Environmental Effects in Compact and Loose Groups of Galaxies

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- Galaxies inhabit a wide range of environments, from isolated galaxies to the core of galaxy clusters and compact groups.
- However, density is not the only relevant parameter when characterising the relationship between environment and galaxy properties.
- The relative speed with which galaxies move may influence the evolution of galaxies and thus modify their properties.

- Galaxy-galaxy interactions, merger or galaxy harassment can substantially change the structure of galaxies and even cause significant loss of mass.
- The relative influence of these processes depend on several physical parameters that vary from one environment to another.
- Comparative studies involving different galaxy environments are useful in achieving a more complete understanding of their effects on galaxy evolution.

- CGs are an extreme case: although their densities are among the highest observed, both, the number of members, and the velocity dispersion of galaxies are smaller than those seen in massive loose groups or clusters of galaxies.
- On the other hand, the number of galaxies and the velocity dispersion of CGs and low-mass loose groups may be comparable, although their crossing times differ substantially.
- These similarities and differences between loose groups and CGs represent a useful scenario to test the influence that different physical processes have on the galaxy evolution.

The hot intra-group medium (HIGM)

- Many CGs show X-ray emission associated with the HIGM.
- Rasmussen et al. (2008) studied the influence of the HIGM on the galaxy evolution and found that galaxy-HIGM interactions would not be the dominant mechanism driving cold gas out of the group members, tidal interactions being the most likely means of removing gas from galaxies in CGs.

The sample of CGs

McConnachie 2009 et al. (2009, MC09) used the original selection criteria of Hickson (1982):

- the number of galaxies within 3 magnitudes of the brightest galaxies is $N(\Delta m=3) \geq 4$;
- the combined surface brightness of these galaxies is $\mu \leq 26.0$ mag. arcsec^{-2},
- and $\theta_N \geq 3\theta_G$, where θ_N is the angular diameter of the largest concentric circle that contains no additional galaxies in this magnitude range or brighter.

- MC09 identified CGs in the public release of the SDSS DR6: 2,297 CGs down to a limiting magnitude of r=18.
- We use a subsample of this catalogue: CGs in the redshift range $0.06 \leq z \leq 0.18$, which have spectroscopic redshifts for at least one member galaxy, and also restricted our analyses to galaxy members with apparent magnitudes $14.5 \leq r \leq 17.77$.
- After meeting all these conditions, our group sample comprises 846 CGs adding up to 2,270 galaxies, among which, 1,310 galaxies (~ 58%) have measured redshifts.

The sample of loose groups

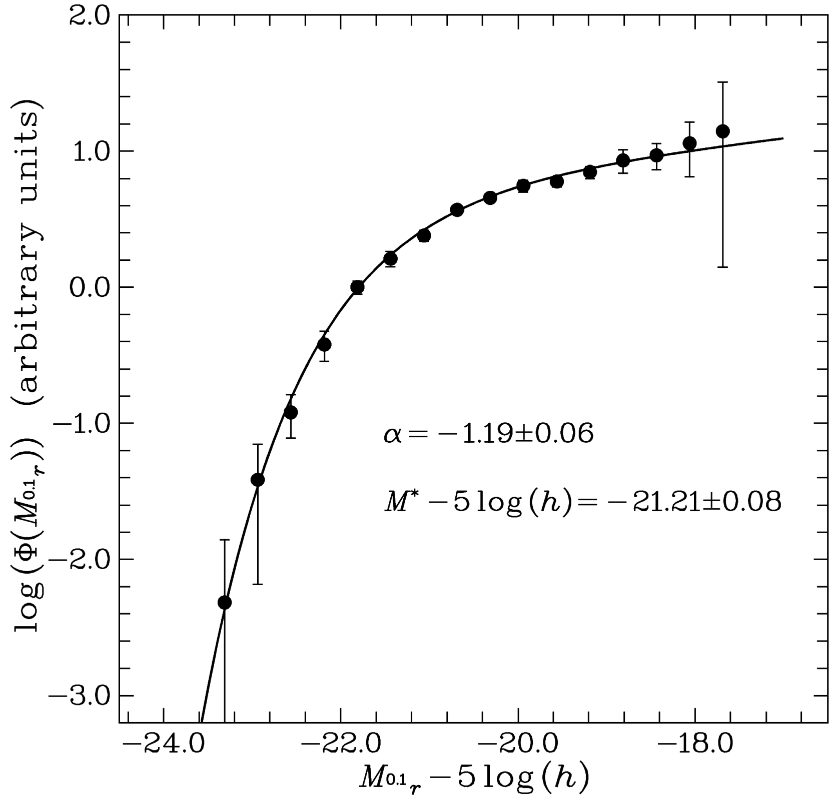
We use groups drawn from the sample of Zandivarex & Martínez (2011, ZM11) identified in the MGS of the DR7 (SDSS). Friends-of-friends algorithm.

- Properties of galaxies in groups are correlated with group mass (e.g. Martínez & Muriel (2006), thus, we compare galaxies in the CGs with galaxies in LGs in different mass ranges.
- We divide the LG sample into two subsamples of low, $\log(M/M_{\odot} h^{1}) \leq 13.2$, and high, $\log(M/M_{\odot} h^{-1}) \geq 13.6$, mass.
- We also perform a comparison of galaxy properties in samples of CGs and LGs with similar luminosity distributions (EQL-LG sample).

The sample of field galaxies

- We consider as field galaxies all DR7 MGS galaxies that were not identified as belonging to LGs by ZM11 groups or to CGs by MC09, with apparent magnitudes $14.5 \leq r \leq 17.77$.

