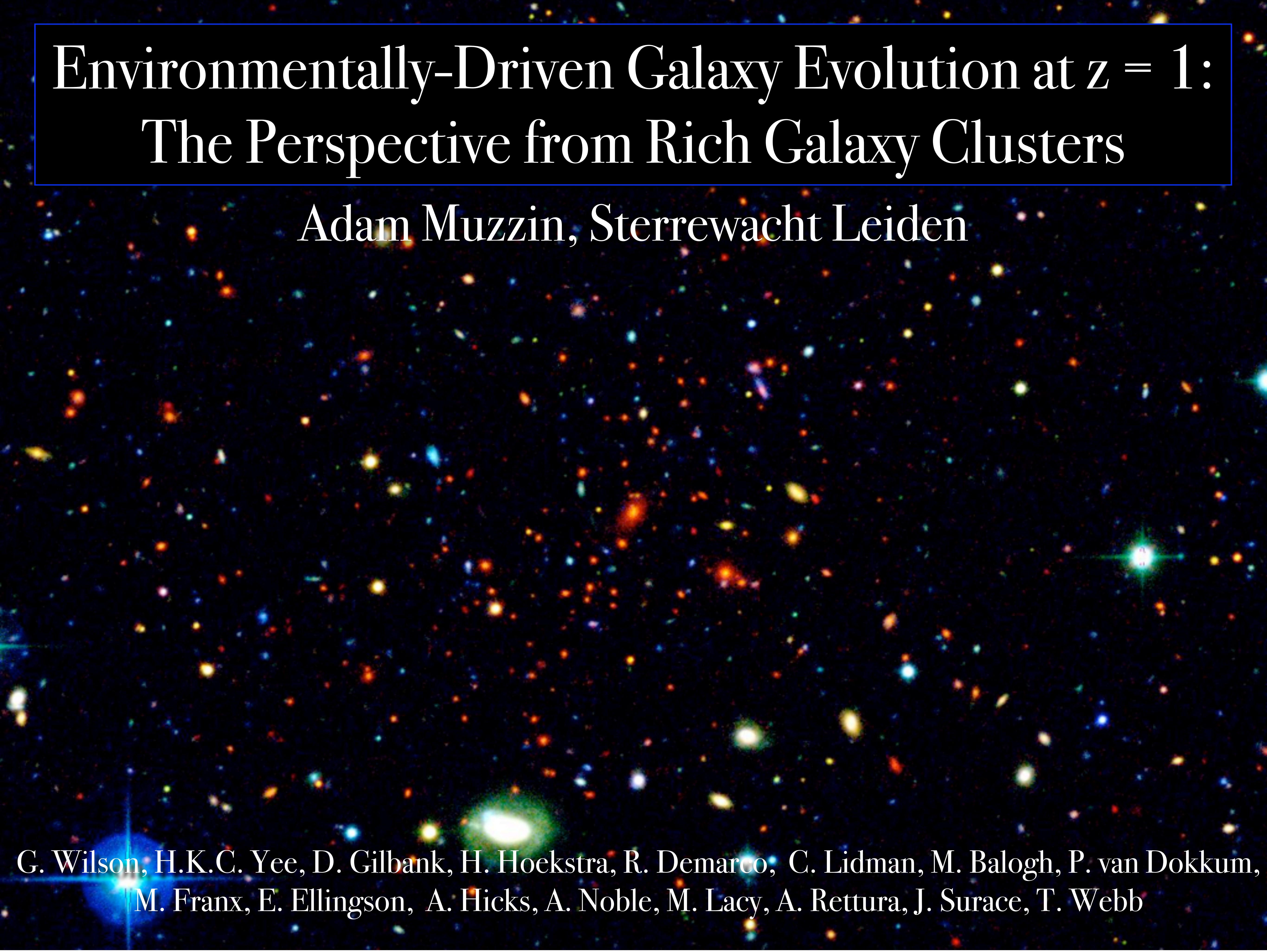
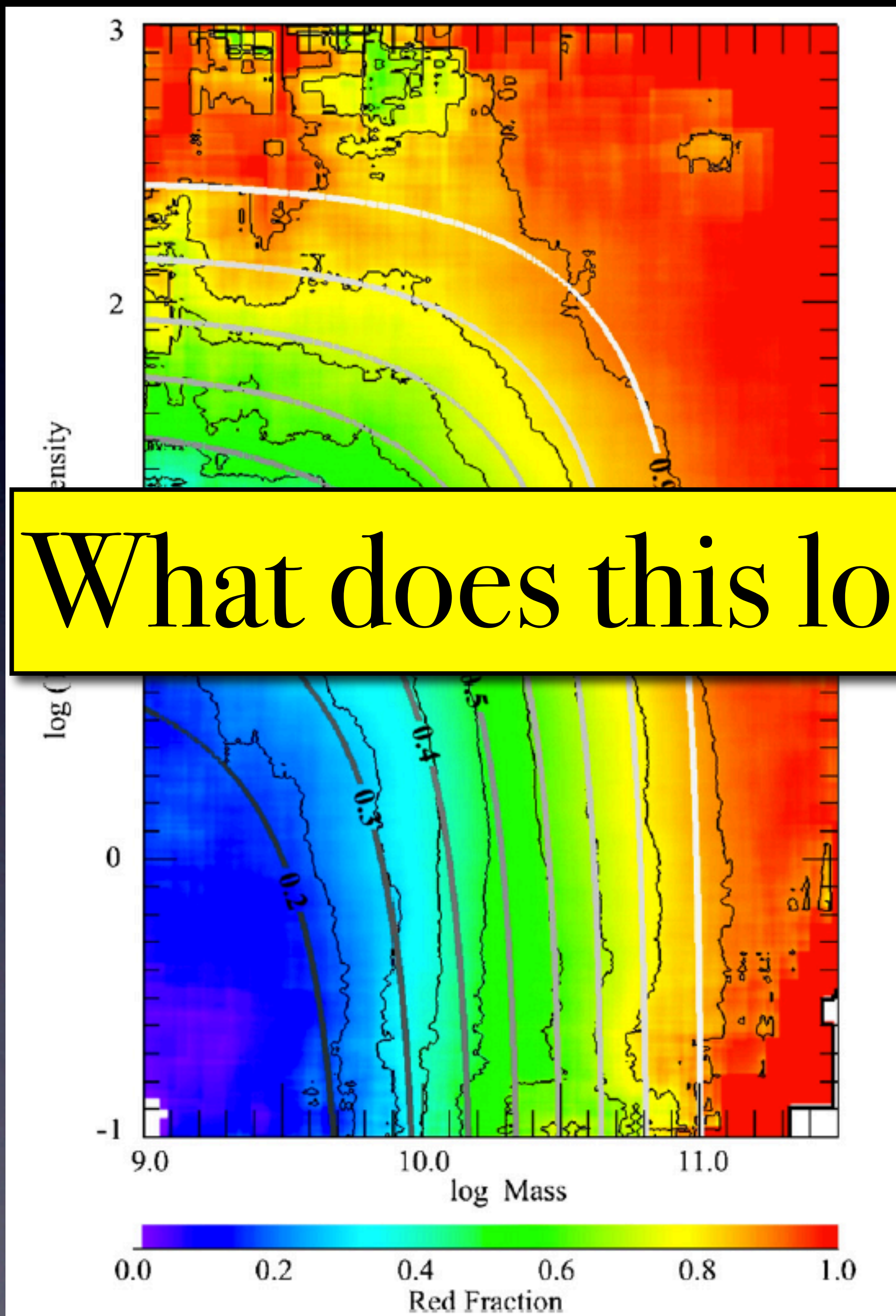
Environmentally-Driven Galaxy Evolution at z = 1: The Perspective from Rich Galaxy Clusters

