Star formation quenching in different environments

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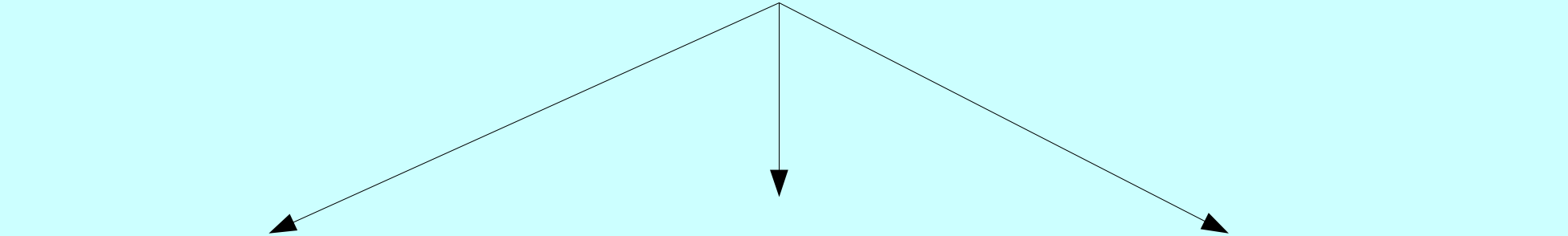
Galaxies in high density environments (cores of rich clusters)



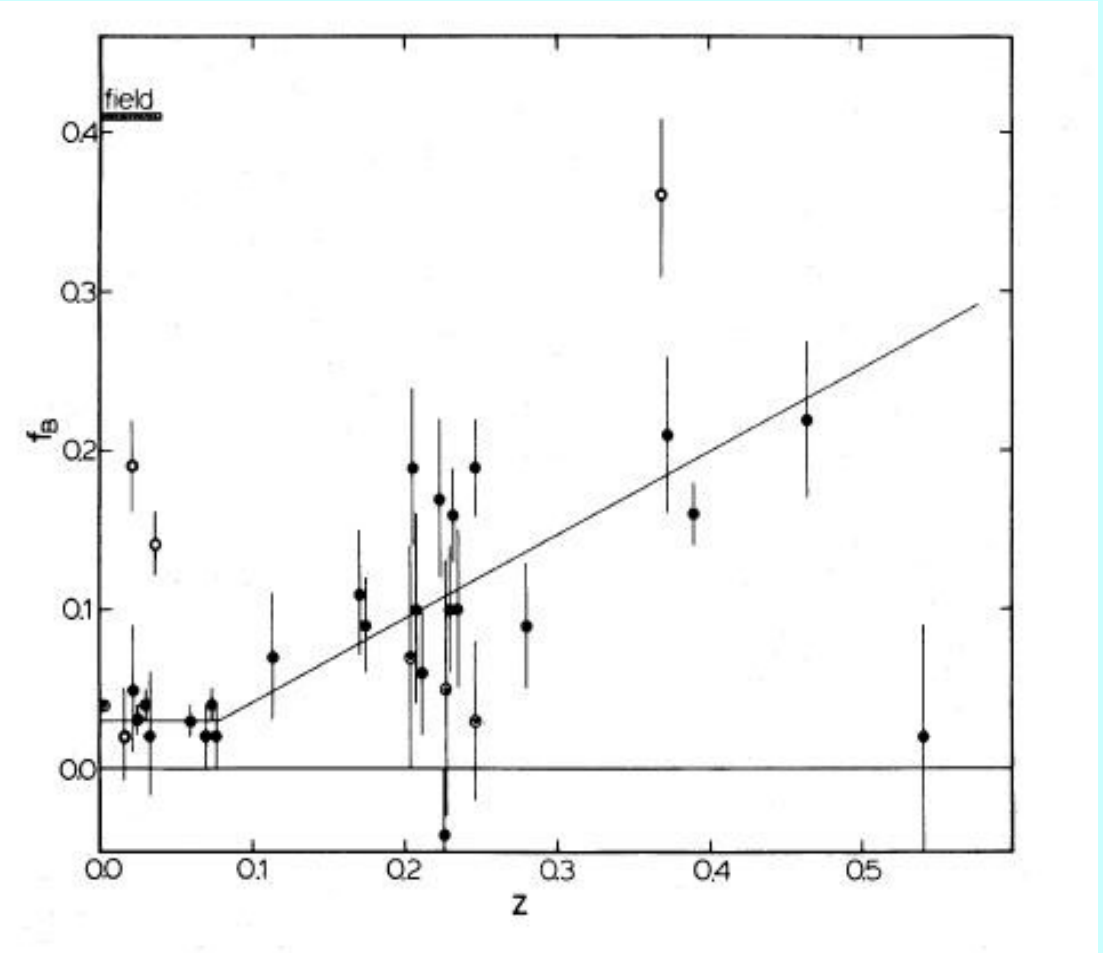
Lower star formation rates

Redder colors

Bulge-dominated morphologies

First studies

Butcher & Oemler (1984) reported an increase in the fraction of blue galaxies in 33 rich galaxy clusters out to z ~ 0.5 compared to local clusters.



Butcher&Oemler (1984)

New studies → many complexities

Star formation vs stellar mass

- Higher stellar mass → higher fraction of quiescent galaxies (Wetzel et al 2013), lower fraction of blue galaxies (Raichoor et al 2012)
- Lower stellar mass → lower fraction of quiescent galaxies (Wetzel et al 2013), higher fraction of blue galaxies (Raichoor et al 2012).

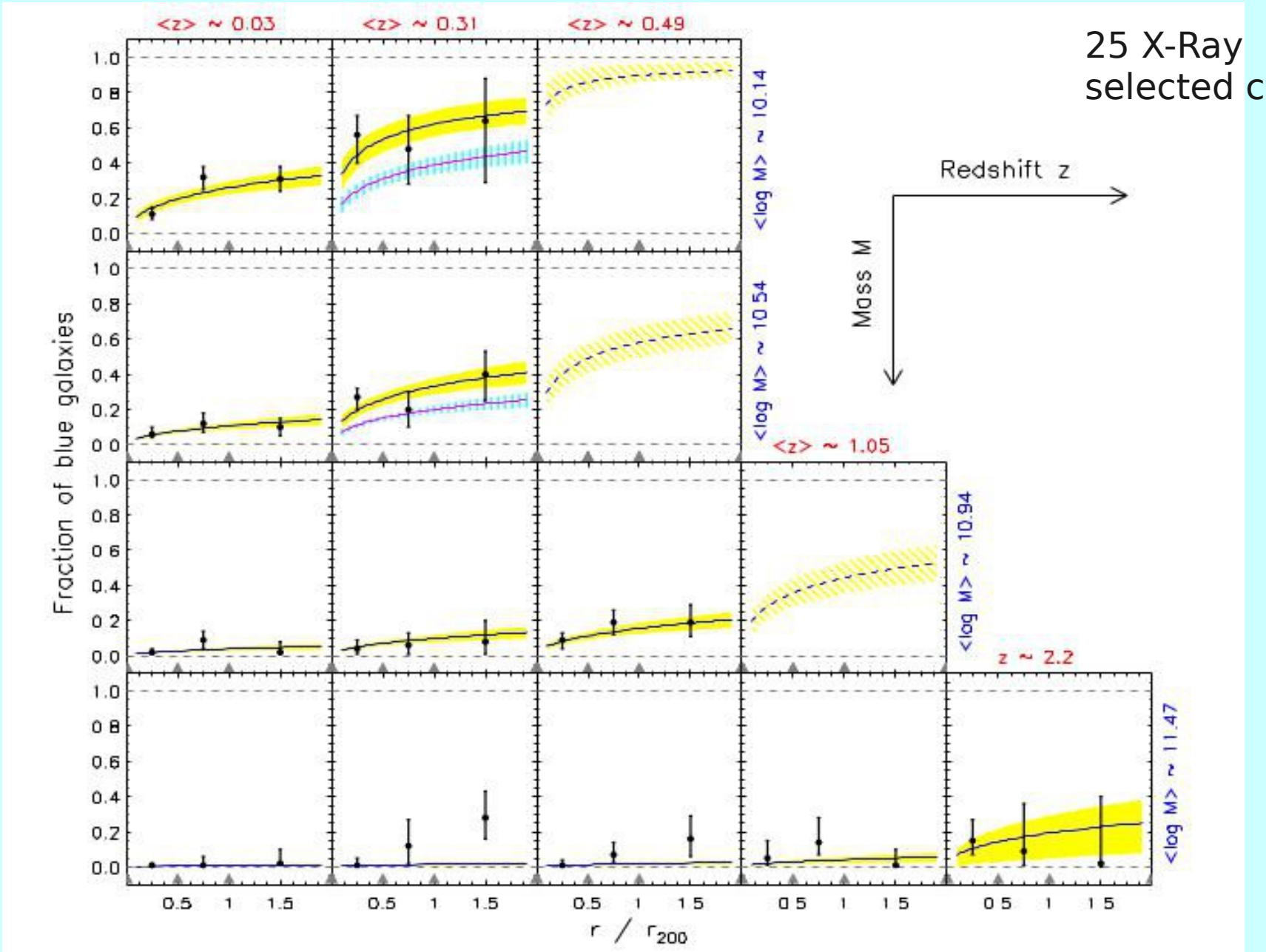
Star formation vs halo mass

- Higher halo mass → higher fraction of quiescent galaxies (Wetzel et al 2013)
- Lower halo mass → lower fraction of quiescent galaxies (Wetzel et al 2013)

