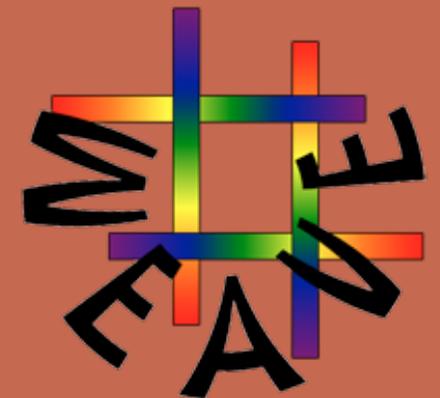
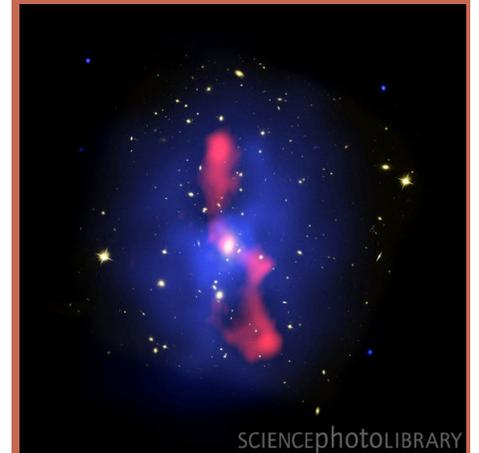
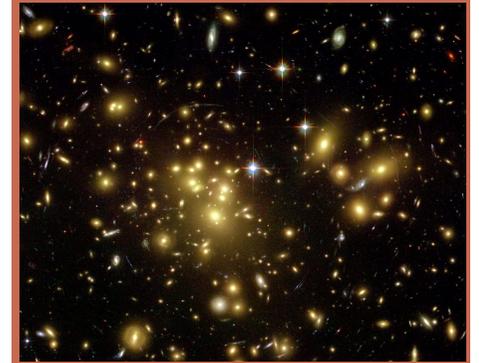


THE WEAVE SPECTROSCOPIC NEARBY GALAXY CLUSTER SURVEY: THE ORIGIN OF LOW- MASS HALOS

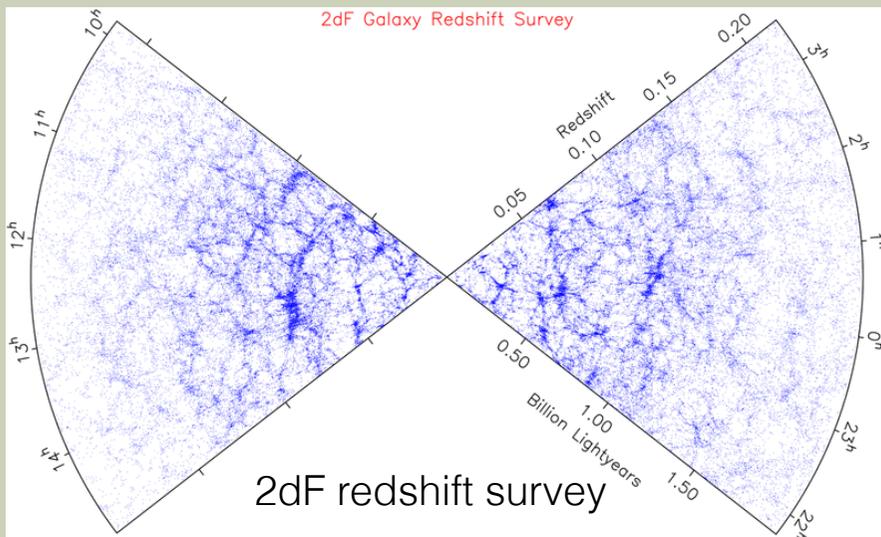
J. Alfonso L. Aguerri
Instituto de Astrofísica de Canarias

04/03/15

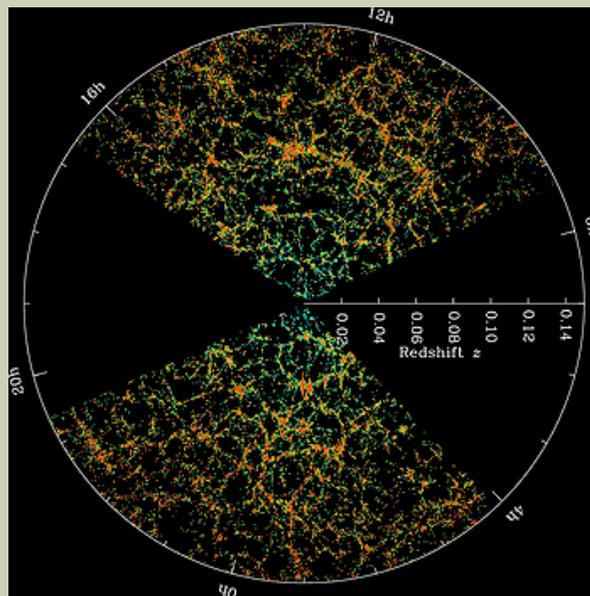
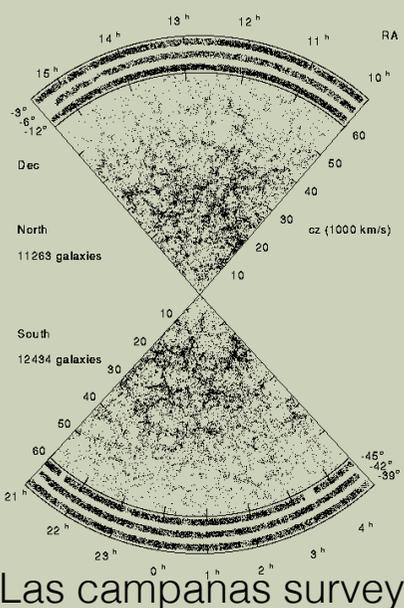
MOS Spectroscopic surveys in the next decay



