

Building the Red Sequence

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See arXiv 1012.3166



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Outline

Problem

We don't understand why red galaxies exist!

Methods

Test 2 quenching mechanisms with cosmological hydro simulations: **Mergers** and **Hot Gas Halo**
- Simple prescriptions applied on-the-fly

Results

- Merger outflows alone fail to make a red sequence
- Hot gas heating can make a red sequence
 - But some difficulties persist

Ongoing work

-Changing hydrodynamics in the poorly-resolved regime

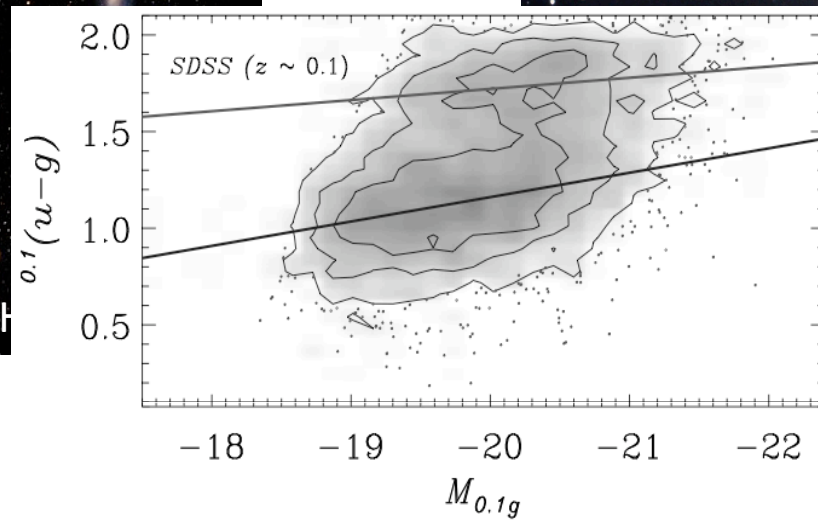
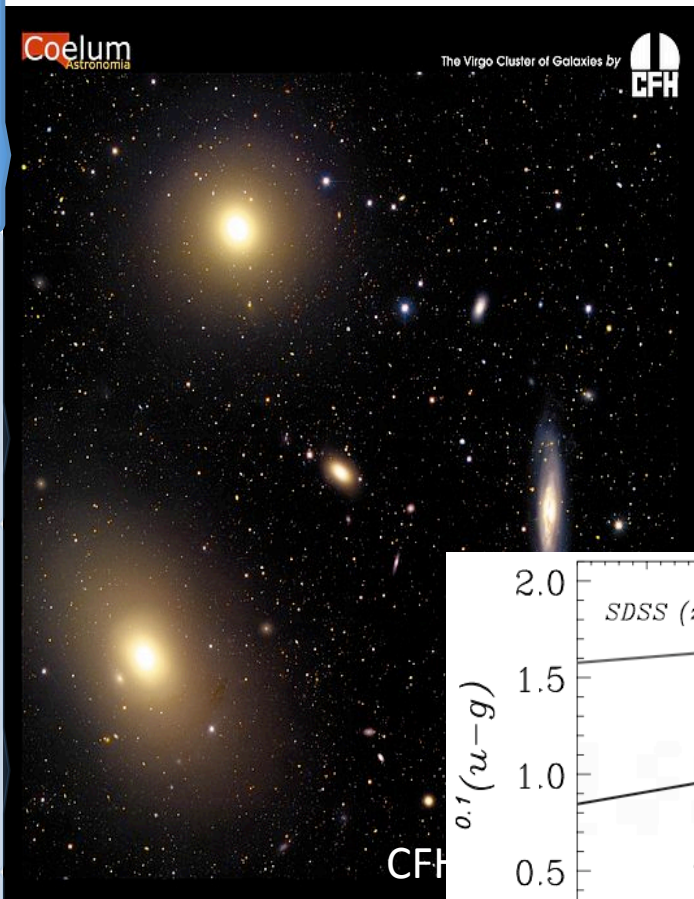
Two Types of Galaxies

