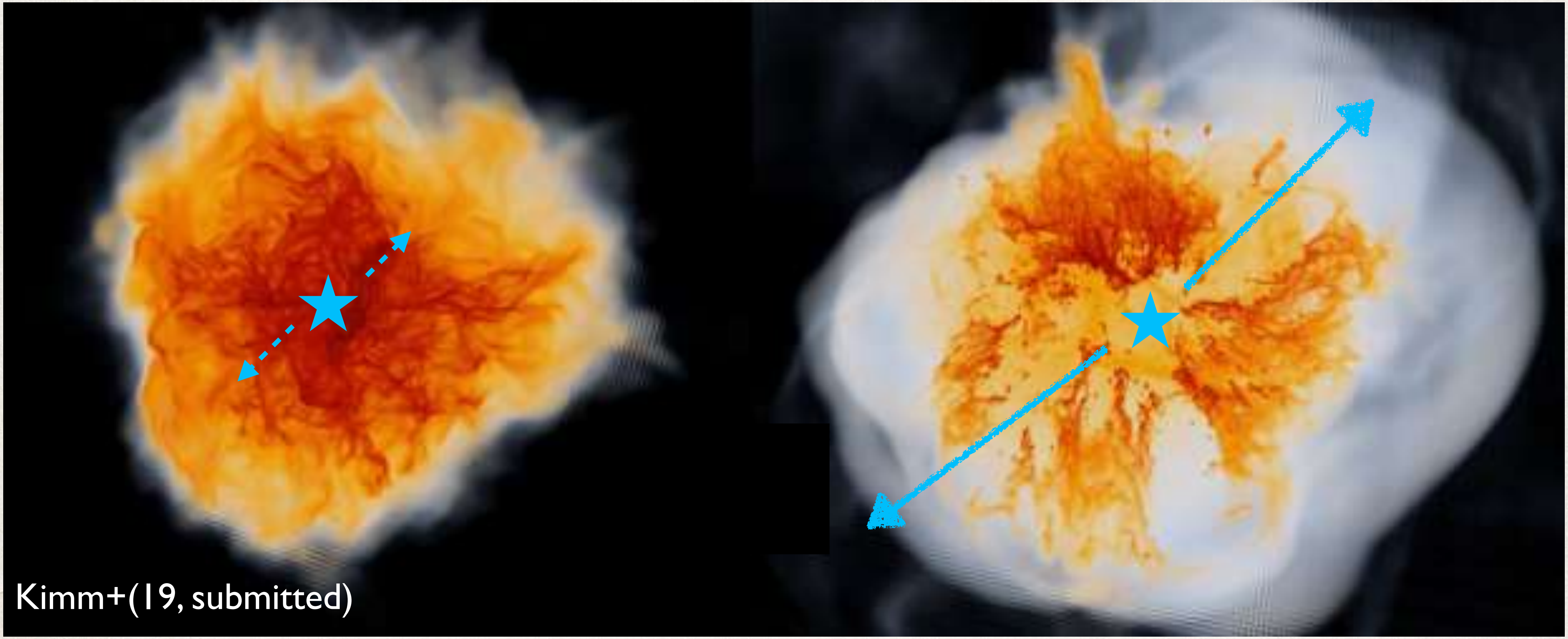
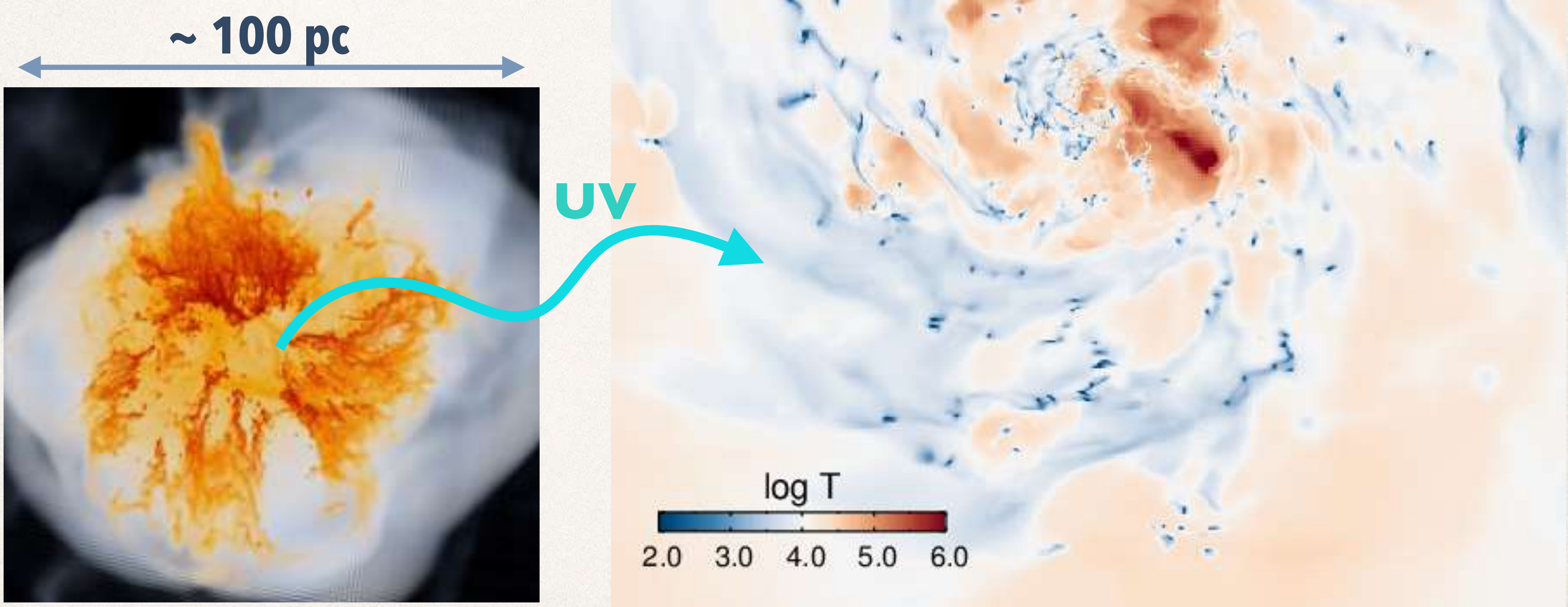
Why LyC photons?



- Photo-ionization heating
- Radiation pressure due to UV, IR, Lya etc.
- Low-density channels for supernova explosions

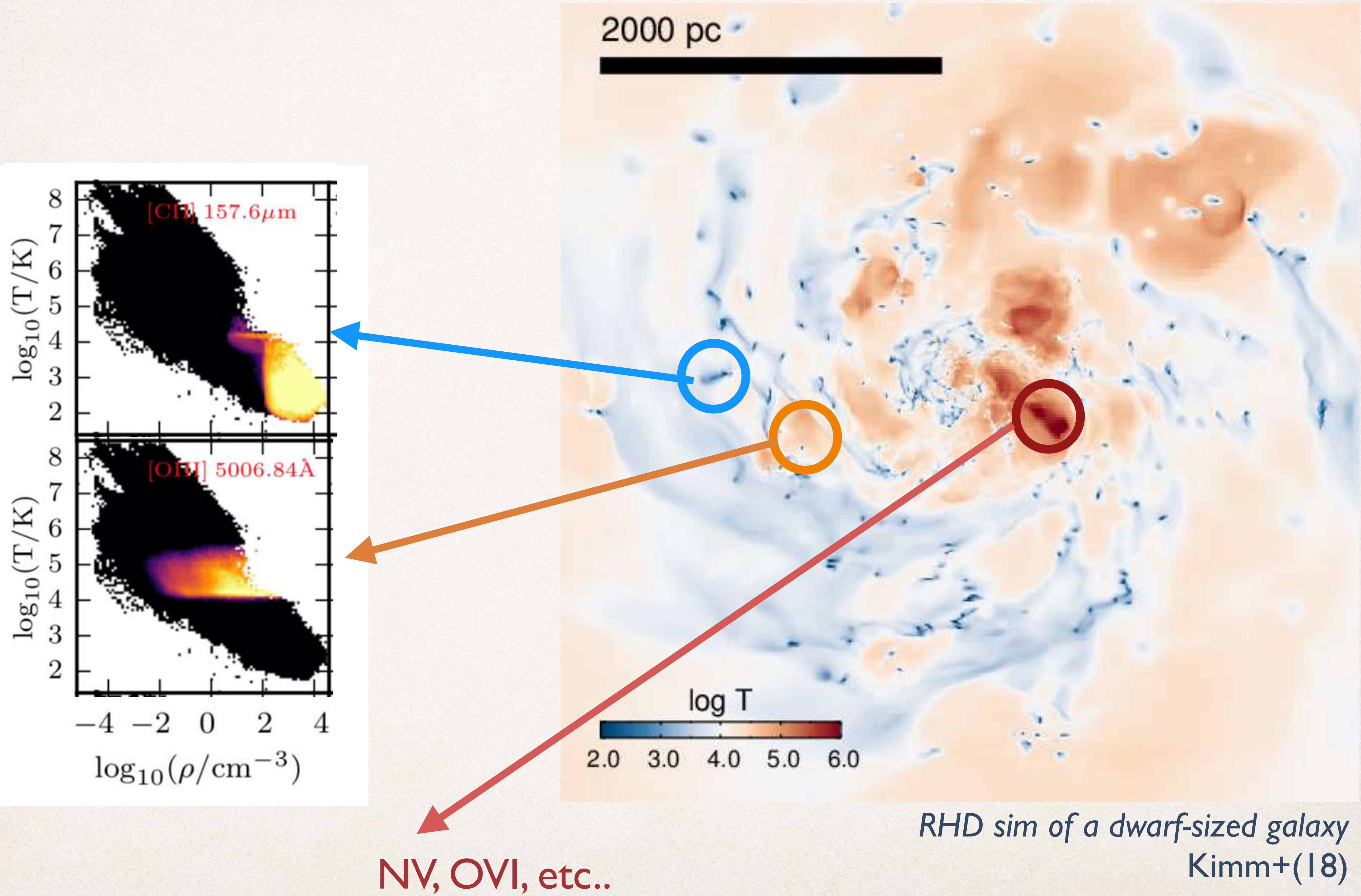
Effects of LyC escape on the properties of ISM

- ISM properties
  - Scale-height
  - Lyman alpha
  - Emission lines



RHD sim of a dwarf-sized galaxy
Kimm+(18)

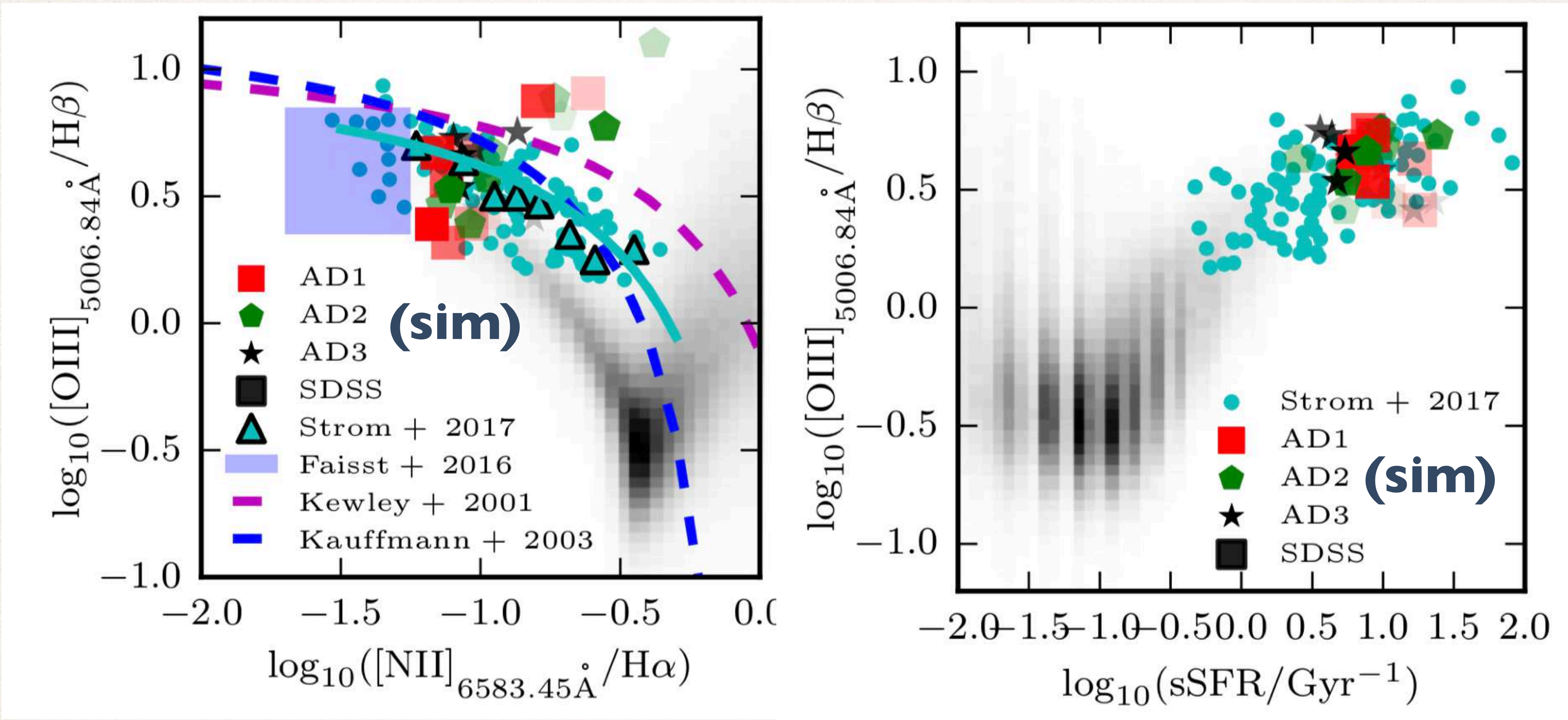
Effects of LyC escape on the properties of ISM



RHD sim of a dwarf-sized galaxy
Kimm+(18)

