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

Benedetta Vulcani
Universita' degli Studi di Padova - INAF Padova

in collaboration with:

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

November, 9th 2011 - Milano, "Galaxy Evolution and Environment 2"

Outline

- 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

Samples used @ low-z

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 $M_V<=-19.5$

Samples used @ low-z

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 $M_V<=-19.5$

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

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

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.

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?

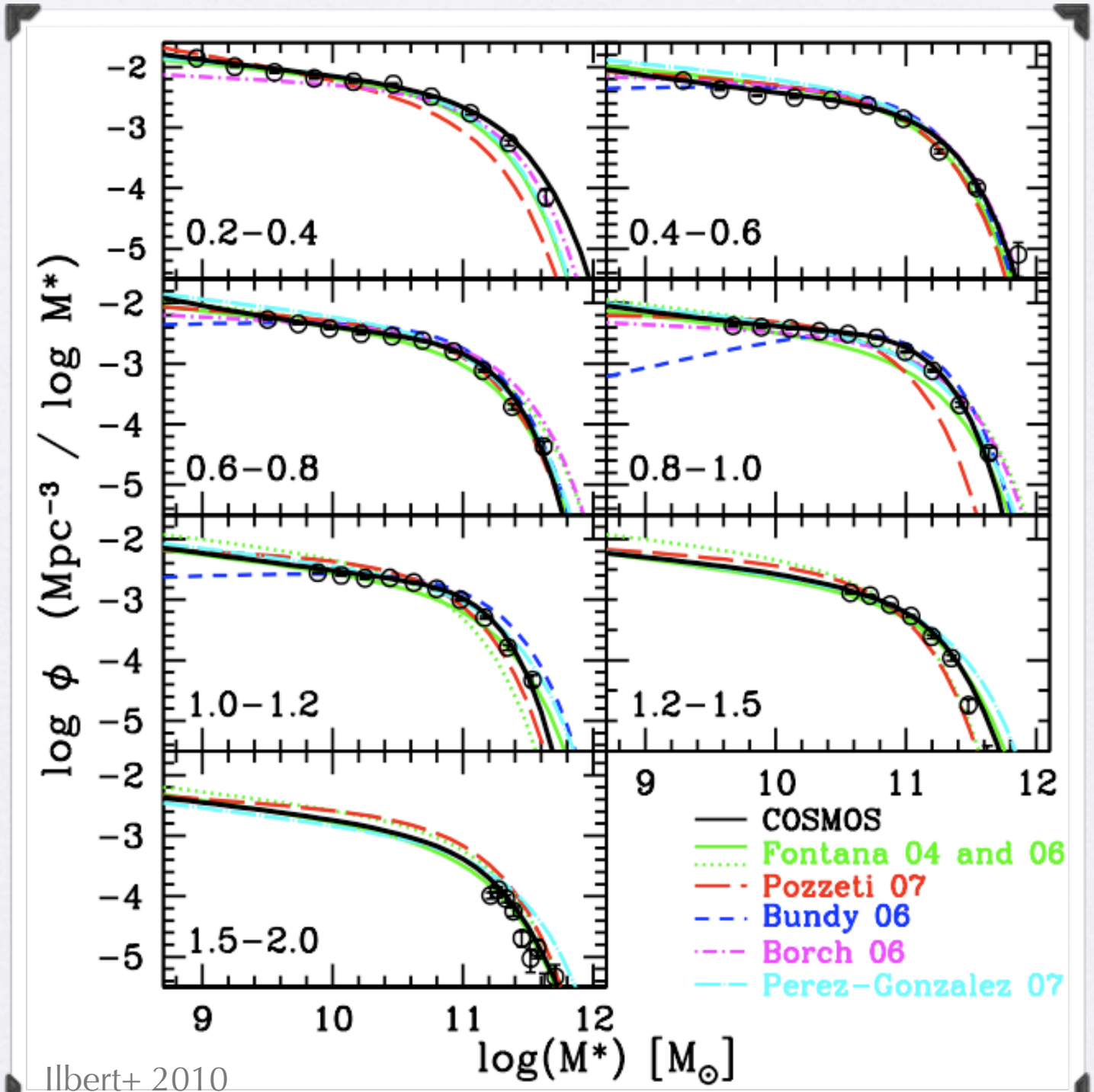
The MF in different global environments

The MF in the field

(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

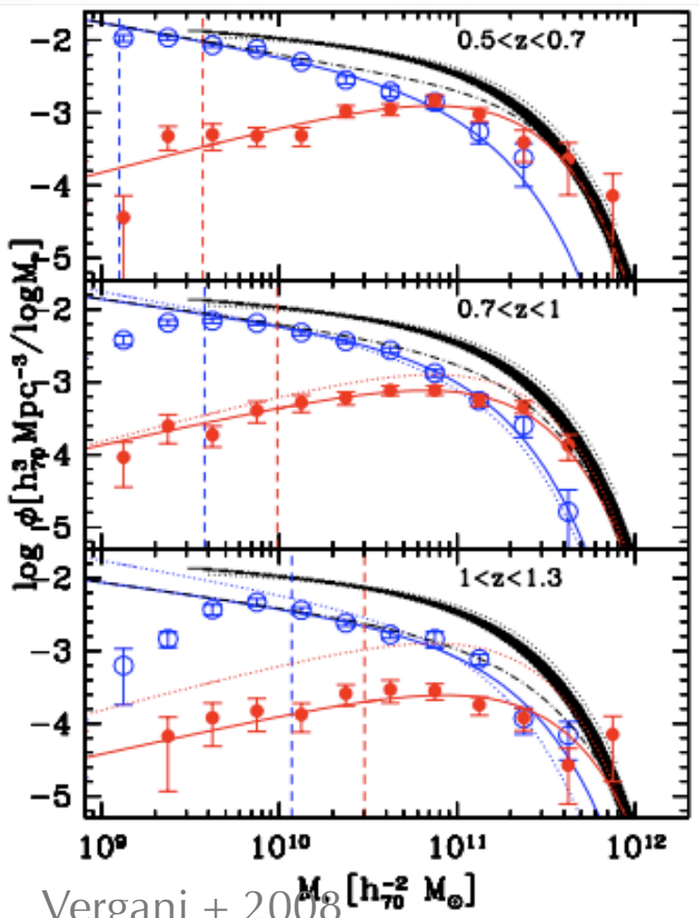
Low mass galaxies evolve more then high mass galaxies



