Too small to form a galaxy? Gas condensation in dwarf galaxies

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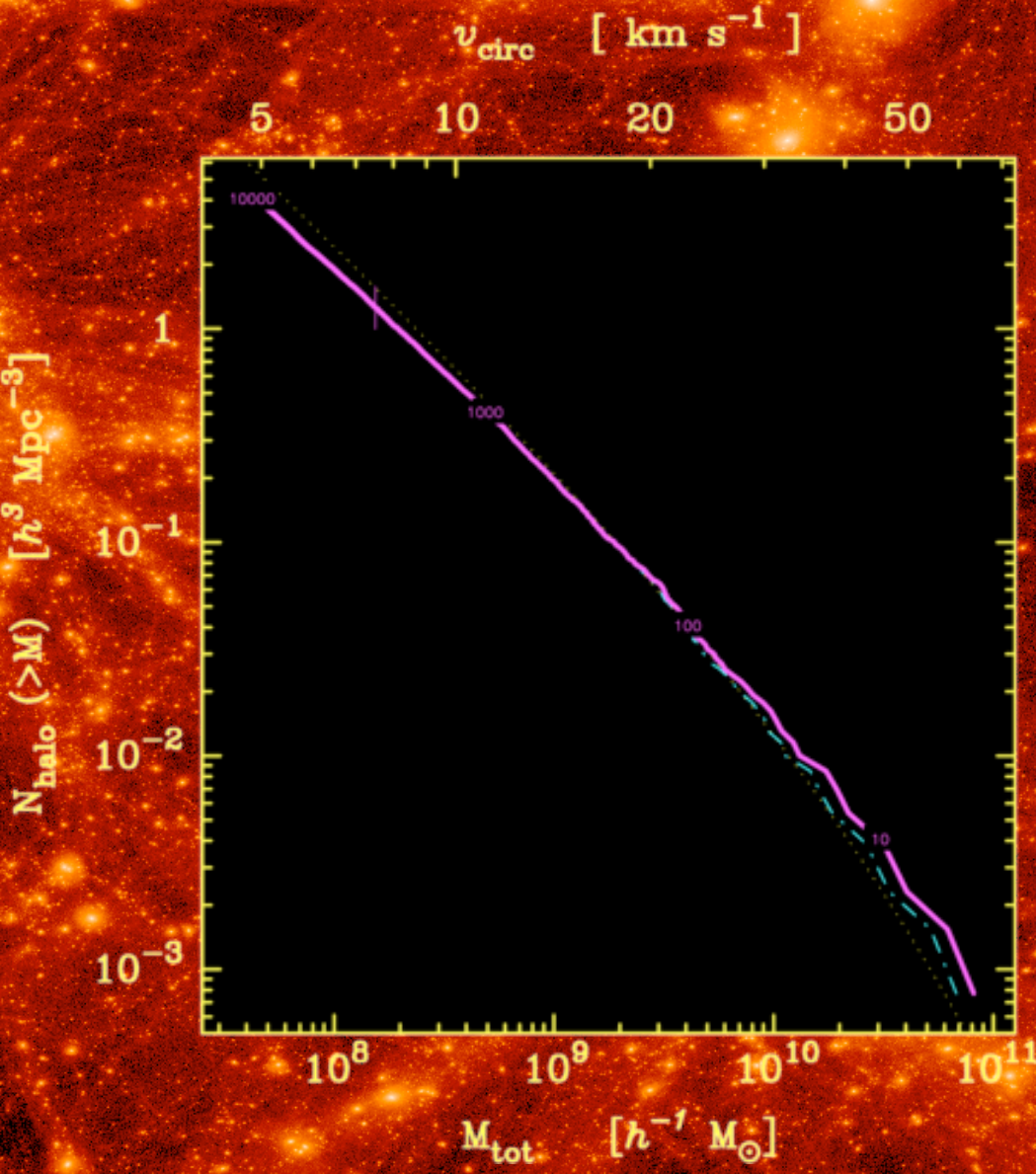
Gustavo Yepes, Stefan Gottöber, Volker Springel

MH, Yepes, Gottlöber, Springel, MNRAS 371, 2006

Things to remember ...

- dark matter halos are very baryon deficient for $M < M_c$
- H&M UV-model robustly gives $M_c \sim 7 \times 10^{10}\ h^{-1} M_\odot$
- can be understood analytically
- M_c is too low compared to observations
- some more heating in the IGM would help out (harder spectrum, x-ray background, shock heating ... ?)
- no room for dark matter halos with HI and no stars

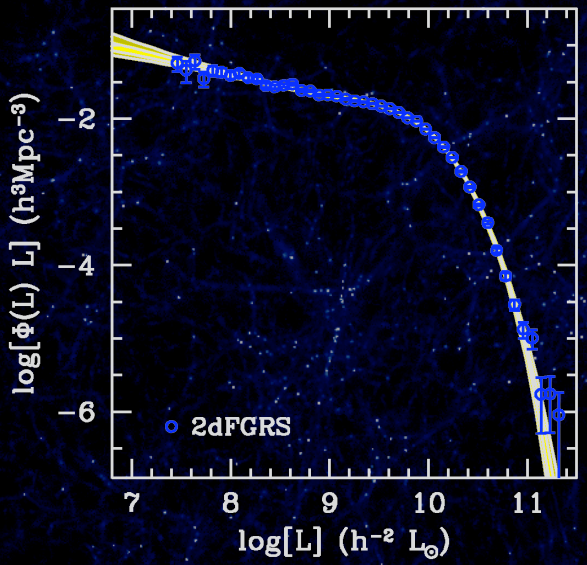
The halo mass function

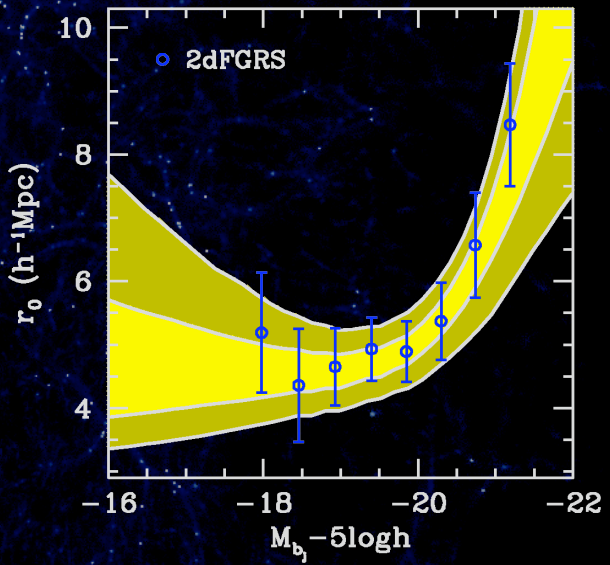


infinite (?) number of small halos

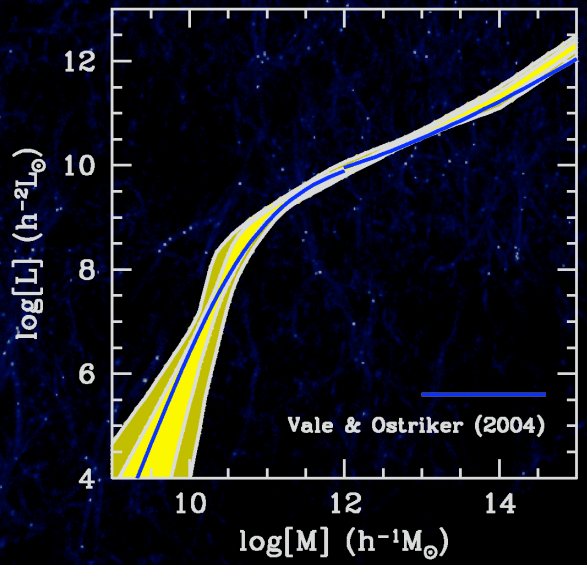
The galaxy dark matter connection

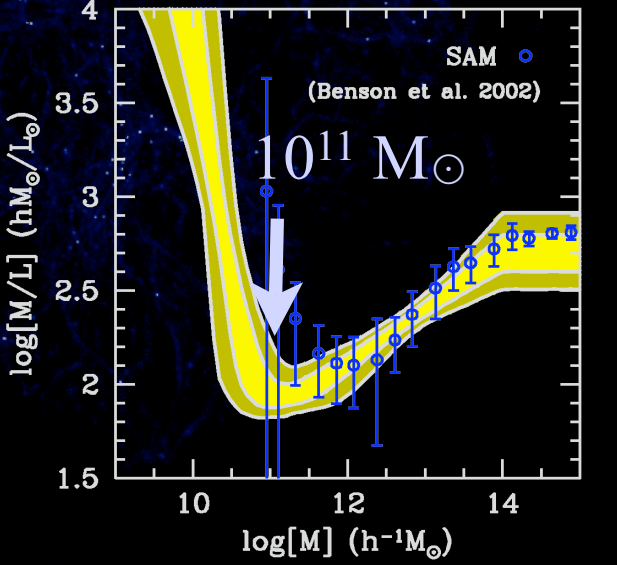
populate simulated dark matter distributions with observed galaxies





