Probing masses of SZ-detected clusters using clustering signatures

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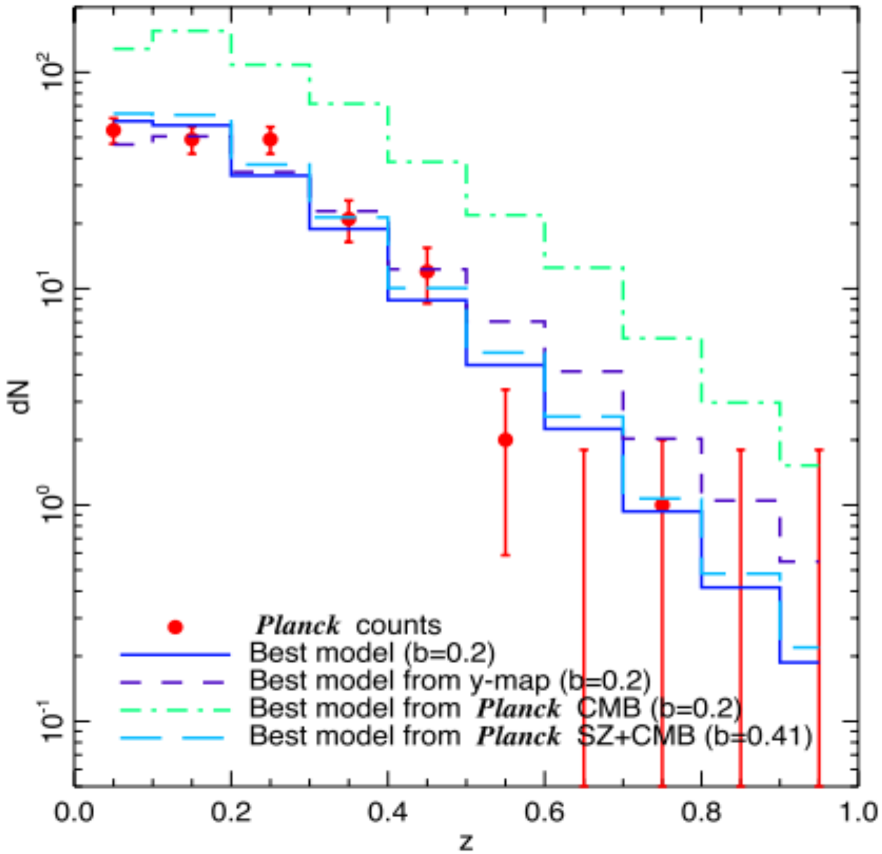
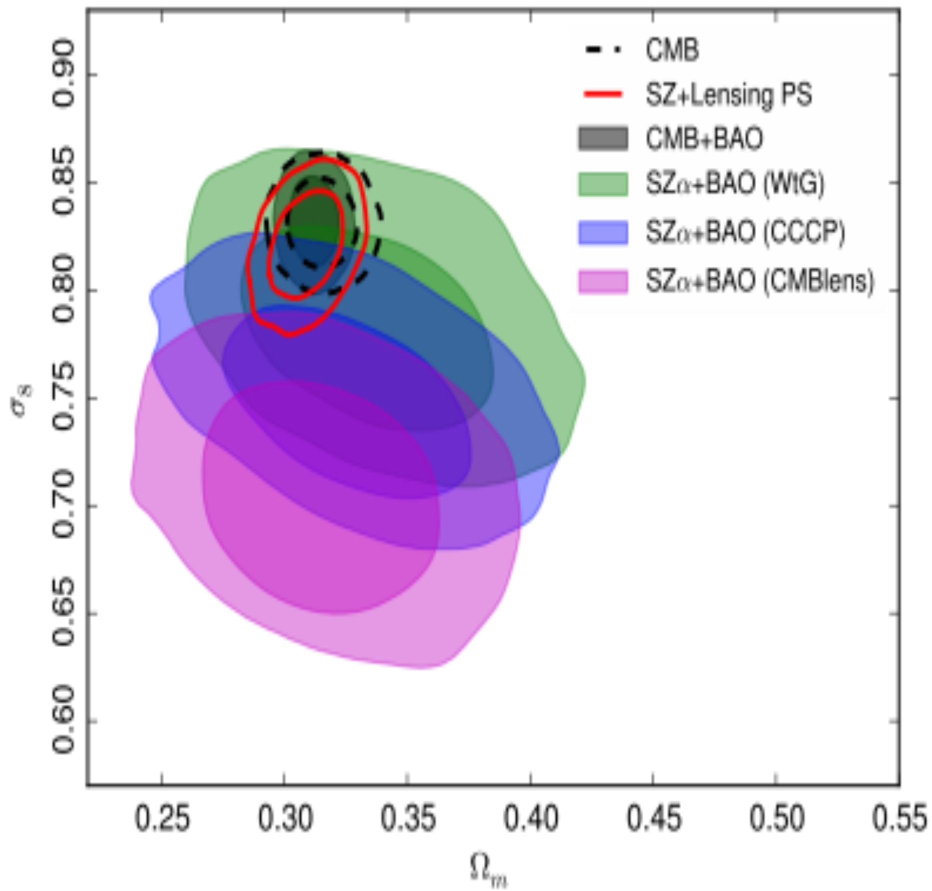
Tension in Planck cluster count - CMB

