Linking galaxies to dark matter halos with stellar mass or with stellar velocity dispersion?

(ApJL submitted, arXiv:1210.5700)

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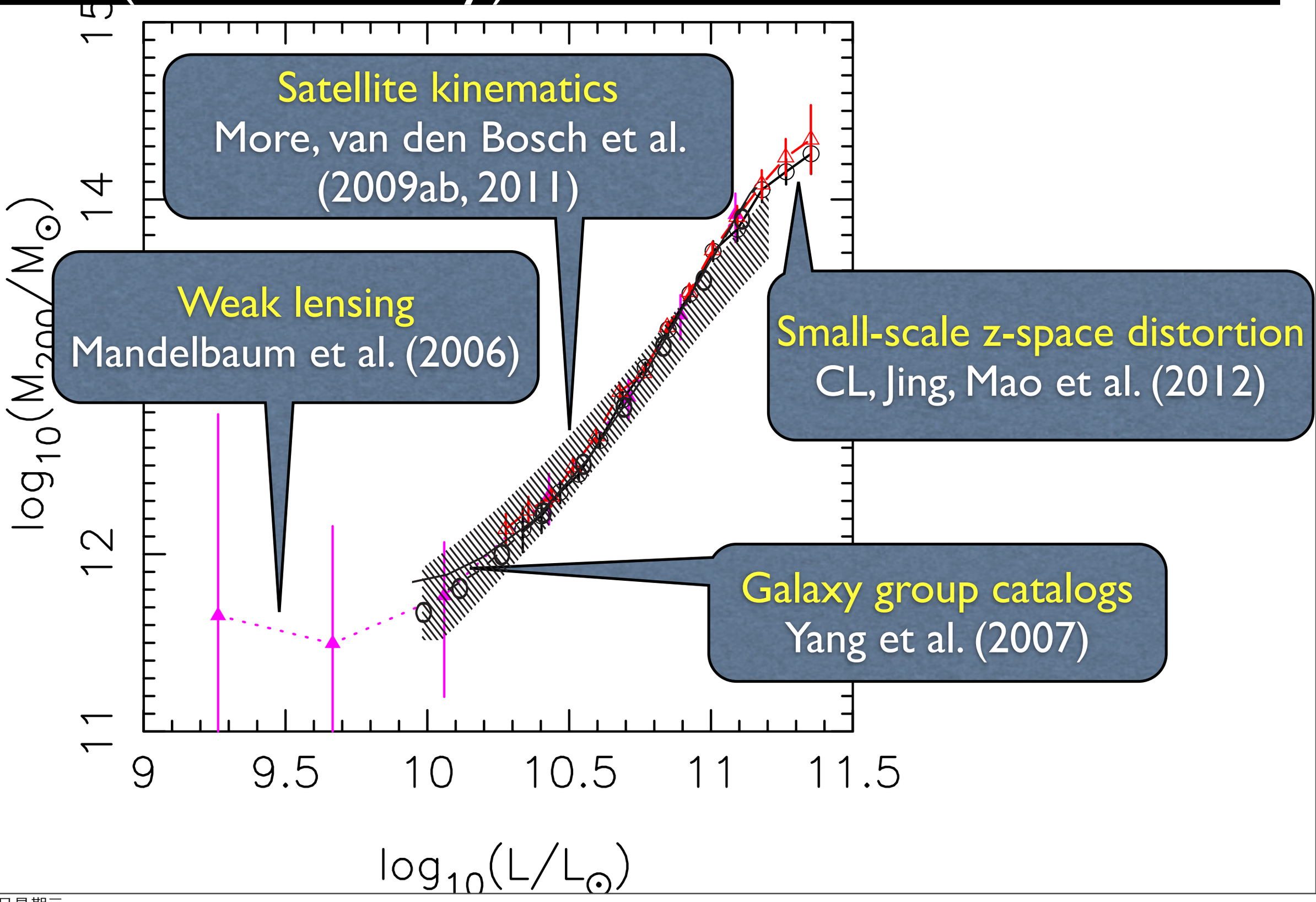
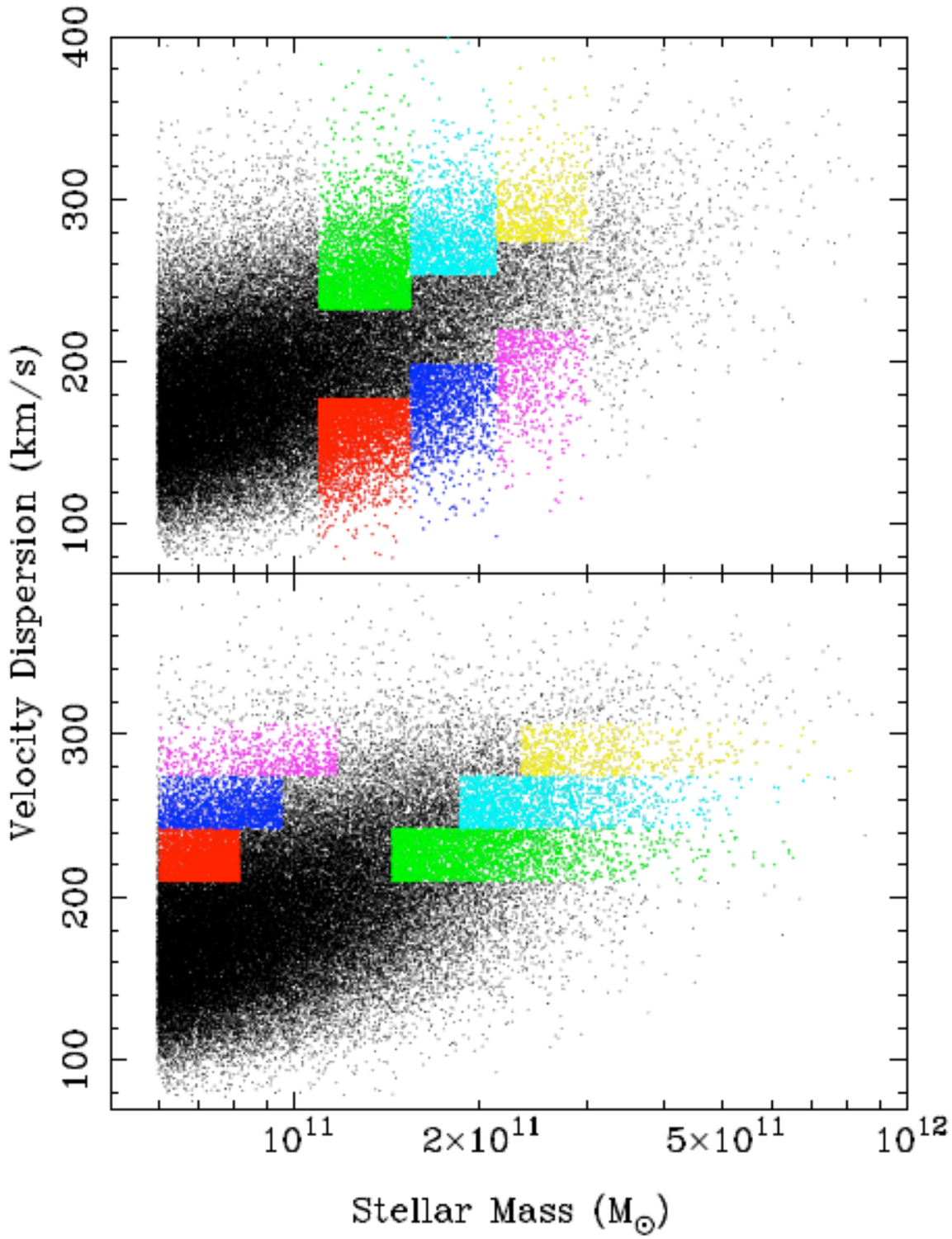
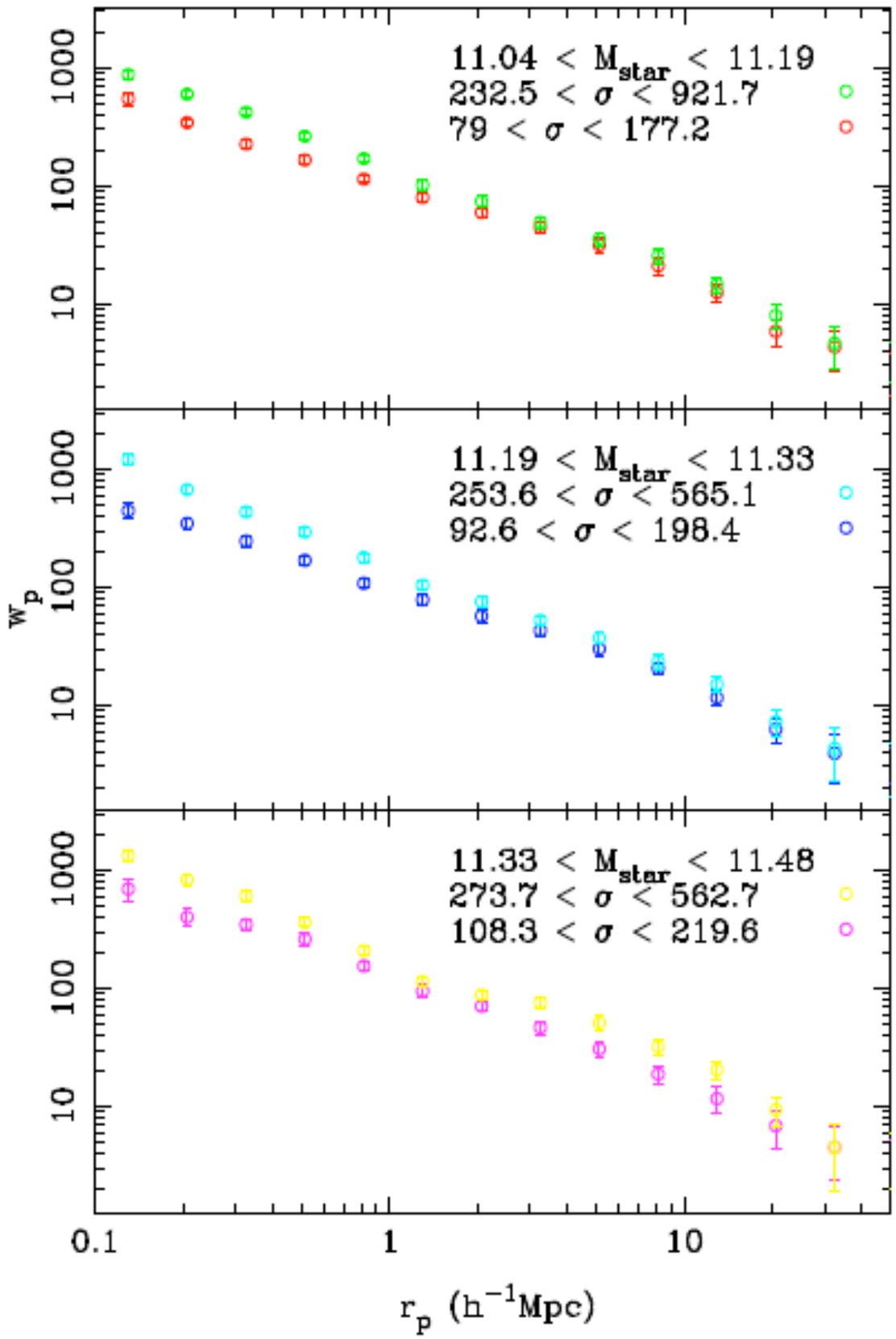
A tight relation exists between central galaxy mass (or luminosity) and dark matter halo mass



