

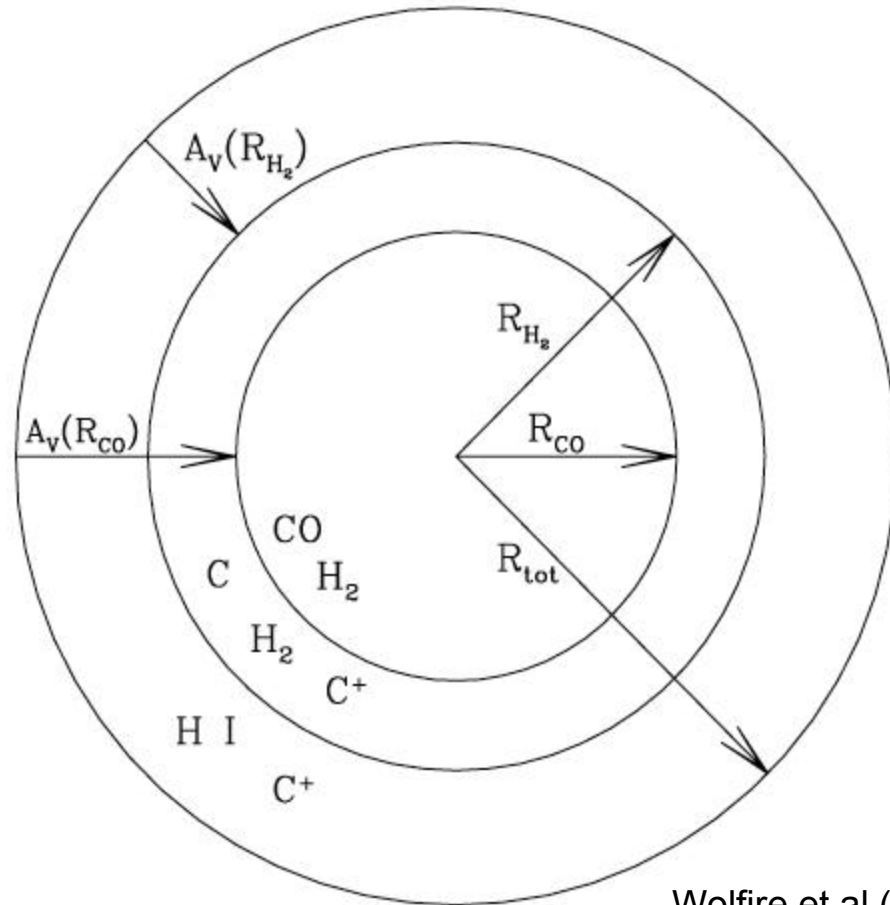
Using [CII] and [OI] to trace CO-dark molecular gas

Simon Glover

Collaborators

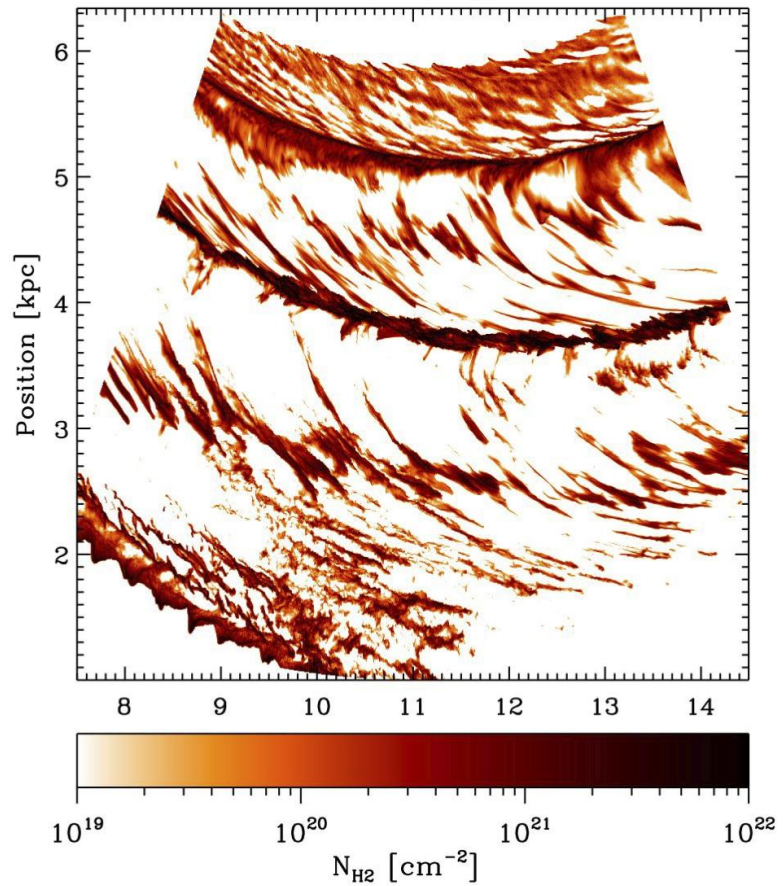
- Rowan Smith
- Erik Bertram
- Paul Clark
- Sarah Ragan
- Ralf Klessen

- Evidence from several different observational tracers ([CII], dust, OH, gamma-rays) for existence of CO-dark molecular phase
- Why is this material interesting? Observing it allows us to probe cloud assembly, cloud dispersal

