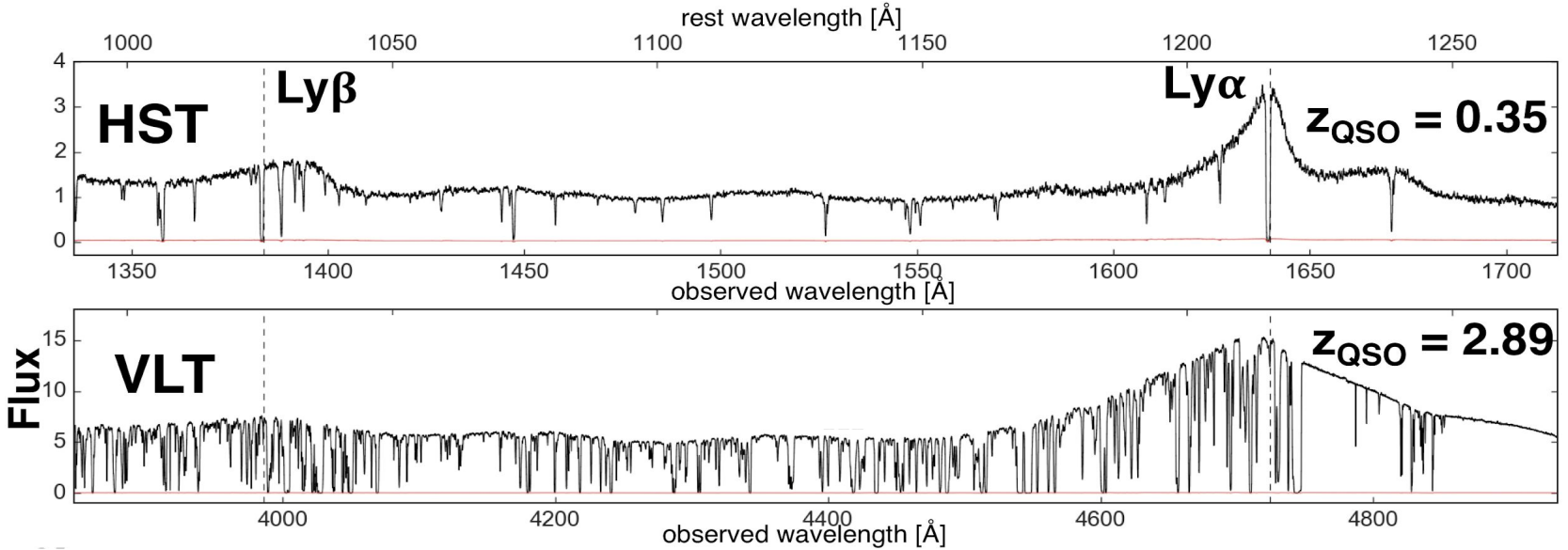
The Lyman-α forest flux auto-correlation function as a source of information on the z>5 universe

Molly Wolfson (UCSB)
Supervisor: Joseph Hennawi

NASA, ESA and J. Olmsted (STScI)

Lyman-α forest flux at high-z



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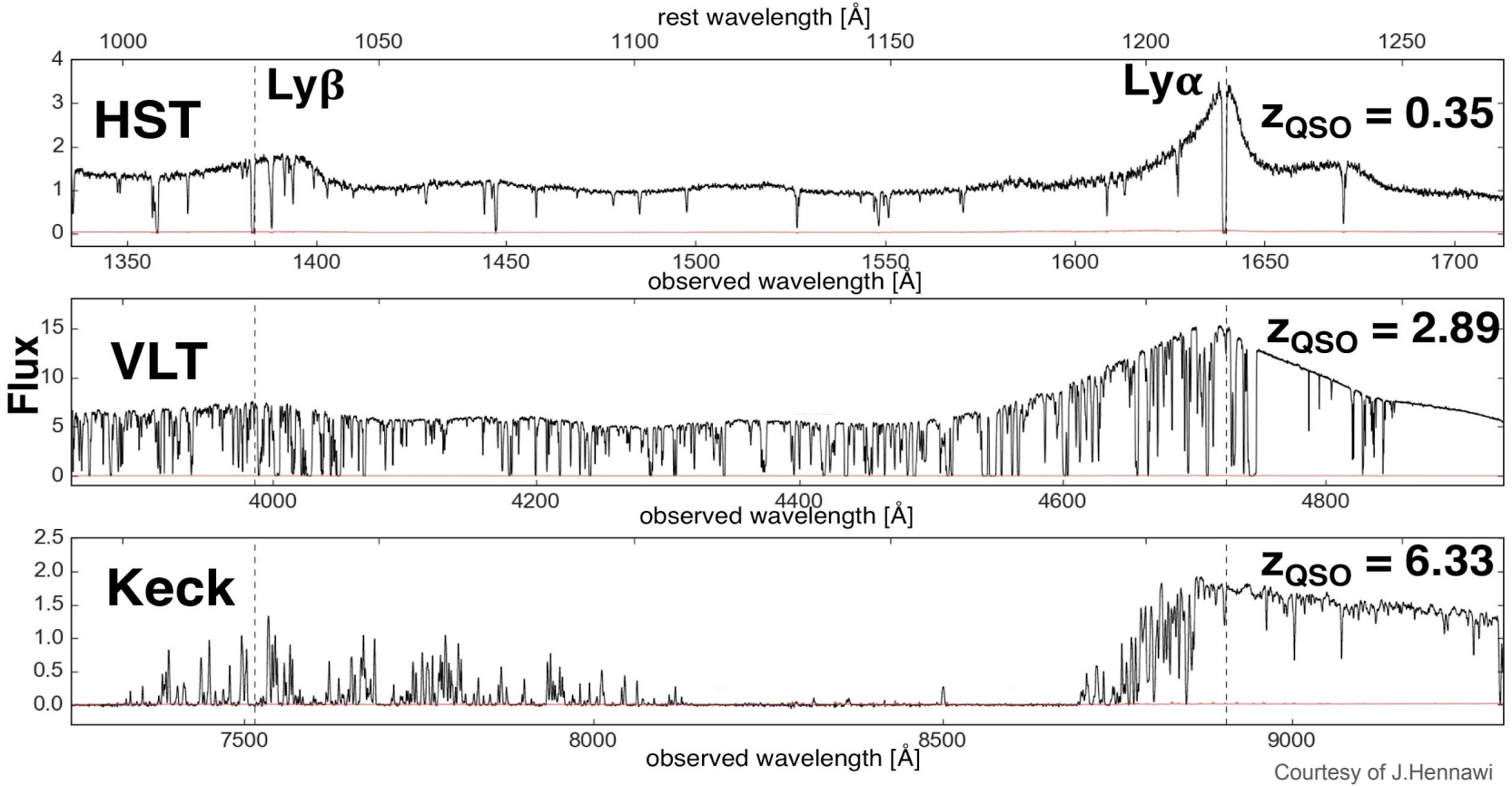

