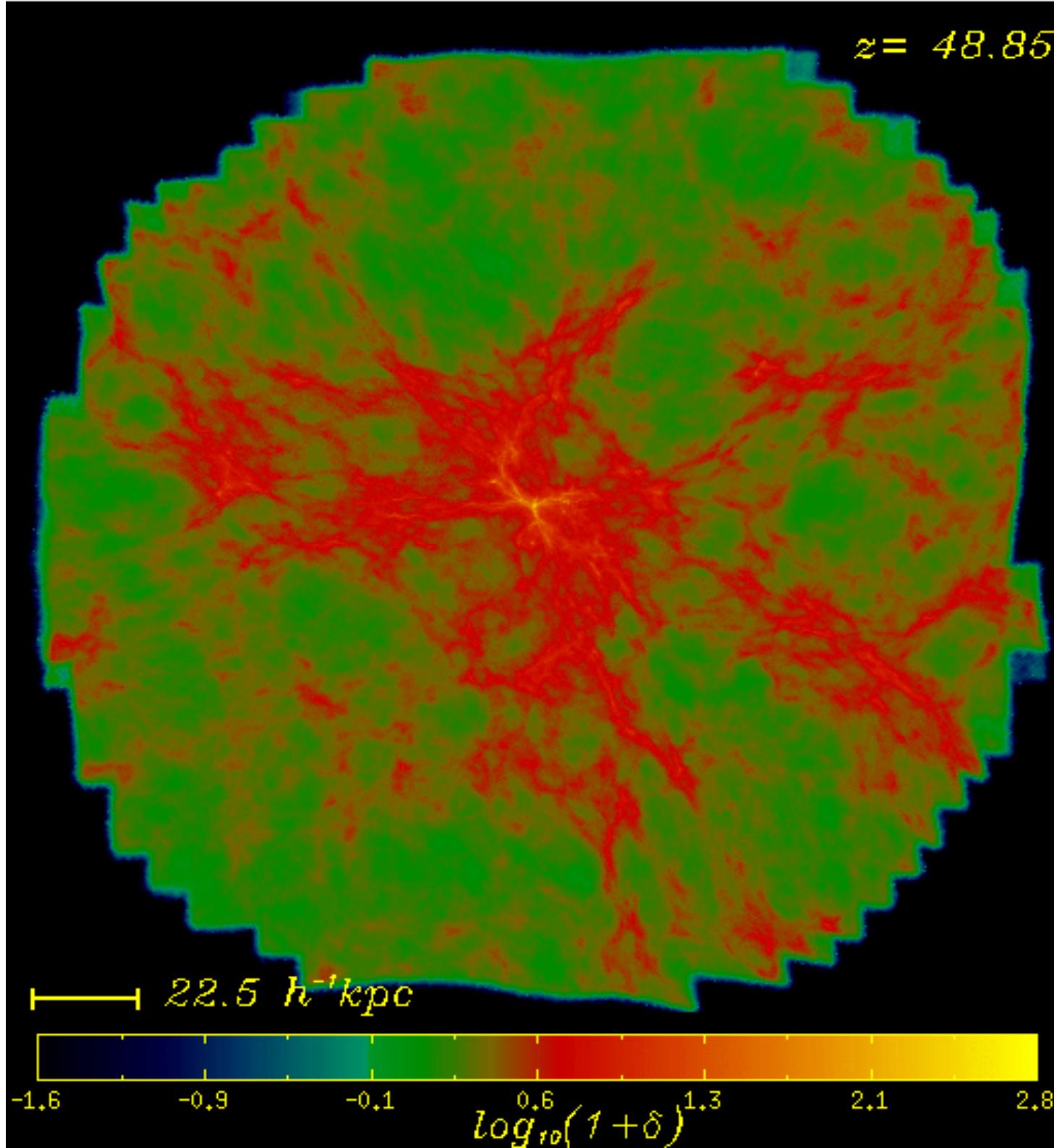


Simulating  
the growth  
of a cluster  
from  $z=100$   
to  $z=0$

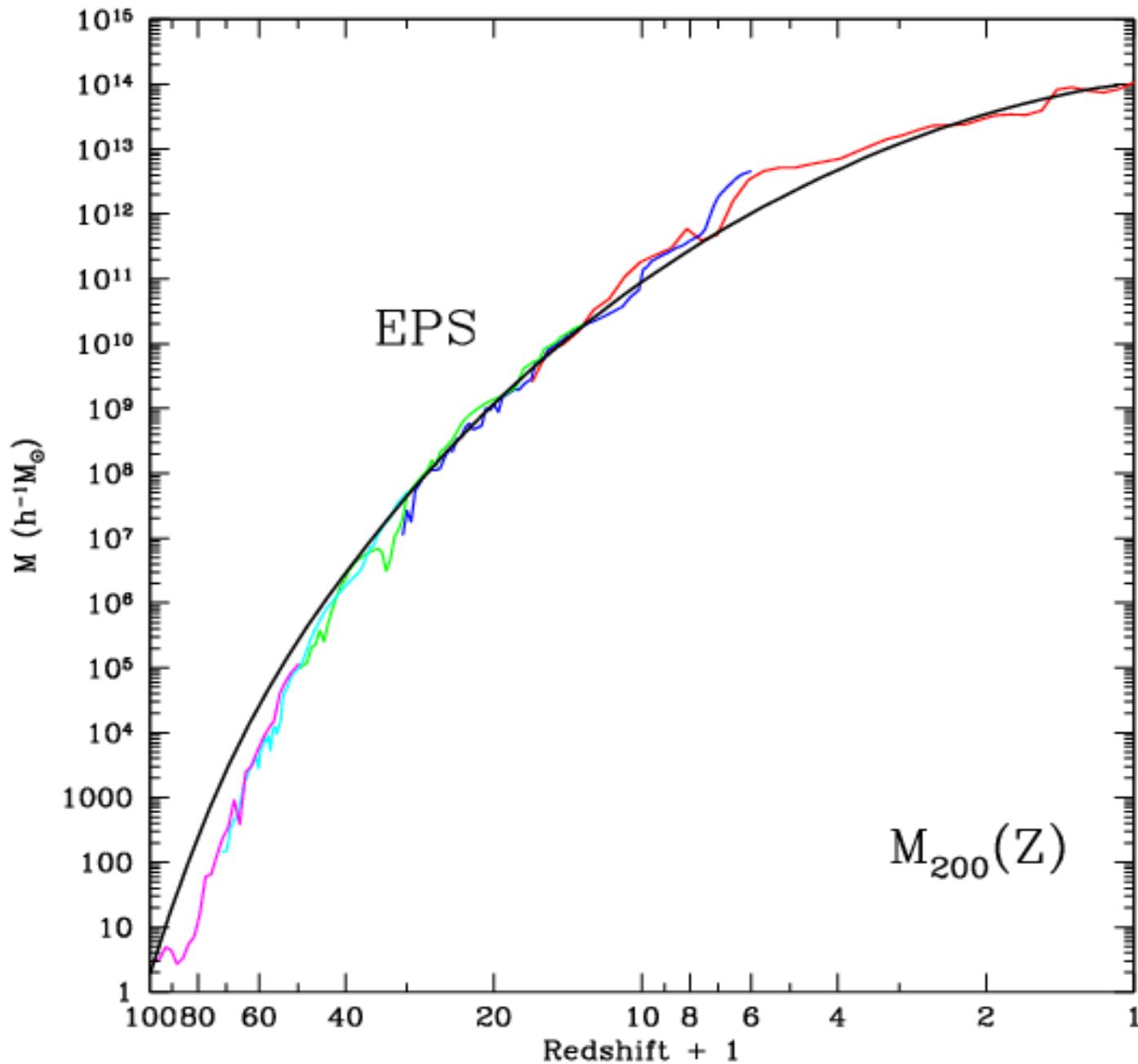
Gao et al 2005



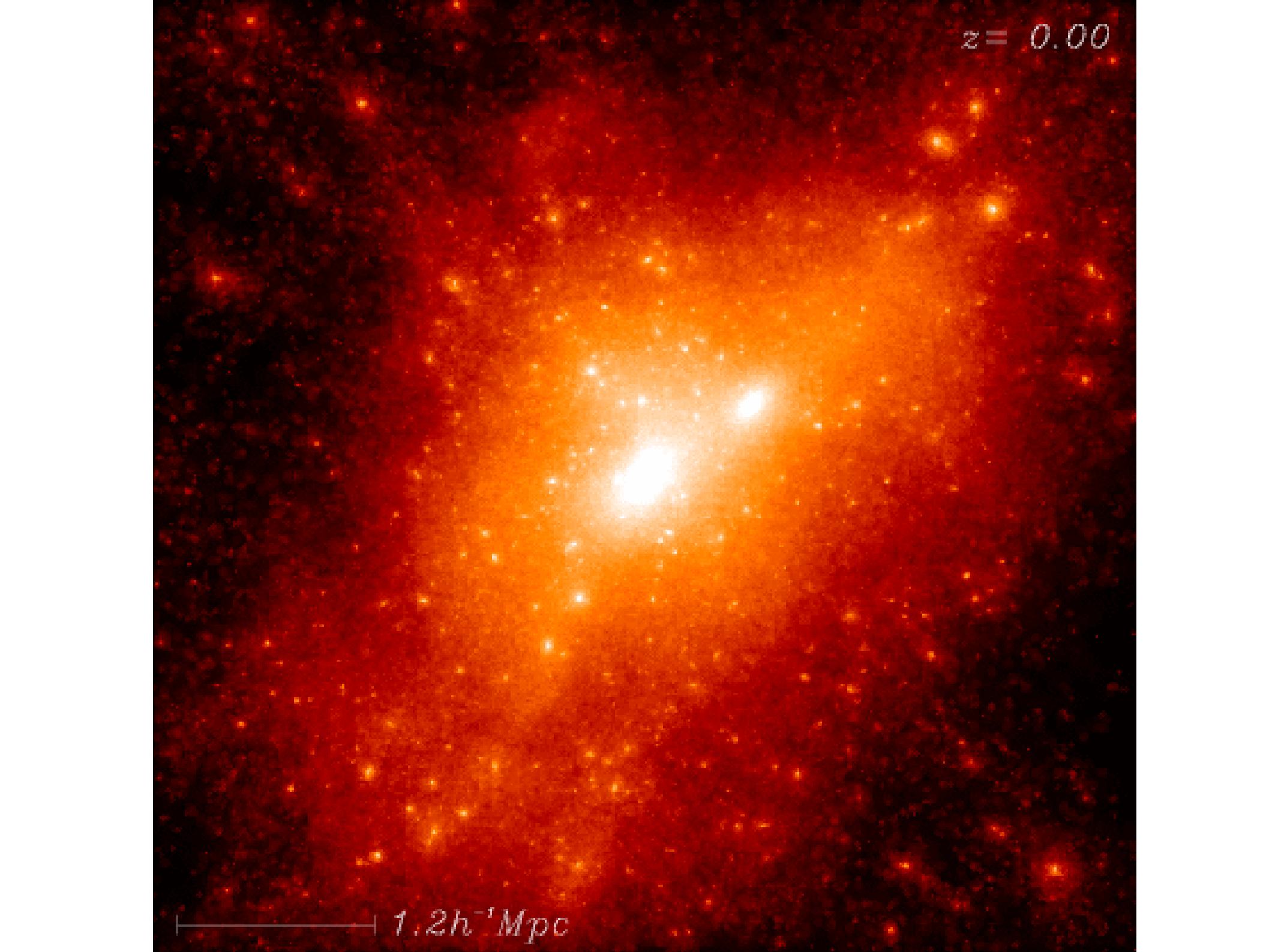
Simulating  
the growth  
of a cluster  
from  $z=100$   
to  $z=0$