Increase in the fraction of star-forming galaxies with cluster-centric distance (Weinmann+06, Haines+09, Raichoor & Andreon+12).

New studies → many complexities

Raichoor&Andreon(2012)

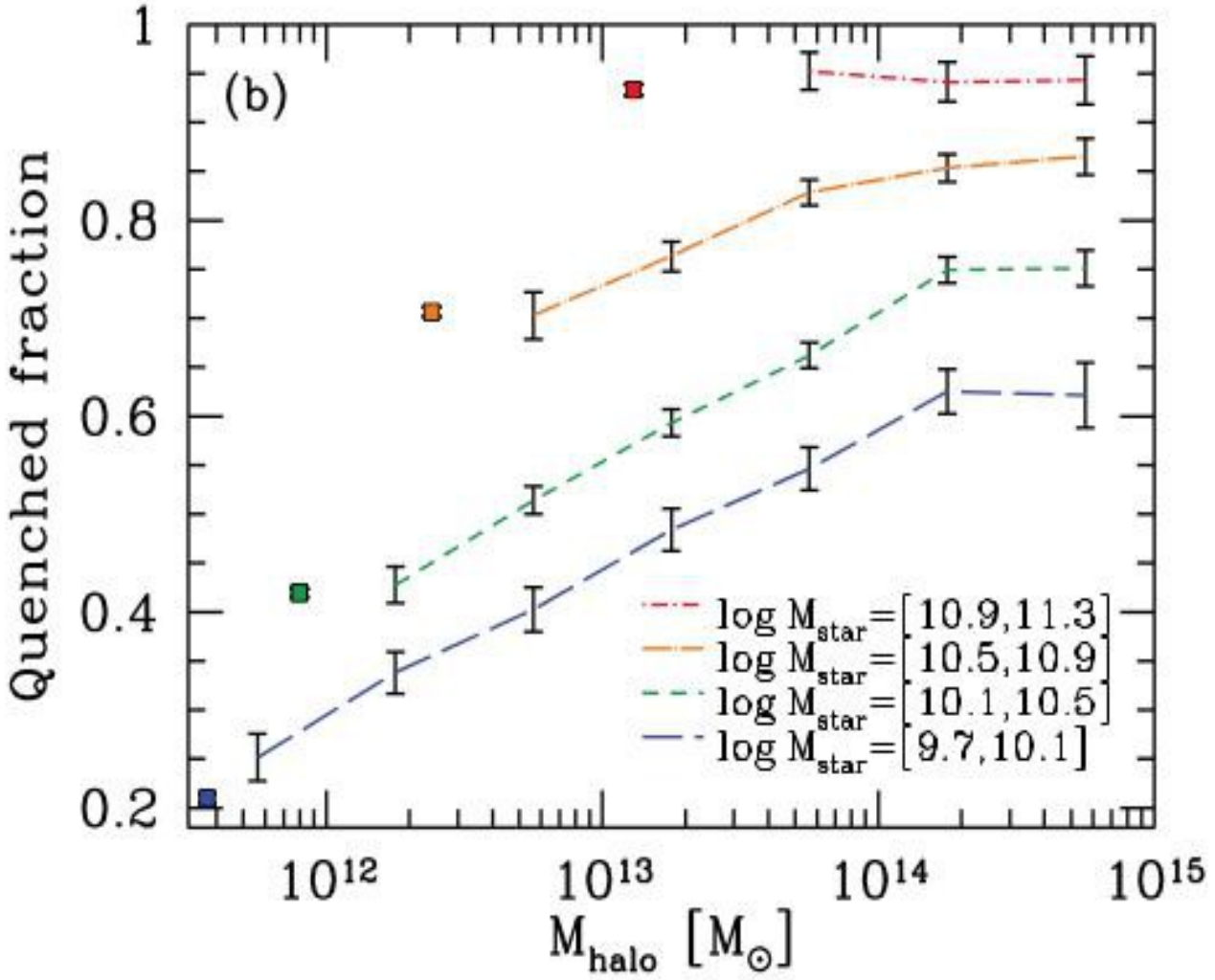


25 X-Ray selected clusters

New studies → many complexities

Wetzel et al (2012)

SDSS DR7 sample.
z~0.045
$M_{star} > 5 \times 10^9$



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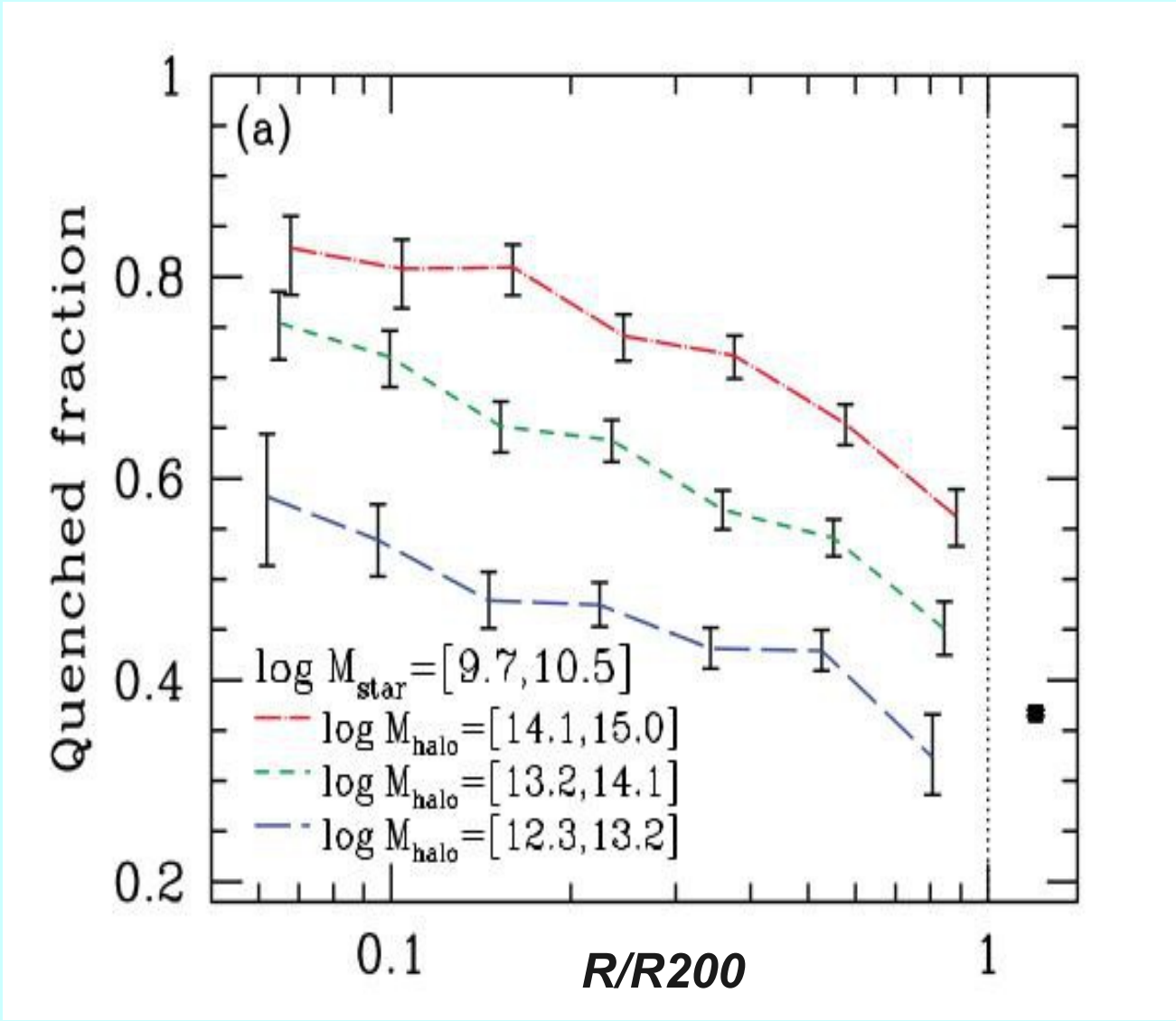