Courtesy of J.Hennawi

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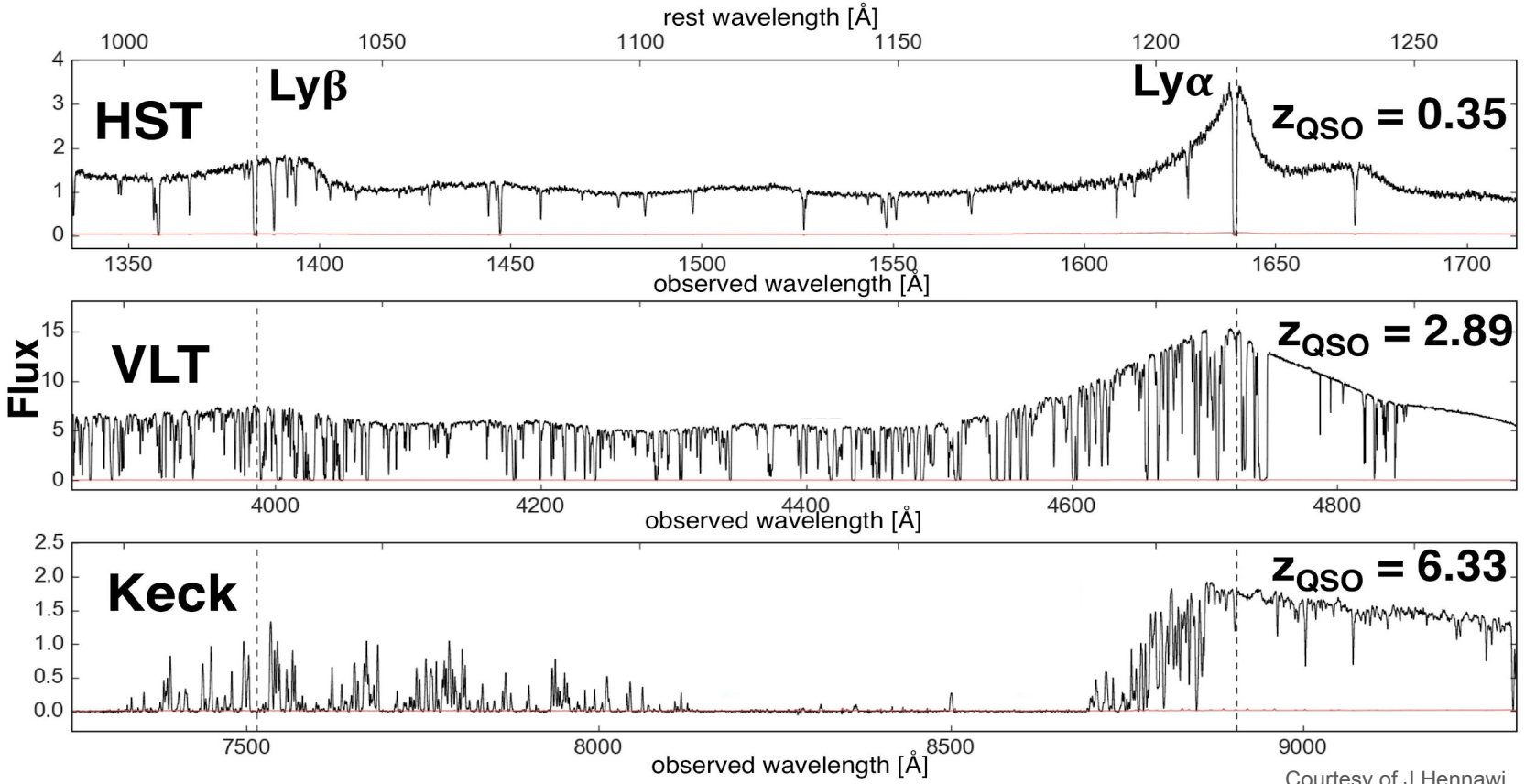

Courtesy of J.Hennawi

Saturates for $\langle x_{\rm HI}(z) \rangle \gtrsim 10^{-4}$

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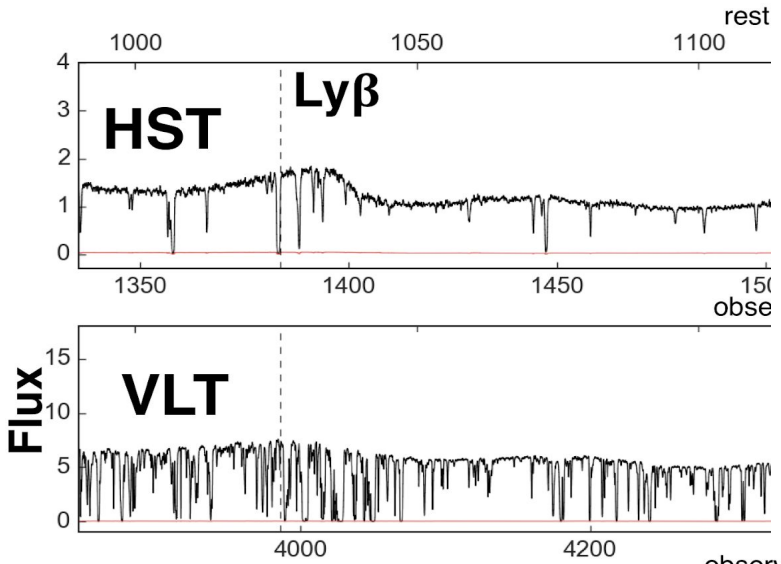