Gao et al 2005

Large-scale at  $z=49$   
does NOT look like  
that at  $z=0$

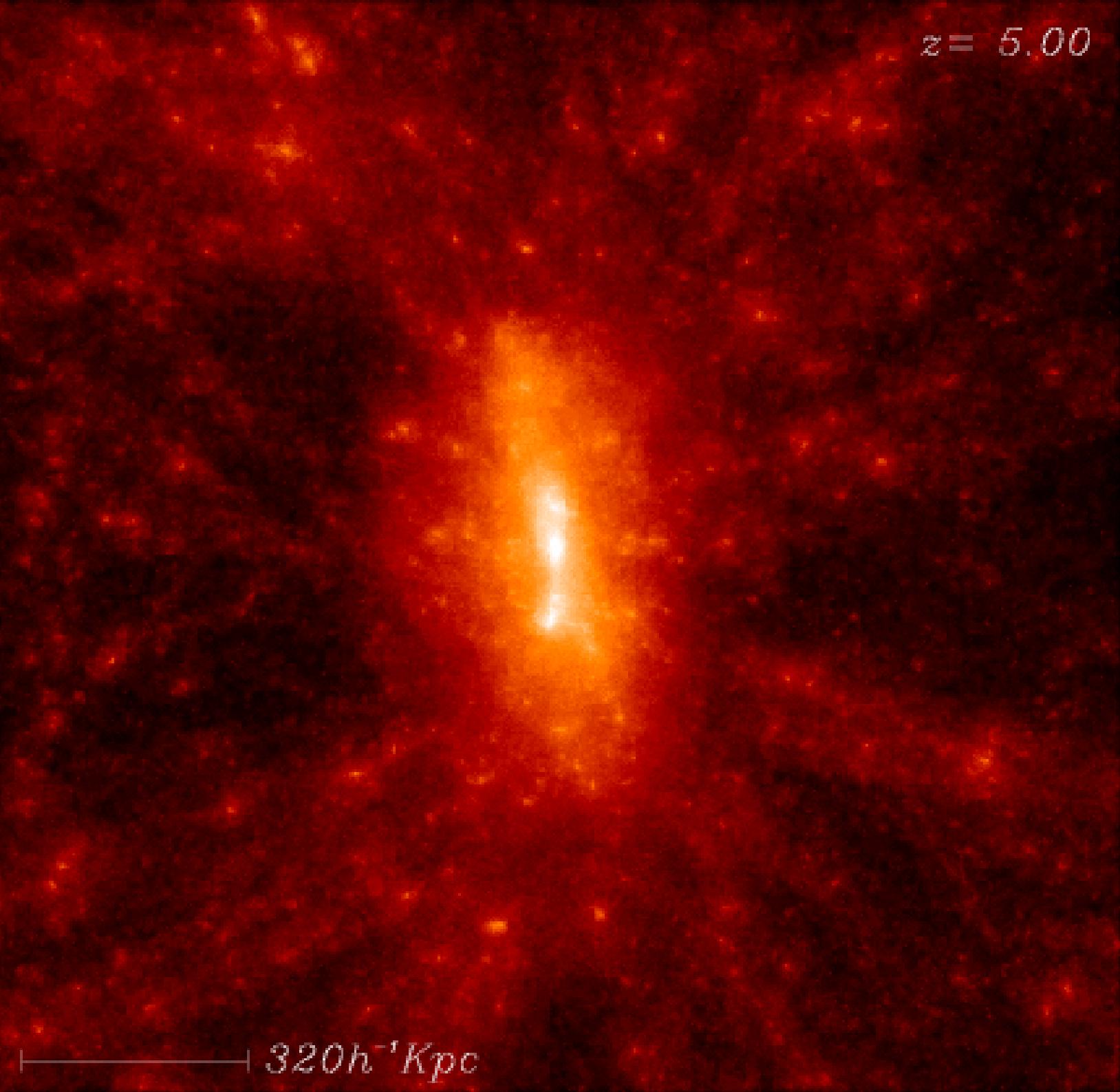


Structure grows  
VERY fast at early  
times



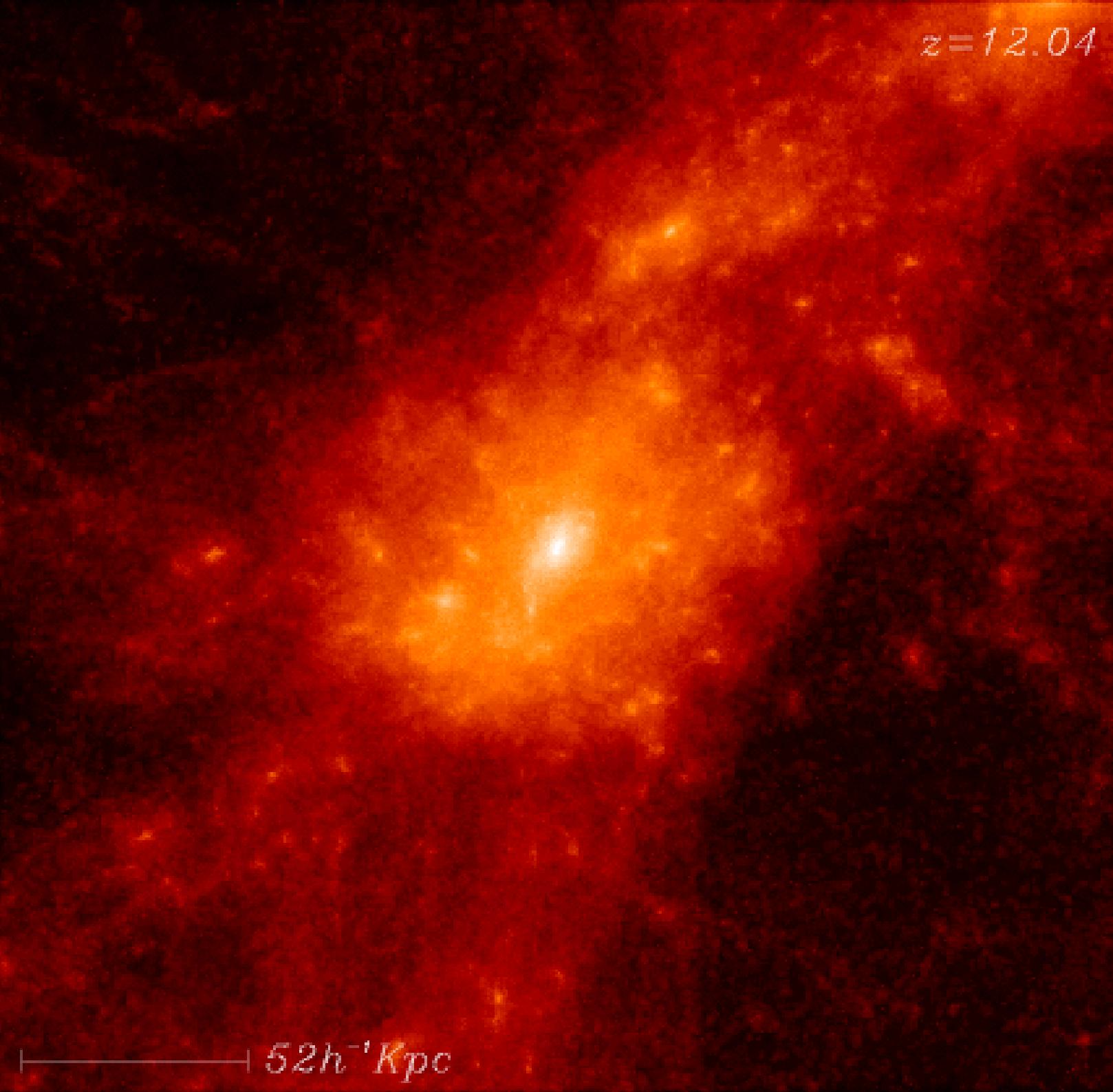
$z = 0.00$

—  $1.2 h^{-1} \text{Mpc}$



$z = 5.00$

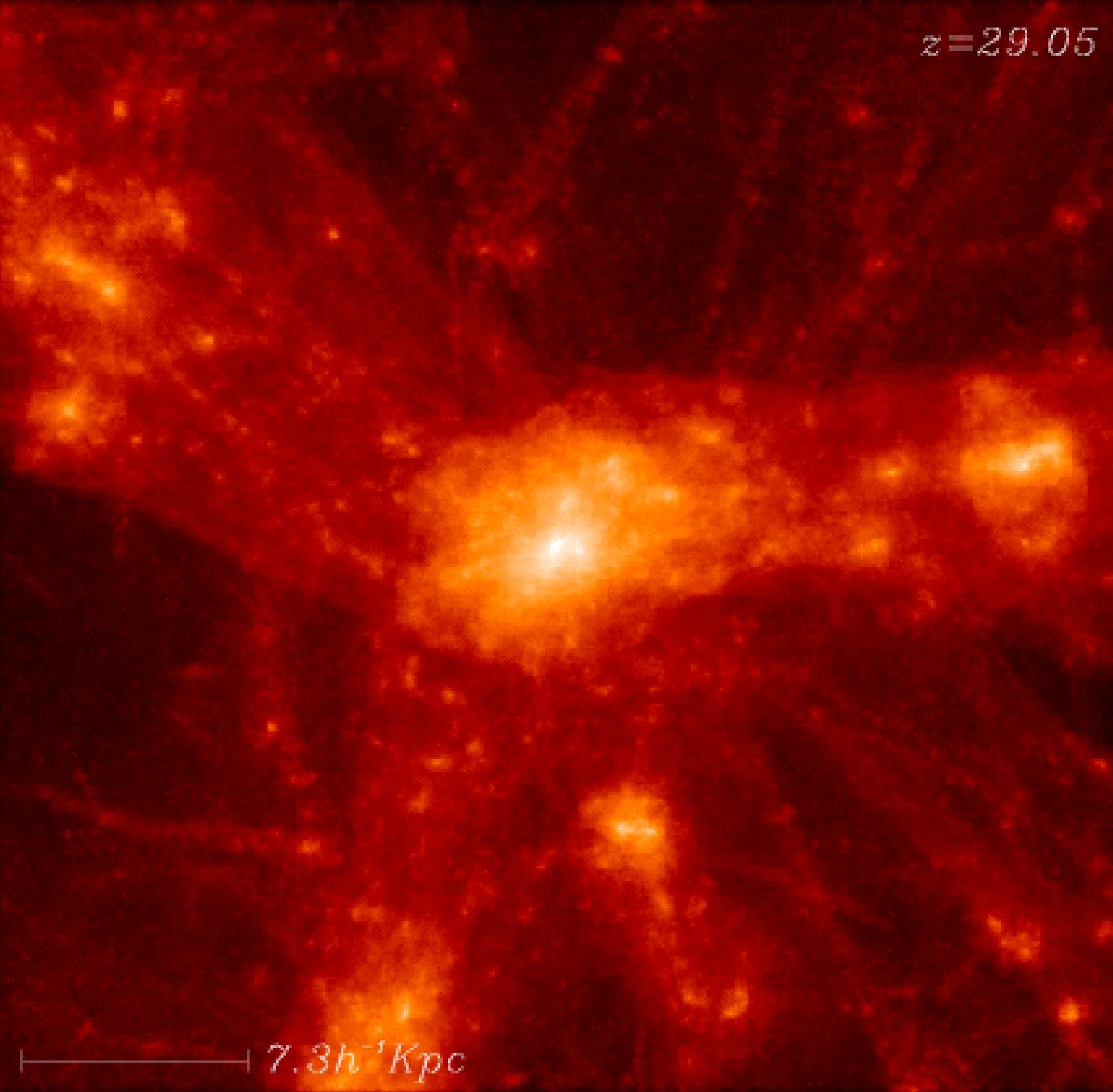
—  $320 h^{-1} Kpc$



$z=12.04$

