SILCC simulations

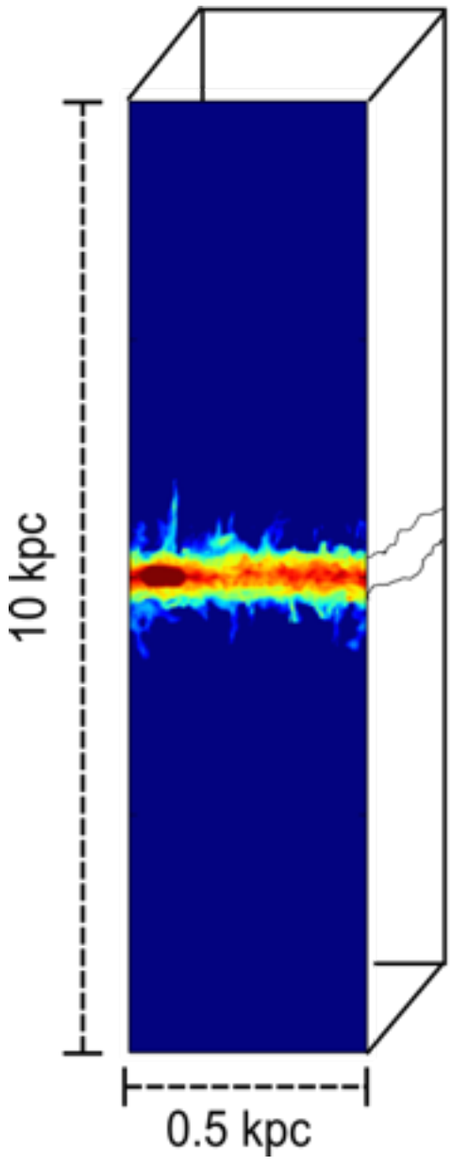
Stefanie **Walch**, Daniel **Seifried**, Dominik **Derigs**, Sebastian **Haid**, Frantizek **Dinnbier**,
Seamus **Clarke**, Volker **Ossenkopf-Okada**, Johanna **Malinen,** Prabesh **Joshi** (Universität zu Köln)
Thorsten **Naab**, Andrea **Gatto**, Thomas **Peters** (MPIA Garching)
Ralf **Klessen**, Simon **Glover** (Zentrum für Astronomie, Heidelberg)
Philipp **Girichidis** (Leibniz-Institut für Astrophysik, Potsdam)
Richard **Wünsch** (Academy of Science of the Czech Republic, Prague)
Paul **Clark** (School of Physics and Astronomy, Cardiff)

and their synthetic [CII] line emission

Annika Franeck
I. Physikalisches Institut
Universität zu Köln

GENESIS meeting
September 28th 2017

Simulation setups

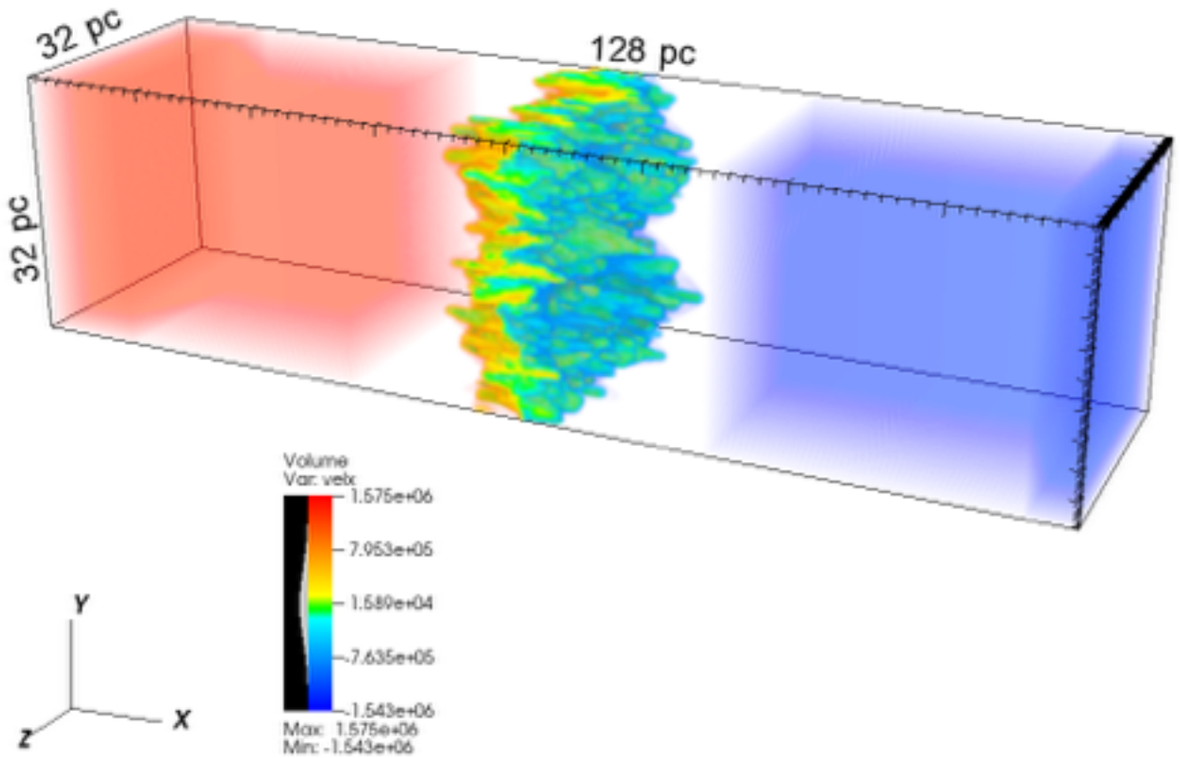


SILCC project

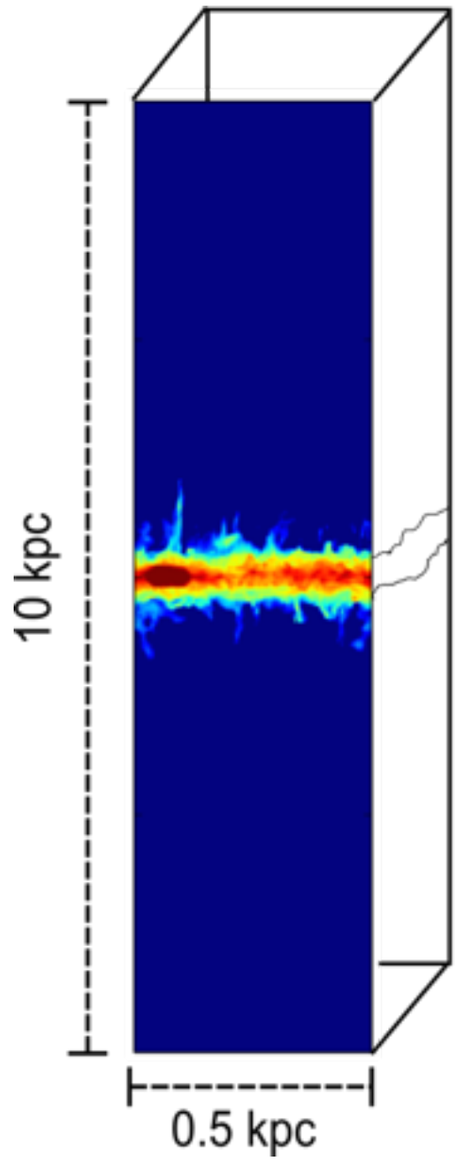
evolution of gas within a piece of a galactic disc

