Photoionisation of Supernova Driven, Turbulent, MHD Simulations of the Diffuse Ionised Gas

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Scotland's first university

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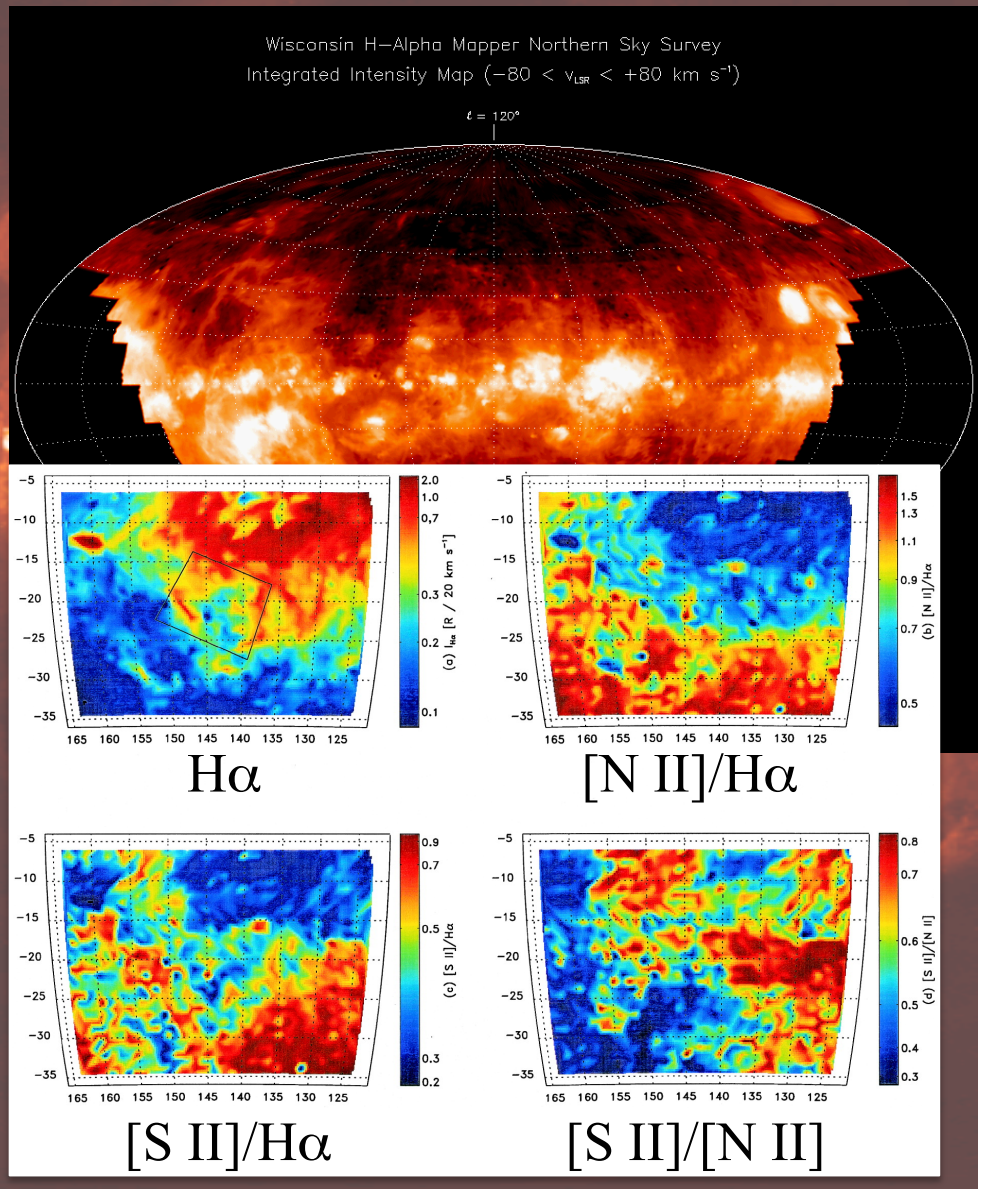
1413 – 2013

Outline

- Observations of the ISM
- MHD and radiative transfer simulations
- Fractal models of the ISM
- Scattered Light
- How far can photons travel in the DIG?
- Conclusions

