The crazy(ing) side of boring passive galaxies

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The «boring» (and old) side

In local Universe passive galaxies (PGs) have

- regular shape : spherical or little flattened;
- no special features: smooth light profile →no spiral arms or dust lane
- old and coeval stellar populations;
- structural and dynamical properties tightly correlated;
- no gas and no dust;
- random motions of stars;

The «boring» (and old) side: 1˚ attempt

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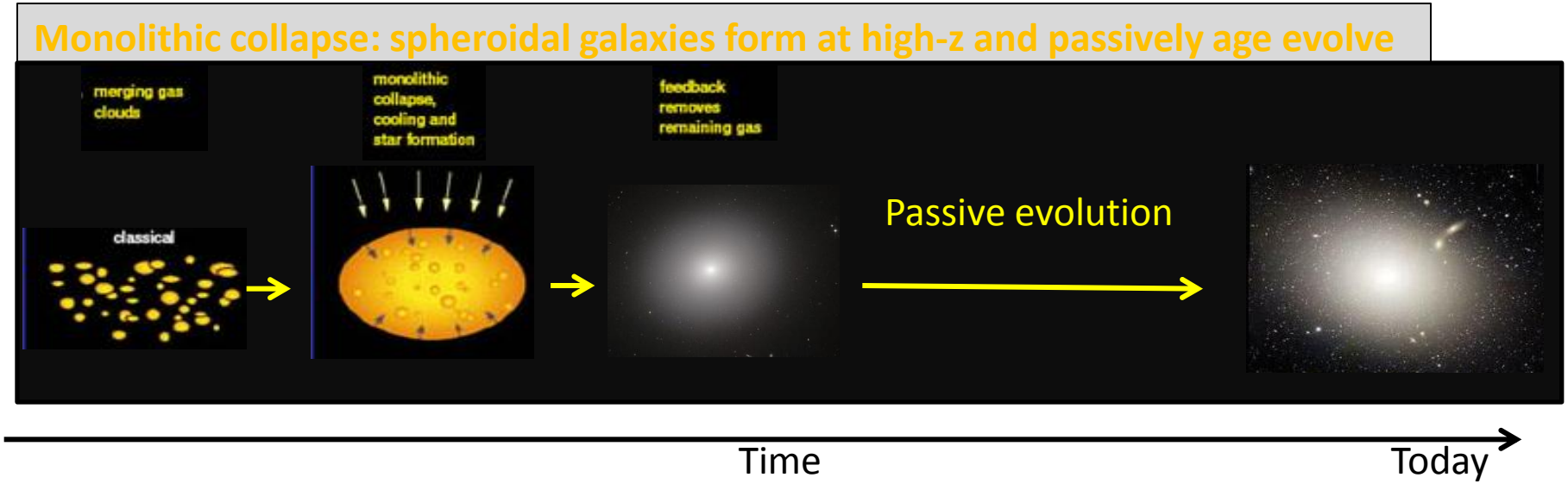
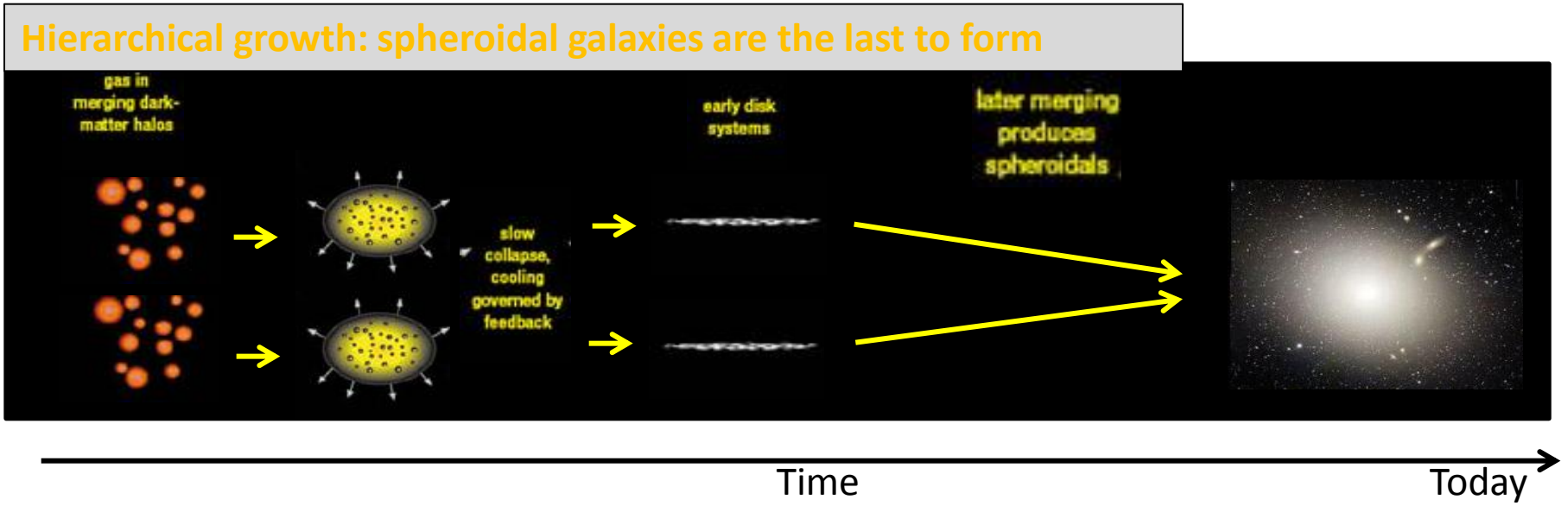