Problem

Methods

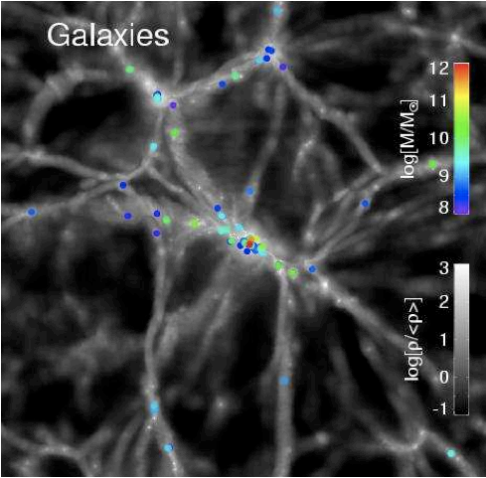
Results

Ongoing

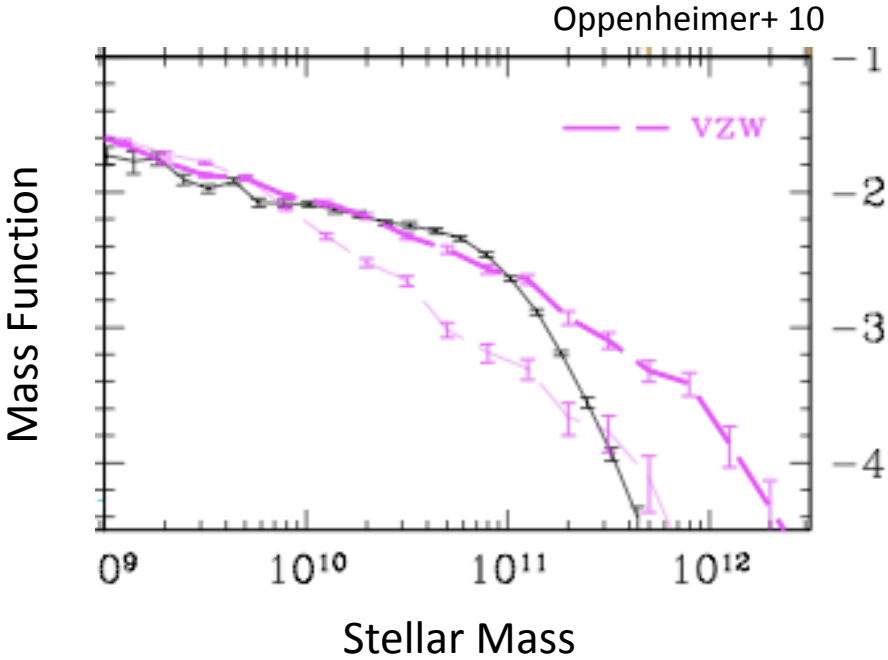


Blanton 06

Cosmological hydro models



Oppenheimer & Davé 09



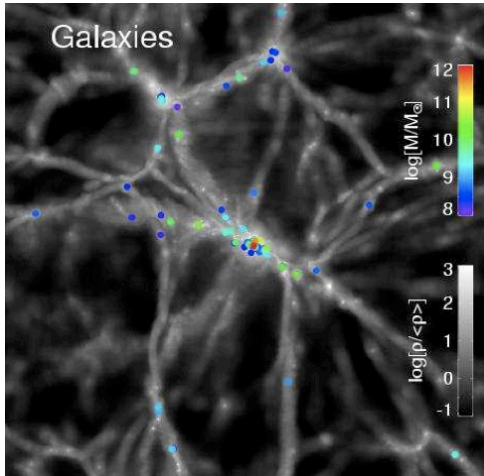
Cosmological hydro models

Problem

Methods

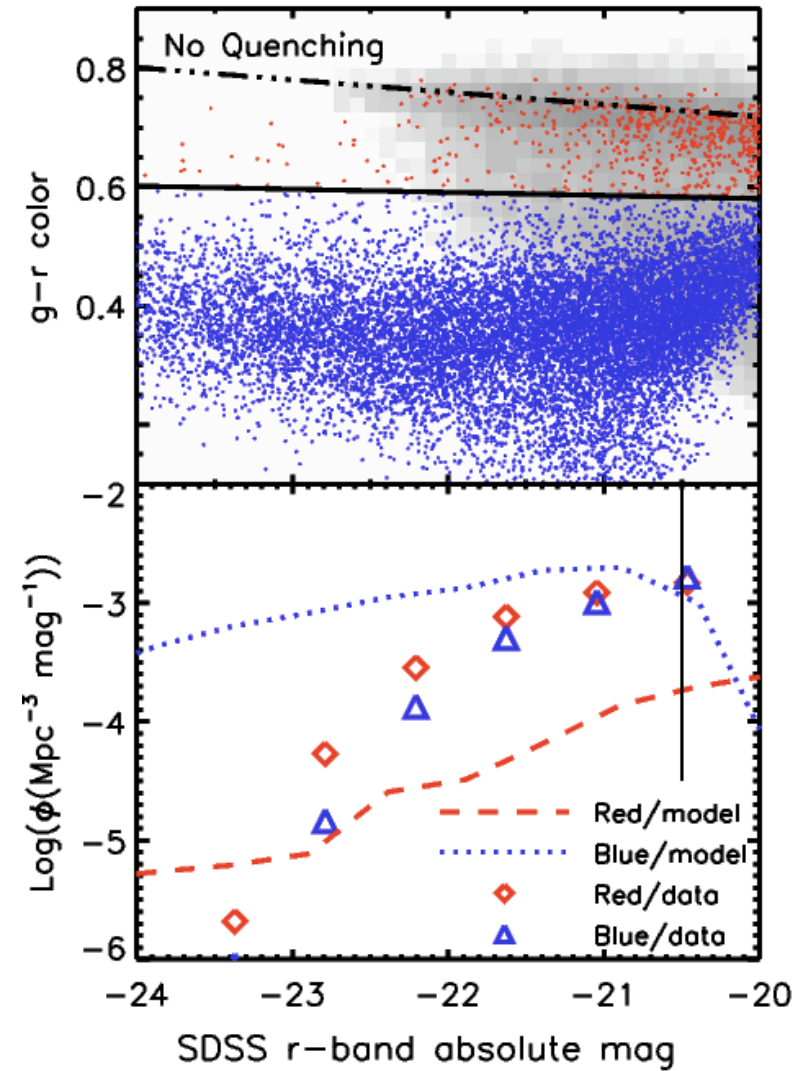
Results

Ongoing

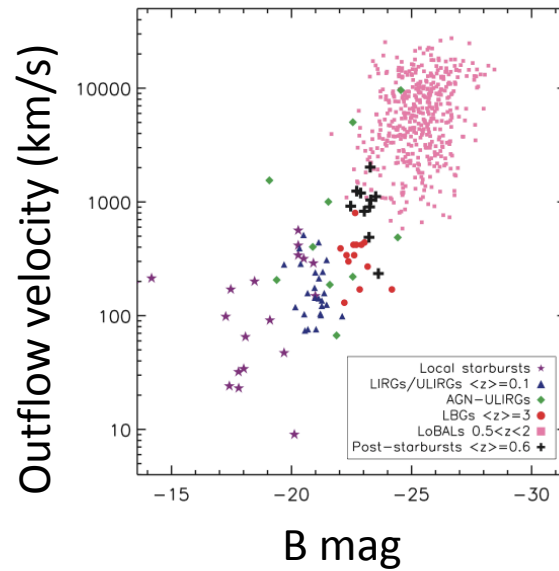


Oppenheimer & Davé 09

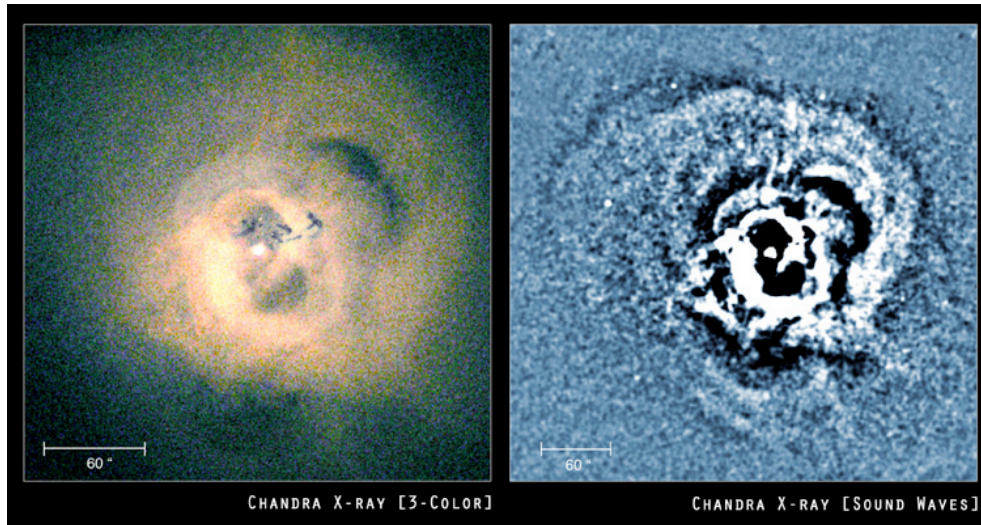
Gabor+ 10



Quenching evidence



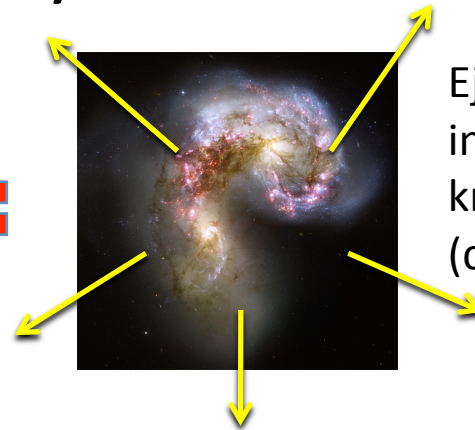
1000 km/s winds from post-starburst galaxies (Tremonti+07).
Also quasars (Feruglio+10, Rupke+11)



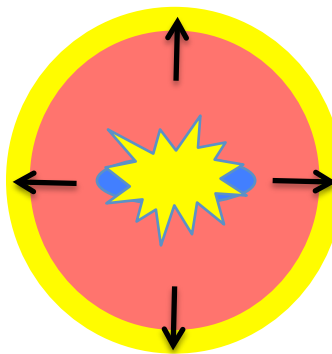
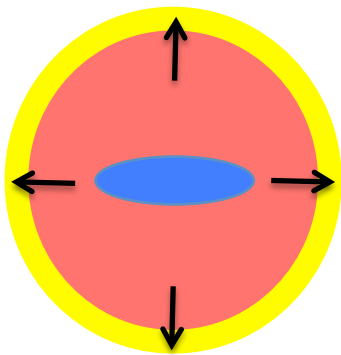
X-ray bubbles in clusters (Fabian+03)

On-the-fly Quenching

- Build physics directly into dynamics



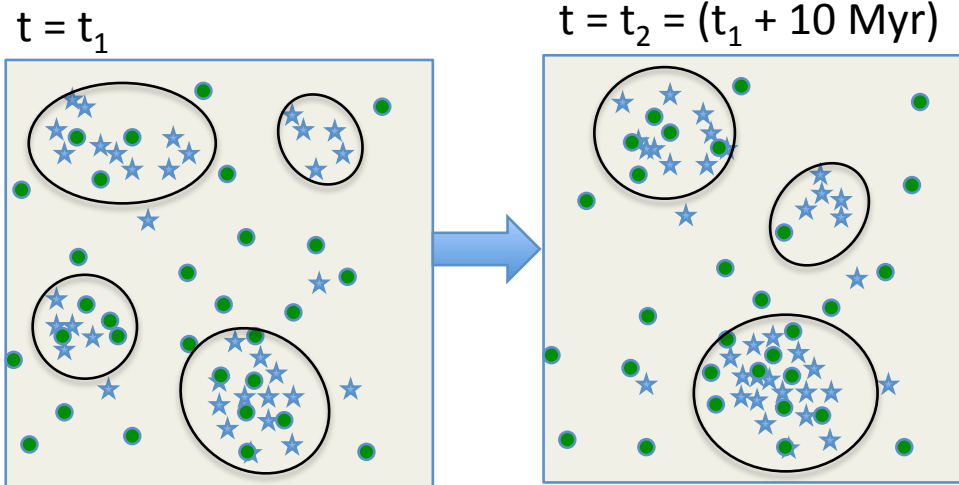
Ejective feedback
in mergers: 1000
km/s winds
(cf. Tremonti+07)



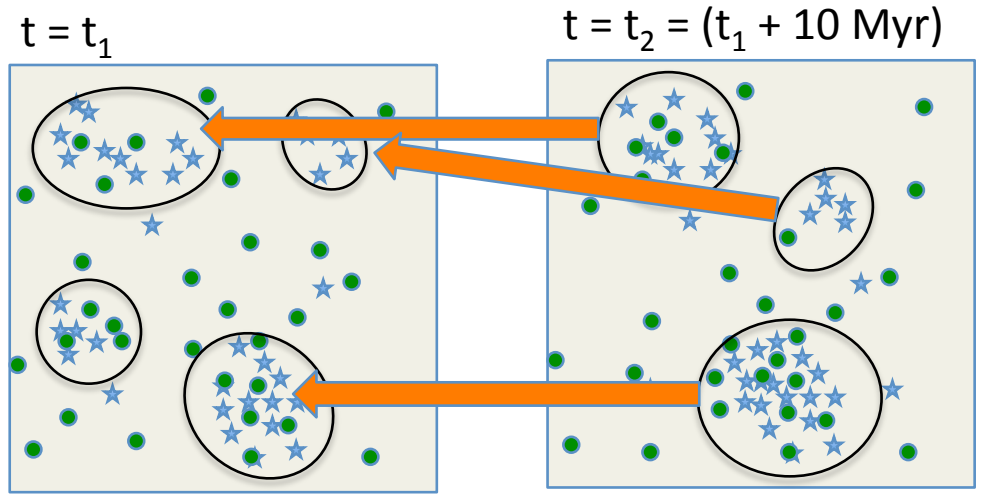
Thermal feedback
in the centers of
hot gas halos
(cf. Voit +
Donahue 2005)

