SIMULATING HYDROGEN & CARBON CHEMISTRY IN COSMO SIMS

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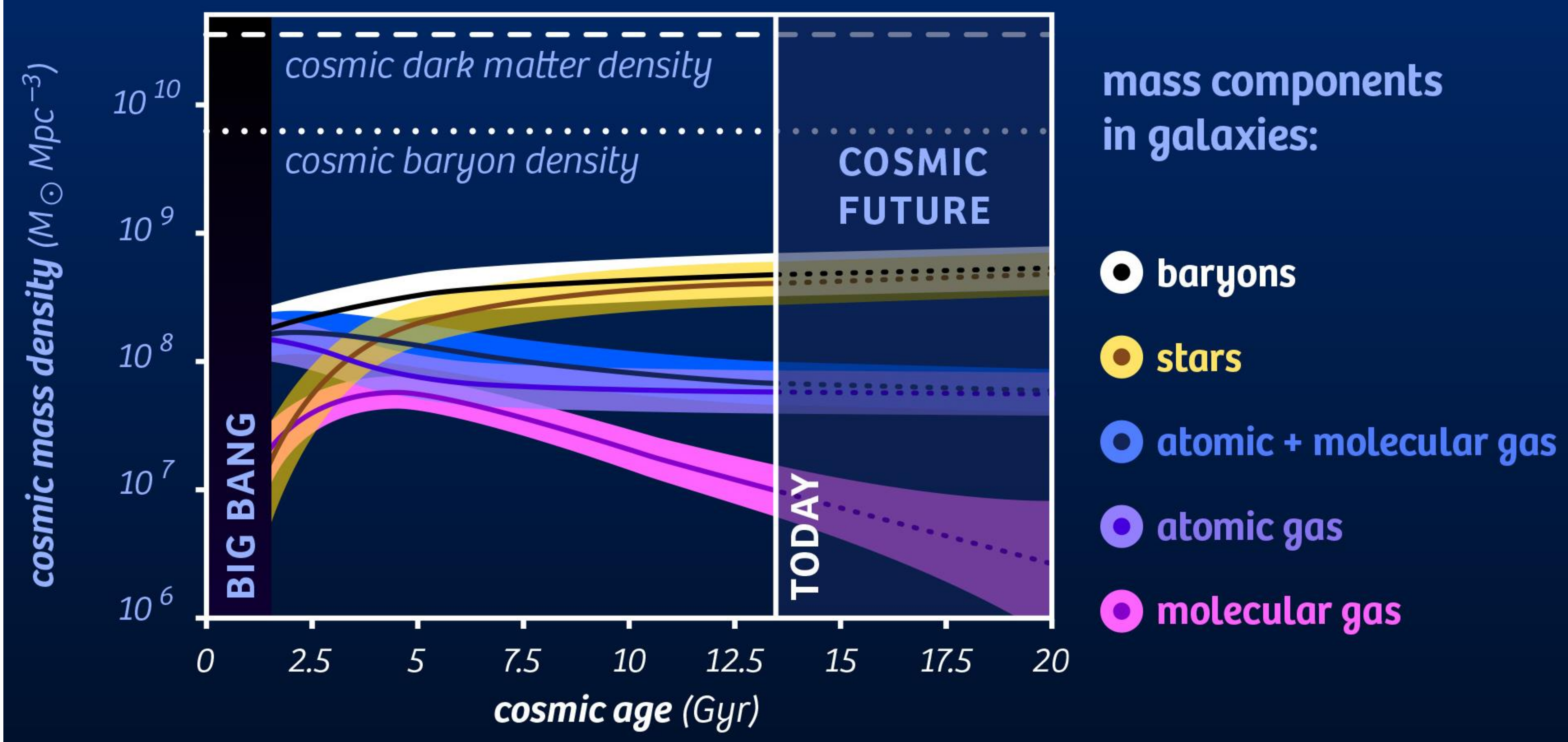
With: Cristiano Porciani, Emilio Romano-Díaz

SFB 1601

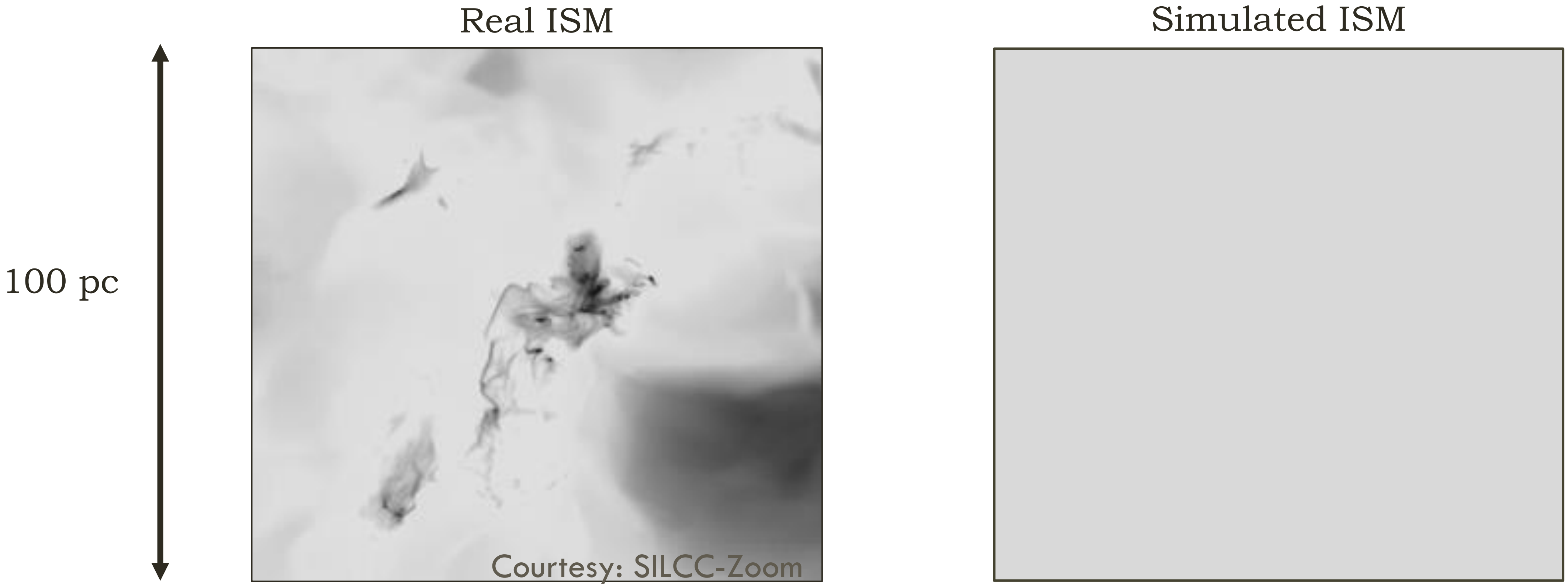
IMPRS astronomy & astrophysics Bonn and Cologne

