Edgeworth Streaming Model

for

redshift space distortions

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in collaboration with

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Redshift space correlation function

Correlation function

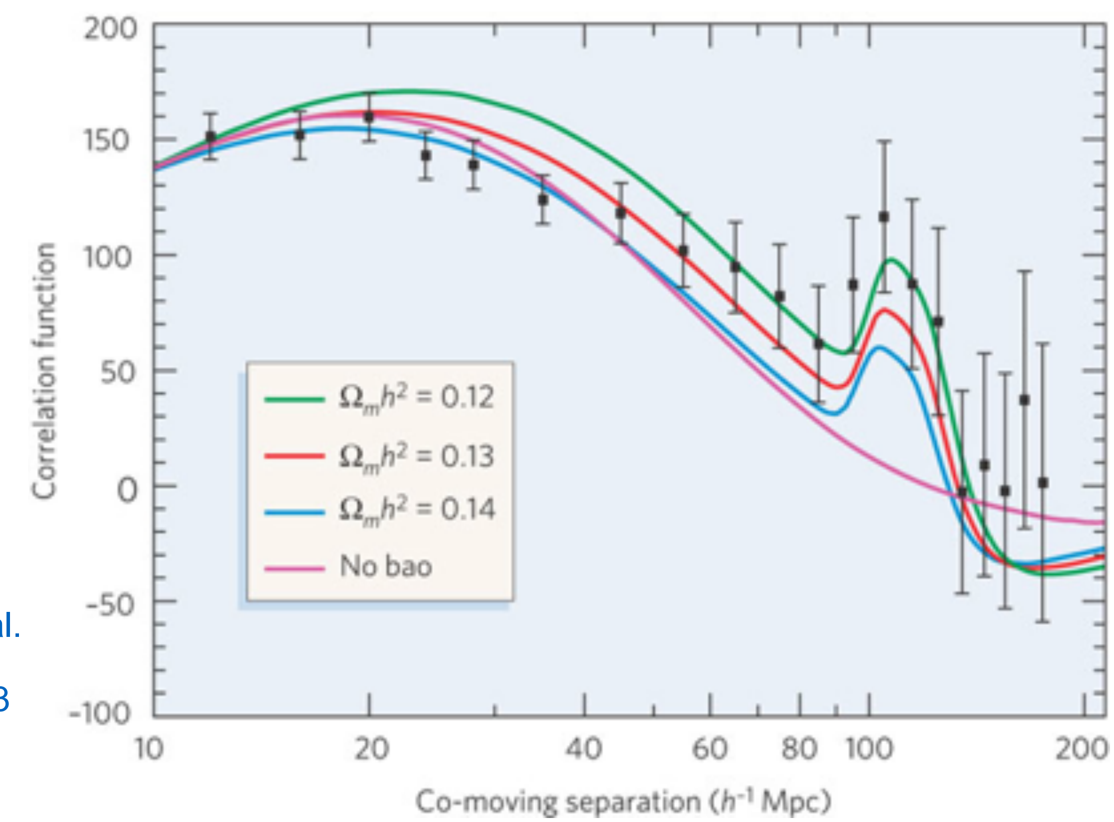
- measures excess probability

$$1 + \xi_X(s) = \Big\langle (1 + \delta_X(s_1))(1 + \delta_X(s_2)) \Big\rangle$$

- halos as biased DM tracers
  - input for halo model
  - powerful probe for cosmology

Eisenstein et al.