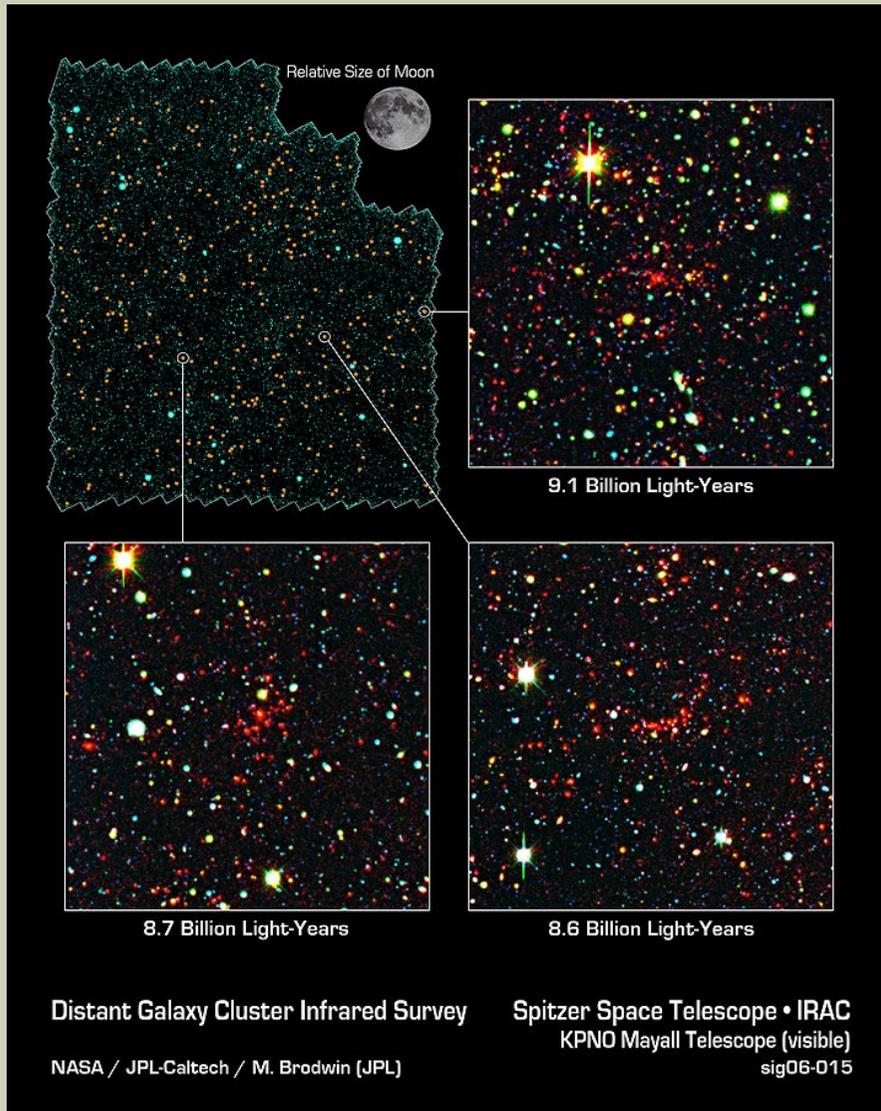
GALAXY CLUSTERS AT THE MASSIVE-END OF THE STRUCTURE FORMATION



- Galaxies are not homogeneously distributed in the Universe. In contrast they are located in groups and clusters of galaxies with 10s -100s members
- Galaxy clusters are very massive structures in our Universe. They span a mass range: $10^{13} - 10^{15} M_{\text{sun}}$
- They are excellent laboratories for:
 - Structure formation
 - Galaxy evolution
 - Physic theories



MAIN OBSERVATIONAL QUESTIONS ON GALAXY CLUSTERS TODAY



Three main questions on galaxy clusters today

1.- *How and when do clusters form?*; How different are proto-clusters and today clusters?

2.- *How do the cluster medium evolve?*; Which is the main enrichment physical mechanism of the intracluster medium?; Conexion between AGN and metal enrichment.

3.- *How do galaxies evolved in galaxy clusters?*; Which is the main formation mechanism of bright and dwarf galaxies?; How does the star formation stops in galaxies in clusters? How does galaxy morphology evolves in clusters?

WEAVE GALAXY CLUSTER SURVEYS

Survey 1: Nearby cluster Survey

- 1.- Large (about 80) and volume limited ($D < 150 \text{ Mpc}$) sample
- 2.- LR Spectra down to $M_r < -16$ ($M^* + 6$)
- 3.- mIFU observations of several thousands of dwarfs

Evolution of low mass halos

- 1.- Spectroscopic LFs
- 2.- Orbital galaxy analysis
- 3.- Stellar populations
- 4.- Stellar kinematics

Survey 2: Evolution of galaxies in the cluster outskirts

- 1.- LR spectra of galaxies in 10 clusters at $z = 0.1$
- 2.- Galaxies located in the external regions $r/r_{200} > 5$

- 1.- Truncation of the star formation in galaxies over a wide mass range and environment
- 2.- Relation between AGN activity, feedback and environment in large mass

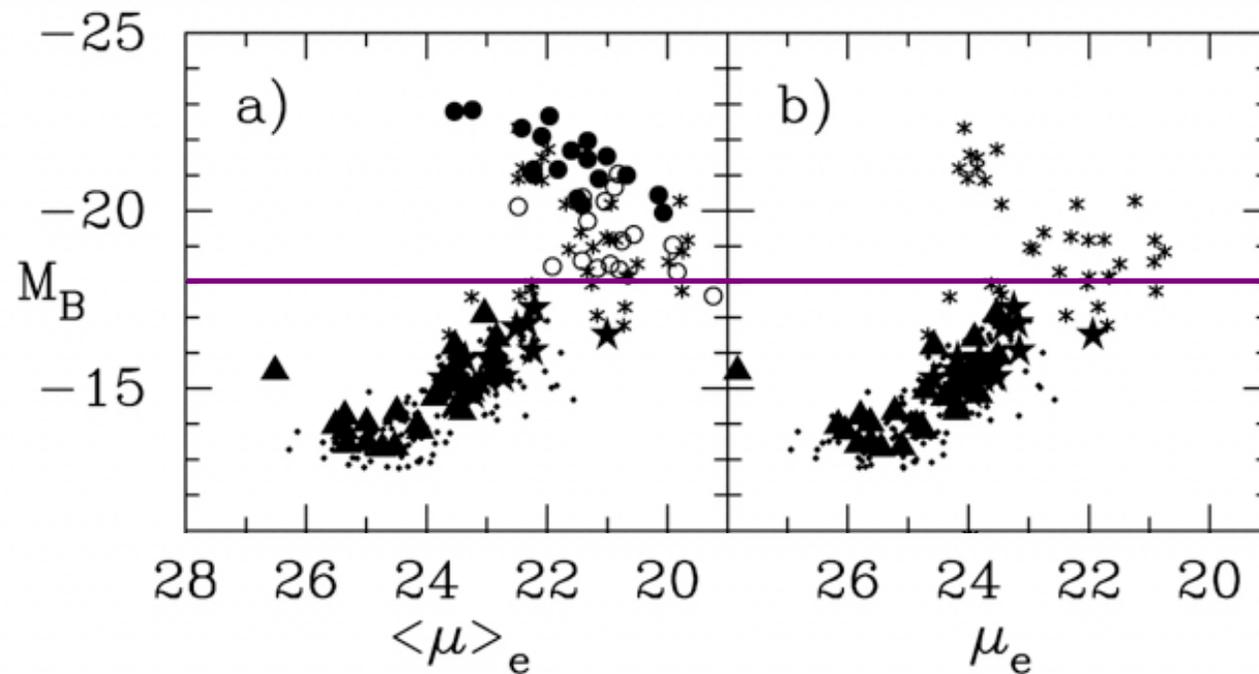
Survey 3: Evolution of galaxies in clusters in the last 6 Gyrs

- 1.- LIFU observations of the central regions of 150 clusters at $0.3 < z < 0.6$

Galaxy stellar population evolution of bright objects in cluster cores during a period of few Gyr
Mass cluster determination for cosmological studies

