halo assembly bias and primordial non-Gaussianities

Takahiro Nishimichi (IPMU, the Univ. of Tokyo)

IPMU INSTITUTE FOR THE PHYSICS AND MATHEMATICS OF THE UNIVERSE

Why primordial nonG?

- ✓ "standard" inflation models
  - Gaussian fluctuations
- ✓ detection of large PNGs = non-standard models
  - amplitude
  - type

$$\phi_{\vec{x}} = \phi^{\rm G}_{\vec{x}} + f^{\rm local}_{\rm nl} (\phi^{\rm G}_{\vec{x}})^2$$

- ✓ observational constraints
  - consistent with Gaussian(?)

WMAP7

$-10 < f^{\rm local}_{\rm nl} < 74$
$-214 < f^{\rm equil}_{\rm nl} < 266$
$-410 < f^{\rm orthog}_{\rm nl} < 6$

PNGs in LSS (local type)

$$\phi_{\vec{x}} = \phi^{\rm G}_{\vec{x}} + f_{\rm nl}^{\rm local}(\phi^{\rm G}_{\vec{x}})^2$$

linear theory

$$\delta_{\vec{k}} = M(k)\phi_{\vec{k}}$$

transfer function

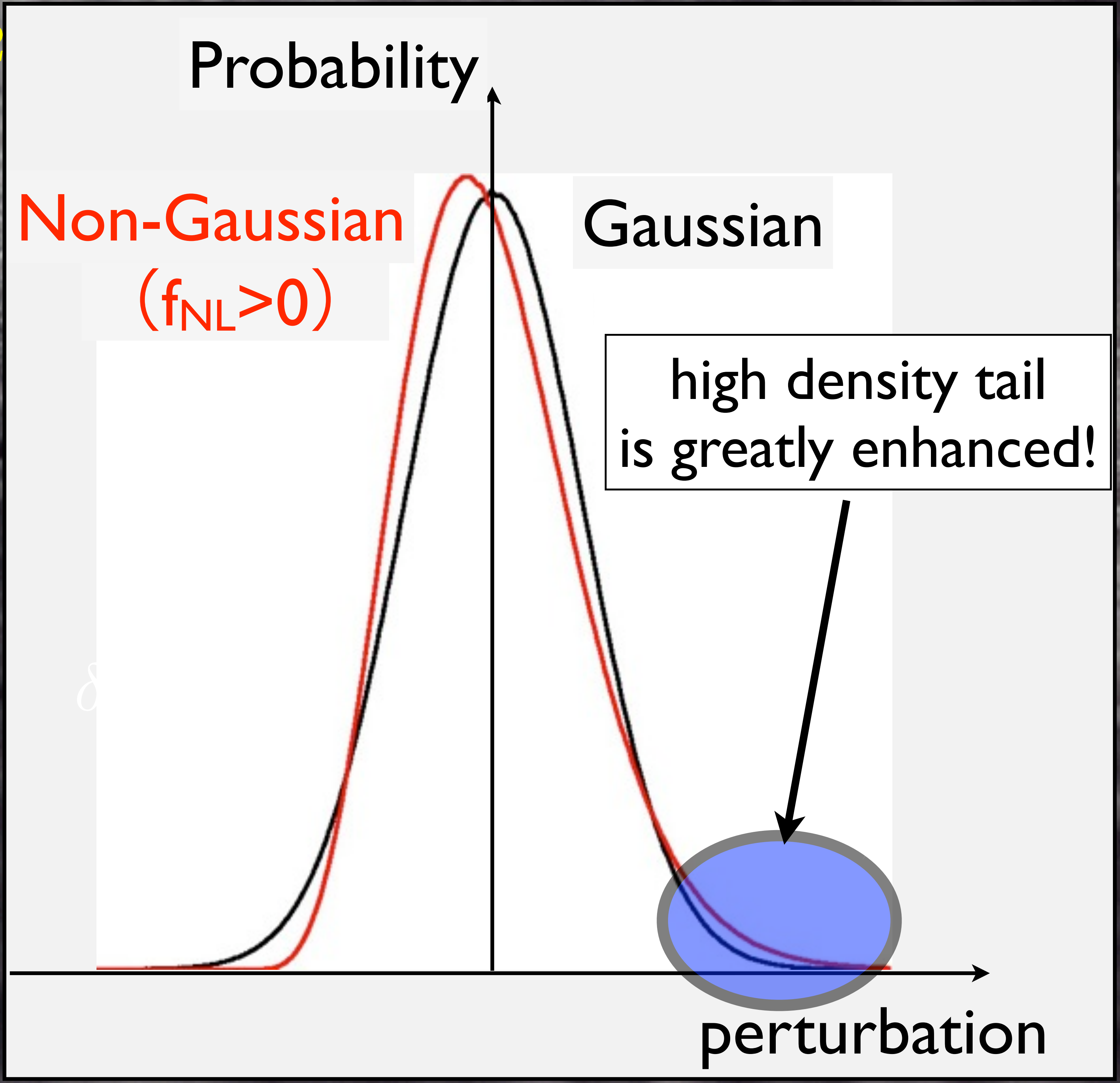
high density tail

↓

halos

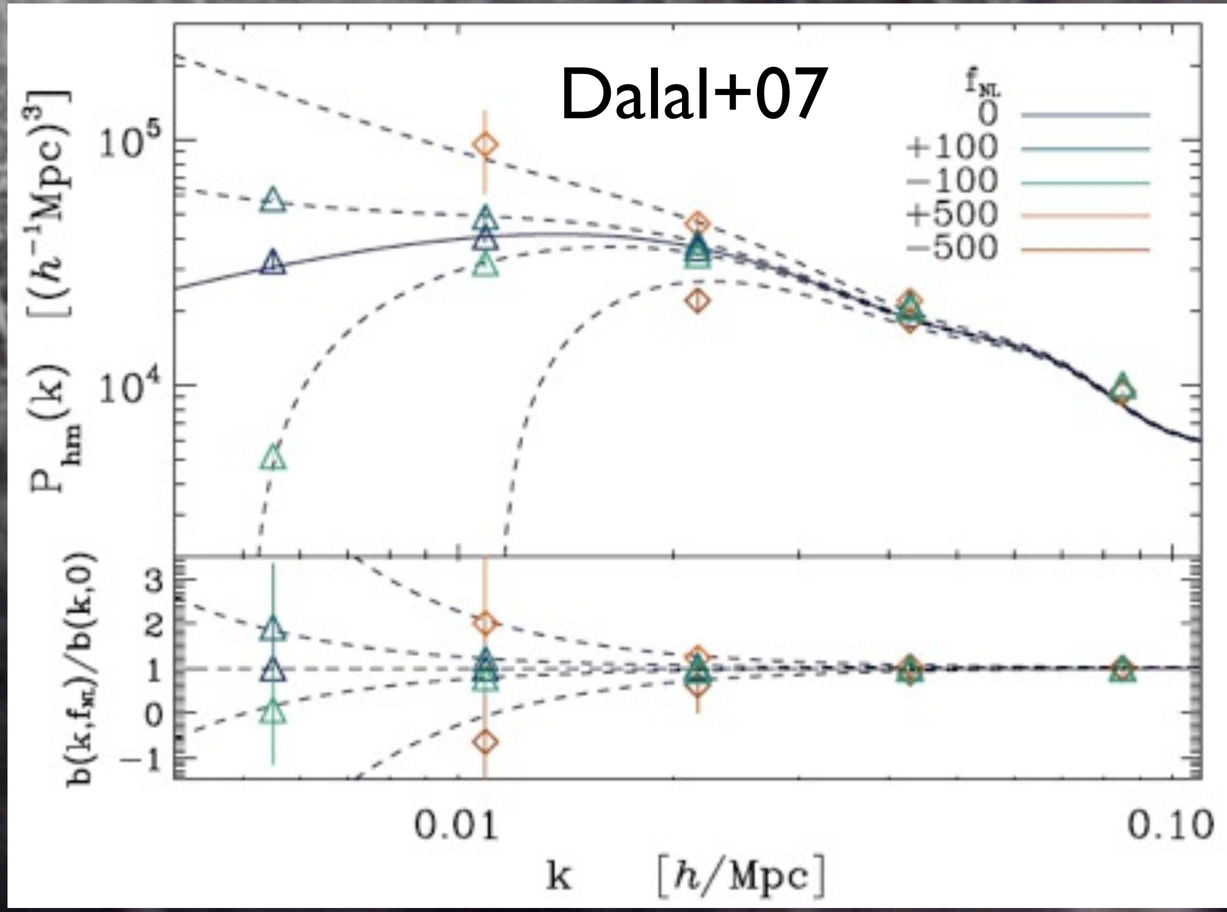
↓

galaxies



scale dependent bias

- ✓ clustering of halos in the presence of local-type nG
- ✓ first found in simulations (Dalal+07)
- ✓ theoretical interpretations
  - Dalal+07 (peak bias)
  - Matarrese+Verde08 (peak bias)
  - Slosar+08 (peak-background split)
  - Afshordi&Tolley08 (halo bias)
  - Taruya+09, McDonald08 (local bias)
  - Giannantonio&Porciani10 (nonlocal bias)
  - and more ...



interpretation: peak-background split

Giannantonio&PorcianI10

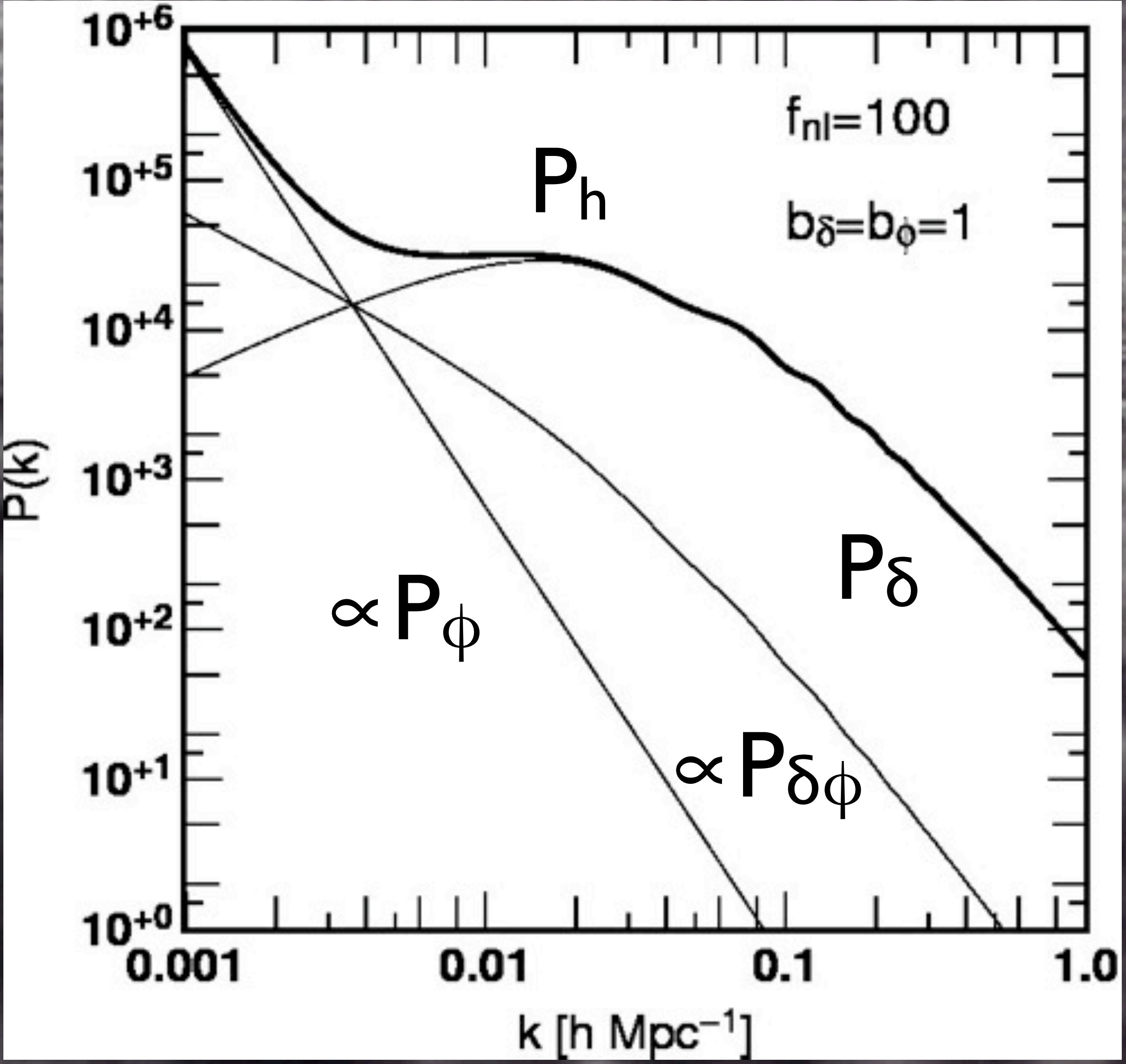
$$\delta^h_{\vec{x}} = b_\delta \underline{\delta_{\vec{x}}} + 2 f_{\rm nl} b_\phi \underline{\phi_{\vec{x}}}$$