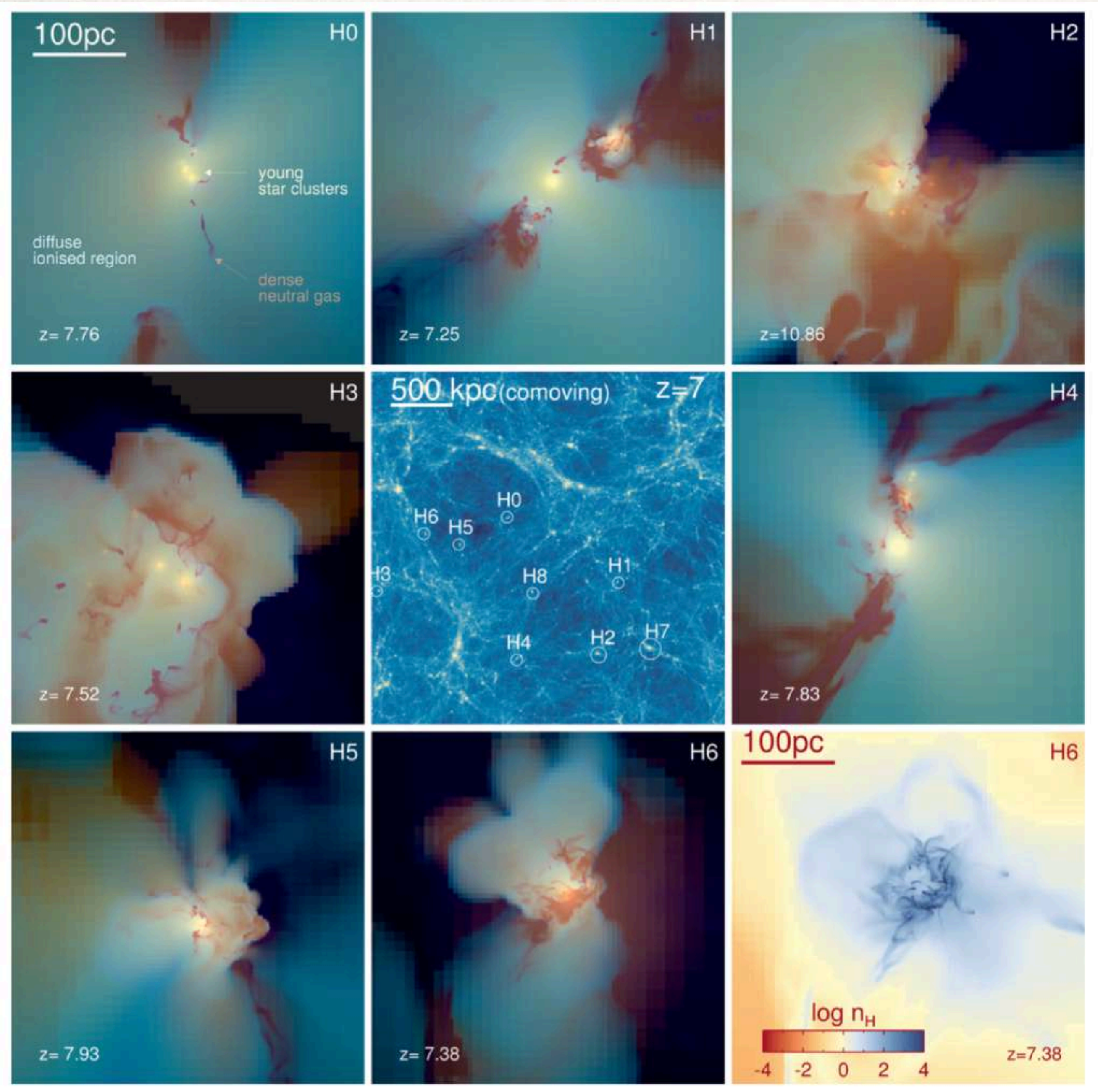
Offset in BPT diagram at high z

Katz, Kimm+(19, submitted)



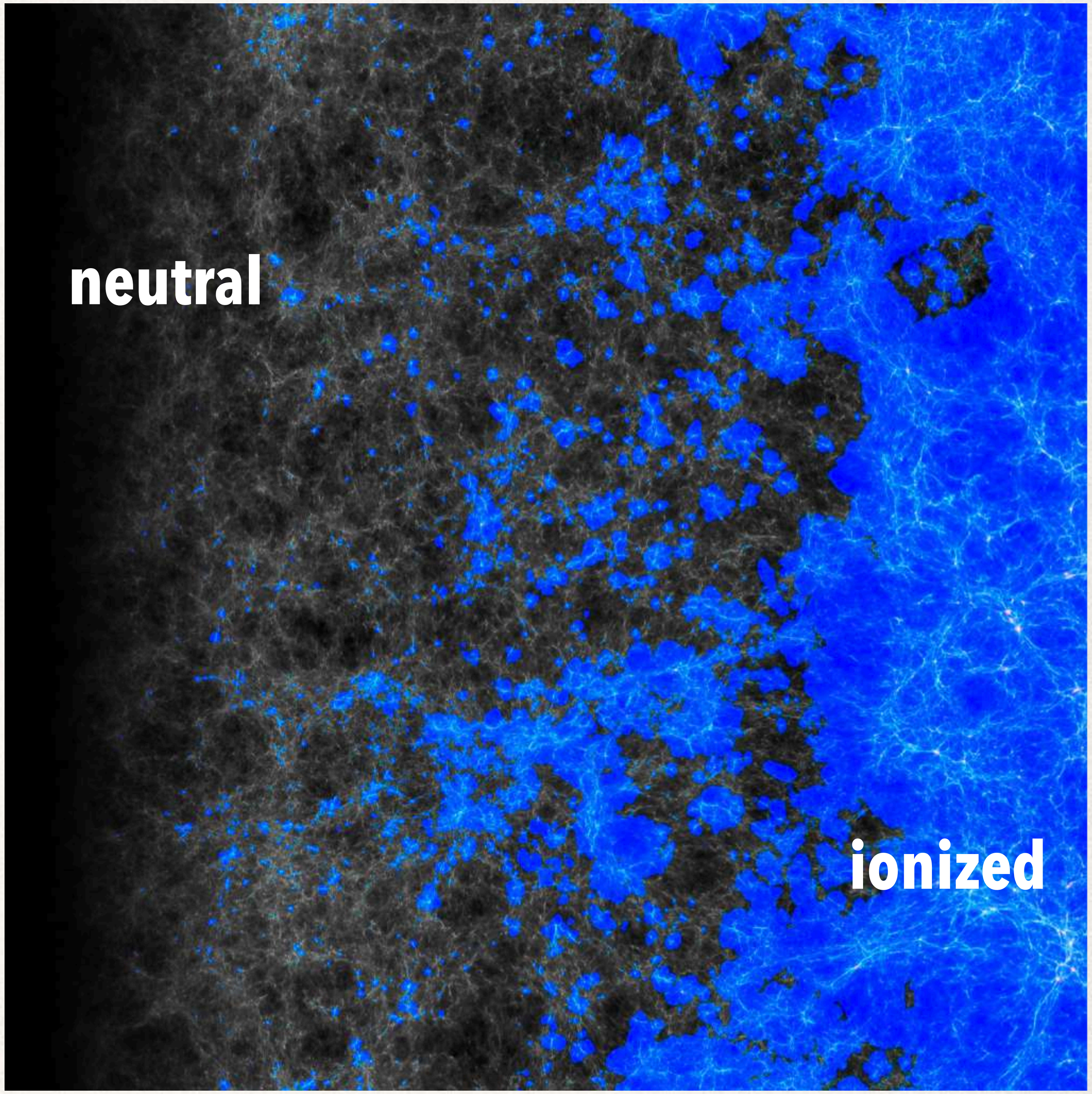
Strong [OIII] and [NII] at high-z may be due to strong radiation + harder spectrum due to binaries

Why LyC photons? Reionization



mini-halo scales (Kimm+17)

(M_{DMH}~10^6-$10^8 M_{sun}$)



t-->

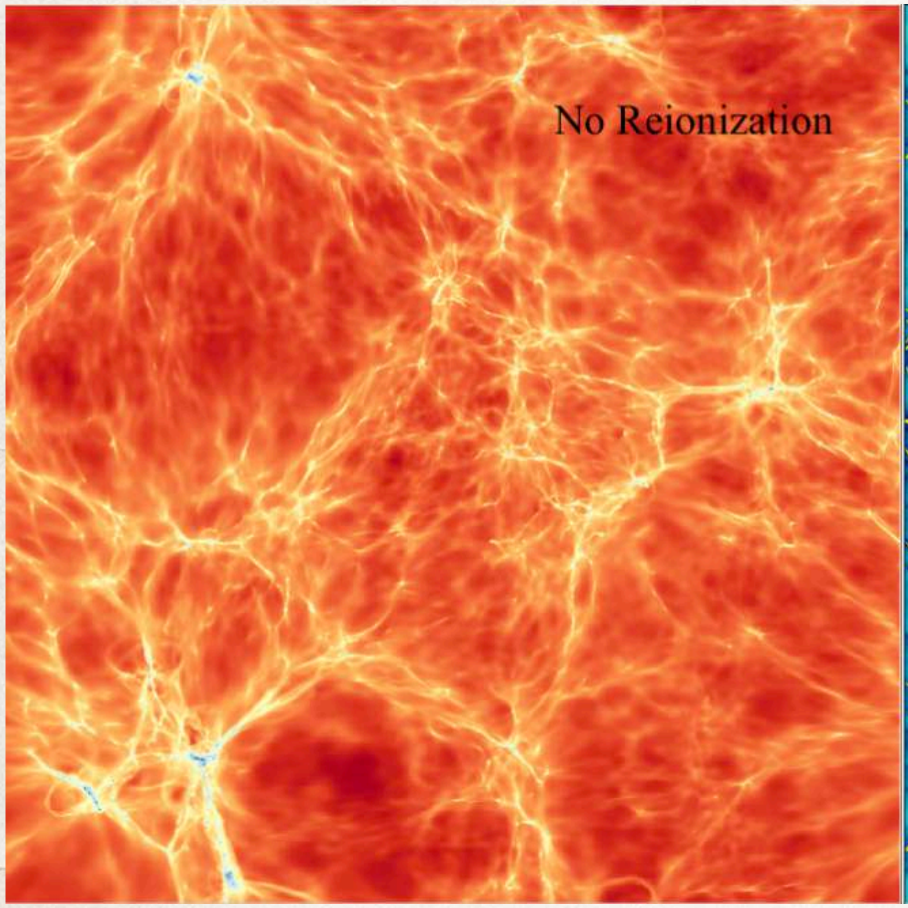
Large scales (Ocvirk, Ahn+18)

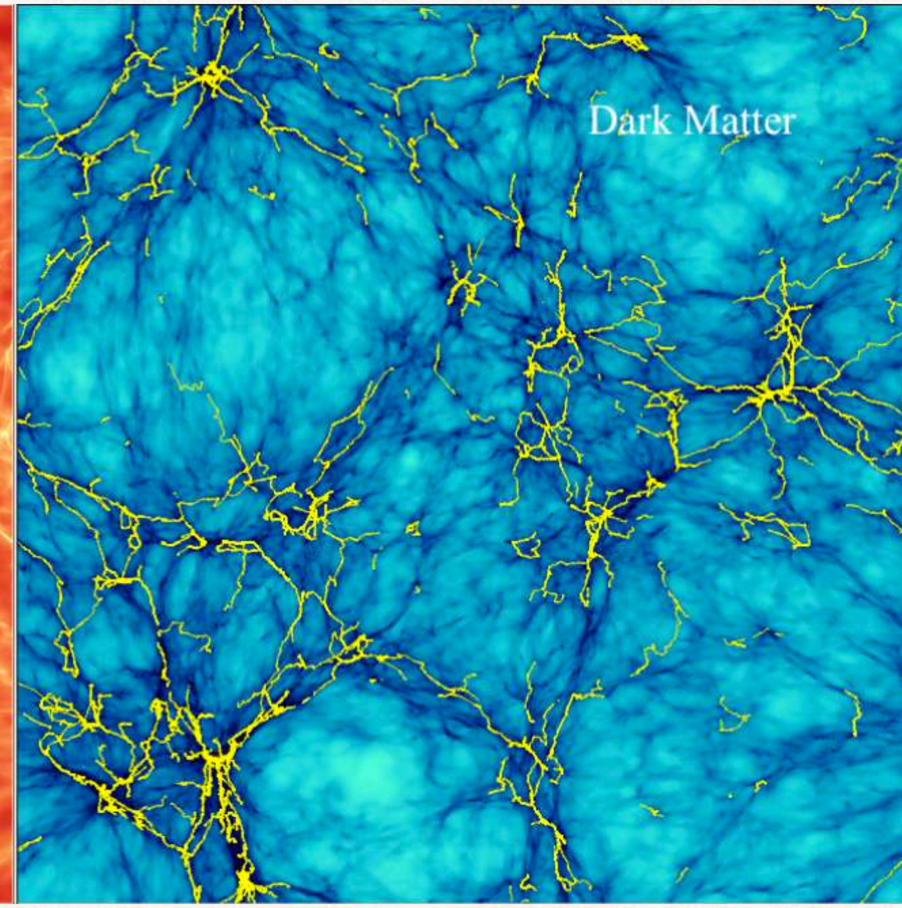
~100 Mpc

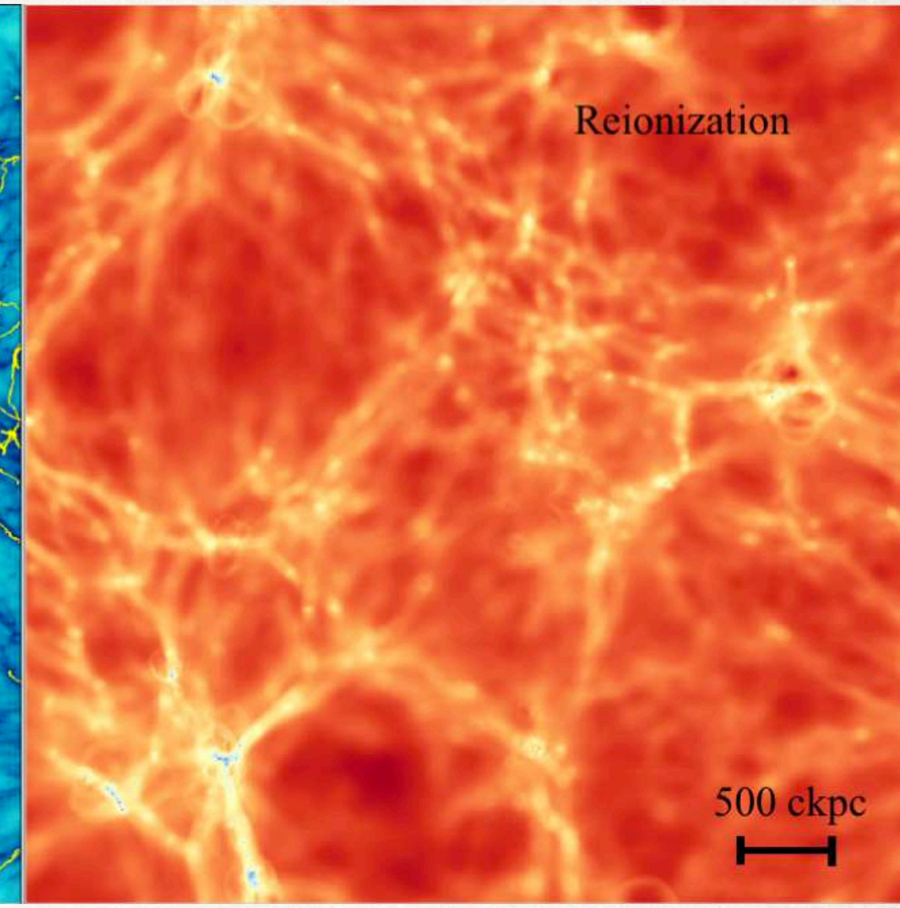
Why LyC photons? Suppression of gas cooling

