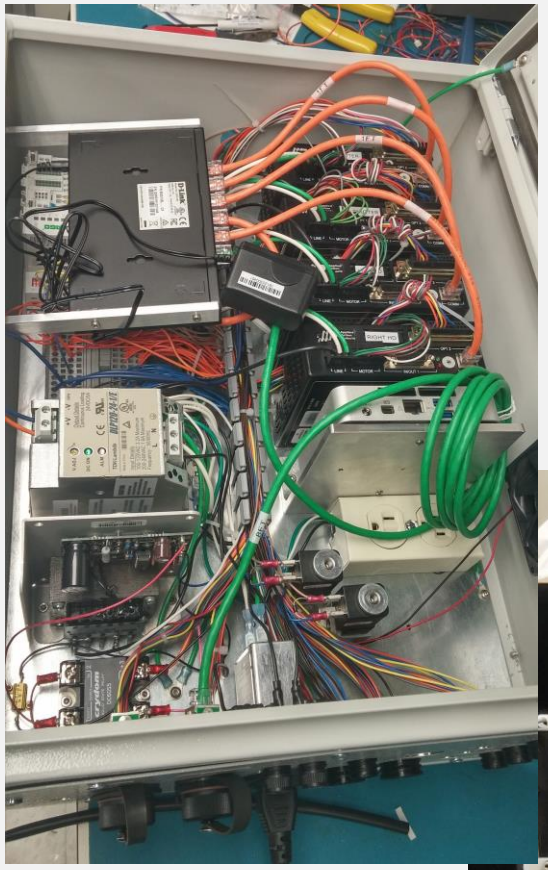
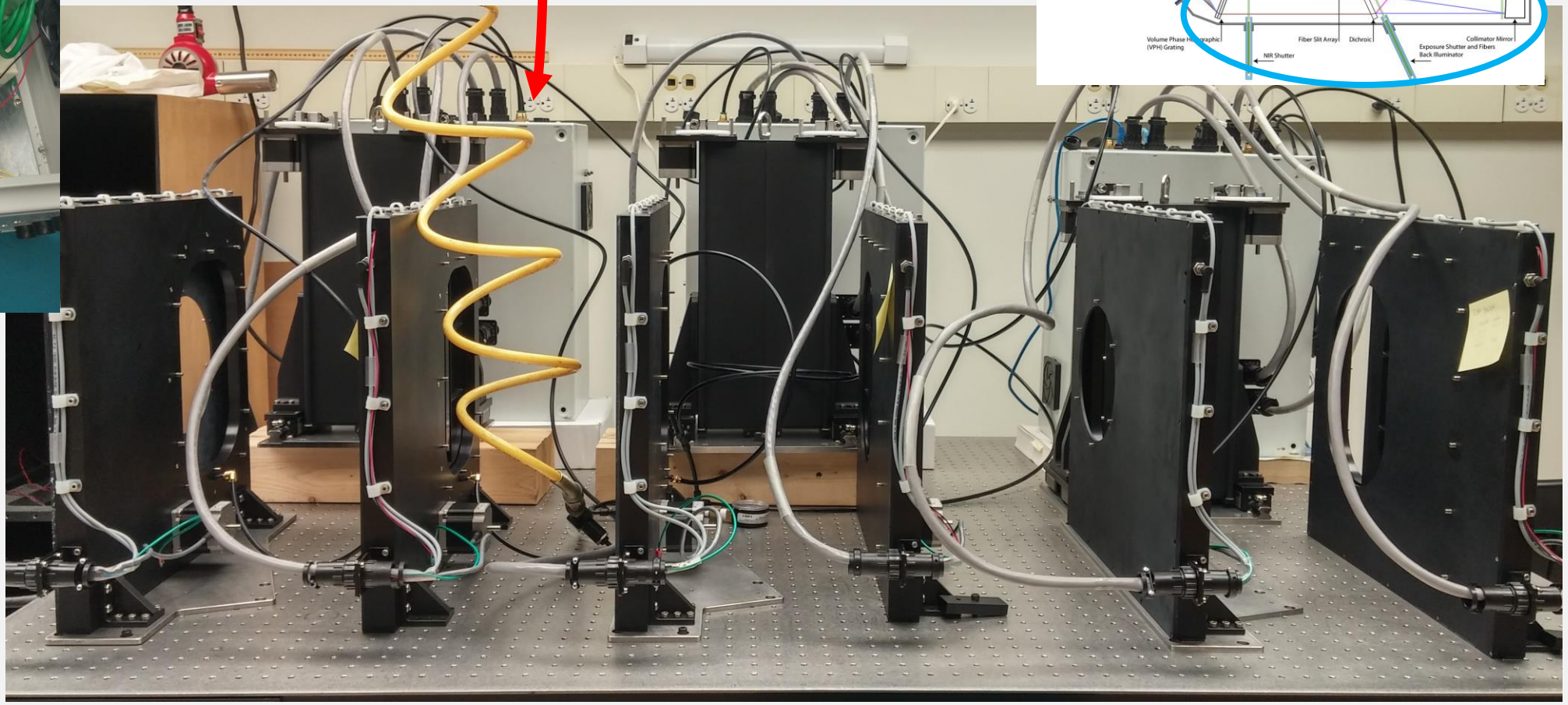
3PCF OF THE LYMAN-ALPHA FOREST

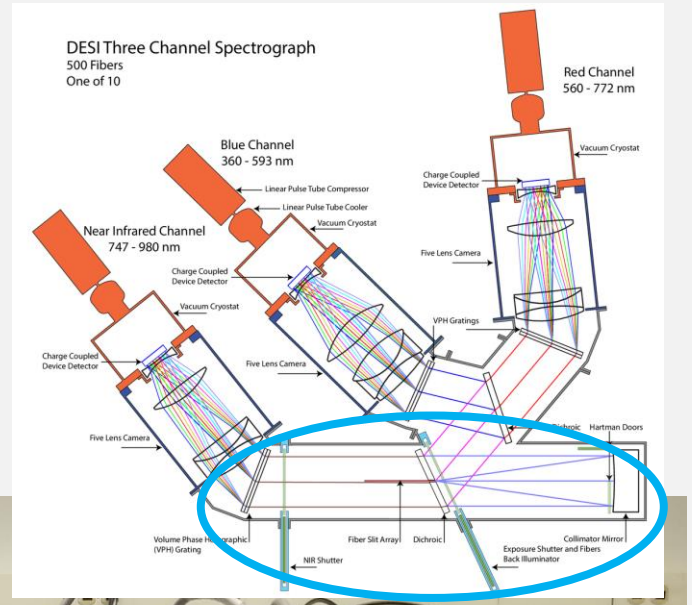
Suk Sien Tie
David Weinberg
Paul Martini
Teresita Suárez-Noguez
Sebastien Peirani

(in prep)