$$b_\phi = \delta_c (b_\delta - 1)$$

density of halos is a *non-local* function of matter density

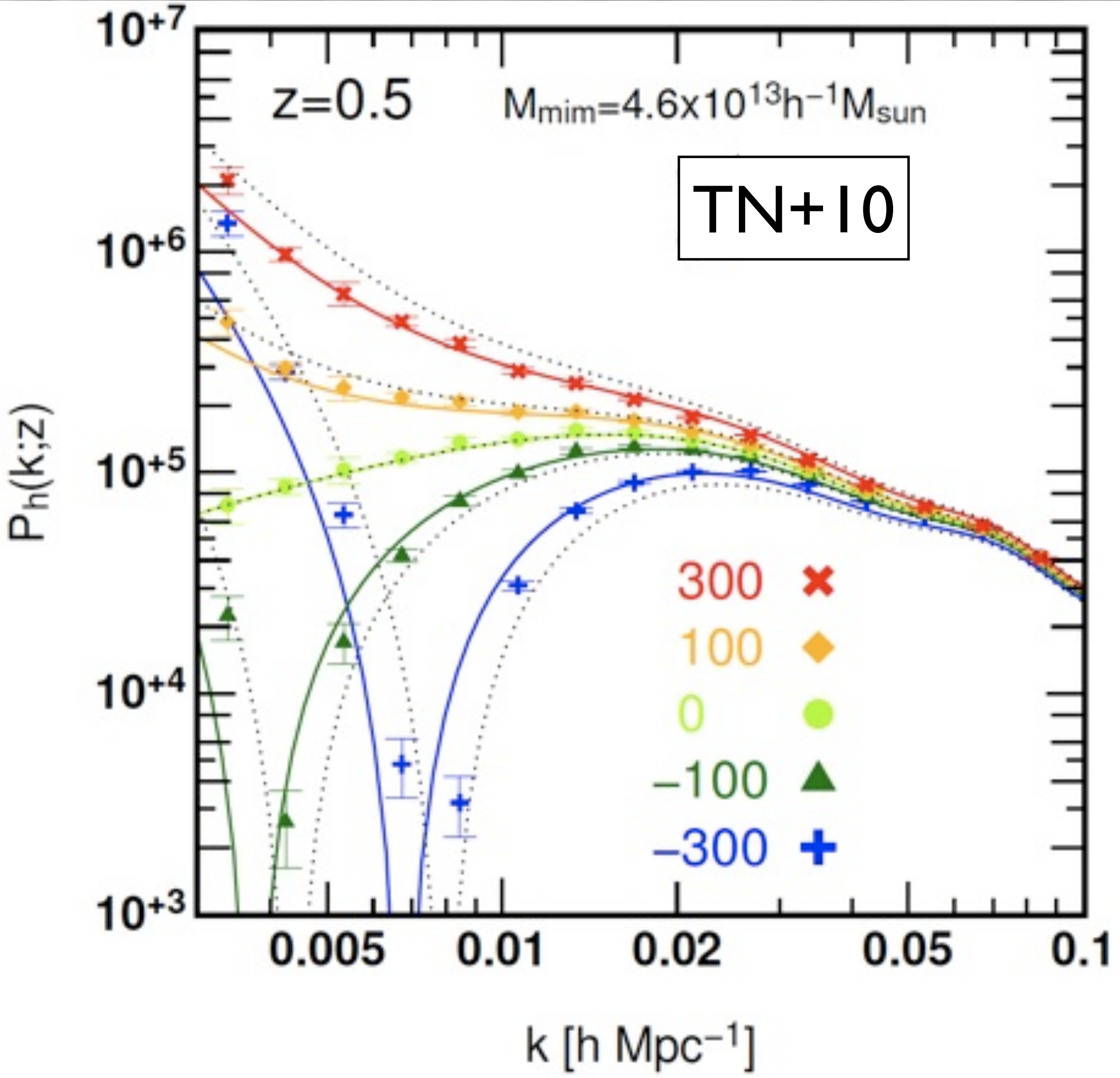
$$\because \ \delta_{\vec{k}} = M(k)\phi_{\vec{k}}$$

$P_{\delta\phi}$, P_ϕ contribute to P_h



calibrating scale dependent bias

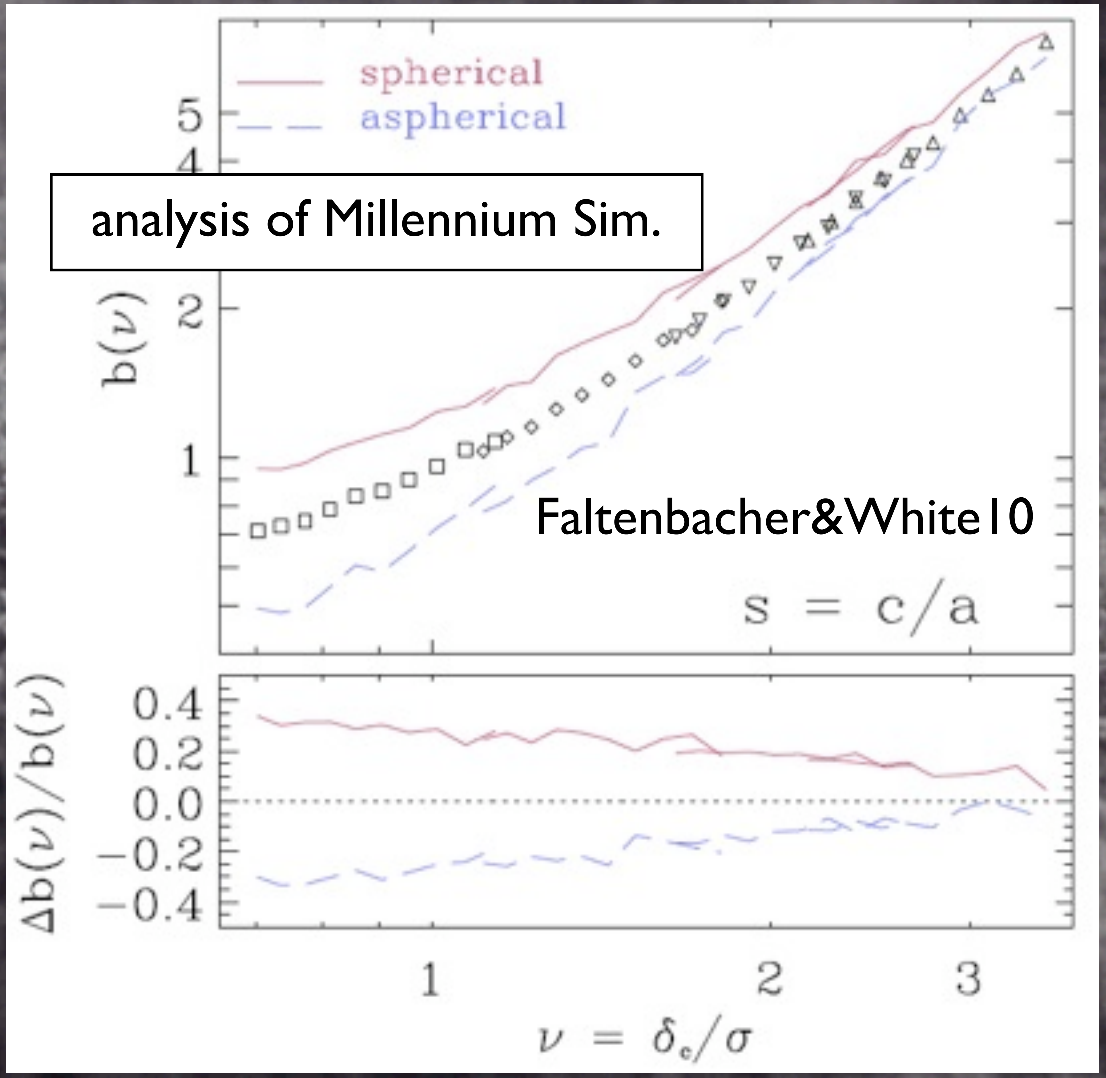
- Large simulations
  - Grossi+09
  - Desjacques+09
  - Pillepich+10
  - TN+10



e.g., fit by Grossi+ $b_\phi = q\delta_c(b_\delta - 1), \quad q = 0.75$

halo assembly bias

- ✓ clustering of halos depends on
  - mass: b=b(M)
  - shape
  - velocity structure
  - formation epoch
  - (→Slosar+08, Reid+10)
  - :