Environmental effects

Physical processes that affect galaxy evolution by removing galaxy's gaseous components:

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- Tidal interactions
- Harassment
- Starvation
- Ram-pressure stripping

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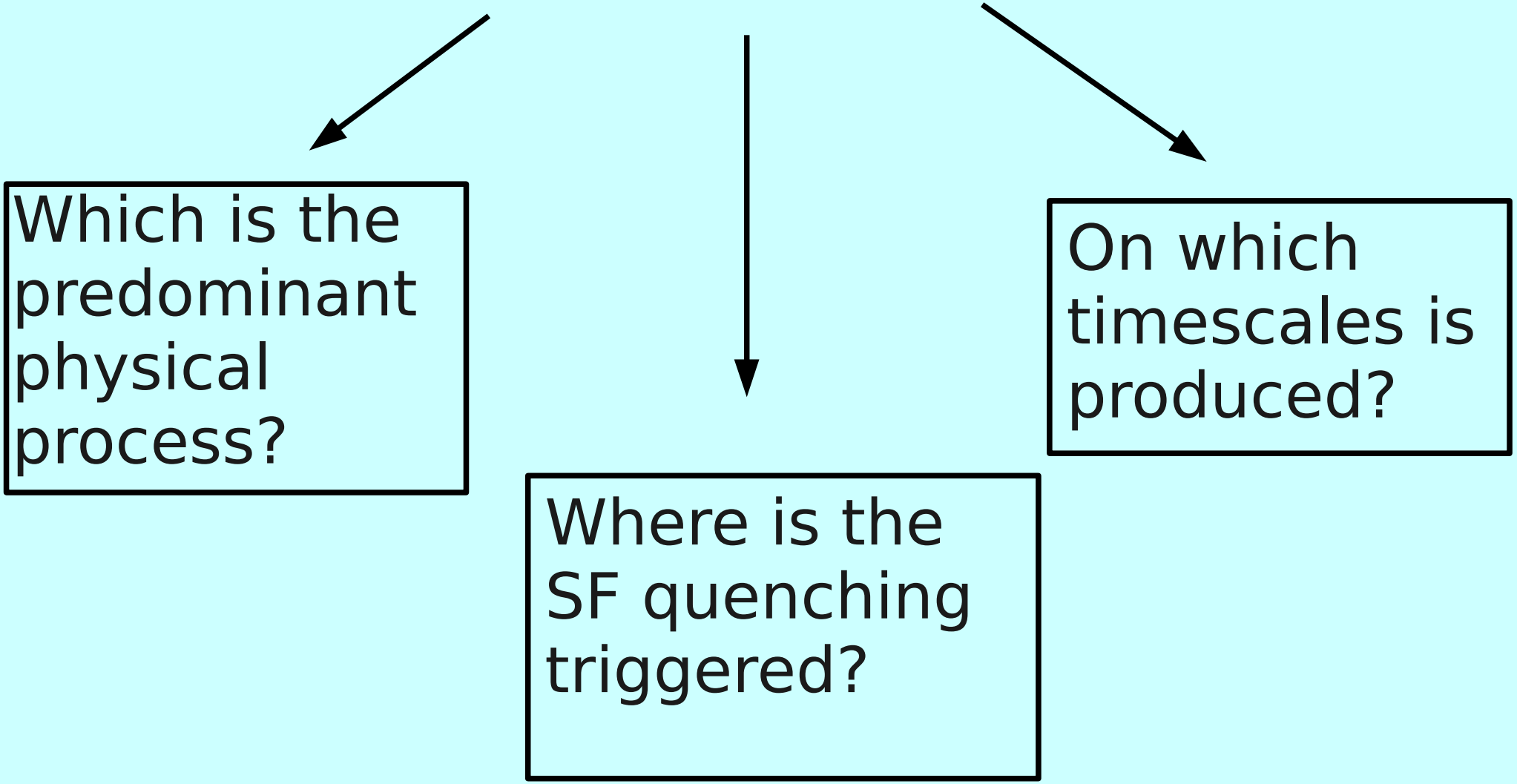
Discusion: SF quenching



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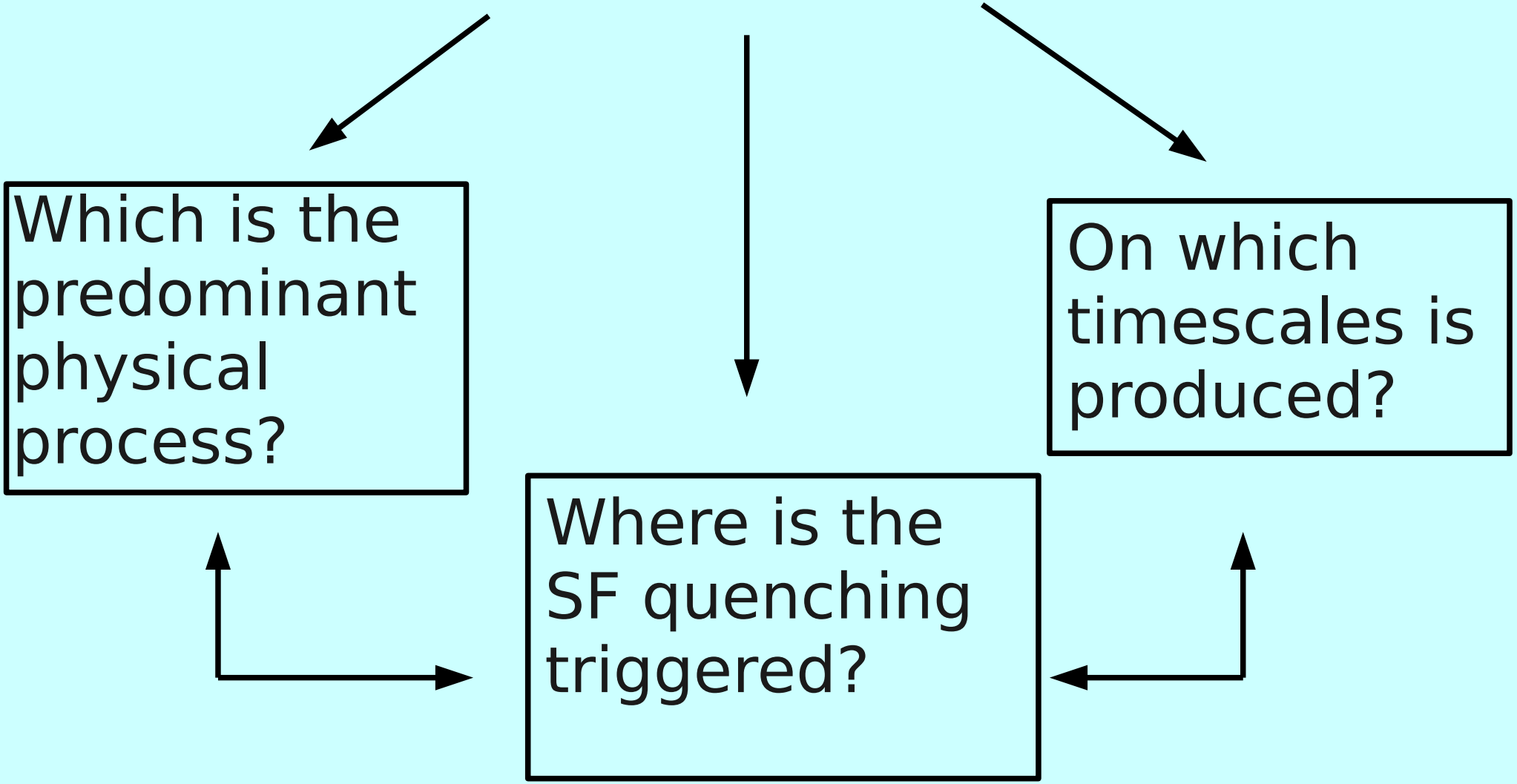