Comparing galaxies in CGs and LGs: the luminosity function of galaxies



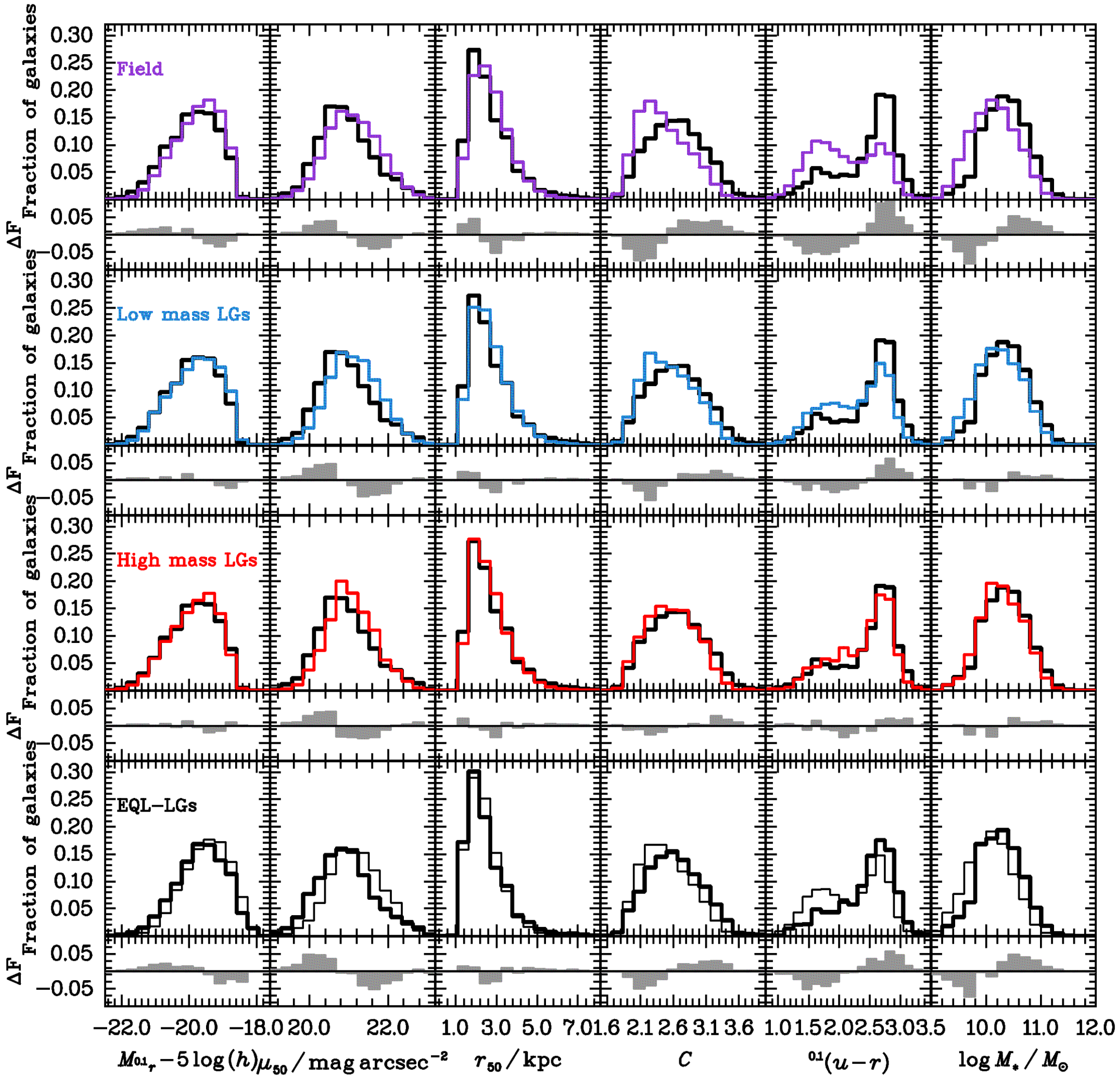
The M* of CGs is comparable with the value that ZM11 found for their highest mass sample.

The faint-end slope value is consistent with the corresponding to LGs of intermediate mass.

Comparing galaxies in CGs, LGs, and in the field

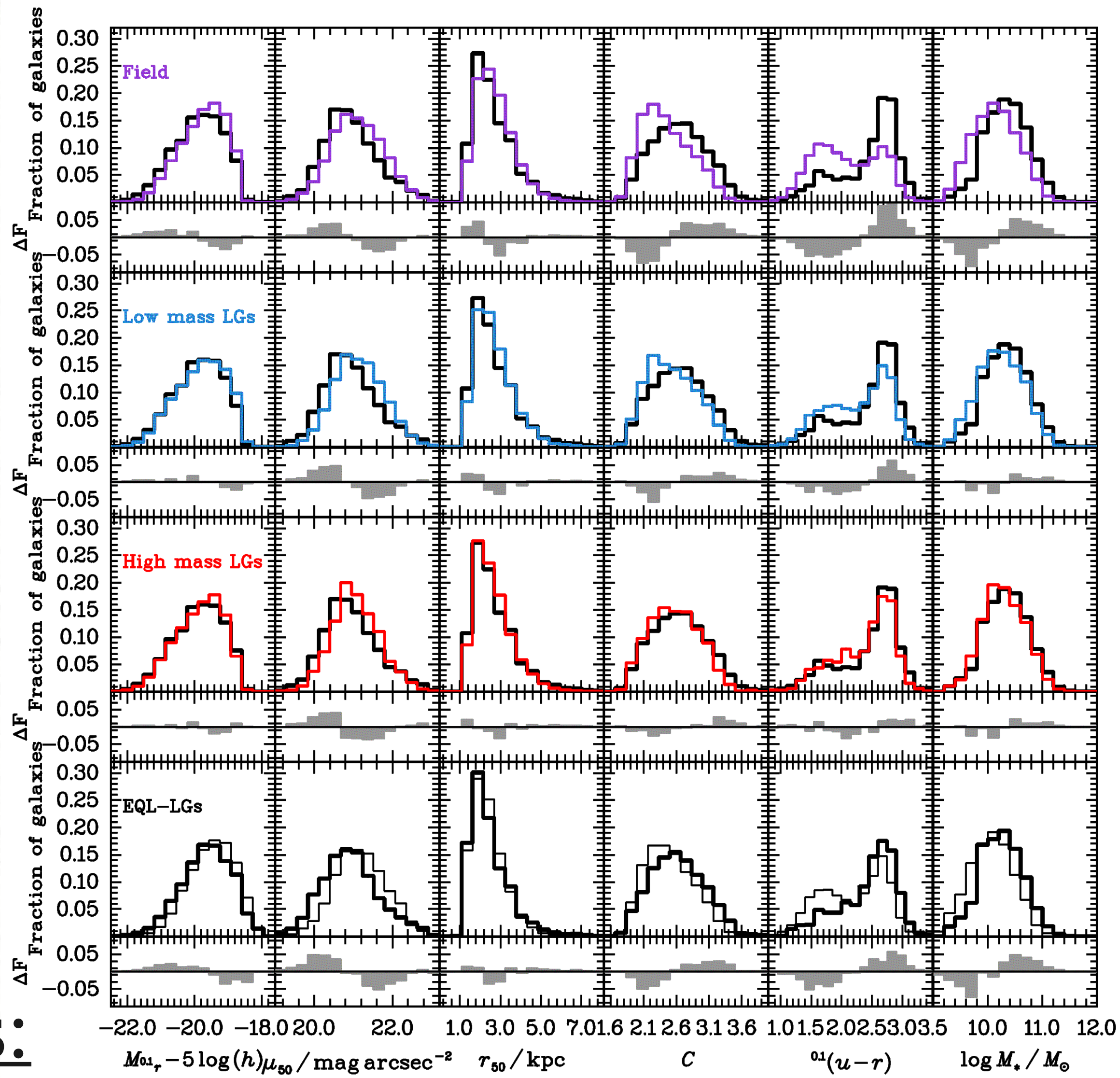
The parameters on which we focus our study are:

- Petrosian absolute magnitude in the $^{0.1}r$-band.
- The radius that encloses 50% of the Petrosian flux r_{50}.
- The *r*-band surface brightness, μ_{50}, computed inside r_{50}.
- The concentration index, defined as the ratio of the radii enclosing 90 and 50 percent of the Petrosian flux, $C=r_{90}/r_{50}$.
- The $^{0.1}(u-r)$ colour.
- The stellar mass, M_* based on luminosity and colour.



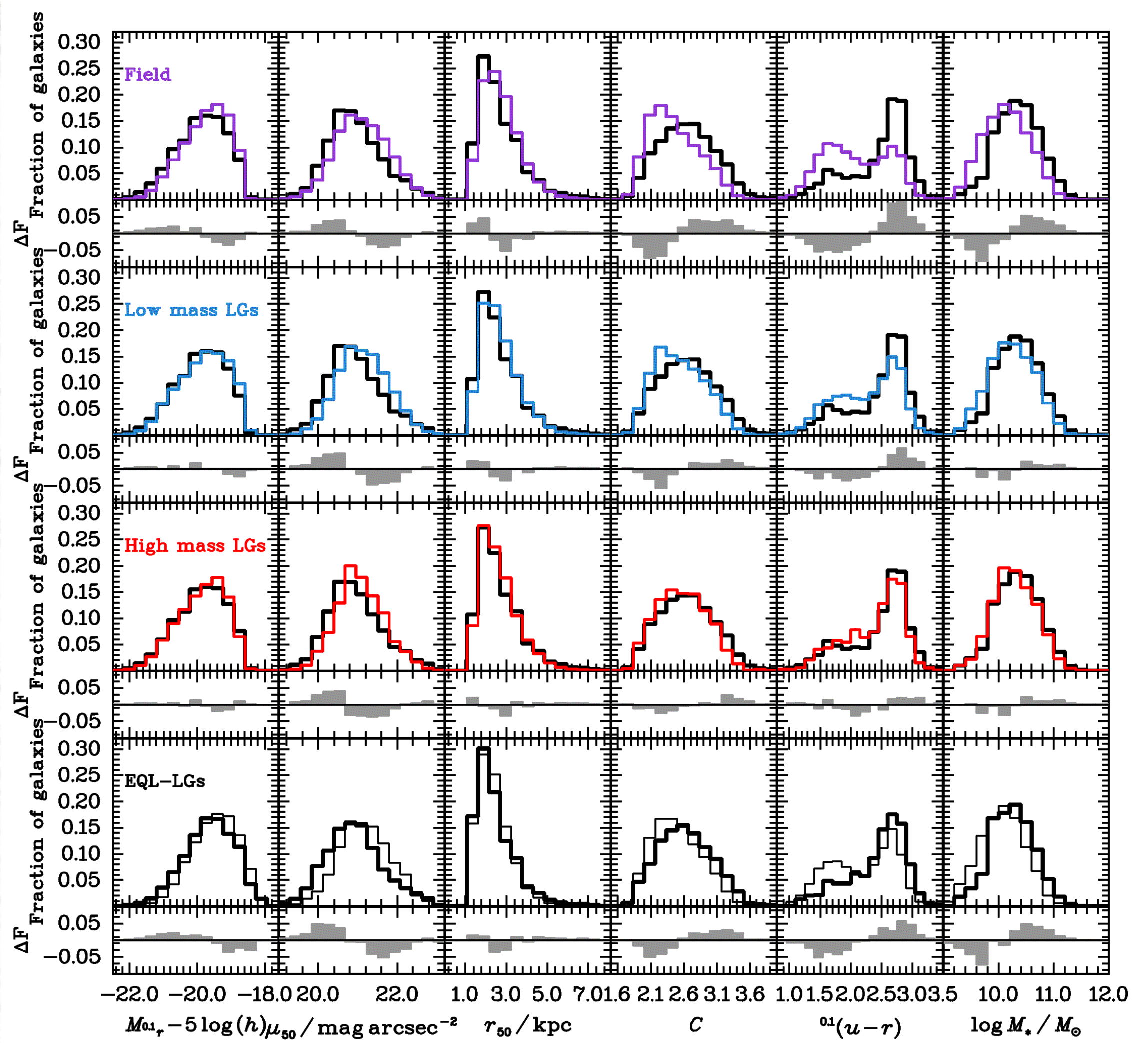
Luminosity:

- **Galaxies in CGs tend to be slightly more luminous than their field counterparts** (in agreement with previous findings of Deng et al. 2008.
- **We find no clear difference from either low or high mass LGs.**



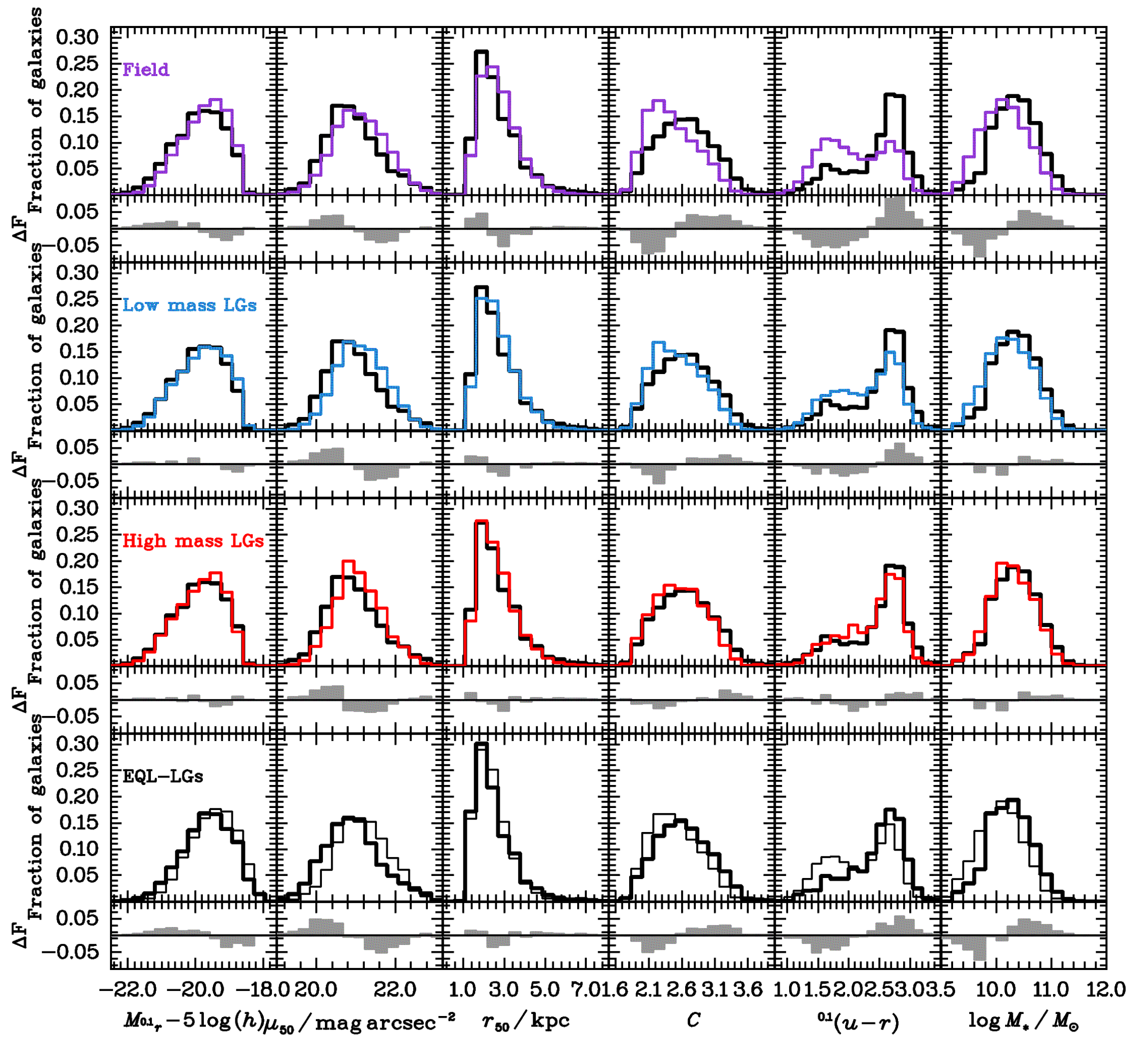
Surface-brightness:

- Compared to all LG samples and the field, **CGs** **have a larger fraction of galaxies with $\mu_{50} \lesssim 20.4$ *mag* arcsec^{-2} and a deficit of lower surface-brightness galaxies.**



