Satellite Galaxy Evolution in Groups & Clusters

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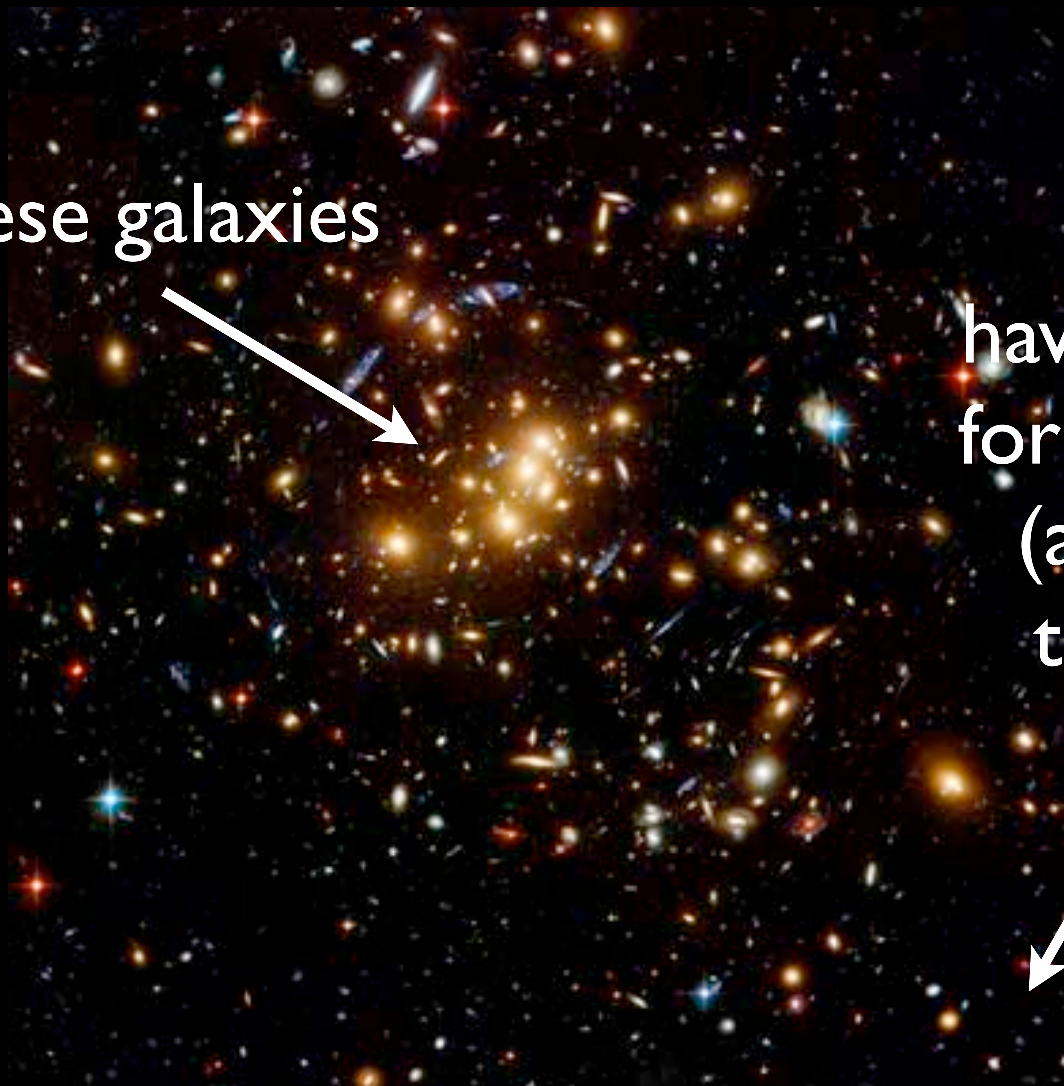
Tinker, Wetzel & Conroy 2011, ArXiv 1107.5046

Wetzel, Tinker & Conroy 2011, ArXiv 1107.5311

Wetzel, Tinker & Conroy, in prep



Why do these galaxies

have lower star
formation rates
(are redder)
than these?

