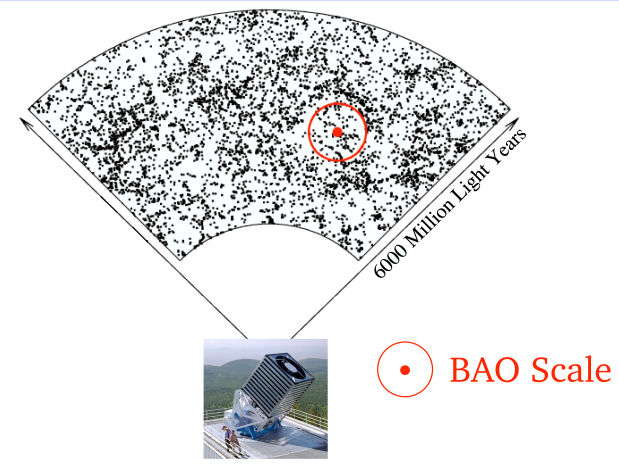
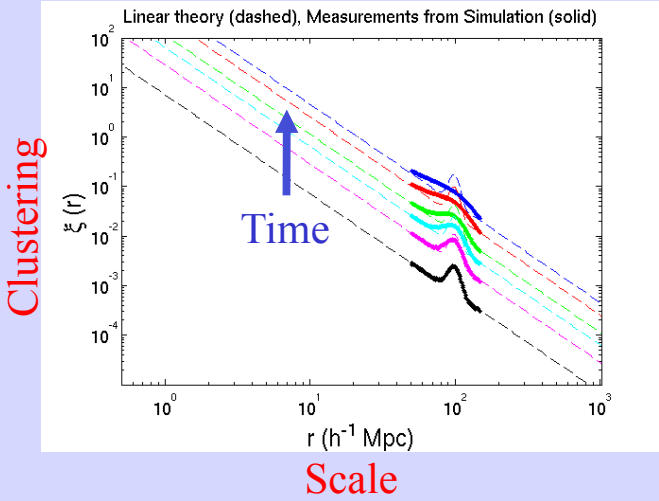
Self-similar Bumps and Wiggles:
Isolating the Evolution of the BAO Peak with Power-law Initial Conditions

Chris Orban (OSU Physics)

with

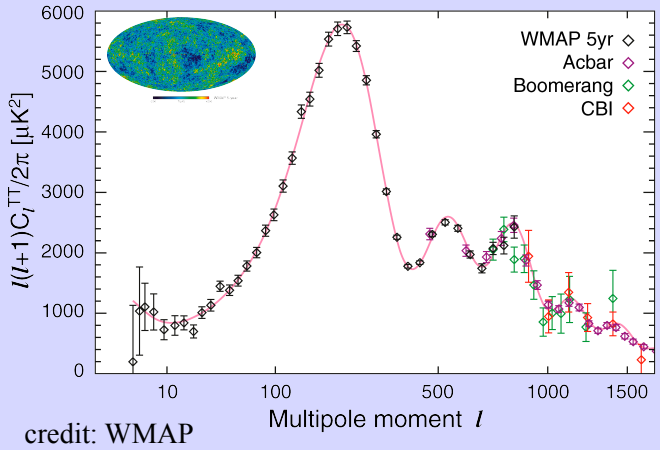
David Weinberg (OSU Astronomy)