UNIVERSITÄT BONN



ASPECS (Walter+20)

BOTTLENECK FOR CHEMISTRY: THE UNRESOLVED DENSITY STRUCTURE



The finite resolution of simulations misses the density structure of the ISM, important for modelling chemical abundances and emission.

HYACINTH: HYdrogen And Carbon chemistry in the INTerstellar medium in Hydro simulations

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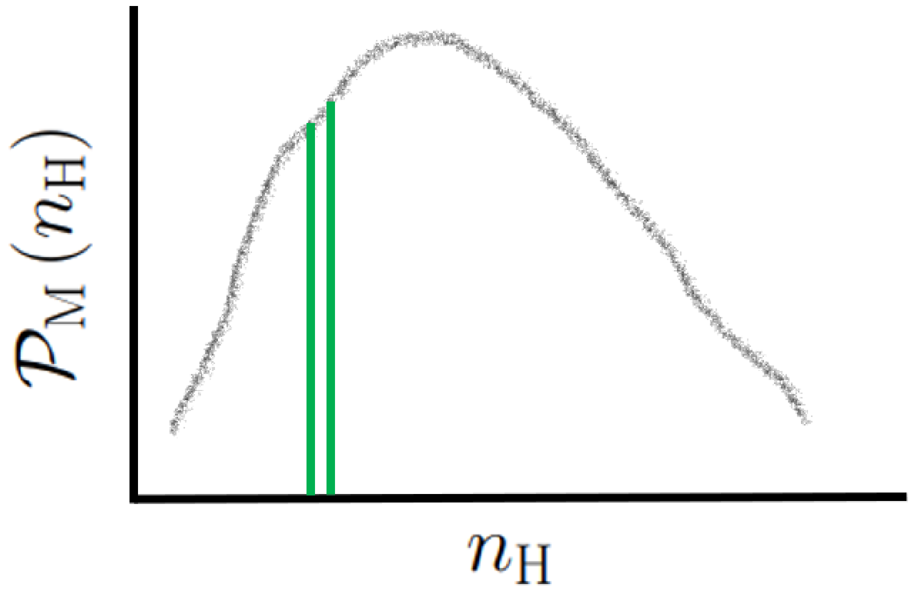
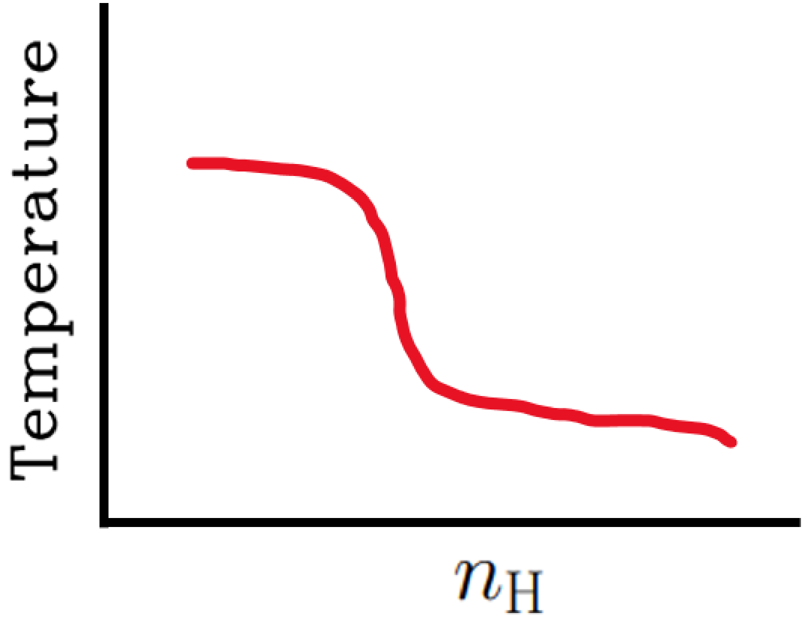
arXiv:2402.11023