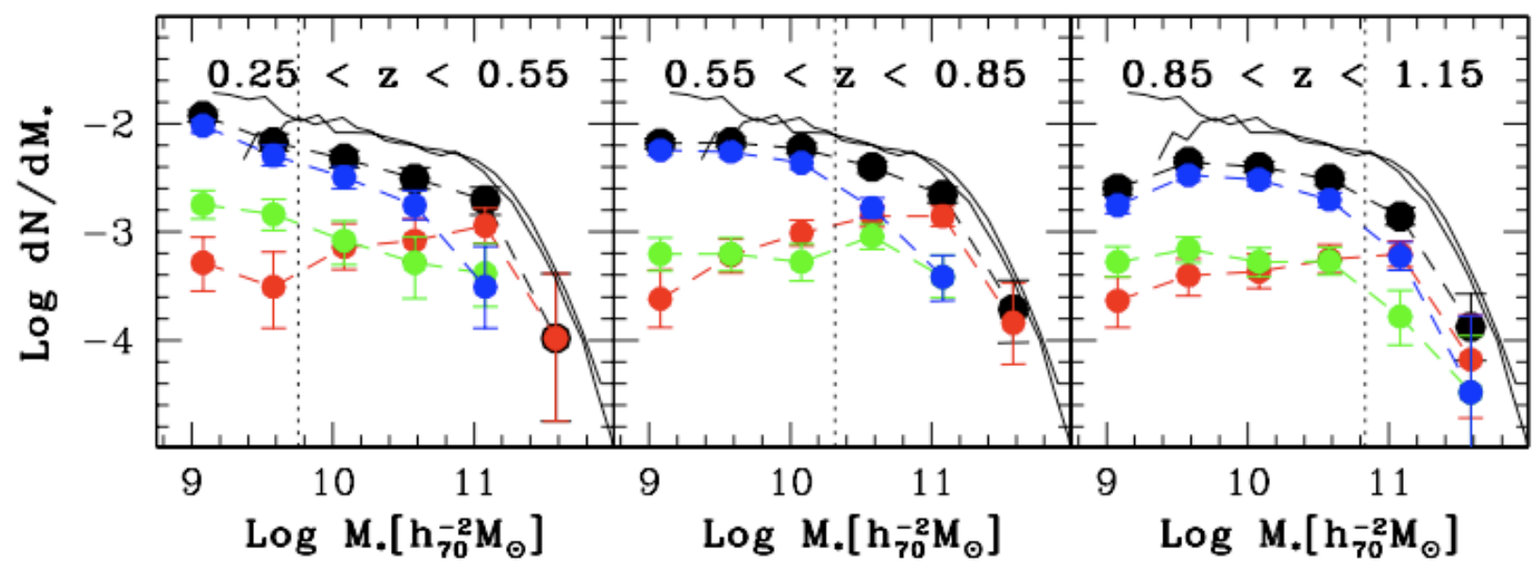
Ilbert+ 2010

The MF in the field

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

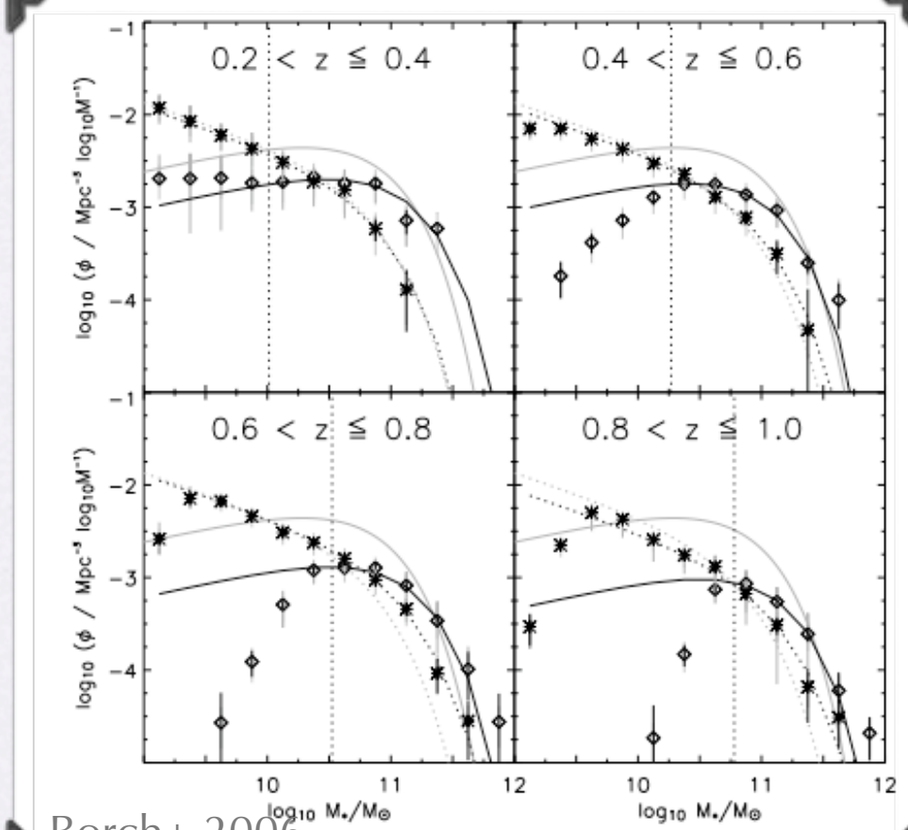


Vergani + 2008



Pannella+ 2006

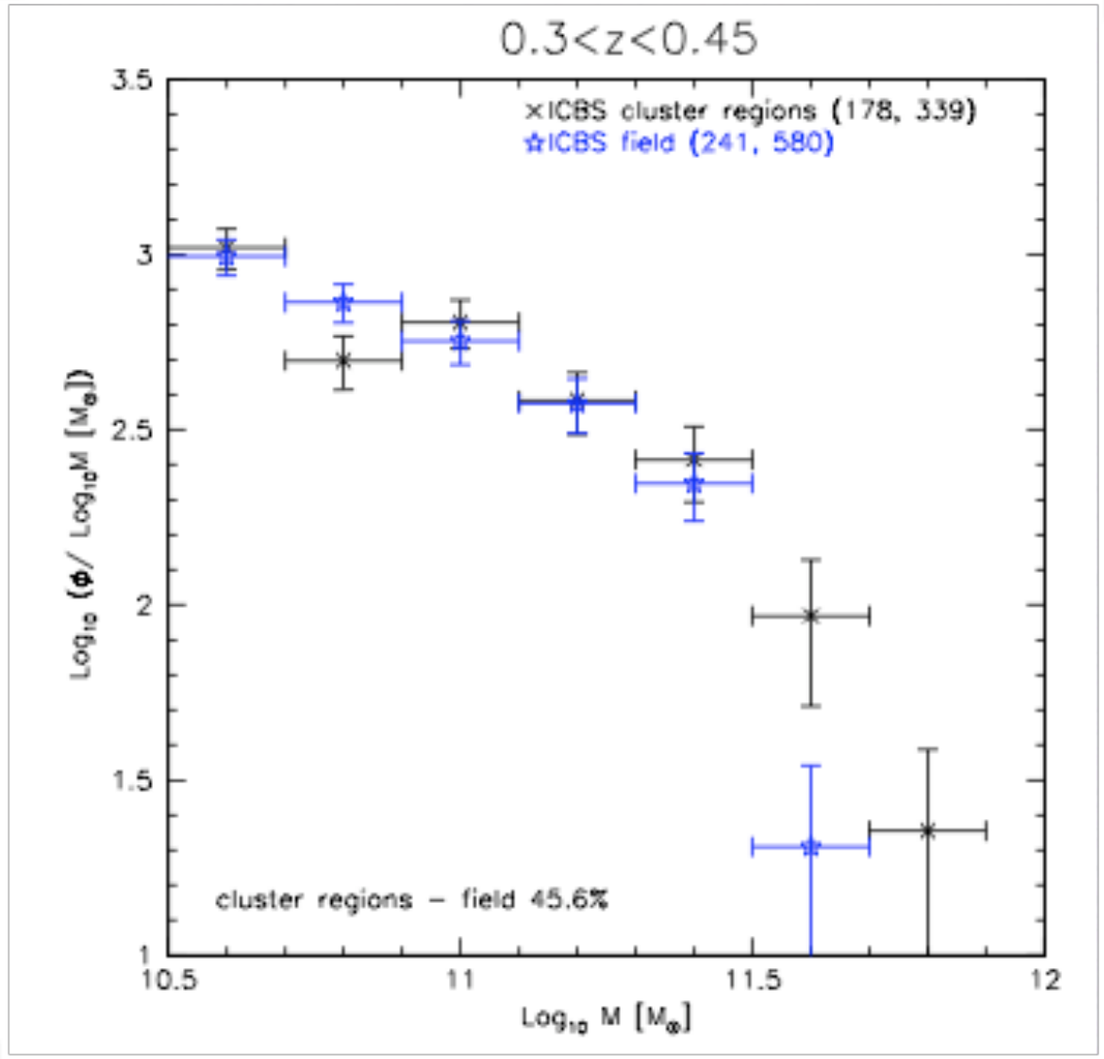
Several studies have analyzed separately galaxies of different types (according to colors, star formation activity, structural parameters, morphologies)



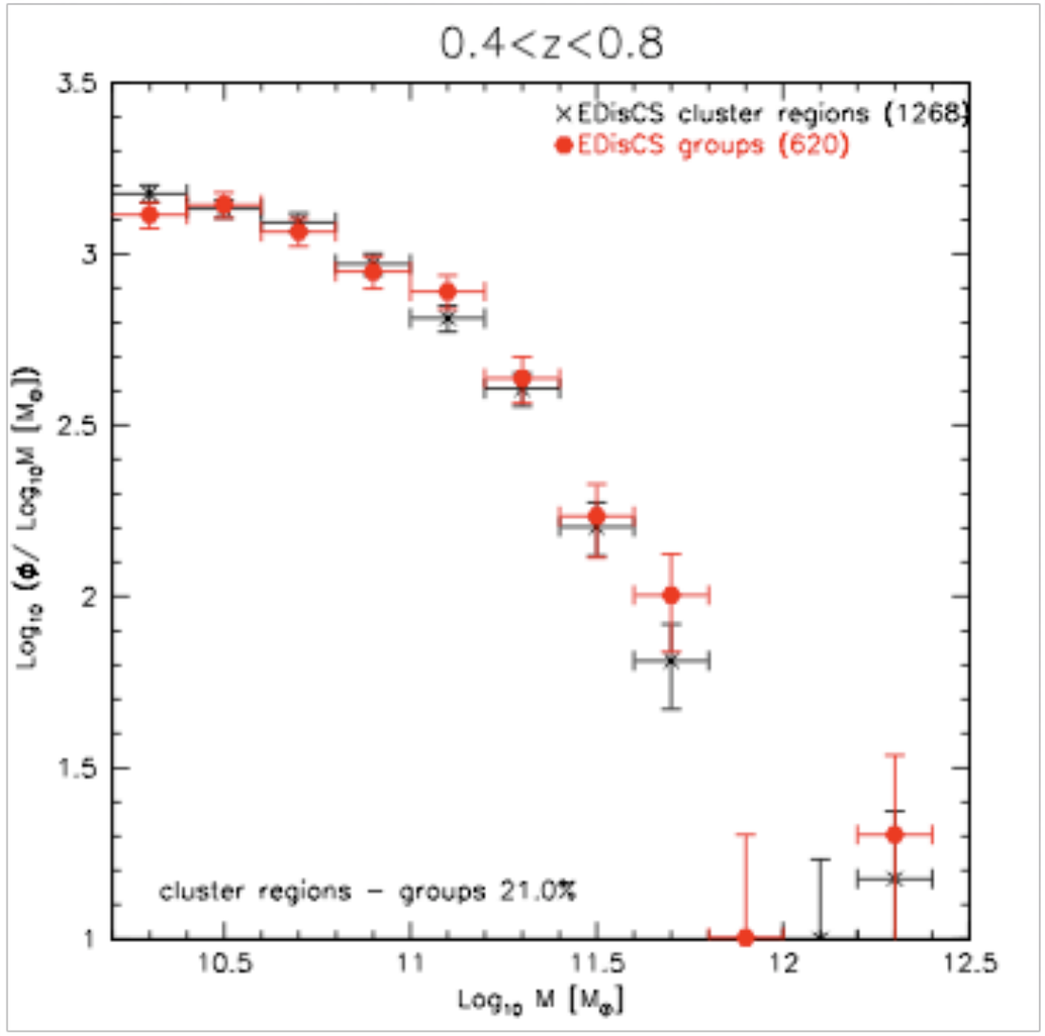
Borch+ 2006

The MF in different GE

@ intermediate redshift



CLUSTERS, GROUPS and FIELD have the same MF



The MF does not depend on global environment

The red/blue MF

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

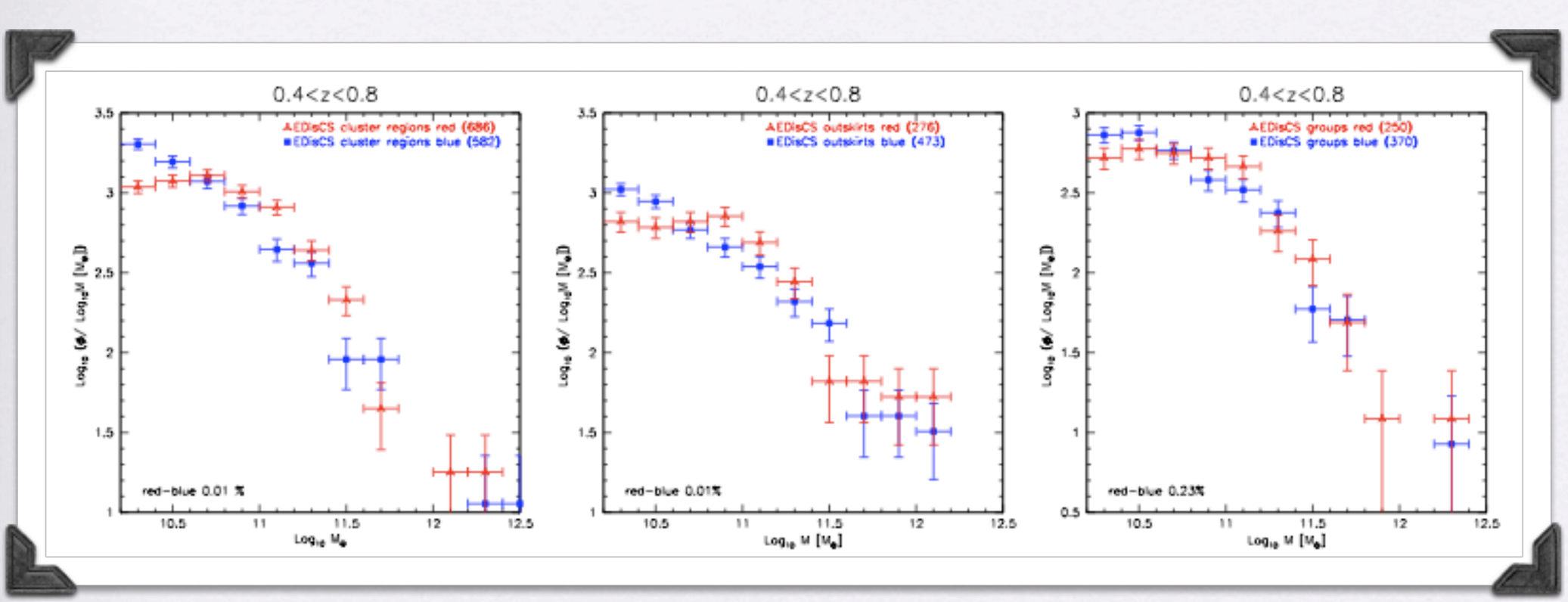
Peng+ (2010)

	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%

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)



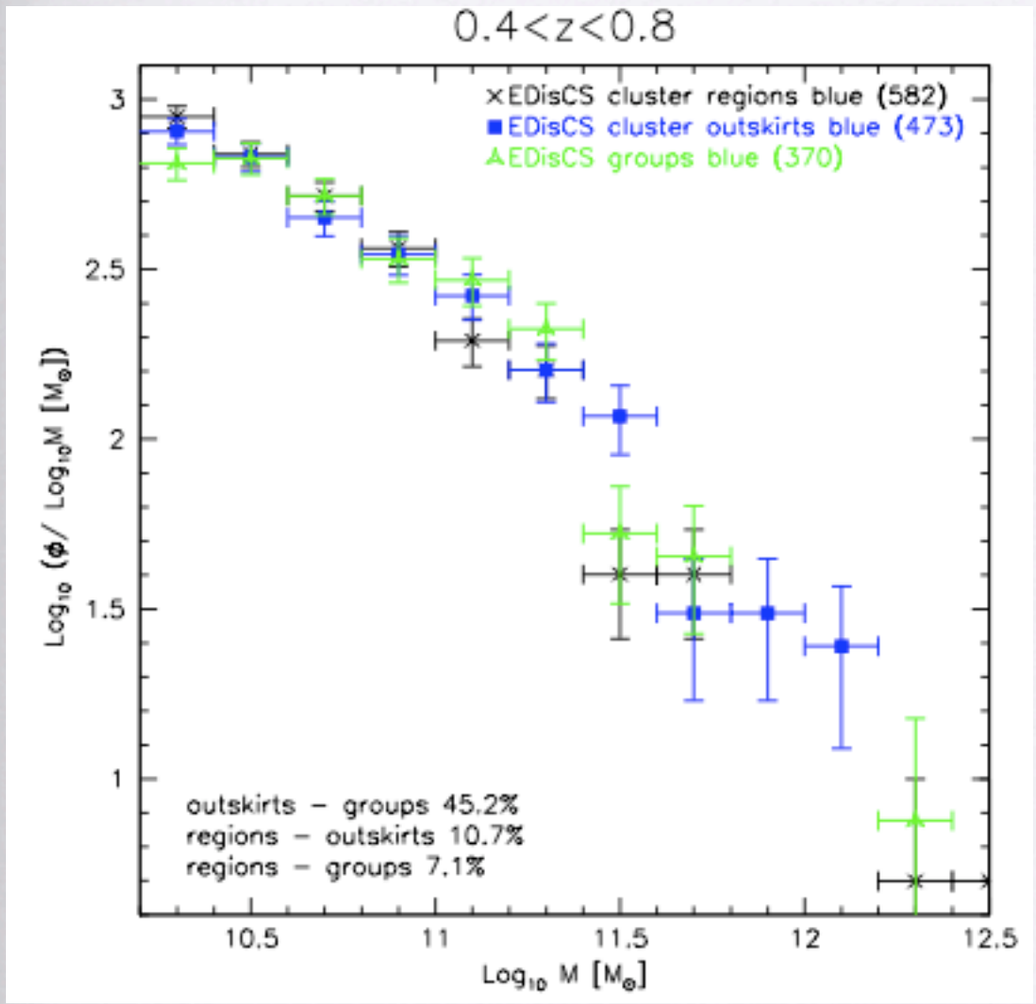
In all environments, red and blue galaxies have different MF

