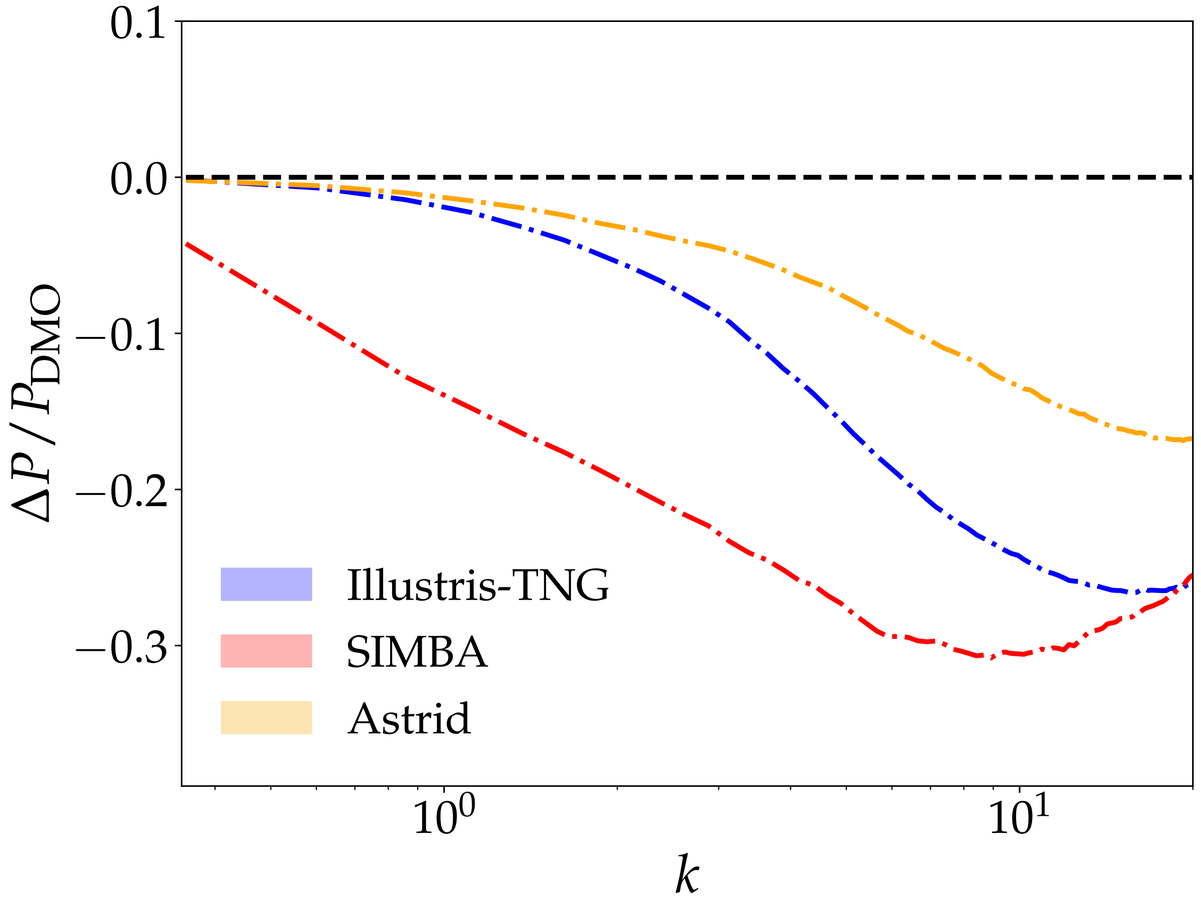
Constraining impact of baryonic physics on matter distribution

Shivam Pandey, Columbia University

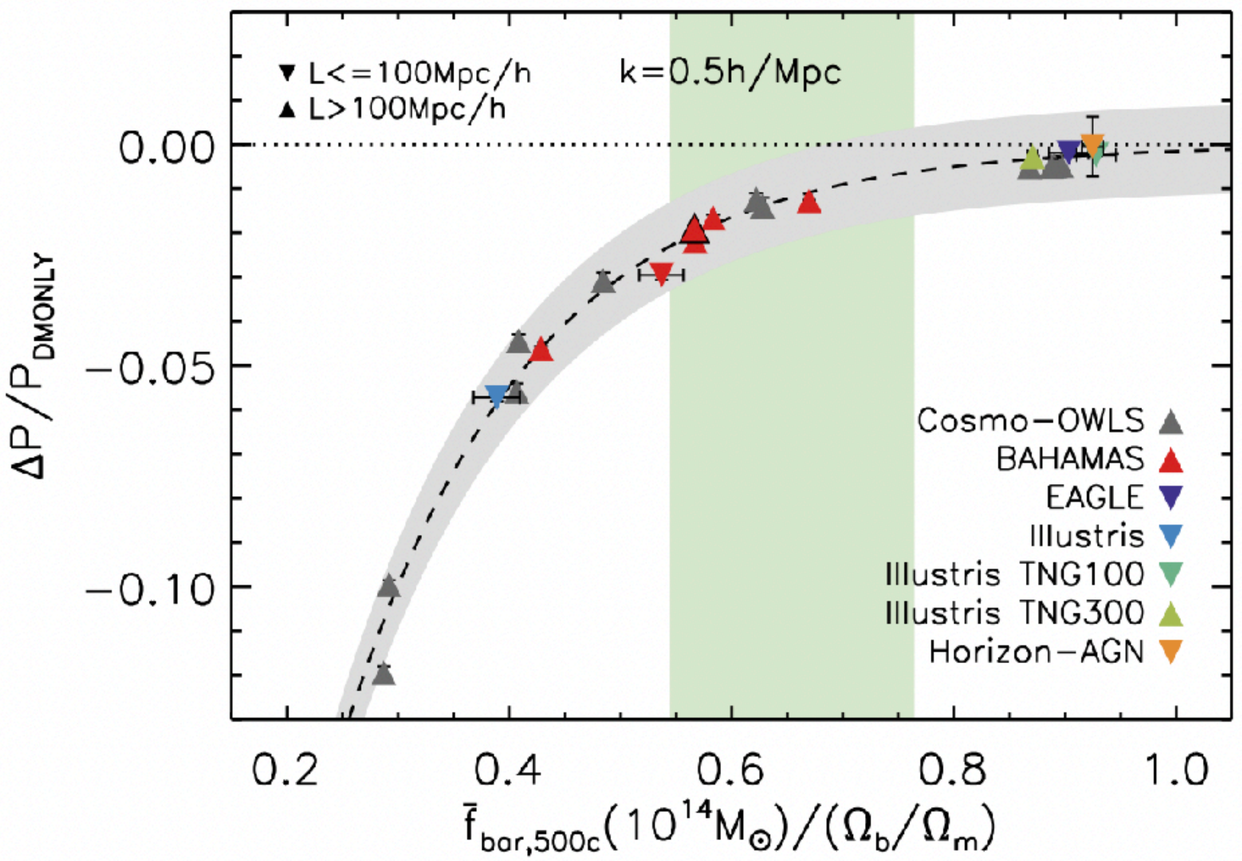
work with: *Kai Lehmann (Masters student @University of Hawaii)*
Eric Baxter (University of Hawaii)