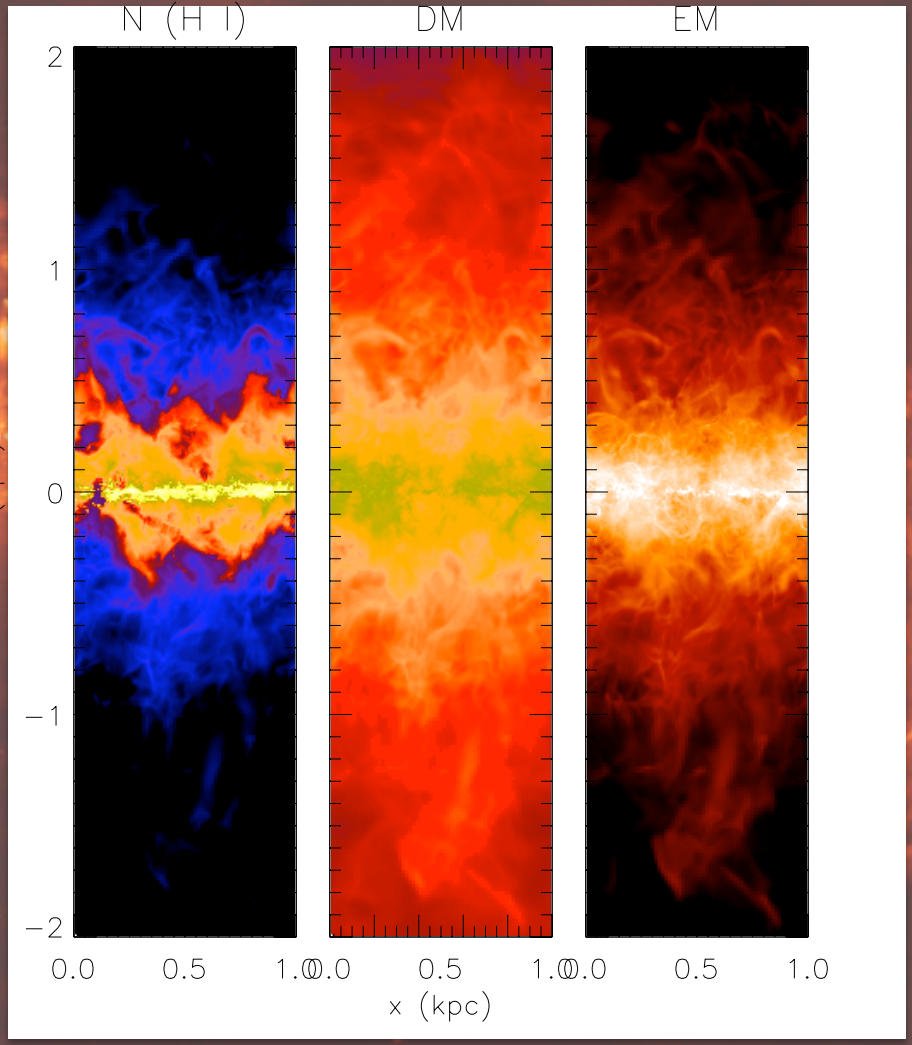
Observations: WHAM Survey

- All sky survey of H α (Haffner et al. 2003,2010)
- Wide area surveys of [NII] λ 6584 and [SII] λ 6716 (Reynolds et al 1998, Hausen et al, 2002)
- Filaments, loops and HII regions
- [NII]/H α and [SII]/H α increase with height above midplane (Haffner 1999)
  - Additional heating mechanism (Reynolds 1999)



MHD simulations

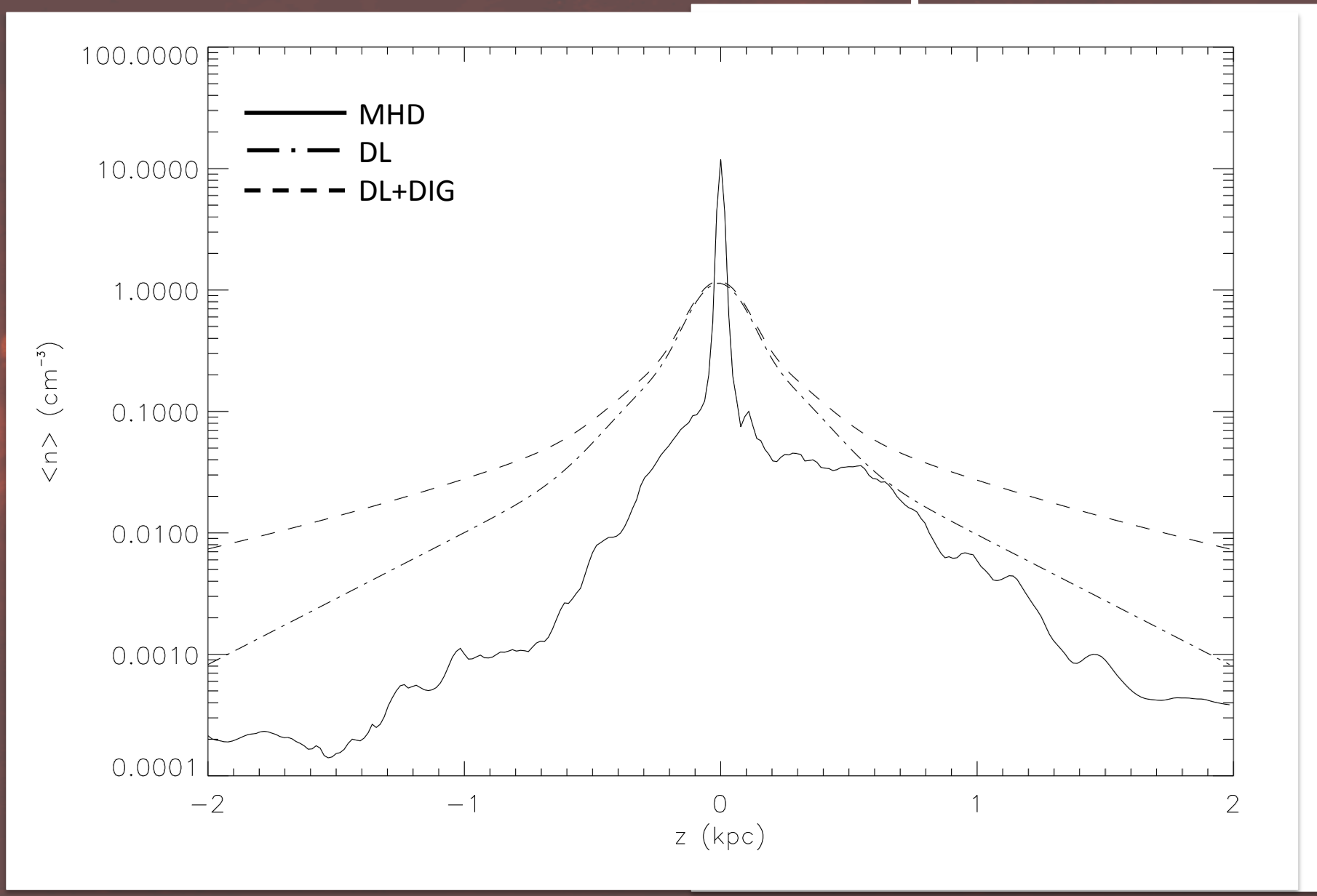
- MHD simulations of ISM from Hill et al. 2012
- Include type Ia and core collapse supernovae, set off at galactic supernova rate
- 3/5 of core collapse distributed to simulate superbubbles in the gas.
- Do not include photoionisation heating



