# Hot Molecular Cores at Mopra

## Molecular line observations of star-forming regions 2000–2002

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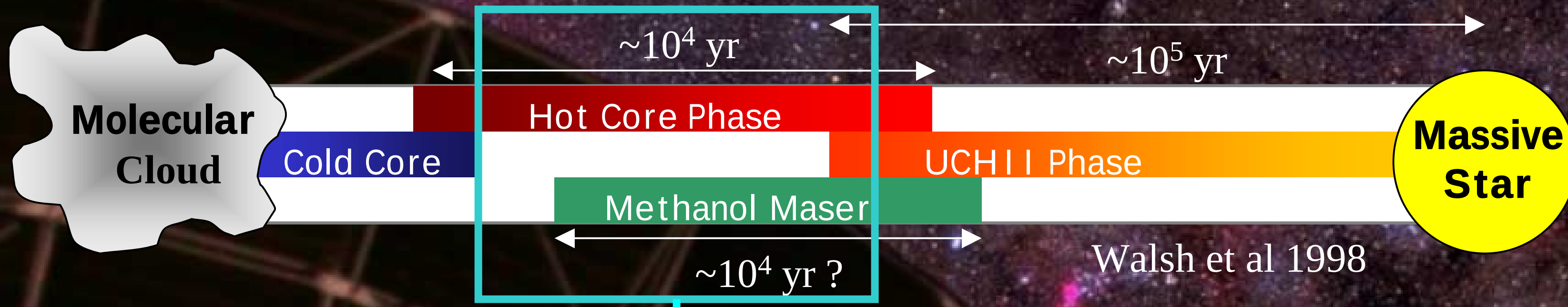
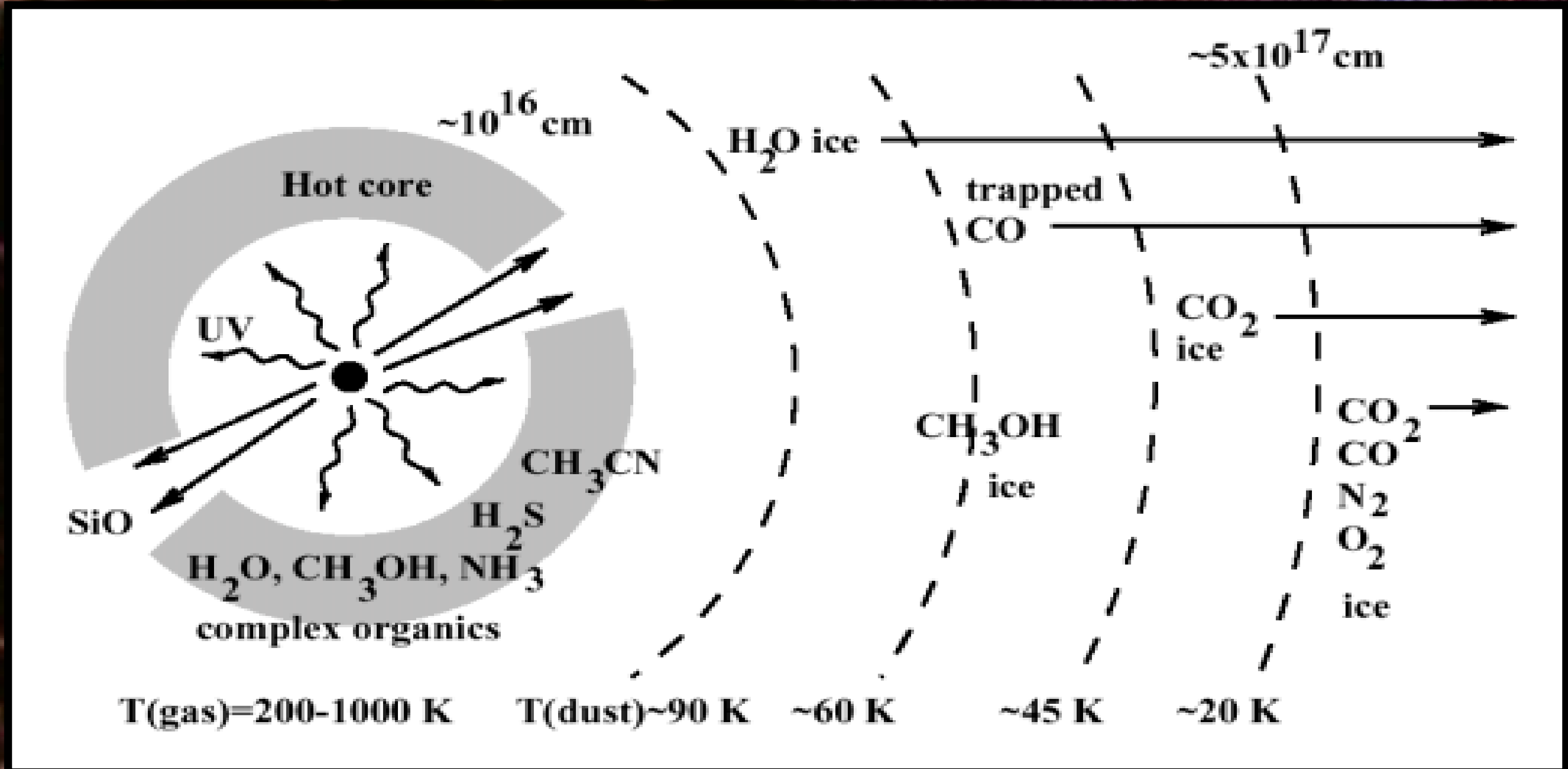
# What is a ‘Hot Molecular Core’?




