The Perseus Molecular Cloud: A Local Laboratory for Studying the HI-to-H_2 Transition in the ISM

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Collaborators

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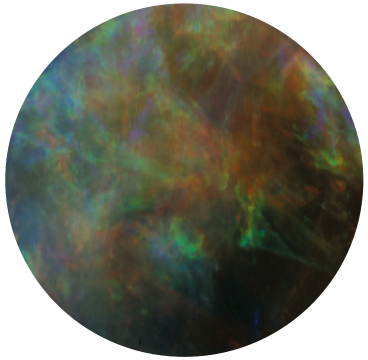
Inflow

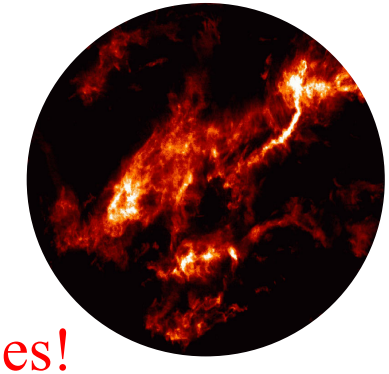
Outflow

Atomic Gas (HI)



Star Formation

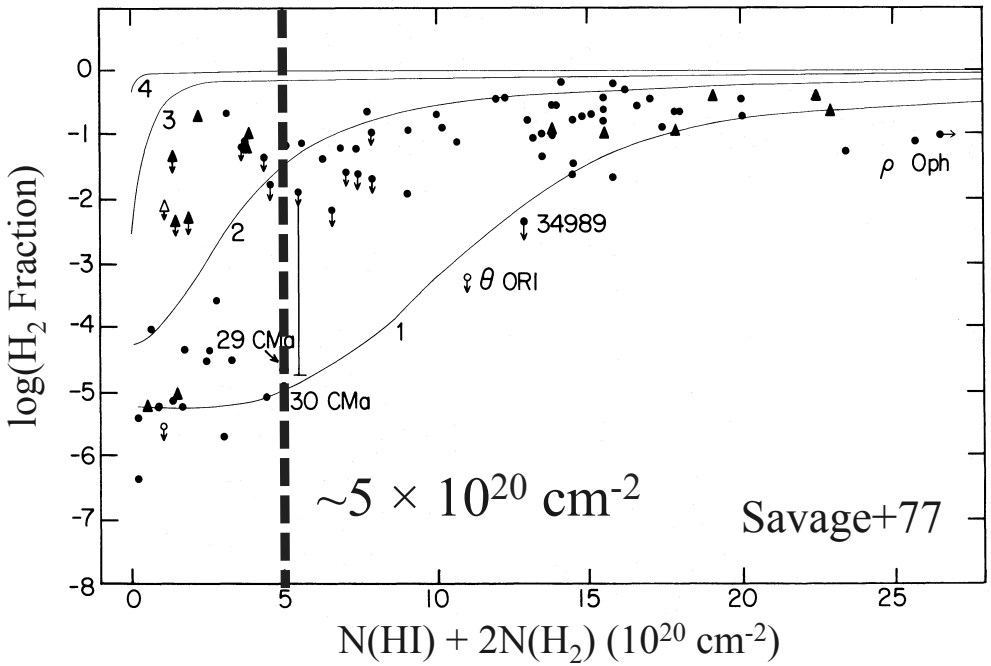
Giant Molecular Cloud (H_2)



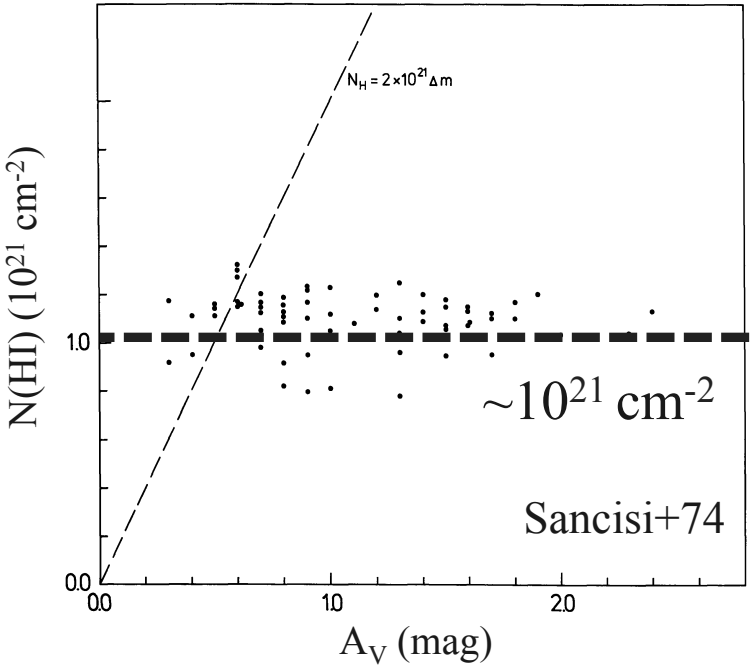
One of the
major bottleneck processes!