Timescales

- Starvation: t_q > 6 Gyr, for Herschel Reference Survey galaxies (Bosseli et al 2014), supported by numerical simulations (McGee et al 2014)
- Galaxy-galaxy interactions: t_q > 3 – 6 Gyr (based on typical timescales, Mastropietro et al 2005)
- Ram-pressure stripping: t_q < 1 Gyr (Roediger & Hensler 2005, McCarthy et al 2008)

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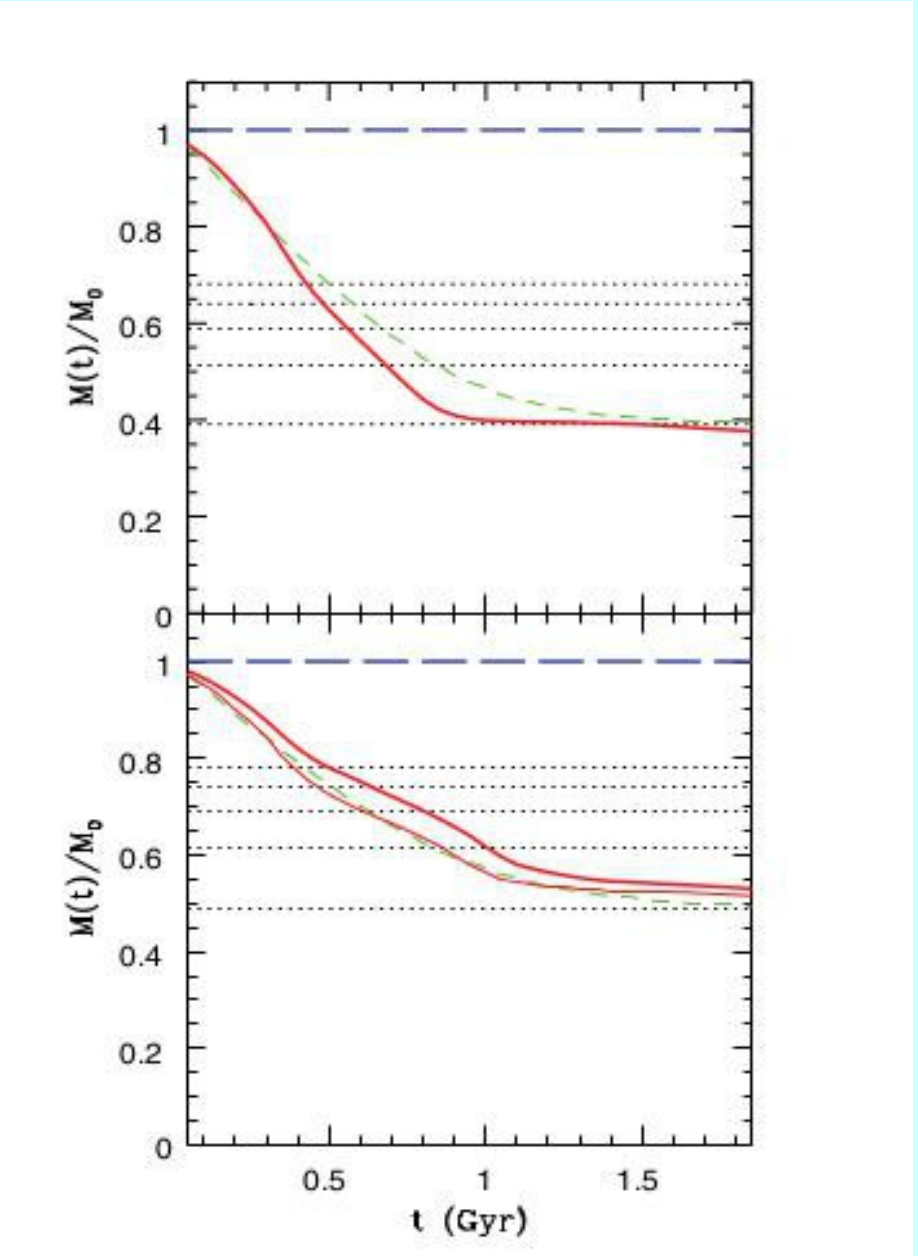

McCarthy et al (2008)

Onset of quenching

- Gas stripping can occur outside viral radius: ~5 x r200 (Bahé et al 2013, 2014)
- Gas stripping starts when a galaxy is accreted (Wetzel et al 2013)
- RPS takes 50% gas content when r500 < r < r200 in 0.5 – 1 Gyr (Roediger & Hensler 2005, HDS)
- RPS is effective as far out as r500 (Merluzzi et al. 2013).

Pre-prossesing

- Quenching timescales and location can account for which mecanism dominates galaxy quenching in high density environments.

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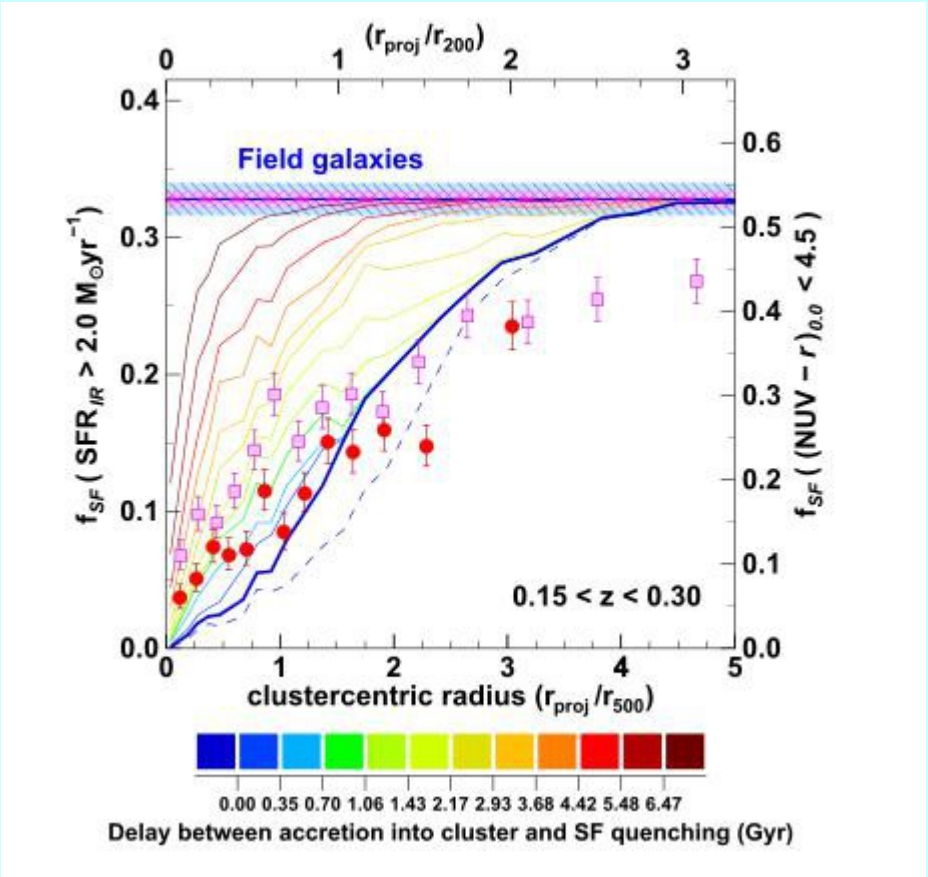
  But its not that simple!

  $\log(M_{halo}/M_{\odot})\sim14\text{-}15$ → the dominant mode of infall is as a satellite in a lower mass halo →pre-prossesing (Wetzel et al 2013).

Pre-prossesing

- “Slow-then-rapid quenching”: some mechanism acts in galaxy groups → group is accreted → rapid quenching.



