

Systematic Deuteration Surveys toward High-Mass Regions

Yancy Shirley
University of Arizona

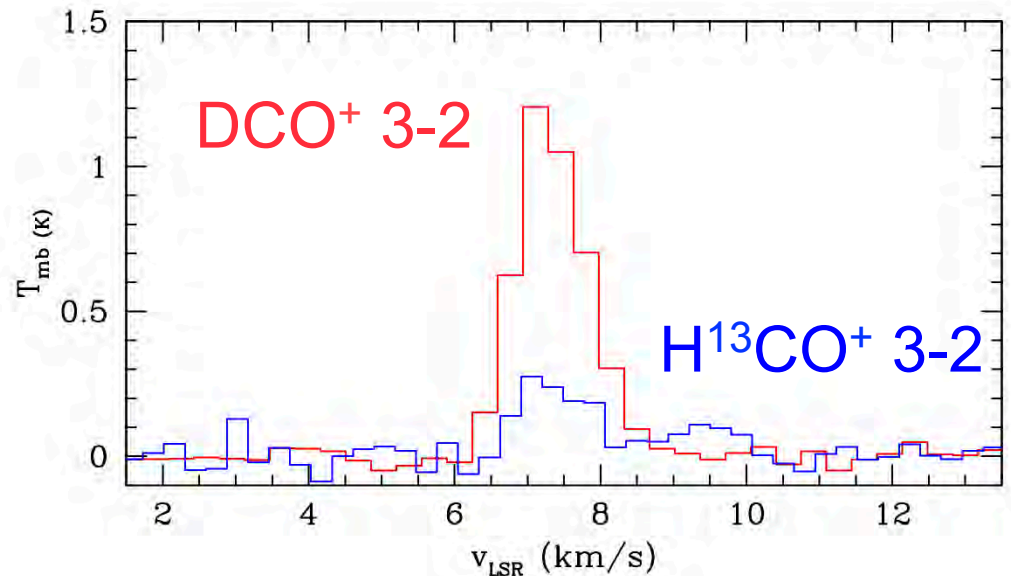
2 Projects to Systematically Study Deuteration

HHT 10m

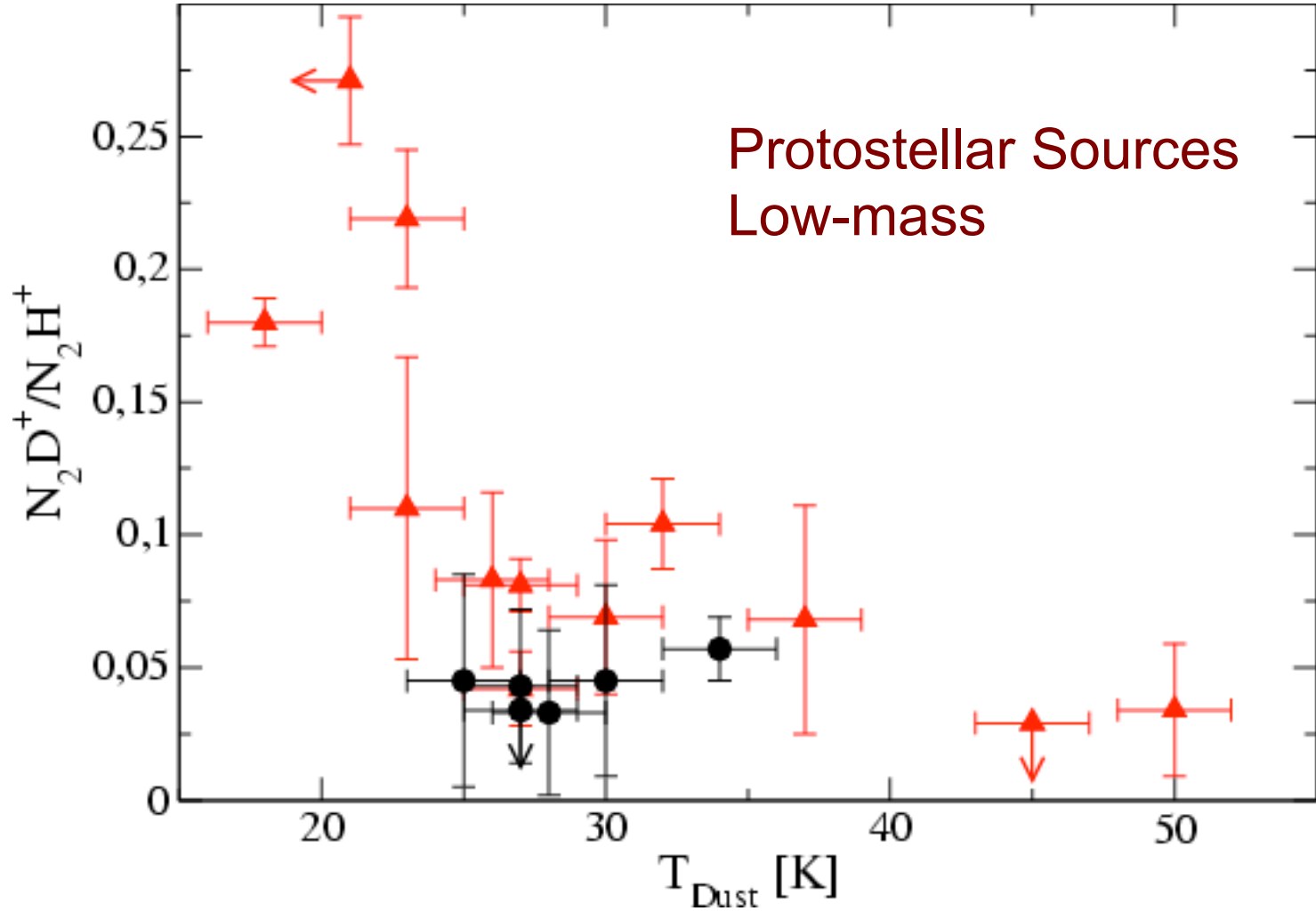


Observed DCO^+ , N_2D^+ , DCN , & DNC toward 60 high-mass clumps in different evolutionary phases

DCO^+ & N_2D^+ were observed toward the 1.1 mm continuum peaks of 55 clumps in the Gem OB 1 complex