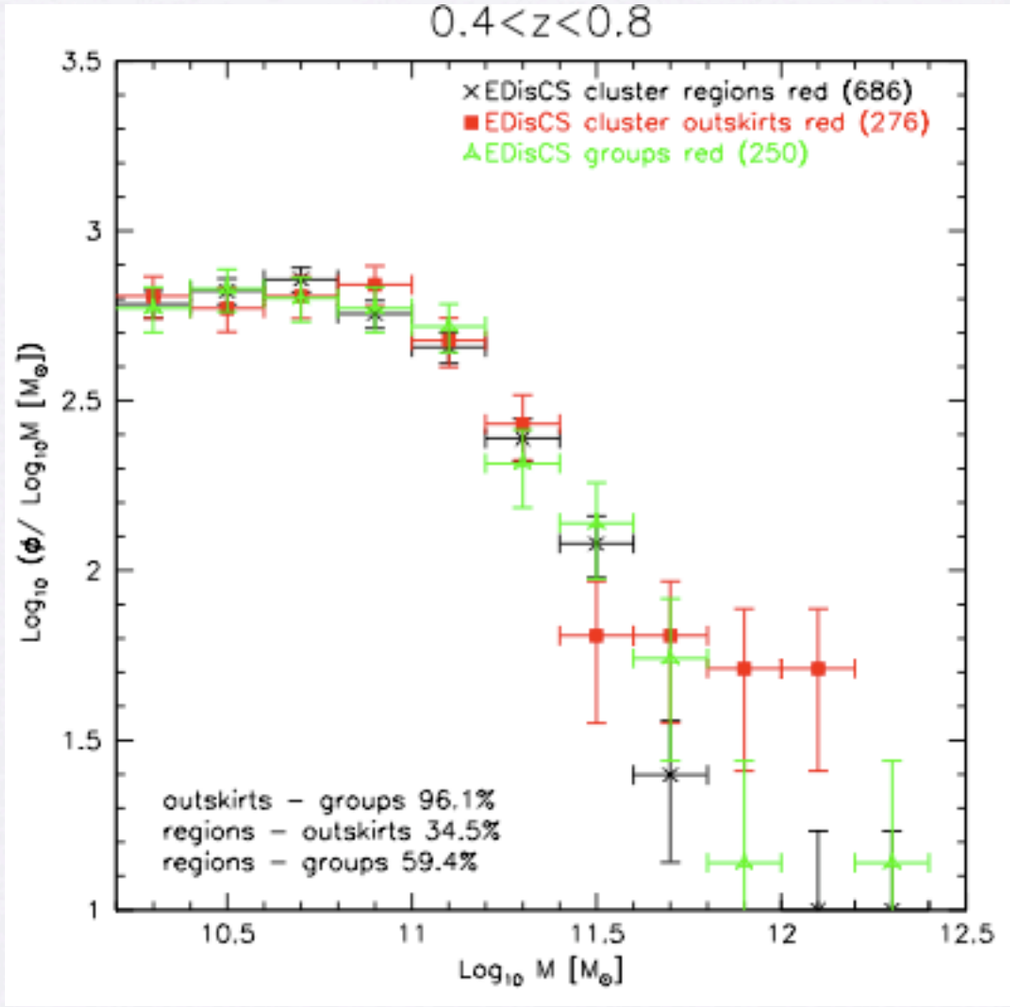
The red/blue MF

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

Peng+ (2010)

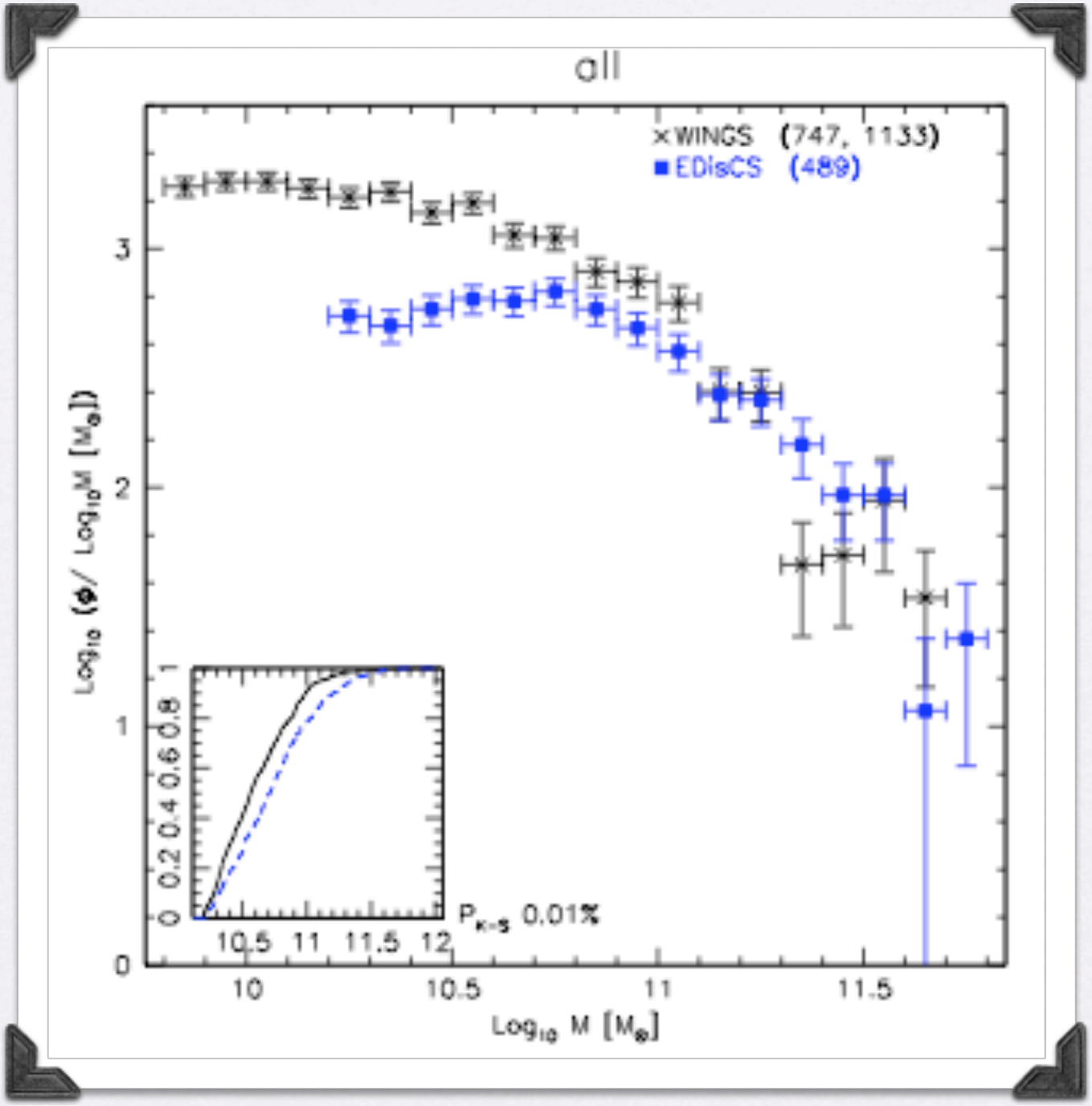
No differences are detected in MF in different environments, for red and blue galaxies separately