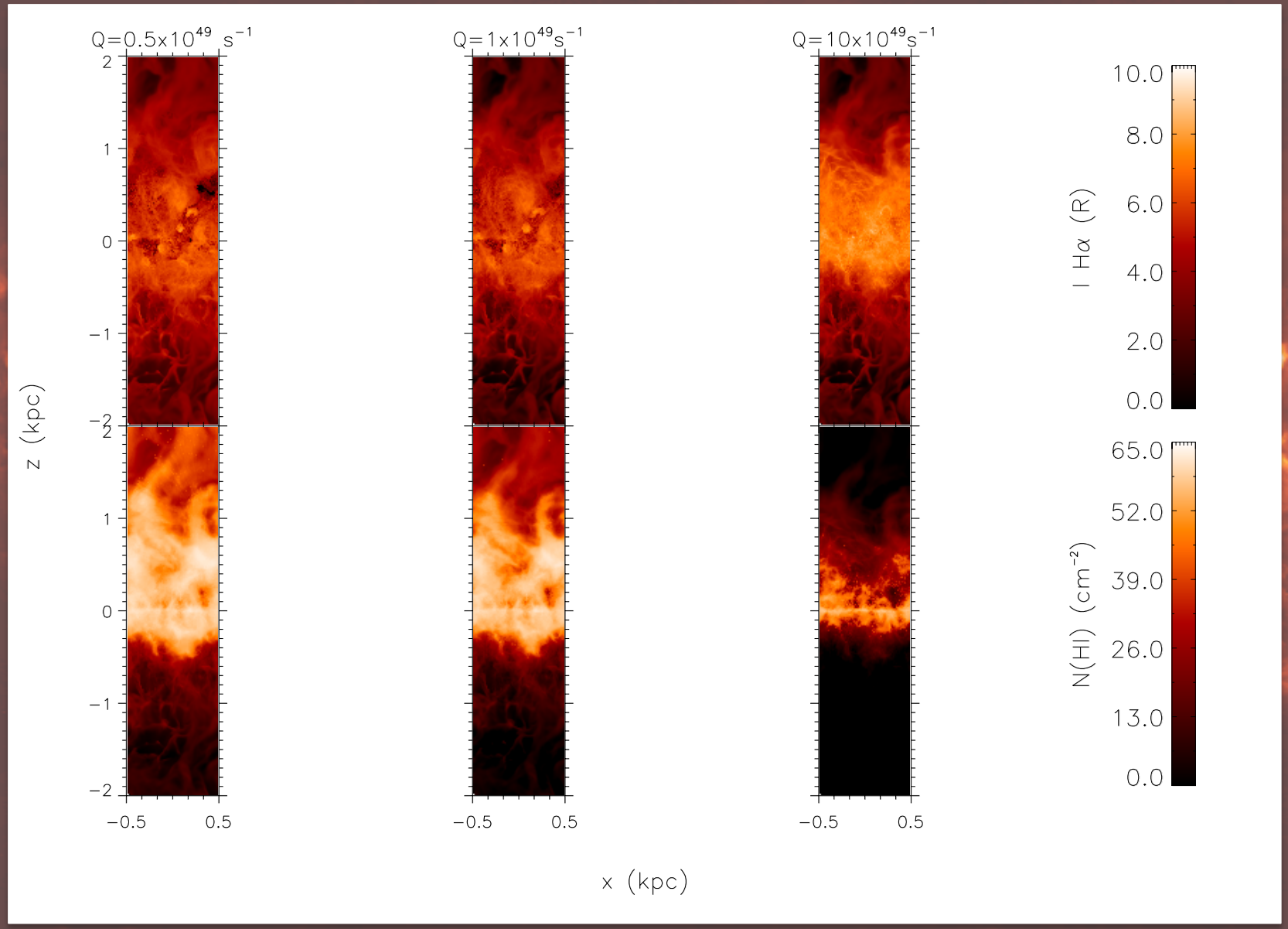
Monte Carlo Radiative Transfer

- Monte Carlo radiation transfer code of Wood et al. 2004.
- Includes ions of H, He, C, N, O, Ne, S
- Outputs 3D temperature and ionisation structure
- Include additional heating sources for diffuse ionised gas in the Milky Way.

