Title: Halo Assembly Bias in Hierarchical Structure Formation

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Abstract:

Halo assembly bias

Neal Dalal (CITA)

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$$\delta_h = b_h \, \delta_m,$$

$$\Rightarrow \xi_{hm} = b_h \, \xi_m, \text{ and } \xi_h = b_h^2 \, \xi_m$$

bias

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1. this greatly simplifies things! Dynamics becomes (mostly) unimportant; problem reduces to Gaussian statistics.
2. one term is time dependent, one term is constant

mass dependence of bias

example: Press-Schechter:

- $\delta_h = b_L \delta \rightarrow b_L = n^{-1}(dn/d\delta) = -n^{-1}(dn/d\delta_c)$.
- $n_{PS} \propto \delta_c \exp(-(\delta_c/\sigma)^2) \rightarrow b_L = \delta_c/\sigma^2 - \delta_c^{-1}$

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two regimes:

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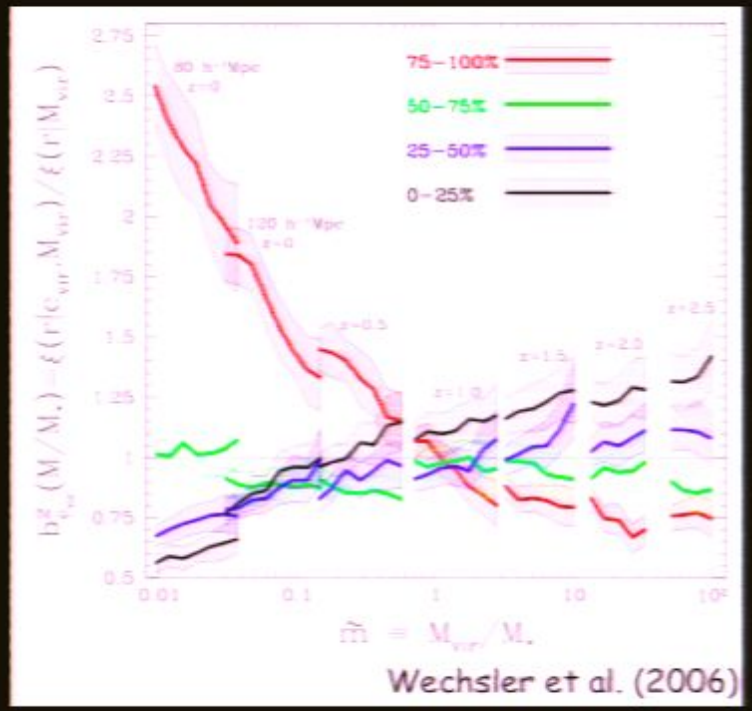
two regimes:

1. high mass, $\sigma \ll \delta_c$. steep mass function gives strong clustering

2. low mass, $\sigma \gg \delta_c$. raising the background density decreases the number of low-mass halos → anti-bias

dependence on other parameters

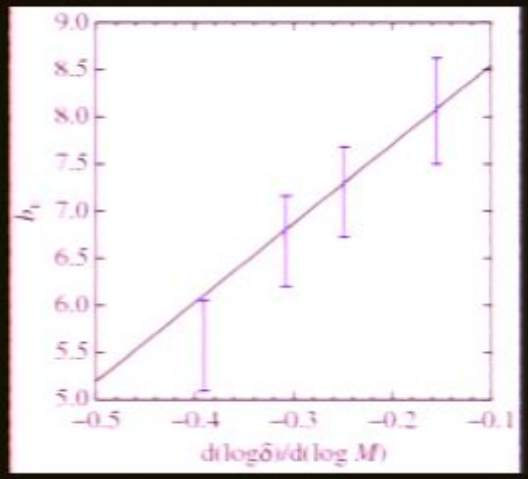
low mass



high mass

high M: summary

halos in high density regions have a larger mass supply, and grow more quickly, than similar halos in low density environments.



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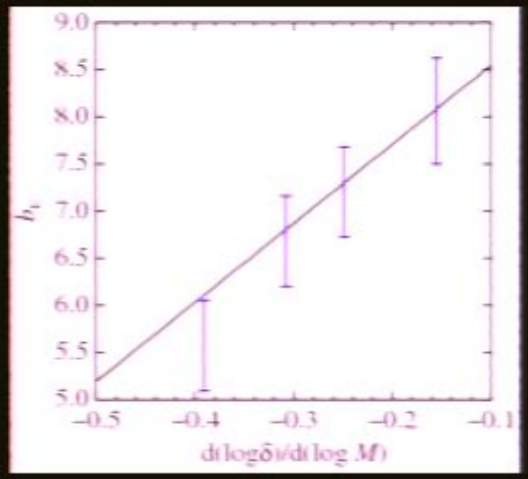

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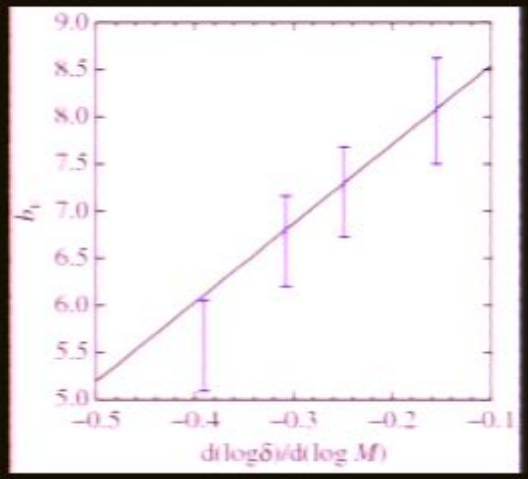

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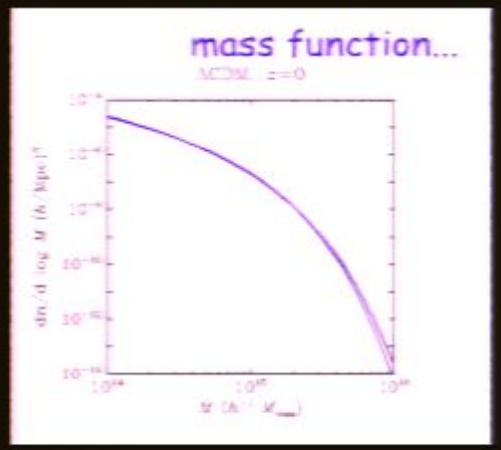

