Galaxy and Mass Assembly (GAMA):

Probing galaxy-group correlations in redshift space with the halo streaming model

Cosmology from Home 2022

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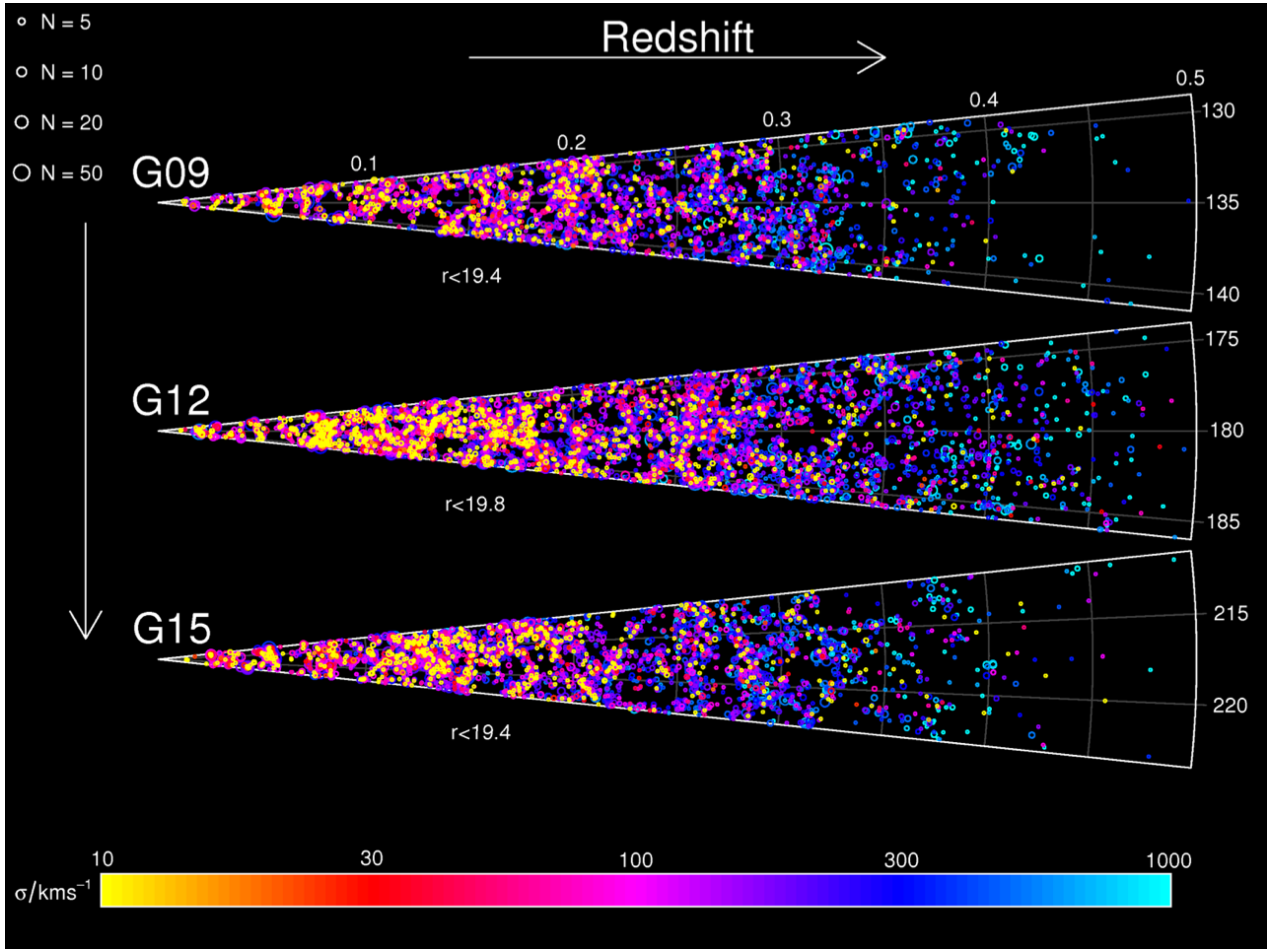
QH, John A. Peacock, Shadab Alam, Yan-Chuan Cai, Katarina Kraljic et al. (2022) [arXiv: 2206.05065]

The GAMA survey

Spectroscopic survey with 98.5% completeness

- Area of each field: 12 x 5 deg^2
- Magnitude limit: r < 19.8
- FoF groups with >= 2 members
- Redshift selection: [0.1, 0.3]

