Fossil Group Origins (FOGO) project: a multiwavelength view of fossil galaxy aggregations

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FOGO

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The "Fossil Group Origins" (FOGO) project

MAIN GOAL:
multiwavelength study of a large sample of FGs, spanning a wide mass and redshift range.

FOGO

Numerical simulations:
Compare theory with observations

Luminosity Functions:
Do FGs have peculiar LFs?

Substructures:
Are FGs old and dynamically relaxed systems?

Formation of the BGGs:
How and when did they form?
Are BGGs in FGs similar to those of non-FGs?

Global properties of FGs:
Are FGs a new type of systems or do they follow the same correlations of regular groups/cluster?

Properties of the intragroup gas:
Which is the mechanism driving the metallicity enrichment of the ICM? Are there cooling cores in FGs?

The sample and observations

Santos et al. (2007) sample selected from the SDSS

wide redshift range
$0.1 < z < 0.5$

34 FG candidates

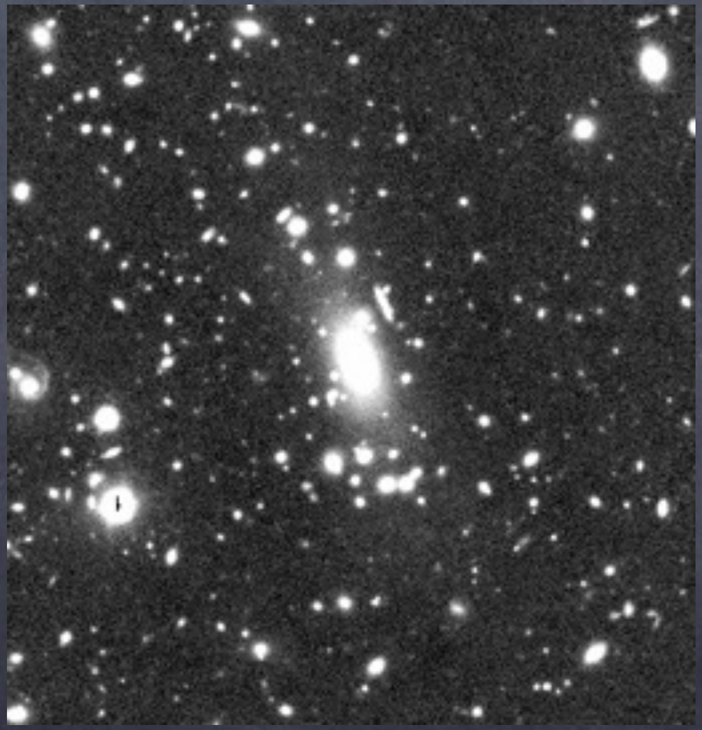
wide X-ray luminosity range
$10^{42} < Lx < 10^{44}$ erg s^{-1}

wide magnitude range for the BGGs
$-21.5 > M_r > -25.5$

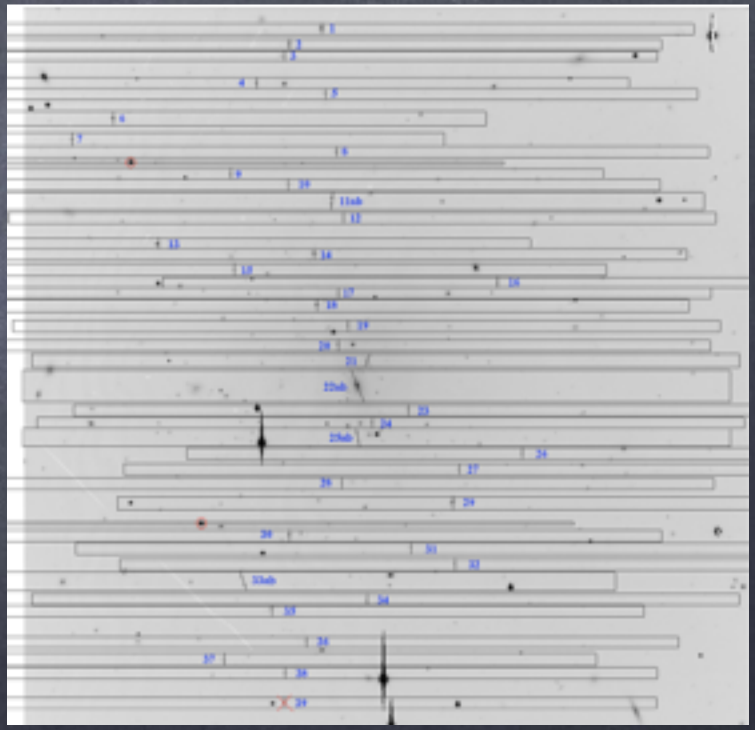
Aguerri et al. (2007) sample selected from SDSS

78 nearby ($z < 0.1$) groups and clusters with spectroscopically-confirmed Δm_{12}

