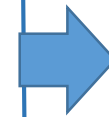
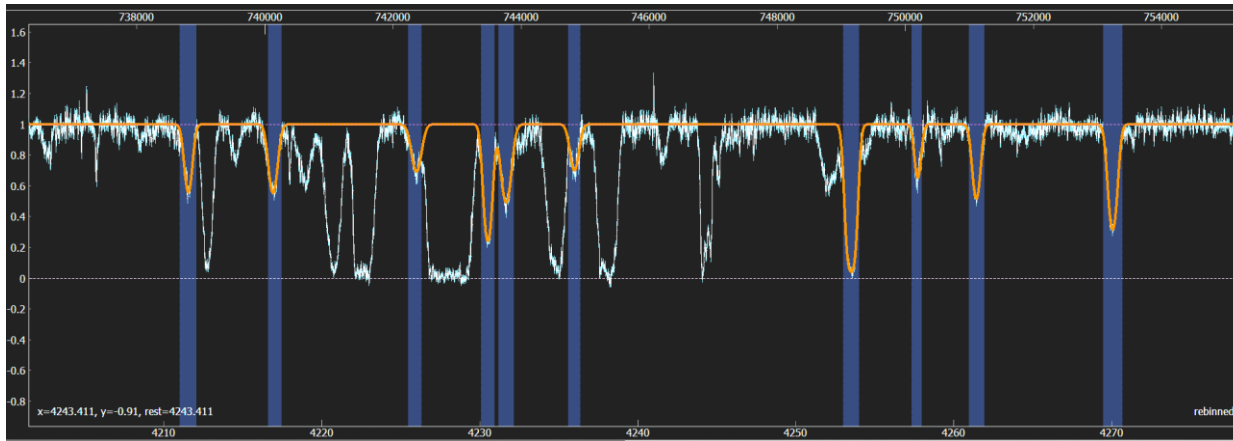


- Effective equation of state of the IGM after reionization

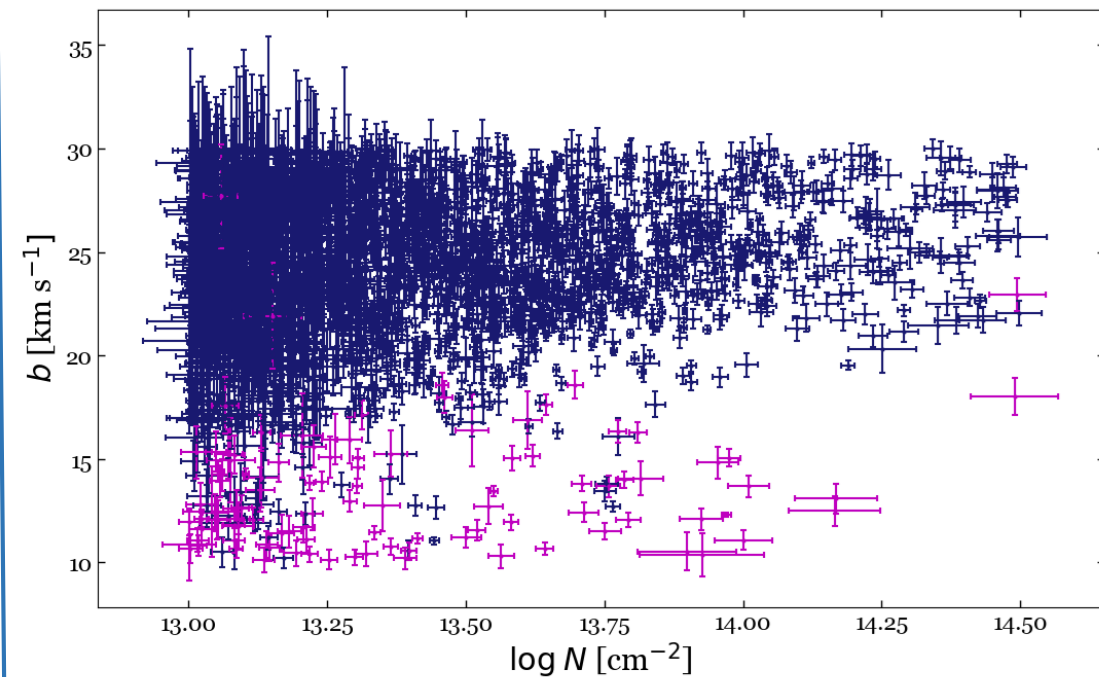
$$T = T_0 \left( \frac{\rho}{\bar{\rho}} \right)^{\gamma-1}$$

*Hui, L., Gnedin, N. Y., 1997, MNRAS, 292, 27*

- Automatic program for Ly $\alpha$  forest analysis



- 50 QSO spectra
- QSOs redshifts  $z \sim 2 - 4$
- Metal line rejection
- 2268 lines

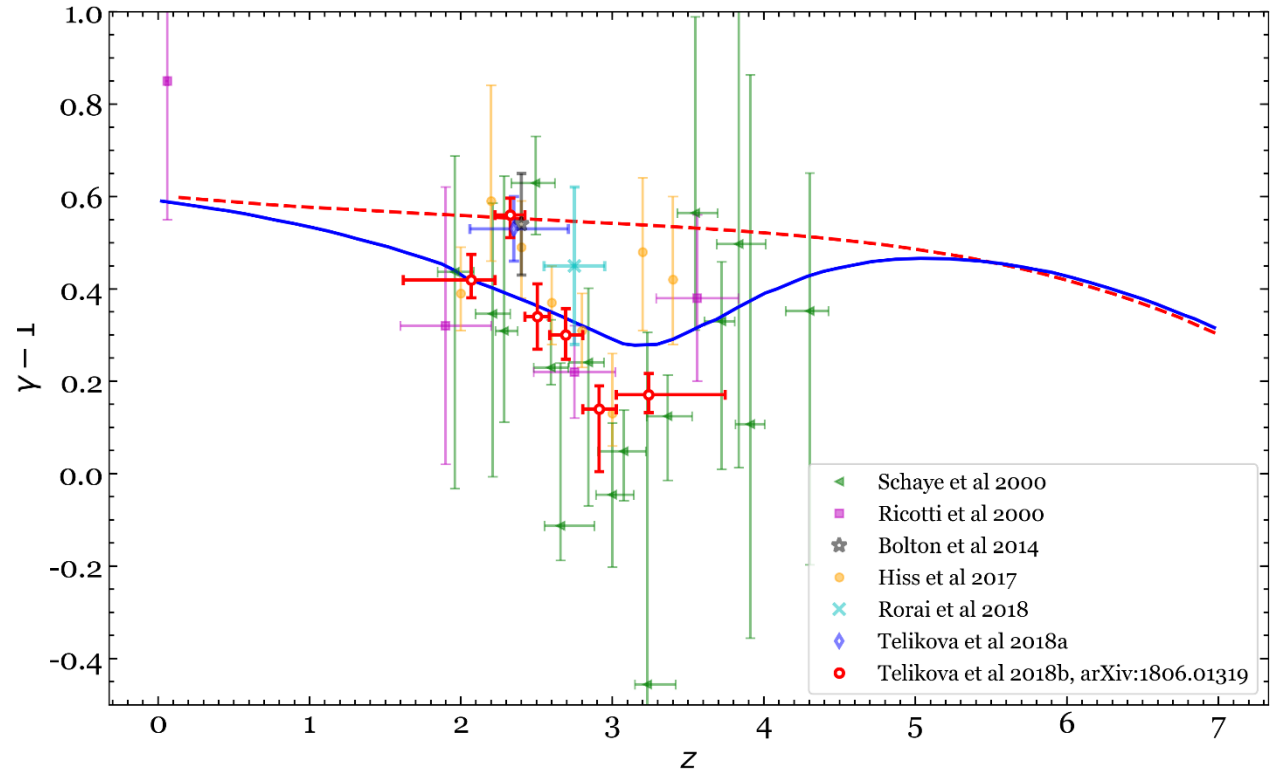
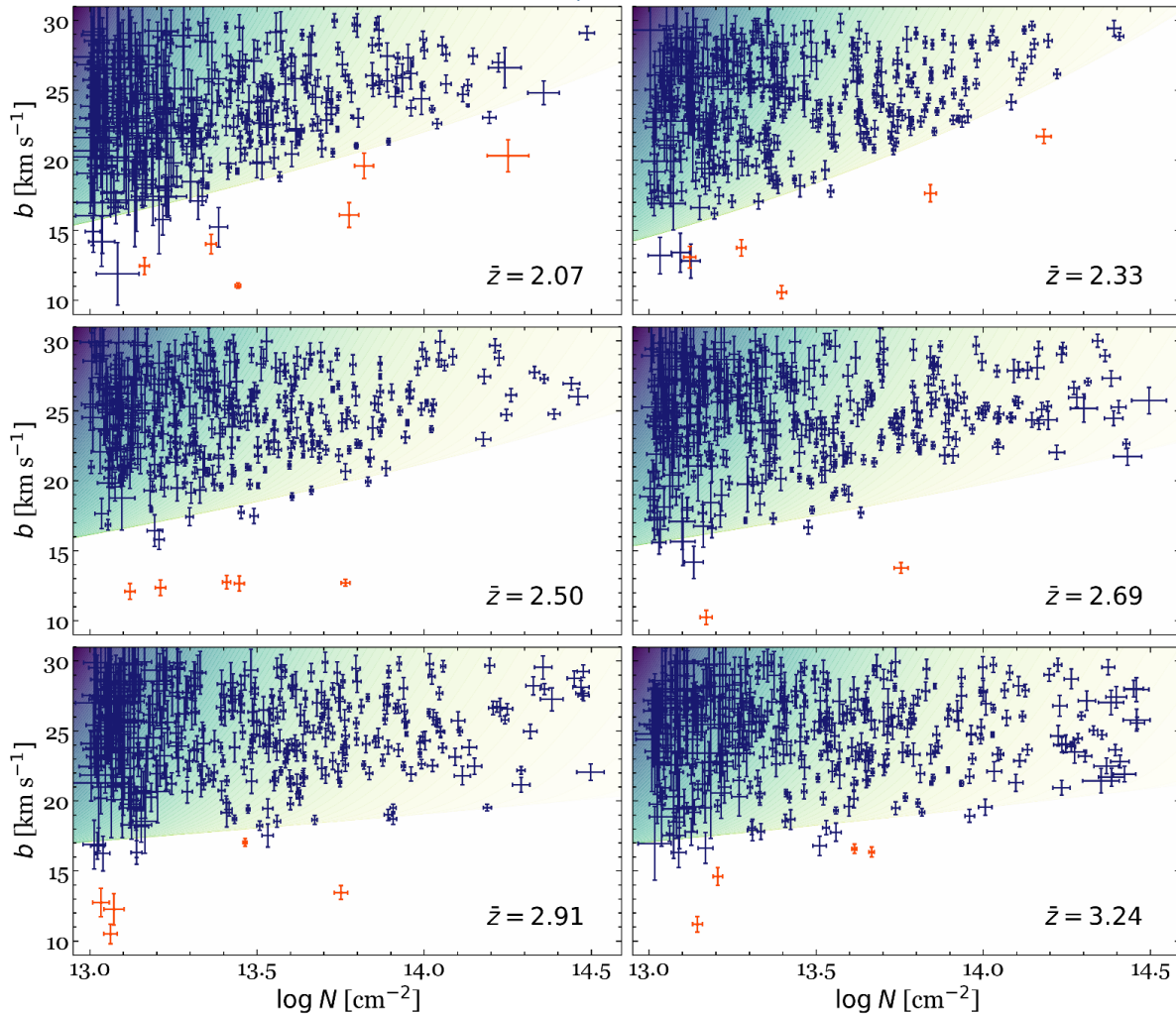


# Results: MLE analysis of the full distribution with account for outliers

$$L = \prod_i [(1 - P_{out})L_{data}(N_i, b_i) + P_{out}L_{out}(N_i, b_i)]$$

+ MCMC sampler

*Hogg D. W., Bovy J., Lang D, 2010*



*Upton Sanderbeck, P. R., D'Aloisio, A., McQuinn, M. J., 2016, MNRAS, 460, 1885*

— Model with HeII reionization  
 - - - Model w/o HeII reionization

- We confirm the dip at  $z \sim 3$  (possibly HeII ionization)