The impact of ionizing radiation on young forming molecular clouds

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Lake Windermere; July 2018

Questions, more questions and even more questions

Credits: NASA,ESA, M. Robberto, Observation Orion A molecular cloud by the Hubble Space Telescope

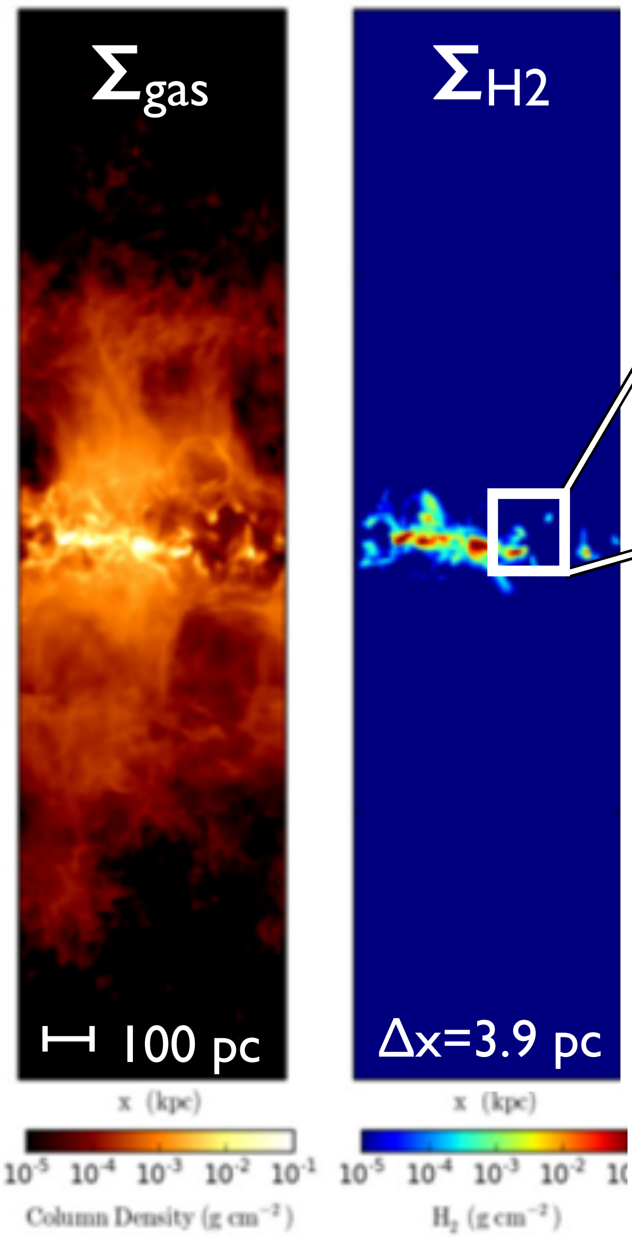
- How does photoionizing radiation change young molecular clouds with respect to…
  …(sub-) structure of the clouds?
  …star formation?

- Is photoionizing radiation really important?
  indicated by impact, energy content

