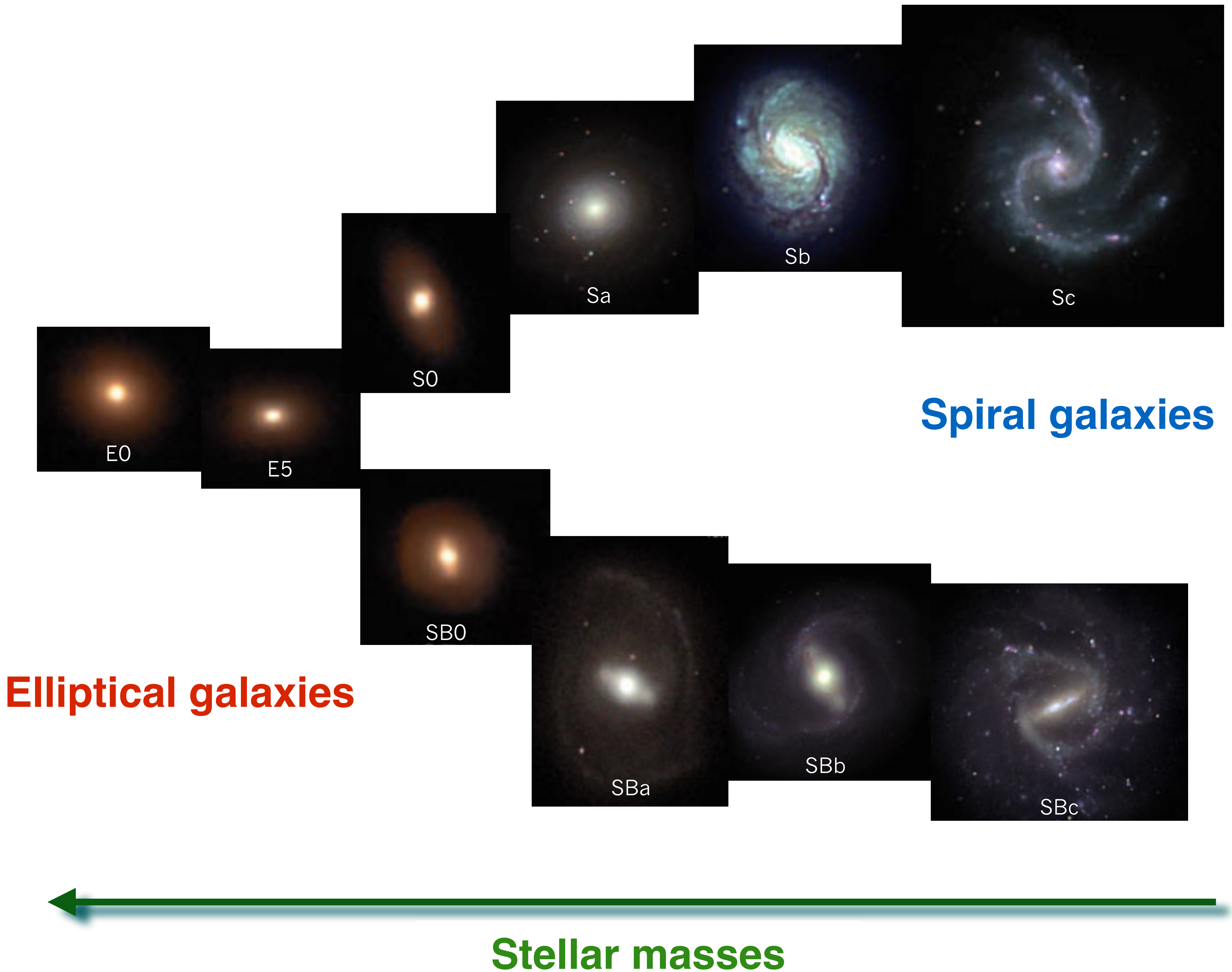
Is the morphology telling us the truth about quenching?

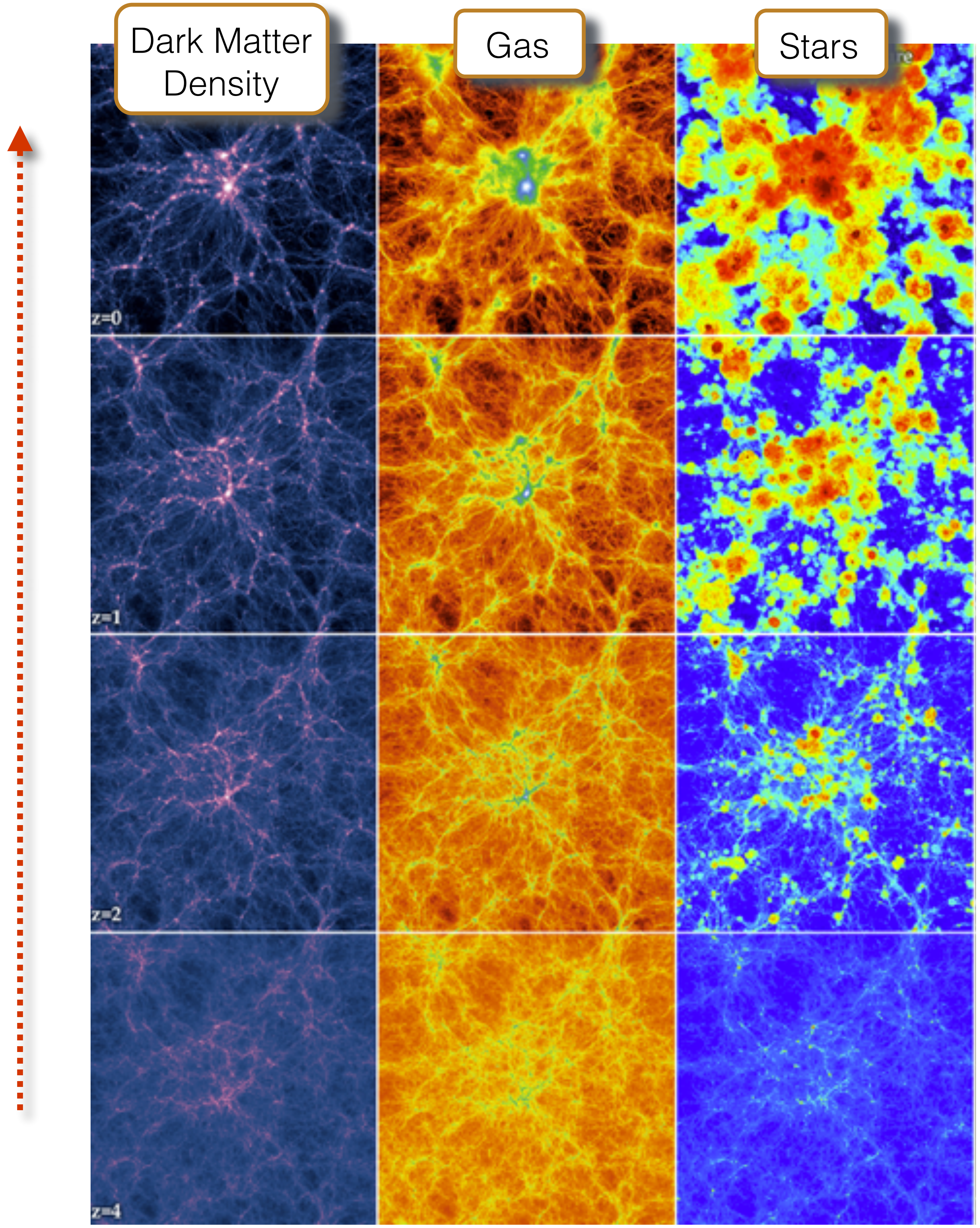
Paola Dimauro

18 April 2019

Hubble sequence



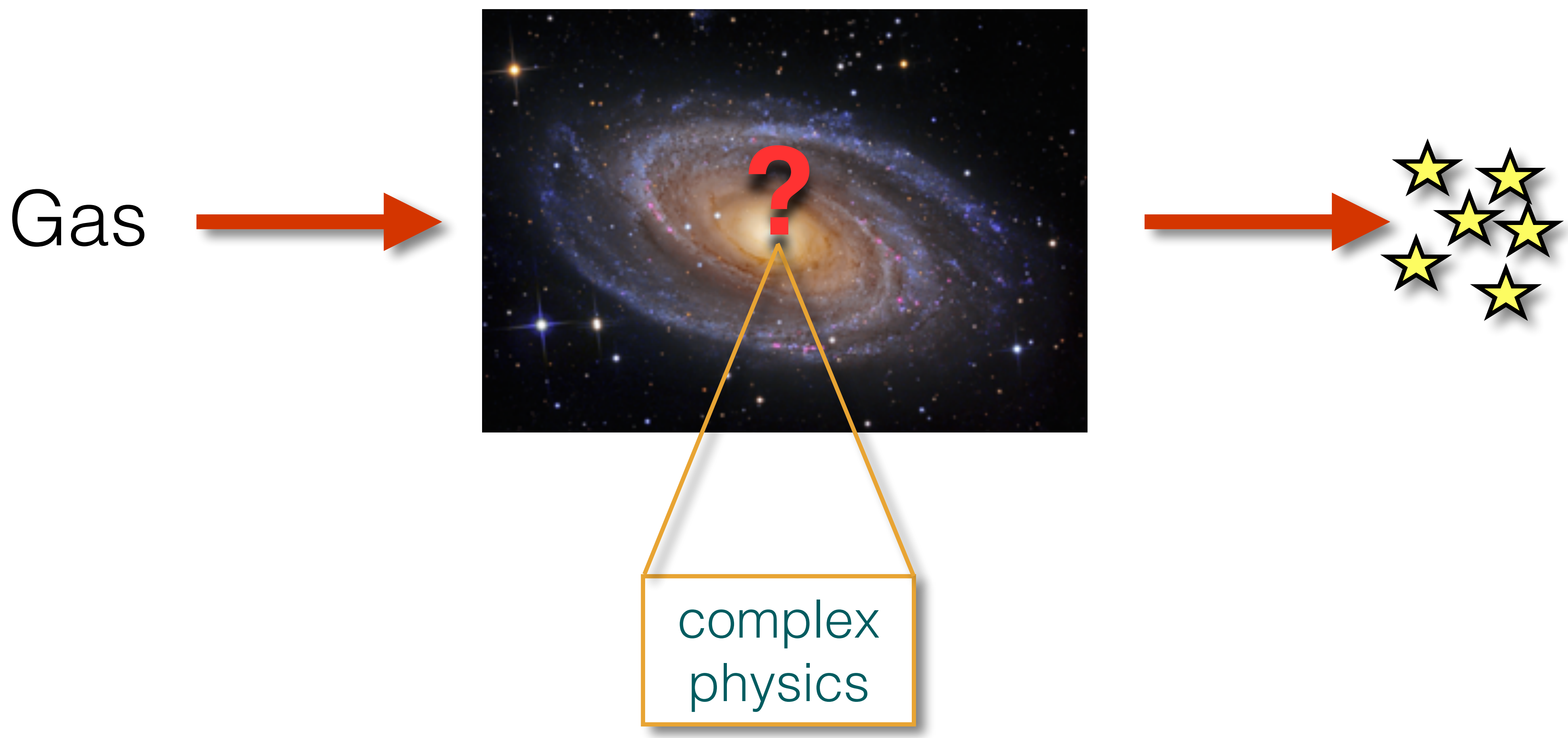
Galaxy formation



Illustris simulation

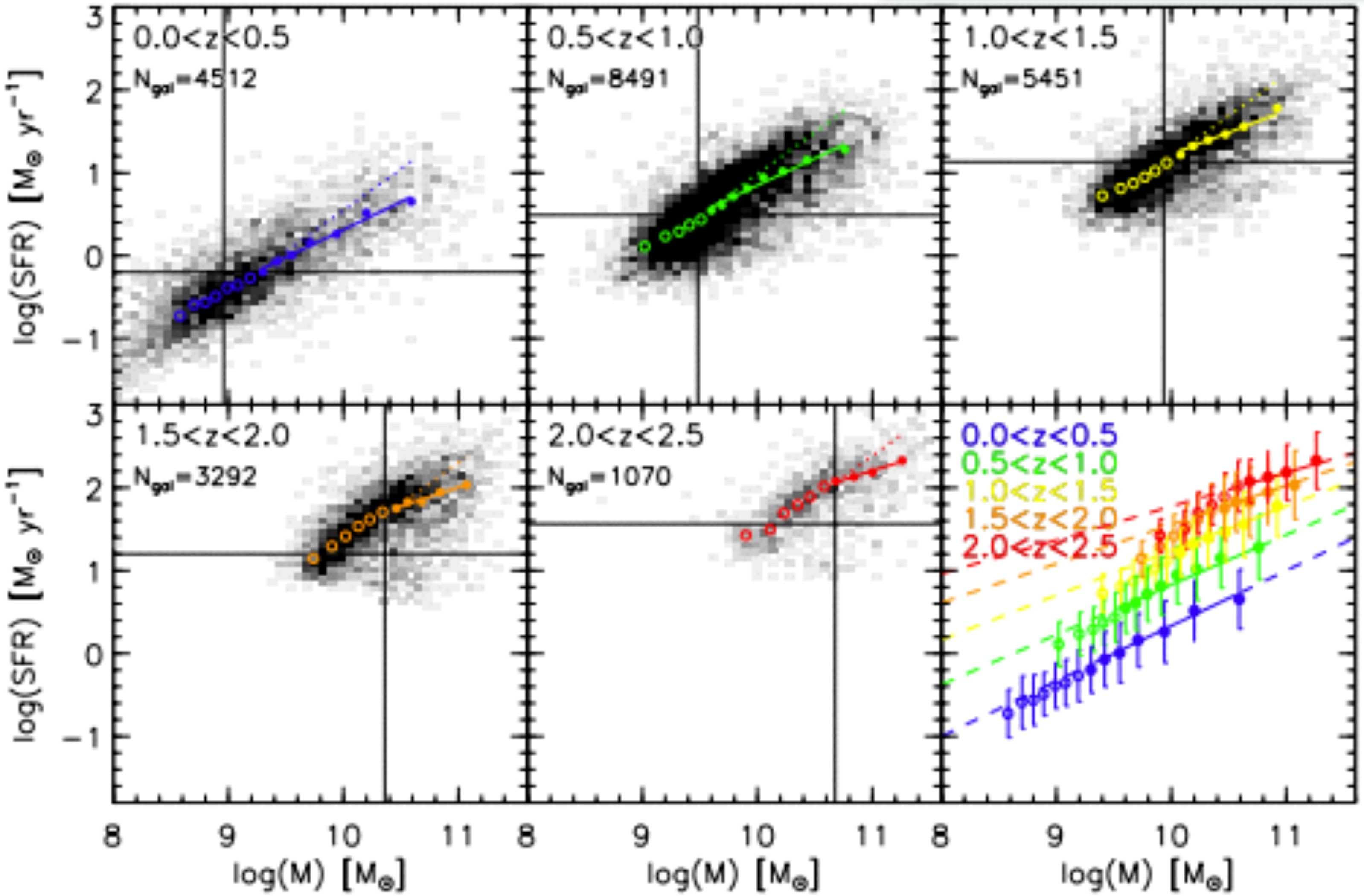
Galaxy - Star formation activity

conversion of gas into stars



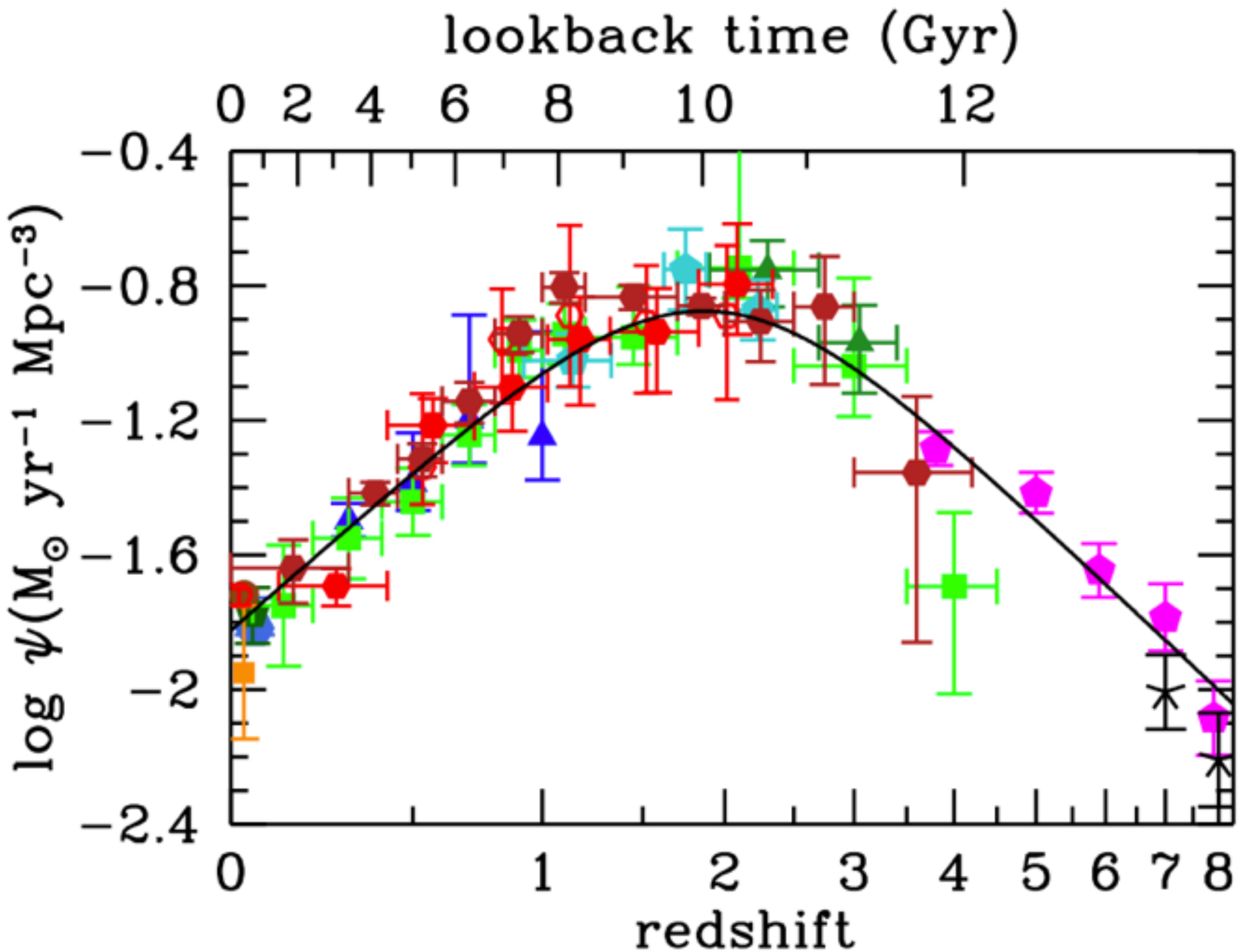
Galaxy - Star formation activity

not a chaotic process



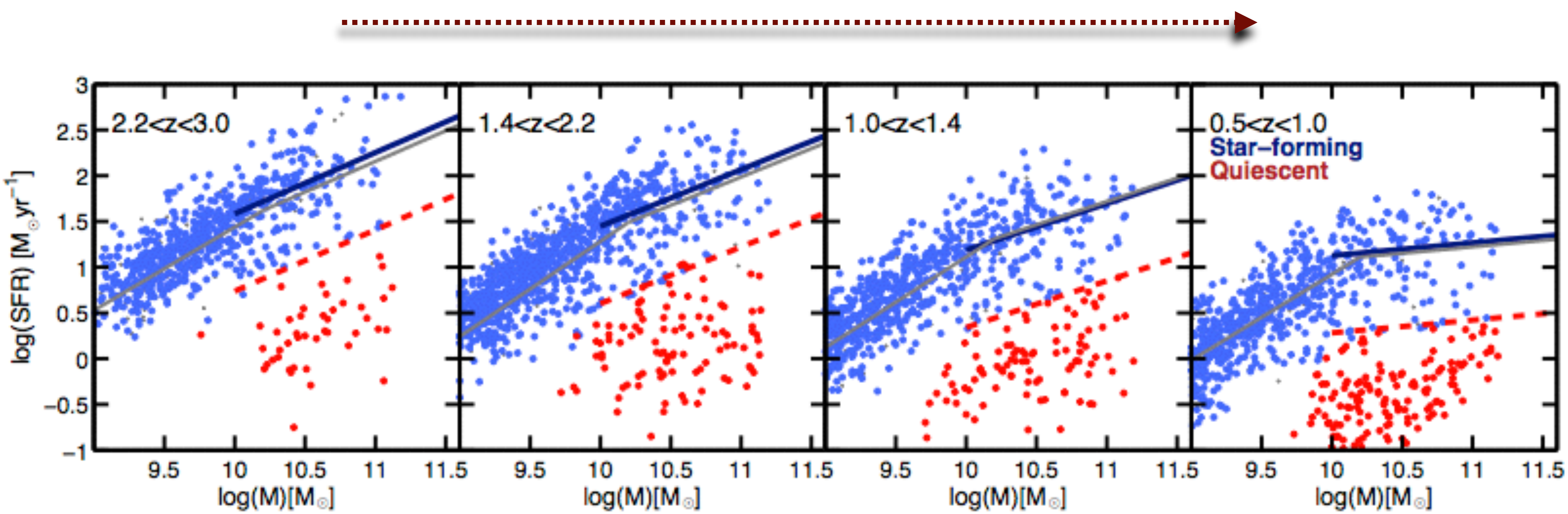
Whitaker et al 2012

Quenching: fundamental question mark



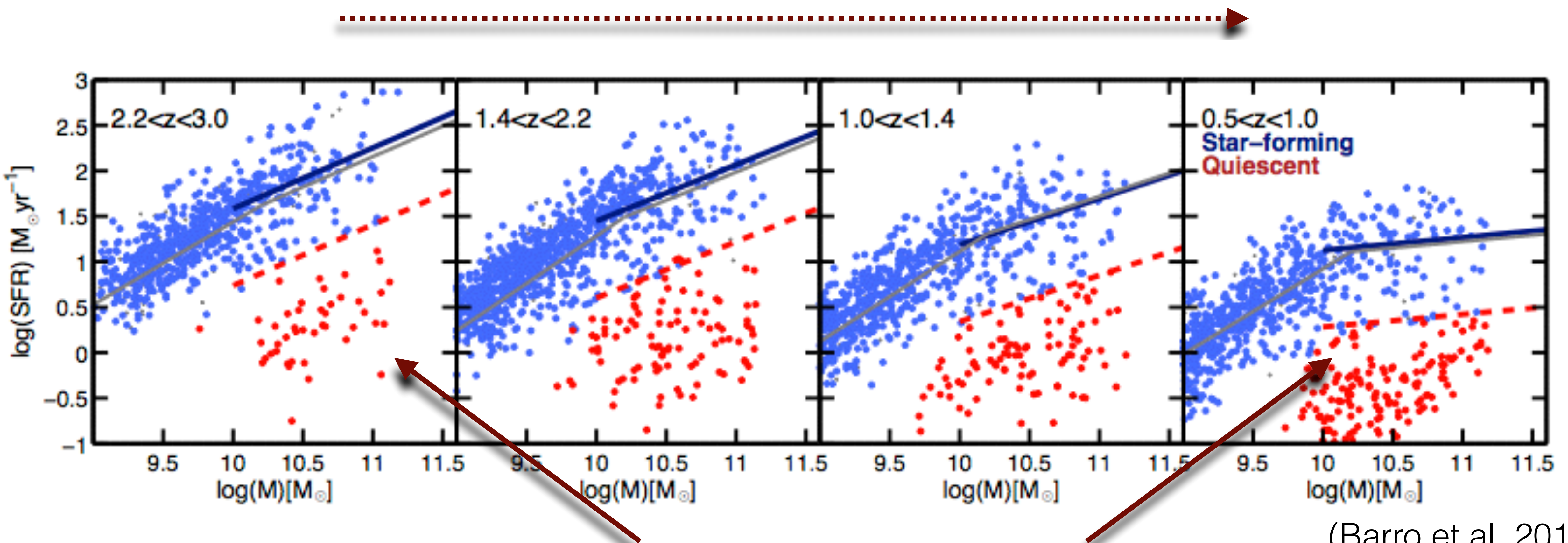
(Madau & Dikinson 2014)