Intergalactic Interconnections, 13 July 2018






DESI Three Channel Spectrograph
500 Fibers
One of 10
Red Channel
560 - 772 nm
Blue Channel
360 - 593 nm
Near Infrared Channel
747 - 980 nm
Linear Pulse Tube Compressor
Linear Pulse Tube Cooler
Vacuum Cryostat
Charge Coupled Device Detector
Five Lens Camera
VPH Gratings
Hartman Doors
Volume Phase Holographic (VPH) Grating
Fiber Slit Array
Dichroic
Collimator Mirror
Exposure Shutter and Fibers
Back Illuminator
NIR Shutter

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NON-GRAVITATIONAL EFFECTS

Lyα forest is a fluctuating Gunn-Peterson effect:

(a) low-density gas in the IGM, (b) photoionization equilibrium $\boldsymbol{\tau_F \propto n_H^2\, T^{-0.7} \Gamma^{-1}}$,

(c) density fluctuations dominate

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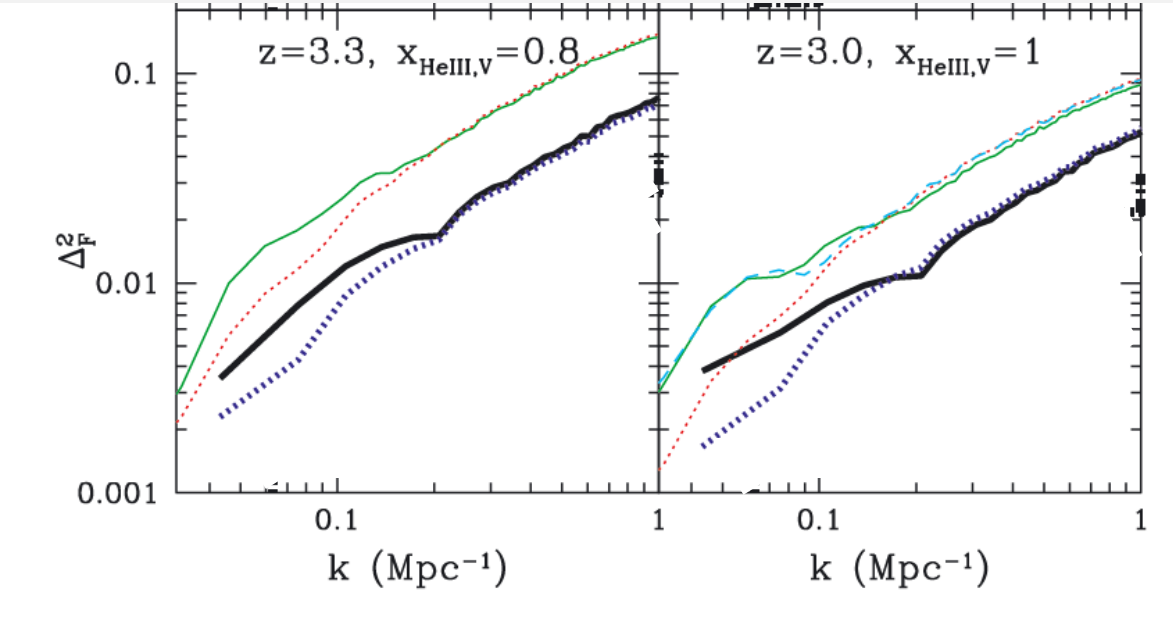
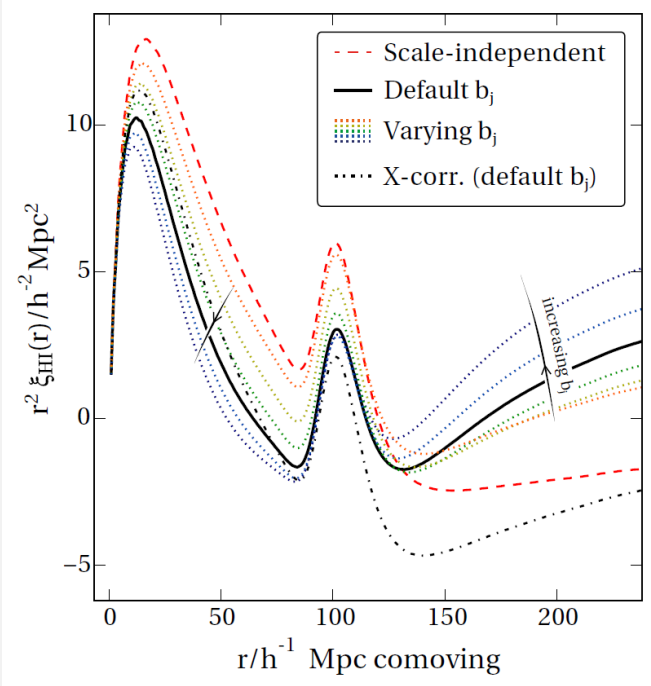


McQuinn et al. (2011): **temperature fluctuations increase 3D power by order unity** (solid vs. dashed lines) * *see also Jose Onorbe's talk yesterday*



Pontzen (2014): **ionizing fluctuations distort 2PCF of HI** (black vs. colored)

3PCF AS A DIAGNOSTIC OF FLUCTUATING UVB?

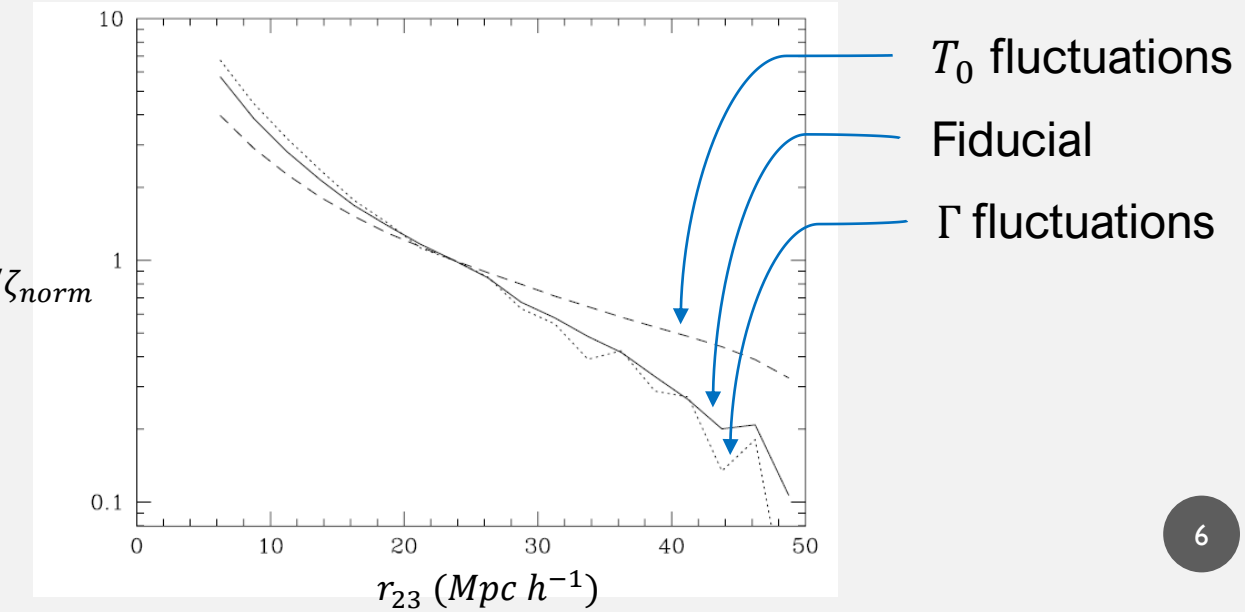
Higher order statistics contain more information