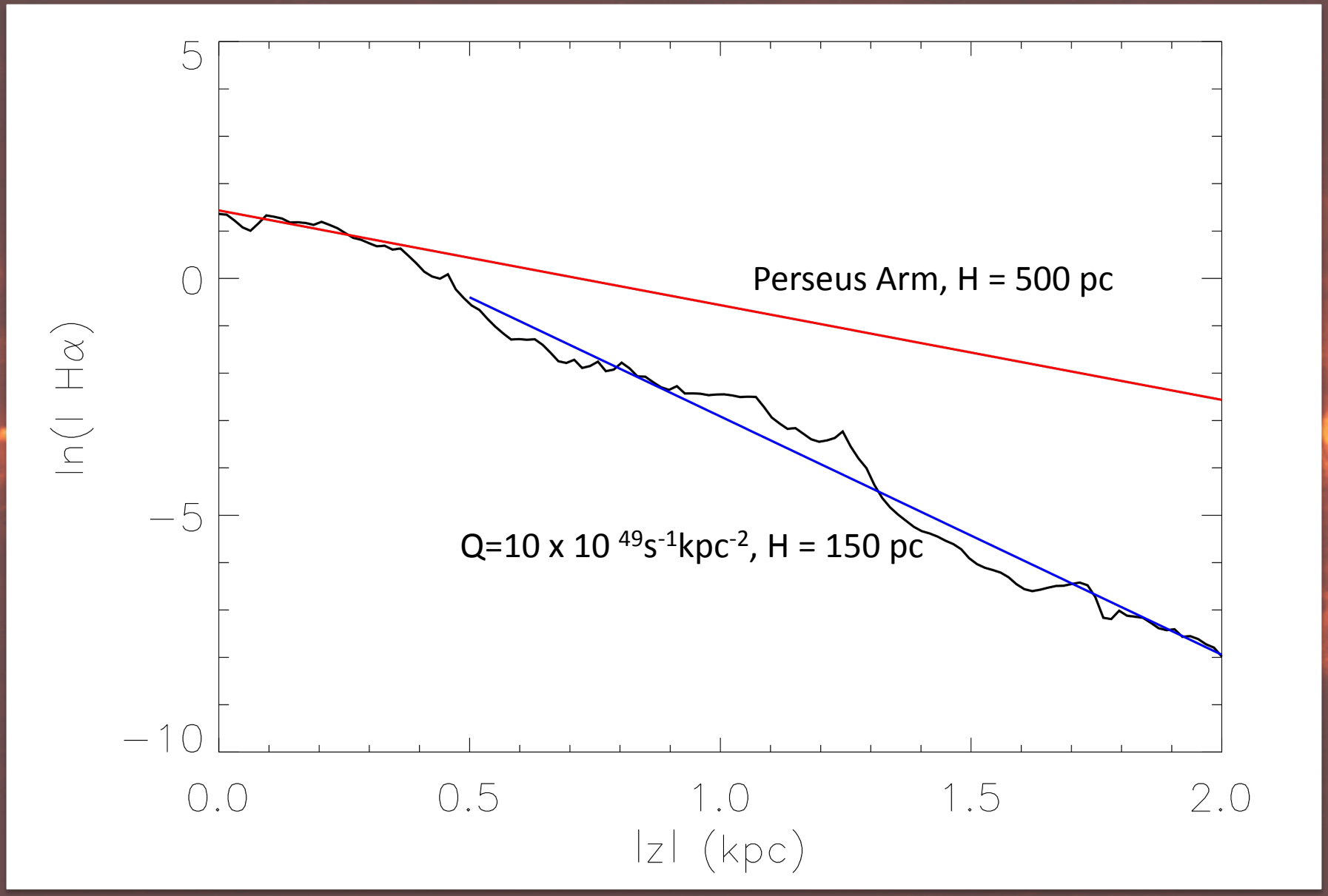
Simulation Setup



Hα and HI

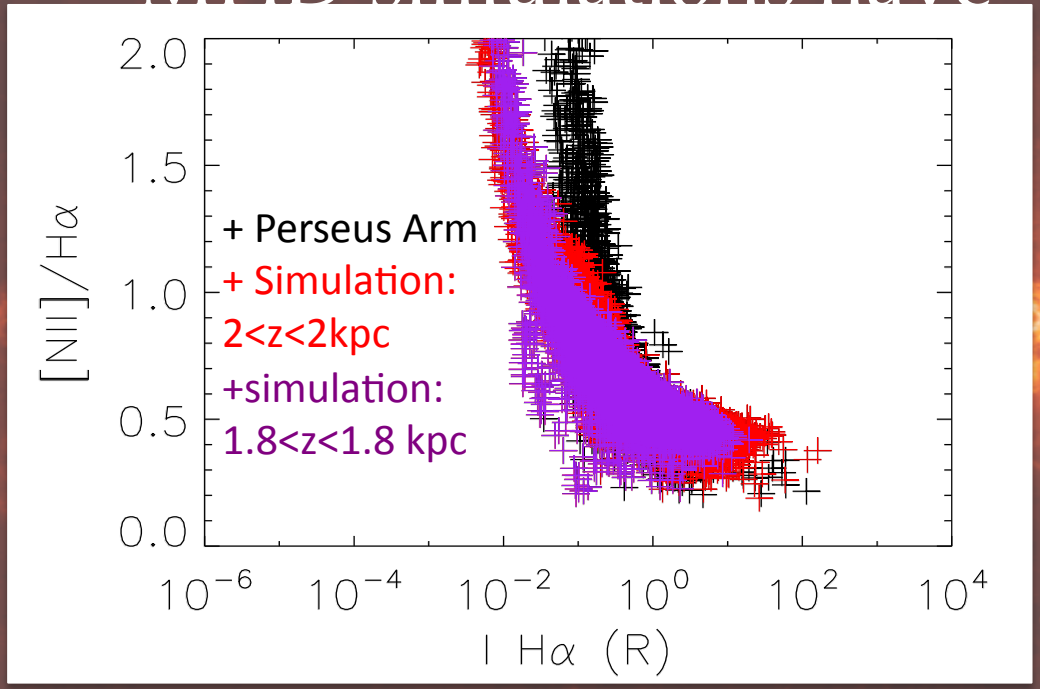


Hα Scale height

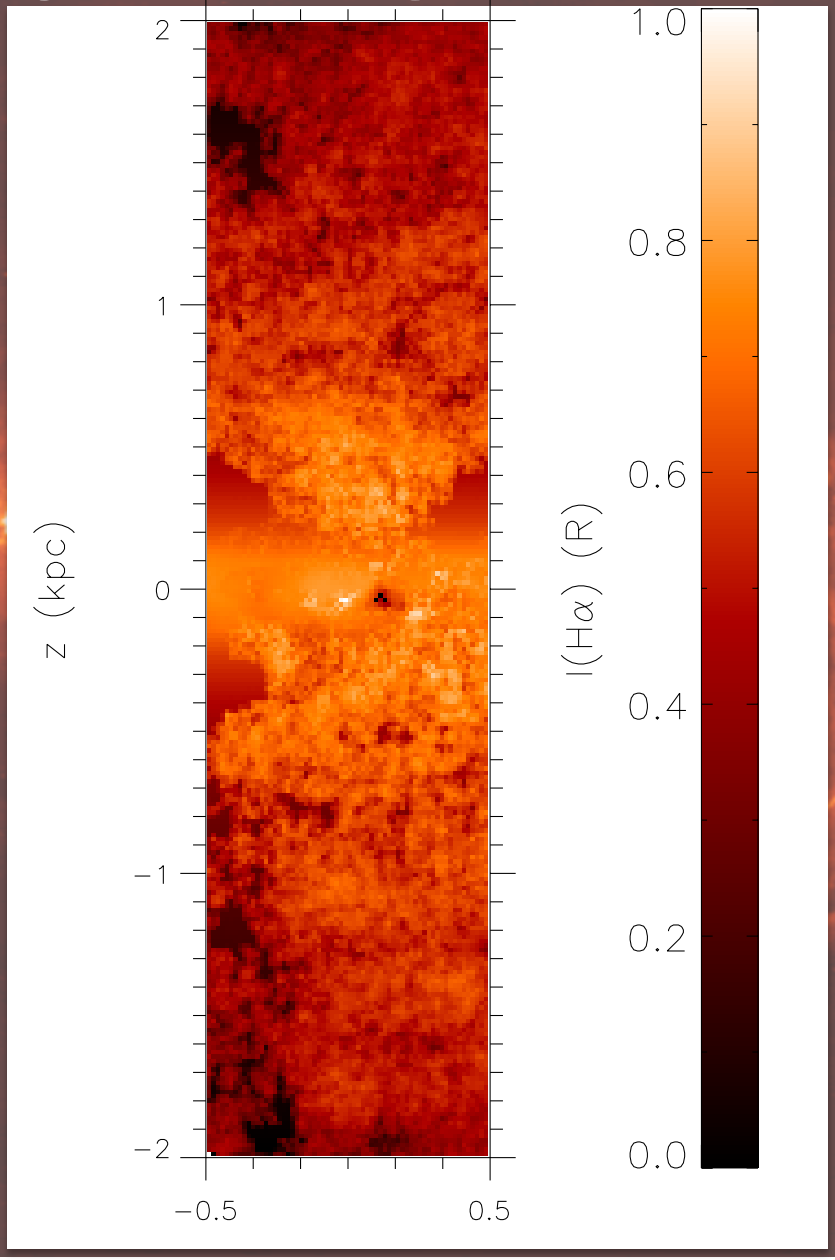


Fractal models of the ISM

