Argelander-Institut für Astronomie

SFB 956

universitätbonn
Rheinische Friedrich-Wilhelms-Universität Bonn

The imprint of inhomogeneous HeII reionization on the HI and HeII Lyα forest

(arXiv:1306.5745)

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Intergalactic Interactions: A Higgs Centre Workshop on the Intergalactic Medium
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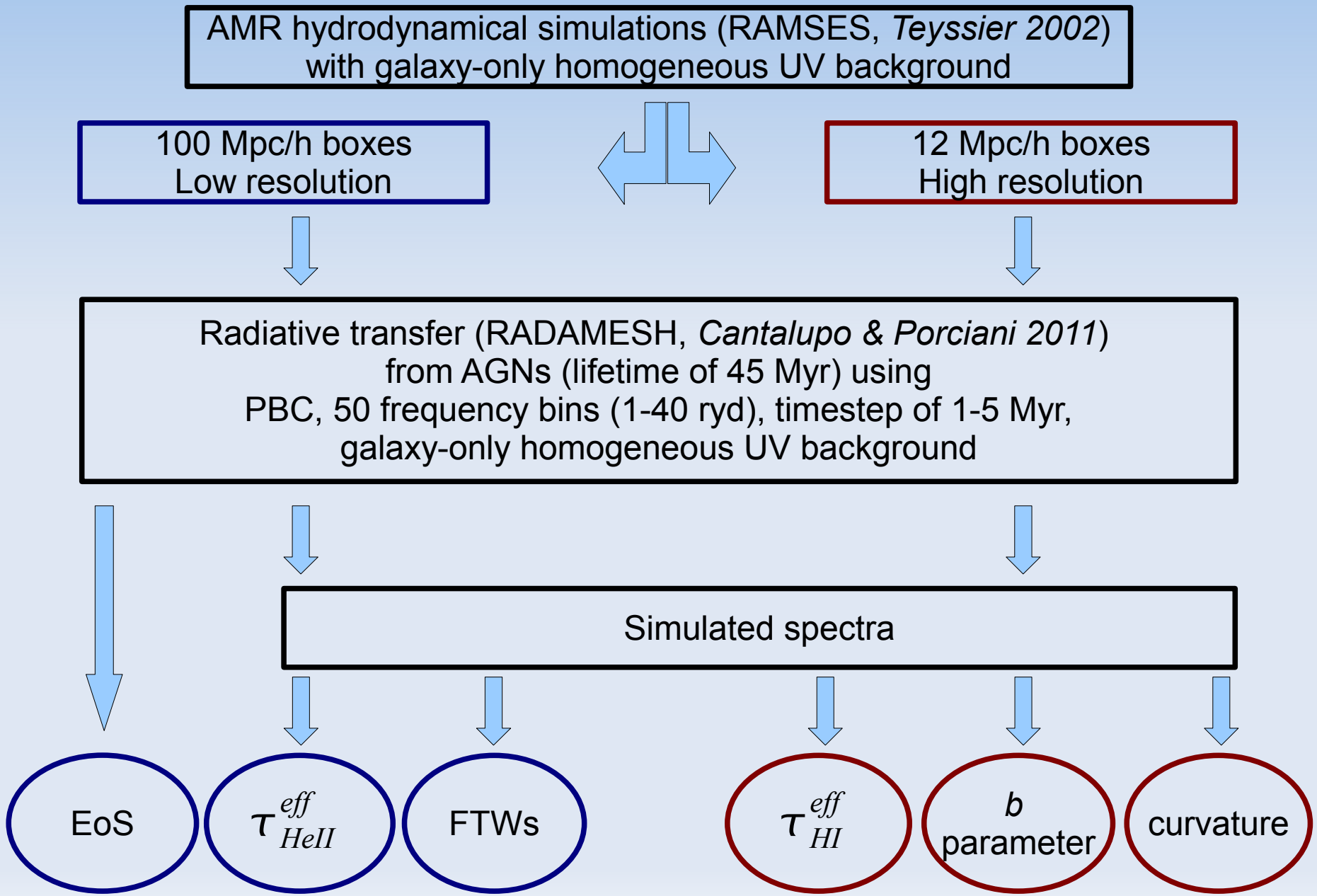
Outline

- **Numerical Methods:**
  - Hydrodynamical simulations
  - Calibration of the sources
  - Radiative Transfer
- **Global ionization history:**
  - Bimodal distribution of the temperature
- **Observational implications:**
  - Combining datasets with different ionization history

Methods


AMR hydrodynamical simulations (RAMSES, *Teyssier 2002*) with galaxy-only homogeneous UV background
100 Mpc/h boxes Low resolution
12 Mpc/h boxes High resolution
Radiative transfer (RADAMESH, *Cantalupo & Porciani 2011*) from AGNs (lifetime of 45 Myr) using PBC, 50 frequency bins (1-40 ryd), timestep of 1-5 Myr, galaxy-only homogeneous UV background
Simulated spectra
EoS
τ^{eff}_{HeII}
FTWs
τ^{eff}_{HI}
b parameter
curvature

Calibration of the sources of UV radiation

- DM halo

  $M_{1450} = f(M_{DM})$

  AGN

- SED:

$$L_\nu \begin{cases} \nu^{\alpha_1} & \lambda \geq 1300\ \text{Å} \\ \nu^{\alpha_2} & \lambda < 1300\ \text{Å} \end{cases}$$

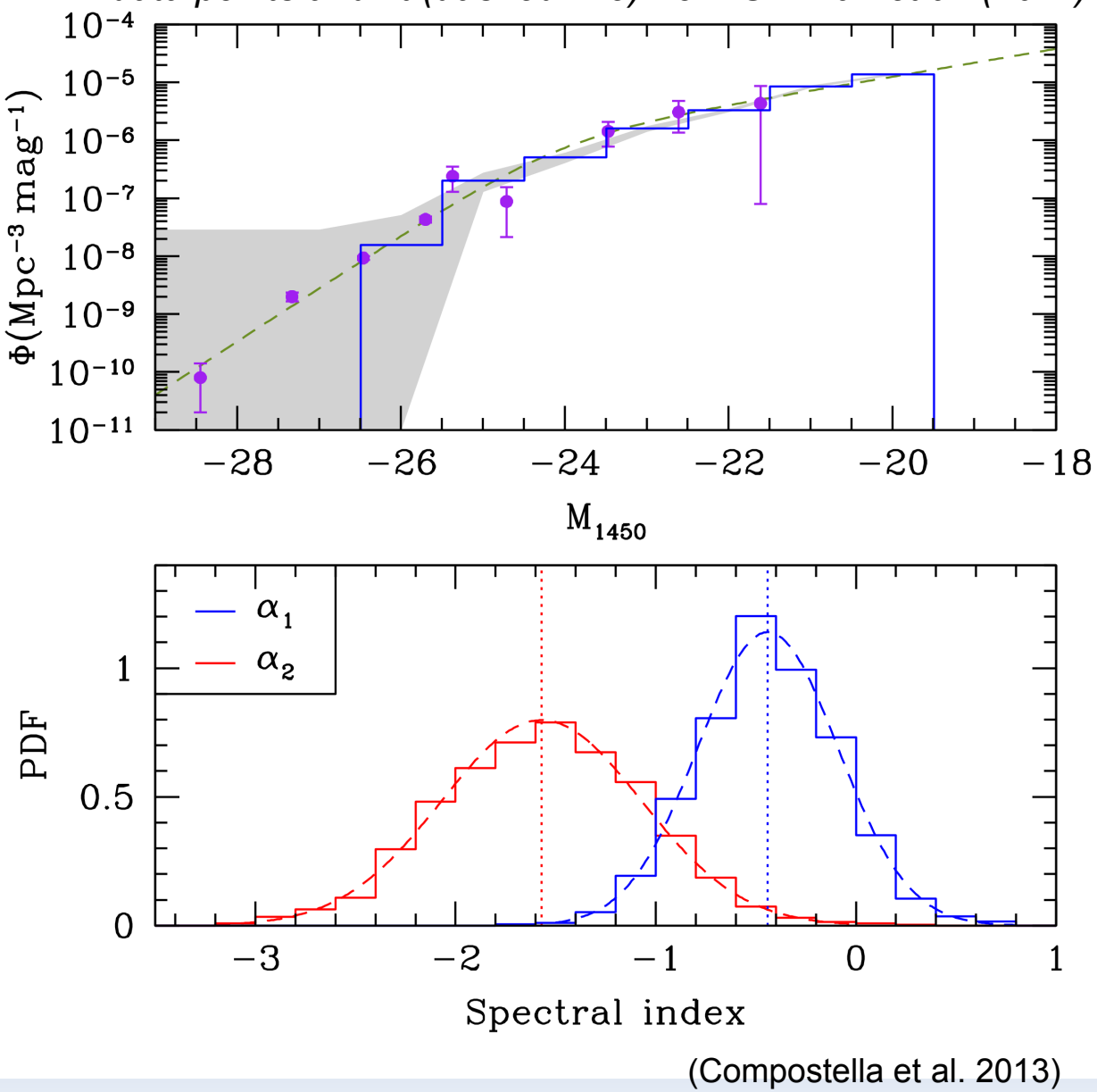
- LF evolution:

Pure Luminosity Evolution (PLE)

or

Pure Density Evolution (PDE)

data points and fit (dashed line) from Glikman et al. (2011)



(Compostella et al. 2013)

Global Ionization History

Reionization histories

- Large volumes

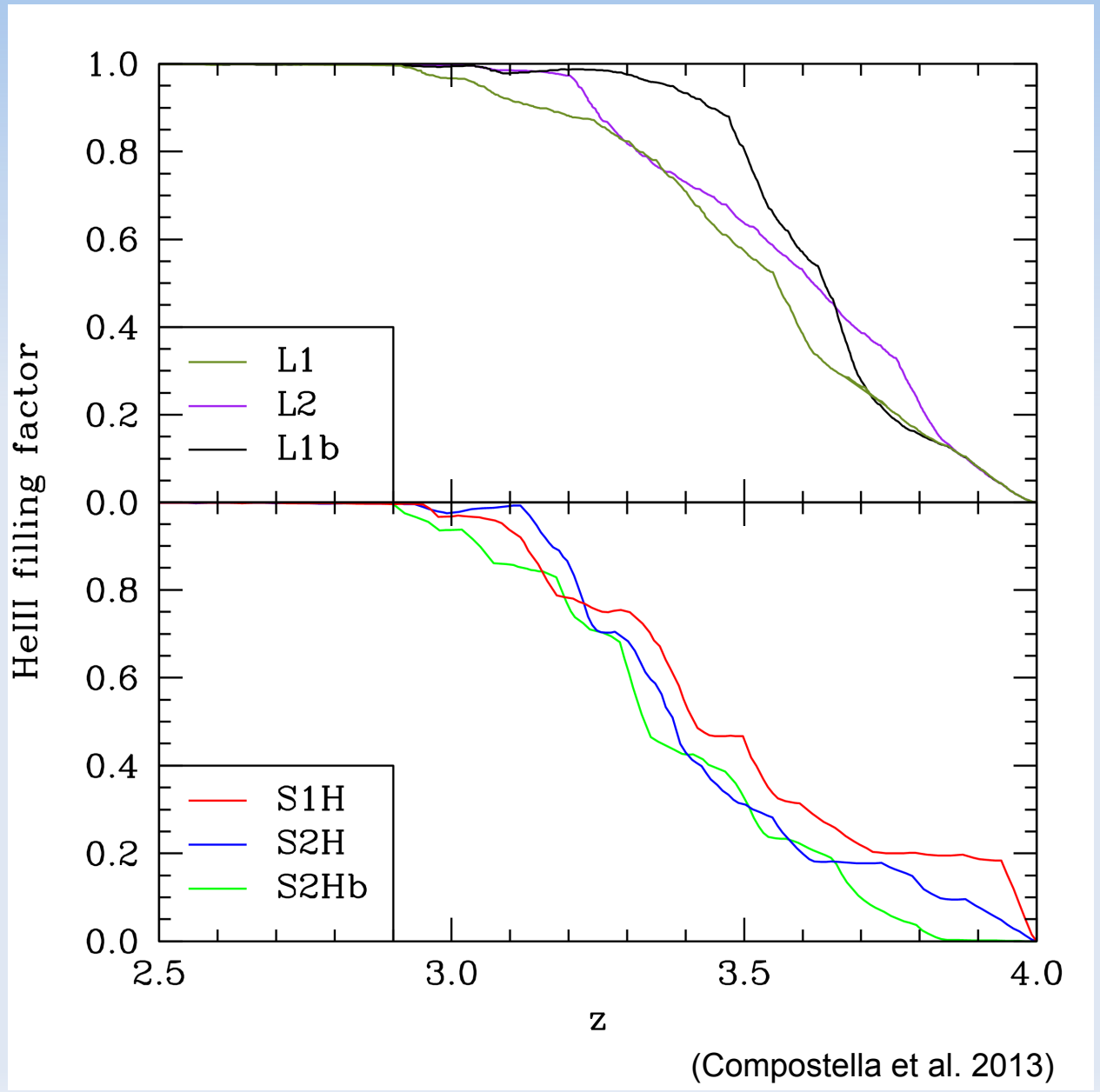
  L1, L1b: PLE model

  L2 : PDE model

- Small volumes

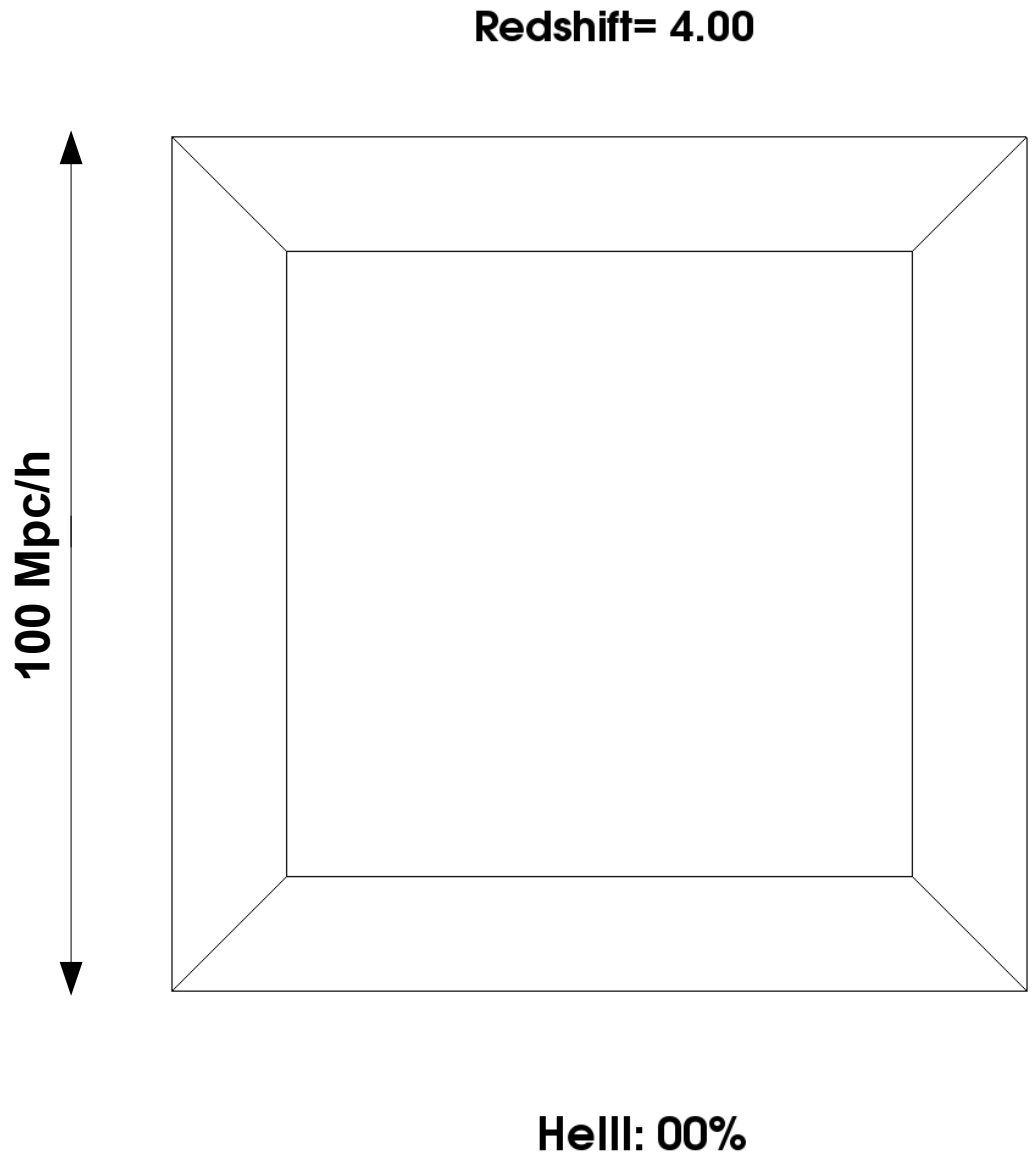
  PLE model for all simulations

  (S1, S2, S2b)

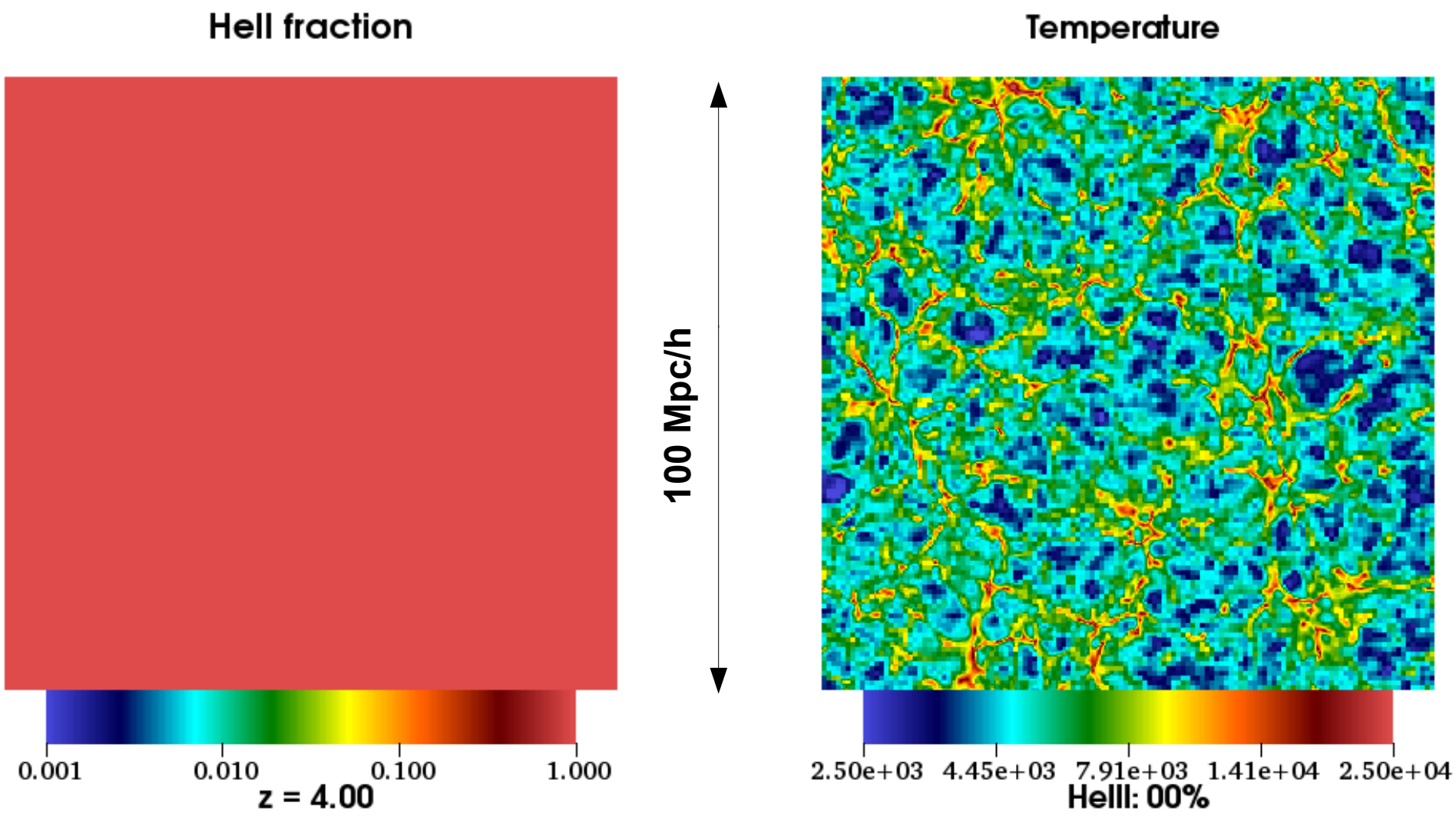


(Compostella et al. 2013)

