

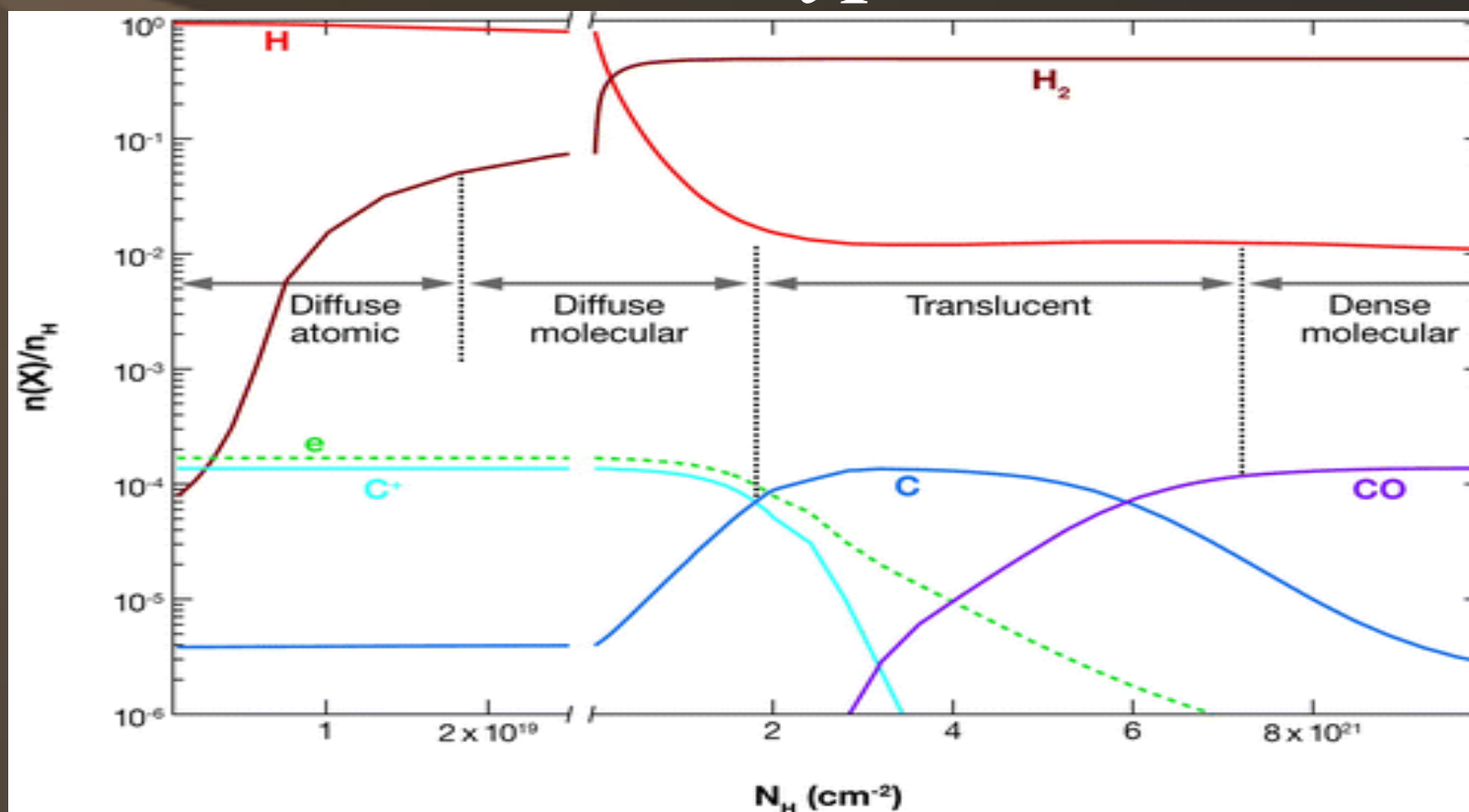
***THE CO TRANSITION  
FROM DIFFUSE MOLECULAR GAS  
TO DENSE CLOUDS:  
PRELIMINARY RESULTS***

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# *Overview*

- Background
  - Transitions Between Chemistries
- Getting The Velocity Structure
  - McDonald and VLT (Very Large Telescope) Observations
- H<sub>2</sub> and CO Column Densities and Temperatures
  - FUSE(Far Ultraviolet Spectroscopic Explorer)Observations
  - HST (Hubble Space Telescope) Observations
- Probing and Characterizing Dark CO Gas
  - CO Emission and Extinction Maps
  - CO Excitation Temperature and Density
- Current Work

# Cloud Types

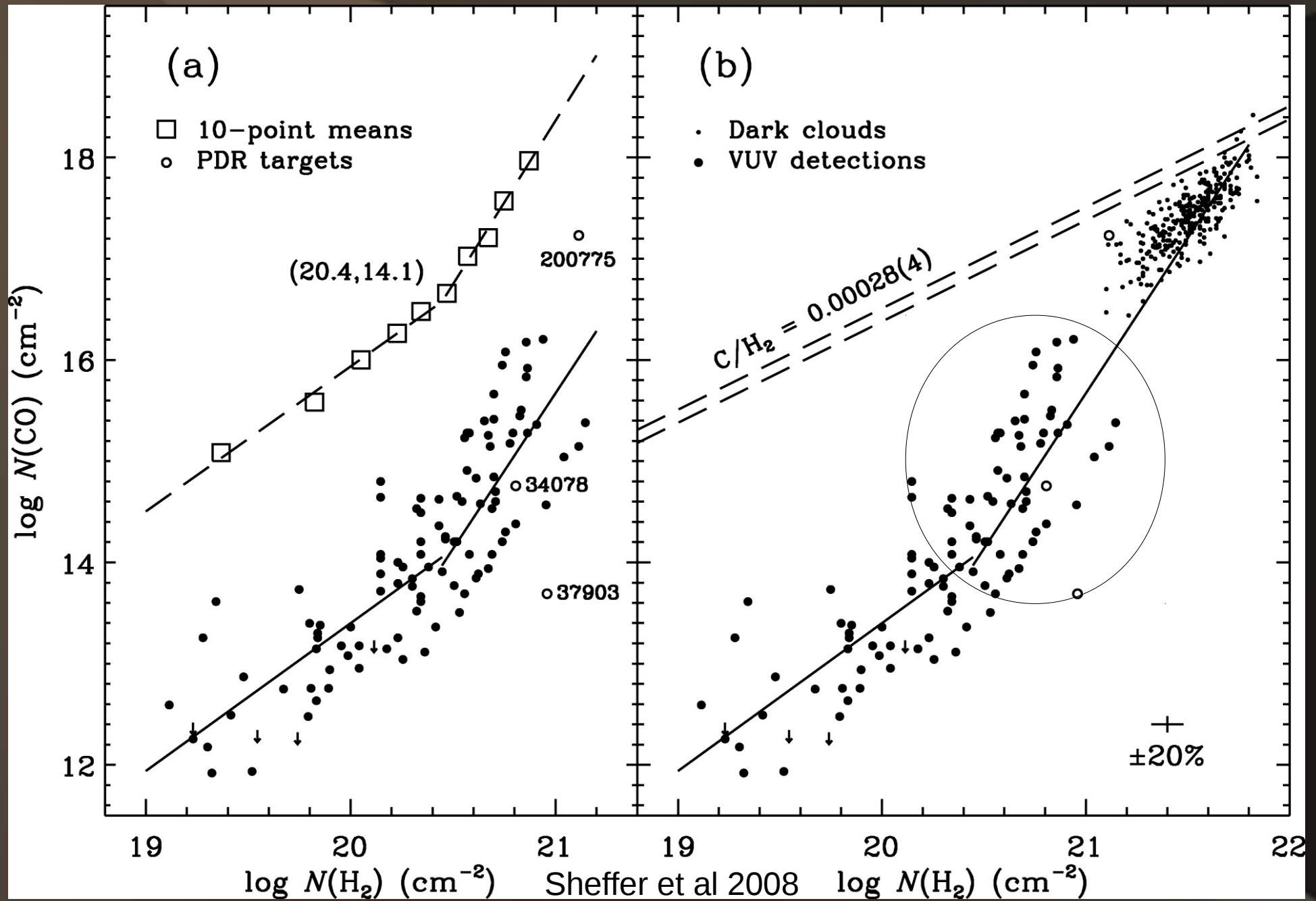


Snow TP, McCall BJ. 2006.

Annu. Rev. Astron. Astrophys. 44:367–414

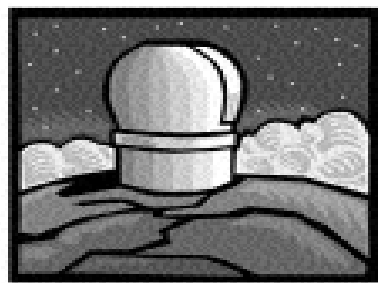
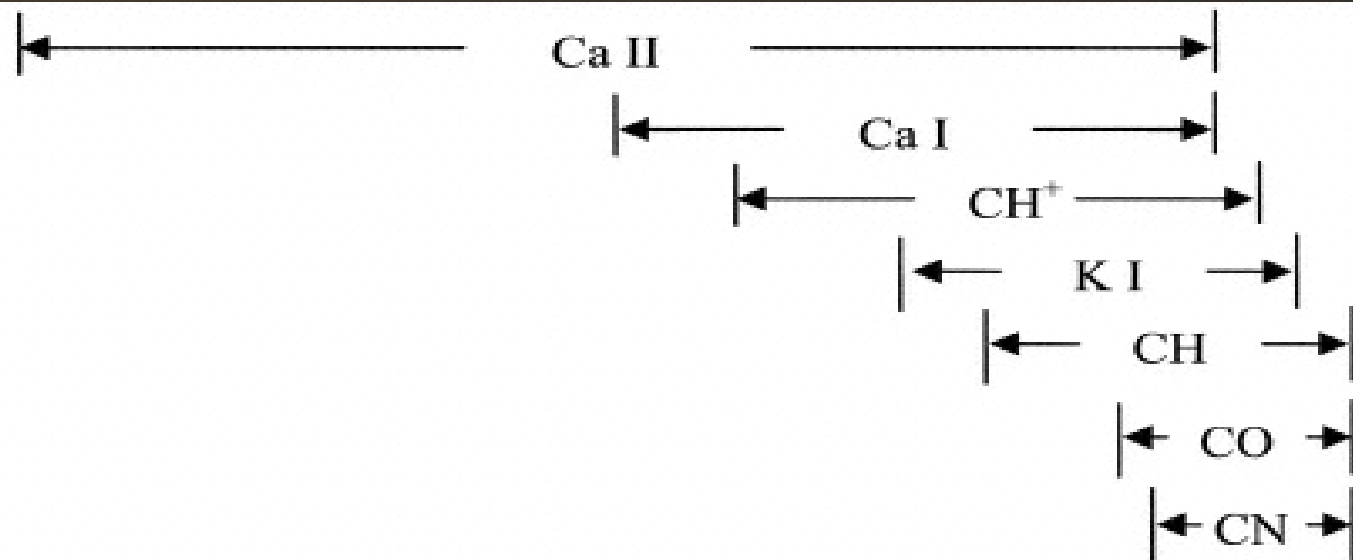
	Diffuse Atomic	Diffuse Molecular	Translucent	Dense Molecular
Defining Characteristic	$f^n_{\text{H}_2} < 0.1$	$f^n_{\text{H}_2} > 0.1$ $f^n_{\text{C}^+} > 0.5$	$f^n_{\text{C}^+} < 0.5$ $f^n_{\text{CO}} < 0.9$	$f^n_{\text{CO}} > 0.9$
$A_V$ (min.)	0	$\sim 0.2$	$\sim 1-2$	$\sim 5-10$
Typ. $n_{\text{H}}$ ( $\text{cm}^{-3}$ )	10–100	100–500	500–5000?	$> 10^4$
Typ. T (K)	30–100	30–100	15–50?	10–50
Observational Techniques	UV/Vis H I 21-cm	UV/Vis IR abs mm abs	Vis (UV?) IR abs mm abs/em	IR abs mm em