Finding mergers

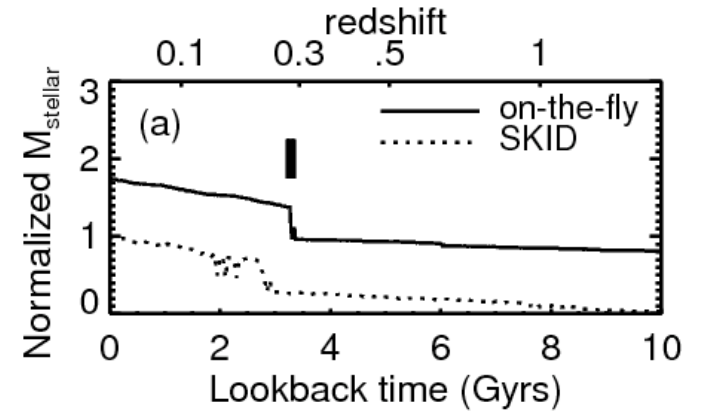
Problem
Methods
Results
Ongoing



Finding mergers



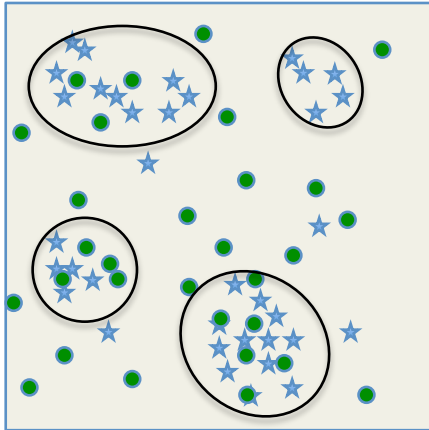
Mergers: $M_{t_2} = M_{t_1} (1 + 1/3)$



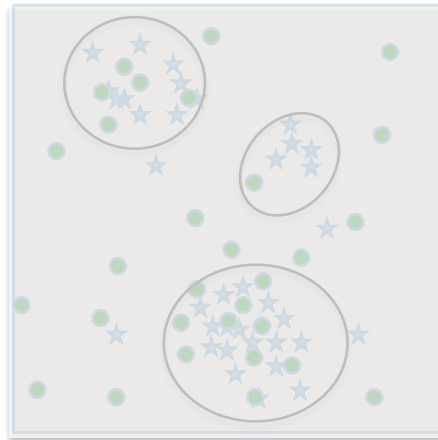
Finding mergers

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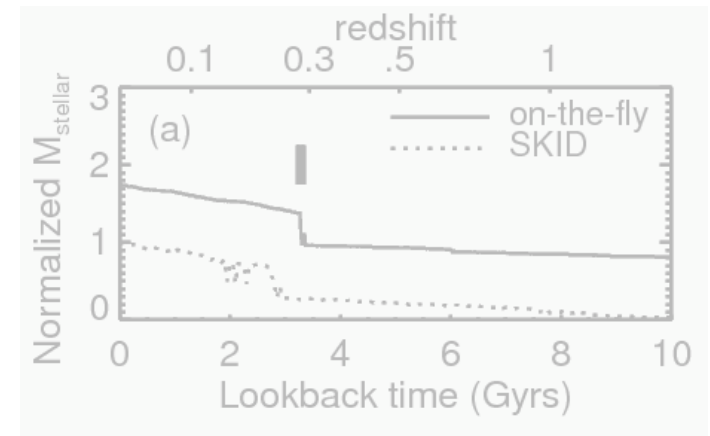
$t = t_1$



