GOGREEN: THE STAR-FORMING MAIN SEQUENCE AT $1 < z < 1.5$

LYNDSAY OLD - ESA RESEARCH FELLOW @ ESAC, MADRID

GOGREEN MEETING 24TH AUGUST 2020

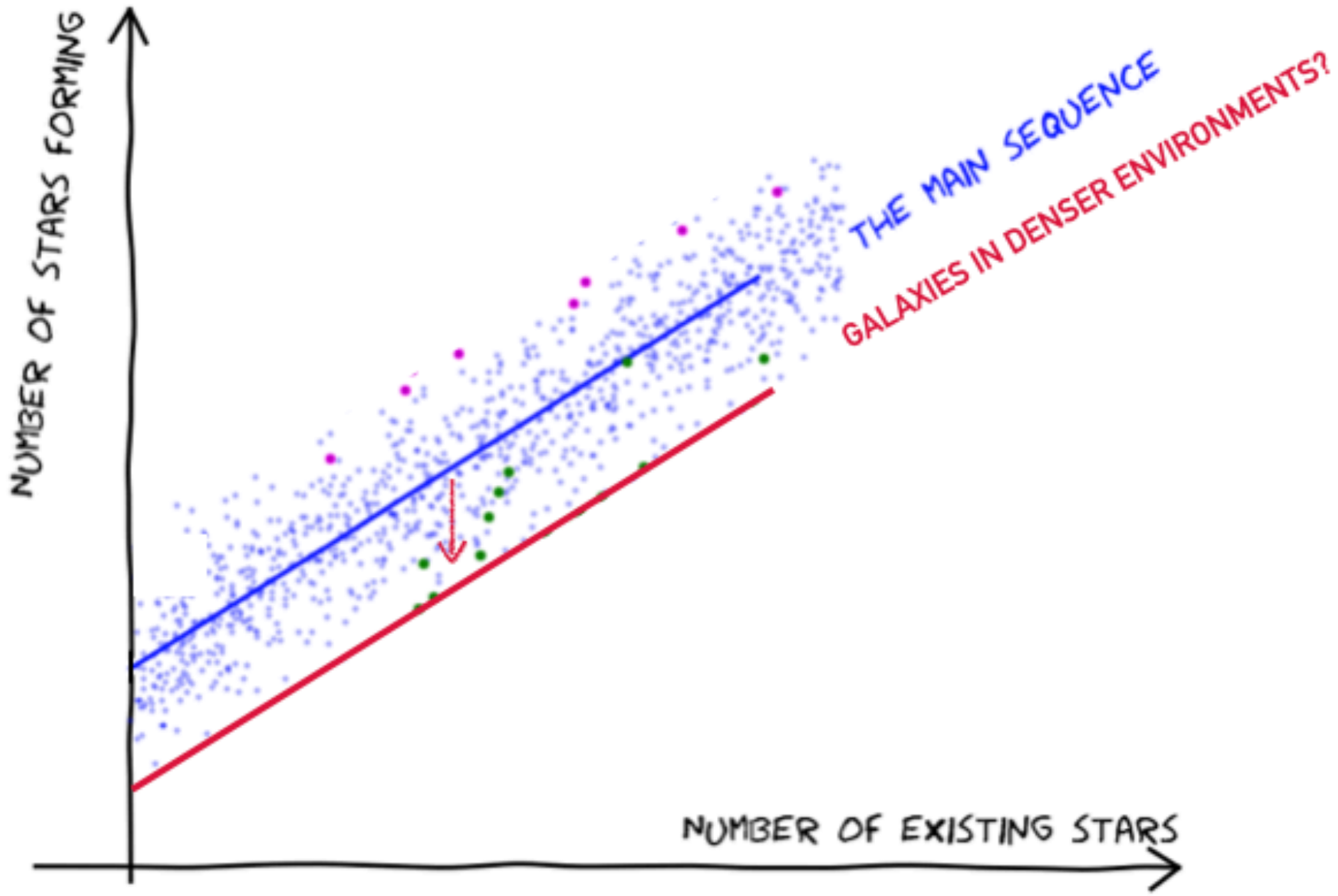
THE GOGREEN SURVEY TEAM

Michael Balogh, Waterloo (PI)
Adam Muzzin, York
Gregory Rudnick, Kansas
Gillian Wilson, UC Riverside
Kristi Webb, Waterloo
Andrew Reeves, Waterloo
Karen McNab, Waterloo
Matthew Pereira Wilson
Bob Abraham, Toronto
Victoria Alonso, Cordoba
Andrea Biviano, Trieste
Richard Bower, Durham
Jeffrey Chan, UC Riverside
Pierluigi Cerulo, Concepcion
Charlie Conroy, CfA Harvard
Michael Cooper, UC Irvine
Warrick Couch, AAO

Gabriella De Lucia, Trieste
Ricardo Demarco, Concepción
Erica Ellingson, Boulder
Alexis Finoguenov, Helsinki
Ben Forrest, UC Riverside
David Gilbank, SAAO
Henk Hoekstra, Leiden
Pascale Jablonka, Lausanne
Egidius Kukstas, Liverpool JM
Mark David Lacy, NRAO
Diego Garcia Lambas, Cordoba
Chris Lidman, ANU
Ian McCarthy, Liverpool JM
Sean McGee, Birmingham
Hernan Muriel, Cordoba
Julie Nantais, Andrés Bello
Allison Noble, MIT

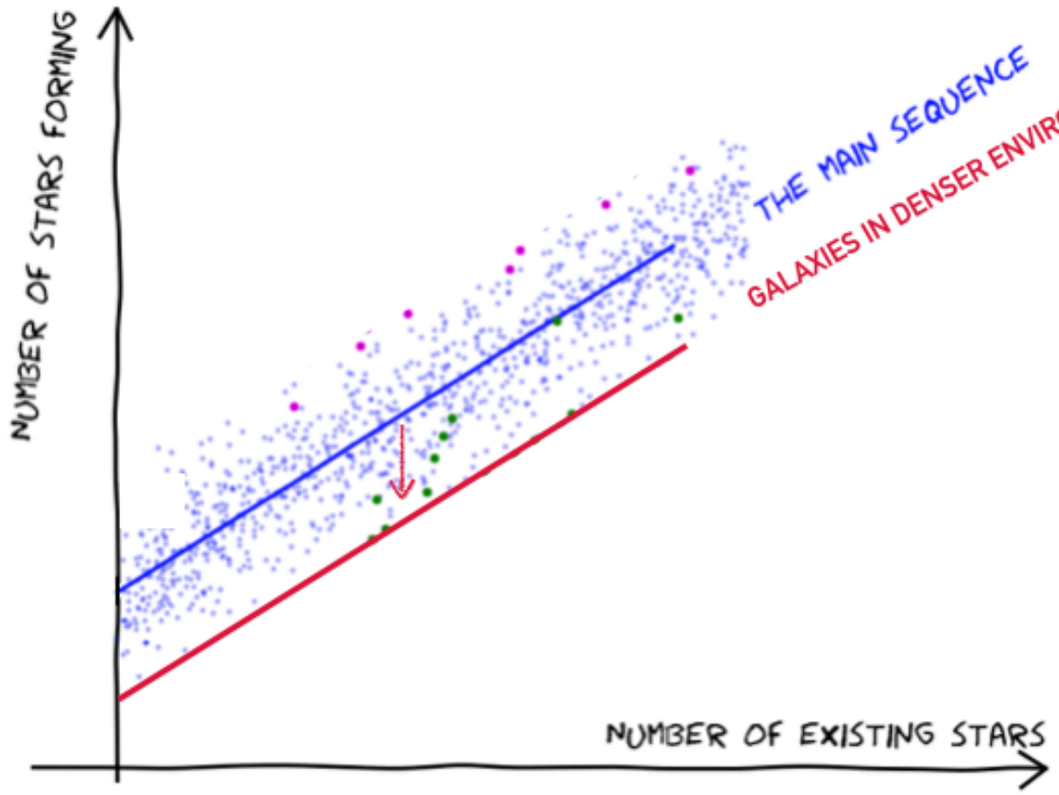
Matt Owers, AAO
Laura Parker, McMaster
Irene Pintos-Castro, Toronto
Bianca Poggianti, INAF/Padova
Alessandro Rettura, JPL
Heath Shipley, McGill
Ian Smail, Durham
Jason Surace, Caltech IPAC
Jeremy Tinker, NYU
Carlos Valotto, Cordoba
Remco van der Burg, ESO
Tracy Webb, McGill
Andrew Wetzel, UC Davis
Jon Willis, Victoria
Benedetta Vulcani, INAF/Padova
Howard Yee, Toronto
Dennis Zaritsky, Arizona

