How does galaxy environment matter in shaping physical properties of VIPERS galaxy subtypes

Małgorzata Siudek

IFAE, Barcelona

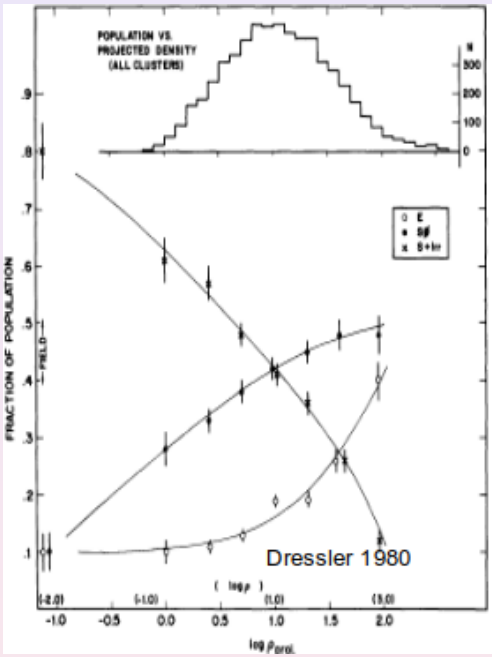
Massively Parallel Large Area Spectroscopy from Space,
23/06/2021

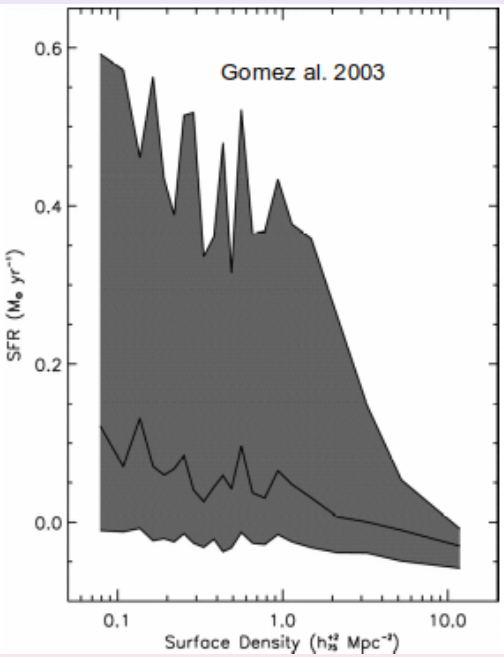
Outline:

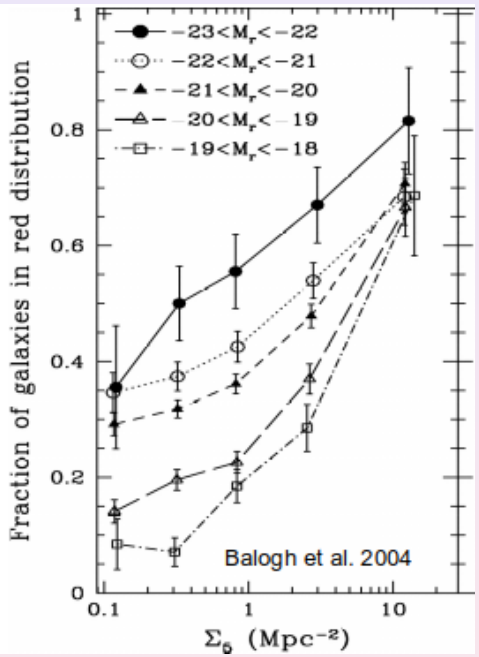
1. The complexity of galaxy population at $z \sim 1$
2. Environment: a key to search for different evolutionary paths of galaxy subclasses
3. Summary

Motivation:

The interplay between evolution of galaxies and their environment is **mostly** studied for blue and red galaxy population.







Is it enough?

Dividing galaxies into only two or at best three broad galaxy populations may not be sufficient for comprehensive studies of all aspects of environmental influence on galaxy evolution.

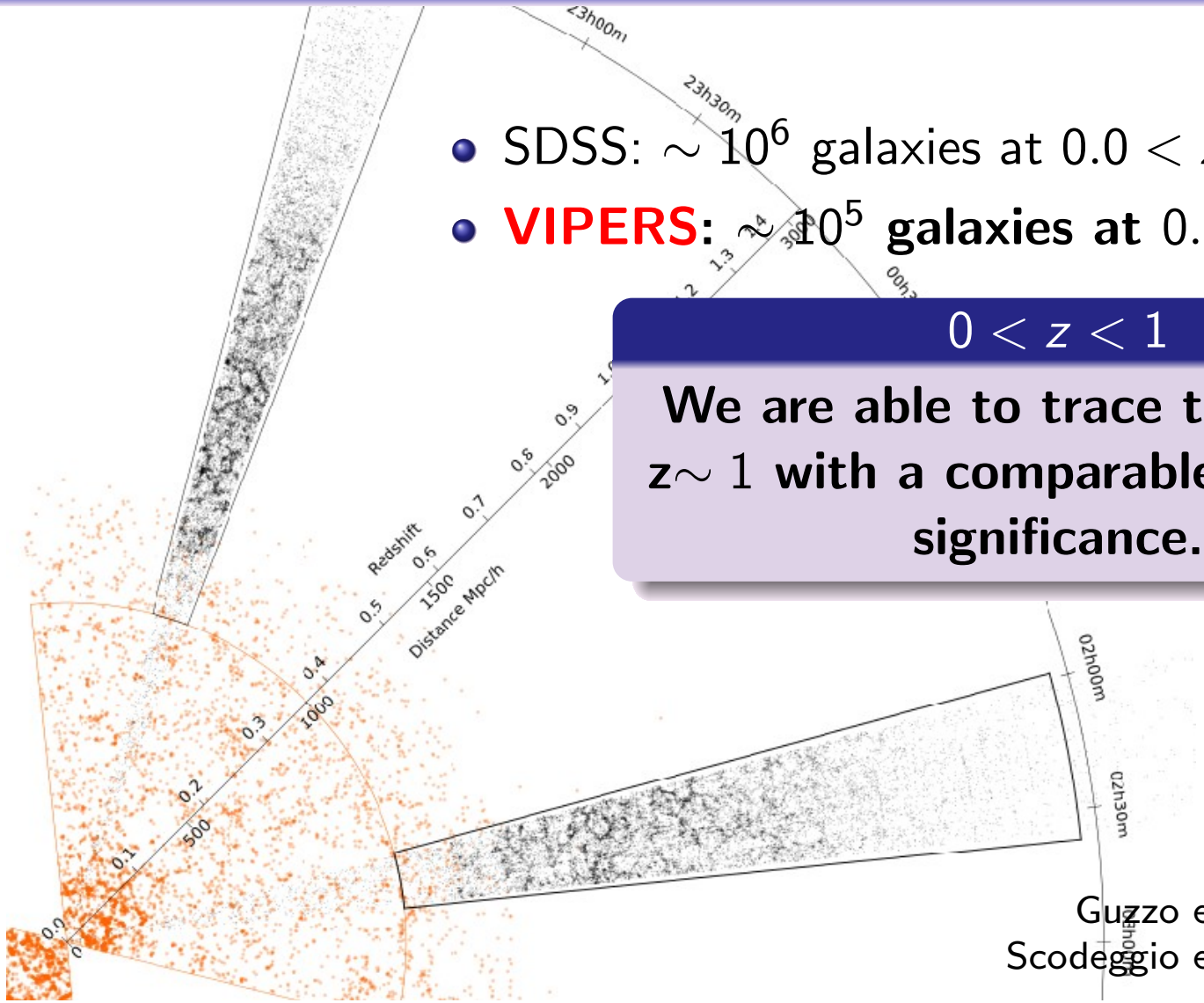
Multi-wavelength look at galaxy population:

Since we have bimodality in colour-colour space, we expect equivalent peaks in a multi-dimensional luminosity space.