$t = t_2 = (t_1 + 10 \text{ Myr})$



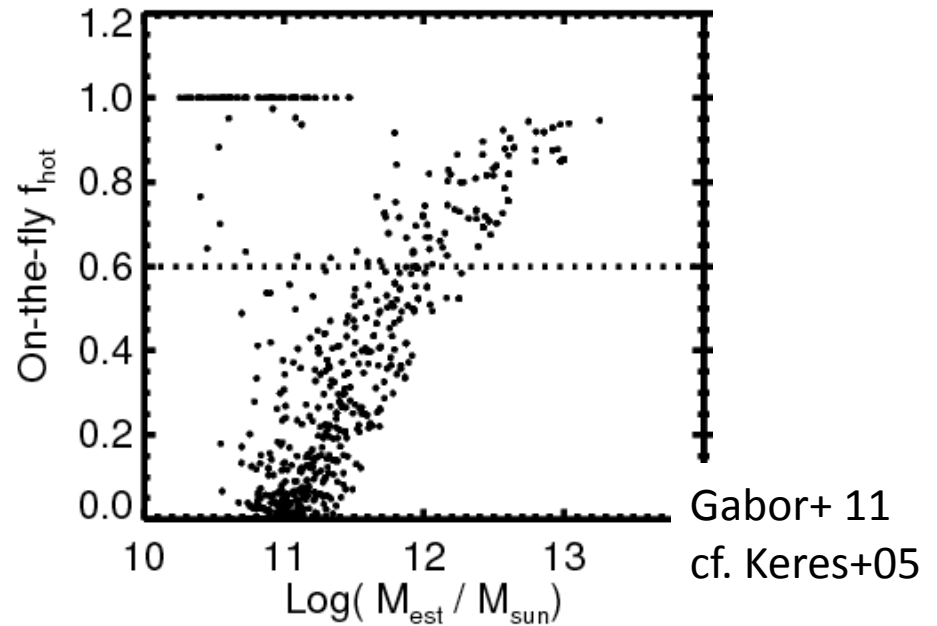
Mergers: $M_{t_2} = M_{t_1} (1+1/3)$



Finding hot halos

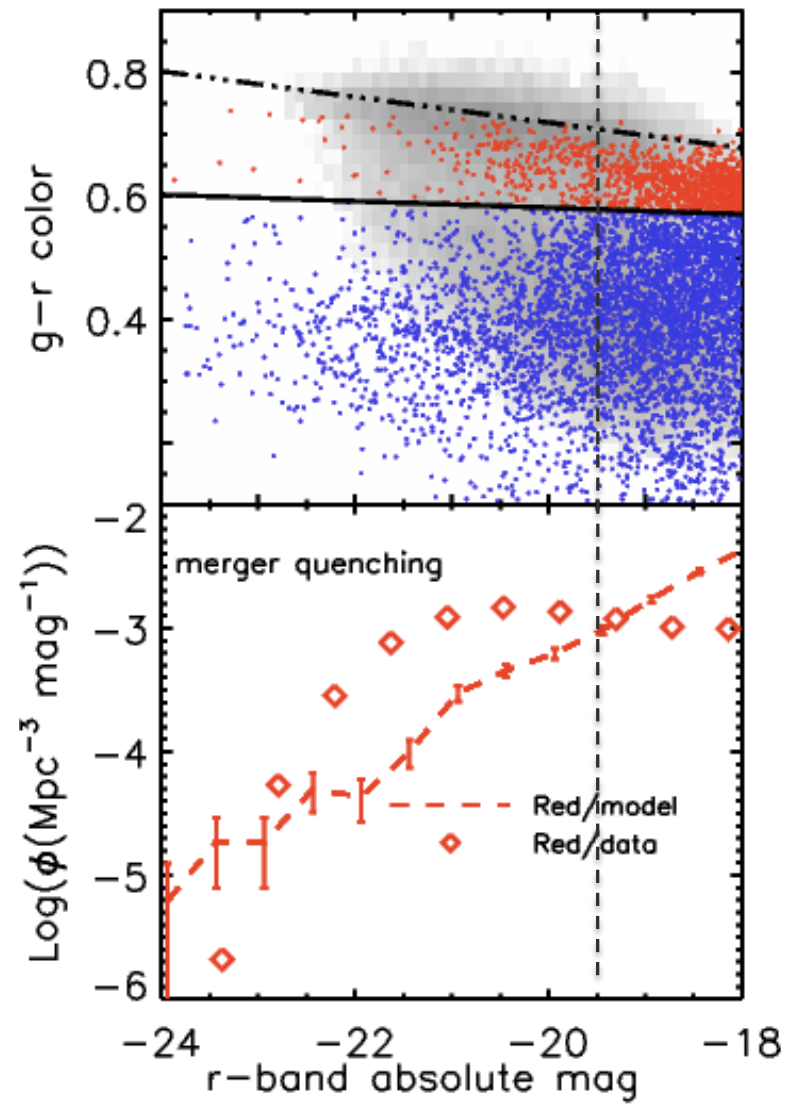
“Hot” gas = over 250,000 K

$$f_{\text{hot}} = M_{\text{hot}} / (M_{\text{hot}} + M_{\text{cold}})$$



Mergers alone don't work

Gabor+ 11



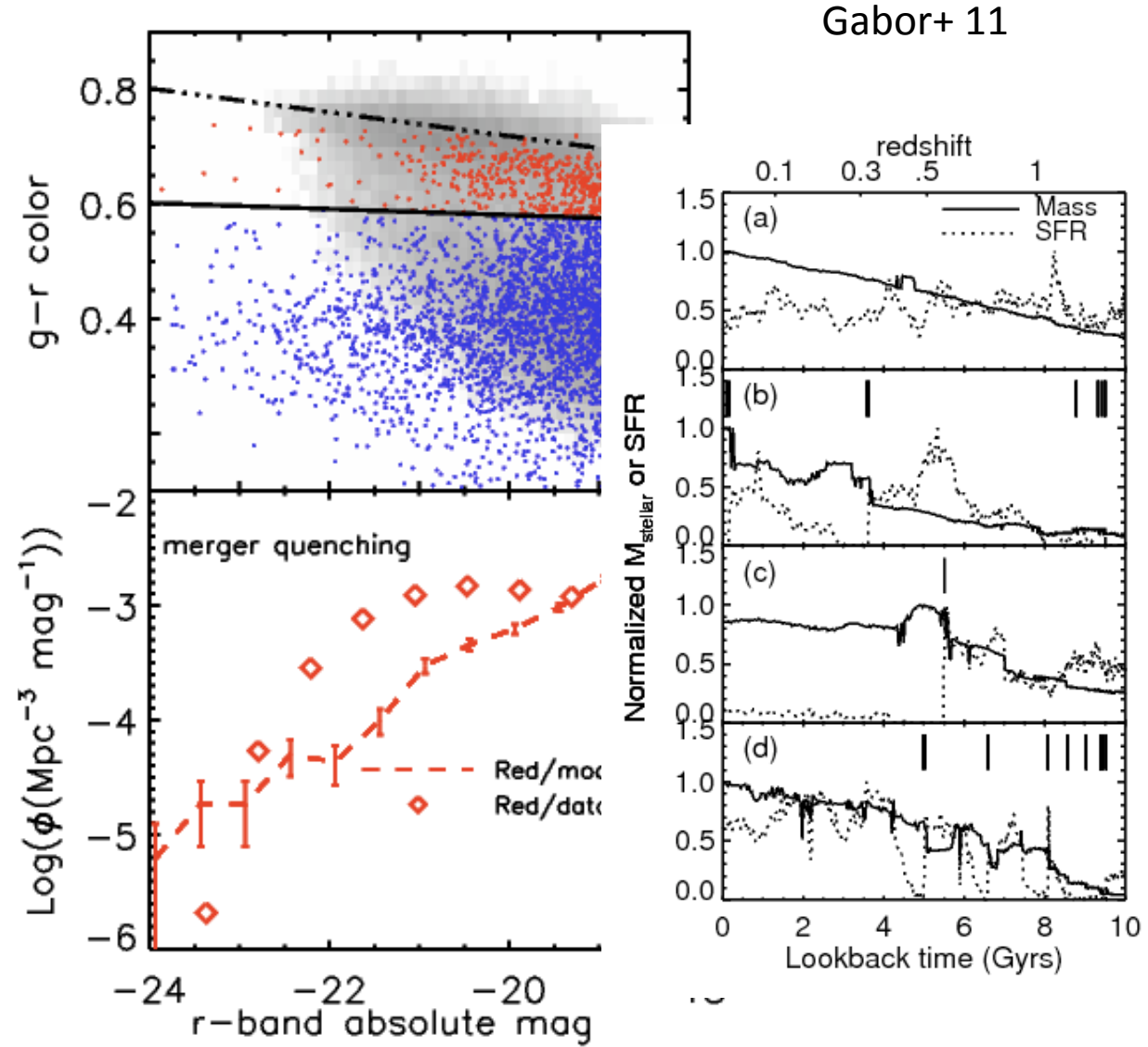