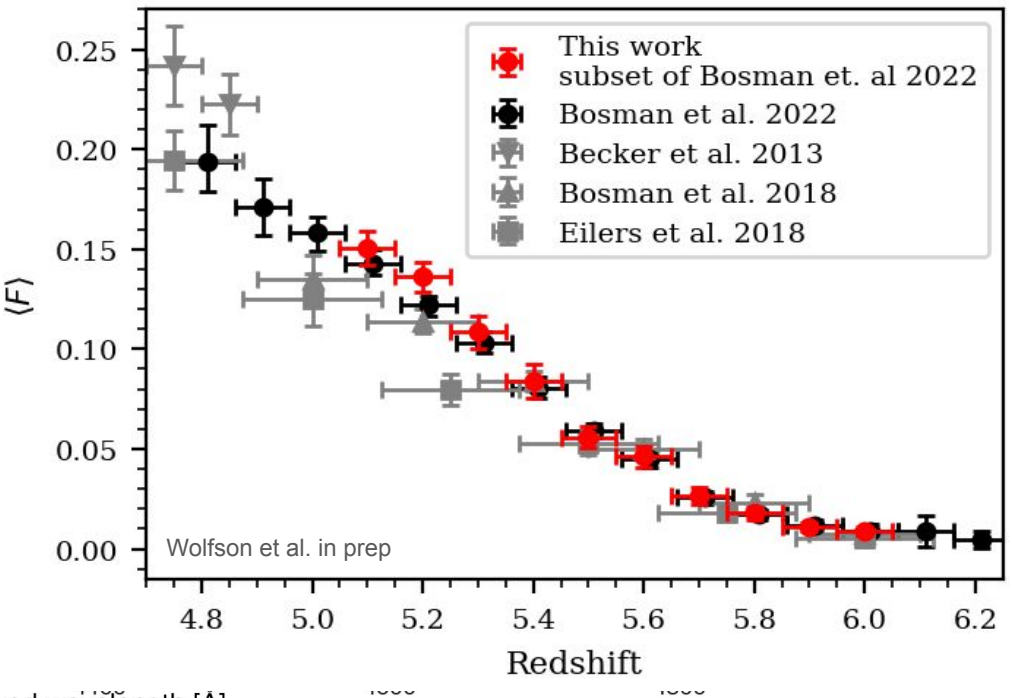

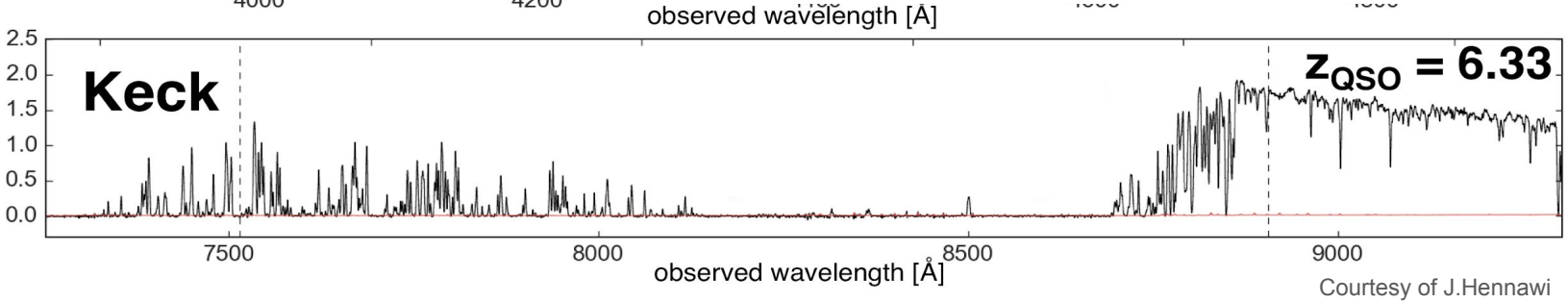

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What can we constrain with the Lyα forest from high-z quasars?

New Constraints on the free-streaming of warm dark matter from intermediate and small scale Lyman-α forest data

Vid Iršič[1,2,3],* Matteo Viel[4,5,6],† Martin G. Haehnelt [7], James S. Bolton [8], Stefano Cristiani[5,6], George D. Becker[7,9], Valentina D'Odorico[5], Guido Cupani[5], Tae-Sun Kim[5], Trystyn A. M. Berg[10], Sebastian López[11], Sara Ellison[10], Lise Christensen[12], Kelly D. Denny[13], and Gábor Worseck[14]

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Revealing Reionization with the Thermal History of the Intergalactic Medium: New Constraints from the Lyα Flux Power Spectrum

