Forming exponential disks in cosmological simulations

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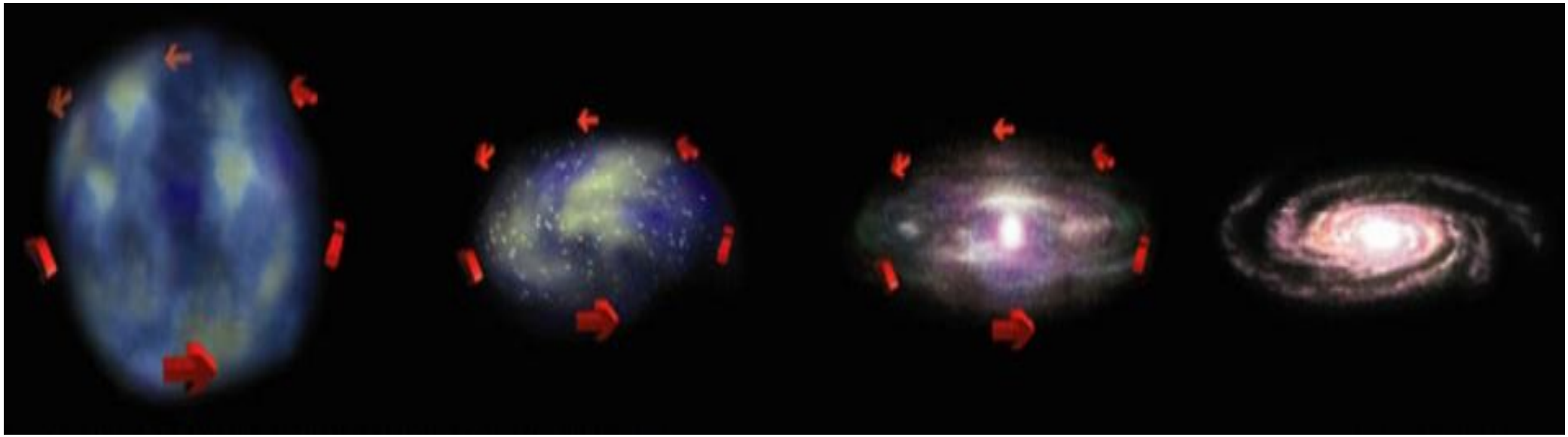
How do we get exponential disks?

Tidal interactions ➡ Angular Momentum Distributions (Peebles 1969)

$$\mathrm{AMD}_{gas}\,(z > z_{dec}) \sim \mathrm{AMD}_{DM}\,(z > z_{dec})$$

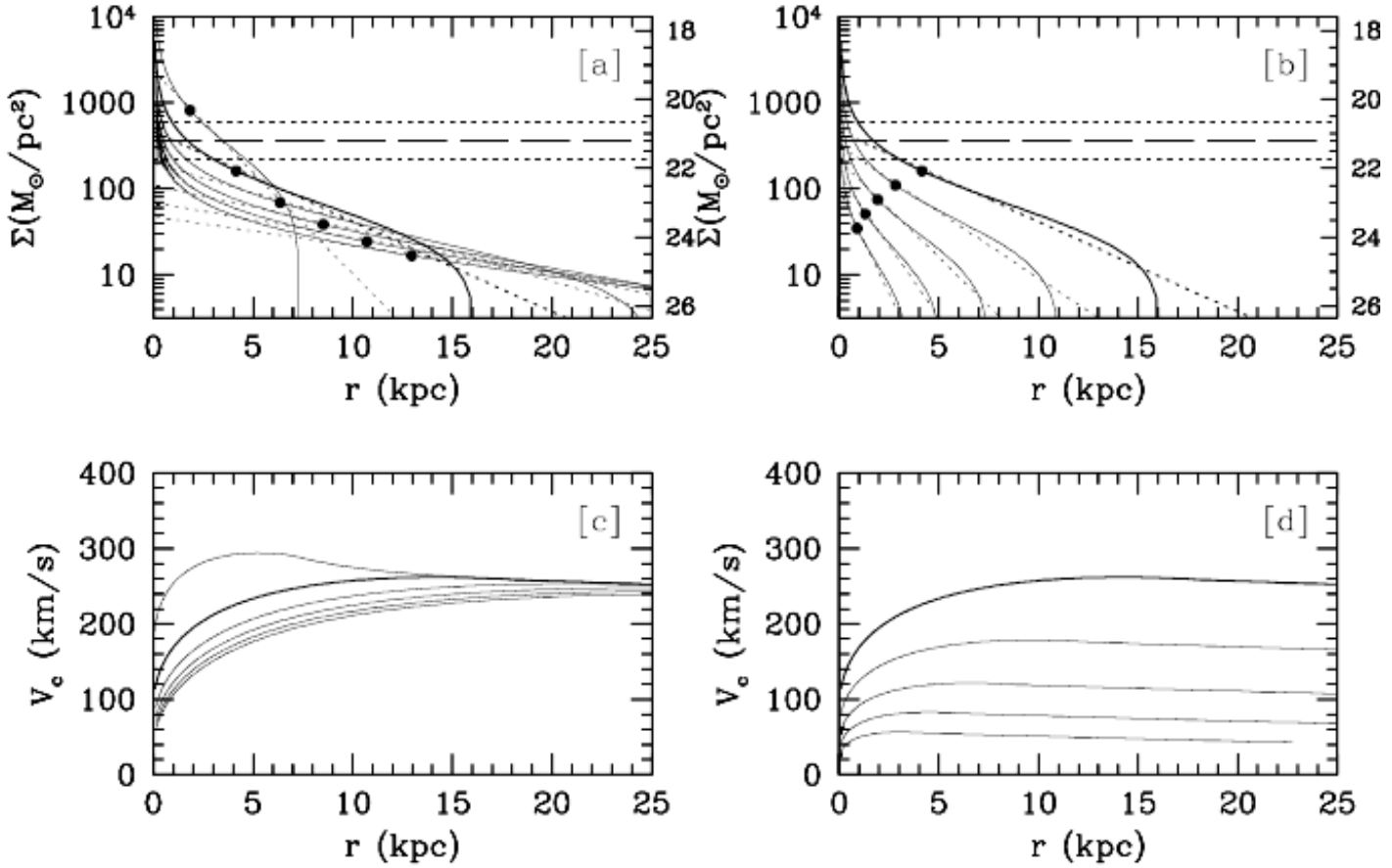
General assumption:

Under detailed AM conservation: gas cloud collapse to a rotational supported disk (Mestel 1963, Freeman 1970, Larson 1976, Fall & Efstathiou 1980)



Detailed assumptions in these models

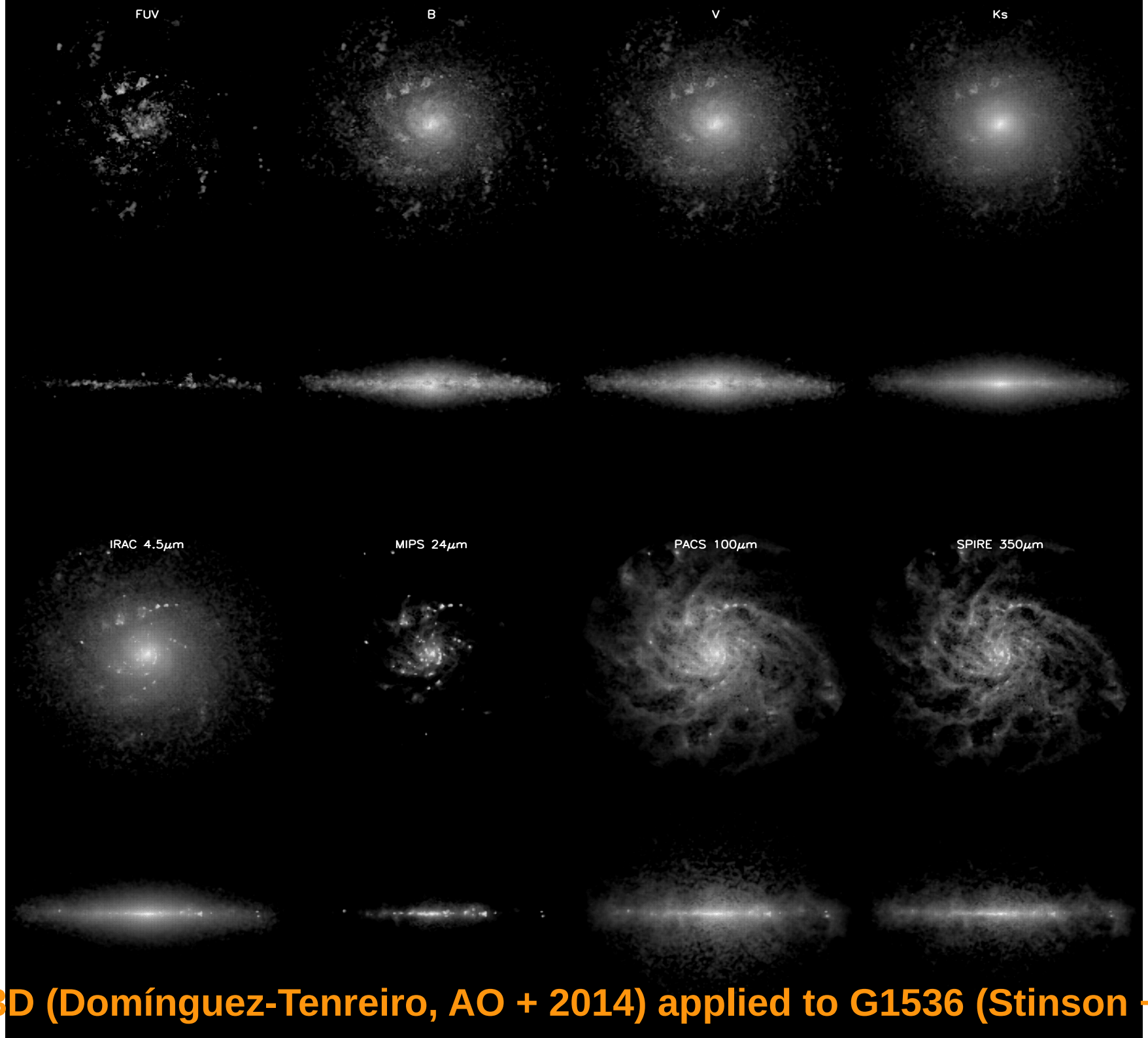
- NFW halo.
- The baryons collapse → adiabatic contraction of the halo.
- Material keeps the angular momentum it starts with as it accretes.
- Initial AMD + final rotation curve → final $\Sigma_{disk}(R)$.



Dalcanton + 1997

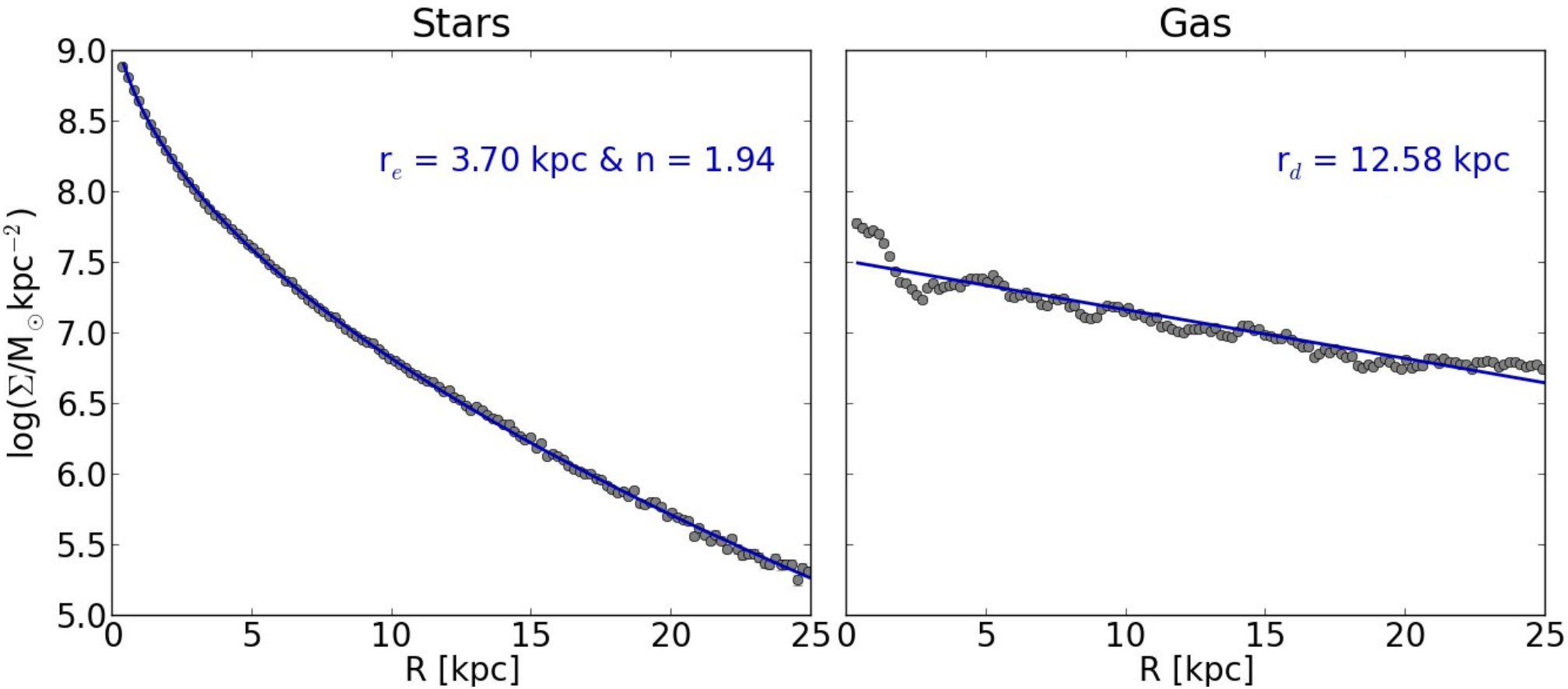
Pure exponential ⟺ expel a high fraction of the low AM gas