# Where The Chemistry Changes



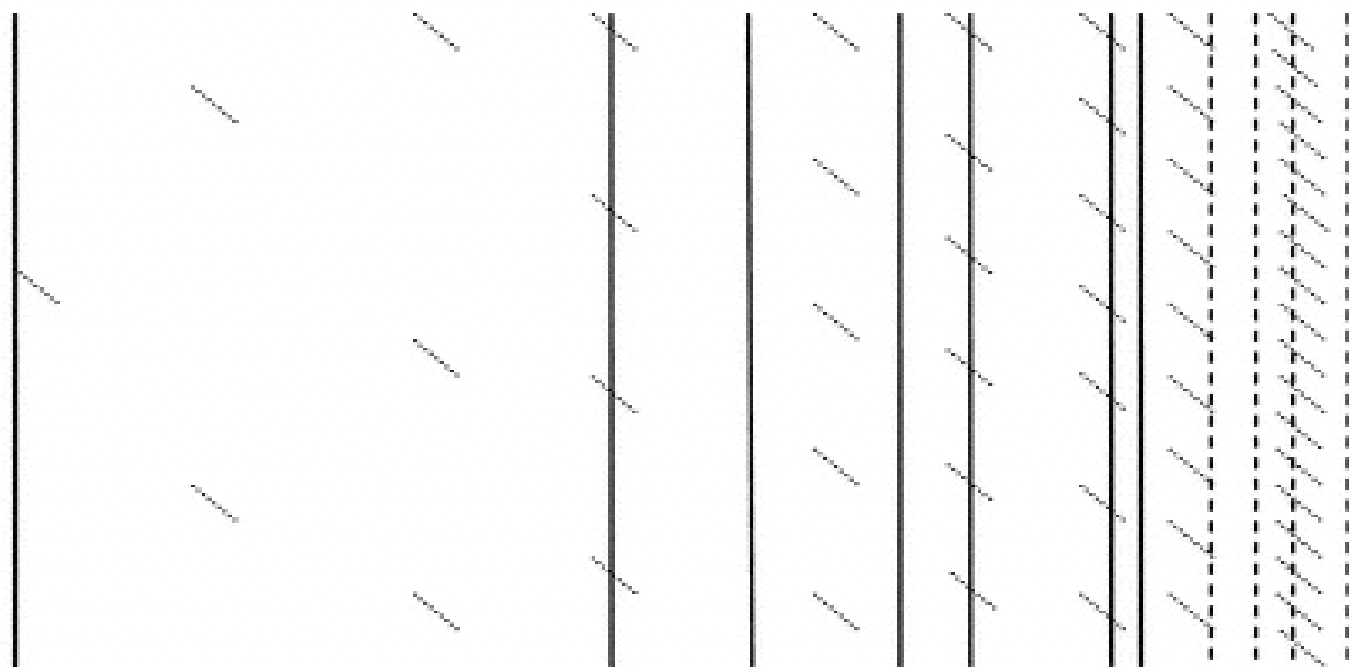


# Cloud Structure



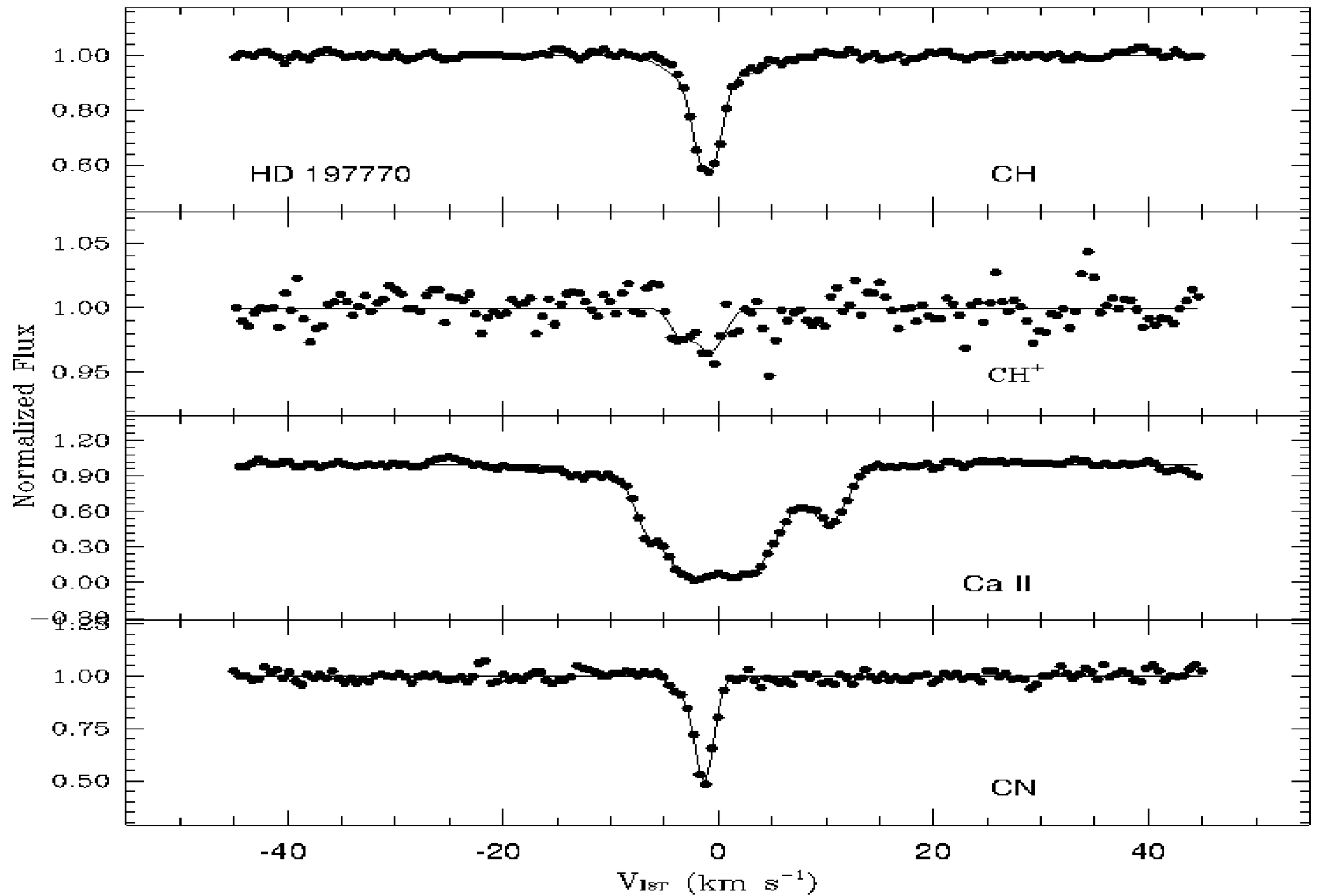
Pan et al. 2005

To observer

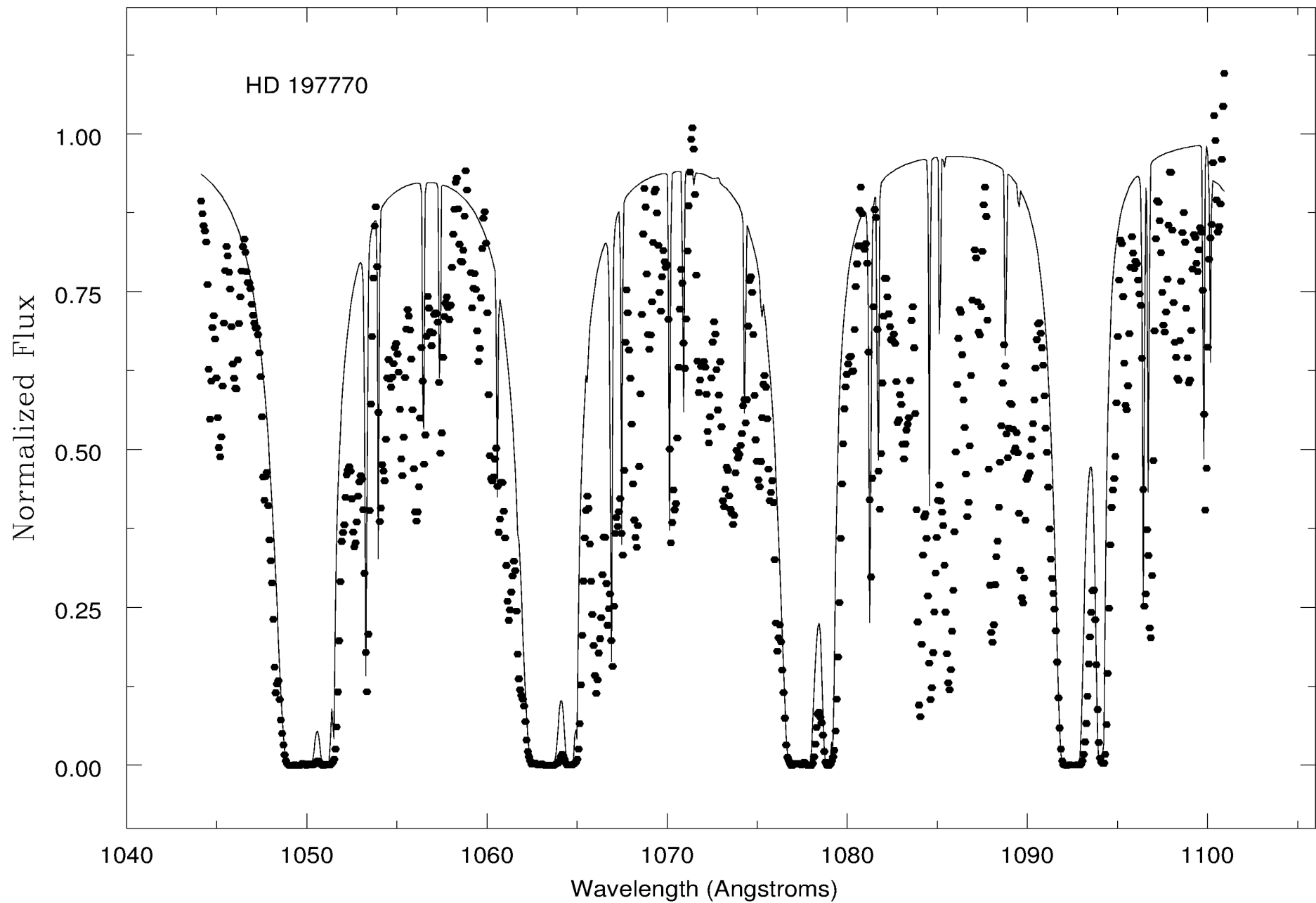


Density increases

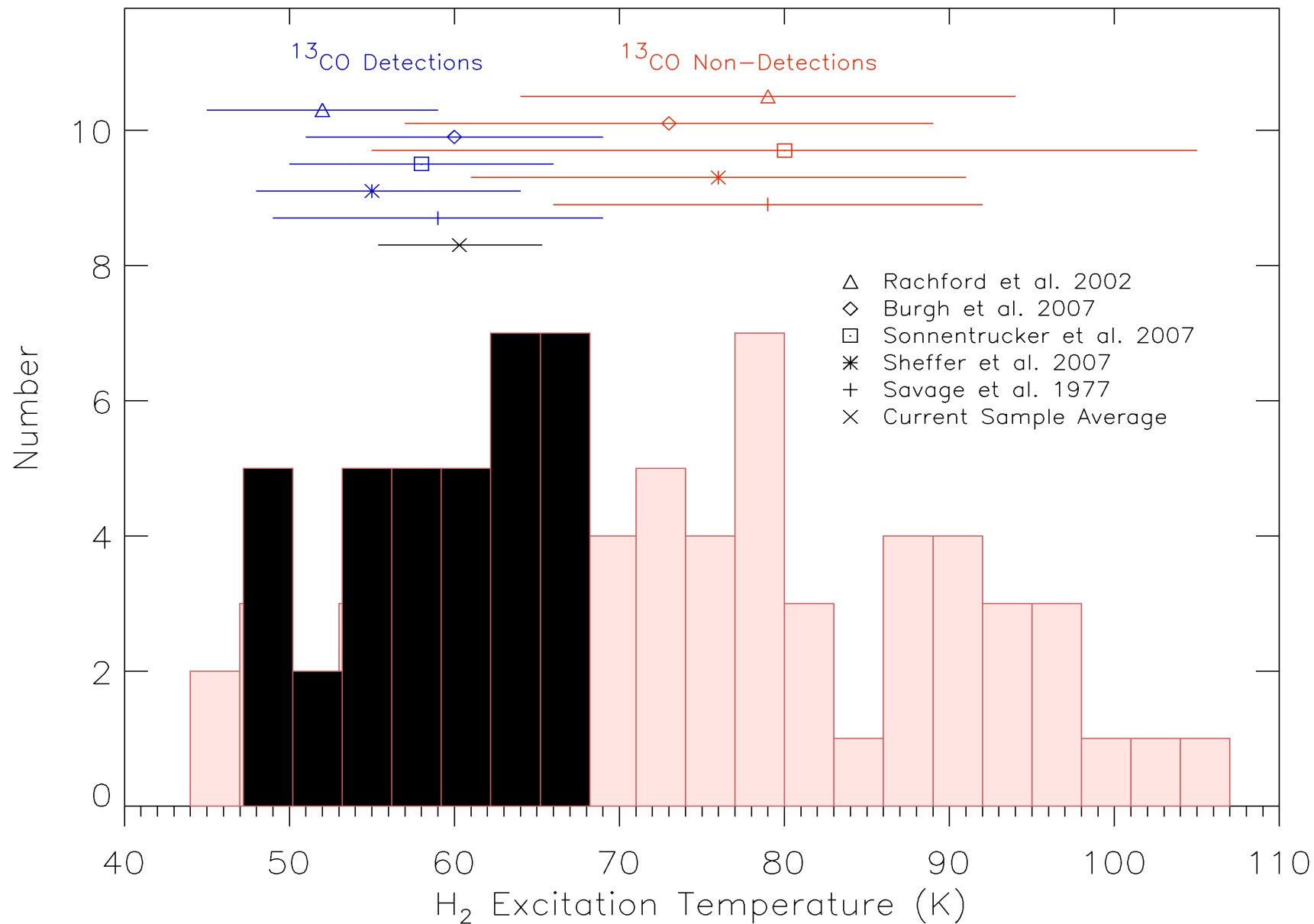
# *Ground Based Observations (Res~185000)*



