Testing grain-surface chemistry in massive hot-core regions

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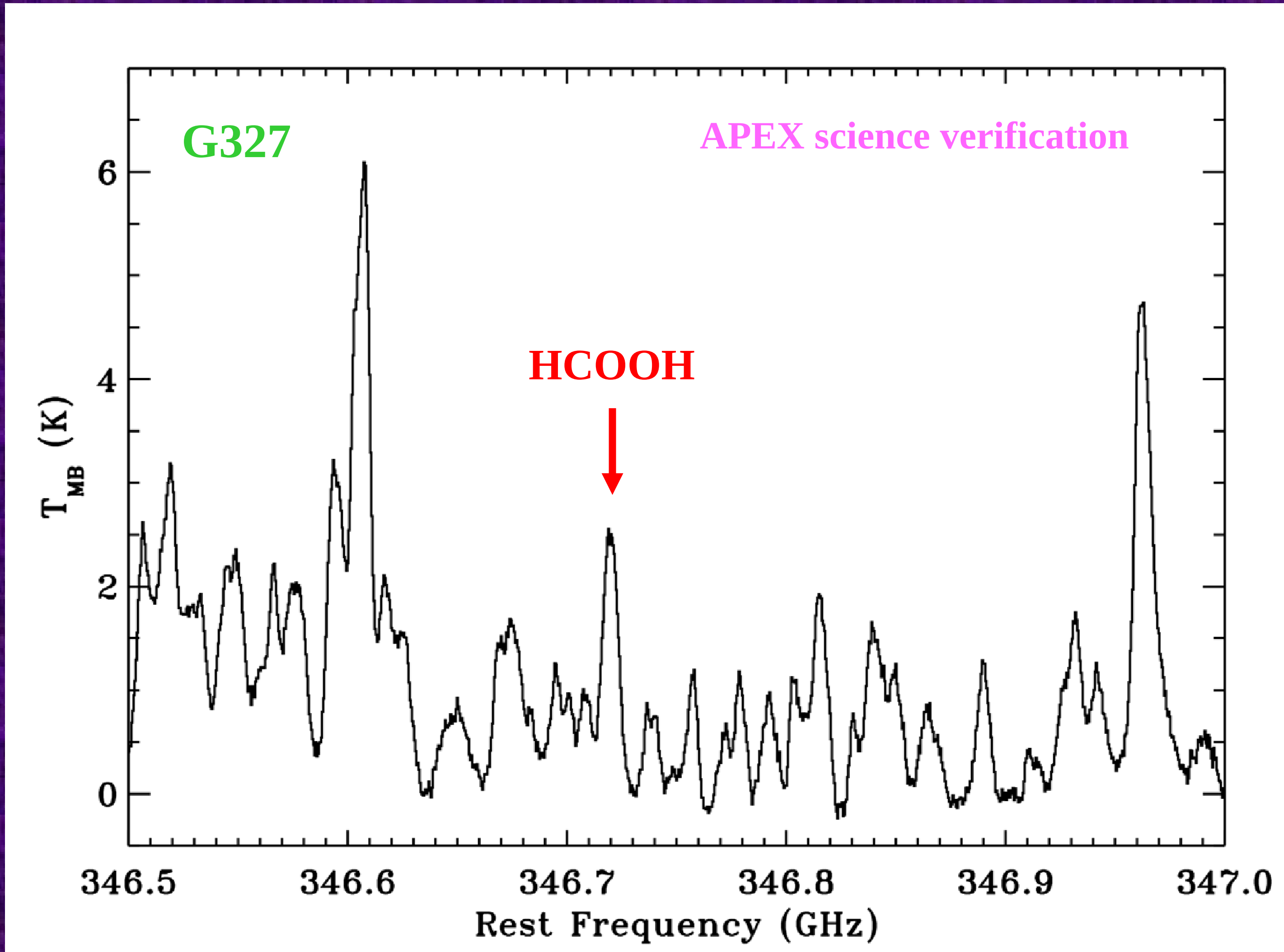
09-05-06

