Exploring LGRB host galaxy through mock observations and radiative transfer

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

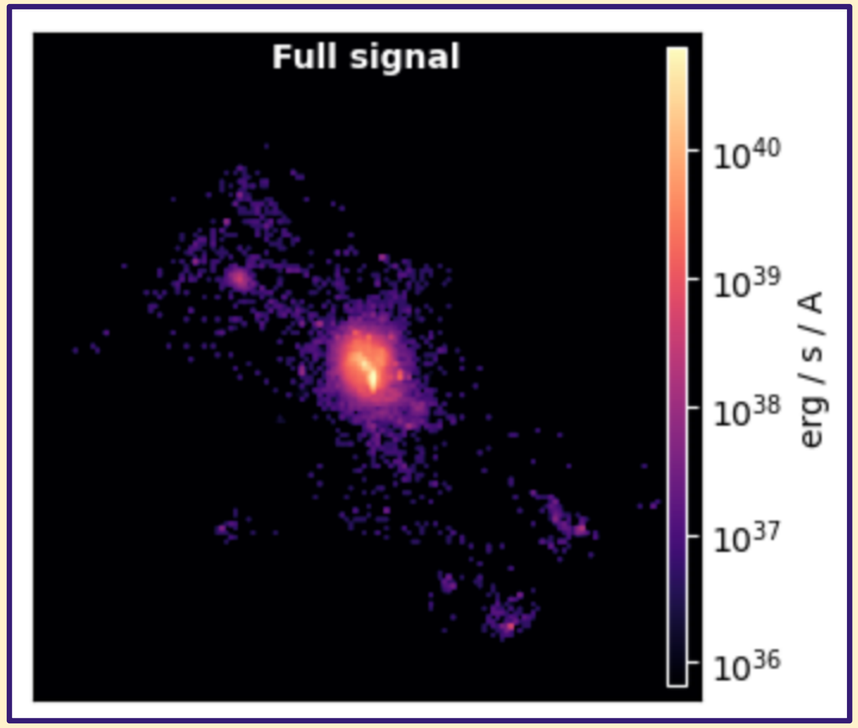
Supervisor: *Susanna Vergani (LUX)*

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

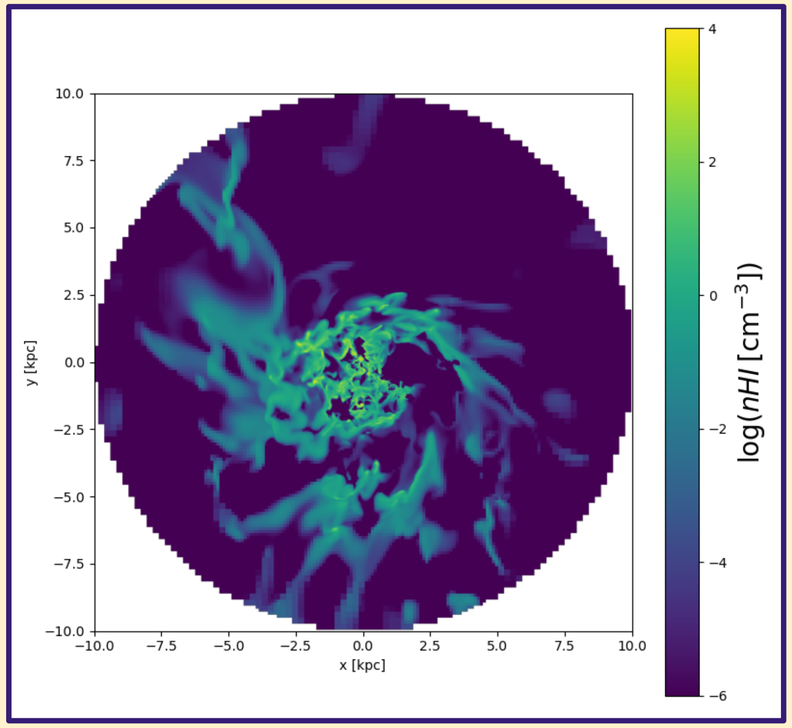
SF2A 2026 - Grenoble - 23/06/2026

Different gas phases in high-redshift galaxies

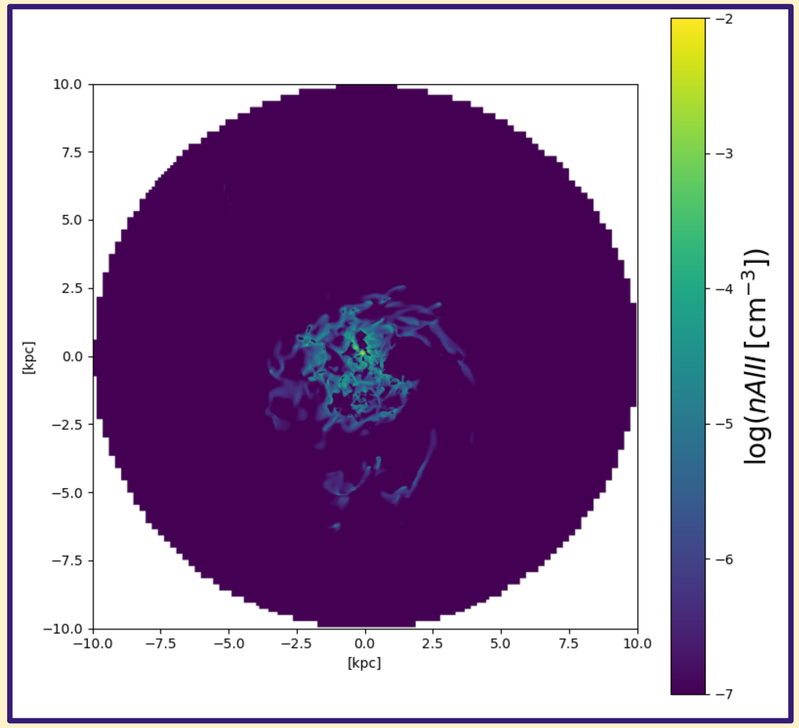
Ionised gas (Hα)



