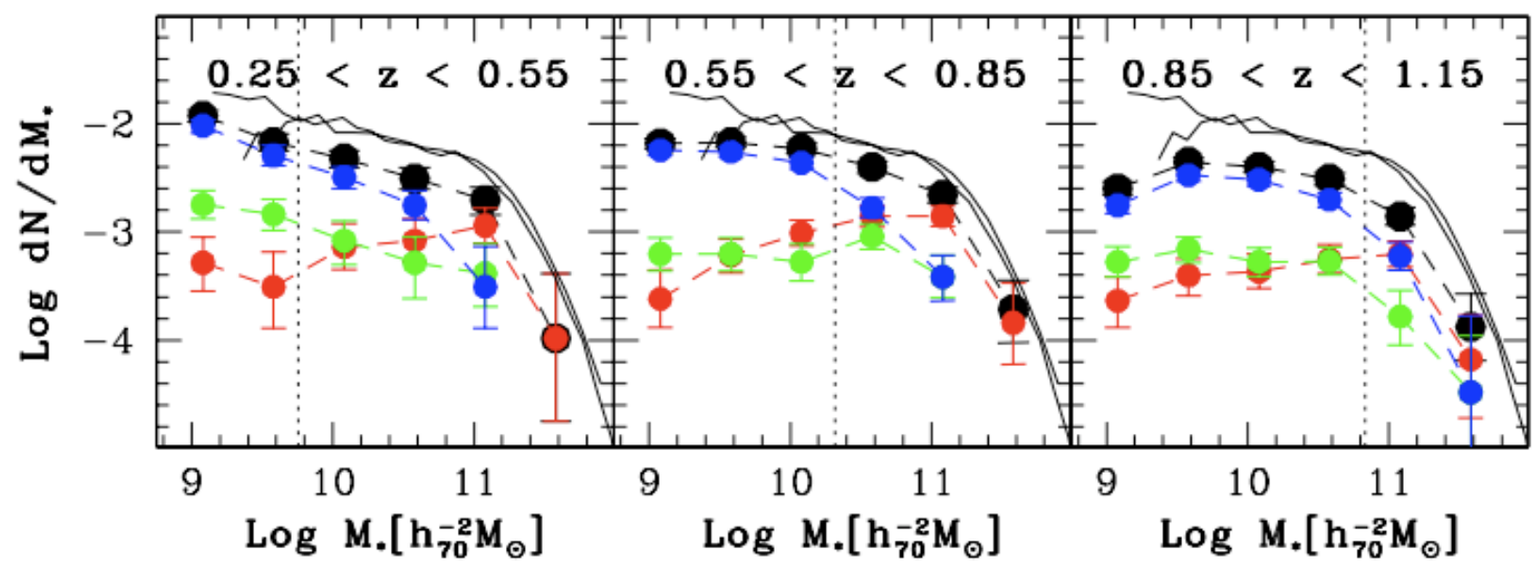
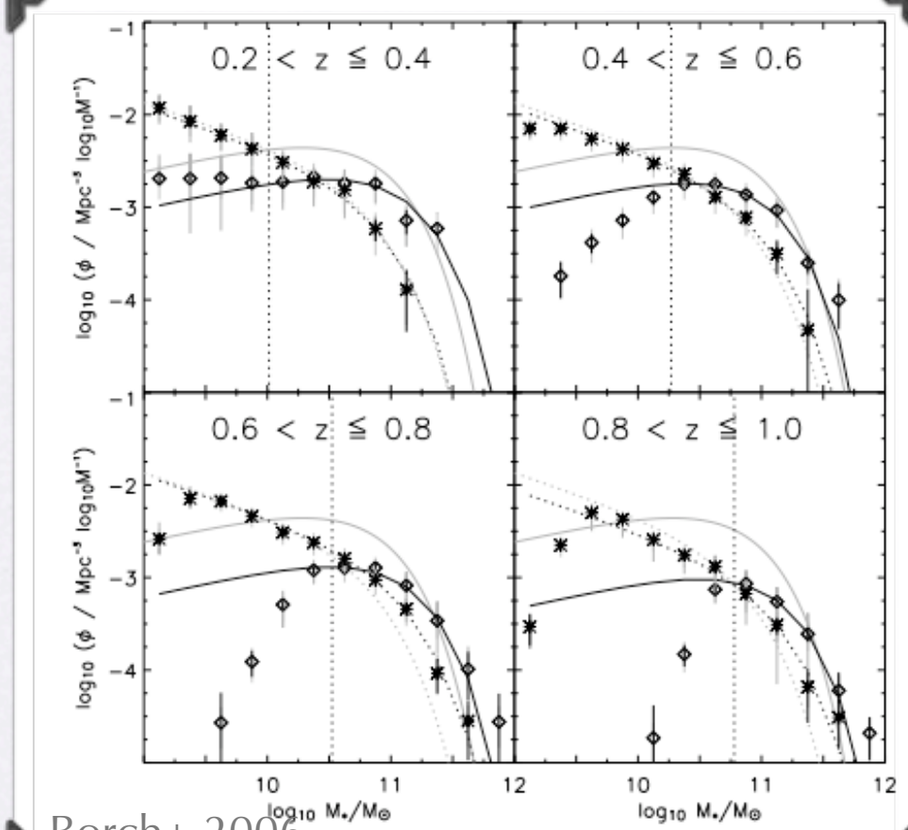


Vergani + 2008



Pannella+ 2006

Several studies have analyzed separately galaxies of different types (according to colors, star formation activity, structural parameters, morphologies)

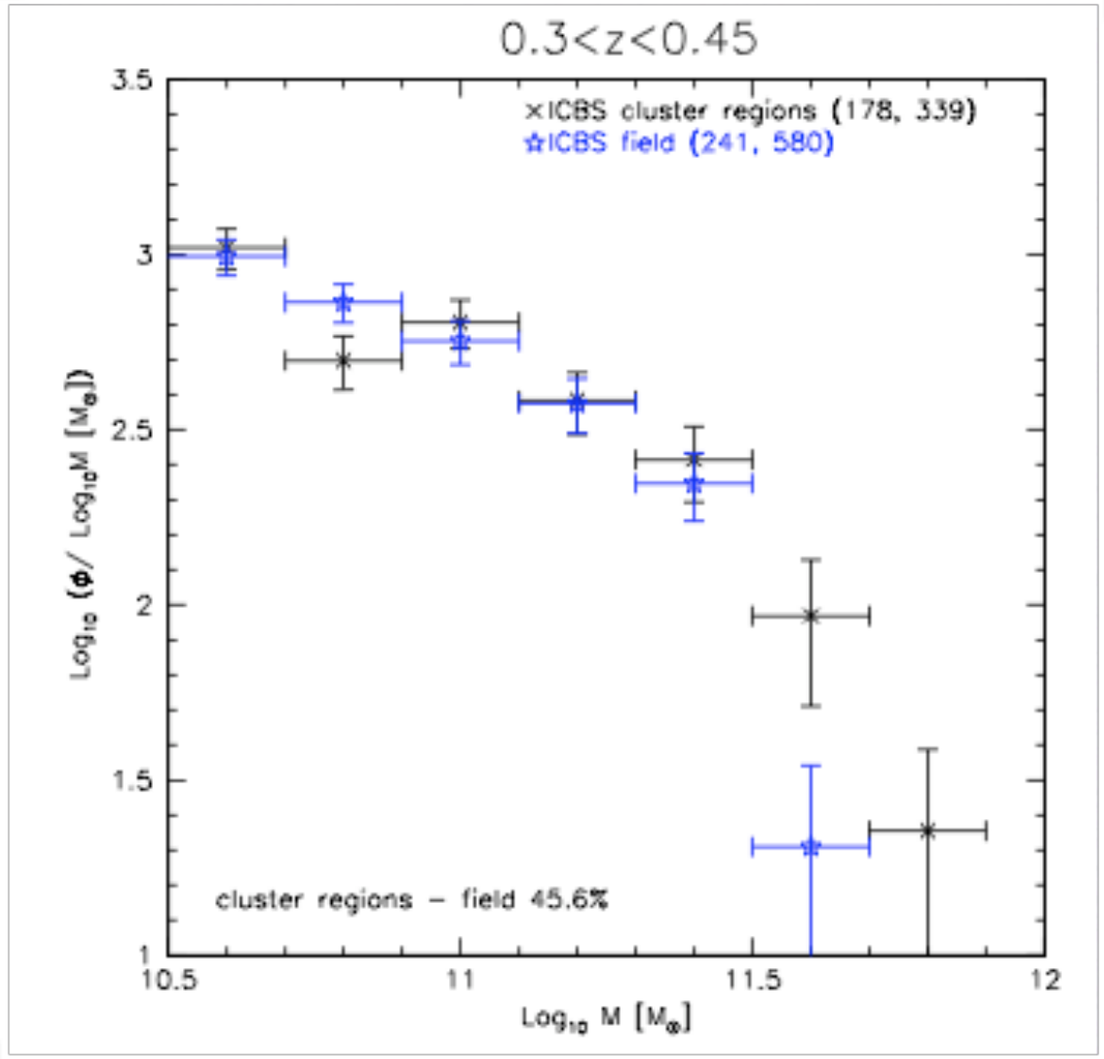


Borch+ 2006

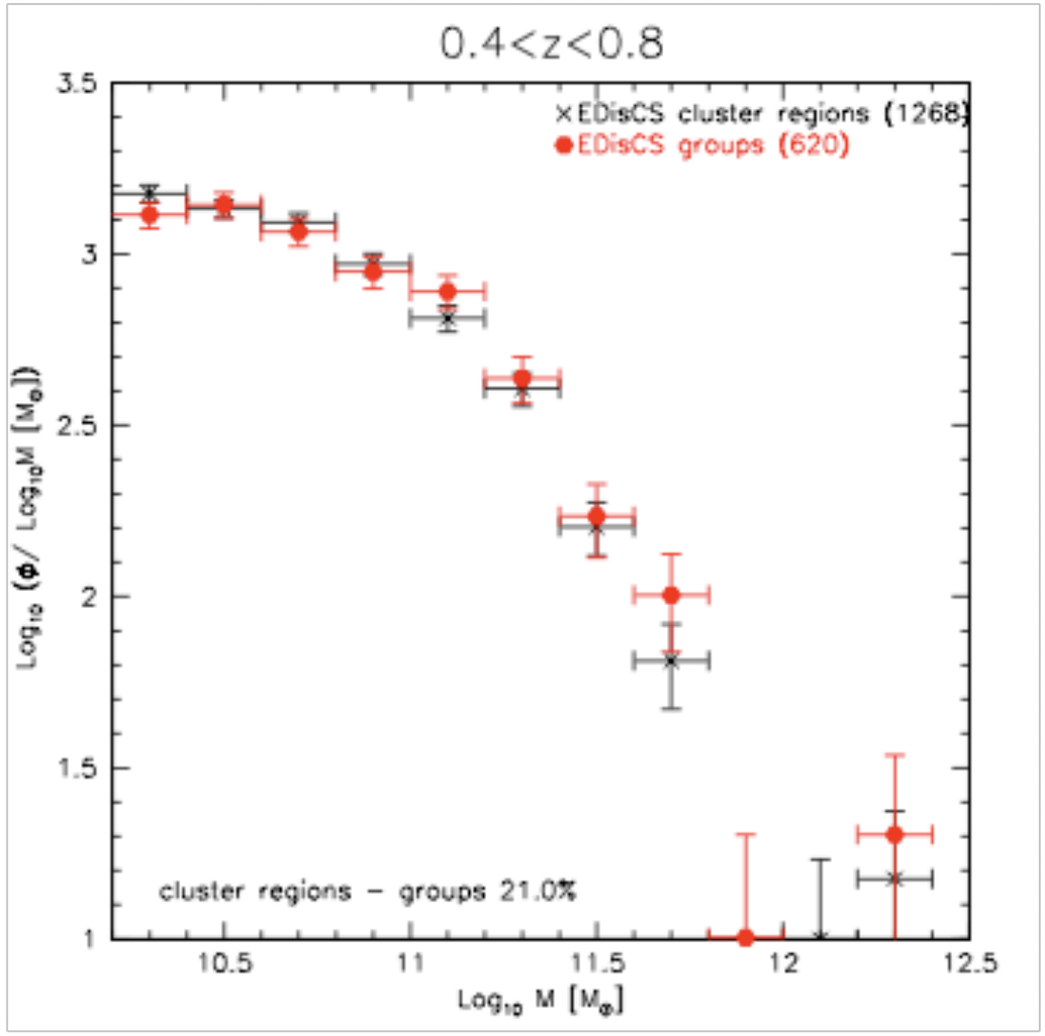
The MF in different GE

The MF in different GE

@ intermediate redshift



CLUSTERS, GROUPS and FIELD have the same MF



The MF does not depend on global environment

The red/blue MF

The red/blue MF

$$(U-B)_{Vega} \geqslant 1.10 + 0.075 \times \log\left(\frac{M \times 1.12}{10^{10} M_{\odot}}\right) - 0.18 \times z - 0.88$$

Peng+ (2010)

	ICBS - $M_* \geq 10^{10.5} M_{\odot}$			
	red		blue	
	$\%_{obs}$	$\%_w$	$\%_{obs}$	$\%_w$
cluster regions	91.2±2.5%	92.9±1.4%	8.8±2.5%	7.1±1.4%
cluster outskirts	41.7±3.2%	40.4±2.1%	58.3±3.2%	59.6±2.1%
groups	67.7±5.3%	67.3±3.5%	32.3±5.3%	32.7±3.5%
pure field	53.0±4.3%	53.4±2.7%	47.0±4.3%	46.6±2.7%
field	58.3±3.3%	57.8.±2.1%	41.7±3.3%	42.2±2.1%
non-clusters	61.0±2.5%	62.2±1.7%	39.0±2.5%	37.8±1.7%