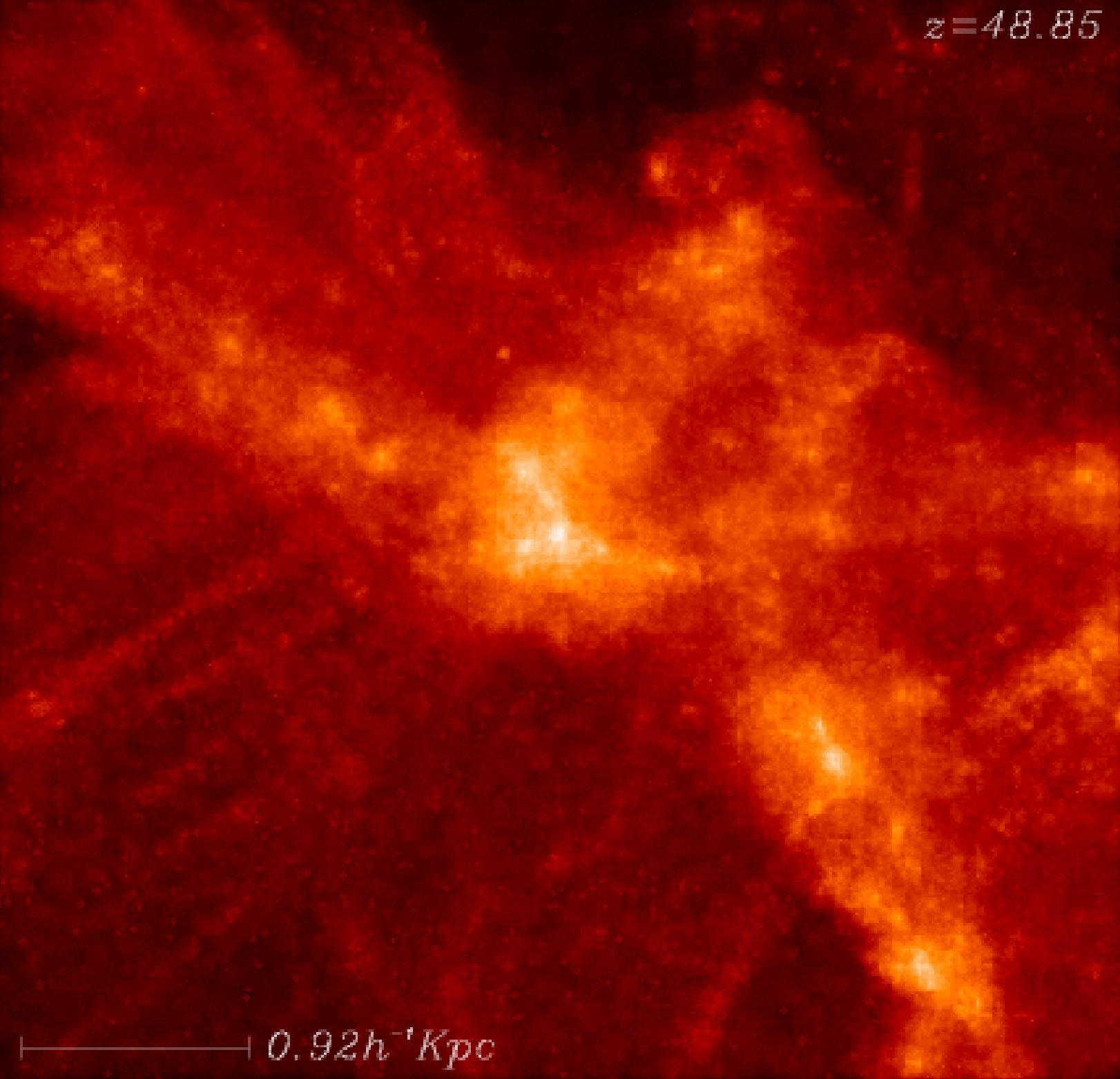
—  $52 h^{-1} Kpc$

$z=29.05$



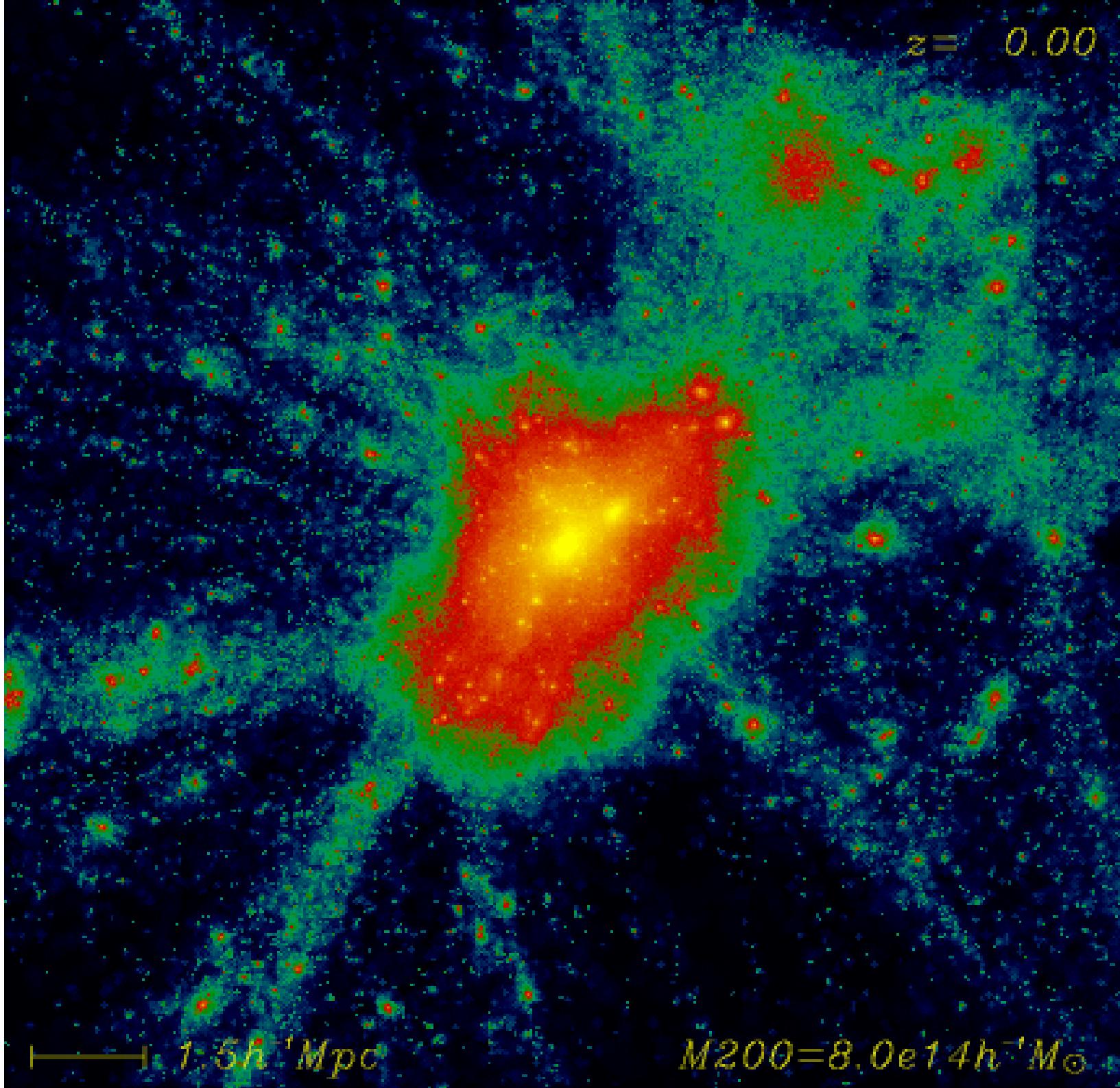
— 7.3  $h^{-1}$  Kpc

$z=48.85$



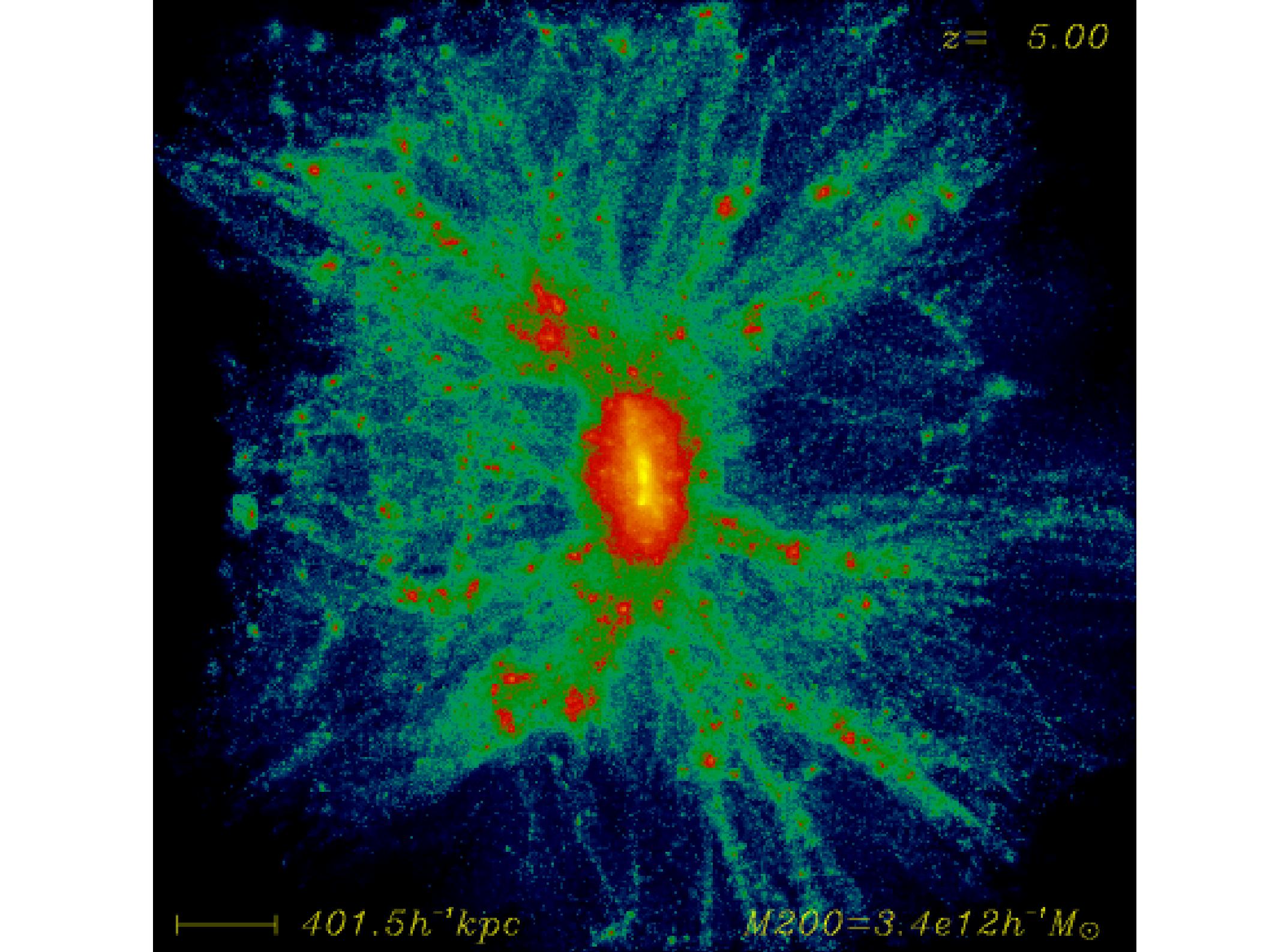
—  $0.92 h^{-1} Kpc$

$z = 0.00$



—  $1.5 h^{-1} \text{Mpc}$

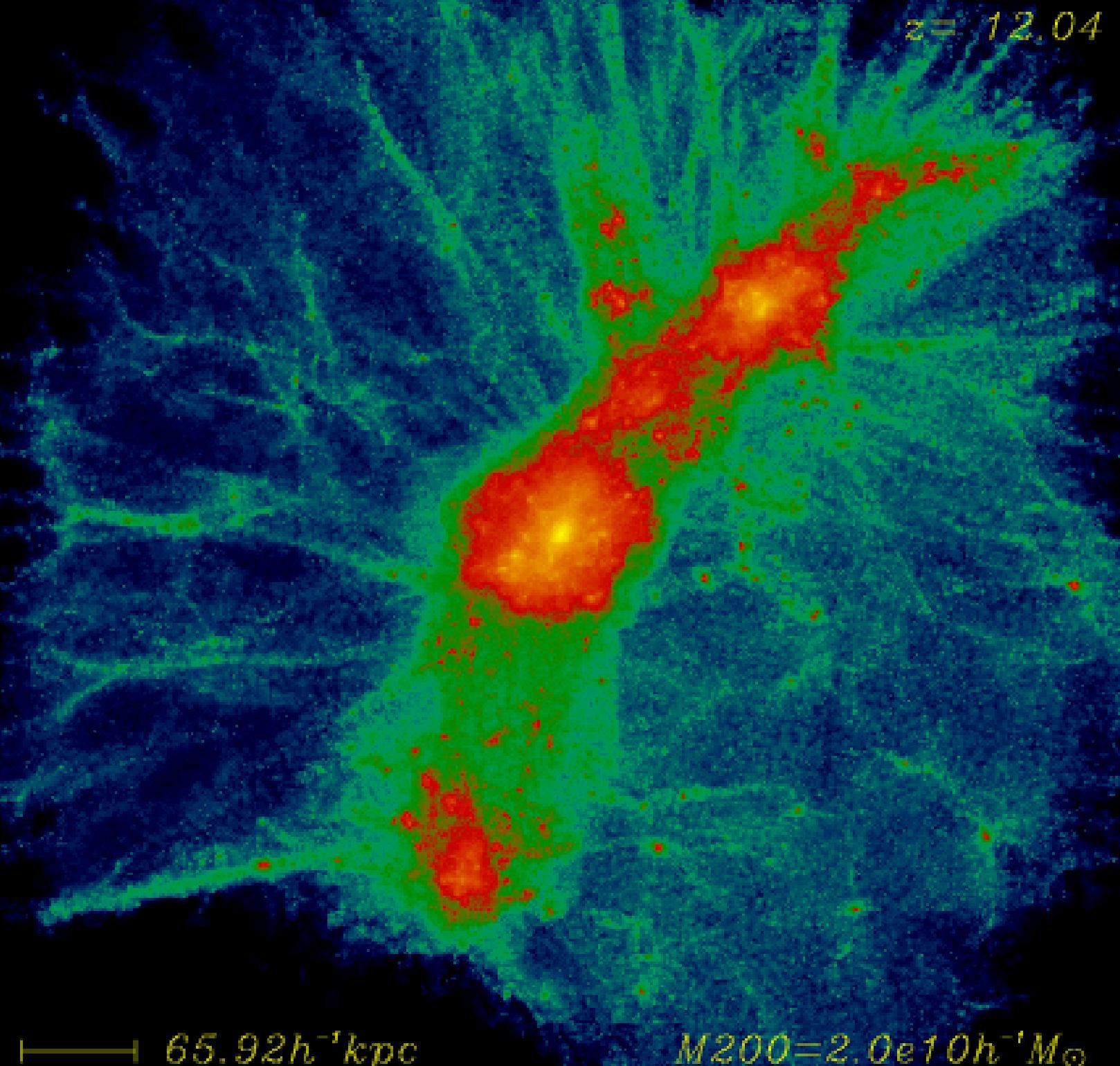
$M_{200} = 8.0 \times 10^{14} h^{-1} M_\odot$