Colliding flows

(PhD project Prabesh Joshi)



Simulating the Life Cycle of molecular Clouds (SILCC)



FLASH code **resolution: 4pc**

- <u>chemical network</u>

  H_2, H, H^+
  CO, ionized C
  O, free electrons

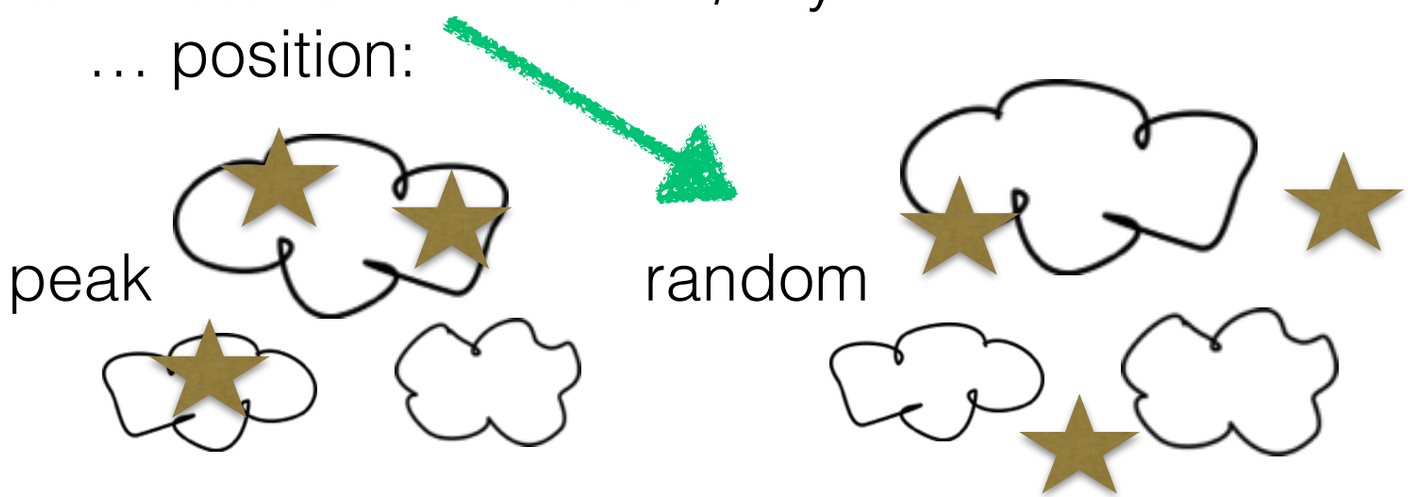
- <u>physical conditions</u>

  gas surface density $\Sigma = 10\ M_{sun} / pc^2$

  self-gravity
  heating and cooling

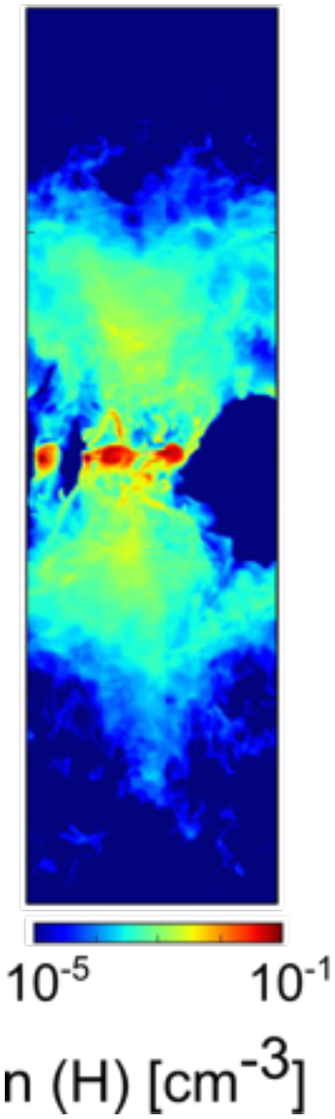
  external stellar gravitational potential
  interstellar radiation field

Supernova … rate: SNR = 15 SN / Myr
… position:



Walch et al. MNRAS 2015
Girichidis et al. MNRAS 2016
Peters et al. ApJL 2015
Gatto et al. MNRAS 2015

Simulations vs observations



Radiative transfer code

RADMC-3D

- <u>chemical network</u>

  H_2, H, H^+
  CO, ionized C

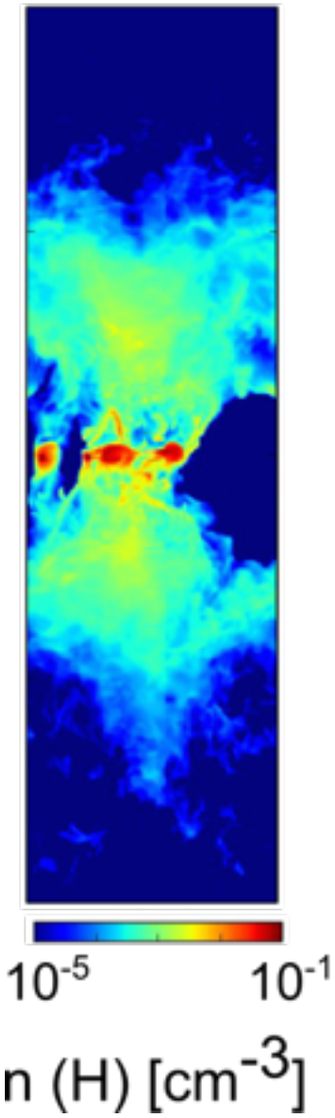
- radiation at different wavelength

$$\frac{dI_\nu(\zeta,s)}{ds} = j_\nu(\zeta,s) - \alpha_\nu(\zeta,s) I_\nu(\zeta,s)$$

emission absorption

RADMC-3D: www.ita.uni-heidelberg.de/~dullemond/software/radmc-3d

Simulations vs observations



Radiative transfer code

RADMC-3D

- non-local thermal equilibrium
- collisional partners: H_2, H, e^-
- number densities
- collisional rates
- temperature and velocity of the gas

[CII]

C^+ fine structure transition:

$^2P_{3/2} \rightarrow {}^2P_{1/2}$

λ = 157.74 μm

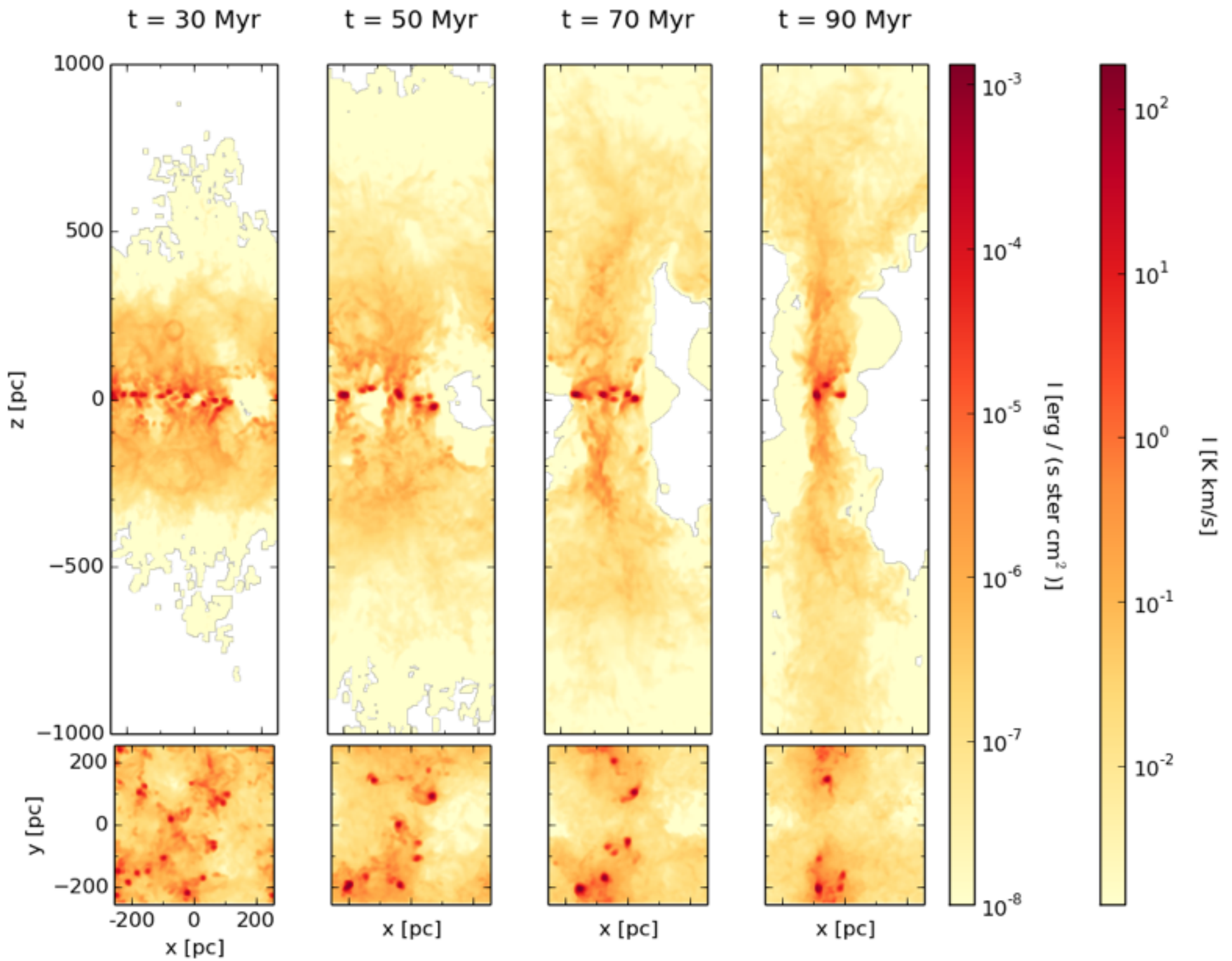
tracer for star formation

tracer for CO-dark H_2

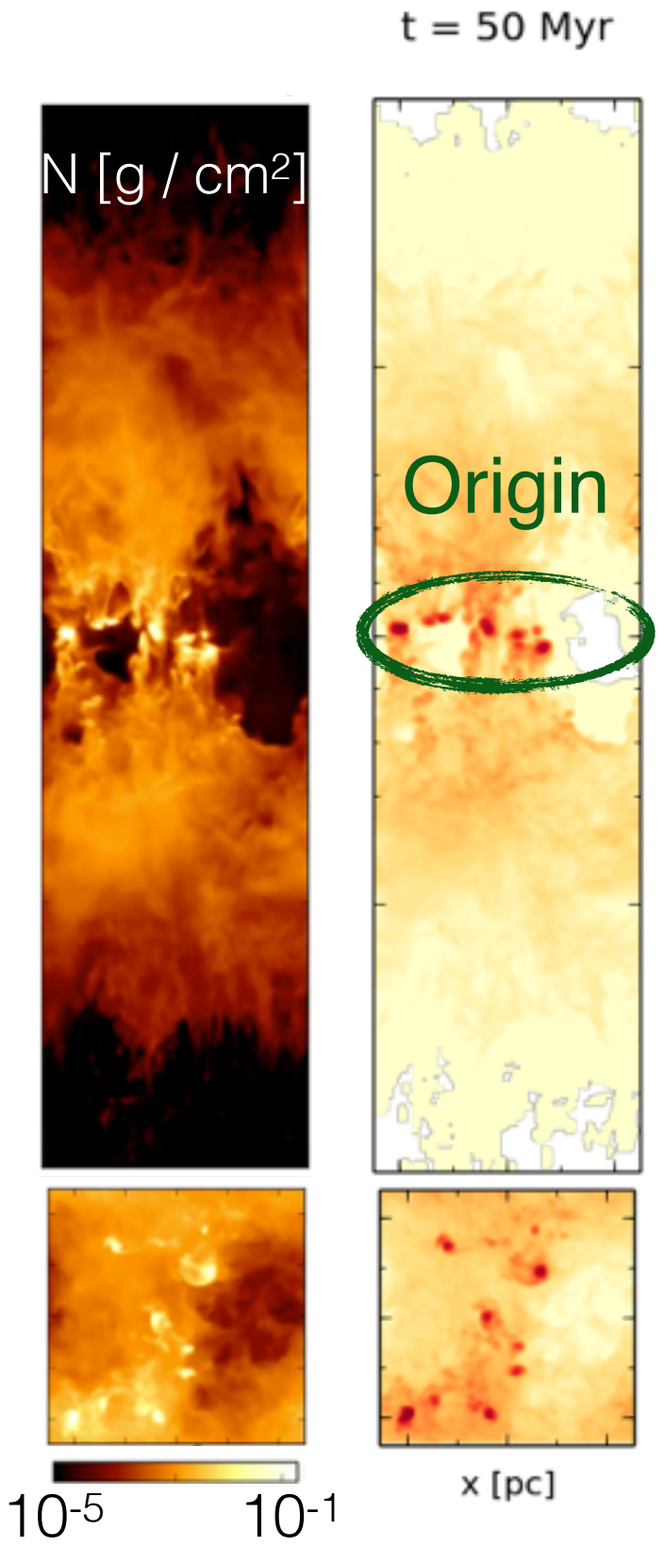
RADMC-3D: www.ita.uni-heidelberg.de/~dullemond/software/radmc-3d

Synthetic [CII] emission maps

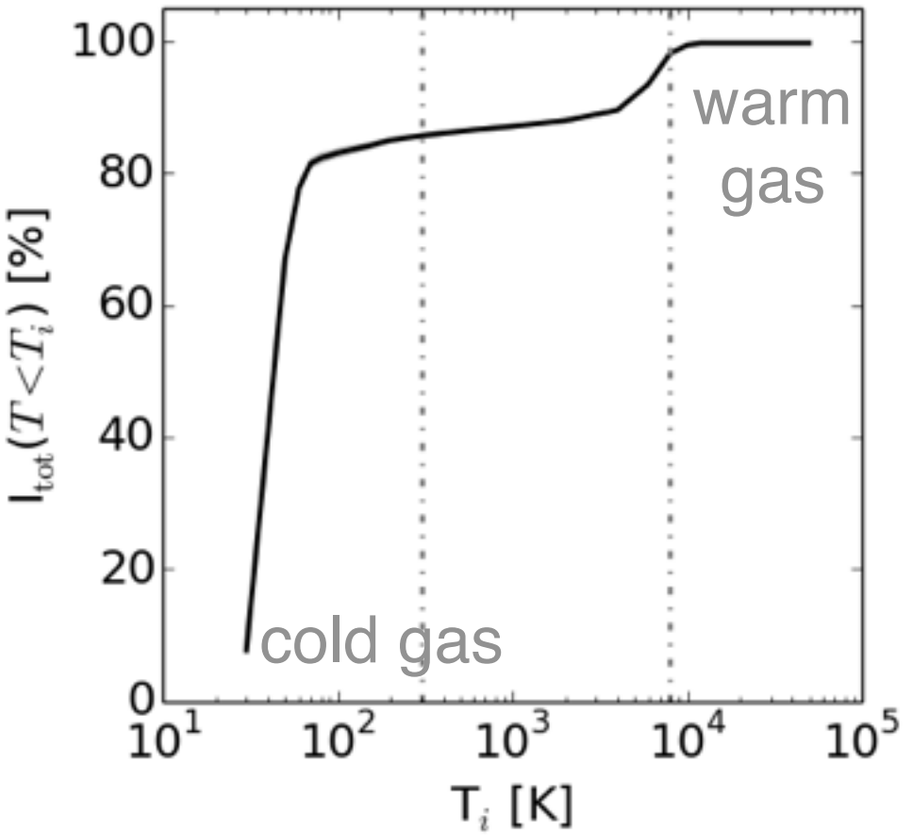
velocity integrated
v = ± 70 km/s



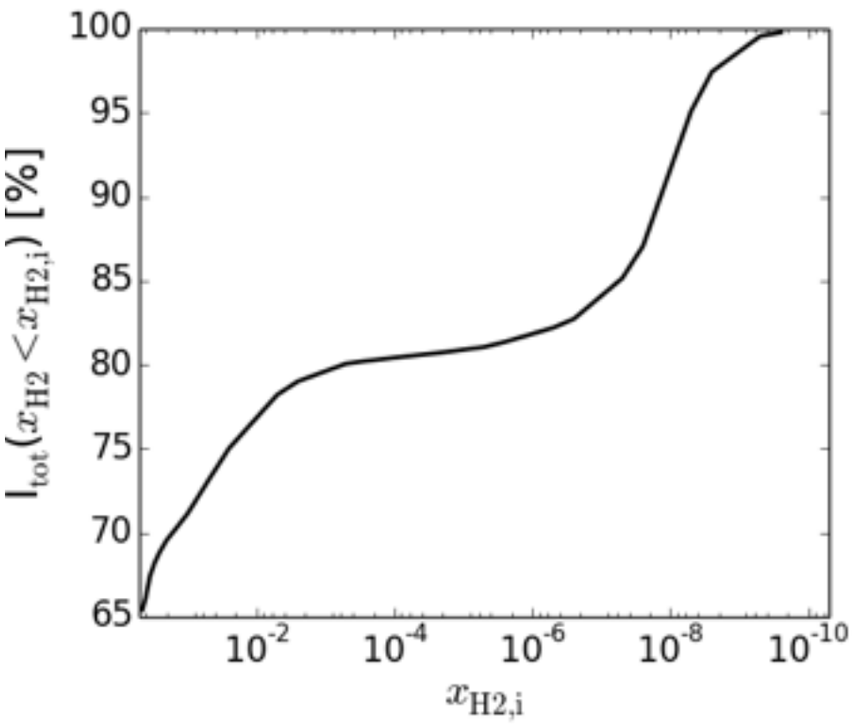
Synthetic [CII] emission maps



Temperature



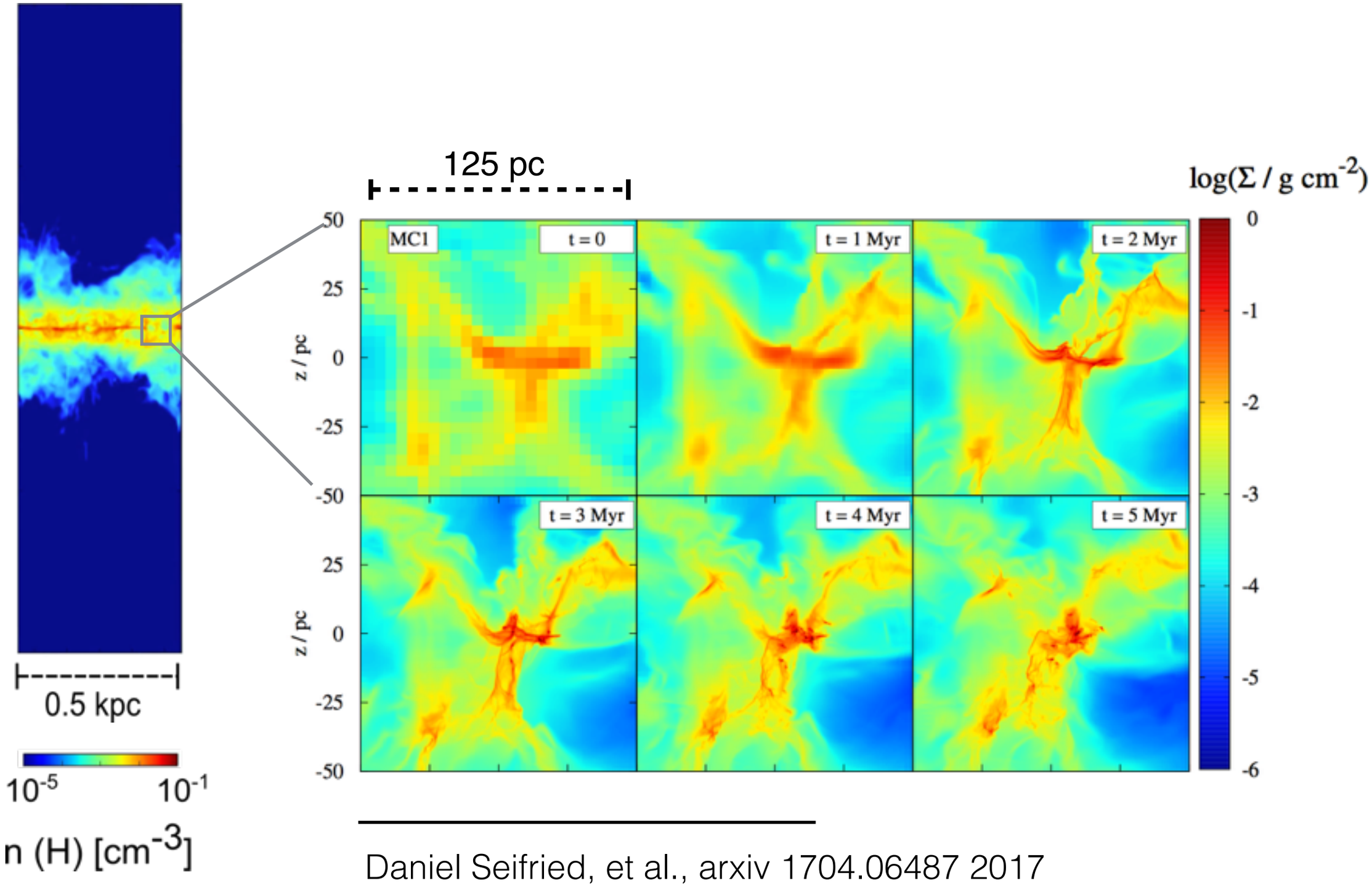
chemical composition



- around 80% from the cold gas
- around 15% from the neutral gas

Zoom-In simulations

- zoom into a region of a molecular cloud simulation with **mixed SN distribution**

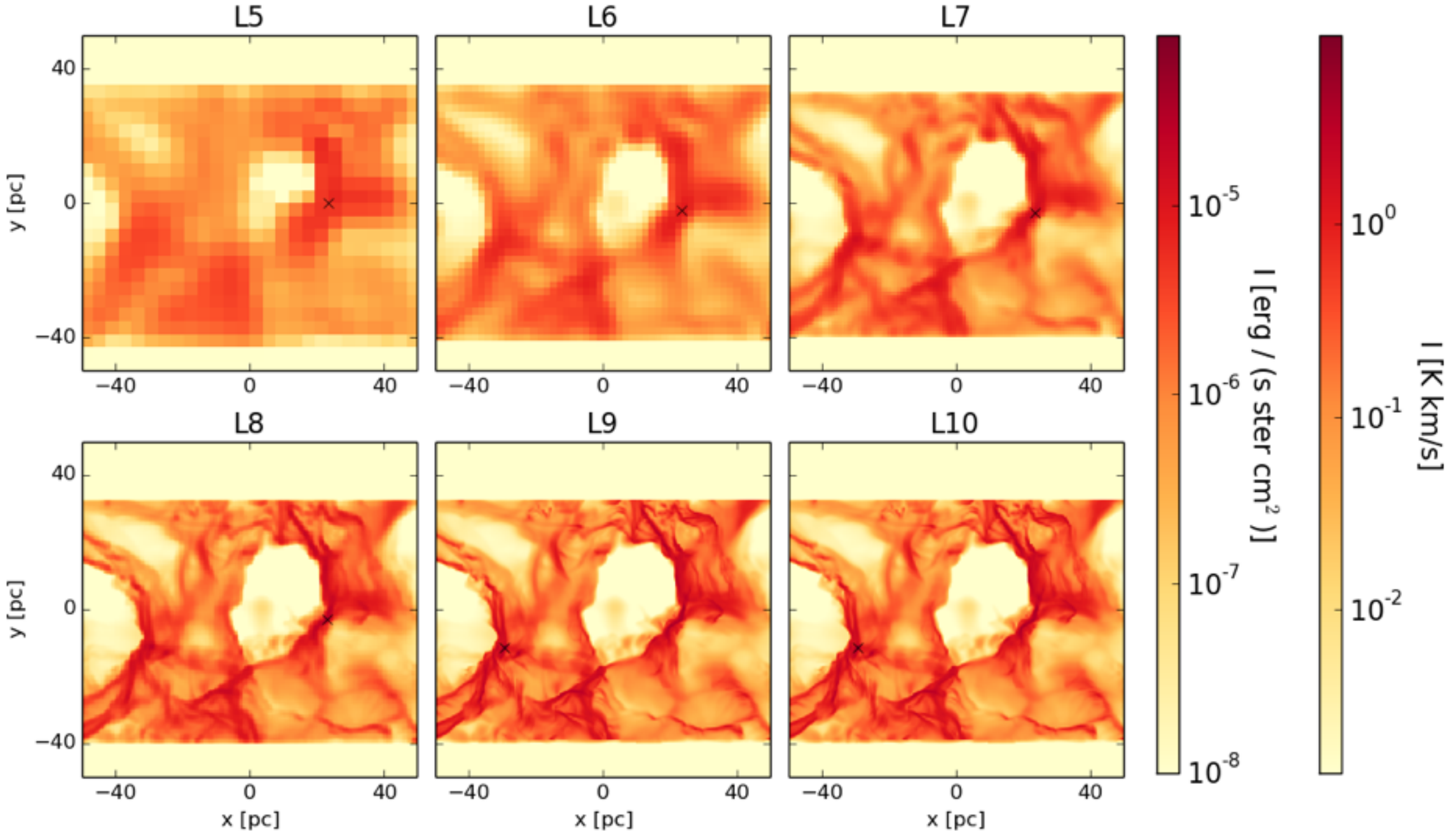


Daniel Seifried, et al., arxiv 1704.06487 2017

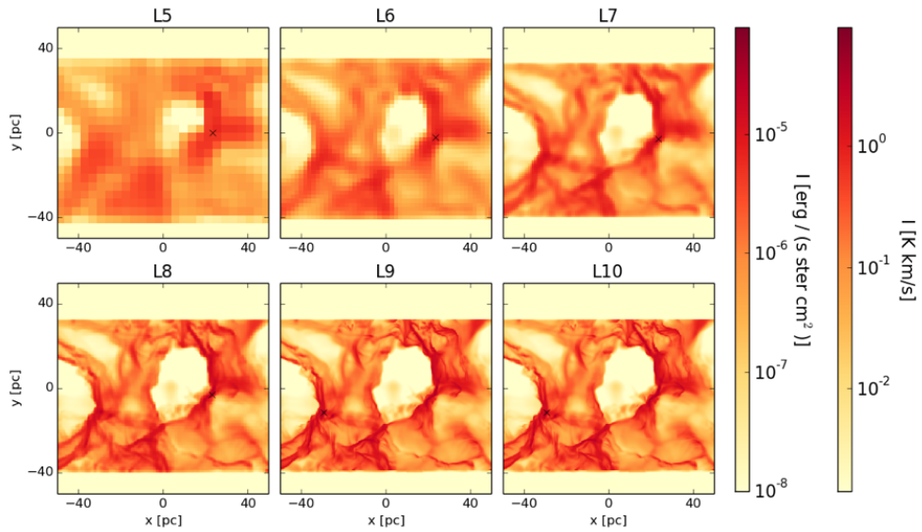
Zoom-In simulations

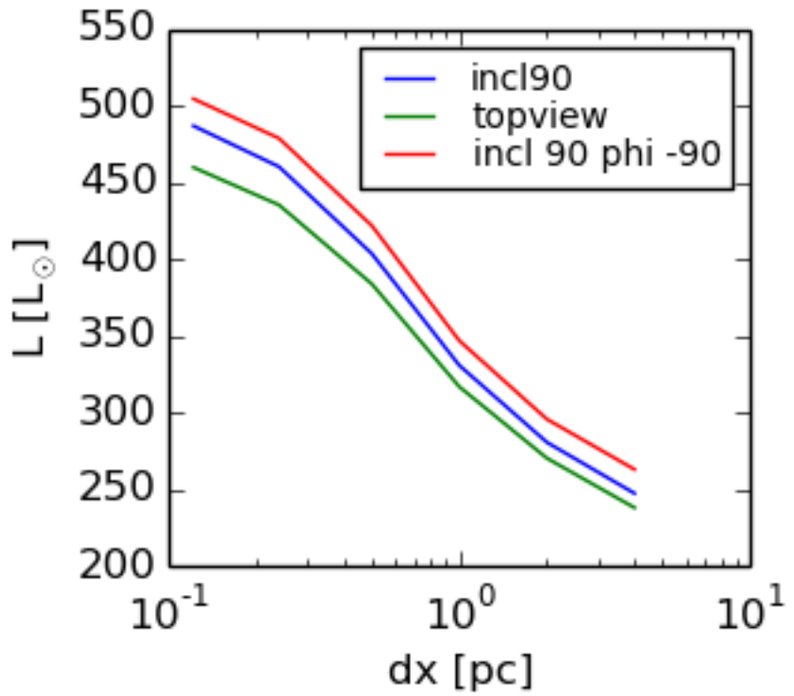
velocity integrated [CII] line emission
v = ± 20 km/s

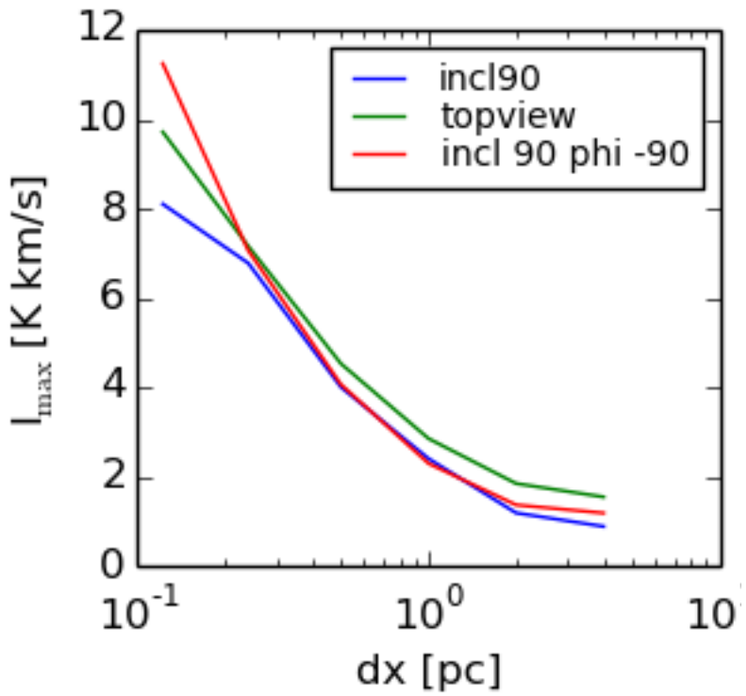
spectral resolution: 0.1 km/s
spatial resolution: 4pc … 0.122pc

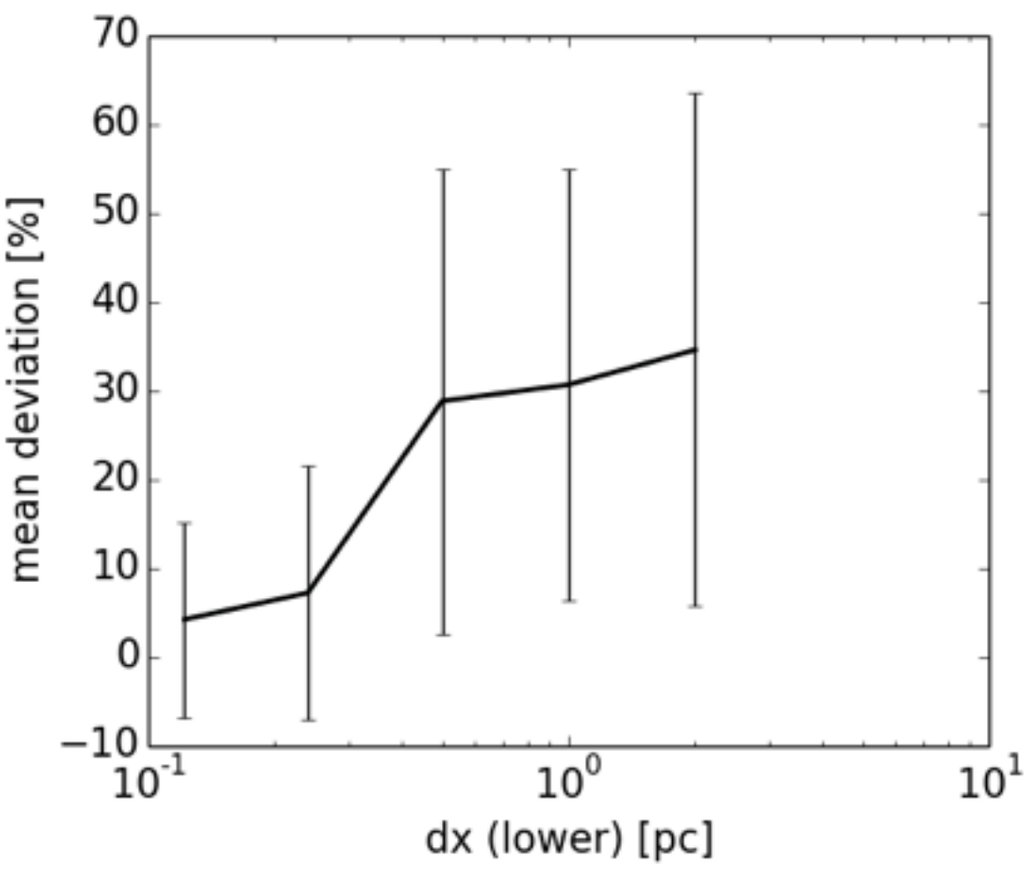


Zoom-In simulations - Convergence



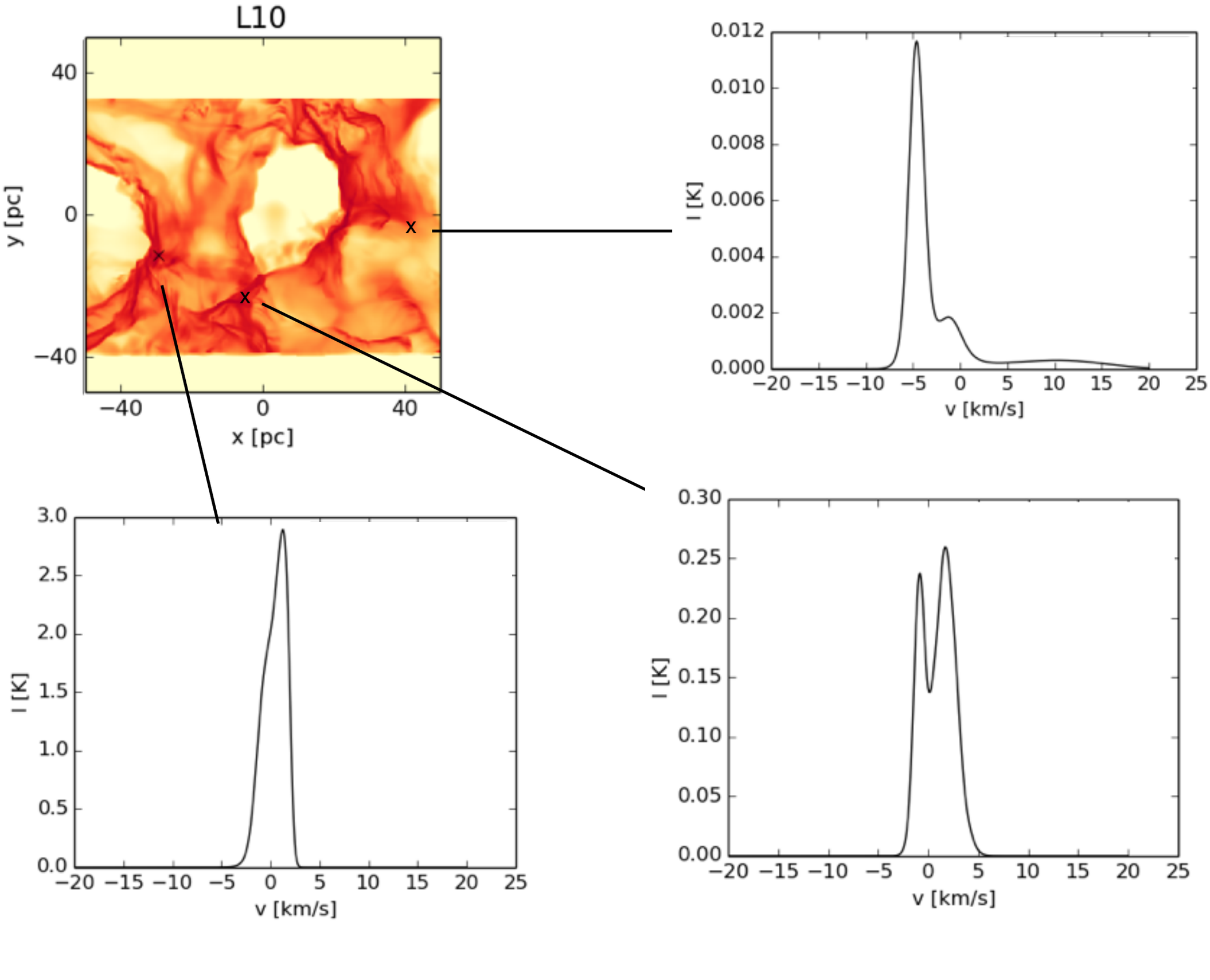






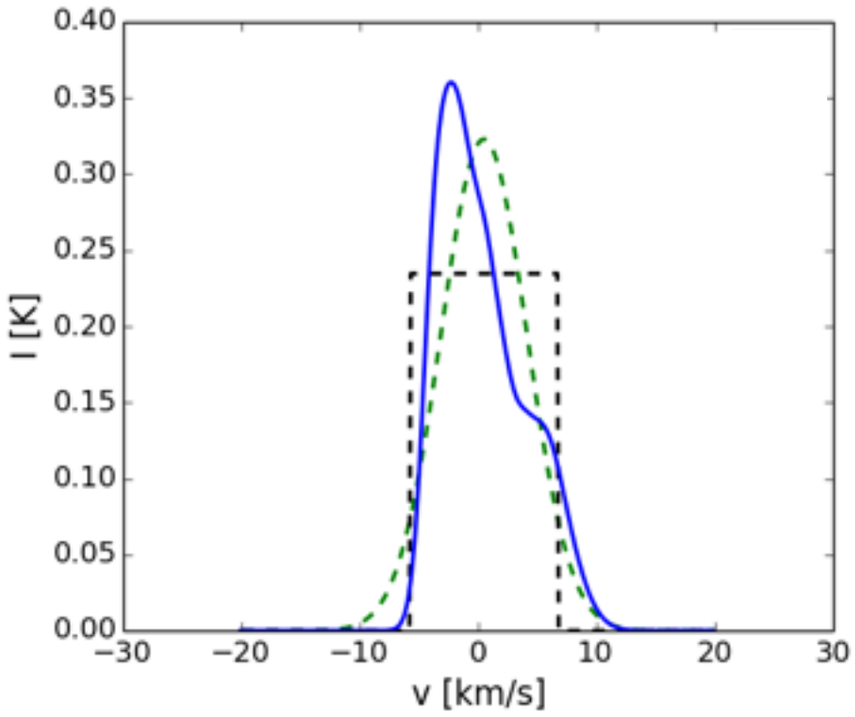
- peak intensity not on the same position
- deviation to the next resolution level becomes smaller

Zoom-In simulations - Lineprofiles



Zoom-In simulations - Statistical Analysis

Method inspired by Tauber (1996)



$$\Delta T_R = \sqrt{\frac{1}{n}\sum_{i=0}^{n}(l_i - r_i)^2}$$

l_i: line profile
r_i: reference function

T_R: Peak of the Reference function

⇨ $\Delta T_R / T_R$: Tauber value

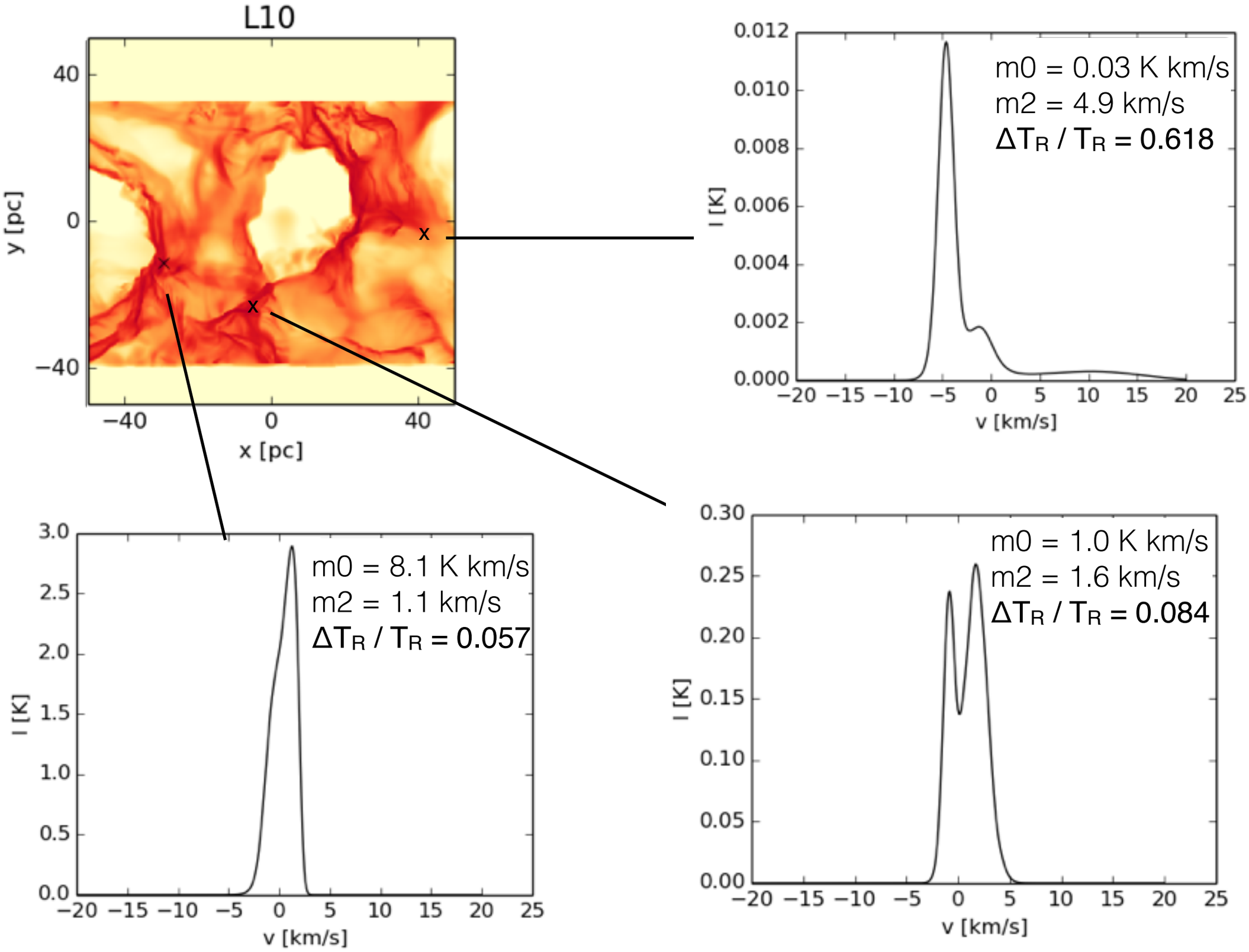
Reference functions
- Gauss function ⟶ optically thin
- Boxcar function ⟶ optically thick

⇨ conservers the area (m0), mean (m1), std (m2) of the line profile

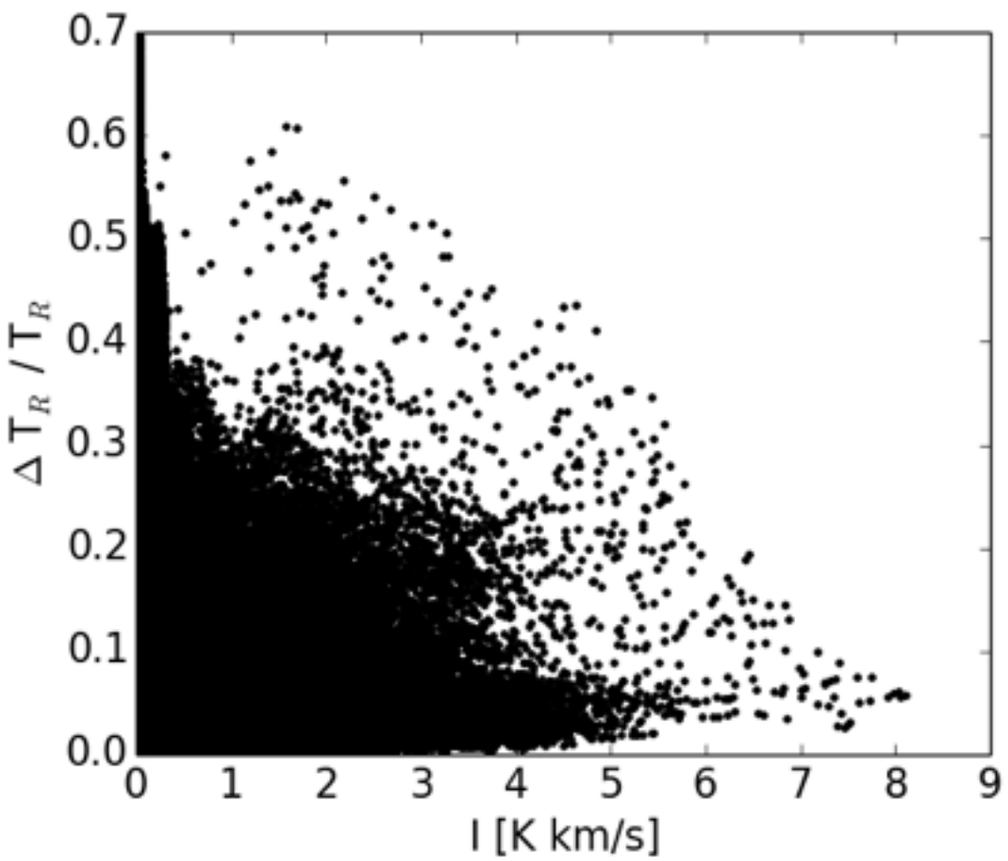
---

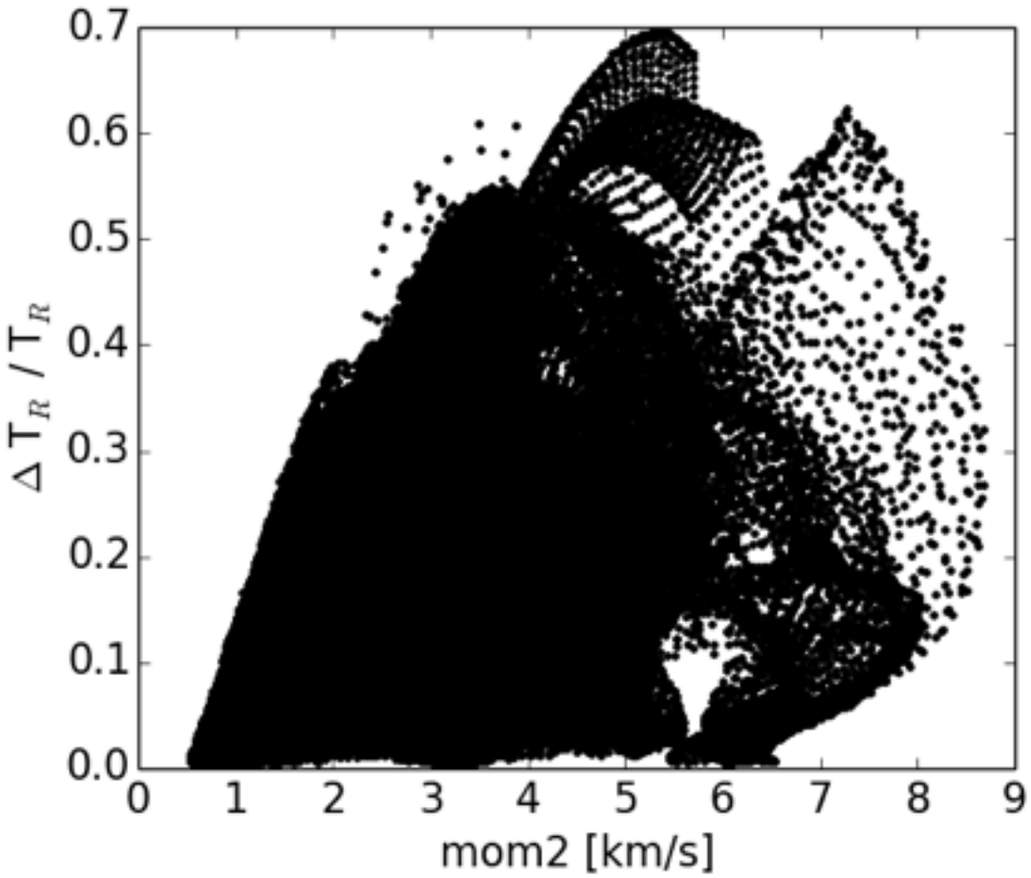
Tauber AA1996

Zoom-In simulations - Lineprofiles



Zoom-In simulations - Scatter plots





Same range of values in observations?

Summary

different scenarios:
- colliding flows
- piece of the galactic disc → SILCC simulations

SILCC simulations
- supernovae determine the evolution of the gas
- [CII] line emission mainly from cold gas

Zoom-in simulations (SILCC project)
- study of molecular clouds
- [CII] line emission from cold gas
- analysis of the line profiles
  Tauber values
  Scatter plots
  …