Galaxy evolution in z=1 groups
The Gemini GEEC2 survey

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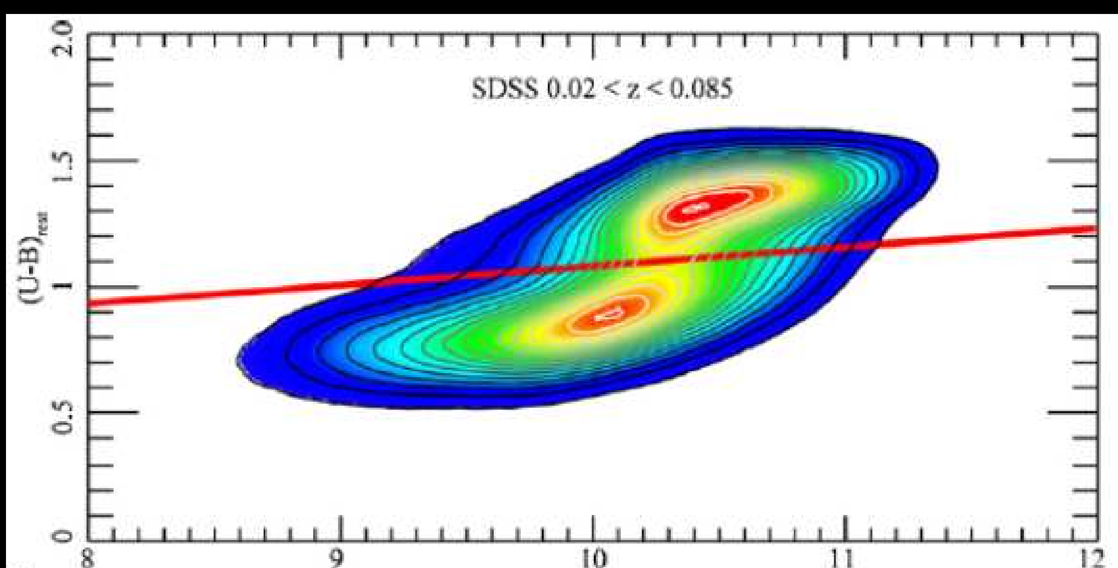
Background

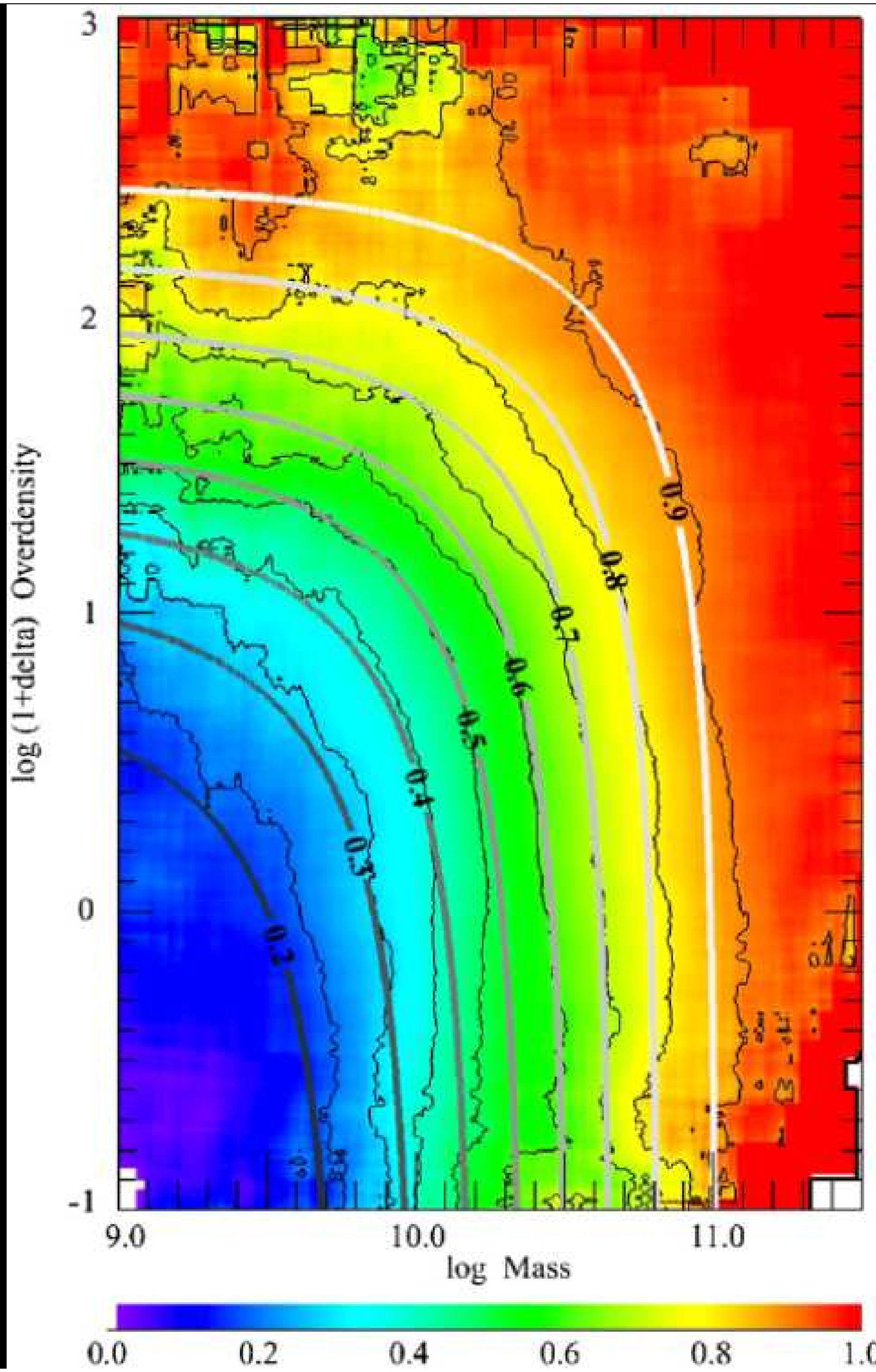
- At z=0, SDSS data have shown galaxies form two sequences
  - SF main sequence
  - Passive population with negligible SF



