Tensions and anomalies: how well do we understand subtle dependencies of galaxy clustering on their properties?

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VIPERS team
GAMA team

Corfu, 11.09.2022

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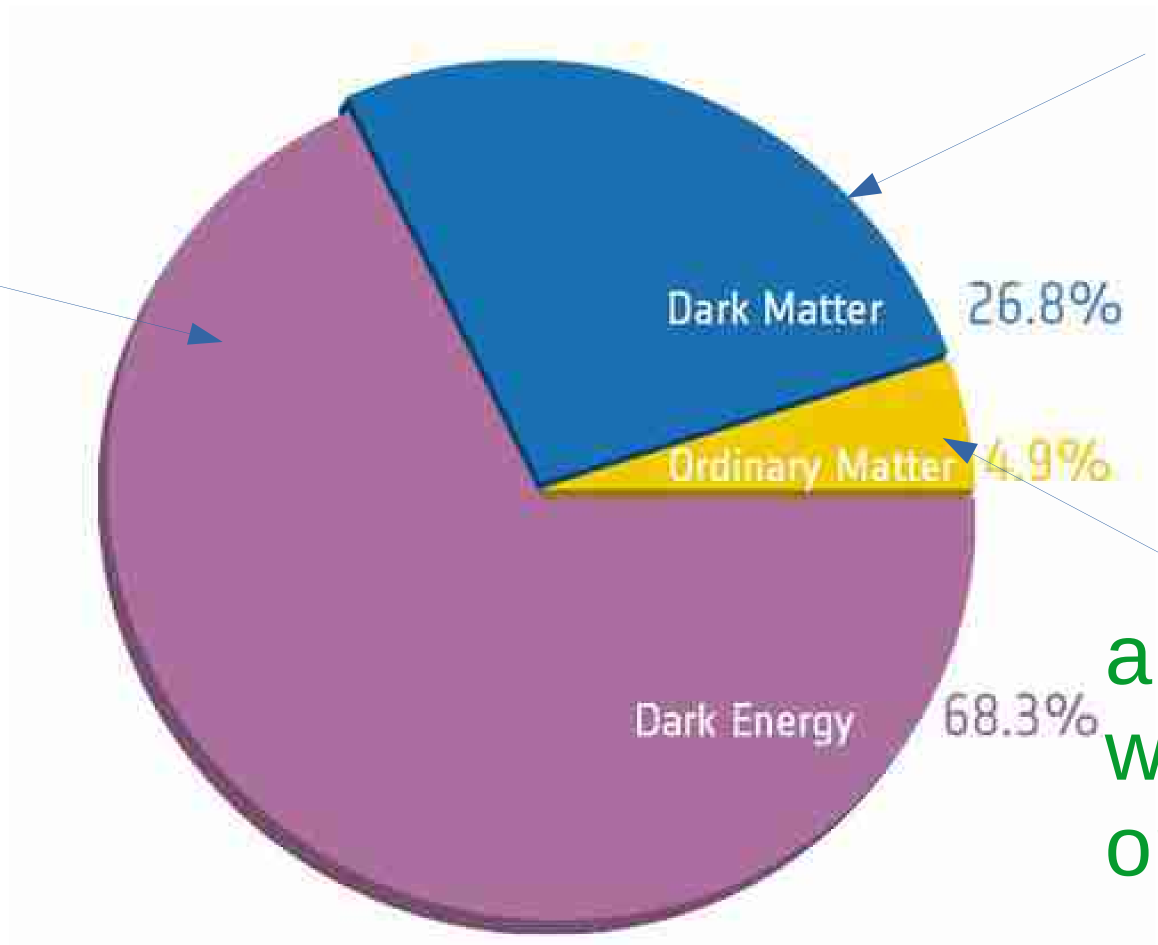


