

# Exploring LGRB host galaxy through mock observations and radiative transfer

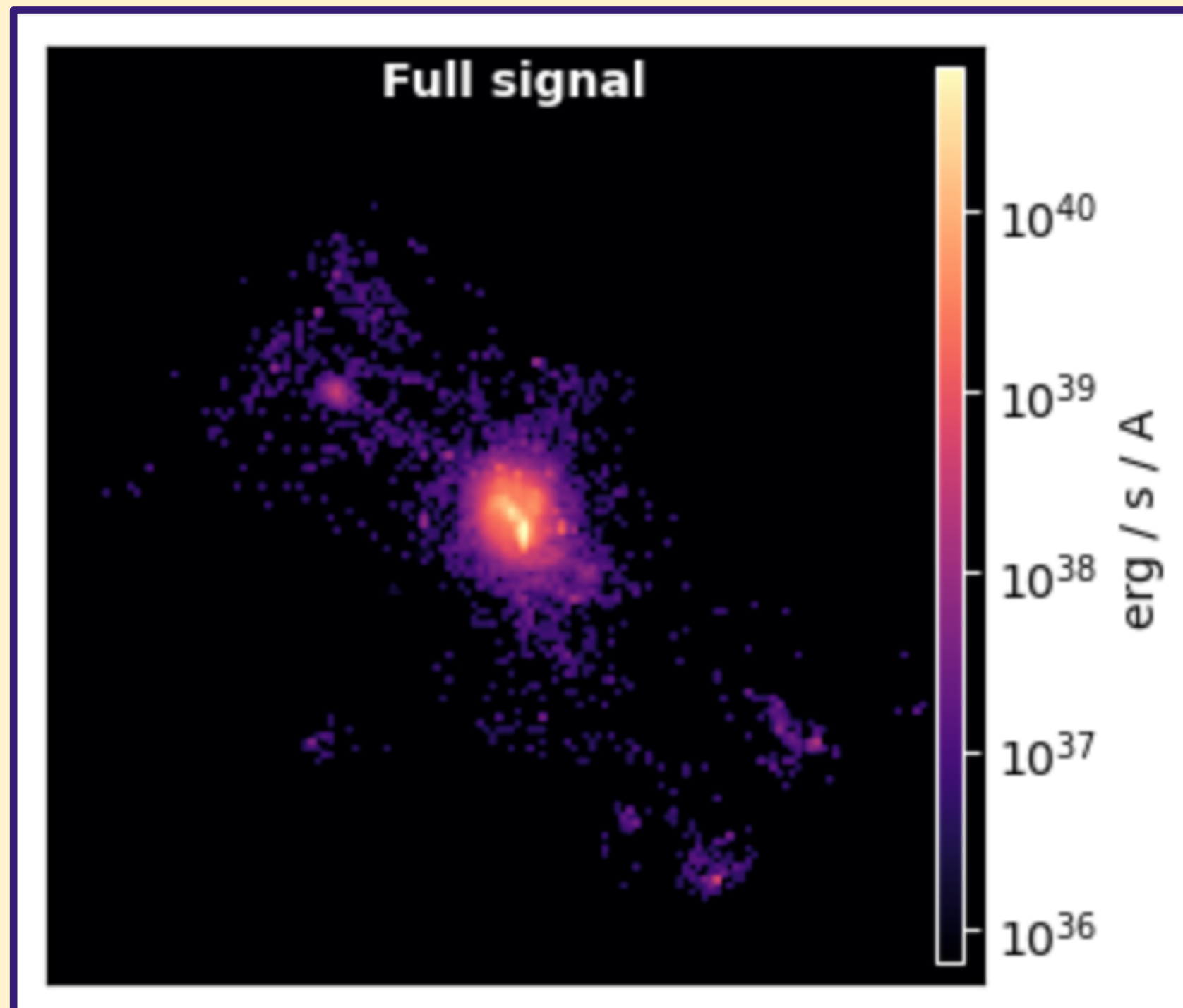
*Marine Garnichey, PhD. Student at LUX - Observatoire de Paris*

*Supervisor: Susanna Vergani (LUX)*

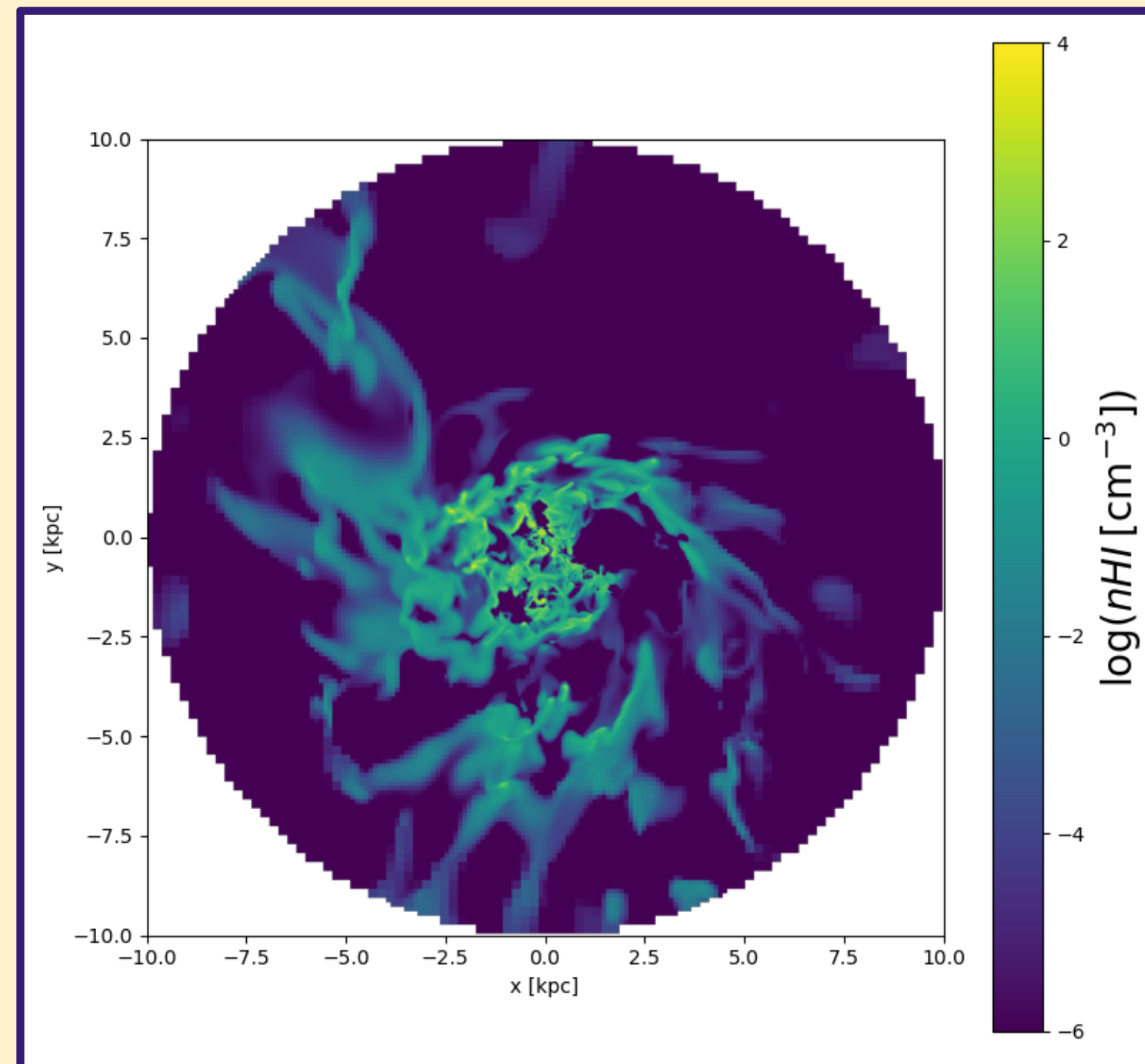
*Collaborators: Maxime Trebitsch (LUX), Jérémy Blaizot (CRAL)*

# Different gas phases in high-redshift galaxies

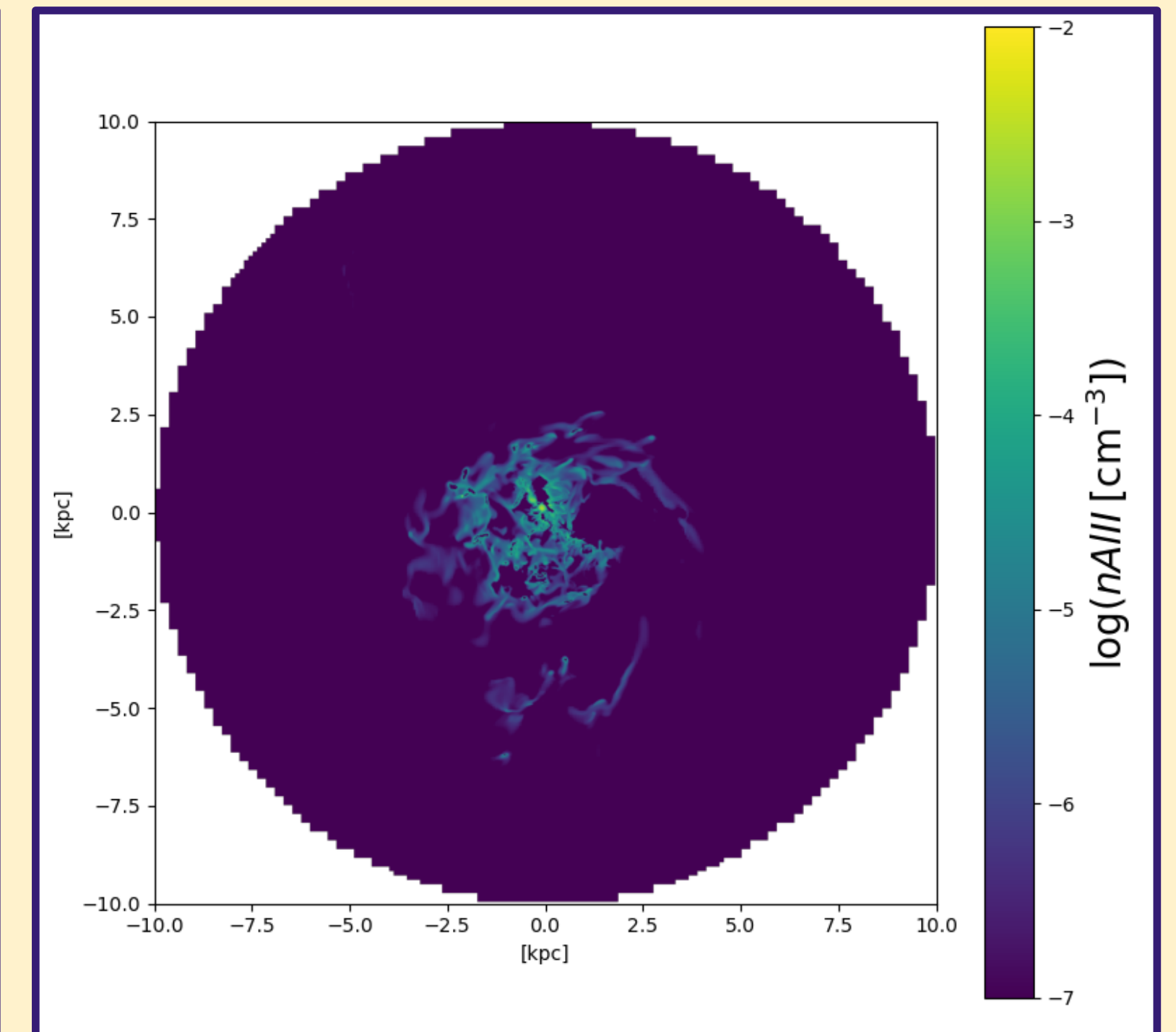
Ionised gas (H $\alpha$ )