- Current and new higher density and wide-area surveys
- Measurements ahead of theory development

Zaldarriaga, Seljak, & Hui (2001) and *Fang & White (2004)*:

$C = \frac{P}{\sqrt{BT}}$, P ~ flux power spectrum, B ~ flux bispectrum, and T ~ flux trispectrum

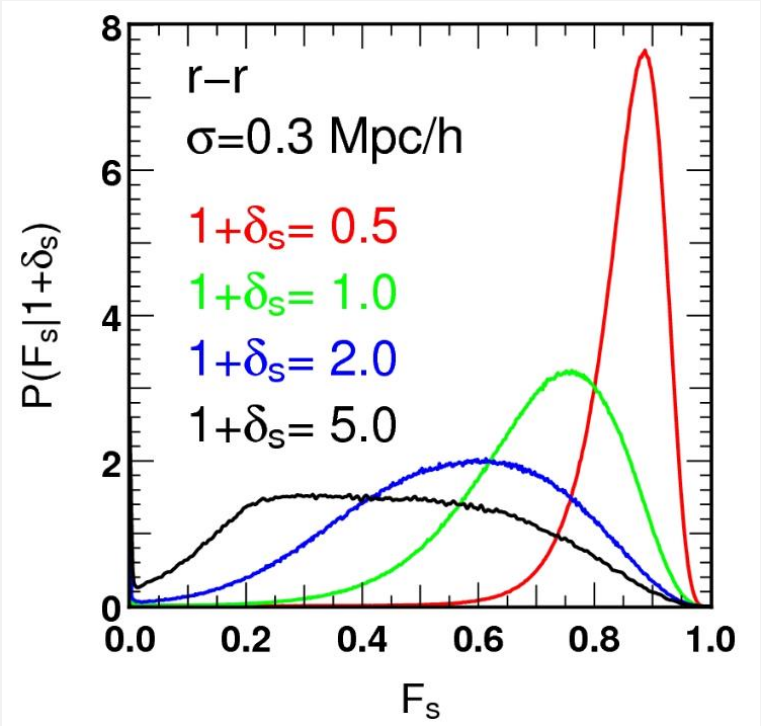
White et al. (2010): Standard 3PCF

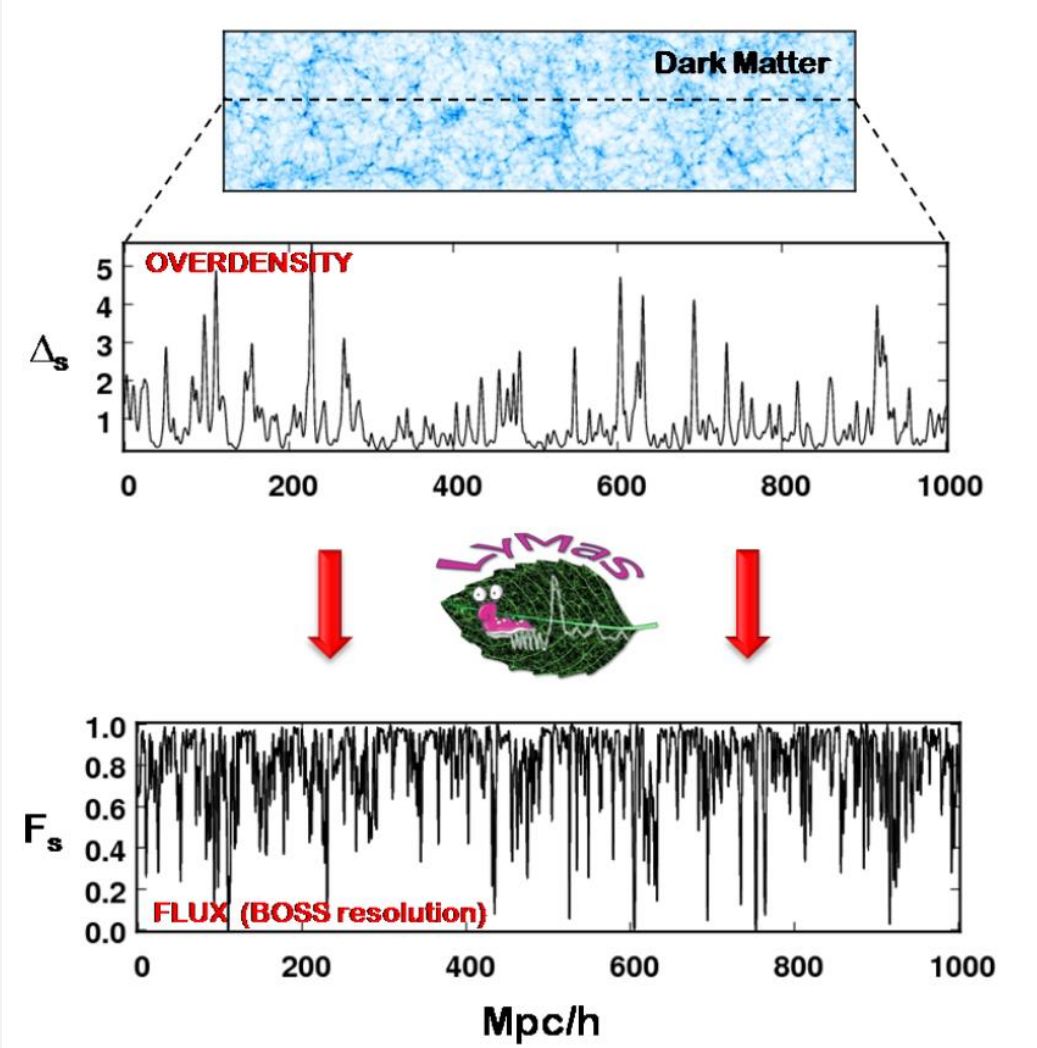


PREDICT FLUXES WITH LYMAS
(*LY*-A *MASS ASSOCIATION SCHEME*)

LyMAS (Peirani et al. 2014):