a large part went missing on the way

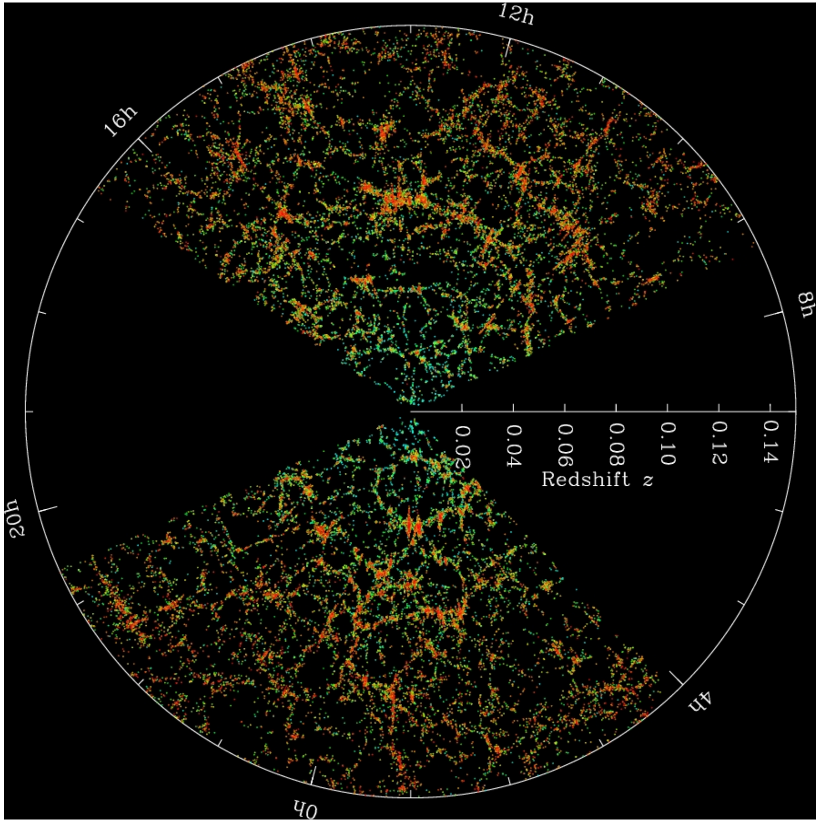
Credit: Planck collaboration

DM (and DE), new physics or whatever is behind

→ baryonic matter is a tracer (moreover, only selected pieces of of baryonic matter)

→ reconstruction as good as our understanding of biases of baryonic tracers

different galaxies – different structure



Credit: SDSS

→ How many different types of galaxies there are and how differently are they tracing LSS?

→What is the imprint on the galaxy clustering measurements (and derived quantities)?

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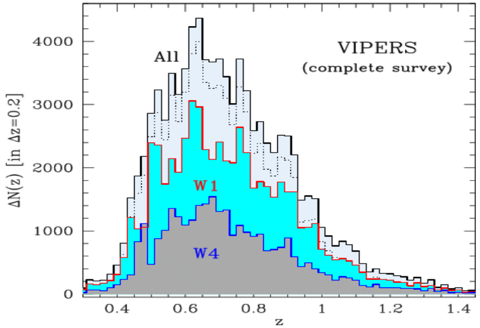
VIMOS PUBLIC EXTRAGALACTIC REDSHIFT SURVEY

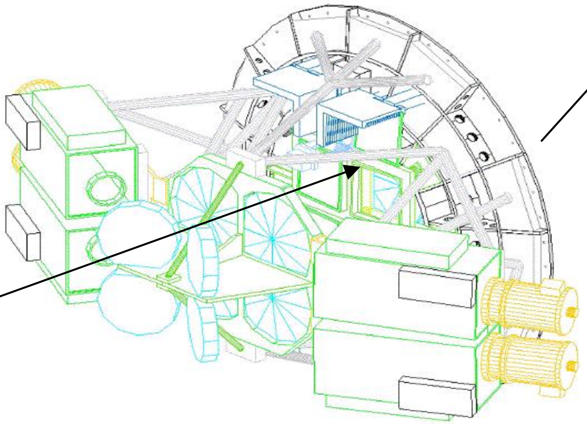
SURVEY STATUS AS OF 06/11/2016

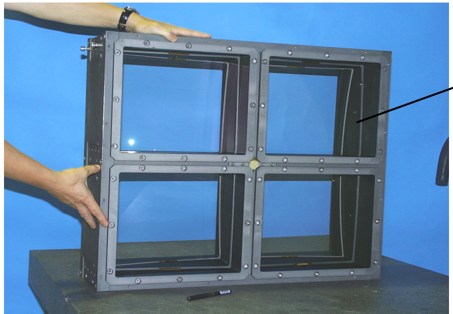
EFFECTIVE TARGETS	MEASURED REDSHIFTS	STELLAR CONTAMINATION	COVERED AREA
93252	88901	2265 (2.5 %)	100.0 %

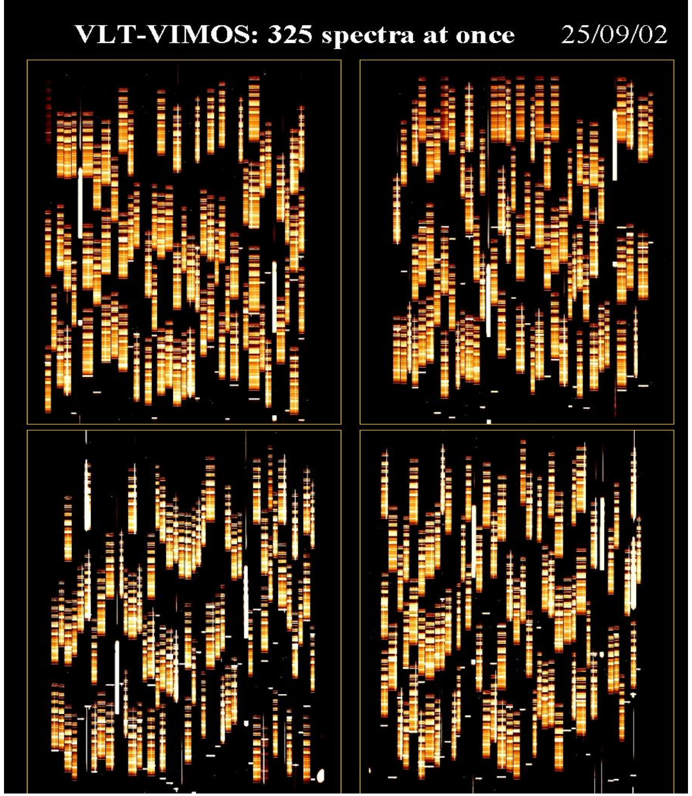
EFFECTIVE TARGETS (ET) are all the primary targeted objects with the exclusion of the ones flagged as -10 (undetected). MEASURED REDSHIFTS (MR) are the fraction of ET for which a redshift has been measured. STELLAR CONTAMINATION are the MR objects which have been identified as stars.



