Low mass galaxy problems in SAMs

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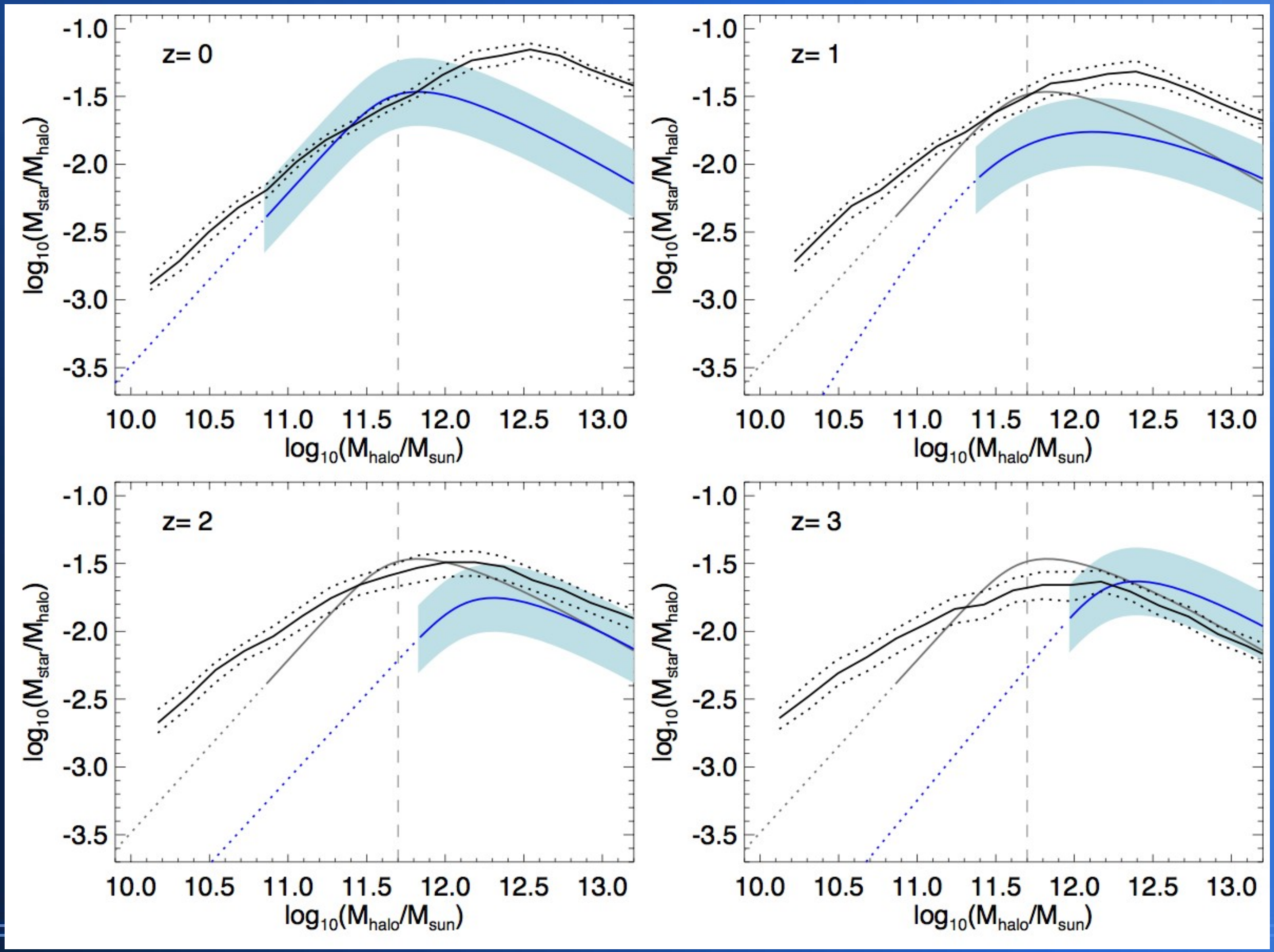
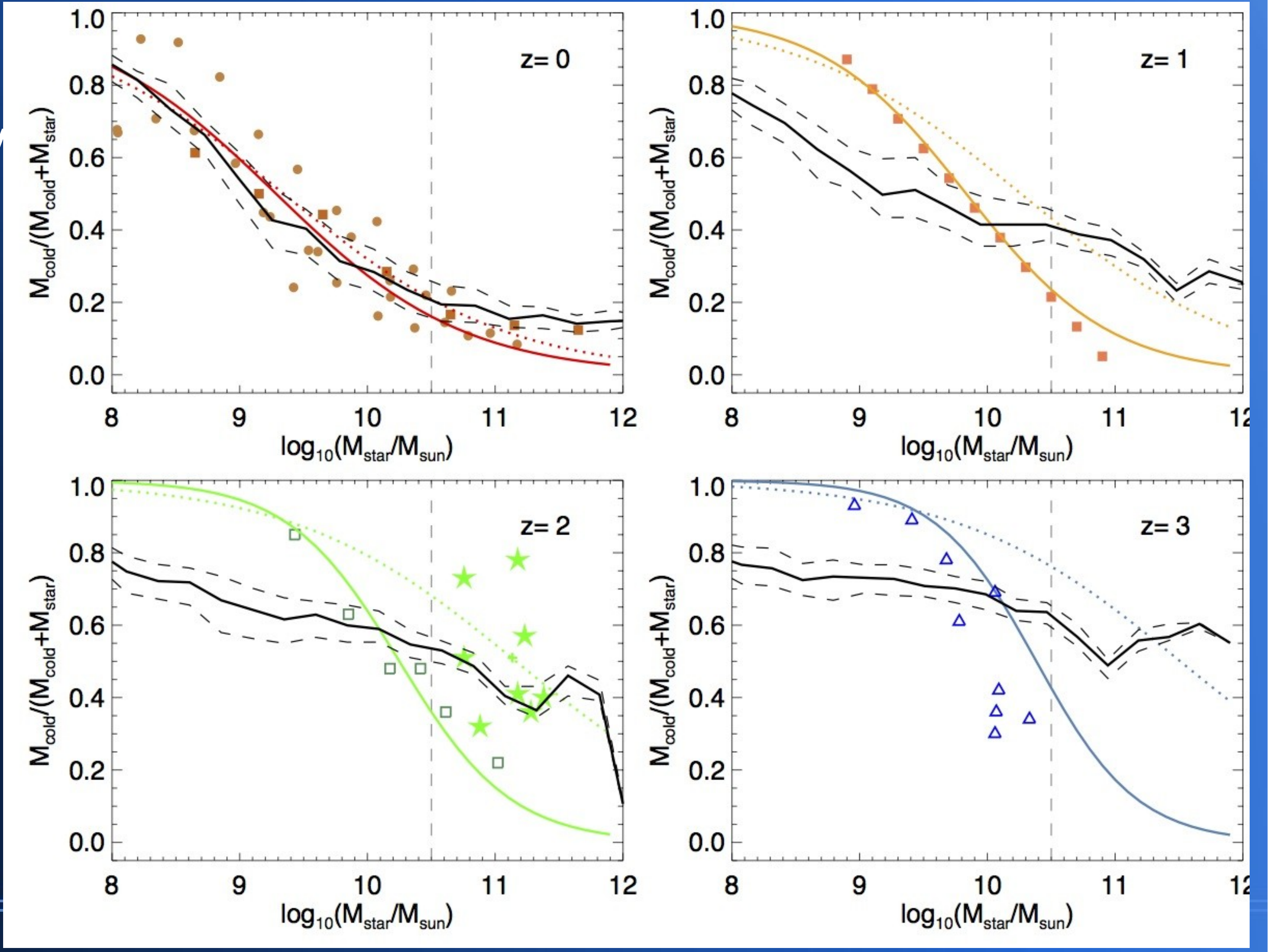
Fiducial model