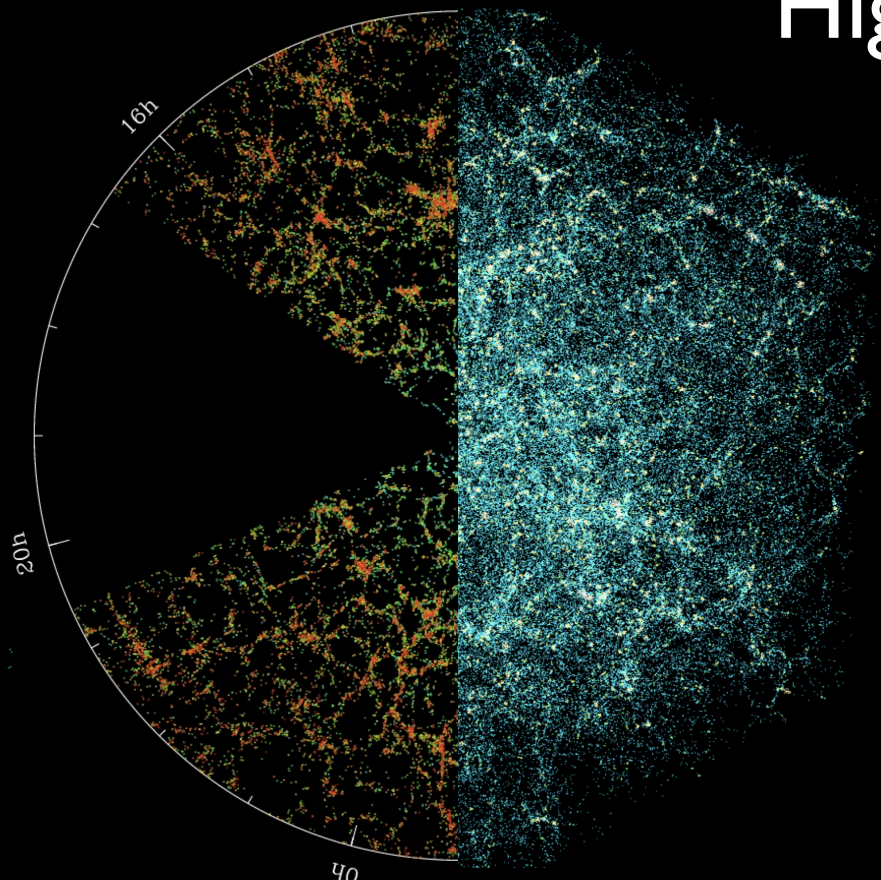
Galaxy Group Catalog

SDSS Data Release 7, NYU value-added catalog Blanton++2004

Spectroscopically derived star formation rates Brinchmann++2004

Group finding based on the Yang++2007 algorithm

High purity & low contamination (~15%), calibrated against mocks



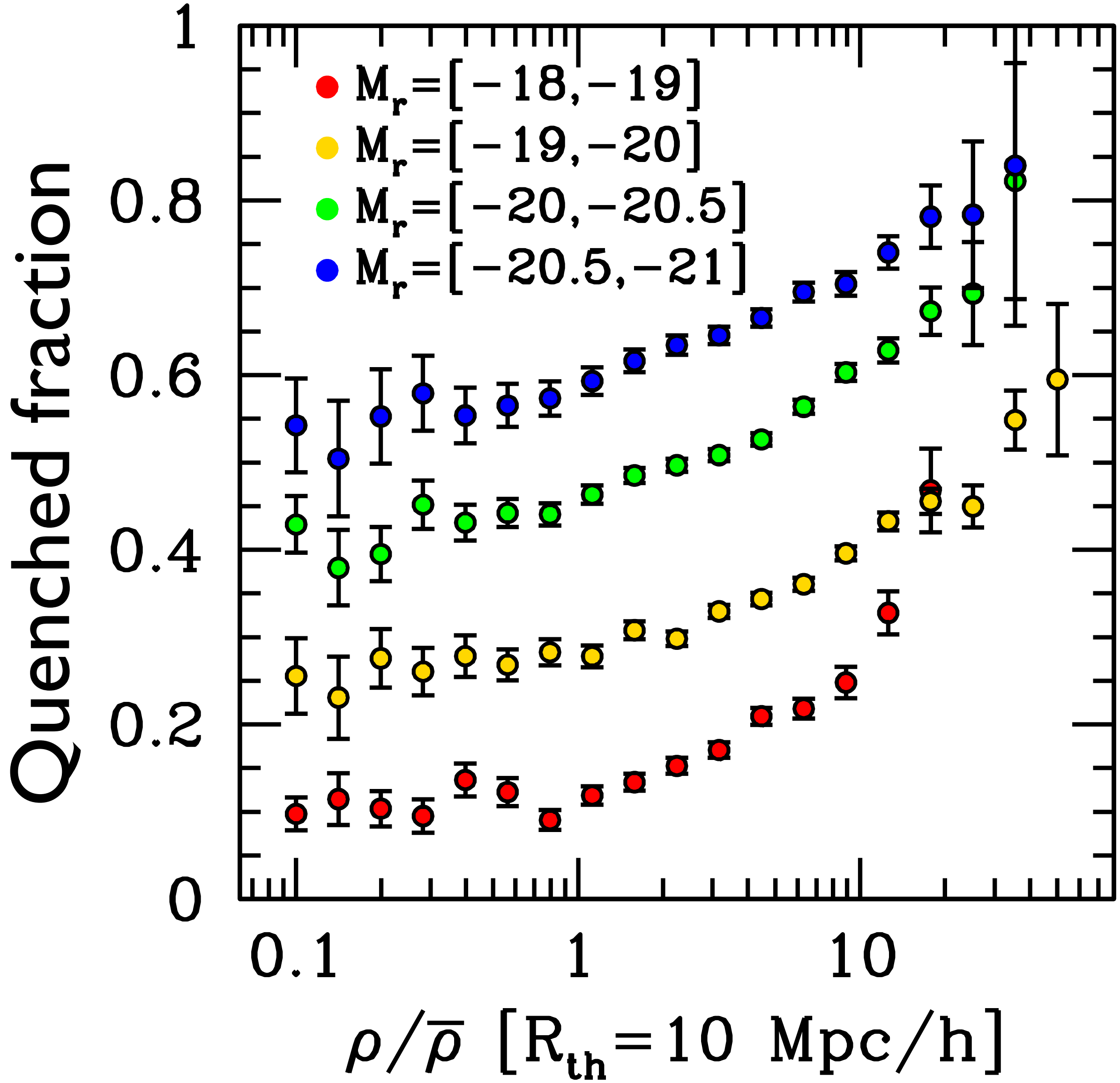
High-Resolution, Cosmological *N*-body Simulation

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

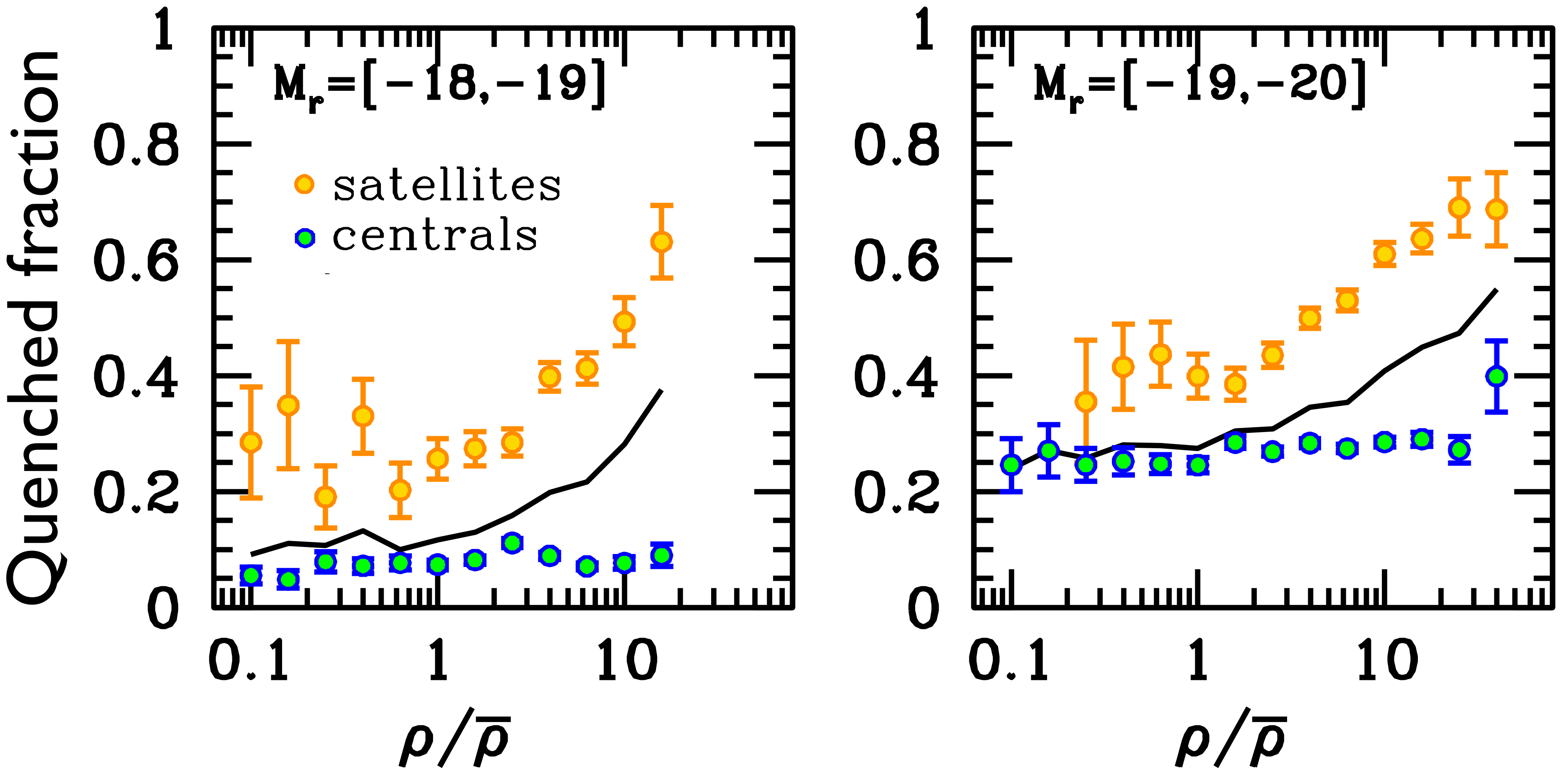
Stellar mass from subhalo abundance matching