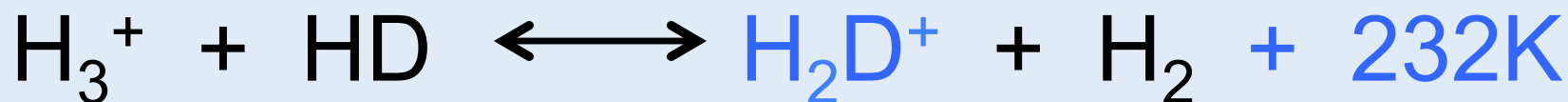


Deuteration is Sensitive to Temperature



Gas Phase Deuteration Chemistry

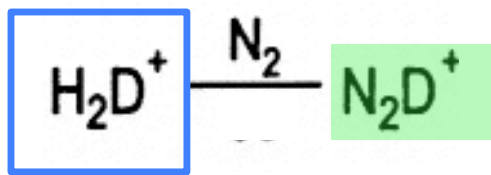
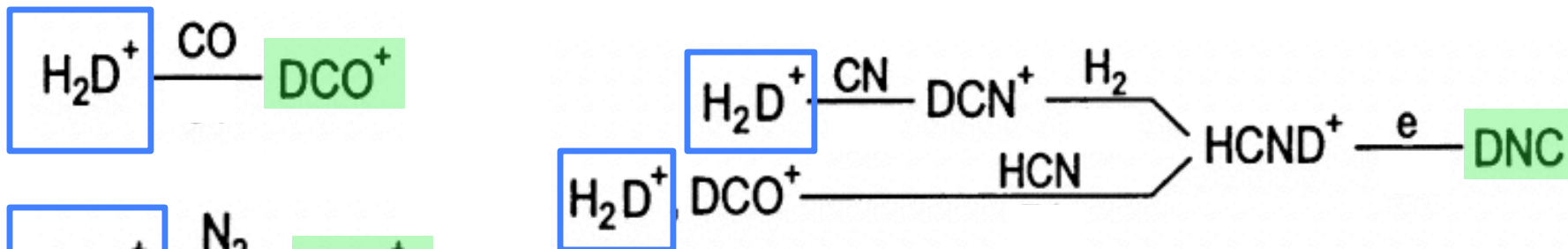
Low T Route



High T Route

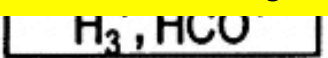
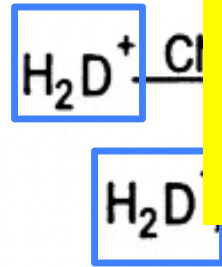


Low T and High T Routes

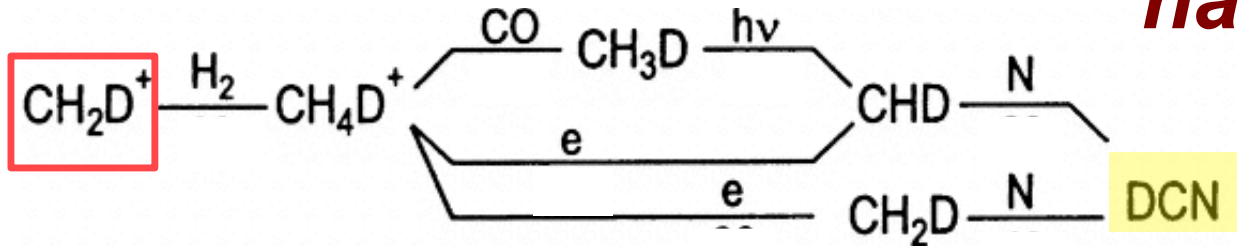


DCO⁺, N₂D⁺, DNC

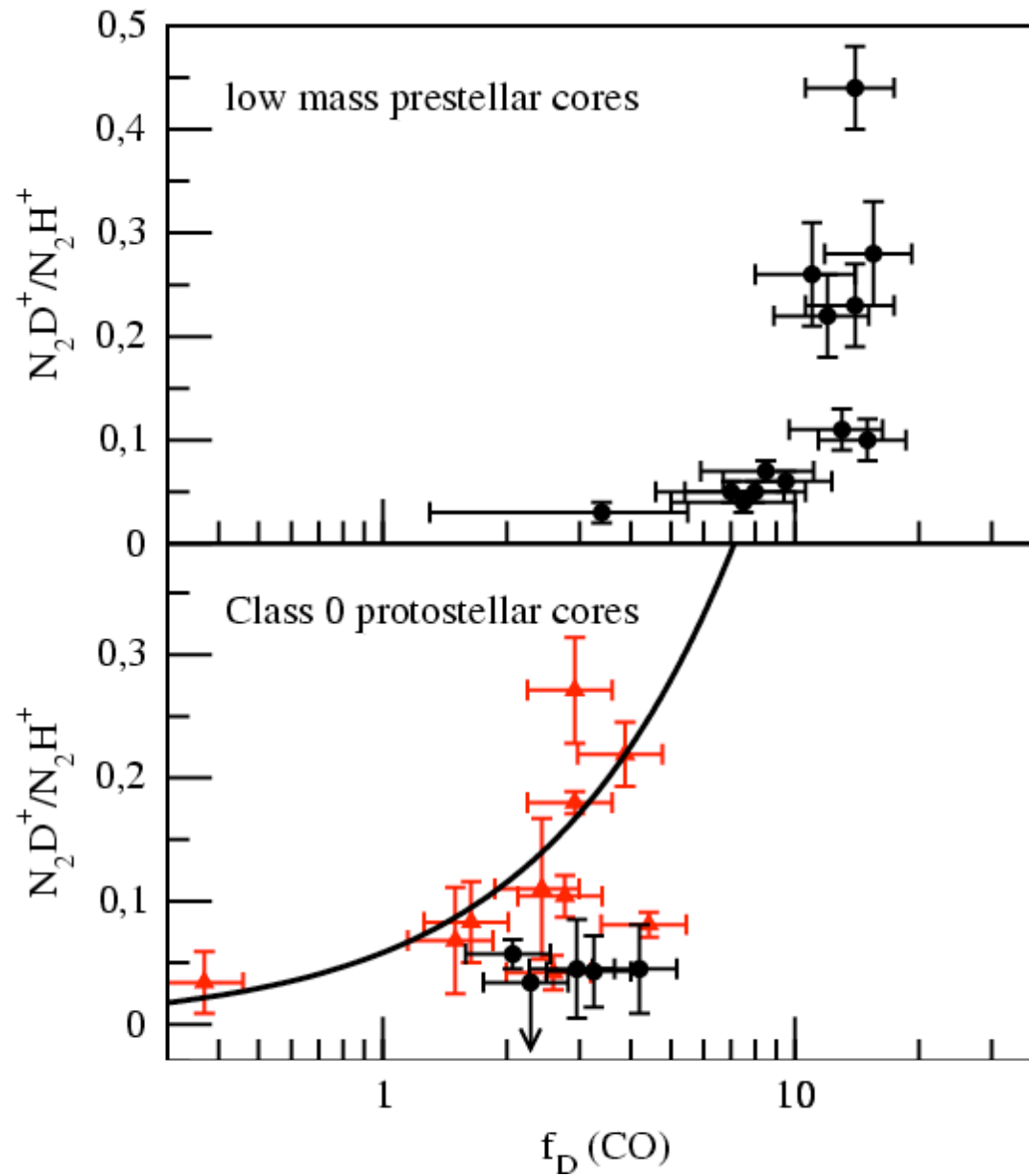
See also Roueff et al. 2007 for detailed discussion of high T chemistry for DCN