WEAVE NEARBY CLUSTER SURVEY

Graham & Guzmán 2003

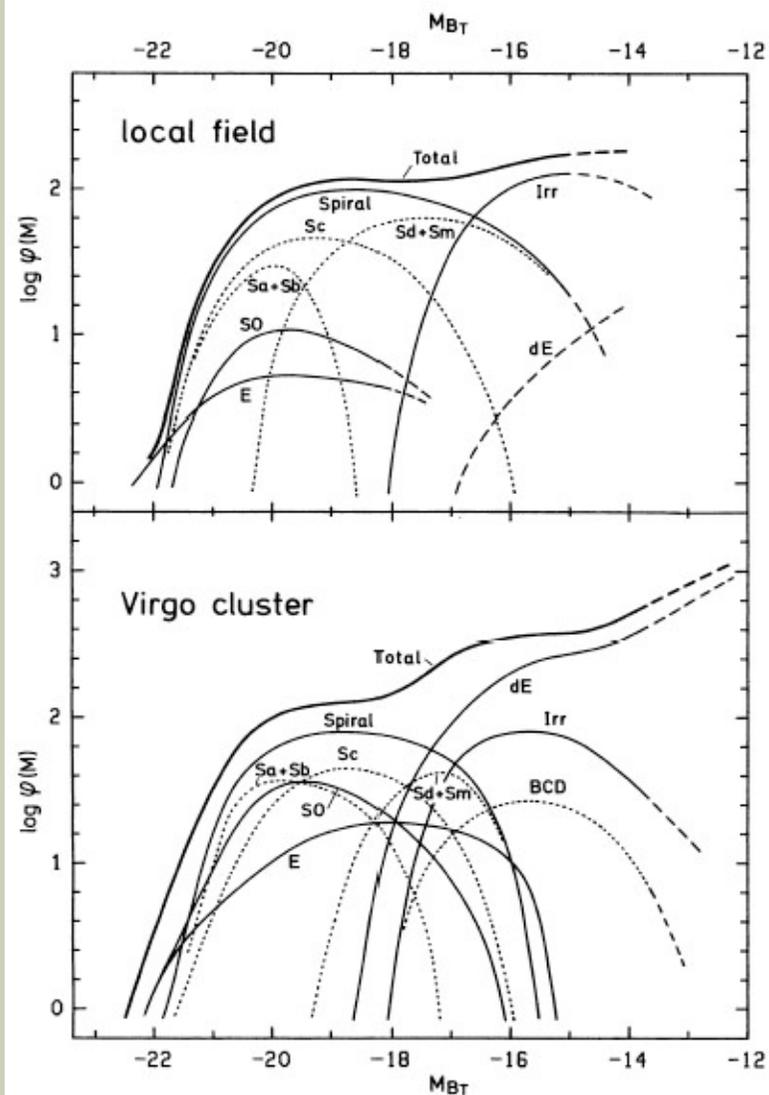


- The galaxy luminosity is usually used in order to classify galaxies.
- Historically dwarf galaxies have been considered as those fainter than $M_B = -18.0$

WHY IS IMPORTANT TO STUDY DWARF GALAXIES?

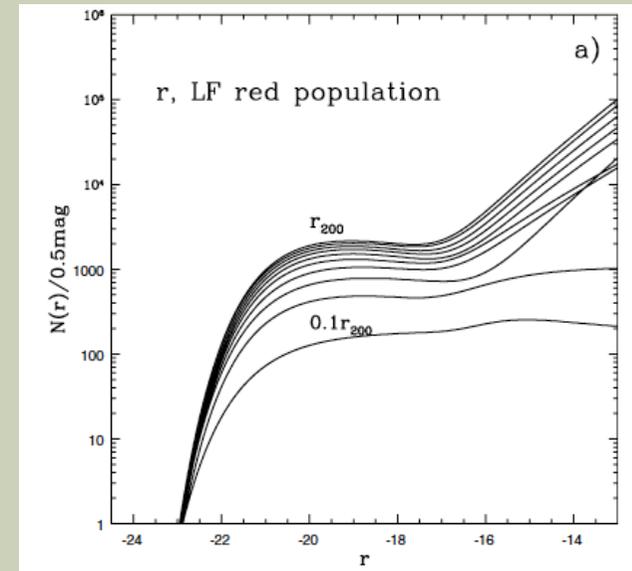
- Dwarf galaxies are important systems due to:
 - They can merge to form larger systems. Building-blocks of more massive and larger galaxies
 - They are relatively simple systems. No merger products.
 - Their shallow potential make them systems that can be affected by environmental processes.
 - Those dwarf galaxies entering in clusters many Gyr ago carry an imprint of the past environmental influence.

