

Constraining the Fraction of Dense Gas in the Galactic Center

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The Galactic center is an extreme environment for gas

Millimeter : cold dust/gas

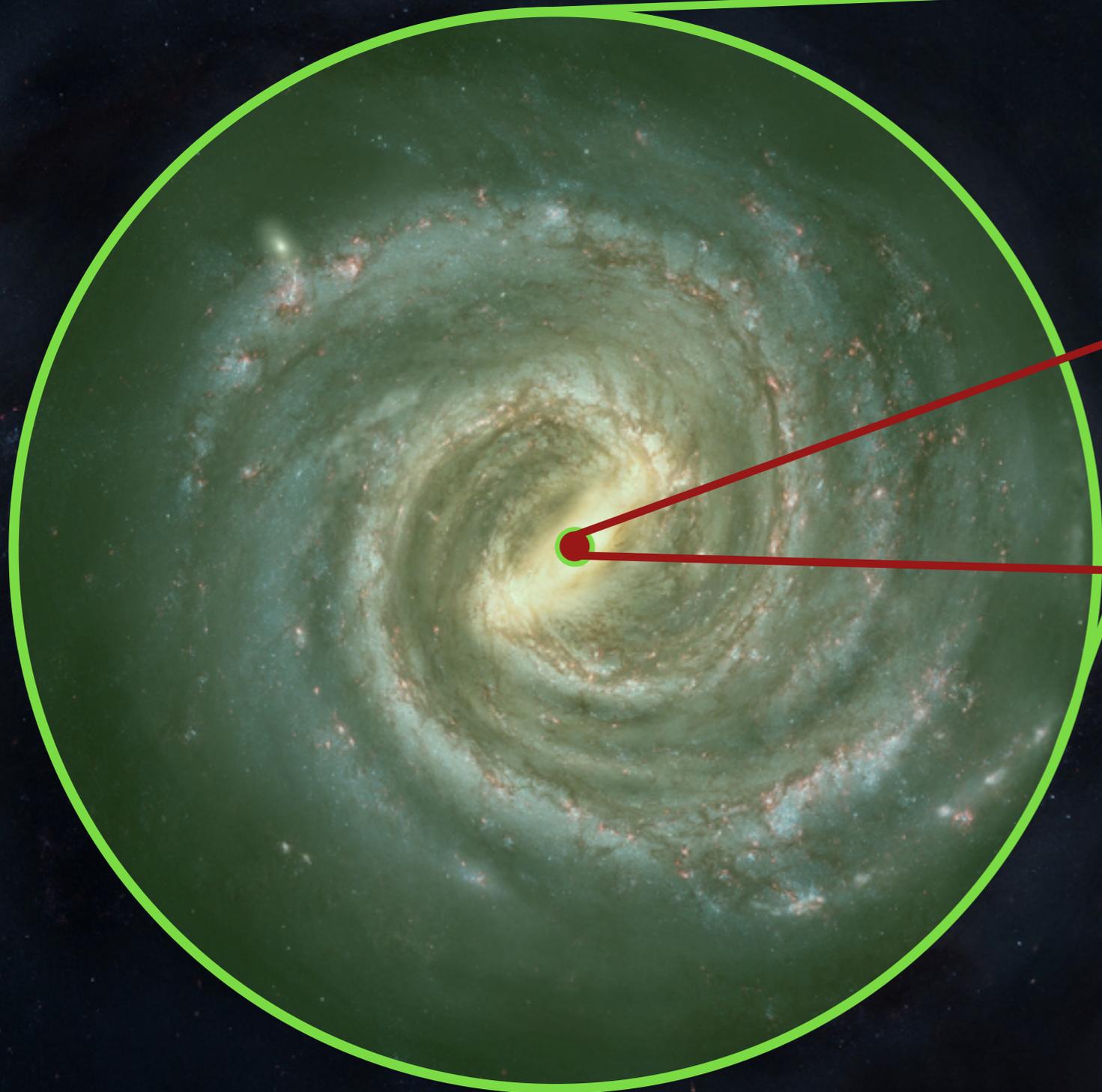
Infrared : hot dust, stars

Radio : hot gas, plasma

← **300 pc** →

Credit: NRAO, A. Ginsburg

Why is Galactic center gas not forming stars like the disk?