- Low mass galaxies form stars too efficiently and too early
- $f_*=M_{star}/M_{halo}$



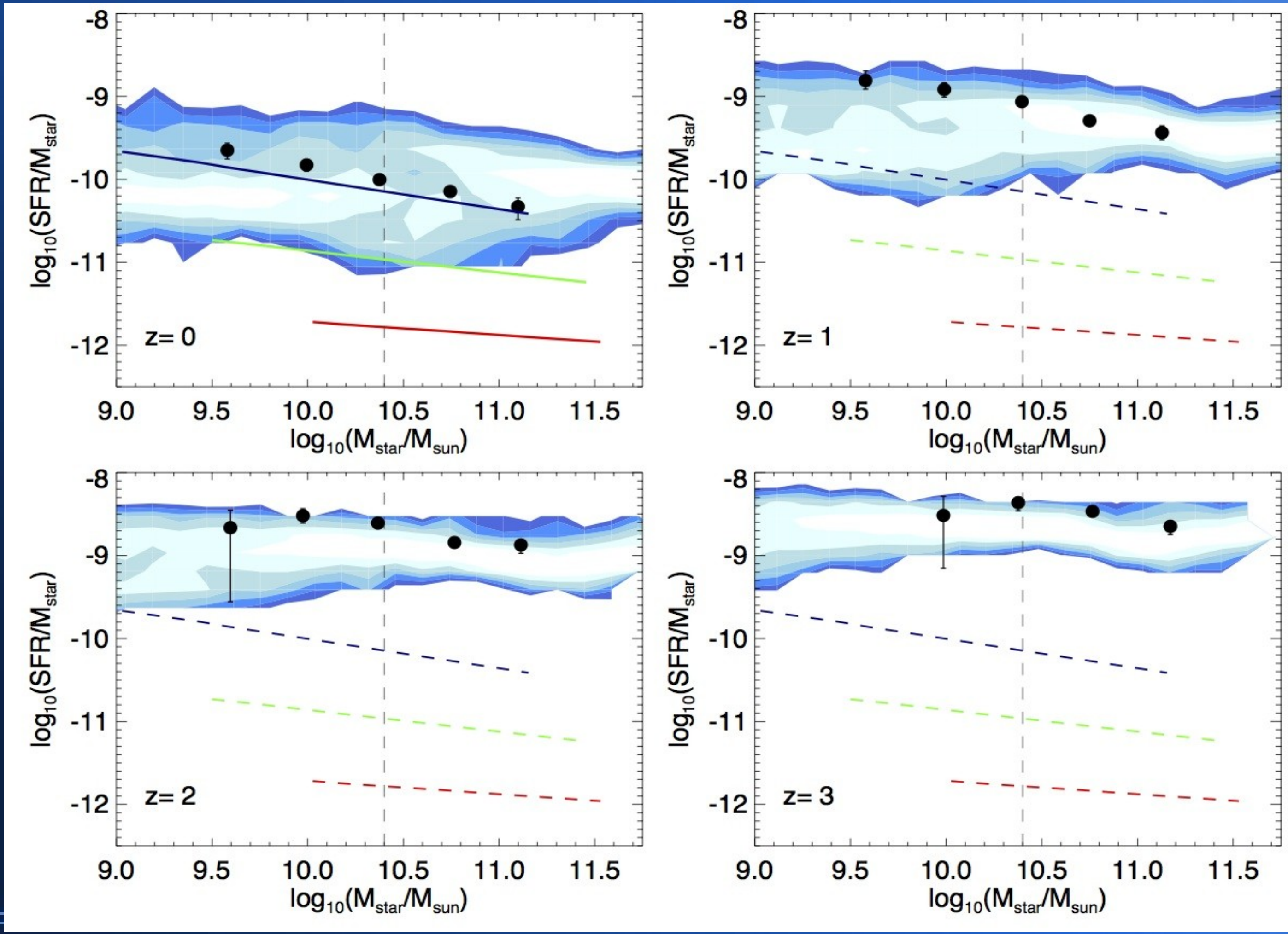
Fiducial model

- Cold gas in the disk is used up too quickly at high redshifts
- $f_{gas}=M_{cold}/(M_{star}+M_{cold})$



Fiducial model

- The blue sequence in the SSFR is too flat



Physical motivation

- Supernova reheating as a function of halo mass may change over time
- Star formation may be less efficient at early times and/or at low galaxy mass
- The changes over time would presumably be due to dependence on a quantity that changes over time
- This exercise was to test what the SN feedback and star formation recipes would have to look like to make the SAMs match observations at $0<z<2$

Supernova Feedback

- Form comes from simple energy or momentum arguments

$$\dot{m}_{\rm rh} = \epsilon_{\rm SN} \left(\frac{V_{\rm disk}}{200\ {\rm km/s}} \right)^{-\alpha_{\rm RH}} \dot{m}_*$$