- ✓ Your galaxies might be preferentially living in halos with certain properties...
- ✓ We have 2 bias params. now... $b_\delta,\ \ b_\phi$ $b_\phi \overset{?}{=} q\delta_c(b_\delta - 1)$

this work

- FOF halos in TN+10 (20 realizations of f_{nl}=100 runs)
- weighted density field

$$\delta_w(\vec{x};n) = \frac{V\sum_i w_i^n \delta_{\rm D}^{(3)}(\vec{x}-\vec{x}_i)}{\sum_i w_i^n} - 1$$

n>0: halos with larger “property” is more weighted

n<0: halos with smaller “property” is more weighted

- measure $P_h(k)$
- fit by

$$[b_\delta^2 P_\delta(k) + 4f_{\rm nl}b_\delta b_\phi P_{\delta\phi}(k) + 4f_{\rm nl}^2 b_\phi^2 P_\phi(k)]$$

$$\times\frac{1+Qk^2}{1+1.4k}$$ nonlinearity

$$+N$$ shot noise

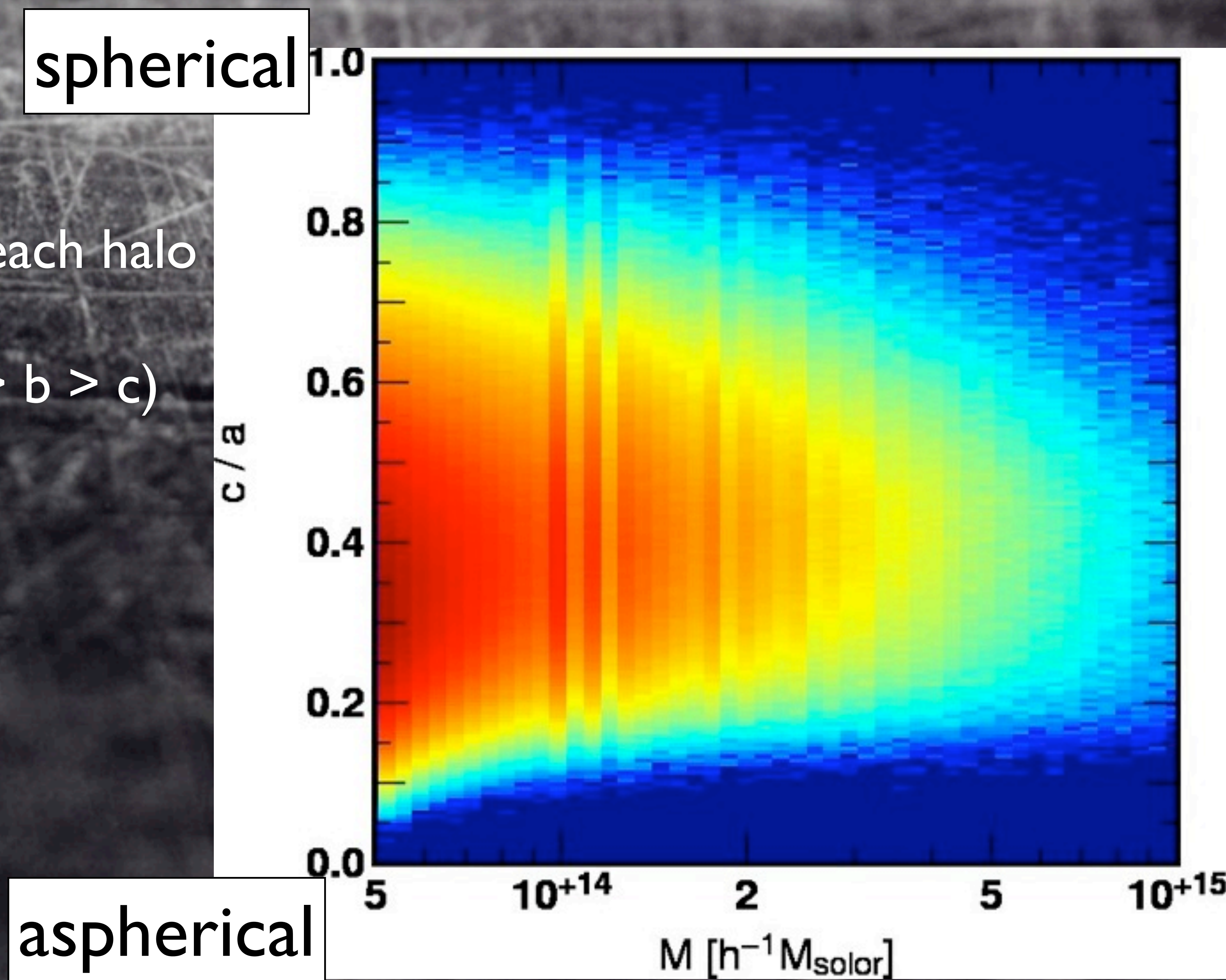
free params.

(b_δ, b_ϕ, Q, N)