Zoom-In on molecular clouds

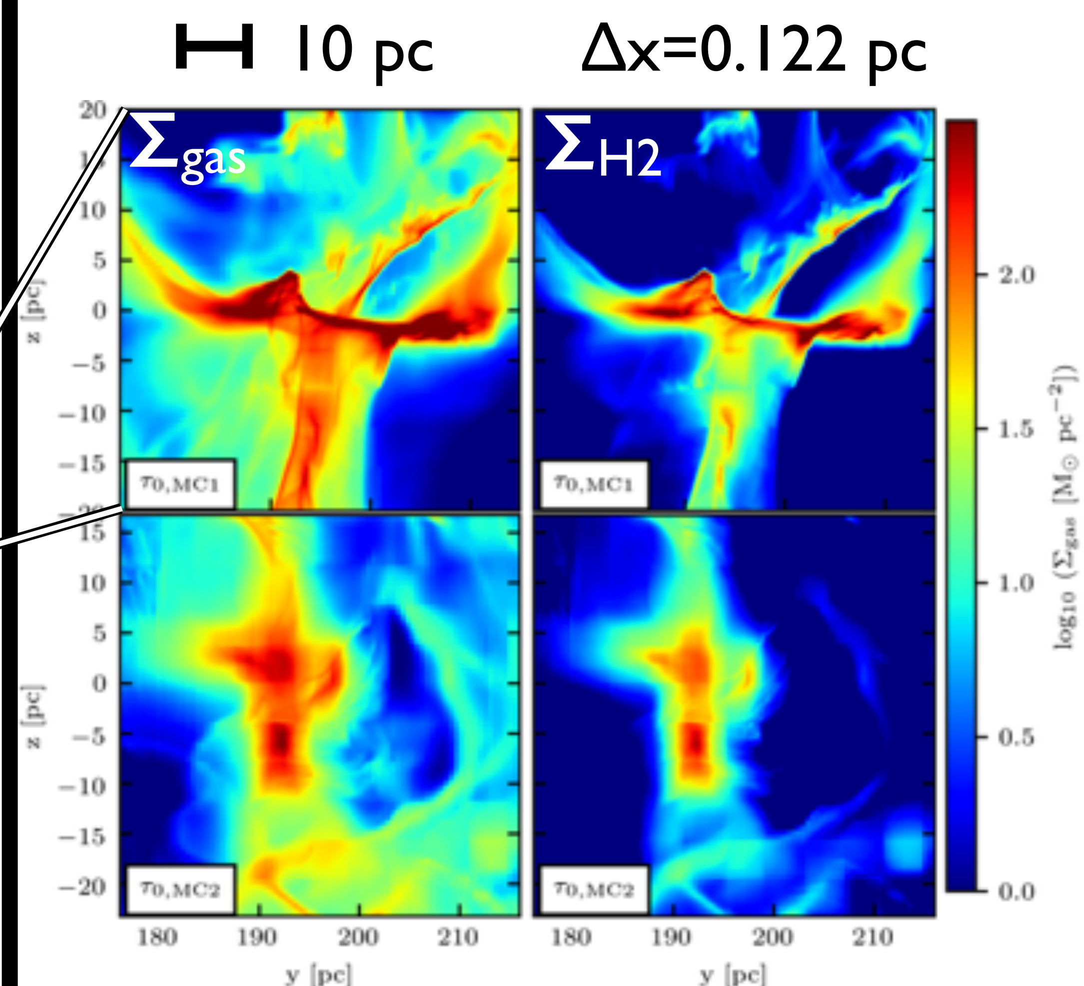
SILCC

Walch+ MNRAS 454, 2015



Zoom-In

Seifried+ MNRAS 472, 2017



Self-consistent formation of molecular clouds

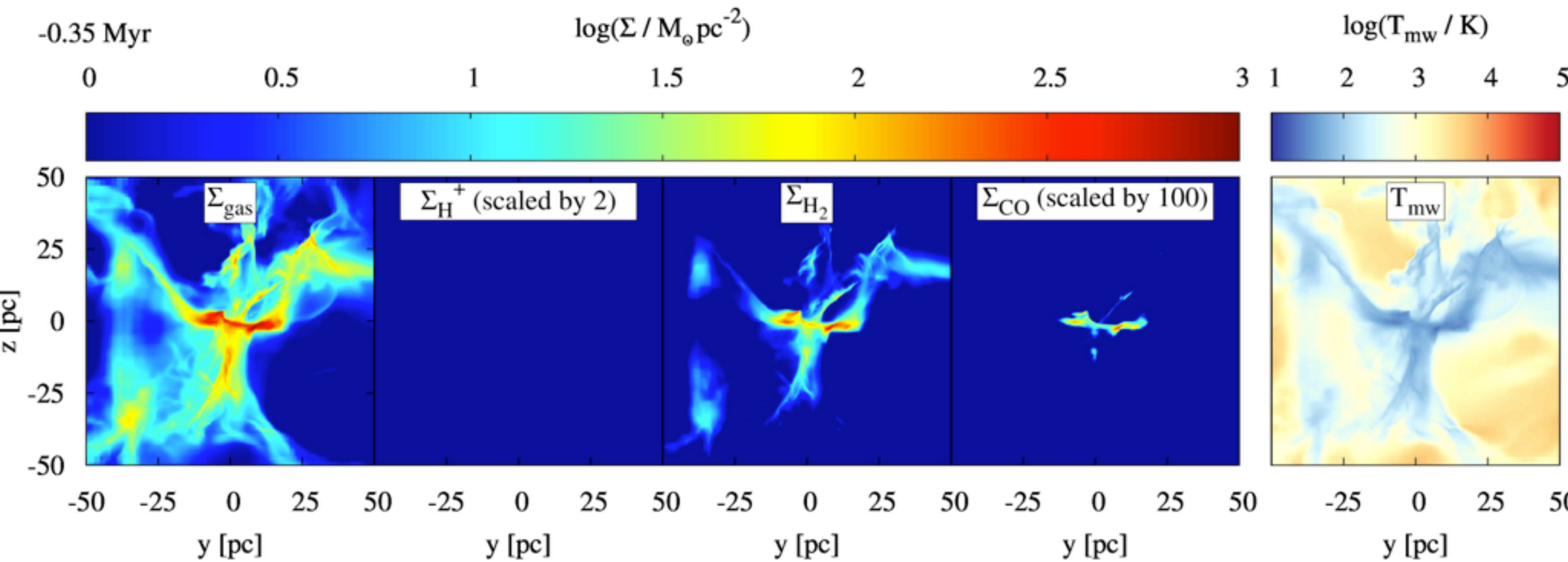
Zoom-In with radiation

Haid+ subm. MNRAS

- 3 Myr evolution
- Cluster Sinks which host massive stars that are coupled to photoionizing radiation