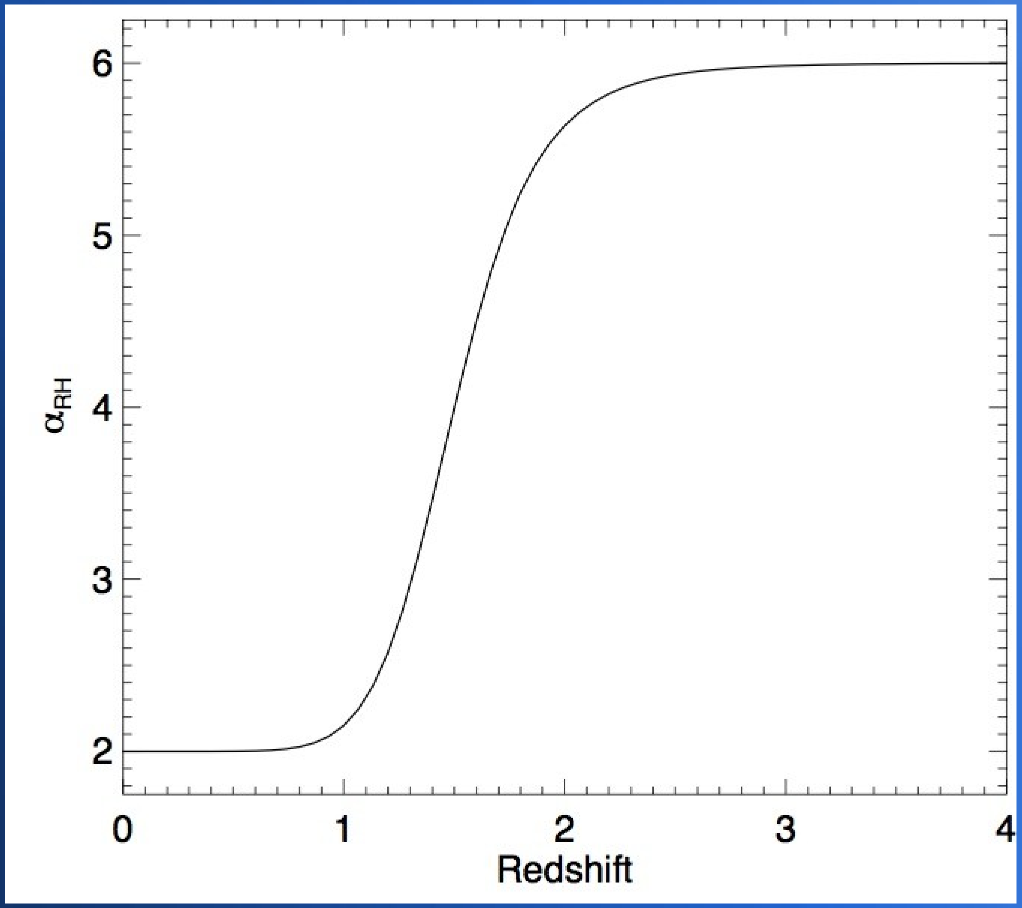
- α_{RH} controls the slope of the low mass end of f_*

Steepening the SN reheating recipe

- To match the observed f_*, the low mass end must be steeper
- The slope of the low mass end is governed by α_{RH}
- The higher the α_{RH}, the steeper the low mass end
- This steepening only needs to happen at higher redshift, so the power alpha must be $\alpha_{RH}(z)$