$k_{\rm max} = 0.15h\,{\rm Mpc}^{-1}$

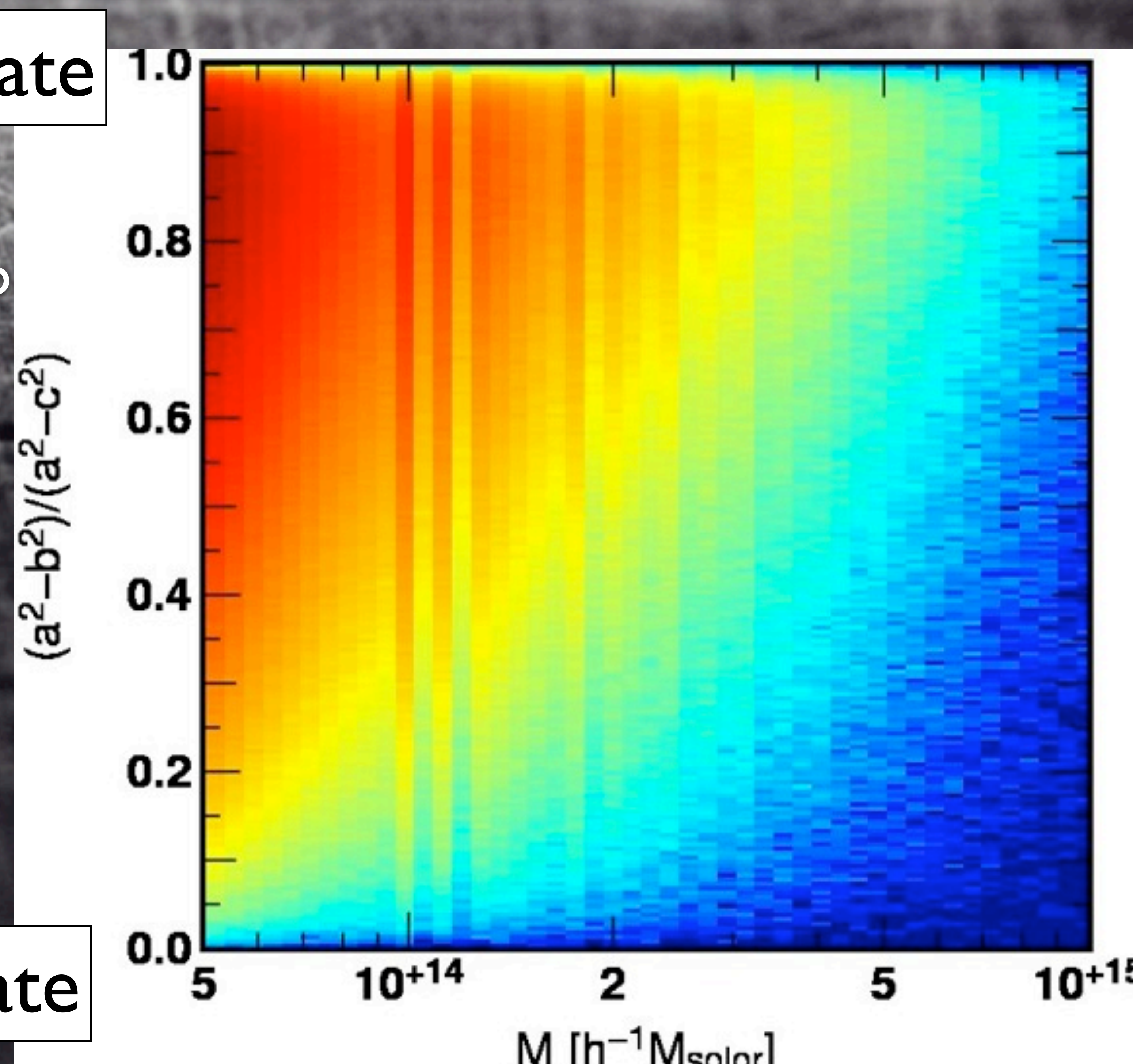
property 1: sphericity

- inertia tensor of each halo
- principal axes (a > b > c)
- c / a



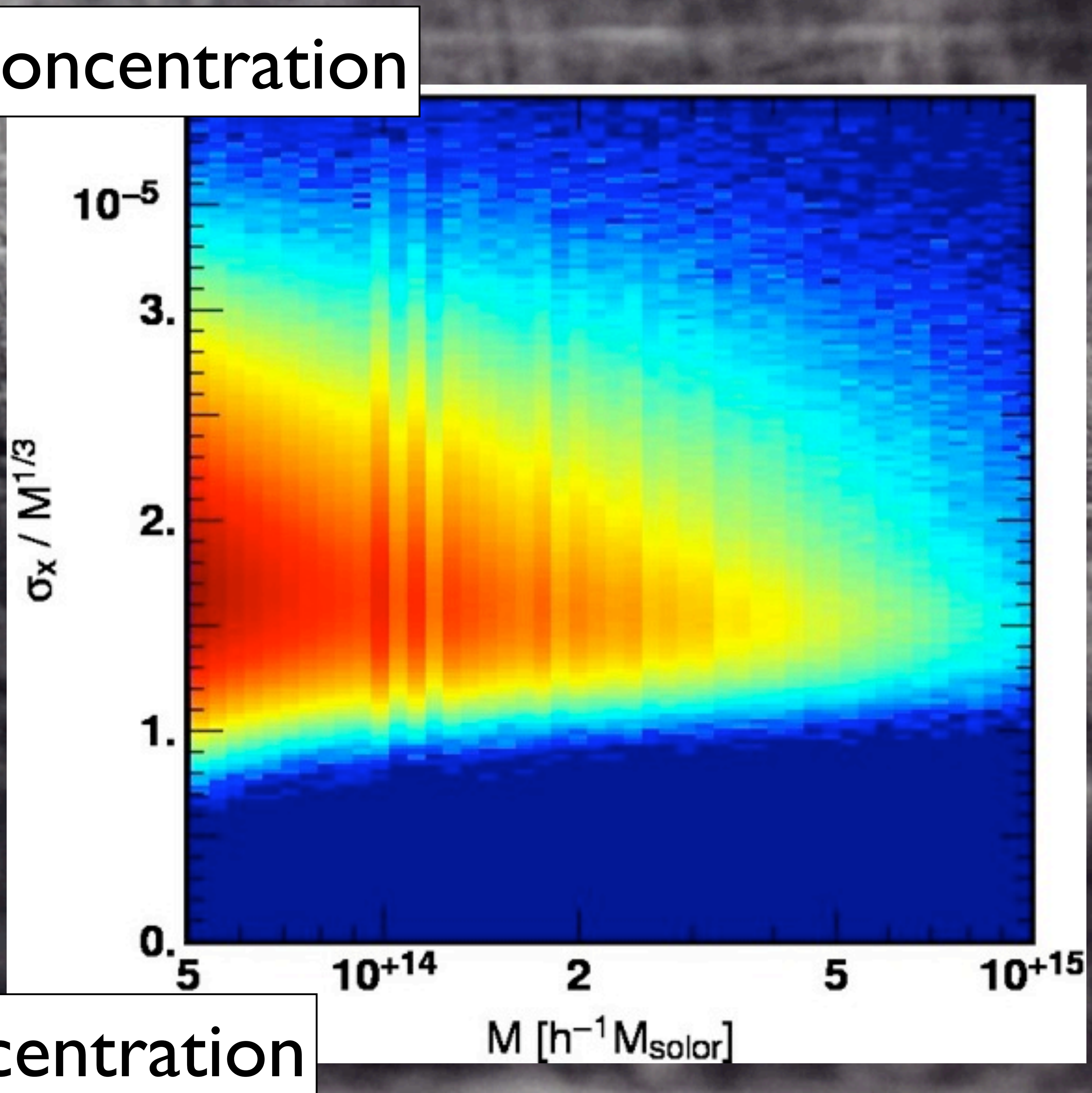
property 2: triaxiality

- inertia tensor of each halo
- principal axes (a > b > c)
- $T = (a^2 - b^2) / (a^2 - c^2)$