THE SUB-GRID INGREDIENTS





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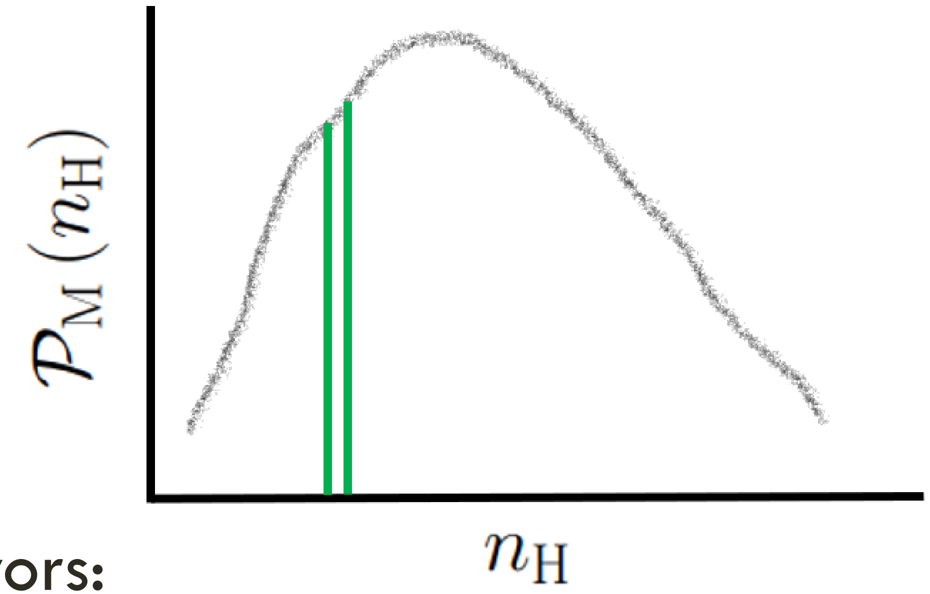

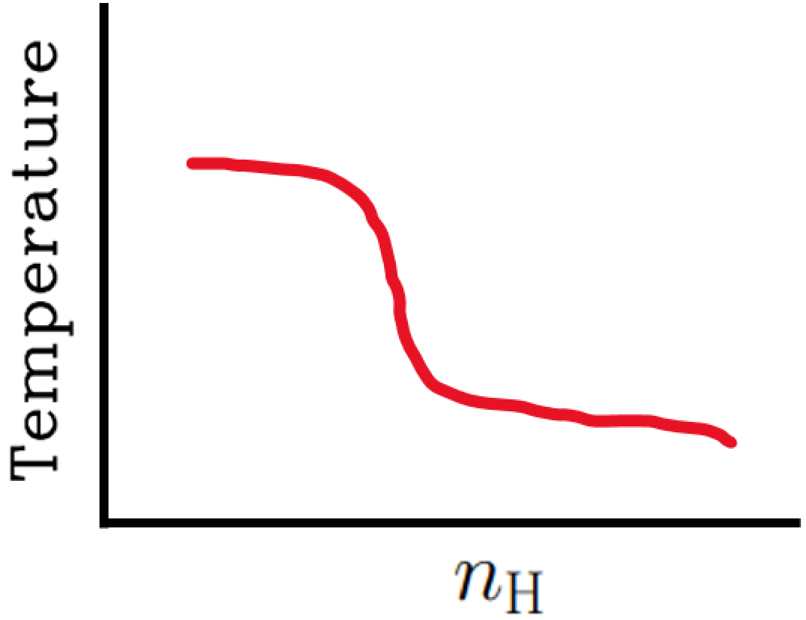

2 flavors:

lognormal – *turbulent regions*

lognormal with a power-law tail – *self-gravitating regions*

(see Kainulainen+09, Kritsuk+11, Federrath+13, Girichidis+14)

Z-dependent (from Hu+21)

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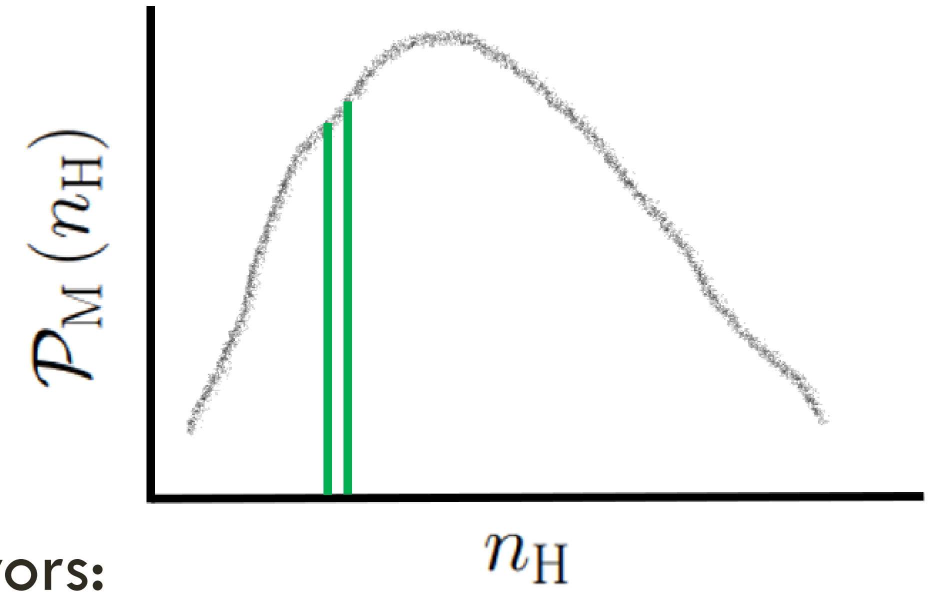

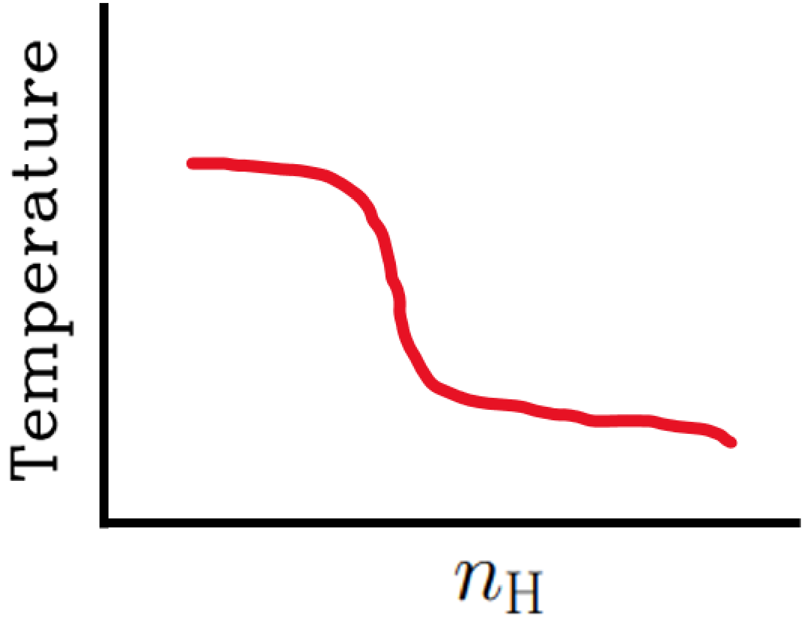

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CAUTION: *The ISM is much more complex and these are effective models*