Galaxy - Star formation activity



(Barro et al. 2015)

Galaxy - Star formation activity



(Barro et al. 2015)

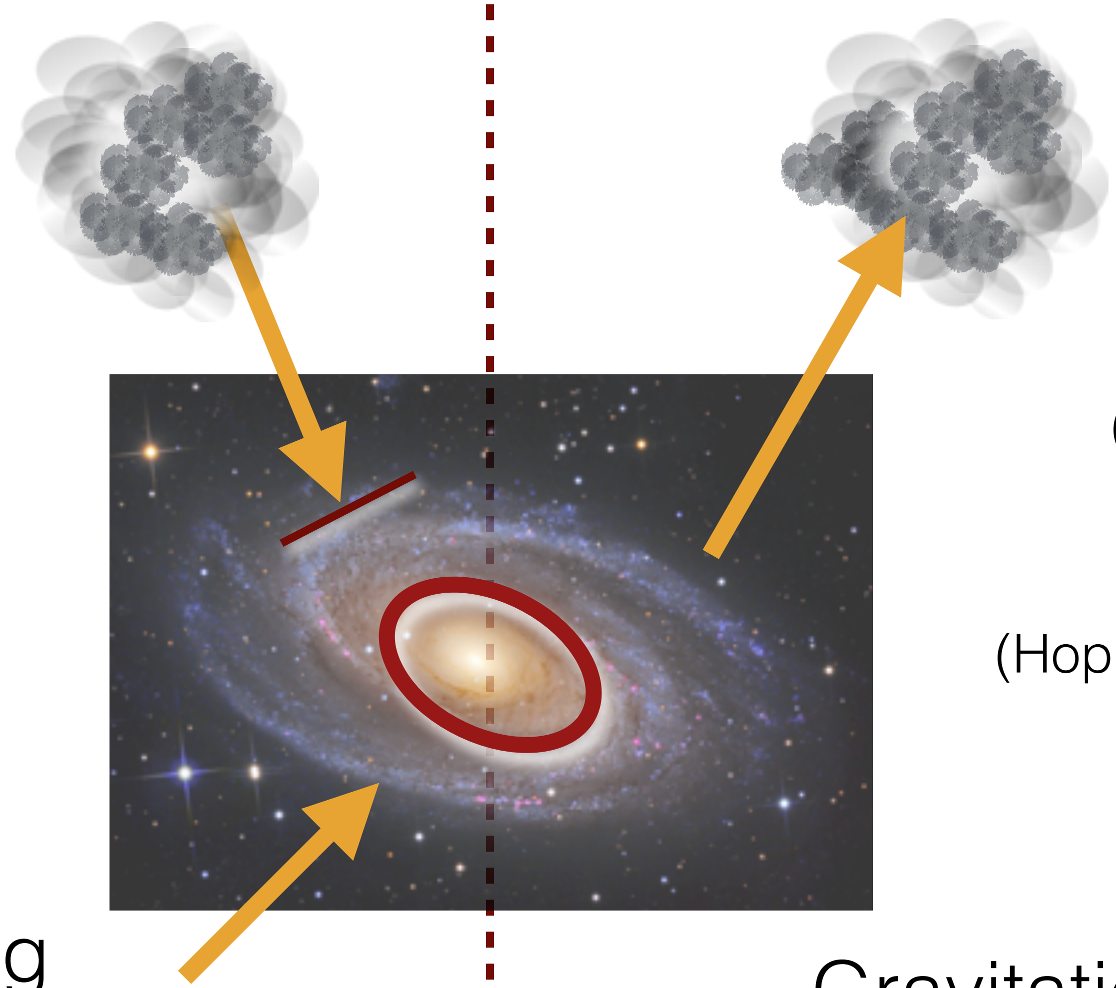
quenched galaxies

Why galaxies stop forming stars?
quenching mechanisms

The main source to produce stars is the gas content

Preventing cooling

Gas removal



Halo mass quenching

stops the accretion of new cod gas

(Birboim & Dekel 2003, Peng 2015)

Outflows of gas

AGN, supernove

(Hopkins 2014, Cattaneo 2009)

Morphological quenching

The accretion of a central density stabilizes the gas in the disk (Martig 2008)

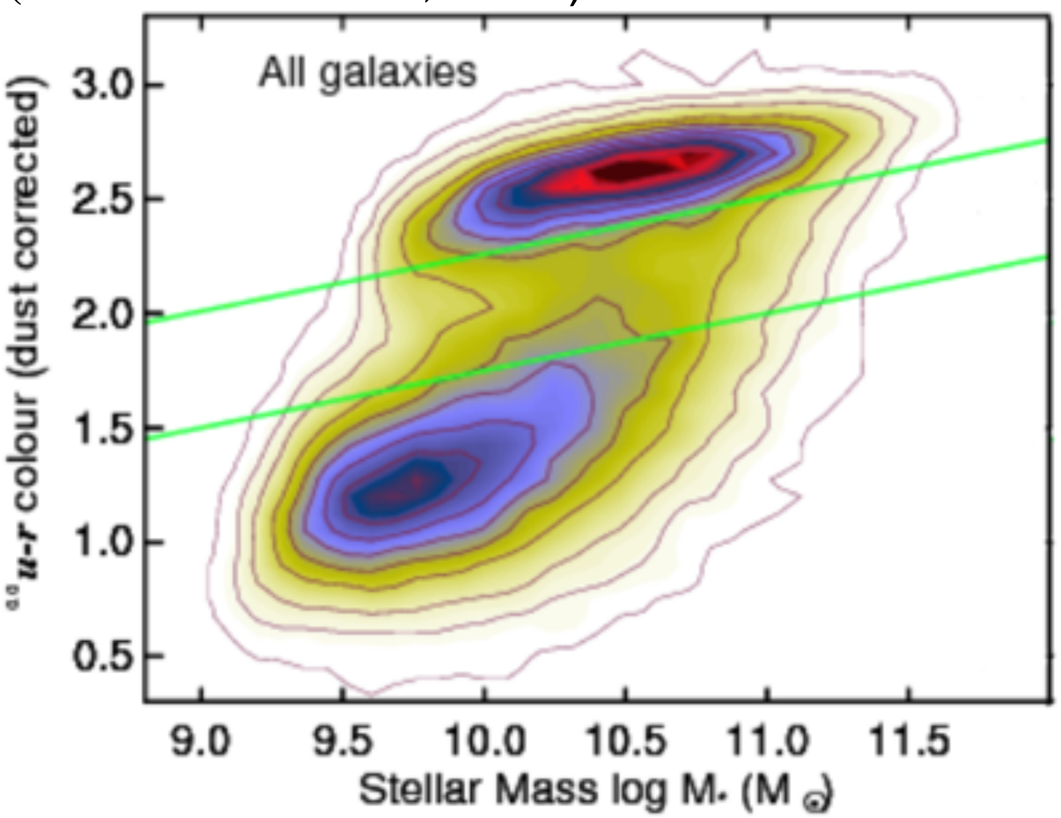
Gravitational interactions

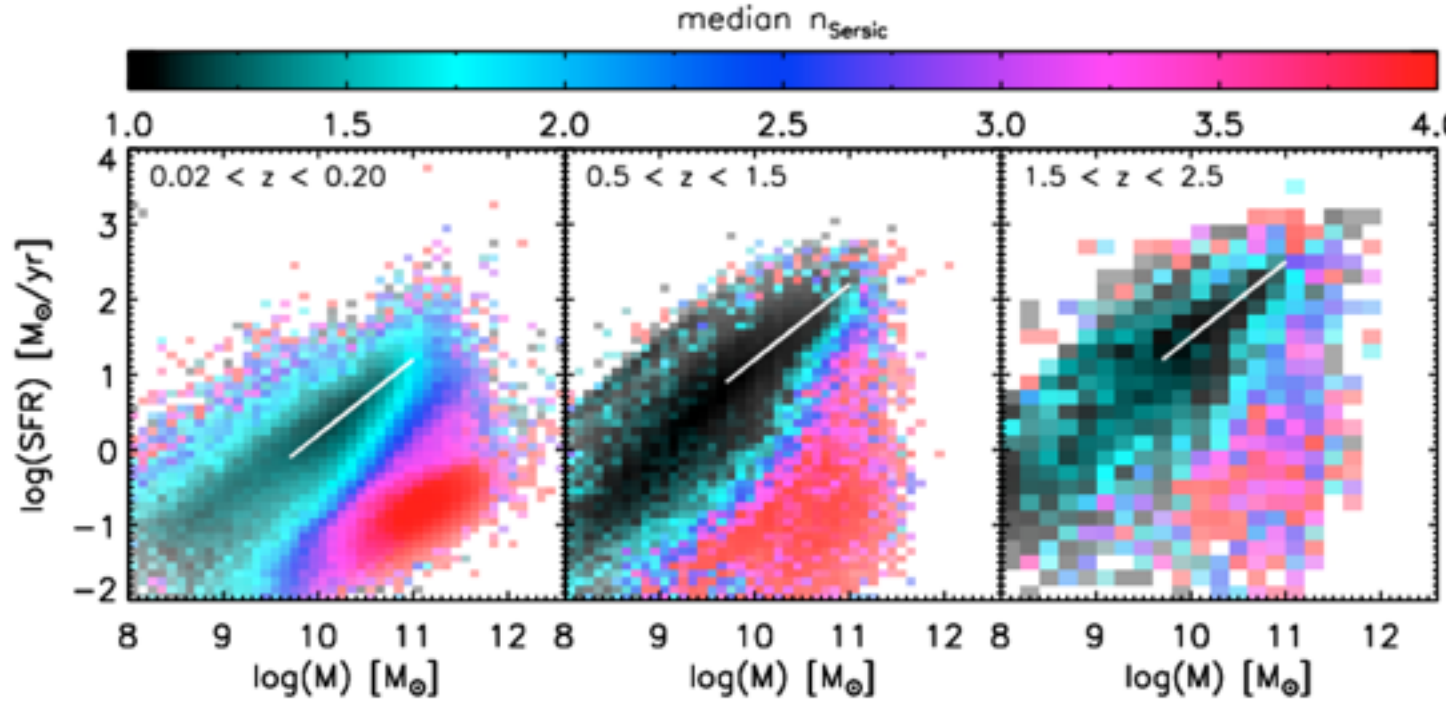
(ram pressure stripping, tidal interaction, etc)

(Gunn & Gott 1972, Nulsen 1982, Moore et al. 1996)

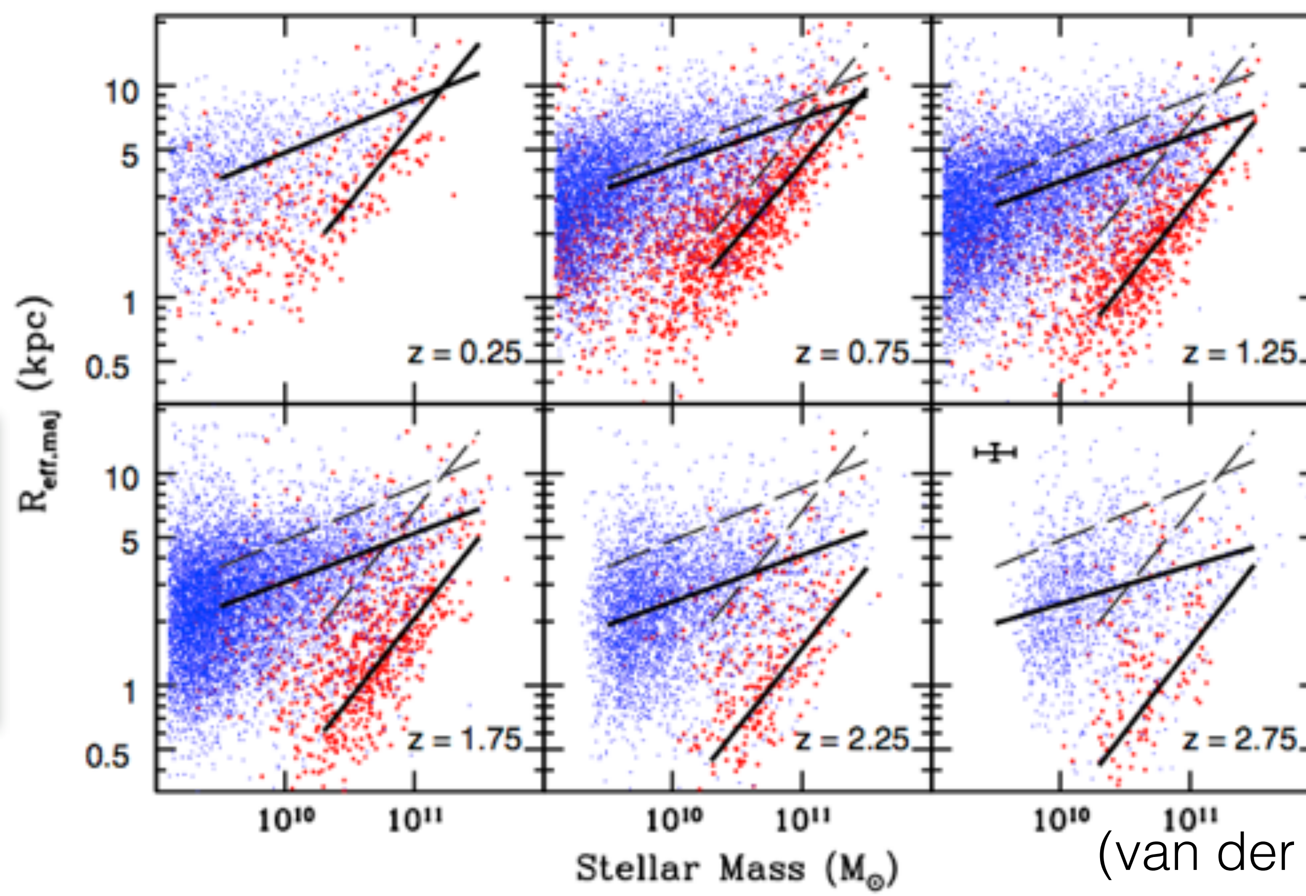
Bimodality of galaxy properties

(Schawinski et al., 2015)



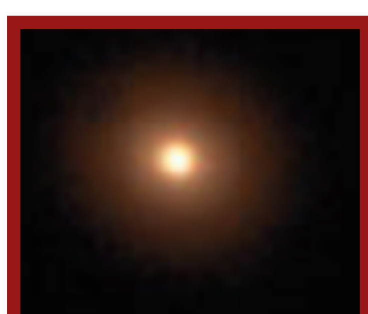


(Wuyts et all 2011)



(van der Well 2014)