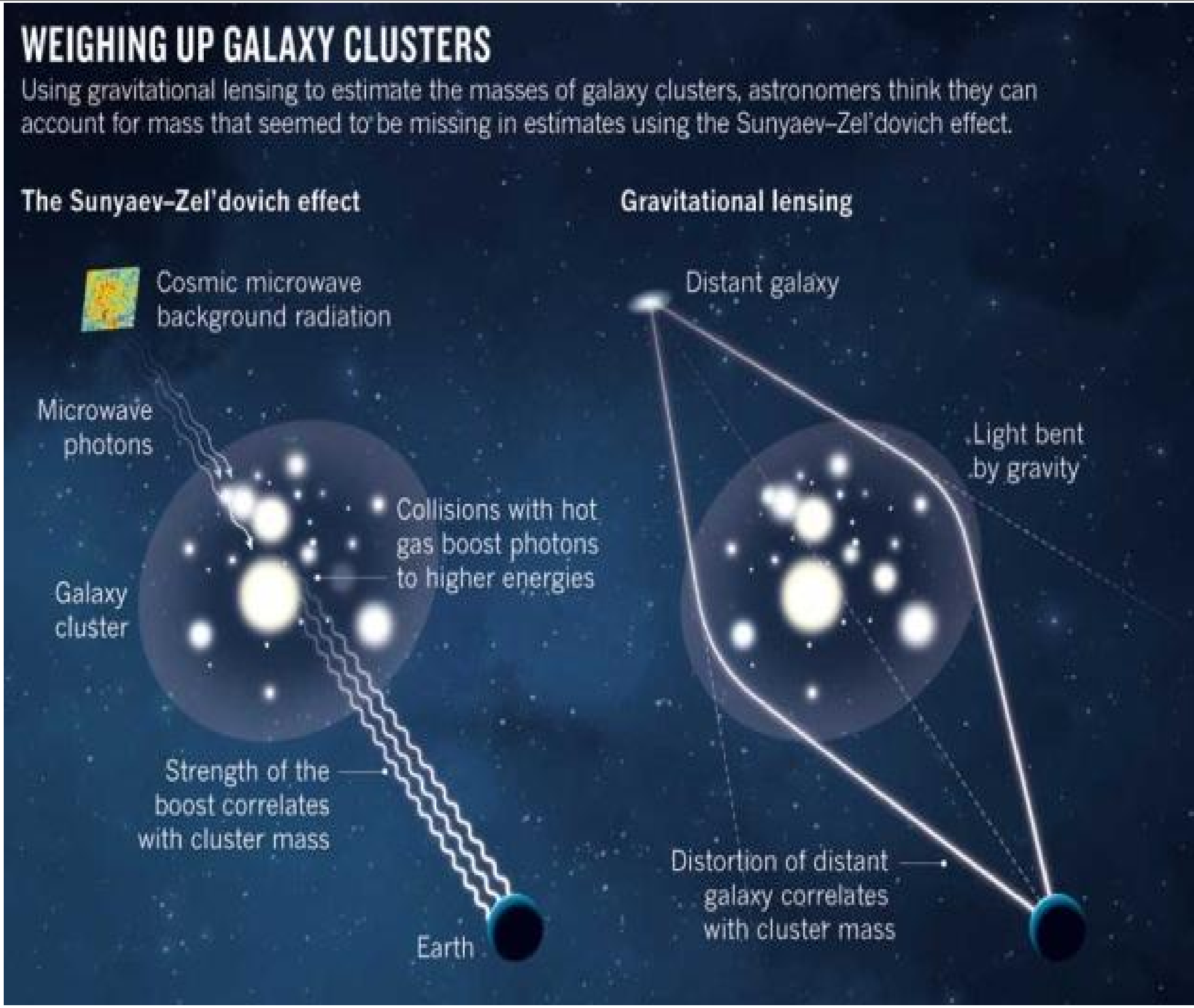




Planck Collab.13 XX, Planck Collab.15 XXIV

Lensing studies show SZ masses under estimated

- Weak lensing studies such as Clash, WtG and CCCP show on average ~ 30-40% higher masses than those estimated through SZ
- Indicating that the problem is in estimating the mass of the clusters



von der Linden et al. 2014..