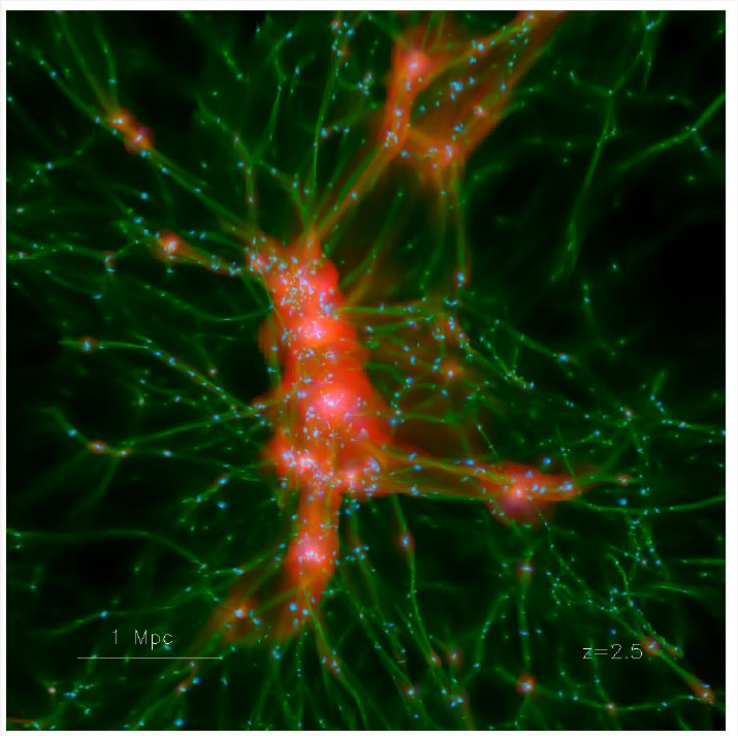
Independent draws from conditional PDF $P(F_s|\delta_s)$



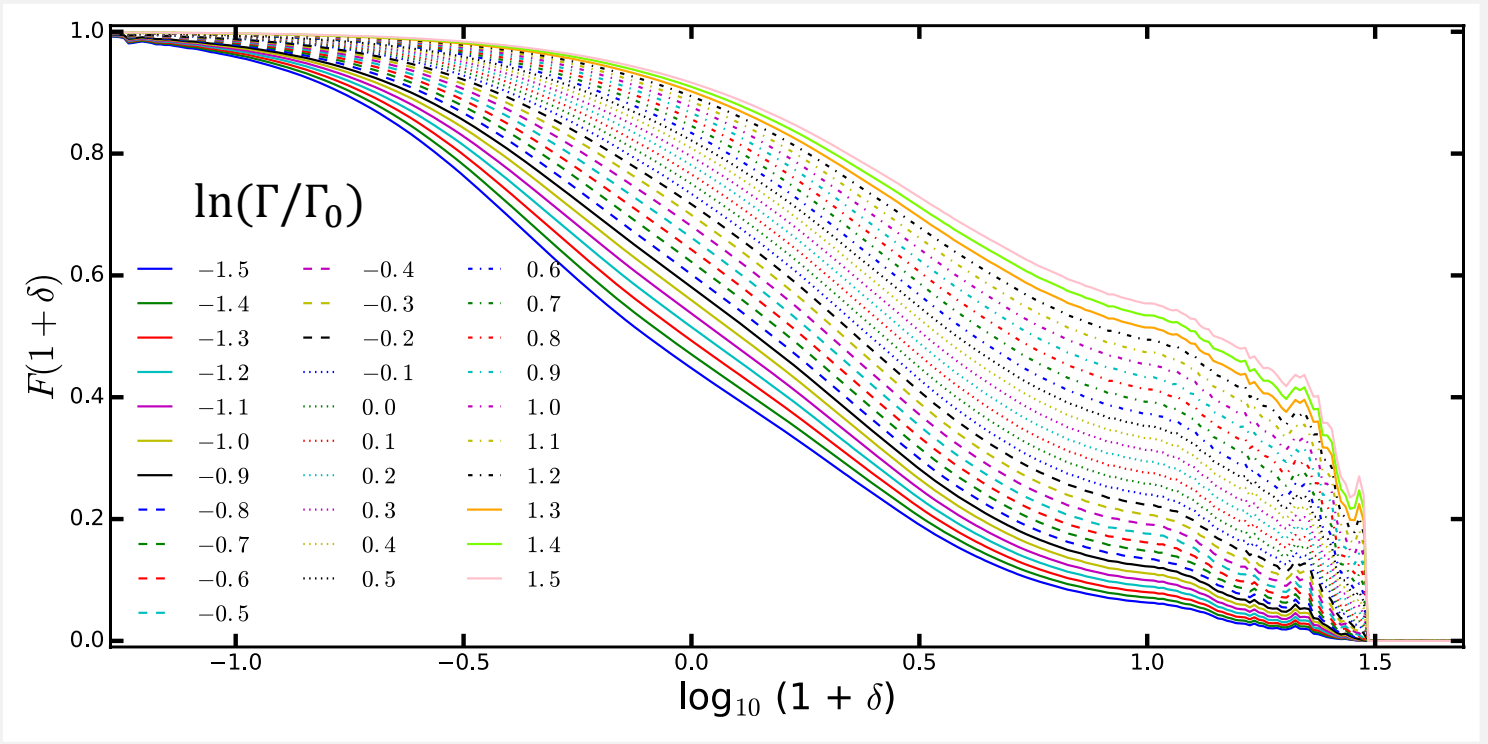


CONDITIONAL MEAN $\bar{F}(\delta)$ FOR CORRELATION FUNCTIONS

Calibrate $\bar{F}(\delta) = \int F\, P(F_s|\delta_s)$ from hydro sims for a range of density and UVB intensity

