VIPERS: The VIMOS Public Extragalactic Redshift Survey

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Introduction

After nearly a decade of work, the VIMOS Public Extragalactic Redshift Survey (VIPERS), an ESO Large Programme, is now complete (Guzzo et al. 2014). The final public data release contains nearly 90,000 galaxy redshifts in the range $0.5 < z < 1.2$ collected in less than 55 nights at the VLT. The combination of large volume and detailed sampling, unprecedented at these redshifts, have allowed us to map and measure the growth rate of the large scale structure of the Universe, and to observe the detailed evolution of galaxy properties over the past 8 Gyrs.

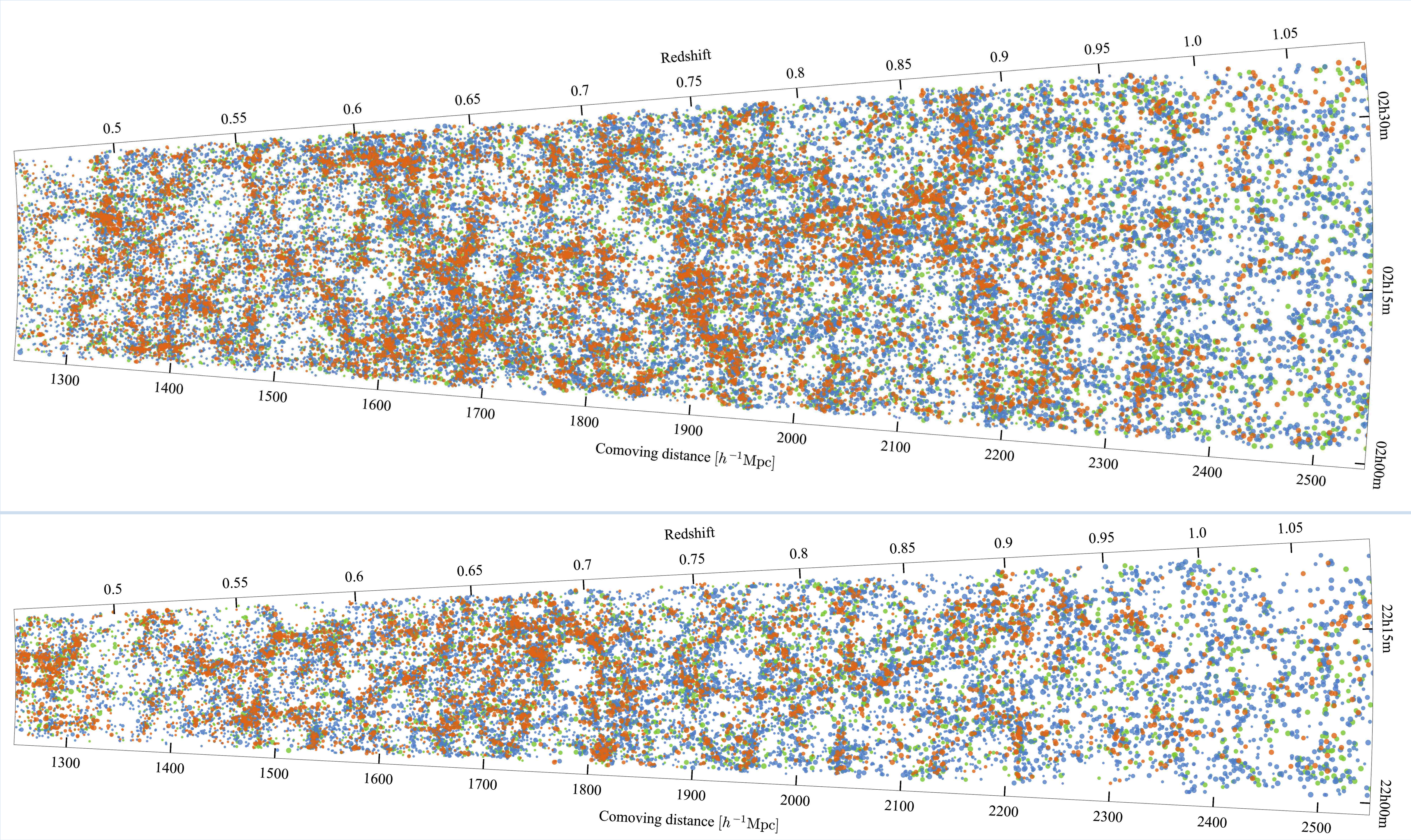

Fig 1. The large scale structure of the Universe as seen by VIPERS, in its two fields: W1 and W4. The size of each dot is proportional to the galaxy B-band luminosity. Colours reflect the intrinsic U-B colour of each galaxy (from Scodeggio et al. 2016).