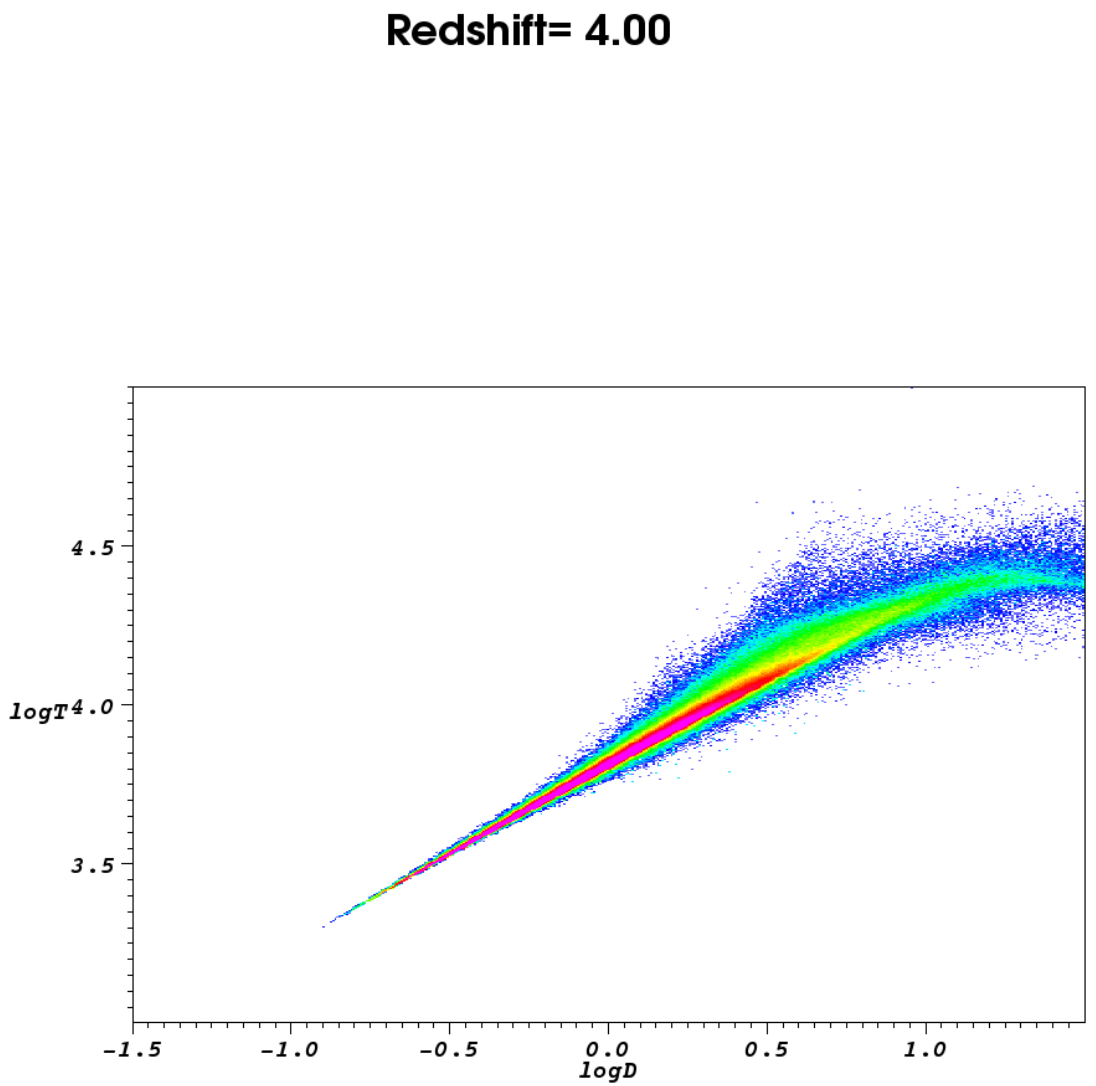
Reionization history



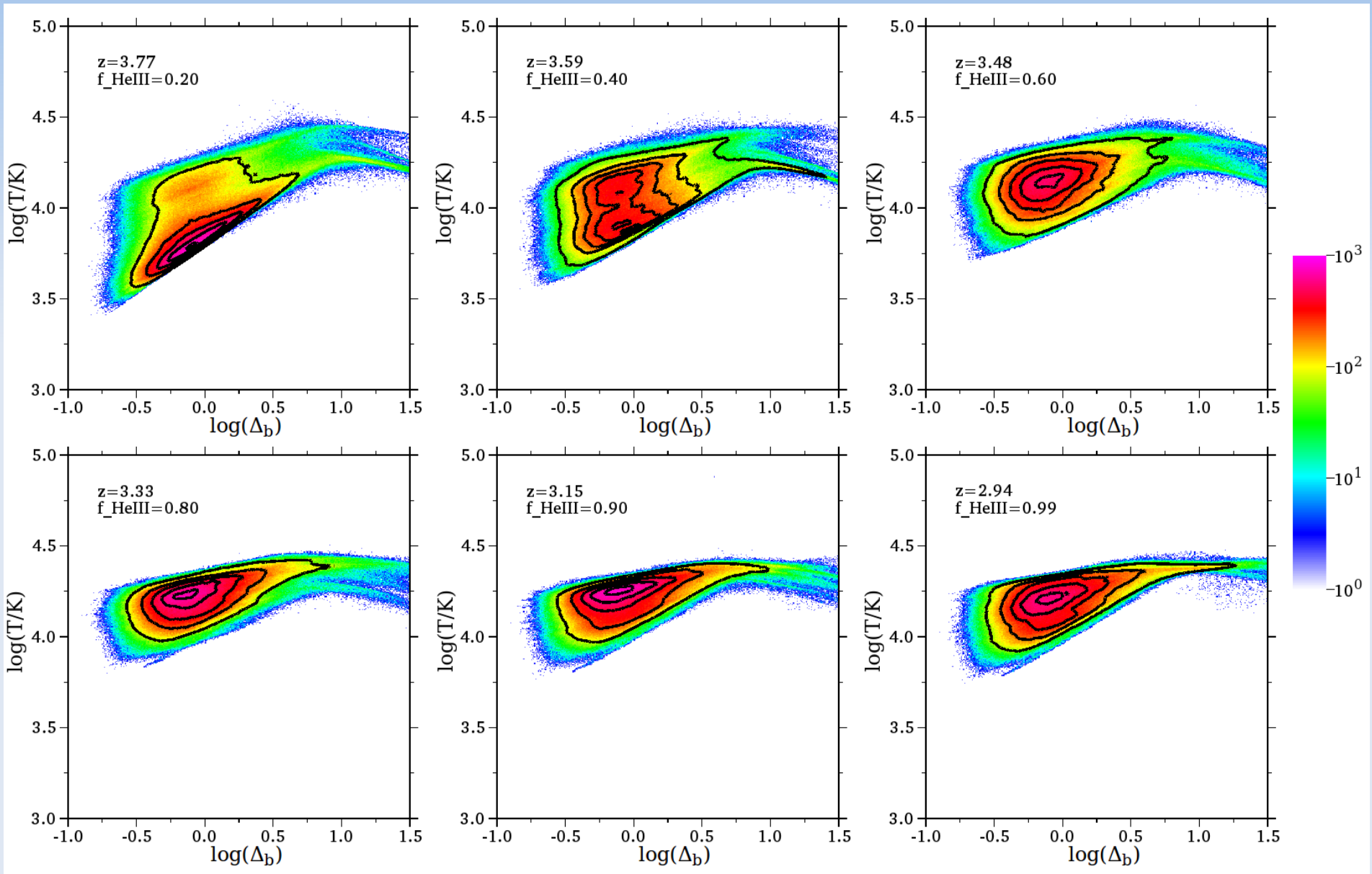
Reionization history



Bimodal equation of state

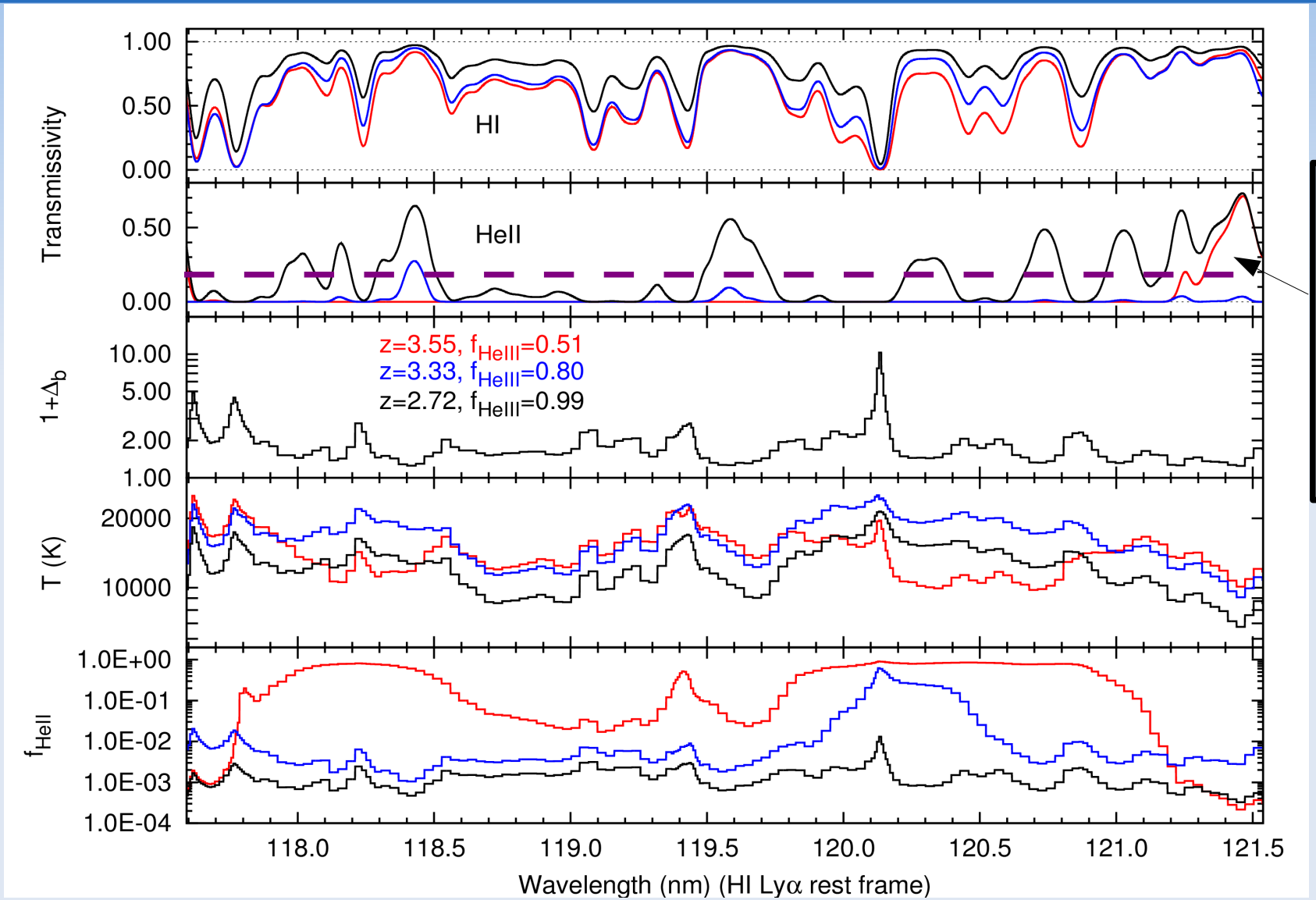


In case you missed it



Contour levels: 10, 30, 50, 70, 90%