HI-to-H_2 Transition: Observation
(See Amiel's Talk for Theory)

1) Direct: UV absorption lines



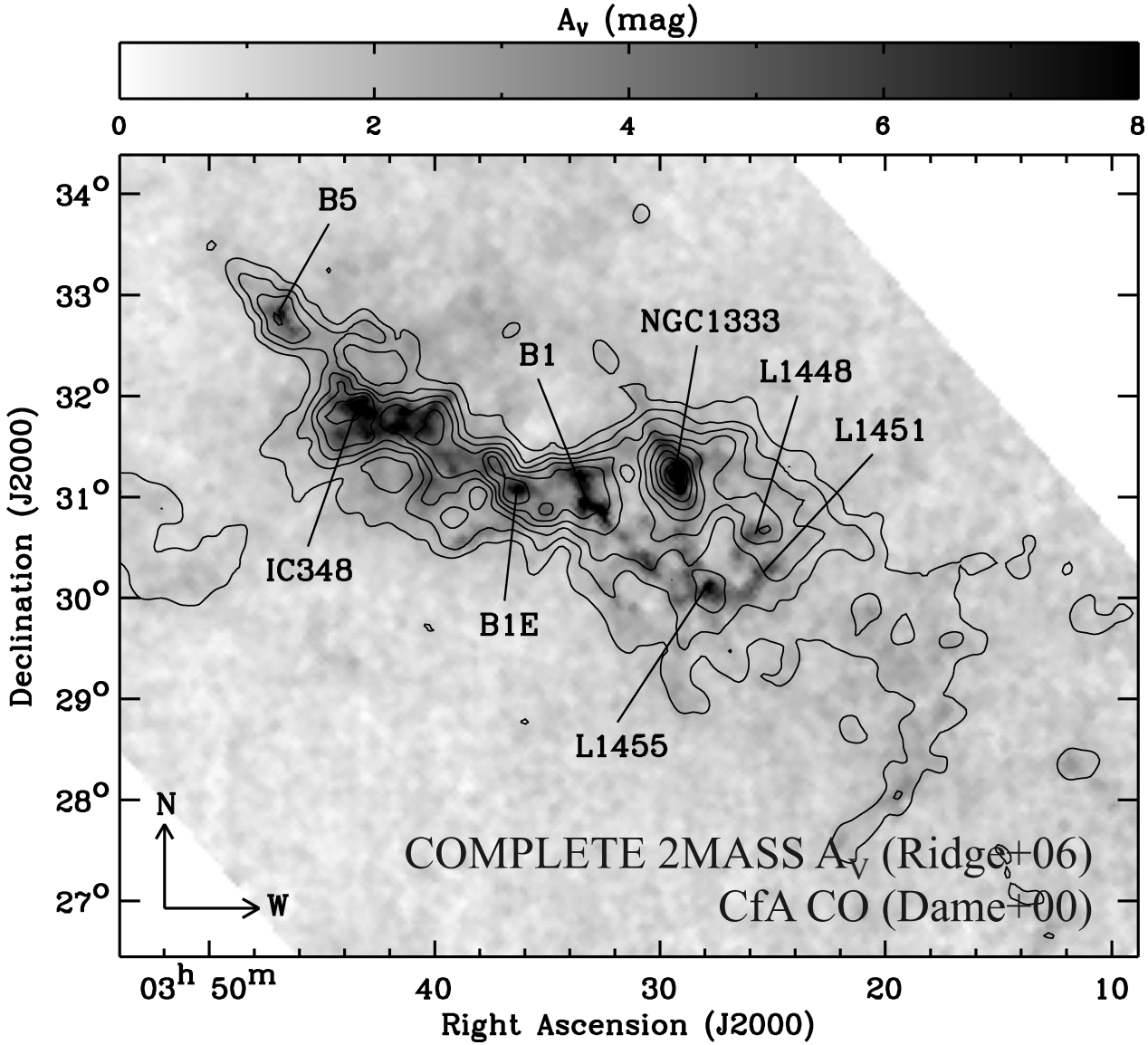
2) Indirect: Gas tracers



<u>Sharp increase of H_2 fraction</u>
e.g., Gillmon+06; Rachford+09

<u>HI saturation</u>
e.g., Leroy+08; Barriault+10