van den Bosch, Yang, Mo, 04





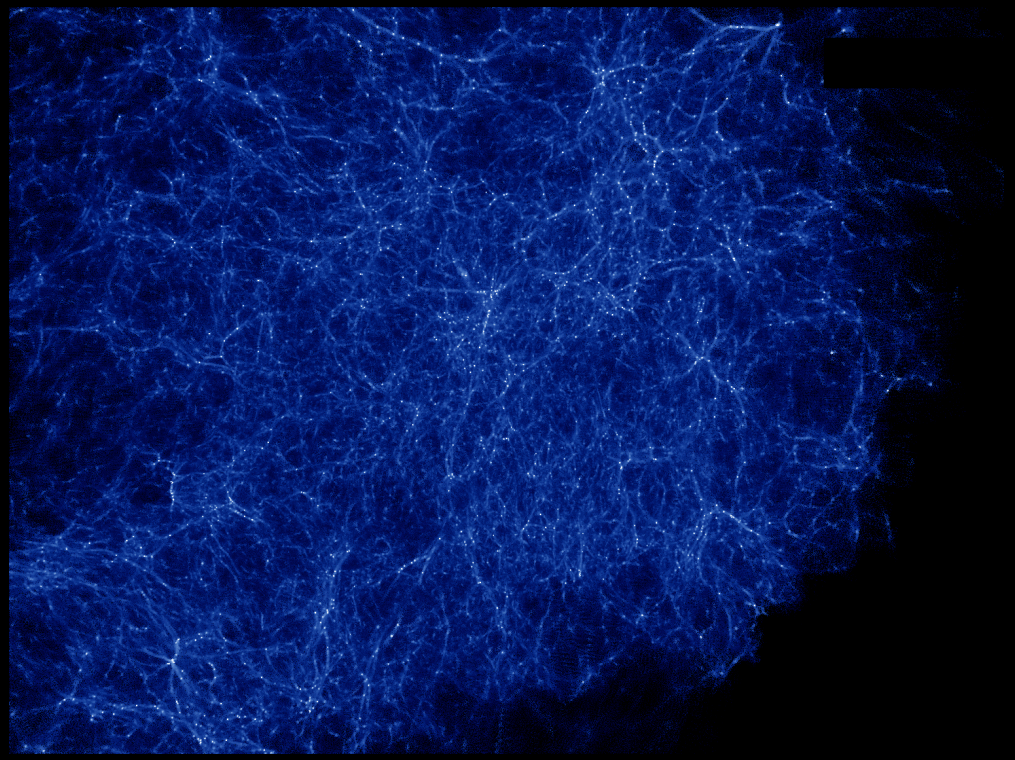
Cosmological hydrodynamical void simulation

Diameter = 16 Mpc
Ω_M = 0.03
Mass resolution (gas) ~ $2\times10^5\ h^{-1}\ M_\odot$

TreeSPH
- Gadget2

Radiative
- cooling
- UV-heating

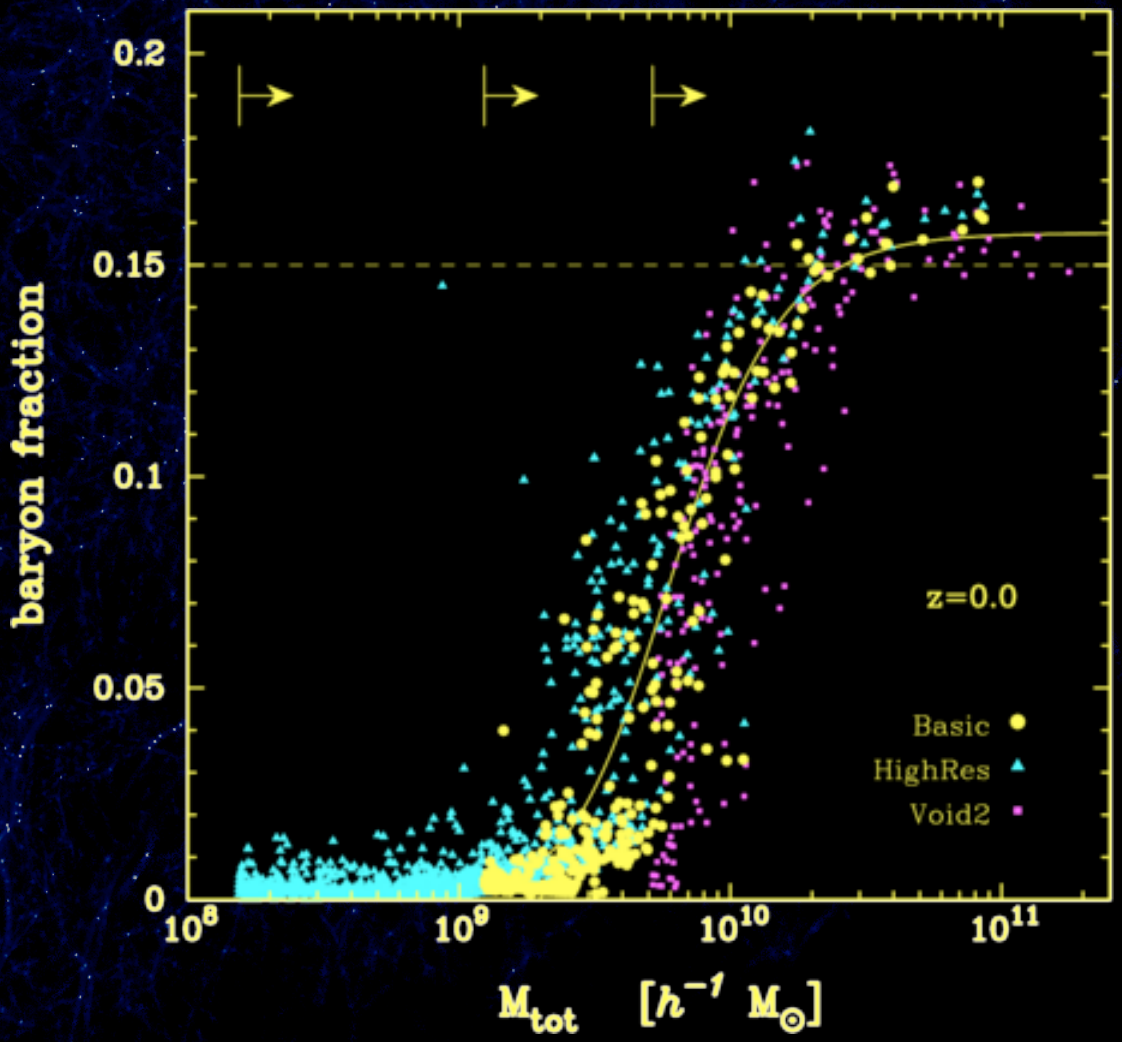
Star formation
- subgrid model
- feedback