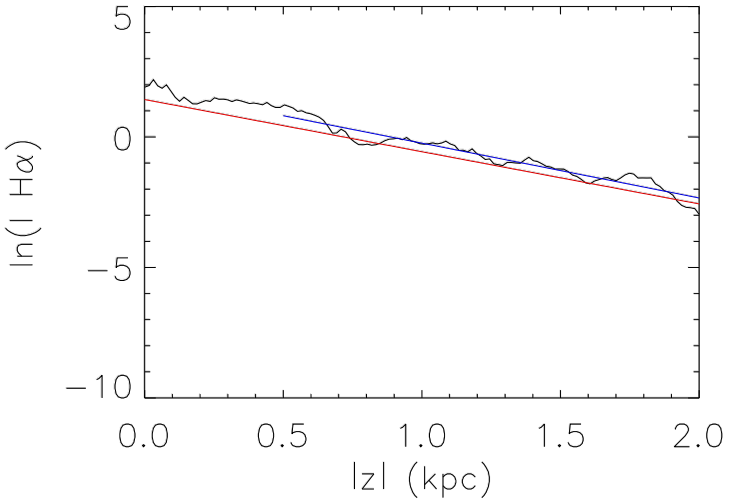
- MHD simulations have

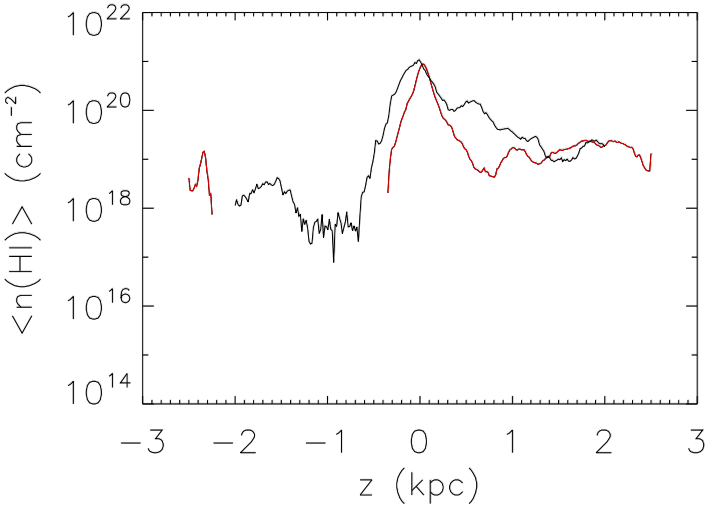


- $Q=16 \times 10^{49}\ s^{-1}\ kpc^{-2}$
- Additional heating:
  - $G = 4 \times 10^{-26}\ n_e$ ergs $cm^{-3} s^{-1}$

