Are the Large-scale Clustering and Lensing of BOSS LOWZ Galaxies Consistent with *Planck*?

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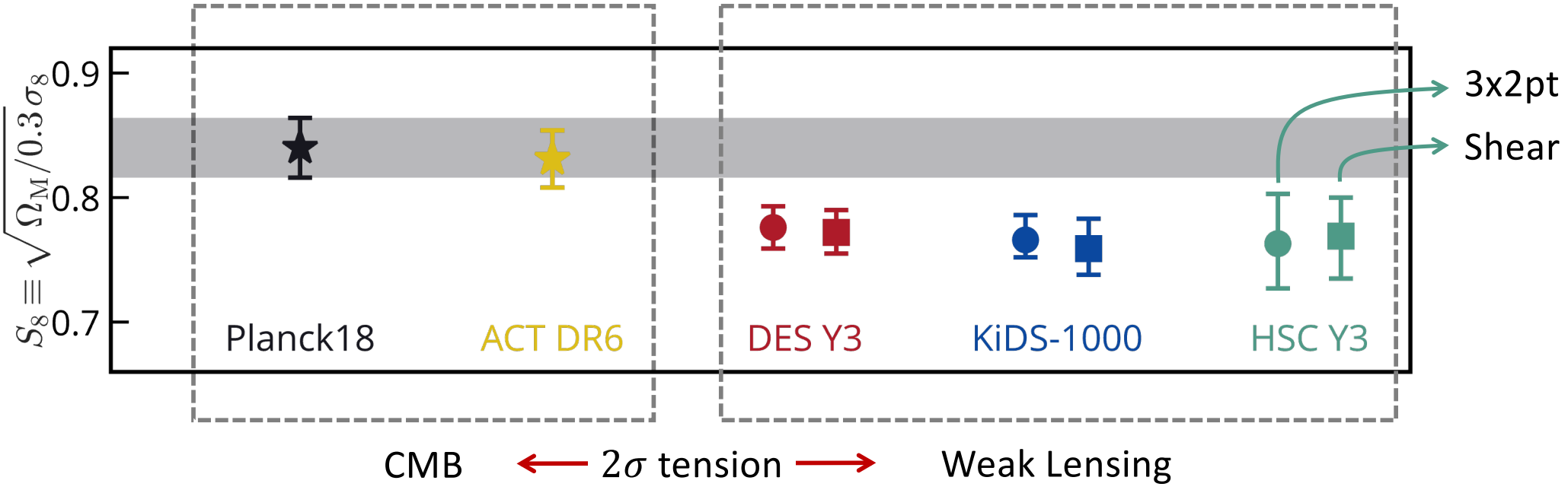
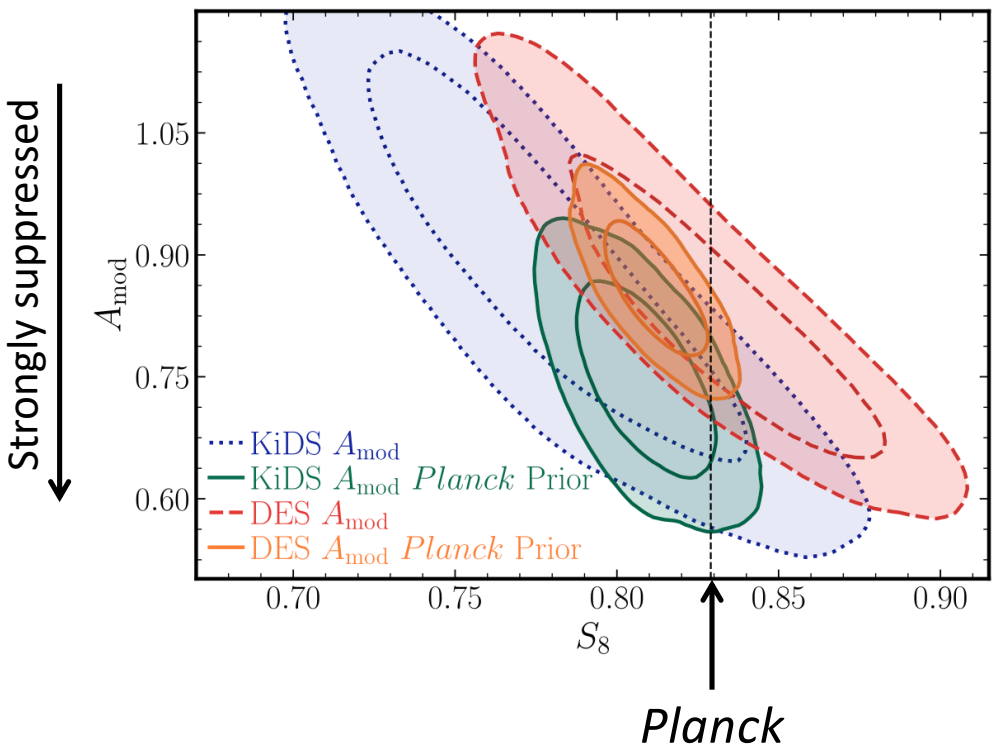
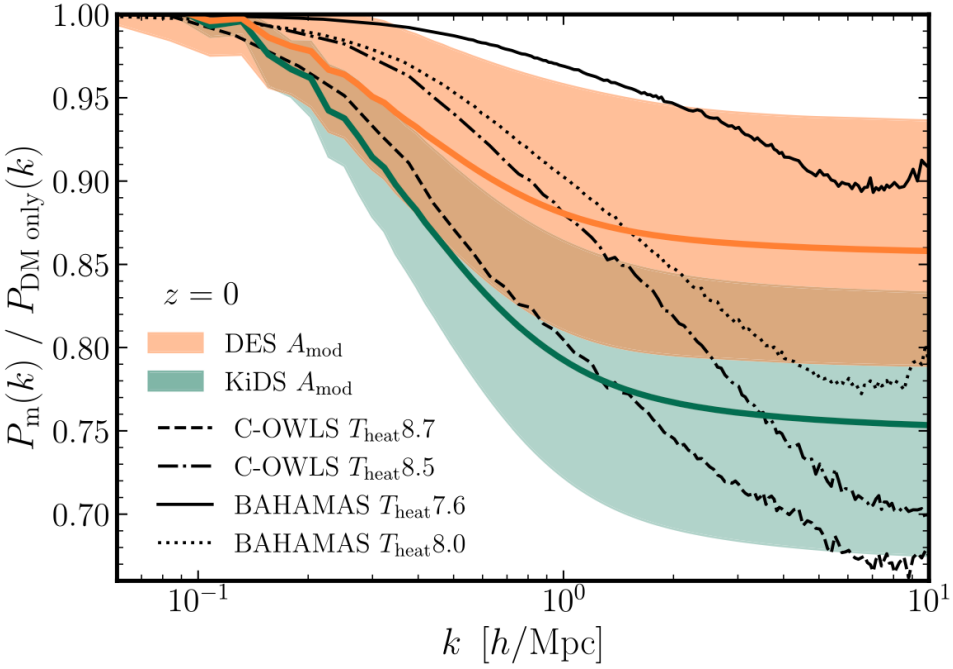
Shao et al. 2023, ApJL, 950, L15; arXiv:2302.08515



S_8 probed by weak lensing surveys are generally lower than *Planck*.