Baryon fraction

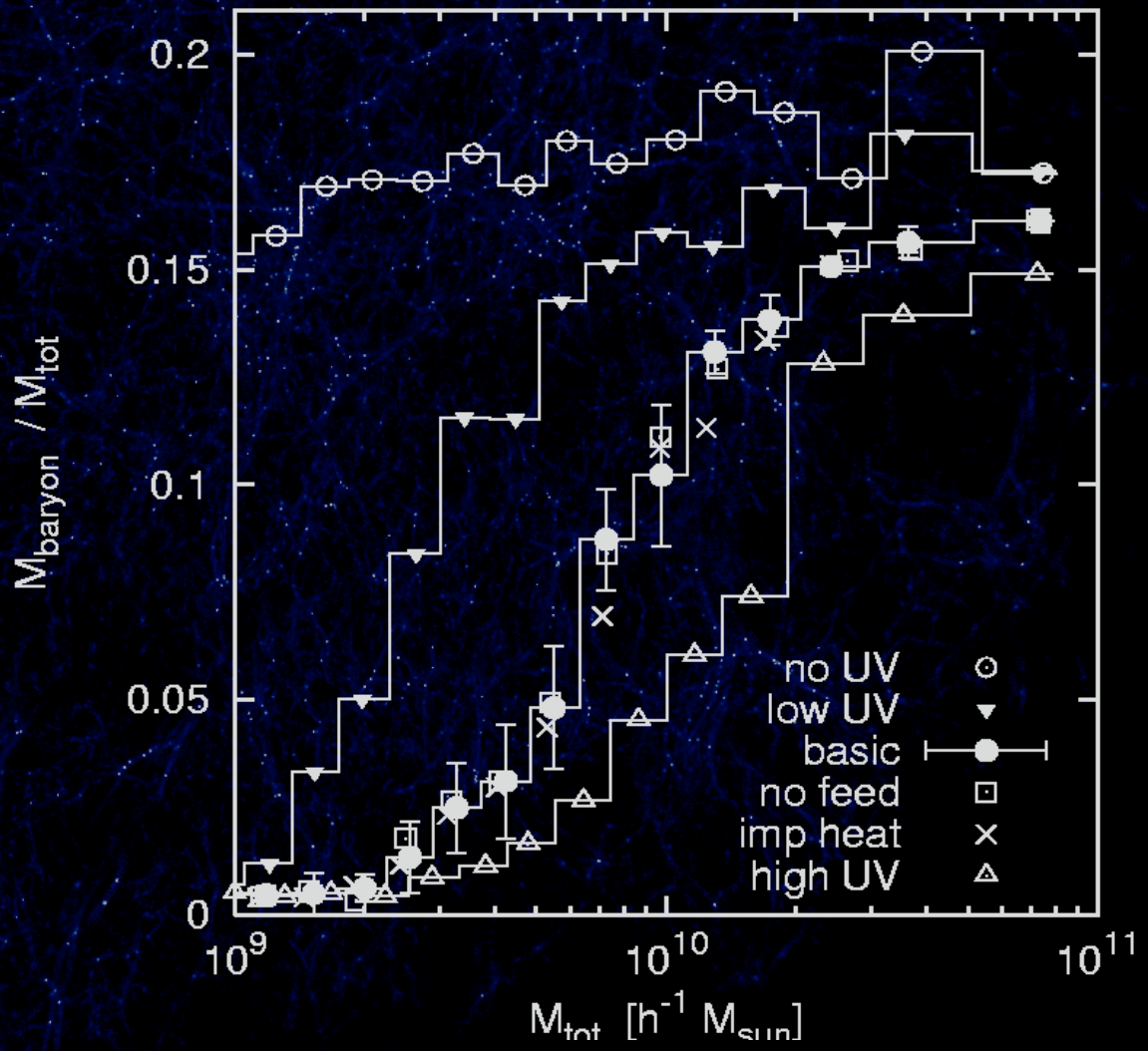
Halos below few times 10^9 $M_\odot$ are *baryon-poor*

***Characteristic mass* scale depends on redshift**



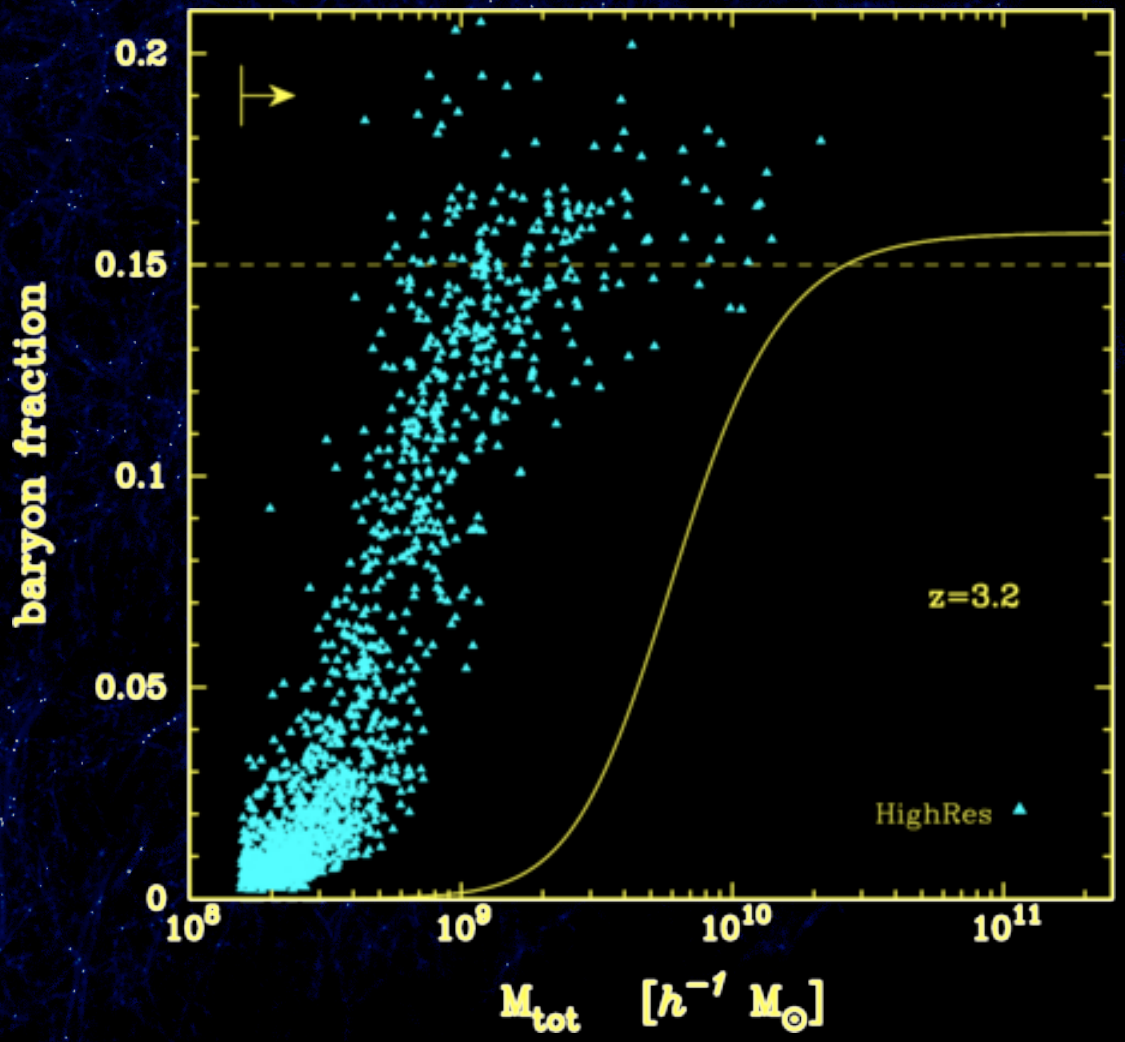
The characteristic mass is “robust”

even a significantly different UV flux has only little effect



Redshift evolution of the baryon fraction

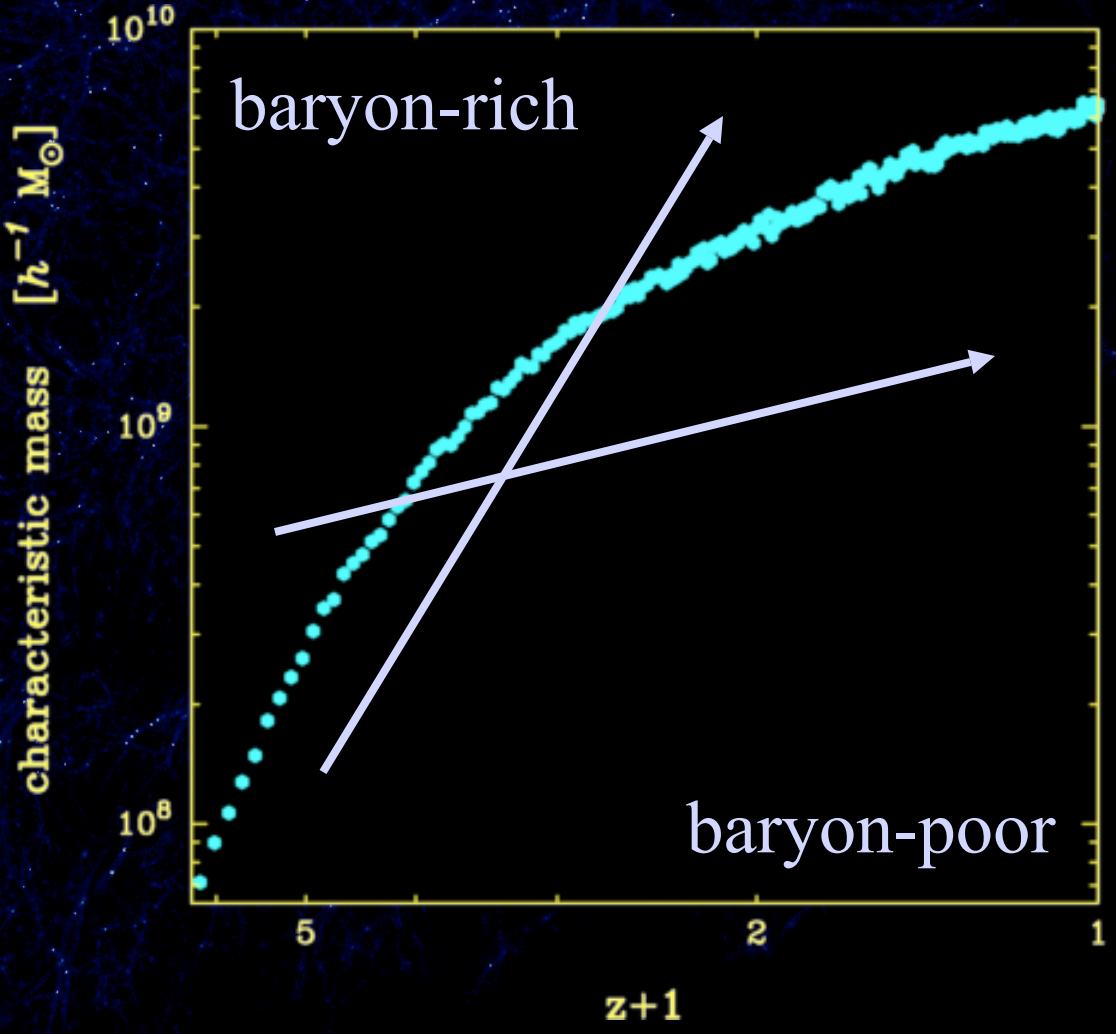
Characteristic mass scale decreases with redshift