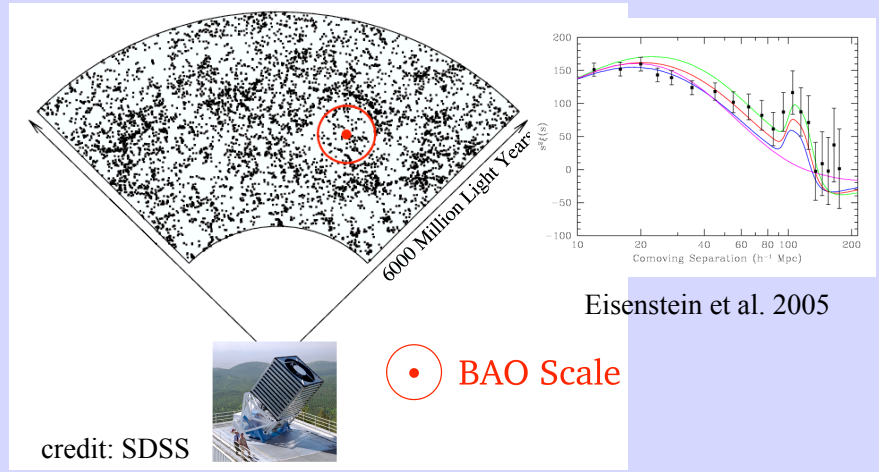
Background

Early Universe



credit: WMAP

Late Universe



Eisenstein et al. 2005

Advantages:

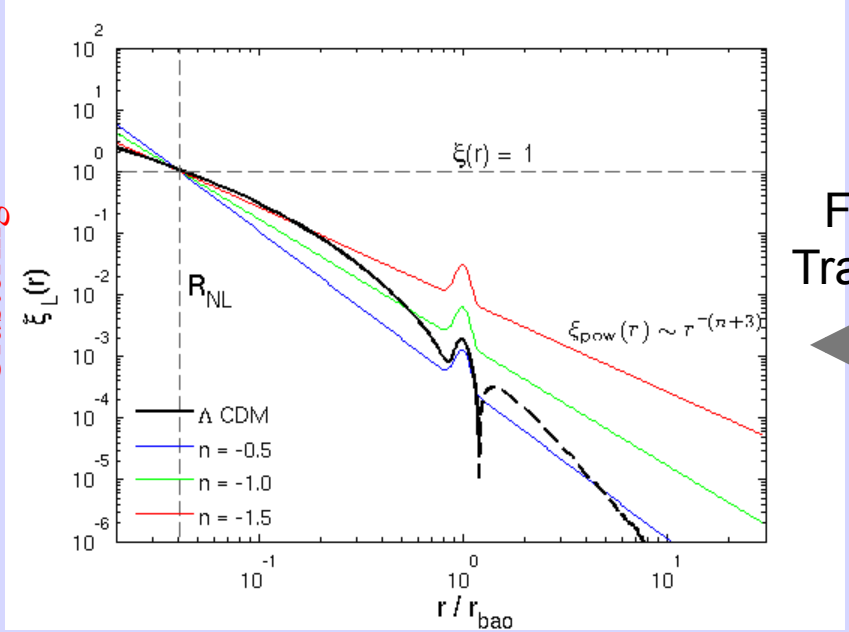
- Distance scale anchored to CMB (not LMC!)
- Very useful for constraining Dark Energy

Theoretical Challenges:

- BAO feature changes over time
- Need <1% accurate theory for any w(z)!