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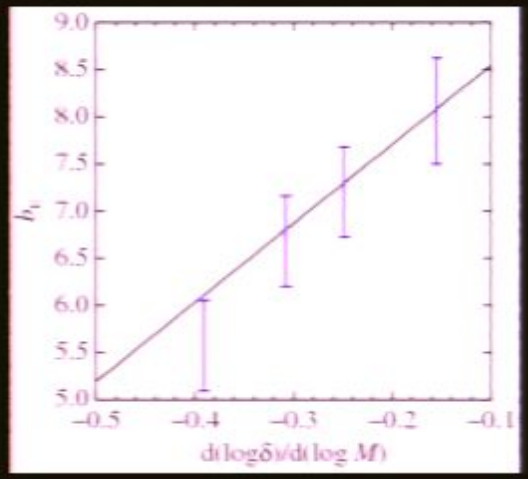

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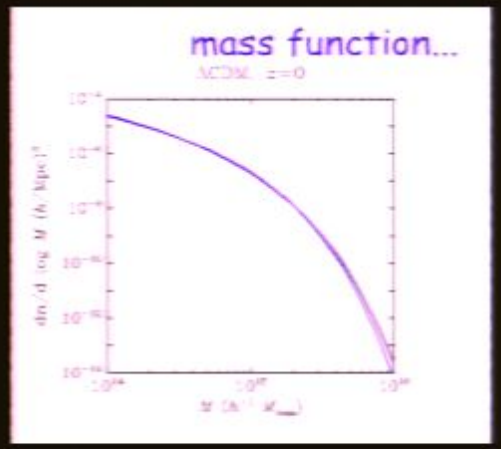

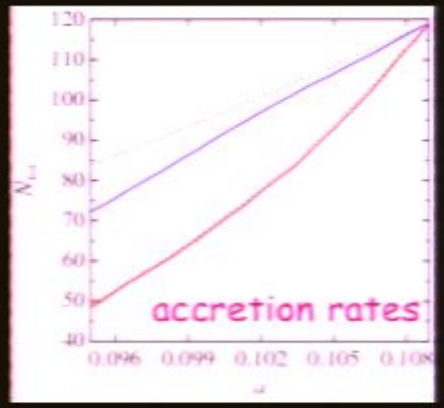

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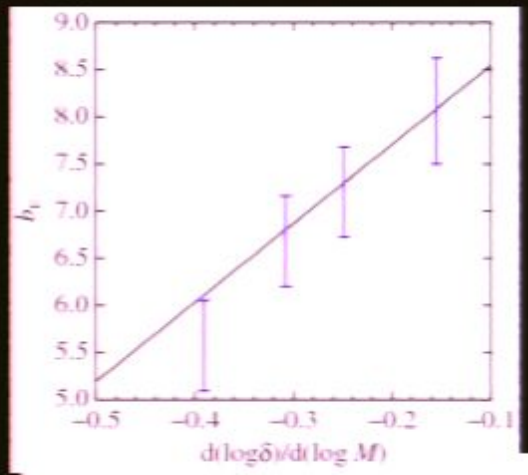

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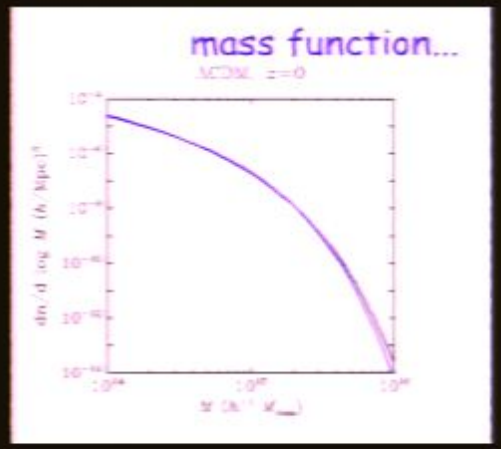
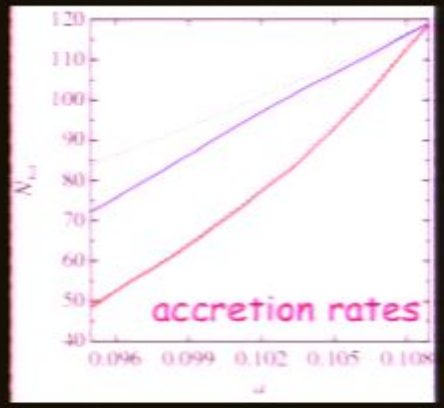
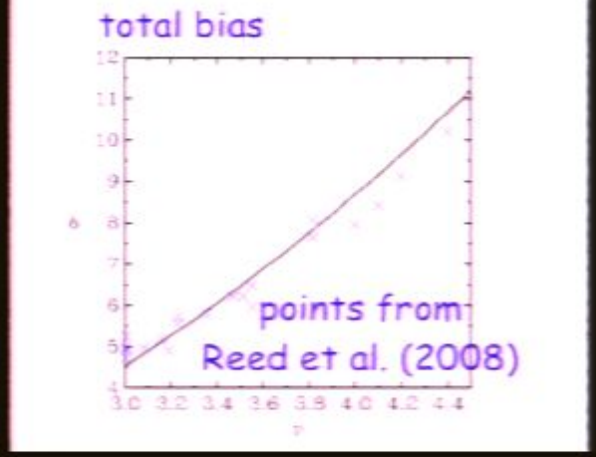


