Segregation effects in the 20k-zCOSMOS group sample: A journey from the outskirts to the inner core of groups

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OUTLINE

- GALAXY GROUPS AND THEIR IMPORTANCE IN GALAXY EVOLUTION
- DEALING WITH TECHNICAL DETAILS: THE HARD LIFE OF COMPLETENESS + FROM TENS TO HUNDREDS
- COLOURS AND MASS SEGREGATION IN OUR GROUP SAMPLE
- ENVIRONMENTAL EFFECTS SUPERIMPOSED ON GALAXY SECULAR EVOLUTION & GROUP DYNAMICAL EVOLUTION: A SIMPLE SCENARIO
- FUTURE: A LOOK AT THE SPECTRA

STAR FORMATION & GROUPS

Strong evolution in star formation that parallels structure growth since $z \sim 1\text{-}1.5$

The percentage of galaxies residing in groups increases with redshift

Environmentally-driven evolution may be the cause of the decline in galactic activity over this same period

➢ ram pressure stripping	τ ~10Myr	Abadi et al. 1999
➢ strangulation	τ ~1-3Gyr	Balogh et al. 2000
➢ collision/harassment	τ ~3Gyr	Moore et al. 1996

Group environment is suspected of being most relevant for the last two physical processes listed

OPEN QUESTIONS

- Can groups drive the observed SF history decrease?

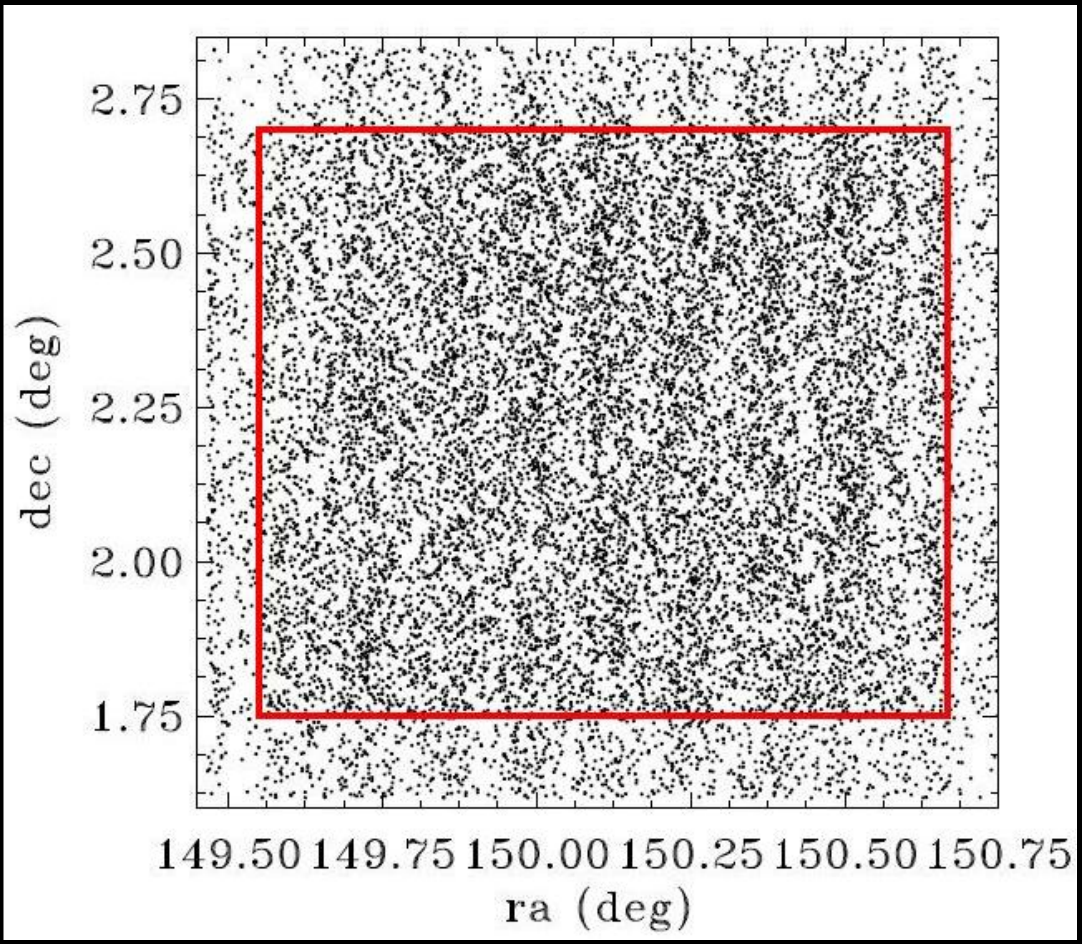
- How rapidly and significantly is suppressed the SF in groups?

- And if this is the case, are we able to reconstruct the accretion history of groups through the SF history of its member galaxies?

Observing the Universe @ large volume and wide redshift range should help finding **if**, **when** **and** **how** SF-environment relation is established and answer these questions

zCOSMOS PROJECT

20K SAMPLE:



COSMOS: HST-ACS survey down to I_{AB}=28.0 in ~2 sq deg
Multivawelength coverage
high z-photo accurancy:
$\sigma_{z\text{-phot}} = 0.007(1+z)$

zCOSMOS provides the spectroscopic redshift to the central part: **~0.9 sq deg**

relatively uniform spectroscopic coverage: **2/3** gals with I_{AB} <= 22.5

~ 62% COMPLETENESS

16623 galaxies with reliable z:
σ_v~ 100 km/s
178 groups with N >= 5

AIMS

Study the SF, colours, morphology group-centric radial trends, if any.

FROM TENS TO HUNDREDS

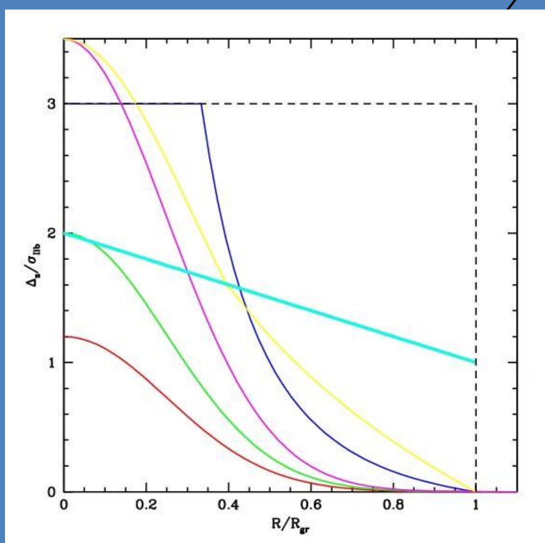
Co-adding spatial info of groups galaxies to build up a composite group both from spectroscopic and photometric catalogues

20k + PHOTO zs:

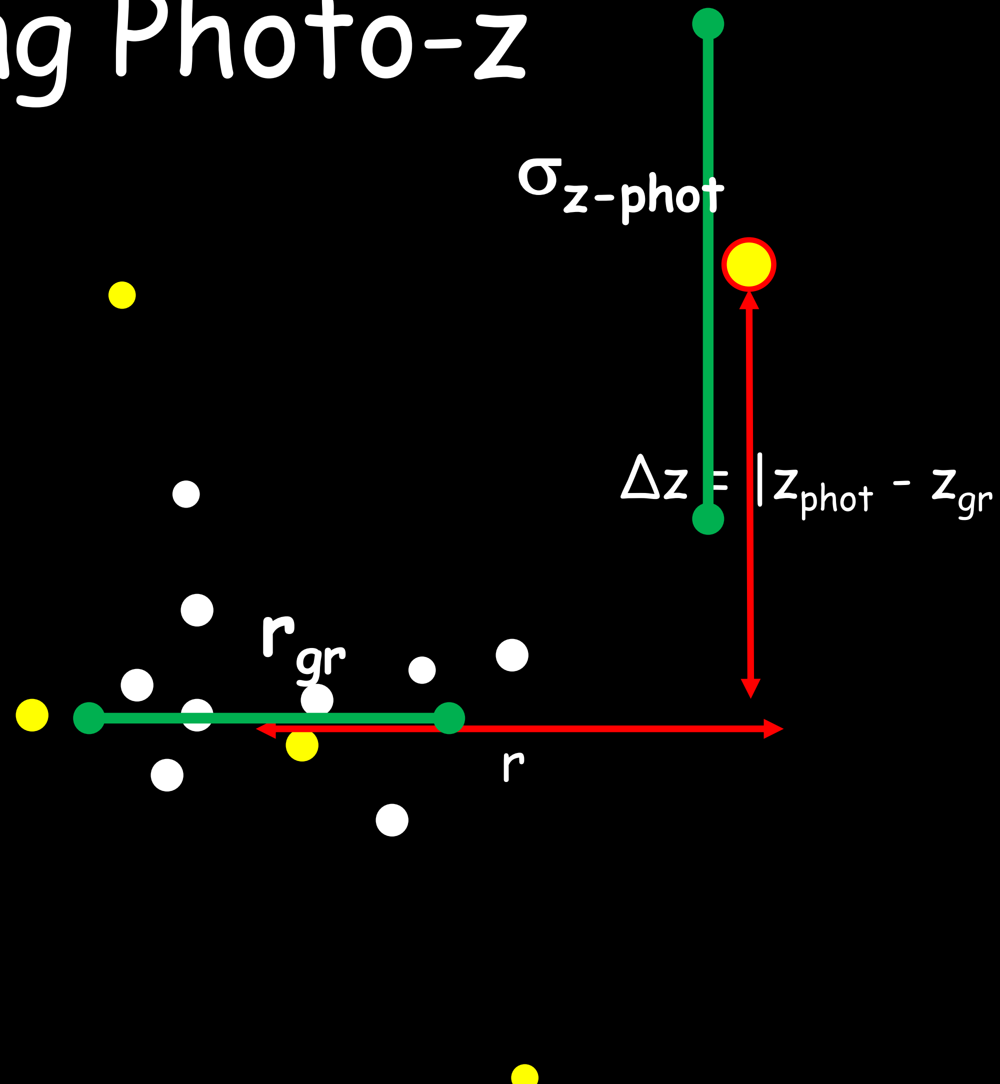
1. higher statistic
2. better definition of the group center
3. More reliable reconstruction of group richness

Adding Photo-z

$$F(x) = 2 - x \text{ where } x = R_{gal}/R_{gr}$$



Iterative process: iter J uses centers and radius of iter J-1 untill it converges

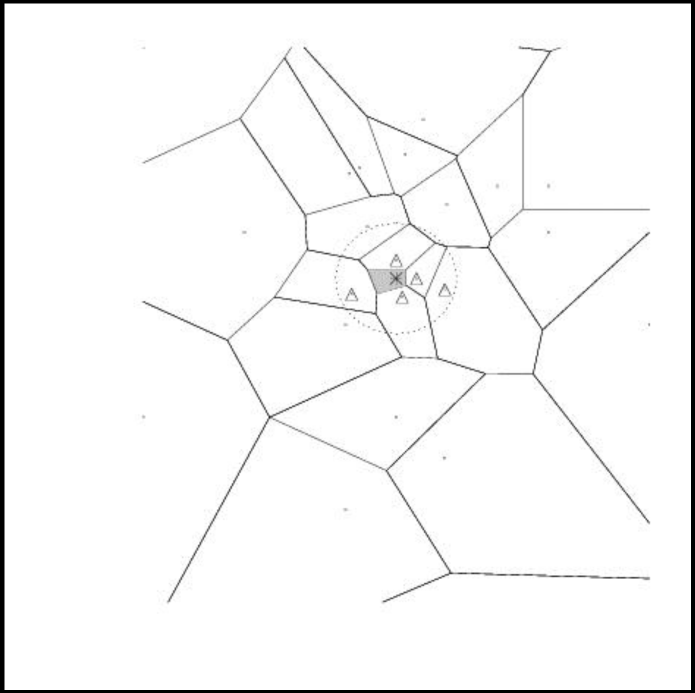


CENTER

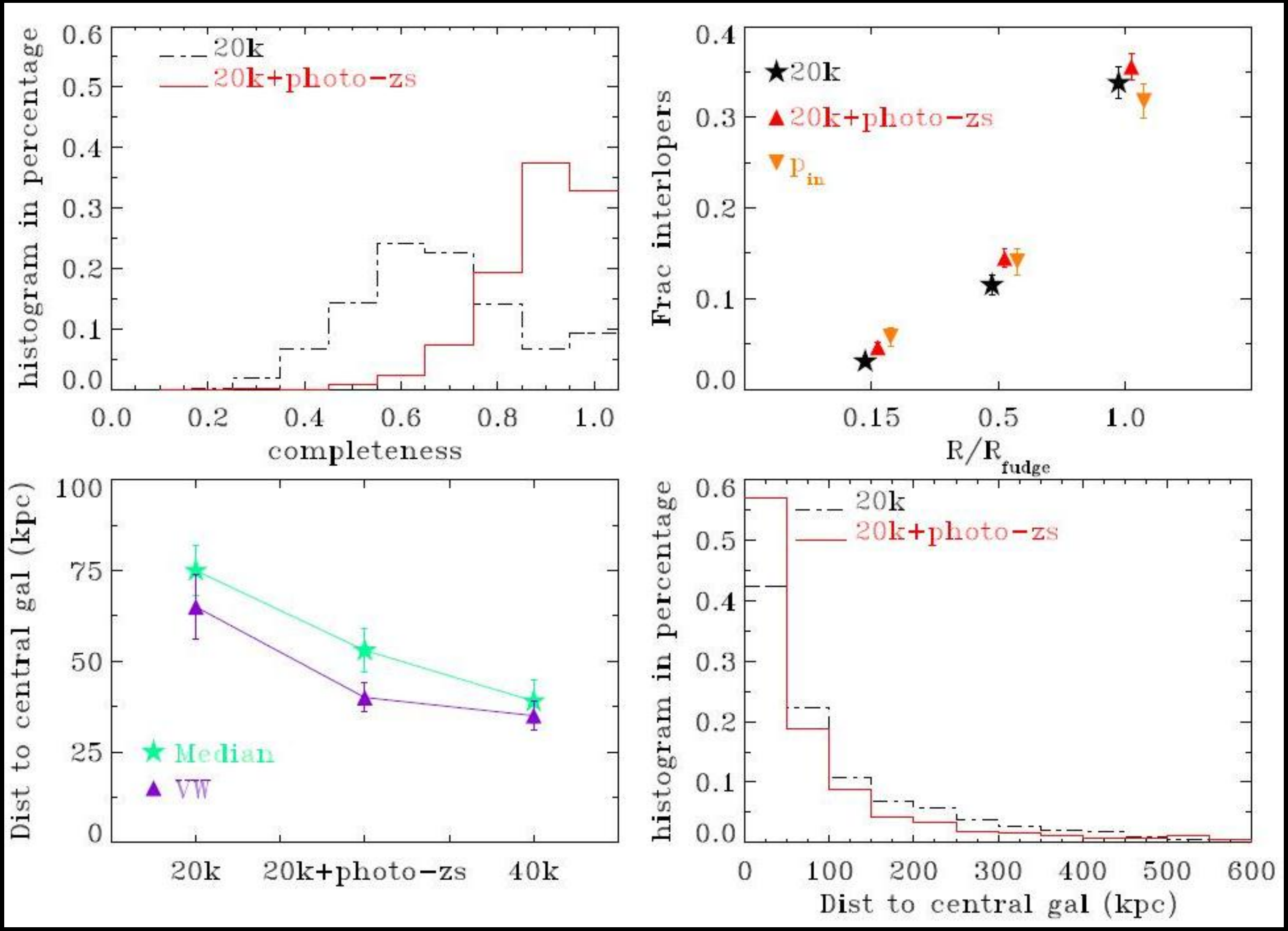
1. Median of the galaxy members coordinates (ra_{med} dec_{med})
2. Voronoi Weighted coordinates (ra_{VW} dec_{VW})