Introduction I

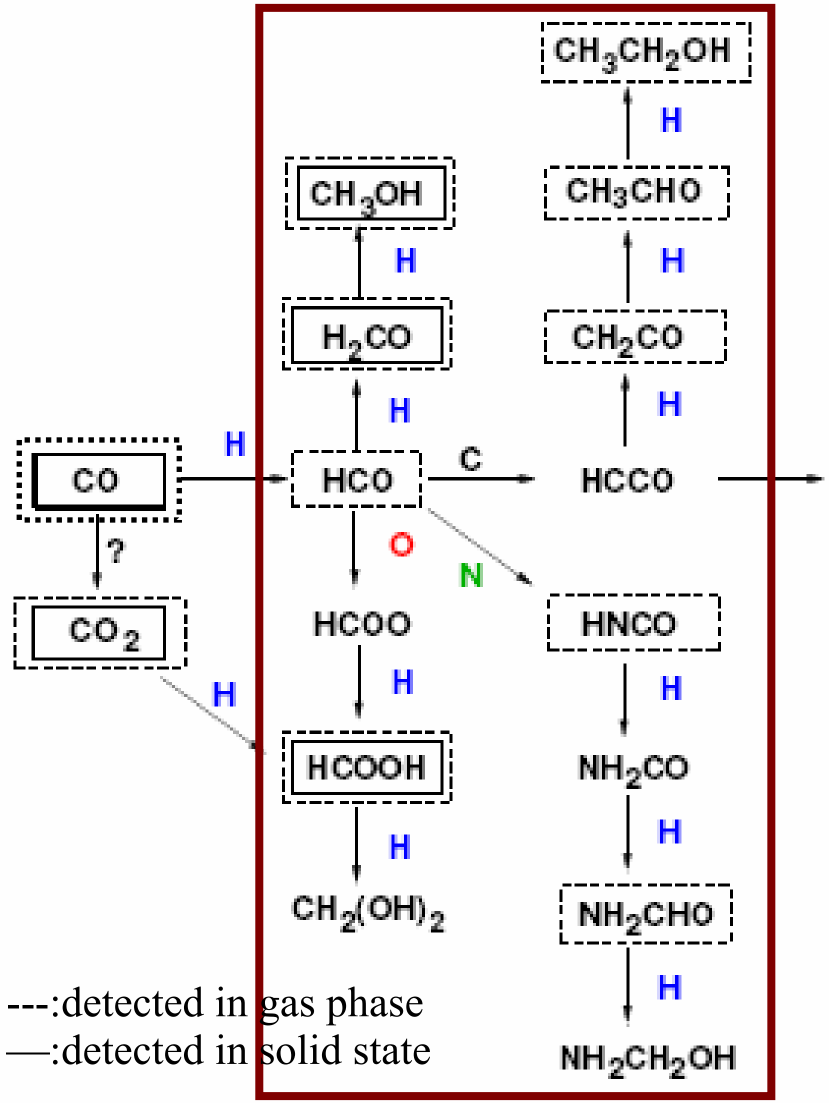


High mass star forming regions rich in organics!

Introduction II

- 2 proposed formation mechanisms:
  - Grain-surface chemistry
  - High temperature gas phase chemistry

Based on Tielens and Charnley 1997



Observations JCMT & IRAM

- 7 high mass YSOs
- Source selection criteria:
  - Lines < 5 km s^{-1}
  - D < 5 kpc
  - T_a > 1 K 338 GHz $7_K - 6_K$ CH_3OH branch
- Luminosities 10^4-10^6 $L_\odot$
- Solid state data available

AFGL 2591
G24.78
G75.78
N6334 IRS1
N7538 IRS1
W 3(H_2O)
W 33A

- Line selection criteria:
  - Low + high lying energy levels
  - Not close to transitions other molecules
  - Isotopes H_2CO, CH_3OH, and HNCO
  - IRAM: low lying energy levels of CH_2CO, CH_3CHO, and HCOOH

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- Rotation temperatures: hot or cold?
- Inventory abundances grain-surface species

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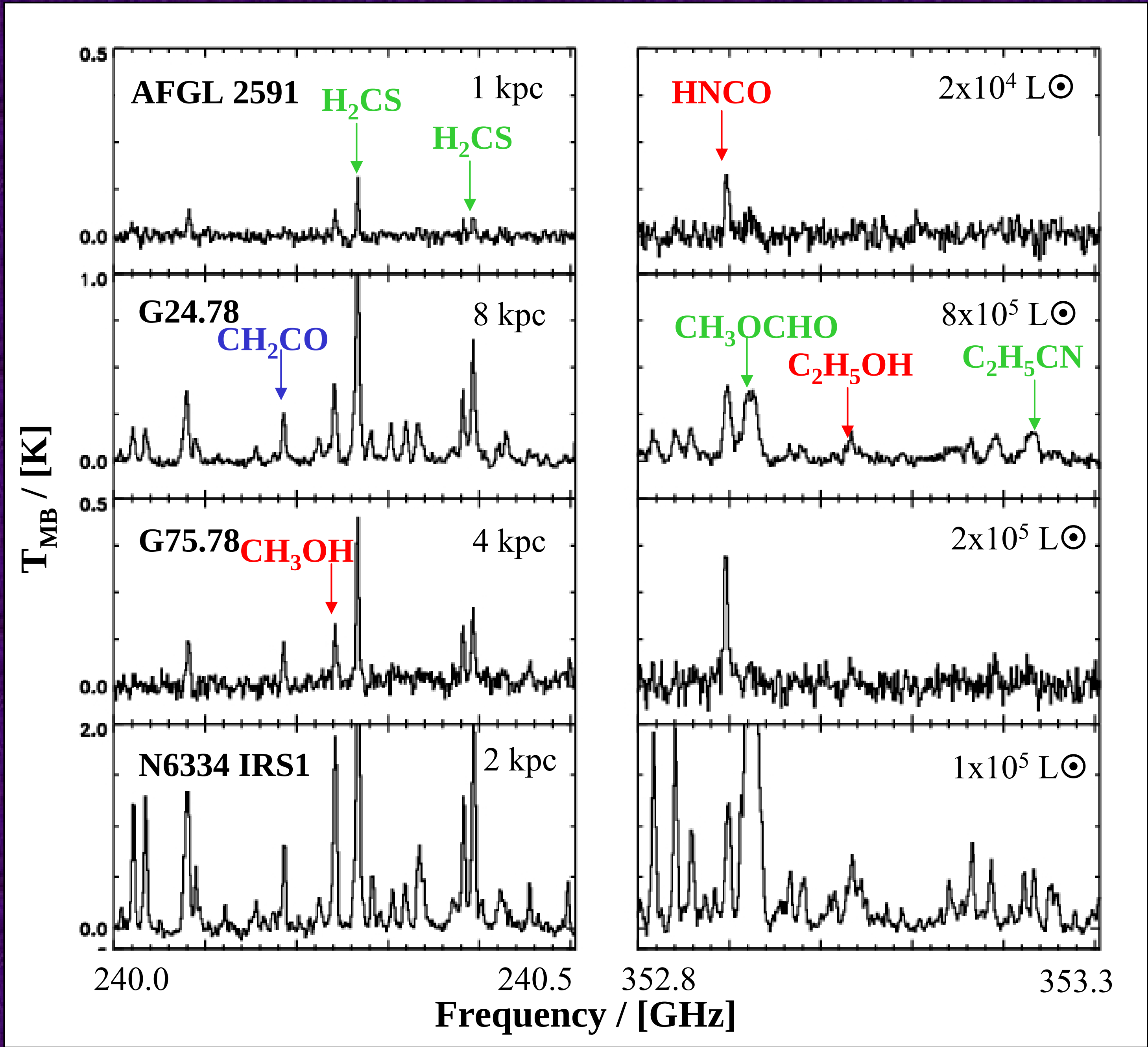
Link molecules chemically