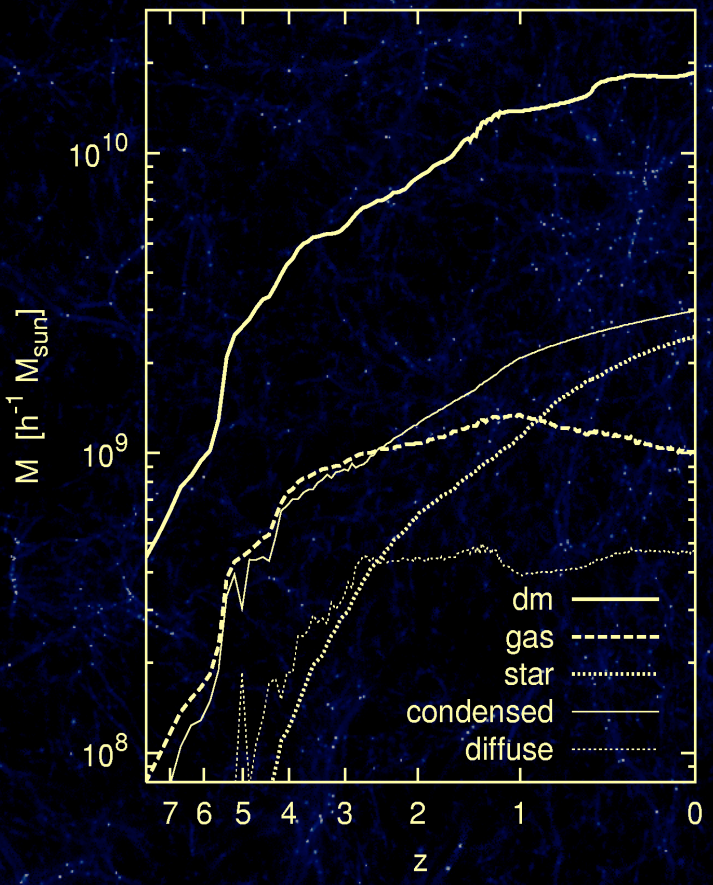
Characteristic mass M_c

M_c rises significantly with redshift

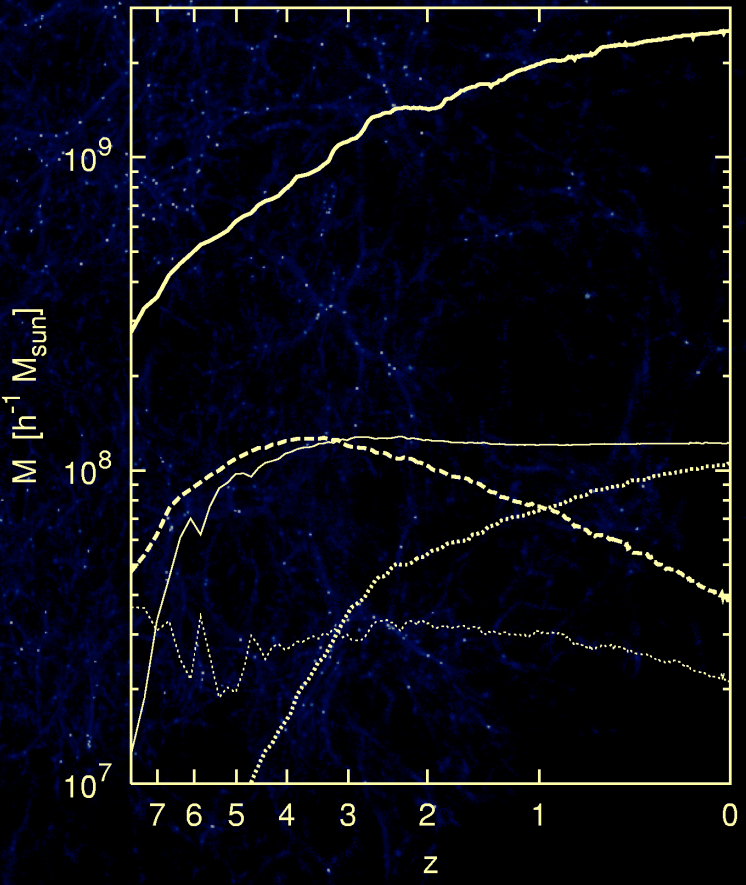
Halo may start baryon-rich and become later baryon-poor