SDSS data u,g,r,i,z
mag. lim. 21.5 r-band

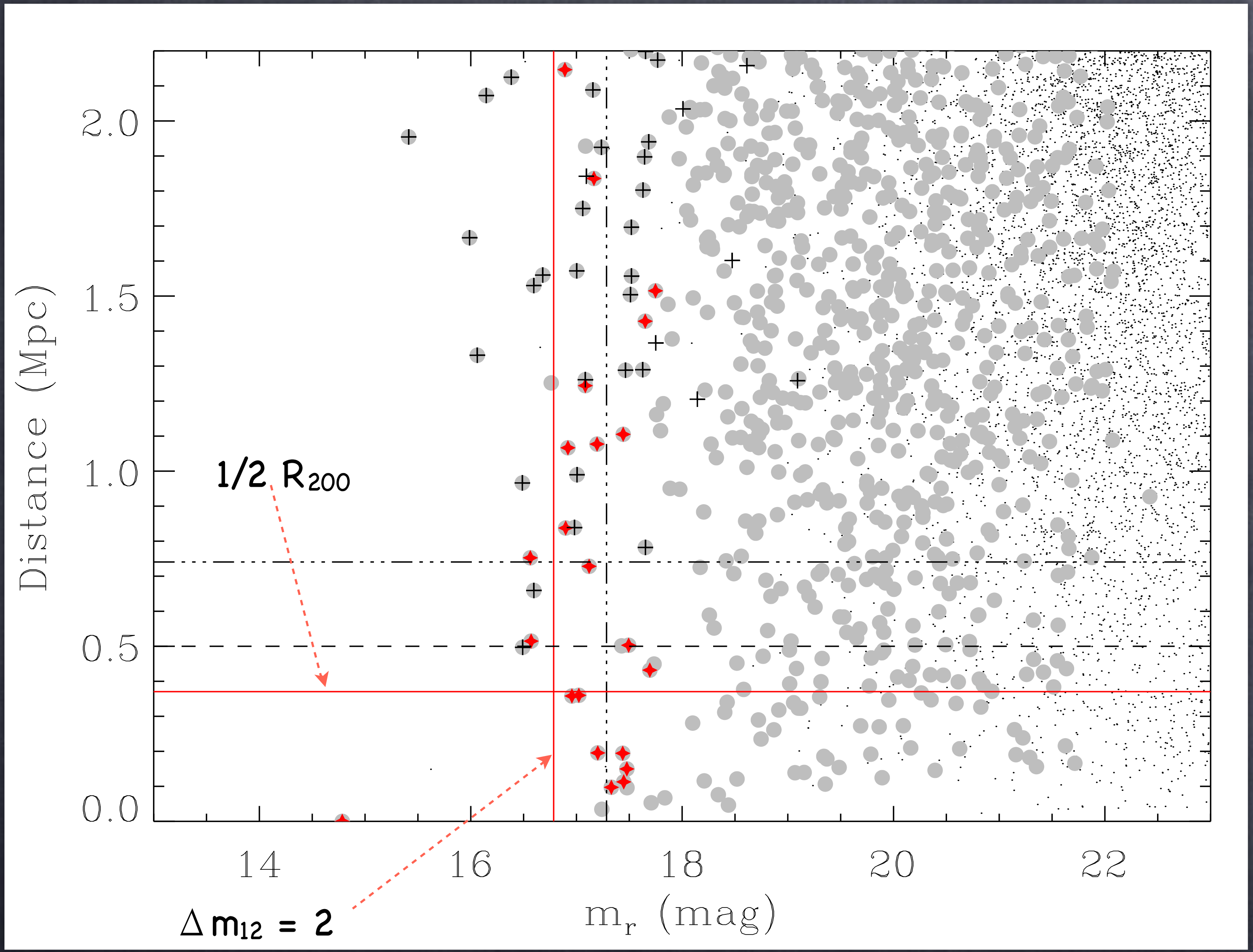


NOT/INT data for 32 systems, mag. lim.
~ 25 r-band



~ 5000 spectra from SDSS DR7 (down to $m_r \sim 18$ and out to 4 R_{200}) plus ~ 1200 new spectra of possible members down to $m_r \sim 21$ mag

Magnitude gap determination



FOGO I: Aguerri+11

Black dots = all galaxies

Grey circles = possible members

Red stars = spectroscopically-confirmed members

Black crosses = spectroscopically-confirmed non-members

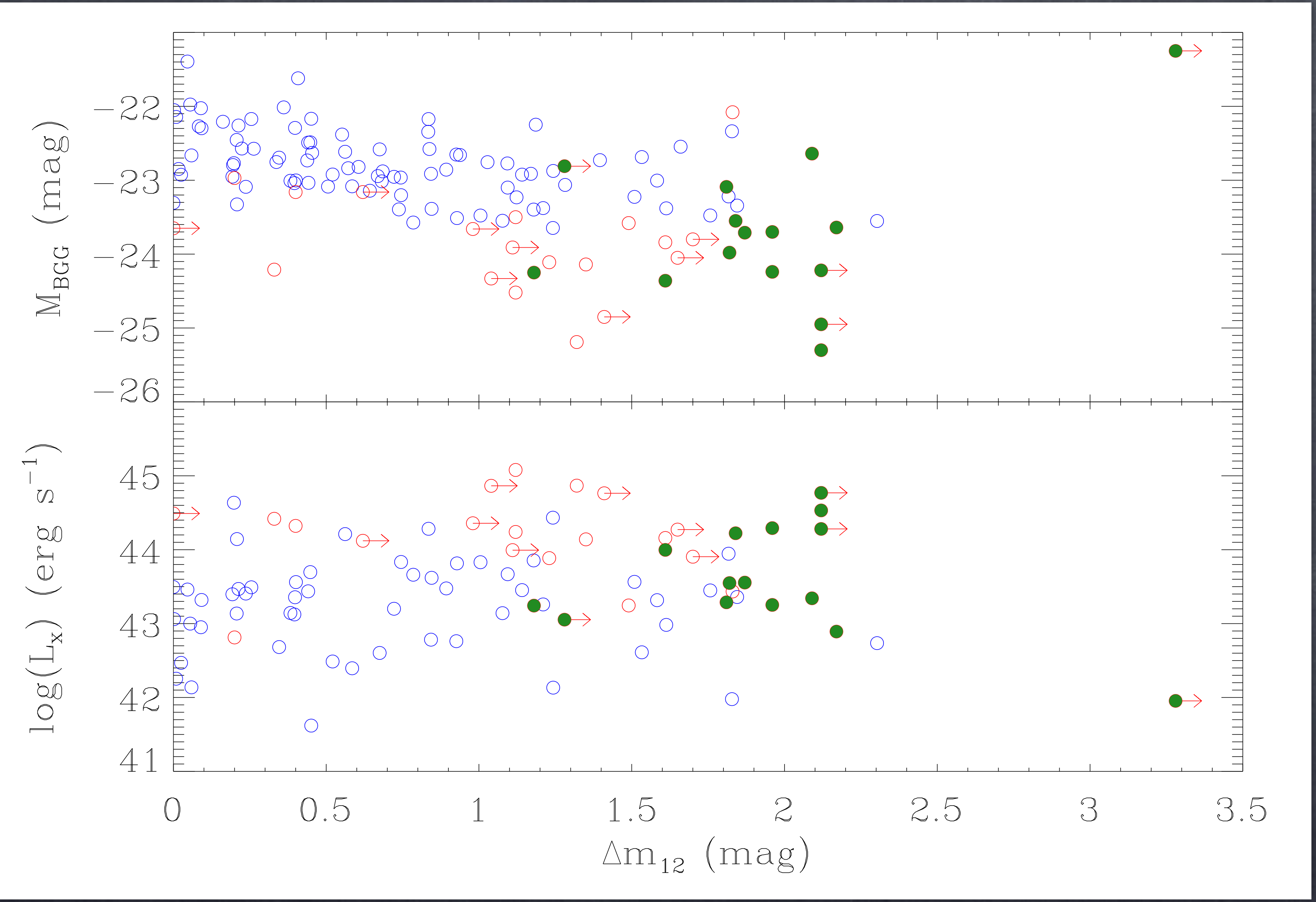
Fossil Criteria:

Δm_{12} > 2 mag (Jones+03)

Δm_{14} > 2.5 mag (Dariush+10)

