

# MODELLING THE NONLINEAR CLUSTERING IN BEYOND- $\Lambda$ CDM COSMOLOGIES

Matteo Cataneo  
University of Edinburgh



DEX XV, ROE

8/1/2019

arXiv: 1812.05594

*In collaboration with:*

Alex Barreira, Sownak Bose, JD Emberson, Joachim Harnois-Deraps,  
Catherine Heymans, Derek Inman, Baojiu Li, Lucas Lombriser, Alex Mead

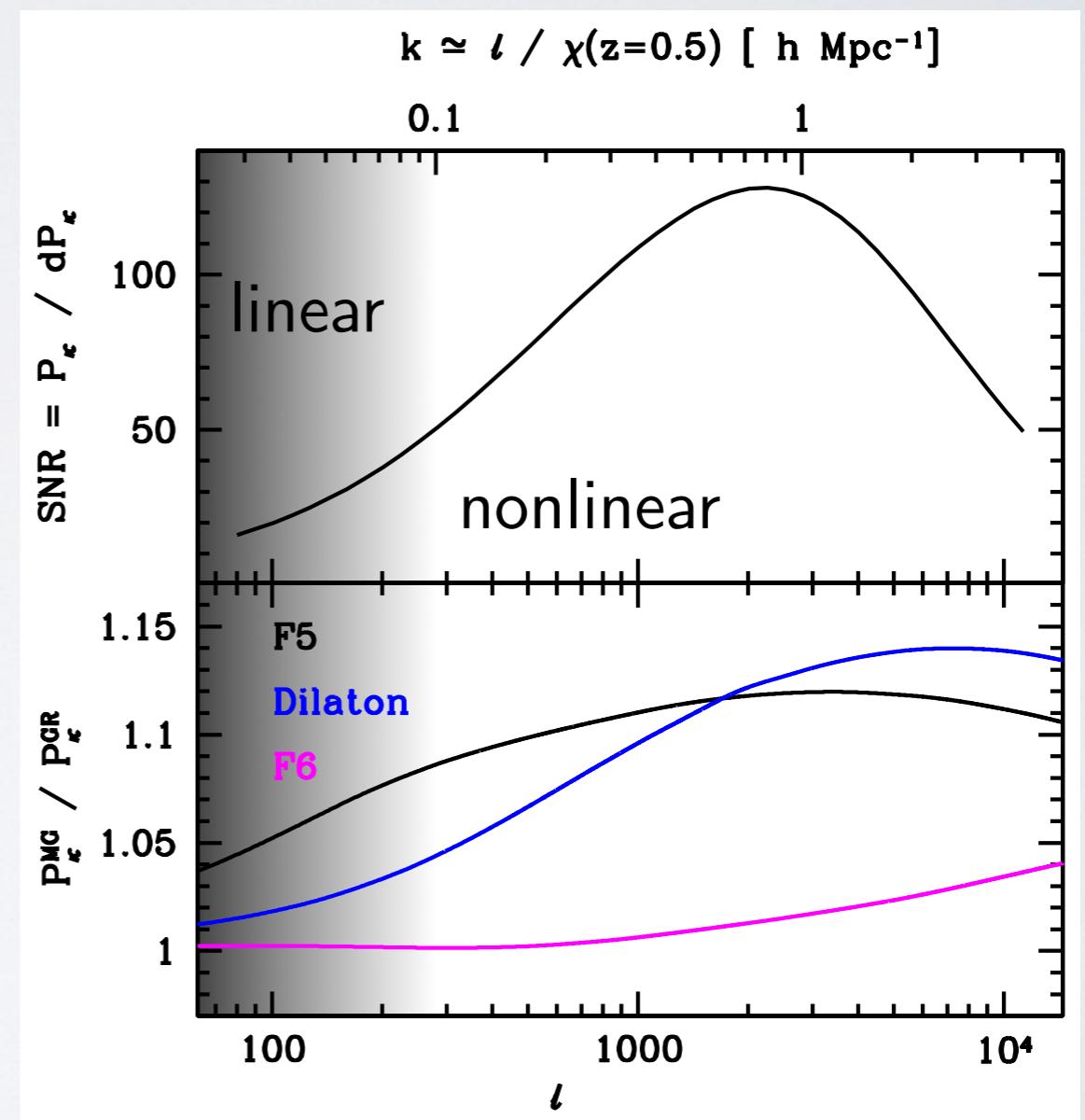


# Why Going Nonlinear?



**1%**

Precision of future  
LSS measurements



Heymans & Zhao 2018

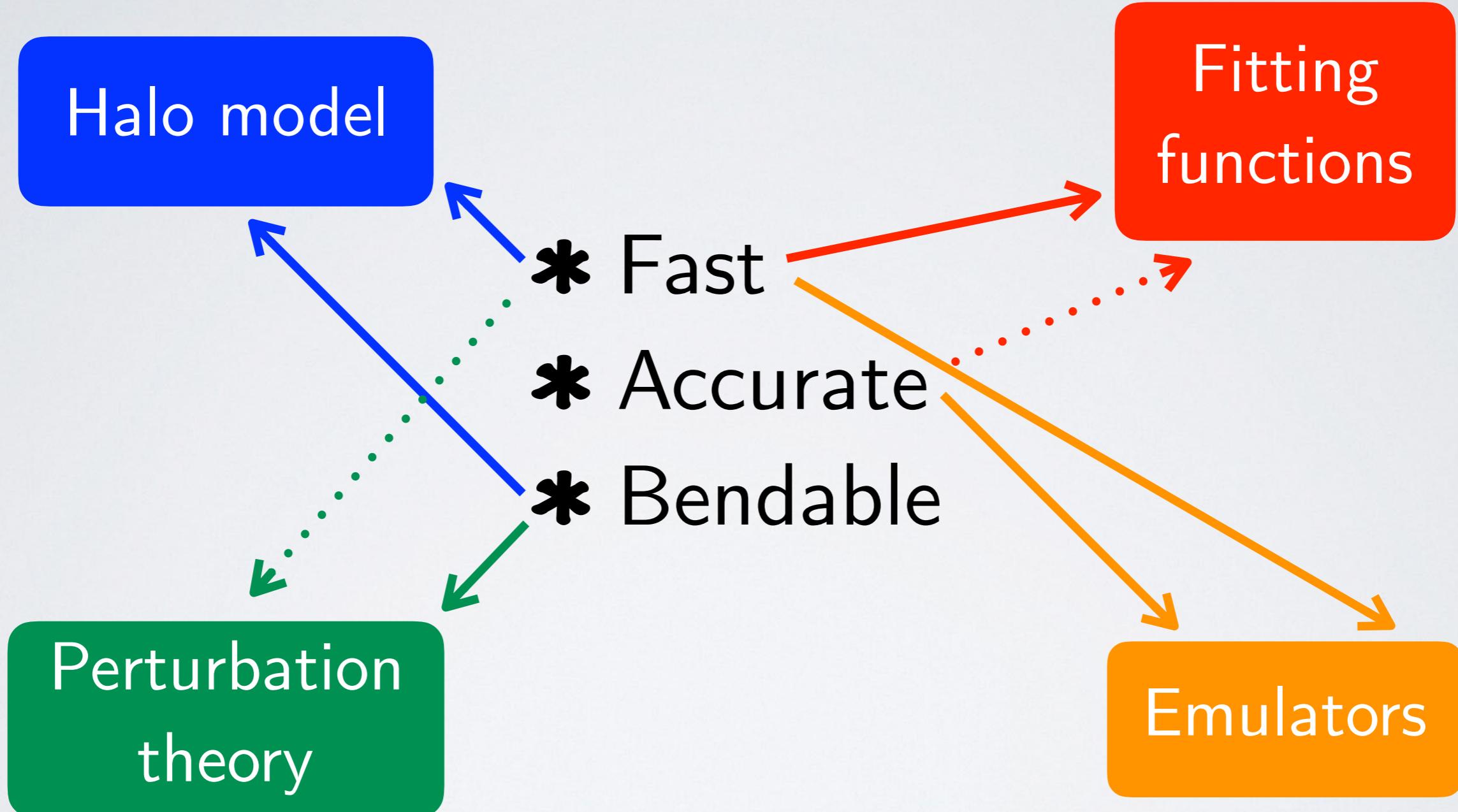