THE ENVIRONMENTAL DEPENDENCE OF THE STAR-FORMING GALAXY MAIN SEQUENCE



Adapted from blog-post by Harry Ferguson

At z < 1, several studies have claimed little to no trend in the SFMS with environment, whilst others find a modest trend with higher SFRs at fixed stellar mass in the field:

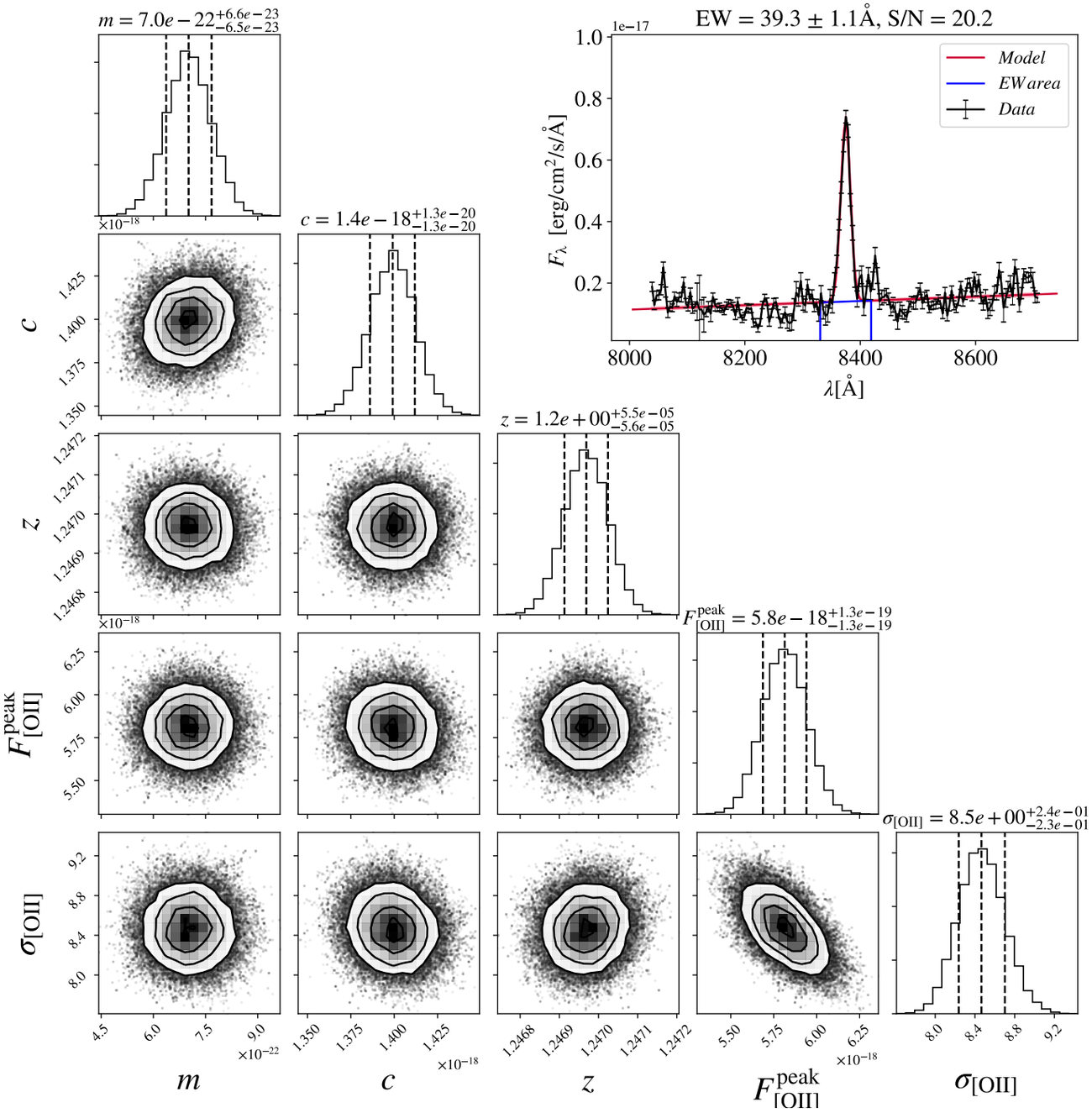


Adapted from blog-post by Harry Ferguson

E.g., Vulcani et al. 2010; Popesso et al. 2011; Patel et al. 2011; Haines et al. 2013; Paccagnella et al. 2016; Rodríguez del Pino et al. 2017; Wang et al. 2018

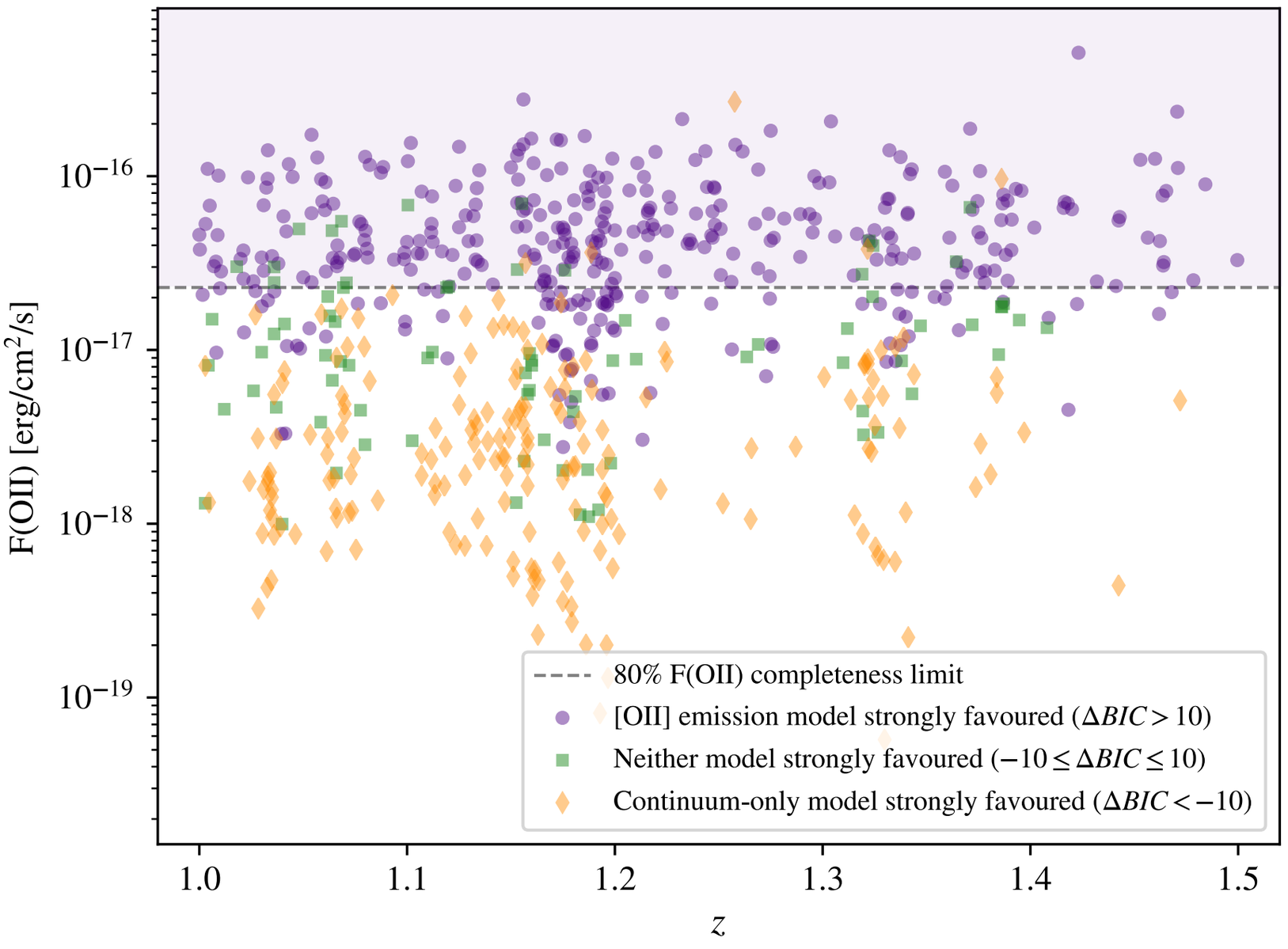
E.g. Peng et al. 2010; Wijesinghe et al. 2012; Muzzin et al. 2012; Wetzel et al. 2012; Koyama et al. 2013