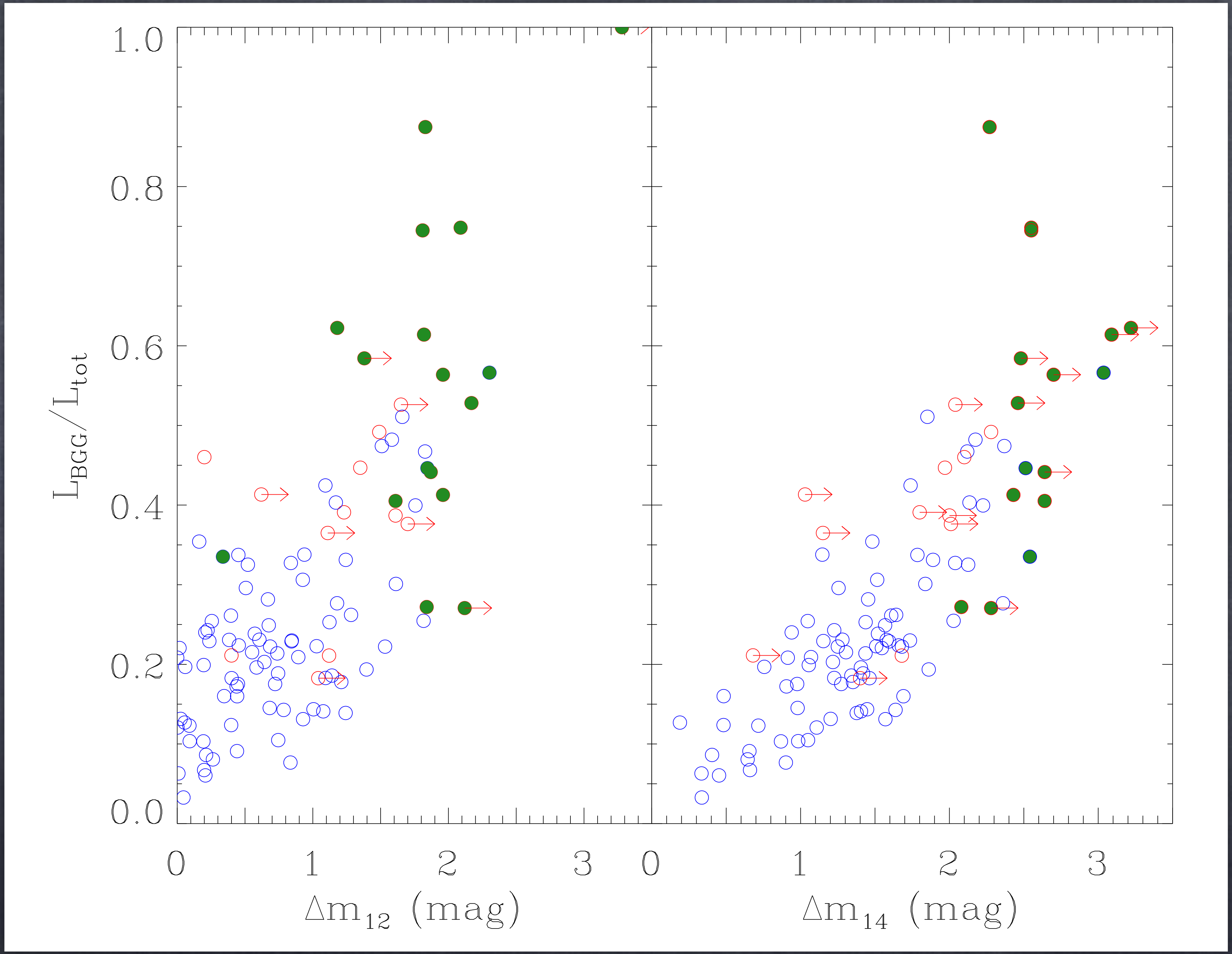
15 confirmed FGs

Global properties # 1



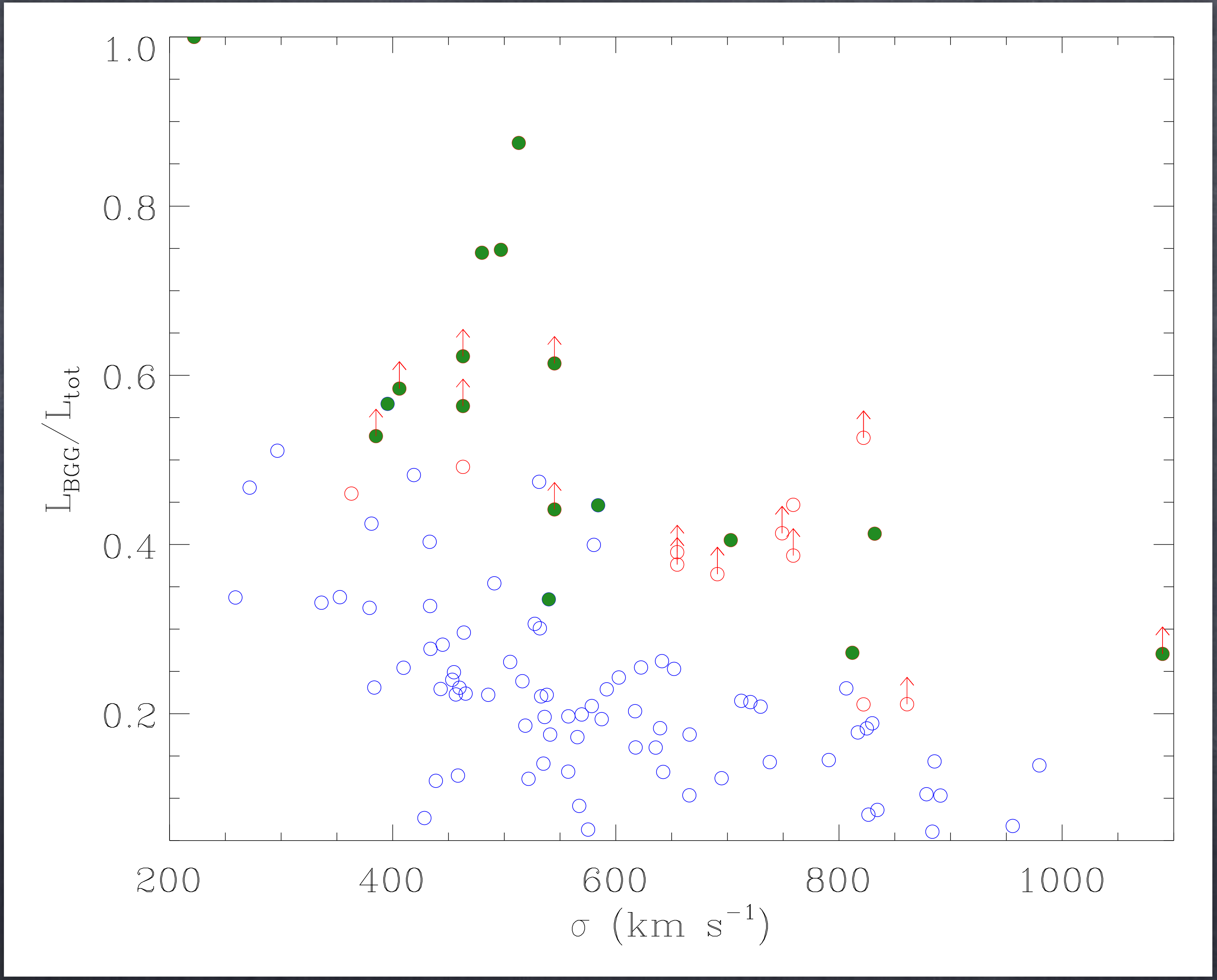
FOGO III: Zarattini+14

Global properties # 2



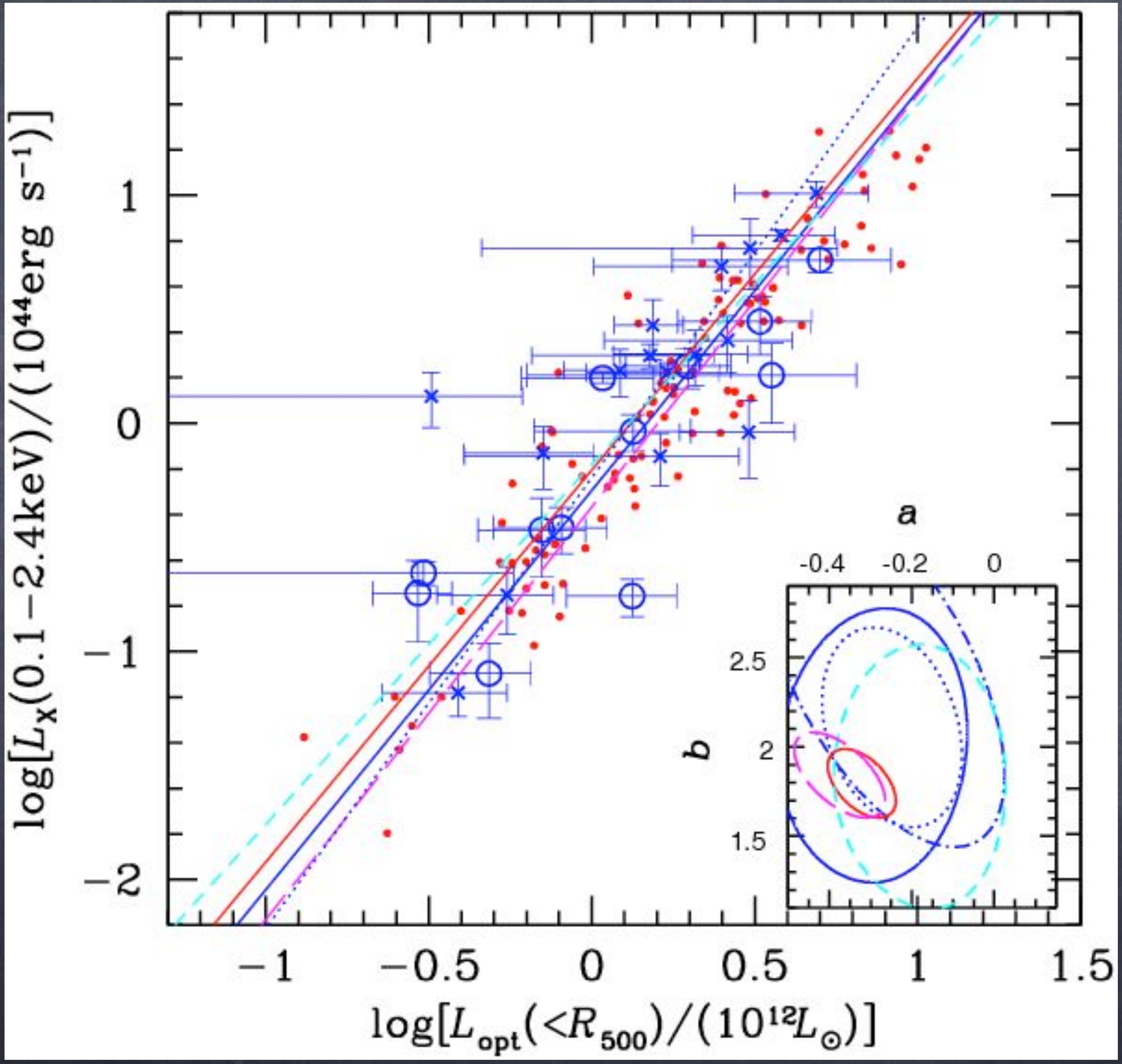
FOGO III: Zarattini+14

Global properties # 3



FOGO III: Zarattini+14

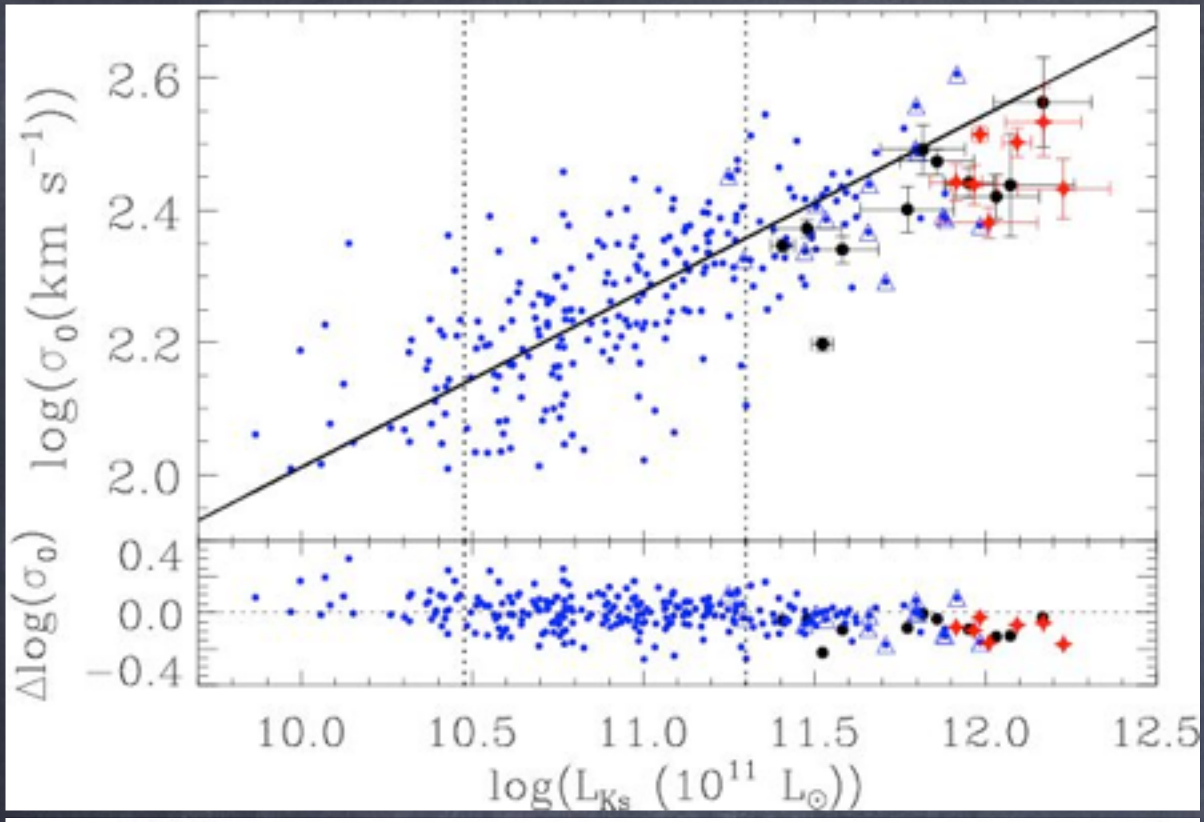
Global properties # 4