  - -sampling from Salpeter IMF
  - -*TreeRay* Haid+ accep. MNRAS 2018; Wünsch+ in prep.
  - - hν > 13.6 eV
- For comparison a simulation wo feedback

Increasing complexity

Simulation of the central part of MC_I



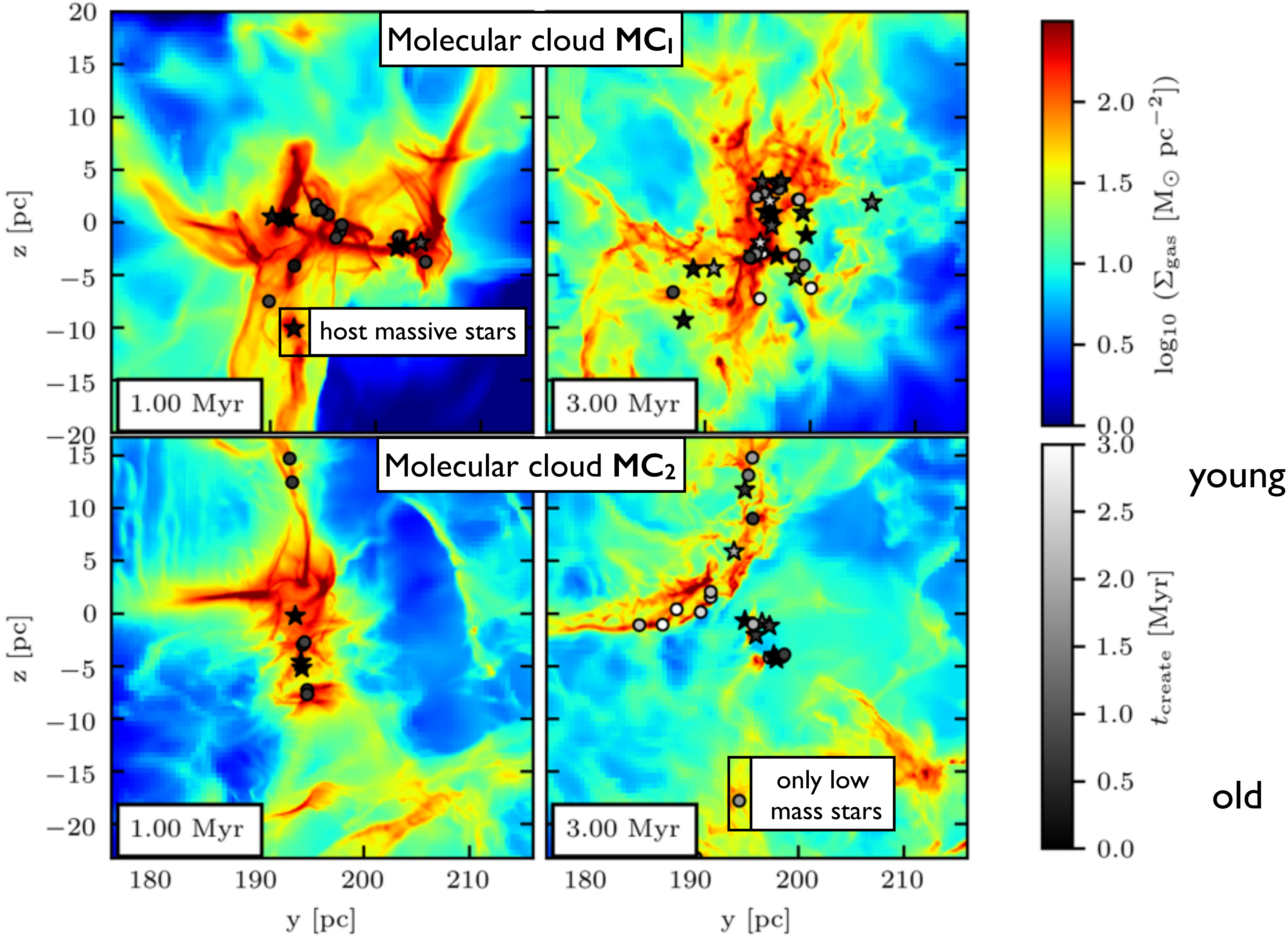
Initial properties Mass ~ a few10^4 $M_\odot$