Growth rate of structure

Galaxy redshifts contain contributions from the peculiar velocities of galaxies moving under the influence of gravity. Identifying these redshift space distortions (RSD) allows us to measure the growth rate of cosmic structure and in doing so constrain deviations from General Relativity. The richness of information and broad selection function of VIPERS has allowed us to apply a number of different estimation techniques and to make measurements at different redshifts.

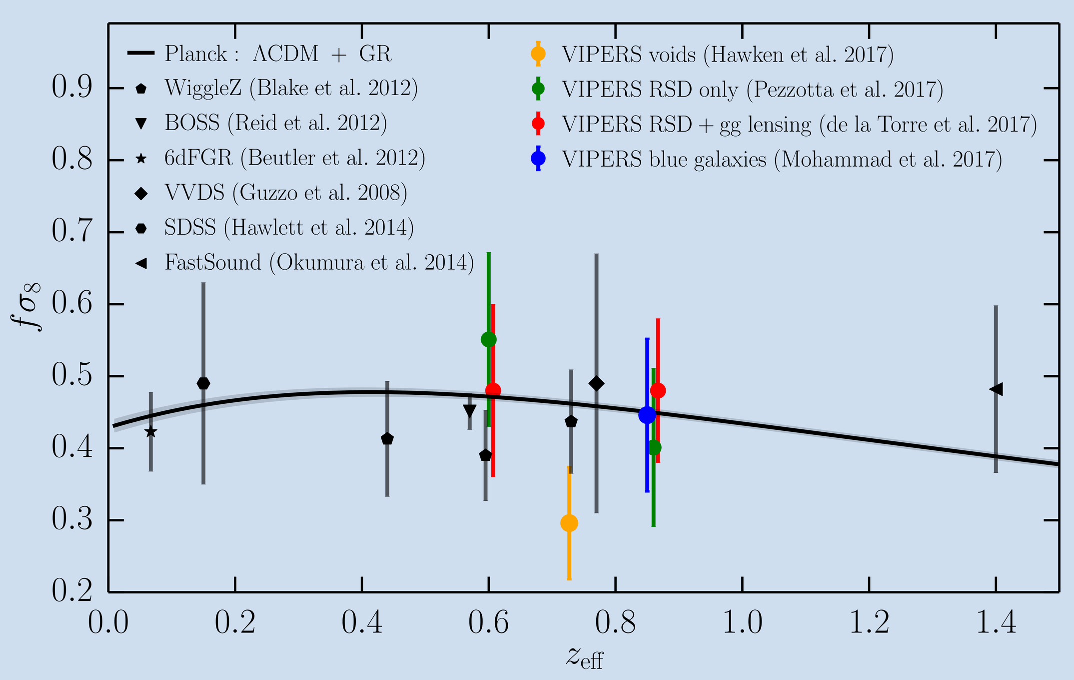

Fig 2. The currently released VIPERS measurements of the growth rate of structure at different redshifts, obtained with complementary techniques from redshift space distortions in the final data. These include modelling of non-linear RSD (Pezzotta et al. 2017, green), combination with galaxy-galaxy lensing (de la Torre et al. 2017, red), selecting only blue galaxies (Mohammad et al. 2017, blue) and a completely independent estimate using galaxy outflows from cosmic voids (Hawken et al. 2017, yellow).

Cosmic Voids

The dense sampling of VIPERS makes it excellent for looking for cosmic voids at high redshift (Micheletti et al. 2014 and Hawken et al. 2017). By deprojecting the observed void-galaxy cross-correlation and then modelling its anisotropy caused by galaxies outflowing from voids, we were able to make a complementary measurement of the growth rate of structure in low density environments.

