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The distinct build up of dense and normal passive galaxies in VIPERS

ADRIANA GARGIULO & THE VIPERS TEAM

Paris – Galaxy evolution across the cosmic time – 12/06/2017

THE OUTLINE OF THE TALK



- Why studying massive ($M_{\text{star}} > 10^{11} M_{\text{sun}}$) passive galaxies (MPGs)
- The evolution of the number density and of the stellar population ages of MPGs at $0.5 < z < 1.0$
- The impact of the environment on the mass assembly history of MPGs

WHY STUDYING MASSIVE PASSIVE GALAXIES (MPGs)

Most of the stellar mass in galaxies today resides in massive passive systems
(e.g. Renzini 2006).

Still unclear WHEN & WHERE the stars in massive galaxies were formed

THE 'MERGER' (EX SITU) HYPOTHESIS

In a Λ CDM Universe the assembly of massive galaxies is dominated by the (dry) accretion of stars formed in other galaxies

(e.g. Naab+ 2009; Qu+ 2017; Rodriguez-Gomez+ 2016; Gabor&Davè 2012; Lackner+ 2012 / e.g. Robertson+ 2006; Cox+ 2006; Pipino+ 2008)

THE IN SITU HYPOTHESIS

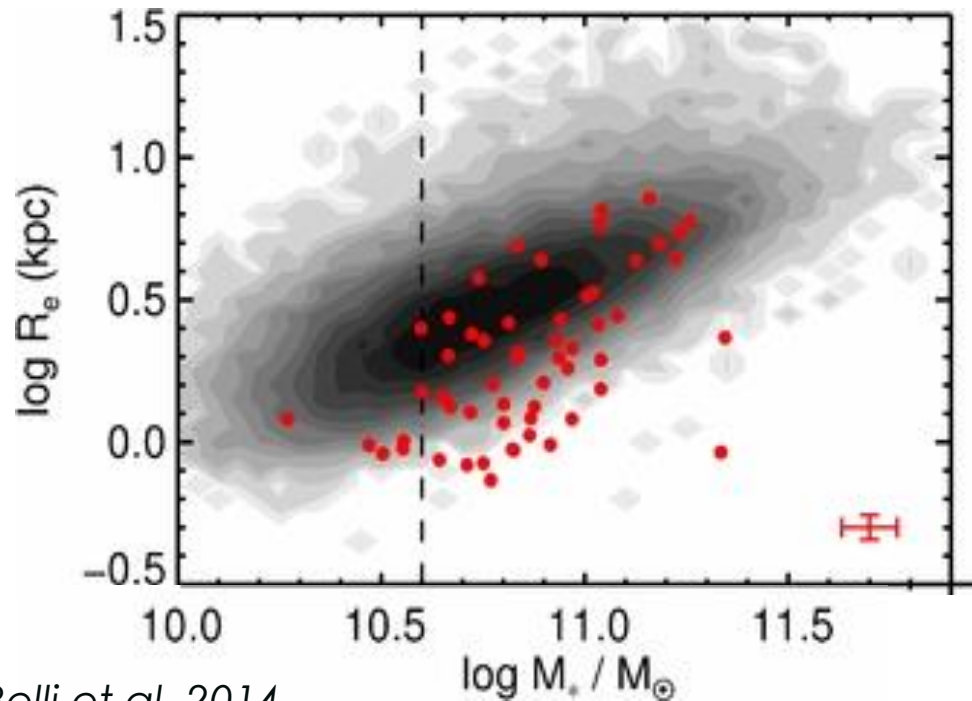
Stars in massive galaxies come from in situ star formation (until an event – e.g. AGN feedback, halo shock, disc fragmentation – does not stop it)

(Genzel+ 2008, 2011; Förster Schreiber+ 2011; Tacconi+ 2013; Wuyts+ 2013)

STRUCTURAL PROPERTIES OF LOCAL AND HIGH-Z MPGs

THE EX SITU HYPOTHESIS vs. THE IN SITU HYPOTHESIS
Do we need a combination of these?

Evolutionary models have to reproduce MPGs properties
as the size-mass relation and its evolution with time



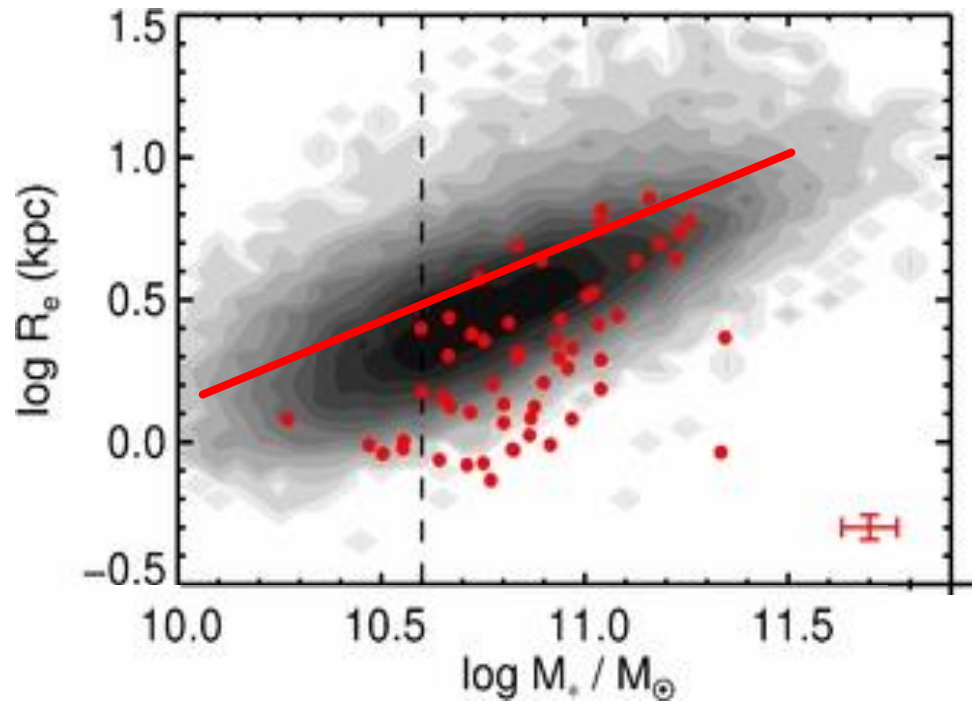
At fixed stellar mass

- local MPGs have dimensions that vary up to an order of magnitude;
- high-z ($z \sim 2$) MPGs are smaller than local MPGs by a factor ~ 5

STRUCTURAL PROPERTIES OF LOCAL AND HIGH-Z MPGs

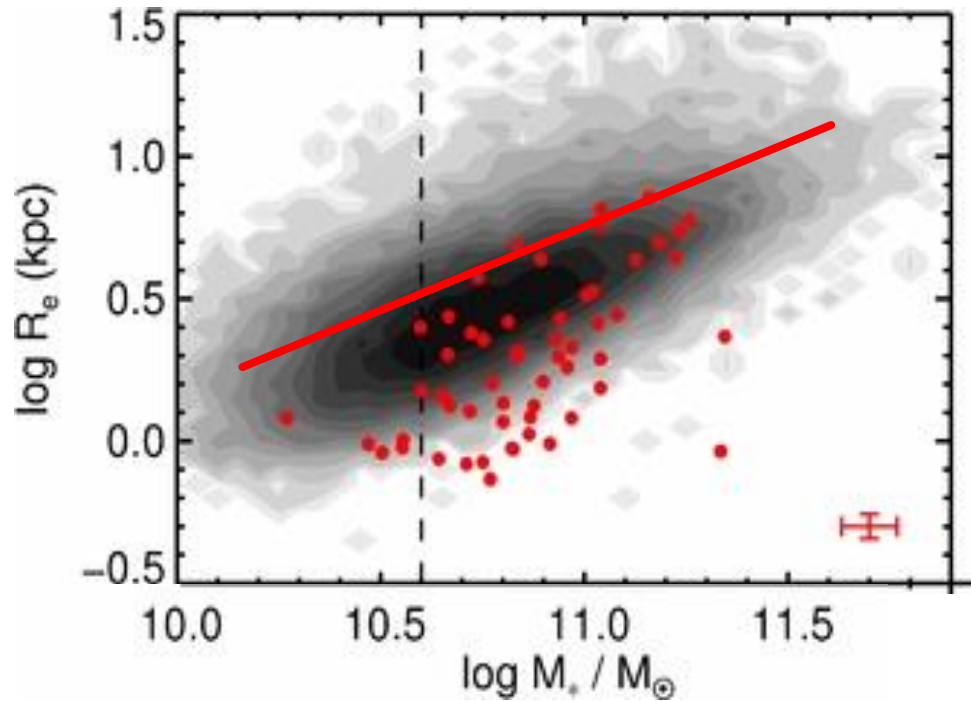
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Given the mean stellar mass density
 $\Sigma = M_*/(2 \pi R_e^2)$
on average
high - z MPGs were denser than local
MPGs

THE OPEN QUESTIONS



- Why, at fixed stellar mass, the typical dimension of a MPGs varies up to an order of magnitude?
- Have dense and less dense local MPGs different stellar mass assembly history?

