Galaxy Star Formation in Groups/Clusters

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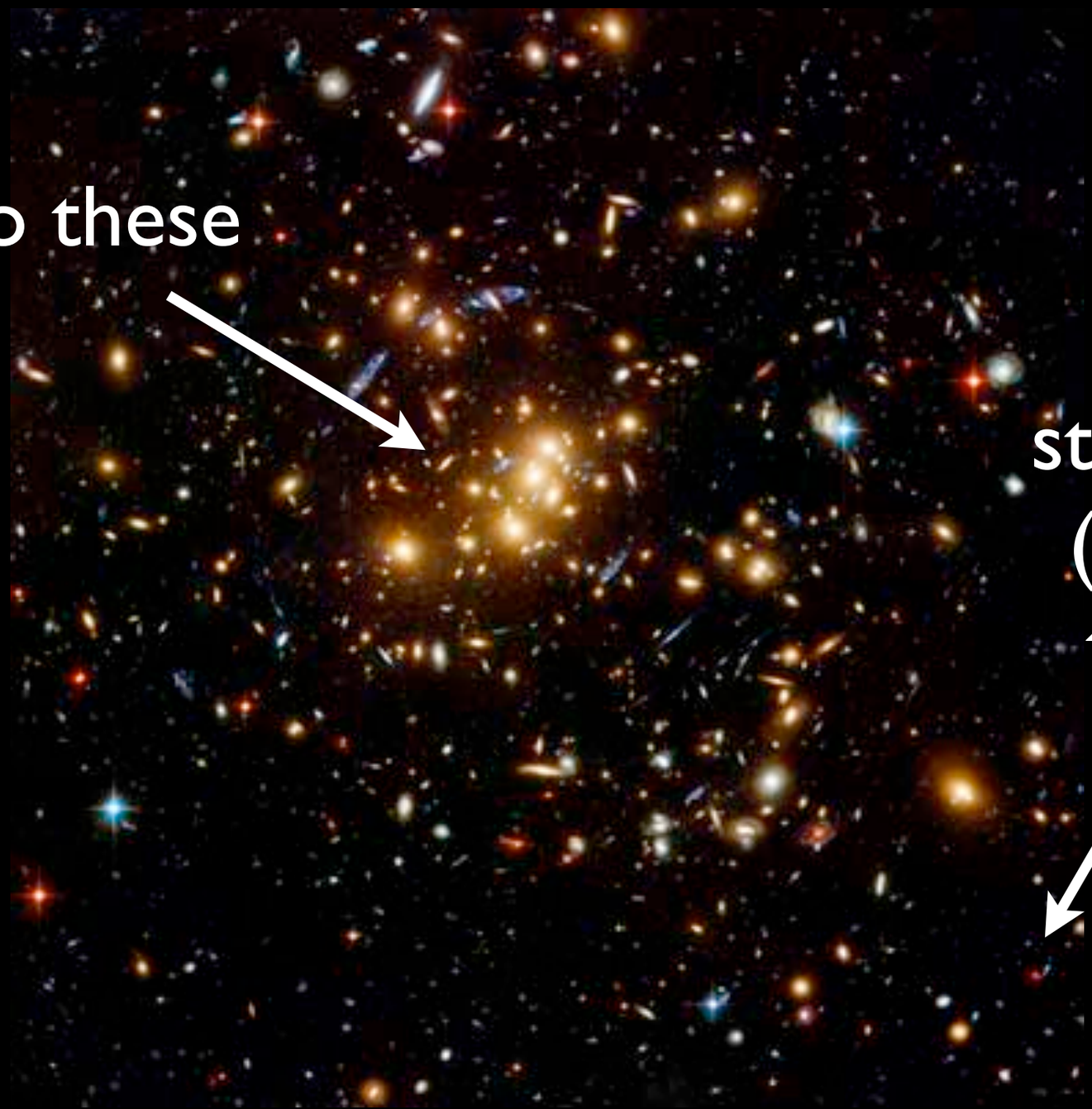
Cosmology on the Beach - January 2011

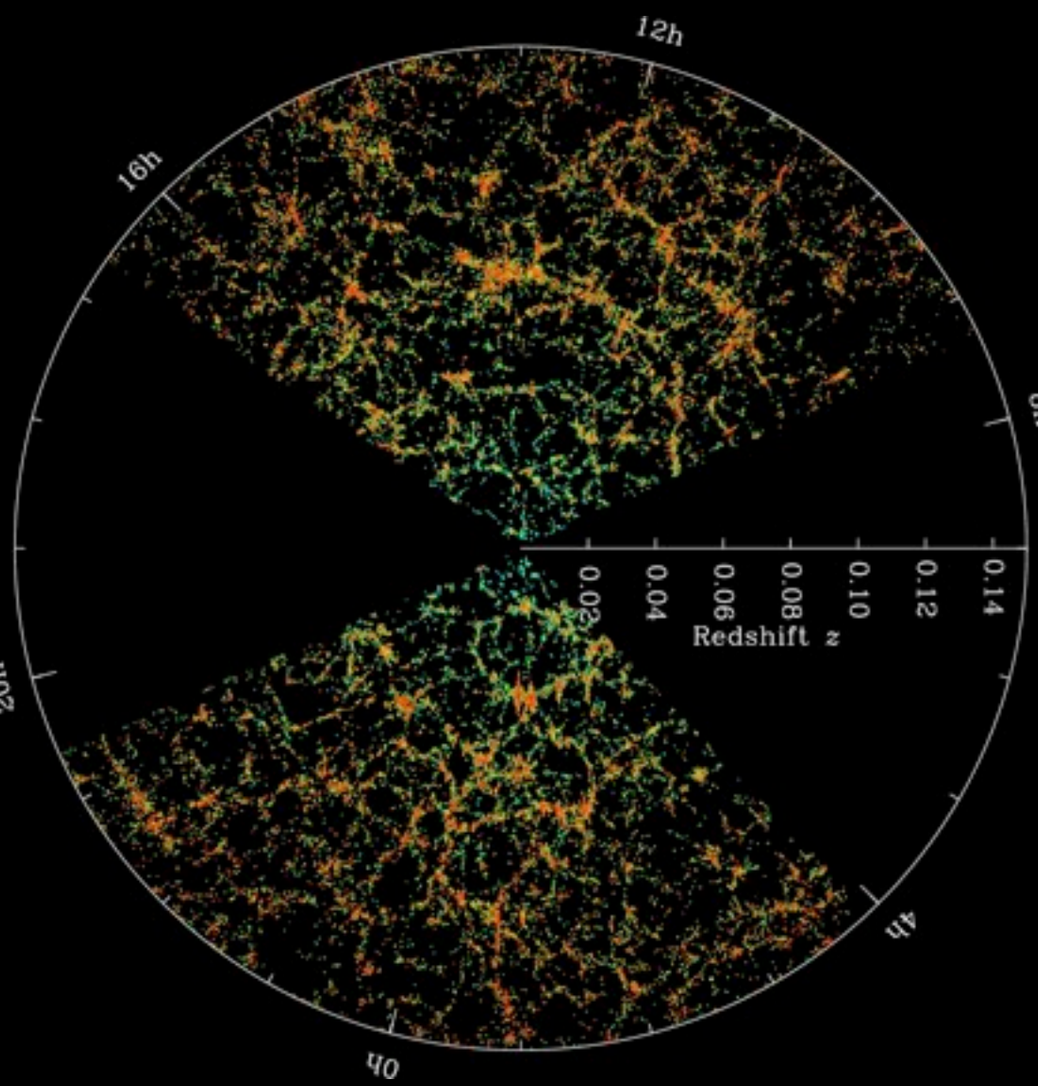
Why do these

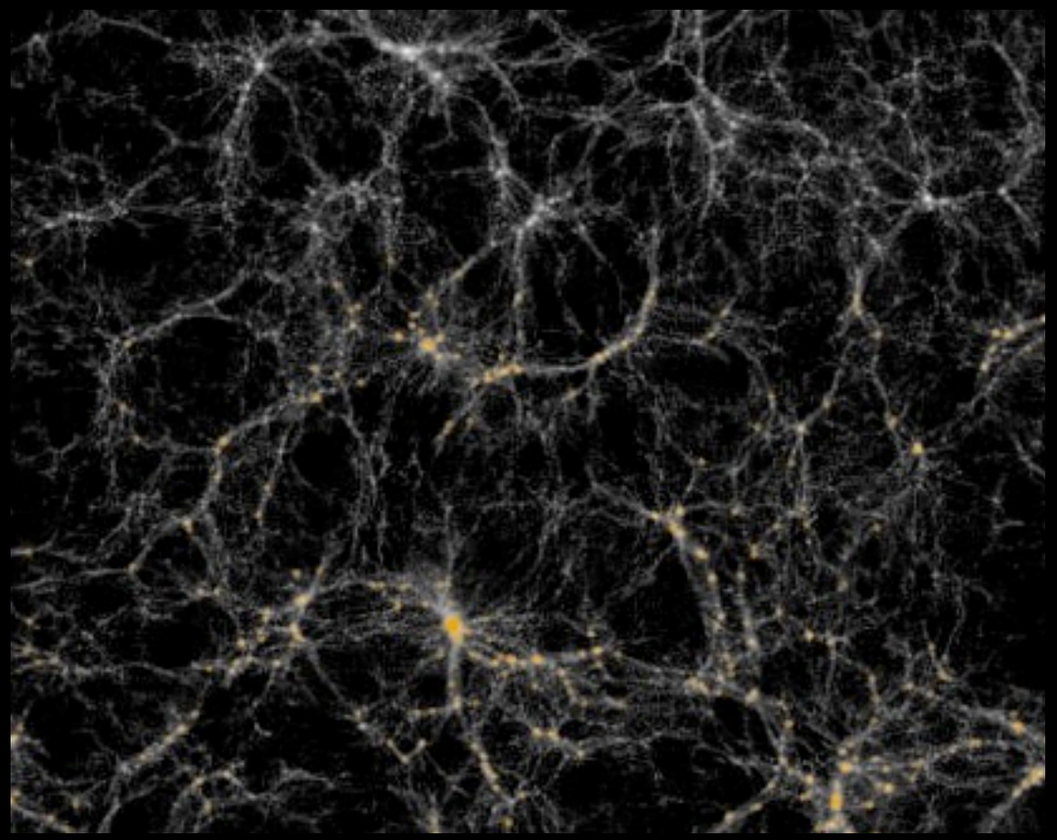


have lower star formation (are redder) than these?