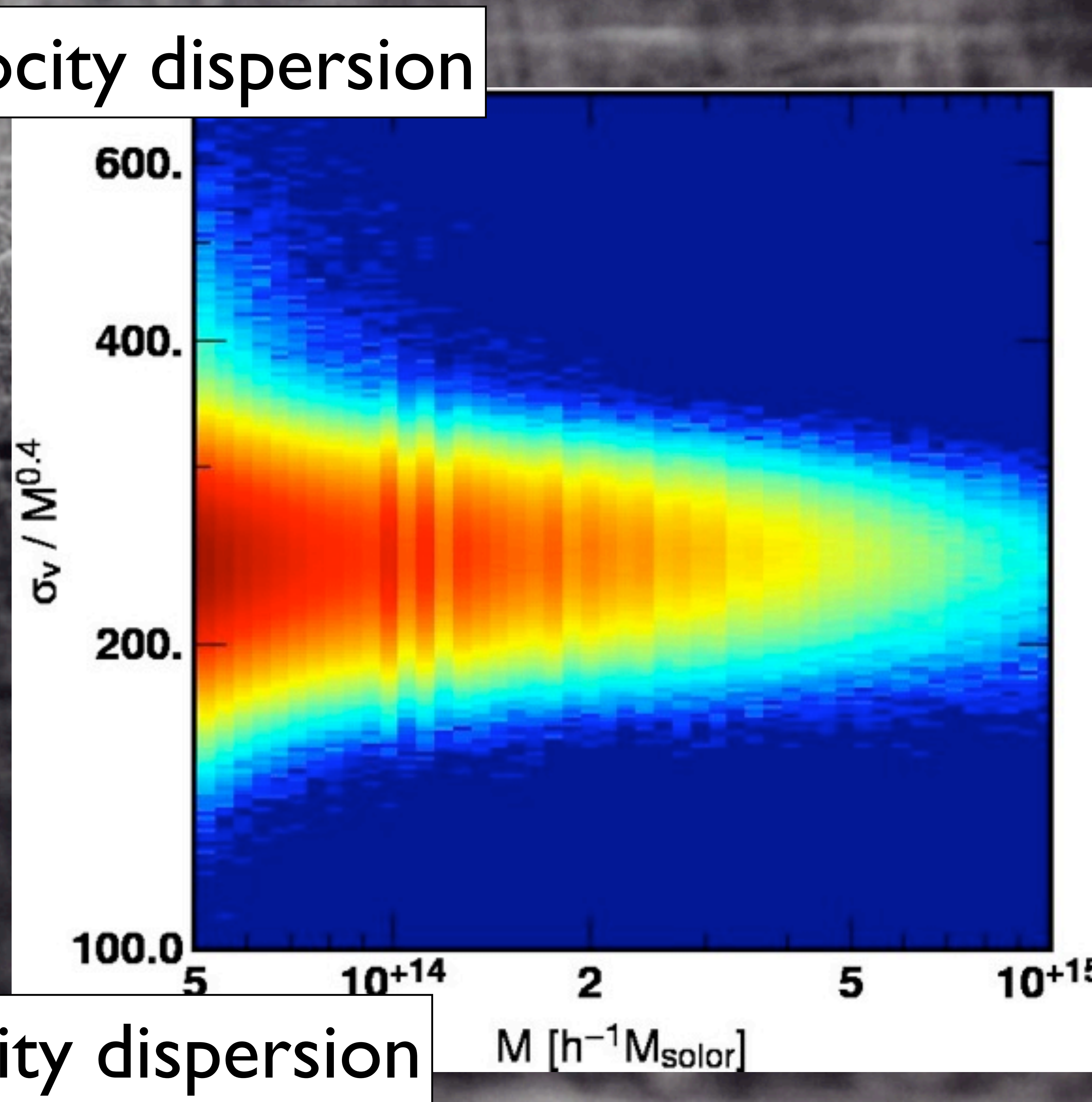
property 3: concentration

- dispersion of particle positions around the center of mass
- divide by $M^{1/3}$ to compensate for the intrinsic dependence on mass