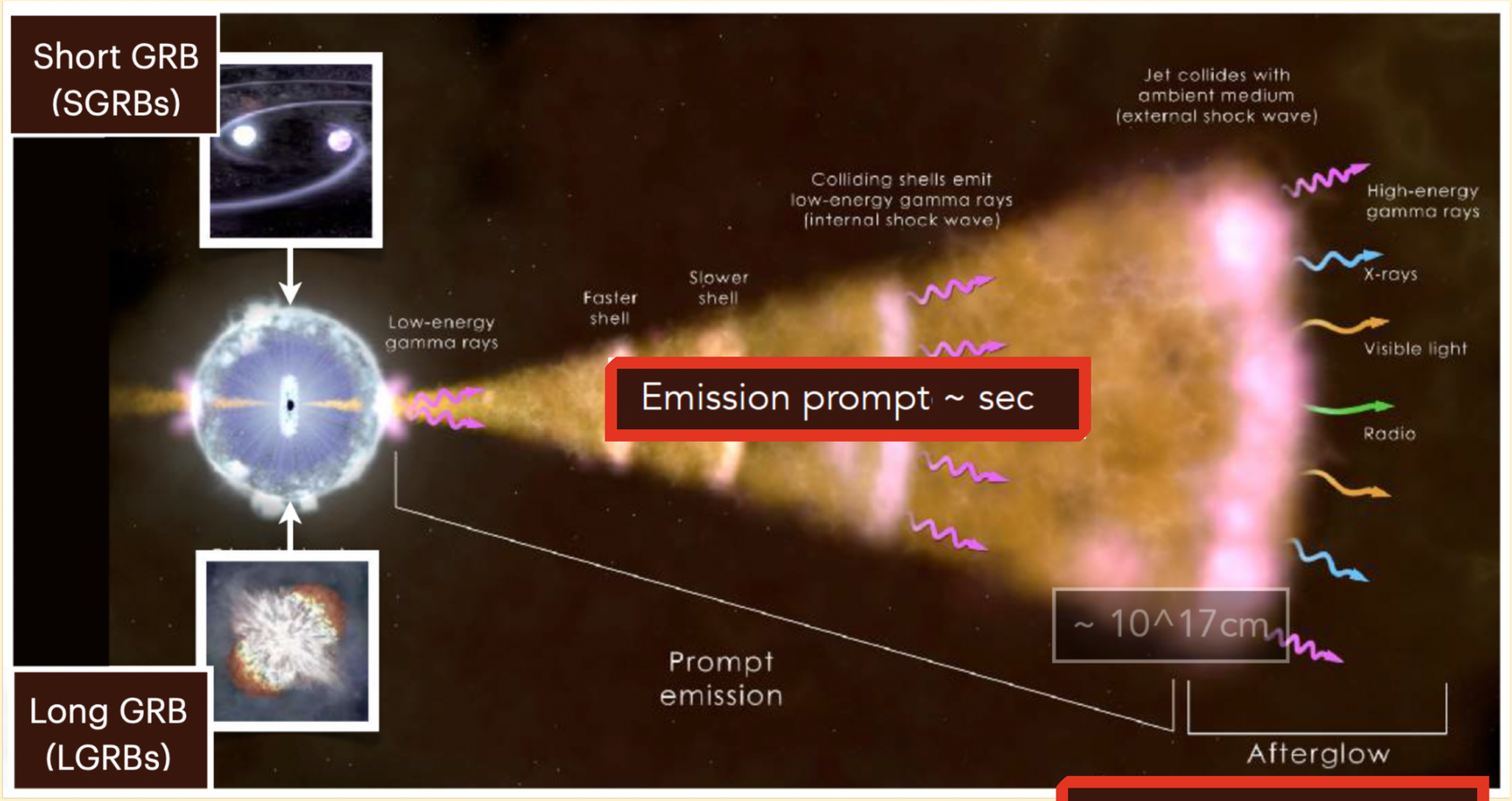
Neutral gas



Metals in the neutral gas



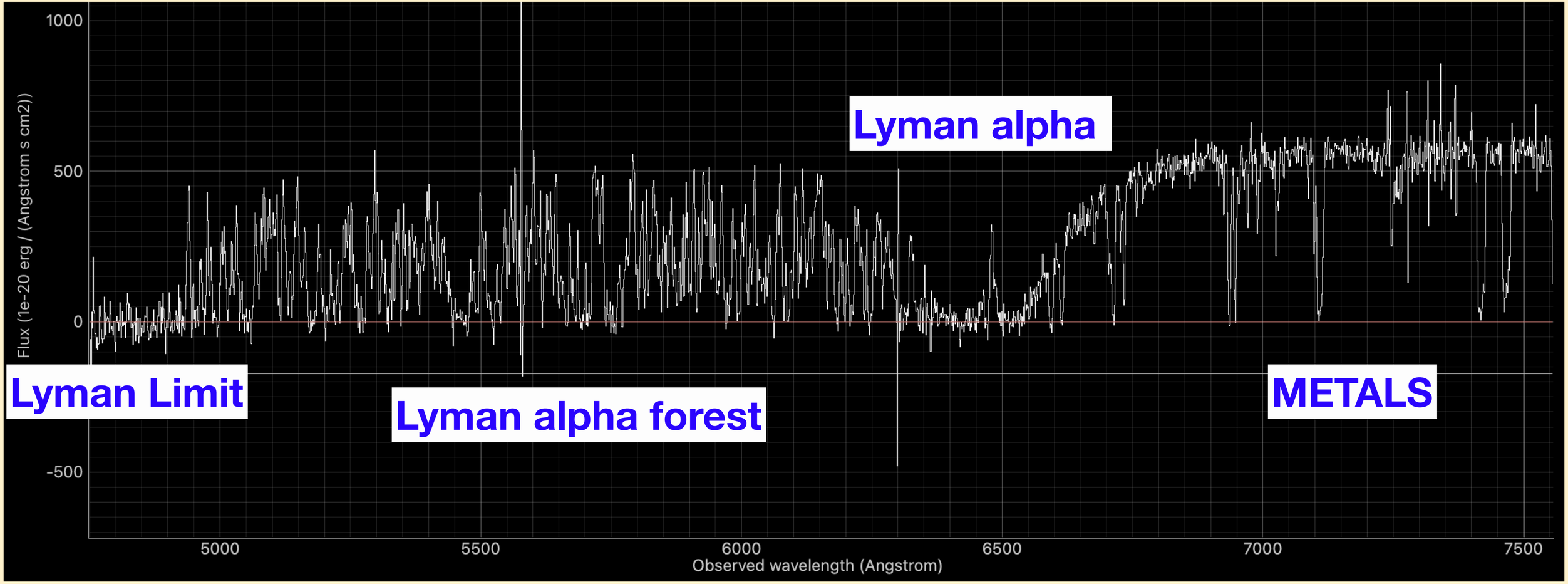
Gamma-Ray Bursts as background sources



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

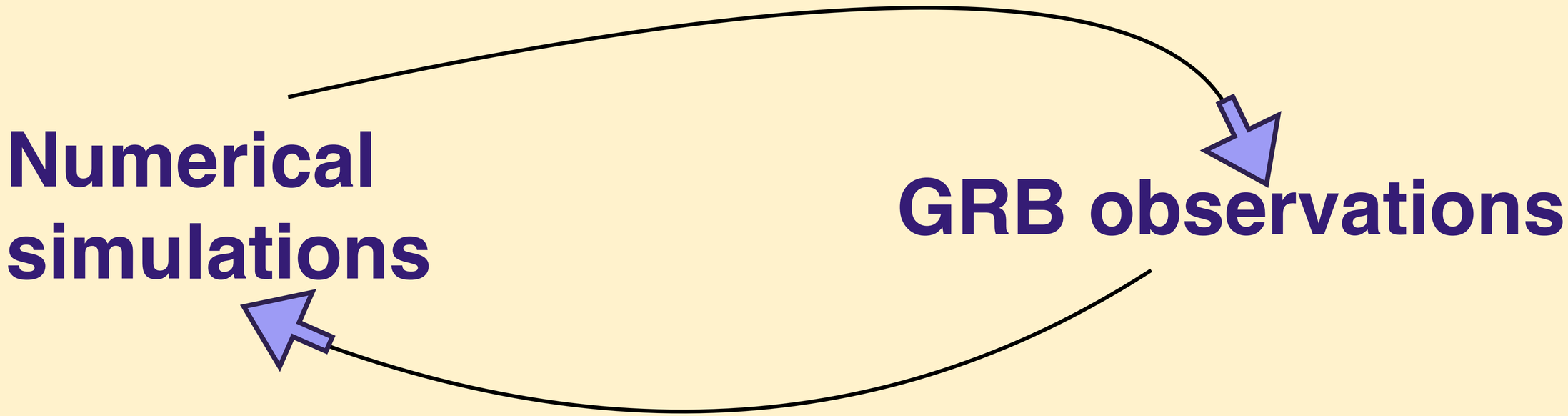
Afterglow emission
a few hours --> years
(depending on
the frequency range)

Example of GRB spectrum



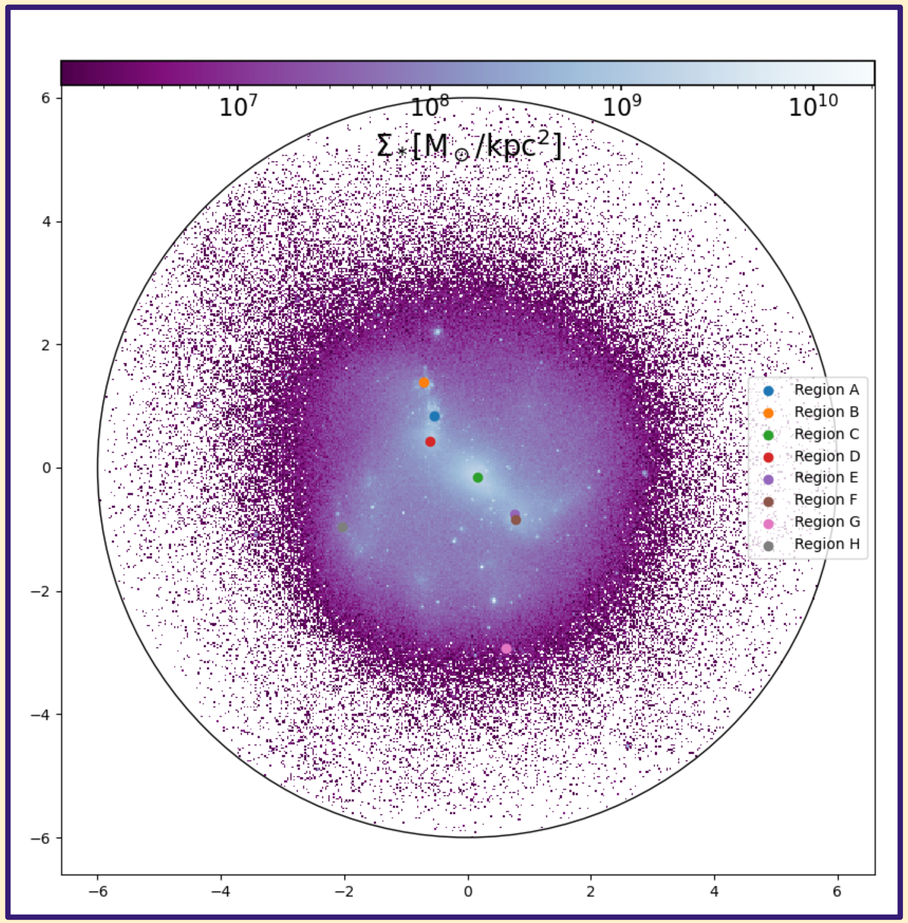
Absorption spectra from the afterglow's emission on the line of sight
*X-Shooter spectrum (**Stargate** collaboration)*

Do galaxy simulation agree with GRB observations ?



Can we use galaxy simulations to interpret GRB observations ?

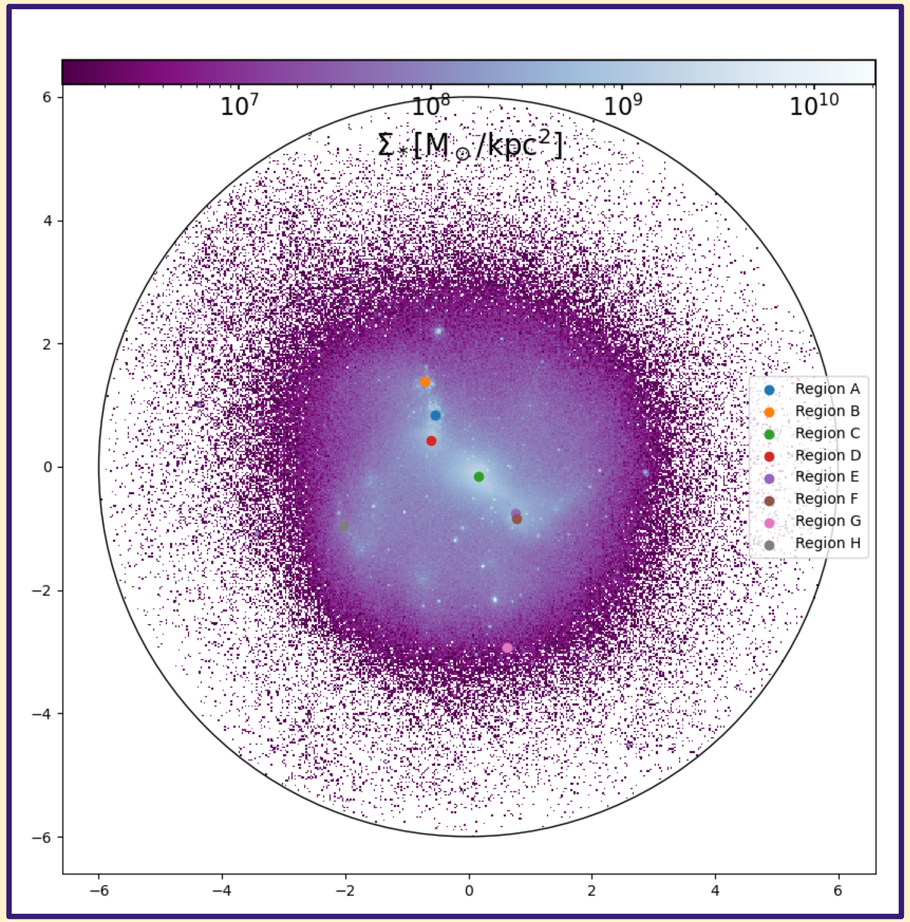
Zoom-in of LGRB galaxy host at z = 3



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)

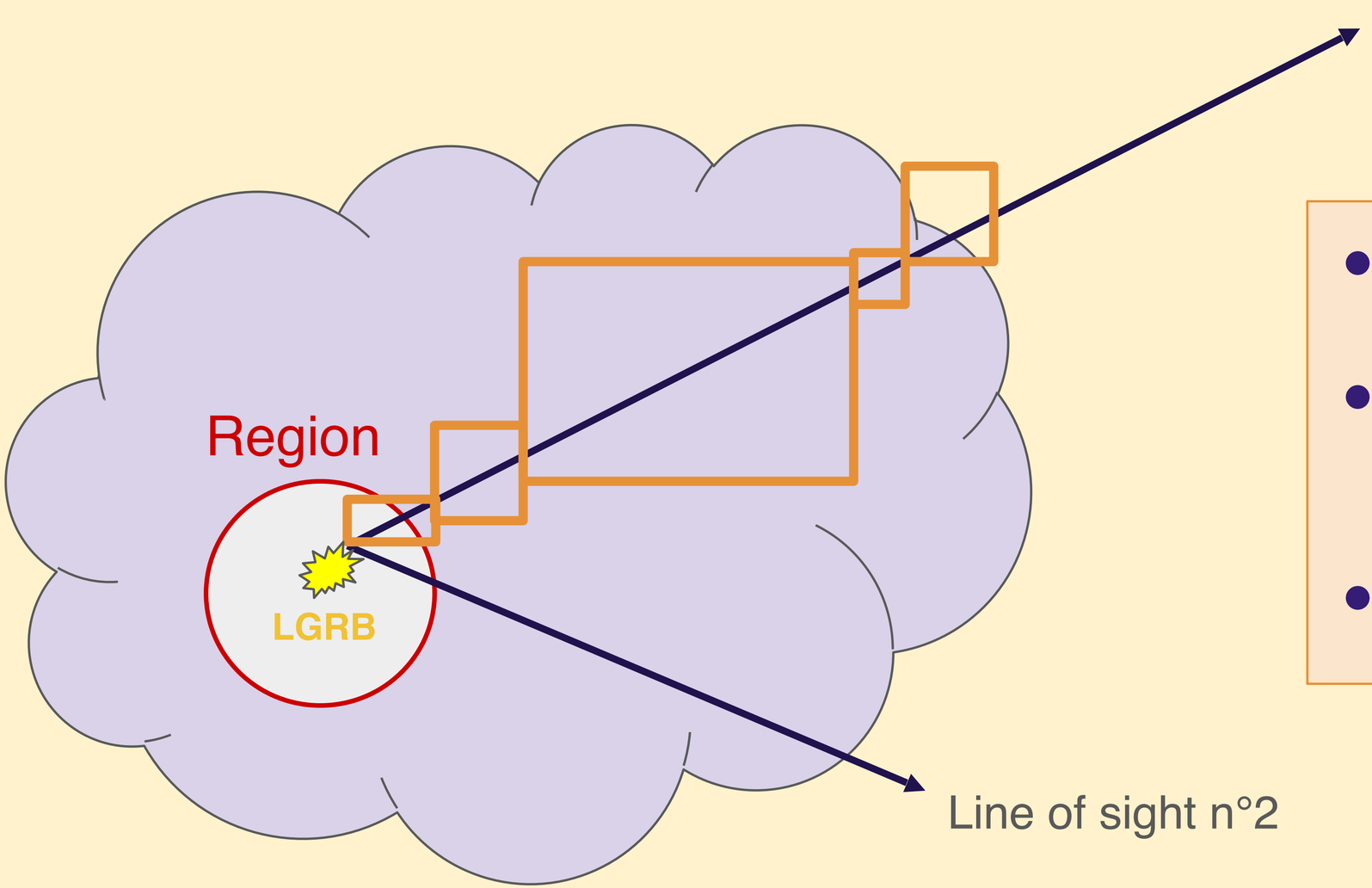
Zoom-in of LGRB galaxy host at z = 3



Site selection

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

Simulate the observations of 100 GRB lines of sights



- **NHI**
- **Travelled distance**
- **Optical depth**

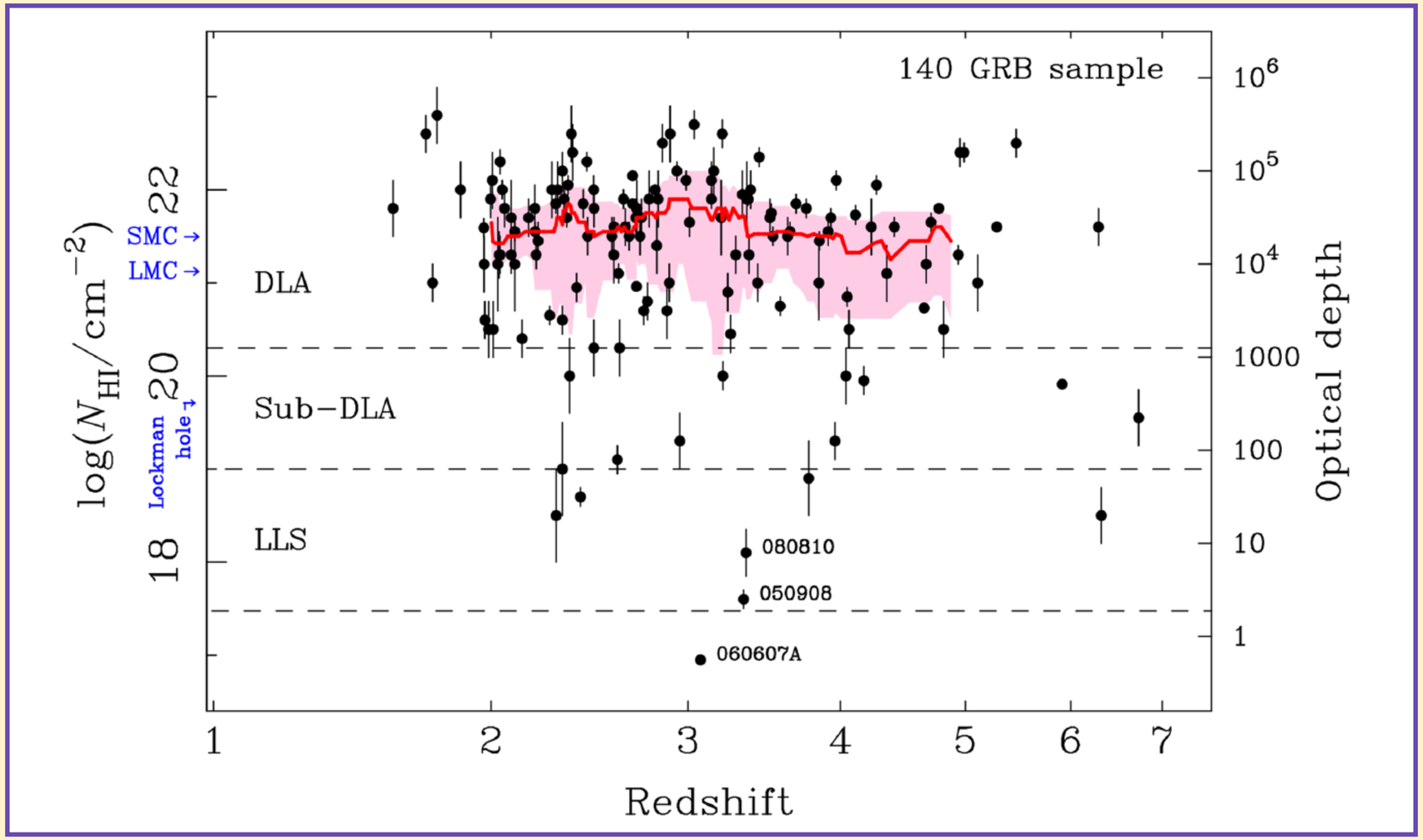
Project goals

Lyman alpha in absorption: HI Column densities

Lyman alpha in emission and escape of ionising photons

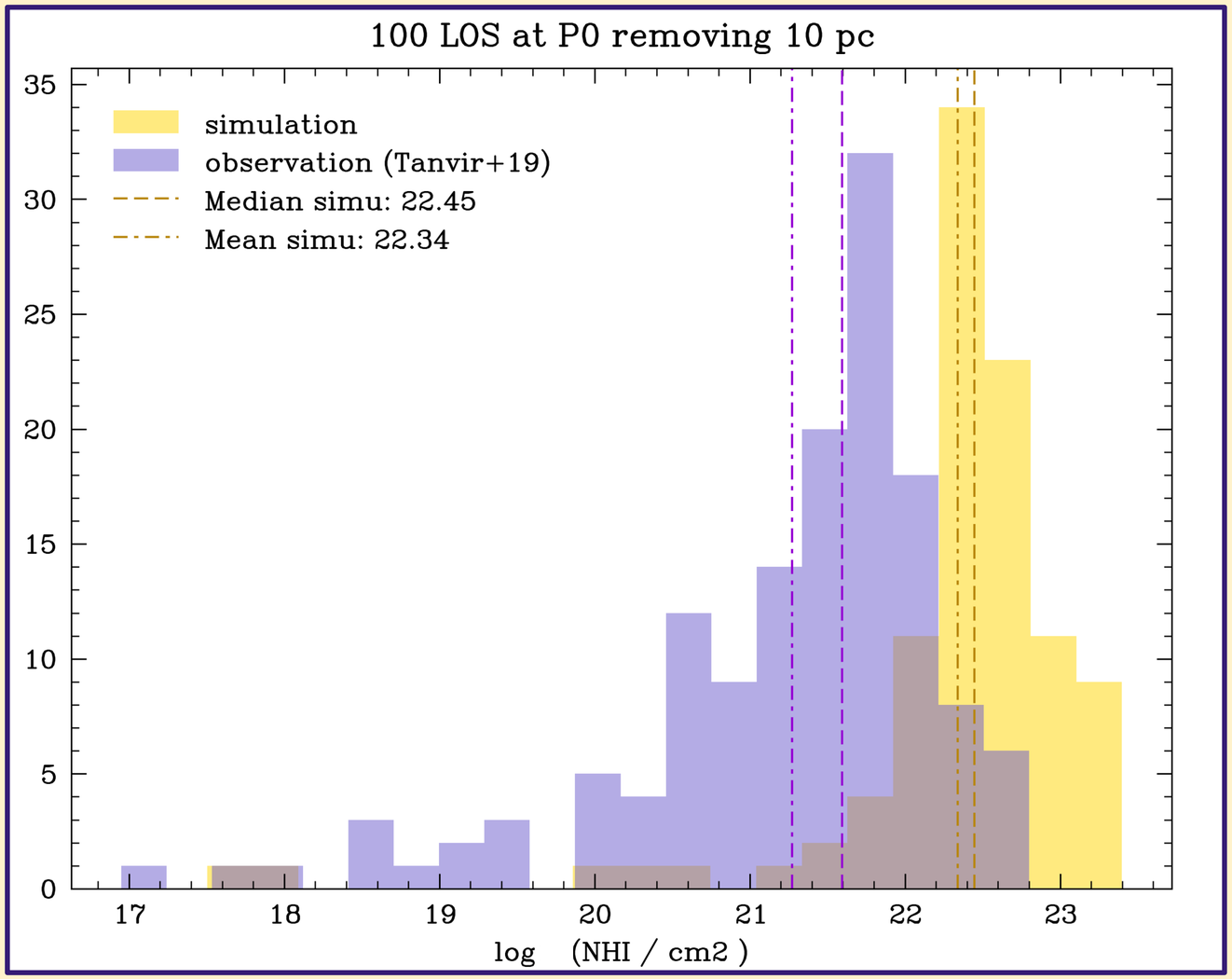
Absorption from metal: kinematics and column densities

Observation results on neutral Hydrogen



Tanvir et al. 2019

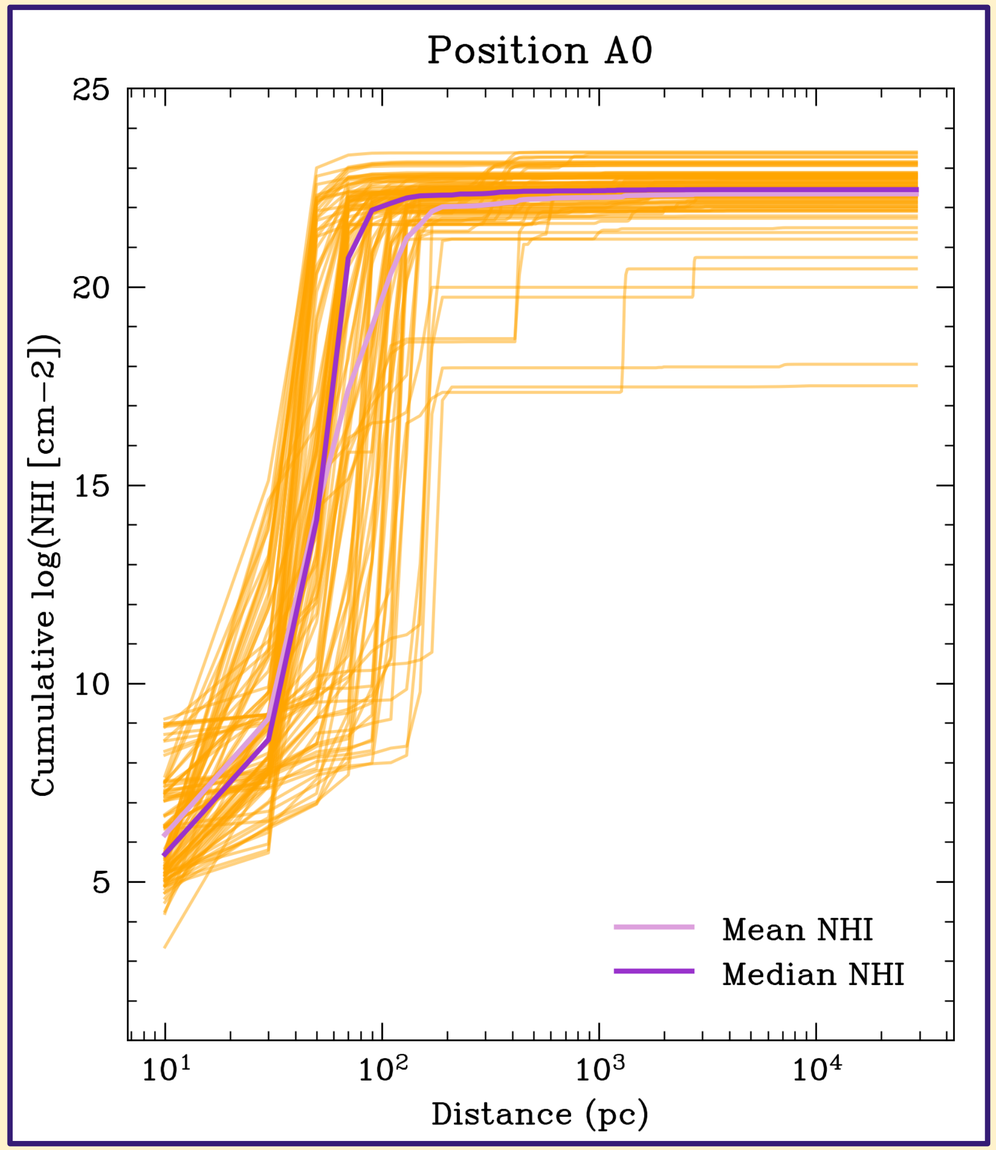
Simulation results on neutral Hydrogen



Possible explanations

- GRB ionisation
- Missing H2
- Problems from simulation

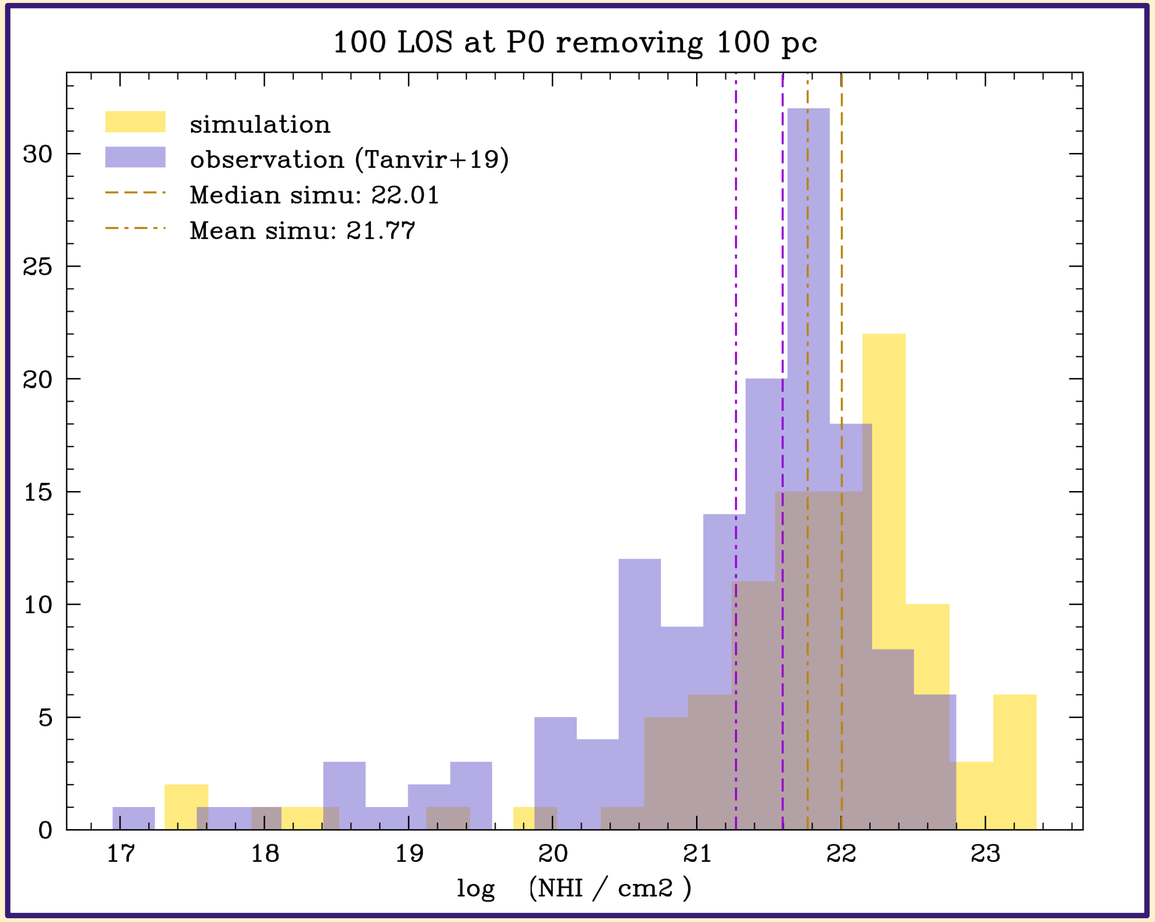
Simulation results on neutral Hydrogen

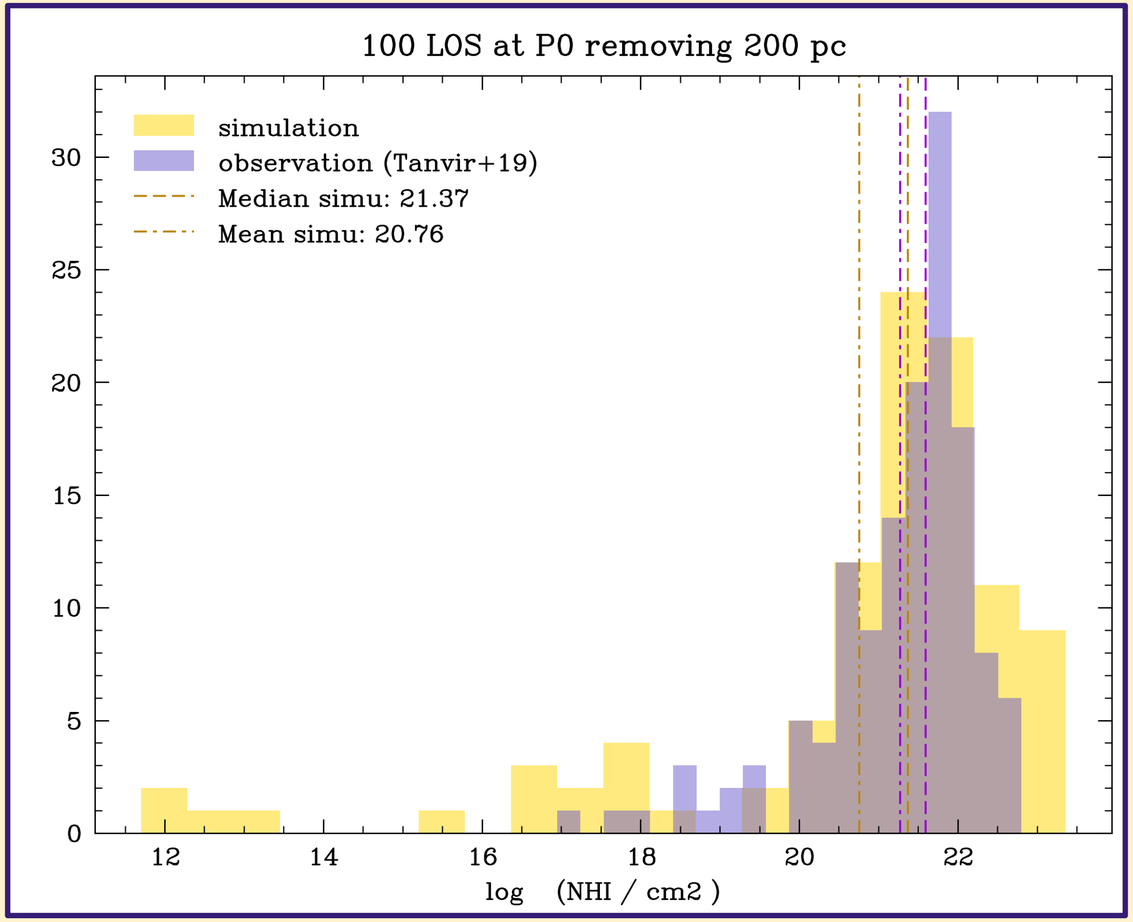


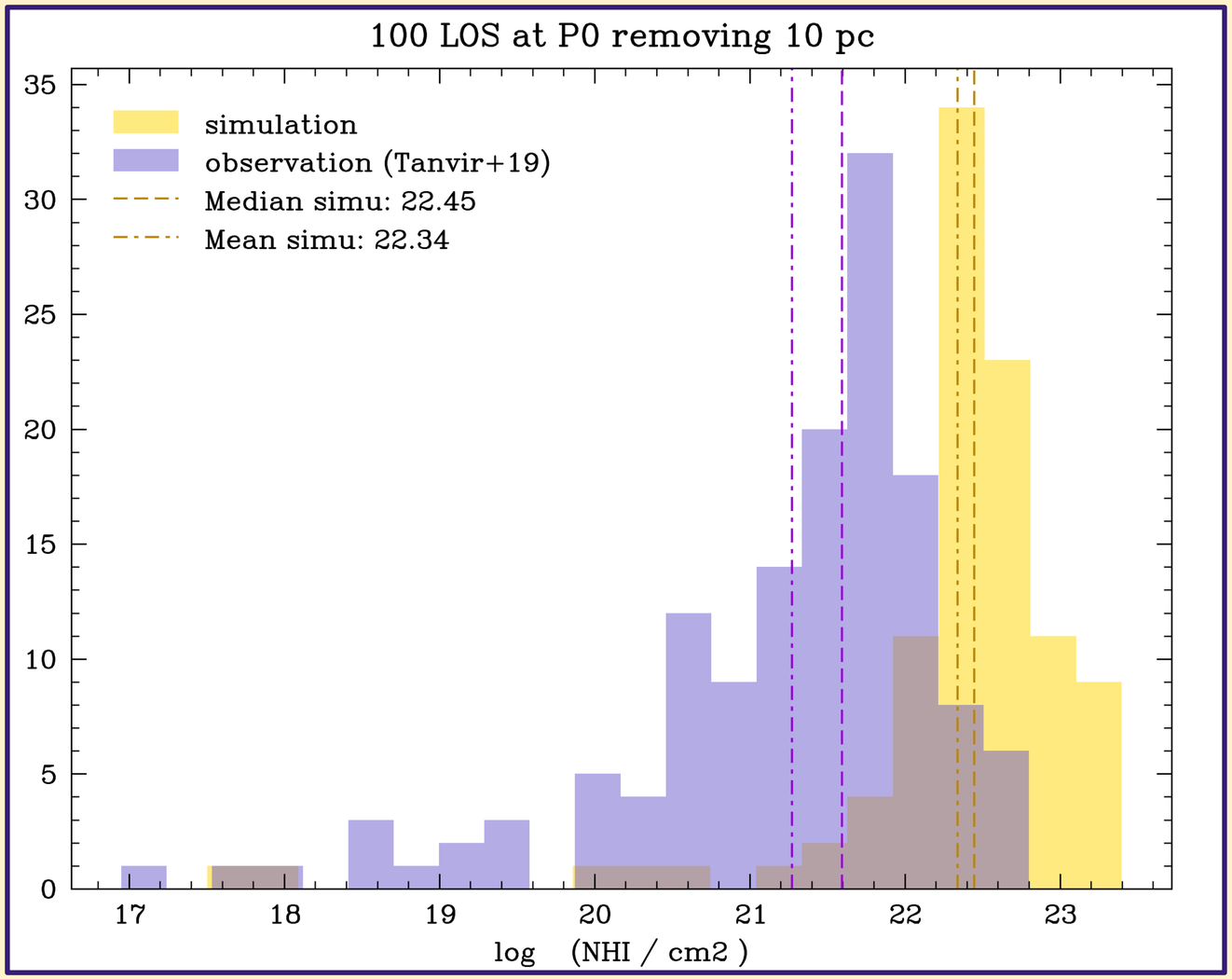
Possible explanations

- GRB ionisation
- Missing H2
- Problems from simulation

GRB ionisation ?

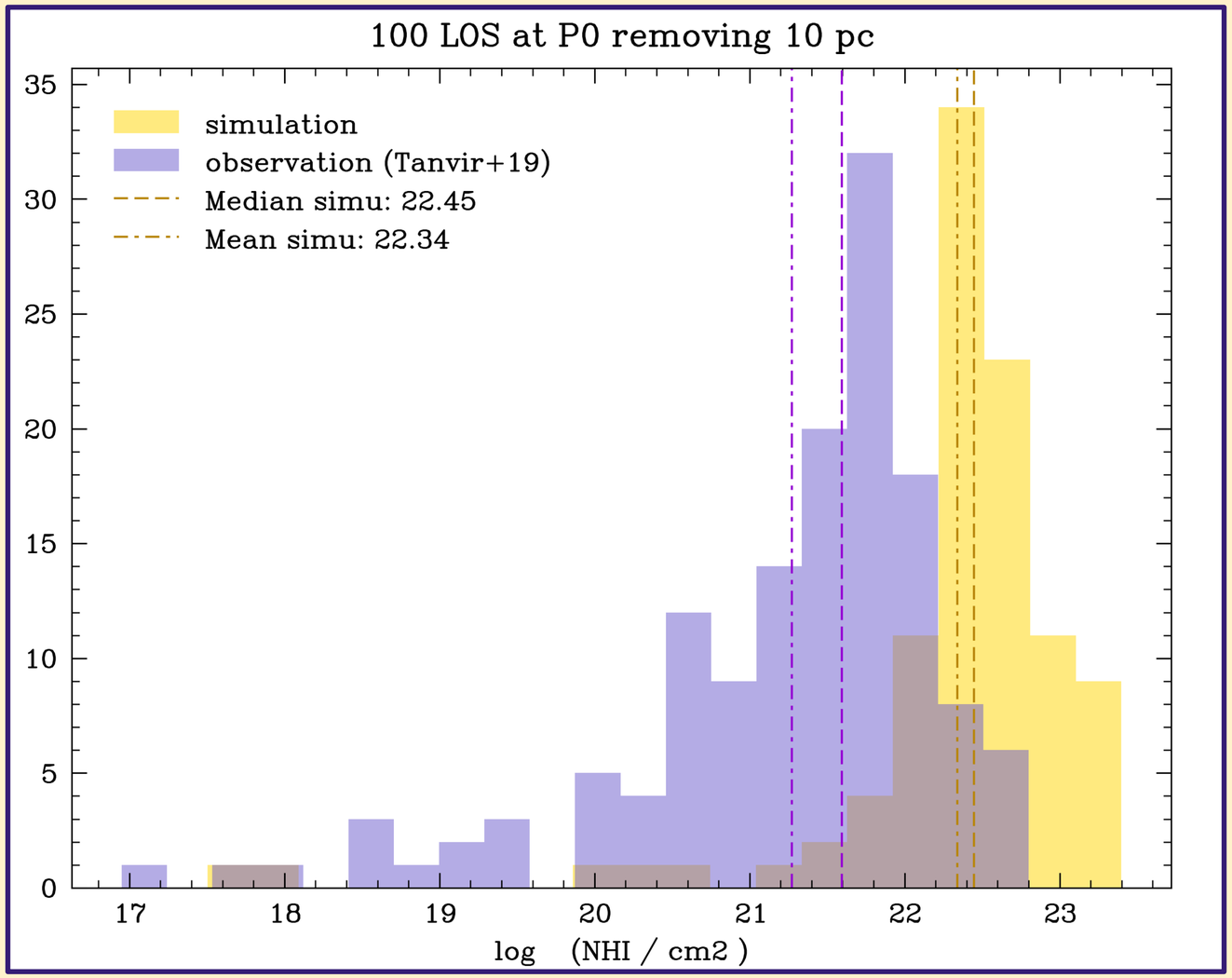






Possible explanations

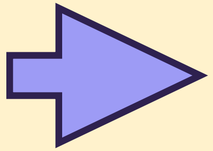
- GRB ionisation
- **Missing H2**
- Problems from simulation



Possible explanations

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

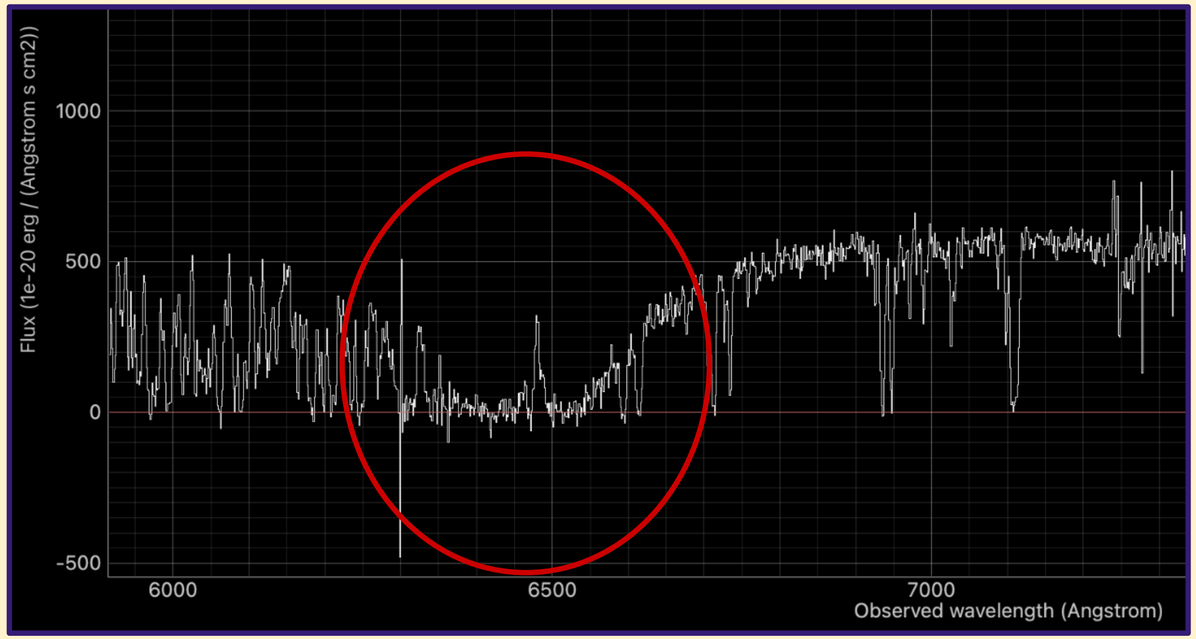
Lyman alpha in absorption: HI Column densities



Lyman alpha in emission and escape of ionising photons

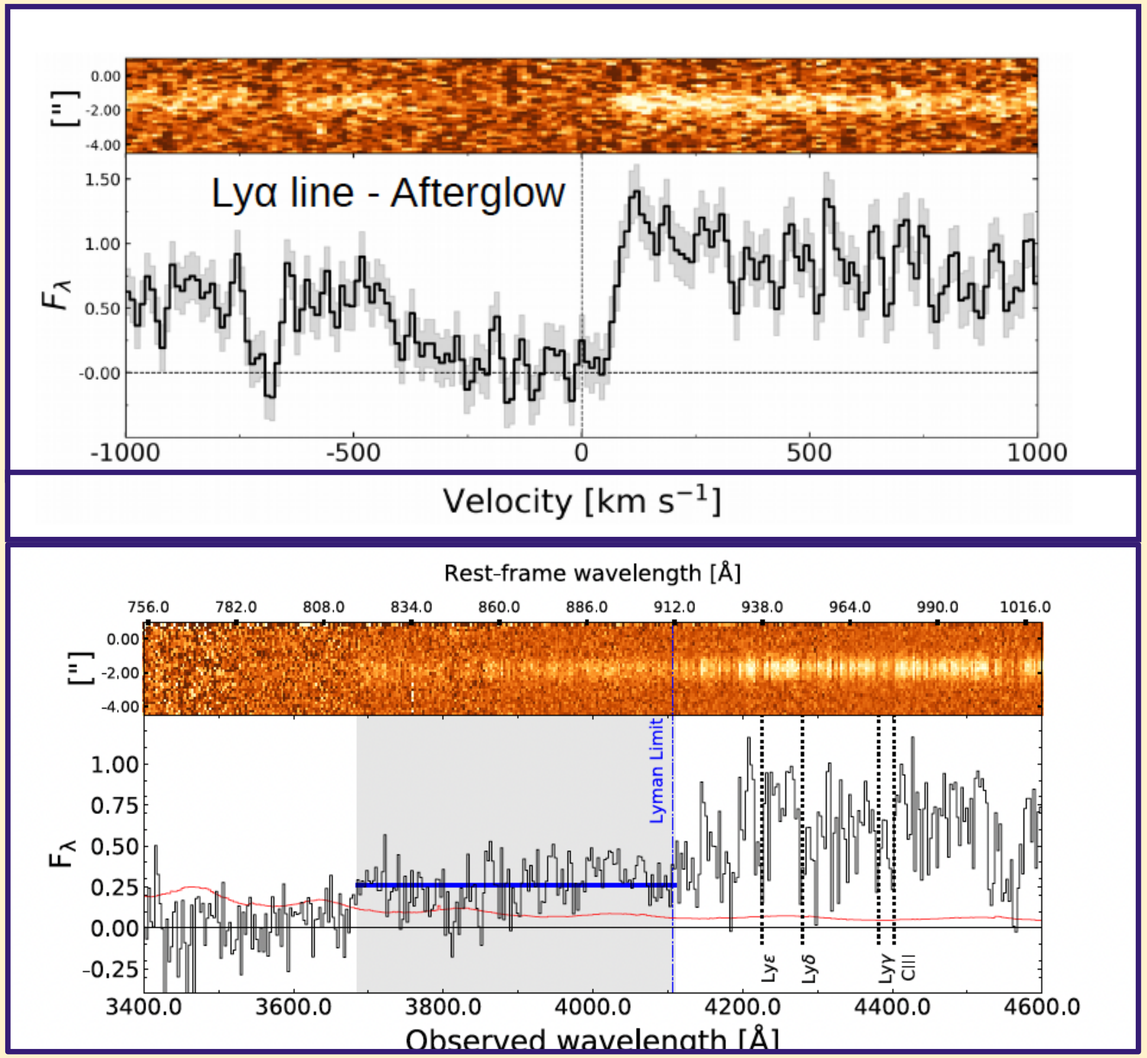
Absorption from metal: kinematics and column densities

Two distinct observation cases



*X-Shooter spectrum (**Stargate** collaboration)*

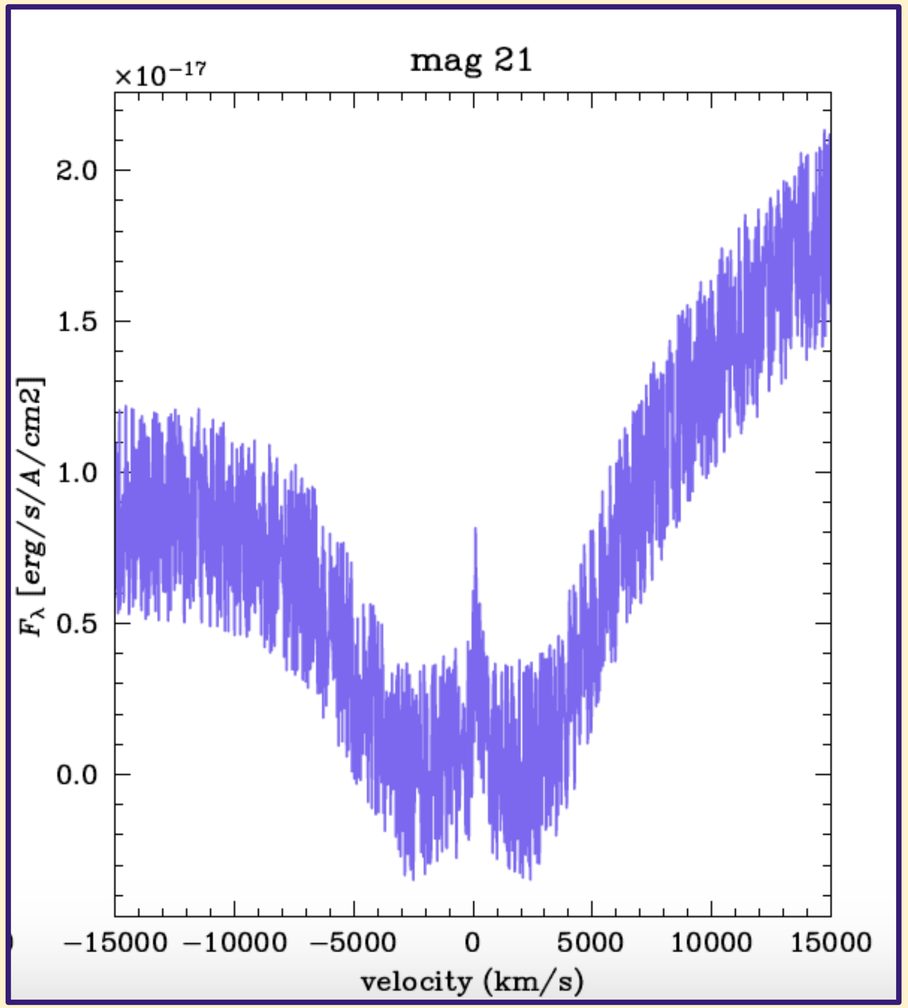
GRB 191004B z = 3.5053



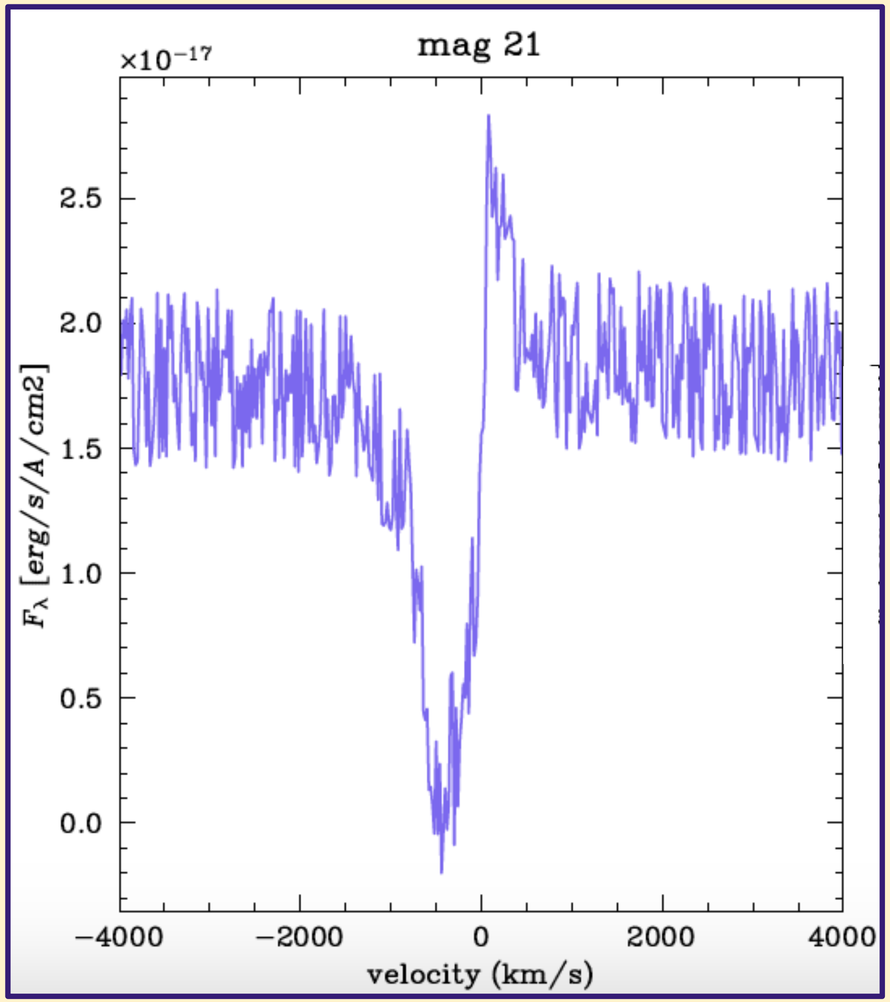
Credits: Vielfaure et al. 2020

Two distinct cases reproduced by simulations

log(NHI [cm-2]) = 22.08

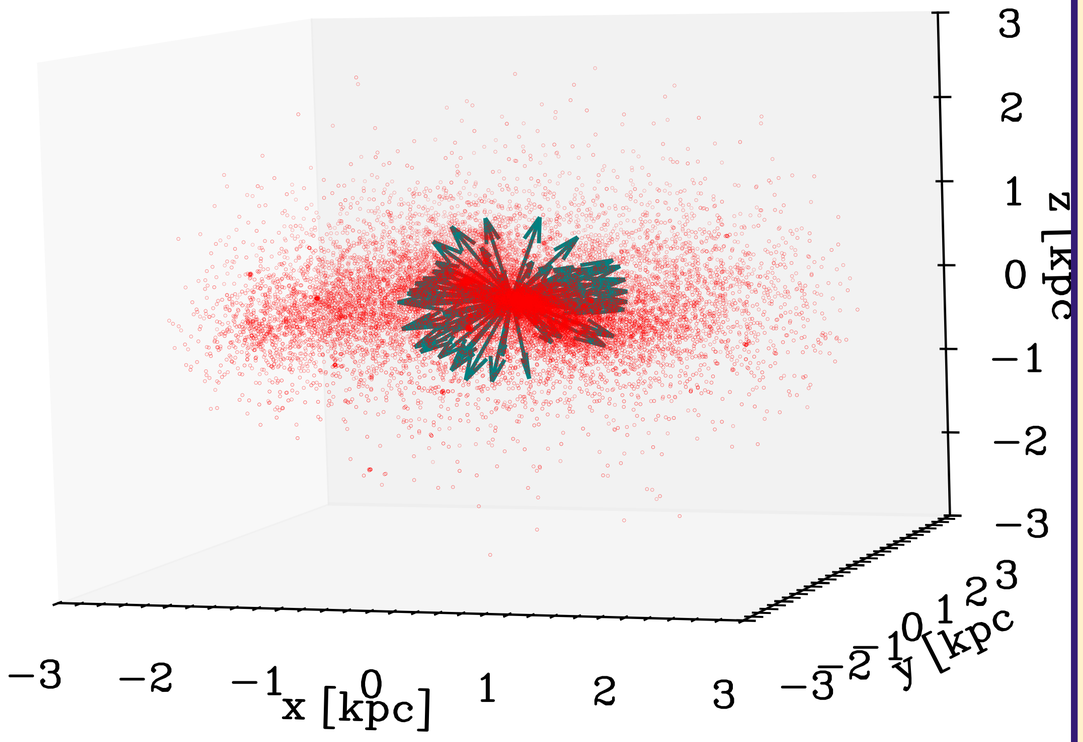


log(NHI [cm-2]) = 16.63

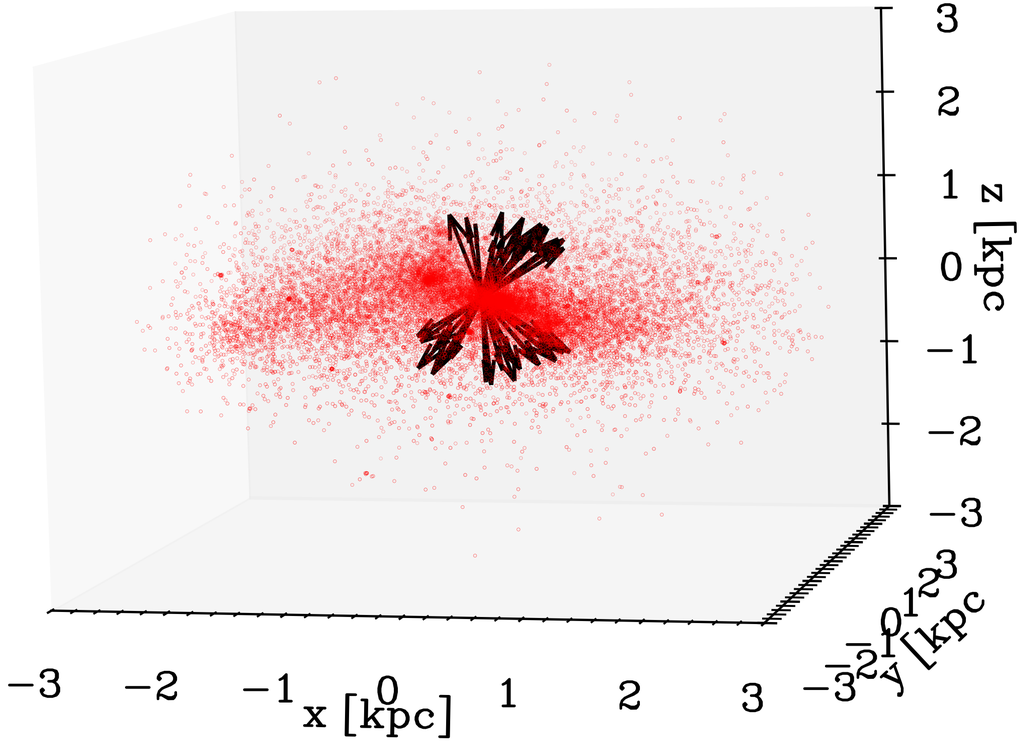


Implication on the viewing angle of the galaxy

Not in 16 < log(NHI/[cm2]) < 17

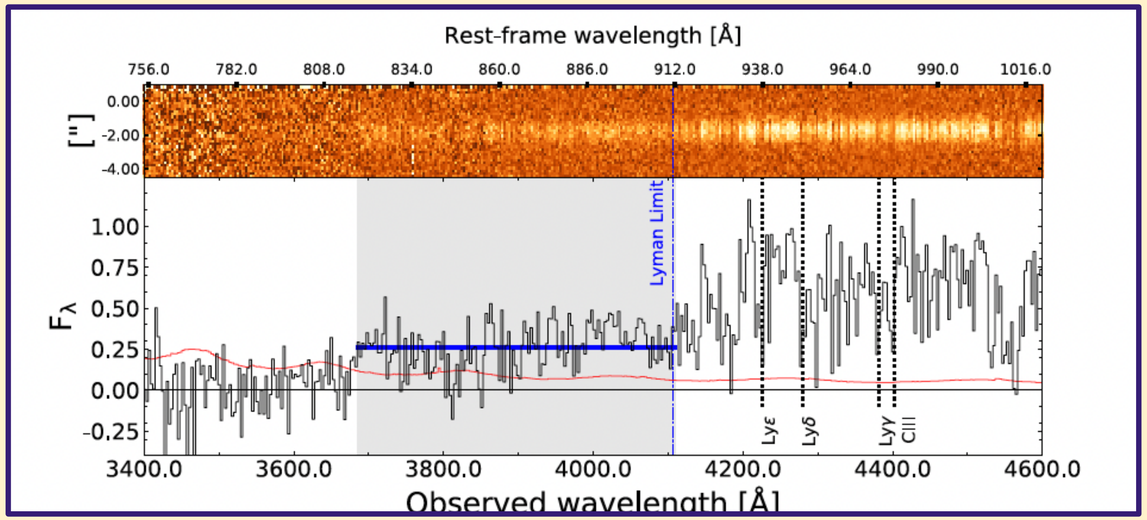


16 < log(NHI/[cm2]) < 17

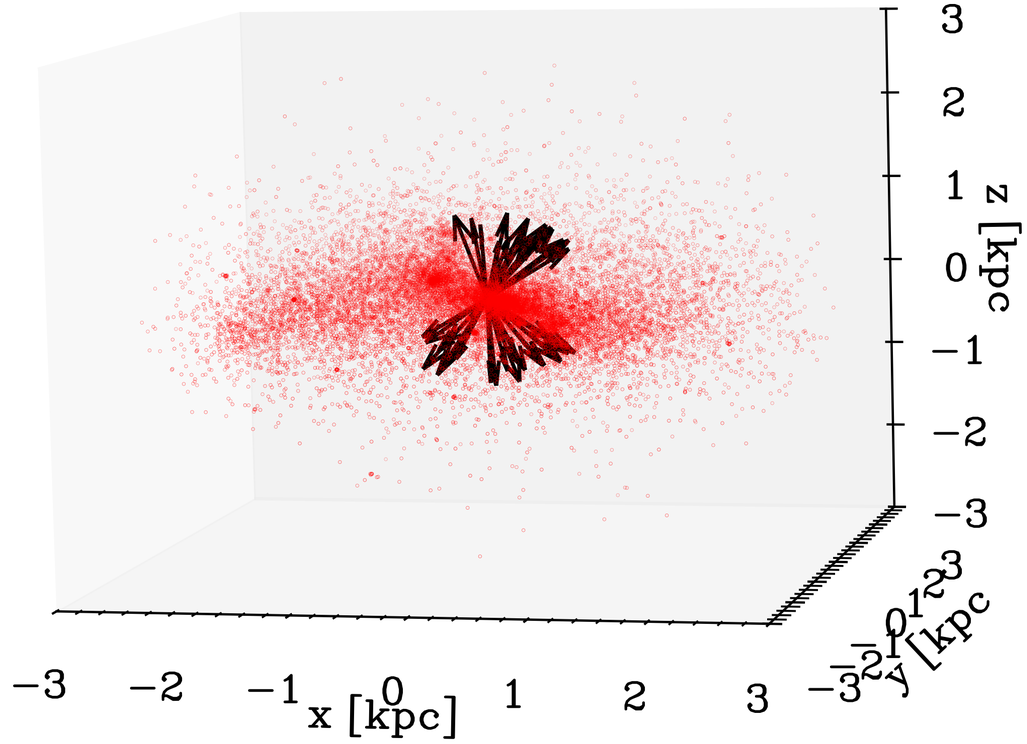


Ionising photons escape ?

GRB 191004B z = 3.5053



16 < log(NHI/[cm2]) < 17



Credits: Vielfaure et al. 2020

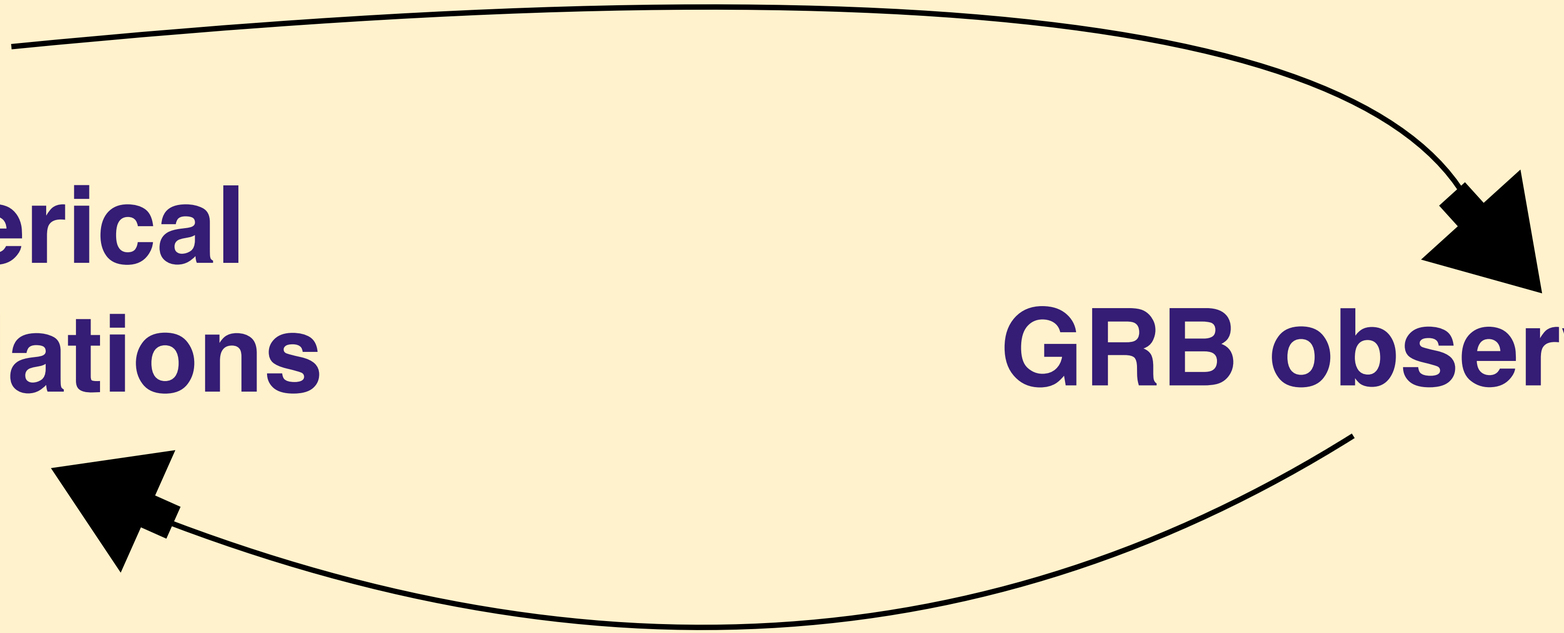
Lyman alpha in absorption: HI Column densities

Lyman alpha in emission and escape of ionising photons

Absorption from metal: kinematics and column densities

Do galaxy simulation agree with GRB observations ?

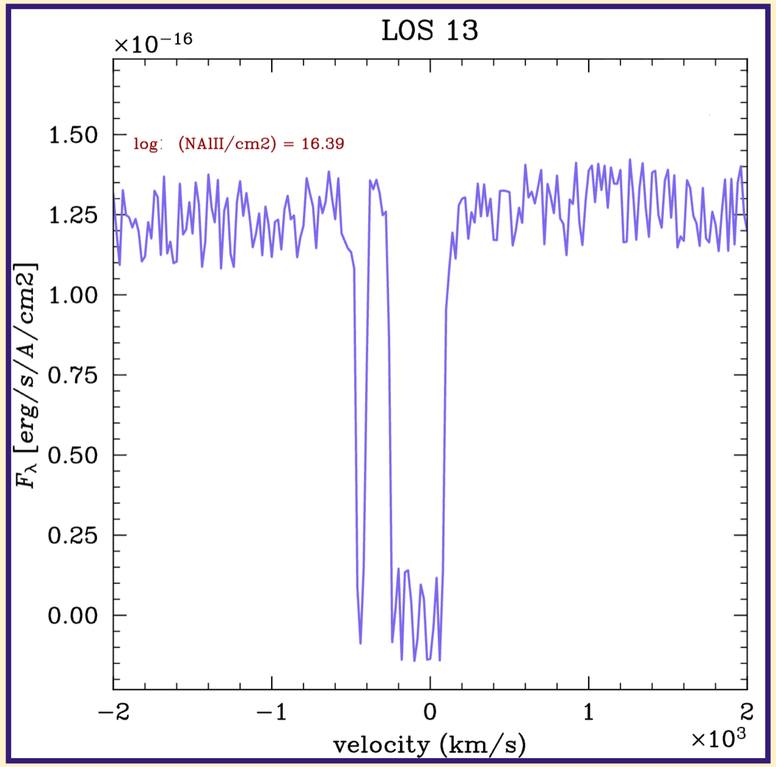
Ongoing work on H2

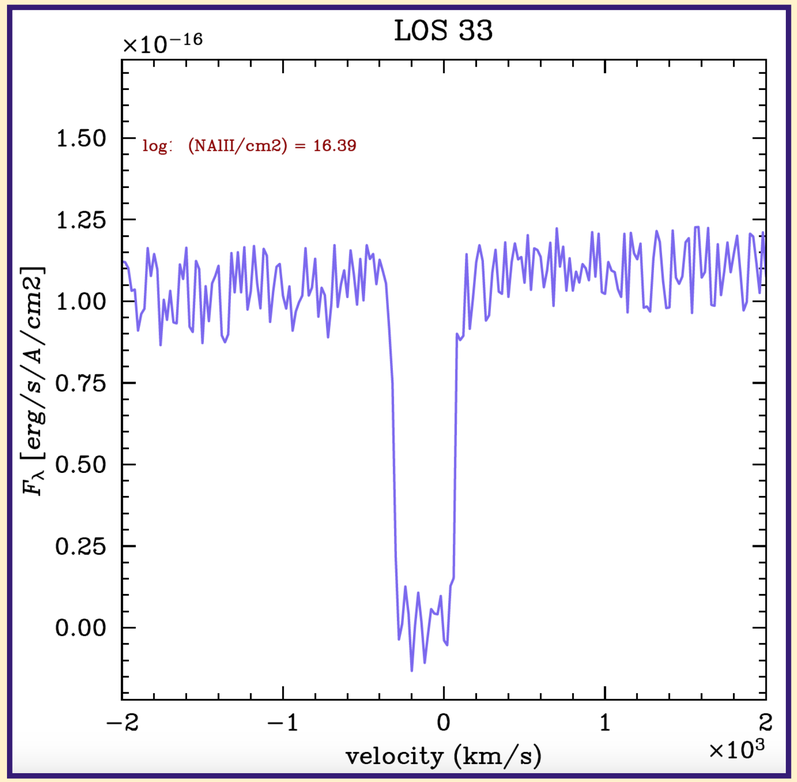


Can we use galaxy simulations to interpret GRB observations ?

Ongoing work on escape fractions and metals

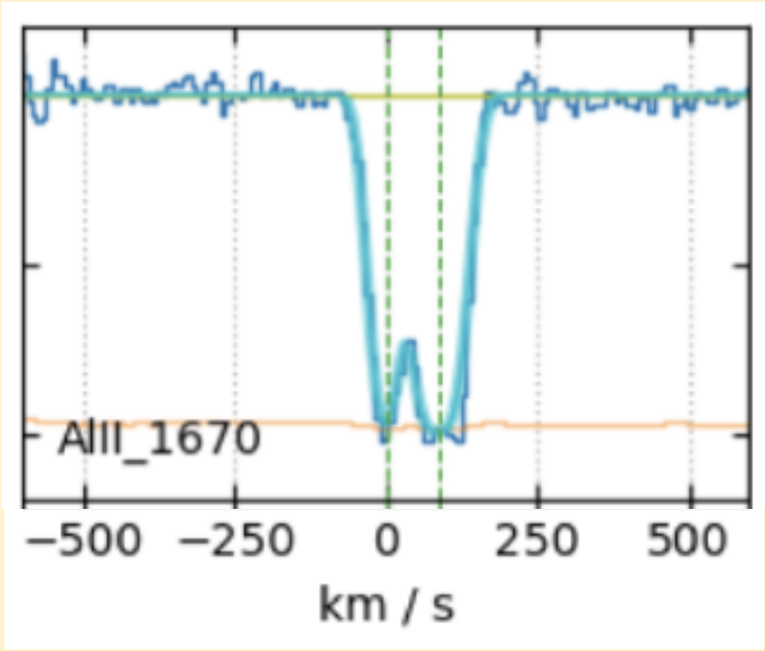
Preliminary results on Al II





Metals

- SiII, AlII, CII, SII, CIV



Credits: Pugliese et al. 2024

Thank you