Group/cluster properties from observation

Satellite galaxy dynamics from simulation





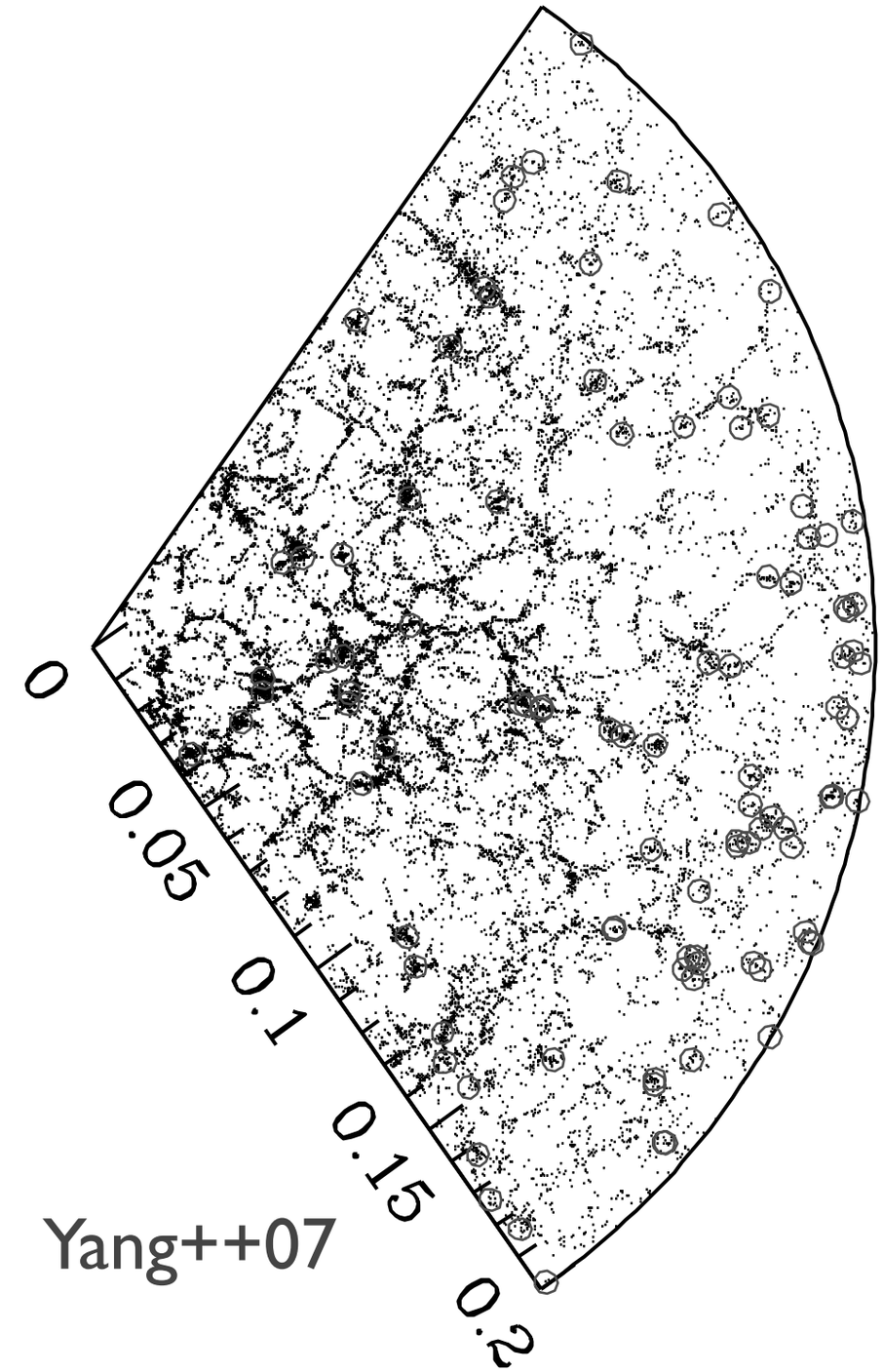
Galaxy Catalog

SDSS Data Release 7

NYU value-added spectroscopic catalog

Spectroscopically derived stellar masses & star formation rates from MPA-JHU

Kauffmann++03, Brinchmann++04, Salim++07



Yang++07

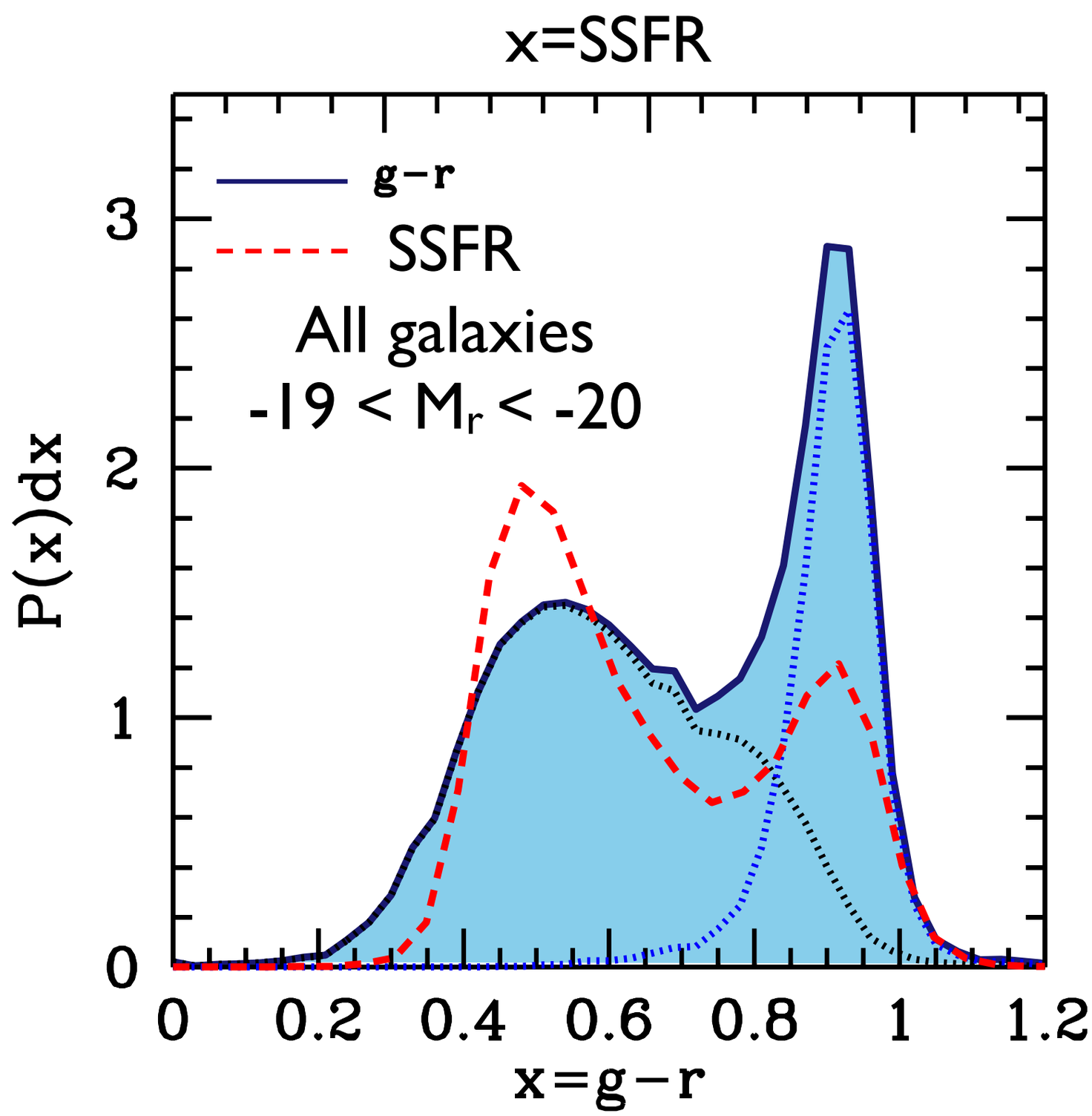
Galaxy Group Catalog

All galaxies in a "group"