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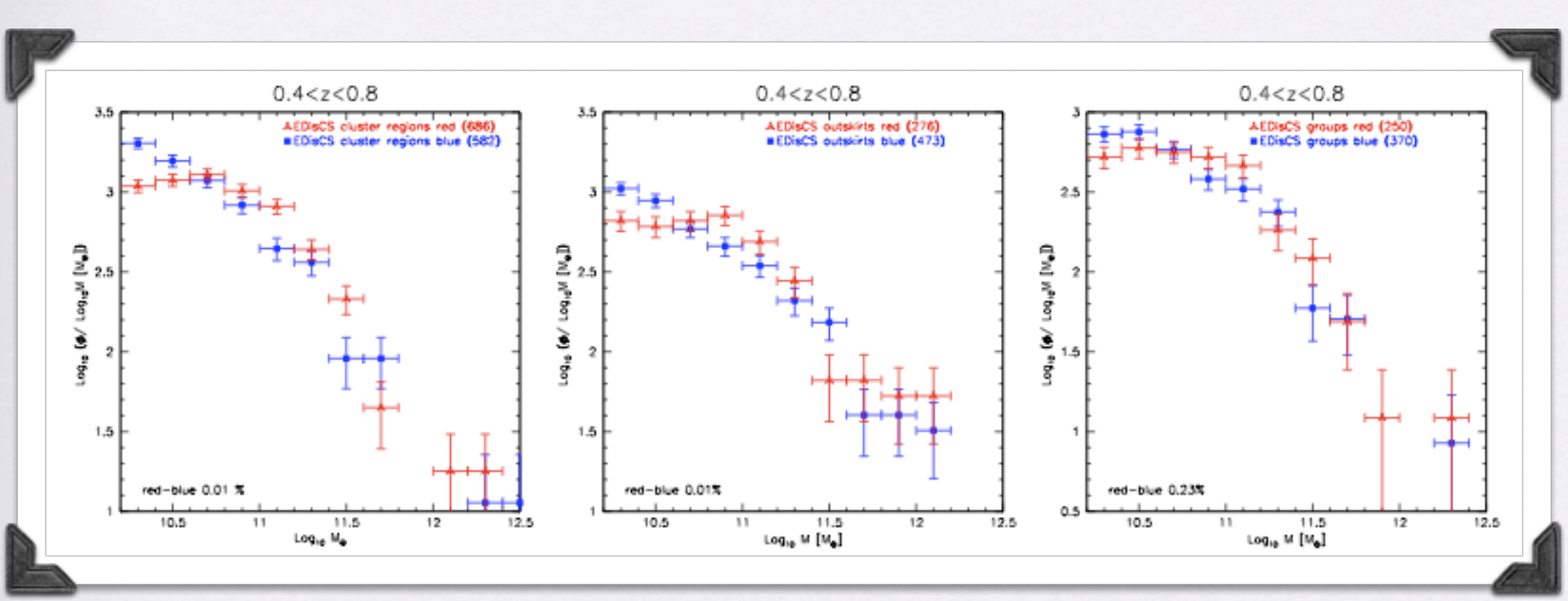


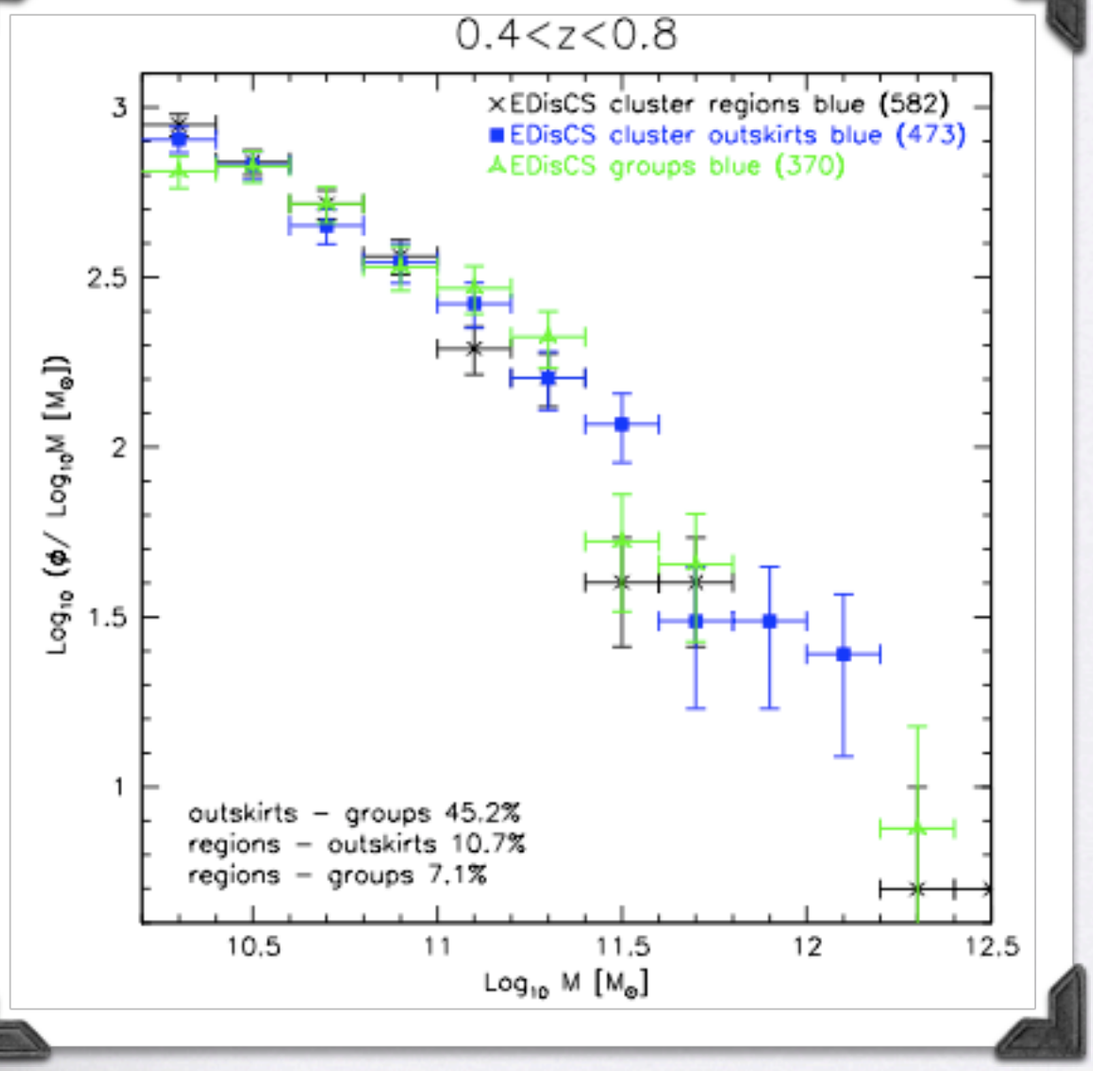
In all environments, red and blue galaxies have different MF

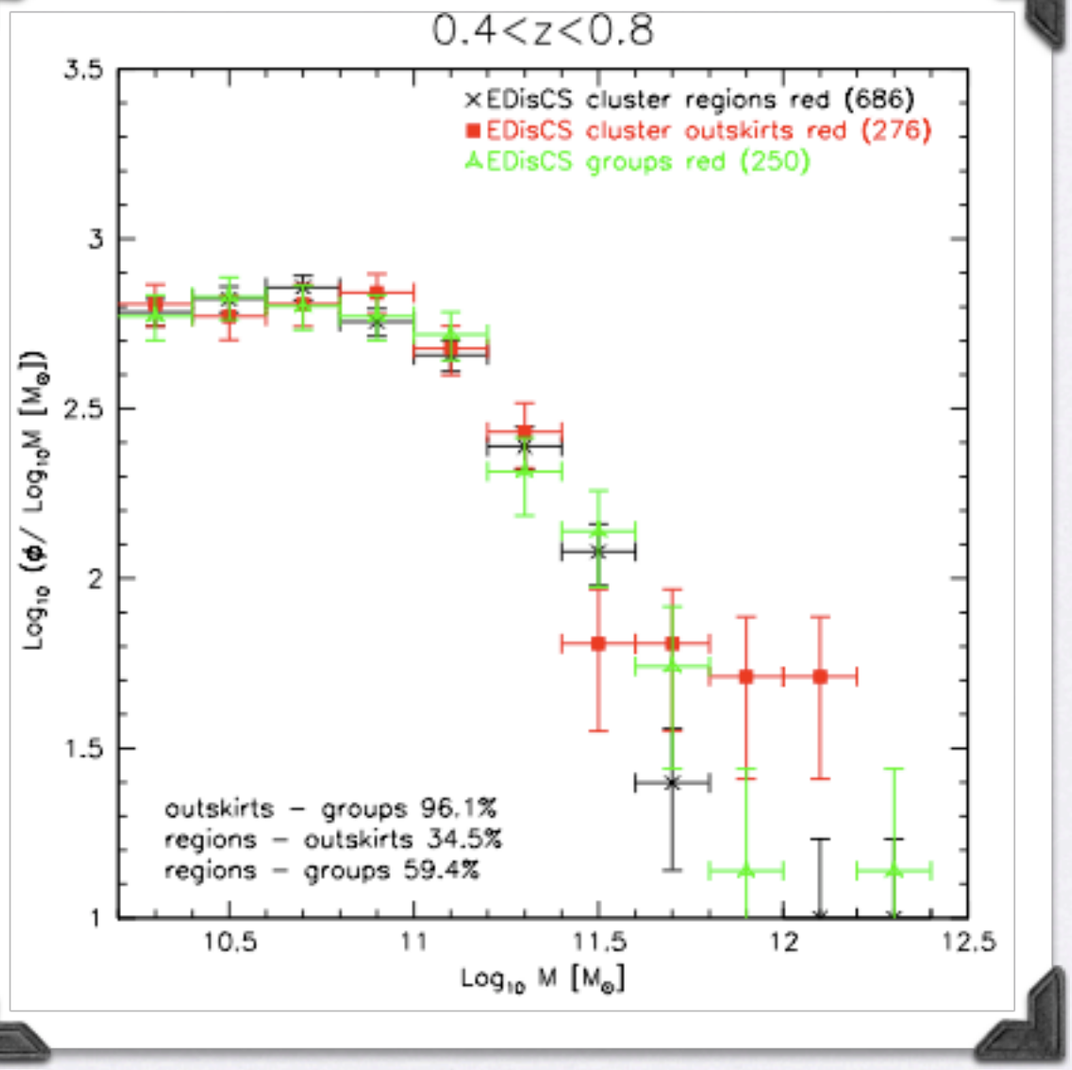
The red/blue MF

$$(U-B)_{Vega} \geqslant 1.10 + 0.075 \times \log\left(\frac{M \times 1.12}{10^{10} M_{\odot}}\right) - 0.18 \times z - 0.88$$

Peng+ (2010)

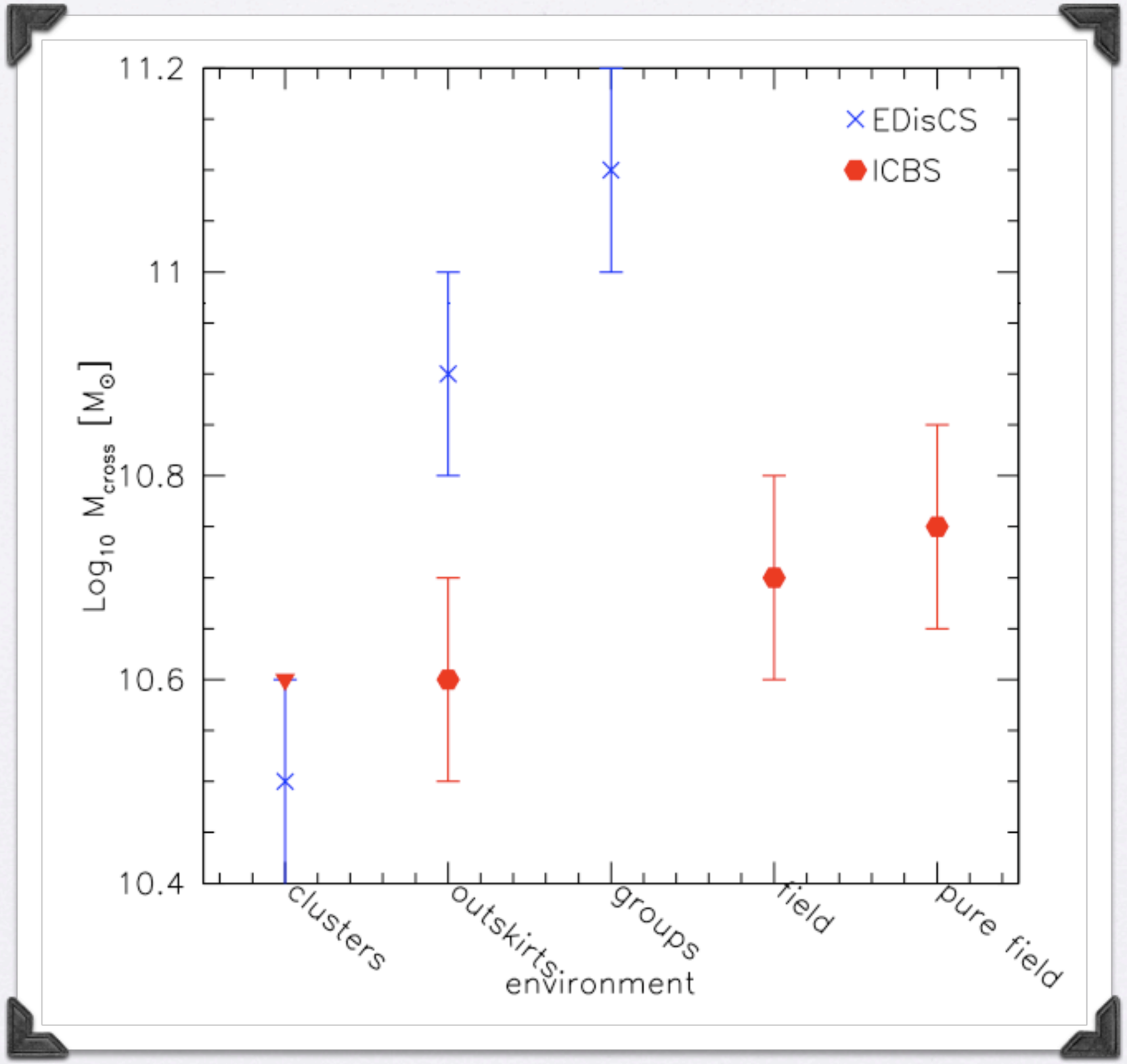
No differences are detected in MF in different environments, for red and blue galaxies separately





but...

but...