But DCN also has high T route

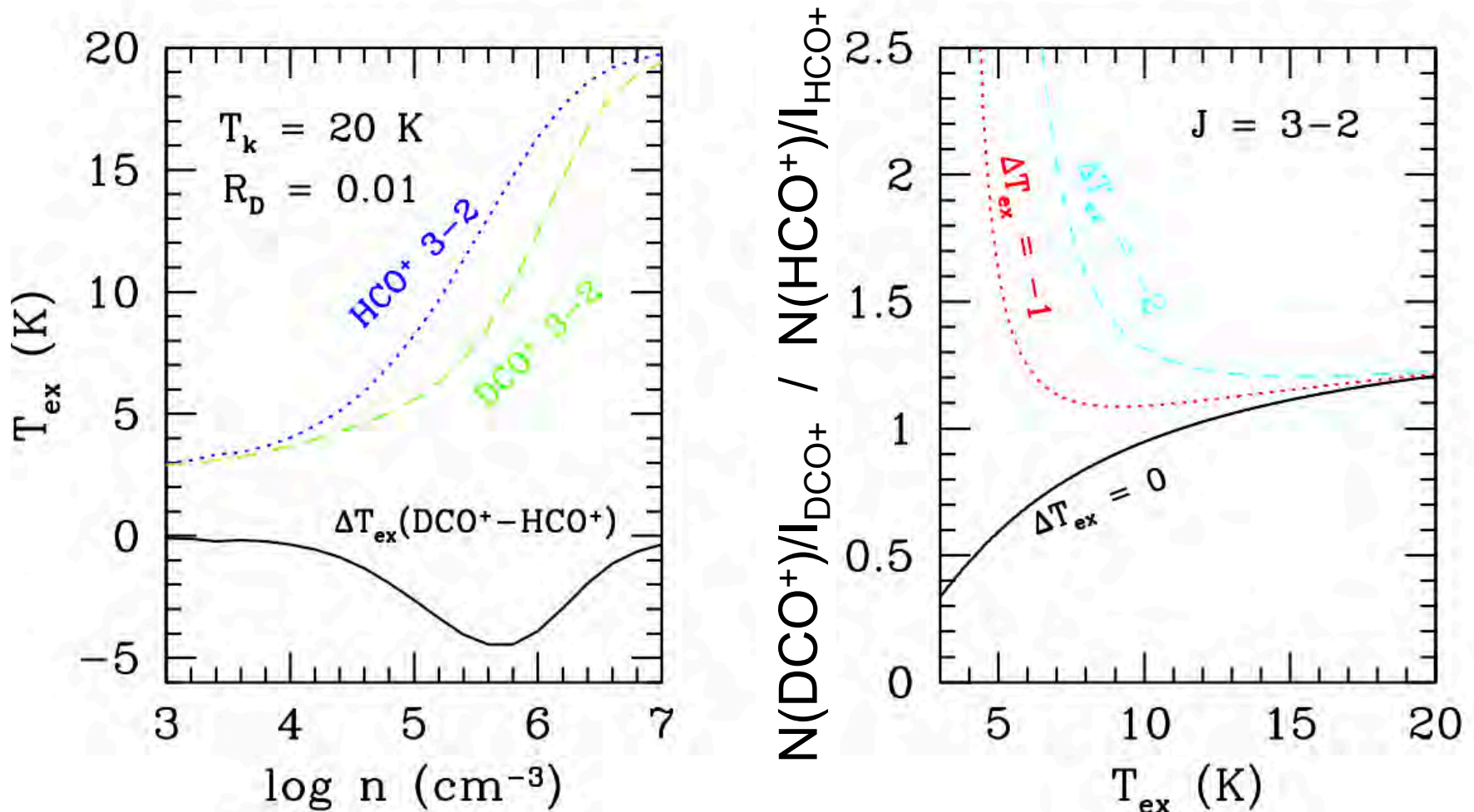


Deuteration Correlated with CO Depletion



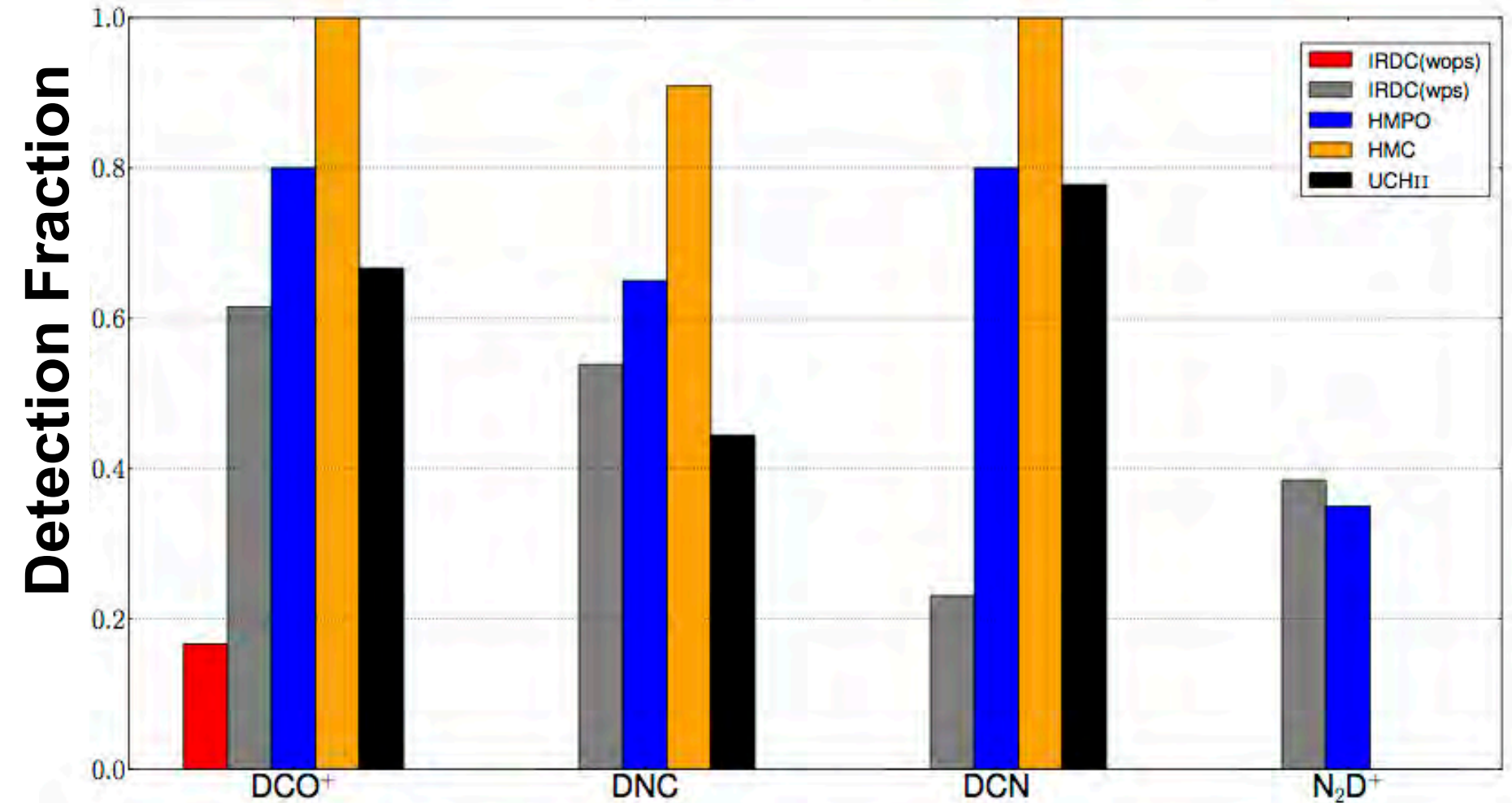
Excitation Temperature

Both DCO^+ and HCO^+ are sub-thermally excited.
Small differences in T_{ex} can cause large error in ratio