$$ra_{VW} = \frac{\sum_{i=1}^{N} ra_i \cdot {}^{1}\!/_{A_W}}{\sum_{i=1}^{N} {}^{1}\!/_{A_W}}$$

$$dec_{VW} = \frac{\sum_{i=1}^{N} dec_i \cdot {}^{1}\!/_{A_W}}{\sum_{i=1}^{N} {}^{1}\!/_{A_W}}$$



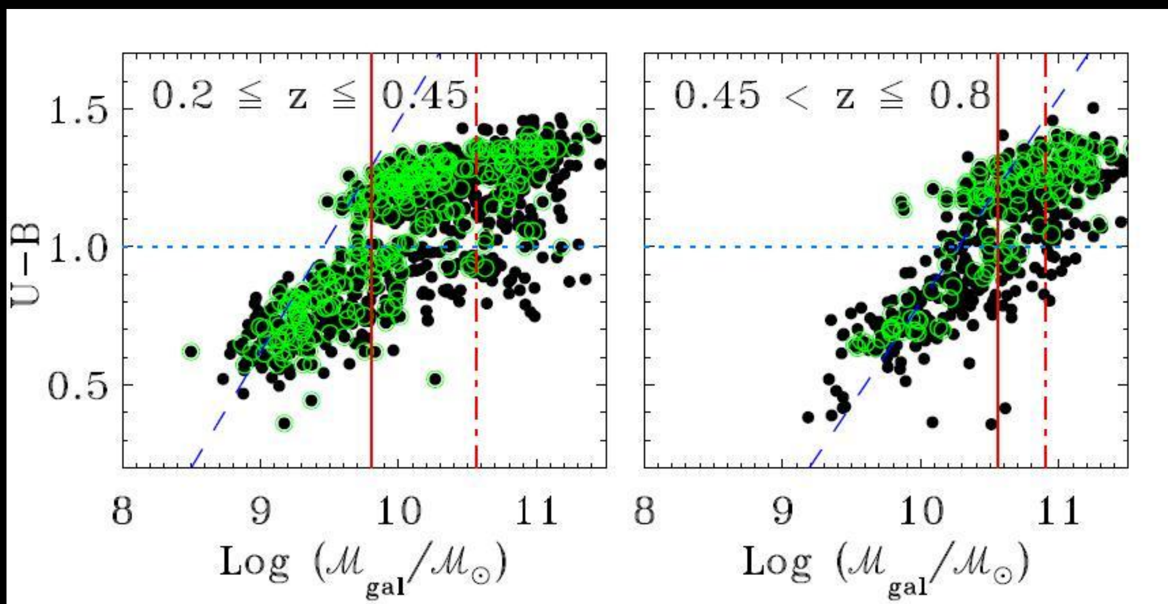
Algorithm results



DATA: GROUP GALS

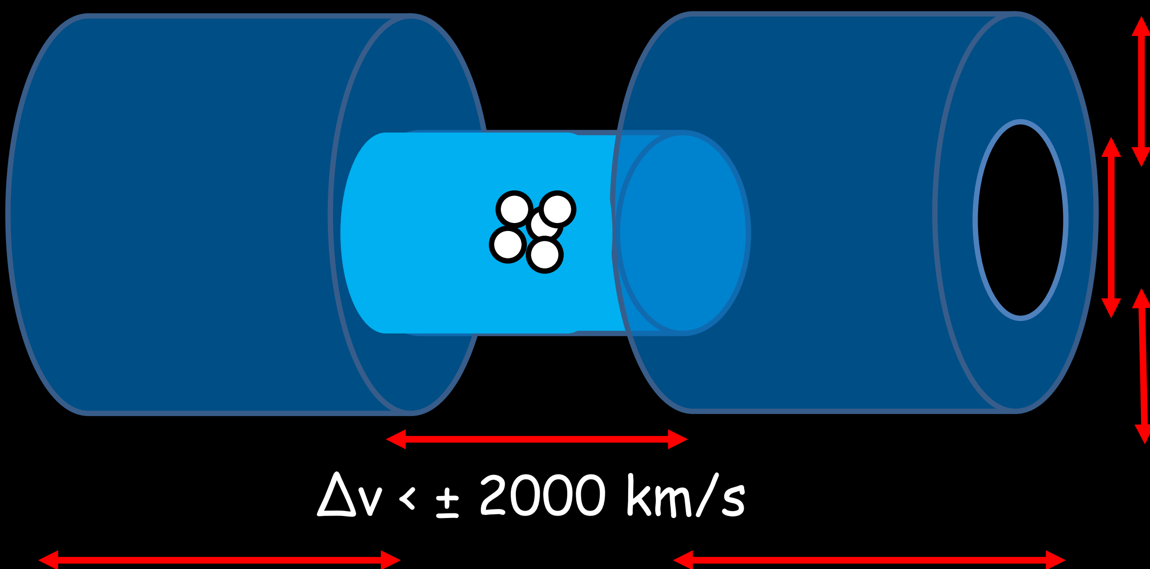
1. N_{20k} >= 5
2. 149.55 <= RA<= 150.666
3. 1.75 <= DEC <= 2.7
4. 1437 SPEC + 634 PHOTO, 178 groups
5. LOW Z: MASS >= 9.8
6. HIGH Z: MASS >= 10.56