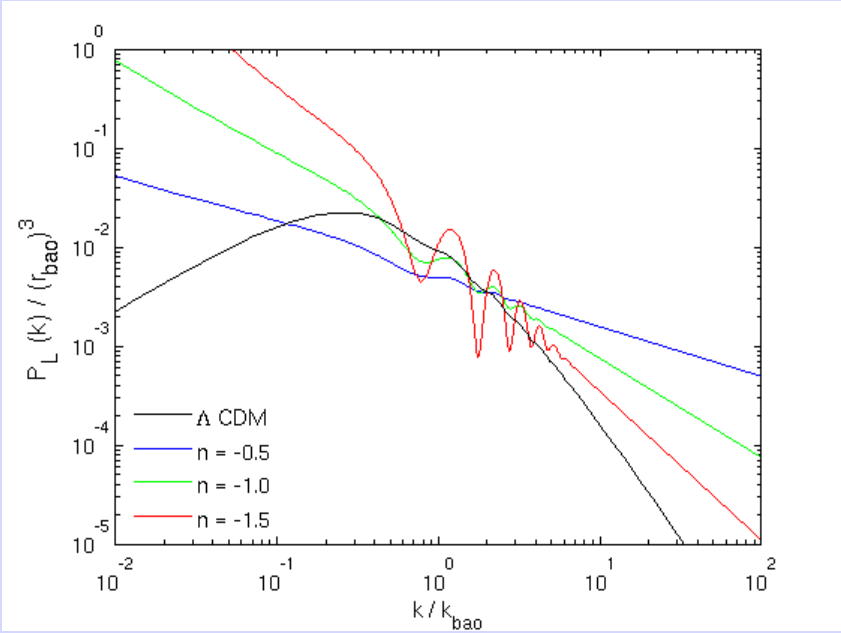
Initial Conditions

Clustering



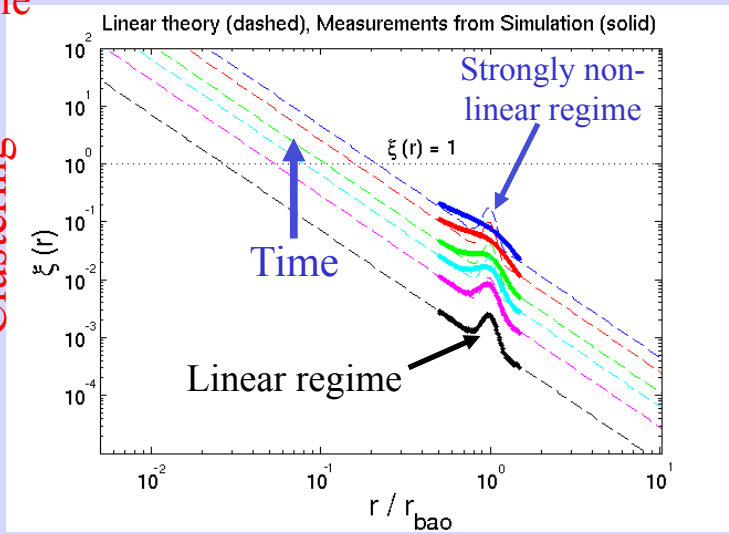
Scale

Fourier Transform



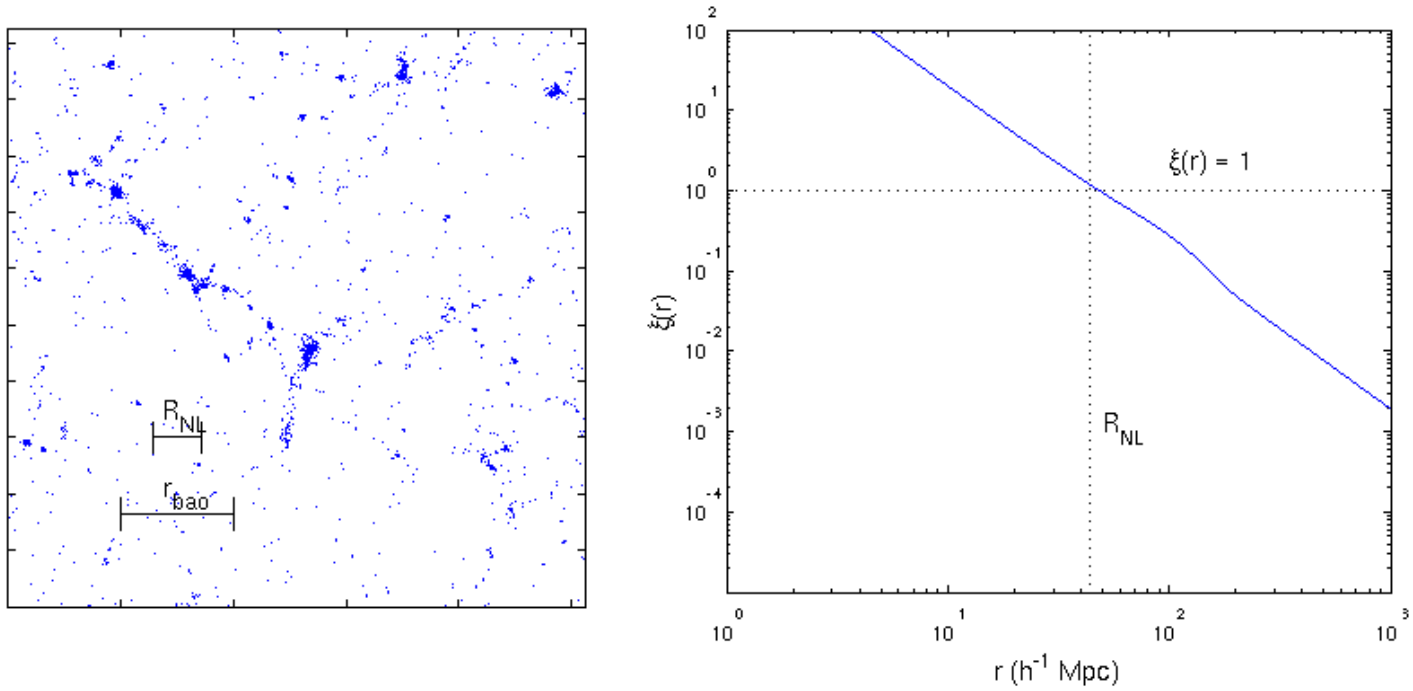
Scale^{-1}

Clustering

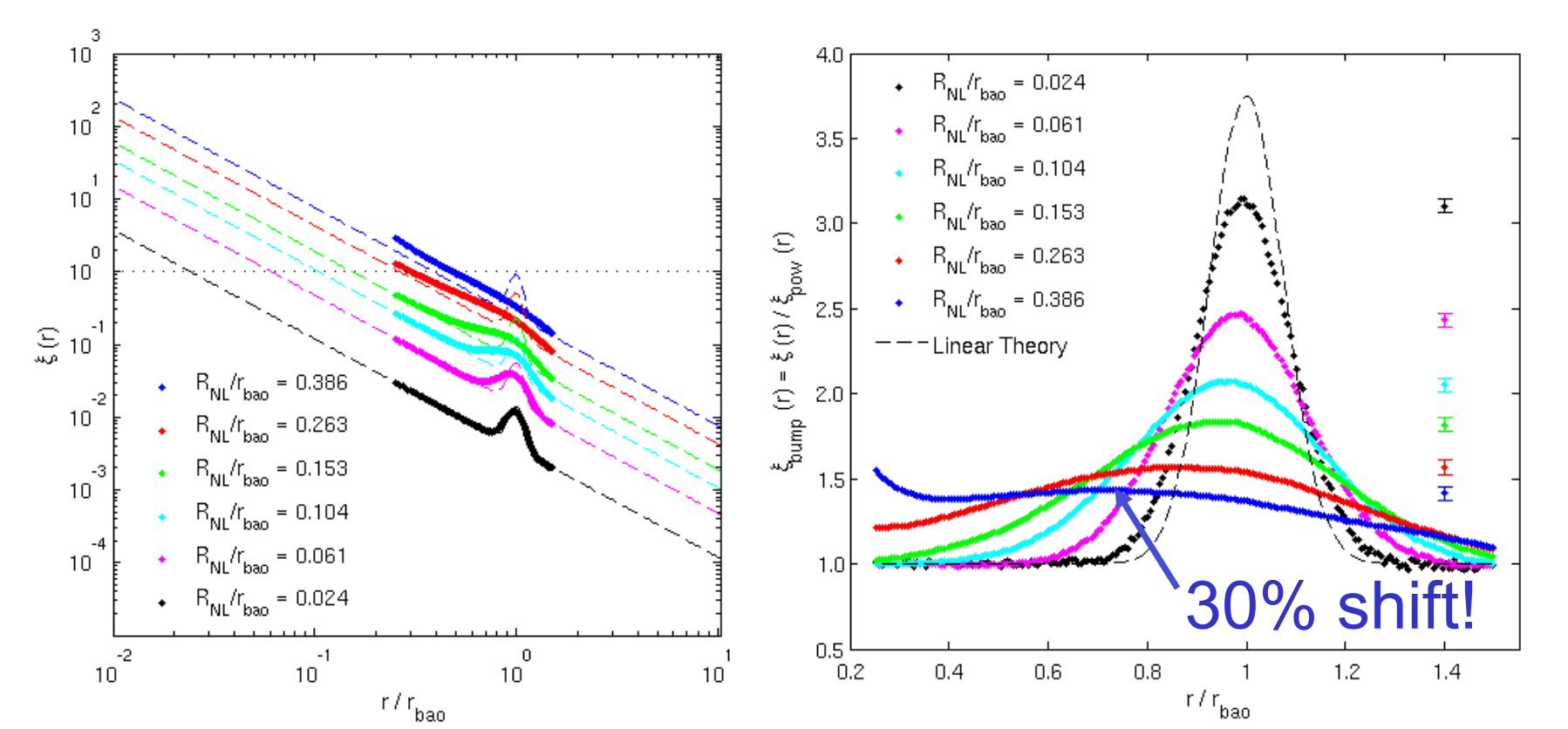


Scale

Non-linear structure formation



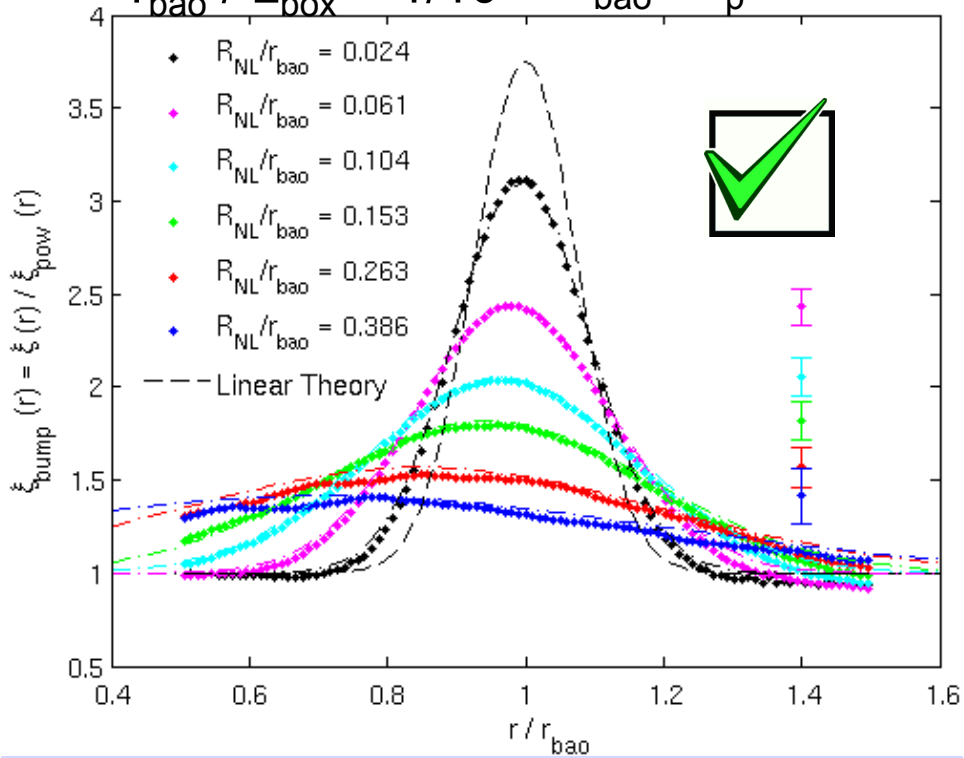
Simplifying the Problem



Bump evolves like an ordinary 1-D diffusion process!

Self-similar Bumps!

$r_{bao} / L_{box} = 1/10$ $r_{bao} / n_p^{-1/3} = 50$

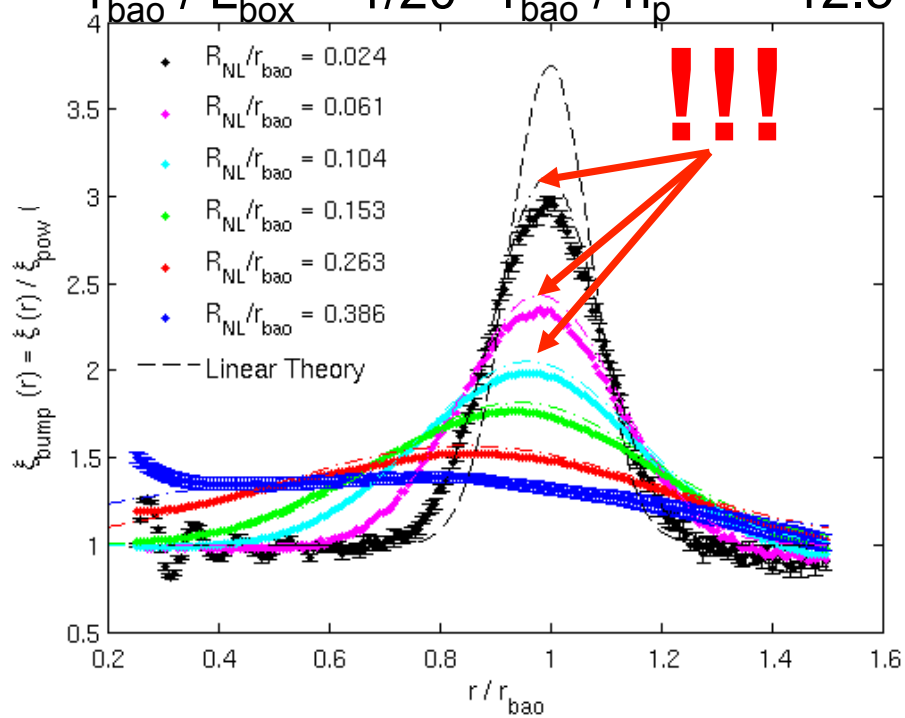


self-similarity =
evolution only depends on R_{NL} / r_{bao}

Departures from this scaling indicates numerical problems

Can't do this with LCDM!

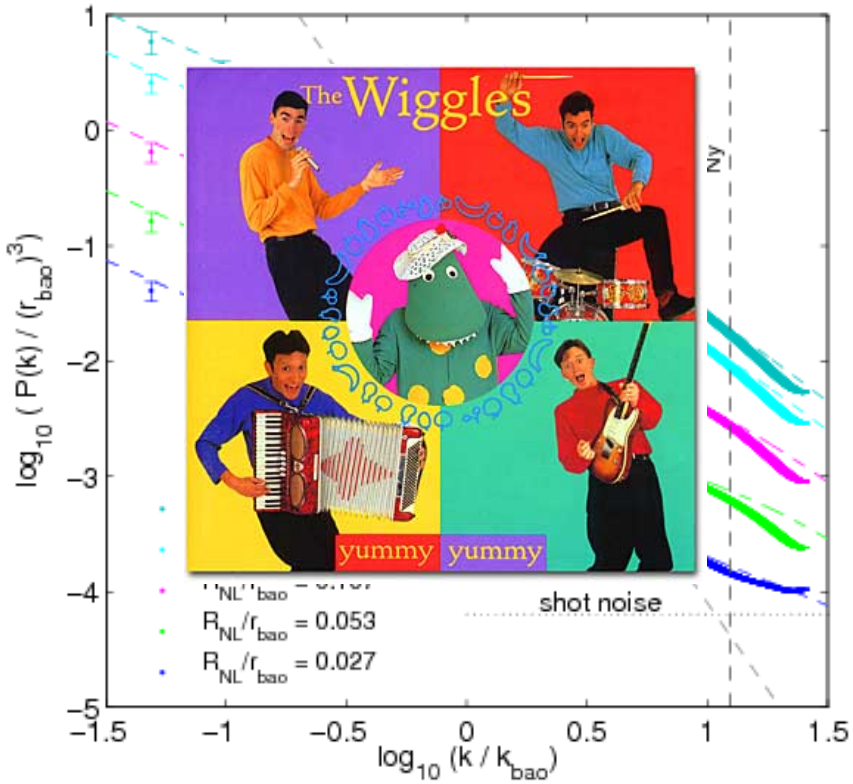
$r_{bao} / L_{box} = 1/20$ $r_{bao} / n_p^{-1/3} = 12.5$

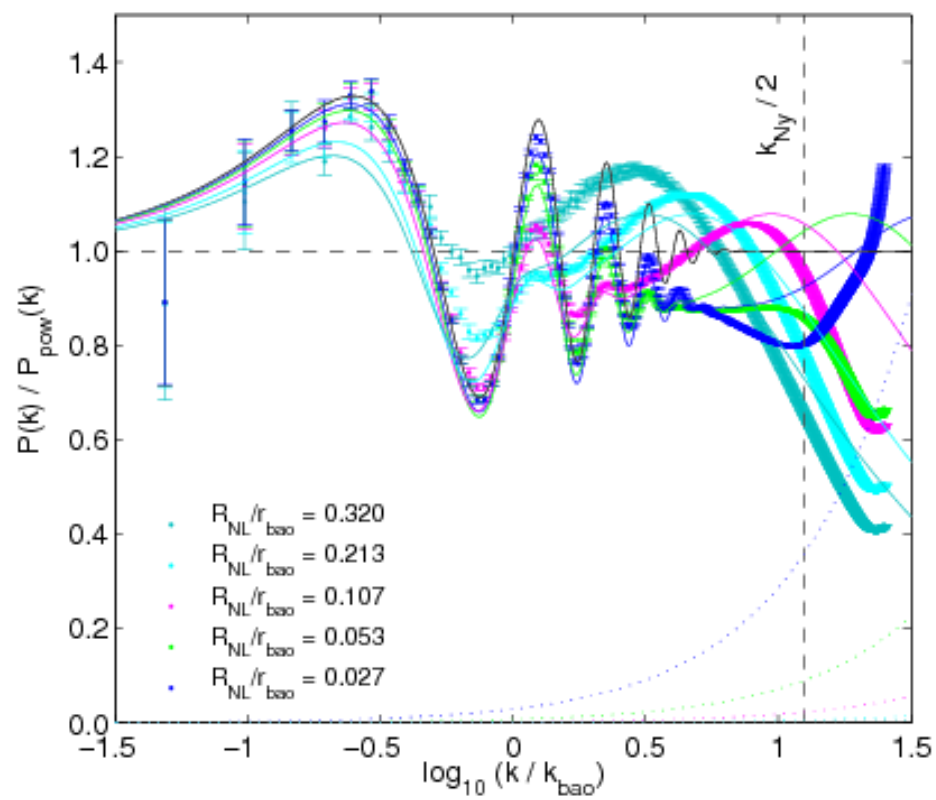


Conclusions:

$r_{bao} / L_{box} > 1/10$, $r_{bao} / n_p^{-1/3} > 25$
seems to always pass this test