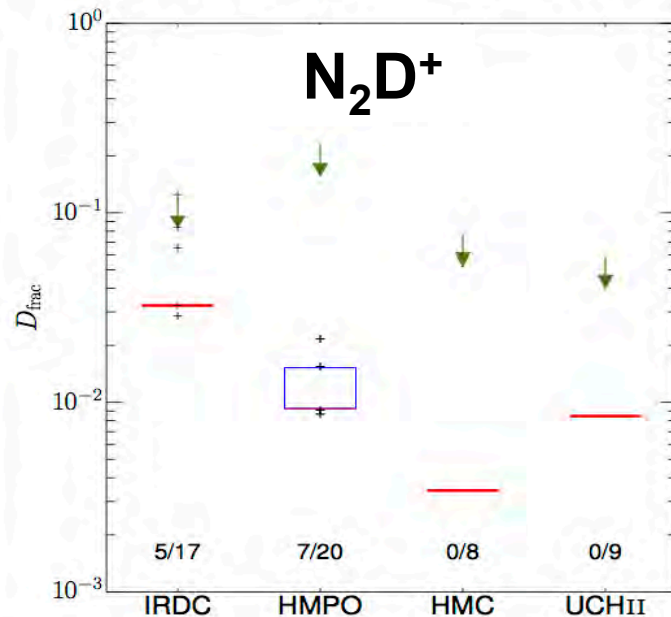
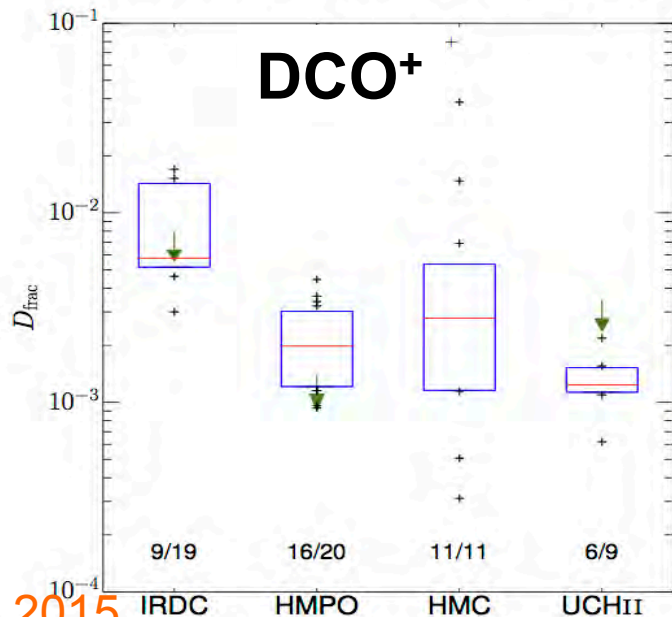
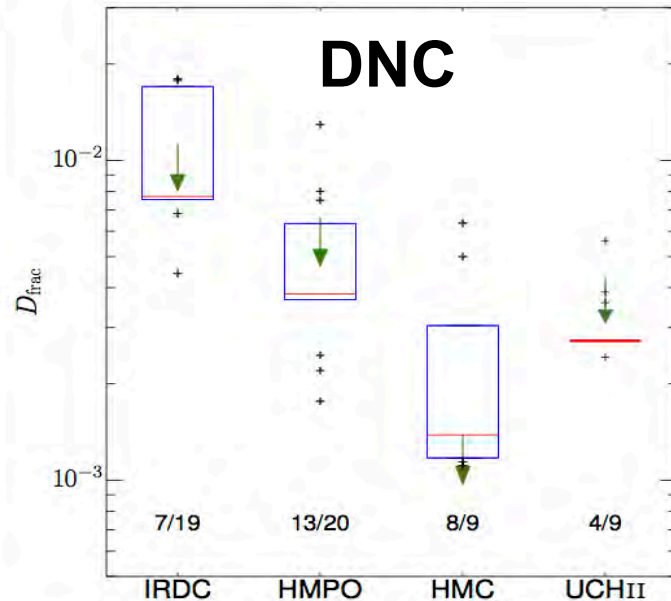
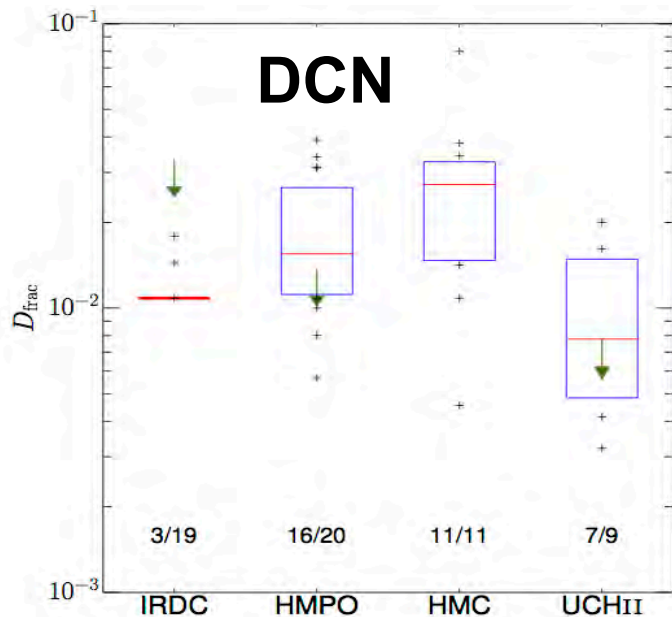
Detection Fractions