LOW MASS GALAXY HALOS & GALAXY CLUSTER

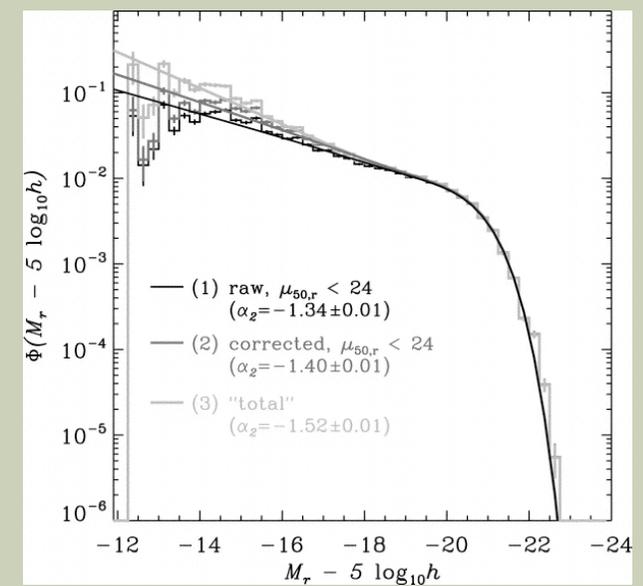


Binggeli & Tamman 1988

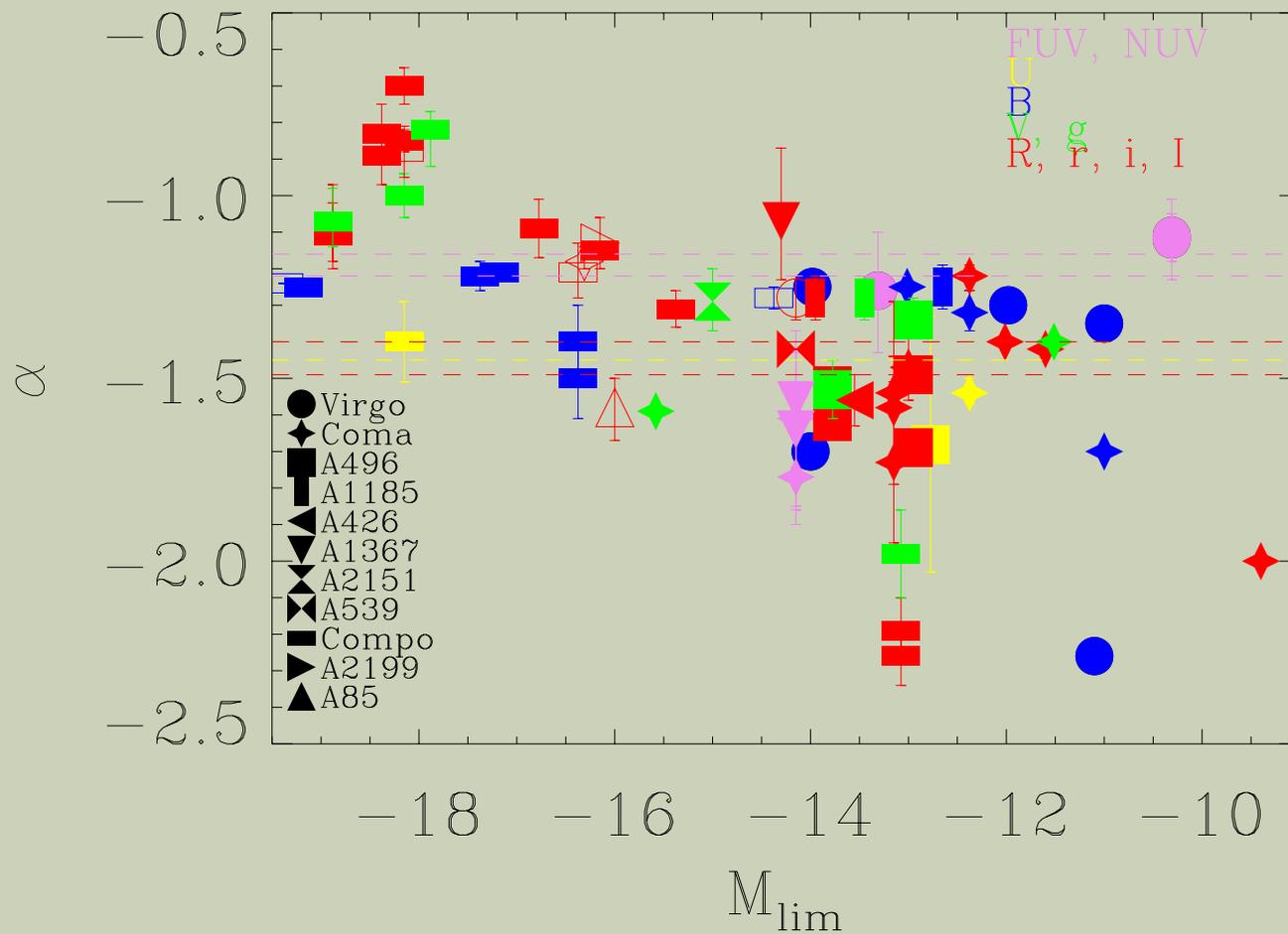
Popesso et al 2006



Blanton et al. 2005



LOW MASS GALAXY HALOS & GALAXY CLUSTERS

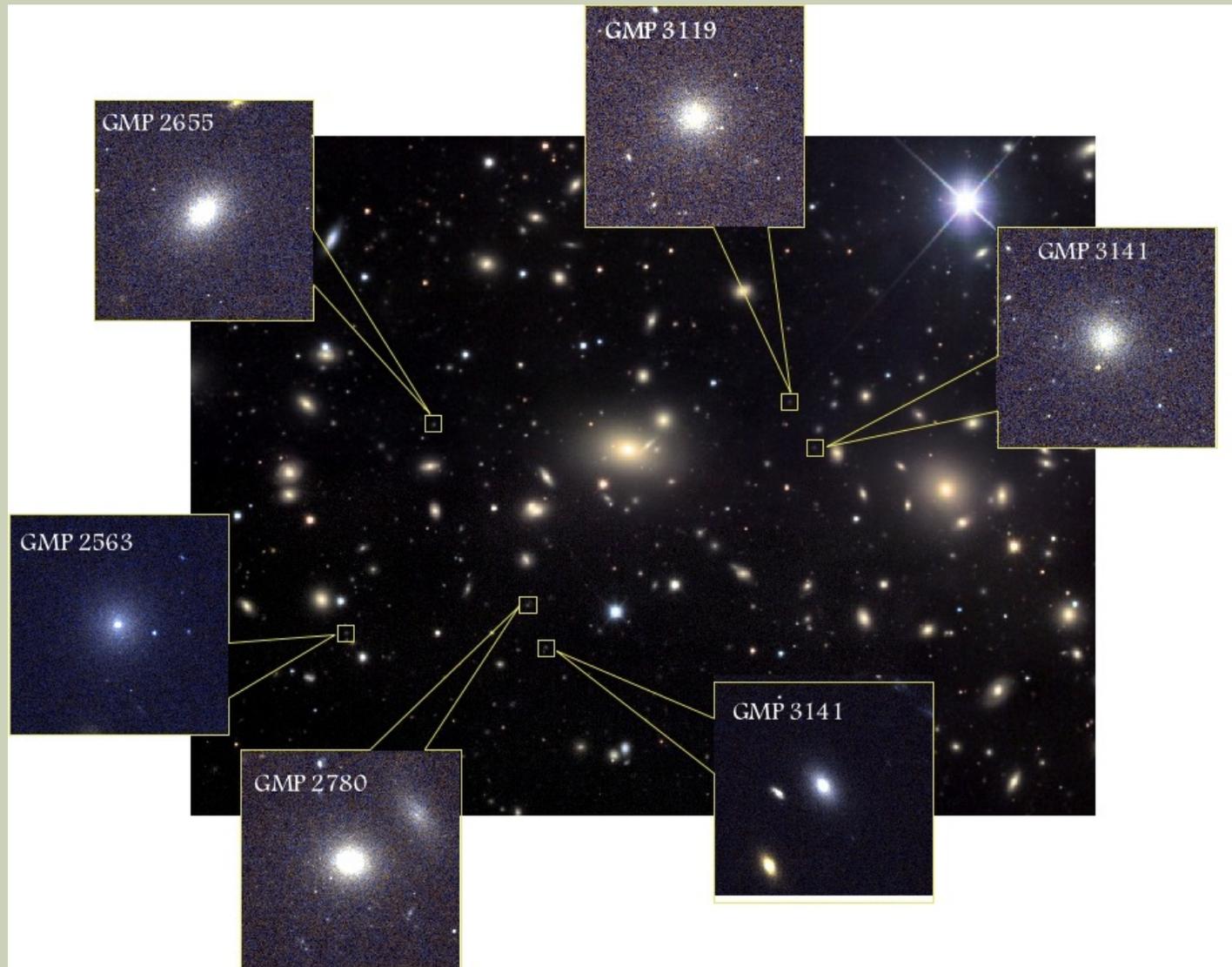


DETAILED STUDIES OF DWARFS IN CLUSTERS

- **Morphology:** roundish objects similar to bright E. But a fraction of early-type dwarf population show similar morphological features as brighter spirals: bars, spirals, disks (see e.g. Aguerri et al. 2005; Lisker et al. 2007; Janz et al. 2012)
- **Kinematics:** About 50% of early-type galaxies show rotation (see Pedraza et al. 2002; Geha et al. 2002, 2003; van Zee et al. 2004). The fraction of rotating systems is larger in the periphery of the cluster (see Toloba et al. 2009, 2014)
- **Stellar populations:** mean age decreases with radial distance to the cluster center (see e.g. Boselli et al. 2008, Toloba et al. 2009, Koleva et al. 2013)

Most of these properties are obtained in a bunch of nearby particular environments: Virgo, Fornax, Coma, A1367,...
A large, deep and systematic spectroscopic survey covering different environments down to the dwarf regime important to be done. MOS instrumentation is crucial to do this.