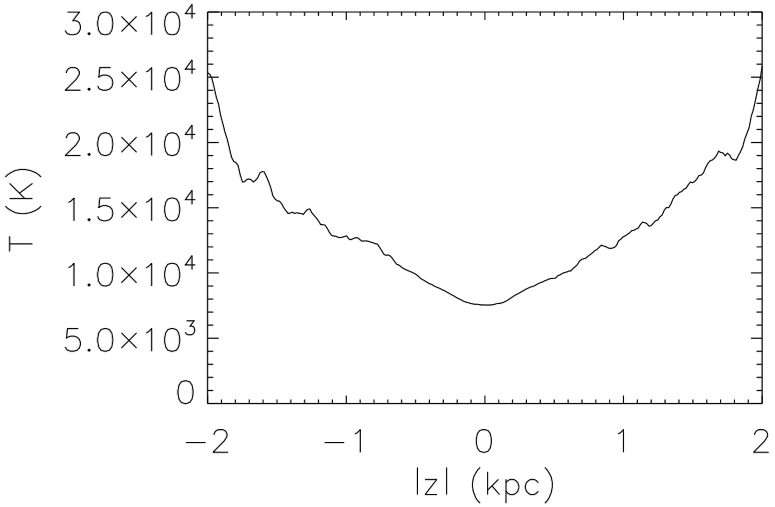


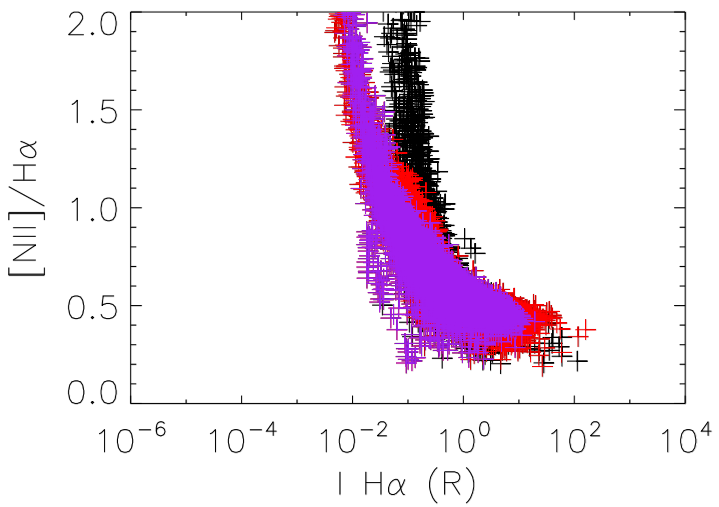
Fractal Models





Additional heating G = 4 x 10^{-26} ergs cm^{-3}s^{-1}, Q_{49}=16



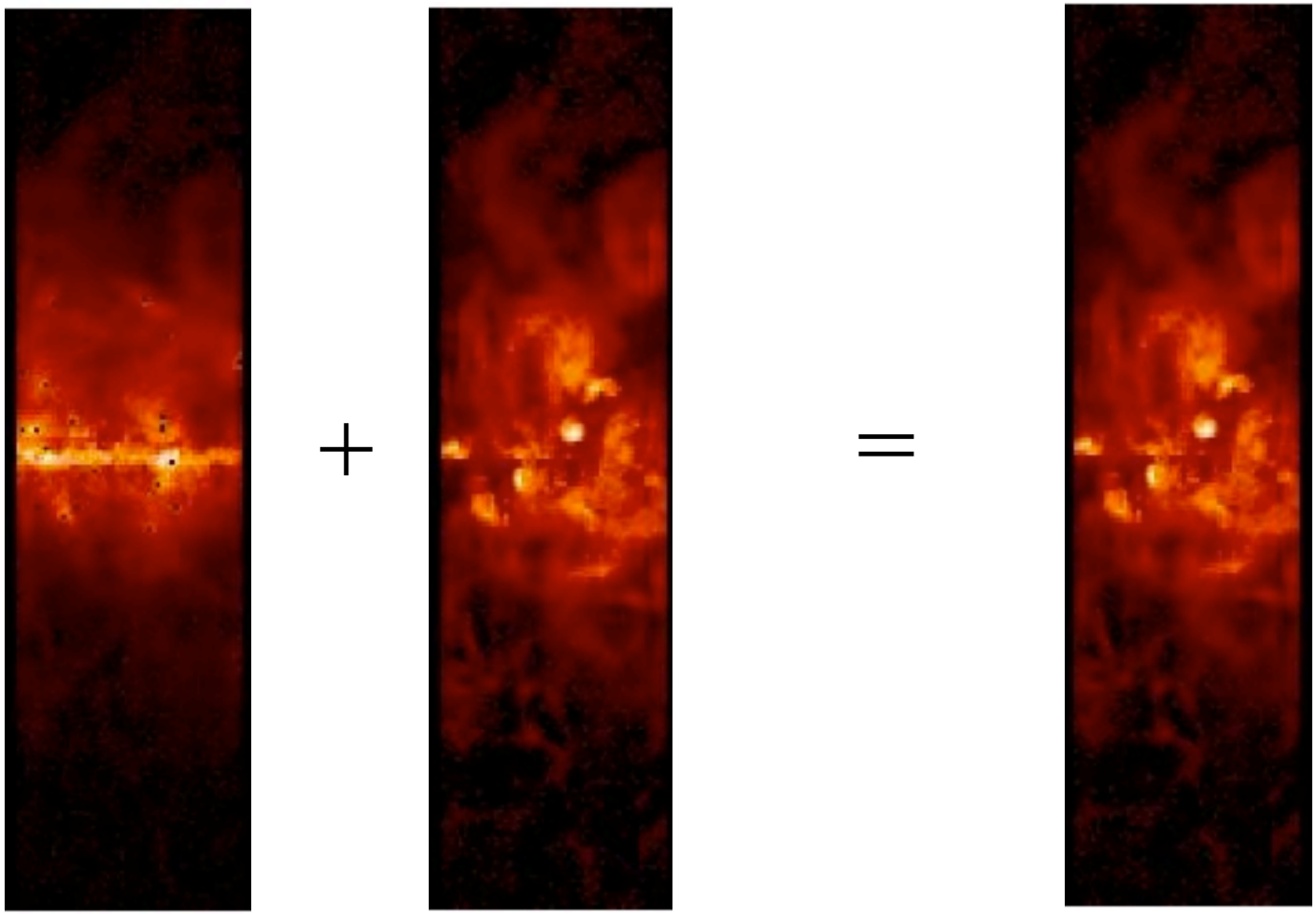


Scattered Light

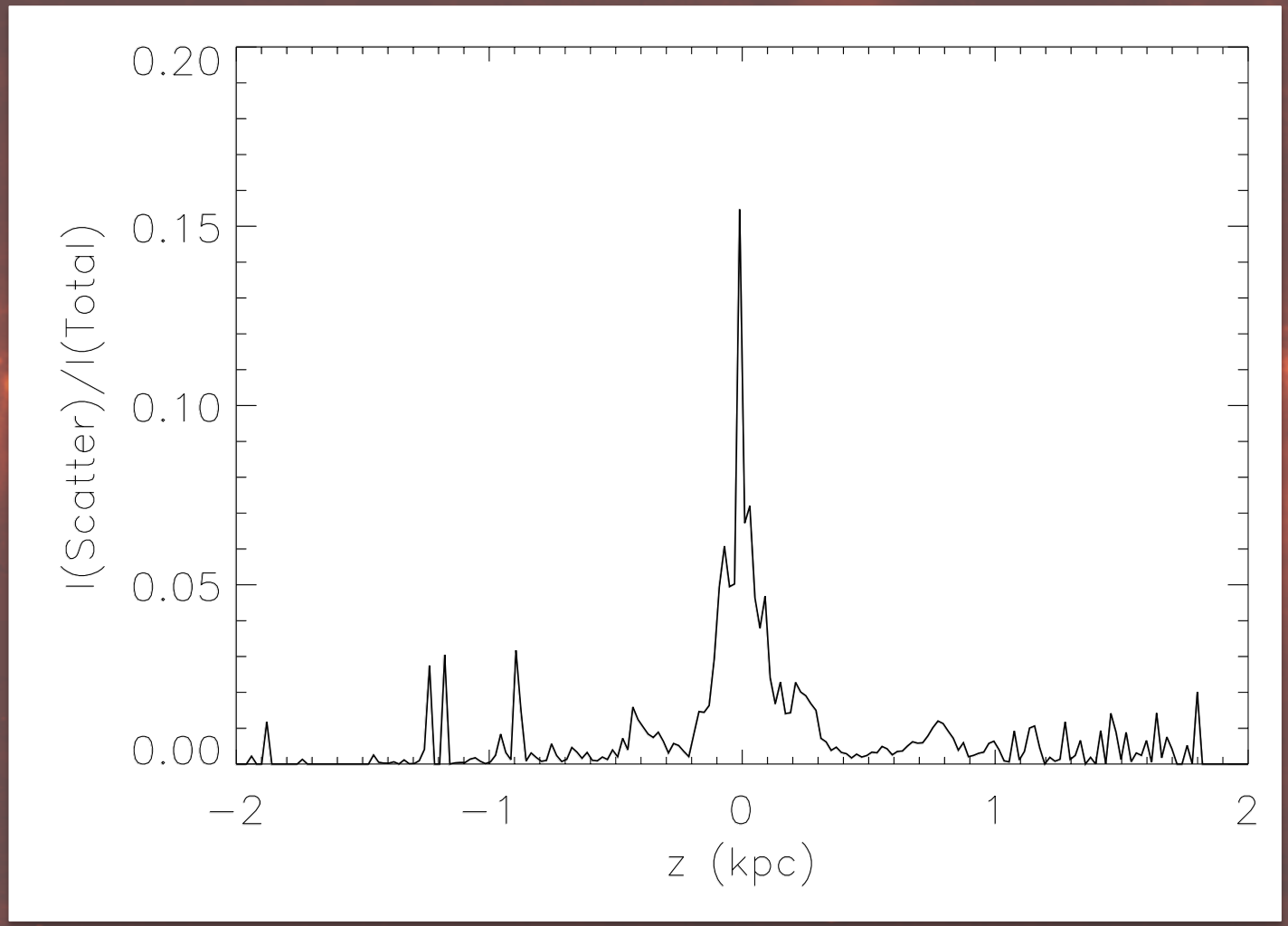
- Monte Carlo scattered light code.
- Look at scattering of photons from HII regions
- Include effects of dust scattering and absorptions in the DIG