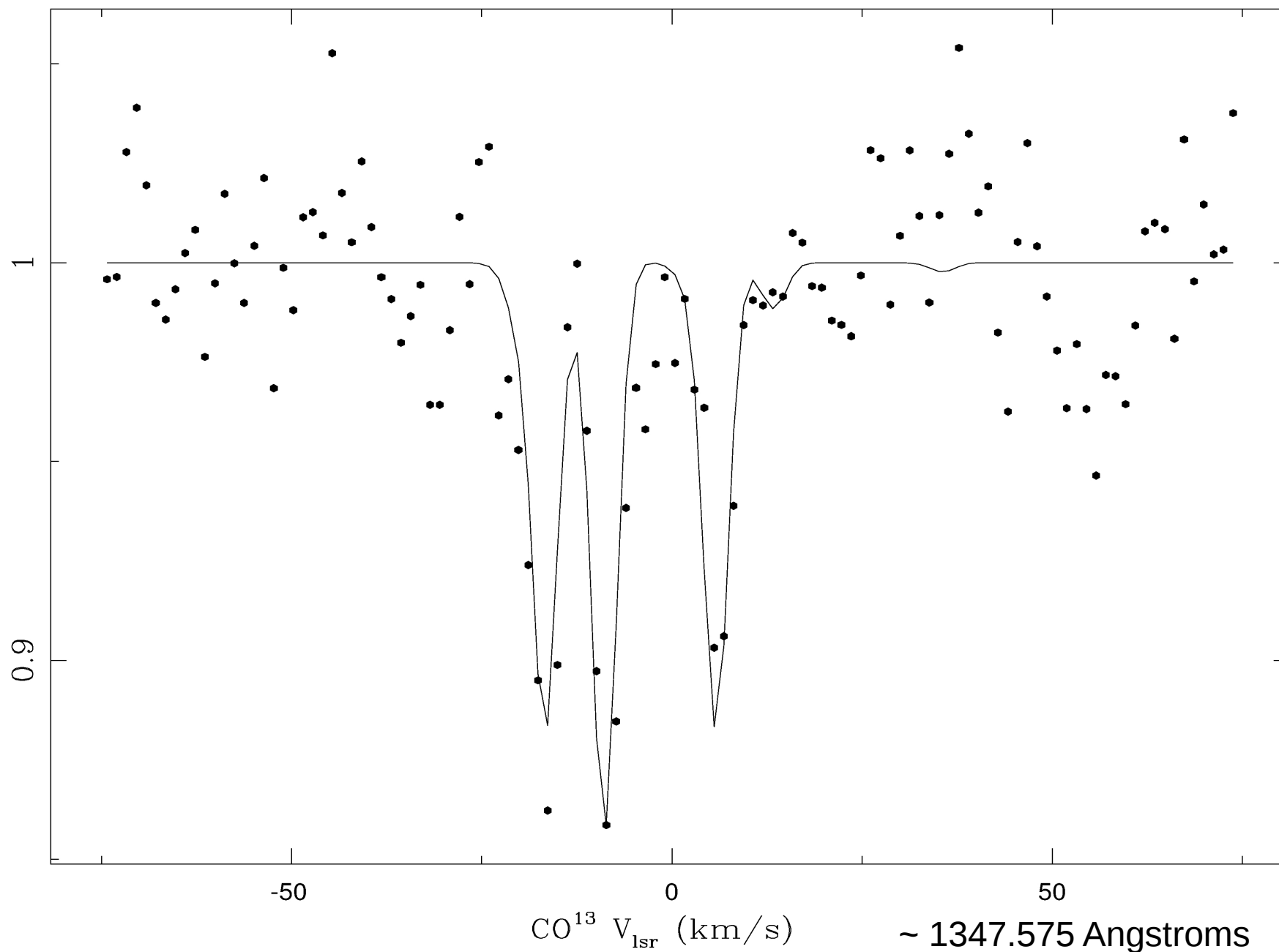
# *UV Observations (Res~17000)*



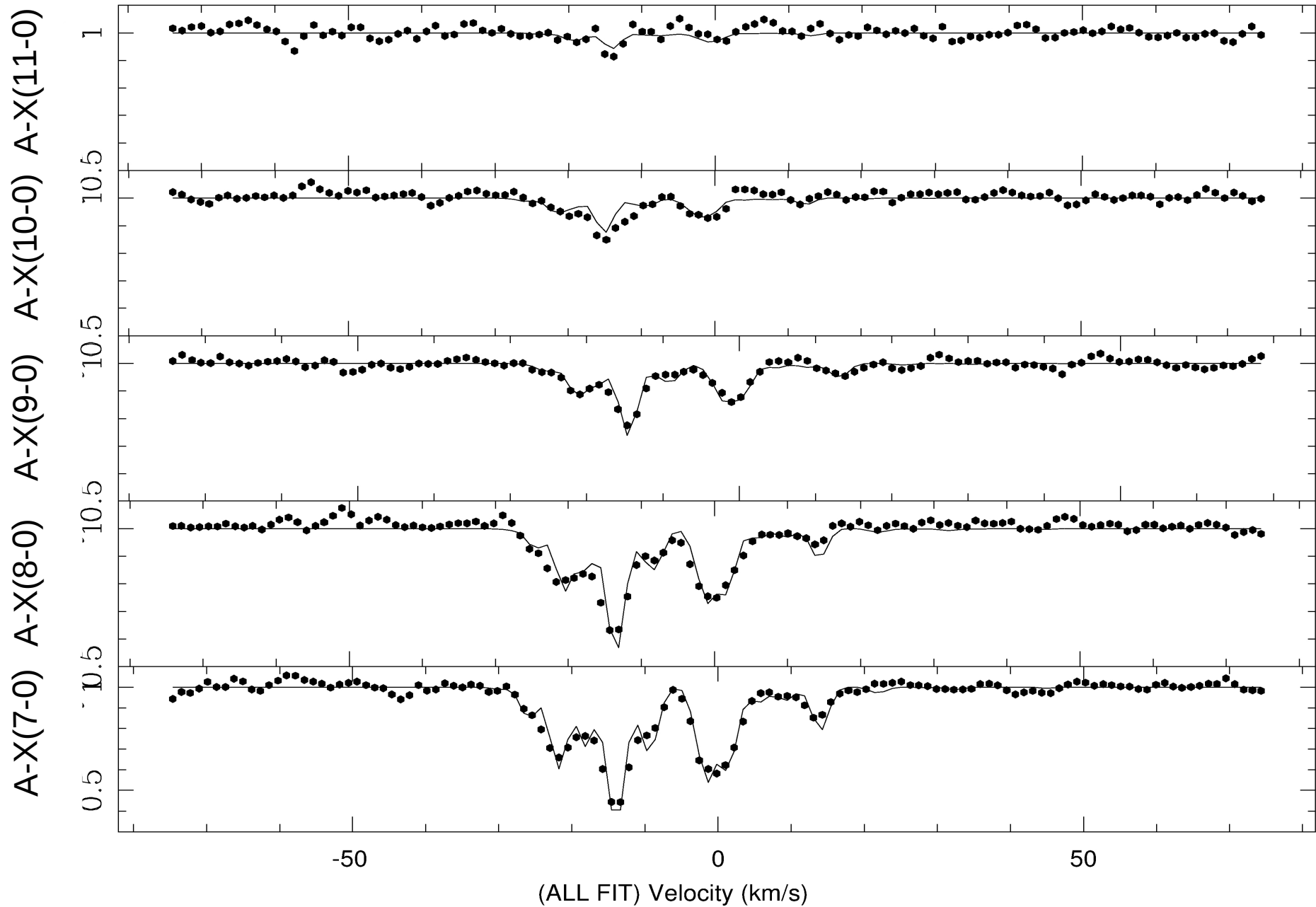
# $H_2$ Excitation and $^{13}CO$ Detections