Mass accretion history

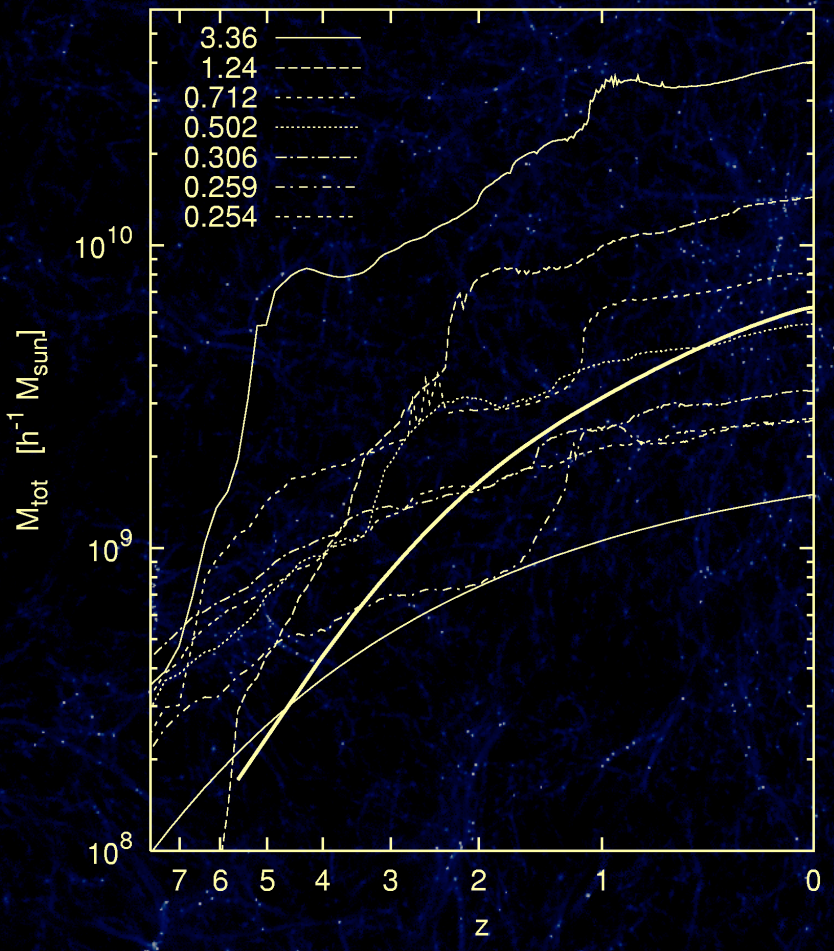


above

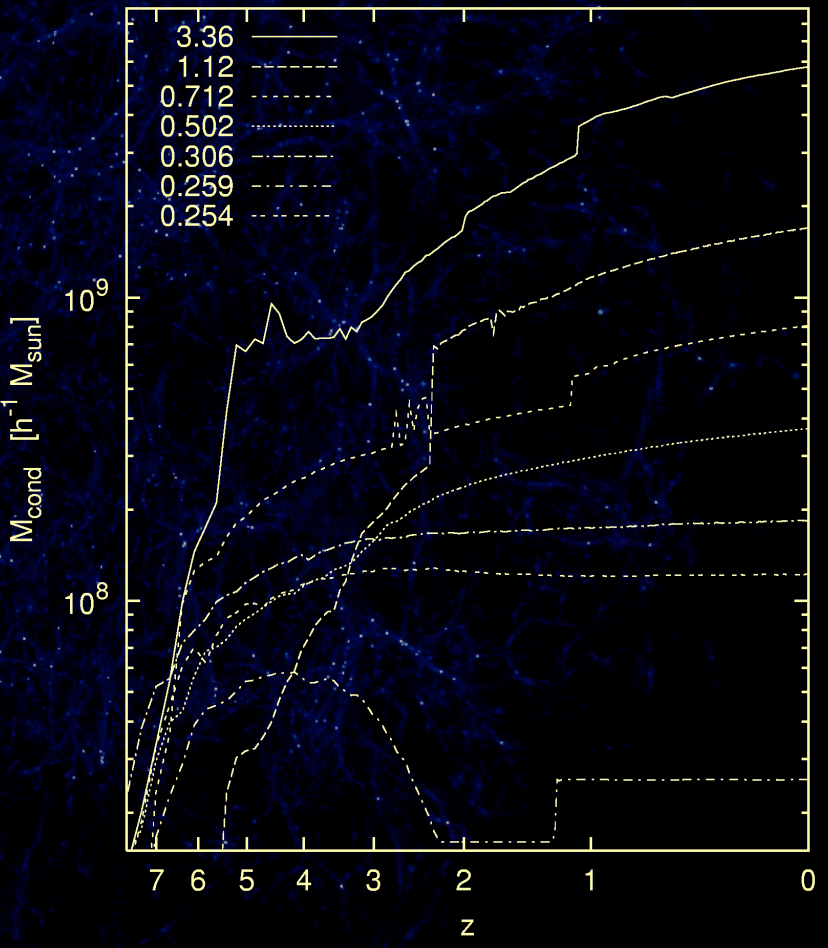


below characteristic mass

Baryon poor small halos



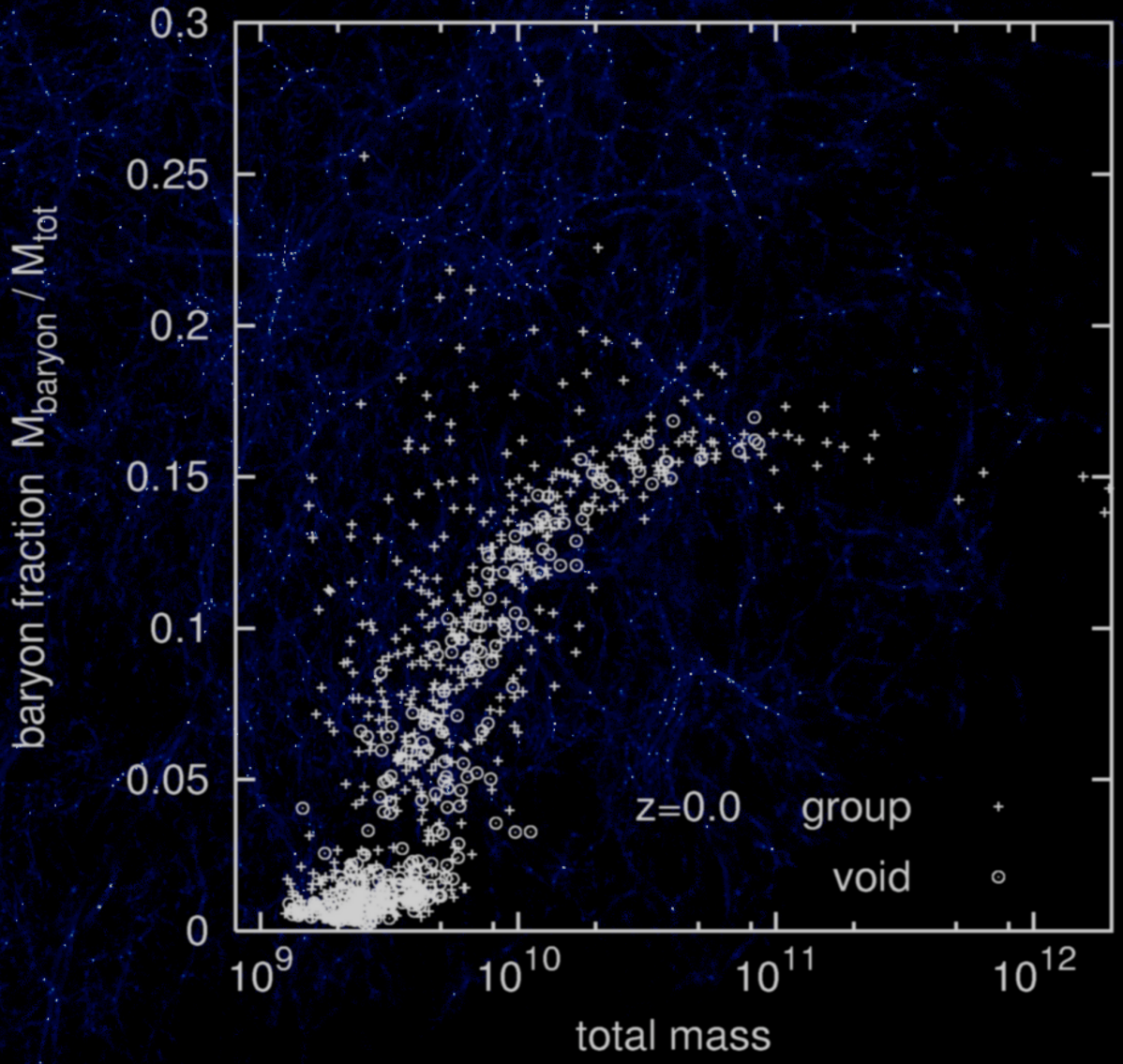
total mass