Group finder applied to simulation

Understanding the environmental dependence of galaxy star formation

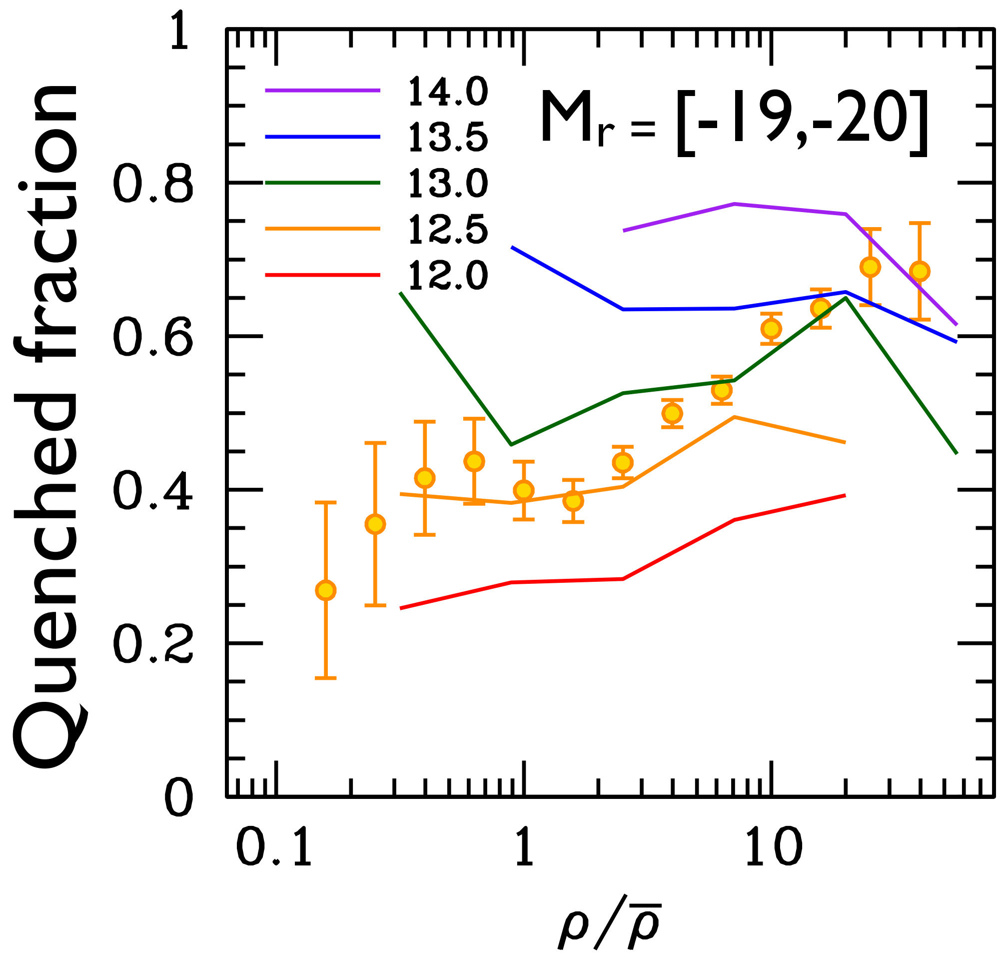


Understanding the environmental dependence of galaxy star formation



Environmental dependence = satellites

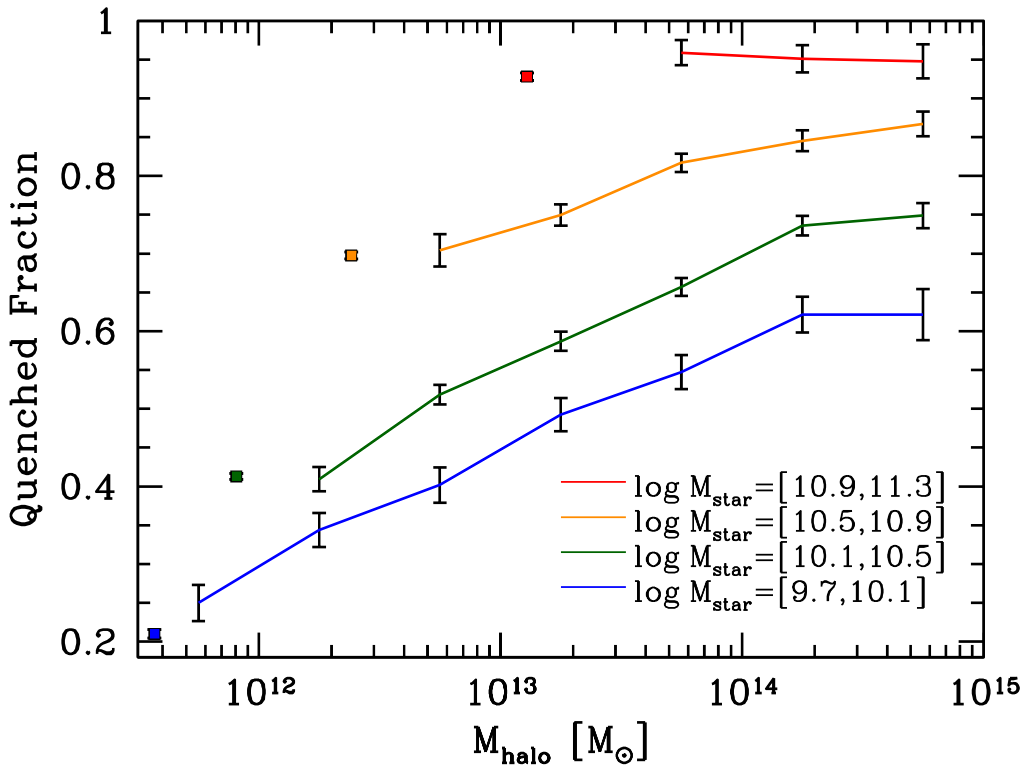
Understanding the environmental dependence of galaxy star formation

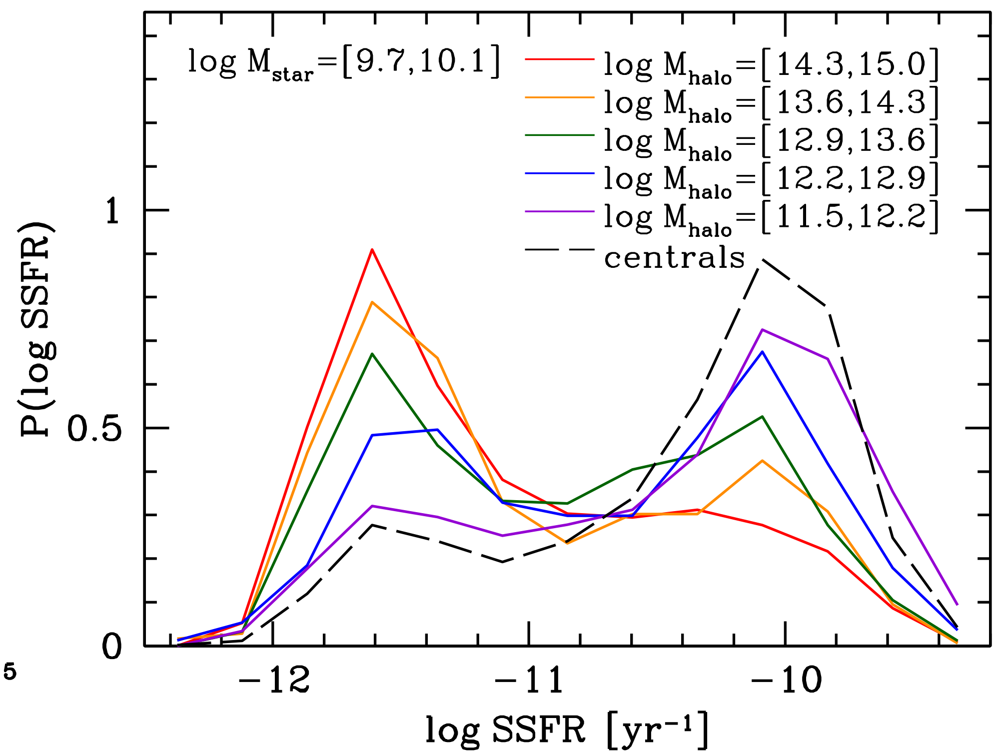


Environmental dependence = satellites in different mass halos

see also
Hogg++2004
Kauffmann++2004
Blanton++2005
Blanton & Berlind 2007
Wilman++2010
Peng++2010, 2011
Joanna Woo's talk