WEAVE NEARBY GALAXY CLUSTER SURVEY



DETAILED ANALYSIS OF DWARF GALAXIES IN ABELL 85



- Nearby galaxy cluster

$$v = 16633 \text{ km/s (} z=0.055)$$

$$\sigma = 979 \text{ km/s}$$

$$R_{200} = 2.10 \text{ Mpc}$$

$$M = 2.5 \times 10^{14} M_{\odot}$$

- Observational properties

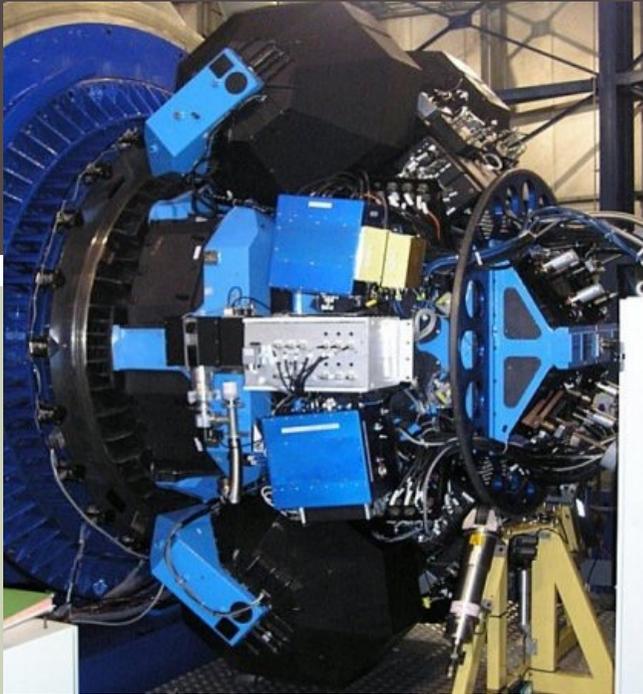
- Mass distribution (e.g. Rines & Diaferio 2006)

- Substructure (e.g. Durret et al 1999; Cava et al. 2010)

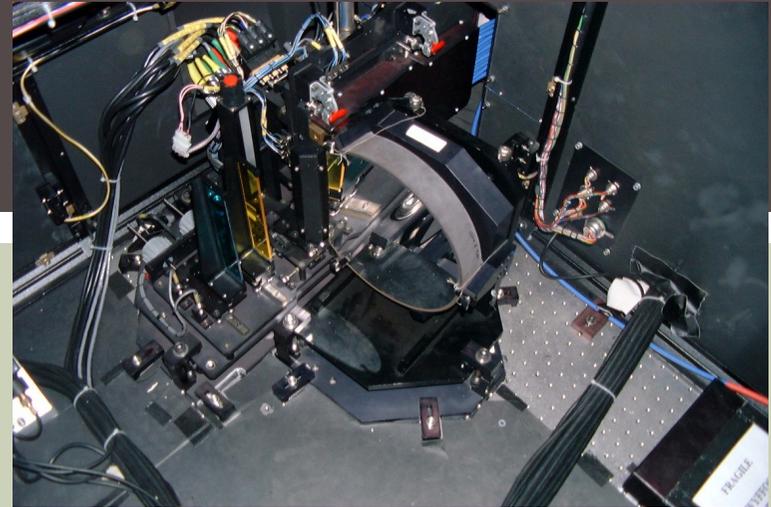
- Galaxy properties (e.g. Aguerri et al. 2007)

Results on Agulli et al. 2014

see poster by: I. Agulli



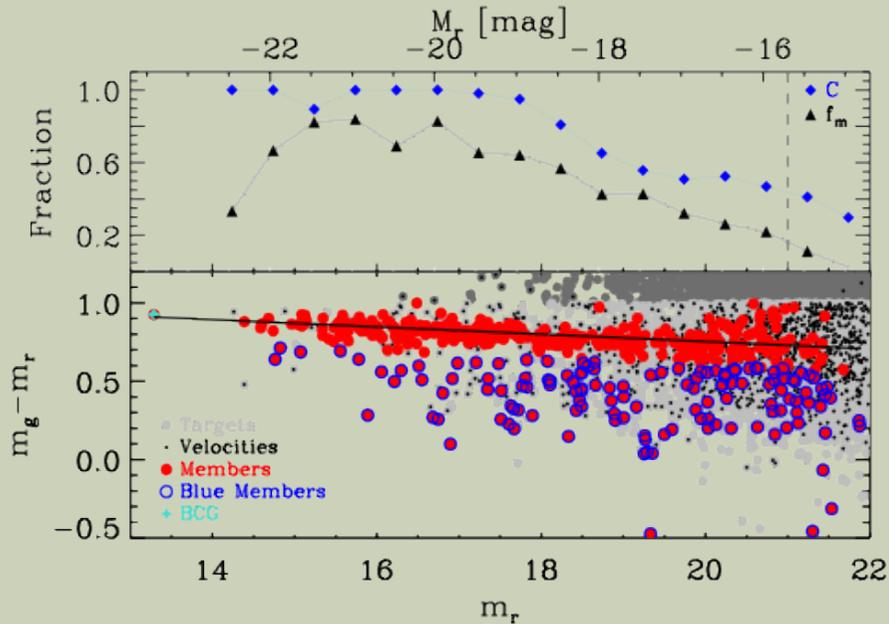
VIMOS@VLT
LR blue R180
370-670 nm
Dispersion 5.3 Å/pixel



AF2@WHT
150 fibers; 1.6 arcsec
FOV 20 arcmin
LR blue R158
Dispersion 3.2 Å/pixel



ABELL 85: TARGET SELECTION



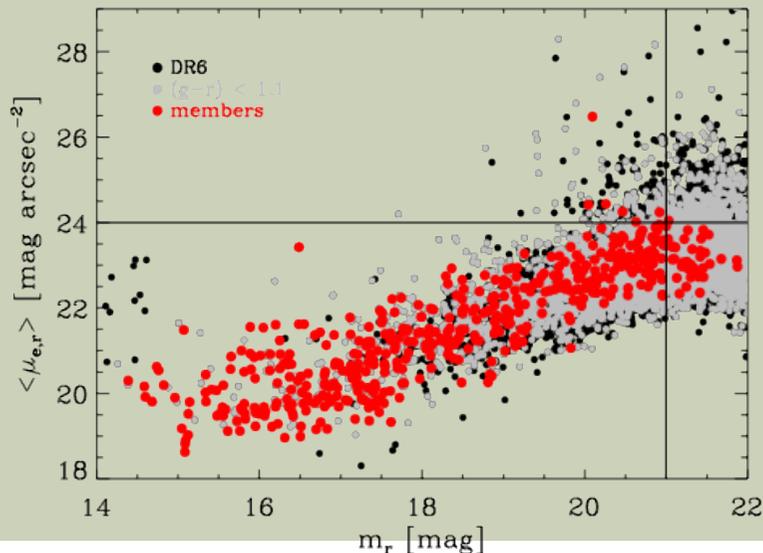
Targets:
 VLT: $m_r < 22$; $g-r < 1.1$
 WHT: $m_r < 20.0$; $g-r < 1.1$