Perseus: Our Local Laboratory



Perseus molecular cloud

D ~ 300 pc

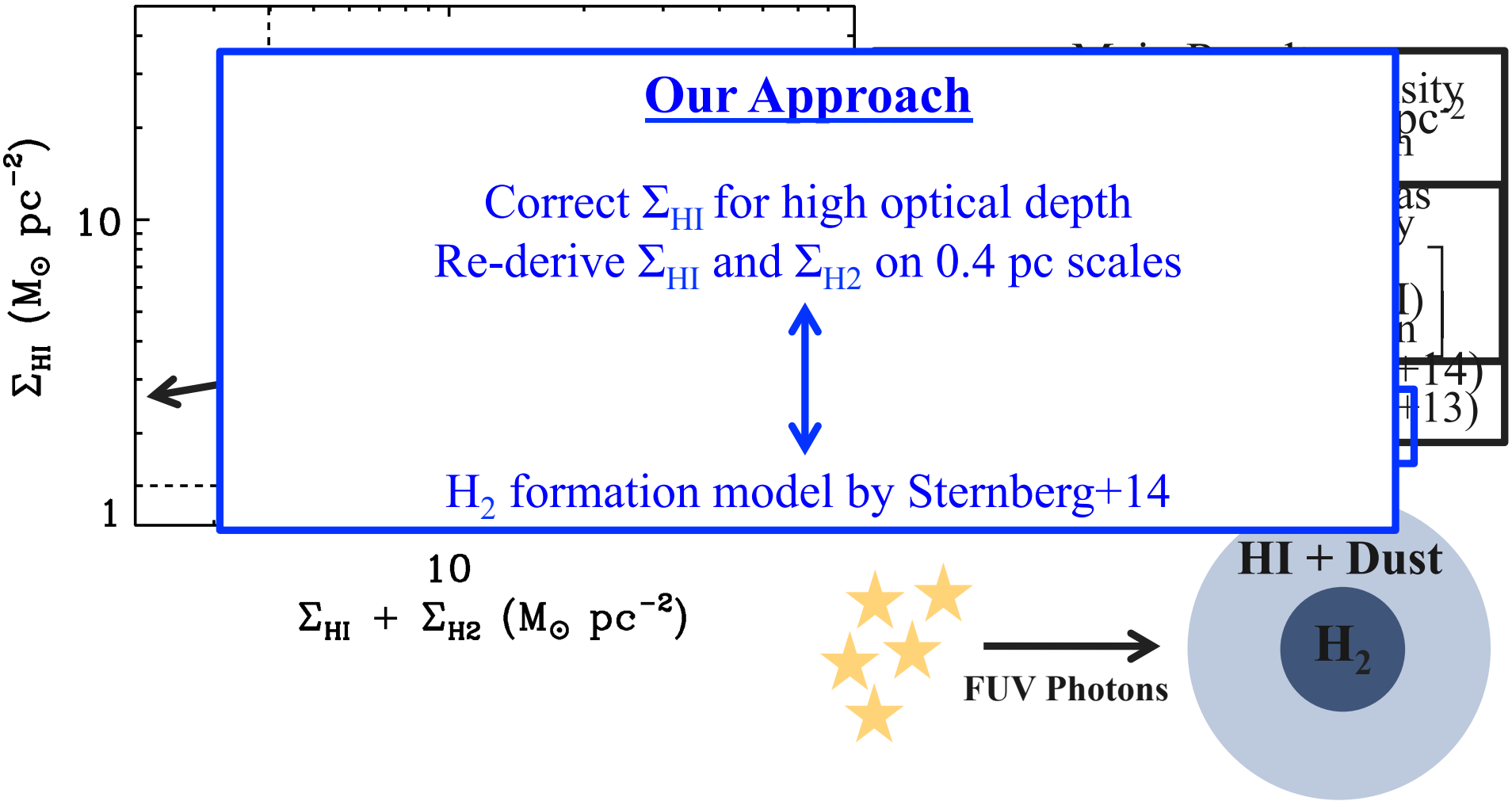
M ~ 10^4 $M_\odot$

Intermediate SF

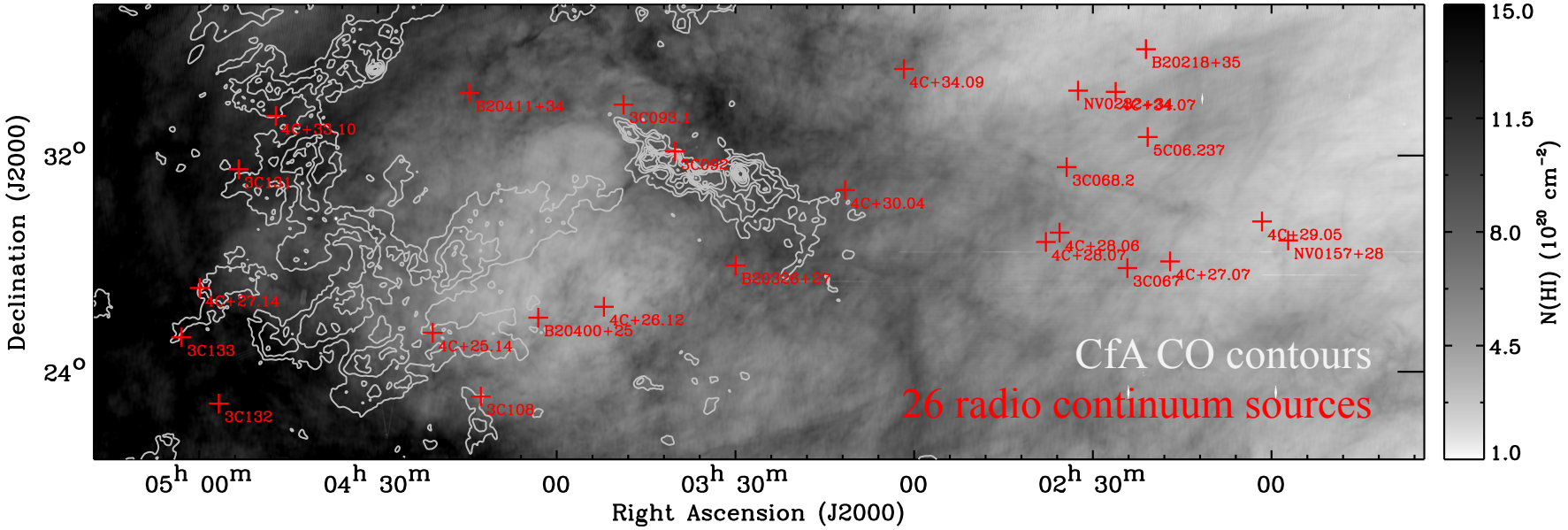
Age ~ 10 Myr

Z ~ 1 $Z_\odot$

HI Saturates on 0.4 pc Scales (Lee+12)