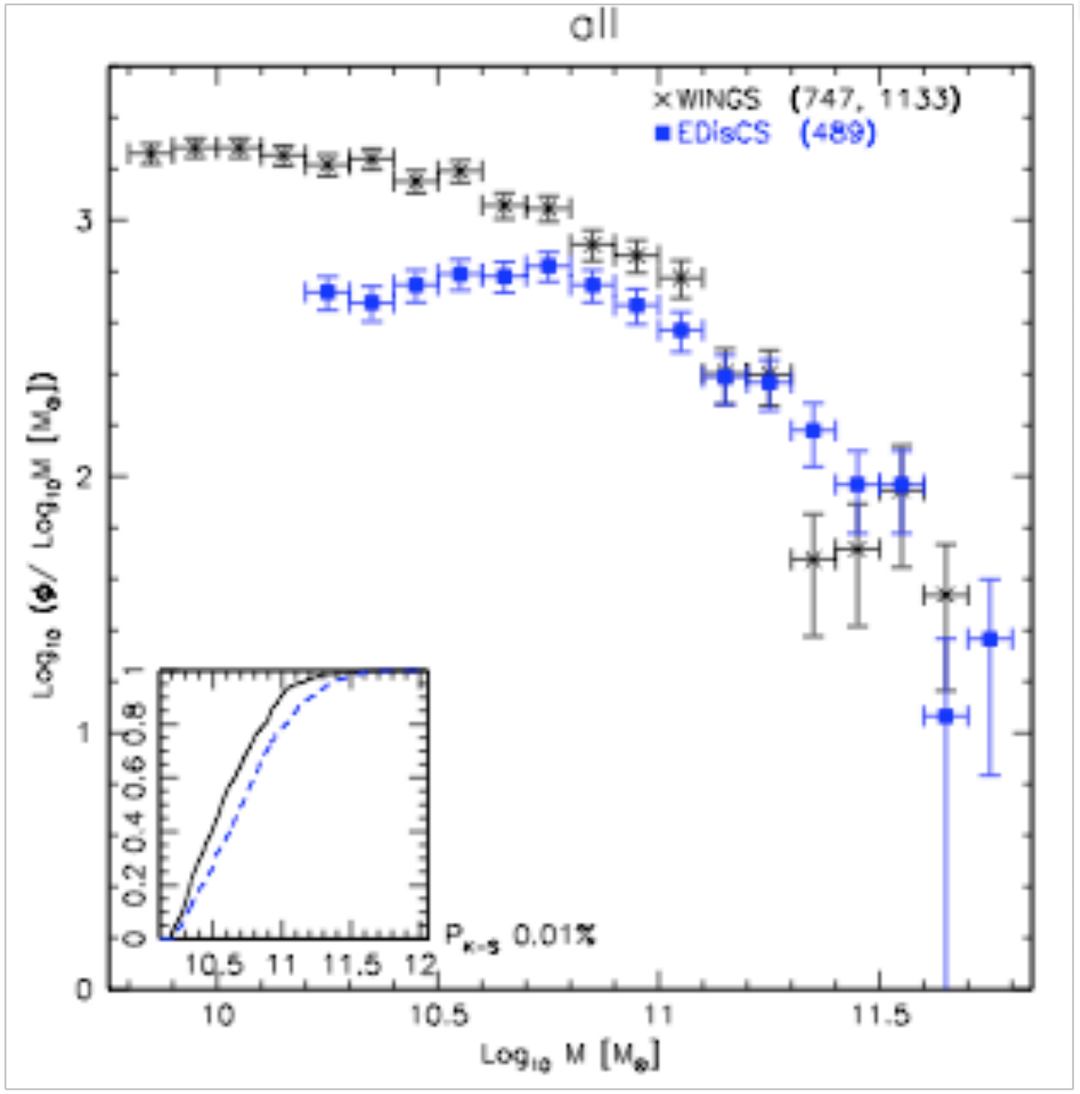


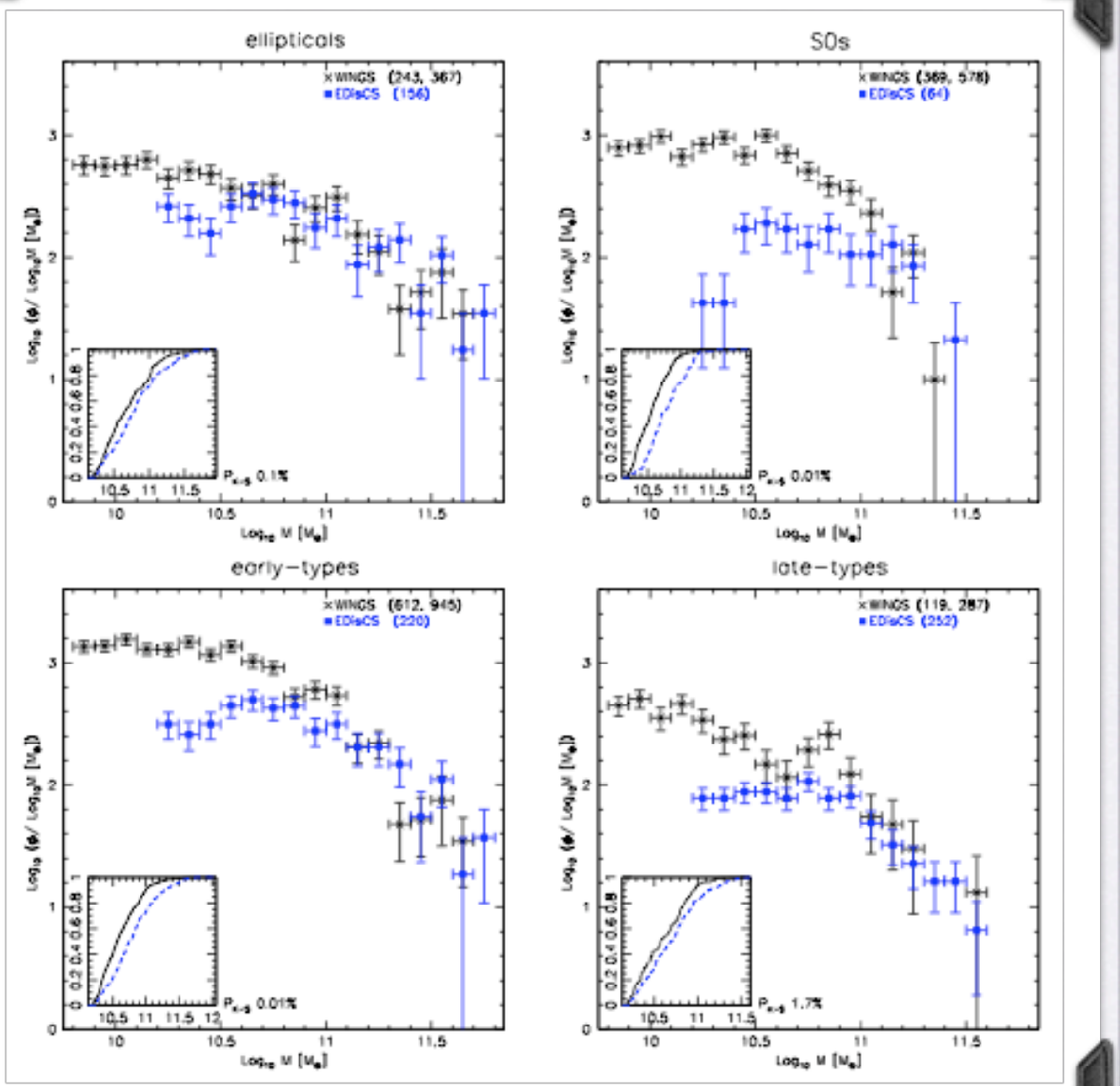
the crossing mass is different!

The evolution in clusters

The evolution in clusters

from z~0.6 to z~0





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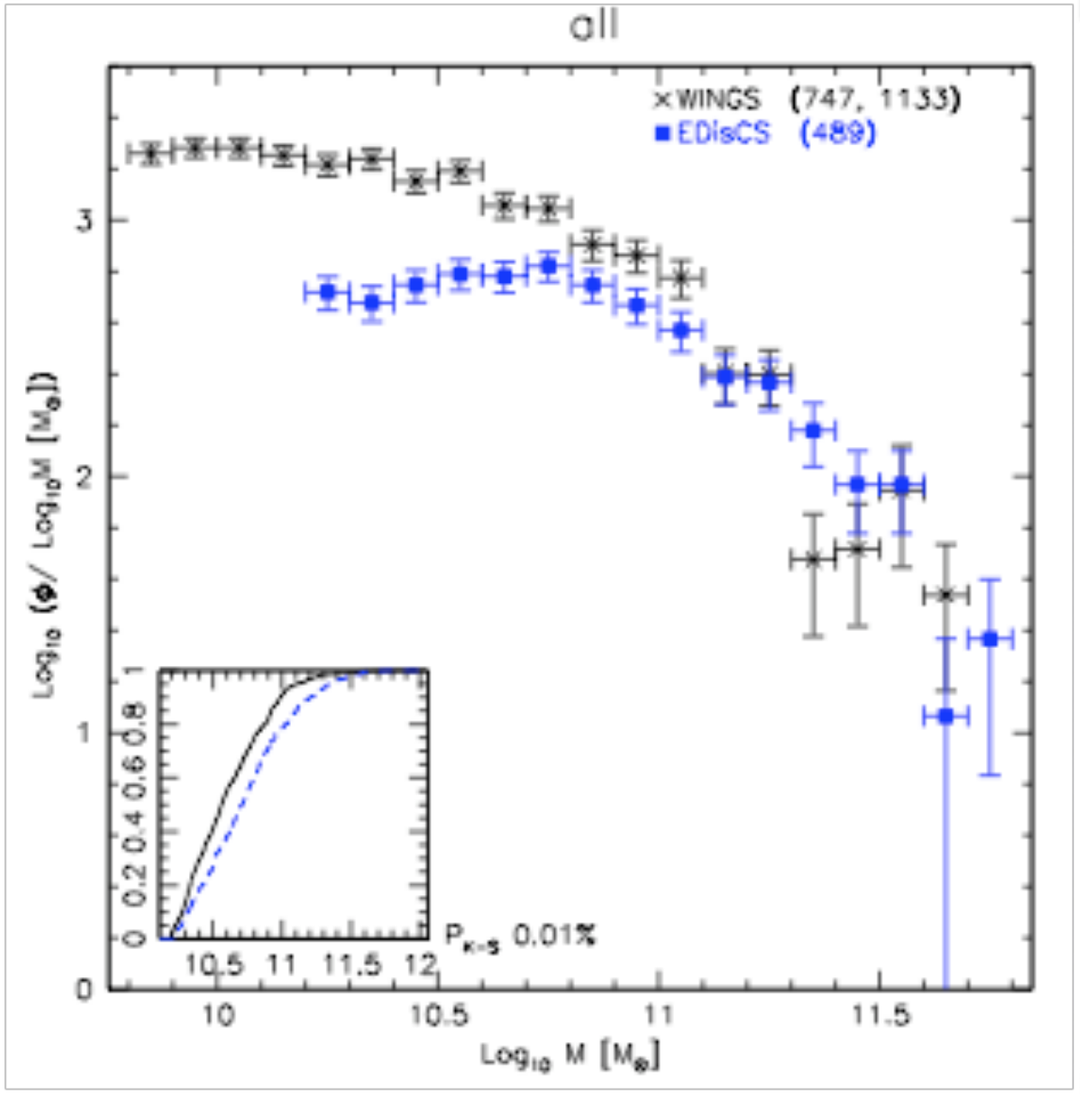
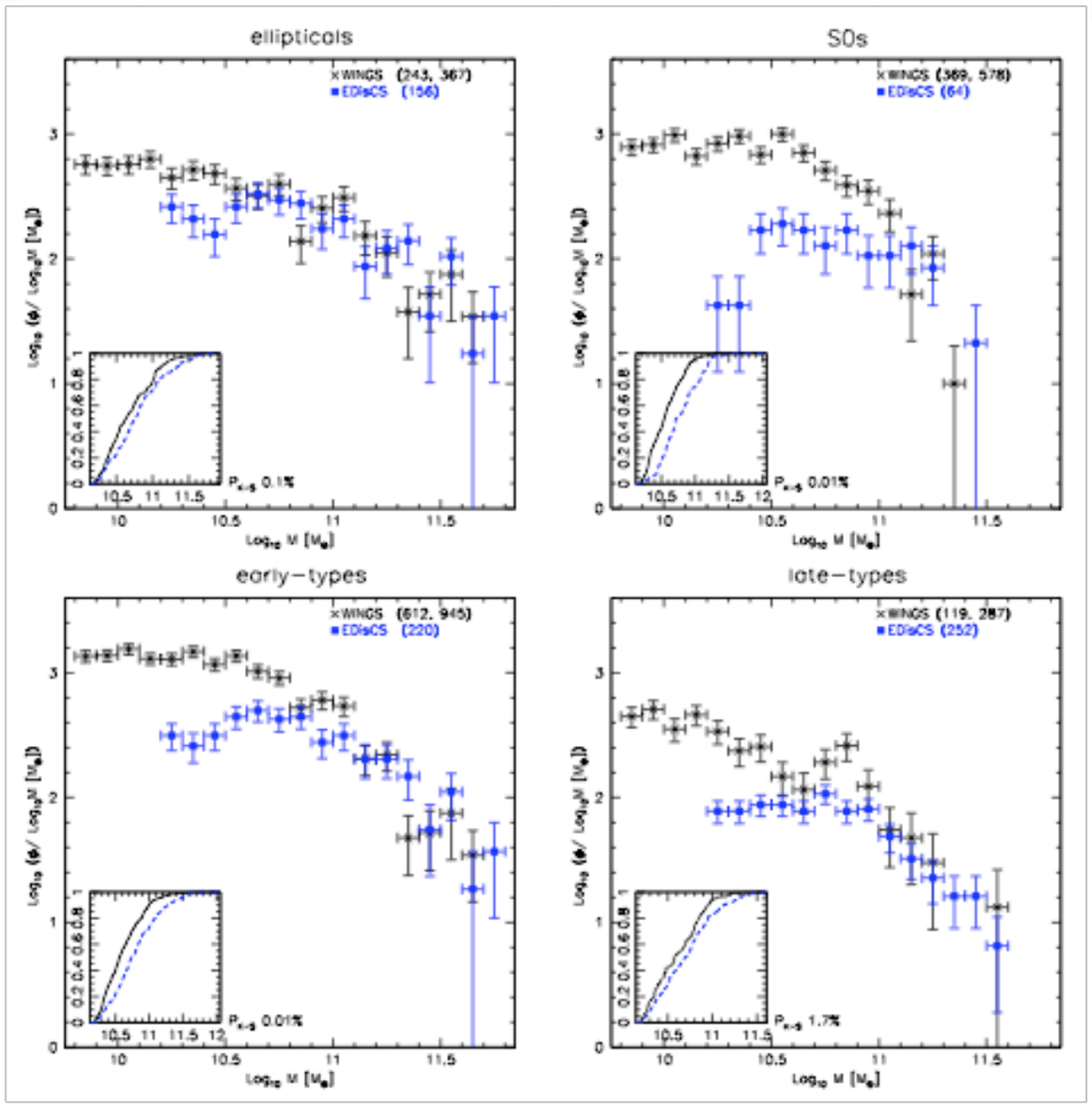


- galaxy merging
- mass loss due to harassment
- environmental mass segregation of infalling galaxies
- mass growth due to star formation
- morphological transformation