Simulated spectra



b_1= 4.7 Mpc/h
M_{1450}= -22.4

4.2 Mpc/h

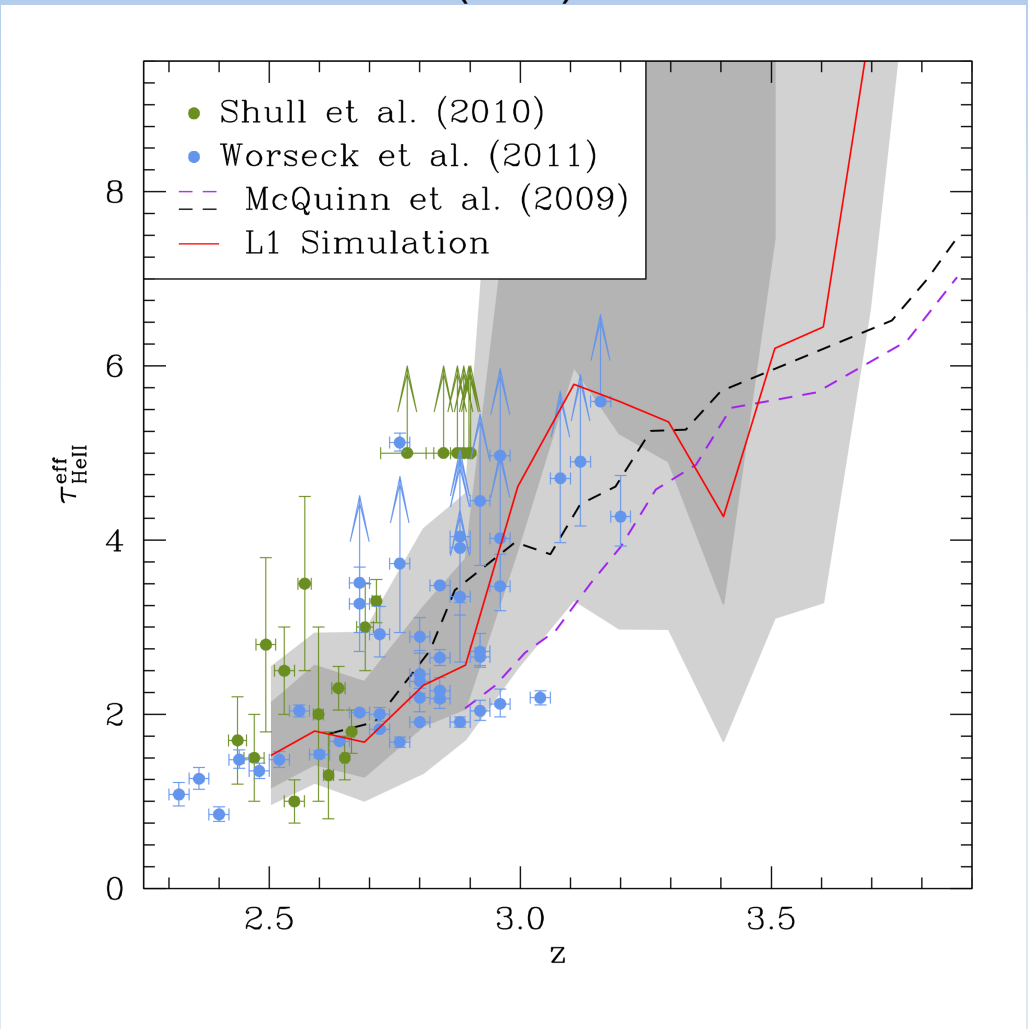
b_2= 7.2 Mpc/h
M_{1450}= -22.9

(Compostella et al. 2013)

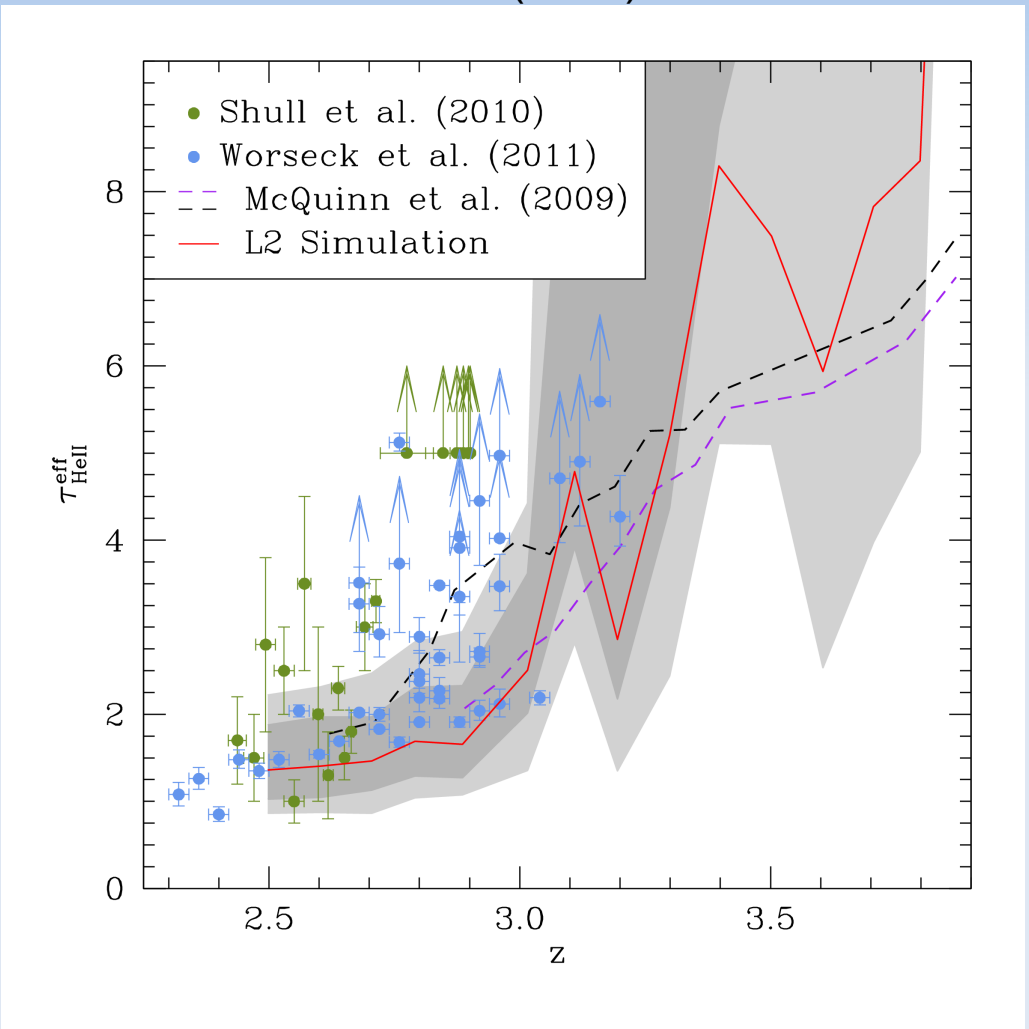
HeII effective optical depth

(Compostella et al. 2013)

L1 (PLE)