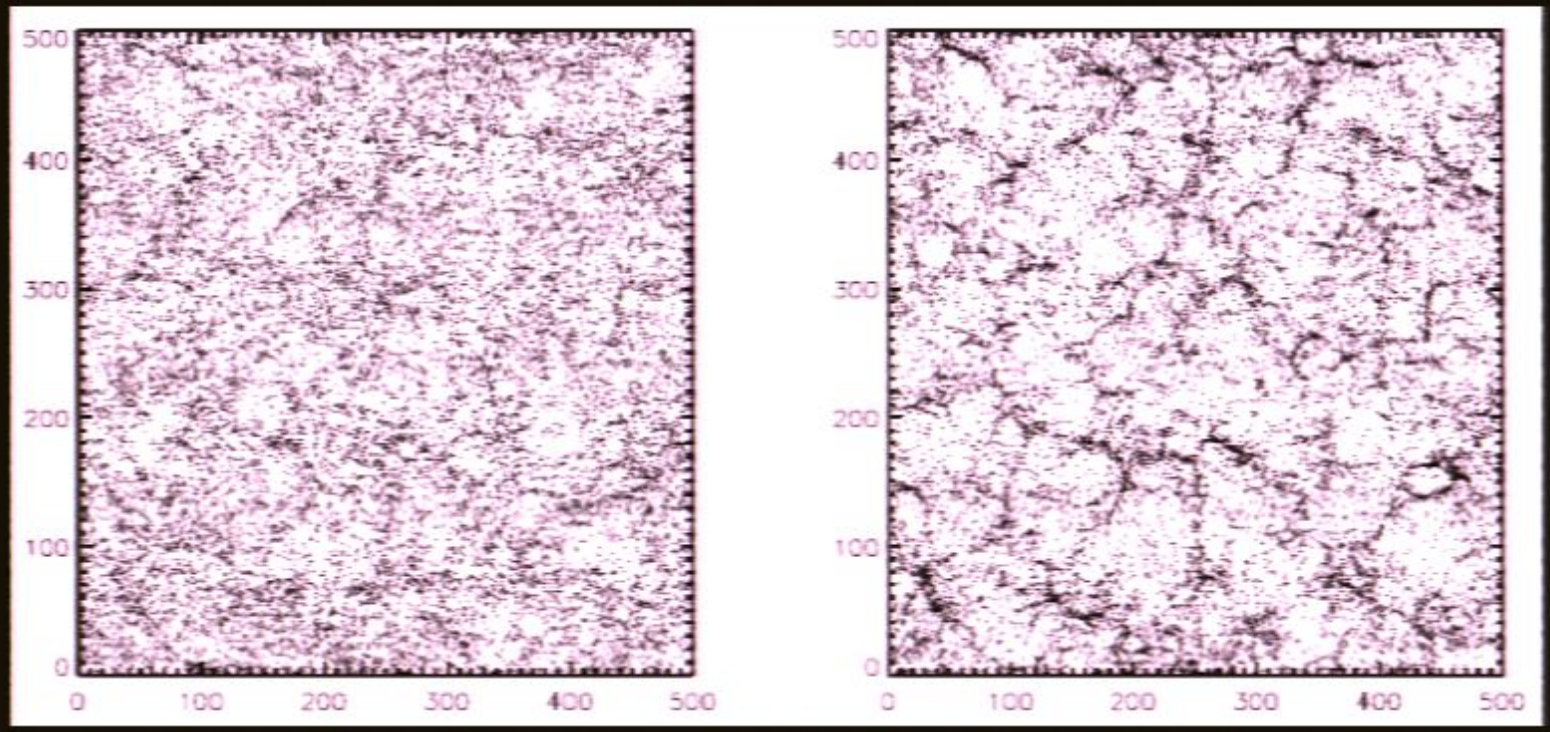




assembly bias at low M

youngest 20%

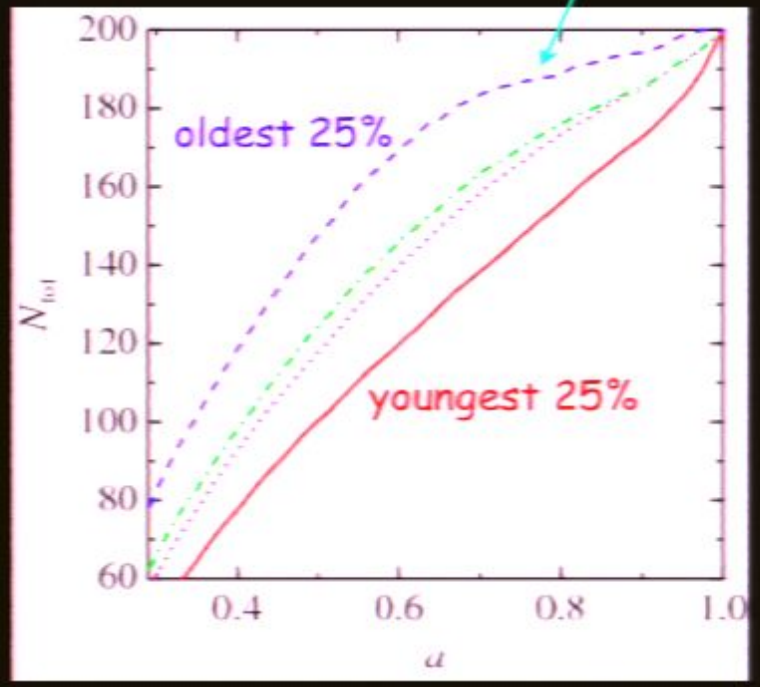
oldest 20%



Gao et al. (2005)

growth of low-mass halos

note the arrested development of a subpopulation



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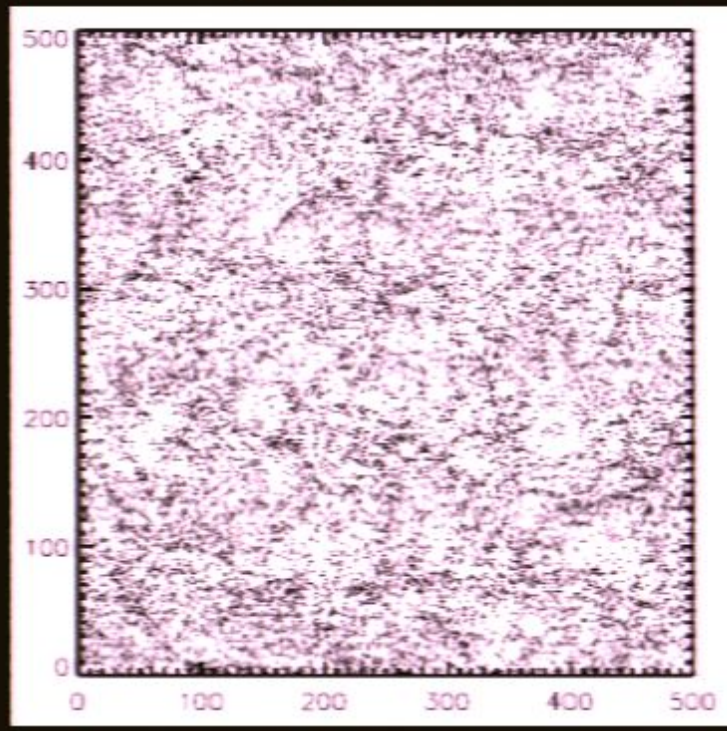