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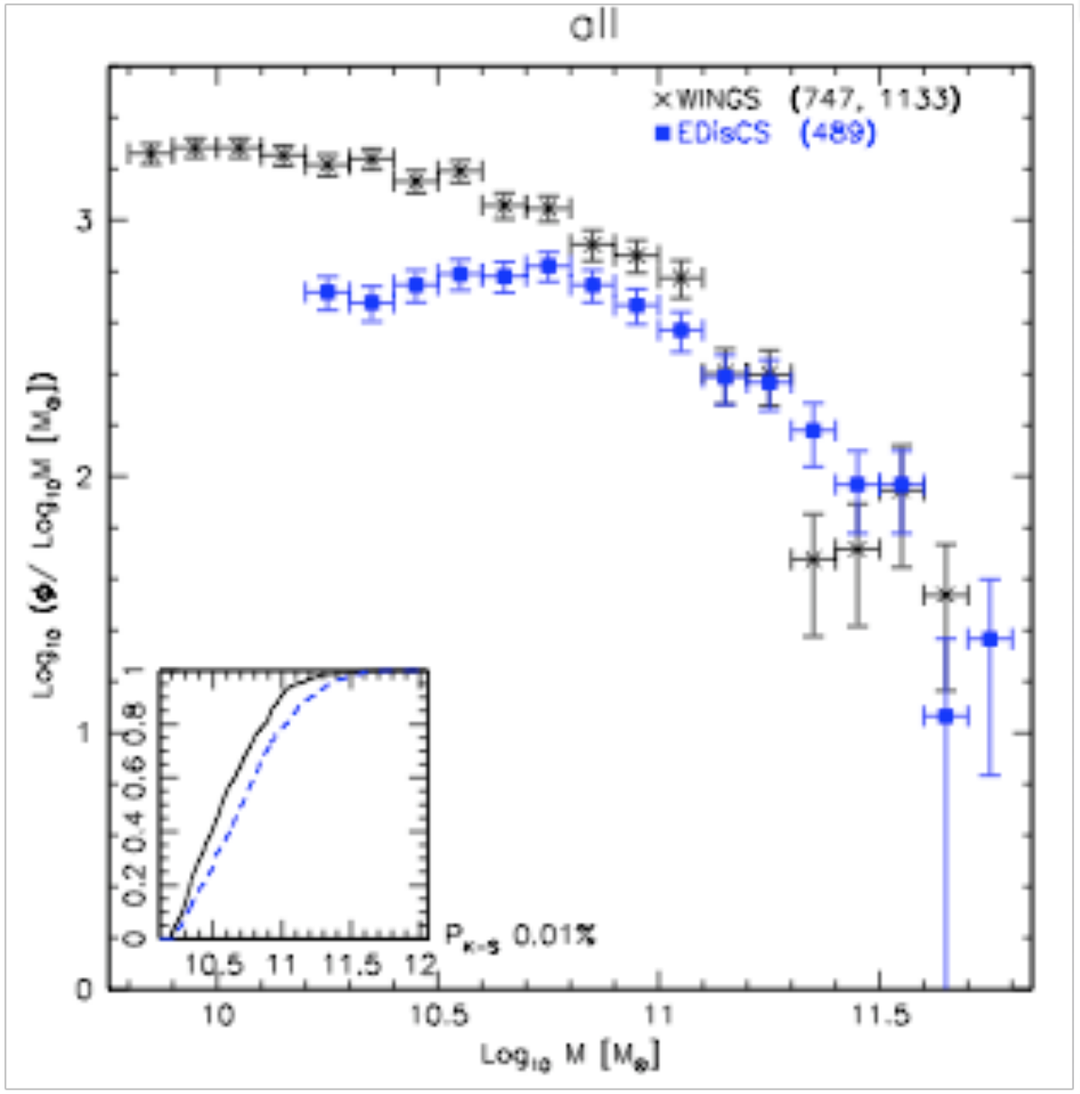

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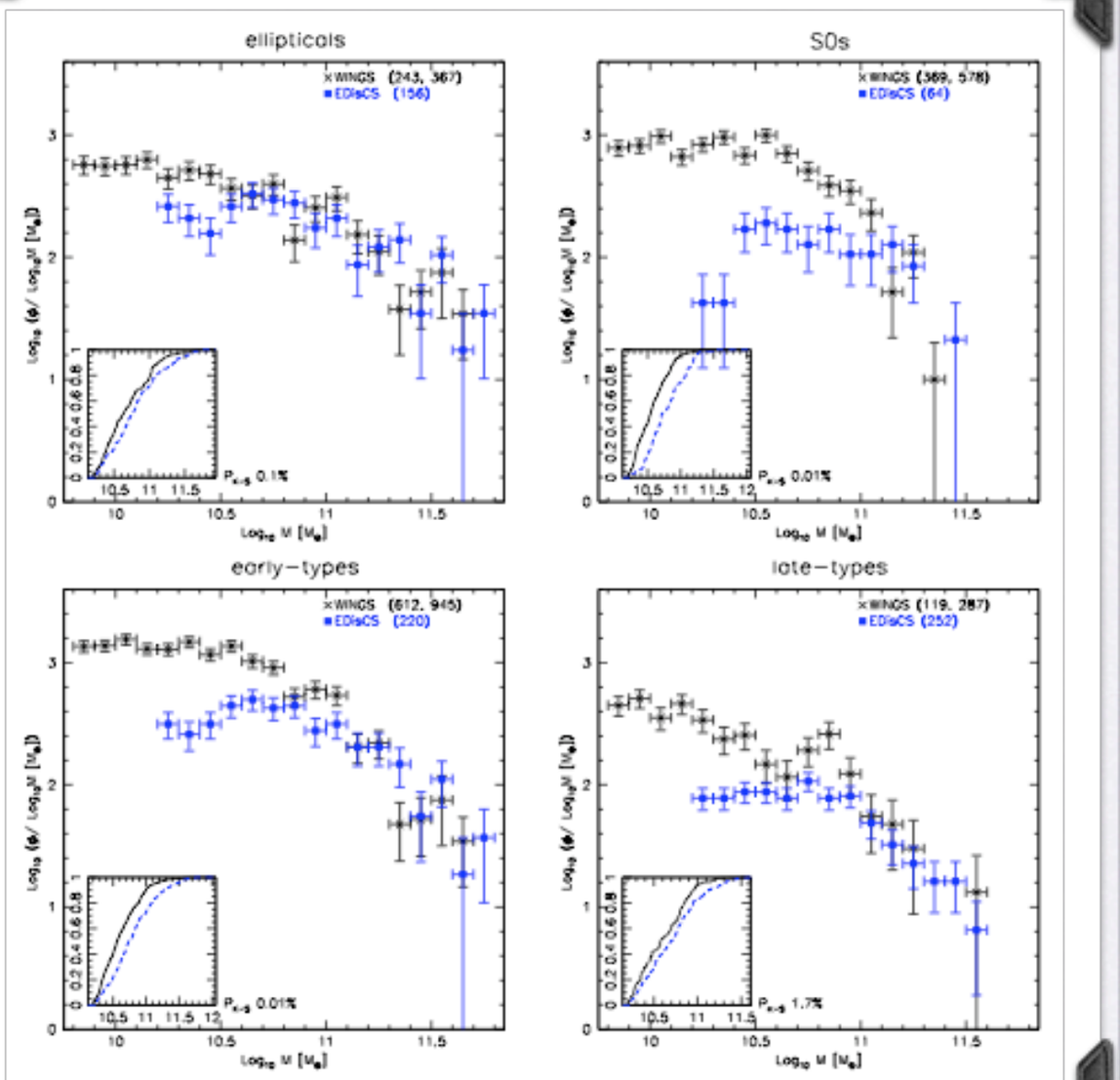
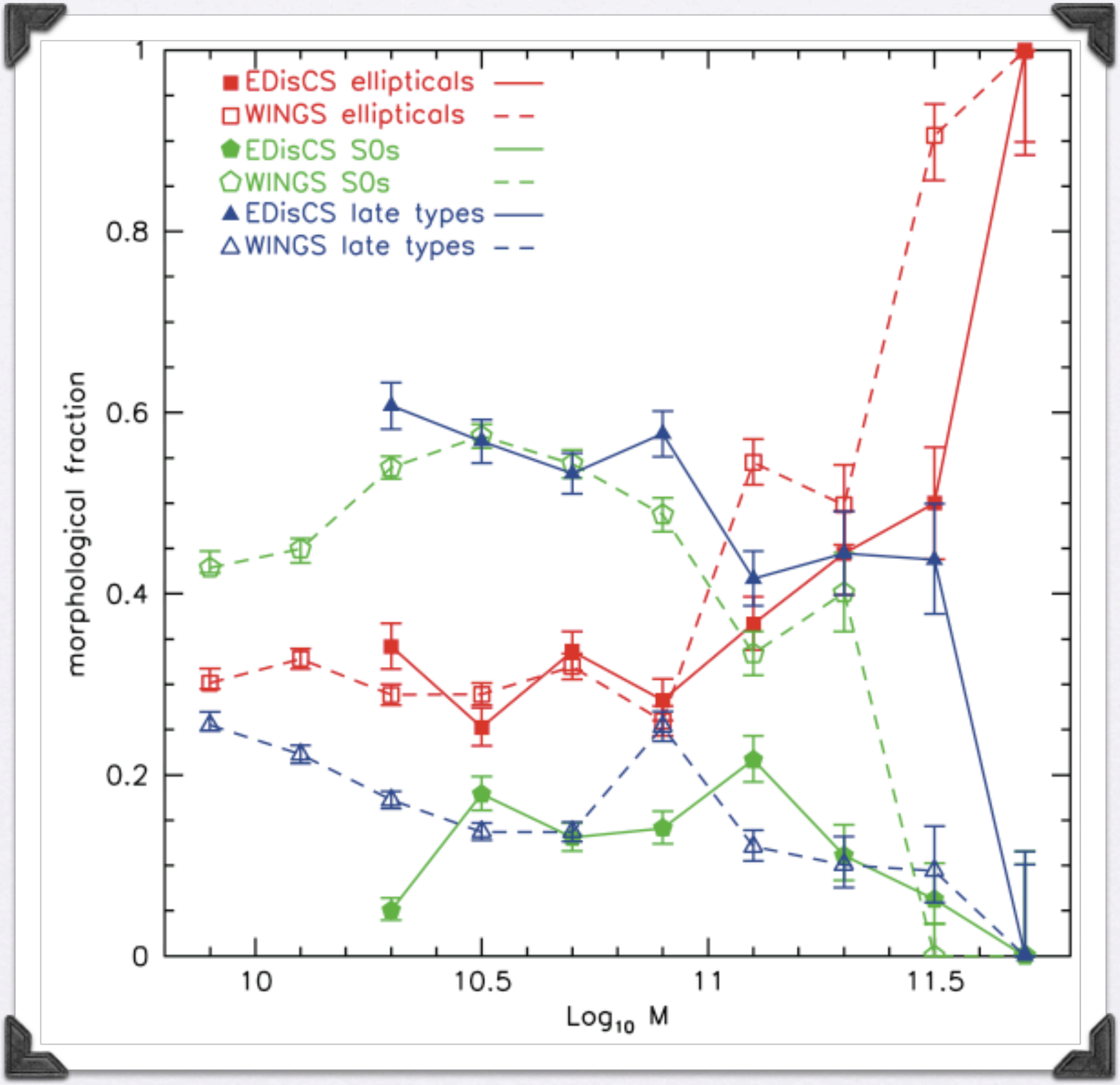


Evolution of each type

Evolution of each type



What drives the evolution of the total MF?

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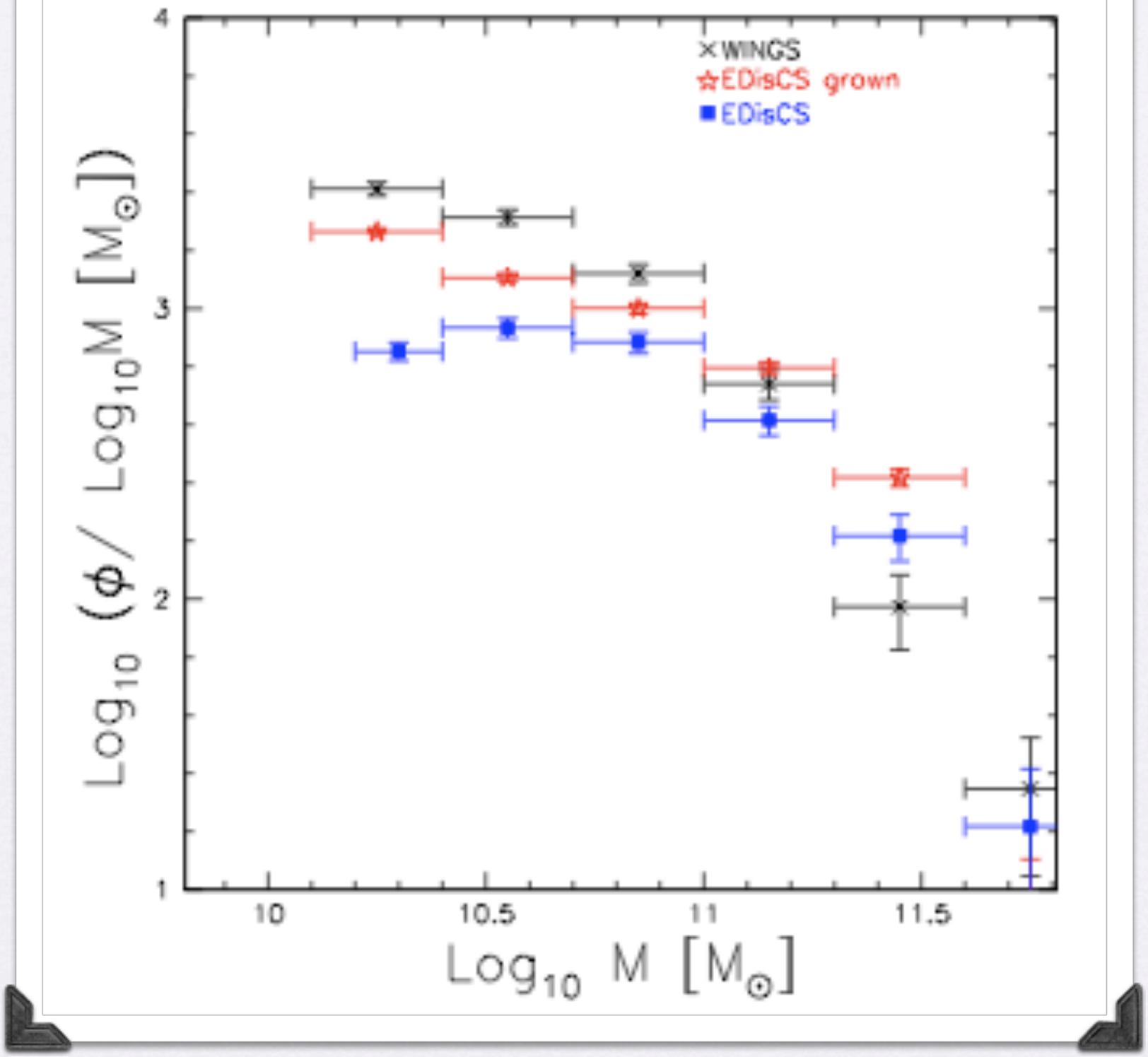
- mergers
- harassment
- star formation
- morphological transformation

