The spatial distribution of satellite galaxies

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1. **The spatial distribution of satellites in galaxy clusters**

2. **The velocity correlations of satellite pairs around massive galaxies**

Milky Way's Vast Polar Structure (VPOS)

Illustris TNG100

Pawlowski, M. S. 2021

▸ The spatial and kinematic correlation of satellite galaxies around the MW.

▸ MW's analogs are rare (~0.001) in ΛCDM simulation.

1. **The spatial distribution of satellites in galaxy clusters**

2. The velocity correlations of satellite pairs around massive galaxies

◉ **Sample selection** $M_{vir} \in (1, 3) \times 10^{14} M_\odot$
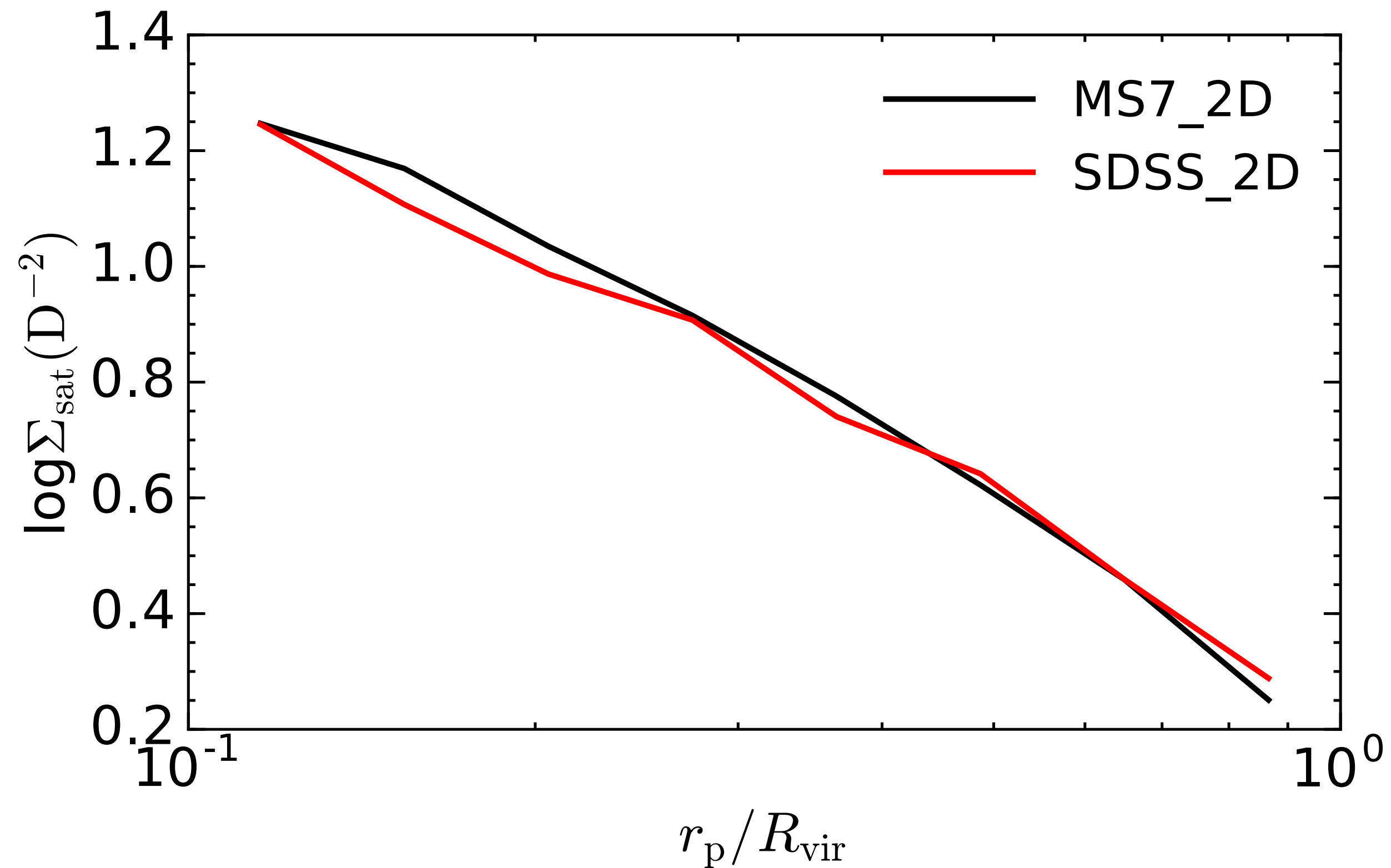
Millennium simulation in WMAP7 cosmology (MS7)

Semi-analytic galaxy formation model Guo et al. (2011)

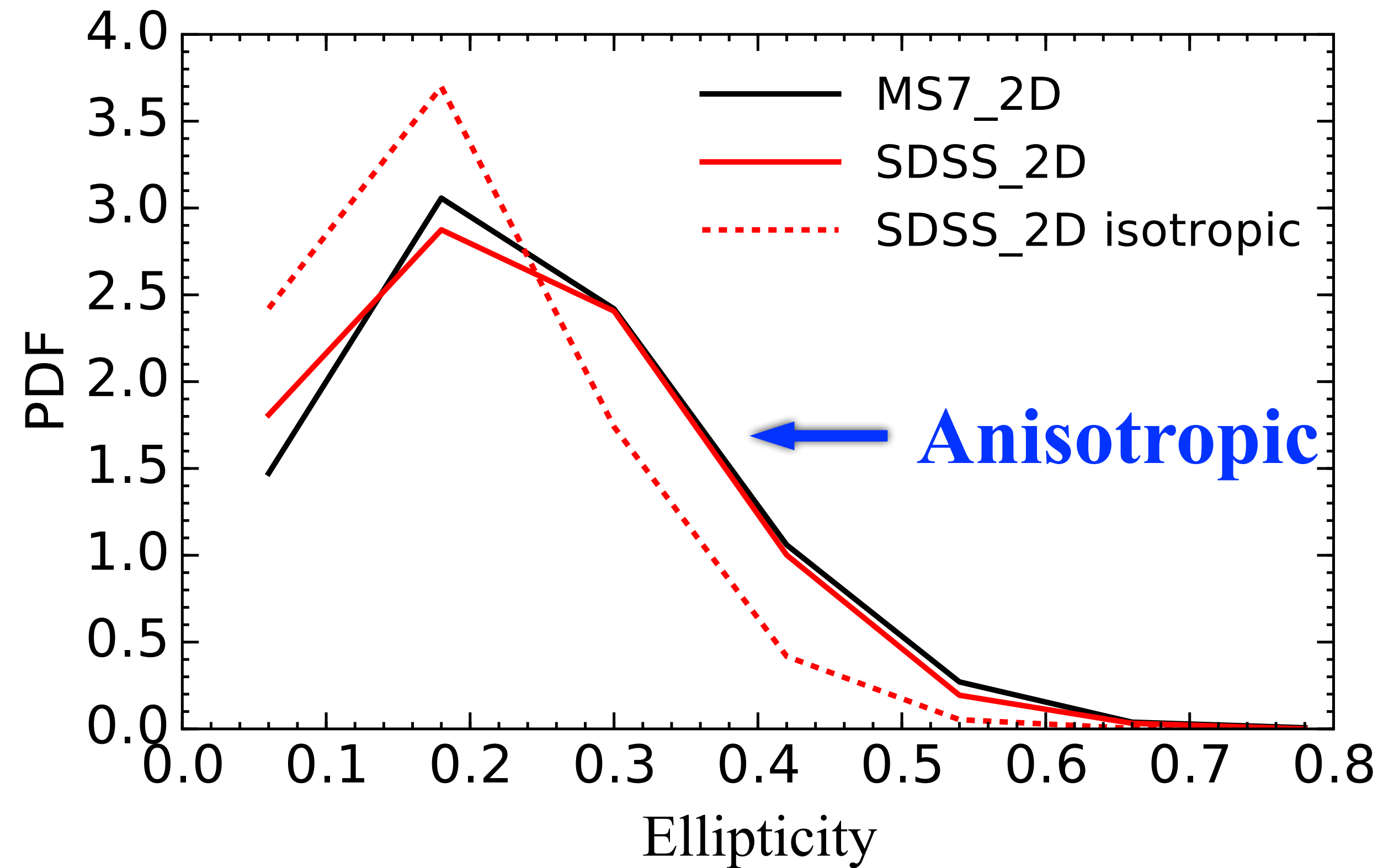L=500Mpc/h, N=2160^3, $m_p = 9.3639 \times 10^8 M_\odot$/h, h=0.704

Catalogue	Satellite definition $M_* > 10^{9.5} M_\odot$ Top 11	Cluster number $N_{sat} \geq 11$
MS7	$r_{3D} < 1$Mpc	2587
SDSS DR7 Yang et al.2007	0.1Mpc $< r_{2D} < 1$Mpc $|c\Delta z| < 1000$km/s	516
MS7 mock	0.1Mpc $< r_{2D} < 1$Mpc $|c\Delta z| < 1000$km/s	2587