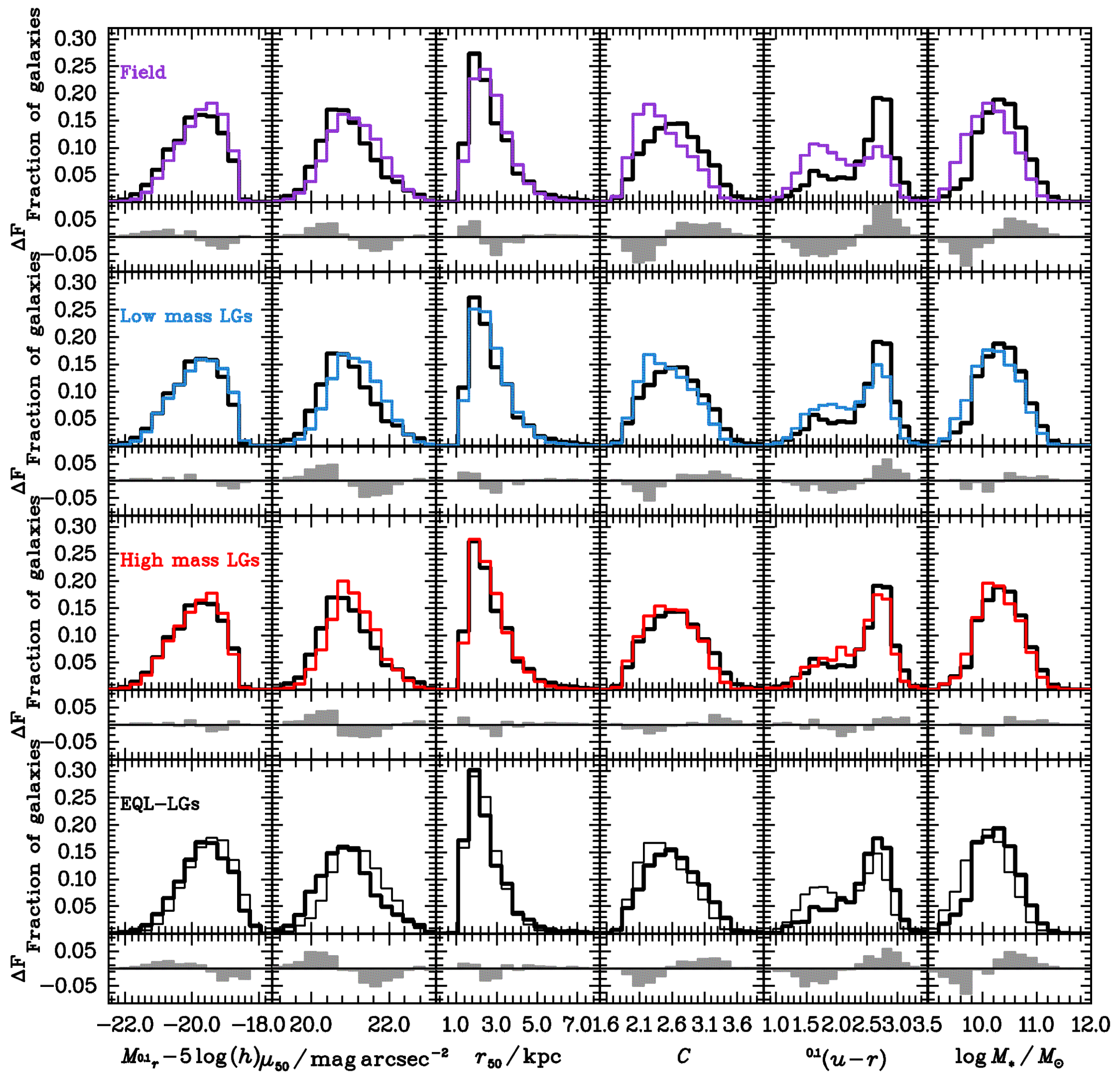
Galaxy sizes:

- We find differences between **CGs** and the other environments for galaxies with $r_{50} \lesssim 3$ *kpc*.
- **Compact groups contain an excess of galaxies with $r_{50} \lesssim$ 2 kpc and a deficit of 2 kpc $\lesssim r_{50} \lesssim$ 3 kpc galaxies.**



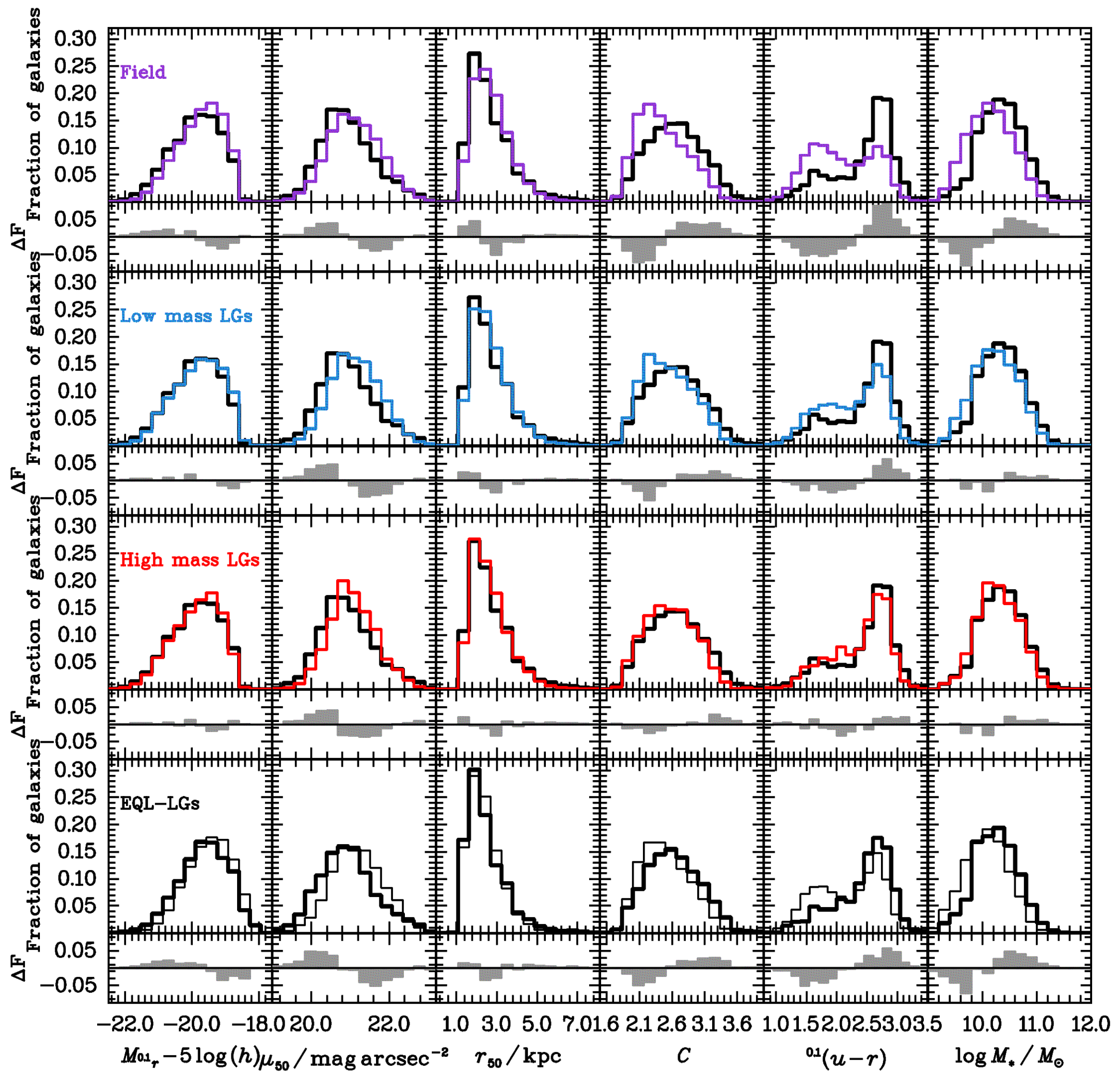
Concentration:

- Galaxies in CGs are systematically more concentrated than their counterparts in the field or in LGs. This difference reflects that galaxies in CGs have, on average, smaller sizes and comparable luminosities to galaxies in the other samples. Thus, CGs have a larger fraction of ETGs. In agreement with our results,Deng et al. 2008 found that CGs have a larger fraction of highly concentrated early-type galaxies than the field.