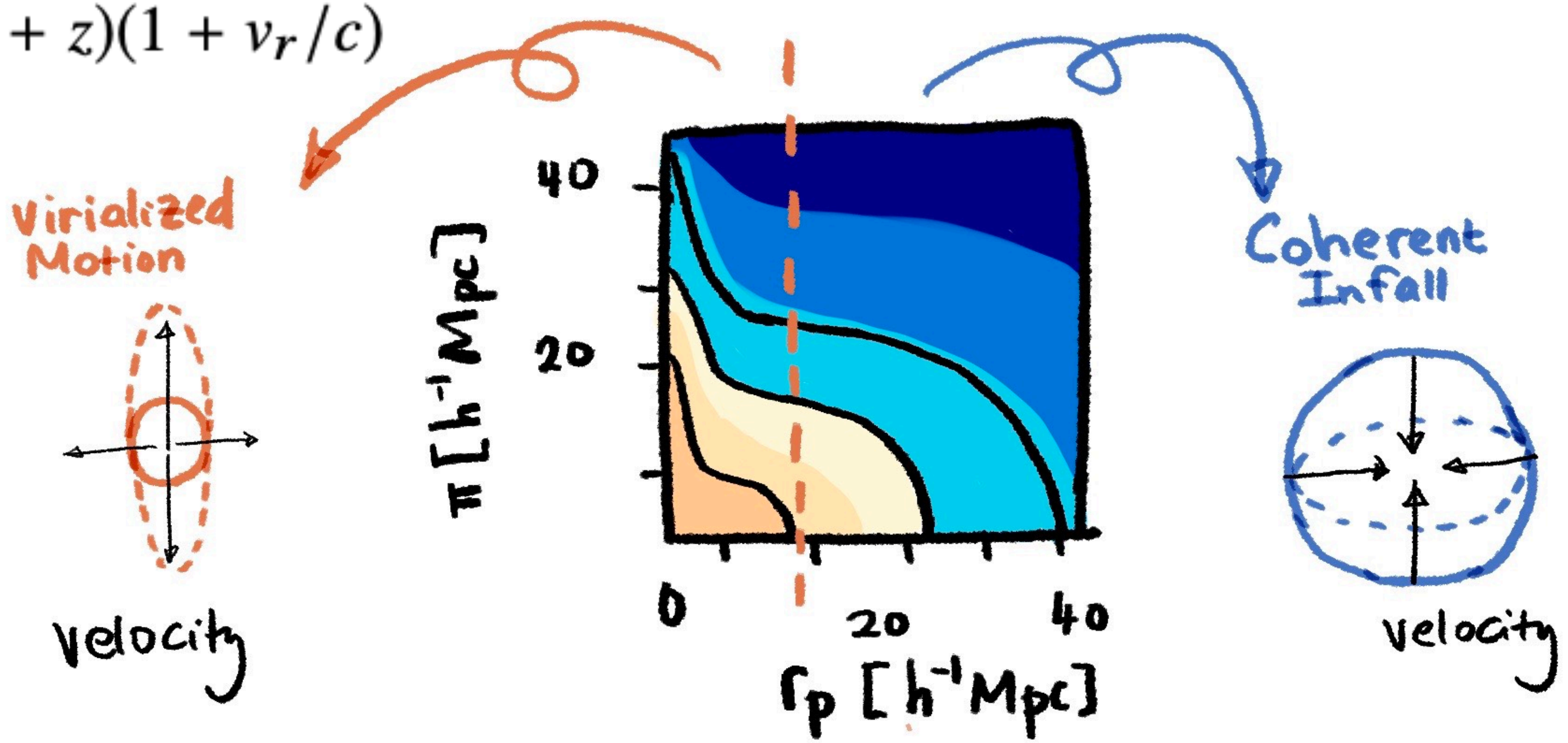


The three equatorial GAMA fields: G09, G12, and G15. The circles represent galaxy groups found in the survey.

Redshift-Space Distortion (RSD)