Fourier-space phenomenology





Non-linear spectrum

Damping

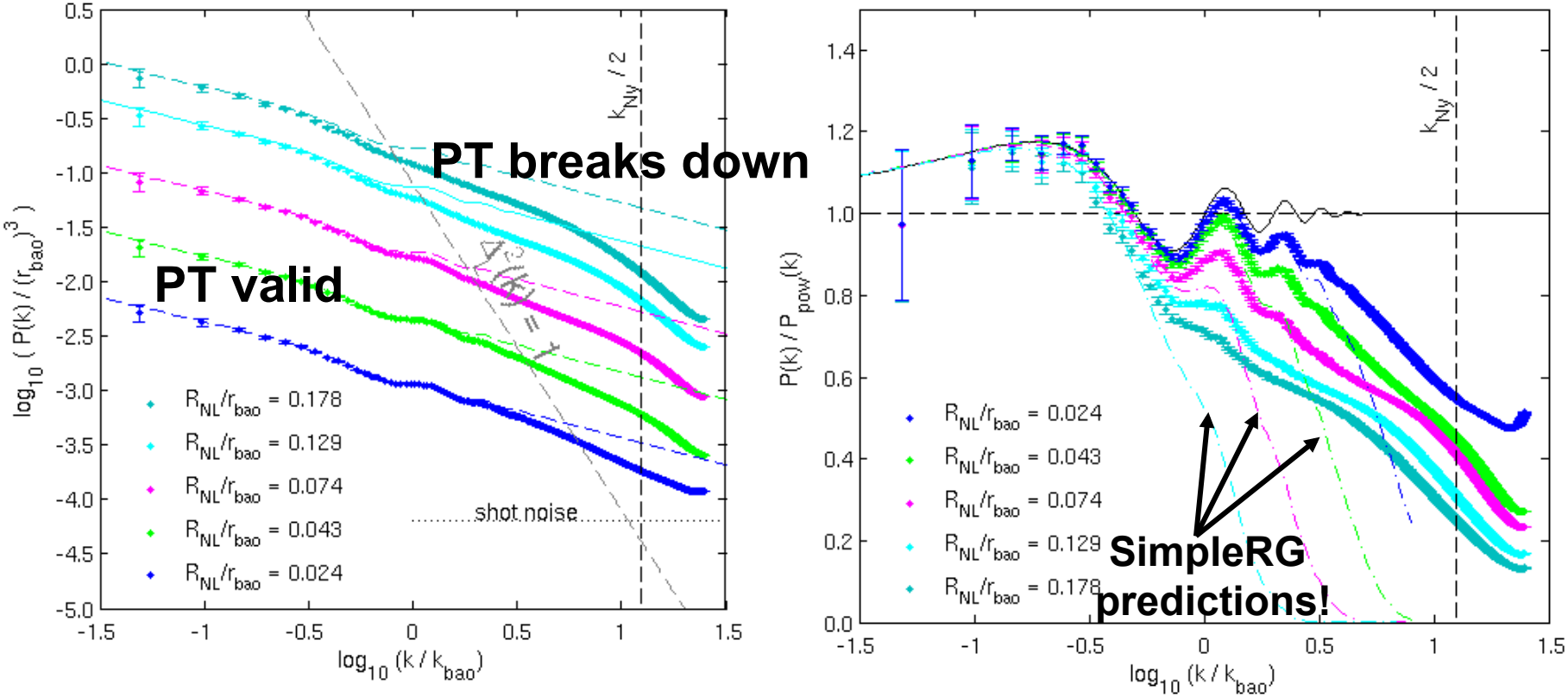
Small-scale model

$$P_{NL}(k) = \exp(-\Sigma^2 k^2/2)\, P_L(k/\alpha) + A(k)$$

Initial spectrum

shift!

Beyond linear-order



- Powerlaw x bump setup is a challenge for PT schemes
- Factors of $\Sigma^2 = \frac{1}{3\pi^2}\int_0^\infty P_L(q)\, dq$ typically diverge
- Pat McDonald's SimpleRG scheme avoids this factor

Conclusions

- New LCDM-ish model for testing PT schemes checking numerical accuracy!
- Bump evolves like a 1-D diffusion process
- Huge shift for case with steepest power spectrum!
- Self-similar tests recommend $r_{bao} / L_{box} > 1/10$, $r_{bao} / n_p^{-1/3} > 25$
- McDonald's SimpleRG predictions provide good match to results

To do:

- Post matter-clustering results on arXiv this summer!
- Halo clustering / scale-dependent bias
- Explore Sirko 2005 approach to running ensembles of simulations