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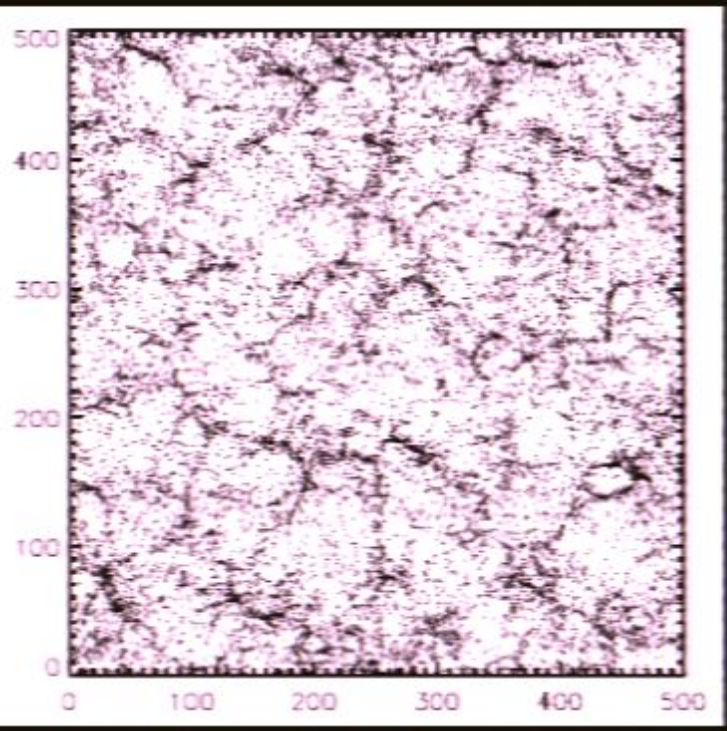

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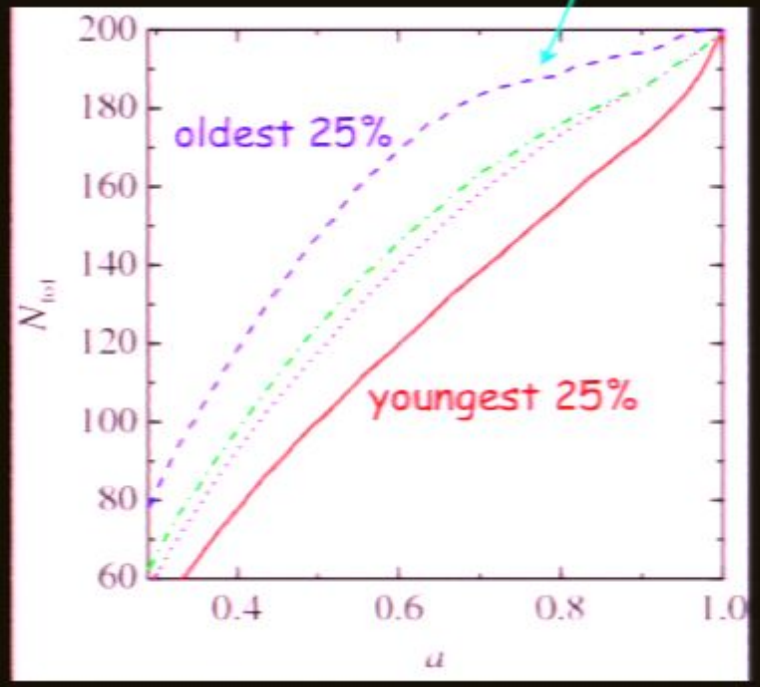
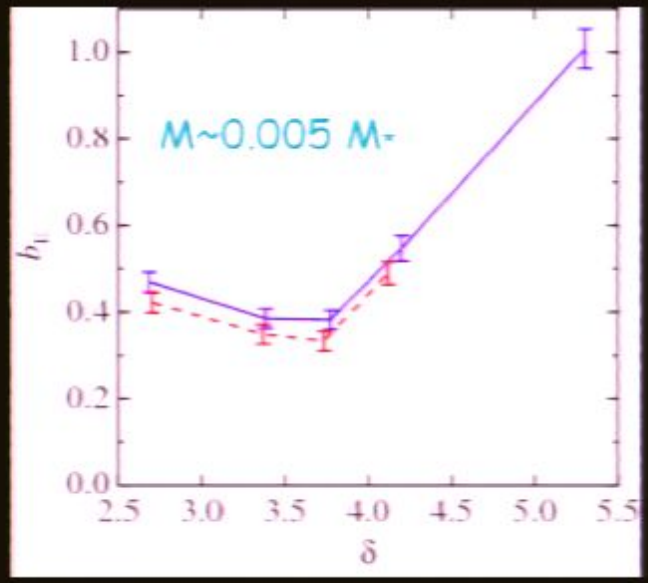


bias at low-masses

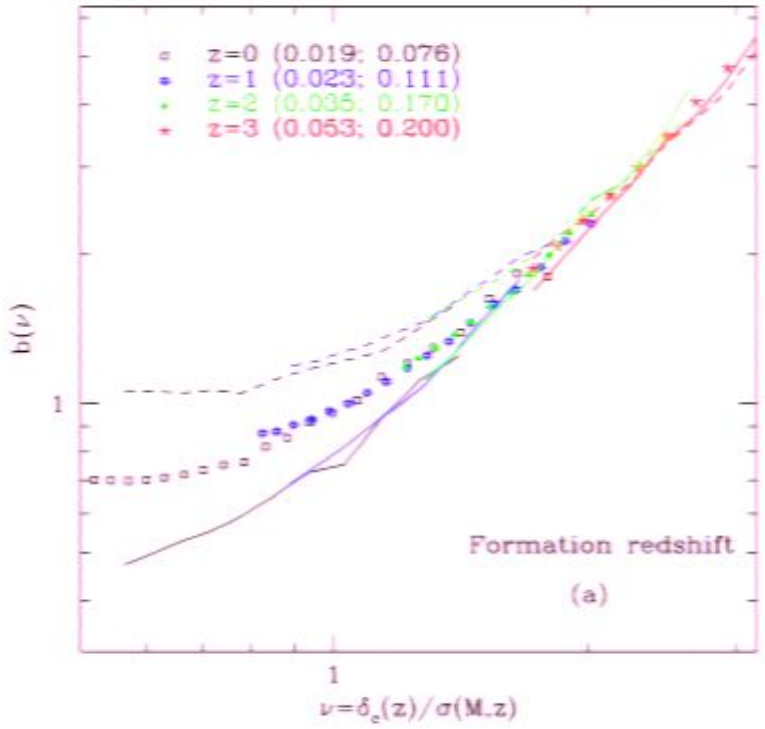
- because oldest halos stop growing, they act like test particles moving along bulk flows
- so they should become unbiased over time, b→1
- other low-mass halos should be anti-biased
- so the extent of assembly bias at low M is not surprising



similar result from Gao & White (2007)