95% of gas
<30% of dense gas
95% of star formation

5% of gas
>70% of dense gas
5% of star formation

We investigate the distribution of gas densities with the GBT

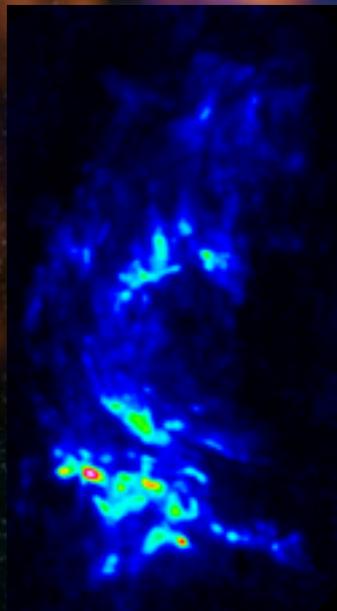
Green Bank Telescope



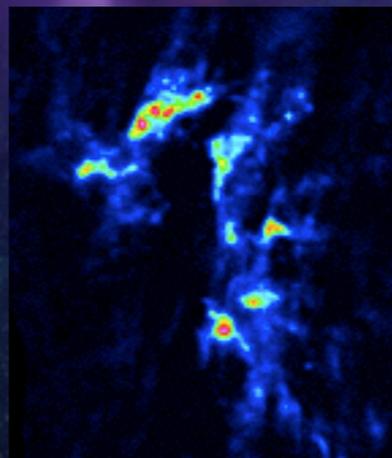
**Galactic center:
8.4 kpc away**

← 300 pc →

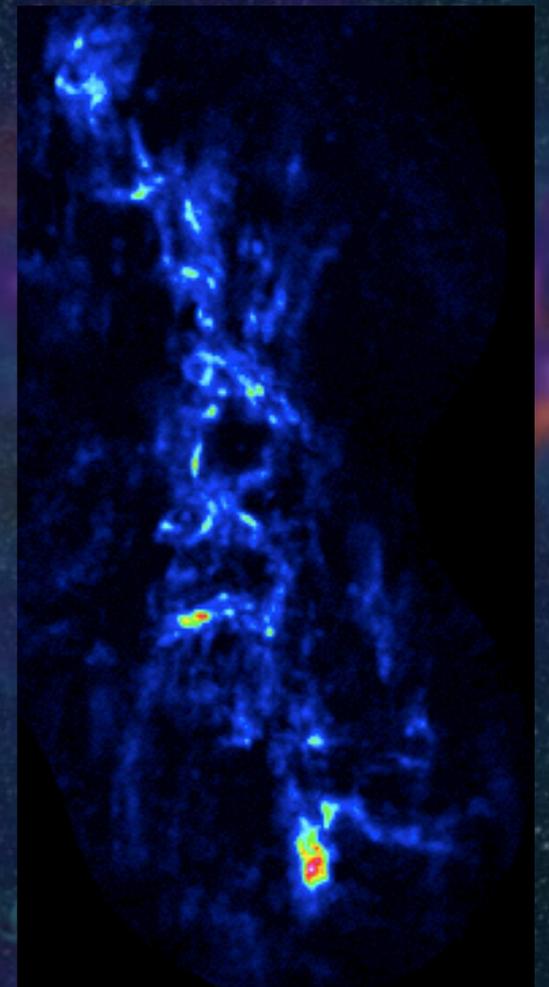
Focus on 3 clouds



Brick
GCM0.25+0.01



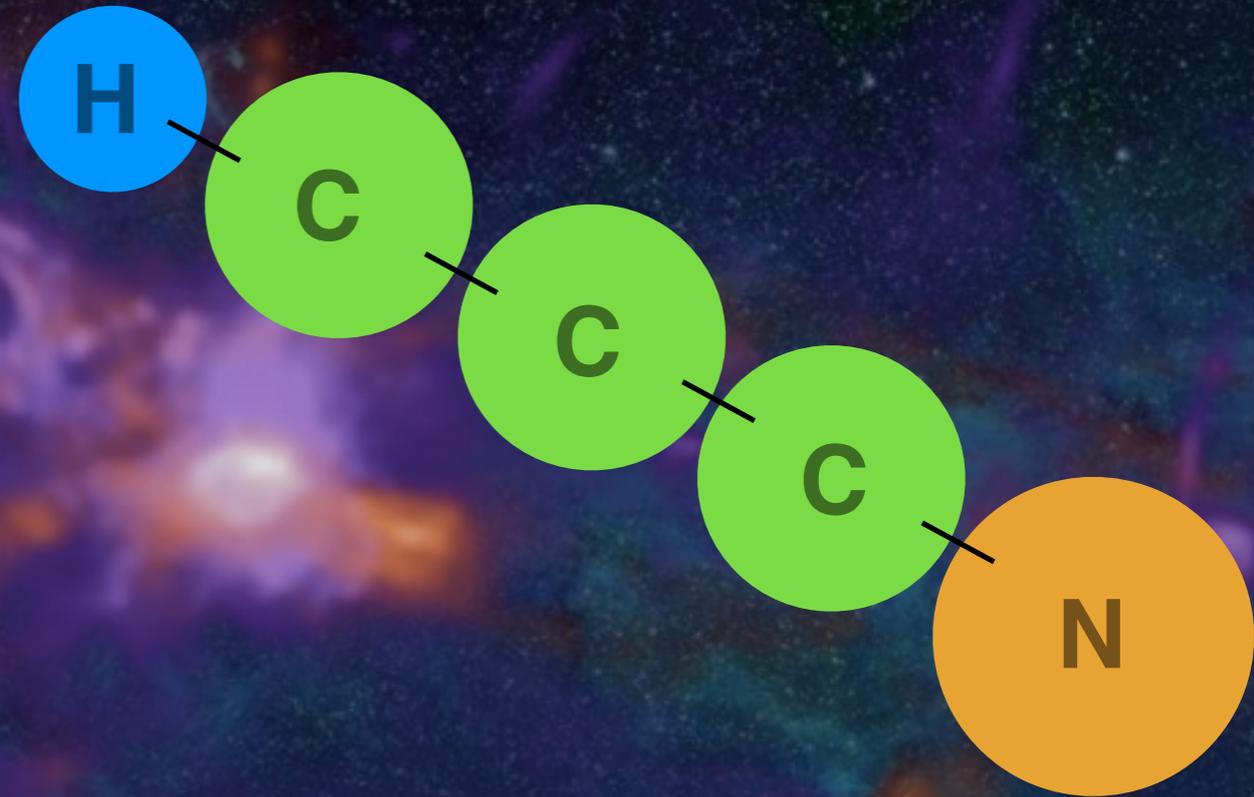
50 km/s cloud
GCM-0.02-0.07



20 km/s cloud
GCM-0.13-0.08

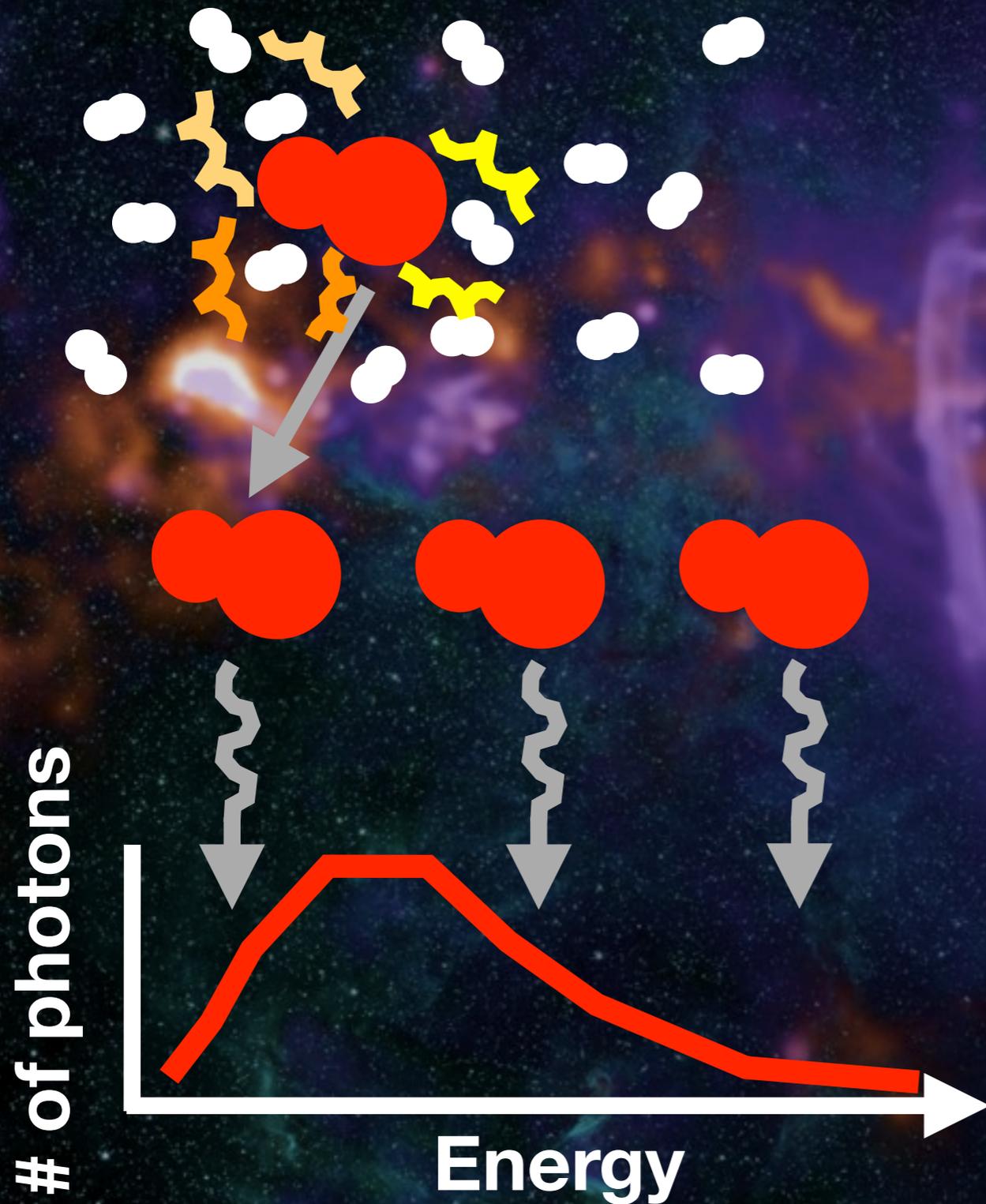
Observe 9 transitions of HC₃N with GBT, MOPRA, APEX

Transitions	n _{CRIT} (50K) (cm ⁻³)
3-2	3.4e4
4-3	7.6e4
5-4	1.5e5
10-9	1.2e6
18-17	1.9e6
19-18	2.2e6
21-20	2.8e6
24-23	4.3e6
30-29	9.1e6