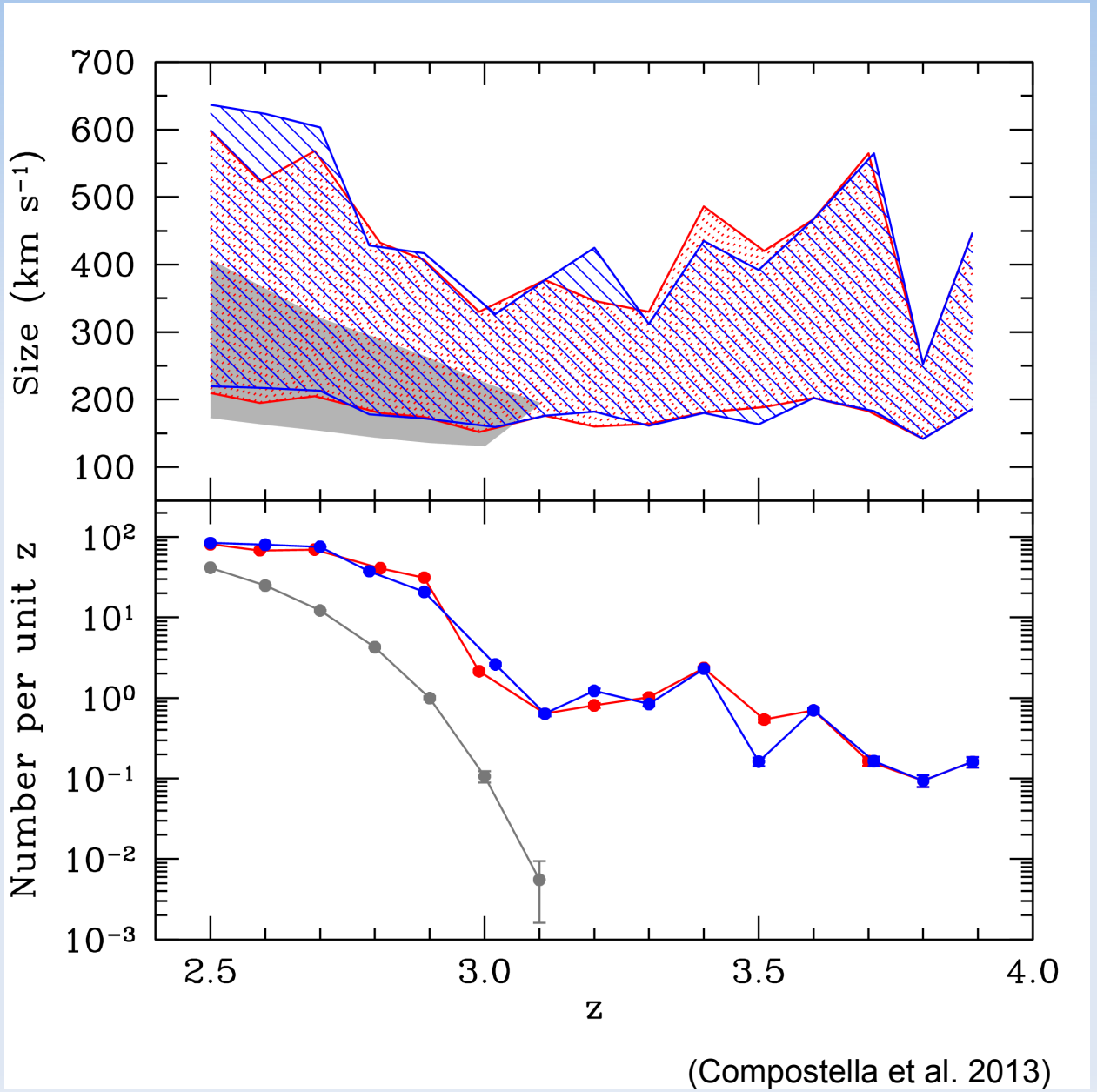
L2 (PDE)



100 spectra, $\Delta z = 0.04$

Flux-transmission windows

PLE (red)
PDE (blue)
HM2012 (grey)



(Compostella et al. 2013)