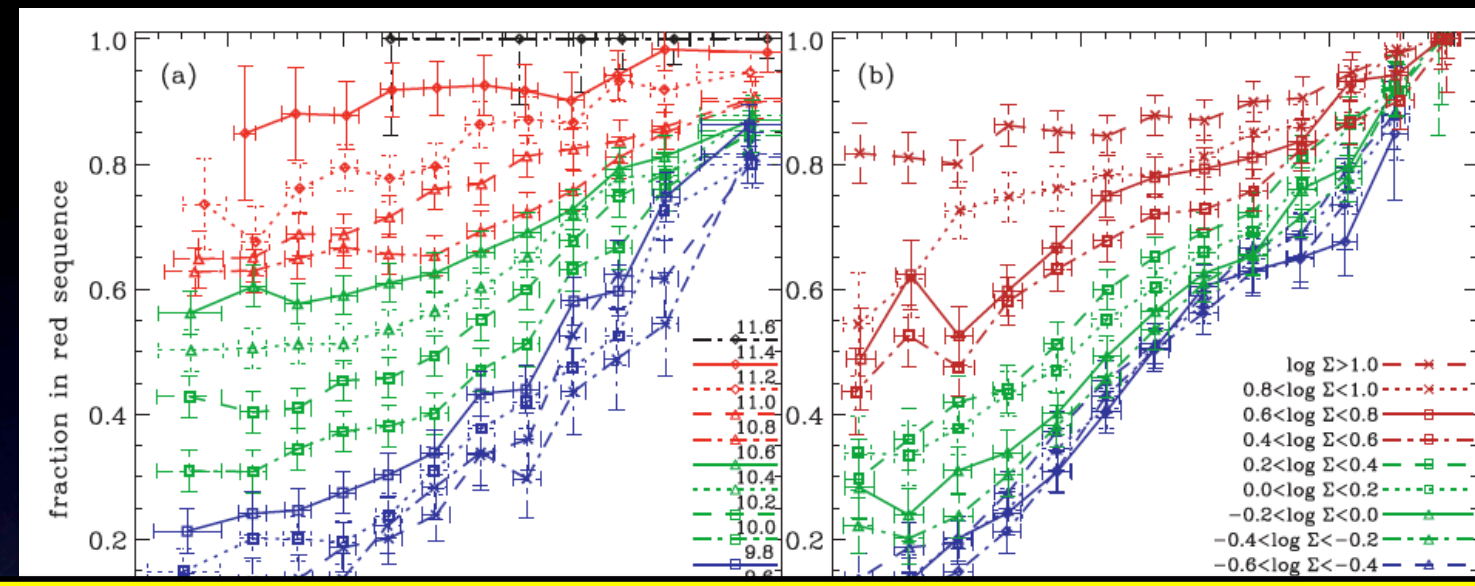
Adam Muzzin, Sterrewacht Leiden



G. Wilson, H.K.C. Yee, D. Gilbank, H. Hoekstra, R. Demarco, C. Lidman, M. Balogh, P. van Dokkum, M. Franx, E. Ellingson, A. Hicks, A. Noble, M. Lacy, A. Rettura, J. Surace, T. Webb