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XQR-30 dataset

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XQR-30 dataset

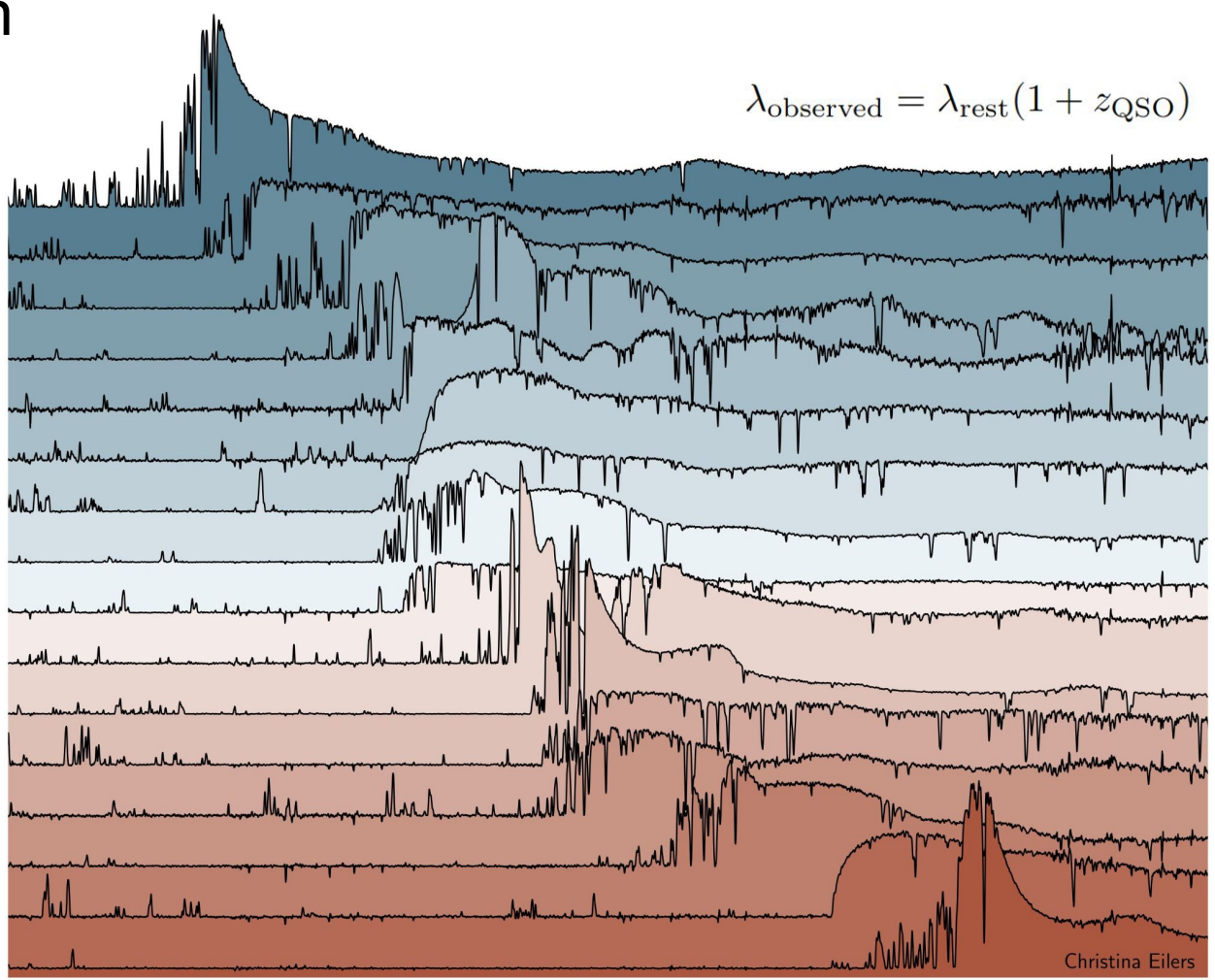
λ_{mf}

p

XQR-30 Collaboration

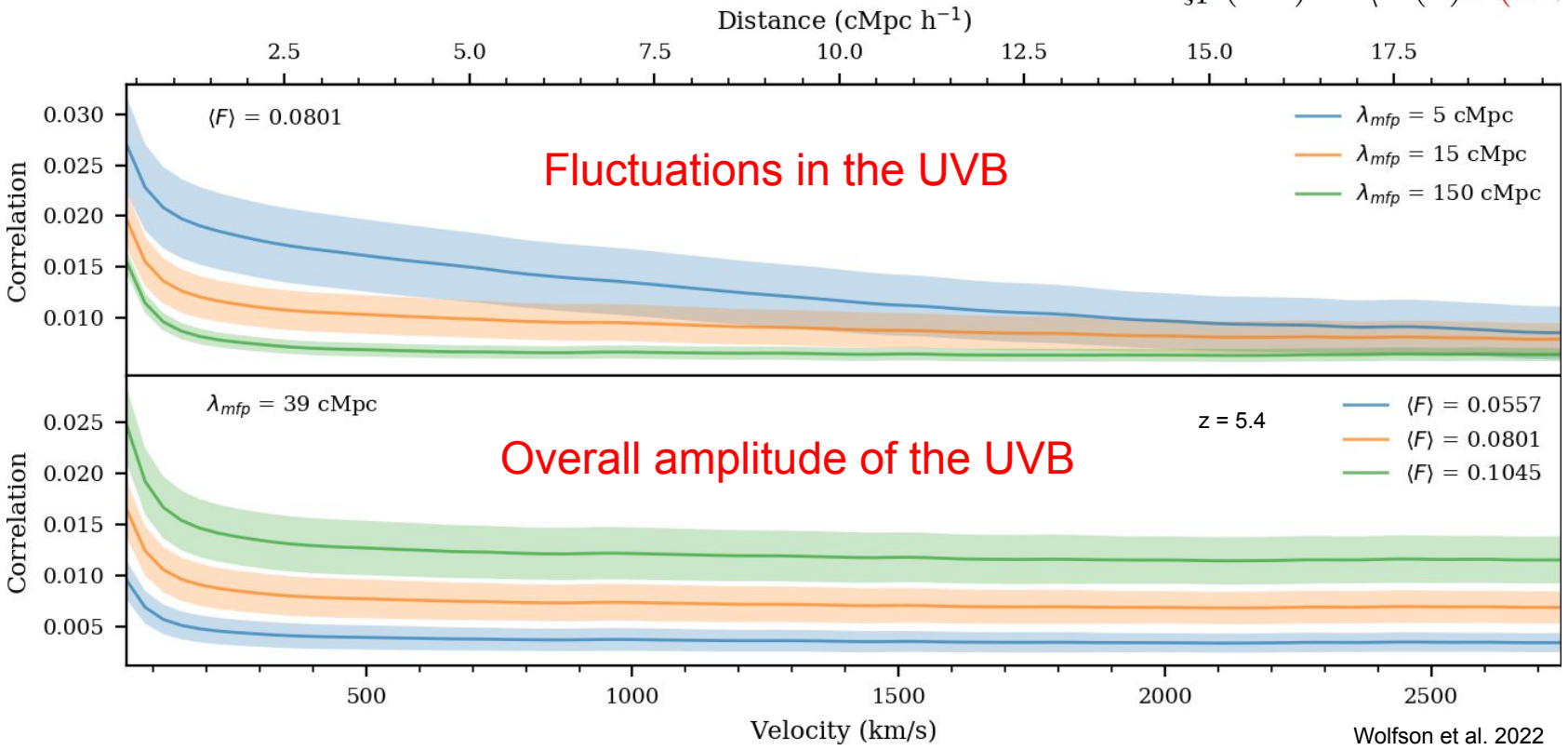
XQR-30 data (xqr30.inaf.it):

- Uses VLT/X-Shooter (R ~ 8800 in the visible)
- 30 new observations of some of the brightest z > 5.8 quasars observed
- Supplemented with 12 archival observations



Effect of λ_{mfp} on the auto-correlation function

$$\xi_F(\Delta v) = \langle F(v) F(v + \Delta v) \rangle$$



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Differences between the models for different λ_{mfp} values are non-linear!

Measuring λ_{mfp} from mock data

Gaussian likelihood:

$$\mathcal{L} = \frac{1}{\sqrt{\det(\Sigma)(2\pi)^n}} \exp\left(-\frac{1}{2}\left(\boldsymbol{\xi} - \boldsymbol{\xi}_{\mathrm{model}}(\lambda_{\mathrm{mfp}}, \langle F \rangle)\right)^{\mathrm{T}} \Sigma^{-1} \left(\boldsymbol{\xi} - \boldsymbol{\xi}_{\mathrm{model}}(\lambda_{\mathrm{mfp}}, \langle F \rangle)\right)\right)$$

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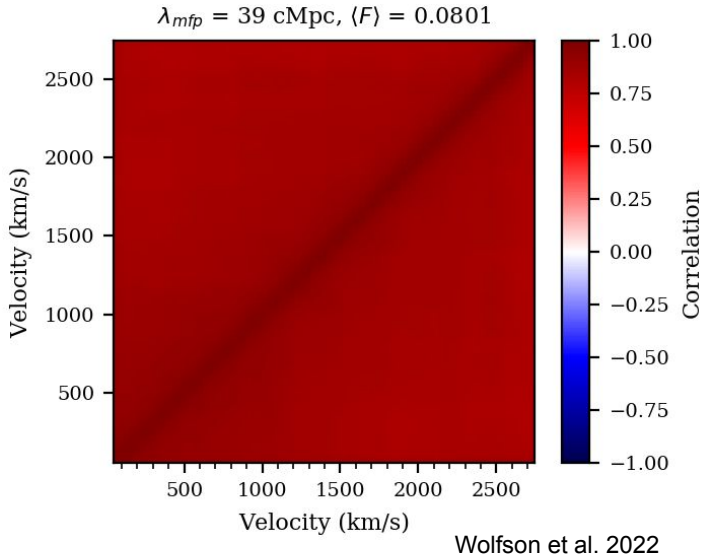