The «boring» (and old) side: 2° attempt

But…dark matter hyerarchically grows



The crazy (and new!!) side: 3°, 4°, 5°, 6° … attempt

But…HST deep fields

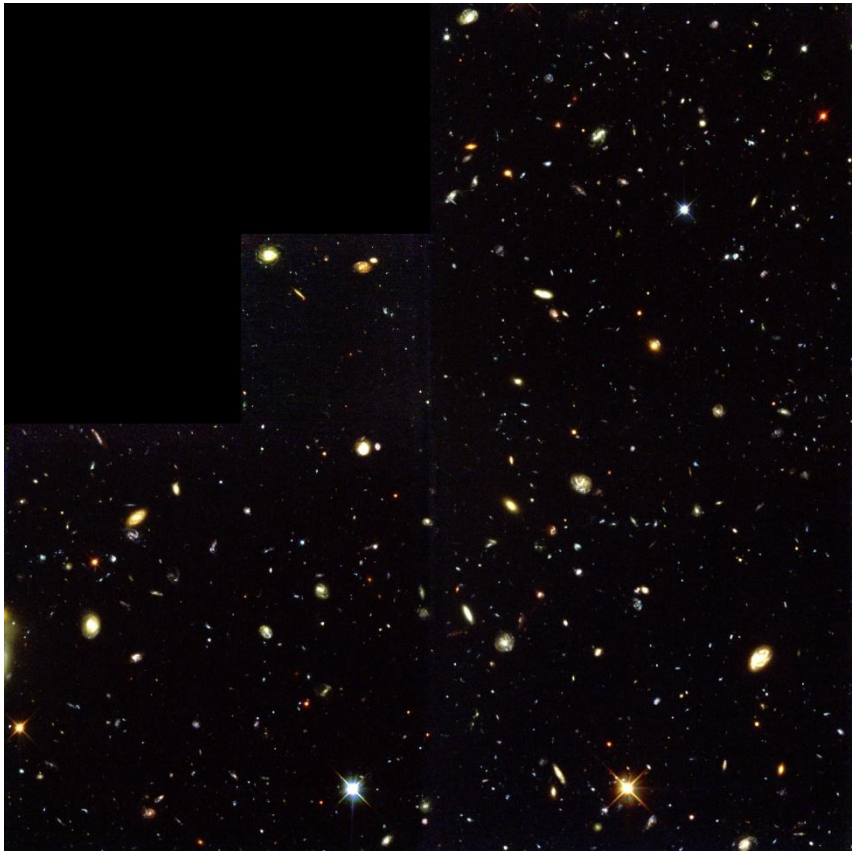
Deep HST imaging:
PGs are already in place at high-z

↓

Come back to the monolithic collapse? **NO**

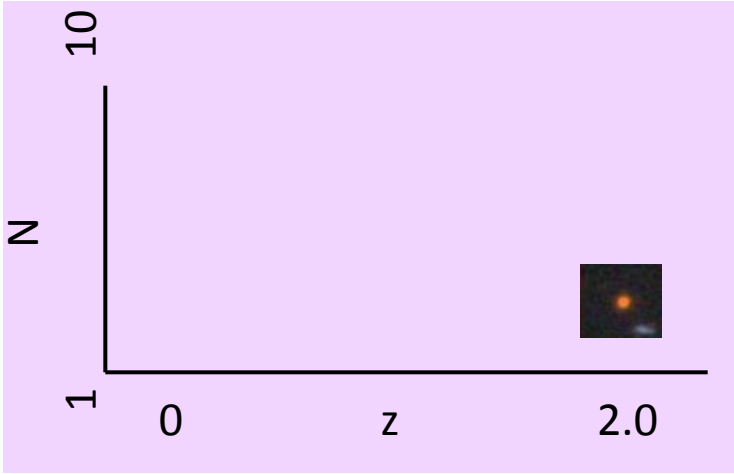
↓

The population of high – z PGs is very different from the population of local PGs.



What we know today: the fixed points

- High-z deep space-based surveys (CANDELS, GOODS, HUDF, …) have revealed the presence of PGs at z = 2 and beyond (e.g. Daddi 2005, Longhetti 2007, van Dokkum 2008, +++);



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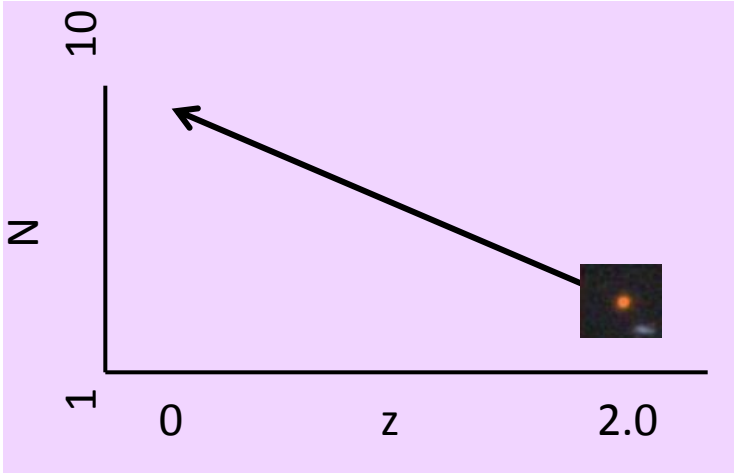