Matter power suppression due to feedback

Can it be captured with astrophysical observables?

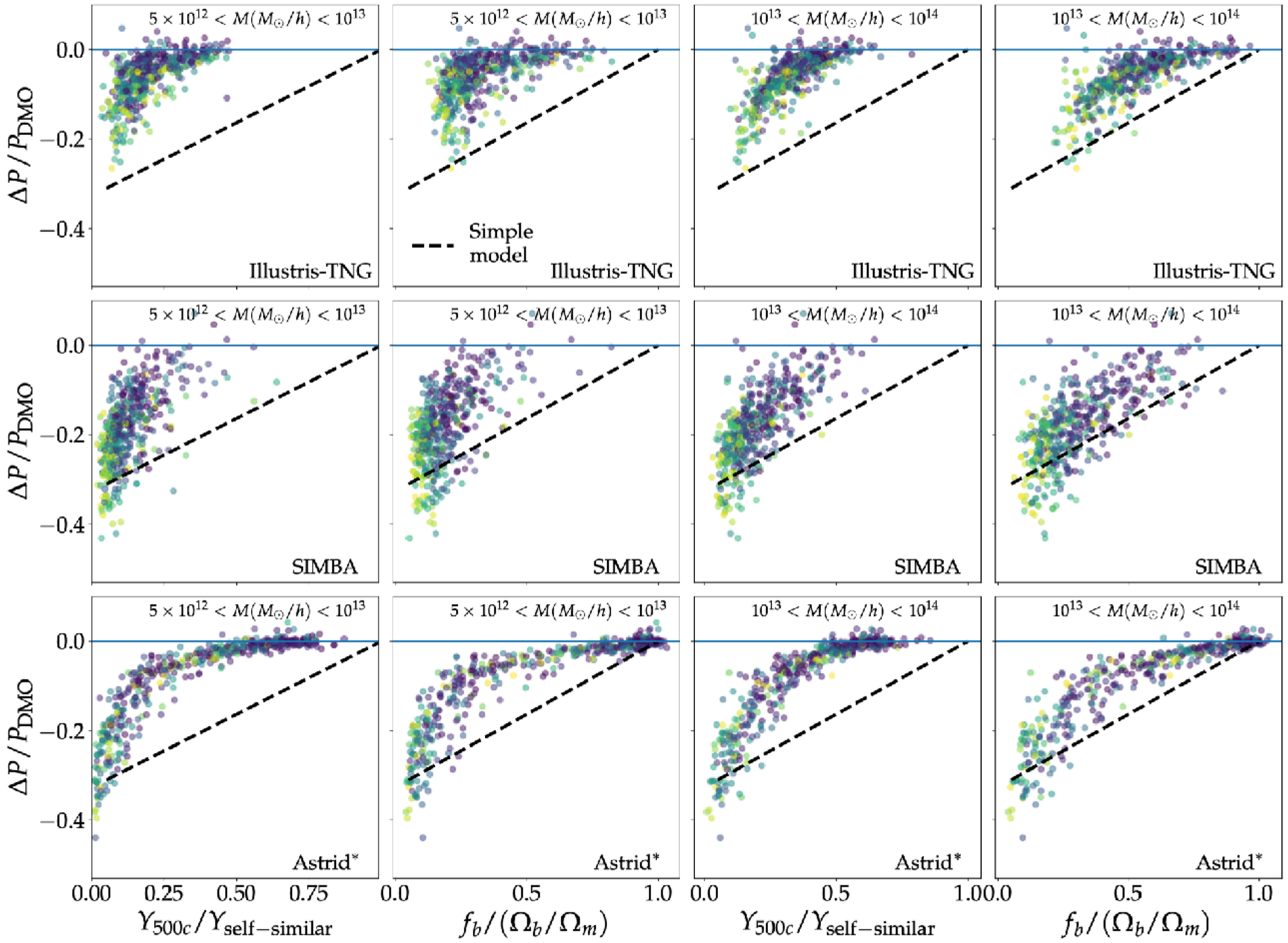


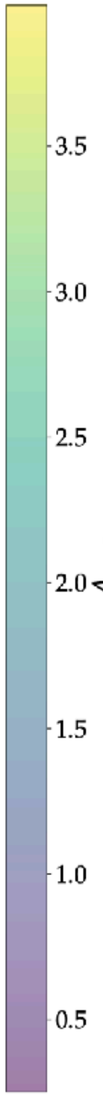
Pandey, Lehmann, Baxter et al. in prep



vanDaleen et al 2019

Generality of astrophysical scalings





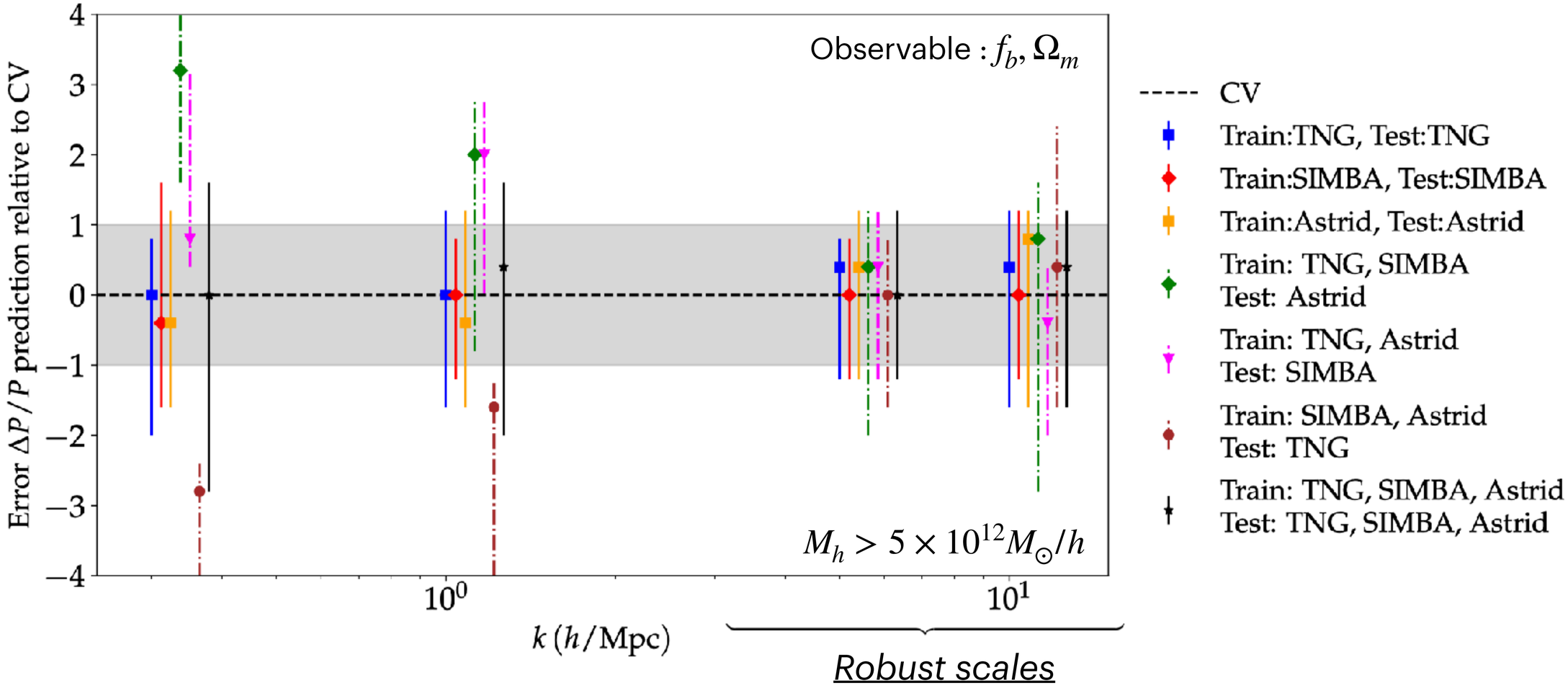
$$\frac{\delta'_m}{\delta_m} = 1 - \frac{M_{\rm ej}}{M}.$$

$$\frac{\Delta P}{P_{\rm DMO}} \sim \left(\frac{\delta'_m}{\delta_m}\right)^2 - 1 \approx -2\frac{M_{\rm ej}}{M},$$