Galaxy clustering depends on σ_* at fixed M_*

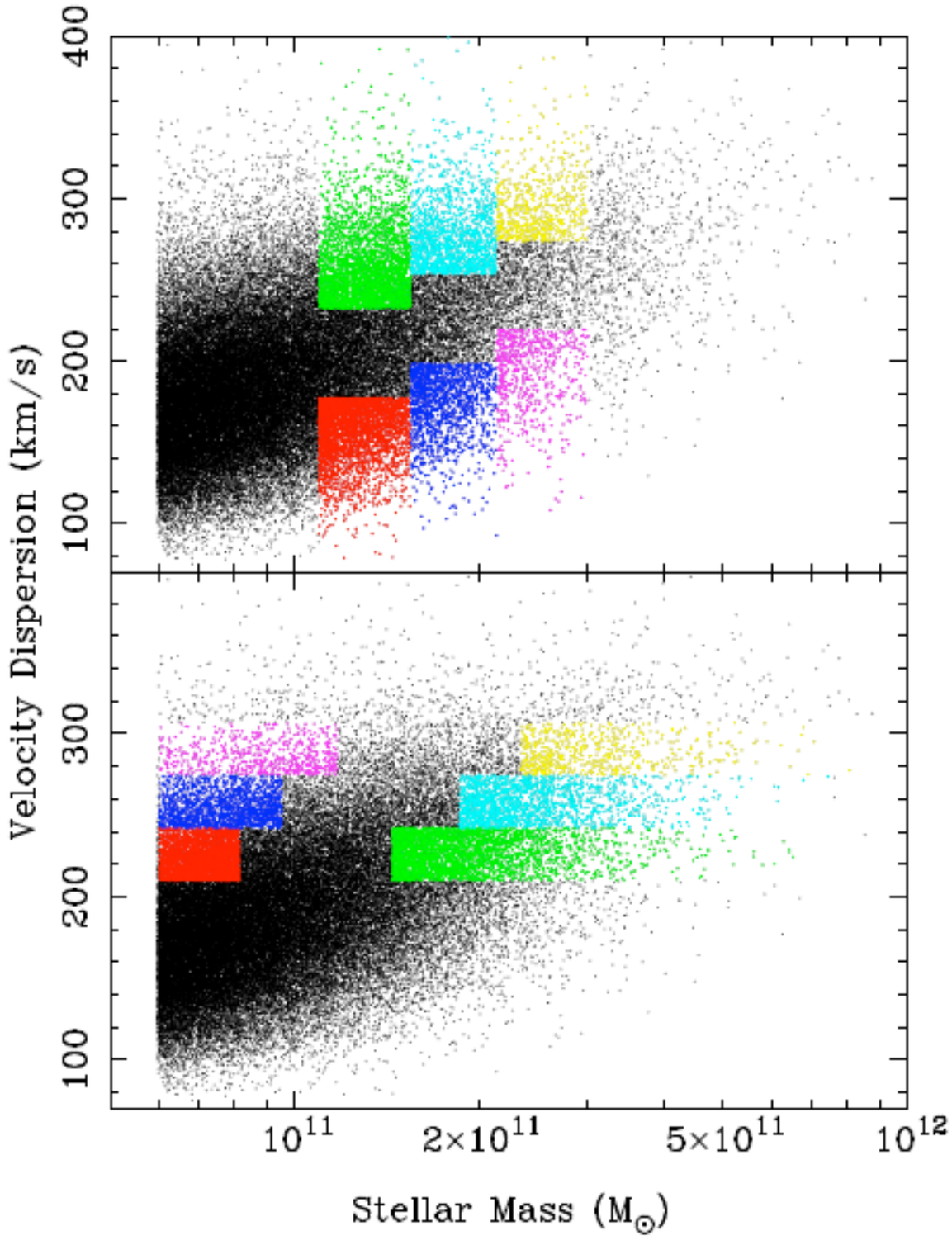
Wake et al. 2012 (arXiv:1201.1913)

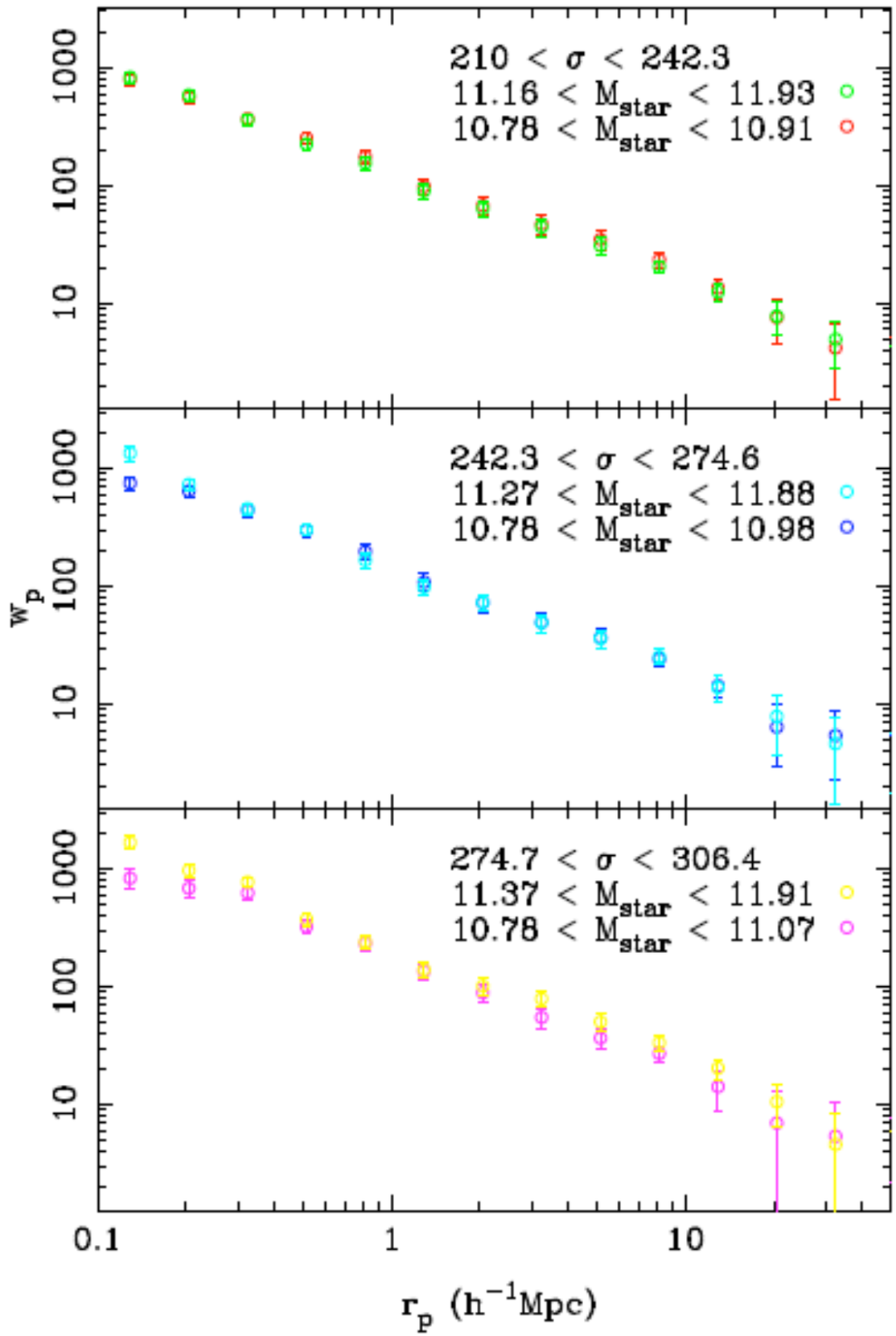




Clustering does NOT depend on M_* at fixed σ_*

Wake et al. 2012 (arXiv:1201.1913)