MEASURING [OII] FLUXES



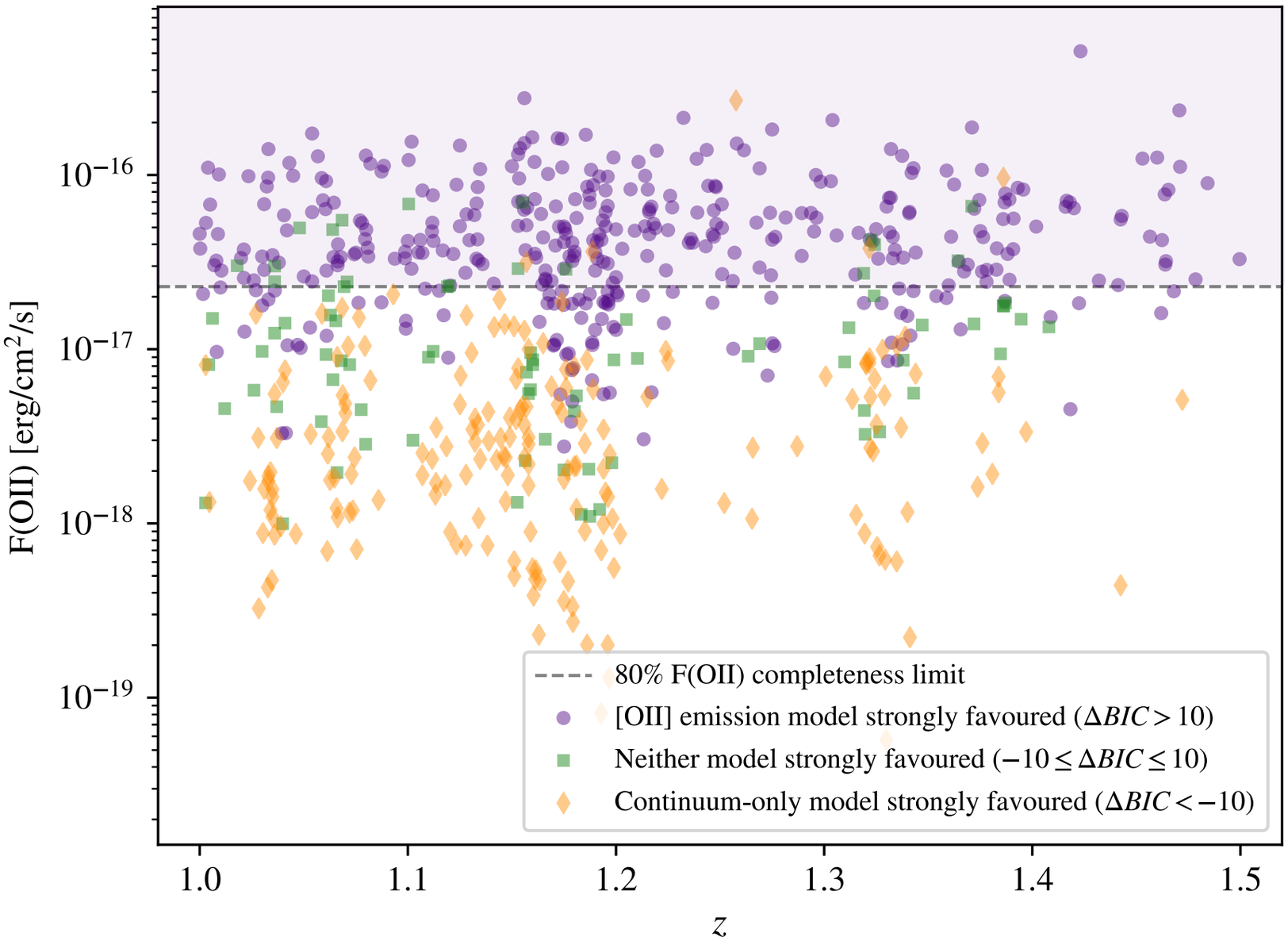
Conservative 80% F([OII]) limit based on Bayesian Information Criterion.

MEASURING [OII] FLUXES



Conservative 80% F([OII]) limit based on Bayesian Information Criterion.