$$M_{\rm ej}/M \sim (\Omega_b/\Omega_m) - f_b$$

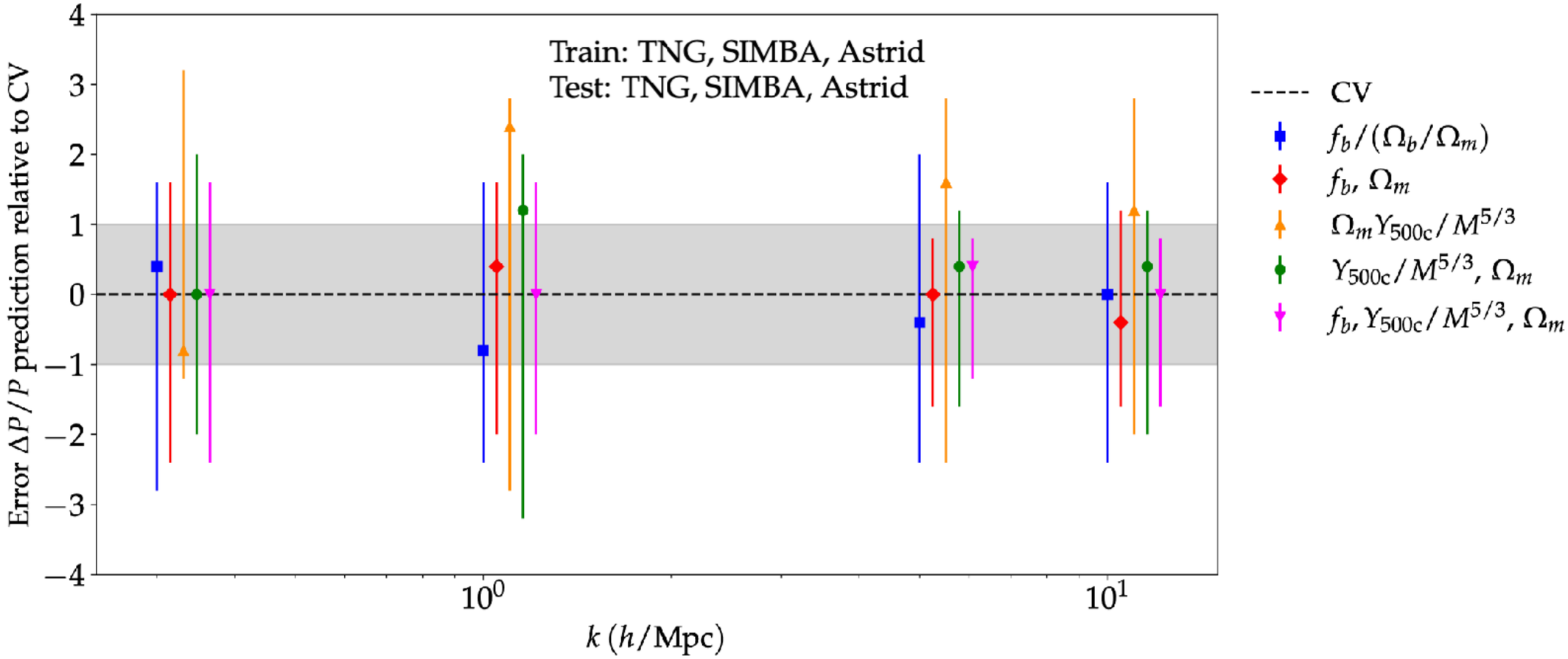
Simple Model

Training a random forest regressor



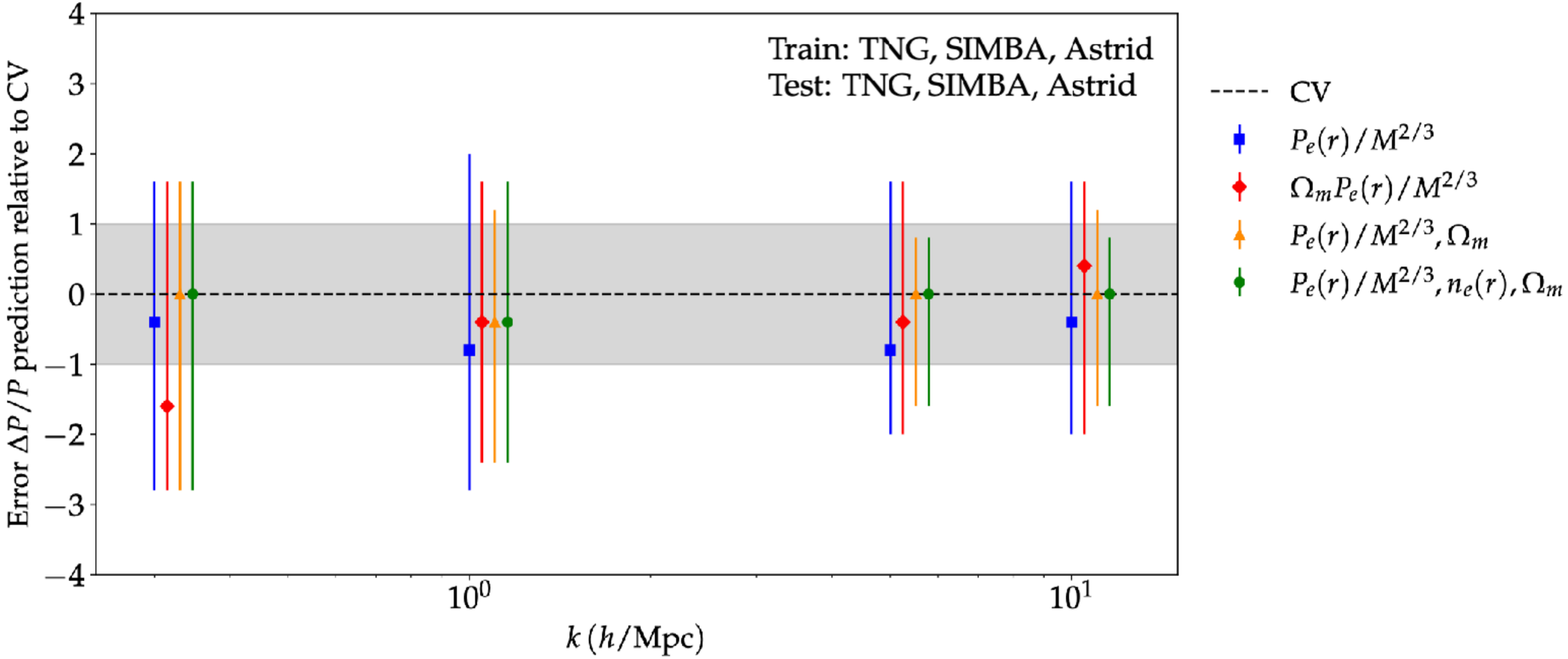
- Functional form is different for different sub-grid model, so training does not generalize robustly over all scales