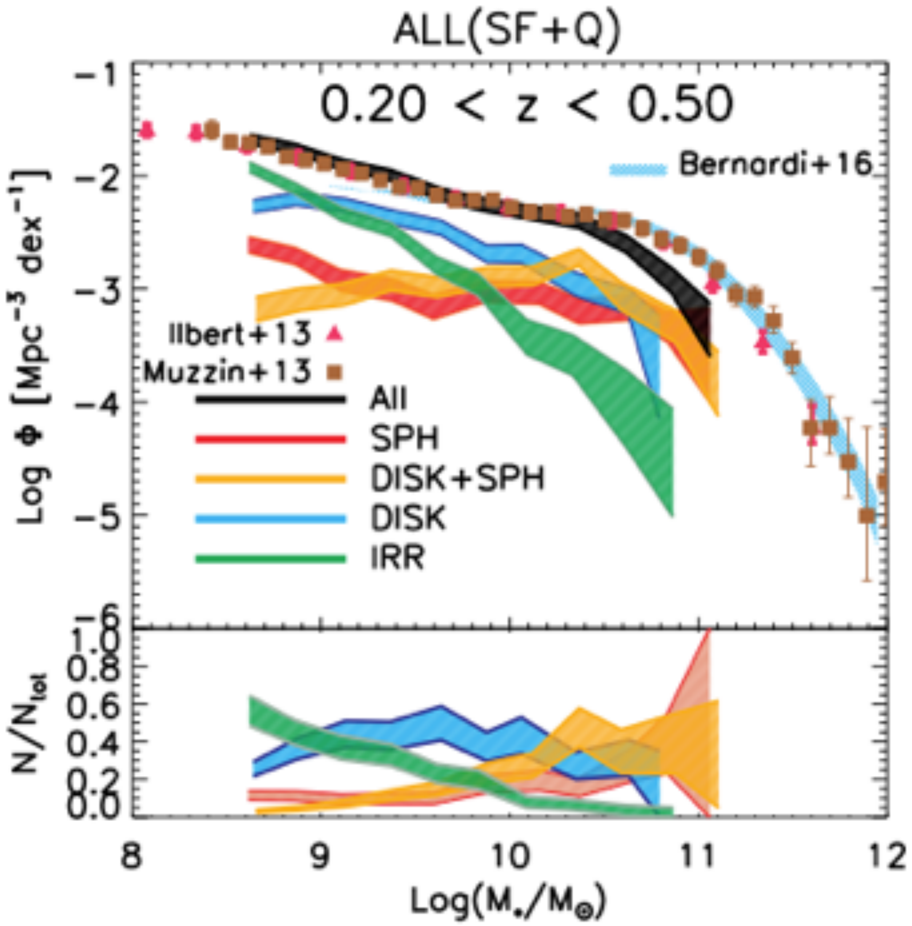
star forming

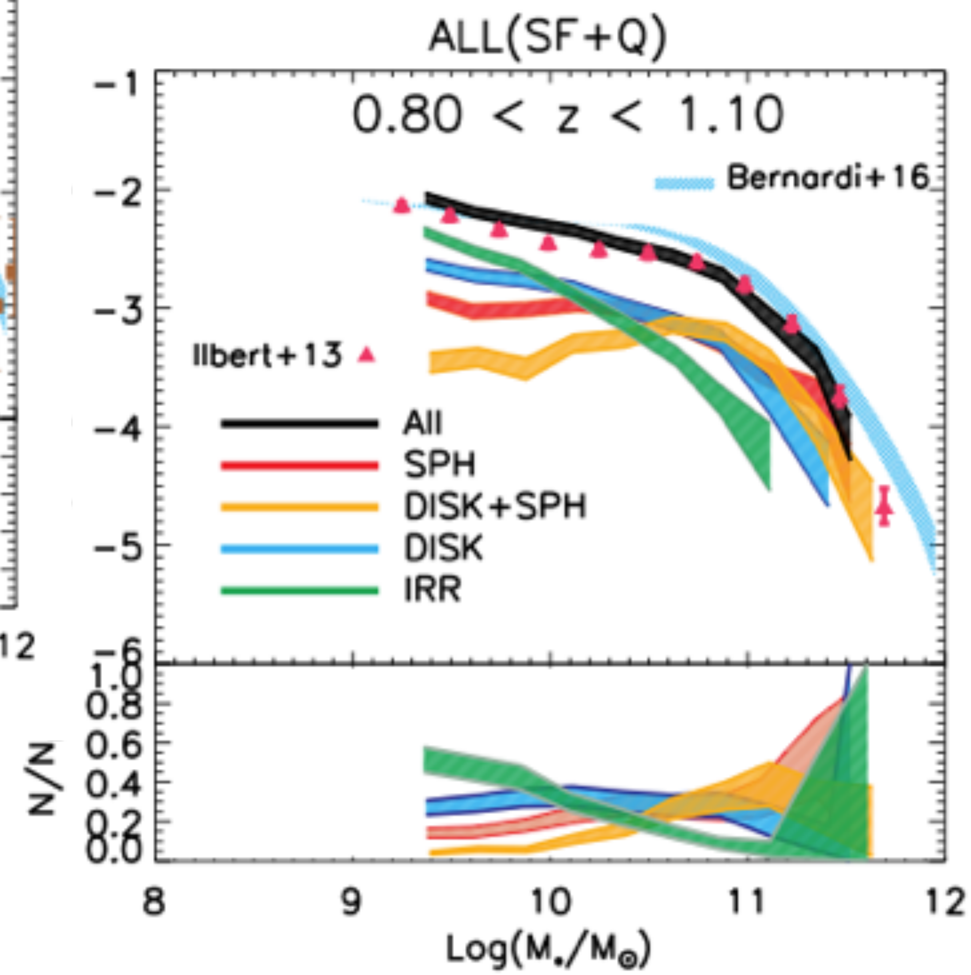


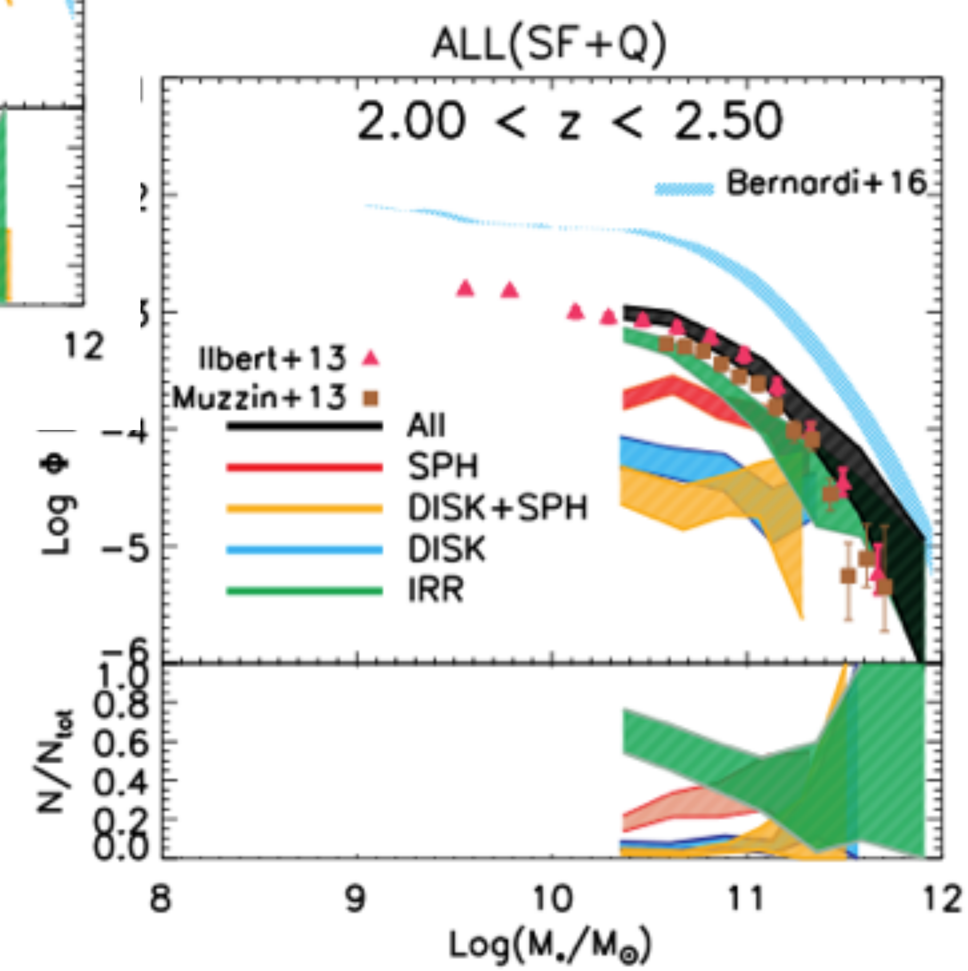
quiescent

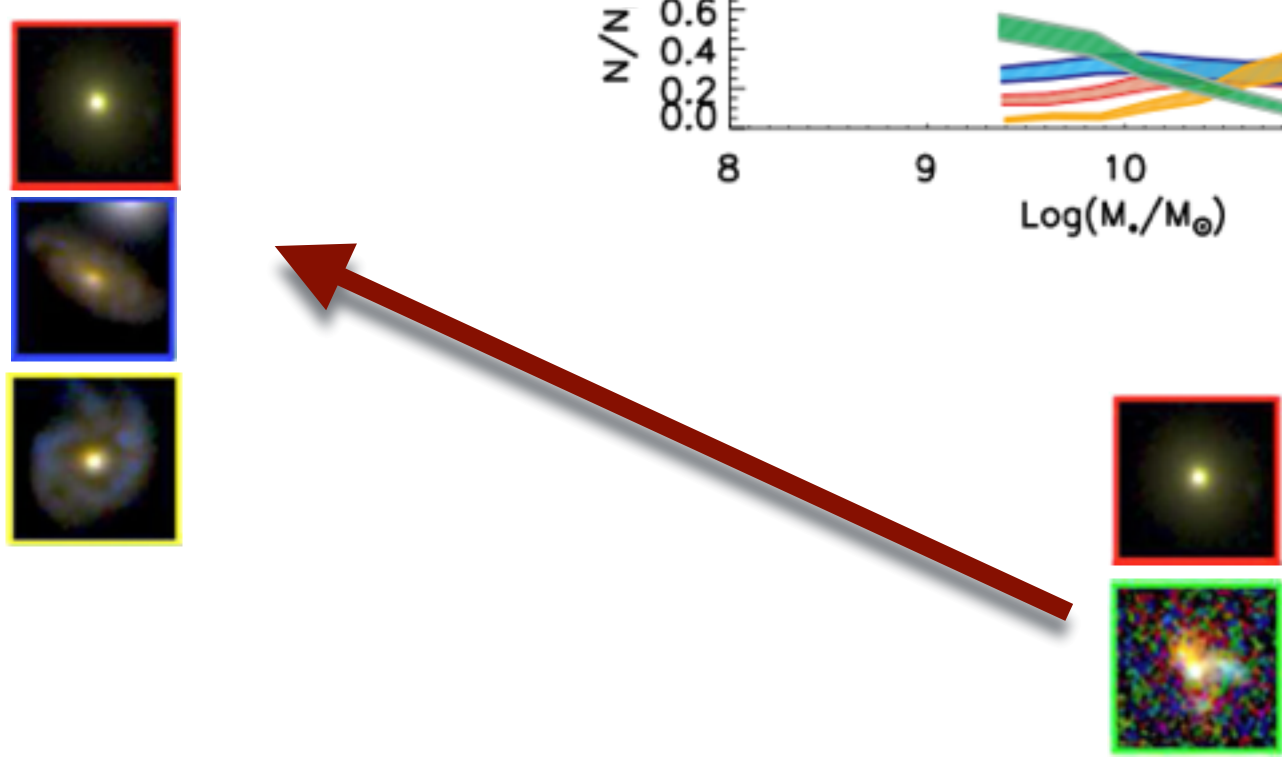
Stellar mass function for different morphologies

Huertas-Company et al. 2016

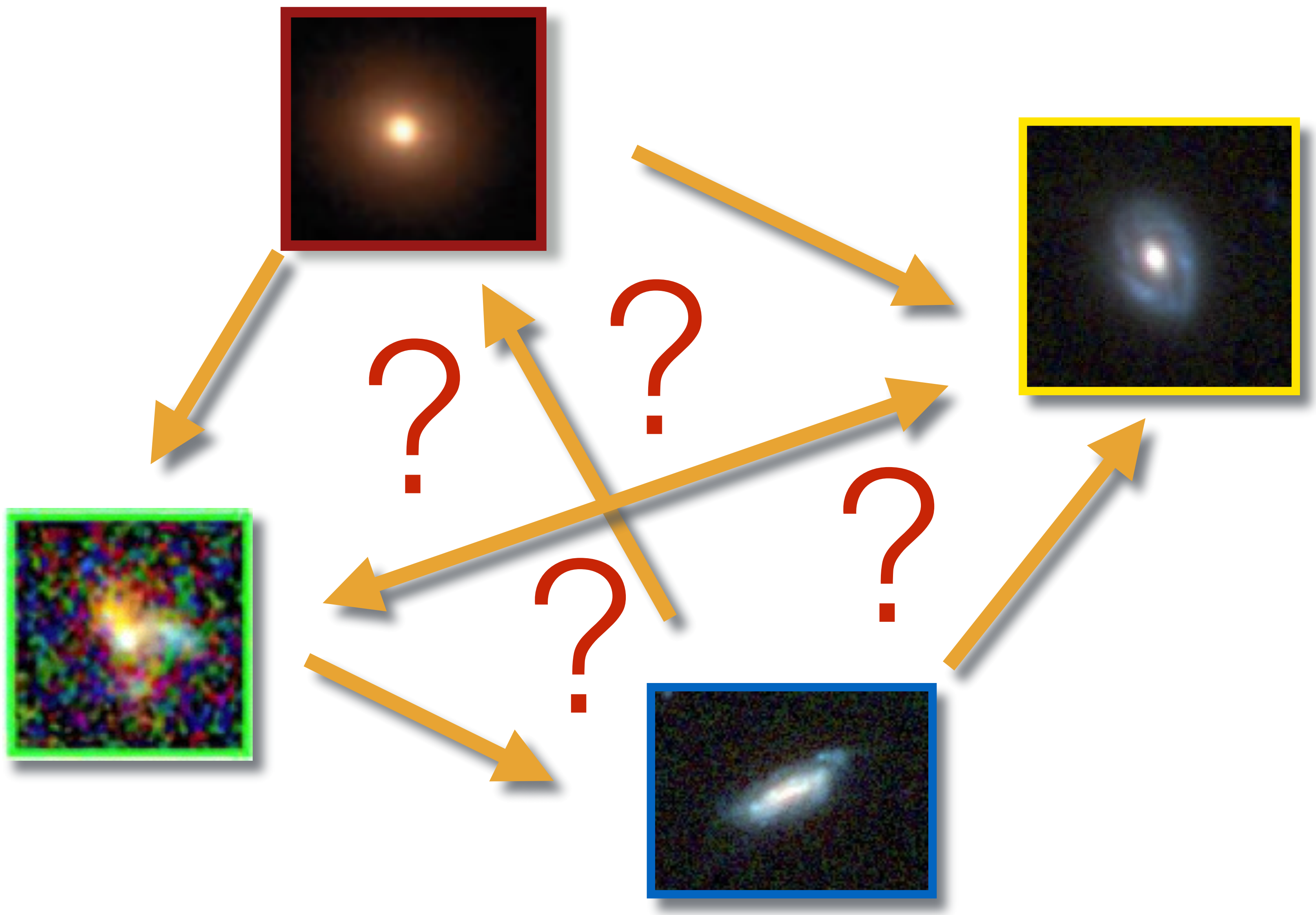








How galaxies evolve?



compaction

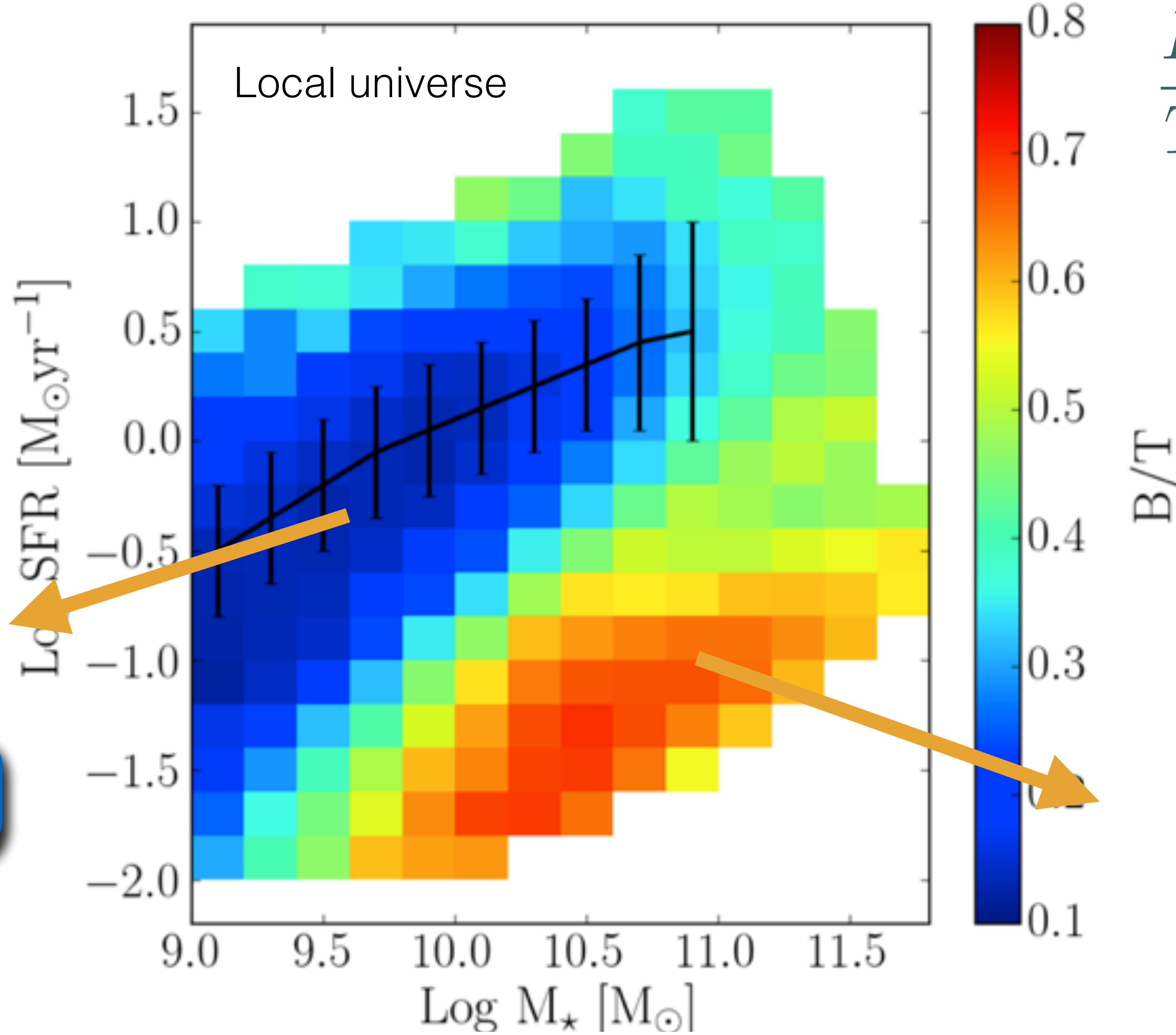
mergers

rejuvenation

disk instability

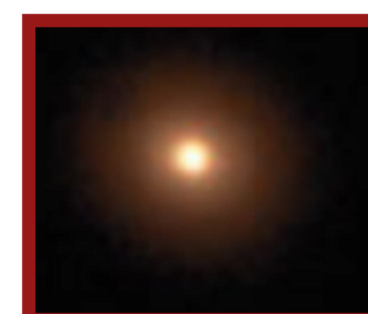
Galaxy properties

Star forming



$$\frac{B}{T}$$ = Bulge / Total

Quiescent



(Morselli et al. 2016)

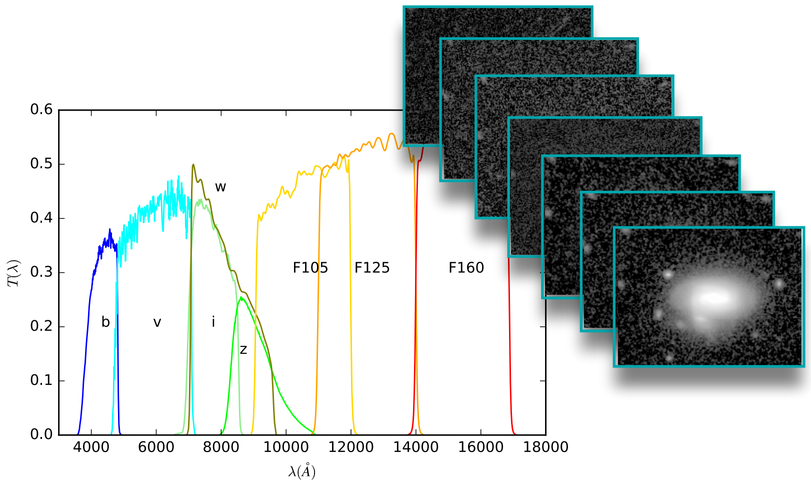
Quenching ⟷ Morphology

(Wuyts 2011, Whitaker 2015, Barro 2015, 2016, Huertas-Company 2016, **Dimauro 2018, 2019**)

Bulge growth

Bulge-disk decomposition

1) Modeling the surface brightness profile

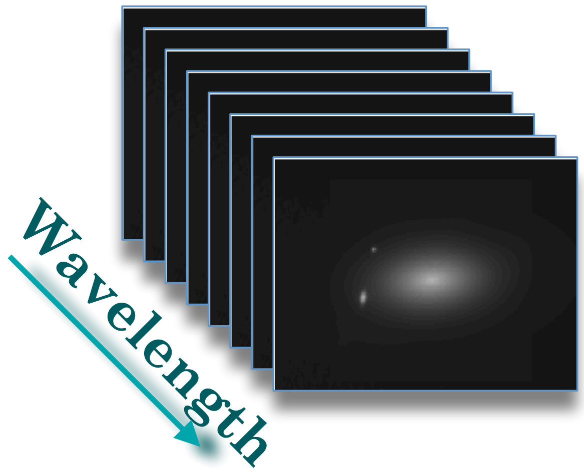


7/4 GOODS/CANDELS
bands (400 - 1500 nm)

GalfitM

(Häussler et al. 2013)

$Mag(\lambda)$
$n(\lambda)$
$Re(\lambda)$
$q(\lambda)$

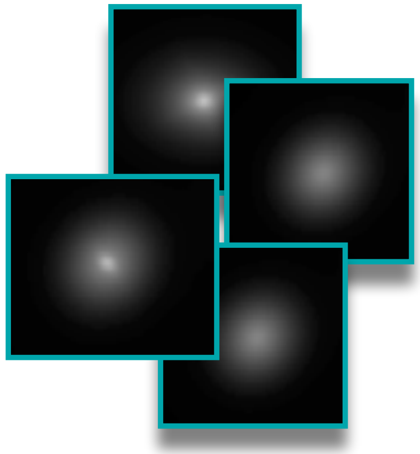


Sersic profile

+

exp.disk

2) Best model selection



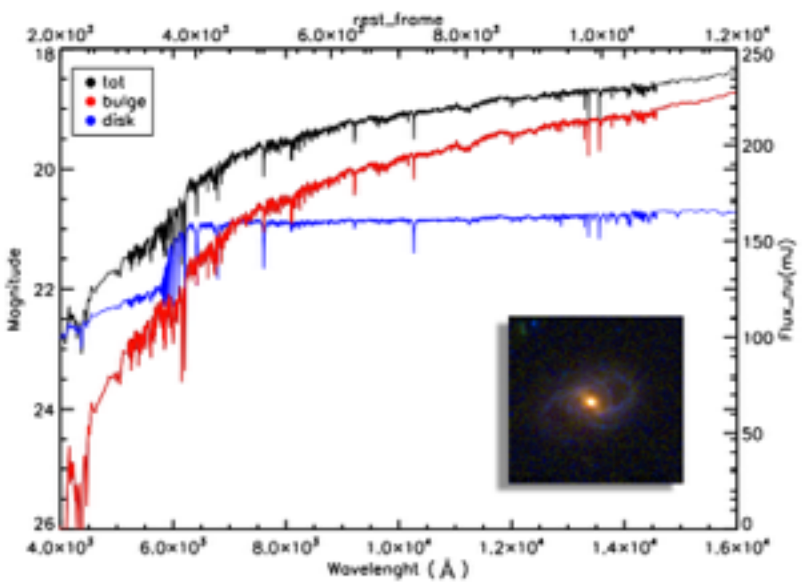
CNN

1 comp

2 comp

(Dimauro 2018, Tucillo 2018)

3) Spectral Energy Distribution



- Stellar masses
- rest-frame colors

Questions

Can we put constraints on bulge formation mechanisms?

Does the quenching imply a morphological transformation?

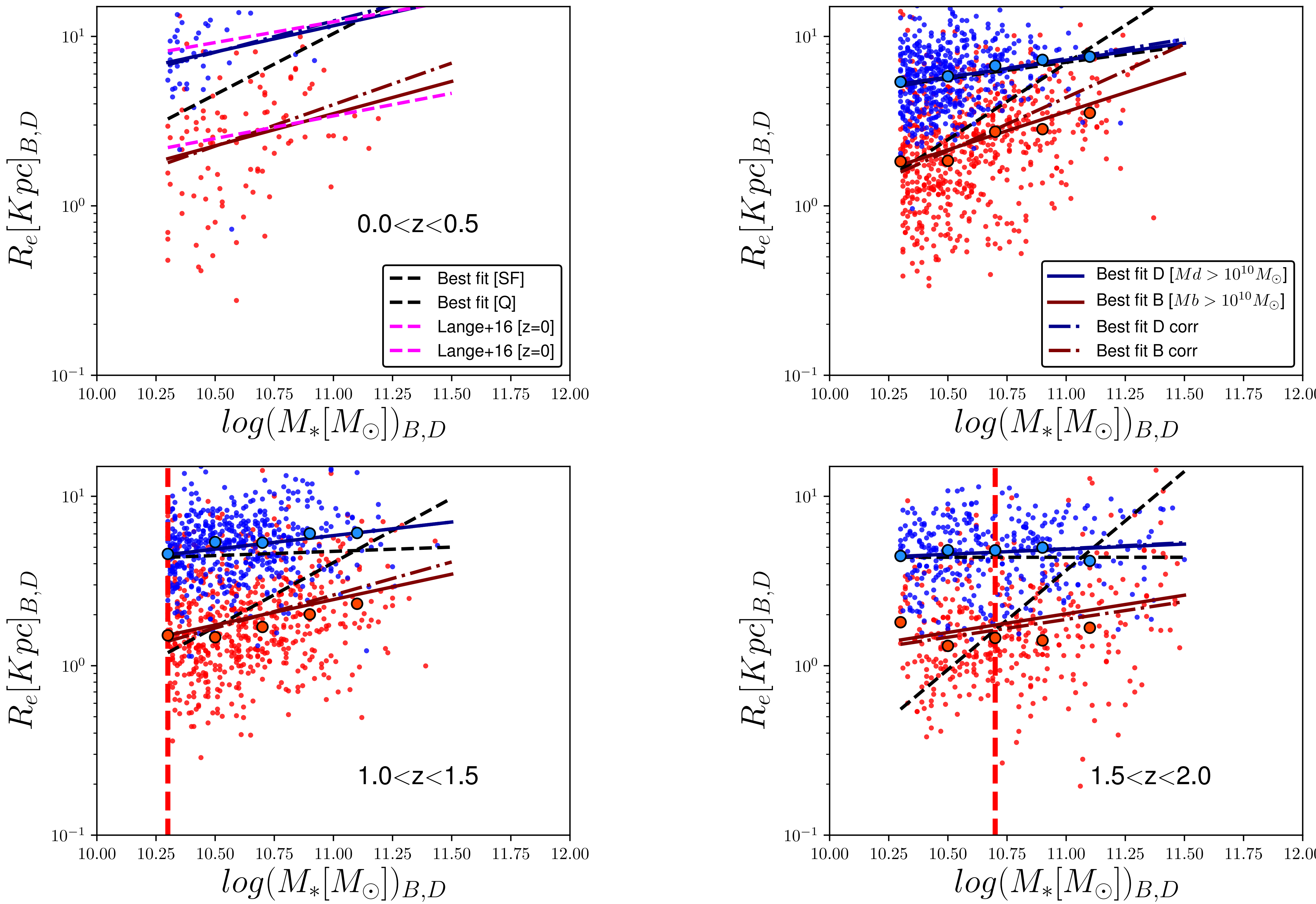
Questions

Can we put constraints on bulge formation mechanisms?