◉ **Comparison of MS7 and SDSS in projection**

Consistent radial profiles

Consistent ellipticity distributions

Gu et al. 2022 MNRAS

◉ **Comparison with MW analogs in simulations**
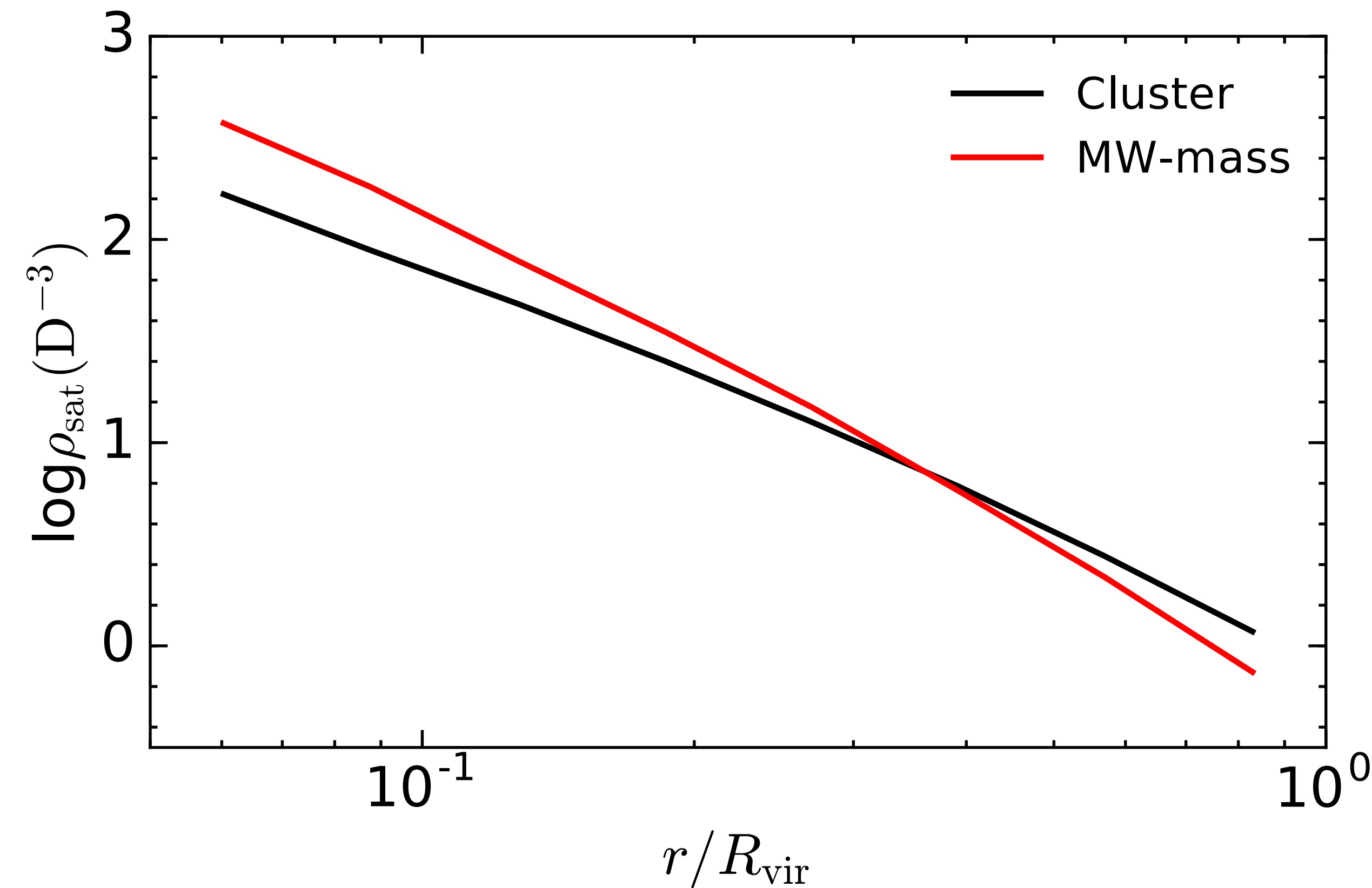
More extended in cluster
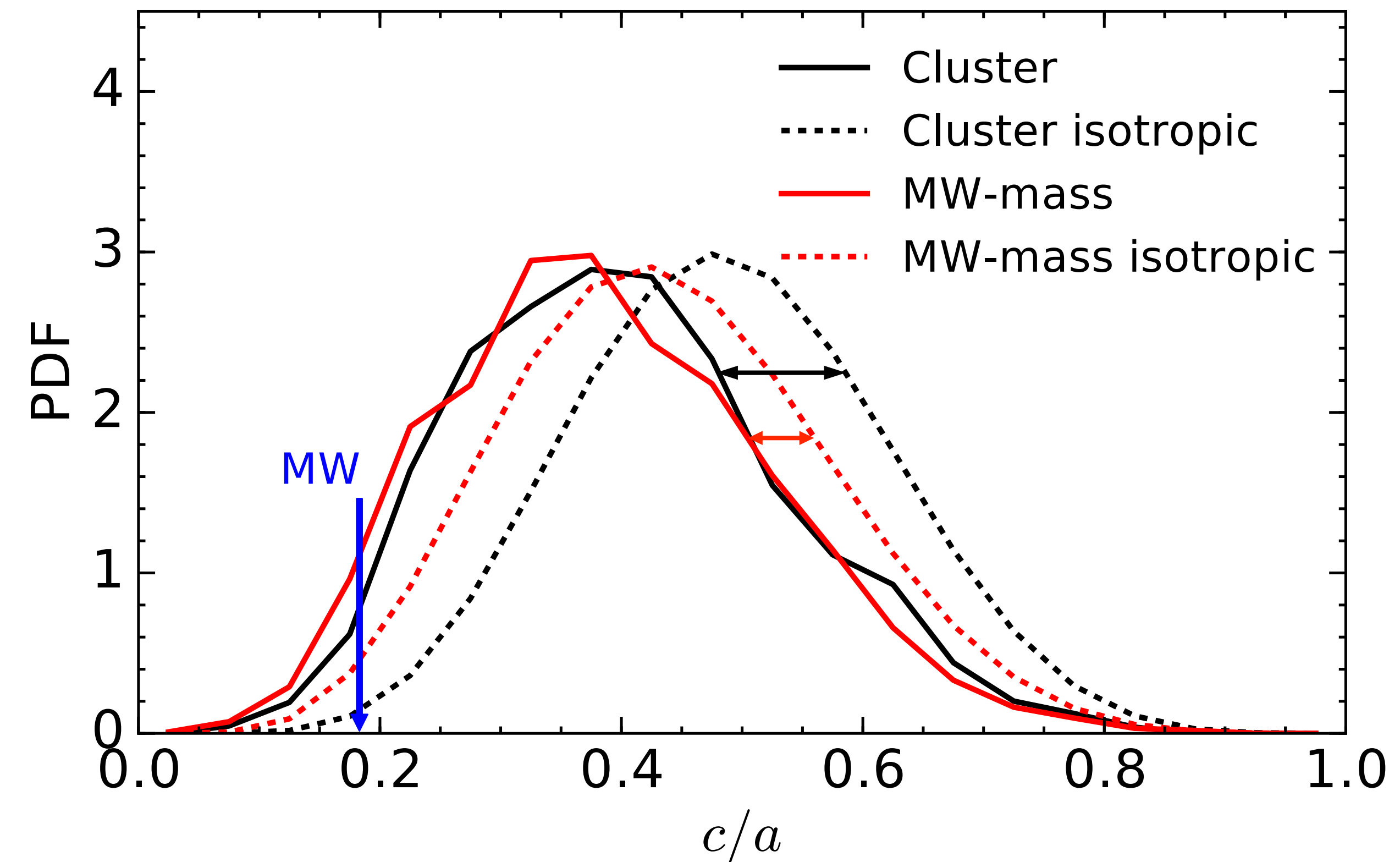
More anisotropic in cluster