Test of theory of gravity

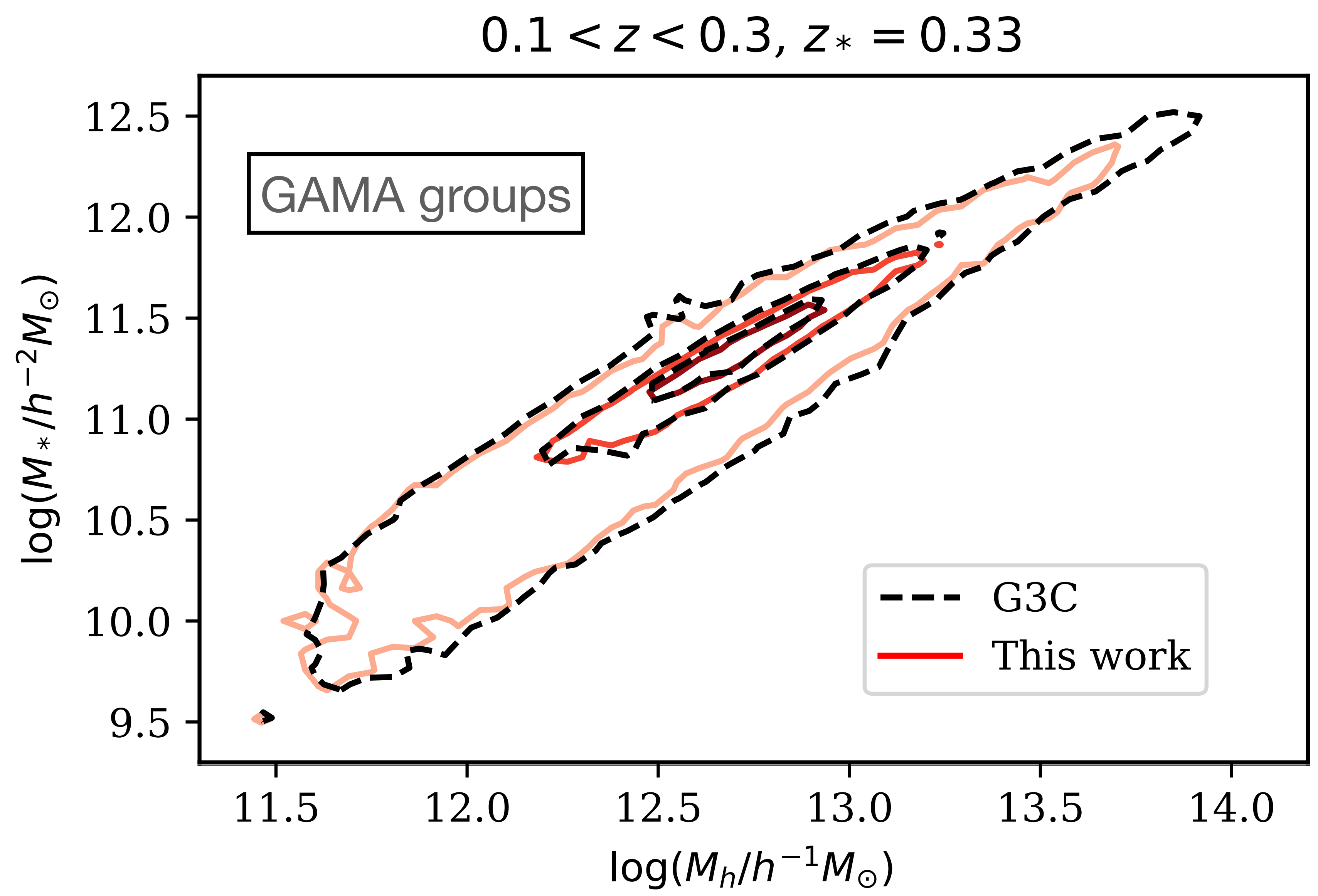
- Peculiar velocities: $1 + z \rightarrow (1 + z)(1 + v_r/c)$
- Large scale: infall velocity "*Kaiser Squashing*"
- Small scale: virial velocity "*Fingers of God*"
- RSD sensitive to the growth rate $f\sigma_8$; a test of GR