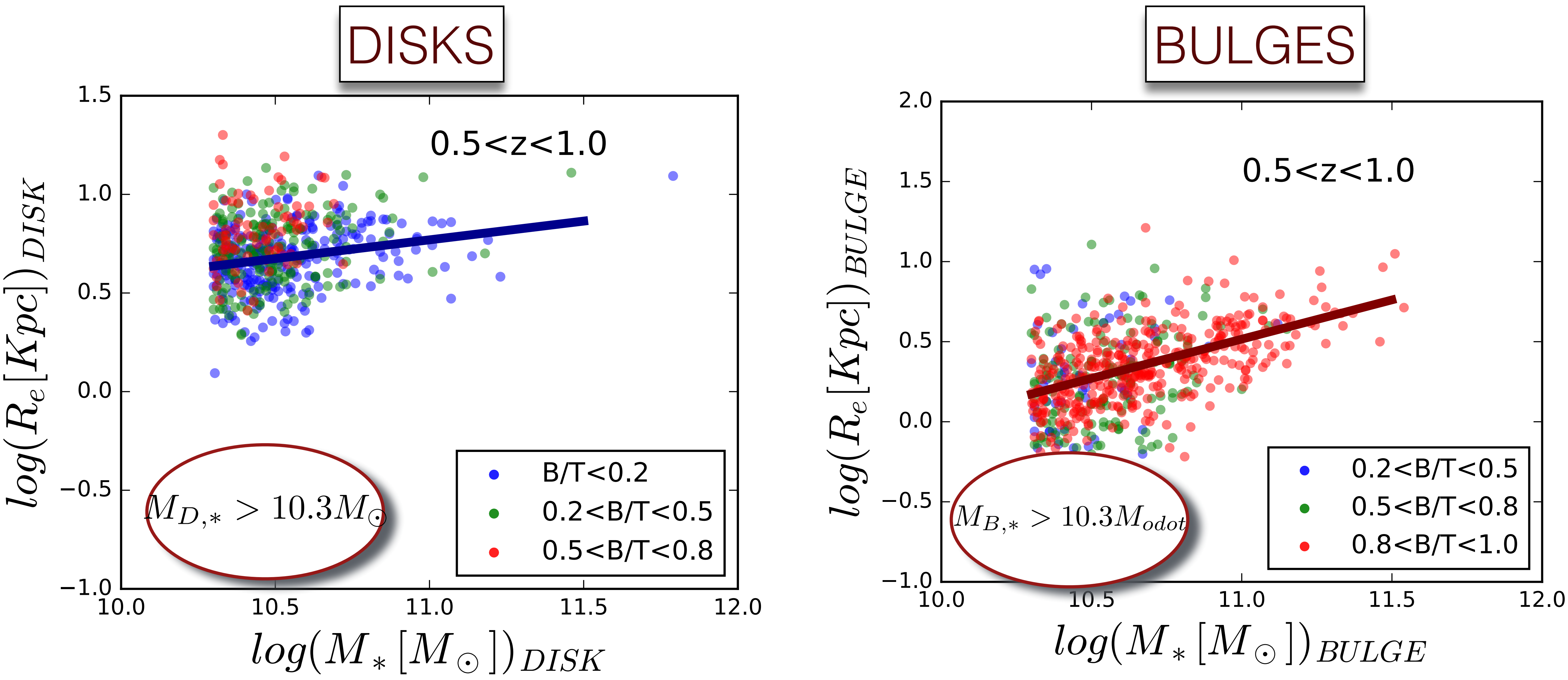
Does the quenching imply a morphological transformation?

Mass-size bulge and disc

Dimauro et al. 2019

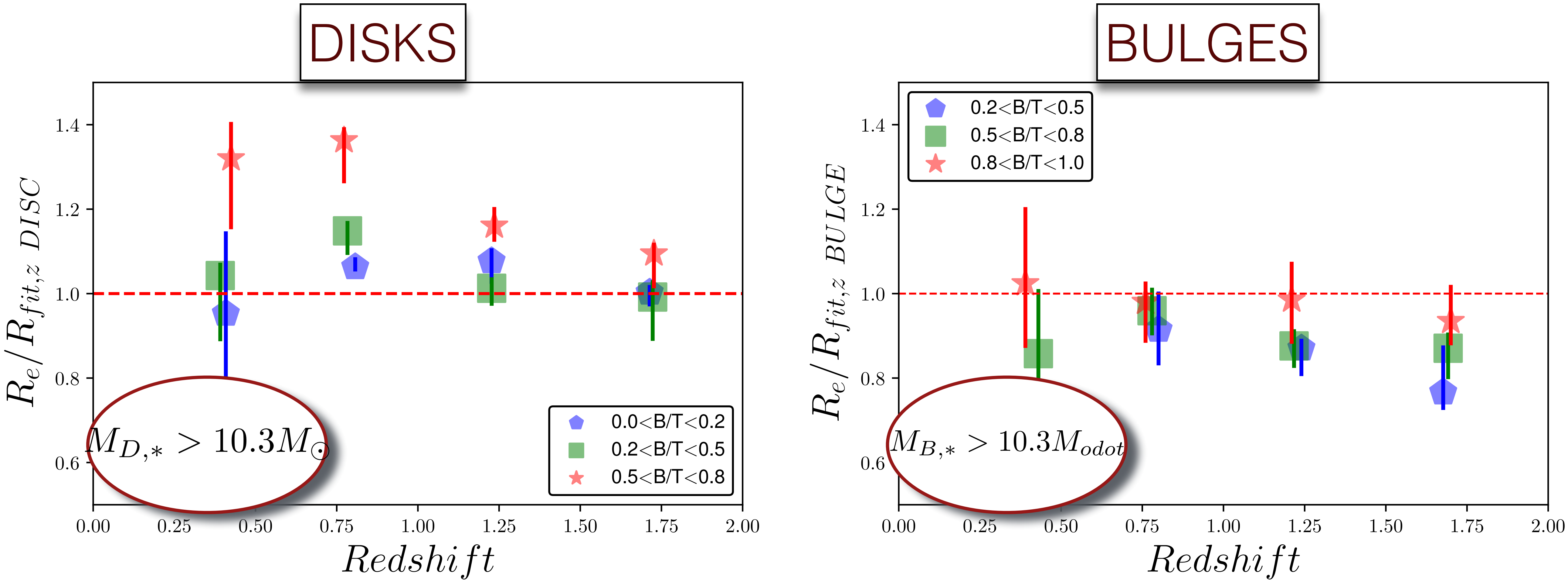


Bulges and Disks in different morphologies



Dimauro et al. 2019

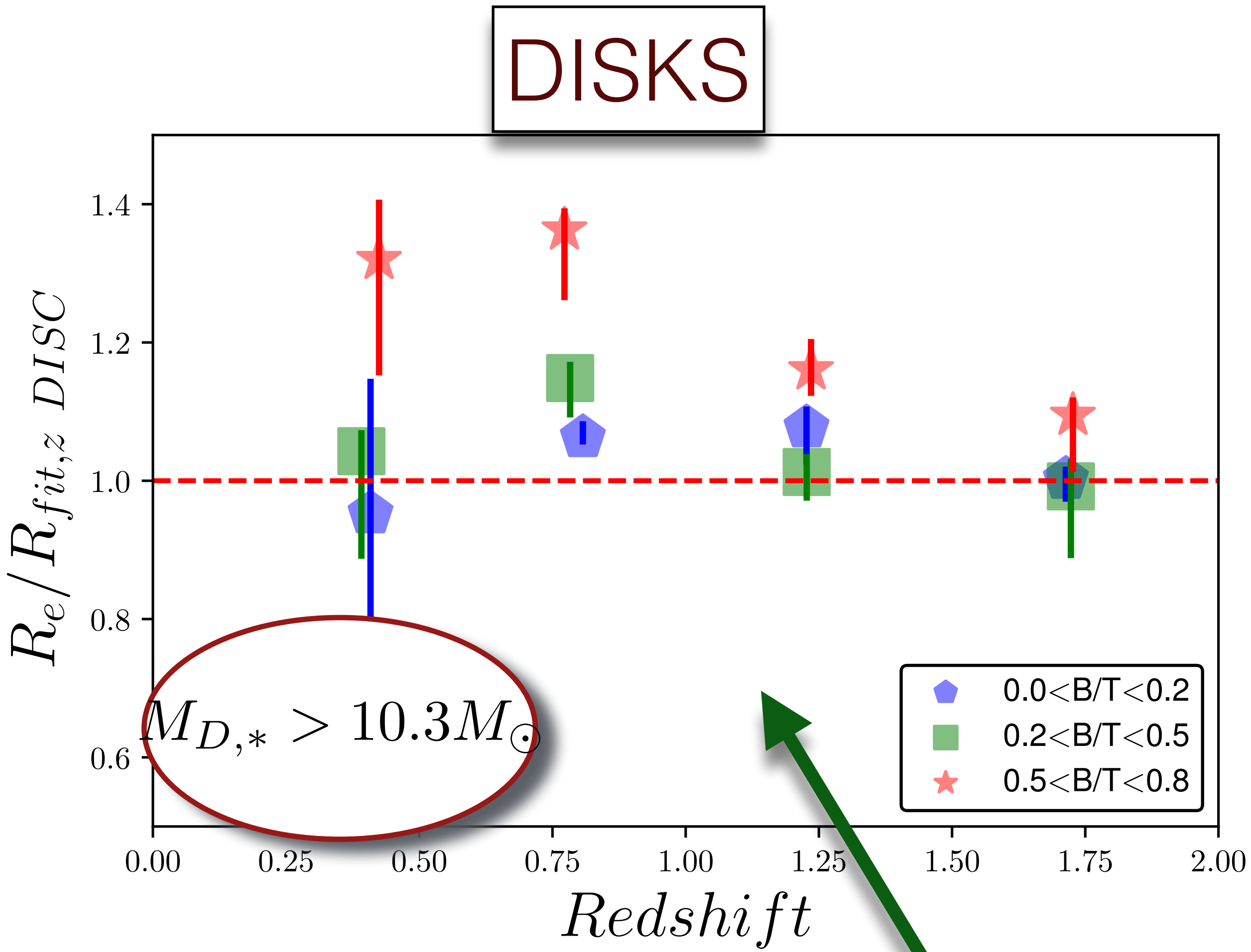
Bulges and Disks in different morphologies

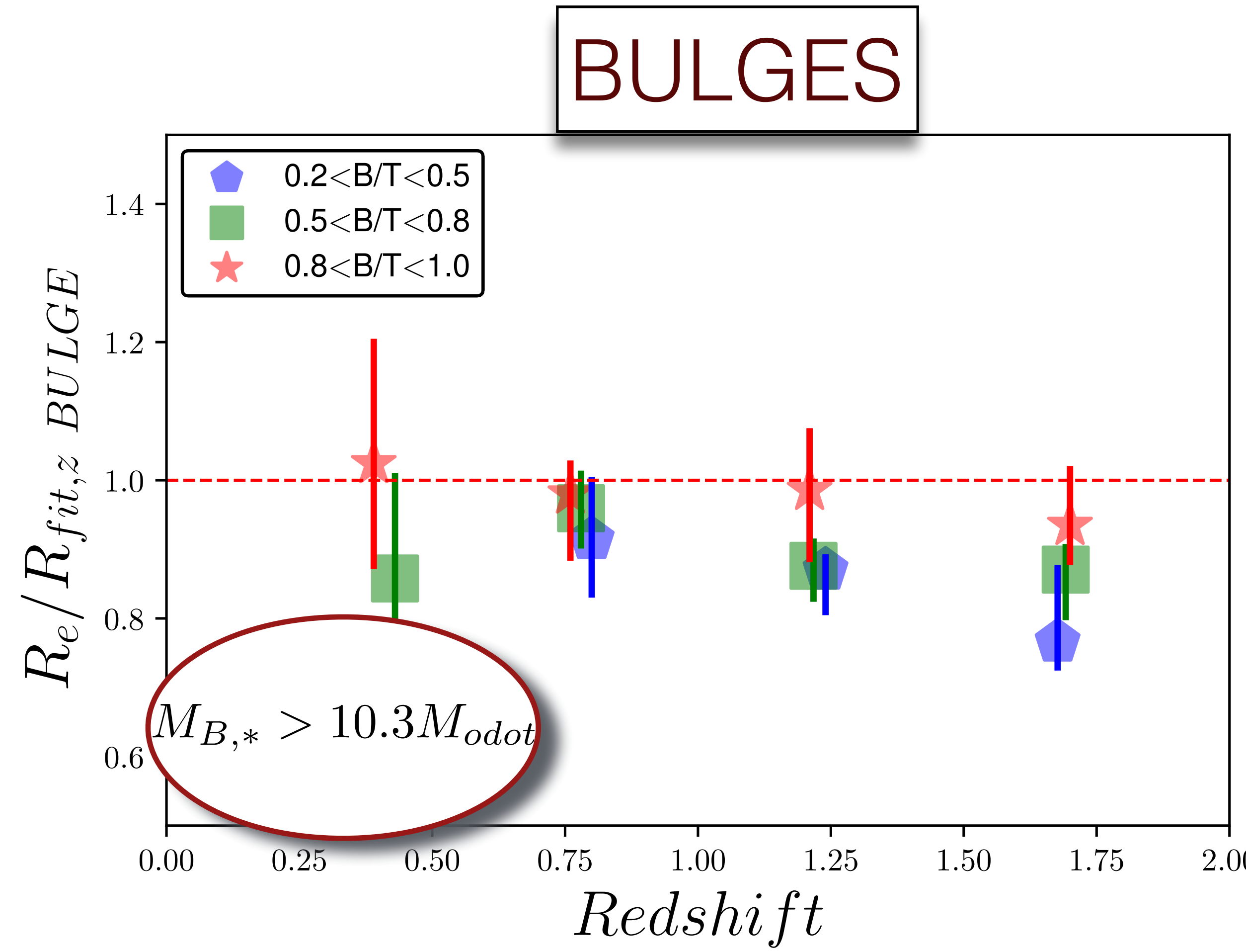


Observed sizes are divided by the expected values from the best fit

Dimauro et al. 2019

Bulges and Disks in different morphologies

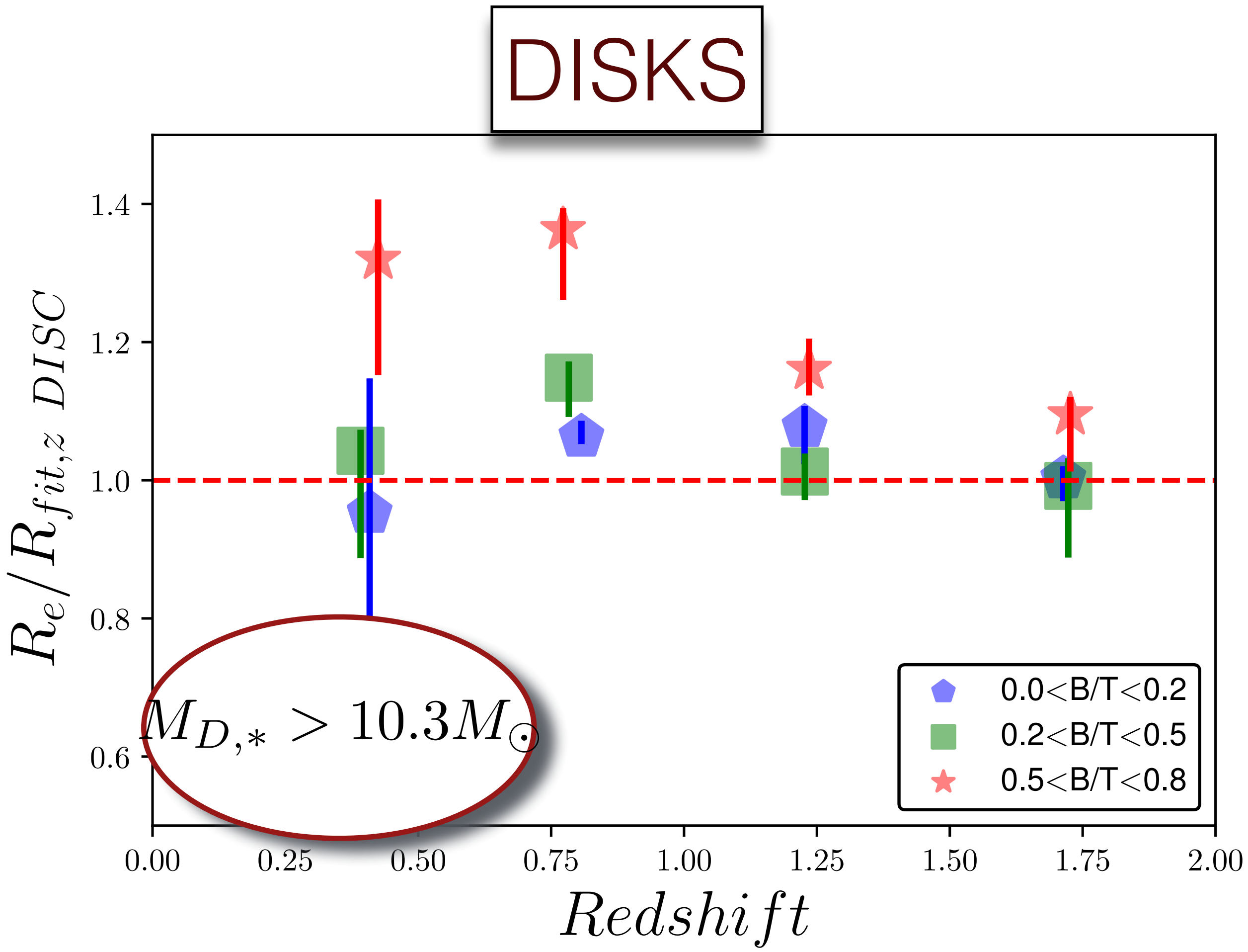


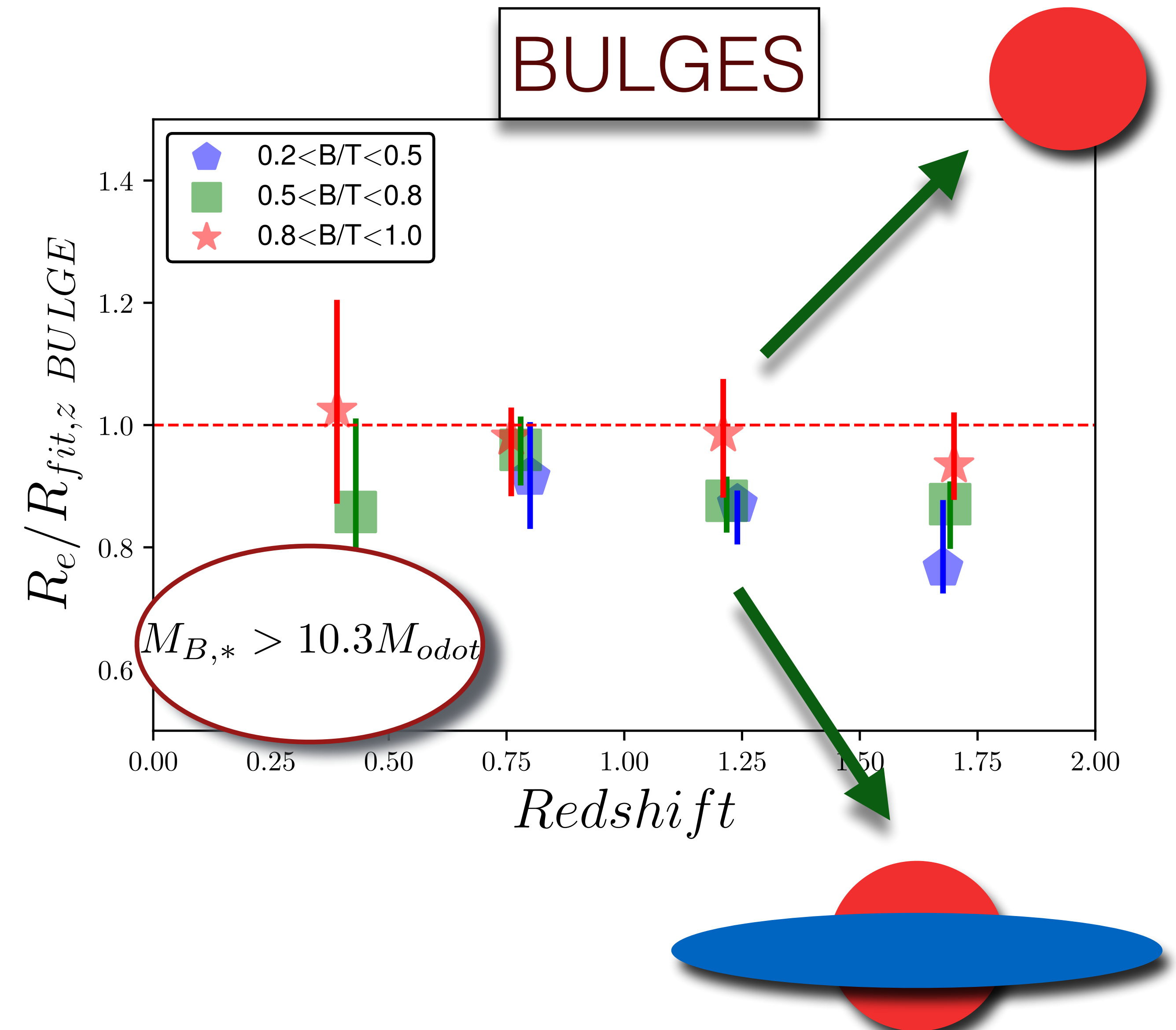


For the same disk mass higher B/T correspond to higher stellar mass, consequently higher halo mass and larger virial radii