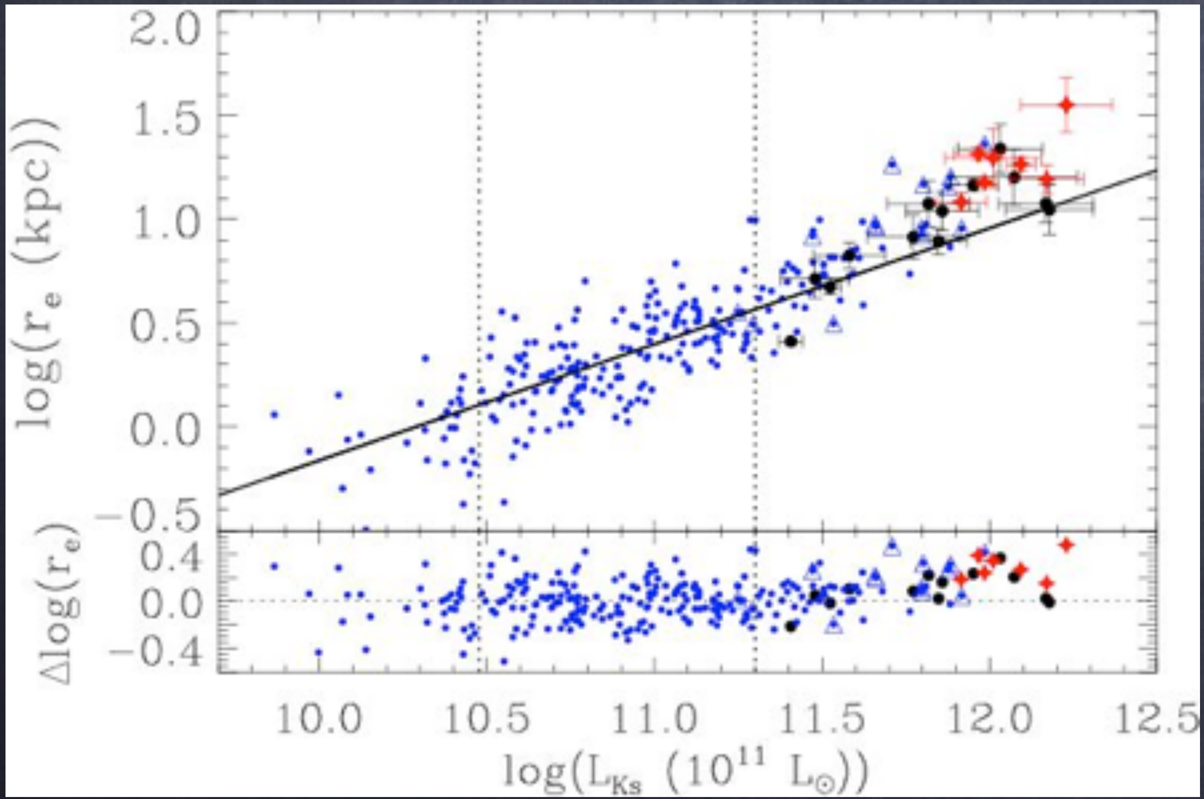


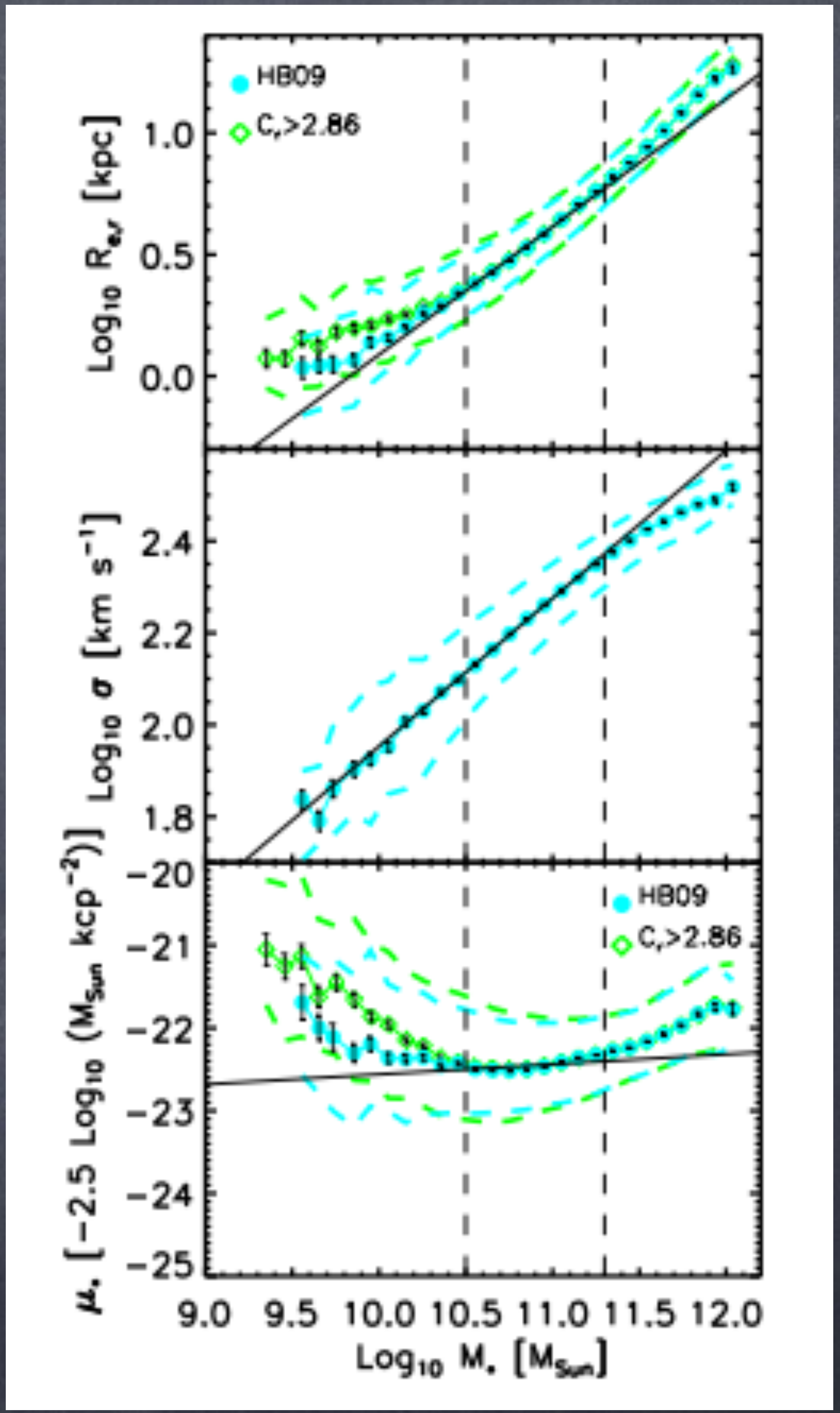
FOGO IV: Girardi+14

Global properties # 5

Bernardi+11







FOGO II: Méndez-Abreu+12

Galaxy luminosity function in Fossil systems

700.000 magnitudes (100.000 also from FOGO) and 6.000 redshifts

$$\varphi_j = N_{m,j} + (N_j - N_{v,j}) \times P_j$$

Velocity
Photometry