$z = 5.00$

→  $401.5 h^{-1} kpc$

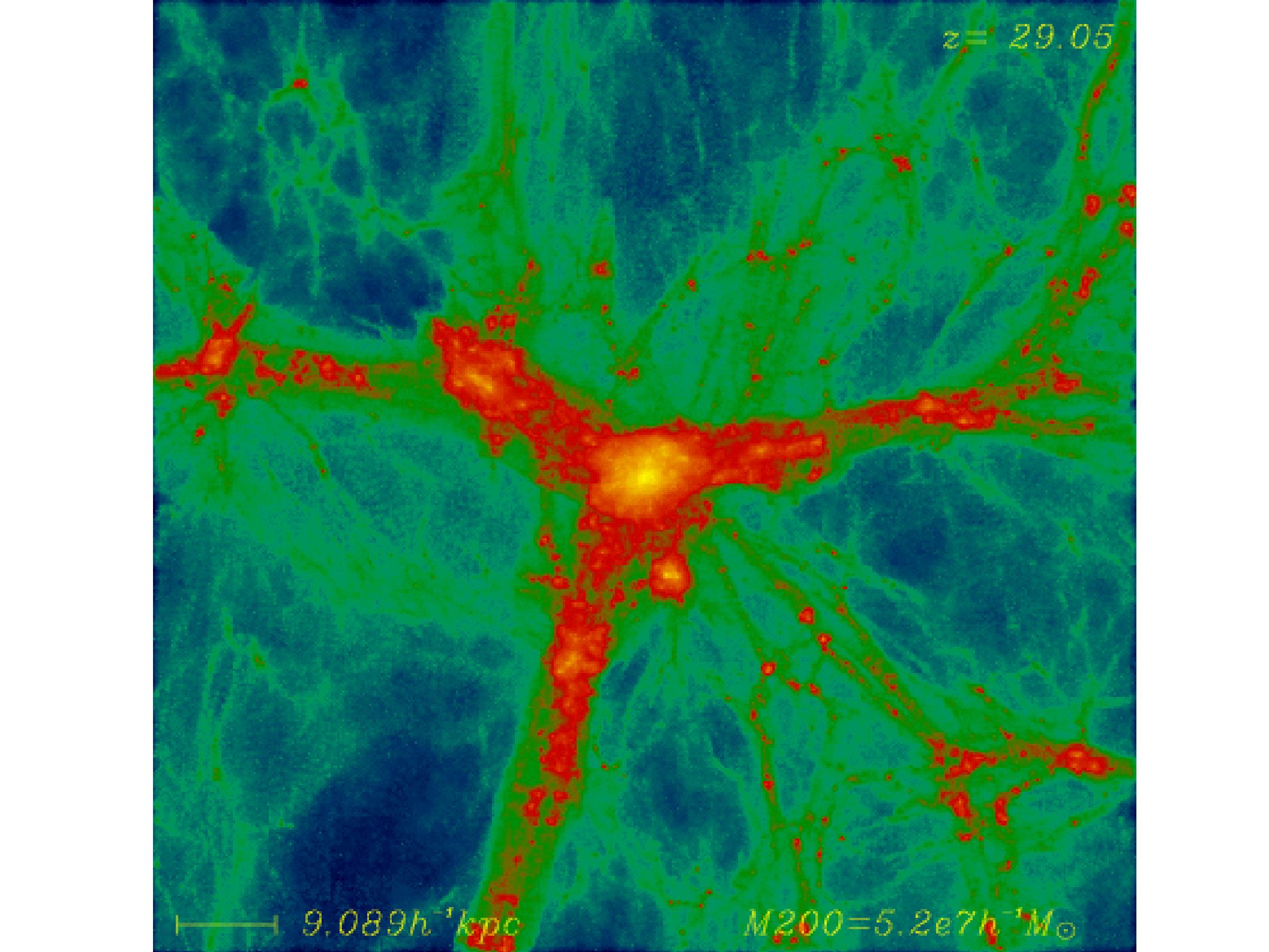
$M_{200} = 3.4 \times 10^{12} h^{-1} M_\odot$



