Challenges in Interpreting Lyα Absorption at High-z

(impacts of an inhomogeneous UVB)

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Reionization is Patchy!

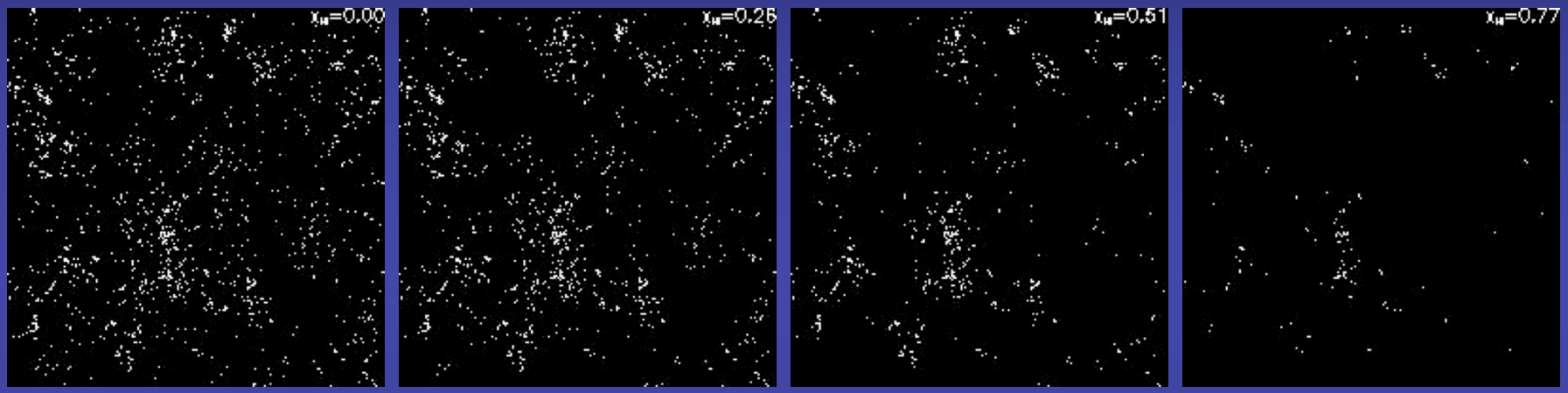
DexM public release available at http://www.astro.princeton.edu/~mesinger

QuickTime™ and a
mpeg4 decompressor
are needed to see this picture.

Patchy Reionization--> LAEs

Reionization modulates the observed LAE maps

$x_{HI} \sim 0$ $x_{HI} = 0.26$ $x_{HI} = 0.51$ $x_{HI} = 0.77$



Mesinger & Furlanetto 2008b

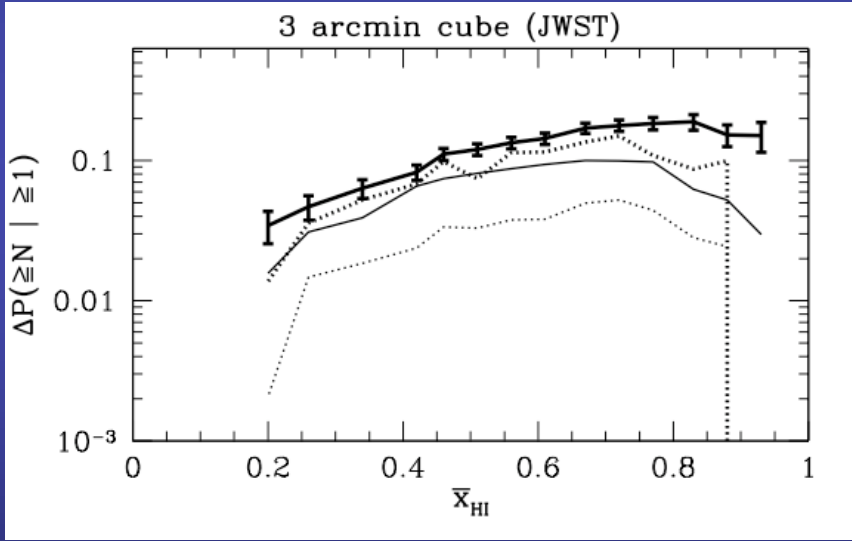
$M > 1.67 \times 10^{10}\ e^{-\tau}\ M_{SUN}$