In which way was build up the population of local MPGs?

TO FIND THE ANSWER WE STUDIED:

1. the evolution of the number density of MPGs as a function of Σ
2. the evolution of the stellar population ages of MPGs as a function of Σ
3. the correlation of Σ and the local environment

USING VIPERS

VIMOS PUBLIC EXTRAGALACTIC REDSHIFT SURVEY



VIPERS IN A NUTSHELL ESO LARGE PROGRAM (PI: L. Guzzo)

SPECTRA :

LRR grism ($R = 200$) \rightarrow $[5500 - 9500]$ A $\rightarrow \Delta z = 0.00047(1 + z)$

TARGET SAMPLE :

- $i(\text{AB}) < 22.5$ on the CFHTLS Wide W1 and W4 fields
- ugri colour pre-selection $\rightarrow z > 0.5$

VOLUME :

$5 \times 10^7 h^{-3} \text{ Mpc}^3$ - comparable to 2DF but at redshift ~ 1

AREA :

24 sq. dg (~ 16 without gaps) – 40% sampling rate

PHOTOMETRY :

NUV, u, g, r, i, z, K ++ (Moutard et al. 2016)

SURVEY STATUS AS OF 30/11/2015

EFFECTIVE TARGETS	MEASURED REDSHIFTS	STELLAR CONTAMINATION	COVERED AREA
93252	88901	2265 (2.5 %)	100.0 %

Now available at
<http://vipers.inaf.it/>

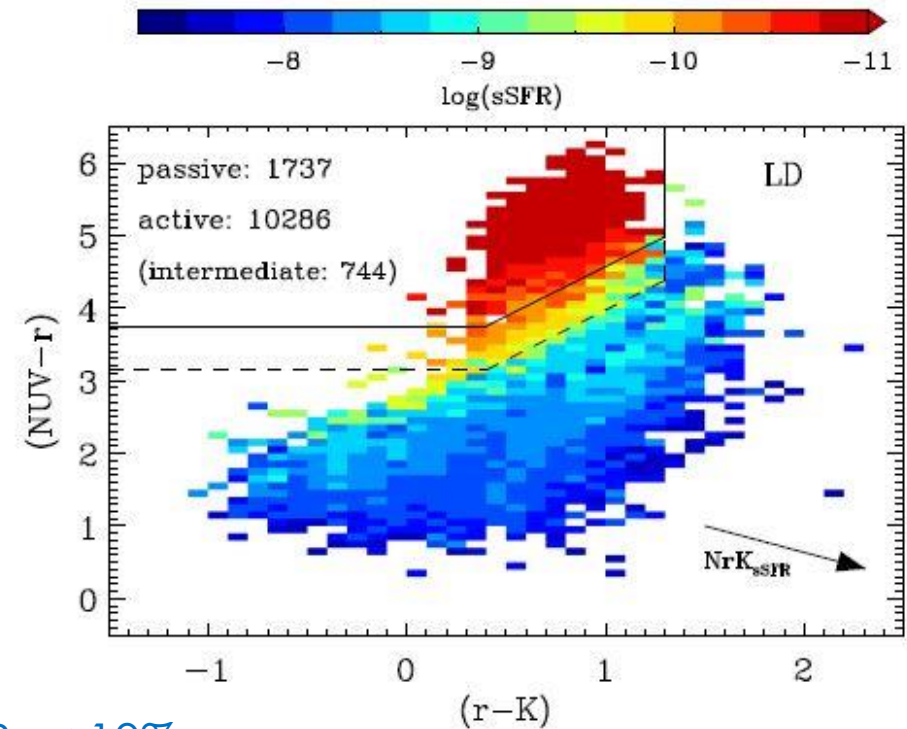
$0.5 < z < 1.2$

THE VIPERS SAMPLE OF MPGs

The selection criteria:

- $2 \leq z_{\text{flag}} \leq 9.0$
- $0.5 \leq z \leq 1.0$
- $(\text{NUV} - r)$ vs $(r - K)$
- $M_{\text{star}} \geq 10^{11} M_{\text{sun}}$ (Cha IMF)

~2000 MPGs at $0.5 < z < 1.0$ with z-spec



For structural parameters in VIPERS see Krywult+ 2016, $\delta R_e < 10\%$

Davidzon et al. 2013, 2016

To derive Σ : R_e in i band for galaxies at $z \geq 0.8$ } ~ U band rest frame
 R_e r band for galaxies at $z < 0.8$ } over the whole redshift range

High- Σ MPGs $\rightarrow \Sigma > 2000 M_{\text{sun}} \text{ pc}^{-2}$ --- Intermediate- Σ MPGs $\rightarrow 1000 < \Sigma \leq 2000 M_{\text{sun}} \text{ pc}^{-2}$
 Low- Σ MPGs $\rightarrow \Sigma \leq 1000 M_{\text{sun}} \text{ pc}^{-2}$

THE EVOLUTION OF THE NUMBER DENSITY OF MPGs AS A FUNCTION OF Z AND Σ

The evolution of the number densities depends on Σ :
the lower the Σ , the faster the evolution

From $z = 1.0 \rightarrow z = 0.5$:

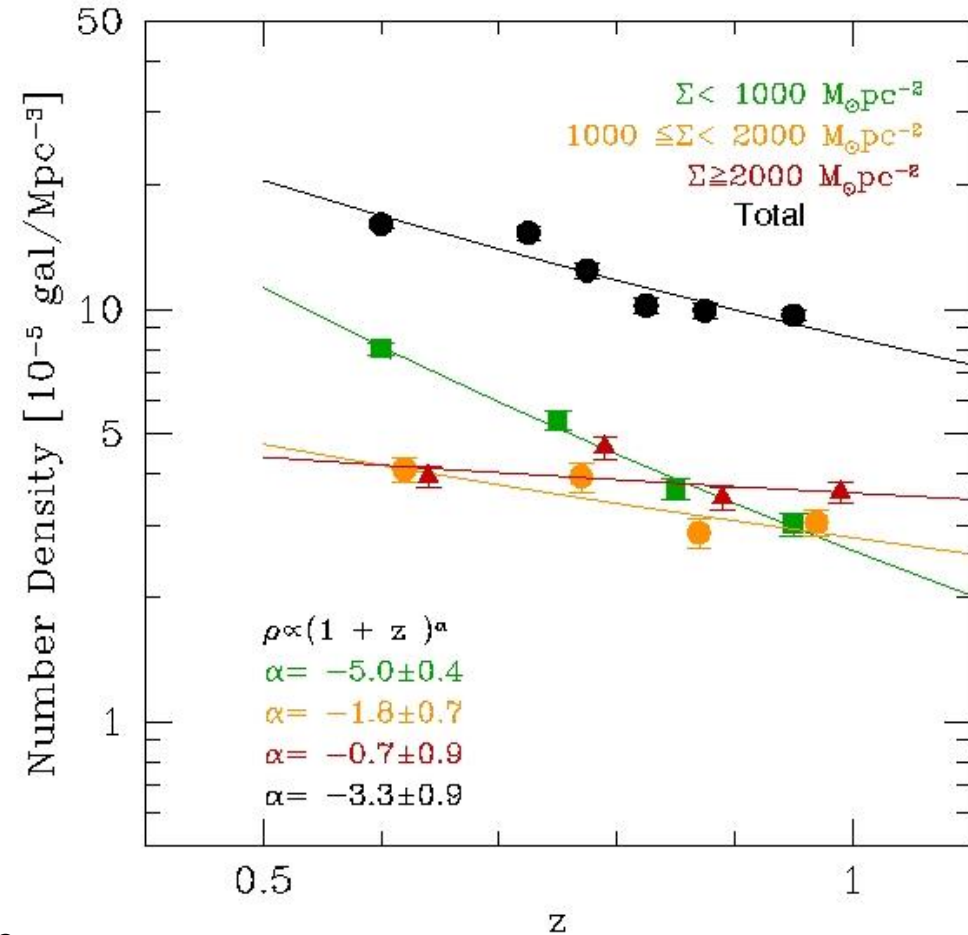
Increase factor:

Total : ~ 2.5

High Σ : ~ 1.2

Int Σ : ~ 1.7

Low Σ : ~ 4.2



Number densities fully corrected for incompleteness
Errors take into account the Poisson fluctuations and the error on Re

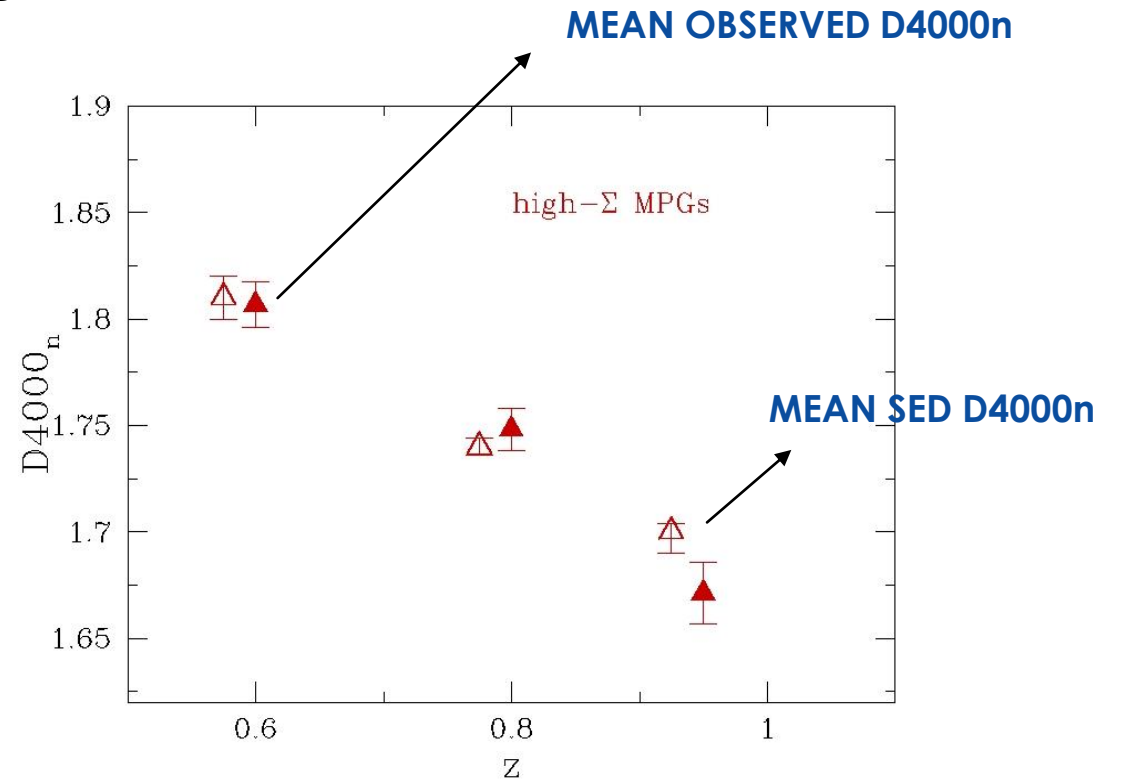
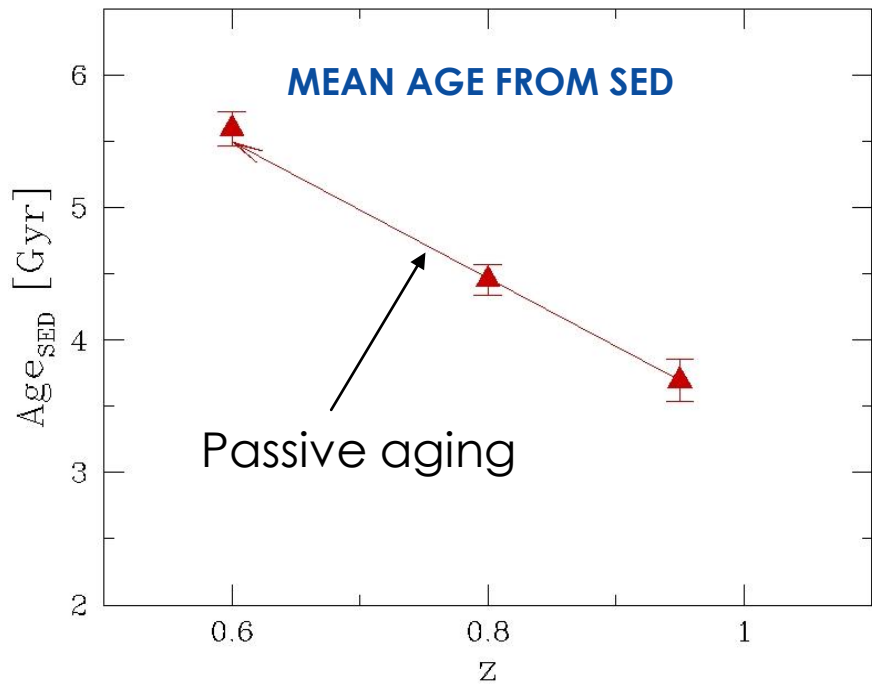
Gargiulo et al. 2017, in press

THE EVOLUTION OF THE STELLAR POPULATION AGES OF MPGs AS A FUNCTION OF Z AND Σ

The approach:

1. ages derived from the SED fitting \rightarrow Mean Age/ Z /Tau (z , Σ);
2. Mean Age/ Z /Tau (z , Σ) + BC03 models \rightarrow $D4000_{\text{SED}}$ (z , Σ);
3. $D4000_{\text{SED}}$ (z , Σ) vs $D4000_{\text{obs}}$ (z , Σ)

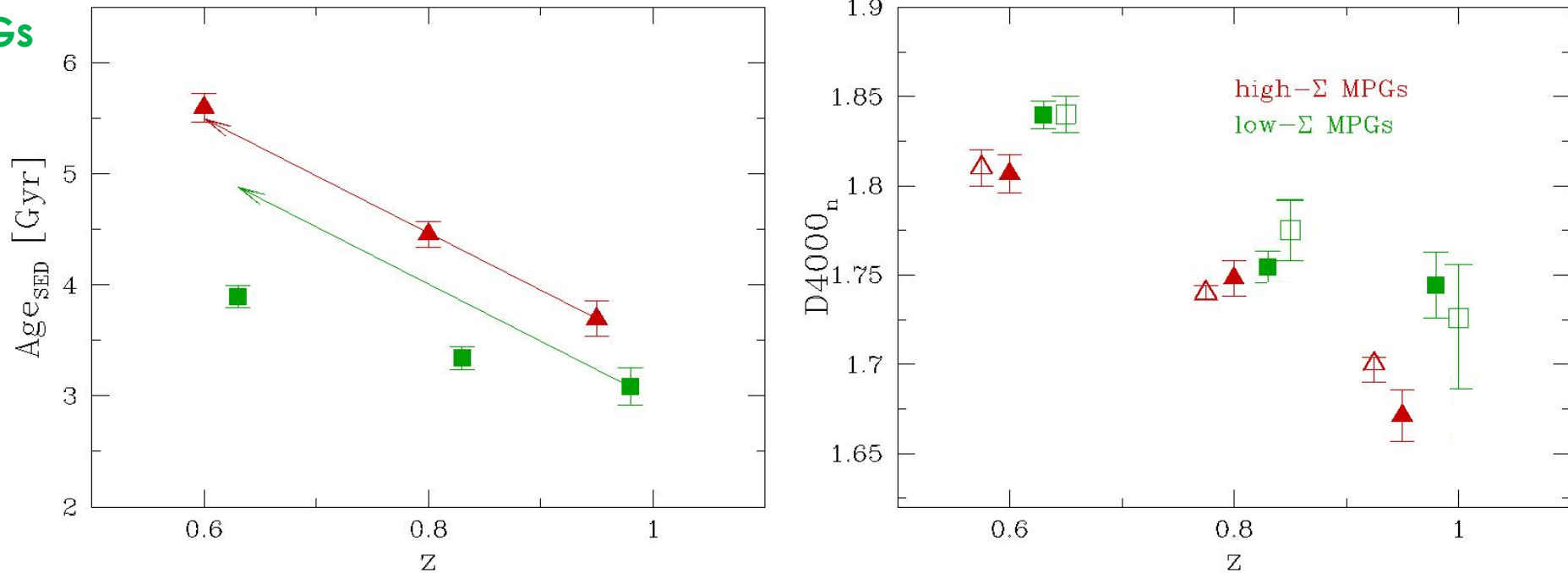
Compact MPGs



The evolution both of the number density and of the mean age of dense MPGs show that they passively evolve

THE EVOLUTION OF THE STELLAR POPULATION AGES OF MPGs AS A FUNCTION OF Z AND Σ

Less dense MPGs



Dense MPGs are older than less dense ones

(see also, e.g., Poggianti+ 2013, Saracco+ 2010, Williams+ 2016, Fagioli+ 2016 at smaller M_{star})

The evolution of the number density and of the mean age of less dense MPGs show that a significant fraction of NEW and YOUNGER MPGs should appear at later epoch

CONCLUSIONS - 1

From redshift 1.0 to 0.5
the population of MPGs (mainly) grows bottom – up:
on top of the population of denser MPGs already in place at $z \sim 1.0$,
new, younger, and larger MPGs appear at lower z

CONCLUSIONS - 1

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Where do these new MPG's come from?