No reionization

Inhomogeneous reionization







Gas structures

DM structures

Gas structures

SPHINX simulations

box size: 10 cMpc
max res: 10 pc

(Katz, Kimm+ in prep)

Why LyC photons? Summary

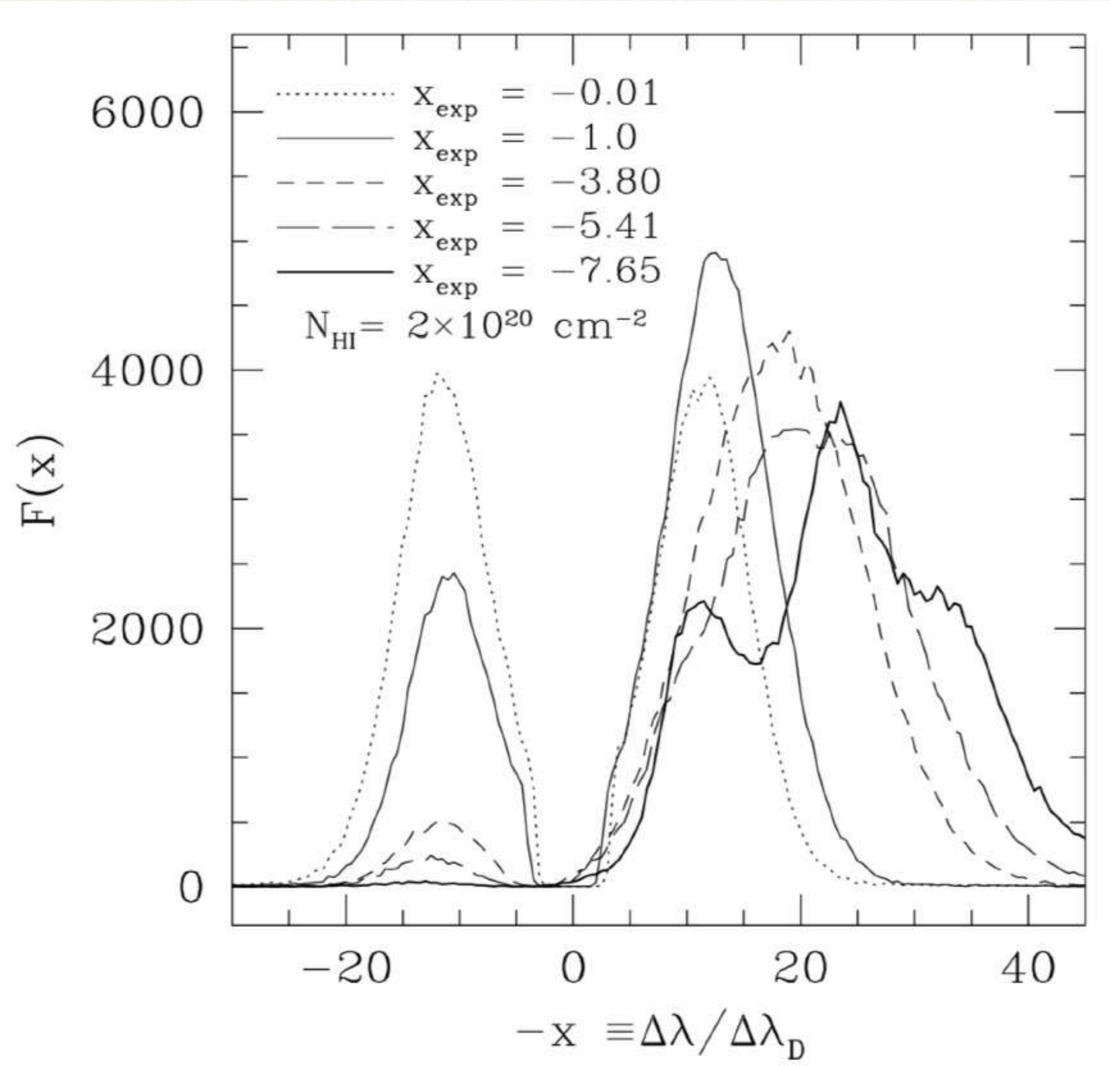
- Disruption of star forming clumps
- Thermal properties of primordial and metallic species
- Suppression of gas cooling on dwarf-sized haloes
- etc..

By measuring escape fractions of LyC photons from galaxies:

Covering fraction of optically thin gas (log N_{HI}<17)

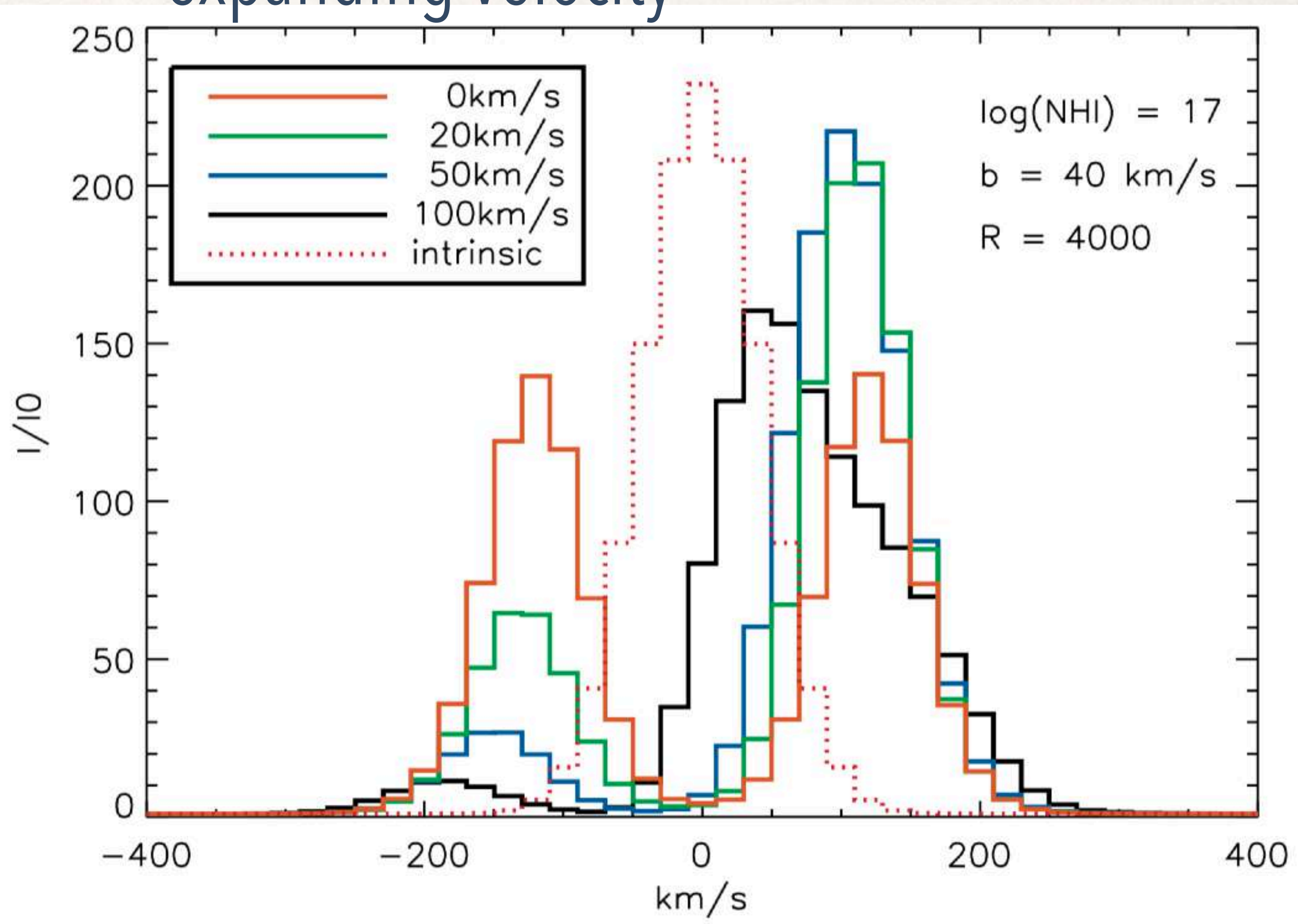
but detailed information about structures and kinematics is still lacking -> Lyman alpha

Lyman alpha is sensitive to gas kinematics



Ahn, Lee, Lee (03)

expanding velocity

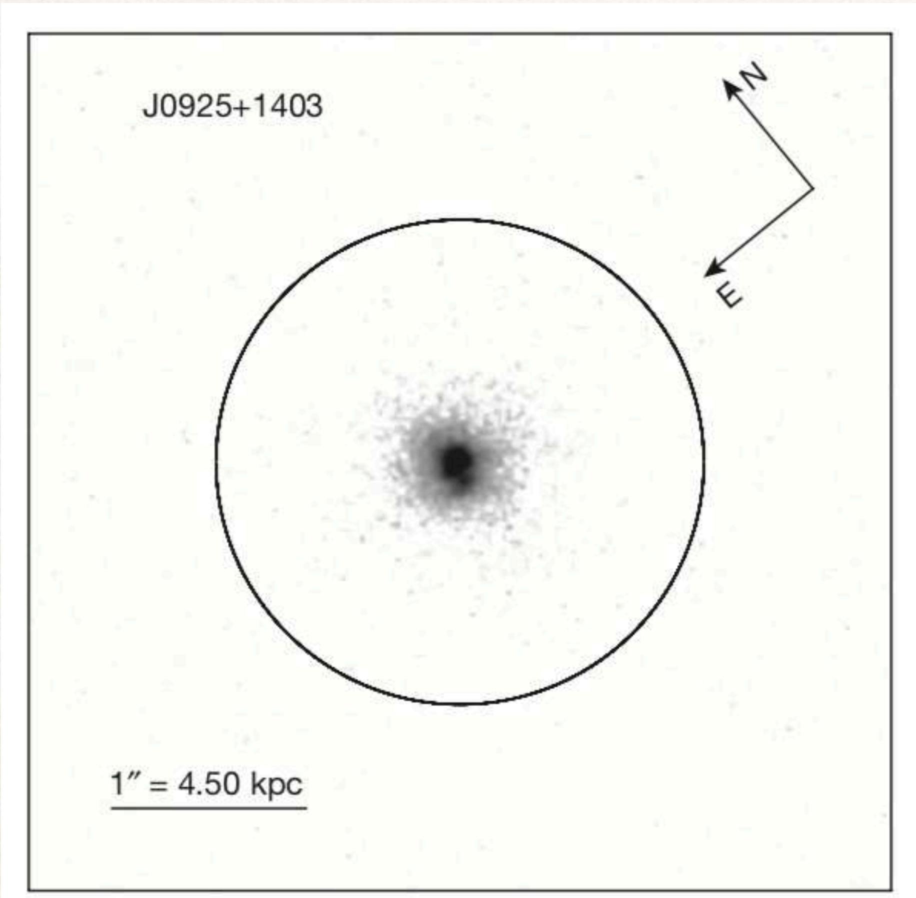


Verhamme+(15)

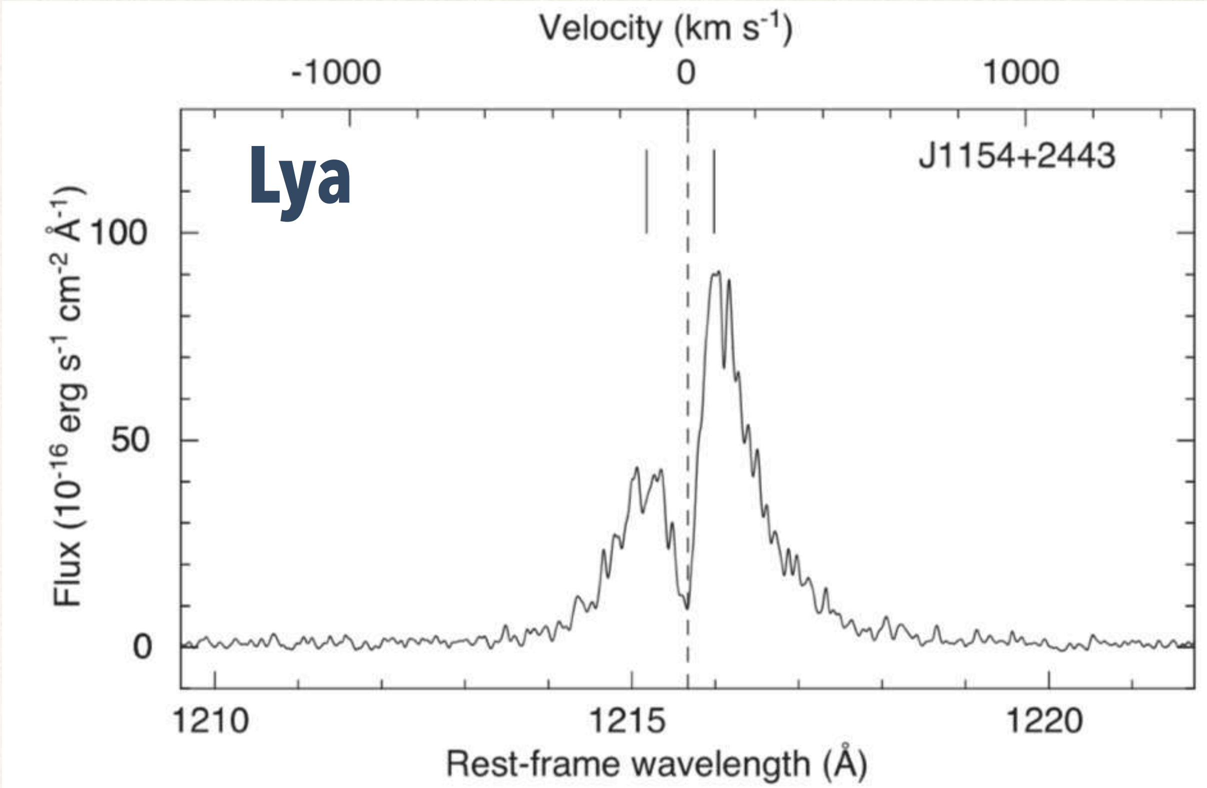
Talks by K. Seon+H. Song, K. Ahn+H. Kim..