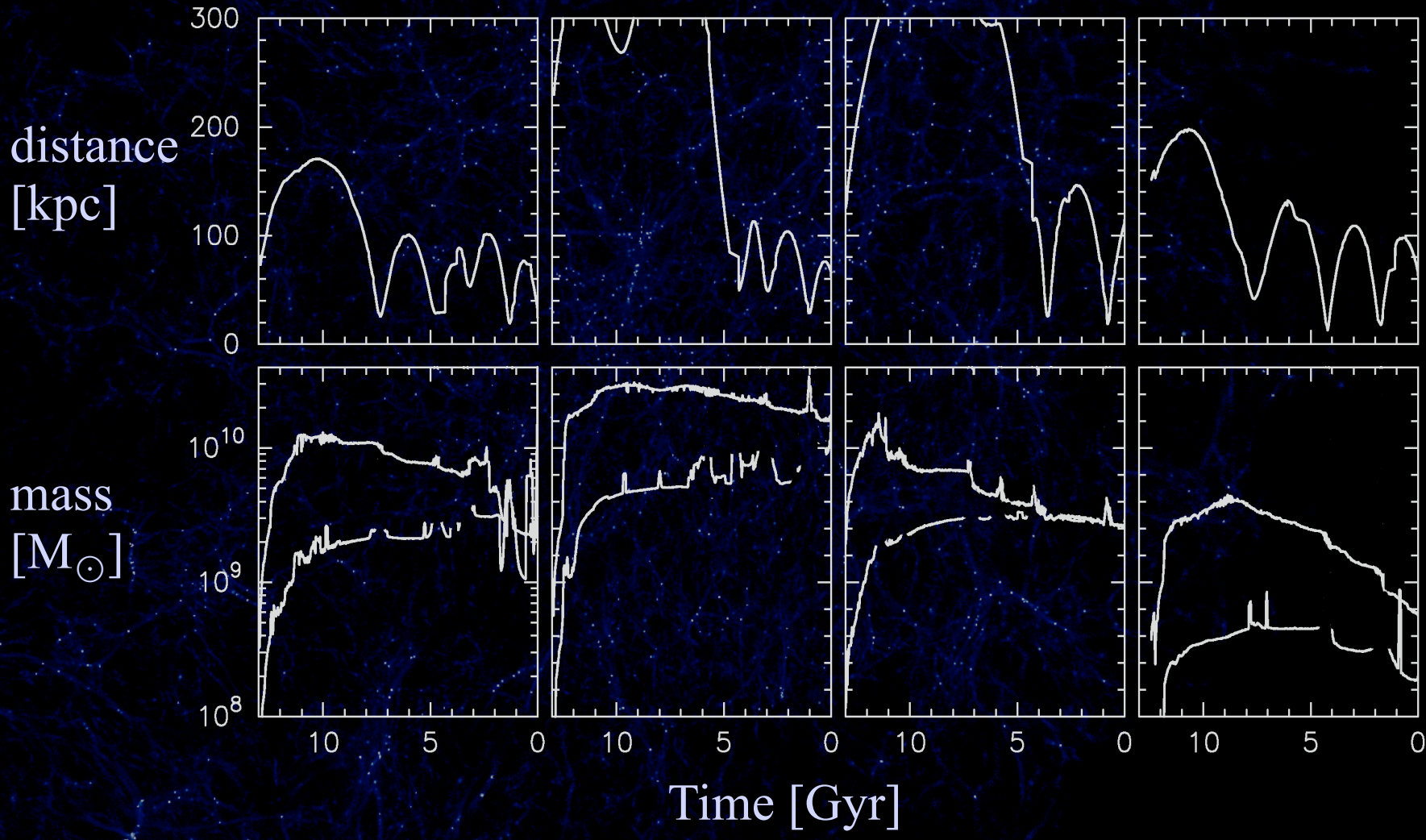
baryonic (condensed) mass

Baryon fraction: Void + Group

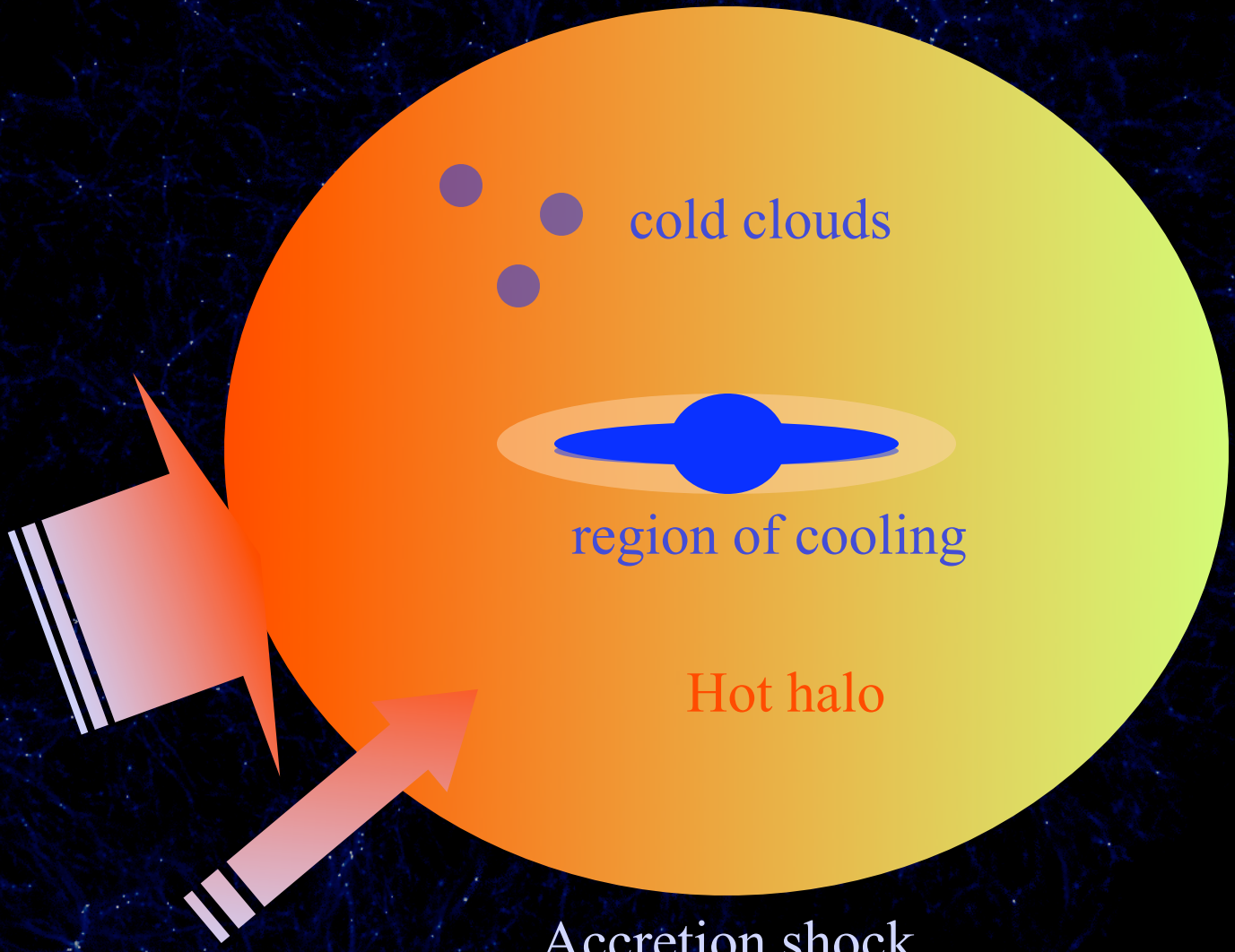
In dense environments the characteristic mass corresponds to that in void regions