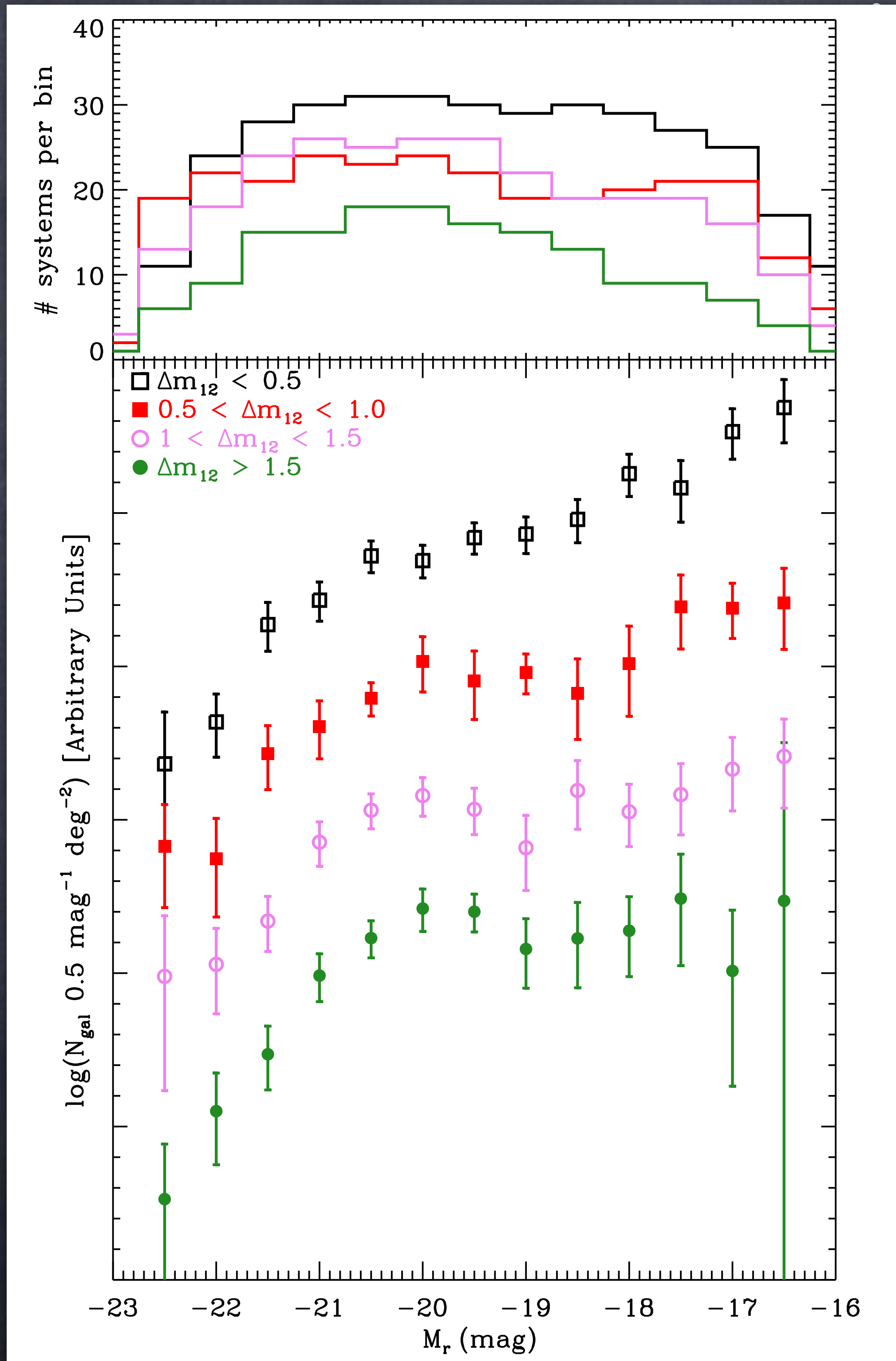
$$P_j = (N_j - N_{b,j}) / N_j$$

RESULT: 102 hybrid individual LFs

(all systems with $z < 0.25$, SDSS r-band model magnitudes)

- 31 with $\Delta m_{12} < 0.5$
- 24 with $0.5 \leq \Delta m_{12} < 1$
- 26 with $1 \leq \Delta m_{12} < 1.5$
- 21 with $\Delta m_{12} \geq 1.5$

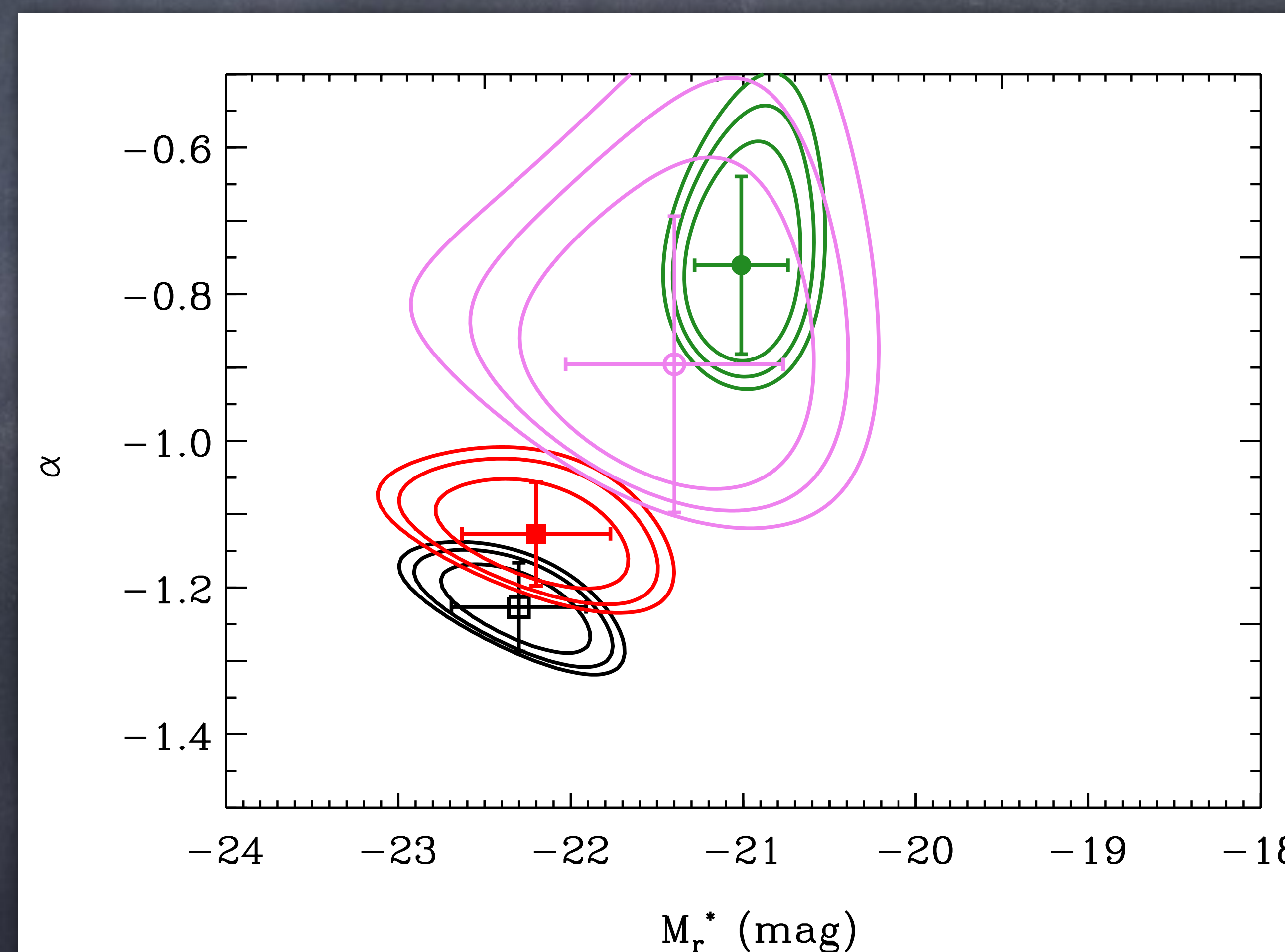
Dependence of the luminosity function on the magnitude gap



Fit of the LFs using the Schechter formula:

$$\varphi(M)dM = \varphi^{*}10^{0.4(M^{*}-M)(\alpha+1)}\exp(-10^{0.4(M^{*}-M)})dM$$

FOGO V: Zarattini+15



Dynamical status of FGs

13 spectroscopically-confirmed FGs with z < 0.25

↓

Are they OLD and dynamically RELAXED systems as predicted by simulations?