Peng et al. (2010)

Role of environment

- At z=0, main influence is onthe fraction of SF galaxies
- Within the SF population, trends with environment are weak at best

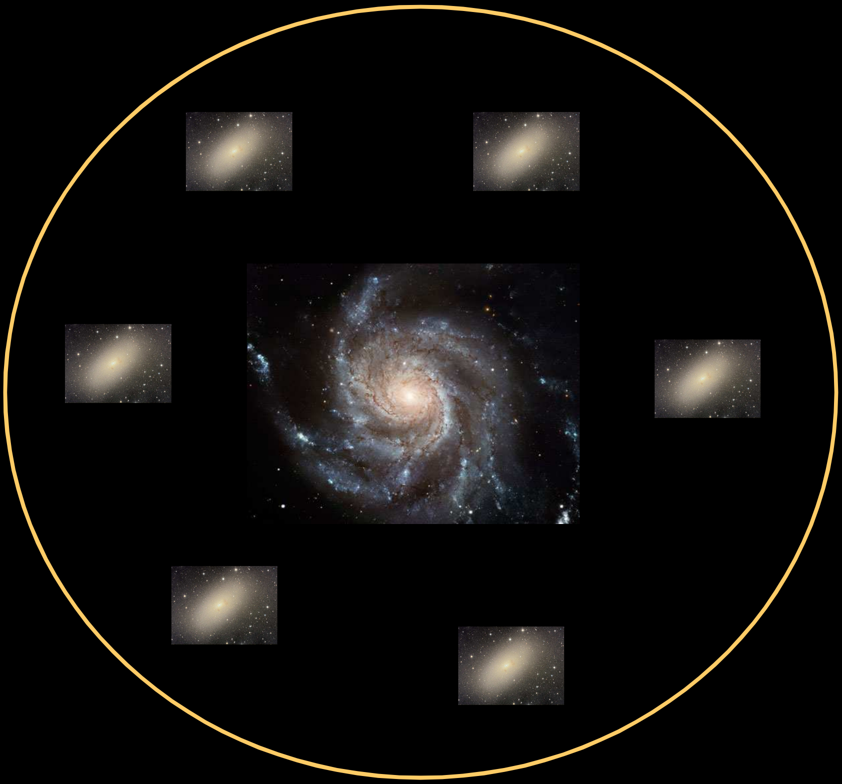


Peng et al. (2010)

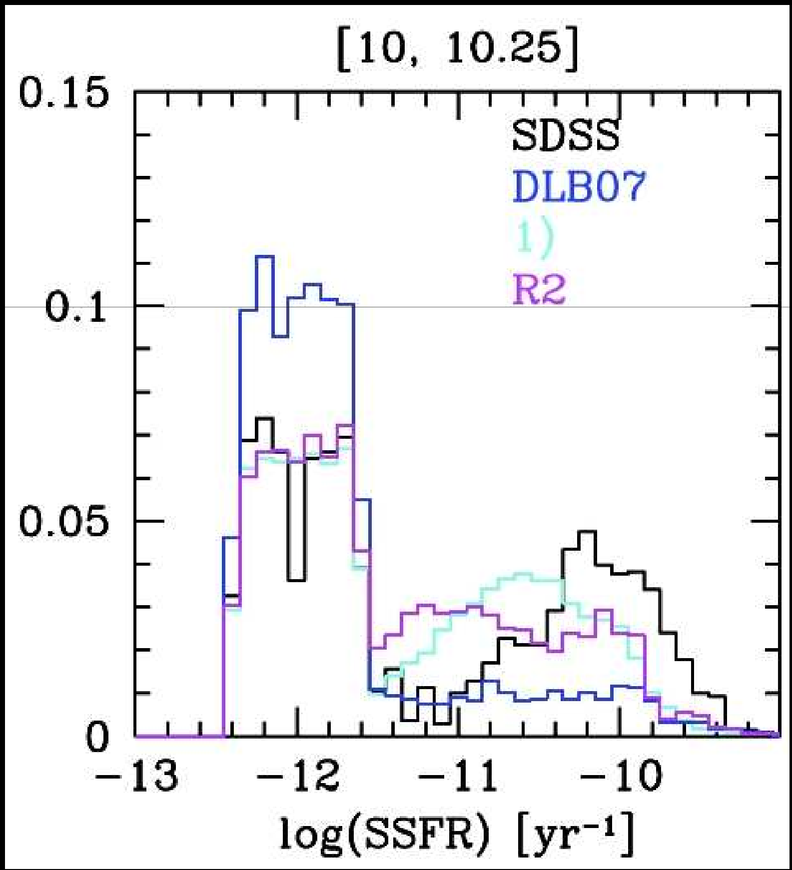
Theory

- Halo model: galaxy evolution proceeds differently for satellite galaxies

- Various gas removal processes are most likely explanation, but so far there has been no successful implementation in models.