(Sharma+2012, Dutton & van den Bosch 2012)

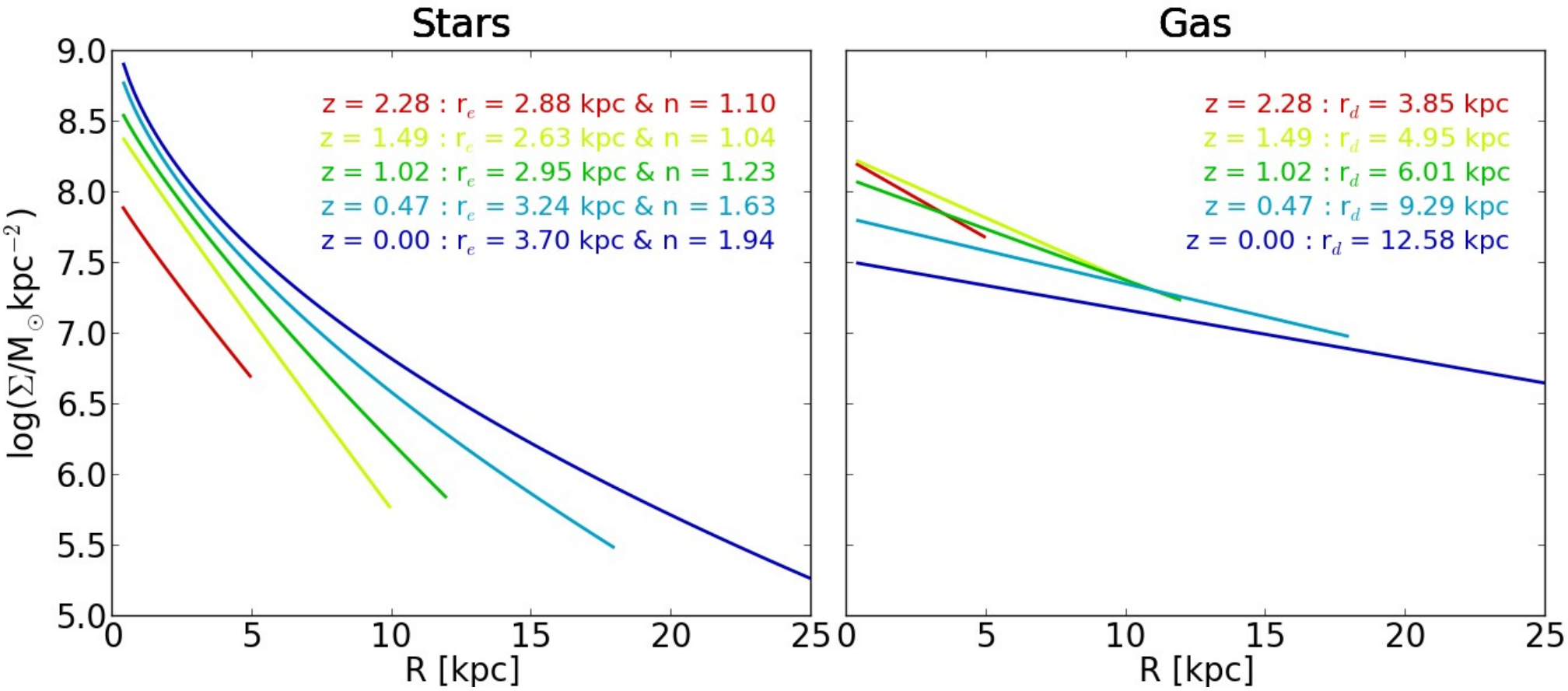


Grasil3D (Domínguez-Tenreiro, AO + 2014) applied to G1536 (Stinson + 2013)

Mass surface density at z=0



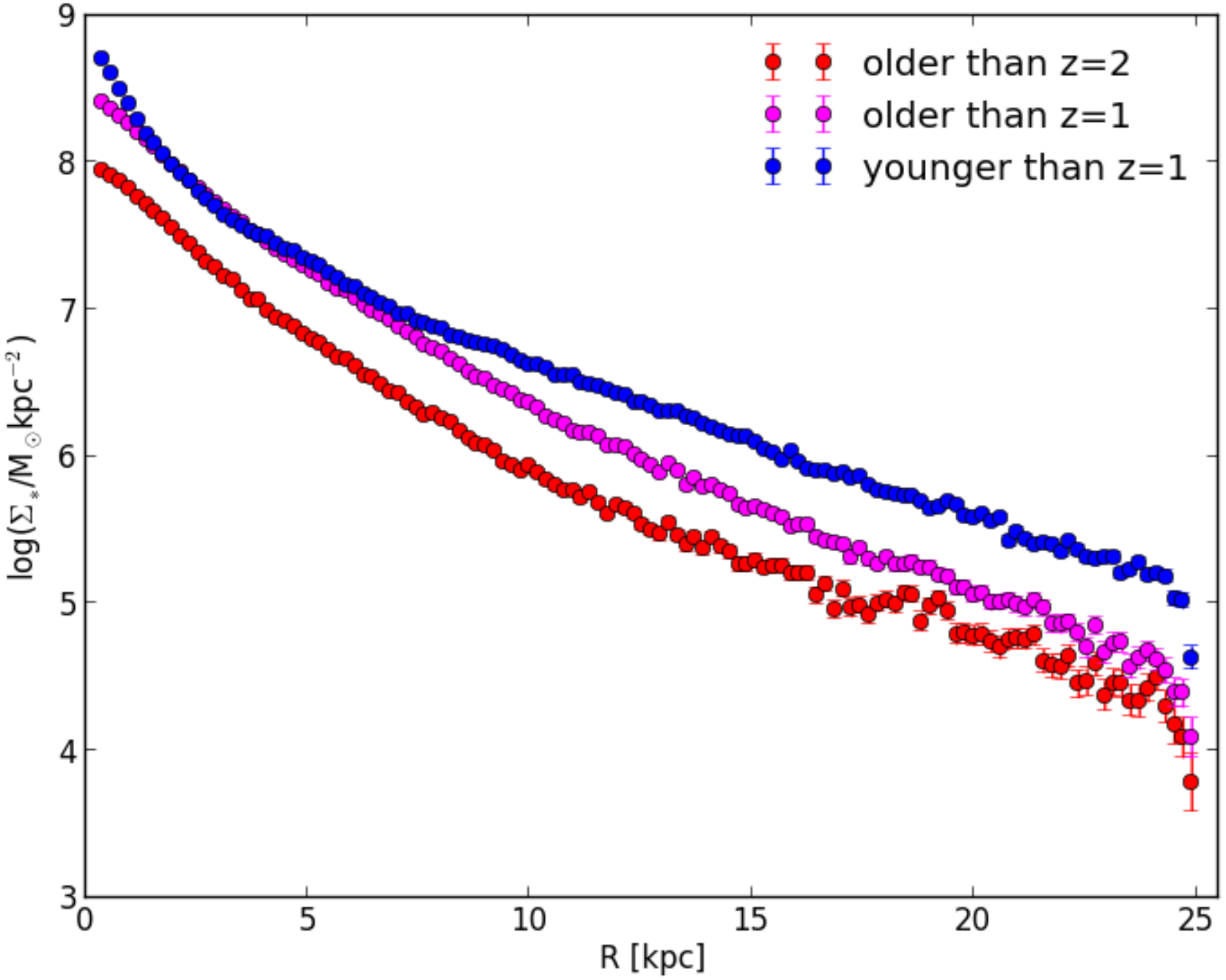
Mass surface density evolution



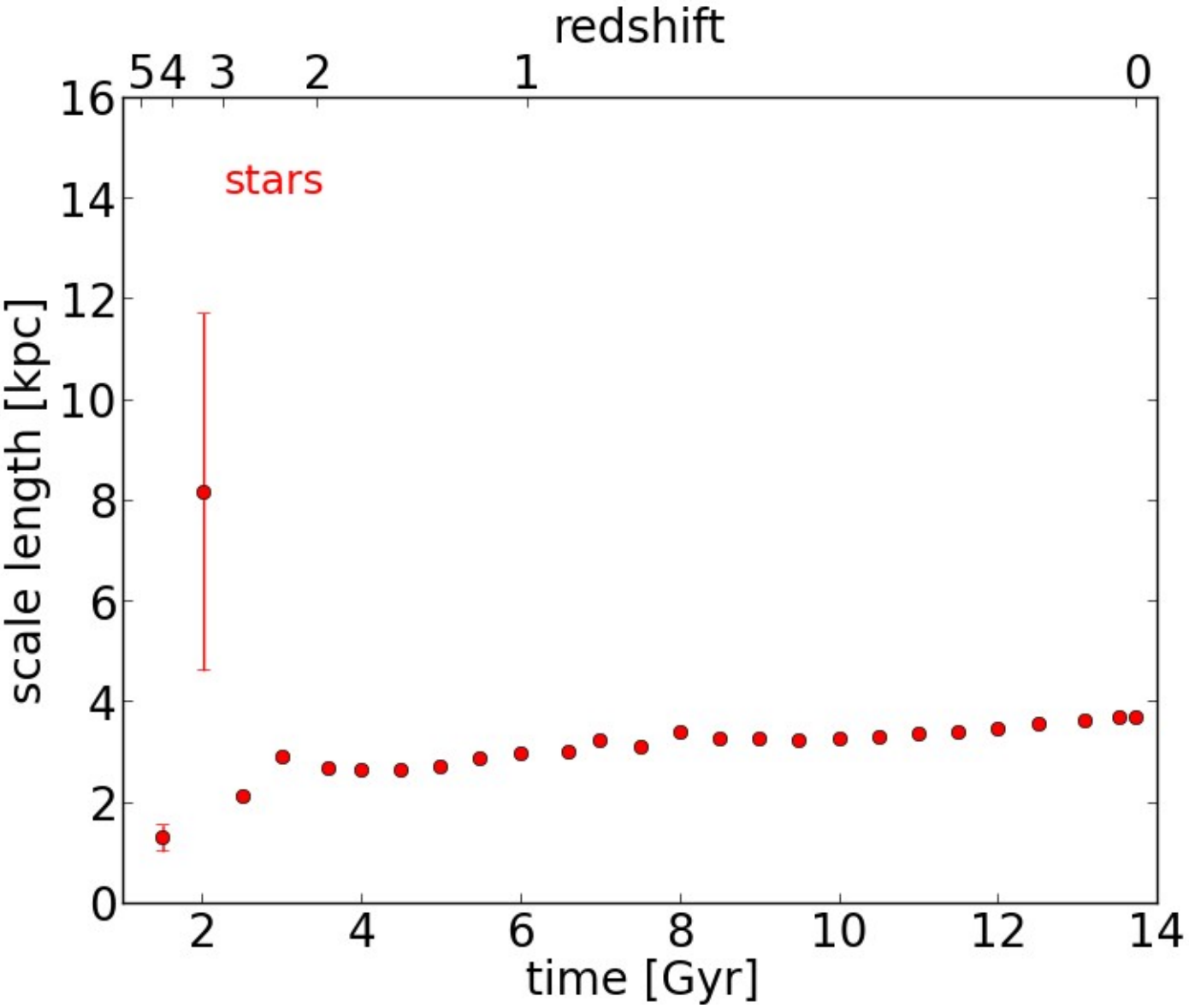
$$\Sigma(R) = \Sigma_e exp[-\kappa(n)[(R/r_e)^{1/n} - 1]]$$