Redshift	Vol-lim	Vol-Mass-lim	
	N_{gals}	N_{gals}	N_{gr}
$0.2 \le z \le 0.45$	829 (570)	571 (410)	79
$0.45 < z \le 0.8$	510 (391)	265 (200)	64



DATA: FIELD GALS

1. LOW Z: MASS >= 9.8 N=293/743
2. HIGH Z: MASS >= 10.56 N=211/728



$R < \pm 4\ R_{fudge}$

$R > \pm 4R_{fudge}$

Field gals closest to the groups possibly contaminated by missed group members

$\Delta v < \pm 2000$ km/s

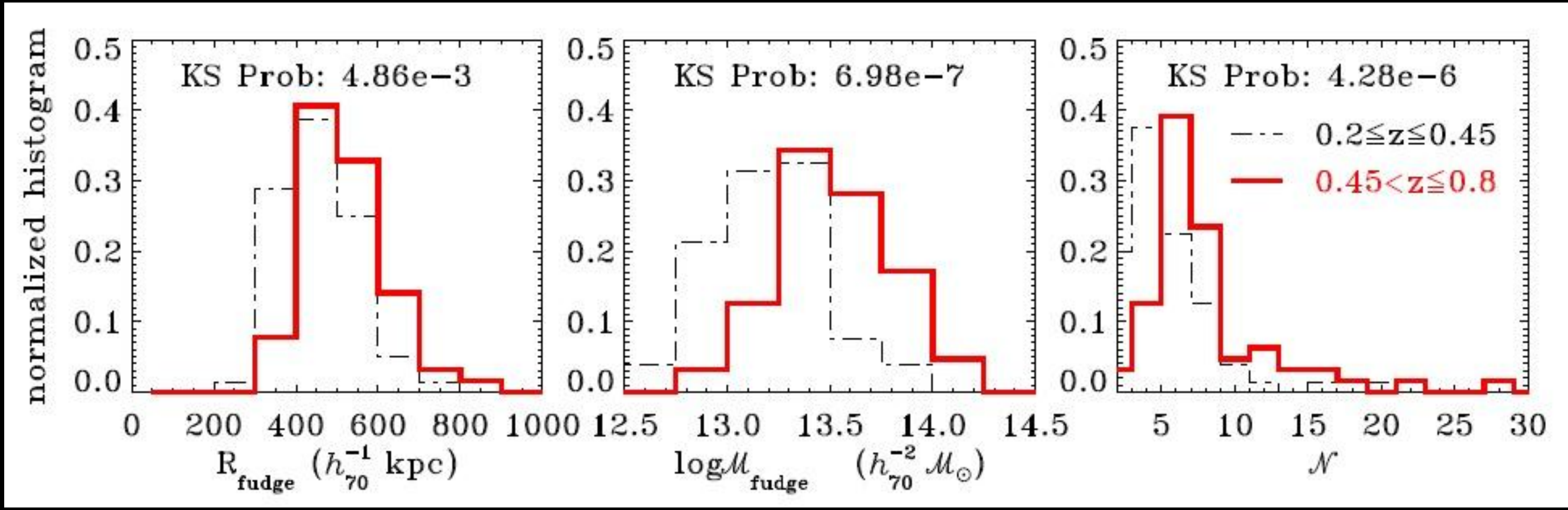
$\pm 2000 < \Delta v < \pm 5000$ km/s

Field gals ideally not affected by group environment

GROUP GLOBAL PROPERTIES

The KS test always rejects with more than 99.99% confidence the hypothesis that properties of low/high-z groups are drawn from the same distribution.

1. **Different richness (remember that we applyed a numerosity rather than a richness cut)**



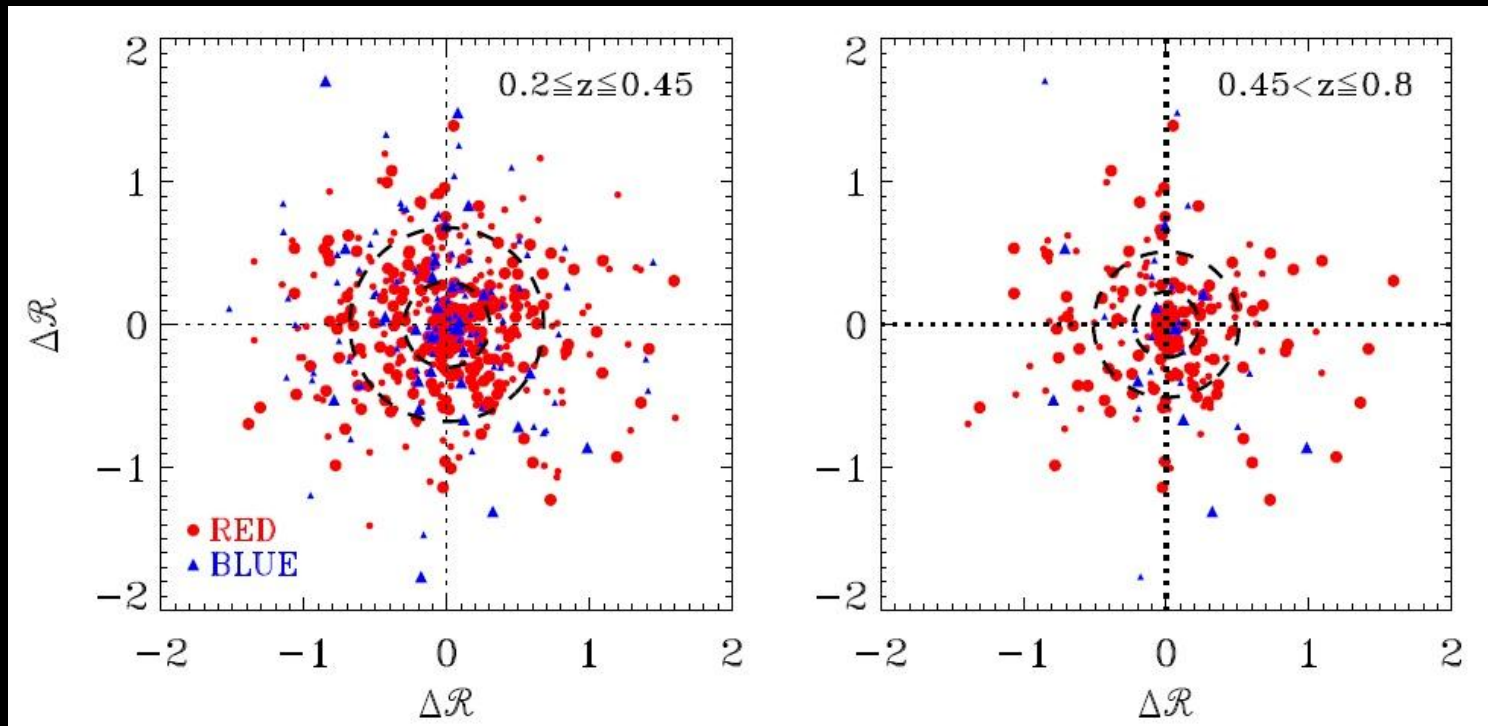
INAF ISTITUTO NAZIONALE DI ASTROFISICA NATIONAL INSTITUTE FOR ASTROPHYSICS

Osservatorio Astronomico di Brera

Cosmic Evolution Survey cosmos

z-COSMOS 40'000 VLT redshifts for COSMOS

THE COMPOSITE GROUPS



Redshift	1st region		2nd region		3rd region	
	range	$\mathcal{R}_{median}$	range	$\mathcal{R}_{median}$	range	$\mathcal{R}_{median}$
$0.2 \leq z \leq 0.45$	$\mathcal{R} \leq 0.30$	0.15	$0.30 < \mathcal{R} \leq 0.68$	0.47	$\mathcal{R} > 0.68$	0.94
$0.45 < z \leq 0.8$	$\mathcal{R} \leq 0.23$	0.13	$0.23 < \mathcal{R} \leq 0.51$	0.37	$\mathcal{R} > 0.51$	0.74