- Protostellar source at an evolutionary stage characterised by rich chemistry.
- High abundances of saturated hydrocarbons fuelled by evaporation from icy grain-mantles
- $n(cm^{-3}) \sim 10^7$   $100K < T < 300K$   $0.05pc < 0.1pc$

# What is a 'Hot Molecular Core'?

- Temperature gradient: the volatile non-polar ices evaporate first leading to an *'onion layer'* effect.



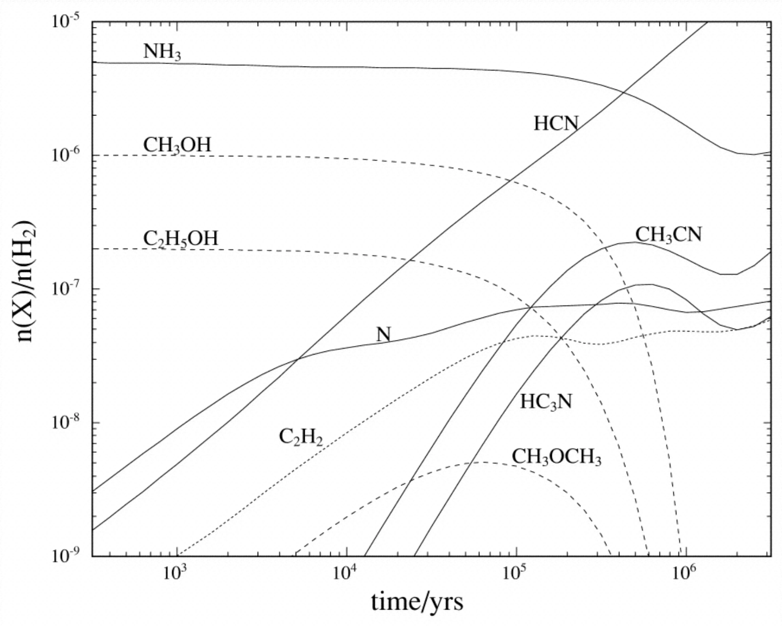

From Van Dishoeck et al 1998, after Tielens et al 1991

- Short lifetimes lead to non-equilibrium chemistry.

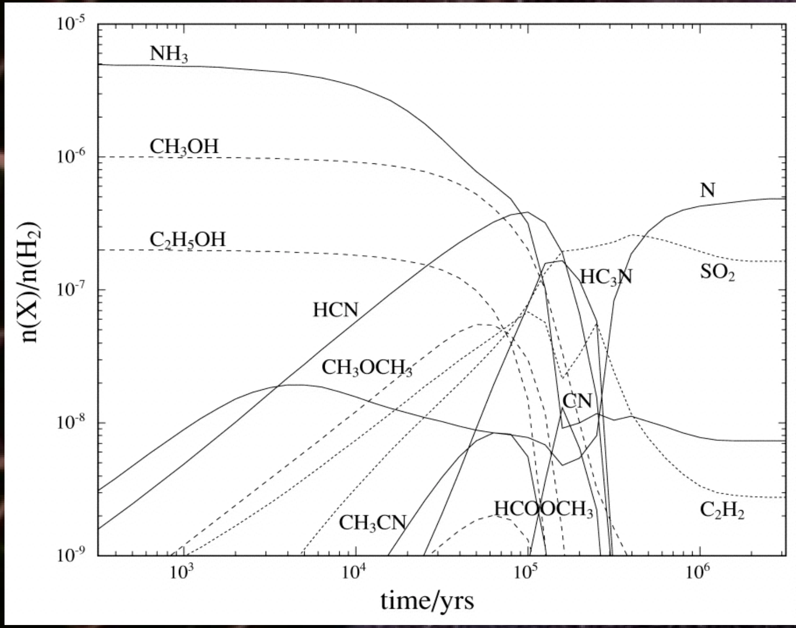
# What is a 'Hot Molecular Core'?