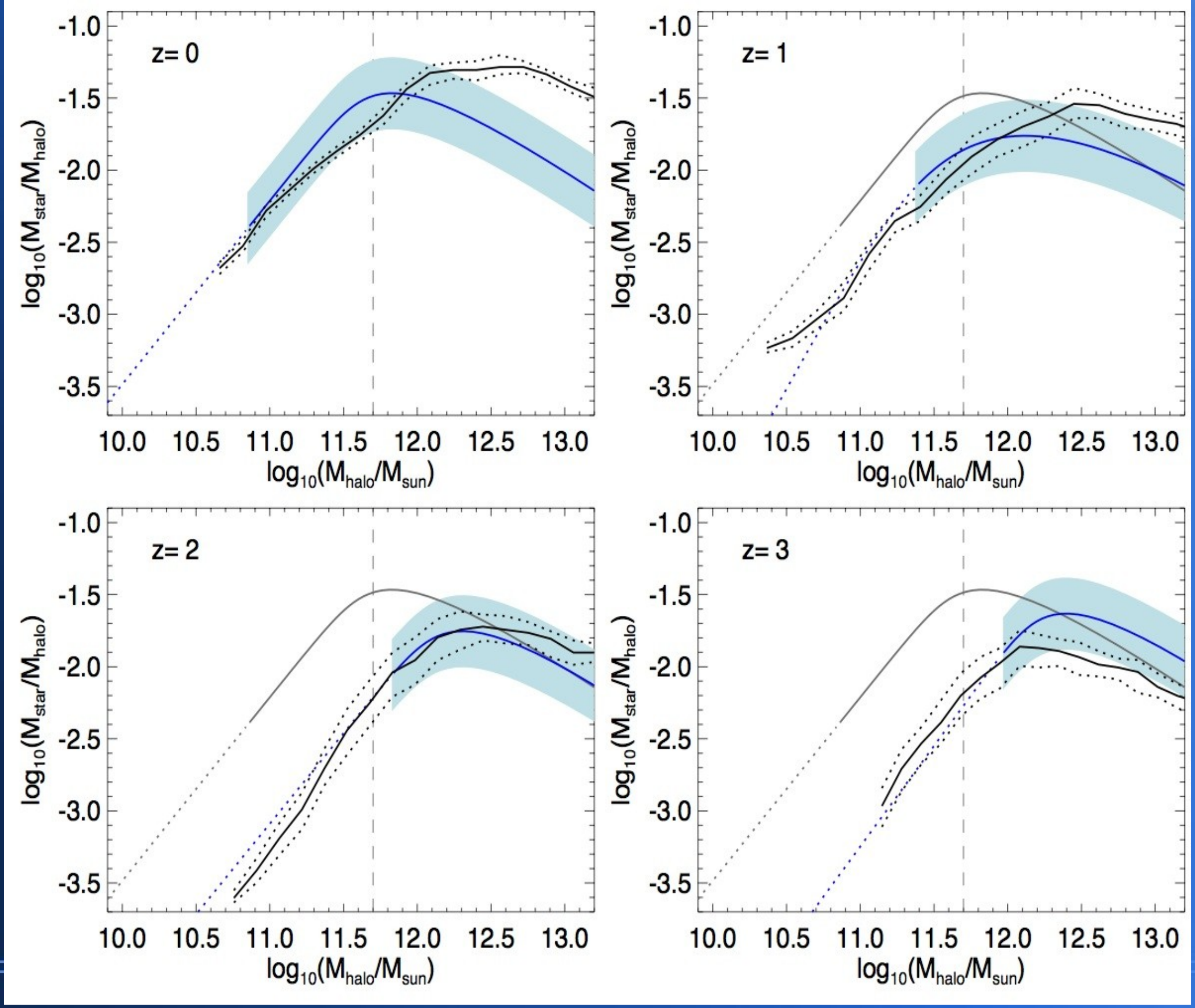
Steepening the SN reheating recipe

- To match the f_* plot, α_{RH} must be around 6 at high redshifts and drop quickly to 2 around z=1.4
- α_{RH}=1 corresponds to momentum driven winds, α_{RH}=2 corresponds to energy driven winds



Steepening the SN reheating recipe

- The f_* plot matches mostly at low mass (it was fit to older data)
- At high mass, galaxies have not formed enough stars, probably because the low mass progenitors had too few stars



Steepening the SN reheating recipe

- Although the steepening improves the stellar masses at low halo mass, it doesn't solve the other problems as neatly
- There is somewhat more cold gas, but it still doesn't match the observations
- The blue sequence in SSFR is still flat

Constant efficiency star formation

- To simplify the recipes, the star formation adjustments were done with a constant efficiency star formation law
- $$\dot{m}_* = \frac{m_{\rm cold}}{\tau_{\rm CE}}$$
- This returns a similar SMF (and thus f_*) and SSFR, cold gas masses are high