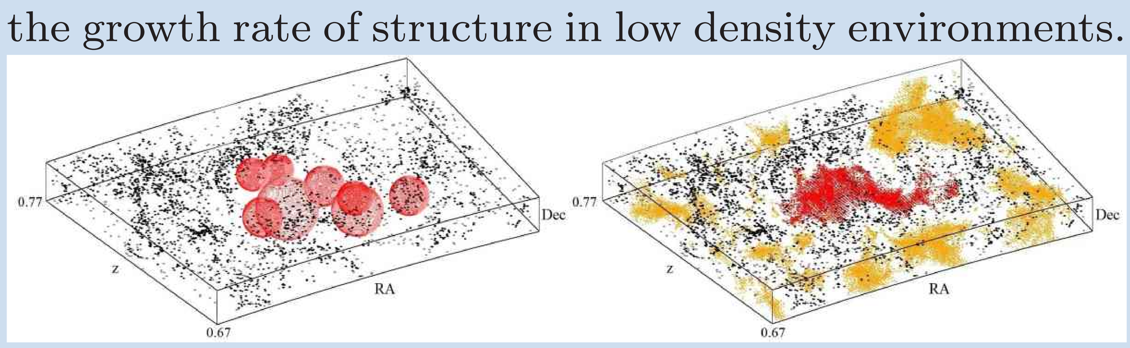

Fig 3. The left-hand panel shows the kind of spherical void regions used in the analysis. The right-hand panel shows, in red, the centres overlapping significant spheres that make up the largest void in the W1 field, other void regions within this area of the survey are shown in orange.

Density Field

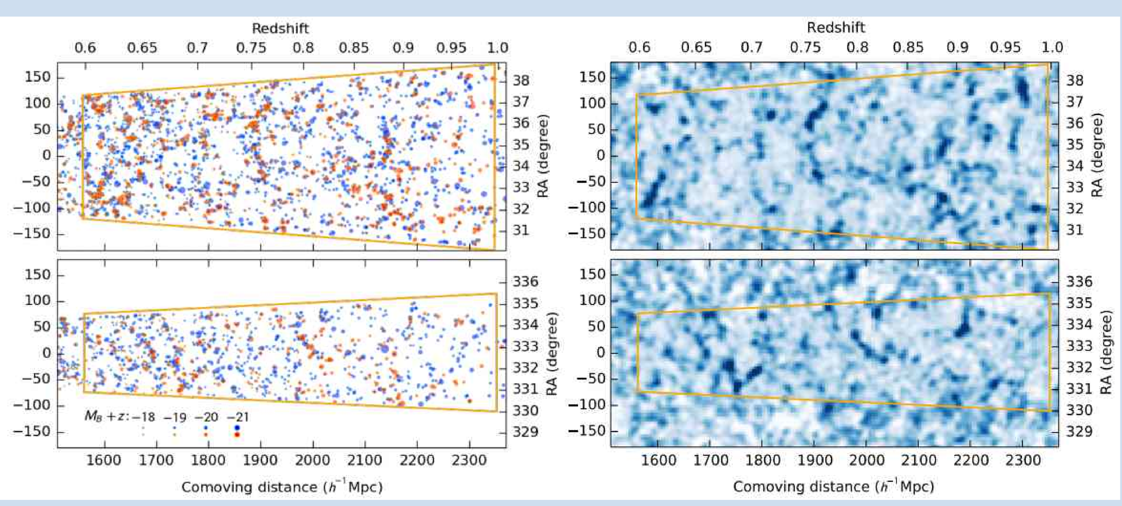

Fig. 4. Weiner filter reconstruction of the density field (Granett et al 2016).

References

A. Gargiulo et al. 2017, A&A, in press, ArXiv:1611.07047; B. Granett et al. 2015, A&A, Vol. 583, P. A61; L. Guzzo et al. 2014, A&A, Vol. 566, P. A108; C. P. Haines et al., A&A, in press, ArXiv:1611.07050; A. J. Hawken et al. 2017, A&A, in press, ArXiv:1611.07046; D. Micheletti et al. 2014, A&A, Vol. 570, P. A106; F. Mohammad et al. 2017, A&A, submitted; A. Pezzotta et al. 2017, A&A, in press, ArXiv:1612.05645; M. Scodeggio et al. 2017, A&A, in press, ArXiv:1611.07048; S. de la Torre et al. 2017, submitted, ArXiv:1612.05647

Galaxy Evolution

Combining VIPERS spectroscopy with ancillary photometric observations enables Spectral Energy Distribution fits and, in turn, estimates of luminosities, colours and stellar masses. This makes VIPERS an excellent laboratory in which to study the evolution of galaxies. VIPERS gives a remarkably consistent picture of how blue star forming galaxies become redder over cosmic time, shaping the observed bimodality of the colour-magnitude diagram.