MEASURING [OII] FLUXES

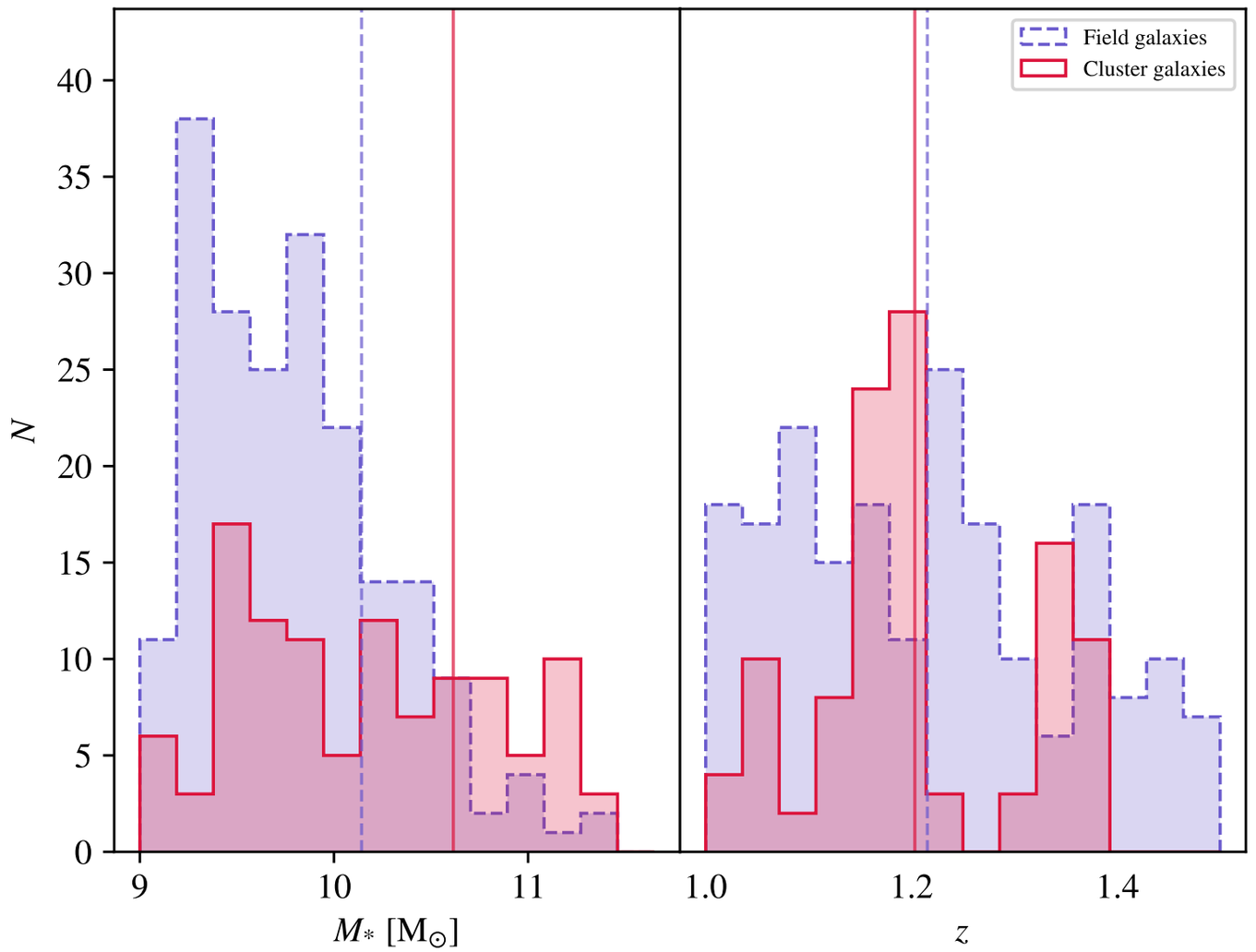


To convert [OII] fluxes to SFRs, we use a relation from Gilbank et al. 2010 with empirical correction derived from Hα to correct for metallicity & dust dependence of L([OII]) on SFR as a function of M$_*$

FOR THIS STUDY: 11 MASSIVE GOGREEN CLUSTERS

Cluster name	z_c	N_{tot}
SPT–CLJ0205–5829	1.320	70
SPT–CLJ0546–5345	1.067	103
SPT–CLJ2106–5844	1.132	71
SpARCS0219–0531	1.325	56
SpARCS0335–2929	1.368	133
SpARCS1033+5753	1.455	61
SpARCS1034+5818	1.385	40
SpARCS1051+5818	1.035	185
SpARCS1616+5545	1.156	214
SpARCS1634+4021	1.177	190
SpARCS1638+4038	1.196	174

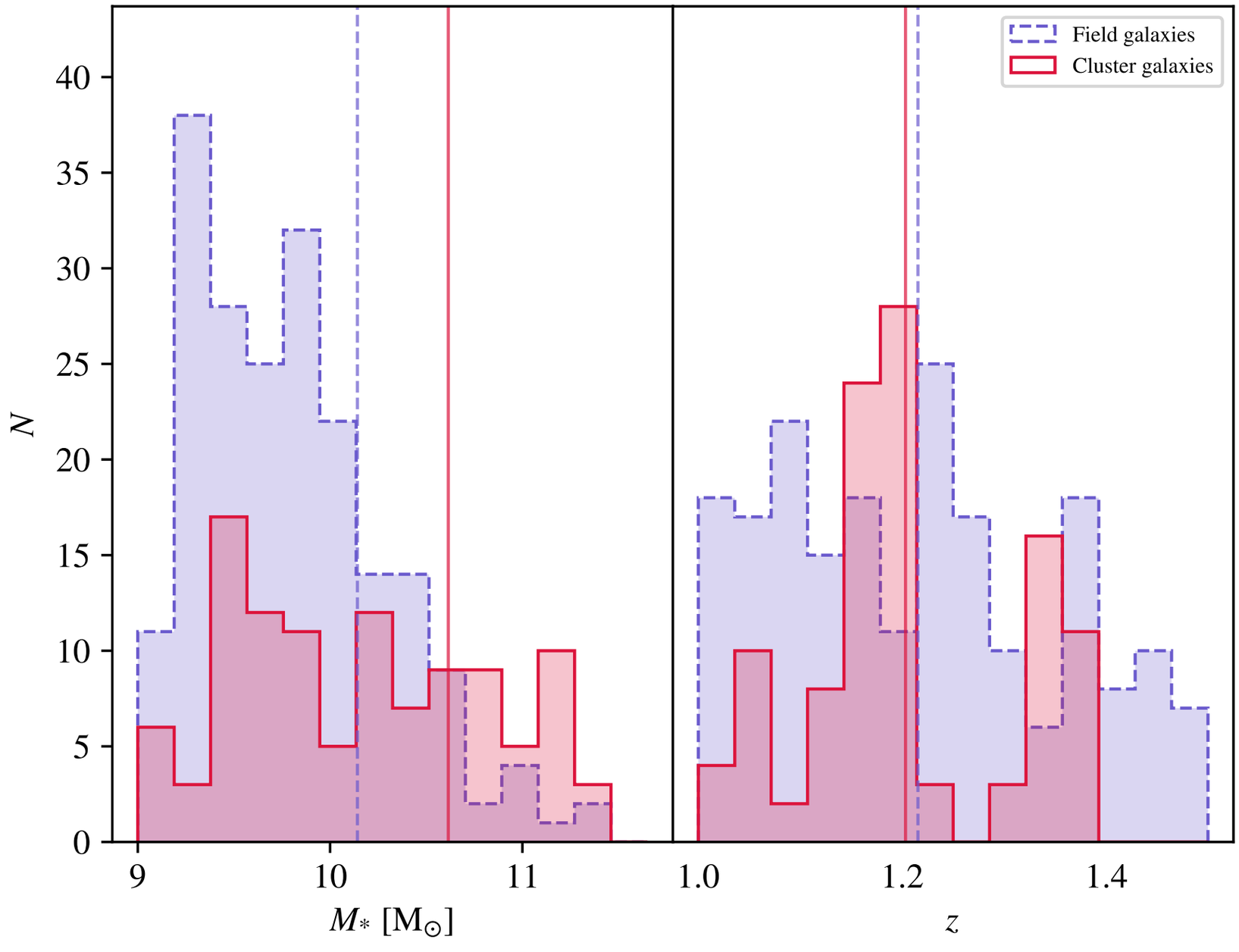
- Cluster membership based on dynamics (Andrea Biviano)
- SED-derived stellar masses (Remco van der Burg)