Large ESO Programme, 2008-2016

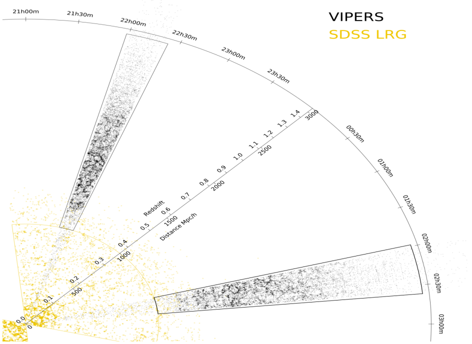






~90 000 spectra of galaxies
at 0.5<z<1.2
2 fields on the sky, 24 deg^2

Guzzo et al. 2014, 2017, Scodeggio et al. 2018 http://vipers.inaf.it/rel-pdr2.html

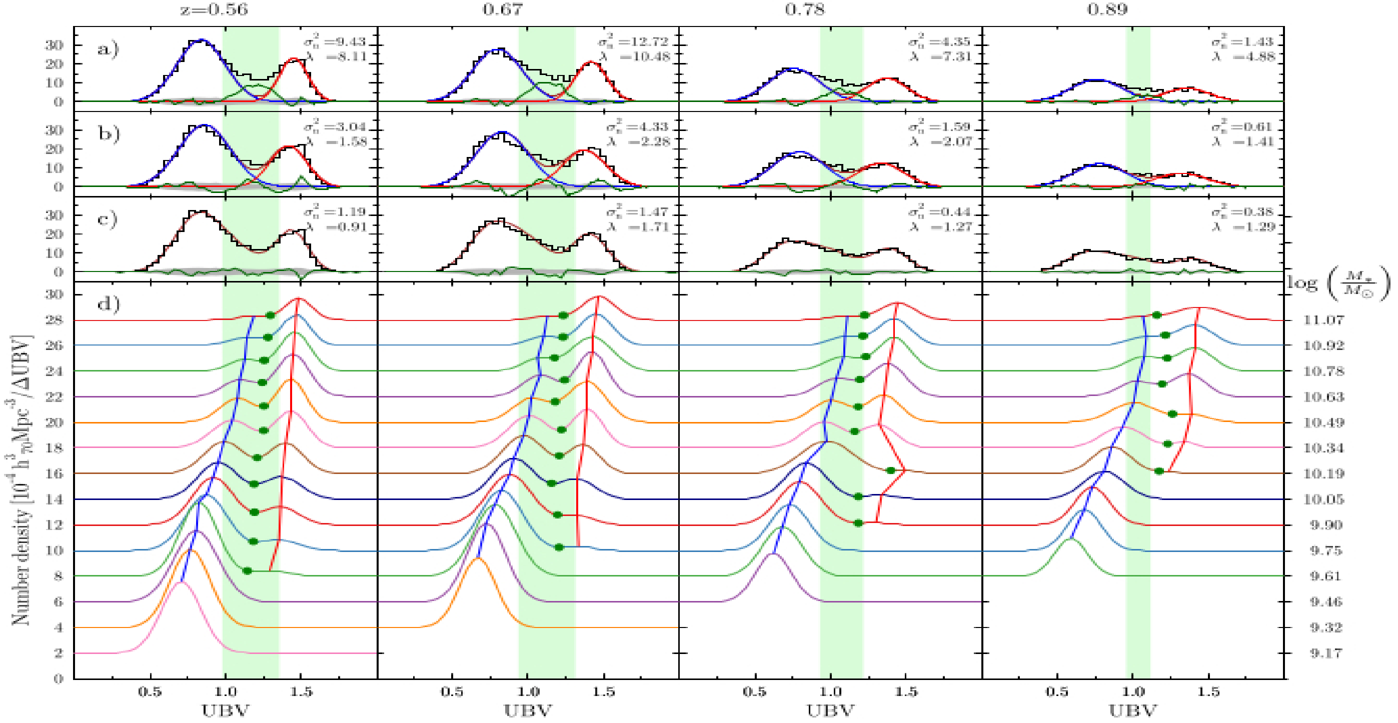


Courtesy Ben Granett

How many galaxy populations are there?

Perfect (moving) bimodality?