Volume ~ (80 pc)^3

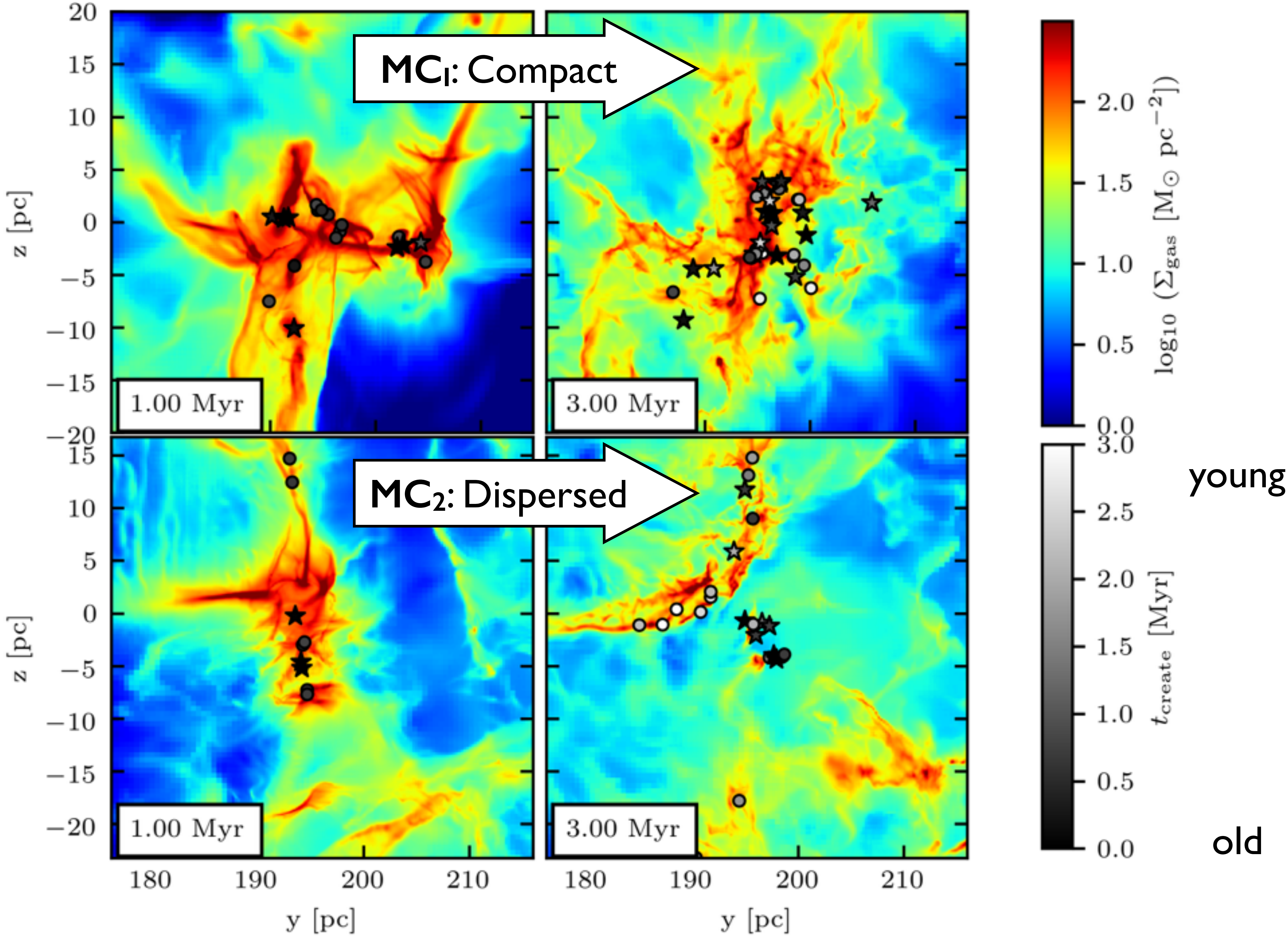
α_{vir} ~ 0.8

v_{esc} ~ 5 km s^{-1}

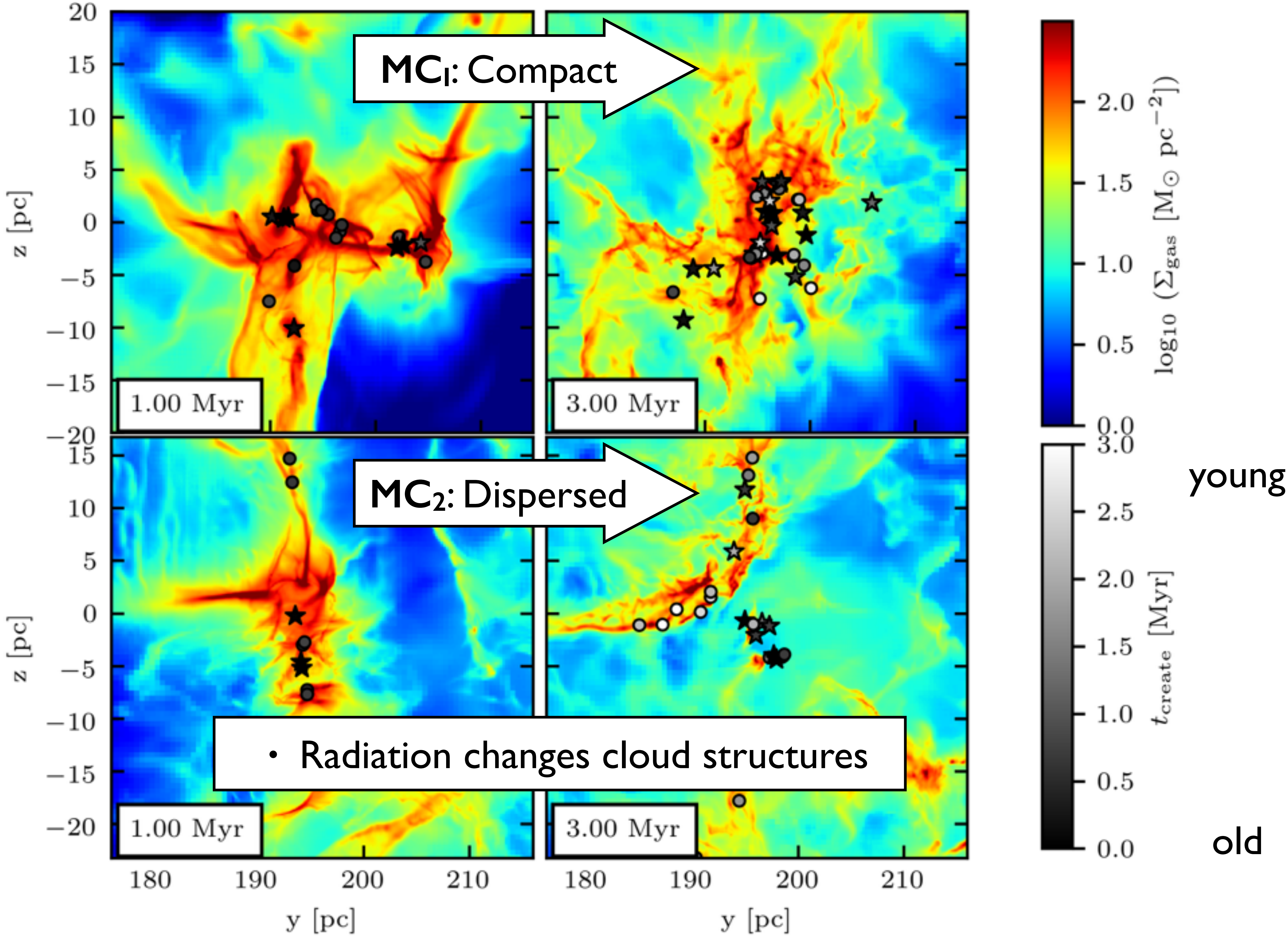
Simulation


Molecular cloud MC1
host massive stars
1.00 Myr
3.00 Myr
Molecular cloud MC2
only low mass stars
1.00 Myr
3.00 Myr
z [pc]
y [pc]
log10 (Σgas [M⊙ pc−2])
tcreate [Myr]
young
old