Idea: Unsupervised clustering algorithm

Using the distribution of galaxies in a multi-wavelength space we avoid incompletness and contamination issues.

VIMOS Public Extragalactic Redshift Survey (VIPERS)



- SDSS: $\sim 10^6$ galaxies at $0.0 < z < 0.25$,
- **VIPERS: $\sim 10^5$ galaxies at $0.4 < z < 1.2$**

$0 < z < 1$

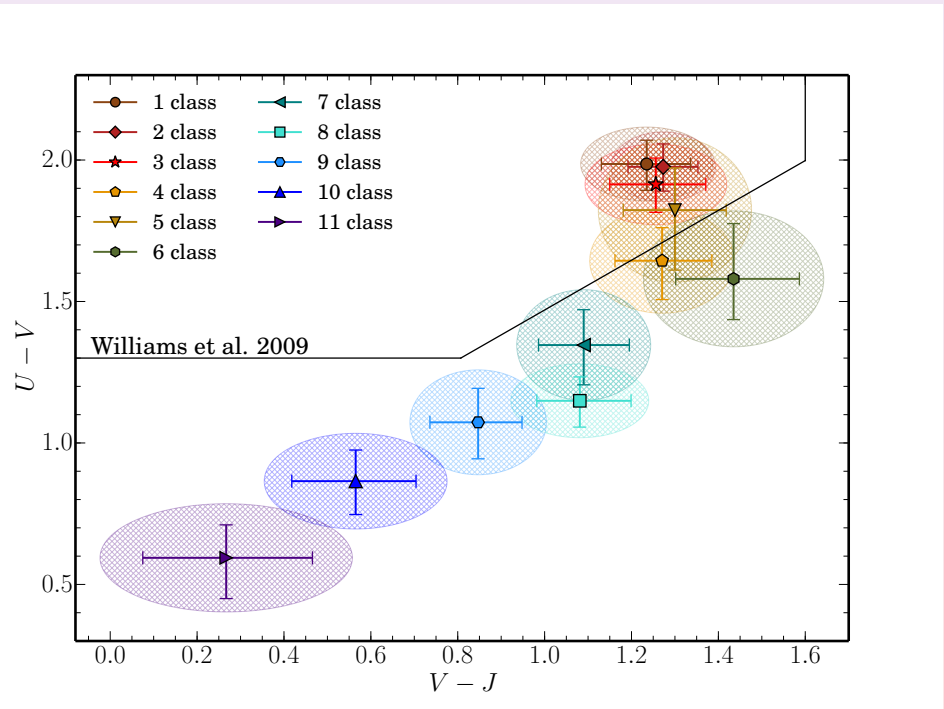
We are able to trace the SFH at $z \sim 1$ with a comparable statistical significance.

Guzzo et al. 2013
Scodeggio et al. 2018

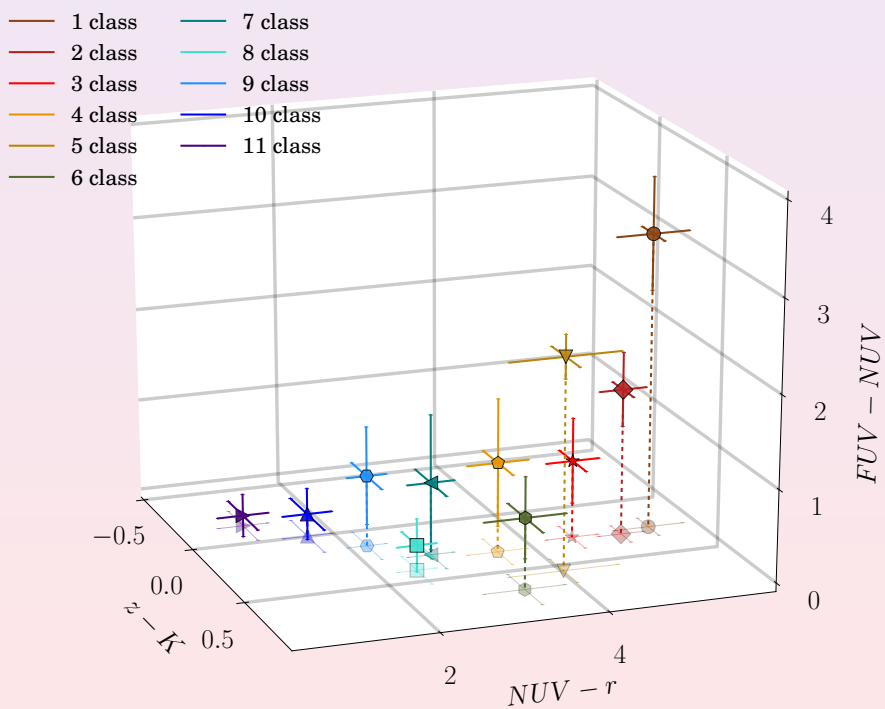
Galaxy classification at $z \sim 0.7$

Unsupervised classification of VIPERS galaxies using a *13-dimensional* feature space (12 absolute magnitudes and spec-z).

2-D colours: not able to reveal a full panoply of galaxy types.