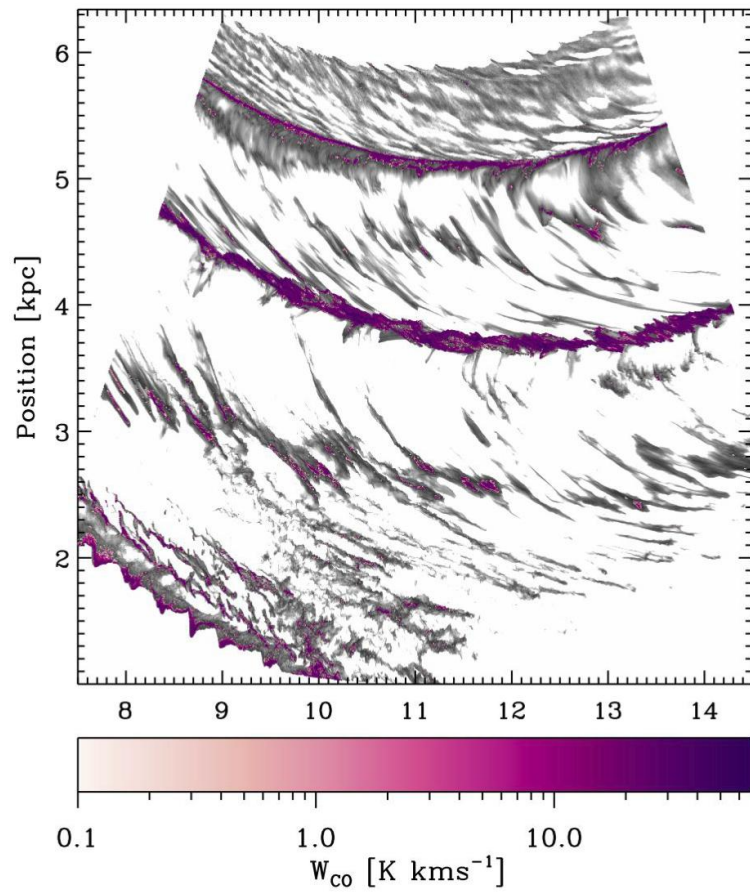


Wolfire et al (2010)