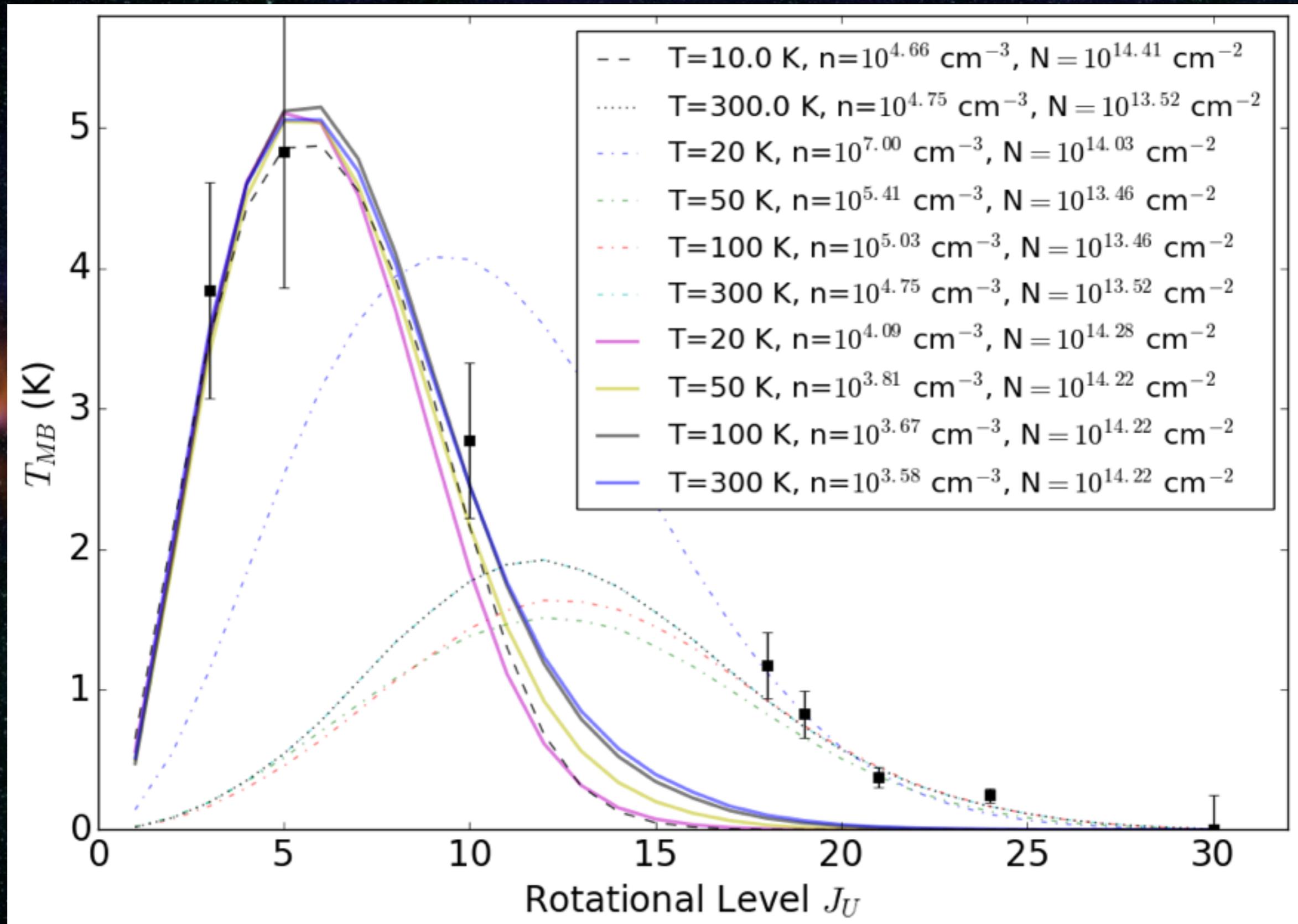


Abundant BUT optically thin
Linear rotor
Large # of transitions in radio, mm

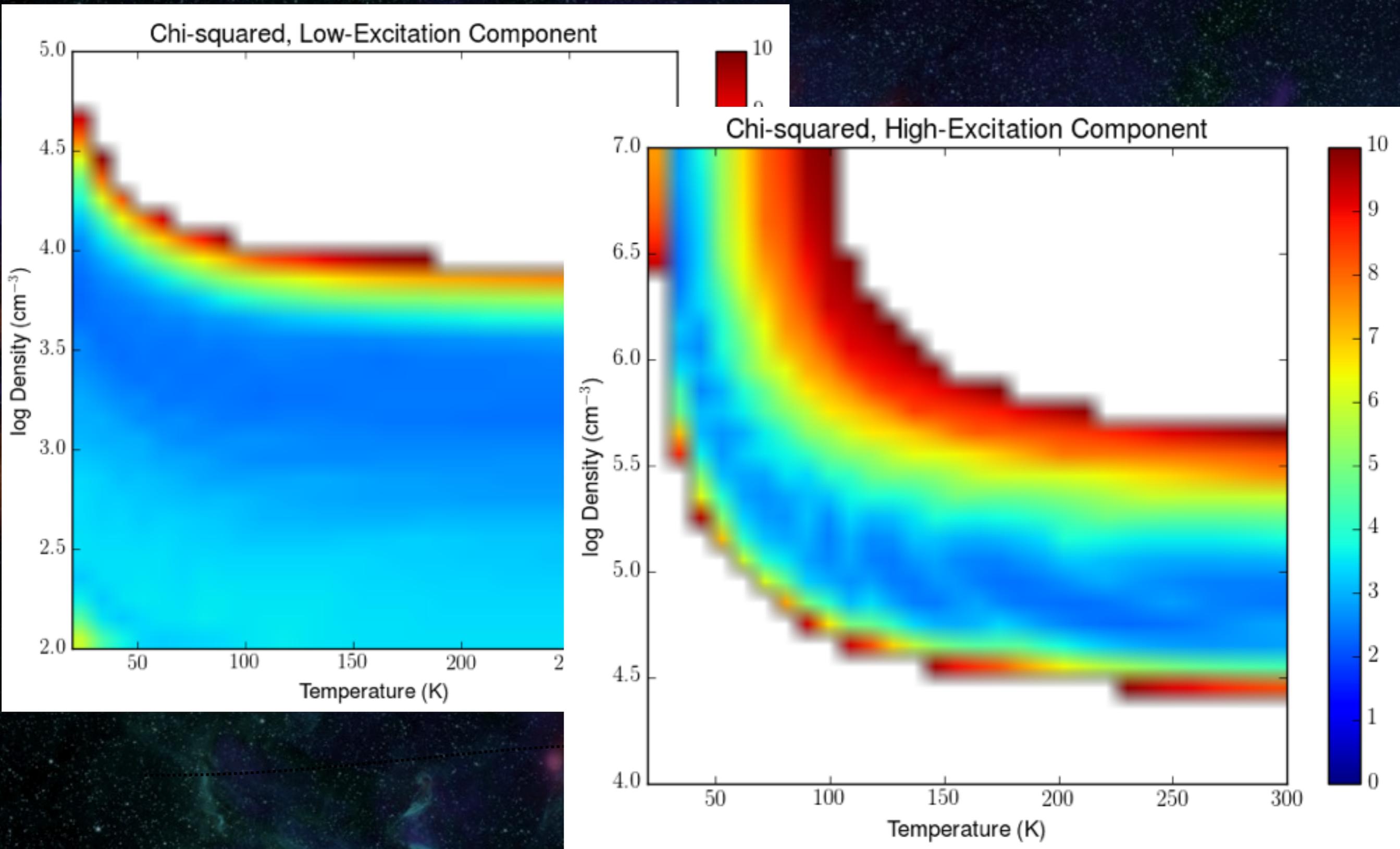
Use the HC3N molecule as a probe of the gas density



Rotation Diagrams (M-0.13-0.08)



Radex Fitting (M-0.13-0.08)

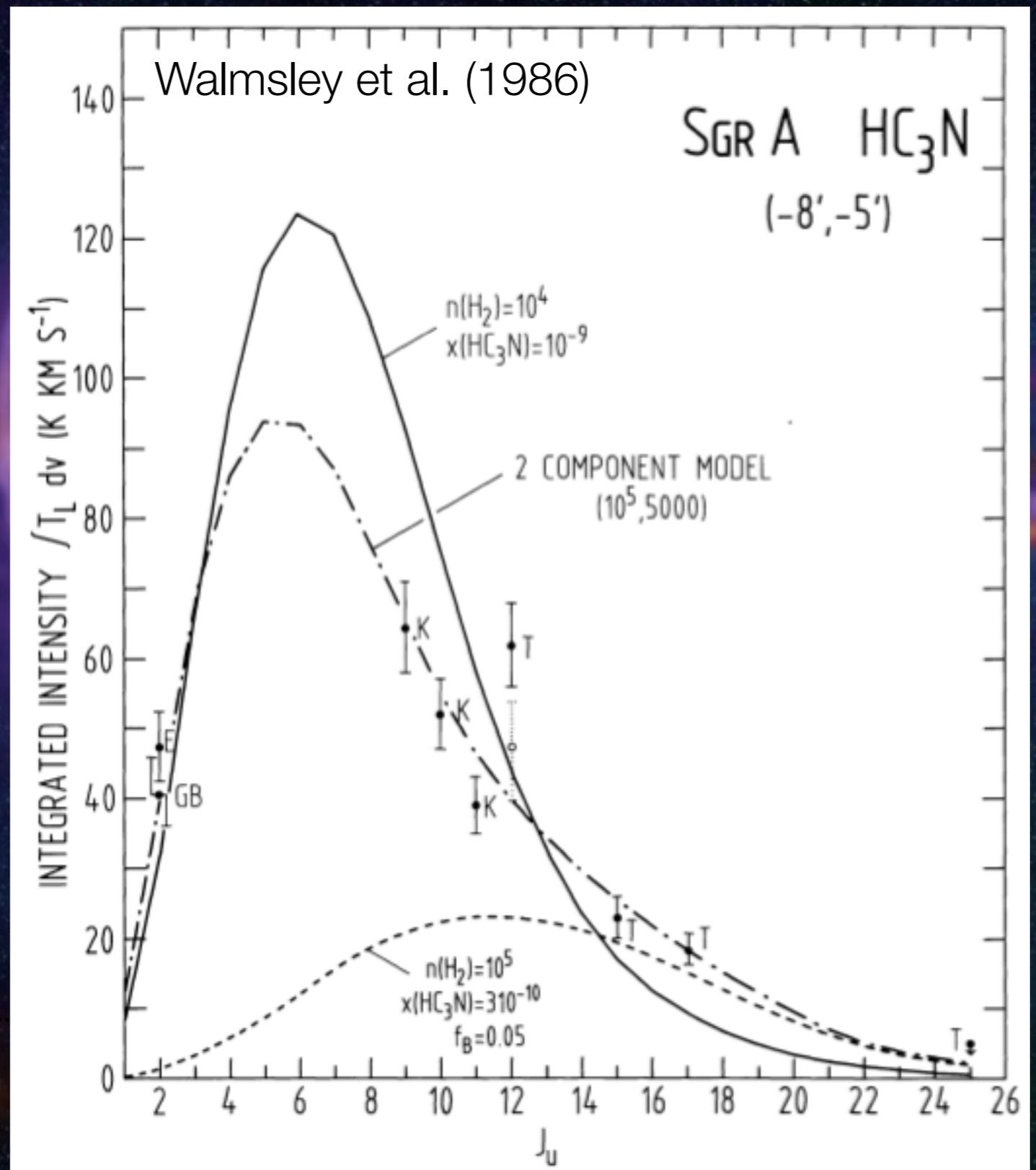


The low-density component: lower than commonly referenced value of 10^4

Best fit density: 3×10^3

Why is this important?