Observational Implications

Similar reionization histories

- Large volumes

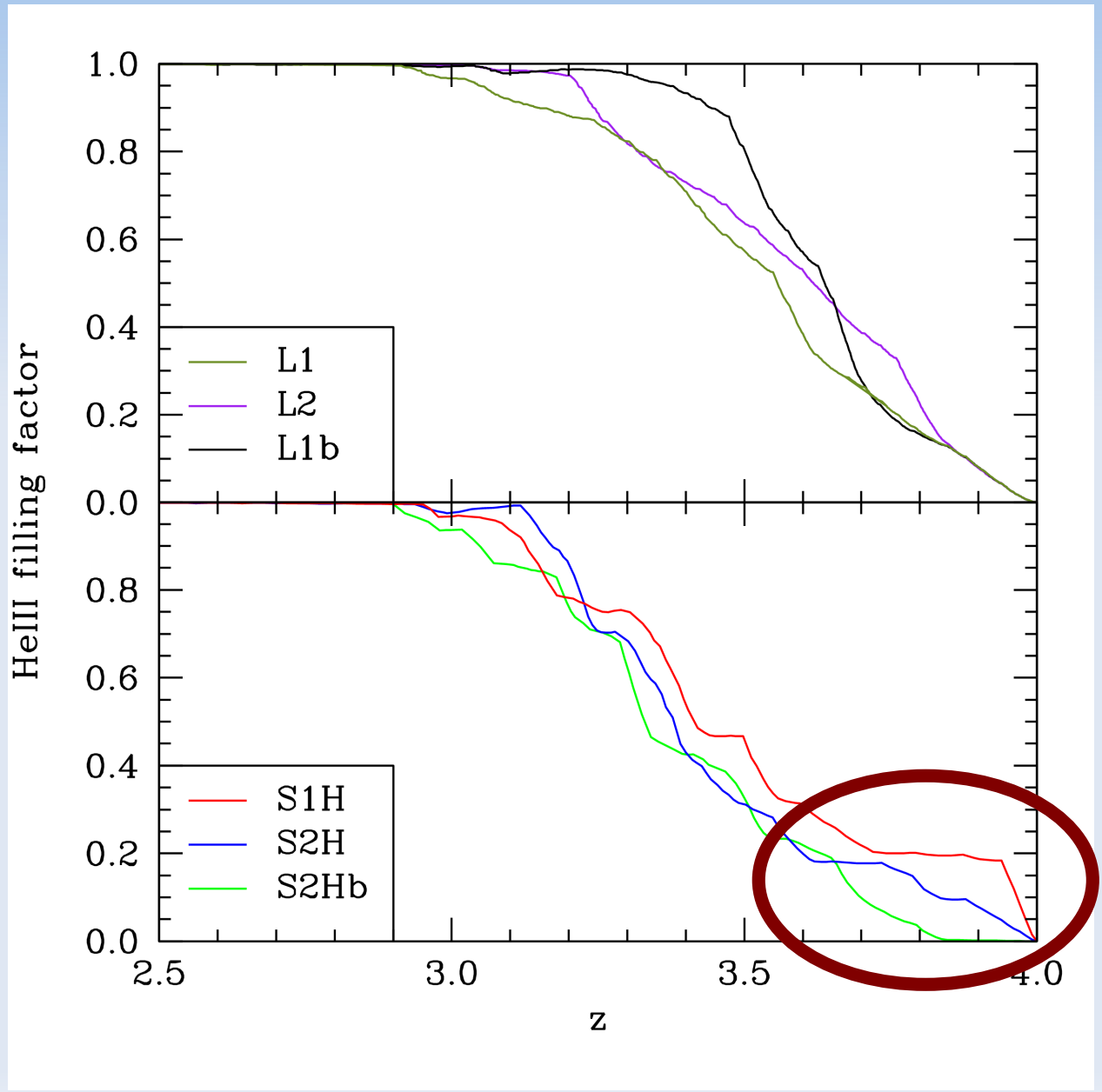
  L1, L1b: PLE model

  L2 : PDE model

- Small volumes

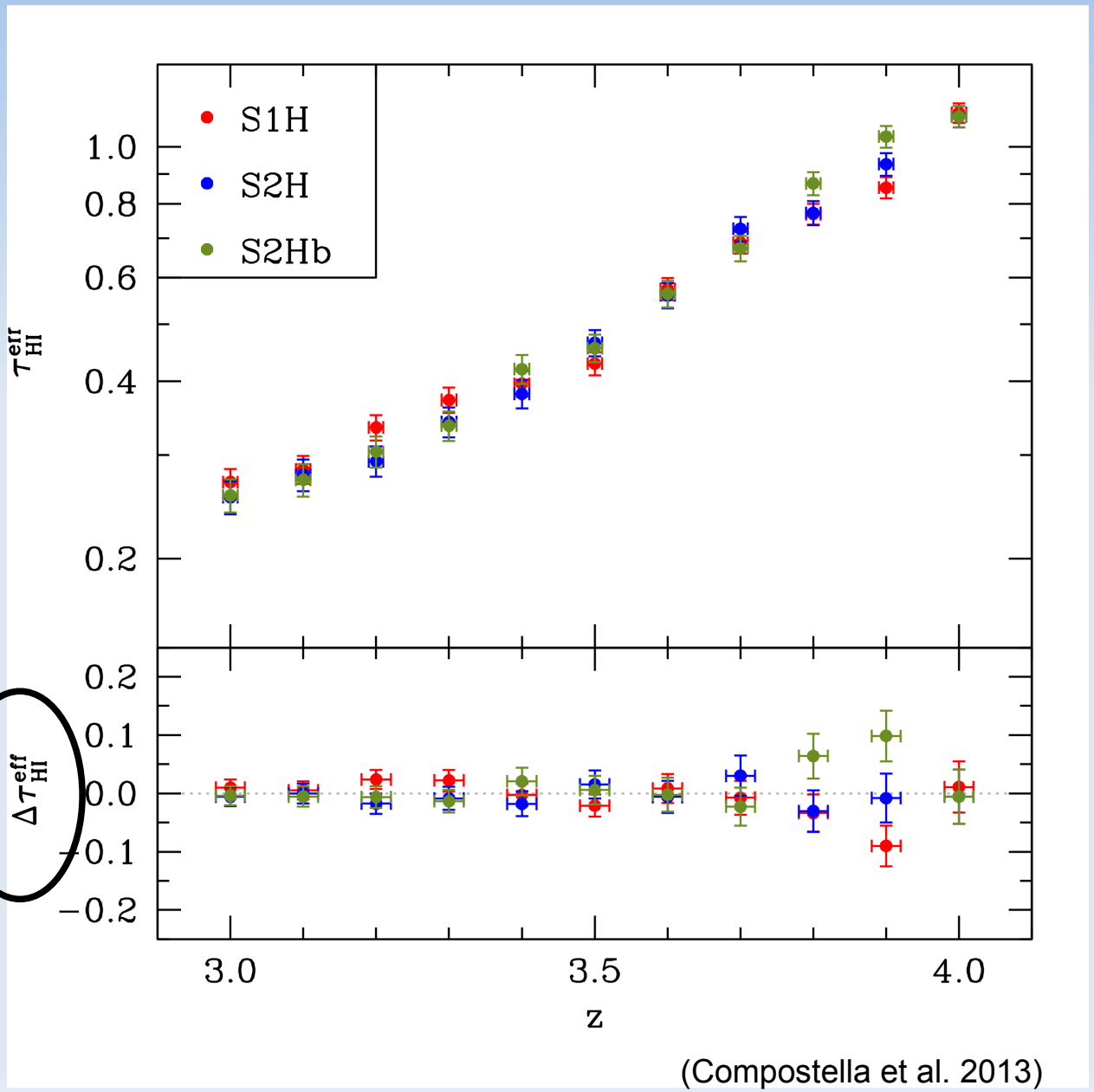
  PLE model for all simulations

  (S1, S2, S2b)



Increased scatter in the HI effective optical depth

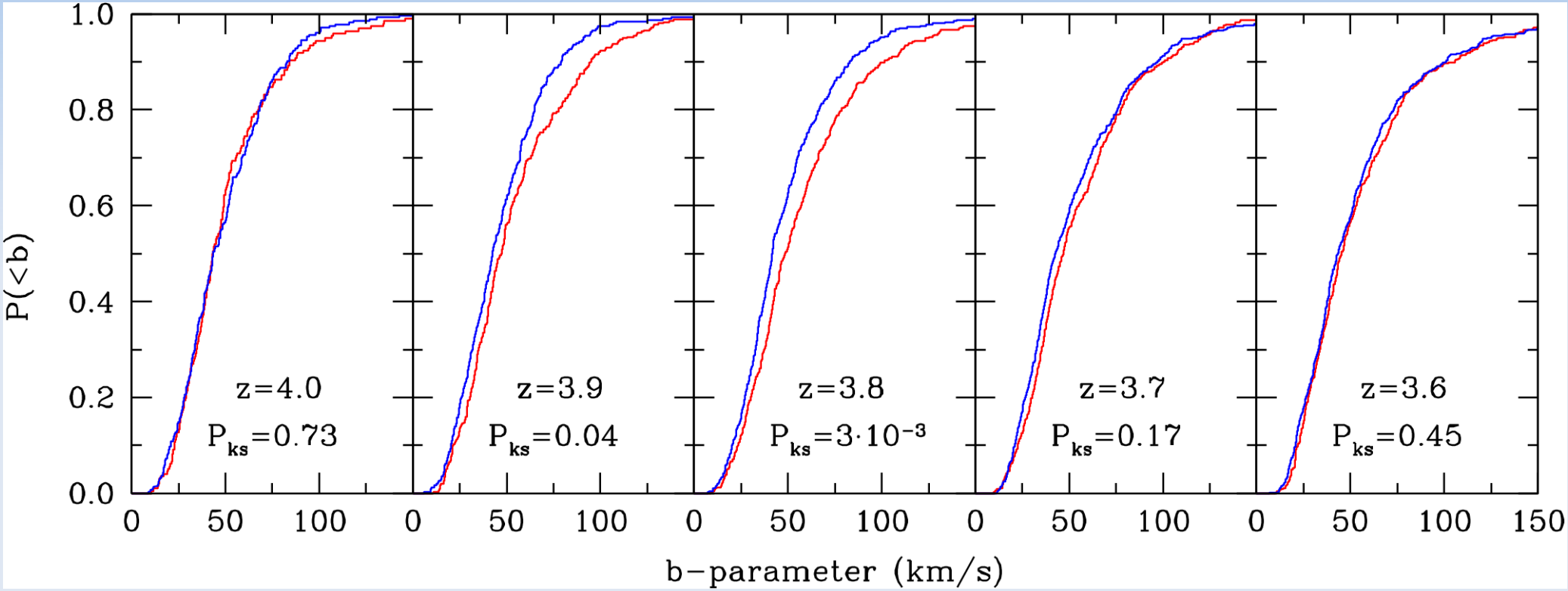
$$\Delta\tau_{HI}^{eff} = \tau_{HI}^{eff,S_i} - \langle \tau_{HI}^{eff} \rangle_i$$



(Compostella et al. 2013)

Doppler *b* parameters

(Compostella et al. 2013)



spectra in the S1H (red) and S2Hb (blue)