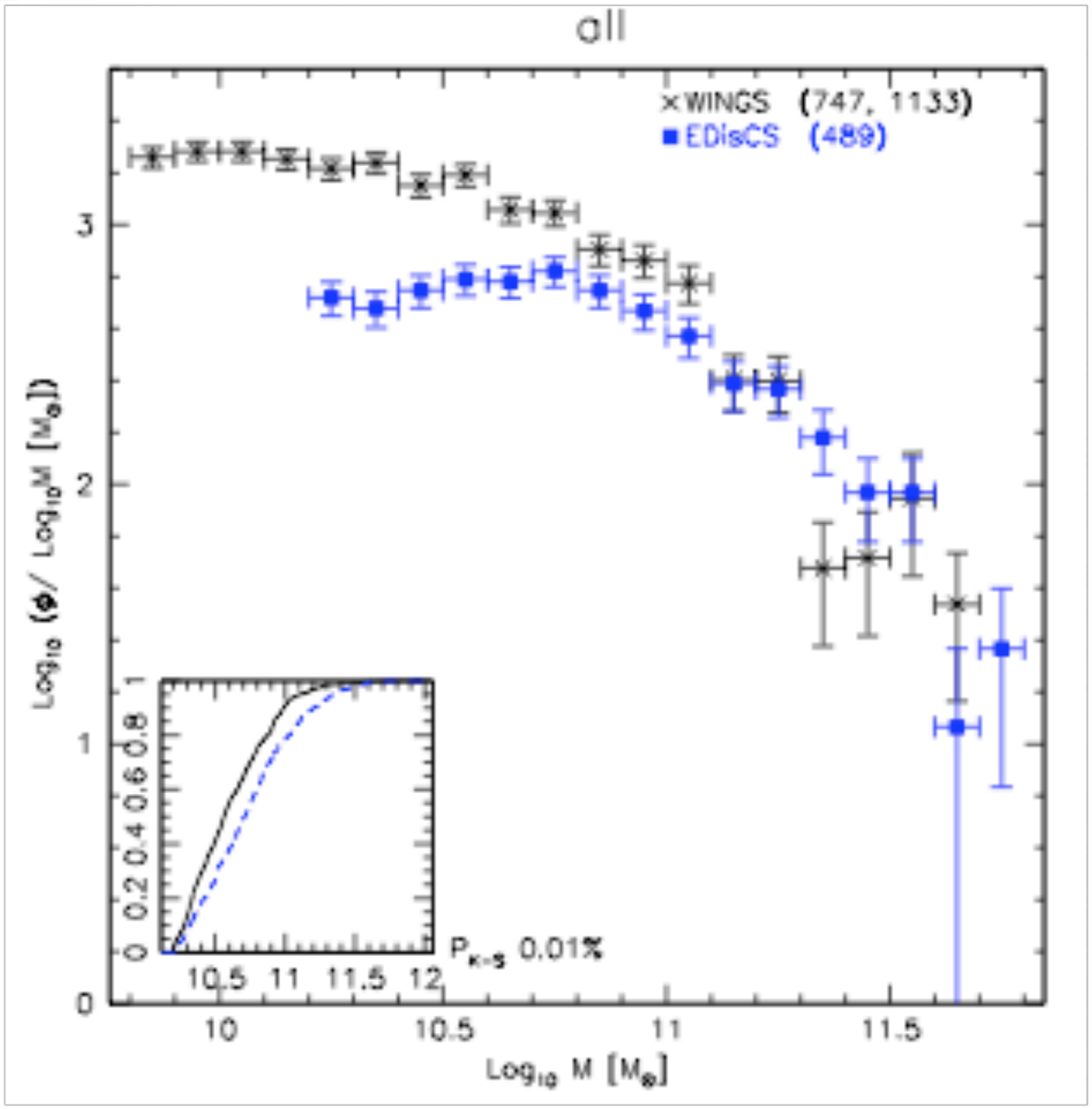
The evolution in clusters

from z~0.6 to z~0



The evolution in clusters

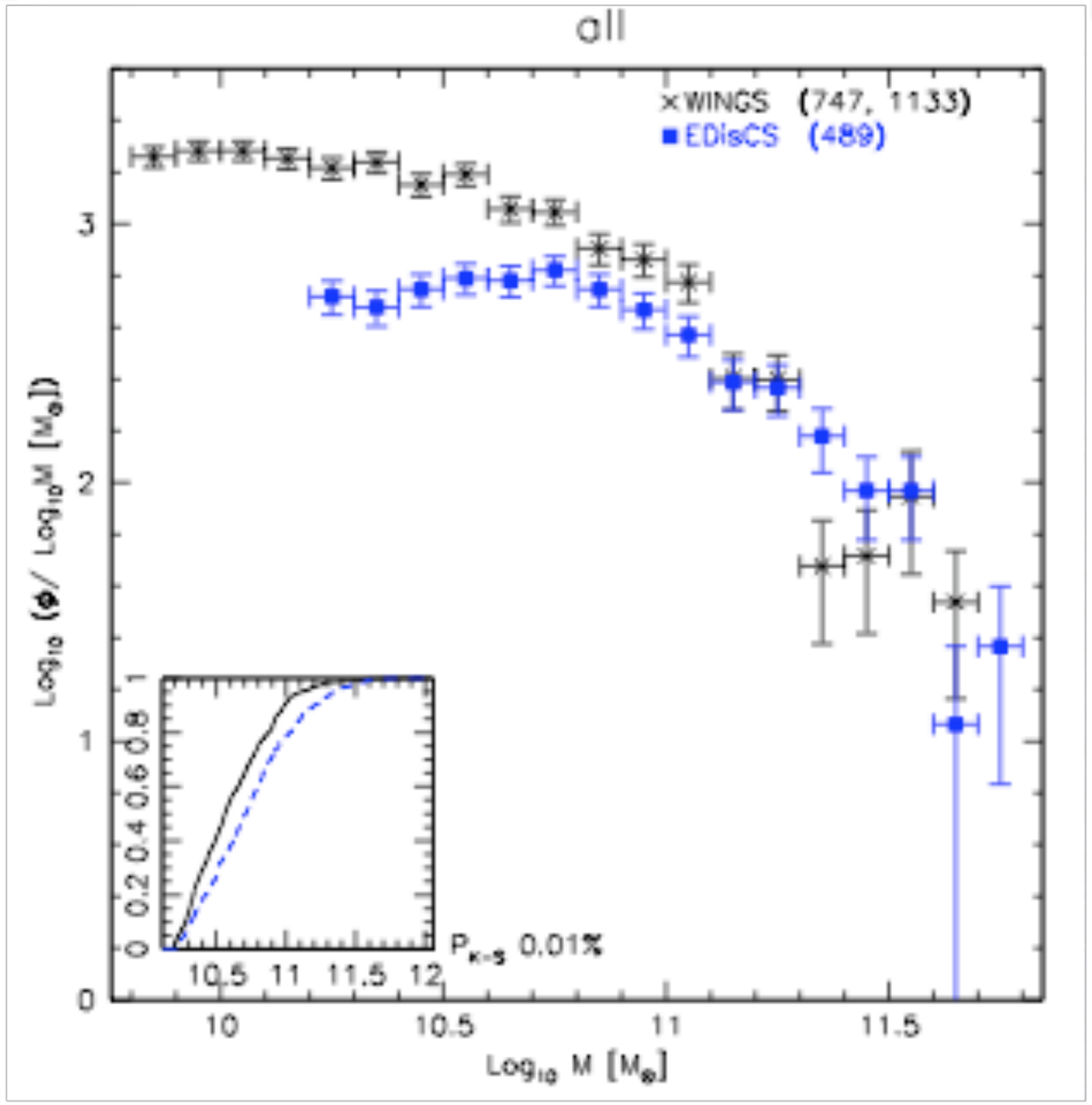
from z~0.6 to z~0



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

The evolution in clusters

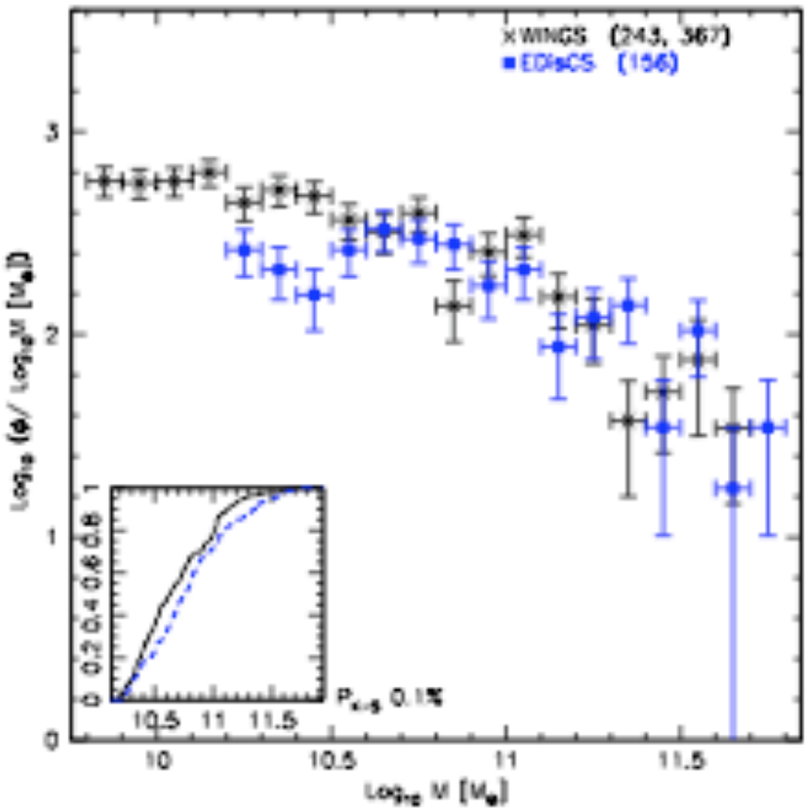
from z~0.6 to z~0



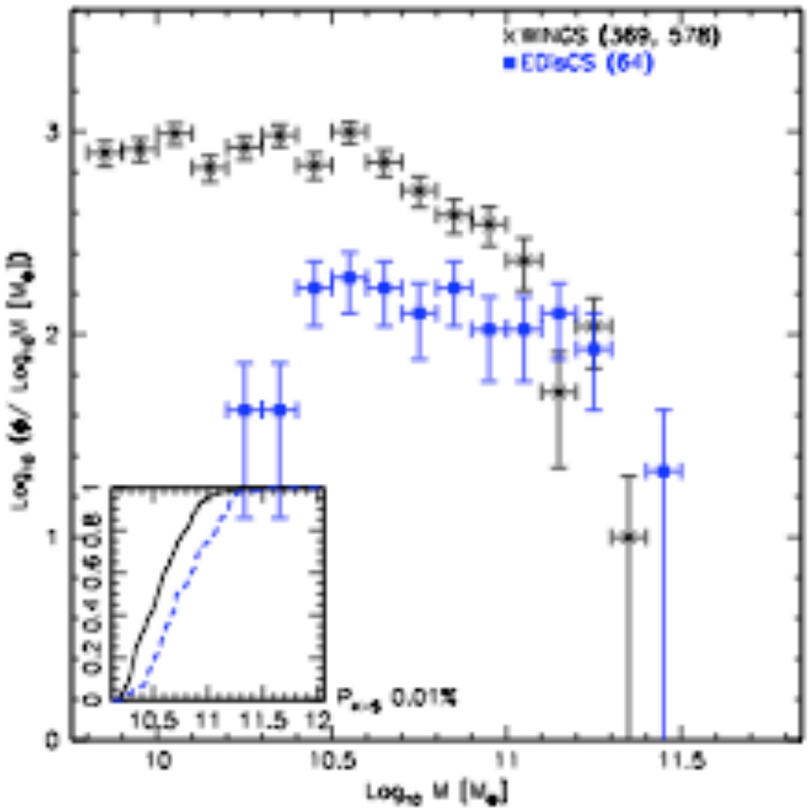
- galaxy merging
- mass loss due to harassment
- ~~environmental mass segregation of infalling galaxies~~
- mass growth due to star formation