$$\Sigma(R) = \Sigma_0 exp[-R/r_d]$$

Age dissected stellar mass surface density at z=0



Evolution of the surface mass density scales



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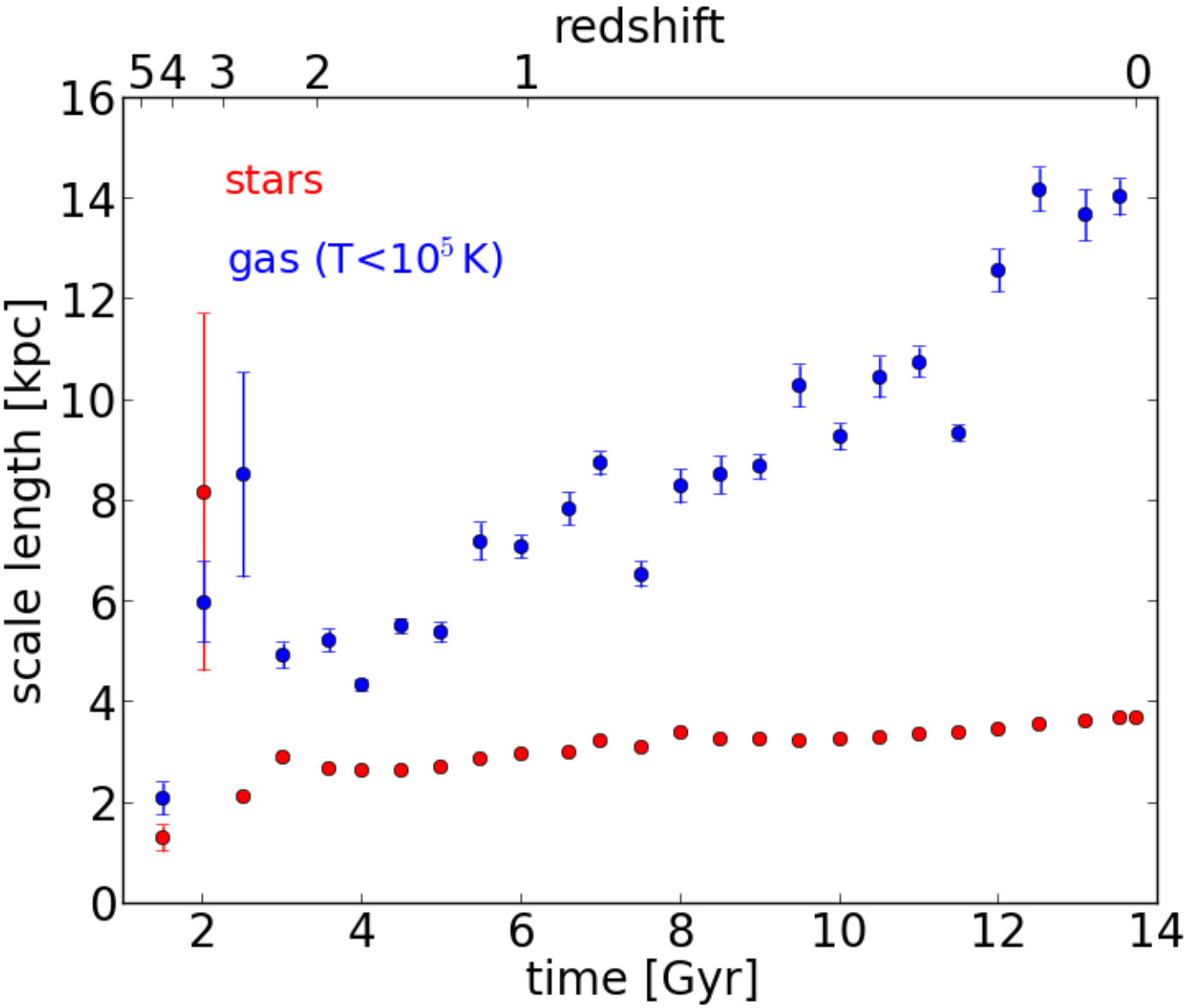
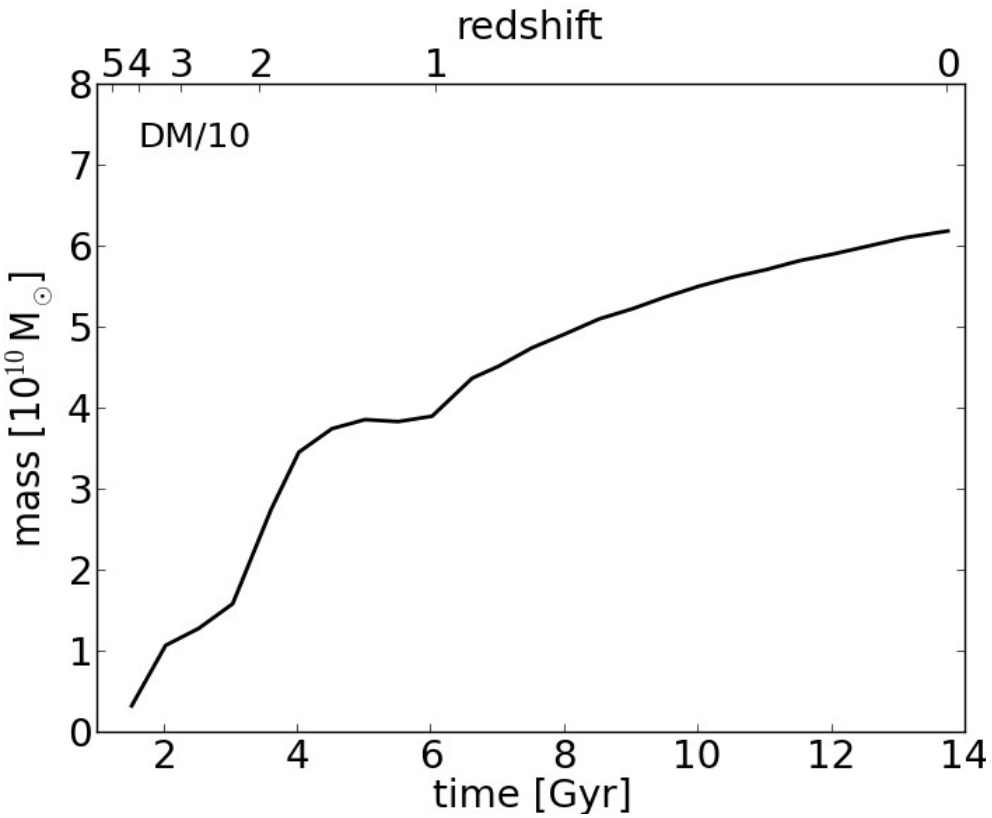
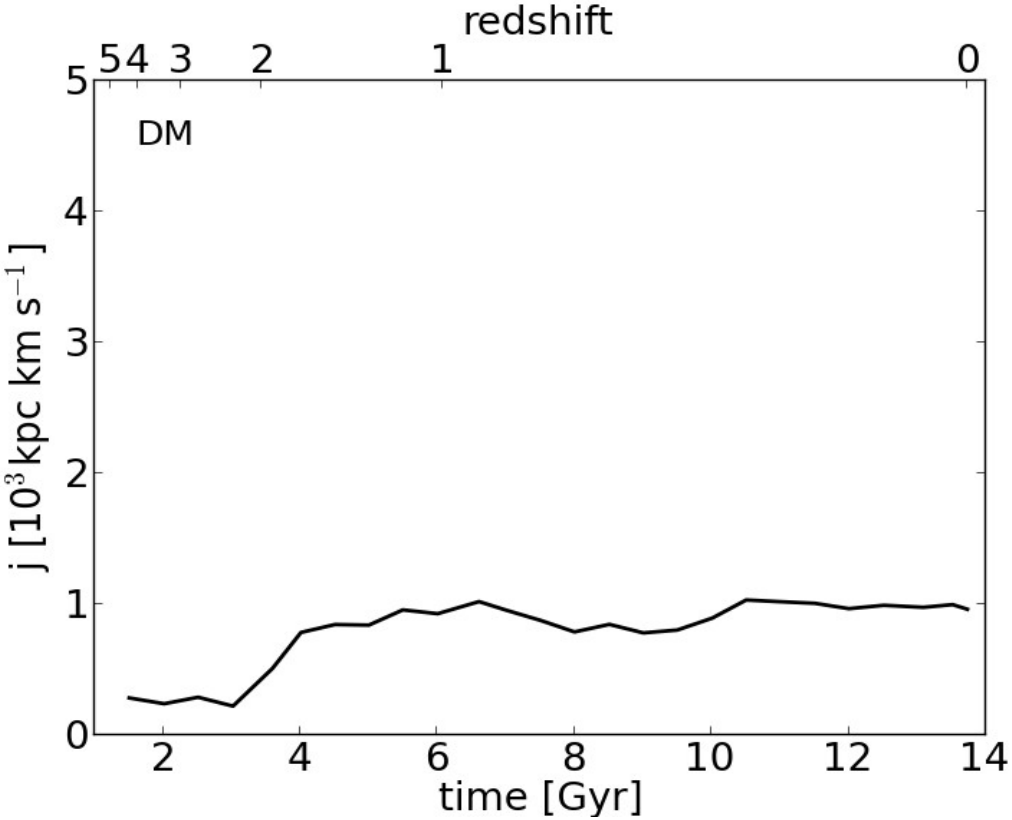


Mass and specific angular momentum build up within Rvir





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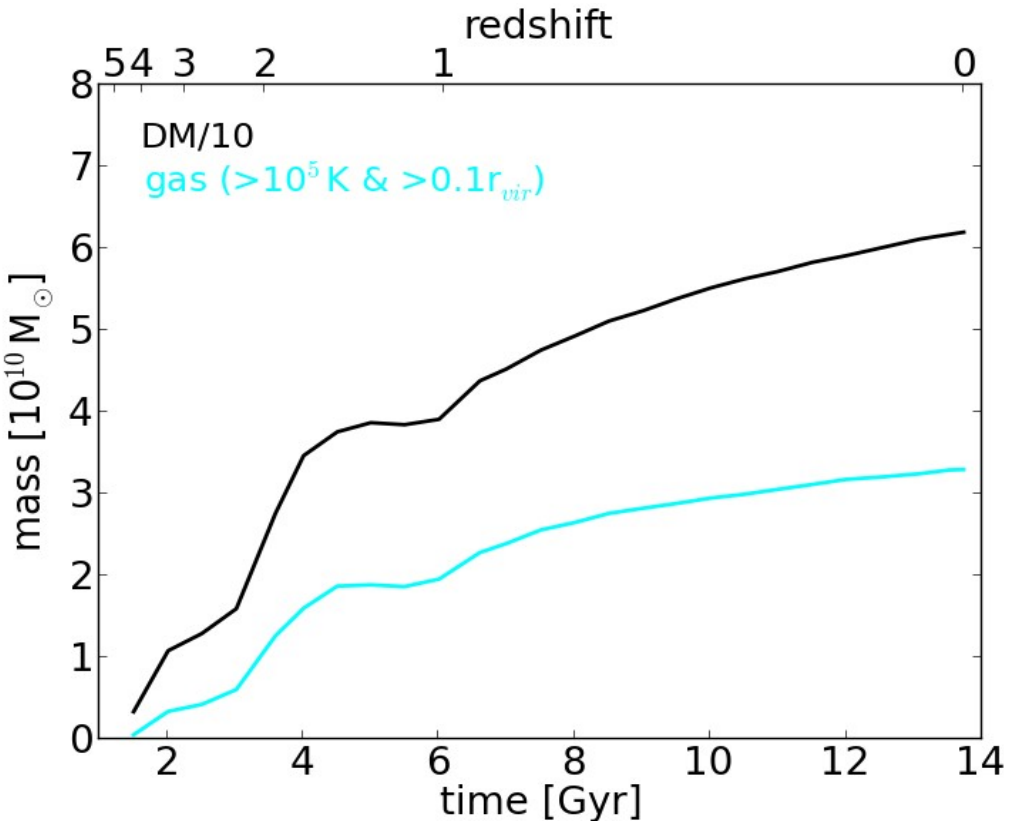