Results: spectra

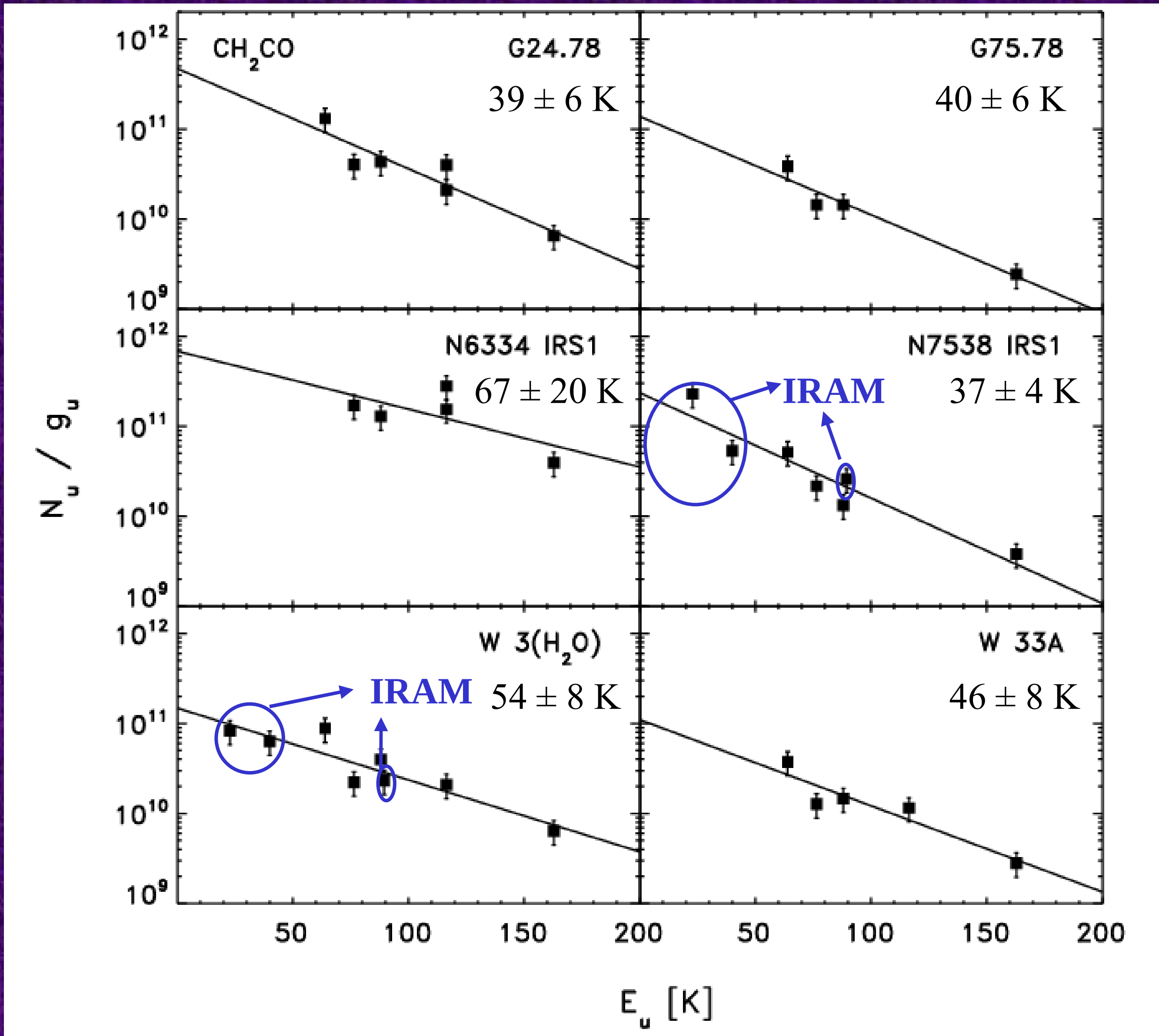
Varying line richness !