Evolution of the MF of each morphological type

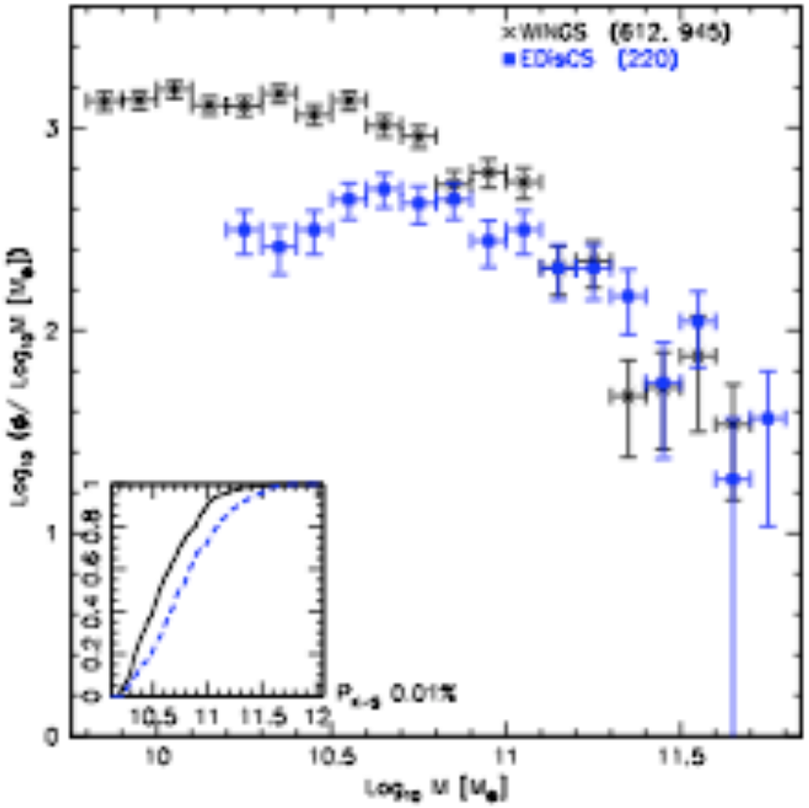
ellipticals



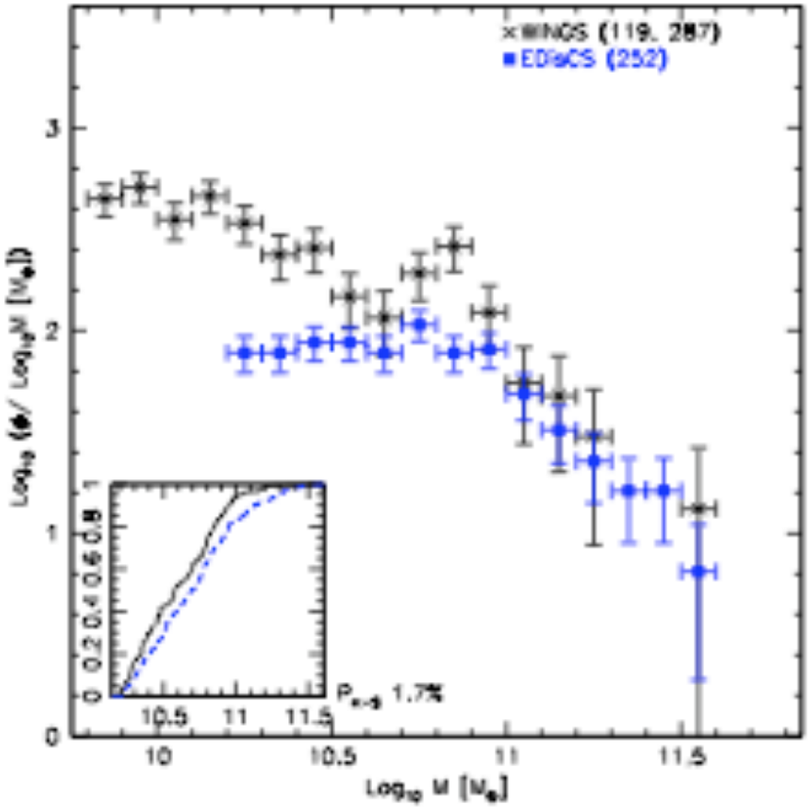
S0s

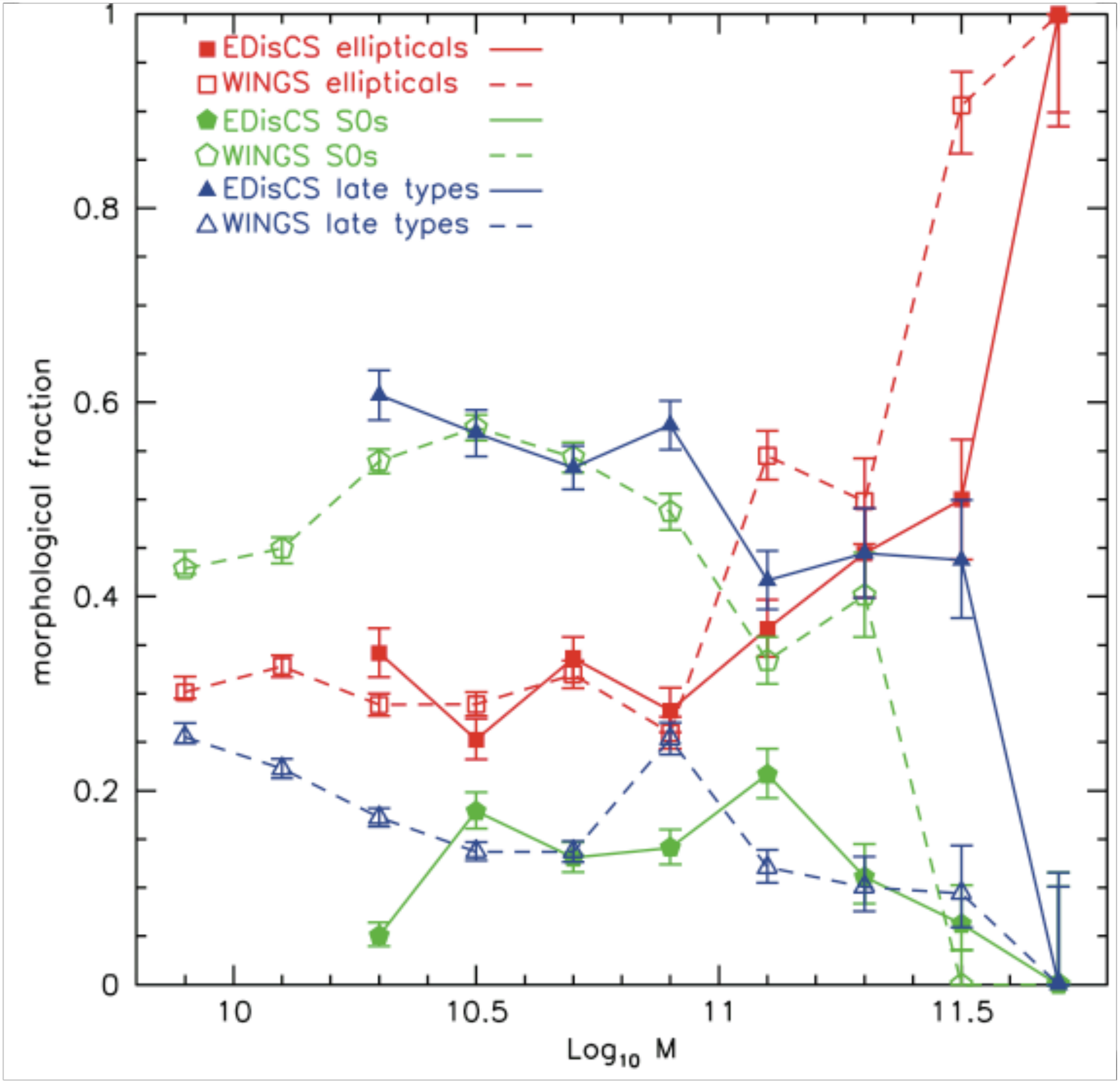


early−types



late−types

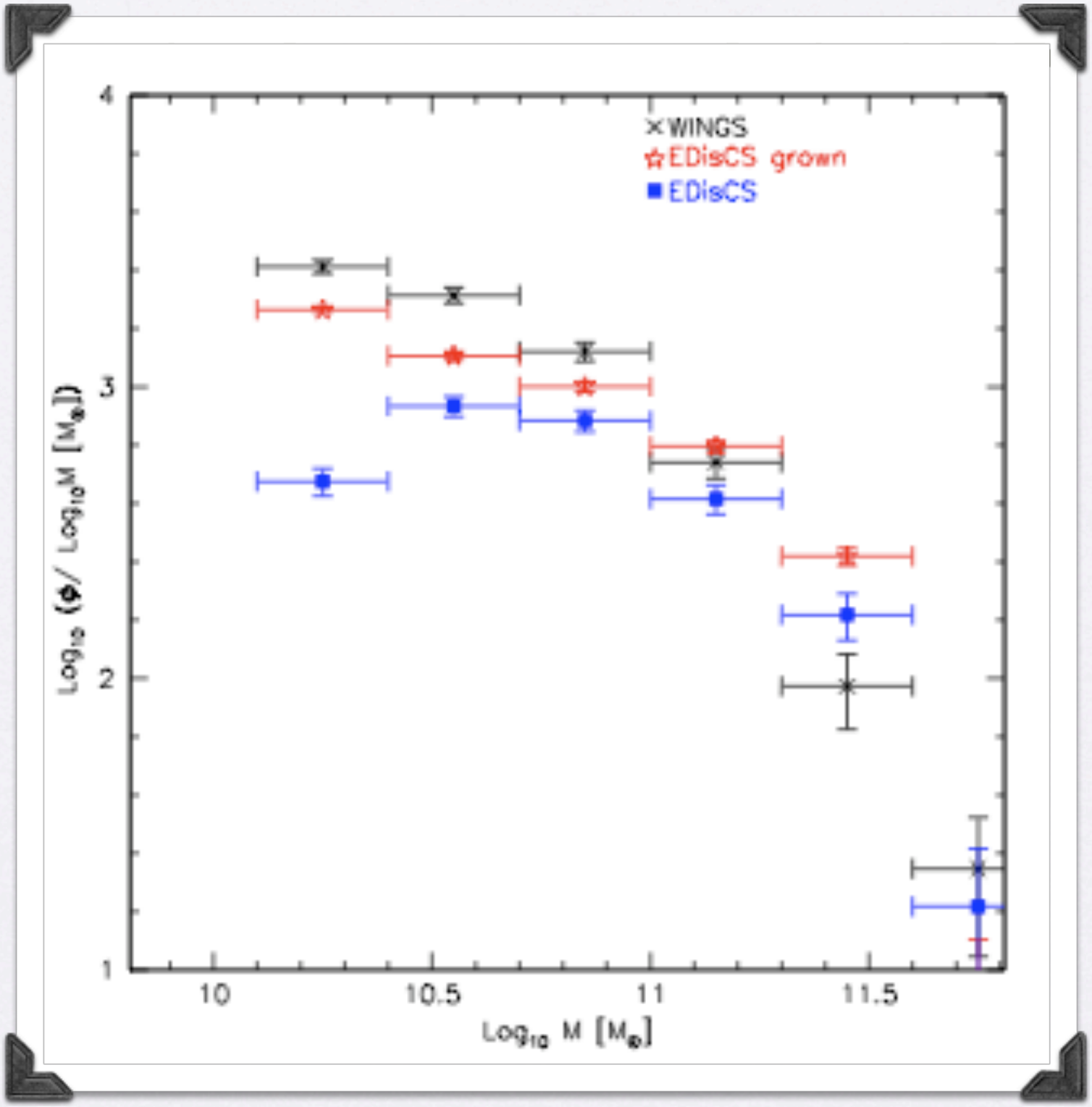



EDisCS ellipticals
WINGS ellipticals
EDisCS SOs
WINGS SOs
EDisCS late types
WINGS late types
morphological fraction
1
0.8
0.6
0.4
0.2
0
10
10.5
11
11.5
Log10 M

What drives the evolution of the total MF?

- mergers
- harassment
- star formation
- morphological transformation

What drives the evolution

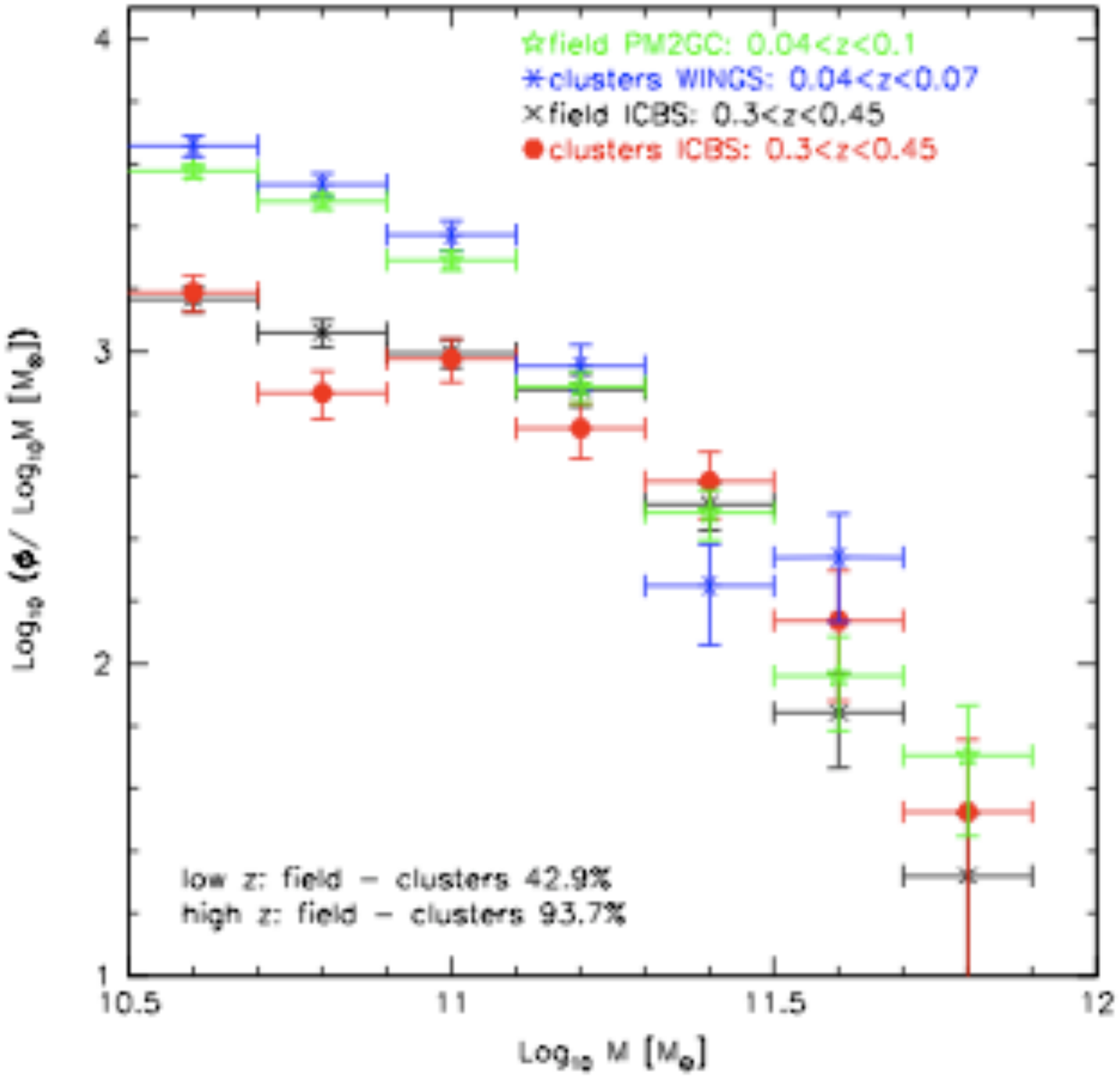


What drives the evolution of the total MF?