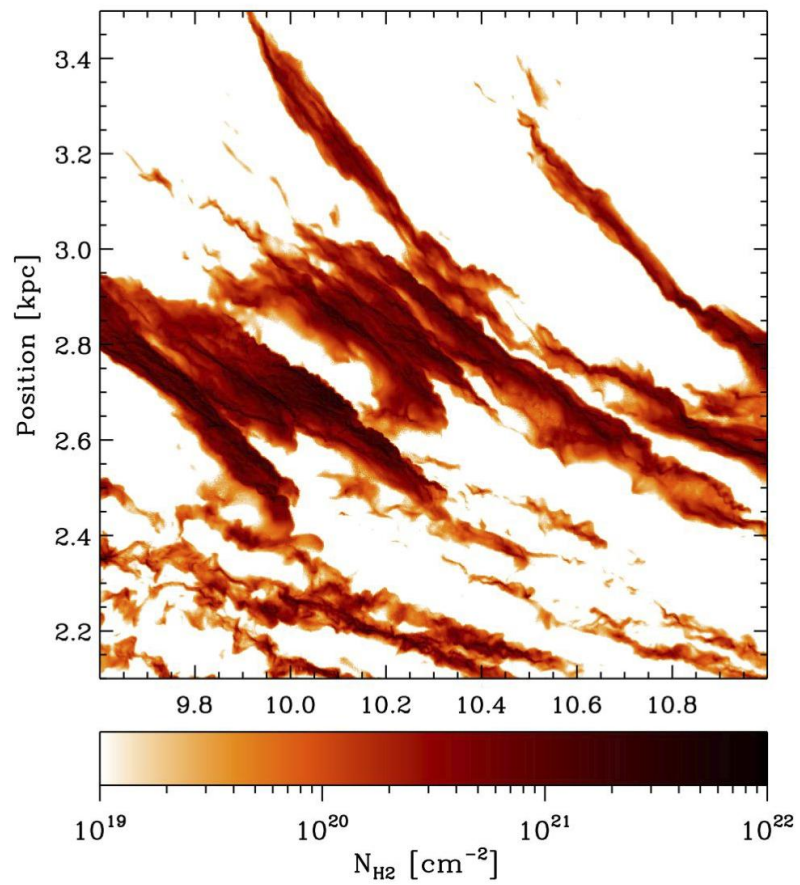
Milky Way N_{H_2}



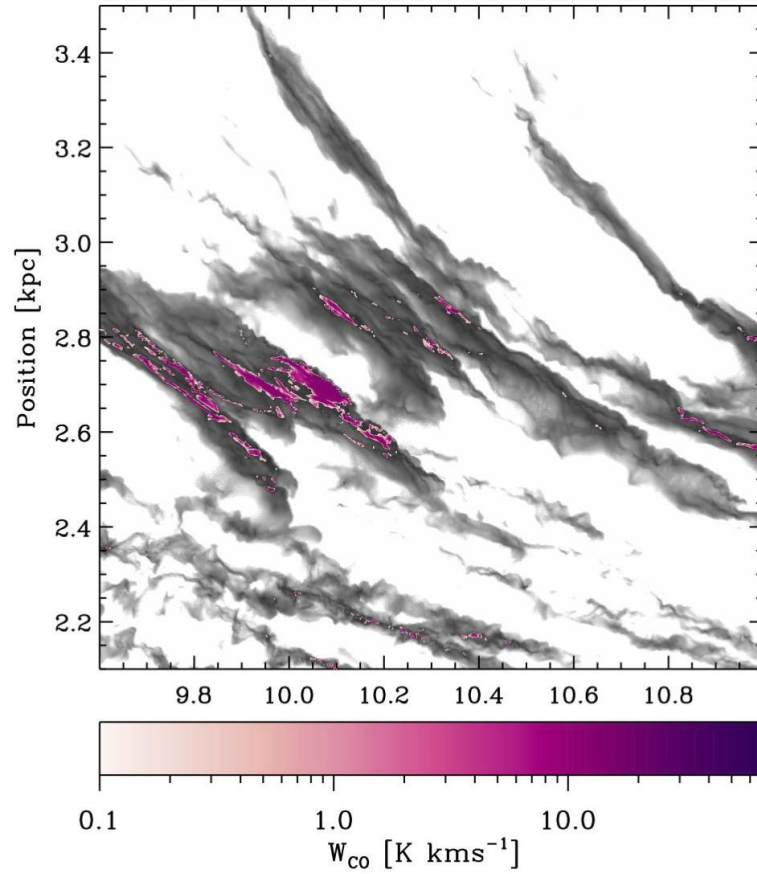
Smith et al (2014)



Smith et al (2014)

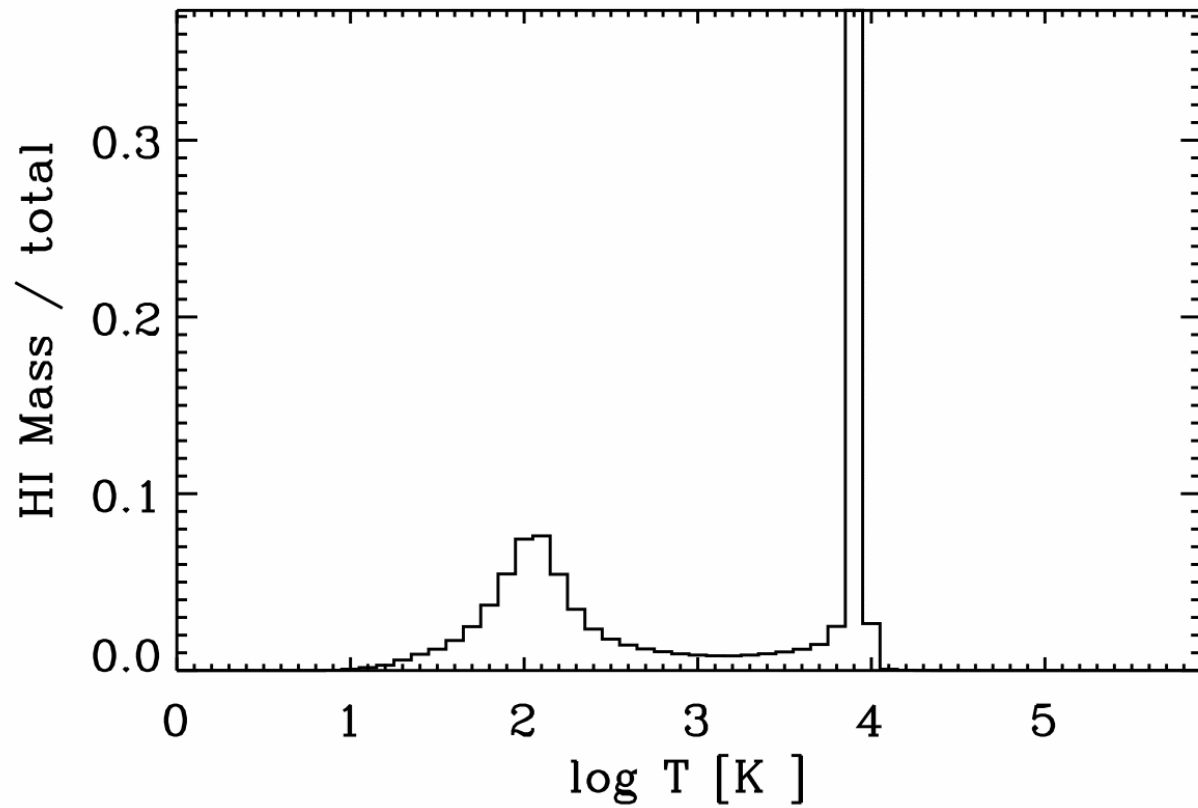


Smith et al (2014)