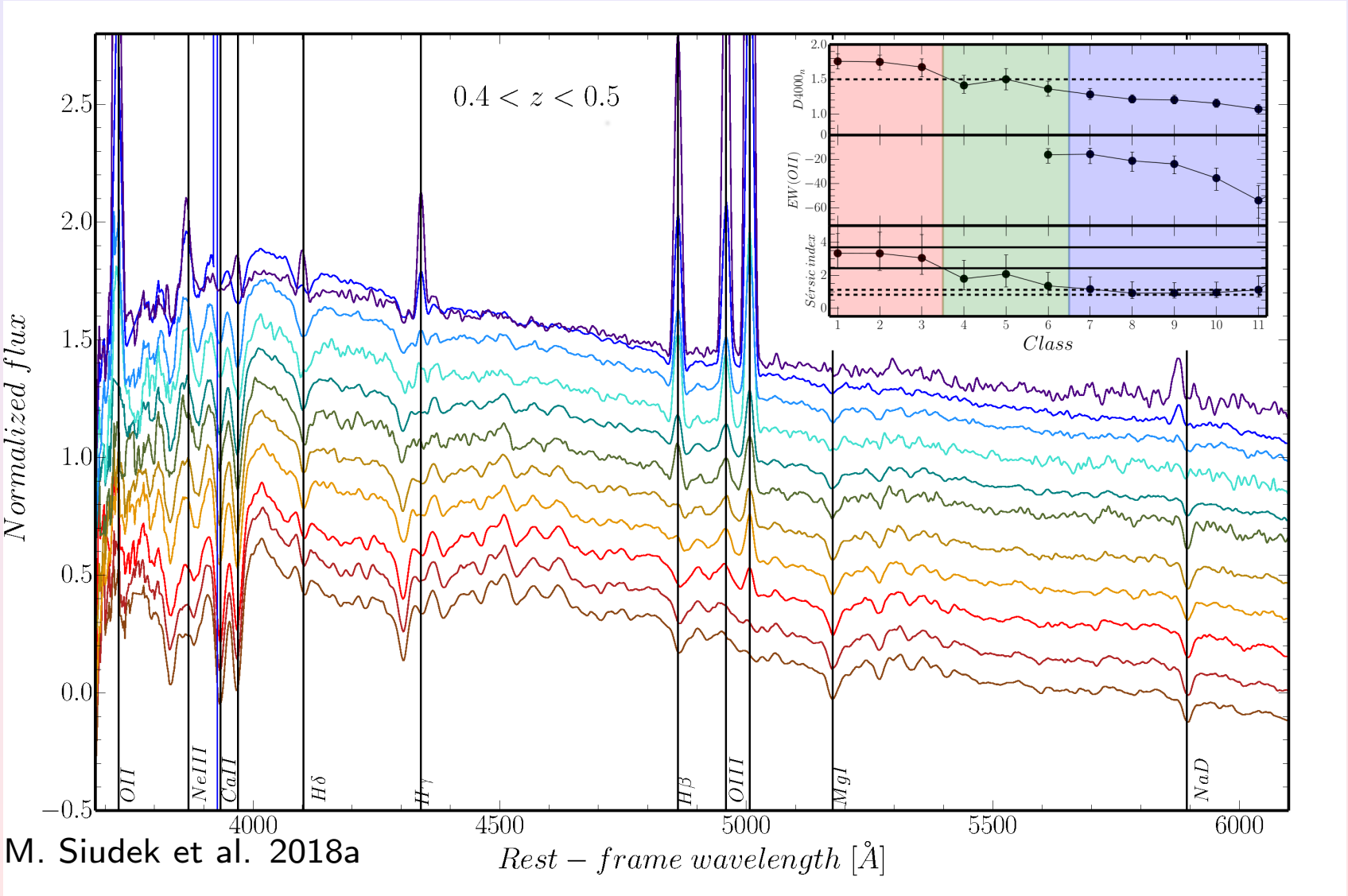


11 subclasses are well separated in a multidimensional space.



M. Siudek et al. 2018a

From blue to red



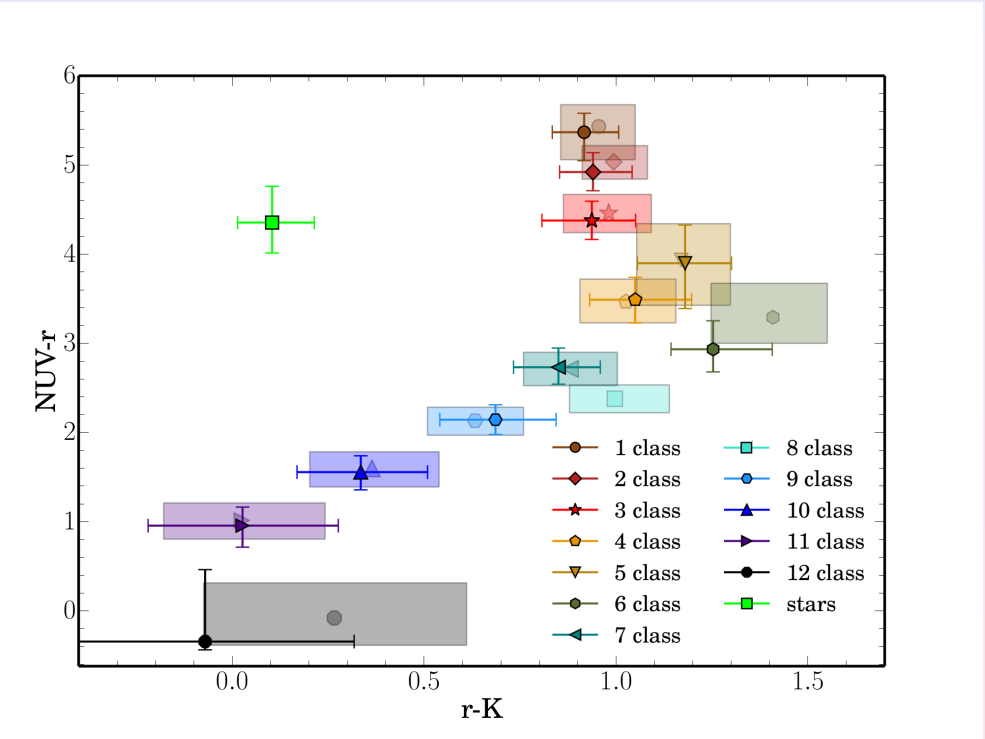
M. Siudek et al. 2018a

The synergy between photometric and spectroscopic classification at $z \sim 0.7$

- **Unsupervised classification of VIPERS galaxies using a 13-dimensional space:**

  12 absolute magnitudes and **photometric** redshift.

- **High accuracy ($\sim 90\%$) of reproducing spectroscopic classification.**
- **Efficient separation of stars & broad-line AGNs.**



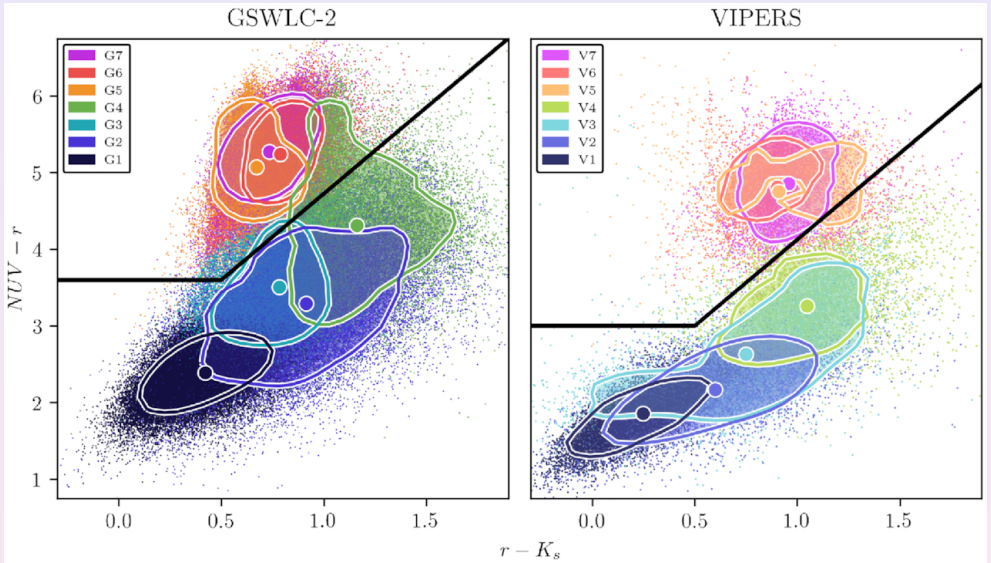
Siudek et al. 2018b

Large photometric samples can be used to distinguish different galaxy classes at $z > 0.5$ with an accuracy not much worse than spectroscopic data. However, test and calibration on spectroscopic sample are necesarry.