Separating Stellar Mass and Environment





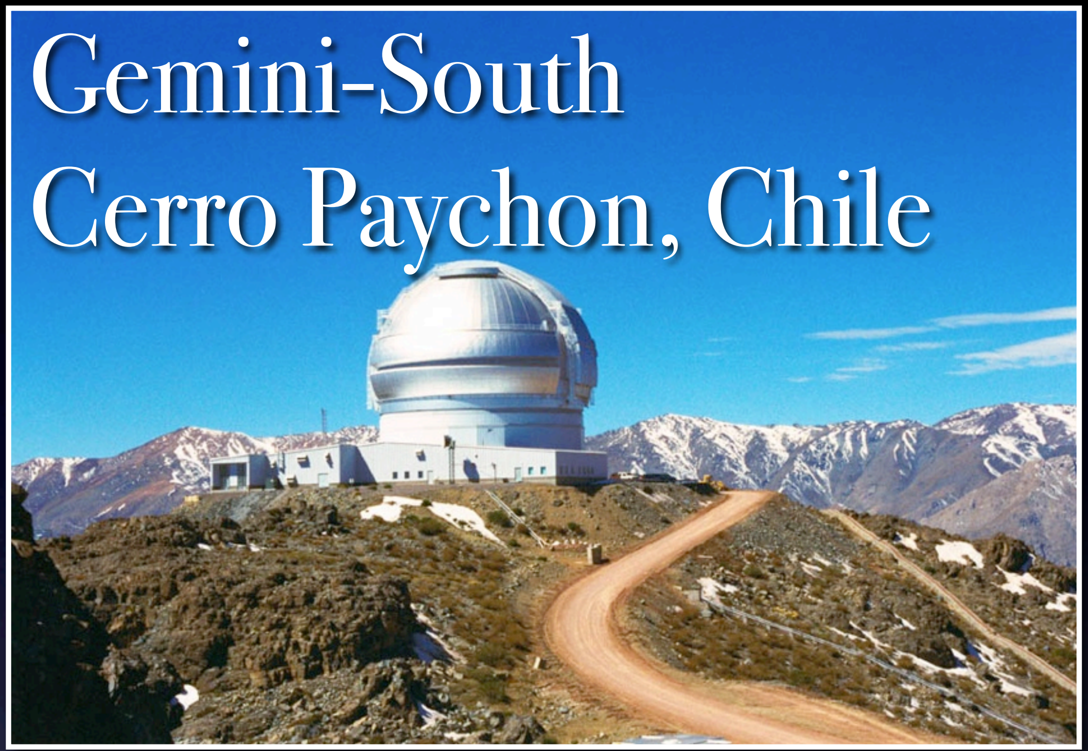
What does this look like at higher redshift?

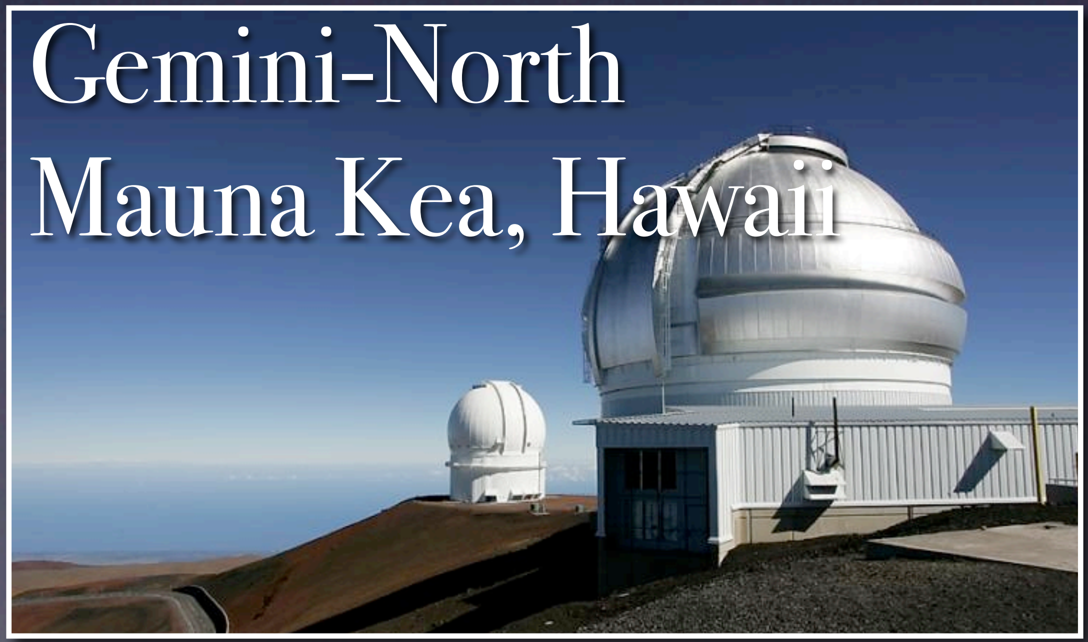
Baldry+2006

It is now clear that in order to understand how the quenching of star formation occurs, we must consider both the mass and environment of galaxies

Peng+2010

The GCLASS Survey





- Spectroscopic survey of 10 rich clusters z = 1 with Gemini/GMOS
- Targets selected on 3.6μm flux (rest-frame H-band)
- Better than 50% sampling for galaxies with $L > 0.5L^*$ and 25% for $L > 0.1L^*$
- 222-hour project over three years with Gemini/GMOS