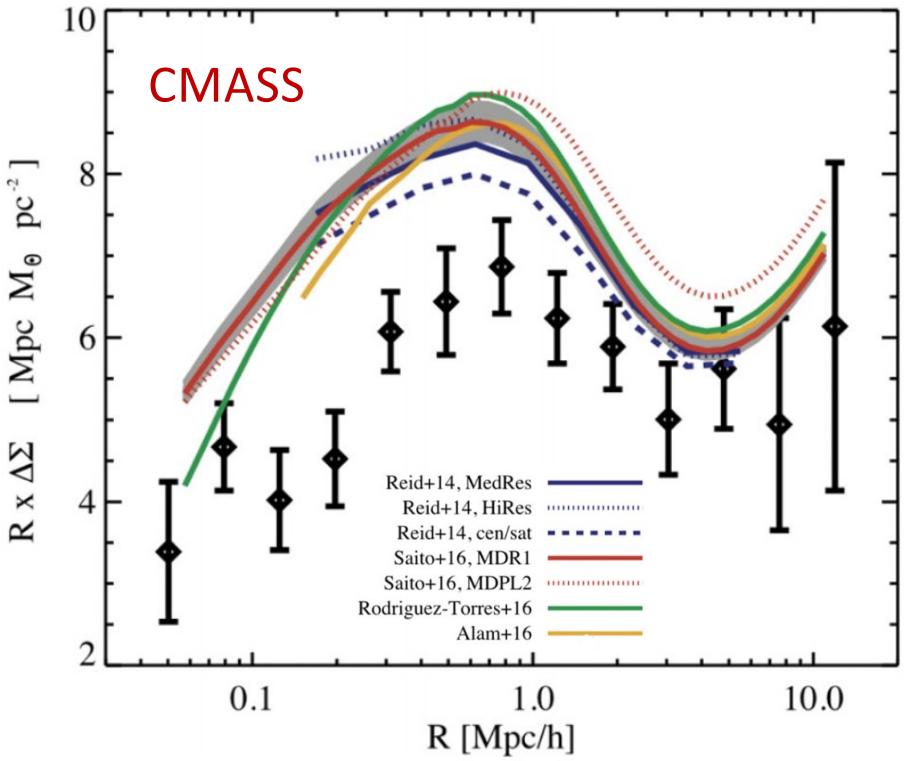




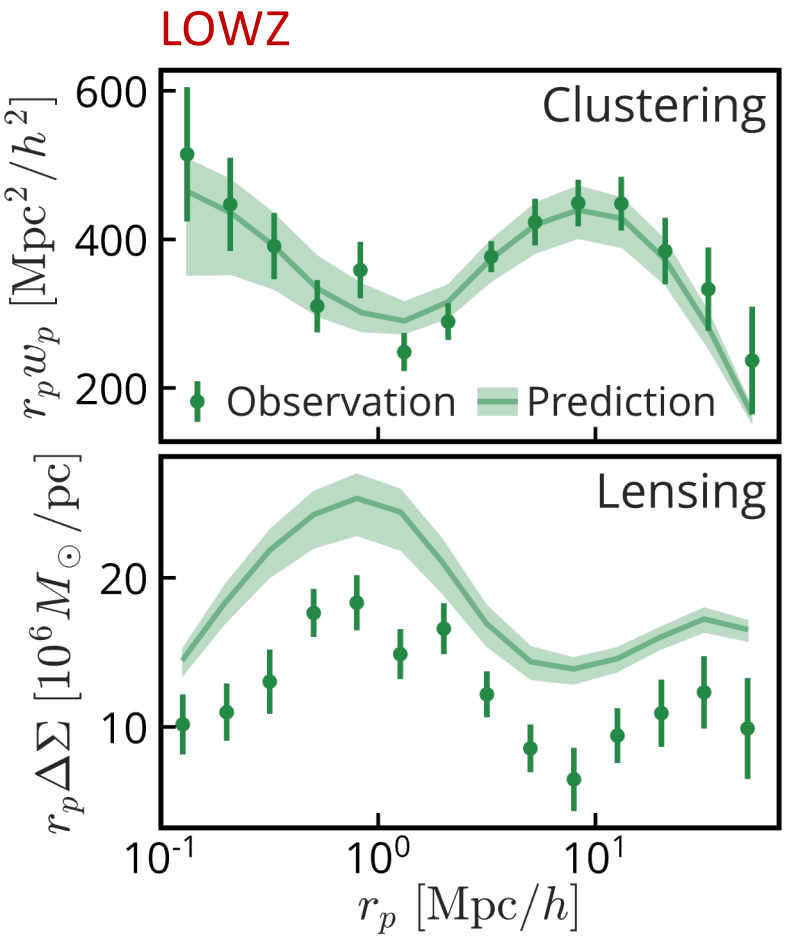
Preston et al. 2023; Amon&Efstathiou 2022

$$P_{\rm m}(k,z) = P_{\rm m}^{\rm L}(k,z) + A_{\rm mod}\left[P_{\rm m}^{\rm NL}(k,z) - P_{\rm m}^{\rm L}(k,z)\right]$$

Baryonic effects on non-linear scales could reconcile the tension, at a cost of much stronger feedback predicted by simulations.



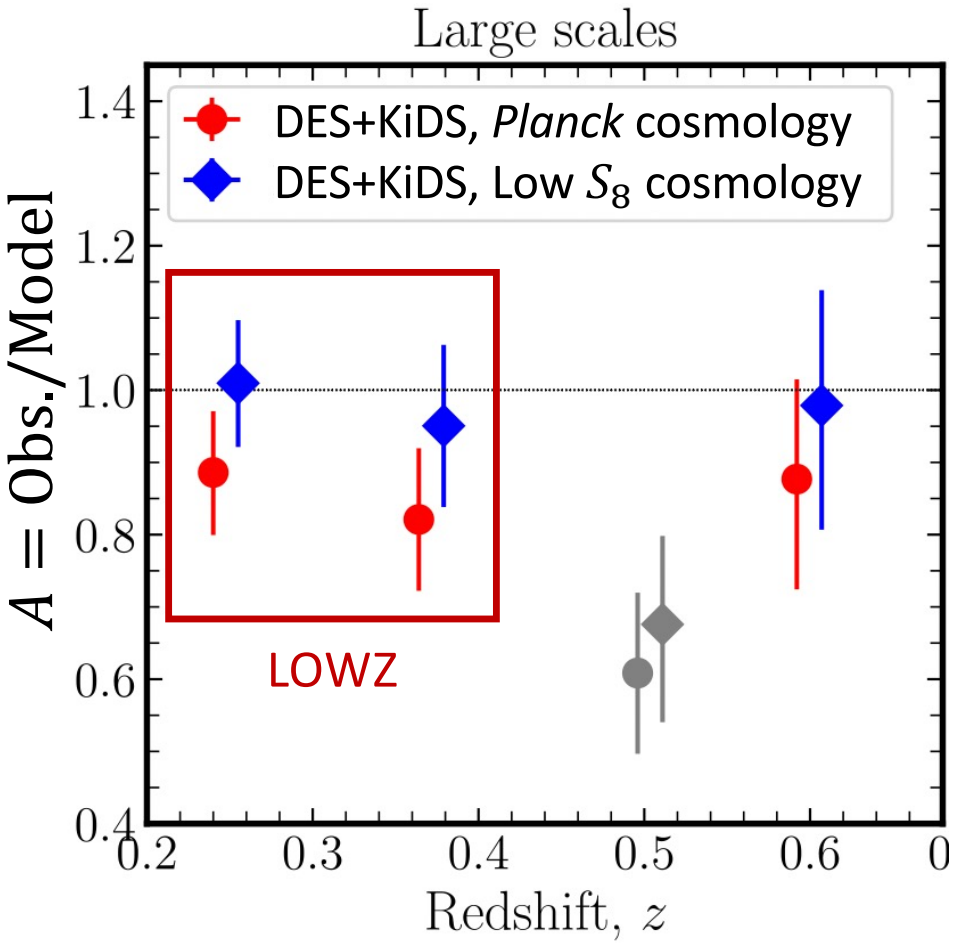
(Leauthaud et al. 2017)



(Lange et al. 2021)

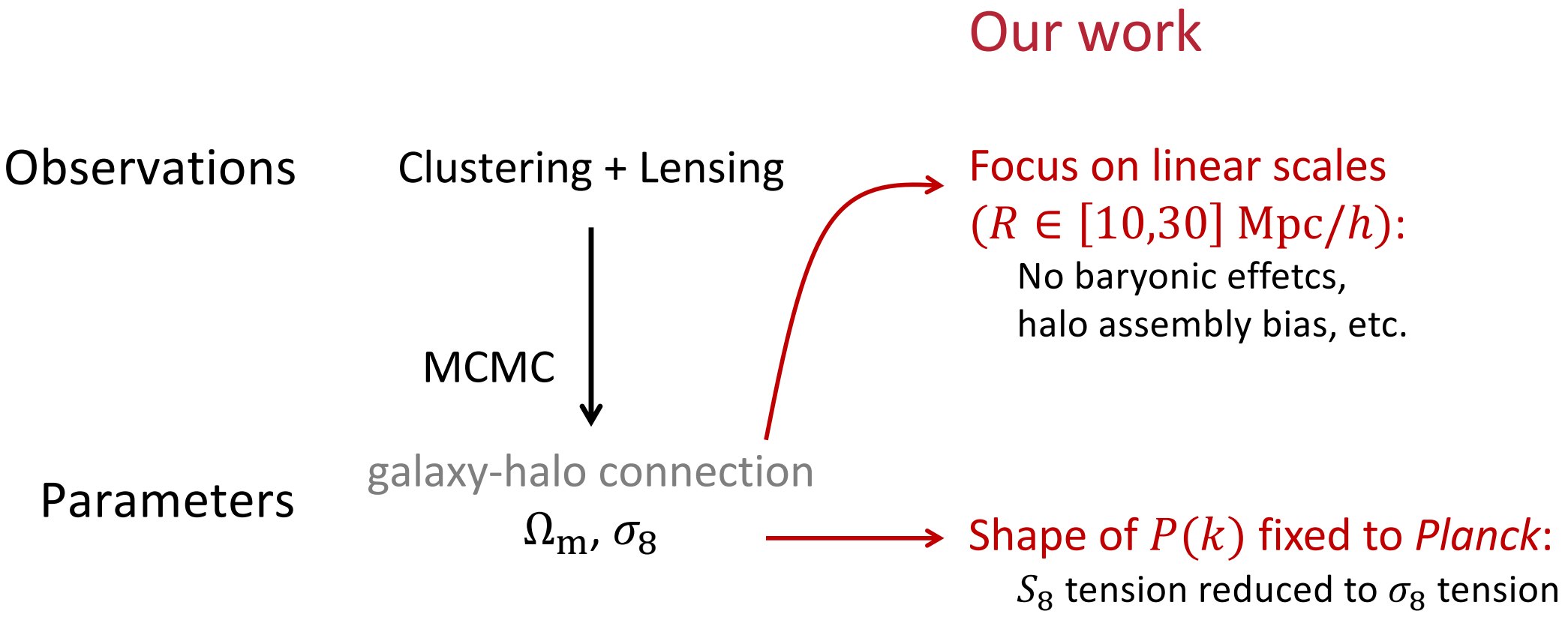
Galaxy weak lensing is overpredicted with best fitting parameters from clustering signals (under *Planck* cosmology).