Scattered Light Maps

HII region Diffuse gas Total

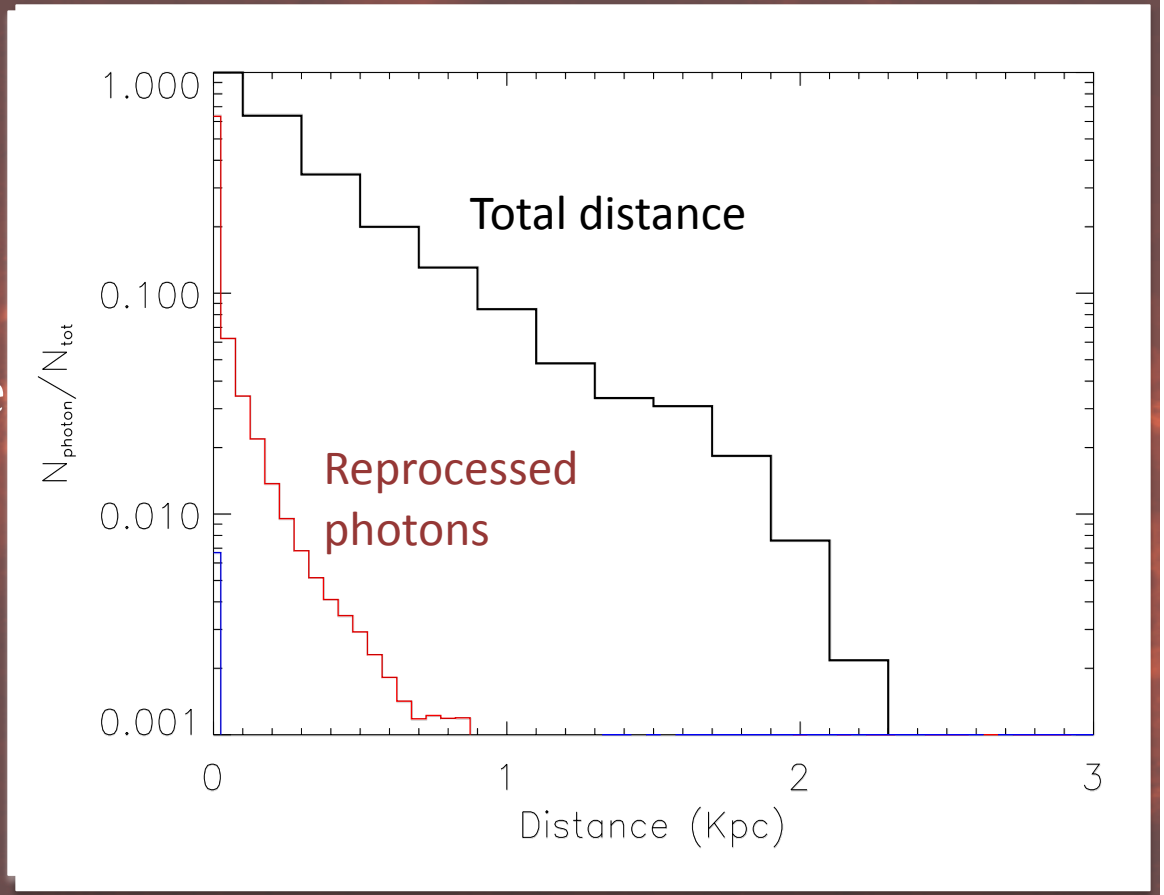


Scattered Light



Distance Travelled by Ionising Photons

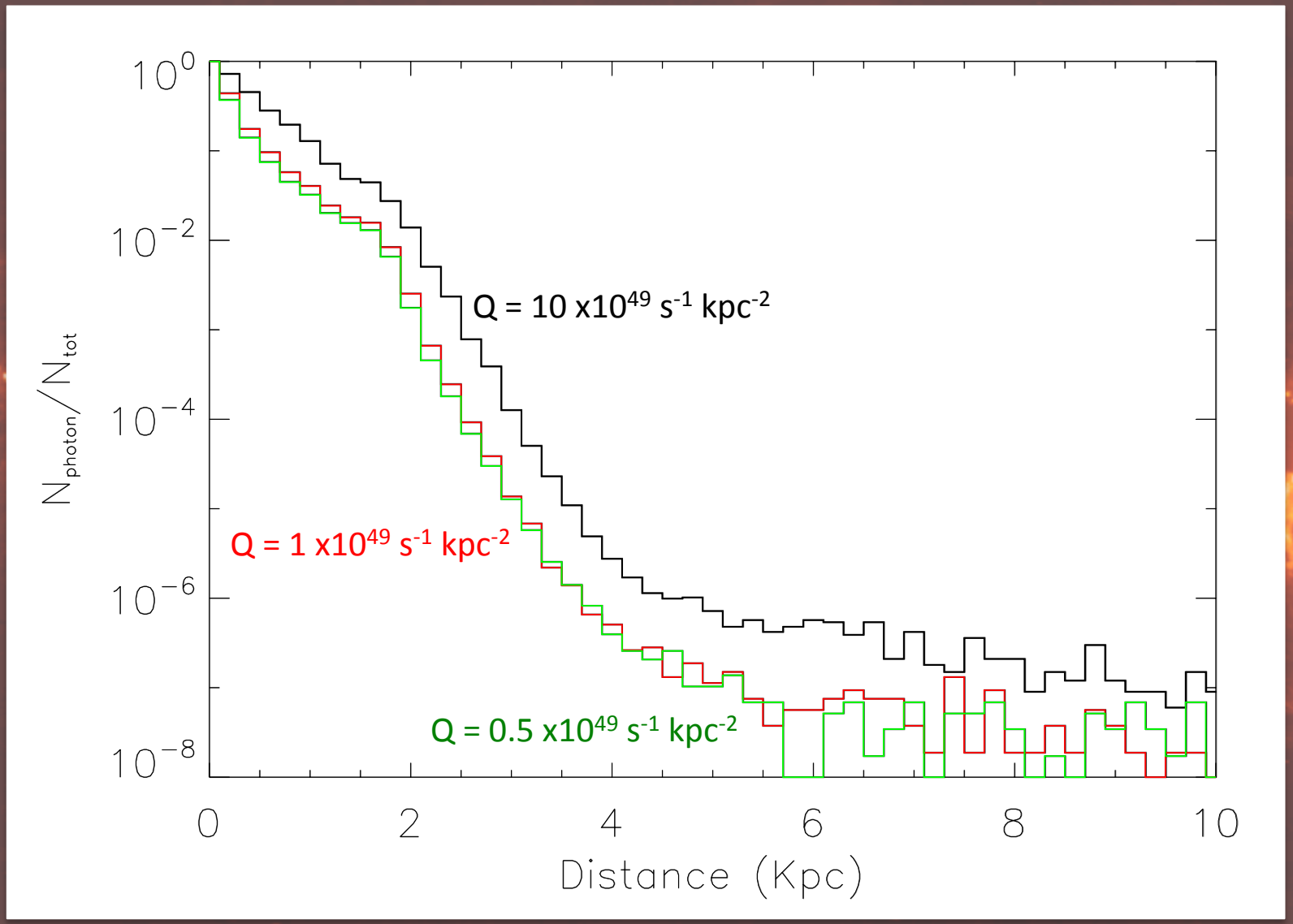
- Ionising photons travel through low density ‘bubbles’ close to the midplane
- Need very few photons to travel to the top of the simulation box.
- Higher ionising luminosity = larger distance
- Photons with higher energy travel further than those with low energy