Clustering(TPCF) signal as mass Probe

- ➢ Clumpiness as function of separation
- ➢ For four cluster samples of increasing richness (mass)- using photometric redshift

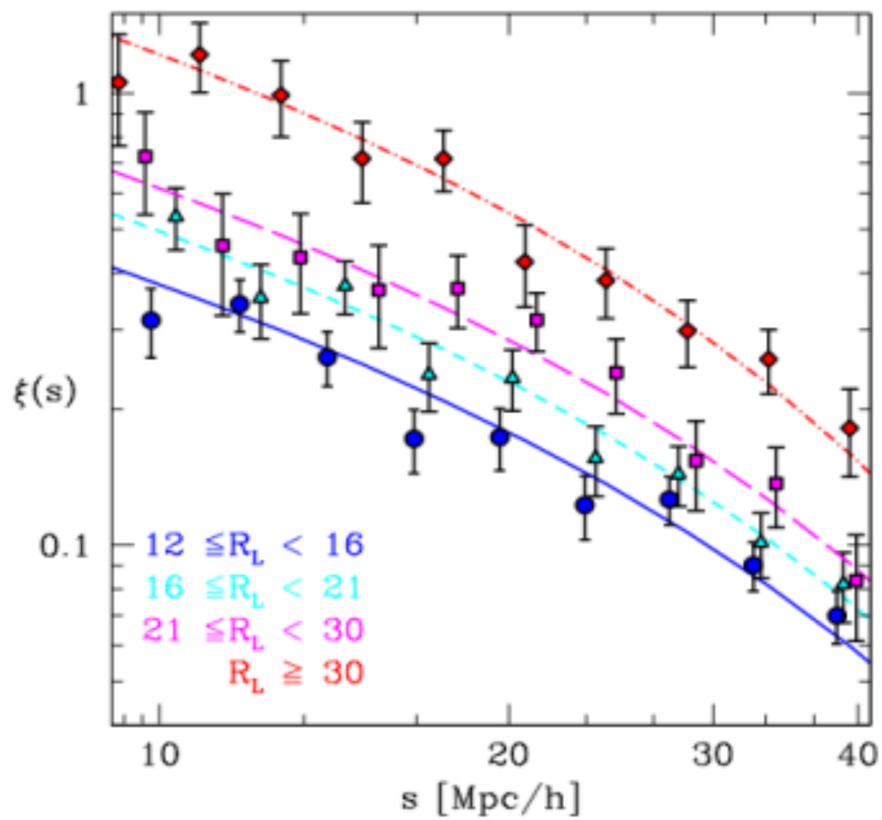


Figure 7. The redshift-space two-point correlation function of the four richness-selected cluster samples (dots), compared to the best-fit model obtained with Eq. (20, lines). The blue, magenta, purple, and red colour codes refer to the $12 \leqslant R_{L_*} < 16$, $16 \leqslant R_{L_*} < 21$, $21 \leqslant R_{L_*} < 30$, and $R_{L_*} > 30$, respectively. The error bars show the square roots of the diagonal elements of the covariance matrix.

Sereno et al.(2015)

Clustering signal, Dark Matter & the Halo Bias

Galaxy cluster: tracing DM

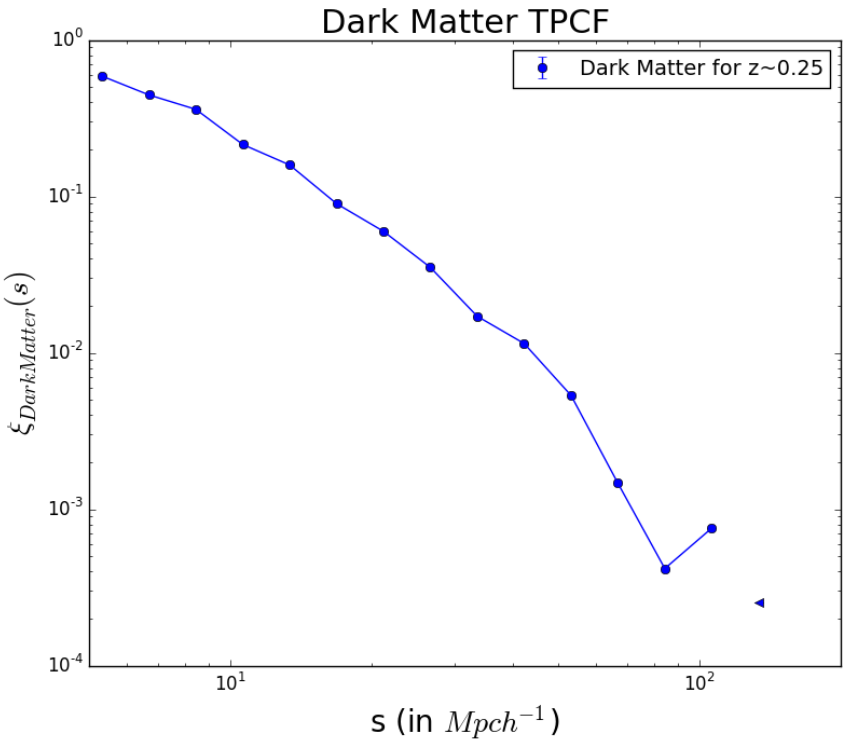
- We know the power spectrum of DM from LCDM (*CAMB*)