What drives the evolution



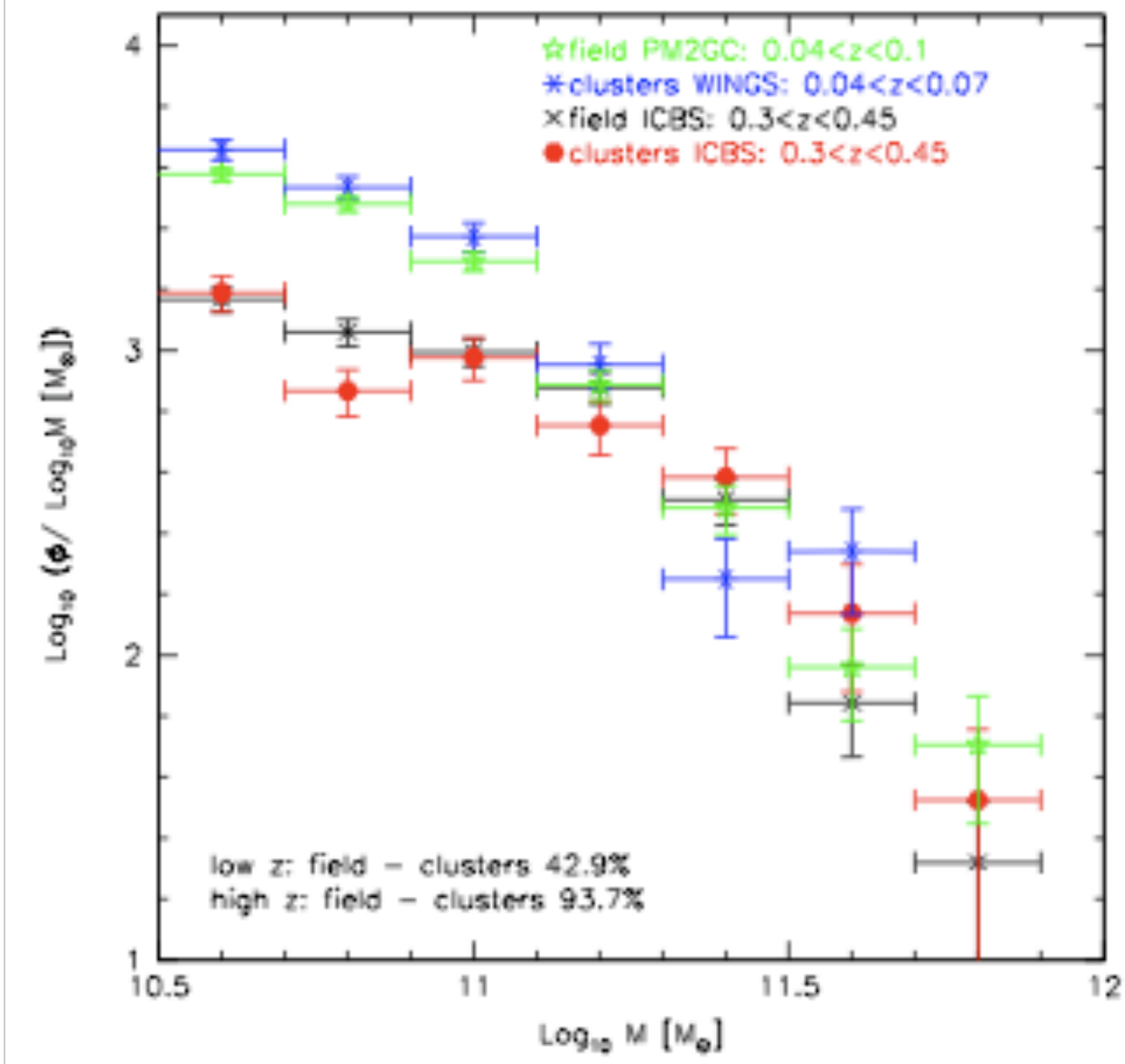
What drives the evolution of the total MF?

MASS GROWTH OF GALAXIES DUE TO STAR FORMATION IN BOTH CLUSTER GALAXIES AND IN GALAXIES INFALLING FROM THE CLUSTER SURROUNDING AREAS. THIS PROCESS IS ACCOMPANIED ALSO BY THE MORPHOLOGICAL TRANSFORMATION FROM ONE TYPE TO THE OTHER.

The evolution in different GE

The evolution in different GE

from z~0.4 to z~0



The evolution of the MF with time is independent of environment

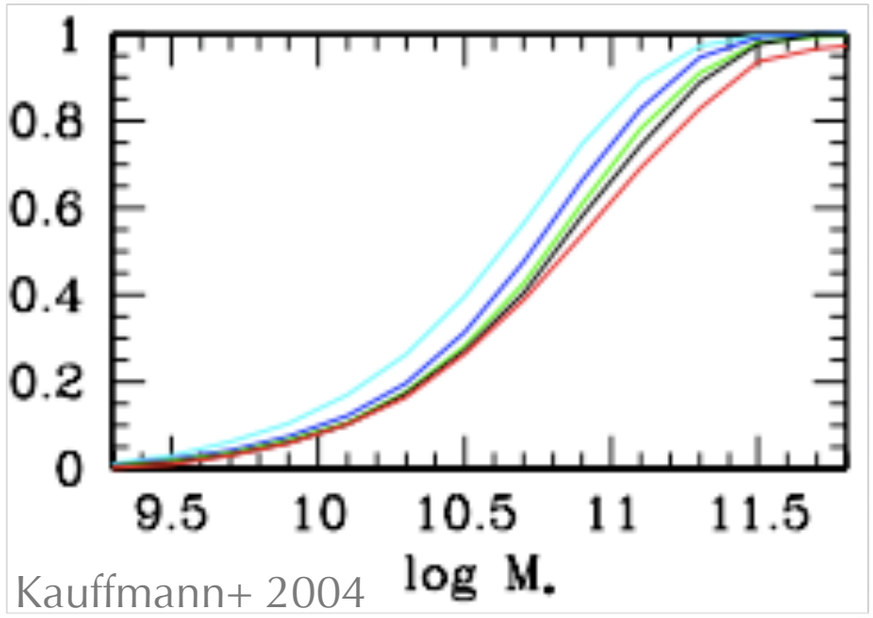
field at low-z from PM2GC (Calvi+ in preparation)

The MF in different local environments

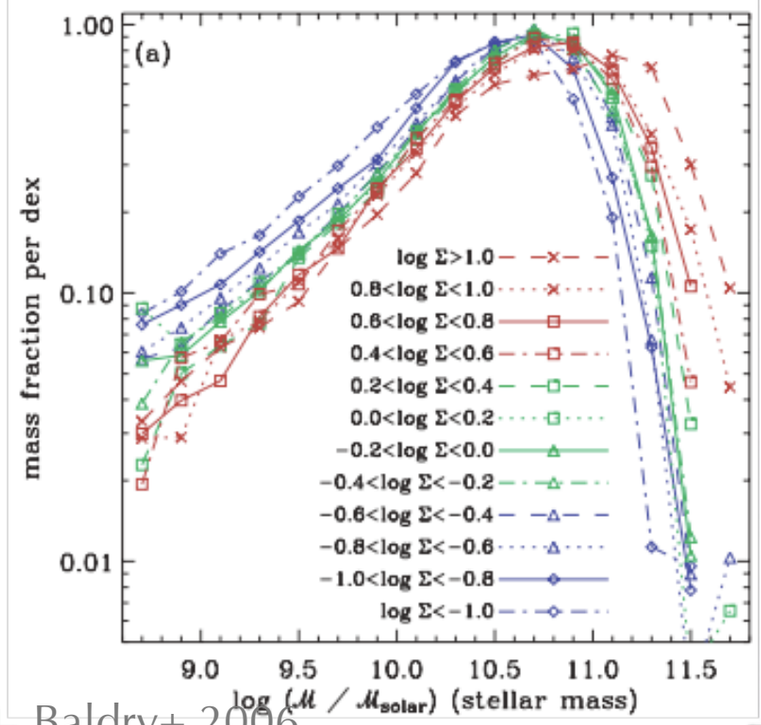
The MF in different LD

The MF in different LD

(e.g. Kauffmann+2004, Baldry+2006, Bundy+2006, Scoville+2007, Scodeggio+2009, Bolzonella+2010)



Kauffmann+ 2004



Baldry+ 2006

LOCAL UNIVERSE

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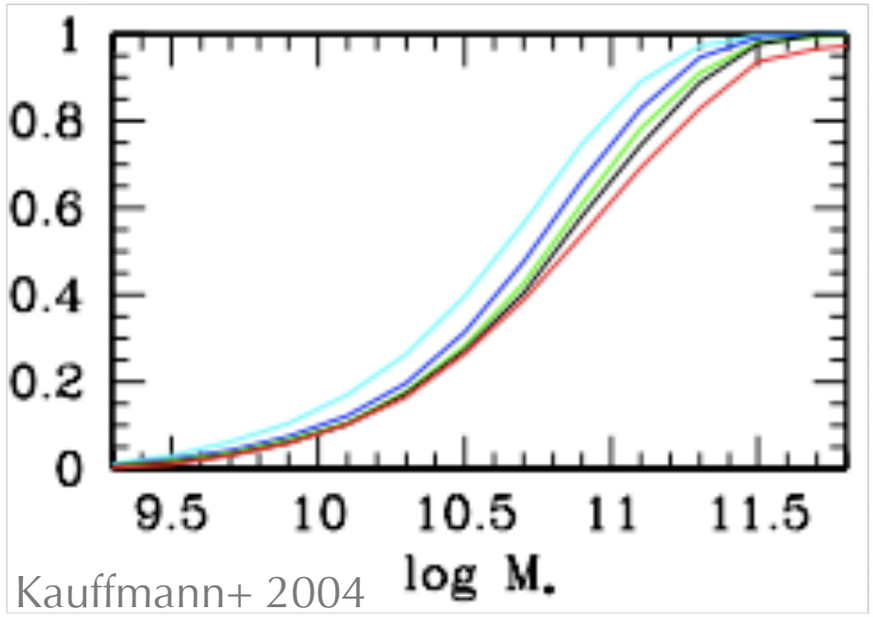
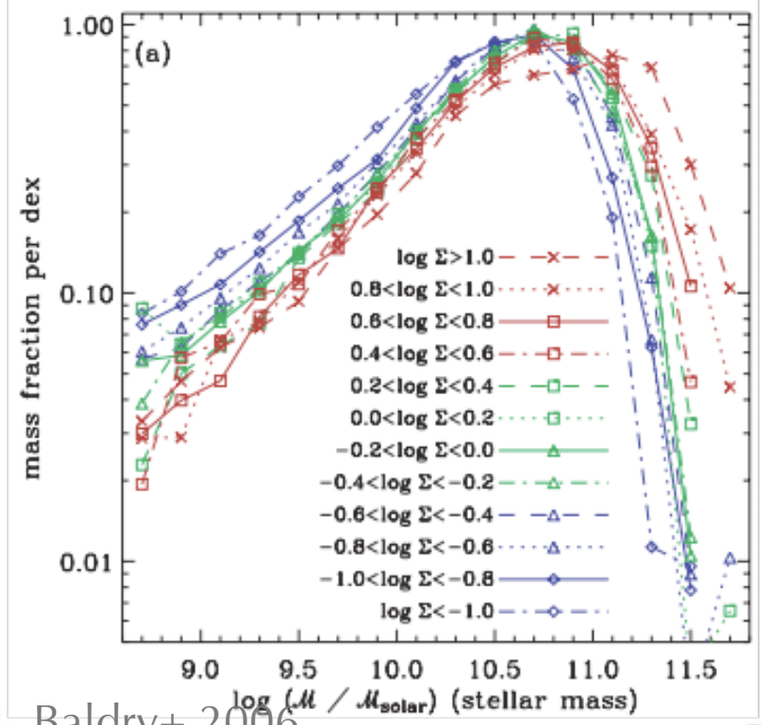
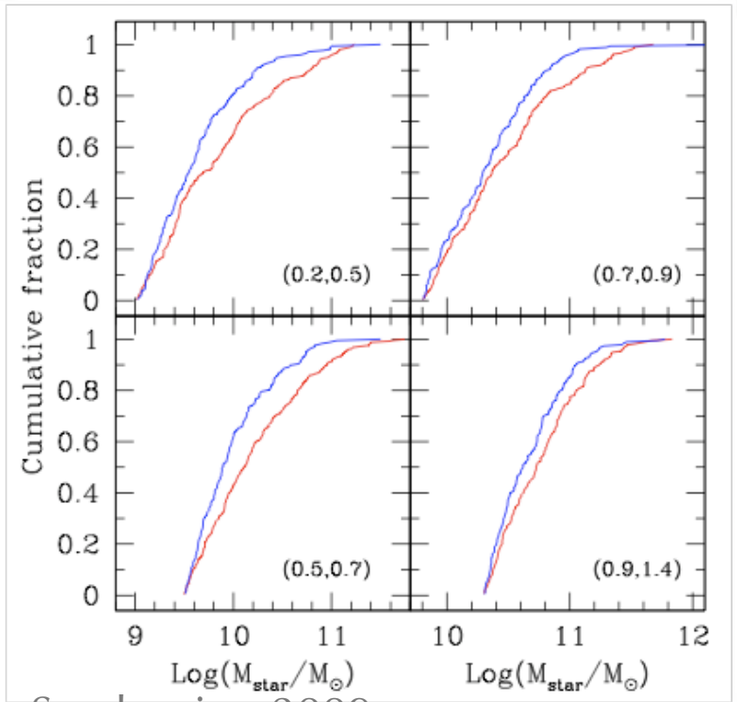