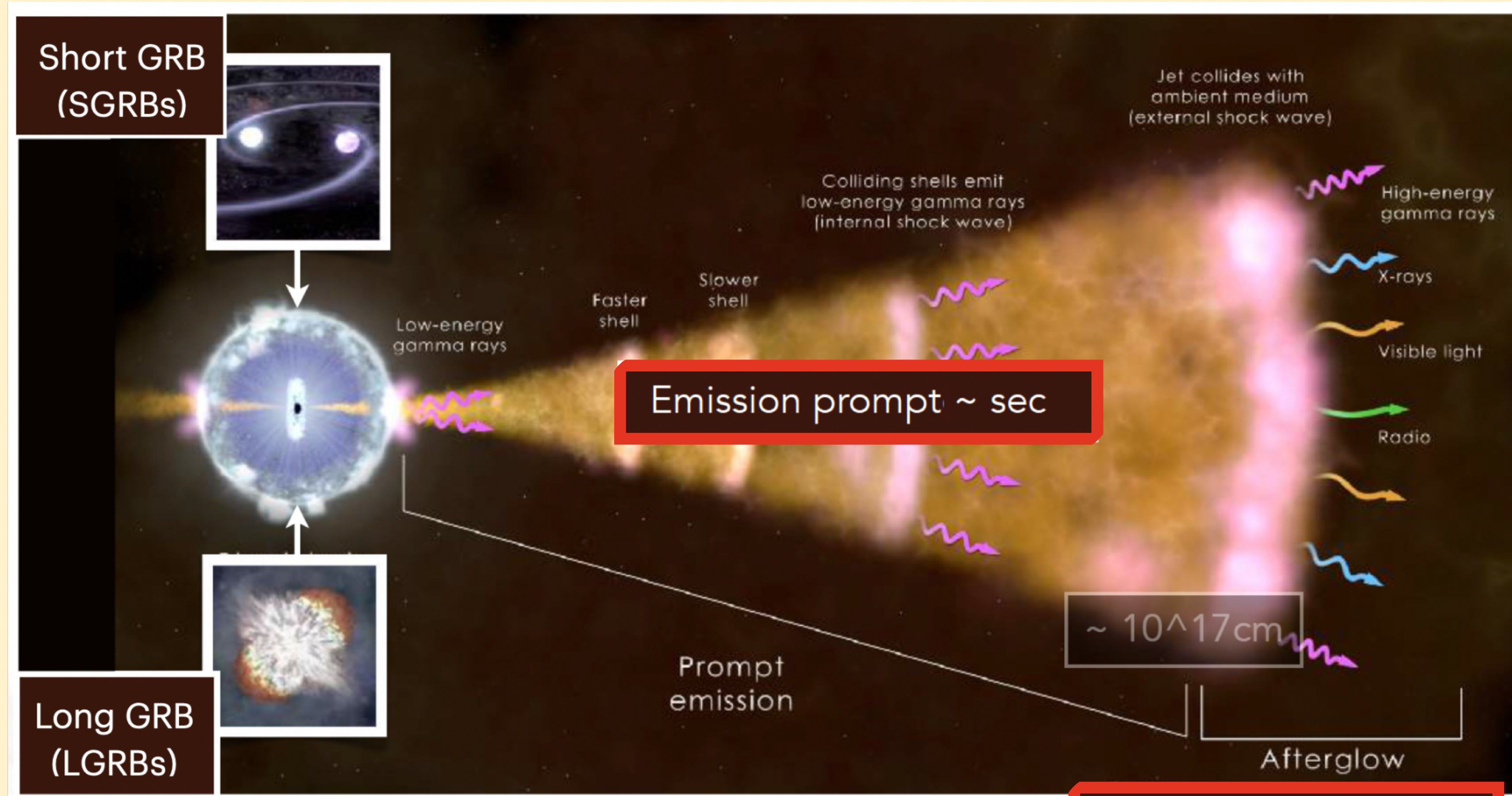
Neutral gas



Metals in the neutral gas



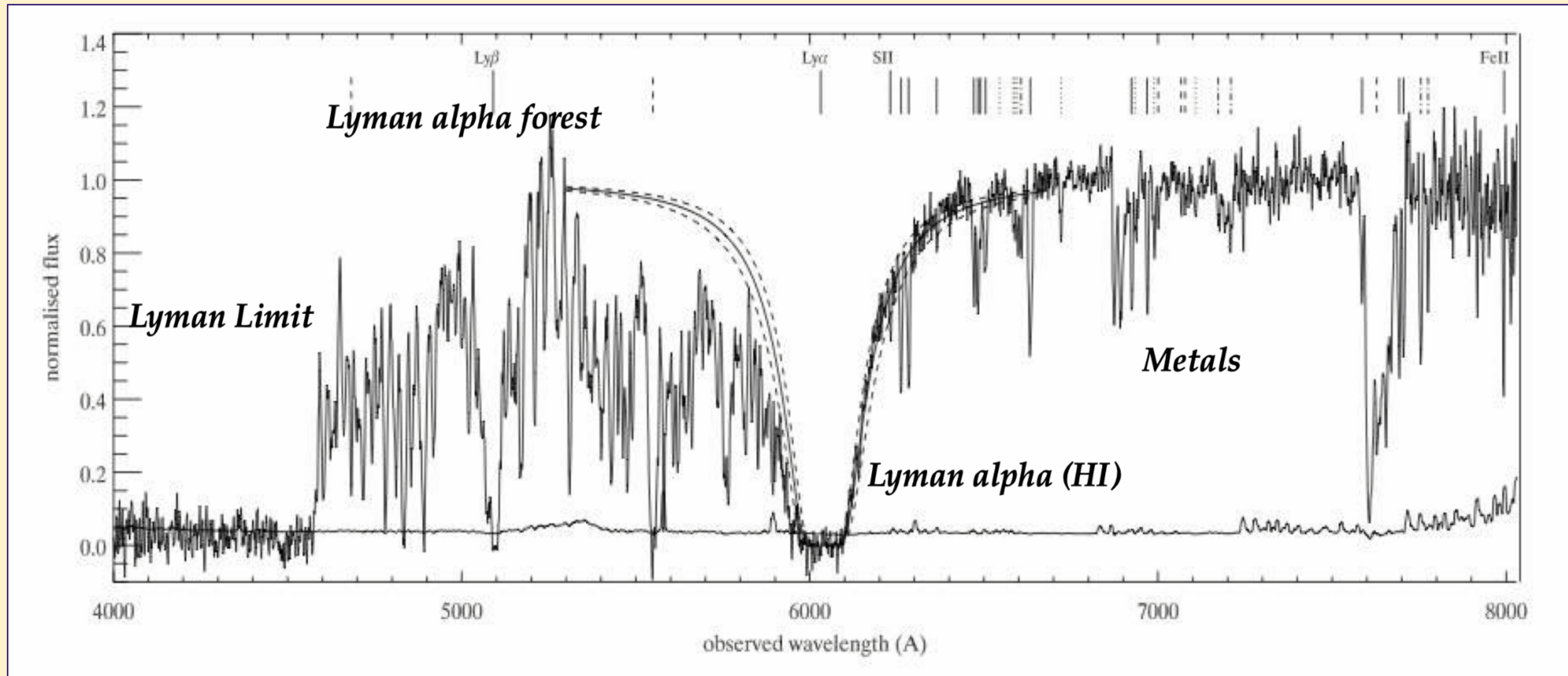
# Gamma-Ray Bursts as background sources



Production of a Gamma-Ray Burst (GRB)  
Credits: NASA

Afterglow emission  
a few hours --> years  
(depending on  
the frequency range)

# Precise information on the chemical environment

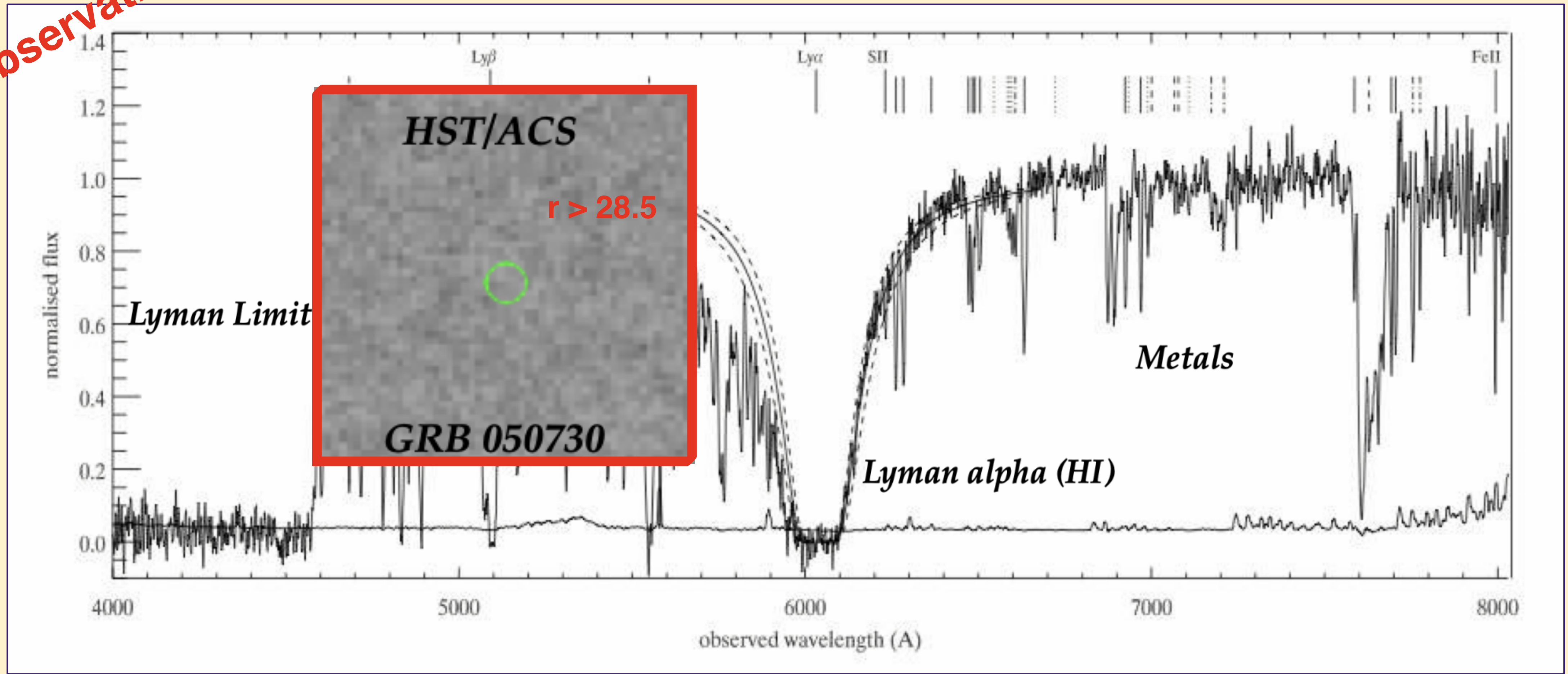


Absorption spectra from the afterglow's emission on the line of sight  
*Starling et al. 2005*

**GRB 050730  $z=3.968$**

# GRB 050730 $z=3.968$

*~1h Observation*



Absorption spectra from the afterglow's emission on the line of sight  
*Starling et al. 2005*

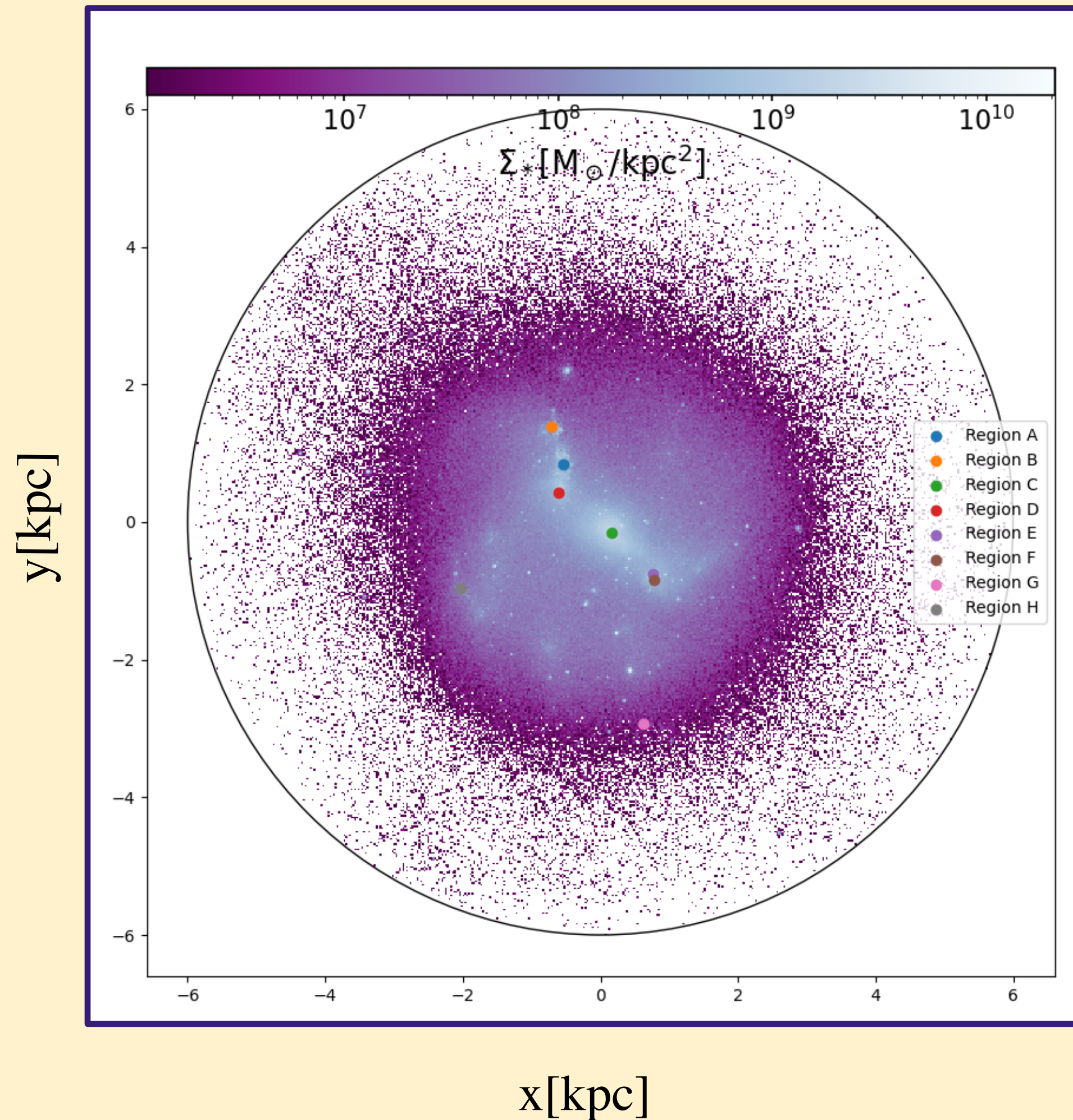
Do galaxy simulation agree with GRB observations ?

**Numerical  
simulations**

**GRB observations**

Can we use galaxy simulations to interpret GRB observations ?