THE SIMULATION

RAMSES simulation with non-equilibrium chemistry on-the-fly

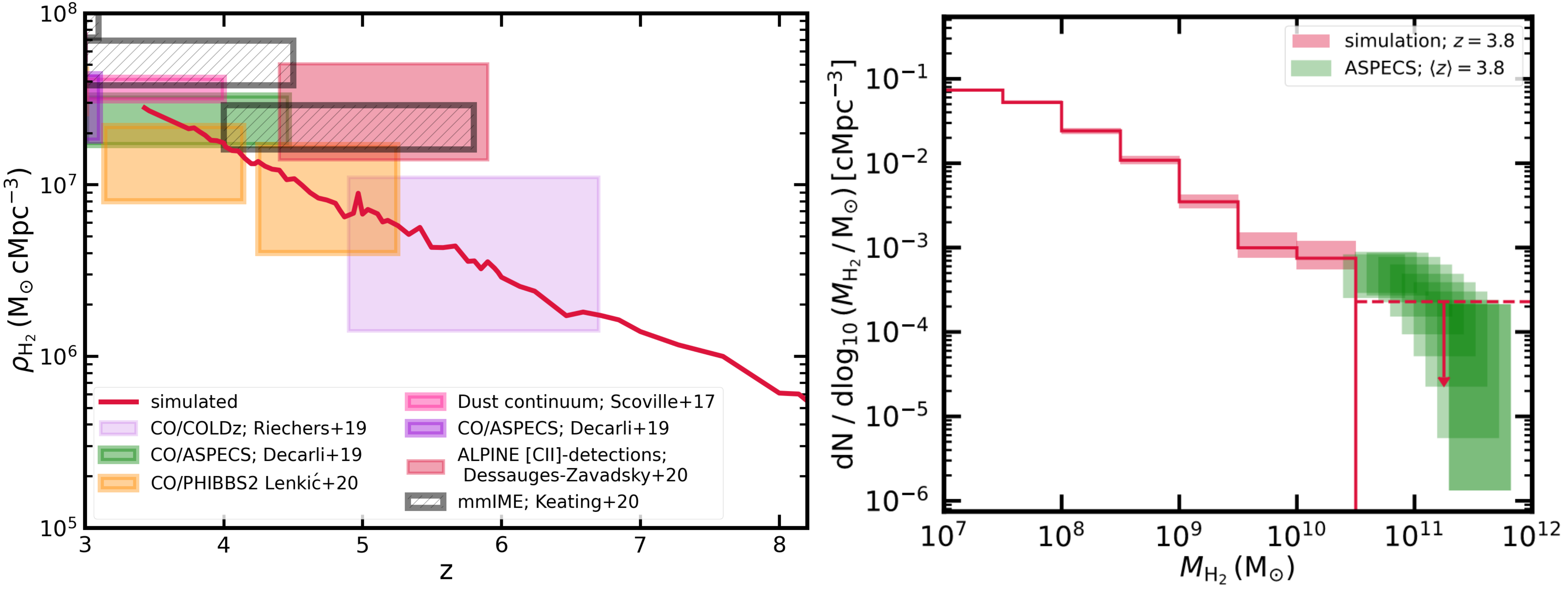
Radiative transfer of Lyman-Werner band (λ = 912 - 1110 Å) photons

Z-dependent dust-to-gas ratio
(Péroux & Howk 20, Popping & Péroux 22)