Impacts:
-Luminosity function
-Clustering

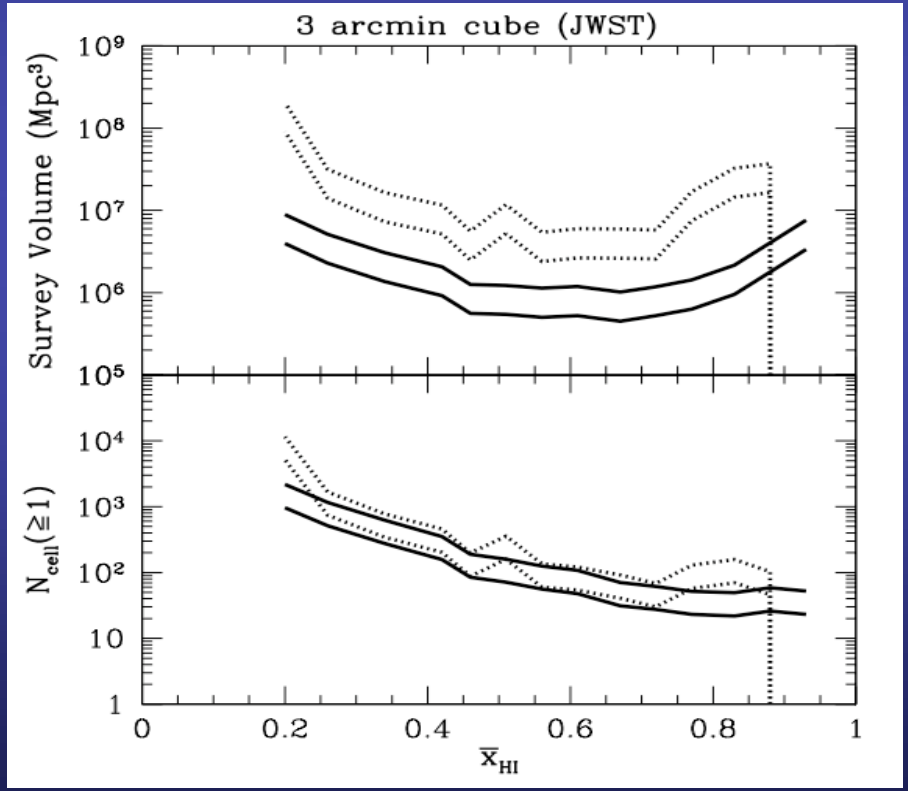
Tough to do since we don't know
M_{halo} <--> L

Counts-in-Cell Statistics

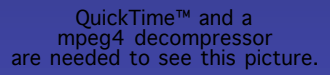
- Includes higher-order, non-Gaussian corrections to clustering, unlike the commonly studied power spectrum (e.g. McQuinn et al. 2007; Iliev et al. 2008)
- Not very model dependent; reionization signal is separable from the evolution in structure, especially in higher-order (see Mesinger & Furlanetto 2008b for details)
- Few constraints on survey geometry; useful for follow-up



Reionization detectable with < 100 fields



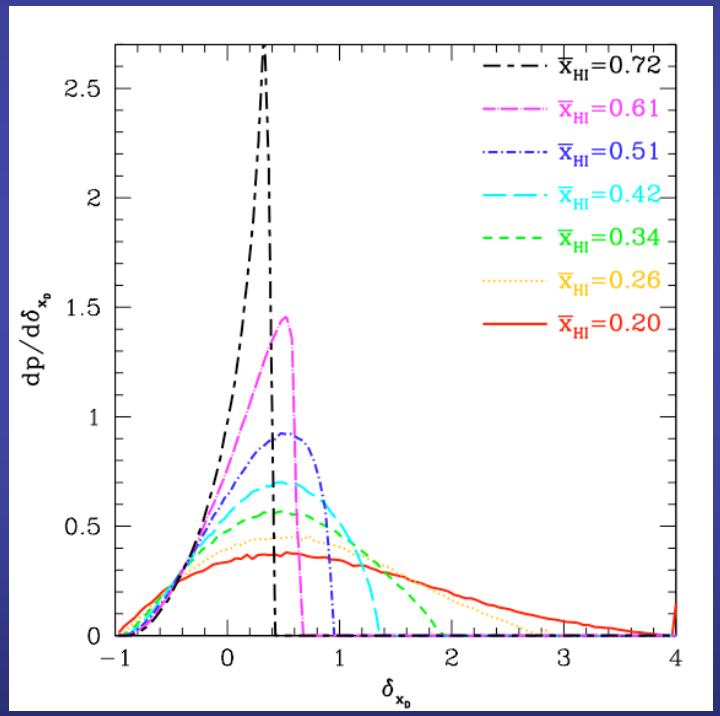
Patchy Reionization --> Lyα Damping Wing



- How dangerous is it to assume a homogeneous x_{HI} or J_{UV} in damping wing studies:
  - QSOs proximity region (Mesinger & Haiman 2004; 2007)
  - GRB after disentangling DLA (Totani et al. 2006)

Bias

- Common reasoning: absorption cross-section is flat in the wings and so is sensitive to a large path length in the IGM, so ionization structure is averaged-over
- Not flat enough! -> bias + scatter



$x_D/x_{HI} - 1$

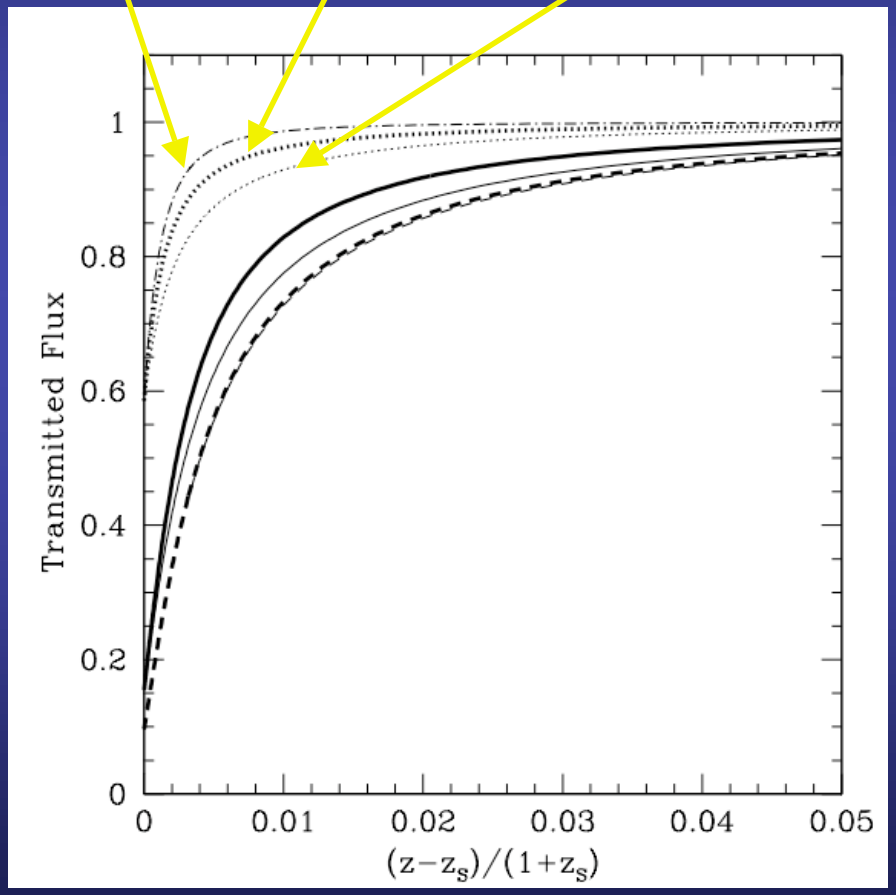
- *constrain x_{HI} with scatter? Noise --> Signal*

- *bias and scatter are reduced if one probes subset (e.g. Rs>40)*

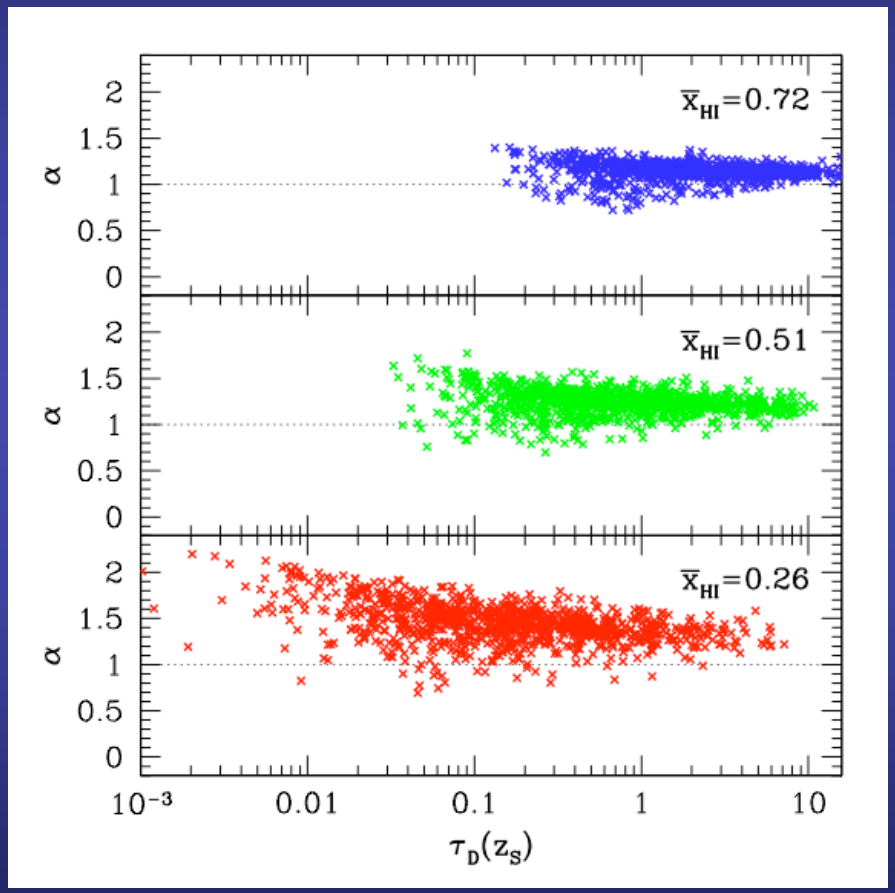
Absorption Profile

$x_{HI}=0.1$

DLA patchy homogeneous



$\tau_D(z) \propto R_{b1}^{-\alpha}$



$\tau_D(z)$

Impact on Present Damping Wing Studies

- Not clear, however profile is more important than bias: steeper profile -> harder detection

  --> weakens upper limit from Totani et al. 2006

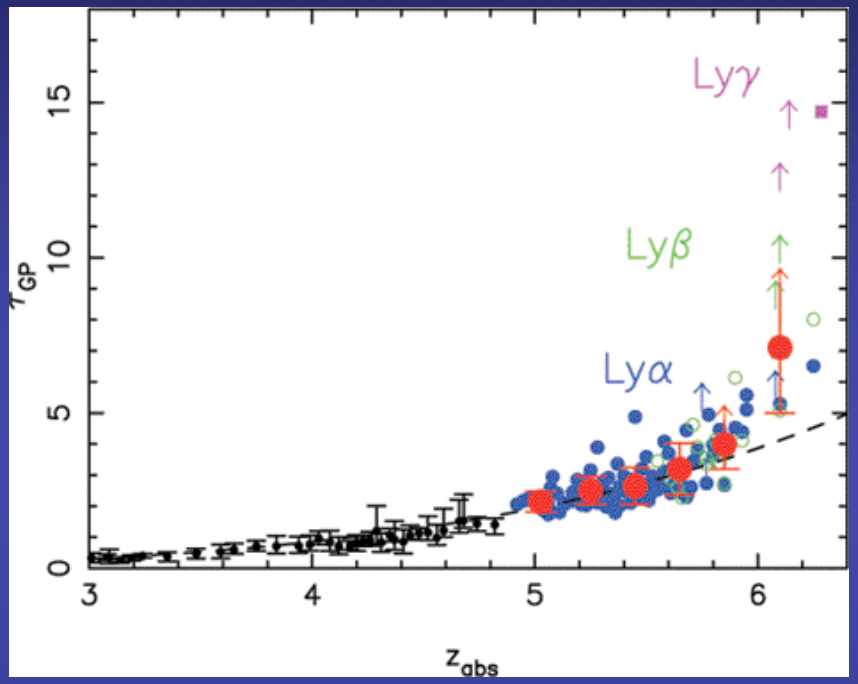
  --> strengthens lower limits from Mesinger & Haiman 2004, 2007

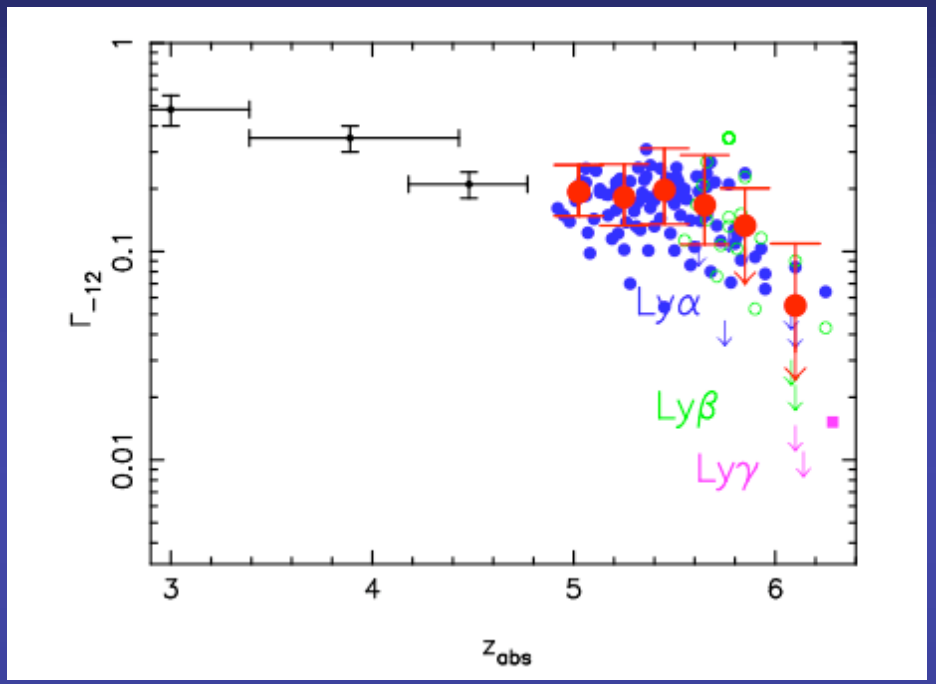
- Scatter likely causes confidence contours to degrade for all studies

- Should be redone! More sources would be nice

Are we witnessing the end of patchiness?

Fan+ (2006)

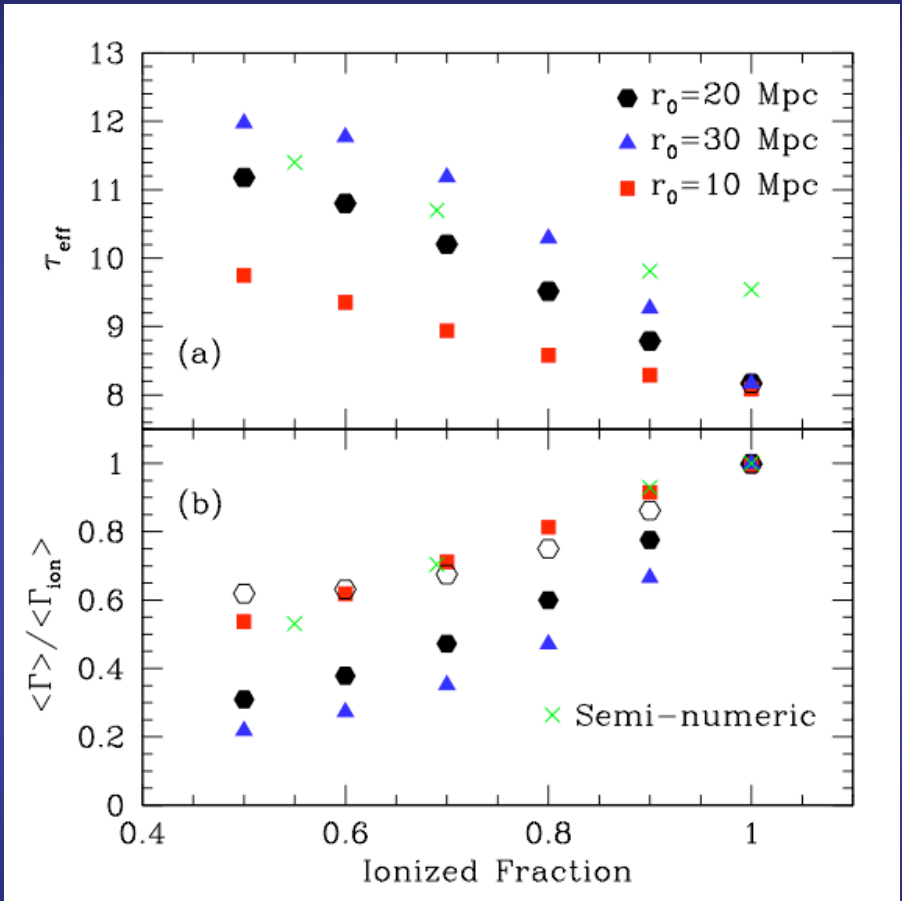




Note empirical objection by Becker+ (2007)

Overlap does NOT directly result in a sharp UVB increase!

Furlanetto & Mesinger (2009)

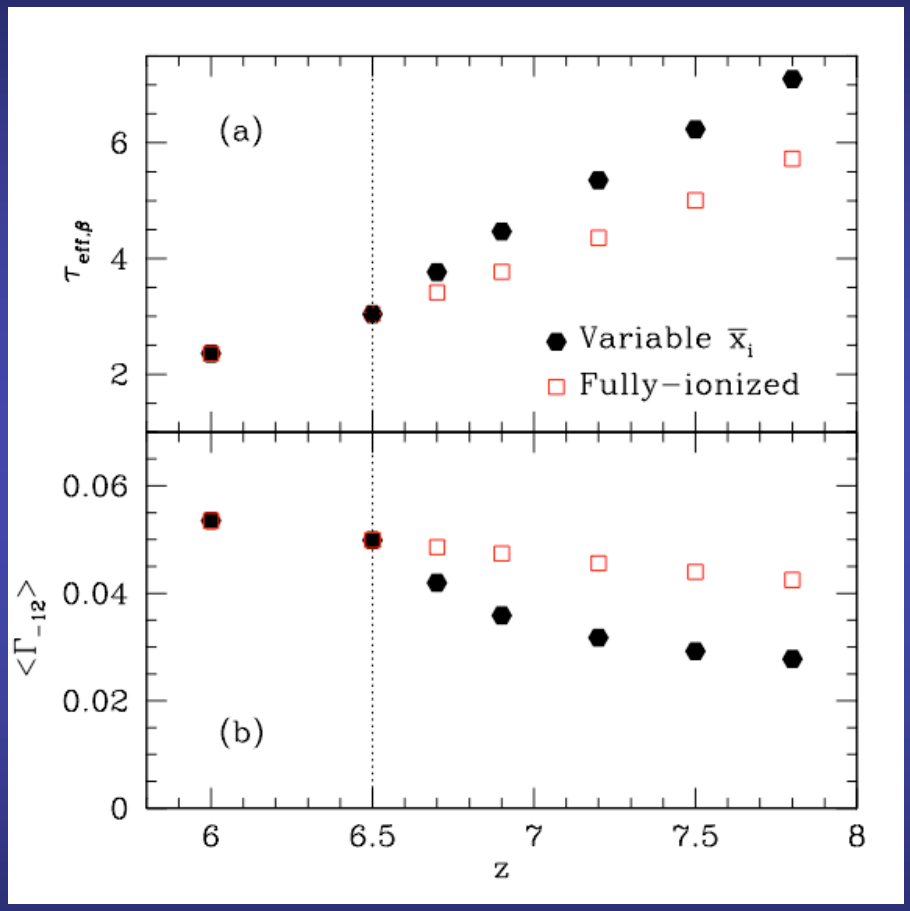


- mfp is fairly modest at these redshifts --> absorption systems regulate the UVB evolution late in reionization

constant z and mfp

Overlap does NOT directly result in a sharp UVB increase!

Furlanetto & Mesinger (2009)



simple model of x_{HI} and mfp evolution

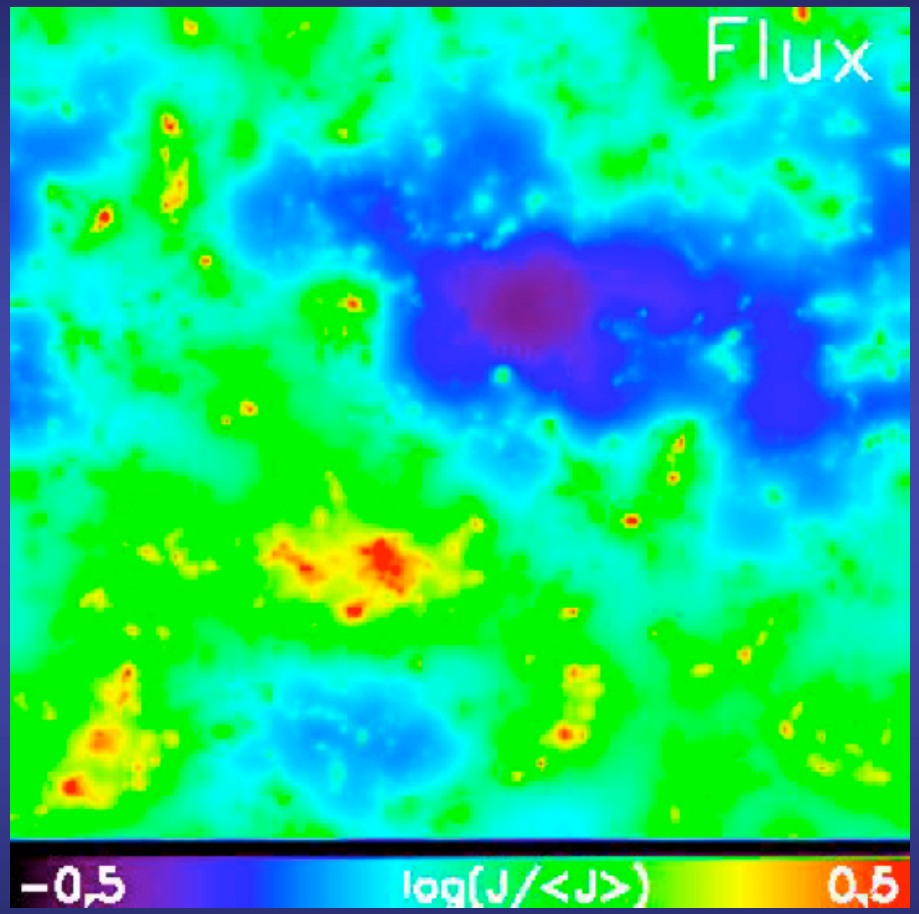
- mfp is fairly modest at these redshifts --> absorption systems regulate the UVB evolution late in reionization
- UVB increases as absorption systems are either photoevaporated or new sources appear in neutral regions --> hard to get sharp rise in UVB

Patchiness even after reionization!

- "modest" mfp at z~5--6
  + clustering of sources
  + $1/r^2$ flux
  = spatial fluctuations in UVB

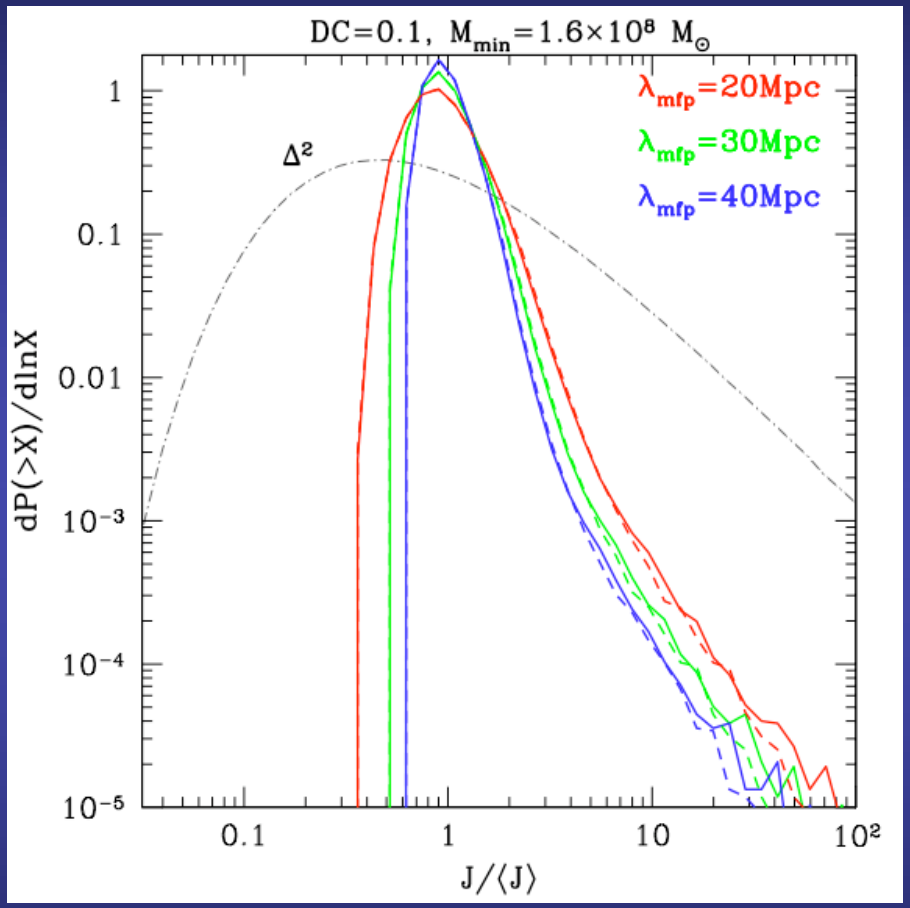
(see also sec. 5 in Bolton & Haehnelt 2007)

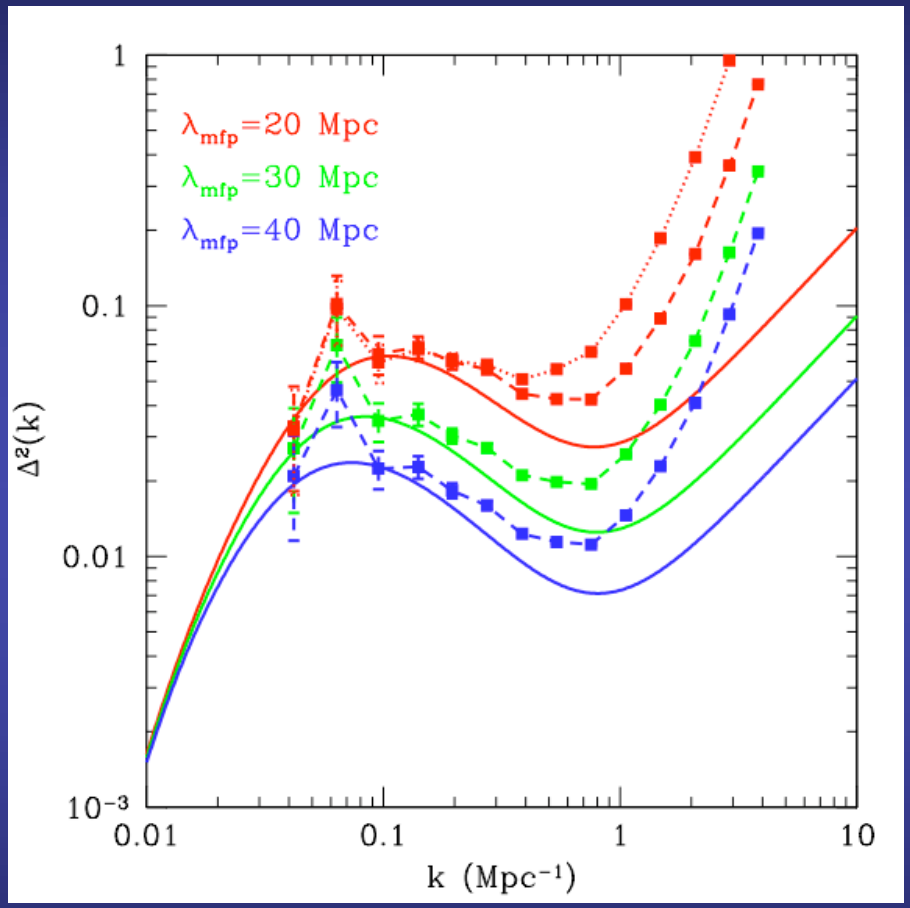
Mesinger & Furlanetto (2009)



SFR taken from Trac+ (2008) z=5.71 output

Inhomogeneous UVB at z~ 5--6



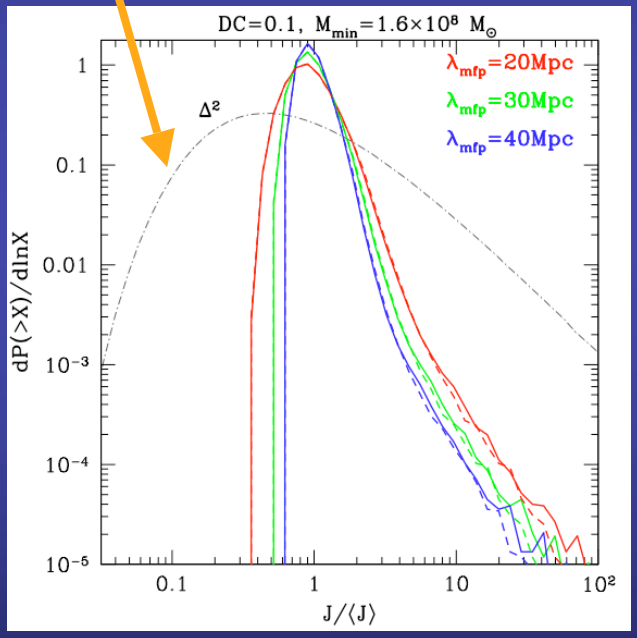


Mesinger & Furlanetto (2009)

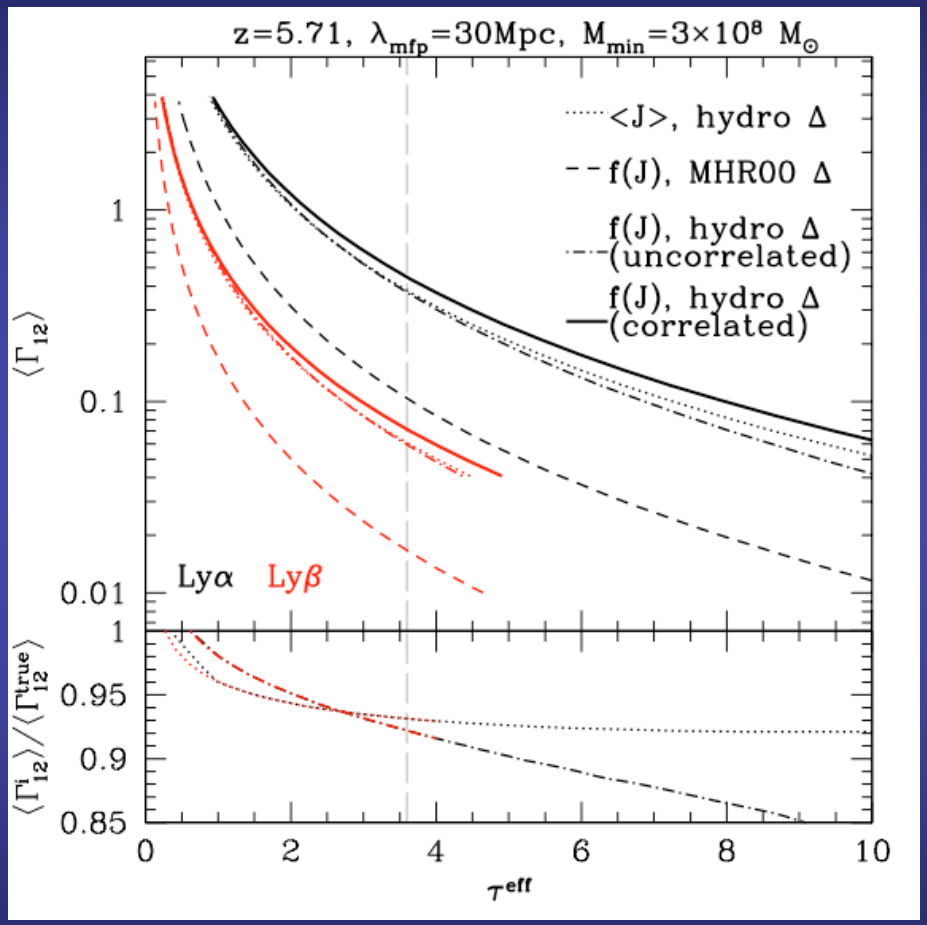
Not important for Lyα forest

- Δ^2 distribution is even wider and dominates

  $\tau \sim \Delta^2/\Gamma$



not real mock spectra, but…



SFR and density taken from Trac+ (2008)