2005 ApJ, 633



Redshift space distortions

- redshift observations affected by peculiar velocities

real space

$$1 + \xi_X(r = |\boldsymbol{r}|)$$

isotropic

$$s_{||} = r_{||} + v/\mathcal{H} \quad s_\perp = r_\perp$$

redshift space

$$1 + \xi_X(s, s_{||})$$

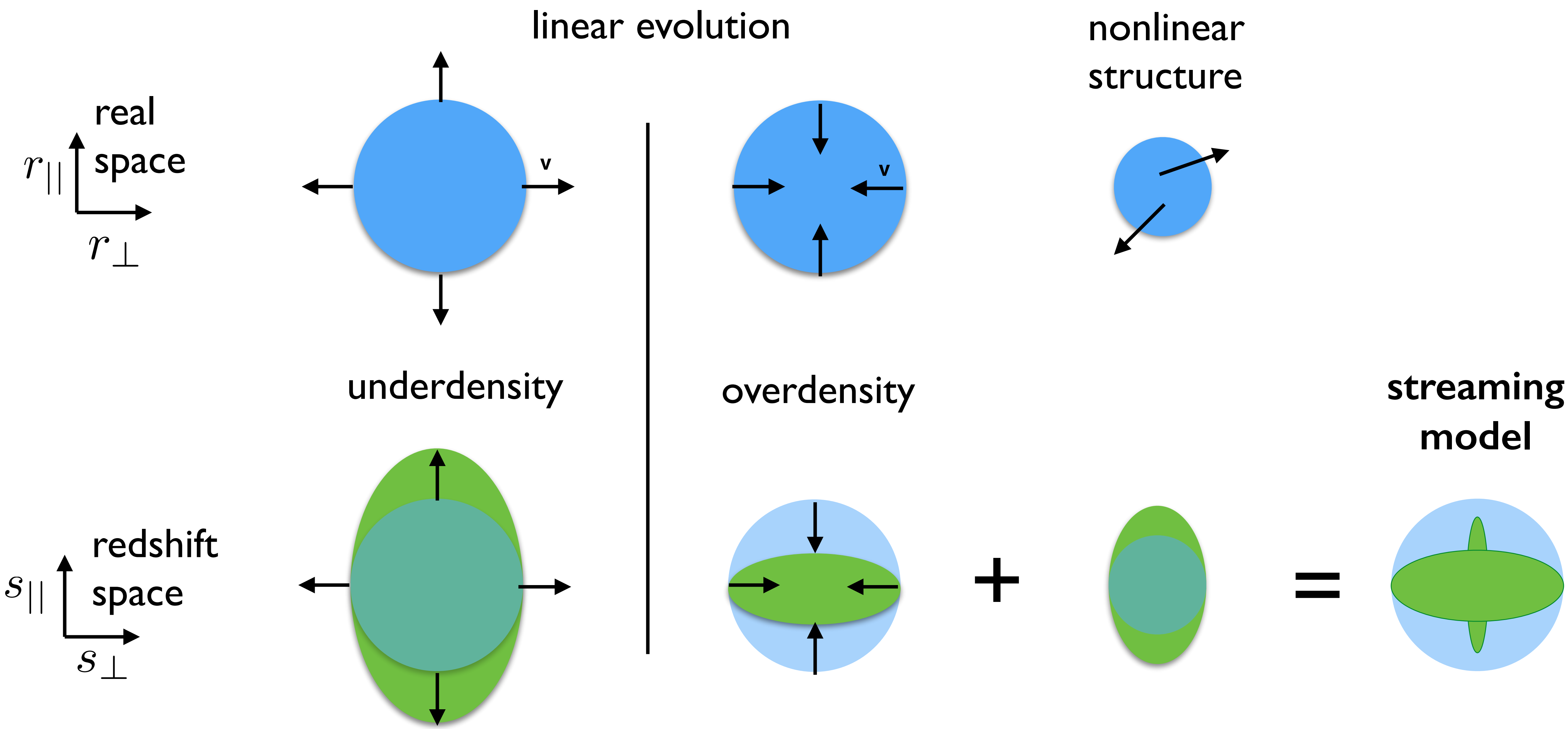
anisotropic

Redshift space correlation function

Redshift space distortions

- observations in redshift space from galaxy surveys
- impact of peculiar velocities along line of sight

$$s_{||} = r_{||} + v/\mathcal{H} \quad s_{\perp} = r_{\perp}$$



Streaming model

Gaussian Streaming Model

real space correlation

Gaussian velocity distribution

mean pairwise velocity & dispersion

$$1 + \xi_X(s_{||}, s_\perp, t) = \int_{-\infty}^{\infty} \frac{dr_{||}}{\sqrt{2\pi}\sigma_{12}} (1 + \xi_X(r,t)) \exp\left[-\frac{\left(s_{||} - r_{||} - v_{12}(r,t) r_{||}/r\right)^2}{2\sigma_{12}^2(r, r_{||}, t)} \right]$$

Fisher (1995, Astrophys.J. 448), Reid & White (2011, MNRAS 417)