Haines et al (2015)

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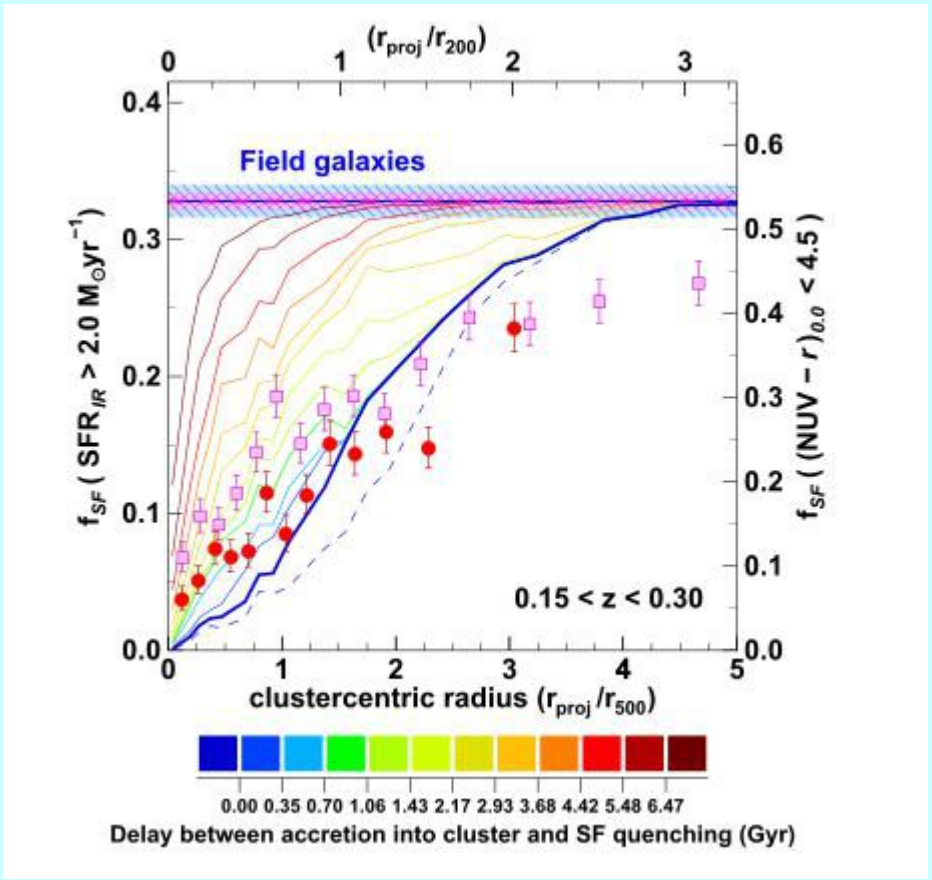

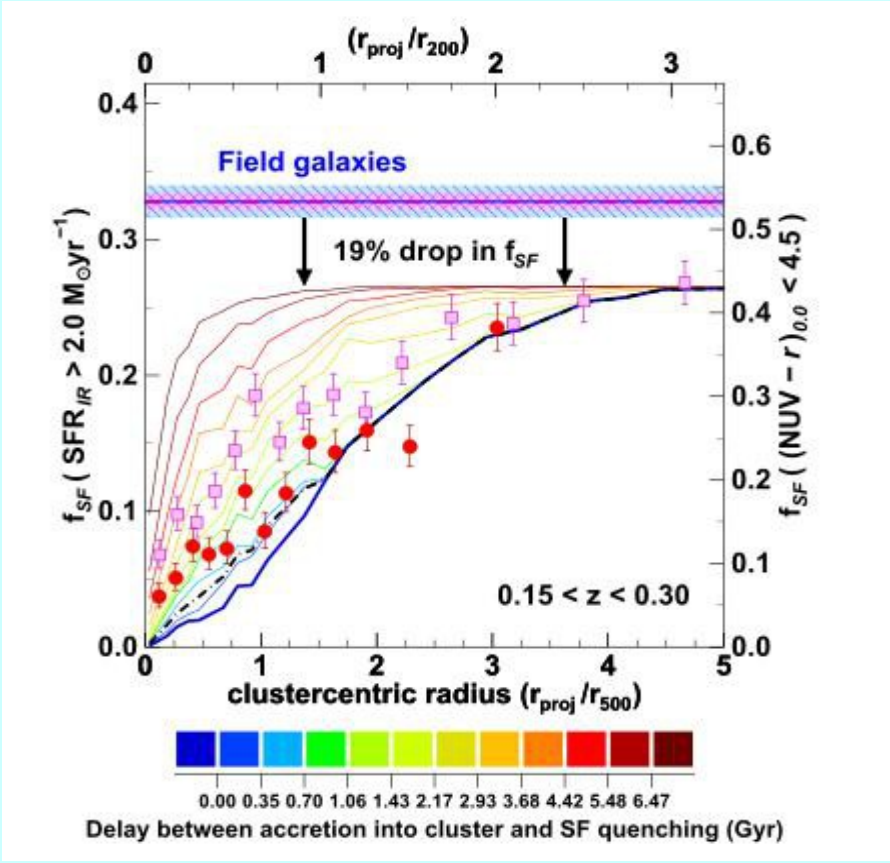

Haines et al (2015)

Current Work
MultiDark Simulation + SAG

Evolution of the fraction of quiescent galaxies:

- Central + satelite galaxies (within R_{200})
- M_{halo}
- M_{star}
- 8 calibration boxes, vol=111.188^3 $(Mpc/h)^3$
- Tidal stripping + RPS on hot gas halo

$$\rho_{\rm ICM} v_{\rm orb}^2 > g_{\rm max}(R)\Sigma_{\rm gas}(R).$$

$$P_{\rm ram}(t) > \alpha \frac{G M_{\rm gal}(R)\rho_{\rm gas}(R)}{R}$$

McCarthy et al (2008)

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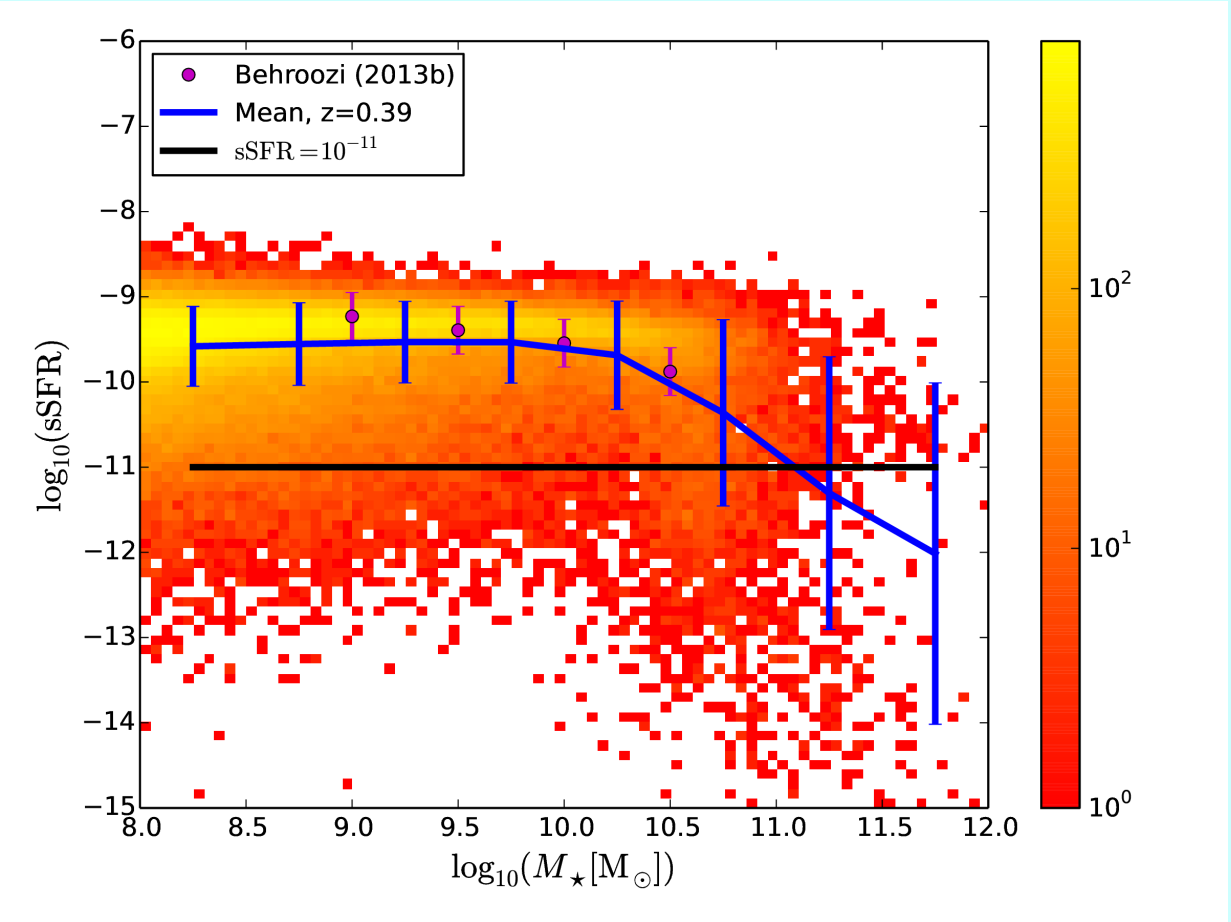