$$\xi(r) = \frac{1}{2\pi^2}\int \mathrm{d}k\, k^2 P(k) \frac{\sin(kr)}{kr}.$$

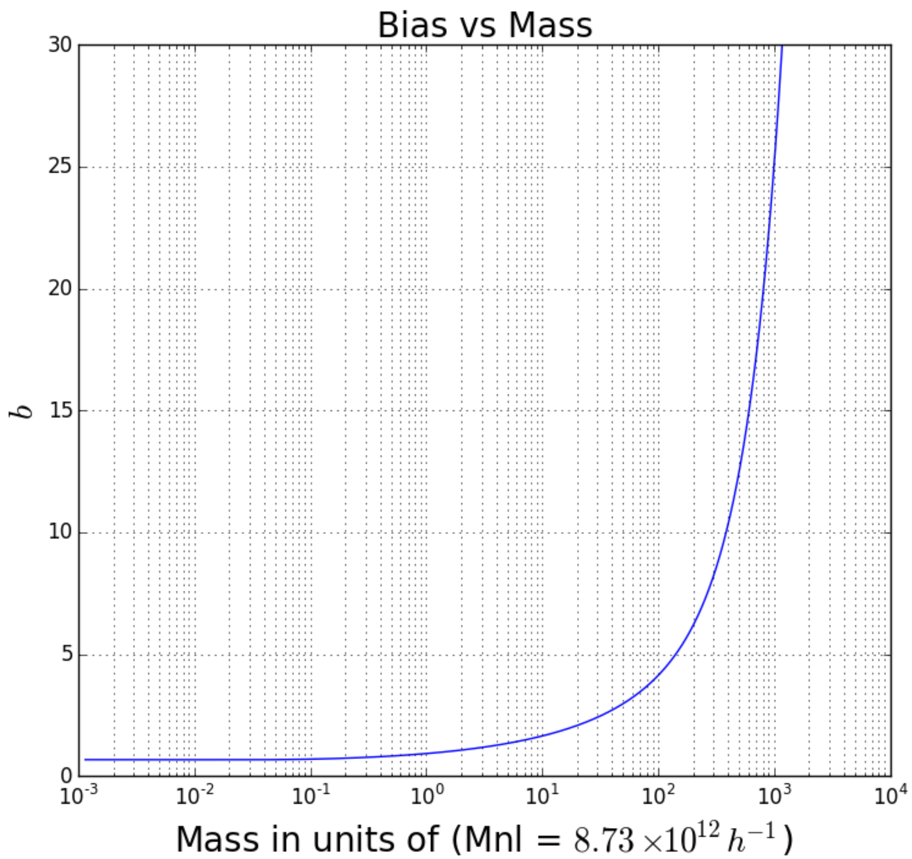
- Relationship of the clustering signals and Halo bias

$$b = (\xi_{\rm gal}/\xi_{\rm dark\ \ matter})^{1/2}$$

(*not the same as b in Planck papers!*)



Fitting Function from Simulation



$$b_0(x = M/M_{\rm nl}) = 0.53 + 0.39x^{0.45} + \frac{0.13}{40x+1} + 5 \times 10^{-4} x^{1.5}.$$

Seljak & Warren 2004

Estimating the Correlation Function:

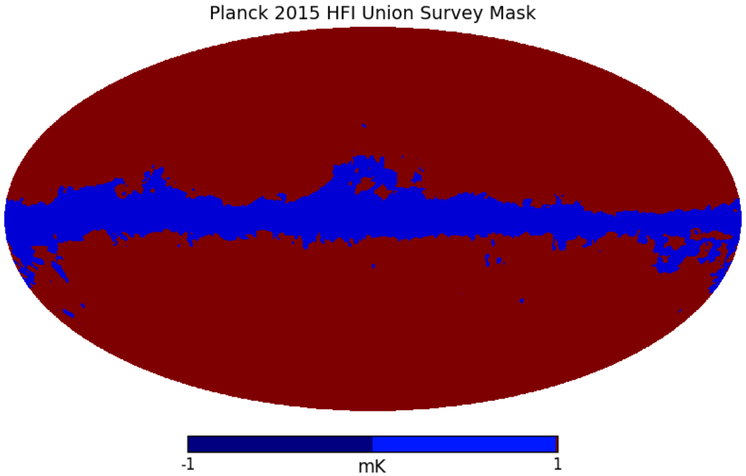
Used the Landy-Szalay estimator:

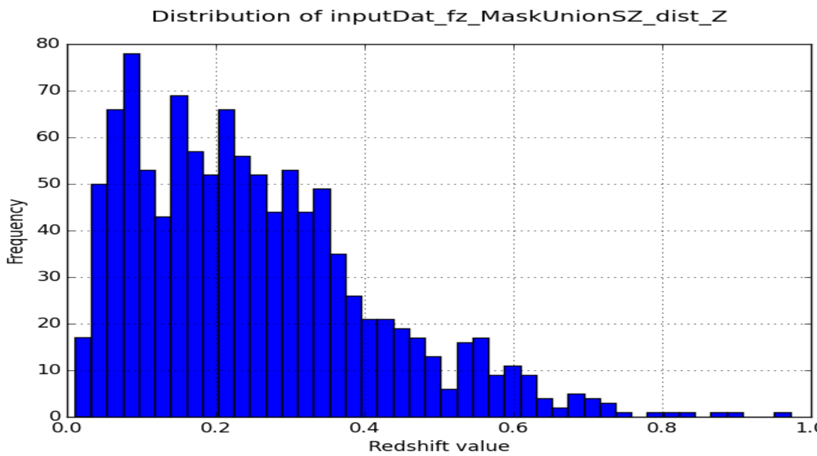
$$\xi(s) = \frac{1}{RR(s)} \times \left[DD(s)\frac{n_{\rm r}^2}{n_{\rm d}^2} - 2DR(s)\frac{n_{\rm r}}{n_{\rm d}} + RR(s) \right]$$

Need to generate random fields in the data regions:

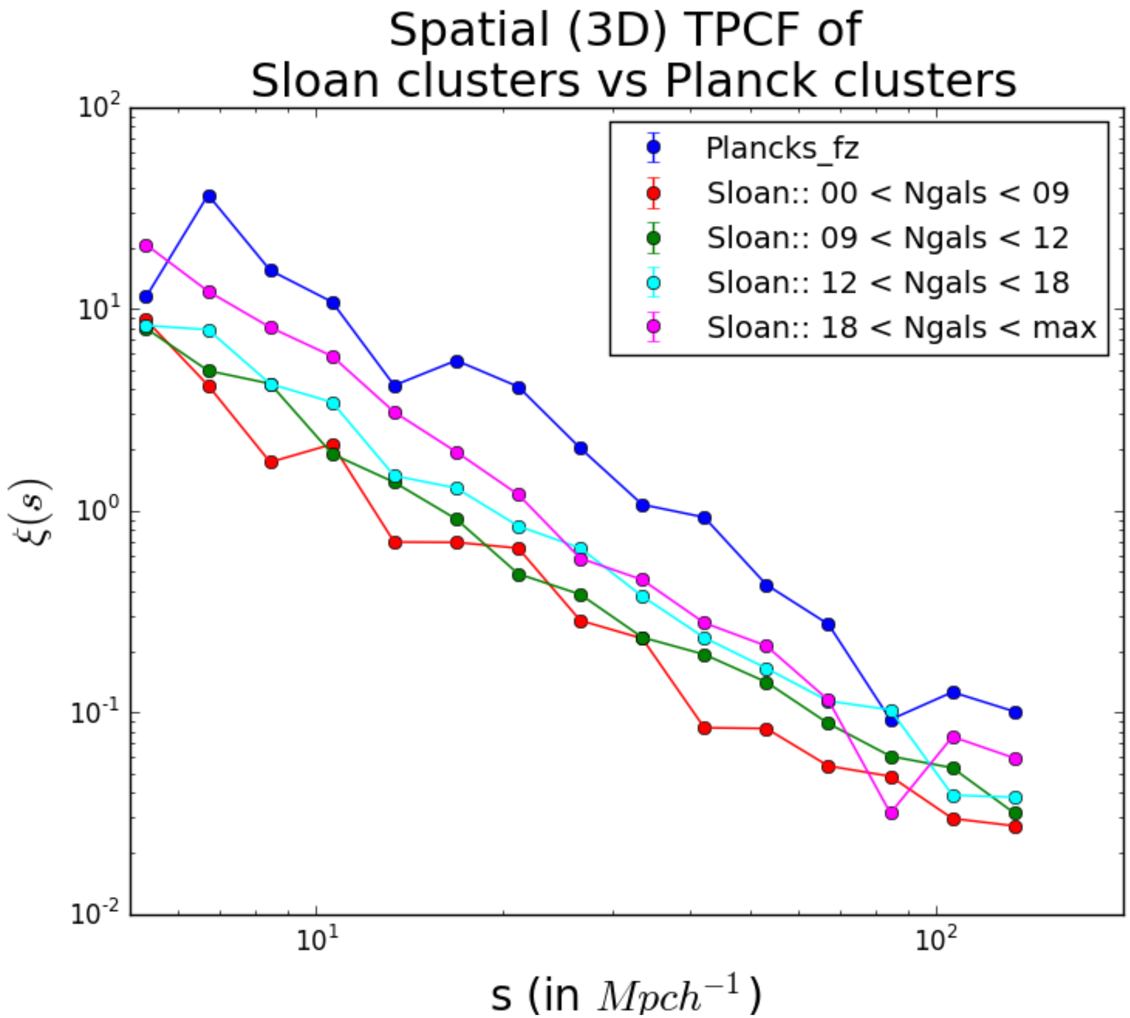
- For Planck used masks at PLA
- For SDSS used contiguous subsample of data with *180<RA<220 and 20<dec<60*