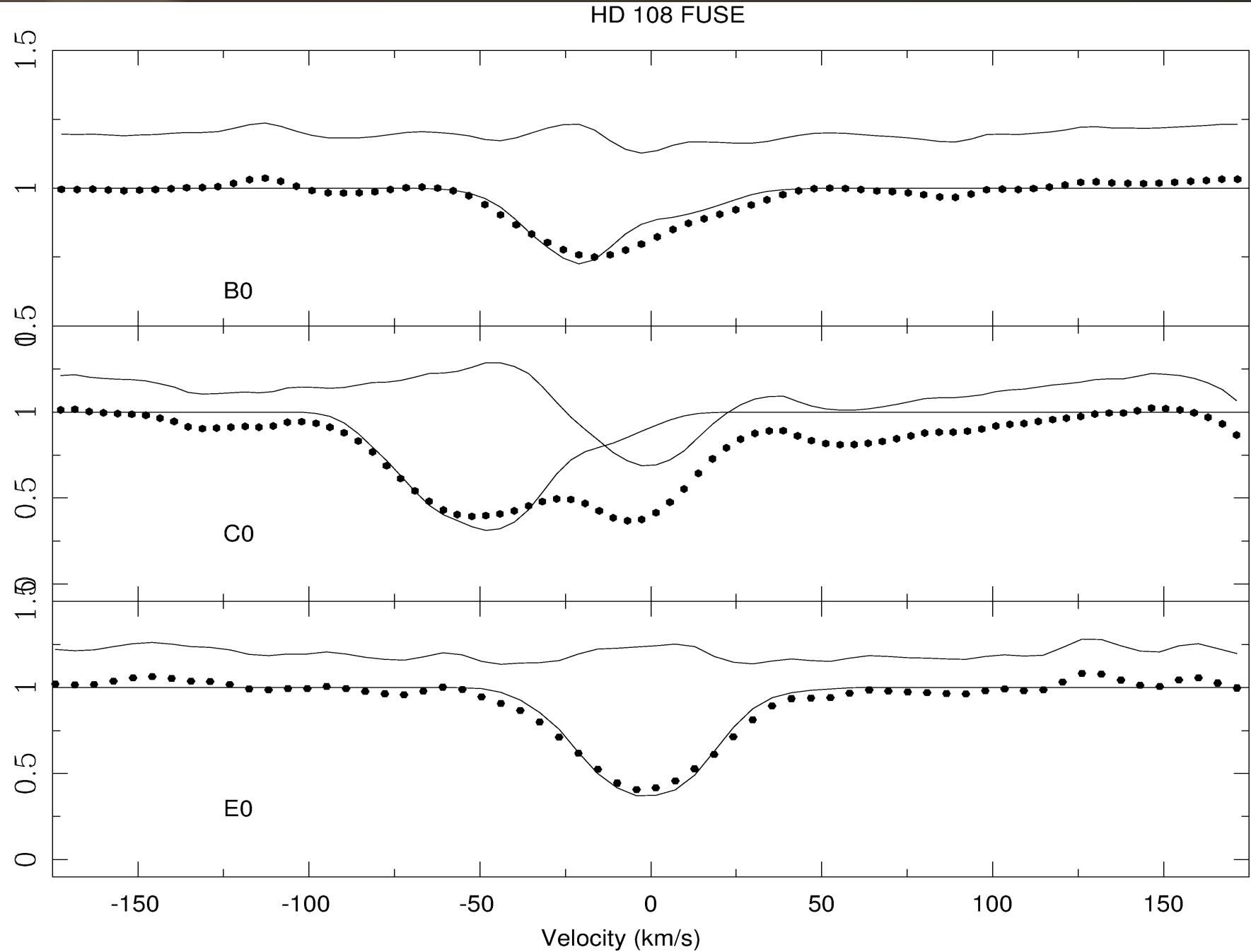
# *$^{13}\text{CO}$ Observations with HST*



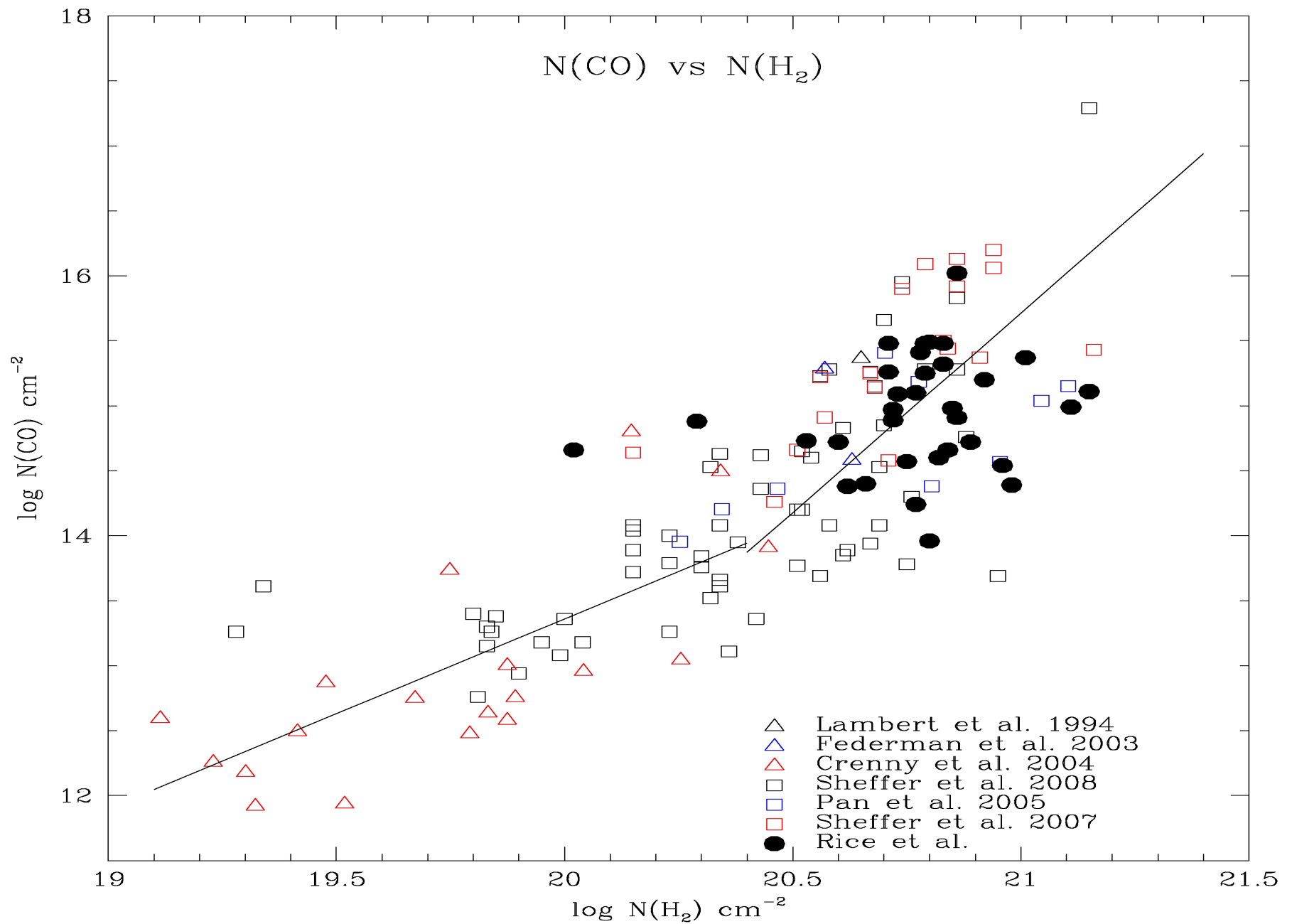
# *CO Observations with HST (Res~143000)*