- VIPERS: ~90,000 spectroscopically measured galaxies at 0.5<z<1.2 in 2 fields of 24 deg^2
- Galaxy colour (and not only) distribution: slight deviations from bi-Gaussianin large redshift and mass bins in the „green" area between red and blue populations seem to be rather an effect of mass-and-redshift dependence of otherwise perfectly bi-Gaussian distributions.



Krywult et al. in prep.

How many galaxy populations can be blindly selected at z~1?

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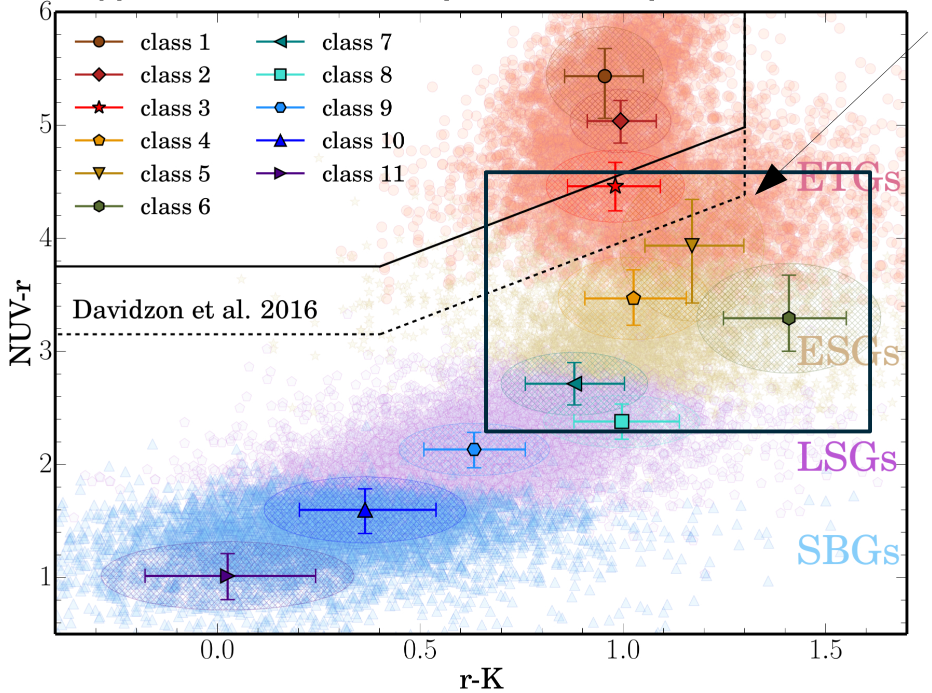
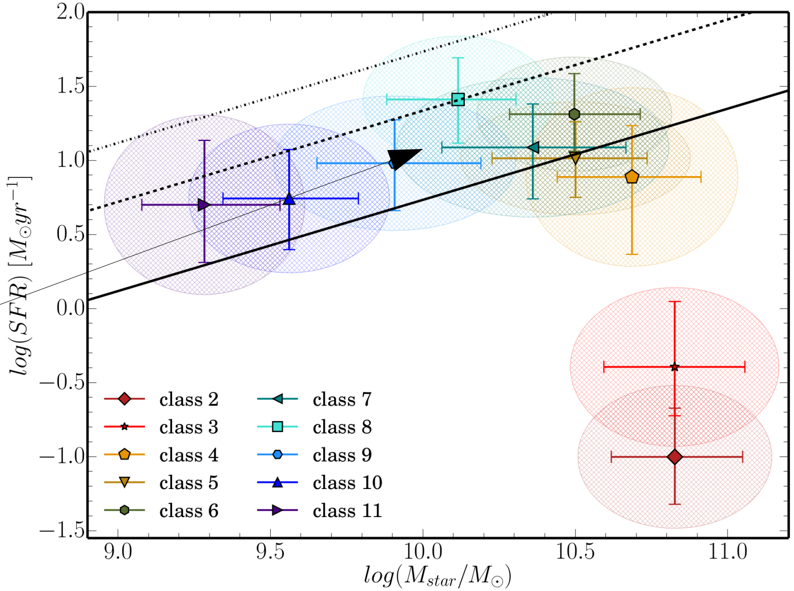
- Method: unsupervised - FEM - Fisher Expectation-Maximization (Bouveyron & Brunet 2011);
- Parameter space: of 12 rest-frame optical magnitudes and a spectroscopic redshift



Dusty galaxies



11 *well separated* classes of galaxies at 0.5<z<1, forming the sequence of: 3, 3, and 5 subclasses of early, intermediate and late types, respectively. Moreover, all these classes but one (dusty intermediate class dominated by NL AGNs) can be well recovered at z~0 in the SDSS.