H_2-based star formation

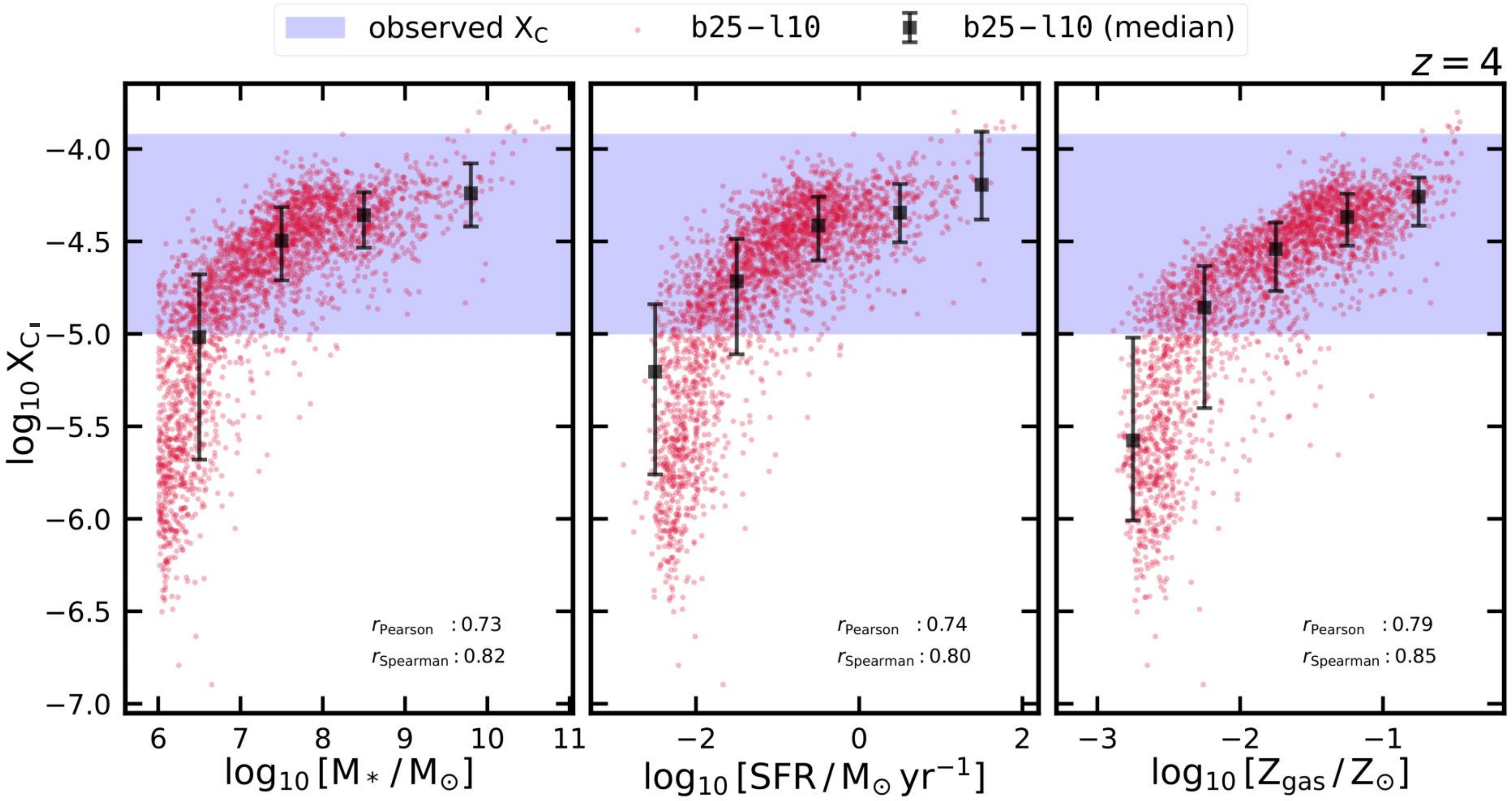
A (25 cMpc)^3 volume
Mass resolution --
DM: $3.37{\times}10^5\, h^{-1} \mathrm{M}_\odot$
Stars: $7.2{\times}10^3\, \mathrm{M}_\odot$
minimum cell size = 32 pc