60 high-mass clumps in different evolutionary stages



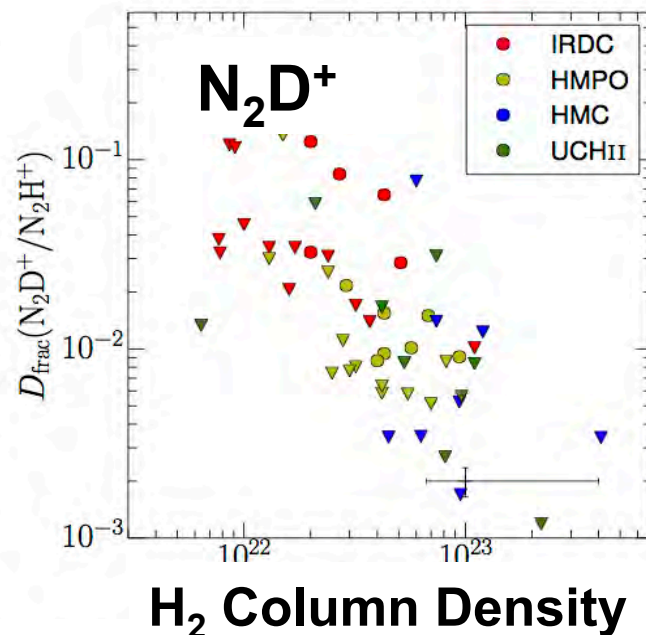
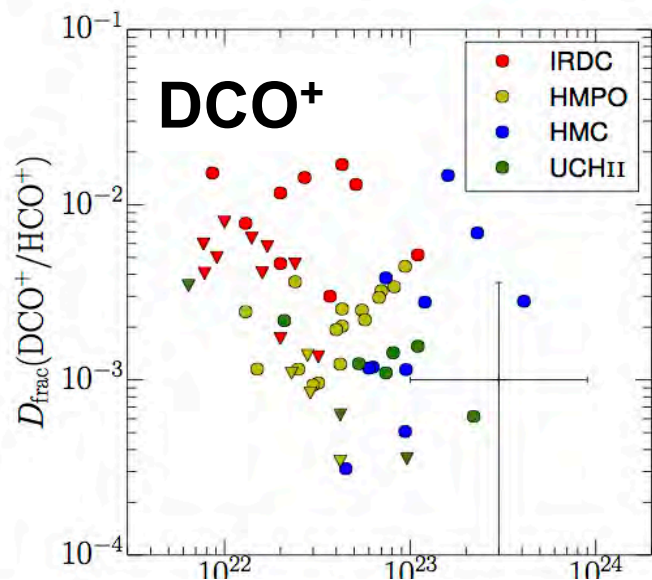
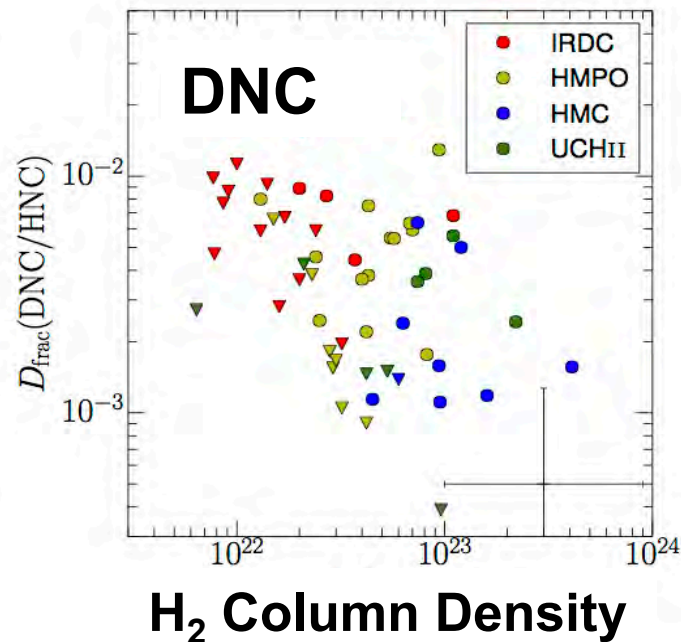
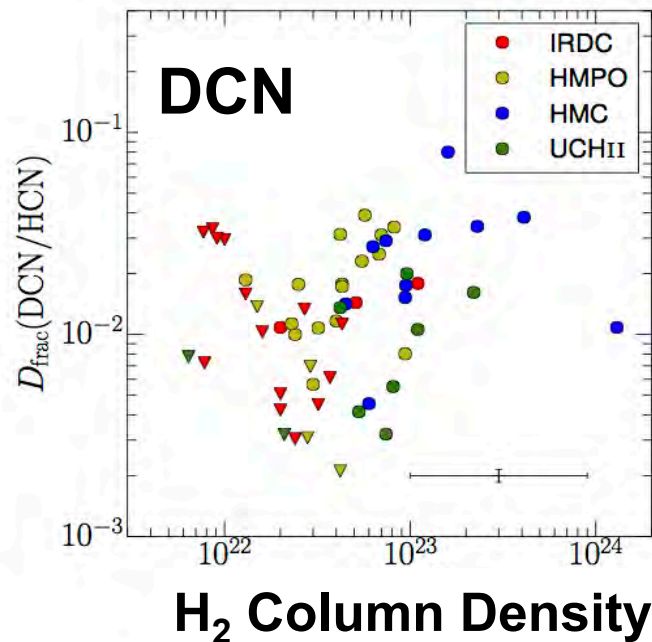