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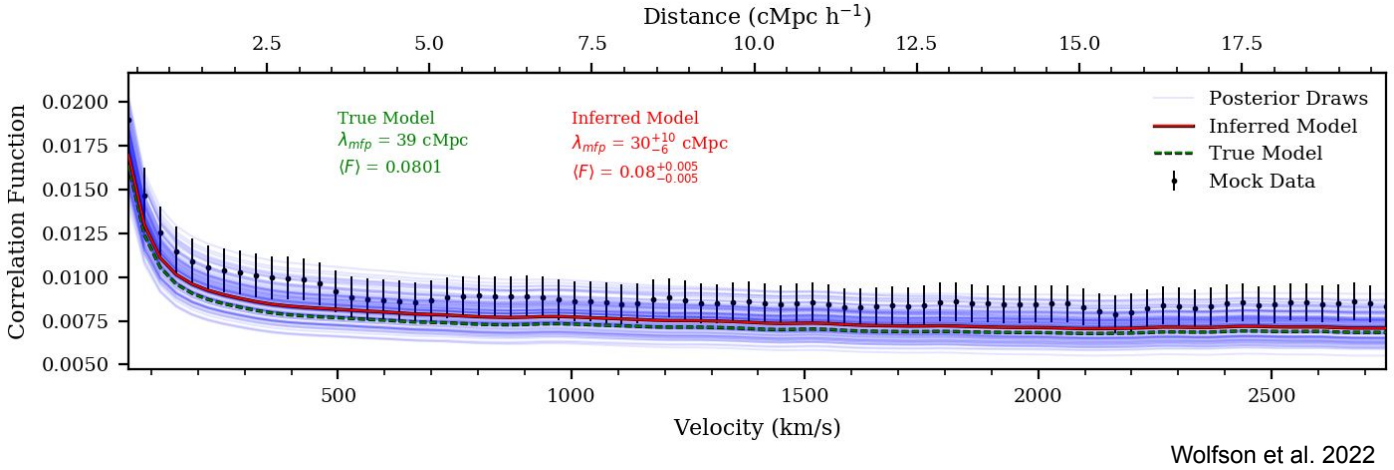
MCMC:



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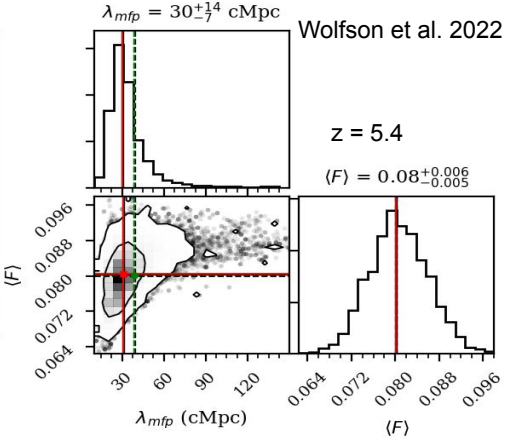

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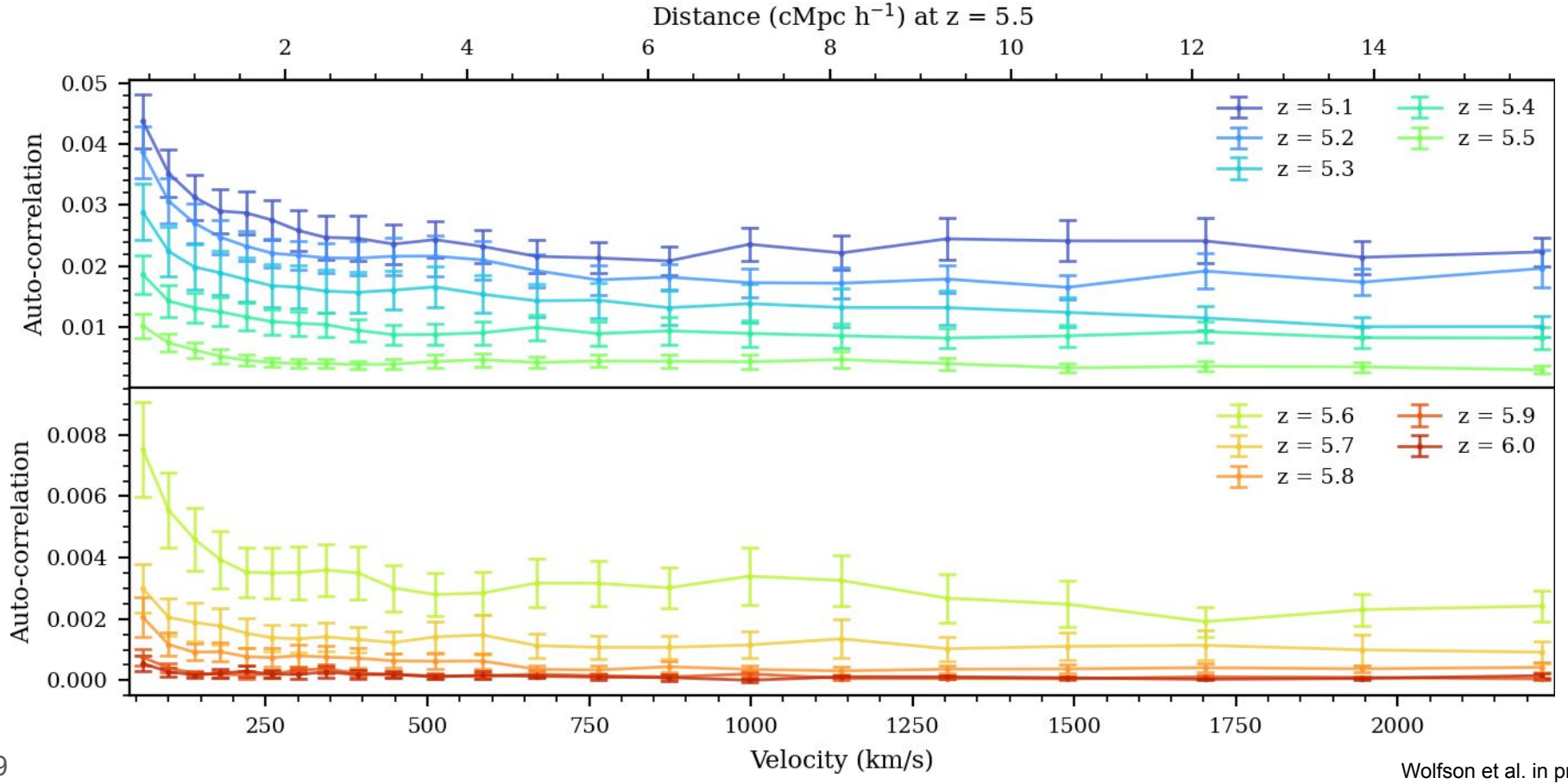
z = 5.4