- Random redshifts obtained using same distribution of the catalog



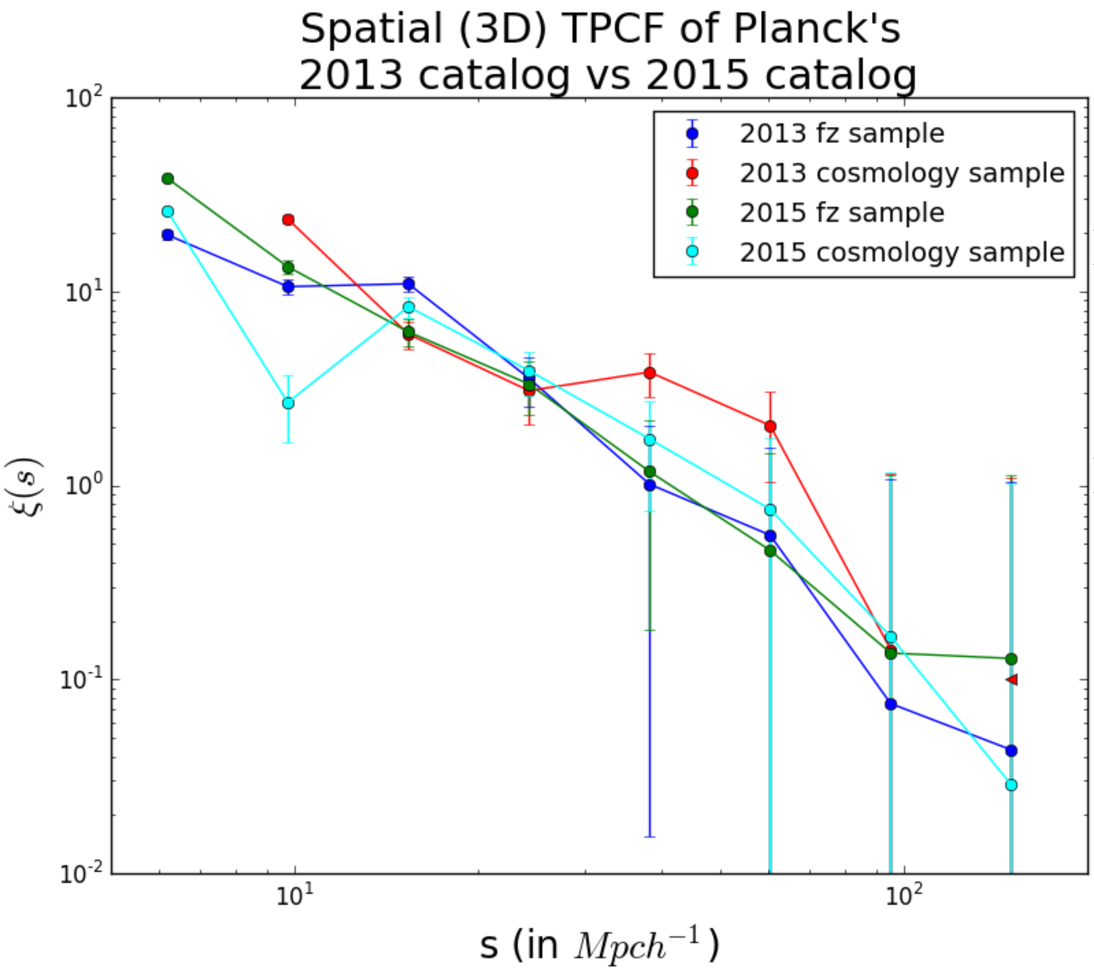


Comparing clustering of Planck vs Sloan



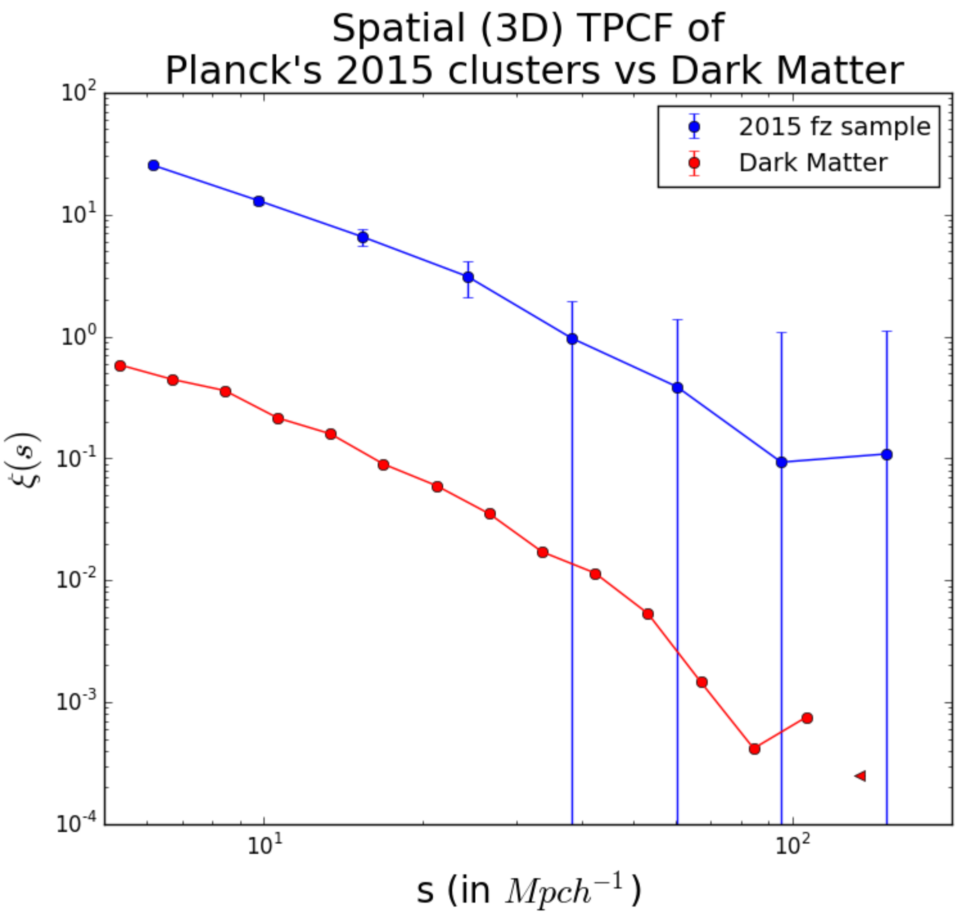
- Used clusters with confirmed redshift
  - Spectroscopic redshifts for sloan GMBCG(DR8)
