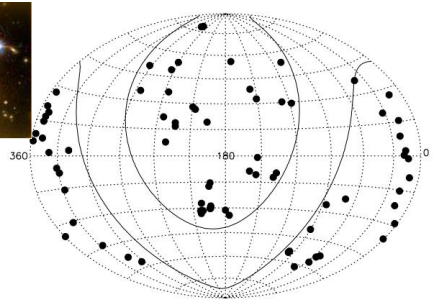
Stellar populations of galaxies in the WINGS and PM2GC surveys

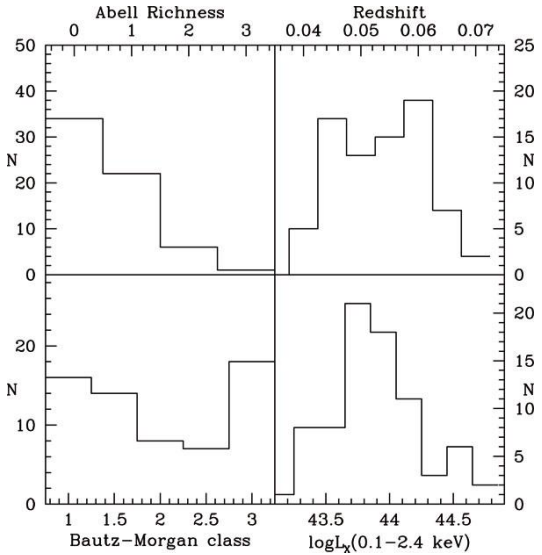
Alessia Moretti for the WINGS team



76 clusters
(36 north and 42 south)

Clusters selected from three X-ray flux limited samples from ROSAT all sky survey as having $|b| \geq 20$ and $0.04<z<0.07$

Fasano et al., 2006



Spectroscopic sample for 48 clusters

Fiber spectroscopy with 2dF@AAT or WYFFOS@WHT (2” or 1.6”)

Magnitude limit at V=20

EW measured for ~4400 galaxies, 63% of which are cluster members (belonging to 29 clusters)

NB Maximum distance from cluster center ~0.5 R_{200}

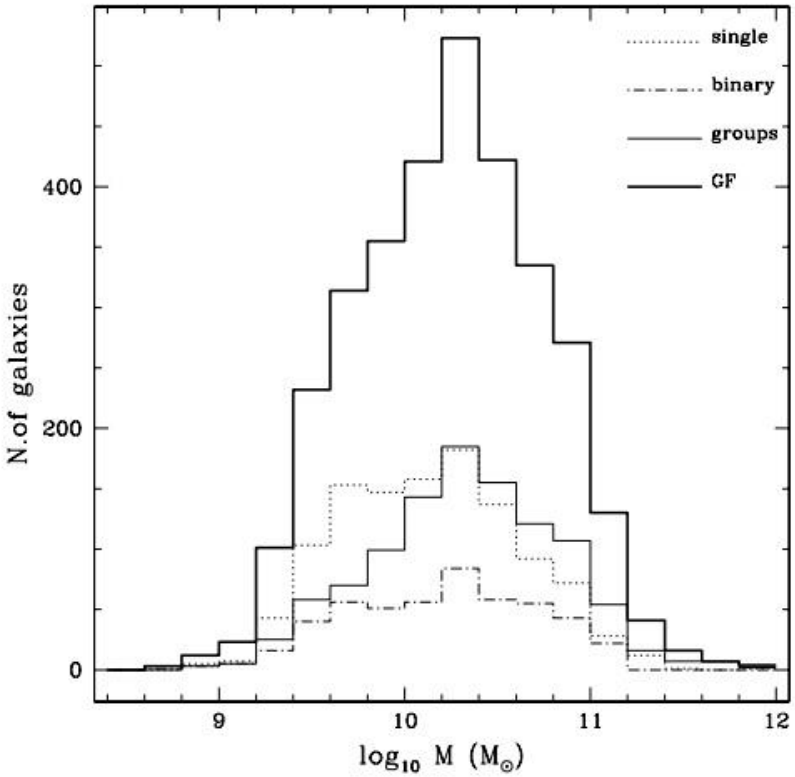
Images, photometric catalogs (opt, J,K), morphologies, structural parameters, redshifts, EWs, SFHs available to the community through VO (Moretti et al., 2014)

The WINGS survey

3210 galaxies extracted from the MGC catalog (Liske et al., 2003) as having

- $M_B < -18.7$
- $0.03 < z < 0.11$

The sample is photometrically deep and spectroscopically complete, and is representative of the general field population in the local universe.
FoF algorithm used to classify them as isolated/binaries/group/general field (Calvi et al., 2011)



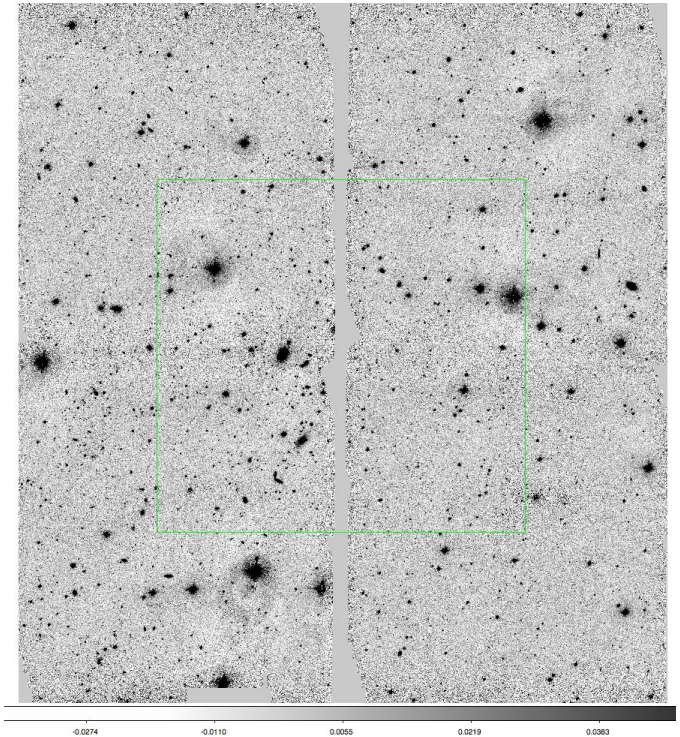
The PM2GC sample (Padova Millennium Galaxy and Group Catalog)