Observed auto-correlation function



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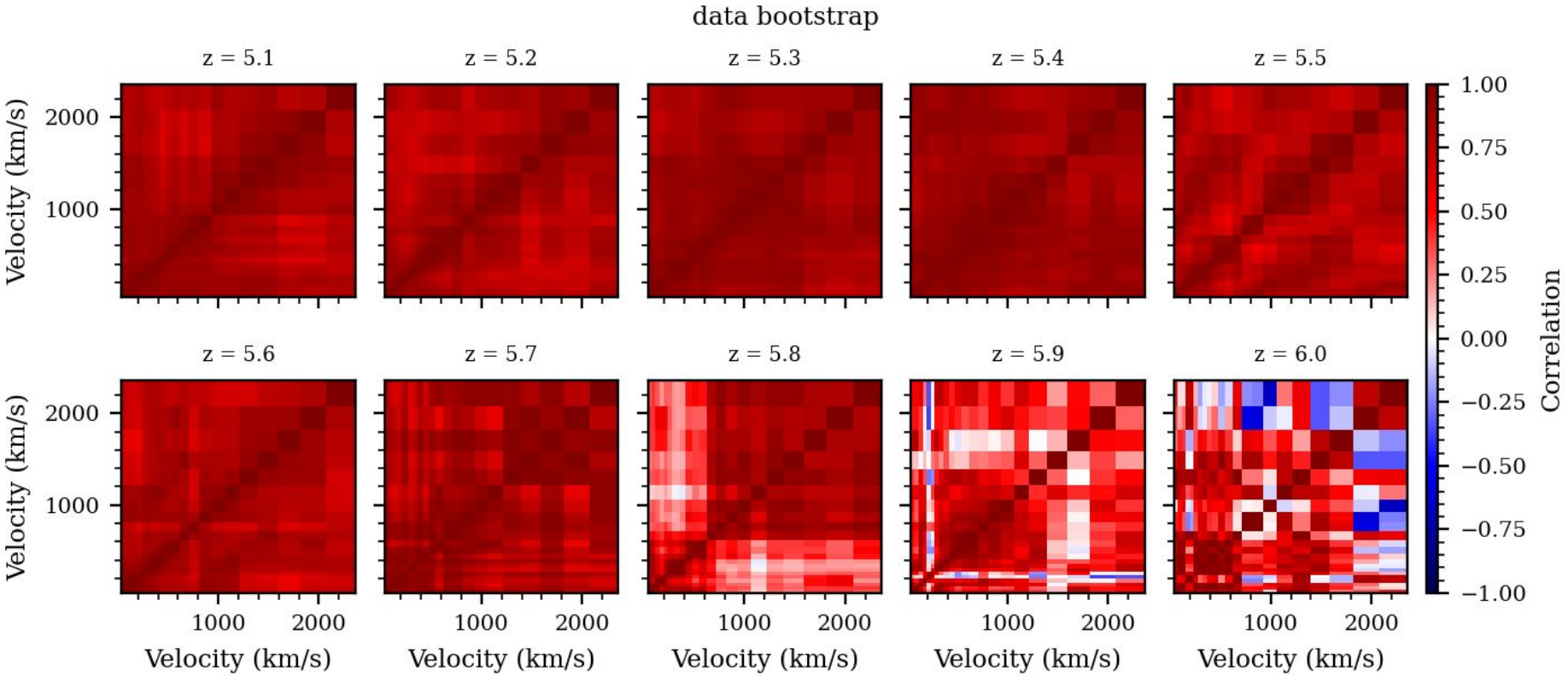
Observed Covariance Matrices



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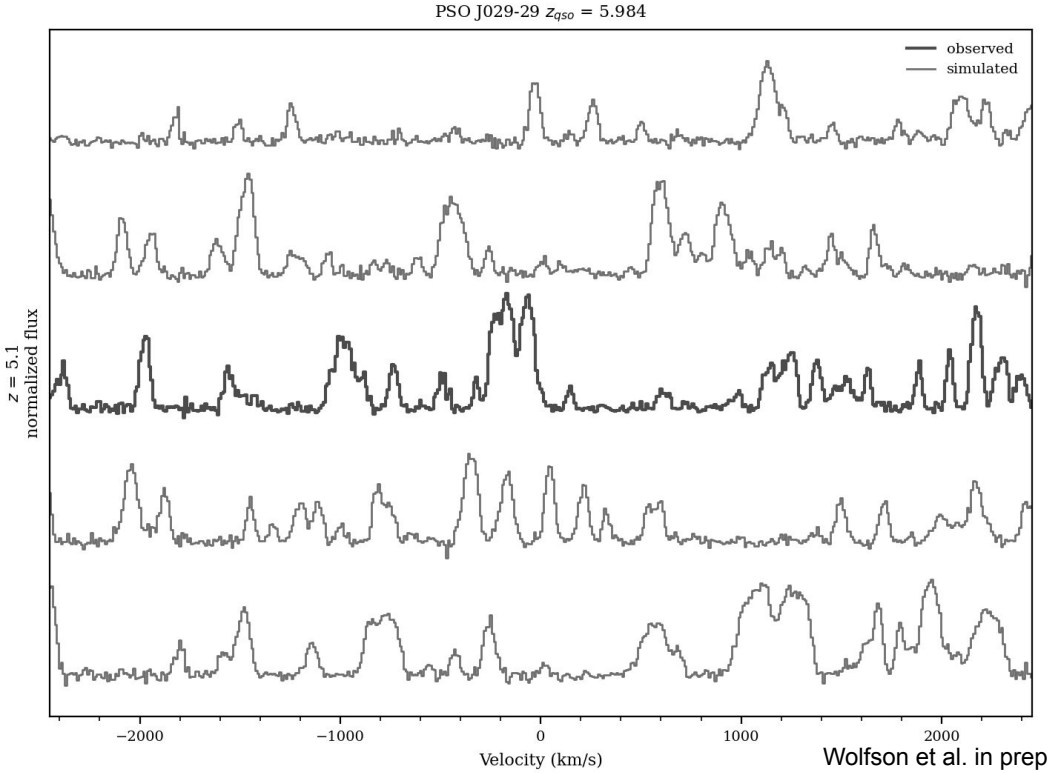
Forward modeled covariance matrices