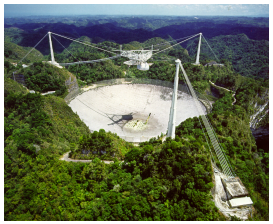
Arecibo HI Absorption Measurements

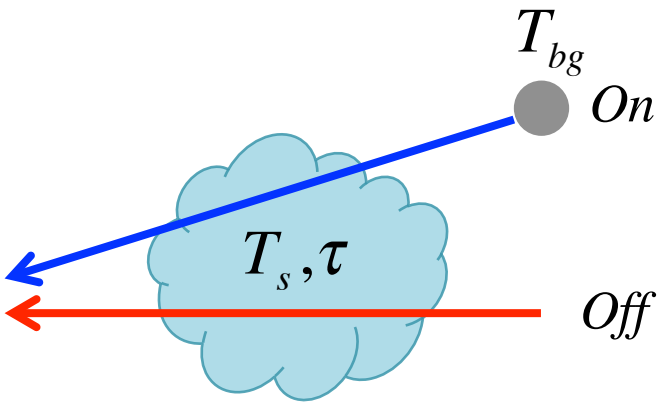


$$T_b^{on} = T_{bg} e^{-\tau} + T_s (1 - e^{-\tau})$$

$$T_b^{off} = T_s (1 - e^{-\tau})$$

"expected" emission spectrum

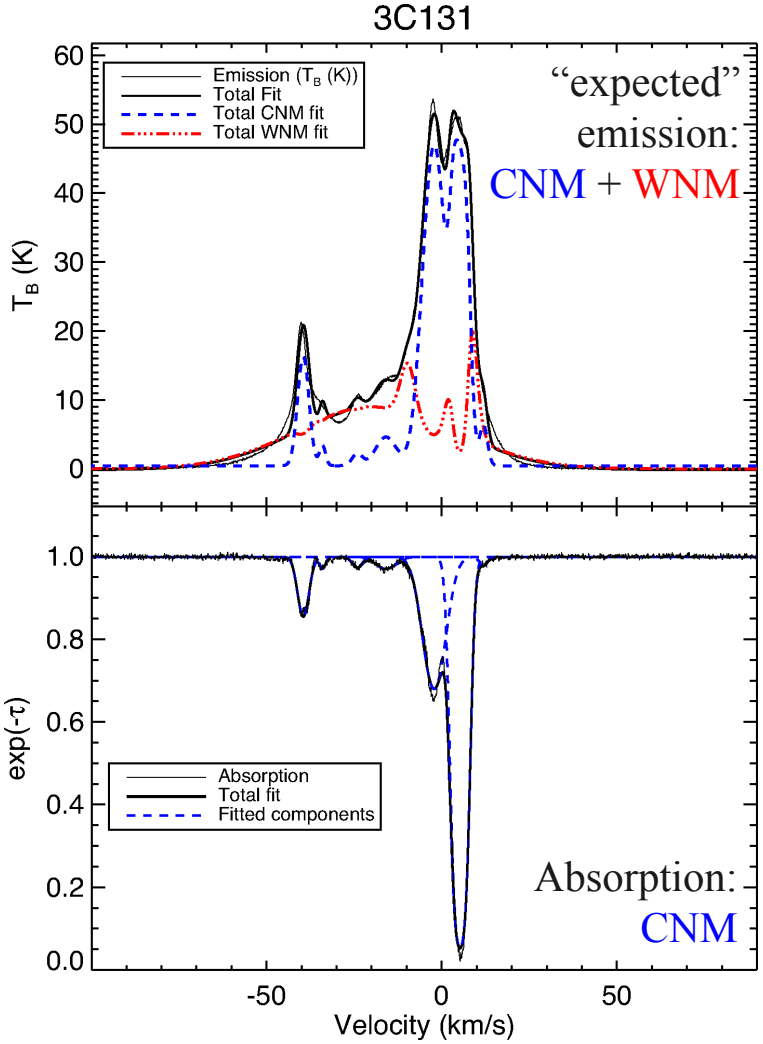




See Claire's talk

Deriving HI Properties

Following Heiles & Troland (2003; "Millennium Survey")



Gaussian decomposition →

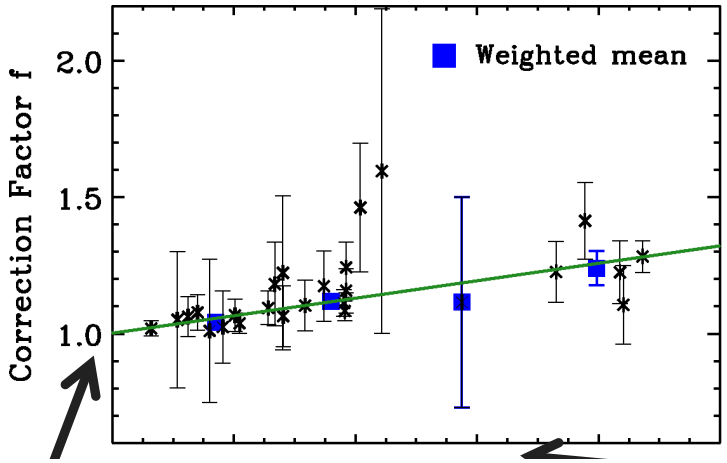
Outputs

For 107 individual components:
$T_{max}, V_0, \Delta V, \tau_{max}, T_s, N(\mathrm{HI})$