Synergy between low- and intermediate-redshift galaxy populations

- **Unsupervised classification of VIPERS ($z \sim 1$) and SDSS ($z \sim 0$) galaxies using a 9-dimensional feature space:**

  9 colours representing shape of UV to NIR SEDs.



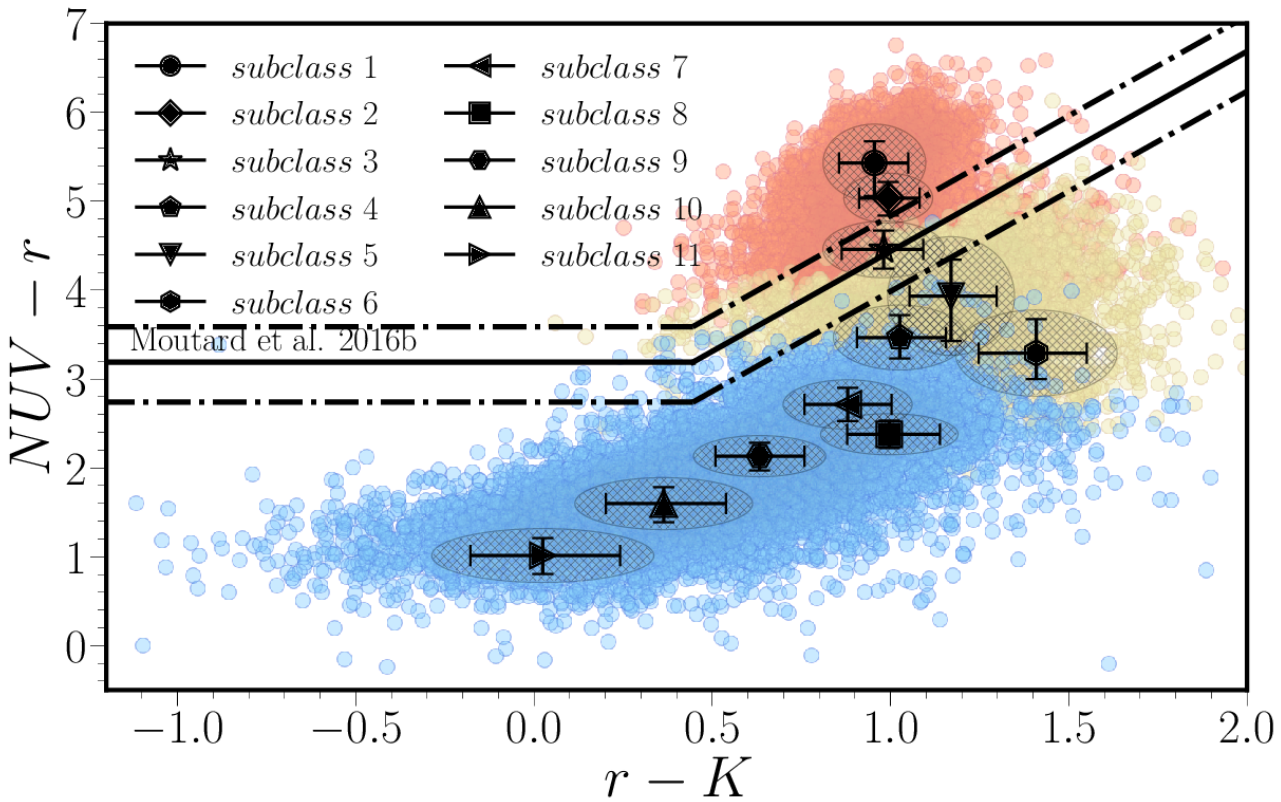
Turner et al. 2021

Galaxy subclasses at $z \sim 0$ and $z \sim 1$ are closely related and differences between them mostly reflect the gradual internally-driven growth of bulges and slow quneching.

Subclasses of red/green/blue galaxies

Does the environment matter?

How the galaxy subclasses are connected to the environment?

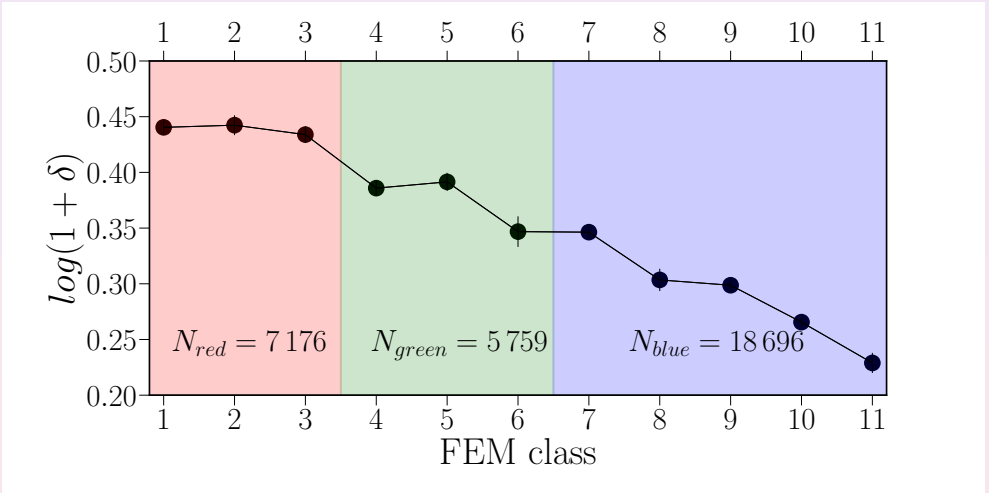


Does the environment matter?

How properties of subclasses of red, green and blue galaxies are altered as they assemble into a denser region?