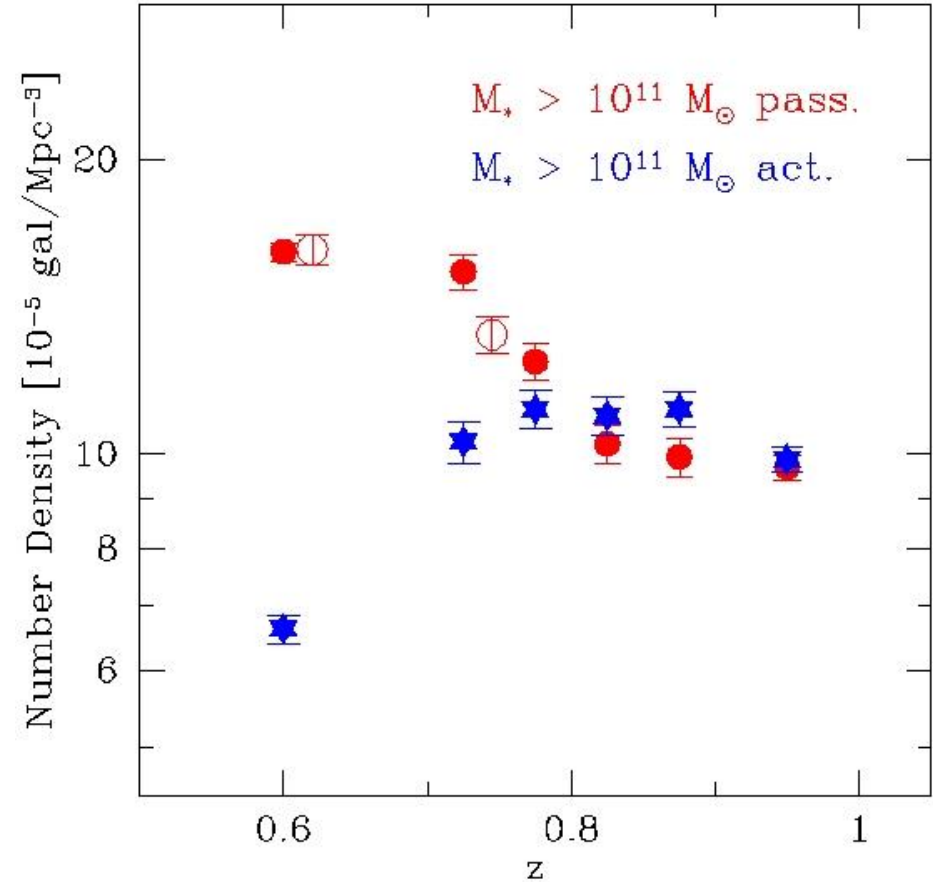
THE PROGENITORS OF (LESS DENSE) MPGs

The increase in number density of MPGs at $z < 0.8$ is totally accounted for by the decrease in number density of active massive galaxies



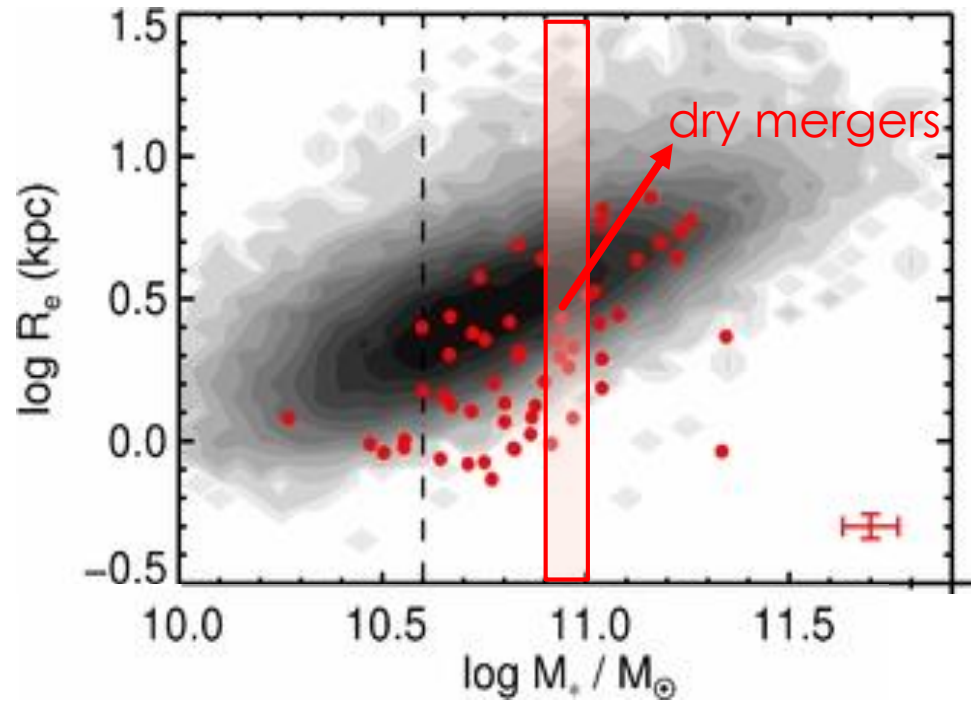
Active massive galaxies most likely progenitors of MPGs

(see, e.g. Lilly & Carollo 2016).

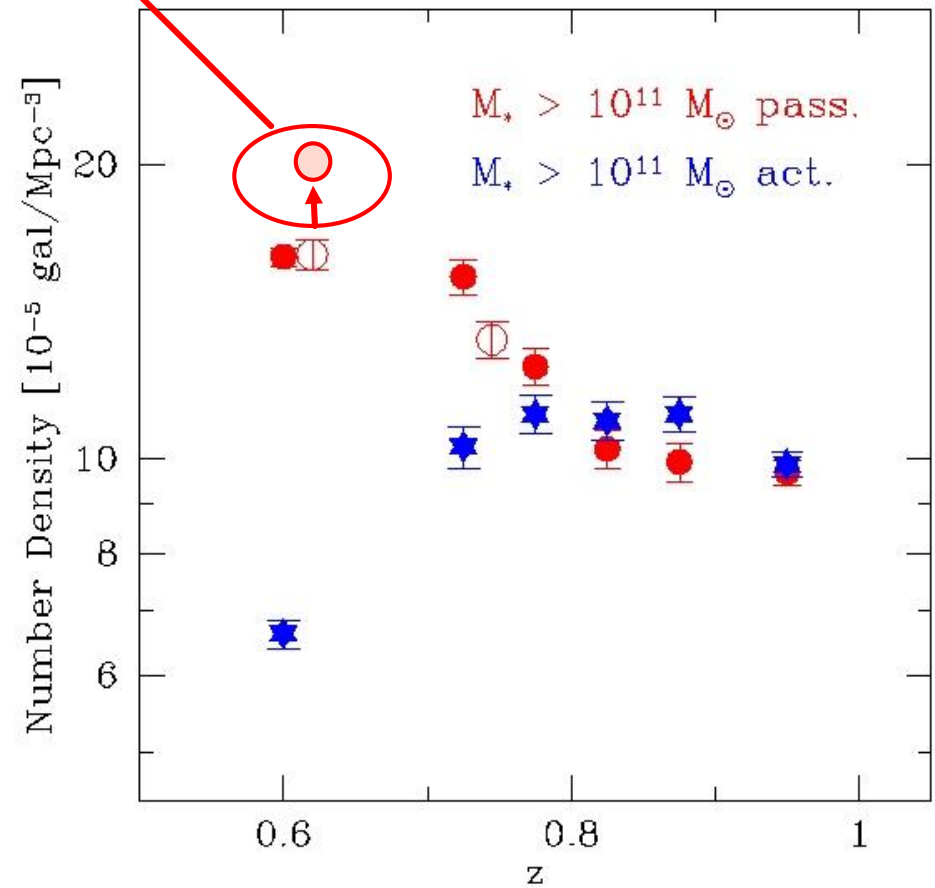


THE PROGENITORS OF (LESS DENSE) MPGs

Any other channel of MPGs formation different from the quenching of active massive galaxies will result in an overabundance of the number of MPGs