Kauffmann+ 2004

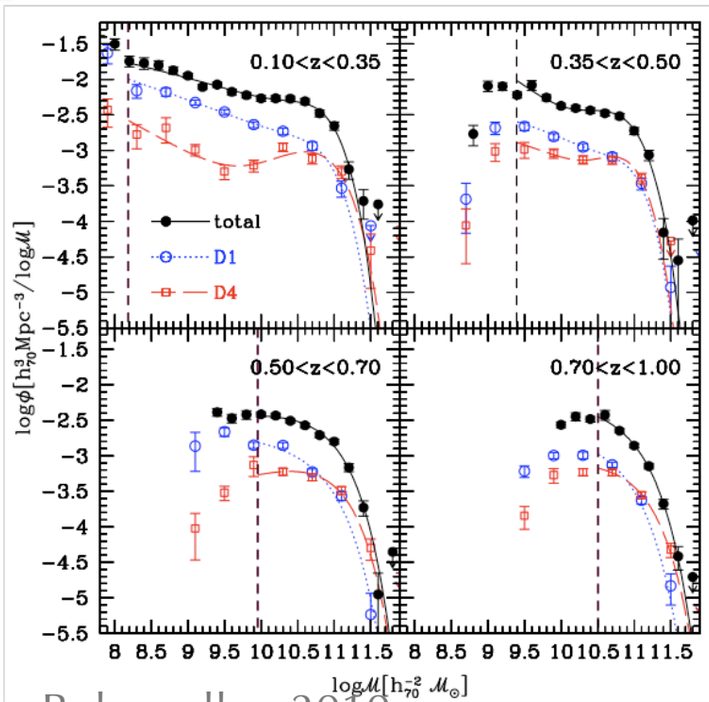


Baldry+ 2006

LOCAL UNIVERSE



Scodeggio+ 2009



Bolzonella+ 2010

DISTANT UNIVERSE

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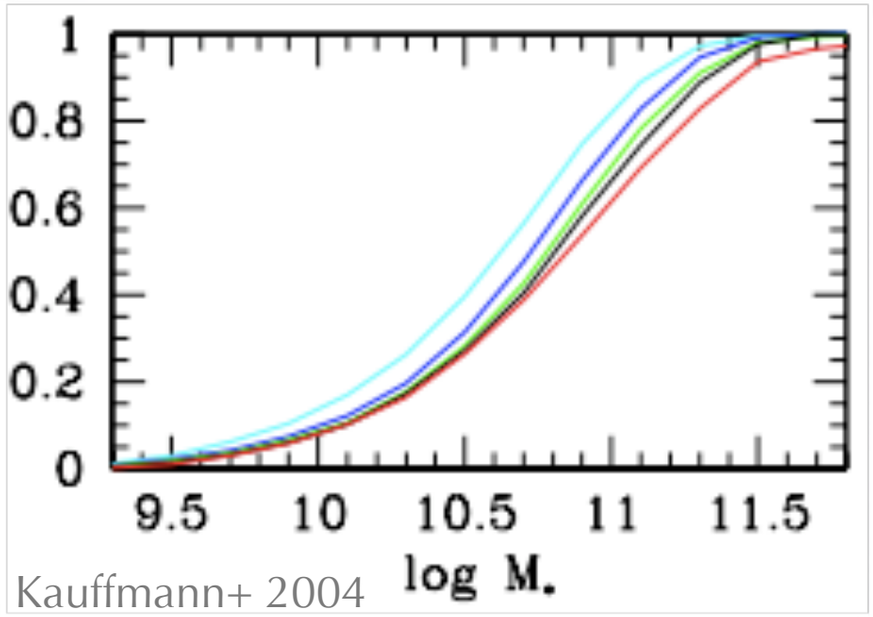
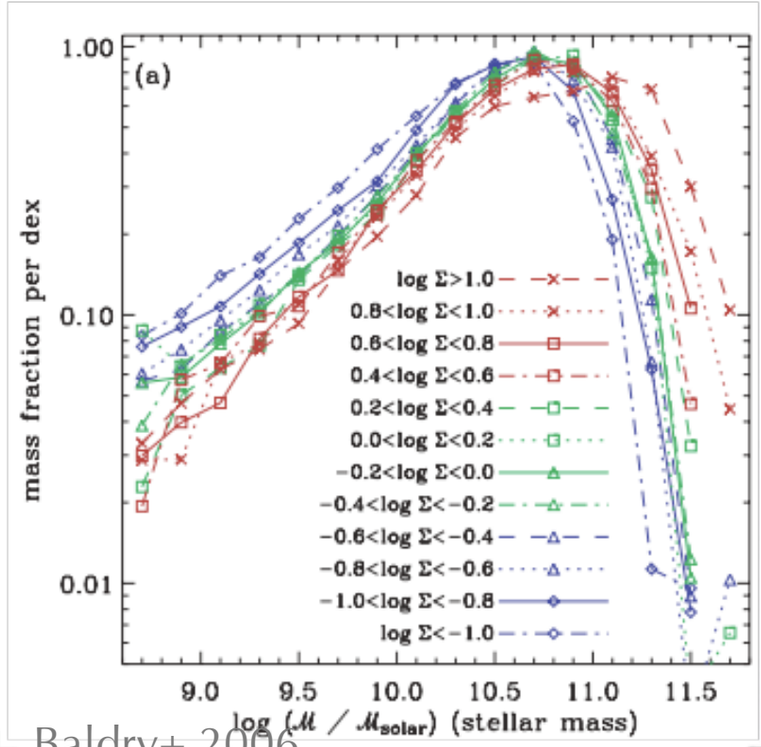


Kauffmann+ 2004

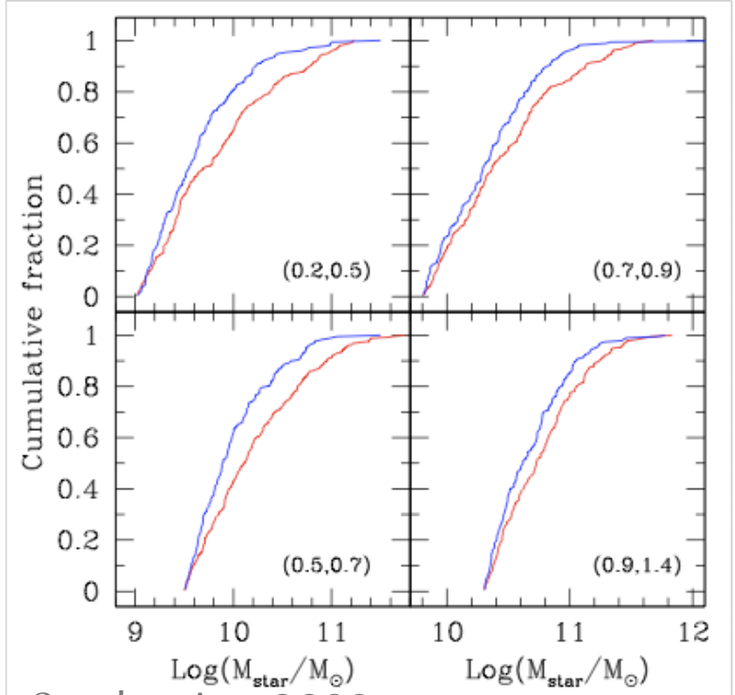
LOCAL UNIVERSE



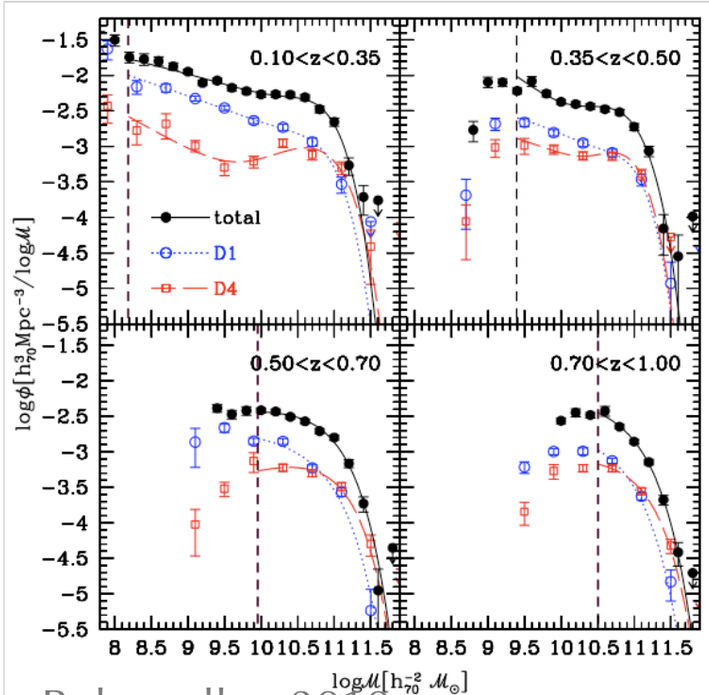
Baldry+ 2006

FIELD

Comparing the most different environments, galaxies in the lowest and highest density regions are regulated by statistically different MF