# *CO Observations with FUSE (Res~17000)*

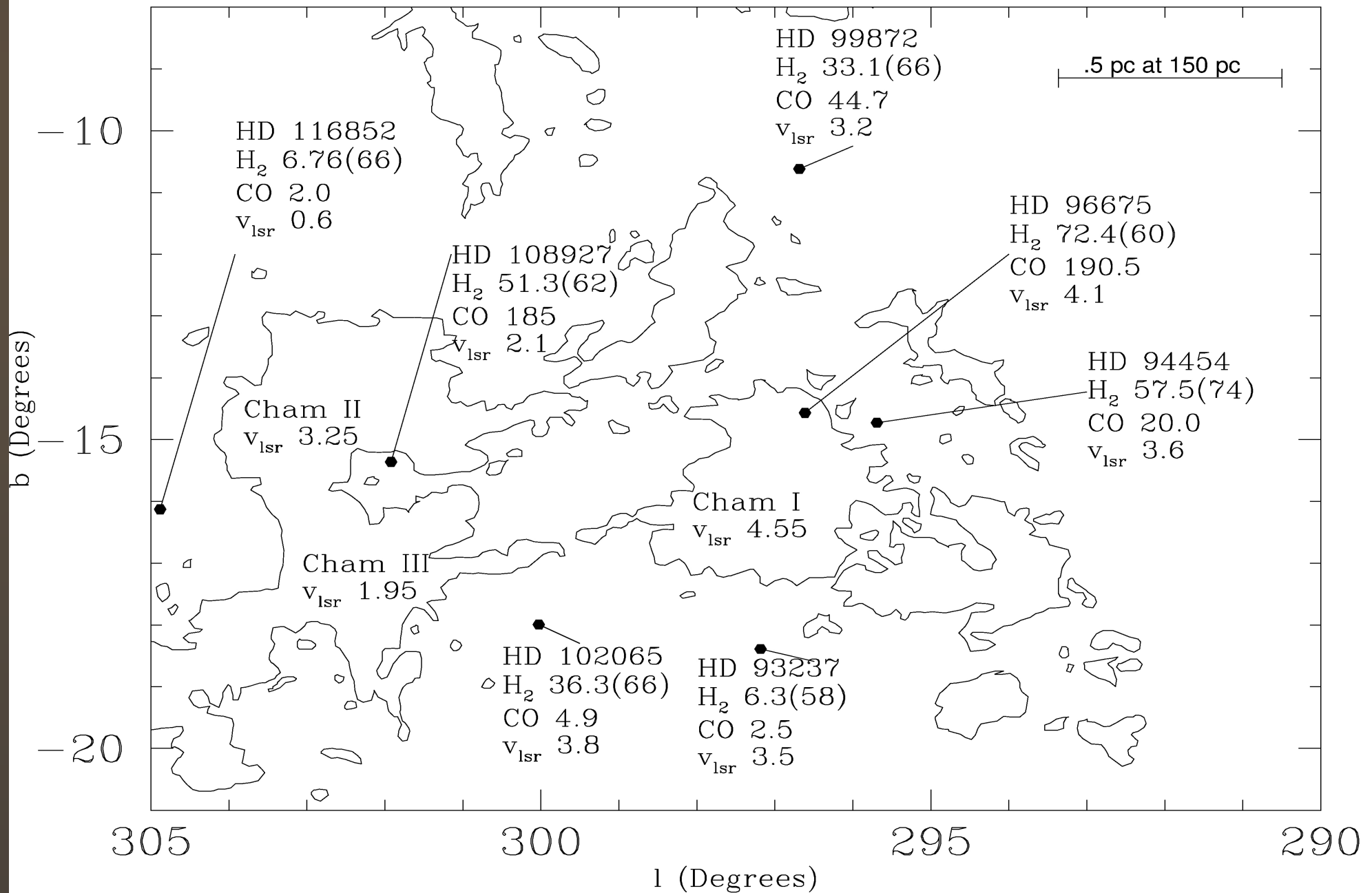


# 36 Additional Sightlines



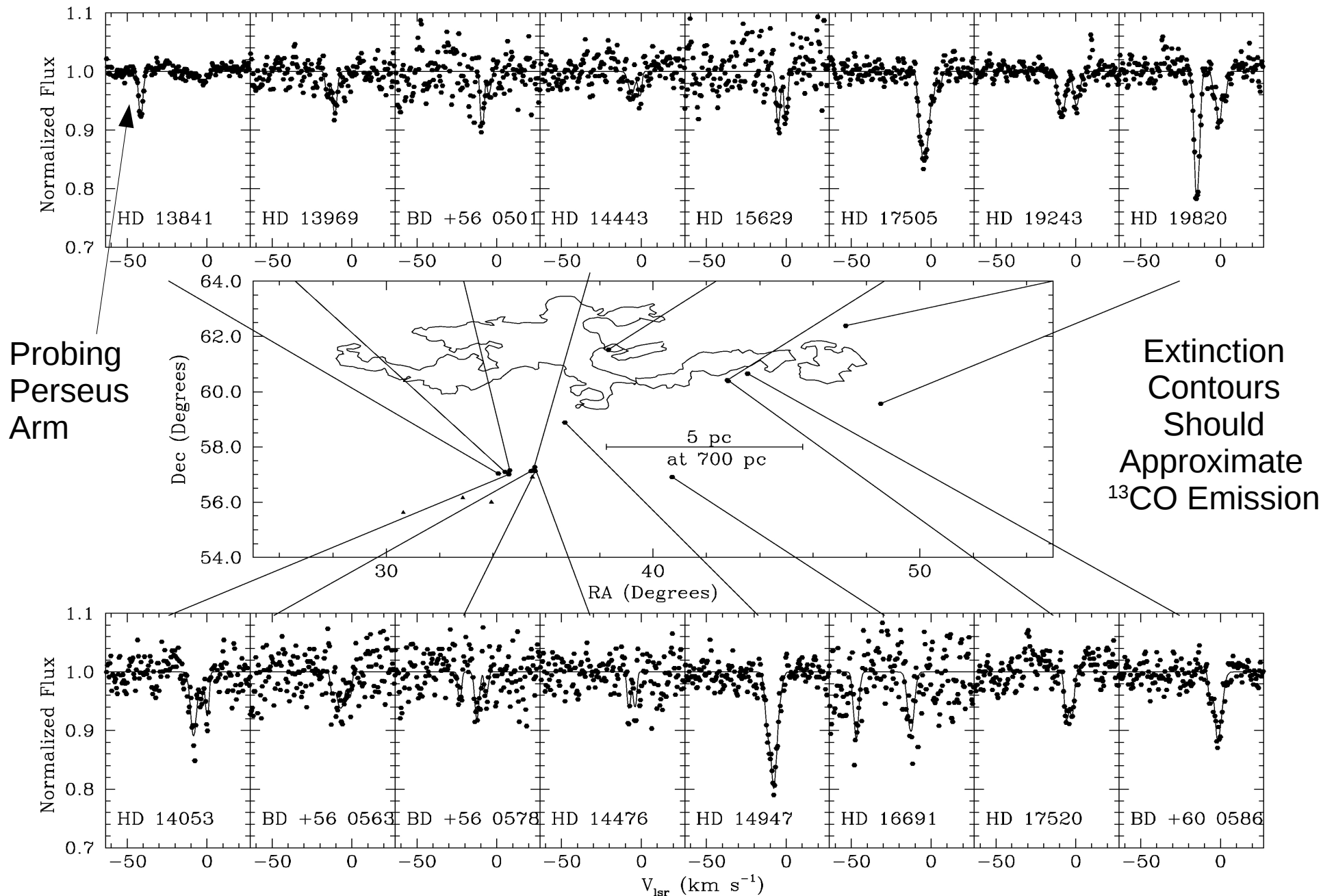


# *Emission vs Absorption in Chamaeleon*

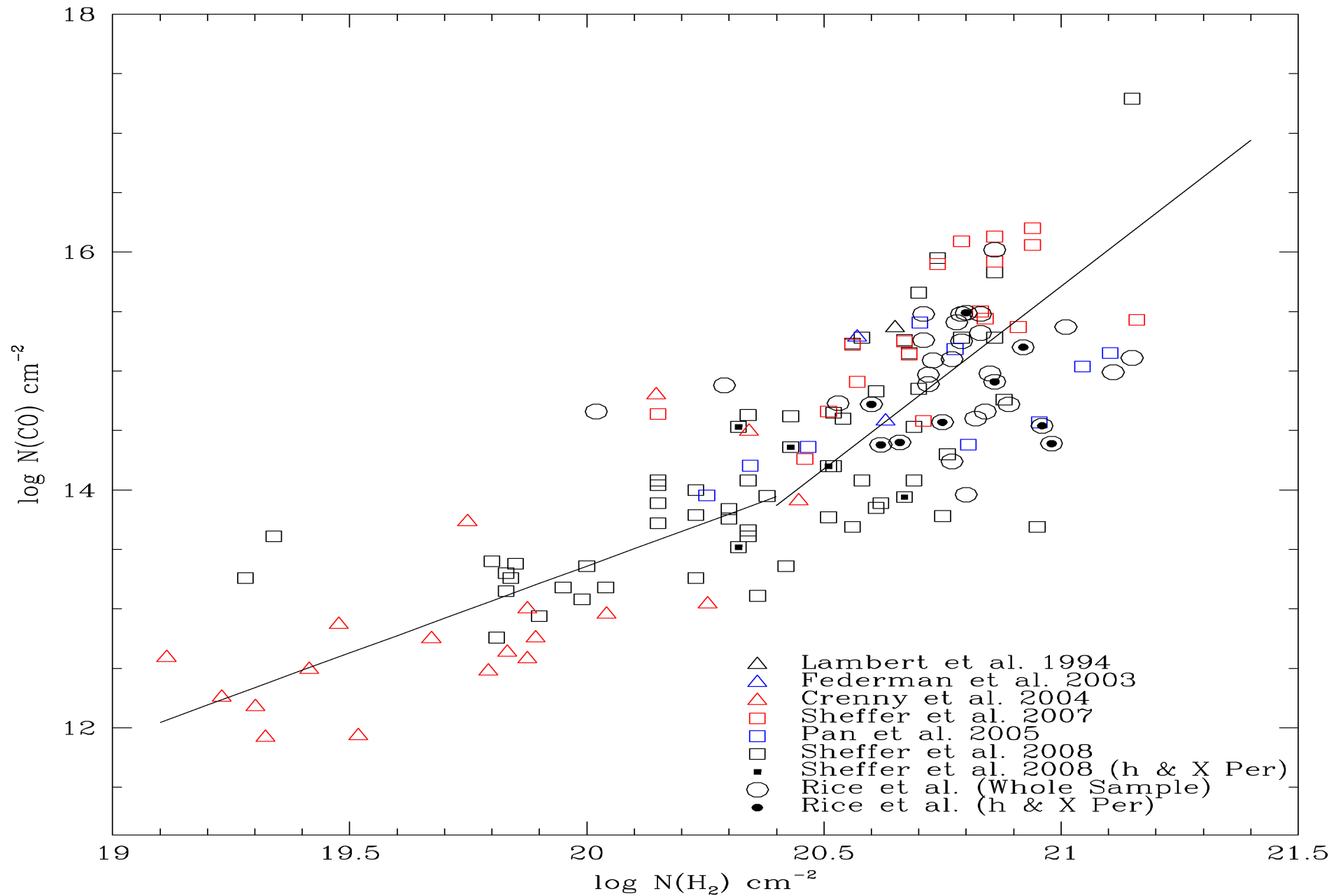


# Extinction Contours for *h* & X Per

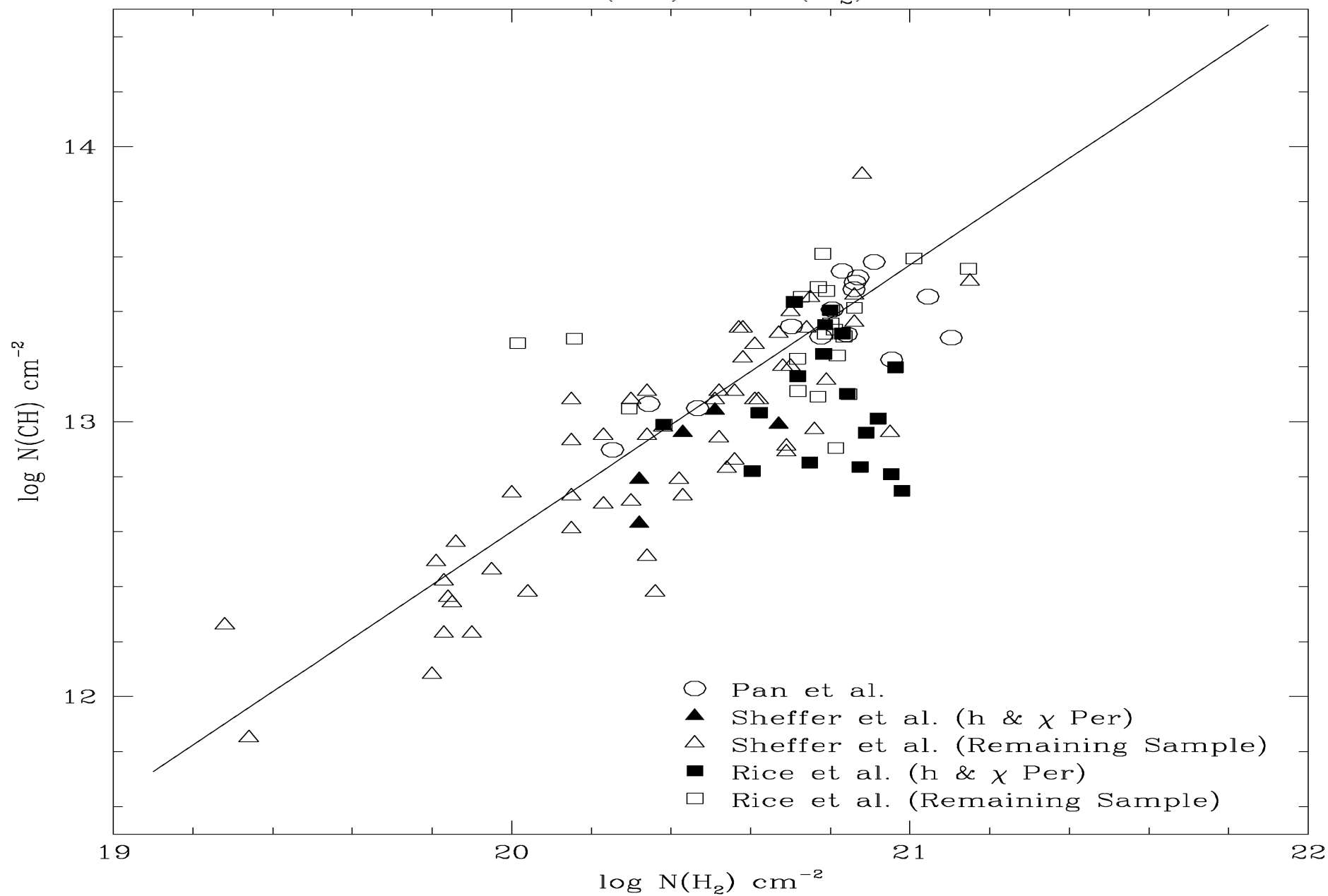
CH Spectra