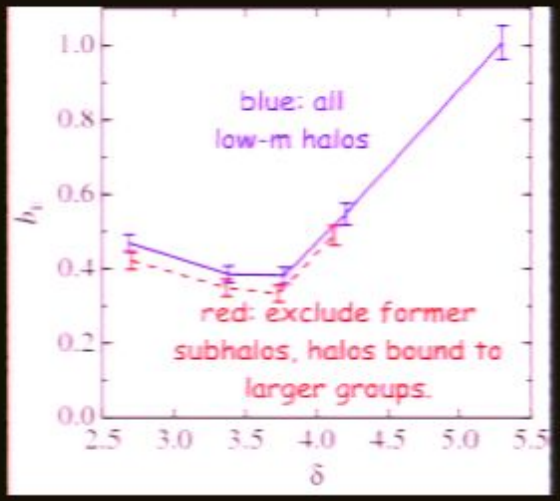
oldest low-m halos
roughly unbiased

youngest low-m halos
b→0.4-0.5



stunted growth

The stunted halos are typically found near bigger halos (Wang et al. 2007). This suggests that environmental effects of the big ones shut off growth in the small ones...



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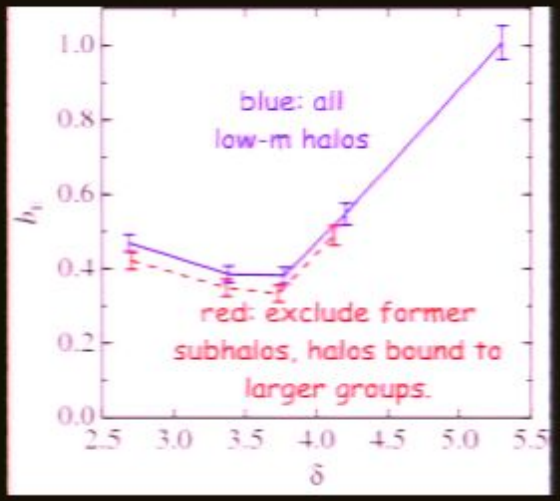

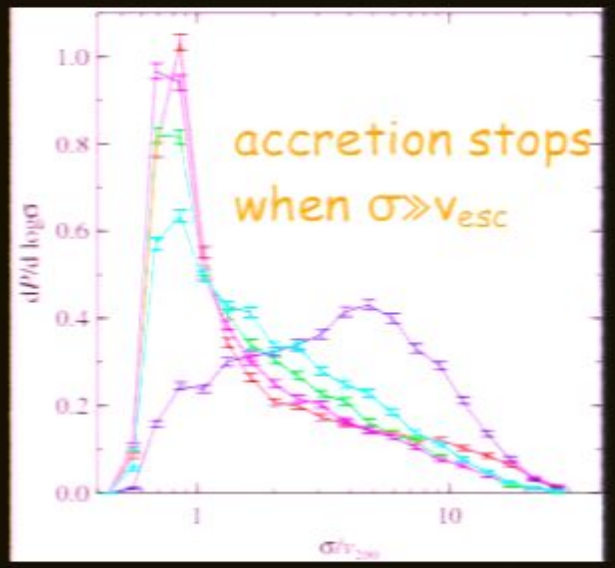

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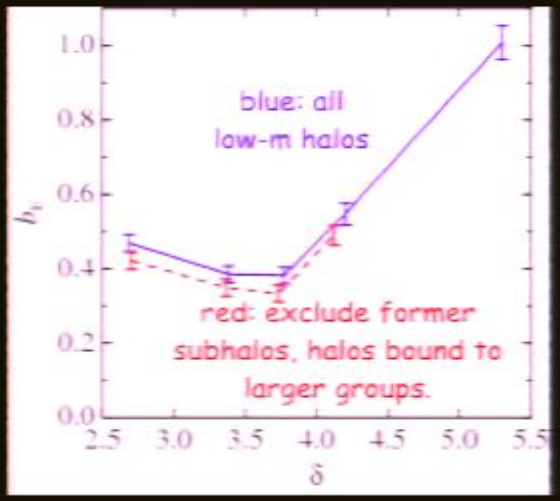