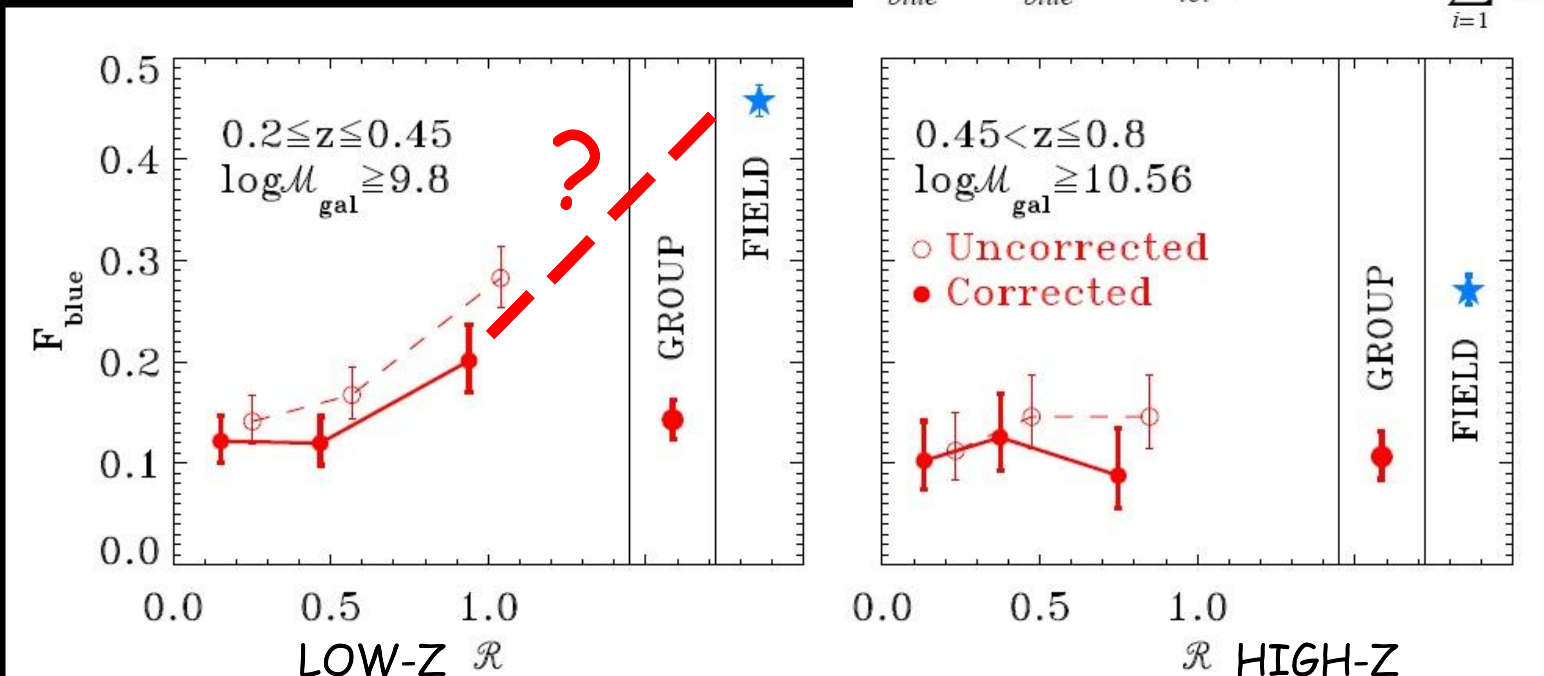
THE BLUE FRACTION

$$F^{GR}_{\rm blue} = \frac{N_{\rm blue}}{N_{\rm tot}} = \frac{N^{GR}_{blue,obs} - N^{INT}_{blue}}{N^{GR}_{tot,obs} - N^{INT}_{tot}}$$

Where:

$$N^{INT}_{tot} = \mathcal{PI} \times N^{GR}_{tot,obs} = \mathcal{PI} \times (N^{GR}_{tot} + N^{INT}_{tot})$$

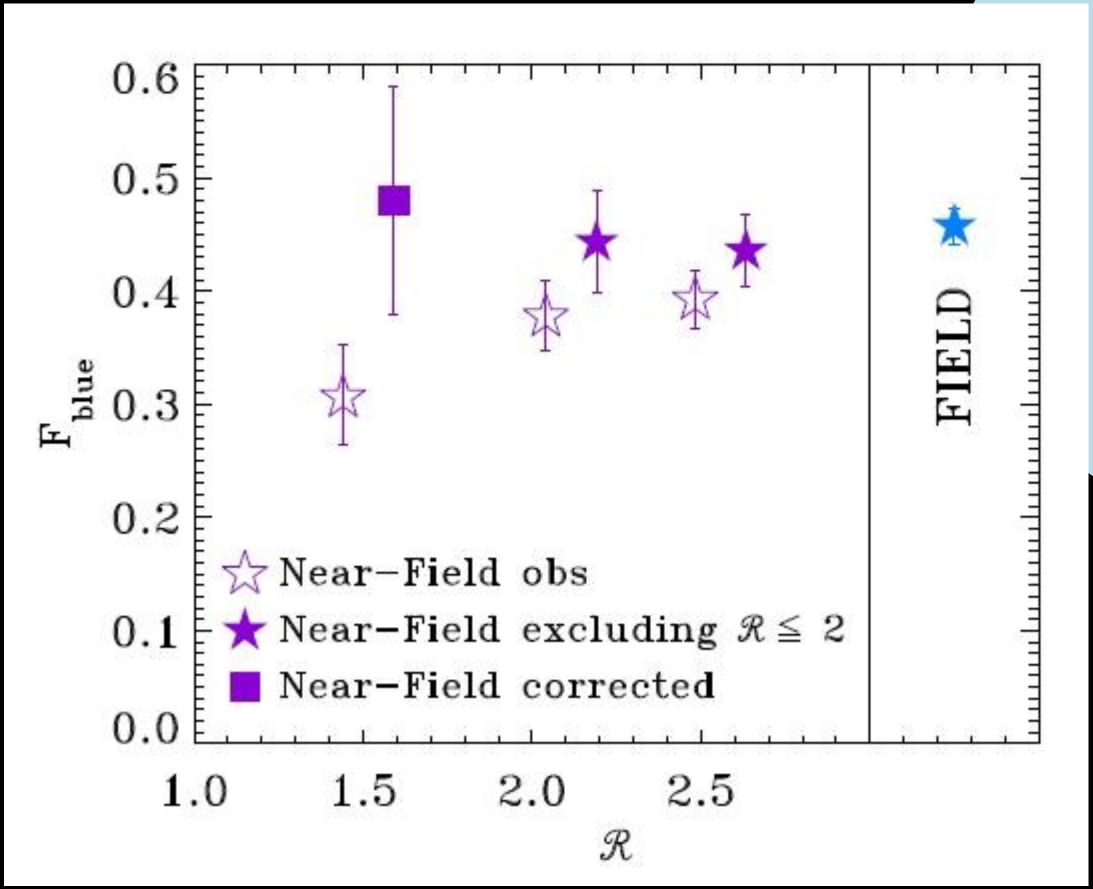
$$N^{INT}_{blue} = F^{FIELD}_{blue} \times N^{INT}_{tot} \qquad \mathcal{PI} = 1 - \sum_{i=1}^{N_{tot,obs}} p_{in,i}/N_{tot,obs}$$