The clustering-lensing mismatch persists in different lensing surveys and is independent of lensing systematics.



(Amon et al. 2023)

Methodology



The cosmological info on linear scales

- Clustering:

$$\xi_{\rm gg} = b_{\rm g}^2 \xi_{\rm mm} \propto b_{\rm g}^2 \sigma_8^2$$

- Lensing:

$$\xi_{\rm gm} = b_{\rm g} r_{\rm gm} \xi_{\rm mm} \propto b_{\rm g} r_{\rm gm} \sigma_8^2$$

$$\frac{\xi_{\rm gm}}{\sqrt{\xi_{\rm gg}}} = r_{\rm gm}\sigma_8 \rightarrow \sigma_8$$

$$A \equiv \sigma_8/\sigma_8^{\rm CMB} \longrightarrow \xi_{\rm mm} = A^2 \xi_{\rm mm}^{\rm CMB}$$

$$\xi_{\rm gg} = b_{\rm g}^2 A^2 \boxed{\xi_{\rm mm}^{\rm CMB}}$$

$$\xi_{\rm gm} = b_{\rm g} r_{\rm gm} A^2 \boxed{\xi_{\rm mm}^{\rm CMB}}$$

Fixed to *Planck*

Free parameters:

$b_{\rm g}$, $r_{\rm gm}$, and A

Clustering:

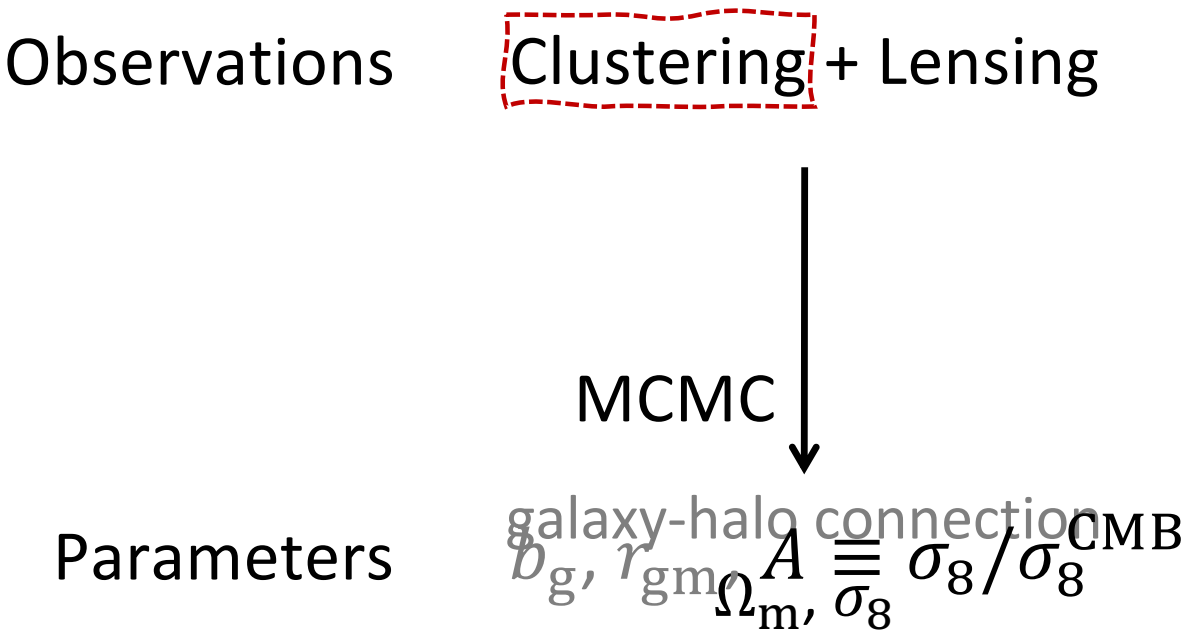
$$w_p(R) = 2\int_0^{\Pi_{\max}} \xi^{\mathrm{rs}}(R,\Pi)\,\mathrm{d}\Pi$$

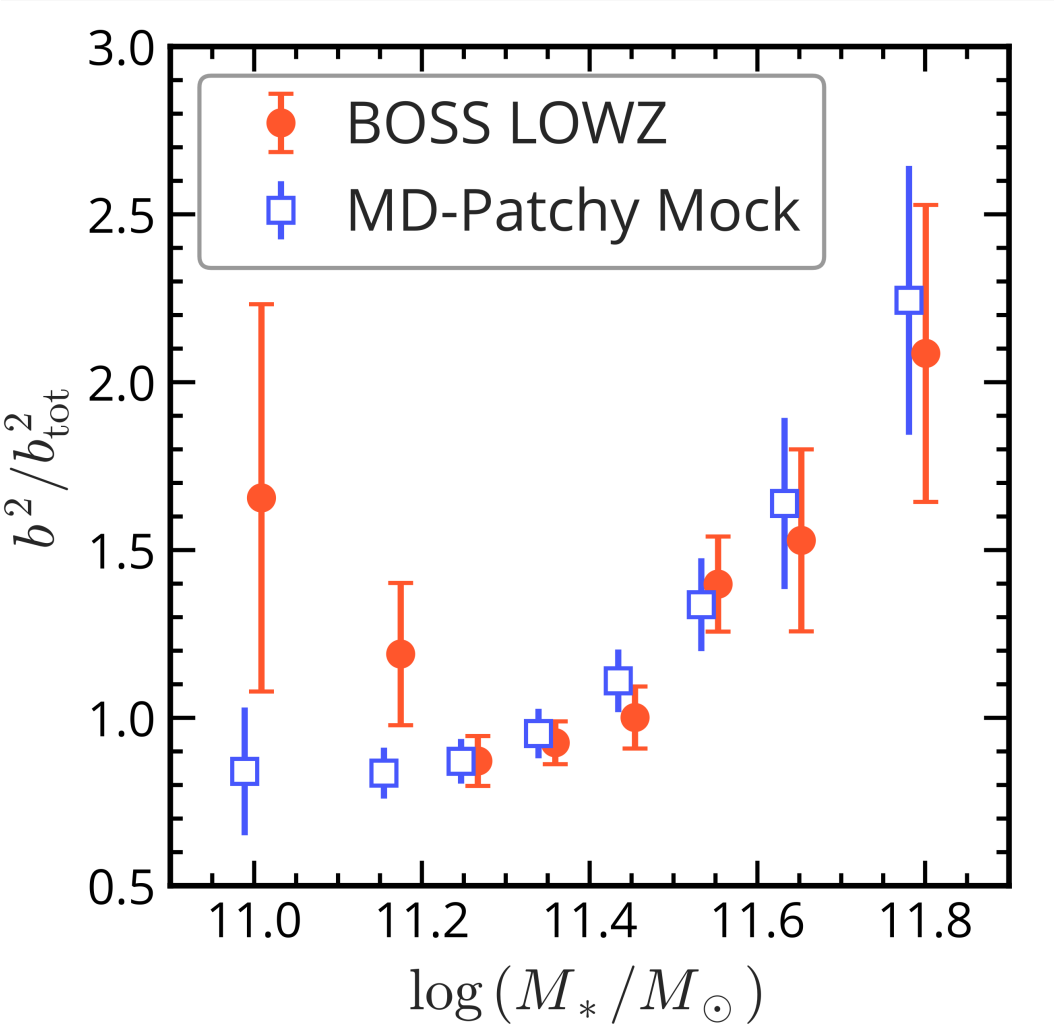
Lensing:

$$\Upsilon(R) = \Delta\Sigma(R) - \left(\frac{R_0}{R}\right)^2 \Delta\Sigma(R_0)$$