Theory: the satellite problem



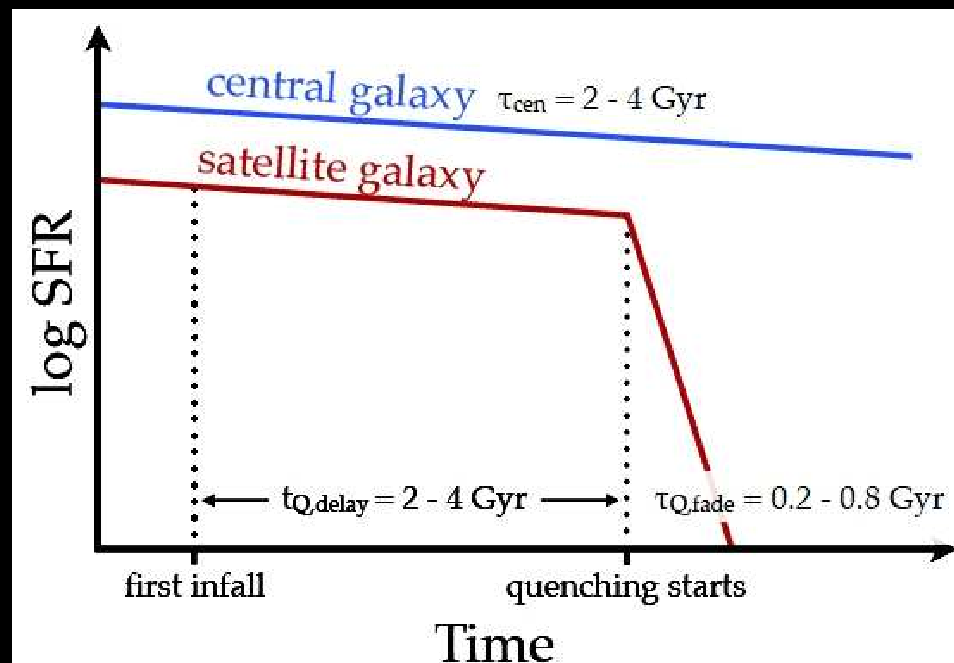
- The simplest models greatly overpredict the number of passive satellites
- Modifications generally predict severe distortions to the SFR distribution that are not observed

Weinmann et al. (2010)

Theory

- Implies transformation must be quick, but not affect all galaxies

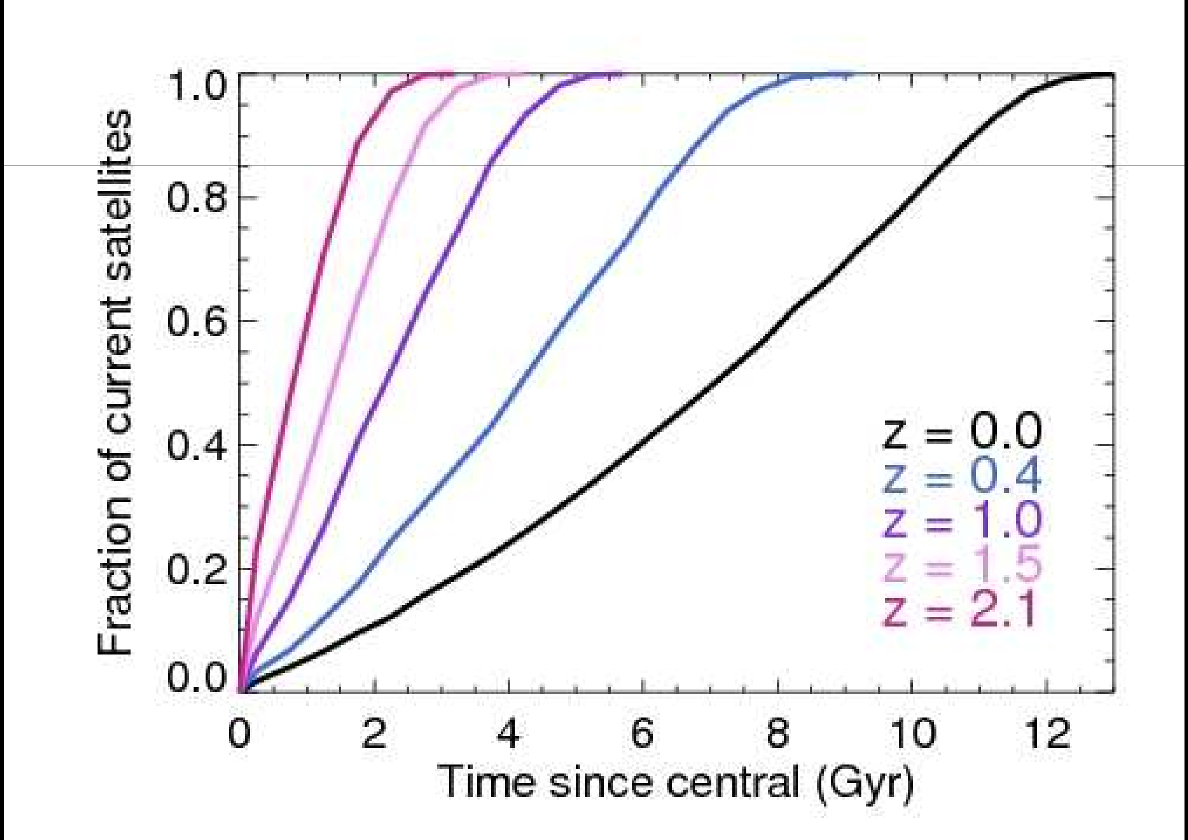
- Parameters constrained by z=0 data. In principle predictive of higher redshift.