Increase in the number density due to other MPGs formation channels, e.g. dry mergers

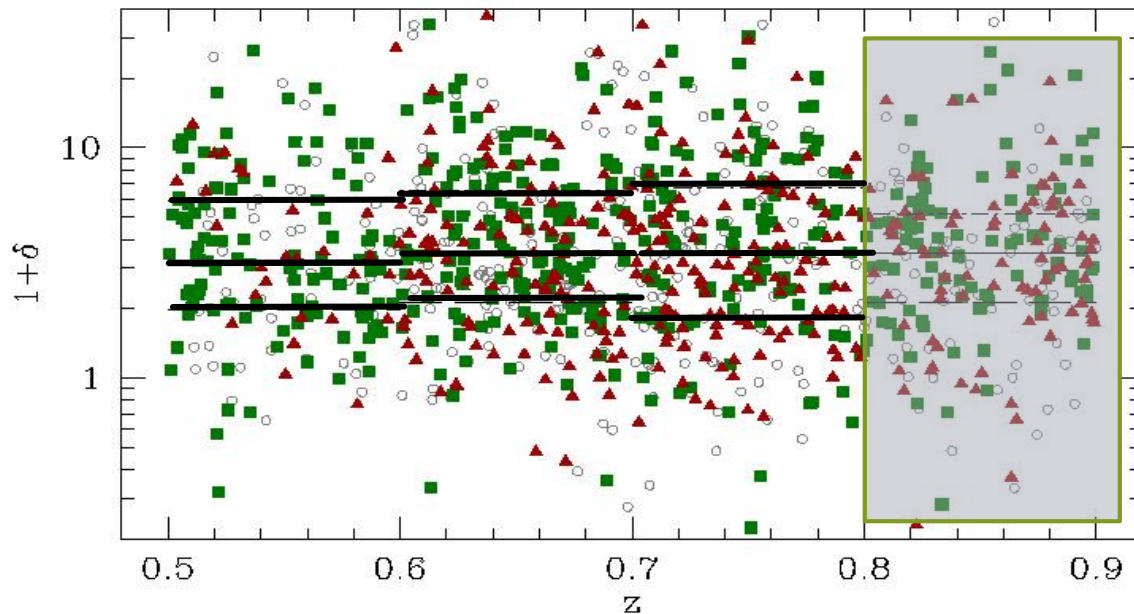


THE IMPACT OF THE ENVIRONMENT ON Σ

Dry mergers increase the galaxy size + merger activity enhanced in higher density regions

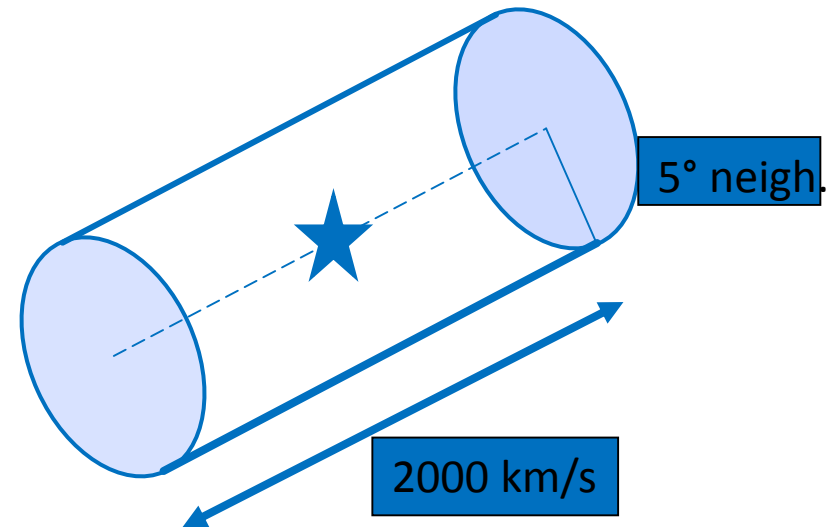


Larger galaxies in denser environment



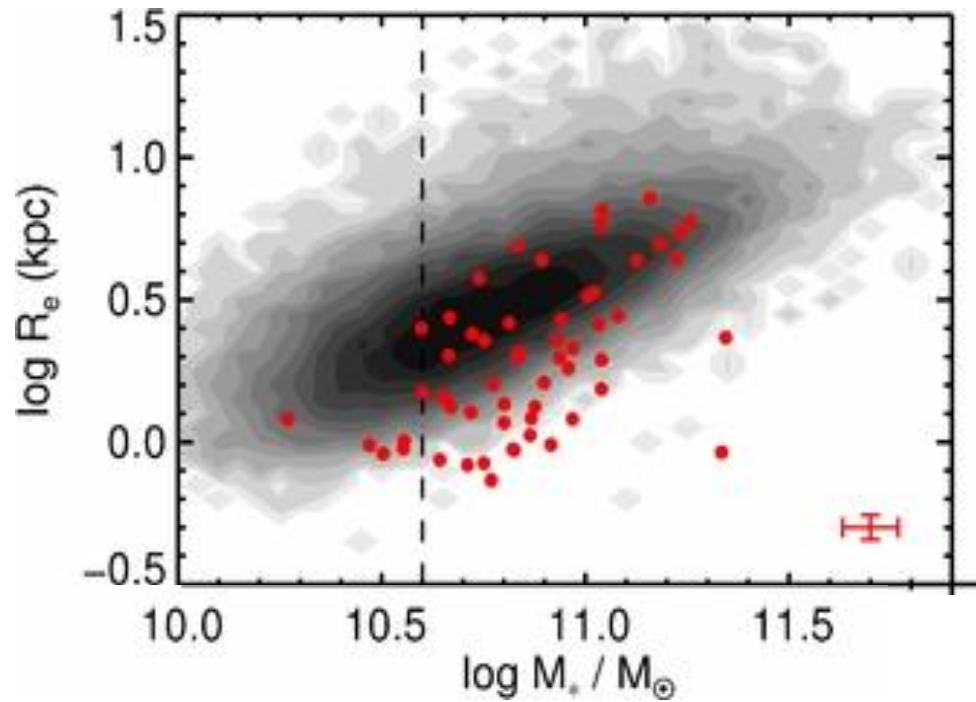
$$\delta = [\rho (ra, dec, z) / \rho (z)] - 1$$

Cucciati et al. 2014, 2017



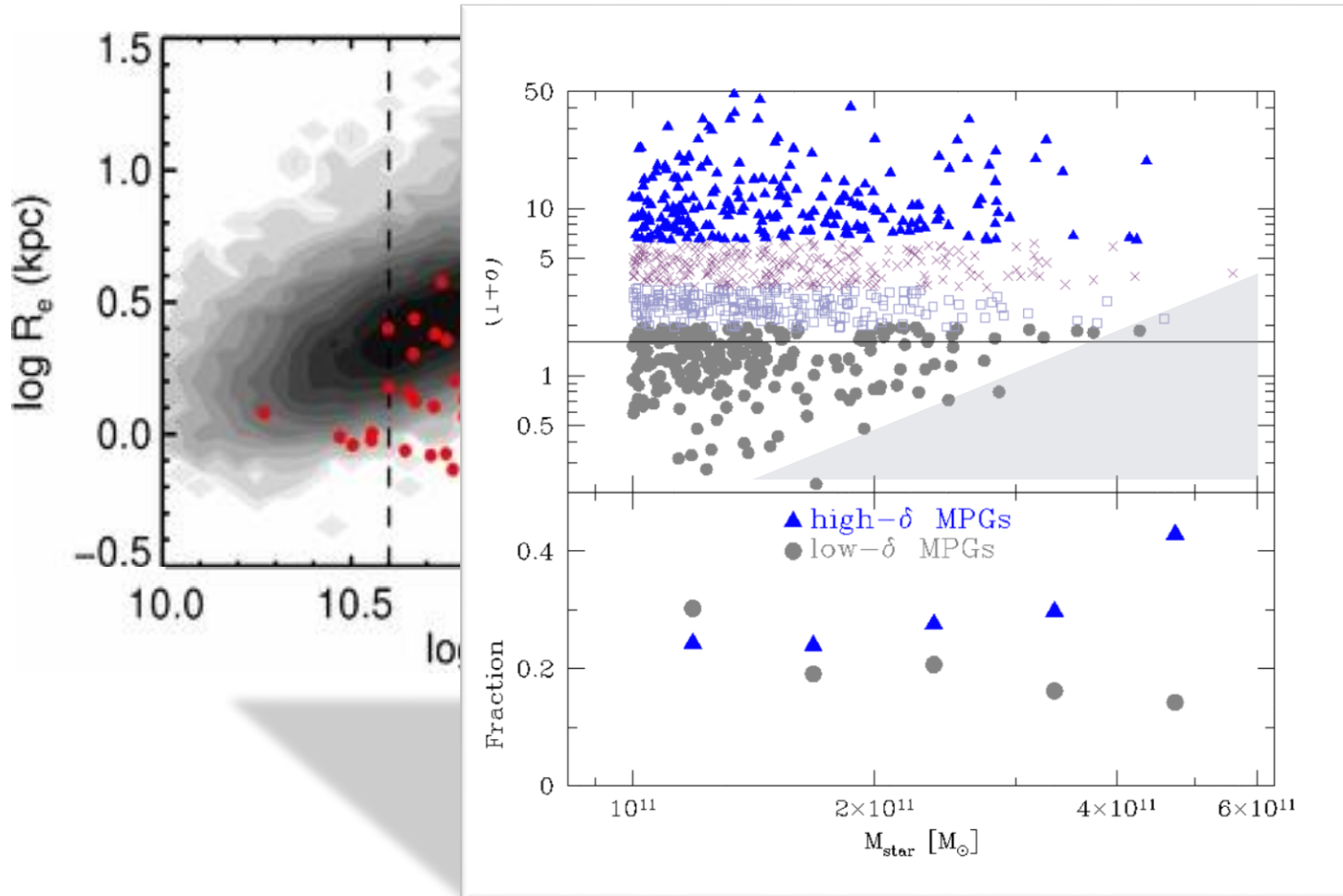
THE IMPACT OF THE STELLAR MASS DISTRIBUTION ON THE δ vs. Σ CORRELATION