1D tests:

Asymmetry Index (AI)
Scale Tale Index (STI)
Weighted gap
1D-DEDICA
V_{BGG}

Applied to 5 FGs with more than 30 members

2D tests:

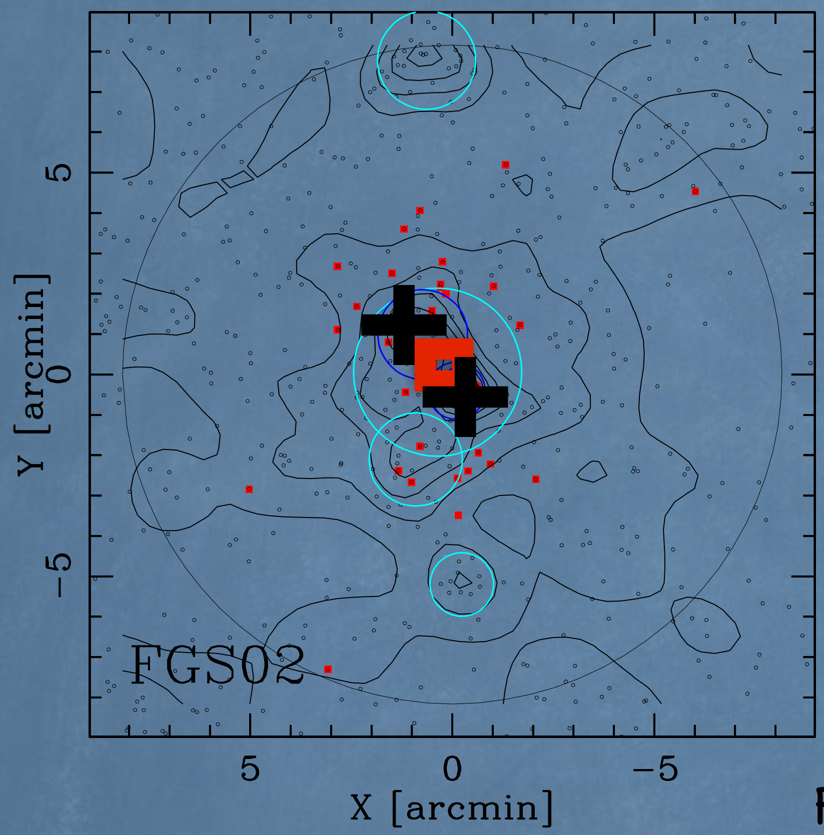
2D-DEDICA
Ellipticity
Voronoi Tessellation and Percolation (VTP)

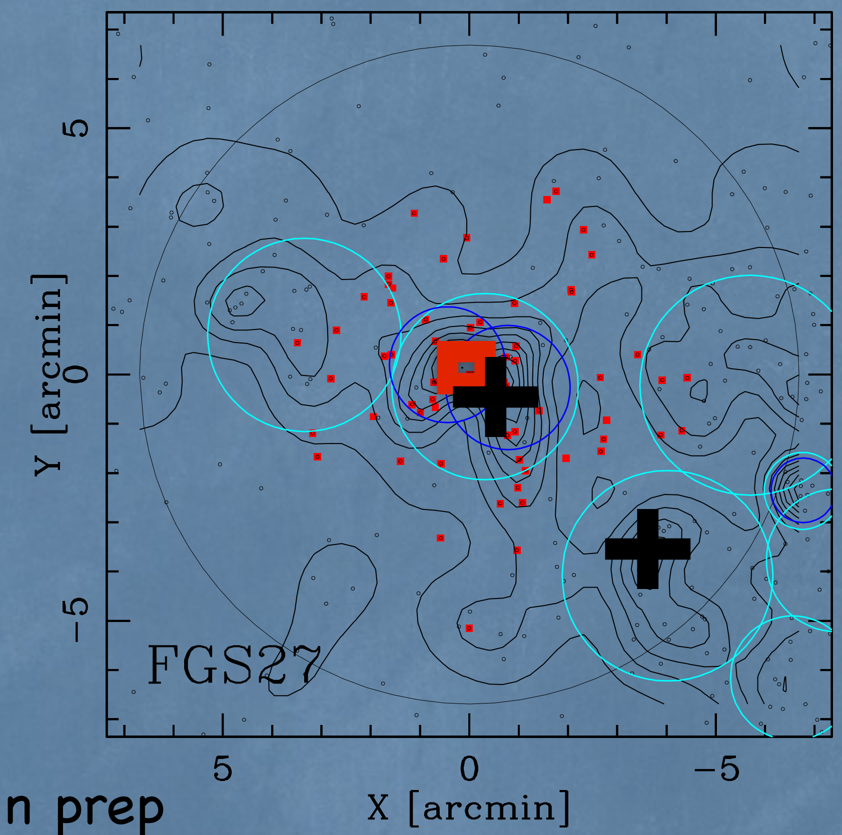
3D tests:

Dressler-Schectman
Velocity gradient

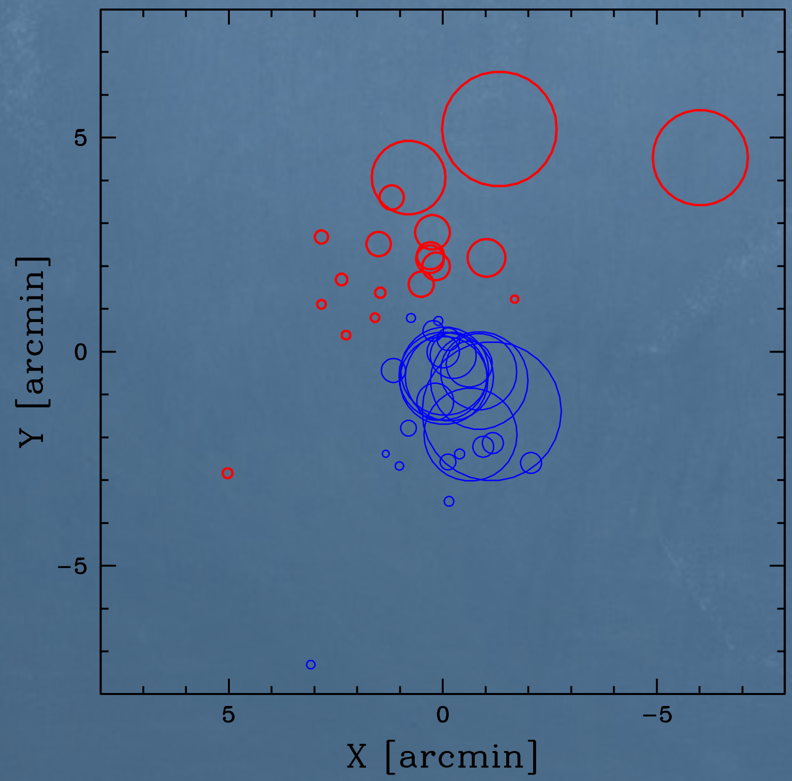
Applied to 5 FGs with more than 30 members

