What turns galaxies off?

The evolution of the old, red and dead galaxy population in a ΛCDM Universe

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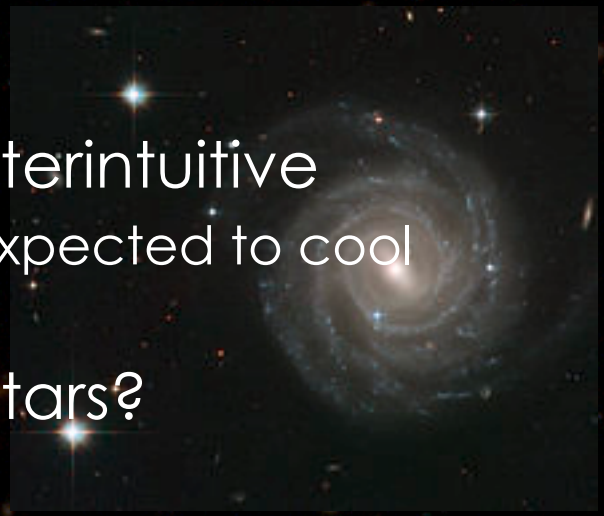
van der Wel, Papovich, Kocevski, Lotz, McIntosh, Kartaltepe, Faber, Ferguson, Koekemoer, Grogin, Wuyts, Cheung, Conselive, Dekel, Dunlop, Giavalisco, Herrington, Koo, McGrath, de Mello, Rix, Robaina, Williams

ApJ, in press (arXiv:1110.3786)

Premise



- Non-star forming galaxies are counterintuitive
  - ~90% of normal matter in diffuse gas, expected to cool and condense.
- Why do some galaxies fail to form stars?

Themes

- Under which circumstances do galaxies lose their cold gas & fail to replenish?
  - Which galaxies fail to form stars?
  - What are their properties?
  - When do they stop forming stars?

Explore themes using
HST/CANDELS Survey
(PIs Faber/Ferguson)

IR/optical/UV WFC3 and ACS
5 fields
- 0.2 sq. degree wide
- 0.04 sq. degrees deep