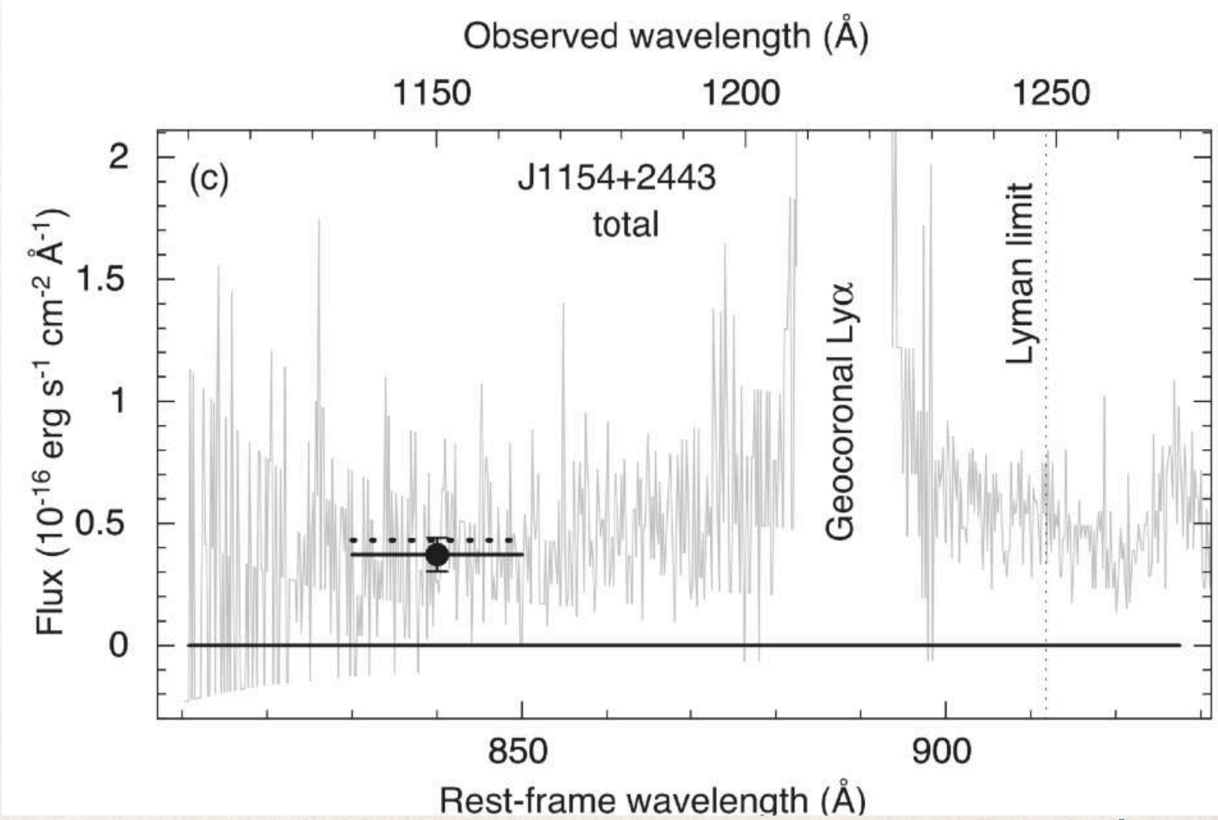
Luminous compact galaxies

- Low-mass (~$10^9 M_{sun}$)
- Low-metallicity (~0.1 Zsun)
- Compact (~1 kpc)
- SFR (~50 M_{sun}/yr)



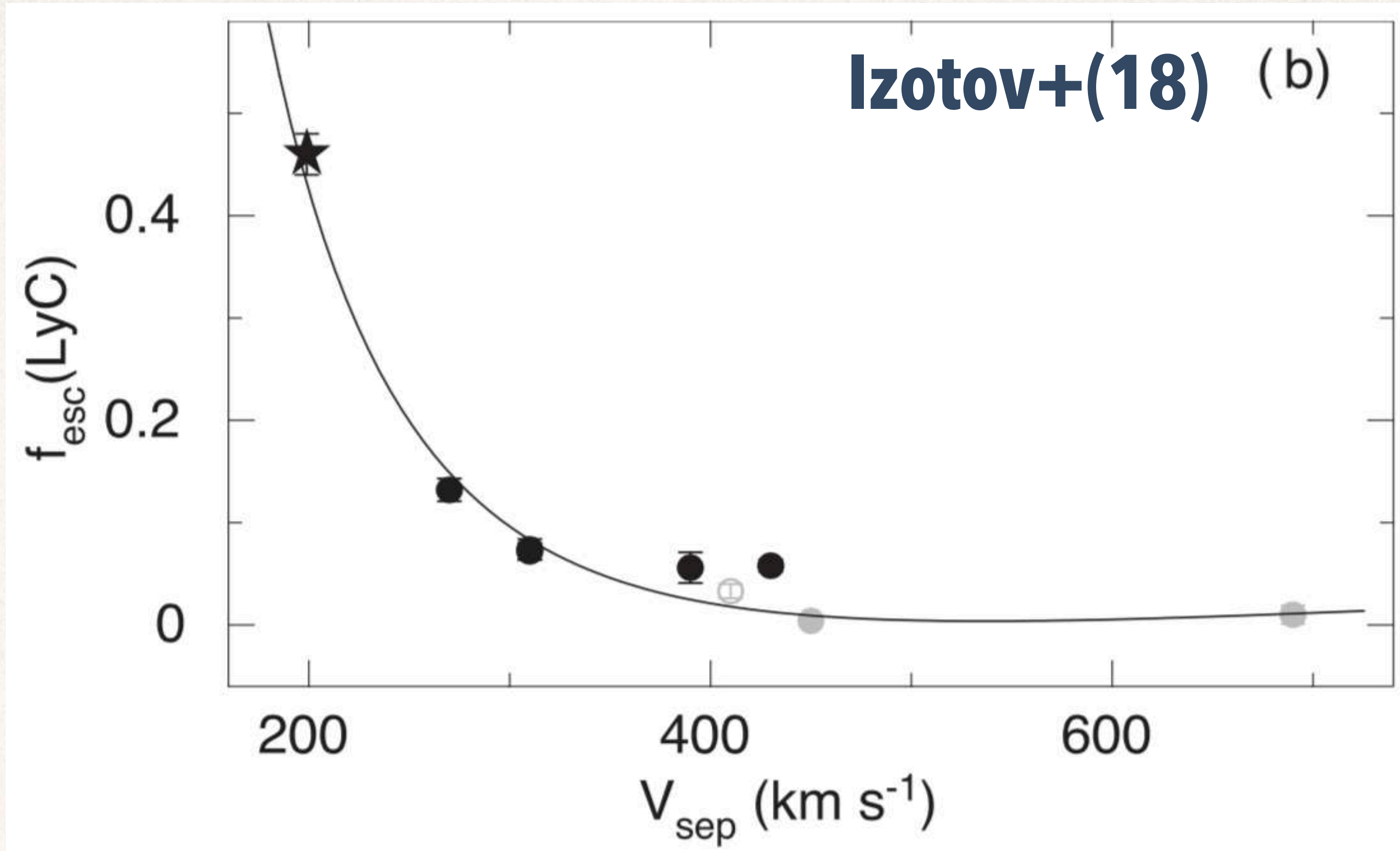
NUV image of J0925+1403 at z~0.3
(HST; Izotov+15)

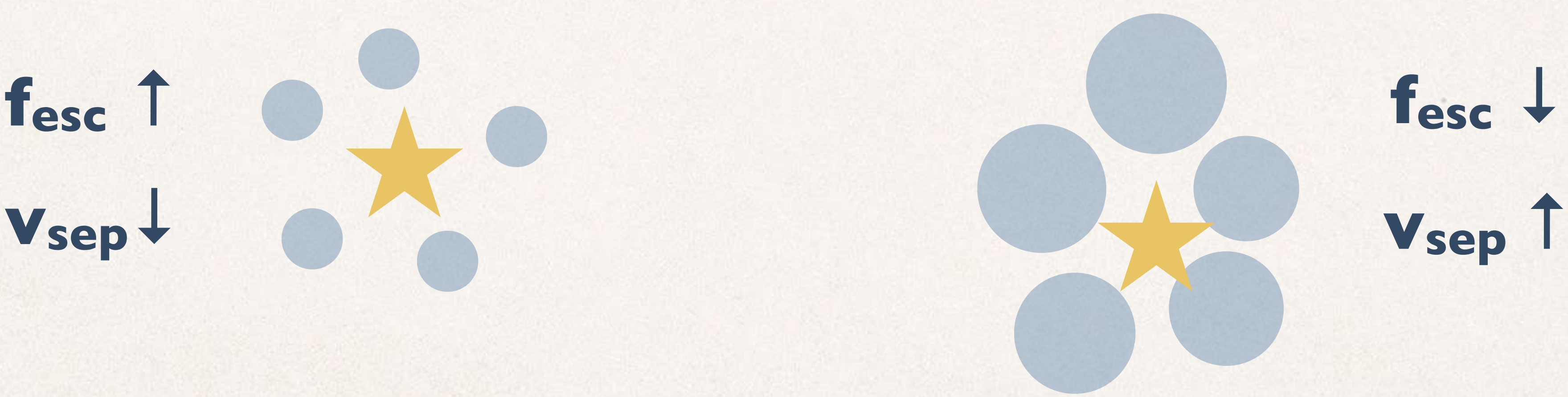




Izotov+(18); z~0.37 HST/COS data

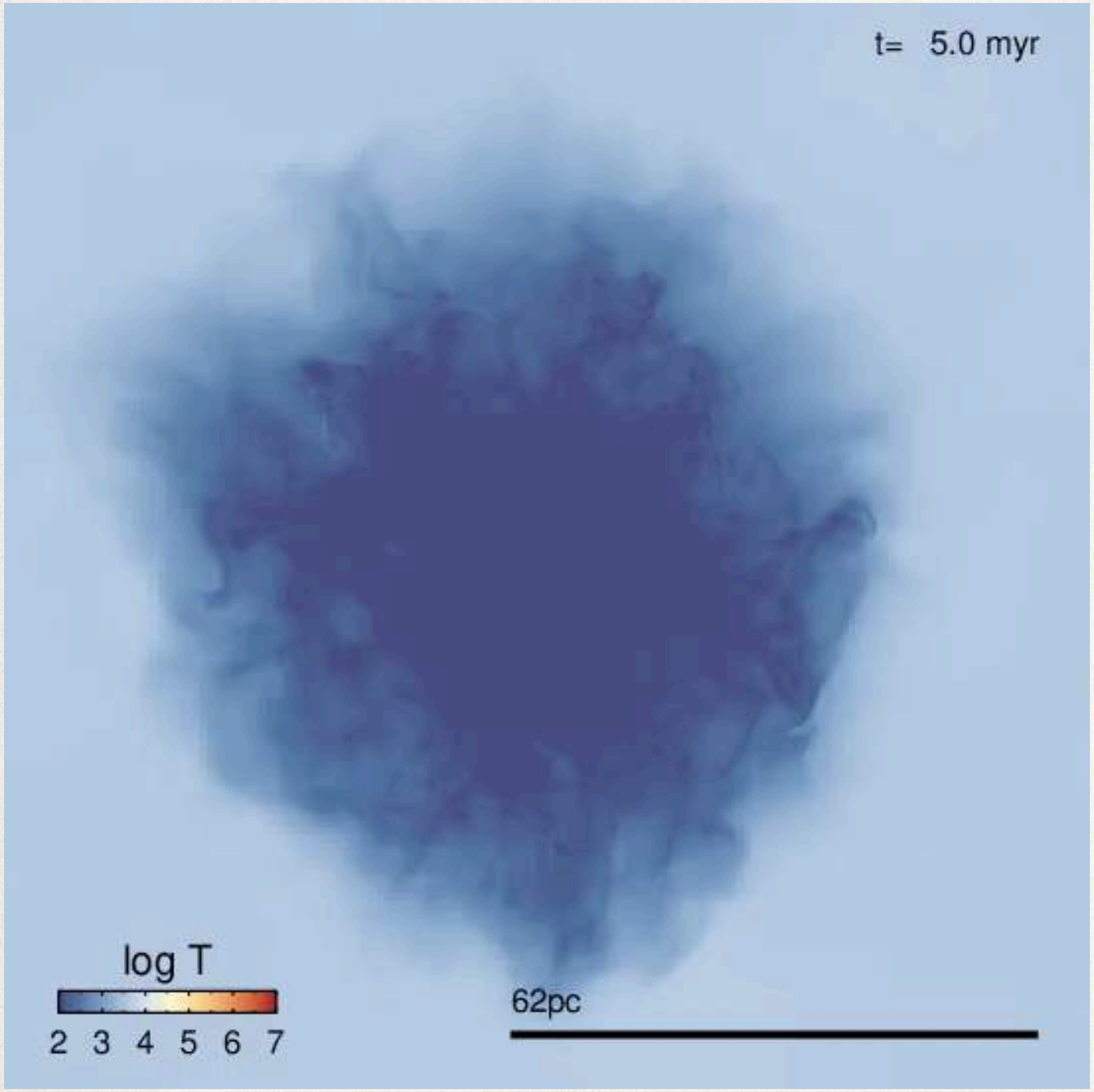
Luminous compact galaxies





Q: Can numerical simulations reproduce this trend?