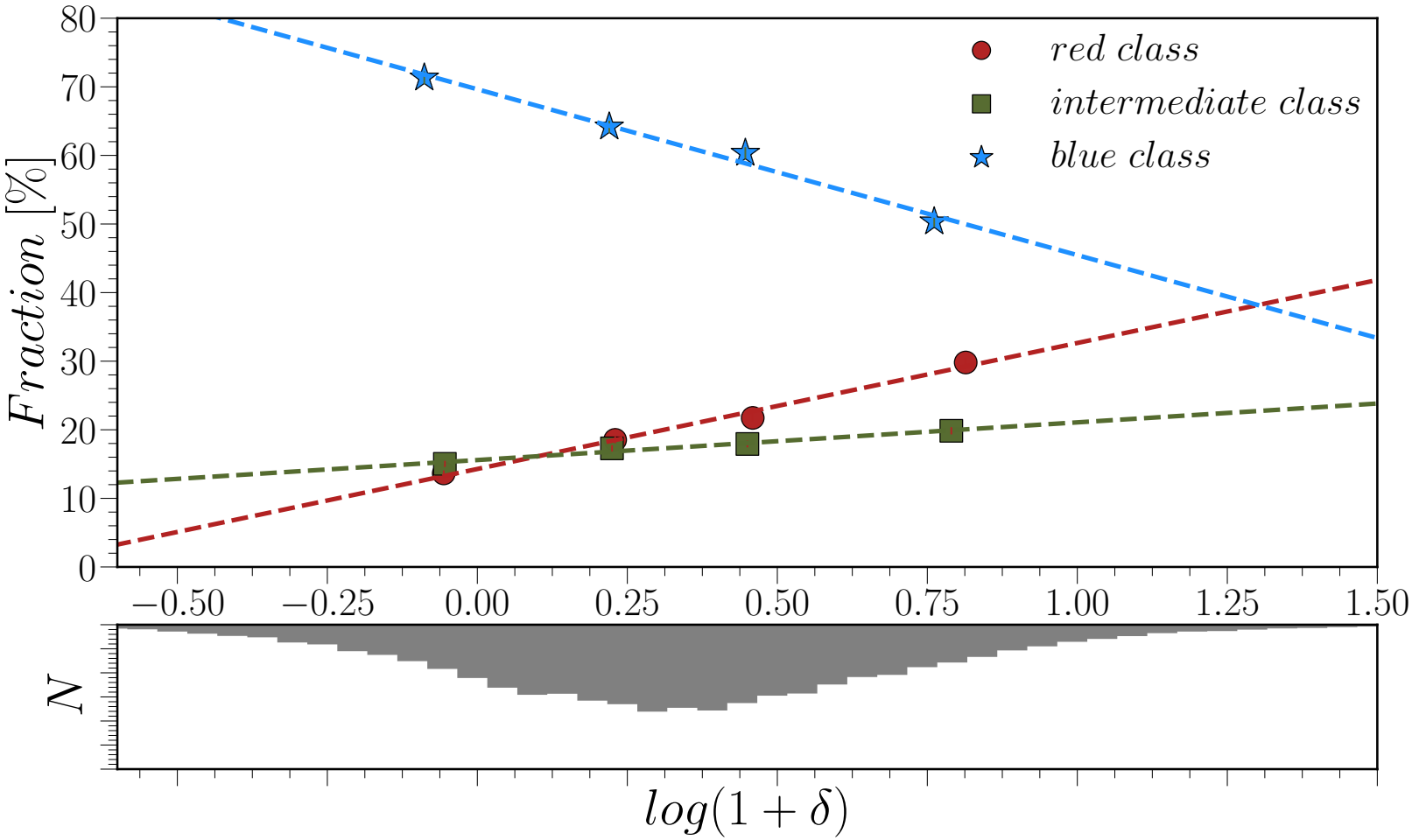
The environment is characterised by the local density contrast, δ:

- Volume-limited tracers $M_B < 20.4 - z$,
- δ is filtered with cylinders ($\pm 1000 km/s$) and the radius $-> 5^{th}$ NN,
- scales between 2 and 6 Mpc/h.

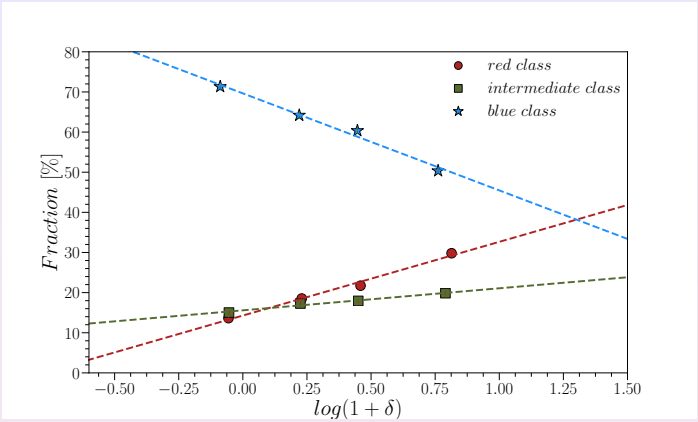


Cucciati et al. 2017
Siudek, et al., in prep.

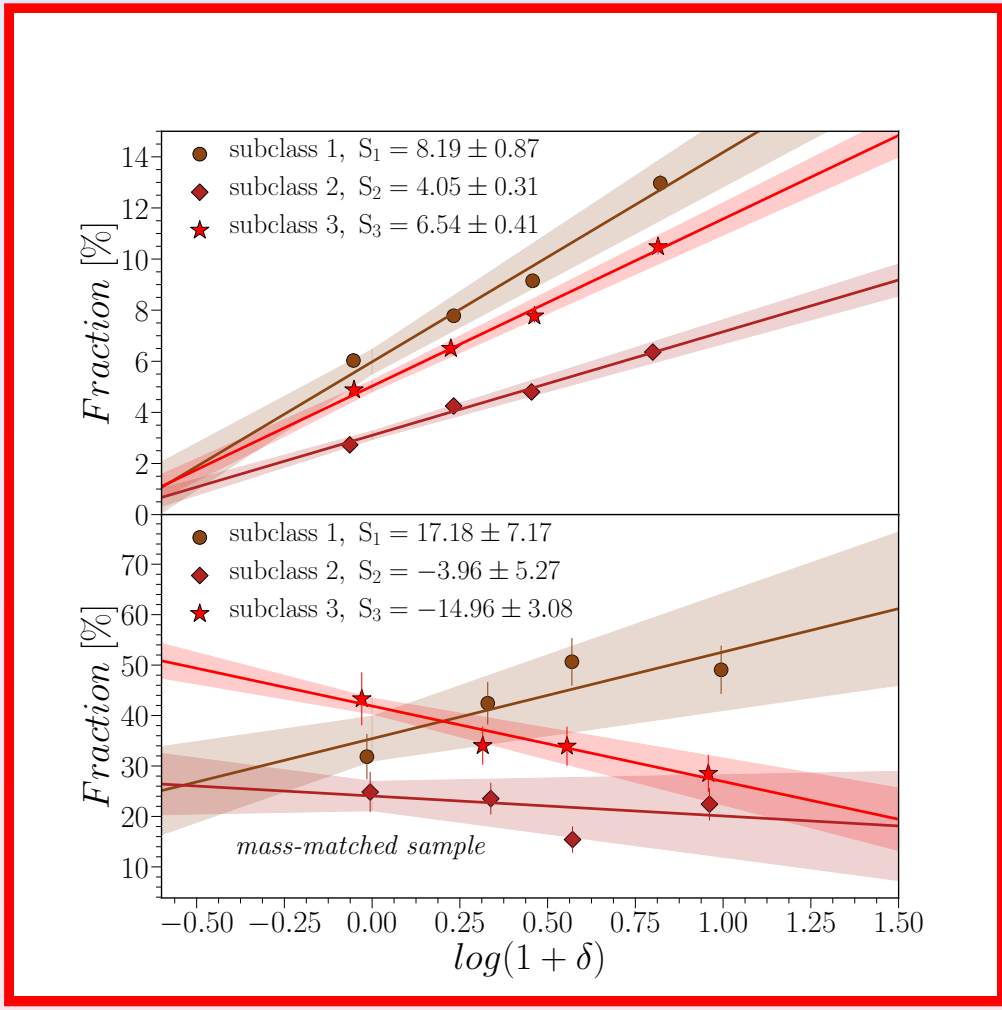
Fraction-density relation



Red galaxies: 3 different subclasses



While, in general, a fraction of red galaxies increases with density, for mass-matched sample **only subclass 1 follows this trend, the other two show the opposite trend!**