Wetzel et al. (2012)

Accretion rates

- Formation history is necessarily compressed at higher redshift



- If quenching timescale is long, redshift evolution will be stronger

From Sean McGee

Why z=1 groups?

- Higher infall rates
- Galaxies are more gas rich with higher SFR
- Less pre-processing
- Greater diversity in accretion histories
- Overall younger ages

GEEC2

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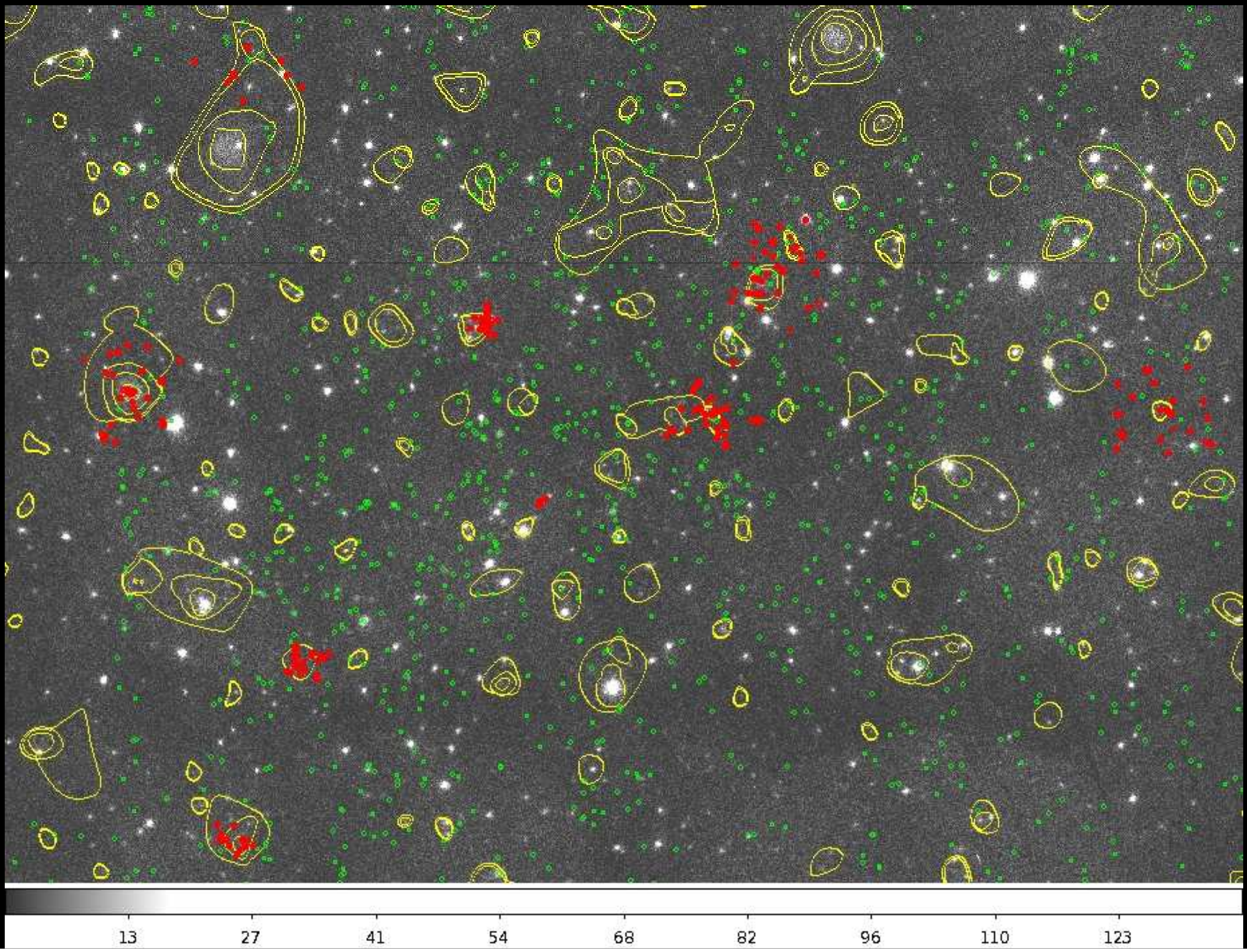
- 20 X-ray confirmed groups at 0.8<z<1 selected from COSMOS
    - Dynamical masses: $3\times10^{13} - 3\times10^{14}$

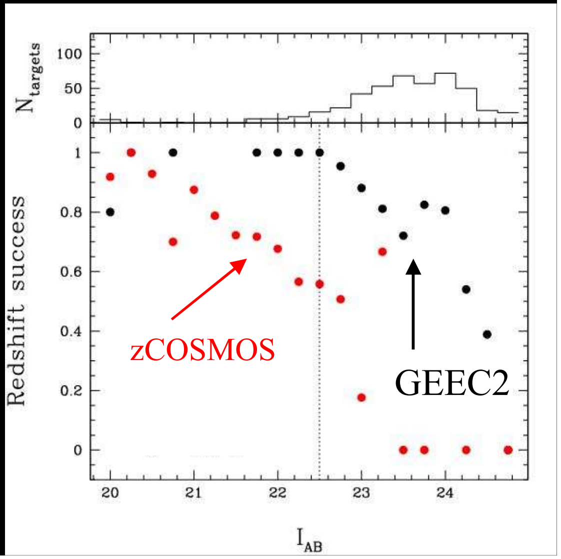
XMM image of COSMOS (Hasinger et al.)