- Train on all three to marginalize over model uncertainty

With integrated observables



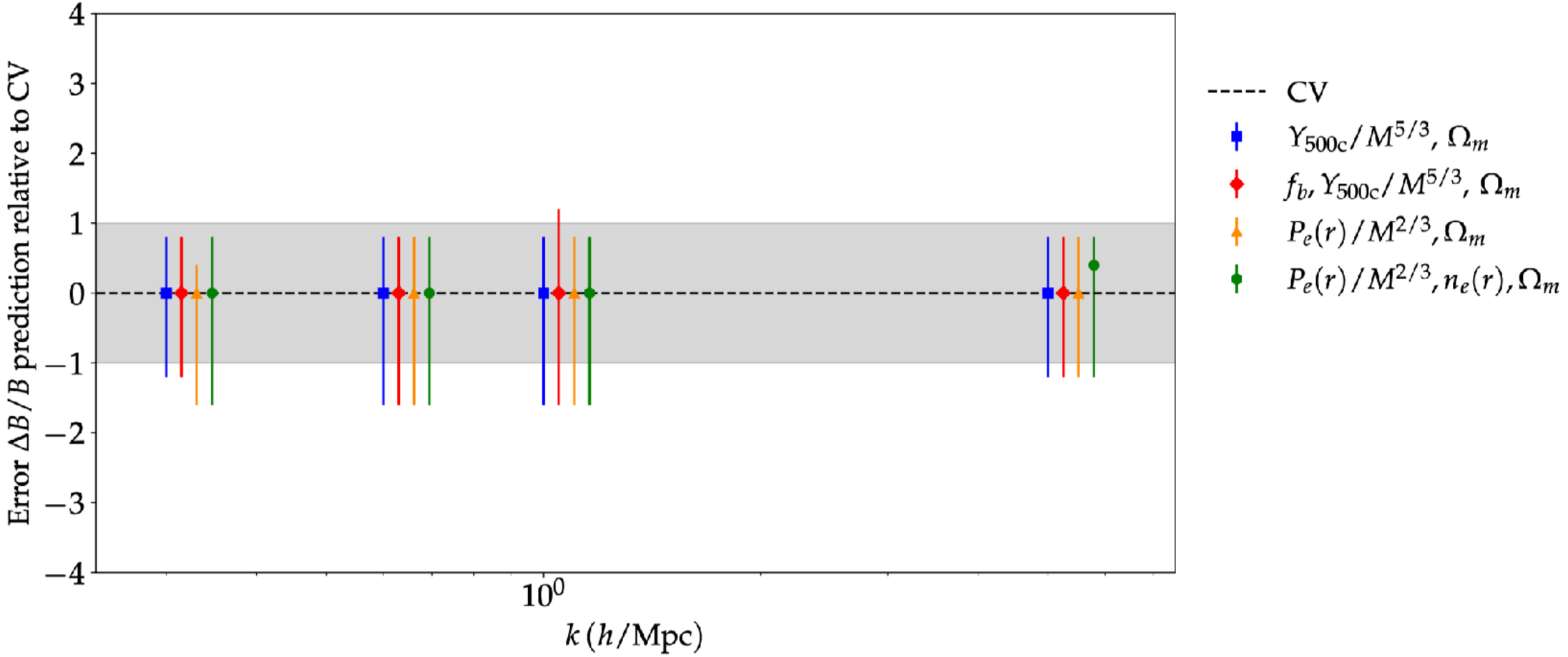
- Having integrated astrophysical observables results in unbiased constraints on suppression
- The errorbars are also comparable to stochastic errors