Grogin et al. 2011
Koekemoer et al. 2011

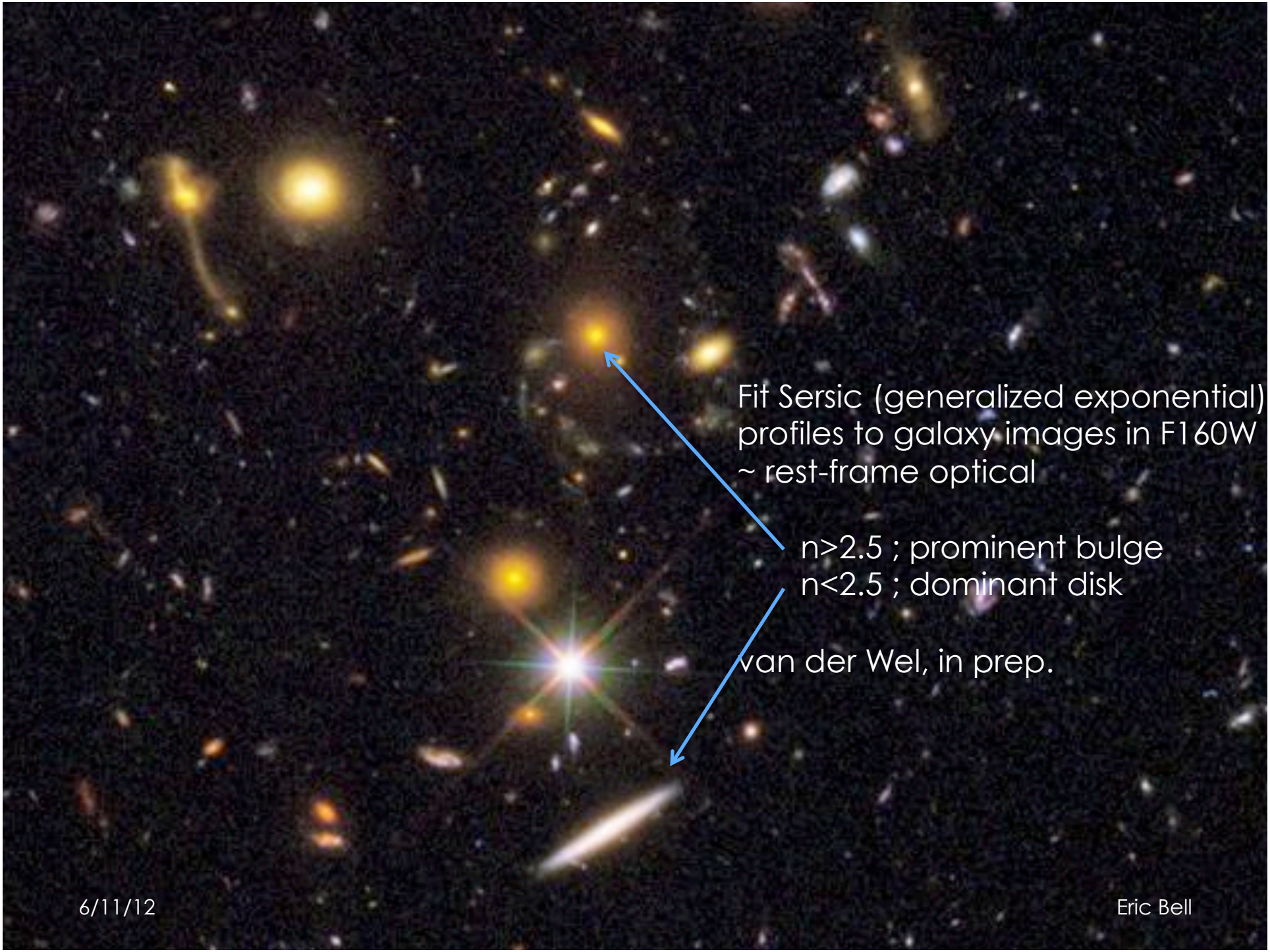
candels.ucolick.org

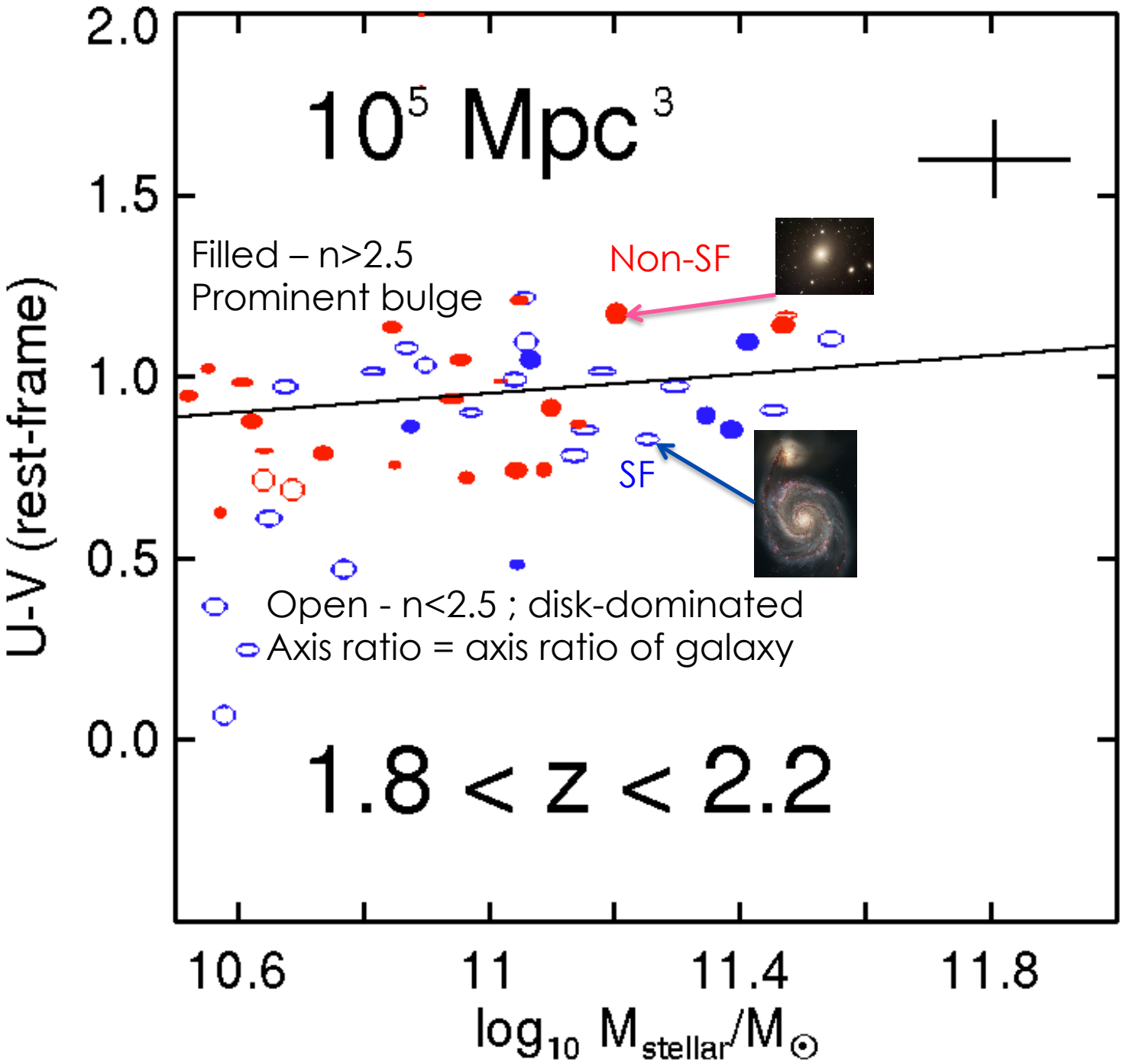
Optical/near IR fluxes

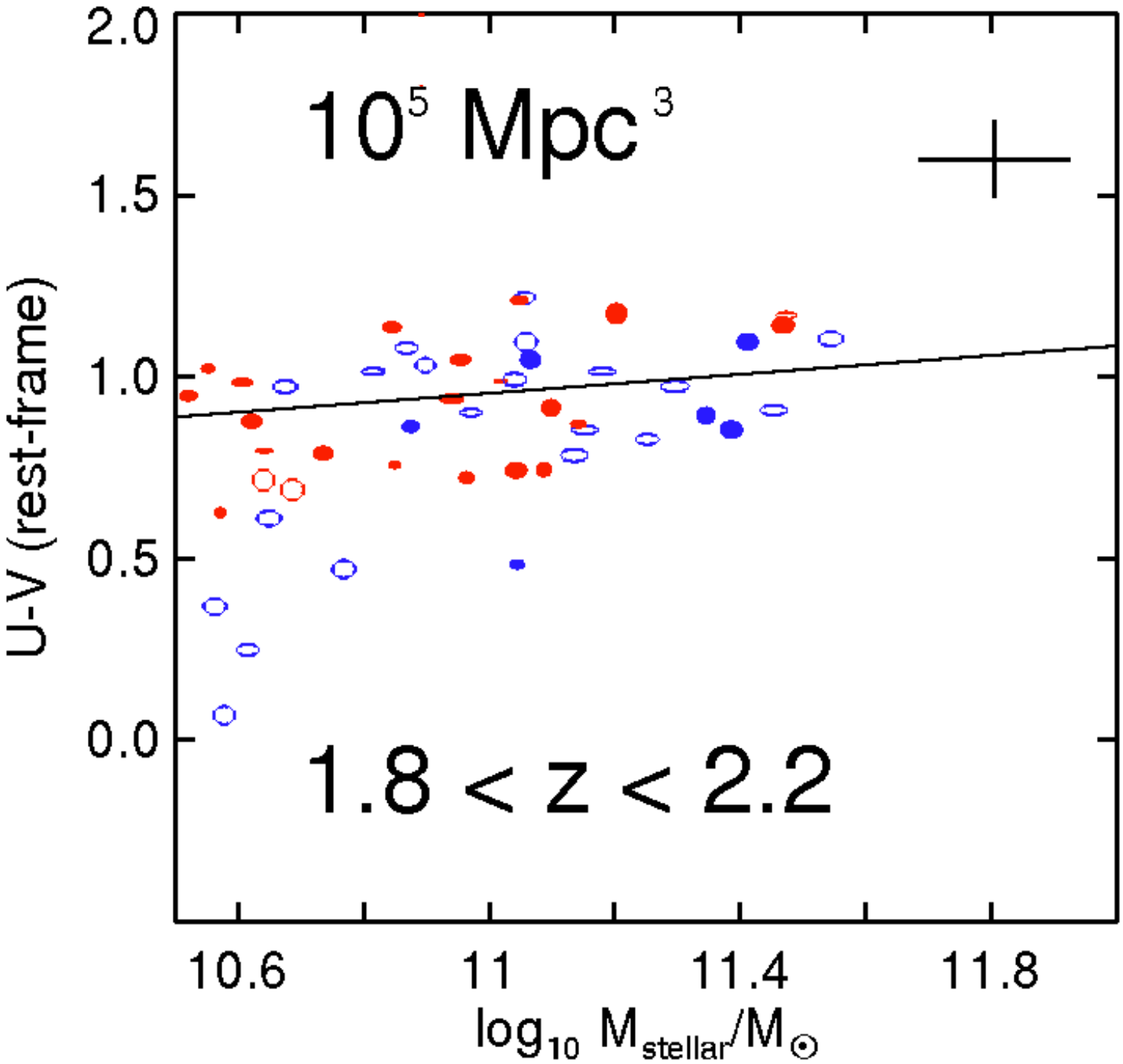
Fit stellar population models
➔ Photometric redshifts
dz/(1+z) ~ 0.05
(Williams et al. 2009)