Color:

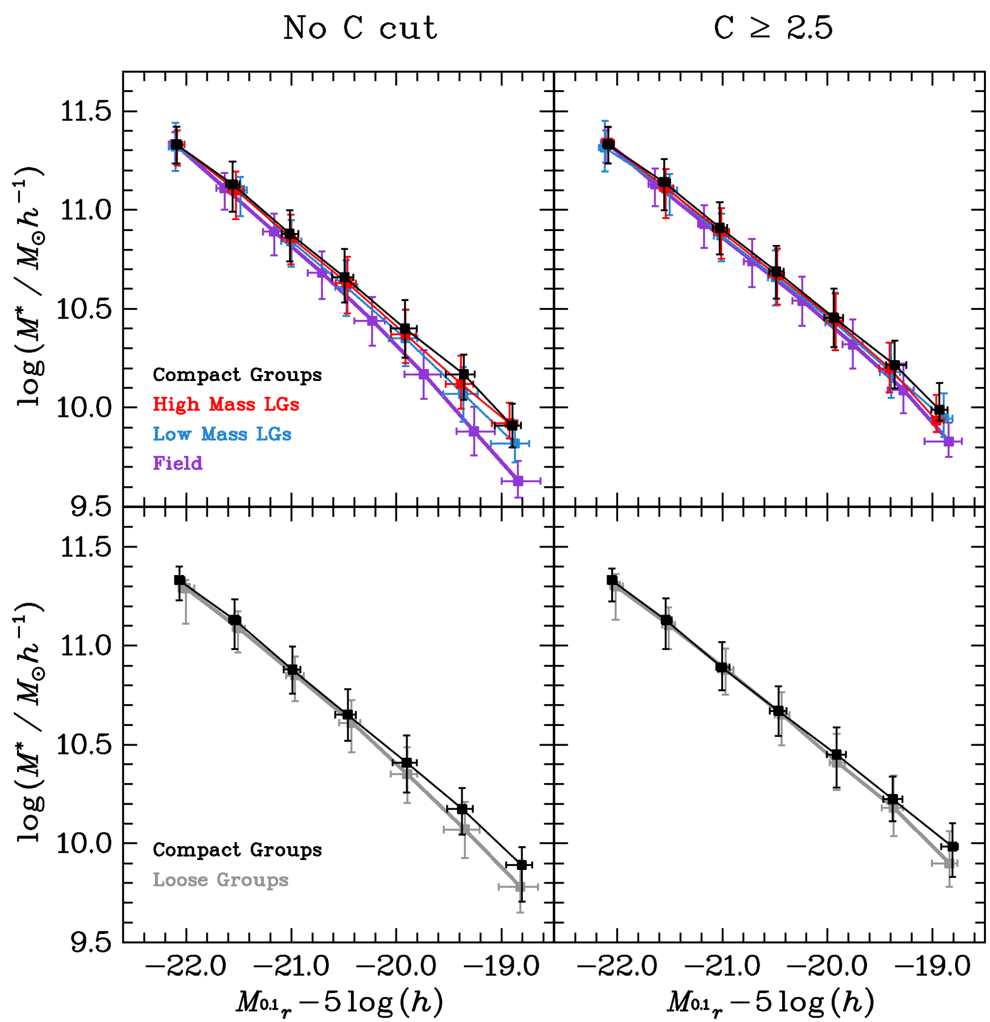
- In agreement with their relatively large fraction of early-type galaxies, **galaxies in CGs show a larger fraction of red galaxies, than the field and the LGs.**
- Our results agree with the comparison of CGs and field galaxies by Lee et al. 2004 and Deng et al. 2008. Brasseur et al. 2009 arrived at similar results performing a similar comparison using mock catalogues based on the Millennium Run simulation.