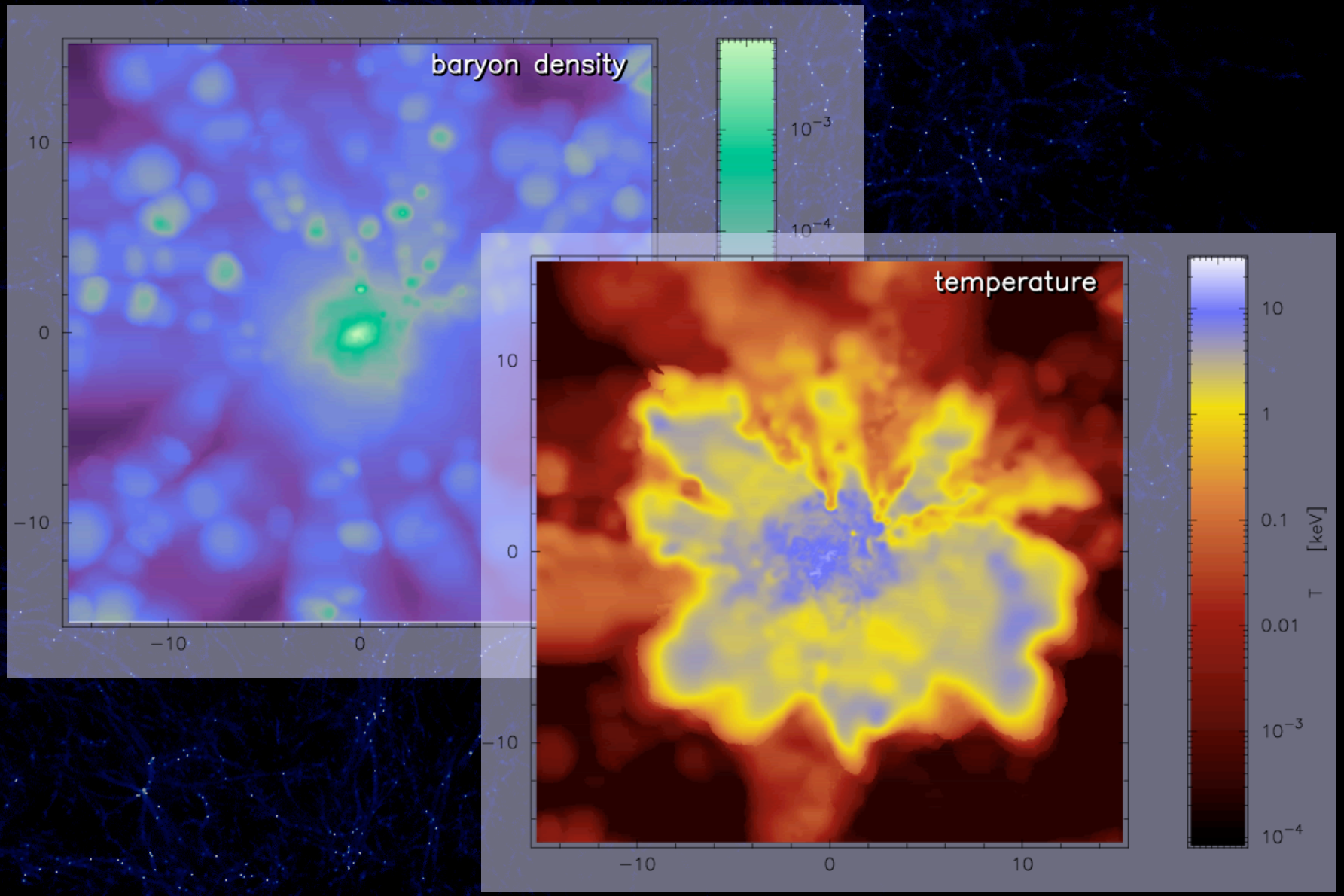
Tidal stripping with cool gas + stars



Gas accretion, schematically

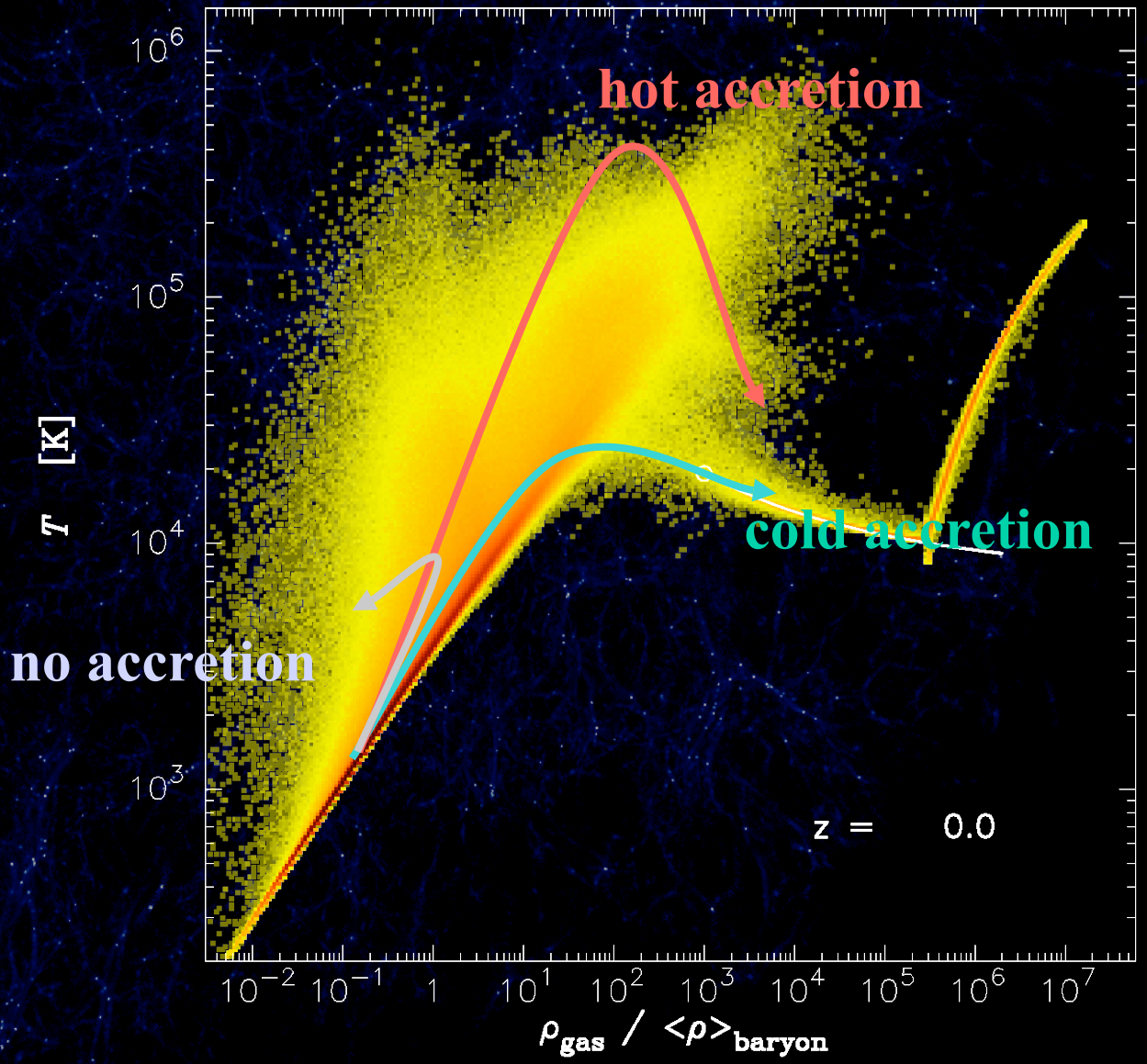


... more realistically shaped



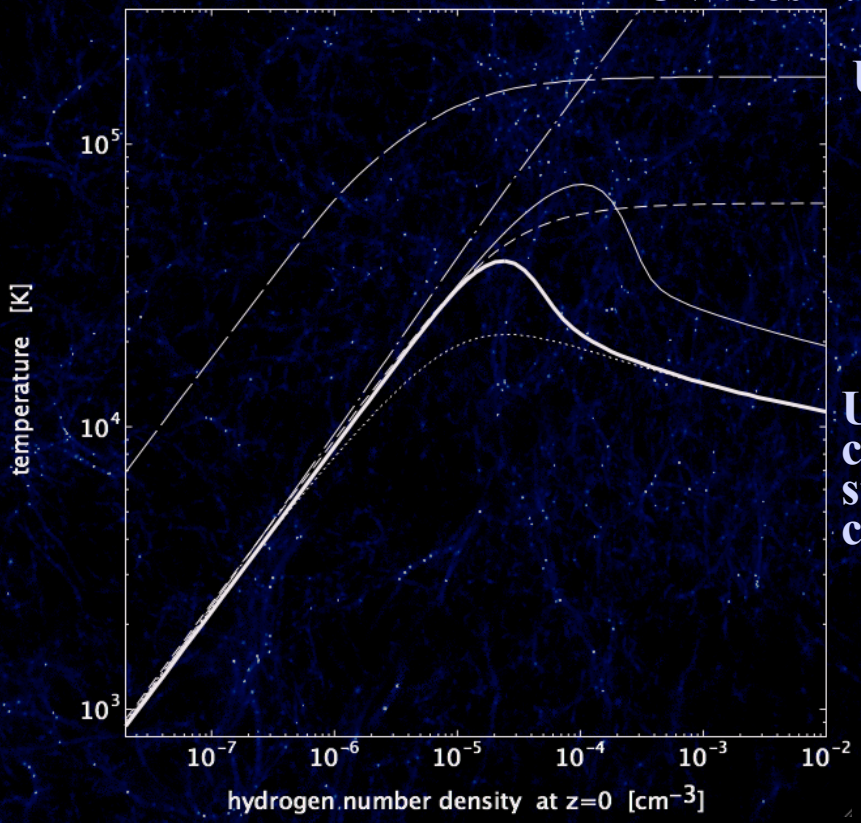
Gas accretion, in density temperature space

"Cold mode" (Keres et al. 04) of galactic gas accretion: gas creeps along the equilibrium line between heating and cooling



What sets the lower limit of T (as a function of n)?

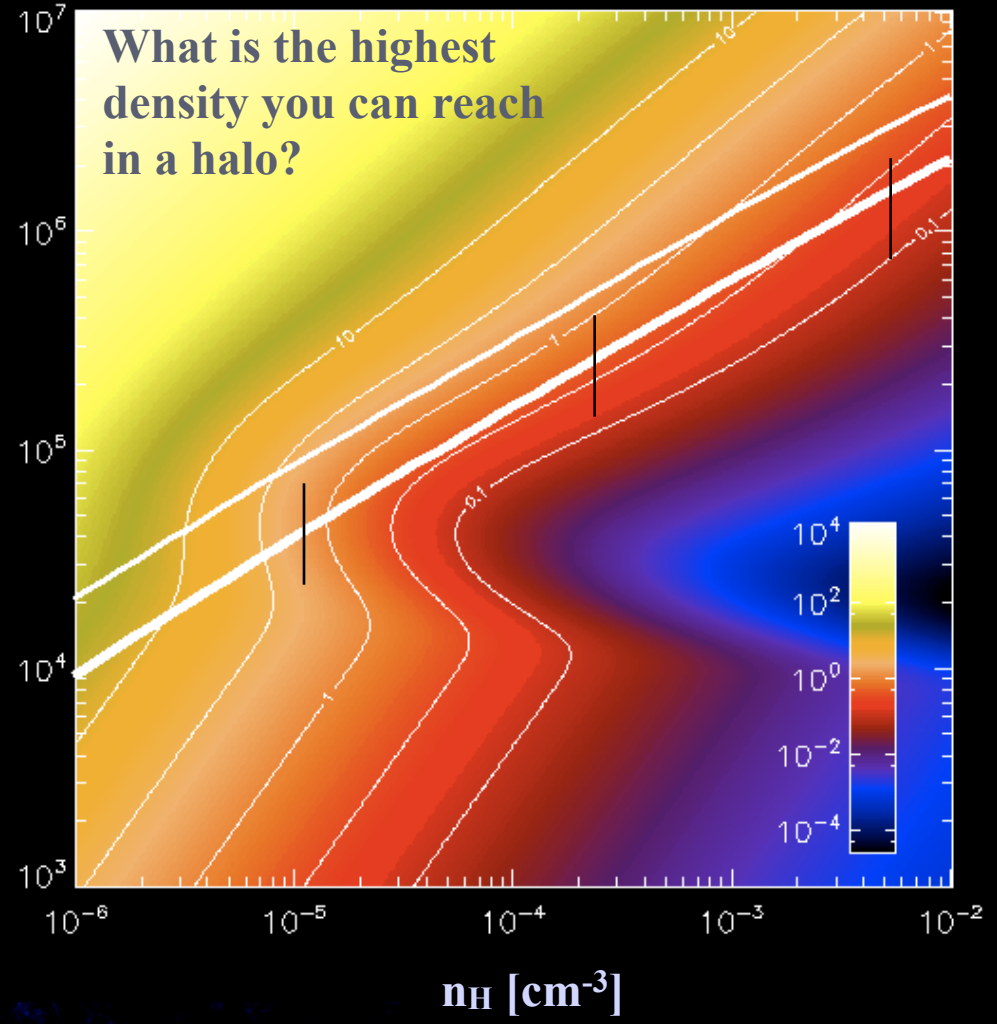
Analytic model:
integrate thermal evolution of a gas element
dT = ...