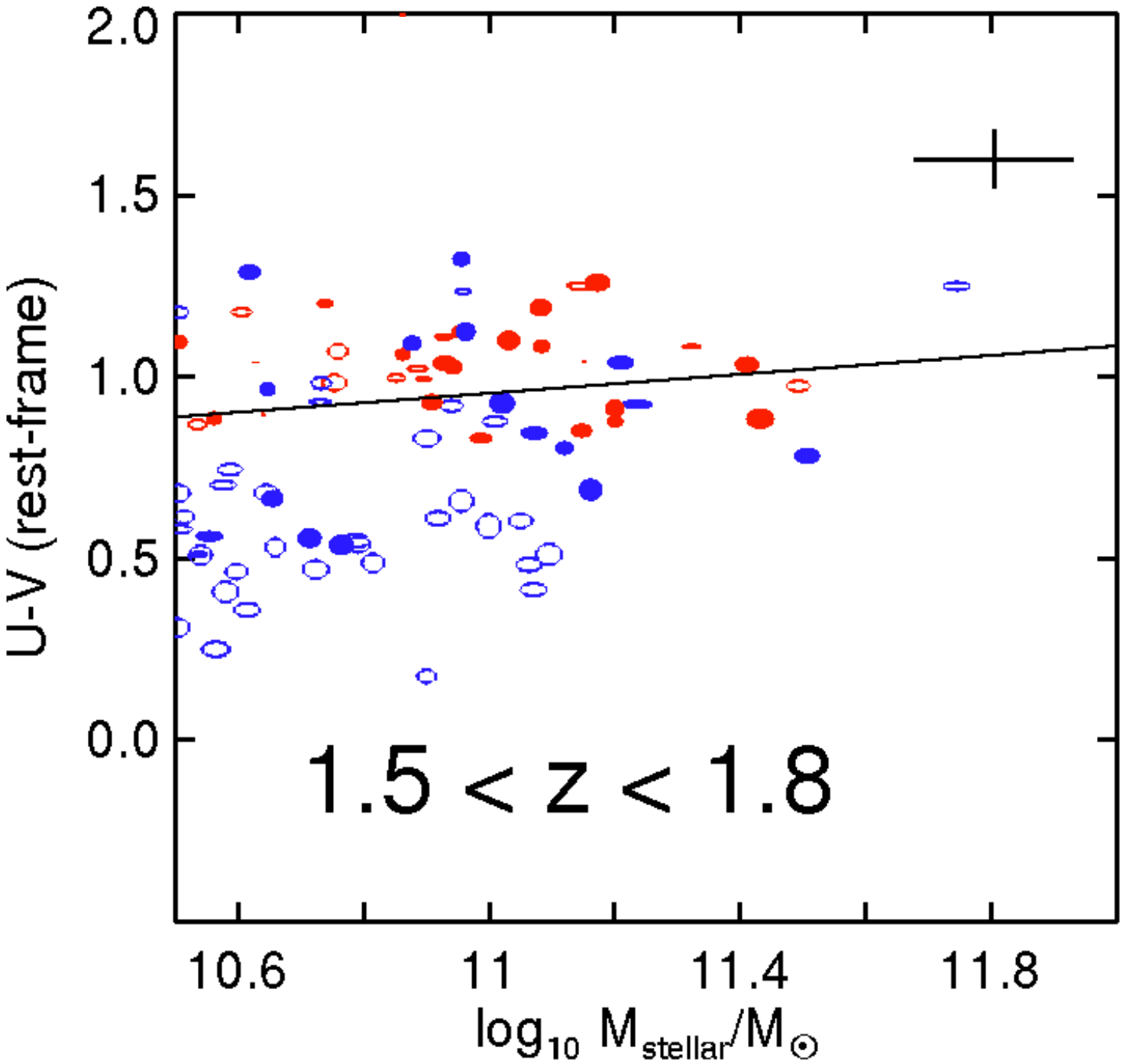
➔ Stellar mass estimates
Quiescent vs. star-forming UVJ
d(log M*) ~ 0.15 dex
(Bell et al. 2012)