u', B and V OmegaCAM imaging for all clusters observable from Paranal (59/76)

2 observing programs in GTO time (PI Poggianti, D' Onofrio)

45 already observed and reduced (B, V)

-> New spectroscopic follow-up with AAOMEGA@AAT



1 deg

1 deg

OMEGAWINGS

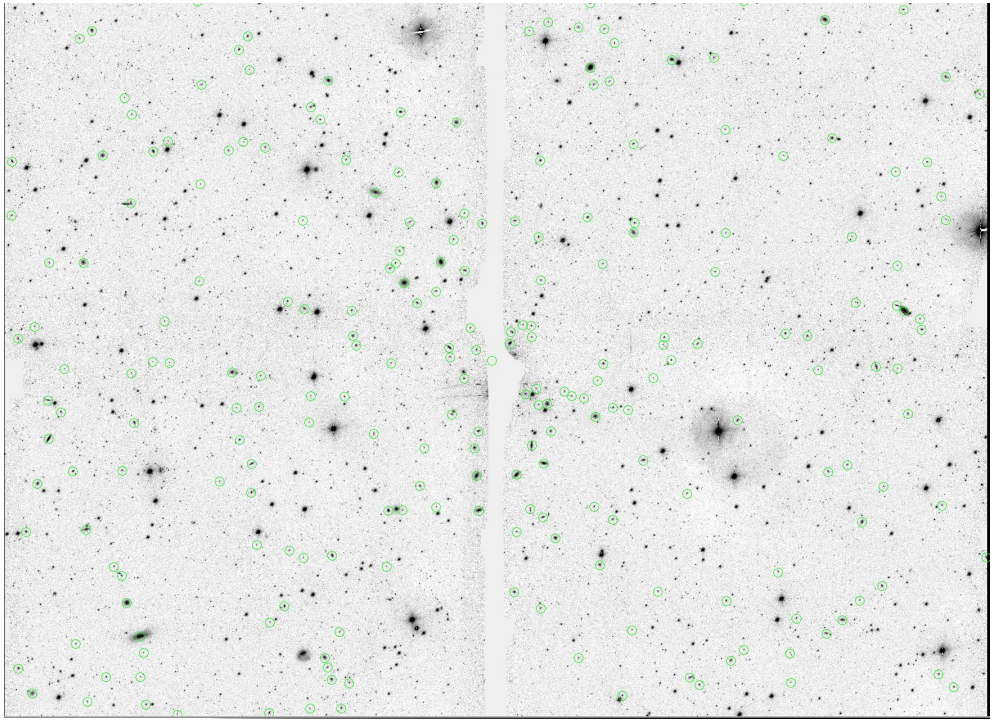
u', B and V OmegaCAM imaging for all clusters observable from Paranal (59/76)

2 observing programs in GTO time (PI Poggianti, D'Onofrio)

45 already observed and reduced (B, V)

-> New spectroscopic follow-up [ONGOING] with AAOMEGA@AAT [~400 fibers, 2deg^2 FoV]

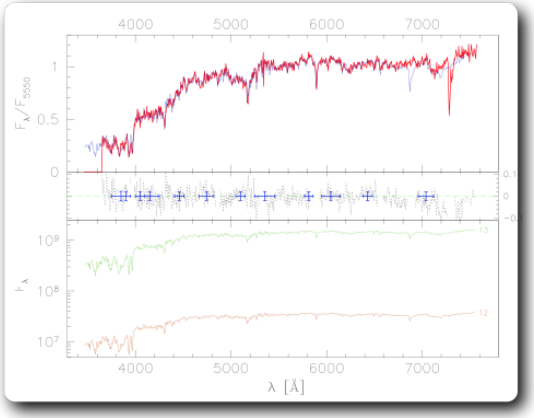
10500 target galaxies with V<20, divided into bright and faint configurations according to the fiber magnitude
9851 measured redshifts (>90% z completeness)
4902 new cluster members

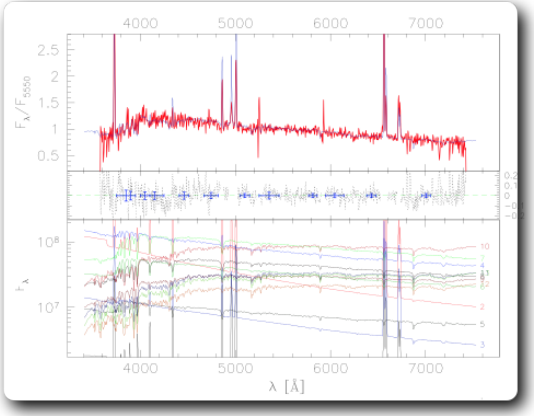


-> new cluster velocity dispersions
-> looking for substructures (out to ~R_{200})