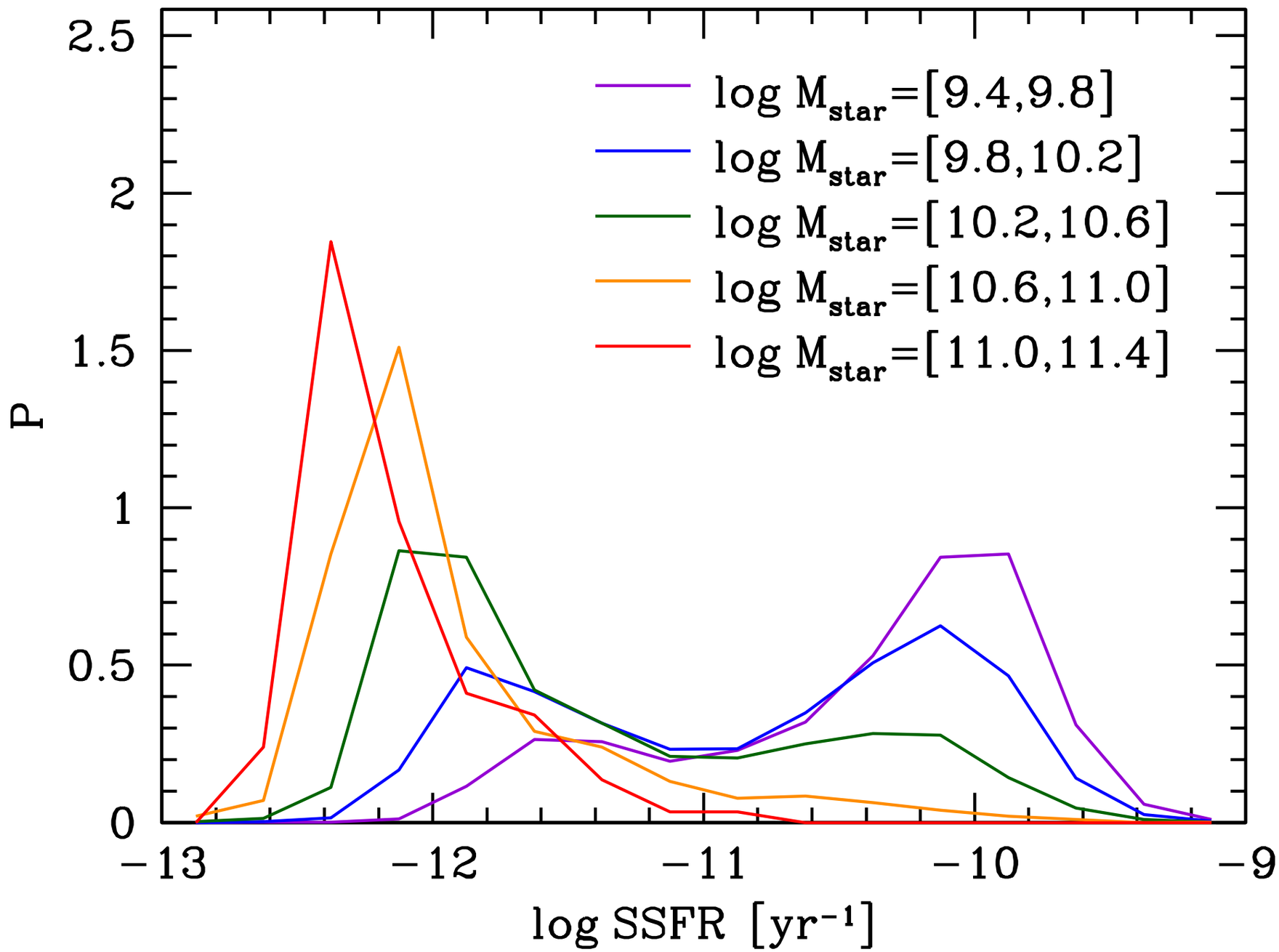
Each group has one "central" (most massive) & possibly several "satellite" galaxies