Problem

Methods

Results

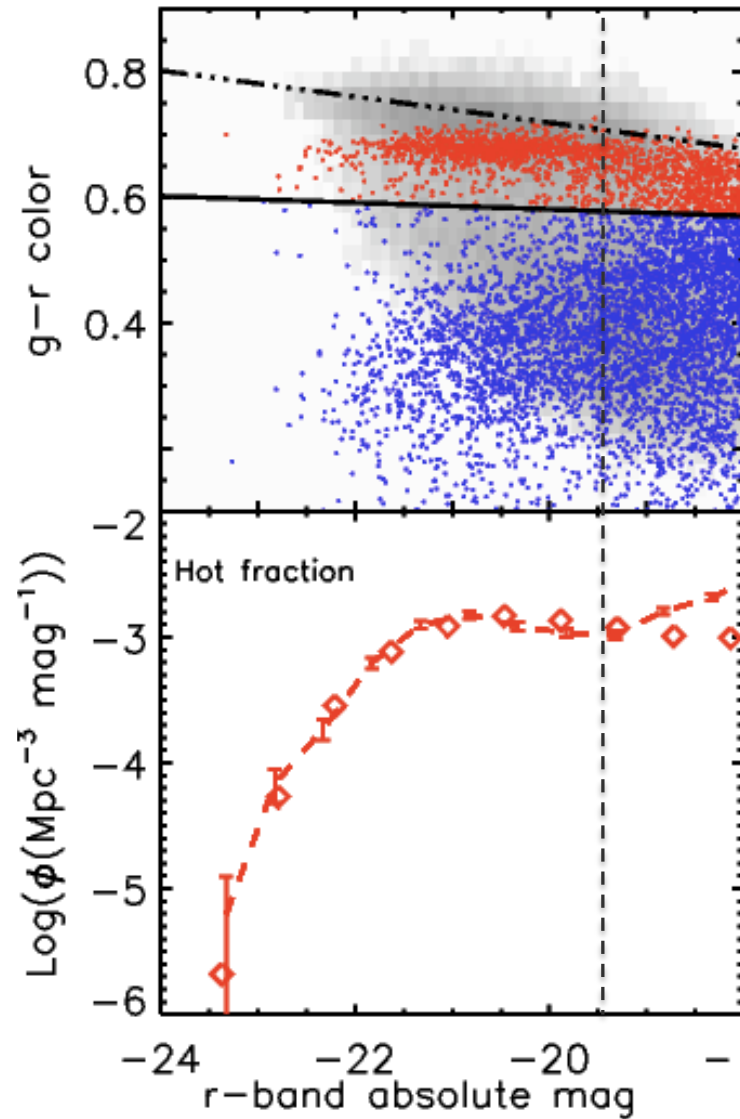
Ongoing

Mergers alone don't work



Hot gas alone can work

Gabor+ 11



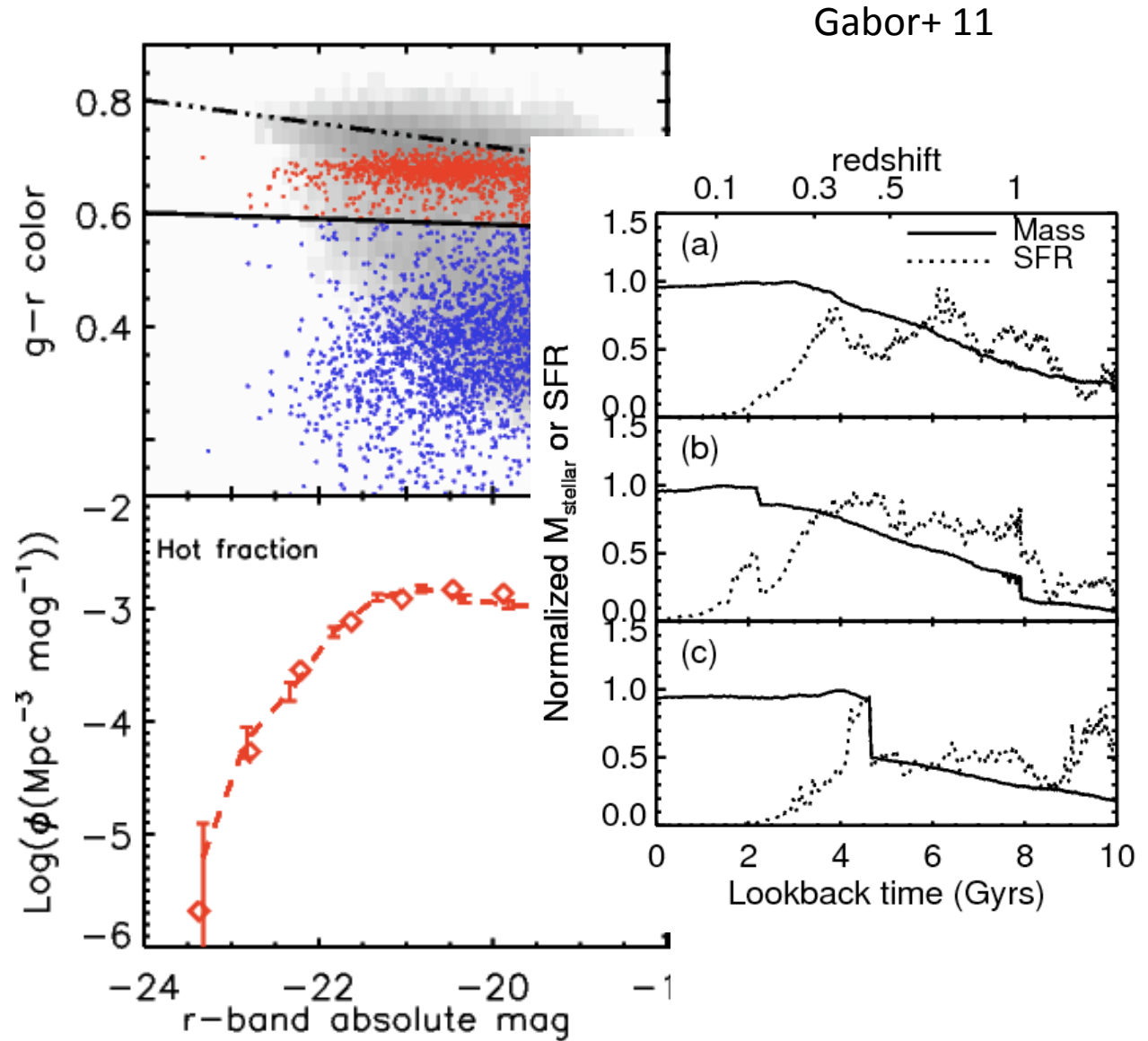
Hot gas alone can work

Problem

Methods

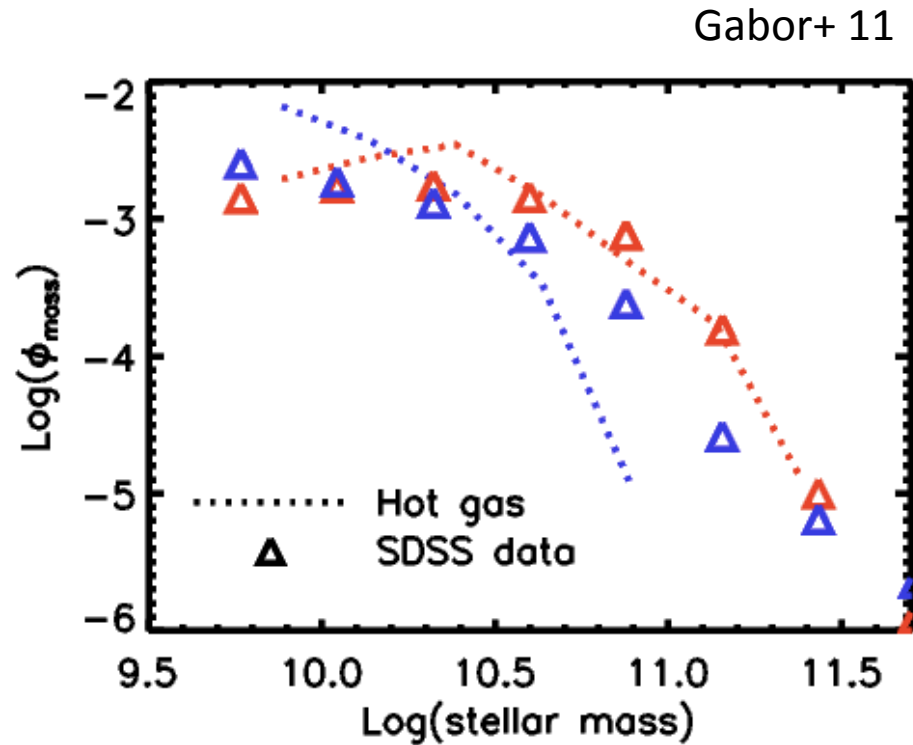
Results

Ongoing



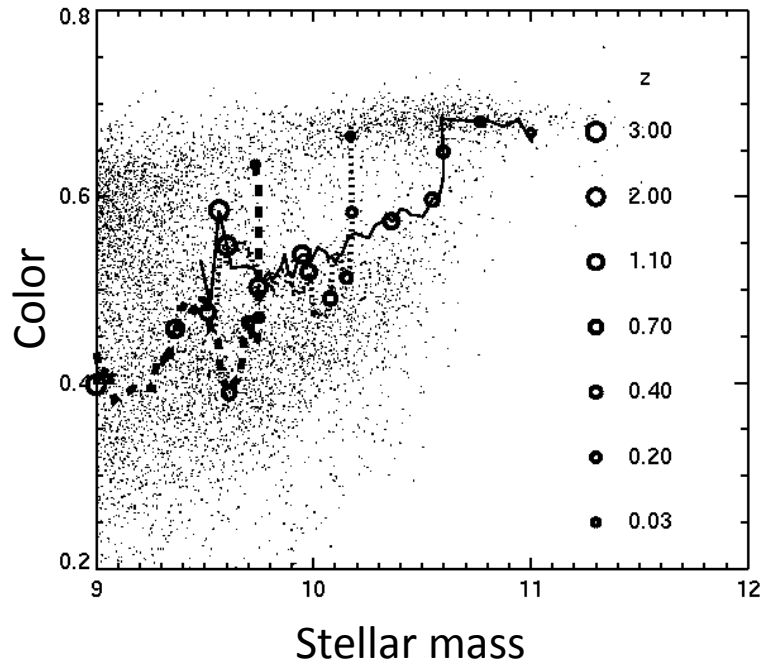
What about blue galaxies?

