Unveiling the Circumgalactic Medium of High-z Galaxies with Spatially-Resolved Lyα Radiative Transfer Modeling

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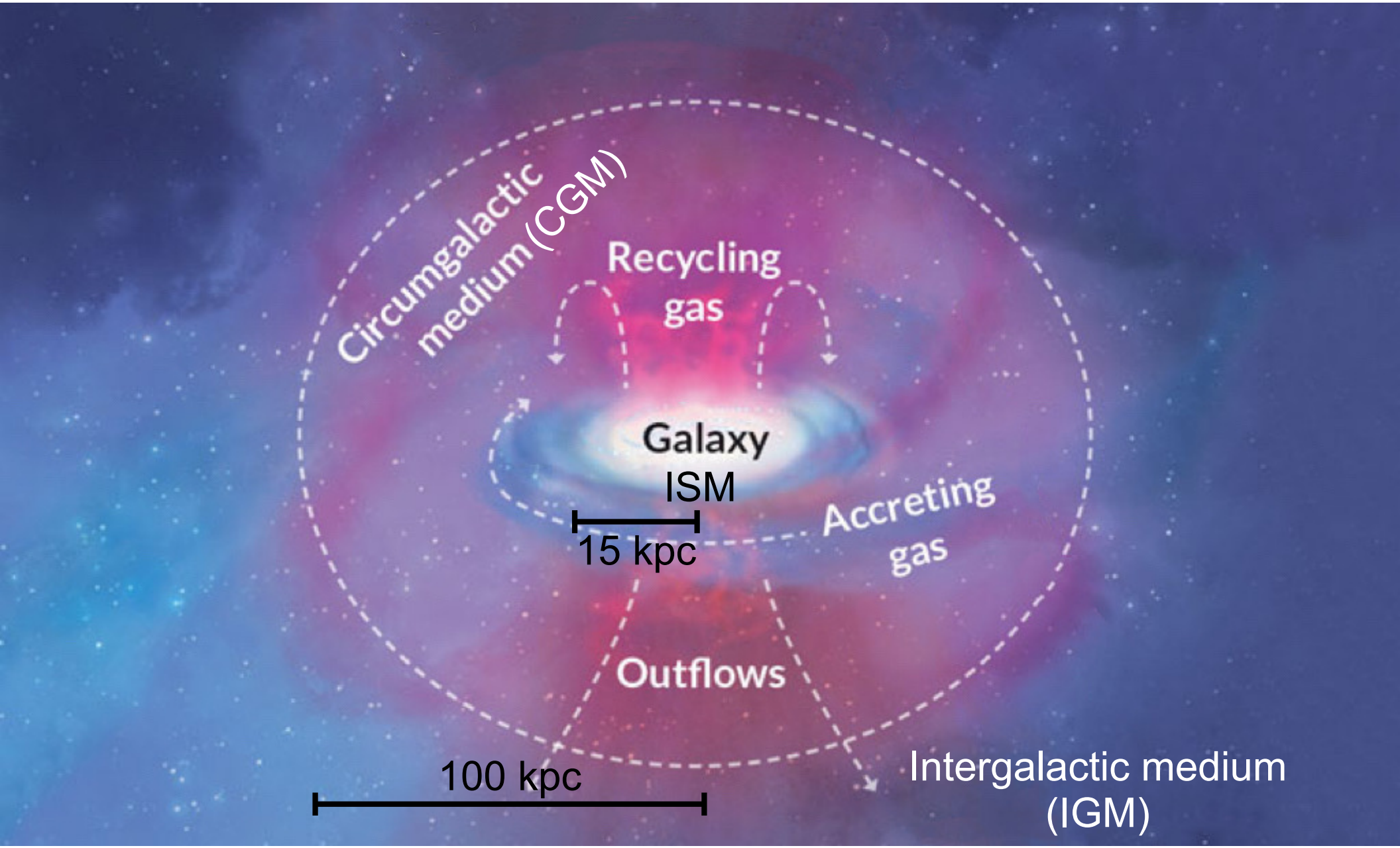
Escape of Lyman radiation
from galactic labyrinths
Apr 18, 2023

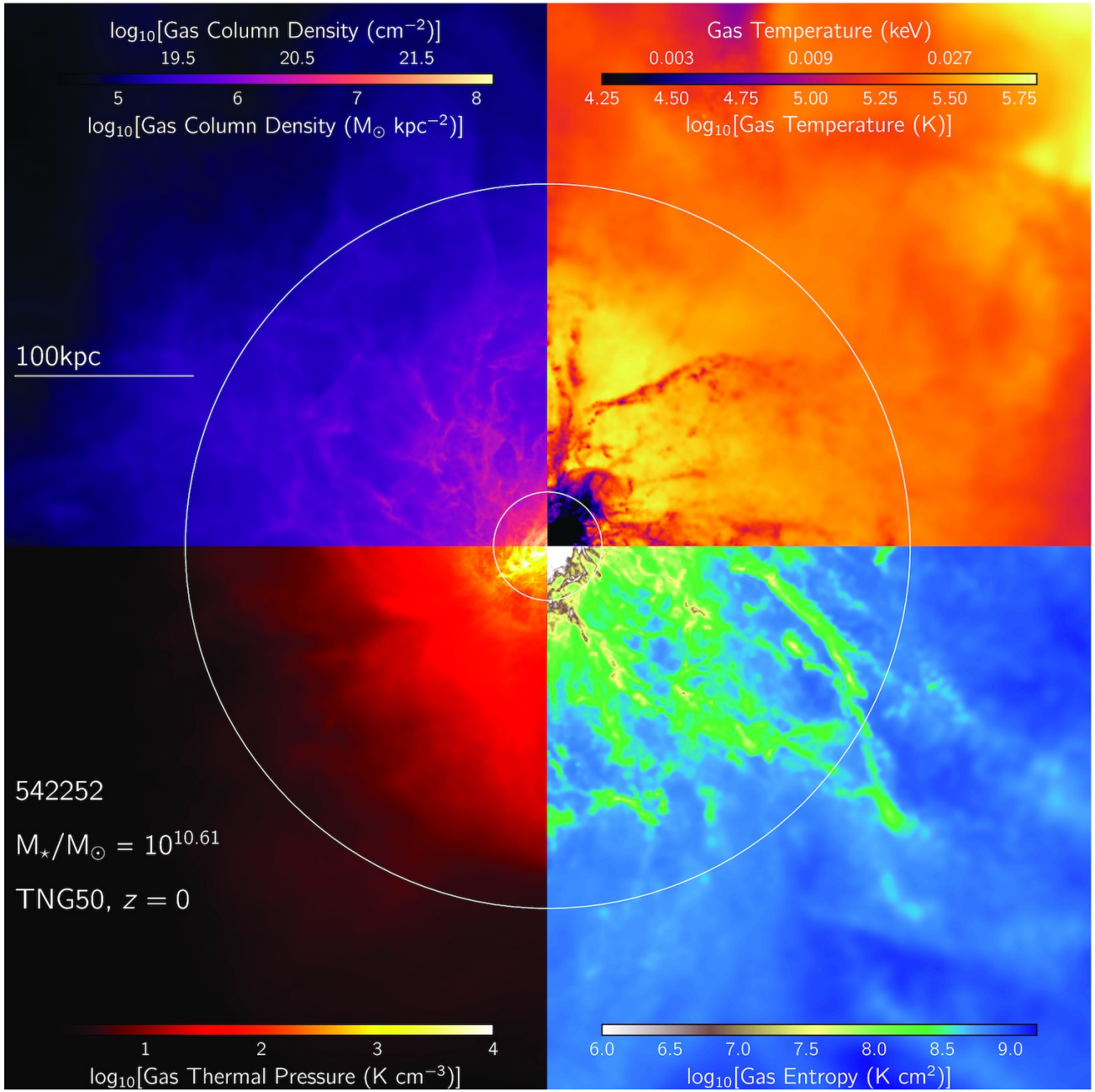
Collaborators: Prof. Chuck Steidel (Caltech), Prof. Dawn Erb (UWM), Prof. Max Gronke (MPA), Dr. Yuguang Chen (UC Davis) et al.

Galactic Environment



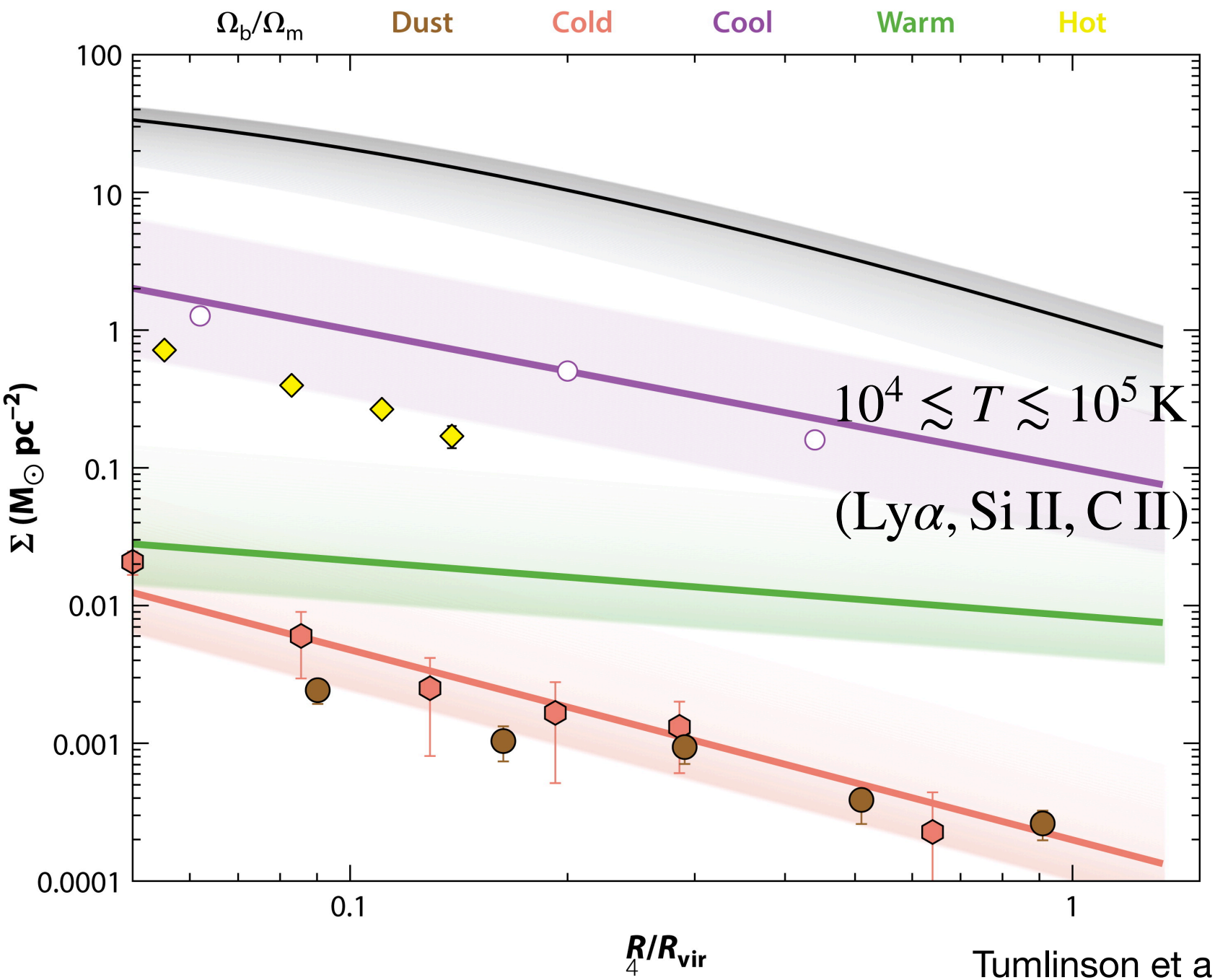
Credit: C. Chang & M.S. Peeples

CGM is Multiphase & Clumpy



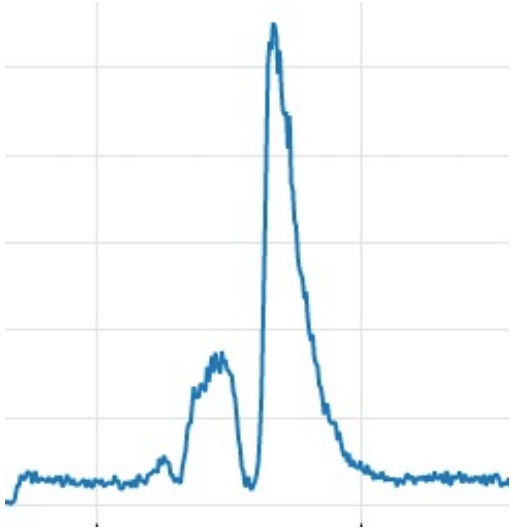
Ramesh et al. (2022)

Cool Gas Dominates the Mass of the CGM



Tumlinson et al. (2017)

Probing the Cool Gas via Lyα RT Modeling

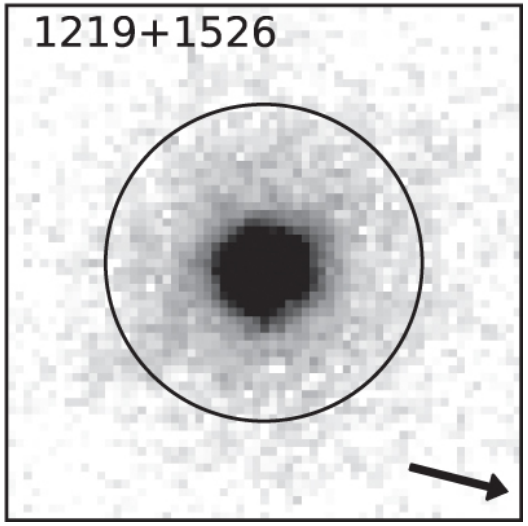


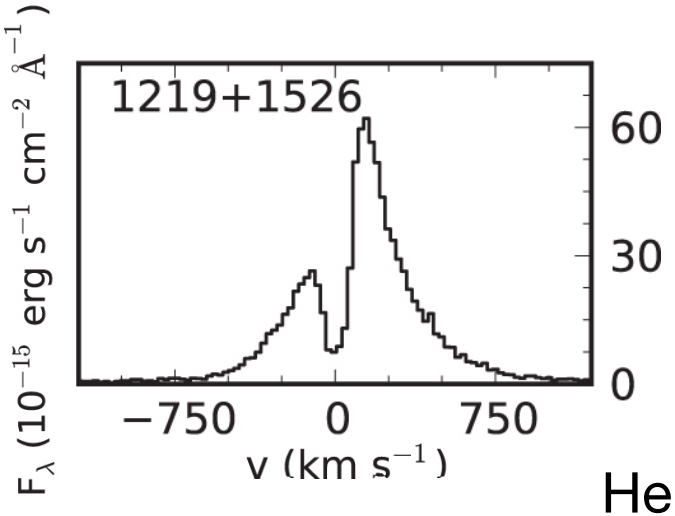
RT modeling

Cool gas properties

(RT = Radiative Transfer)

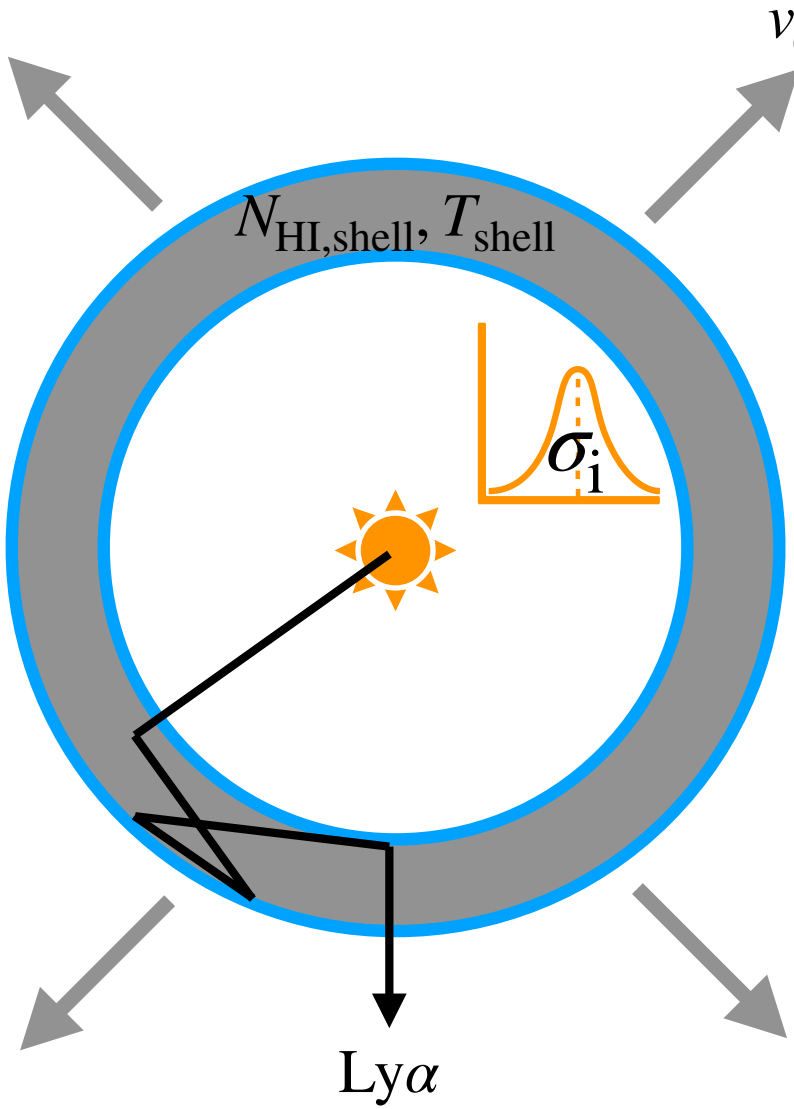
GP1219+1526 (z = 0.2), HST/COS

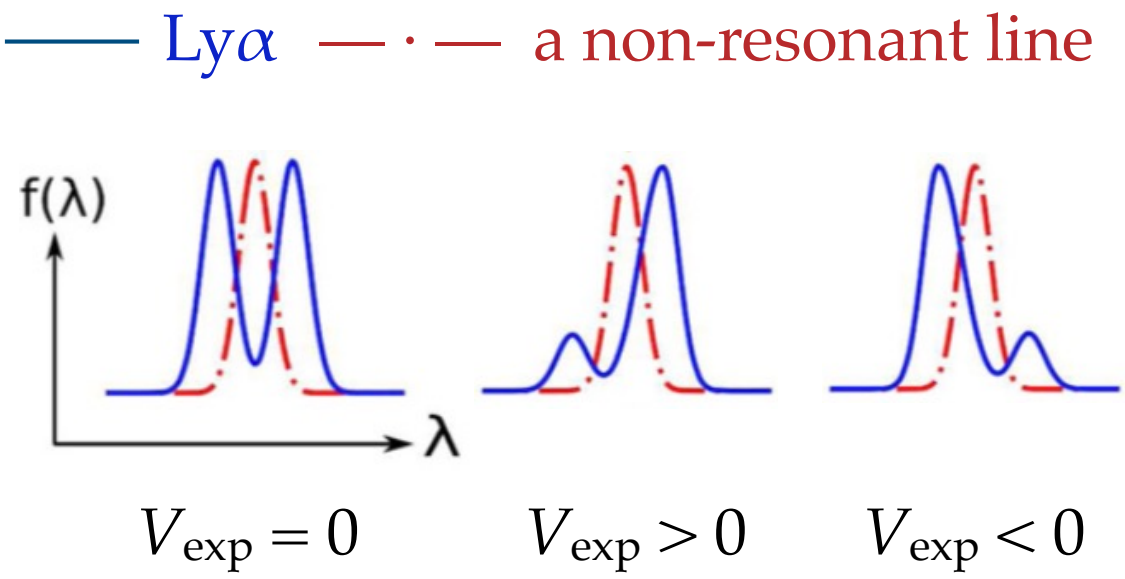




Henry et al. (2015)

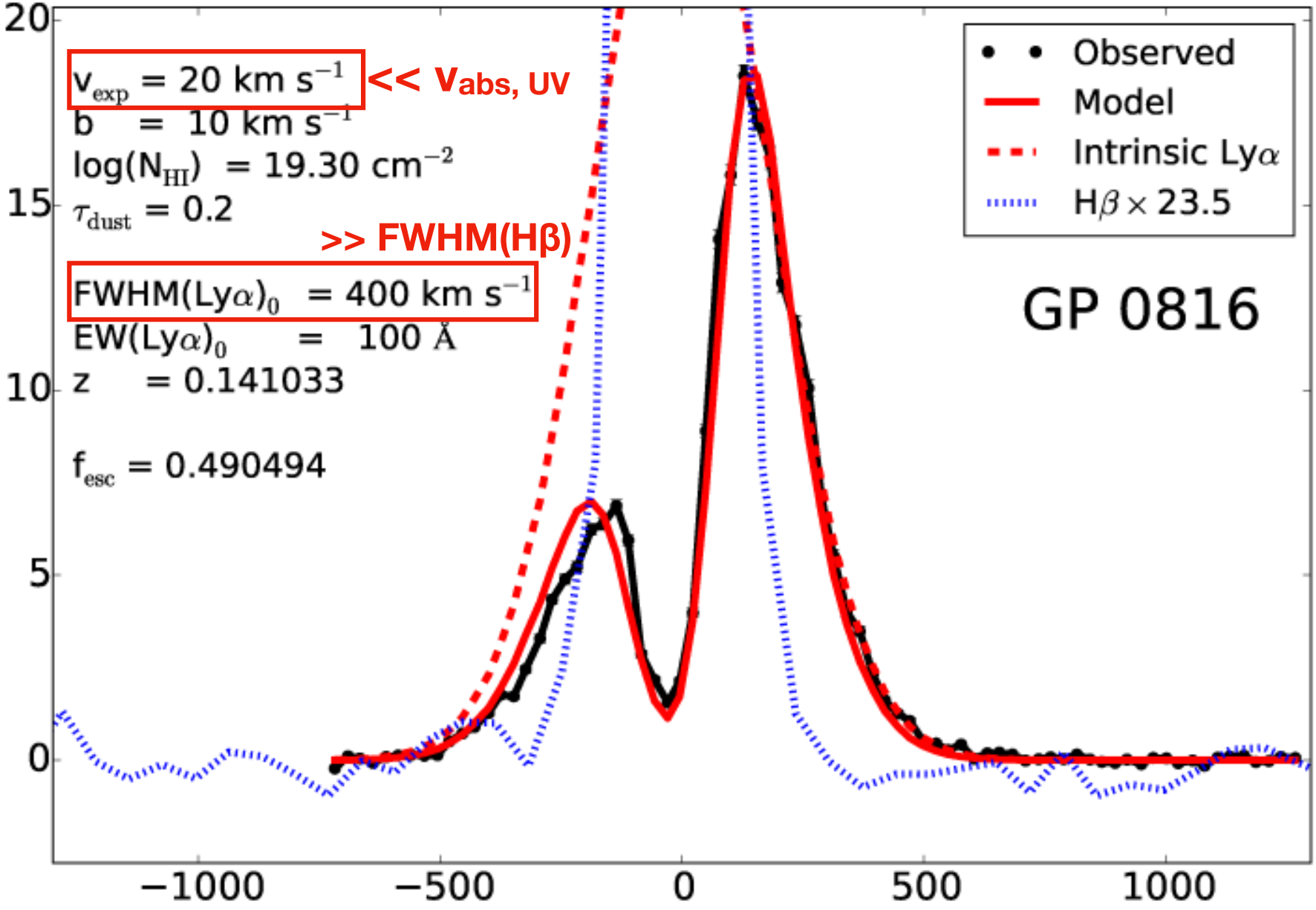
Modeling Lyα Profiles: Shell Model





(e.g. Zheng+02, Ahn+03, 04, Dijkstra+06, Verhamme+06, 08, 15, Schaerer+11, Gronke+15, 17, Song+20, …)

Spatially-Integrated Modeling with the Shell Model

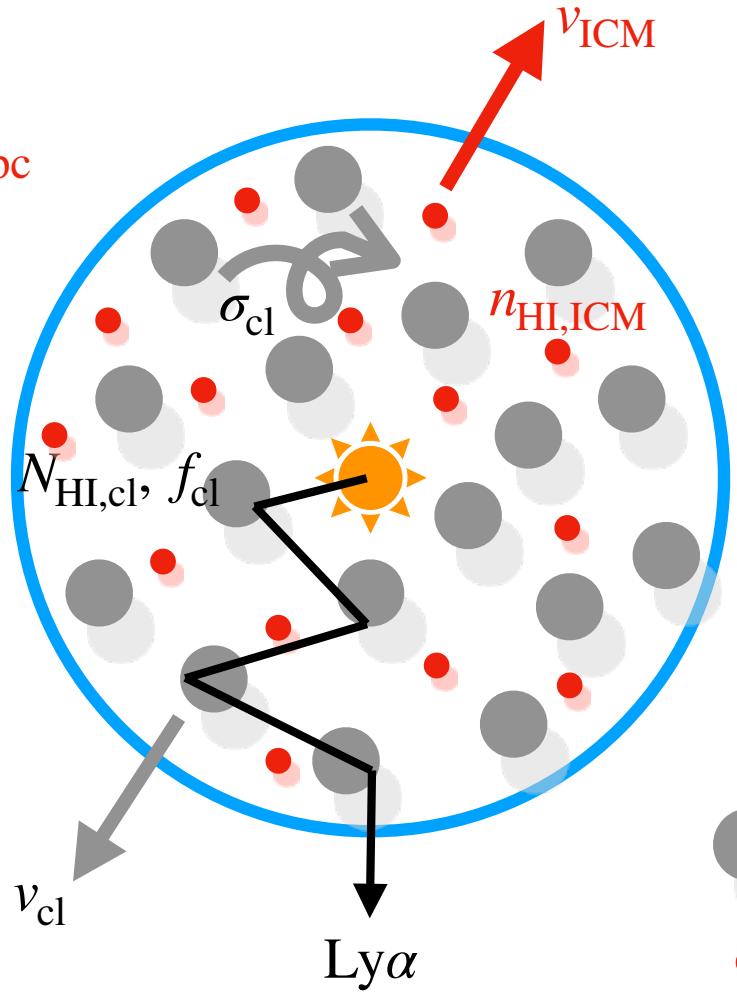


Orlitova et al. (2018)

A Multiphase, Clumpy Model

(e.g. Richling 03, Hansen & Oh 06, Dijkstra & Kramer 12, Laursen+13, Duval+14, Gronke & Dijkstra 16)

$$N_{\rm HI,ICM} = n_{\rm HI,ICM} R_{\rm halo}$$
$$\simeq 10^{-6}\,{\rm cm}^{-3} \times 10\,{\rm kpc}$$
$$\simeq 10^{16}\,{\rm cm}^{-2}$$



Cool Clumps

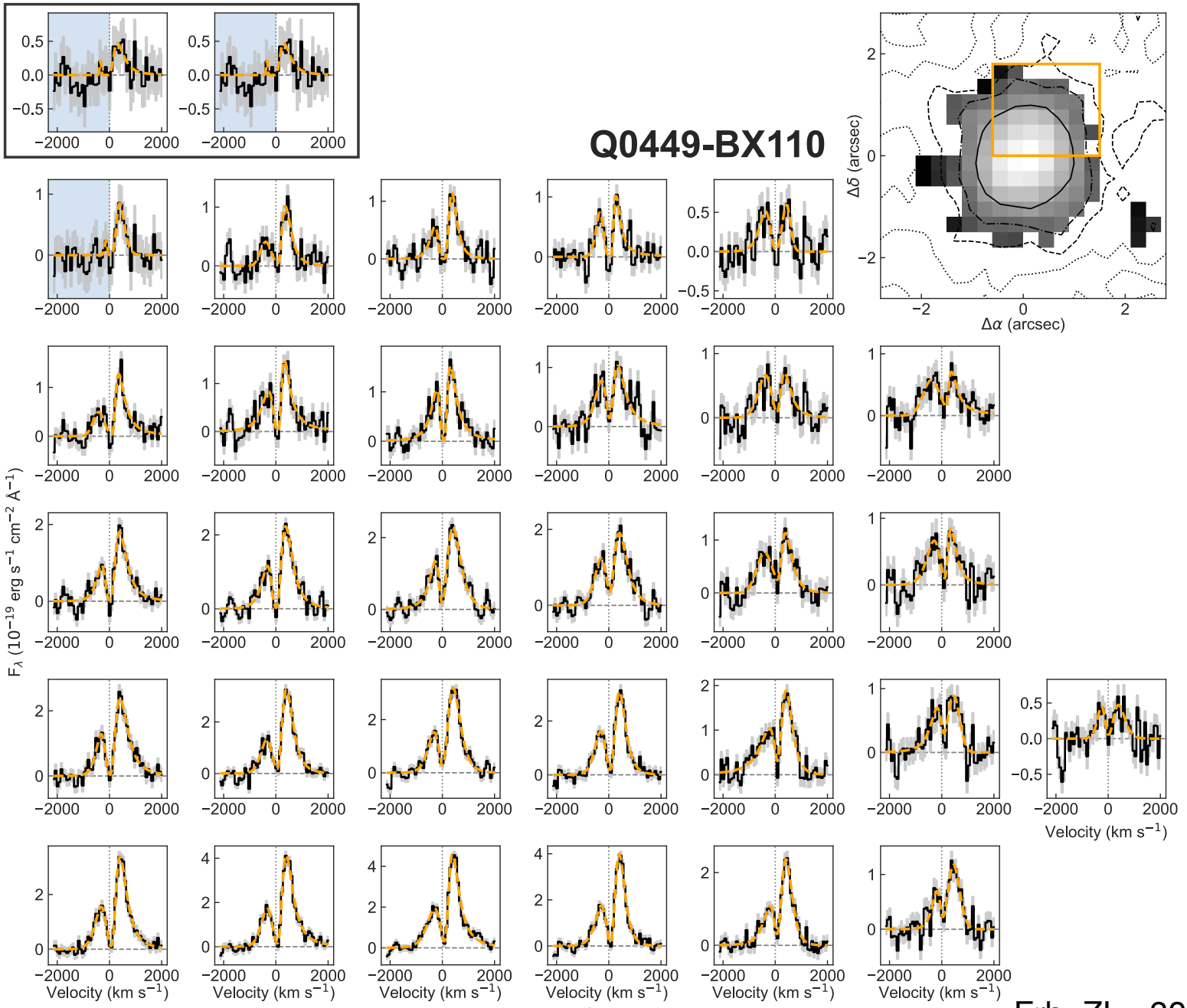
Hot Medium

Lyα Source

(ICM = Inter-Clump Medium)

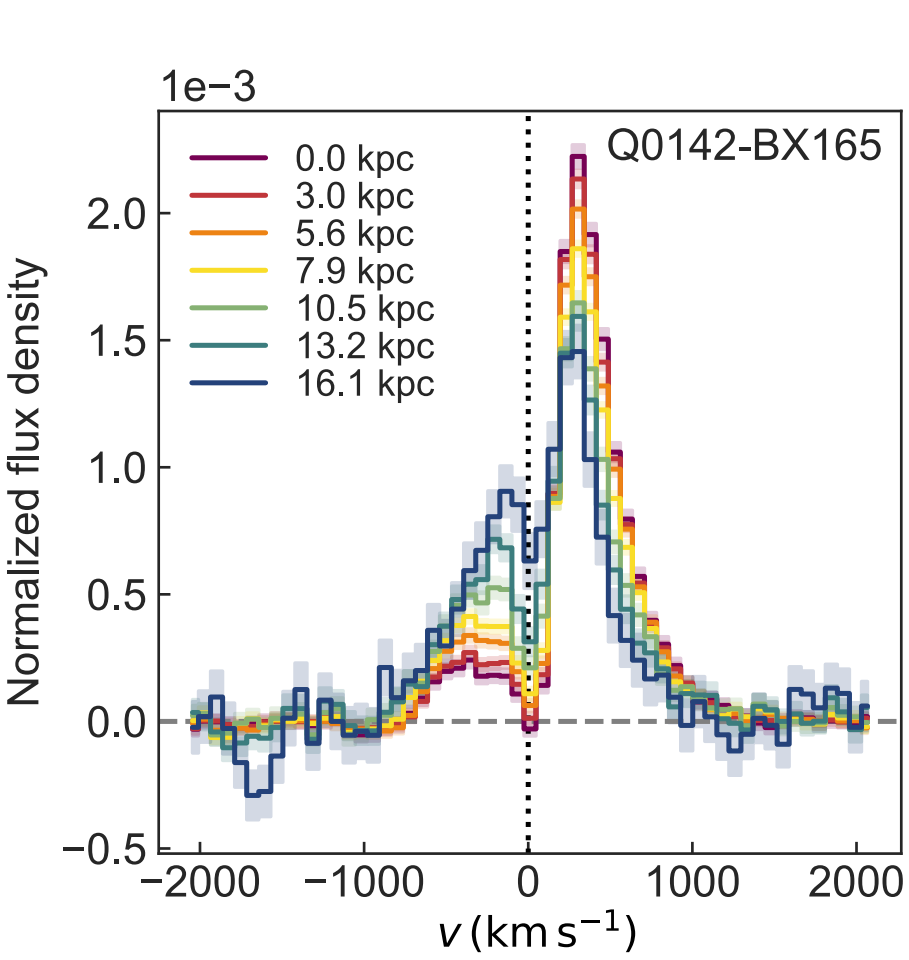
Li & Gronke (2022)

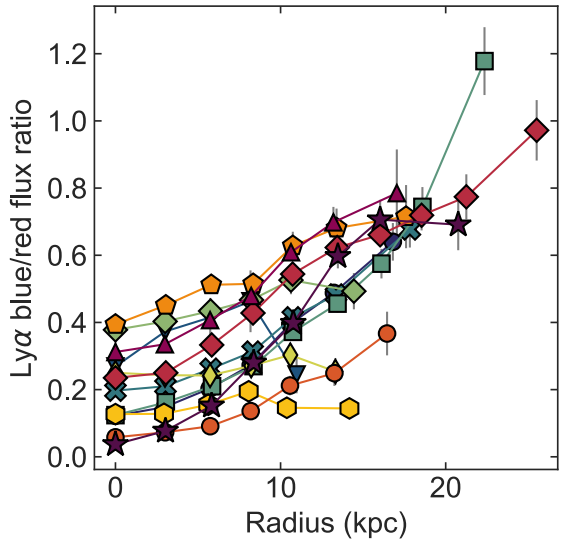
Spatially-Resolved Lyα Profiles

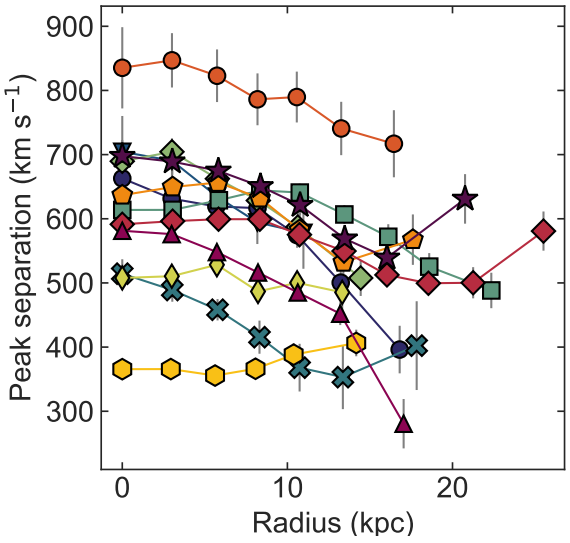


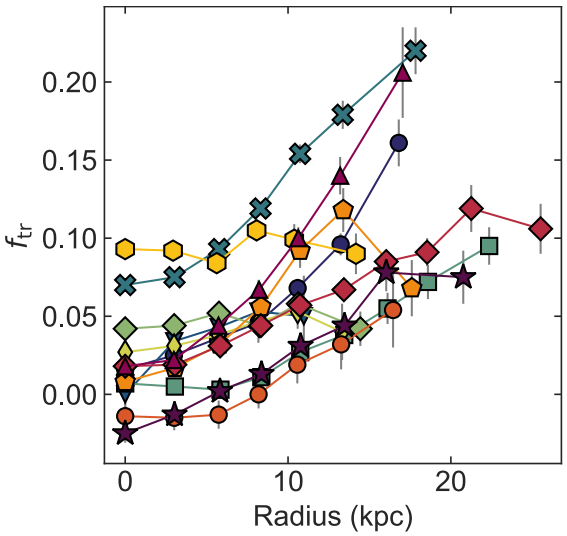
Erb, ZL+ 2022, submitted

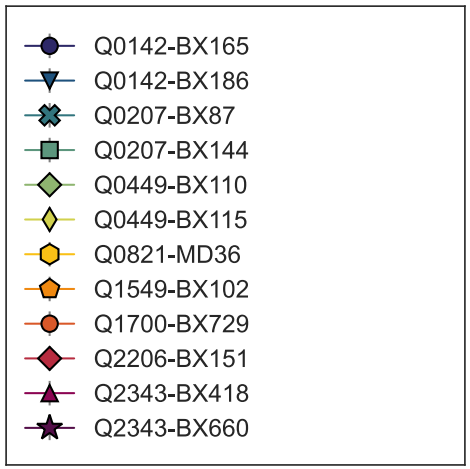
Radial Variation of Lyα Profiles





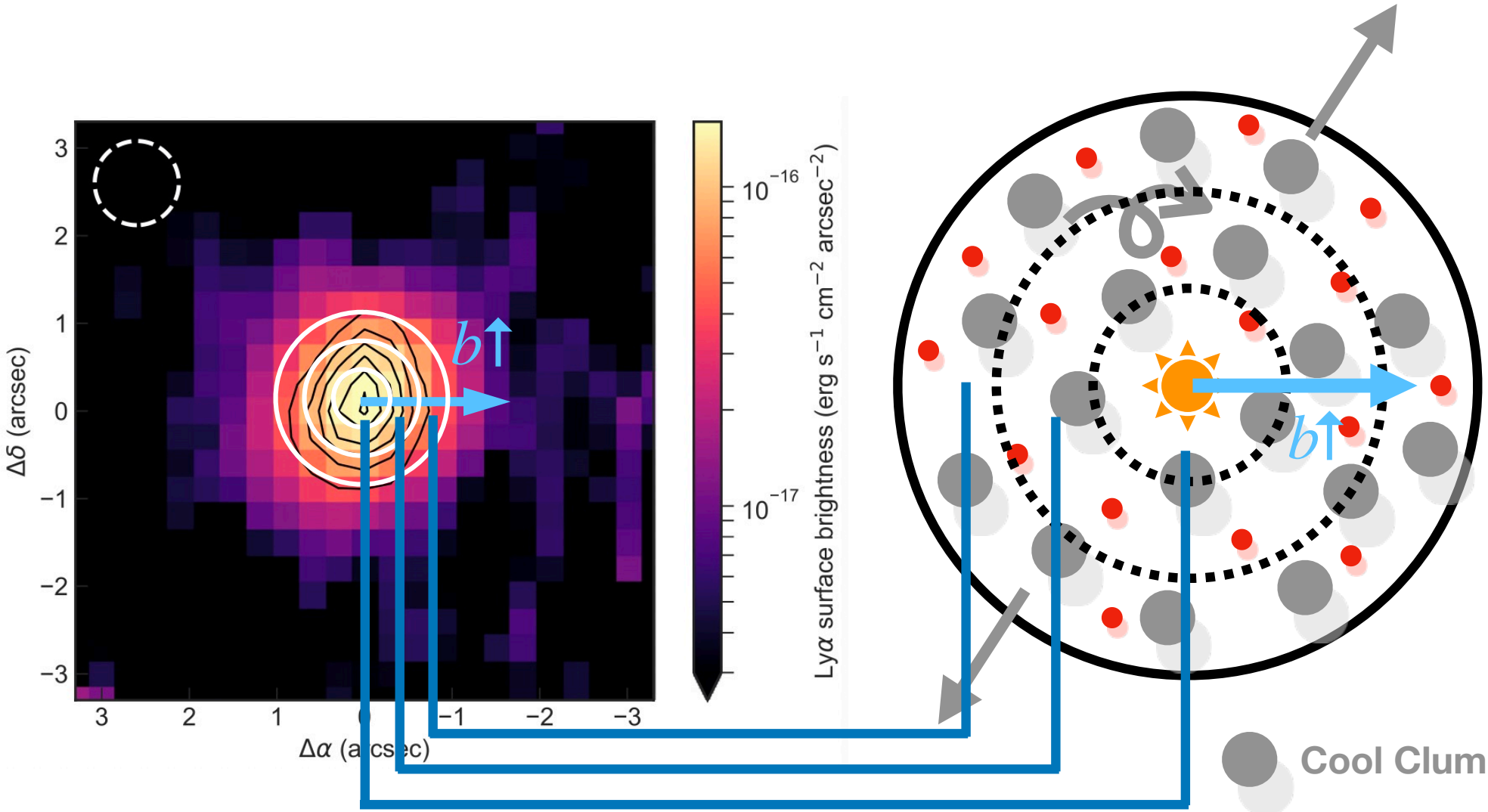






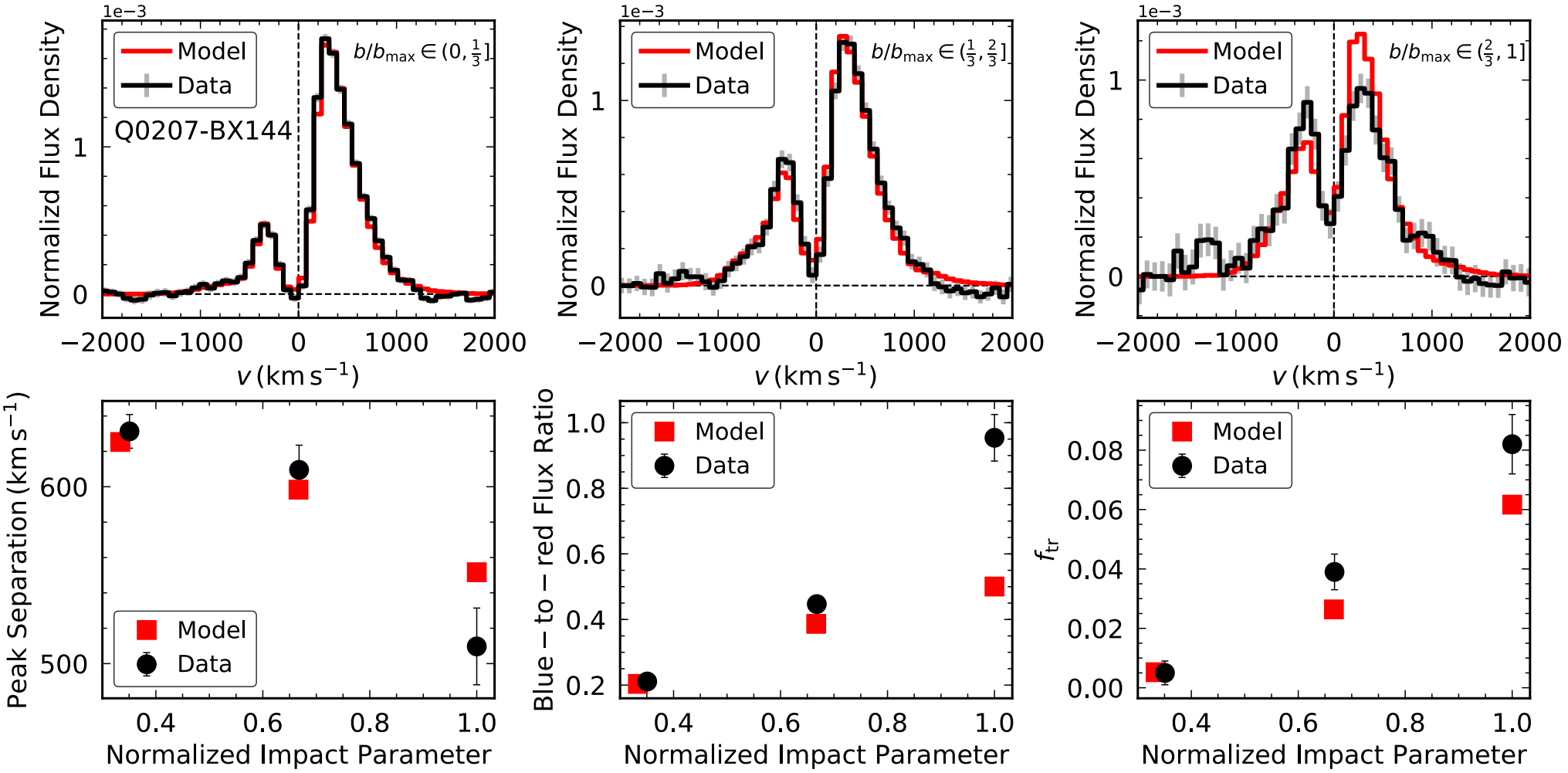
Erb, ZL+ 2022, submitted

Spatially-Resolved Lyα Modeling

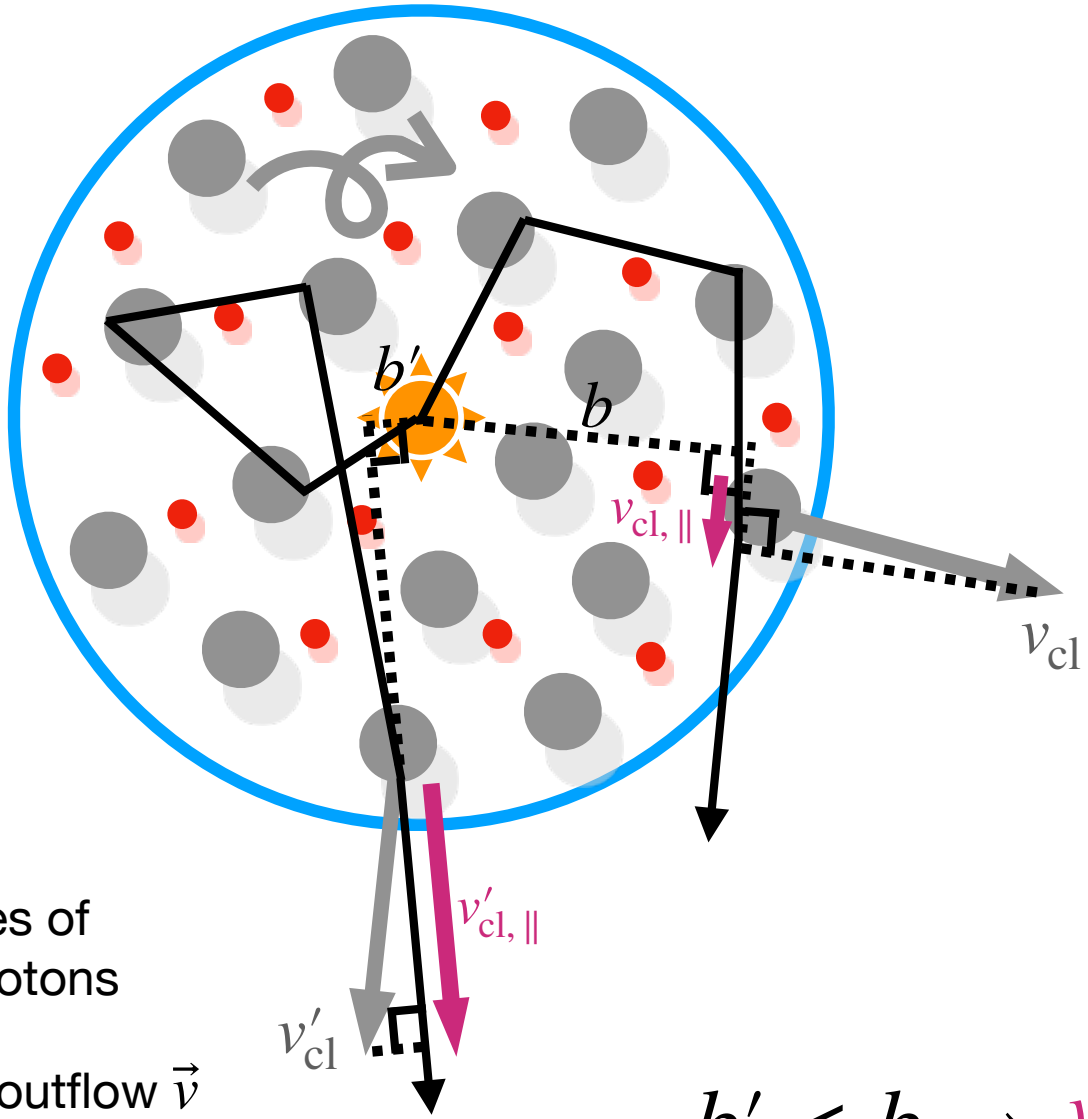


Compare corresponding binned Lyα spectra

Results of Spatially-Resolved Lyα Modeling



Understanding Radial Trends from an RT Perspective



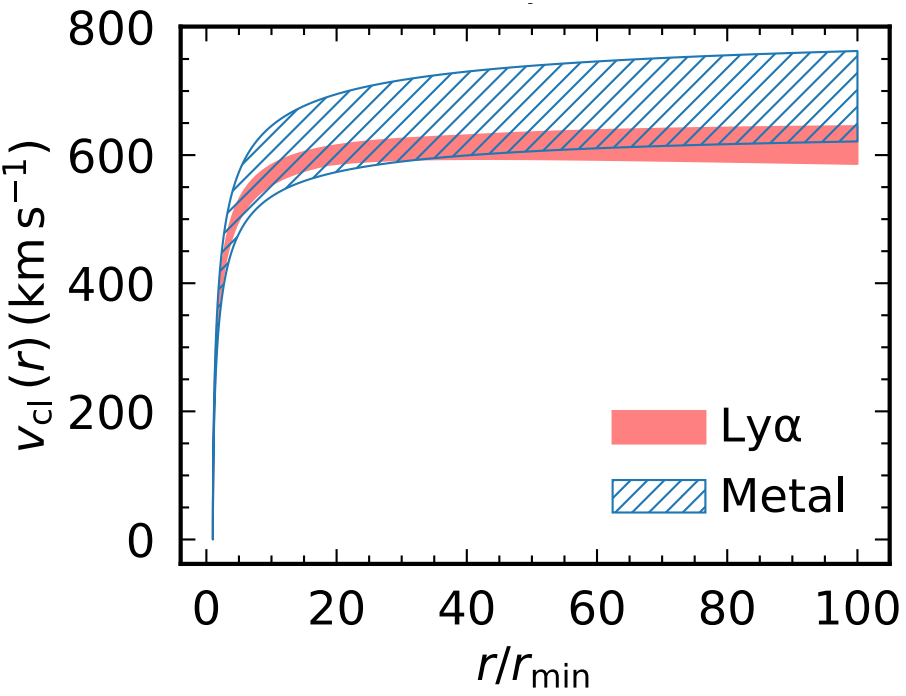
Trajectories of two Lyα photons

Clump radial outflow $\vec{v}$

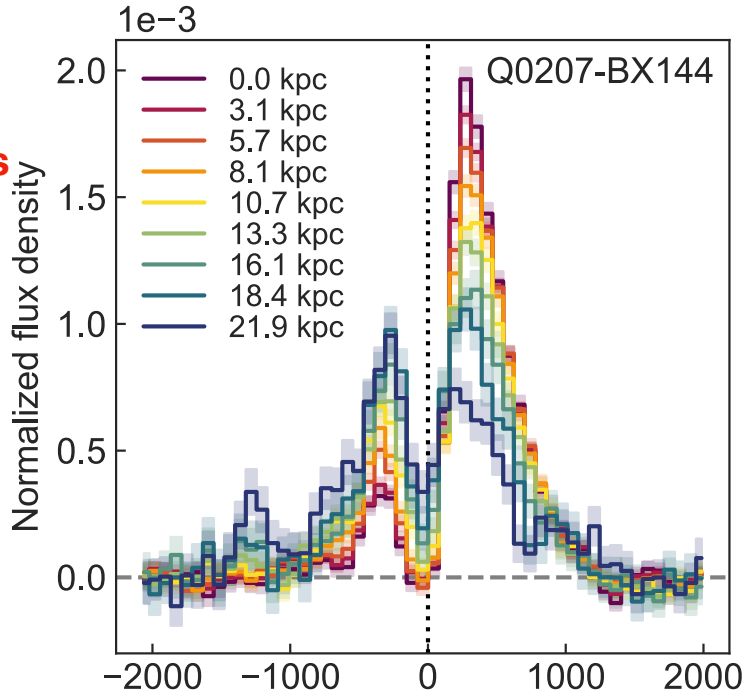
Projected clump $\vec{v}$ along the photon's traveling direction

$$b' < b \rightarrow v'_{\mathrm{cl},\parallel} > v_{\mathrm{cl},\parallel}$$

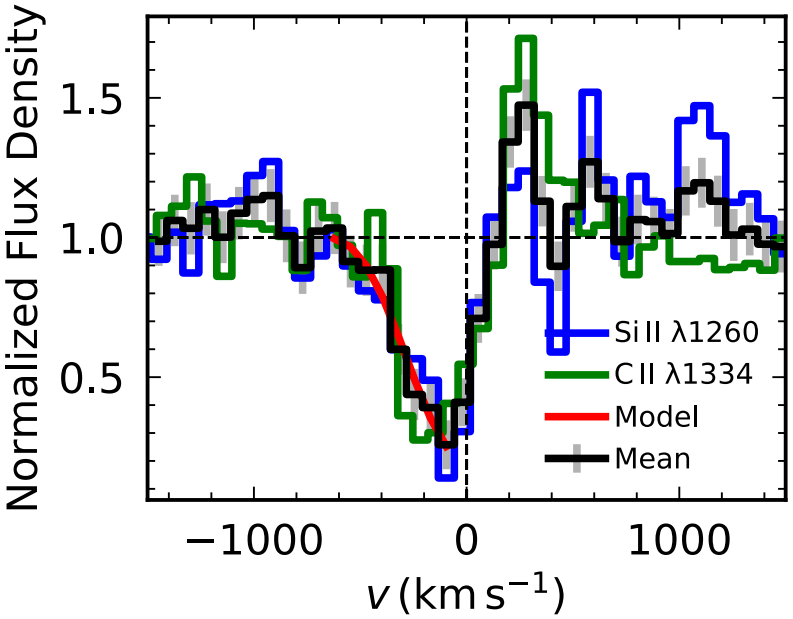
Accounting for Down-the-Barrel Metal Absorption Lines



Different impact parameters



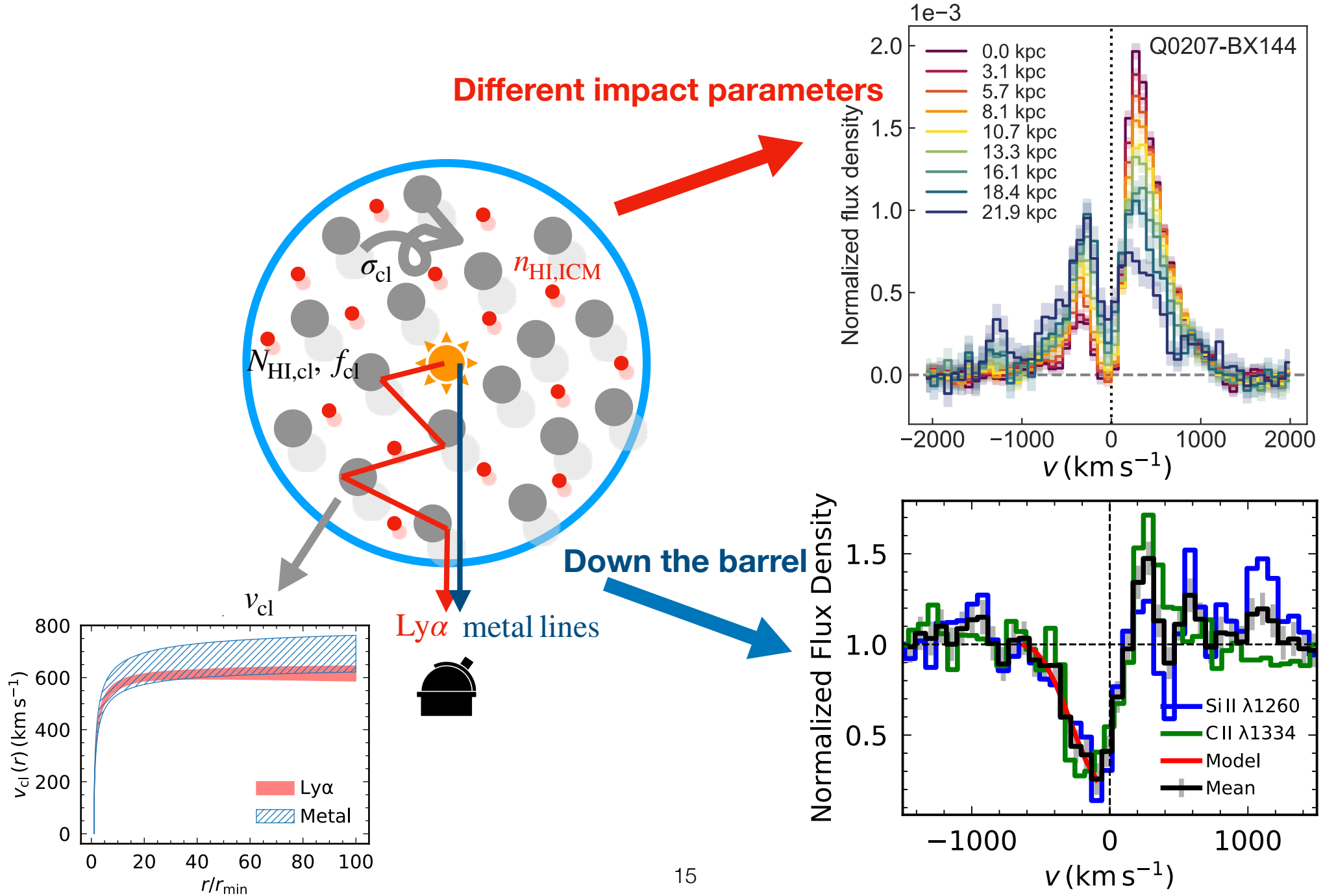
Down the barrel



(Non-RT) Modeling DTB metal absorption, assuming:

1. **Same kinematic model as Lyα**
2. **Saturated absorption**

A Coherent Picture of the CGM



Advantages of Spatially-Resolved Modeling

Spatially-resolved modeling:

- Fully leverages spatial information ✓
- Constrains radial velocity profiles ✓

Spatially-integrated modeling:

- No spatial information ✗
- Yields averaged parameter values ✗

Spatially-resolved RT modeling is promising for decoding IFU datacubes

Key Takeaways

- The cool phase of the CGM can be probed by Lyα emission
- The multiphase, clumpy model can be utilized to interpret the spatially-varying Lyα profiles
- Spatially-resolved RT modeling is powerful for capturing the spatial variation and decoding the CGM