High purity & low contamination (10-20%) as calibrated against mock catalogs

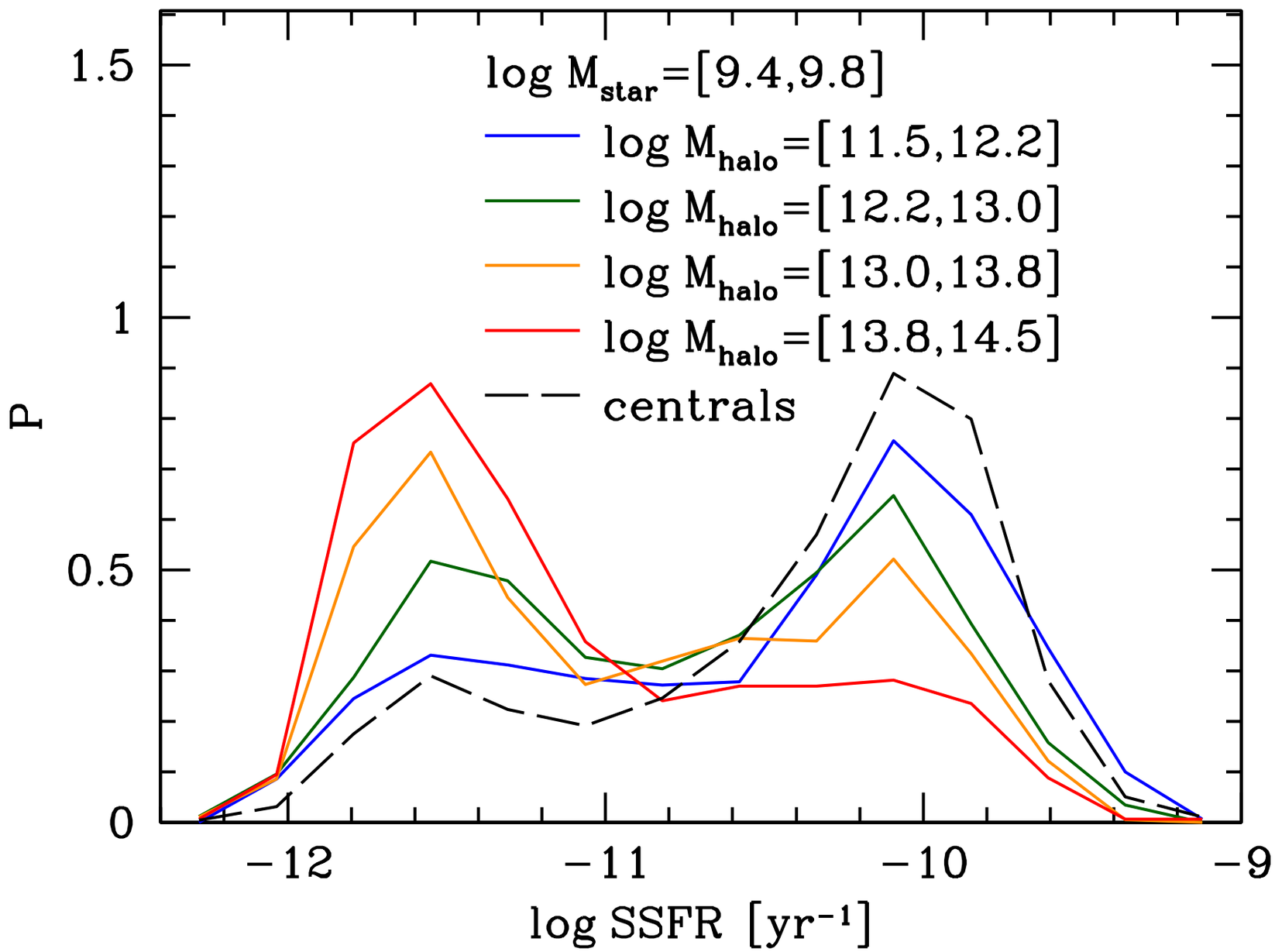
Danger of using galaxy color



Central galaxy specific star formation rate (SSFR) distribution

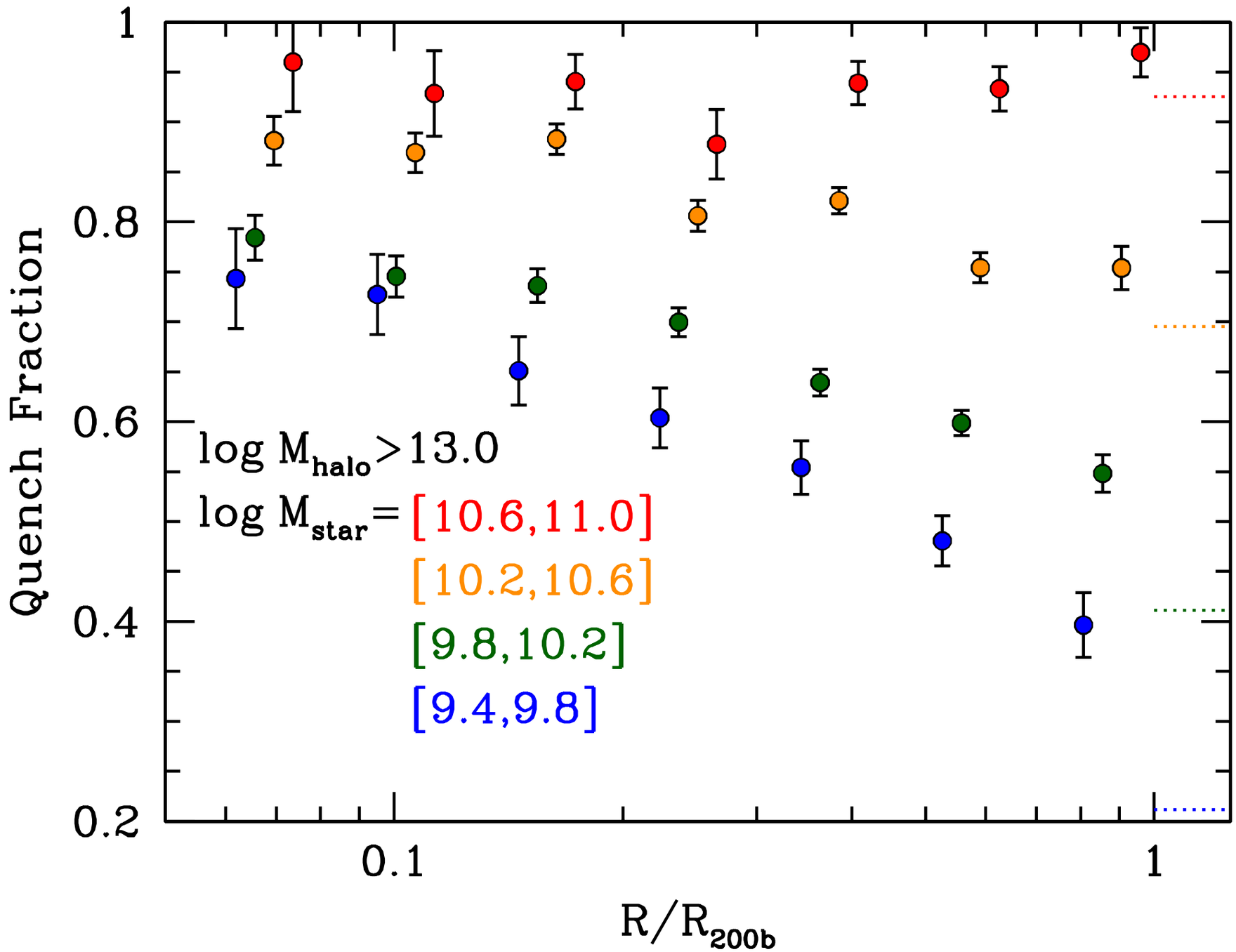


Strong group mass dependence to satellite star formation rate



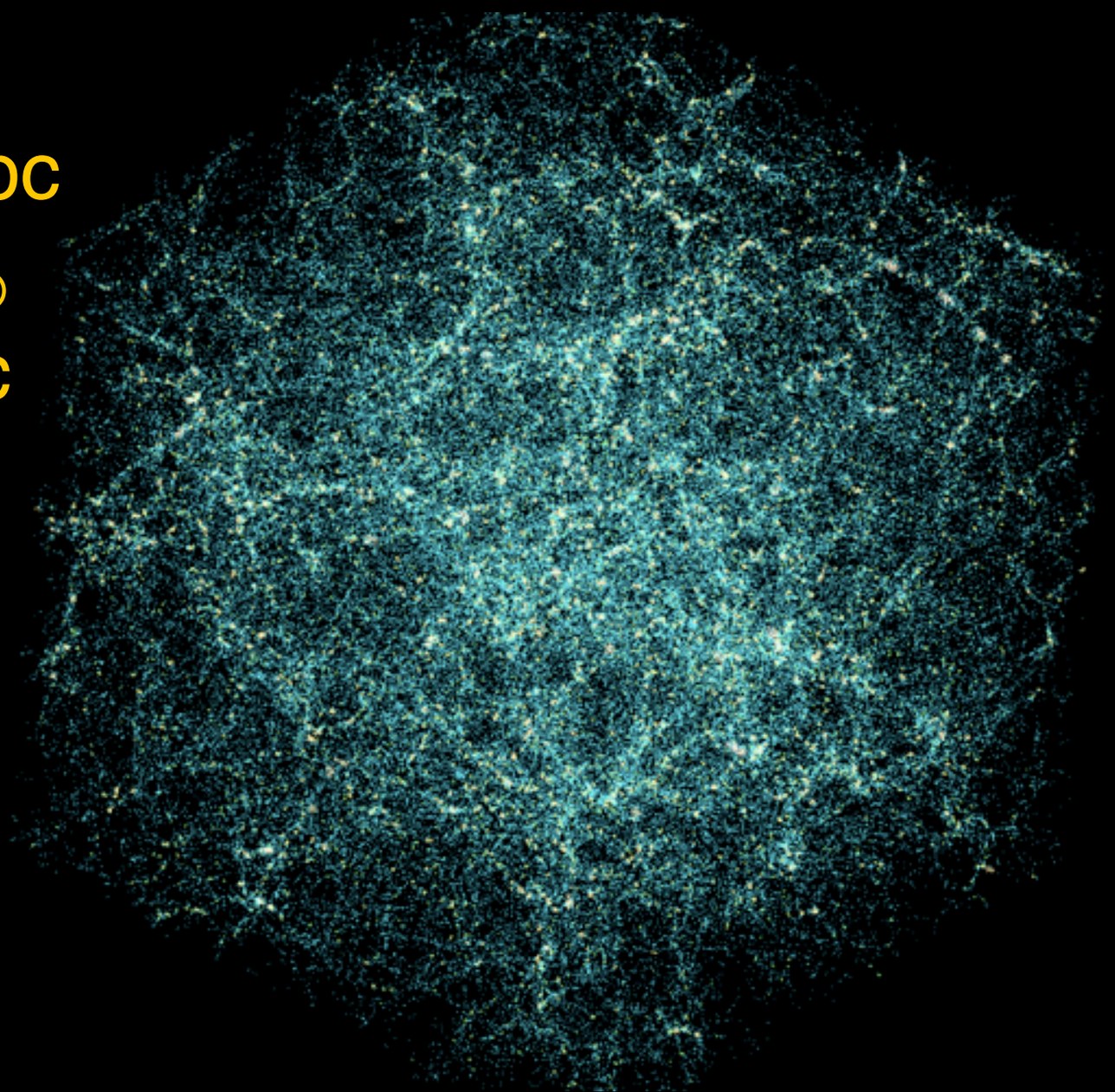
Bimodality persists at all group masses

Satellite quenched fraction depends on location in group



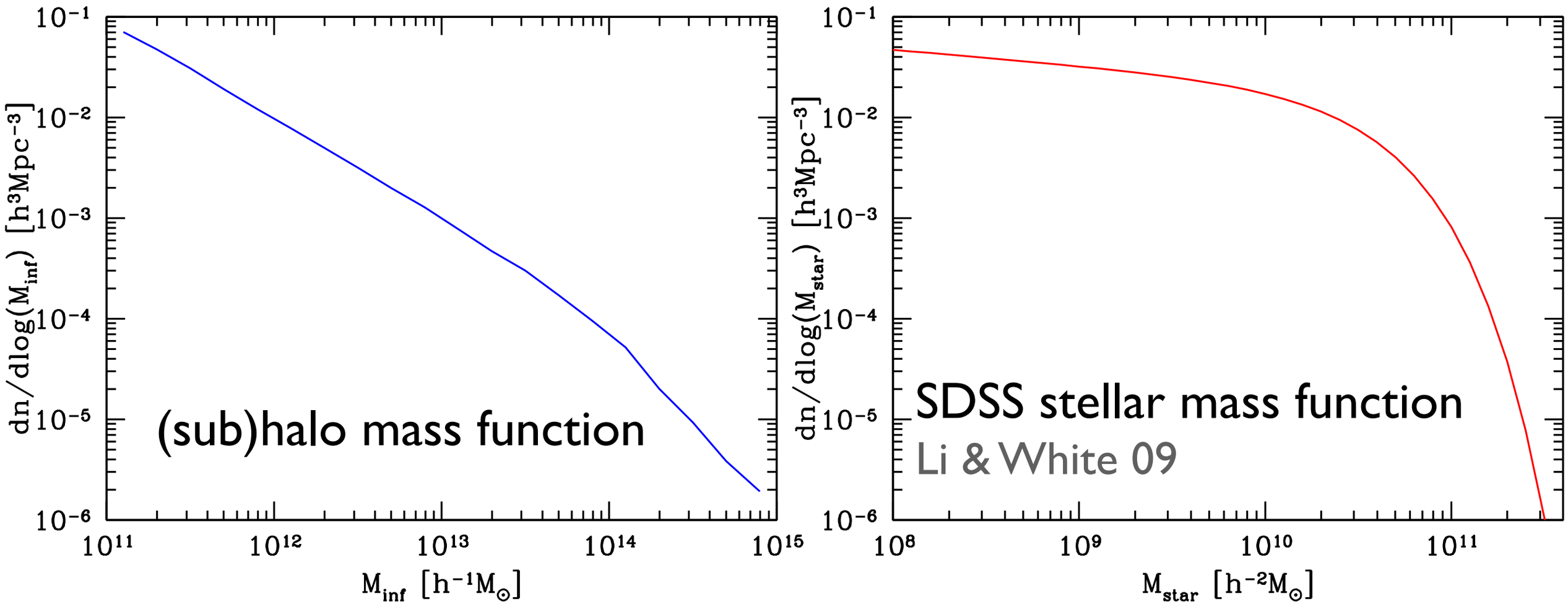
High-Resolution, Cosmological N-body Simulations