- Higher clustering signal for Planck clusters

Comparing full/cosmology and 2013/15 samples



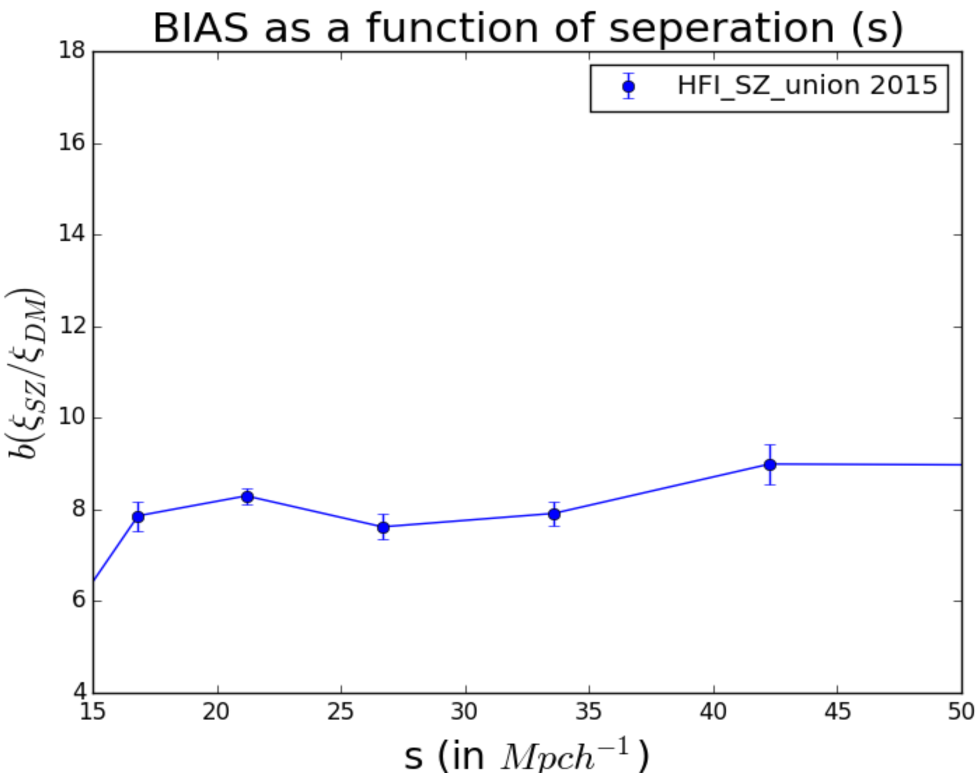
- Signal is similar in the samples
- Although slight indication of strong clustering in 2013 sample