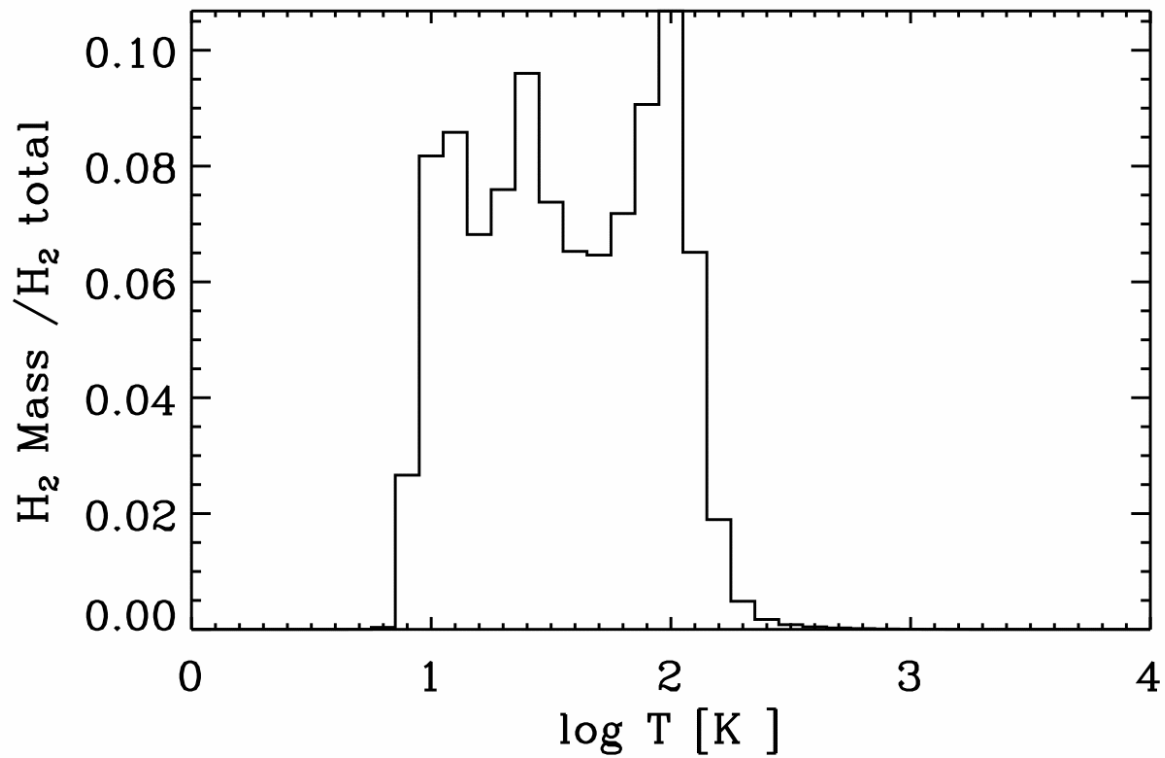


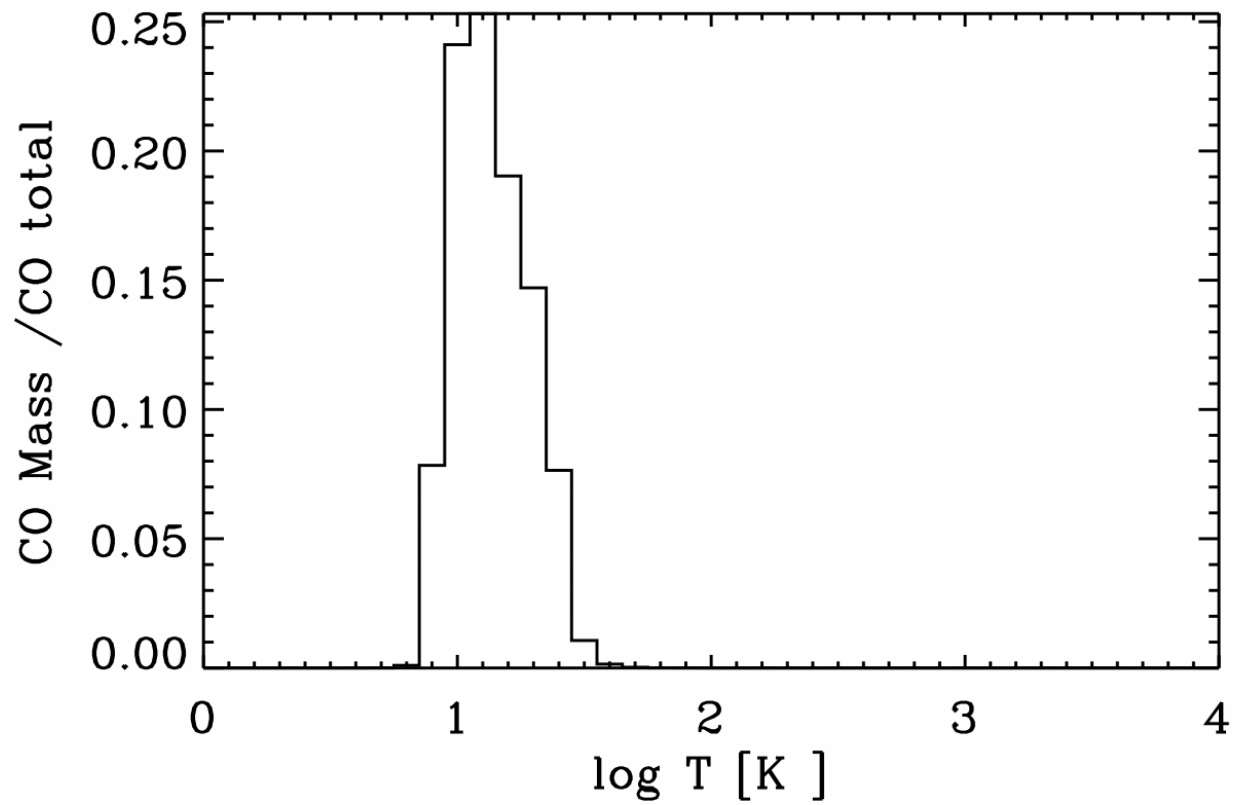
Smith et al (2014)

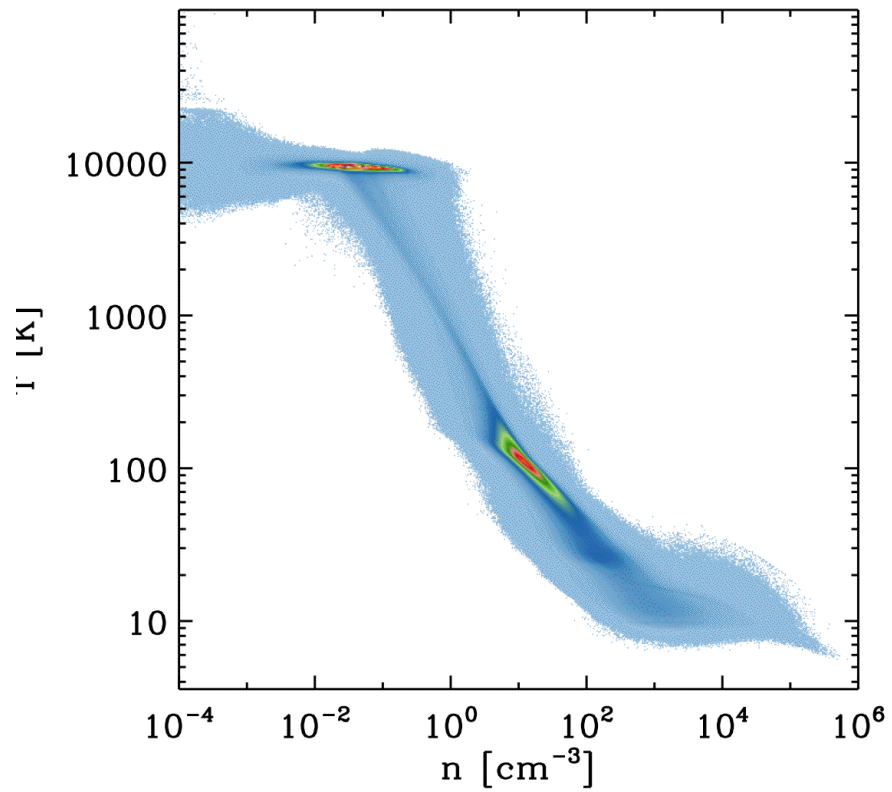
- Can we map this CO-dark gas using [CII], [OI]?
- Observability depends on density, temperature structure of this gas - warm & dense = GOOD, cold & diffuse = BAD
- Can't assume that conditions in CO-dark molecular clouds are same as in HI-dominated clouds
- Use simulations to study T, n structure of this gas



Glover & Smith (in prep.)







Some simple estimates

Assume $n = 10 \text{ cm}^{-3}$, $T = 100 \text{ K}$, $\Sigma = 10 M_{\text{sun}} \text{ pc}^{-2}$

$$\begin{aligned} L_{\text{CII}} &= 10^{38} \text{ erg s}^{-1} \text{ kpc}^{-2} && \text{(HI dominated gas)} \\ &= 3 \times 10^{37} \text{ erg s}^{-1} \text{ kpc}^{-2} && \text{(H}_2 \text{ dominated gas)} \end{aligned}$$

Faint, but detectable.

[OI] even fainter: $[\text{OI}]/[\text{CII}] \sim 0.2$

More simple estimates

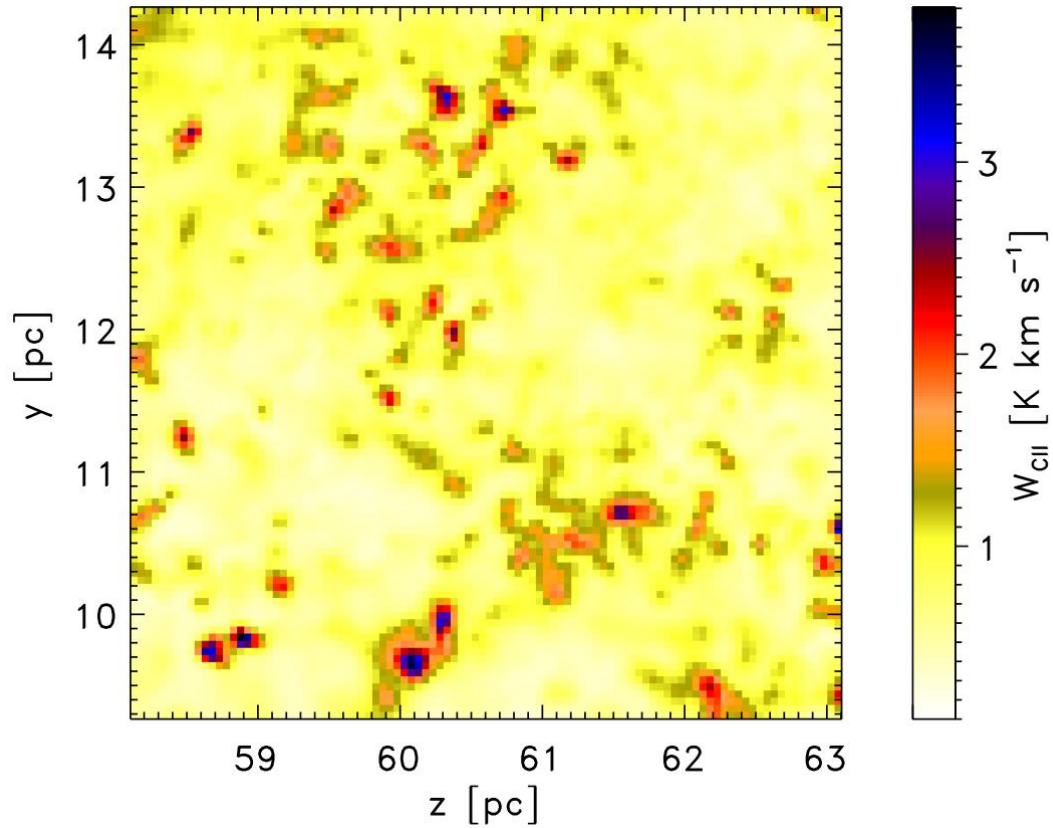
Using same n , T , Σ :

$$W_{\text{CII}} = 0.035 - 0.1 \text{ K km s}^{-1} \text{ (depending on H}_2\text{/H ratio)}$$

Higher density helps: $n=100 \text{ cm}^{-3}$, $T=50 \text{ K}$, same Σ

$$W_{\text{CII}} = 0.15 - 0.4 \text{ K km s}^{-1}$$

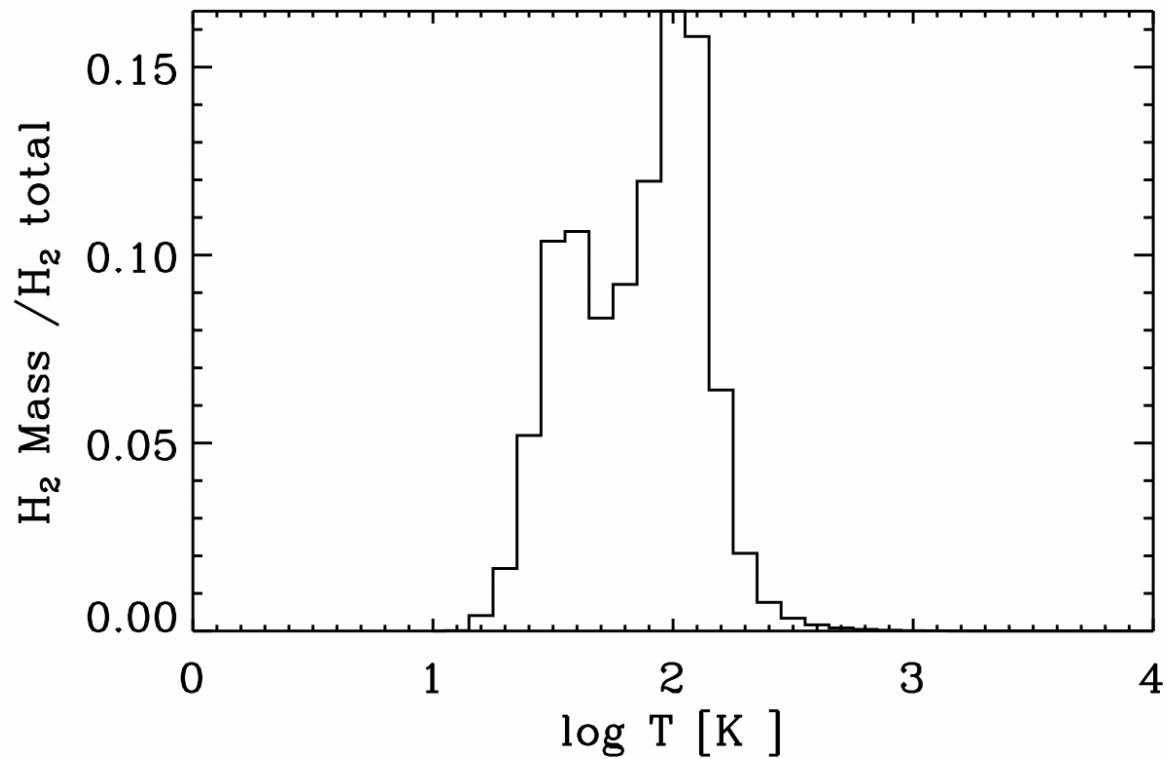
c.f. GOT-C+ detection limit: 0.21 K km s^{-1}



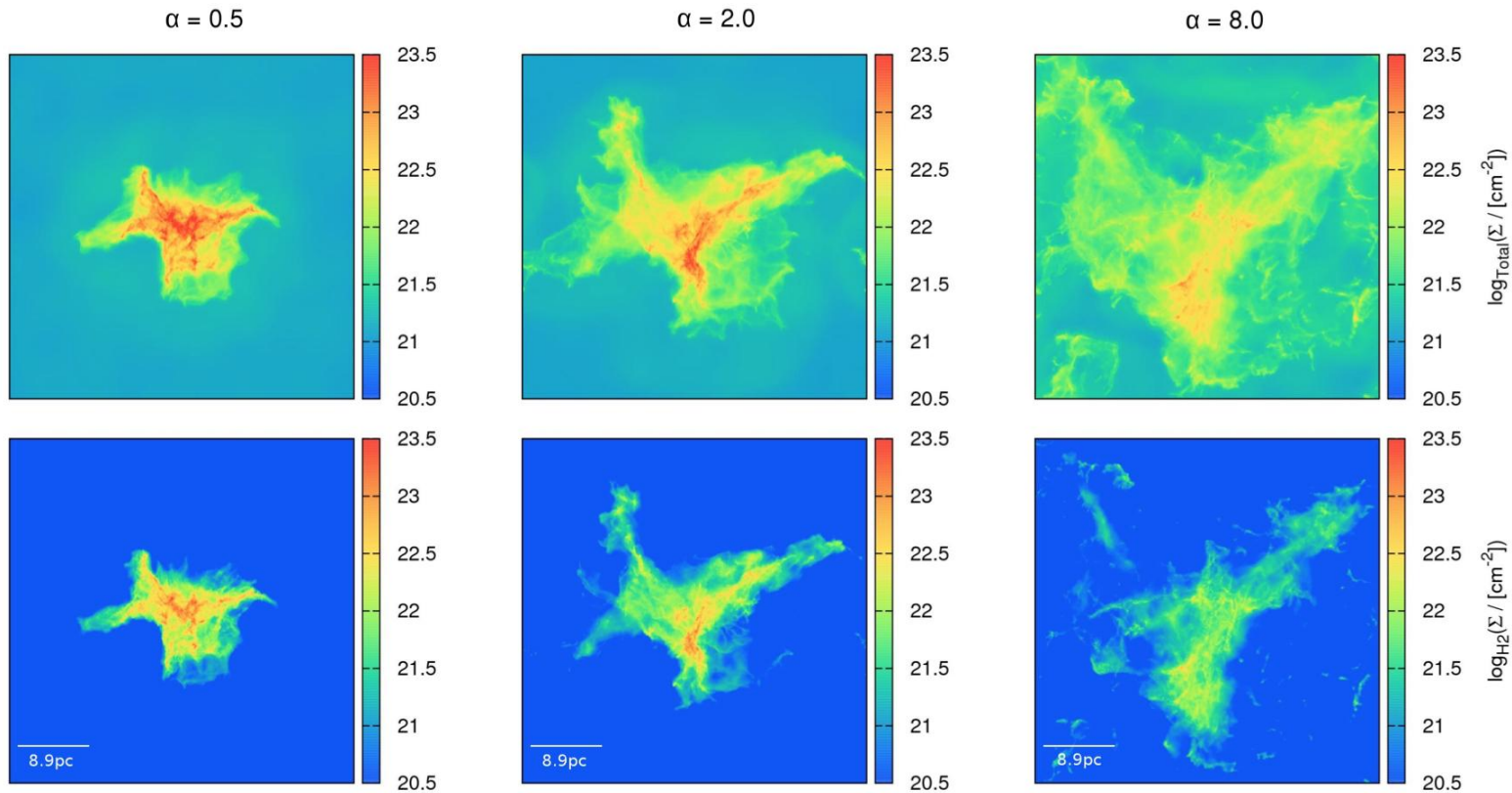
Clark et al (in prep.)

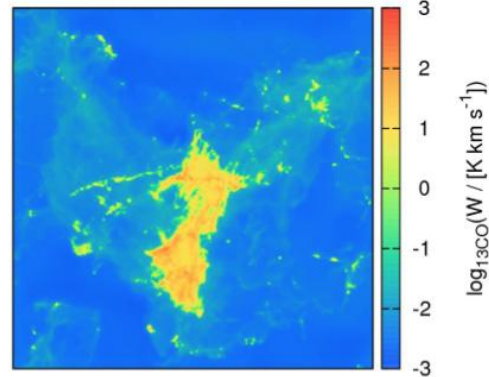
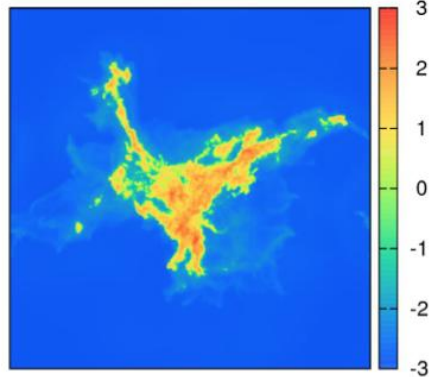
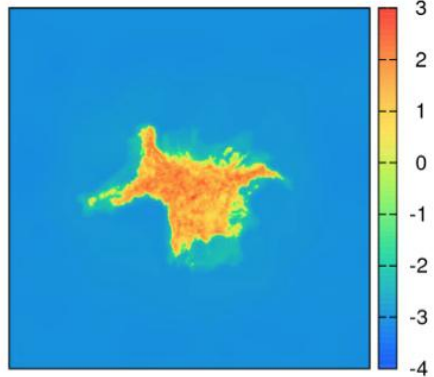
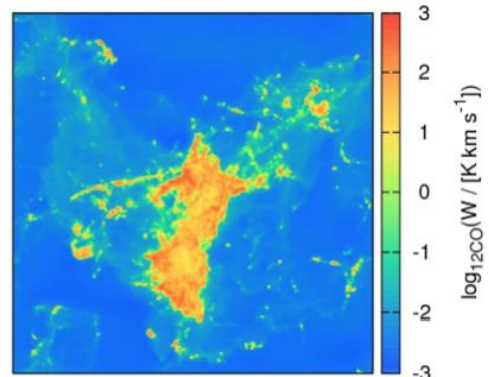
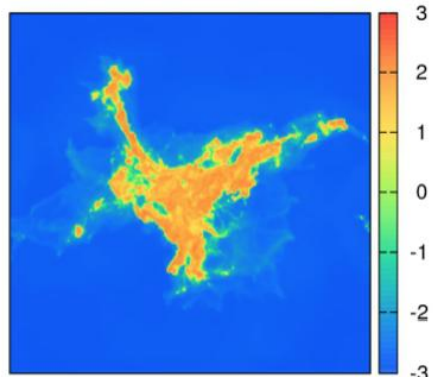
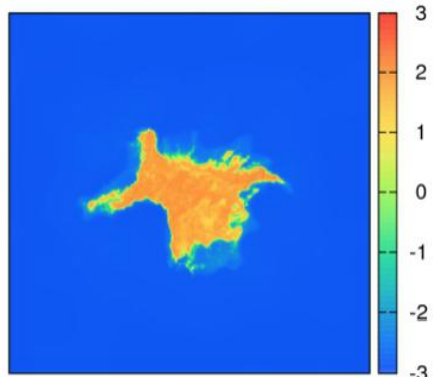
- [CII] in conditions typical of local ISM will be faint, blobby, difficult to detect and to interpret
- [OI] is even worse!
- Key problem is low temperature of high density C⁺ dominated gas - still significant C⁺ at $n = 1000 \text{ cm}^{-3}$, but too cold to see
- Solution: look in regions with higher UV fields

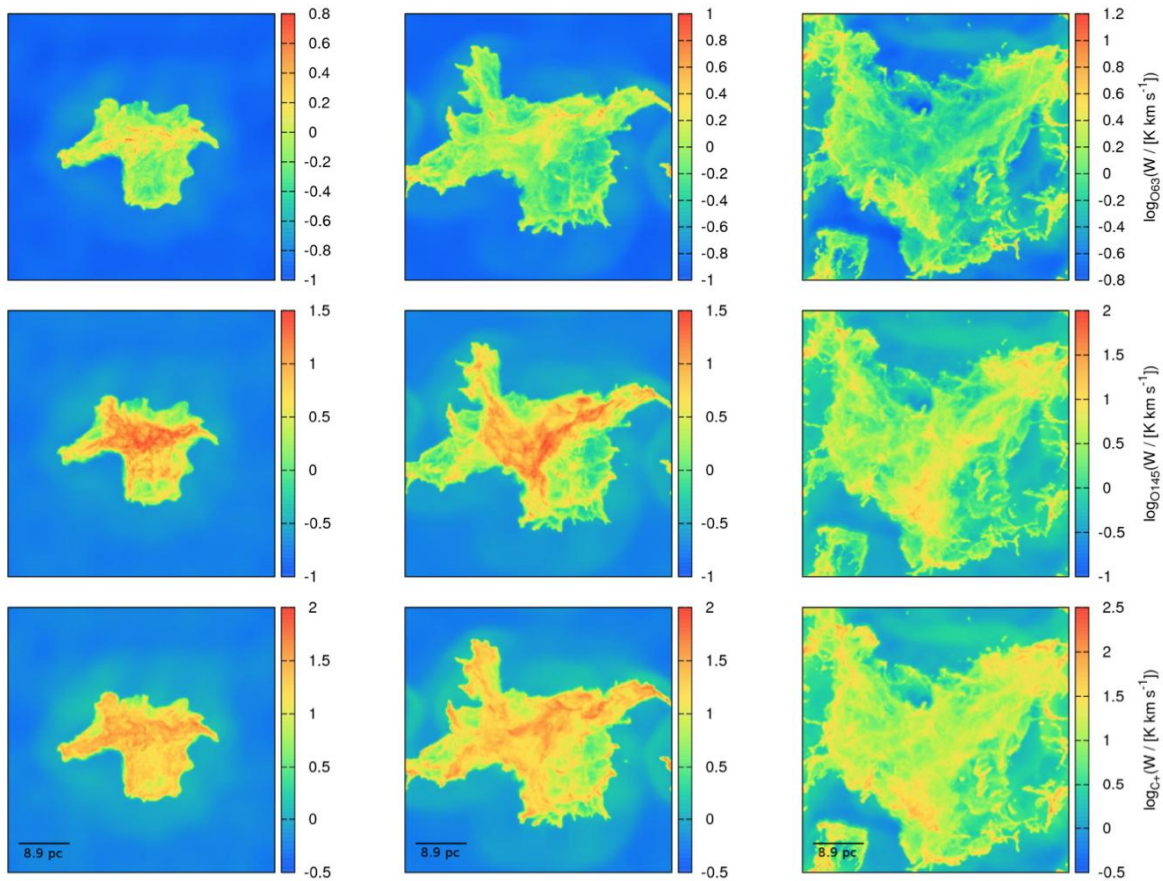
G0 = 10



Glover & Smith (in prep.)







Conclusions

- Difficult to map local GMCs using [CII] or [OI]
 - Warm gas too diffuse
 - Dense gas too cold
- Better prospects in regions with higher UV
 - Even factor of 10 increase in G_0 helps a lot
 - CMZ is an ideal location