Box size	250 h^{-1}Mpc
Particle mass	10^8 $h^{-1}M_\odot$
Force resolution	2.5 h^{-1}kpc
Particle count	8.6 billion
Halo finder	FoF
Subhalo finder	FoF-6D



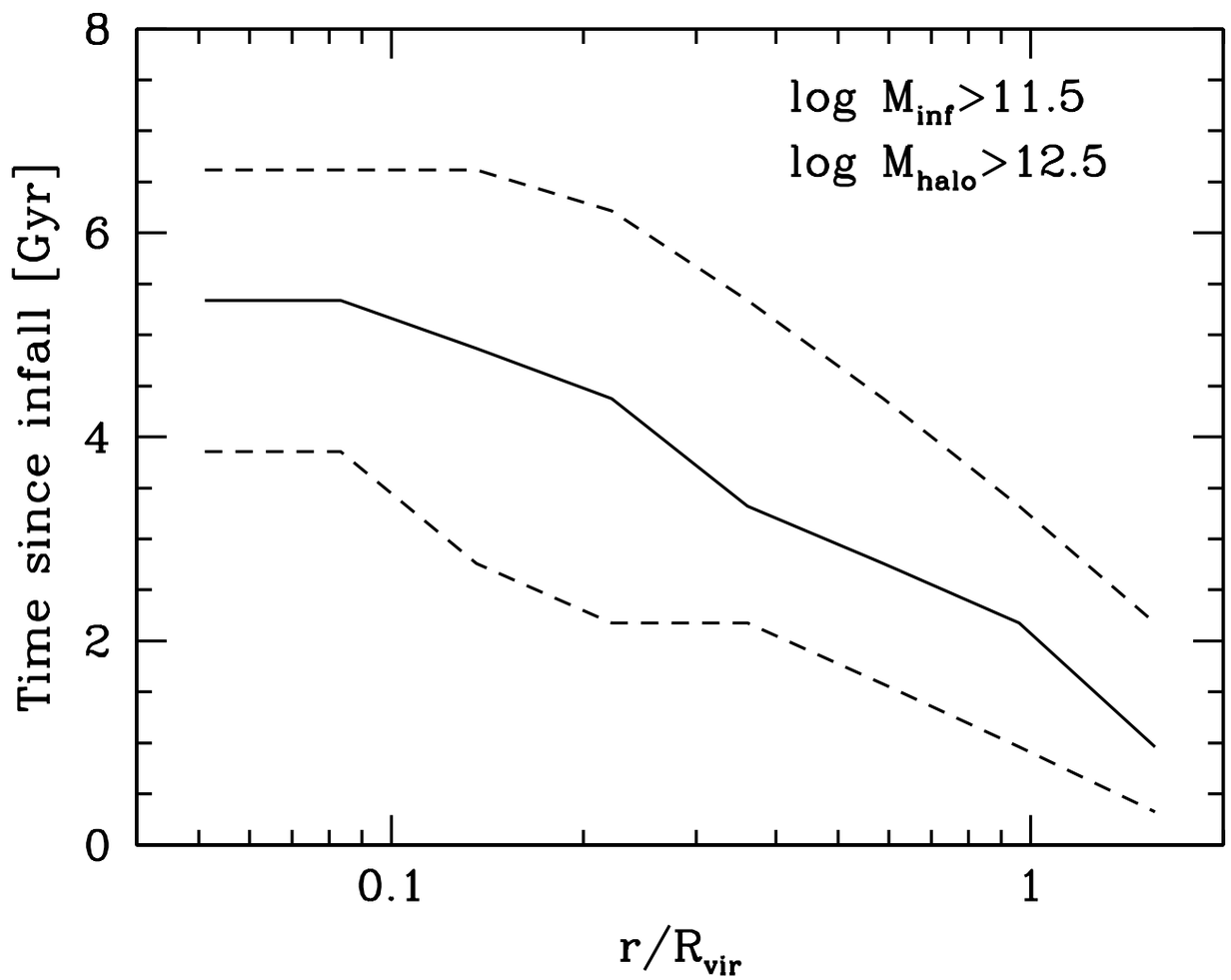
Assign stellar mass via subhalo abundance matching (SHAM)

$$n_{sub}(>M_{inf}) = n_{gal}(>M_{star})$$

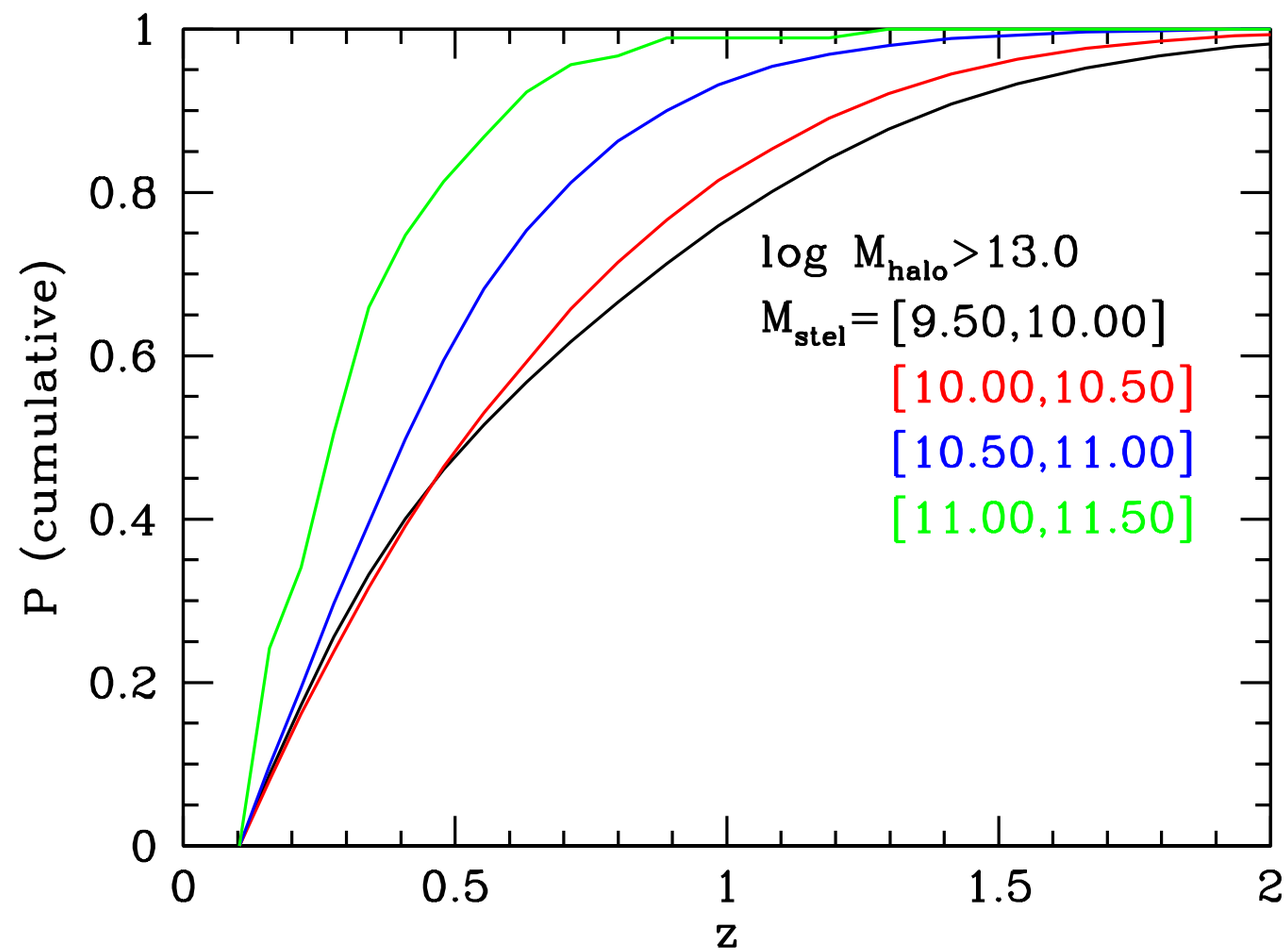


Empirically match to observed stellar mass function (with M_{star}-$M_{(sub)halo}$ scatter)

Satellite Infall Time Properties



(2D projected)