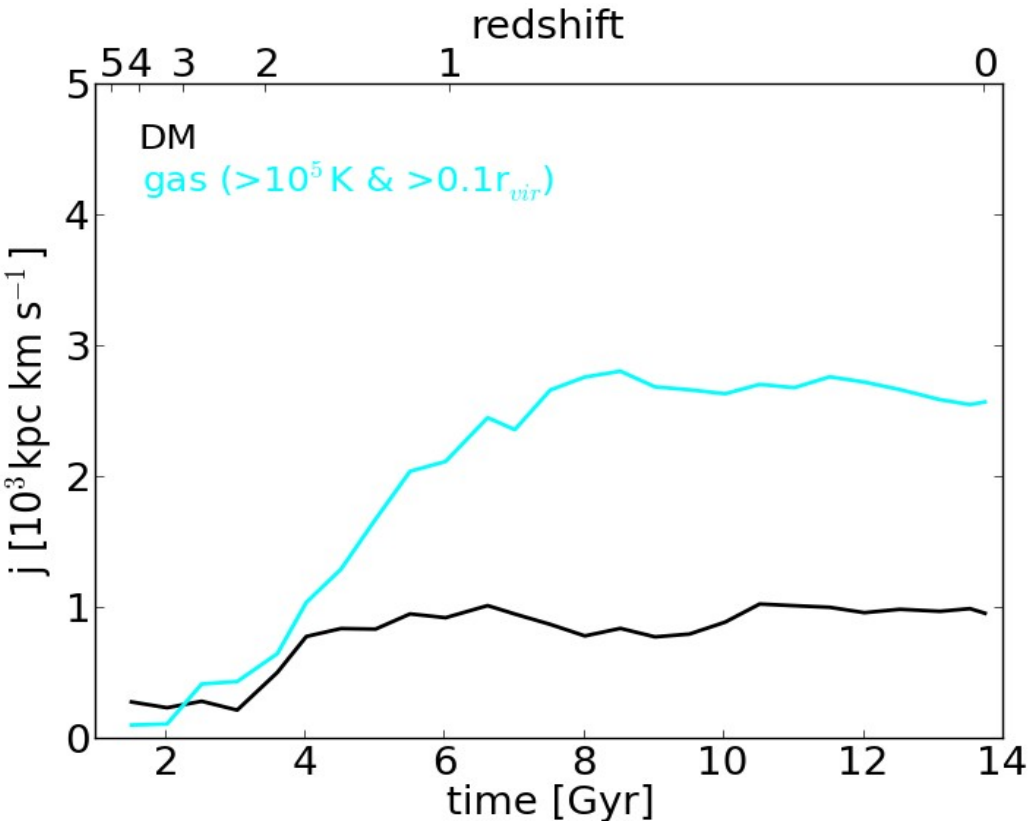

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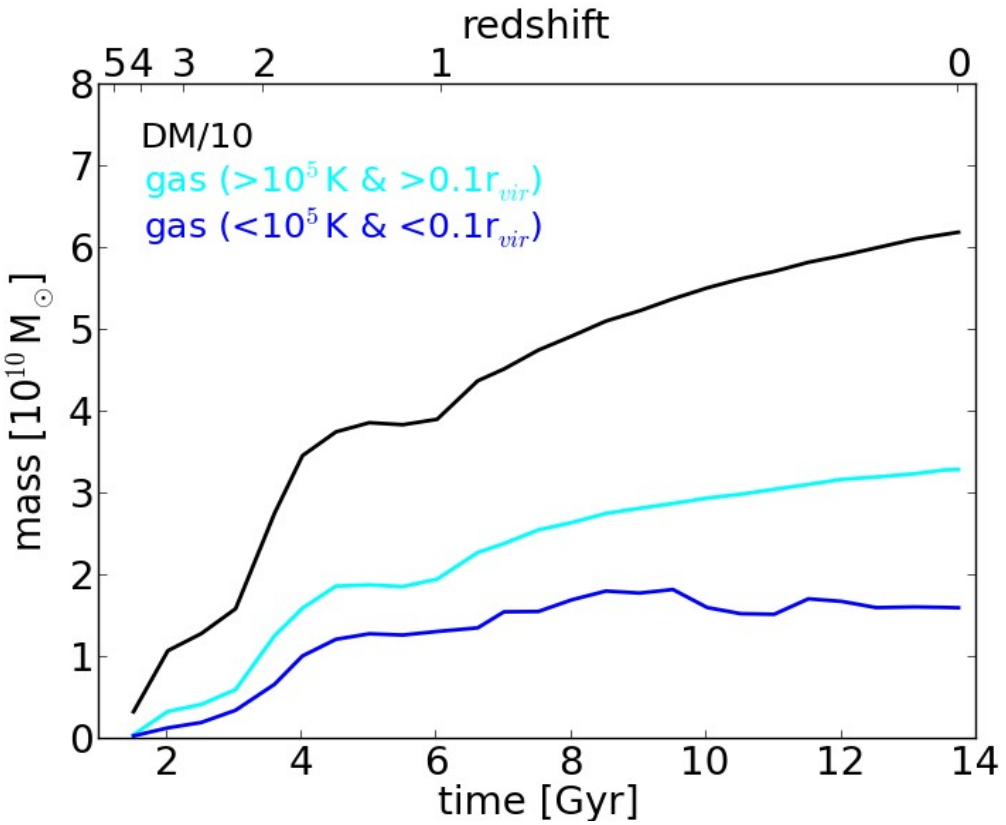