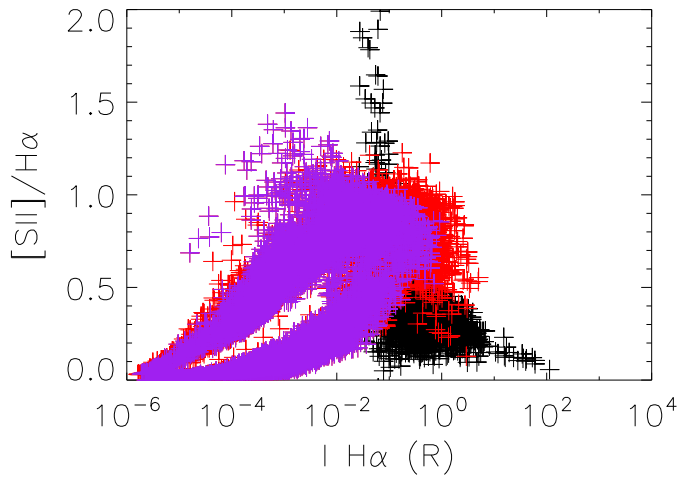


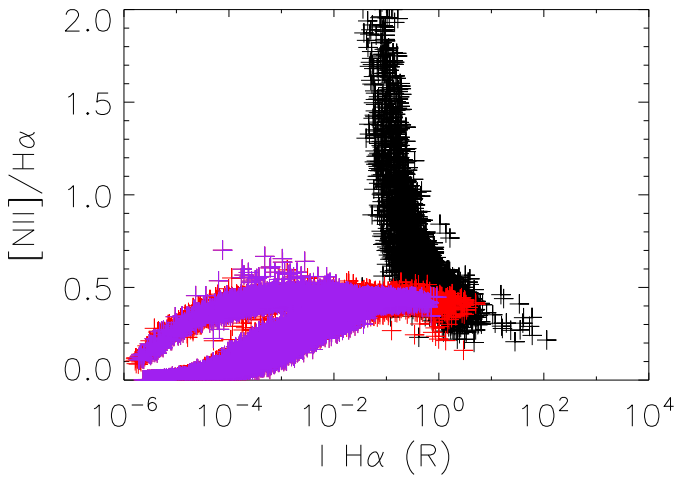
Conclusions

- Photoionisation of MHD simulations produces general H α and HI with different scale heights
- Able to reproduce general trends that we see in the Milky Way
- Fractal models produce line ratios and scale heights similar to those in the Perseus Arm
  - But structure not the same as observed
- Along many sightlines scattered light has a very small impact on the observed light. Along other sight lines, particularly close to the midplane, scattered light may have a significant effect on the intensity of light observed.
- Only a small number of photons are required to travel large distances to ionise the DIG, but enough are able to reach the top of the simulation box and ionise the gas

Distance Travelled by Ionising Photons




[SII]/Hα
2.0
1.5
1.0
0.5
0.0
10^-6 10^-4 10^-2 10^0 10^2 10^4
I Hα (R)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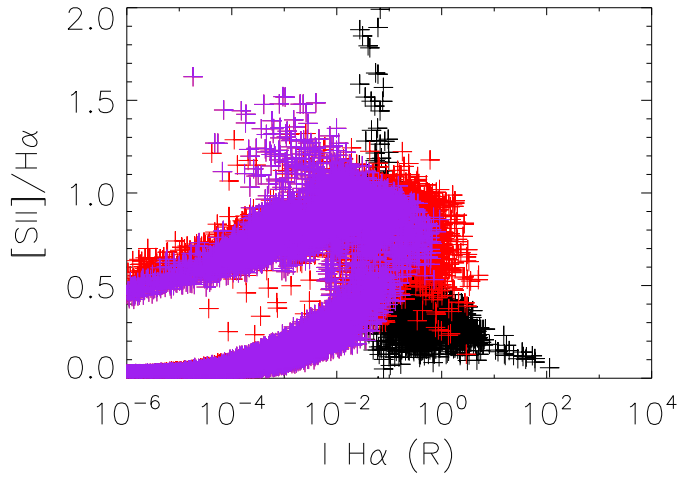
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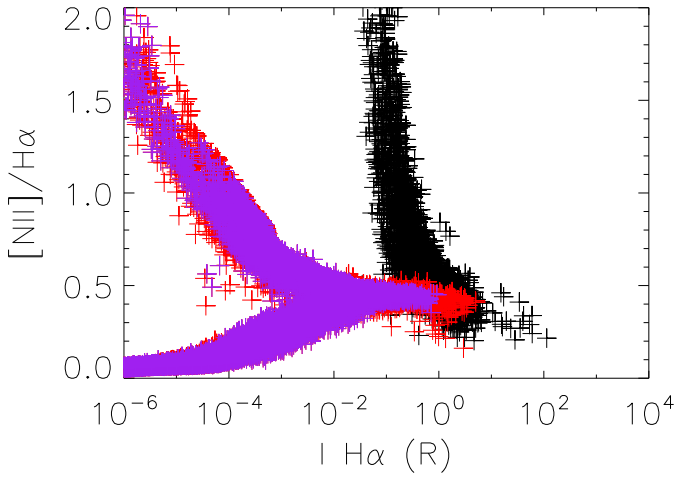
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