OMEGAWINGS

- Measures spectral features (continuum flux, absorption & emission lines)
- Reproduces them by summing SSPs spectra of different ages and common Z
- 3 values of metallicity explored





- each spectrum is multiplied by a given stellar mass
- it is then extinguished with a given Av value (uniform slab)
- the spectra are then summed
- and the result compared to observed quantities
- repeated until best fit is found (adaptive simulated annealing)

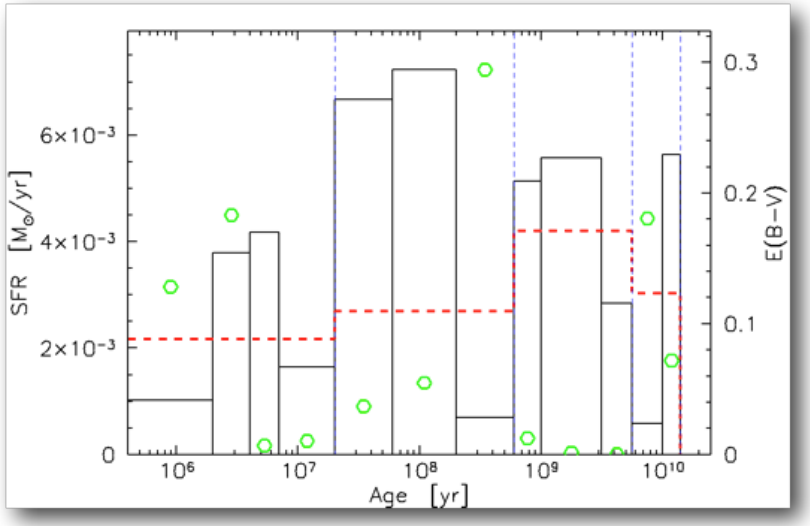
Red: observed spectrum, blue: model spectrum
Lower panel: set of SSPs used to build the model spectrum
Middle: residuals and continuum bands

SINOPSIS (SImulatiNg OPtical Spectra wIth Stellar populations models)

SFH prescription

Free-form

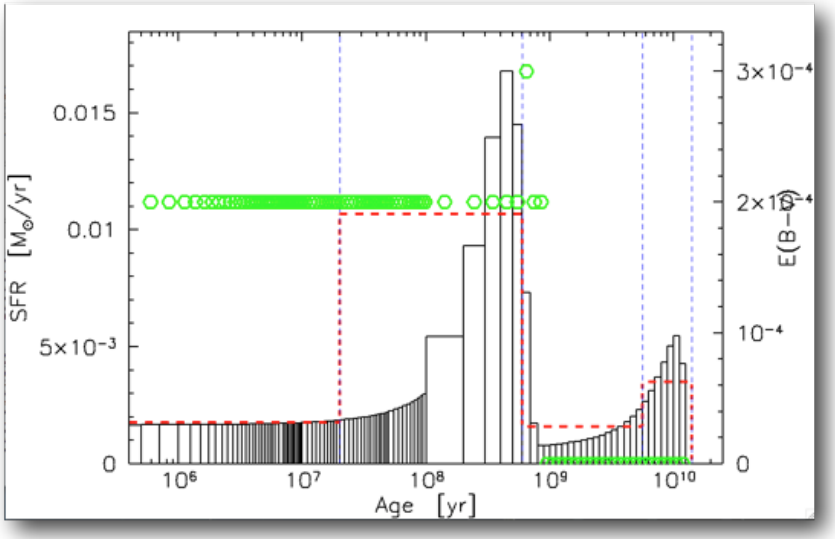
12 SFR values
12 Av values
homogeneous Z (x3)
adjustable extinction law



Analytical

Up to 108 SSP of different ages

Double exponential



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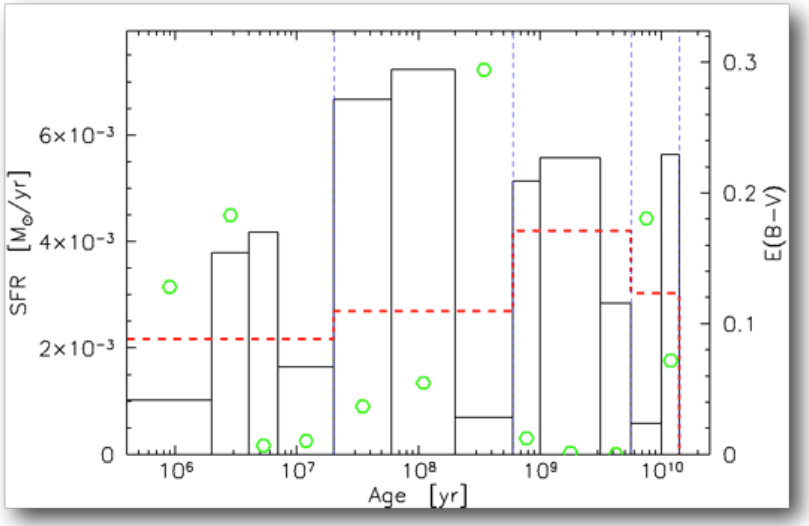
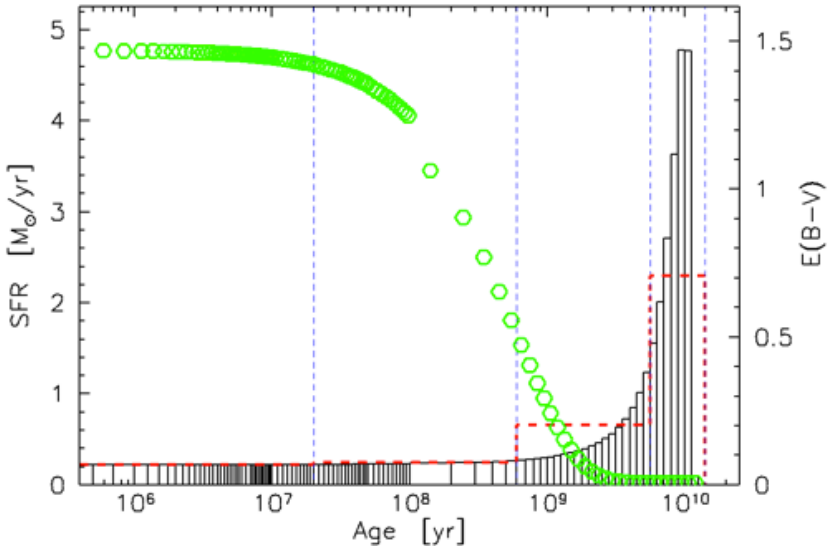