- Time dependent chemical models (Rodgers & Charnley)
- Depending on the initial abundances, the chemistry can be N-rich or O-rich

**N-Rich Chemistry**




**O-Rich Chemistry**




Rodgers & Charnley, 2001

- Chemical fingerprints for different evolutionary stages

# UNSW HMC Project

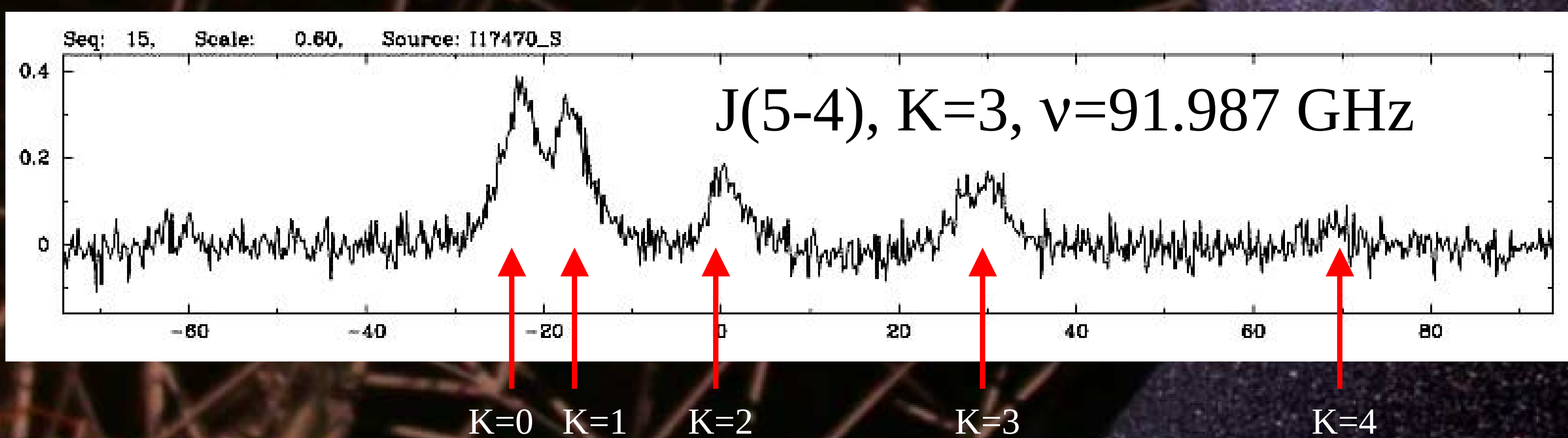
- Project Objectives:
  - Identify HMCs through their $CH_3CN$ emission.
  - Undertake a mm line survey of candidate hot molecular cores and establish their chemical and physical characteristics.
  - Constrain current chemical models of hot cores with observations, leading to the development of a time dependent ‘chemical fingerprint’.

# Source Selection

- 82 sources towards the inner galaxy.
- Source selection criteria:
  - Red IRAS colours- difference between 12, 25 & 60μm fluxes.
  - Association with methanol maser at 6.67GHz.
  - Association with a radio continuum source signifying a UCHII region.
- Sample split into two groups with strong and weak radio continuum.

# The Molecules- $CH_3CN$

- Confined to hot core phase of star formation.
  - Formed by reactions involving species desorbed from dust grains
- Symmetric top- each (J+1) to J transition has K=0 to K=J components.