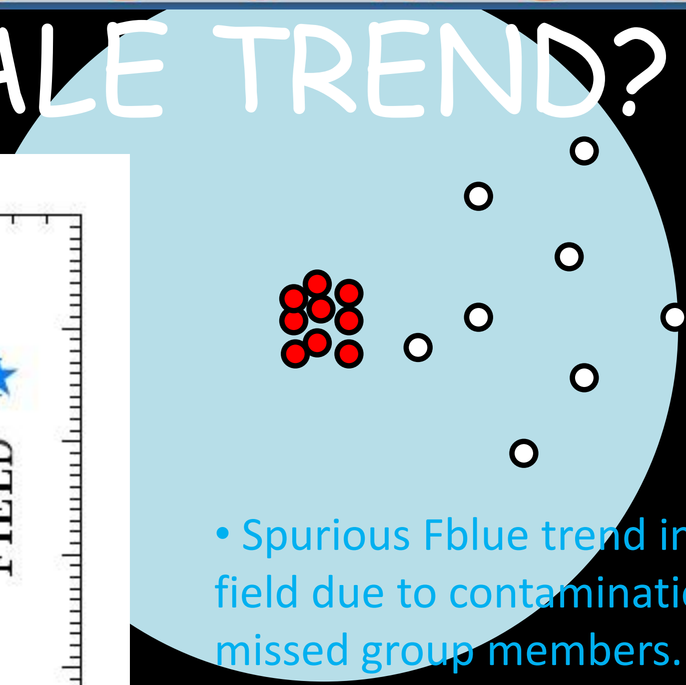


- Trend of increasing Fblue moving from inner core to outskirts and further away to the field
- entering the group has a significant influence in changing colours but the most relevant difference is between core and field

- Absence of a colour radial trend but still a significant difference between group and field
  - higher mass cut off and richer groups

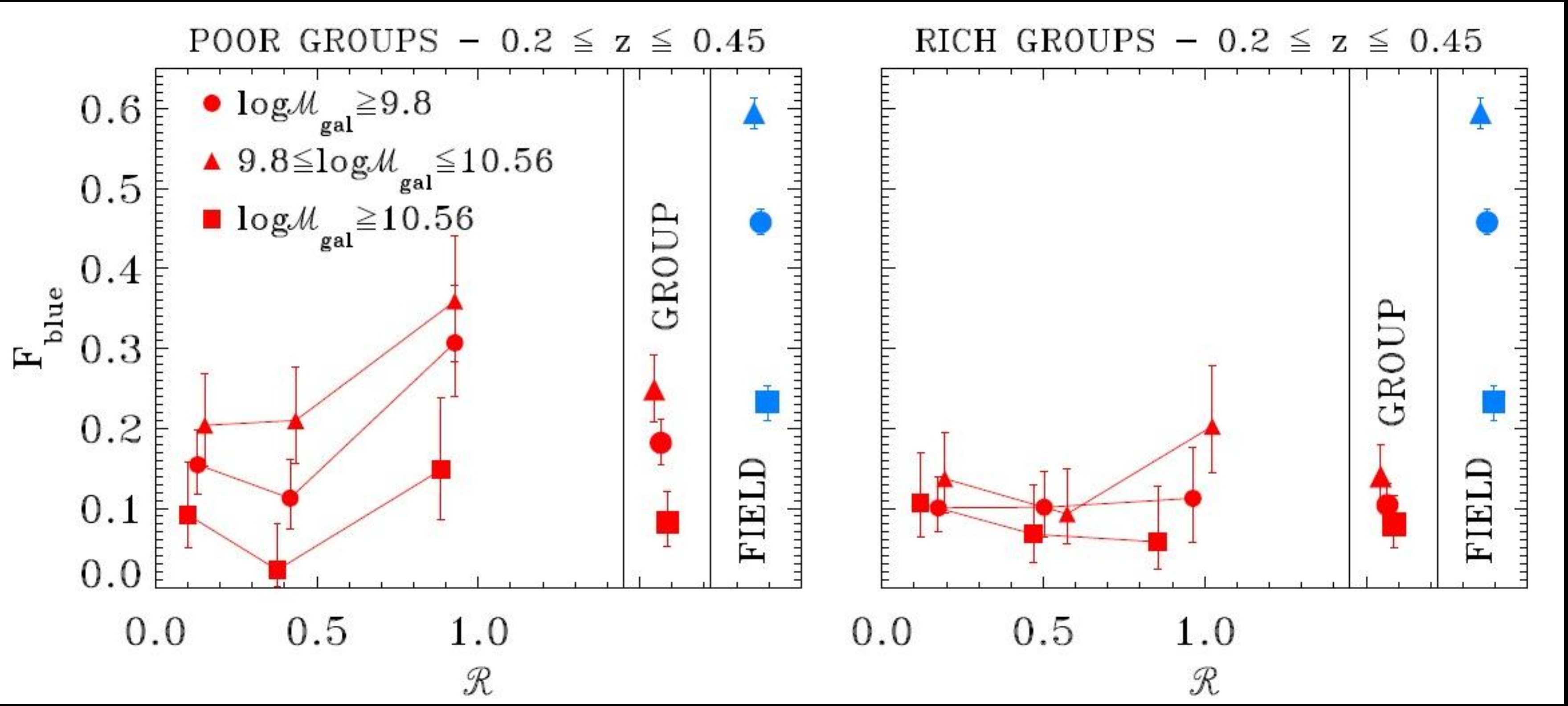
LARGE-SCALE TREND?