1. Want this value defined correctly for simulations, understanding of shear, and even for estimating our fraction of gas which is 'dense'

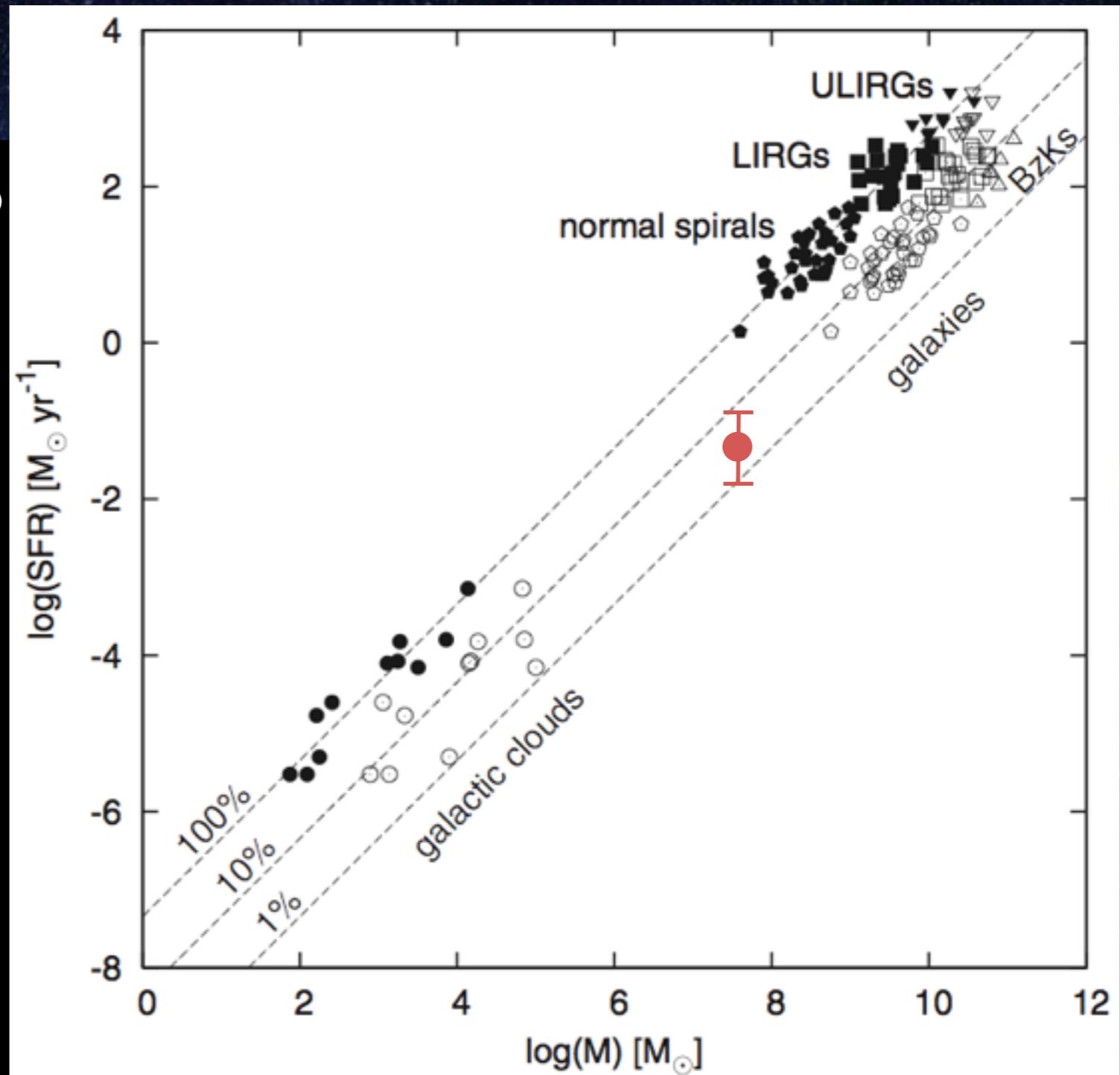


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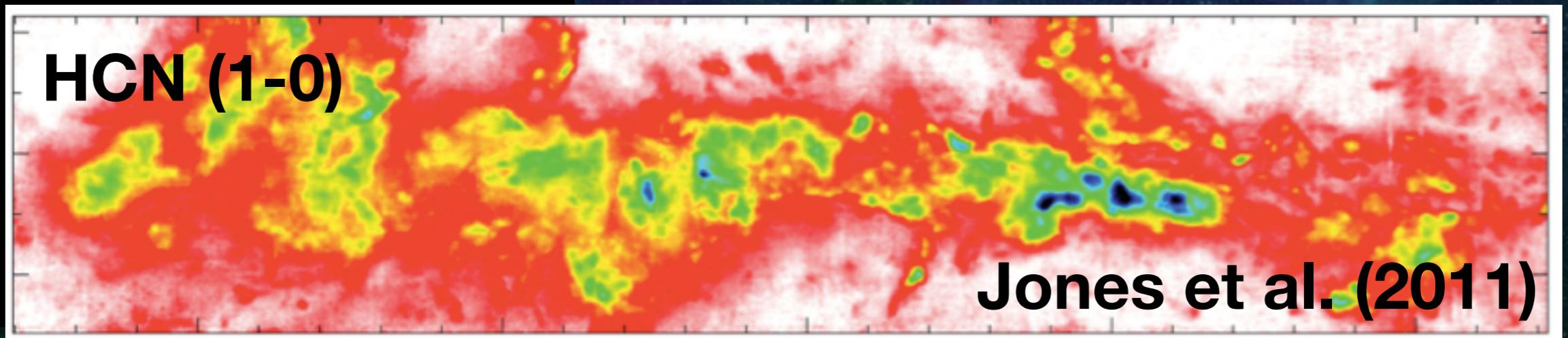
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Best fit density: 3×10^3

Why is this important?

2. Many tracers may be subthermally-excited!

Not everything that looks dense is.