Infall time correlates with radius

Median infall redshift is z~0.5

Slow fade (strangulation) model for satellite quenching

$$SFR(t) = SFR_{inf} \exp[-(t-t_{inf})/\tau]$$

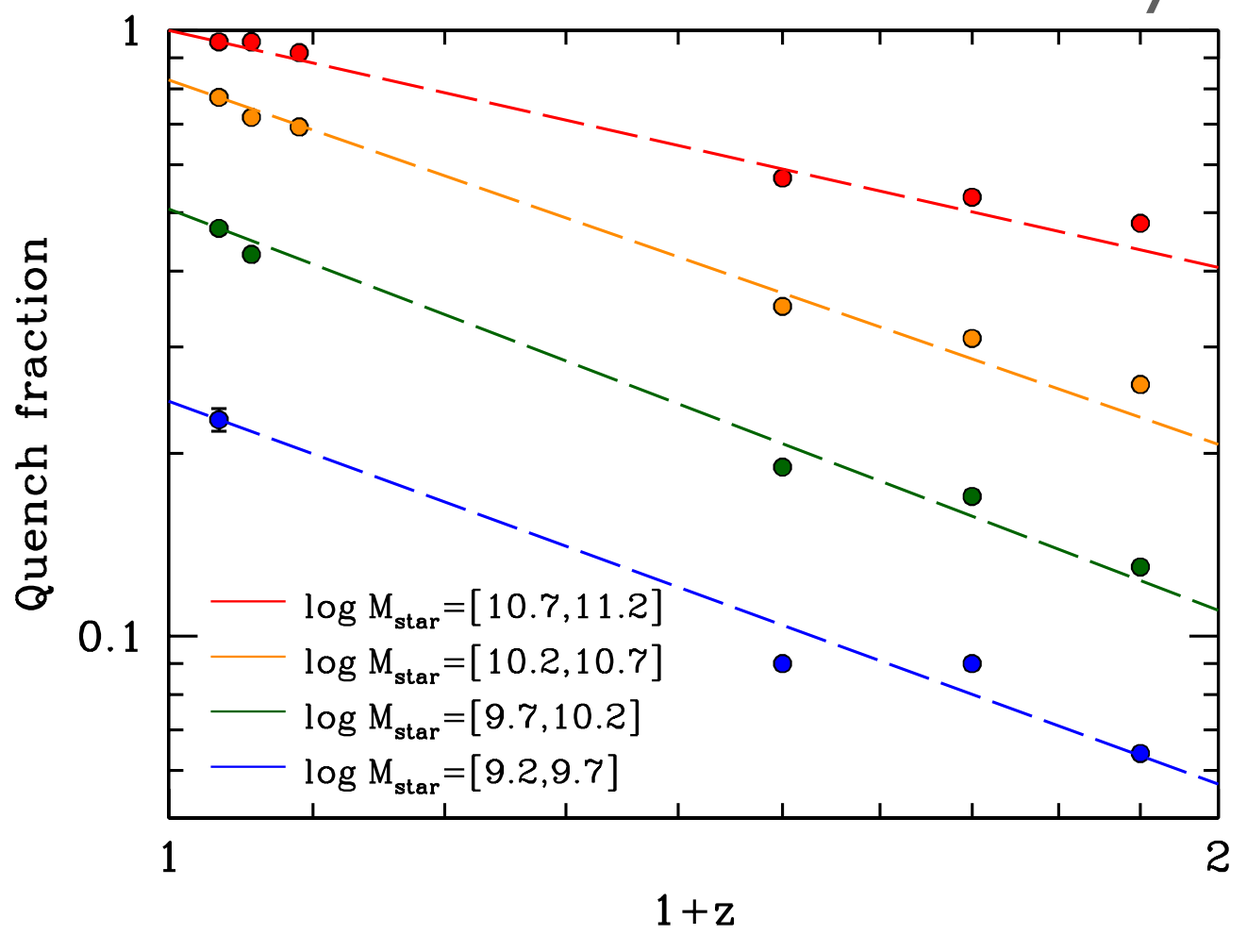
Use overall quenched fraction to constrain τ

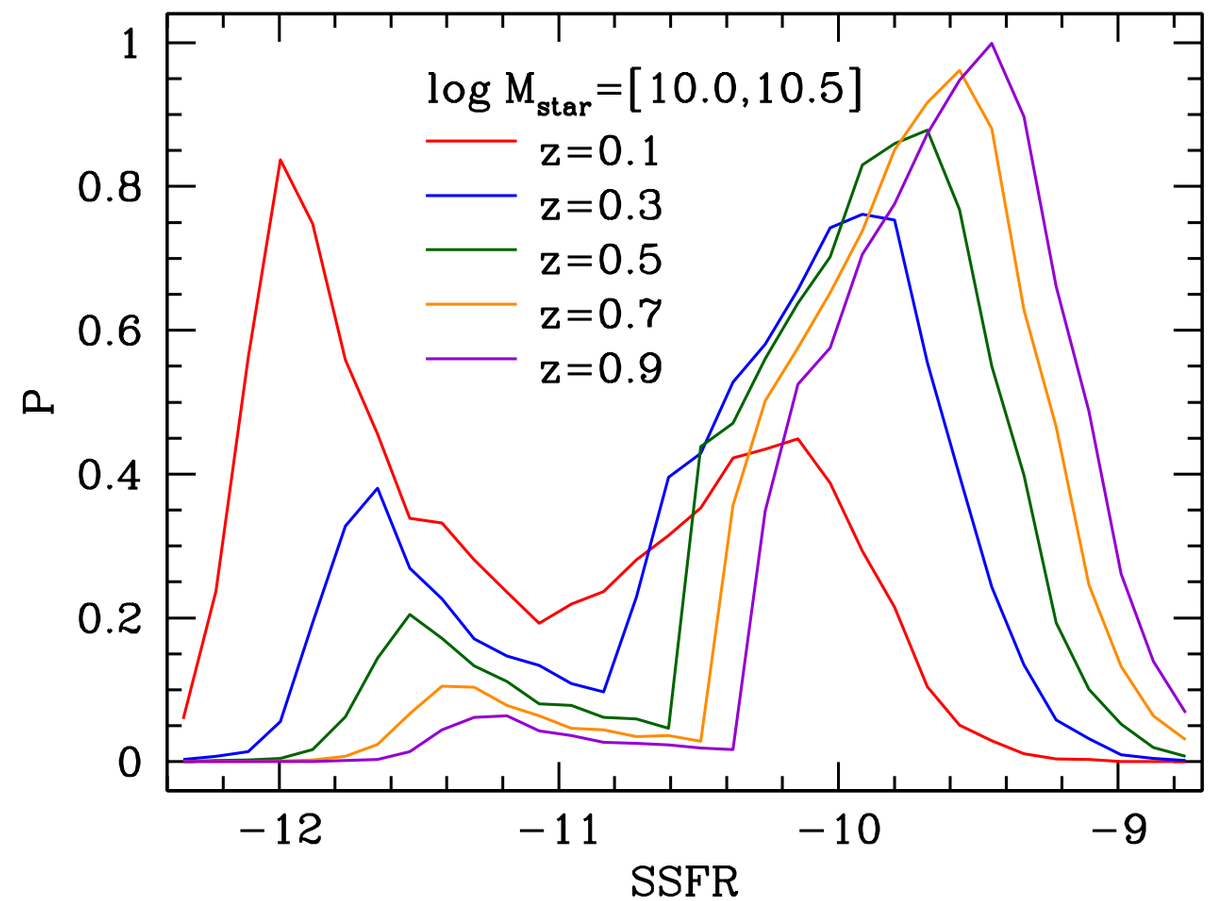
Can match quenched fraction vs. radius?

