New Observational Power from Halo Bias

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With Neal Dalal, Dragan Huterer
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Motivation

Constraints on the local model:

- *CMB* *(WMAP 7 year, Komatsu et al)*

  $-10 < f_{NL} < 74$ (95%)

- *LSS* *(Slosar et al)*

  $-29 < f_{NL} < 69$ (95%)

BUT...
LARGE LOCAL NON-GAUSSIANITY
COMES FROM
MULTIPLE FIELDS....

- What does f_{NL} measure/constrain?
- What do multi-field models predict?
- Are observations sensitive to details?

A generalized local ansatz

- Factorizable, symmetric extension:

$$B_\Phi(\mathbf{k}_1, \mathbf{k}_2, \mathbf{k}_3) = \quad f_{NL} \quad P_\Phi(k_1)P_\Phi(k_2) + 5 \text{ perm} .$$

- Mild scale-dependence:

Byrnes et al: $$n_{f_{NL}} \equiv \frac{d \ln |f_{NL}|}{d \ln k}$$

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A generalized local ansatz

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$$\xi_{s,m}(k) = \xi_{s,m}(k_p)\left(\frac{k}{k_p}\right)^{n_f^{(s),(m)}}$$

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Why?

- Multi-field function: Two or more fields contribute to curvature: *(Kendrick Smith's talk)*

$$\Phi_{NG} = \phi_G + \sigma_G + \tilde{f}_{NL}(\sigma_G^2 - \langle\sigma_G^2\rangle)$$

$$\xi_m = \frac{\mathcal{P}_{\zeta,\sigma}(k)}{\mathcal{P}_{\zeta,\phi}(k) + \mathcal{P}_{\zeta,\sigma}(k)}$$

$$f_{NL}(k) = \tilde{f}_{NL}\xi_m^2(k)$$

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- Natural? If observably large local type, yes.

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Note...

- One of these functions is familiar:

$$\Phi(\mathbf{x}) = \Phi_G(\mathbf{x}) + f_{NL} * \left[\Phi_G^2(\mathbf{x}) - \langle \Phi_G^2(\mathbf{x}) \rangle\right]$$

$$f_{NL}^{\rm eff}(k) = f_{NL}^{\rm eff,0} \left(\frac{k}{k_0}\right)^{n_f}$$

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Local Non-Gaussianity

- Correlation between long and short modes: enhanced clustering

- Effect of local and generalized local NG:

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$$\Delta b_{NG}(k, M, f_{NL}) \propto \frac{f_{NL}}{k^2}$$

(Dalal et al)

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- Effect of local and generalized local NG:

$$\Delta b_{NG}(k, M, f_{NL}) \propto \frac{f_{NL}}{k^2} \rightarrow \frac{f_{NL}^{eff}(M)}{k^{2-n_f^{(m)}}}$$

(Dalal et al) (Shandera et al)

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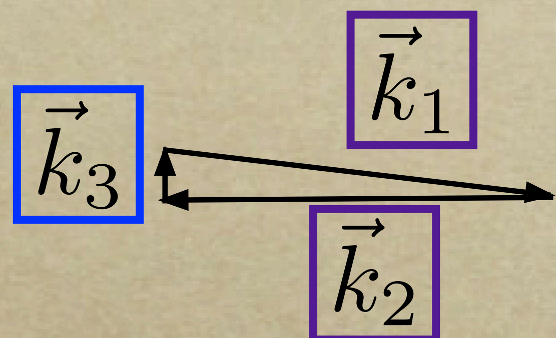
Non-Gaussian Bias from ANY bispectrum



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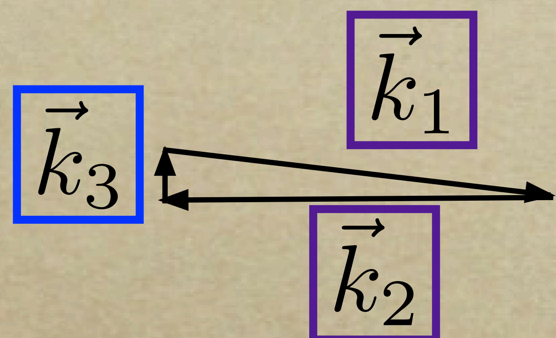

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eg: $B(k_1, k_2, k_3) \approx 2\xi_s(k_s)\xi_m(k_s)\xi_m(k_l)P(k_s)P(k_l)$

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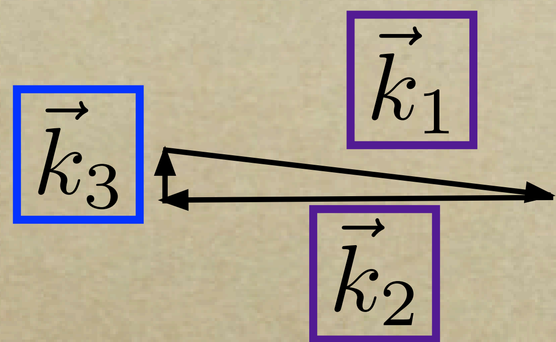