Stellar mass functions →

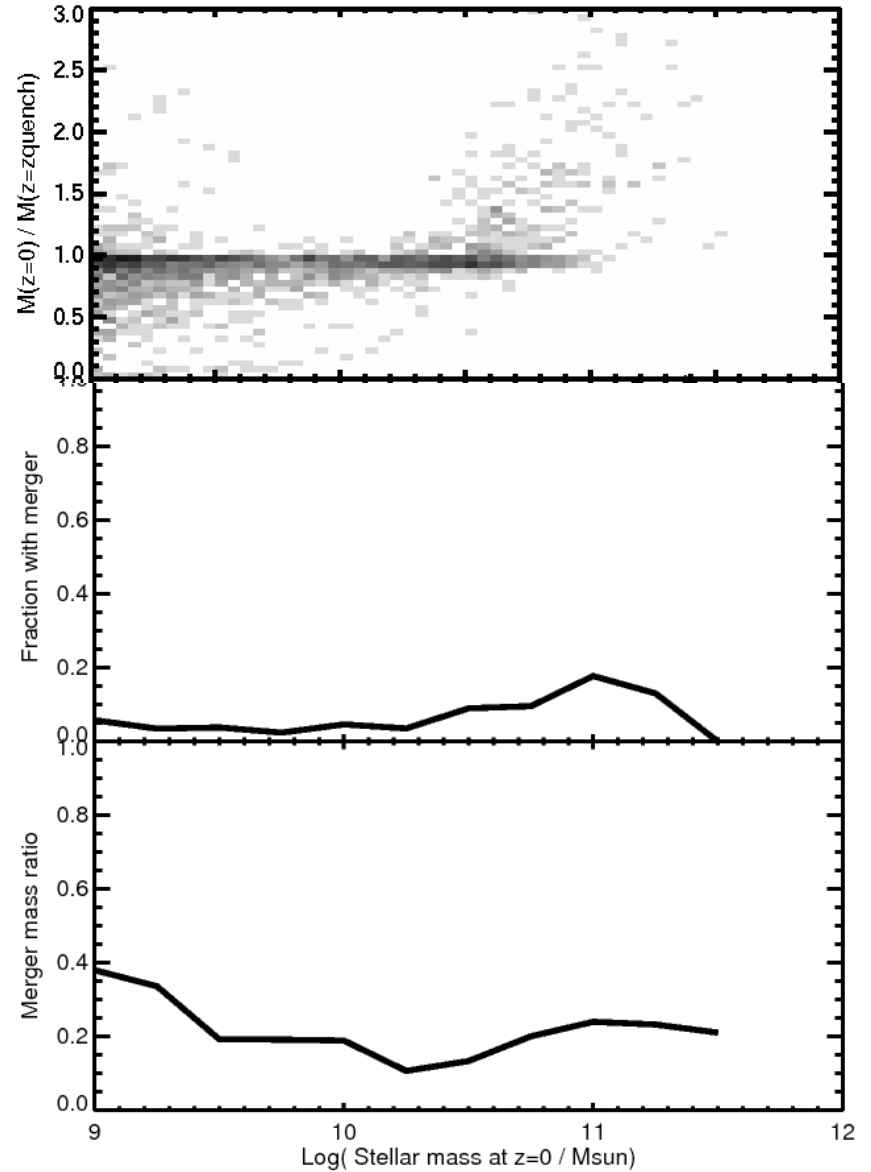


Mergers on the Red Sequence

Gabor+ in prep

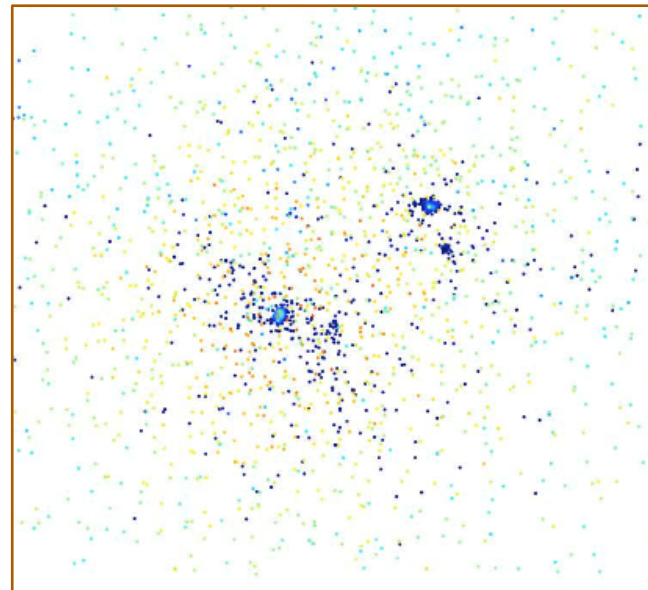


cf. Faber+ 07



Ongoing and Future Work

- More physical models of hot gas heating
 - 1) When does energy injection (e.g. AGN) occur?
 - 2) How much feedback energy is available?
 - 3) How is that energy distributed?
- Better tracking of SF winds
 - Instabilities
 - Conduction
 - Metal mixing



Conclusions

- Mergers alone do not yield a red sequence
- Adding heat to hot halos *can* yield a red sequence
 - Seems necessary *and* sufficient
 - Consistent w/ SAMs, but see Hopkins+08
- Lingering problems:
 - Sharp cutoff in blue mass function
 - Red galaxies grow too much
 - Details of hot gas heating

THE END

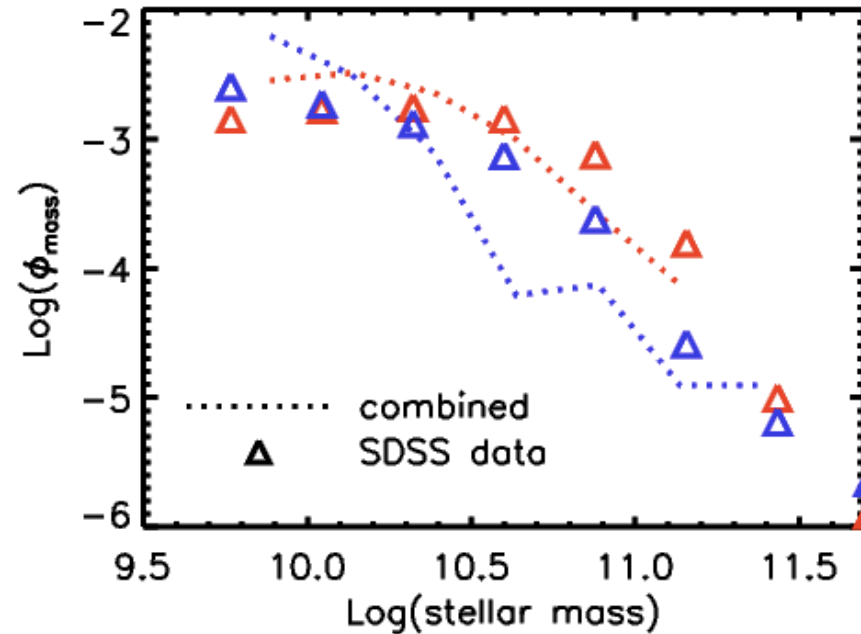
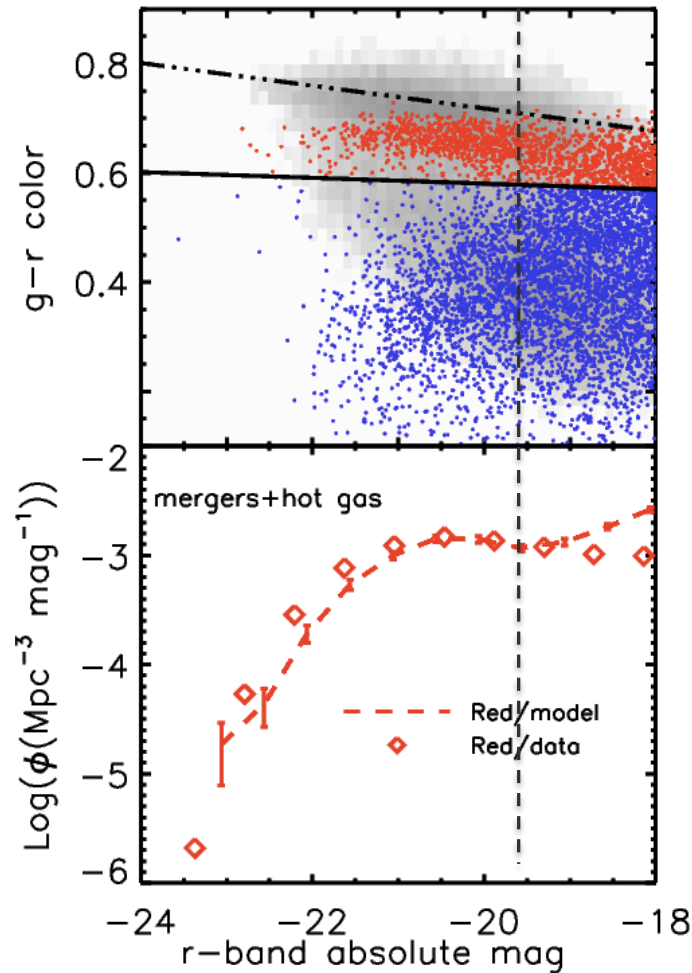
See arXiv 1012.3166

EXTRA STUFF

Model variation

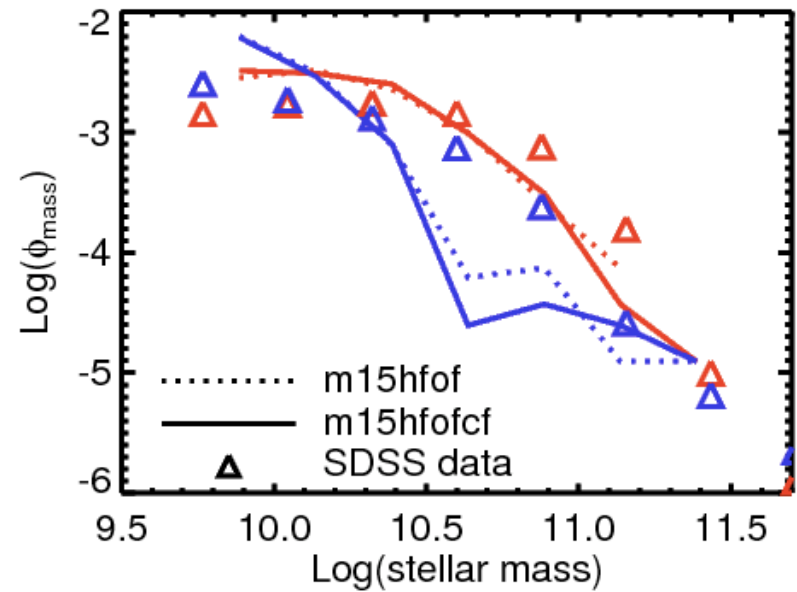
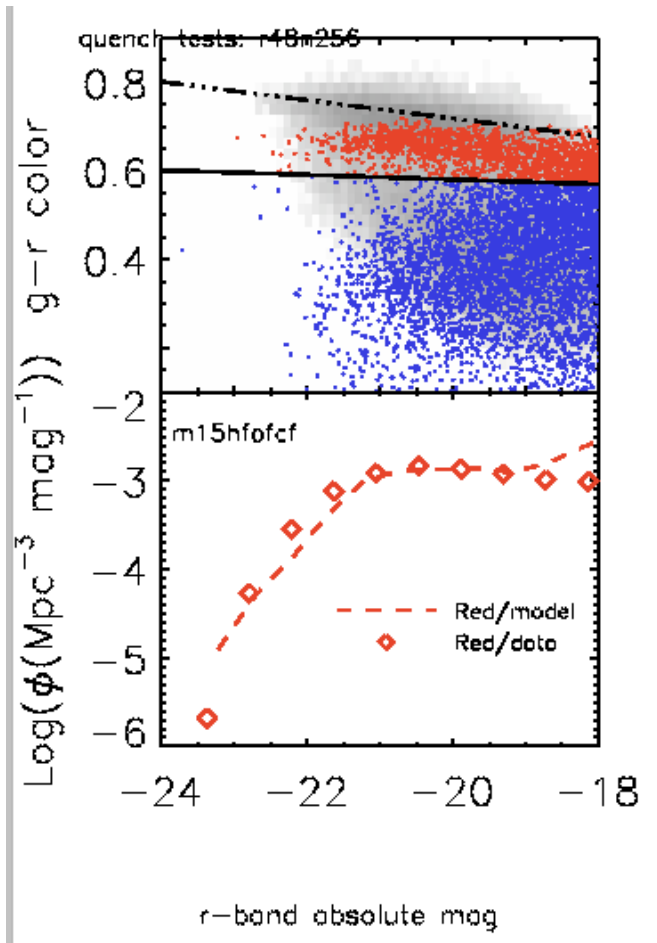
Combined merger winds + hot gas heating