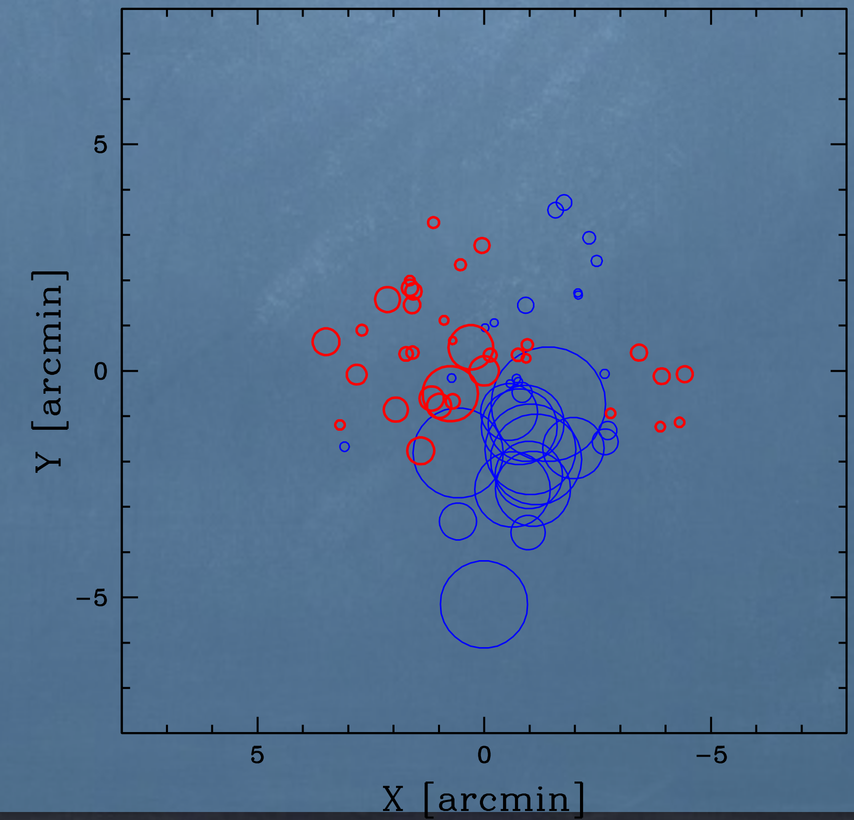
Substructures in FGs: 2D & 3D tests





FOGO V: Zarattini+15 in prep





Substructures in FGs: results

name	AI	STI	weighted gap	1D-DEDICA	V_{BGG}	DS	V_{grad}	2D-DEDICA	VTP	ϵ	BGG
FGS02	N	Y	N	N	N	Y	N	Y	Y	N	N
FGS03	-	-	-	-	-	-	-	N	N	N	N
FGS14	N	Y	N	N	Y	N	N	Y	N	N	N
FGS17	-	-	-	-	-	-	-	N	N	N	N
FGS20	-	-	-	-	-	-	-	N	N	N	N
FGS23	N	N	N	Y	N	N	N	N	N	N	N
FGS26	-	-	-	N	-	-	-	N	Y	N	N
FGS27	N	N	N	N	N	Y	N	Y	Y	Y	N
FGS28	-	-	-	-	-	-	-	-	-	-	Y
FGS29	-	-	-	-	-	-	-	N	N	N	N
FGS30	N	Y	N	N	N	N	N	N	Y	Y	N
FGS32	-	-	-	-	-	-	-	N	N	N	N
FGS34	-	-	-	-	-	-	-	Y	N	N	N

Substructures in FGs: results

name	AI	STI	weighted gap	1D-DEDICA	V_{BGG}	DS	V_{grad}	2D-DEDICA	VTP	ϵ	BGG
FGS02	N	Y	N	N	N	Y	N	Y	Y	N	N
FGS03	-	-	-	-	-	-	-	N	N	N	N
FGS14	N	Y	N	N	Y	N	N	Y	N	N	N
FGS17	-	-	-	-	-	-	-	N	N	N	N
FGS20	-	-	-	-	-	-	-	N	N	N	N
FGS23	N	N	N	Y	N	N	N	N	N	N	N
FGS26	-	-	-	N	-	-	-	N	Y	N	N
FGS27	N	N	N	N	N	Y	N	Y	Y	Y	N
FGS28	-	-	-	-	-	-	-	-	-	-	Y
FGS29	-	-	-	-	-	-	-	N	N	N	N
FGS30	N	Y	N	N	N	N	N	N	Y	Y	N
FGS32	-	-	-	-	-	-	-	N	N	N	N
FGS34	-	-	-	-	-	-	-	Y	N	N	N

Each FG gives at least one positive result for the presence of substructures when velocities are considered

Substructures in FGs: results

name	AI	STI	weighted gap	1D-DEDICA	V_{BGG}	DS	V_{grad}	2D-DEDICA	VTP	ϵ	BGG
FGS02	N	Y	N	N	N	Y	N	Y	Y	N	N
FGS03	-	-	-	-	-	-	-	N	N	N	N
FGS14	N	Y	N	N	Y	N	N	Y	N	N	N
FGS17	-	-	-	-	-	-	-	N	N	N	N
FGS20	-	-	-	-	-	-	-	N	N	N	N
FGS23	N	N	N	Y	N	N	N	N	N	N	N
FGS26	-	-	-	N	-	-	-	N	Y	N	N
FGS27	N	N	N	N	N	Y	N	Y	Y	Y	N
FGS28	-	-	-	-	-	-	-	-	-	-	Y
FGS29	-	-	-	-	-	-	-	N	N	N	N
FGS30	N	Y	N	N	N	N	N	N	Y	Y	N
FGS32	-	-	-	-	-	-	-	N	N	N	N
FGS34	-	-	-	-	-	-	-	Y	N	N	N

Each FG gives at least one positive result for the presence of substructures when velocities are considered

When only positions are considered, several FGs give positive results

Conclusions

1.- Galaxy population properties of FGs:

The main differences in the galaxy population between FGs and non-FGs are in the two extremes of the galaxy luminosity function

BGGs: Fossil systems host the most central luminous galaxies

The BGGs in FGs have larger fraction of stars than BGGs in non-FGs

BGGs in FGs have grown by accreting L* nearby galaxies

Dwarfs: The faint-end slope of the galaxy LF in FGs is flatter than non-FGs —> different dwarf formation and/or evolution??

2.- Properties of the FGs halos:

Fossil systems at all mass ranges

Halos of Fossil and non-fossil systems with similar global X-ray scaling relations

3.- Dynamics of FGs

Not all Fossil systems are dynamically relaxed objects