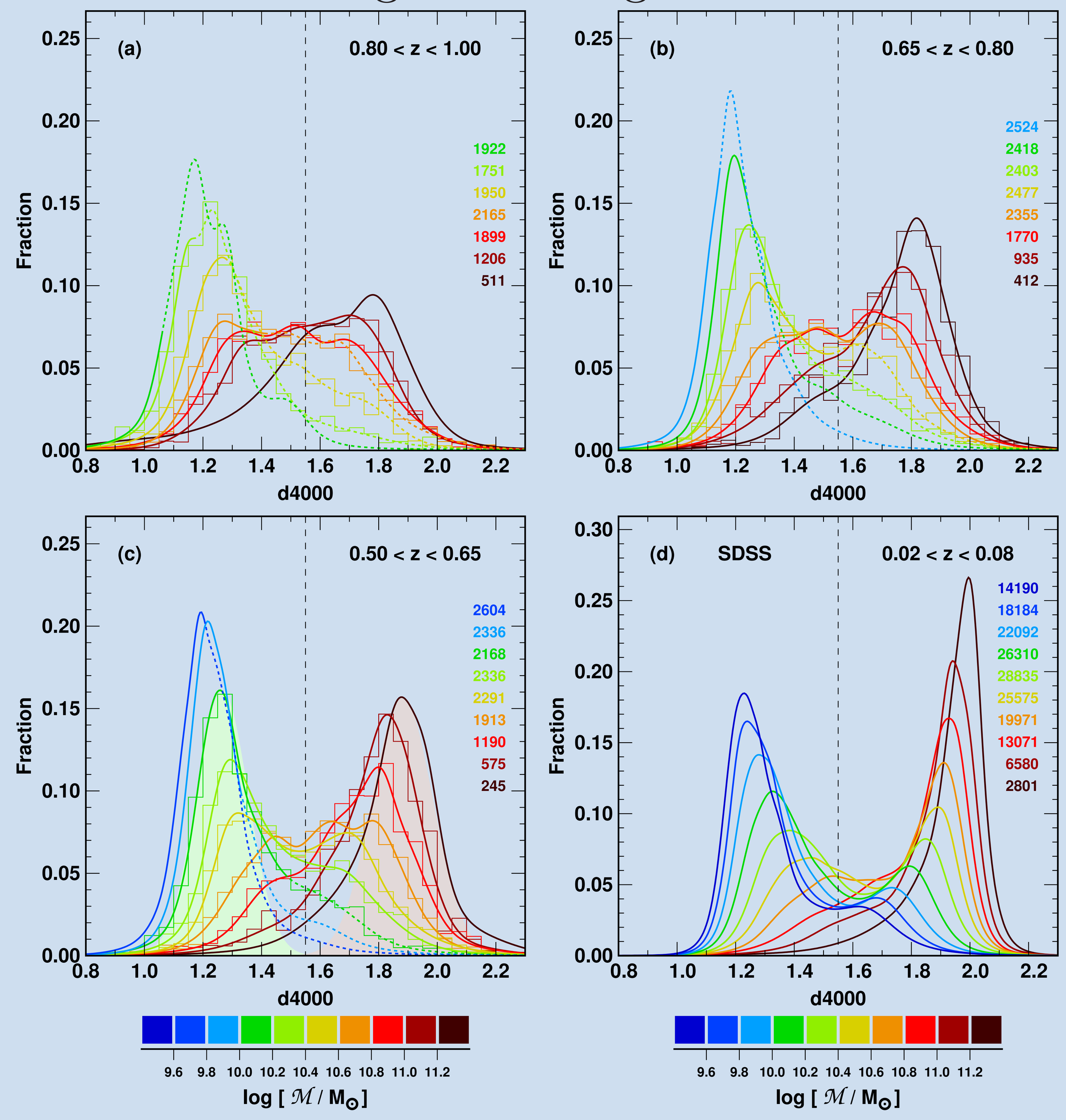

Fig 4. Haines et al. (2017), combined VIPERS and SDSS SDSS-DR7 data to trace the evolution in redshift of the bimodality of galaxy properties, producing a clear and coherent picture. This figure shows the evolution from $z = 1$ of the bimodal distribution of the 4000-Angstrom spectral break (d4000, a measure of the age of a stellar population) of galaxies with different stellar masses. The coloured numbers down the right-hand side indicate the number of galaxies in each stellar mass bin.