“Thinning” the cold gas disk

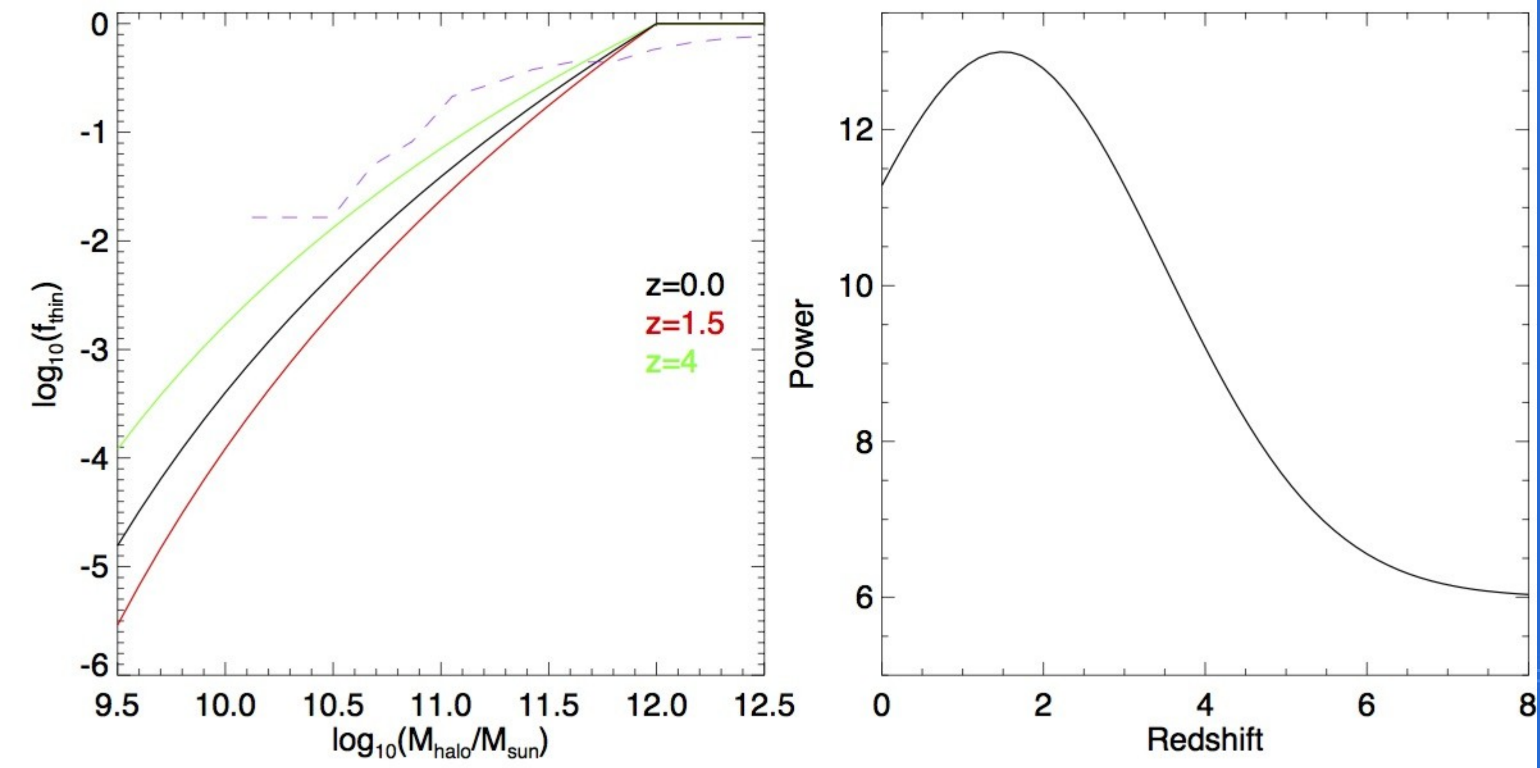
- To adjust the star formation law, we changed the SF law to

$$\dot{m}_* = f_{\rm thin}(M_{\rm H}, z)\frac{m_{\rm cold}}{\tau_{\rm CE}}$$

- Due to the nature of the problem, f_{thin} must be a function of halo mass
- No time independent forms for f_{thin} reproduced the proper evolution of the low mass galaxies

