Measuring large-scale UV background inhomogeneities with the HeII forest and metals

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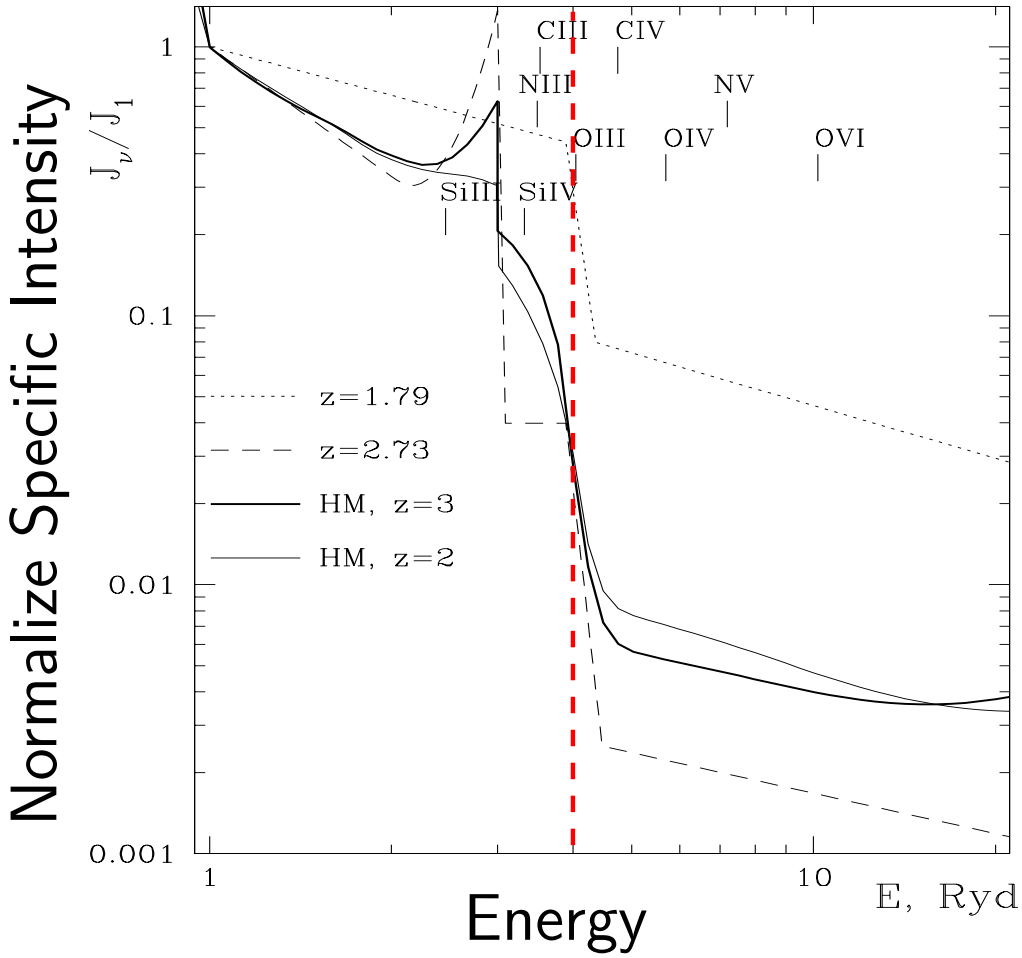
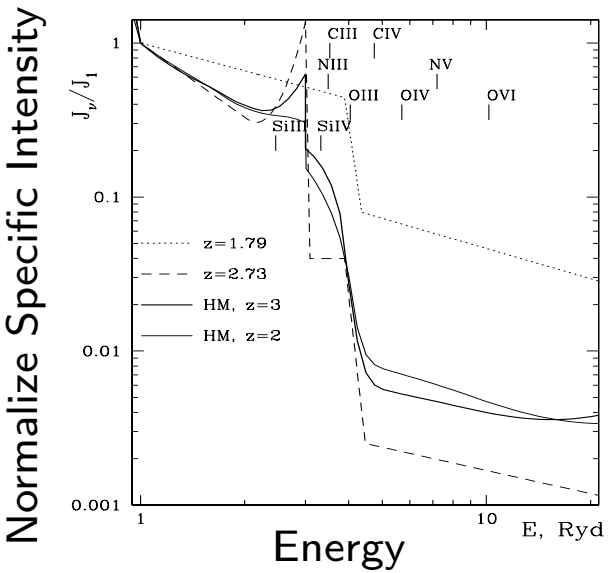
UV Background Shape & Intensity

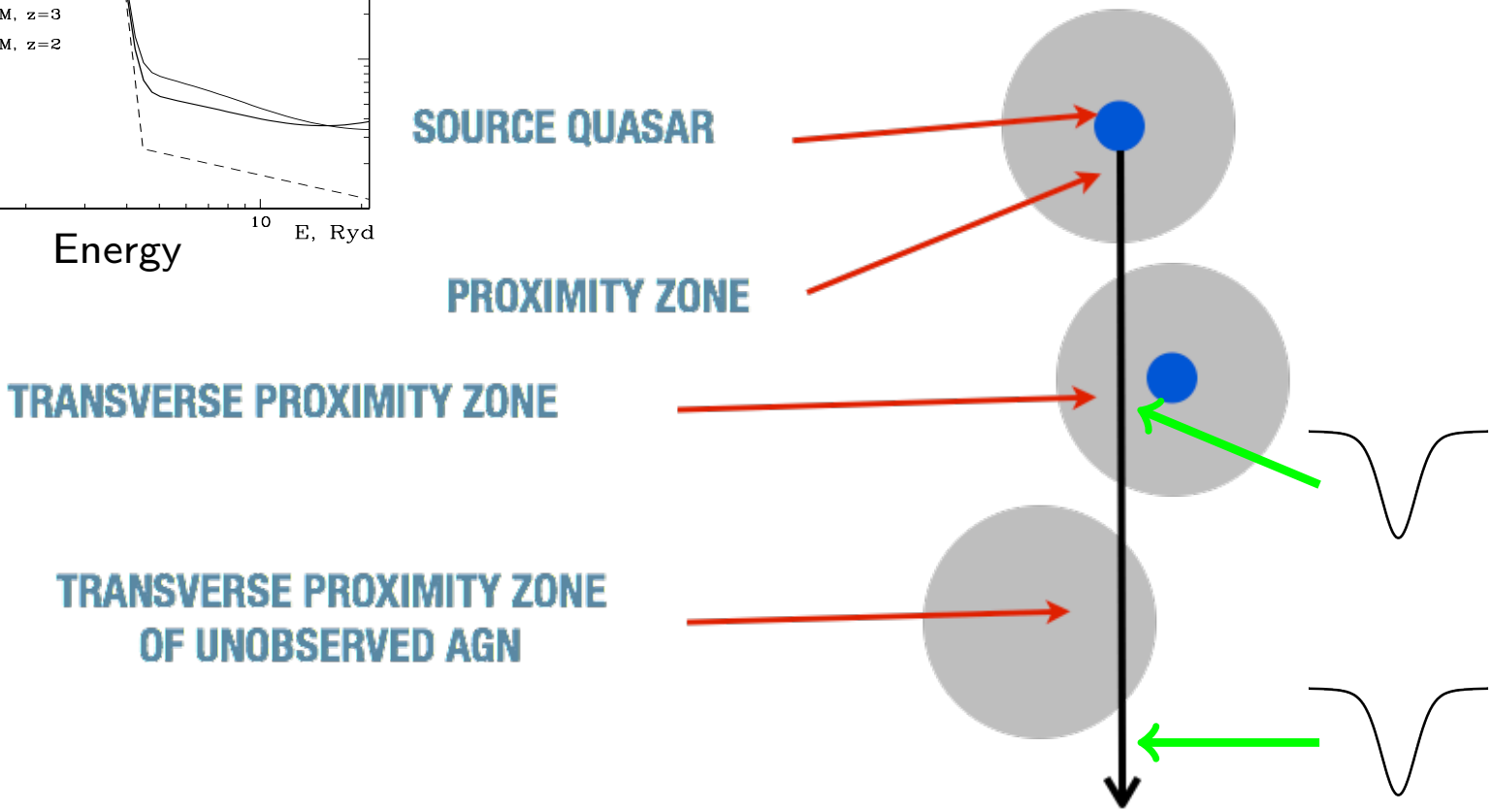
- H I and He II reionization
- Quasar population, galaxy population
- Traced using various ionization species