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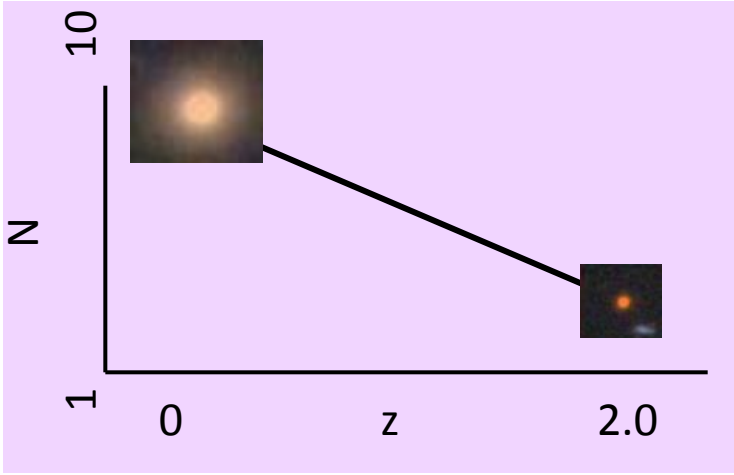

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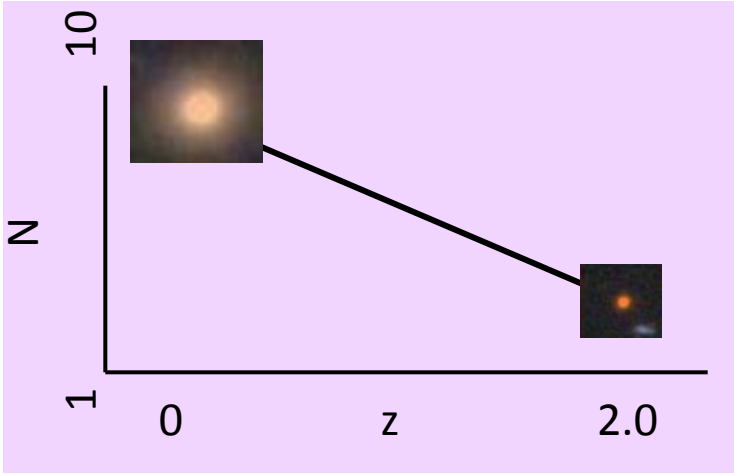
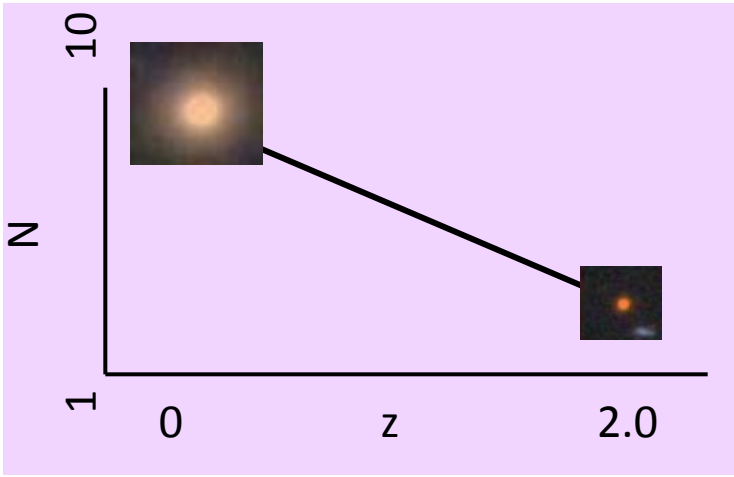
- On average, at fixed stellar mass, high-z PGs are smaller (≥ 4-5 times) than local PGs;
- In term of mean stellar mass density Σ , at fixed stellar mass, high-z PGs are denser.



$$\Sigma = M_* / (2 \pi R_e^2)$$

How the population of PGs was build up?

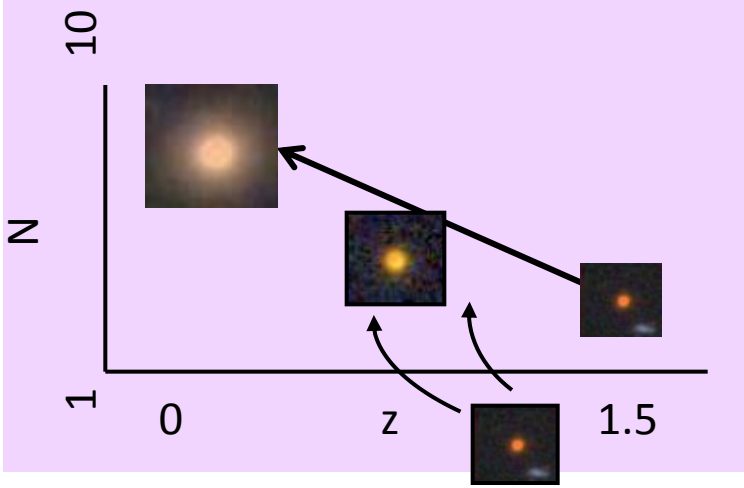
FACTS →



How the population of PGs was build up?