Dimauro et al. 2019

Bulges and Disks in different morphologies



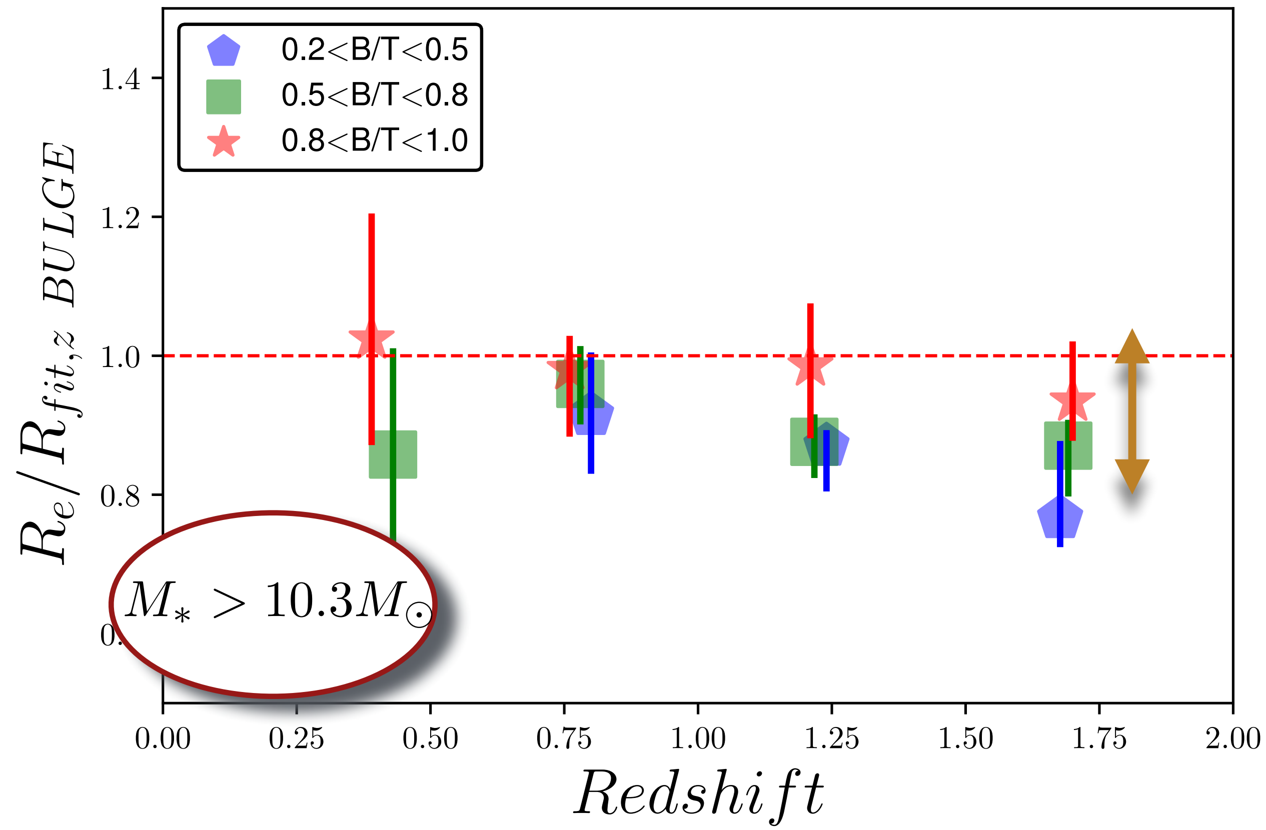


Bulges sizes in different morphologies are compatible confirmed by the K-S test

Dimauro et al. 2019

Bulges in different morphologies

BULGES

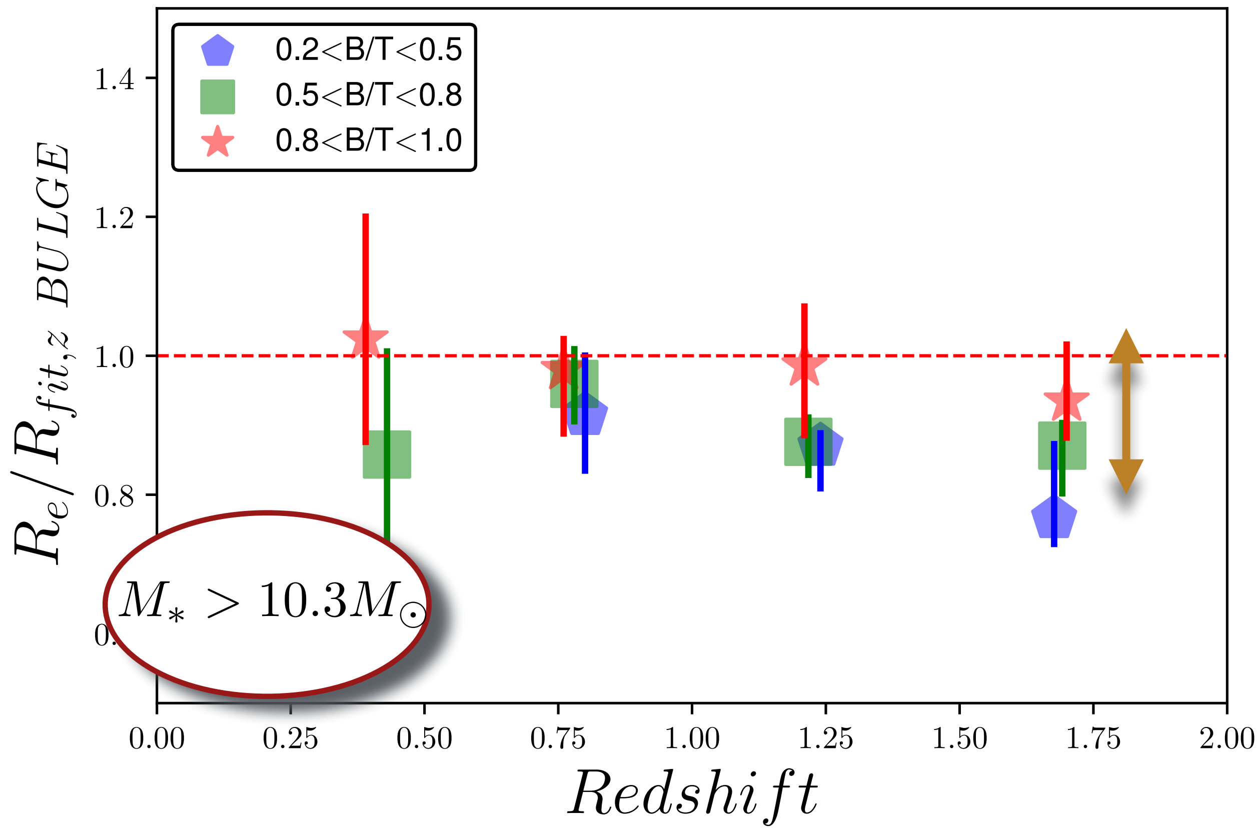


Uncertainties on the model

Dimauro et al. 2019

Bulges in different morphologies

BULGES



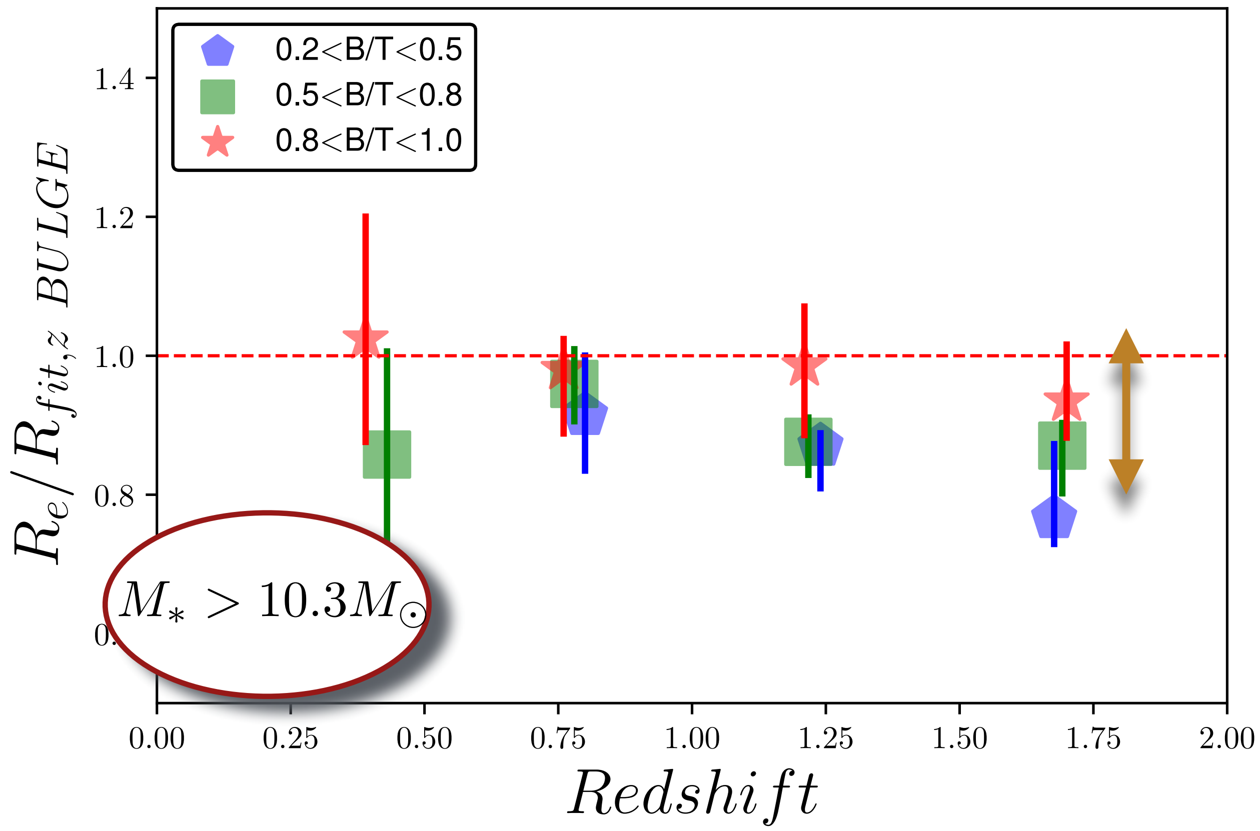
Uncertainties on the model

Dependence between size and B/T

Dimauro et al. 2019

Bulges in different morphologies

BULGES



Uncertainties on the model

Dependence between size and B/T

Pearson coefficient:

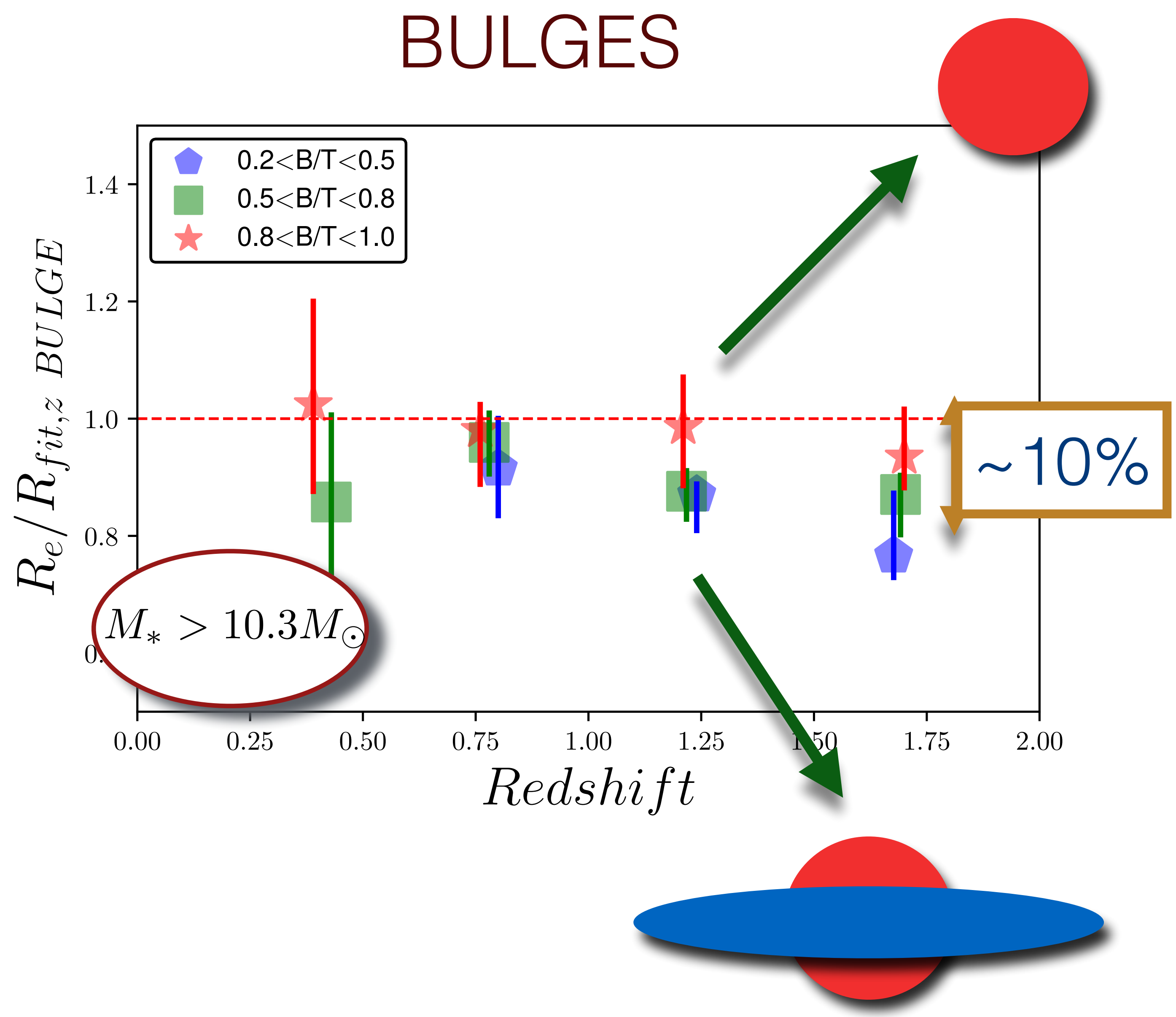
B/T - reB = 0.14

B/T - reD = 0.17

NO correlation

Dimauro et al. 2019

Bulges in different morphologies



Uncertainties on the model

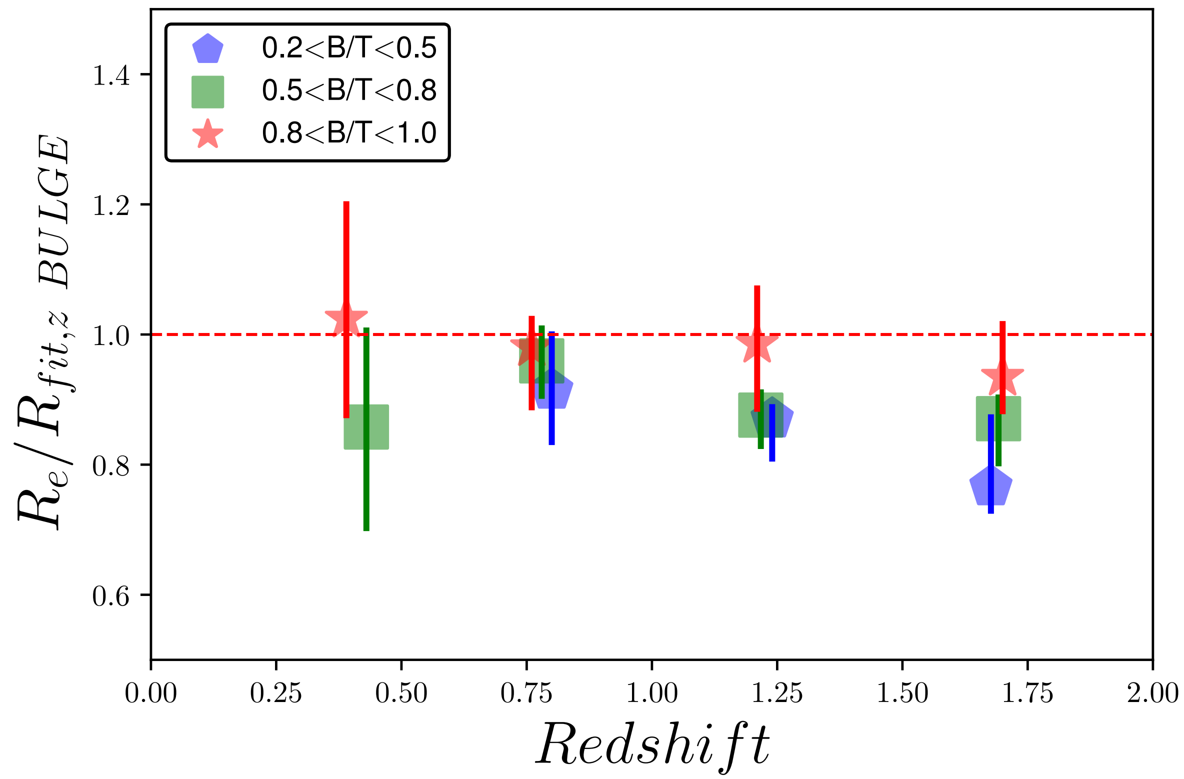
Dependence between size and B/T

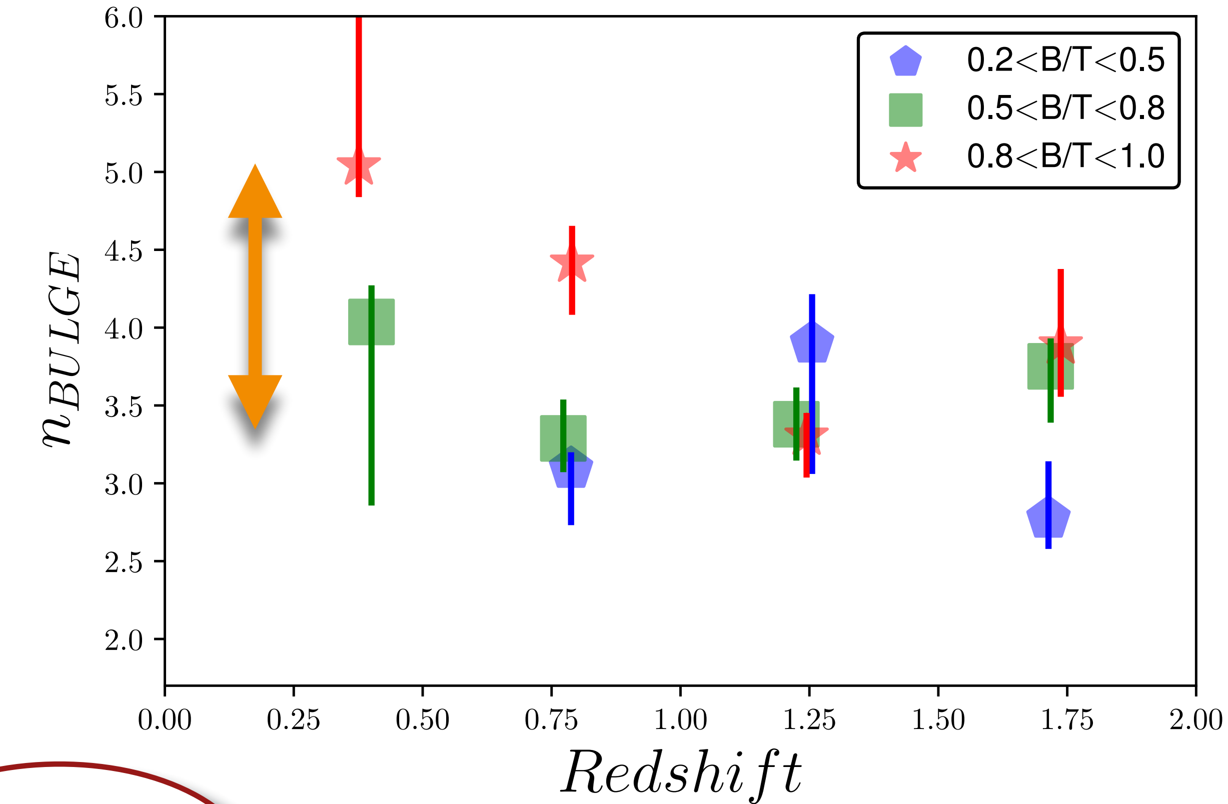
Different formation mechanisms

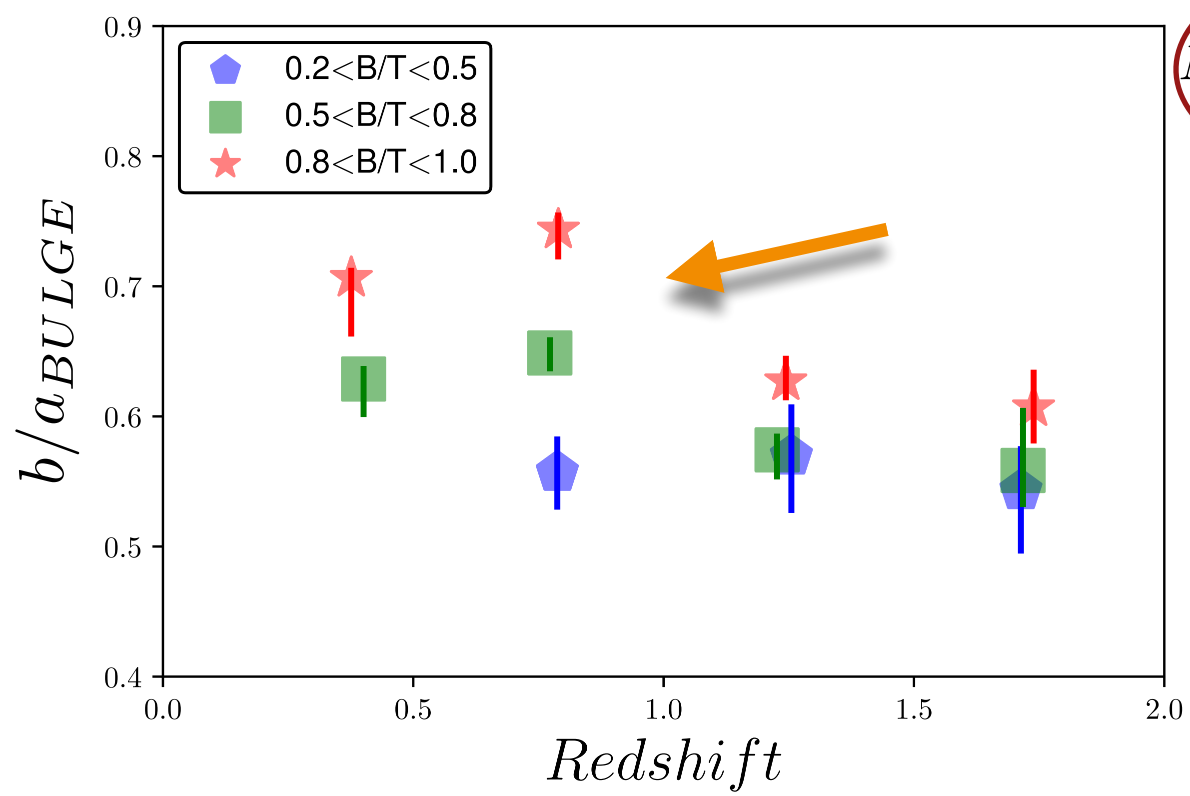
- Merger
- Disk instability
- Wet Compaction

Dimauro et al. 2019

Bulges in different morphologies







$M_{B,*} > 10.3 M_{odot}$

Different evolution

Naked bulges galaxies experience more merger events

Dimauro et al. 2019

Questions

Can we put constraints on bulge formation mechanisms?