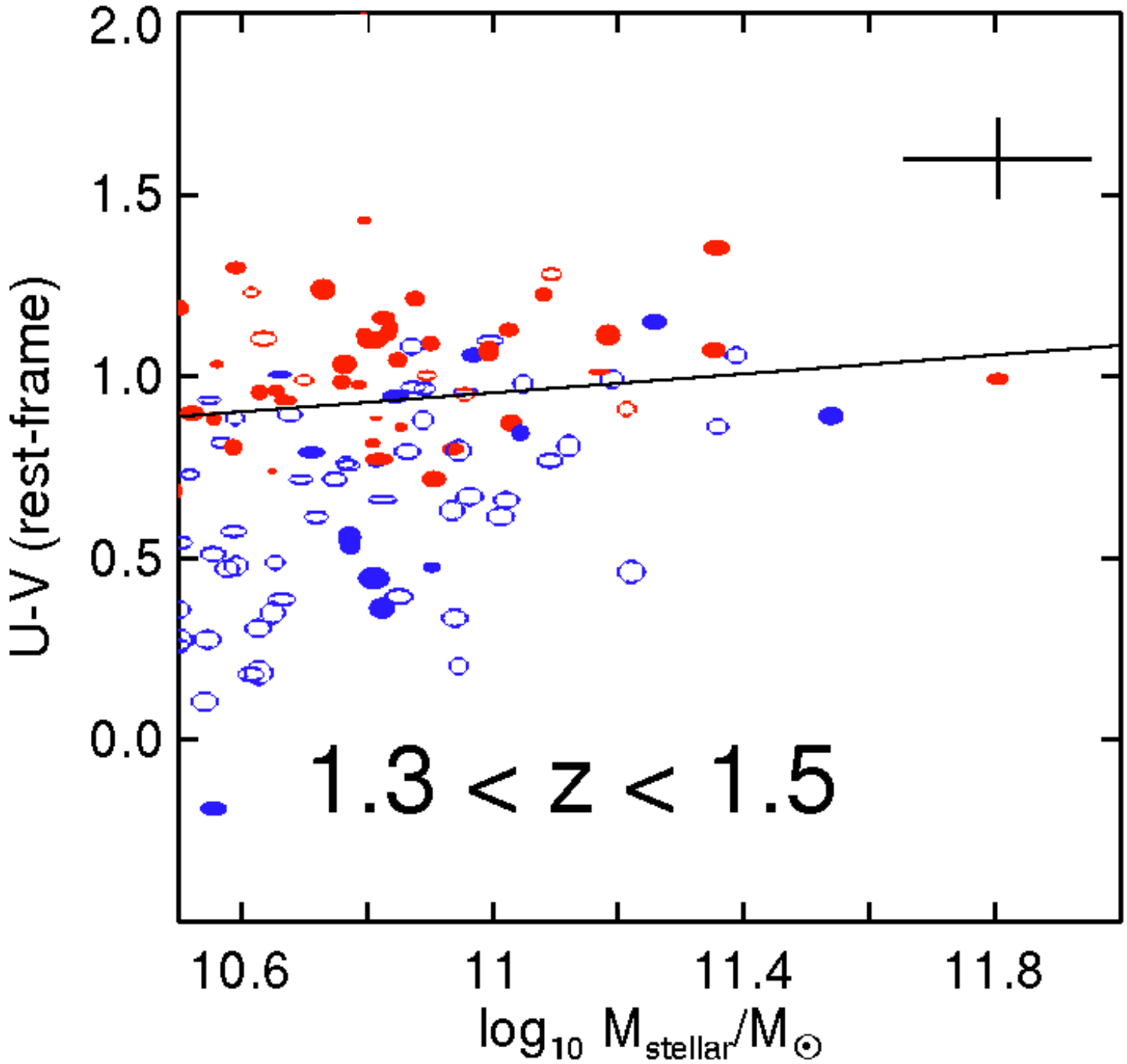
Focus on galaxies $M^* > 3 \times 10^{10}\ M_{sun}$
Halos >~ $10^{12}\ M_{sun}$