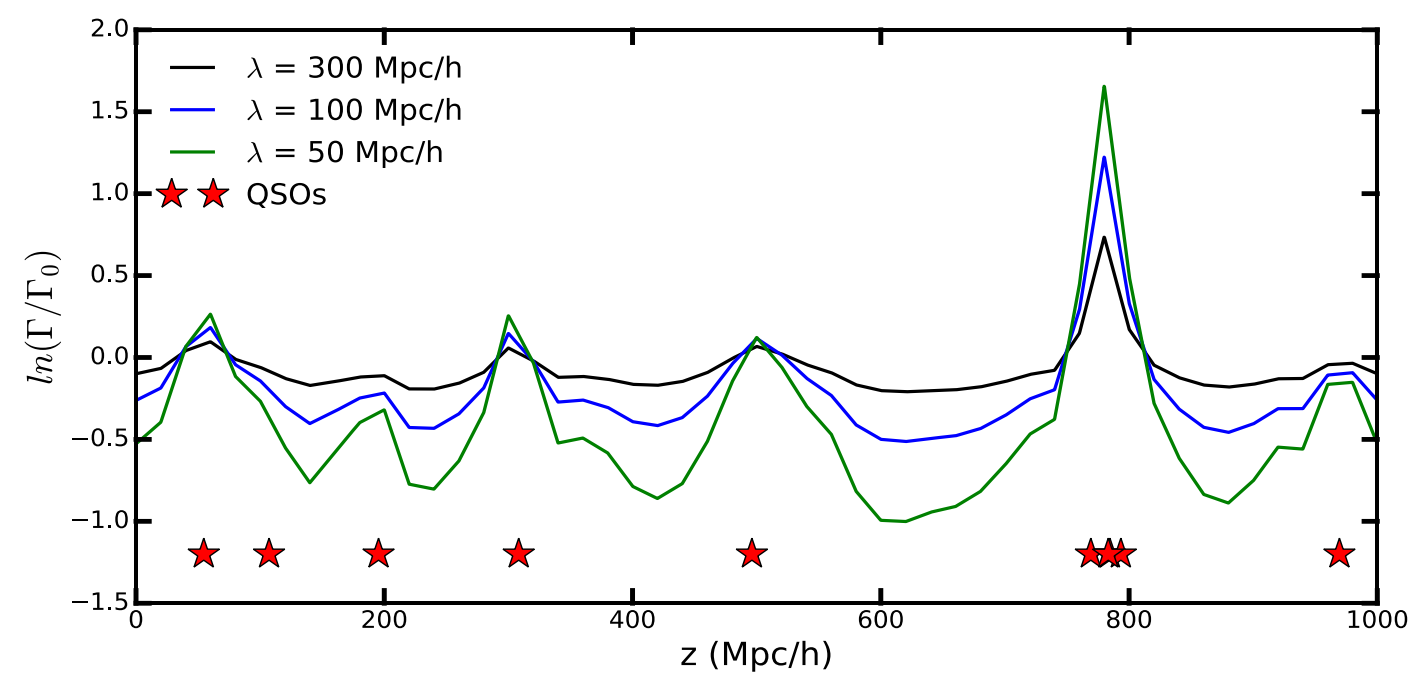


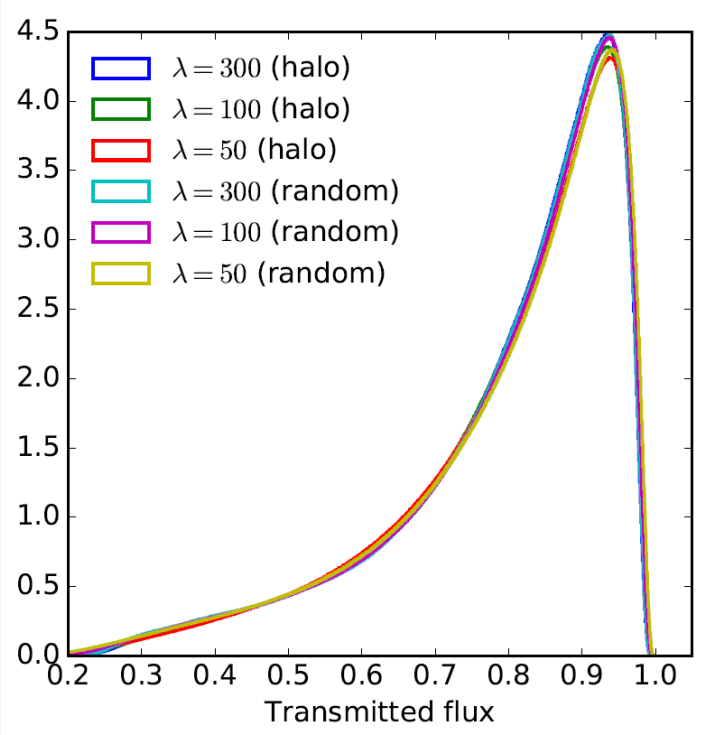
Horizon-noAGN



FLUCTUATING RADIATION FIELD

Assume quasars as ionizing sources, either (i) randomly-distributed, or (ii) found in massive halos, with $n_q = 10^{-5}\ h^3\ Mpc^{-3}$. Assign certain mean free path λ for ionizing photons.





CLUSTERING 101… (MAYBE 102)

2PCF:

$$\xi_{ij}(r) = \langle \delta_i \delta_j \rangle; \;\; \delta_i = \frac{F}{\langle F \rangle} - 1$$

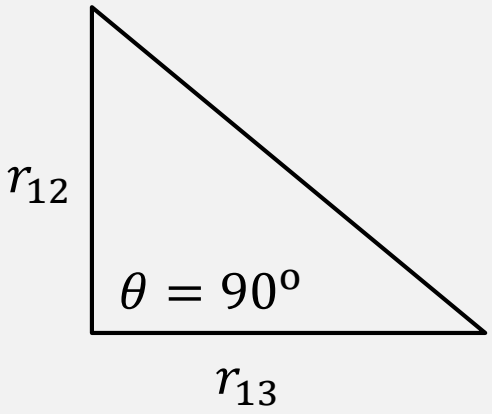
3PCF:

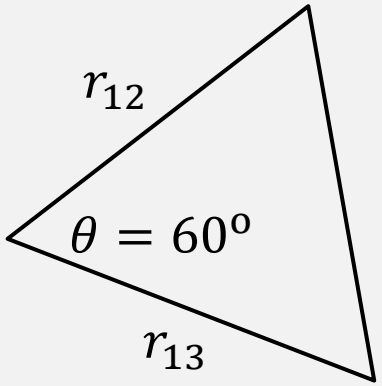
$$\zeta(r_{12}, r_{13}, \theta) = \langle \delta_1 \delta_2 \delta_3 \rangle$$

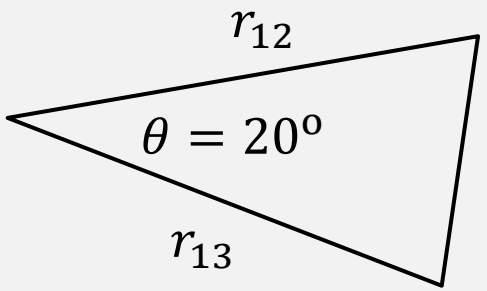
Reduced 3PCF:

$$Q(r_{12}, r_{13}, \theta) = \frac{\xi_{123}(r_{12}, r_{13}, \theta)}{\xi_{12}(r)\xi_{13}(r) + \xi_{13}(r)\xi_{23}(r) + \xi_{12}(r)\xi_{23}(r)}$$

Q ~ constant for galaxies.
True for the forest?