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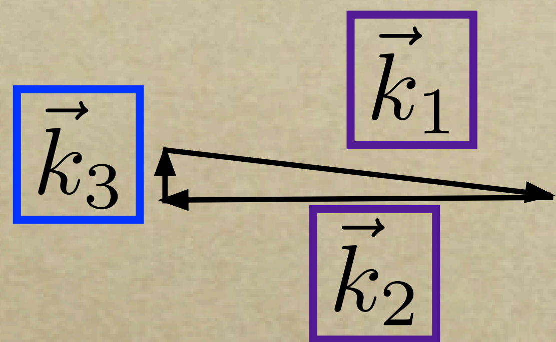

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Short wavelength

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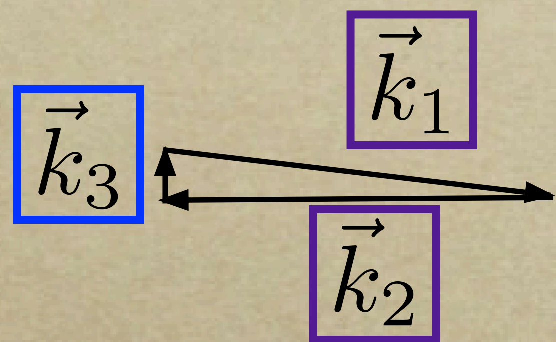

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Short wavelength

Long wavelength

(Licia's talk; templates)

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Do we care?

- Can observations constrain $n_f^{(m)}, \; n_f^{(s)}$?
- Careful about using different mass tracers to constrain f_{NL}

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- Can observations constrain $n_f^{(m)}$, $n_f^{(s)}$?
  (Becker's talk)
- Careful about using different mass tracers to constrain f_{NL}

Forecasts with naive prediction

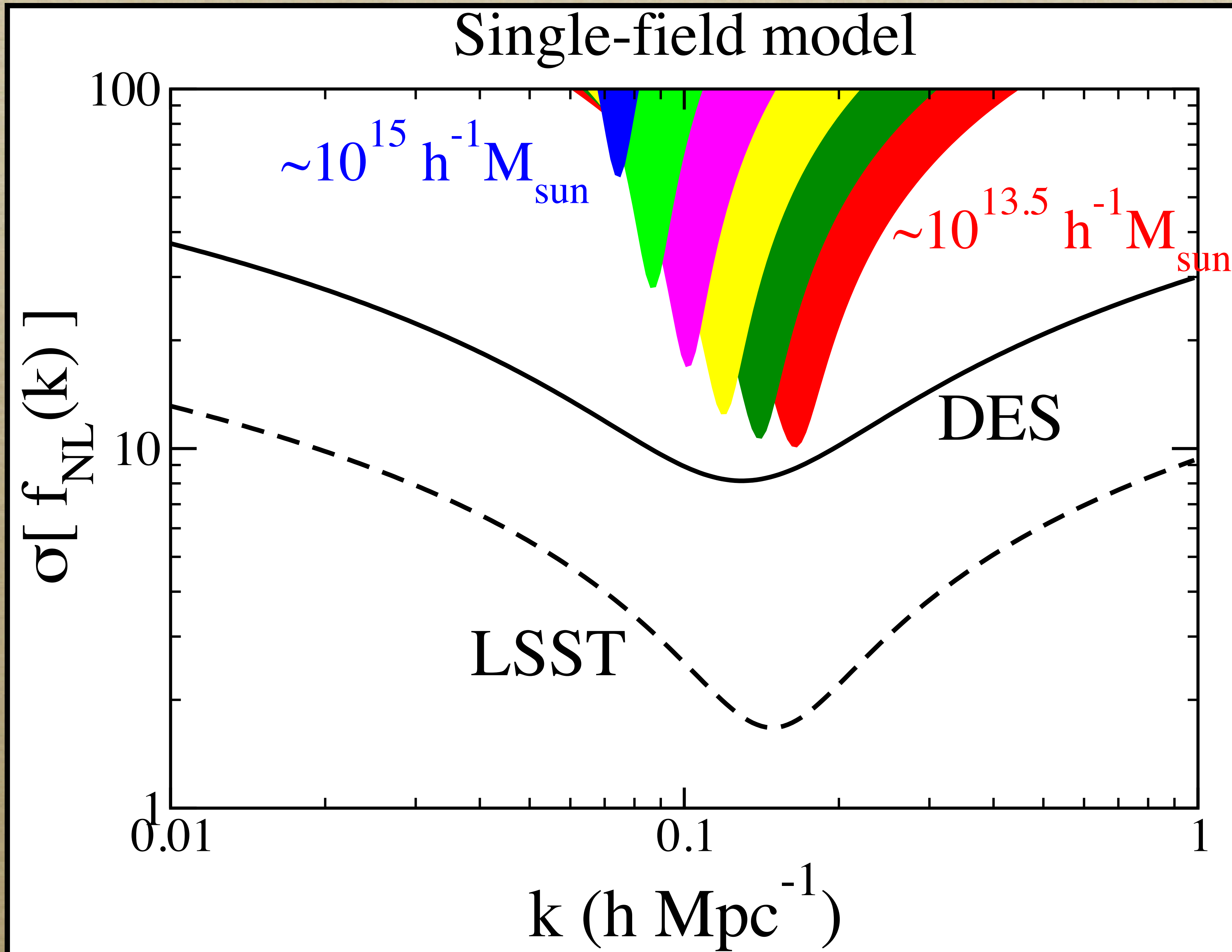
- Plots will show:

$$f_{NL}(k) = \xi_s(k_p)[\xi_m(k_p)]^2 \left(\frac{k}{k_p}\right)^{n_f^{(s)}+n_f^{(m)}}$$

- Fiducial values:

$$f_{NL}(k_p) \equiv \xi_s(k_p)\xi_m^2(k_p) = 30,\ n_f^{(s),(m)} = 0$$

- Wrong analytic model: Real effect is stronger



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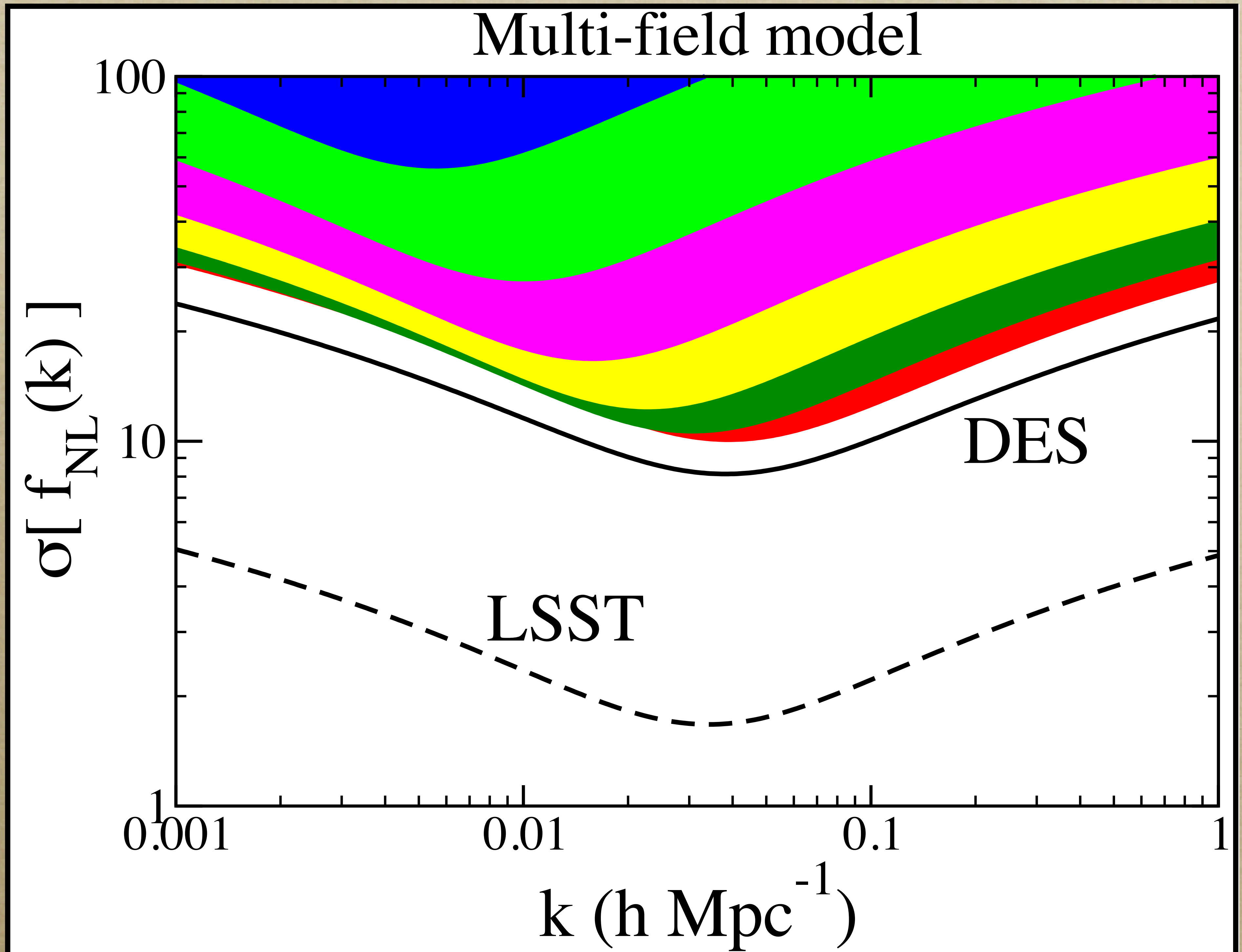