Analysis

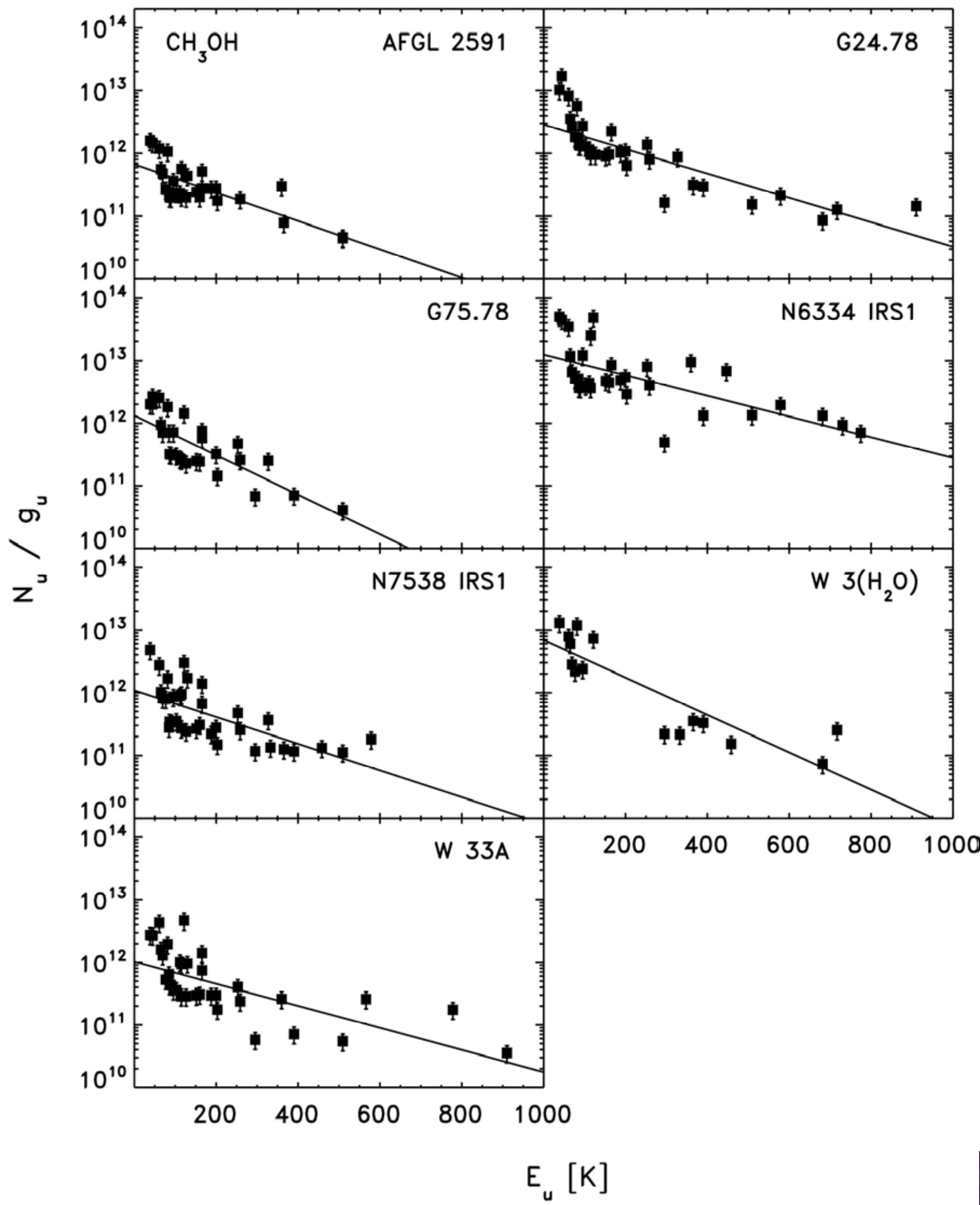
- Rotation diagram
  - T_{rot} & N
- Dust radiative transfer models based on 850 μm SCUBA data + L
  - $R_{T=100\ K} \rightarrow$ beam-dilution: $N(X)/bf$
  - $N(H_2)_{T>100\ K} \rightarrow$ abundances: $N_{bf}(X)/N(H_2)$
- Correlation abundances