Forward model the simulation with the observed properties:



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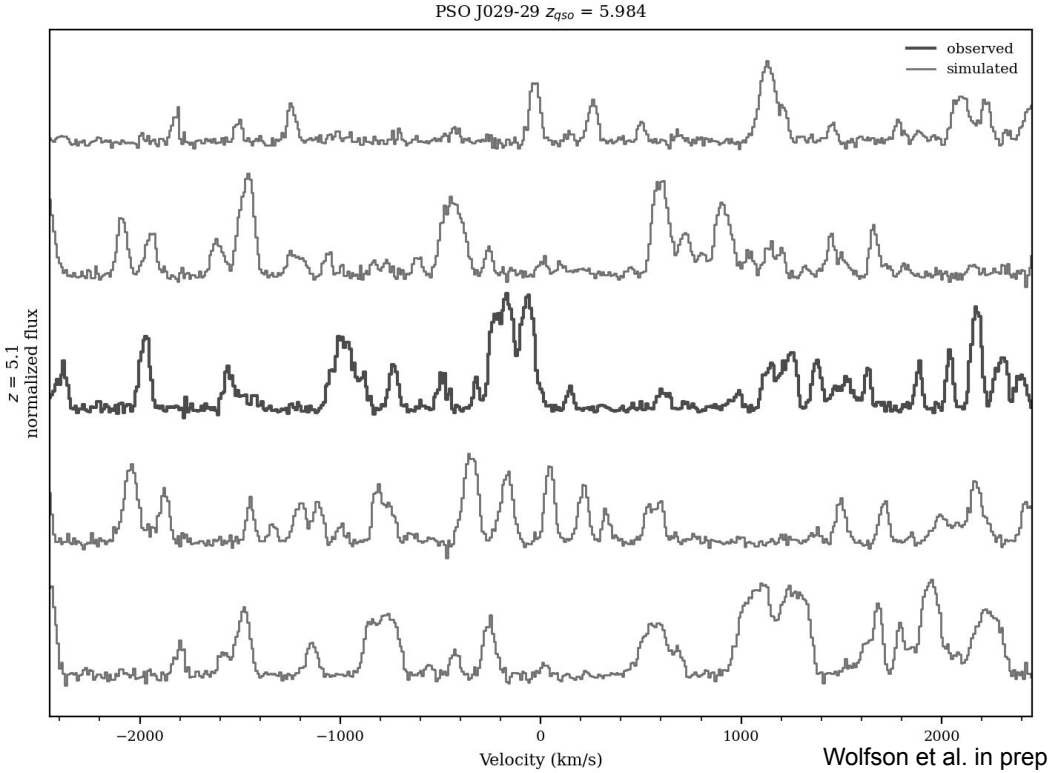

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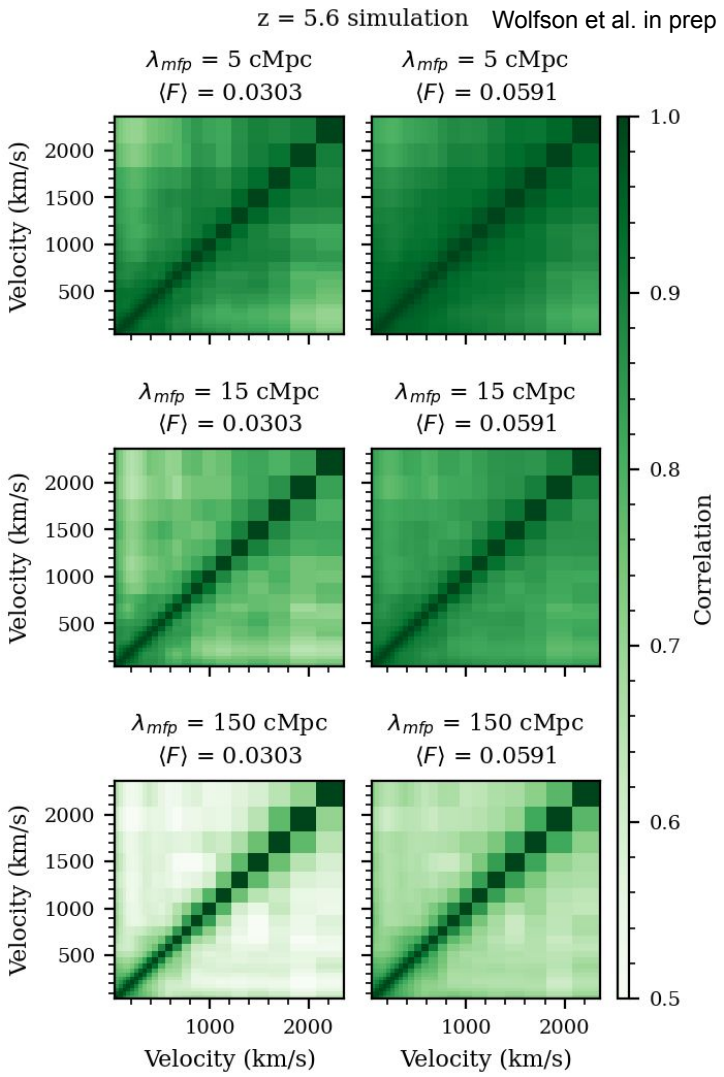