Stanimirovic, Murray, Lee+14

Optically Thick HI is Not Substantial

For all 26 continuum sources

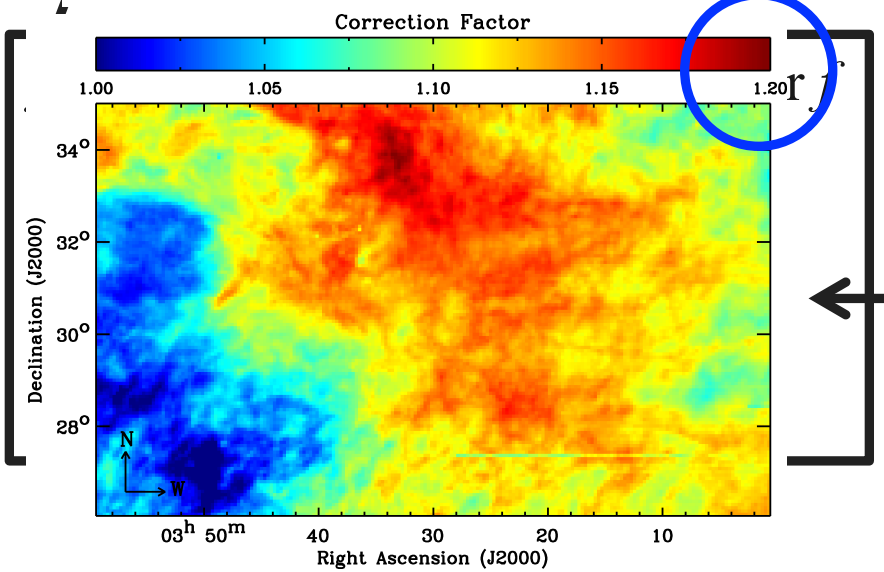


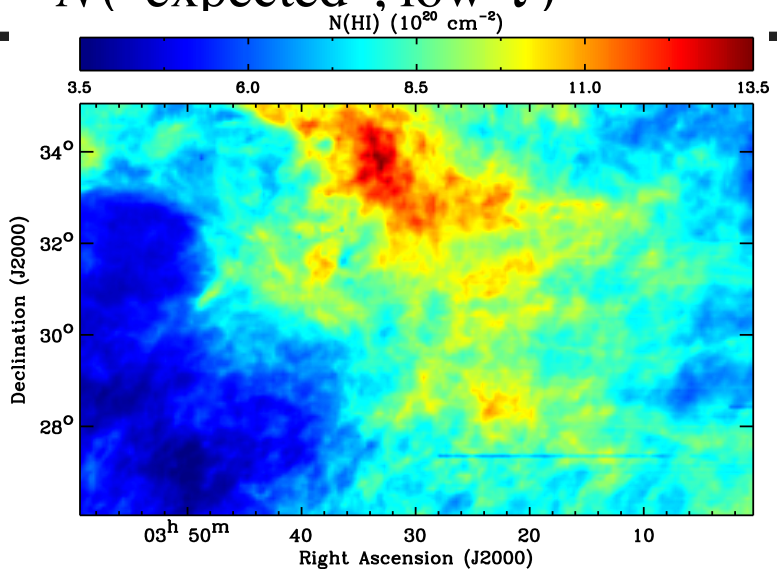
$$f = 0.32 \times \log_{10}[N(\text{"expected"}, \text{low-}\tau)] + 0.81$$

x-axis: Optically thin HI column density

Correction factor (Lee+15) **Max ~ 1.2!** Optically thin N(HI) (Lee+12)