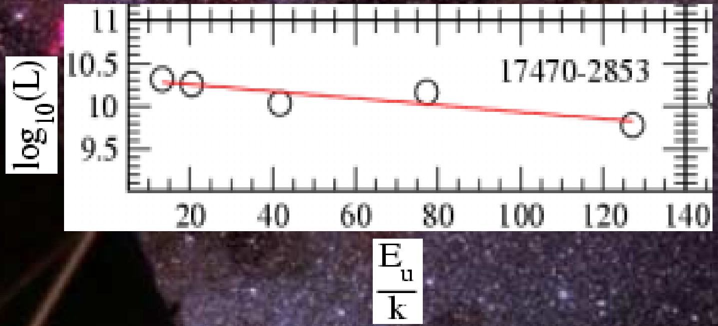



Cormac Purcell, Star Formation Group, UNSW.

# The Molecules- $CH_3CN$

- Derived Parameters: rotational temperature, $T_{rot}$ and beam-averaged column density.

$$\left(\frac{N(CH_3CN)}{Q_{rot}}\right) - \frac{E_u}{kT_{rot}} = \ln\left(\frac{3k\int T dv}{8\pi^3 \nu S \mu^2 g_l g_k}\right)$$

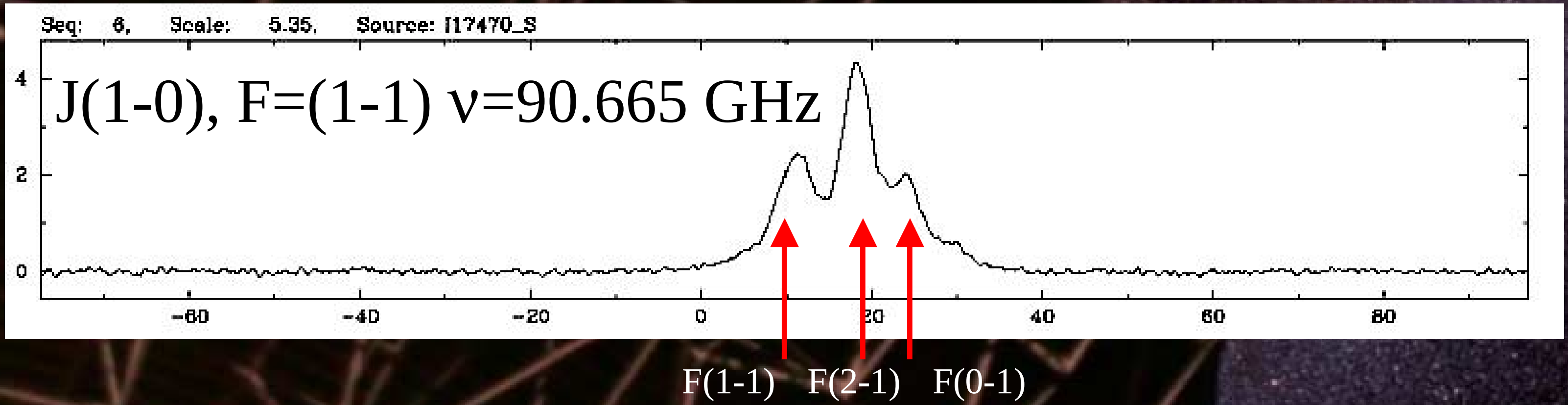



J.M. Hollis, ApJ 160:159-162

  - Slope of line fitted through integrated fluxes of K-components ~ $T_{rot}$
  - Y-axis intercept ~ beam-averaged column densities.
- Assumes LTE conditions and optically thin lines
  - May not always be valid.