Deuteration Ratio

Deuteration Ratio



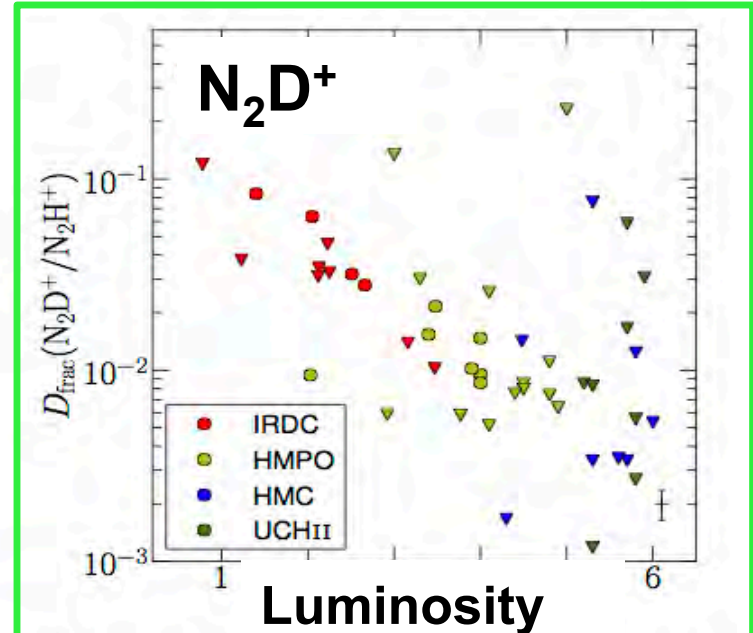
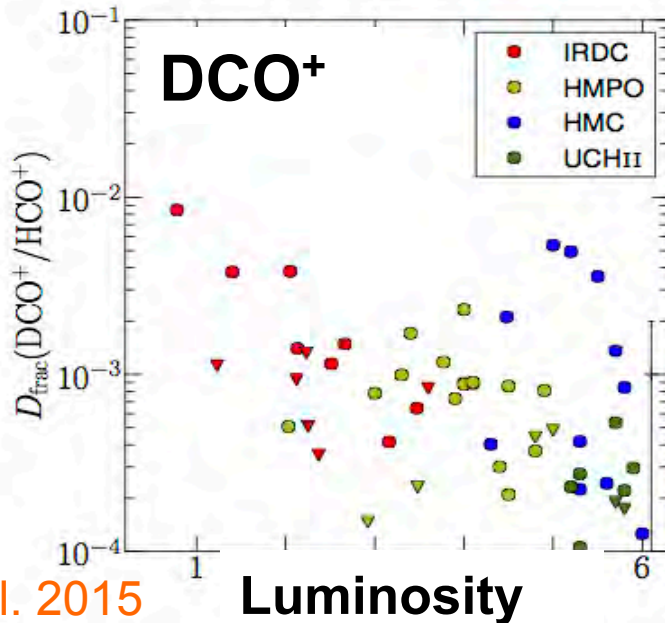
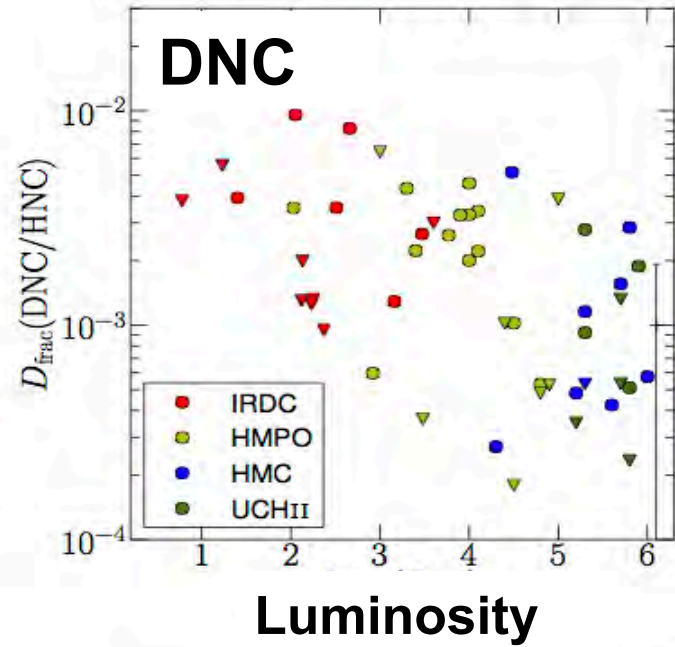
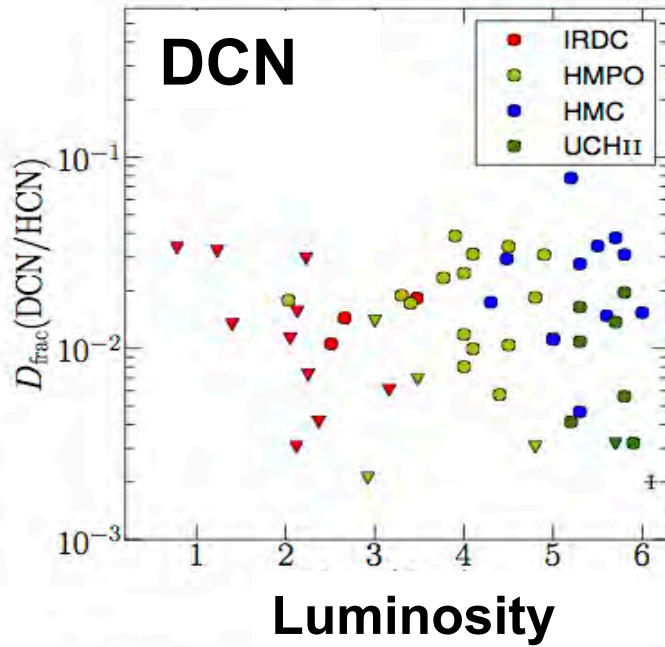
General Lack of Correlation