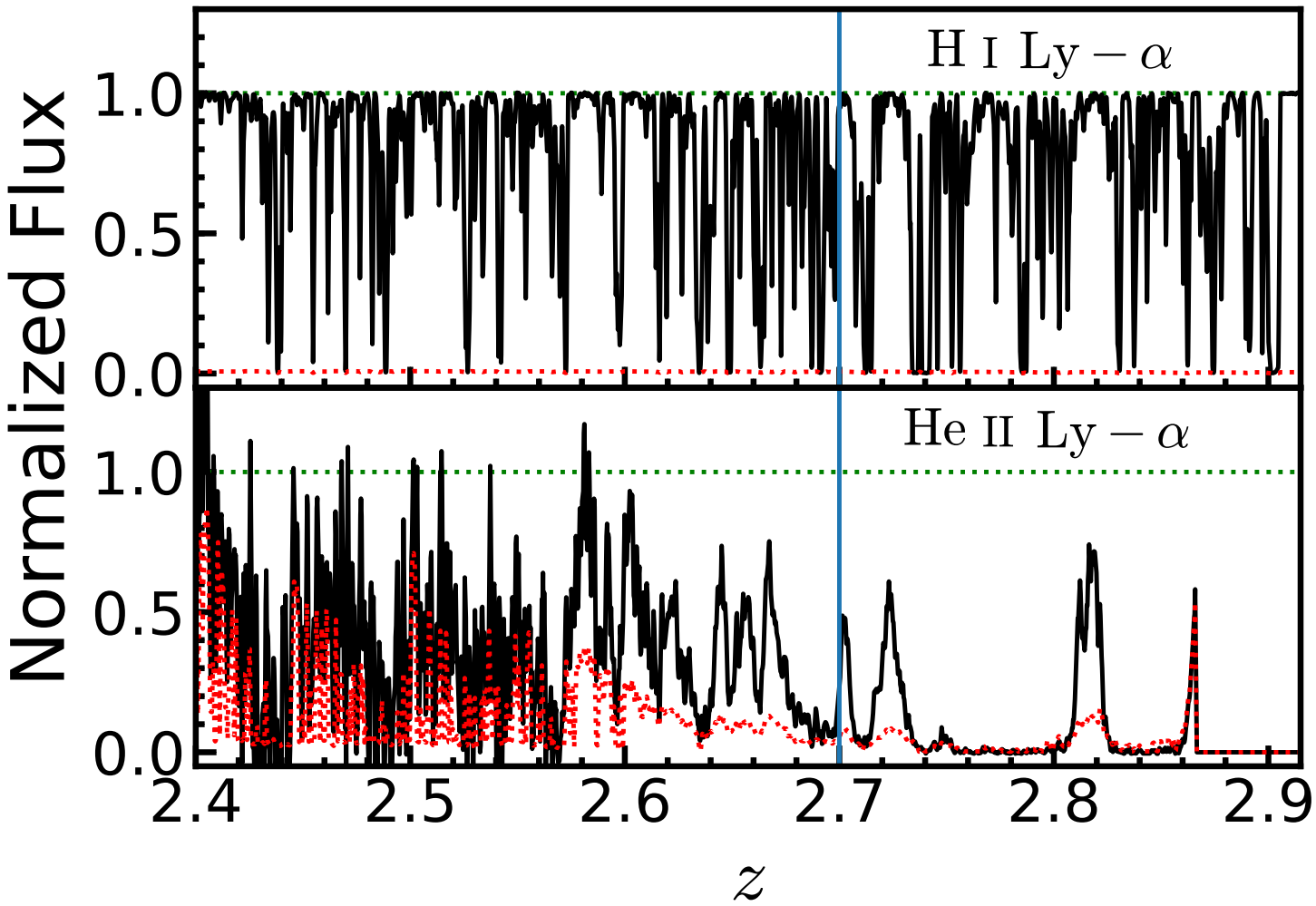
Agafonova et al. (2007)

Quasar/Transverse Proximity Effects





Gunn-Peterson Trough in HE2347-4342



η: The Ratio of He II to H I

$$\eta = \frac{N_{\mathrm{He\,II}}}{N_{\mathrm{H\,I}}} \approx \frac{4\tau_{\mathrm{He\,II}}}{\tau_{\mathrm{H\,I}}}$$

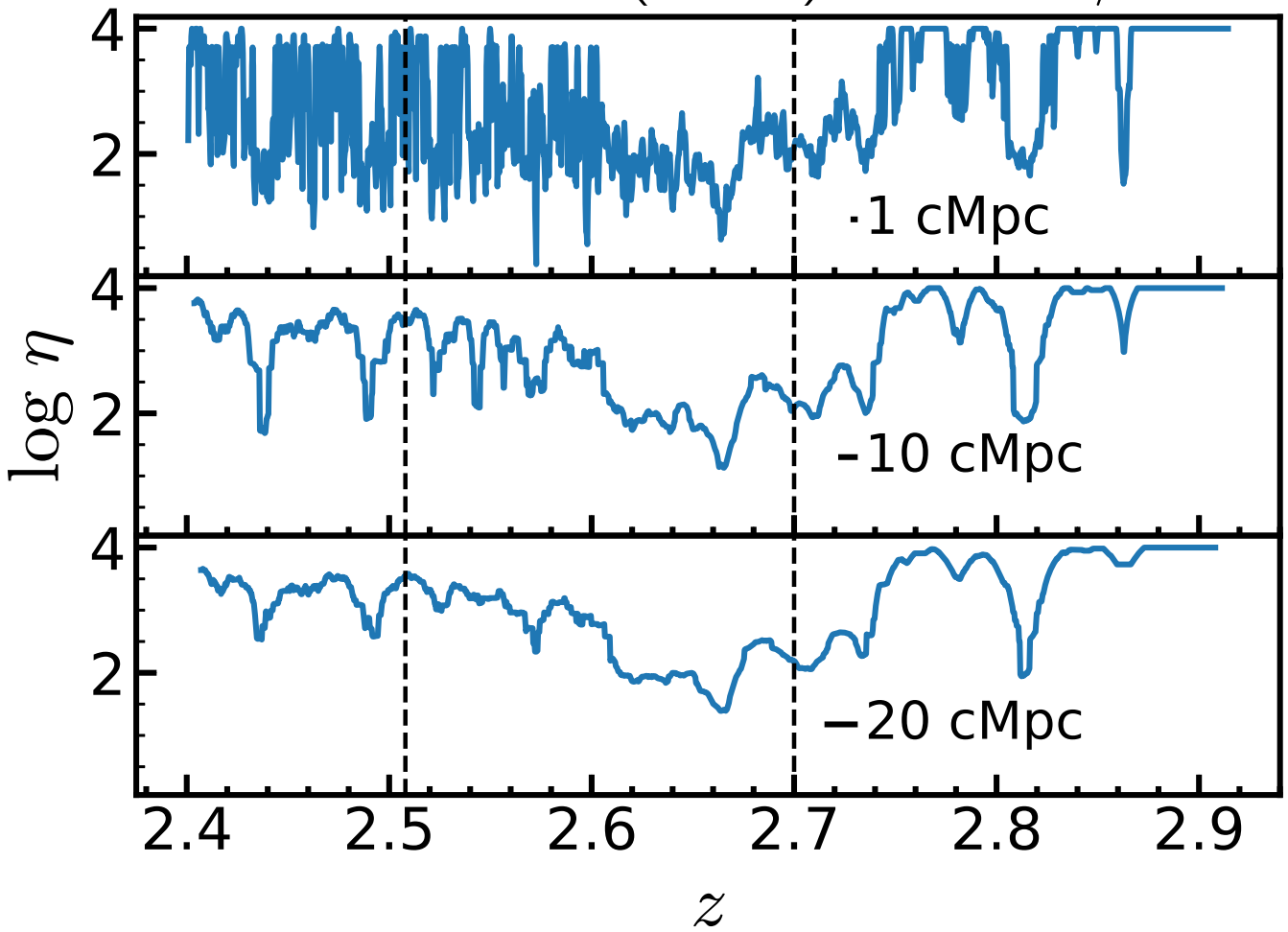
- Density independent
- Large η: soft radiation
- Small η: hard radiation
- η sensitive on