# A FAB Method

Nonlinear predictions must be

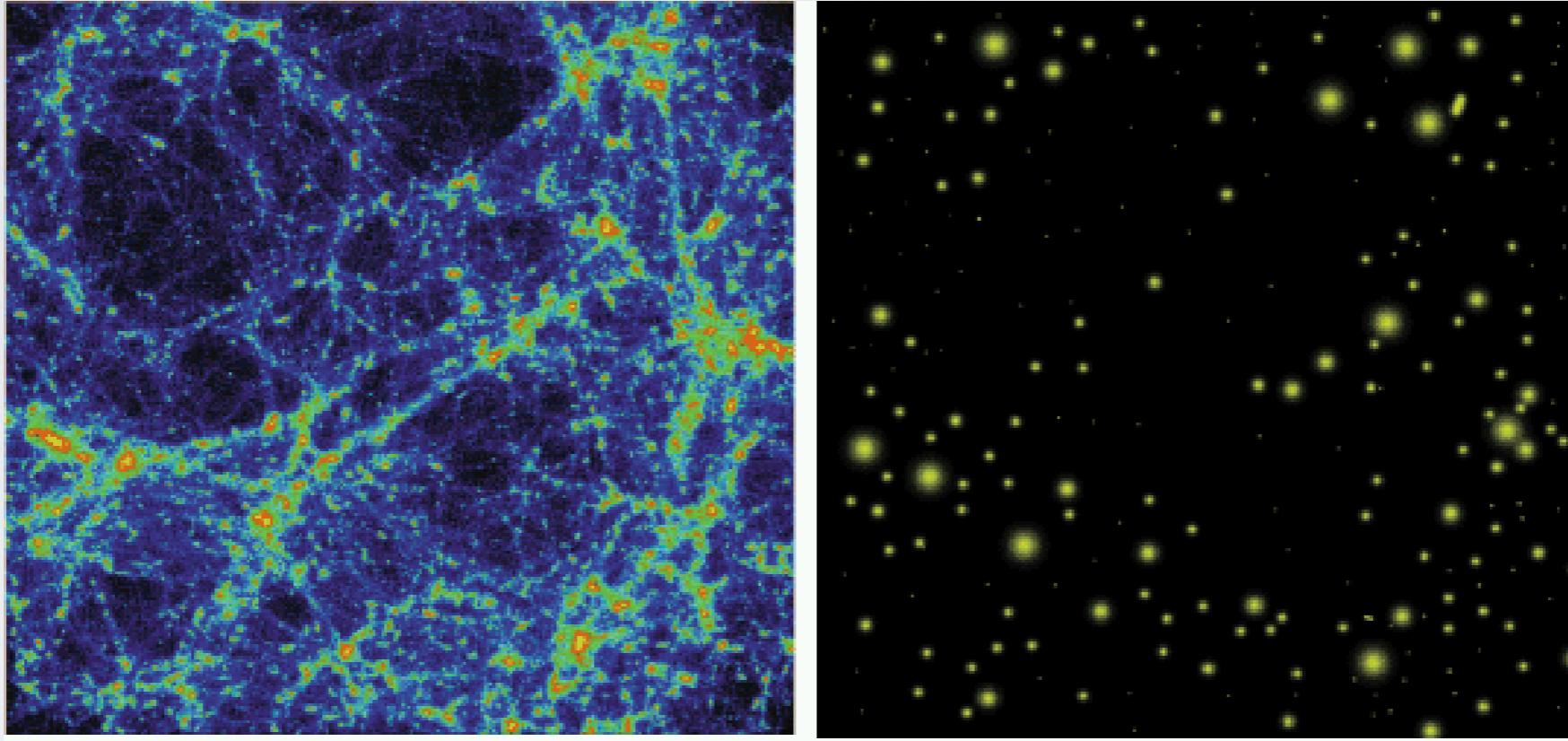
- \* Fast
- \* Accurate
- \* Bendable



# What's Out There?



# The Halo Model



Cooray & Sheth 2002

$$P(k) = P_{2h}(k) + P_{1h}(k)$$

(quasi)linear PT