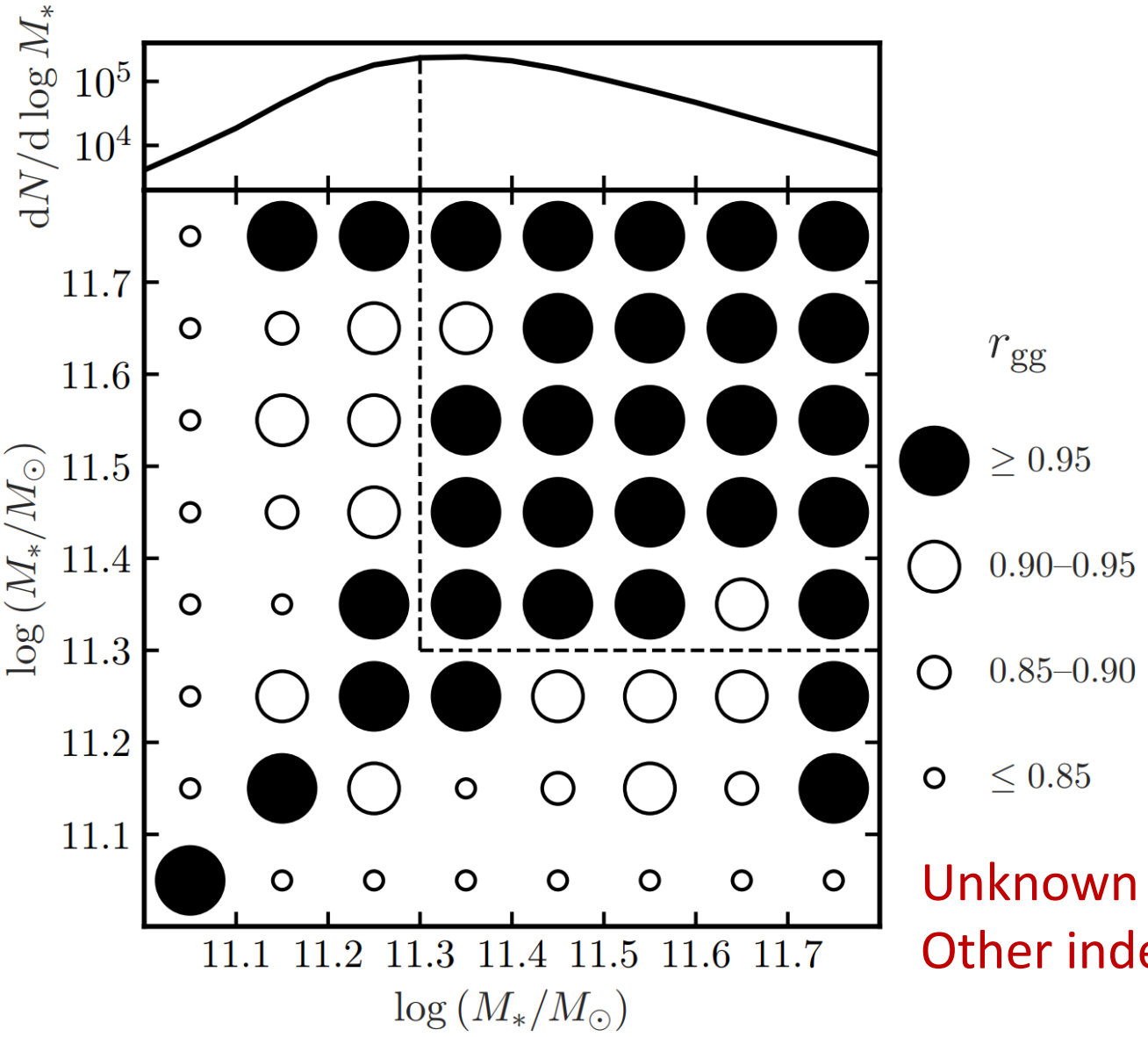
Remove the information below R_0 (Baldauf et al. 2010).

Methodology





Large-scale bias from clustering shows non-monotonic trend with stellar mass.

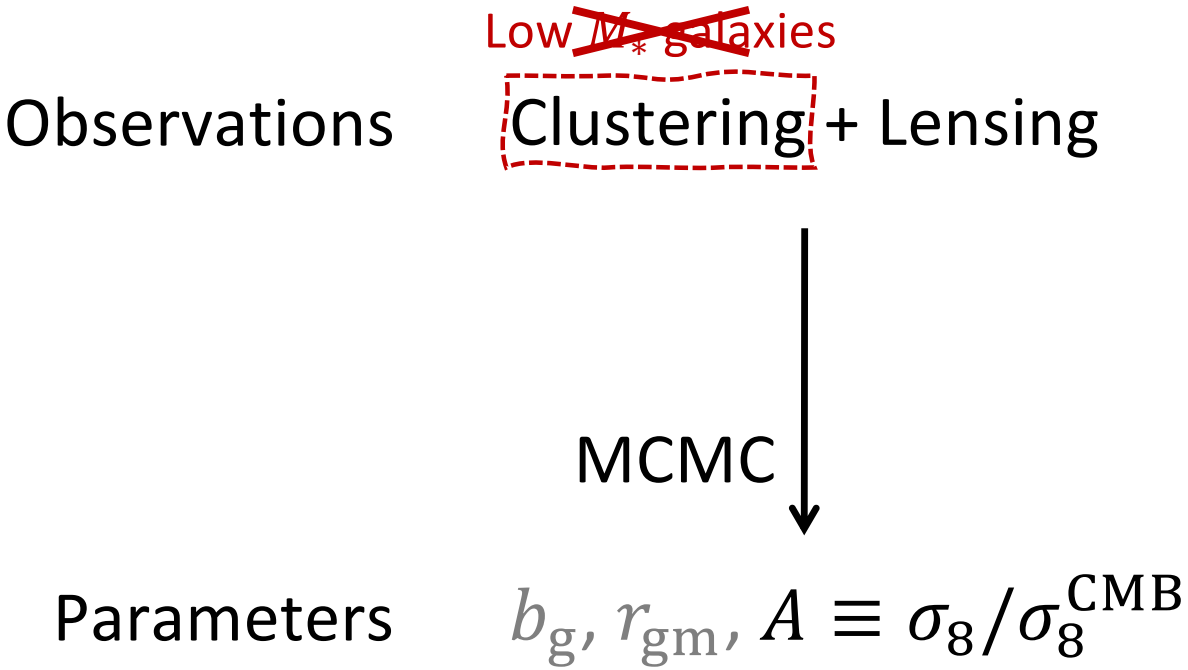


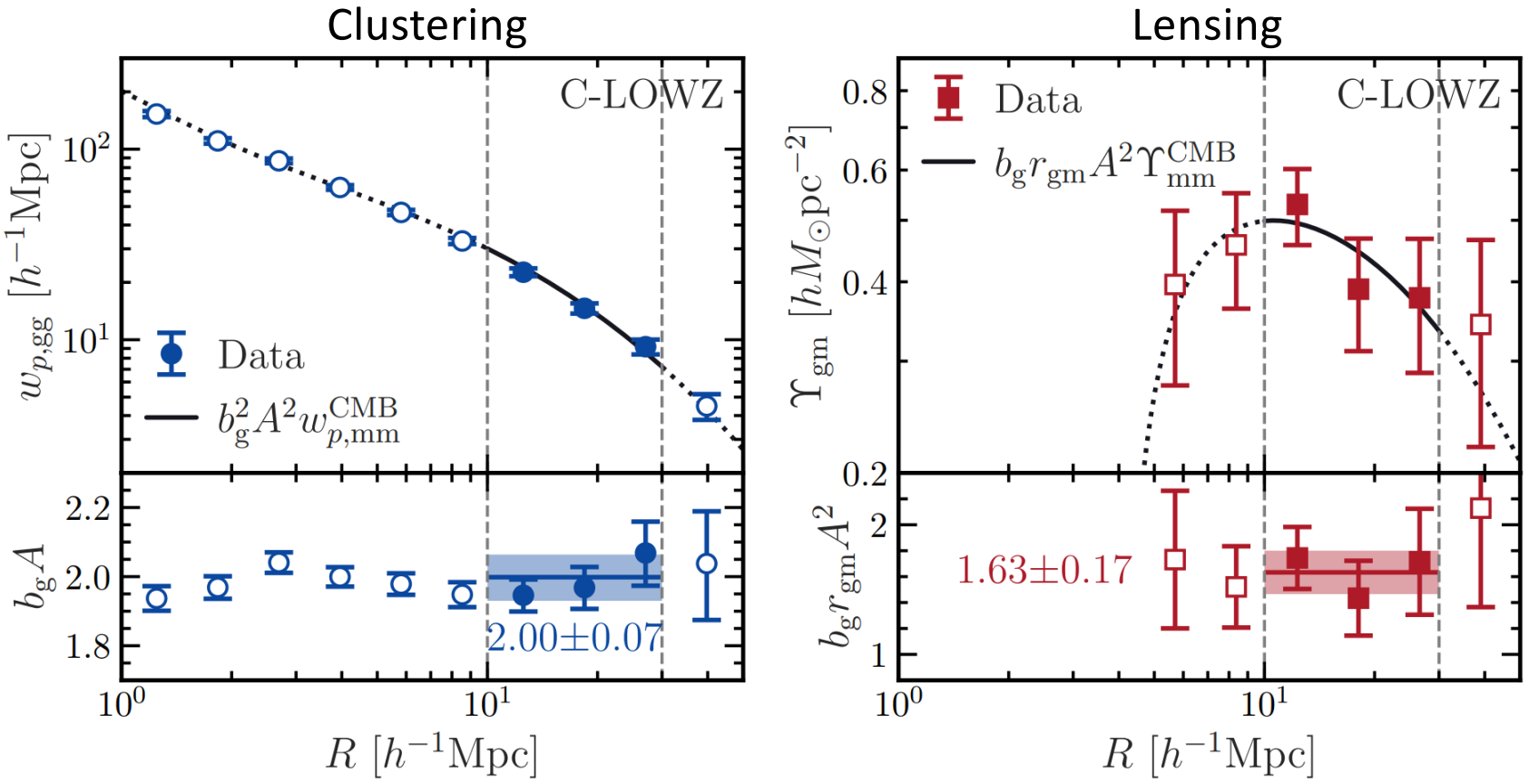
Cross-correlation coefficient between galaxies:

$$r_{\rm gg}^{ij} = \frac{w_p^{ij}}{\sqrt{w_p^{ii} w_p^{jj}}}$$

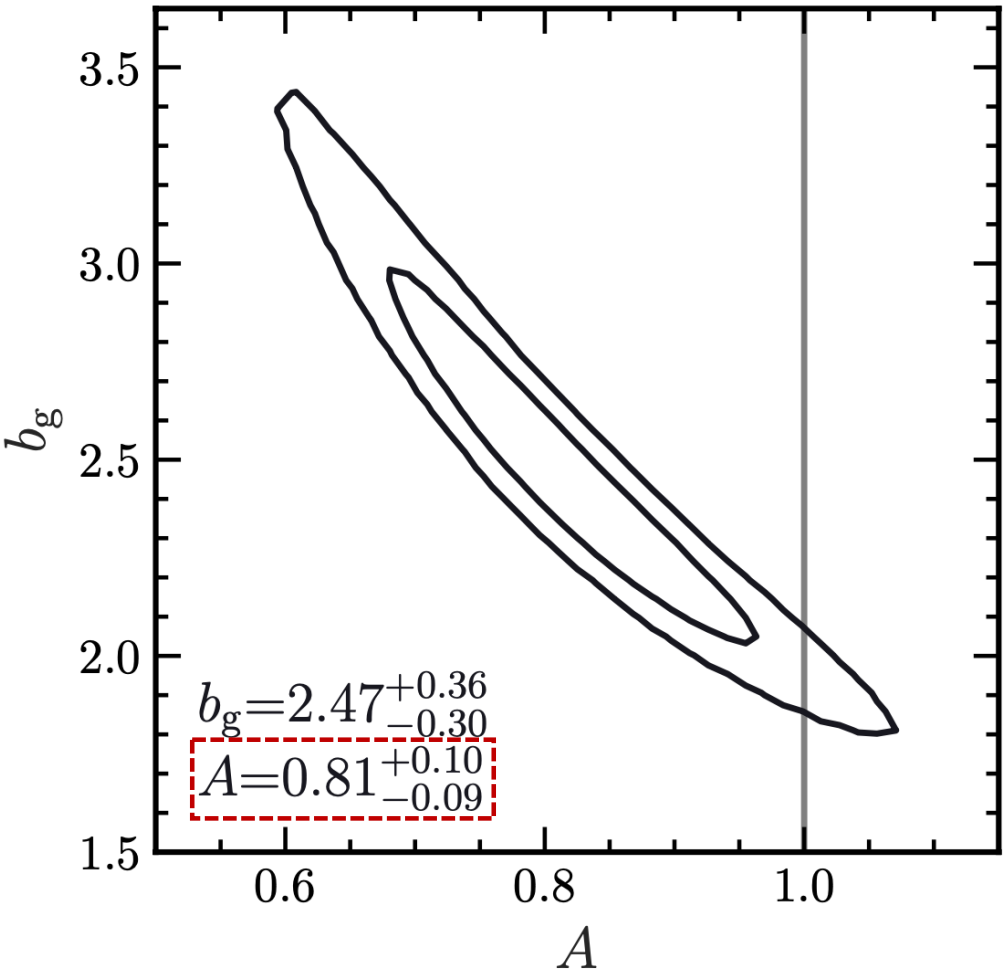
Unknown systematics for $\log M_* < 11.3$;
Other independent validation is required!

Methodology





Under *Planck* cosmology ($A = 1$), clustering-lensing mismatch exists in large scales.



Clustering + lensing constrain σ_8 to be 2σ lower than *Planck,* but with strong degeneracy between $b_{\rm g}$ and A!

An independent $b_{\rm g}$ measured from cross-correlation with clusters

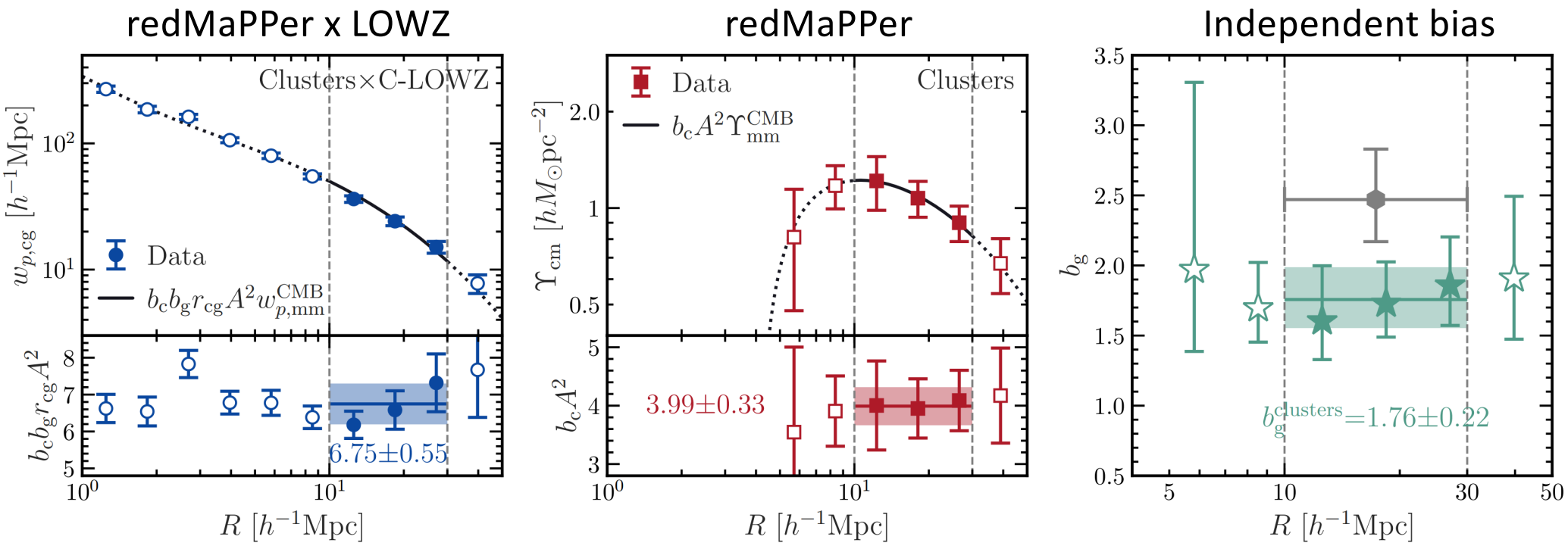
$$\xi_{\rm cg} \propto b_{\rm c} b_{\rm g} r_{\rm cg} A^2$$