Comparing clustering of Planck vs DM



- ➢ Significant offset in the clustering of the Planck clusters relative to that of the expected Dark matter

Bias and Inferred Mass



$$b = (\xi_{\rm gal}/\xi_{\rm dark\ \ matter})^{1/2}$$

Estimate bias ~ 8

Applying Seljak-Warren relation:

we get an average mass of clusters ~ 2.5 x10^{15} solar masses!

But, Why so high?

Preliminary

Still Investigating...

- The clustering signal indicates that the Planck SZ clusters are significantly more massive than predicted by SZ signature.

- However, we are still investigating:
  - Other estimates of bias-mass relation
  - bias evolution with redshift
  - assembly bias (eg. *Miyatake et al. 2015*)
  - SZ cluster selection correlated with line-of-sight structure? (eg *Kosyra et al. 2015*)
  - Other selection effects? (*At Least we know there is no correlation of cluster positions with Planck noise or galactic latitude*)

Other estimates of bias-mass relation

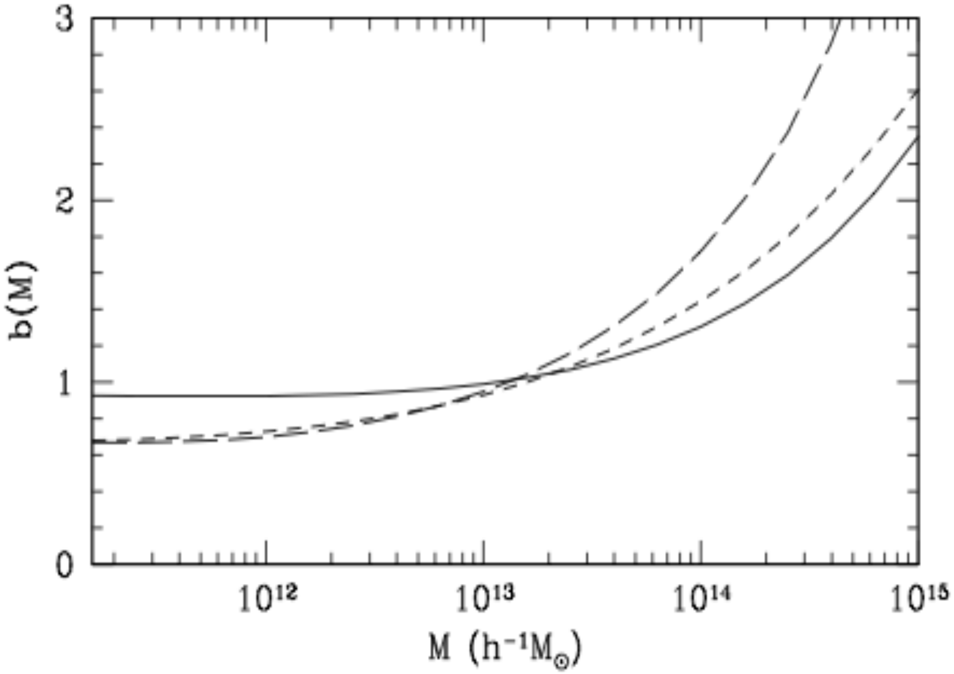


FIG. 4.— The bias parameter as a function of the halo mass at the present epoch. The solid line corresponds to our predictions, while the dashed and the long dashed lines to those of the Jing (1998) and Seljak & Warren (2004) models, respectively.

Basilakos et al:
=>even more massive than Seljak-Warren

Need new bias-mass calibration in large sims?