- halo mass function
- virial radius
- halo concentrations

# Halo Model Reactions

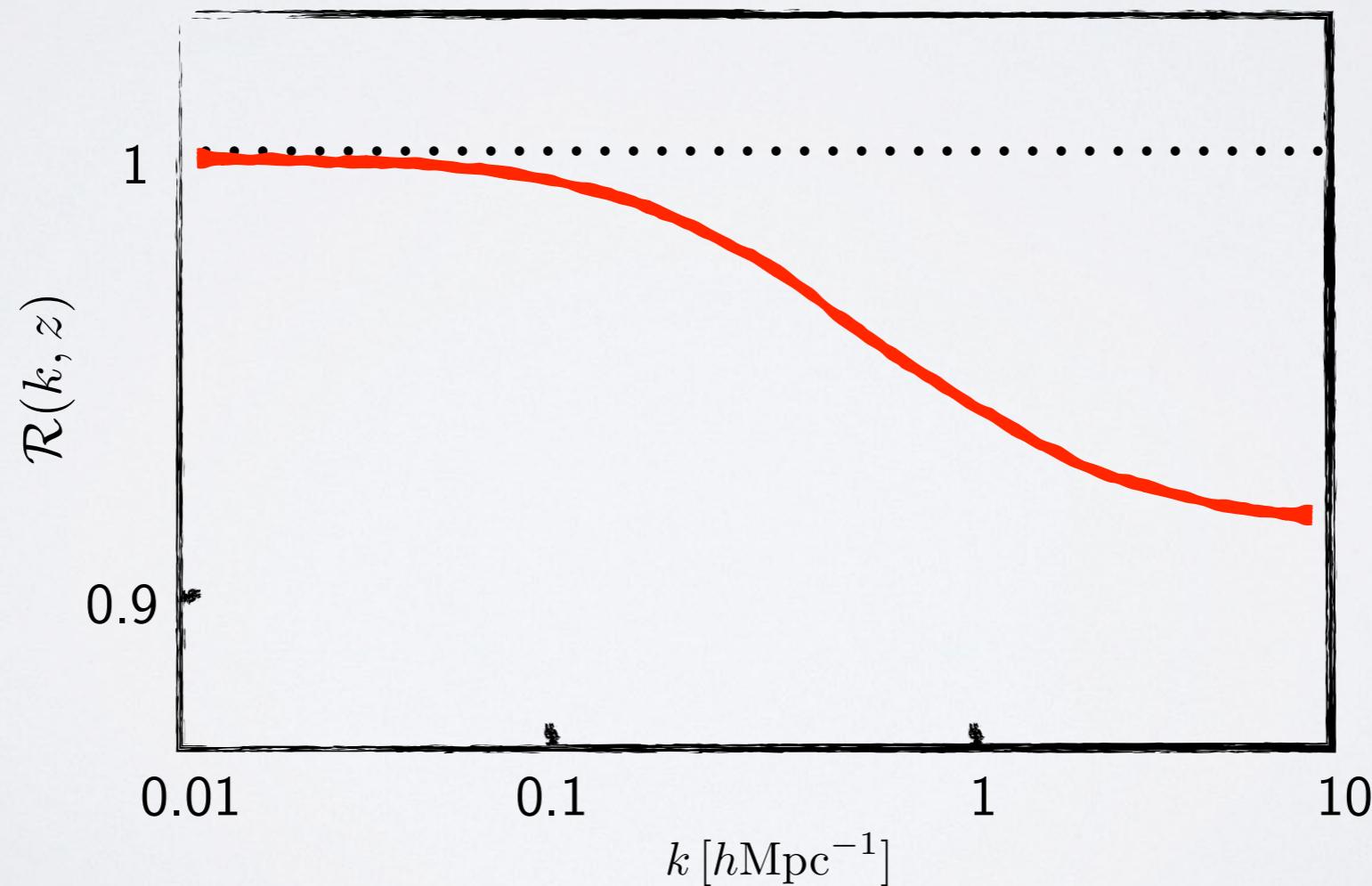
## 1) *Pseudo cosmology*

$\Lambda$ CDM cosmology with ICs adjusted to  
*match*  
*real* cosmology  $P_{\text{lin}}(k, z_0)$