Possible explanations

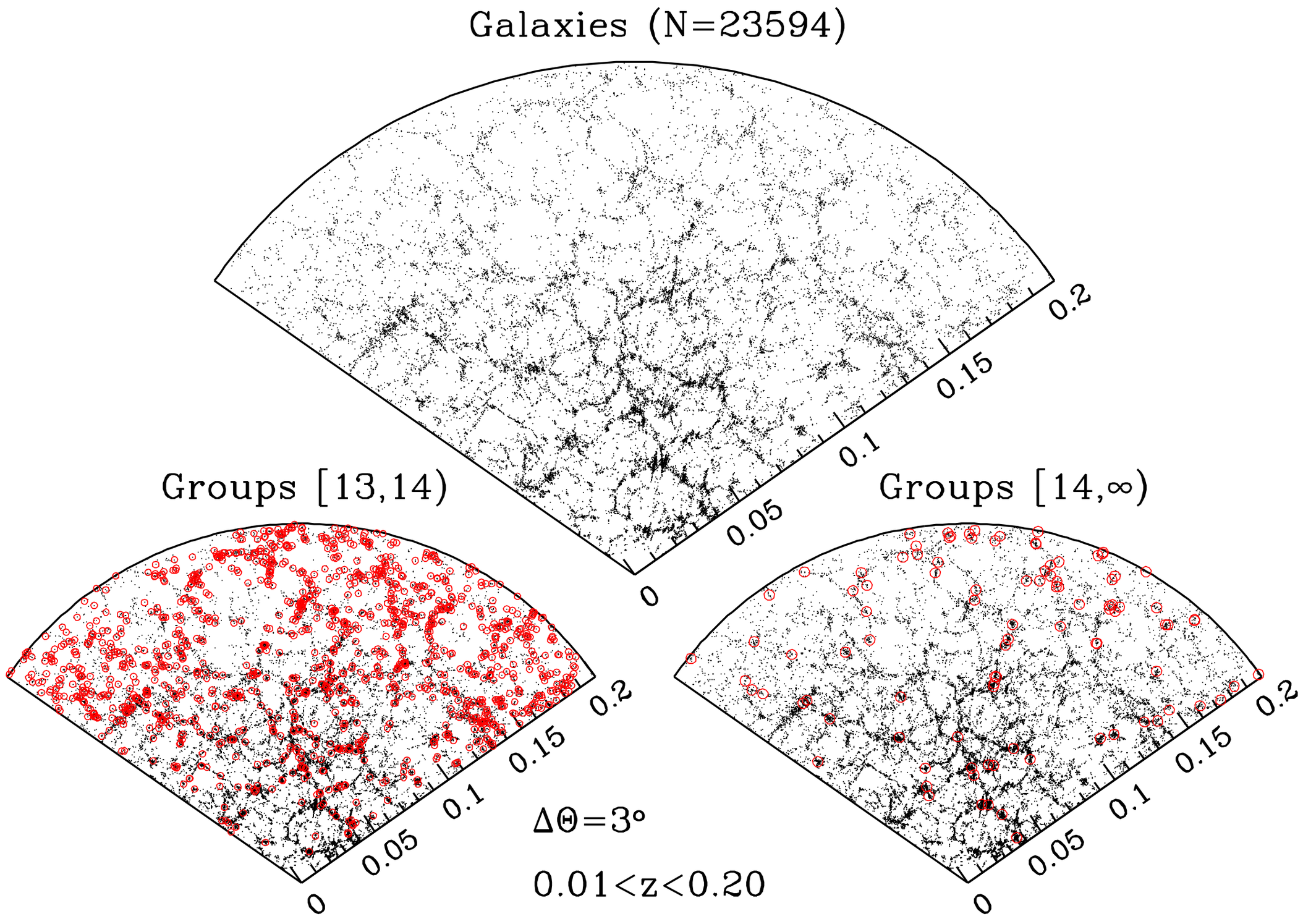
Wake et al. 2012 (arXiv:1201.1913)

- Halo mass is more tightly related to stellar velocity dispersion than to stellar mass
- Halo age (or concentration) is more tightly related to stellar velocity dispersion than to stellar mass
- The clustering properties are attributed to satellite galaxies, which may deviate from the stellar mass vs. halo mass relation of central galaxies due to tidal stripping, an effect that is stronger to stellar mass than to stellar velocity dispersion

Our idea

- We study the cross-correlation between galaxies and central galaxies of groups, instead of the galaxy-galaxy cross-correlation probed by Wake et al.
  - allowing us to directly obtain the correlation for central galaxies, avoiding the effect of satellites
- We estimate the velocity dispersion profile of satellite galaxies within groups
  - a director measure of dark matter halo mass, better than the indirect measure from clustering amplitude
- Our work thus should be able to discriminate between the possibilities proposed by Wake et al.

16000 groups of galaxies with ≥ 3 members from SDSS/DR7 (Yang et al., 2005, 2007)

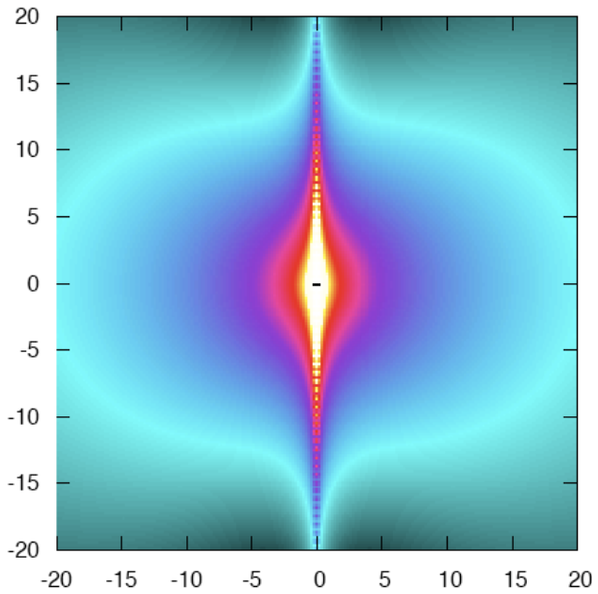


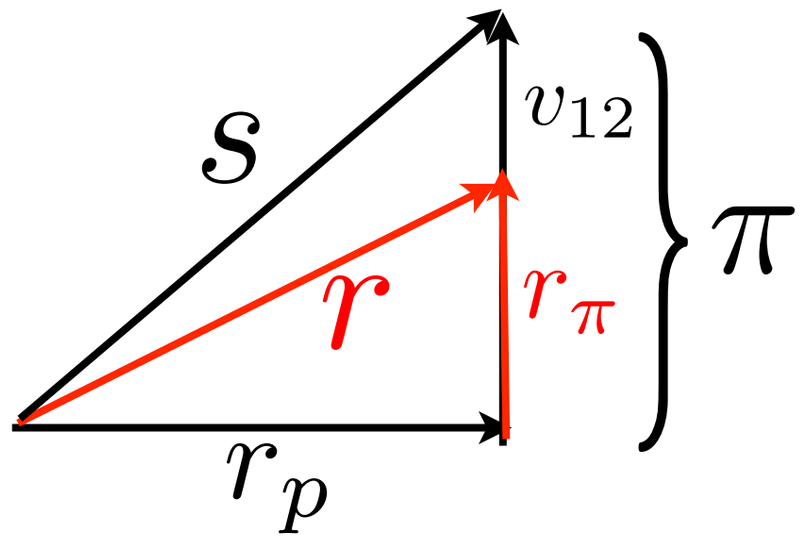
Projected 2PCF: $$w_p(r_p) = \int_{-\infty}^{\infty} \xi(r_p, \pi) d\pi$$

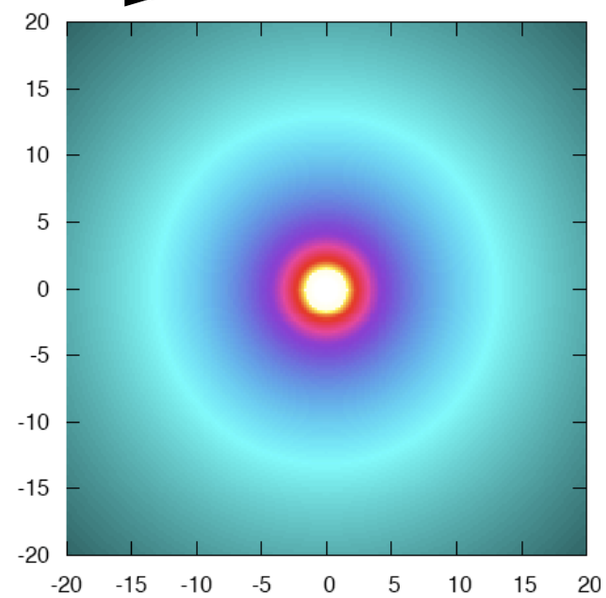
Real-space 2PCF: $$\xi(r) = -\frac{1}{\pi} \int_r^{\infty} \frac{dw/dr_p}{\sqrt{r_p^2 - r^2}} dr_p$$