Strong halo mass dependence of satellite quenched fraction





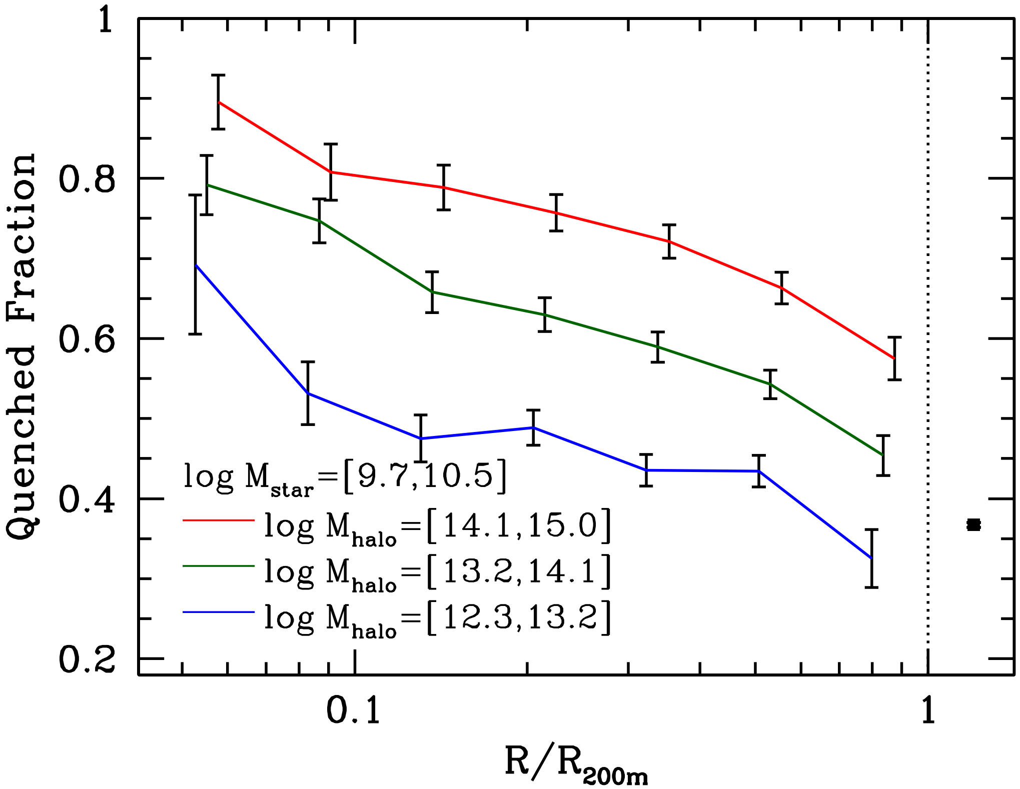
But, SSFR bimodality persists at all halo masses

SFR is not affected for active satellites

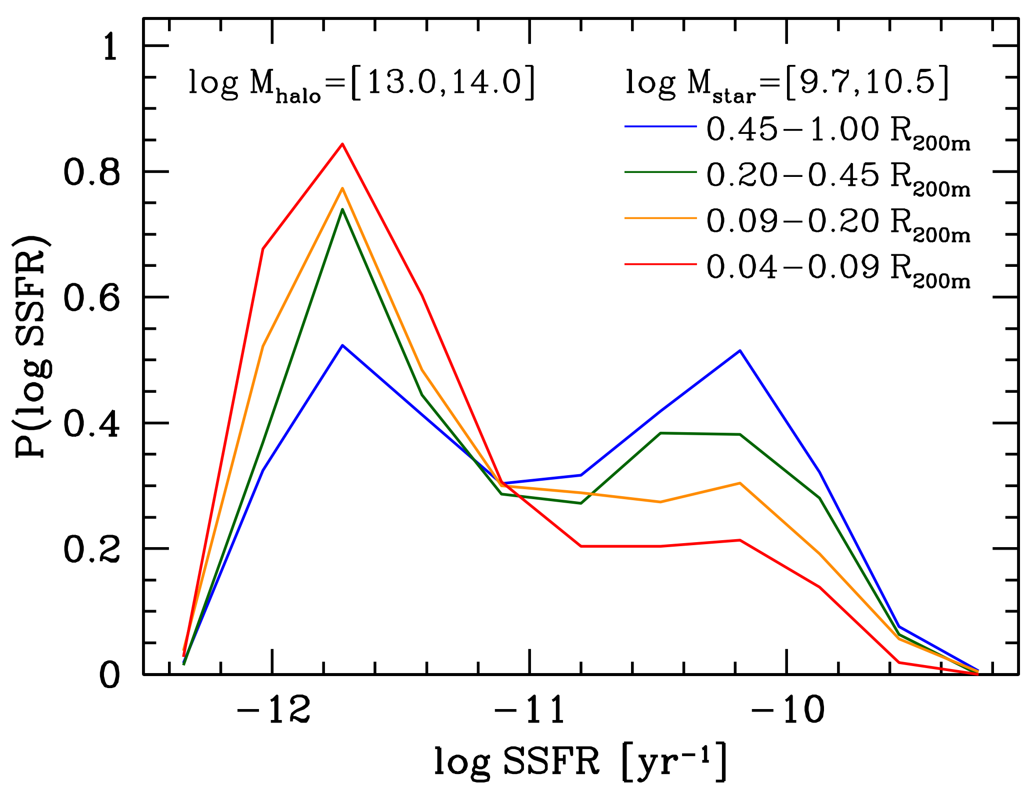
No lower halo mass threshold

Brinchmann++2004, Kauffmann++2004, Weinmann++2006, Kimm++2009, Peng ++2011, Pasquali++2010