Siudek et al. 2018, Turner et al. 2021

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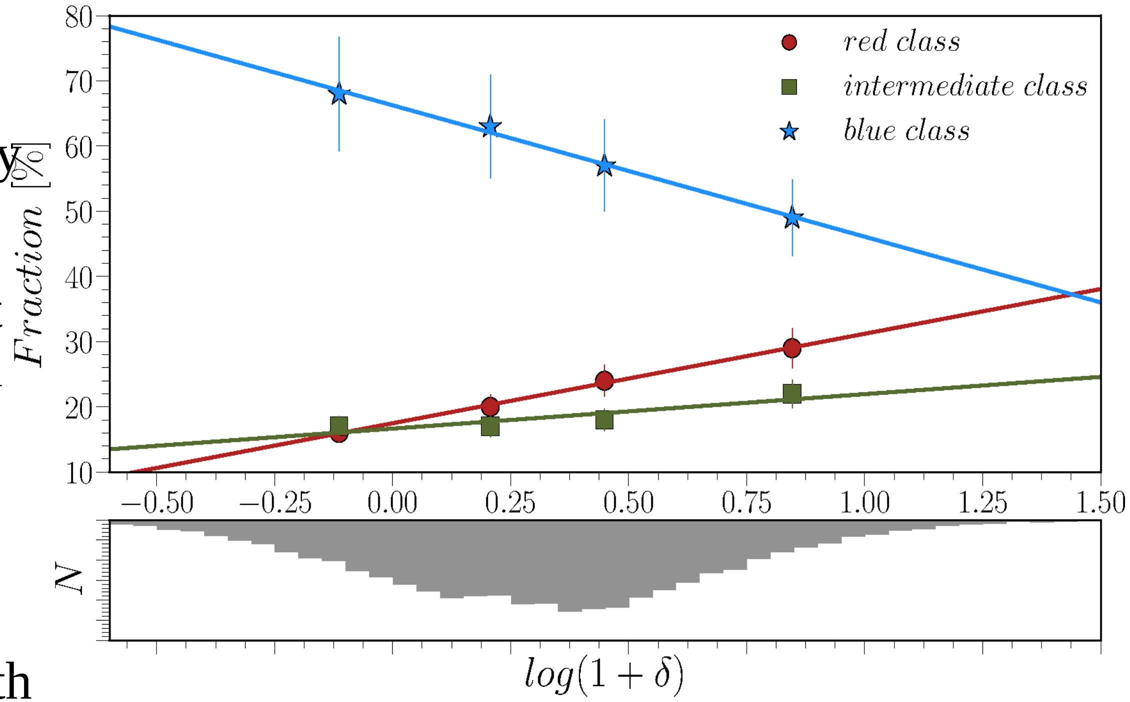
Does this 11 class division reflect actual physical information?

- Traces of different galaxy evolutionary paths seen in multi-color space?
- See what happens when quantities not related to classification are introduced
- Environment: environmental dependence → biases and differences in how galaxies trace LSS
- Global tendency at z~1 consistent with local: red galaxies are most aboundant in the dense environments, blue ones dominate the field → downsizing and mass-driven evolution



Siudek et al. 2022
density field: Cucciati et al. 2014

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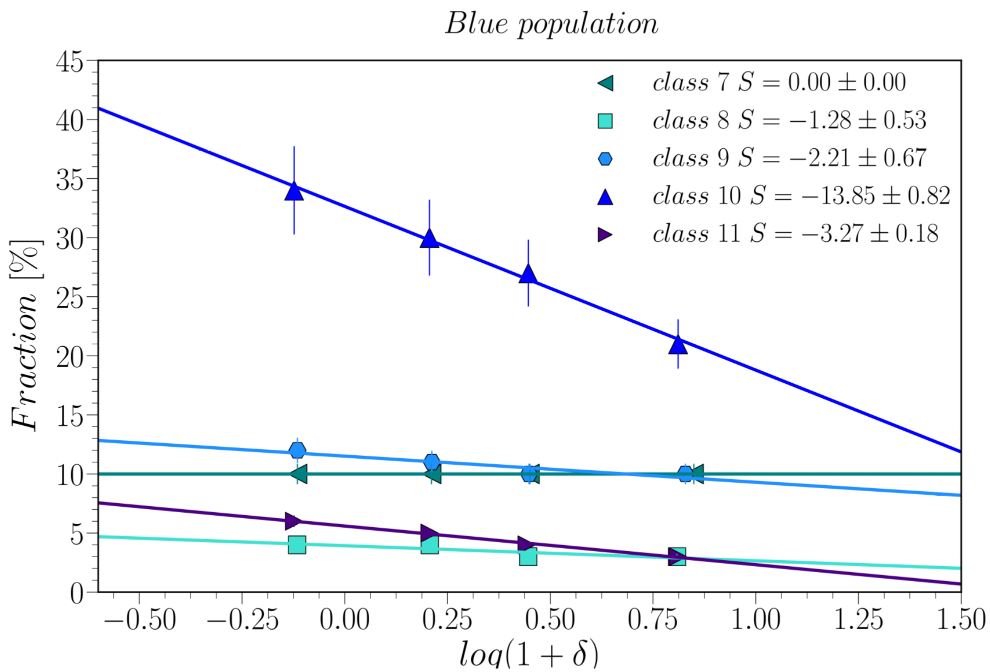
Looking into details: blue