Result1: Cloud structures



Result1: Cloud structures



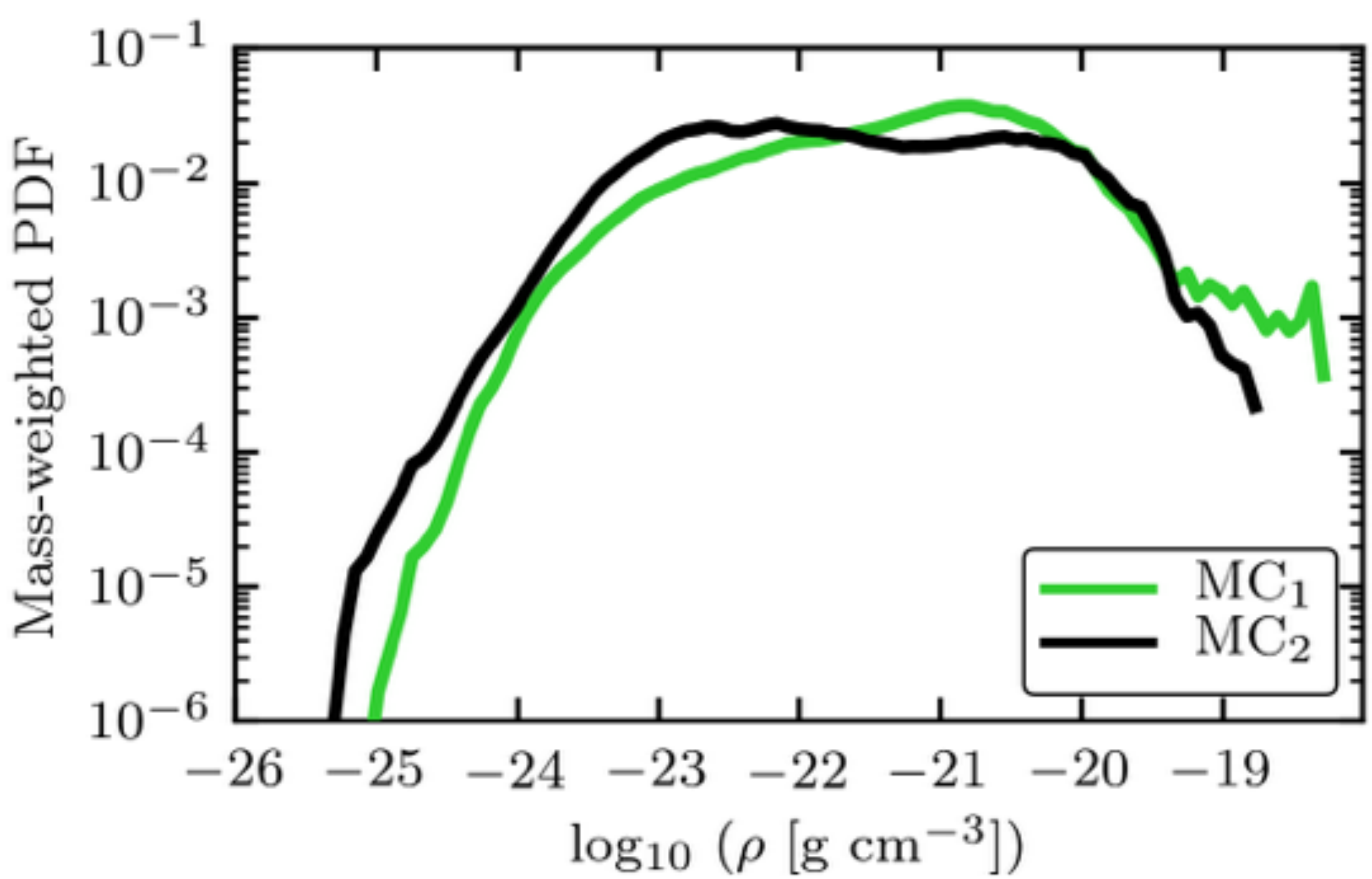
- Radiation changes cloud structures

Result1: Cloud structures

Why does radiation reshape cloud structure differently?

Initial cloud properties…similar
Luminosity evolution…similar
Time averaged star formation efficiency…similar
Total gas distribution…inconclusive

Density distribution of the total gas



Result1: Cloud structures

Why does radiation reshape cloud structure differently?

Initial cloud properties…similar

Luminosity evolution…similar

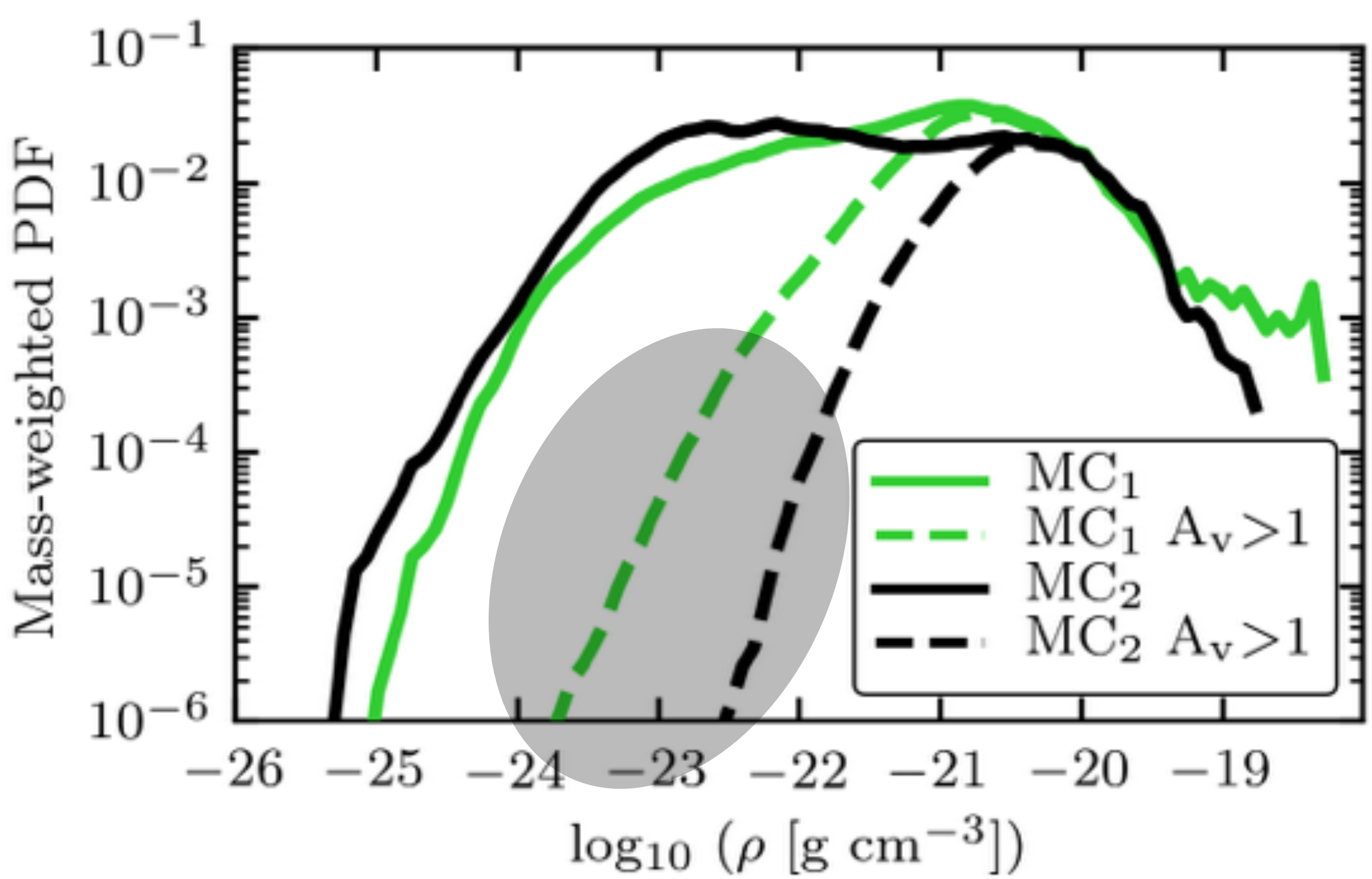
Time averaged star formation efficiency…similar

