Popesso P.
and
Ziparo F., Biviano A., Finoguenov A., Salvato M., Altieri B., Santos J., and the PEP, GOODS-H and XMM2235 teams

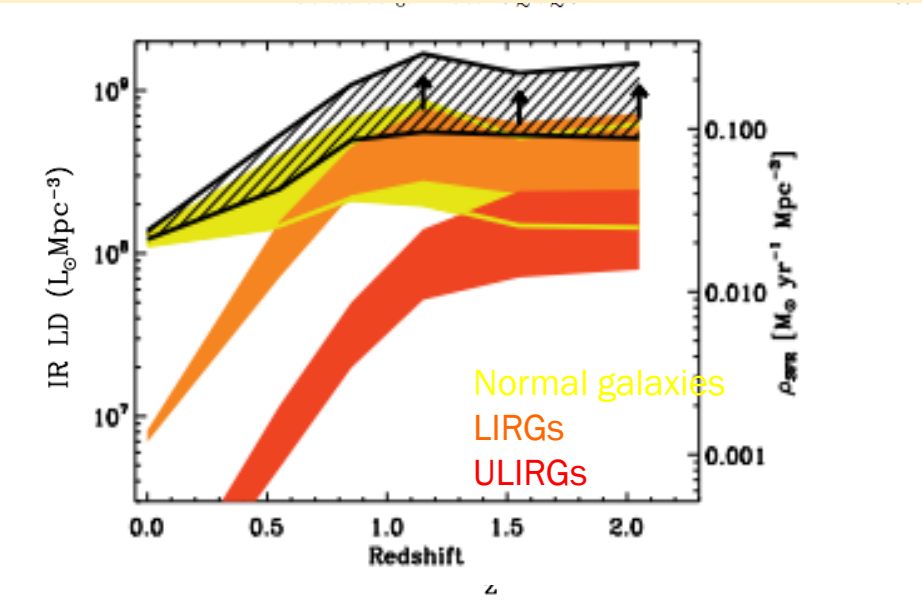
A STAR FORMATION OASIS IN THE MIDDLE OF A CLUSTER DESERT

WHY SUCH A STRANGE TITLE?

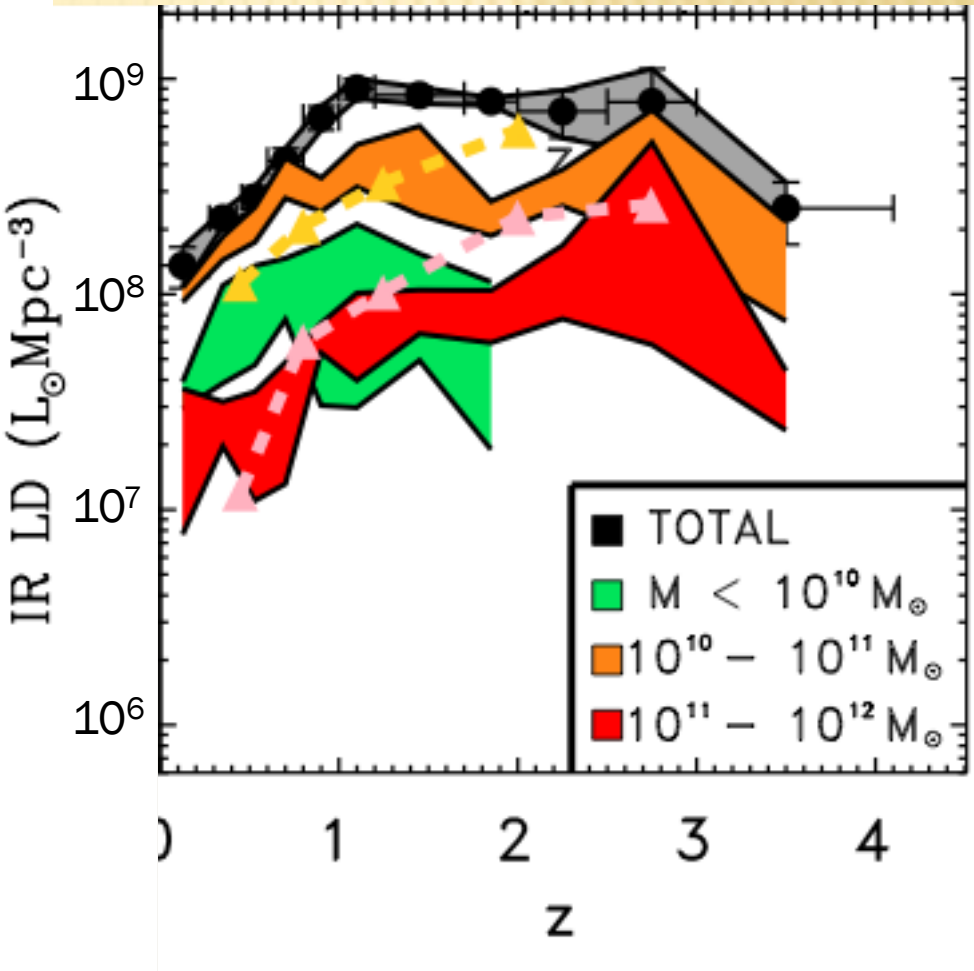
- The Star Formation Rate (SFR)-density relation in the local Universe is a clear anti-correlation (Gomez et al. 2003)

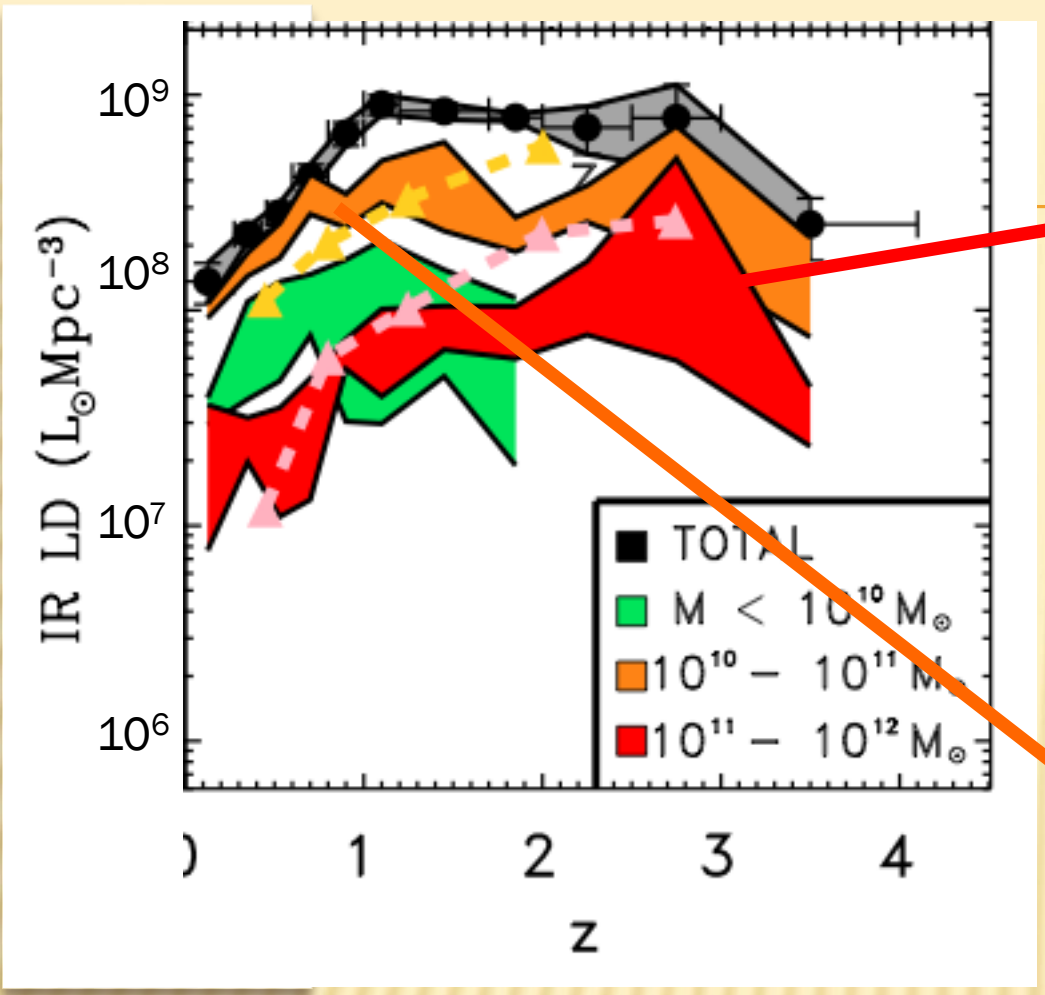
- As we approach the epoch when the quiescent behemoths, typical of cluster and group cores, should be forming the bulk of their stars at $z \geq 1.5$ (“***cluster desert***”), the relation between star formation activity and environment should progressively reverse.

Evolution of the IR Luminosity density (Magnelli et al. 2009)

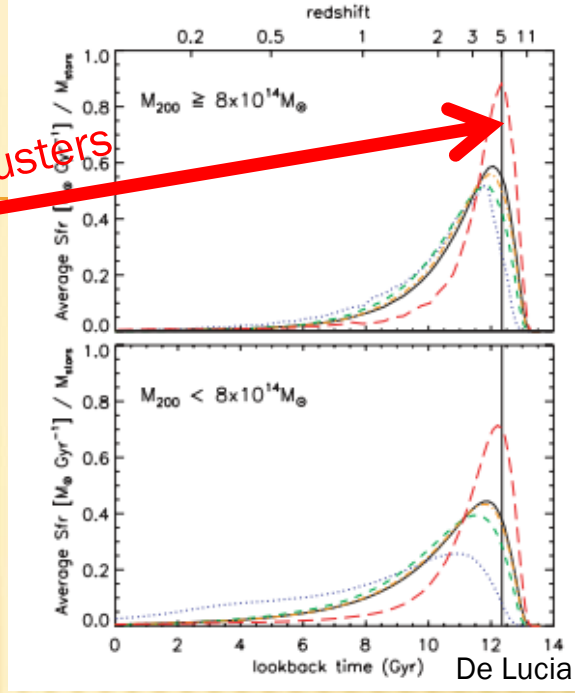


Evolution of the IR LD observed with Herschel per stellar mass bin.
(Gruppioni et al. 2012 in prep.)



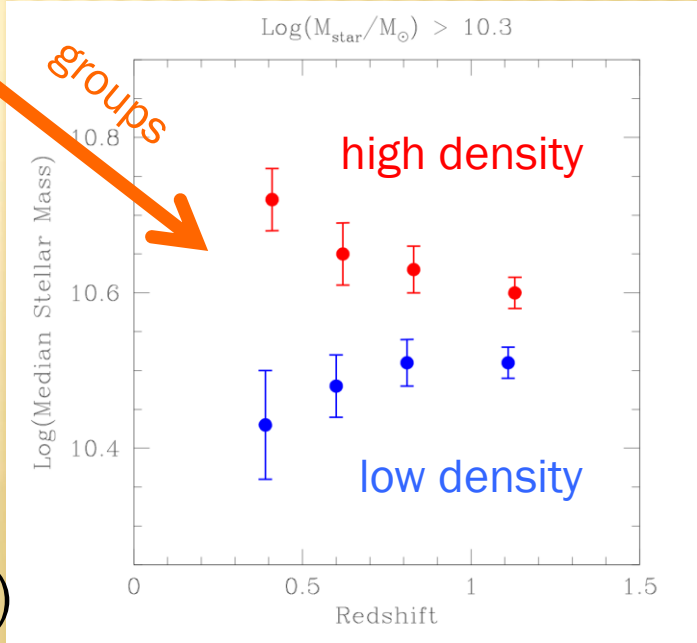


clusters



De Lucia et al. (2006)

groups



(Gruppioni et al. 2013 in prep.)

mass segregation up to z~1
(Scodeggio et al. 2008, VVDS survey)

THE GROUP AND CLUSTER SAMPLE

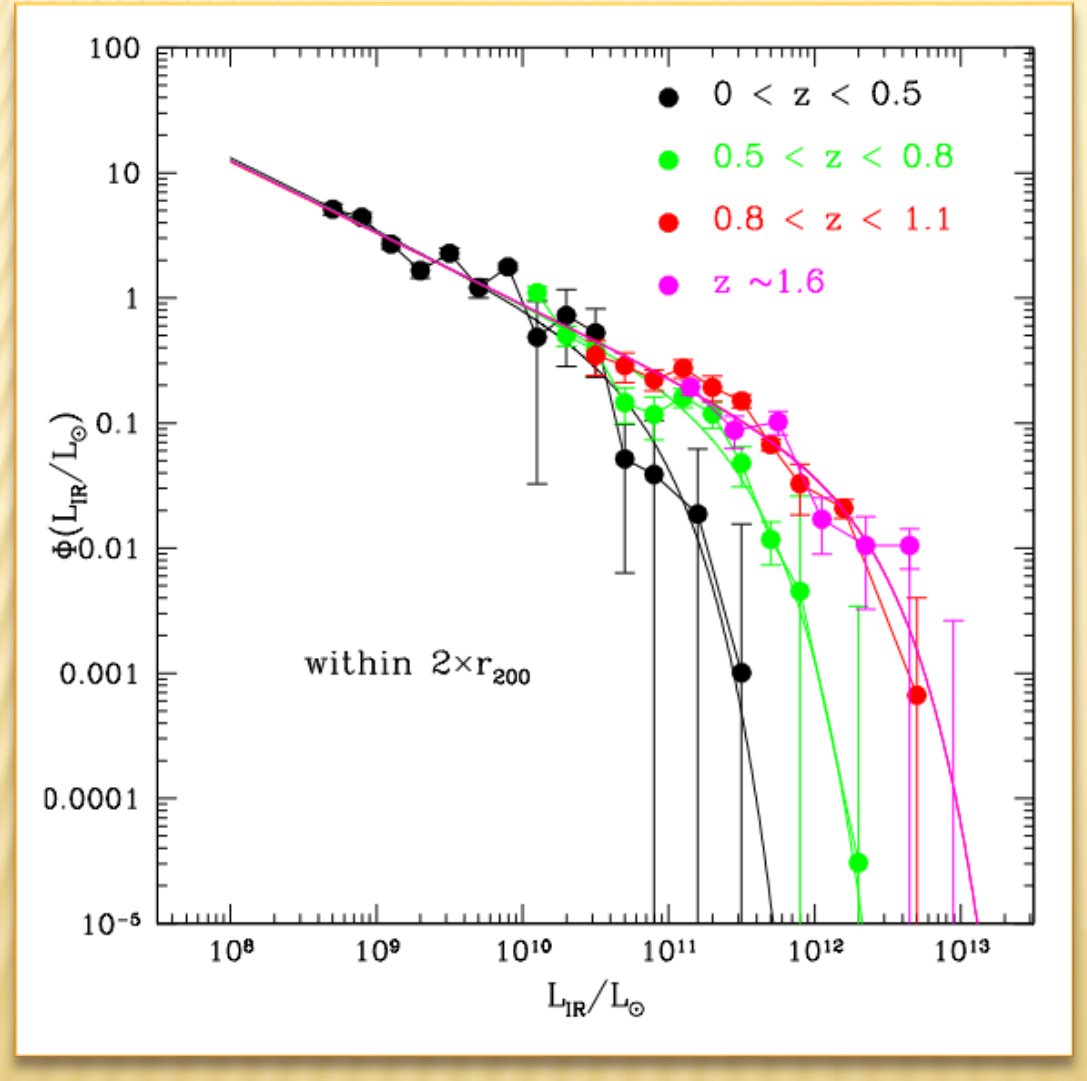
- **The quenching epoch:**
  - **35 groups** at $0.1< z <1.6$ ($<M_{200}>\sim 2\times10^{13}\ M_{\odot}$) observed with PACS in the ECDFS, GOODS and COSMOS fields as part of the *PEP* (PI:D. Lutz) and *GOODS-H* (PI: D. Elbaz) surveys
  - **8 clusters** at $0.1< z < 0.8$ ($<M_{200}>\sim 5\times10^{14}\ M_{\odot}$) observed with PACS as part of the *PEP* (PI:D. Lutz)
  - Observations and analysis completed (high spectroscopic coverage)
- **The cluster desert:**
  - 100 h of PACS observation of **8 systems** at $1.5< z <1.9$ with M_{200} ranging from 8×10^{13} to $8\times10^{14}\ M_{\odot}$ (*"A star formation oasis in the middle of a cluster desert"*, PI: P. Popesso)
  - Observations completed, analysis in progress (poor spectroscopic coverage)

X-ray selected sample!!!

AIM OF THE PROJECT

- Define the group and clusters IR Luminosity function to estimate structure contribution to the evolution of the IR LD
  - IR luminosity function
  - Evolution of the total SF per halo mass
- Comparison between group, cluster and field galaxy population SF activity to quantify evolution of the SF quenching
  - SFR-density relation
  - MS of (cluster) group and field galaxies

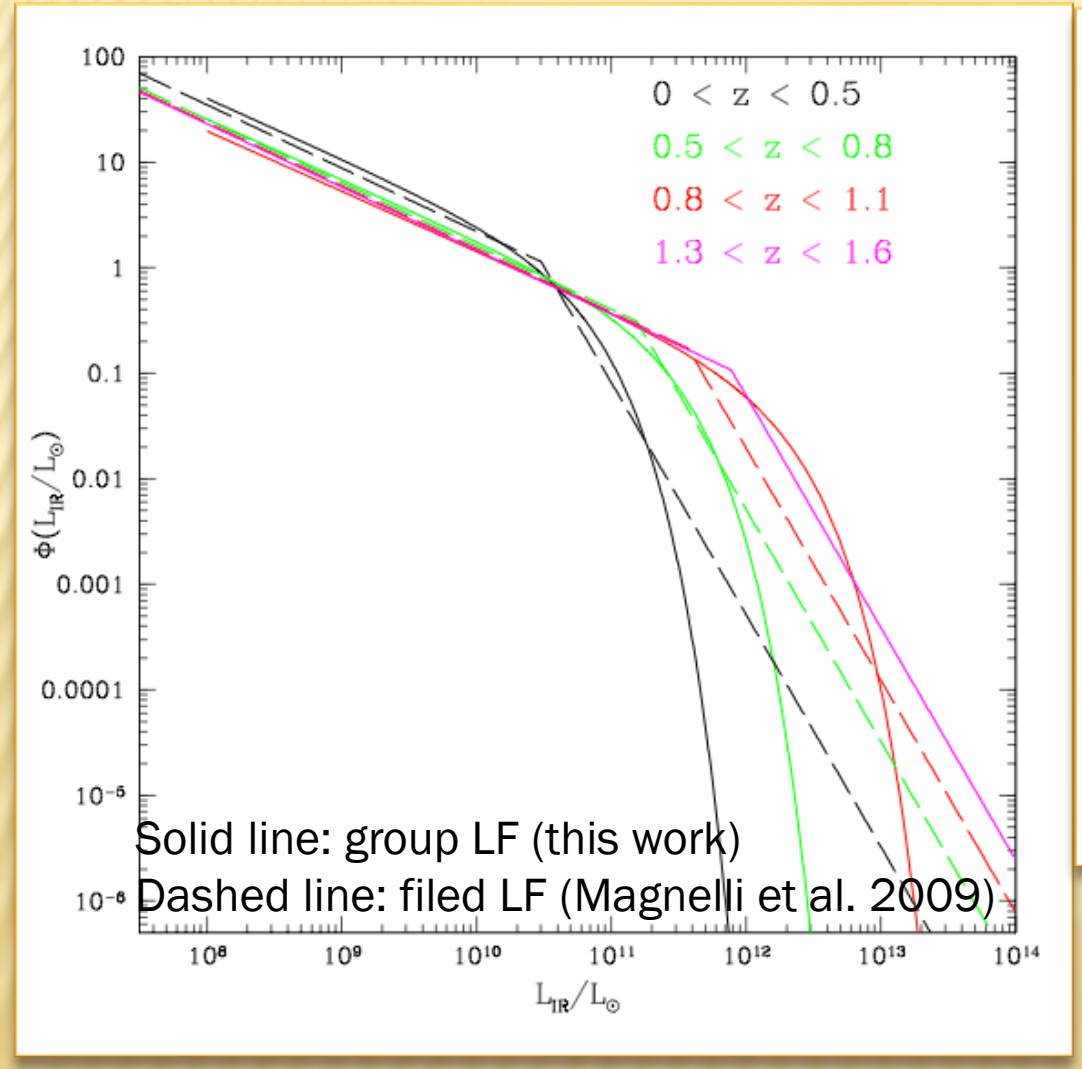
THE GROUP IR LUMINOSITY FUNCTION

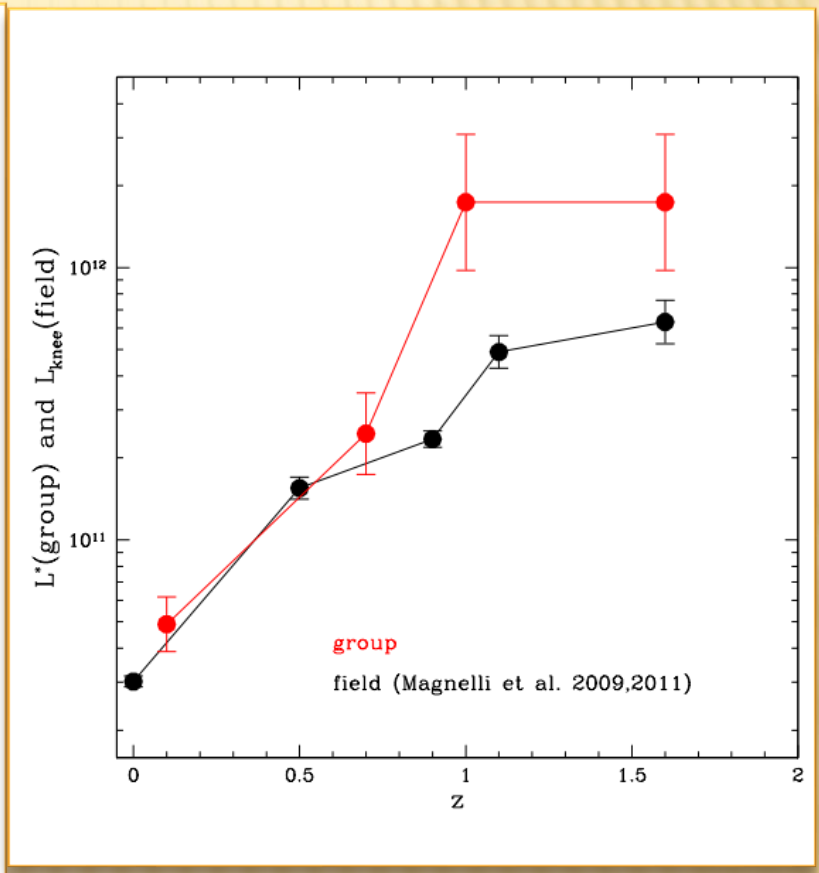


- Groups at $M_{200} < 10^{14}\,M_{\odot}$
- IR luminosities derived with Herschel-PACS data
- Only spectroscopic members
- Composite LF obtained per redshift bin by stacking individual group LF (Colles 1980 method).
- faint-end slope fitted only in the low redshift bin

Popesso et al. (2012a) in prep.

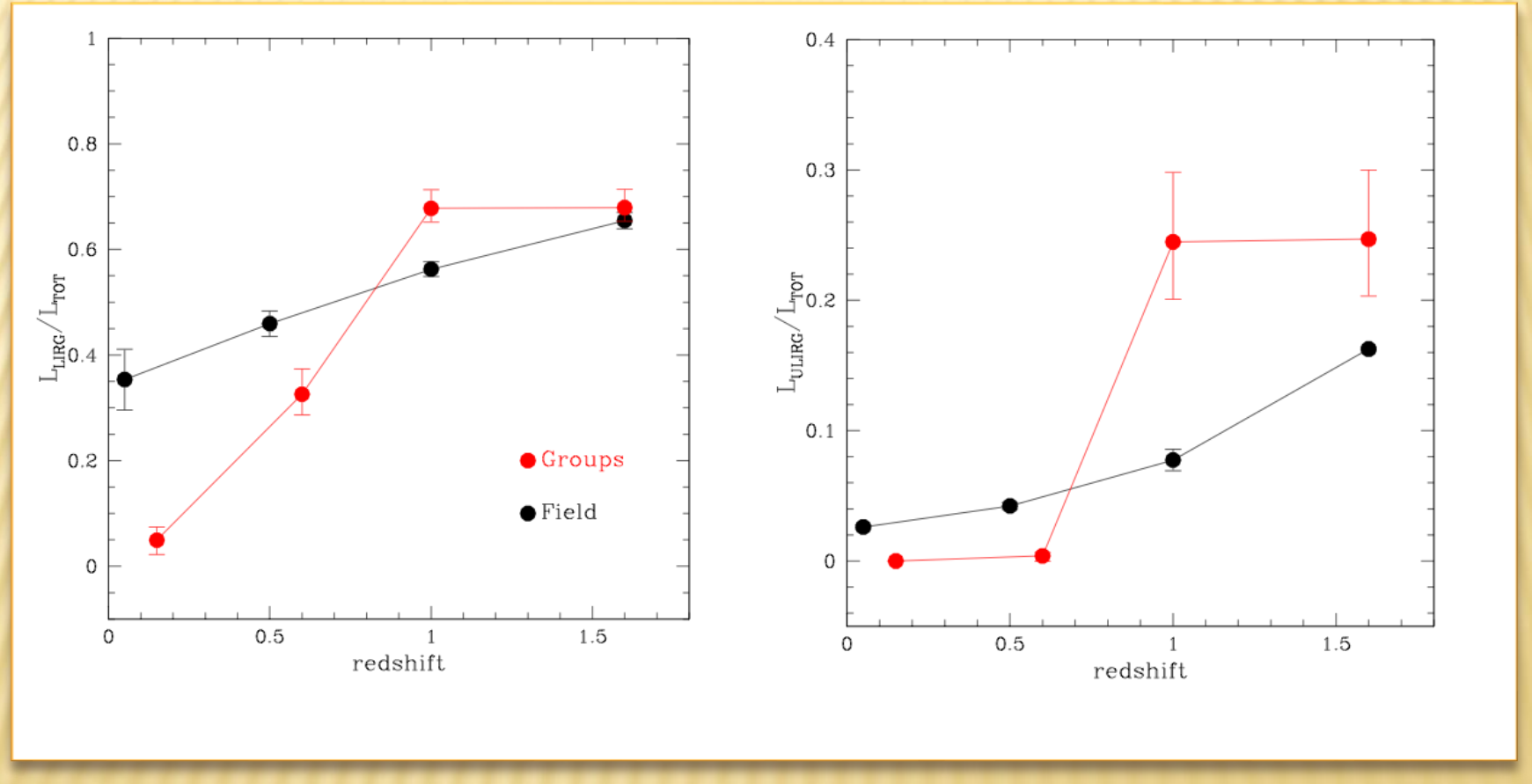
GROUPS LF VS. FIELD LF





Popesso et al. (2012a) in prep.

EVOLUTION OF THE (U)LIRG FRACTION



Popesso et al. (2012a) in prep.

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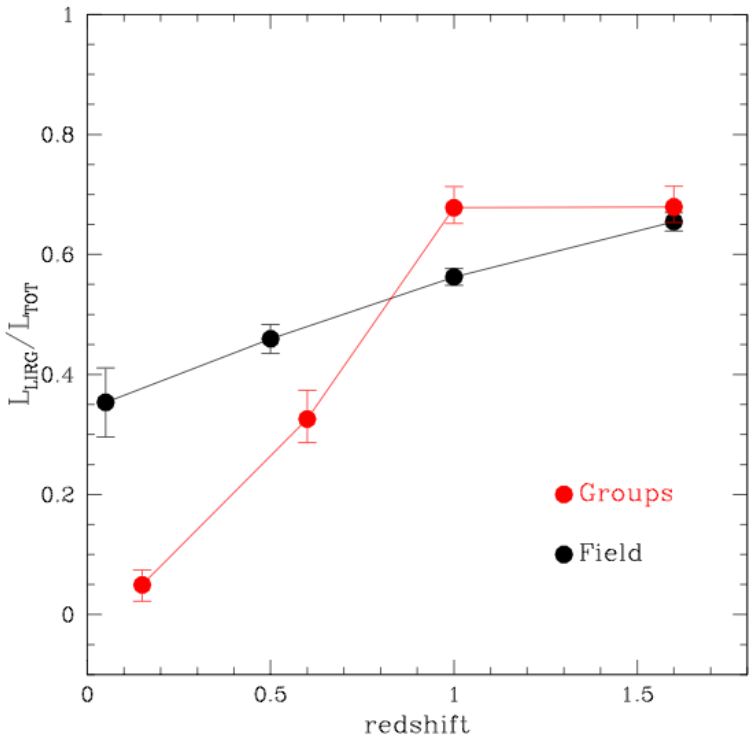
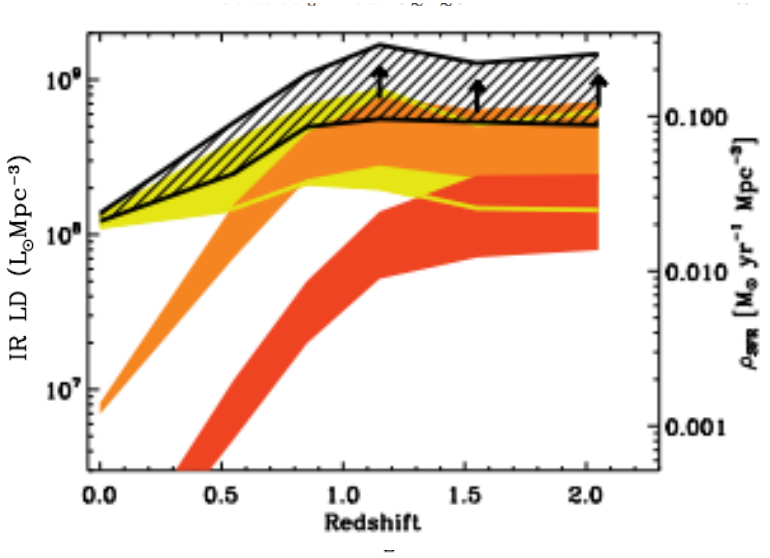
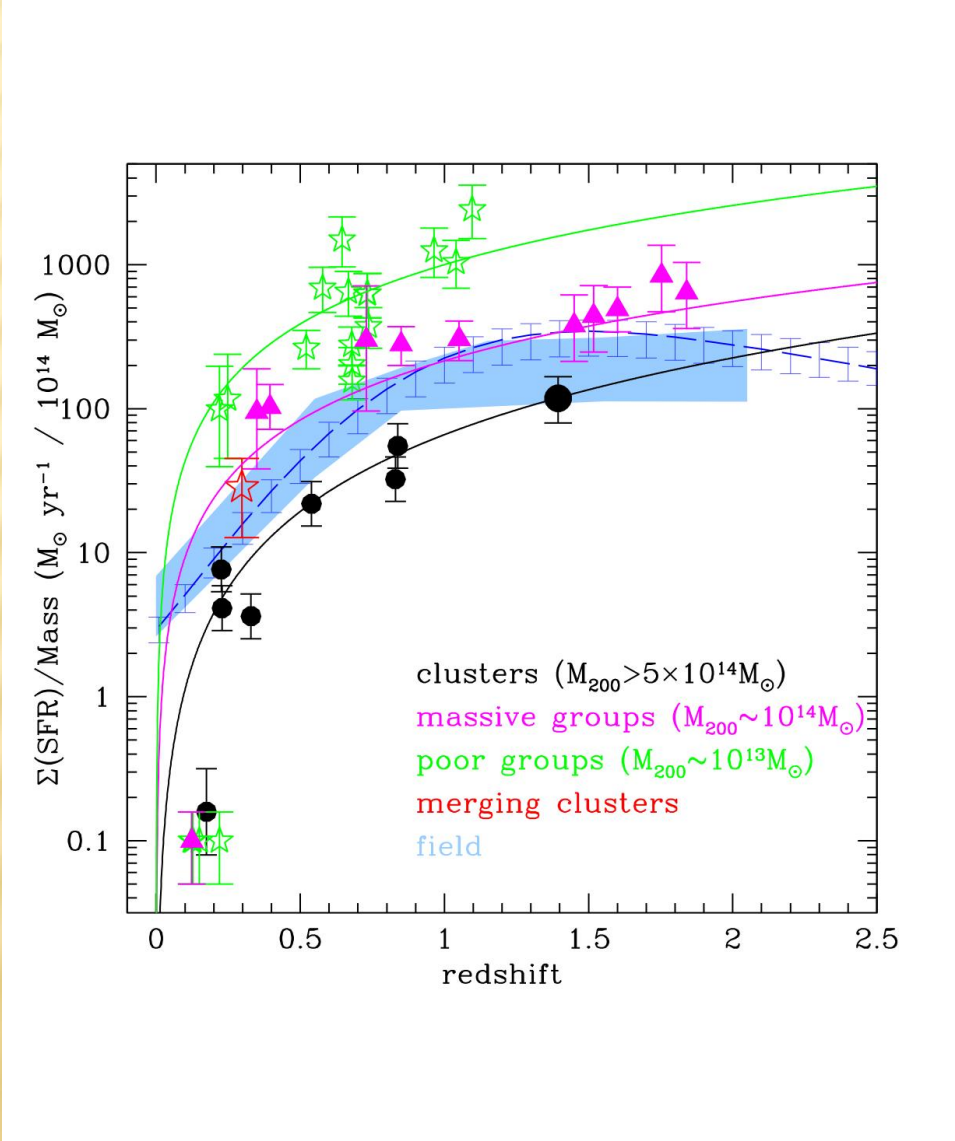




can the quenching phase be due to the lower and lower contribution of group LIRG below z~1?

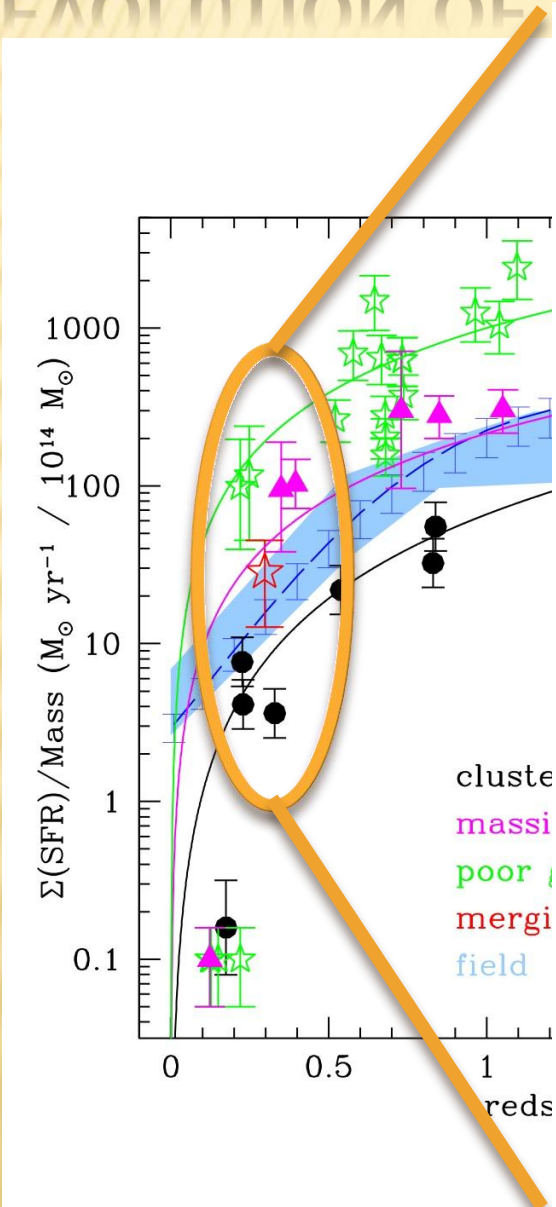
EVOLUTION OF THE SFR PER HALO MASS



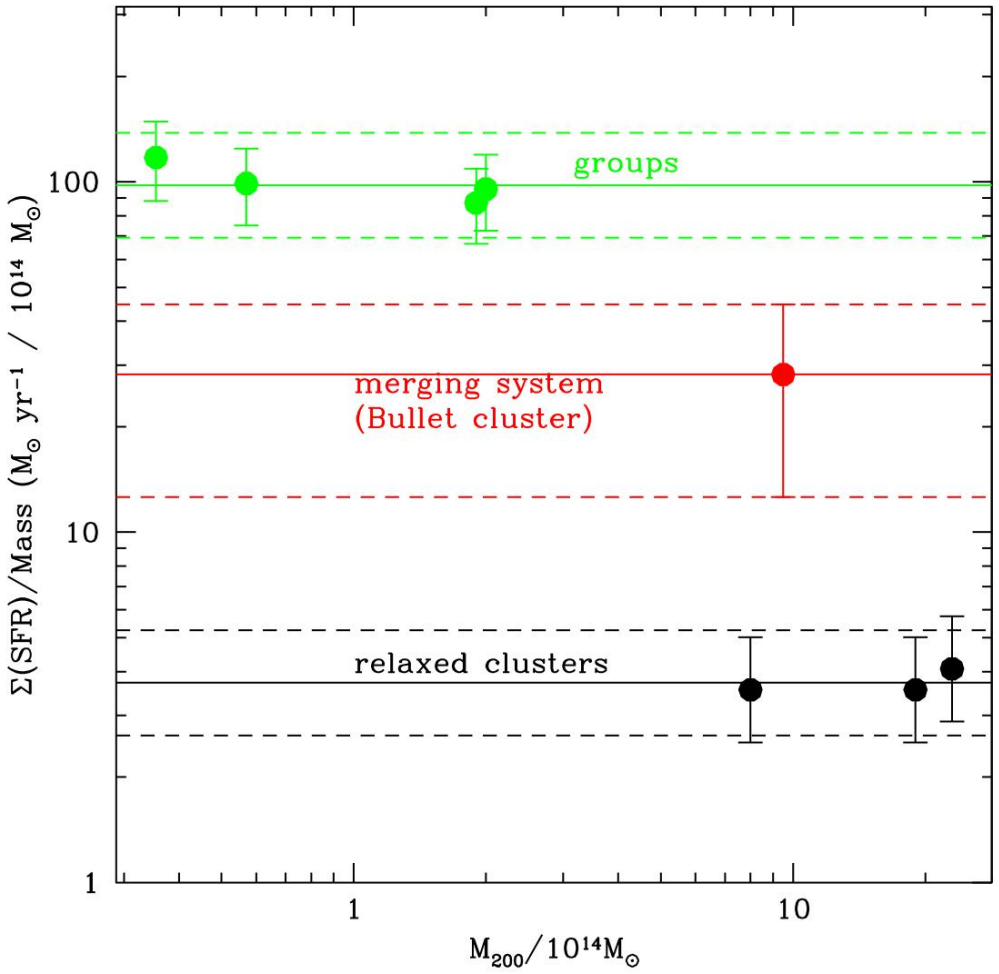
- Total SFR per structure is estimated as the sum of the SF of LIRG spectroscopic members within r_{200}
- field relation is derived from Magnelli et al. (2009) and Gruppioni et al. (2010)
- SFRD multiply by the comoving density
- merging system is the Bullet cluster

Popesso et al. (2012) and (2012b) in prep.

EVOLUTION OF THE SFR PER HALO MASS



z~0.3

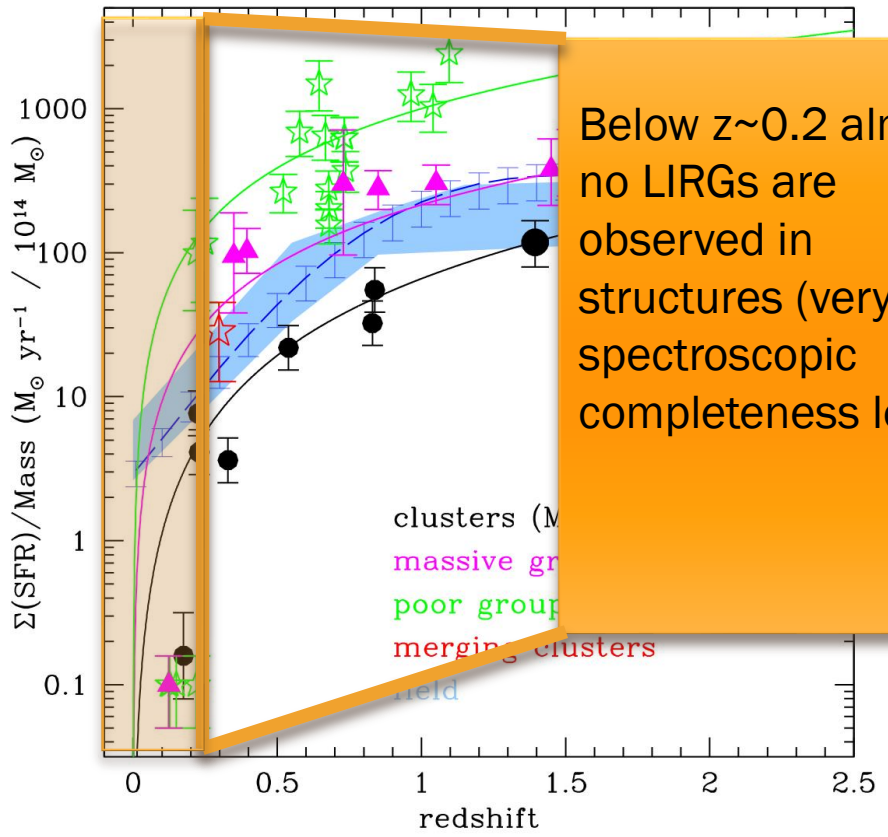


is

09)

10)

EVOLUTION OF THE SFR PER HALO MASS



Below z~0.2 almost no LIRGs are observed in structures (very high spectroscopic completeness level)

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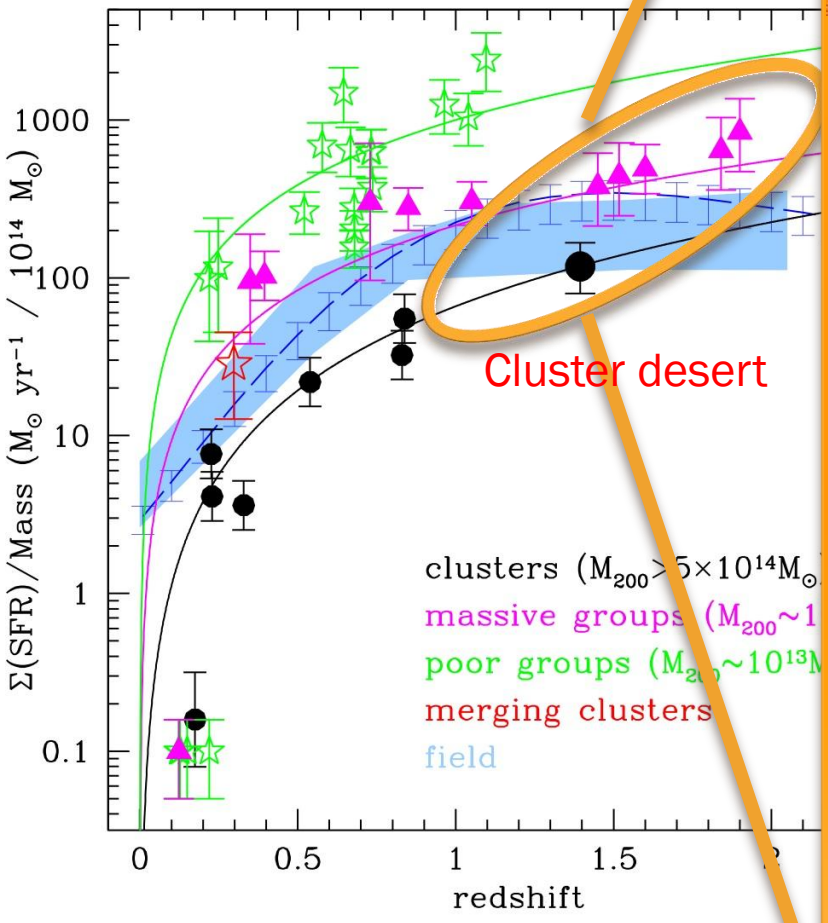
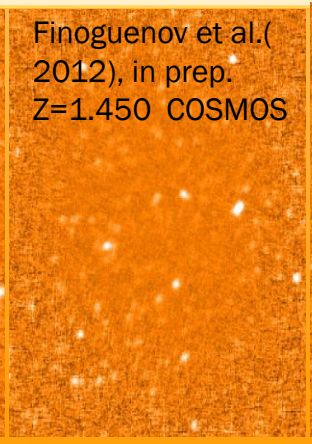



Aravena et al.(2012)
Z=1.518 COSMOS


Finoguenov et al.(2012), in prep.
Z=1.450 COSMOS


Finoguenov et al.(2012) in prep
Z=1.84 COSMOS

Herschel-PACS observations down to the LIRG flux limit at the system redshift.

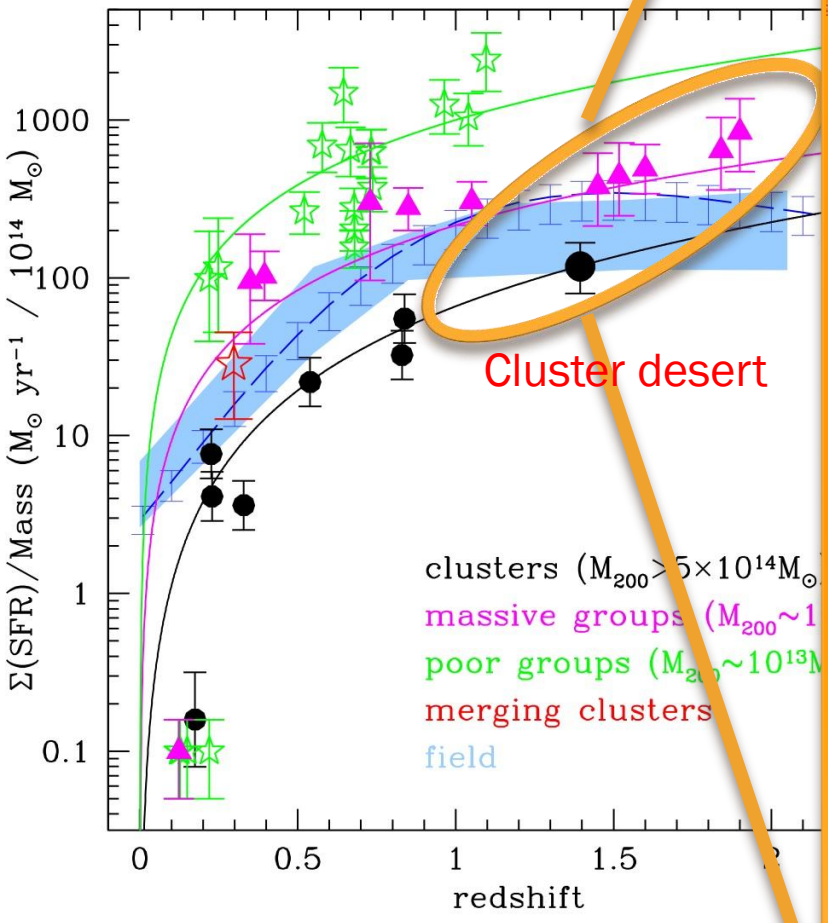

Kurk et al.(2007)
Z=1.618 GOODS-S


Henry et al.(2010)
Z=1.753 Lockman Hole


Mullis et al.(2005)
XMMJ 2235-.32557
Z=1.394

Popesso et al. (2012b) in prep.

EVOLUTION OF THE SFR



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z_spec members


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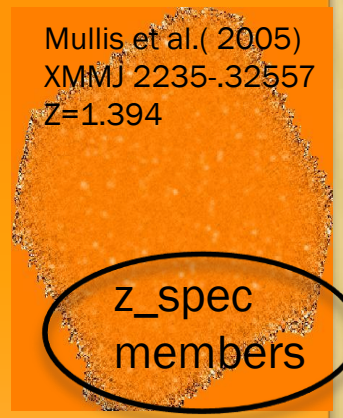
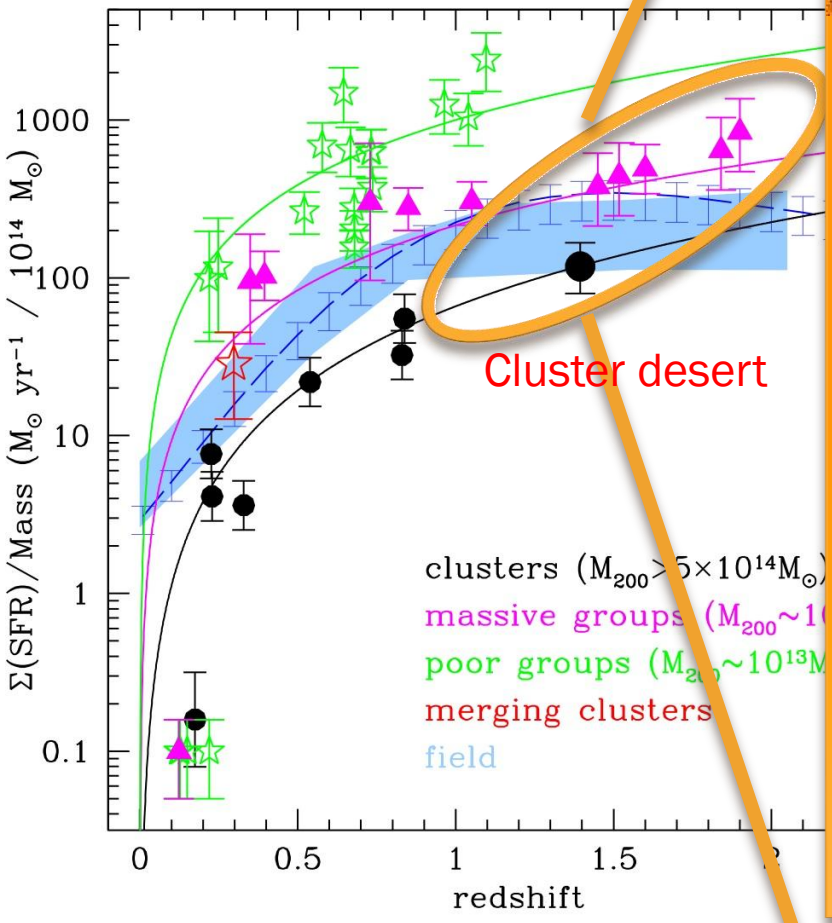

Mullis et al.(2005)
XMMJ 2235-.32557
Z=1.394

z_spec members

See also the poster of J. Santos on XMM2235

Popesso et al. (2012b) in prep.

EVOLUTION OF THE SFR



Aravena et al.(2012)
Z=1.518 COSMOS

Finoguenov et al.(2012), in prep.
Z=1.450 COSMOS

Finoguenov et al.(2012) in prep
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Henry et al.(2010)
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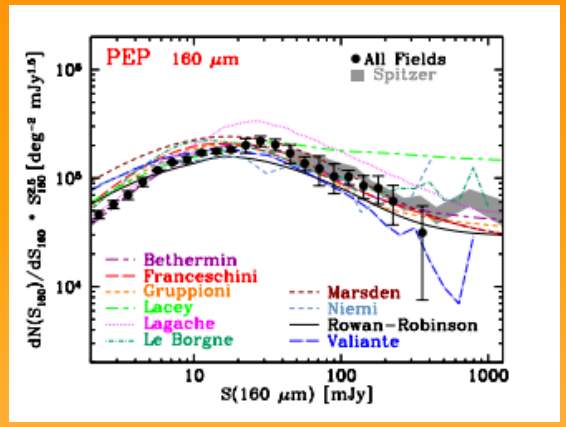
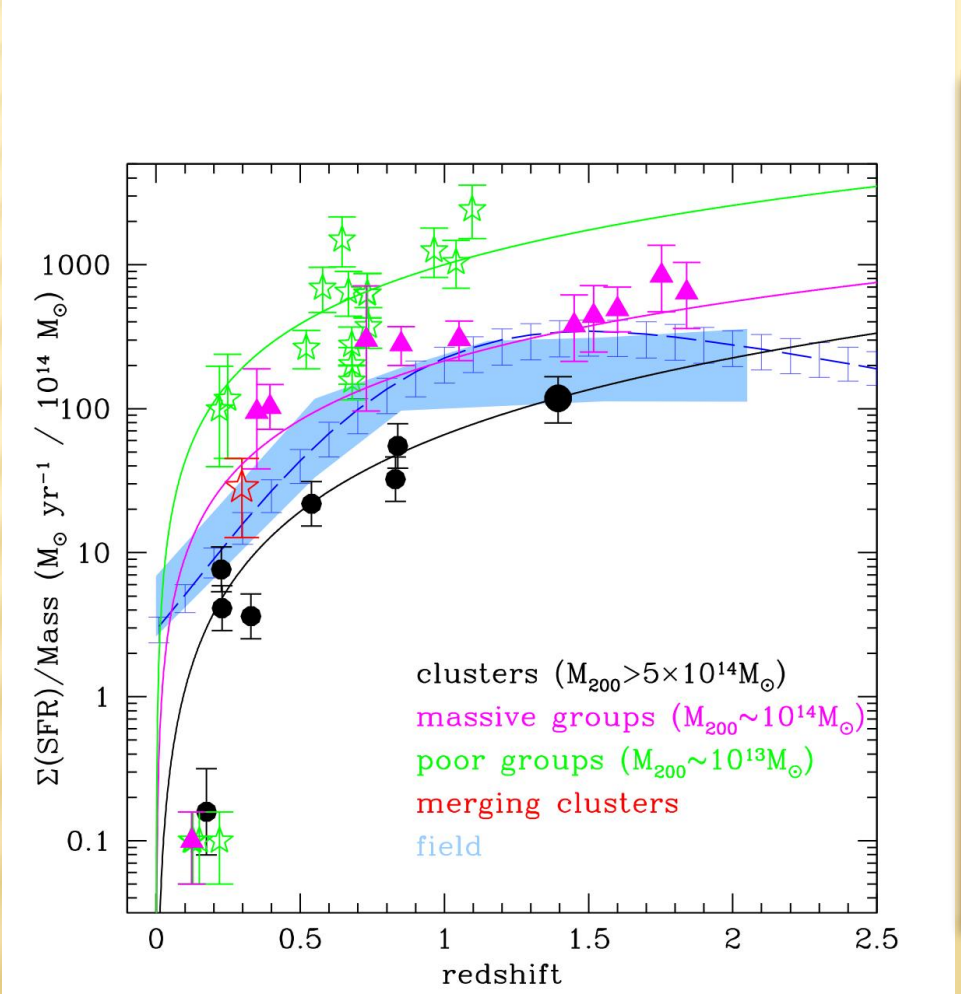
Statistical subtraction of the local/global background

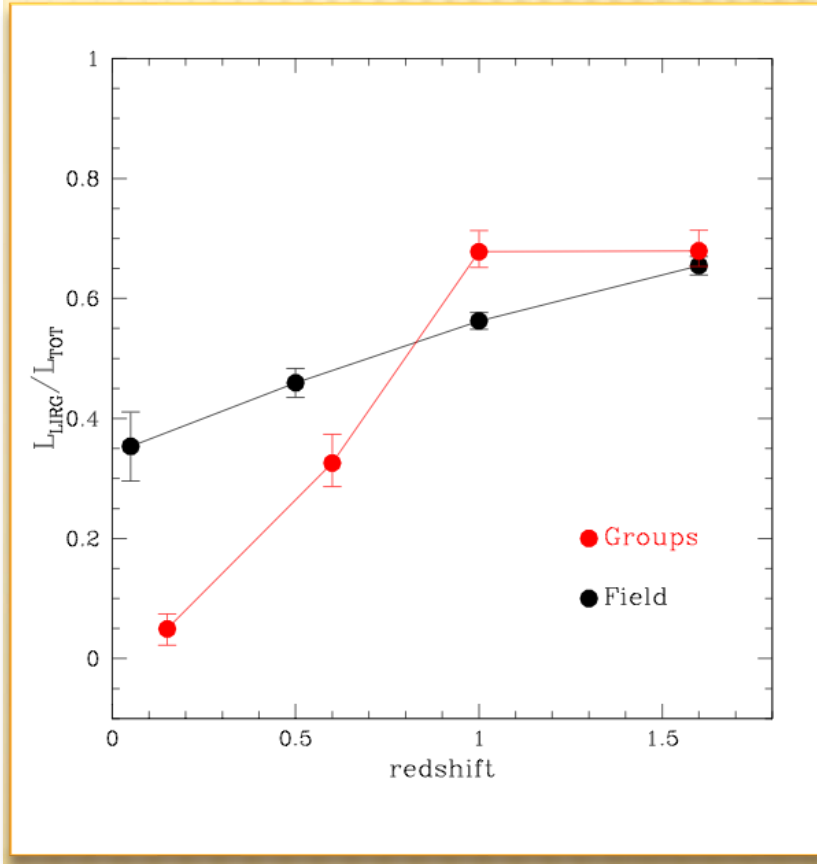


Berta et al. (2010)

Mullis et al.(2005)
XMMJ 2235-.32557
Z=1.394

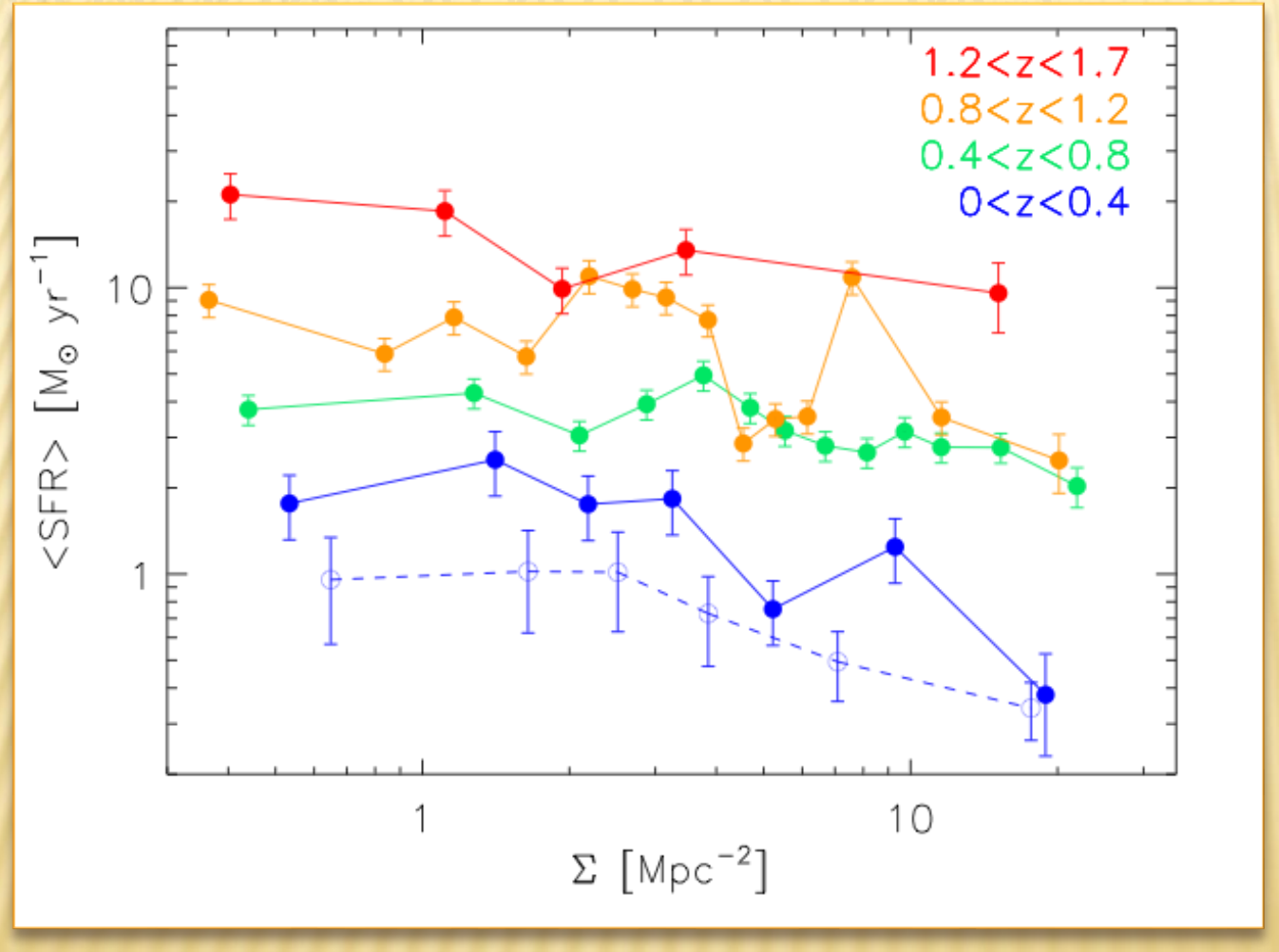
EVOLUTION OF THE SFR PER HALO MASS





Popesso et al. (2012) and (2012b) in prep.

THE SFR-DENSITY RELATION:
REVERSING OR NOT REVERSING?

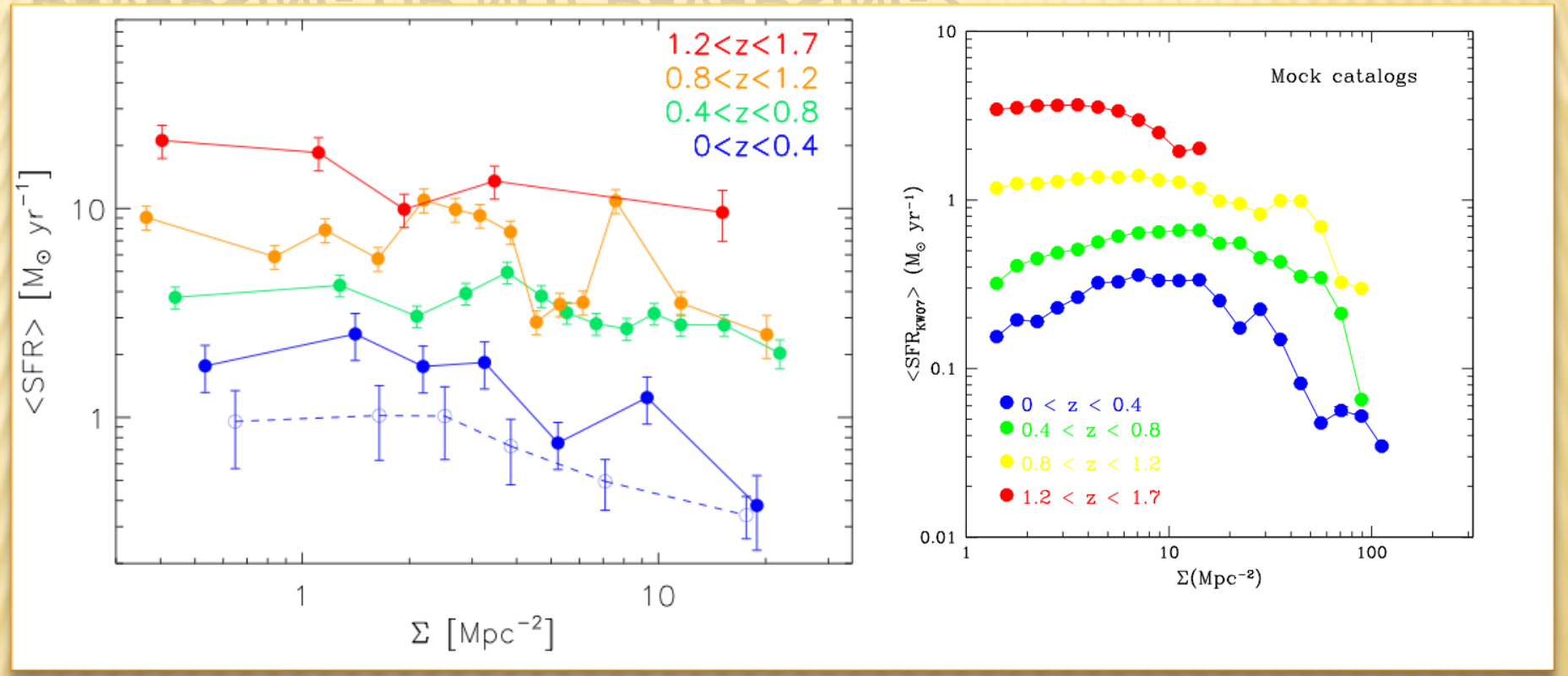


- SFR-density relation in the ECDFS+GOODS-N field
- all galaxies with mass > 10^{10} $M_\odot$
- SFR derived from IR fluxes for all Main Sequence galaxies
- SFR derived via SED fitting for quiescent galaxies

See also Poster of F. Ziparo Nr 30

Ziparo et al. (2012) in prep.

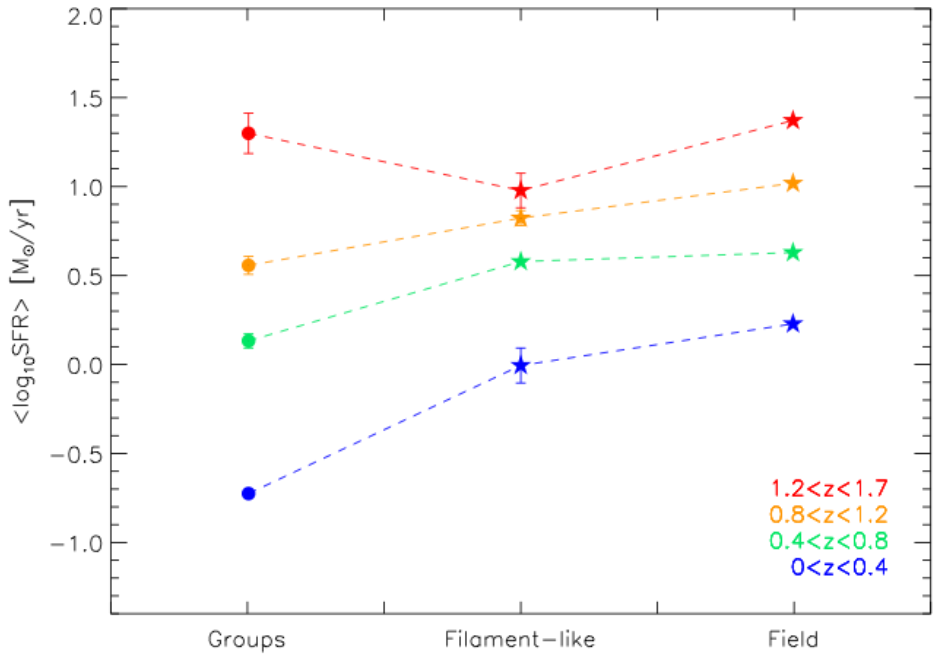
THE SFR-DENSITY RELATION:
REVERSING OR NOT REVERSING?

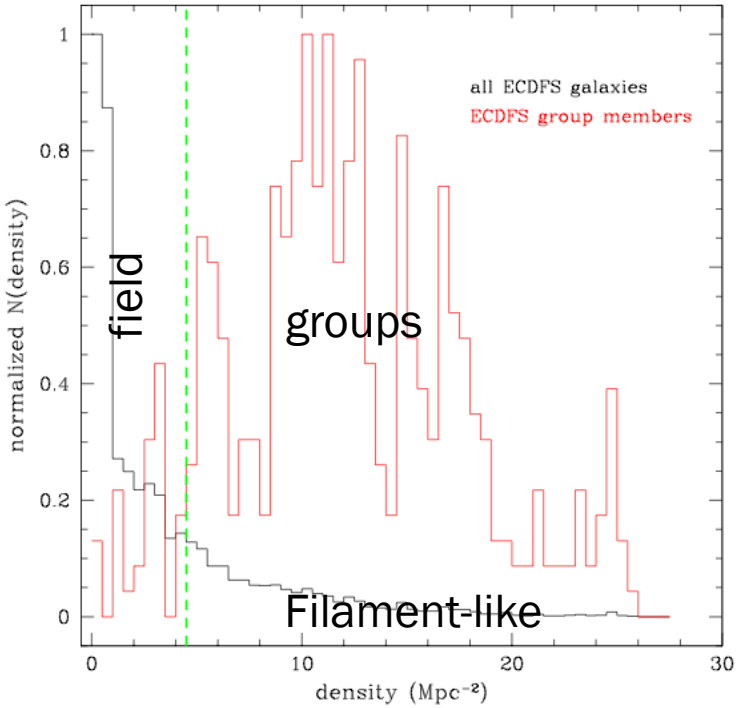


No reversal of the SFR-density relation up to z~1.6 in agreement with Kitzbichler & White (2007, Millennium Simulation)

Ziparo et al. (2012) in prep.

SFR-DENSITY RELATION:
A DYNAMICAL APPROACH

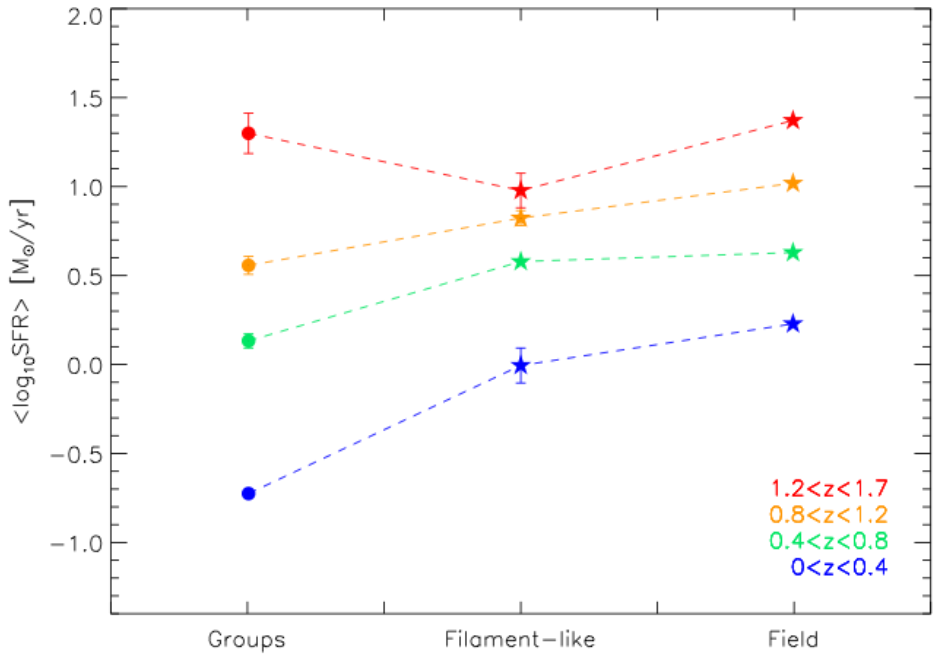


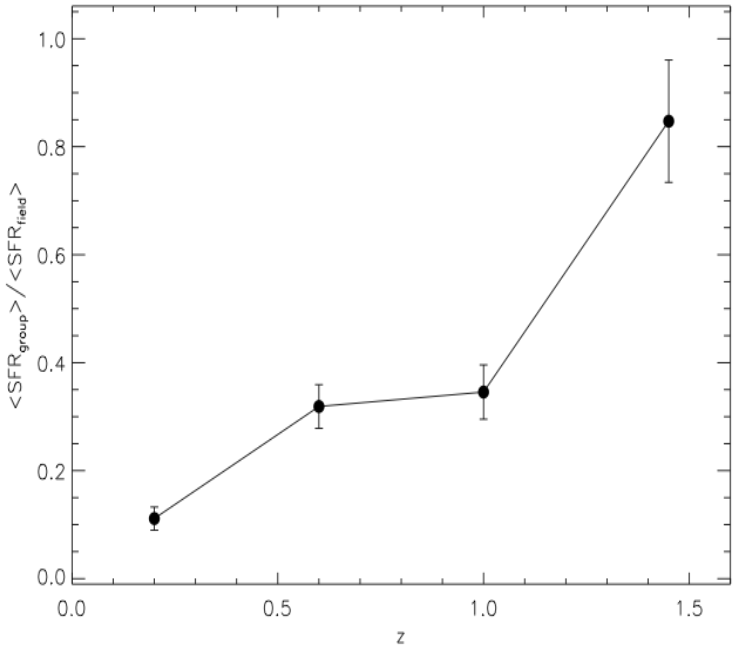


Environment defined via dynamical properties rather than density

Ziparo et al. (2012) in prep.

SFR-DENSITY RELATION:
A DYNAMICAL APPROACH

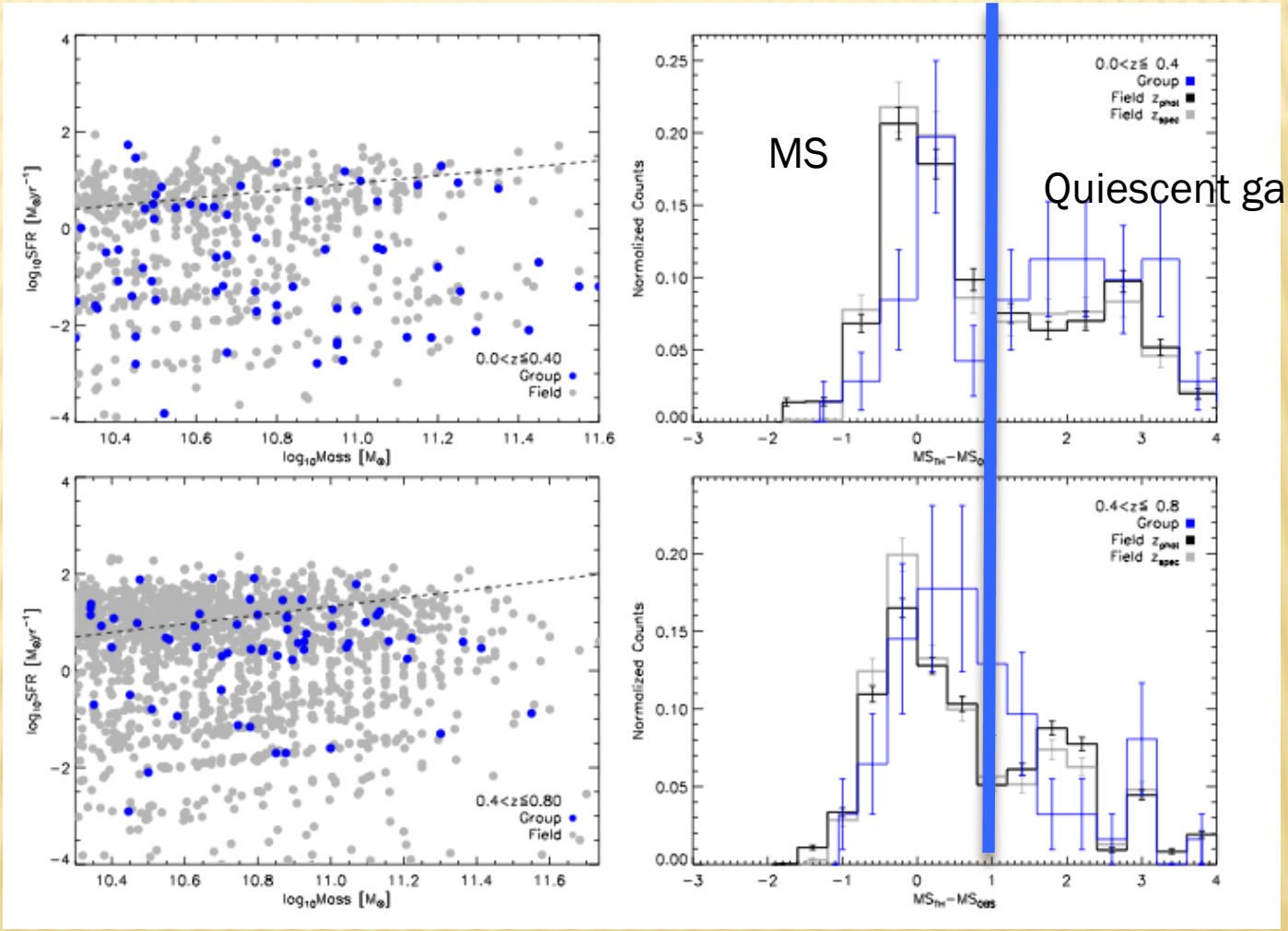




Environment defined via dynamical properties rather than density

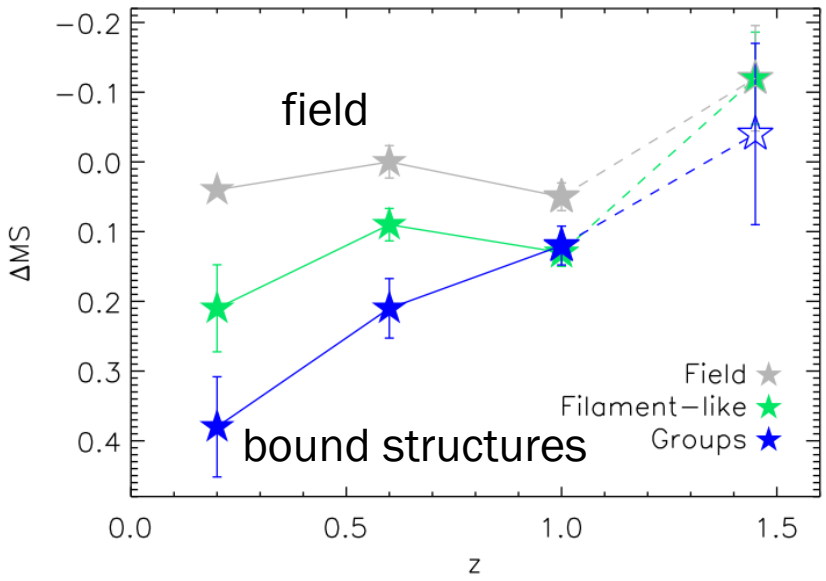
Ziparo et al. (2012) in prep.

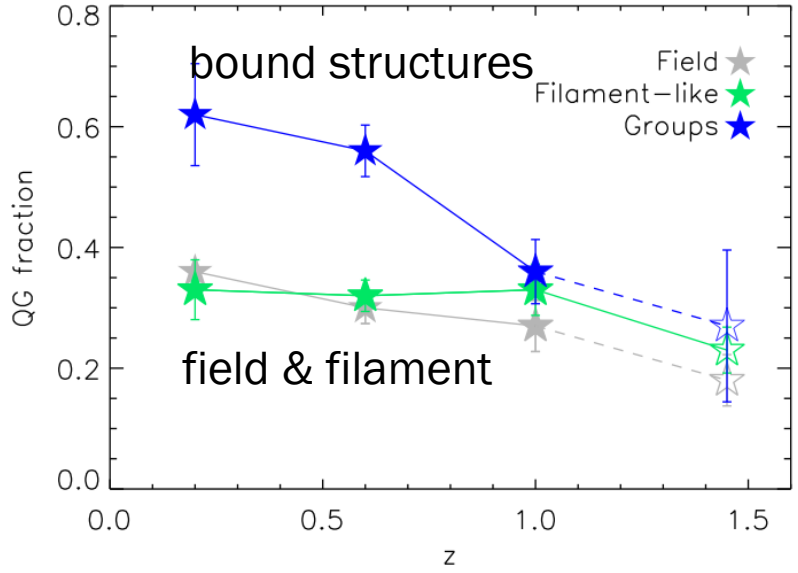
THE SFR-STELLAR MASS PLANE: *LOCATION OF GROUP GALAXIES*



Ziparo et al. (2012) in prep.

HALO MASS DEPENDENCE OF SF QUENCHING





- We observe quenching of SF in group galaxies with respect to galaxies at the same density but in unbound structures (filament)
- Quenching is not density dependent but DM halo dependent

Ziparo et al. (2012) in prep.

CONCLUSIONS

- As shown by the evolution of the group IR LF and the SFR-density relation through our novel “dynamical approach”, the group galaxy population become similar to the field galaxy population by z ~1
- The LIRG fraction in groups drops at z < 1 similarly to the contribution of the LIRG population to the IR LD. Is there a link?
- Clusters and groups show similar and higher level of SF activity per halo mass with respect to the field in the so called cluster desert
- The “traditional” SFR-density relation does not reverse up to z~1, at maximum it flattens
- The evolution of the galaxy SF activity must be related more to the parent halo mass rather than the local galaxy density
- We observe both a quenching of SF in group star forming galaxies (offset below the MS at z<~1) and a fast evolution of the galaxy type mix with respect to other environments