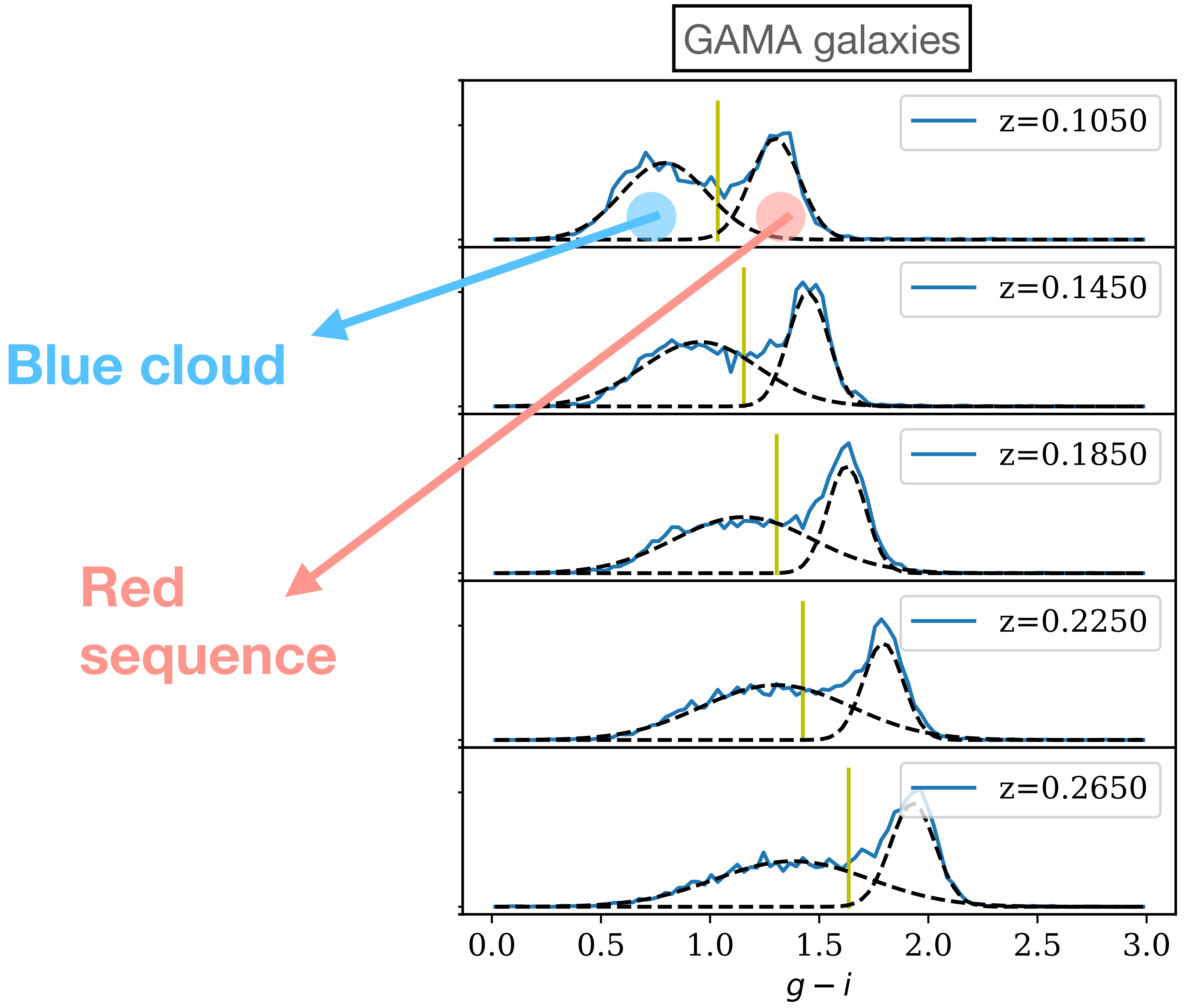


One quadrant of the 2-point correlation function measured along and perpendicular to the line of sight

Split the density field

- Typical group stellar mass: $\log(M_*/h^{-2}M_\odot) = [9.5 - 12.5]$
- 3 stellar mass bins: lower 40% (LM), median 50% (MM), higher 10% (HM)
- Red and blue galaxies: redshift-dependent cut in the apparent *g* - *i* colour