Hypothesis 1:

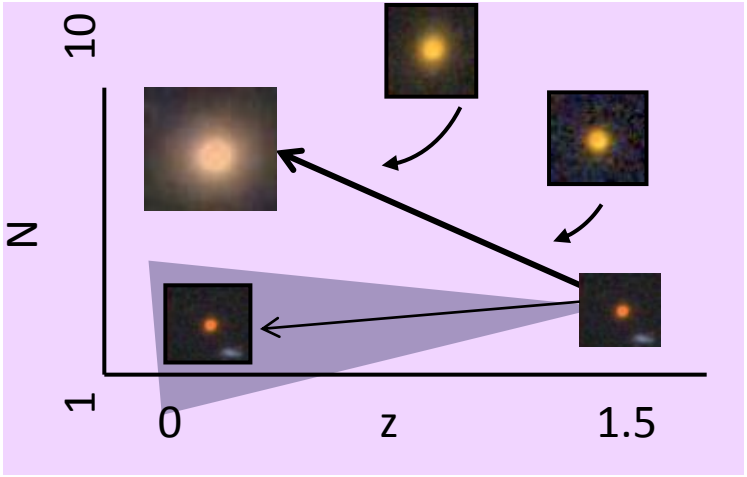
Individual PGs increase their size.
(e.g. Hopkins et al. 2009, Naab et al. 2009, van Dokkum et al.2015)



→ new dense PGs have to appear at lower redshift
→ dense PGs should be present at any z and should be the youngest

How the population of PGs was build up?

Hypothesis 2:



'Progenitor bias' :
galaxies which quenched later are larger.
(e.g. Carollo et al. 2013, Poggianti et al. 2013)

→ number density of dense PGs remains constant;
→ age of dense PGs is consistent with a passive evolution (+ the oldest ones)

Hypothesis 1 or 2? → number density and age evolution of PGs as a function of their surface mean stellar mass density

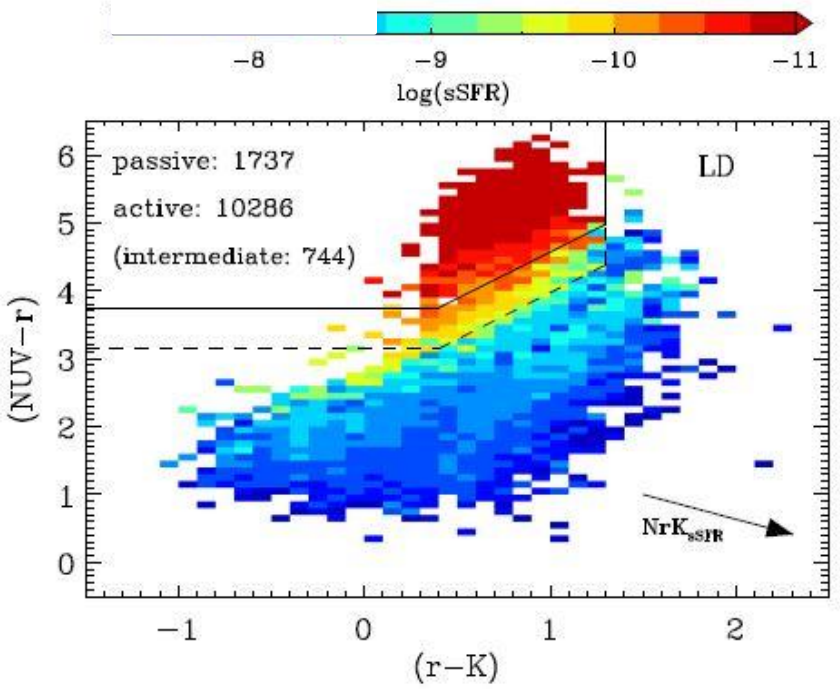
The VIPERS MPGs sample

Size evolution expected larger for the most massive PGs ($M_* \geq 10^{11}\ M_{sun}$,MPGs)

MPGs are rare → few works have tackled the evolution of number density and ages for their subpopulations (e.g. Carollo et al. 2013, Fagioli et al. 2016).

- $2 \leq zflag \leq 9.0$
- $0.5 \leq z \leq 1.0$
- (NUV – r) vs (r –K)
- $M_* \geq 10^{11}\ M_{sun}$ (Cha IMF)

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



Davidzon et al. 2015

To derive Σ:

Re in i band for galaxies at $z \geq 0.8$
Re r band for galaxies at $z < 0.8$
} ~ U band rest frame over the whole redshift range

The evolution of the number densities of MPGs as a function of z and Σ with VIPERS

The evolution of the number densities depends on Σ

From z = 1.0 → z = 0.5:

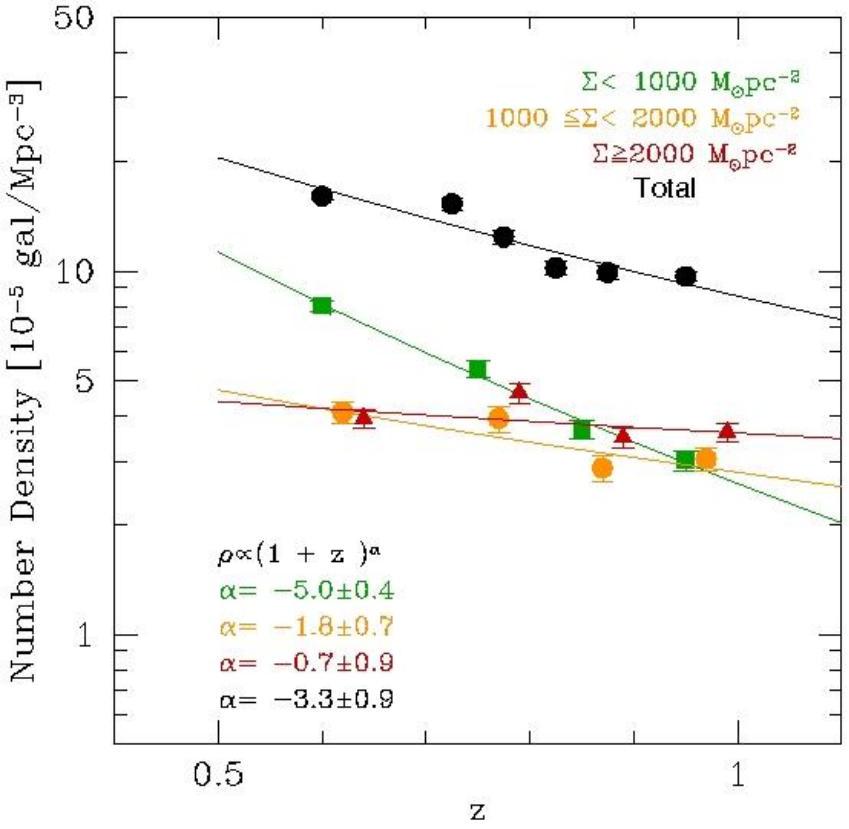
Increase factor:

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

The evolution of stellar population ages of MPGs as a function of z and Σ with VIPERS

Two independent estimates of stellar population age:
the age from the fit of the spectral energy distributions (SEDs) + D4000n

Age from D4000 depends on metallicity Z (and on the timescale τ)

APPROACH:

SED fitting

⬇

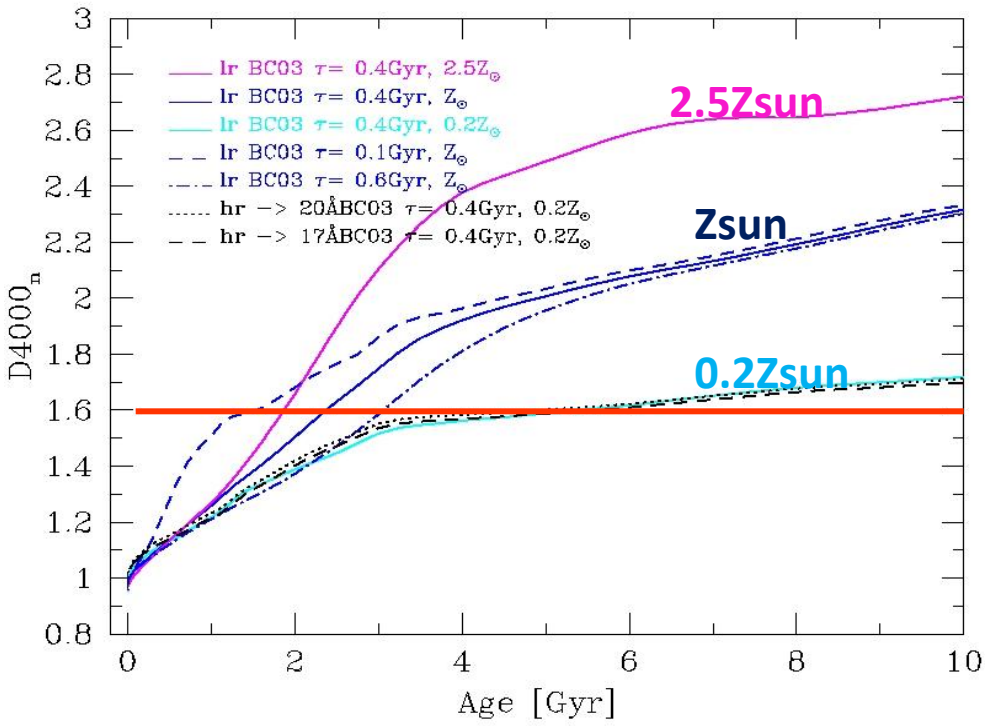
Mean Age/Z/Tau (z, Σ)

⬇

BC03 models → $D4000_{SED}$ (z, Σ)