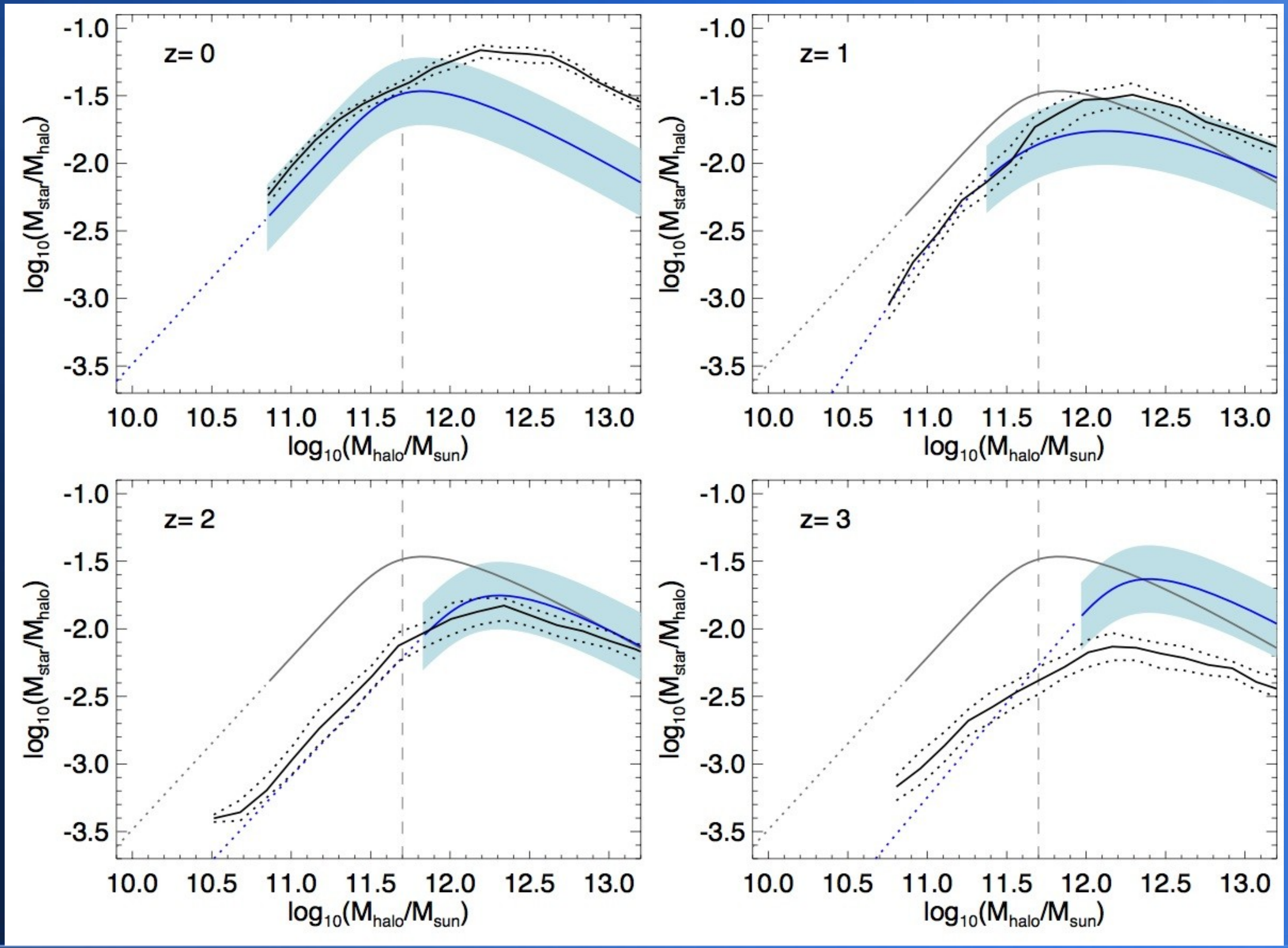
“Thinning” the cold gas disk

- The thinning fraction is a power law in halo mass up to $f_{thin}=1$
- f_{thin} has to be steeper at intermediate redshifts than at high redshifts to allow massive galaxy progenitors to form enough stars