Analytical

Up to 108 SSP of different ages

Double exponential or lognormal



SINOPSIS (SImulatiNg OPtical Spectra wIth Stellar populations models)

INPUT

- spectra or
- spectra + photometry (up to 3 μ)

Will be upgraded to cope with

- dust emission in the IR
- photometric data only

OUTPUT

- Stellar mass (3 definitions: total mass turned into stars, mass of living stars+remnants, mass of living stars)
- Recent star formation (the last 2e7 yr)
- Star Formation History (SFR in 4 age bins)
- Dust attenuation
- Average ages (luminosity and mass-weighted)

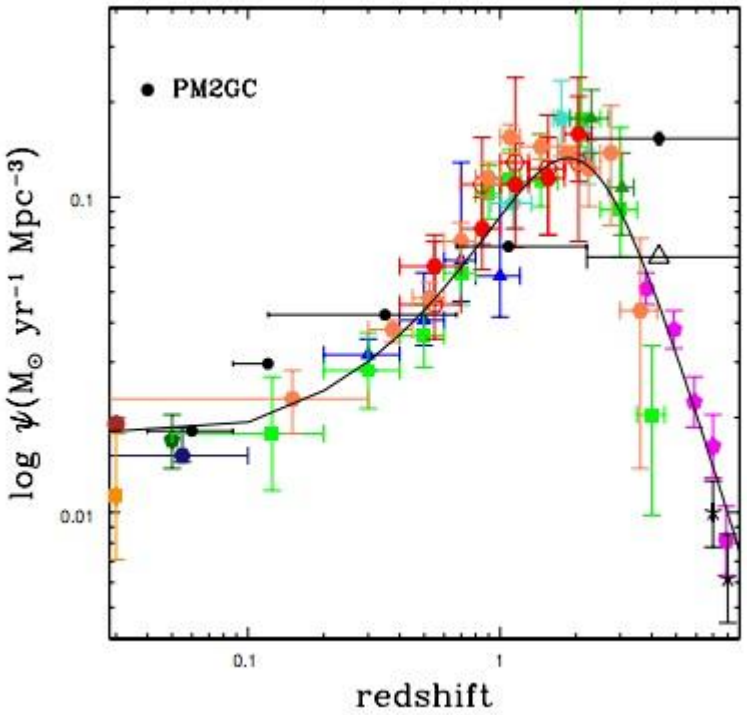
SINOPSIS can be downloaded here
http://users.ugent.be/~jfritz/jfhp/SINOPSIS.html
see also Fritz et al., 2007; 2011 for further details

SINOPSIS (SImulatiNg OPtical Spectra wIth Stellar populations models)

SFH of each galaxy derived from the 12 age bins defining 5 age macro-bins, into which the SFR is considered constant (i.e. mean value of SFR in that time interval).
For these 5 age bins derived SFR density (using the appropriate comoving volume)

-> WINGS sample restricted to only members, same magnitude limit as PM2GC (Mv<-18.7), spectroscopic completeness taken into account, all scaled to Salpeter IMF from 0.1 to 100 Msun to be compared with literature

Guglielmo et al., in prep.



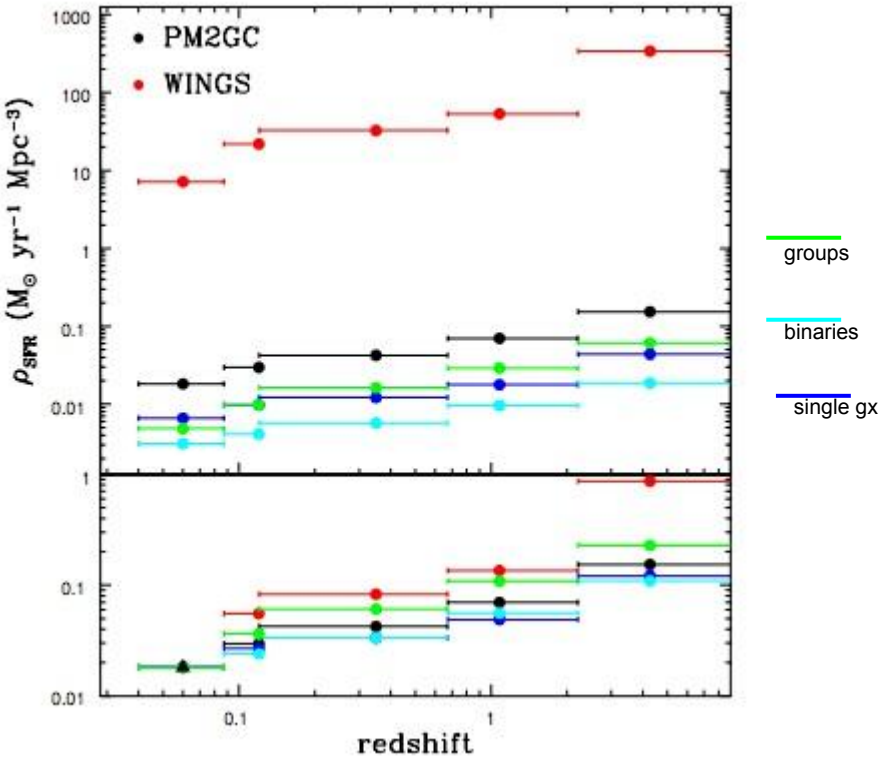
The cosmic SFH derived from PM2GC agrees with the most recent literature (Madau & Dickinson 2014)