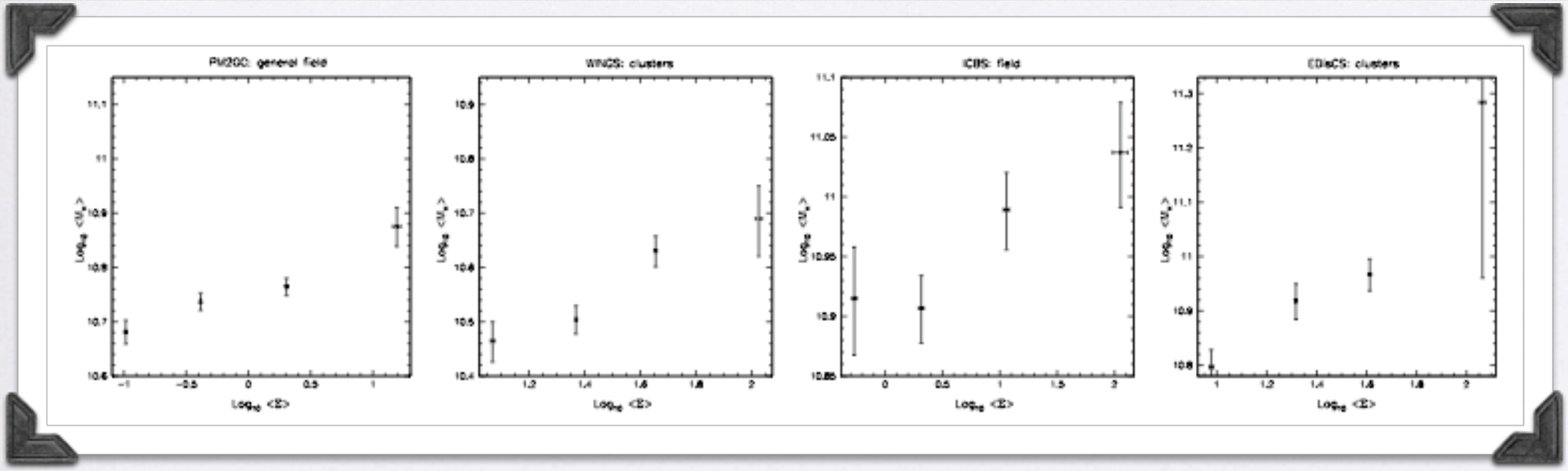


Scodeggio+ 2009



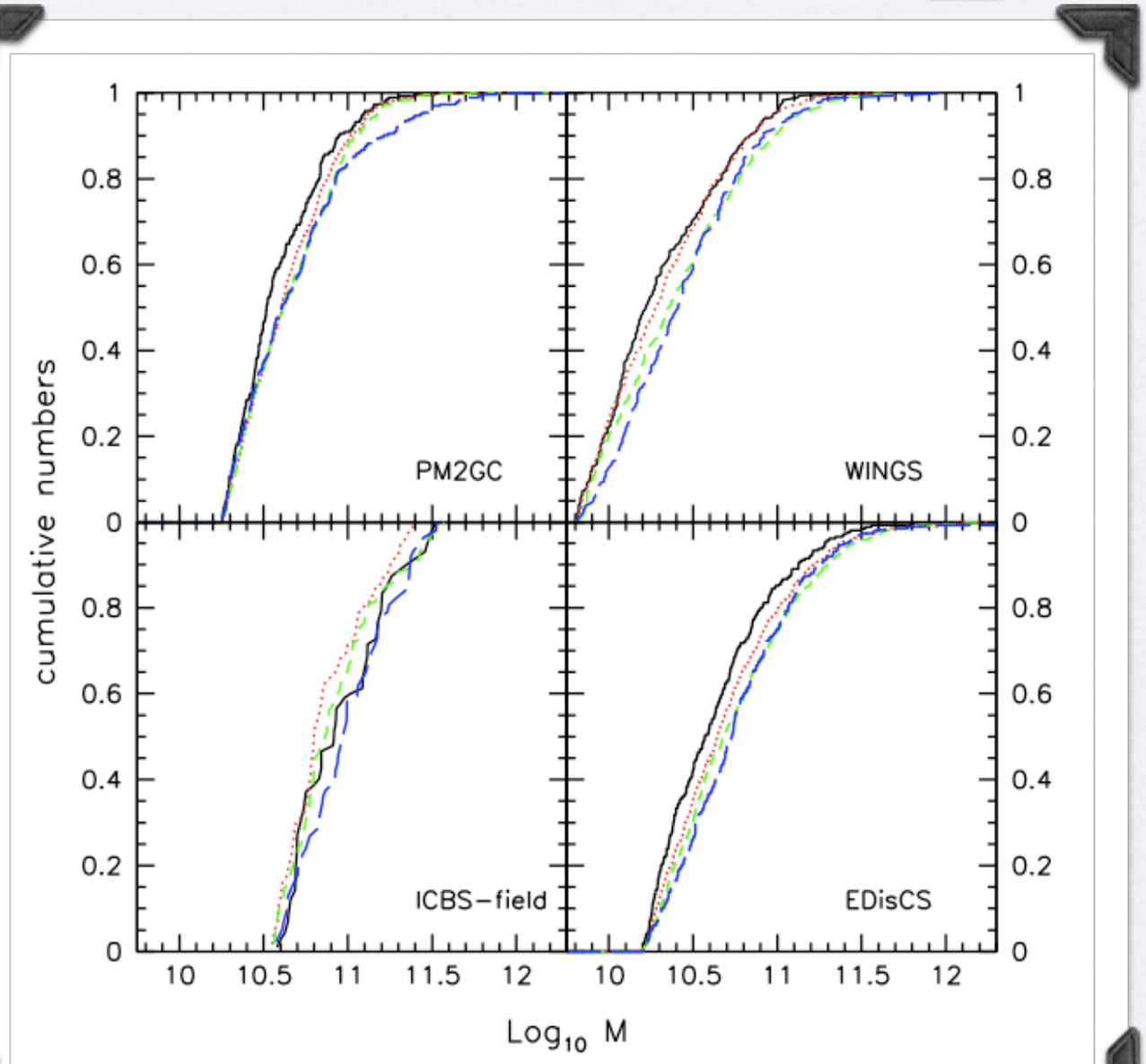
Bolzonella+ 2010

DISTANT UNIVERSE

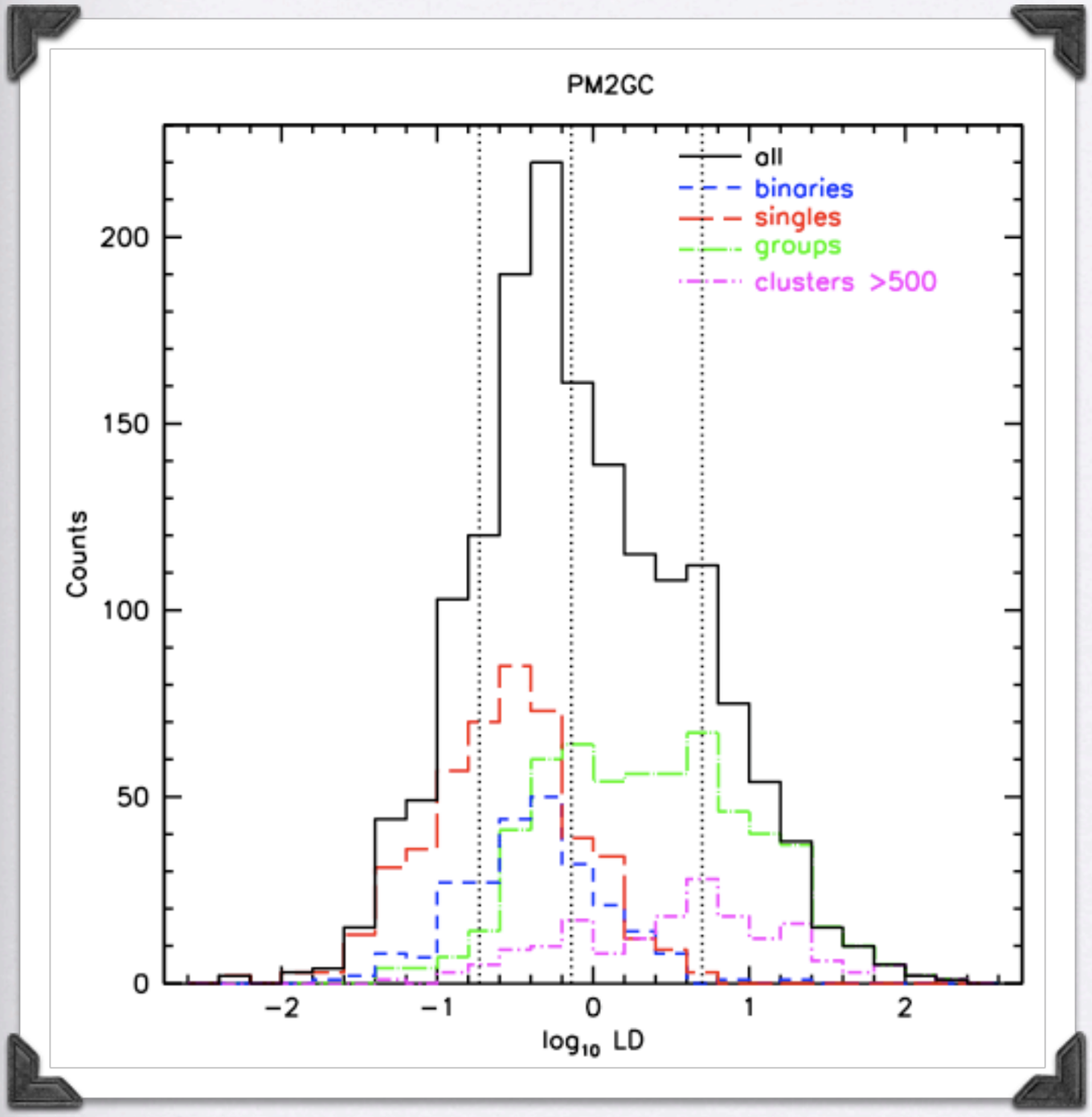


Both the mass functions and the largest mass and the mean mass are different

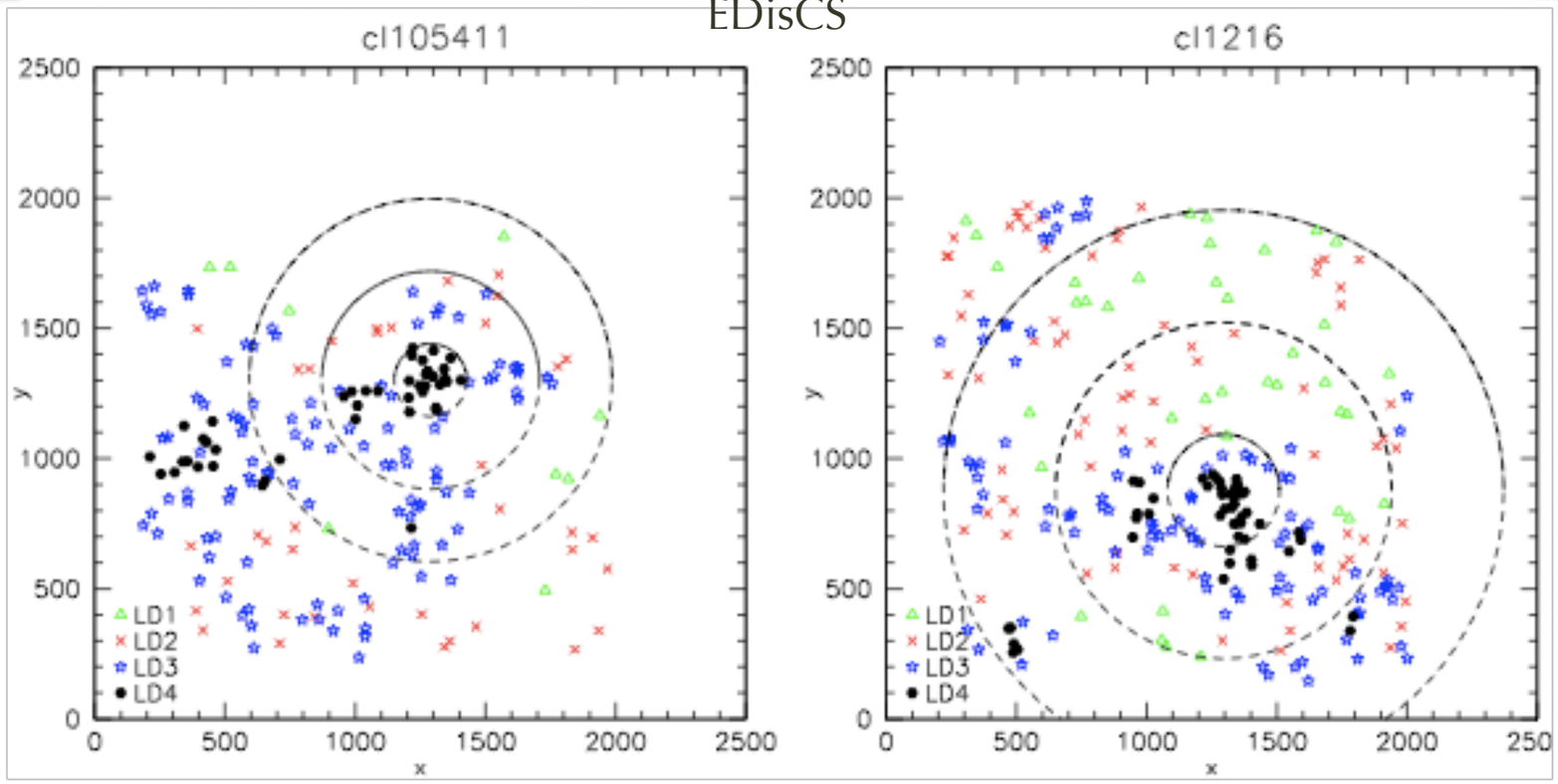
but in clusters and in the field trends are different

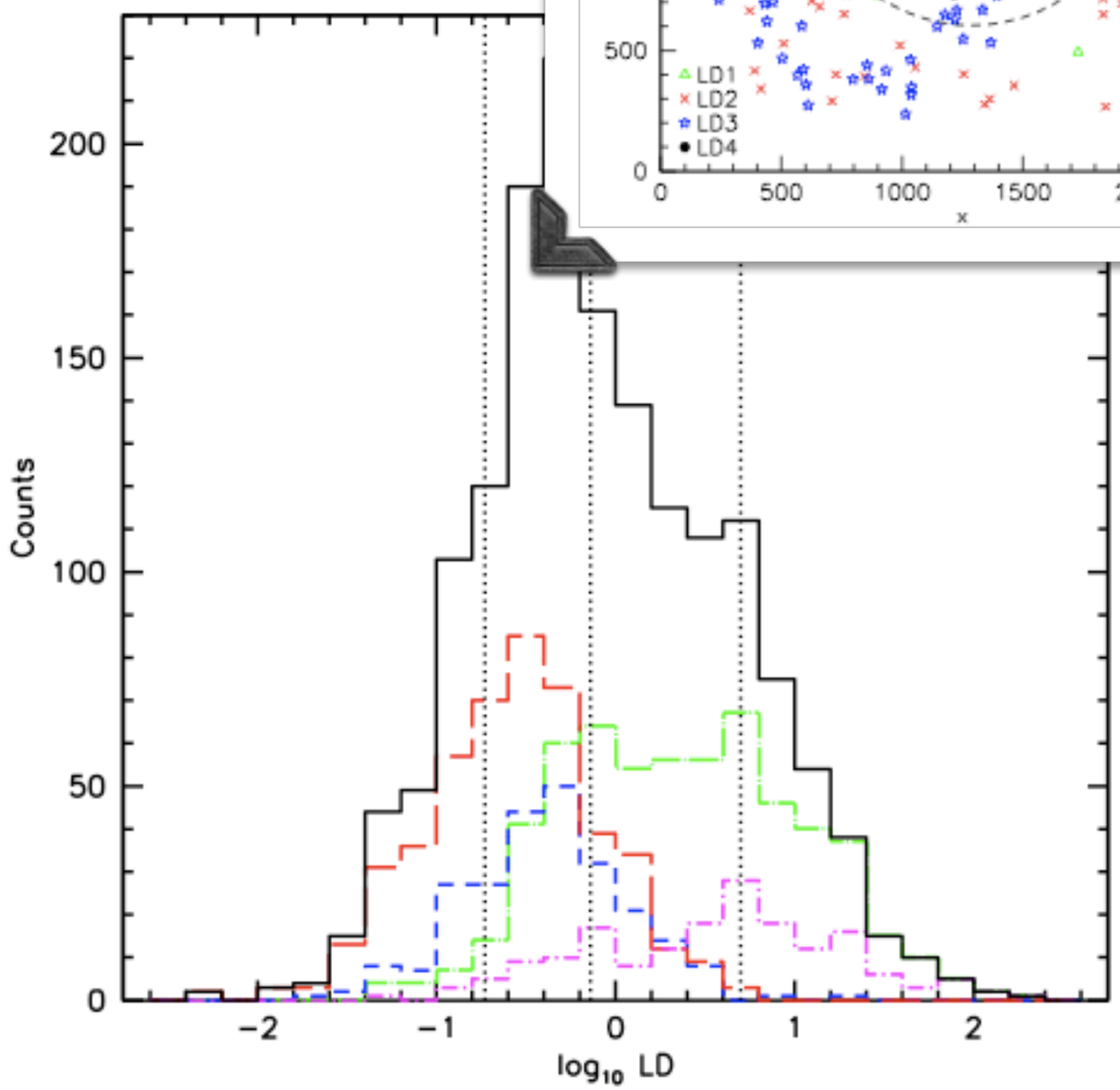


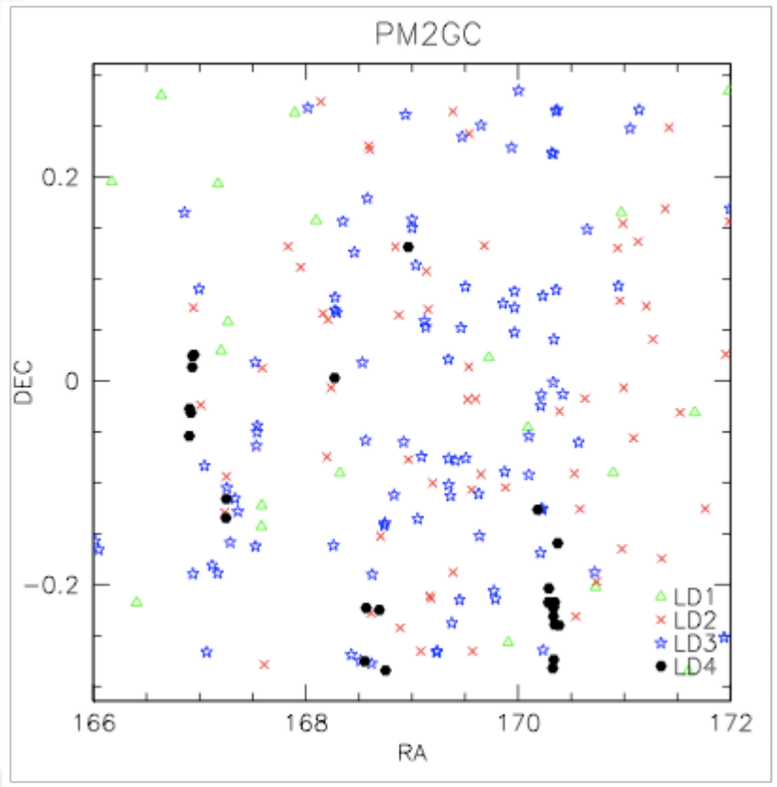
HOW ARE RELATED THE GLOBAL AND THE LOCAL ENVIRONMENT?


PM2GC
all
binaries
singles
groups
clusters >500
200
150
100
50
0
Counts
−2
−1
0
1
2
log10 LD

EDisCS


cl105411
cl1216
LD1
LD2
LD3
LD4
x
y
0
500
1000
1500
2000
2500


Counts
log10 LD
0
50
100
150
200
−2
−1
0
1
2


PM2GC
DEC
RA
LD1
LD2
LD3
LD4
0.2
0
−0.2
166
168
170
172

Summary (1)

Summary (1)

- Galaxy in clusters, groups and field follow the same mass distribution. THE GALAXY STELLAR MASS FUNCTION DOES NOT VARY WITH THE GLOBAL ENVIRONMENT AT z=0.3-0.8.

- In all environments, red and blue galaxies are regulated by different MF. Comparing the MF in different environments separately for blue and red galaxies, no differences are detected, but the crossing mass is different.