  Mpc scales to the locations of transverse quasars

  smaller scales to thermal broadening, galactic outflows, and proximity to local galaxies

Measuring η on Large Scales

- Measuring He Ly-α to H Ly-α (η) ratio smoothed on >1 Mpc scales.
- Data from Hubble COS (for He) and UVES/HIRES (H)



HE 2367-4342

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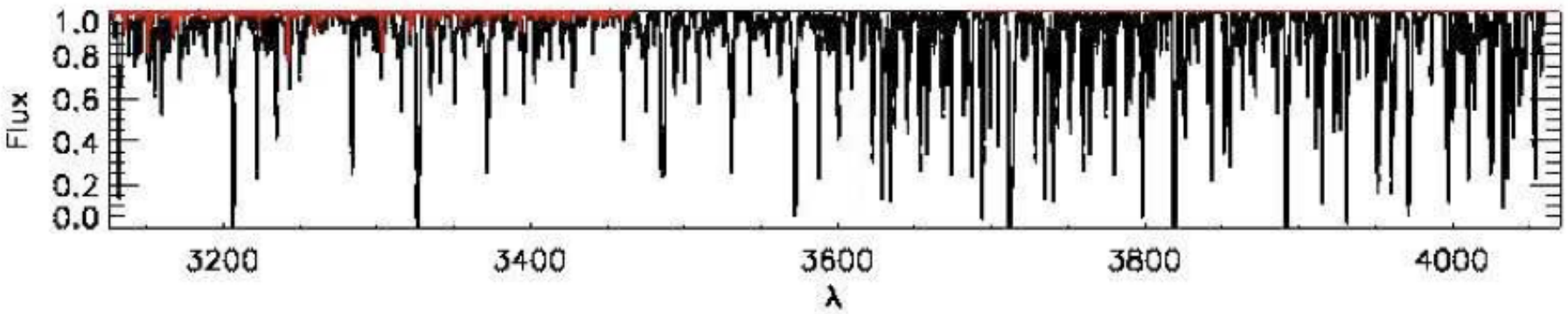
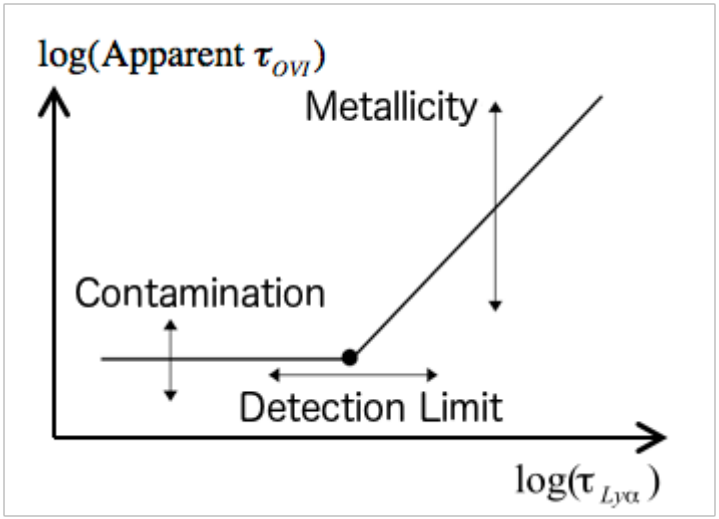
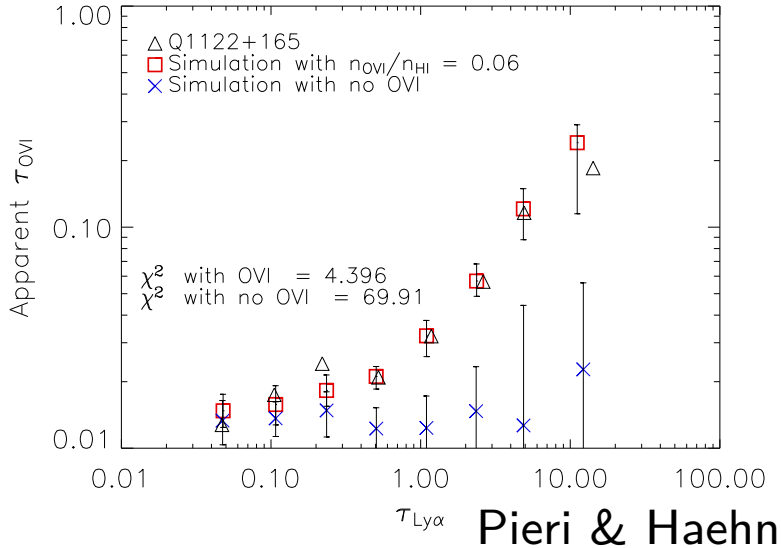
Measuring Metals in the IGM

- Pixel Optical Depth Techniques (Songaila et al. 1995; Schaye et al. 2003)
- A example (simulated) Ly-α forest in a quasar spectrum
  with an OVI forest (5 times ionized oxygen)







Pieri & Haehnelt (2004)

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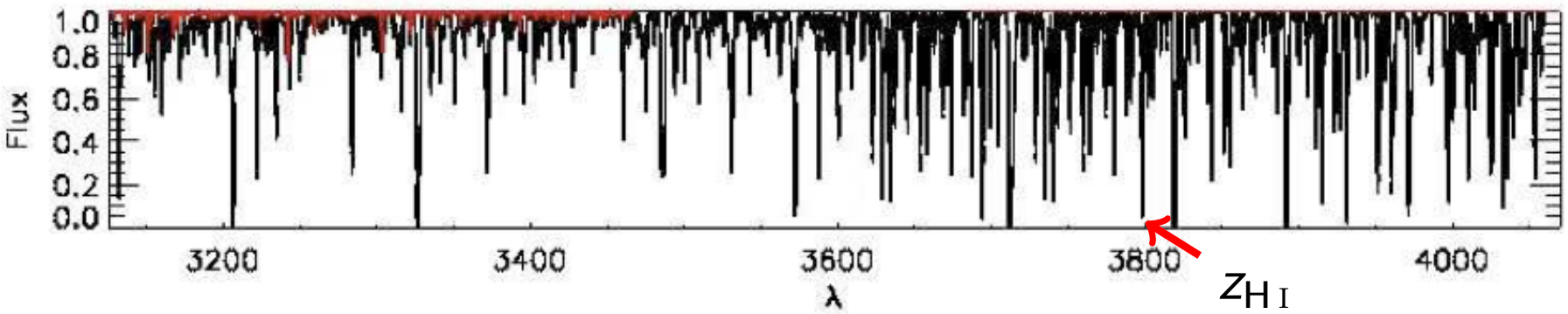