Results: (cosmic) star formation histories

The cluster SFR density is much higher than the field one at any redshift (because clusters host more galaxies and hence mass wrt groups and field)

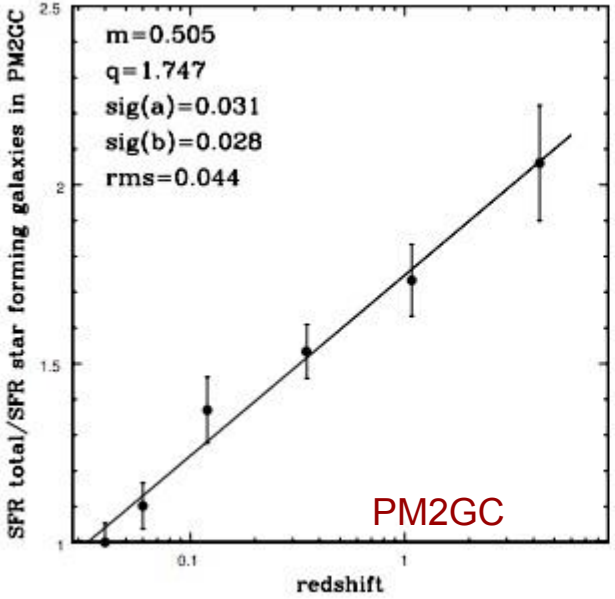
If normalizing at the z=0 value
SFR higher at high redshift
decline steeper in clusters than in the field: ~⅔ of cluster stars were formed before z=2, while more than 50% of field stars are formed at z<2

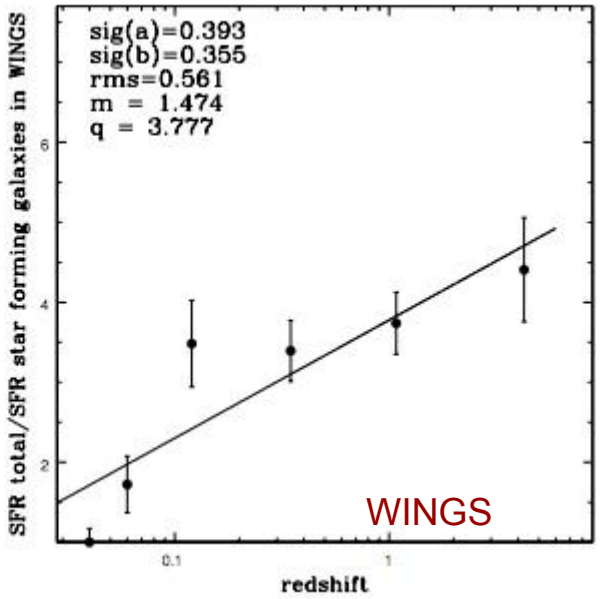
Can we disentangle the effects of declining SF in star forming galaxies from the increasing number of quenched galaxies?



Results: star formation histories in field and clusters

Comparing the total SFR density with the one of today star forming galaxies (sSFR >$10^{-12}yr^{-1}$ [2094 in the field, 612 in clusters]): linear relation in the field, not linear in clusters + relation much steeper in clusters than in the field => the SF at high redshift is mainly due to galaxies that are not active today (more so in clusters)





Results: star formation histories in field and clusters

Equivalent widths (abs. and em.) measured by SINOPSIS with a fully automated procedure, which is able to properly take into account also the presence of both components in the same line (i.e. Hβ)

SP.TY.	Cat ID	[OII]		Hβ		[OIII]		Hδ	N (%)
e(a)	1	<0	OR	<0	OR	<0	AND	≥4	6.9%
e(b)	2	<−40	OR	< −12.5		...	AND	<4	2.5%
e(c)	3	−40 to 0	OR	−12.5 to 0	OR	<0	AND	<4	29.9%
k	4	>0	...	...	...	...	AND	<3	49.6%
k+a	5	>0	...	...	...	...	AND	3 to 8	10.4%
a+k	6	>0	...	...	...	...	AND	≥8	0.7%

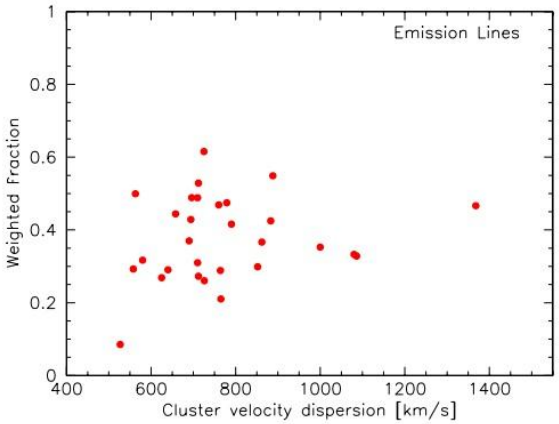
Emission line galaxies
- dusty starburst
- starburst
- star forming (Sp like)

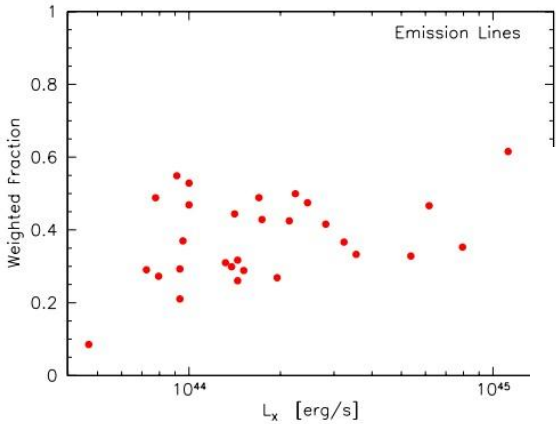
Passive

Post-starburst
Post-starforming

The galaxy population in local clusters is dominated by the k (~50%) and e(c) (~30%) spectral types. The post-starburst classes (k+a and a+k) represent about 11% of all the galaxies, while the two other emission-lines classes, e(a) and e(b), contain 7 and 3% of all members, respectively

Results: equivalent widths (Fritz et al., 2014)

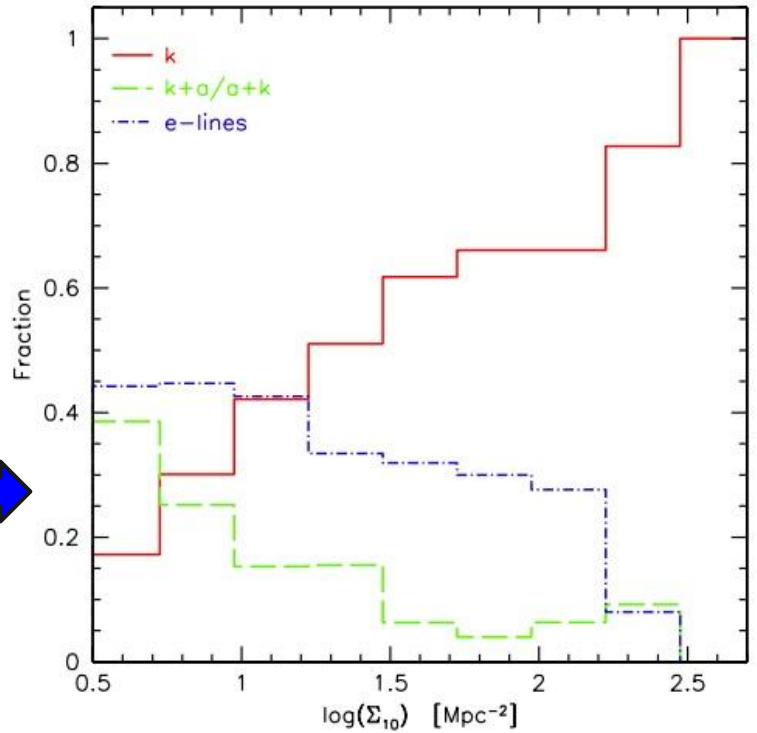




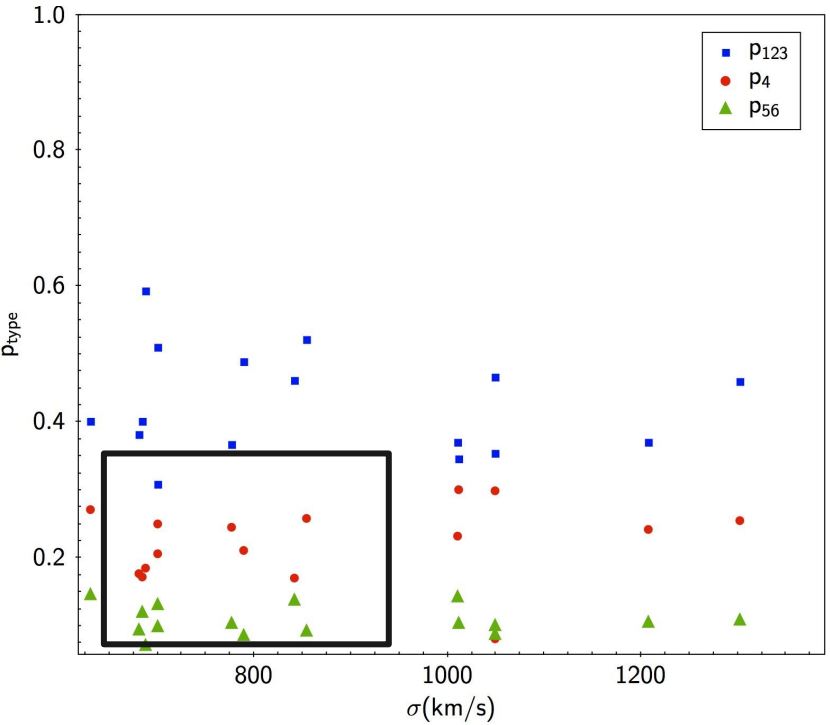
No correlation between the fraction of emission line galaxies (or the fraction of post-starburst) and the global properties of a cluster (at least in this velocity dispersion range)

The morphological mix is clearly a function of the local environment (here the local density calculated from a circular area containing the 10 most nearby galaxies)

Influence of global and local environment



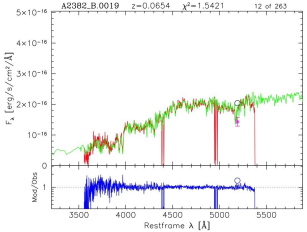
Results: spectral types and cluster environment (WINGS)



Observations and data analysis ongoing

Results from the first 15 clusters with bright and faint configurations

9225 spectra analyzed (SINOPSIS on blue spectrum + 2 bands)



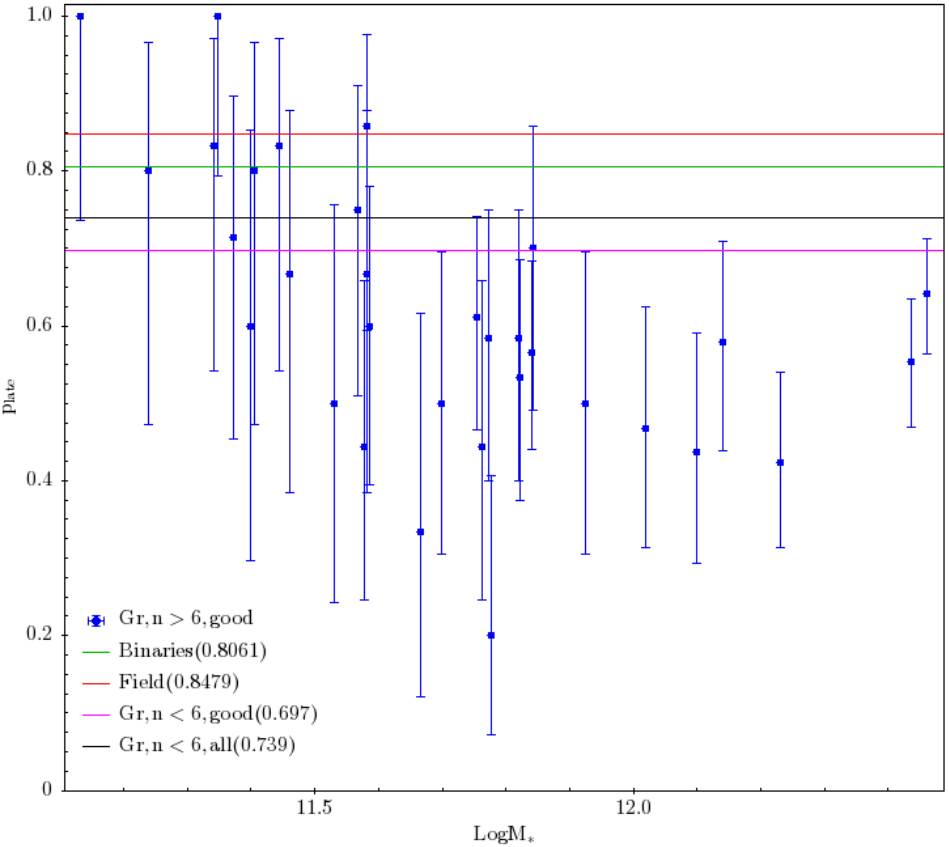
4695 members

-> fraction of passive and post-starburst galaxies constant

-> emission line galaxies decreasing with cluster velocity dispersion (but sample incomplete)

Paccagnella et al., in prep

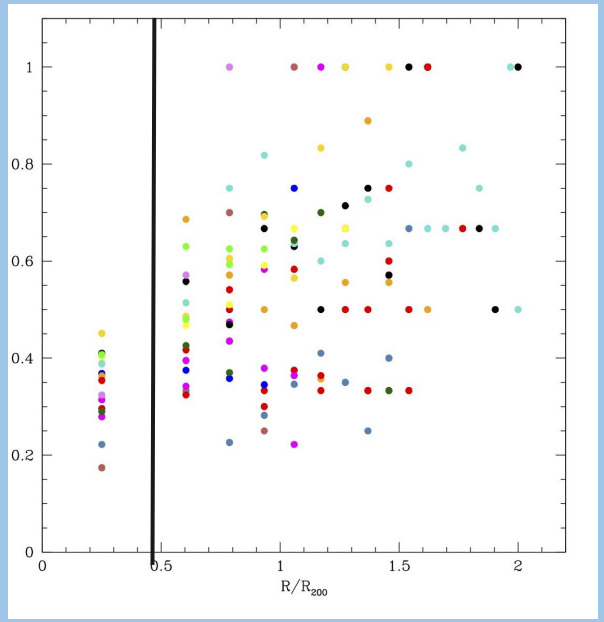
Results: spectral types and cluster environment (ΩWINGS)



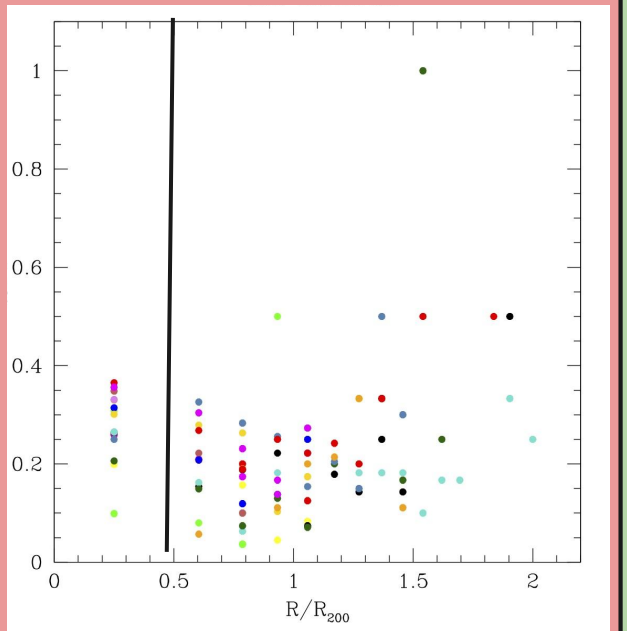
Among the 176 groups found by FoF algorithm in our PM2GC survey we selected those for which the same FoF run on simulations is able to identify the correct number of members (92) + they possess at least 6 members

On the group scale there is a trend for more massive groups hosting a lower fraction of late types

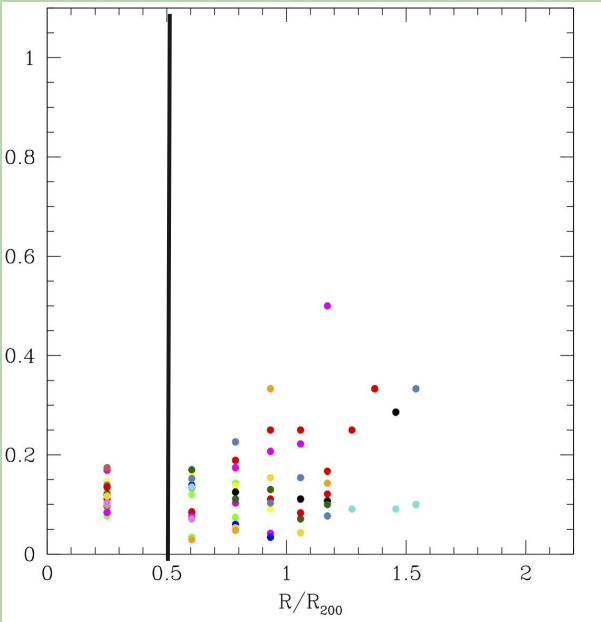
Results: spectral types and groups environment (PM2GC)



Emission line galaxies avoid the central regions



Passive gx gather toward the cluster center, but their fraction is not negligible even in the outskirts



Post-starburst are increasing (?) fraction of galaxies toward the external regions

Results: spectral type at various distances

Summary

To study the influence of environment in shaping galaxy properties we are extending the stellar population analysis to

1) external regions of clusters (out to ~2 R_{200}) [OMEGAWINGS images, AAOMEGA spectra]

2) lower masses environments (groups) [PM2GC]

We find:

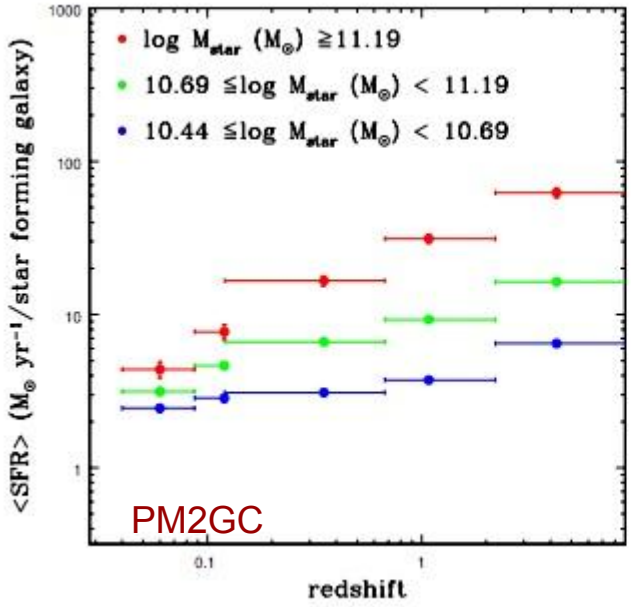
No influence of the “global” environment at least inside 0.5 R_{200} (to be confirmed at larger distances) on cluster scales

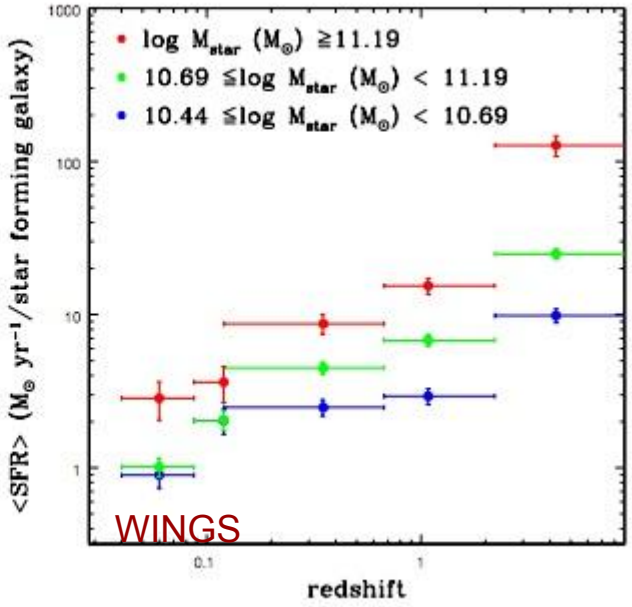
Dependence of properties on “local” environment

Influence of global environment when including lower masses groups

Increasing number of emission lines (+post starburst?) galaxies at R_{200}>1

SF galaxies defined as the ones with sSFR >$10^{-12}yr^{-1}$ [2094 in the field, 612 in clusters], divided into 3 mass bins
-> their average SFR has been declining with time (and more so for more massive galaxies both in clusters and in the field)





Results: star formation histories in field and clusters