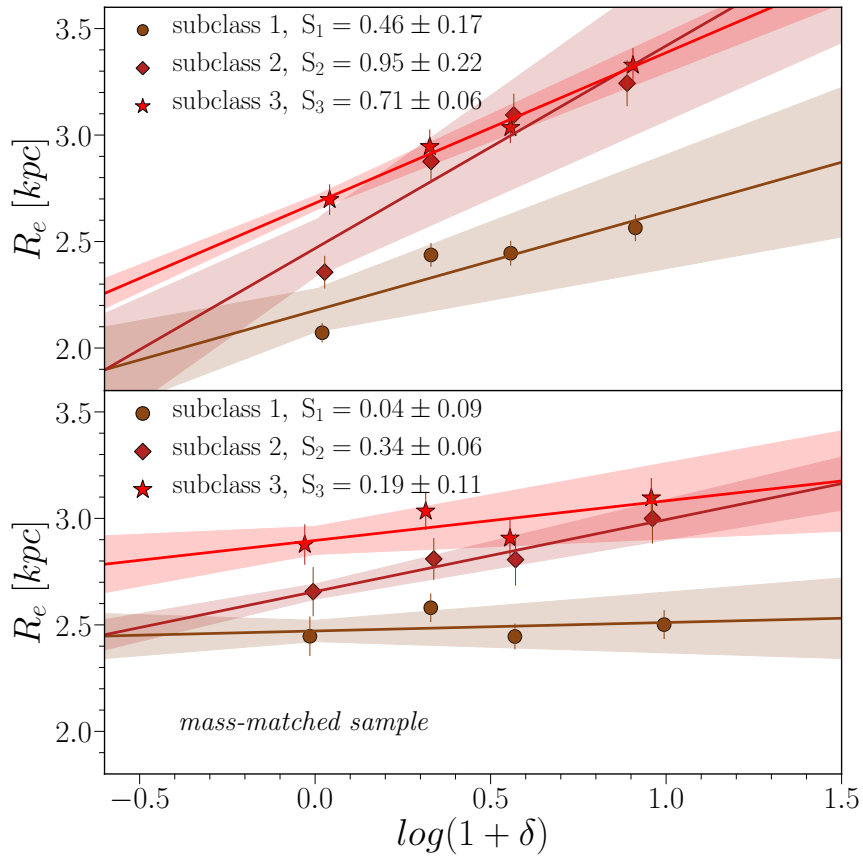


mass-matched: a way to separate mass- and environment- driven effects.

Red galaxies: 3 different subclasses

Three red subclasses also differ in their sizes:

Subclass 1 gathers the smallest galaxies and their sizes are independent on environment, while the other two subclasses gather larger galaxies.



mass-matched: a way to separate mass- and environment- driven effects.

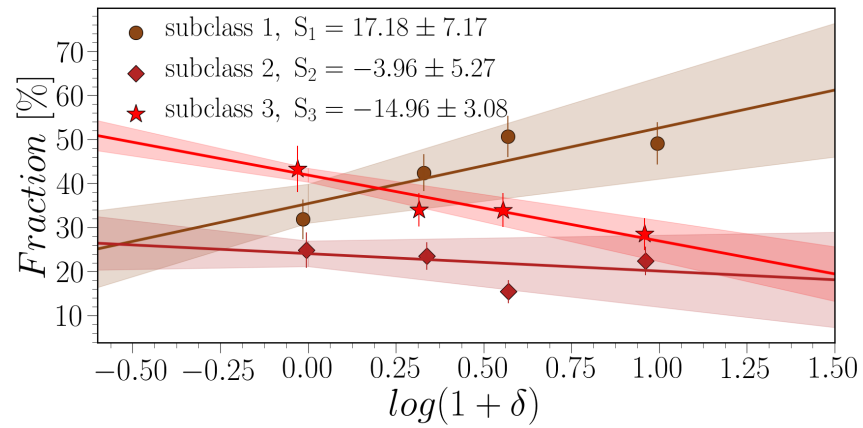
Red galaxies: 3 different subclasses

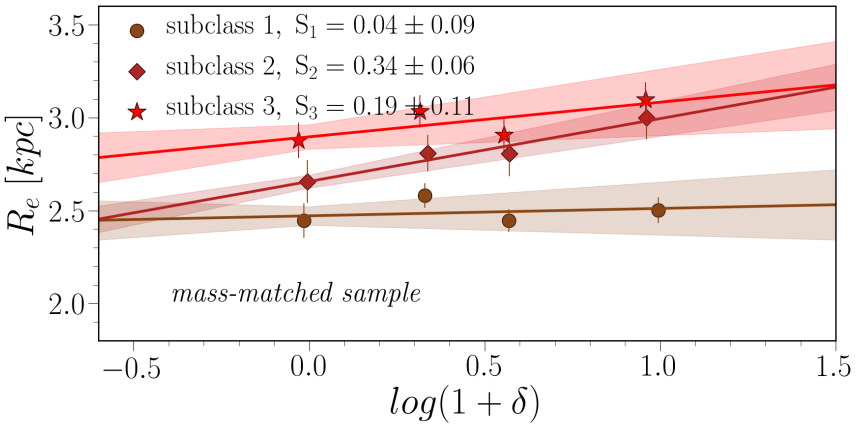
Red subclass 1:

Compact galaxies dominate in the highest-density environments. Mass-matched samples: their evolution is mainly mass-driven.

Red subclasses 2 & 3:

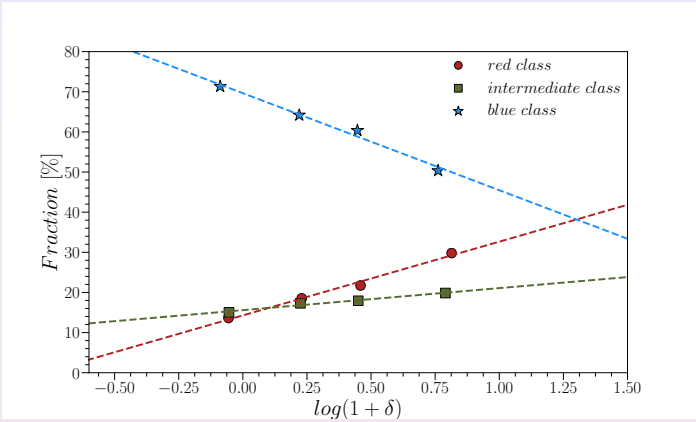
More abundant at lower densities, larger at the same stellar mass. Mixture of mass-driven and environment-driven evolution.