2100 recession velocities

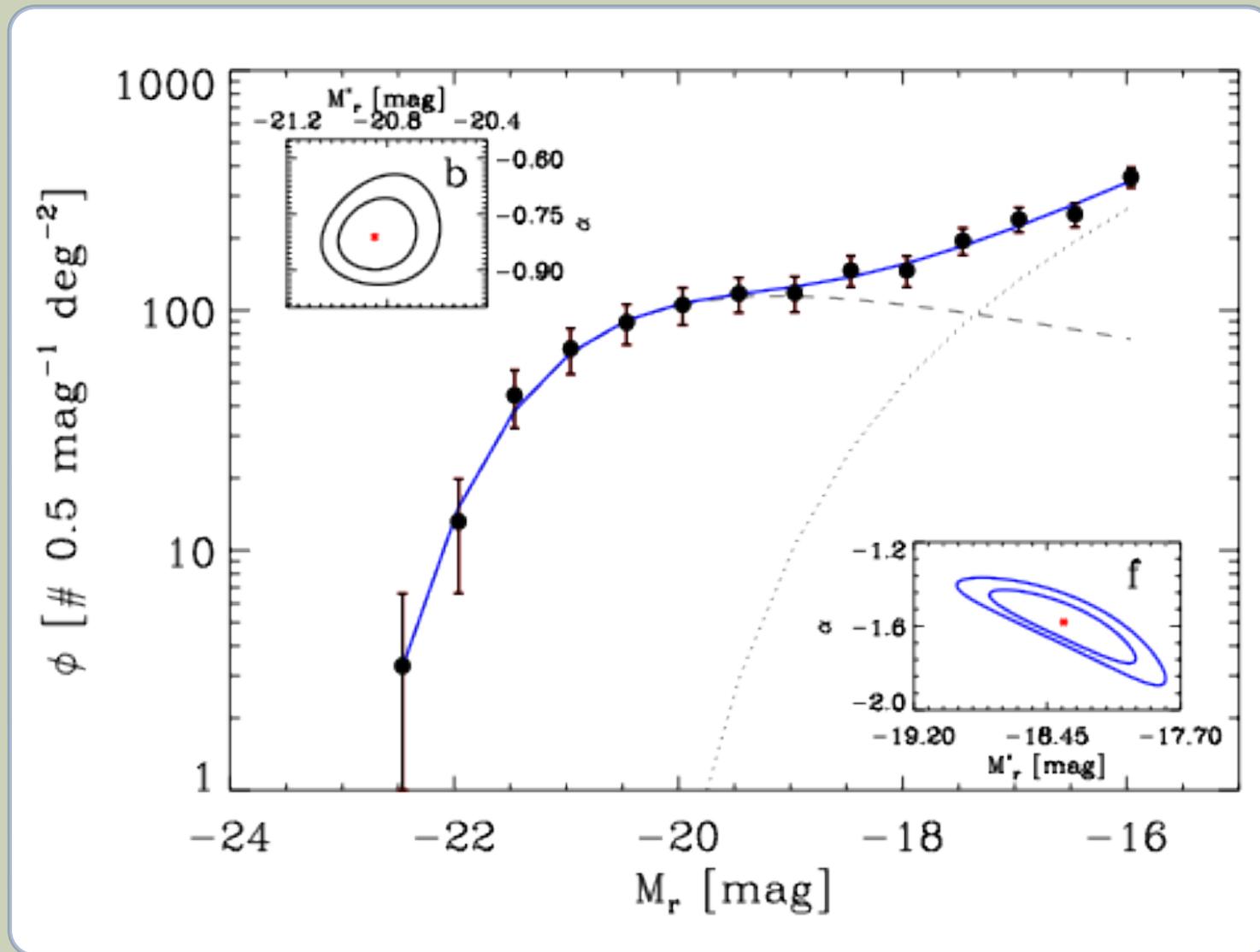
459 cluster members down to
 $M_r < -16.0$ (about $M^* + 6$)

Two examples what can we learn
 with this kind of data:

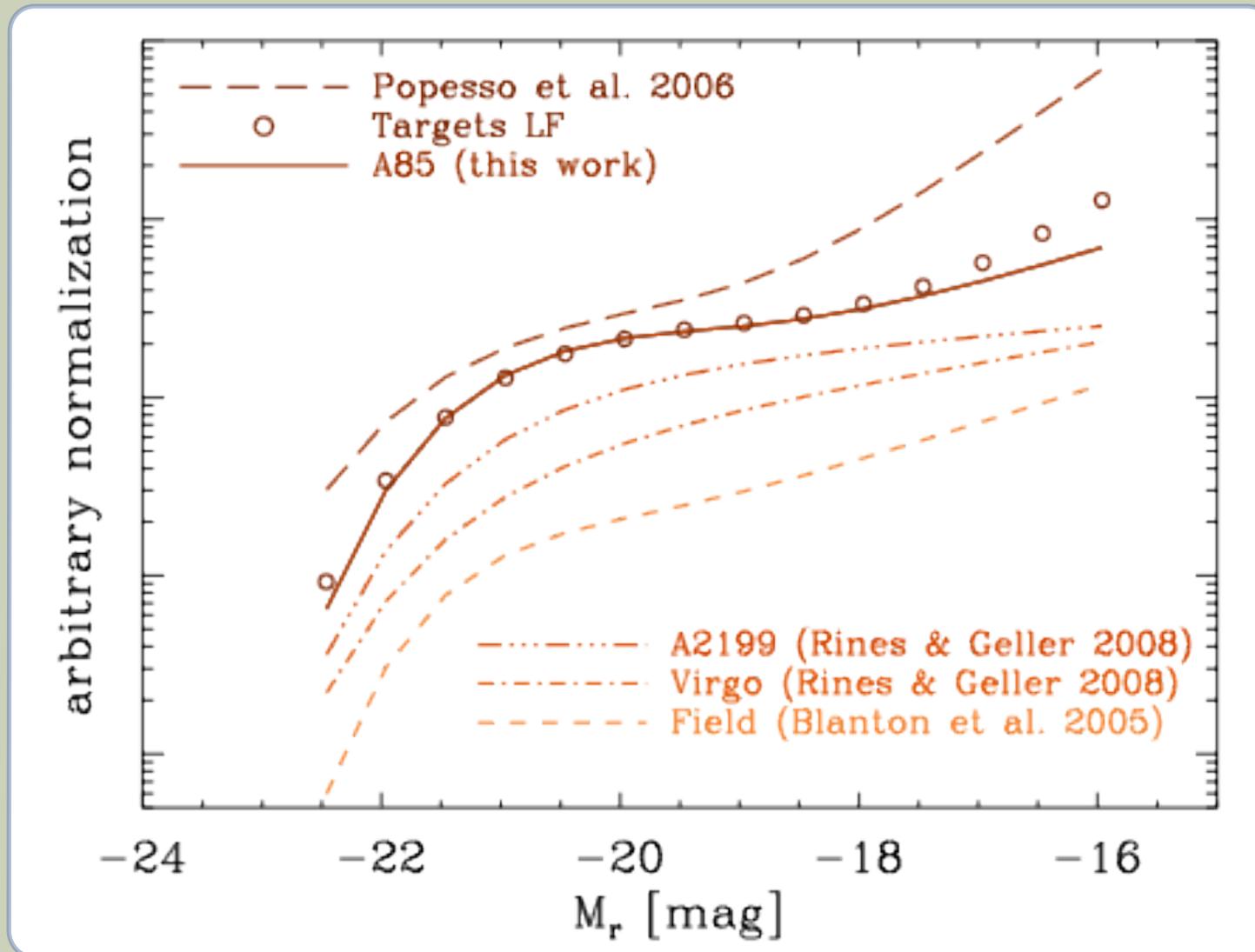
- 1.- Spectroscopic galaxy LFs
- 2.- Orbital structure of galaxies
 down to $M^* + 6$