# Halo Model Reactions

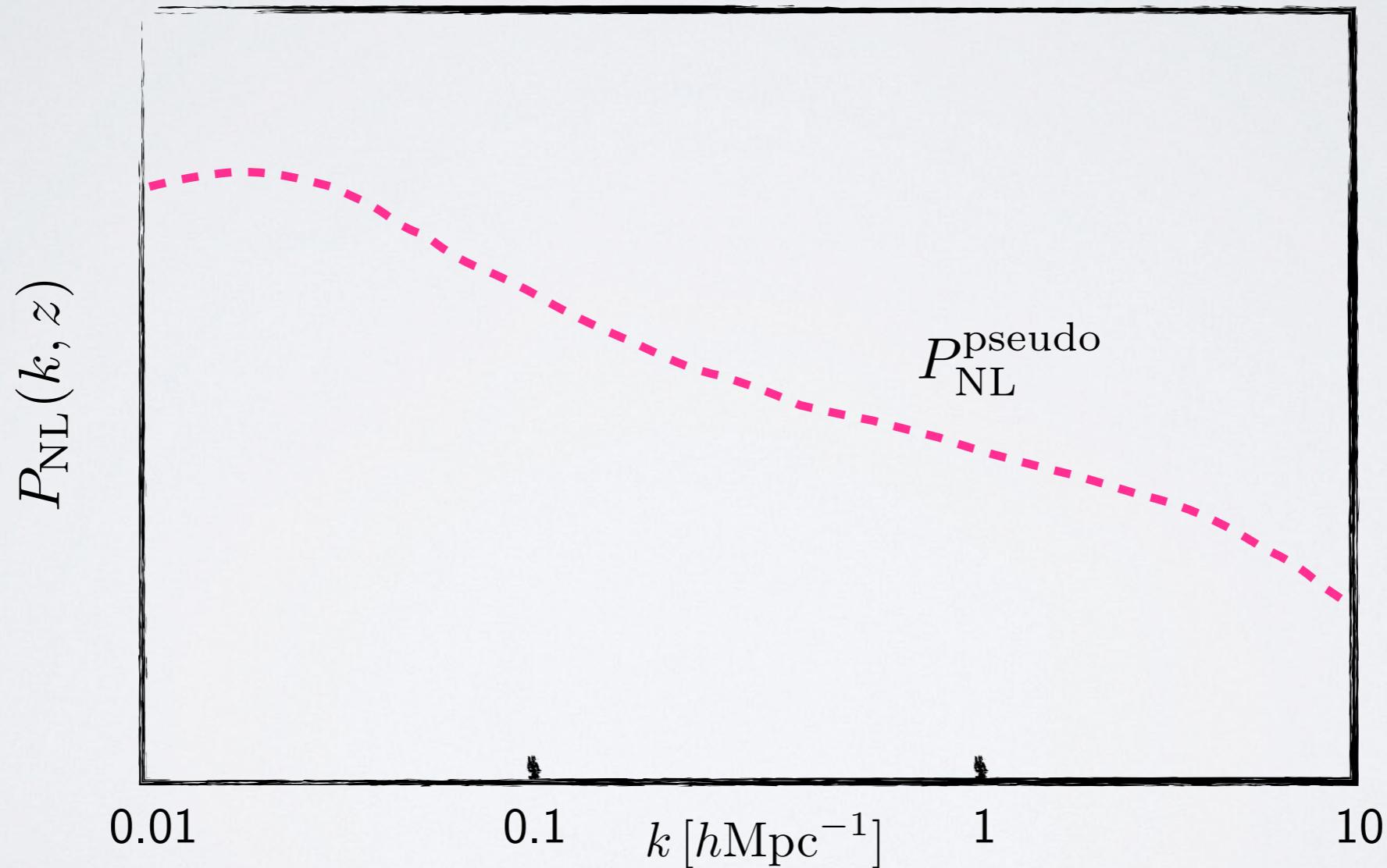
## 2) Reaction

$$\mathcal{R}(k, z) \equiv \frac{P_{\text{NL}}^{\text{real}}(k, z)}{P_{\text{NL}}^{\text{pseudo}}(k, z)} = \frac{P_{2\text{h}}^{\text{real}}(k, z) + P_{1\text{h}}^{\text{real}}(k, z)}{P_{2\text{h}}^{\text{pseudo}}(k, z) + P_{1\text{h}}^{\text{pseudo}}(k, z)}$$