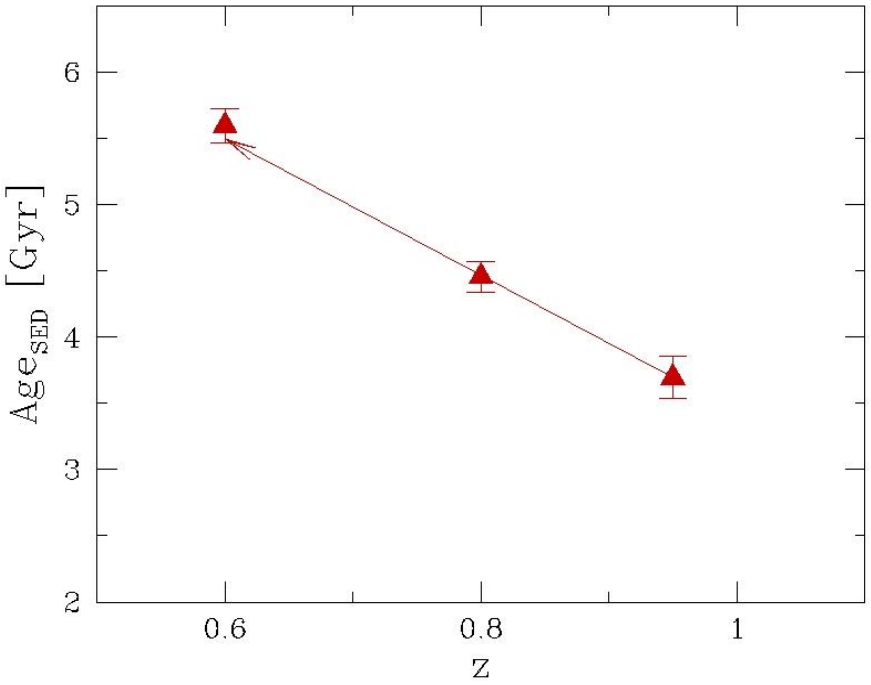
⬇

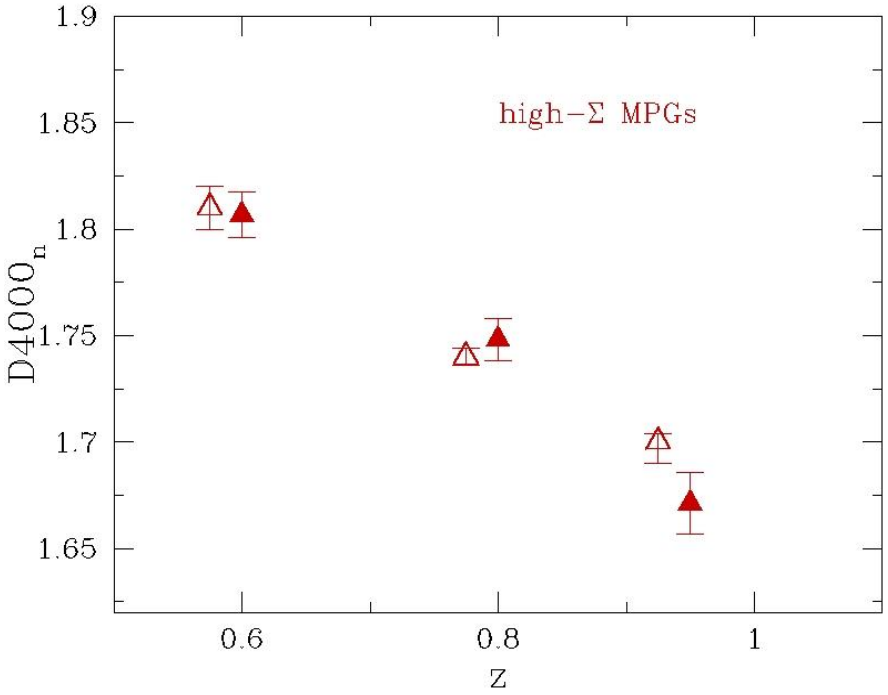
$D4000_{SED}$ (z, Σ) vs $D4000_{obs}$(z, Σ)



The evolution of stellar population ages of MPGs as a function of z and Σ with VIPERS