Positive correlation between M_{star} and R_e



THE IMPACT OF THE STELLAR MASS DISTRIBUTION ON THE δ vs. Σ CORRELATION

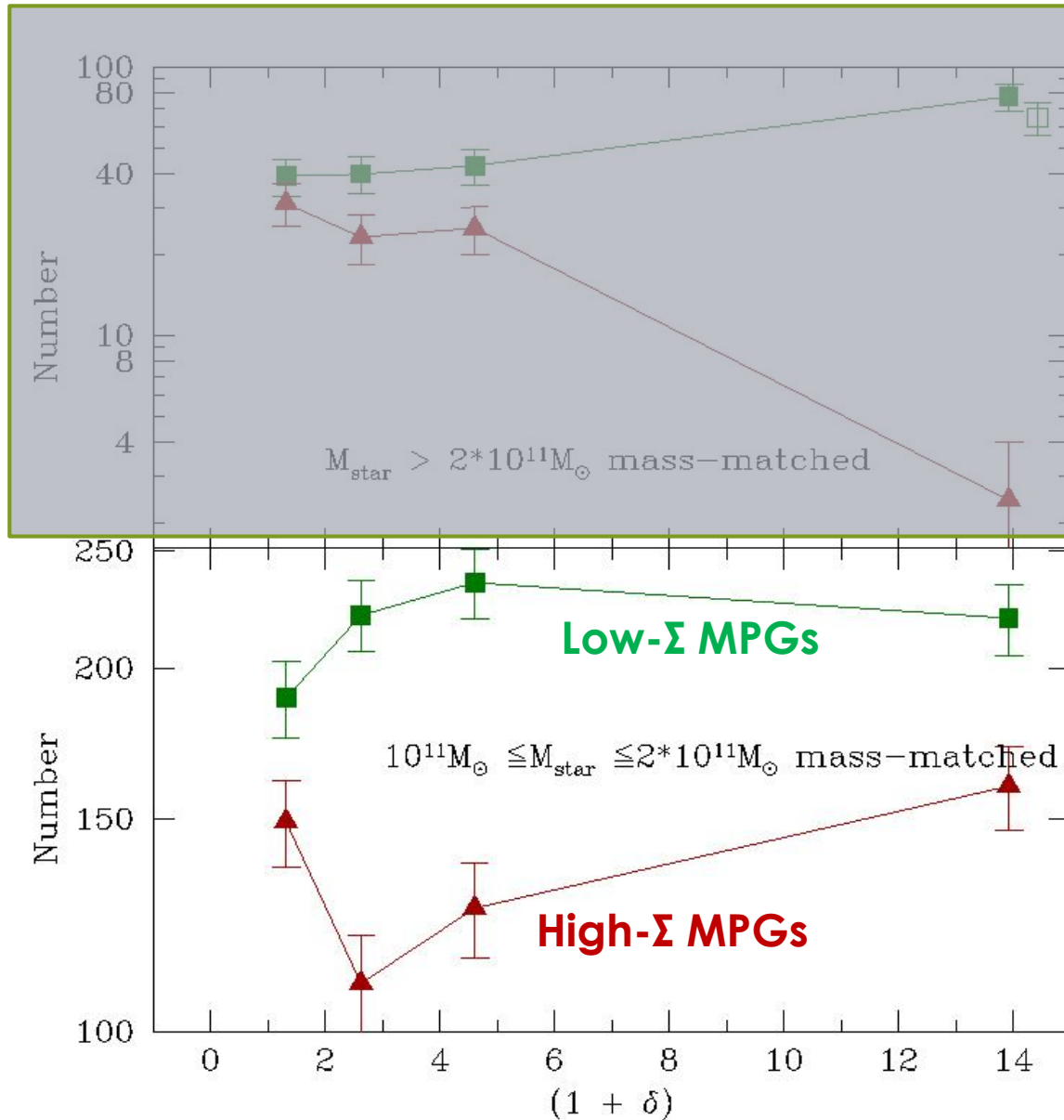
Positive correlation between M_{star} and R_e & δ