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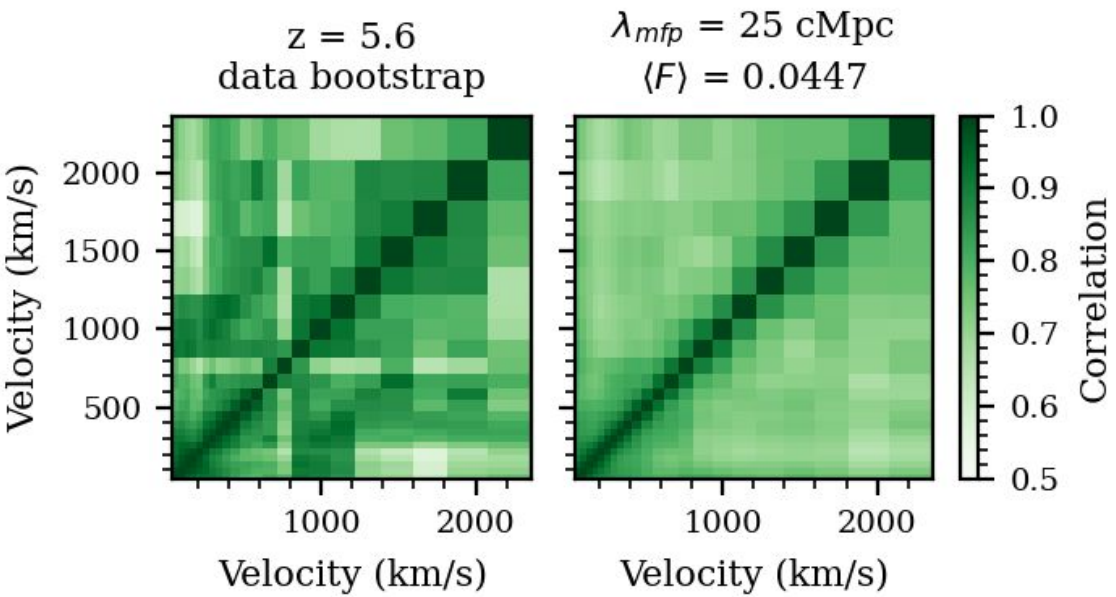

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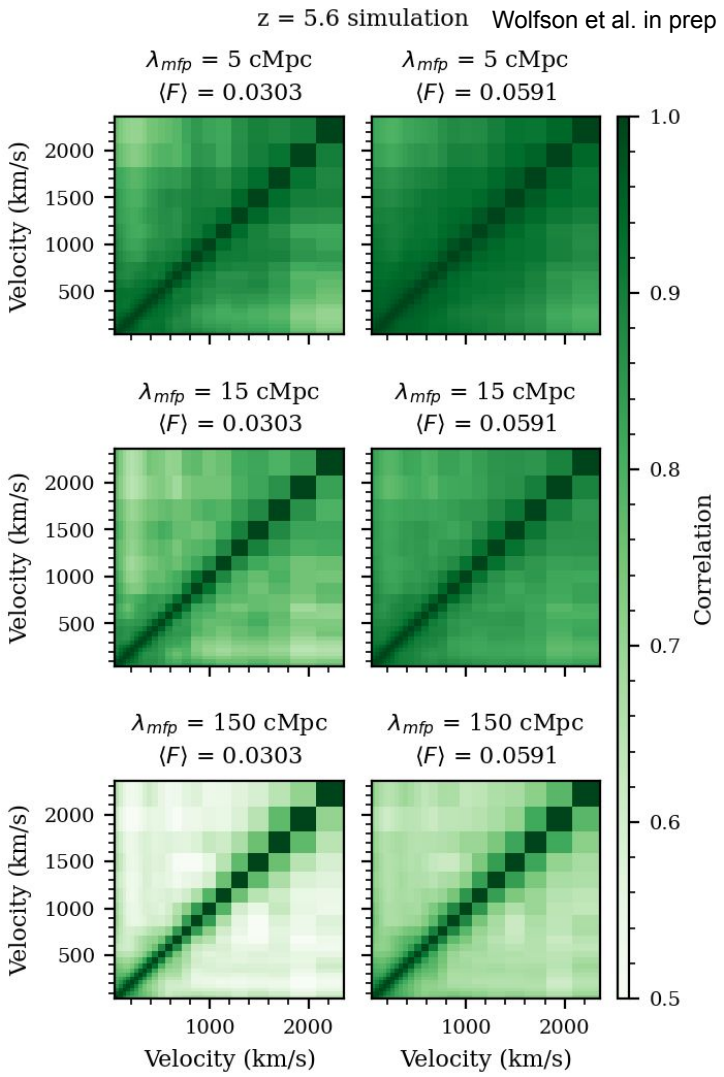

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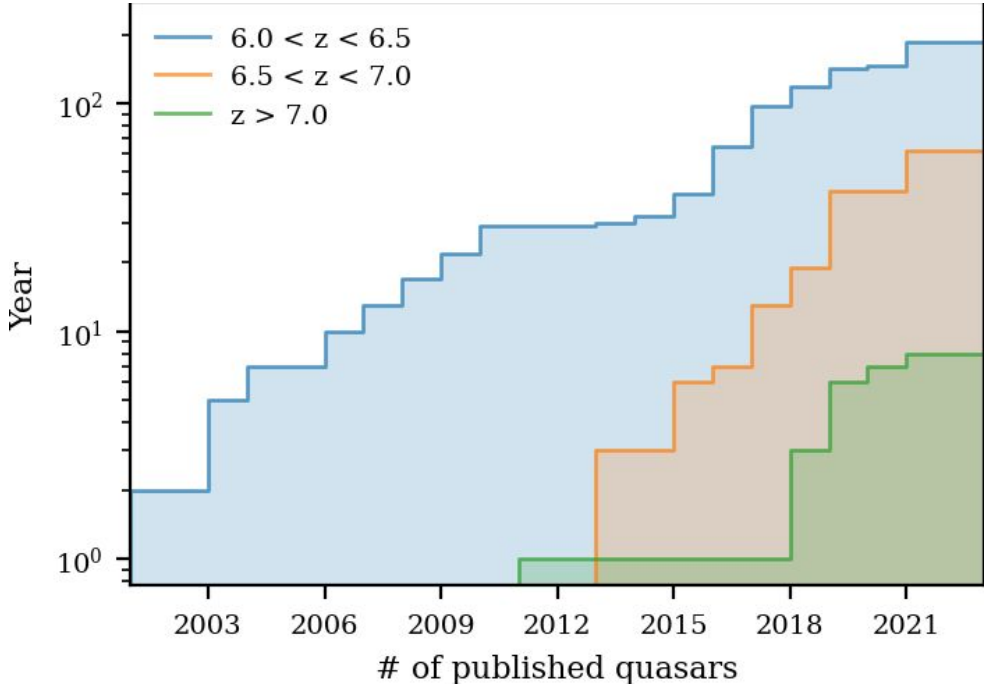
  - The data is being built up!



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  - The data is being built up!
- The auto-correlation function provides a new way to competitively constrain the evolution with redshift of λ_{mfp} with existing data
- Measurement of λ_{mfp} from XQR-30 data is ongoing
  - Estimating covariance matrix from limited data and uncertain modeling has been challenging

Things I would be happy to discuss:

- Re-weighting posteriors to correct for assumptions in our likelihood function (such assuming the data is Gaussian distributed)
- Measuring the thermal state of the IGM with high-resolution (KECK/HIRES) z > 5 quasar data