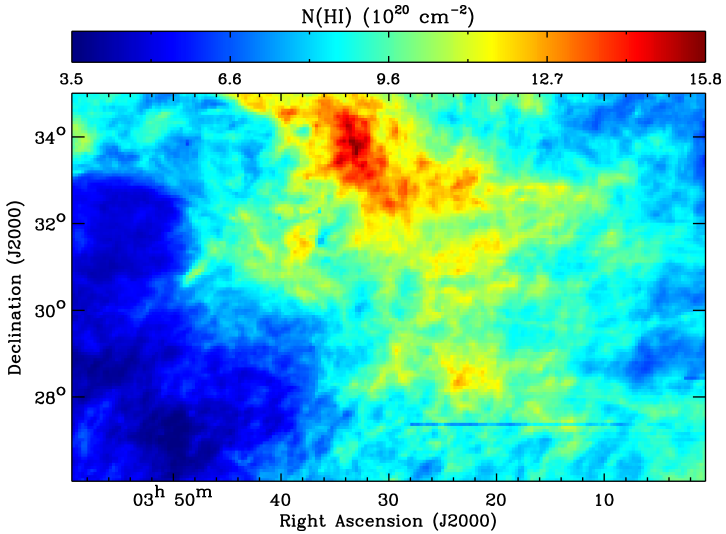
$N(\text{"expected"}, \text{low-}\tau)$



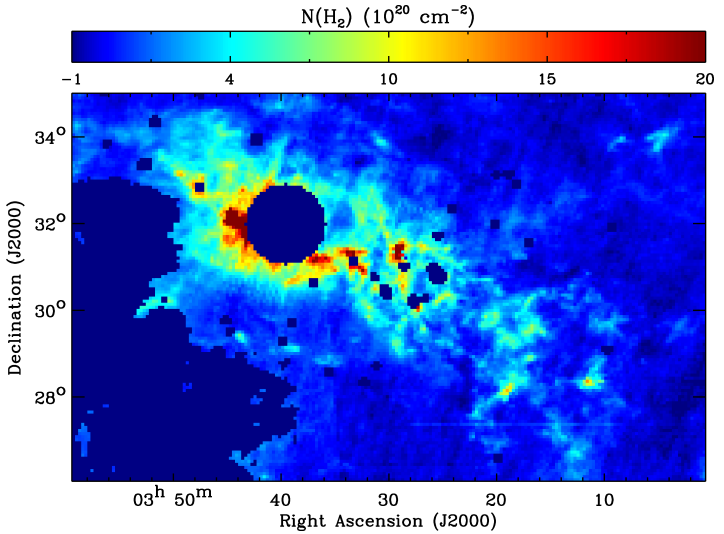


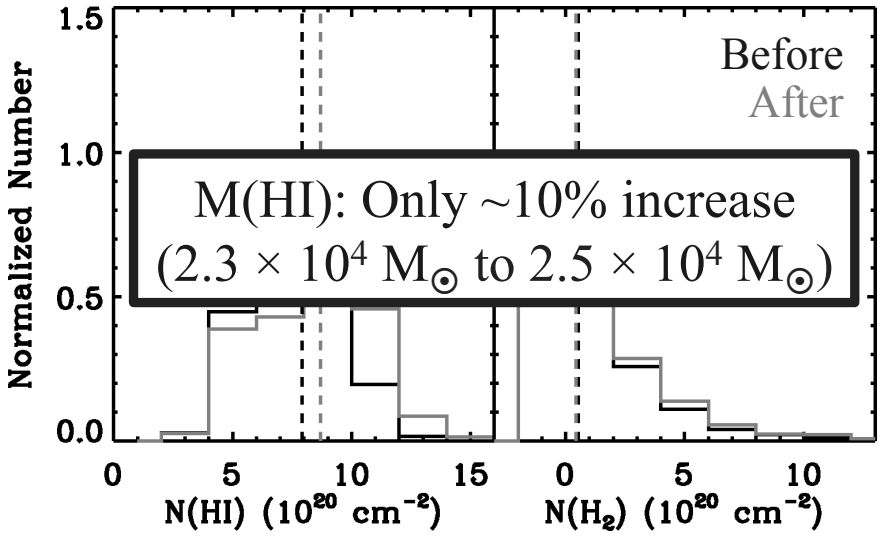