Deuteration Ratio



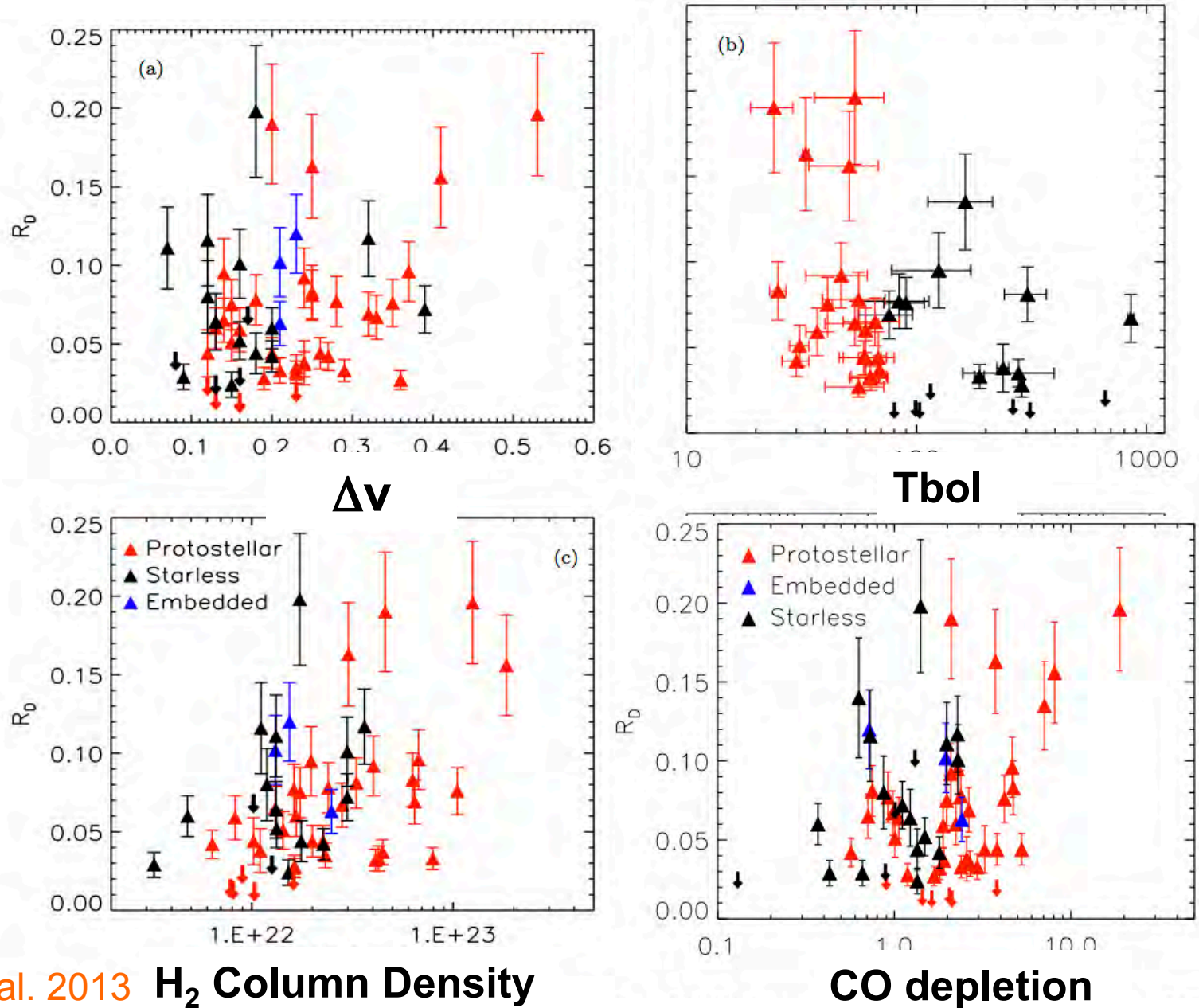
Luminosity

Deuteration Ratio

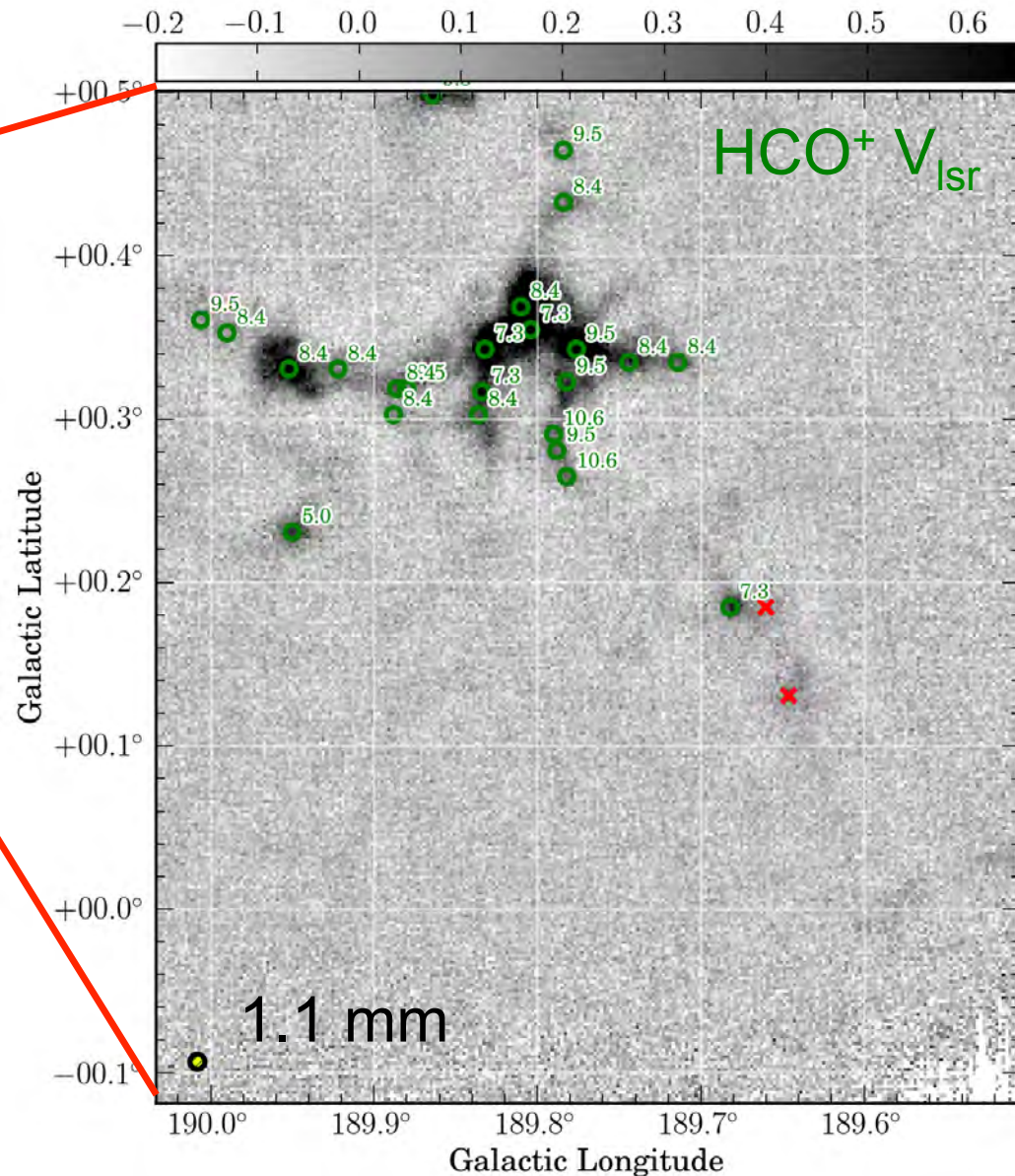
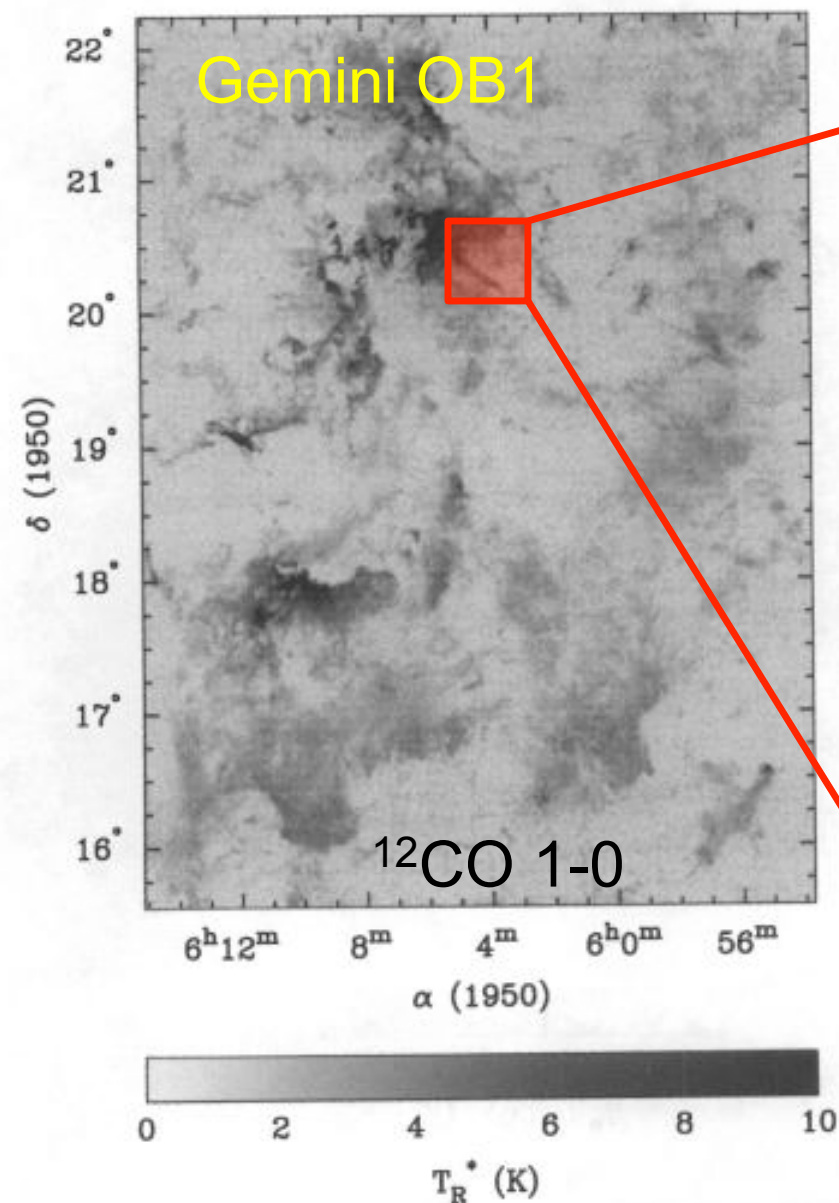