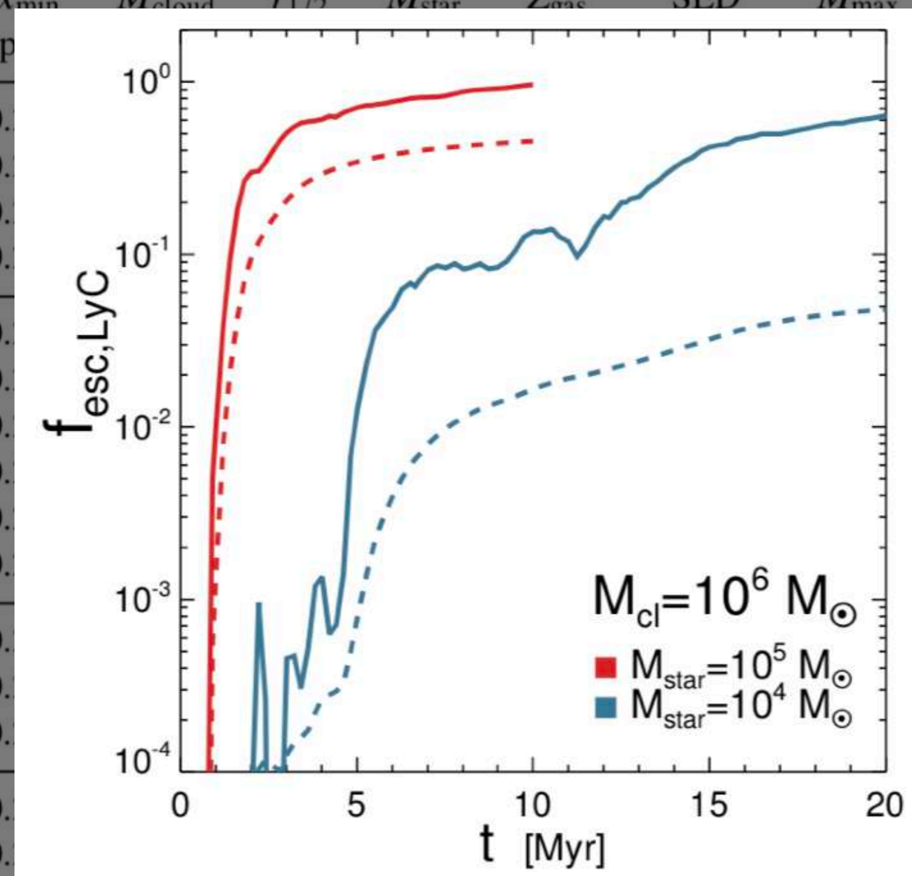
Cloud simulations with radiation+SN



RAMSES-RT (Teyssier02; Rosdahl+15)

- Photo-ionisation heating
- Direct radiation pressure
- IR pressure
- Type II SN explosions
- Non-eq. photo-chemistry
- Resolution: 0.2 pc

Cloud simulations with radiation+SN



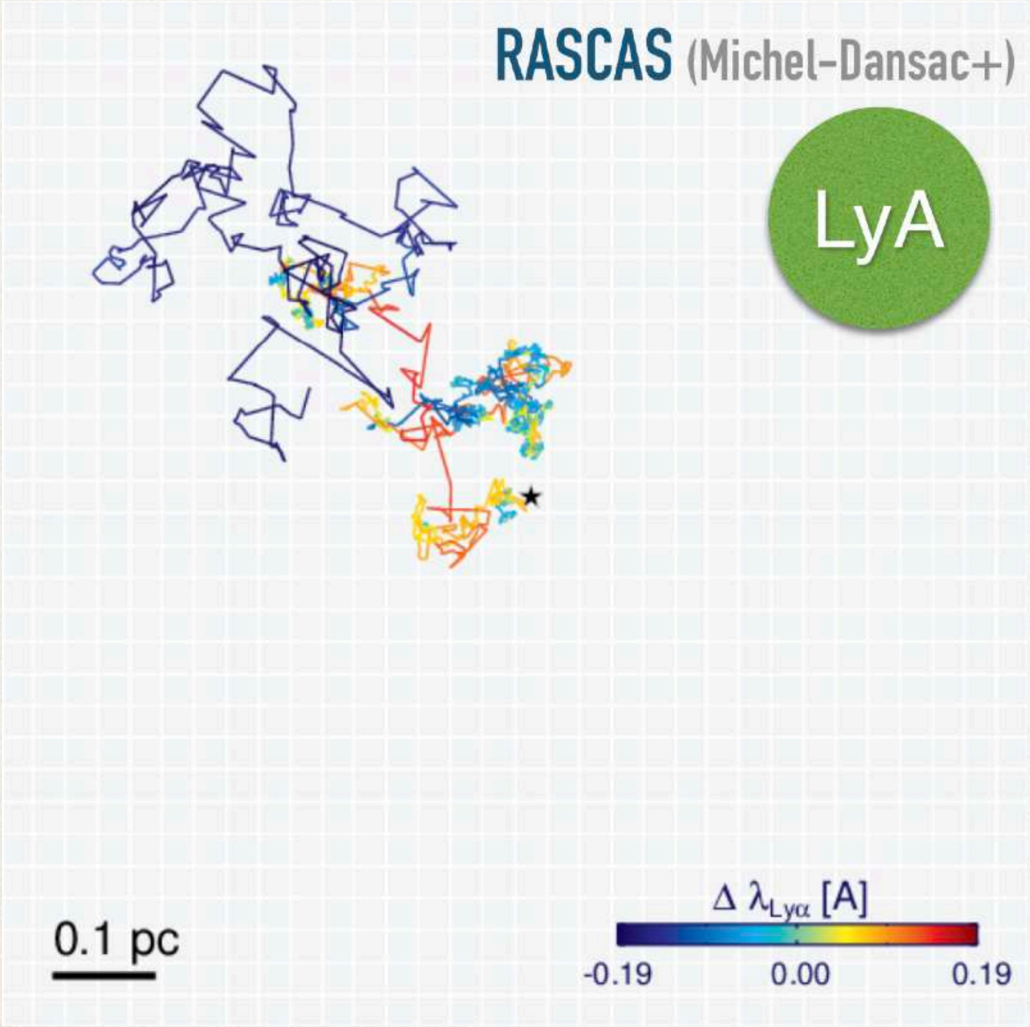
Name	L_{box} [pc]	t_{final} [Myr]	SF	Remarks
M6_SFE10	512	10	random	
M6_SFE1	512	20	random	Fiducial
M5_SFE10	256	7	random	
M5_SFE1	256	20	random	
M6_SFE10_sng	512	10	random	Single stellar SED
M6_SFE1_sng	512	20	random	Single stellar SED
M6_SFE10_300	512	10	random	
M6_SFE1_300	512	20	random	
M6_SFE10_Zsun	512	10	random	
M6_SFE1_Zsun	512	20	random	
M6_SFE1_noTurb	512	20	random	No turbulence
M6_SFE10_noSN	512	10	random	No SNe
M6_SFE1_noSN	512	20	random	No SNe
M6_SFE1_dSF	512	20	dense	
M6_SFE1_dSF_PLya	512	20	dense	Lyα pressure

- **L-weighted $\langle f_{esc,LyC} \rangle$ on cloud scales is ~ 5 - 50 %**
- **Even with turbulent structures, $f_{esc,LyC}$ does not fluctuate wildly**
  ($f_{esc,LyC}$ reflects the evolutionary phase of star formation episodes)
- **$\langle f_{esc,LyC} \rangle$ increases with Z_{gas} ↓, SFE ↑, M_{cloud} ↓, and by making SEDs harder**

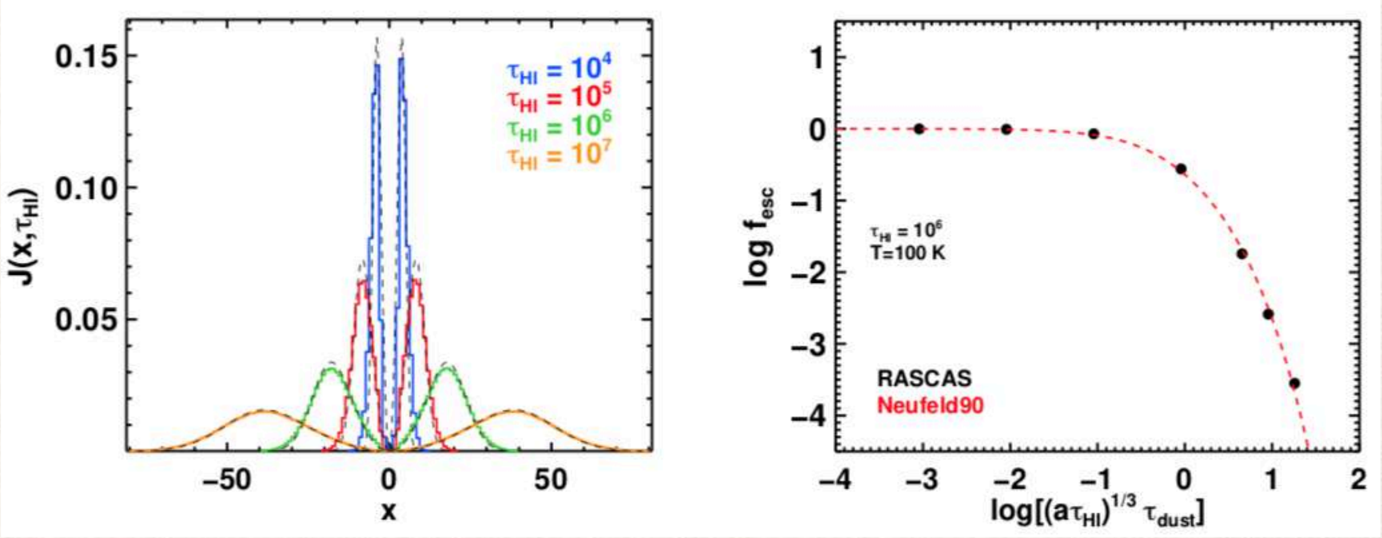
RASCAS: a (new) Monte-Carlo RT code

RAdiation SCattering in Astrophysical Simulations :

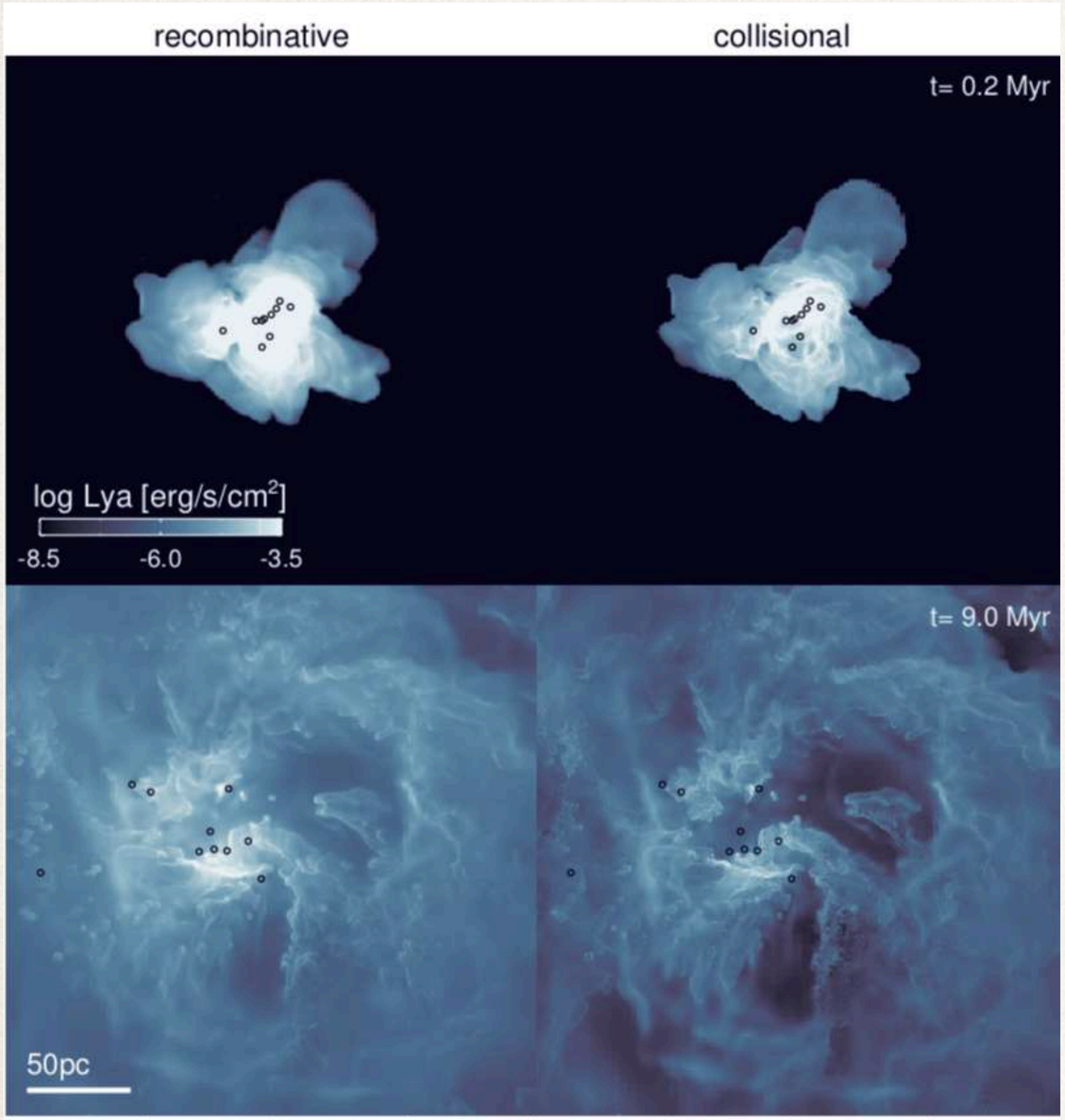
Michel-Dansac, Blaizot, Garel, Verhamme, Kimm, Trebitsch (19, submitted)