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

from z~0.4 to z~0



The evolution of the MF with time is independent of environment

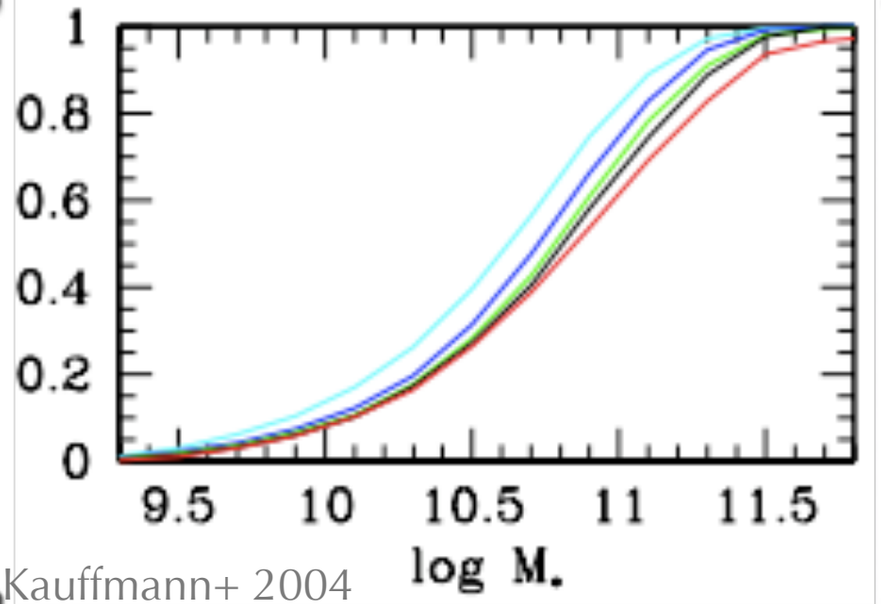
field at low-z from PM2GC (Calvi+ in preparation)