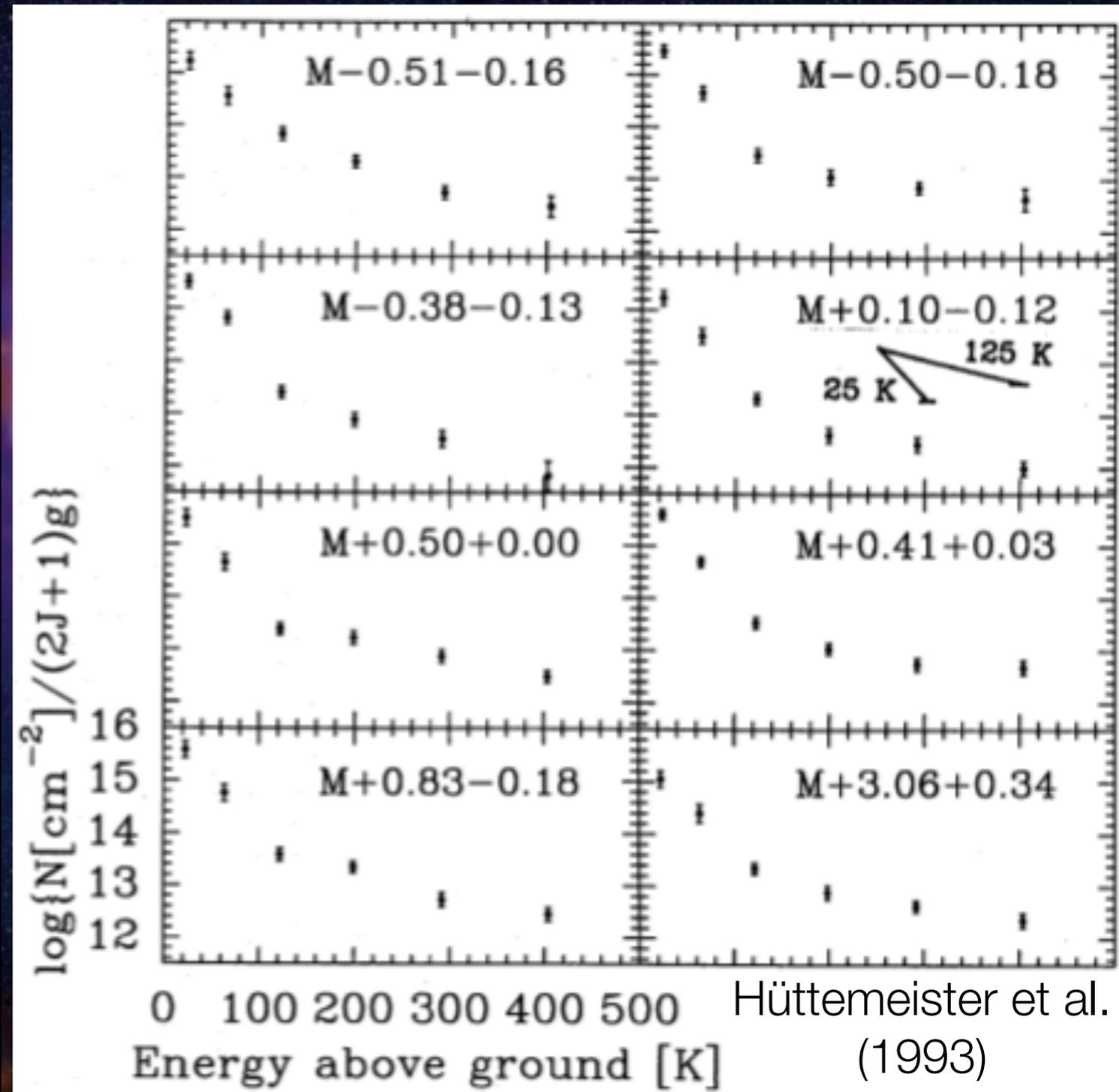
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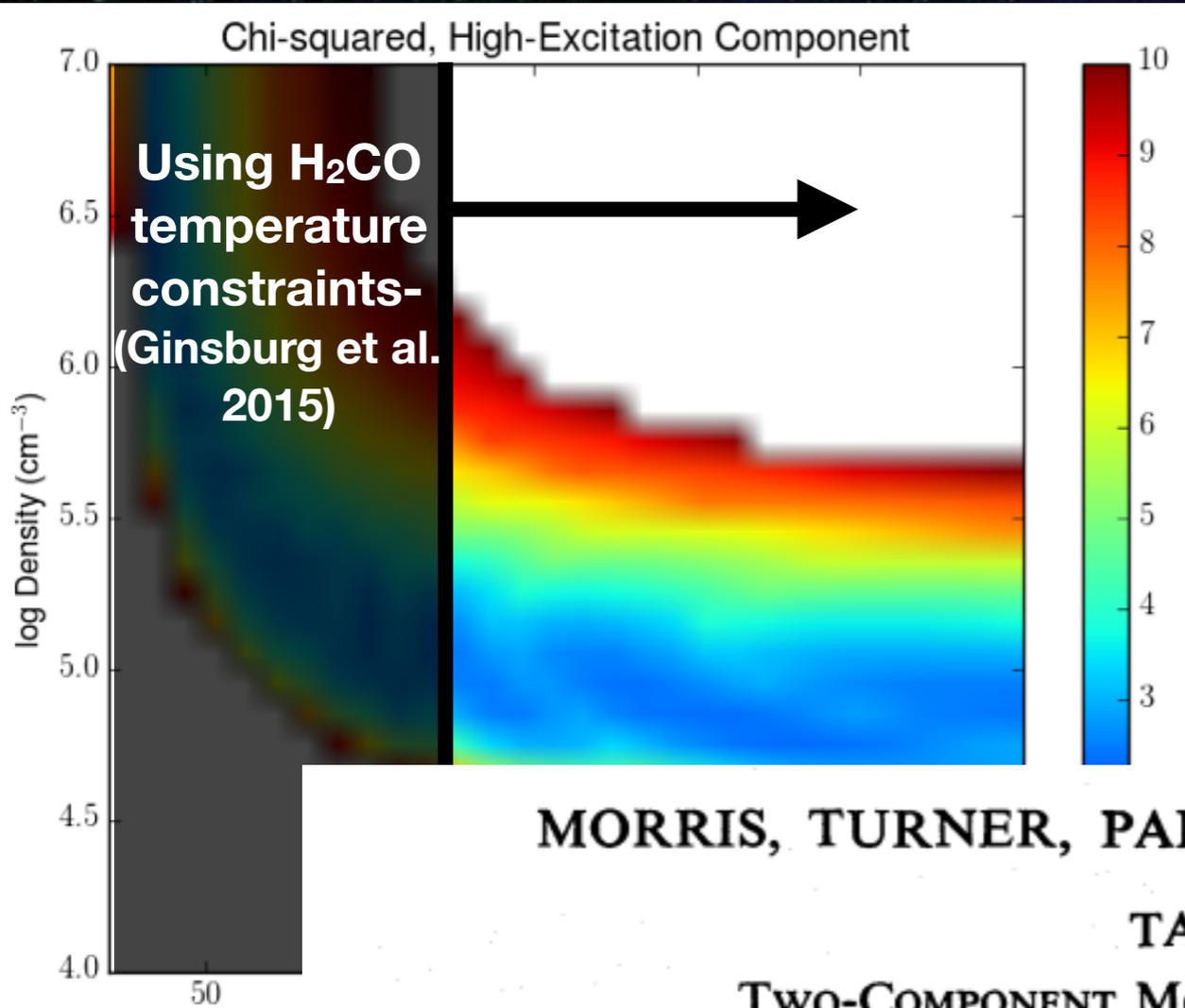
Why is this important?

2. Many tracers may be subthermally-excited!

Not everything that looks cold is.



The high-density component



Two Scenarios:

1. The high-excitation component is cold (and very dense)

2. The high-excitation component is warm (and dense)

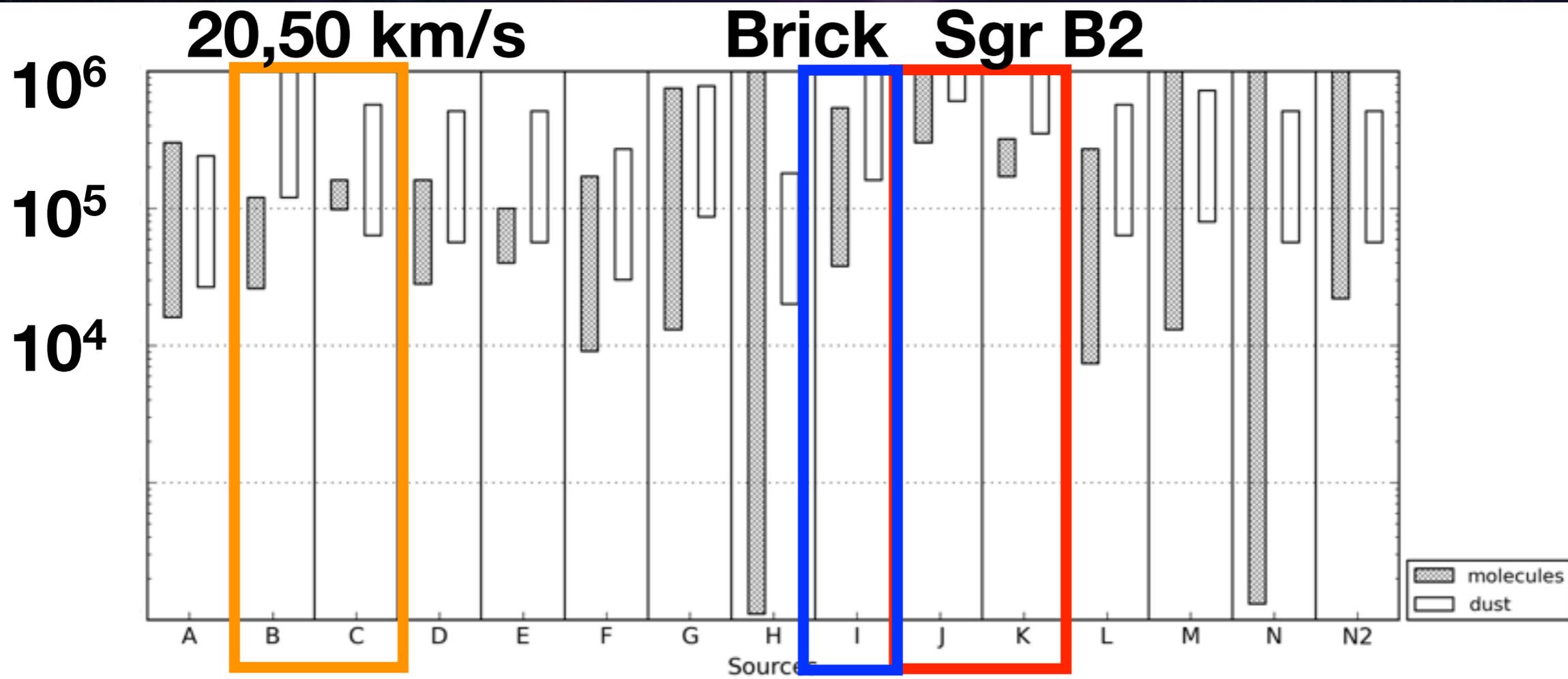
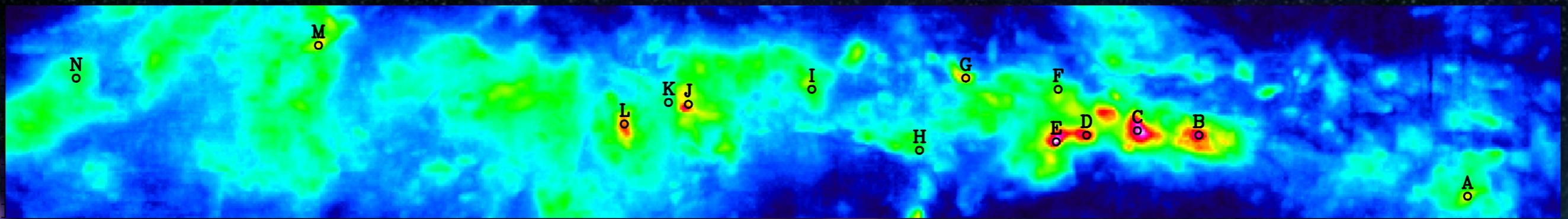
MORRIS, TURNER, PALMER, AND ZUCKERMAN 1976