# Halo Model Reactions

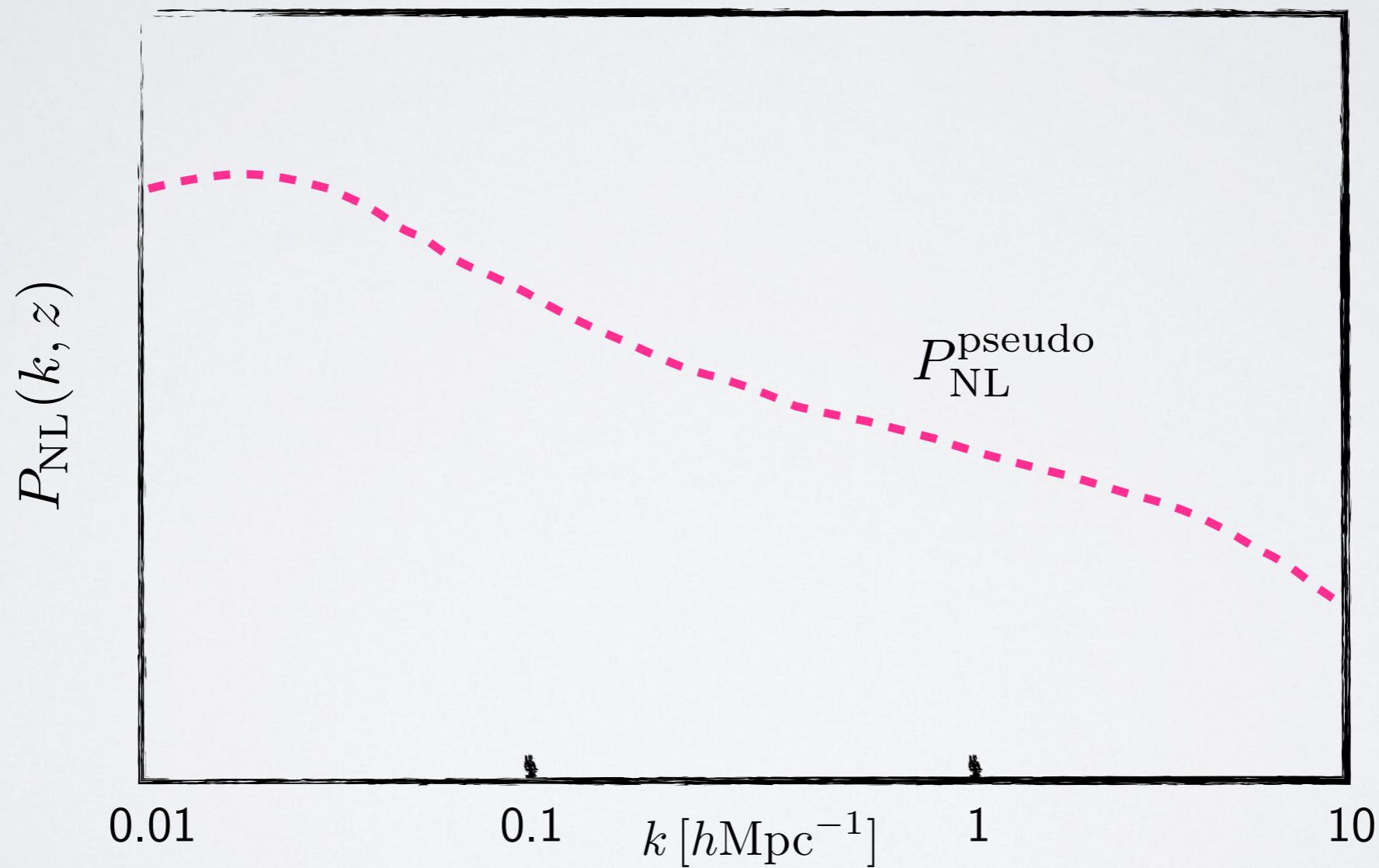
## 3) Power spectrum



# Halo Model Reactions

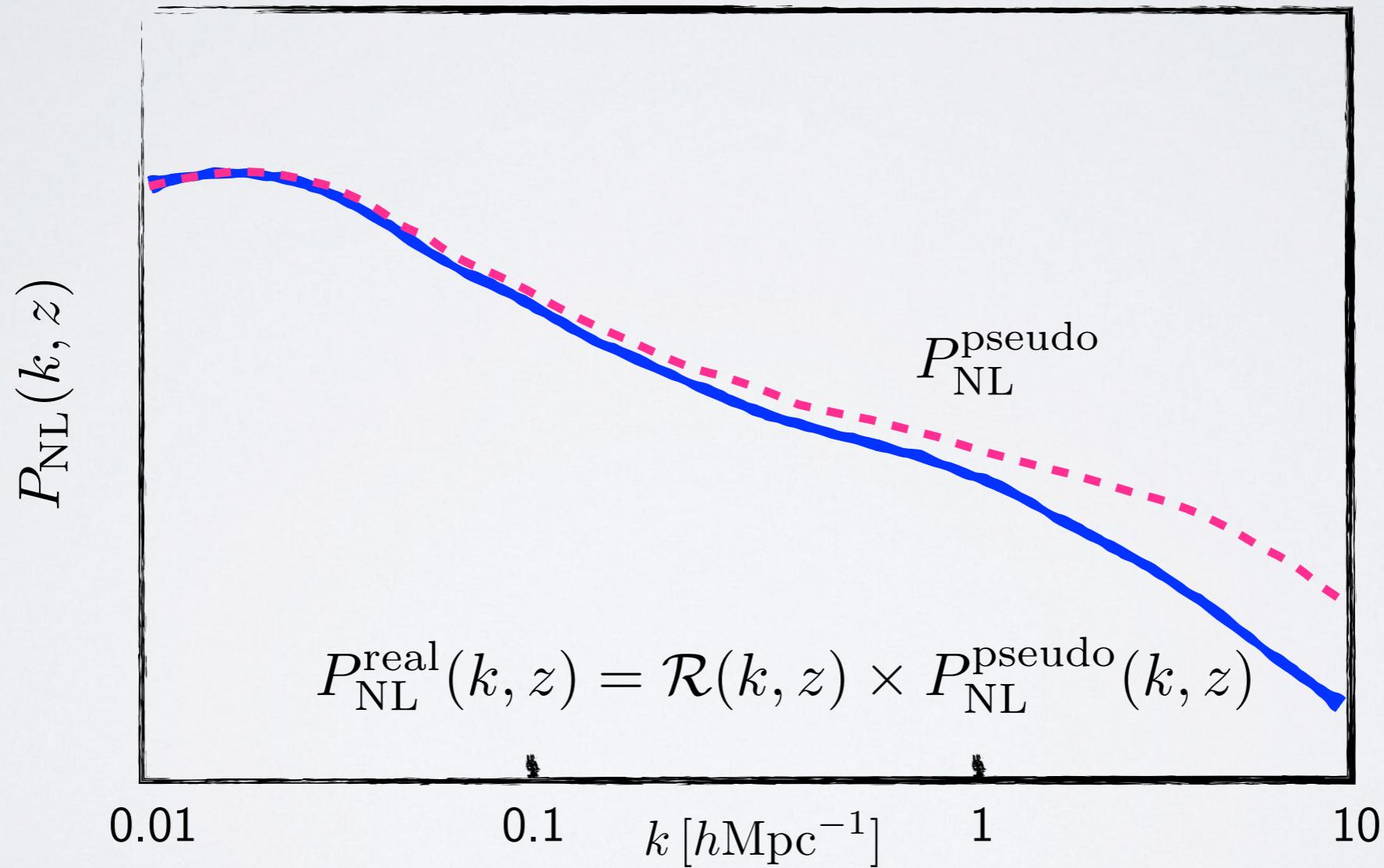
## 3) Power spectrum

See Ben Giblin's talk

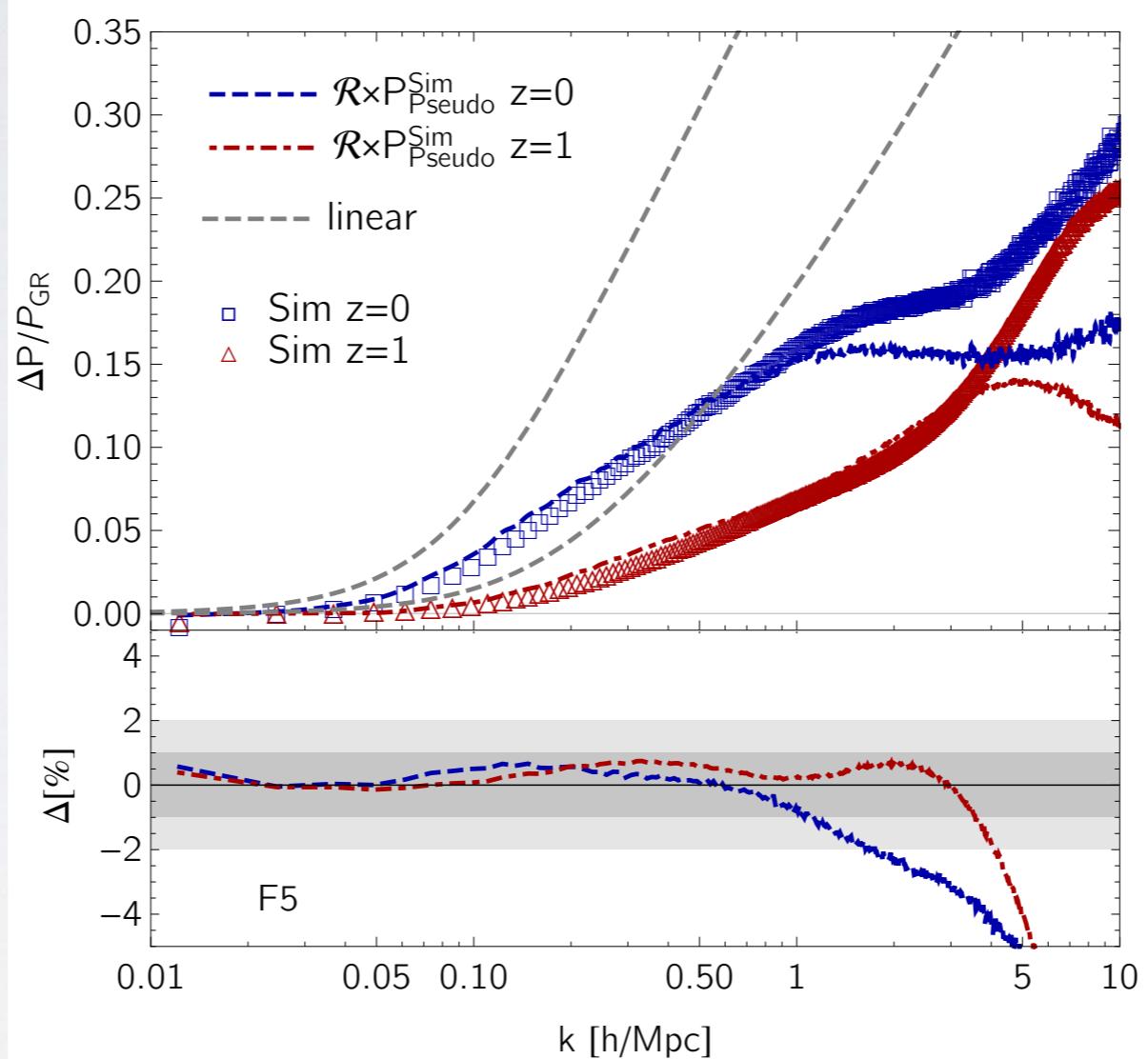