Bulges show weak dependence with the morphology of the host galaxies

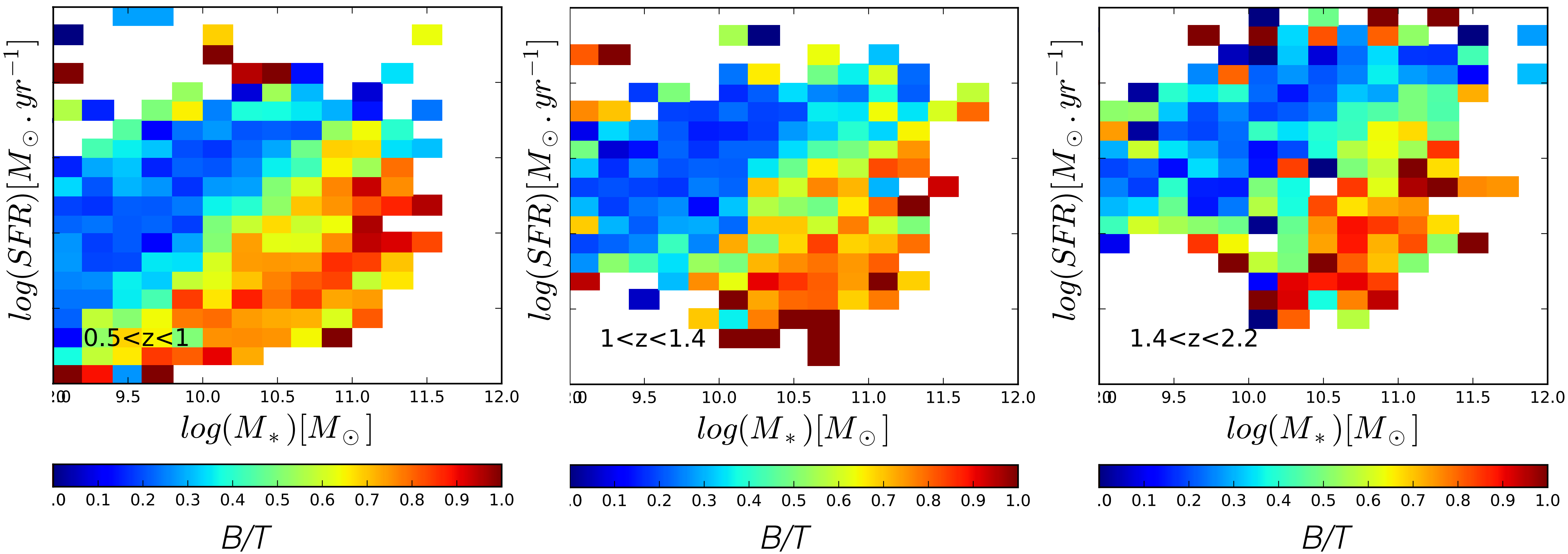
Hint of possible different assembly history

Questions

Can we put constraints on bulge formation mechanisms?

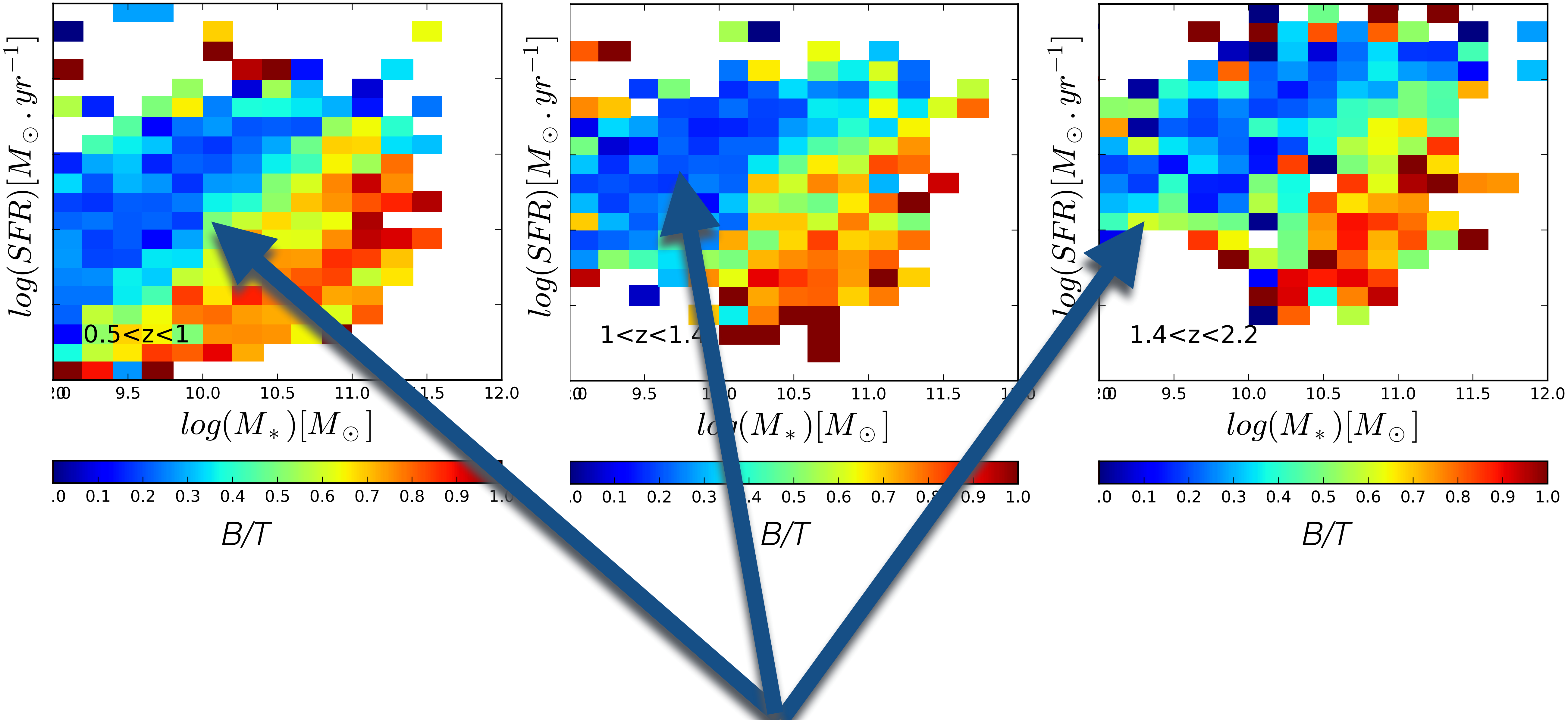
Does the quenching imply a morphological transformation?

Galaxy - Main SF sequence



Dimauro et al. 2019b in prep

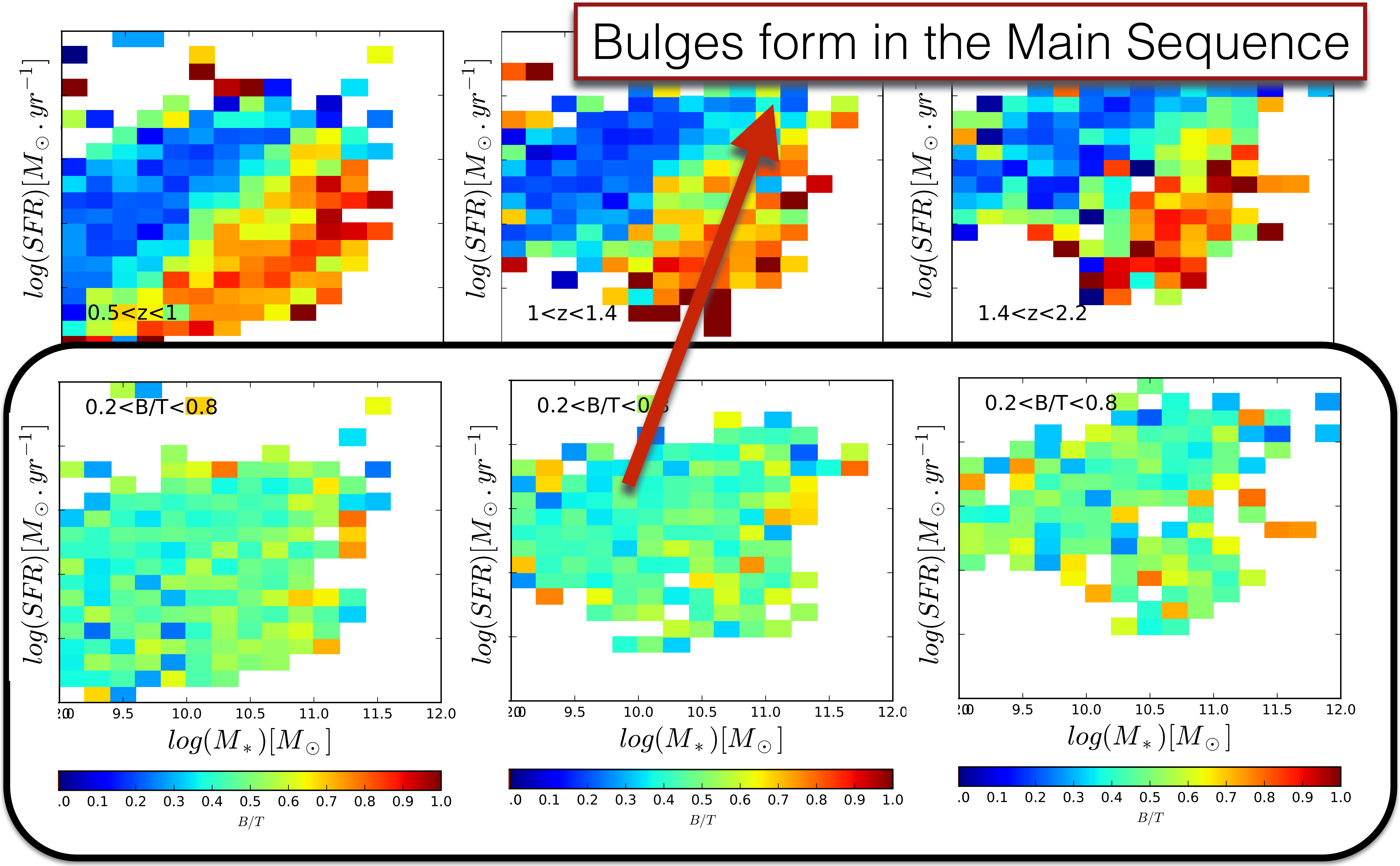
Galaxy - Main SF sequence



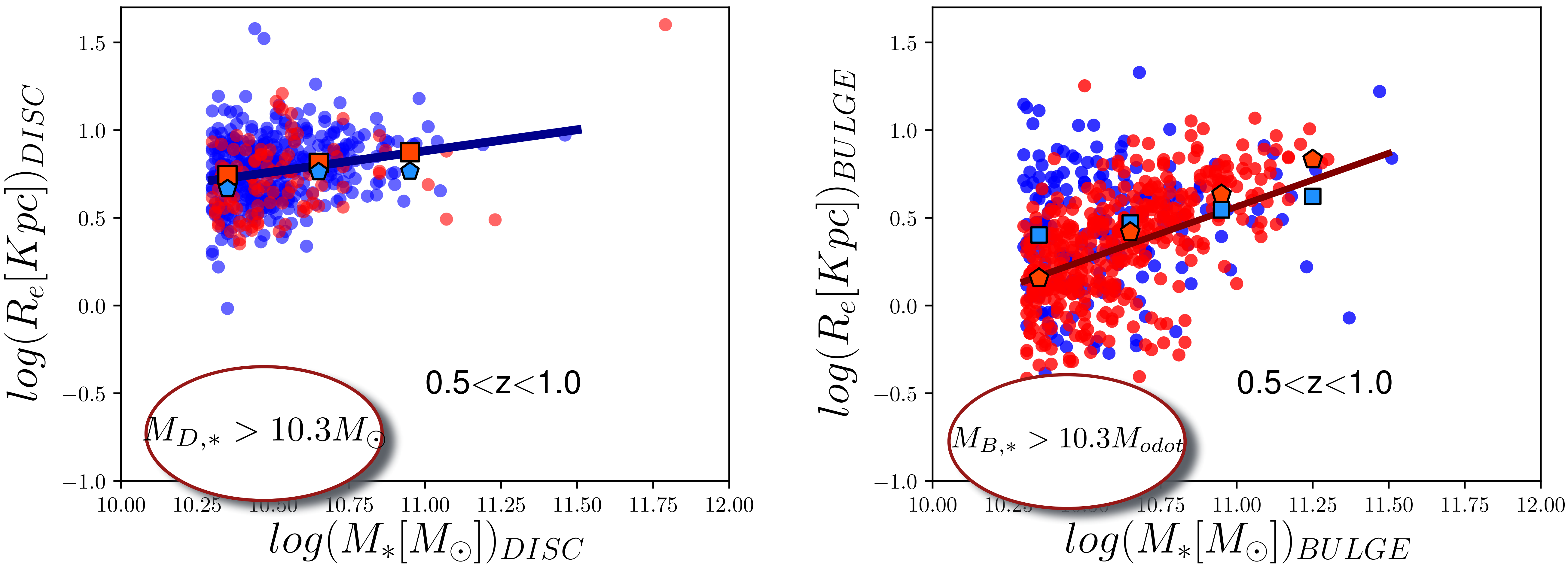
Star forming galaxies are disk dominated