The MF in different local environments

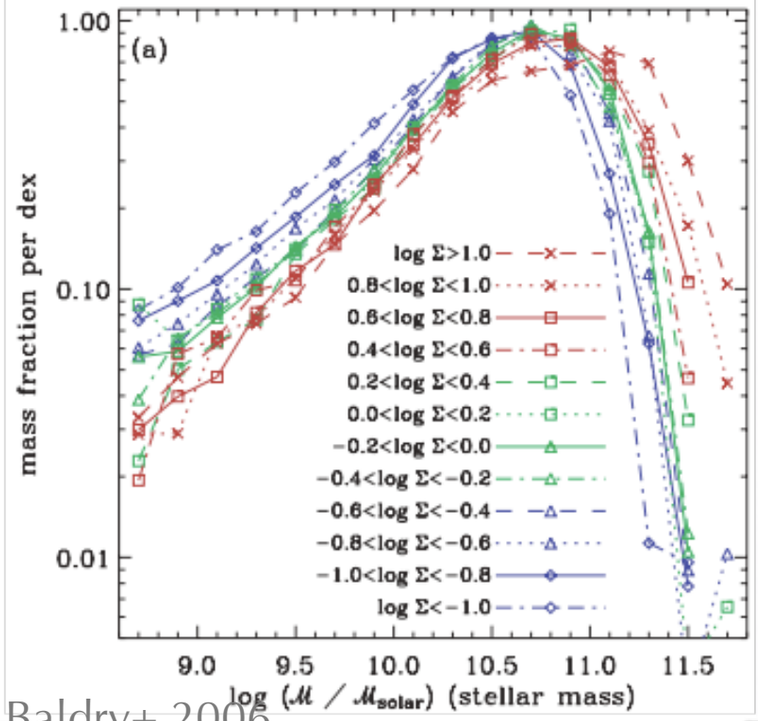
The MF in different LD

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

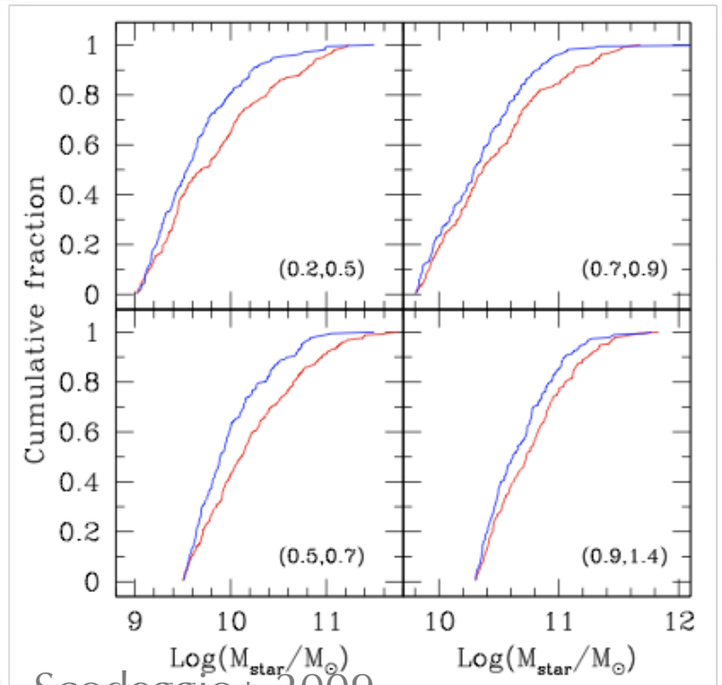
LOCAL UNIVERSE



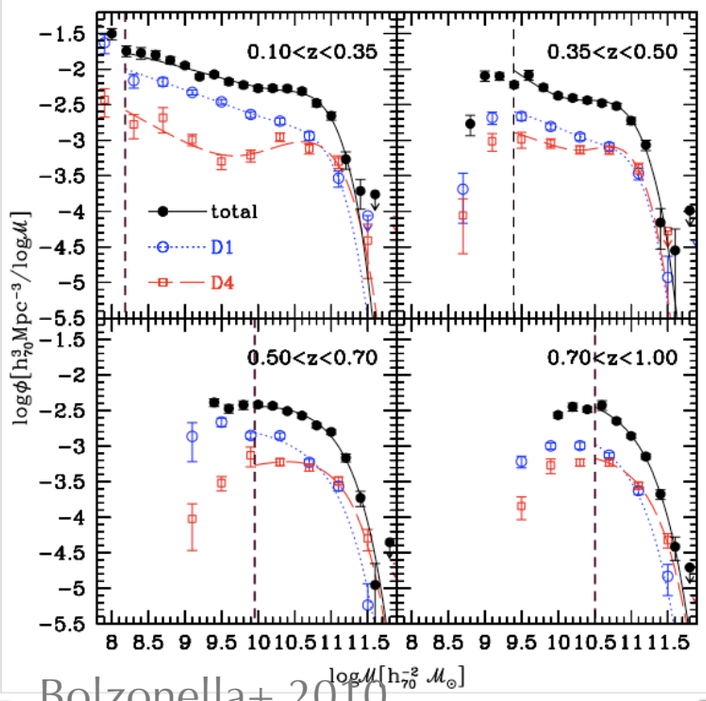
Kauffmann+ 2004



Baldry+ 2006



Scodeggio+ 2009



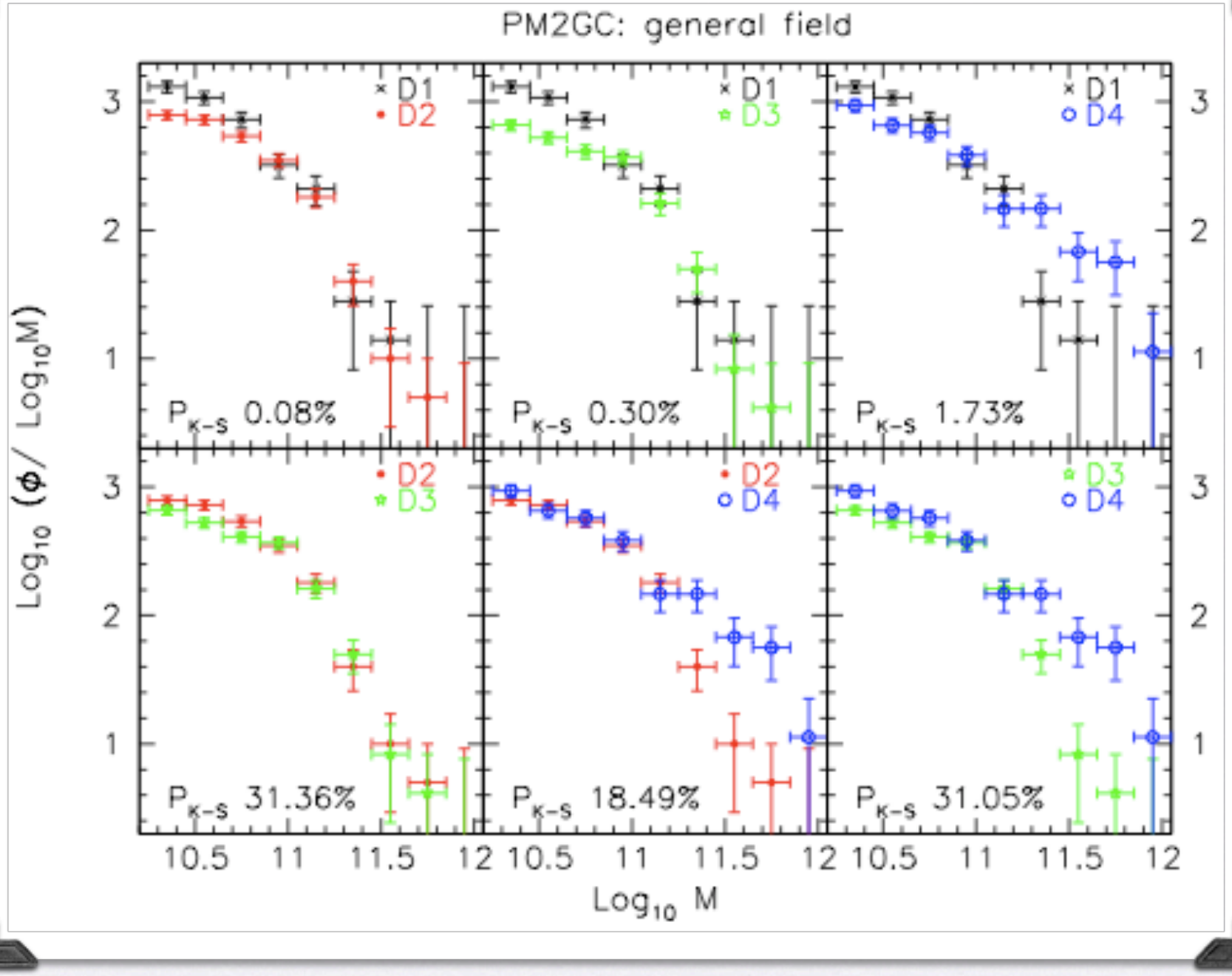
Bolzonella+ 2010

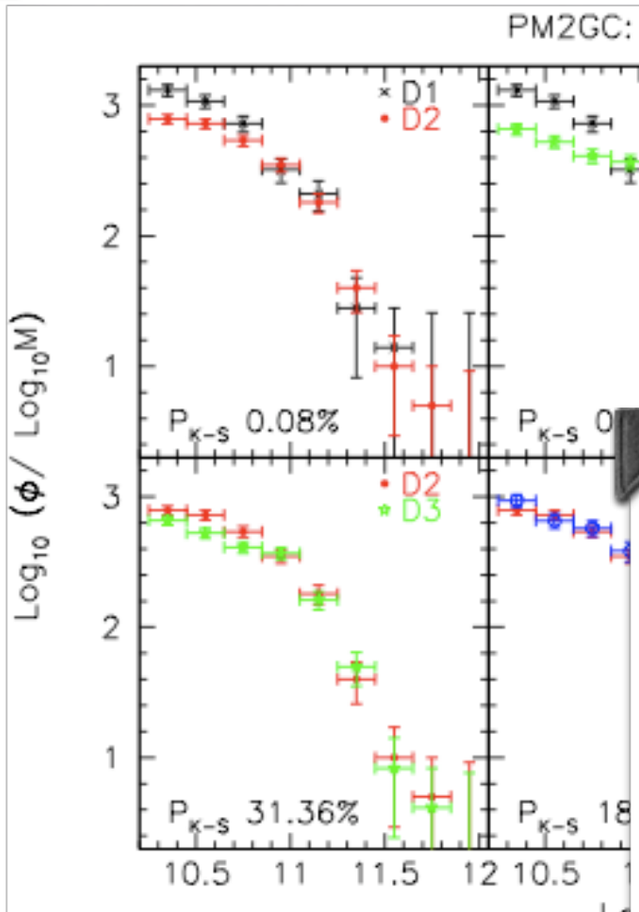
FIELD

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

DISTANT UNIVERSE

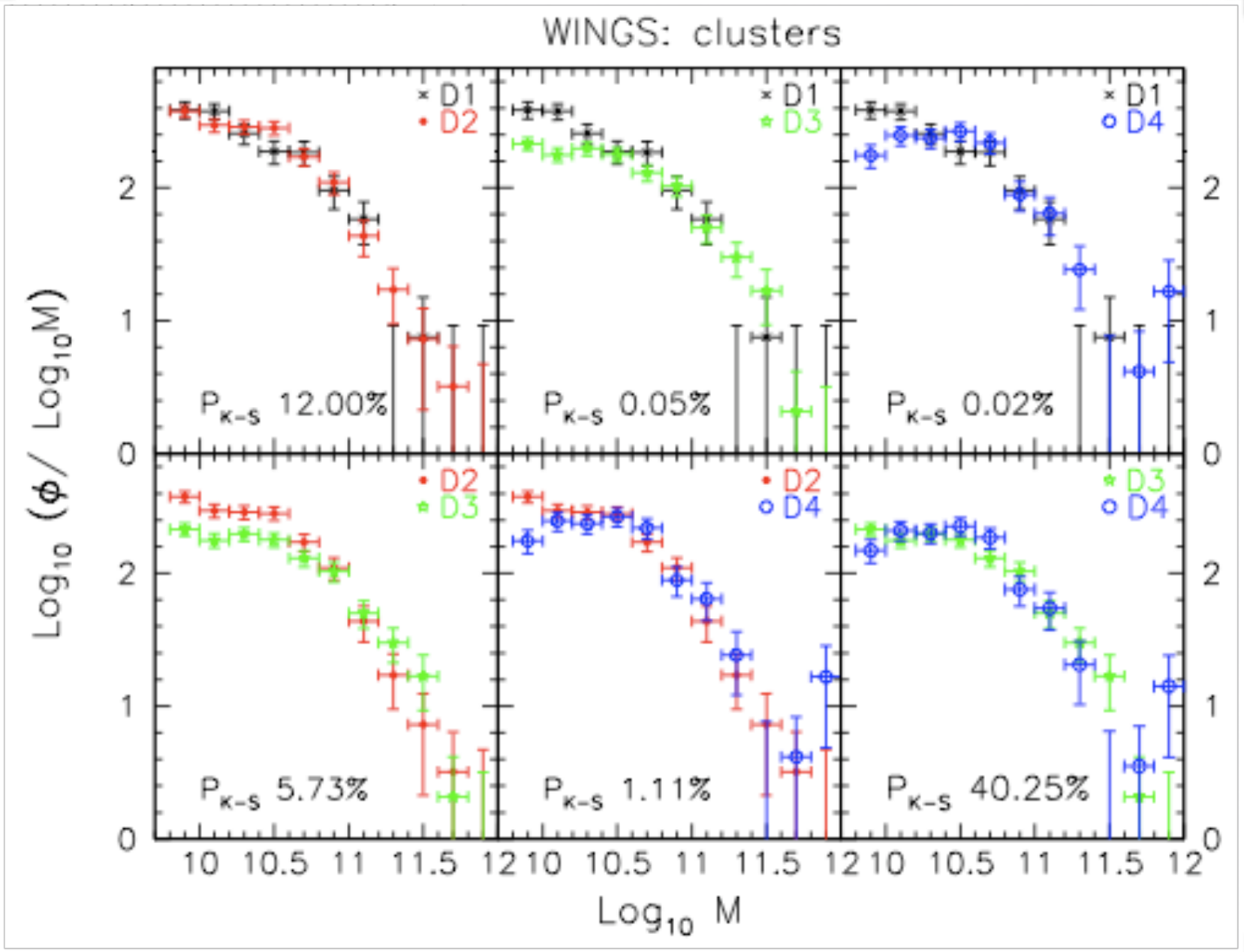
FIELD @ LOW z


PM2GC: general field
D1
D2
D3
D4
P_{K-S} 0.08%
P_{K-S} 0.30%
P_{K-S} 1.73%
P_{K-S} 31.36%
P_{K-S} 18.49%
P_{K-S} 31.05%
Log_{10} (ϕ/ Log_{10}M)
Log_{10} M
10.5
11
11.5
12
1
2
3