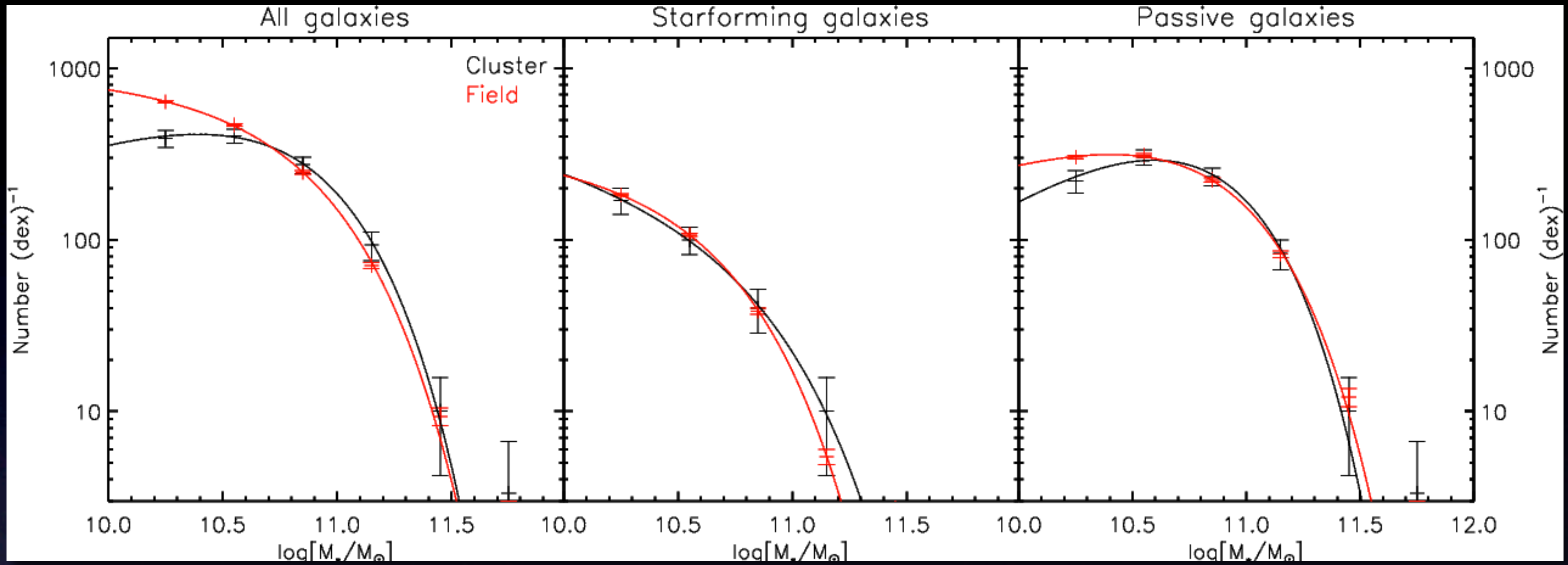
The GCLASS Cluster Sample

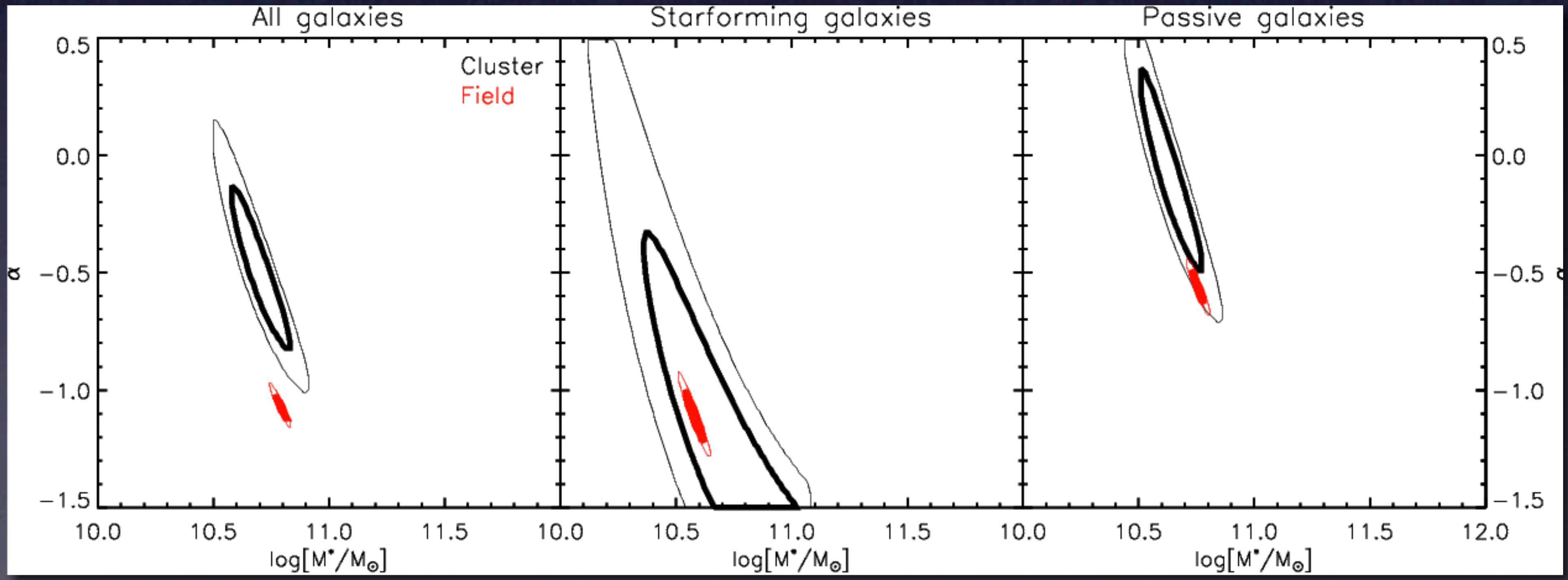
IR red-sequence-selected cluster sample drawn from the 42 deg^2 SpARCS/SWIRE survey

Name	Redshift	Velocity-Disp	Members
SpARCS J003645-441050	0.867	700 km s^{-1}	45
SpARCS J161312+564930	0.869	750 km s^{-1}	48
SpARCS J003442-430753	0.871	1350 km s^{-1}	93
SpARCS J104737+574137	0.956	660 km s^{-1}	31
SpARCS J021524-034331	1.004	640 km s^{-1}	48
SpARCS J105111+581803	1.034	500 km s^{-1}	34
SpARCS J161641+554513	1.157	680 km s^{-1}	46
SpARCS J163435+402151	1.177	790 km s^{-1}	50
SpARCS J163852+403843	1.196	480 km s^{-1}	44
SpARCS J003550-431224	1.335	780 km s^{-1}	23
Field Galaxies	$0.85 < z < 1.20$	N/A	294