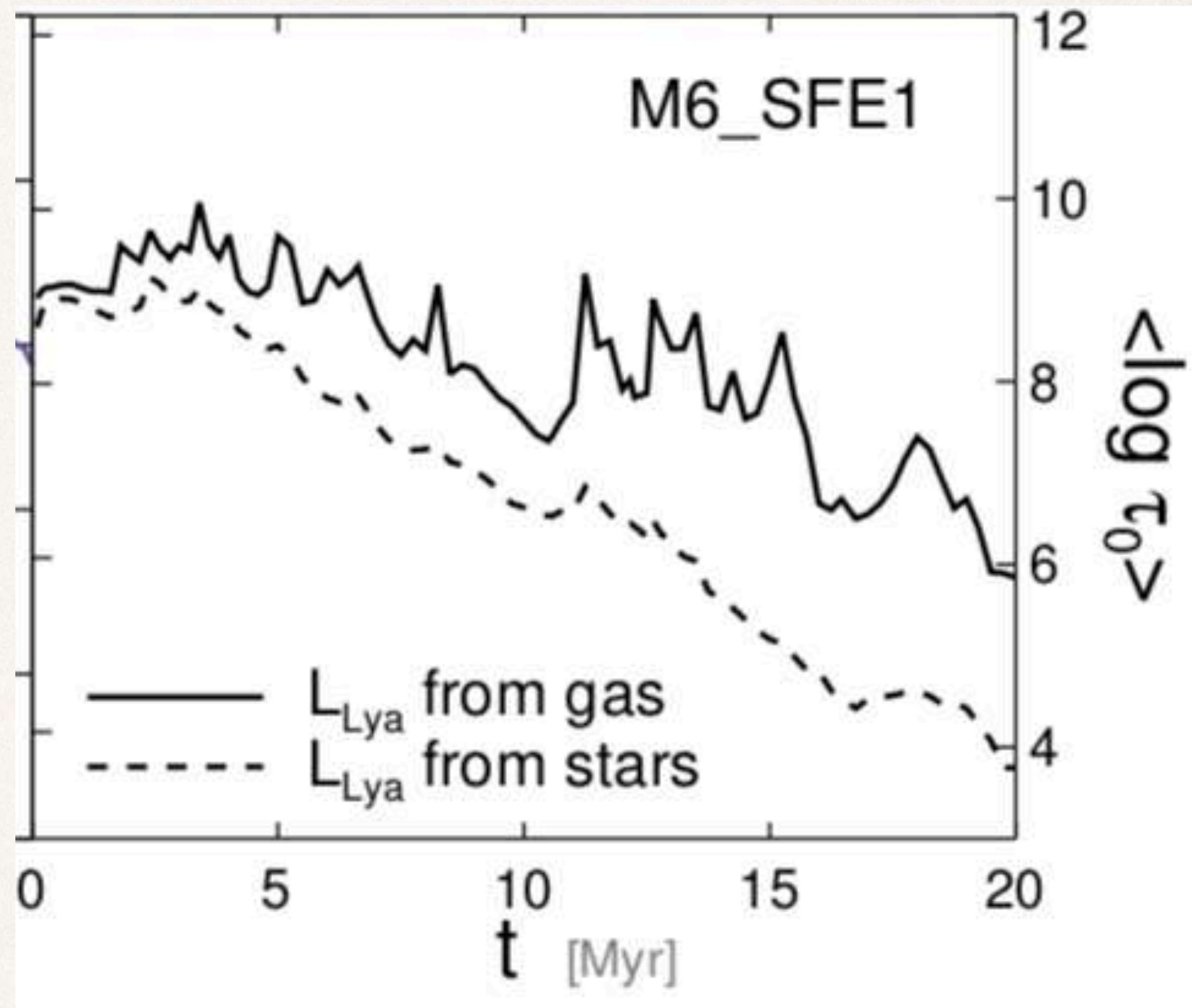


- Efficient domain decomposition for MPI
- Tailored for AMR simulations
- Not only Lya, but also other resonant lines (Si II, Mg II, Fe II, etc..)



Lya from stars or gas?

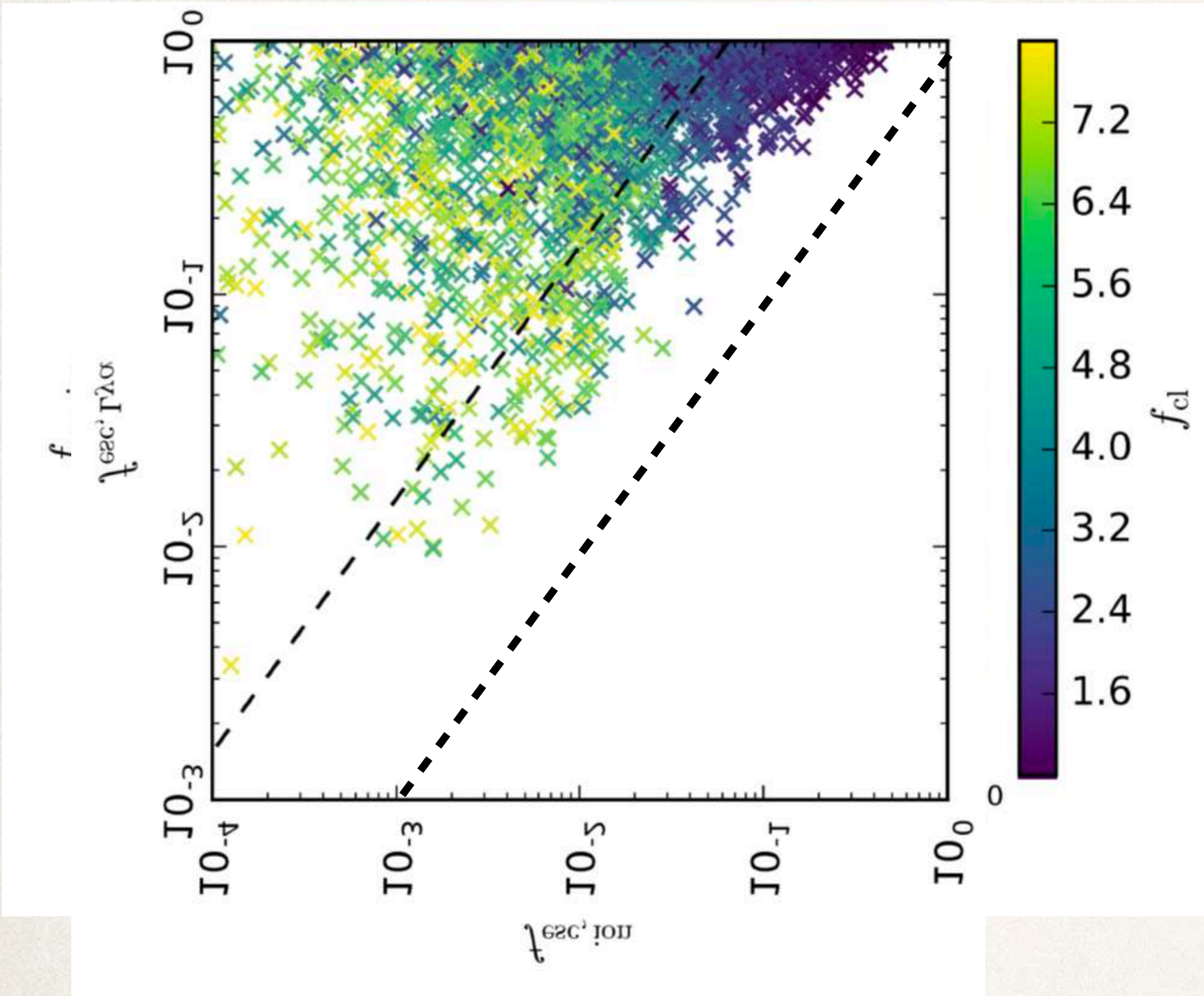


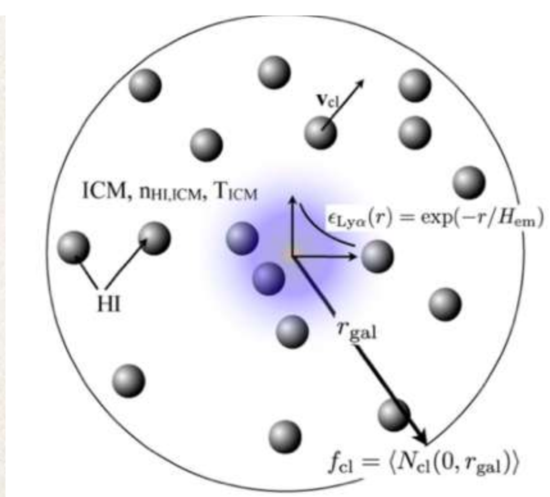


Assumption that Lya arises from stellar components is likely to under-estimate the number of scattering