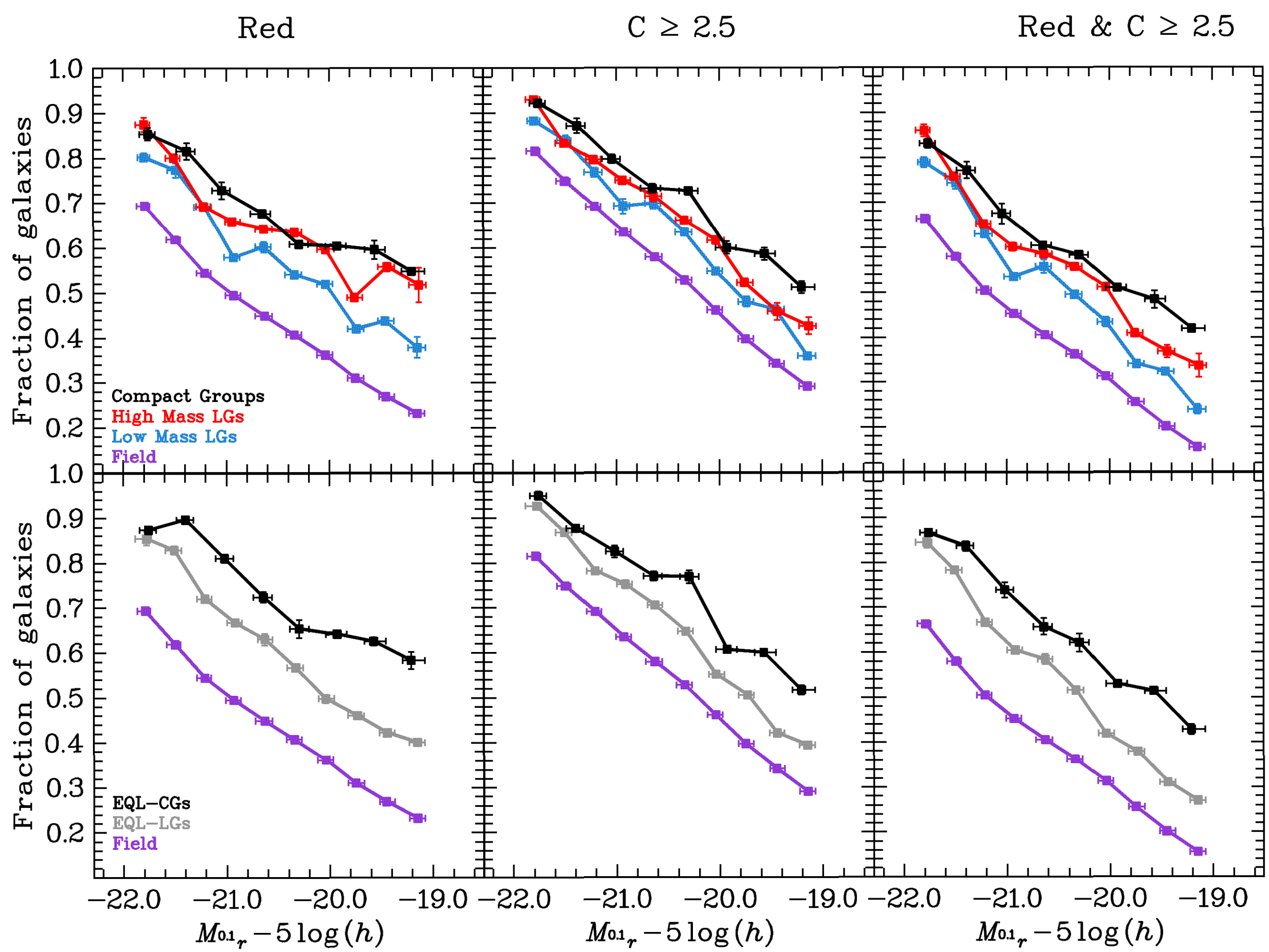
Stellar masses:

- **Galaxies in CGs tend to have higher stellar masses than their field and EQL-LGs counterparts.**

Stellar mass-absolute magnitude



- Differences arise at the lower luminosities: galaxies in groups differ from field galaxies, being more massive at fixed luminosity. The differences are almost erased when we consider early types only.

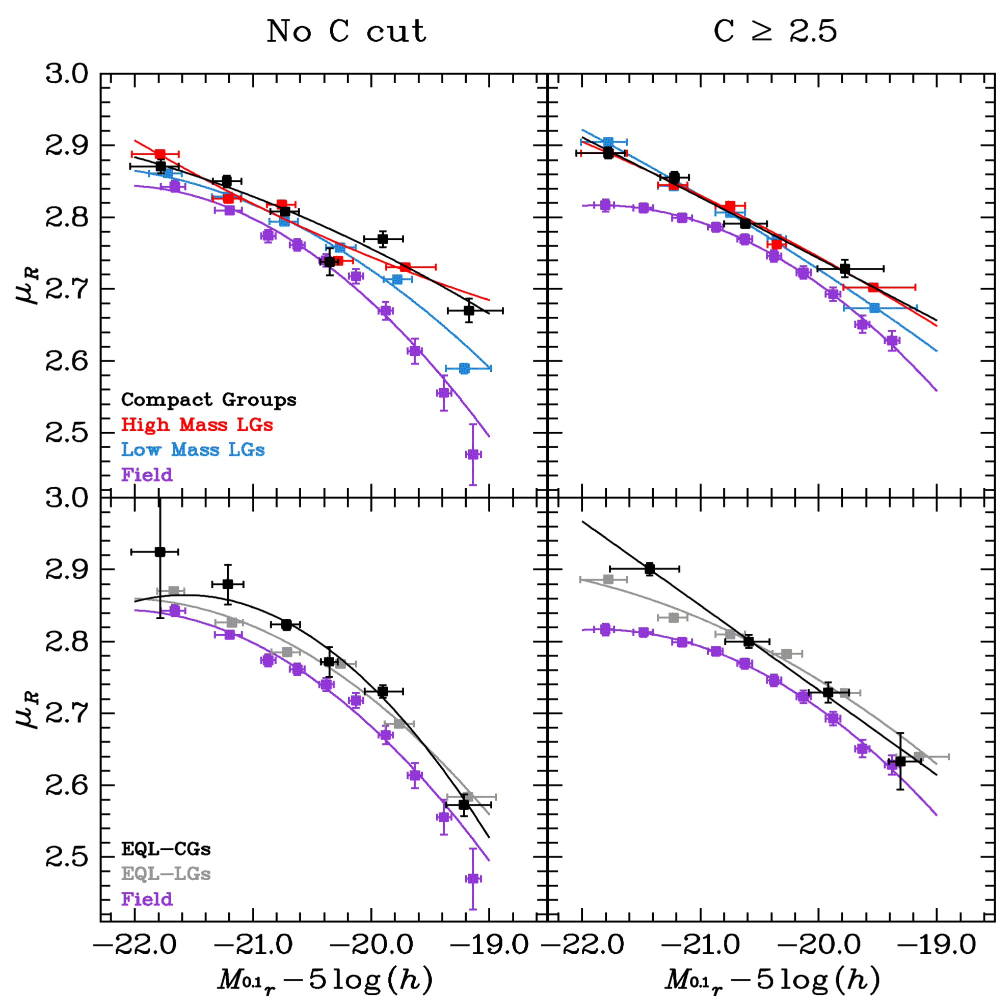


<u>The fraction of red and early-type galaxies in groups:</u>

- **CGs have a larger fraction of red early-type galaxies over the whole absolute magnitude range.**
- For brighter luminosities, CGs and high mass LGs have similar fractions of red galaxies, the largest difference being observed when red and early-types galaxies are considered. Important differences can be seen between CGs and LGs of similar luminosities.