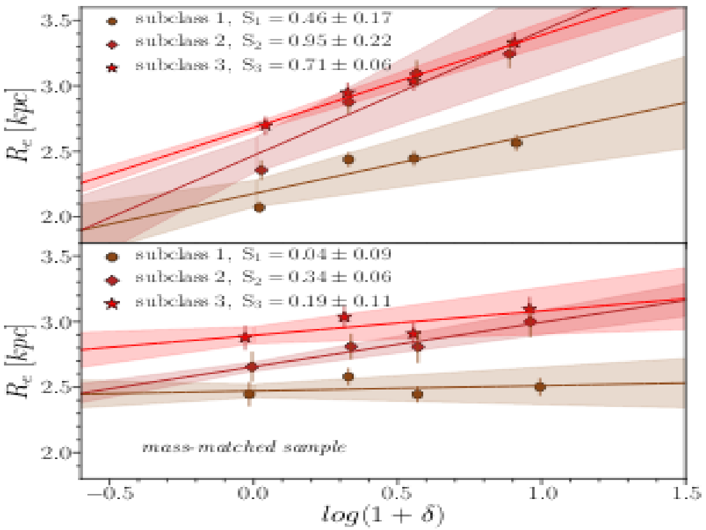
Siudek et al. 2022

→ Blue galaxies at z~1: not all follow the downsizing trend!

→ For blue galaxy populations: the downsizing trend is mostly driven by only one (admittedly, the largest) subpopulation (and in this case it it consistent with mass-driven passive evolution)

→ the fractions of other blue SF galaxies are much less mass/environment-dependent – environmental effects play a role in keeping them blue

Looking into details: red



...the reddest red class:

→ the smallest in size

→ size does not depend on environment (independently on stellar mass): may be a product of early fast quenching (while the other two might have grown also through mergers)

Siudek et al. 2022;
morphology: Krywult et al. 2018

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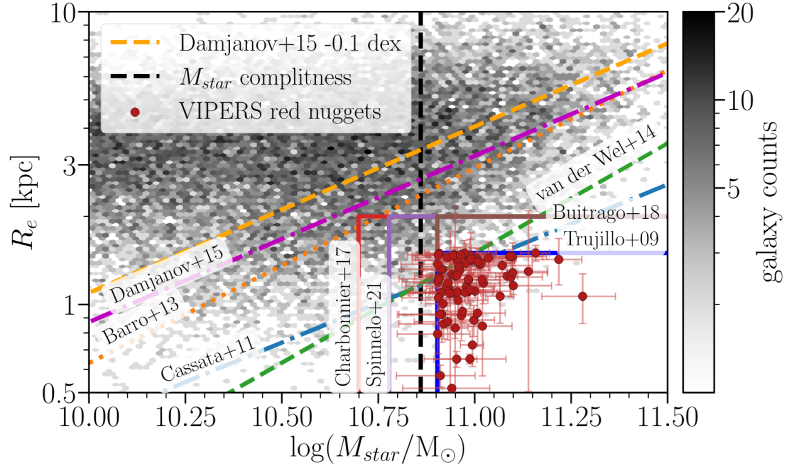
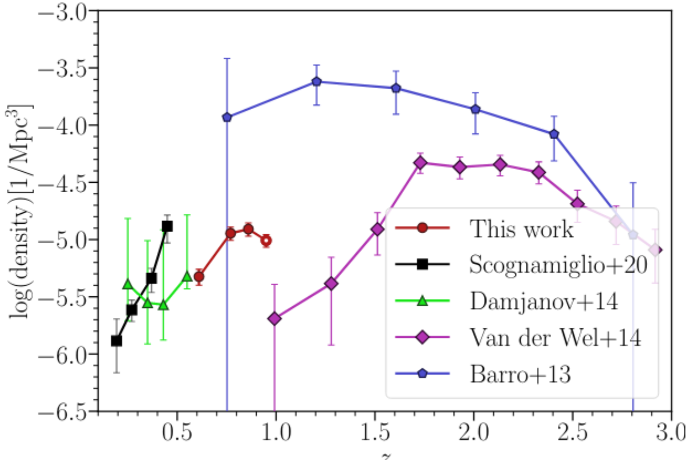
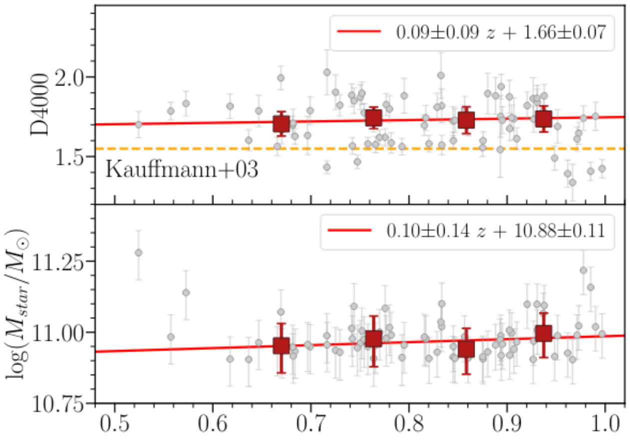