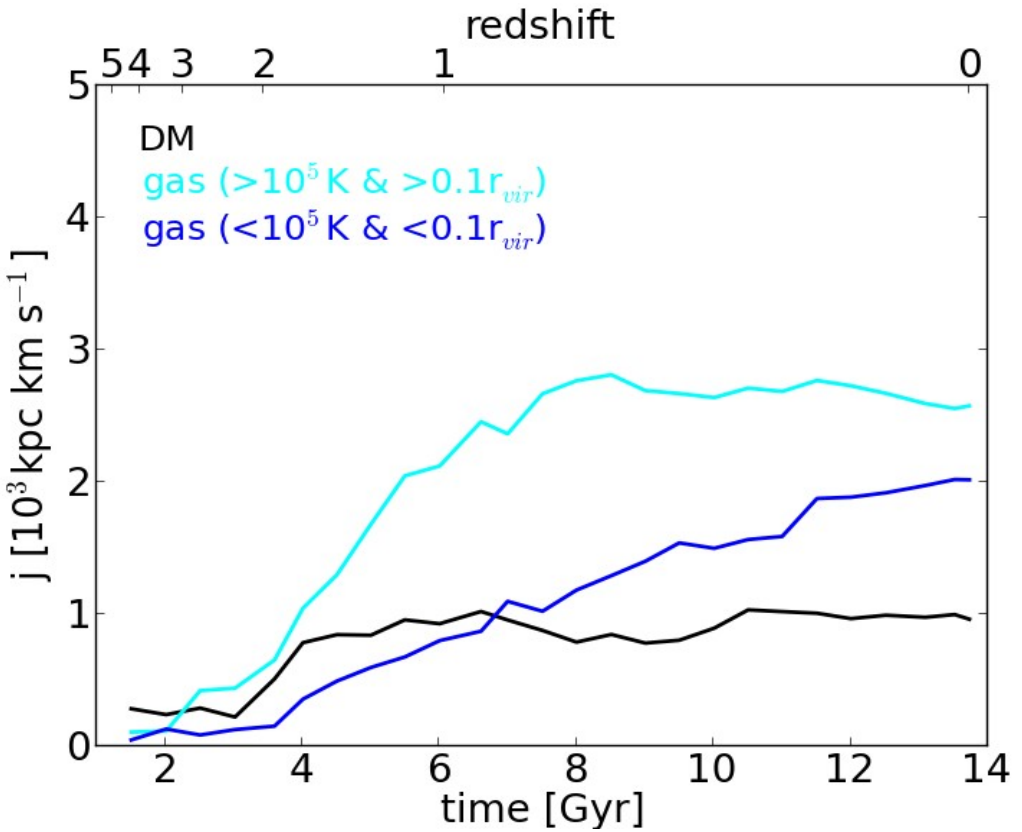

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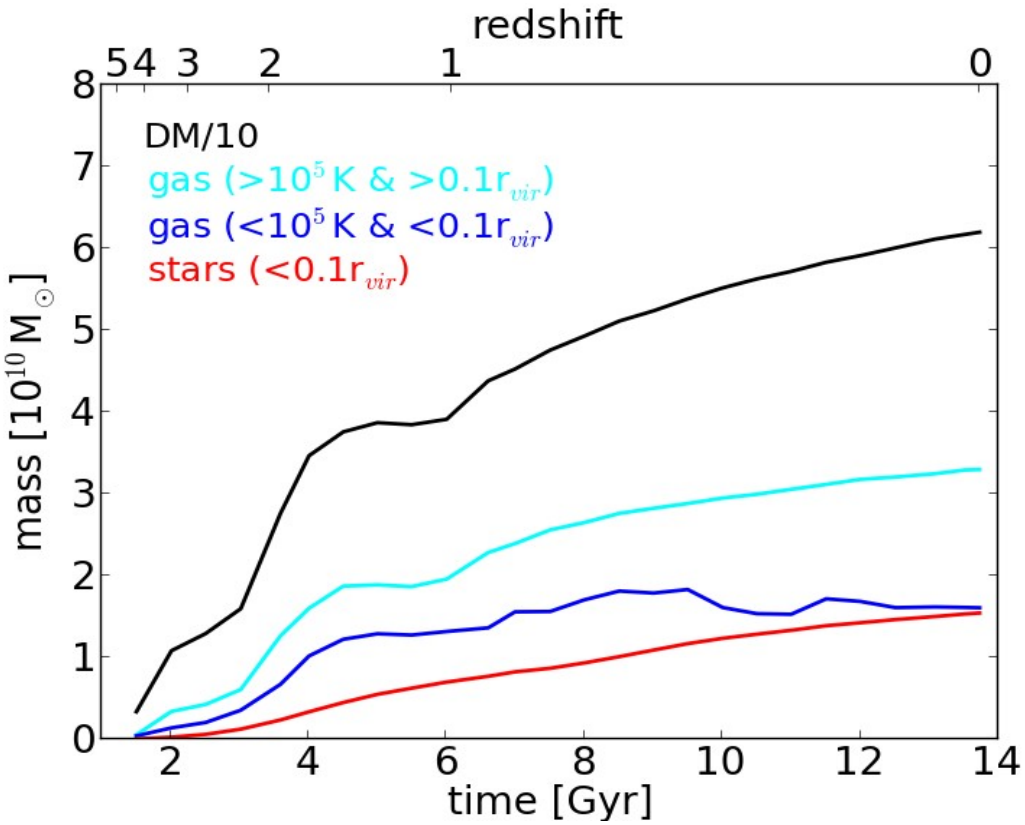
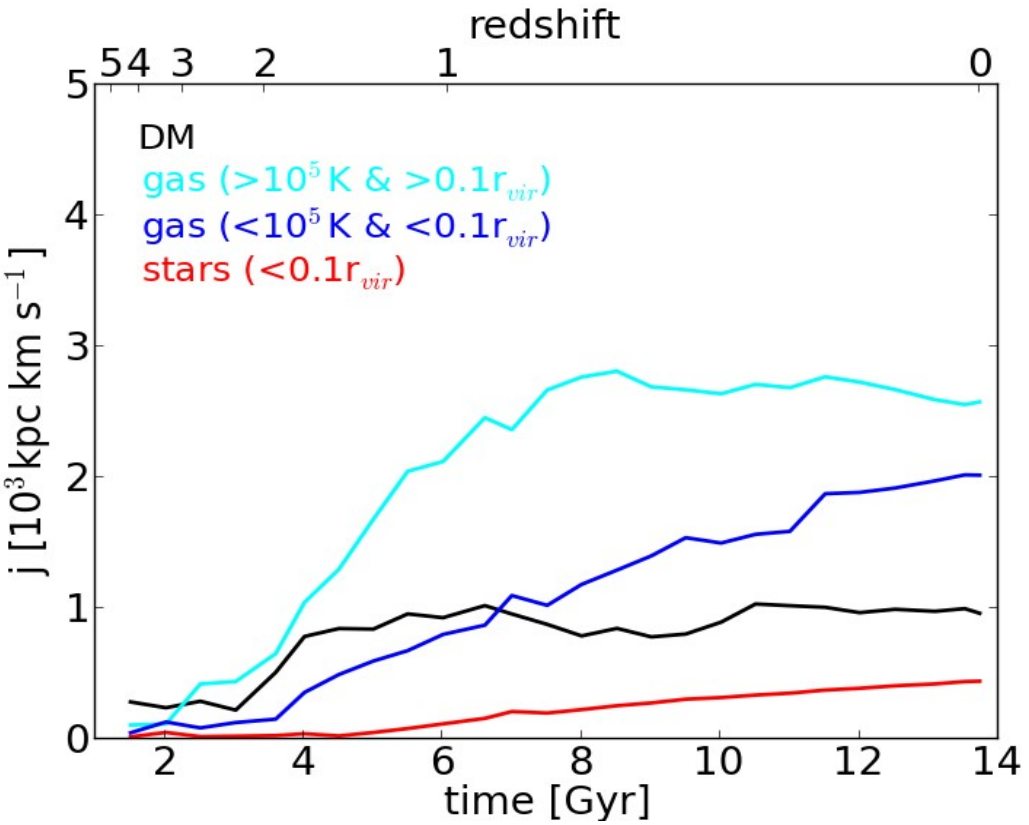
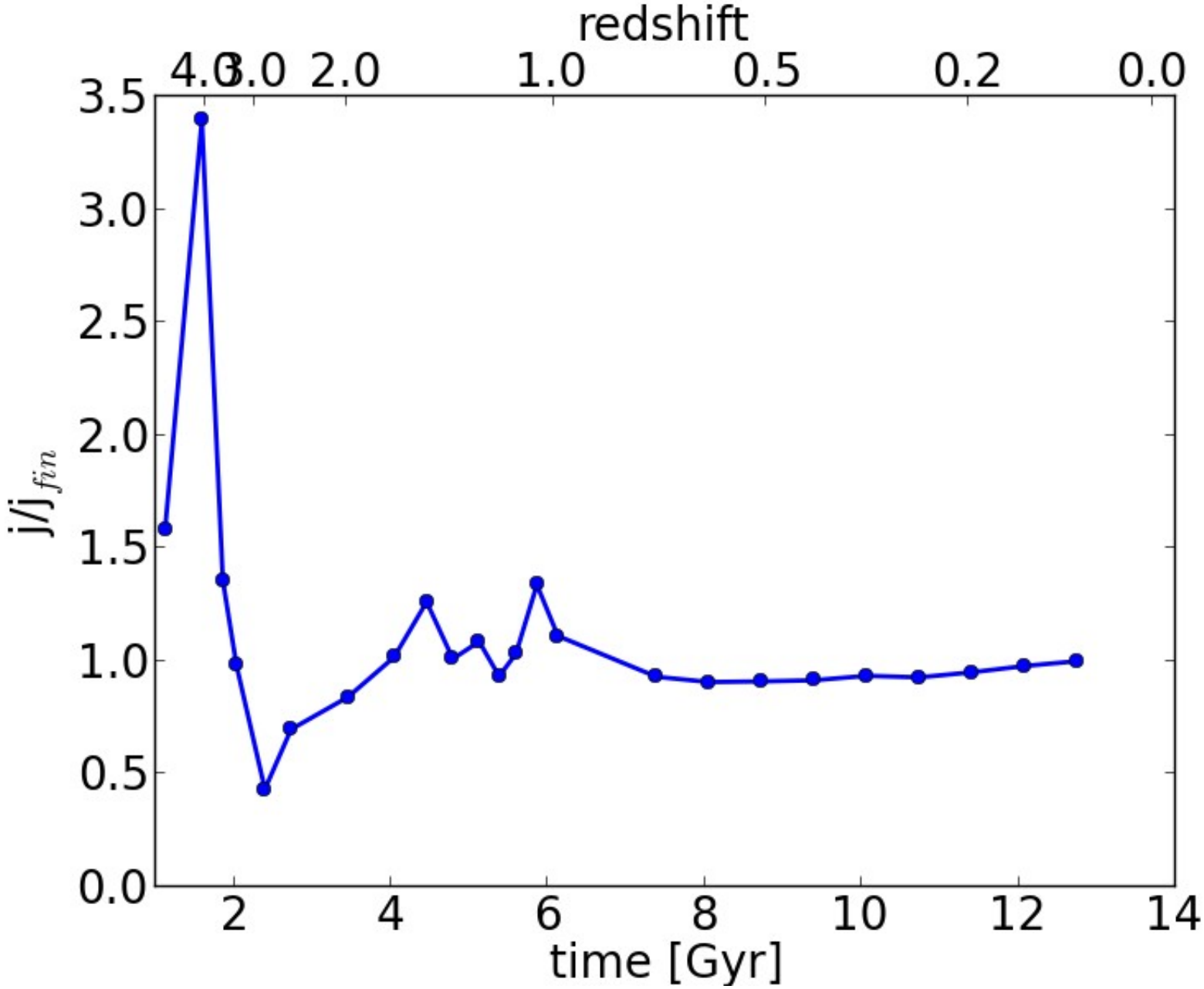
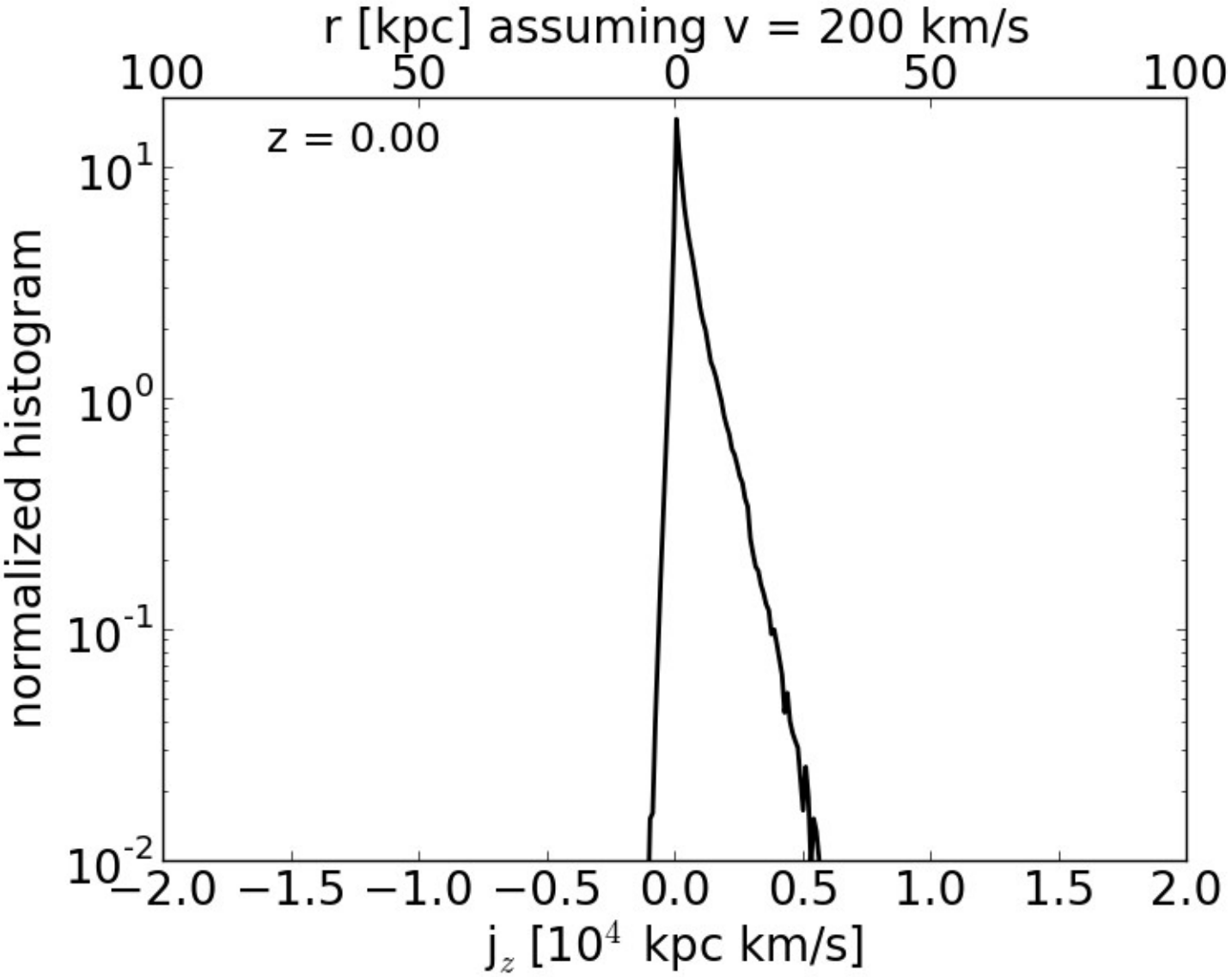




Is the total angular momentum conserved?



What is the progenitor gas AMD?



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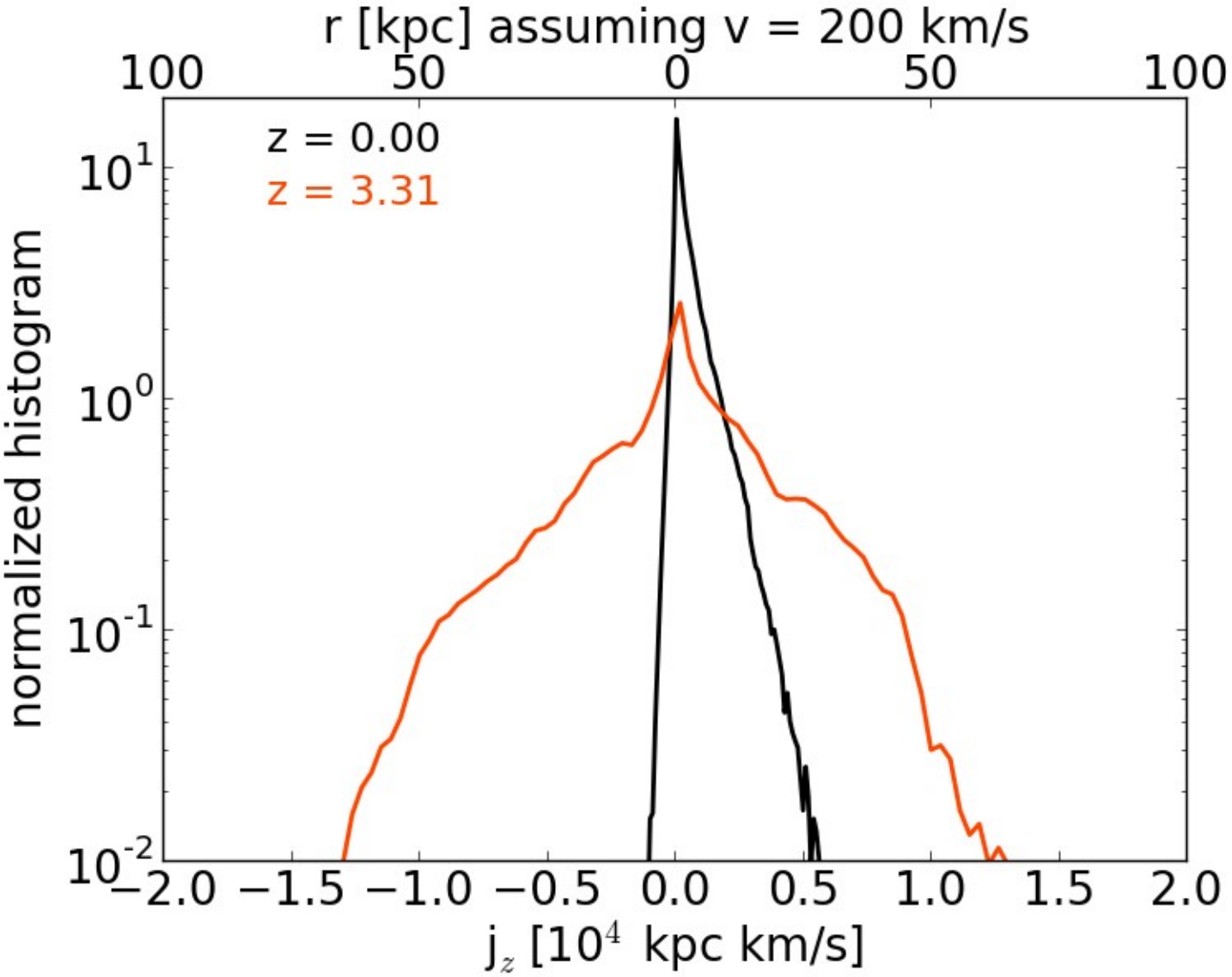