TABLE 3

TWO-COMPONENT MODEL FOR SAGITTARIUS B2

Parameter	Core	Halo
$\log [n_T(\text{cm}^{-3})]$	6.0 ± 0.5	4.0 ± 0.7
T_k (K)	25–50	20–80
$N(\text{HC}_3\text{N}) \text{ cm}^{-2}$	$(2.0 \pm 0.4) \times 10^{14}$	$(1.8 \pm 0.8) \times 10^{14}$
D (pc)	7	15
$\log [N(\text{HC}_3\text{N})/N(\text{H}_2)]$	-11.0 ± 0.7	-9.4 ± 0.7
Mass (M_\odot).....	$\sim 10^7$	$\sim 10^6$

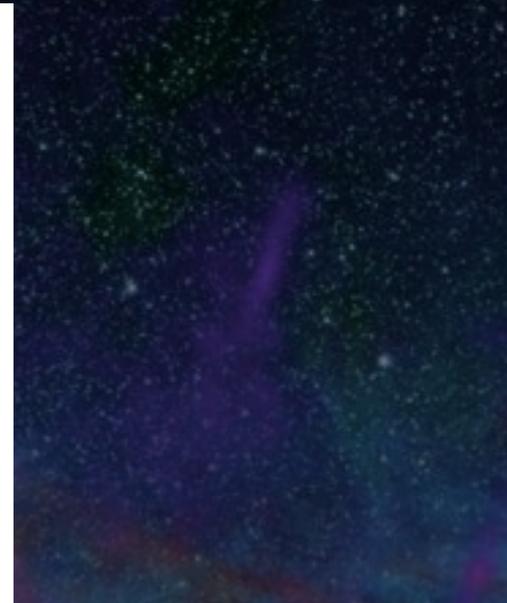
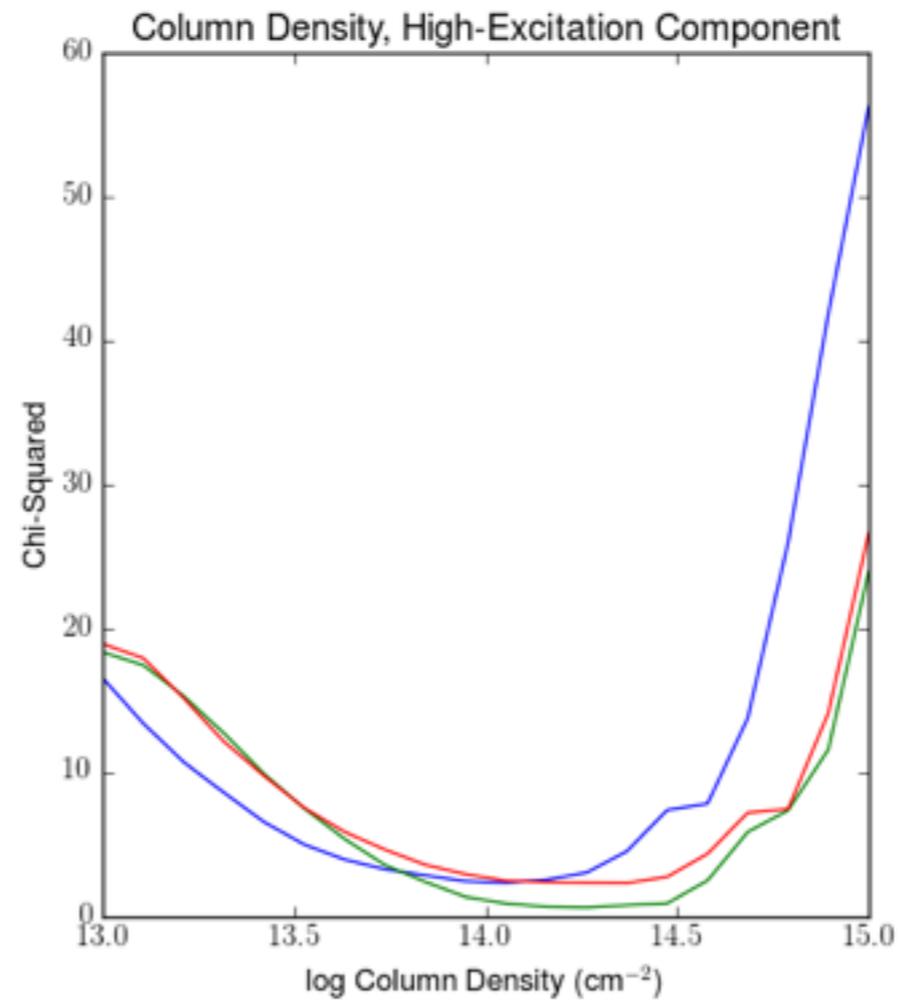
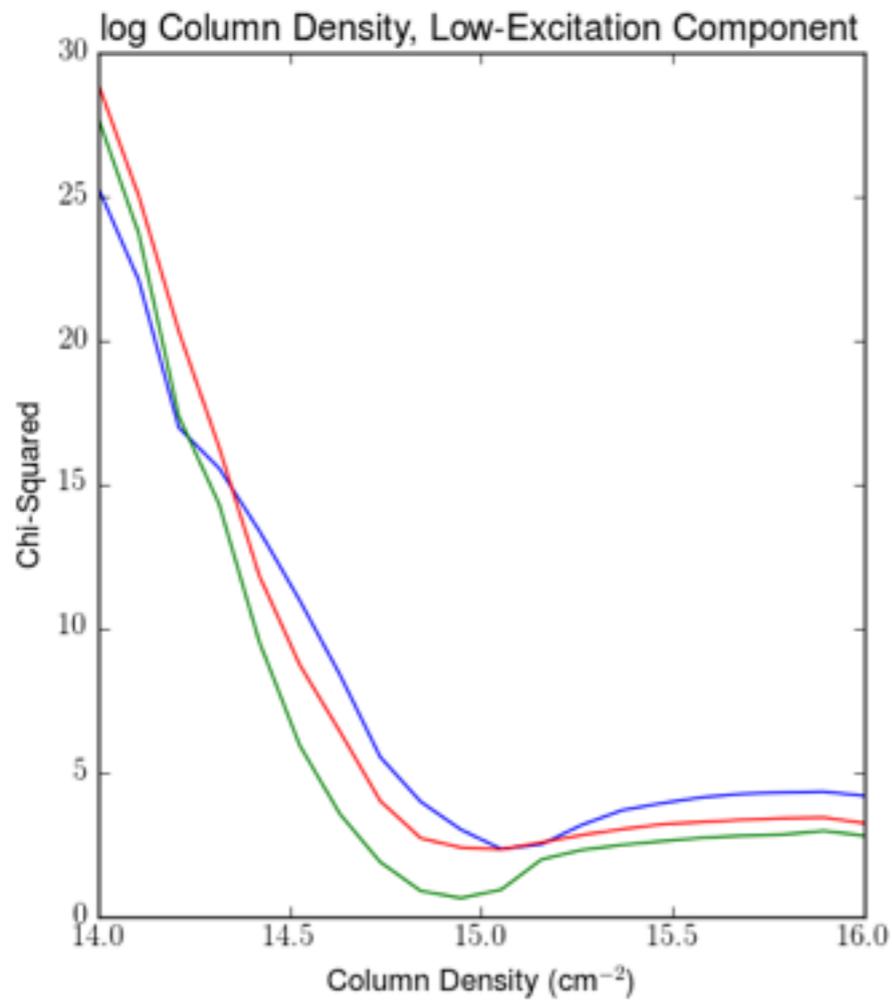
Density measurements with other tracers