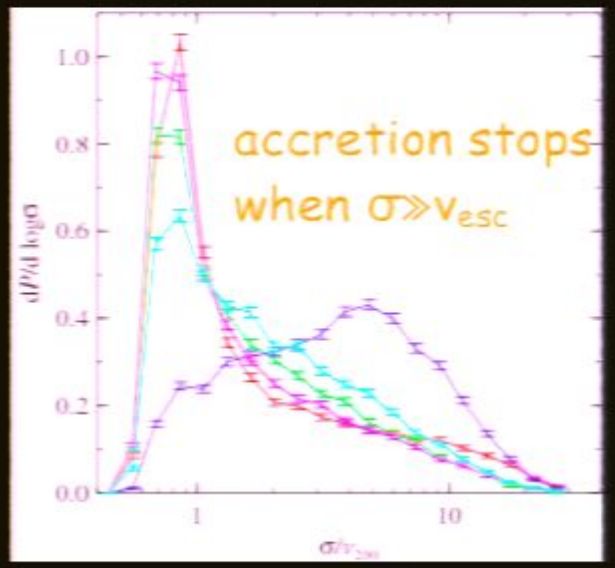

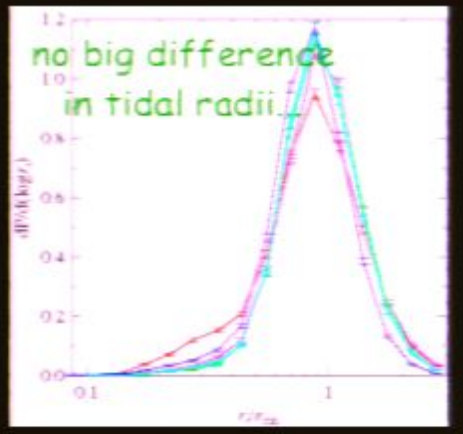

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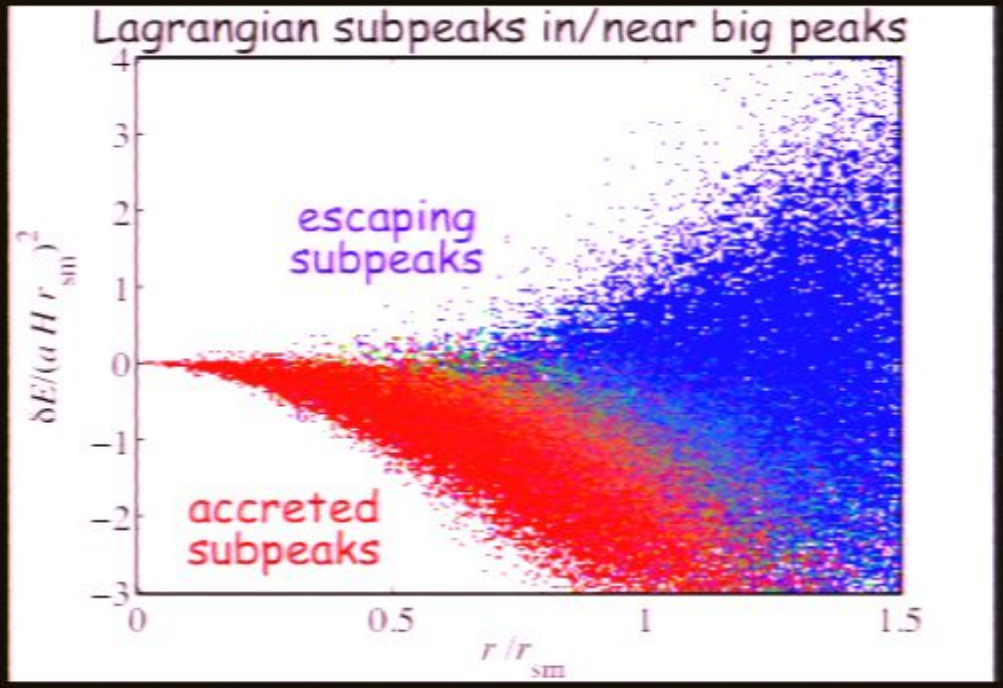

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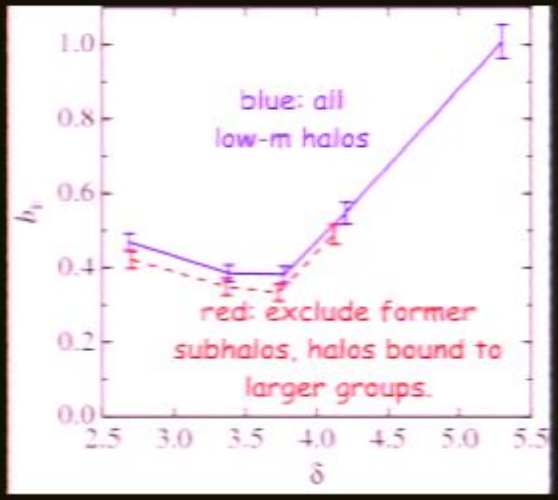

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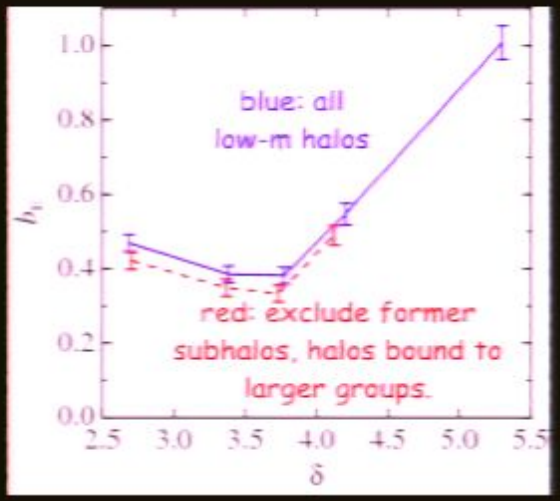

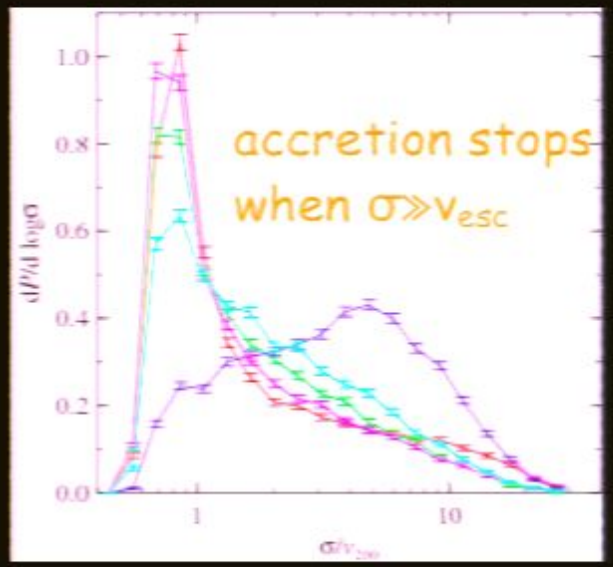

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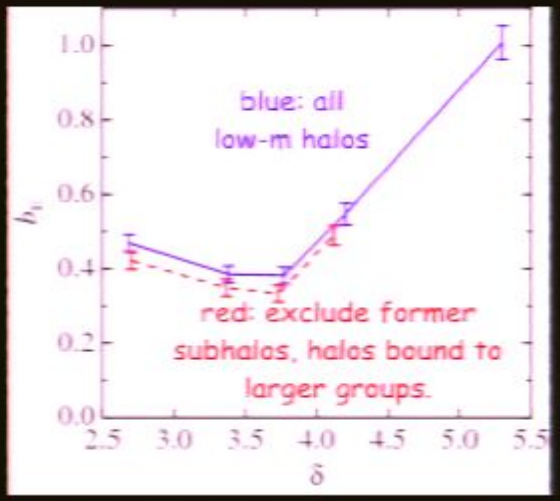