→ mass complete catalog of 77 "red nuggets" at z~0.7

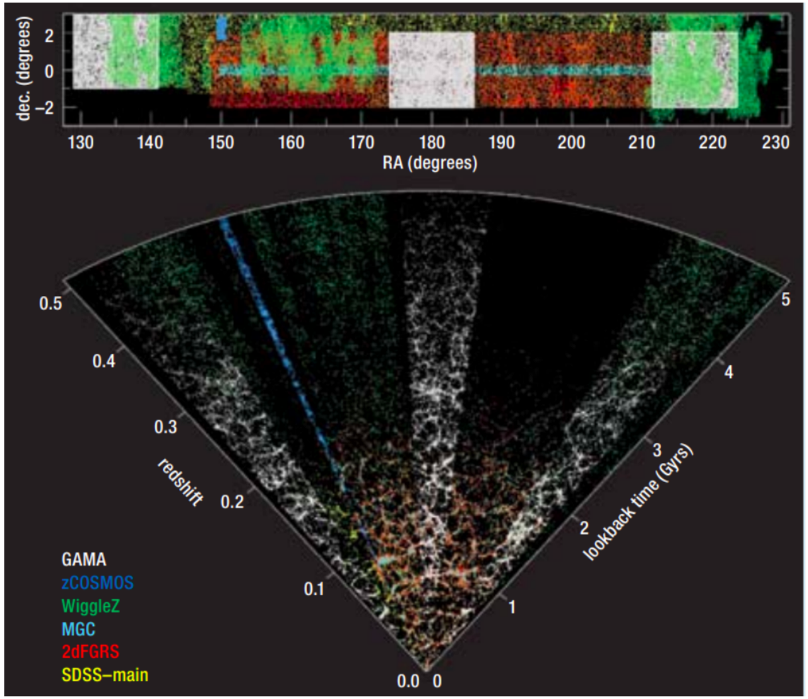
→ filling the gap between high z "red nuggets" and low-z "relics"

→ on the way to new sample of galaxies with well controlled passive evolution histories?





Lisiecki et al. 2022



Driver et al. 2009

Unnikrishnan Sureshkumar

Galaxy and Mass Assembly Survey

→ Galaxy clustering vs galaxy properties

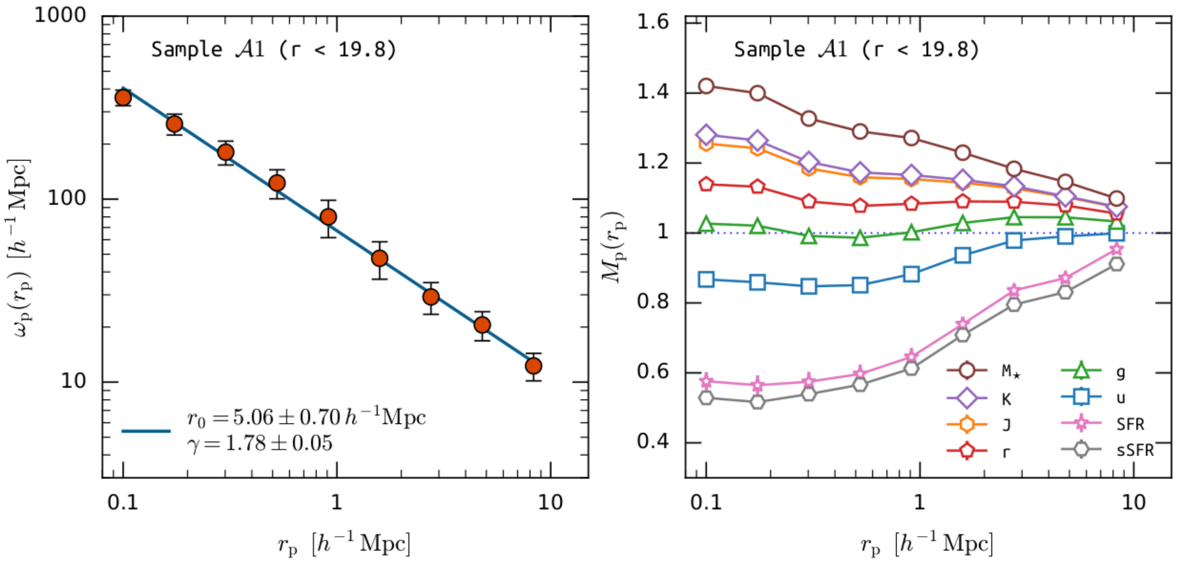
→ Method: marked correlation function (Skibba, Sheth et al. 2006, 2009, 2013)

→ concept: in order to see how a given galaxy property correlates with environment and on which scale, we use this property as a weight ("mark")

→ M = ξ_marked(r)/ξ(r)

→ applied at $0.1<z<0.16$, volume limited sample(s)