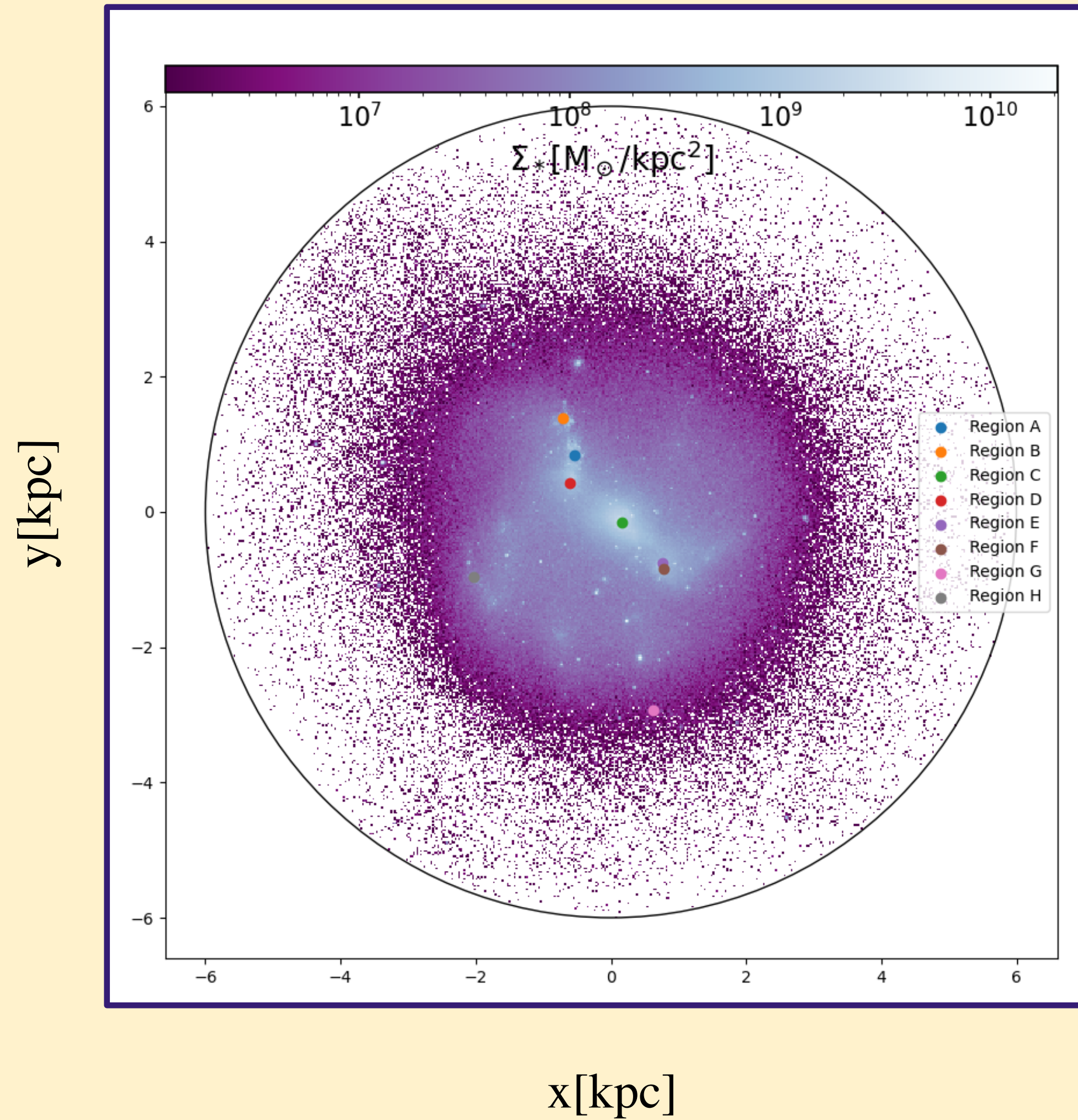
# Zoom-in of LGRB galaxy host at $z = 3$



## Simulation description

- RAMSES-RT (Rosdahl et al. 2013)
- SPHINX Physics (Rosdahl et al. 2018)  
(Mitchell et al. 2018)
- Zoom-in up to 15pc resolution  
(Mauerhofer et al. 2021)
- RASCAS (Michel-Dansac et al. 2020)

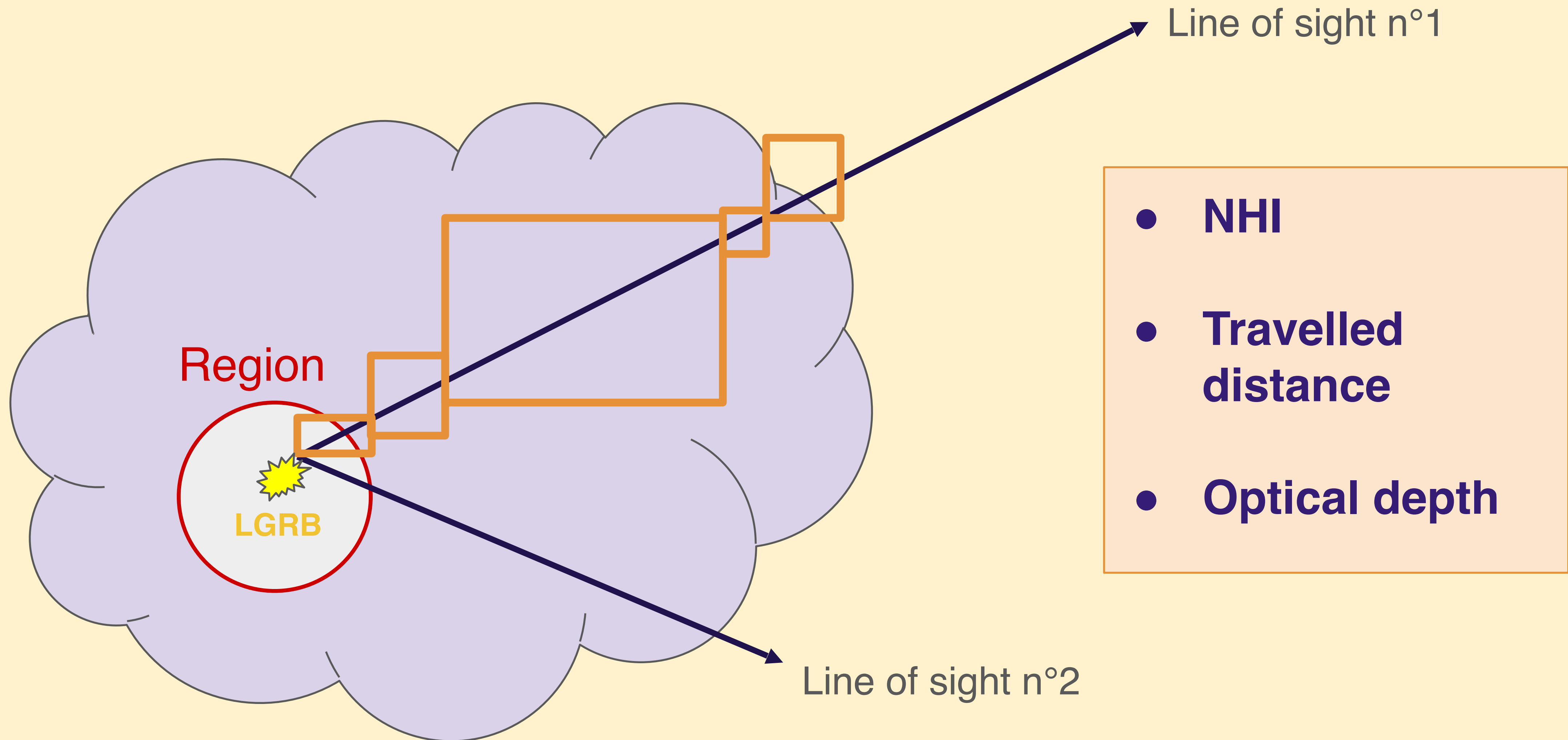
# Zoom-in of LGRB galaxy host at $z = 3$