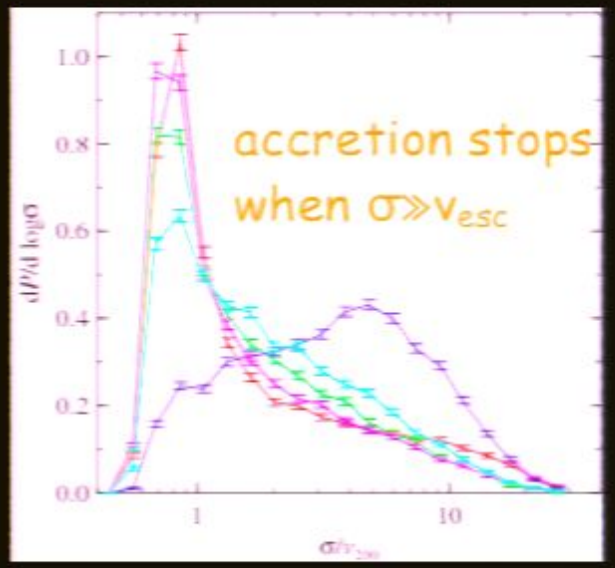

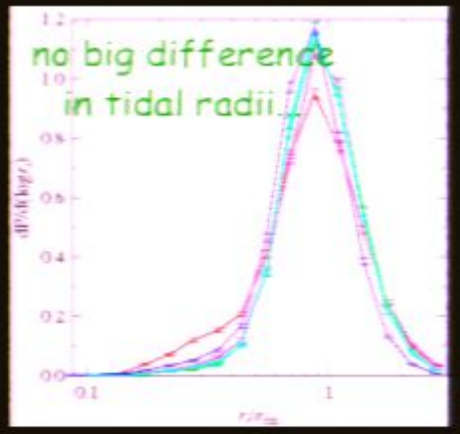

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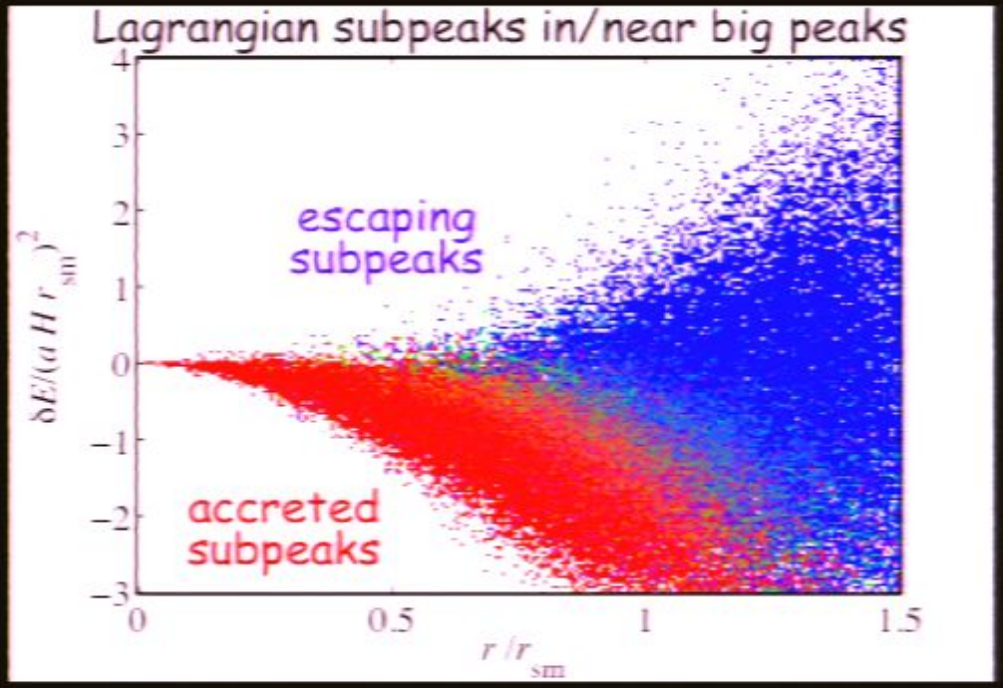
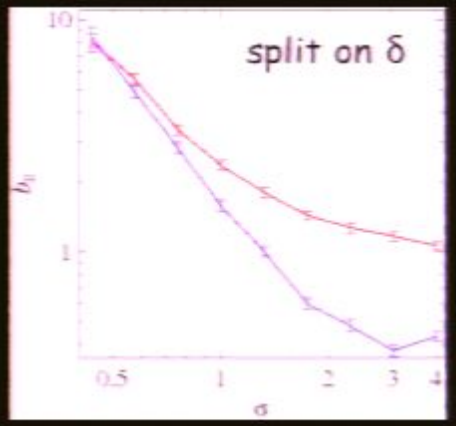
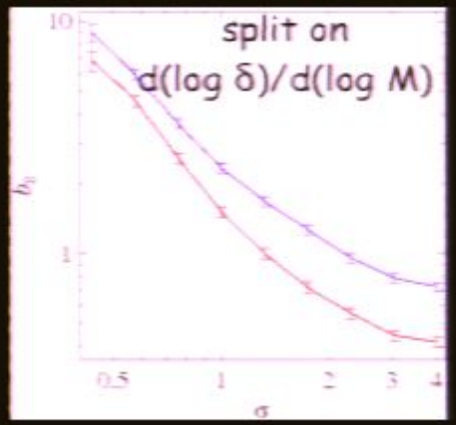
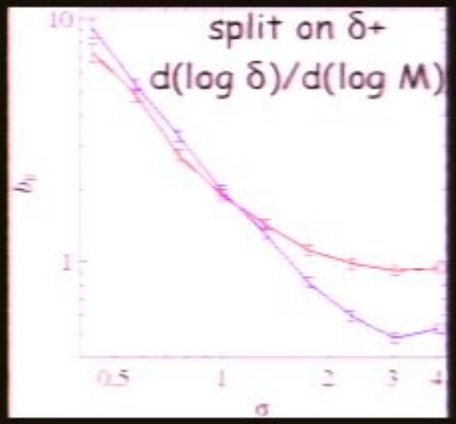


putting it all together

- bias and age both depend on peak height and slope (curvature)
- higher δ : higher age, higher bias
- higher |s| : higher age, lower bias