GEEC2 survey

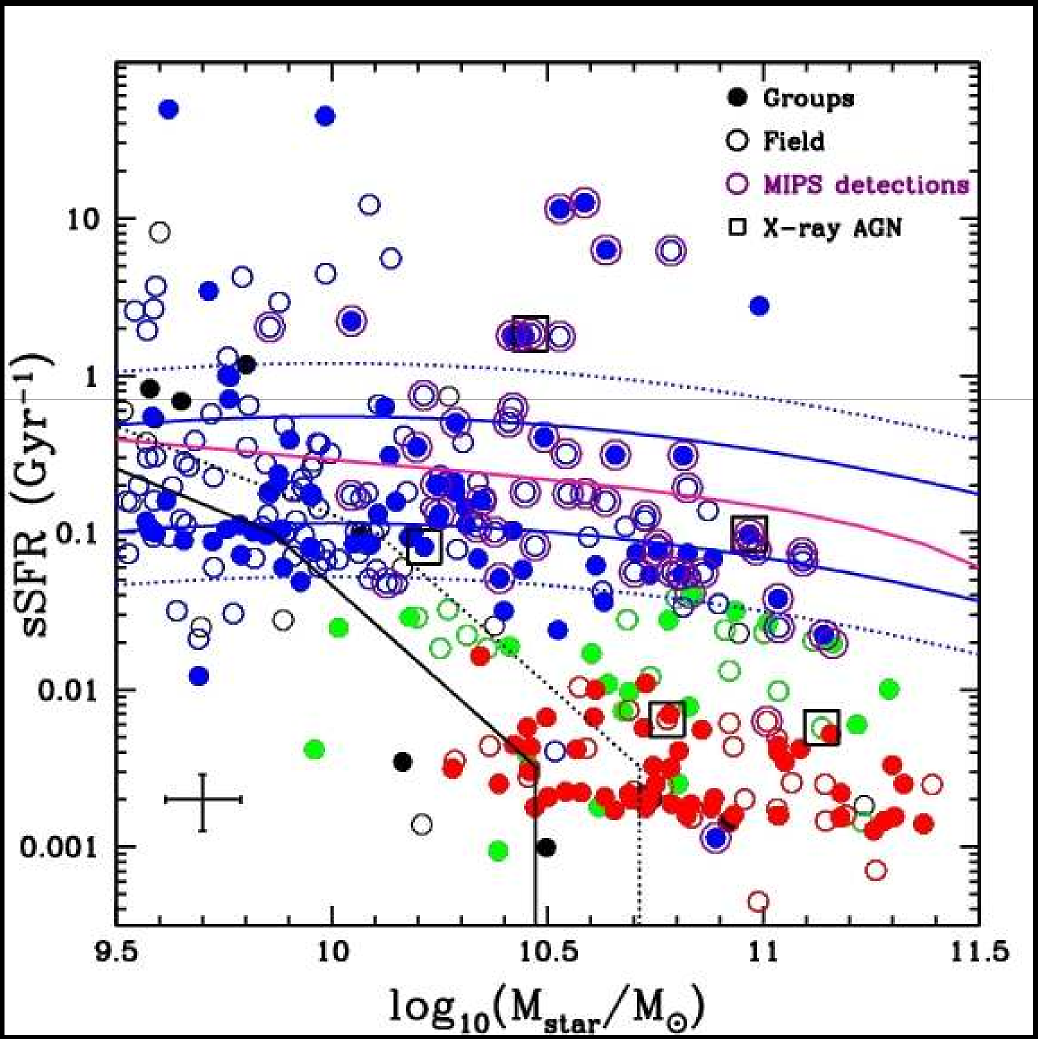
- 11 followed up in 10A and 11A
  - R<23.75 nod-shuffle spectroscopy with GMOS-S
  - High (80%) completeness. Good photo-z makes selection efficient.



- Measure redshifts, [OII], Hdelta spectral features for 600 galaxies.
- 150 group members (72.5h GMOS time)