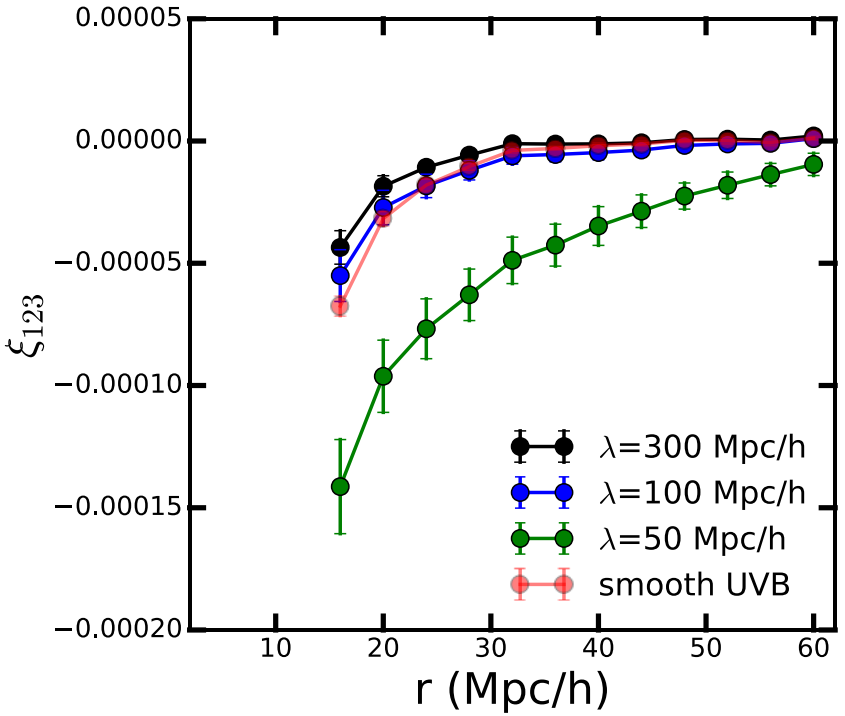


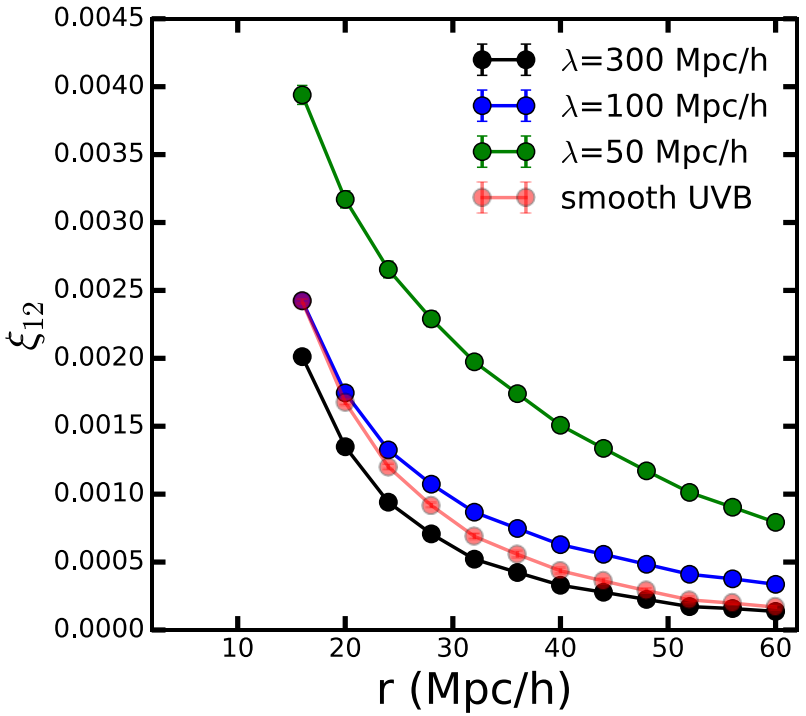


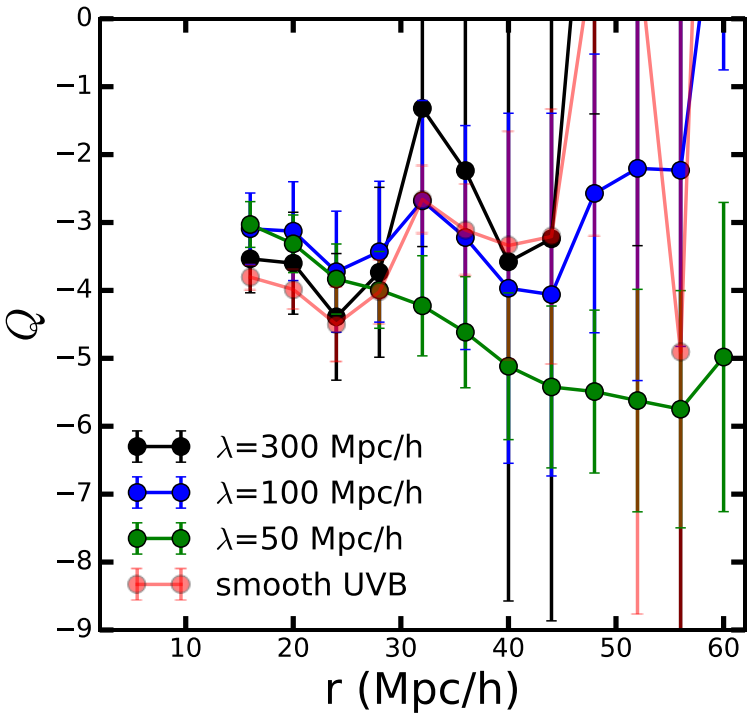
$r_{12} \sim r_{13} \sim r$

FLUCTUATING UVB CHANGES LYA FOREST CLUSTERING

QSOs in massive halos; $\theta = 60^o$







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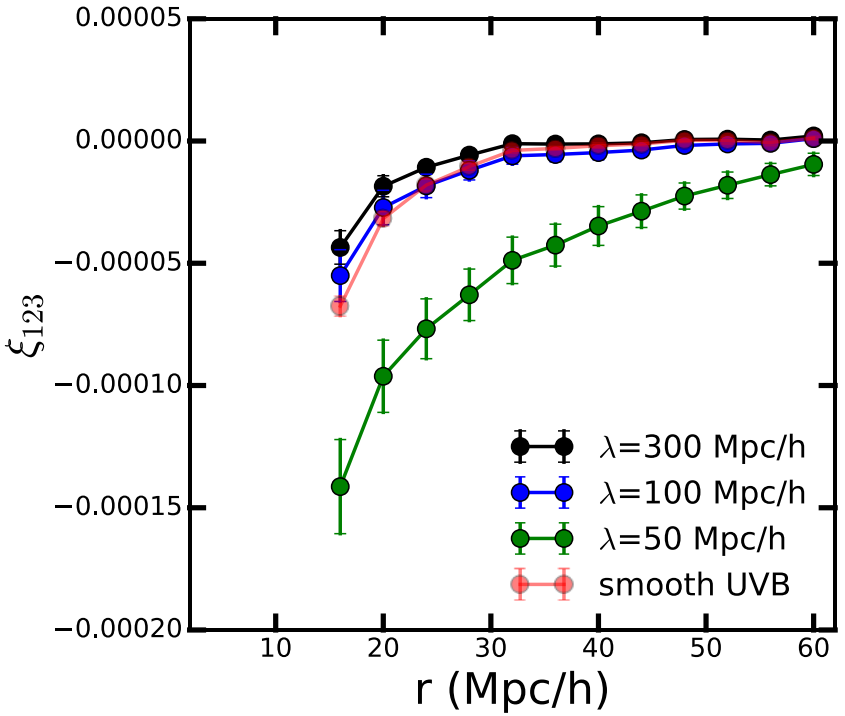