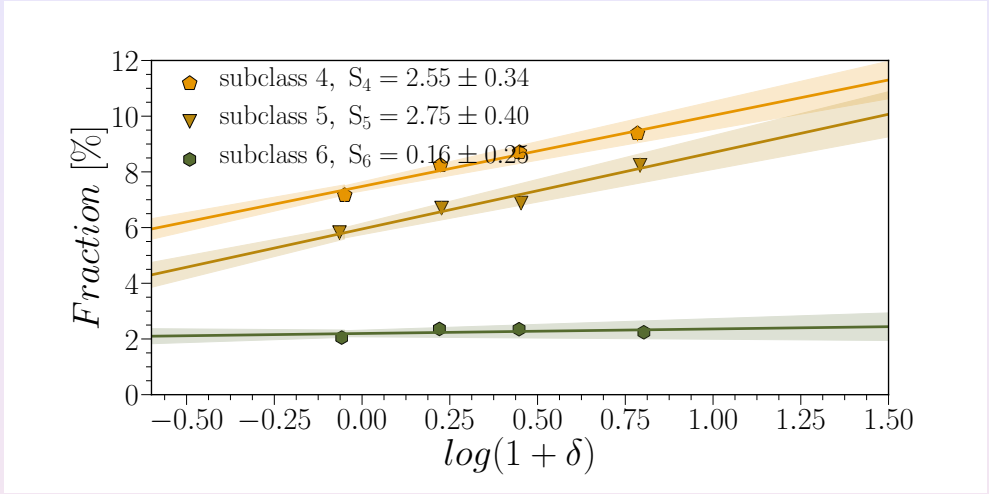




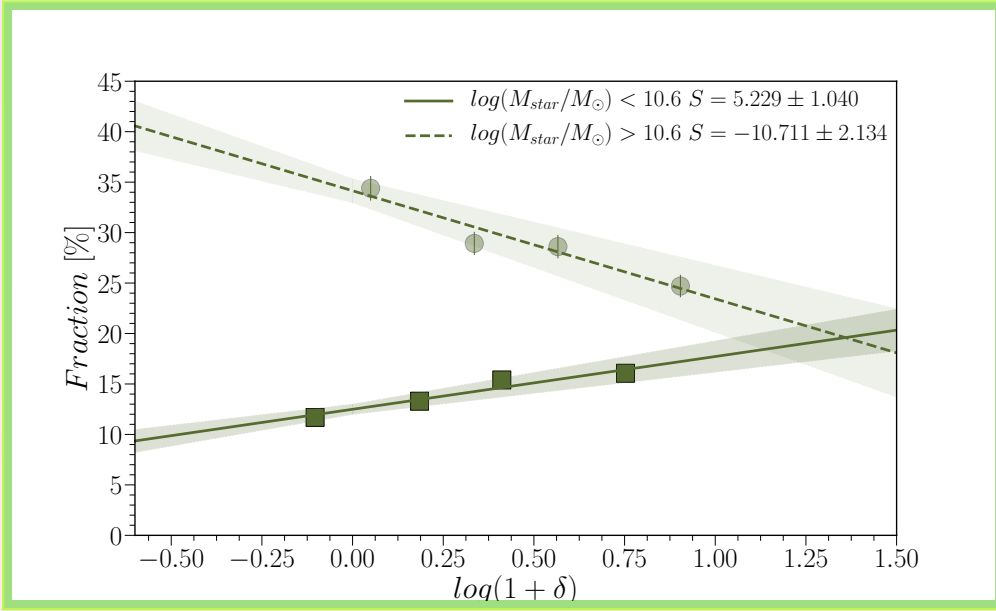
mass-matched: a way to separate mass- and environment- driven effects.

Green galaxies: 3 different subclasses

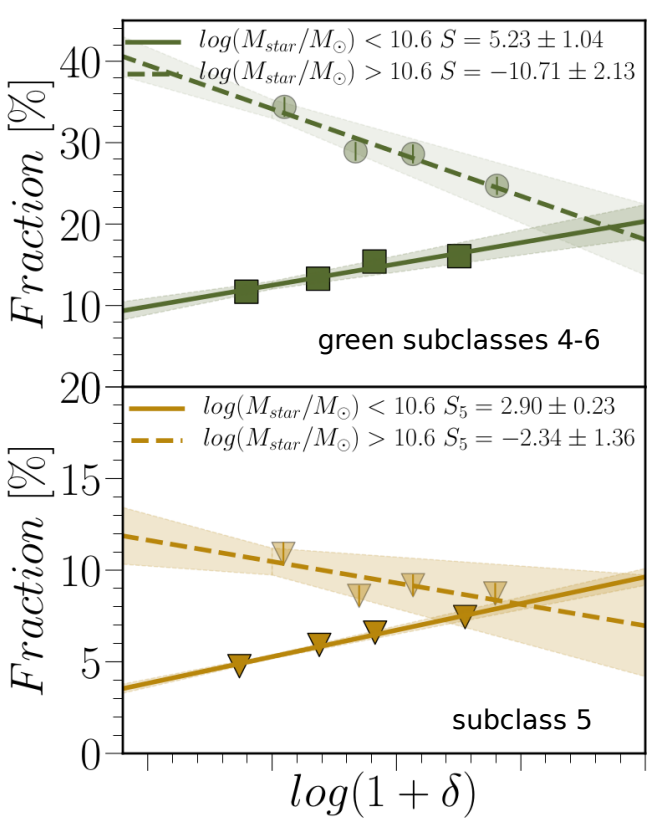


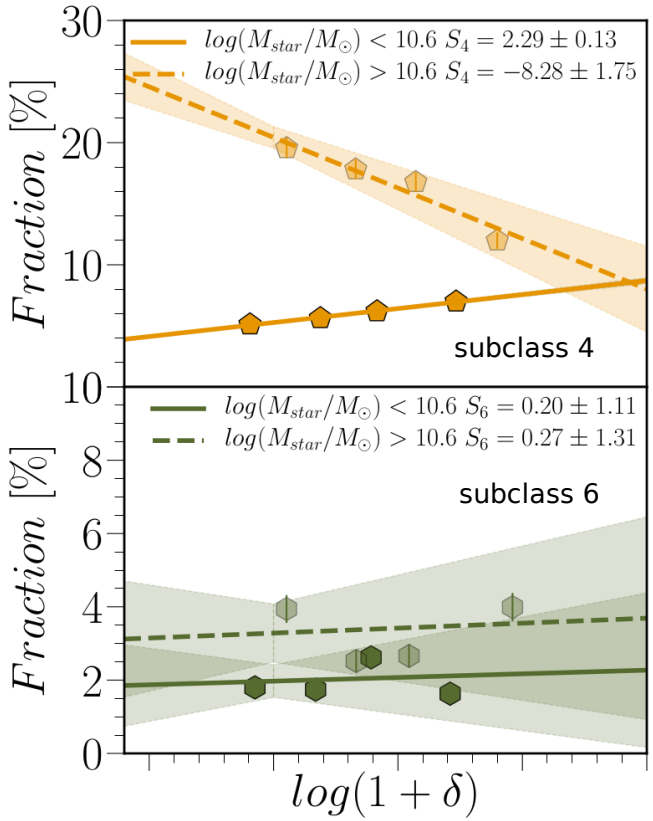


The environmental dependence of green galaxies shows strong dependence on transmition mass.