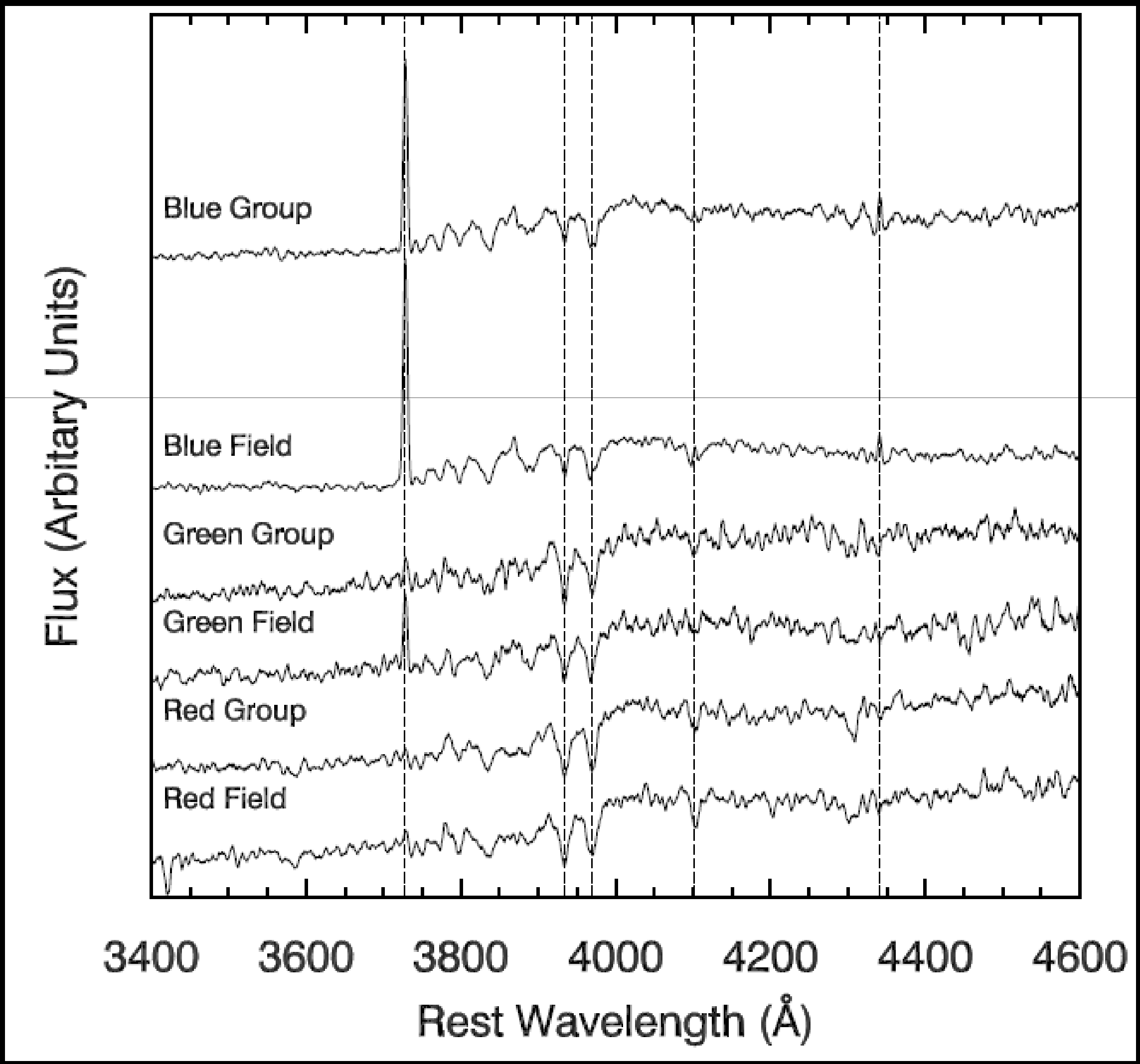
Low sSFR galaxies



Mok et al. (in prep)

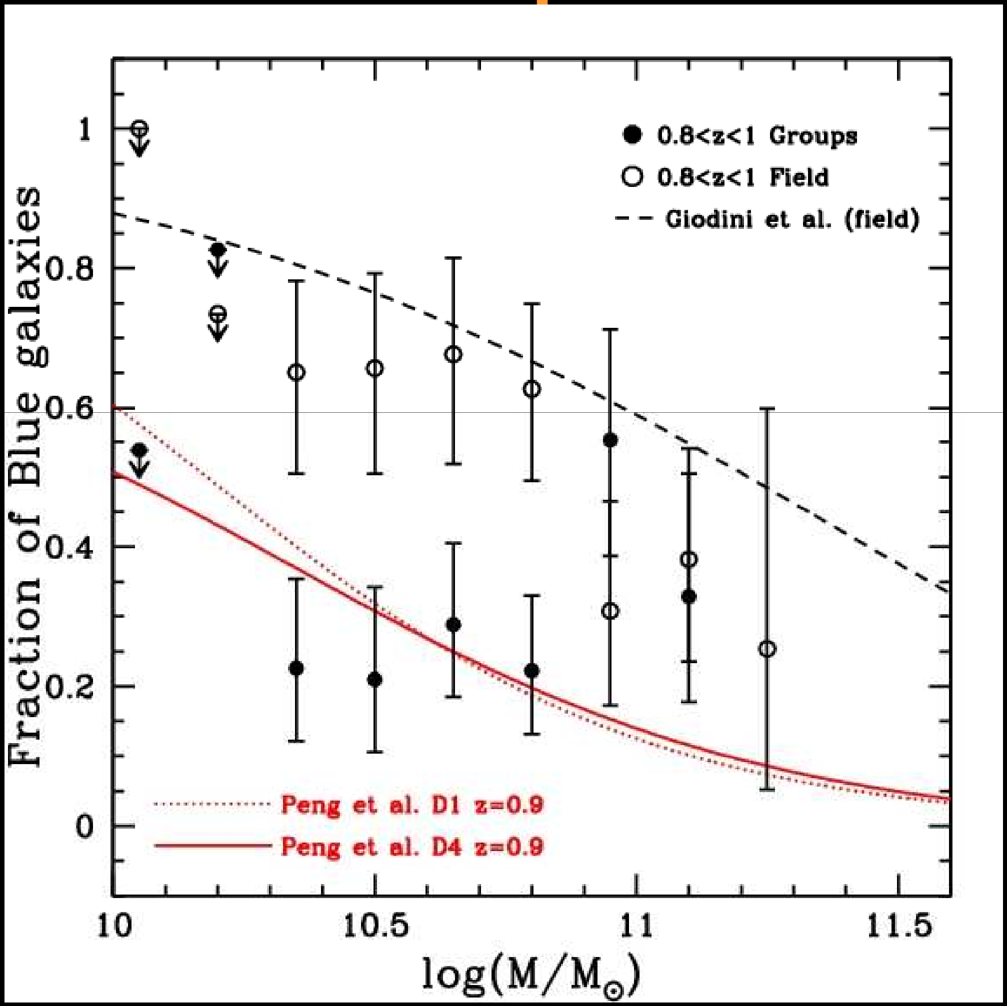
- These lie well off the SF “main sequence” but are not passive
- See also Whitaker et al. (2012), Grützbauch et al. (2011), Vulcani et al. (2010)