Uniform HI = Shielding Layer for H_2!

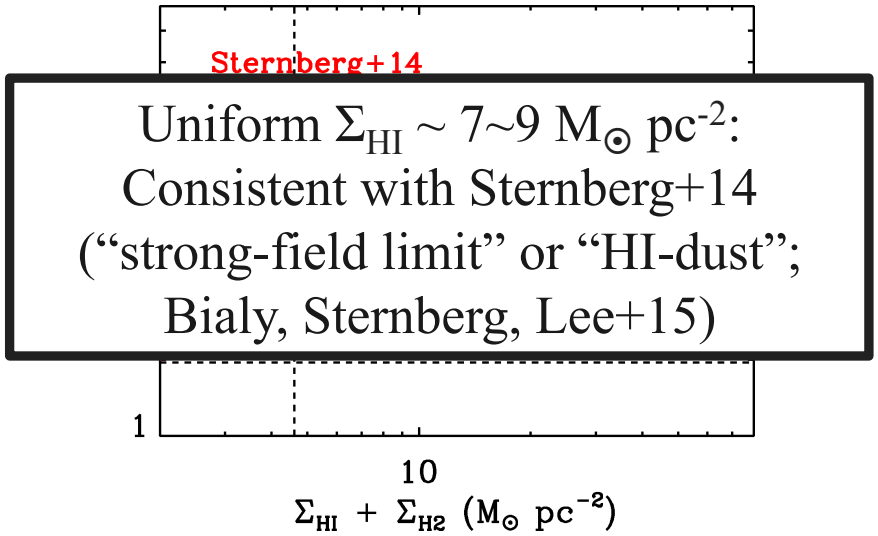
Opacity-corrected N(HI) (Lee+15)



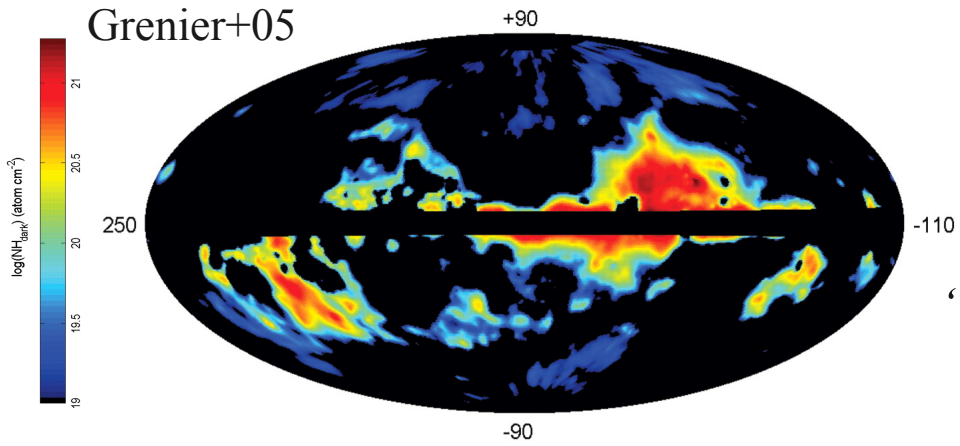
Re-derived N(H_2) (following Lee+12)