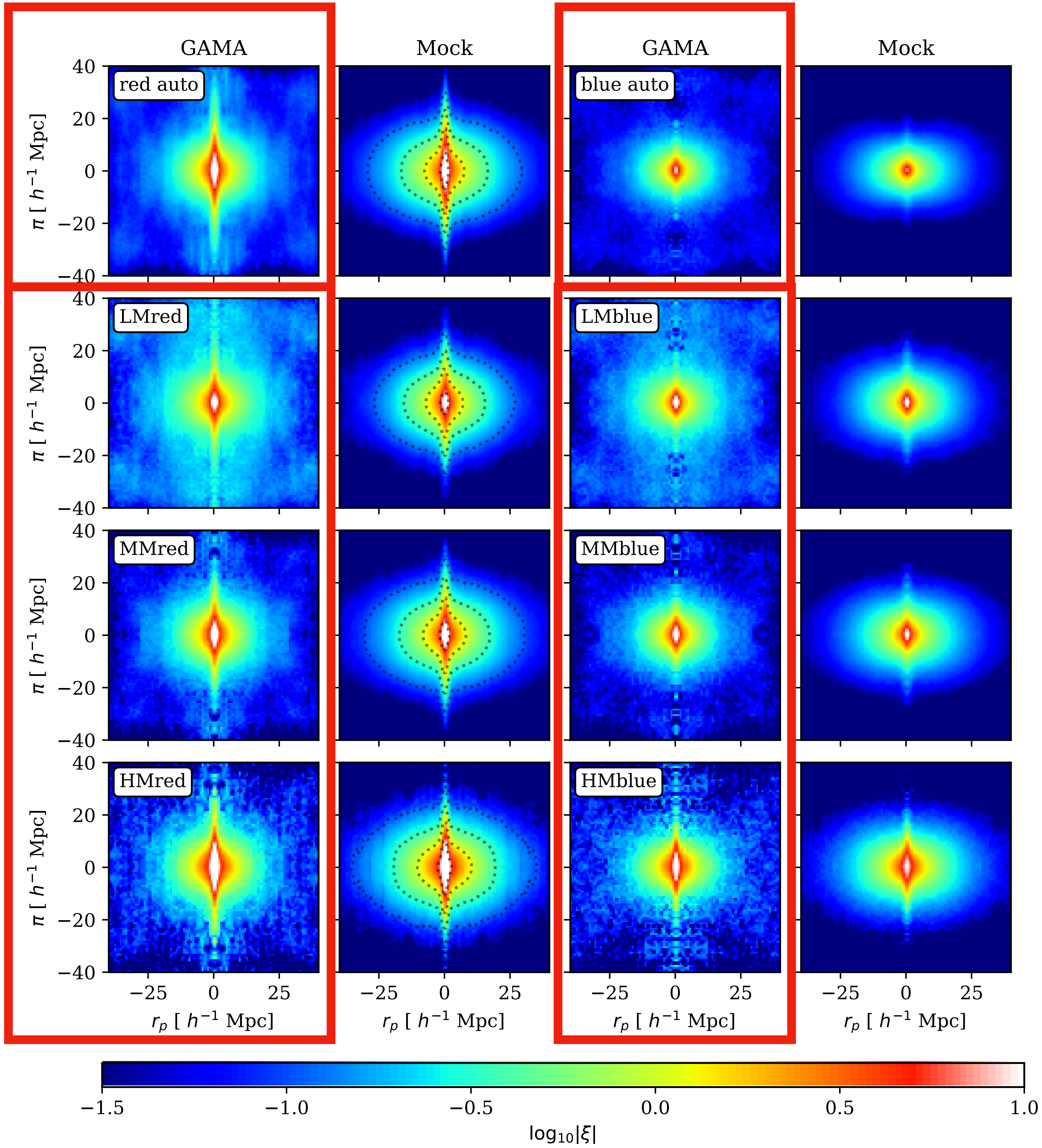


Measurements of the 2-pt correlation function

- Davis-Peebles estimator:

$$\langle \xi \rangle = \frac{D_{\rm gal} D_{\rm grp}}{R_{\rm gal} D_{\rm grp}} - 1$$

- Difference in red vs blue goes away in cross-correlations
- Larger FoG in red galaxies and for higher mass groups
- Small scale feature varies with the sample largely



Modelling RSD

The quasi-linear dispersion (QD) model

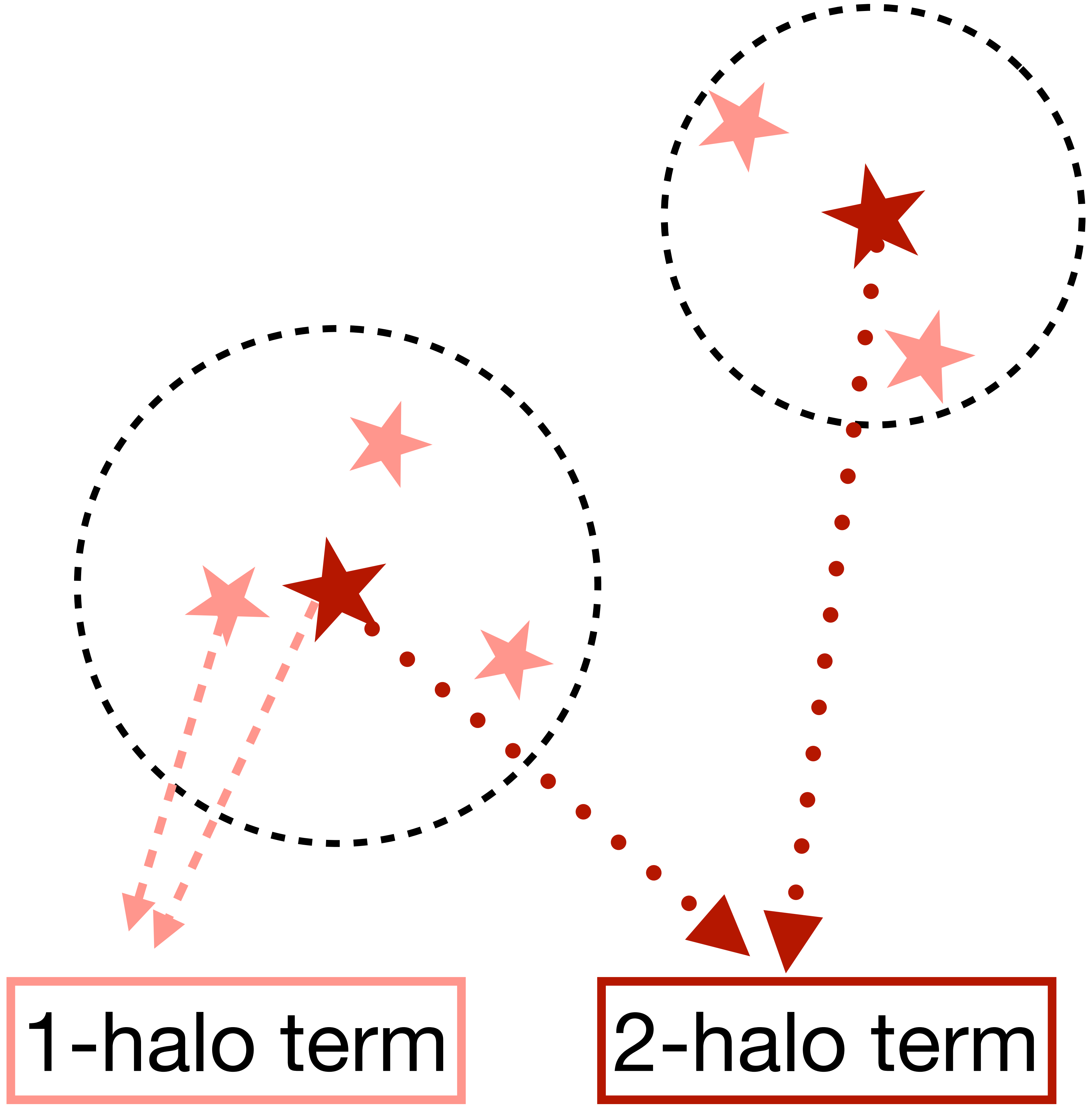
- Kaiser linear: $P(k,\mu) = (1+\beta_{\mathrm{grp}}\mu^2)(1+\beta_{\mathrm{gal}}\mu^2)P_{\mathrm{nl}}(k)$
  - μ: cosine angle with respect to the line of sight.
  - Distortion parameter: $\beta_i = f/b_i$
- FoG - Lorentzian velocity profile damping: $D(k\mu) = [1+(k\mu\sigma_{12})^2/2]^{-1}$
  - σ_{12}: velocity dispersion