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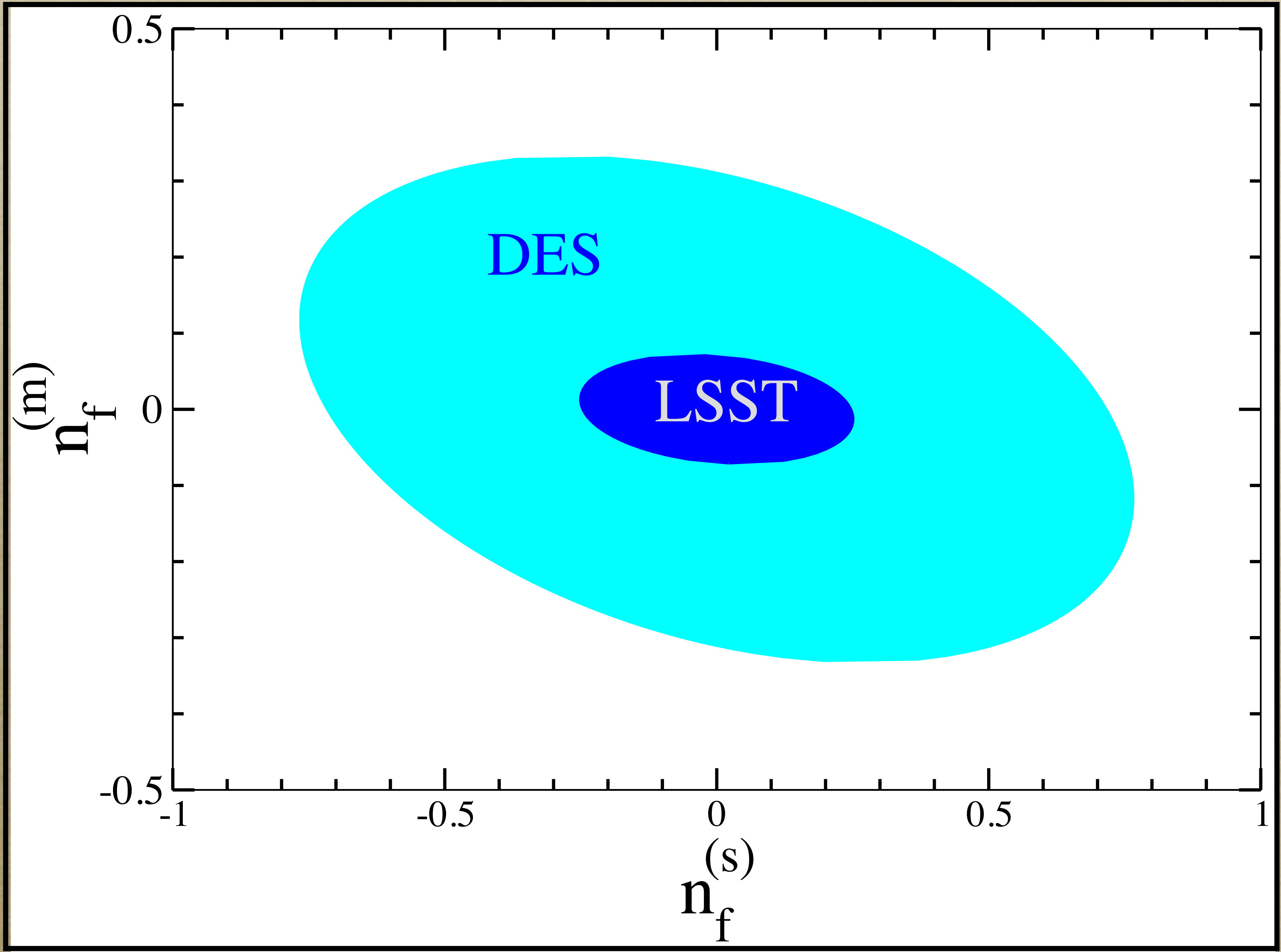
Distinguishing the Effects...