Strong dependence on halo-centric radius



Quenching not simply dependent on current, local halo density

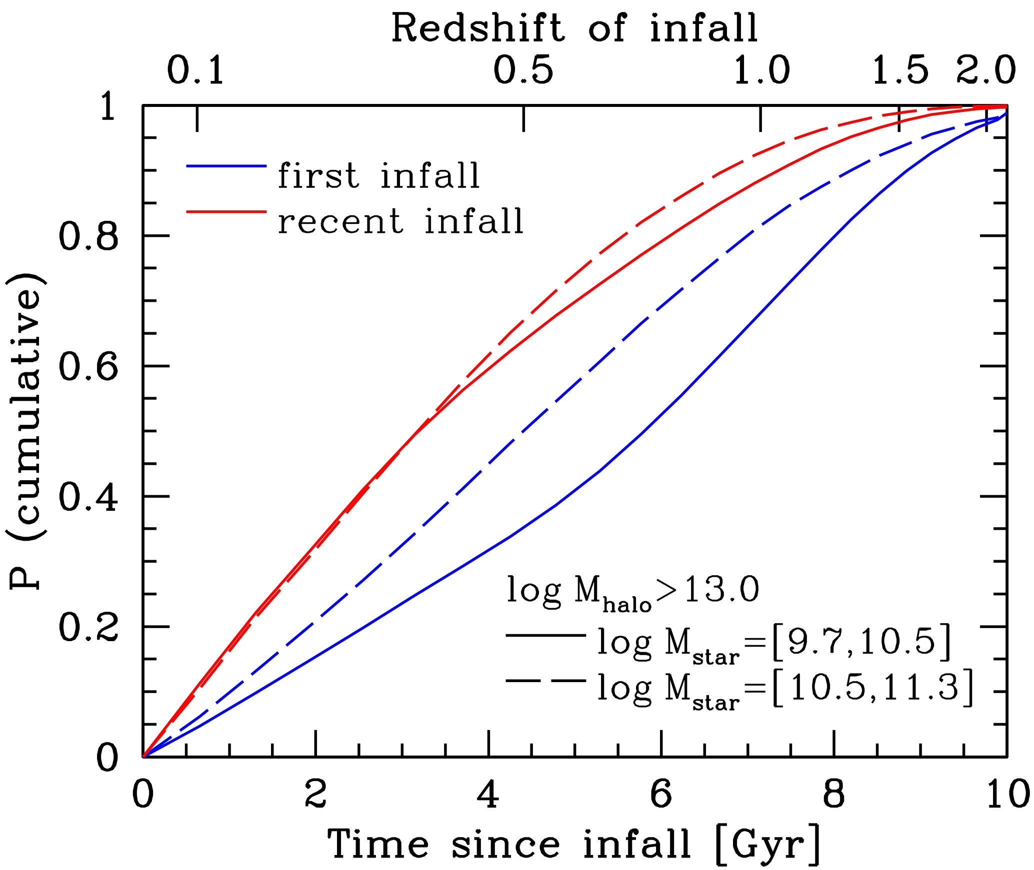


SSFR bimodality persists at all radii

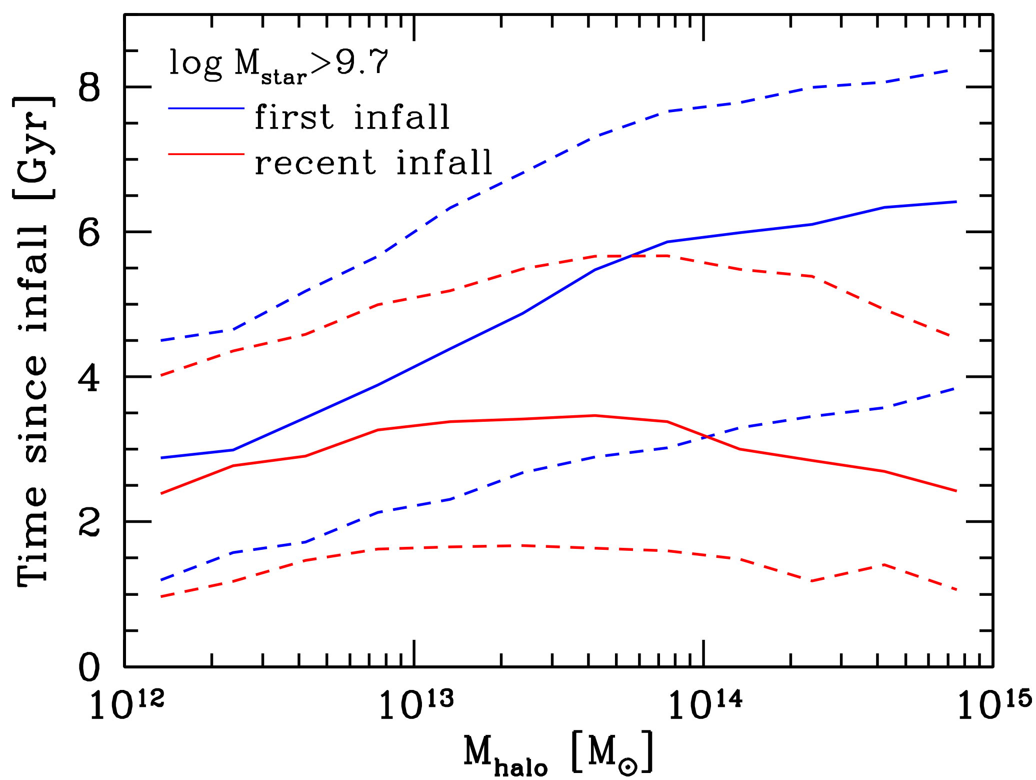
De Propris++2004, Blanton & Berlind 2007, Hansen++2009, Balogh++2000, Ellingson++2001, Weinmann++2006, von der Linden++2010, Prescott++2011, van den Bosch++2008, Pasquali++2009

Satellite infall times
&
SFR initial conditions

Satellite Infall Times



Median infall redshift is z~0.5



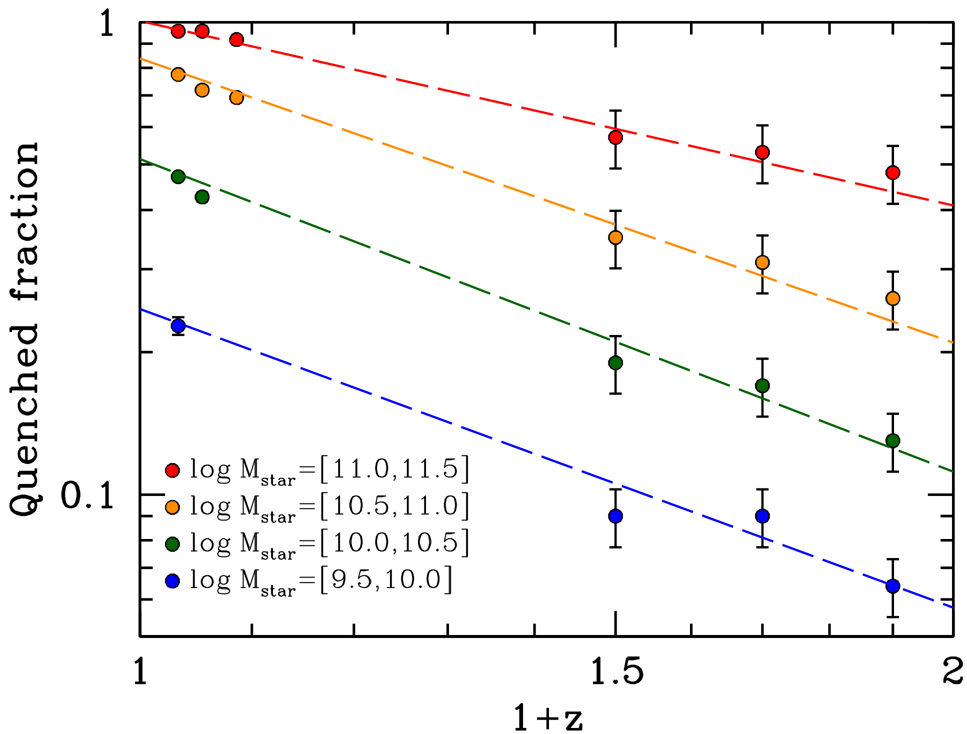
Importance of group pre-processing & ejection/re-infall

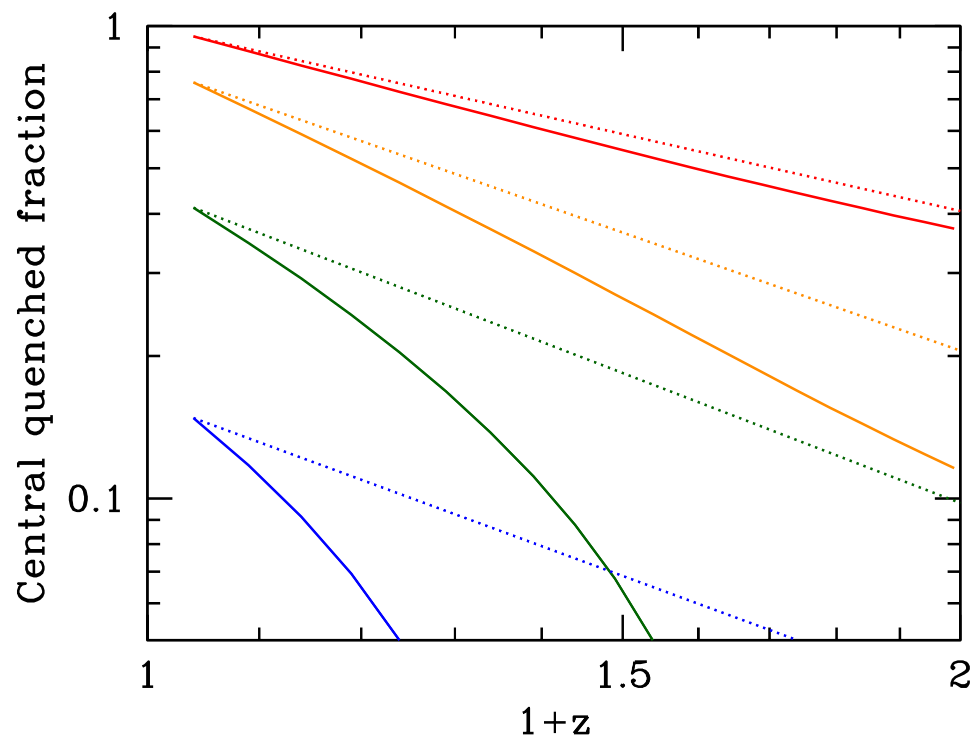
Understanding satellite quenching requires knowing central galaxy SFRs to z ~ 1