The quasi-linear model fails at scales $\leq 10 - 20h^{-1}\mathrm{Mpc}$.

Modelling RSD

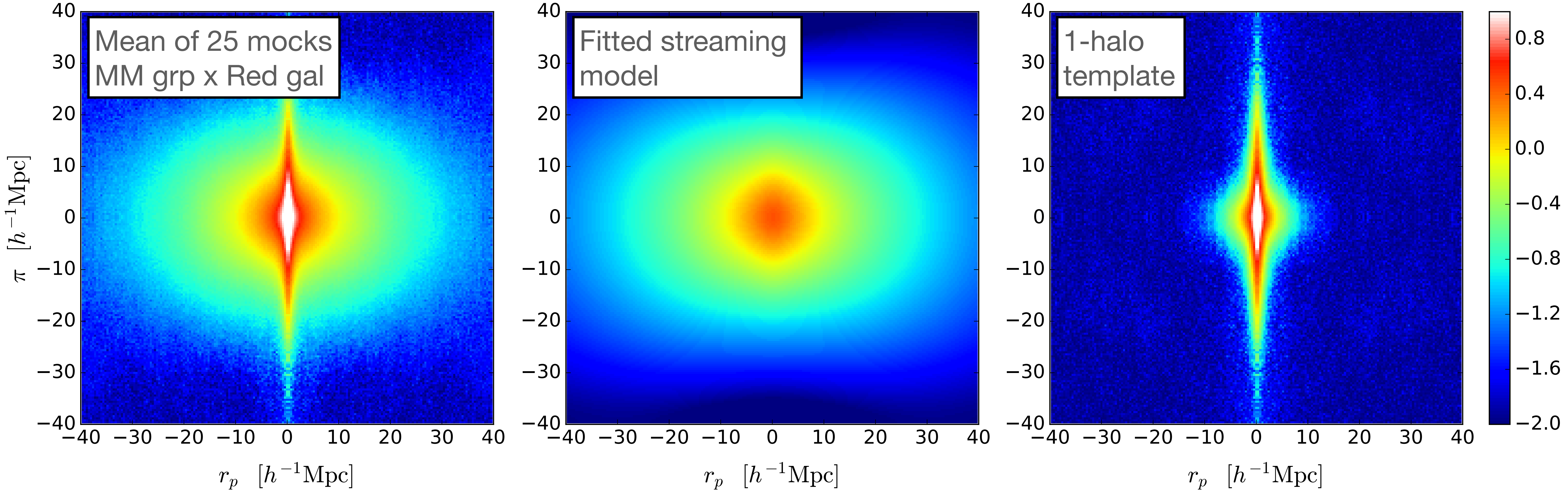
The halo streaming (HS) model: 1-halo and 2-halo split