EVOLUTION OF THE COSMIC H_2 DENSITY



Khatri+ in prep

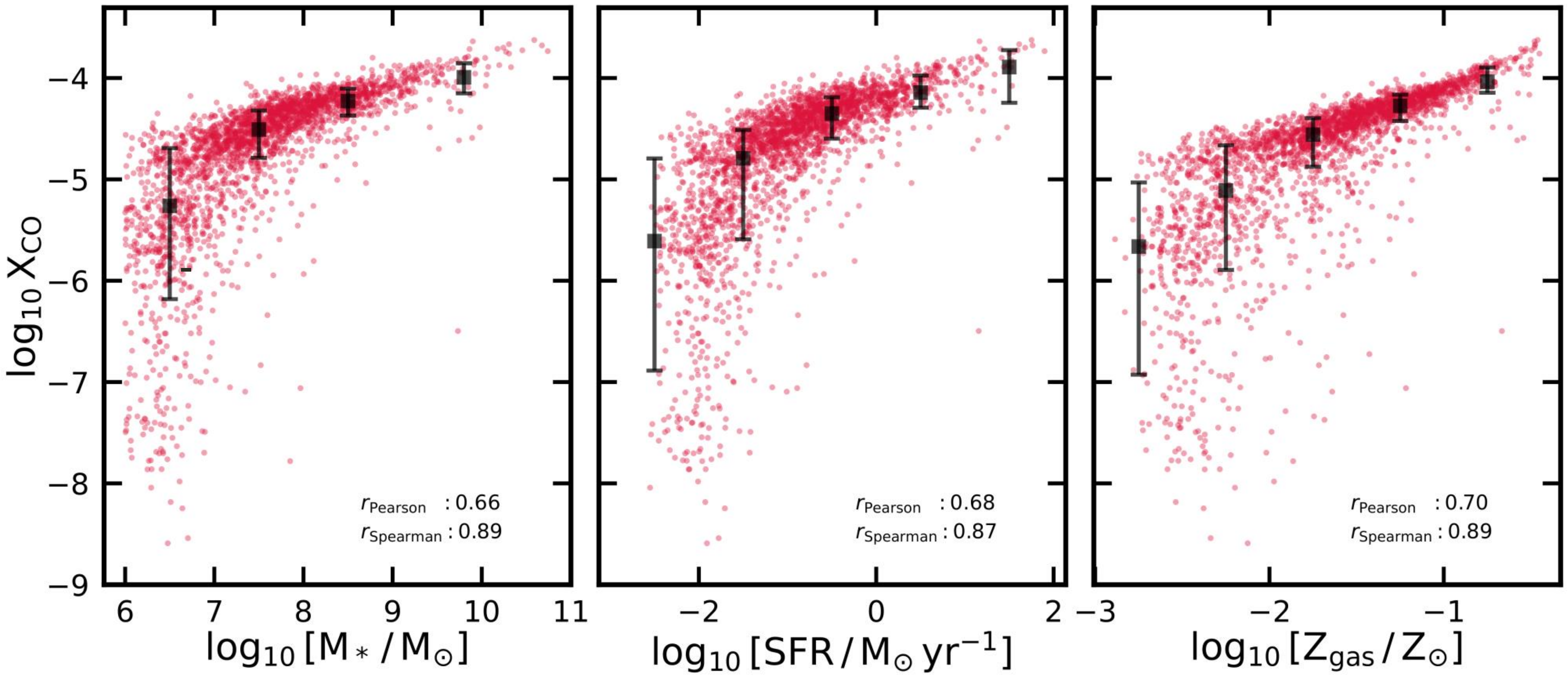
ATOMIC CARBON ABUNDANCE



$$X_{\mathrm{C\,I}} = \frac{M_{\mathrm{C\,I}}}{6\, M_{\mathrm{H_2}}}$$

Khatri+ in prep

CO ABUNDANCE



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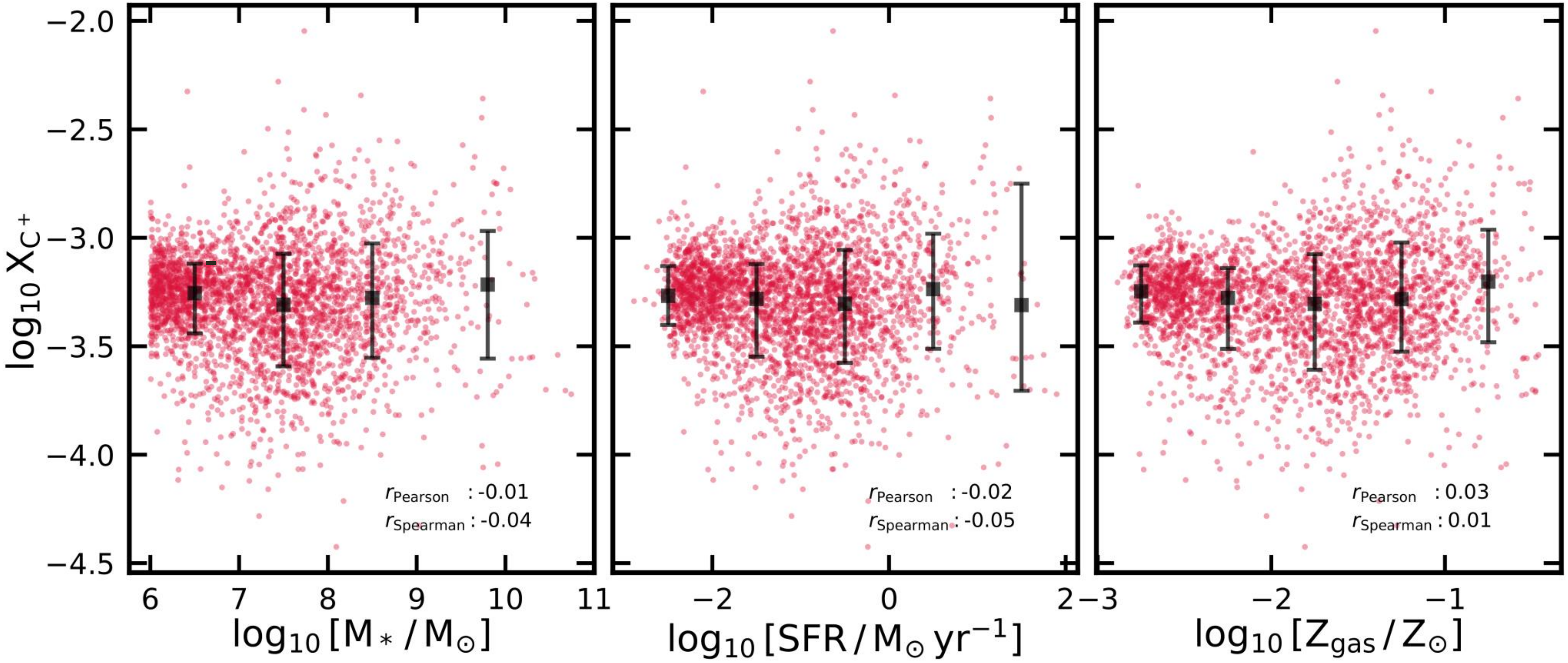
C^+ ABUNDANCE