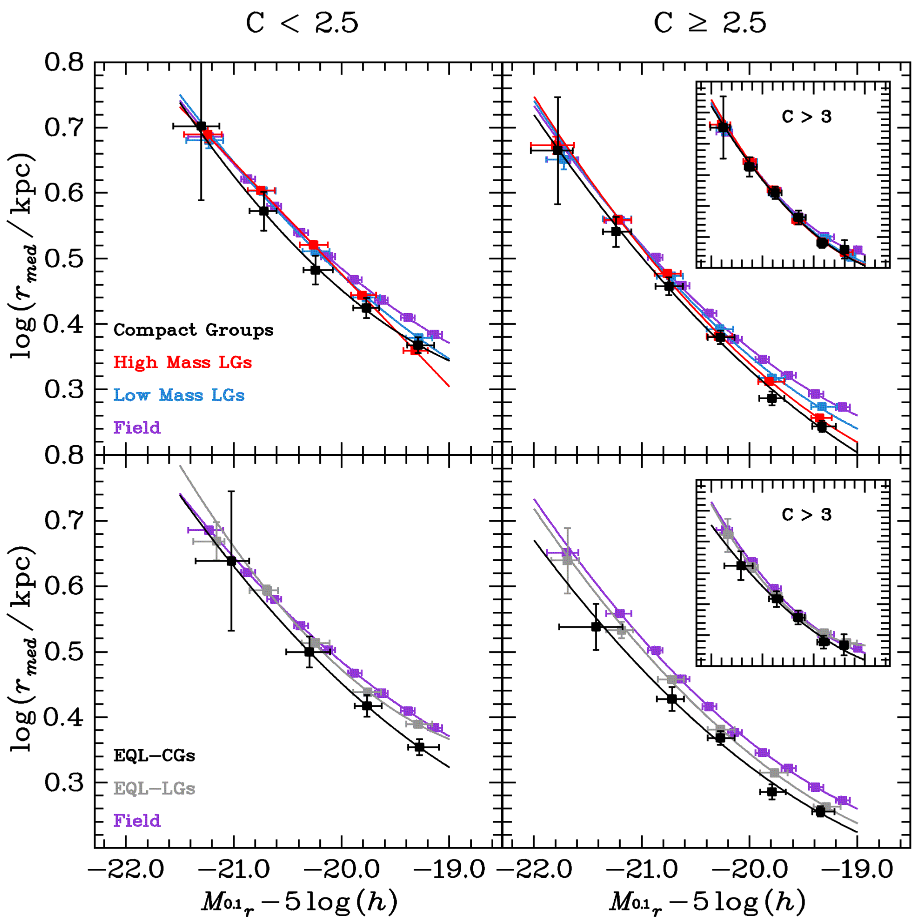
Photometric Relations

- Colour-magnitude diagram: red sequence
- Luminosity-size relation



Colour-magnitude diagram: red sequence

- The μ_R of **CG** galaxies agrees with that of galaxies in high mass LGs over the whole range of absolute magnitudes.



Luminosity-size relation:

- Taking into account the error-bars, the differences among the different sequences are insignificant for most of the bins. The only clear difference is seen between early-type galaxies populating the EQL-CG sample and the field.
- Nevertheless, **a systematic behaviour can be seen over the whole range on luminosities, galaxies in CGs tend to be the smallest, while field galaxies are the largest.**
- This effect is observed for both early and late-type galaxies.

Conclusions and Discussion

- **The properties of galaxies in either LGs or the field do not match those of galaxies in CGs.**
- **CGs are the environment that contains the largest fraction of both early-type and red galaxies.**
- This effect is observed for the whole range of absolute magnitude and stellar mass.
- **Galaxies in CGs are, on average, smaller, more compact, and have higher surface brightnesses and stellar masses than in either LGs or the field.**

Conclusions and Discussion

- **The luminosity function of galaxies in CGs has a characteristic magnitude comparable to that of the most massive LGs, while its faint-end slope is similar to that of LGs of intermediate mass.**

- *These parameters might indicate that the compact group environment is effective in producing bright galaxies and, at the same time, is a more hostile environment for fainter galaxies than LGs.*

Conclusions and Discussion

- One of our most important results is that of galaxies in **CGs** tend to be more compact, redder, and have higher μ than their LG or field counterparts.
- *These galaxies could be the descendants of galaxies that inhabited LGs before going through a GC phase. In the CG environment, galaxies have undergone mergers and tidal effects caused by the high densities and small velocity dispersions that characterise CGs.*
- *The large fraction of red galaxies in CGs suggests that the aforementioned processes are efficient in producing objects with earlier morphological types.*
- *The differences between the LF of galaxies in CGs and LGs also support a scenario where low luminosity galaxies merge efficiently leading to both a smaller number of faint galaxies and larger number of bright ETGs, as observed.*

- Lee 2004: the colours of CG galaxies differ from those of field galaxies in the sense that CGs have a larger fraction of elliptical galaxies.
- Deng 2008: found that, in dense regions, galaxies have preferentially greater concentration indexes and early-type morphologies.
- Walker 2010: suggested that the compact group environment accelerates the evolution of galaxies from star-forming to quiescent
- Tzanavaris 2010: estimated the SFR using both ultraviolet and infrared information and found that the compact group environment accelerates the galaxy evolution by enhancing the star formation processes and favouring a fast transition to quiescence.

Identification of CGs

- Hickson 1982 compiled a sample of 100 CGs that has been extensively studied, although the small number of systems does not allow the implementation of statistical studies that could differentiate between the dependences on galaxy properties and environment.
- McConnachie et al. 2009 identified two samples of CGs in the public release of the SDSS DR6 (one of 2,297 CGs down to a limiting magnitude of r=18, and a deeper sample of 74,791 down to r=21).