see Muzzin+2009, Wilson+2009, Demarco+2010, Hildebrandt+2011

The Stellar Mass Function at z = 1



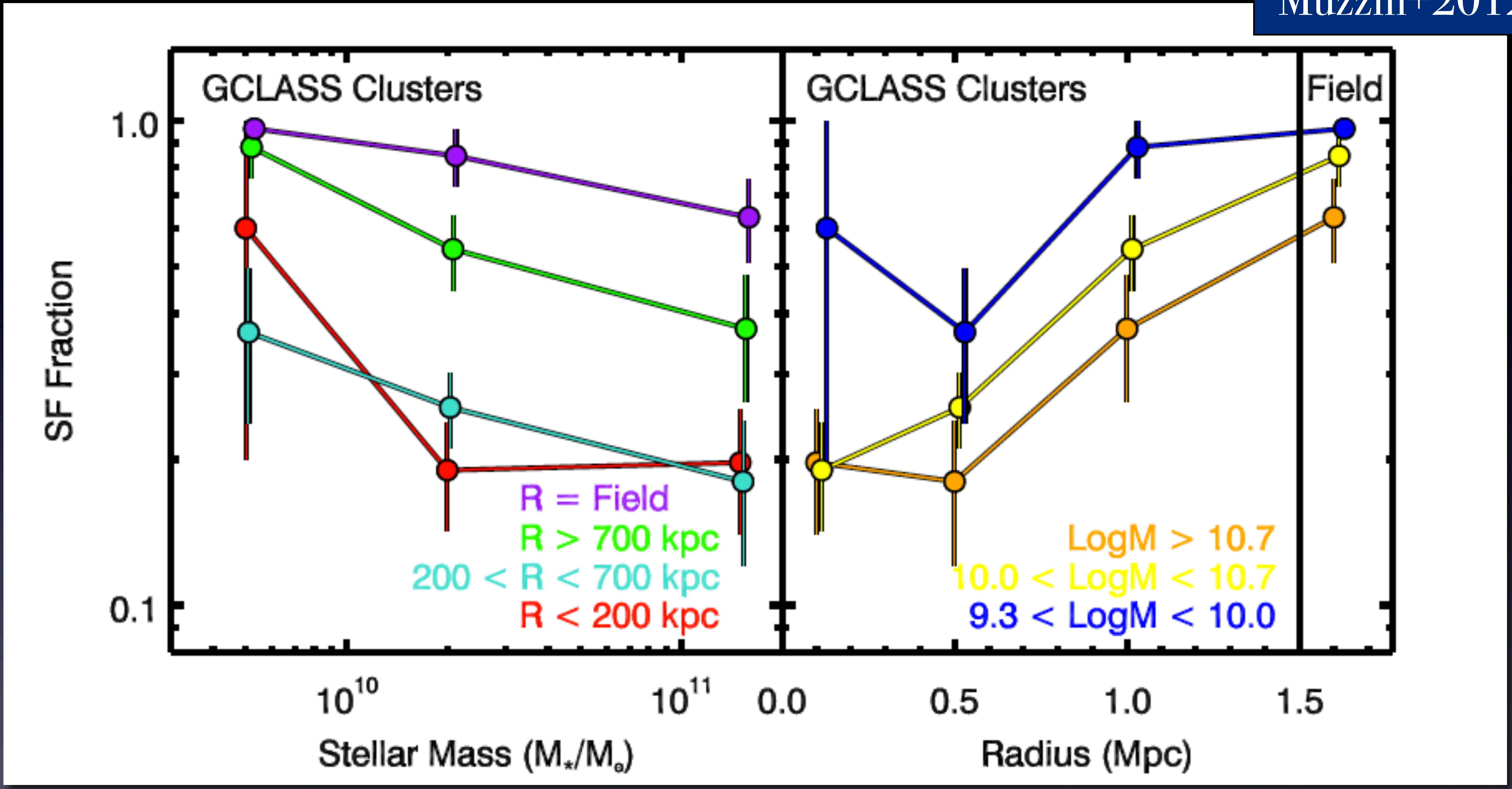


See poster by Remco van der Burg

Total SMF depends on environment, but star forming and quiescent SMF are the same between cluster and field

Star Forming Fraction Dependence

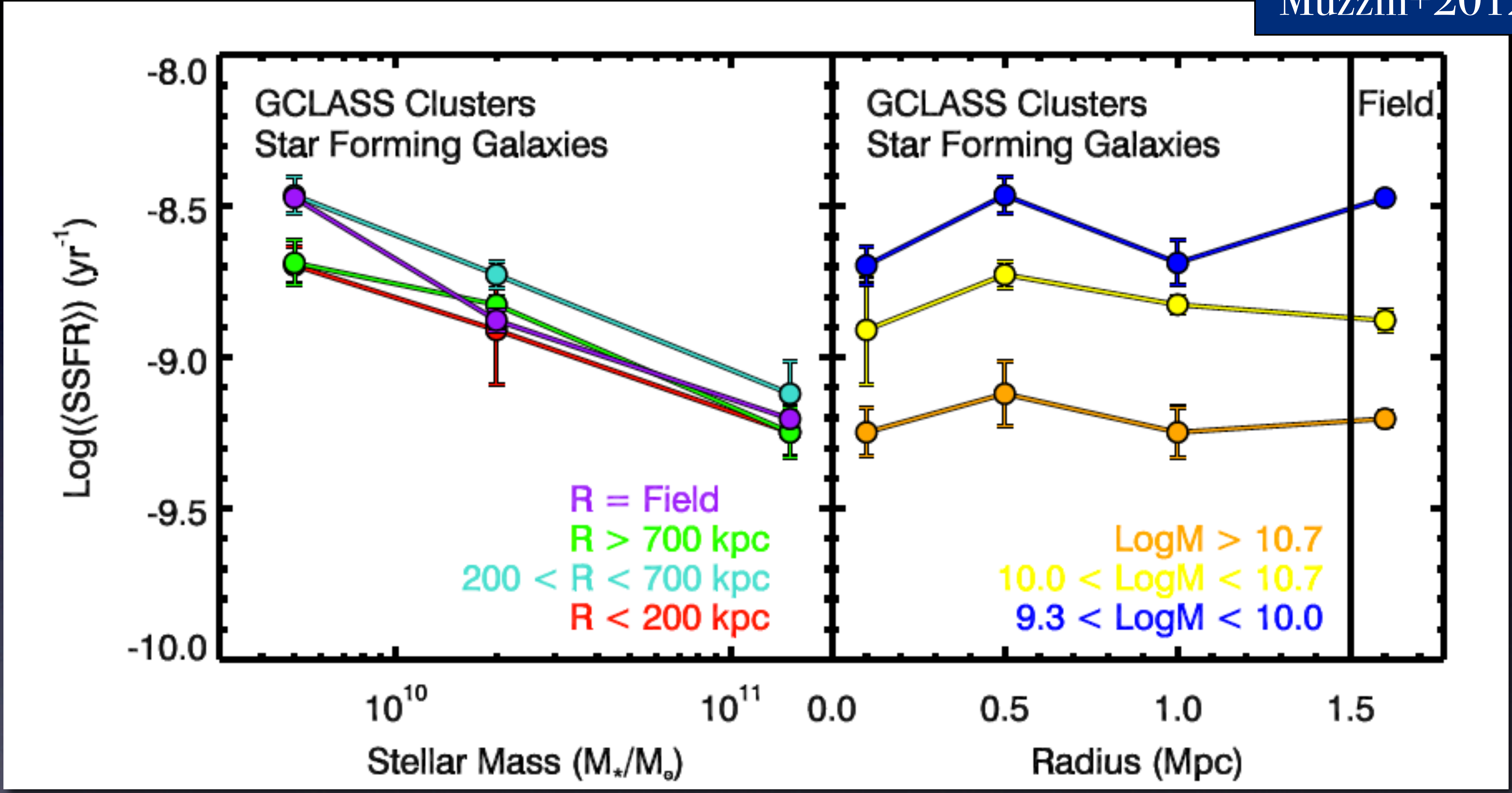
Muzzin+2012



The fraction of star forming galaxies correlates with both stellar mass and environment

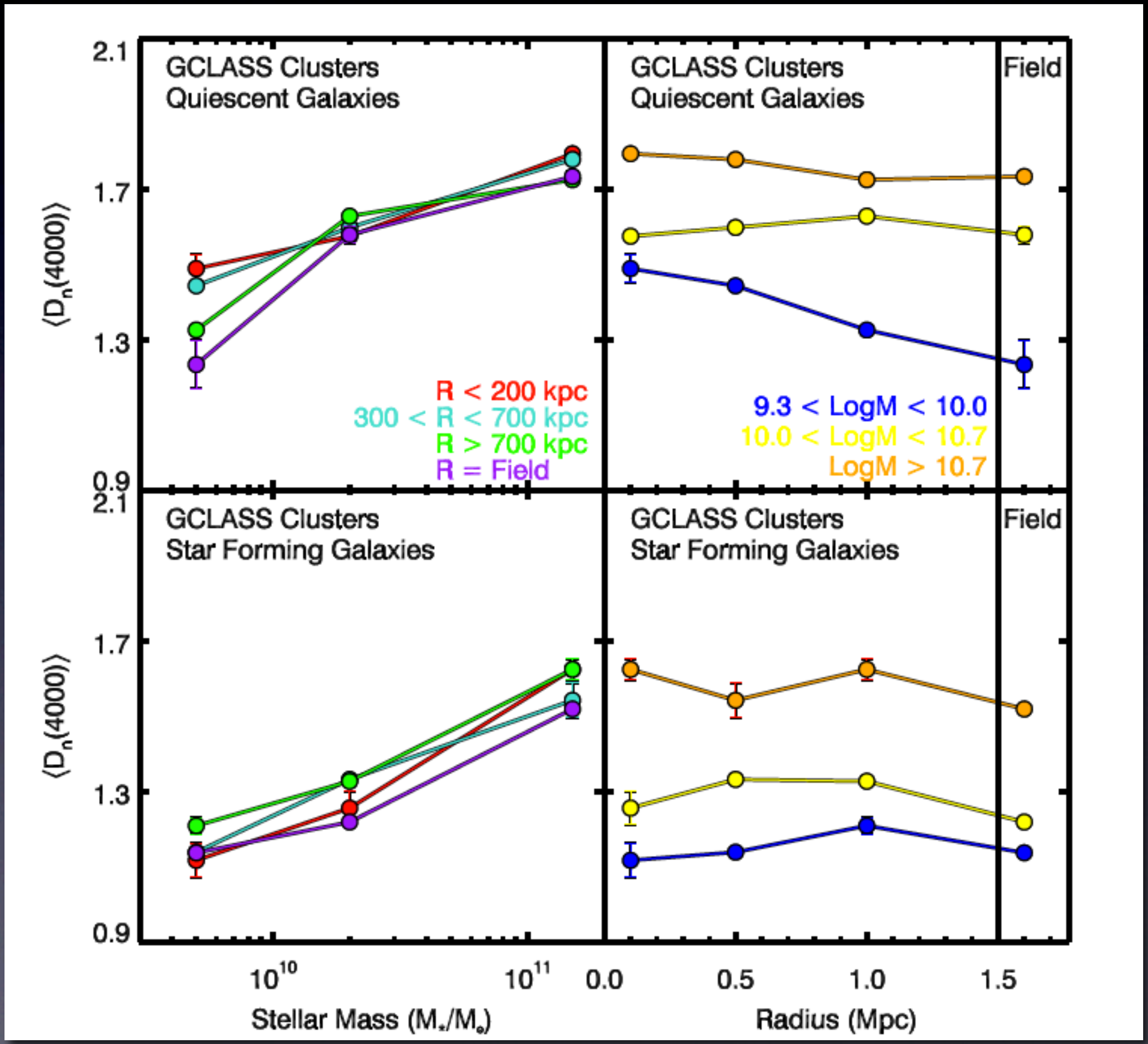
Specific Star Formation Rates

Muzzin+2012



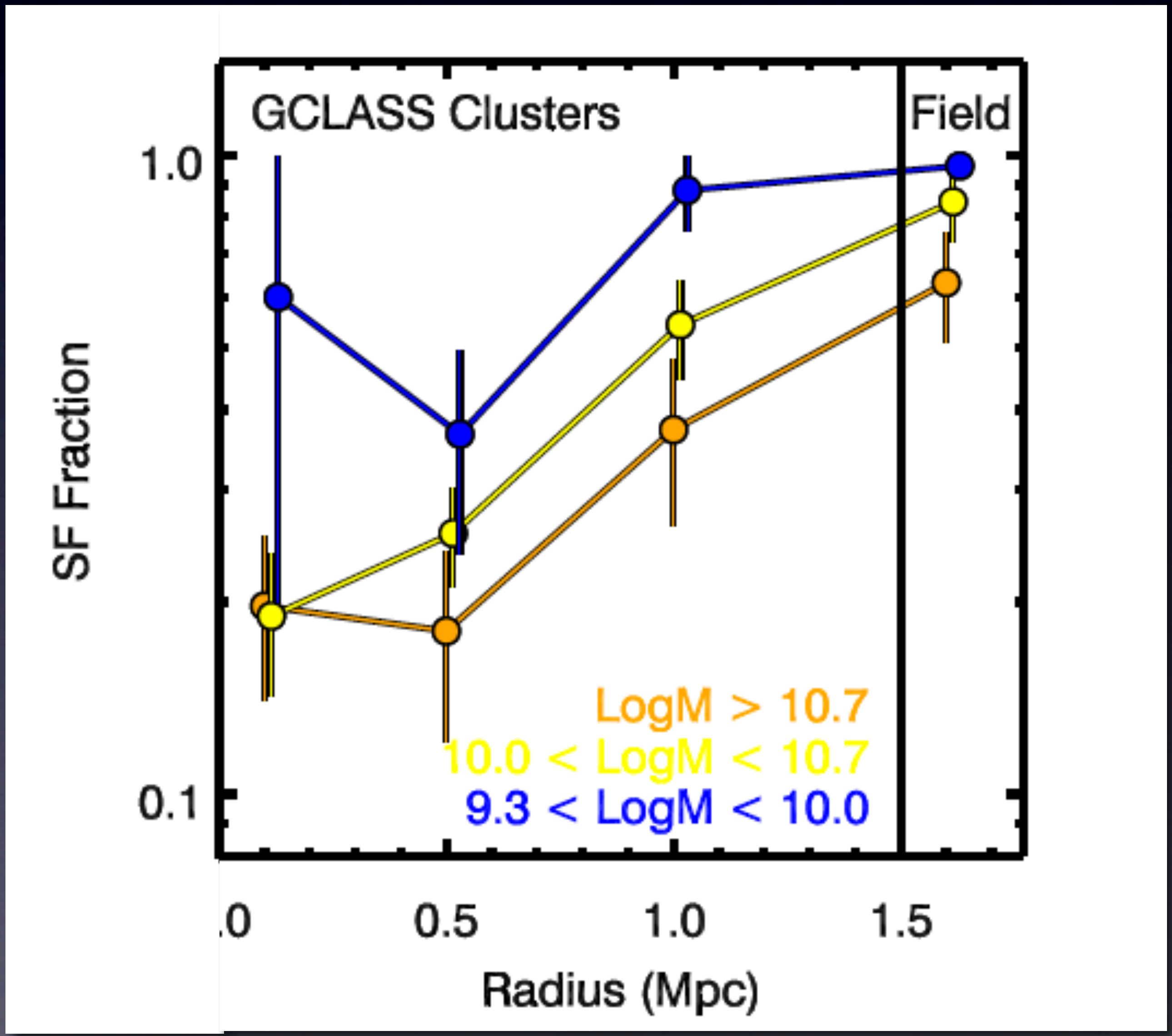
Specific star formation rates of star forming galaxies depend on stellar mass, not environment