$z = 12.04$

→  $65.92 h^{-1} kpc$

$M_{200} = 2.0 \times 10^{10} h^{-1} M_\odot$



$z = 29.05$

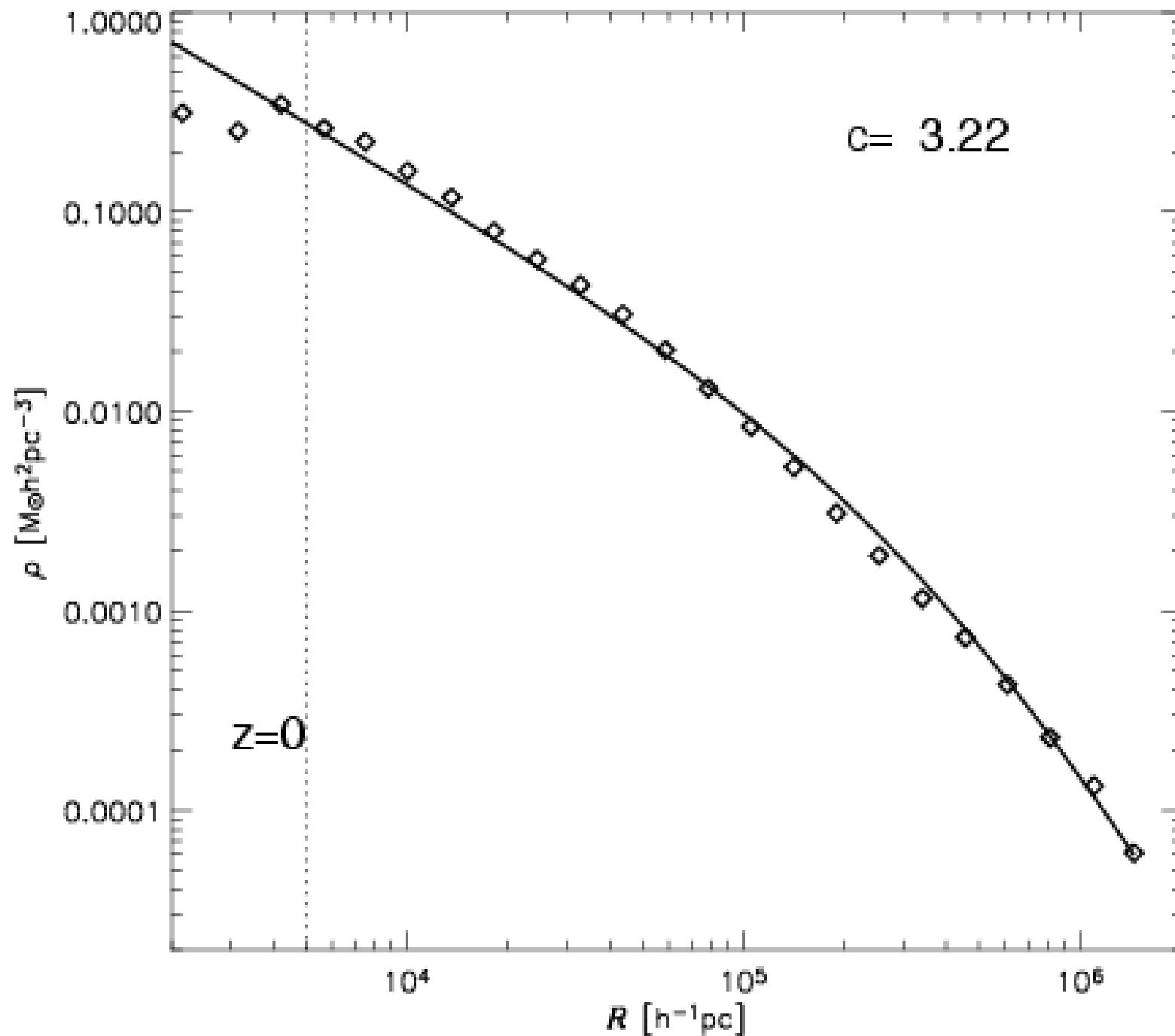
9.089  $h^{-1} \text{kpc}$

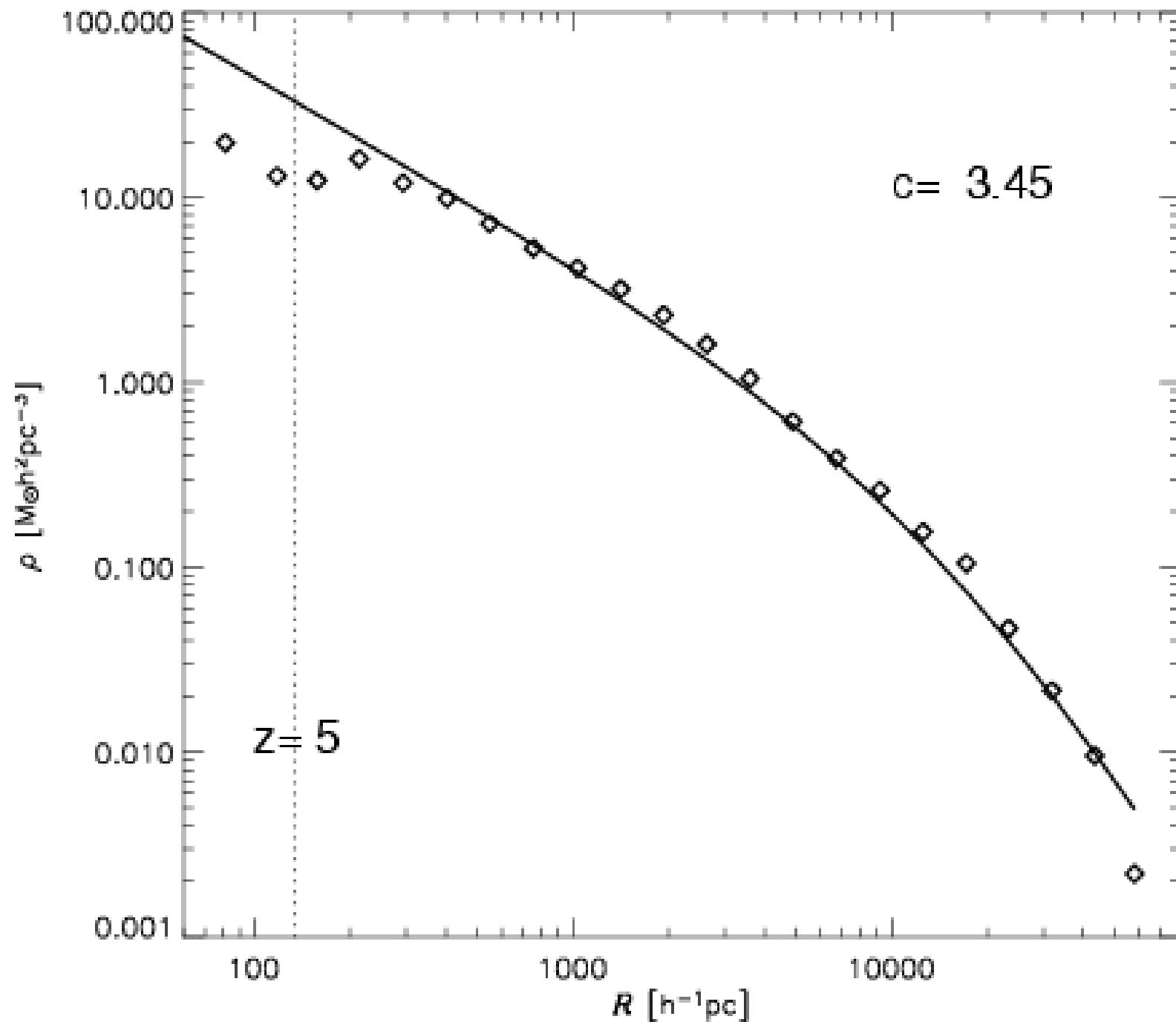
$M_{200} = 5.2e7 h^{-1} M_\odot$

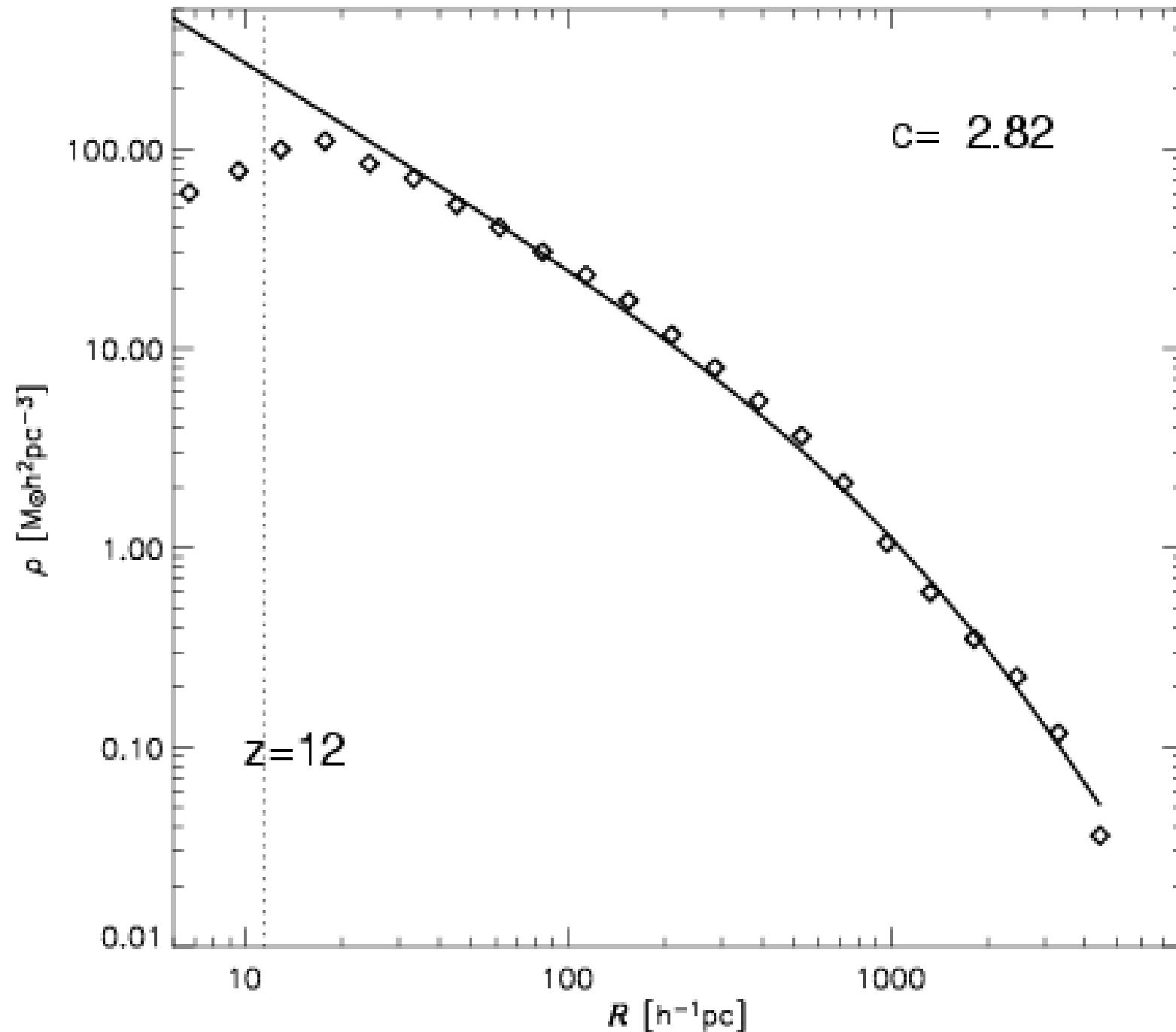
$z = 48.85$

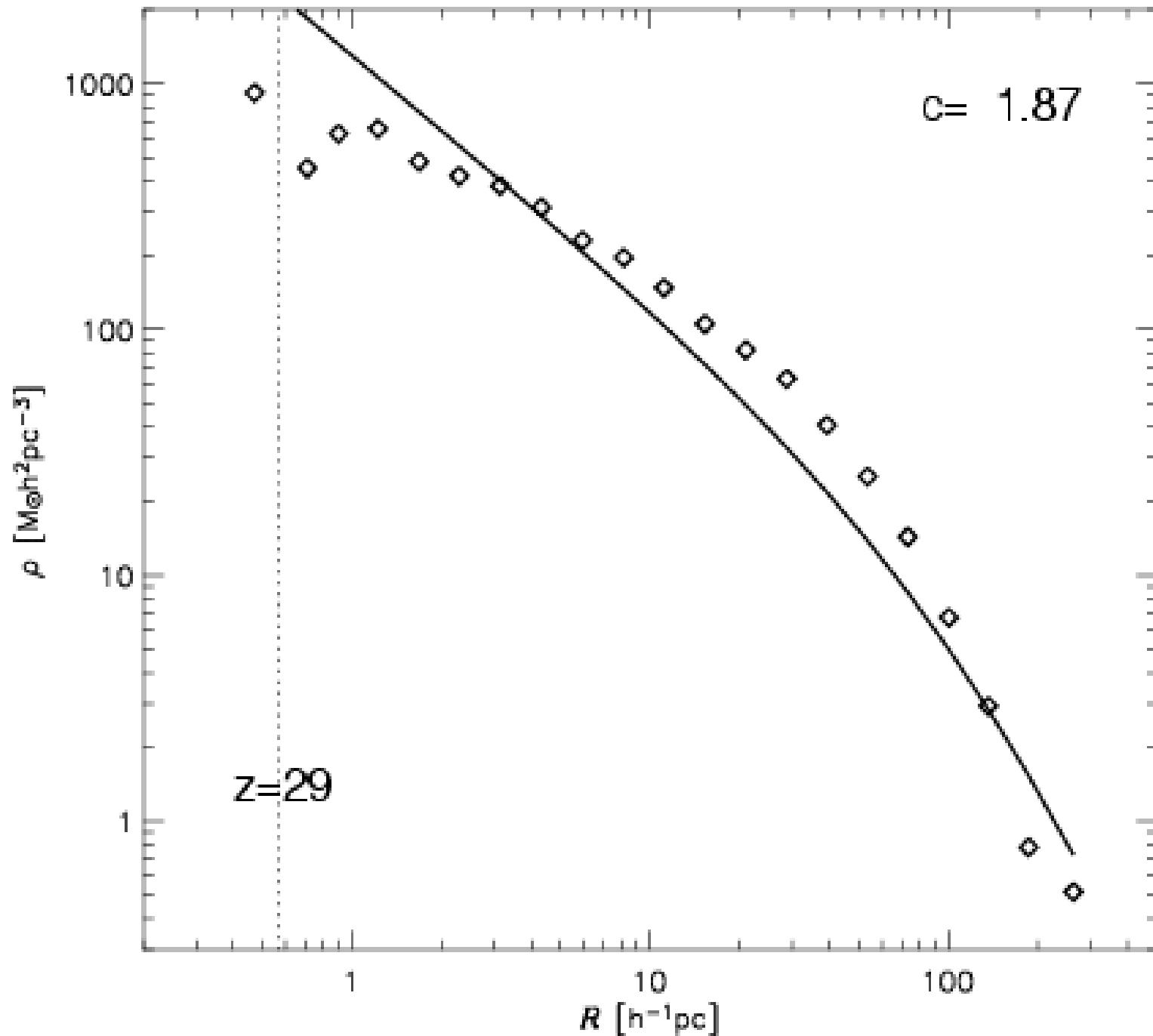
1.184  $h^{-1} \text{kpc}$

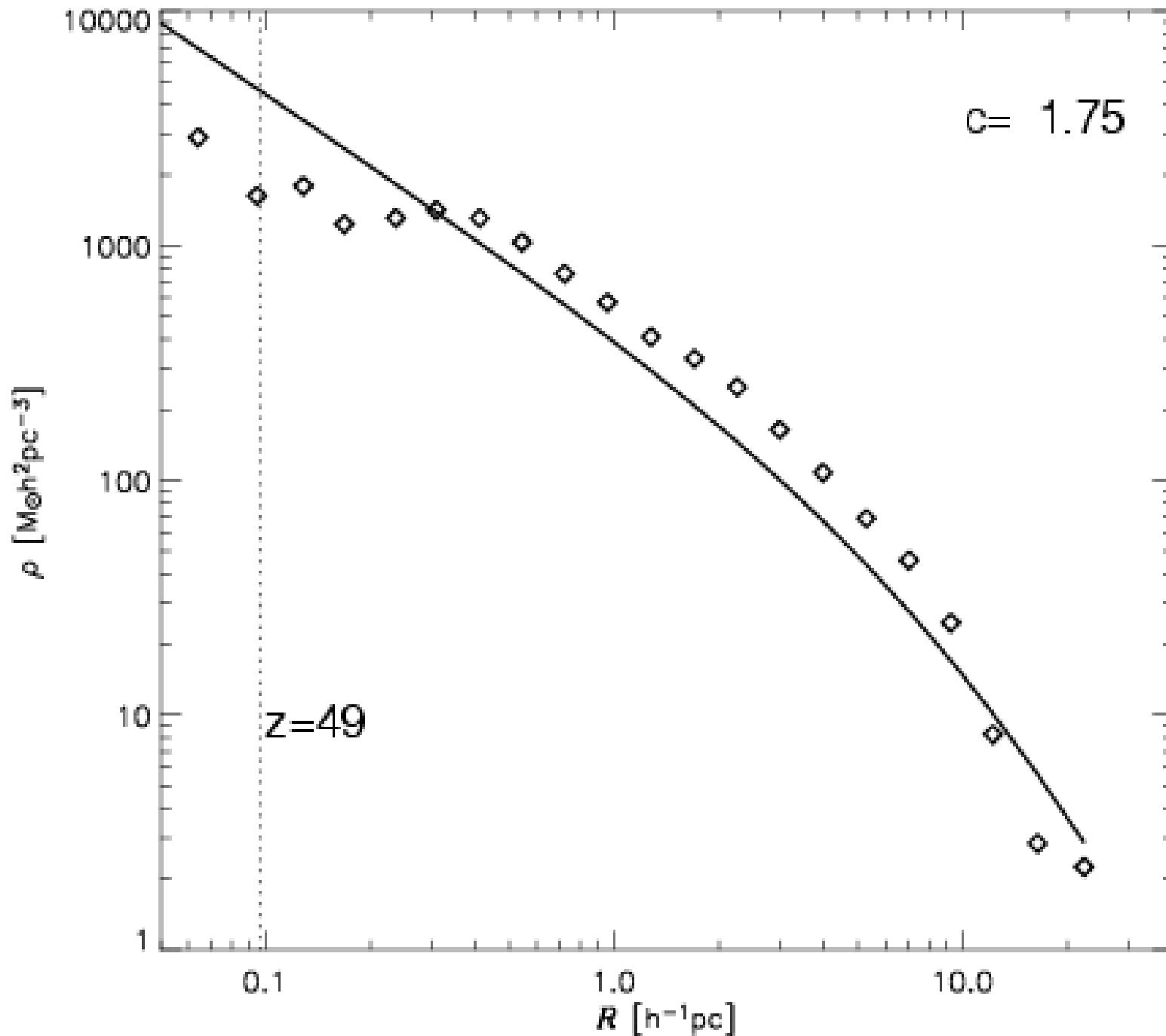
$M_{200} = 1.2e5 h^{-1} M_\odot$