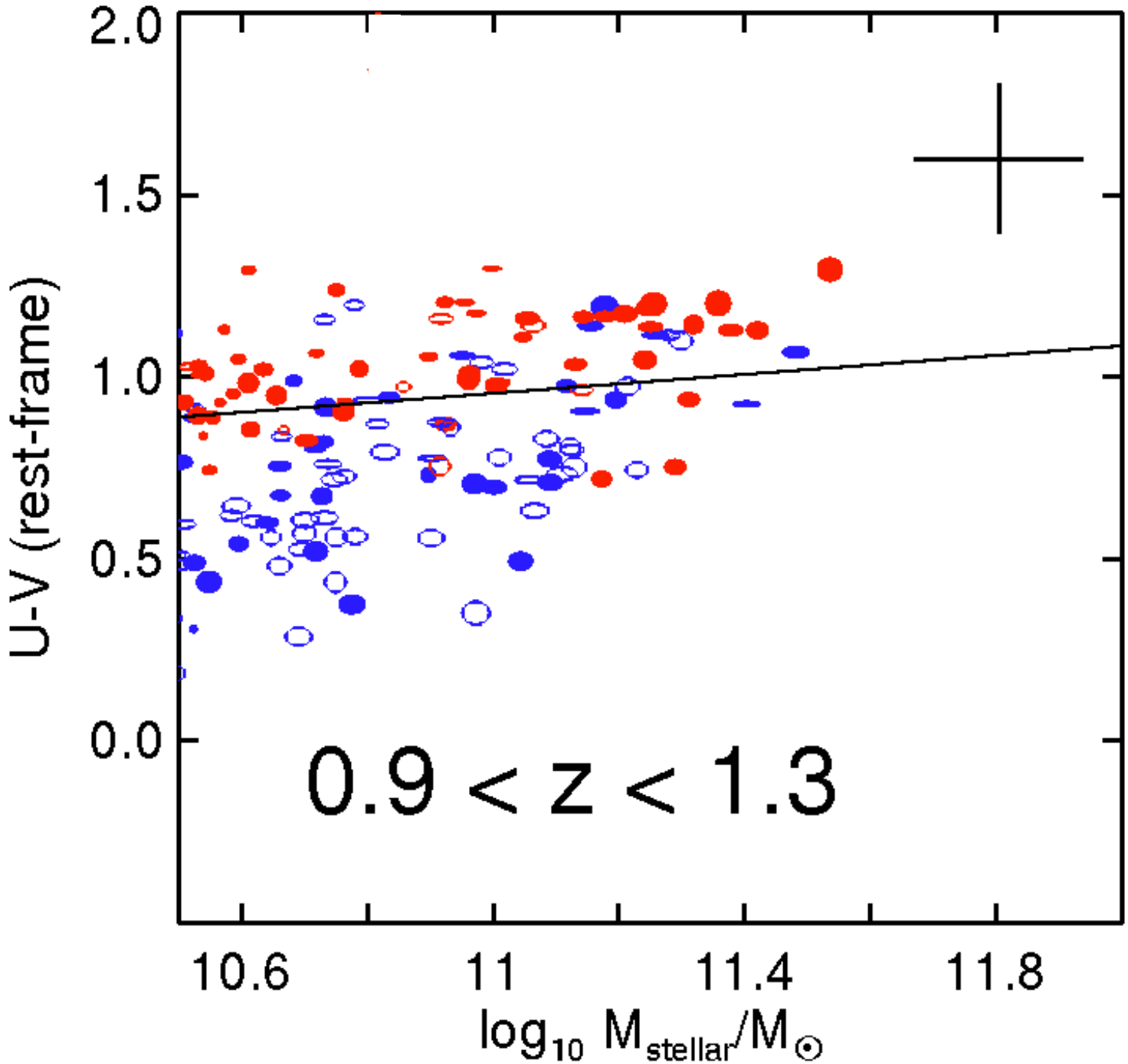

Fit Sersic (generalized exponential) profiles to galaxy images in F160W ~ rest-frame optical
n>2.5 ; prominent bulge
n<2.5 ; dominant disk
van der Wel, in prep.

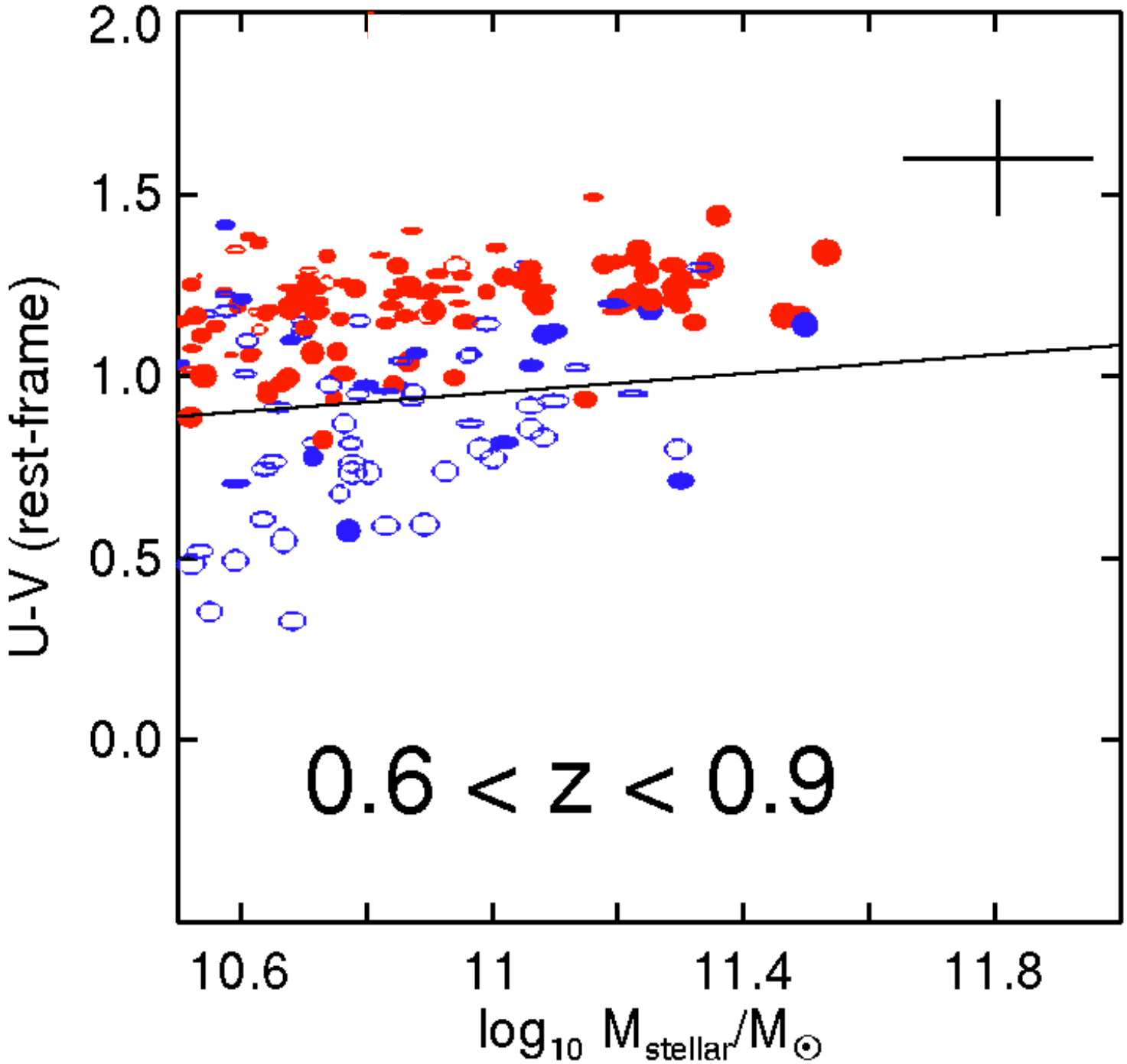

10^5 Mpc^3
Filled – n>2.5
Prominent bulge
Non-SF
SF
Open - n<2.5 ; disk-dominated
Axis ratio = axis ratio of galaxy
$1.8 < z < 2.2$
U-V (rest-frame)
2.0
1.5
1.0
0.5
0.0
10.6
11
11.4
11.8
$\log_{10} M_{stellar}/M_\odot$