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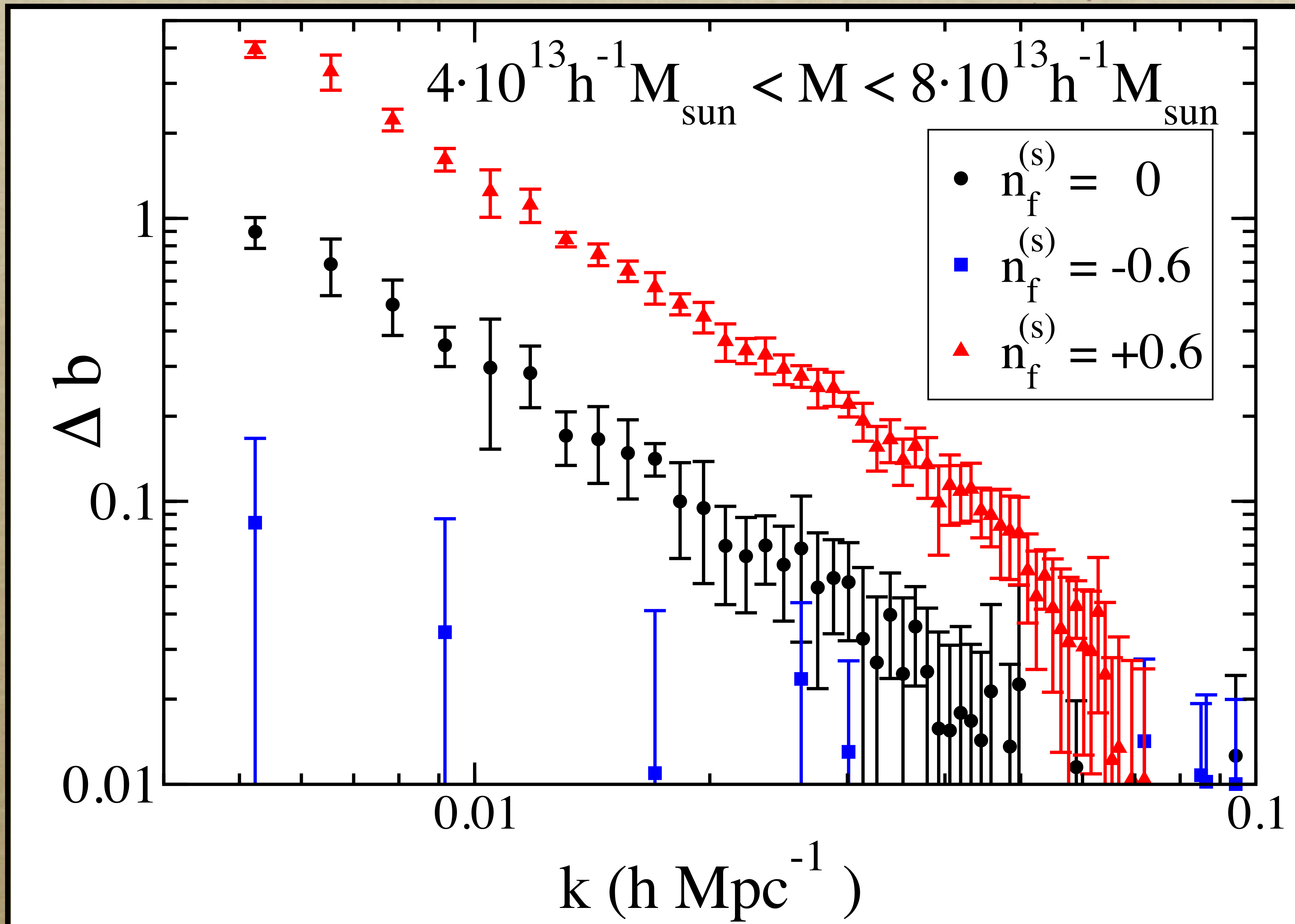
Simulation Results: low mass