Need initial conditions of satellite star formation rate before infall

Evolution of central SFR distribution

SDSS COSMOS Drory et al. 09



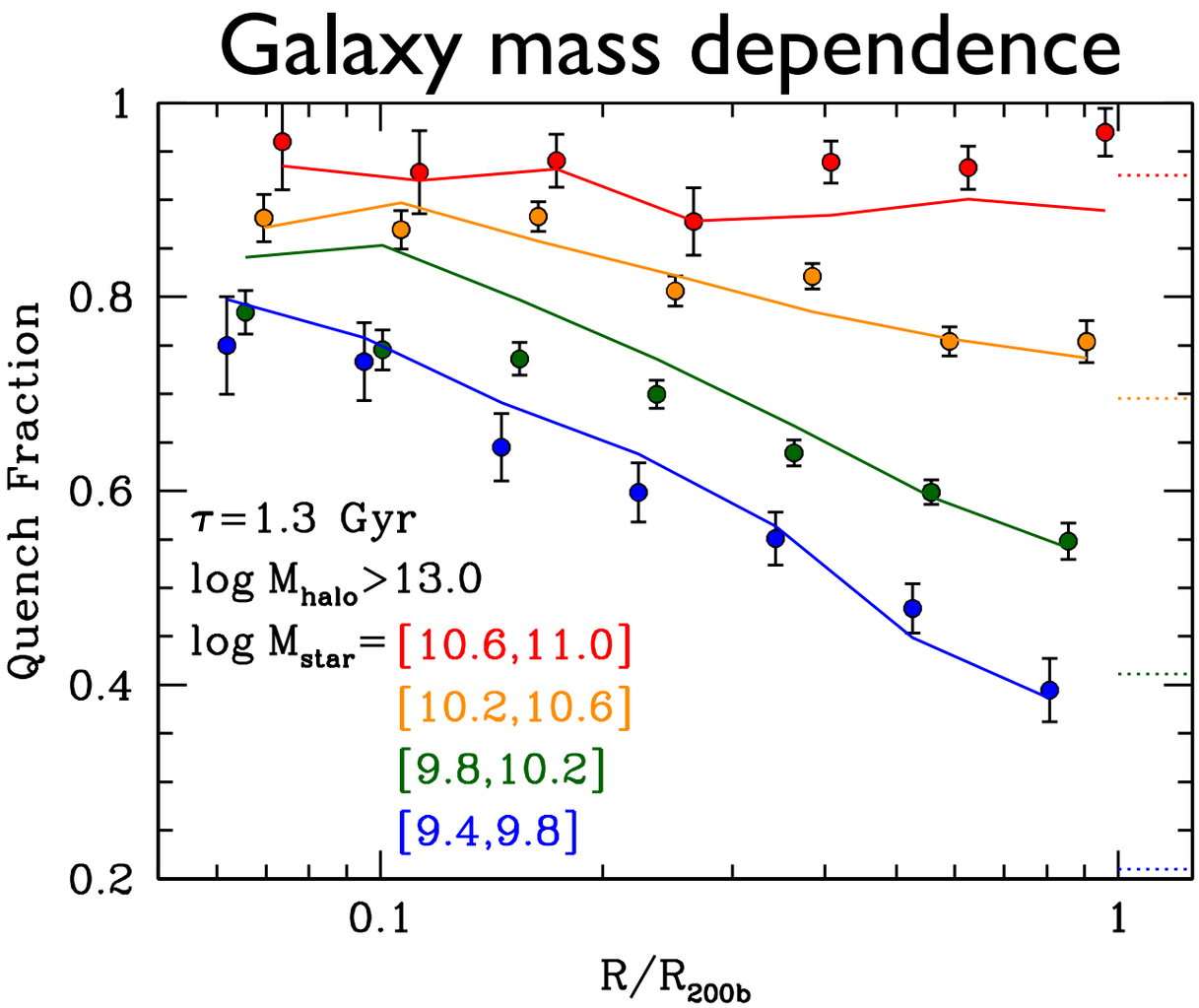


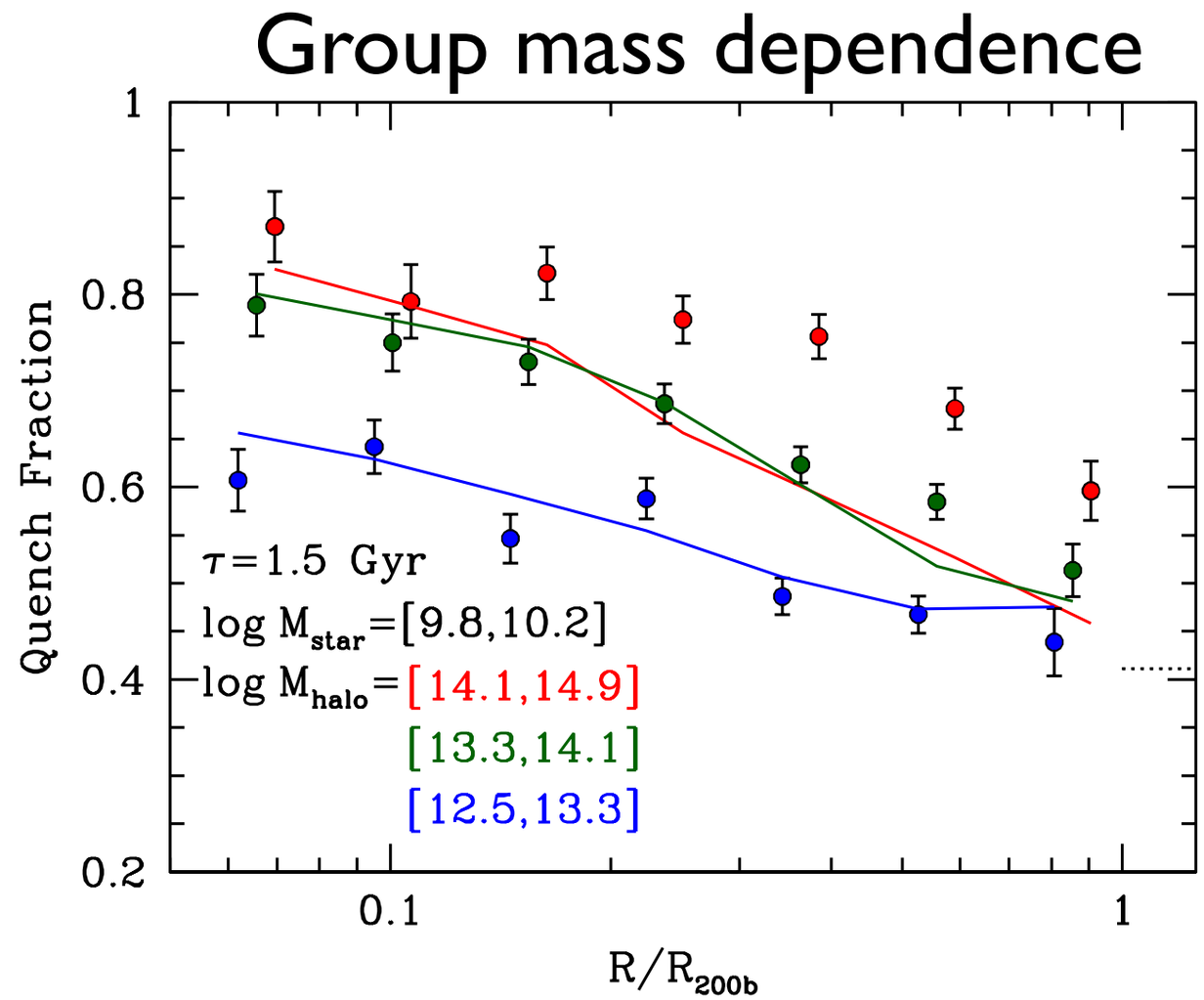
SSFR distribution width remain unchanged

Median SSFR shifted via SPS evolution model

(in agreement with DEEP2 - Noeske et al. 07)

Slow-fade Model - Quenched Profile

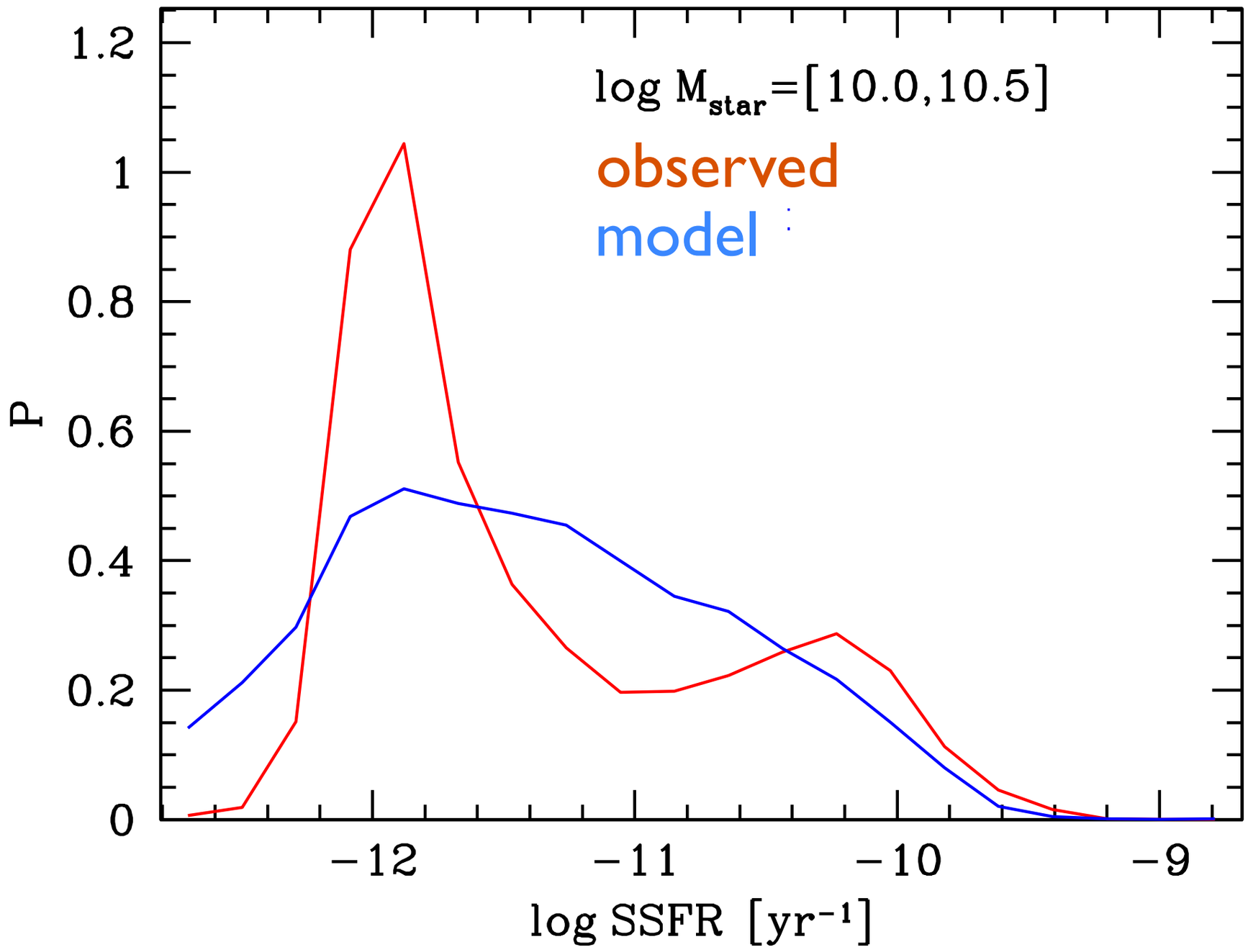




τ = 1-1.5 Gyr works well for all galaxy mass

Disagreement at high halo mass
Additional quenching mechanism?