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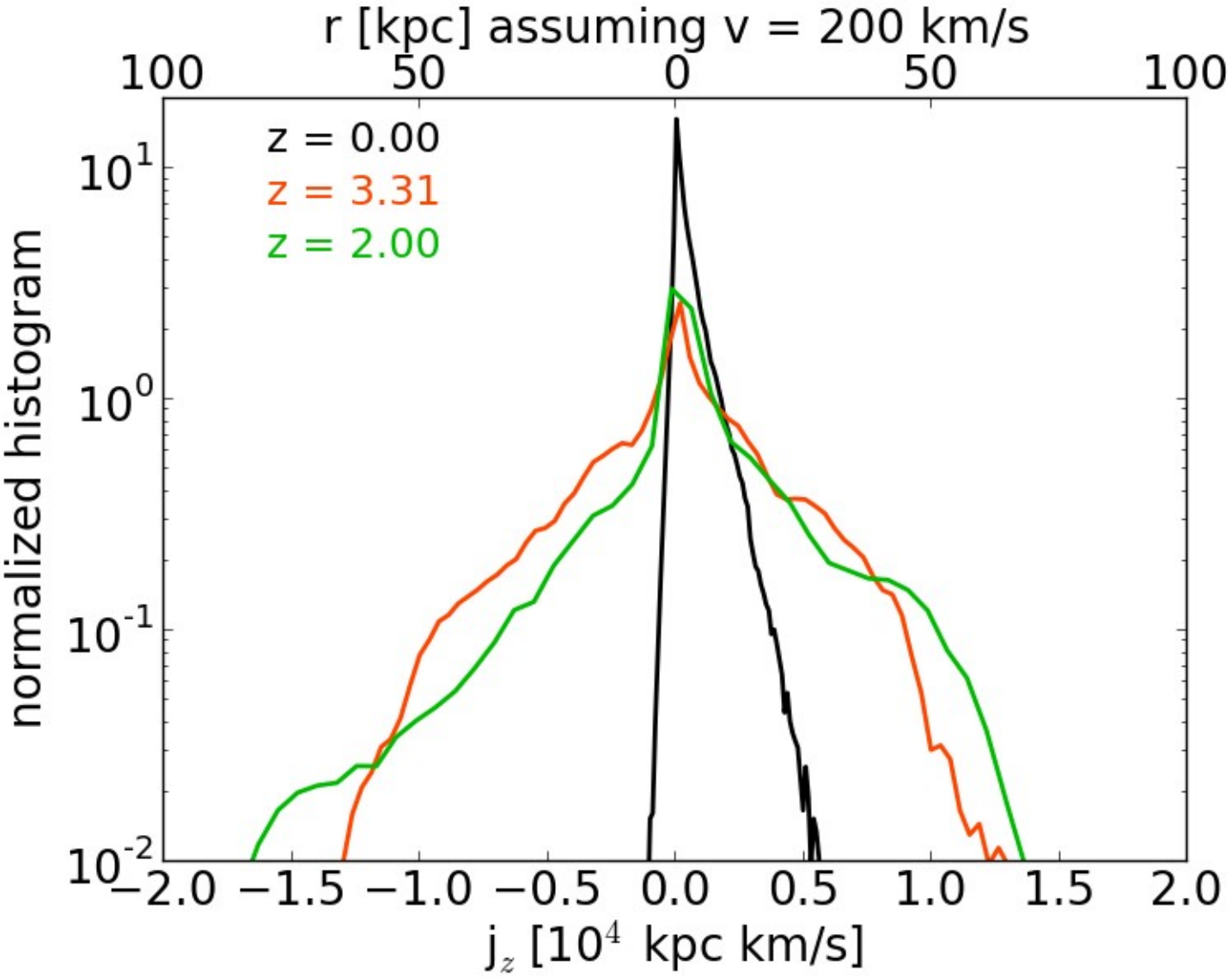

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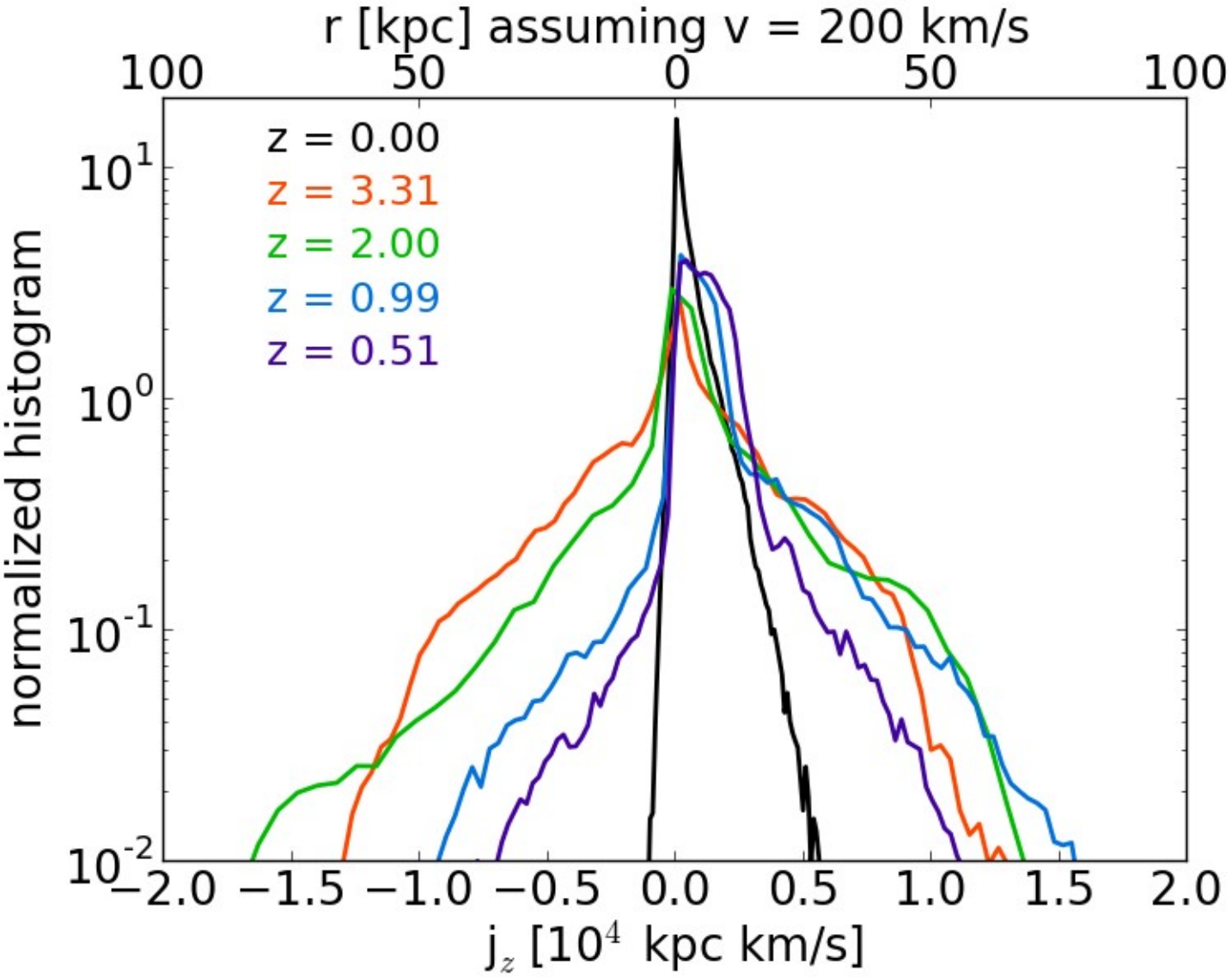
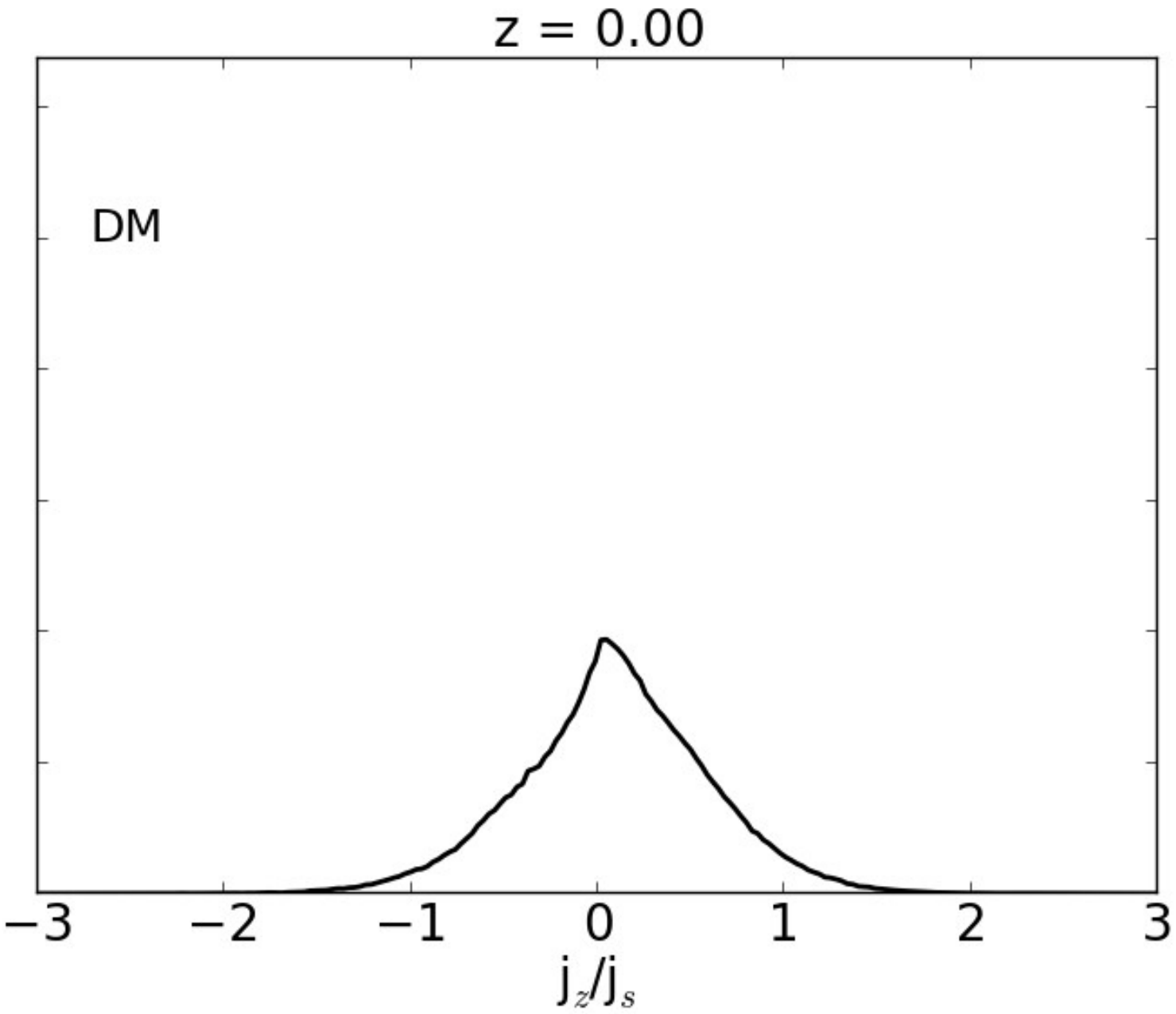


Scaled halo AMD



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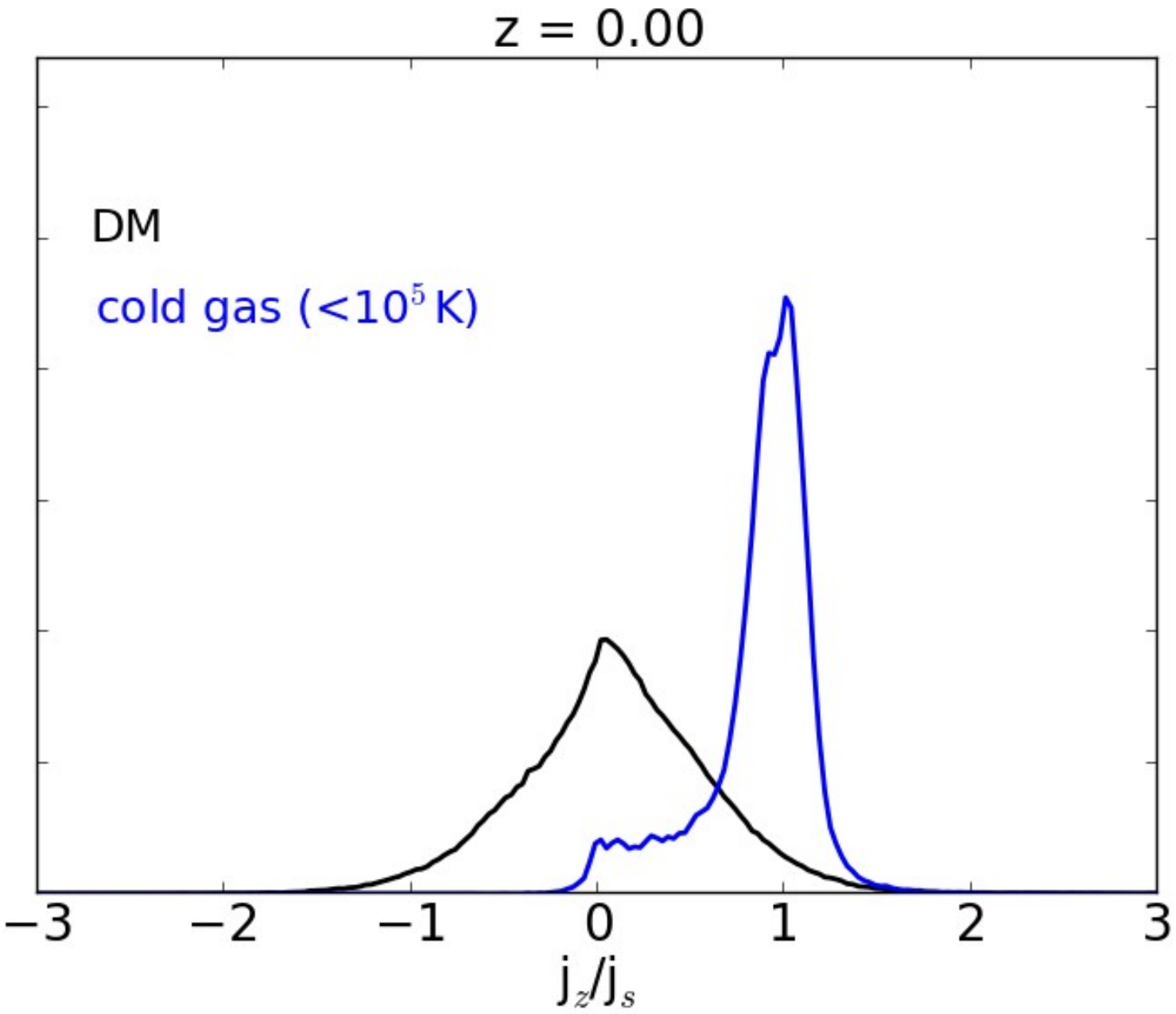