Perseus Systematic Deuteration Survey

N_2D^+ Ratio

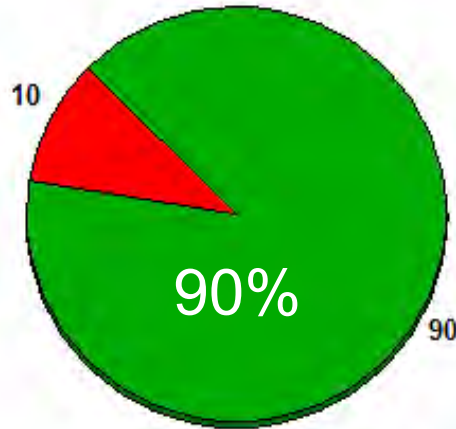


BGPS 1.1mm Survey of Gemini

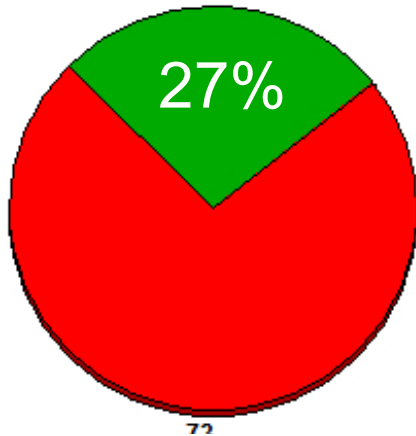


Detection Fractions

Gemini

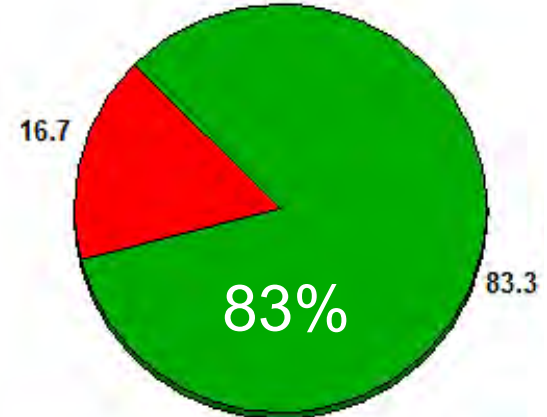


DCO⁺

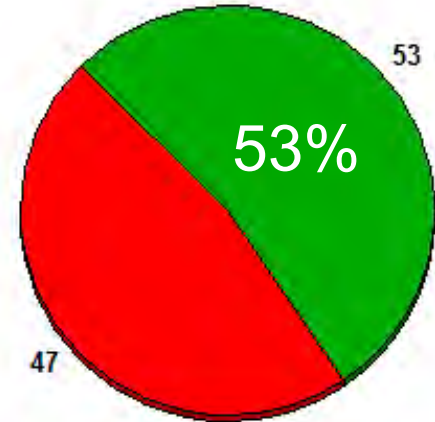


N₂D⁺

Perseus



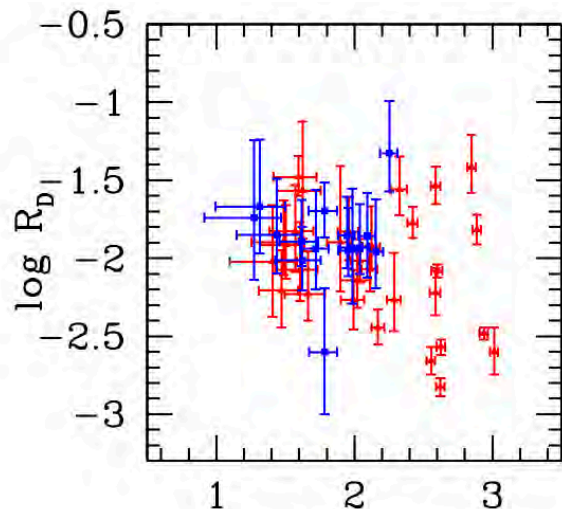
DCO⁺



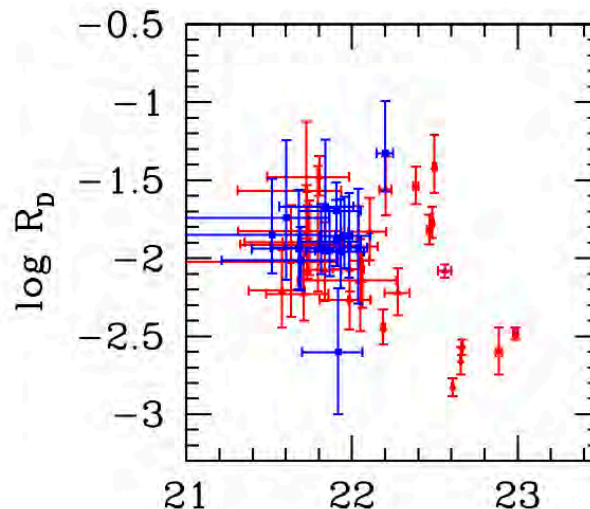
N₂D⁺

Gemini Deuterium Ratio Trends?

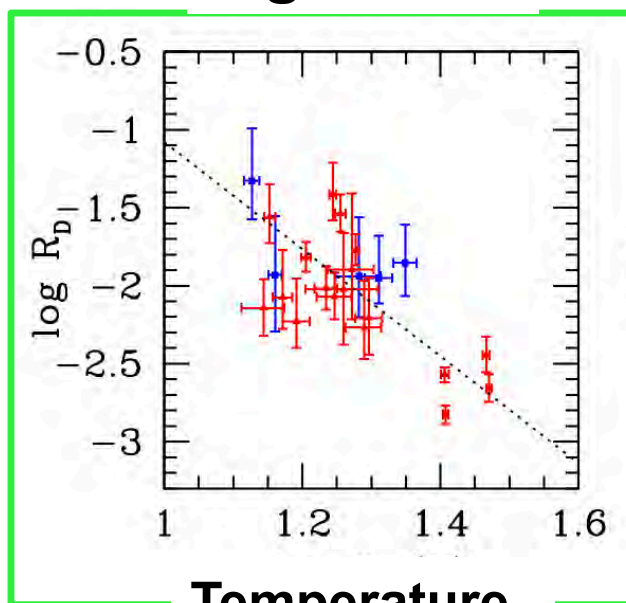
DCO⁺ Ratio



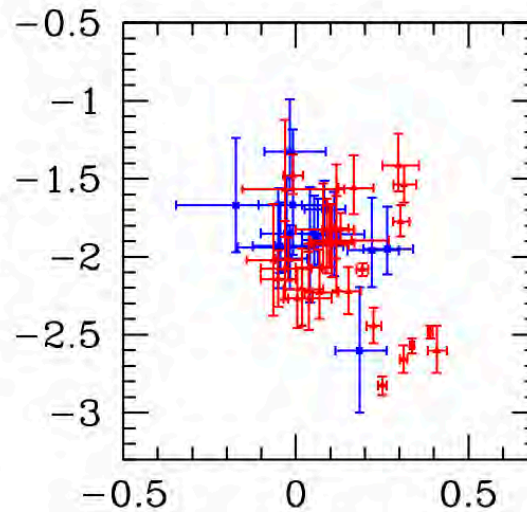
$\log \text{Mass}$



$N(\text{H}_2)$



Temperature



$\log \Delta v$

Summary

- High DCO⁺ (> 80%) detection fraction and low N₂D⁺ (< 40%) detection fraction in high-mass regions
- DCO⁺, N₂D⁺, DNC fraction decreases toward more extreme/"evolved" stages (HMC, UCHII). DCN shows evidence of higher T deuteration chemistry
- Anti-correlation with T_k confirmed in high-mass regions
- Significant variation within phases and general lack of correlation with physical variable at clump resolution