With Profiles



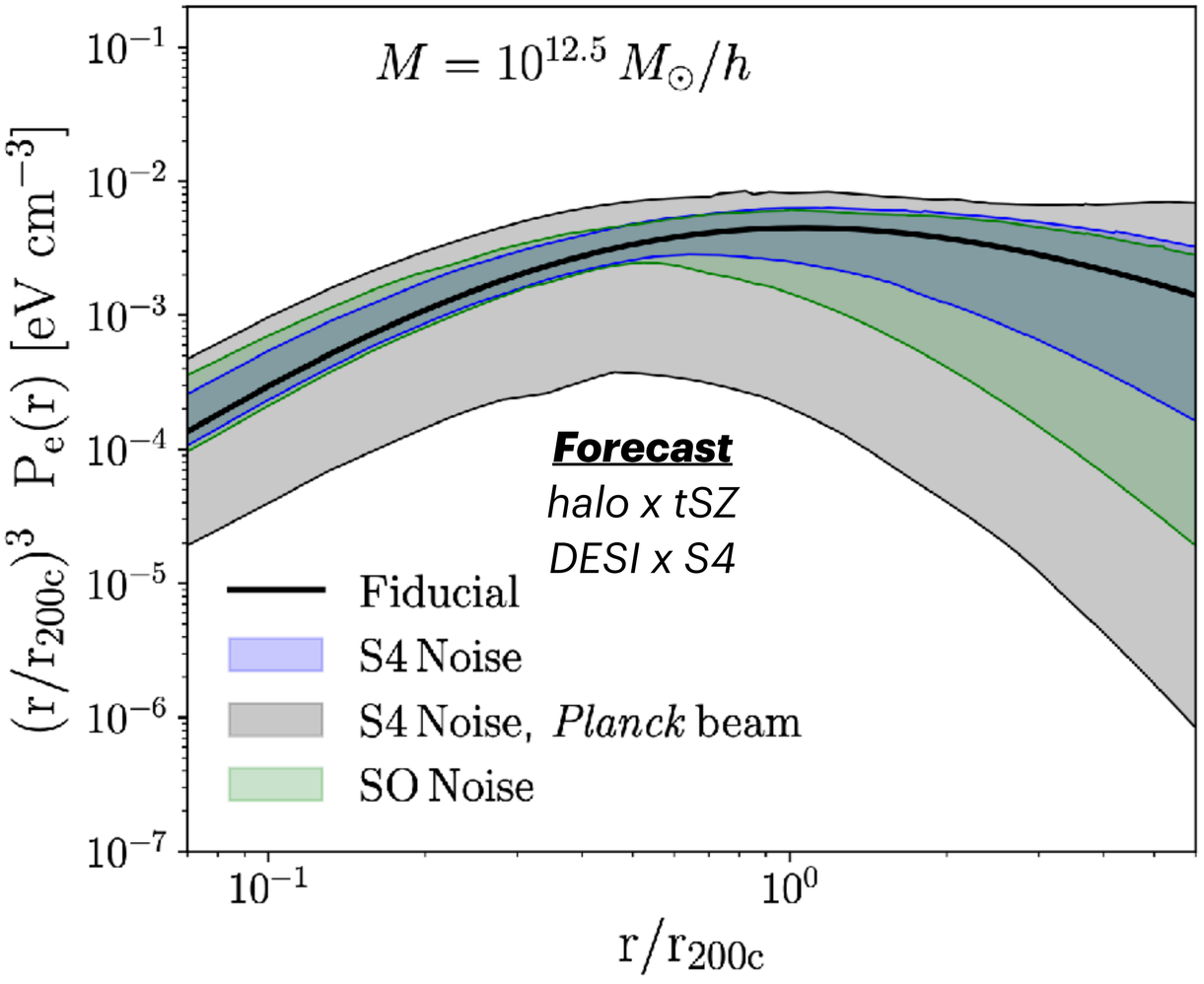
- Having full profile information results in more robust constraints!
- tSZ profile alone with information about matter density gives tight constraints!

Can we also do bispectrum?