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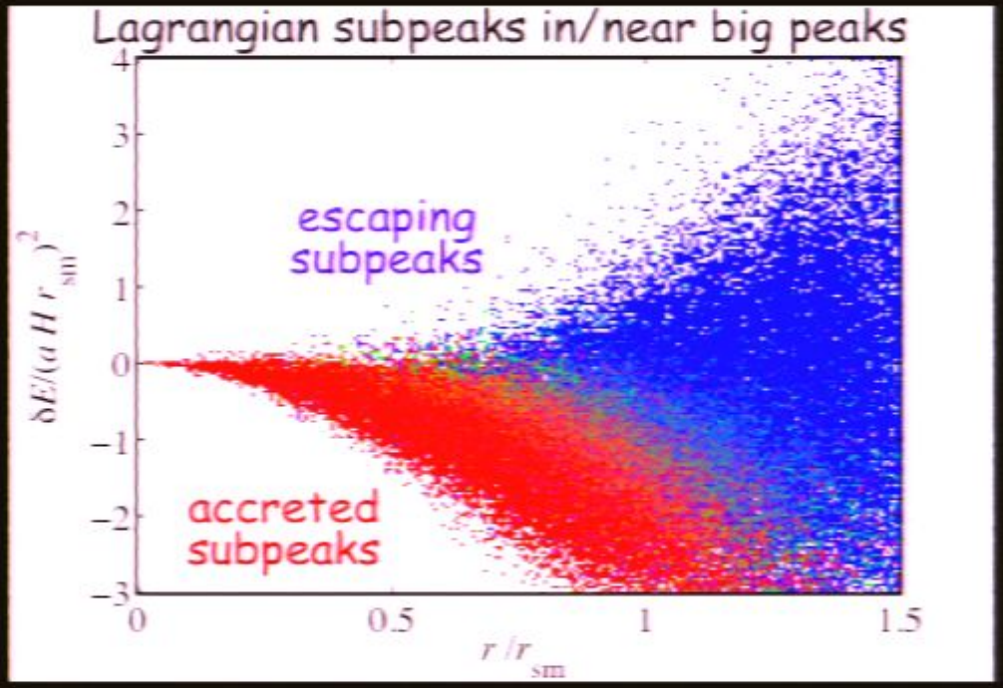

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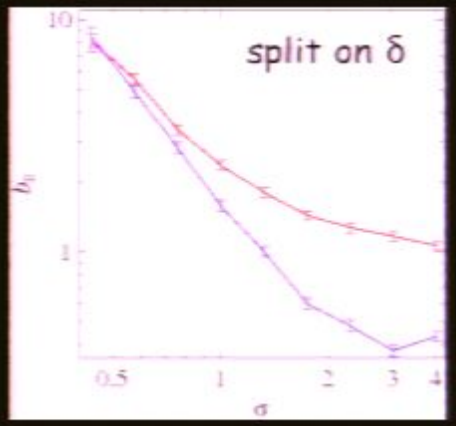
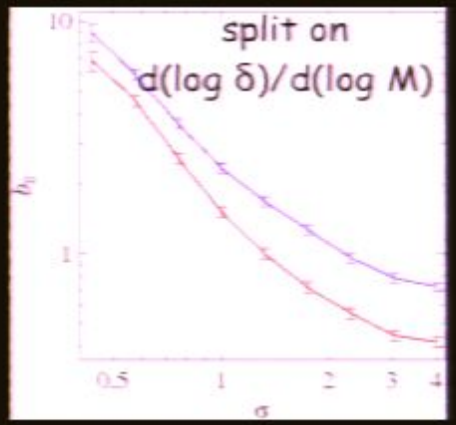
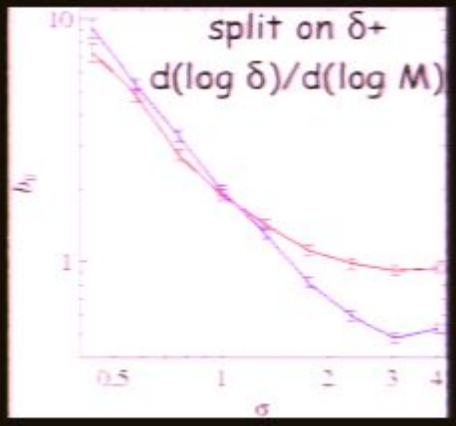
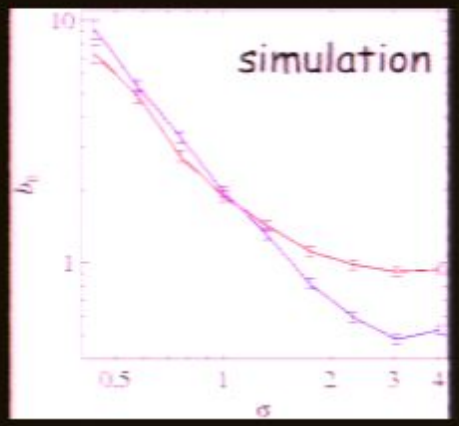


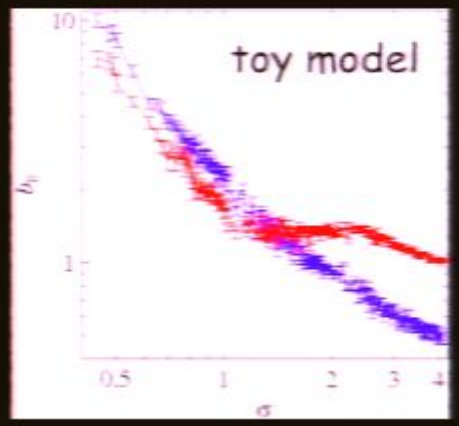




toy model

- generate Gaussian random density field
- smooth on mass scale M and find peaks
- label as collapsed those peaks with $\delta > \delta_{ec}$
- allow subpeaks to collapse also if $E_{bnd} > 0$





summary

- assembly bias at high masses is explained by statistics of Gaussian peaks
- at low masses, assembly bias largely driven by non-accreting low-mass halos in hot environments.
- the stunted low-mass halos tend to become unbiased, while other low-M halos are anti-biased