Spurious positive correlation between δ and Σ

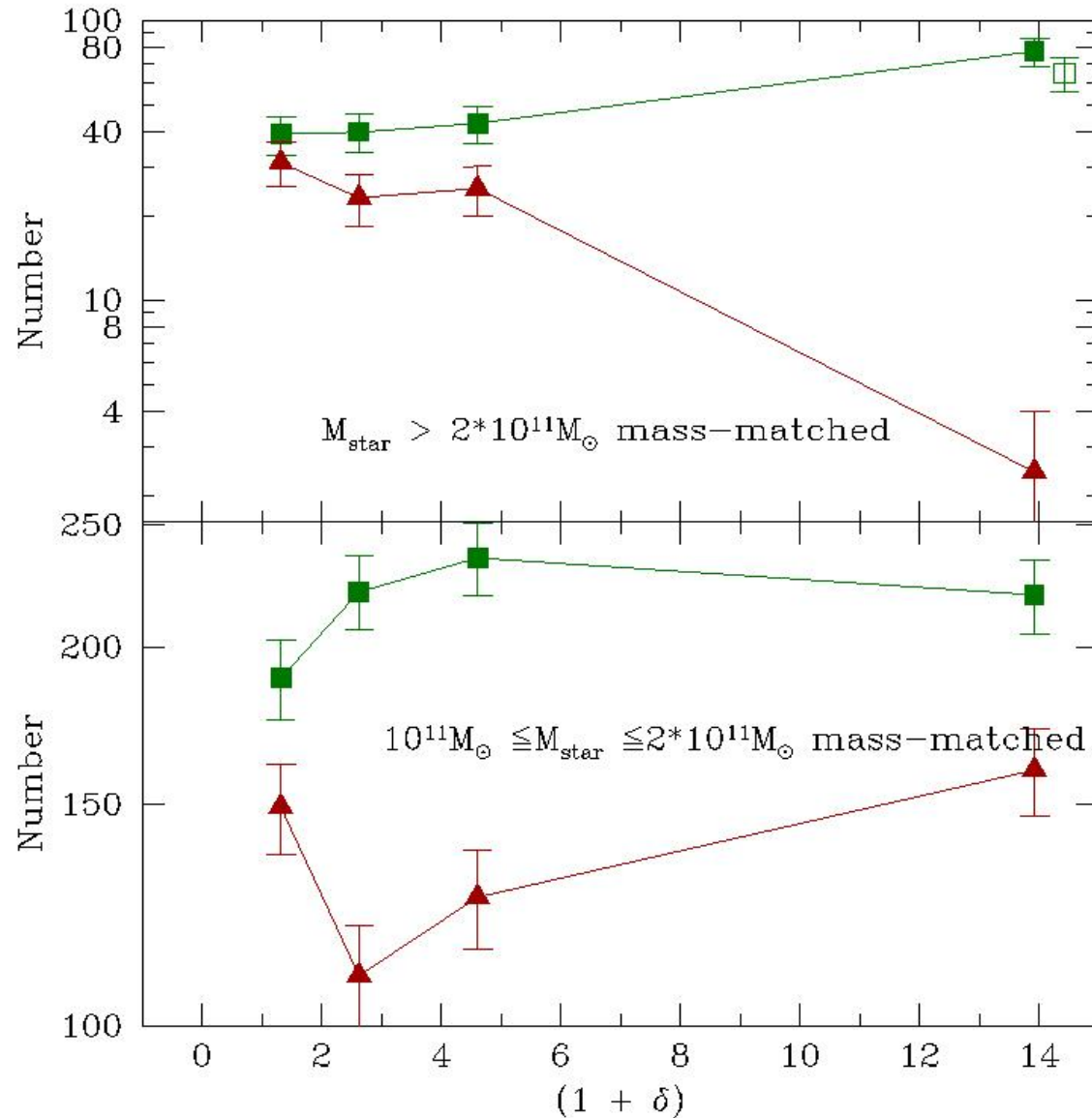
Mass-matched samples

(PRELIMINARY) RESULTS



At $M_{\text{star}} < 2 \cdot 10^{11} M_{\text{sun}}$ we do not find significant evidence of a trend between δ and Σ

(PRELIMINARY) RESULTS

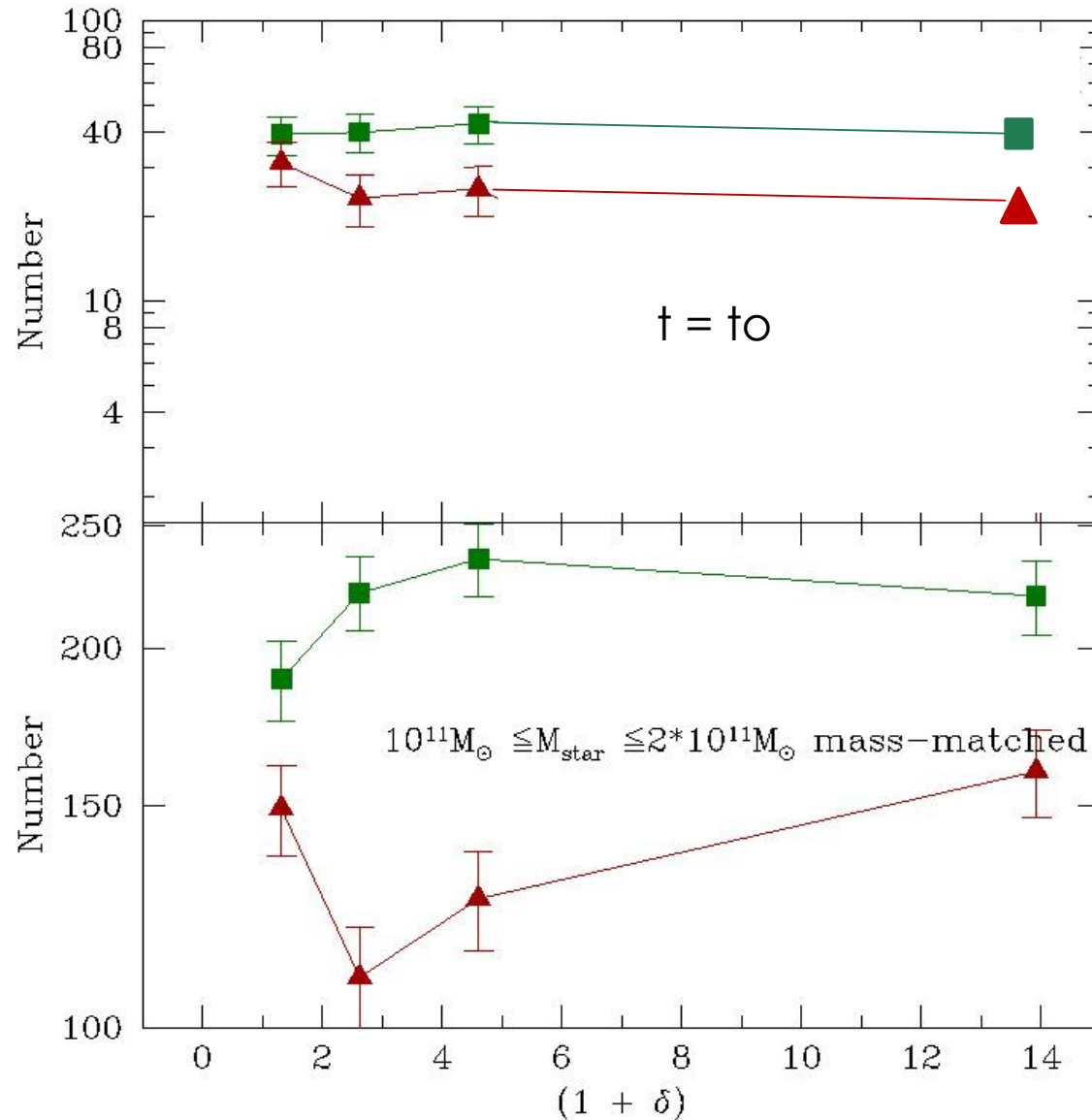


Lack(abundance) of compact(less dense) verymassive PGs in the densest regions:



1. High density regions prevent(favor) the formation of compact(less dense) MPG with $M_{\text{star}} > 2 \cdot 10^{11} M_{\text{sun}}$