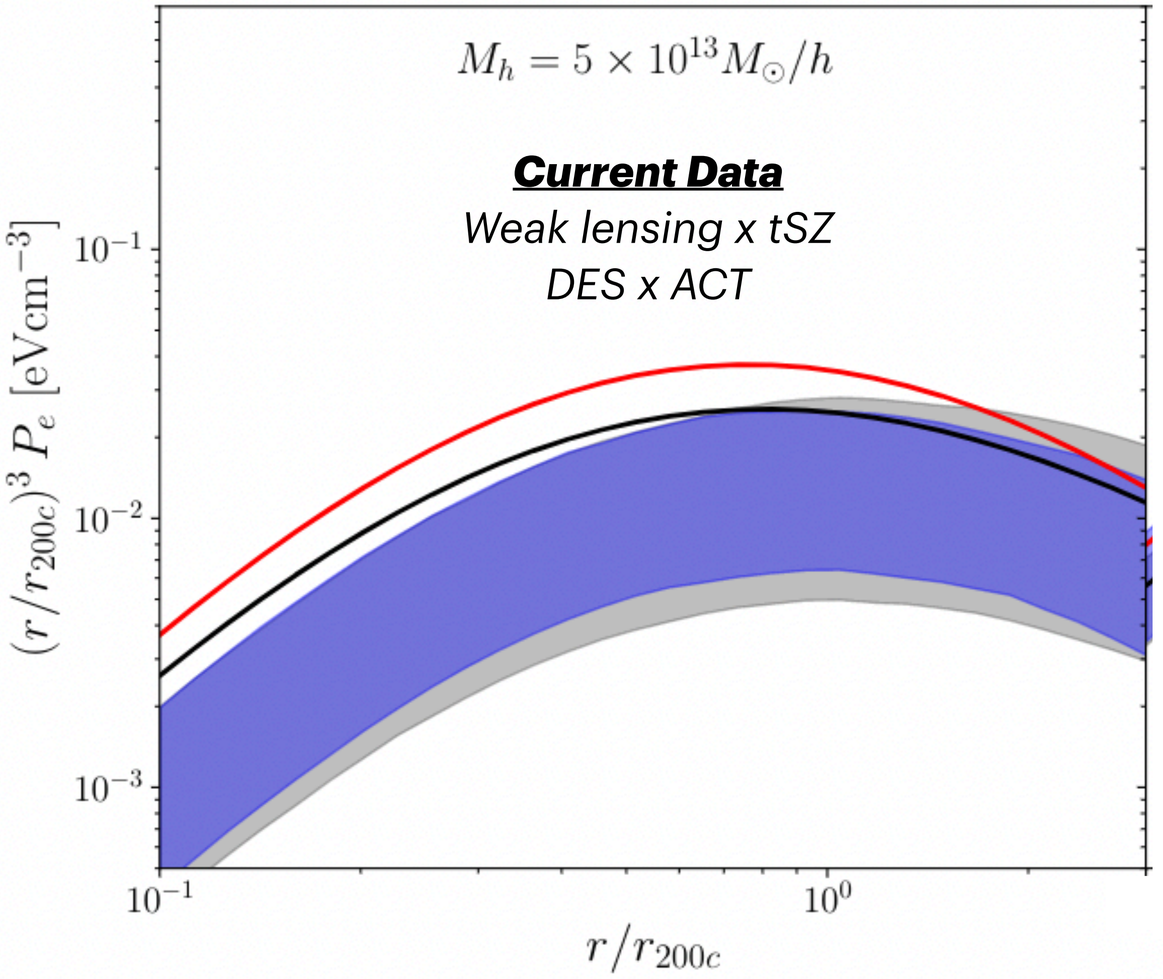


- *Bispectrum is more sensitive to higher mass halos (which are missing from CAMELS), so take this with more than a pinch of salt*