Dimauro et al. 2019b in prep

Galaxy - Main SF sequence

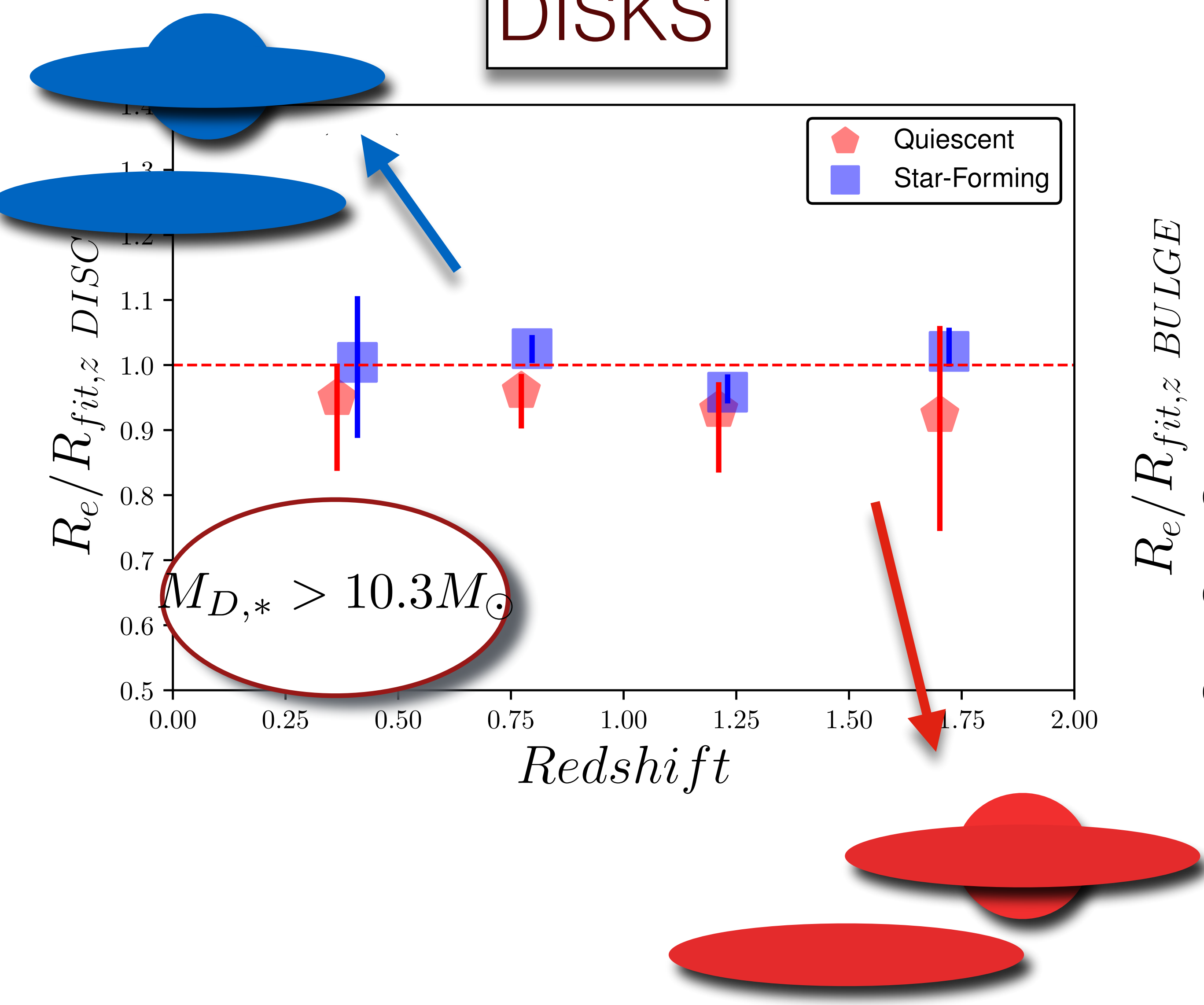


Bulges and Disks in SF or Q host galaxies

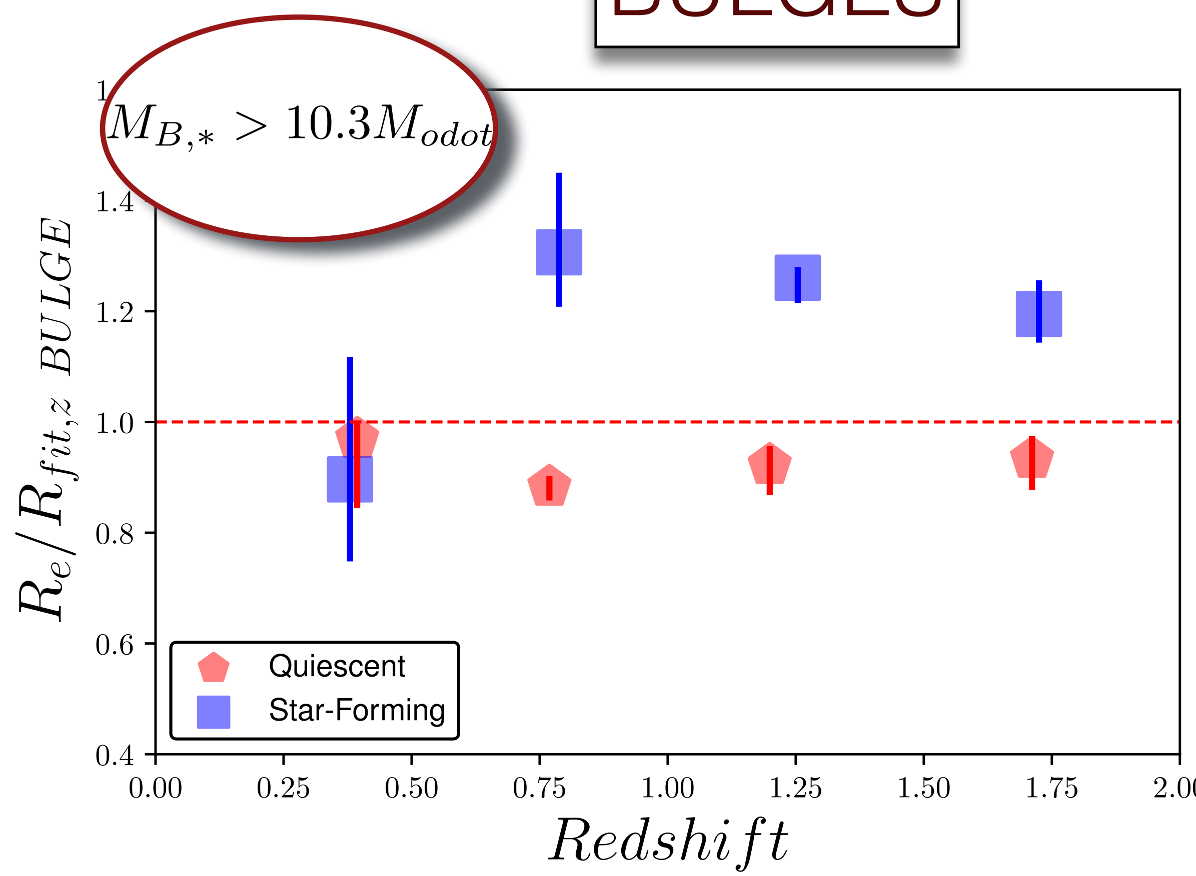


Bulges and Disks in SF or Q host galaxies

DISKS

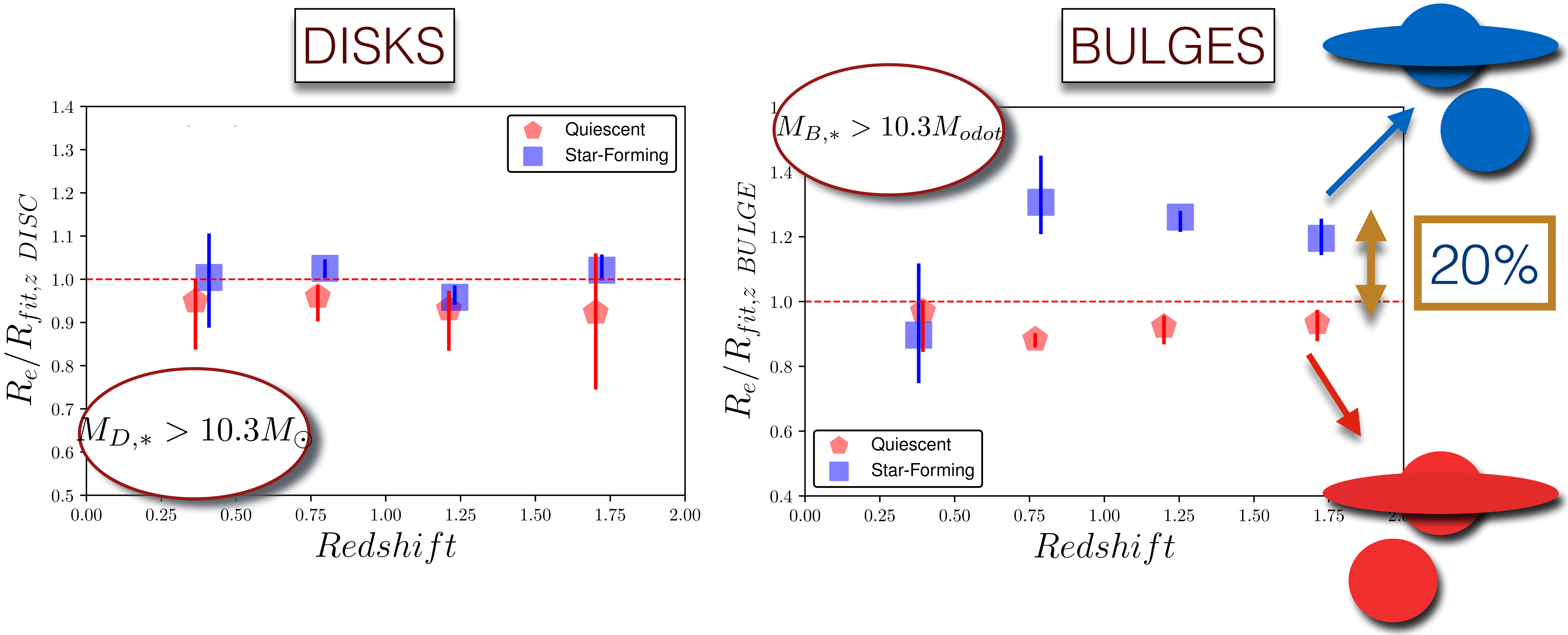


BULGES



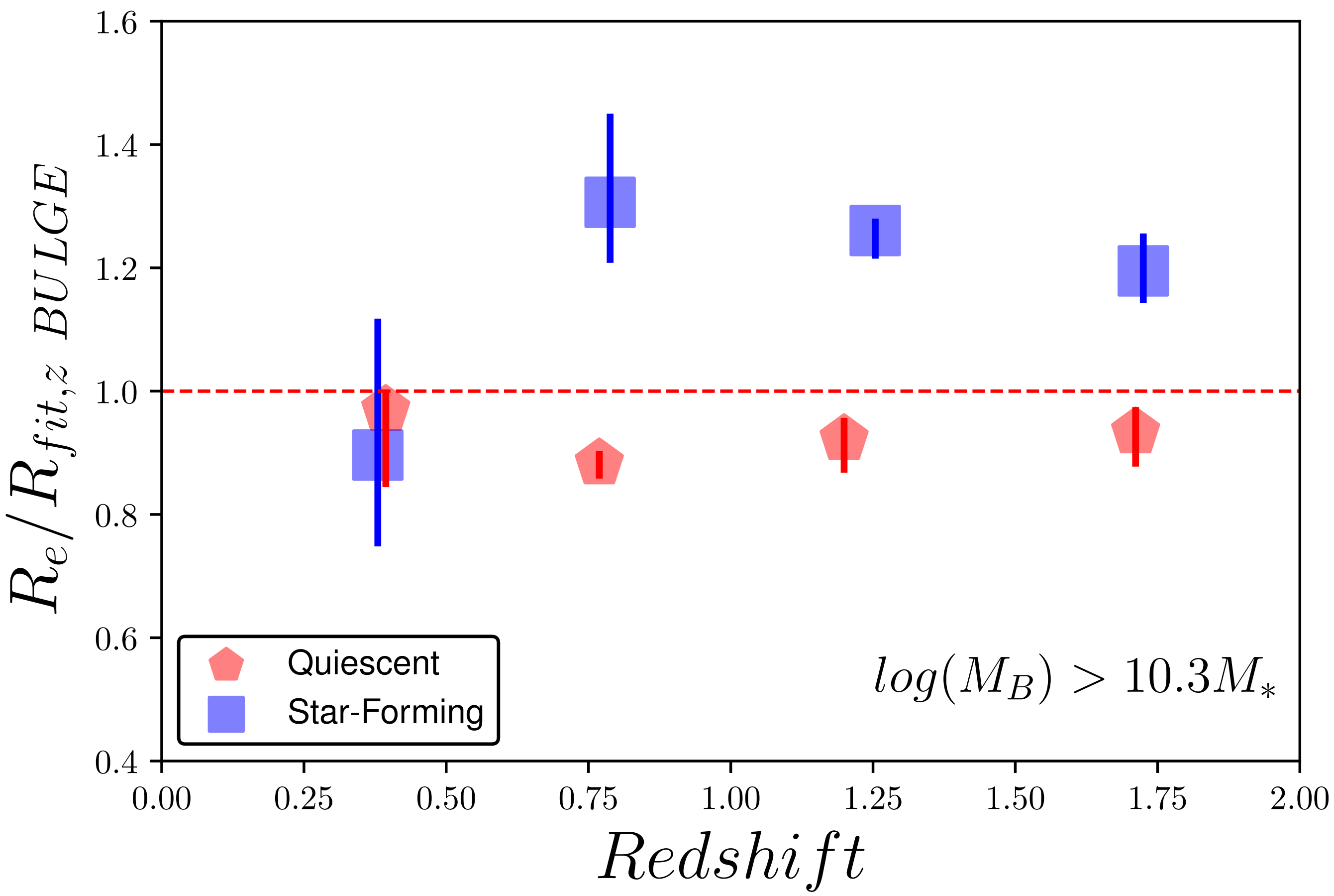
Dimauro et al. 2019

Bulges and Disks in SF or Q host galaxies



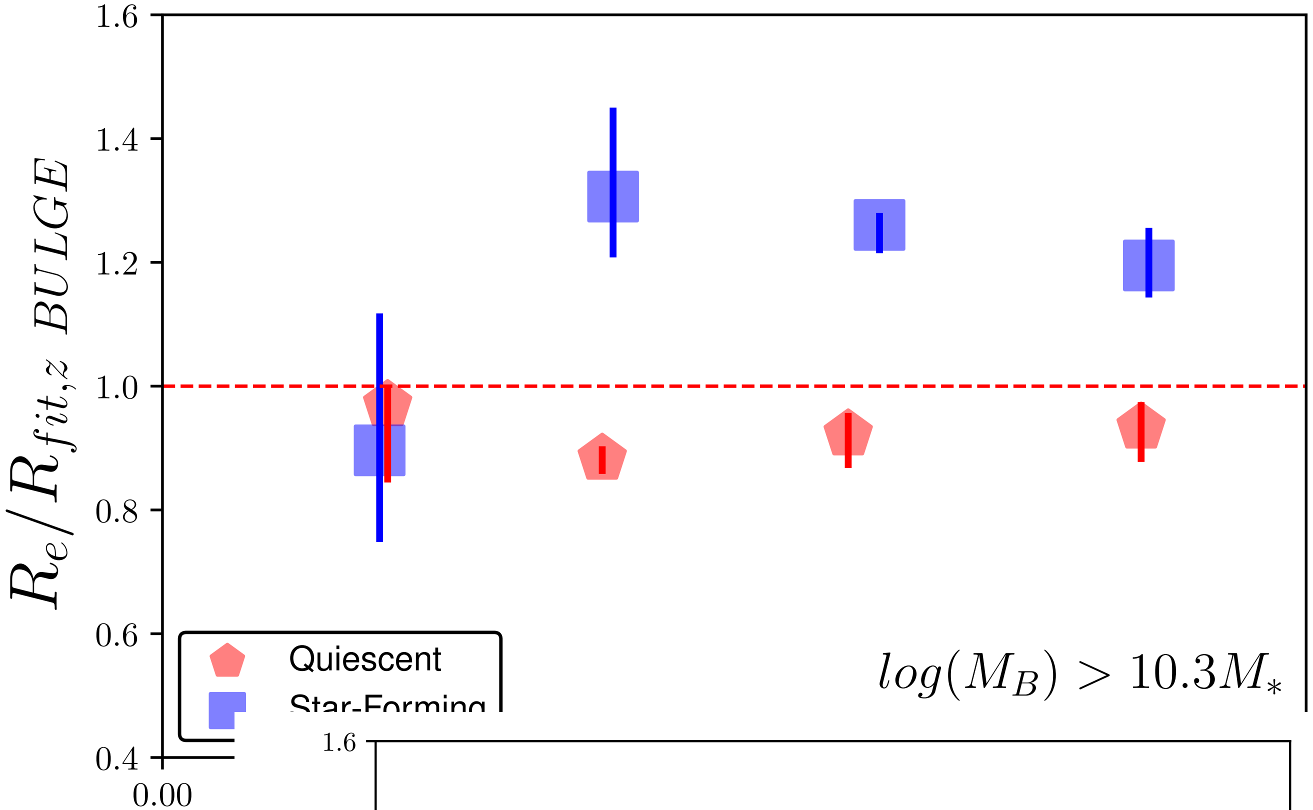
Dimauro et al. 2019

Bulges in SF or Q host galaxies



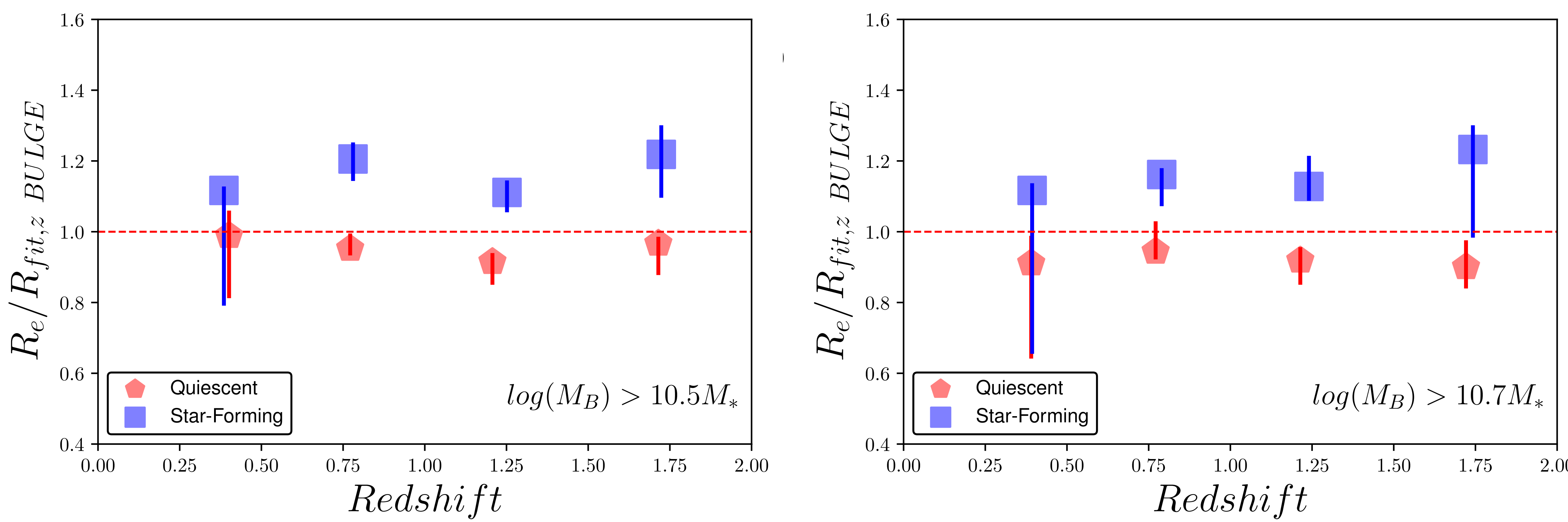
Systematics from the fit?

Bulges in SF or Q host galaxies

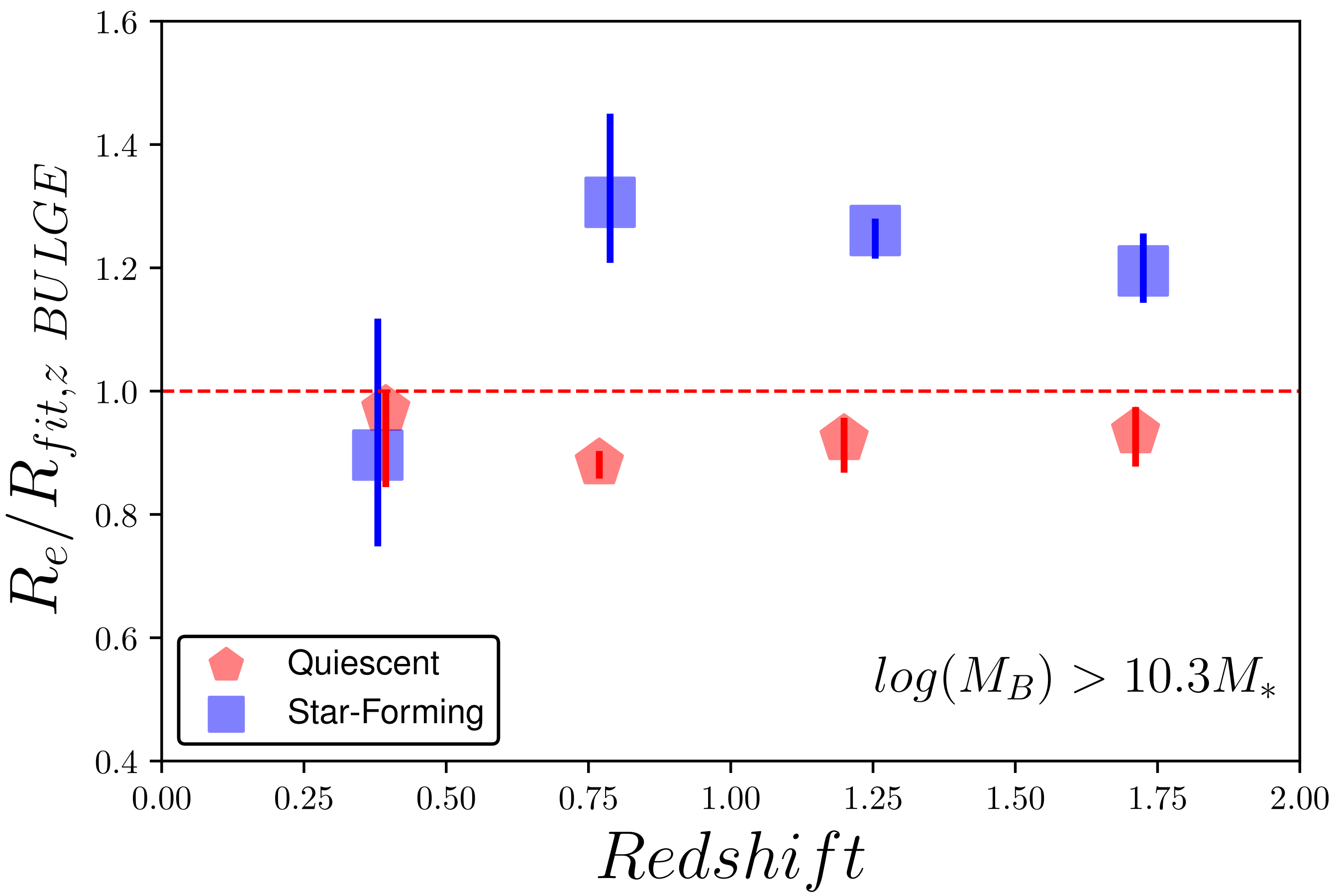


Systematics from the fit?

Mass distribution?



Bulges in SF or Q host galaxies

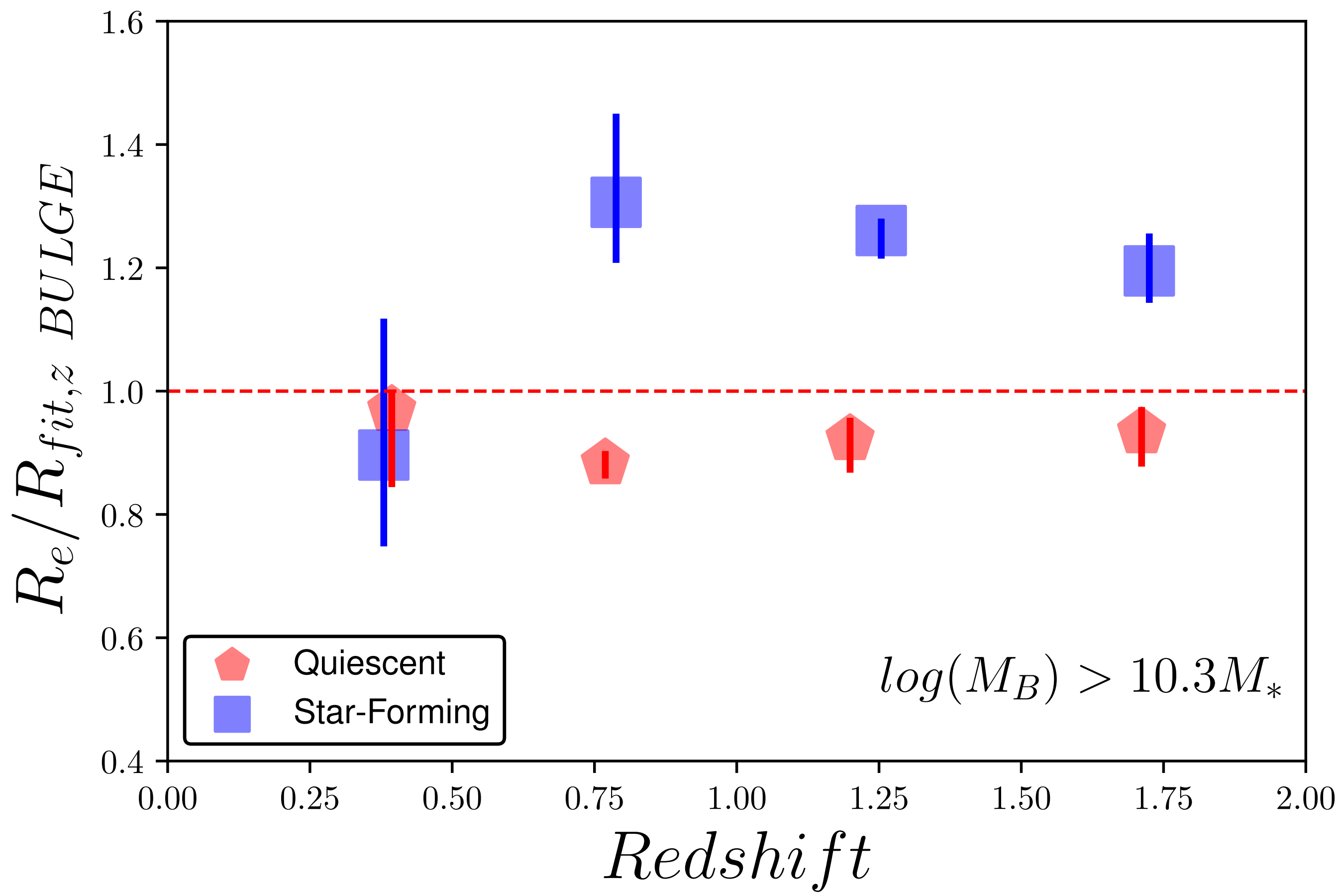


Systematics from the fit?

Mass distribution?

Additional accretion of mass to the central region

Bulges in SF or Q host galaxies

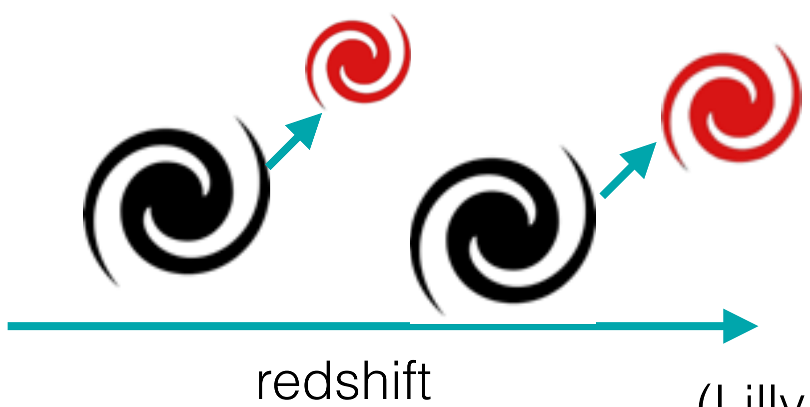


Systematics from the fit?