Rotation diagrams CH_2CO

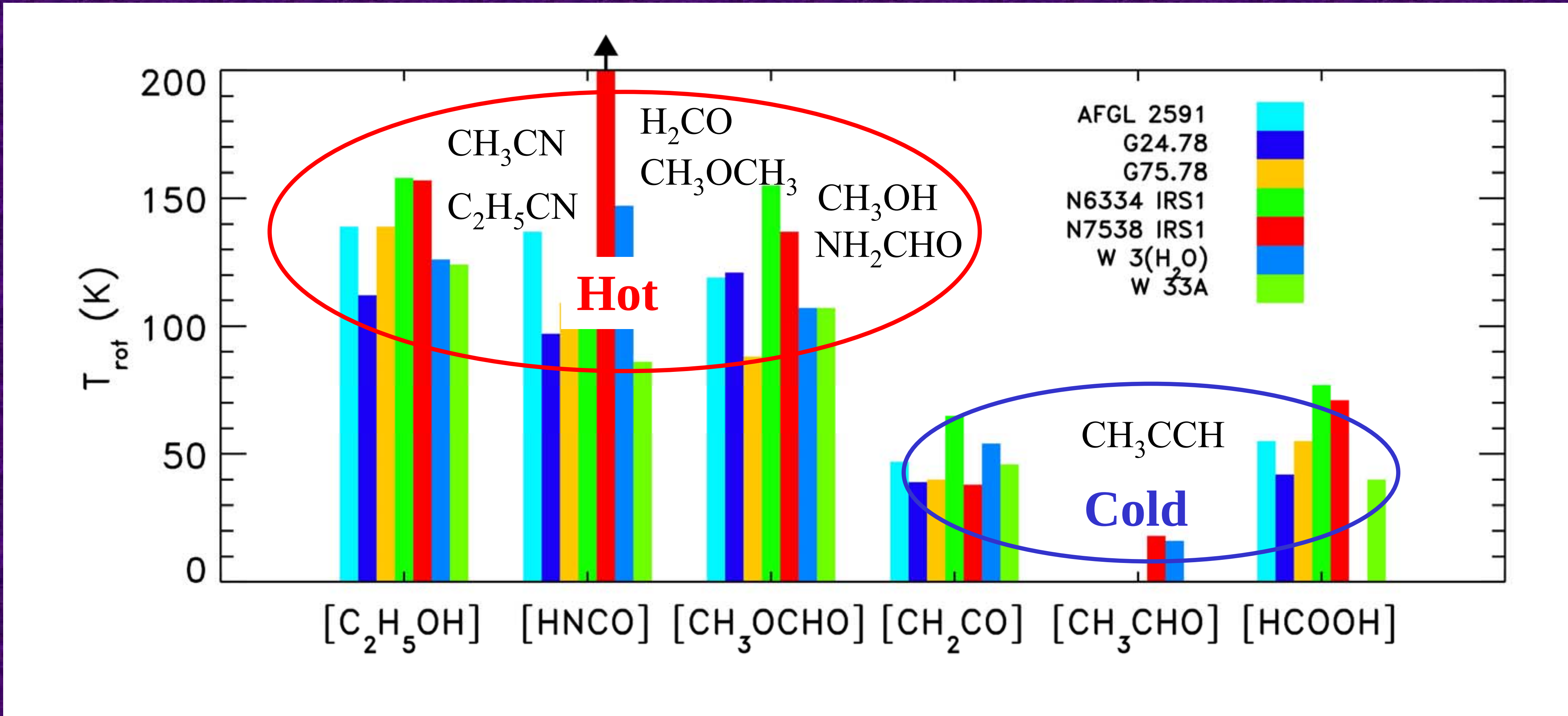


Assumptions: emission coming from a region with a single temperature and emission optically thin