Connection with SZ xcorr forecast/data

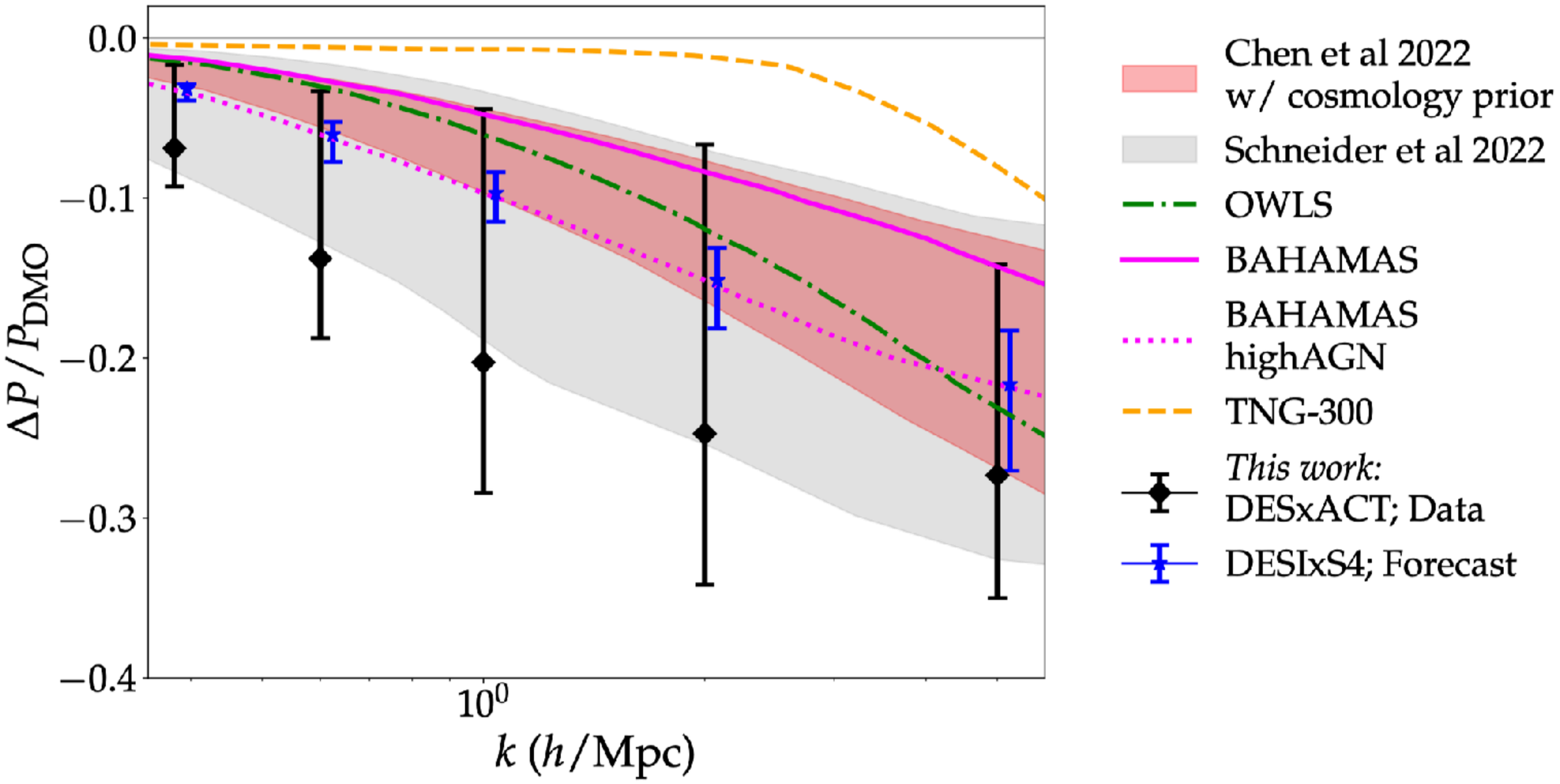


Pandey, Baxter, Hill 2020

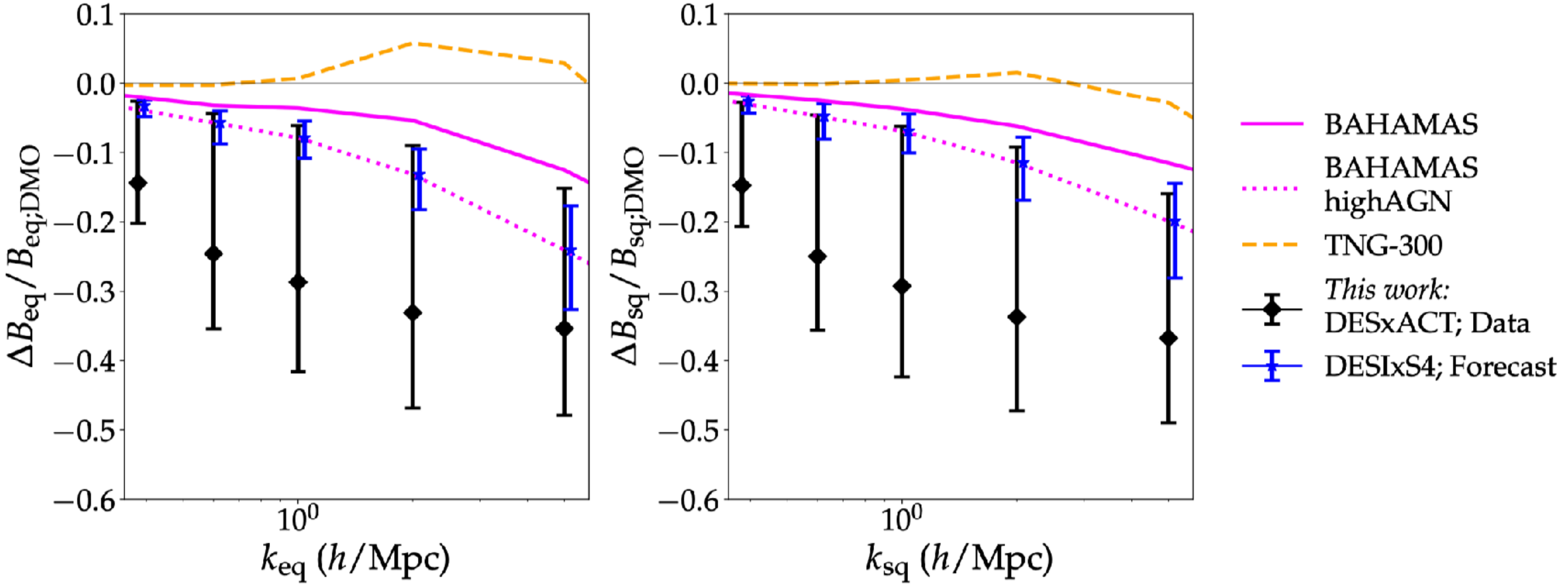


Pandey, Gatti, Baxter, et al 2021

Inference from data



Bispectrum



- These would probably change with larger simulation boxes, but probably still an useful proof of concept

Conclusions

- In the era of multiprobe cosmology, we have several probes with complementary information on baryons and LSS.
- Cross-correlations of these offer insights on evolution and properties of baryonic processes. We have detected these at high significance and its sensitivity to small scales will dramatically improve with upcoming data.
- tSZ, probing pressure of hot gas, is easy to measure and also carries information about the impact of feedback on total matter distribution.
- The hydrosims suites, like CAMELS, provide a new way to effectively understand this relation and use it to analyze the current and future data.