- **2-halo term**: streaming model - an extension to the quasi-linear regime
- **1-halo term**: in real space, this could take the form of e.g. NFW profile; more complicated in redshift space
- The two terms also require different velocity dispersions



Modelling RSD

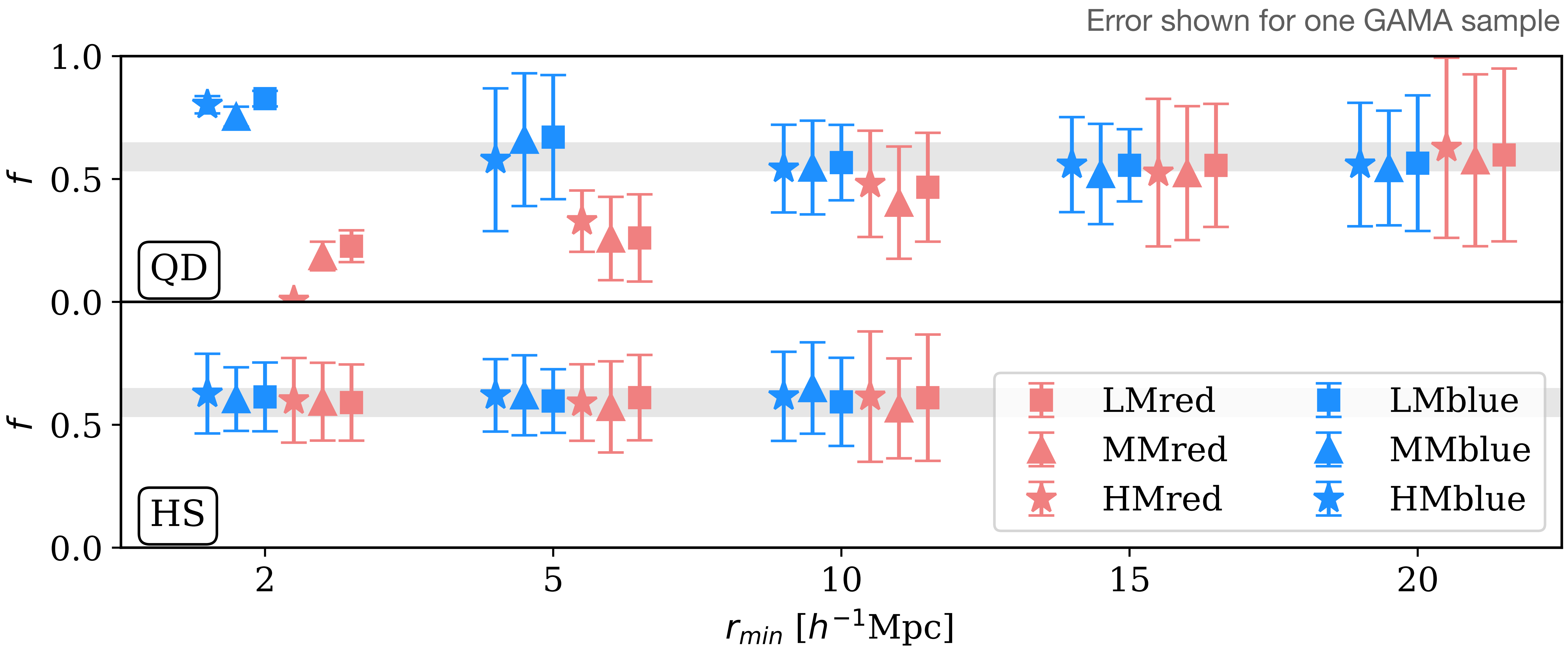
HS model: the 1-halo template



- In practice, we extract the 1-halo term from the mock catalogue as a template
- 2 nuisance parameters (α, η): adjust amplitude and scale along line of sight

Model validation

25 semi-analytic mock catalogue



Mean growth rate (fixed σ_8): the HS model consistent with the fiducial value down to minimum scale of $2h^{-1}\mathrm{Mpc}$.