- In clusters, both the total galaxy stellar mass function and that of each morphological type evolve with z. There are proportionally more massive galaxies at high- than at low-z.

- Comparing the cluster and field MF at high a low z, we find that they evolve in the same way. THE EVOLUTION OF THE MF WITH z IS INDEPENDENT ON ENVIRONMENT

- At all redshifts and in all environments local density plays an important role in shaping the mass function

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- In all environments, red and blue galaxies are regulated by different MF. Comparing the MF in different environments separately for blue and red galaxies, no differences are detected, but the crossing mass is different.

- In clusters, both the total galaxy stellar mass function and that of each morphological type evolve with z. There are proportionally more massive galaxies at high- than at low-z.

- Comparing the cluster and field MF at high a low z, we find that they evolve in the same way. THE EVOLUTION OF THE MF WITH z IS INDEPENDENT ON ENVIRONMENT

- At all redshifts and in all environments local density plays an important role in shaping the mass function

GALAXY PROPERTIES ARE NOT MUCH DEPENDENT OF HALO MASS BUT DO DEPEND ON LOCAL SCALE PROCESSES

SFR-Mass relation in different environments

FIELD: strong correlation between SFR and mass. It shifts to higher SFRs at higher z (e.g. Noeske+2007a, Elbaz+2007, Daddi+2007)

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CLUSTERS: ?

GROUPS: ?

EDisCS

Spectroscopic data, mass limited sample, limit: log(M/Msun)>10.8 for Salpeter (1955) IMF

SFR for 24μm detected: from IR luminosity (Finn+2009) using Kennicutt (1998)

from [OII] luminosity (Poggianti+2008)

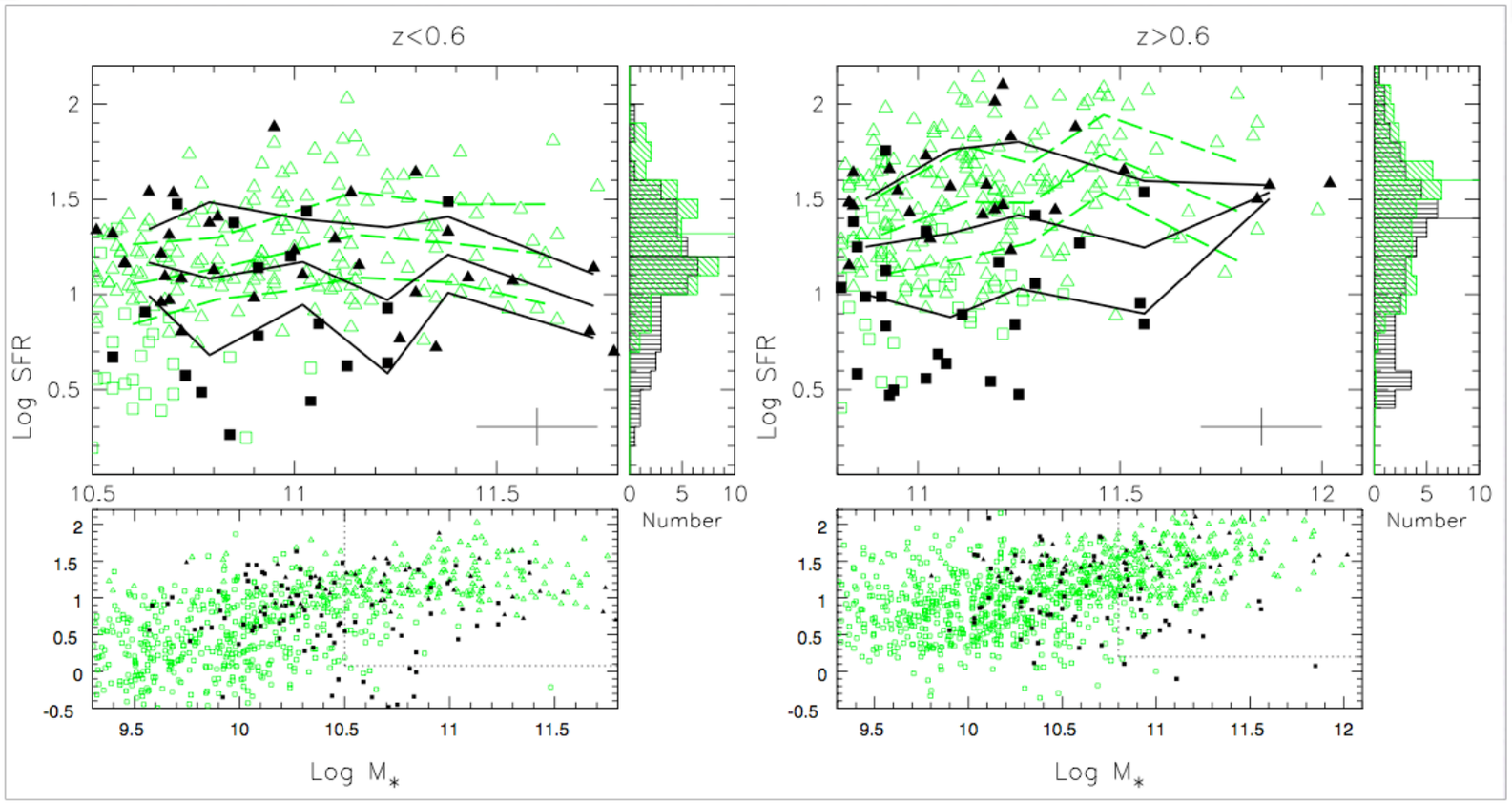
$SFRtot=SFR_{IR}+SFR[OII]$

SFR for galaxies without 24μm detection: from [OII] luminosity (Poggianti+2008) dust- corrected

Galaxies without 24μm detection are divided into red and blue:

U-B> -0.032(MB+21.52)+0.454-0.25

AGN contamination?



Field data from Noeske+(2007a)

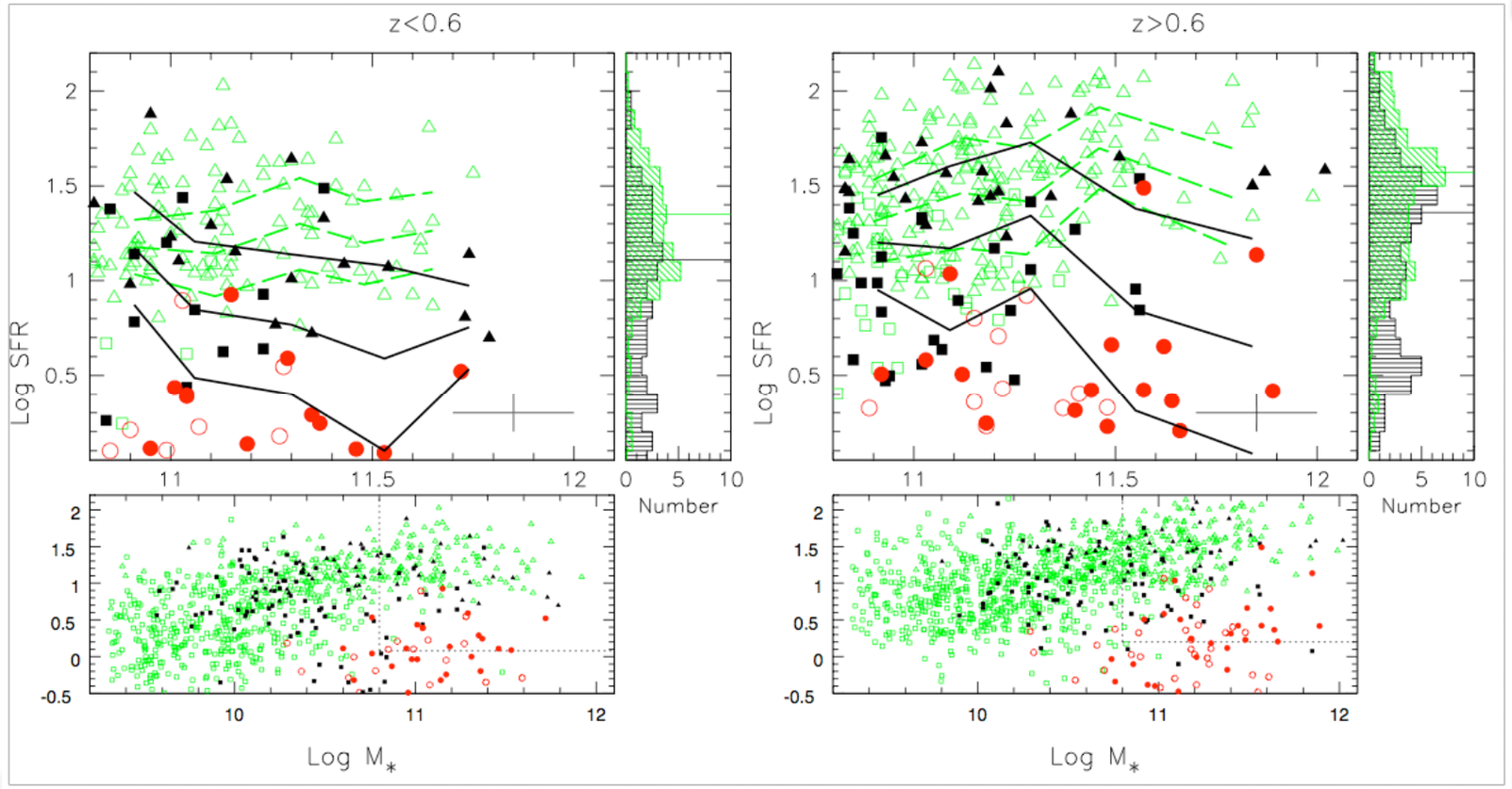
Clusters+groups, field

24 μm + blue emission lines

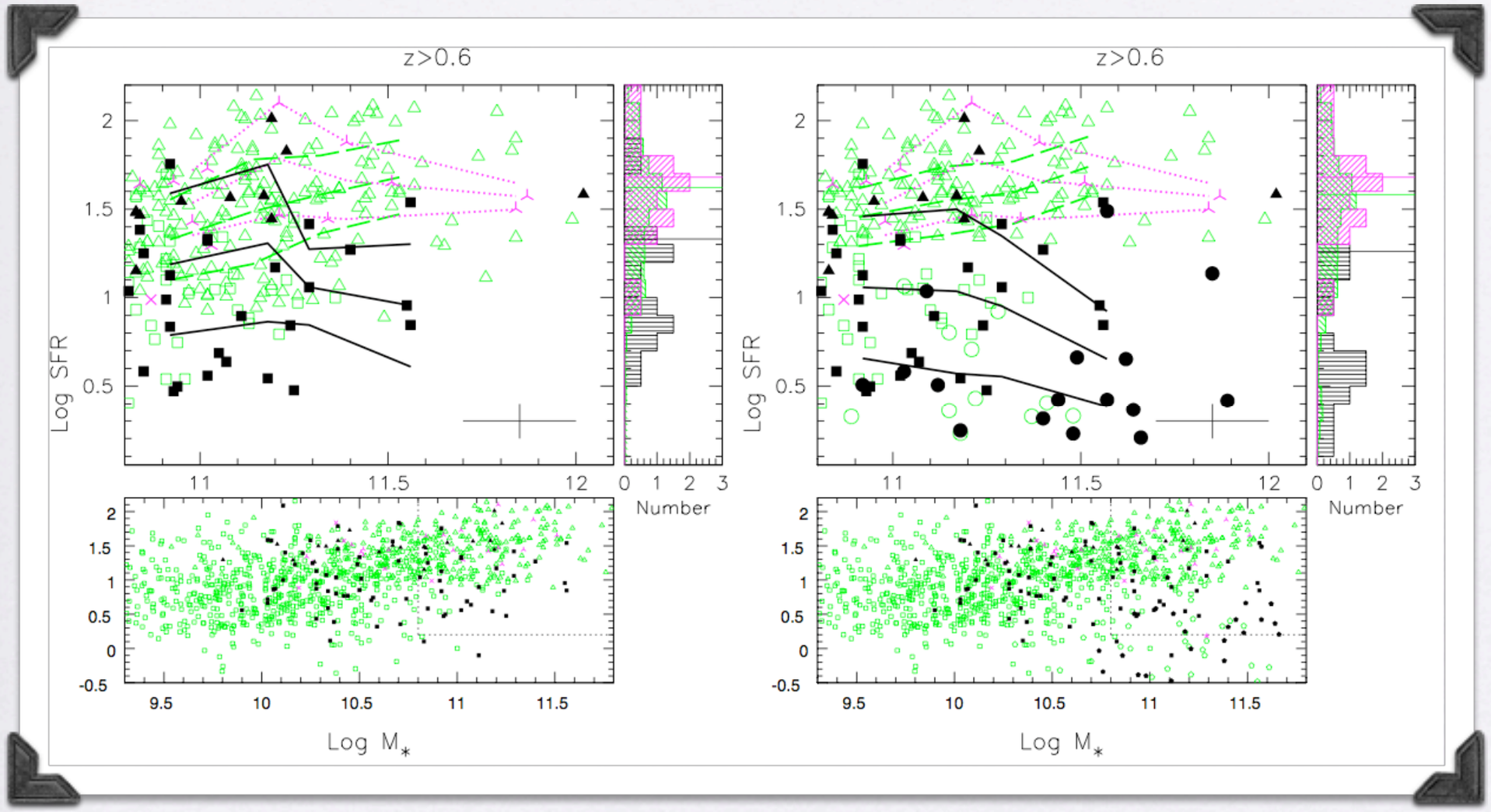
Delta <SFR>=1.35 +/- 0.15

24 μm + blue and red emission lines

Delta <SFR>=1.63 +/- 0.20



Clusters, groups, field



24 μm + blue emission lines

Delta <SFR>=1.93 +/- 0.02

24 μm + blue and red emission lines

Delta <SFR>=2.13 +/- 0.02

Summary (2)

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- The relation between SF activity and galaxy mass depends on environment

- There are significant differences between the SF activity of star-forming galaxies of the same mass in different environments.

- Clusters show a lower SF activity than the field, not only because they have a pre-existing large population of early-type galaxies passively evolving since high z, but because currently star-forming galaxies host an average lower SFR than their field counterparts of similar mass

- Environmental effects suppress SF in clusters. Fast-acting mechanisms would leave the SFR–mass relation unchanged, while processes with a longer timescale would affect it.

thanks for the attention!

based on

Vulcani et al. 2011 (MNARS, 412 246-268)

Vulcani et al. 2011c (MNRAS 2146)

Vulcani et al. 2011d (A&A submitted, arXiv1111.0830V)

Vulcani et al. 2010 (ApjL, 710, 1)