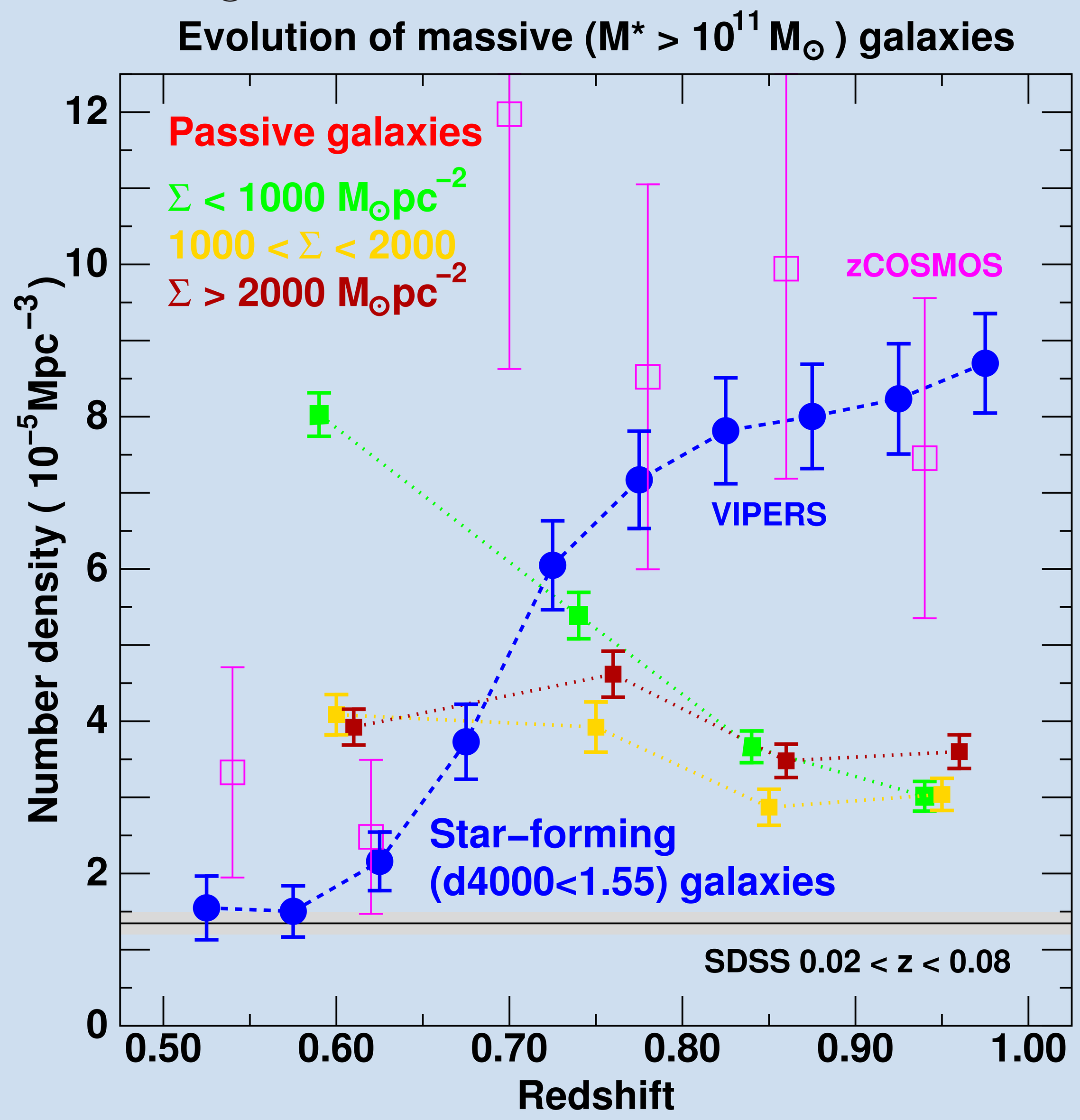

Fig 5. Gargiulo et al. (2017) studied the evolution of both the number density and stellar population ages of massive ($> 10^{11} M_\odot$) passive (red, non star forming) galaxies (MPGs) and star forming galaxies (blue circles). Objects were further separated into those that look very compact in size (yellow and brown) and larger objects with lower surface mass density, Σ, (green). With an unprecedented sample of more than 2000 such galaxies, VIPERS provides a novel insight into the origin of the current population of massive red galaxies. VIPERS strikingly demonstrates, that over its redshift range, the decay of the number density of star forming objects (blue) is compensated by the increasing number density of passive galaxies, suggesting that the former are transformed into the latter when star formation is quenched.

ercDARK LIGHT