FIELD @ LOW z

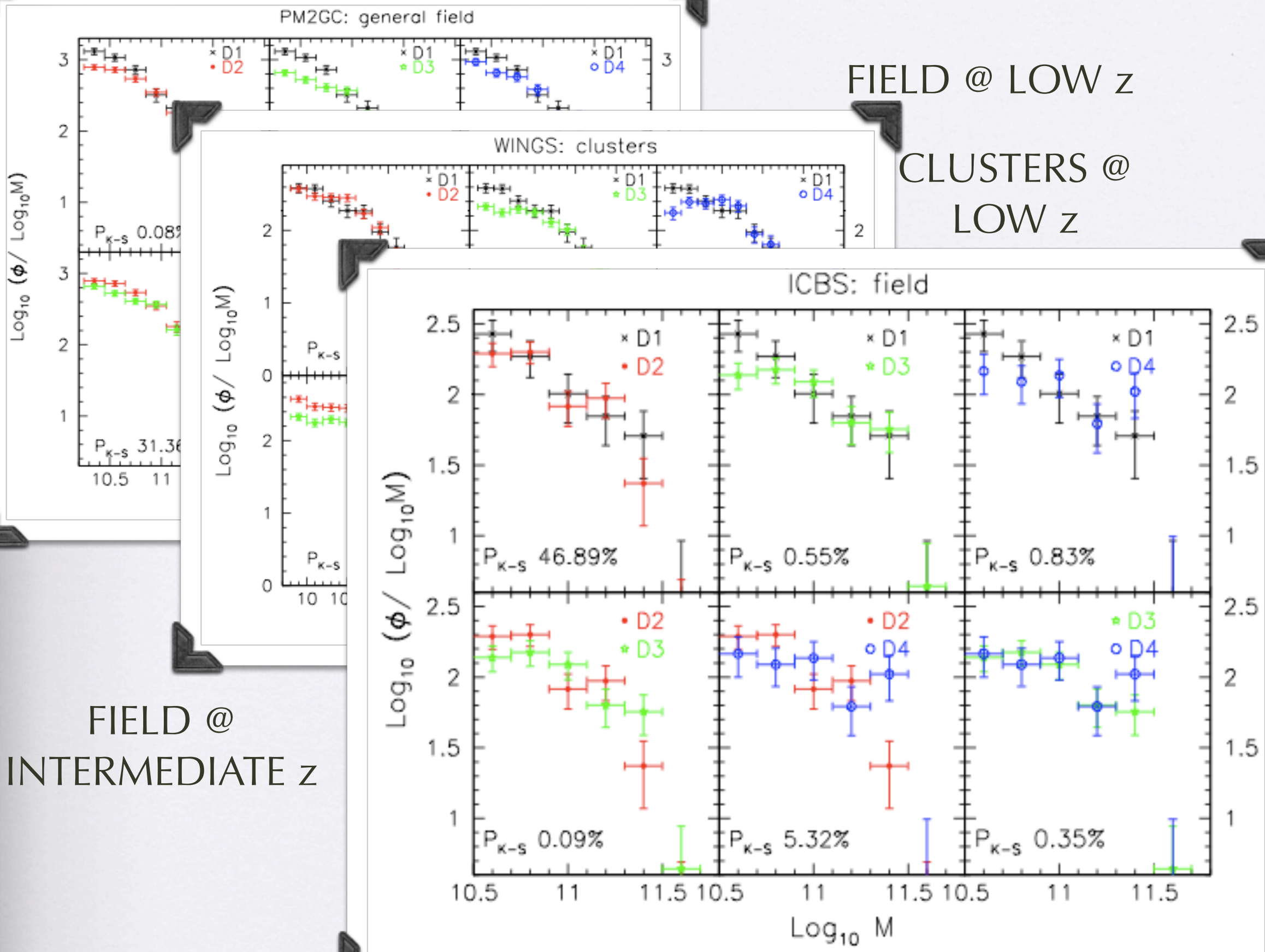
CLUSTERS @ LOW z

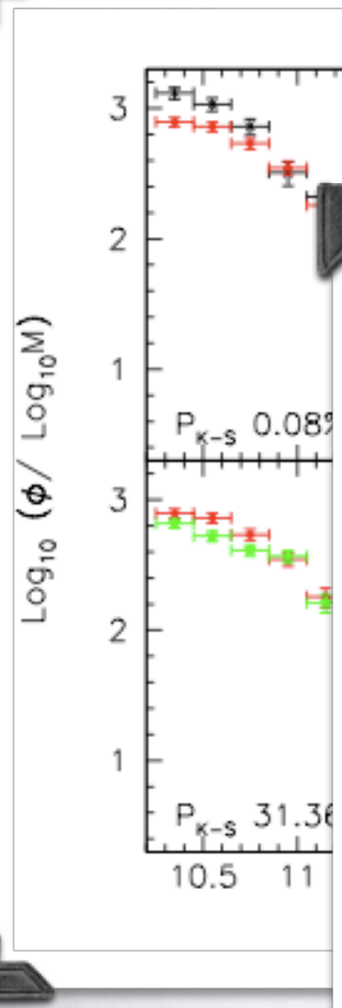


FIELD @ LOW z

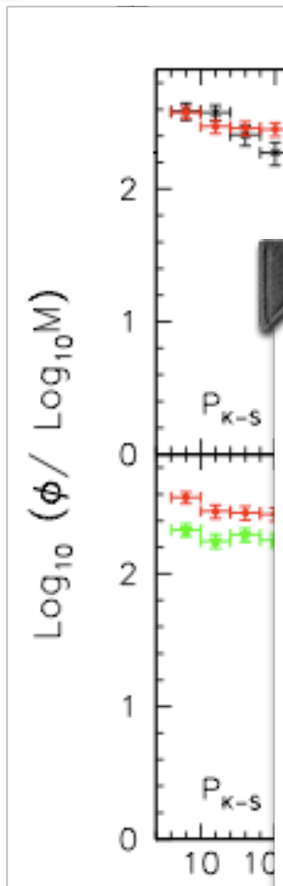
CLUSTERS @ LOW z

FIELD @ INTERMEDIATE z





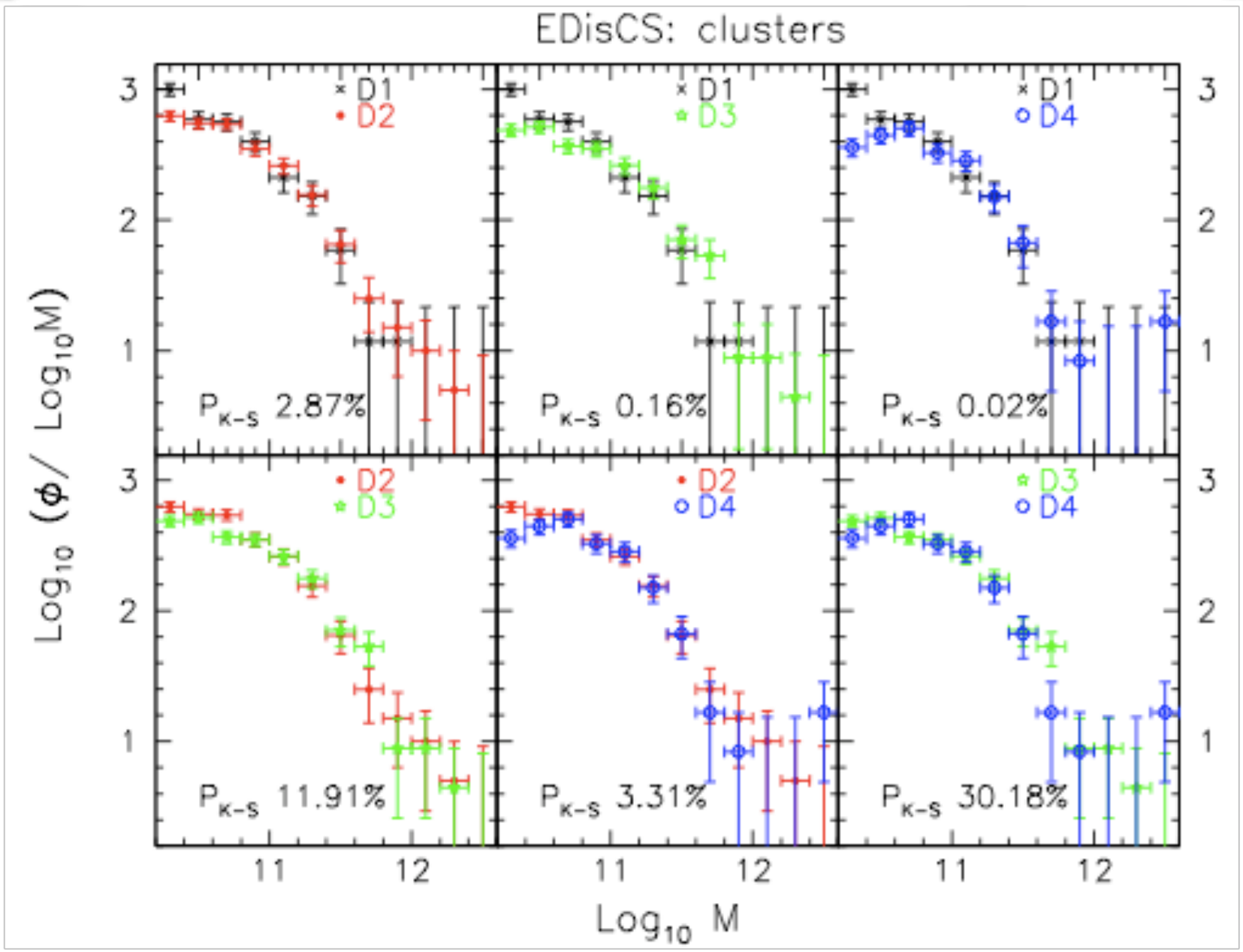
FIELD @ INTERMEDIATE z

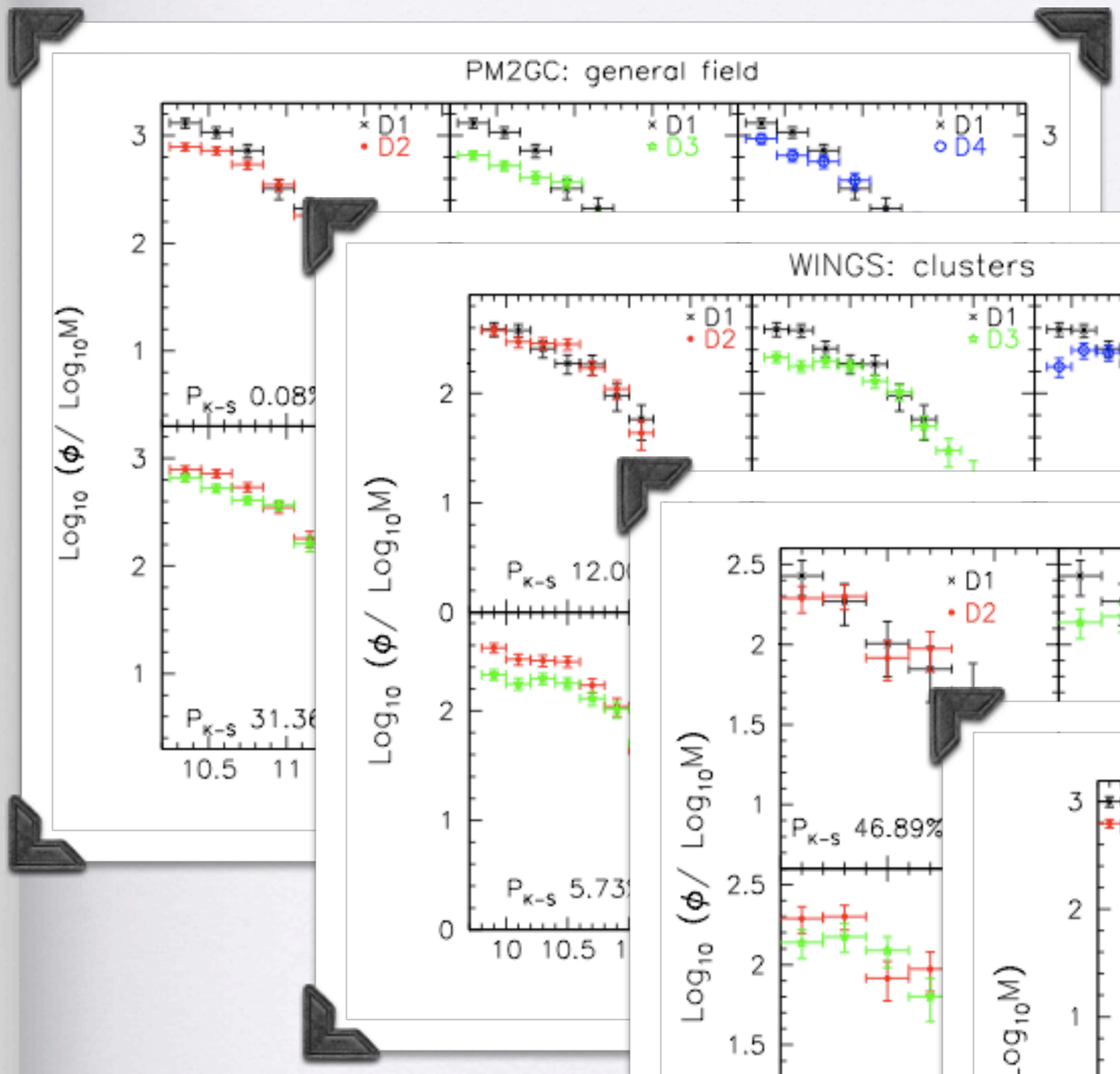


CLUSTERS @ INTERMEDIATE z

FIELD @ LOW z

CLUSTERS @ LOW z





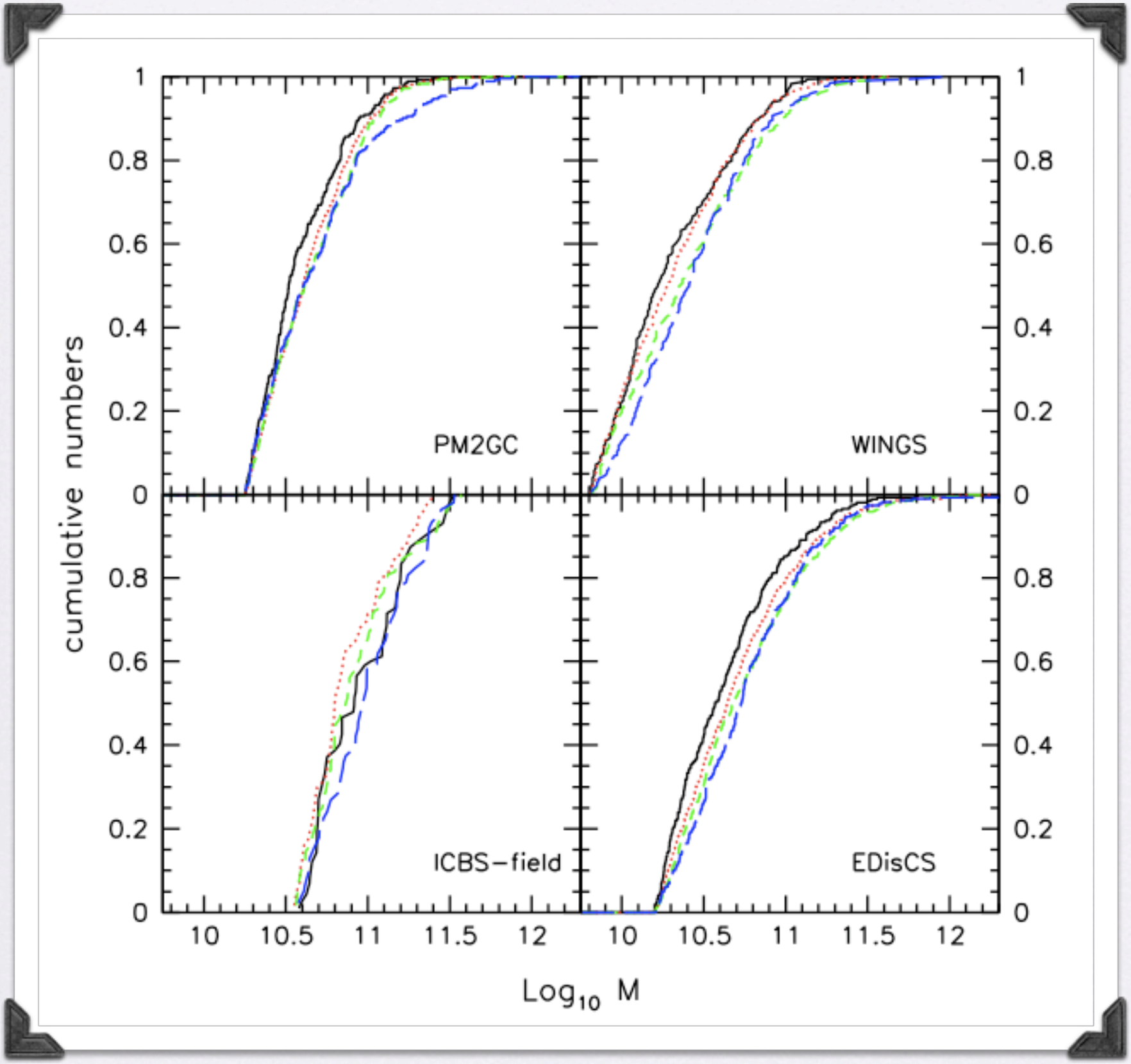
FIELD @ LOW z

CLUSTERS @ LOW z

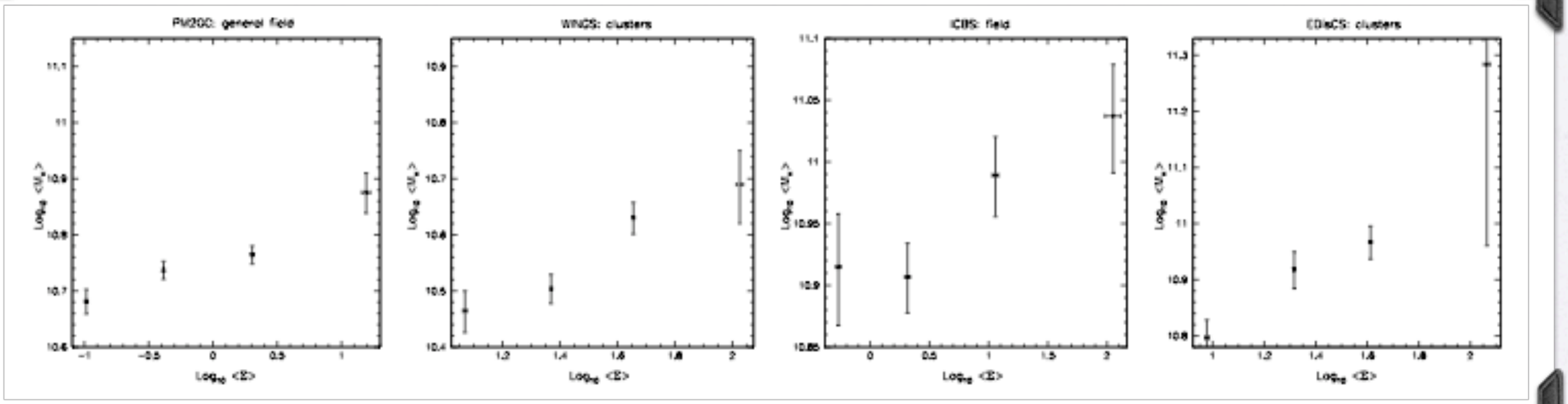
FIELD @ INTERMEDIATE z

CLUSTERS @ INTERMEDIATE z

Not only the mass functions are different, but also the largest mass and the mean mass



Not only the mass functions are different, but also the largest mass and the mean mass



Summary

- 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.

- 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.

- 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

Summary

- 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.

- 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.

- 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

thanks for the attention!

based on

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

Vulcani et al. 2011c (MNRAS in press, arXiv1111.0832V)

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