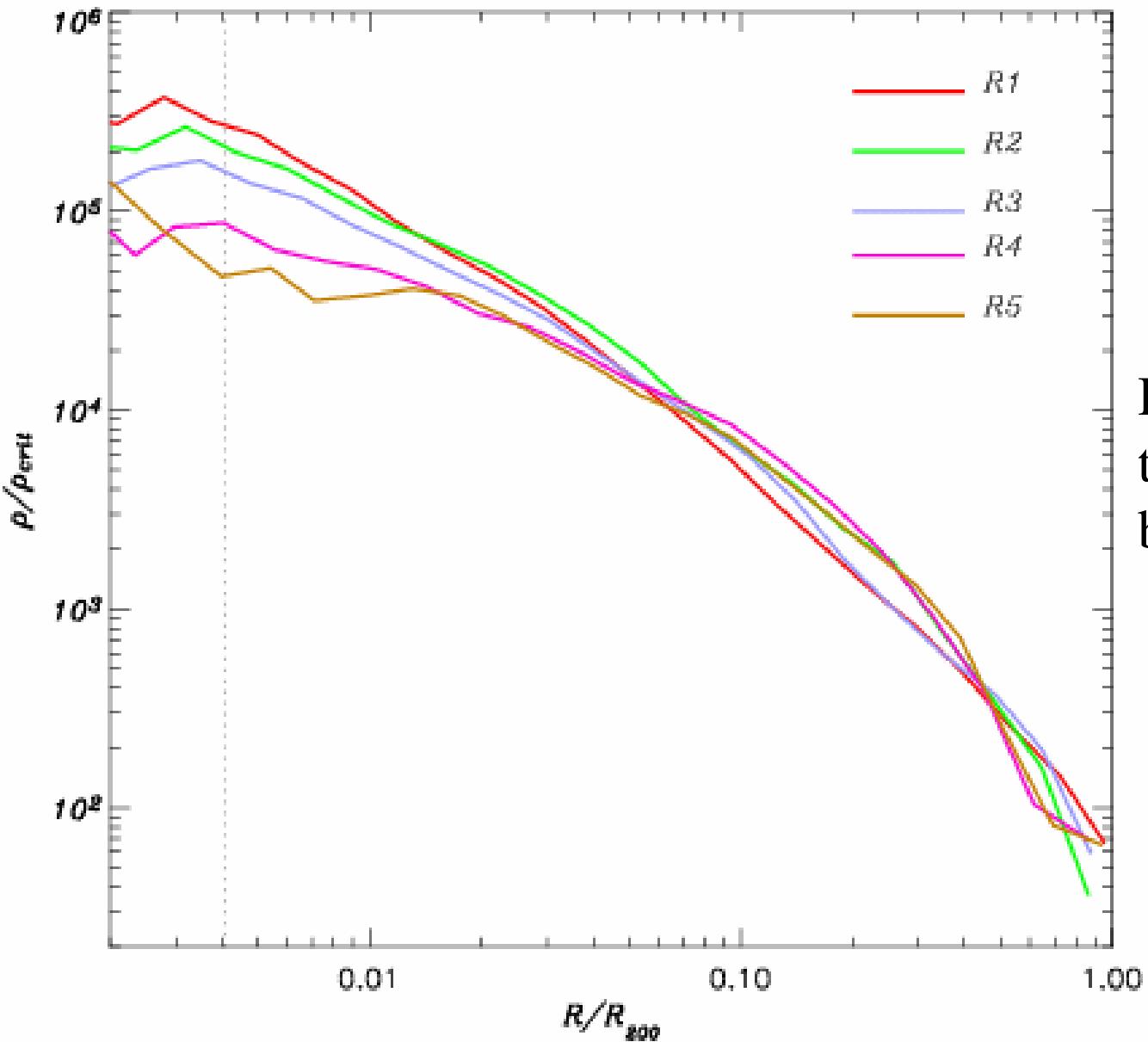




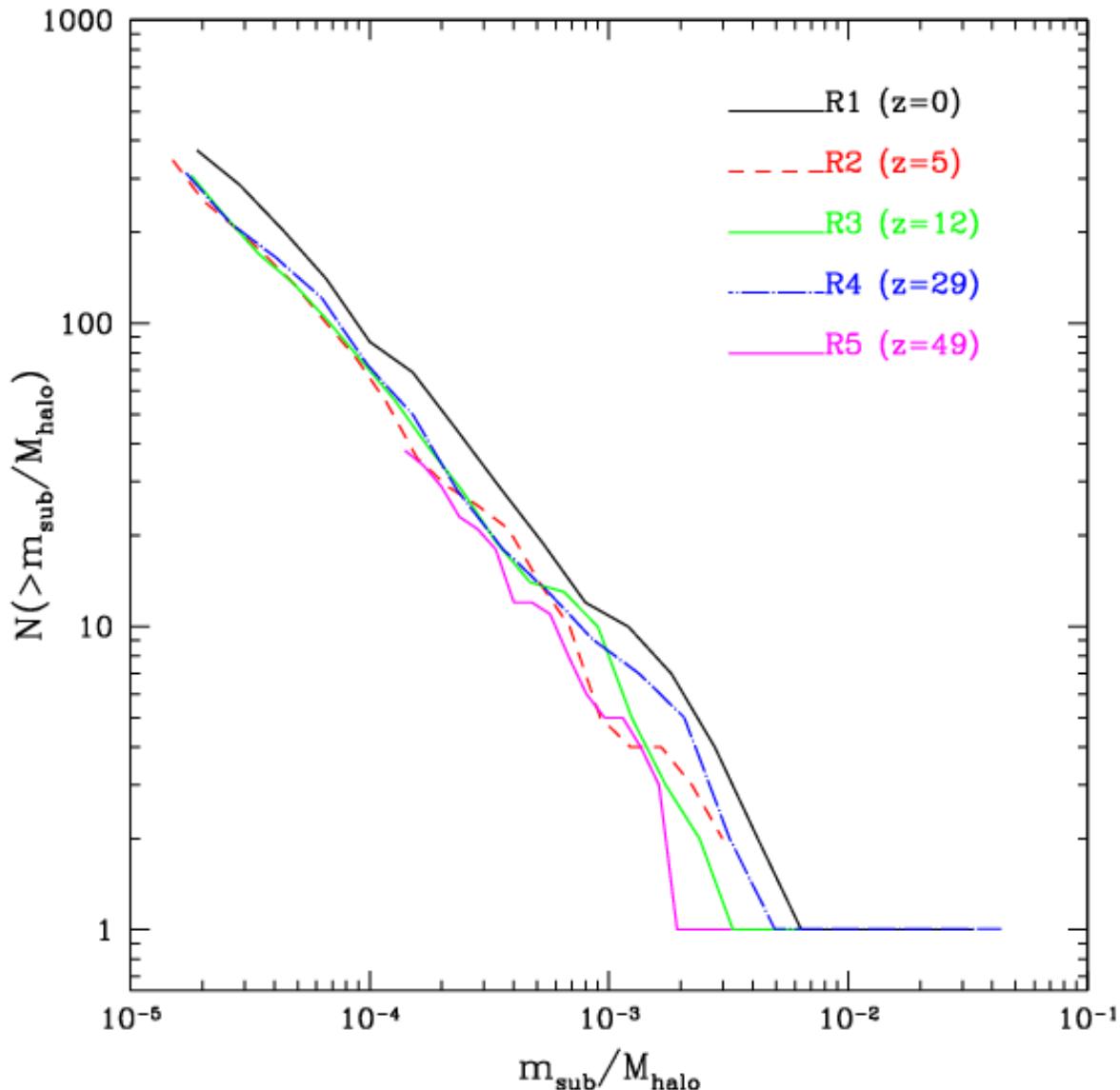




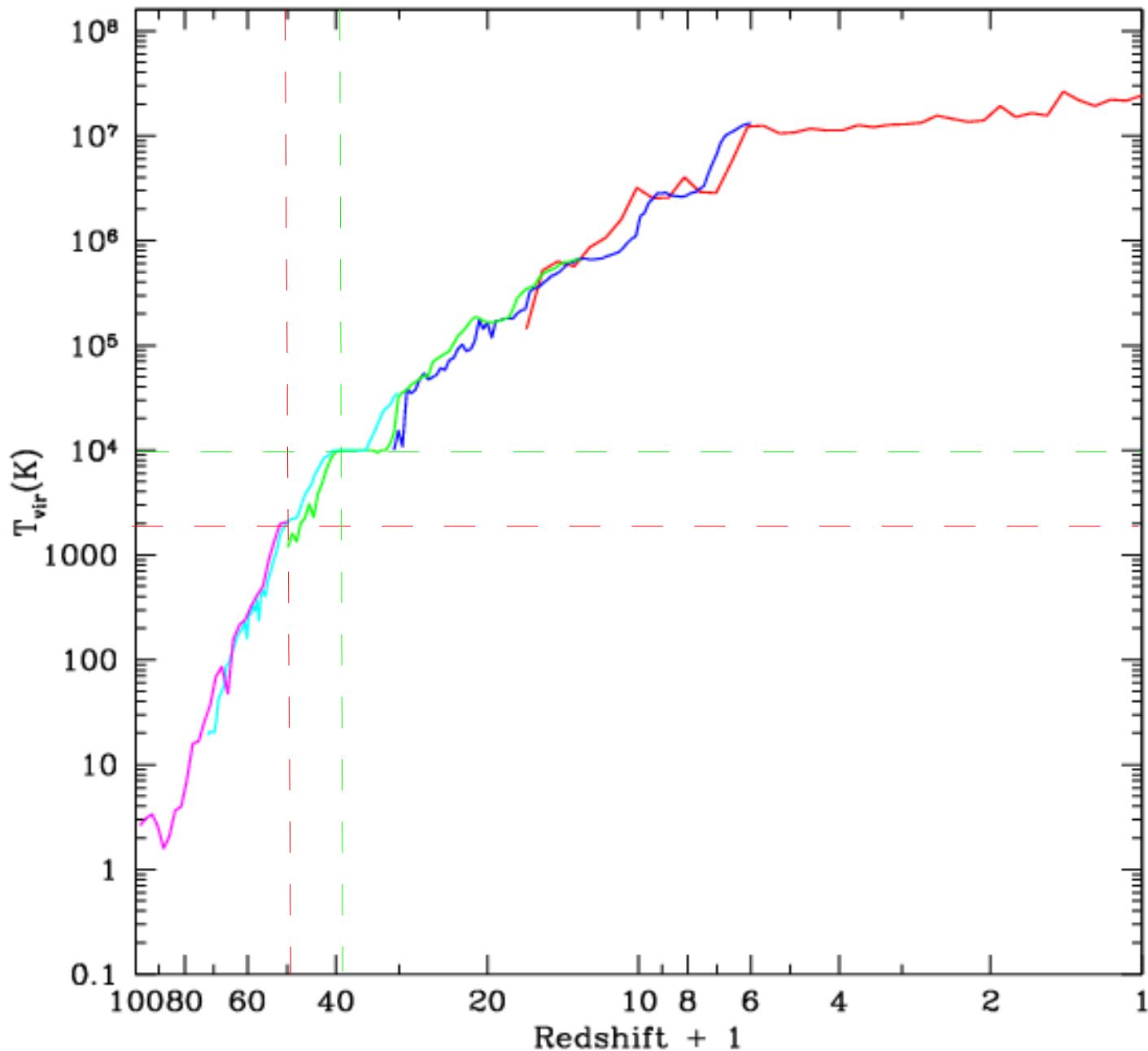




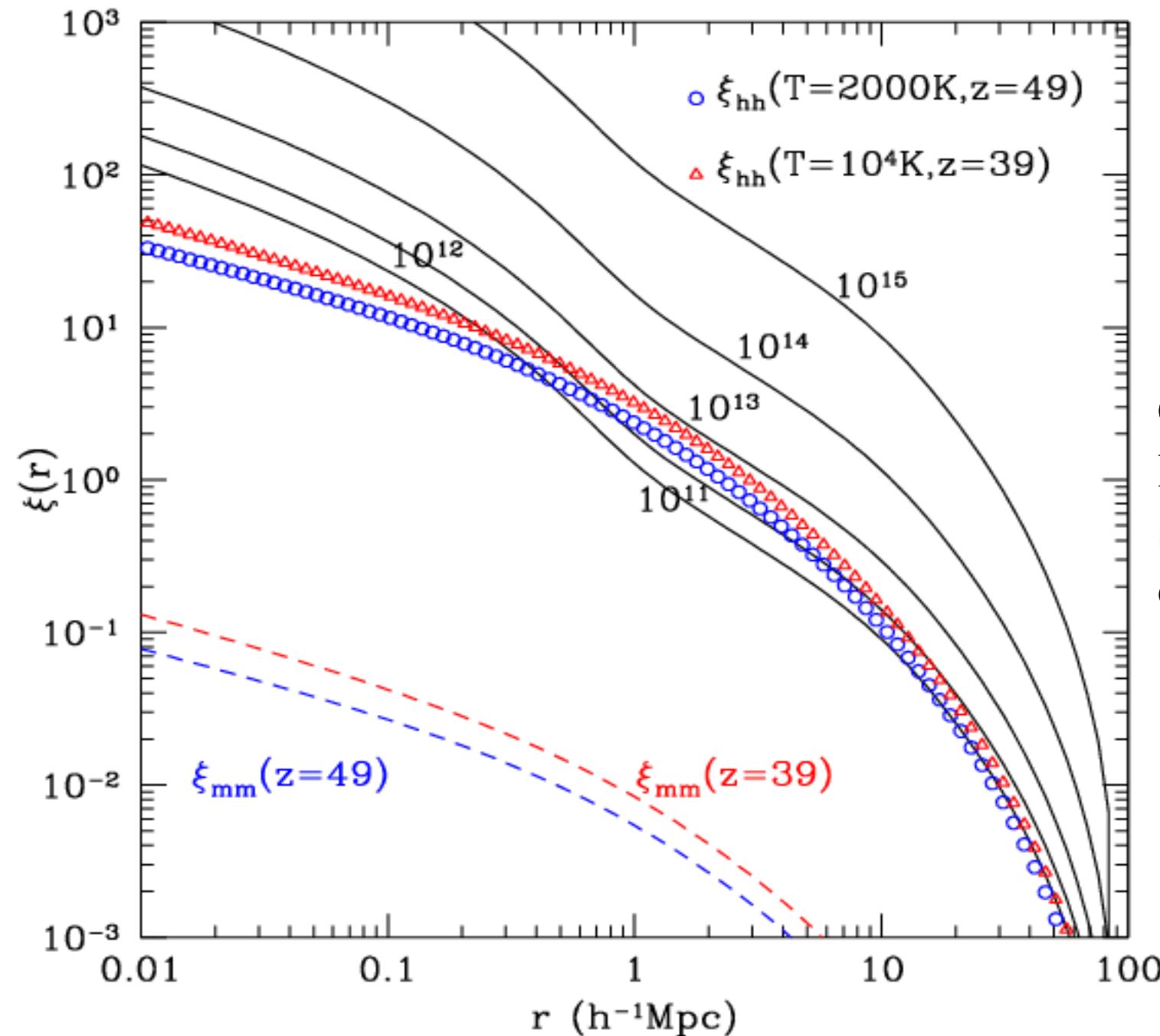
Density profiles at early times are less concentrated but not so different



Substructure levels at different times are similar



Temperature reaches  
levels for effective  
cooling at  $z \sim 50$  ( $\text{H}_2$ )  
or  $z \sim 40$  (HII)