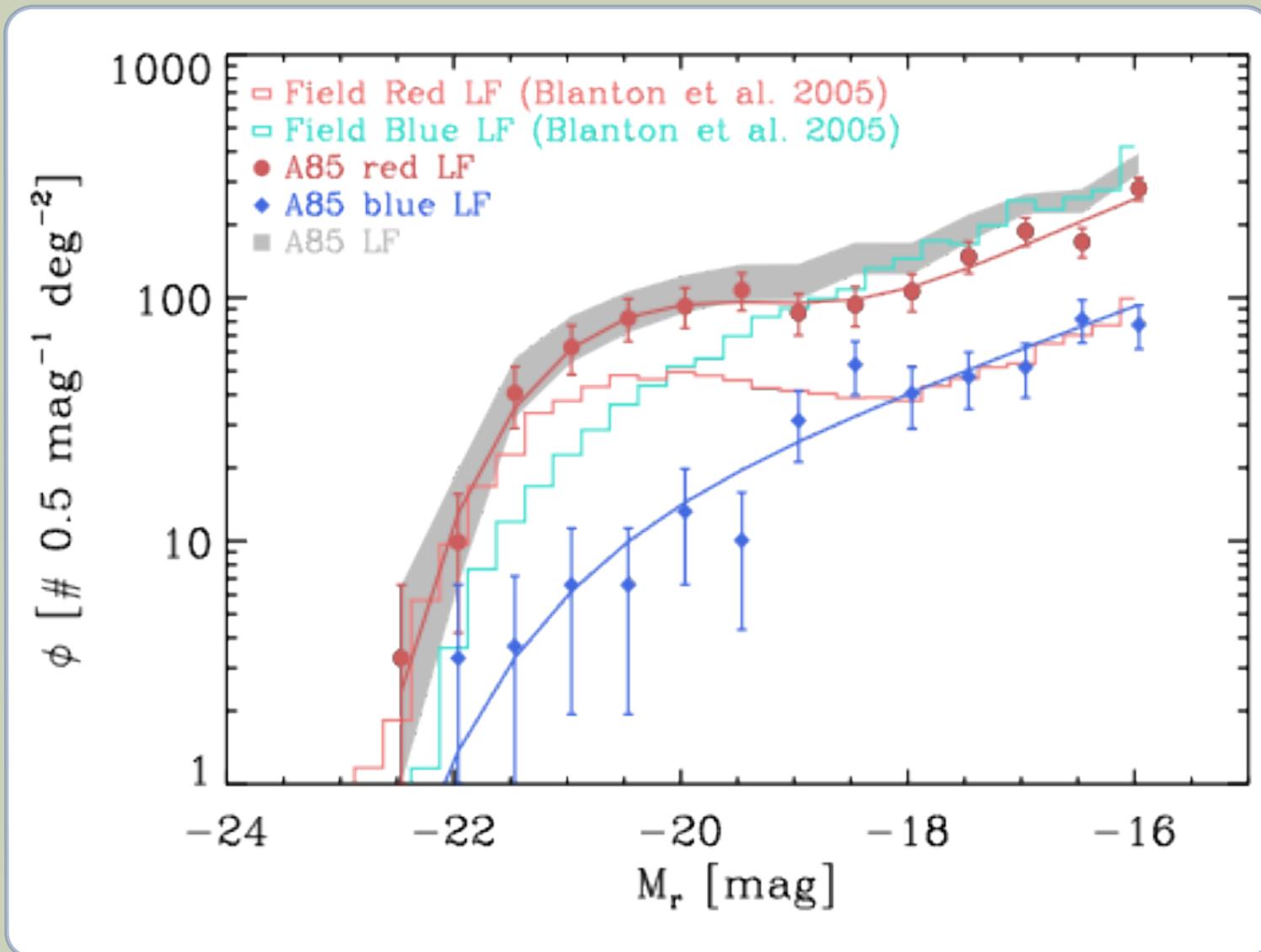
A85: SPECTROSCOPIC GALAXY LF



A85: SPECTROSCOPIC GALAXY LF



A85: SPECTROSCOPIC GALAXY LF



GALAXY ORBITS IN CLUSTERS

Observed quantities

Galaxy projected density

Observed velocity dispersion

Mass distribution



Jeans equation



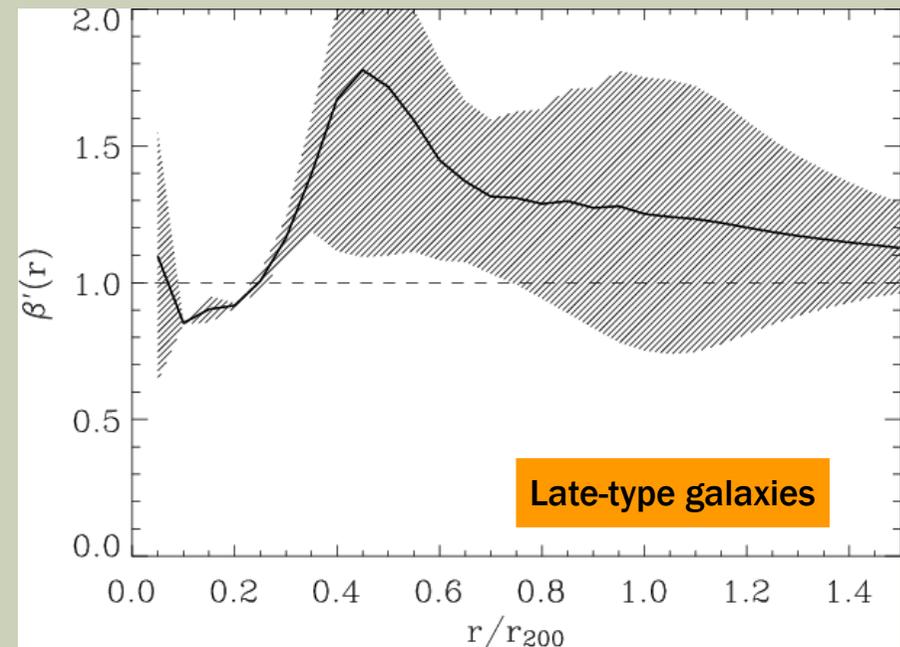
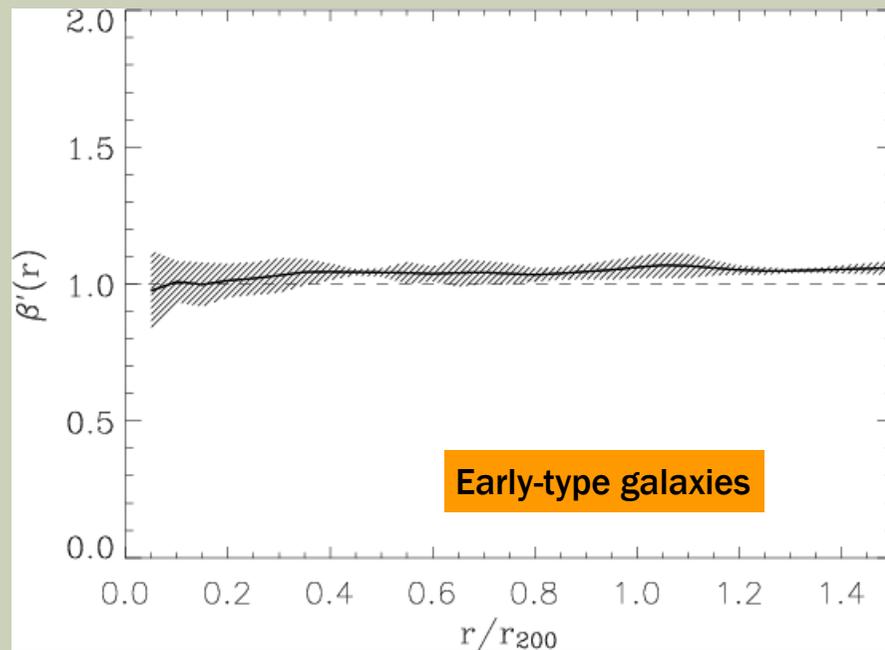
$$\beta(r) \equiv 1 - \frac{\langle v_t^2 \rangle(r)}{\langle v_r^2 \rangle(r)},$$