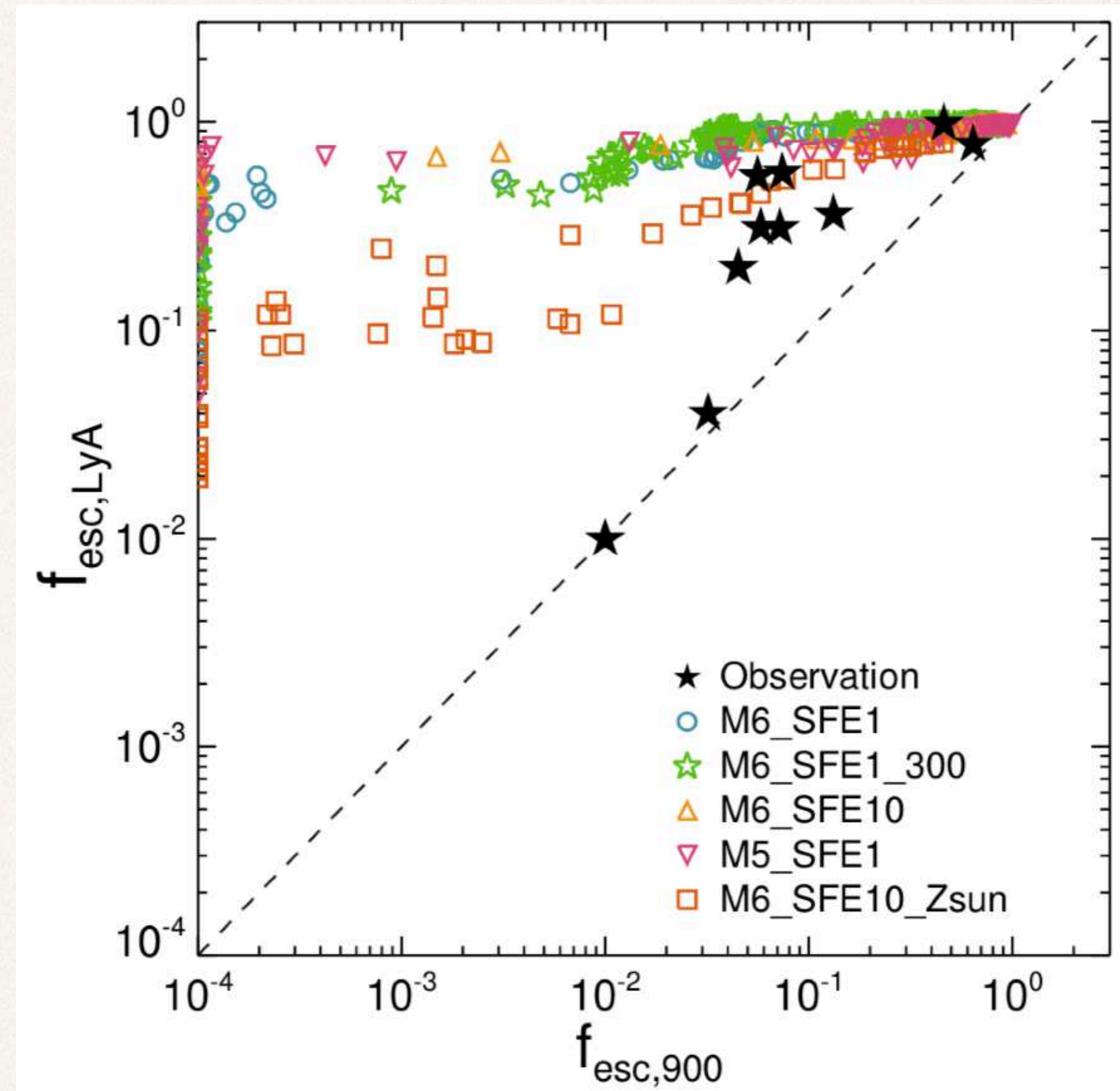
Escape of LyC vs LyA

Clumpy ISM



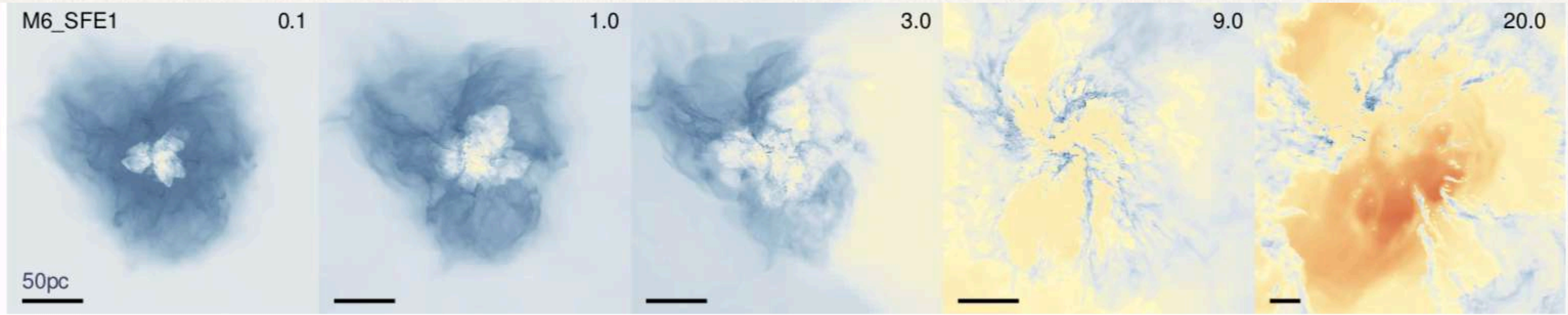


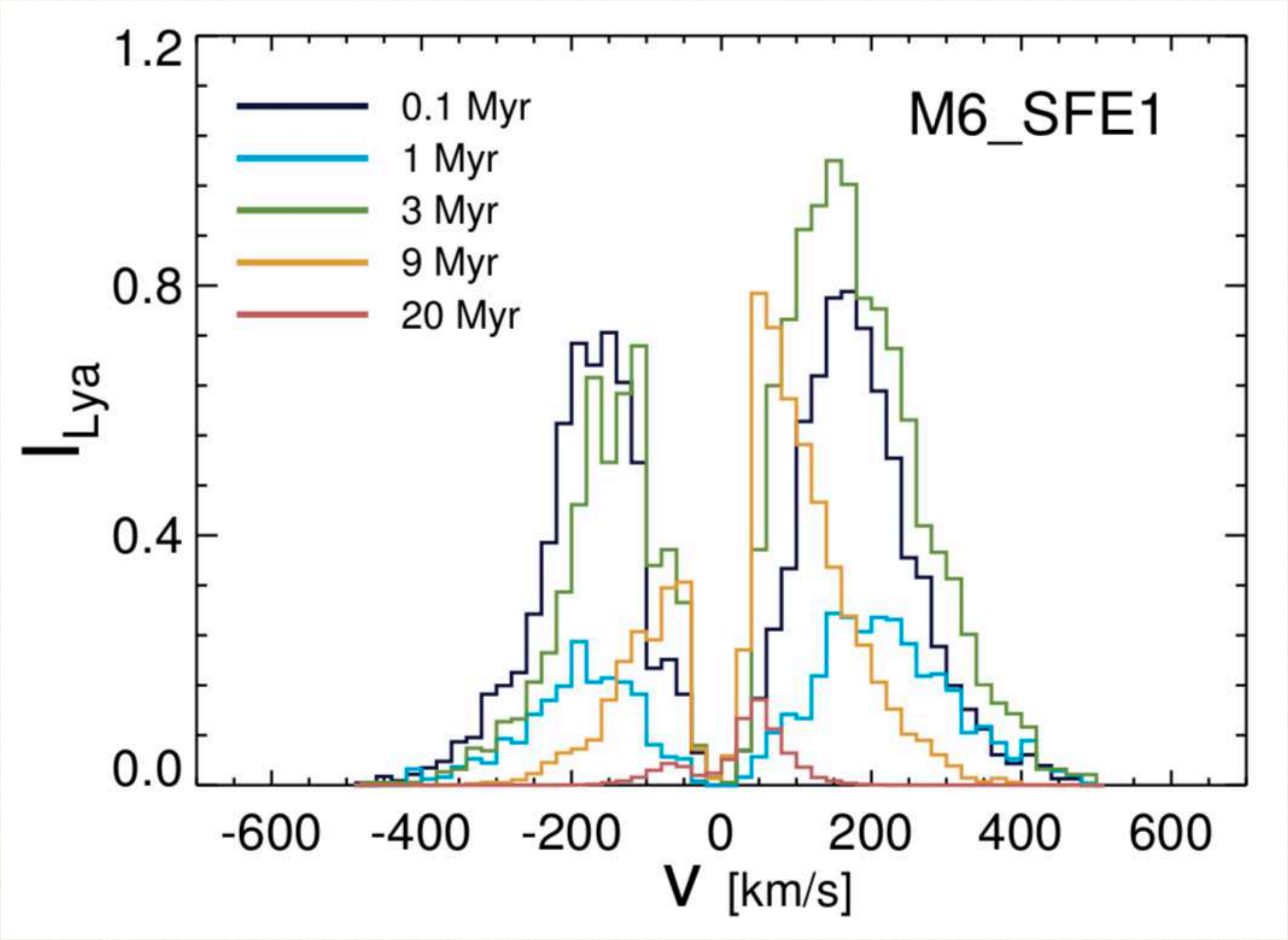
Turbulent clouds



Kimm+(19, submitted)

Cloud simulations with radiation+SN

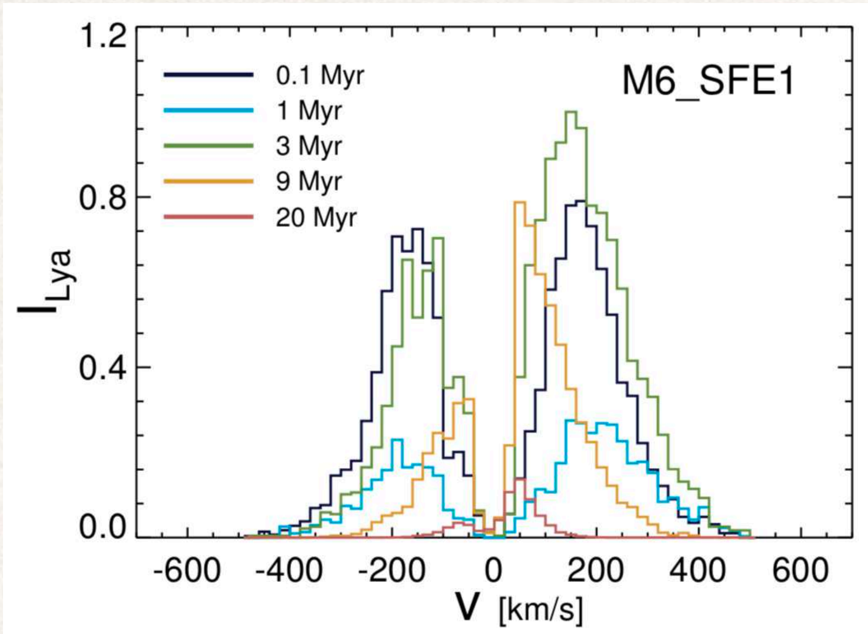


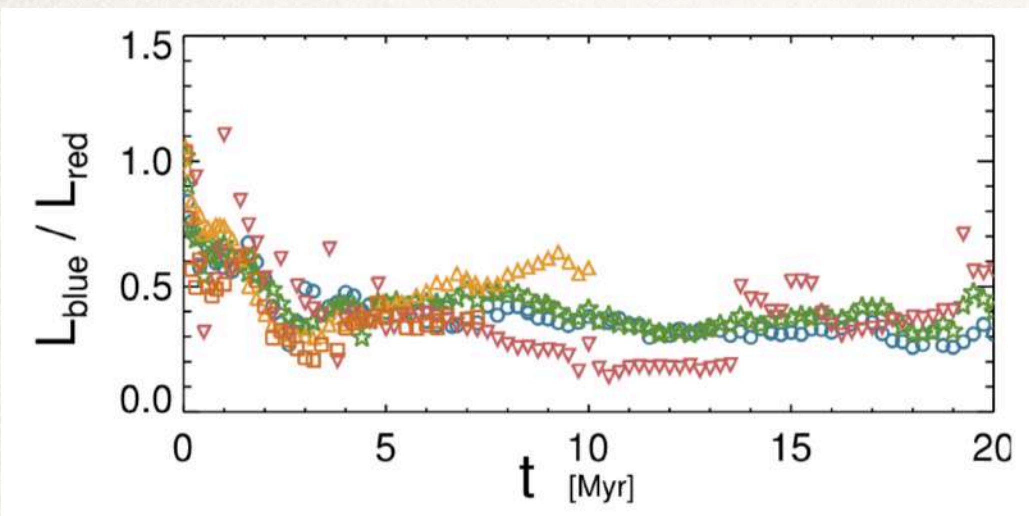


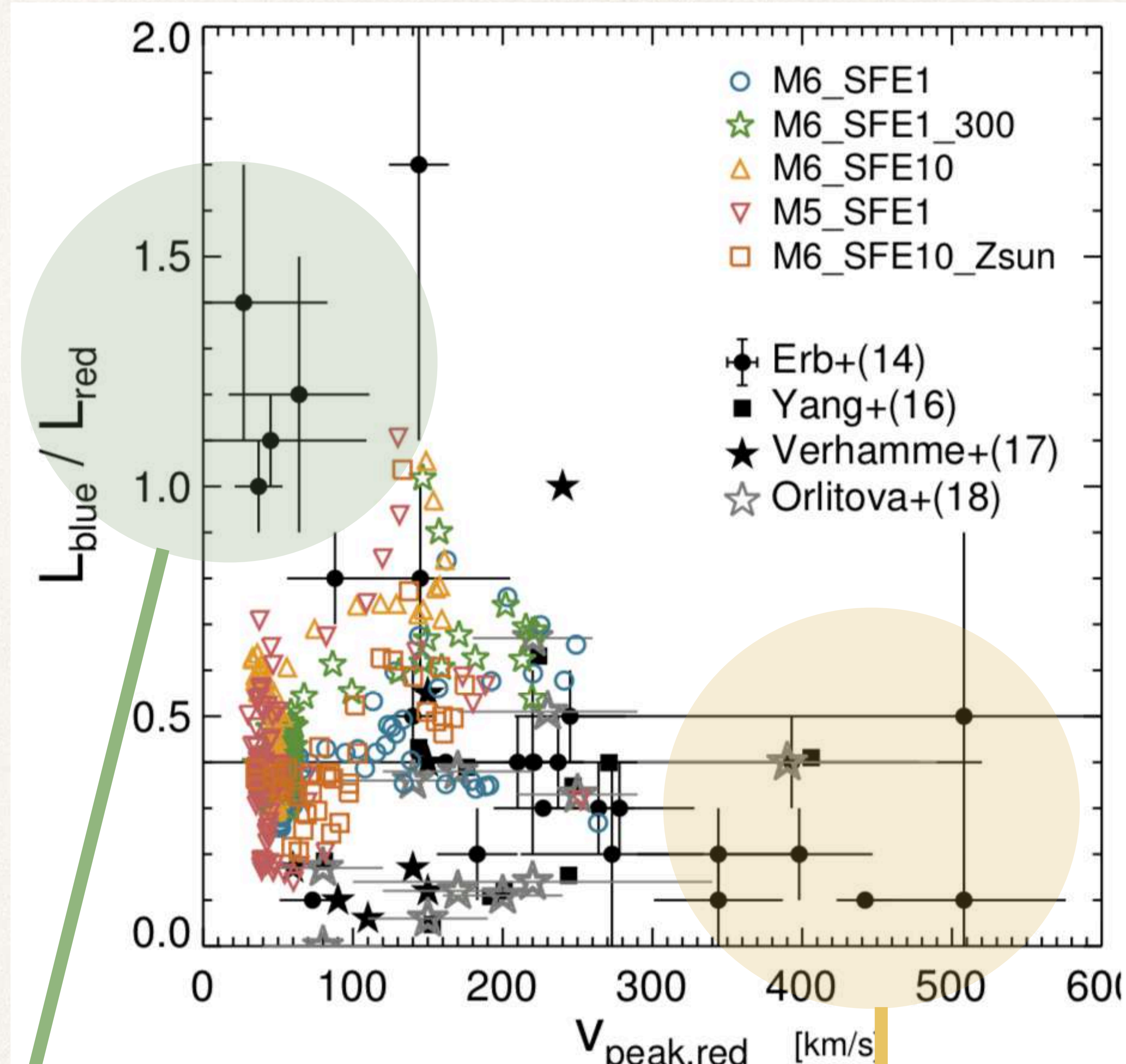
Kimm+(19, submitted)

Lya spectrum can be broad on cloud scales!

Asymmetry of Lya



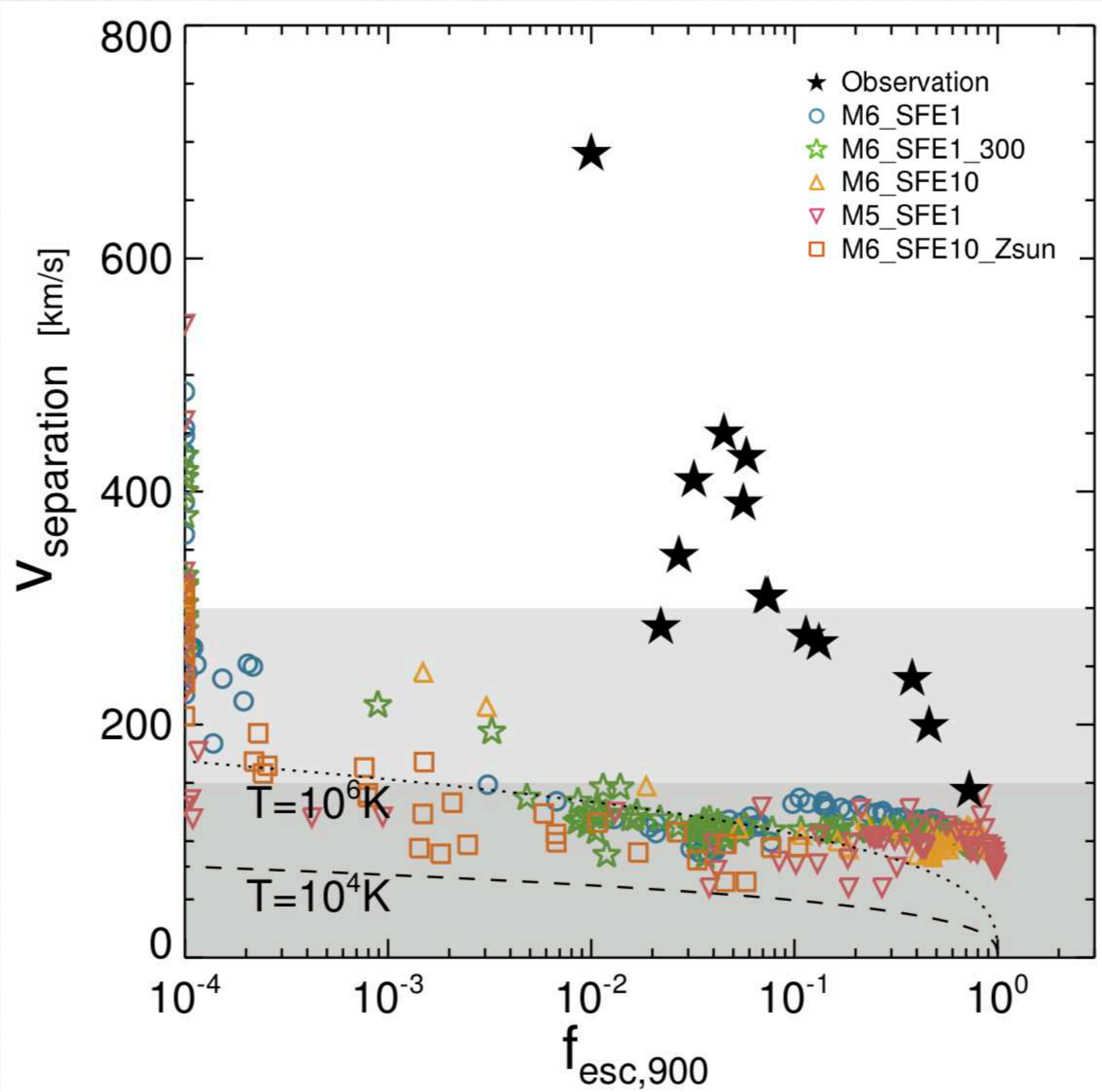




optically thin, static ISM or inflow?

optically thick outflow?

Separation of blue and red peak



Three possibilities

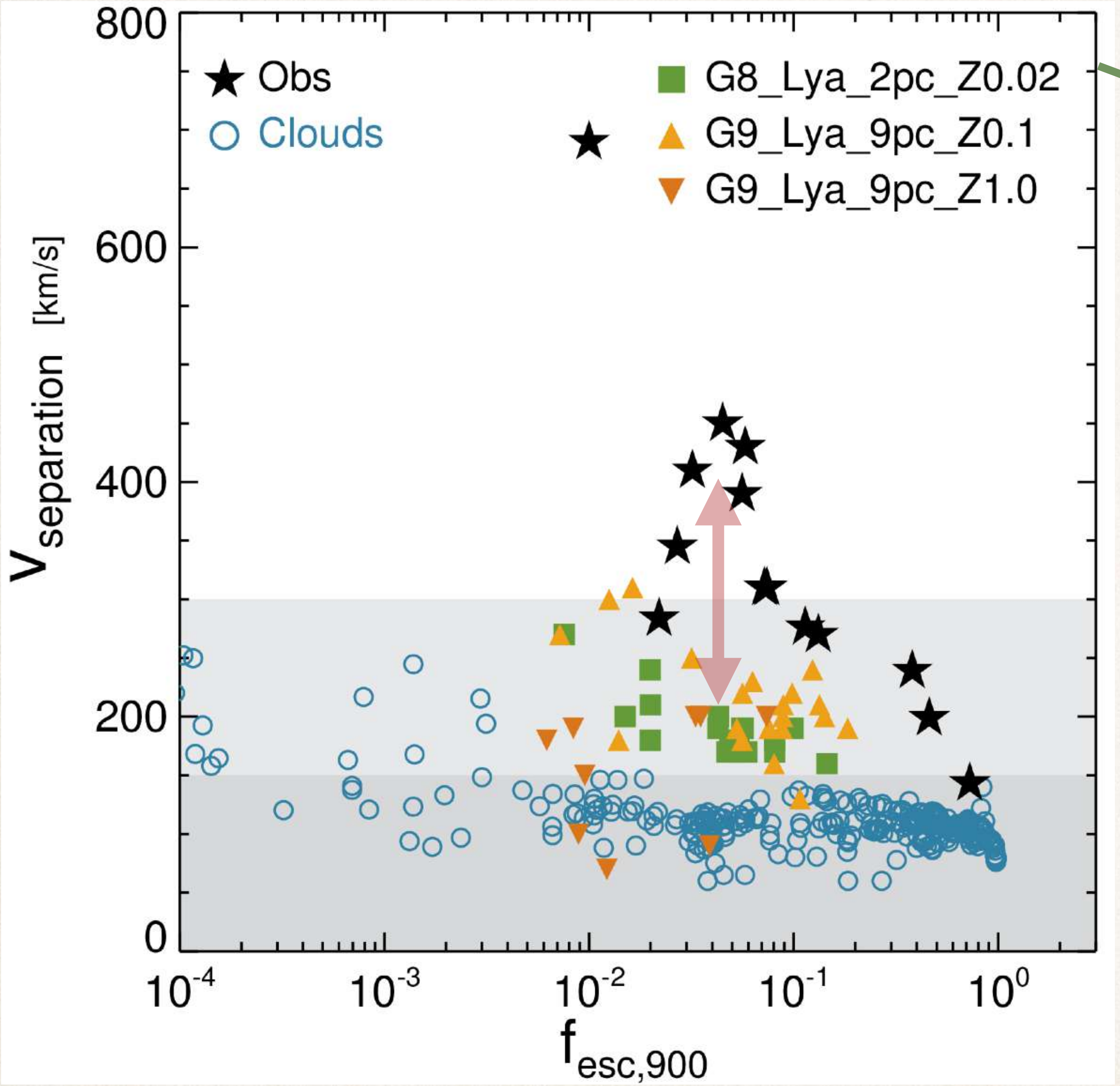
1) more Lya scattering due to ISM (N_{HI} ↑)

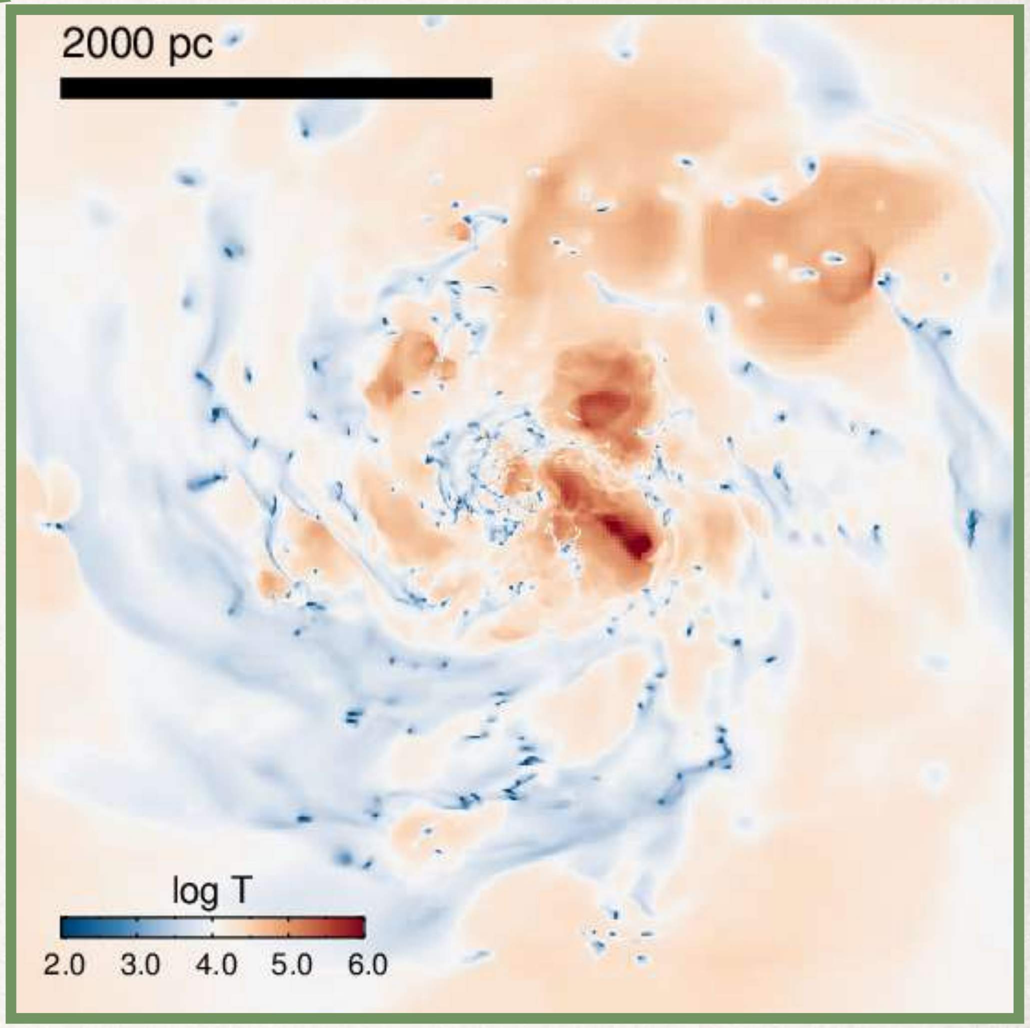
2) Combination of different stages of multiple clouds?

3) Other possibilities?

Isolated disk galaxies

Preliminary!!

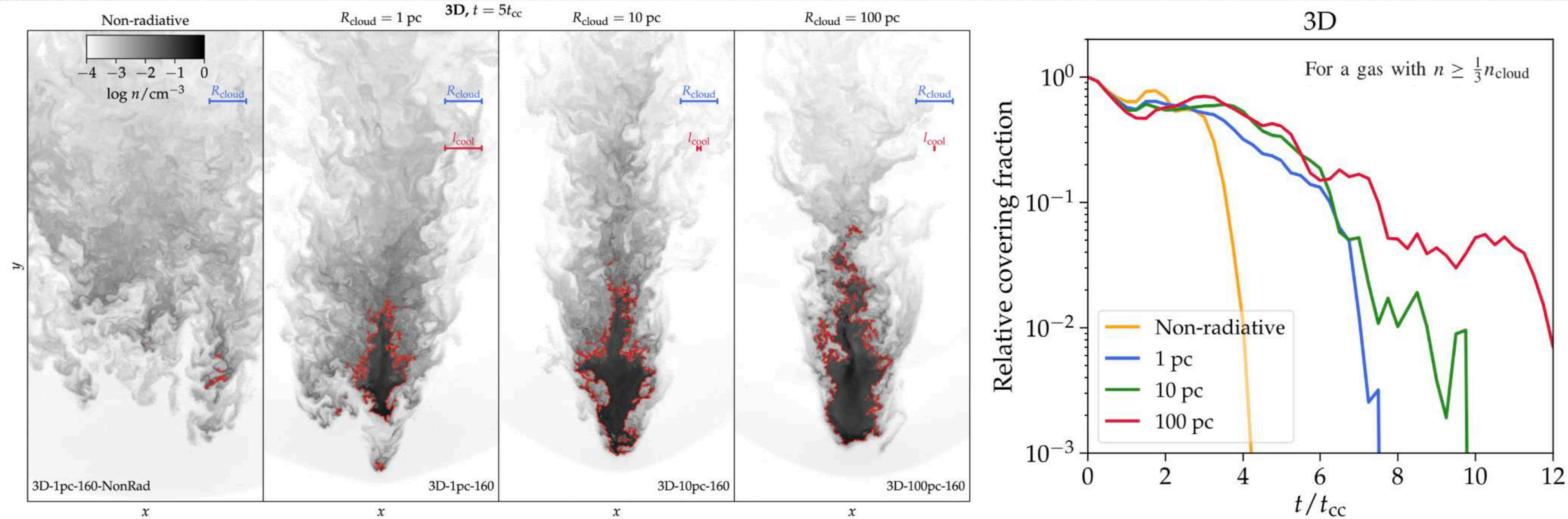




G8: $M_{star} \sim 10^9$Msun

G9: $M_{star} \sim 10^{10}$Msun

Gas shattering and foggy CGM



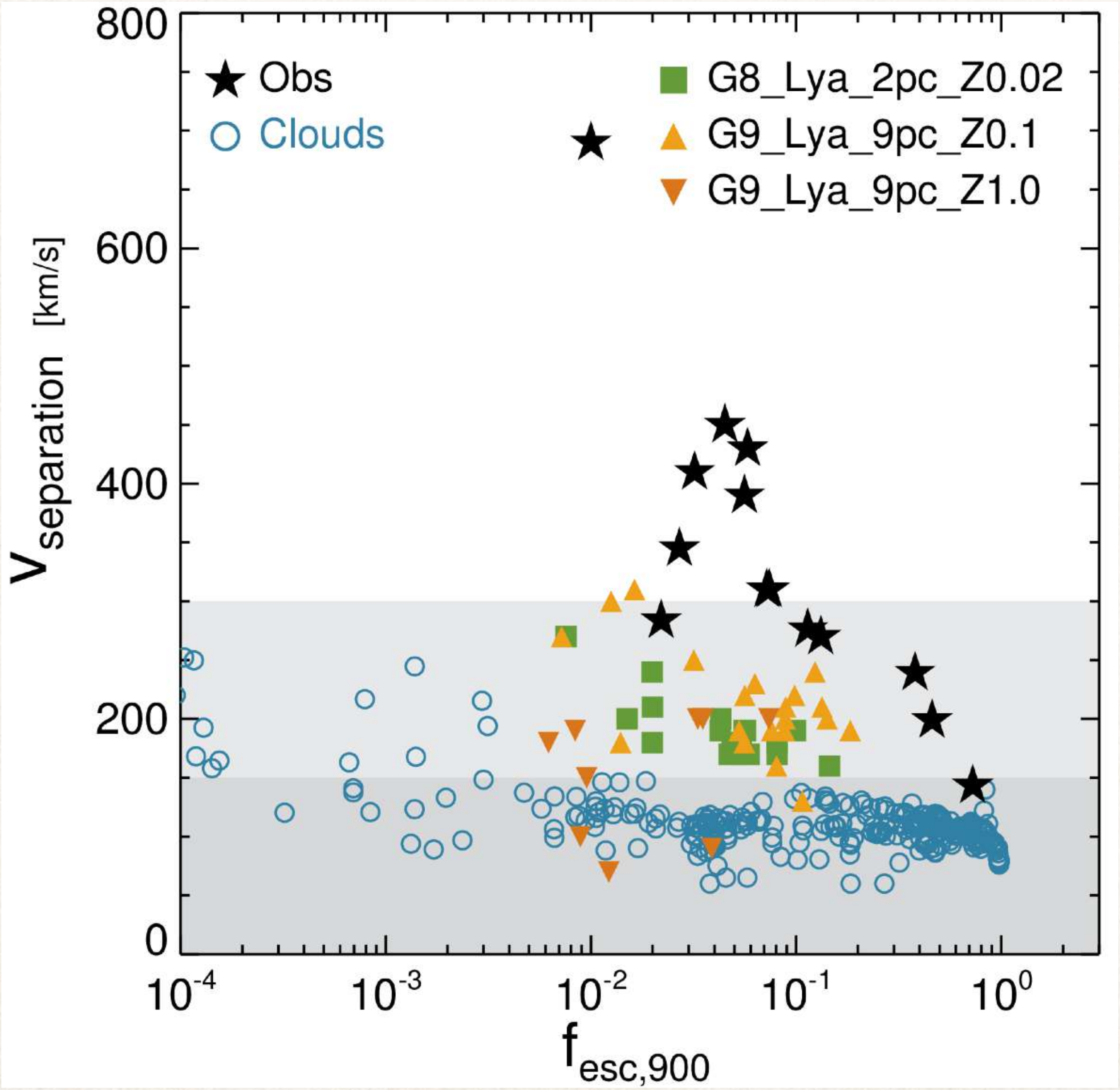
Sparre+(19); McCourt+(18)

Bigger clouds easily fragment into smaller pieces and survive longer!

$$\ell_{\rm cloudlet} \sim \min\left(c_{\rm s} t_{\rm cool}\right) \sim (0.1\,{\rm pc}) \left(\frac{n}{{\rm cm}^{-3}}\right)^{-1},$$

Summary

LyC - covering fractions of $N_{HI}<10^{17}$ cm²
LyA - kinematic information of neutral hydrogen



LyC-LyA gives us a unique opportunity to learn about kinematic properties of star-forming galaxies

-> foggy CGM?