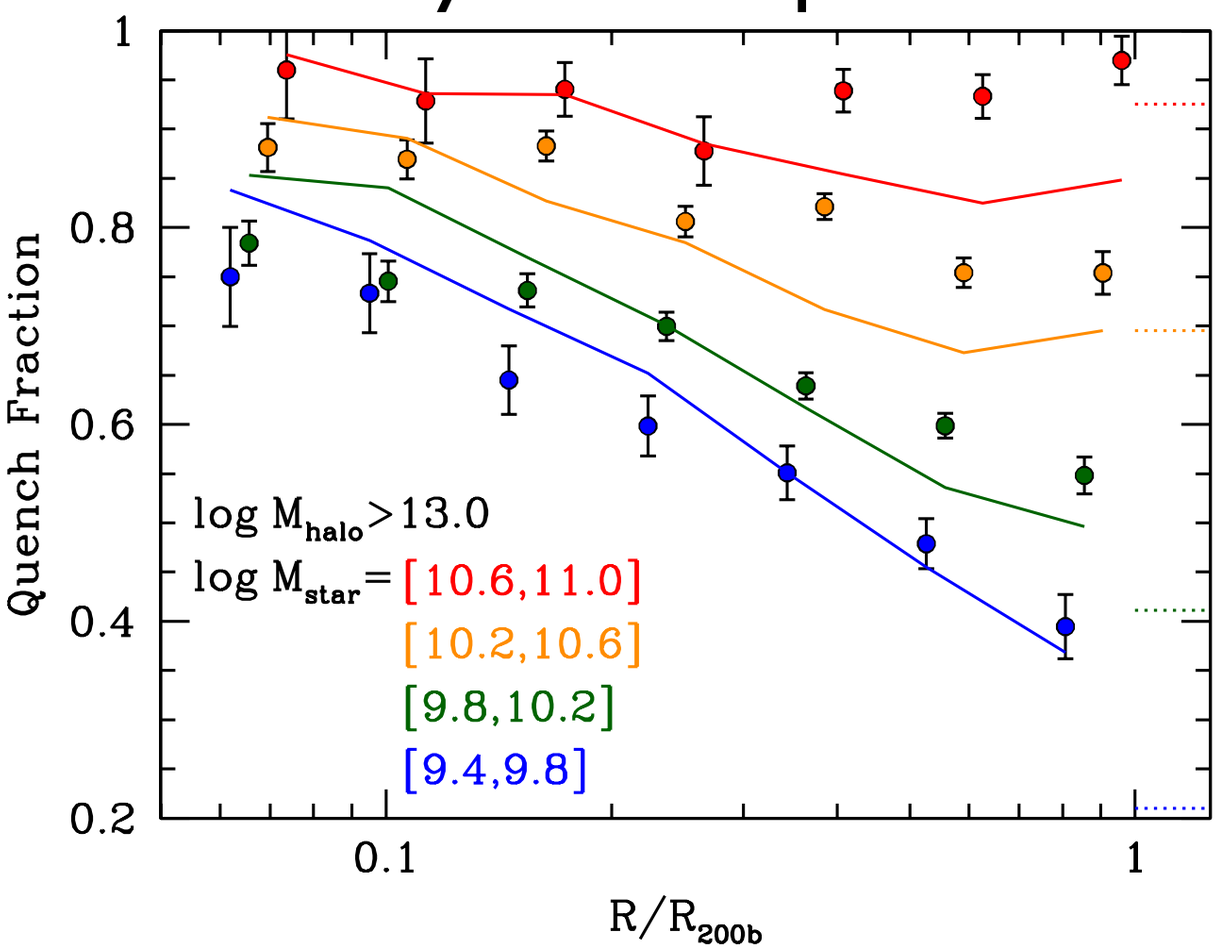
Slow-fade model cannot match satellite SFR bimodality



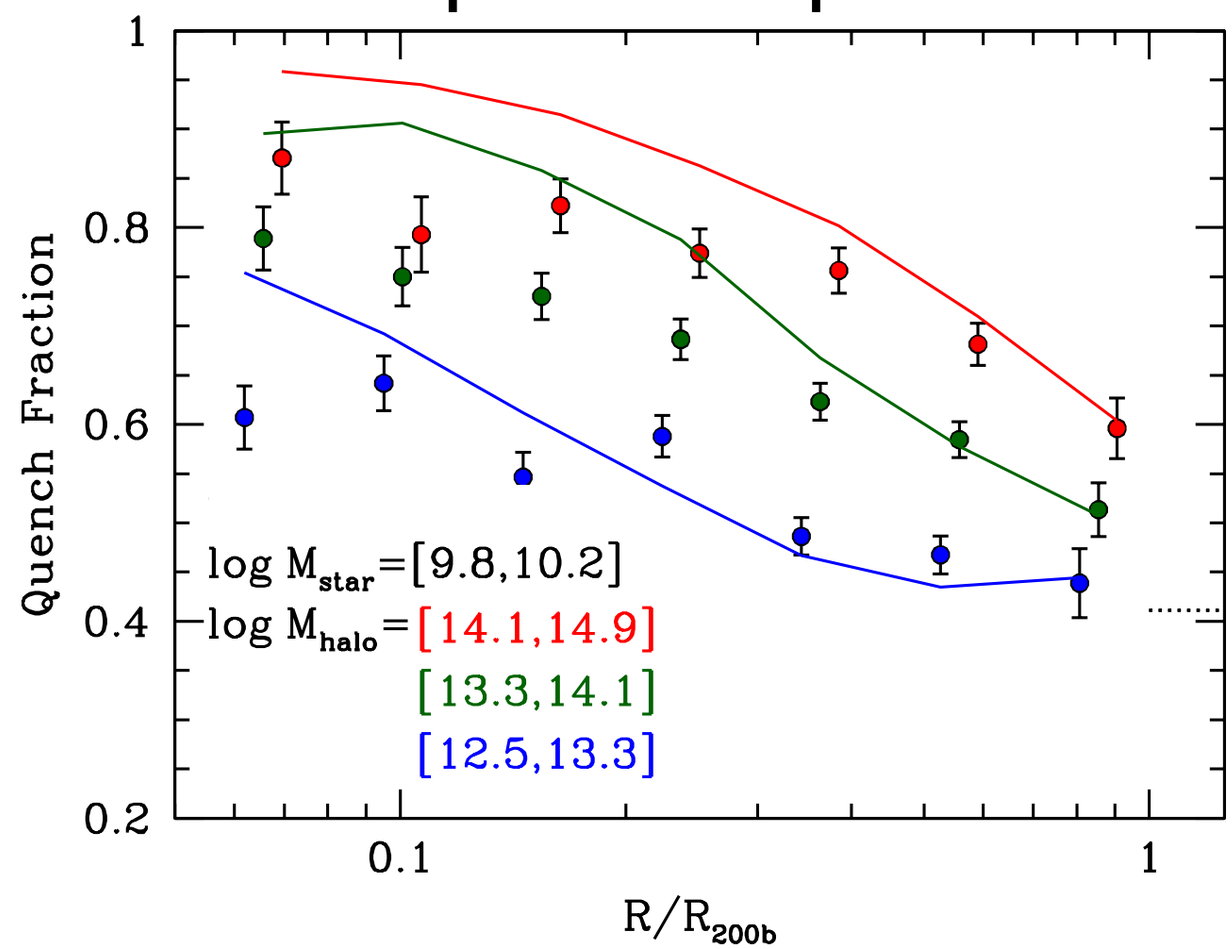
Ram-pressure Model

‘instantaneous’ quenching if $\rho_{halo} v^2 > C$

Galaxy mass dependence



Group mass dependence



Can ram-pressure be efficient in low-mass groups?

Galaxy Star Formation in Groups/Clusters

- Satellite galaxies in groups/clusters have suppressed star formation rates - more severe in more massive groups, less massive galaxies
- Satellites preserve their star formation rate bimodality - rapid quenching
- Slow-fade (strangulation) model matches quenched satellite profile, but fails to reproduce SFR bimodality
- Rapid quenching models (ram-pressure) preserve SFR bimodality, but not match quenched satellite profile as well