◉ **Relation to the host halo, the LSS and the accretion history**
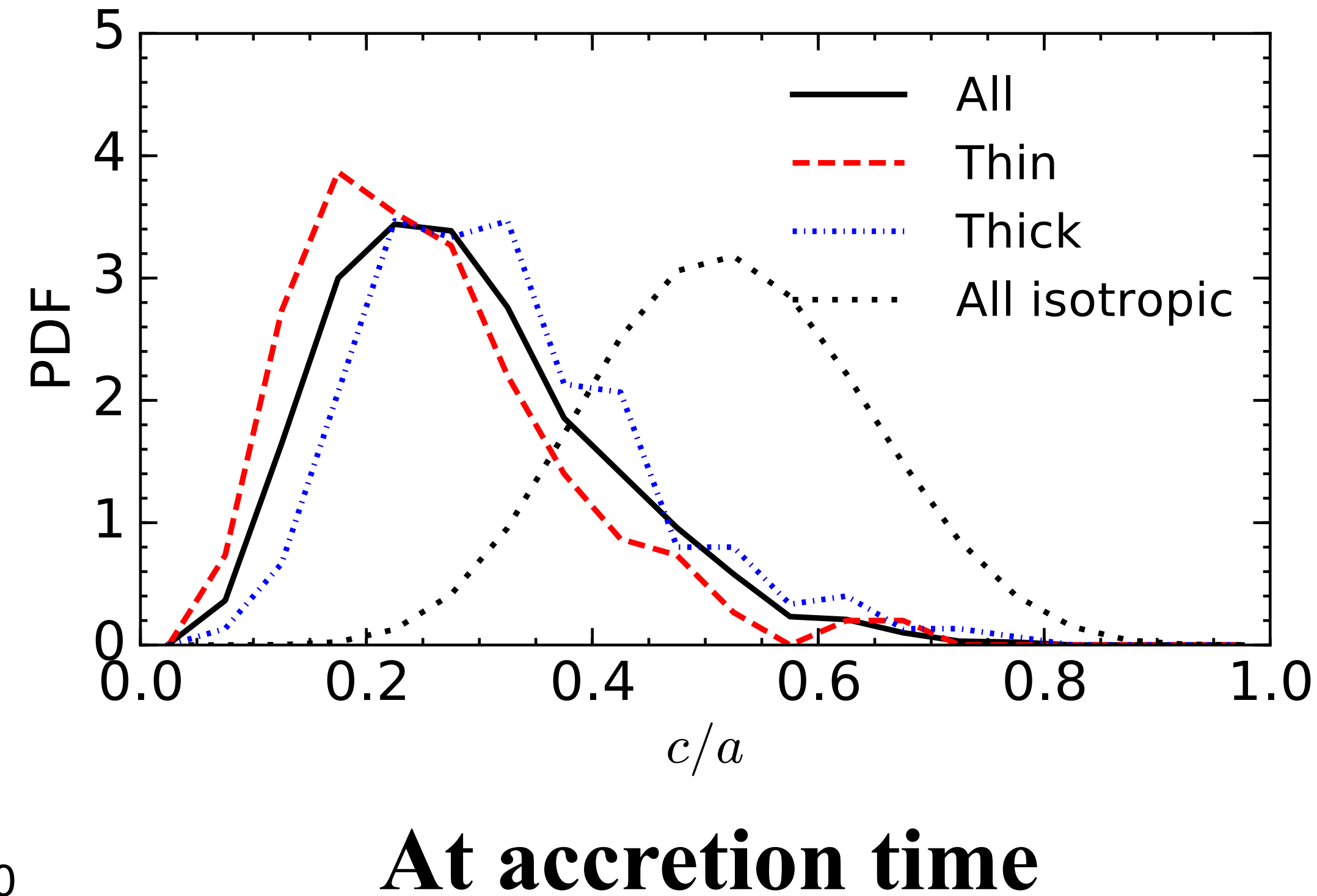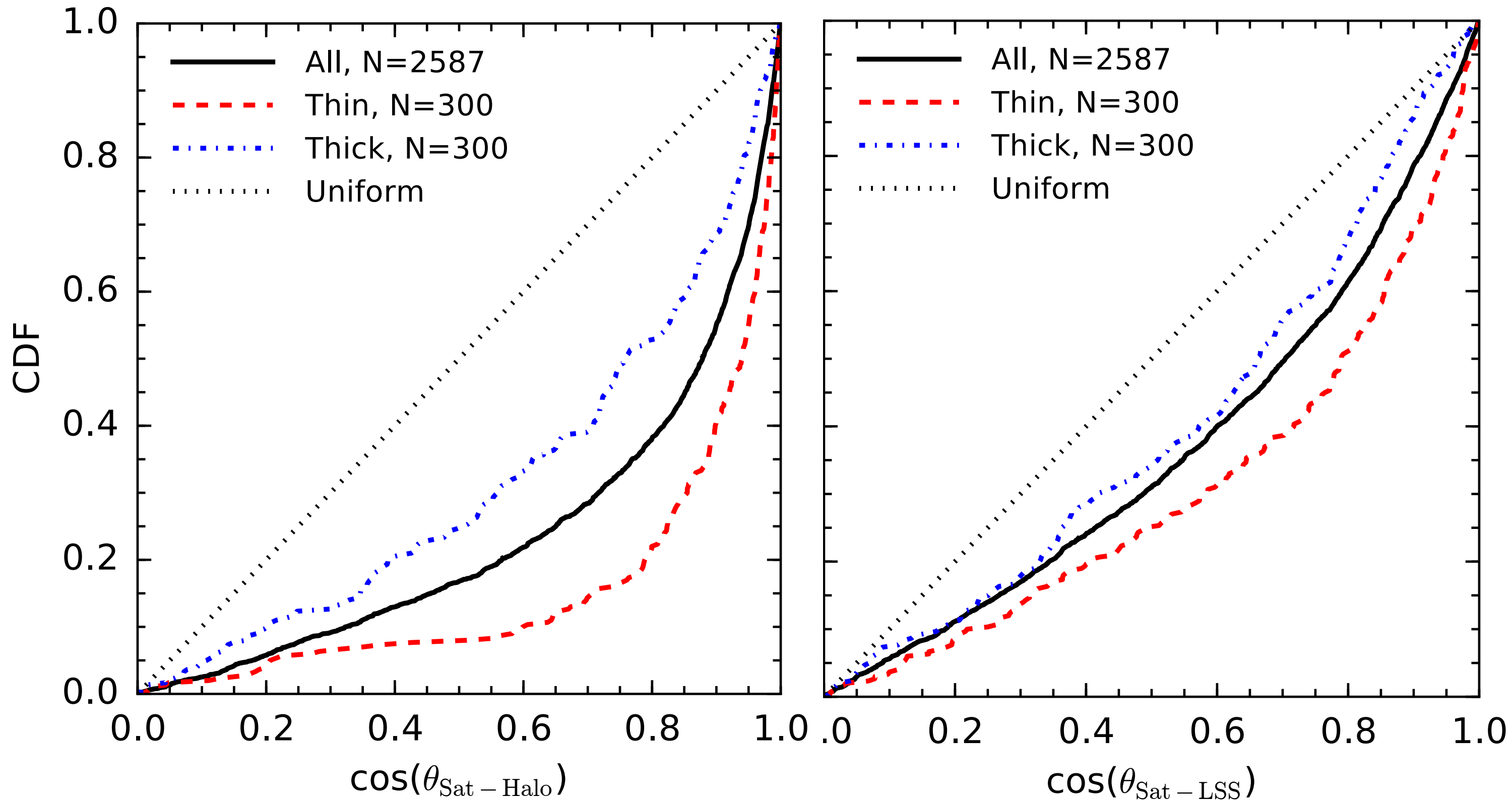
At accretion time
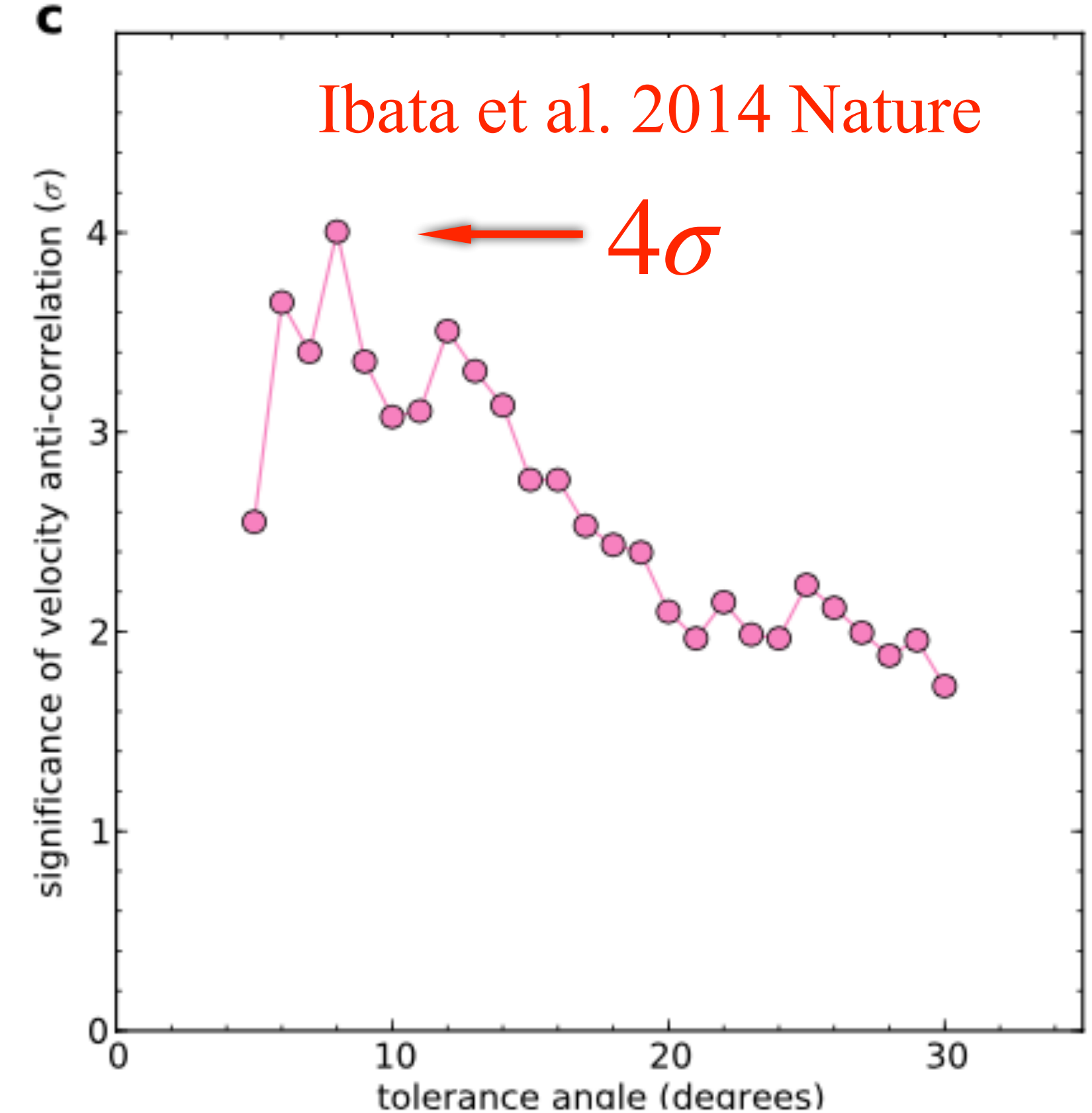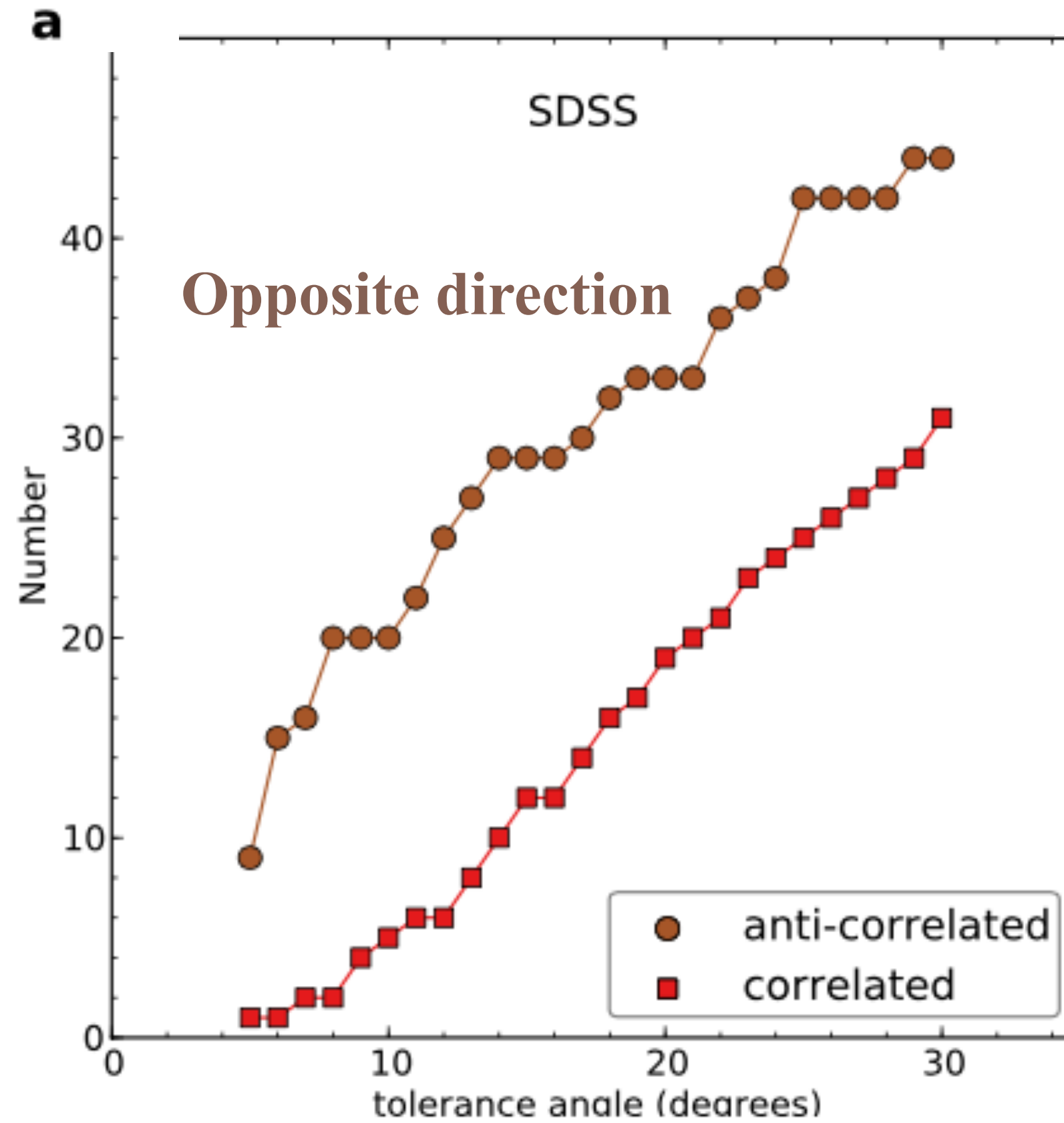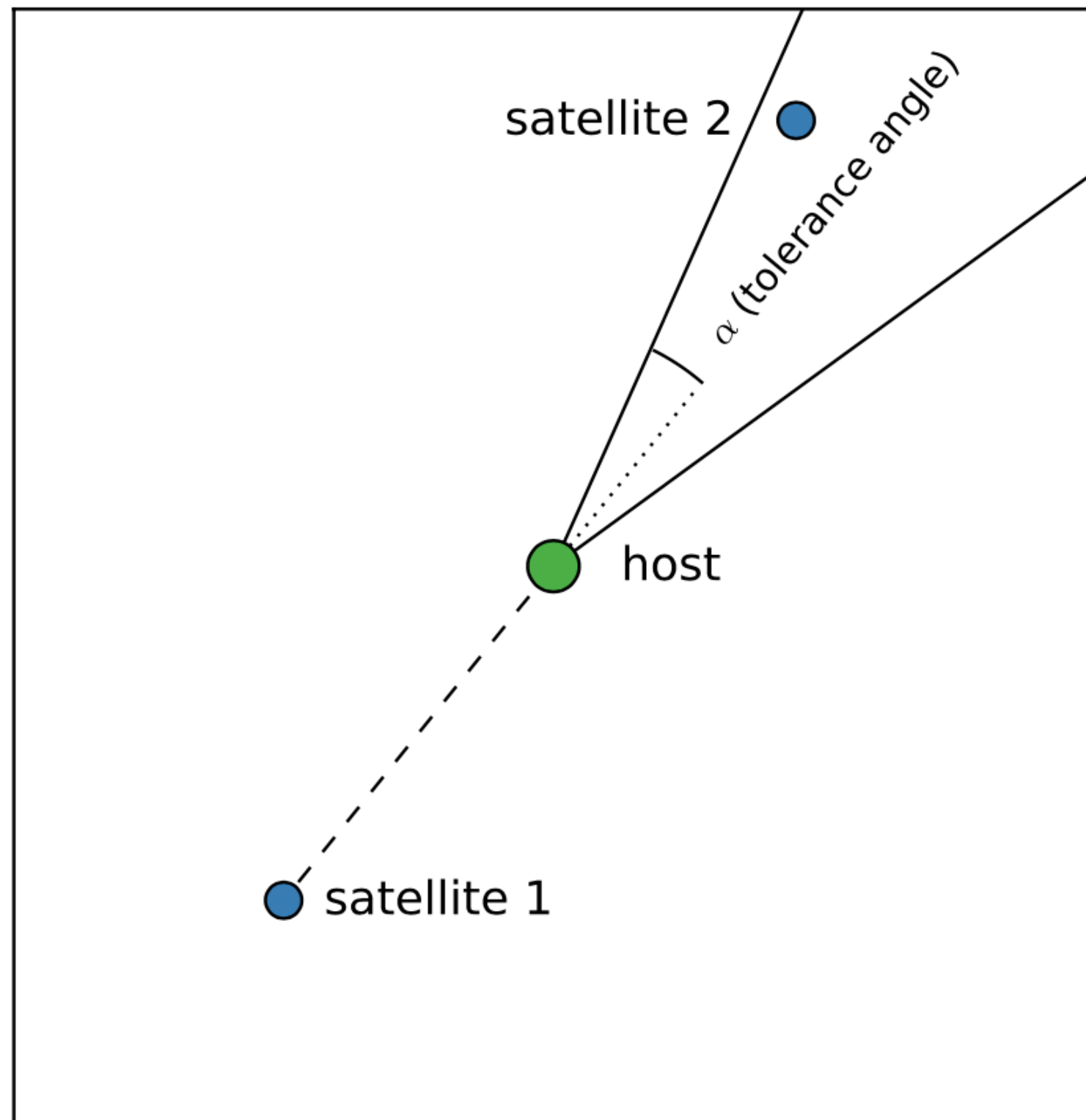
1. The spatial distribution of satellites in galaxy clusters