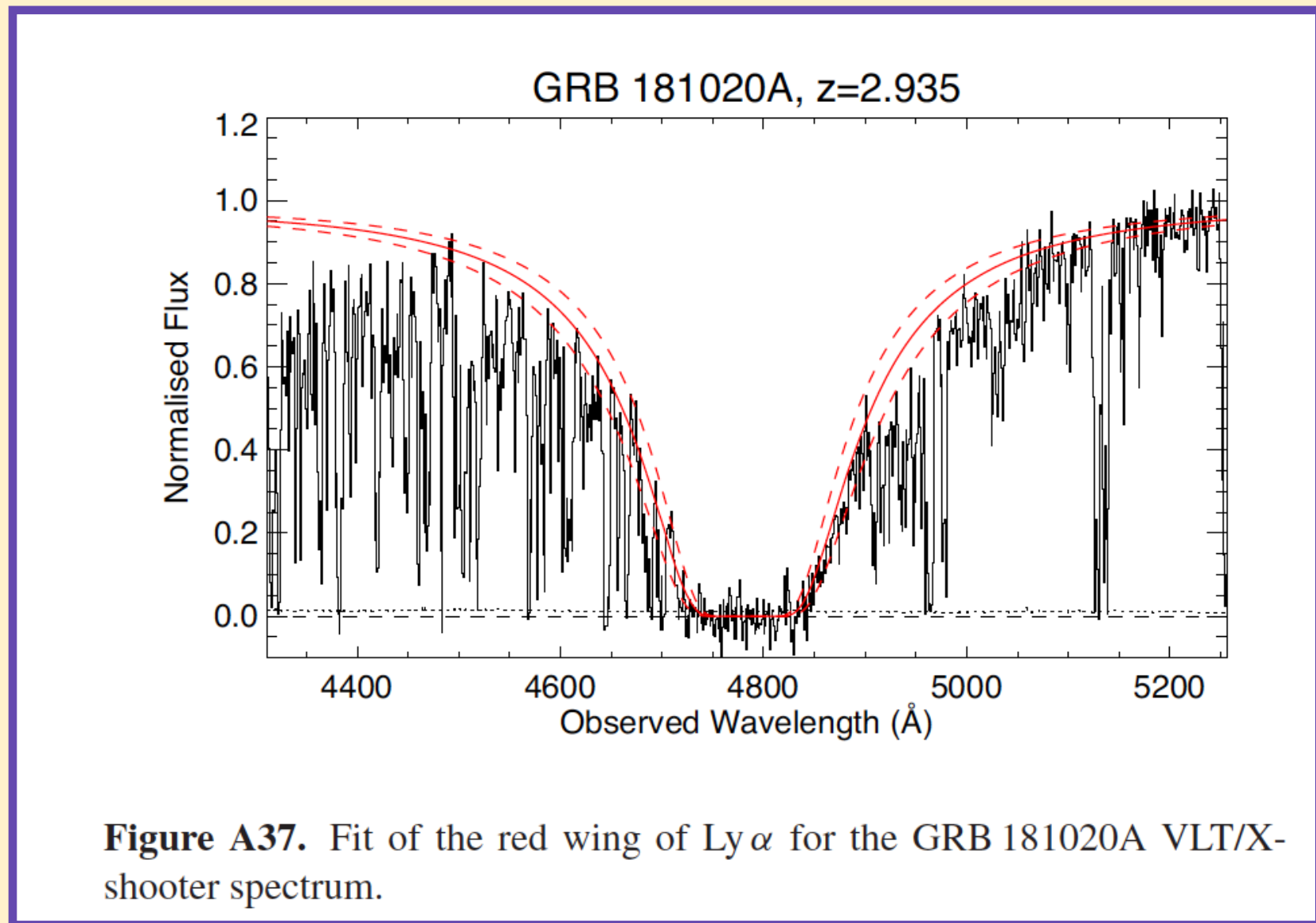


## Site selection

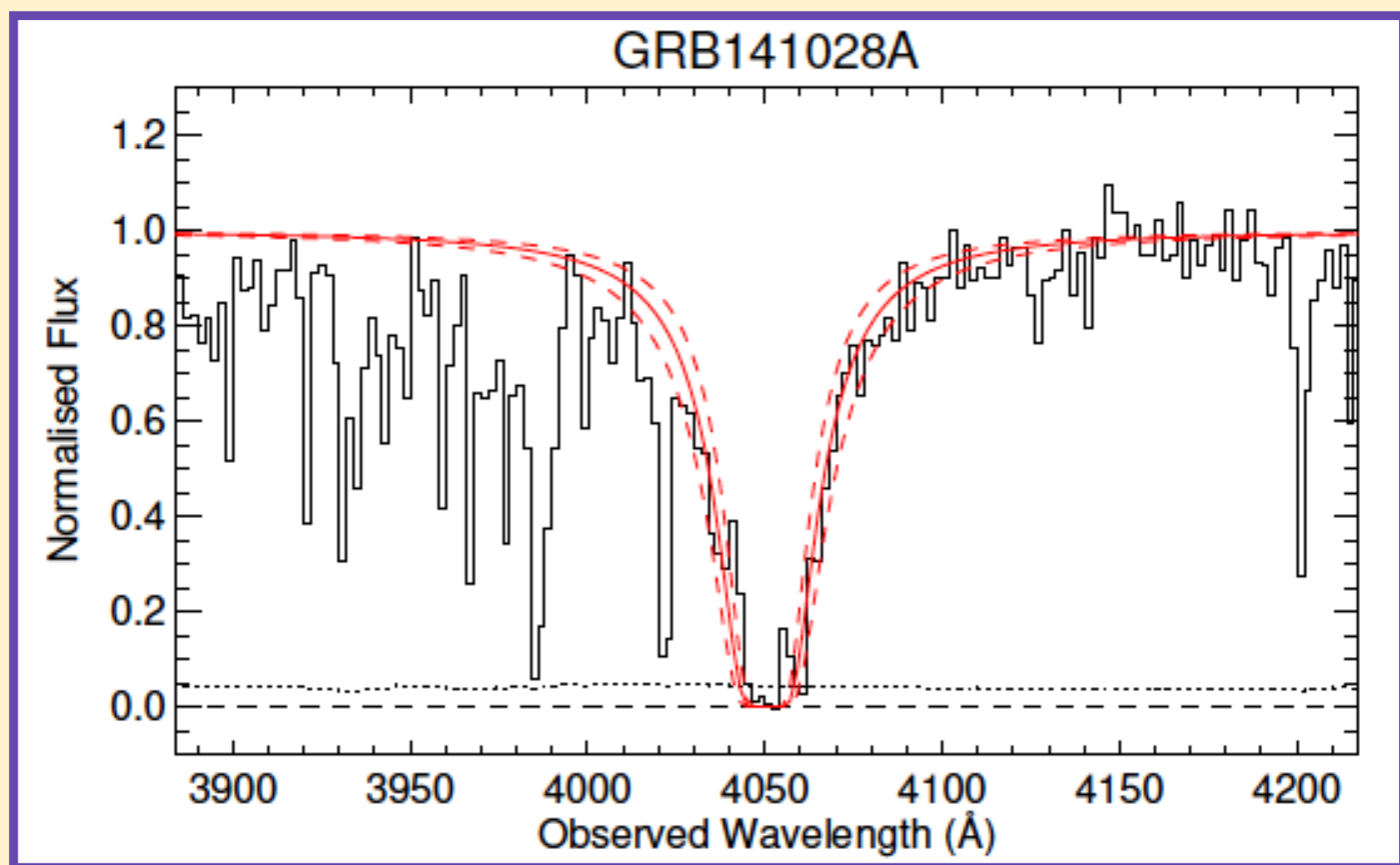
- Stellar age between 5 and 10 Myr
- Sub solar metallicity
- Dense regions

# Simulate the observations of 100 GRB lines of sights

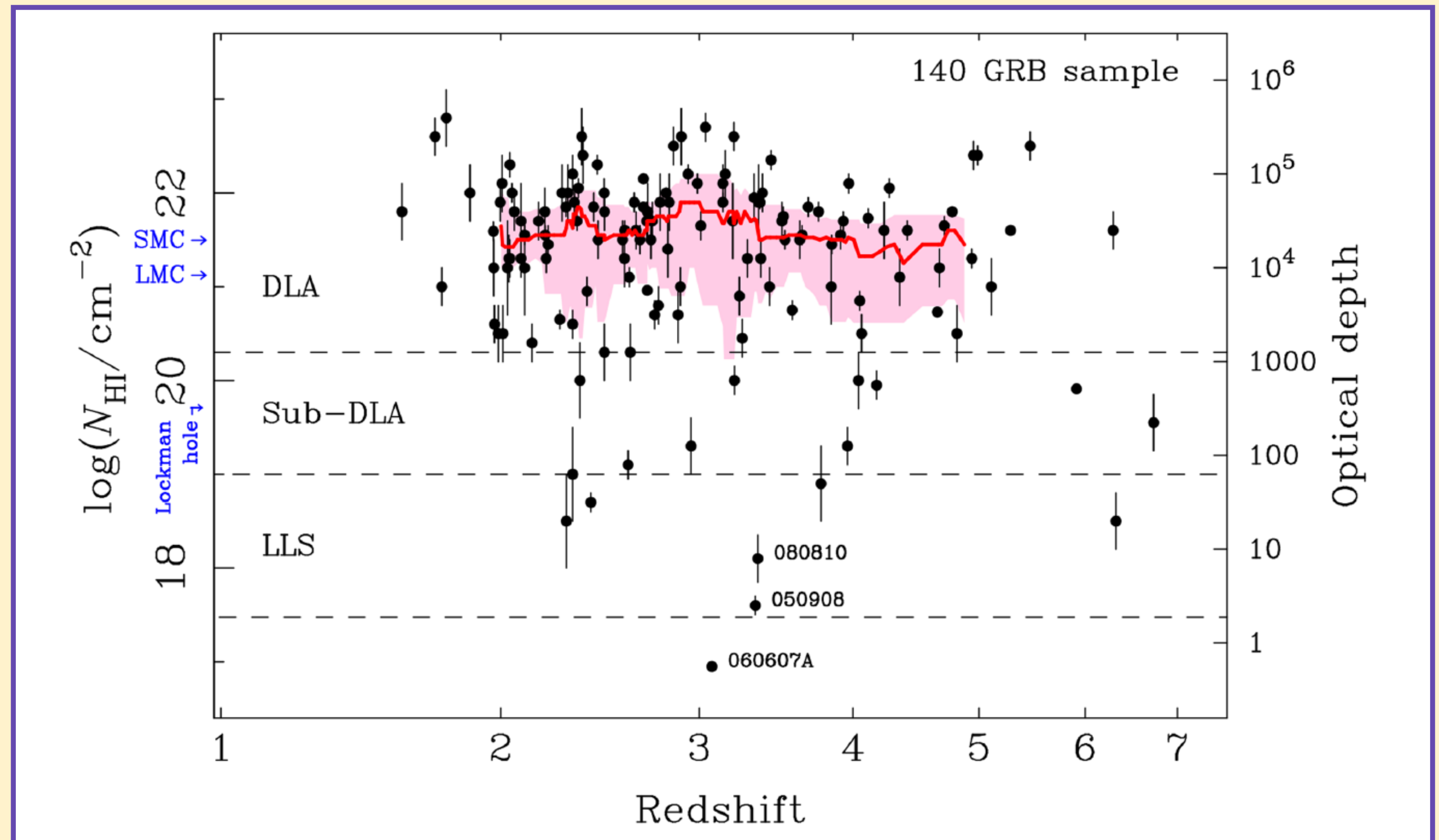




$$\log_{10}(N_{\text{HI}}/\text{cm}^2) = 22.20$$

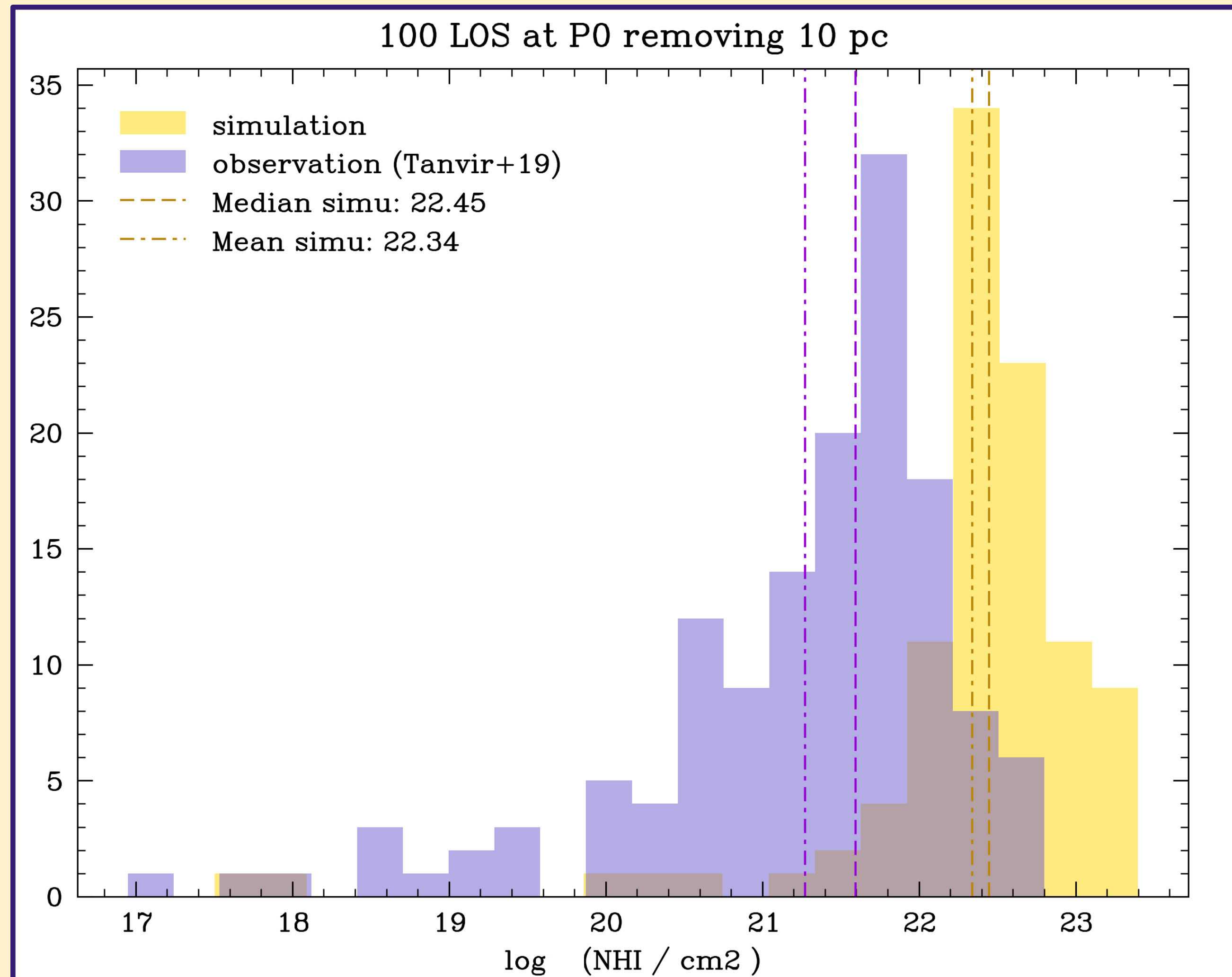


$$\log_{10}(N_{\text{HI}}/\text{cm}^2) = 20.6$$



Tanvir et al. 2019

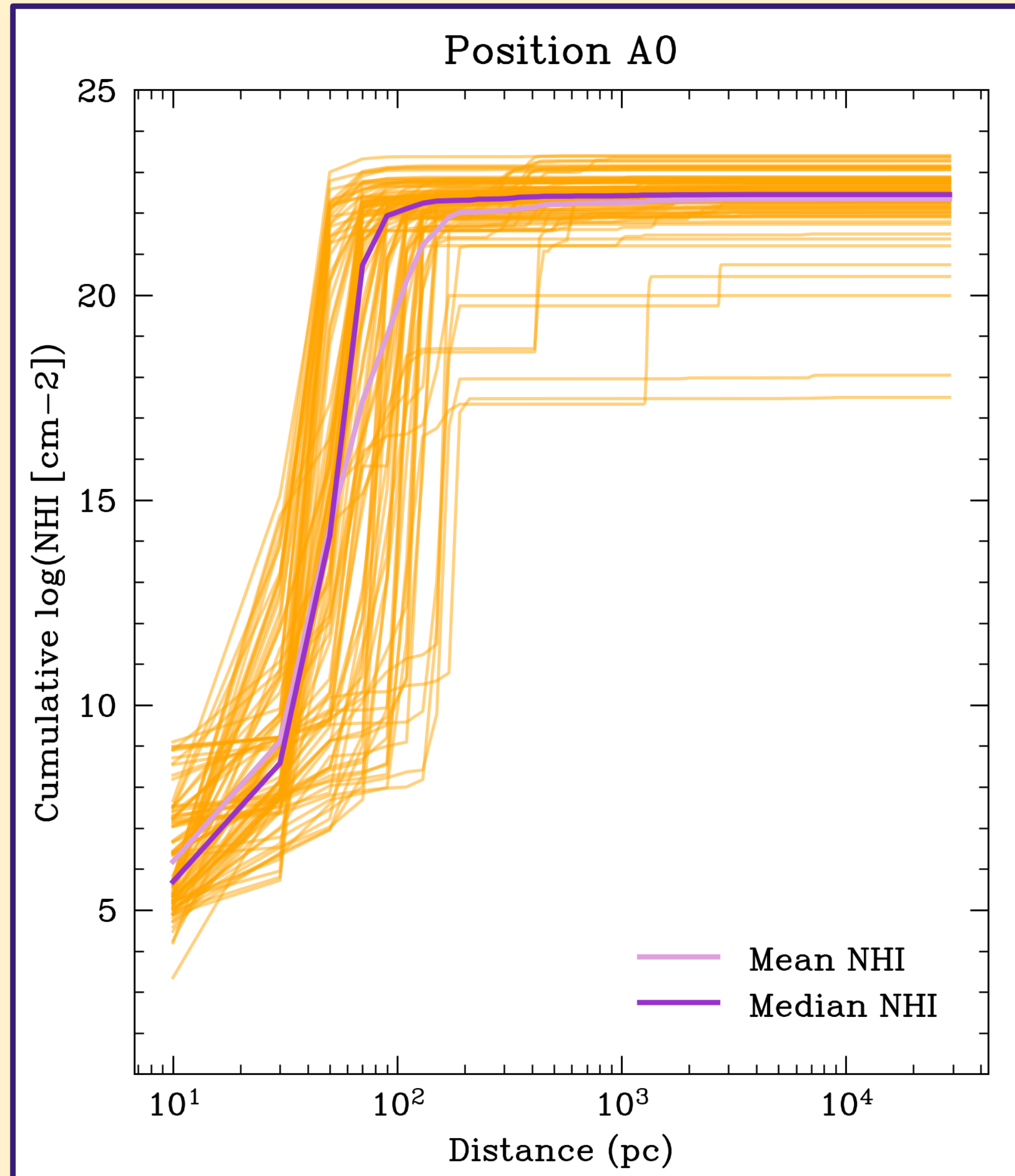
# Simulation results on neutral Hydrogen



## Possible explanations

- GRB ionisation
- Missing H<sub>2</sub>
- Problems from simulation

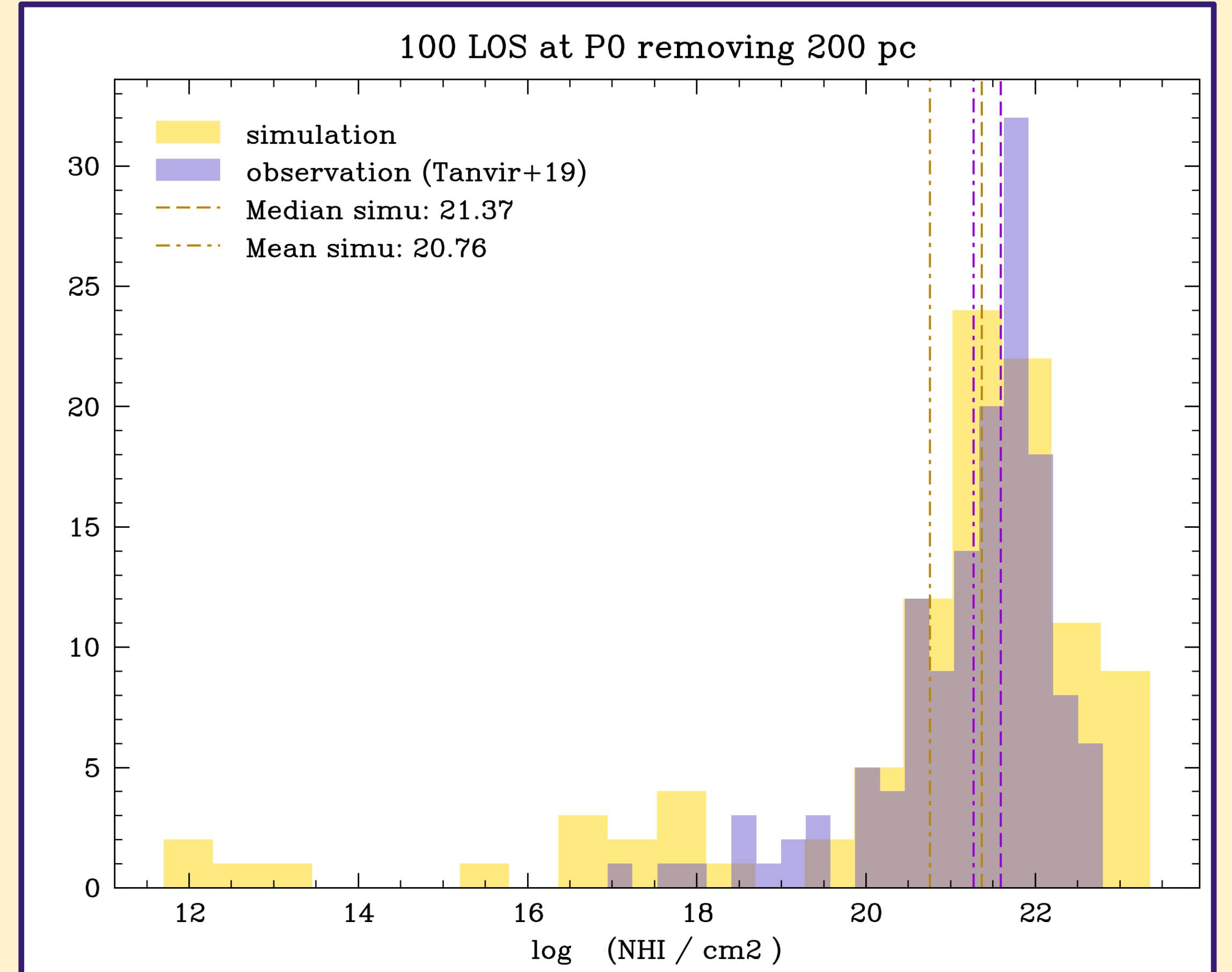
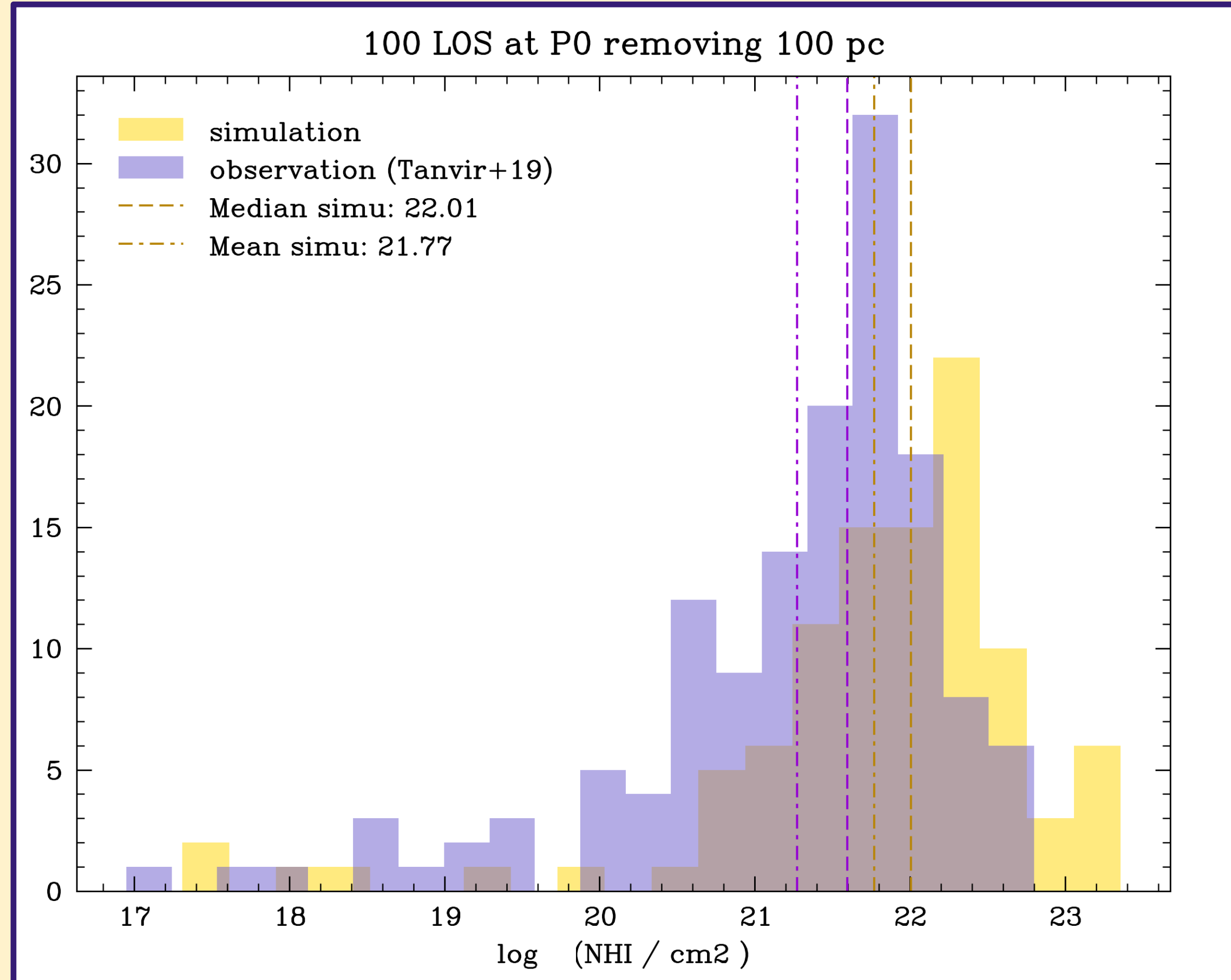
# Simulation results on neutral Hydrogen

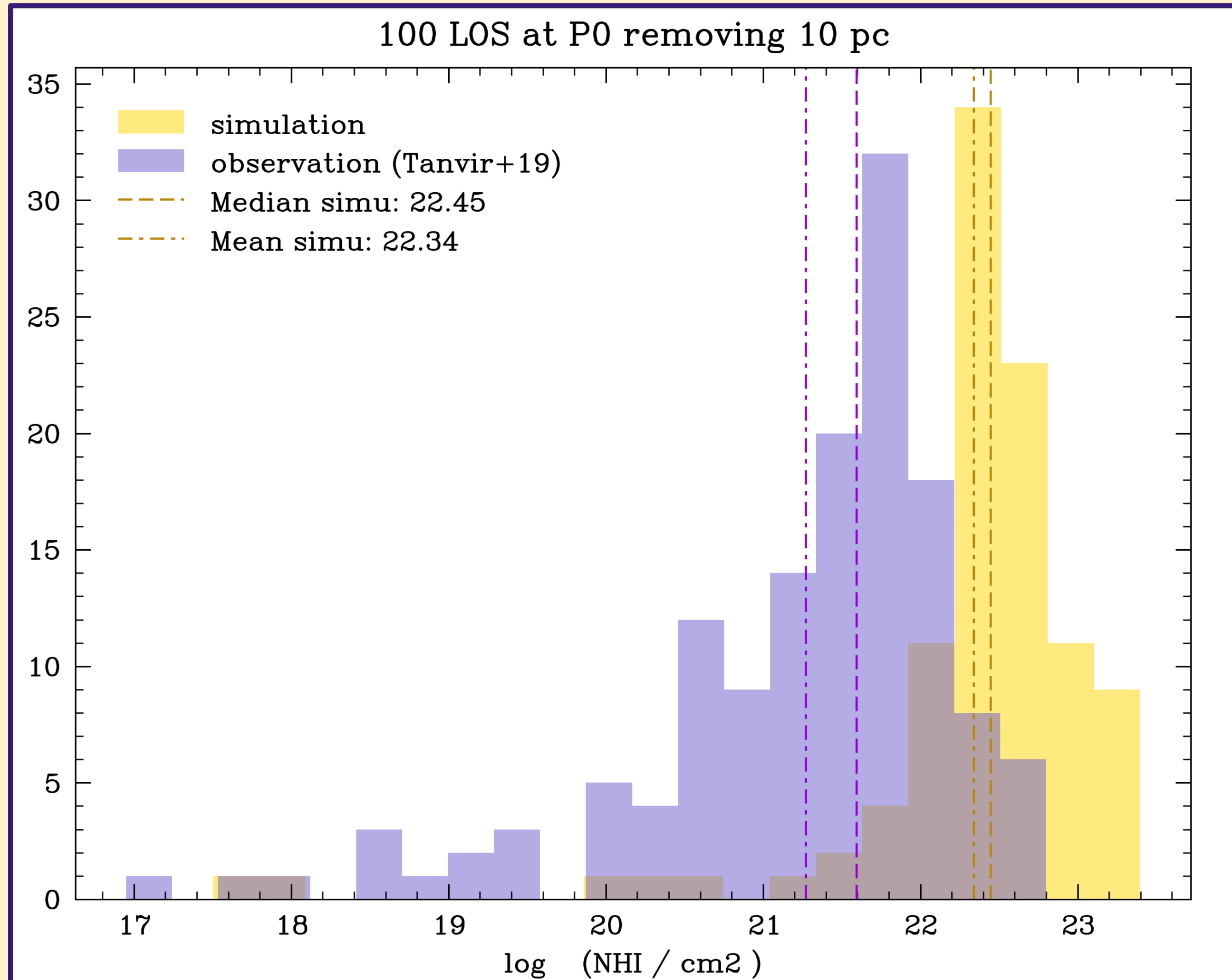


## Possible explanations

- GRB ionisation
- Missing H2
- Problems from simulation

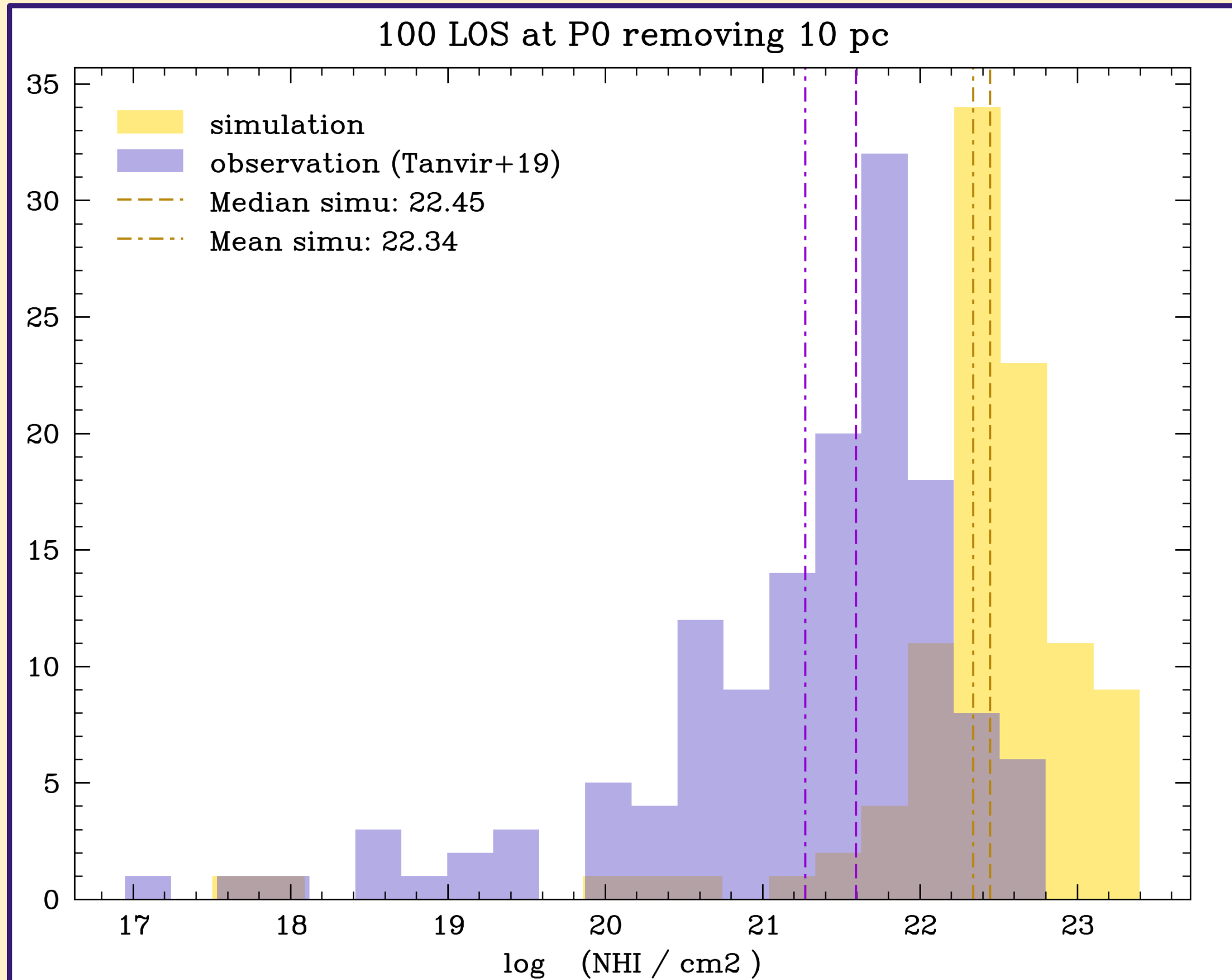
# GRB ionisation ?





## Possible explanations

- GRB ionisation
- **Missing H2**
- Problems from simulation



## Possible explanations

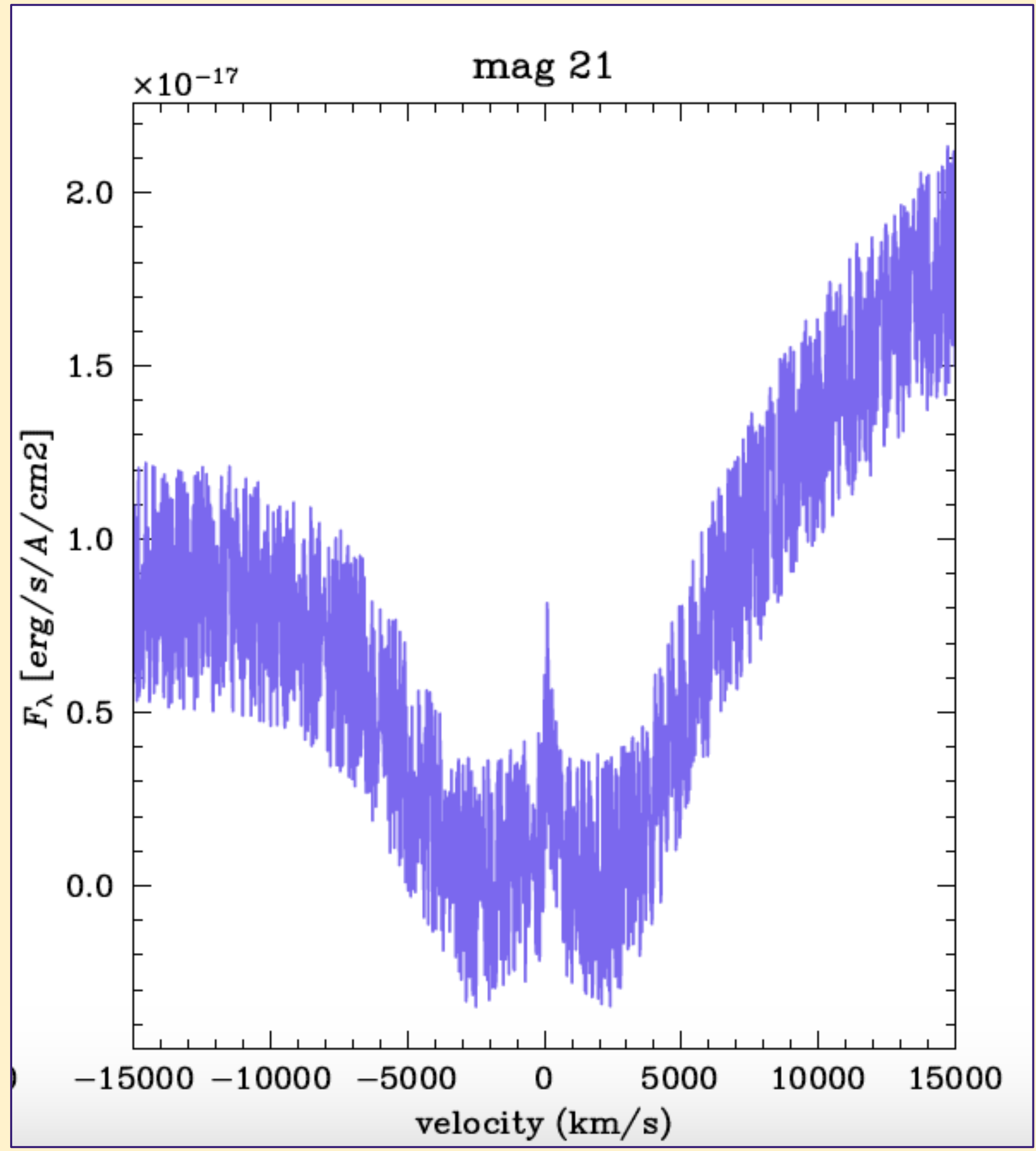
- GRB ionisation
- Missing H<sub>2</sub>
- **Problems from simulation**

# Two distinct observation cases



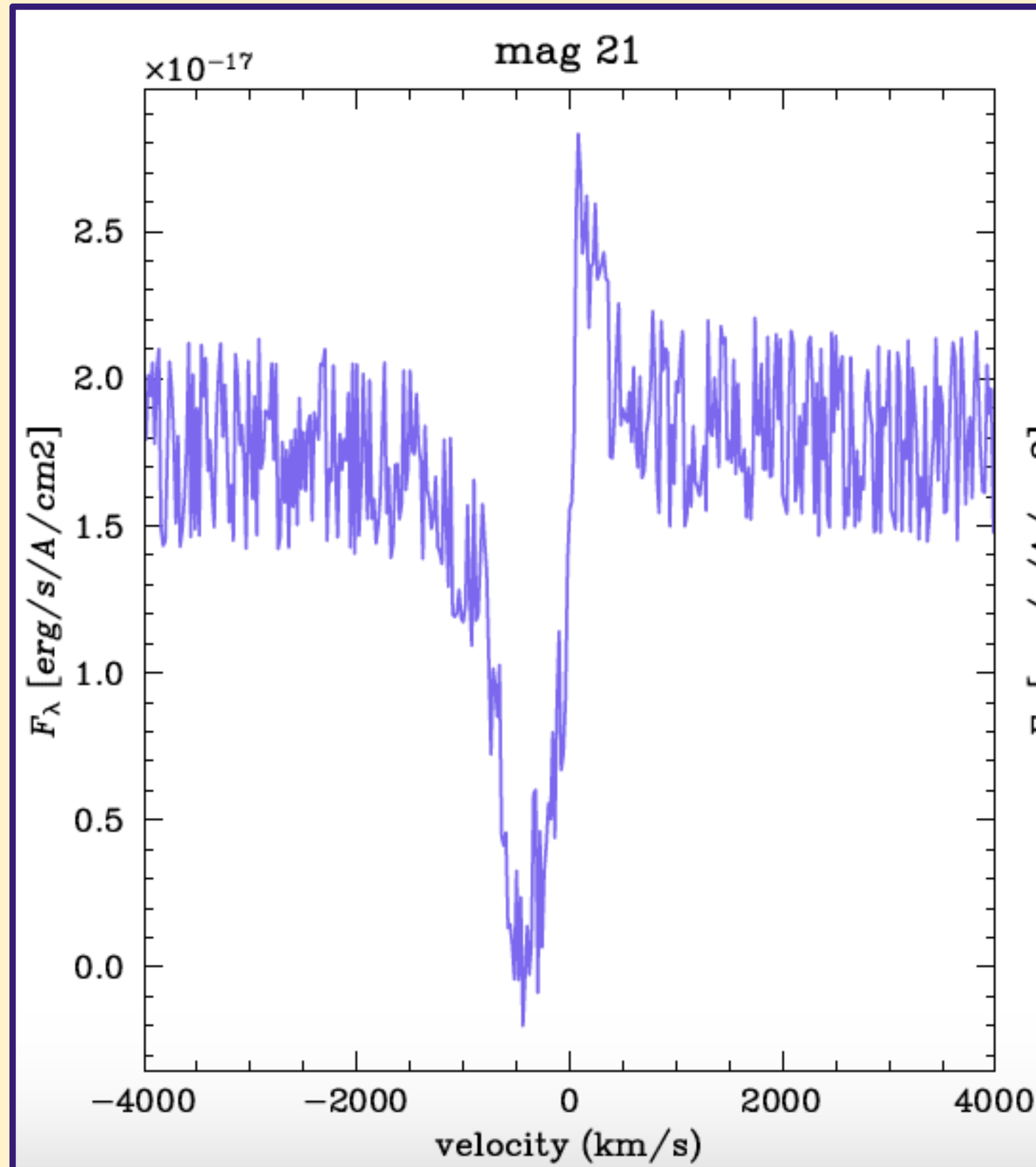
*X-Shooter spectrum (Stargate collaboration)*

$$\log_{10}(\text{NHI} [\text{cm}^{-2}]) = 22.08$$

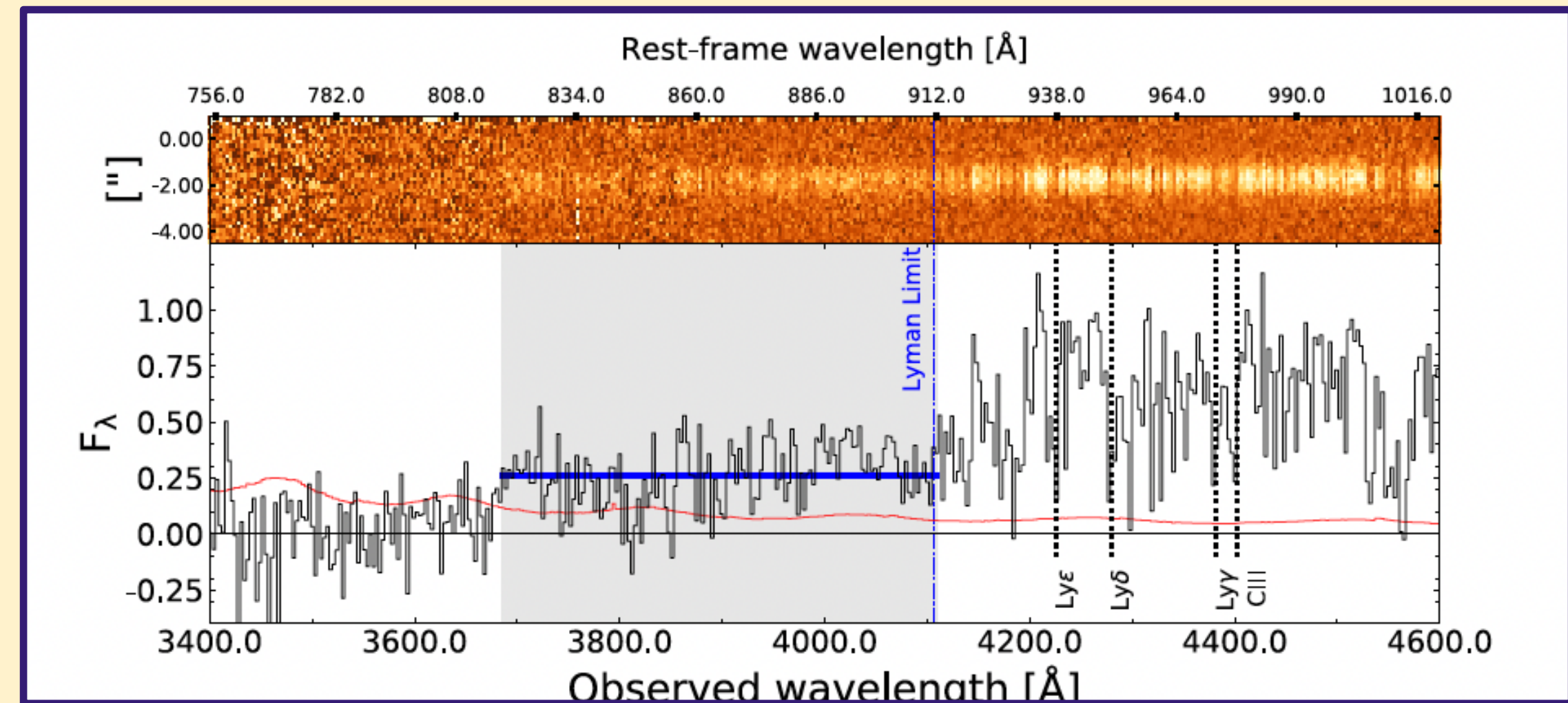
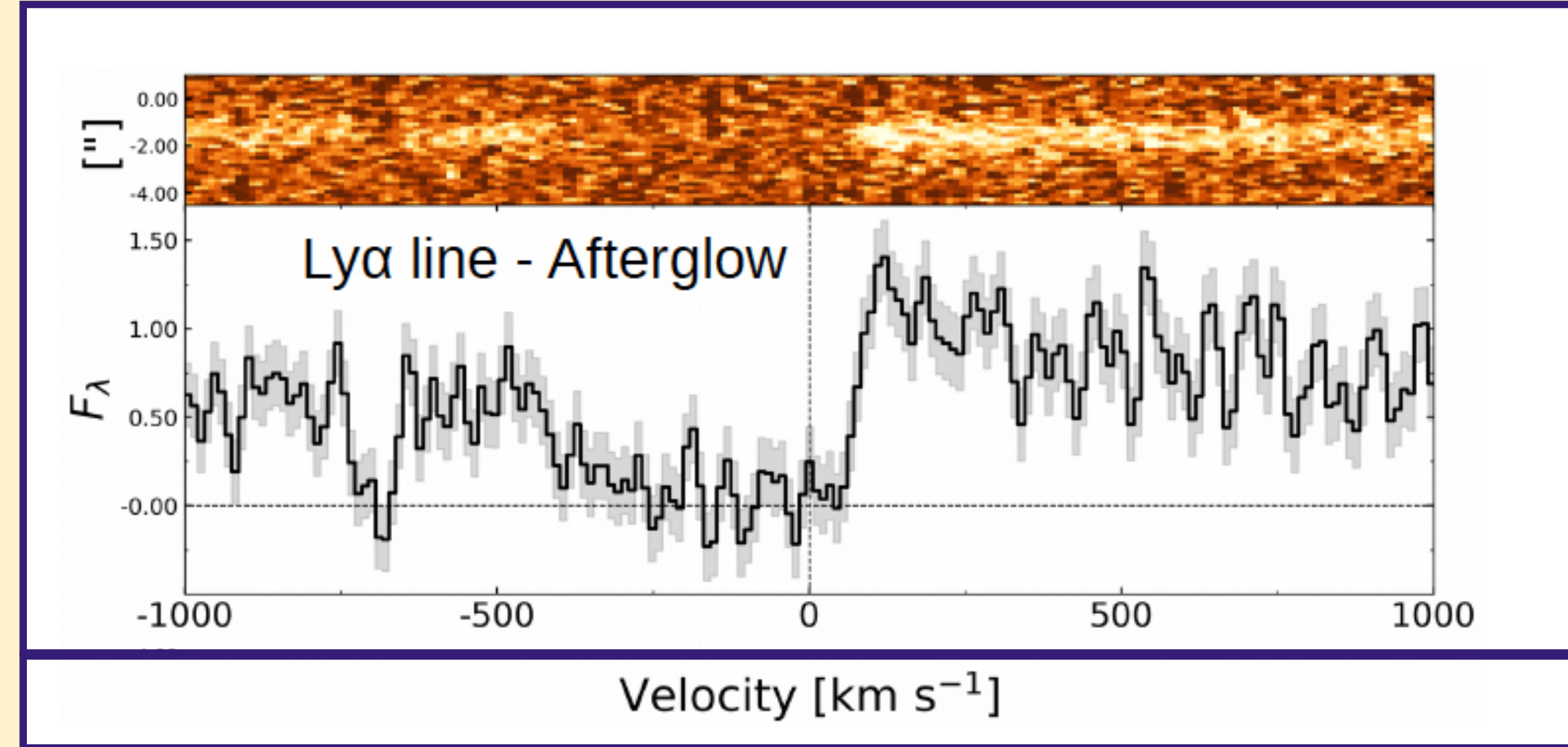


# Two distinct observation cases

$\log(N_{\text{HI}} [\text{cm}^{-2}]) = 16.41$



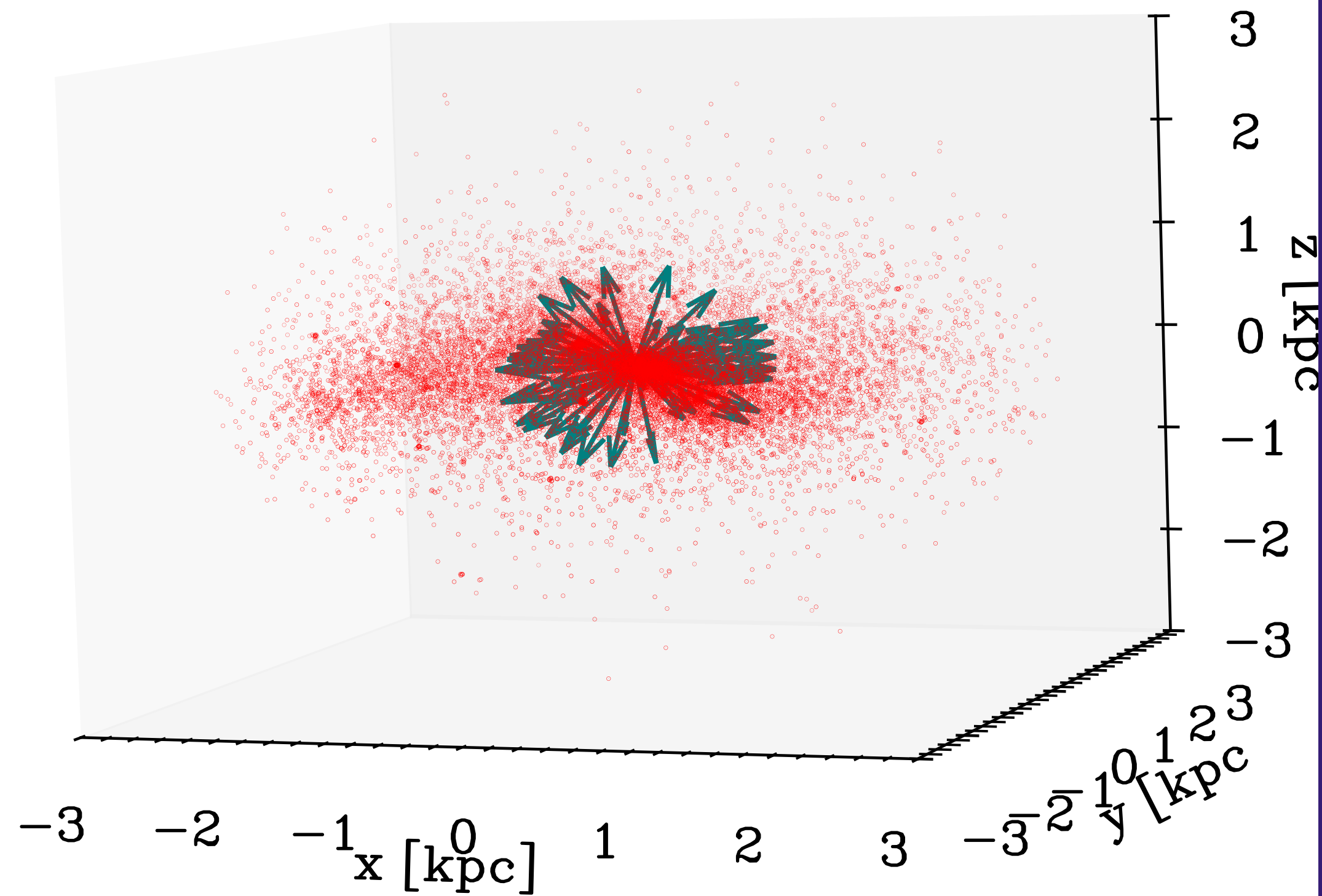
GRB 191004B  $z = 3.5053$



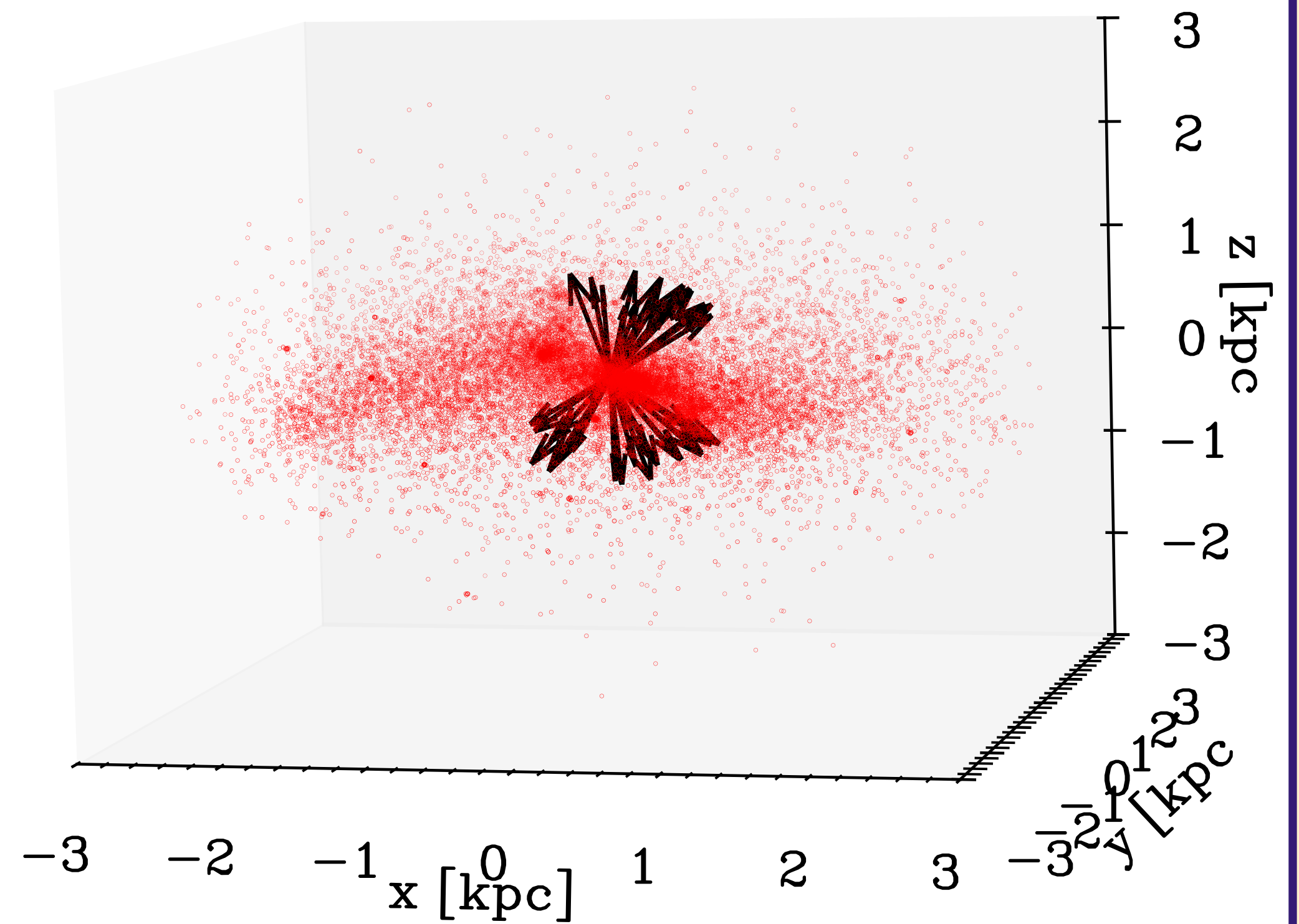
Credits: Vielvaure et al. 2020

# Implication on the viewing angle of the galaxy

Not in  $16 < \log(\text{NHI}/[\text{cm}^2]) < 17$

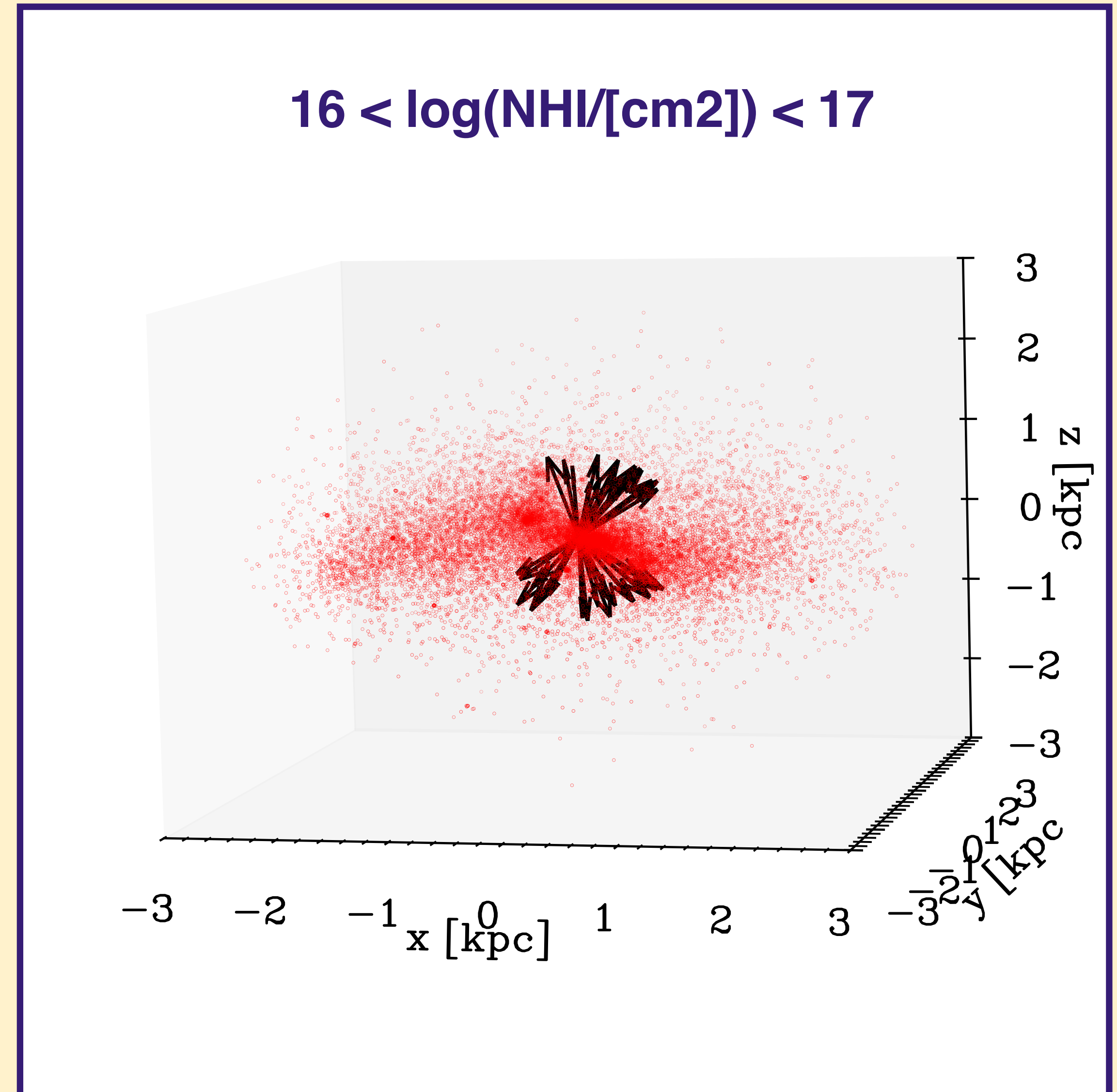
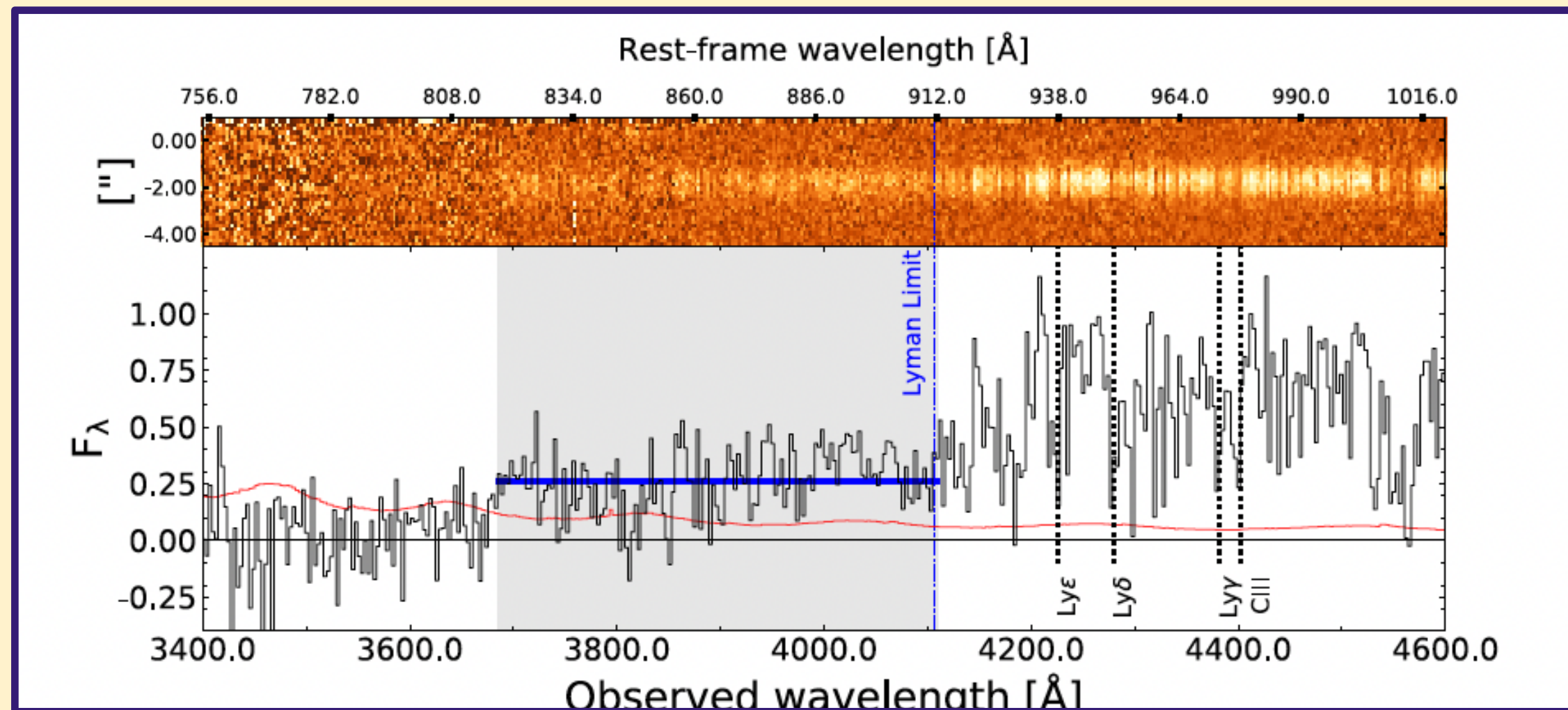


$16 < \log(\text{NHI}/[\text{cm}^2]) < 17$



# Ionising photons escape ?

GRB 191004B  $z = 3.5053$



Credits: Vielhaire et al. 2020

Do galaxy simulation agree with GRB observations ?



Ongoing work on H2

**Numerical  
simulations**

**GRB observations**

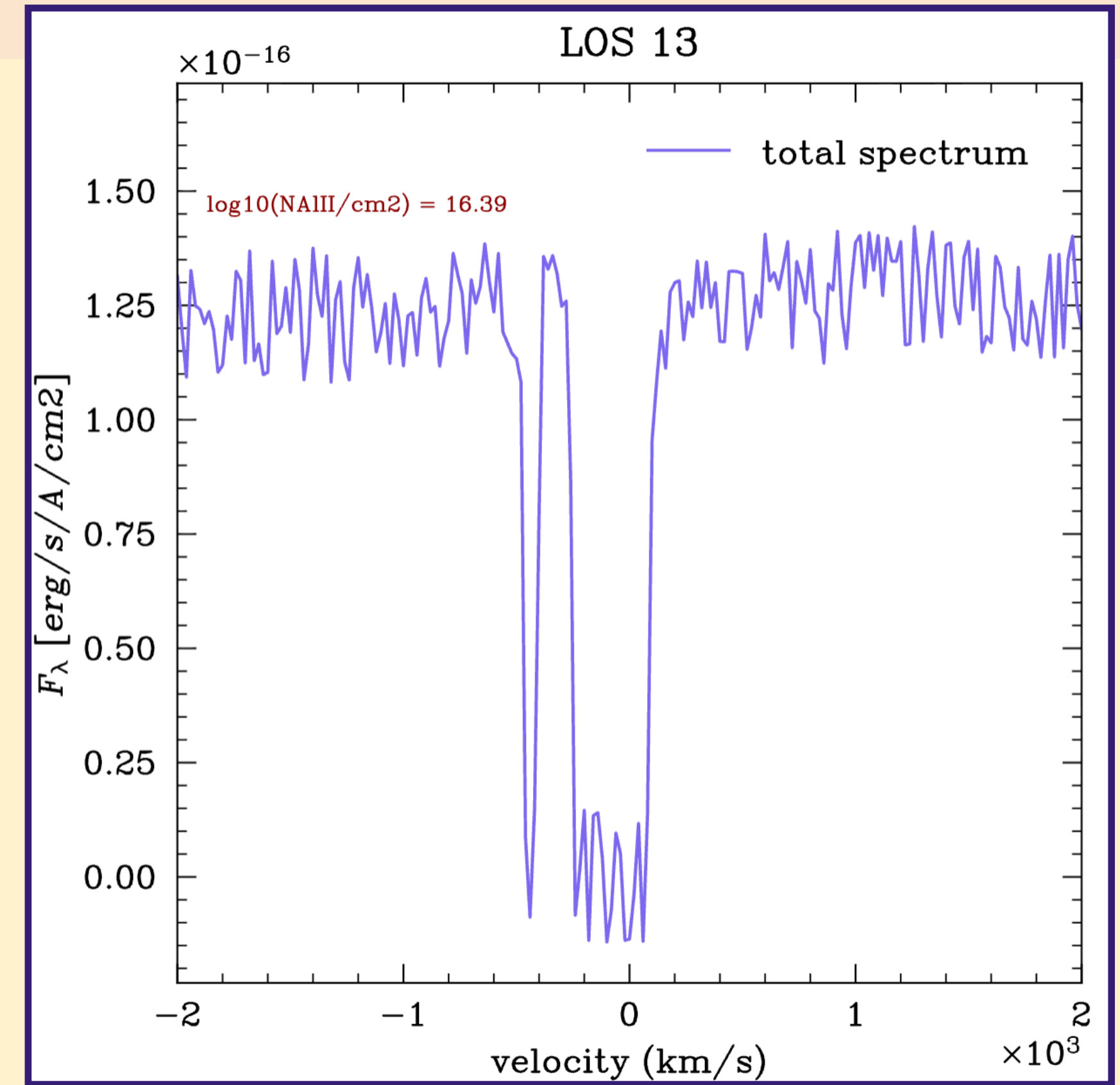
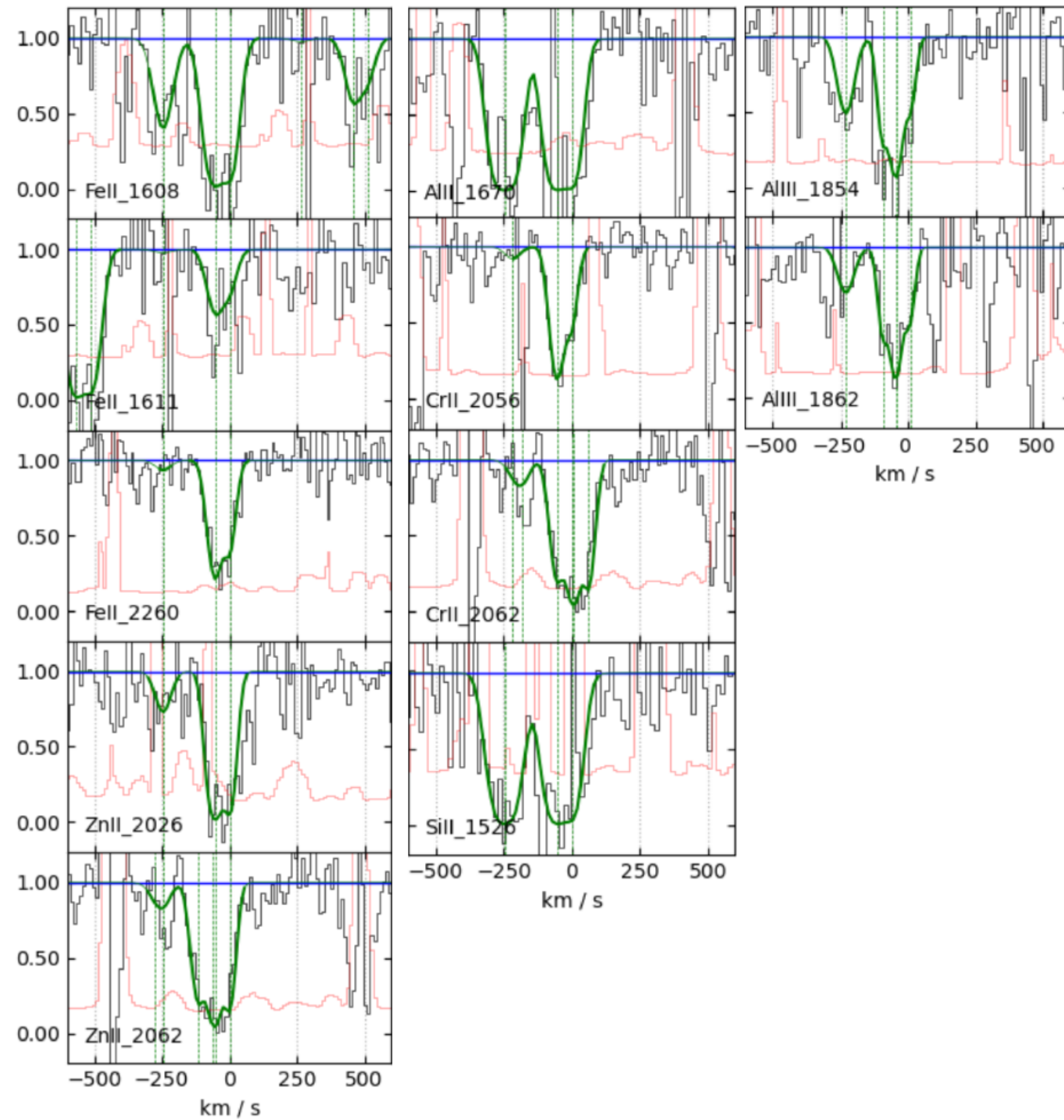
Can we use galaxy simulations to interpret GRB observations ?



Ongoing work on escape fractions and metals

# Metals

- SiII, AlII, CII, SII, CIV



Credits: Saccardi et al. 2025

**Thank you**