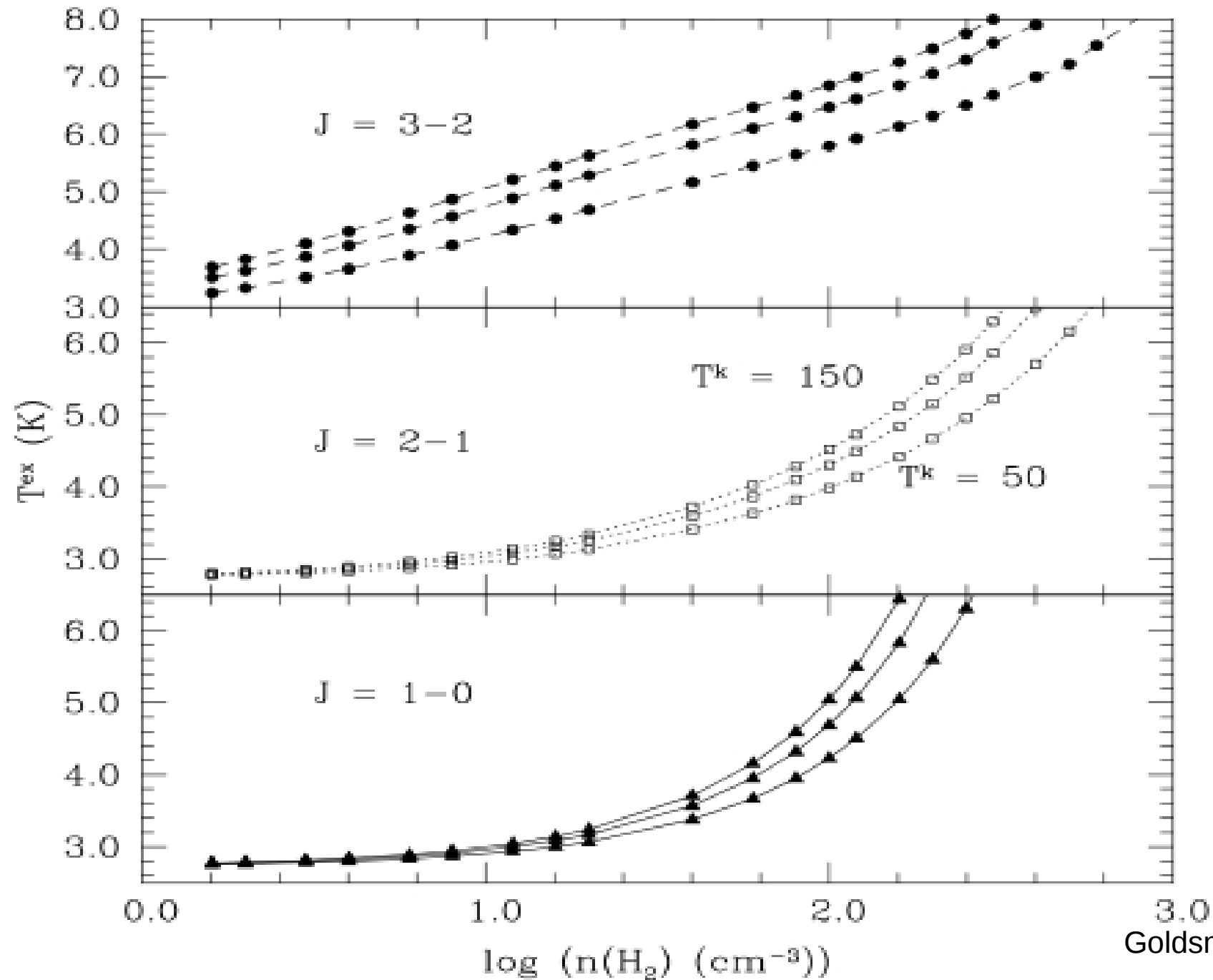
# *CO Towards h & X Per*



# *CH Towards h & X Per*



# CO Excitation Temperatures & Density



## *Current Work*

- 36 New Sightlines Observed in Translucent Cloud Regime
- Use CO Excitation Temperatures to Model Densities
- Compare Densities to Other Diagnostics
- Look at Small Scale Variations in Density and CO Abundance