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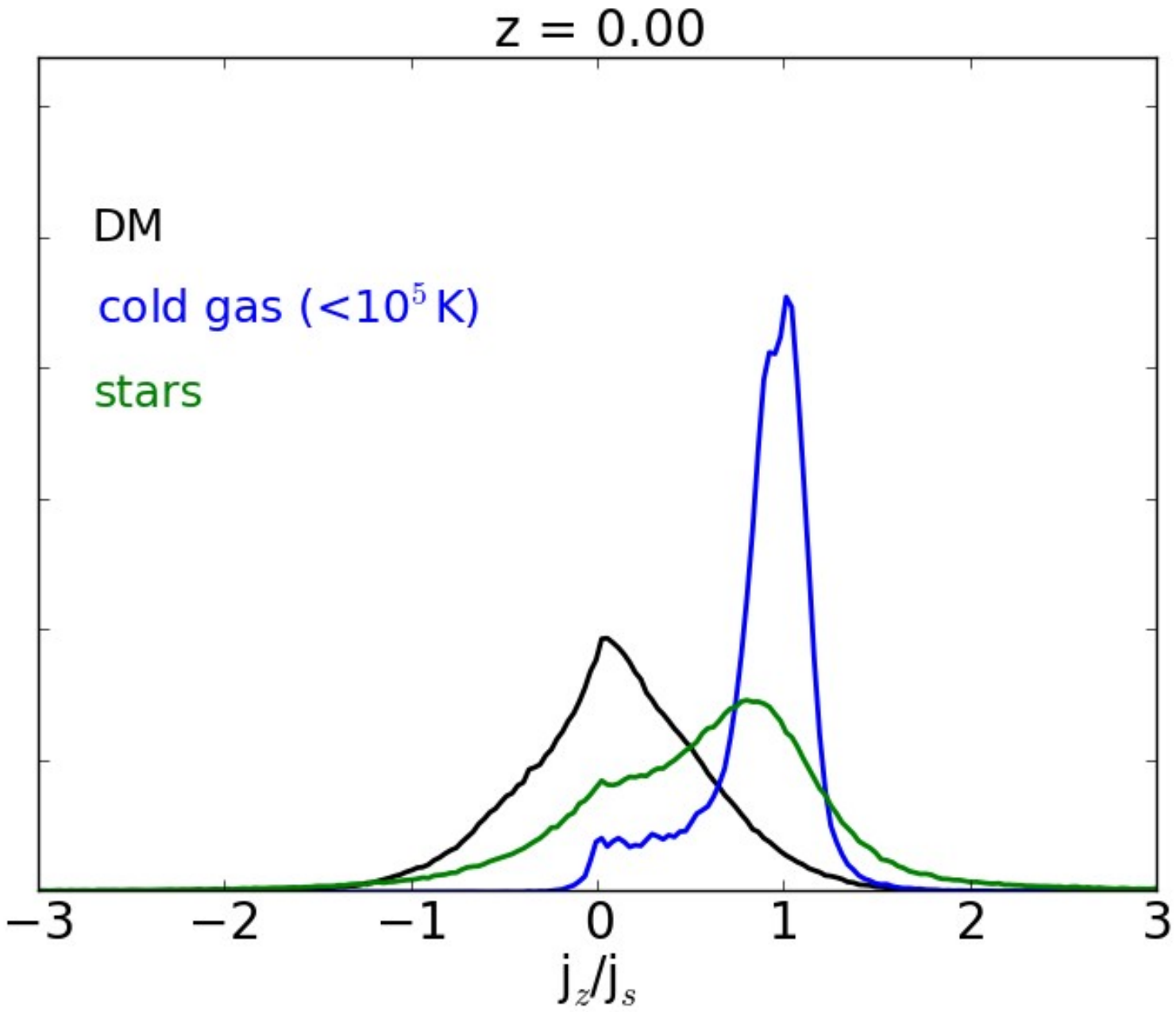
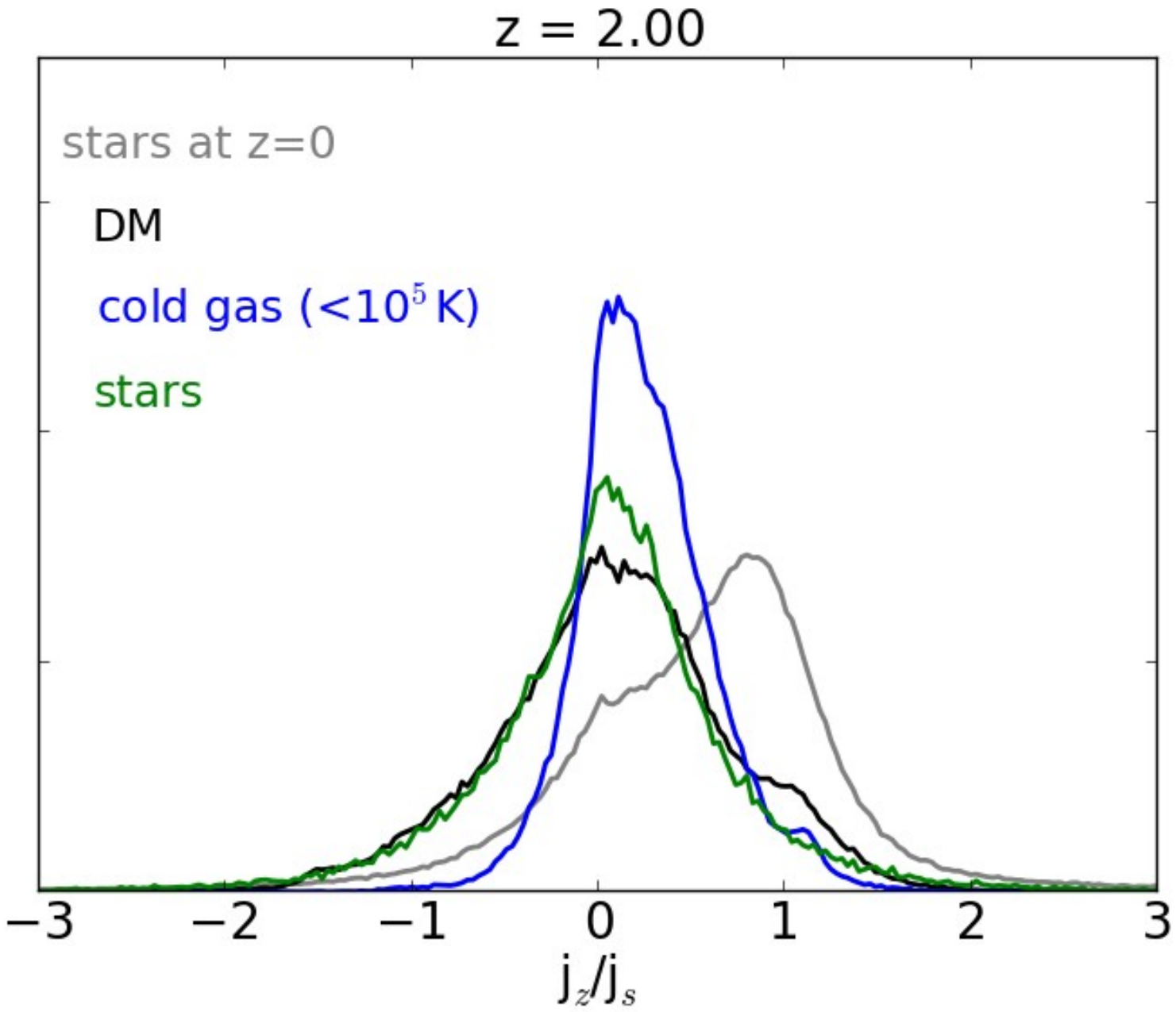


How does the AMD of the halo material evolve?