Rotation diagrams: CH_3OH

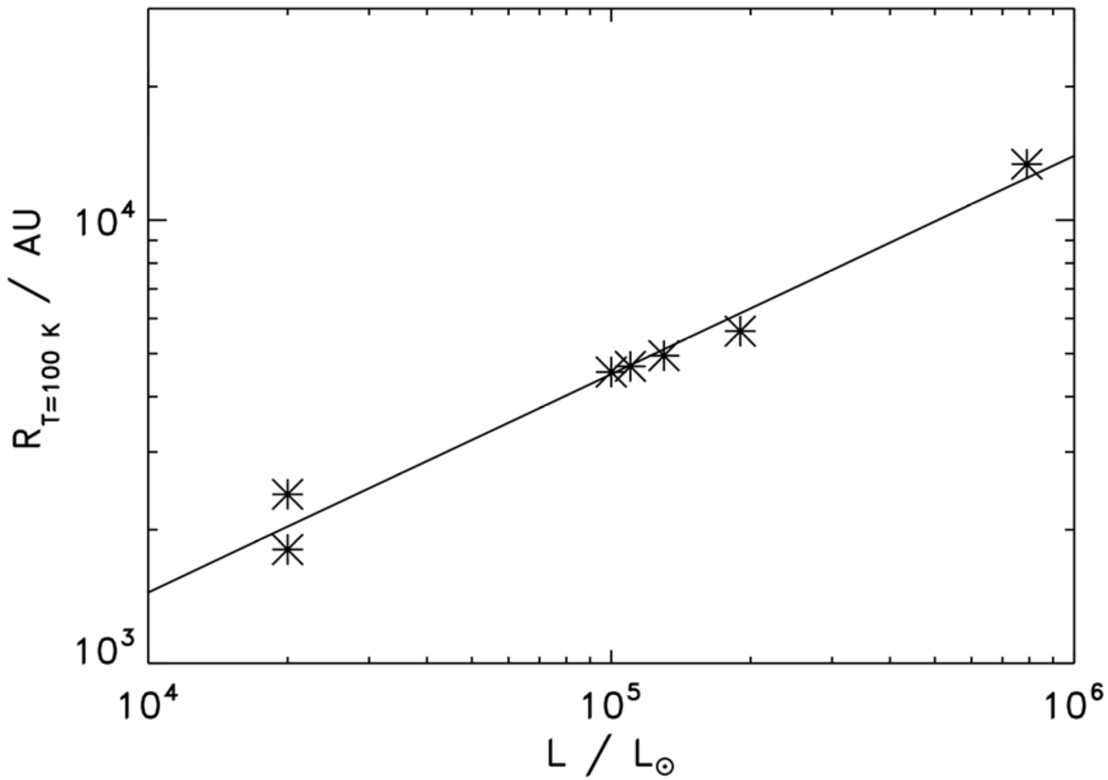


Rotational temperatures



Beam-dilution and $N(H_2)_{T>100\ K}$

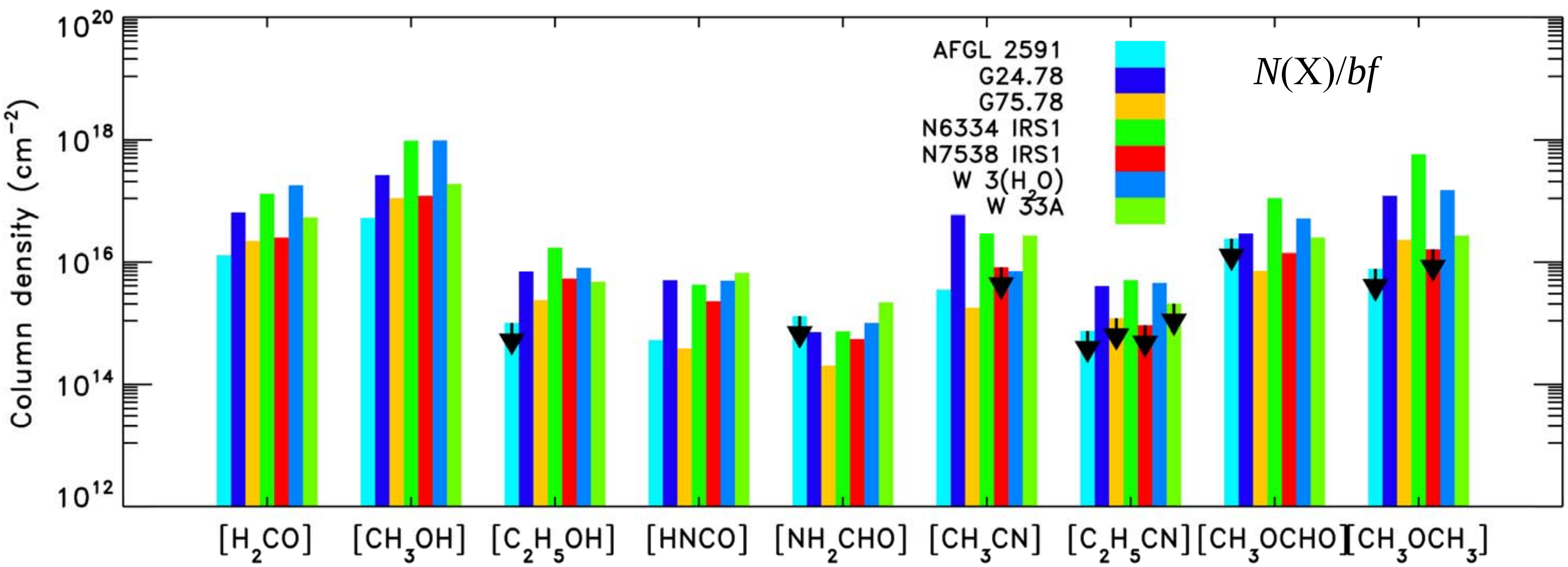
- $R_{T=100\ K}$: 10^3-10^4 AU
- $N_{T>100\ K}$: 10^{22}-10^{23} cm^{-2}
- *Bf*: 0.02-0.1



Aim:

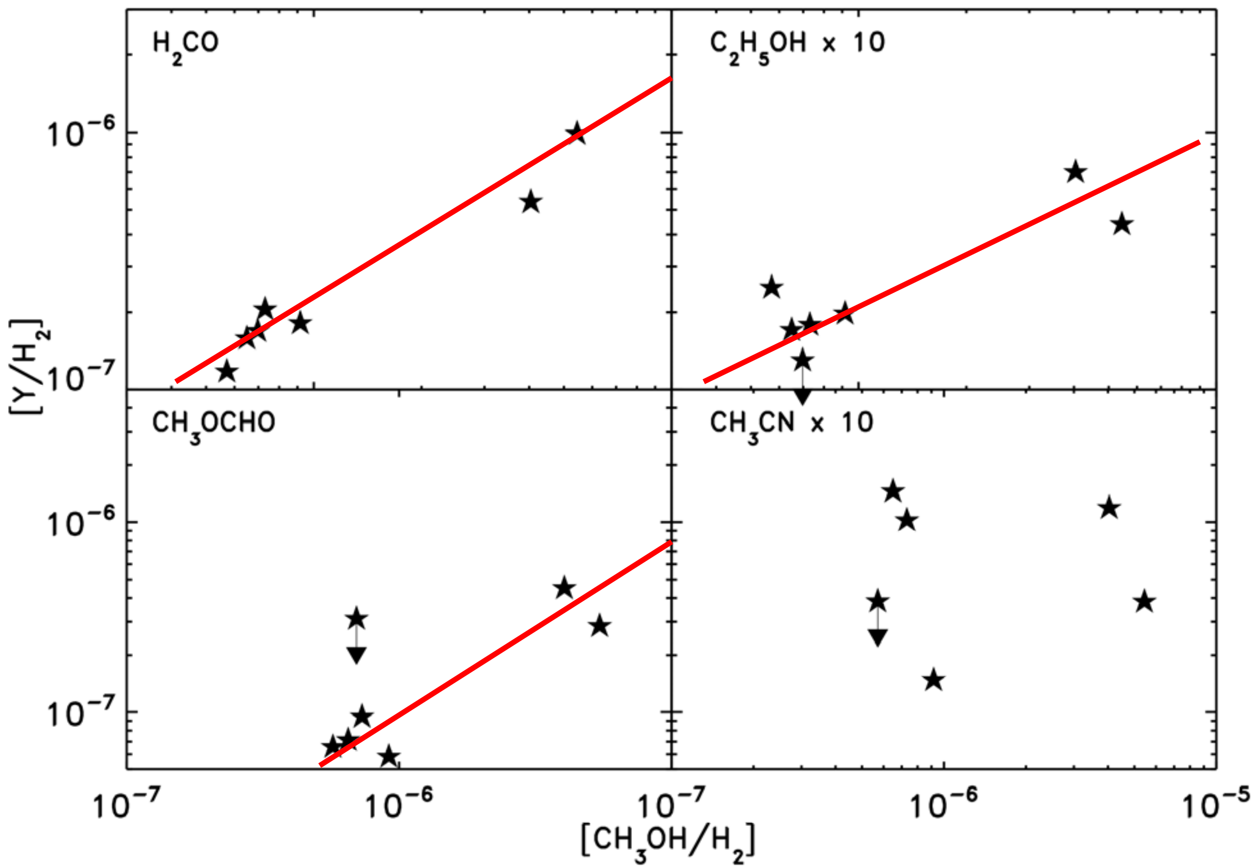
- $N(X)/bf$: source averaged column densities
- $N_{bf}(X)/N(H_2)_{T>100\ K}$: abundances

Column density trends (hot gas)



- Similar column density variations (1-2 orders of mag.) for
  - H_2CO, CH_3OH, C_2H_5OH, CH_3OCH_3, and CH_3OCHO
  - HNCO, NH_2CHO
- Note independent of beam-dilution correction!

Correlation abundances
with respect to CH_3OH

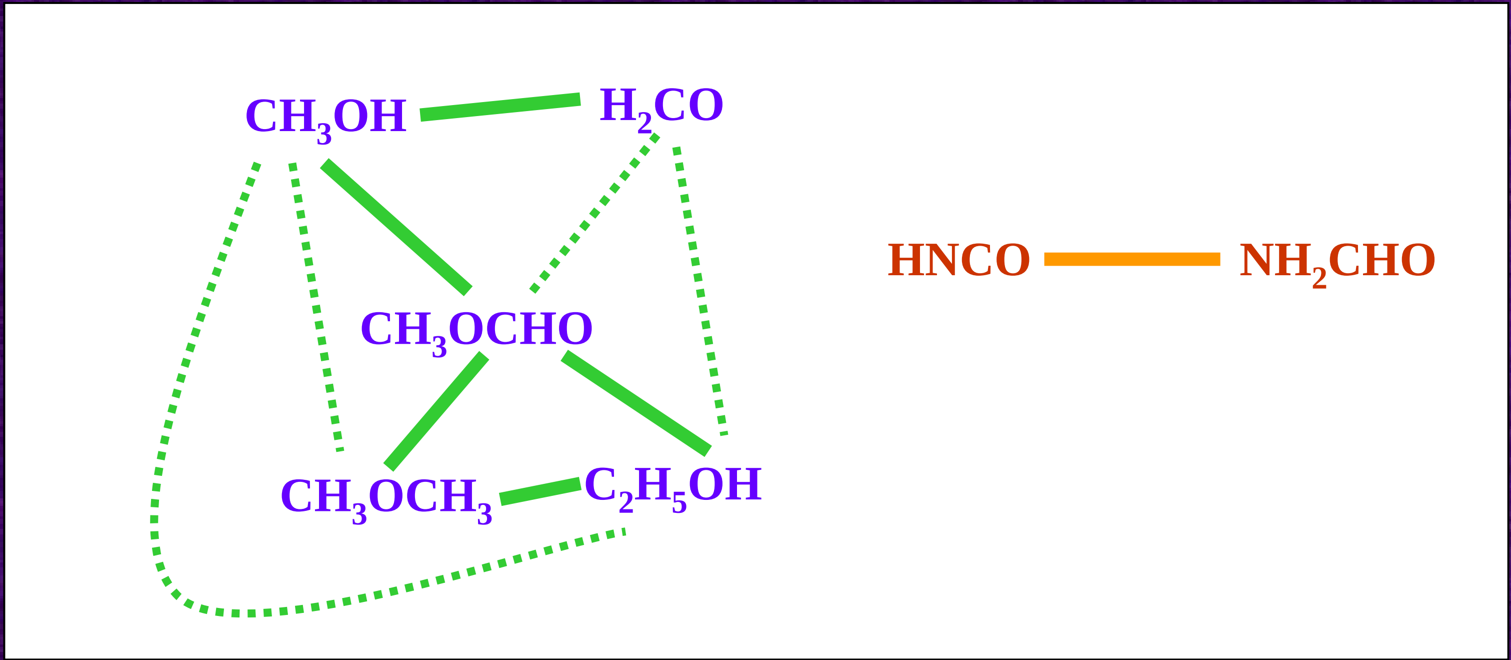


- Abundances of molecules compared in 100 K gas
  - O-bearing species correlate
  - N-bearing species correlate (HNCO & NH_2CHO)