Green galaxies: 3 different subclasses

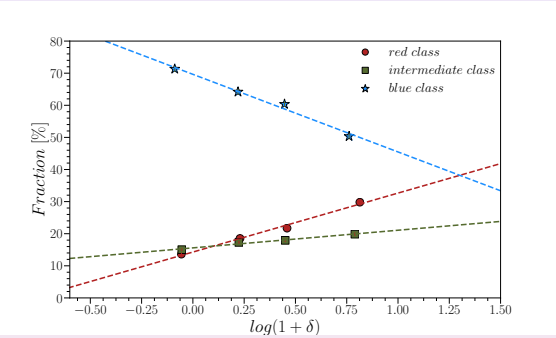


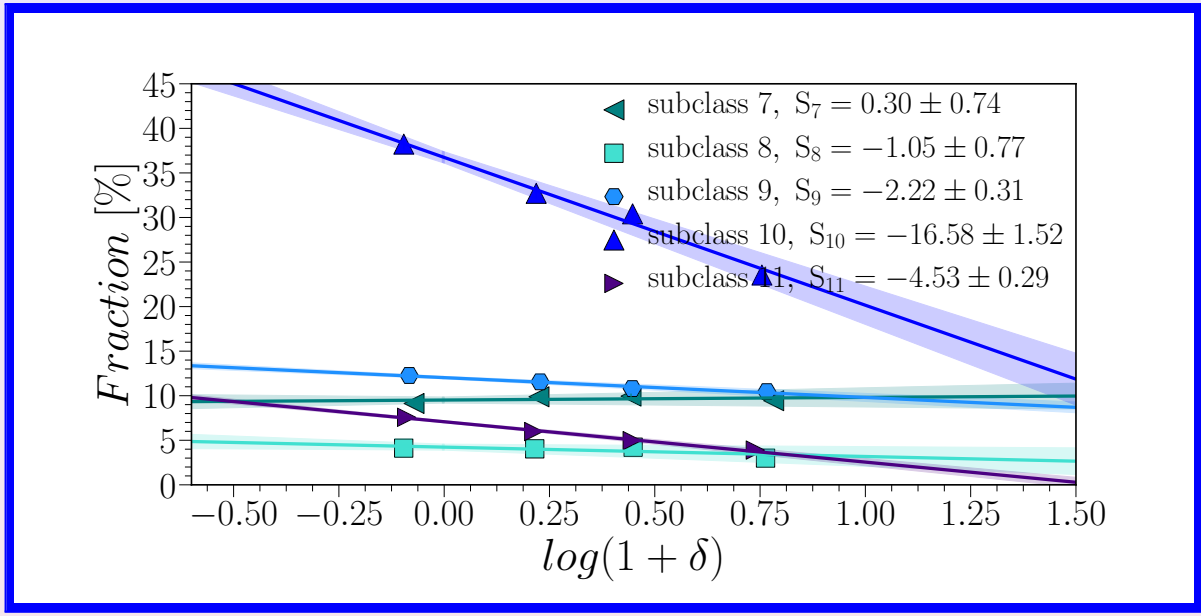


Environment played a stronger role for low-mass galaxies:

Fraction of low-mass galaxies increases with density, while the fraction of high-mass galaxies show the opposite trend.

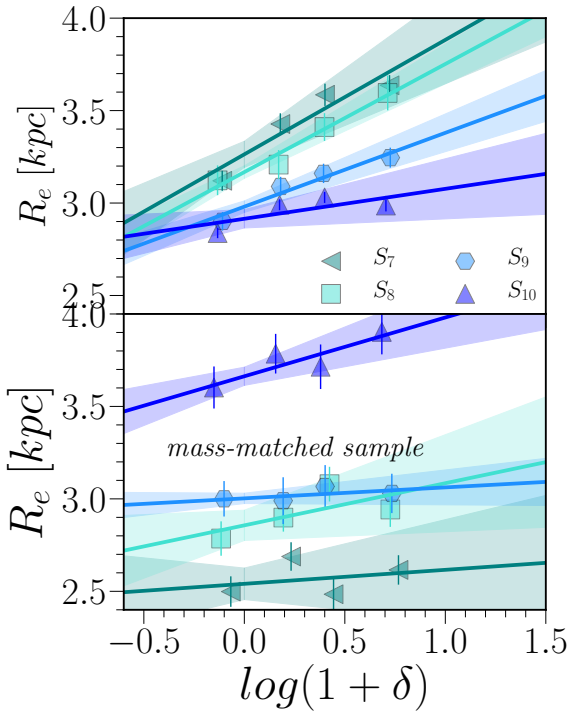
Blue galaxies: 5 different subclasses

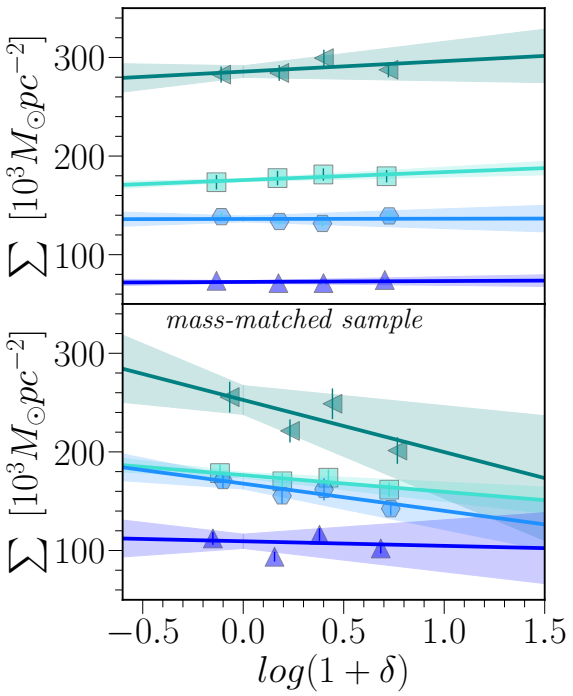




The trend of the fraction-density relation of blue galaxies is driven mostly by only one subclass.

Blue galaxies: 5 different subclasses





Downsizing driven mainly by one subclass:

of the smallest and least-masive galaxies, which seem to follow path of slow accretion of surrounding gas. The other blue subclasses may be a subject of a mixture of mass- & environment-driven evolution.

Summary

- Multi-dimensional classification of VIPERS galaxies:
  32k galaxies at $0.5 < z < 0.9$ separated into 11 classes.
- Fraction-density relation already at place at $z \sim 0.9$.

The more detailed classification allows us to have deeper in-sight into the influence of the environment on the properties of different populations of galaxies.

- Red compact galaxies are preferentially found in denser environments. Red large galaxies show a negative trend of fraction-density relation.
- Strong dependence of green galaxies on the transmition mass.
- The downsizing trend for blue galaxies is driven mostly by one blue subclass gathering the smallest and the least massive galaxies.