(PRELIMINARY) RESULTS

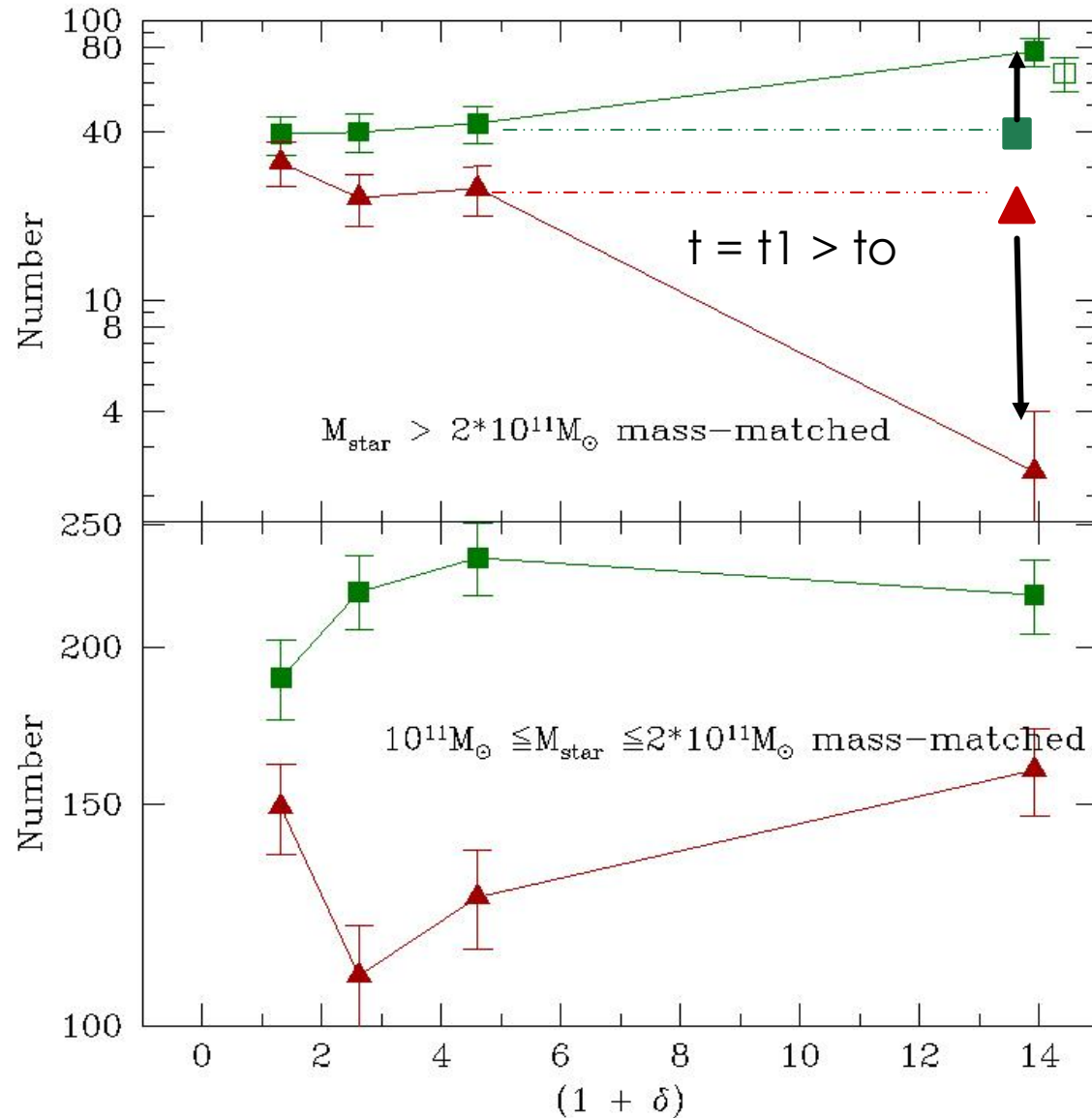


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(PRELIMINARY) RESULTS

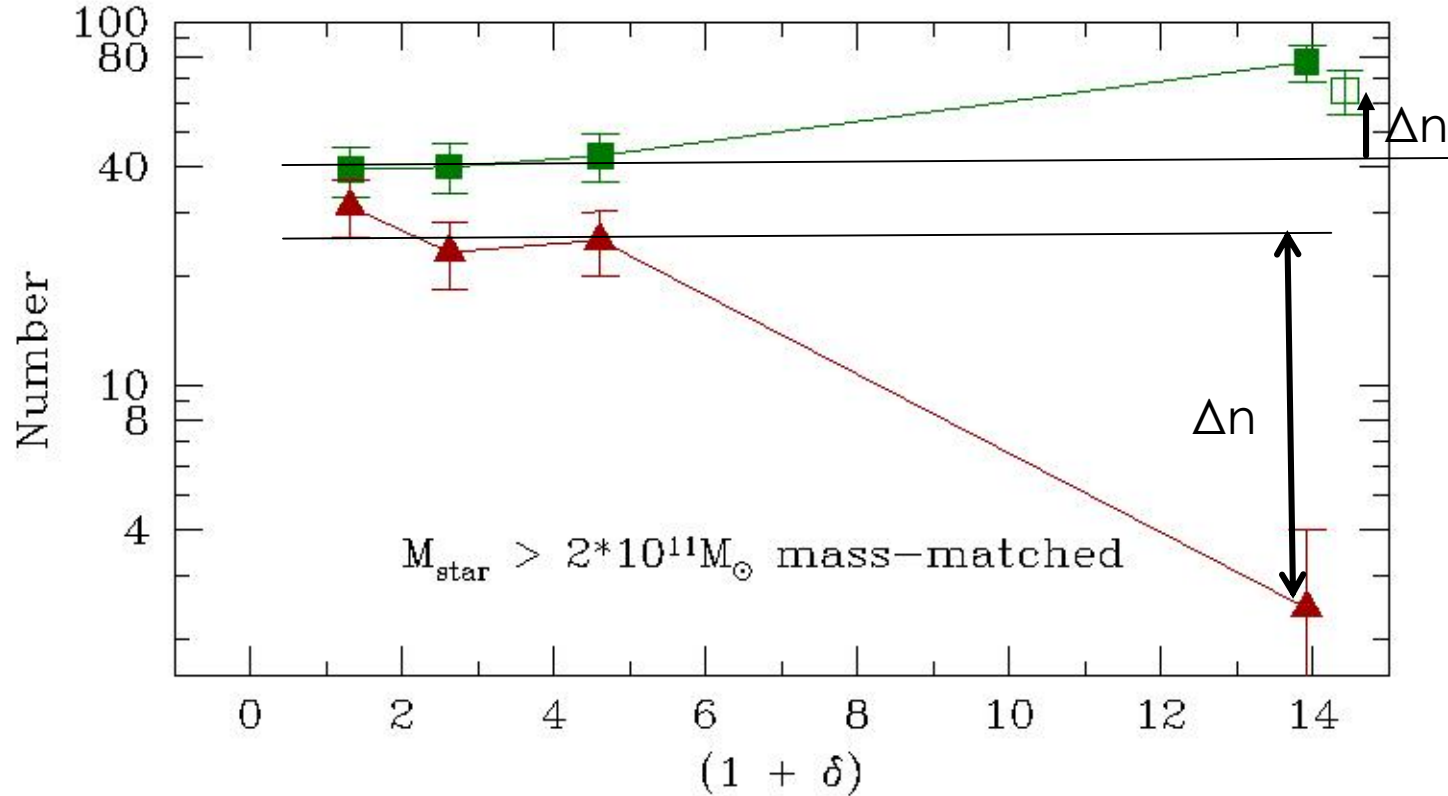


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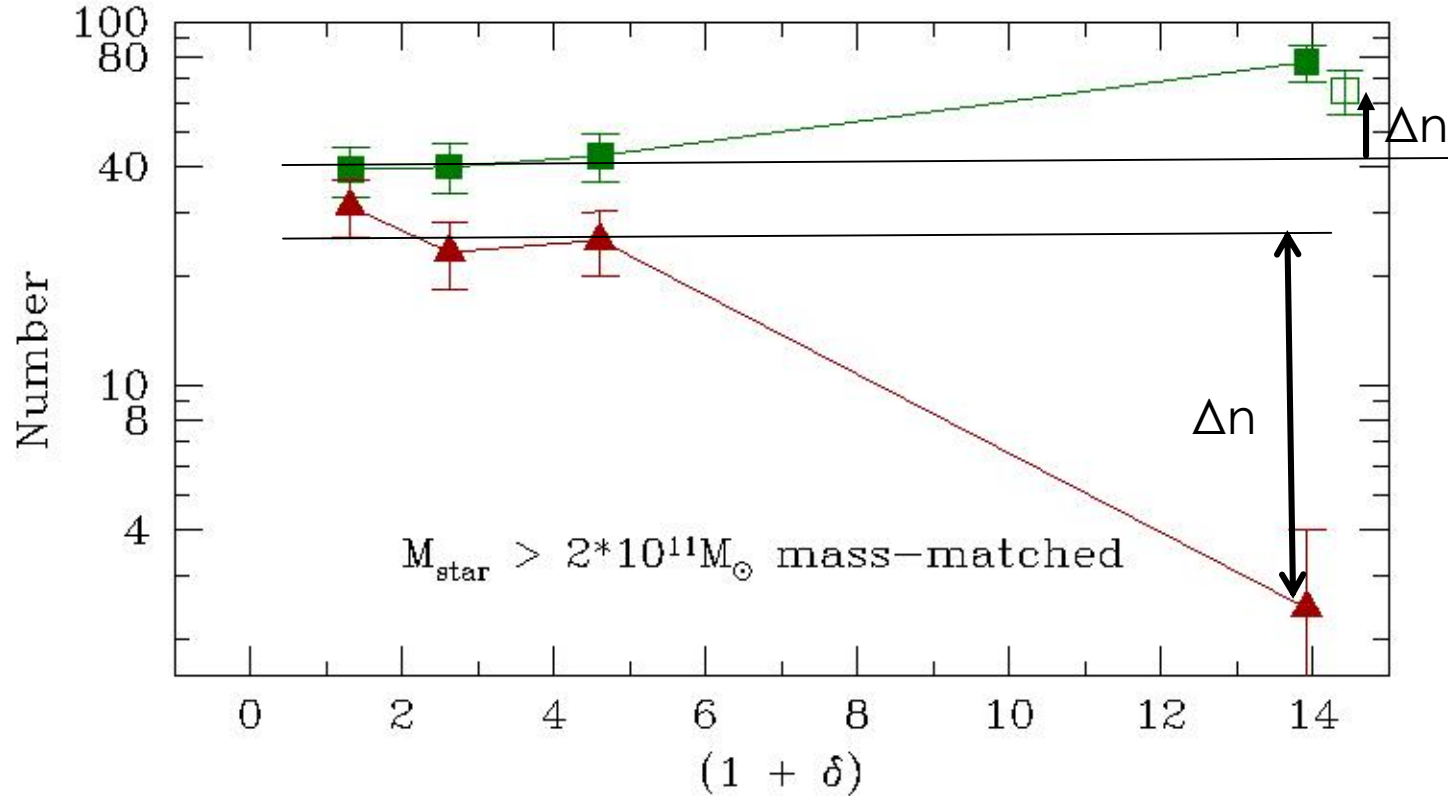
(PRELIMINARY) RESULTS



The drop in the number of compact
MPGs in the highest density regions
=
to the increase in the number of less
dense MPGs in the highest density
regions

BCGs 'creation'?

(PRELIMINARY) RESULTS



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Thank you!