# The Molecules- HCN

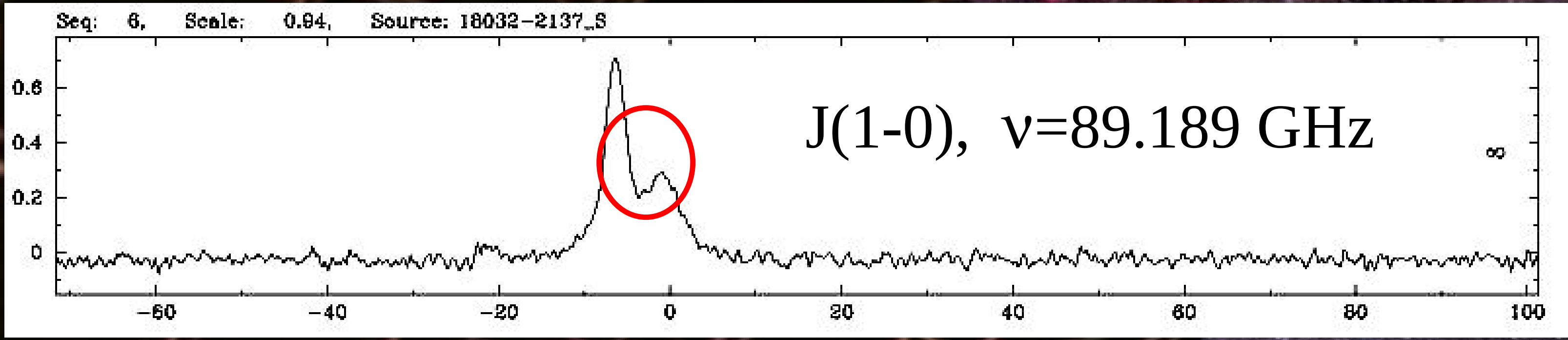
- Large dipole moment & high abundance
  - good tracer of dense gas.
- Each rotational transition split into F = 0-1, F=1-1 & F=2-1 levels, with angular momentum J-1, J & J+1




- Ratios of hyperfine components sensitive to optical depth effects.
  - At LTE predicted integrated fluxes in the ratio of 1:3:5

# The Molecules- $HCO^+$

- Large dipole moment & high abundance
  - Abundance enhanced near central source where the ionisation fraction is highest.

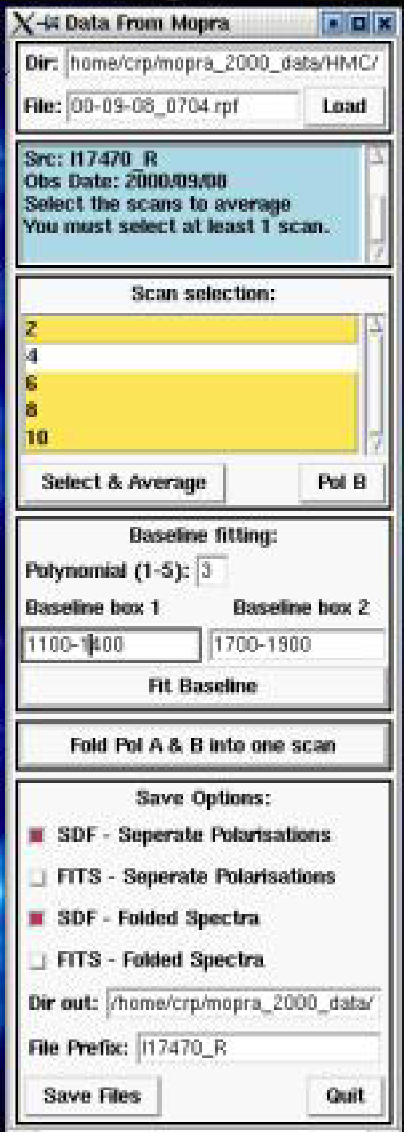


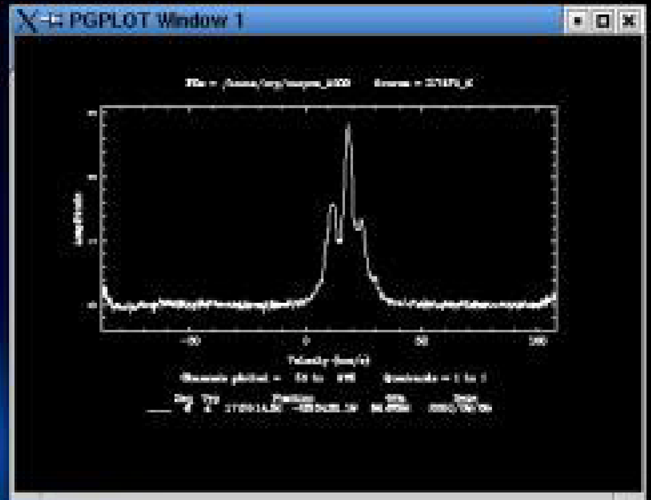

- Exhibits saturated and self-absorbed line profiles in regions of massive star-formation.
  - Signatures of infall / outflow in line profile asymmetries.