# Halo Model Reactions

## 3) Power spectrum

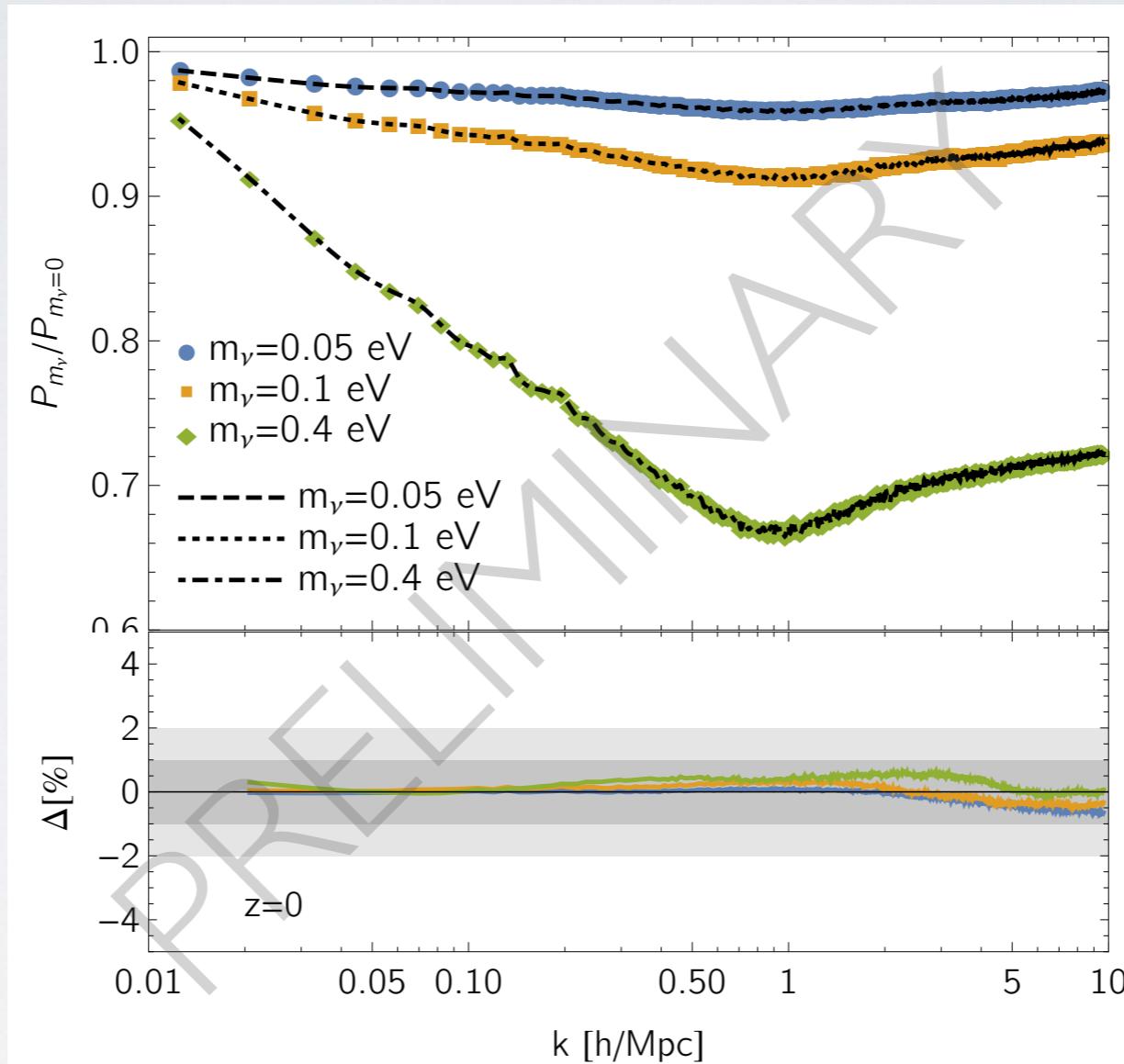


# $f(R)$ Gravity



Cataneo+ 2018

# Massive neutrinos



Cataneo+ 2019 in prep.

# Summary & Outlook

- Halo model reactions are:

- Fast (runtime ~second)
  - Accurate ( $\lesssim 1\%$  for  $k < 1 \text{ h/Mpc}$ )
  - Bendable ( $\Lambda\text{CDM}$  extensions)
- 

- Improve highly NL regime in MG/DE ( $1 < k \text{ Mpc/h} < 10$ )
- Build *pseudo* cosmology emulator (see Ben Giblin's talk)
- Include baryonic physics
- Extend to Horndeski theory
- Explore degeneracies in physics beyond vanilla  $\Lambda\text{CDM}$