Cluster vs. Field z and M_* distributions

CLUSTER & FIELD SAMPLE PROPERTIES

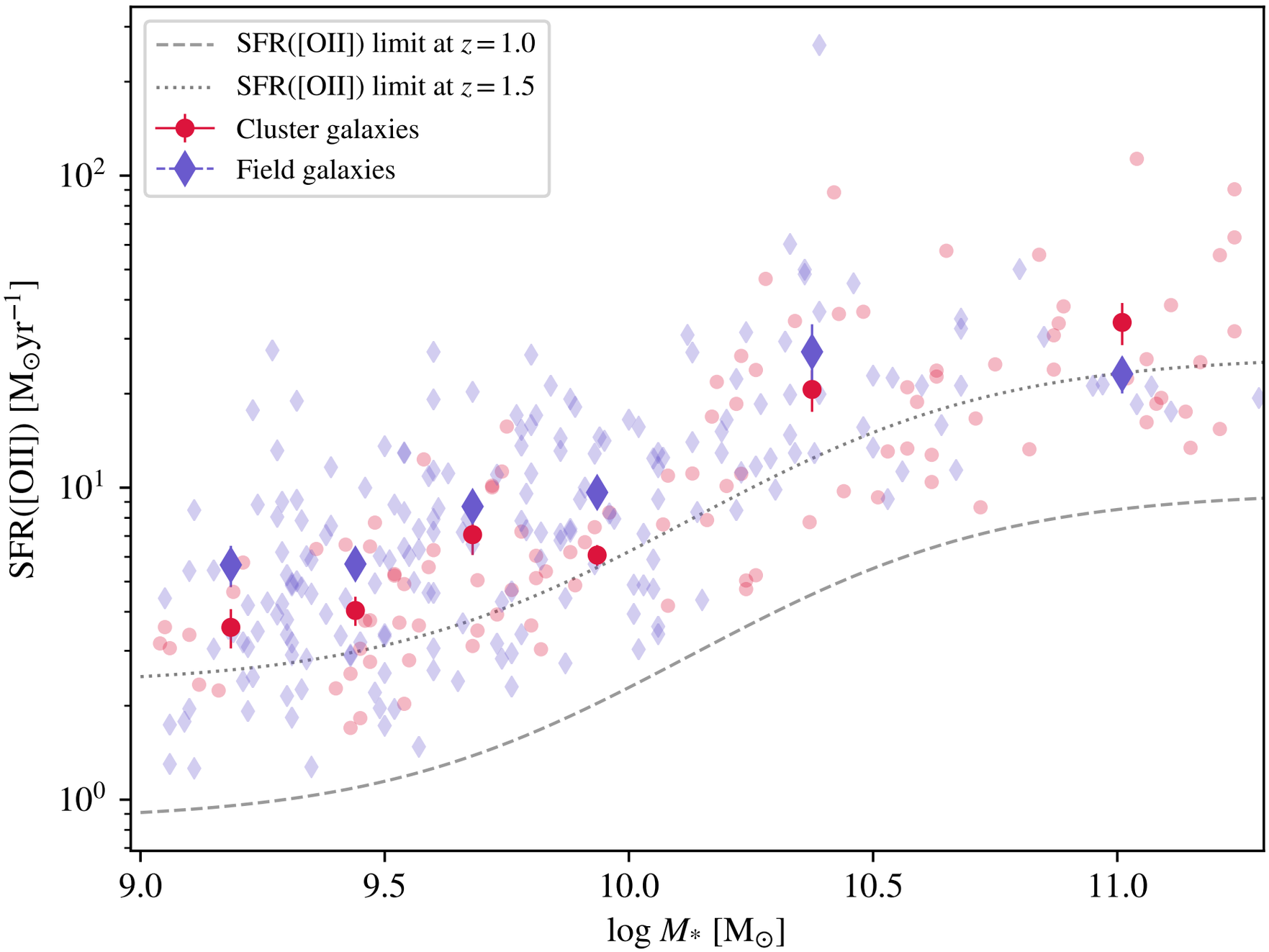
We apply a correction to the field SFRs based off the cluster vs. field z differences in stellar mass bins using the observed cosmic star formation redshift relation for field galaxies from Schreiber et al. (2015).



109 cluster gals

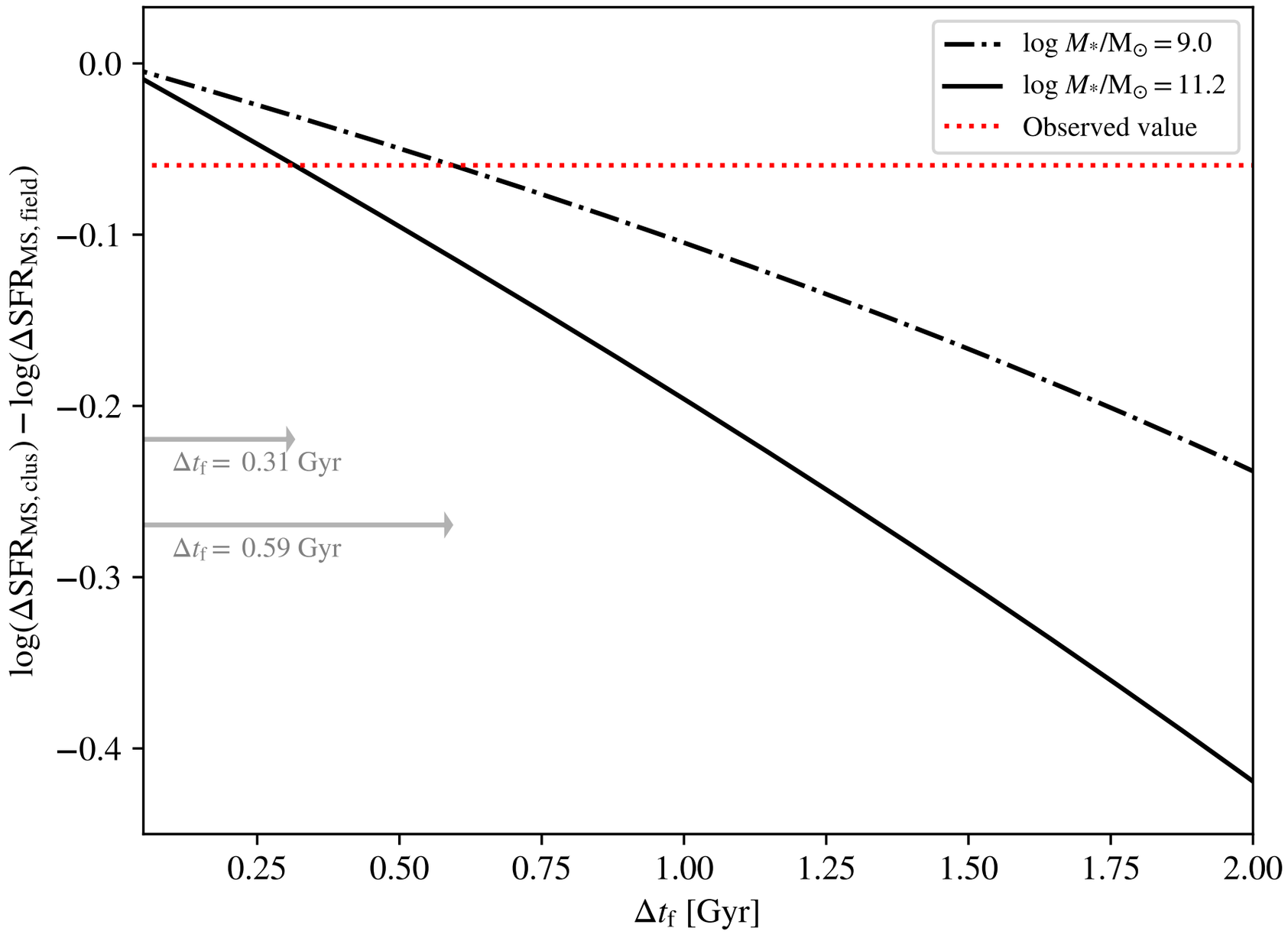
202 field gals

GOGREEN STAR-FORMING MAIN SEQUENCE



What do we see? A small 2σ difference between cluster and field at z = 1.0 - 1.5

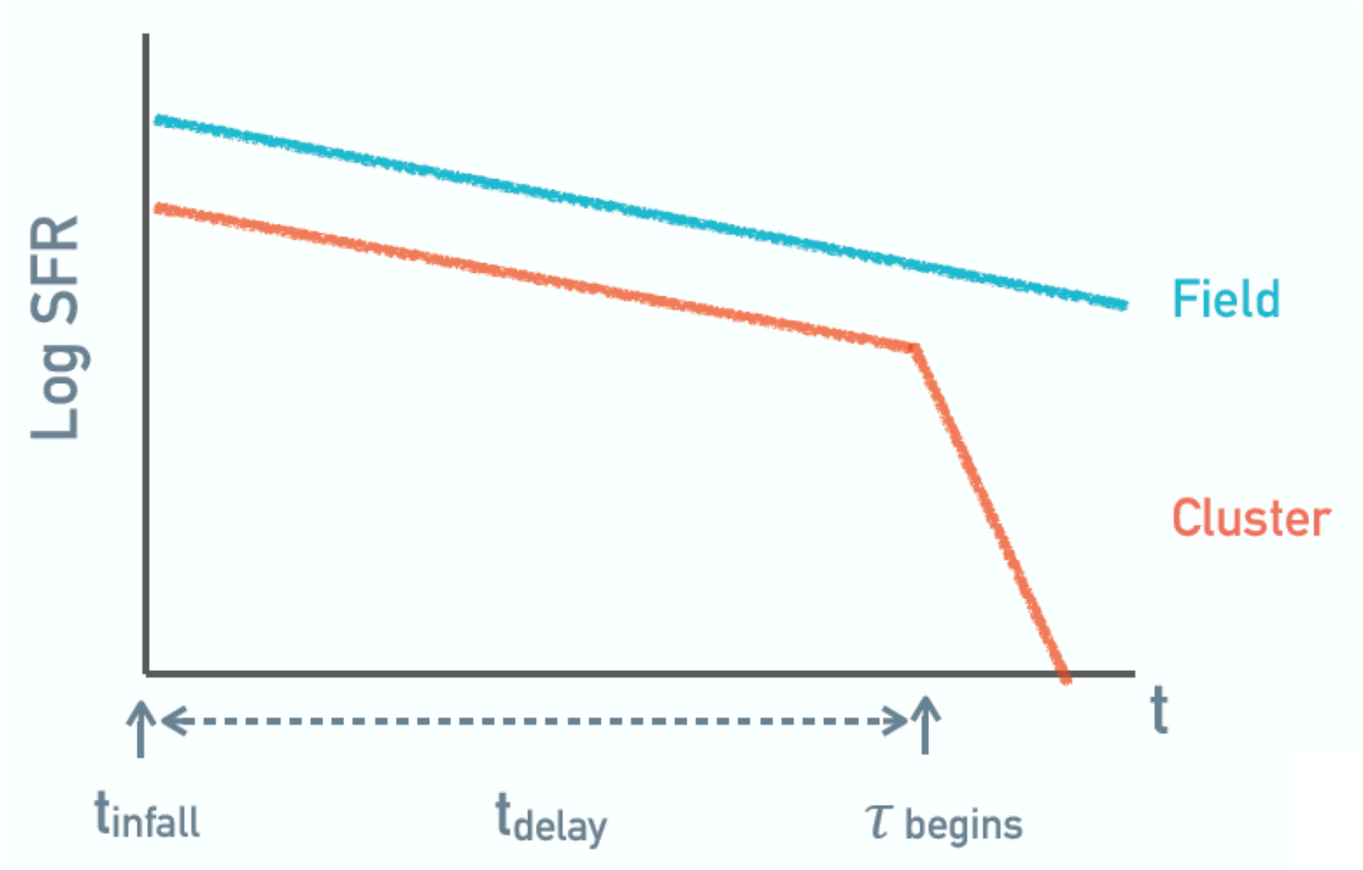
CONSTRAINTS ON FORMATION TIME SCENARIOS



SFMS [OII] data favours differences in formation times between cluster and field galaxies of ~0.3-0.6 Gyr to reproduce the slightly higher field galaxy star-forming main sequence.

IMPLIED QUENCHING TIMESCALES

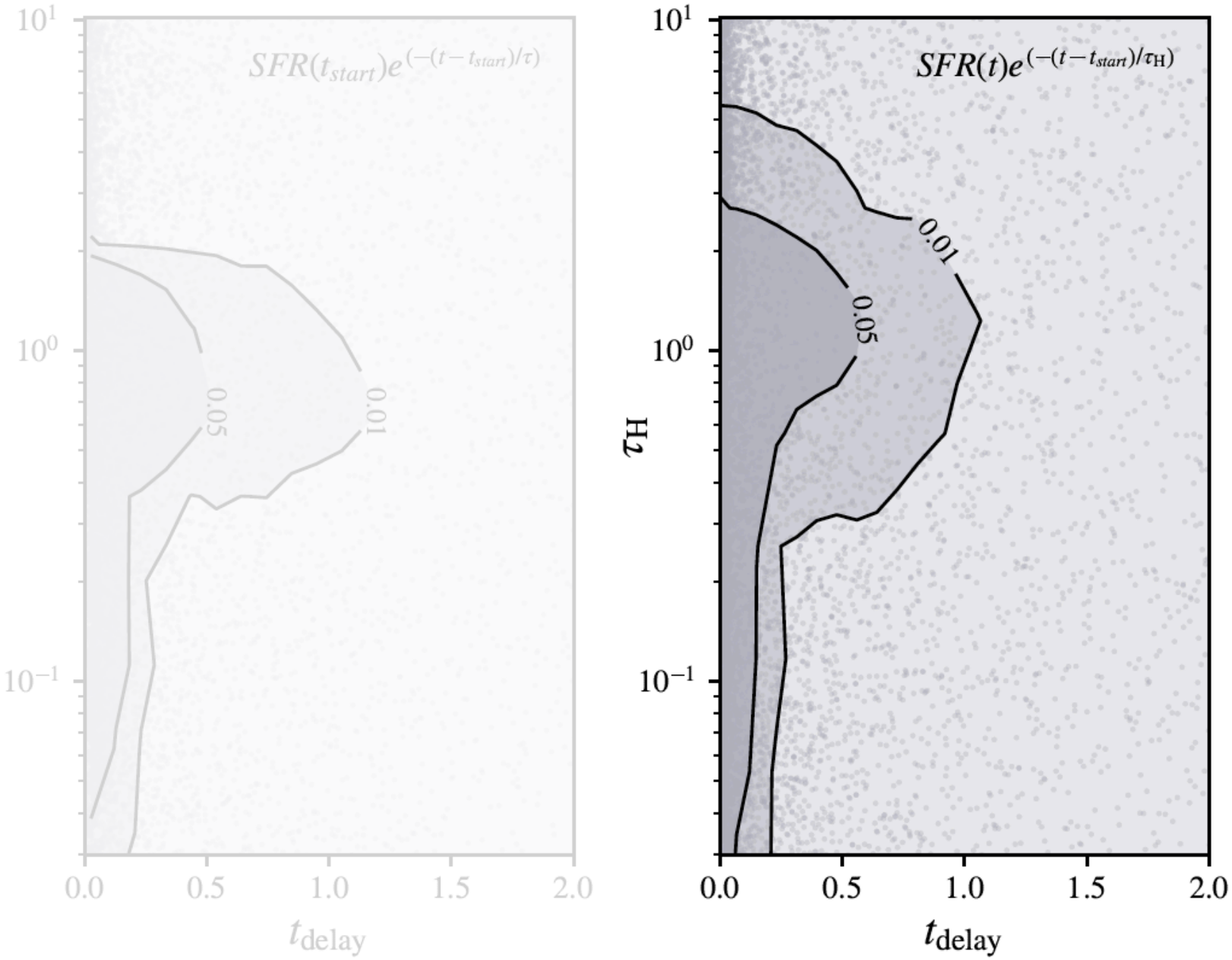
Delayed-than-rapid quenching model (e.g., Wetzel et al 2013):



$$SFR = \begin{cases} SFR(t)e^{(-(t-t_{\rm start})/\tau_{\rm H})}, & t > t_{\rm start} \\ SFR(t), & t \leq t_{\rm start}. \end{cases}$$

IMPLIED QUENCHING TIMESCALES**

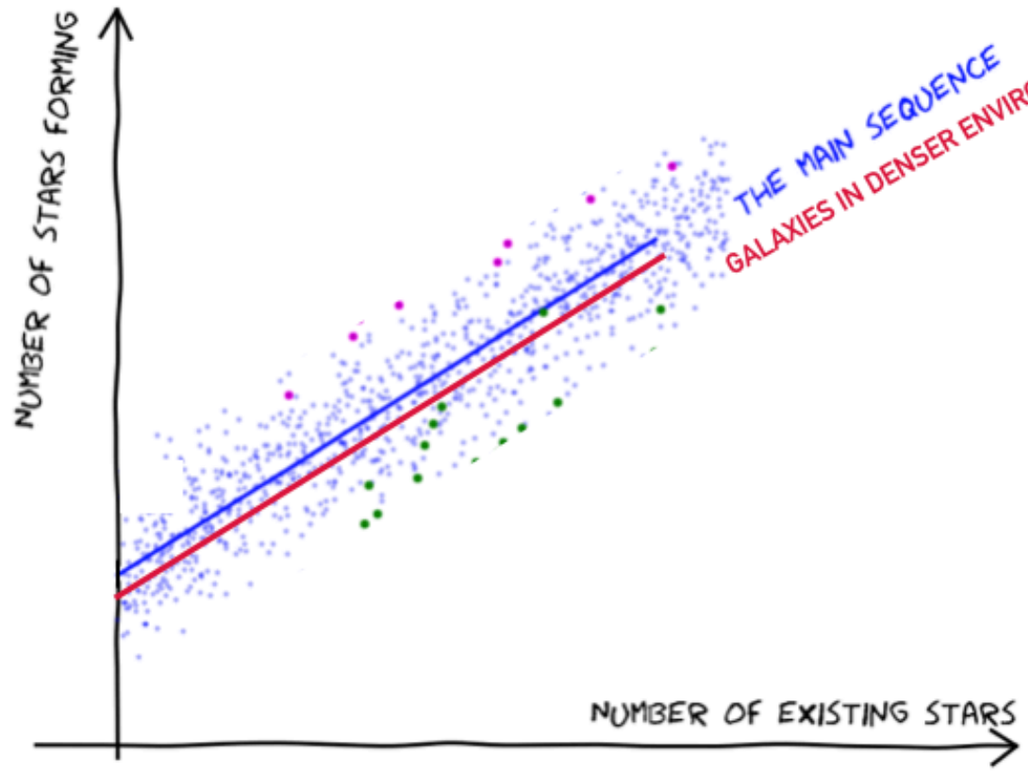
Still in progress! For previous sample:



Contrained t_{delay} < 1.1 Gyr at the 99% level.
For rapid quenching scenarios, the constraint on the delay time is even stronger.

ENVIRONMENTAL DEPENDENCE ON SF MS SUMMARY

- We use a homogenously selected cluster and field galaxy sample complete down to log $M_* = 10.3$ for 11 GOGREEN fields at $1.0 < z < 1.5$.
- Cluster galaxy [OII] star-forming main sequence is slightly lower than the field at $1.0 < z < 1.5$.

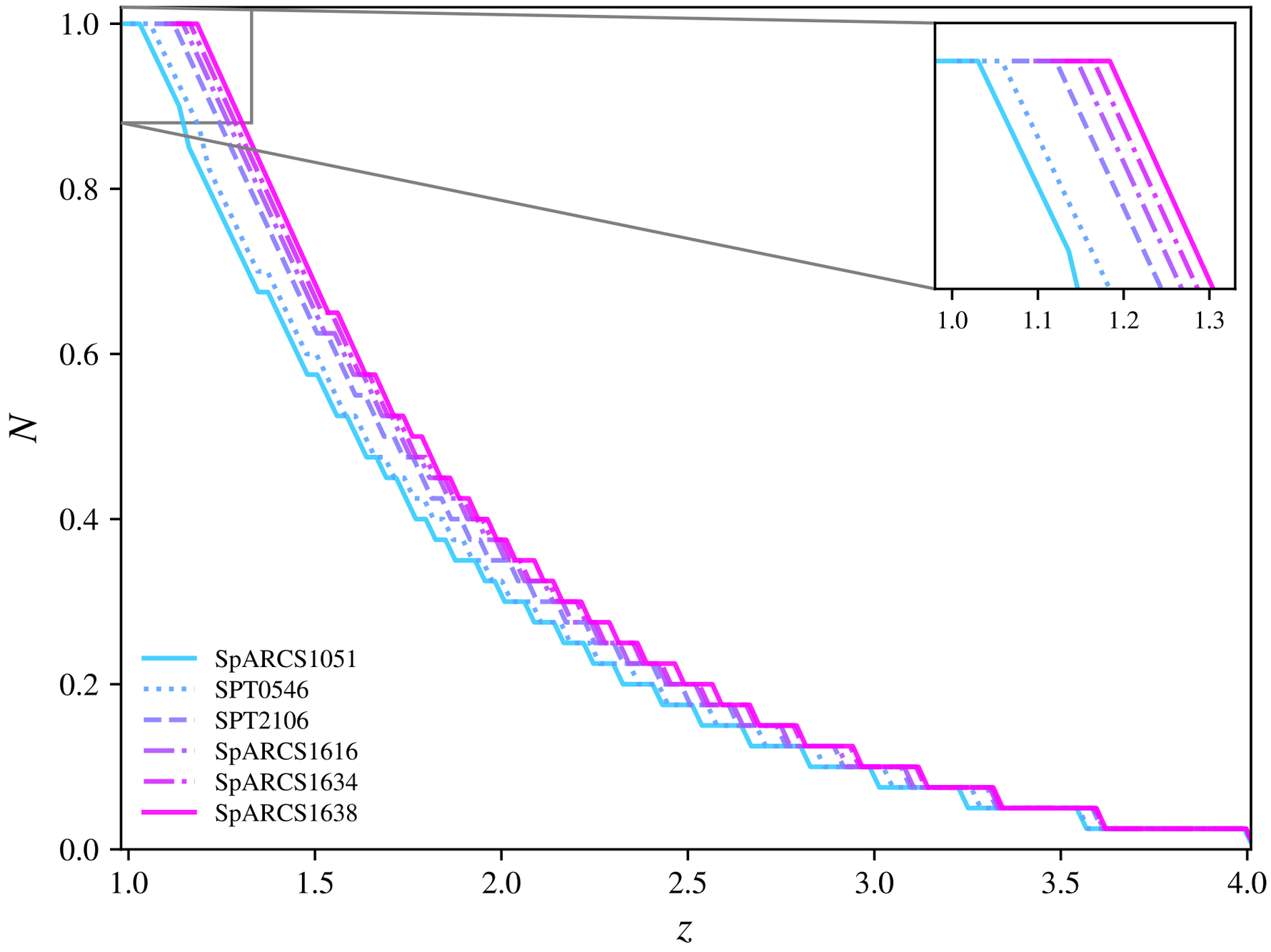


Adapted from blog-post by Harry Ferguson

- Formation time constraints based on observed difference between cluster & field imply formation time differences of 0.3-0.6 Gyr.
- Quenching timescales based on observed difference between cluster & field still to come.