e.g., Berrier++2009, McGee++2009, Gill++2005, Ludlow++2009, Wang++2009

Evolution of central galaxy SFR

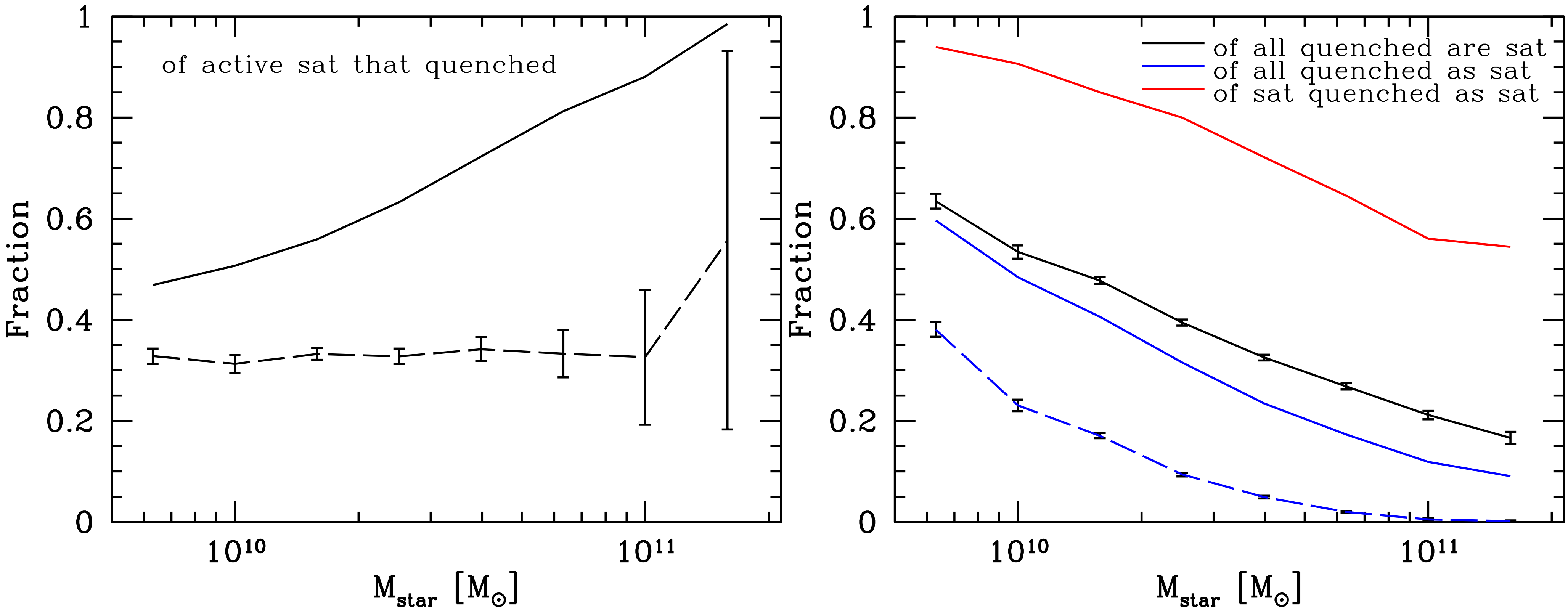
SDSS COSMOS Drory et al. 09





Tinker & Wetzel 2010

Importance of satellite quenching



Satellite quenching is more efficient/rapid in more massive satellites

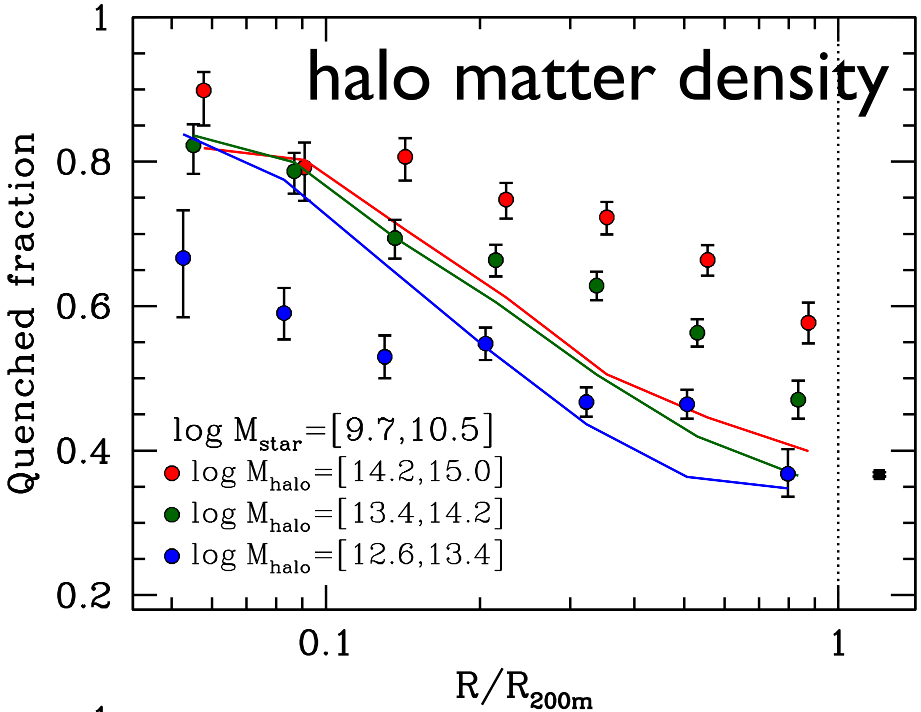
But, more galaxies quenched as satellites at lower mass

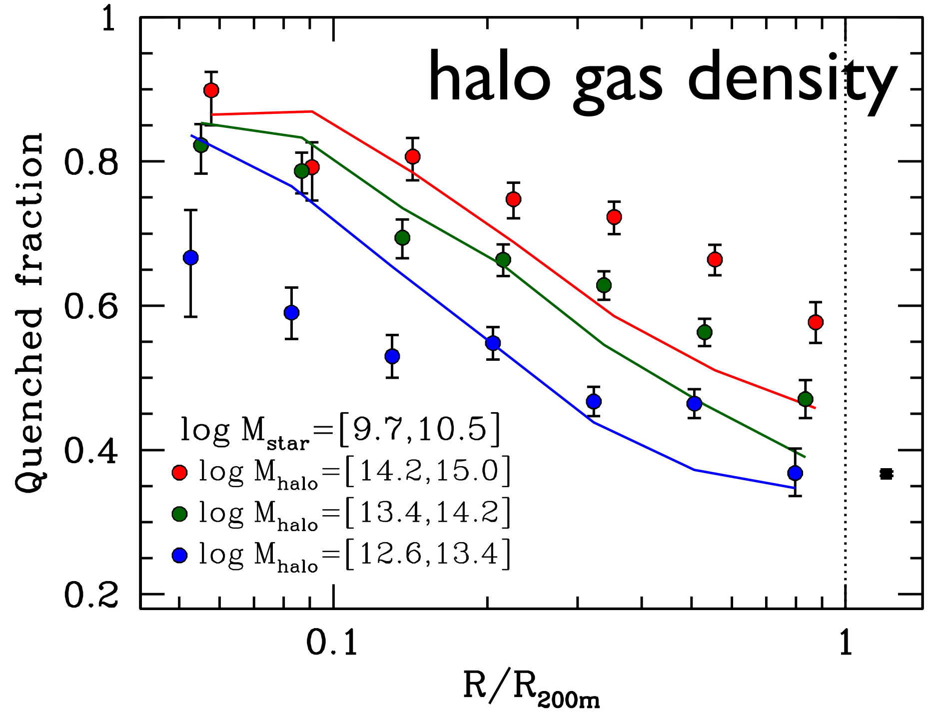
Majority of quenched galaxies quenched as satellites at $M_{star} < 10^{10}\, M_\odot$