# The Molecules- Others

- $N_2H^+$
  - Distinguishes between the two primary reaction networks- N-rich and O-rich.
- HNC & $H^{13}CO^+$
  - Complimentary to the HCN and $HCO^+$ observations, may reveal optical depth effects.
  - HCN / HNC ratio depends on a number of key reactions.
- $CH_3OH$
  - Compare line strenghts to methanol maser fluxes and the number of  maser spots.

# Observations & Data Reduction




- Position switching
  - 10` / $1^0$ nod
- Bandwidth: 64MHz
- Typical $T_{sys}$ ~290K
- Sensitivities:
  - $CH_3CN$: 25 mK
  - Others: 50mK
- SPC coupled with in-house scripts used to form quotients and average scans.
- TCL/TK script available at :
  - www.phys.unsw.edu.au/astro/mopra

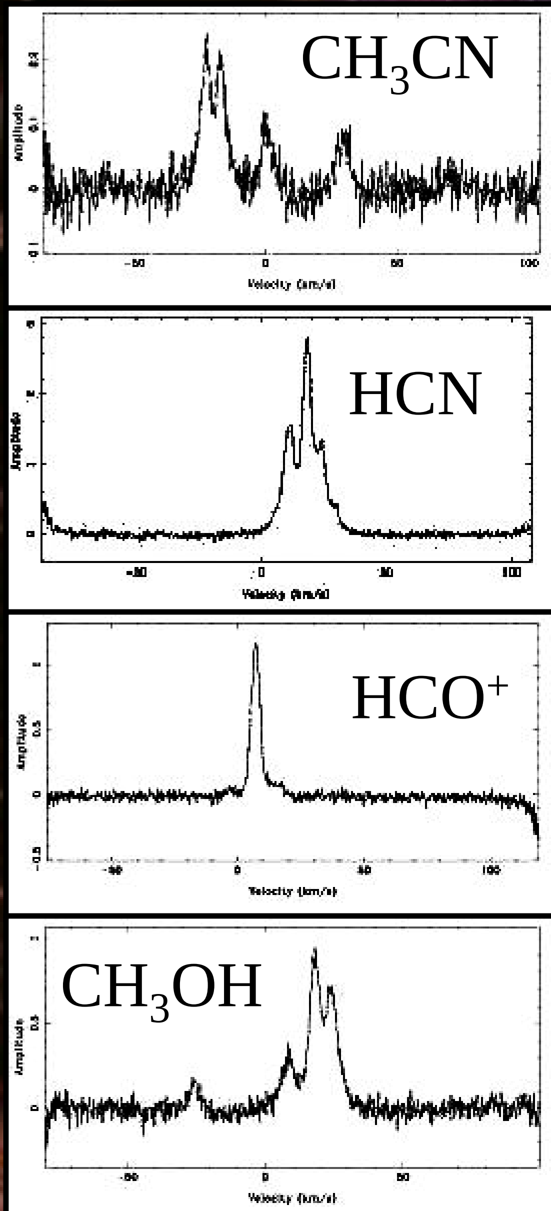
# Initial Results

- 600+ spectra taken from 2000 to 2002
- Initial reduction on the 2000 & 2001 data:

| Molecule: | Reduced: | Detection Rate: |
|---|---|---|
| $CH_3CN$ | 79 / 82 | 32% |
| HCN | 79 / 82 | 85% |
| $HCO^+$ | 79 / 82 | 91% |
| HNC | 68 / 82 | 95% |
| $H^{13}CO^+$ | 45 / 82 | 88% |

- 25 detections of $CH_3CN$ from our source list.

# IRAS 17470-2853 (G0.54-0.85)




- Strong candidate Hot Core
- Strongest $CH_3CN$ emission of the 25 detections ~ 0.2 K.
- $T_{rot}$ derived to be 108.2 K.
- Strong methanol maser emission ~ 19 Jy.
  - Strong methanol line at 96.7 GHz ~ 1 K.
- Weak associated radio flux at 8.7 GHz ~ 87 mJy
  - Supports hypothesised evolutionary scenario.

# Looking Forward

- Next 3 months:
  - Reduce and analyse current data.
- 2003
  - Any other interesting lines?- Thermal SiO
  - Additional sources- cold cores seen in 1.2mm SIMBA maps (Tracey Hill).

- High-resolution molecular maps of selected sources using ATCA
  - See  Vincent Minier's presentation.