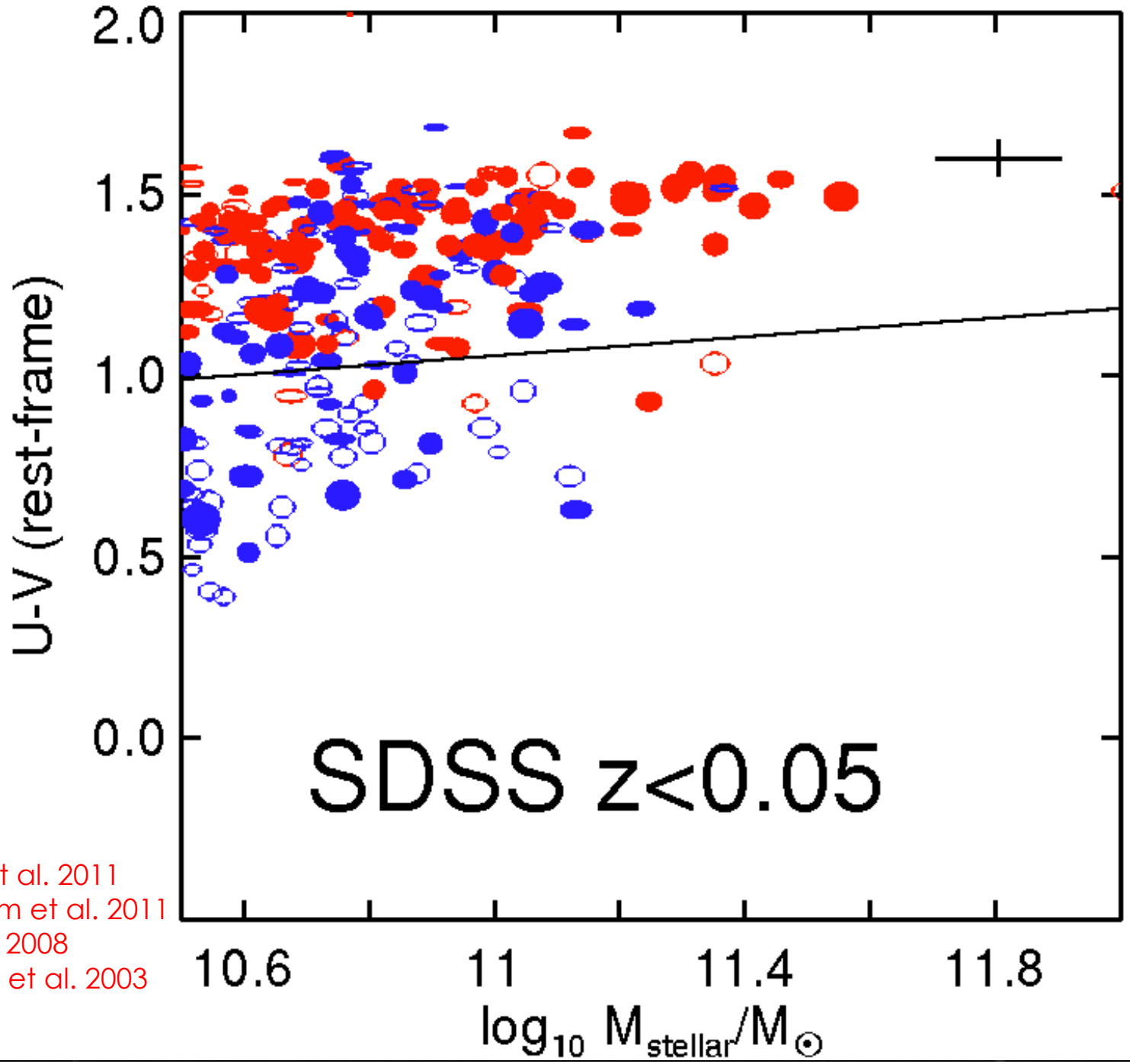

10^5 Mpc^3
1.8 < z < 2.2
U-V (rest-frame)
2.0
1.5
1.0
0.5
0.0
10.6
11
11.4
11.8
$\log_{10} M_{stellar}/M_\odot$


2.0
1.5
1.0
0.5
0.0
U-V (rest-frame)
1.5 < z < 1.8
10.6
11
11.4
11.8
log10 Mstellar/M⊙

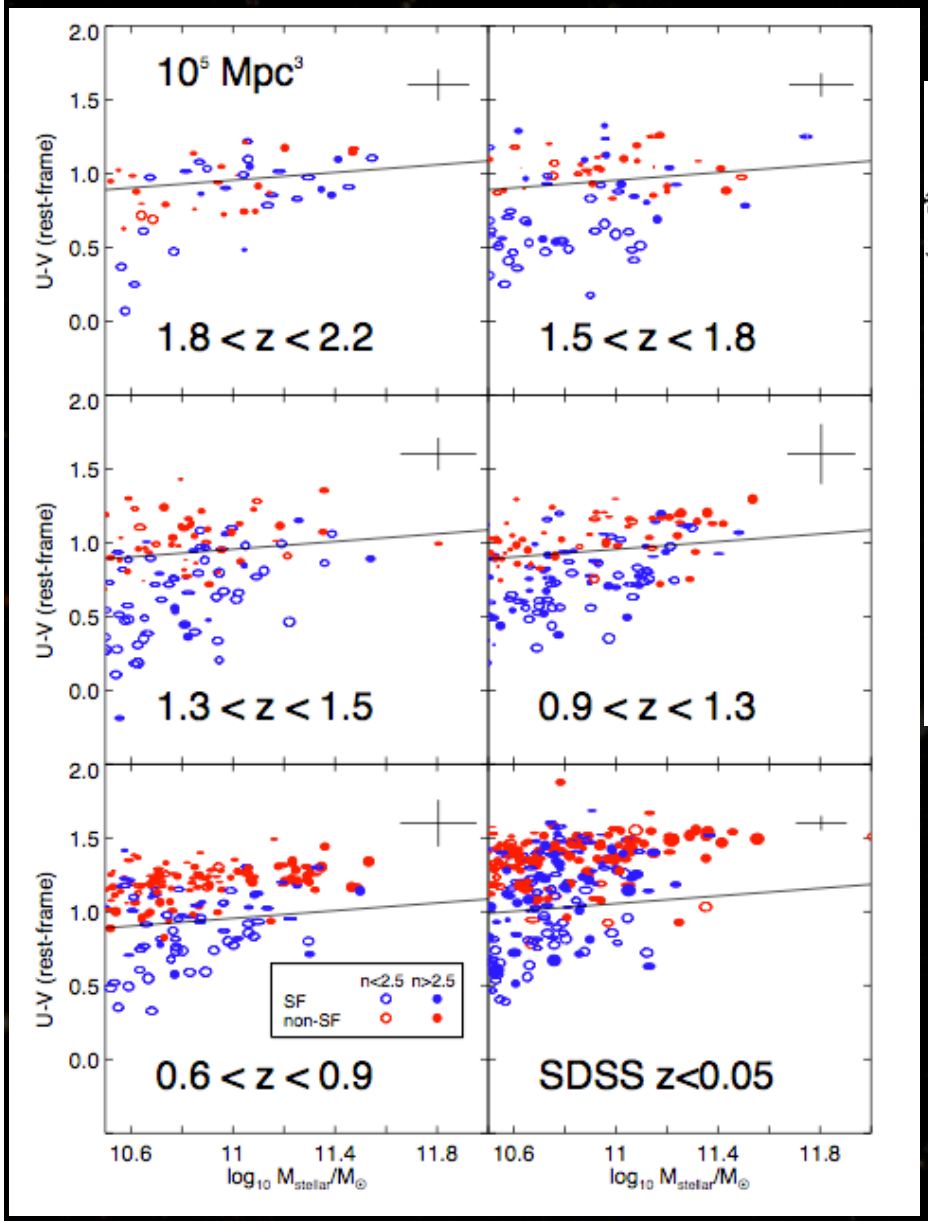

2.0
1.5
1.0
0.5
0.0
U-V (rest-frame)
1.3 < z < 1.5
10.6
11
11.4
11.8
log10 Mstellar/M⊙


2.0
1.5
1.0
0.5
0.0
U-V (rest-frame)
0.9 < z < 1.3
10.6
11
11.4
11.8
log10 Mstellar/M⊙

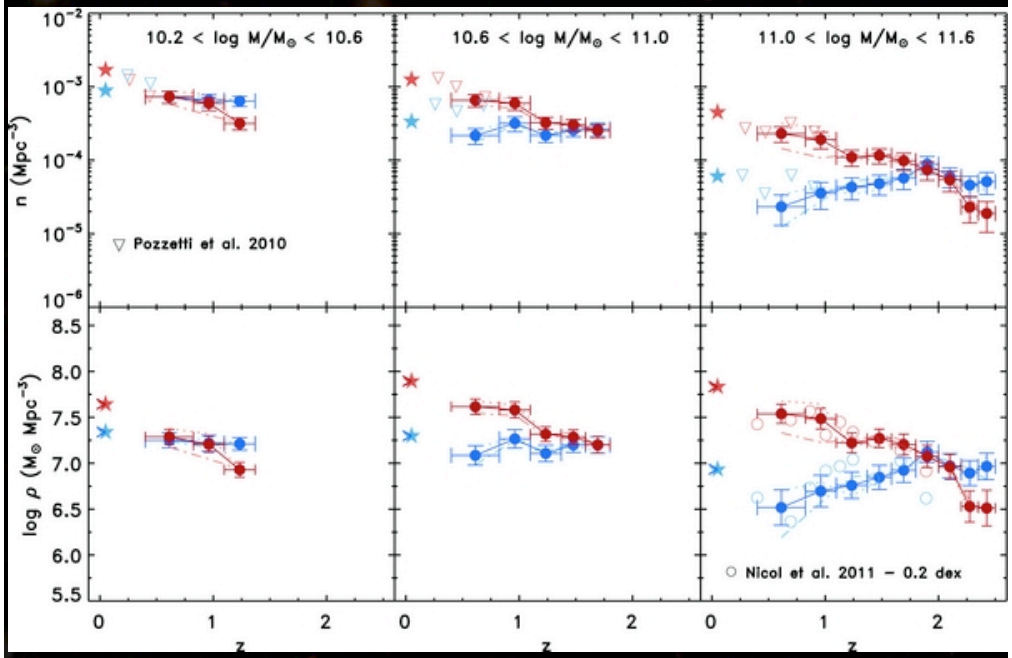

2.0
1.5
1.0
0.5
0.0
U-V (rest-frame)
0.6 < z < 0.9
10.6
11
11.4
11.8
log10 Mstellar/M⊙



See also:
Brammer et al. 2011
Van Dokkum et al. 2011
Franx et al. 2008
Kauffmann et al. 2003
Bell 2008



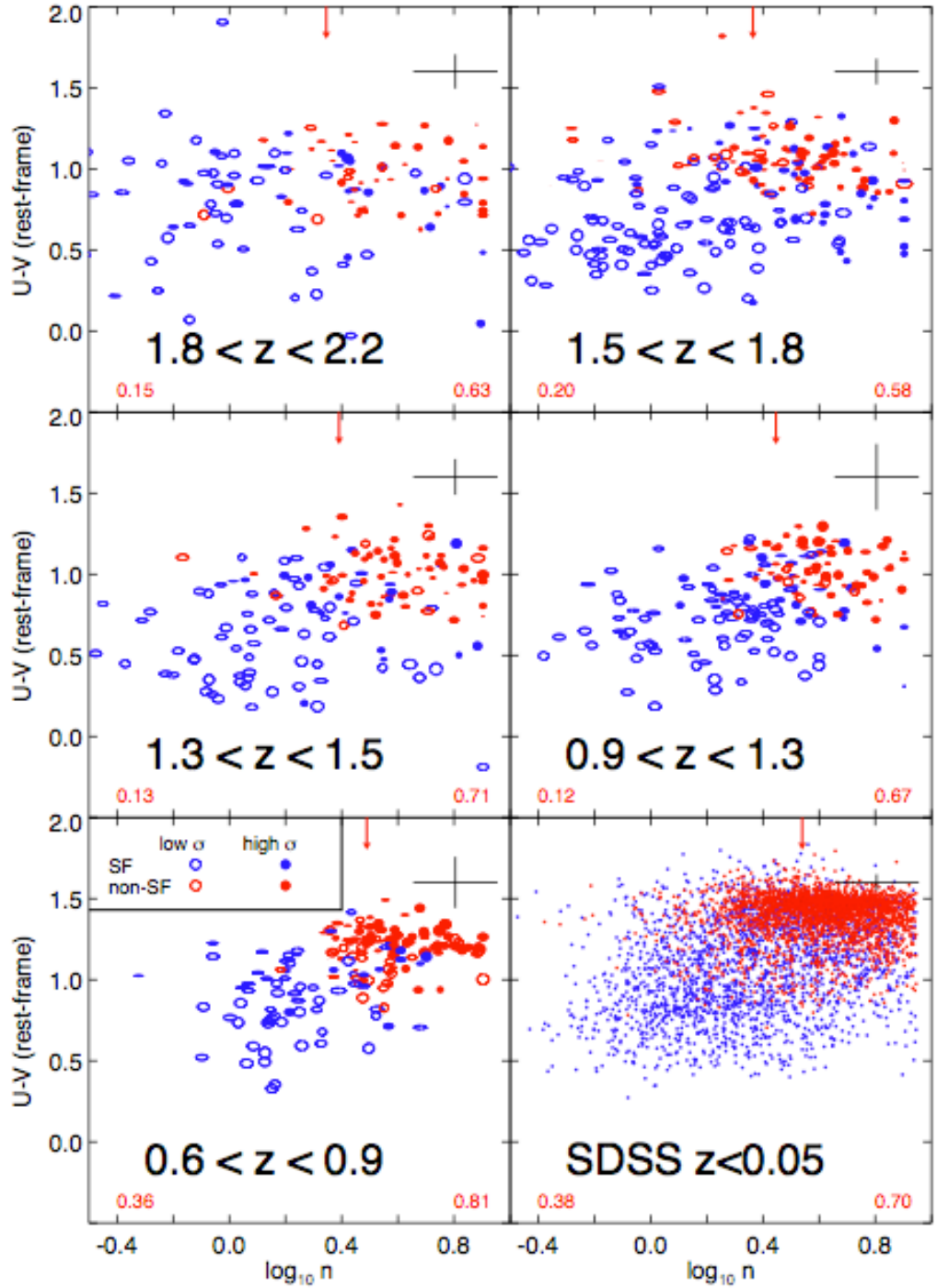
Bell et al. 2012

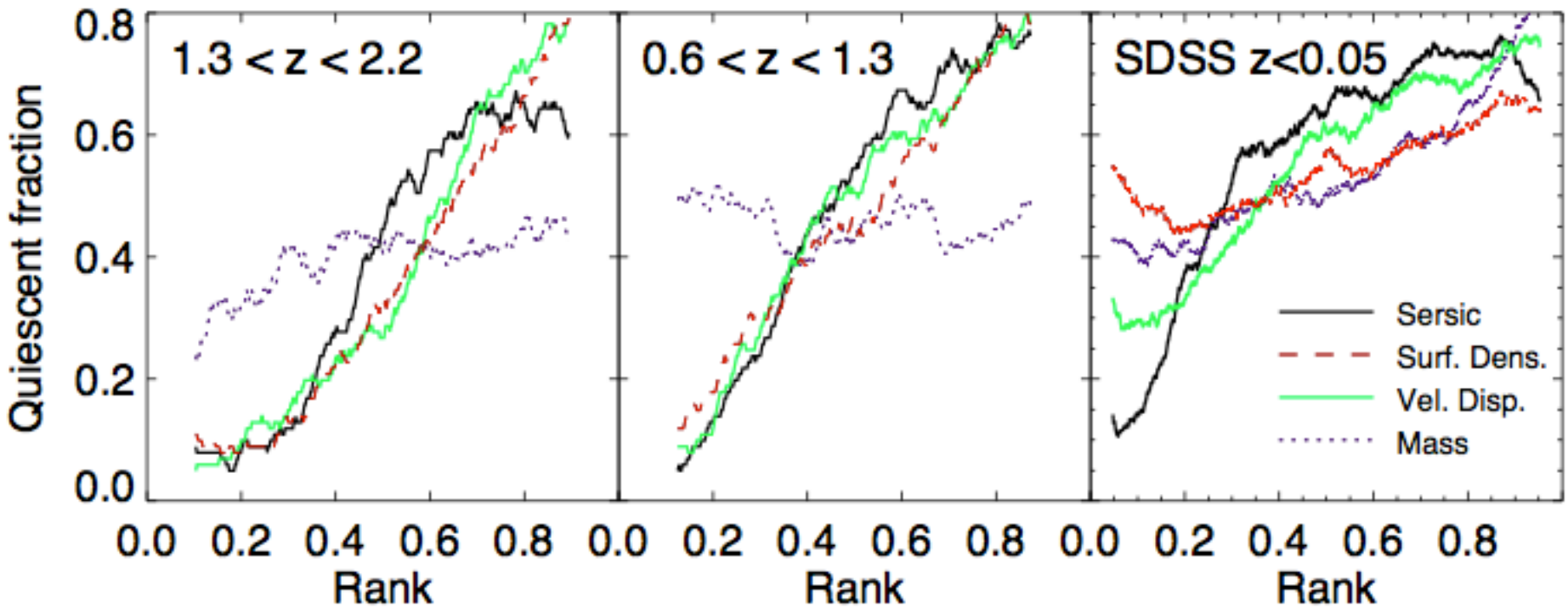


Brammer et al. 2011

- Dramatic emergence of massive galaxy population
  - x5-10 increase in number of massive, non star-forming galaxies
- In a variety of environments (only ~few % of galaxies >3e10 Msun are in clusters)

- Most non-star forming galaxies have high n
  - Prominent bulge





- Stellar mass is a poor predictor of quiescence
- Sersic index / velocity dispersion / central density correlate better with quiescence
  - Having a bulge appears to be important for turning off star formation
    - Some star-forming bulge-dominated galaxies
    - Very small fraction of disk only quiescent galaxies, @ z~0 most satellites

Discussion

- Dramatic emergence of massive galaxy population
  - x5-10 increase in number of massive, non star-forming galaxies
  - The epoch of the bulk of quiescent galaxy formation is $0<z<2$ (~half at $z>1$, ~half at $z<1$)

- Quenching mechanisms
  - Correlates well with galaxy structure (~bulge)
    - Very poor correlation with stellar mass
    - Stellar mass – dark halo mass correlation strong; quiescence is not only driven by dark halo mass
  - Bulge formation
    - Merging, disk instabilities
    - Gas removal?
    - Black hole mass-bulge mass (or sigma) correlation
      - Consistent with zeroth order prediction from AGN feedback paradigm