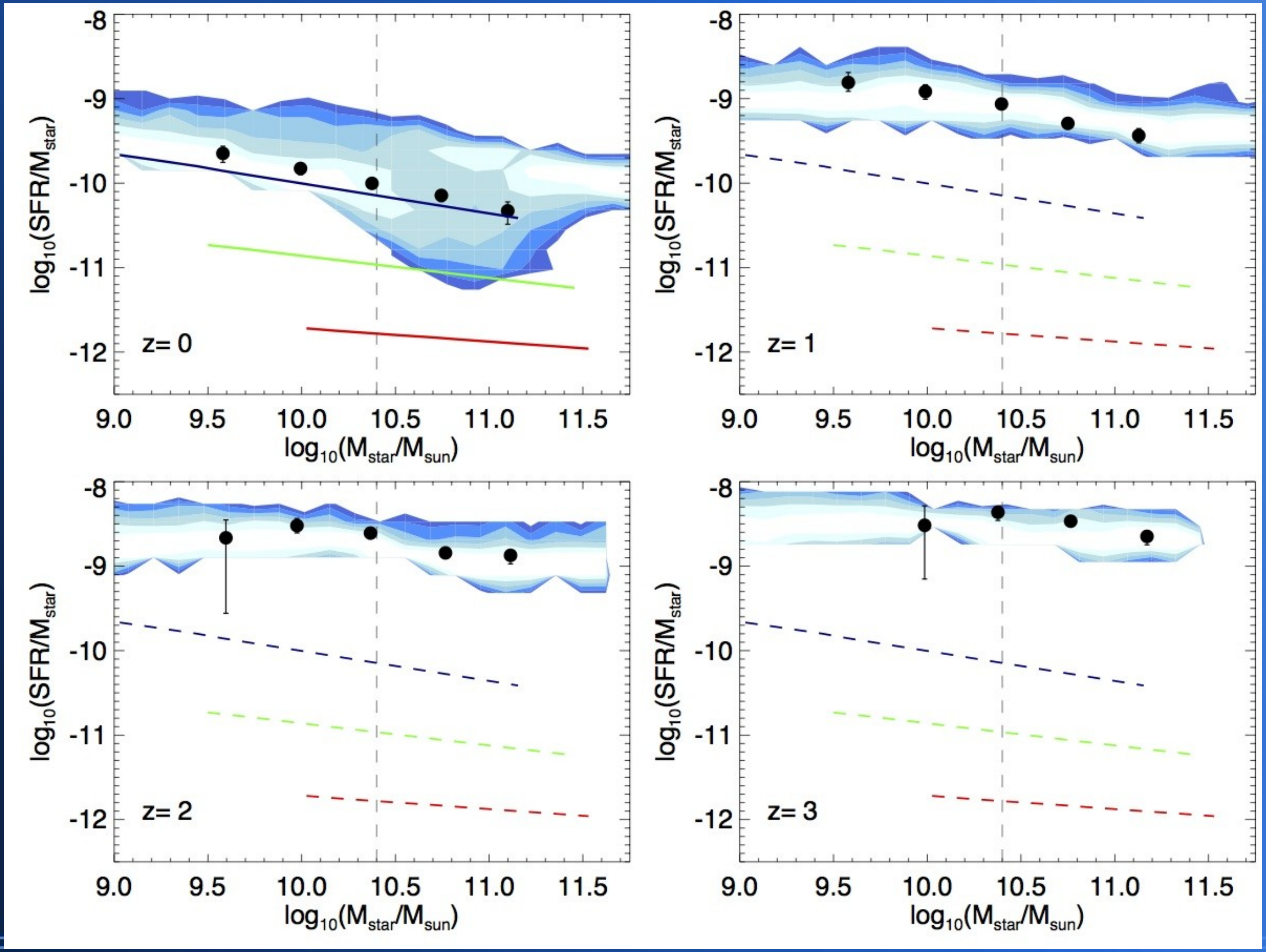
“Thinning” the cold gas disk

- Matches f_* well up to z=2
- Matches the cold gas fraction better at high redshifts, overproduces cold gas at z=0



“Thinning” the cold gas disk

- Reproduces the slope of the blue sequence and the evolution of its normalization- not something we fit for



Conclusions

- There are solutions for both forms
- Both solutions must be time and halo mass dependent to match the evolution of the low mass end of M_{star}/M_{halo}
- The steepening fixes only the problems with stellar masses
- The thinning fixes stellar masses and SSFR and helps with cold gas