$$\xi_{\rm cm} \propto b_{\rm c} r_{\rm cm} A^2$$

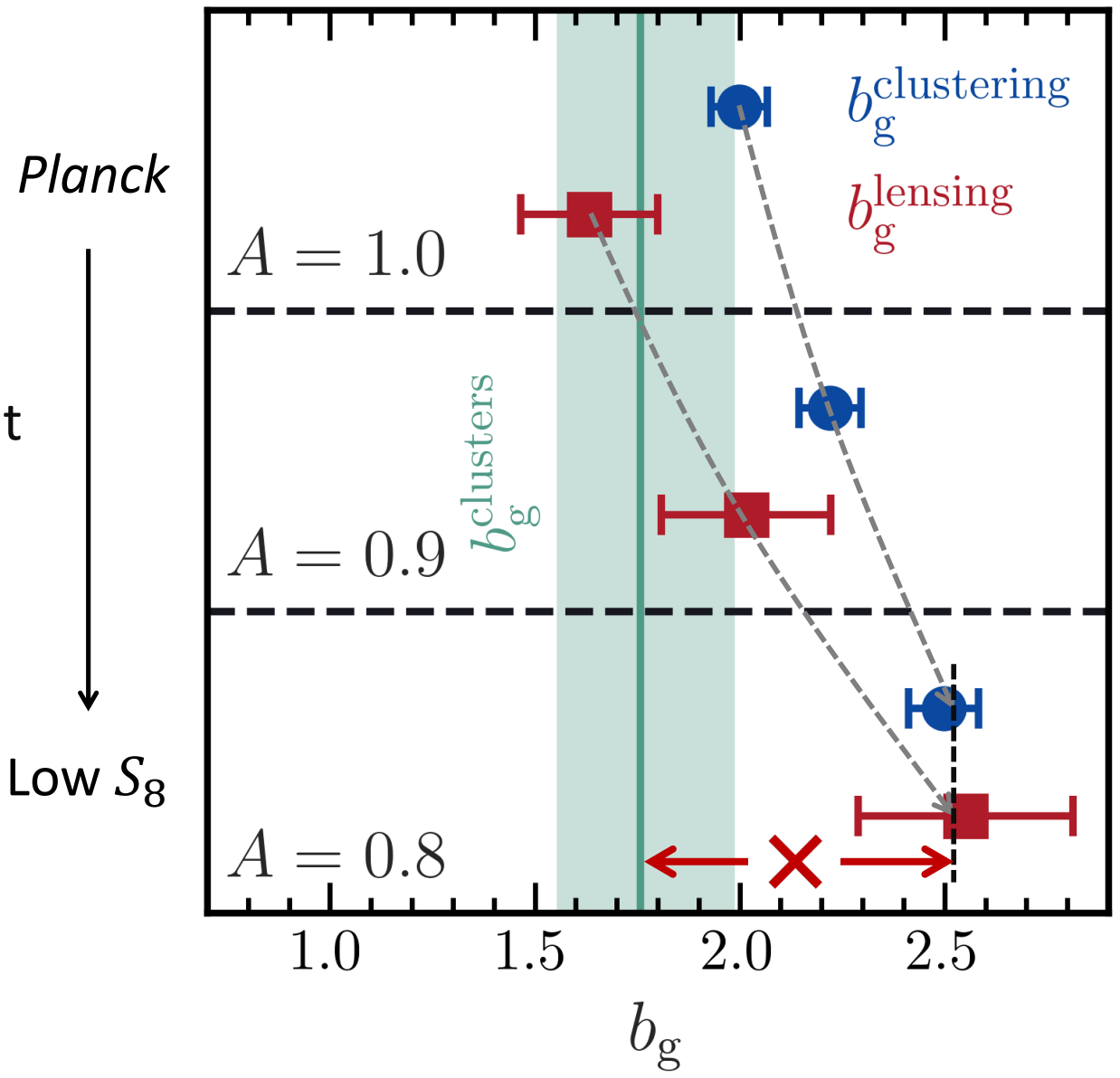
$$\longrightarrow \quad b_{\rm g}^{\rm clusters} = \frac{\xi_{\rm cg}}{\xi_{\rm cm}} \times \frac{r_{\rm cm}}{r_{\rm cg}} \approx 1$$

$$= \frac{w_{p,\rm cg}}{\sqrt{w_{p,\rm cc} w_{p,\rm gg}}}$$

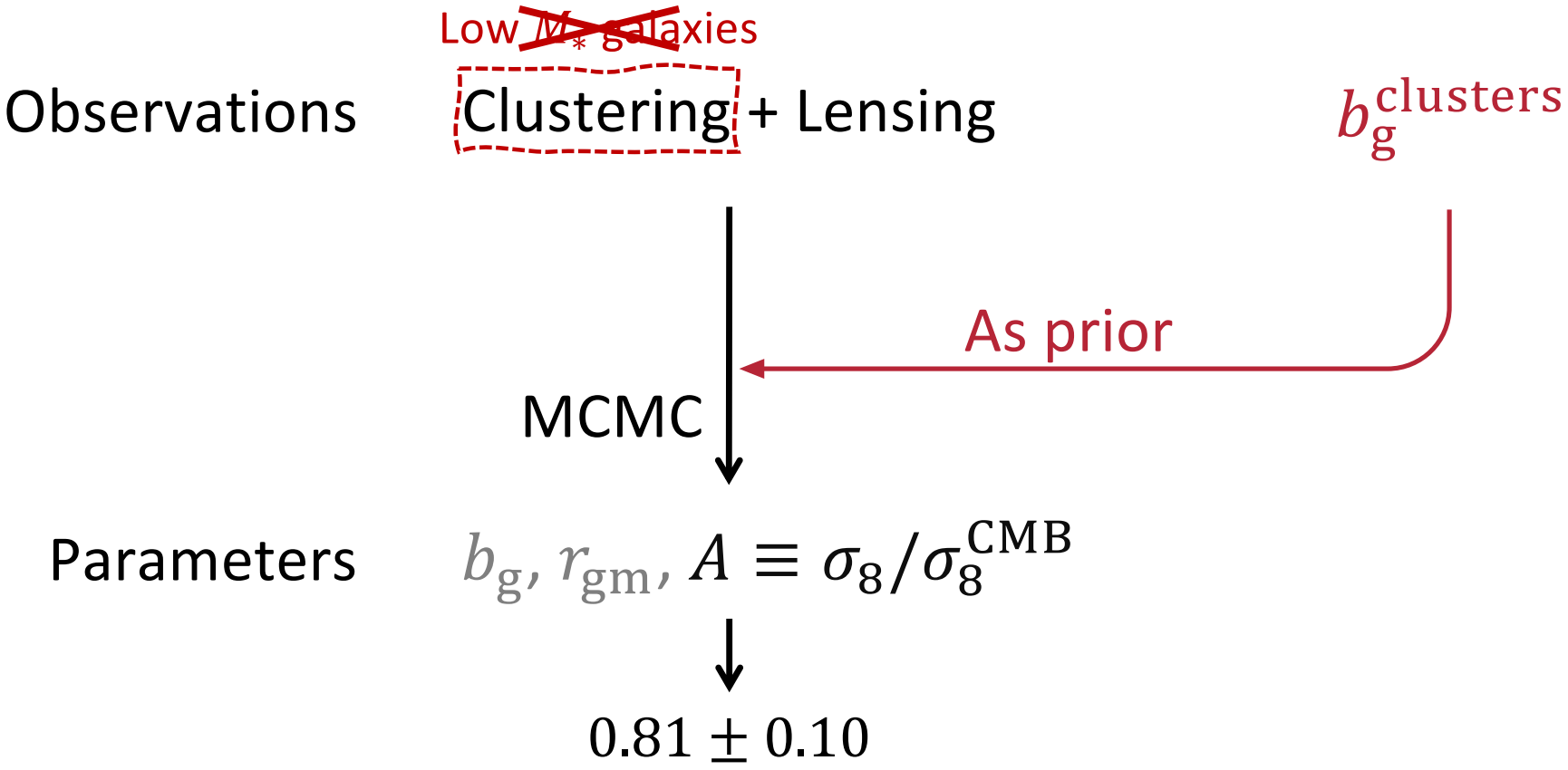
$$= 0.96$$


redMaPPer x LOWZ
Clusters×C-LOWZ
Data
$b_c b_g r_{cg} A^2 w_{p,mm}^{CMB}$
$w_{p,cg}$ $[h^{-1}\mathrm{Mpc}]$
$b_c b_g r_{cg} A^2$
6.75±0.55
R $[h^{-1}\mathrm{Mpc}]$
redMaPPer
Clusters
Data
$b_c A^2 \Upsilon_{mm}^{CMB}$
Υ_{cm} $[hM_\odot \mathrm{pc}^{-2}]$
$b_c A^2$
3.99±0.33
R $[h^{-1}\mathrm{Mpc}]$
Independent bias
b_g
$b_g^{clusters}$=1.76±0.22
R $[h^{-1}\mathrm{Mpc}]$