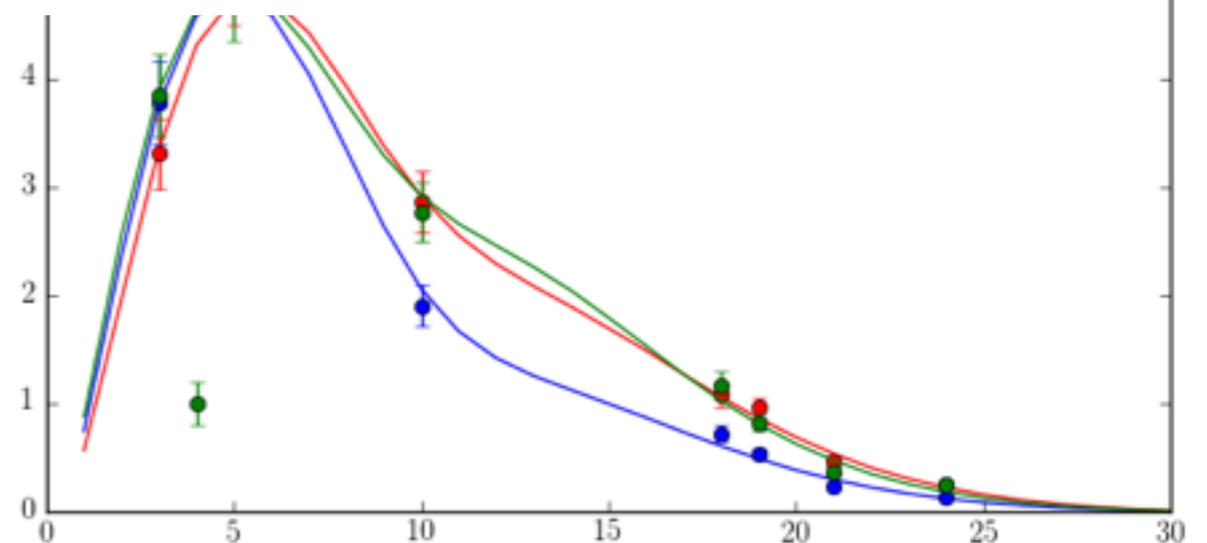
8 lines in H₂CO, 6 in C₃H₂, 5 in HC₃N, 3 in H¹³CO+, and 3 lines in HN¹³C

A. Ahmadi
(Masters thesis)

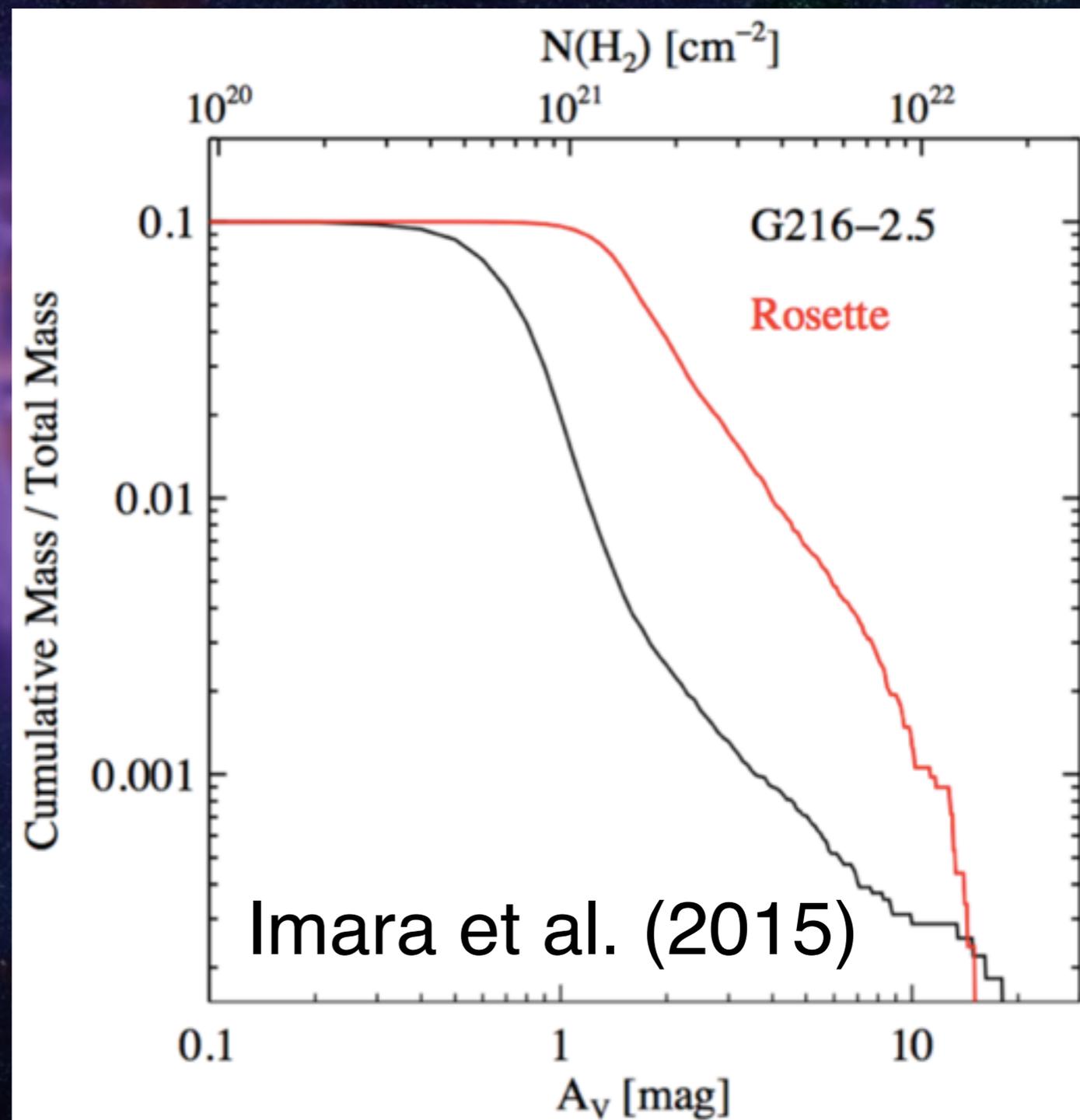
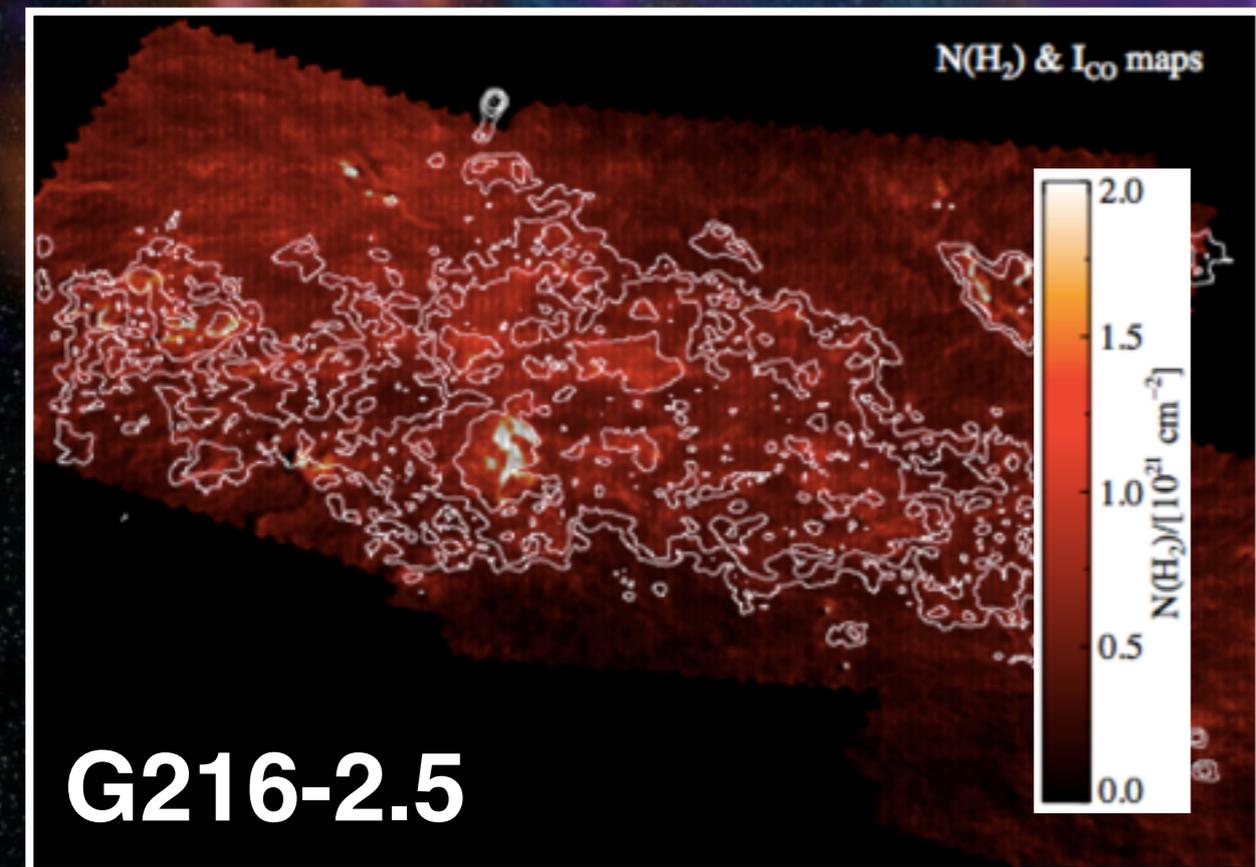
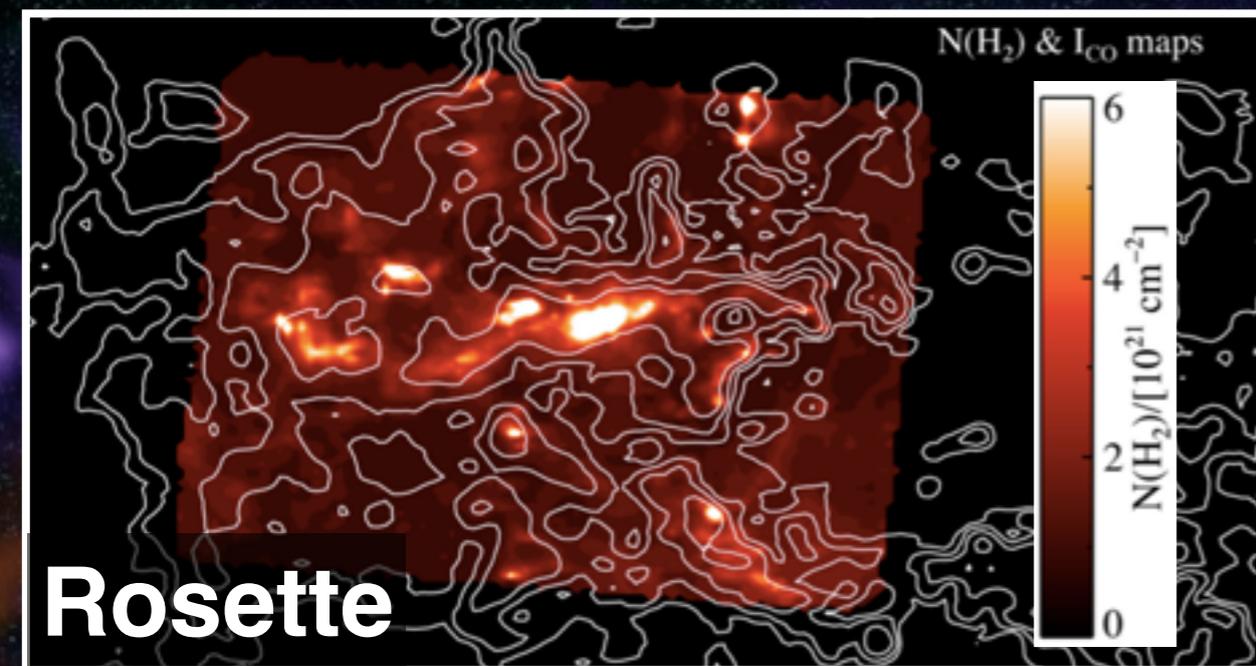
The fraction of dense gas