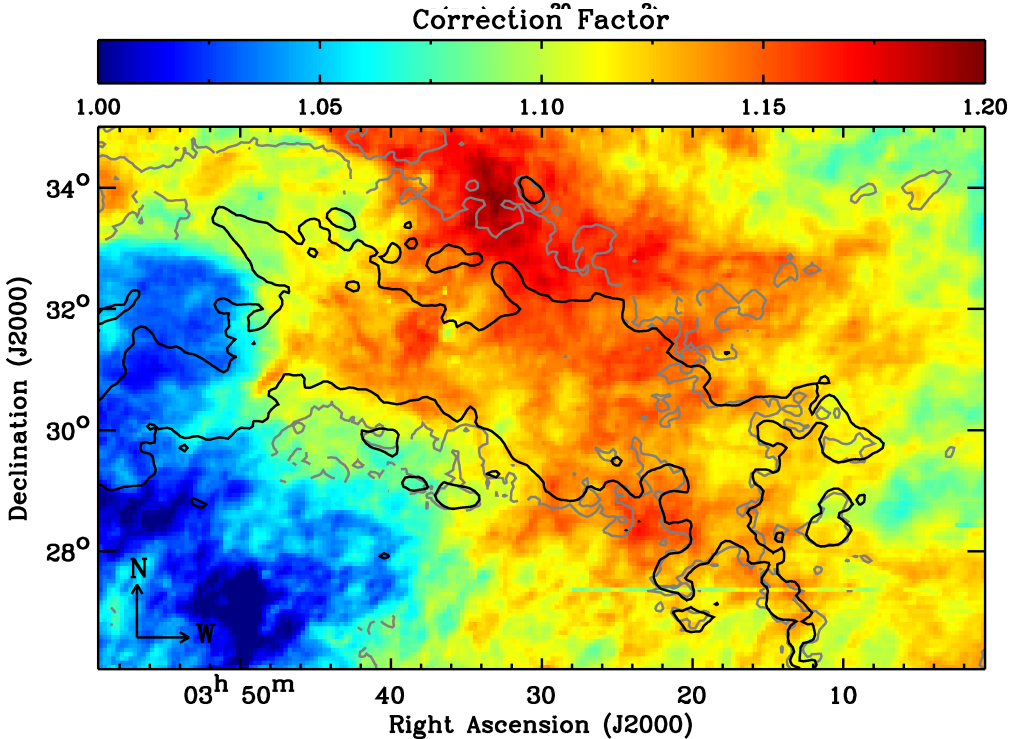


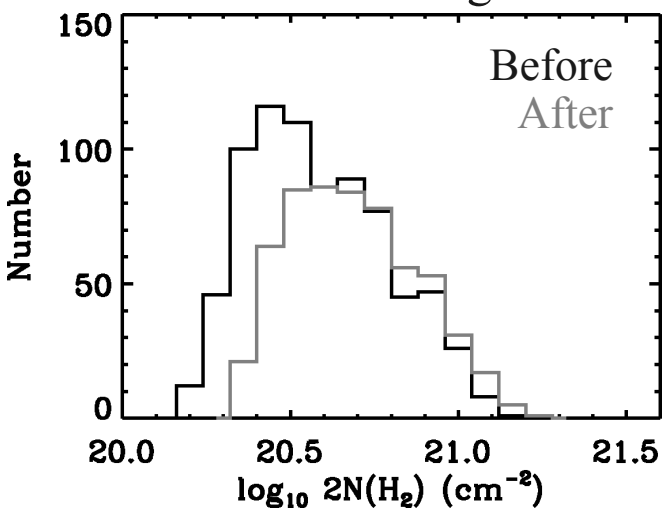
Optically Thick HI ≠ "CO-dark" Gas!



"CO-dark" gas: Gas undetectable either in the HI and CO emission

Fukui et al. (2015):
"CO-dark" gas ~ Optically thick HI?





Optically thick HI ~
Only 20% of the "CO-dark"

Summary

1. The correction for high optical depth HI is minor (up to ~20%).
2. The opacity-corrected HI is uniform with 7~9 $M_\odot$ pc^{-2} and H_2 formation is responsible for this HI saturation on 0.4 pc scales.
3. The optically thick HI is a small fraction of the "CO-dark" gas.

Future Work

WNM ⇄ CNM ⇄ "CO-dark" H_2? Optically thick HI? ⇄ "CO-bright" H_2

Other Galactic clouds under investigation:
(Arecibo/VLA/Planck; Bernstein-Cooper, Stanimirovic, Lee+ in prep)

→ Great pilot study for the upcoming SKA era!
(e.g., ASKAP and Apertif; See Naomi's talk)

N(HI) & $N(H_2)$ Distributions

- N(HI): GALFA-HI data
- $N(H_2)$: