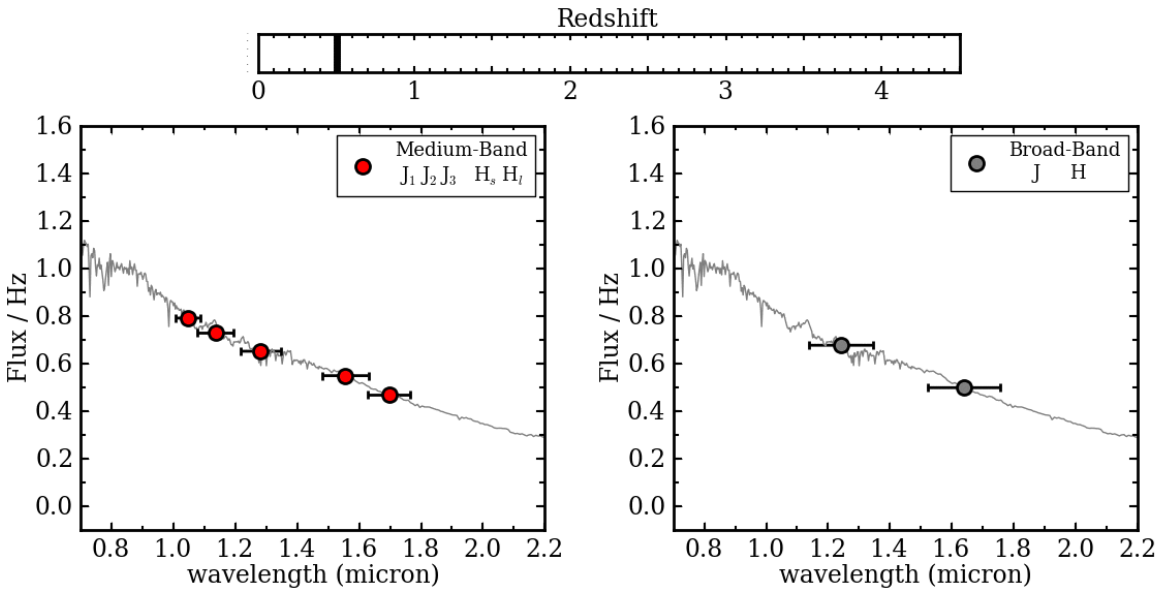
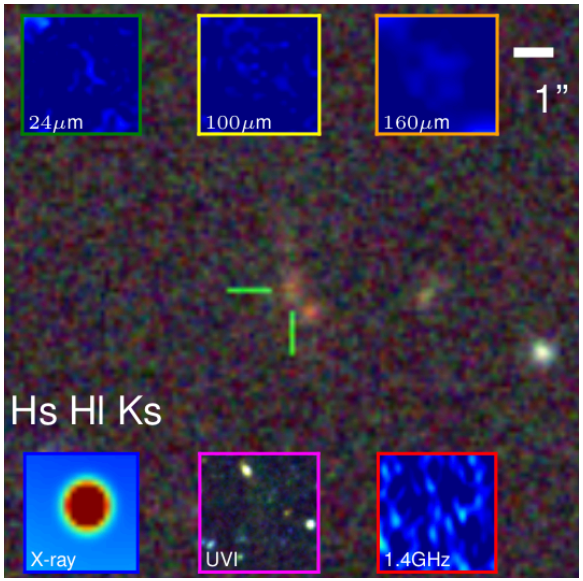




Highlights from the ZFOURGE survey

Lee Spitler

Australian Government
Department of Industry and Science

MACQUARIE University
SYDNEY·AUSTRALIA

ZFOURGE

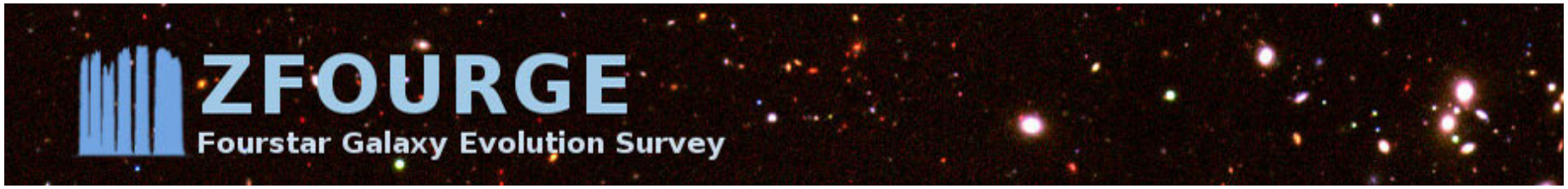
Fourstar Galaxy Evolution Survey

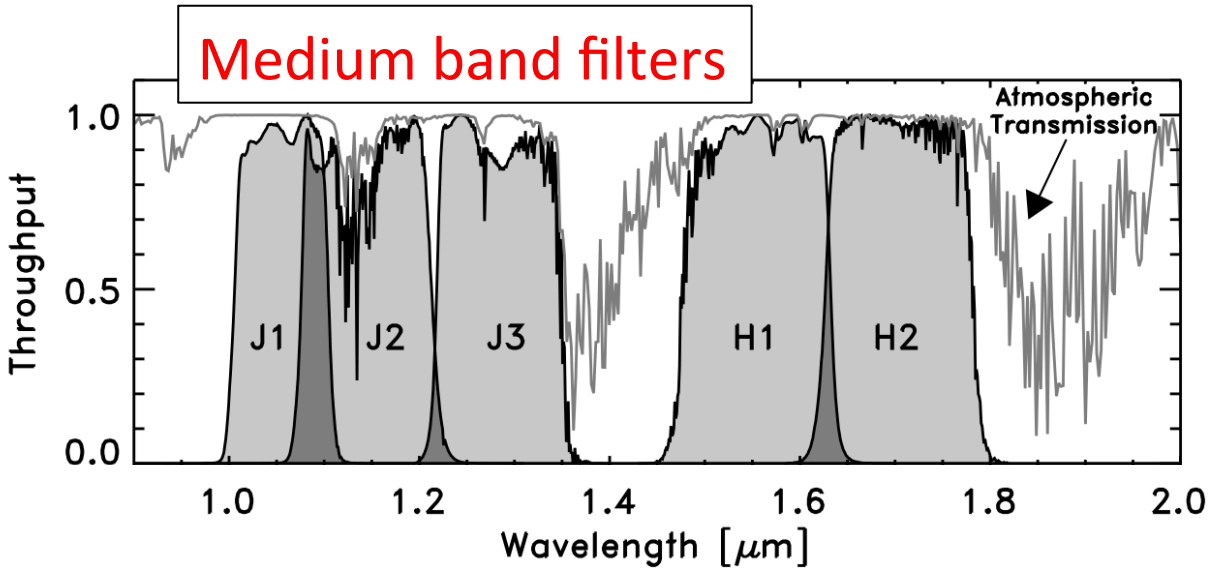
Australian Government Department of Industry | AAO | MACQUARIE University SYDNEY·AUSTRALIA | CARNEGIE INSTITUTION FOR SCIENCE

Sterrewacht Leiden | MITCHELL INSTITUTE TEXAS A&M UNIVERSITY | SWINBURNE CENTRE FOR ASTROPHYSICS AND SUPERCOMPUTING

	Rebecca Allen	Swinburne	Casey Papovich	TAMU	
	Michael Cowley	Macquarie	Eric Persson	Carnegie	
	Karl Glazebrook	Swinburne	Ryan Quadri	TAMU	
	Glenn Kacprzak	Swinburne	Glen Rees	Macquarie/CASS	
	Nancy Kawinwanichakij	TAMU	Lee Spitler	Macquarie/AAO	Data lead
	Daniel Kelson	Carnegie	Caroline Straatman	Leiden	Catalog lead
PI	Ivo Labbe	Leiden	Vithal Tilvi	TAMU	
	Patrick McCarthy	Carnegie	Adam Tomczak	TAMU	
	Nicola Mehrtens	TAMU	Kim-Vy Tran	TAMU	
	Andrew Monson	Carnegie	Pieter van Dokkum	Yale	
	Themiya Nanayakkara	Swinburne			

http://zfourge.tamu.edu/





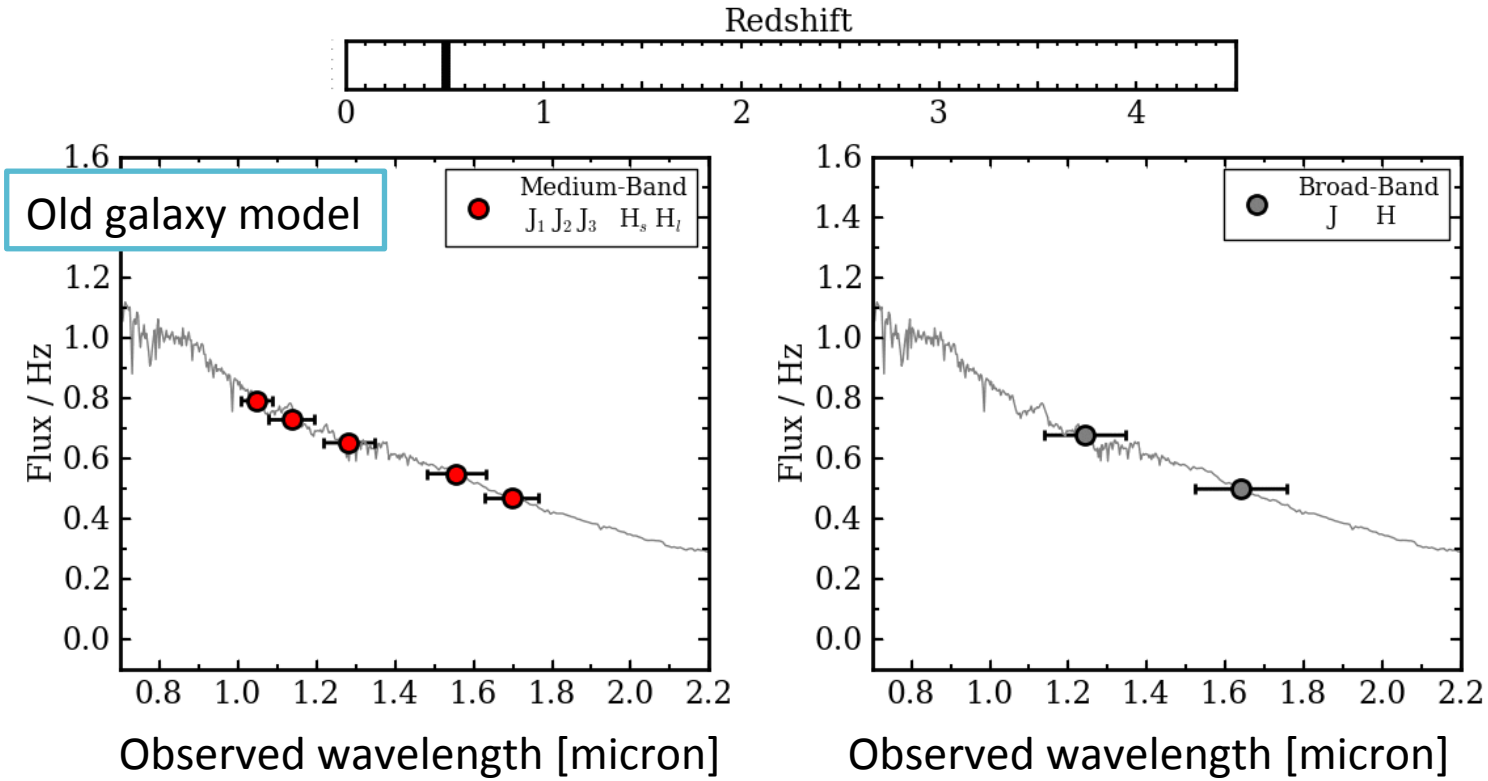
45 nights with FourStar/Magellan

5-sigma: J1 J2 J3 to 26 AB, H1 H2 to 25 AB, Ks to 25 AB

1-2% redshifts uncertainties, $\sigma/(z+1)$, at $1.5 < z < 3.5$

COSMOS, UDS, CDFS 11x11 arcmin^2 each

Full public release in 2015



ZFOURGE filters

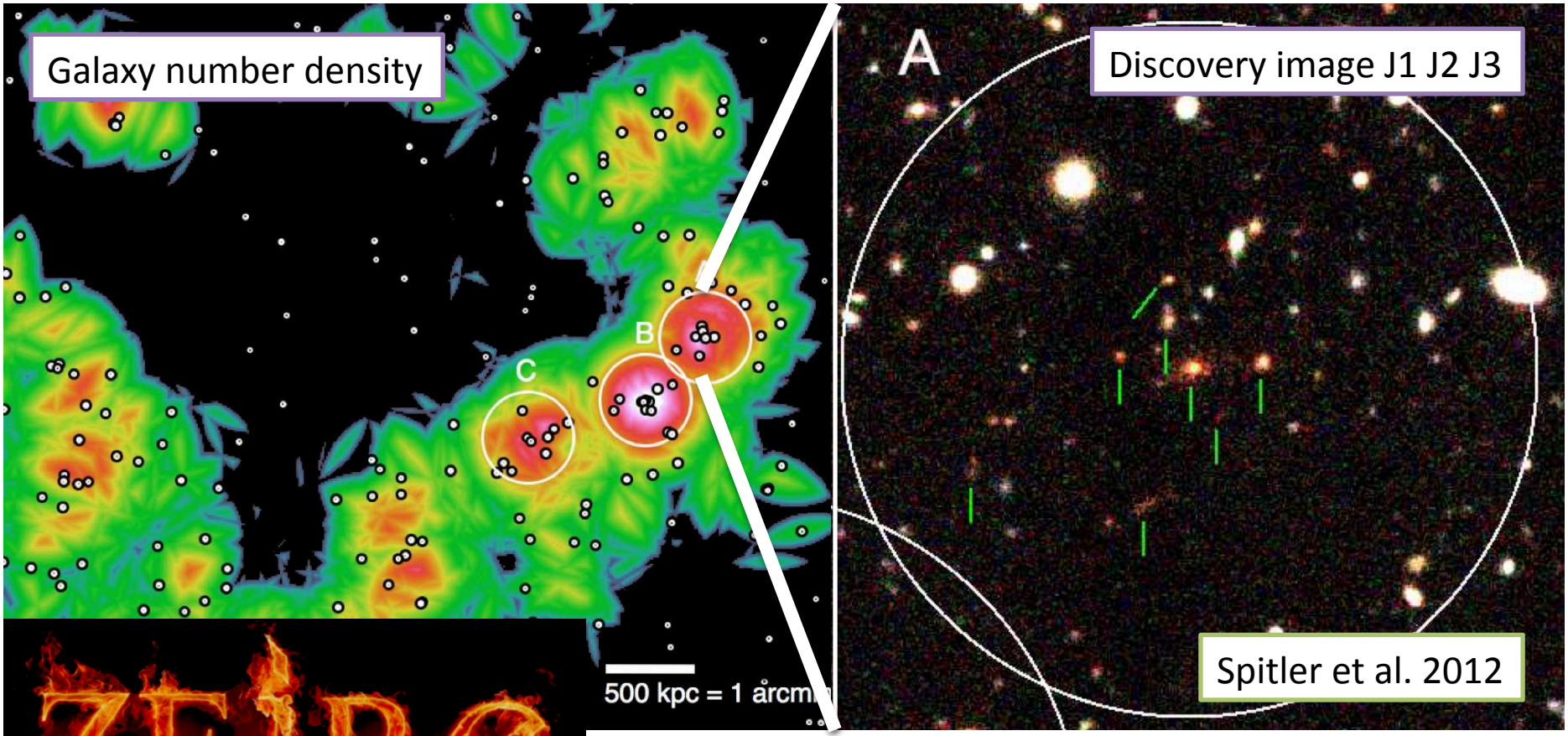
Traditional filters

<u>Depths</u>
Hs, Hl & Ks ~ 25
J123 ~ 26

http://zfourge.tamu.edu/

Animation credit: Adam Tomczak

Discovery of a redshift z=2.09 galaxy cluster right in the middle of COSMOS!

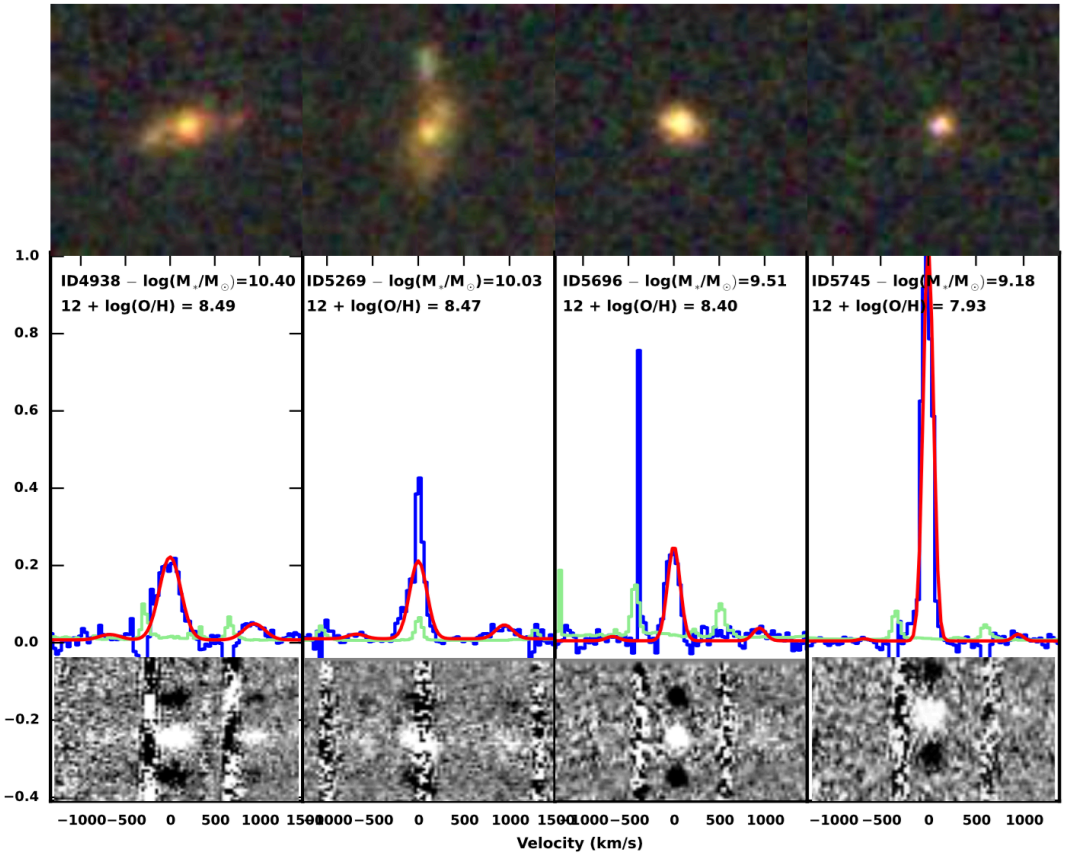


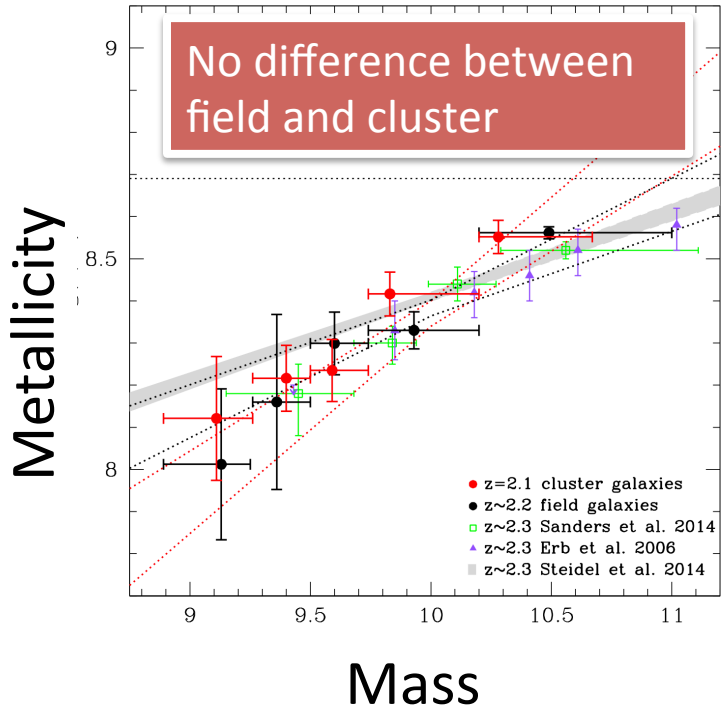
ZFOURGE + MOSFIRE

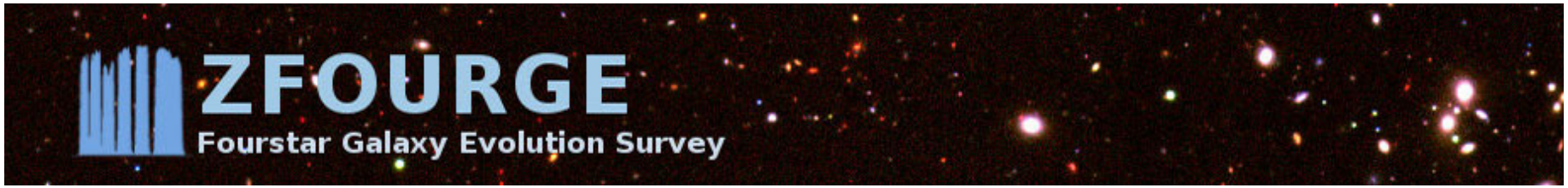
ZFOURGE + MOSFIRE

Tran, Glazebrook, Kewley
Yuan, Nanayakkara, Kacprzak
Spitler, Labbé, Straatman, Tomczak

57 confirmed cluster galaxies
at z=2.095 (Yuan et al., 2014)

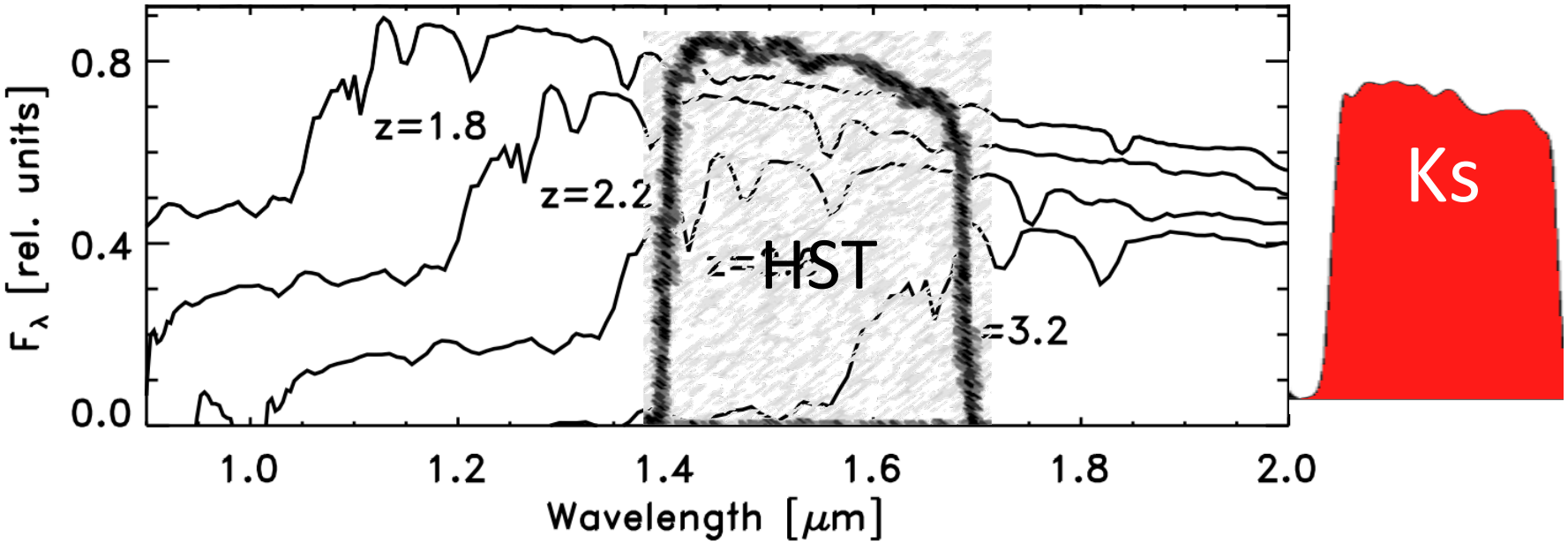






- Identify/select galaxies using evolved star light
  - Stellar mass-limited

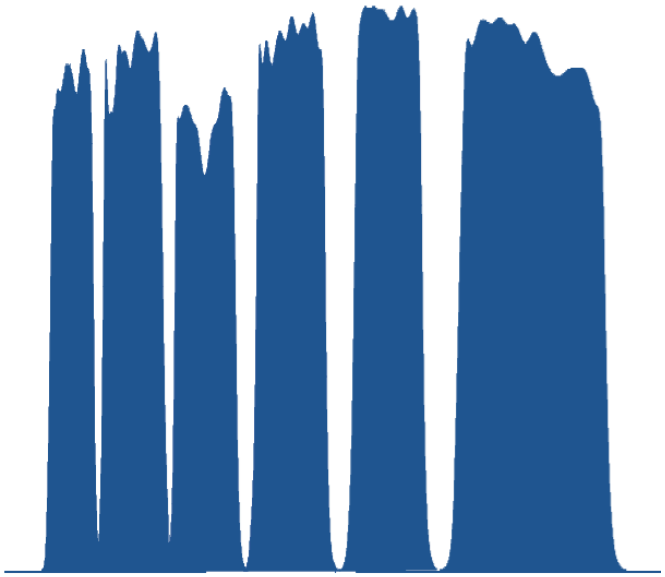
    select galaxies with Ks-band: access older stars



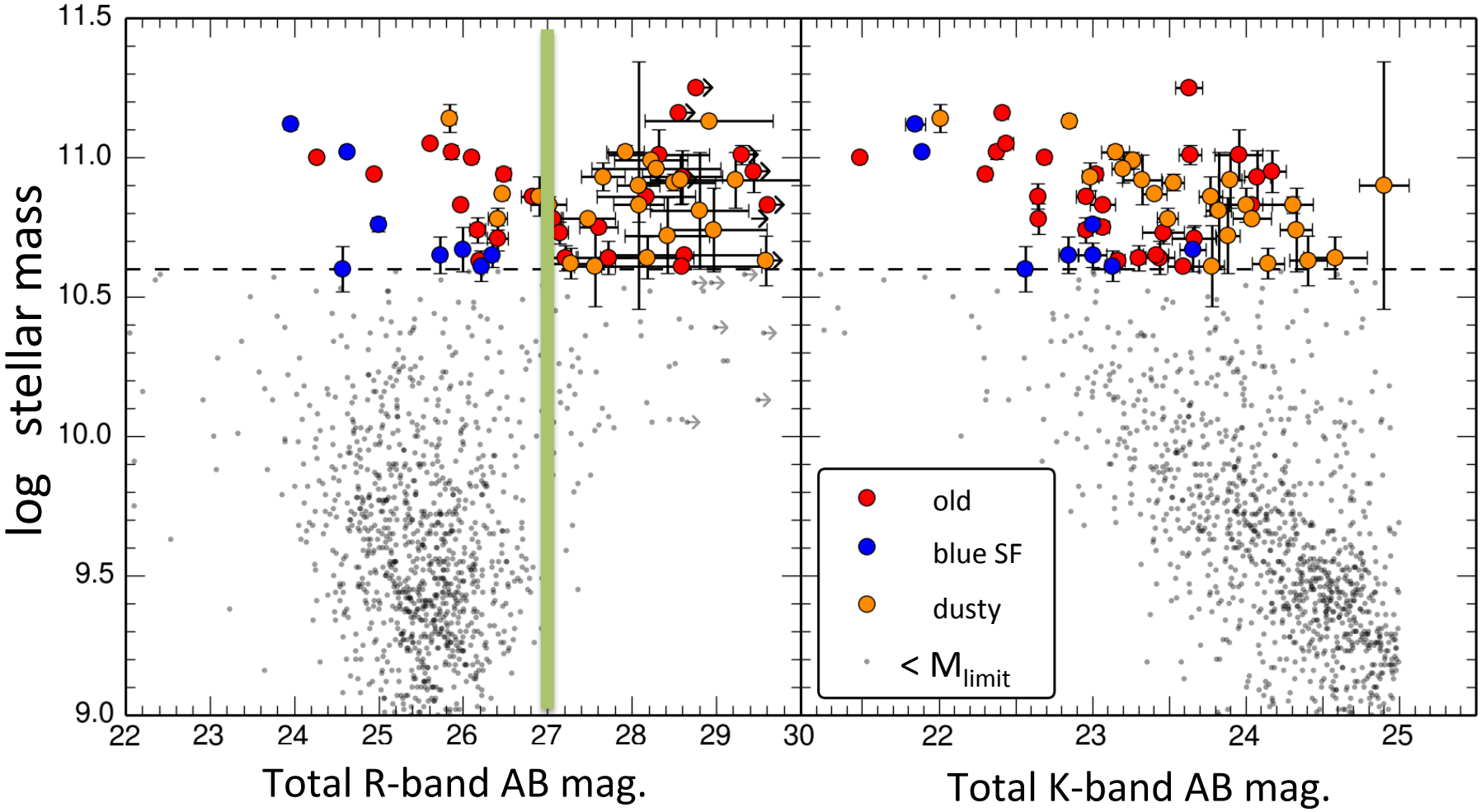
A mass-limited census at z=3-4

Exploring the z=3-4 massive galaxy population with ZFOURGE: the prevalence of dusty and quiescent galaxies

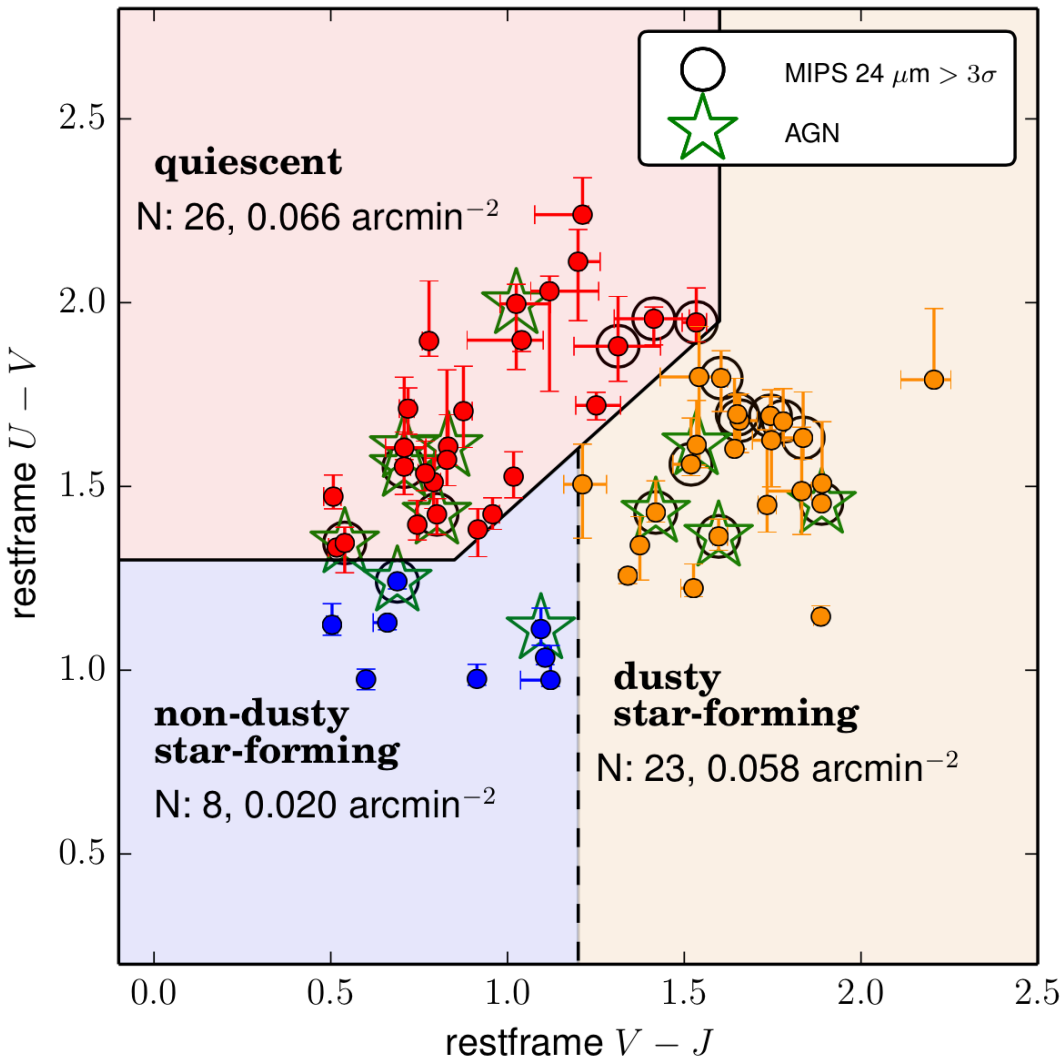
Spitler et al. 2014

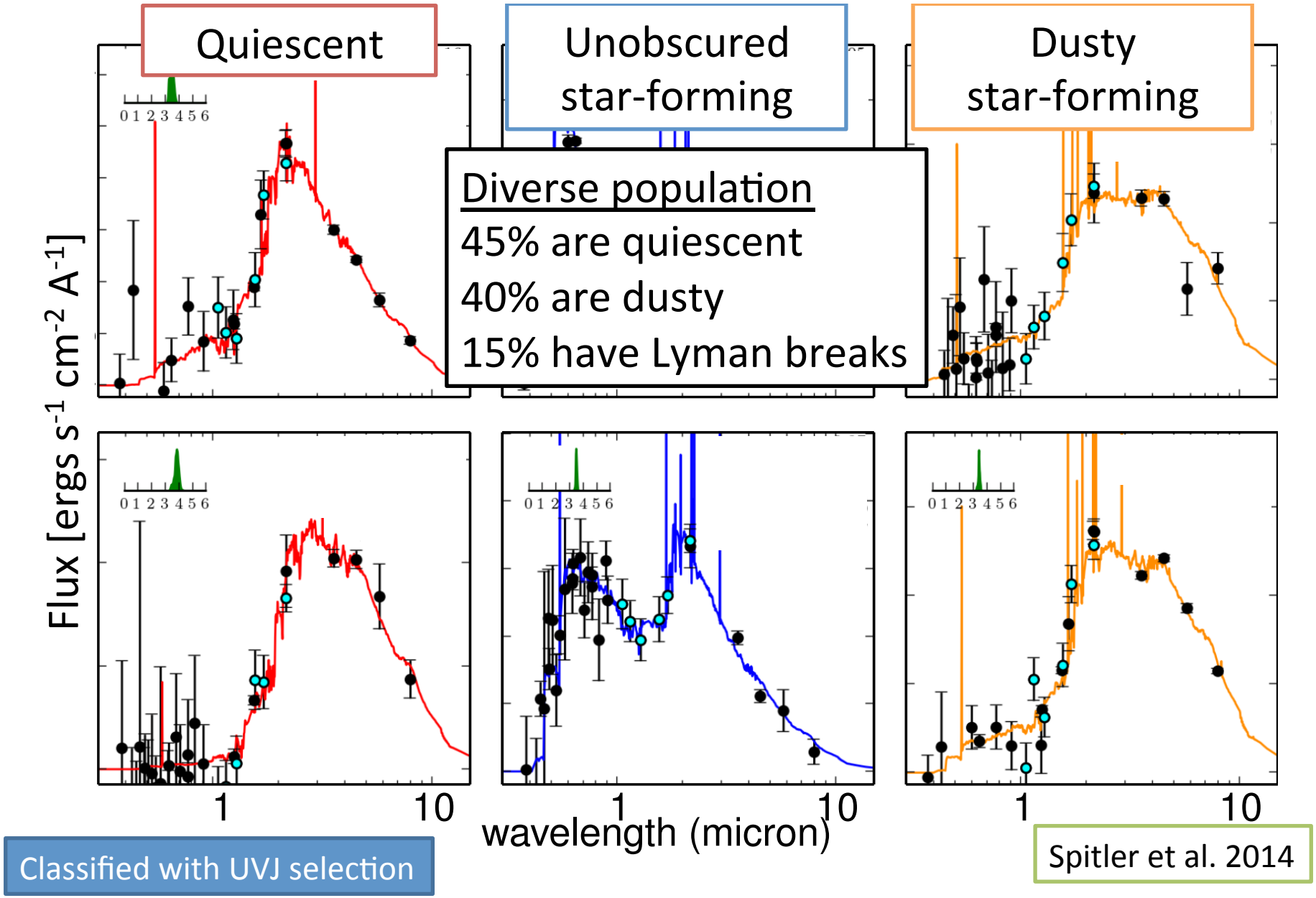


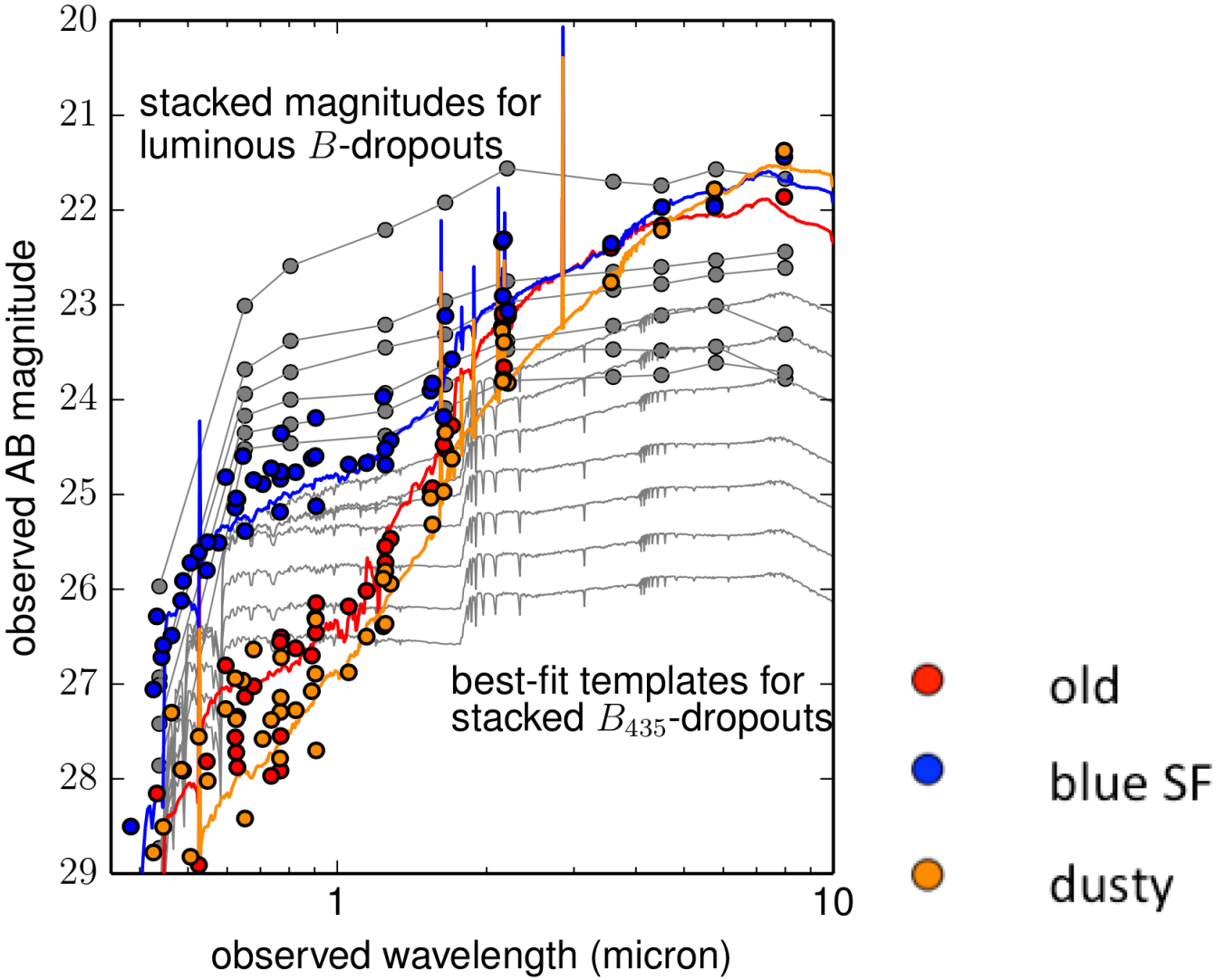
Massive z=3-4 galaxies are red



Spitler et al. 2014

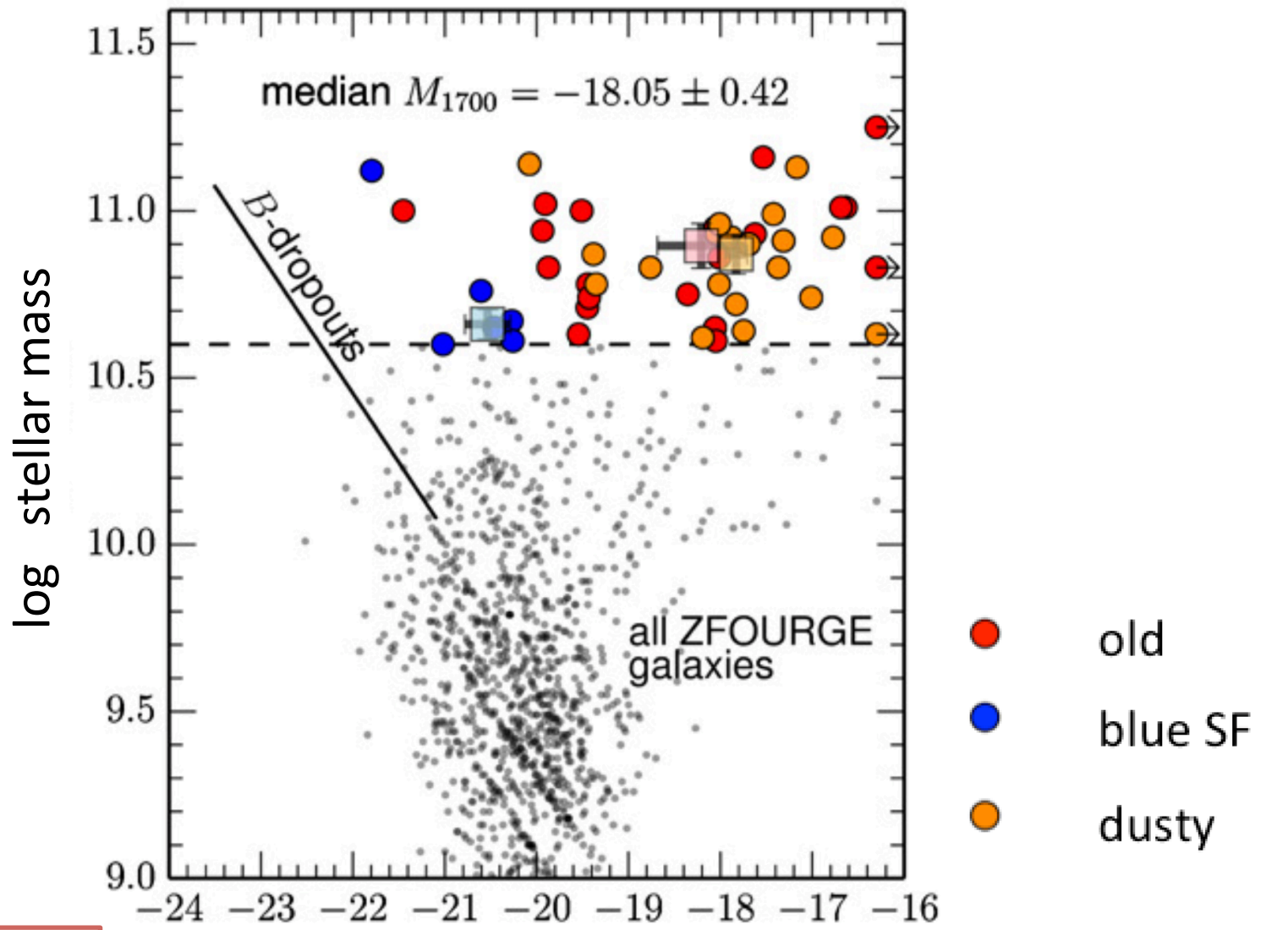

MIPS 24 μm $> 3\sigma$
AGN
quiescent
N: 26, 0.066 arcmin^{-2}
non-dusty
star-forming
N: 8, 0.020 arcmin^{-2}
dusty
star-forming
N: 23, 0.058 arcmin^{-2}
restframe $U - V$
restframe $V - J$
0.0
0.5
1.0
1.5
2.0
2.5


Quiescent
Unobscured star-forming
Dusty star-forming
Diverse population
45% are quiescent
40% are dusty
15% have Lyman breaks
Flux [ergs s-1 cm-2 A-1]
wavelength (micron)
1
10
0 1 2 3 4 5 6
Classified with UVJ selection
Spitler et al. 2014



median $M_{1700} = -18.05 \pm 0.42$

Spitler et al. 2014

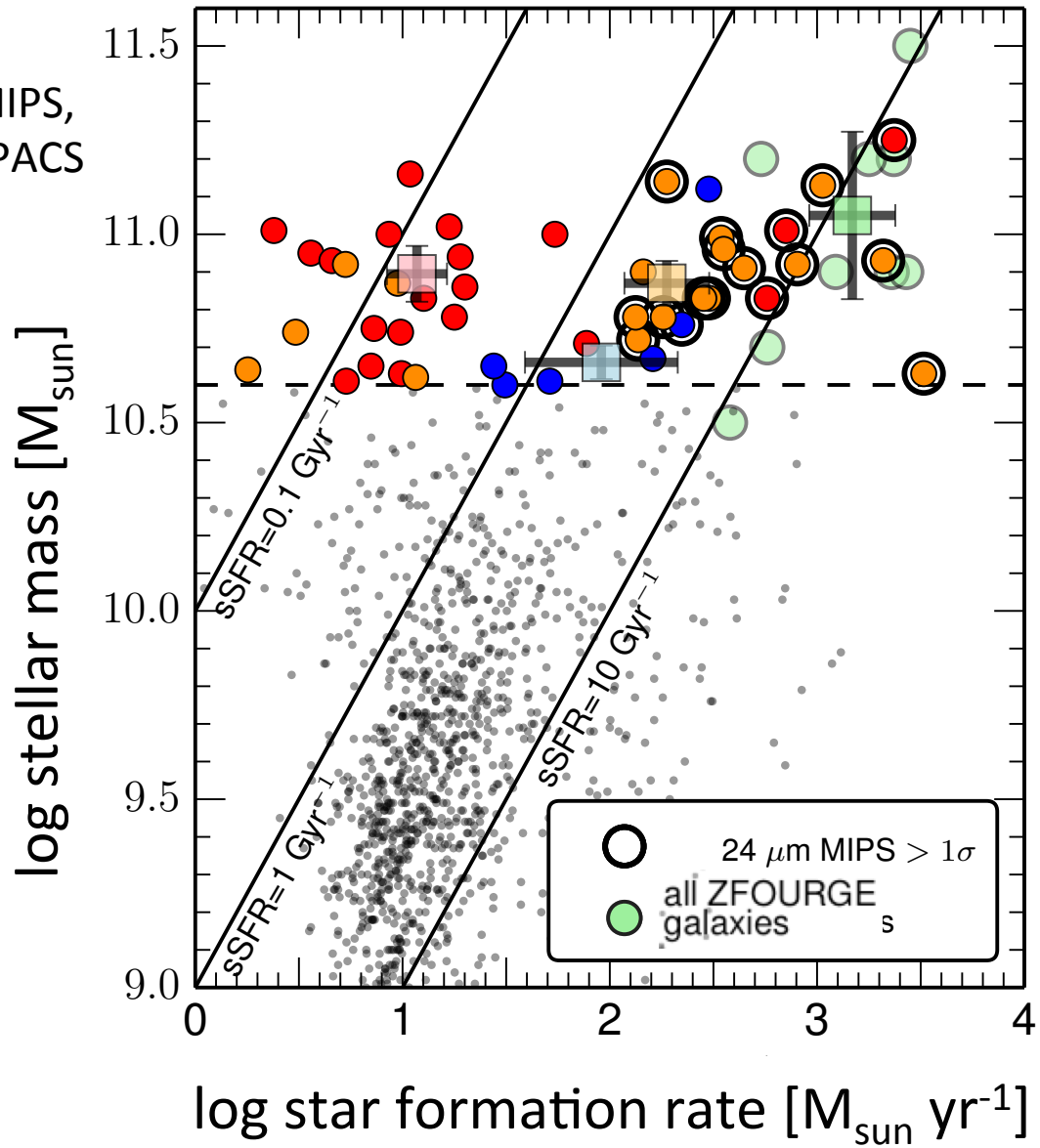


M_{UV} != mass

M_{1700} restframe magnitude

Spitler et al. 2014

SFRs from UV+MIPS, confirmed with PACS



Submillimeter galaxy (SMG) sample from Toft et al., 2014

old

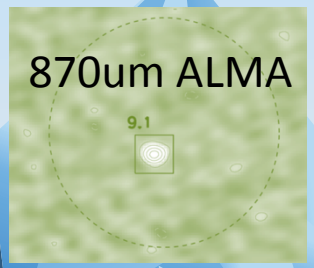
blue SF

dusty

Spitler et al. 2014

Tip of the iceberg

Rare submillimeter galaxies (SMGs) with star-formation rates SFRs > 1000 $M_{sun} yr^{-1}$

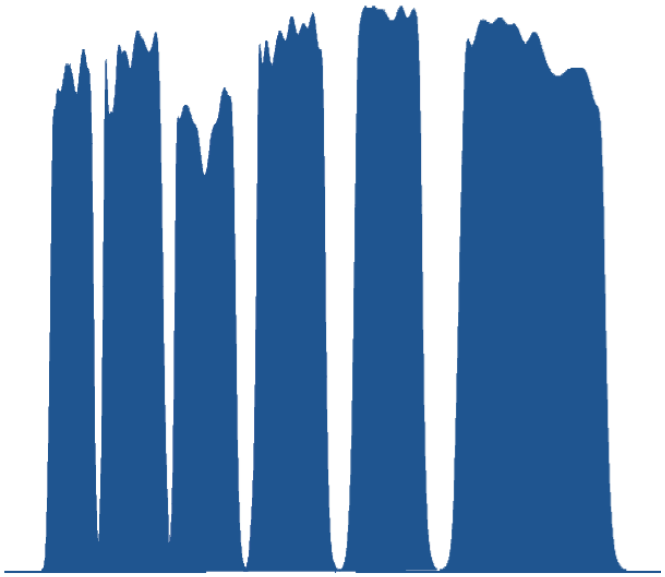


Karim et al. 2013

ZFOURGE results: the bulk below

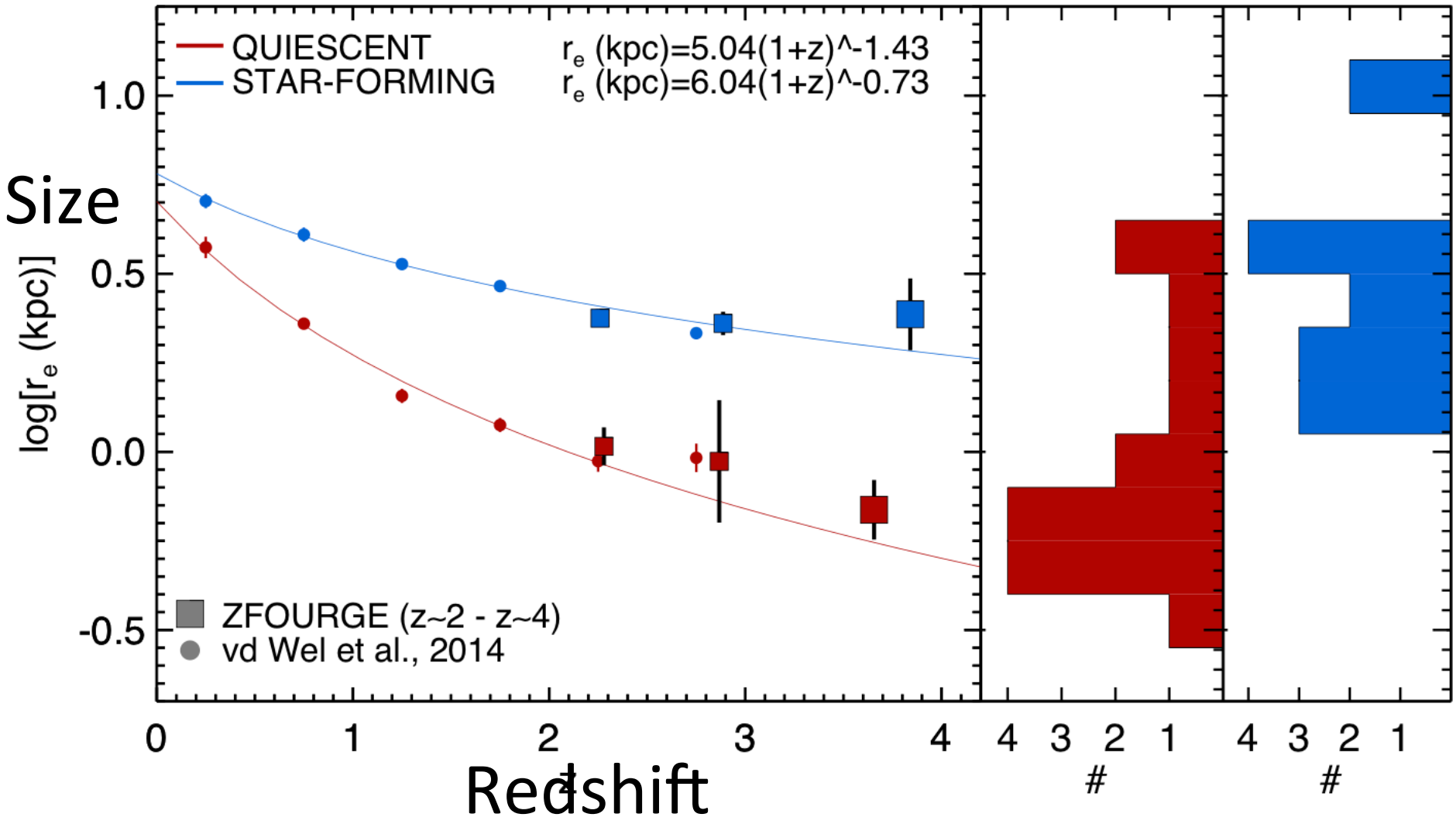
Substantial population of massive **dusty** galaxies with SFRs ~ 200 $M_{sun} yr^{-1}$

The First Quiescent Galaxies



A substantial population of massive quiescent galaxies at z~4 from ZFOURGE
Straatman, Labbe, Spitler, et al. 2014

The sizes of massive quiescent and star forming galaxies at z~4 with ZFOURGE and CANDELS
Straatman, Labbe, Spitler, et al. submitted

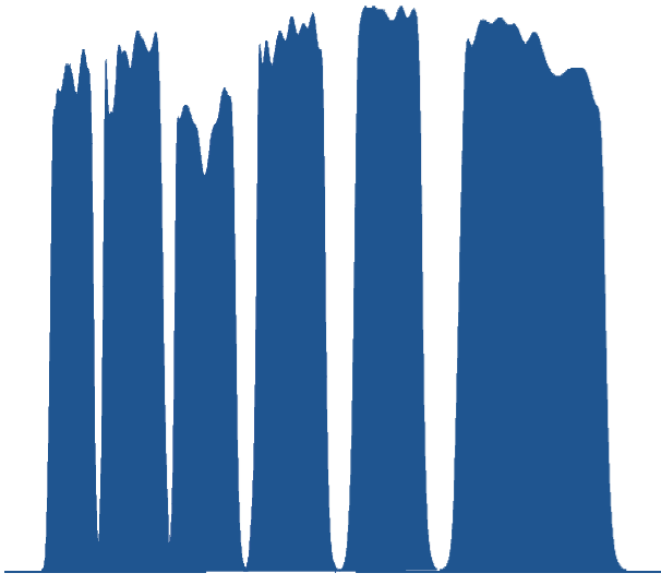


Average age 0.8 Gyr

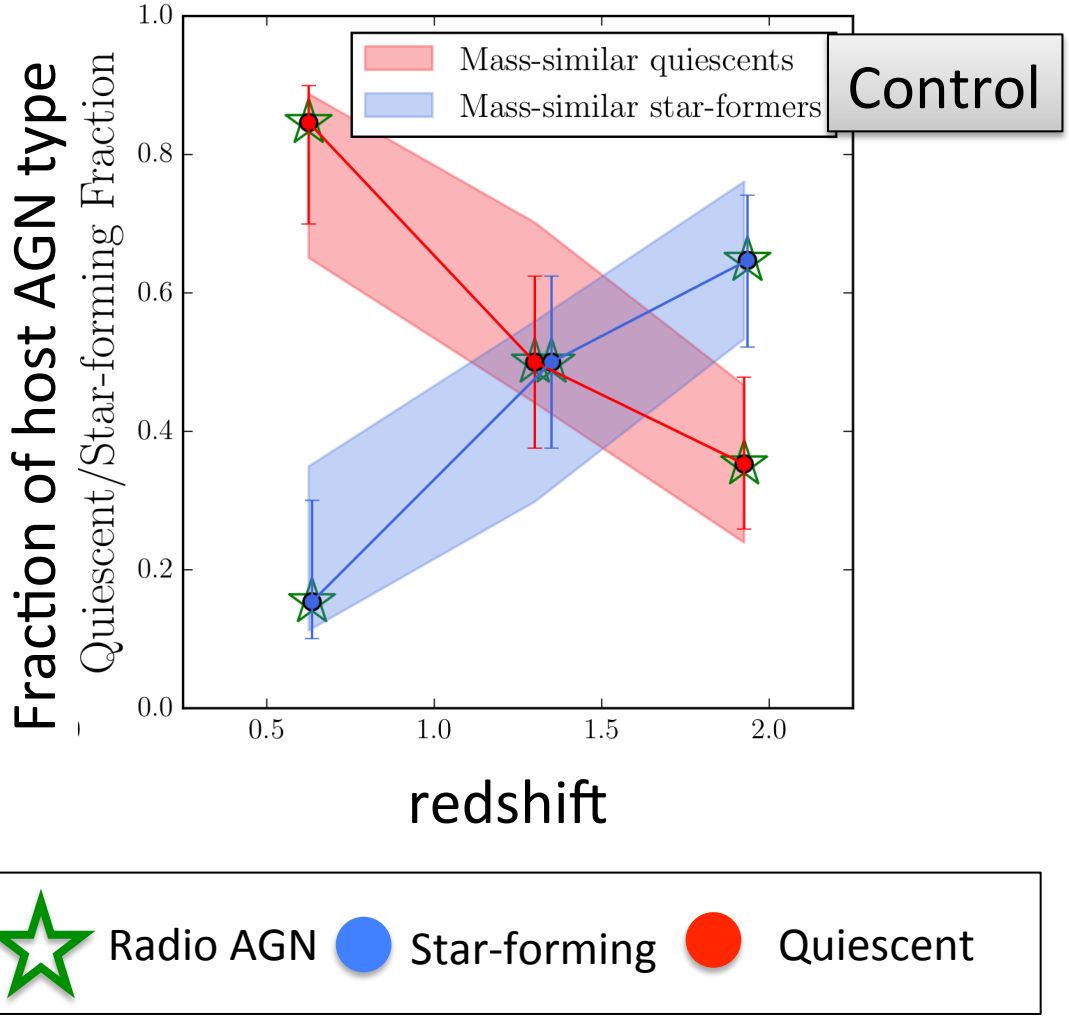
Formed 10^{11} M_{sun} worth of stars at z > 10

Stellar populations of AGN hosts

Rees, Spitler, Norris et al. submitted
Cowley, Spitler et al. in prep.

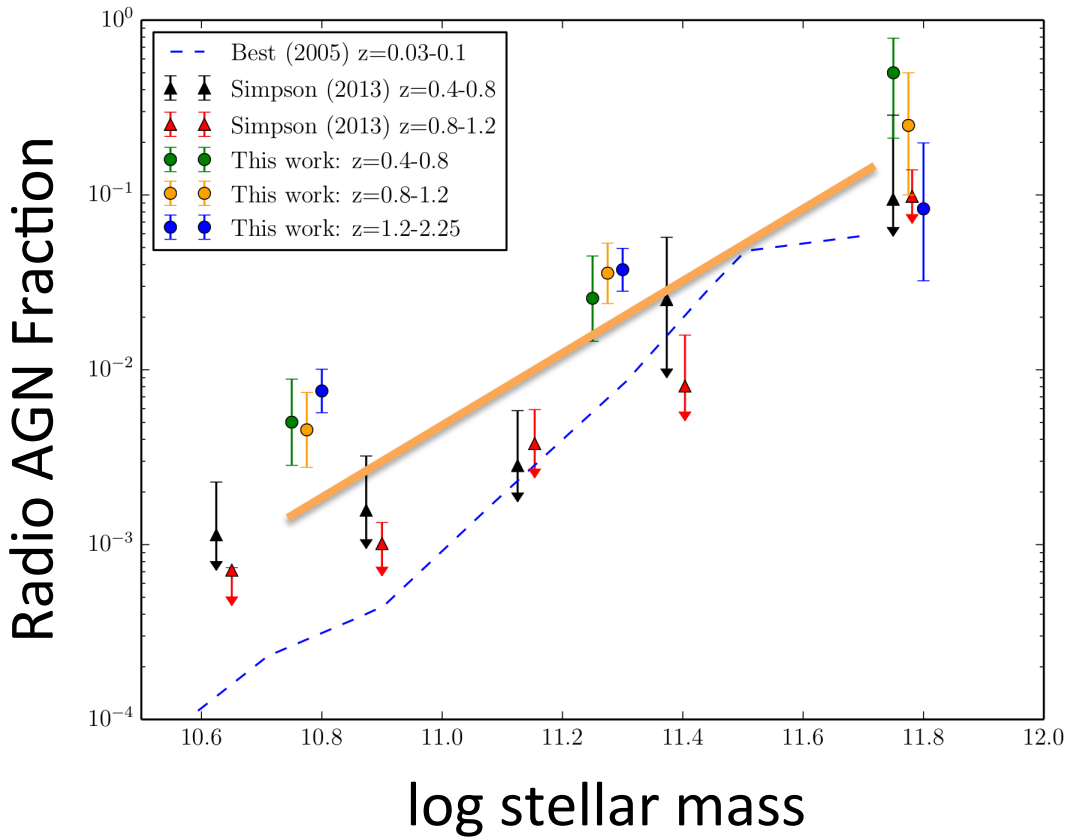


Evolution in radio AGN host matches non-AGN population



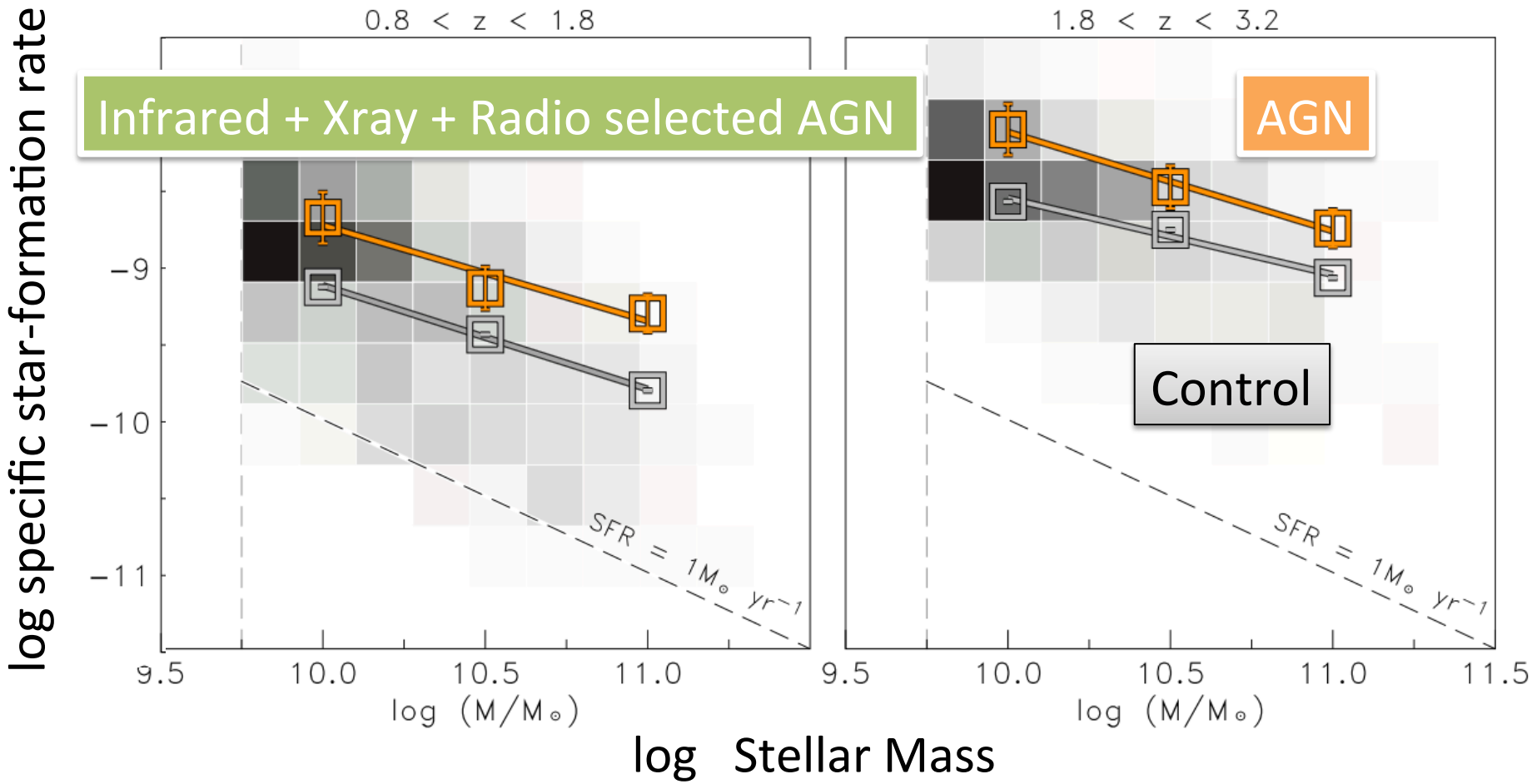
Rees, Spitler, Norris, submitted

Mass / radio AGN fraction shows no change from z=0 to z=2



Rees, Spitler, Norris, submitted

AGN hosts tend to be hosted by star-forming galaxies



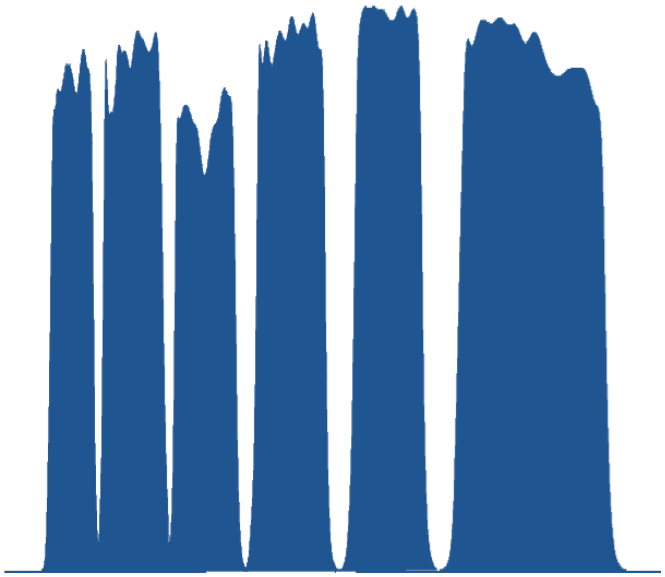
PACs SFRs

Cowley, Spitler et al., in prep.

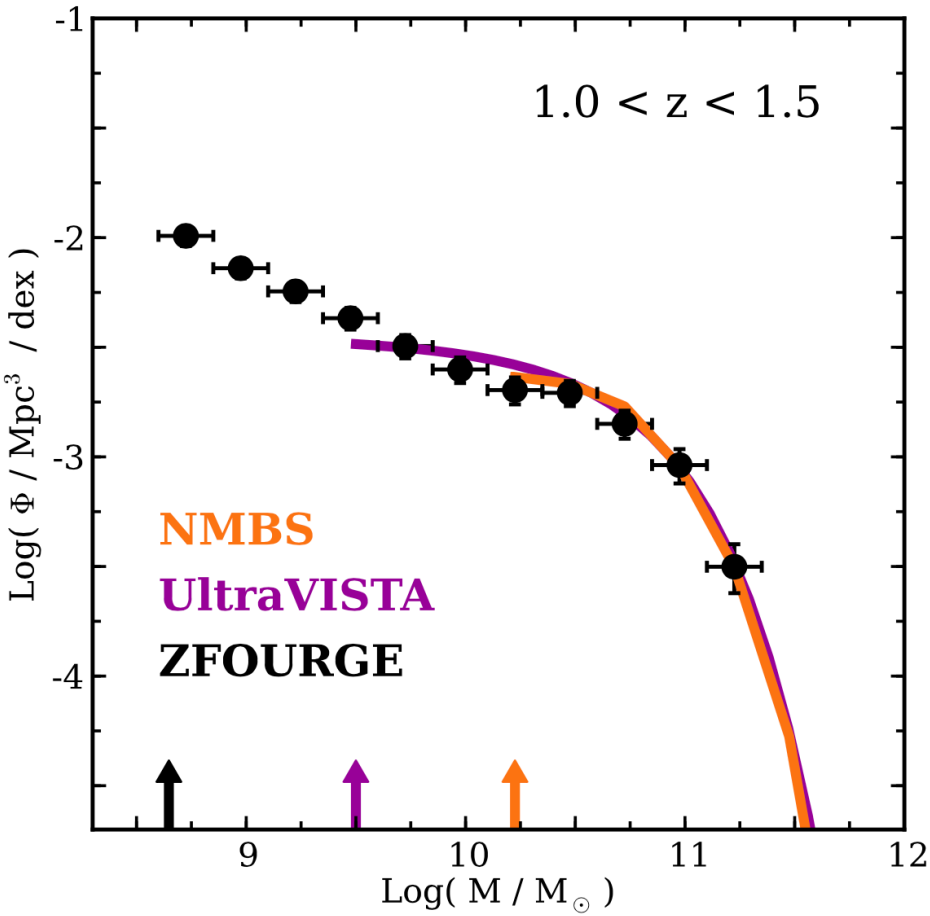
Evolution of the galaxy stellar mass function

Galaxy Stellar Mass Functions from ZFOURGE/CANDELS: An Excess of Low-Mass Galaxies Since z=2 and the Rapid Buildup of Quiescent Galaxies

Tomczak et al. 2014

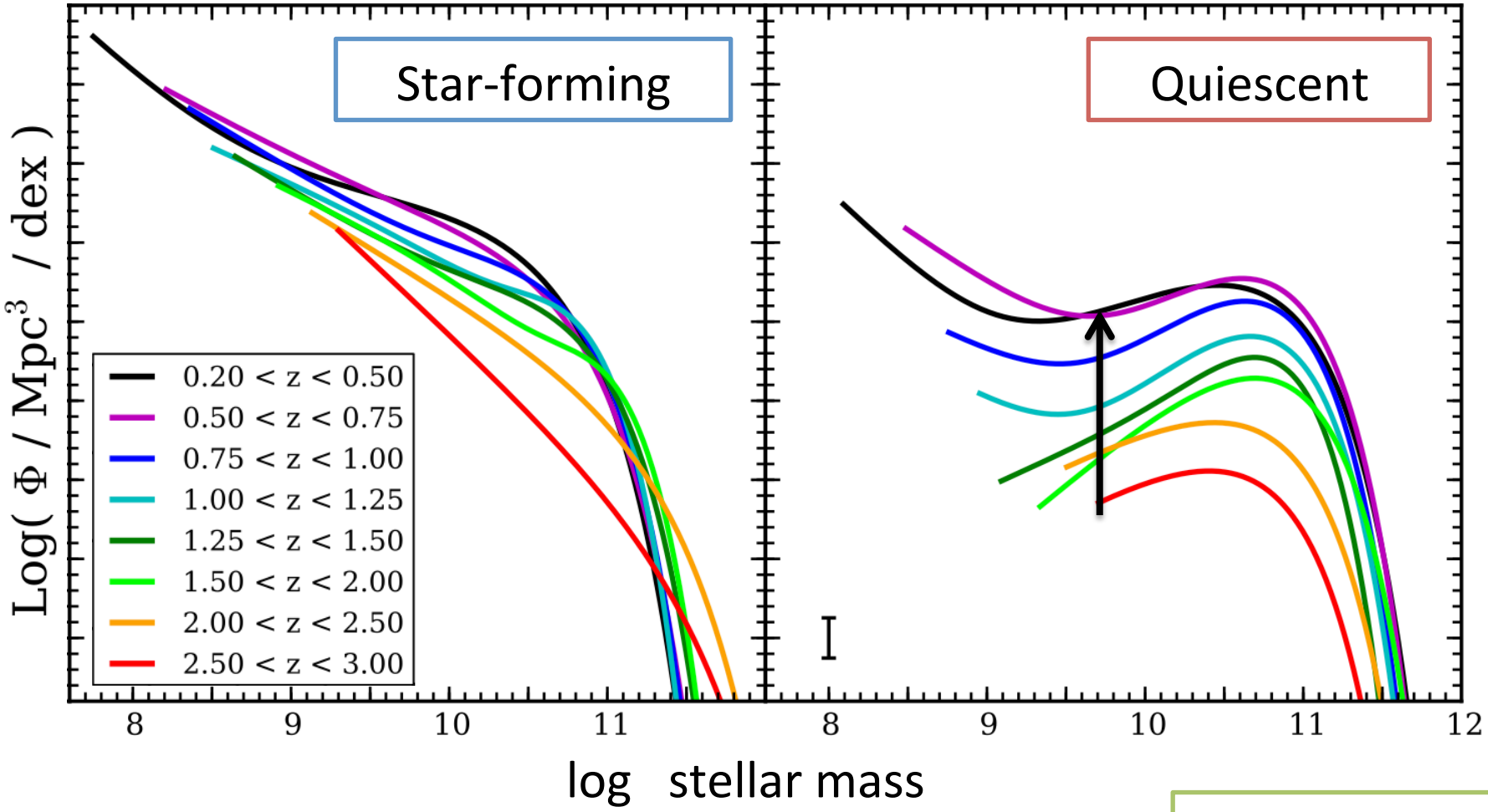


Mass limits



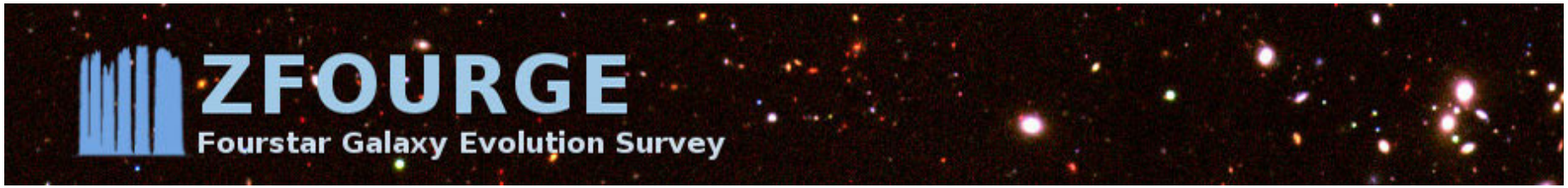
H_{160} selected

ZFOURGE mass functions to z=3



H_{160} selected + NMBS

Tomczak et al. 2014



- Discovered distant galaxy (proto-) cluster
  - MOSFIRE follow-up program: ZFIRE
- Mass-limited census at z=3-4
  - Most are red, not like Lyman-break galaxies
  - 45% quiescent, 35% dusty, 15% blue star-forming
- Quiescent galaxies are very compact at z~4
- Host properties of radio AGN change
  - AGN hosts have higher star-formation rates
- Strong evolution in the quiescent galaxy mass function