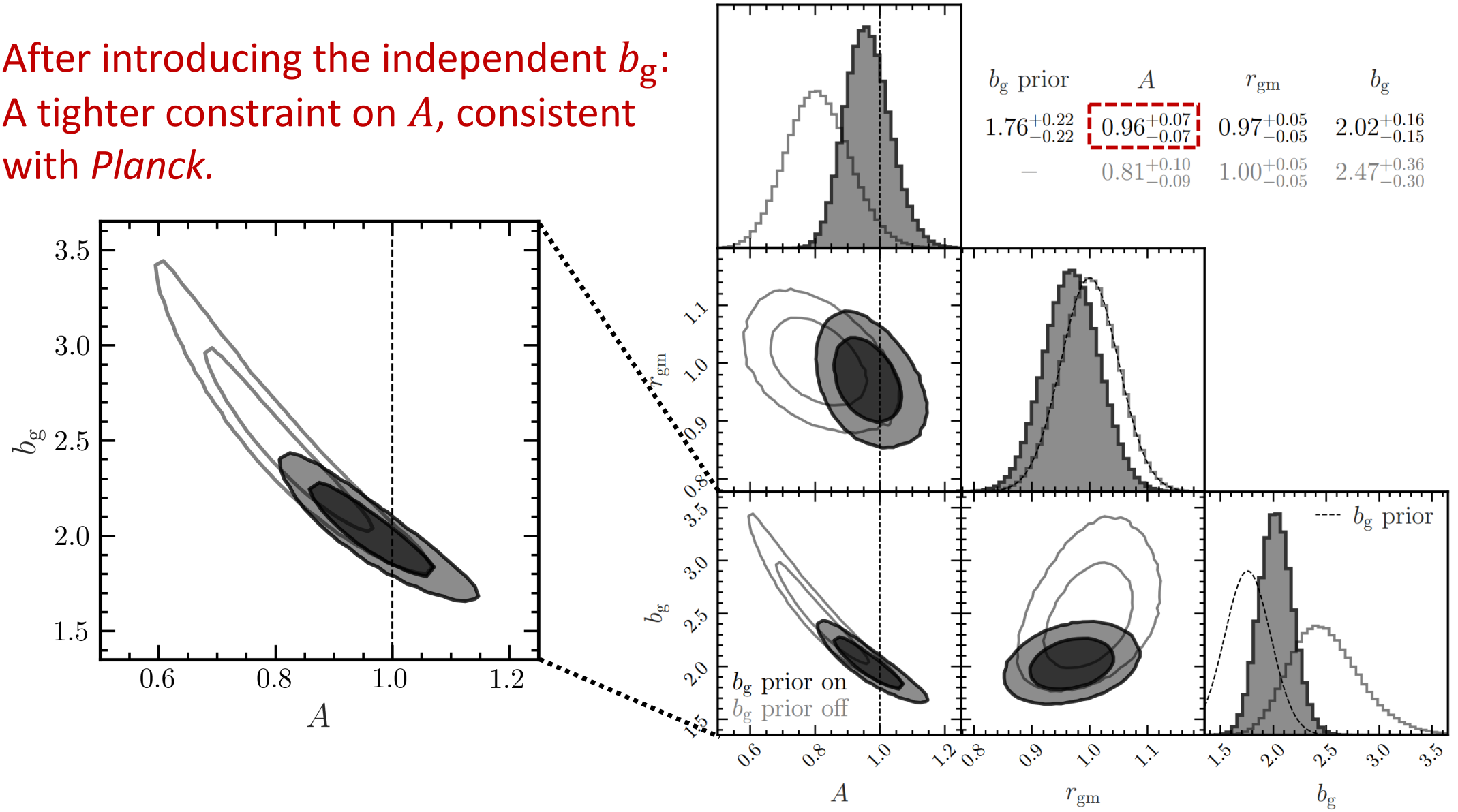
As A decreases, lensing and clustering become more consistent with each other,
while both are in stronger tension with cluster measurement.



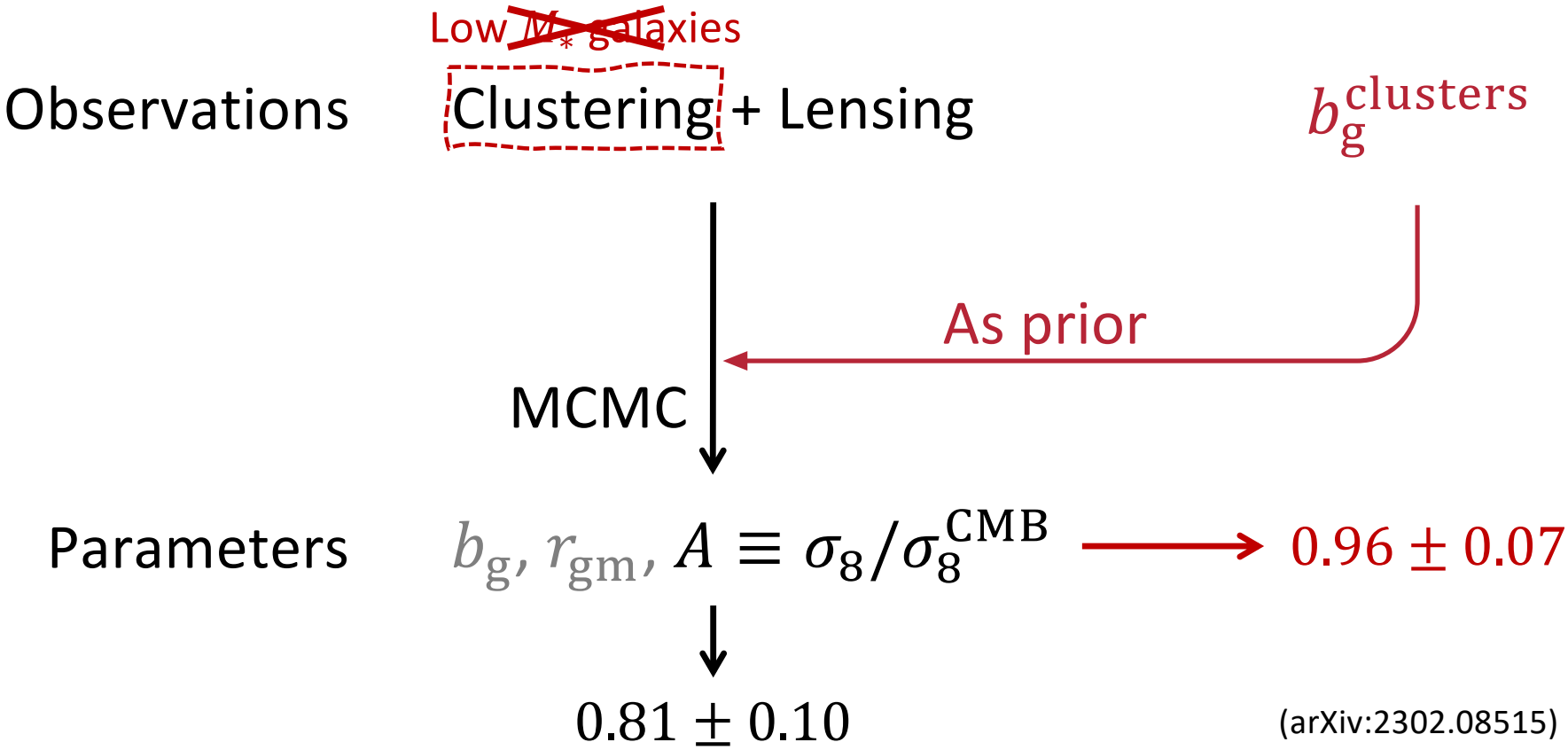
Methodology

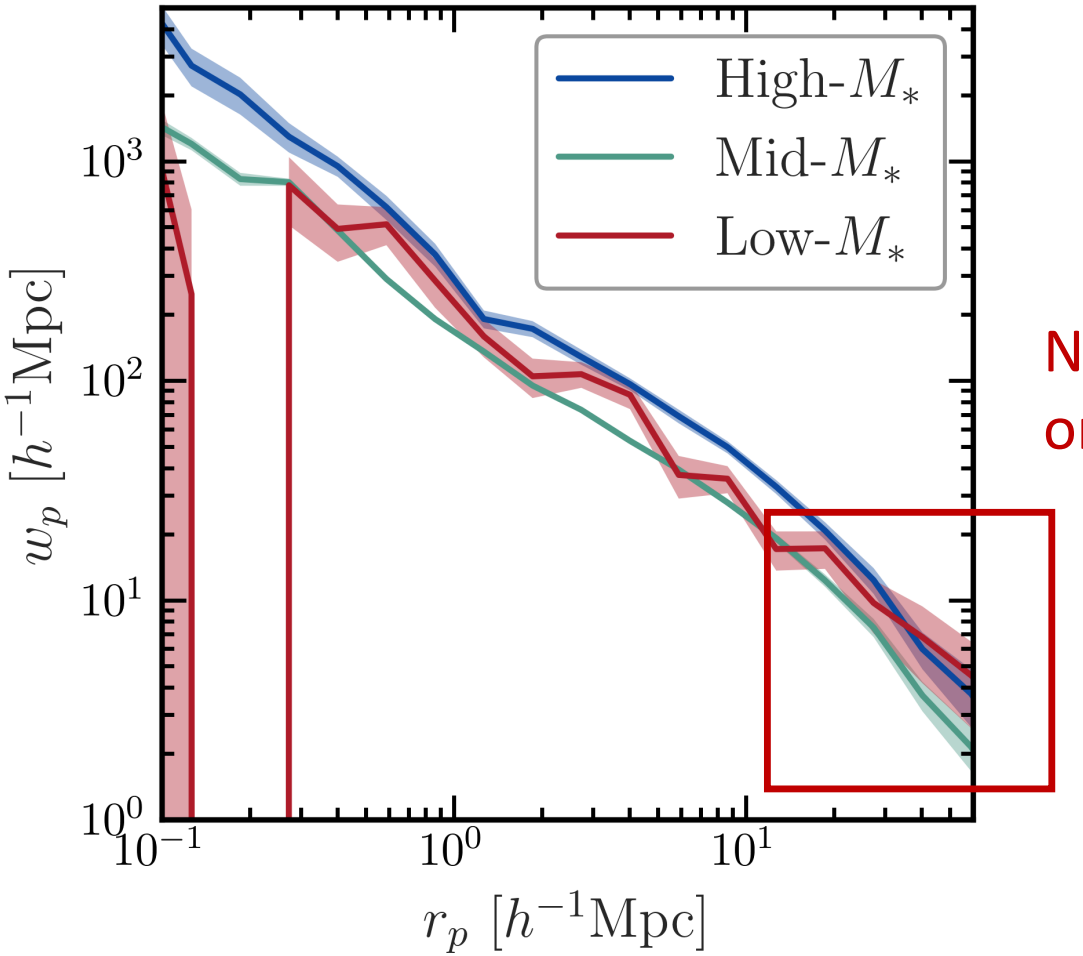


After introducing the independent $b_{\rm g}$:
A tighter constraint on A, consistent with *Planck*.