z=0.39

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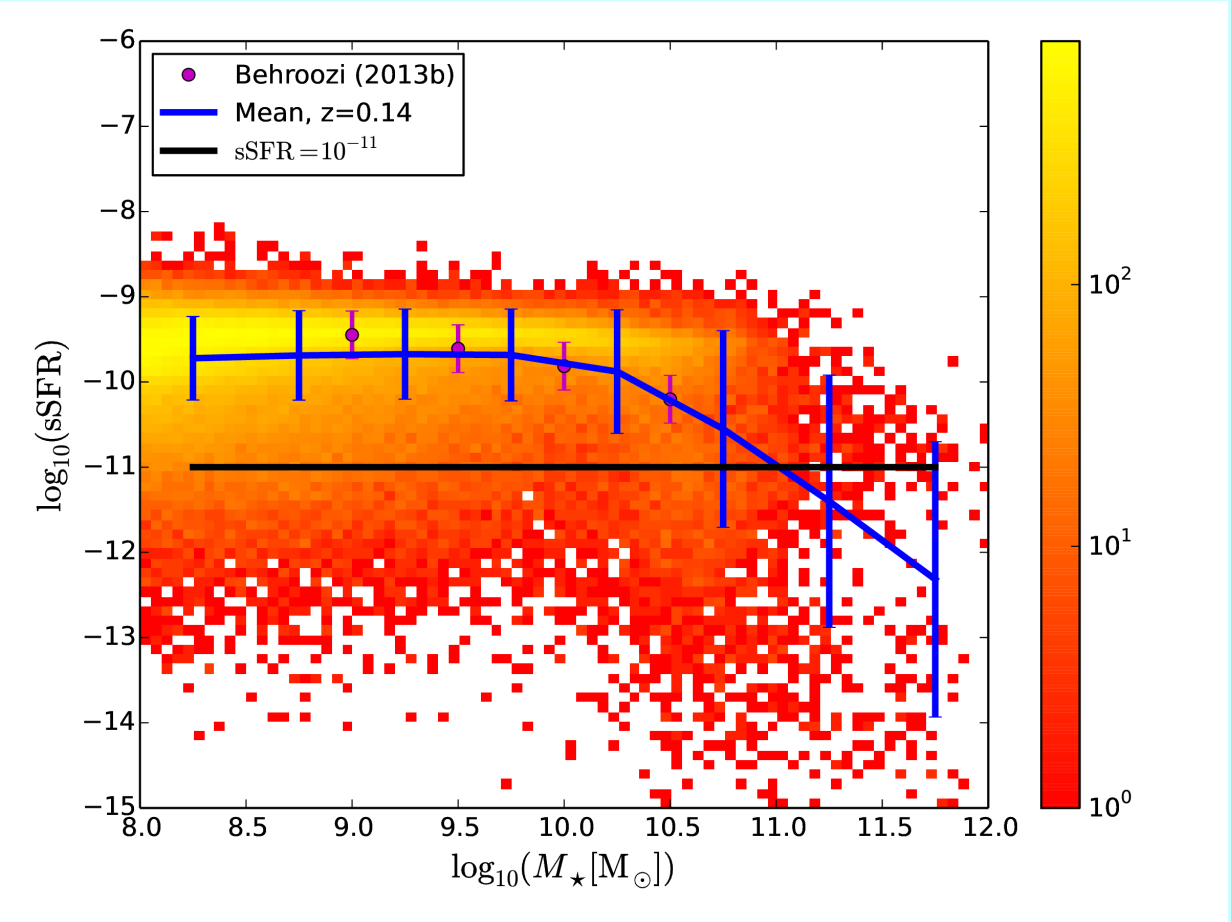

z=0.14

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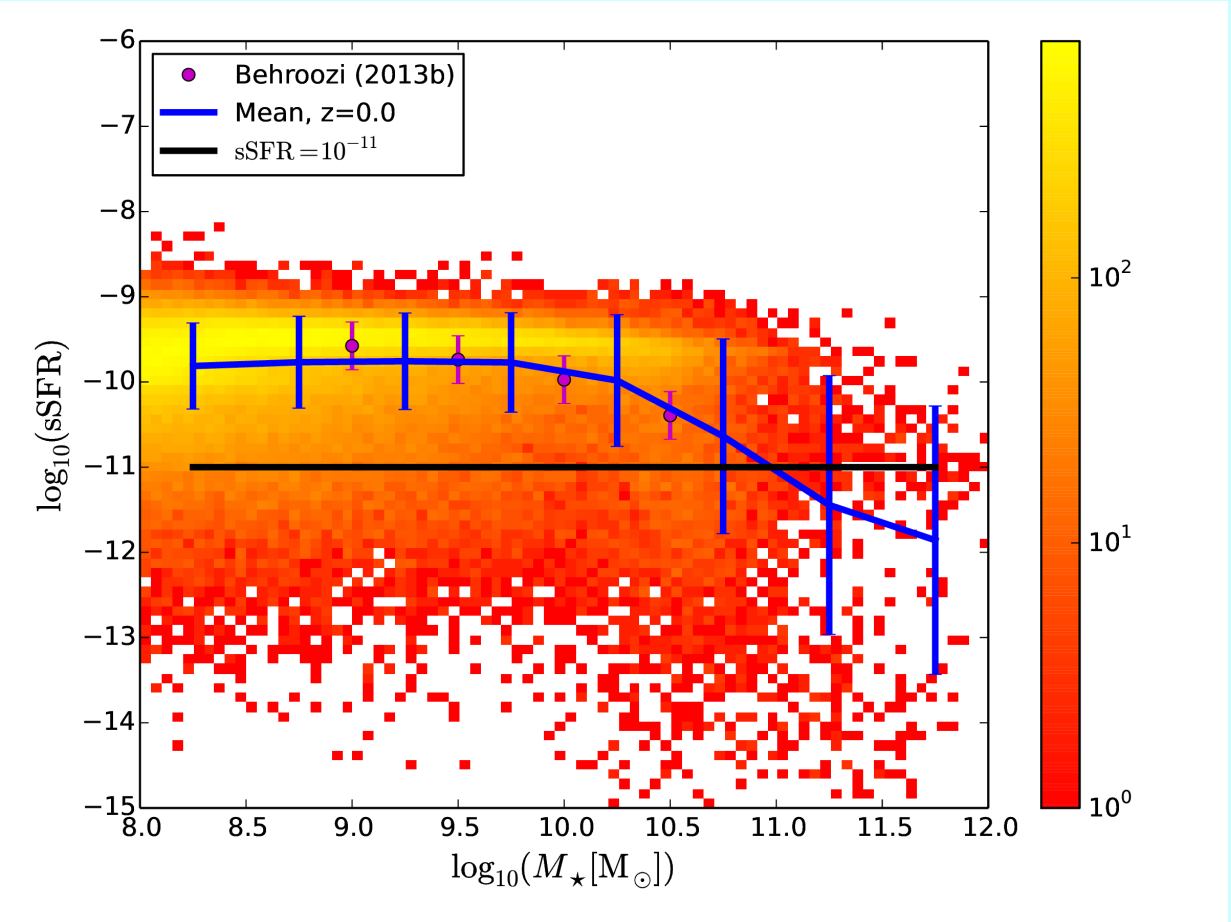

z=0

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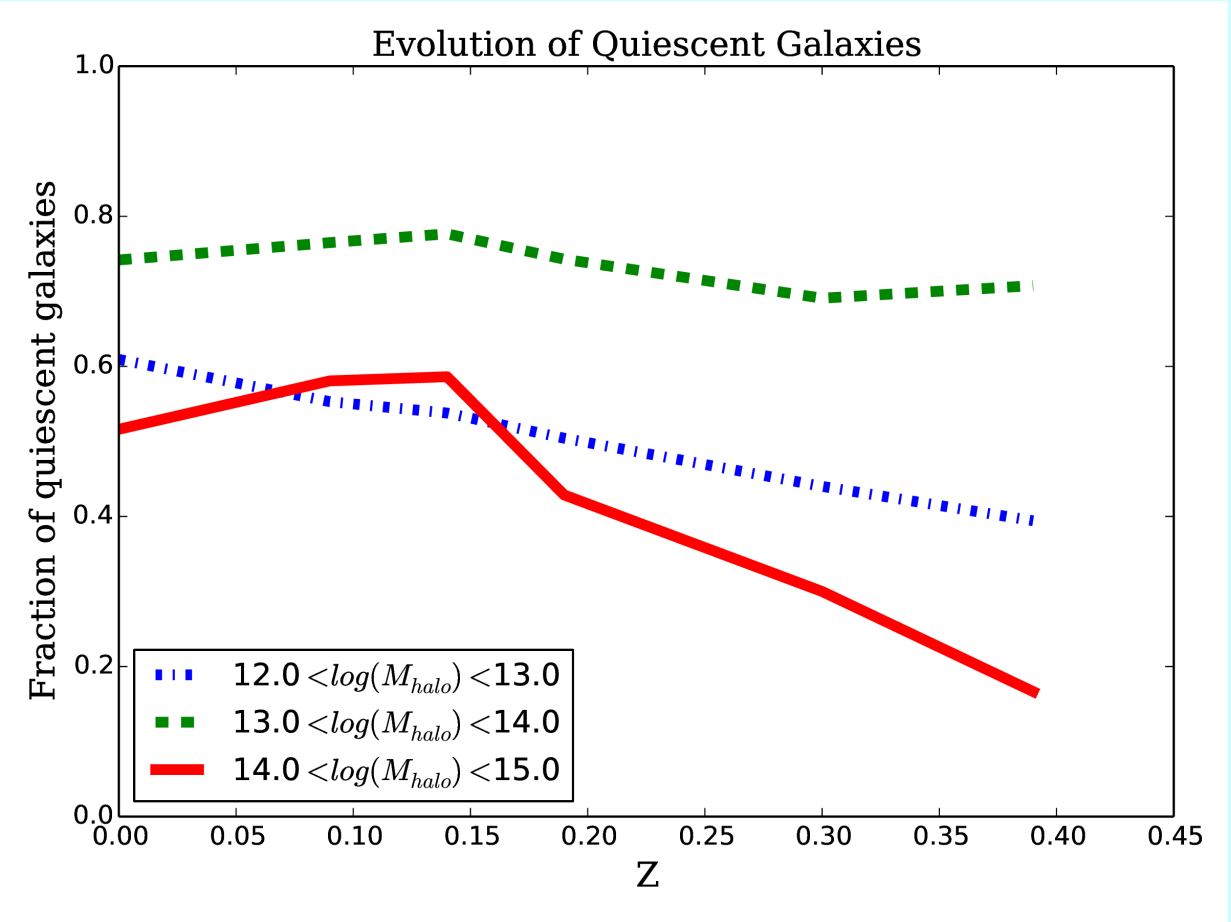
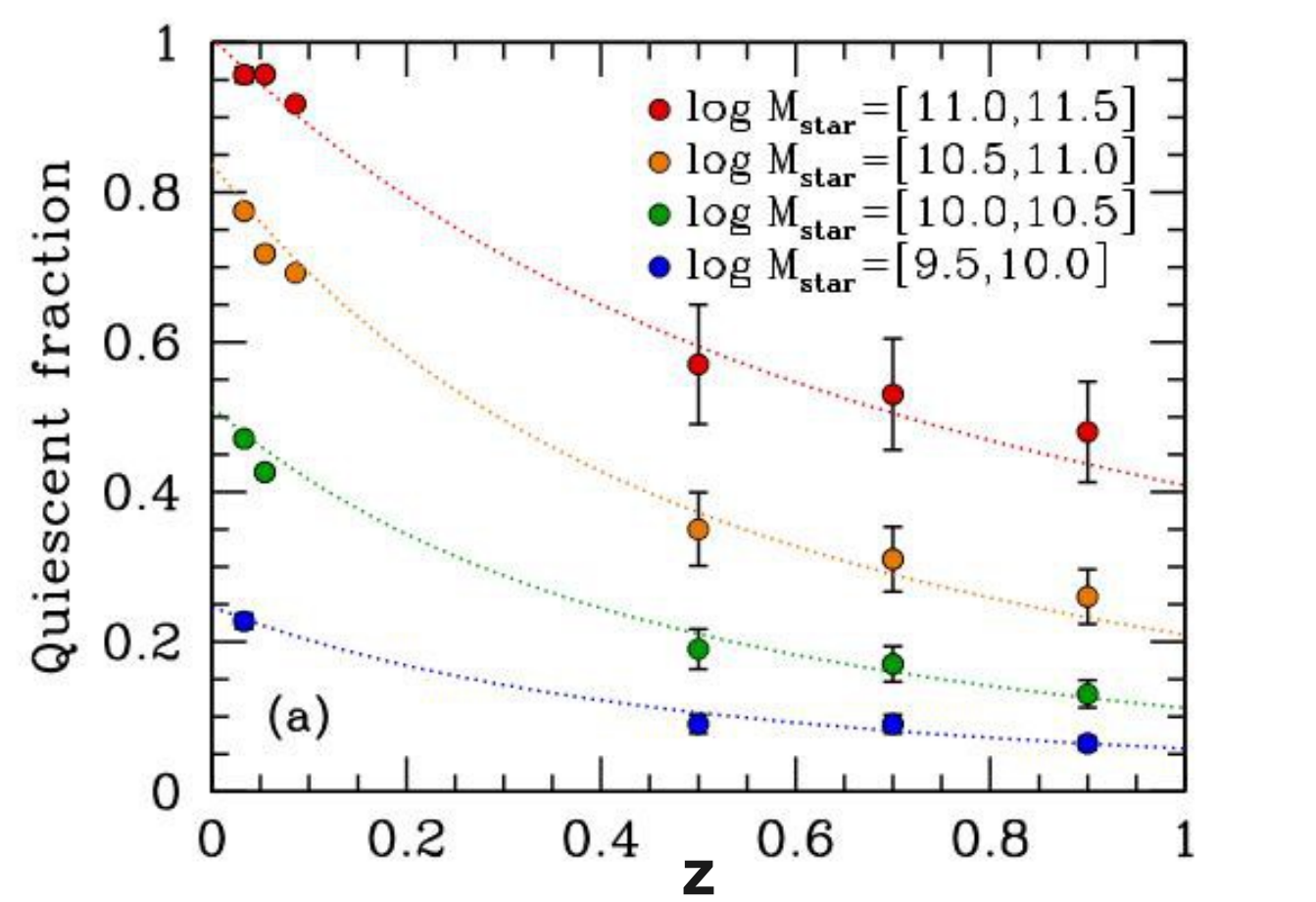


Preliminary results

Quiescent fraction: dependence on halo mass

Current Work
MultiDark Simulation + SAG



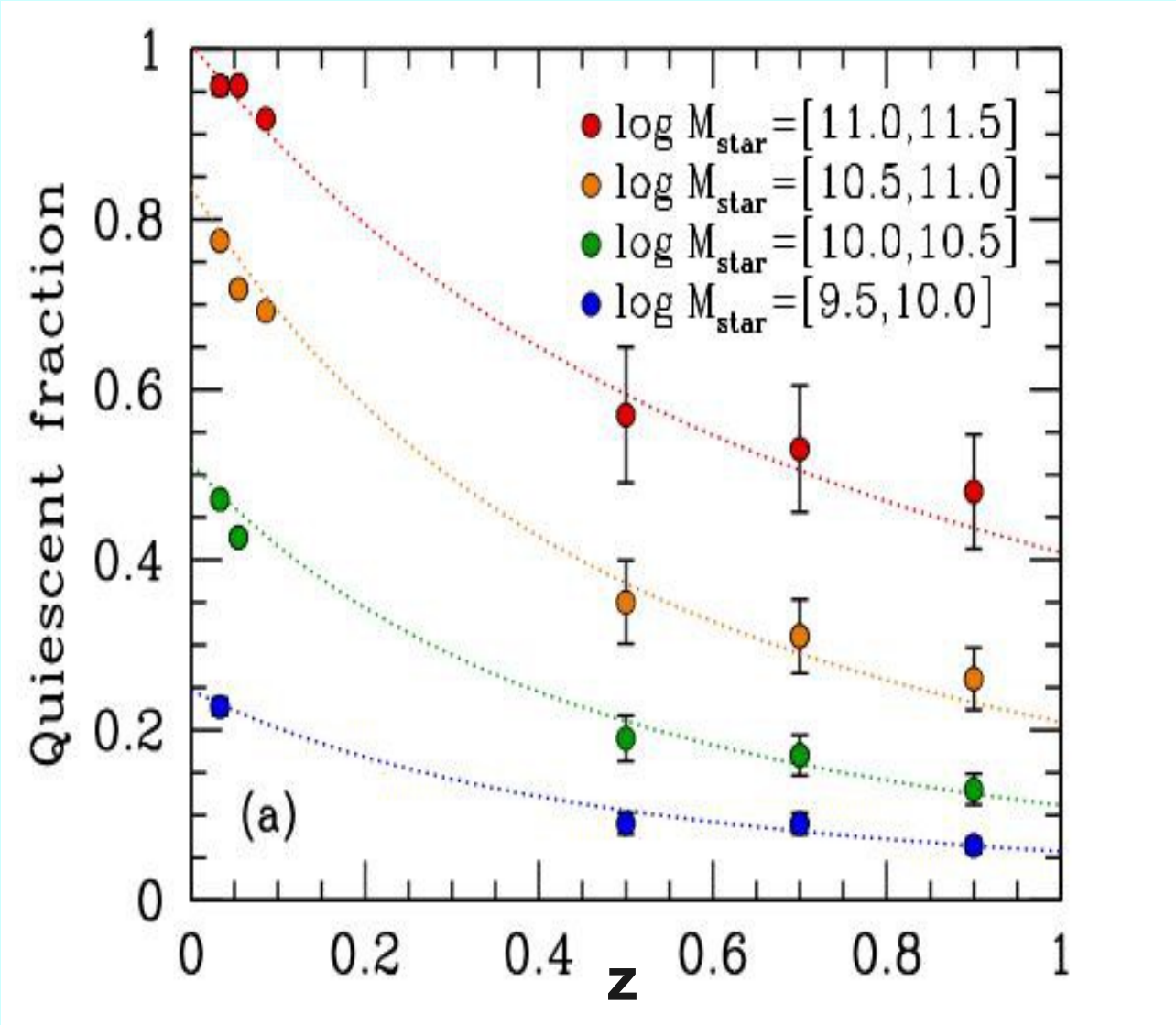
Wetzel (2013)

Quiescent fraction: dependence on stellar mass

New studies → many complexities

SDSS DR7 sample (z~0) $M_{star}>5x10^9$ + Cosmic Evolution Survey (Drory et al 2009).

Wetzel et al (2013)



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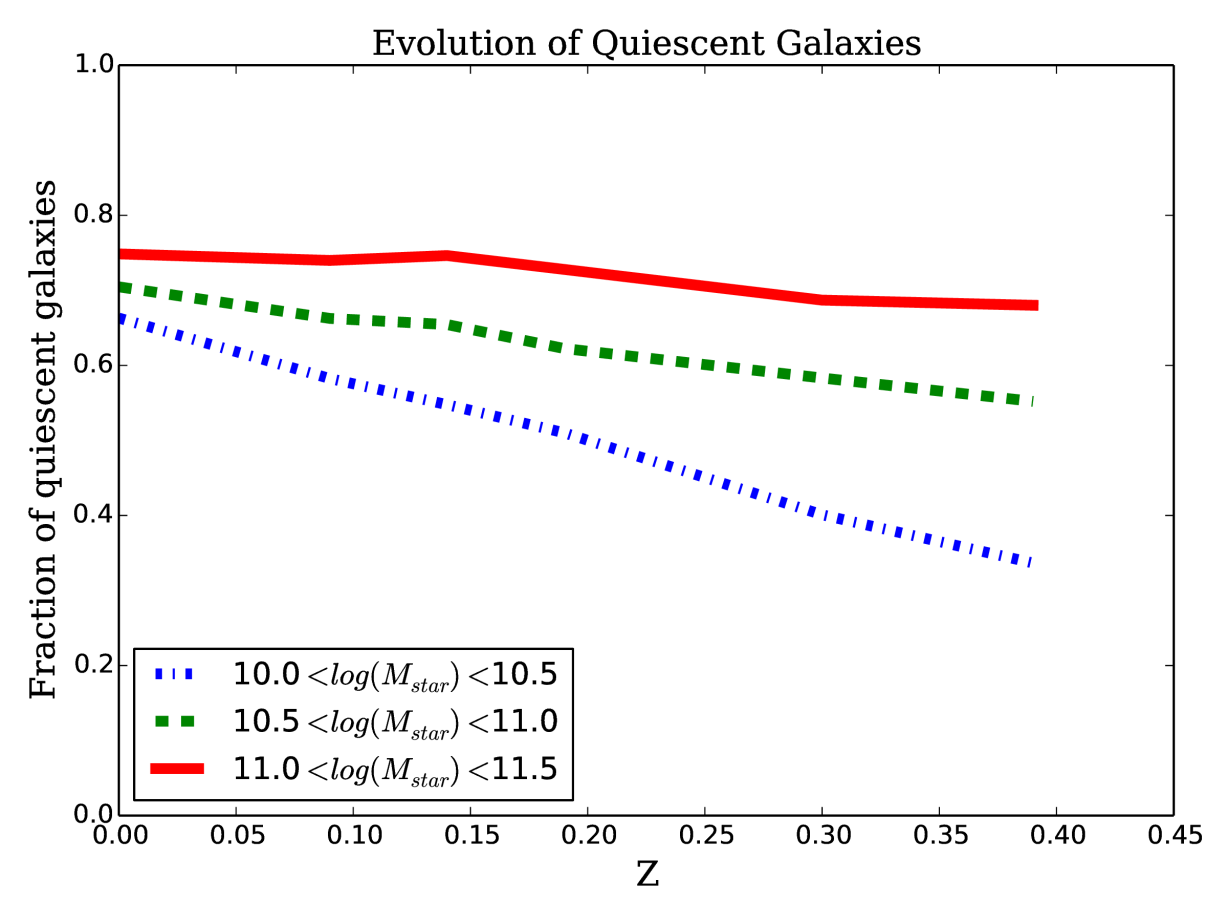
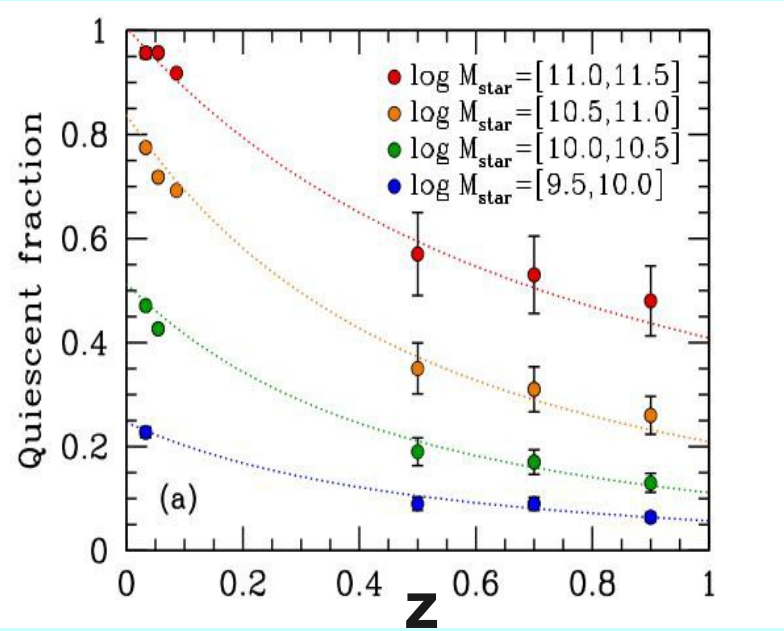


Wetzel (2013)



Preliminary results

Quiescent fraction: dependence on stellar mass

Future Work

- Analize central and satelite quenching separatedly (Wetzel et al 2012, 2013; Bluck et al 2016)
- Explore different SF classification criteria (Weinmann et al 2006)
- Analize SF activity of galaxies to be accreted and the environment in which they reside (pre-prossesing).

THANK YOU!