Streaming model

Edgeworth Streaming Model

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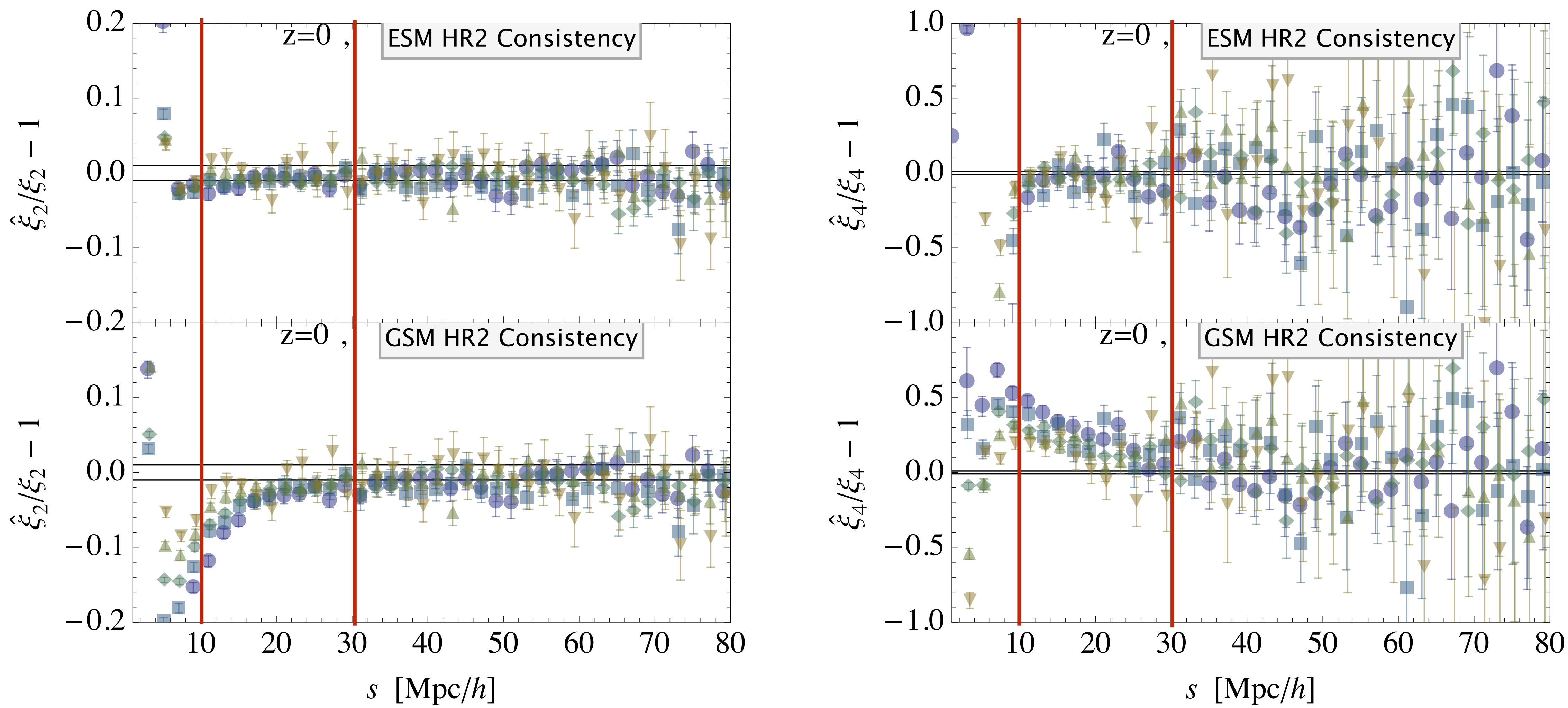
$$\times \left(1 + \frac{\Lambda_{12}}{6\sigma_{12}^3} \left[\left(\frac{\Delta_{srv}}{\sigma_{12}} \right)^3 - 3\frac{\Delta_{srv}}{\sigma_{12}} \right] \right)$$

pairwise velocity skewness

CU, Kopp and Haugg (2015, arXiv: 1503.08837)

- 2% down to 10 Mpc/h (ESM) vs. 30 Mpc/h (GSM)



Streaming model ingredients

Gaussian Streaming Model

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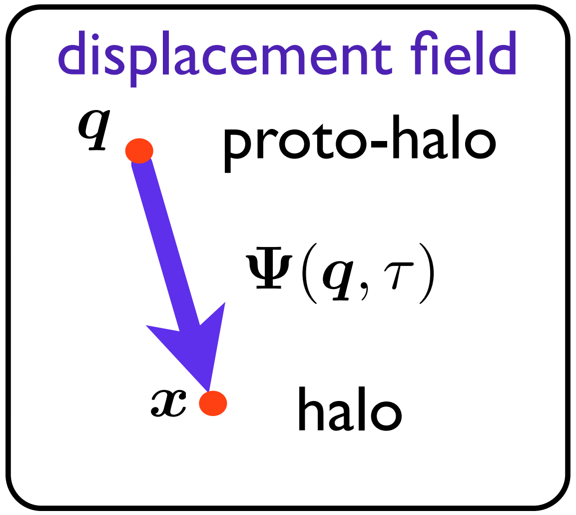
Wang, Reid & White (2014, MNRAS 437)

Lagrangian Perturbation Theory
+ local Lagrangian bias

- **Zel'dovich approximation** Zel'dovich (1970, A&A 5, 84)
  - 1st order Lagrangian PT
  - physically motivated resummation of SPT



- **Post Zel'dovich approximation**
  - higher order Lagrangian PT
  - partial resummation: Convolution LPT

Carlson et al. (2012, MNRAS 429)

Streaming model ingredients

Gaussian Streaming Model

real space correlation

Gaussian velocity distribution

mean pairwise velocity & dispersion

$$1+\xi_X(s_{||},s_\perp,t)=\int_{-\infty}^{\infty}\frac{dr_{||}}{\sqrt{2\pi}\sigma_{12}(r,r_{||},t)}(1+\xi_X(r,t))\exp\left[-\frac{\left(s_{||}-r_{||}-v_{12}(r,t)r_{||}/r\right)^2}{2\sigma_{12}^2(r,r_{||},t)}\right]$$

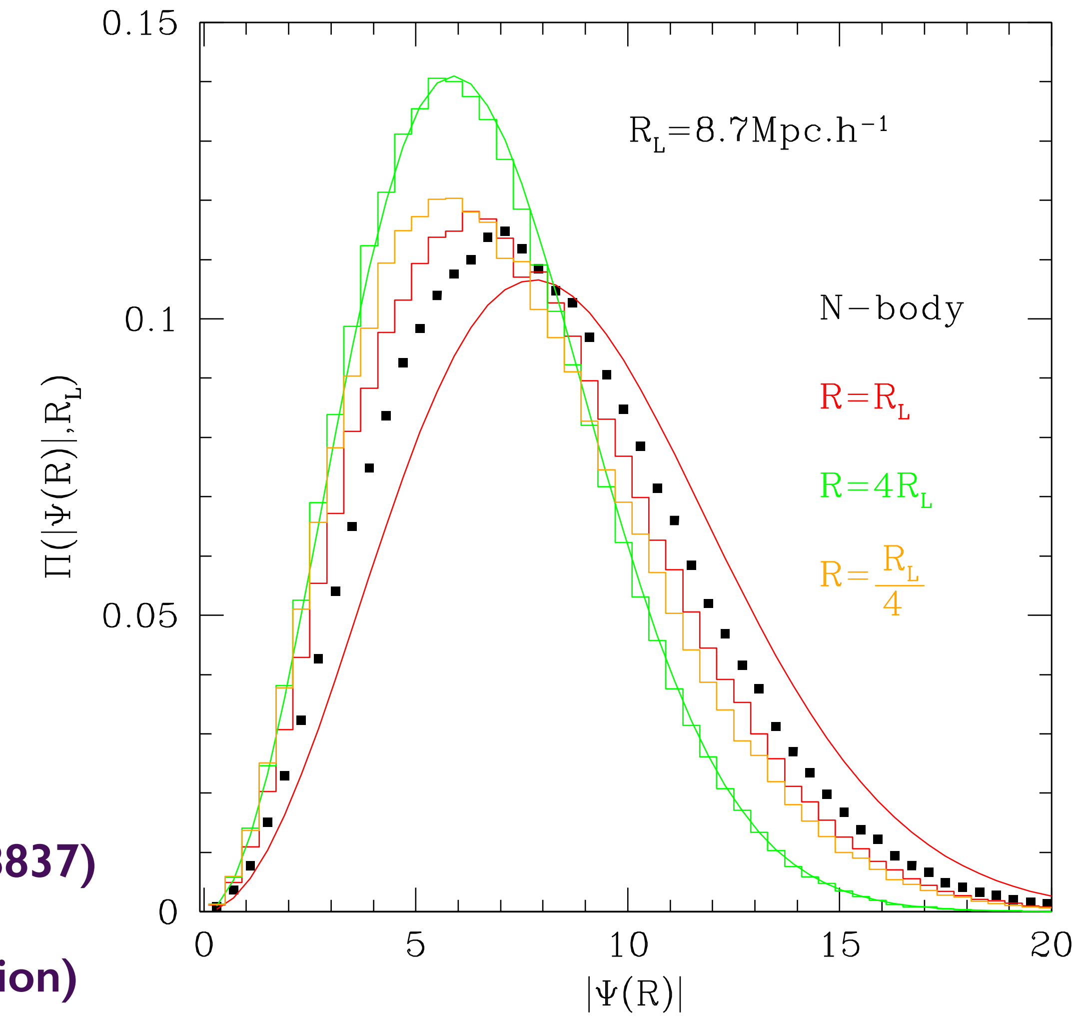
Wang, Reid & White (2014, MNRAS 437)

Lagrangian Perturbation Theory
+ local Lagrangian bias

- **Why smoothing?**
  - implement halo size in fluid description
  - improves Zel'dovich predictions in N-body

- **truncated Zel'dovich**
  - Zel'dovich with smoothed input power spectrum
  - improves agreement with N-body

  Coles, Melott, Shandarin (1993, MNRAS 260)



coarse-grained dust model — **CU & Kopp (PRD 91, 084010)**; **CU, Kopp & Haugg (arXiv: 1503.08837)**

truncated CLPT — **Kopp, CU & Achitouv (in preparation)**

Streaming model ingredients

Truncated CLPT

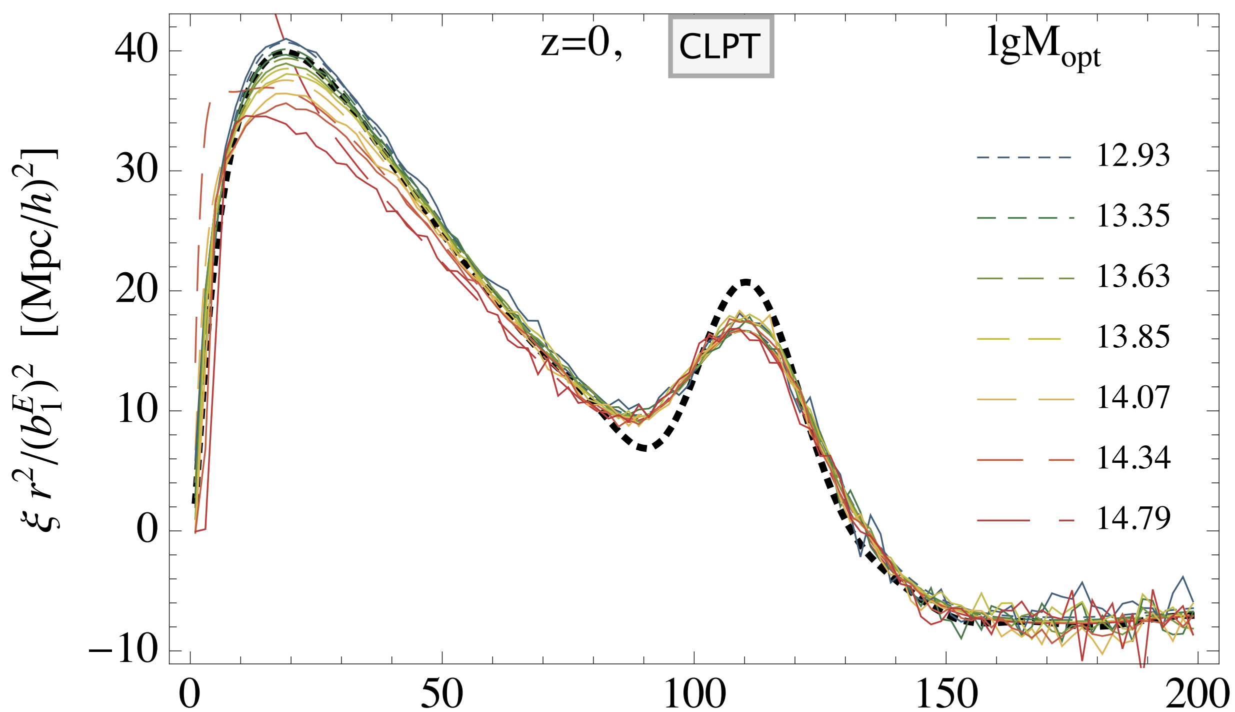
Kopp, CU & Achitouv (in preparation)

Real space halo correlation ξ(r)

- best agreement for 1 Mpc/h
- smoothing in R(M) worse

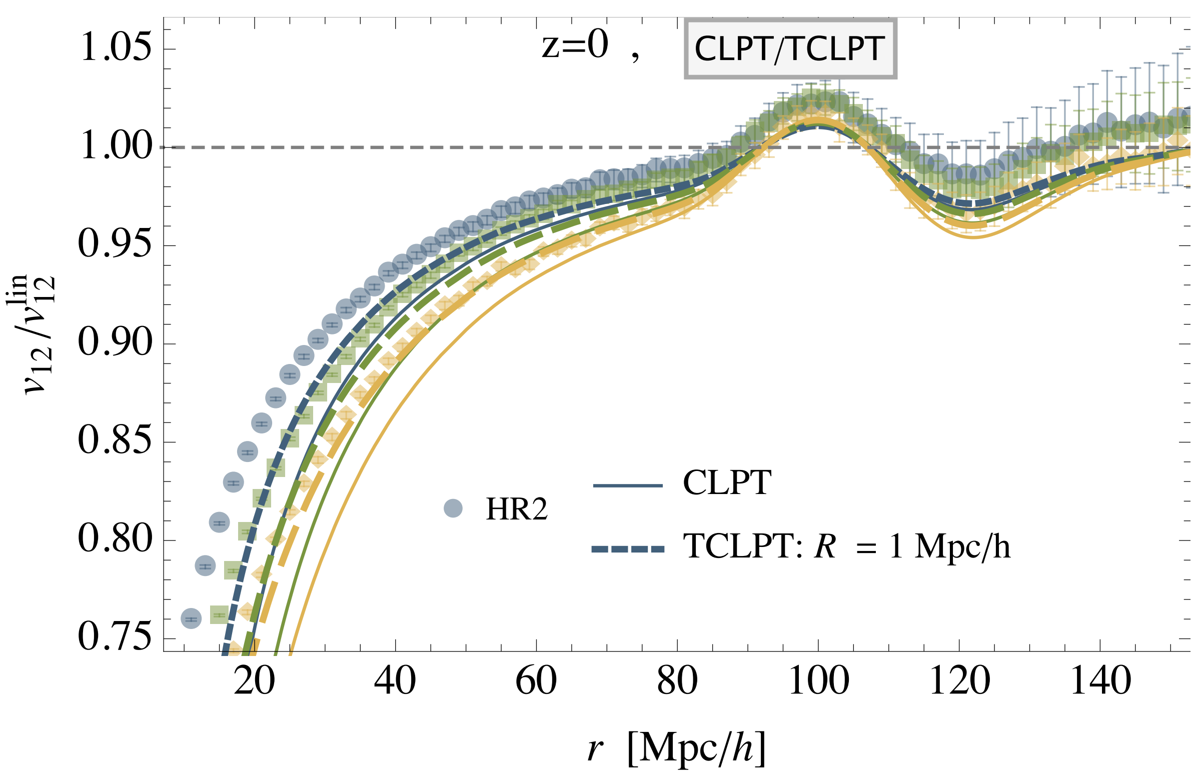
  need to include peak bias

  Baldauf, Desjacques & Seljak (arXiv: 1405.5885)



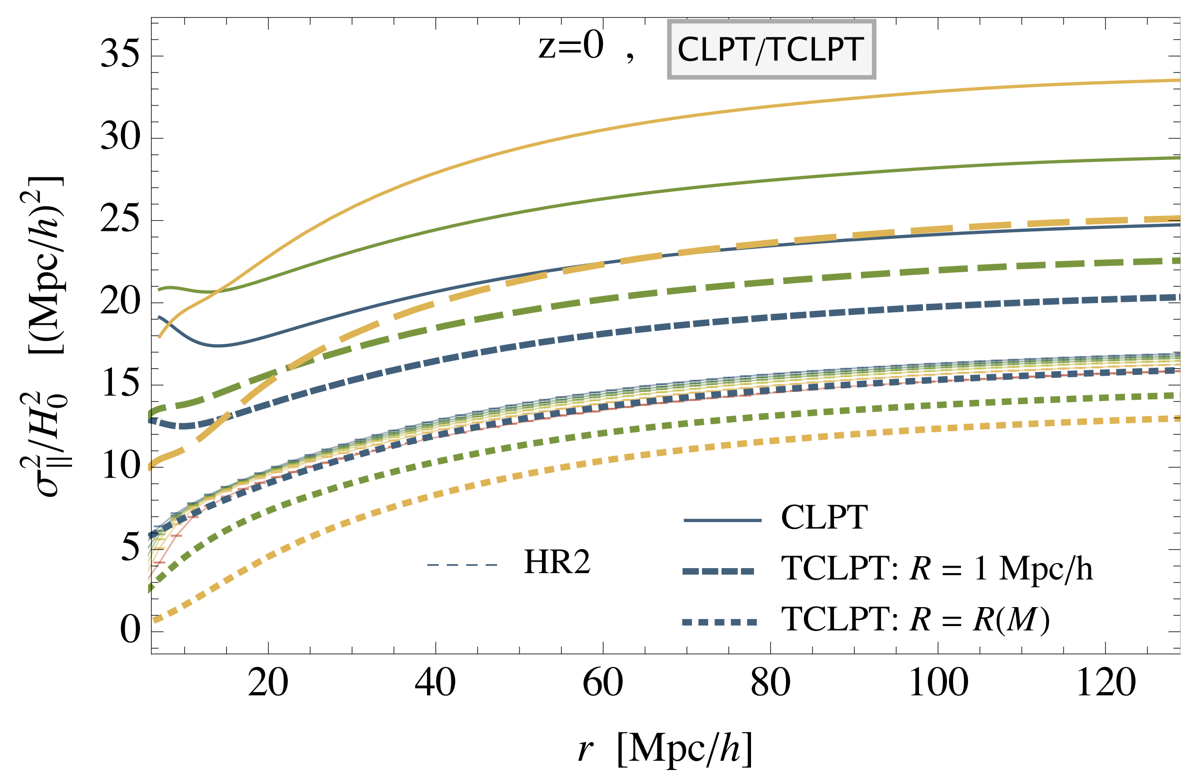
Pairwise velocity $v_{12}(r)$

- best agreement for 1 Mpc/h
- smoothing in R(M) slightly worse



Pairwise velocity dispersion $\sigma_{12}(r)$

- best agreement for R(M)
- consider cumulant not moment



Streaming model predictions

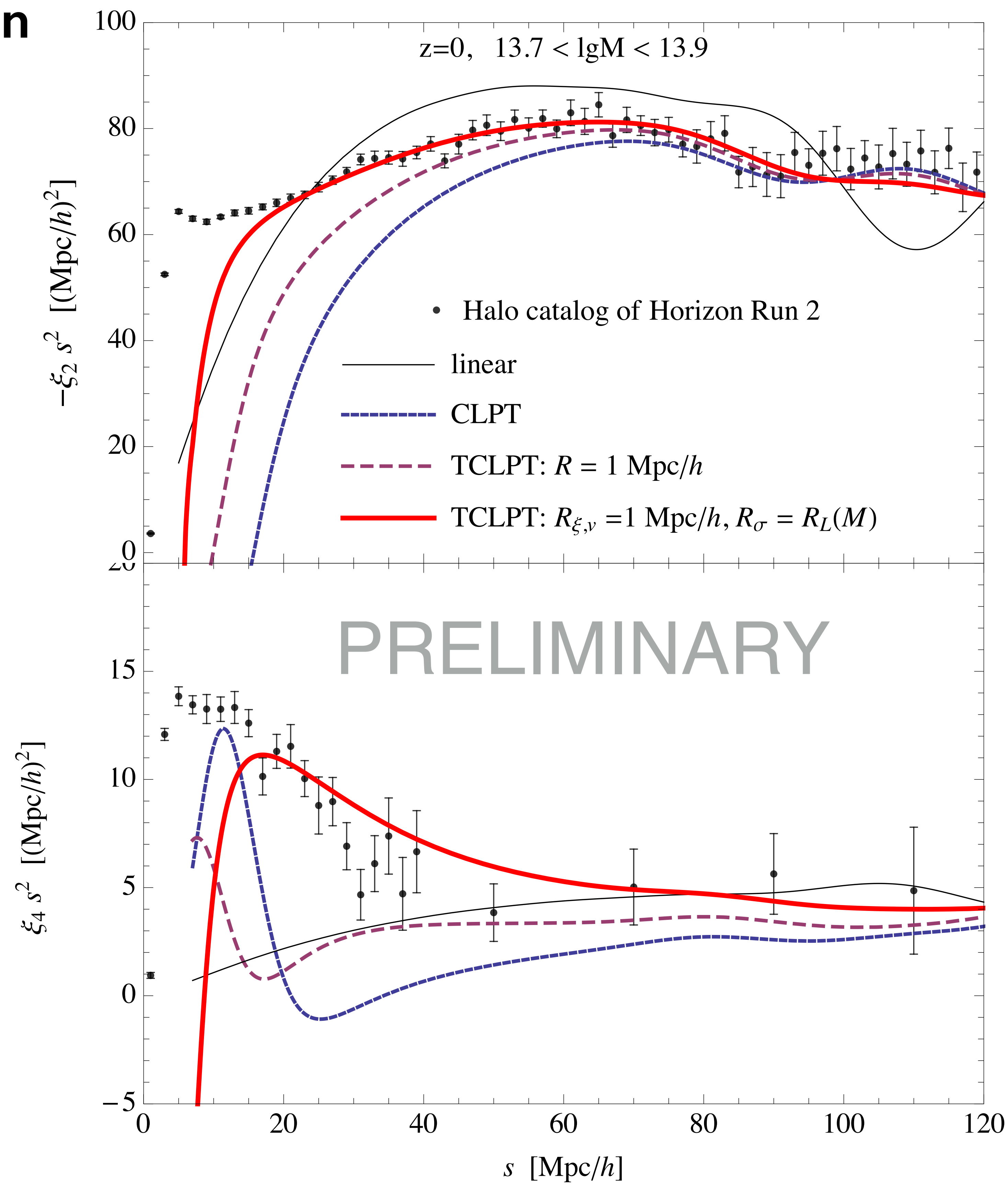
Redshift space correlation function

Kopp, CU & Achitouv (in preparation)

- plug streaming model ingredients in to obtain redshift space multipoles
  - monopole $\xi_0(s)$
  - quadrupole $\xi_2(s)$
  - hexadecapole $\xi_4(s)$

- TCLPT outperforms CLPT
  - simultaneously improves all higher redshift-space multipoles

- optimal: two-filter TCLPT smoothing
  - $\xi(r)$ & $v_{12}(r)$: 1 Mpc/h
  - $\sigma_{12}(r)$: Lagrangian scale R(M)

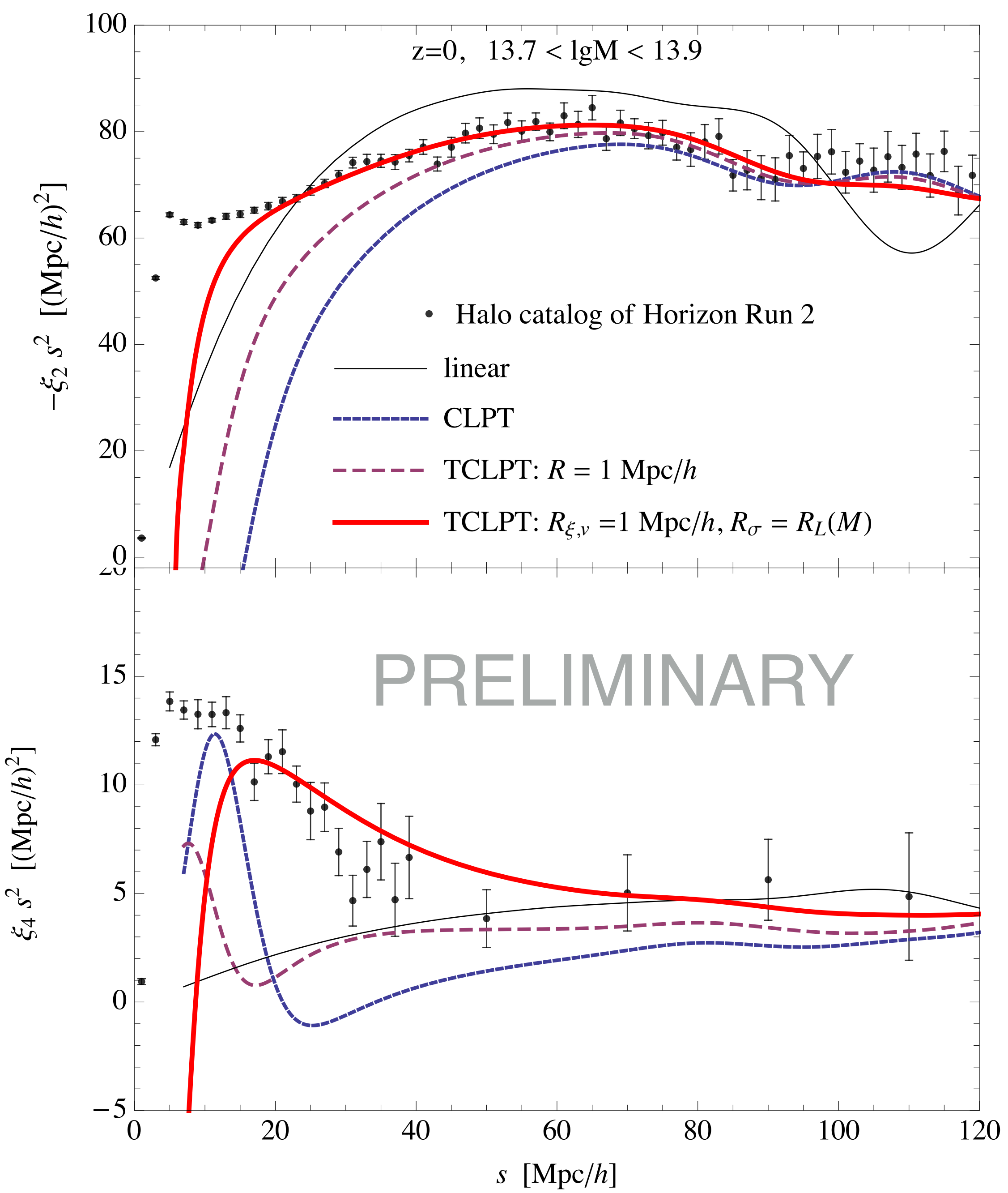


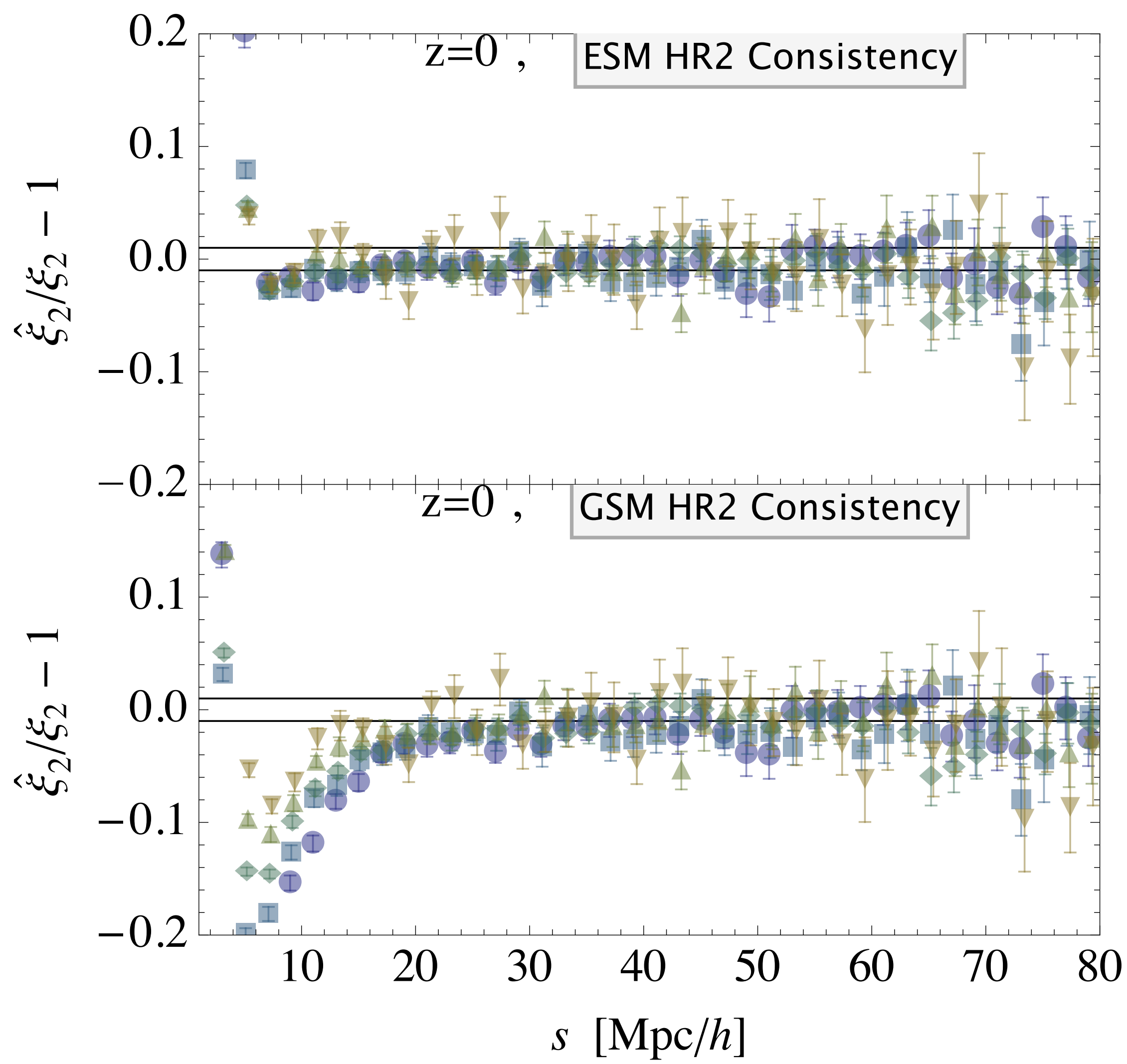
Summary

Edgeworth streaming model

- generalization of Gaussian streaming model
- pushed 2% accuracy from 30 down to 10 Mpc/h

CU, Kopp and Haugg (2015, arXiv: 1503.08837)





Truncated Zel'dovich approximation

- truncated Post-Zel'dovich approximation (TCLPT)
  - optimal with two filters: 1 Mpc/h & R(M)
  - consistent results for $\xi_0, \xi_2, \xi_4(s)$

    Kopp, CU & Achitouv (in preparation)

  - peak bias effects relevant