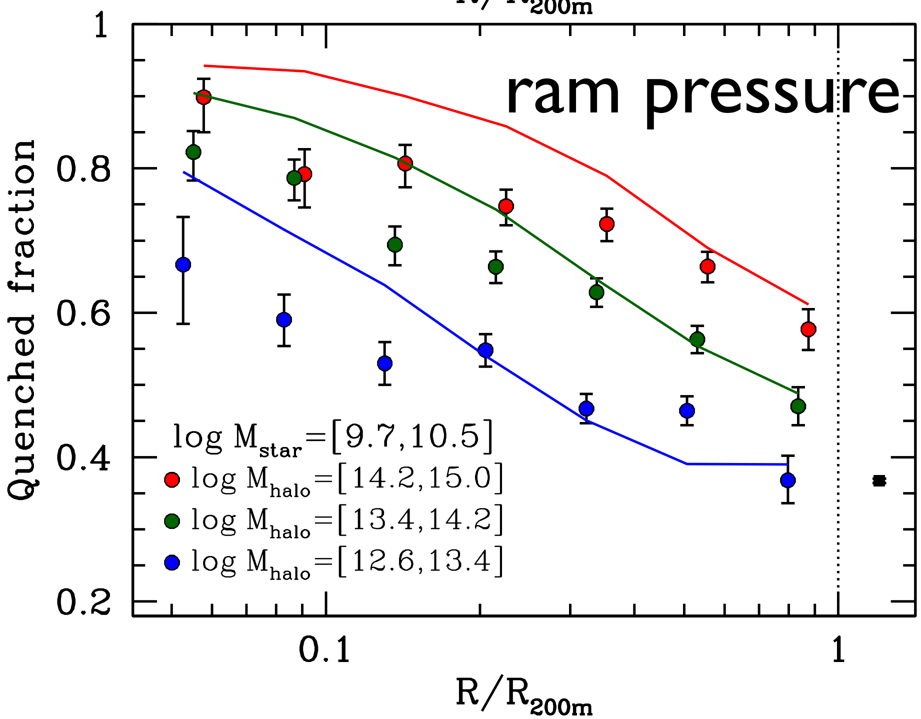
e.g., van den Bosch++2008

Testing Timescales & Mechanisms for Satellite Quenching

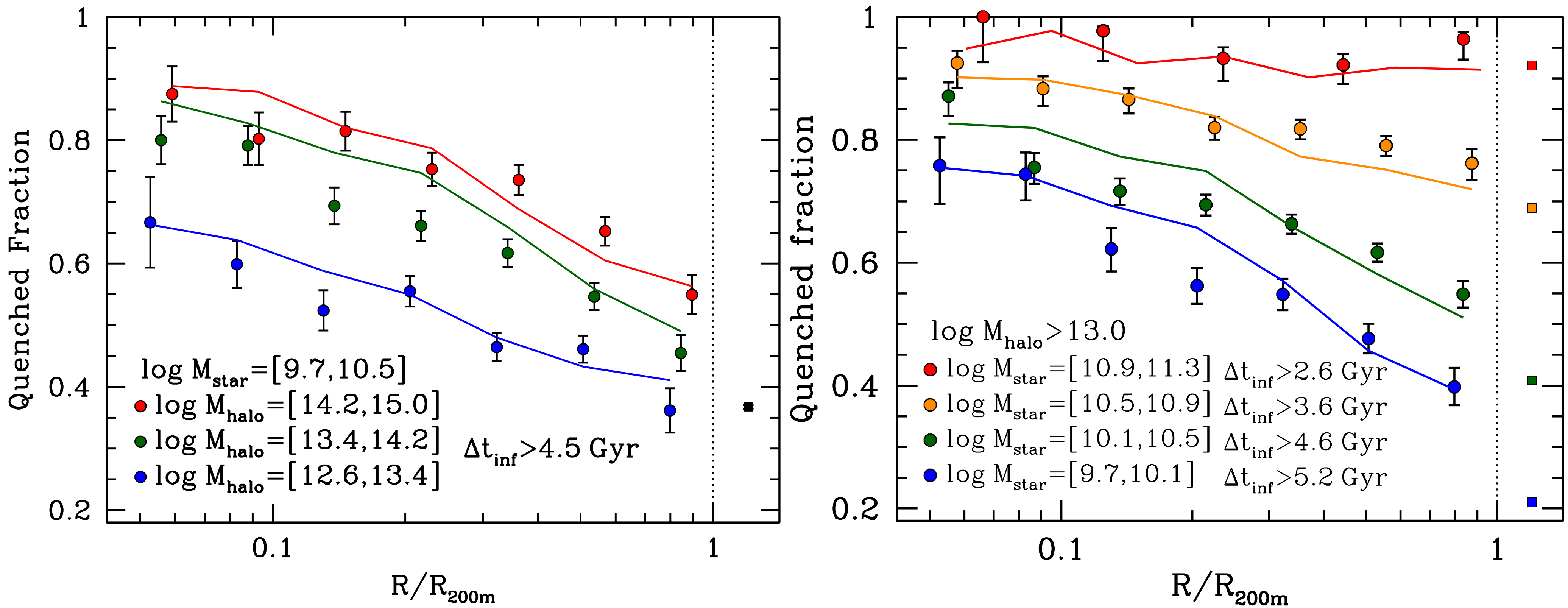
Threshold for quenching based on...







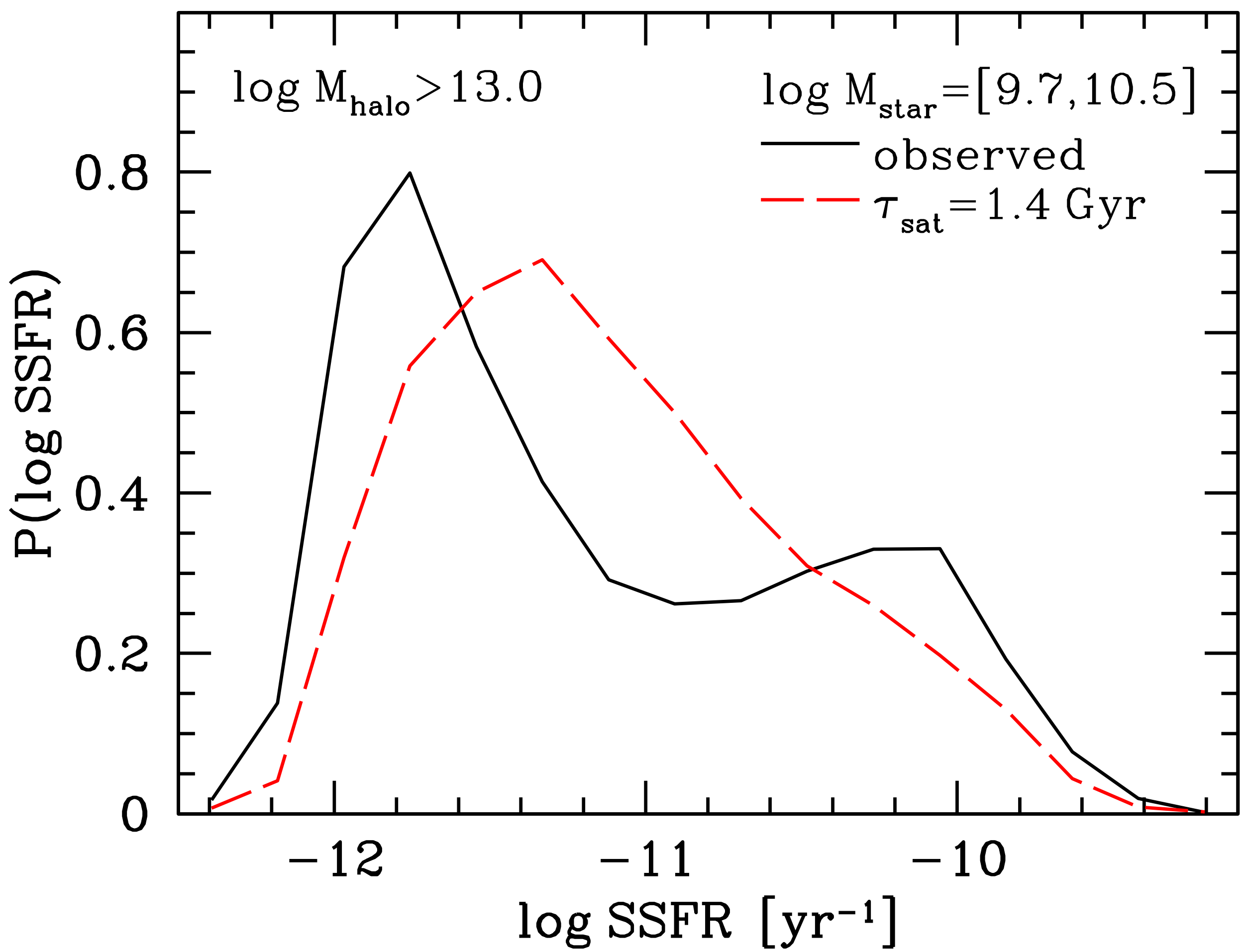
Satellite quenching best correlates with time since infall