Gabor+ in prep



Ongoing Results Methods Problem

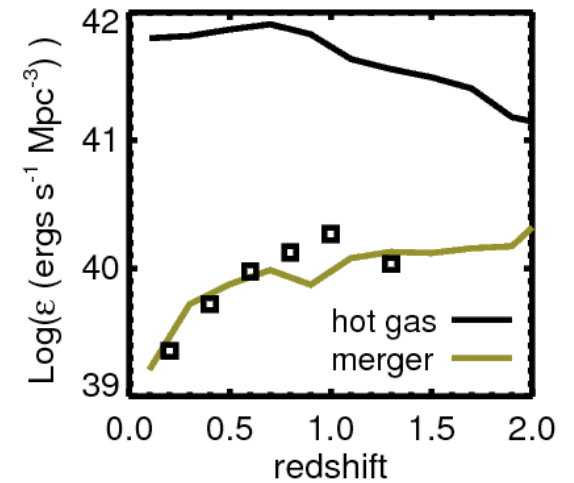
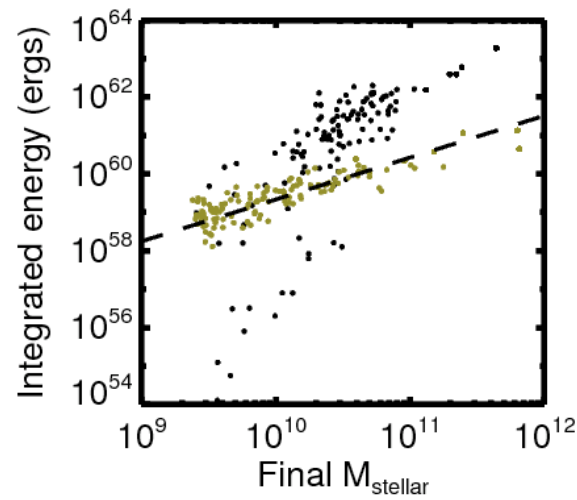
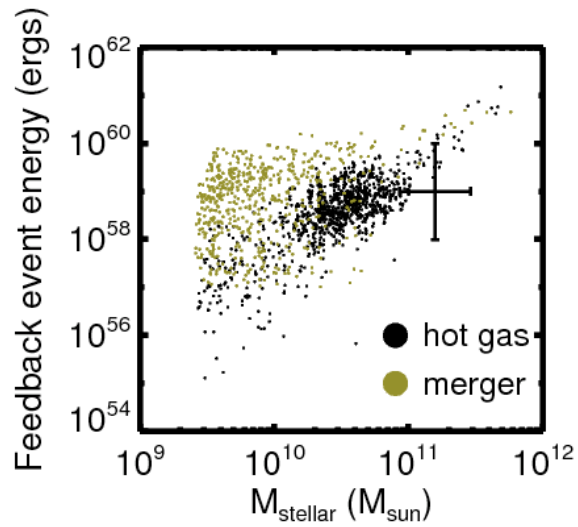
Combined Quenching