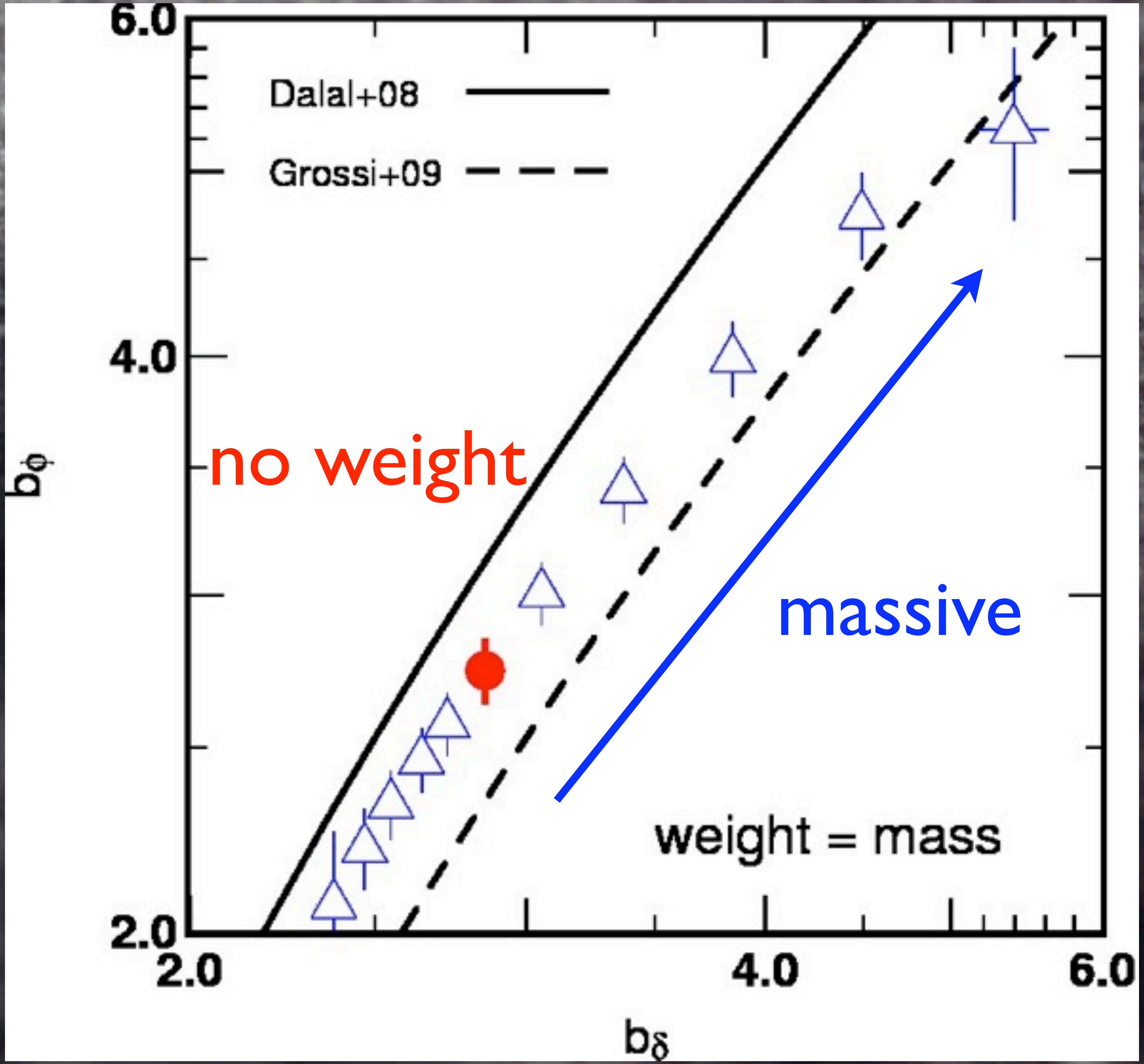


property 4: velocity dispersion

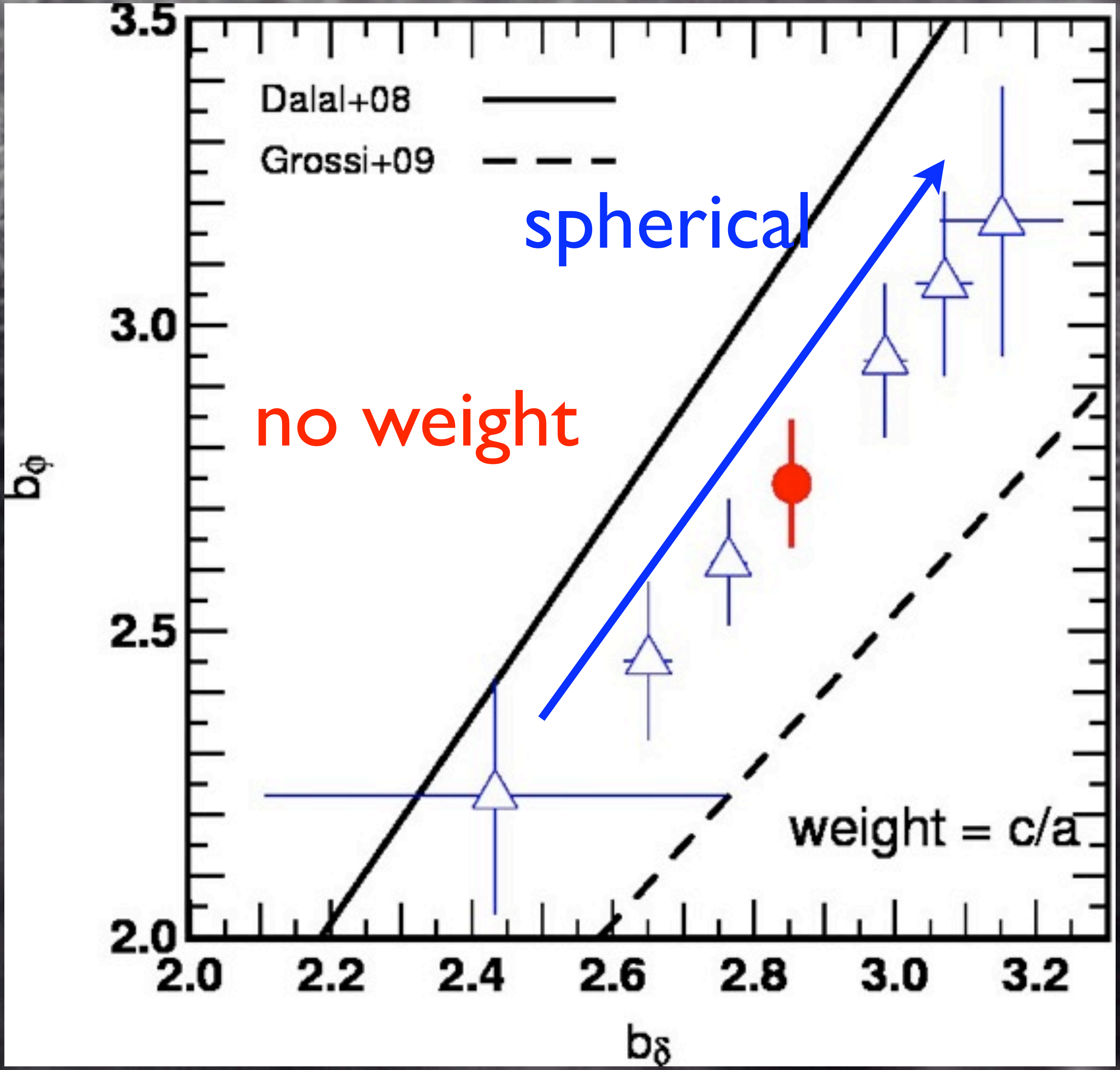
- dispersion of particle velocities around the center of mass velocity
- divide by $M^{0.4}$ to compensate for the intrinsic dependence on mass