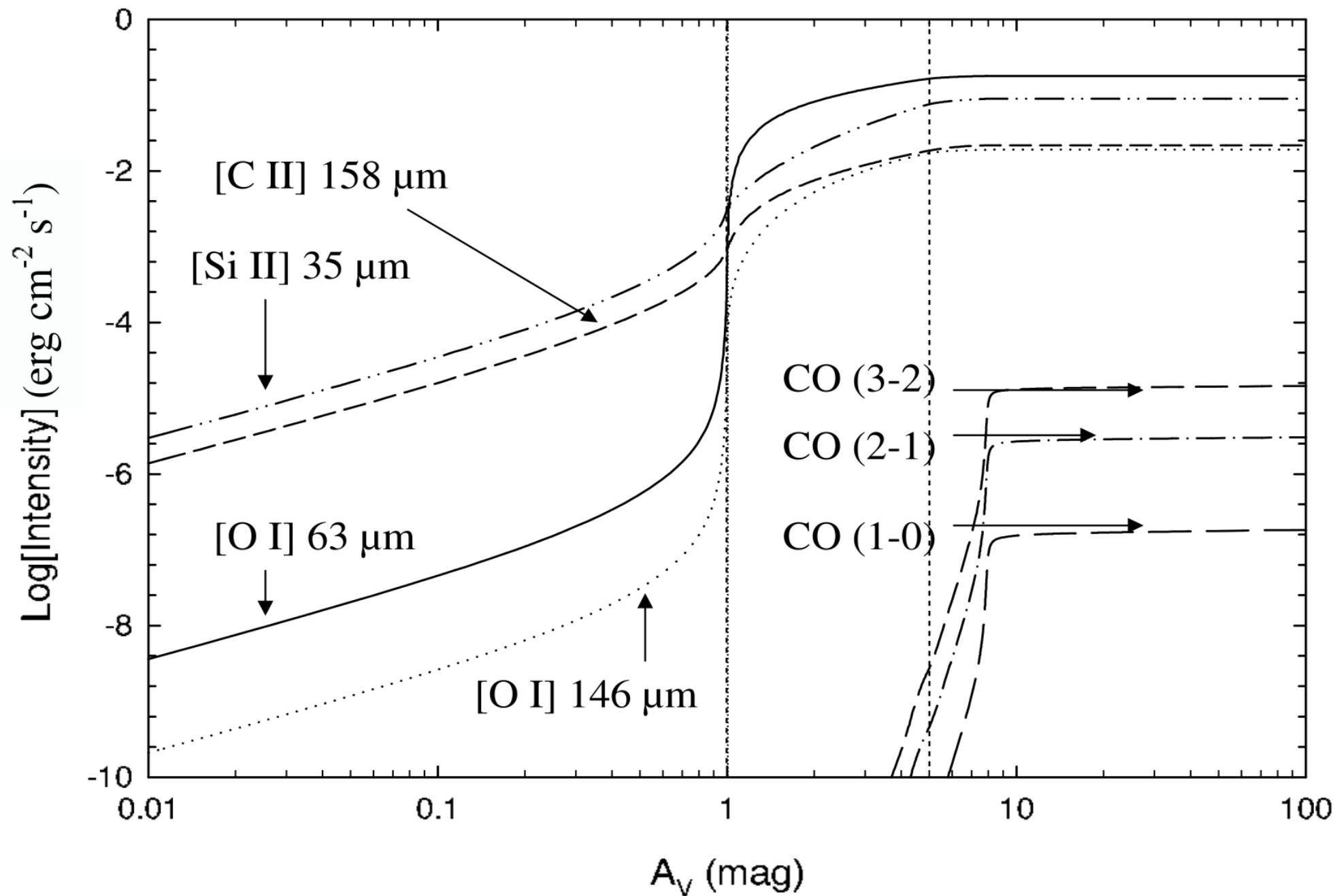


# *Overview*

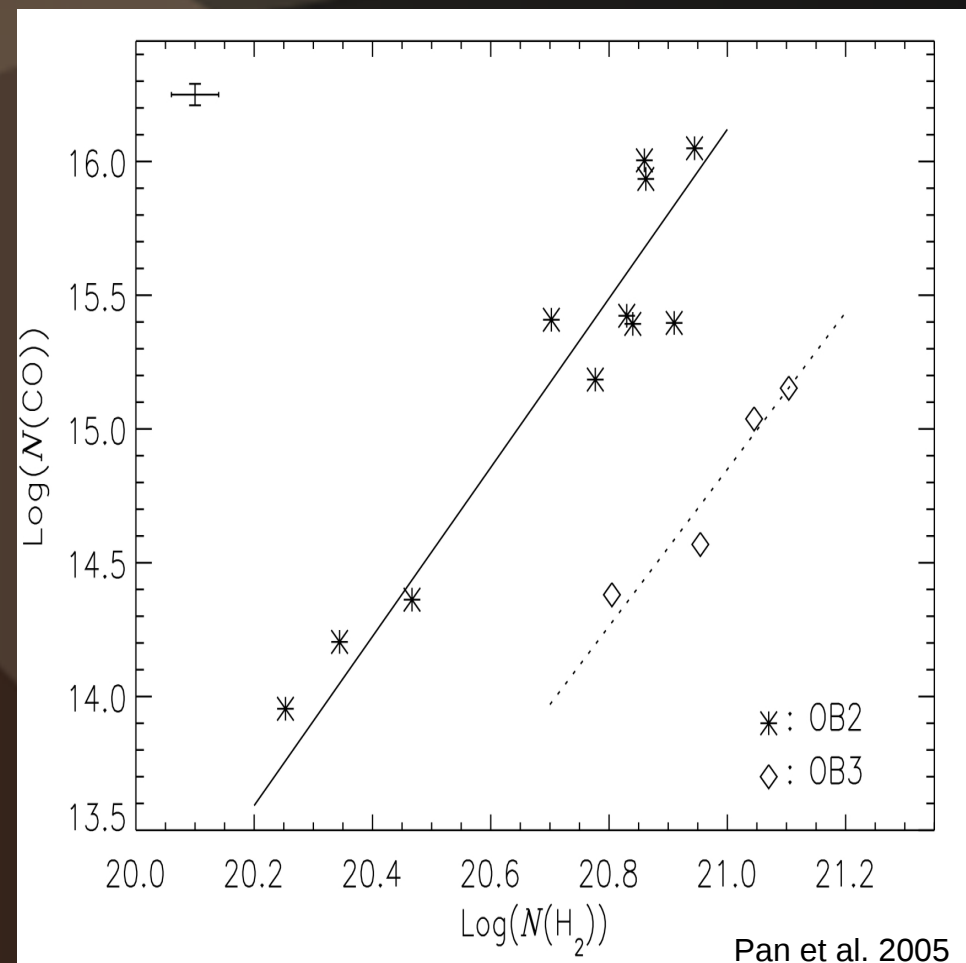
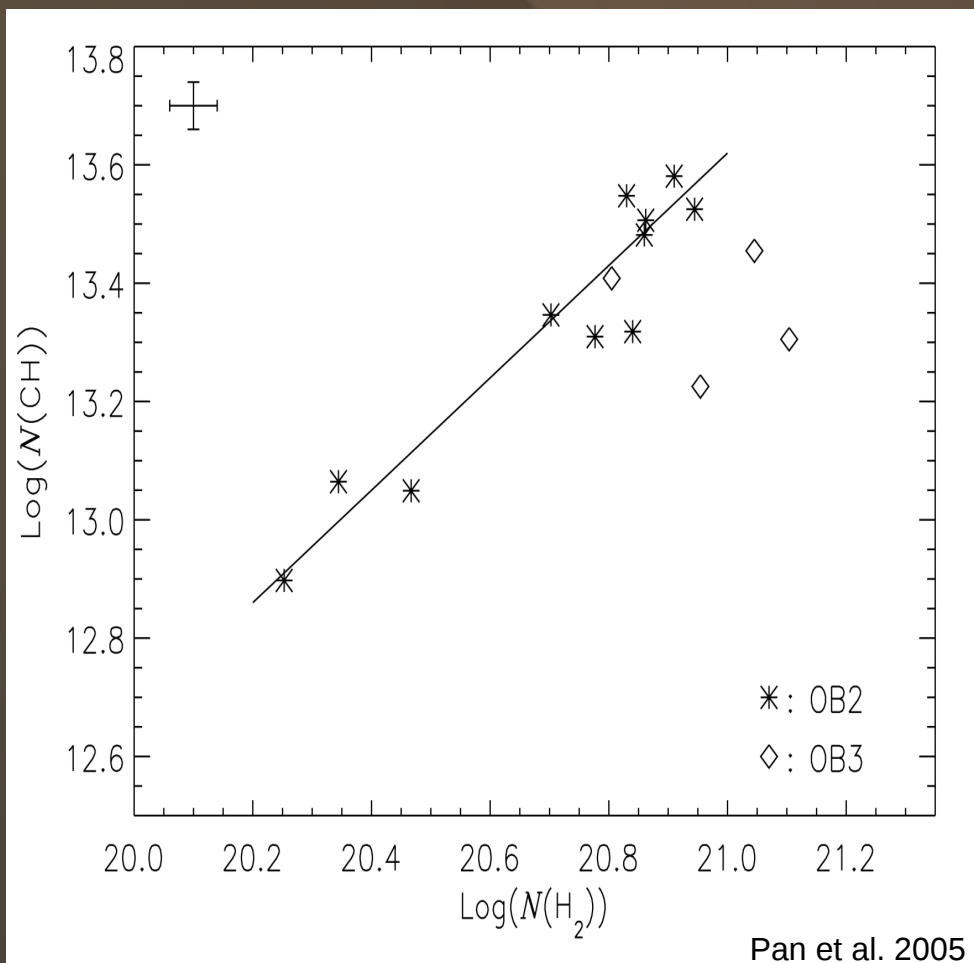
- 36 new sight lines
- Optical transitions (3874Å to 4300Å)
  - CN, CH, CH<sup>+</sup>, Ca I, Ca II
- HST transitions (1550Å to 1250Å)
  - A-X bands (0-0) to (11-0)
- FUSE (mainly 1150Å to 1076Å) & down to 925Å
  - B-X(0-0) B-X(1-0) C-X(0-0) E-X (0-0) & up to W-X