$f_{NL}(k_p) = 300$



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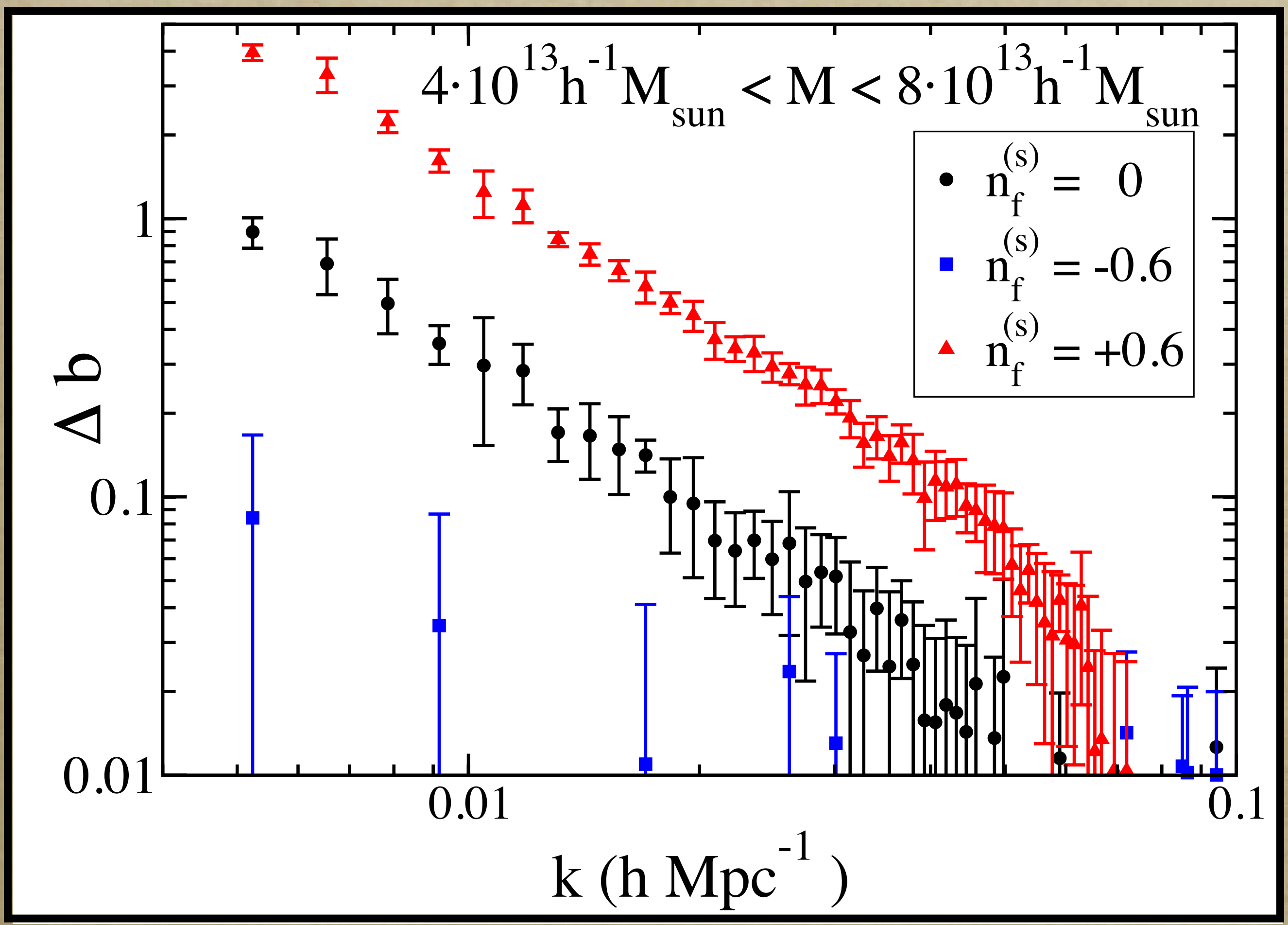
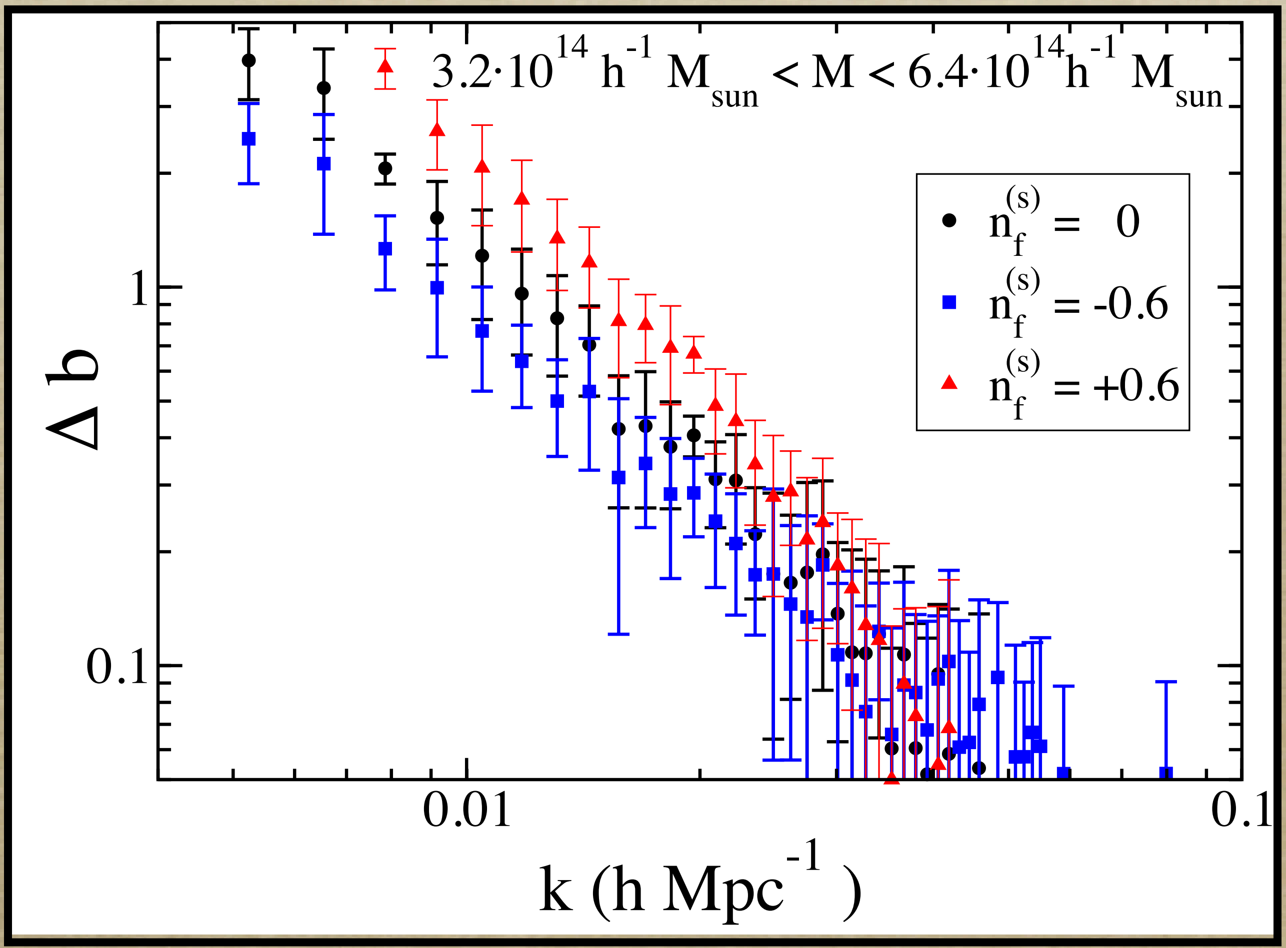
Compare High Mass