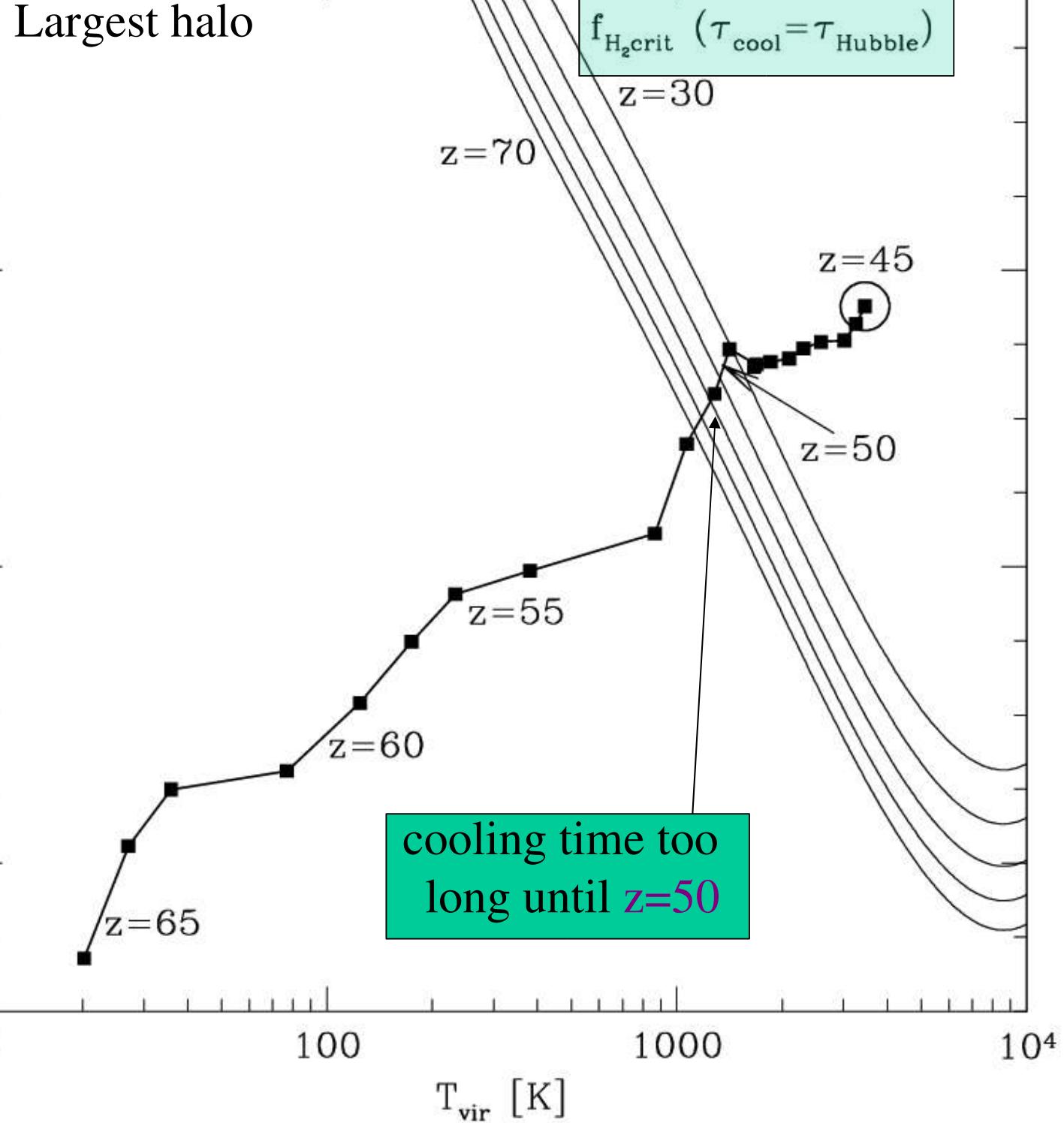
Clustering of the first  
luminous objects is  
similar to that of  
dwarf galaxies today

# Critical H<sub>2</sub> fraction

#1  $\tau_{\text{cool}} < \tau_{\text{Hubble}}$

$$f_{\text{H}_2} = n_{\text{H}_2}/n_{\text{H}}^{-5}$$

Reed et al 2005



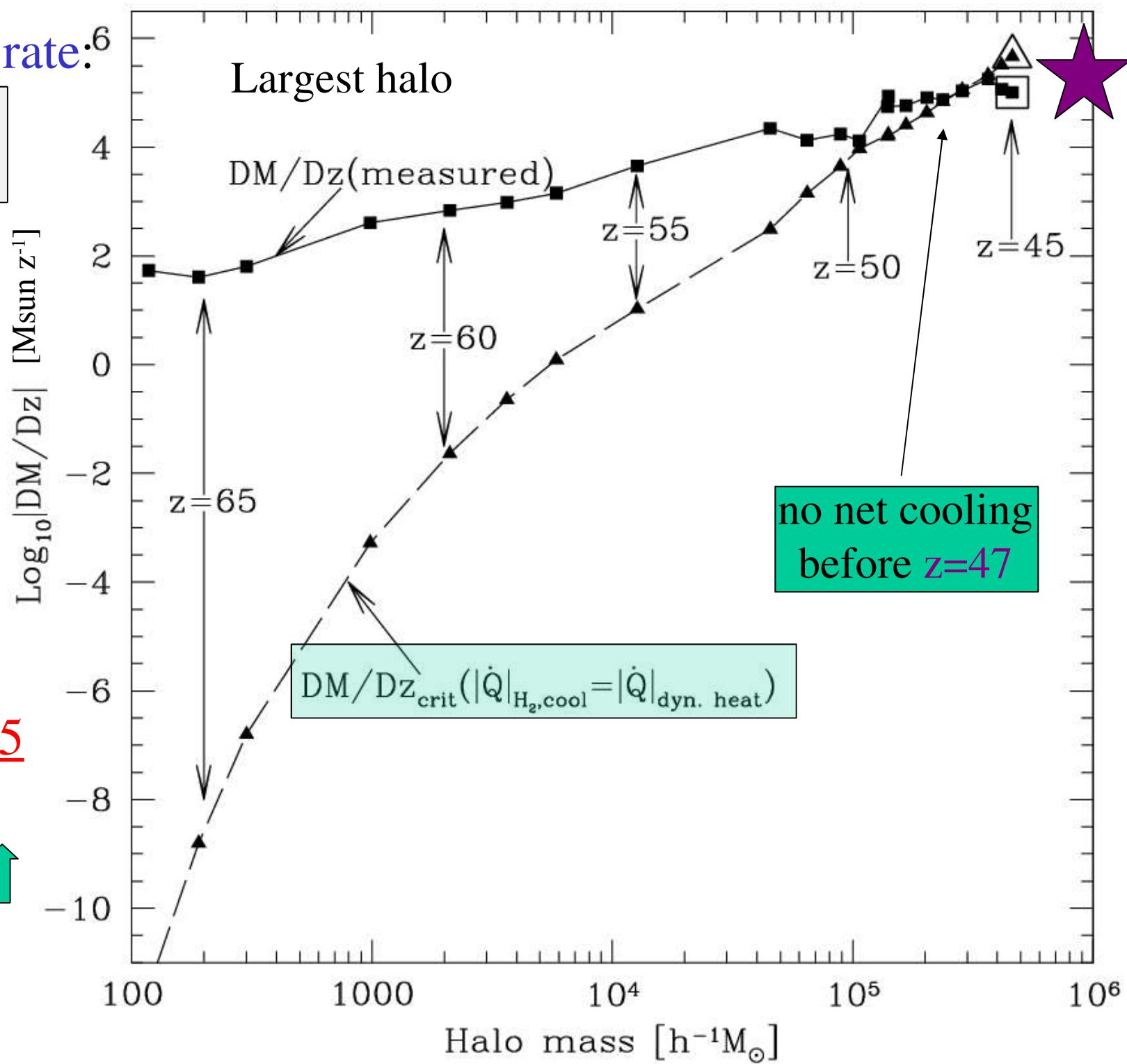
Critical growth rate:

#2 H<sub>2</sub> cooling >  
Dyn. heating

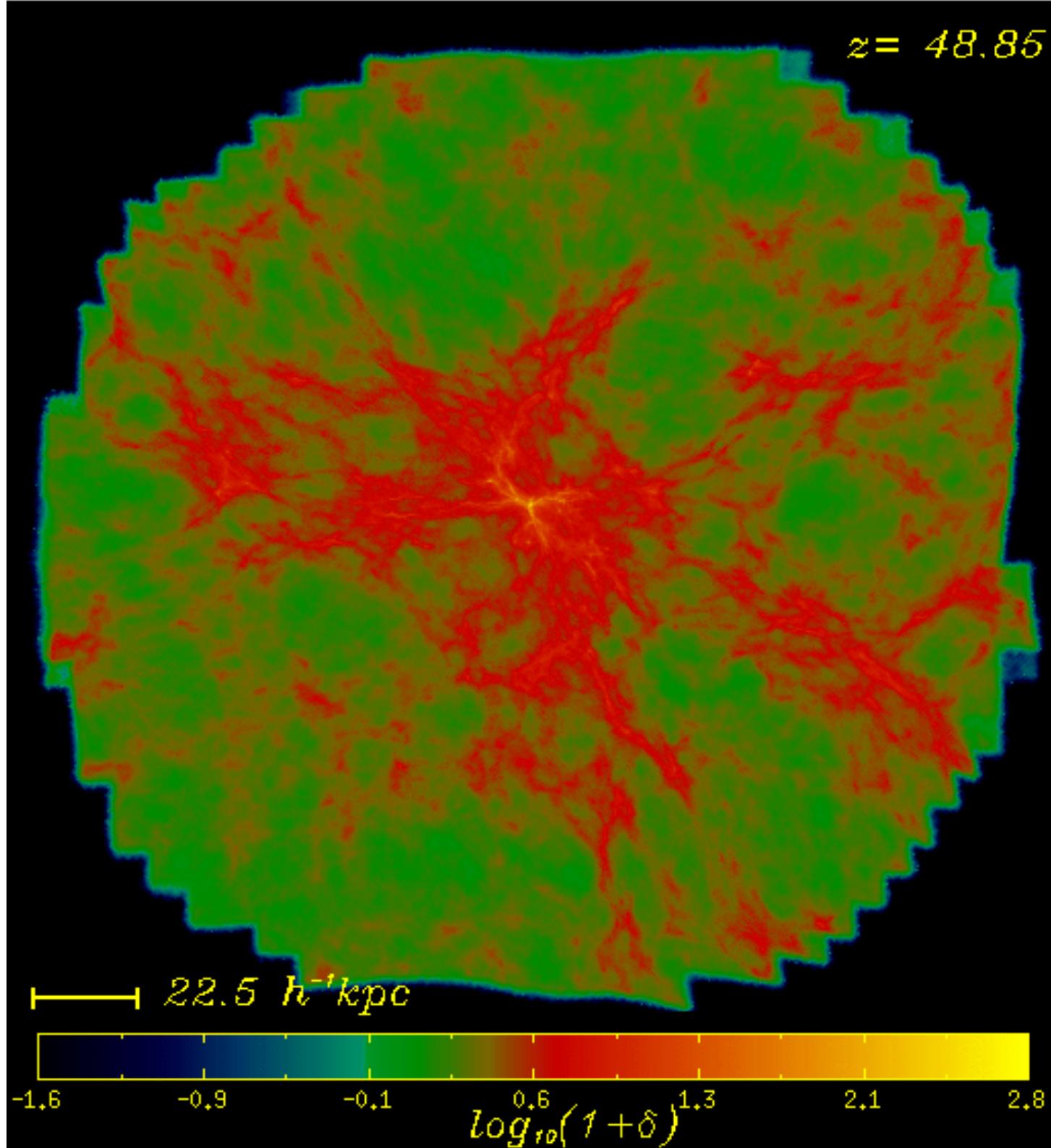
Fast halo  
growth  
prevents  
net cooling