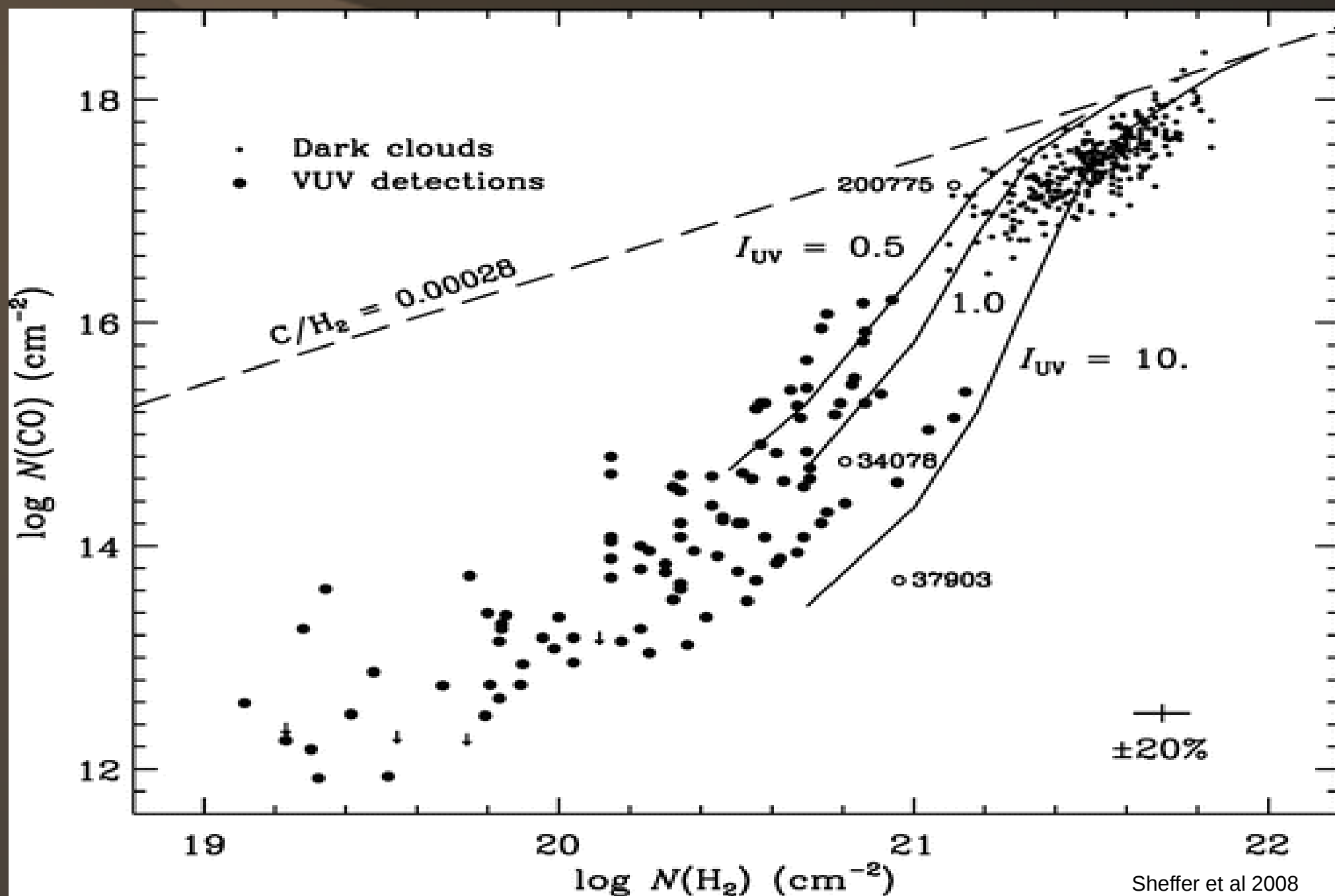
# *Dark CO Gas*



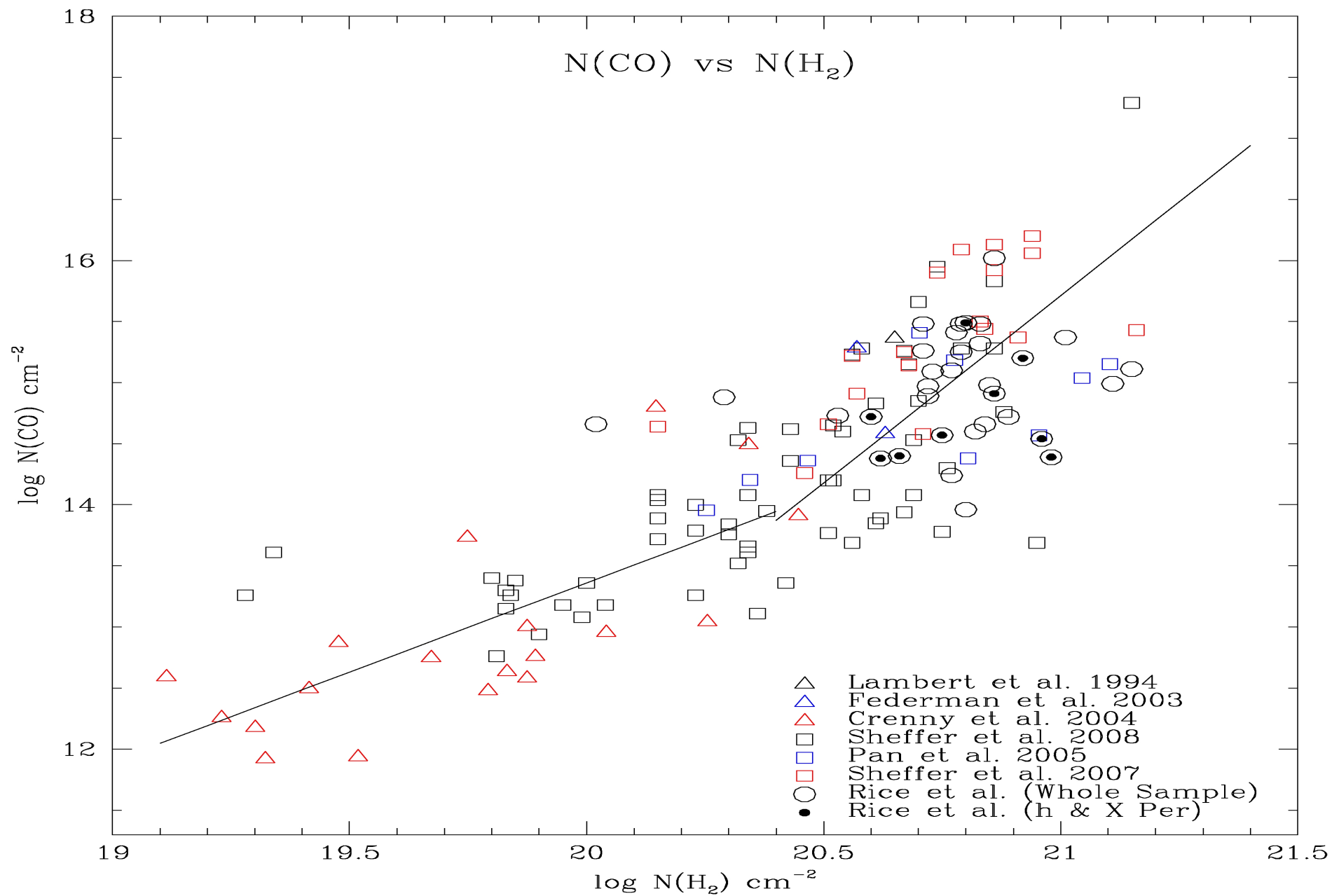
# *The Role of Density* *Cep OB2 vs Cep OB3*



# *The Role of the $I_{UV}$ field*

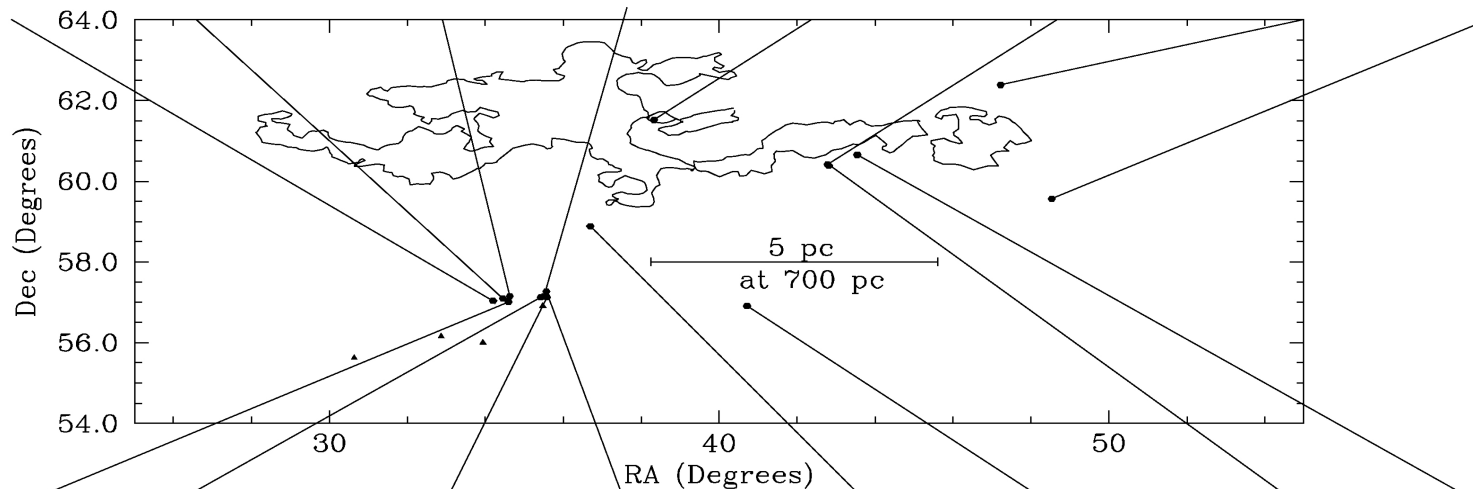


# *h & X Per*



# Small Scale Variations

HD 13841 N(CH)=7 N(CH <sup>+</sup> )=14 N(CN)<1 N(CaII)=12 Log(N(H <sub>2</sub> ))=20.6 T <sub>ex</sub> =60 f <sub>H2</sub> =0.32	HD 13969 N(CH)=7 N(CH <sup>+</sup> )=16 N(CN)<2 N(CaII)=11 Log(N(H <sub>2</sub> ))=20.9 T <sub>ex</sub> =58 f <sub>H2</sub> =0.46	BD +56 0501 N(CH)=7 N(CH <sup>+</sup> )=17 N(CN)<3 N(CaII)=21 Log(N(H <sub>2</sub> ))=20.8 T <sub>ex</sub> =57 f <sub>H2</sub> =0.37	HD 14443 N(CH)=6 N(CH <sup>+</sup> )=19 N(CN)<1 N(CaII)=9 Log(N(H <sub>2</sub> ))=20.8 T <sub>ex</sub> =63 f <sub>H2</sub> =0.45	HD 15629 N(CH)=10 N(CH <sup>+</sup> )=14 N(CN)<4 N(CaII)=16 Log(N(H <sub>2</sub> ))=20.9 T <sub>ex</sub> =67 f <sub>H2</sub> =0.39	HD 17505 N(CH)=23 N(CH <sup>+</sup> )=35 N(CN)<1 N(CaII)=11 Log(N(H <sub>2</sub> ))=20.8 T <sub>ex</sub> =67 f <sub>H2</sub> =0.41	HD 19243 N(CH)=13 N(CH <sup>+</sup> )=19 N(CN)<1 N(CaII)=6 Log(N(H <sub>2</sub> ))=20.8 T <sub>ex</sub> =66 f <sub>H2</sub> =0.51	HD 19820 N(CH)=27 N(CH <sup>+</sup> )=21 N(CN)<3 N(CaII)=7 Log(N(H <sub>2</sub> ))=20.7 T <sub>ex</sub> =61 f <sub>H2</sub> =0.23
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HD 14053 N(CH)=16 N(CH <sup>+</sup> )=33 N(CN)<2 N(CaII)=9 Log(N(H <sub>2</sub> ))=21.0 T <sub>ex</sub> =61 f <sub>H2</sub> =0.65	BD +56 0563 N(CH)=11 N(CH <sup>+</sup> )=15 N(CN)<2 N(CaII)=13 Log(N(H <sub>2</sub> ))=20.6 T <sub>ex</sub> =66 f <sub>H2</sub> =0.25	BD +56 0578 N(CH)=10 N(CH <sup>+</sup> )=7 N(CN)<3 N(CaII)=11 Log(N(H <sub>2</sub> ))=20.4 T <sub>ex</sub> =66 f <sub>H2</sub> =0.15	HD 14476 N(CH)=6 N(CH <sup>+</sup> )=14 N(CN)<2 N(CaII)=10 Log(N(H <sub>2</sub> ))=20.9 T <sub>ex</sub> =55 f <sub>H2</sub> =0.39	HD 14947 N(CH)=25 N(CH <sup>+</sup> )=20 N(CN)<2 N(CaII)=10 Log(N(H <sub>2</sub> ))=20.8 T <sub>ex</sub> =55 f <sub>H2</sub> =0.28	HD 16691 N(CH)=18 N(CH <sup>+</sup> )=45 N(CN)<8 N(CaII)=13 Log(N(H <sub>2</sub> ))=20.8 T <sub>ex</sub> =62 f <sub>H2</sub> =0.26	HD 17520 N(CH)=9 N(CH <sup>+</sup> )=10 N(CN)<2 N(CaII)=19 Log(N(H <sub>2</sub> ))=20.8 T <sub>ex</sub> =55 f <sub>H2</sub> =0.32	BD +60 0586 N(CH)=15 N(CH <sup>+</sup> )=17 N(CN)<2 N(CaII)=7 Log(N(H <sub>2</sub> ))=20.7 T <sub>ex</sub> =65 f <sub>H2</sub> =0.30
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