EXTRA SLIDES

CUMULATIVE DISTRIBUTIONS OF MODEL INFALL REDSHIFTS



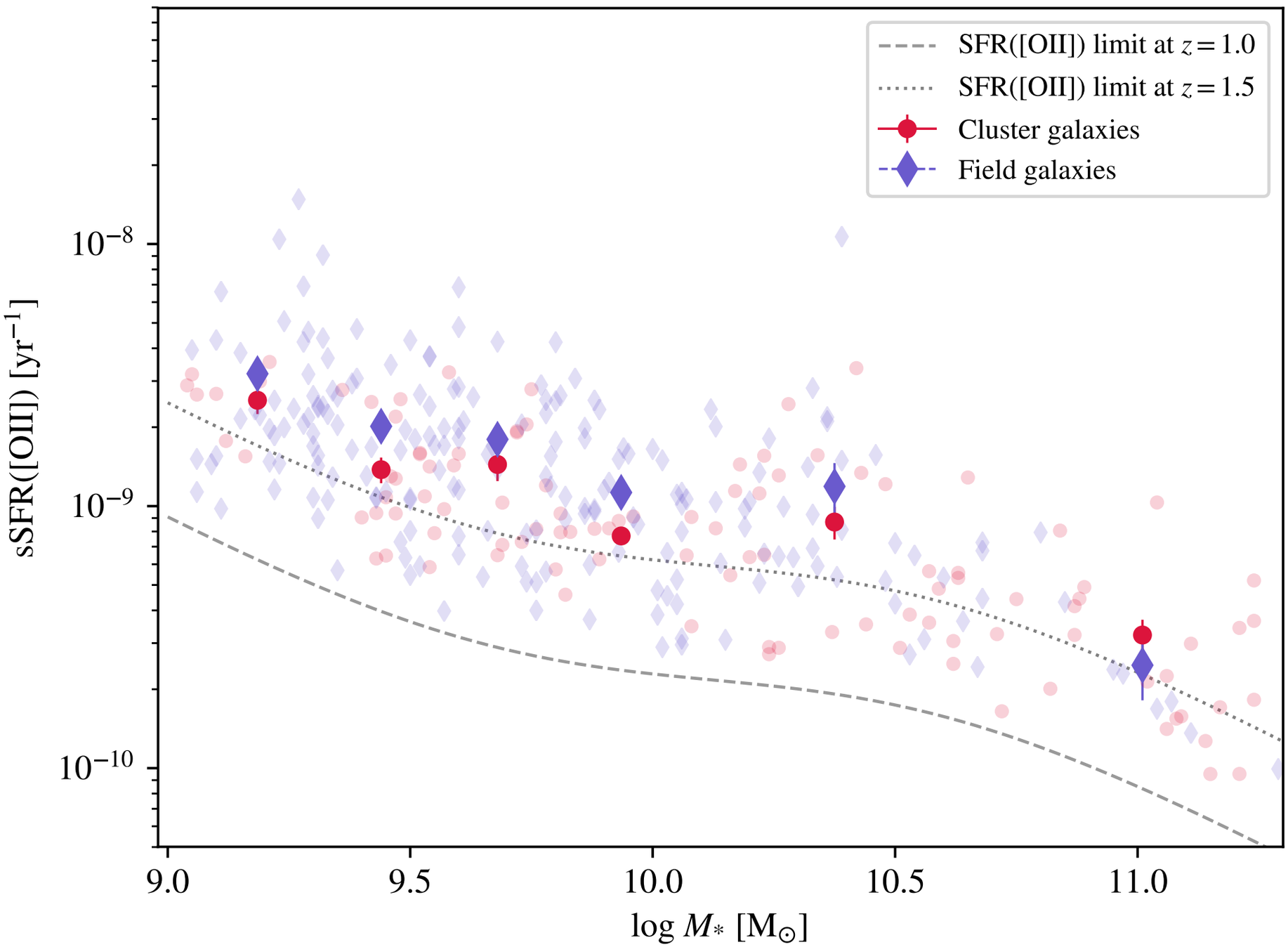
THE ENVIRONMENTAL DEPENDENCE OF THE STAR-FORMING GALAXY MAIN SEQUENCE

At $z < 1$, several studies have claimed little to no trend in the SFMS with environment, whilst others find a modest trend generally where SF galaxies in denser environments have lower SFRs at fixed stellar mass than the field:

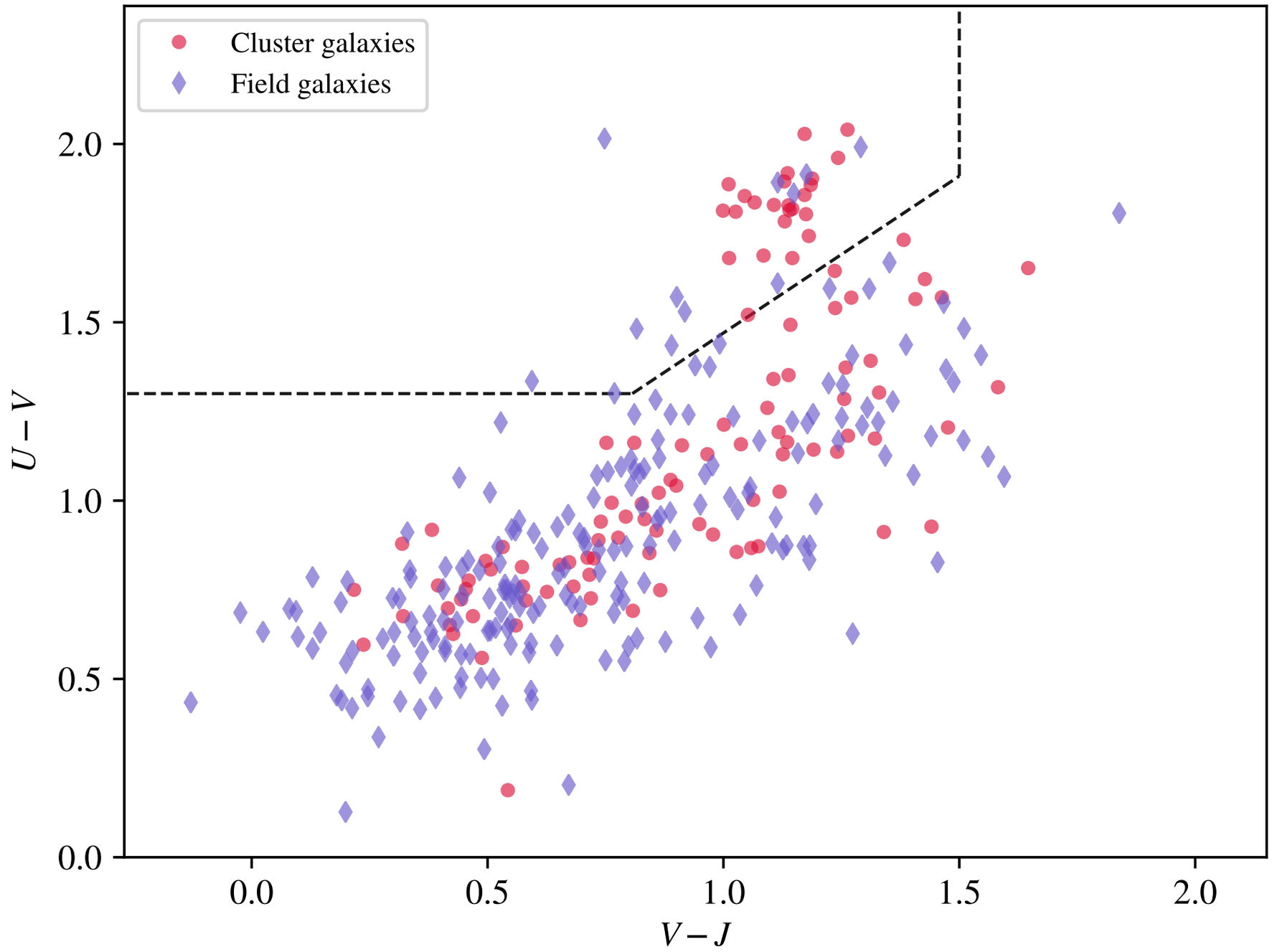
Little/no trend with environment	Modest trend with environment
Peng et al. 2010	Vulcani et al. 2010
Wijesinghe et al. 2012	von der Linden et al. 2010
Muzzin et al. 2012	Popesso et al. 2011
Wetzel et al. 2012	Patel et al. 2011
Koyama et al. 2013	Haines et al. 2013
	Paccagnella et al. 2016
	Rodríguez del Pino et al. 2017
	Wang et al. 2018

With GOGREEN we have the opportunity to measure the difference between the SFMS between cluster and field galaxies with a deep spectroscopic sample of homogeneously targeted galaxies at $z > 1$.

GOGREEN SPECIFIC STAR-FORMING MAIN SEQUENCE



UVJ CLUSTER VS. FIELD



COMPARISON WITH ZEIMANN ET AL. 2013 Hα ΔSFMS