Mass distribution?

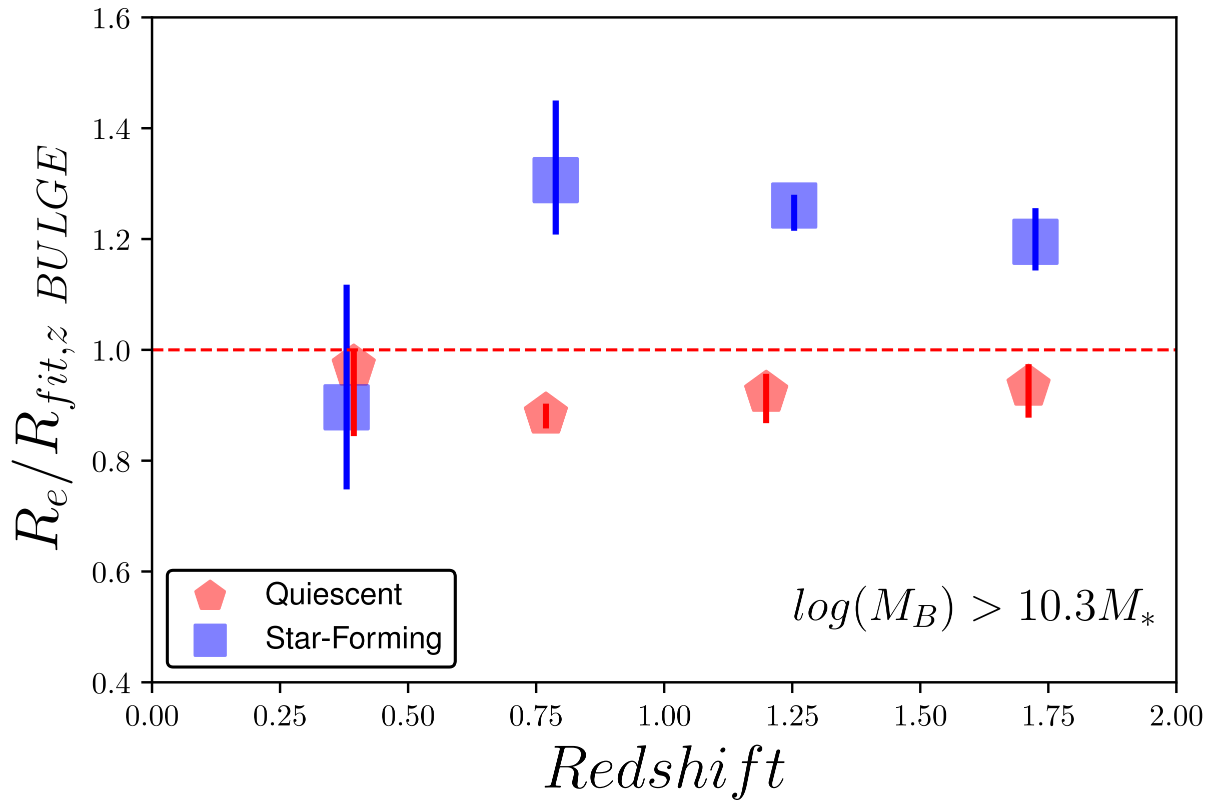
Additional accretion of mass to the central region

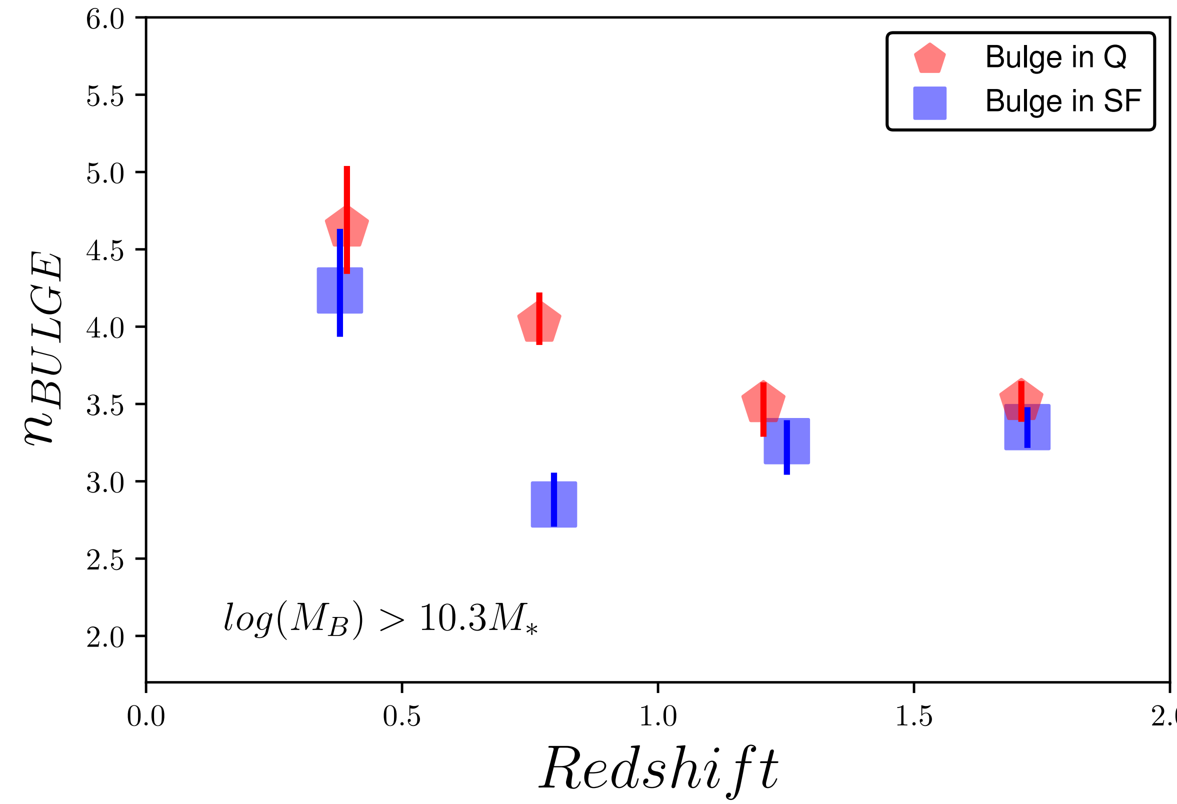
Progenitor bias?

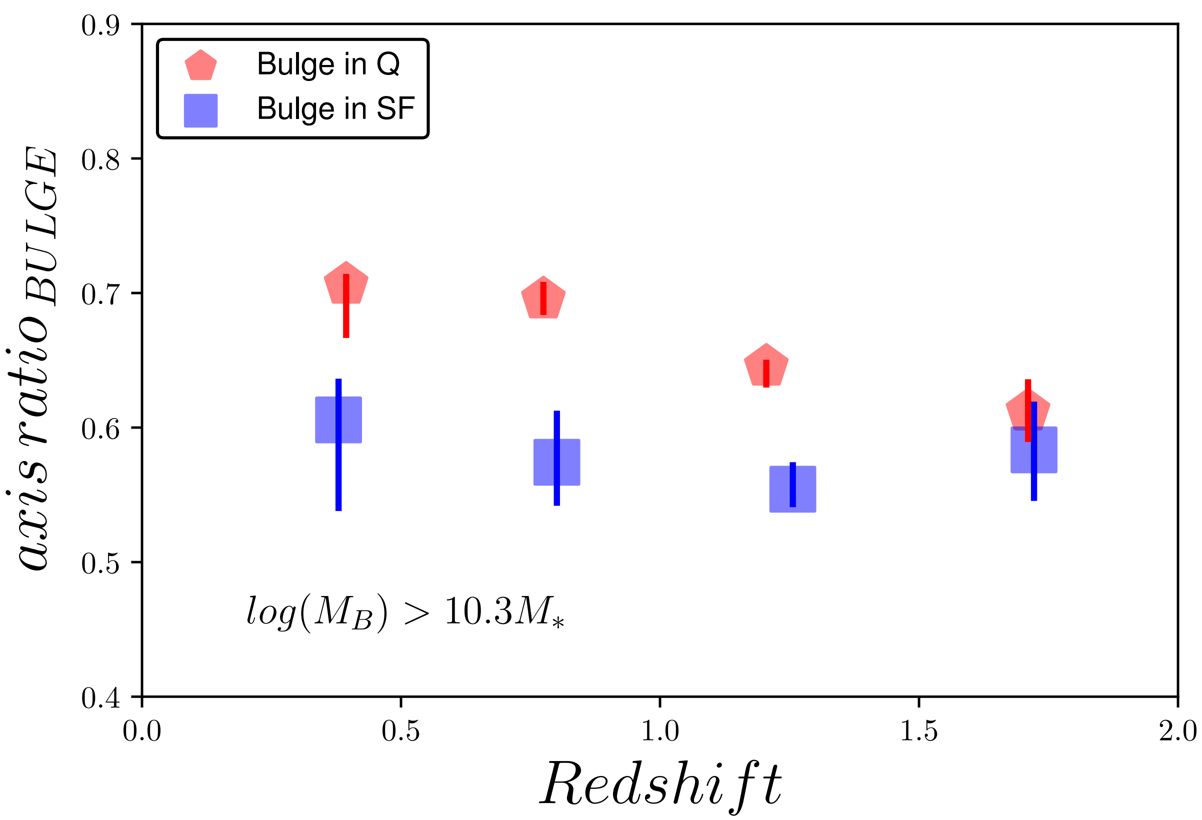


(Lilly & Carollo 2016)

Bulges in SF or Q host galaxies







Sersic index progressively increases through cosmic time, no significant difference detected between the two populations of bulges.

Bulges in star forming galaxies are more elongated.

Dimauro et al. 2019

Questions

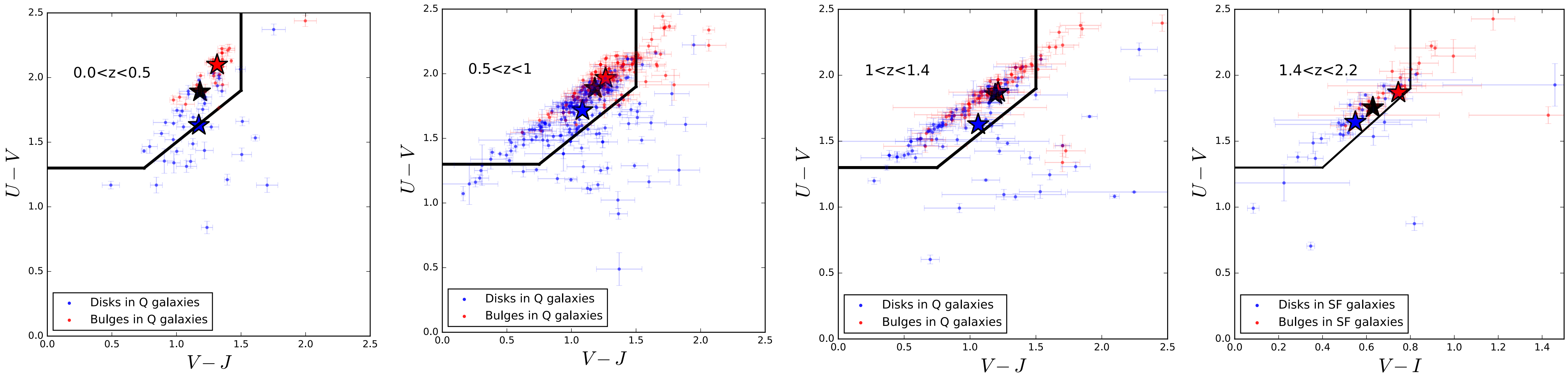
Does the quenching imply a morphological transformation?

Bulges in star forming systems are larger (~20%) than those in quiescent systems -> compaction or progenitor bias?

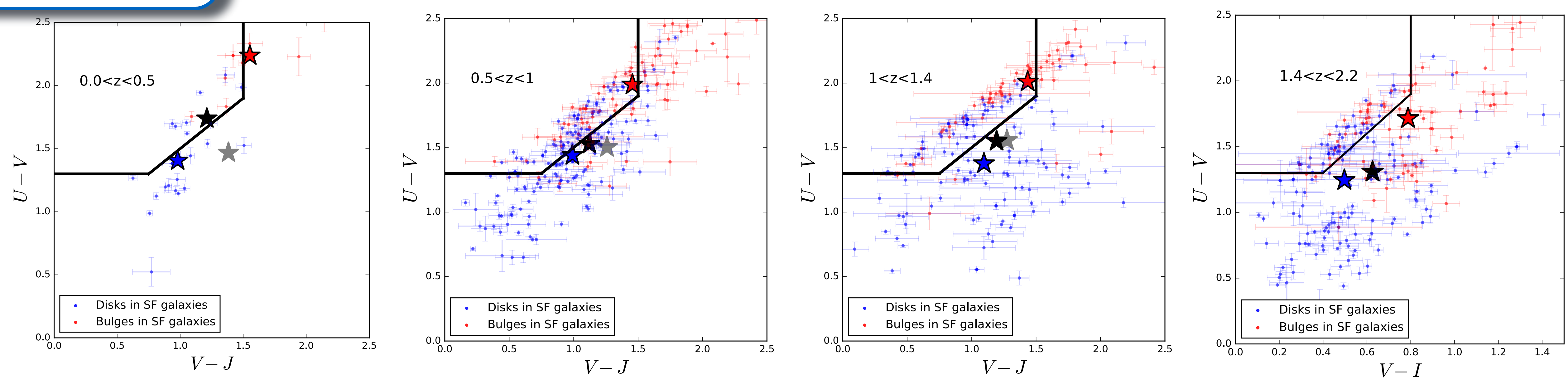
Disk structure is similar in star forming and quiescent galaxies -> disks are weekly affected by the quenching process, that it's mostly affecting the central part of the galaxy

Colors of bulges and disks

Quiescent

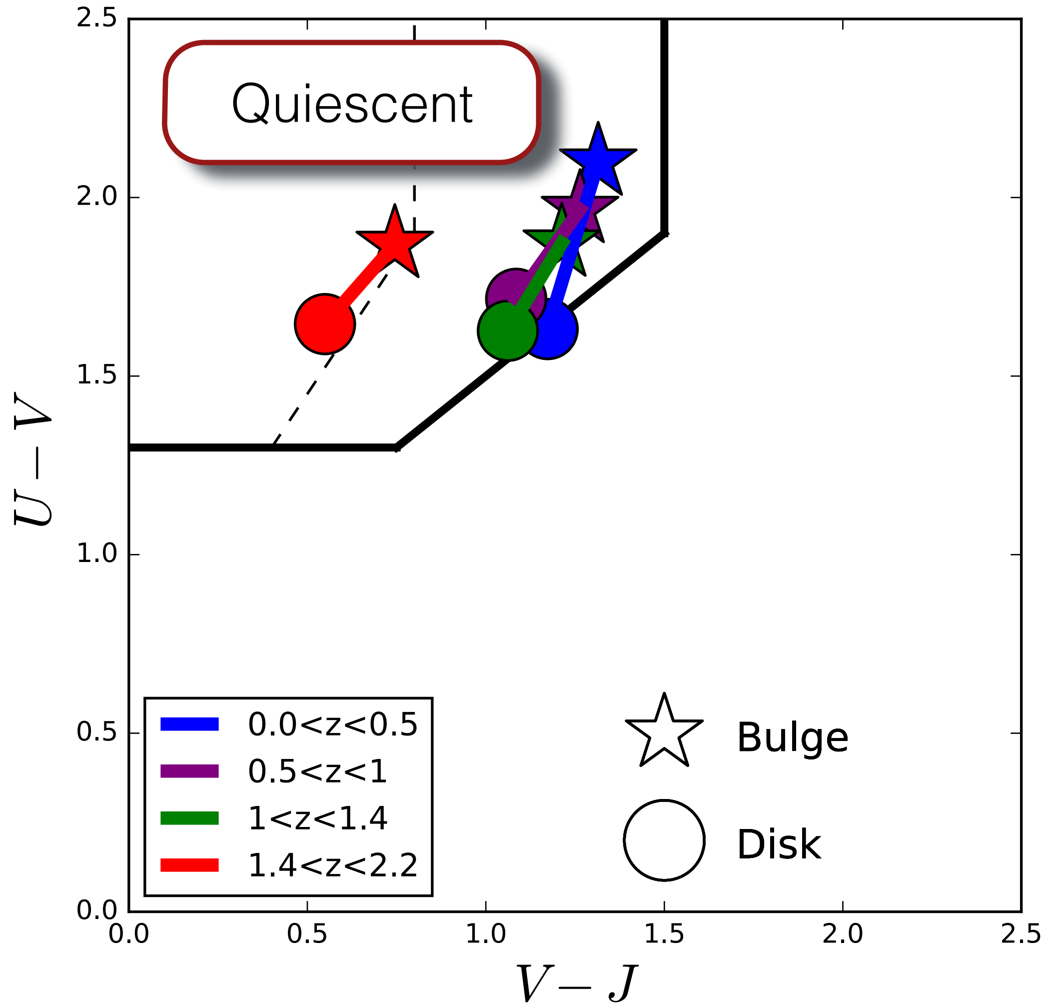


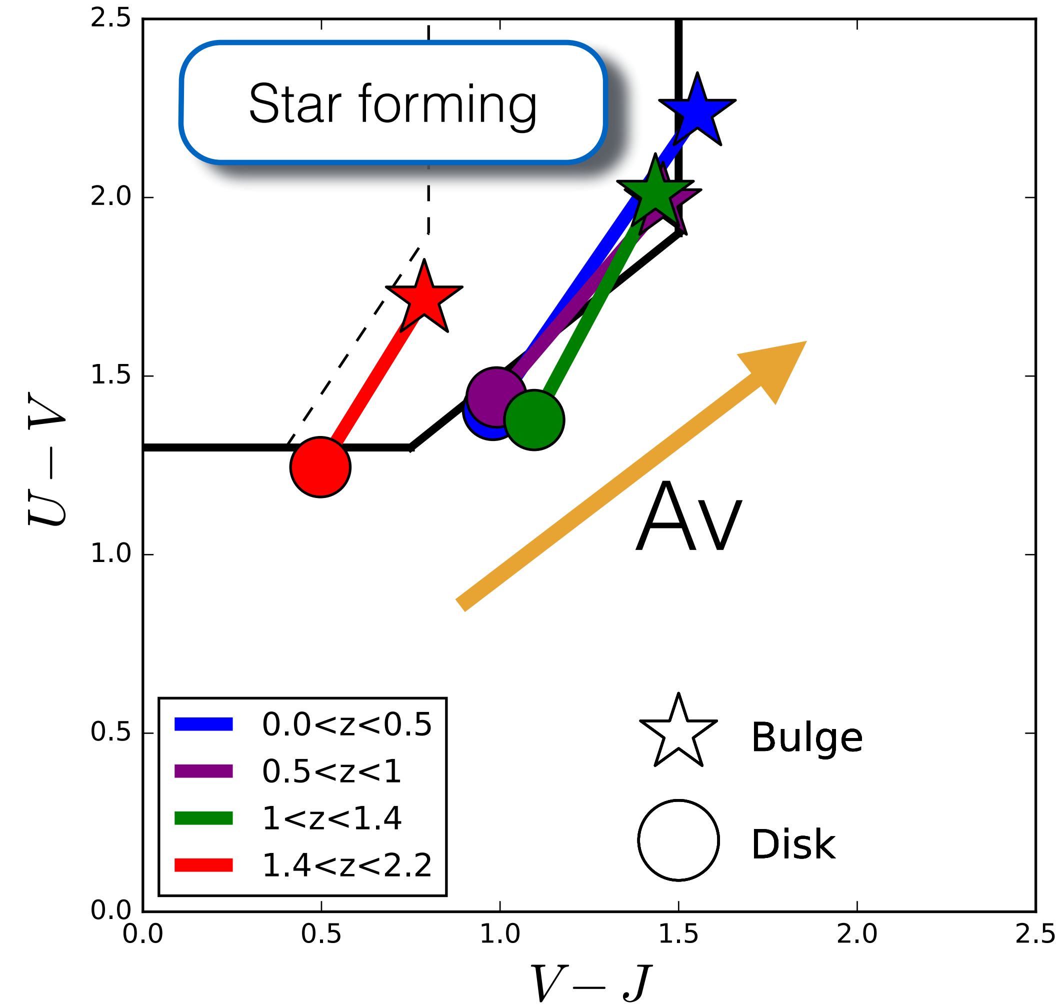
Star forming



Dimauro et al. 2019b in prep

Colors of bulges and disks





Disks are blue in star forming systems and red in quiescent ones

Bulges are always redder than disks

Bulges are more dusty in star forming systems than those in quiescent ones

Dimauro et al. 2019b in prep

Future projects

- Extend the analysis on other datasets -> larger wavelength coverage (Dimauro et al 2019b i*n prep)*
- Larger sample -> automatic modeling (Tucillo et al 2018, 2019 *in prep)*
- Compare results with numerical simulations
- Study the effect of dense environments on bulge and disk properties

Conclusions

Part 1: catalog

- We built a catalog for ~17.300 galaxies, using 7/4 bands, released to the community http://lerma.obspm.fr/huertas/form_CANDELS
- It is the largest catalog of bulge and disk properties available today
- We introduced a novel selection algorithm

Part 2: Properties of bulges

Can we put constraints on bulge formation mechanisms?

- Bulge sizes are similar over a wide range of B/T (0.2<B/T<0.8)
- Pure bulges (B/T>0.8) are 20% larger than bulges embedded in disks
- Possible different assembly histories

Does the quenching imply a morphological transformation?

- Bulges in star forming systems are larger (~20%) than those in quiescent systems
- Compaction or progenitor bias

Thank you very much!