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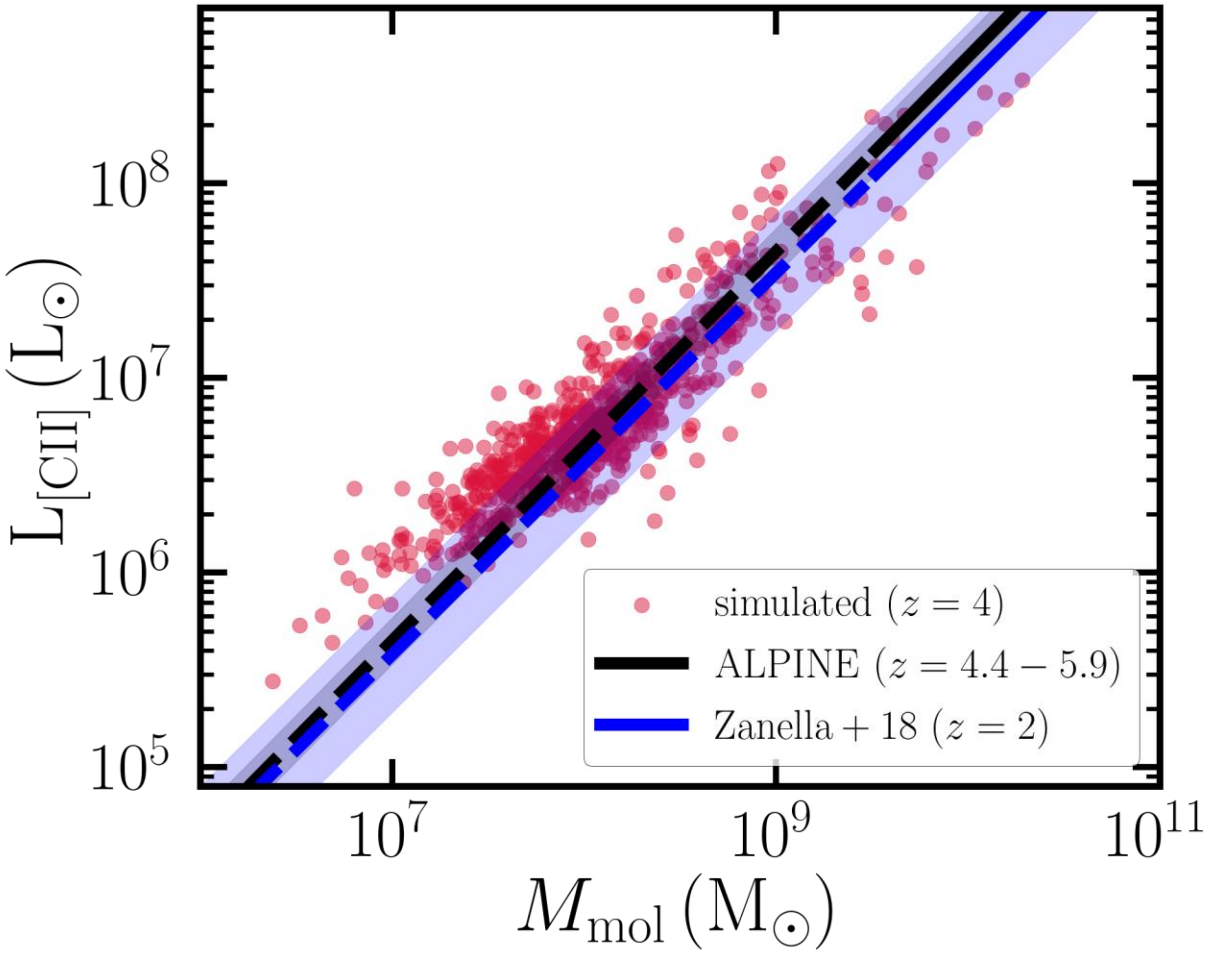
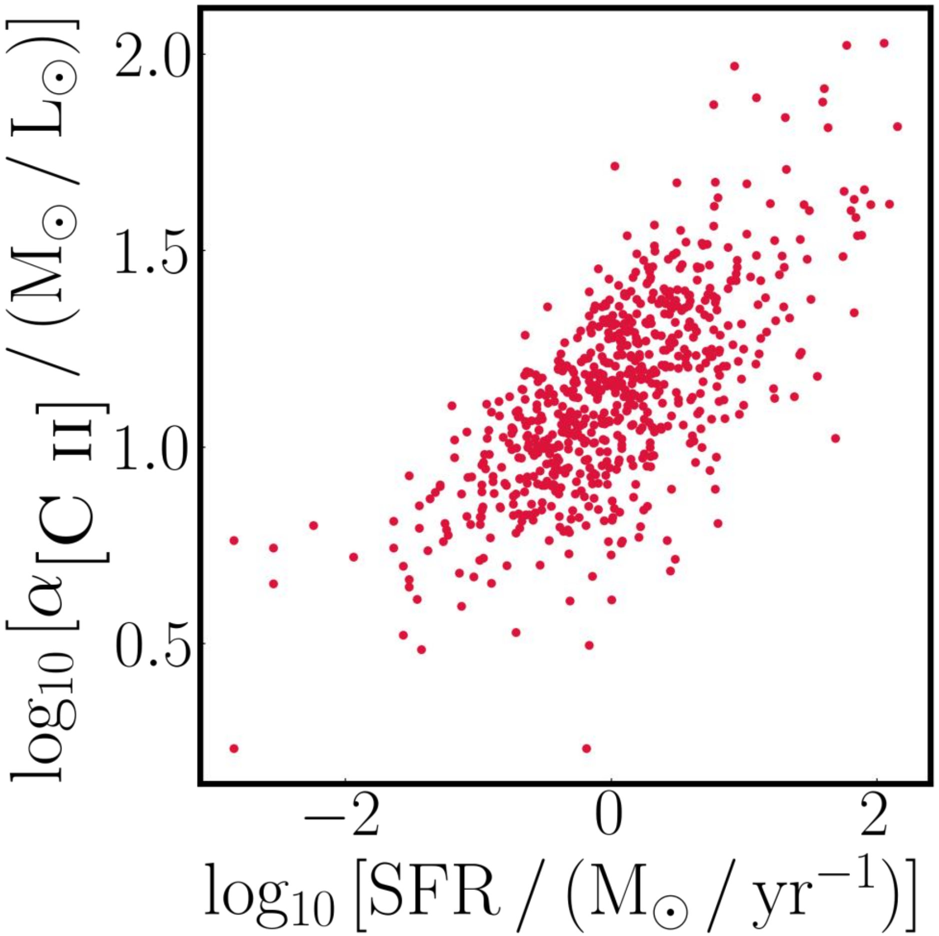
[CII]-M_{mol} RELATION





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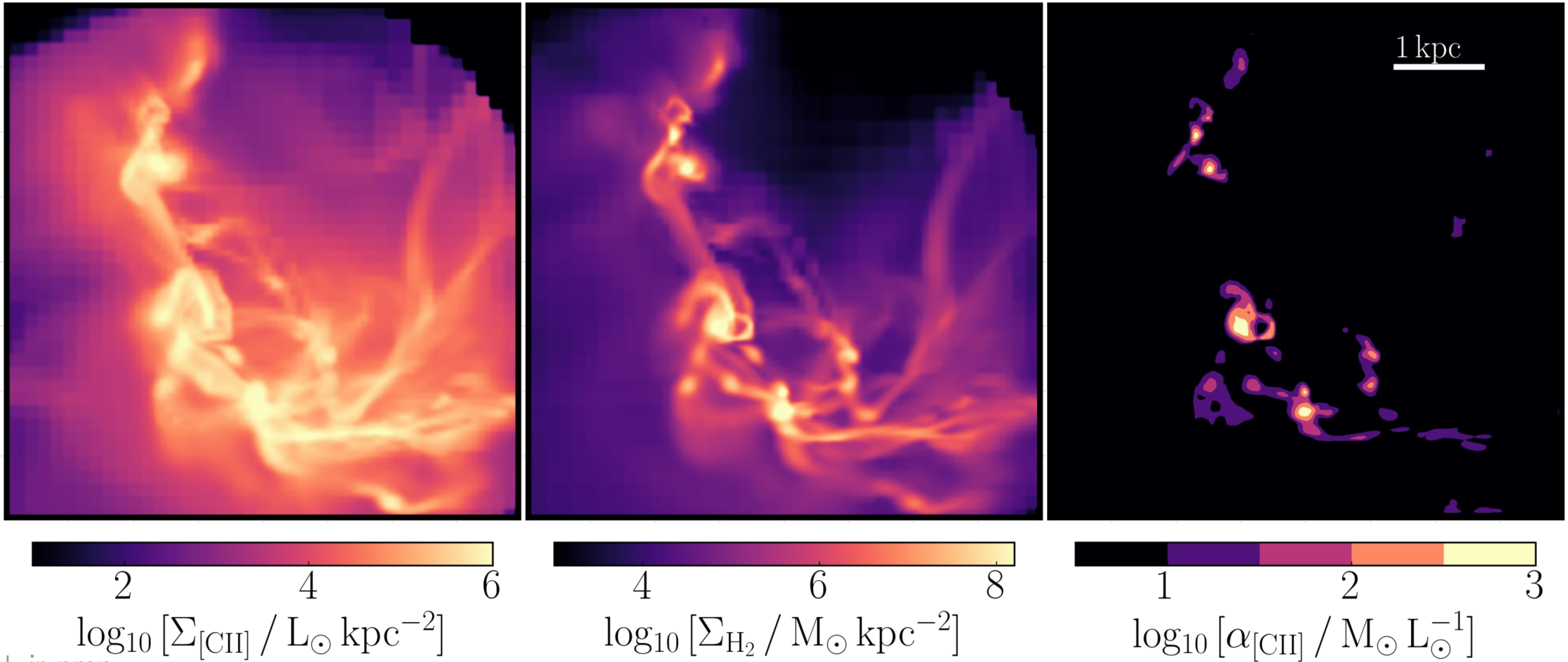
SPATIAL VARIATION OF $\alpha_{[CII]}$



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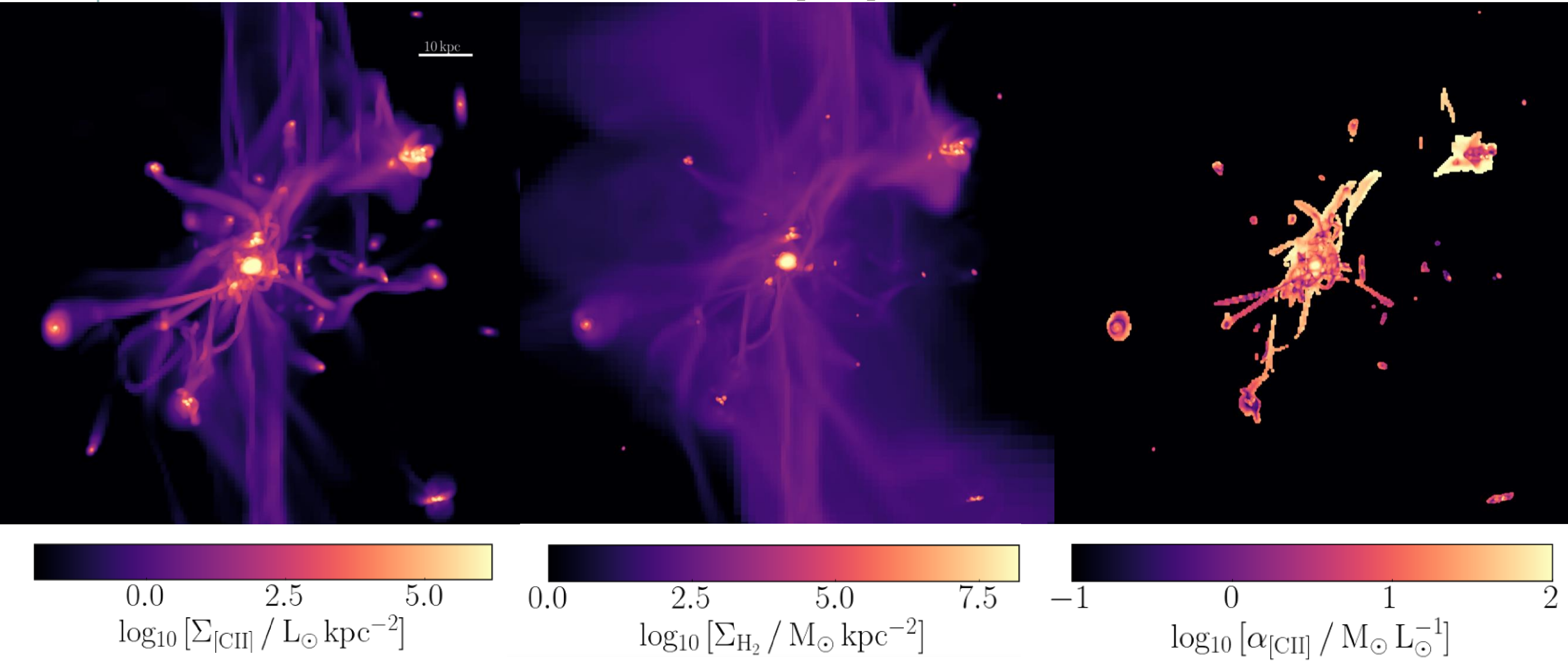

CONCLUSIONS

- HYACINTH: A sub-grid model for non-equilibrium hydrogen and carbon chemistry on-the-fly in cosmological simulations **arXiv:2402.11023**

- C^+ / H_2 abundance insensitive to galaxy properties

- $\alpha_{[CII]}$ varies across galaxies – with the star formation rate and within galaxies/galaxy groups.