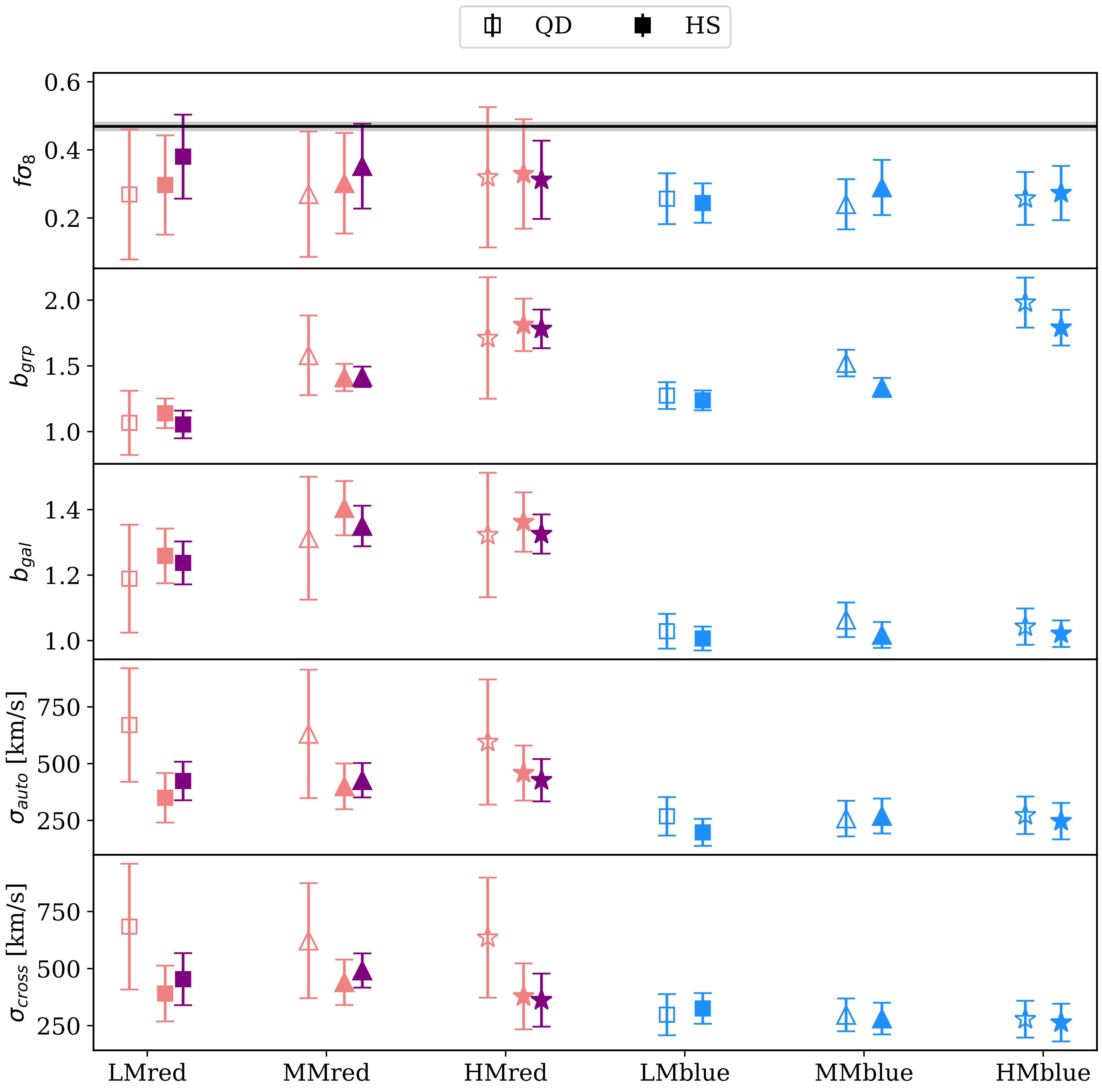
Growth rate measurements from GAMA

- Combining all subsets:
  $f\sigma_8(z = 0.2) = 0.29 \pm 0.10$
  using WMAP 7 cosmology

- Lower than Planck by 1.8σ

- Other parameters are in qualitative agreement with other GAMA studies

- Nuisance parameters marginalised over



Discussion

- Other GAMA measurements: $f\sigma_8(z = 0.18) = 0.36 \pm 0.09$ (Blake et al. 2013), also lower than Planck;
  - GAMA fields have a substantial dip at $z \approx 0.24$, a local LSS?
- In light of the recent σ_8 tension in lensing: a reduction of 10%
  - Our result is 1.3σ away from the revised fiducial value of 0.42

Looking into the future:

Surveys such as DESI BGS and WAVES will be able to tell us more!

Summary and Outlook

Real Space	Redshift Space
	

- We measured group-galaxy cross-correlation in 6 subsets from GAMA
- We develop an empirical model: Halo streaming model to disentangle the strong FoG and the linear RSD effects
- Nominal growth rate is $f\sigma_8(z=0.2) = 0.29 \pm 0.10$, consistent across all subsets and slightly lower than Planck
- DESI BGS and WAVES survey will provide tighter constraints on the growth rate.
- May be able to shed light on the σ_8 tension from a different angle