$$\beta' \equiv \left(\langle v_r^2 \rangle / \langle v_t^2 \rangle \right)^{1/2} \equiv (1 - \beta)^{-1/2}.$$

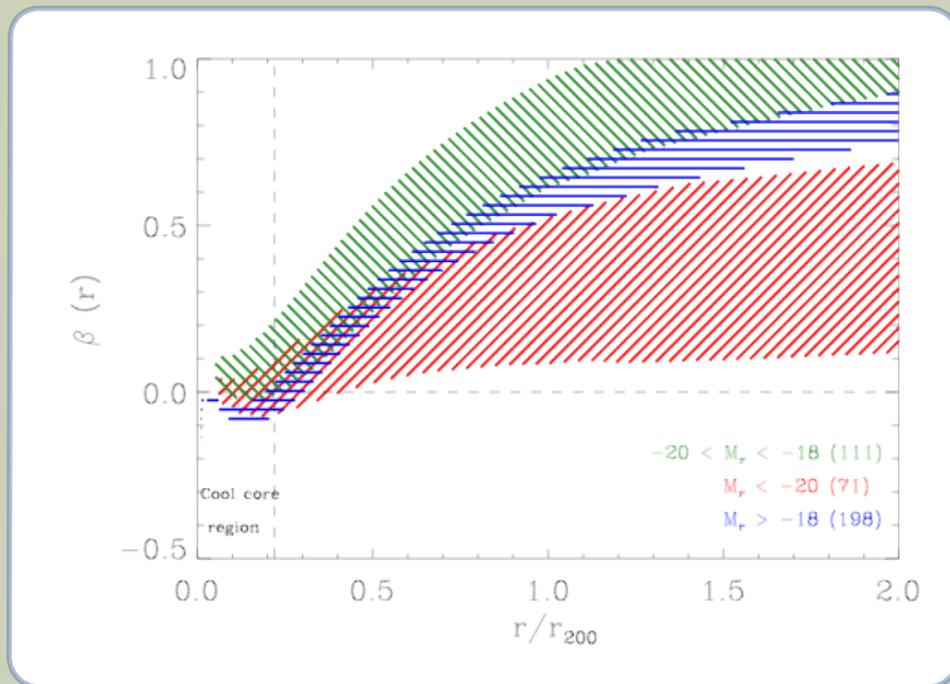
See e.g. Binney & Mamon 1982;
Solanes & Salvador-Sodr e 1990;
Biviano & Katgert 2004

KINEMATIC DECOUPLING OF GALAXIES IN CLUSTERS.

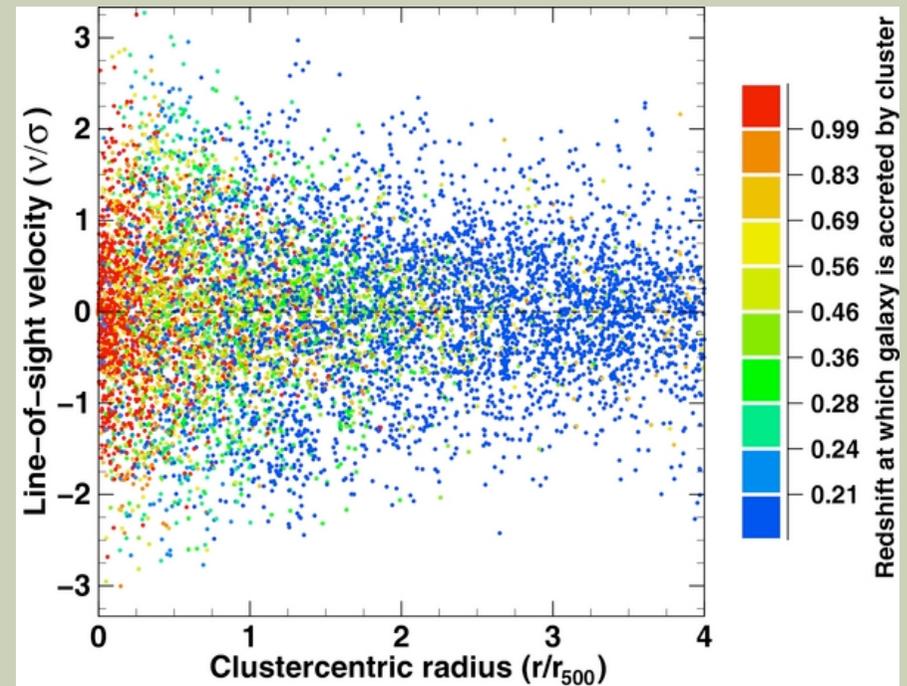


- **Different orbits:** Early-type galaxies are located in more isotropic orbits than late-type spirals. (Adami et al. 1998; Biviano & Katgert 2004)
- Results from ENACS survey (Katgert et al. 2002). Focused on bright galaxies.
- Which is the orbital structure of dwarf galaxies in clusters?

KINEMATIC DECOUPLING OF LOW-MASS HALOS IN A85



Aguerri et al. 2015 in prep



Haines et al. 2012

CONCLUSIONS

- MOS instrument like WEAVE will allow us to obtain deep, large and systematic spectroscopical surveys of galaxies in very different environments and down to the dwarf regime (M^*+6)
- WEAVE cluster surveys are planning in order to bright light to big questions about galaxy evolution in galaxy clusters
 - Formation and evolution of dwarf galaxies in nearby clusters
 - Galaxy evolution in the outskirts of galaxy clusters
 - Galaxy evolution in the clusters cores in the last 6 Gyr