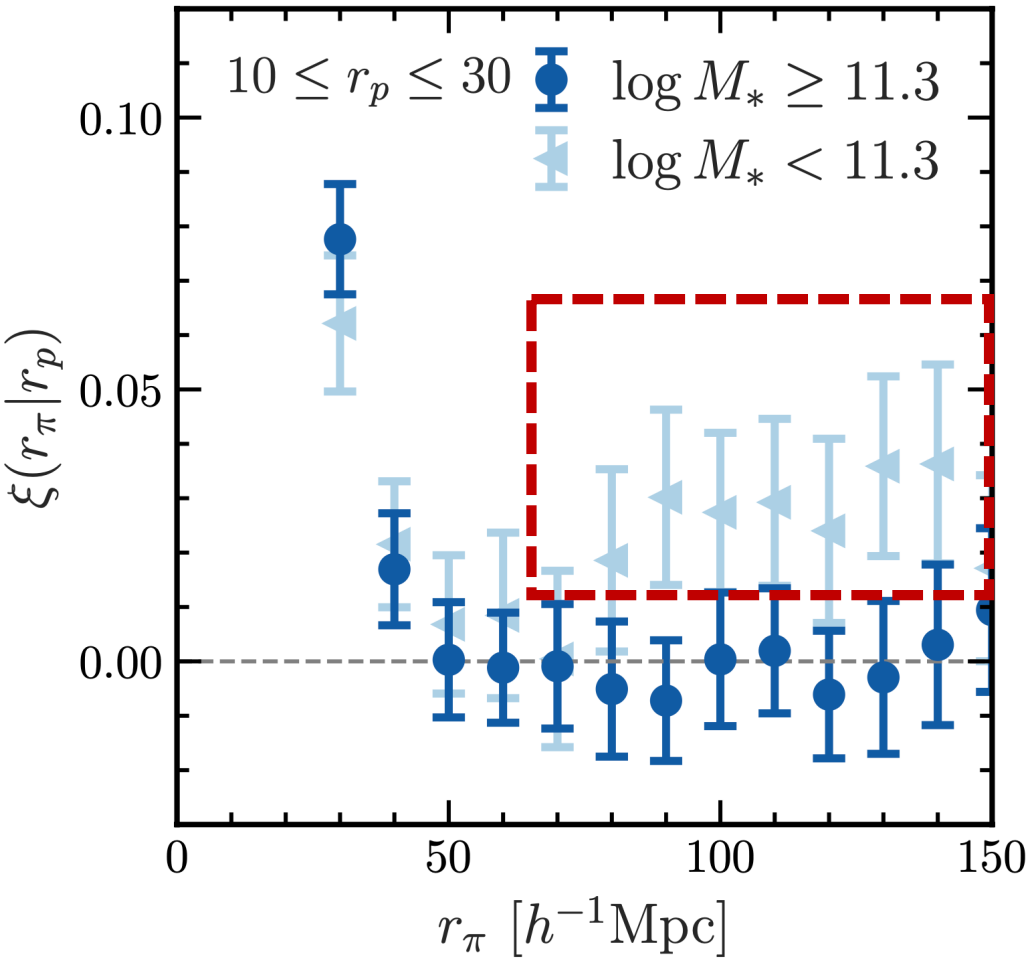
Summary


Low M_* galaxies
Observations
Clustering + Lensing
$b_g^{clusters}$
As prior
MCMC
Parameters
$b_g, r_{gm}, A \equiv \sigma_8/\sigma_8^{CMB}$
0.96 ± 0.07
0.81 ± 0.10
(arXiv:2302.08515)

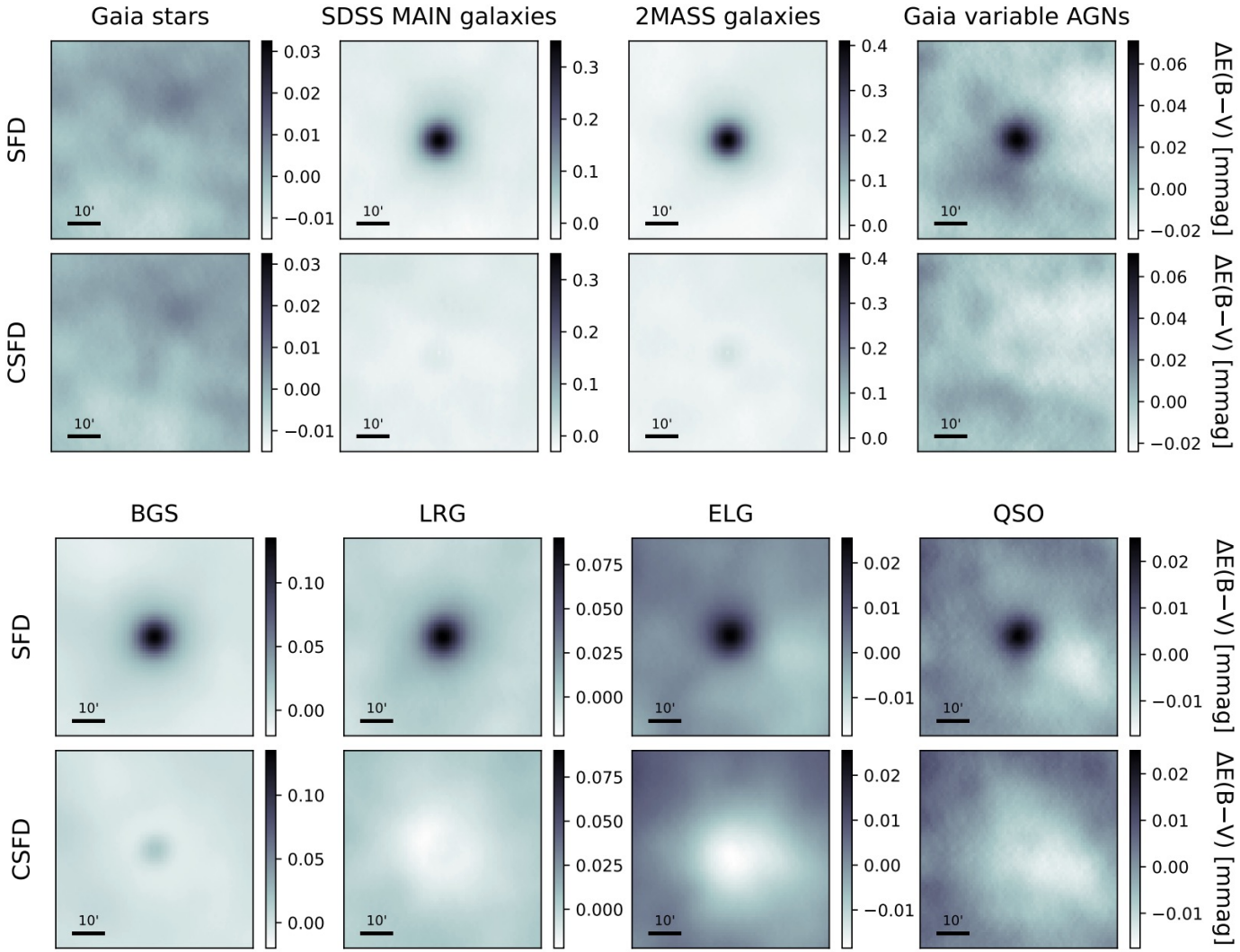


(Zu 2020)

Non-monotonic trend with stellar mass on large scales.



Unphysical correlation even at hundreds of h^{-1}Mpc along LOS.


Gaia stars
SDSS MAIN galaxies
2MASS galaxies
Gaia variable AGNs
SFD
CSFD
10'
ΔE(B−V) [mmag]
BGS
LRG
ELG
QSO

Chiang 2023

How $\Upsilon(R)$ helps to remove small-scale information:

$$\Delta\Sigma(R) = \bar{\Sigma}(< R) - \Sigma(R)$$

$$\bar{\Sigma}(< R) = \frac{2}{R^2}\int_0^R R'\Sigma(R')\mathrm{d}R'$$

$$\Upsilon(R) = \Delta\Sigma(R) - \left(\frac{R_0}{R}\right)^2 \Delta\Sigma(R_0)$$

$$= \frac{2}{R^2}\int_{R_0}^R R'\Sigma(R')\mathrm{d}R' - \frac{1}{R^2}\left[R^2\Sigma(R) - R_0^2\Sigma(R_0)\right]$$