Stacked spectra



- Green galaxies have weak SF, weak Balmer lines
- Generally each category of galaxy shows similar properties in group and field environments

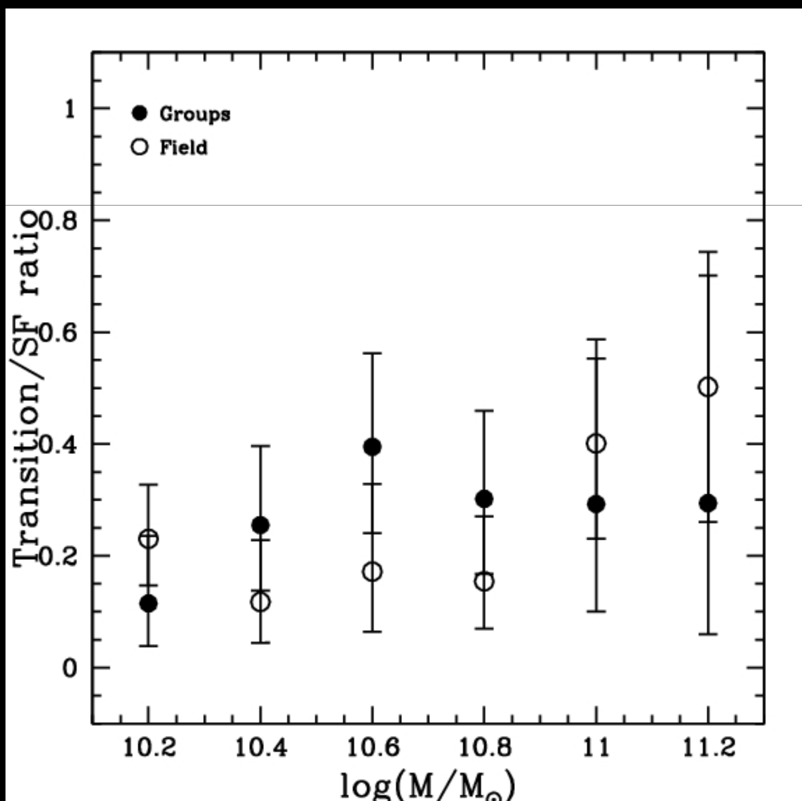
Population fractions

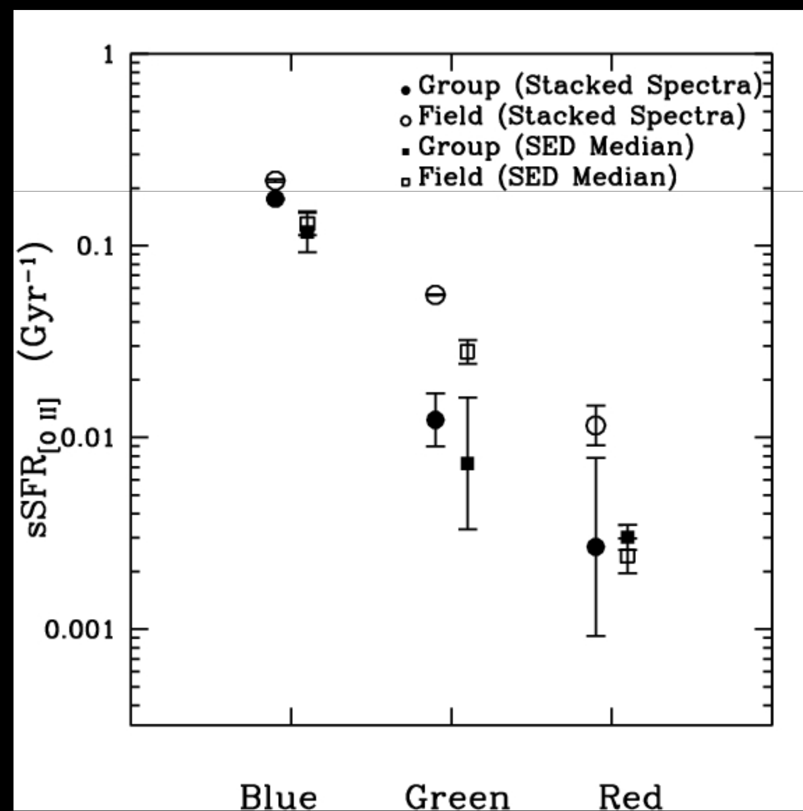


- Fraction of SF galaxies is significantly lower in groups, for $M_{star}<10^{11}$
- Note Peng model predicts no significant environmental dependence, and few SF galaxies even in the field.