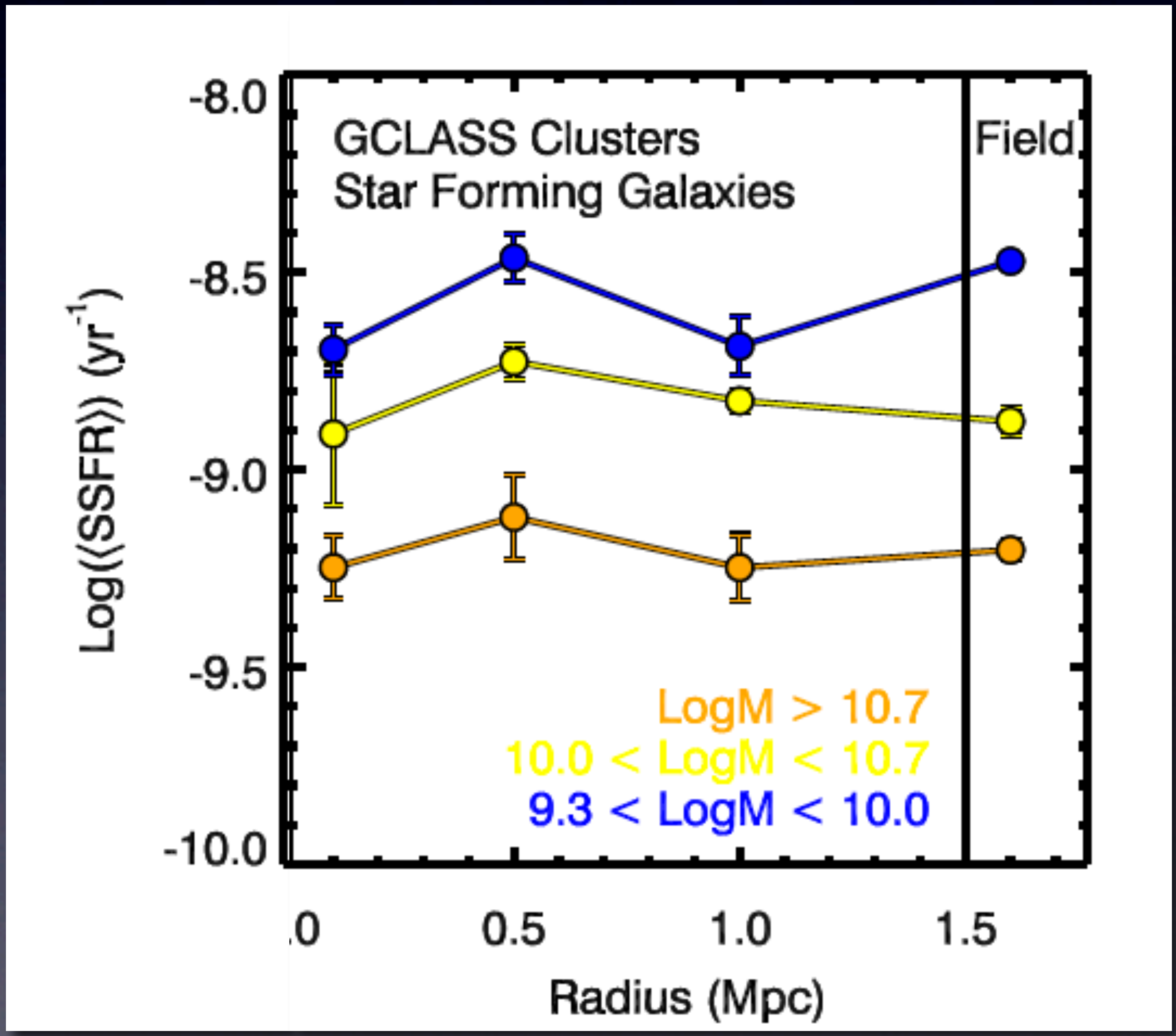
D(4000) vs. Mass and Environment



- D(4000) of star forming and quenched galaxies depends on stellar mass, not on environment

How Can We Explain the Unusual Environmental Correlations?





How Can We Explain the Unusual Environmental Correlations?

The "light switch" analogy

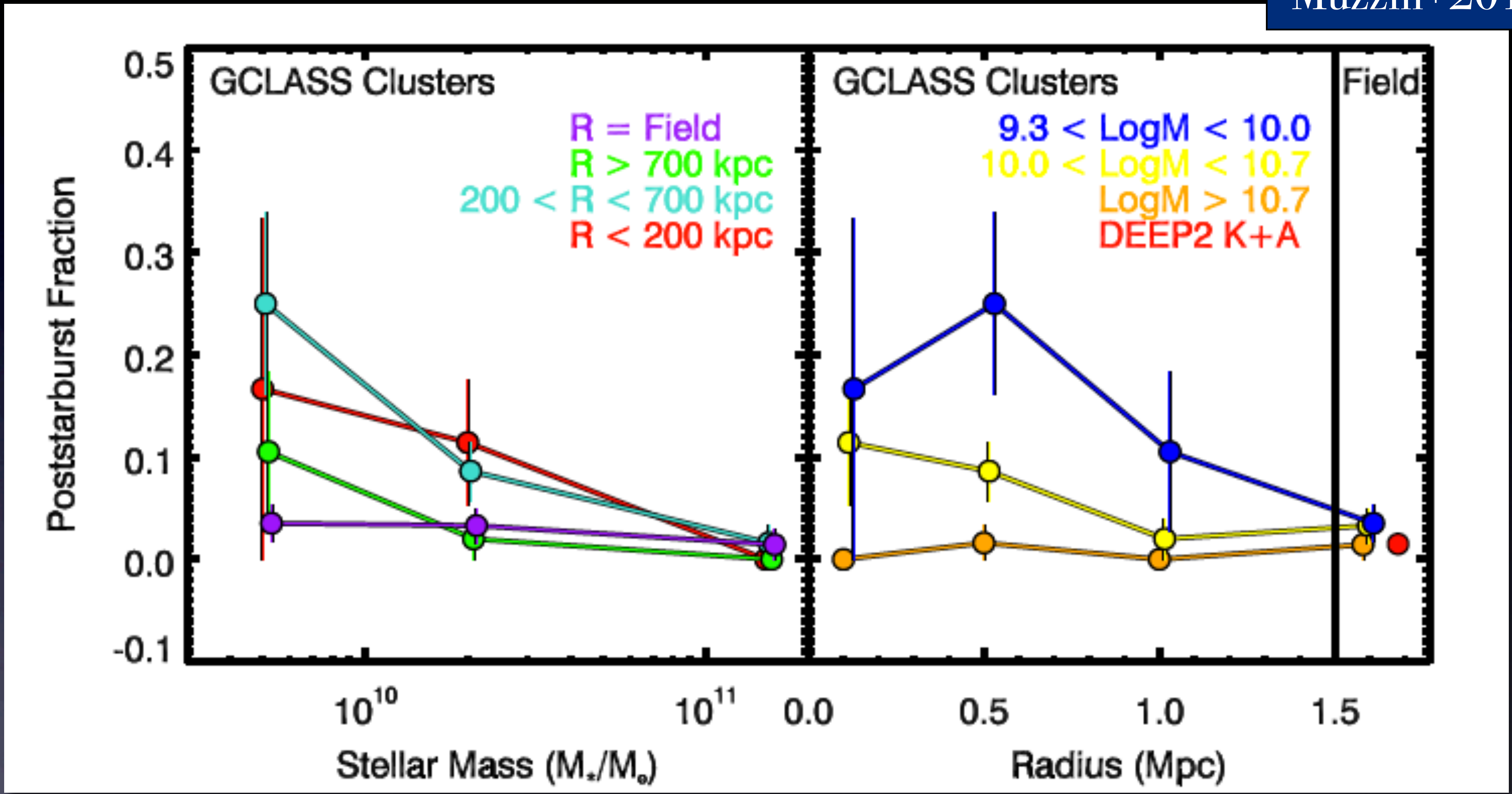
Stellar Mass: Smoothly regulates star formation, mass goes up, SFR goes down

Environment: An abrupt on/off switch, quickly moves galaxies between star forming/quiescent

Is this testable?

The Poststarburst Fraction

Muzzin+2012



Environment appears to cause rapid quenching at z=1

Conclusions

- Effects of environment and stellar mass similar at z=1 and z=0; no "reversal of SFR-density relation" at z = 1
- Environment determines only fraction of star-forming galaxies, not galaxy properties
- Stellar mass determines both fraction of star-forming galaxies and galaxy properties
- Stellar mass function of star-forming and quiescent galaxies independent of environment; total depends on environment
- Substantial population of poststarburst galaxies in z = 1 clusters suggesting environmental quenching process must be rapid