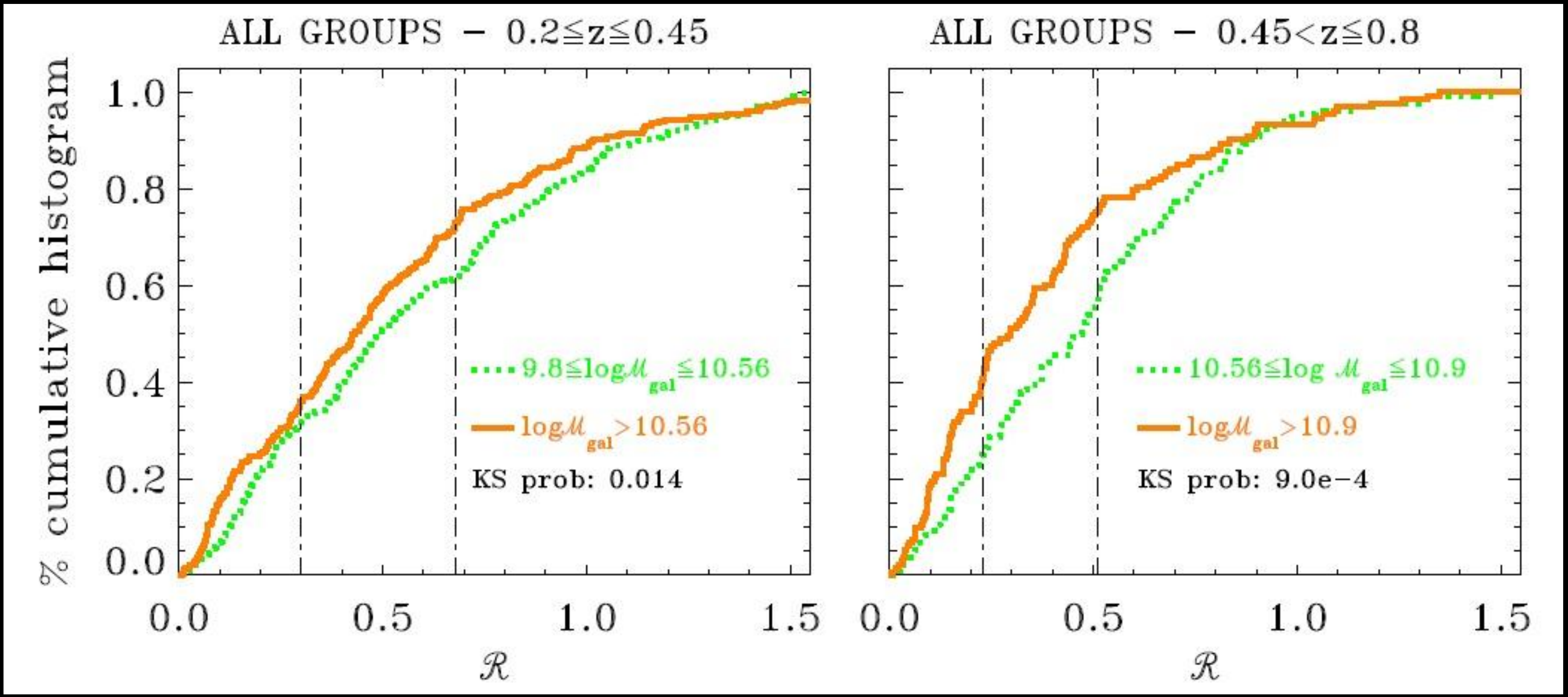
- Spurious Fblue trend in the near field due to contamination by missed group members.
- Environment plays its role on group physical scales: no transition region from field to group, no large scale trend.
- Galaxies start getting affected by the group as soon as they enter it

A CLOSER LOOK: MASS/RICHNESS ROLE



- Applying the same mass cut-off to the low-z SG, the previous colour radial trend disappears: at these galaxy masses colour evolution is more advanced (even in the field)
- Color radial trends survive only in poor groups
- Mean Fblue is higher in poor groups than in rich groups.

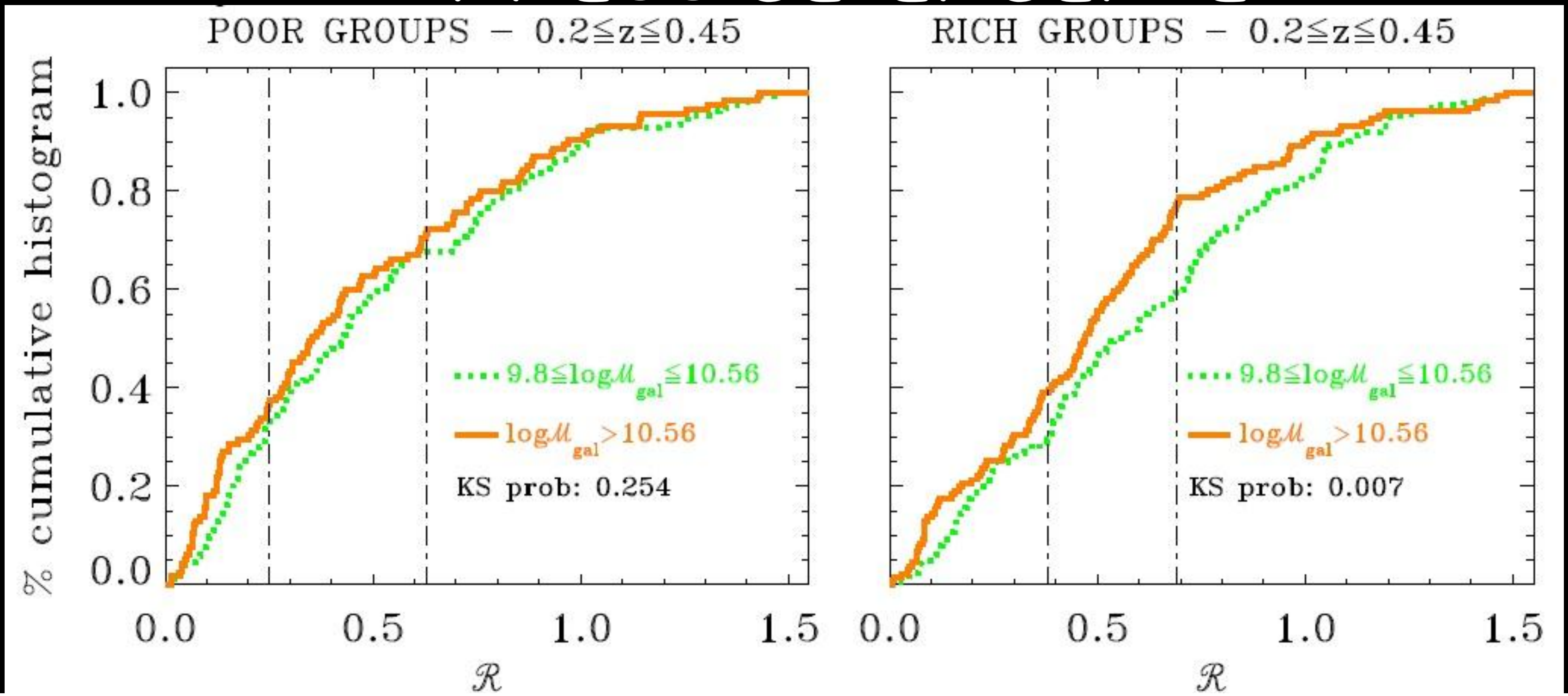
MASS SEGREGATION



- We study the radial distribution within our SG of galaxies with different masses: massive galaxies populate the innermost regions while less massive galaxies prefer the outer ones

- A KS test confirms with confidence higher than 98.6/99.99% the existence of a mass segregation for the low/high-z SG.