2. **The velocity correlations of satellite pairs around massive galaxies**

◉ Background

▶ The satellite pairs of MW-like systems are preferentially co-rotating (opposite direction of line-of-sight velocities) in SDSS.

◎ Sample selection

Observation: SDSS DR7 spectroscopic catalogue

▸ *Primary*: $M_* \in (10^{11},\ 10^{11.5})\ \mathrm{M}_\odot$

Isolation criteria: (i) $r_\mathrm{p} < 0.5$ Mpc, $|c\Delta z| < 1000$ km/s, $M_\mathrm{primary} < M_\mathrm{neighbor} + 1$

(ii) $r_\mathrm{p} < 1$ Mpc, $|c\Delta z| < 1000$ km/s, $M_\mathrm{primary} < M_\mathrm{neighbor}$

▸ *Satellite*: 0.1 Mpc $< r_\mathrm{p} < 1$ Mpc, $\sqrt{2} \times 25$ km/s $< |c\Delta z| < 1000$ km/s

Simulation :

Millennium Simulation: (*Planck2013*)

Illustris TNG-300: (*Planck2015*)

◉ **Sample selection**

Select galaxies: $z < 0.065$

$M_* > 10^{10.08} \ M_\odot$
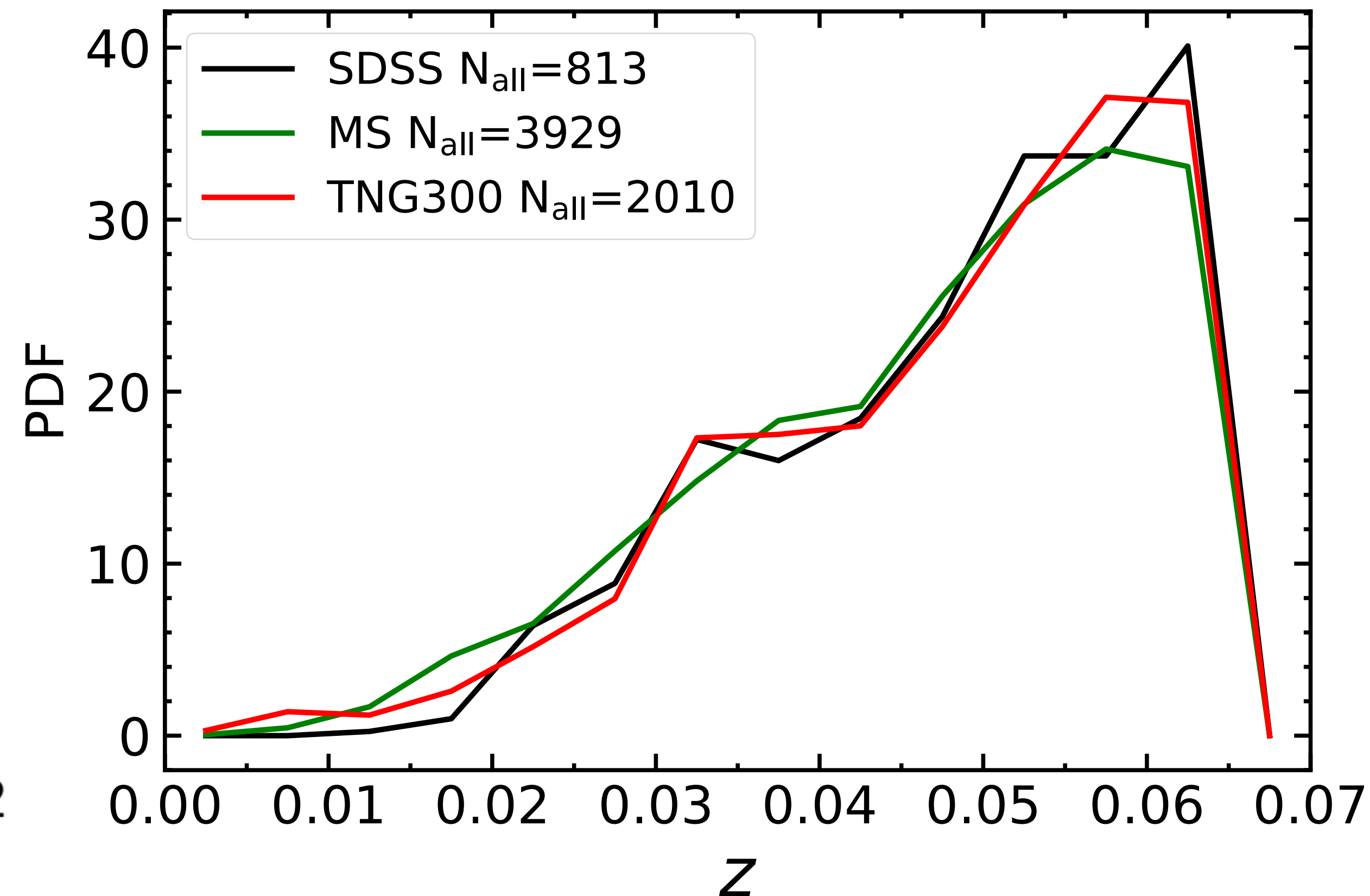
Consistent redshift distributions

⊙ **Sample selection**

Consistent tolerance angles
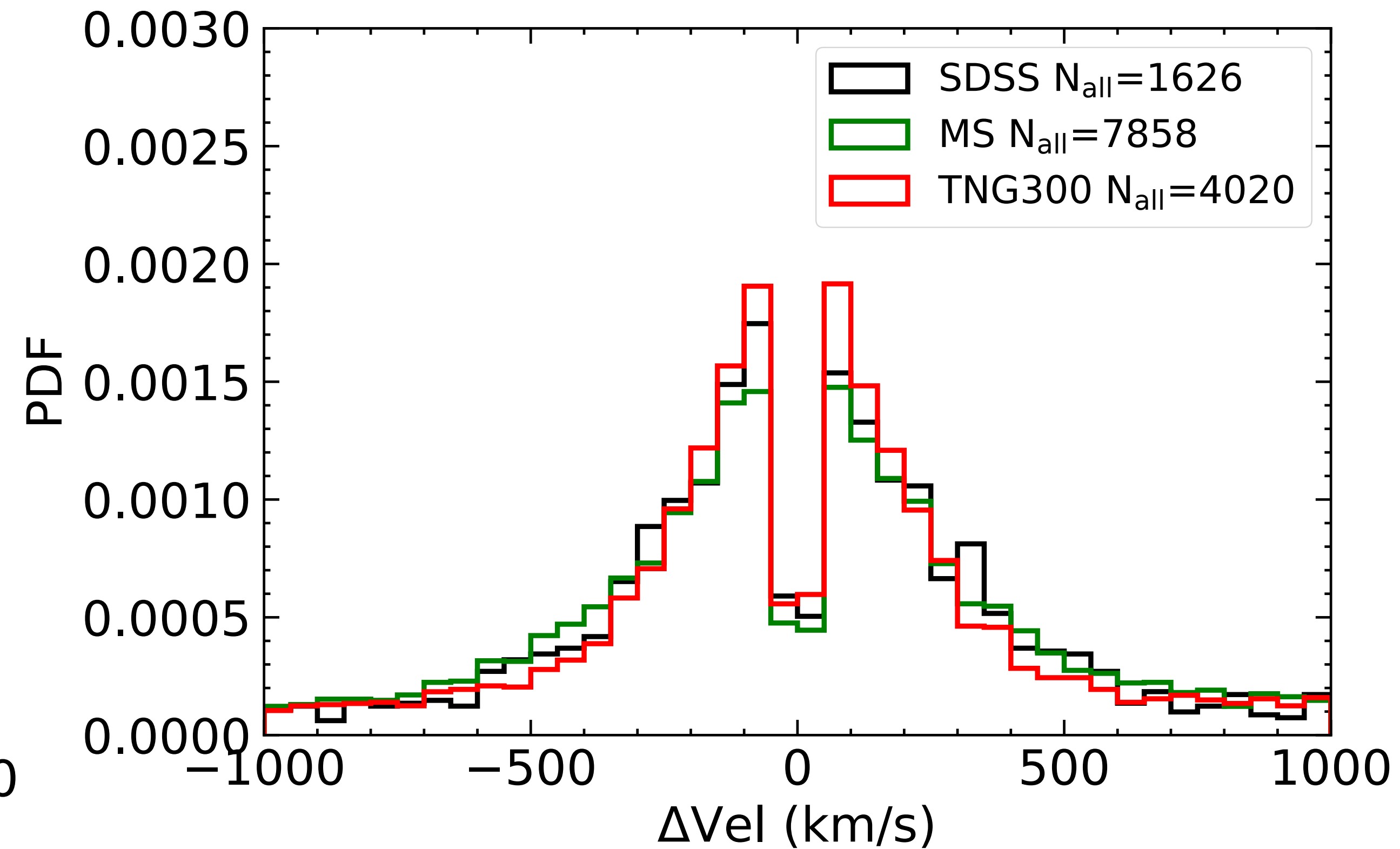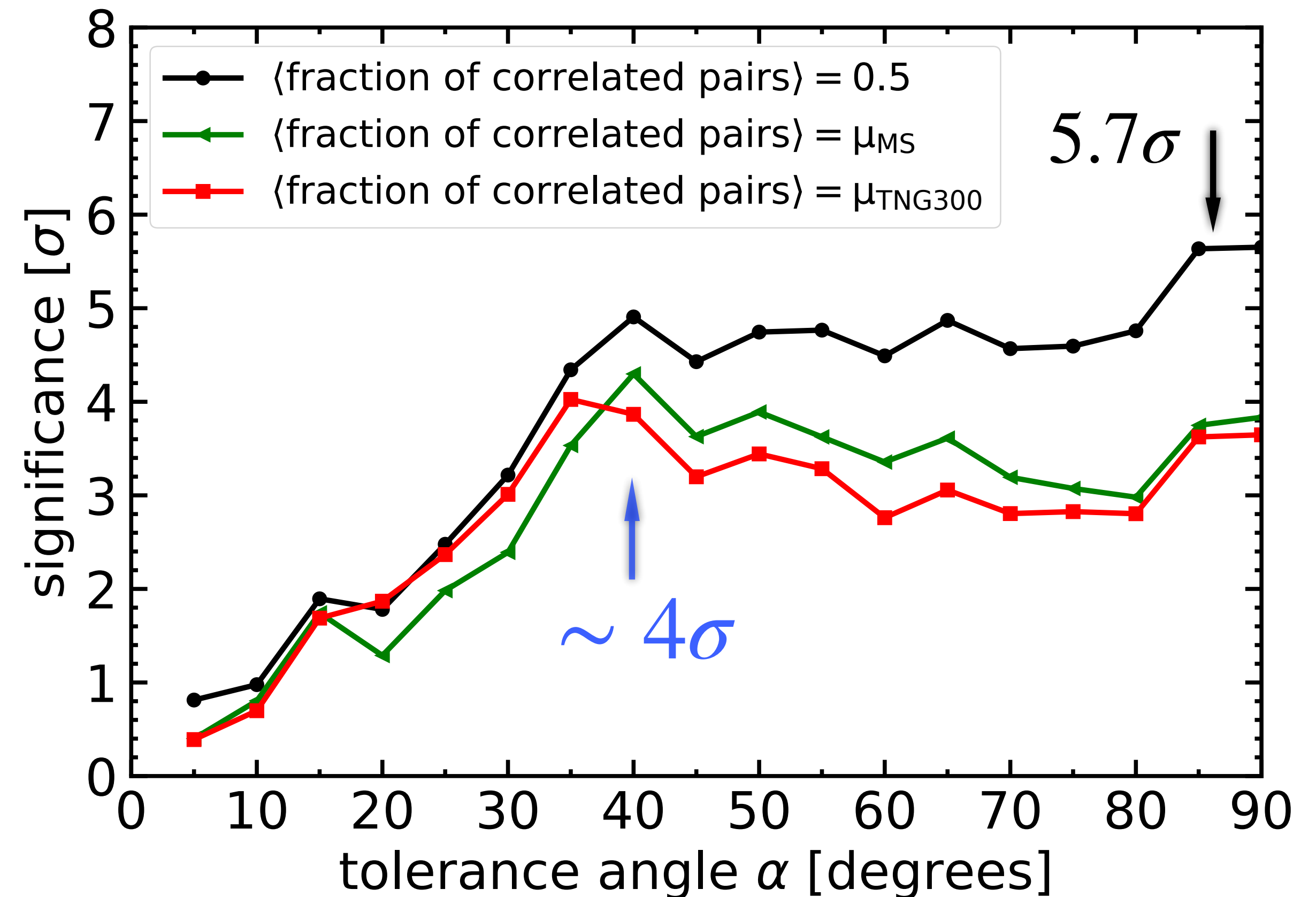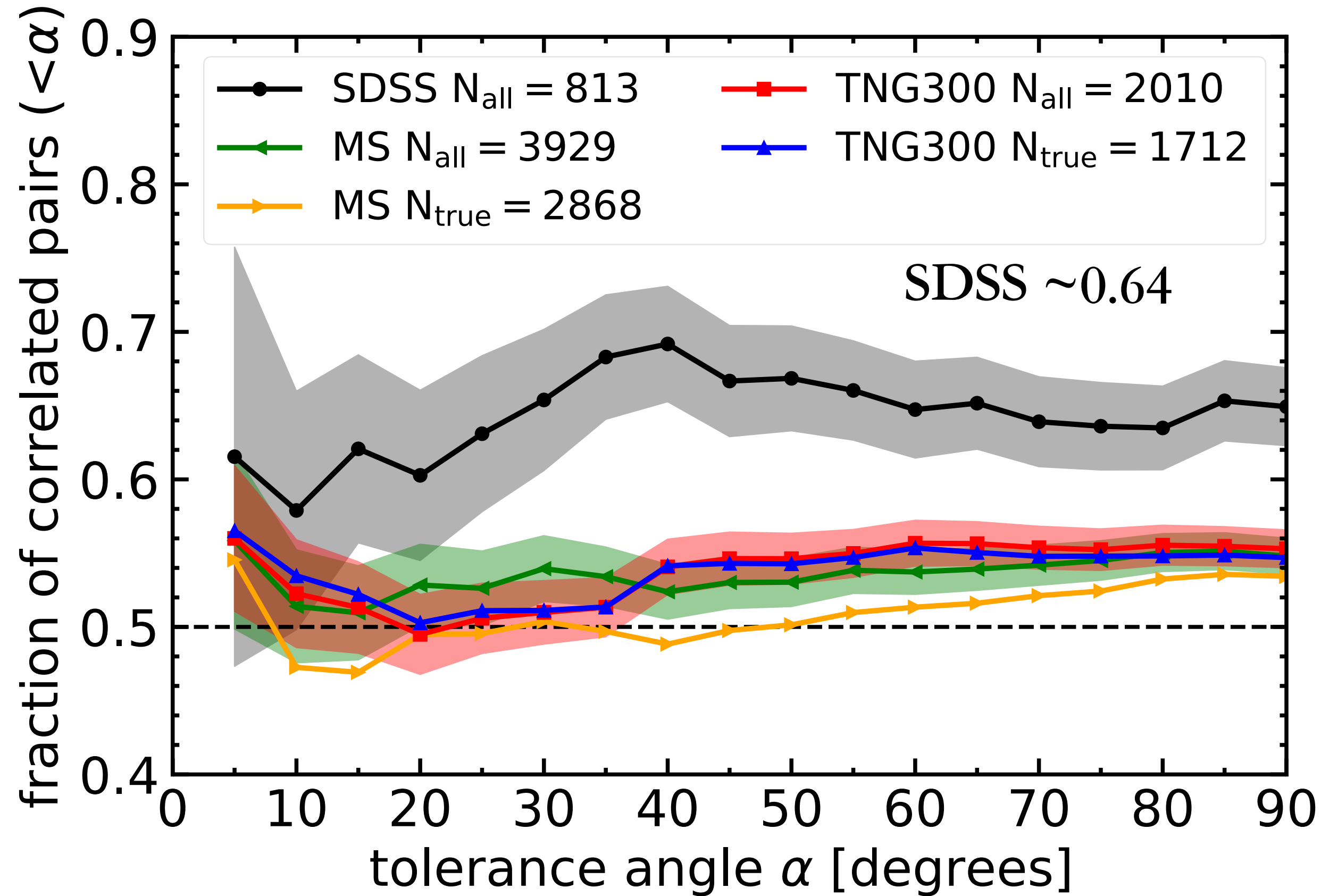
Consistent velocity differences

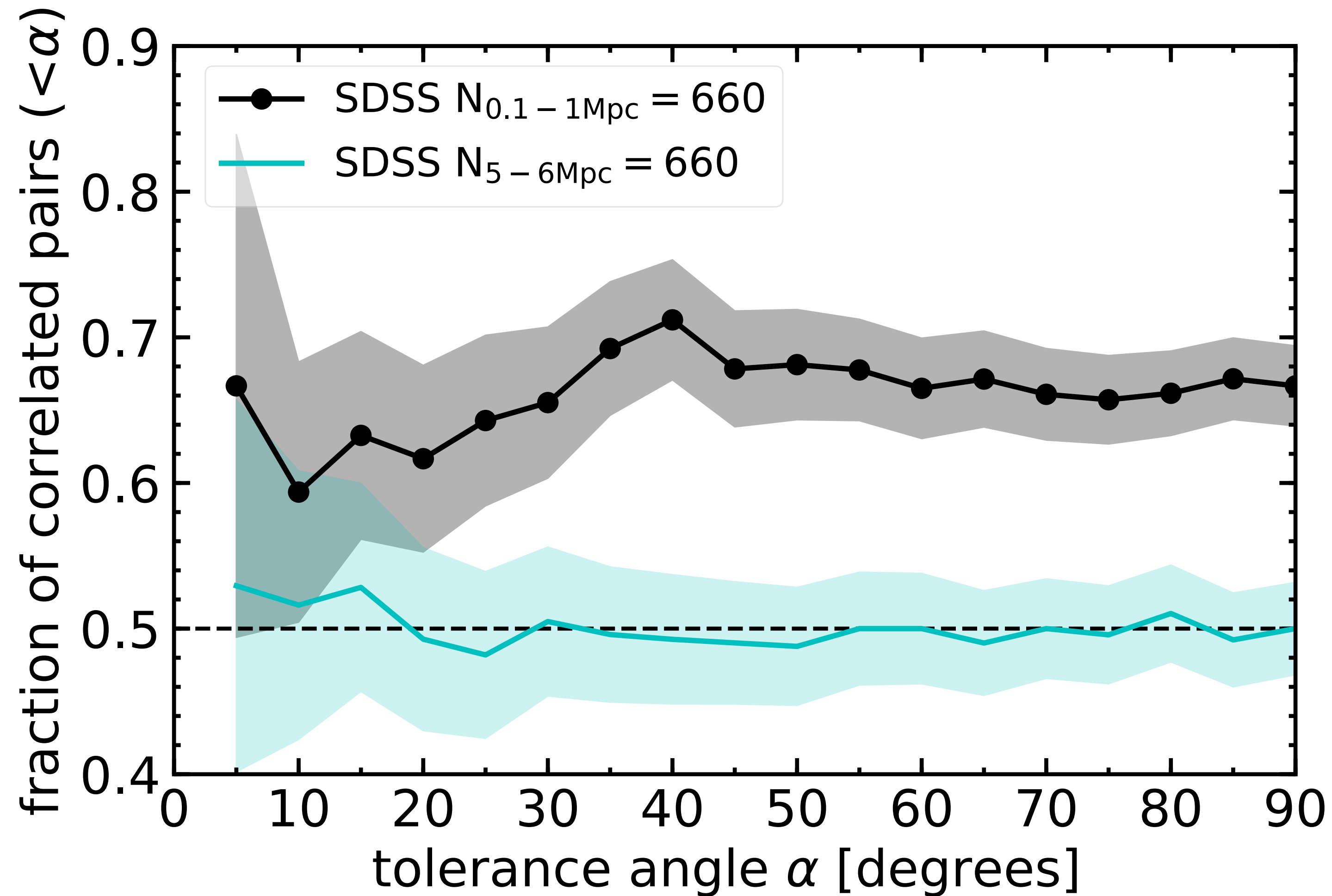# Velocity correlations of satellite pairs around massive galaxies

◉ **Comparison with simulations**

▶ There are $\sim 4\sigma$ discrepancies between SDSS with MS and TNG300.
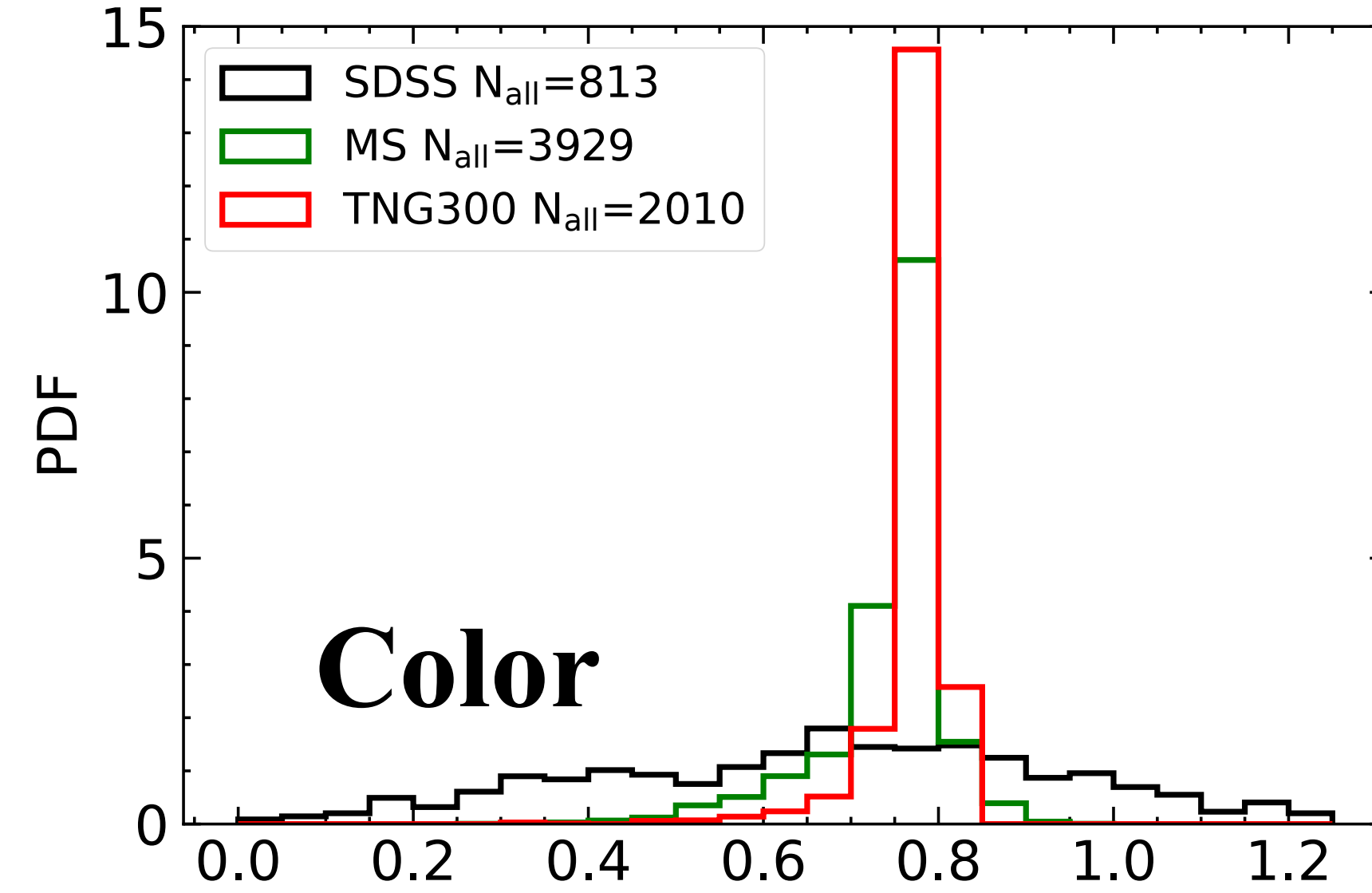
◎ **Comparison with neighbor galaxies**

▶ The neighbor galaxies have a near random distribution.

◉ **Physical properties of primaries and satellites**
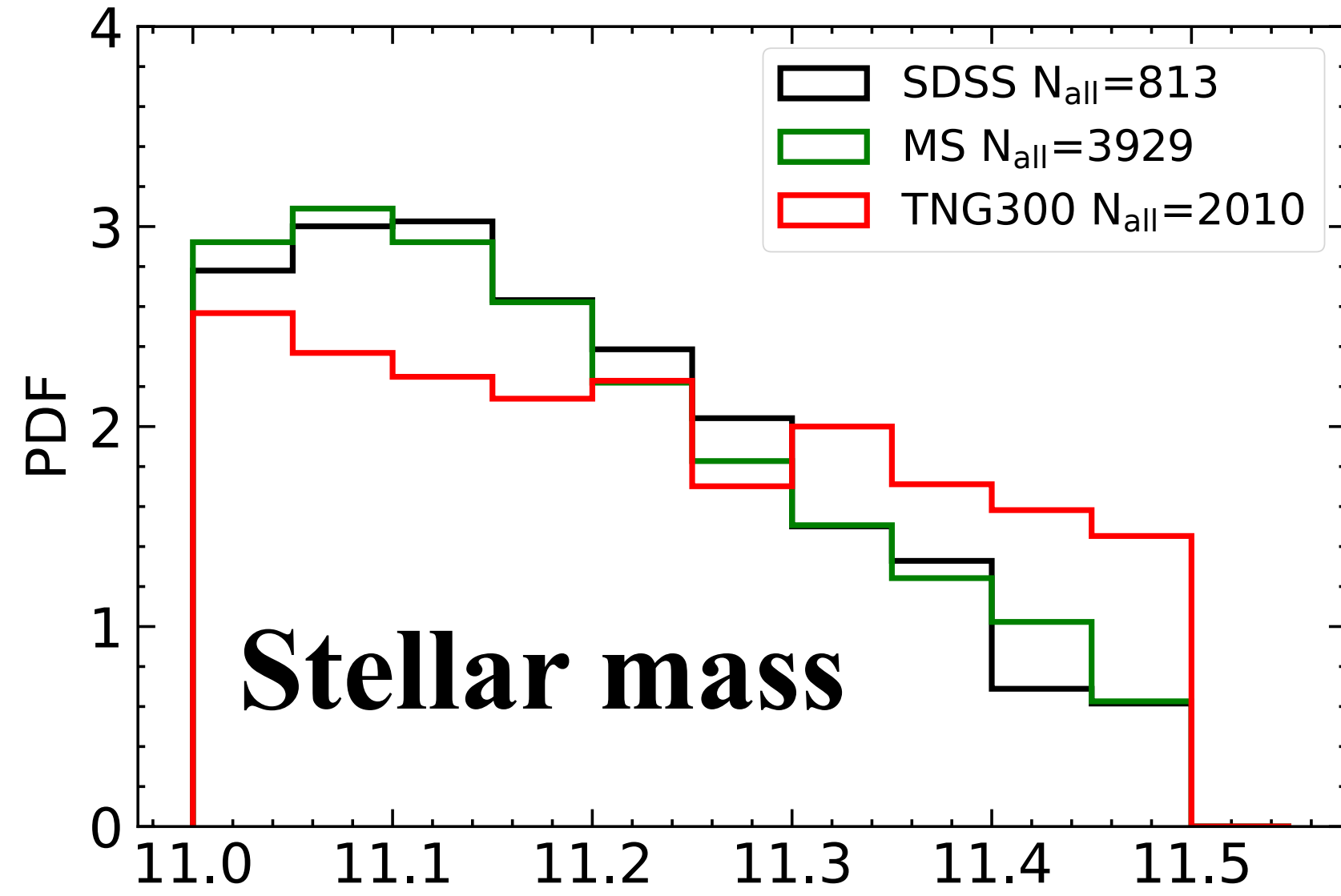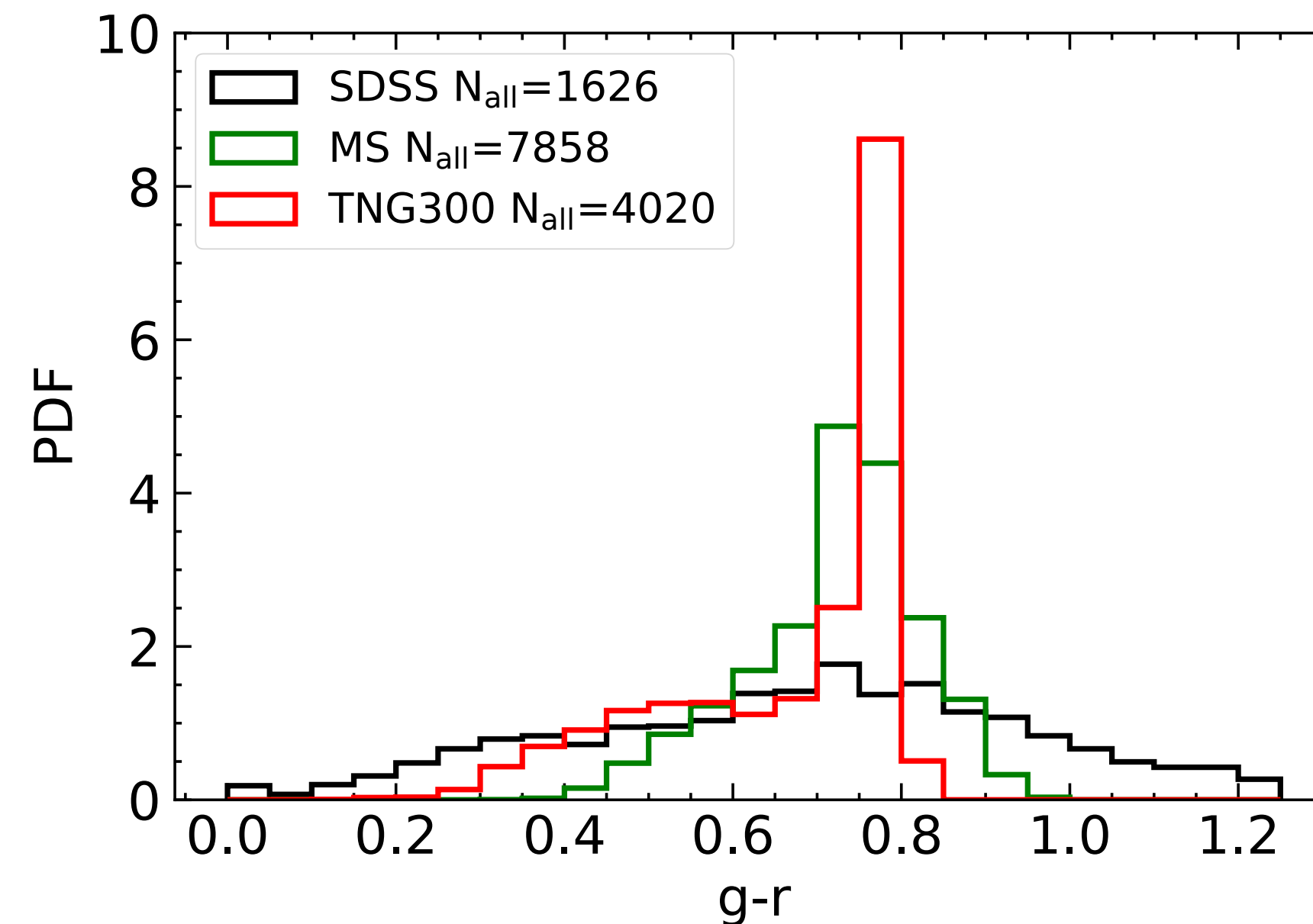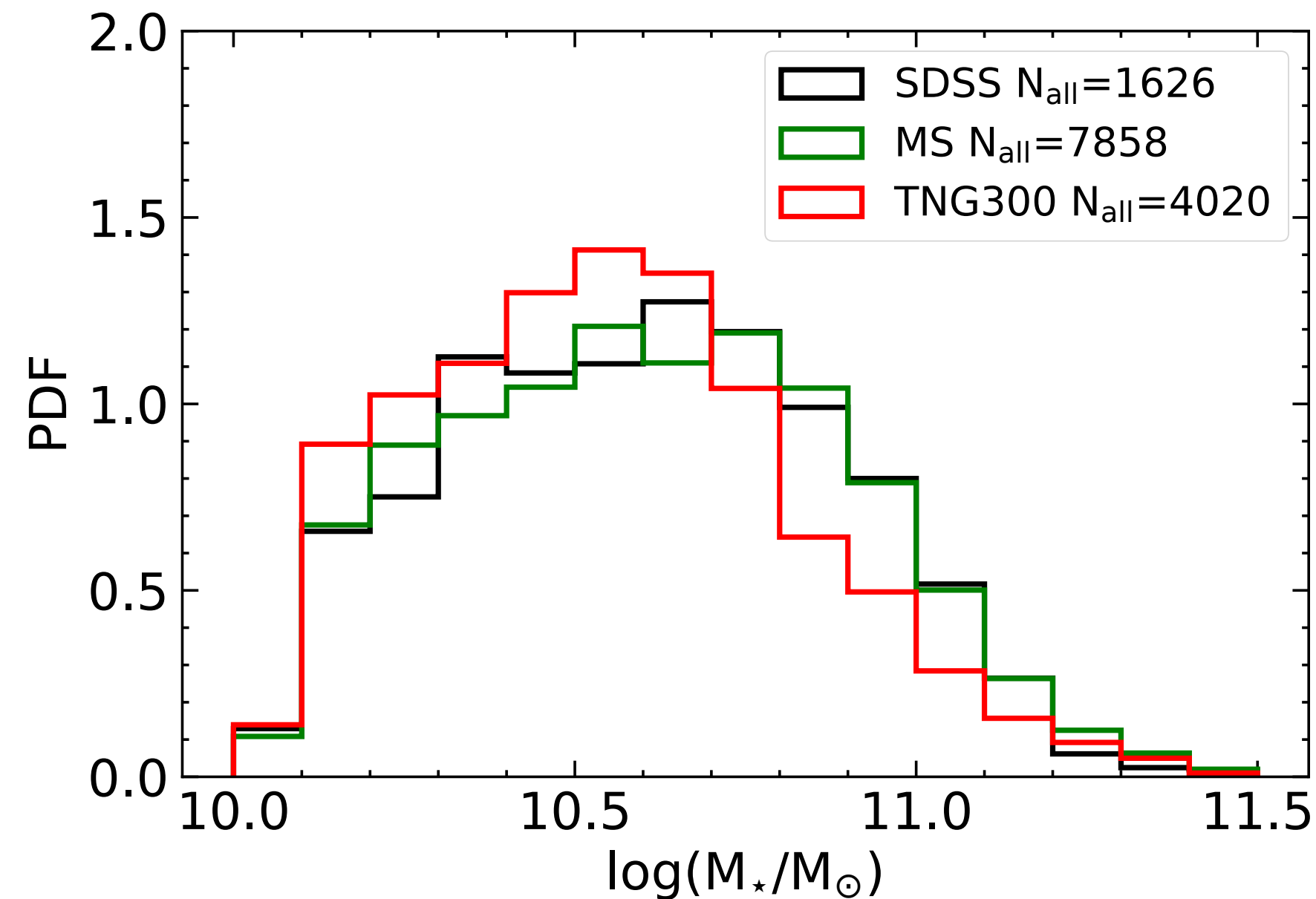
◉ **Toy model of possible drivers of the observed signal**

X-axis: non-zero velocity dispersion of central galaxy with respect to the DM halo.
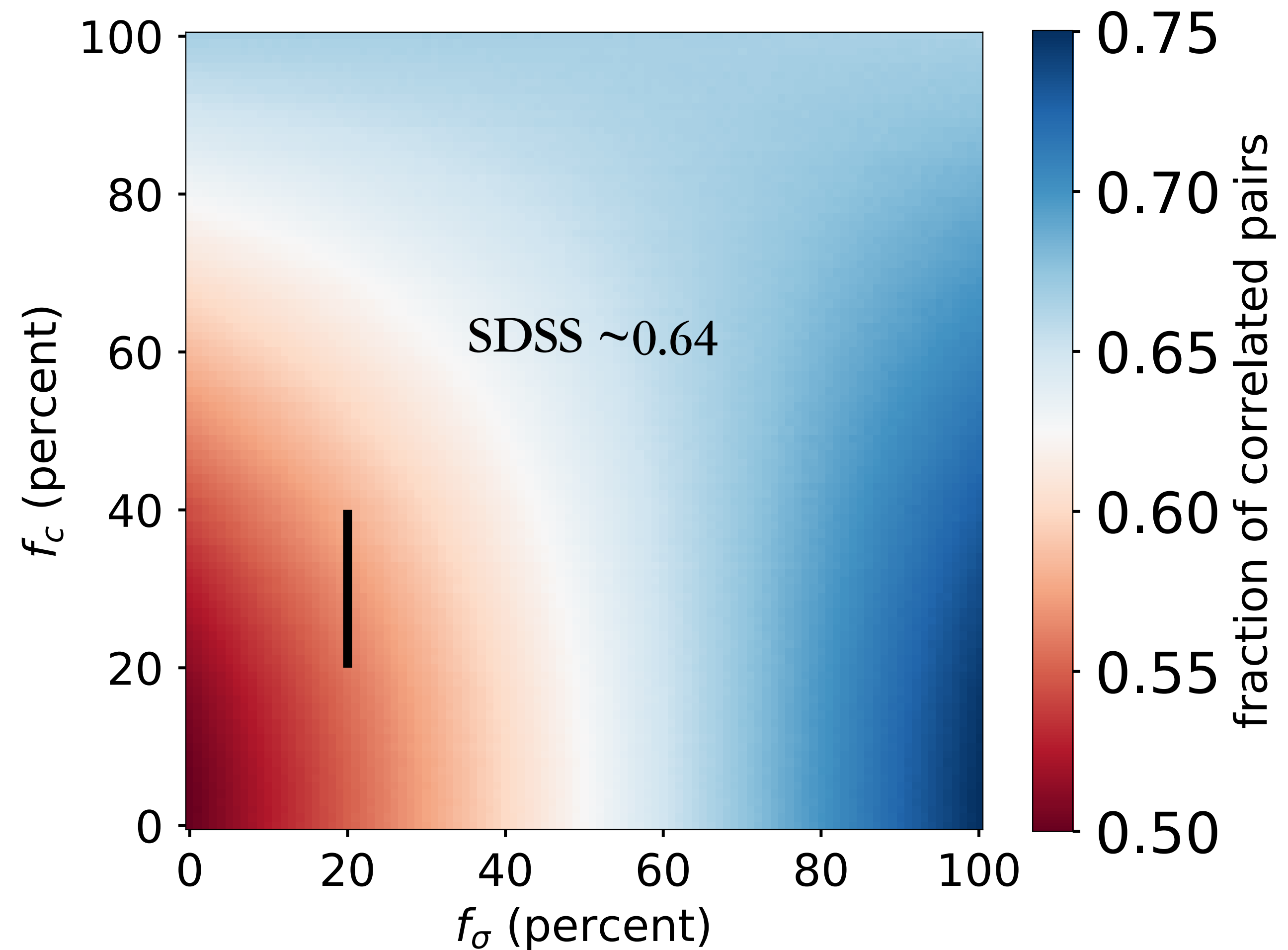
$$\sigma_{\text{cen}} = f_\sigma \sigma_{sat}$$

In simulation, $10^{13}\text{M}_\odot$ **halos:** $f_\sigma = 0.2$
(Ye et al. 2017)
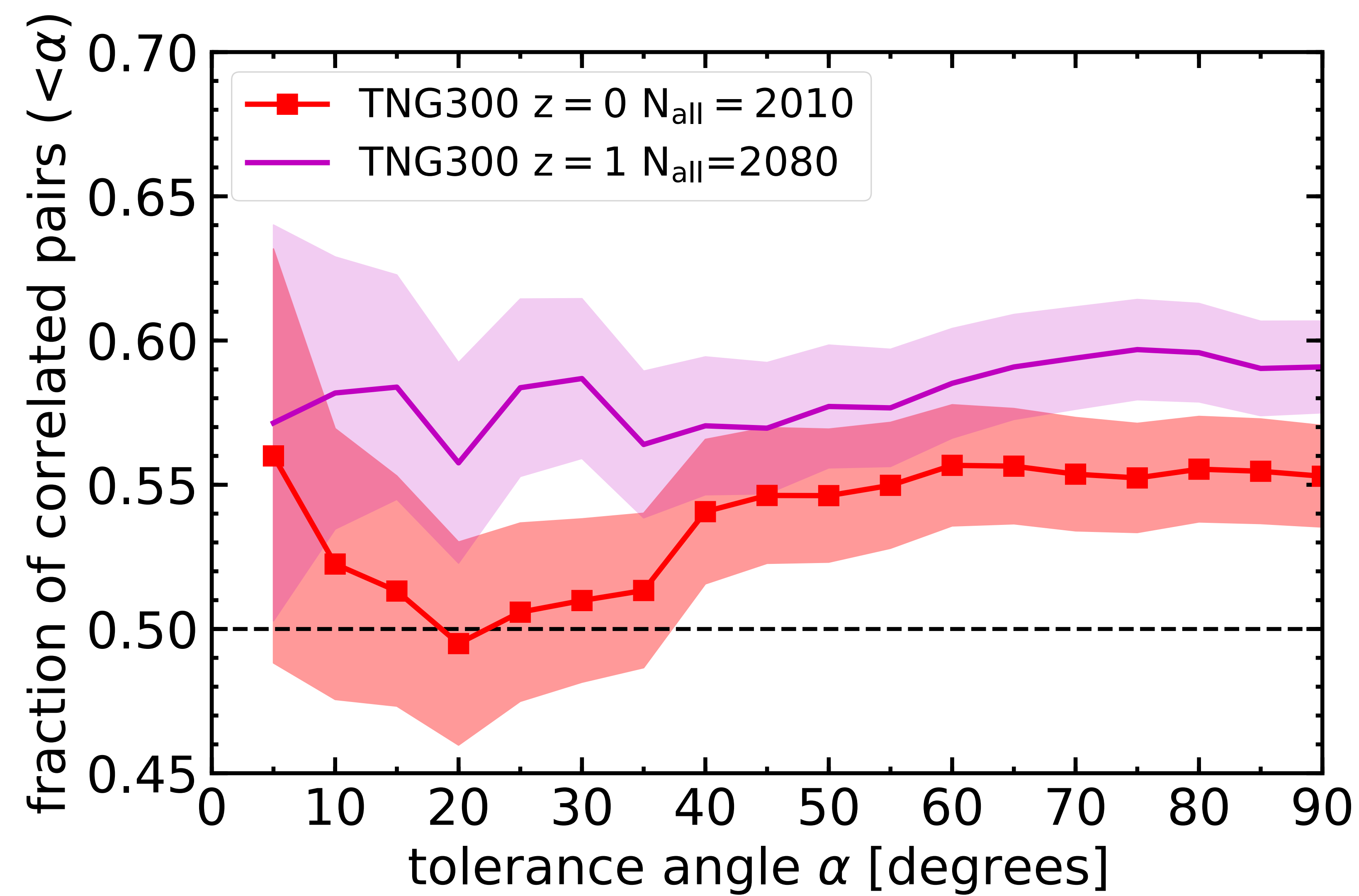
Y-axis: f_c of centrals are actually misidentified satellites

MS: $f_c = 0.27$; **TNG-300:** $f_c = 0.15$
In observation, $f_c = 0.2 \sim 0.4$
(Skibba et al. 2011)

SDSS ~0.64

◉ **Results at higher redshift in TNG300**

Summary

1. MS7 predicts both the observed radial profile and the ellipticity of the top 11 satellites.

2. Satellites in galaxy clusters are more anisotropic than that of MW analogs.

3. Satellite distributions are strongly aligned with the host halo and moderately aligned with the LSS. They are anisotropic accreted to the host halo.

4. In SDSS, the excess of correlated satellite pairs around isolated massive galaxies is higher in $\sim 4\sigma$ than those in Millennium and Illustris TNG300.

5. In simulation the sub-grid physics may need to be improved.

6. The observed systems may be younger than those predicted by the ΛCDM model with Planck cosmological parameters.

Thanks for your attention!