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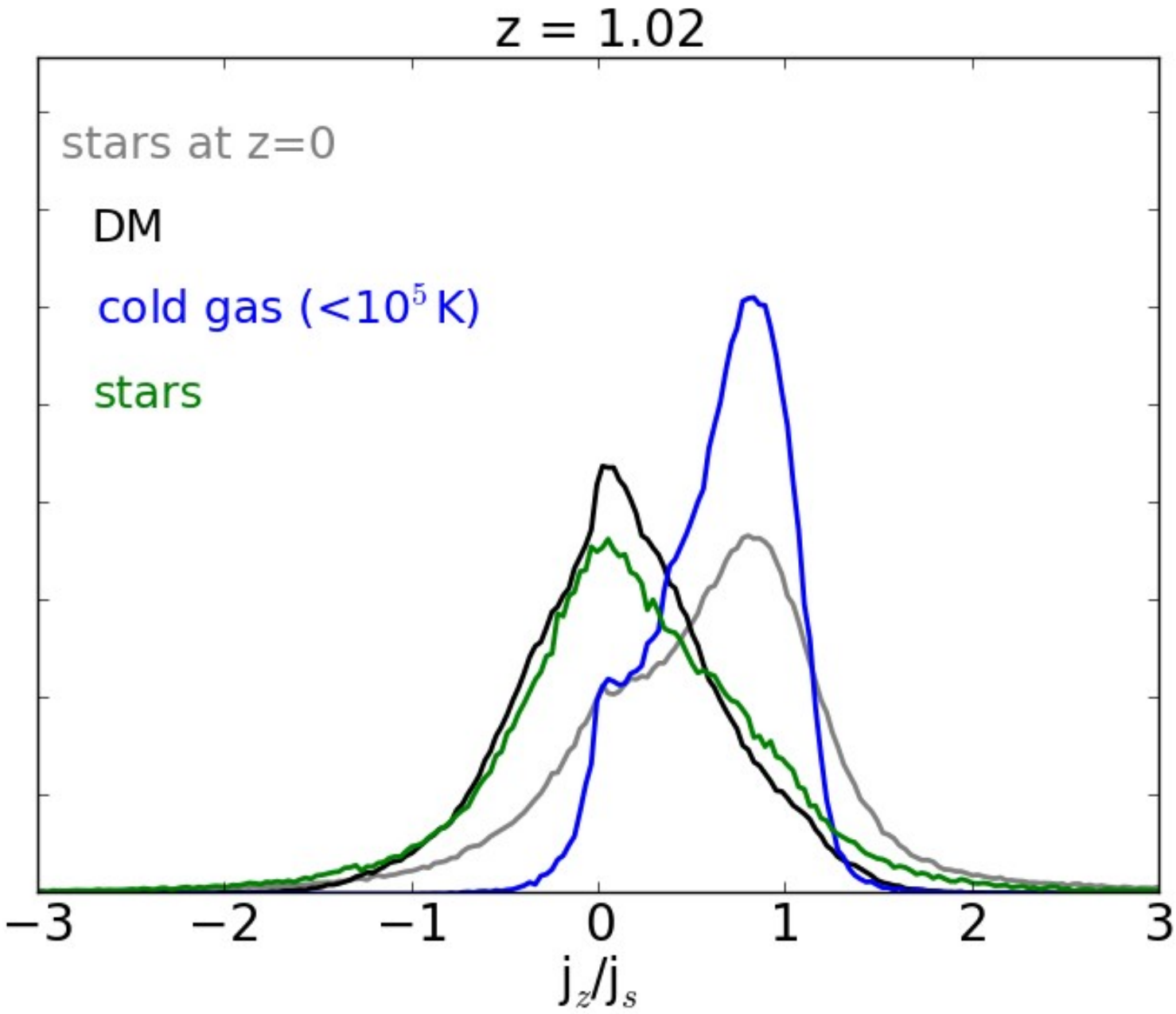
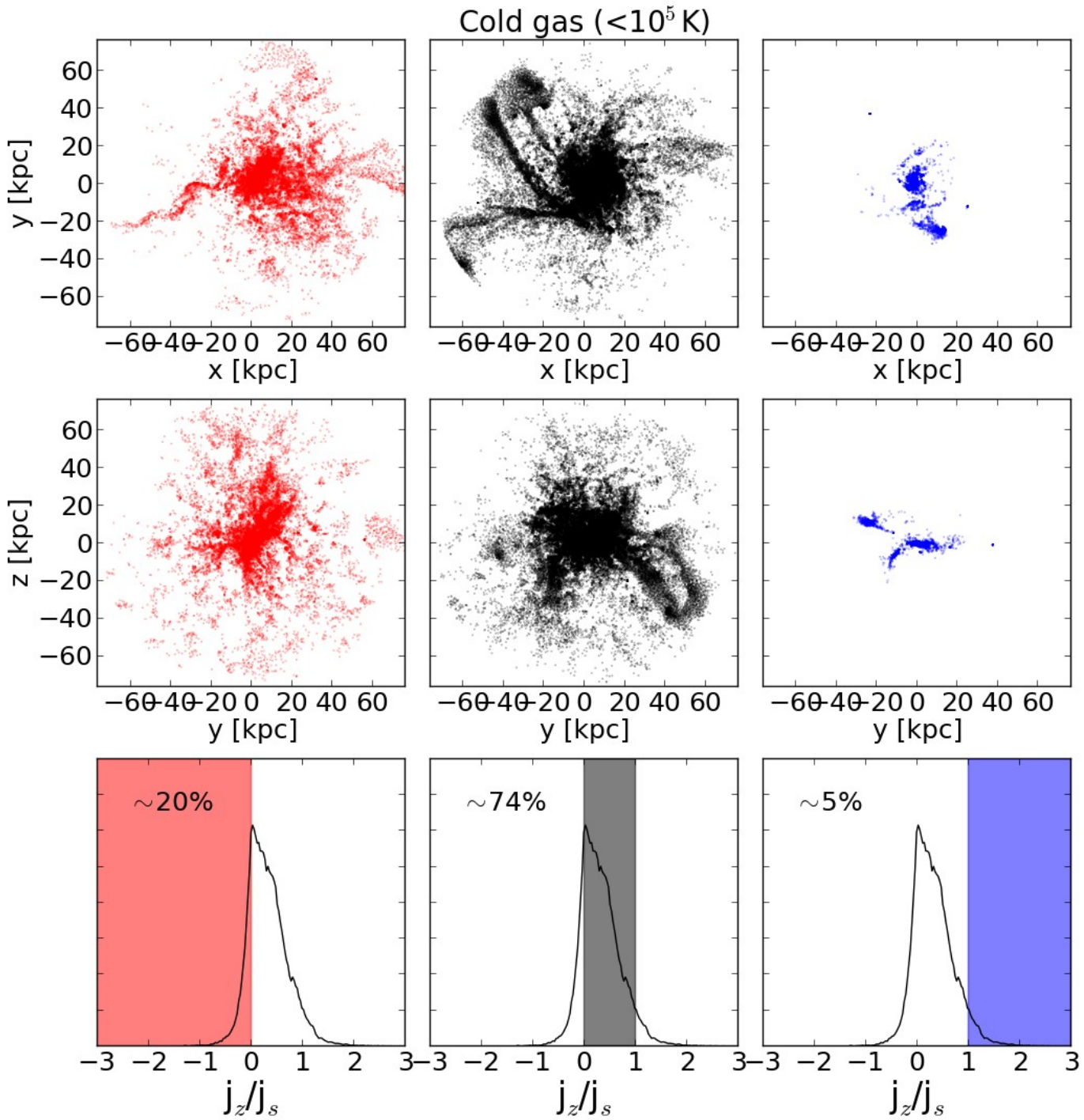
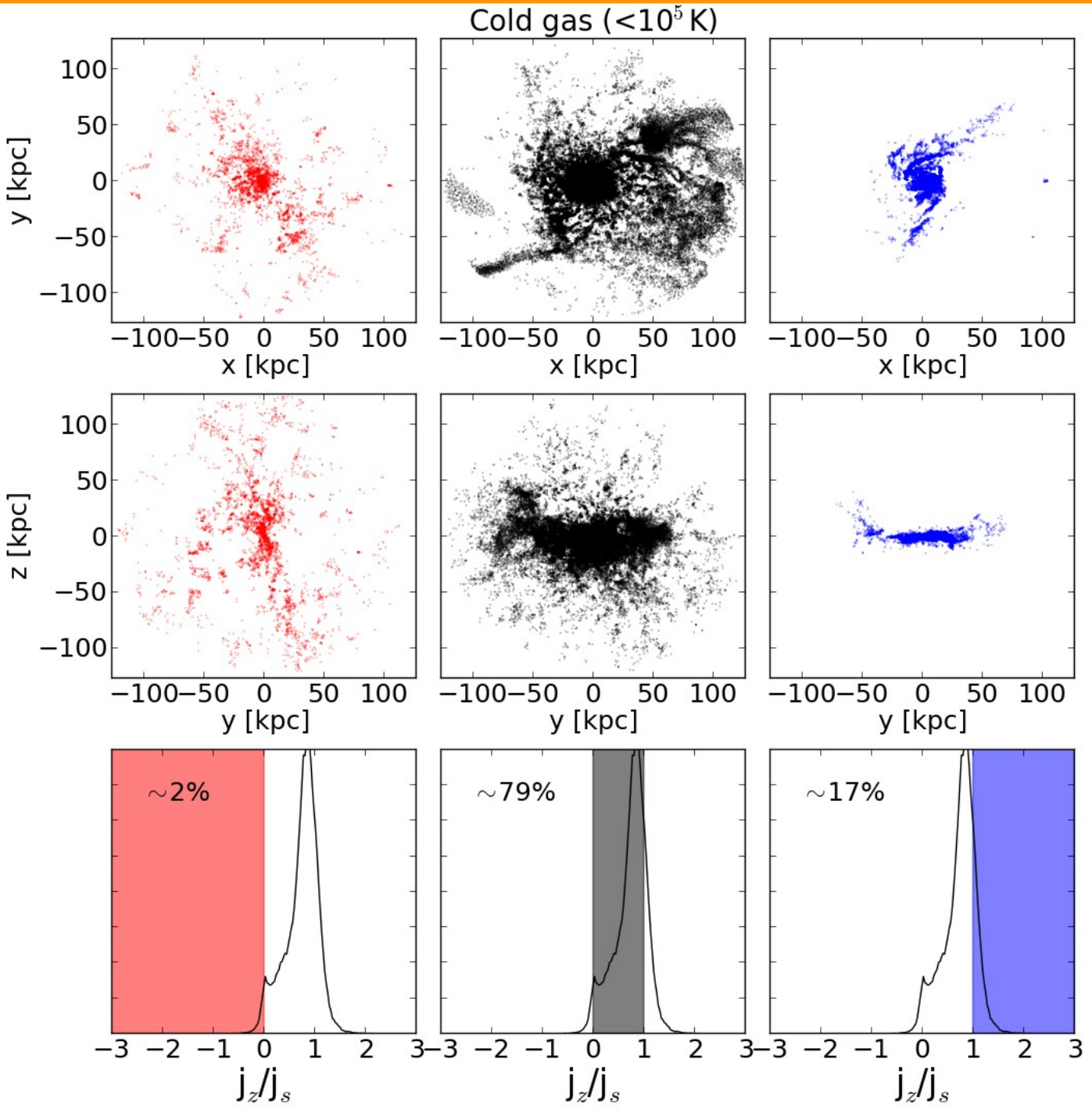


Where is the high and low cold AM gas at z=2?



Where is the high and low cold AM gas at z=1?



Conclusions

Cold gas follows an exponential profile at all zs.

Stellar mass profile starts to be slightly more centrally concentrated than an exponential after z=1.

AMD of gas and DM decouple at z ~ 2 – 3.

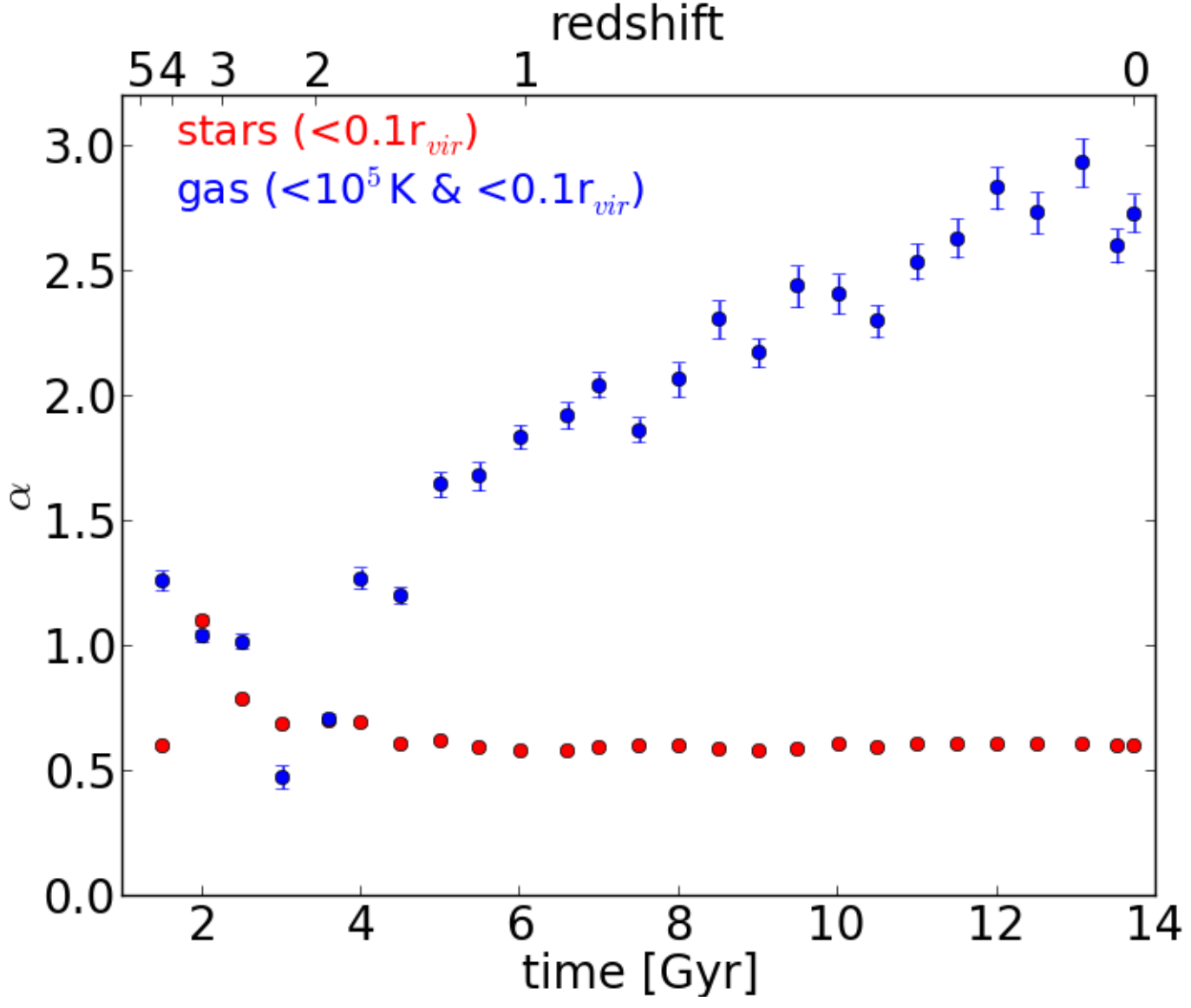
After the gas rich merger at z~2,
symmetric cold gas AMD → positive skewed AMD.

Total baryon AM conserved, but the AMD evolves.

Mass and AM build up during mergers.

Analytical AMD: Sharma & Steinmetz 2005

$$P(<s) = \frac{M(<s)}{M} = \frac{\gamma(\alpha, \alpha s)}{\Gamma(\alpha)} \quad where \quad s = \frac{j_z}{\sqrt{2} r_{vir} v_{vir} \lambda} > 0$$



Mass and specific AM buildup