Cooling time / Hubble time

or: which halos will develop a cool core?

T(n) is virtually polytropic

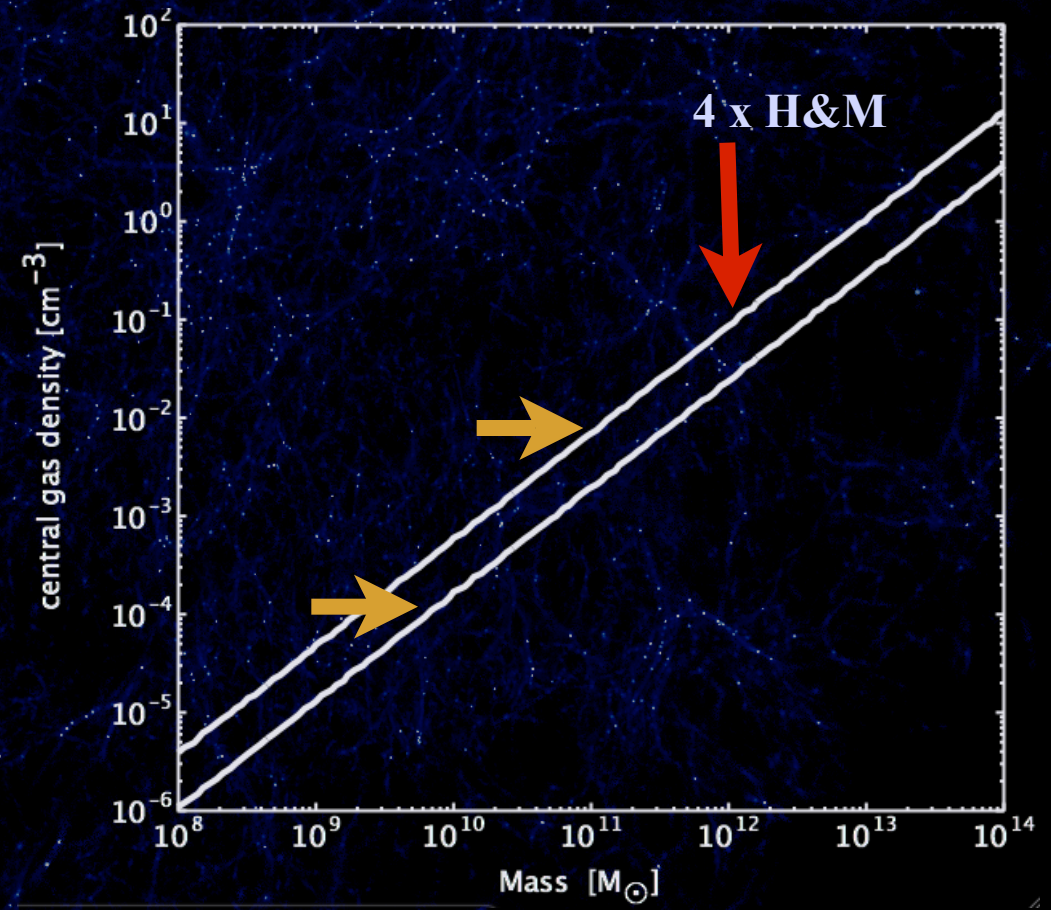


Integrate a spherical halo, with a ‘polytropic’ T(n)

and compute the central gas density

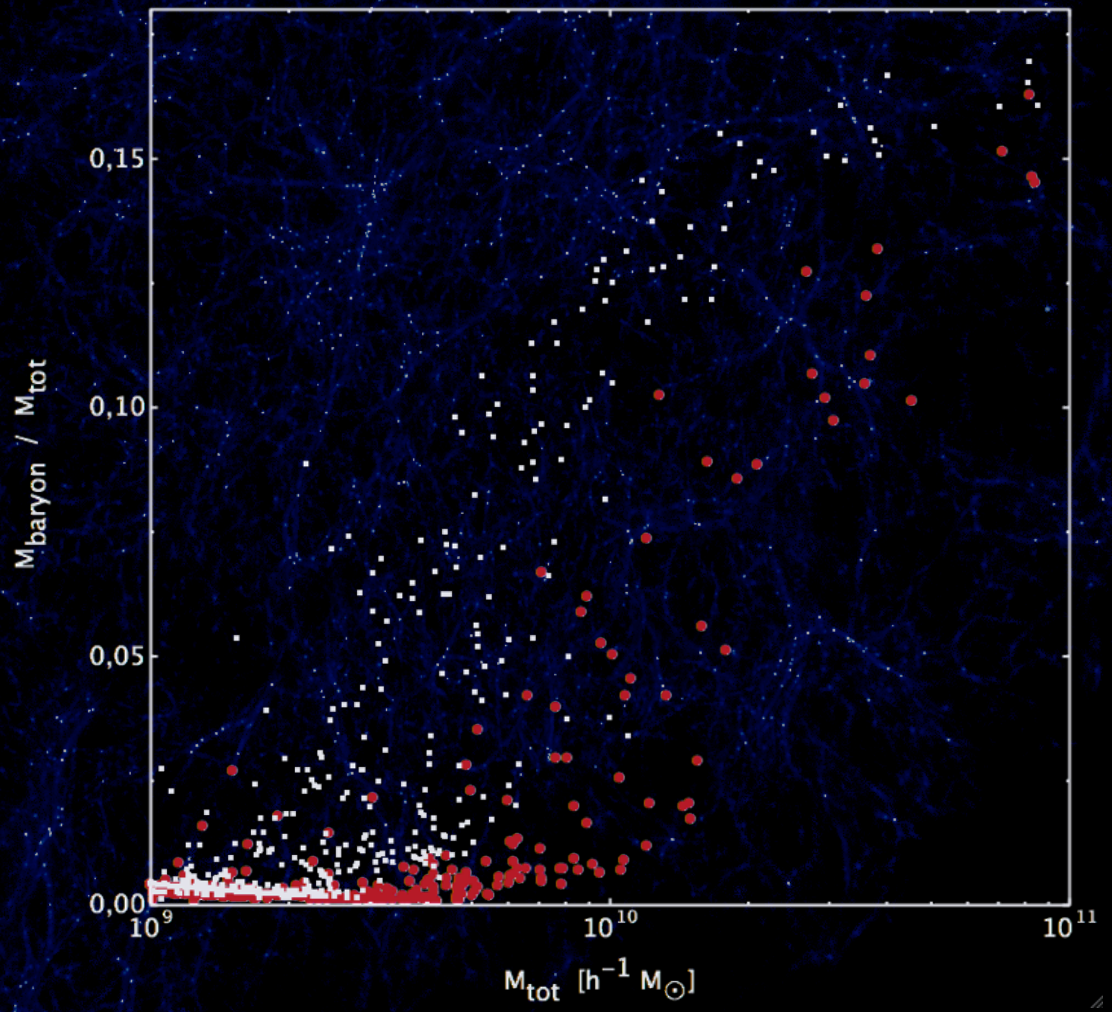
Haardt&Madau (96)
which gives

$$T = 10^4\,\mathrm{K}\left(\frac{n_\mathrm{H}}{10^{-6}}\right)^{0.54}$$

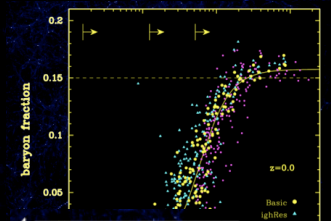


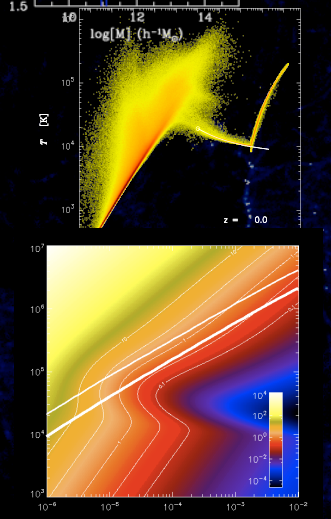
Simulation with 4x increased energy per photon

has a significant effect on the characteristic mass



Summary





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