Higher mass satellites quench faster

SFR fading timescales

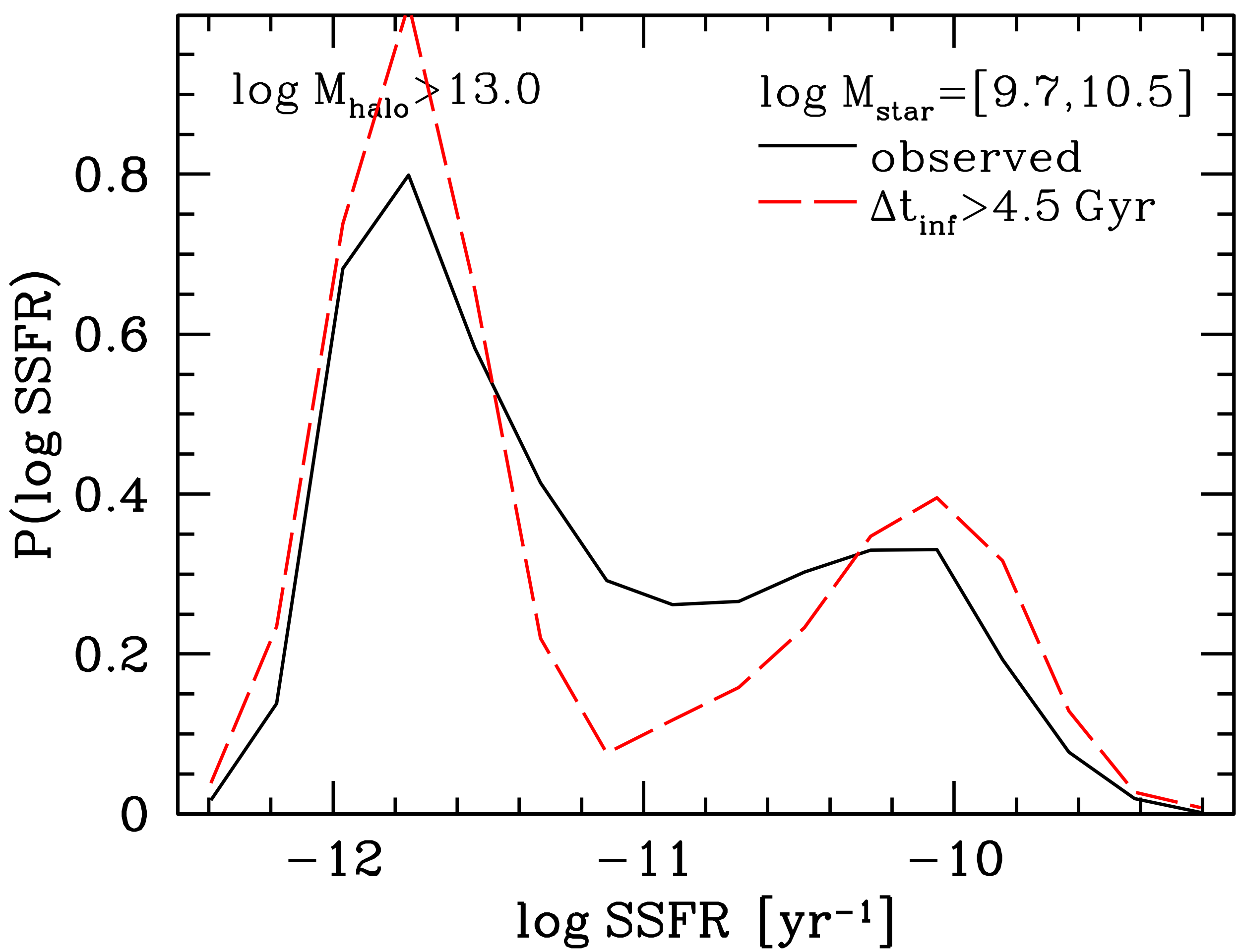
$$SFR(\Delta t_{inf}) = SFR_{inf} \exp[-\Delta t_{inf}/\tau]$$



SFR fading timescales

$$\mathrm{SFR}(\Delta t_{inf}) = \mathrm{SFR}_{cen}(\Delta t_{inf}) \qquad \Delta t_{inf} < \Delta t_o$$

$$\mathrm{SSFR}(\Delta t_{inf}) \sim 10^{-12}\ \mathrm{yr}^{-1} \qquad \Delta t_{inf} > \Delta t_o$$



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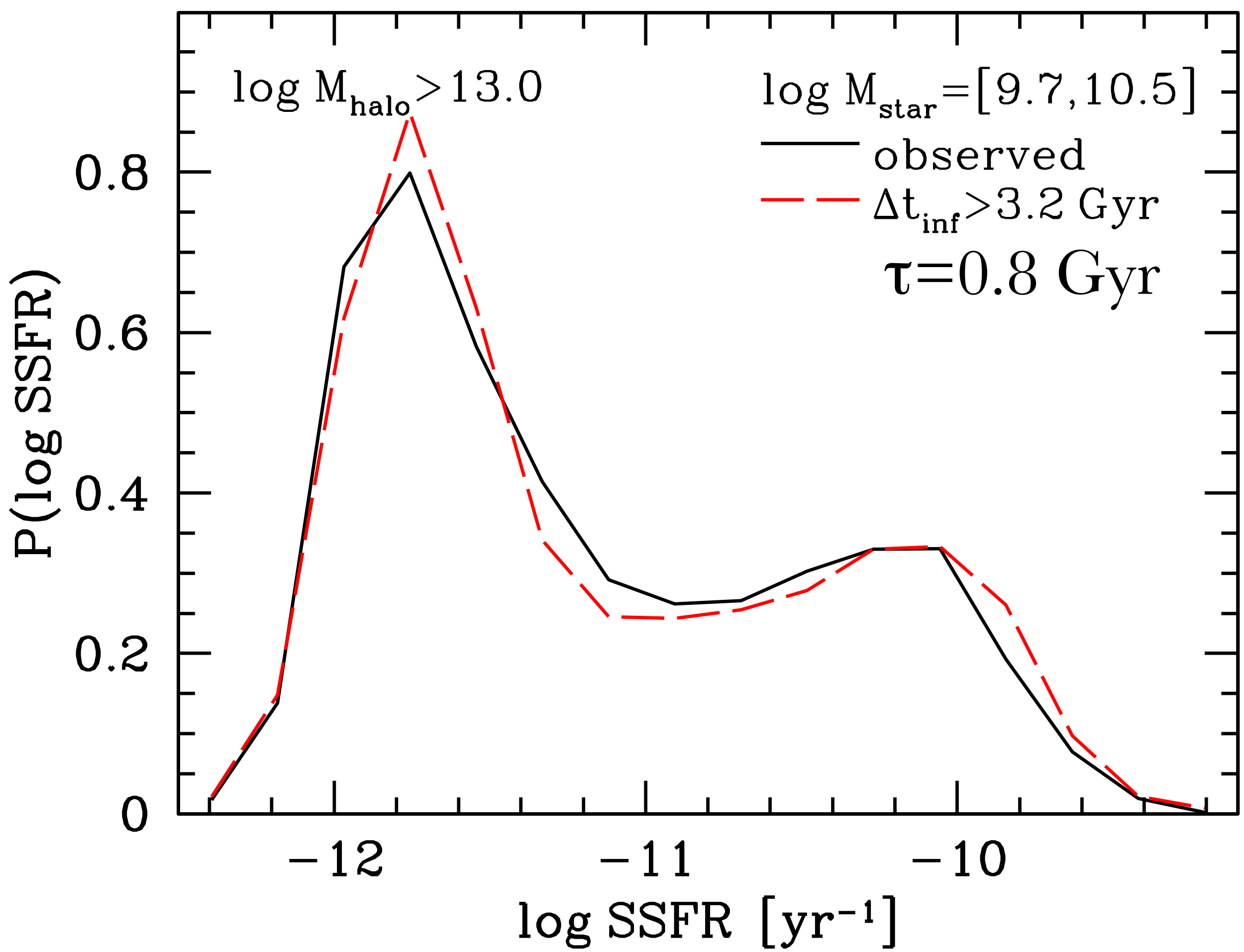

Satellite Galaxy Evolution in Groups & Clusters

- Satellite galaxies drive environmental SFR trends
- Satellite quenching responsible for most quenched/red-sequence galaxies at $M_{star} < 10^{10} M_{\odot}$
- Satellite quenched fraction increases with halo mass (no lower halo mass threshold) and toward halo center
- Satellites preserve SFR bimodality: delayed (2.5-5 Gyr) then rapid (800 Myr) quenching
- Satellite time since infall best correlates with quenching