MASS SEGREGATION
RICHNESS DEPENDENCE



Sample	s far field
$0.2 \le z \le 0.45$ & $\mathcal{M}$	6
$0.2 \le z \le 0.45$ & $\mathcal{M}$	7
$0.2 \le z \le 0.45$ & $\mathcal{M}$	5
$0.45 < z \le 0.8$ & $\mathcal{M}$	1

For rich low-z groups the KS test confirms a mass segregation with a median confidence level of $97.8^{+1.9}_{-5.9}$, where the quoted errors correspond to the lowest and highest quartiles of the distribution. For high-z groups, the KS test confirms a mass segregation with a median confidence level of $99.9^{+0.1}_{-1.2}$, quoted errors are defined as above.

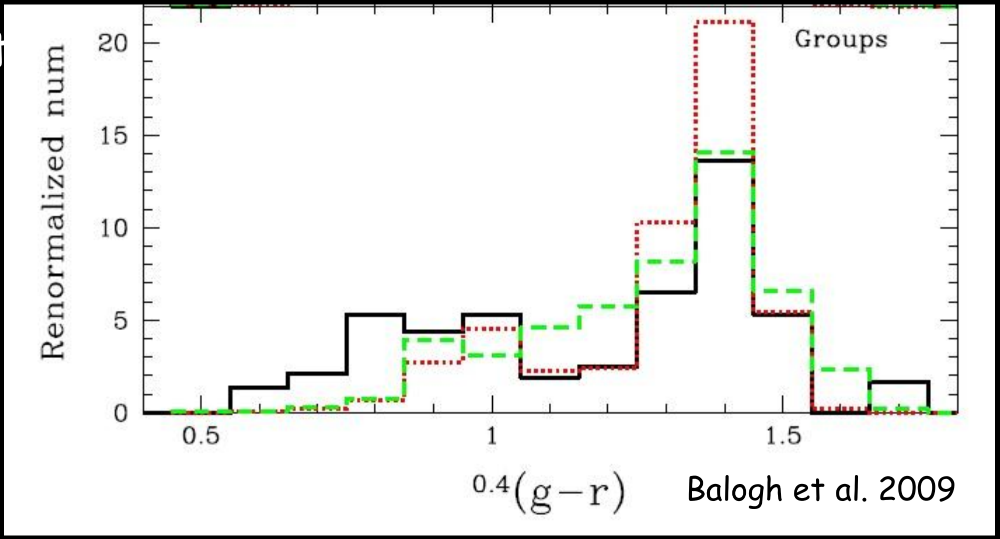
THE PICTURE

SEGREGATION EFFECT	POOR LOW-Z GROUPS	RICH LOW-Z GROUPS	RICH HIGH-Z GROUPS
COLOURS	V	X	X
MASSES	X	V	V

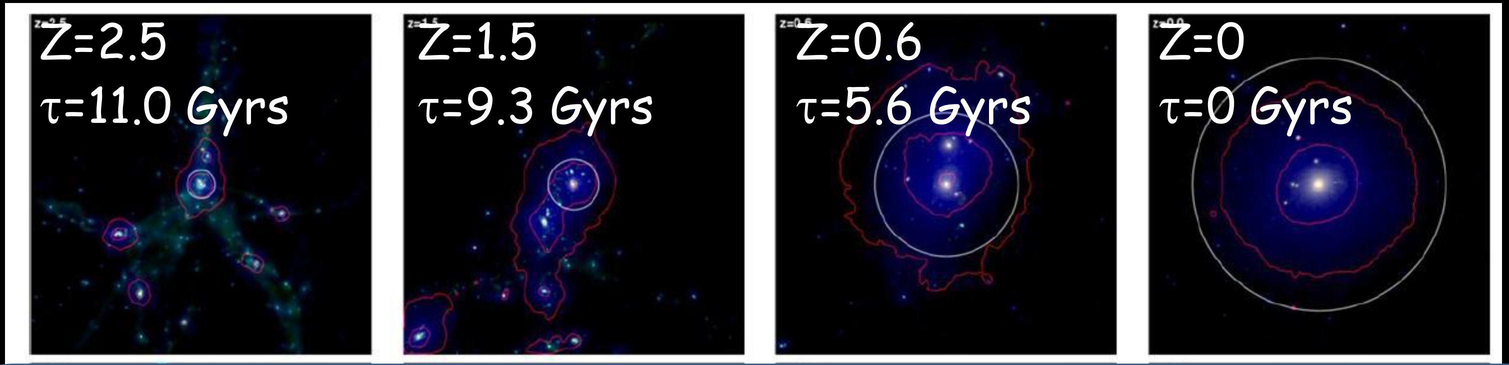
Colour and mass segregation originat

$$\tau_{cross} \sim 1.3 \text{ Gyr}$$

- ram pressure stripping → τ
- strangulation → τ
- collision/harassment → τ

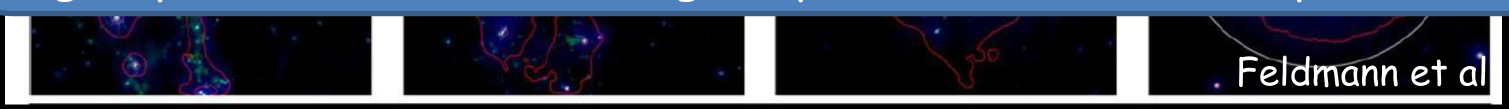


FROM SIMULATIONS



Mass segregation is driven by dynamical phenomena within groups, and therefore its presence/absence in rich/poor groups is a possible indication that poorer groups start to assemble later in cosmic time than richer structures.

The parallel absence/presence of colour segregation in rich/poor groups hints to the fact that nurture effects are still in action in poorer structures, whereas in richer systems are already largely over, so that all galaxies are red irrespective of their position within the group (at least down to the galaxy stellar masses we explored).



Feldmann et al 2010

CONCLUSIONS

• The evolution of most massive galaxies (M>10.6) is mainly driven by internal processes, as no strong group-centric environment dependence is visible.

• For galaxies of lower masses (9.8<M<10.6) there is a radial dependence in the changing mix of red and blue galaxies, red galaxies residing preferentially in the group center.

• Such colour segregation is most evident in poor groups, whereas richer groups do not display any obvious color trend.

• Interestingly mass segregation shows the opposite behavior: it is visible only in rich groups, while poorer groups have a a constant mix of galaxy stellar masses as a function of radius.

• These two findings can be explained in a simple scenario where colour and mass segregation originates from different physical processes. The segregation effects we reveal simply reflect different times of infall of the galaxy population in exam.

• Poorer groups hold the smoking gun of environmental effects in action superimposed to secular galaxy evolution: galaxies display gradually redder colors as a consequence of the still recent accretion history of these groups.

END