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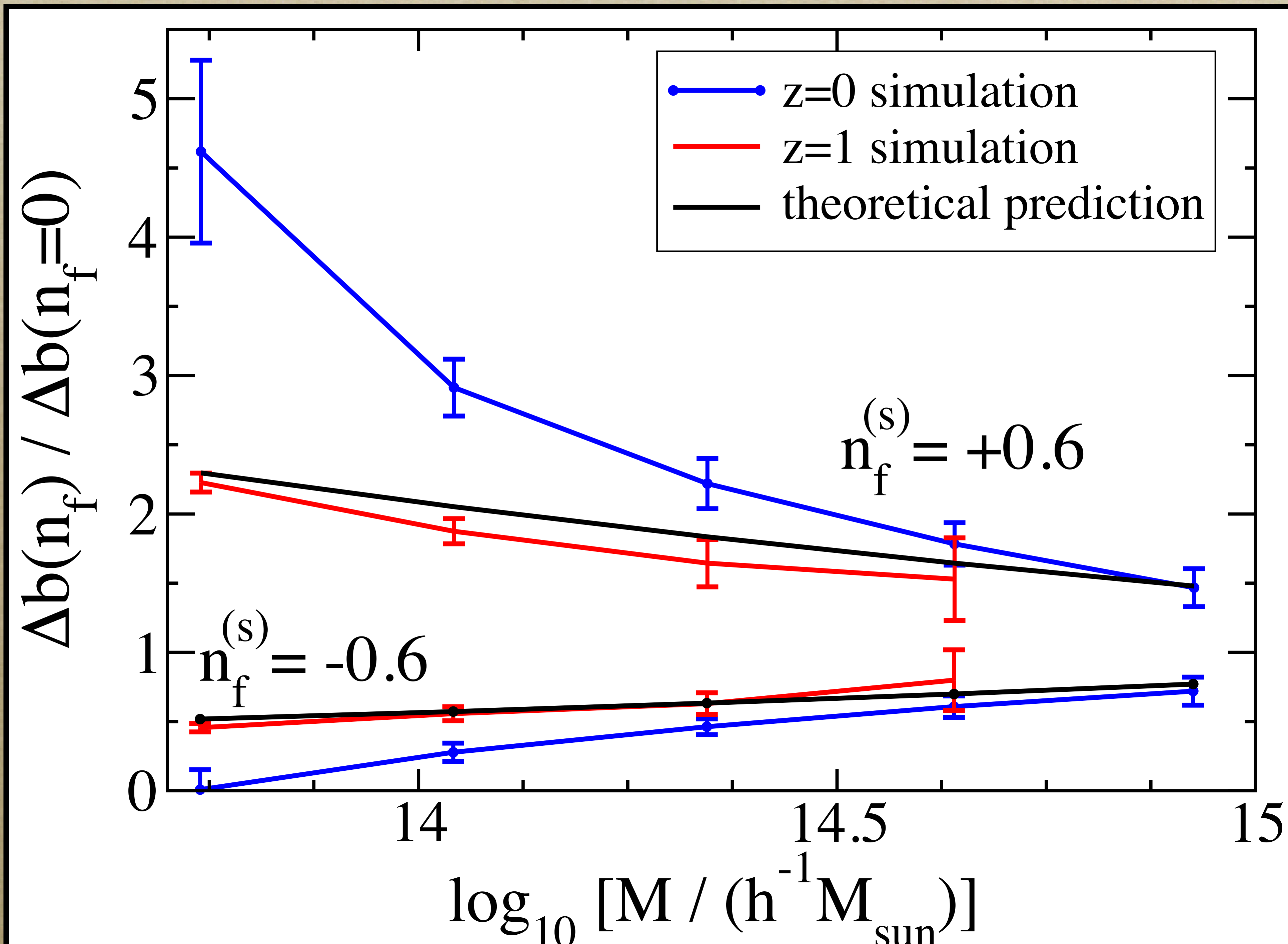
But, compare with theory:



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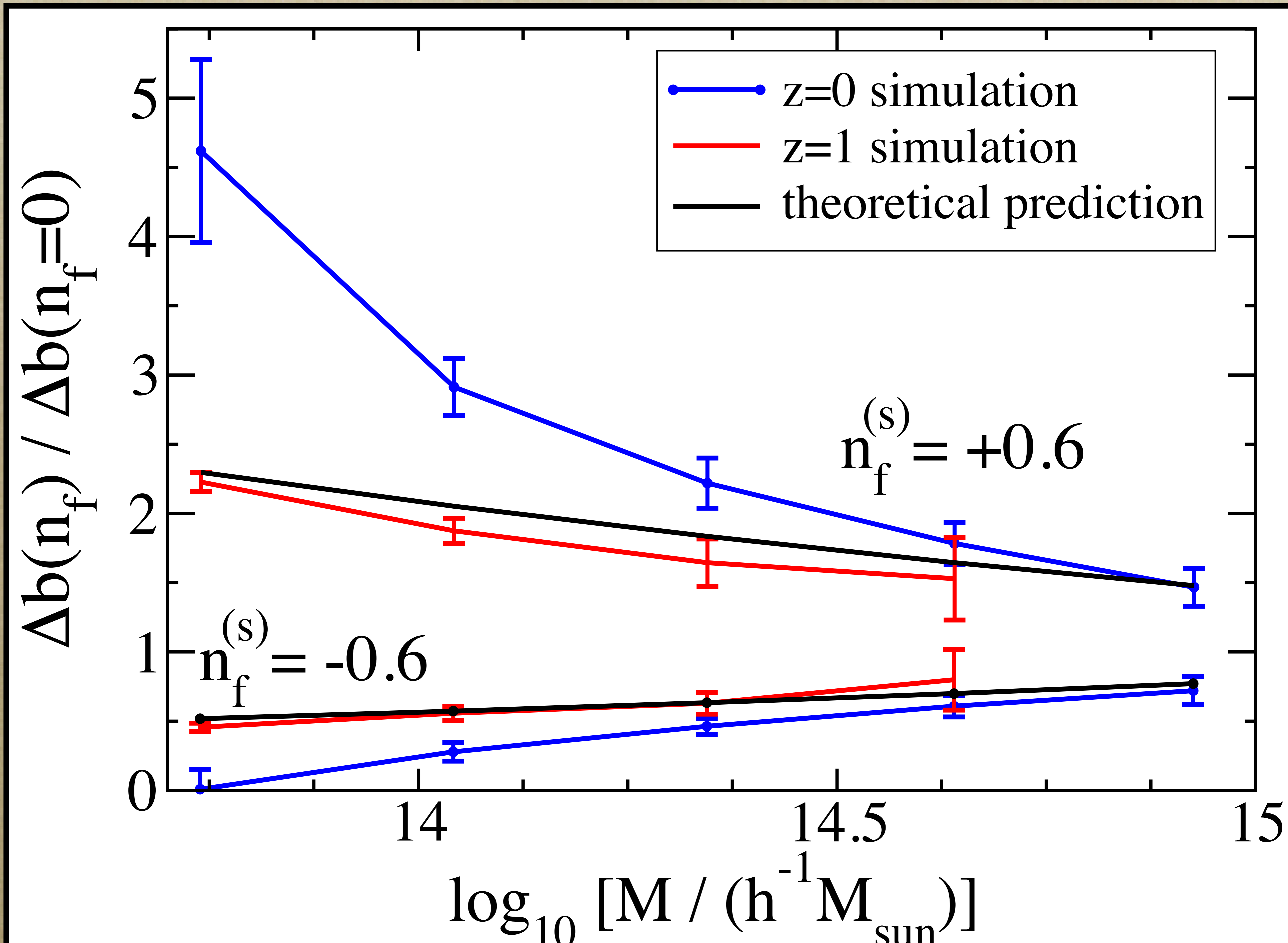

But see Schmidt, Desjacques!

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Conclusions

- Generalized local ansatz

$$B_\Phi(\mathbf{k}_1,\mathbf{k}_2,\mathbf{k}_3)=\xi_s(k_3)\xi_m(k_1)\xi_m(k_2)P_\Phi(k_1)P_\Phi(k_2)+5\text{ perm}\ .$$

- Generalized bias:

$$\Delta b_{NG}\propto\ \frac{f_{NL}^{eff}(M)}{k^{2-n_f^{(m)}}}$$

Short scale stuff

Long scale stuff

- Observable (careful with constraints, add CMB) (Sefusatti et al)
- Adjust analytic predictions (Schmidt, Desjacques; Scoccimarro

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