Reed et al 2005

As f<sub>H<sub>2</sub></sub> ↑  
DM/Dz<sub>crit</sub> ↑



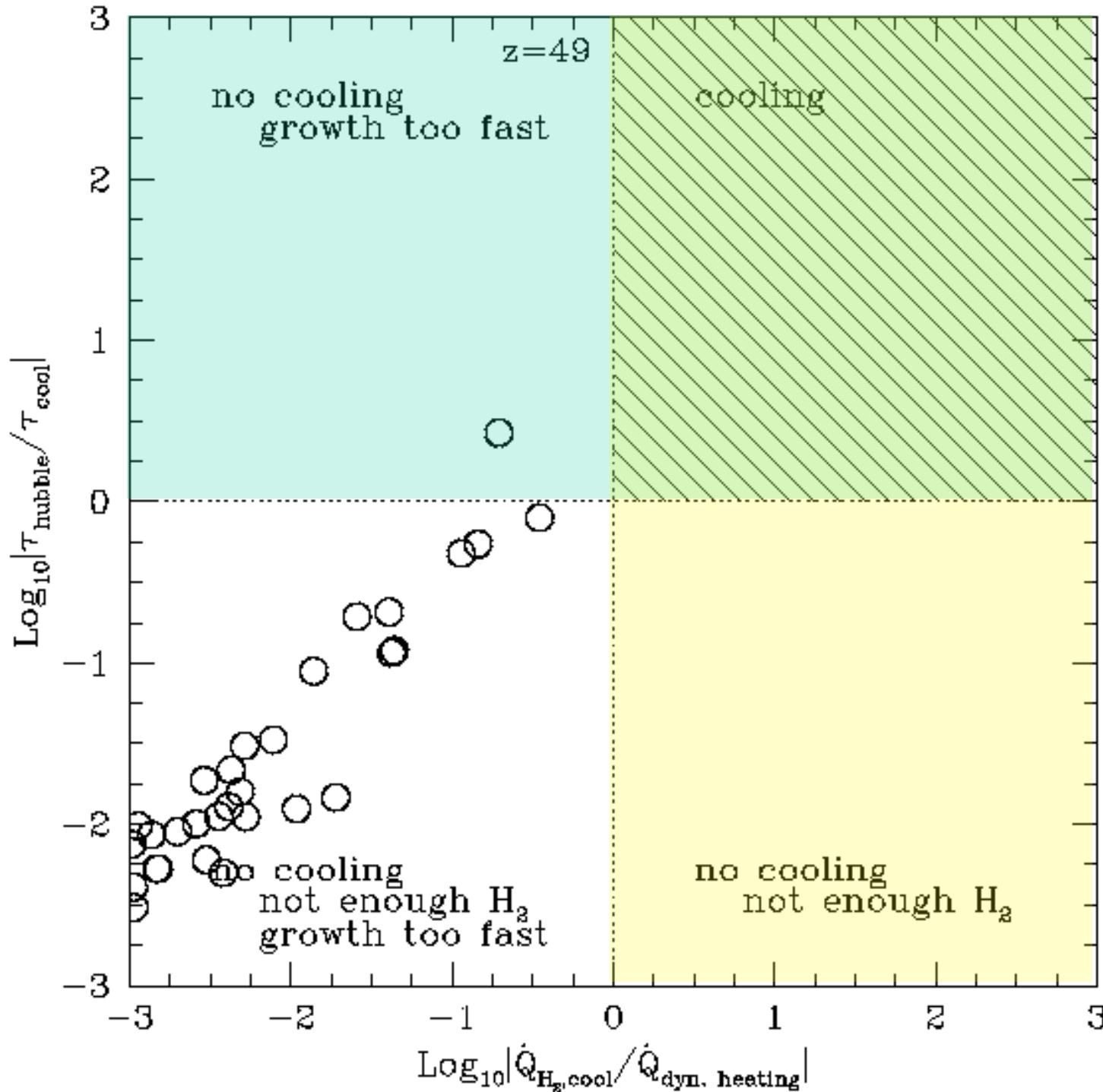
$z = 48.85$



$z=49$

Collapsed Halos: 0

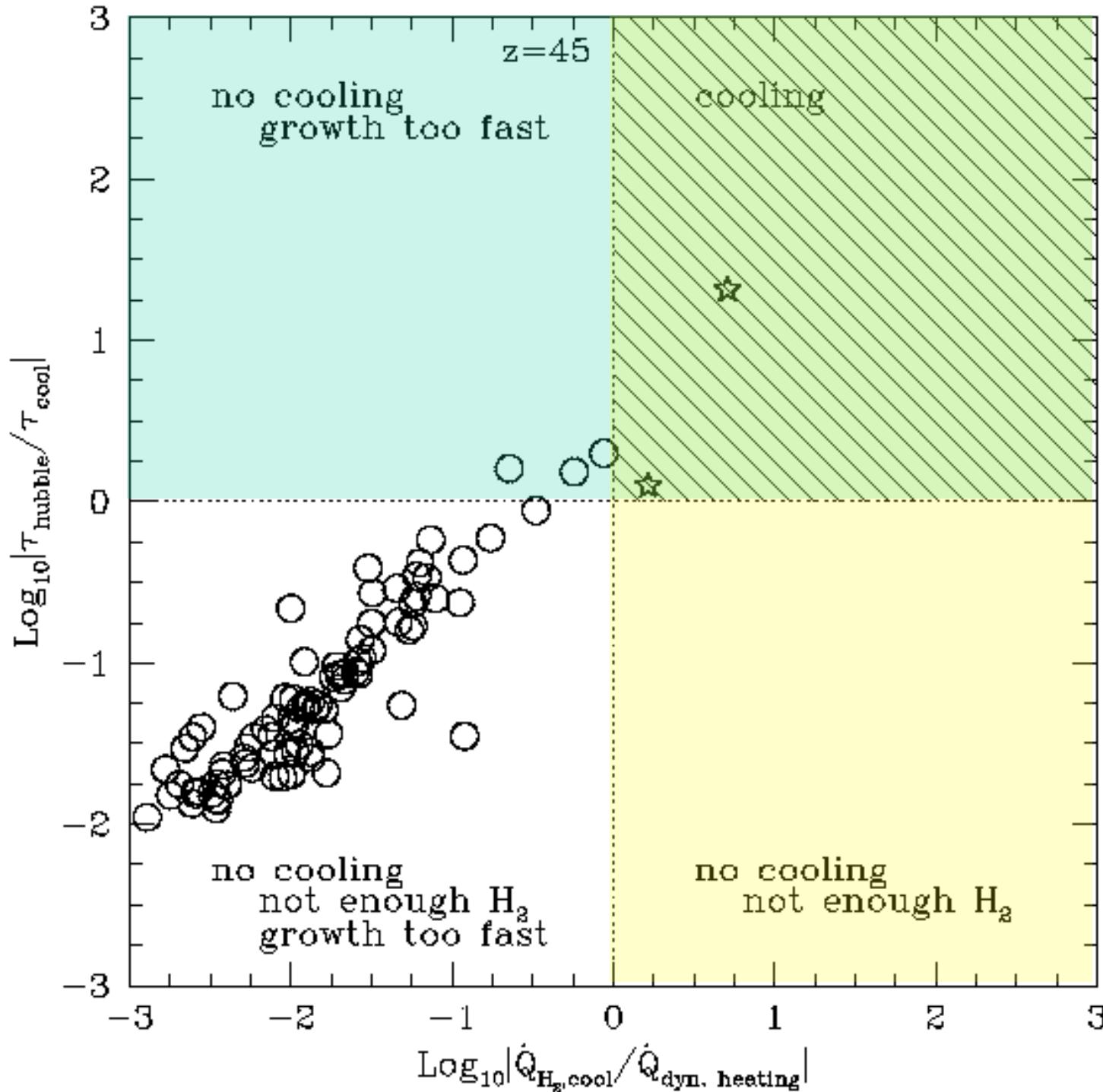
Reed et al 2005



$z=45$

## Collapsed Halos: 2

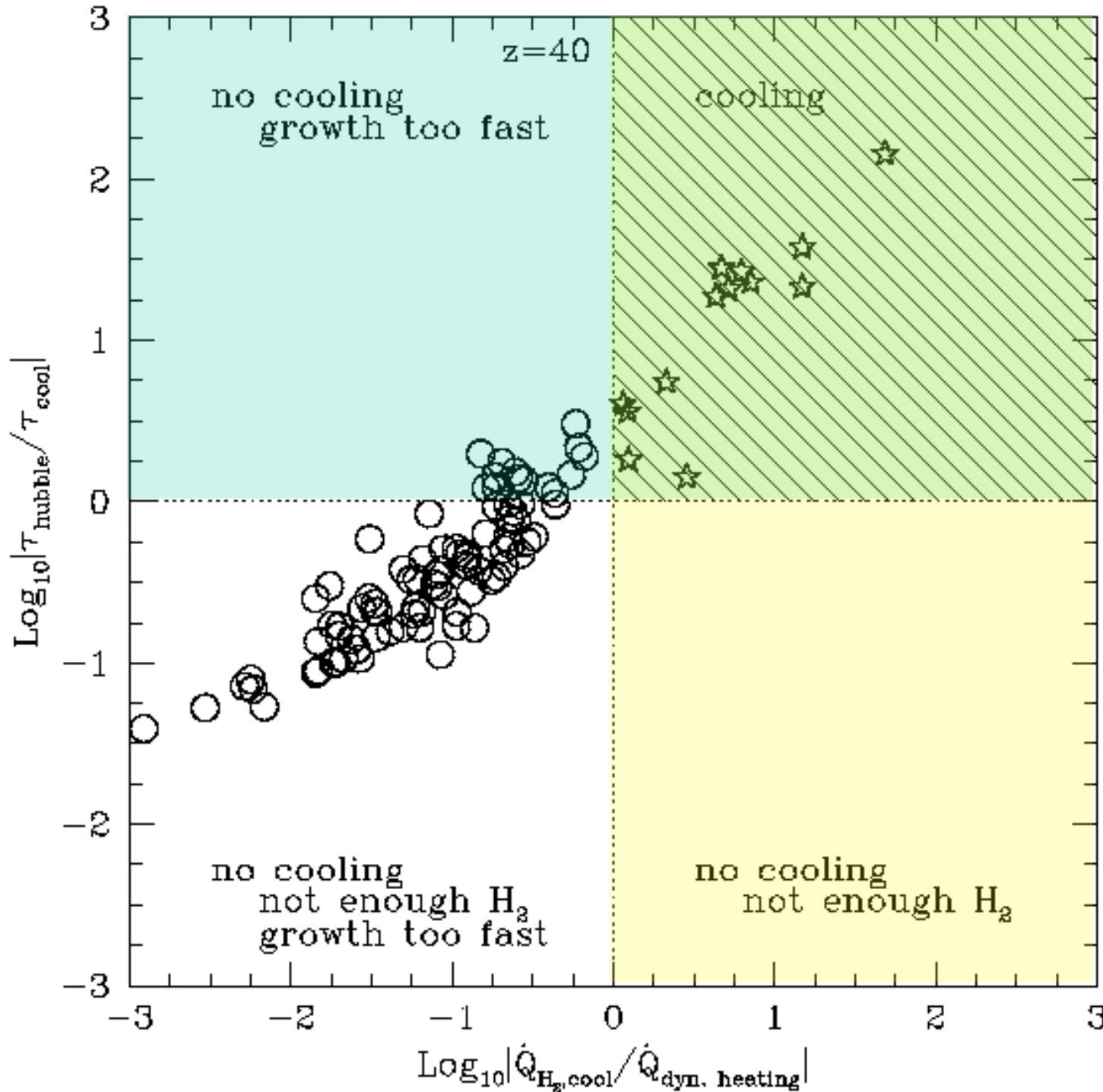
Reed et al 2005



$z=40$

Collapsed Halos: 13

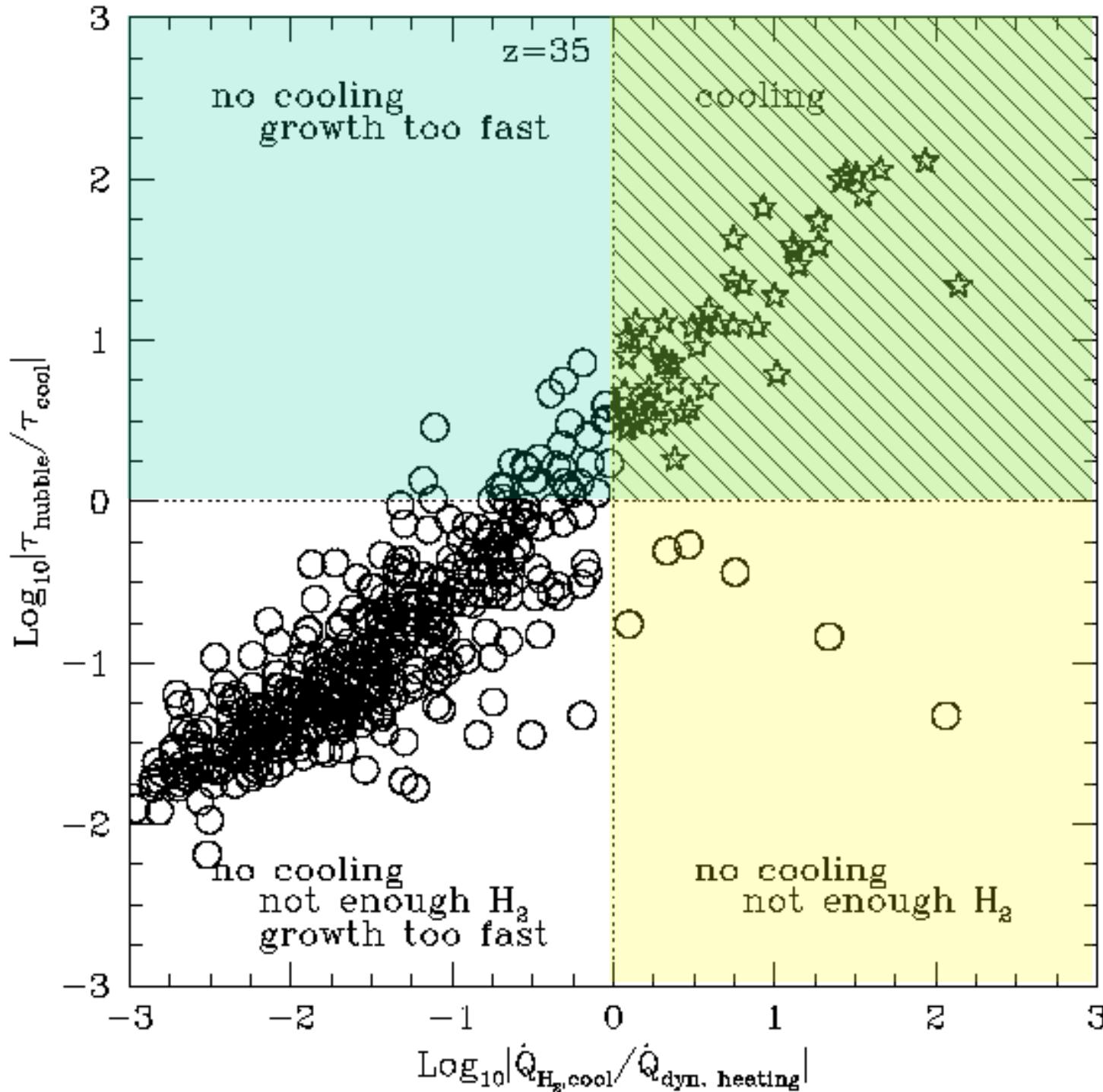
Reed et al 2005



$z=35$

Collapsed Halos: 45

Reed et al 2005



$z=29$

Collapsed Halos: 83

Reed et al 2005