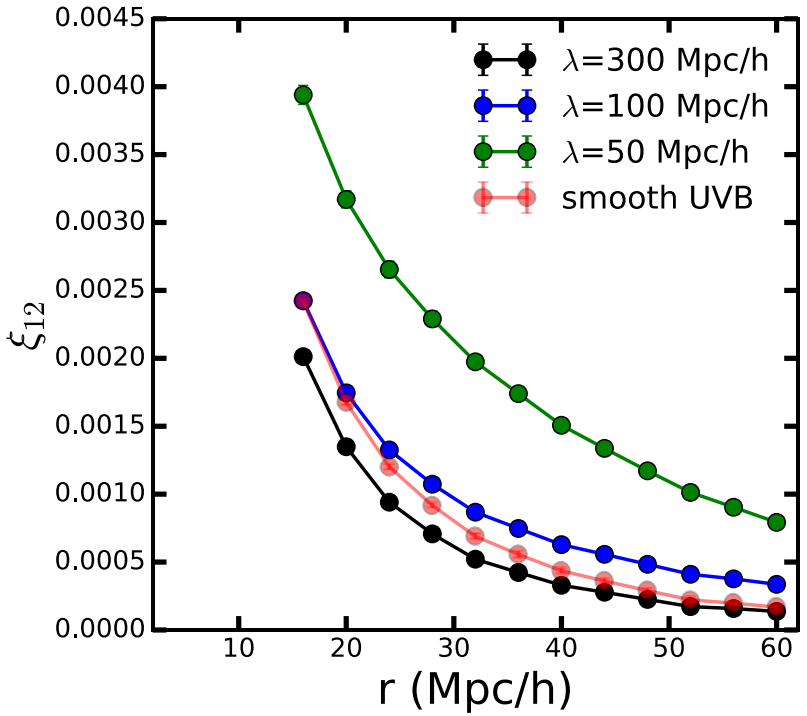


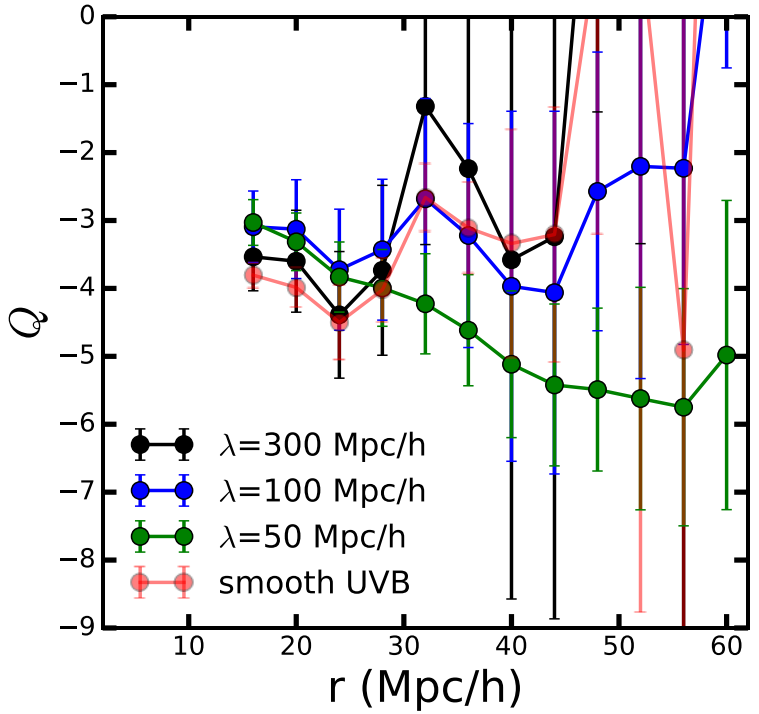


- Change in 2pt- and 3pt-clustering at all scales.
- Radiative effect competes with matter clustering.

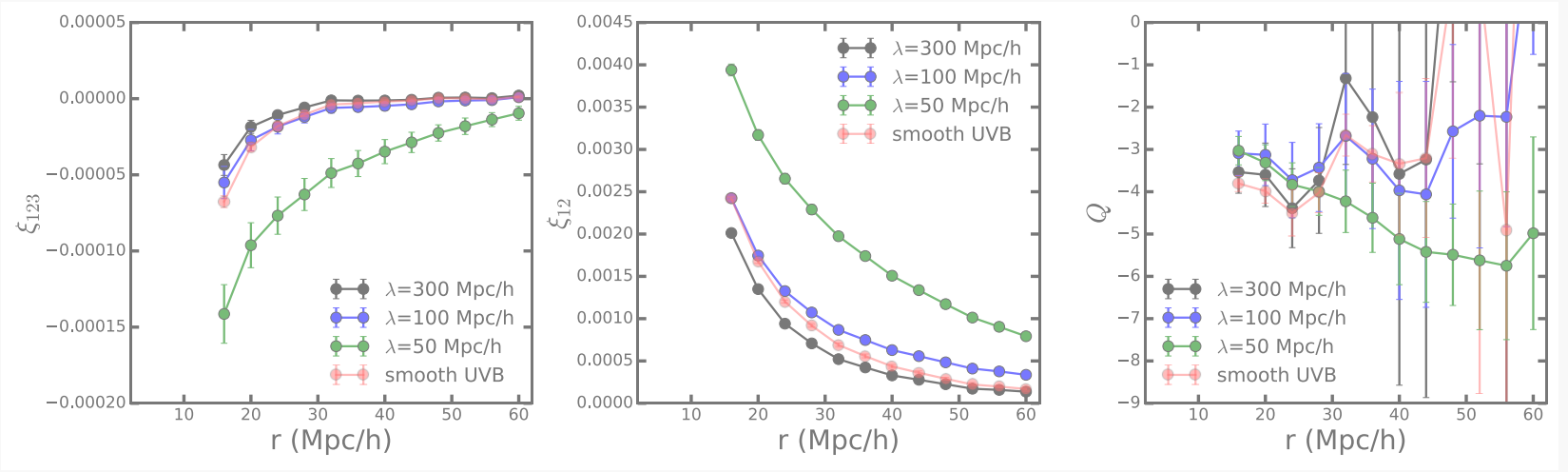
FLUCTUATING UVB CHANGES LYA FOREST CLUSTERING