$\log (N_{HI}) \leq 14.0$ cm^{-2}

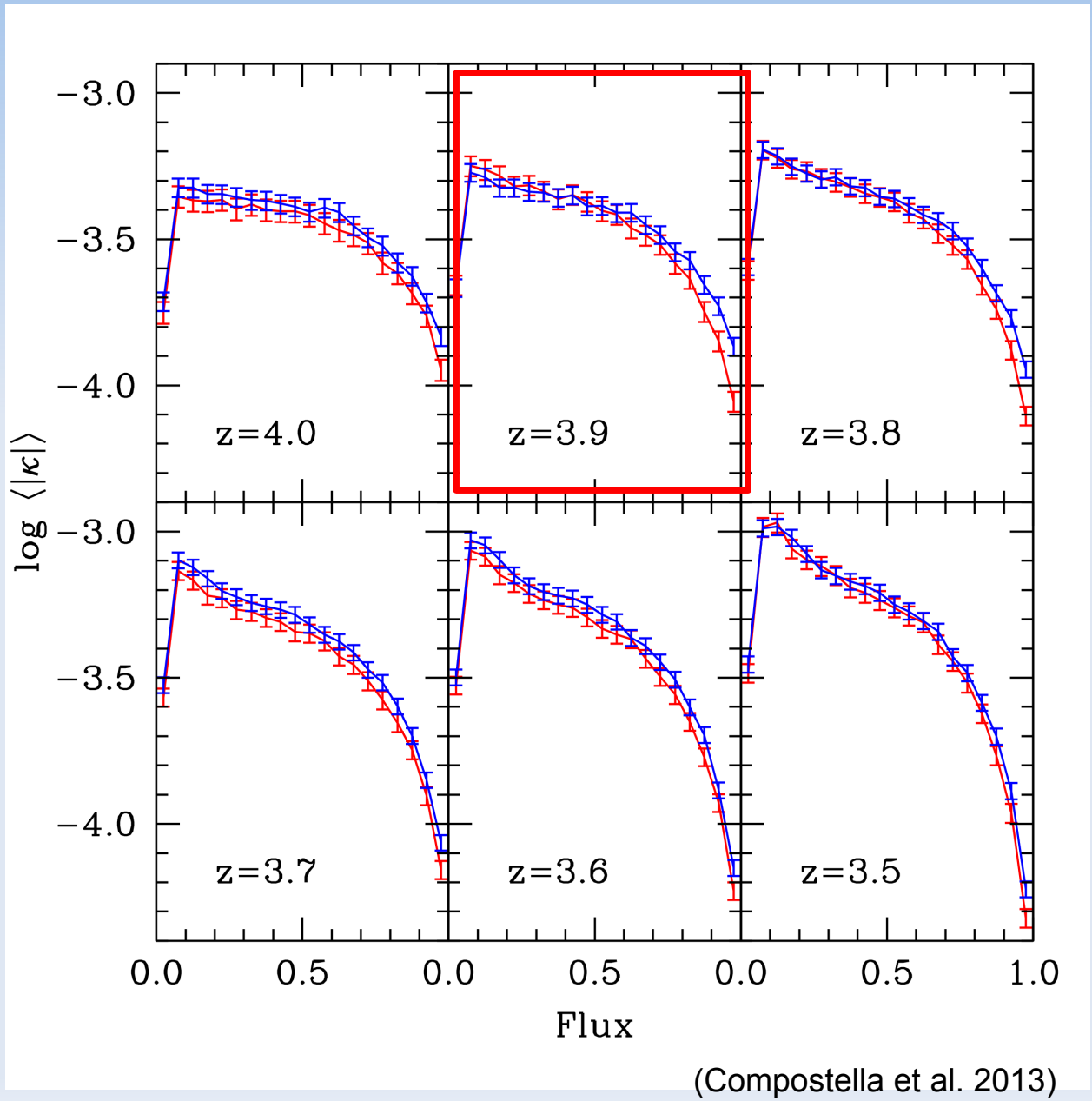
$\Delta b \leq 10$ km/s

The curvature is sensitive to HeII reionization

$$\kappa = \frac{F_{HI}''}{\left[1+\left(F_{HI}'\right)^2\right]^{3/2}}$$

(Becker et al. 2011)

S1H (red)
S2Hb (blue)



(Compostella et al. 2013)

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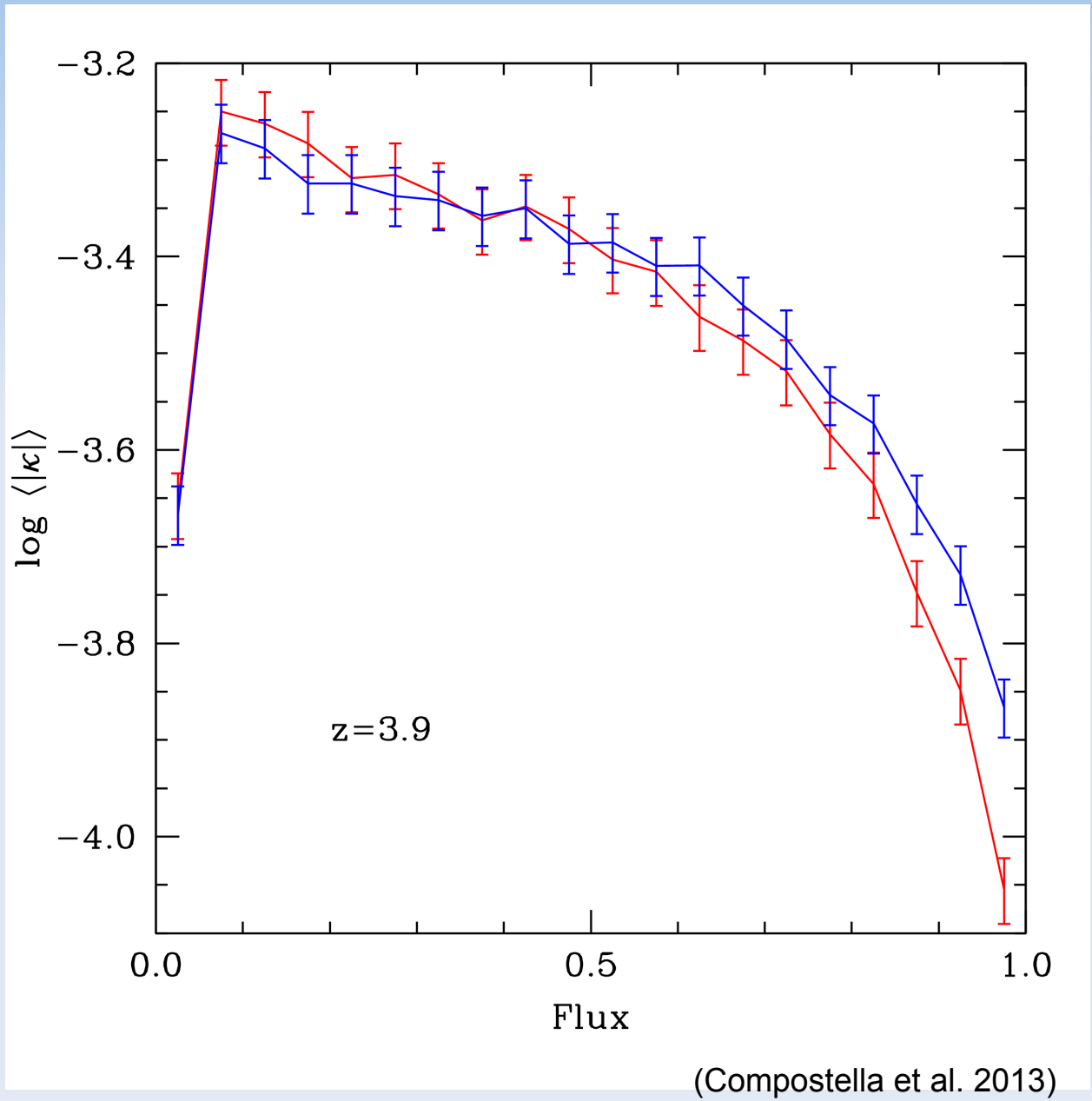

(Compostella et al. 2013)

Summary of the results

i. HeII reionization is patchy and extended in redshift ($\Delta z \geq 1$). ΔT_0 from z=4 to z=3 between 9,000 and 10,000 K.

ii. "Normal" equation of state:

γ=1.56 → Bimodal EoS → γ=1.20

iii. Initial stages of HeII reionization are characterized by:

- Increased scatter in the HI effective optical depth
- Increased scatter of the cumulative distributions of the doppler *b* parameters.
- Decrease of the mean absolute curvature in bins of high transmissivity

For all the details check arXiv:1306.5745