Dense MPGs

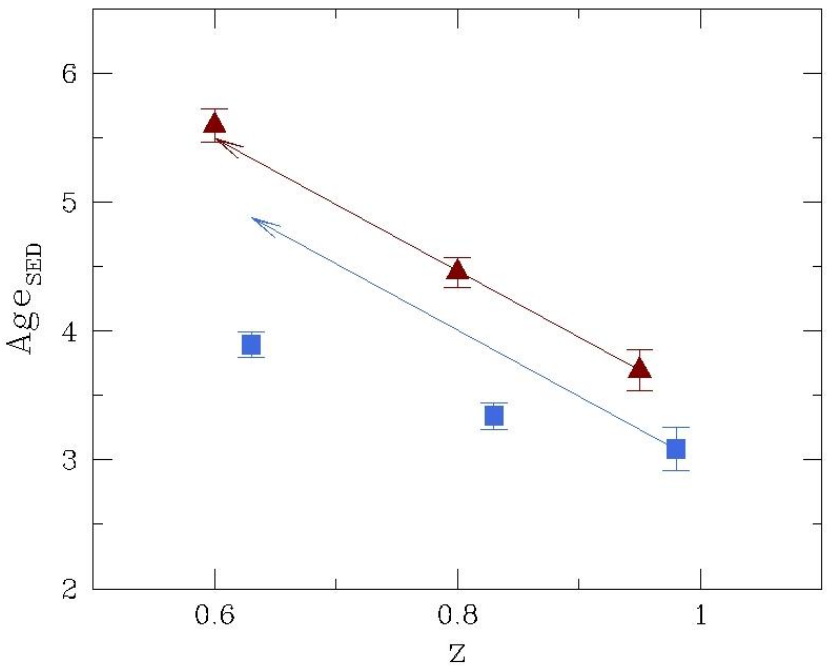


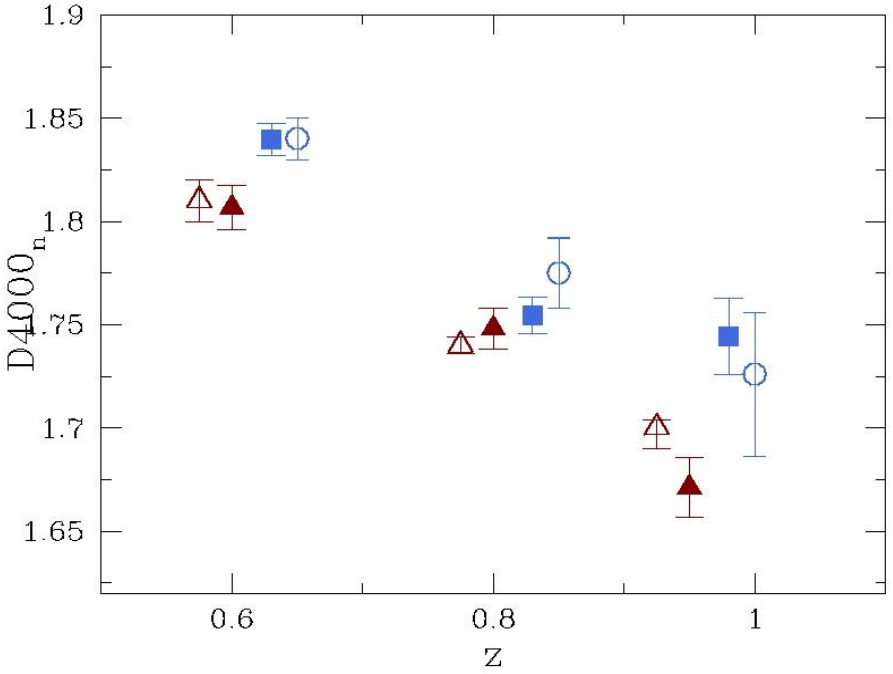


The evolution both of the number density and of the mean age of dense MPGs show that they passively evolve

The evolution of stellar population ages of MPGs as a function of z and Σ with VIPERS

Less dense MPGs + correction aperture bias

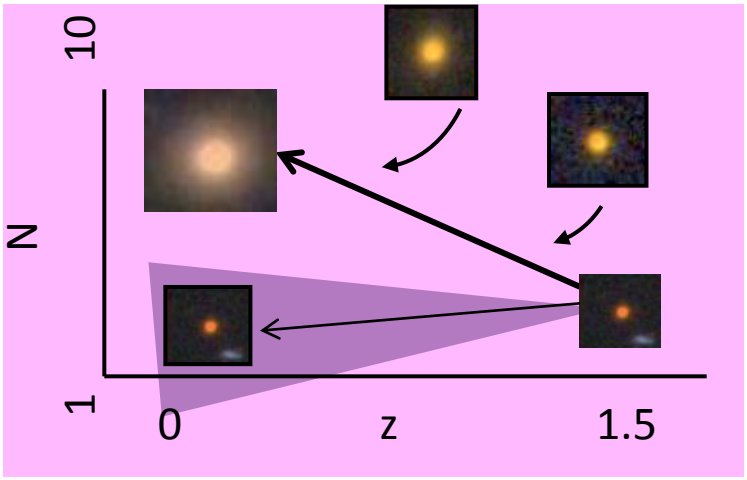




The evolution of the number density and of the mean age of less dense MPGs show that a significant fraction of NEW and YOUNGER MPGs should appear at later epoch

Conclusions

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 ~ 1.0,
new, younger, and larger MPGs appear at lower z



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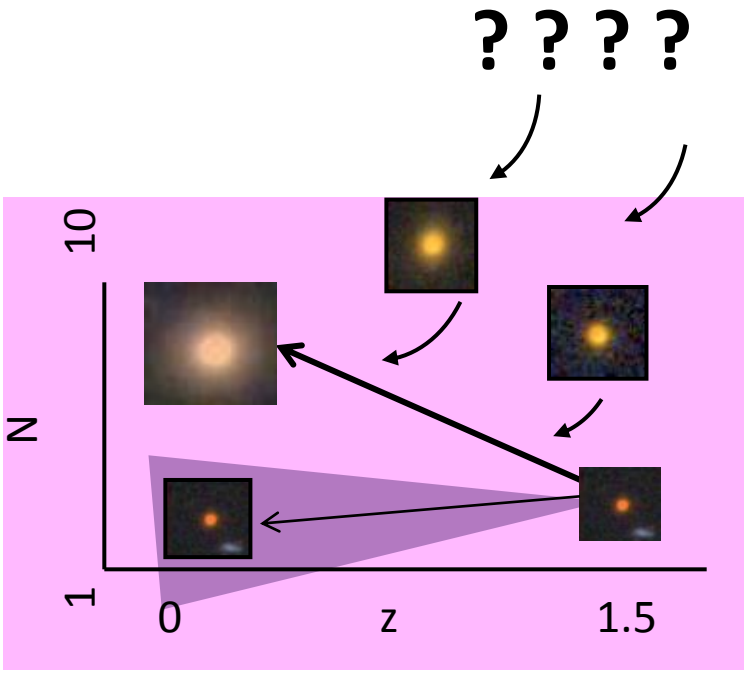
Where do these new MPGs come from?