QSOs in massive halos; $\theta = 60^o$

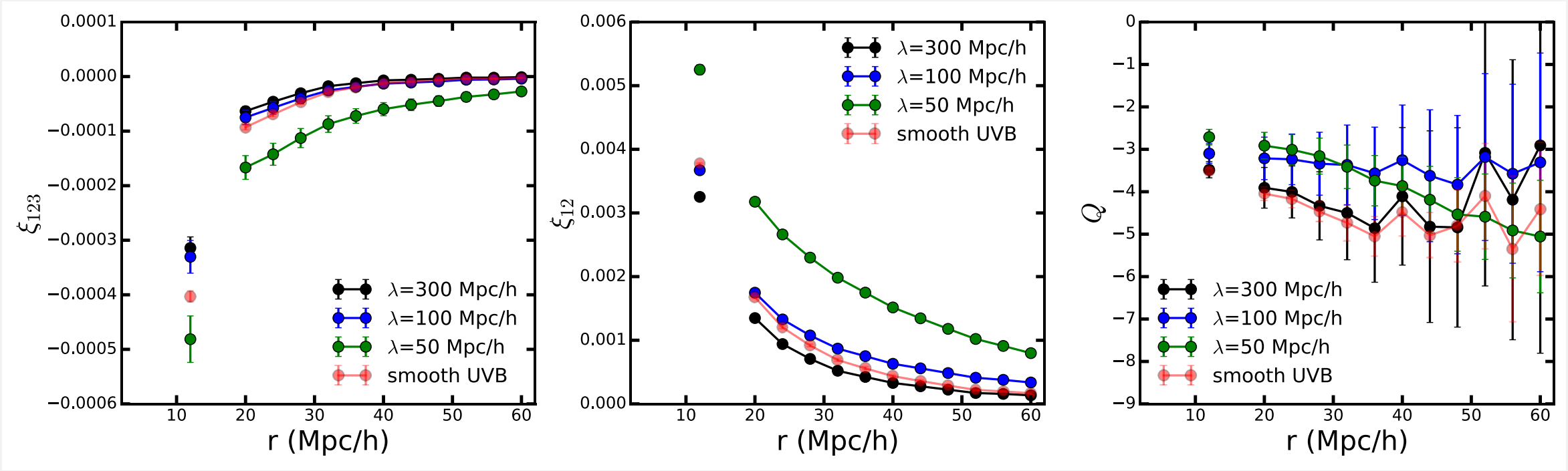
- $Q \sim -3$ to -4, slightly different amplitudes for smooth vs. fluctuating backgrounds.
- Largest λ ~ smooth UVB; evolution with scale for smallest λ?
- Error bars @ large r: cosmic variance



Previous figure



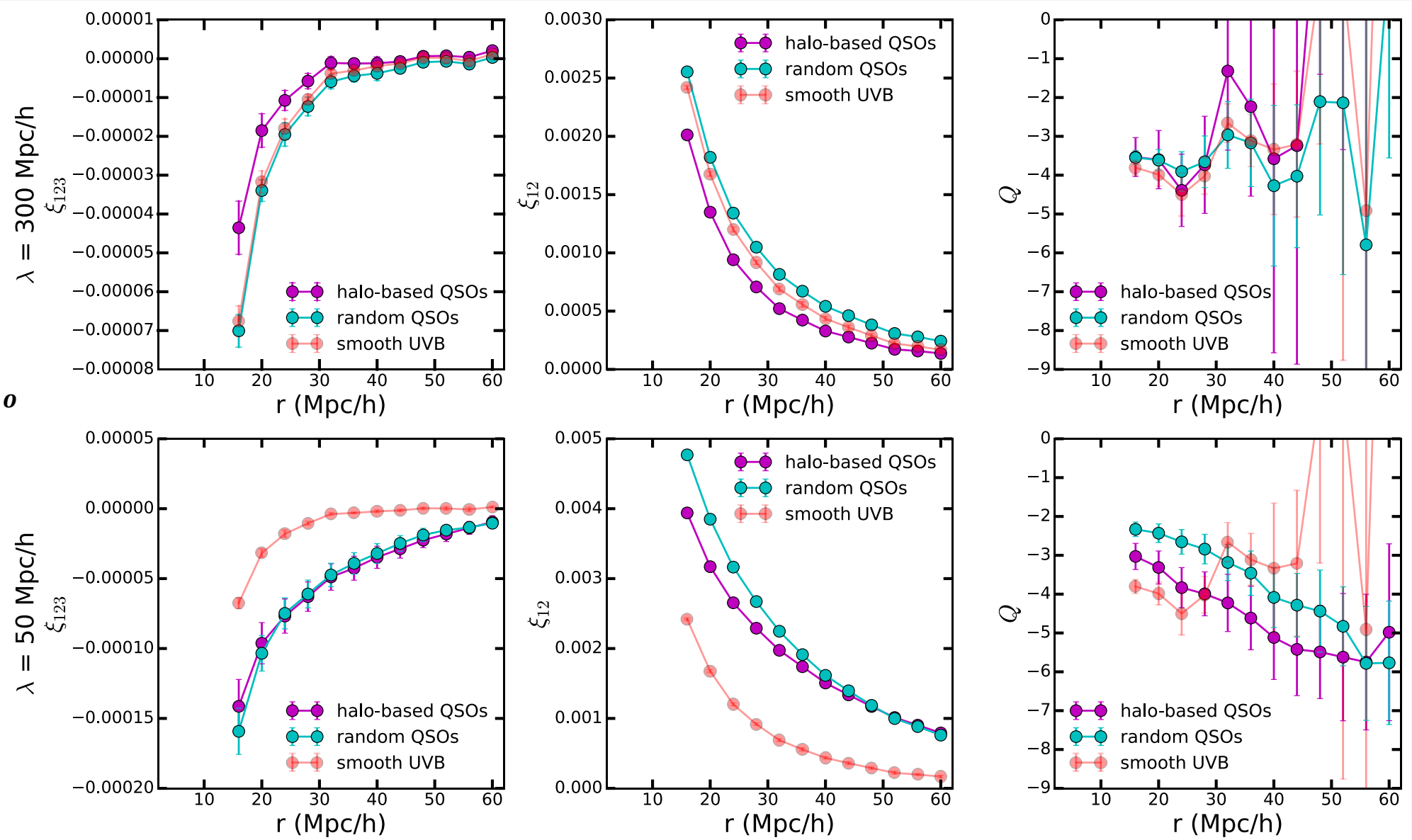
$\boldsymbol{\theta = 20^o}$



Weak shape dependence, and approximately constant Q with shape and scale.

IMPACT OF SOURCE CLUSTERING

$\theta = 60^{o}$



SUMMARY

We investigated the effect of fluctuating UVB on the 2PCF, 3PCF, and Q.

- LyMAS to predict the fluxes for large volume DM-only simulation.

There is impact from a fluctuating UVB on the CFs.

- Change in 2PCF and 3PCF, different Q
- Contribution from source clustering

Future work:

(i) Improve LyMAS with LOS peculiar velocity

(ii) Assess the observability for e.g., DESI

(iii) 3pt-cross correlation with quasars