Measuring the velocity dispersion profile (PVD) of galaxy groups

$\xi(r_p, \pi)$ → $\xi(r)$





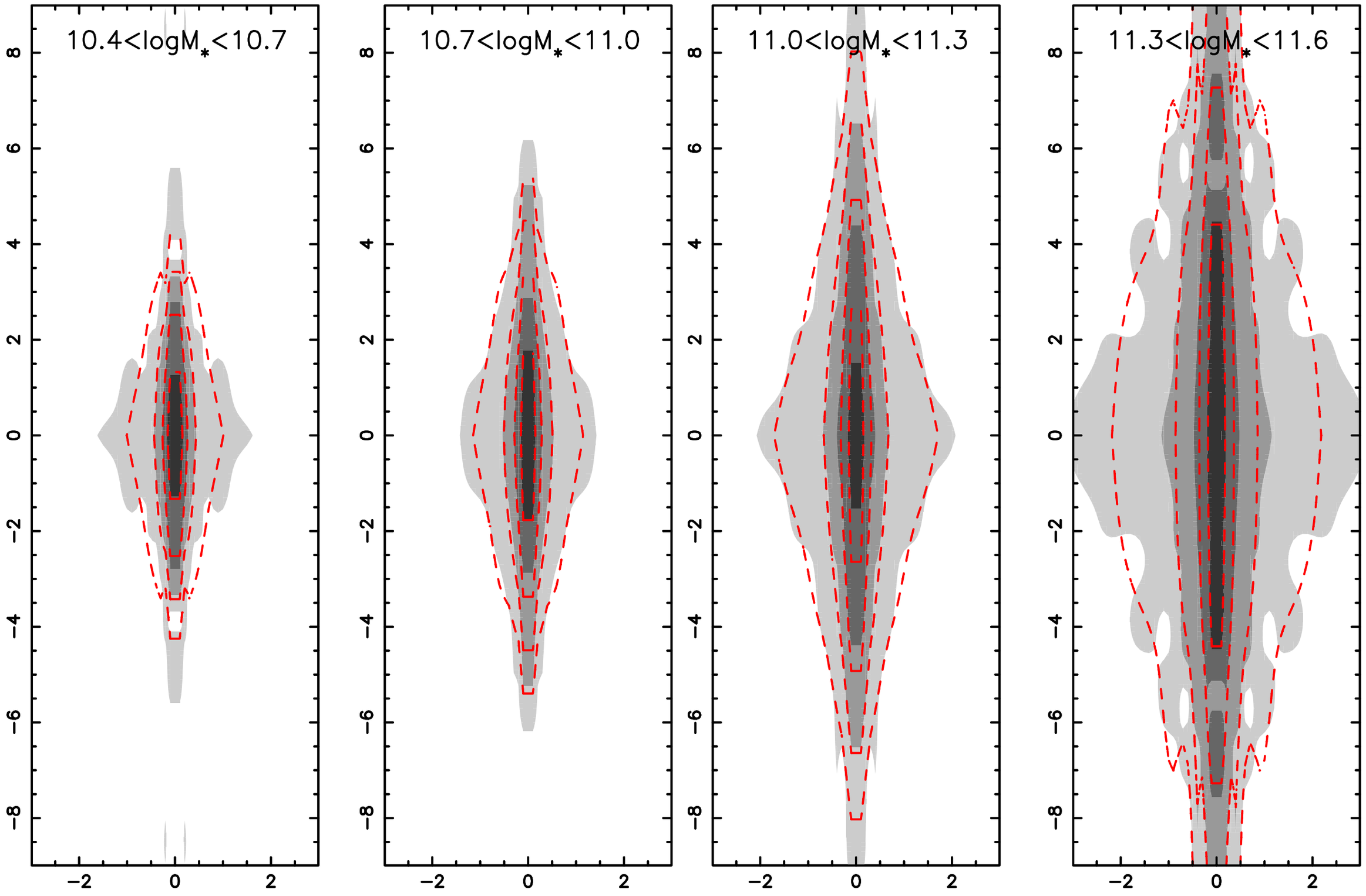


$\xi(r)$ → $\xi(r_p, \pi)$

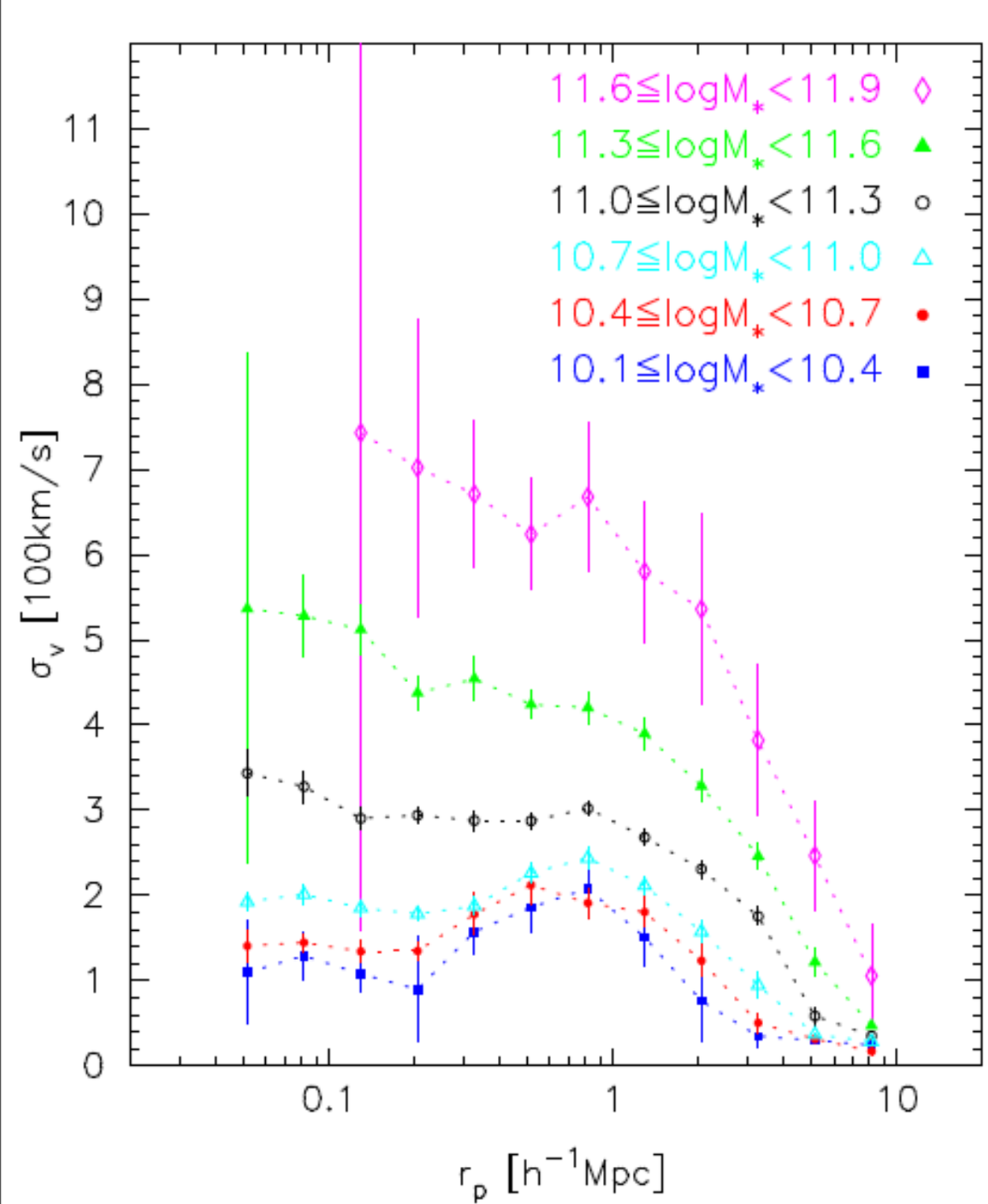
Redshift-space 2PCF: $$\xi(r_p, \pi) = \int f(v_{12}) \xi\left(\sqrt{r_p^2 + (\pi - v_{12})^2}\right) dv_{12}$$

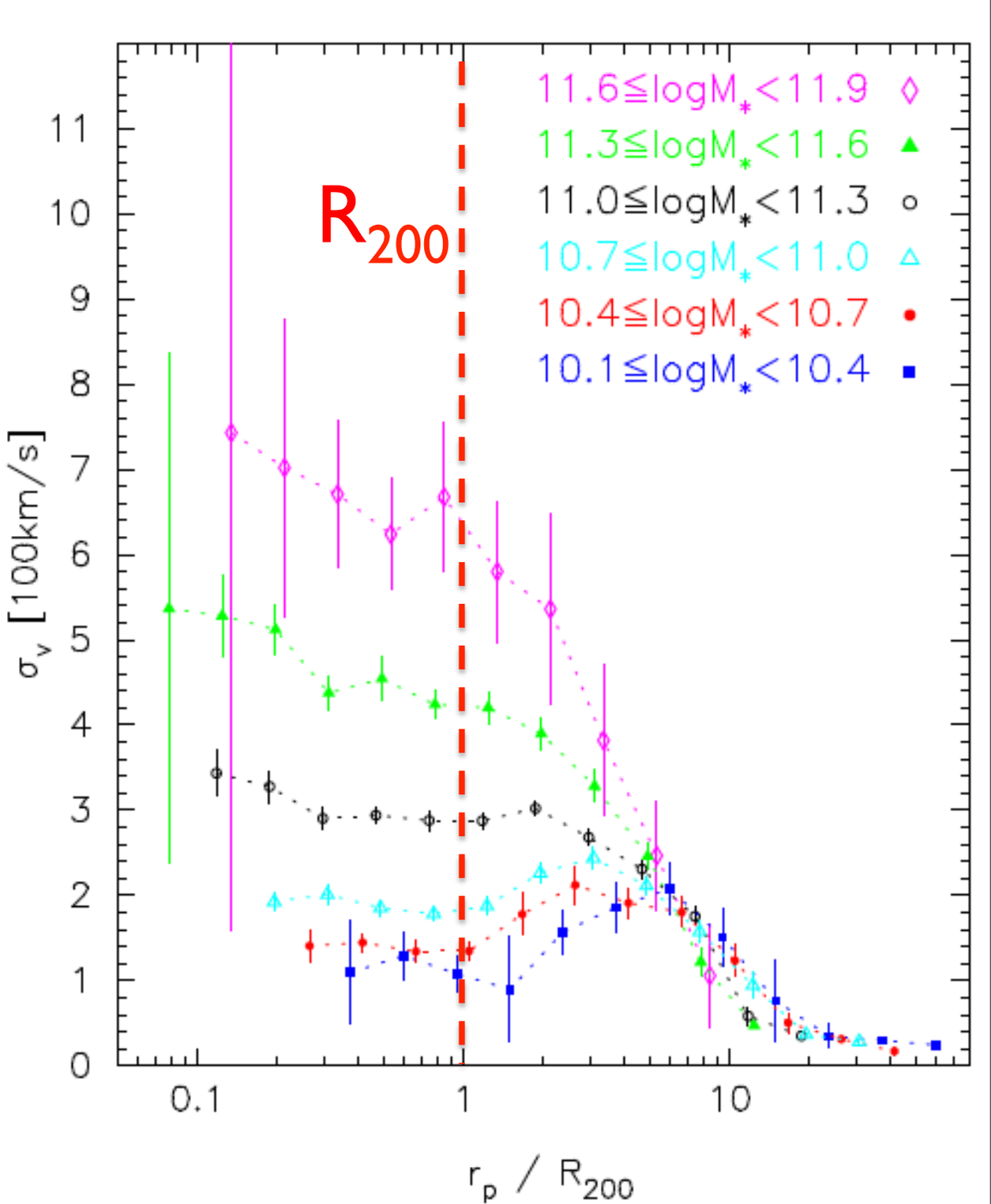
satellite velocity distribution function: $$f(v_{cs}) = \frac{1}{\sqrt{2\pi}\sigma_v} \exp\left[\frac{-(v_{cs} - \overline{v_{cs}})^2}{2\sigma_v^2}\right]$$

Cross-correlation function between groups and galaxies in z-space for groups of different masses



- Velocity dispersion strongly depends on central galaxy mass
- Velocity dispersion profile is roughly flat within the halo, slightly rising at small radii (<0.3R_{200}) for high mass systems

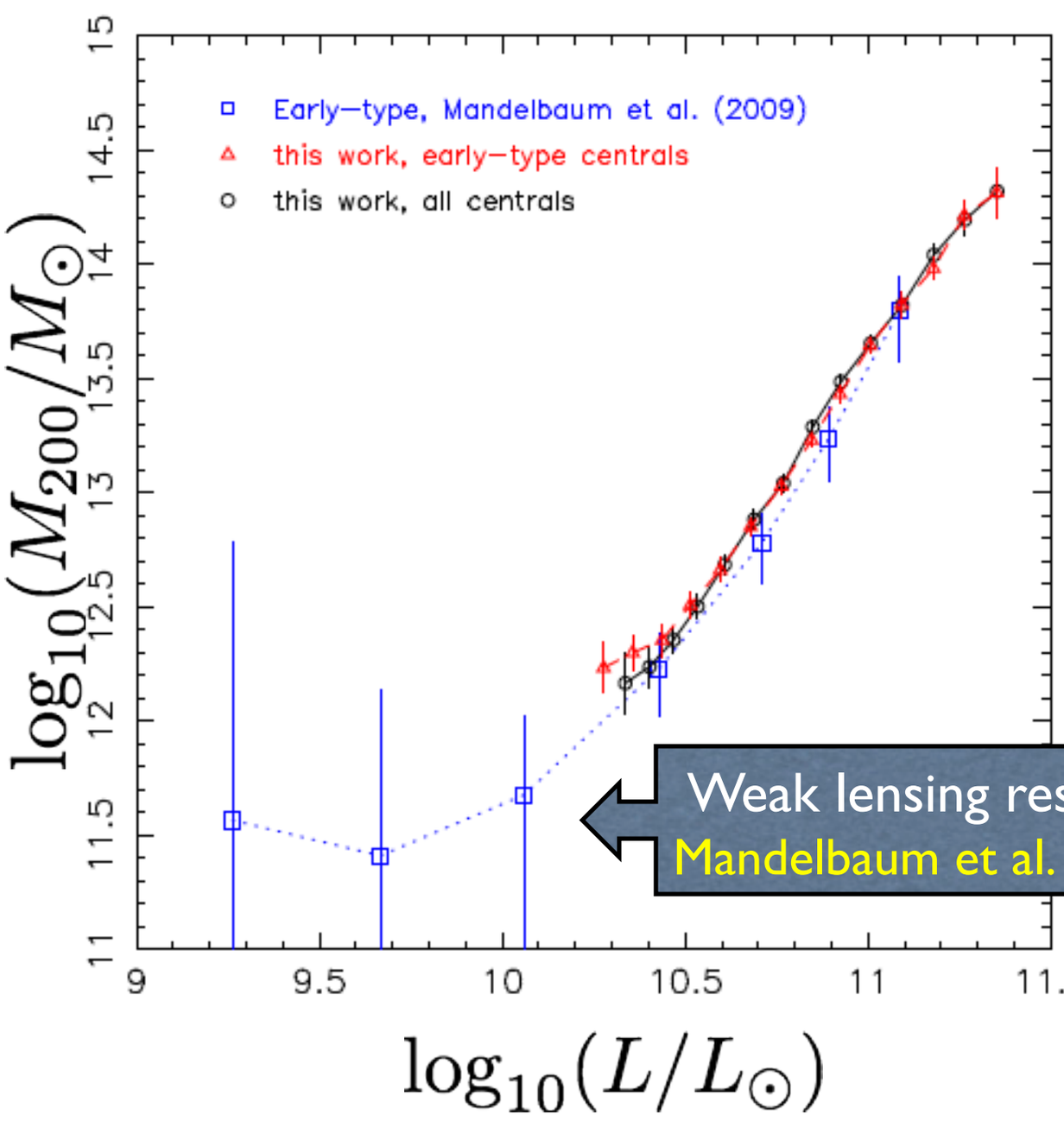




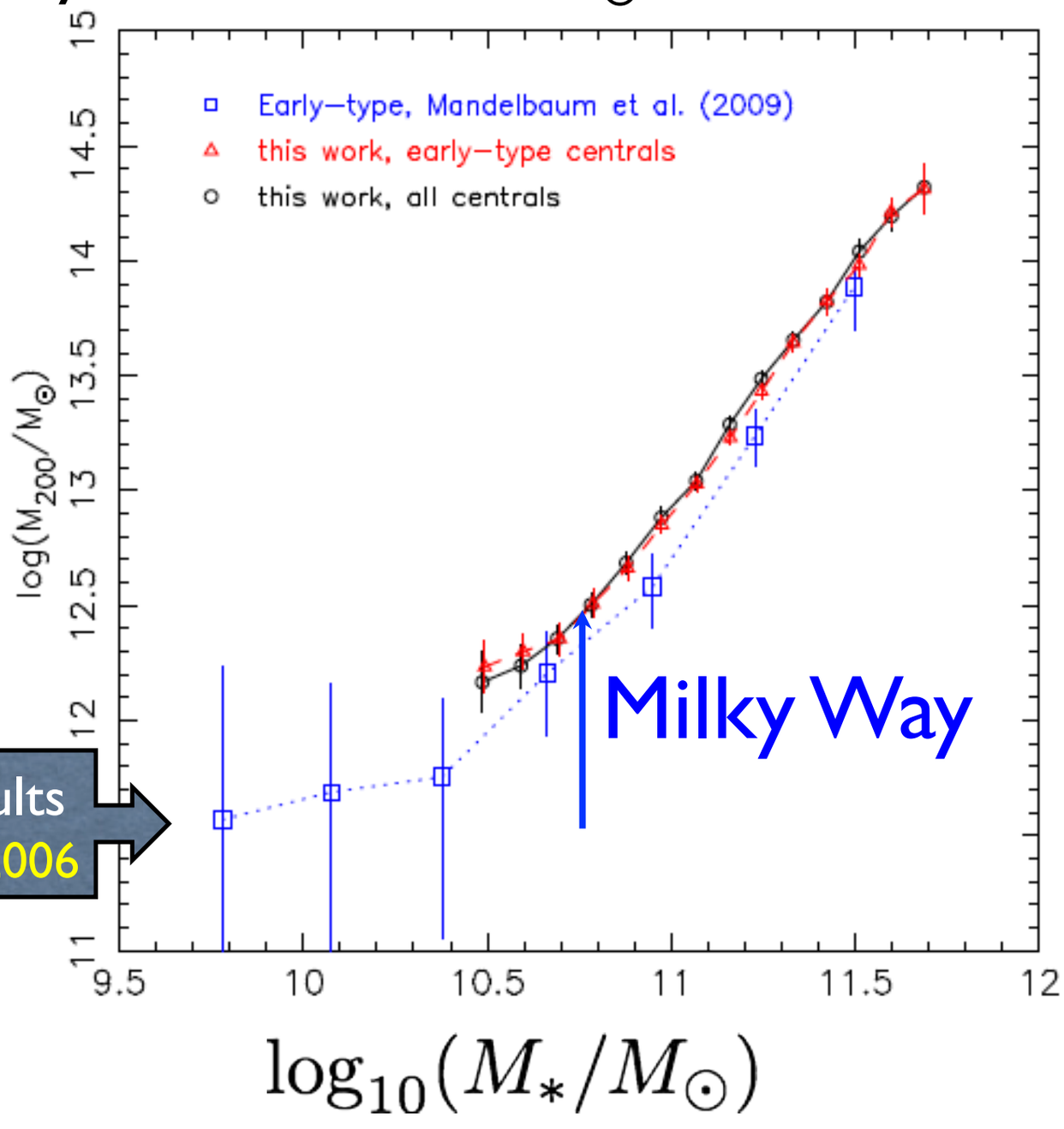
Halo mass as function of luminosity and stellar mass

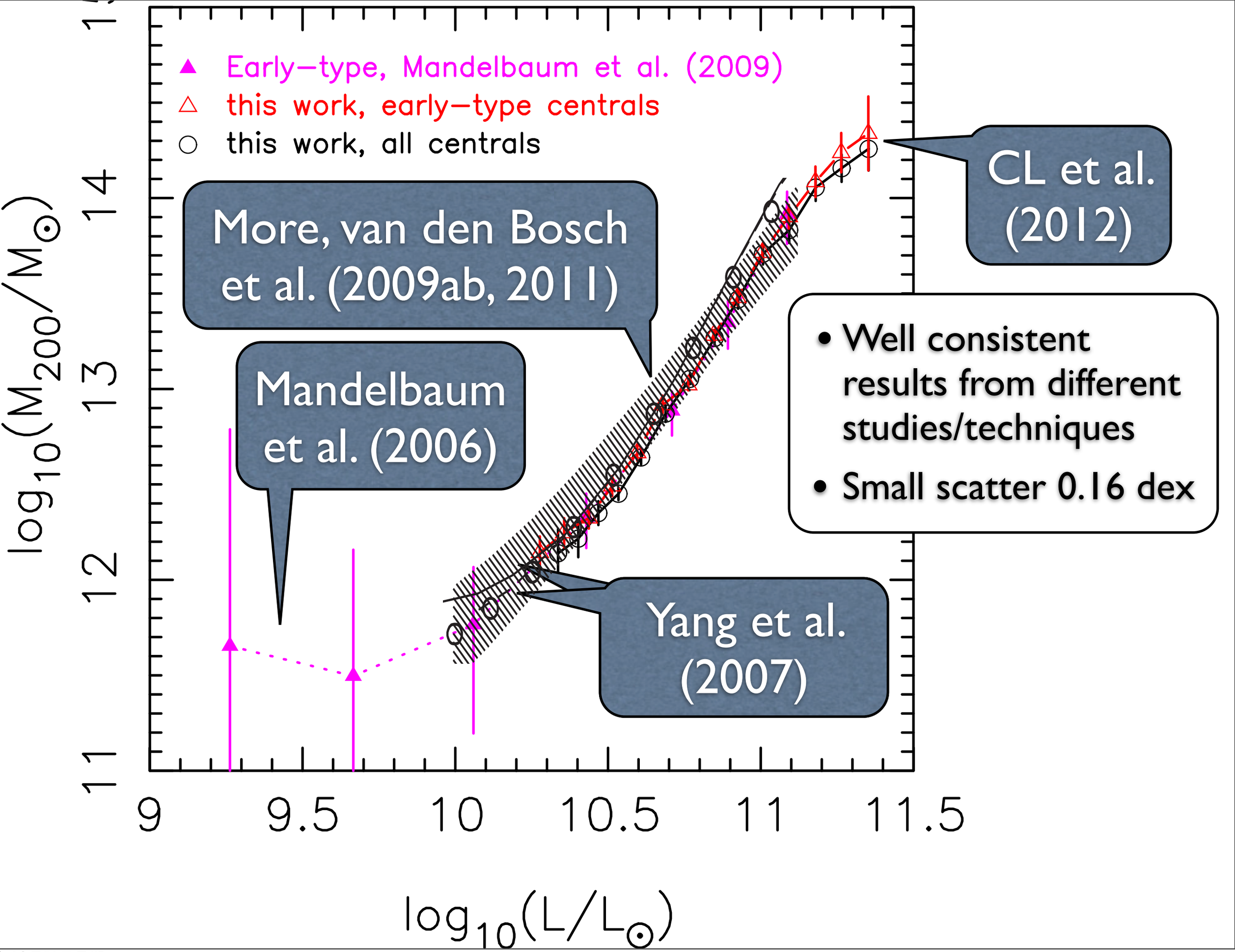
CL, Jing, Mao et al. 2012, ApJ (arXiv:1206.3566)

- M_{200}-L relation in good agreement with gal-gal weakling lensing result
- Small difference in M_{200}-M_* relation due to different M_* definitions
- $M_h=2.8\times10^{12}M_\odot$ implied for Milky Way with $M_*=6\times10^{10}M_\odot$

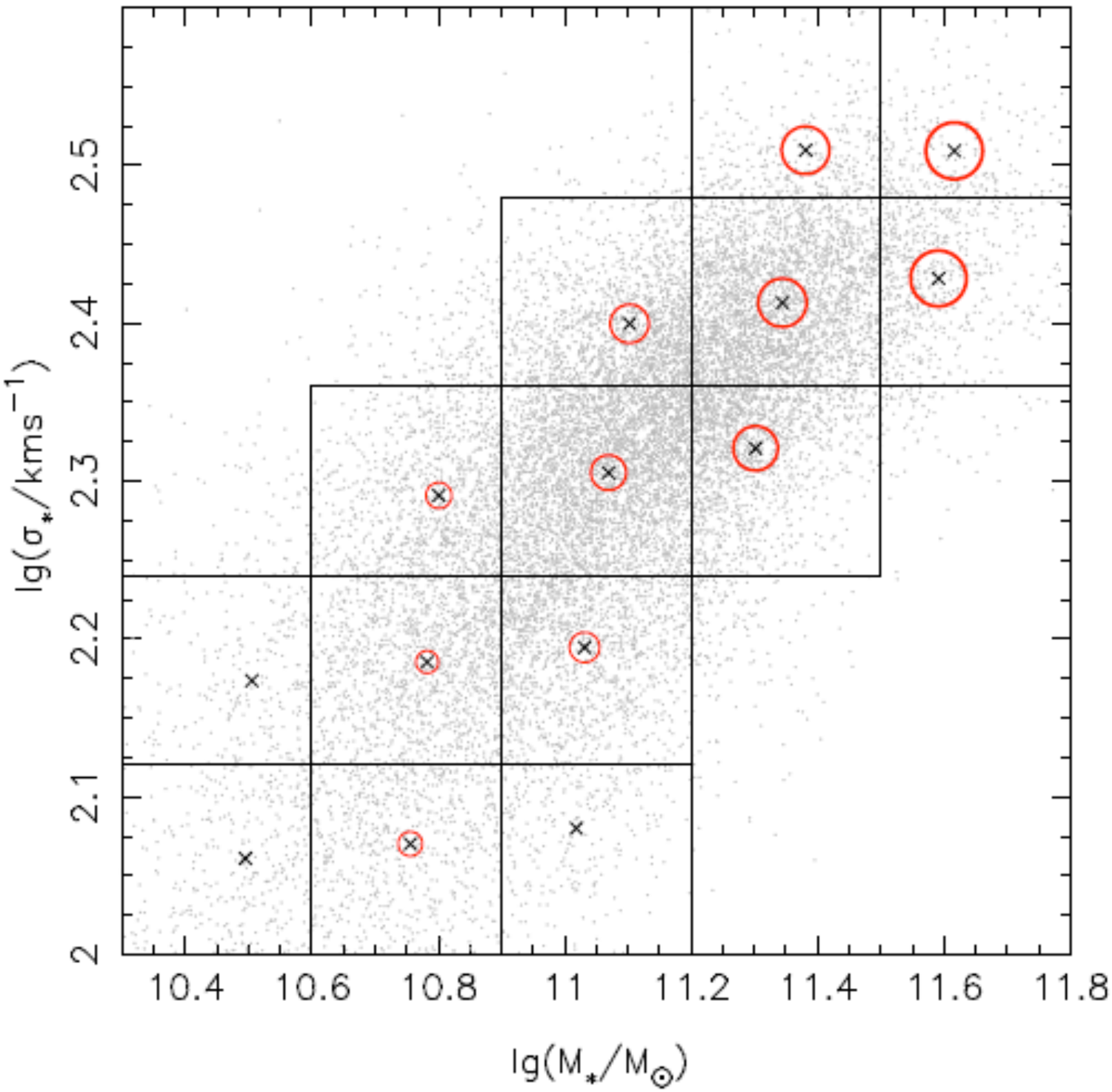


Weak lensing results
Mandelbaum et al. 2006

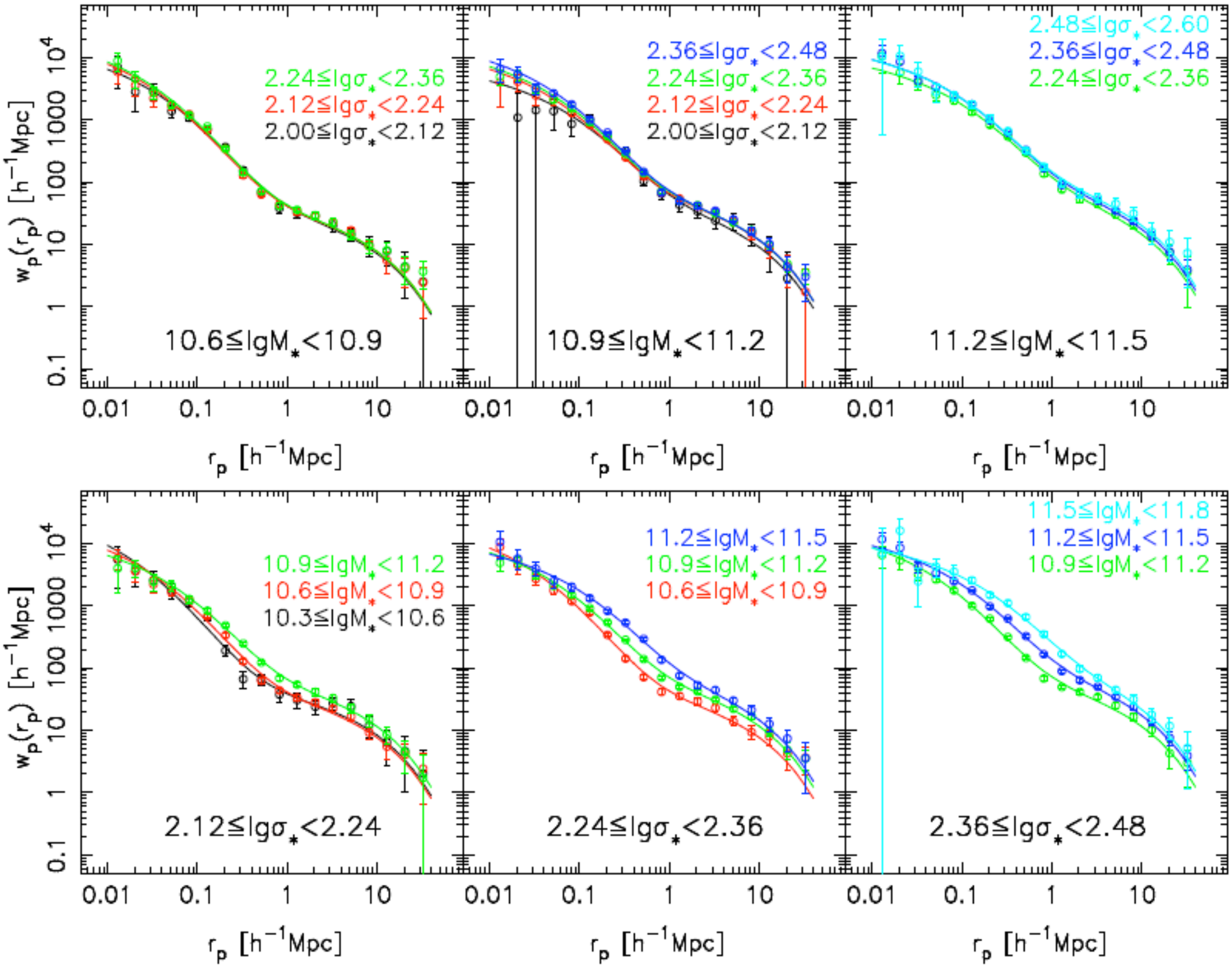



Early−type, Mandelbaum et al. (2009)
this work, early−type centrals
this work, all centrals
More, van den Bosch et al. (2009ab, 2011)
Mandelbaum et al. (2006)
CL et al. (2012)
• Well consistent results from different studies/techniques
• Small scatter 0.16 dex
Yang et al. (2007)
0.16 dex
log10(M200/M⊙)
log10(L/L⊙)
11
12
13
14
9
9.5
10
10.5
11
11.5

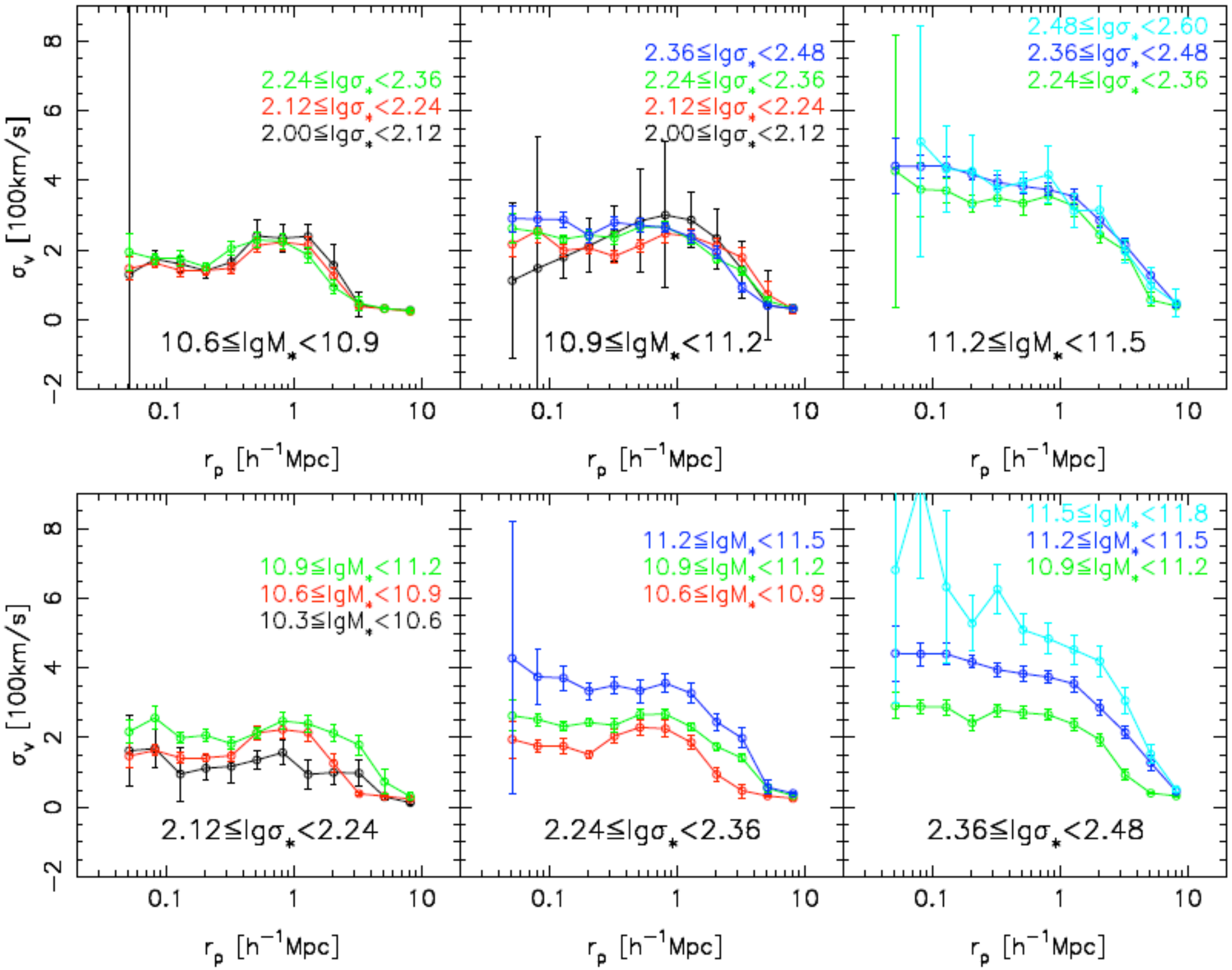
Subsamples selected on the plane of stellar mass and stellar velocity dispersion



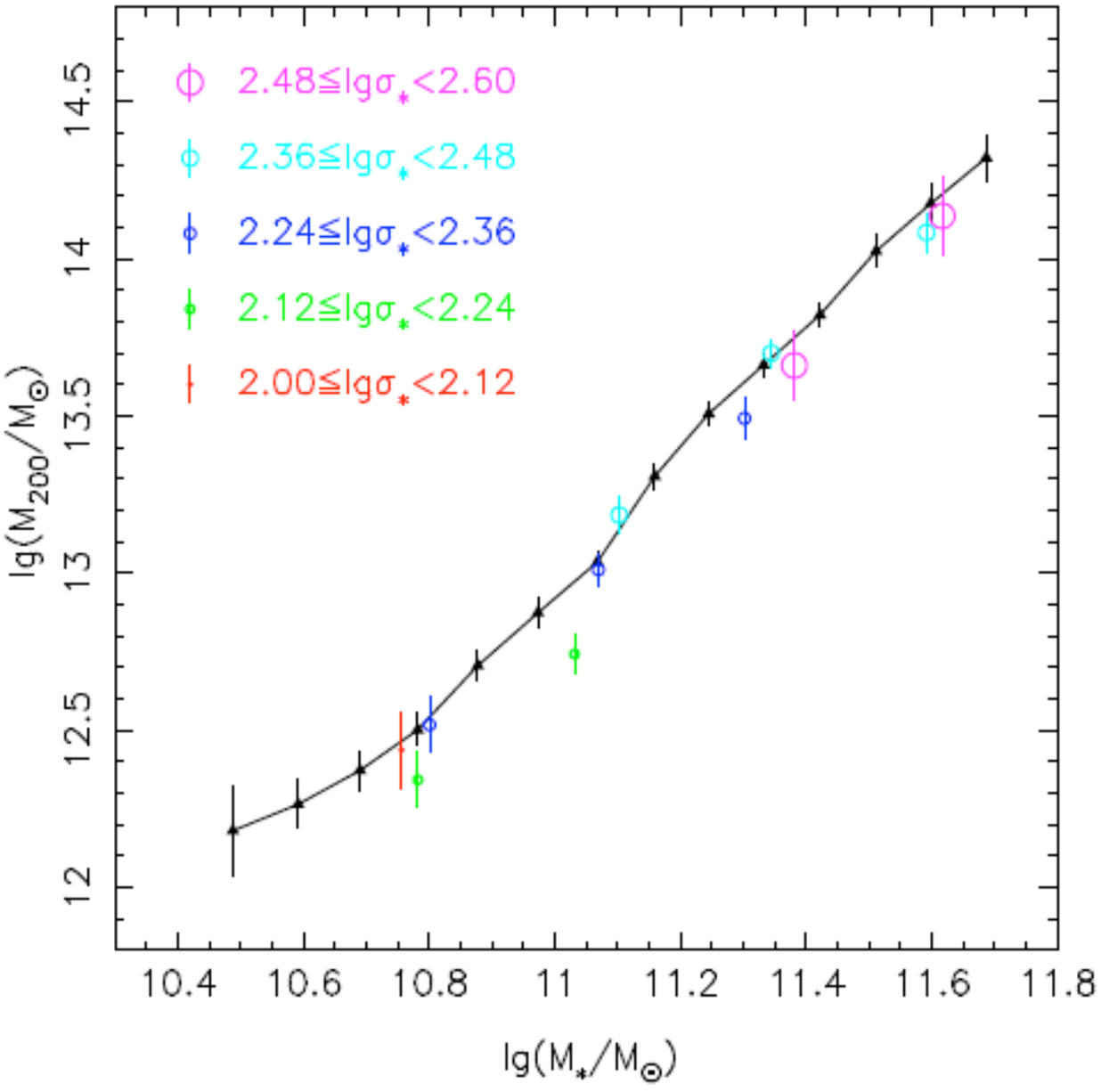
The projected cross-correlation function between galaxies and group centers

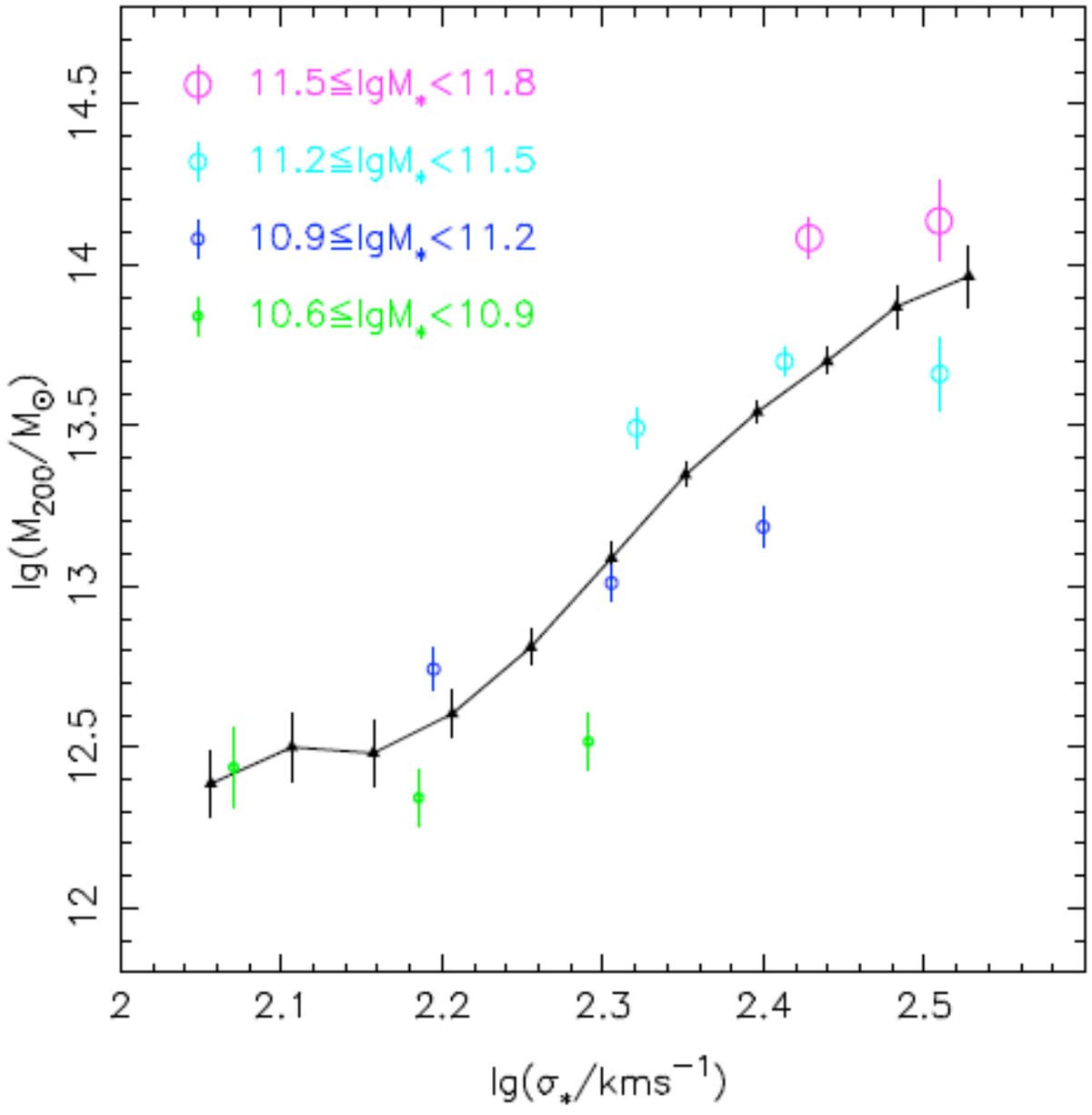


The velocity dispersion profile of satellite galaxies around central galaxies

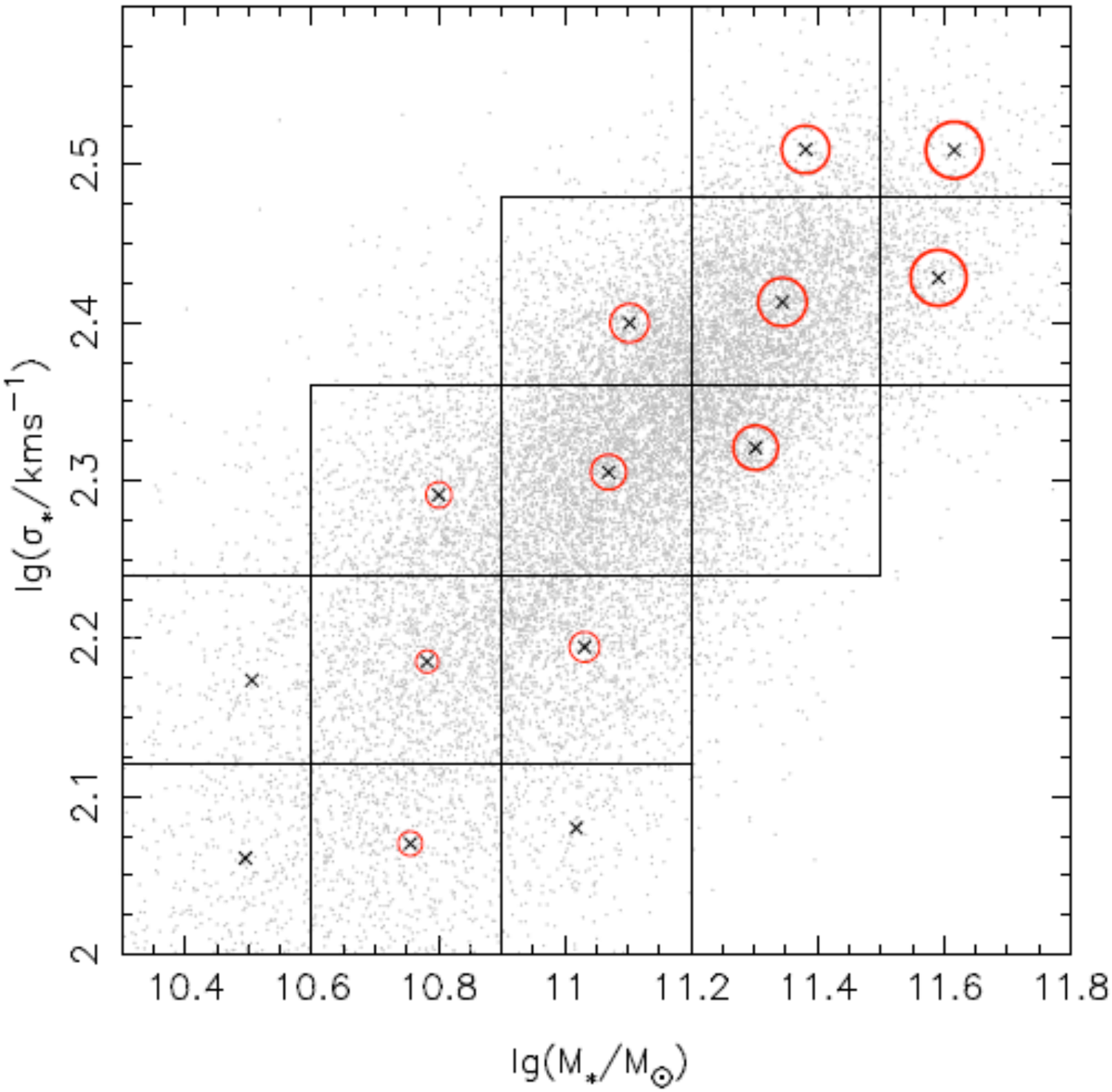


Halo mass as function of stellar mass and stellar velocity dispersion





Halo mass is clearly related to stellar mass more tightly than to stellar velocity dispersion



Is σ_* a better indicator than M_* ?

(CL, Wang, Jing, 2012, ApJL submitted, arXiv:1210.5700)

- Halo masses can be directly measured from estimating the velocity dispersion profile of satellite galaxies around central galaxies
- These measurements firmly demonstrate that the halo mass vs stellar mass relation is more tighter than the halo mass vs. stellar velocity dispersion relation
- The clustering dependence on mass at fixed velocity dispersion may be explained by the contamination of satellite galaxies to the galaxy-galaxy clustering measurement, due to their deviation from the halo mass - galaxy mass relation.
- This might be caused by tidal stripping occurring within halos, which has stronger effect on stellar mass than on central stellar velocity dispersion.

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