mass dependence

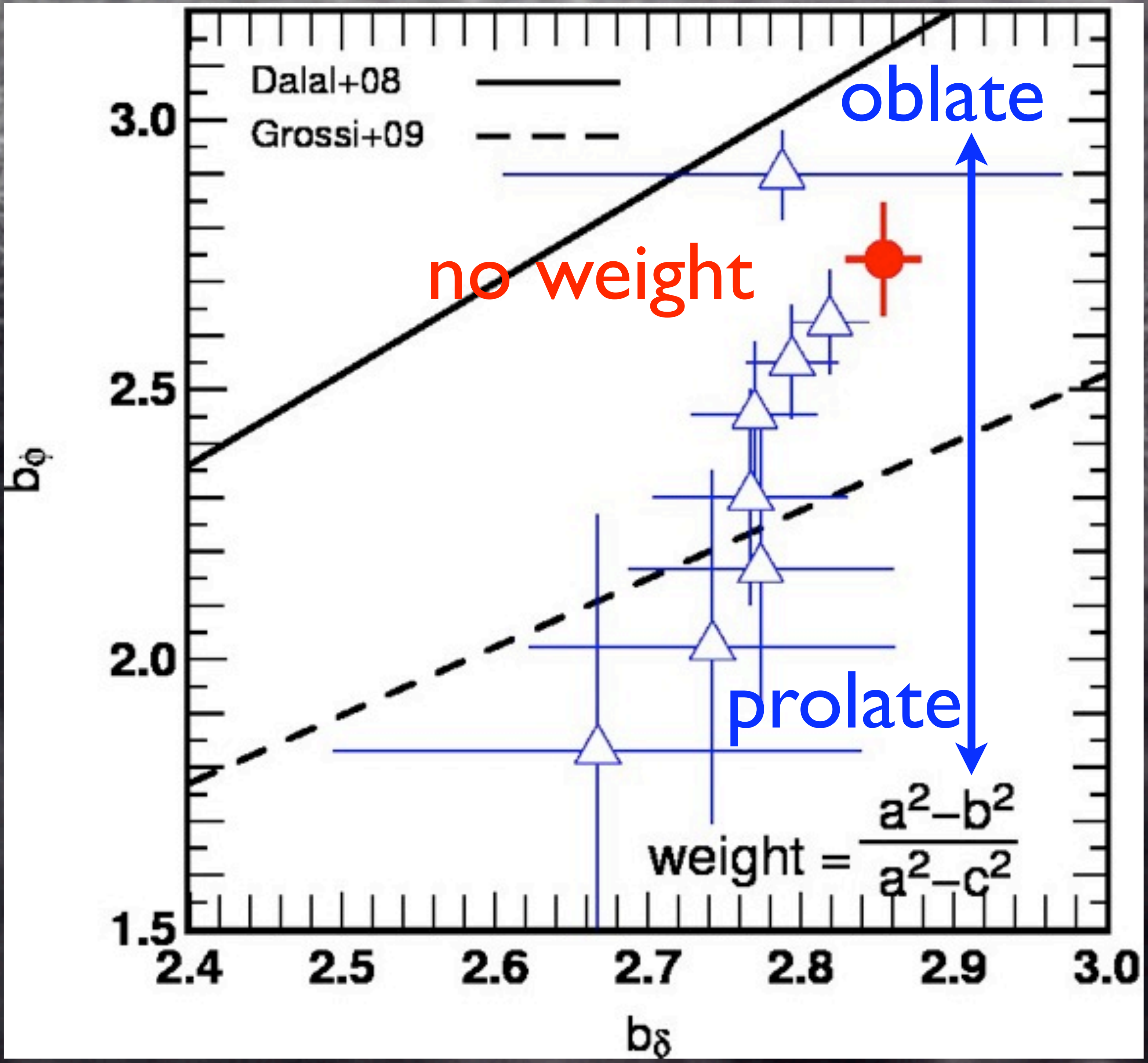


sphericity

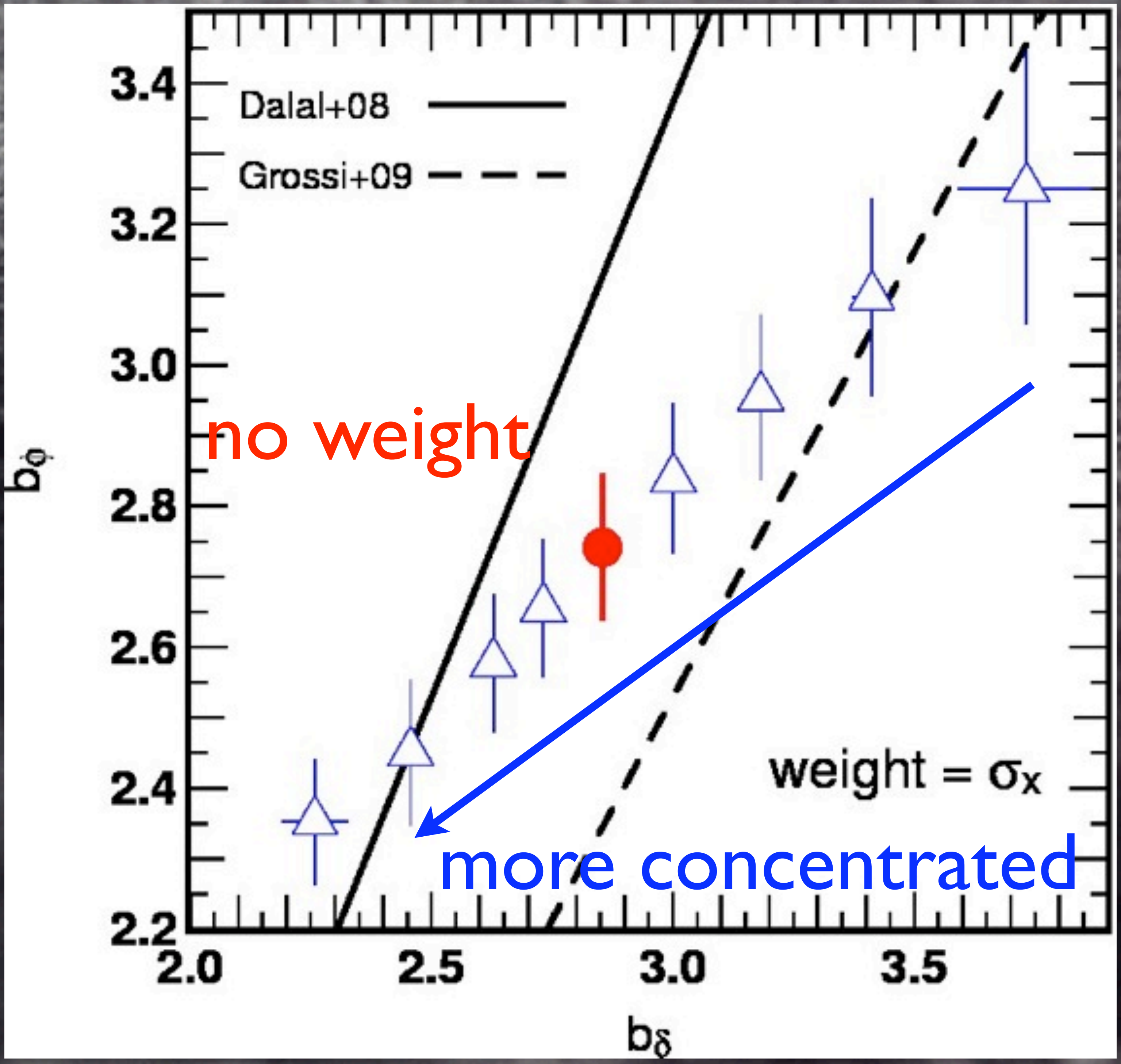


Dalal+08
Grossi+09
spherical
no weight
weight = c/a
3.5
3.0
2.5
2.0
2.0
2.2
2.4
2.6
2.8
3.0
3.2
b_ϕ
b_δ

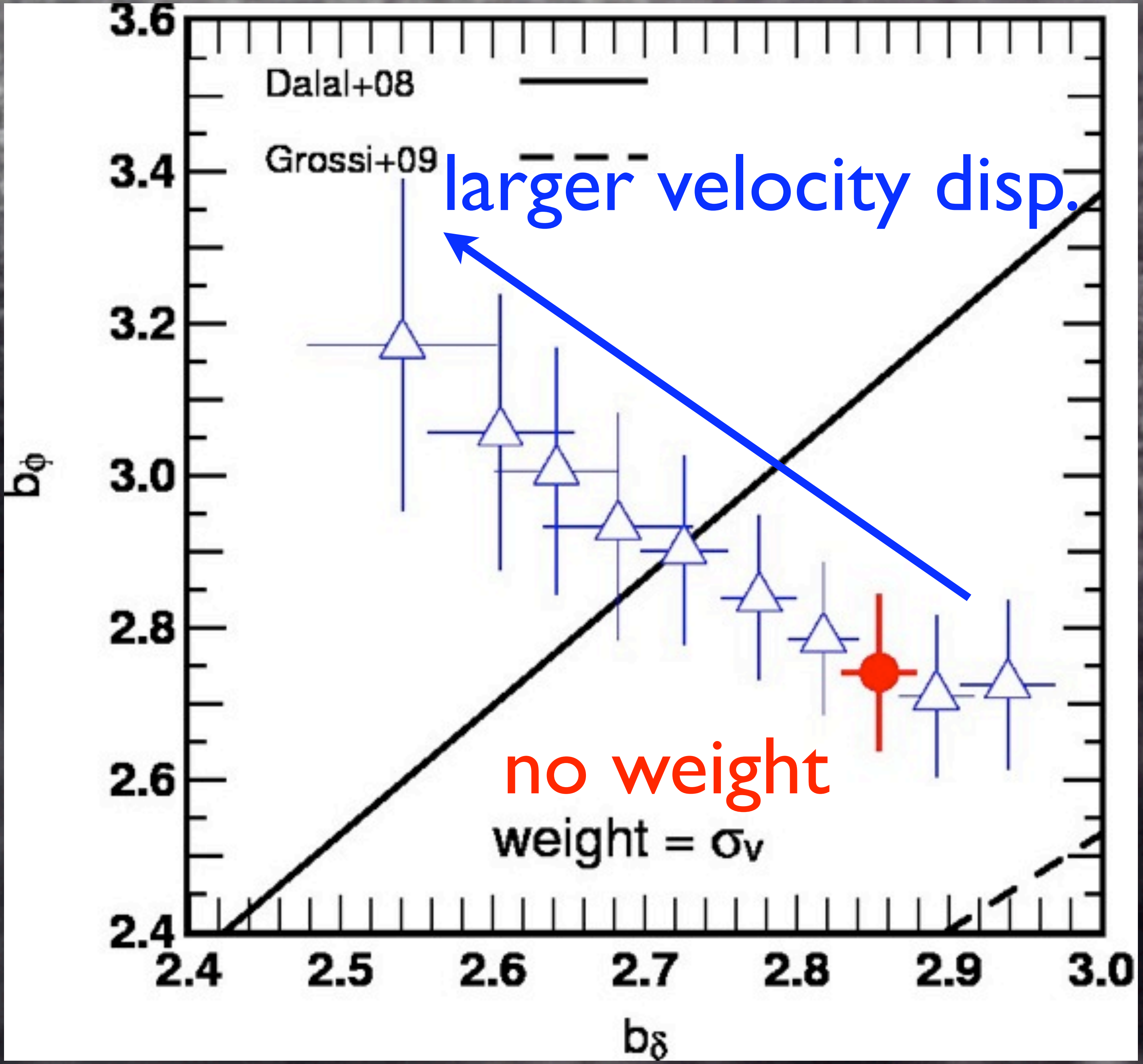
triaxiality



concentration



velocity dispersion



discussion

- Model the bias as a function of halo properties + the halo occupation number?
  - $b_\delta(M), b_\phi(M) \rightarrow b_\delta(M,p_1,p_2,...), b_\phi(M,p_1,p_2,...)$
  - $N(M) \rightarrow N(M,p_1,p_2,...)$

- bispectrum can break the degeneracy!
  - $\Delta P \propto f_{nl}\, b_\varphi,\ \ \Delta B \propto f_{nl}^2\, b_\varphi$

on going project

summary

- ✓ $\delta_h = b_\delta \delta + 2\, f_{nl}\, b_\varphi \varphi$
- ✓ b_δ & b_ϕ depend on halo properties.
- ✓ Assembly bias can modify the relation between b_δ & b_φ.

future work

- ✓ breaking the degeneracy between f_{nl} and b_φ by power + bi-spectra