Total gas density distribution…inconclusive

Distribution of shielded gas ($A_V > 1$)…different

Density distribution of the total gas ——

Density distribution of shielded gas - - -

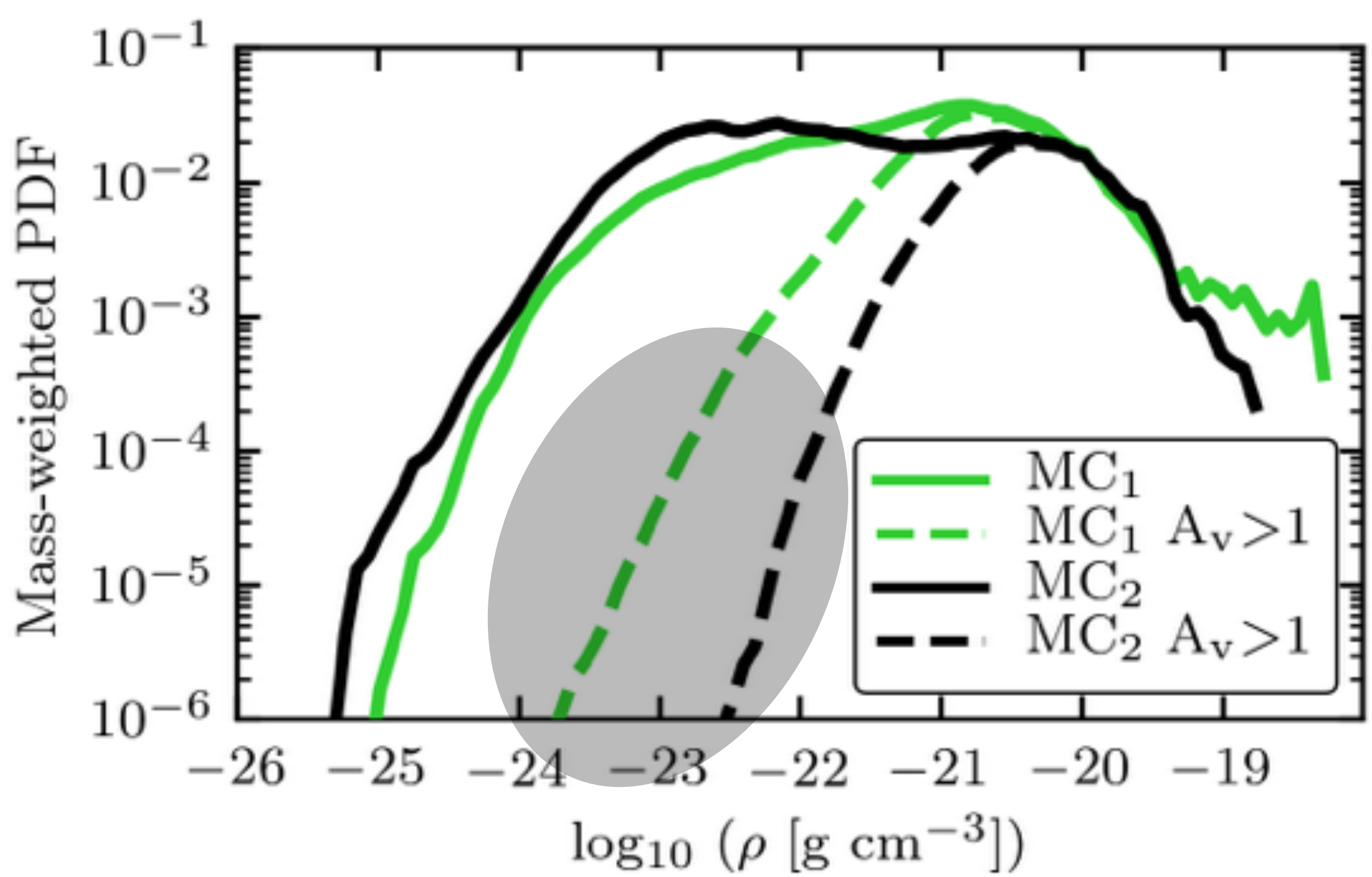


Result1: Cloud structures

- Well-shielded gas & (sub)-structures influences radiative impact

- mass, α_{vir} and v_{esc} are **not enough** to describe a molecular cloud
- distribution of (well-shielded) gas might be more meaningful
- distribution of gas evolves during the formation

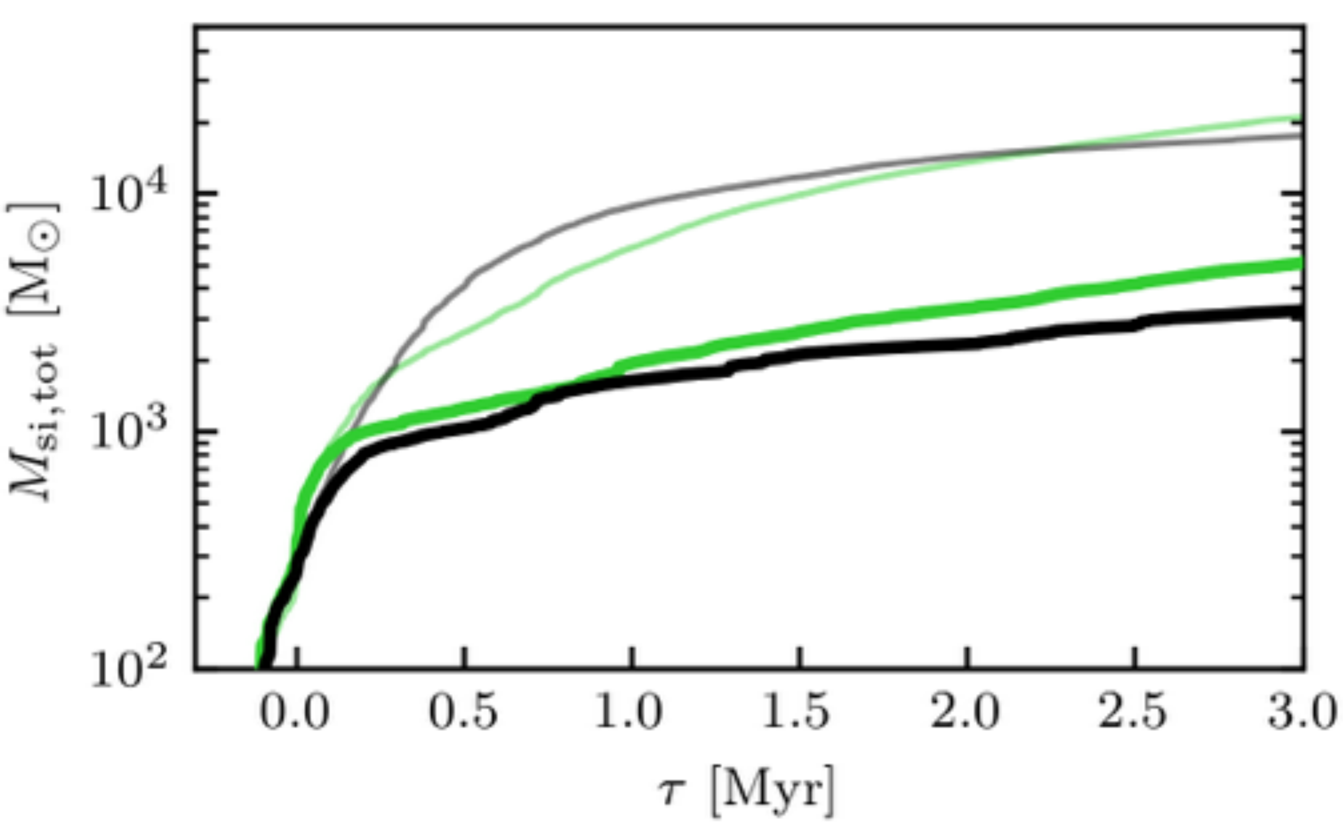
Density distribution of the total gas ———
Density distribution of shielded gas - - -