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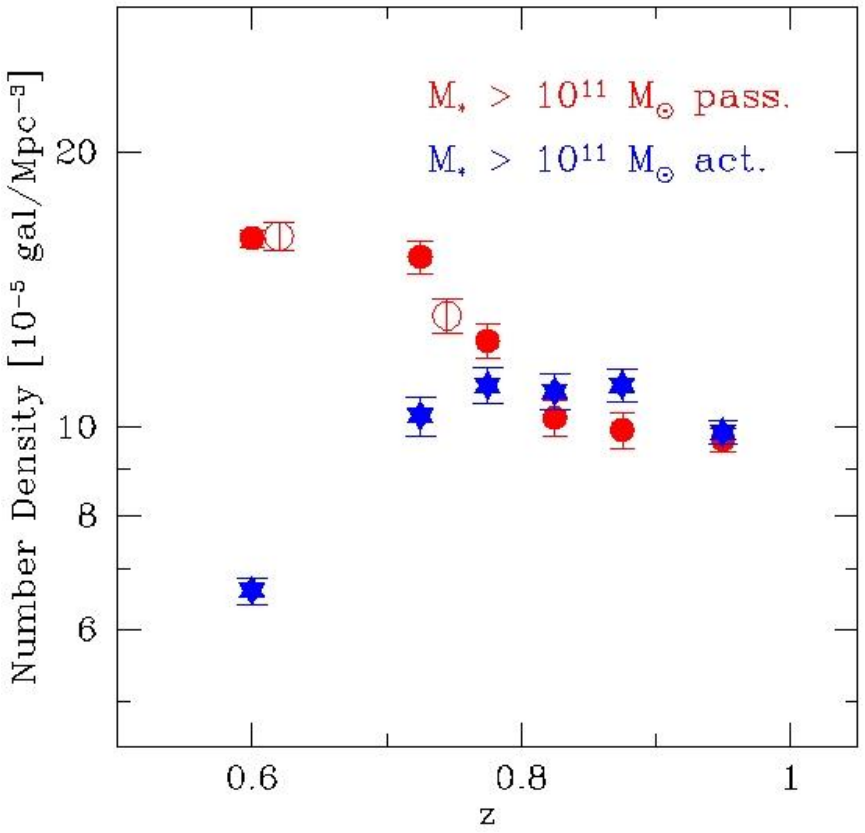
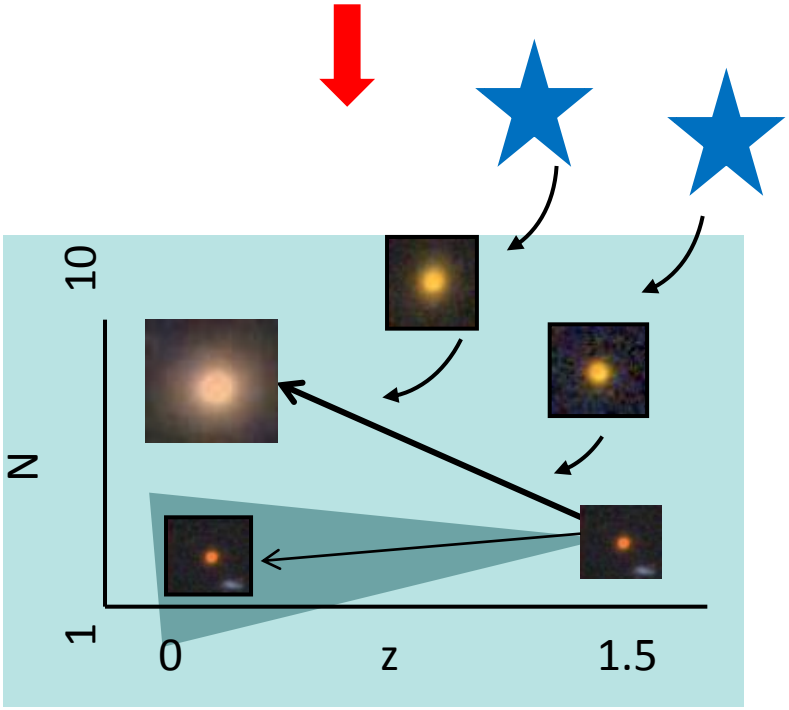


The increase in number density of MPGs at z < 0.8 is totally accounted for by the decrease in number density of active massive galaxies.



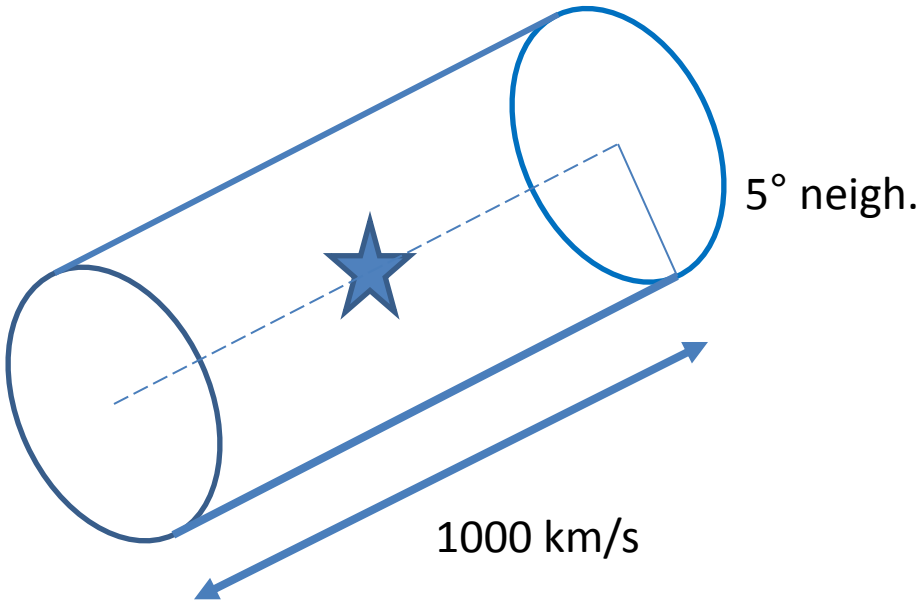
The effect of the environment

What about the build up of individual MPGs with different Σ?
Different mechanisms act in different environment:

do MPGs with different Σ populate different environment?

Environment defined as:

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



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