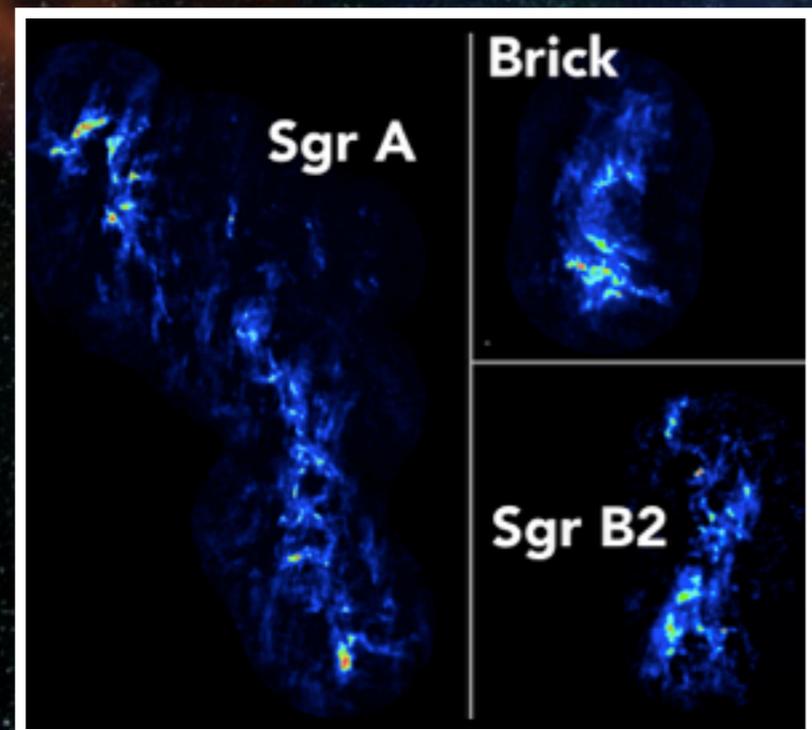
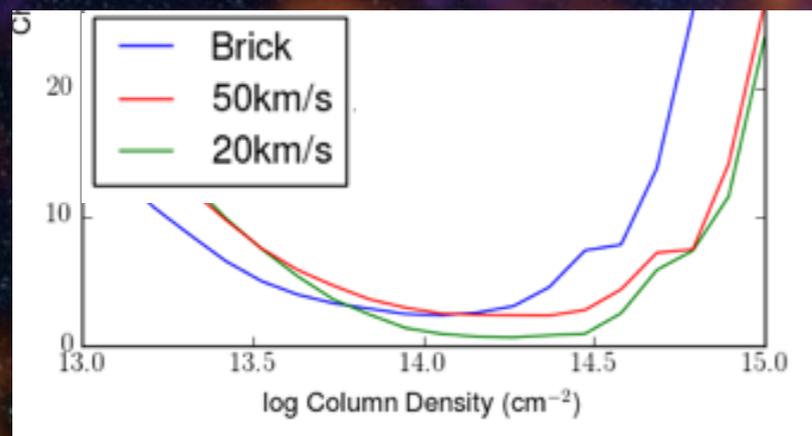
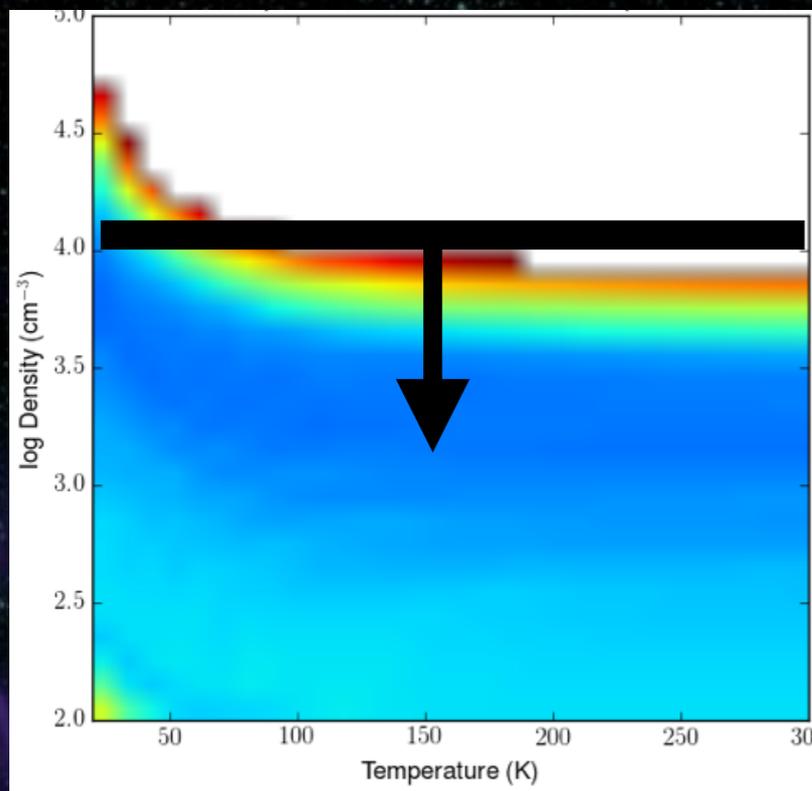
The fraction of dense gas in the Brick is 10%, compared to 20% for the 50 and 20 km/s clouds



Fraction of high-density gas seen to correlate with current star formation



Results



Need to start thinking about the bulk of the gas in CMZ clouds as less than 10^4 cm^{-3}

See less high-density gas in the Brick (which has no advanced massive star formation) compared to the 20, 50 km/s clouds.

Either less high density gas and/or lower-density gas in all of these clouds compared to Sgr B2.