Mok et al. (in prep)

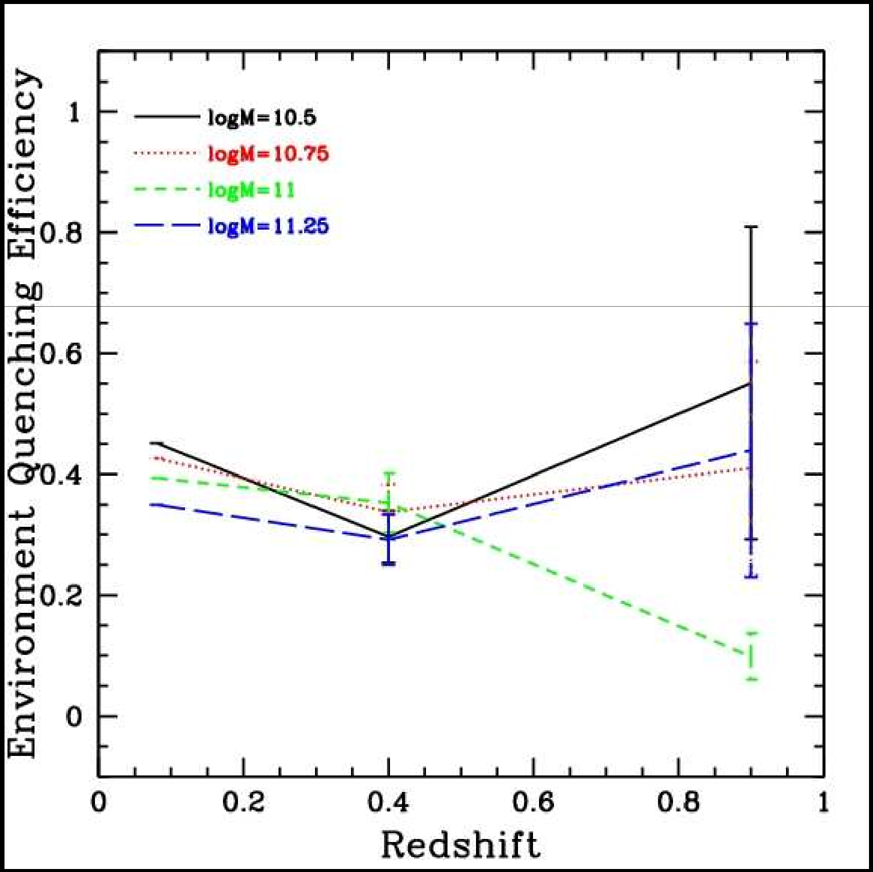
- "Transition" galaxies represent about 20% of the SF population
  - This is also independent of environment
  - Group population does have lower sSFR





Mok et al. (in prep)

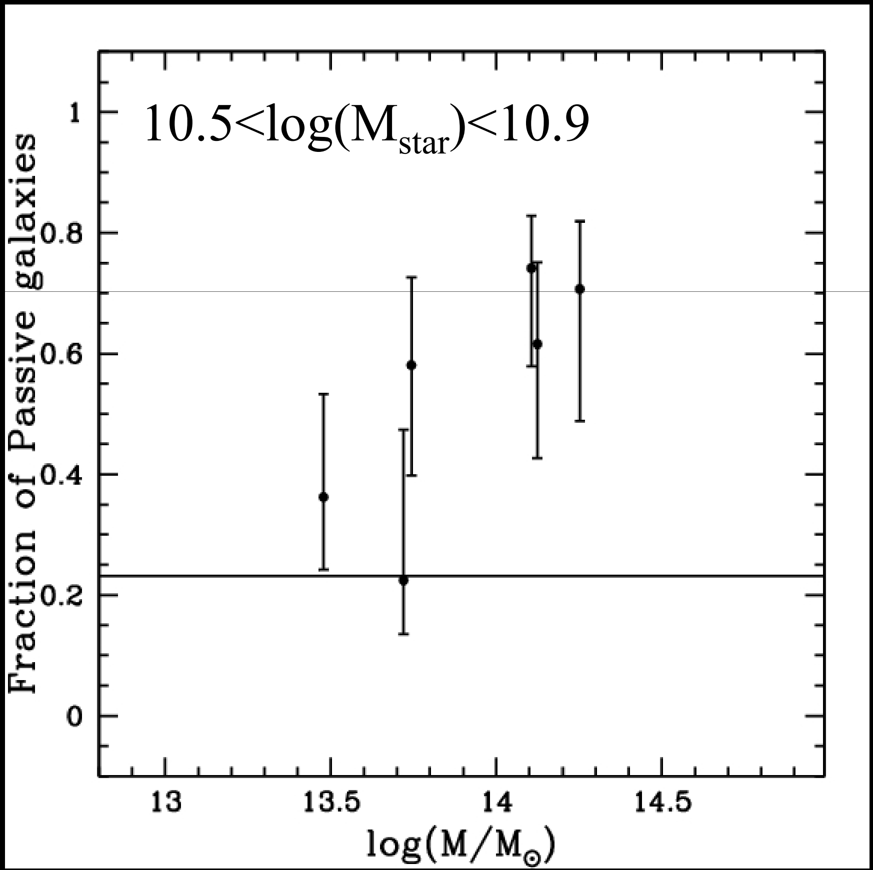
Quenching efficiency



Mok et al. (in prep)

- Fraction of active "centrals" that are quenched by the group:
  - About 40% independent of stellar mass and redshift
  - Recall that most z=1 group members have only been satellites for about 2 Gyr

Dependence on halo mass



Mok et al. (in prep)

- One of the goals of GEEC2 was to look for variations amongst groups
- Possible trend with group mass (see also Giodini et al. 2012)

Conclusions

- Galaxy groups at z=1 show lower fractions of SF galaxies than the field.
  - If SF fractions are as low as found by GEEC, it implies any delay time cannot be too long
- Little or no distortion of the SF main sequence or “green” transition population
  - Implies quenching must be rapid.
- Work in progress to find models that satisfy these constraints