Quenching energetics

Gabor+ in prep

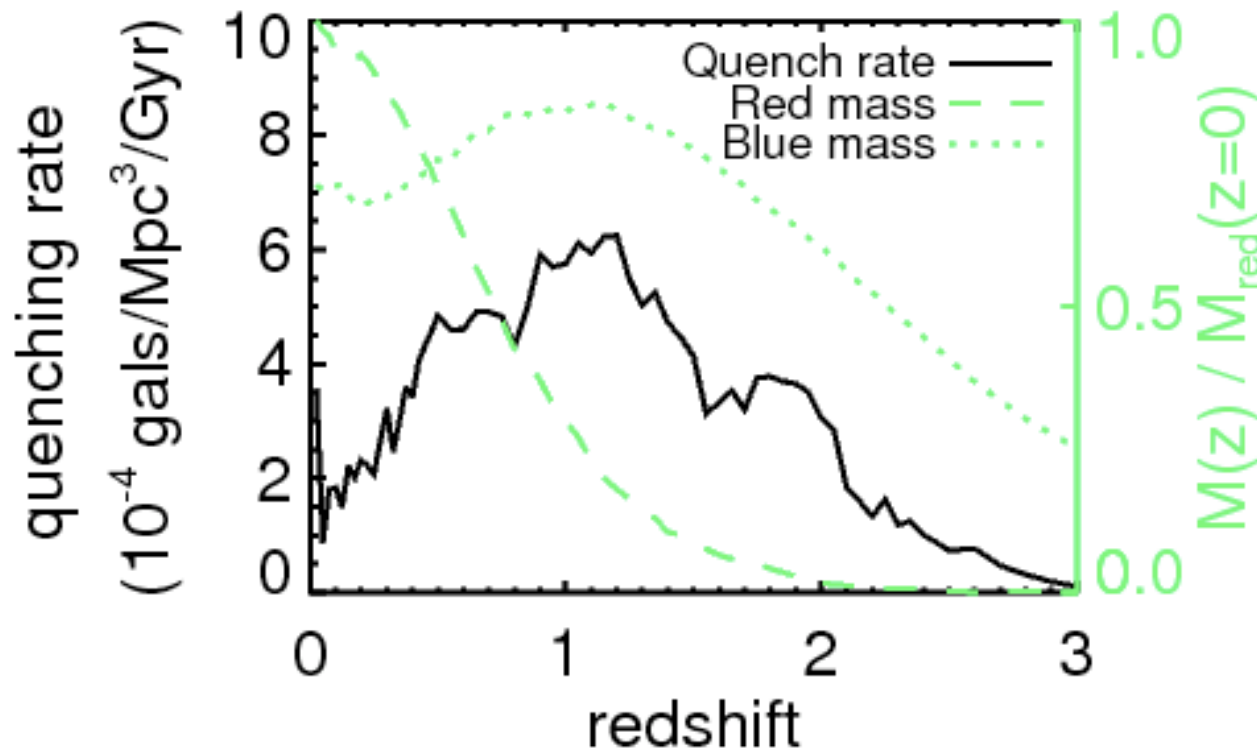
Ongoing Results Methods Problem



Red sequence growth over time

Hot gas heating model

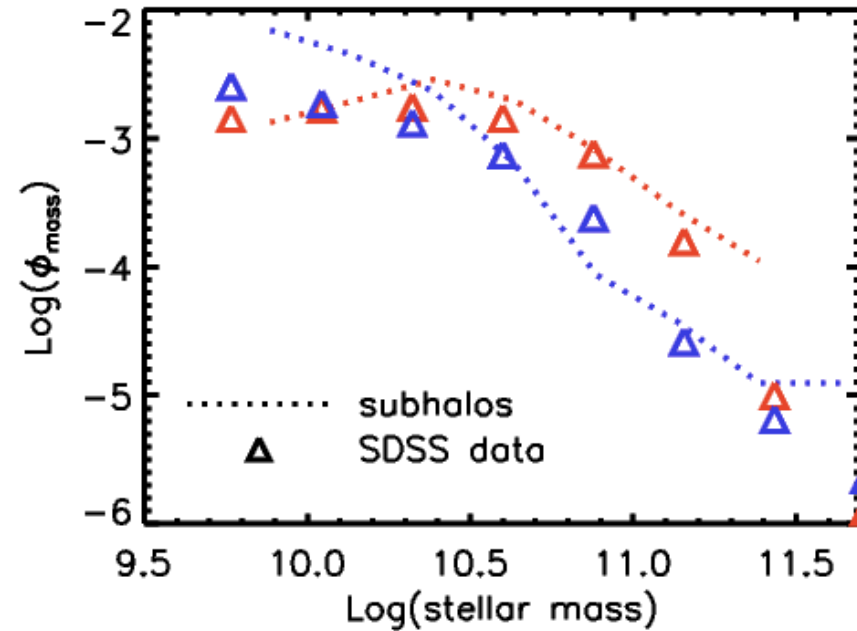
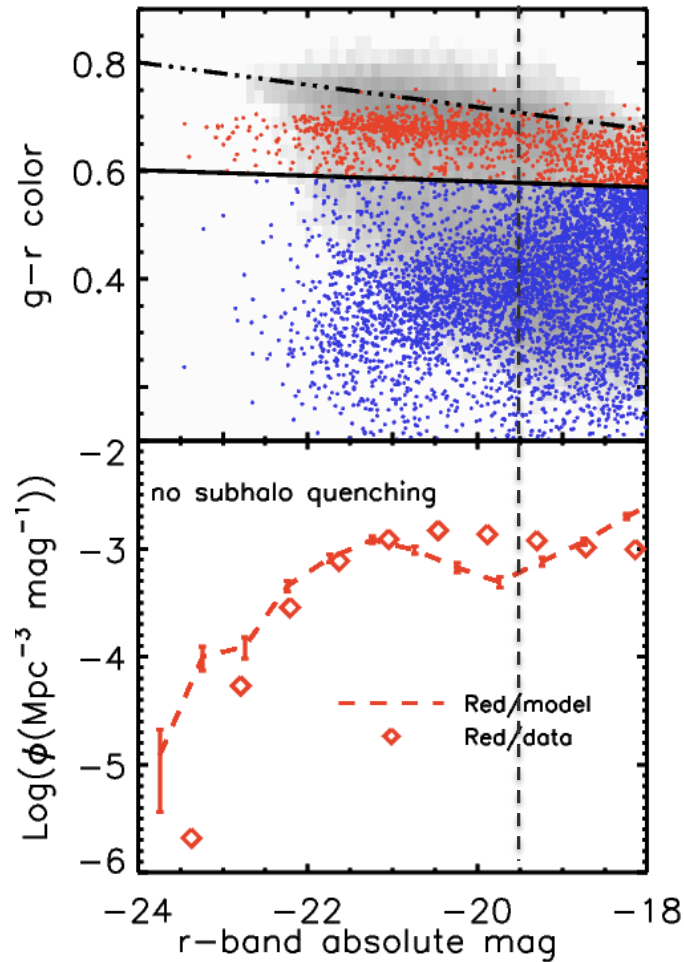
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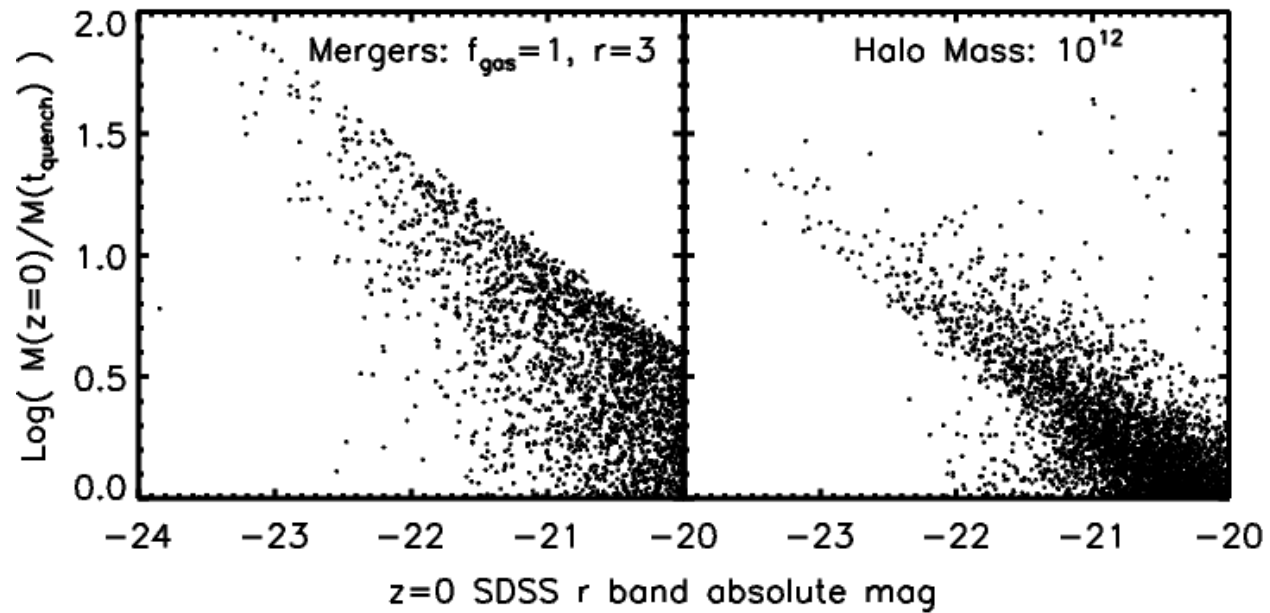
Model variations

Don't heat gas around sub-halos

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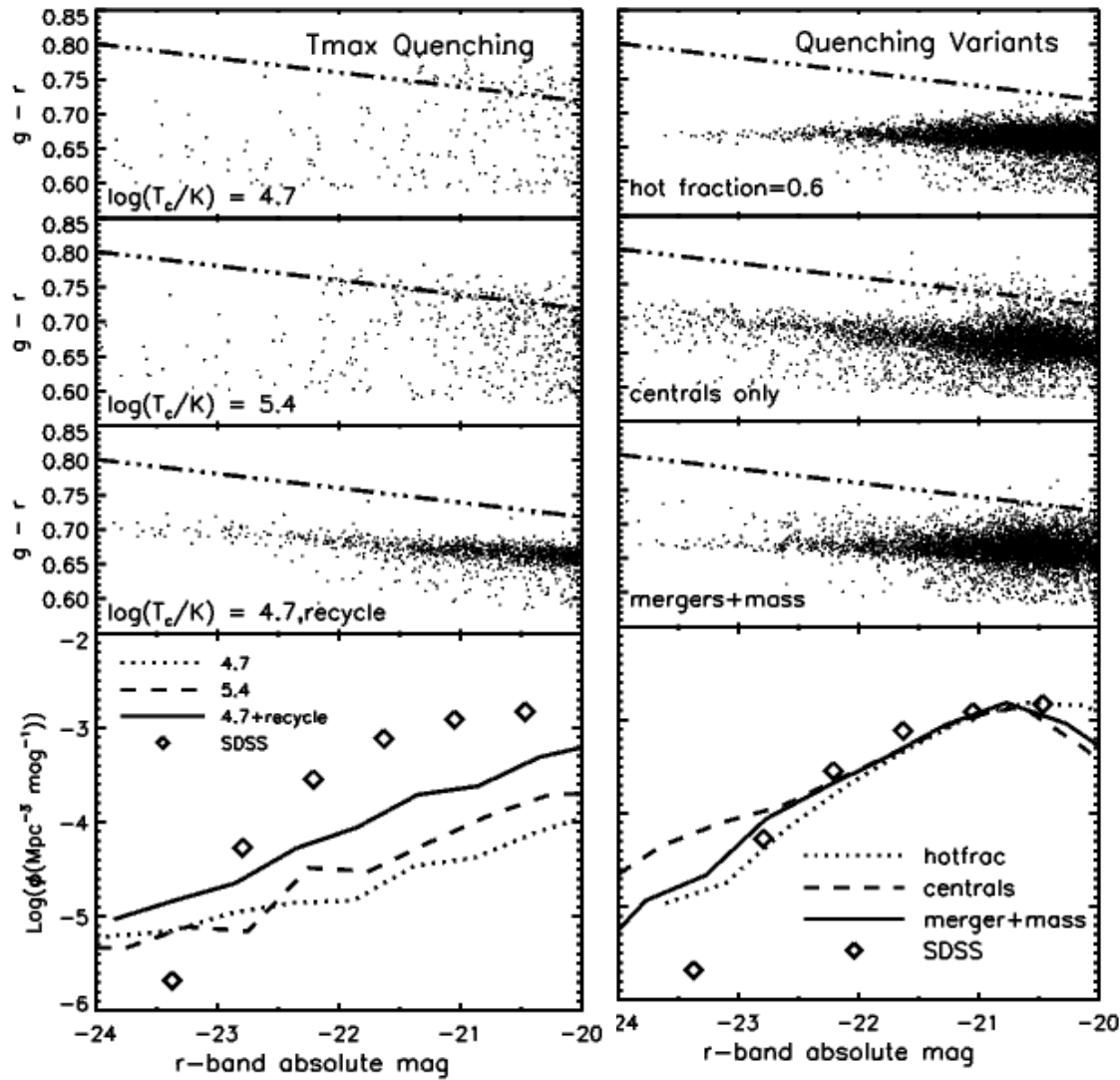
Post-quenching mergers



More variant mechanisms

Prevent “hot”
gas from ever
cooling

Also prevent gas
“recycled” from
winds



Fraction of halo
gas that is “hot”

Don’t quench
satellites

Combined mergers
+halo mass

Gabor+ 10