Branching ratios

	Ratio	σ
H_2CO/CH_3OH	0.21	0.05
C_2H_5OH/CH_3OH	0.025	0.013
CH_3OCHO/CH_3OH	0.098	0.032
CH_3OCH_3/CH_3OH	0.31	0.20
$NH_2CHO/HNCO$	0.27	0.14

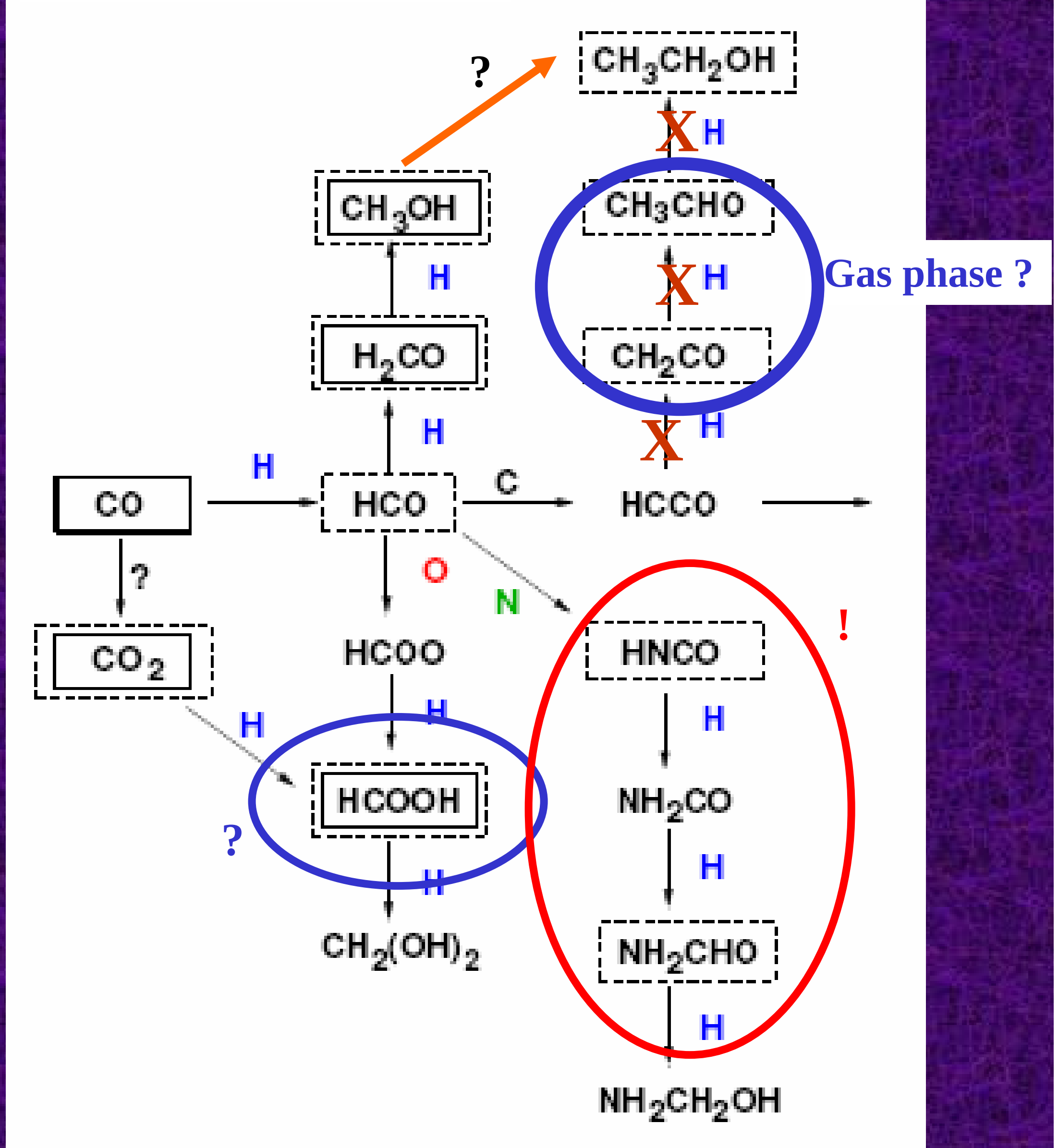
- Correlating species have constant branching ratios



Implications

- Hydrogenation to C_2H_5OH very efficient?/ Route through CH_3OH?
- Formation CH_2CO and CH_3OH?
- HCOOH relation unclear
- HNCO and NH_2CHO related

Based on Tielens and Charnley 1997



Conclusions

- Some molecules always hot, others always cold
- Significant column density (abundance) variations in hot gas
- Strong correlations for O-bearing and N-bearing species, but not with each other!

Future work:
- Spatially resolved observations
- Laboratory experiments