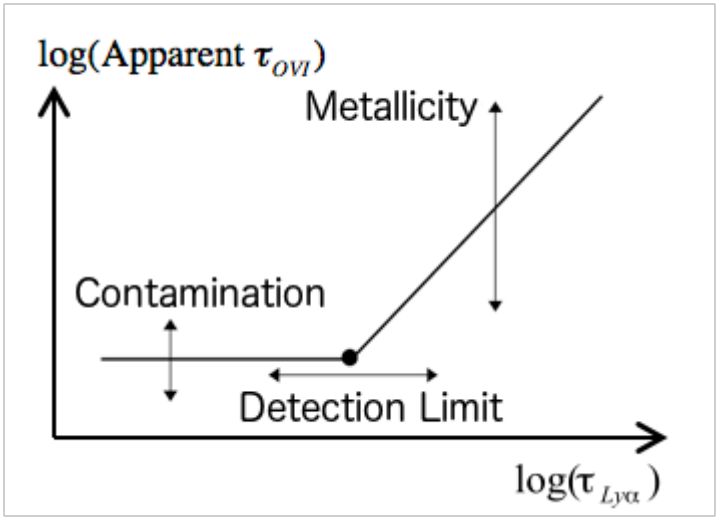

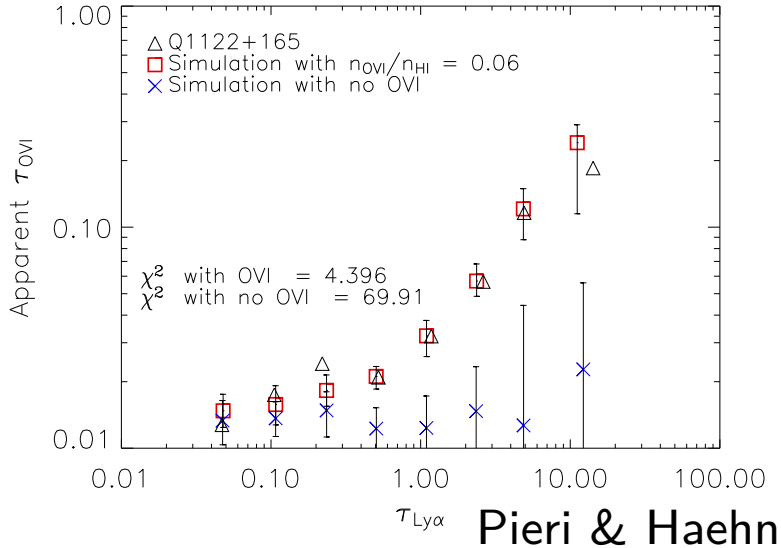

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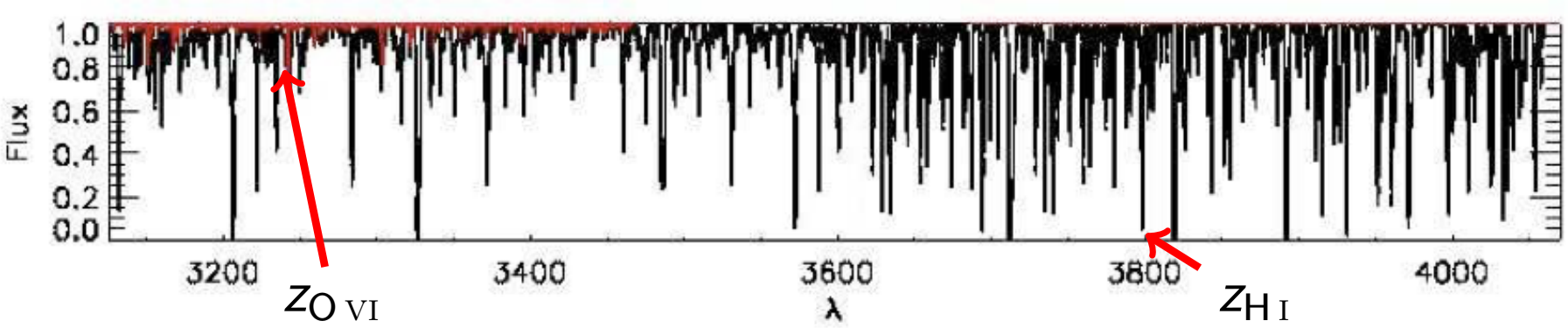

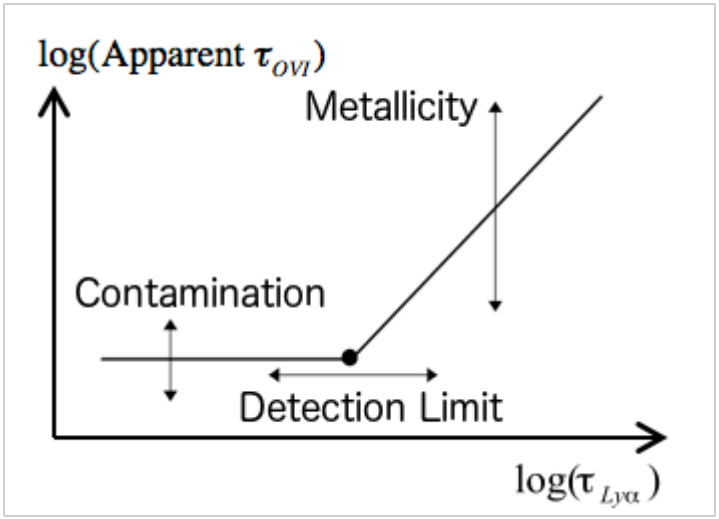

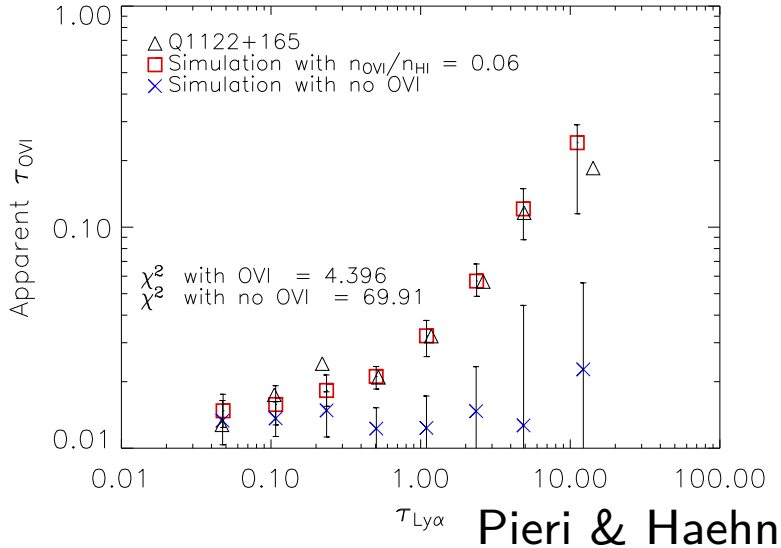

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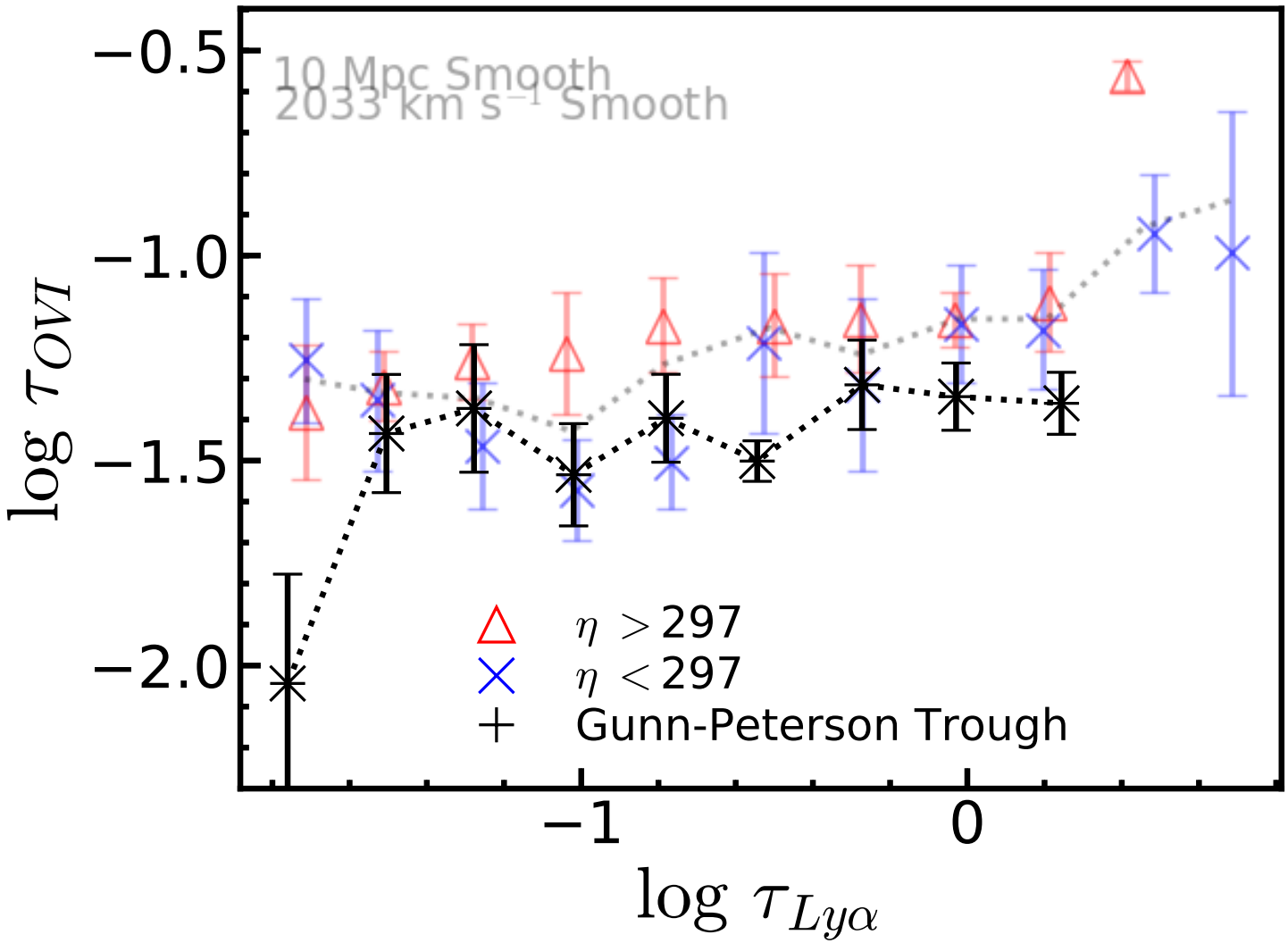
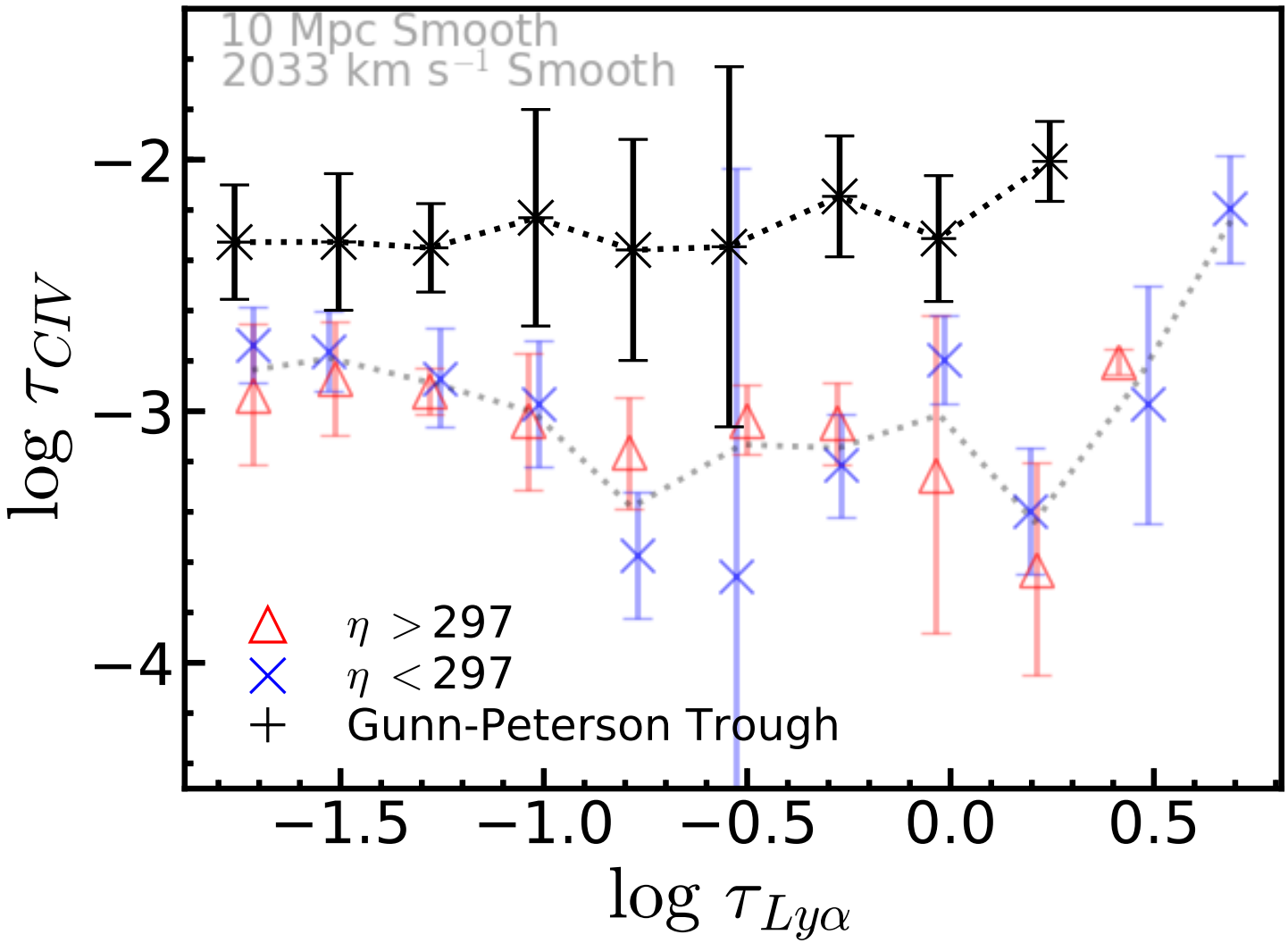
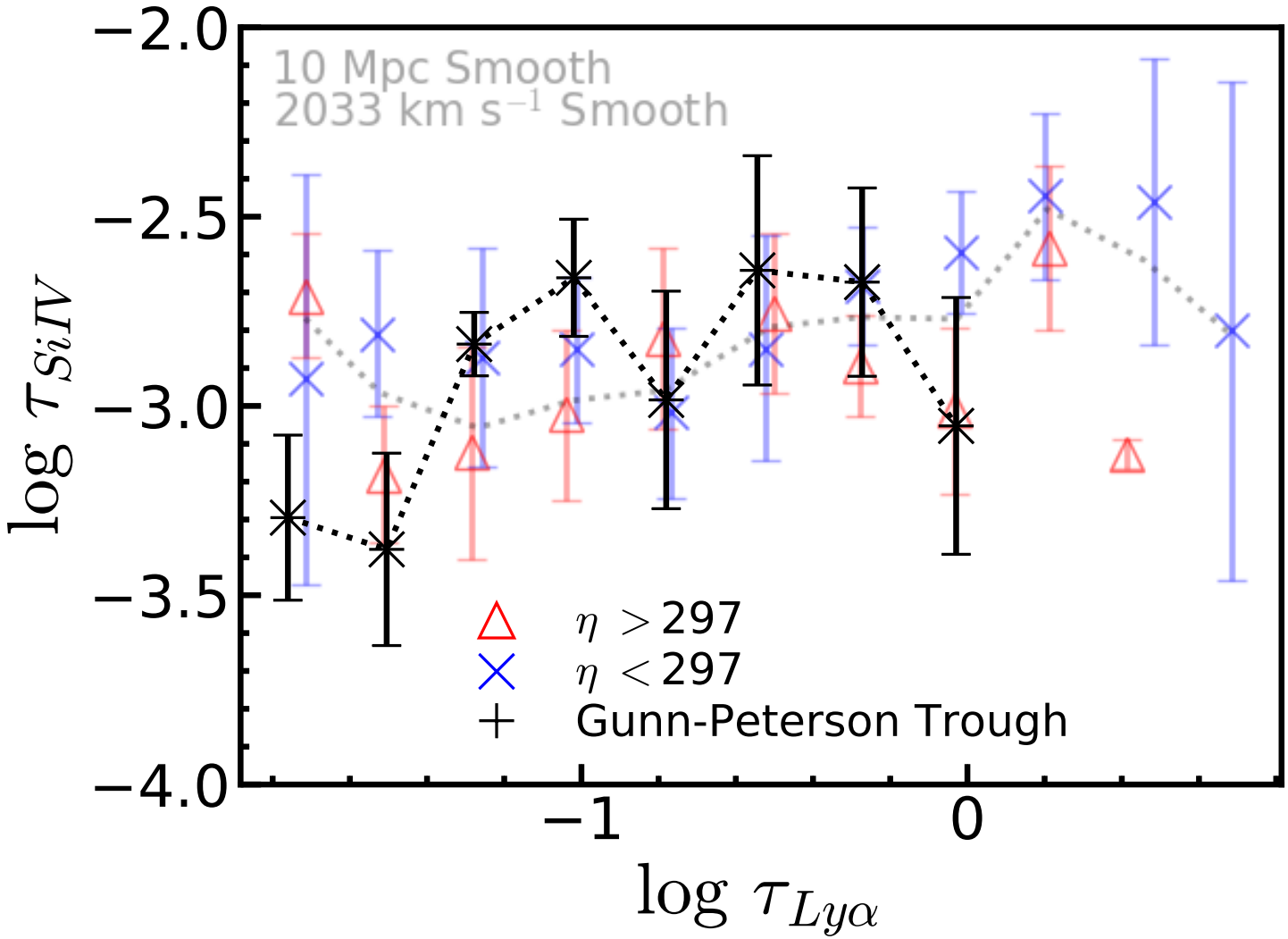
POD in the Gunn-Peterson Trough: O VI



POD in the Gunn-Peterson Trough: C IV

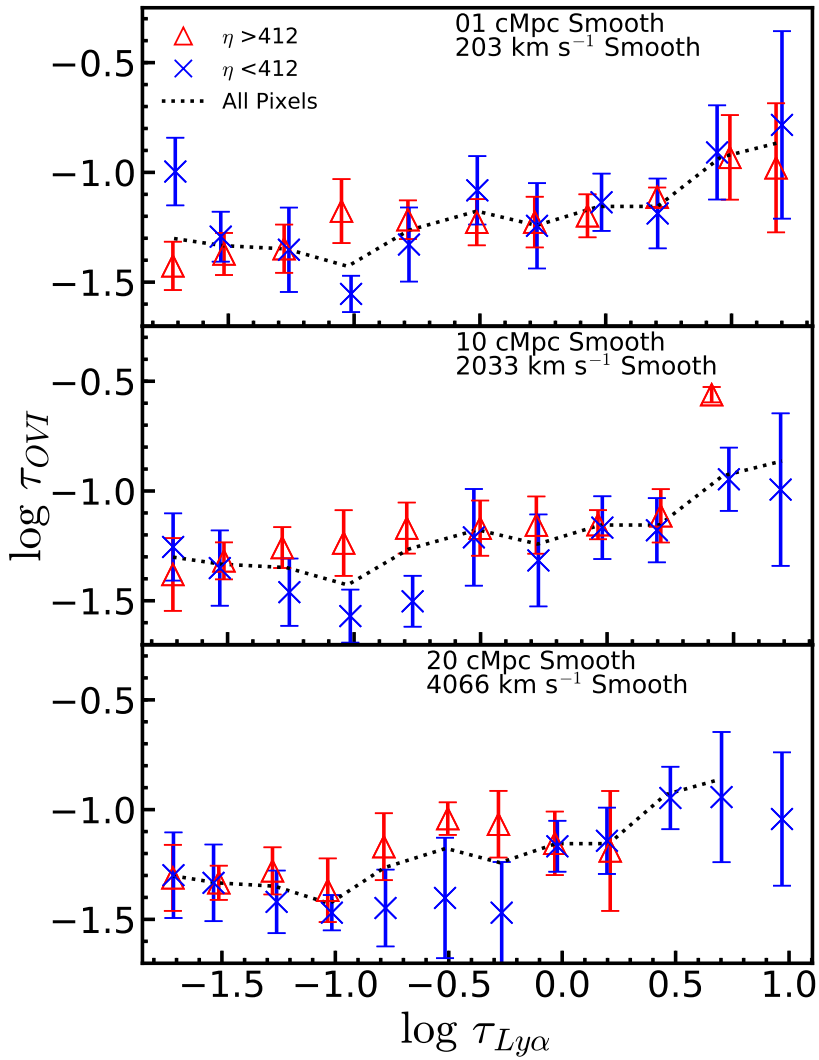


POD in the Gunn-Peterson Trough: Si IV

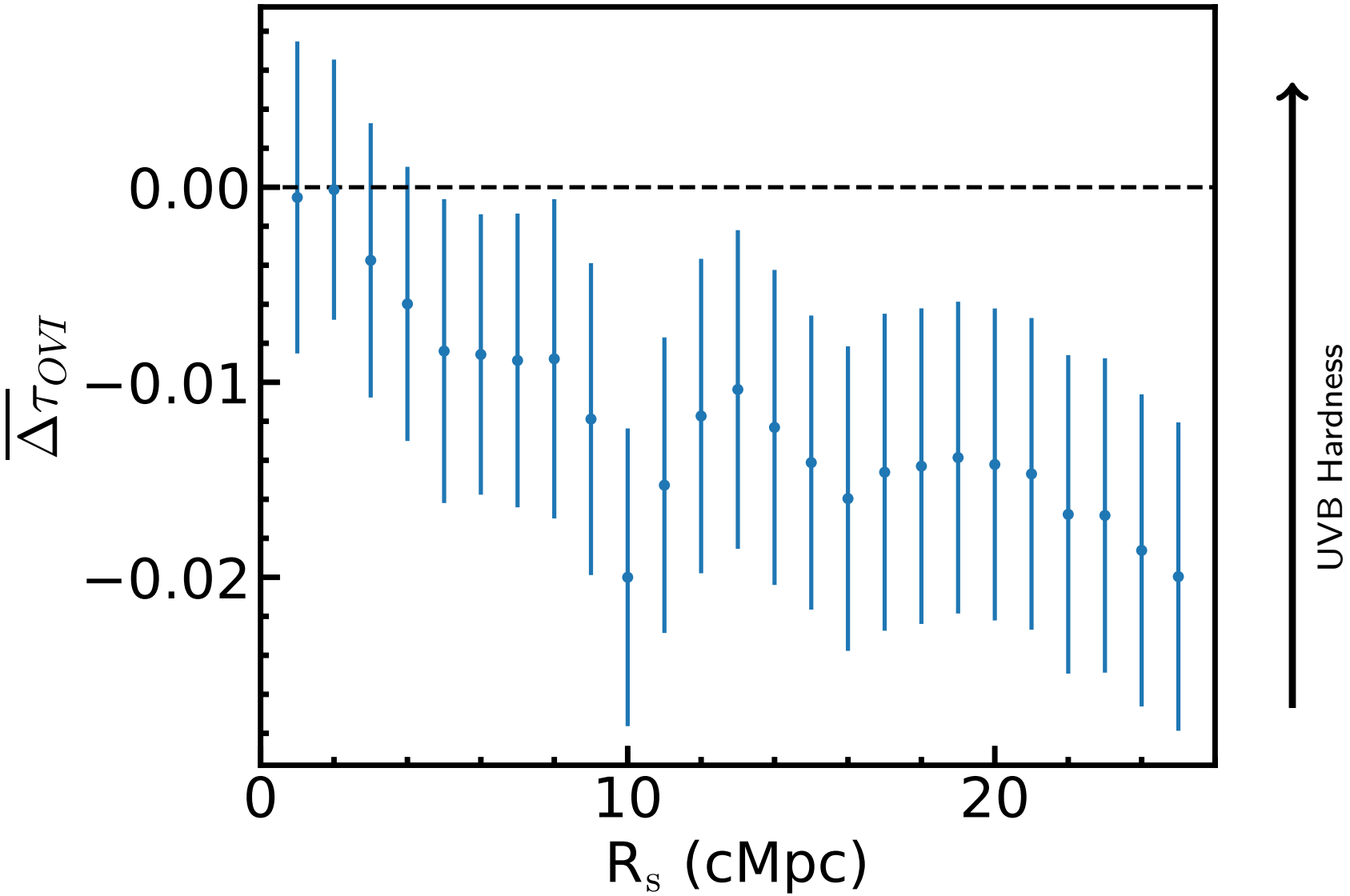


UVB Soft/Hard Split: Raw POD

Statistical measurement of O VI absorption cut by high/low η.



Soft/Hard Split as a Function of Scale: O VI



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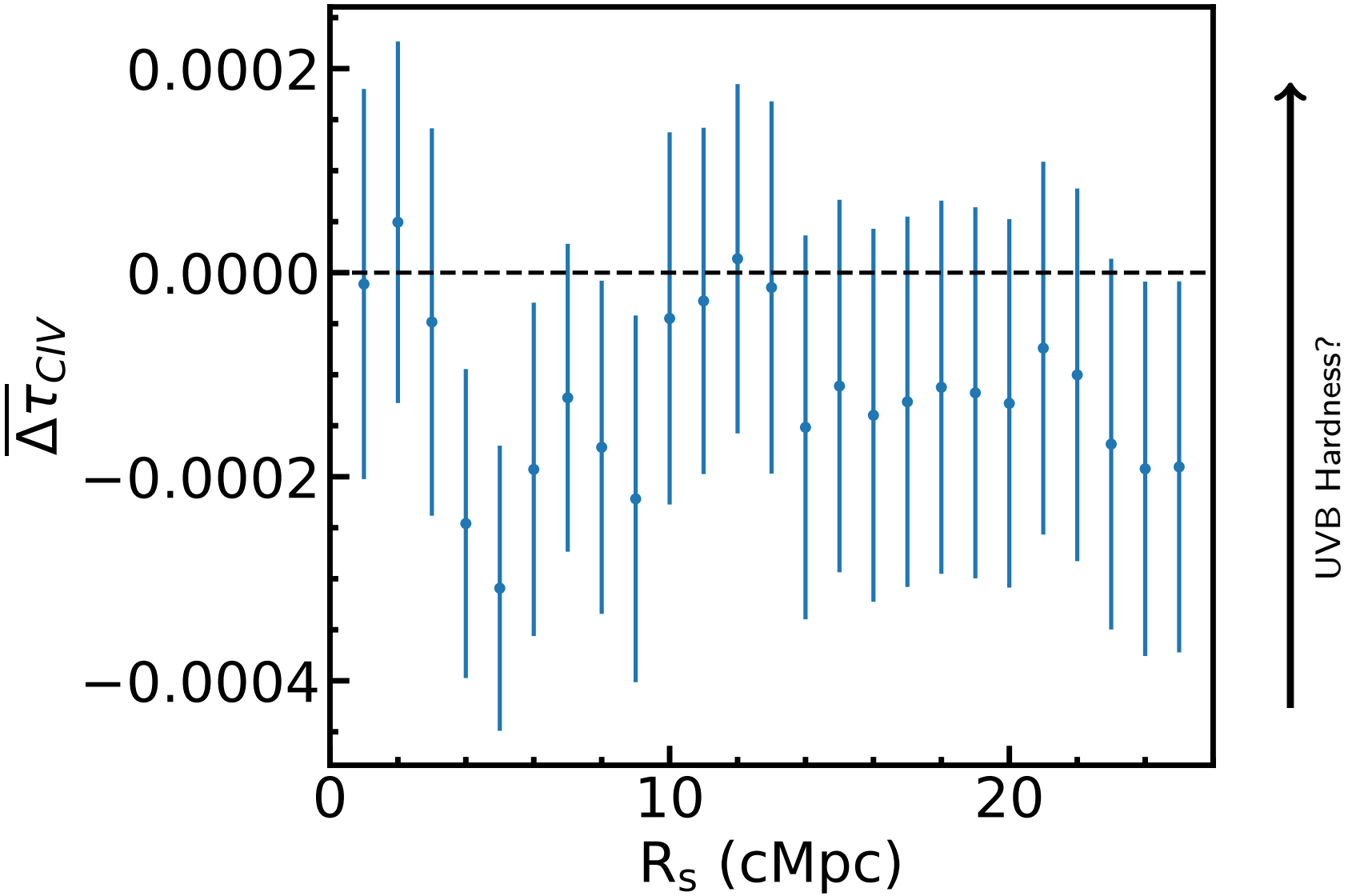