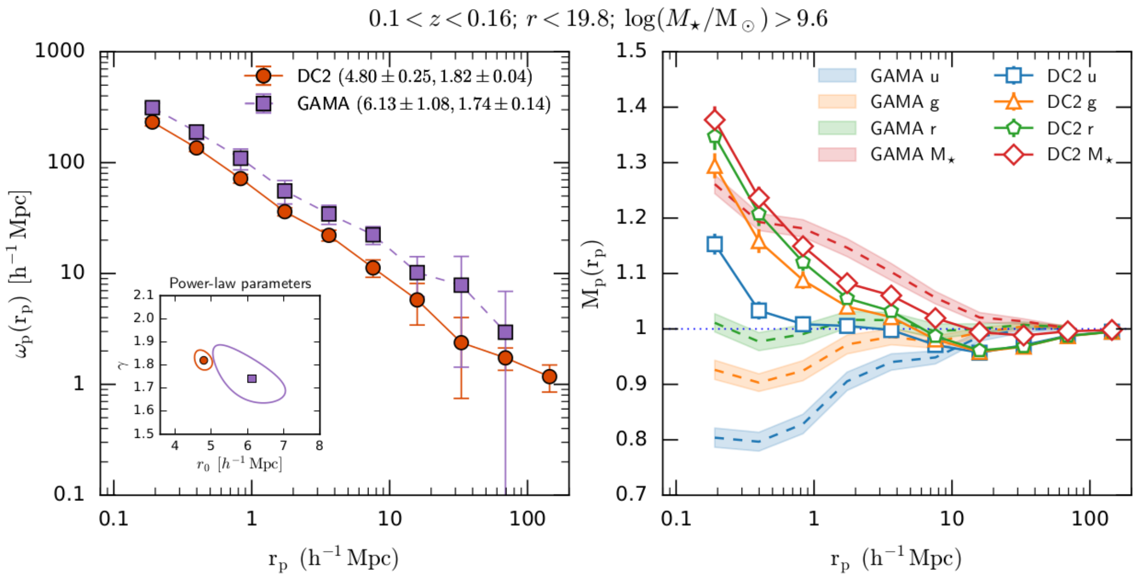
From ξ to mass-SFR-luminosity marked ξ



→ Different properties differently mark LSS at small scales
→ the strongest overdensity traces is the stellar mass, the weakest sSFR, luminosities from red to blue form a hierarchy in between
→ monotonously steepening galaxy spectral slope when moving to small scales (dense environments)

Sureshkumar et al. 2021

Not reproducible by simulations (yet)



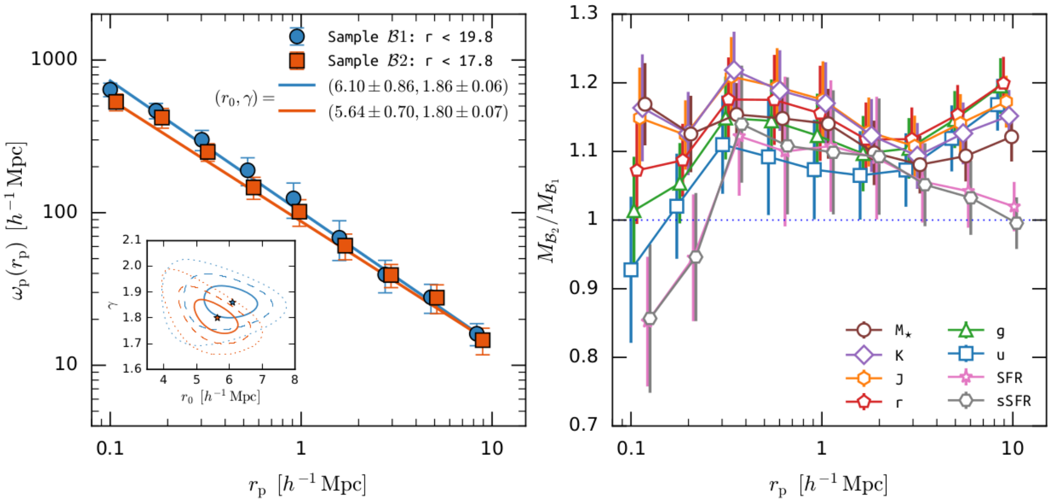
Sureshkumar et al. in prep.

→ Comparison with "mock GAMA" built from DC2 (DESC LSST's official simulations, galaxy modeled by UniverseMachine, Behroozi et al. 2019)

→ similar hierarchy but environmental dependencies not quite the same (galaxies much less diverse than in the real data and no negative trend with a blue band u)

→ need to be careful interpreting small scale clustering with the aid of simulations

Mass is not light, light is not mass: effect of flux limit on mass selected sample for ξ and M



→ (unavoidable) flux limit affects completeness of volume limited catalogs

→ between GAMA and SDSS flux limit:

- marginal effect on ξ(r) itself

→ but: enhanced dependencies of MCF on galaxy properties – brighter galaxies at the same mass mark the small scale structure more strongly

Sureshkumar et al. 2021

Summary

- Different evolutionary paths of different galaxies depend (also) on their environments → superficially similar galaxies may have quite different histories, and quite different relations with environment
- ...which implies they trace the LSS differently
- small scale dependence of clustering on galaxy properties on environment – monotonic change of average galaxy properties with scale instead of bi/multi-modality
- ...(not surprisingly) not reproduced by simulations
- flux incompleteness affects mass completeness – which is visible in the MCF