Result 2: Star Formation

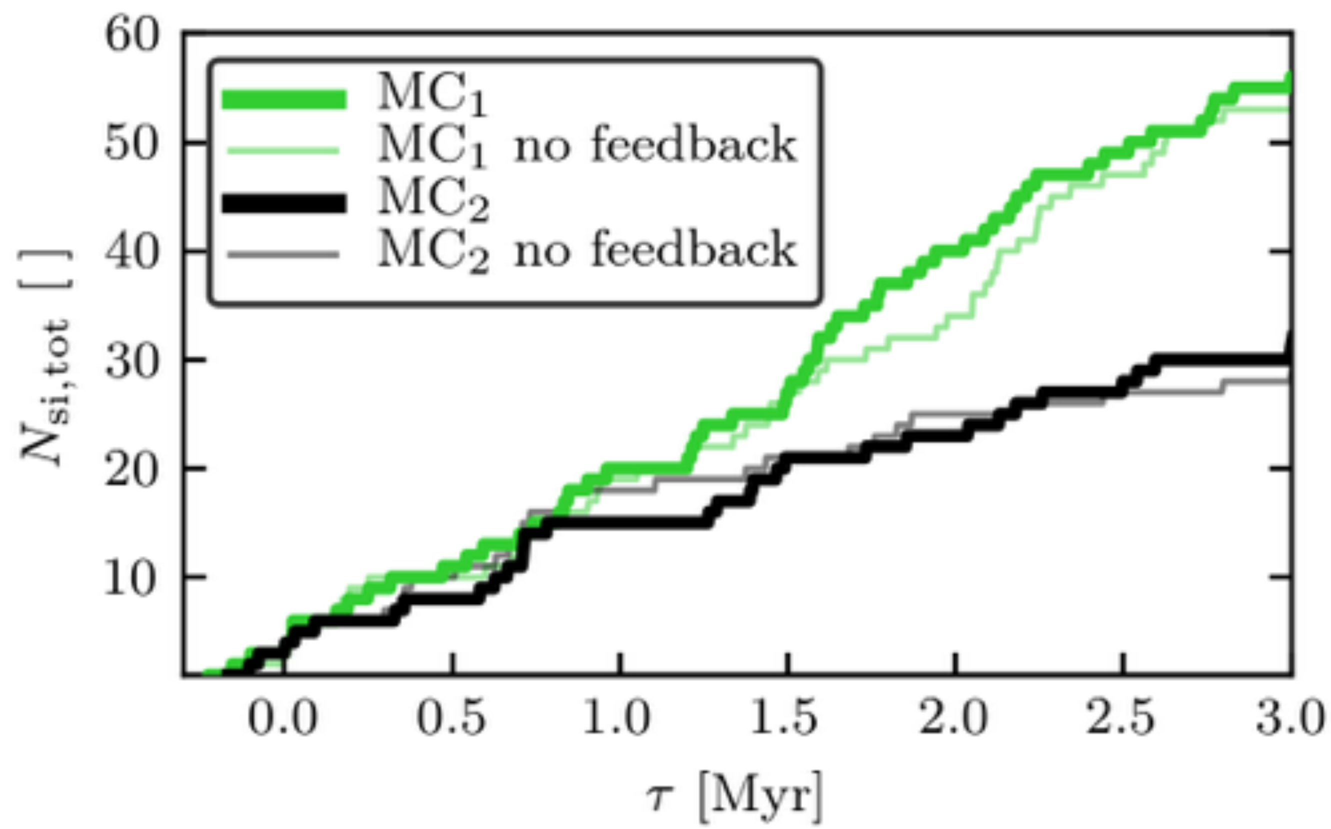
- Radiation efficiently reduces star formation efficiency