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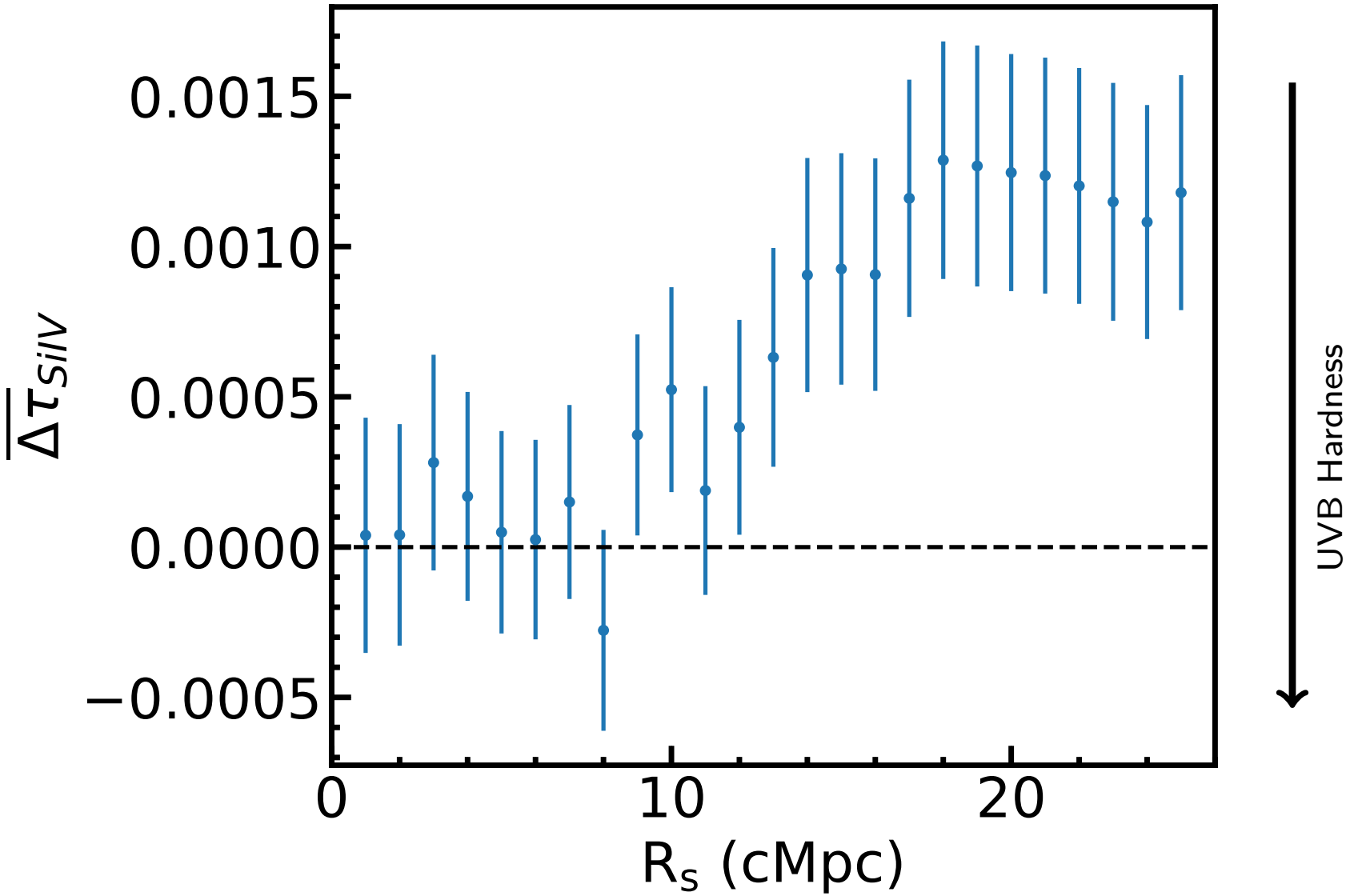
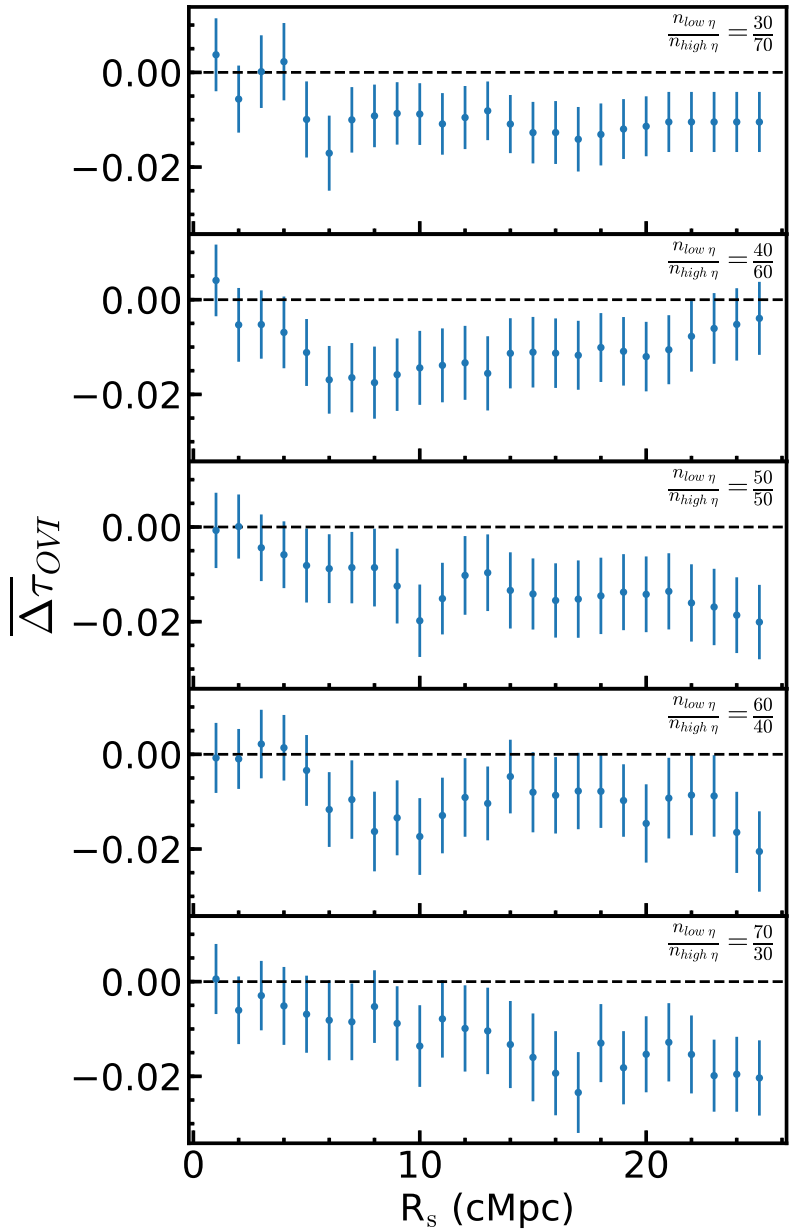


Variable Soft/Hard Splits in O VI



Summary

- Difference in Metal (O VI & C IV) Column Densities in and out of Gunn-Peterson Trough
- Seems to supports claim that η actually probes large scale effects rather than just noise (which has been source of controversy)
- (Potential) future work:
  - Comparison with simulations
  - Better S/N UV data for additional He II Quasars
  - Quasars positions in large surveys