Pressure profile constraints

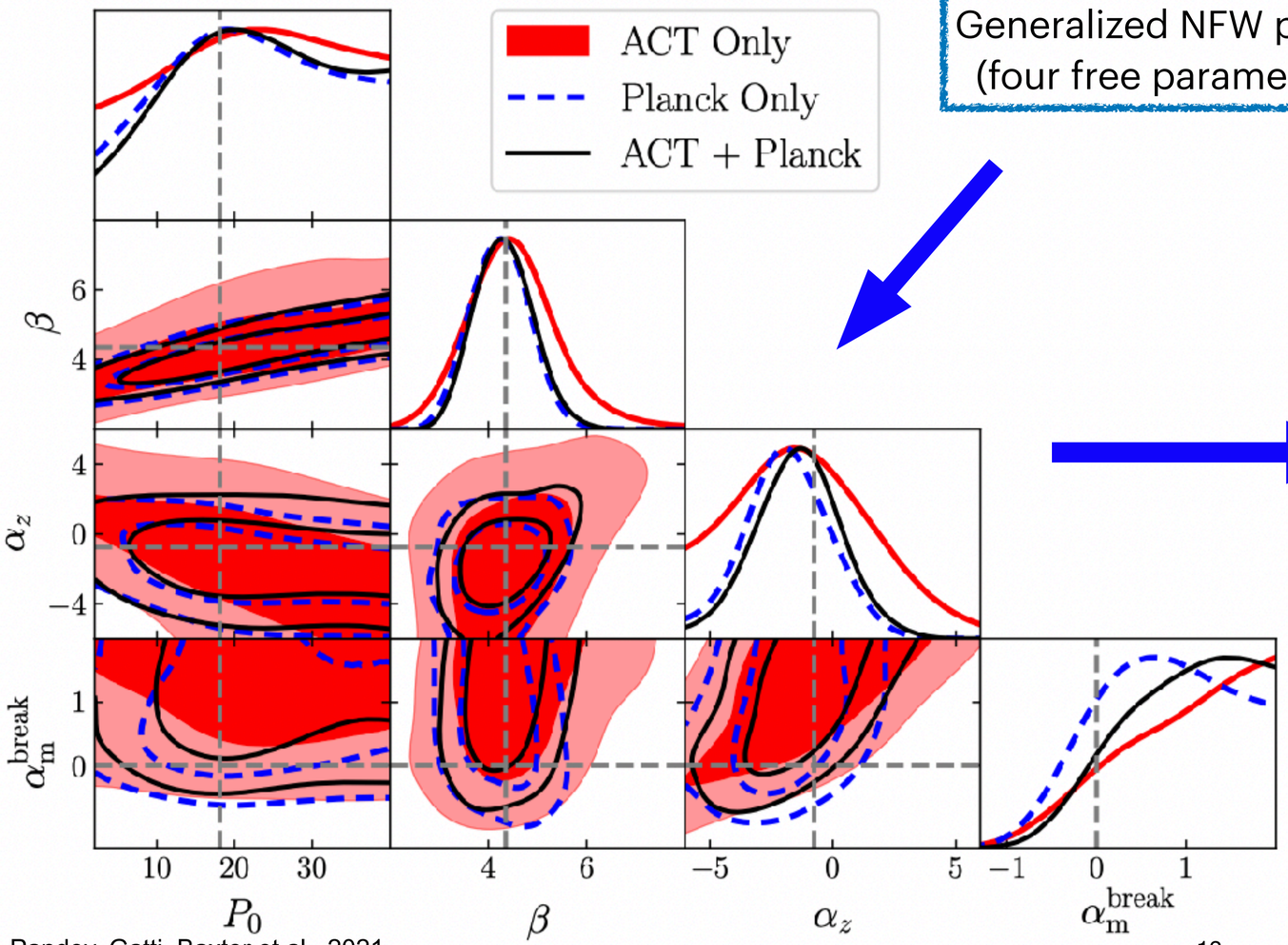
- We model the signal with halo model framework:

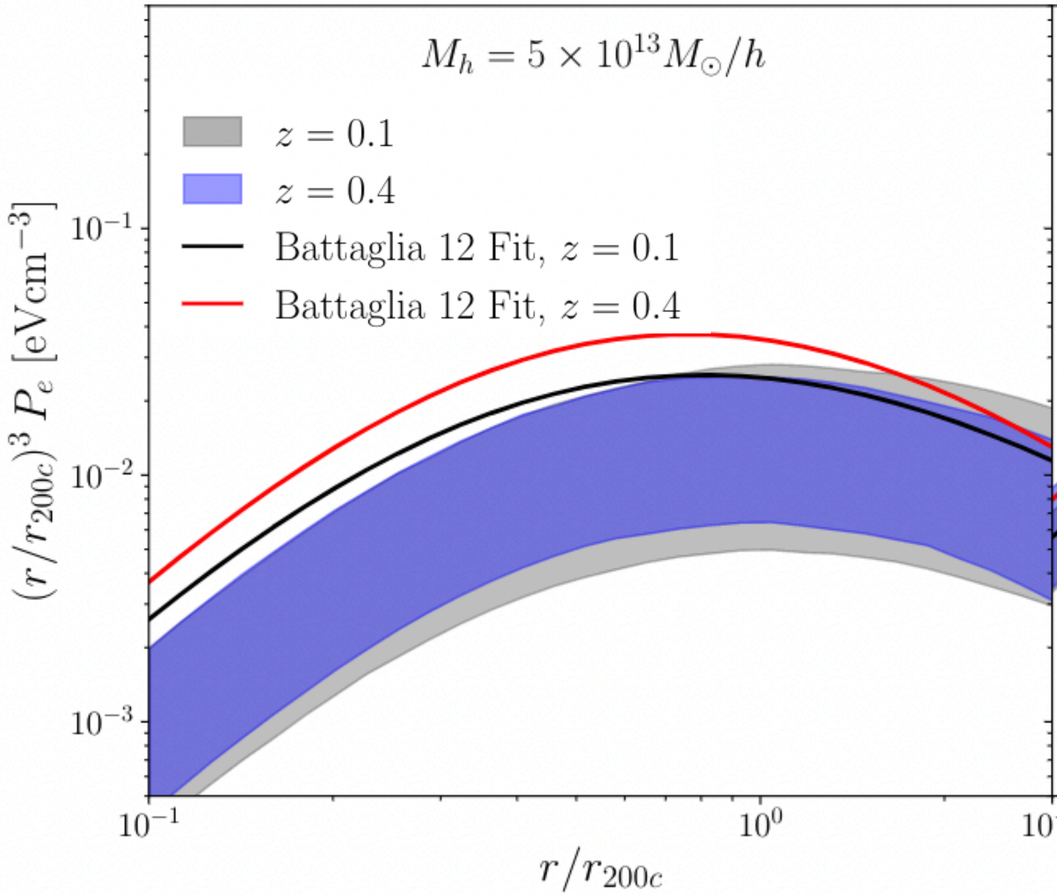
$\langle \gamma_t y \rangle$ = 1-halo + 2-halo + $\langle$IA $\times$ $y\rangle \sim f$(pressure-profile) $\times$ g(DM-profile) $\times$ h(cosmology)

Generalized NFW profile (four free parameters)

Generalized NFW profile (two free parameters)

Fixed to Planck/DES bestfit values





Pandey, Gatti, Baxter et al., 2021

Robustness of analysis