  Time averaged efficiency reduced by a factor of ~4-5 to values < 10 %



Sink mass evolution

$M_{si,radiation} < M_{si,no\ feedback}$

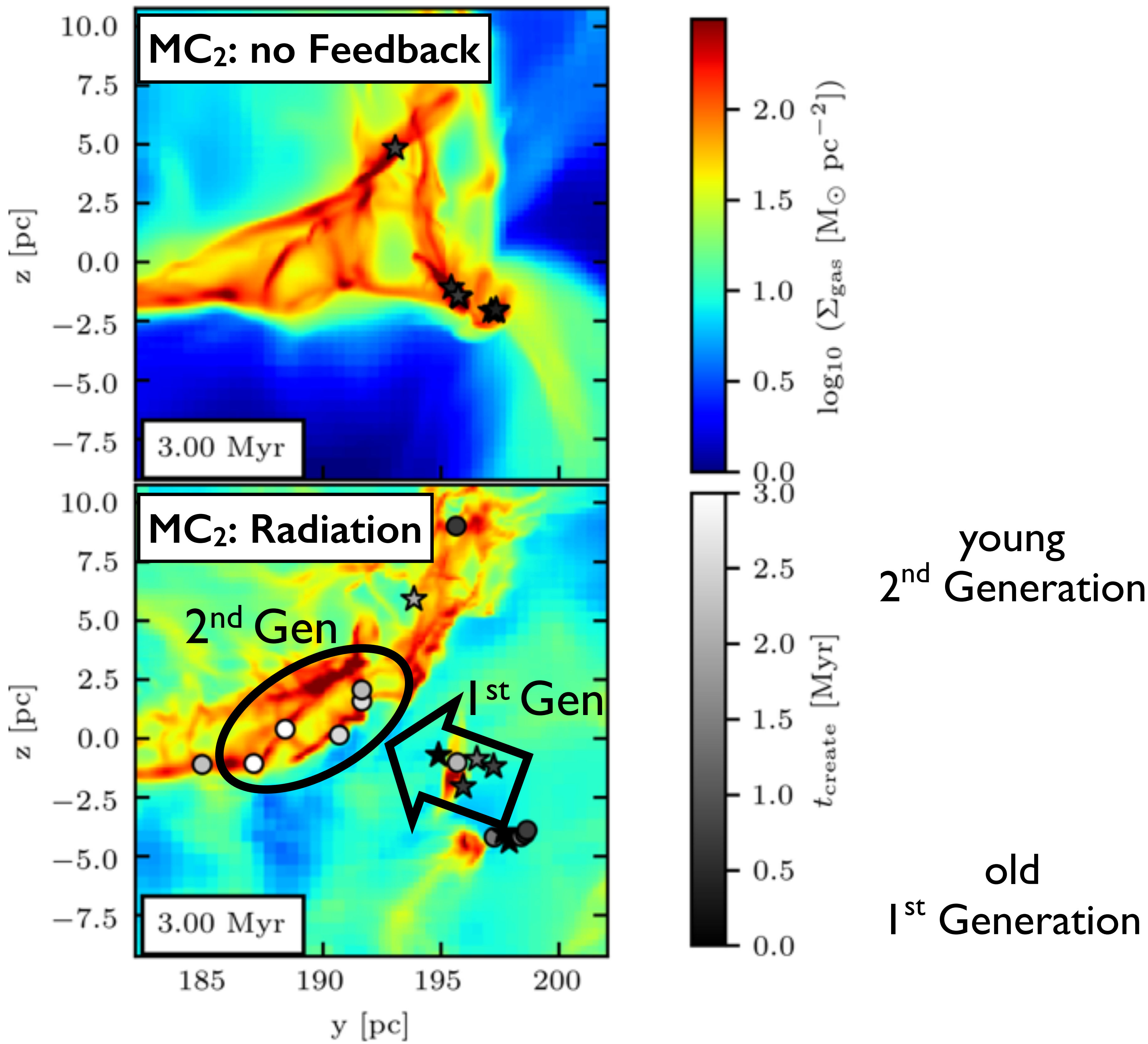


Evolution of number of sinks

$N_{si,radiation} \sim N_{si,no\ feedback}$

Result 2: Star Formation

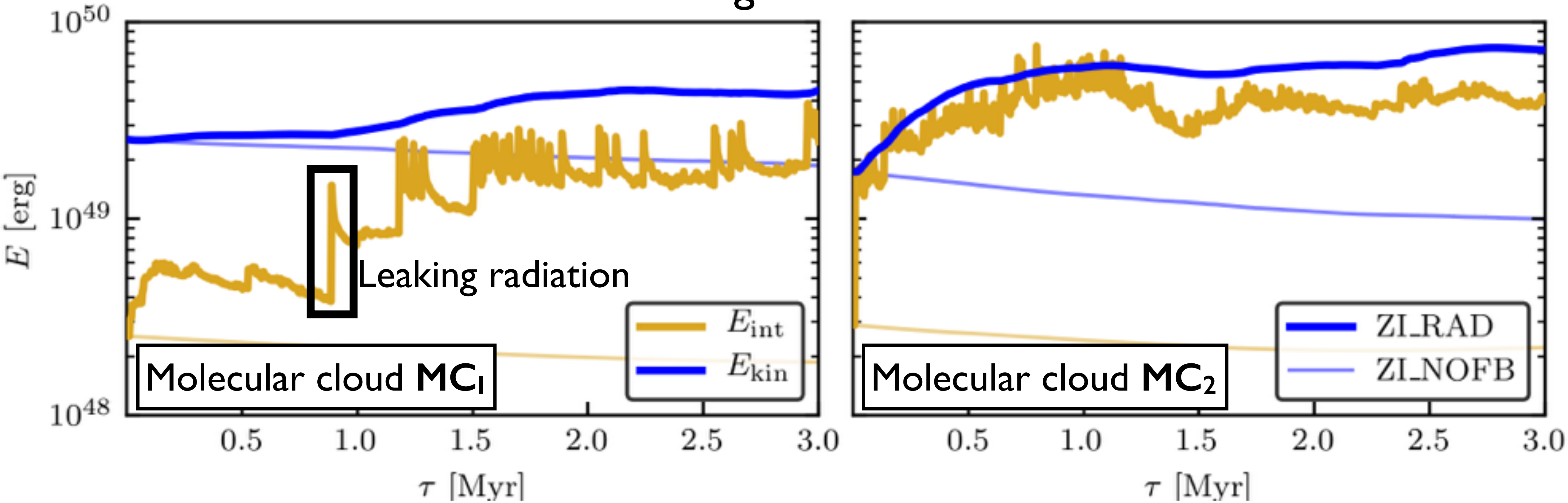
- Indications that radiative feedback triggers star formation



Result 3 Energy support

- Initial phase dominated by evolving H_{II} regions (E_{int})
  - Radiation introduces kinetic motions
  - Jumps caused by leaking radiation
- Later phase cloud supported by constant energy
  - Radiative support against gravitational collapse

Energetic evolution



Leaking radiation: Caused by cloud motions and their ability to shadow radiation

Summary

YES photoionizing radiation is important

at least on cloud-scales

- Radiative feedback reduces the star formation efficiency
  Star formation might be triggered

- Photoionizing radiation supports clouds against collapse and changes cloud structures

- Environmental structures determine the cloud evolution
  Shielded gas important for the impact of the radiative feedback
  Substructures evolve during the self-consistent formation

- mass, α_{vir} and v_{esc} are not enough to fully describe a cloud