Observations of Organic Molecules in Southern Molecular Clouds

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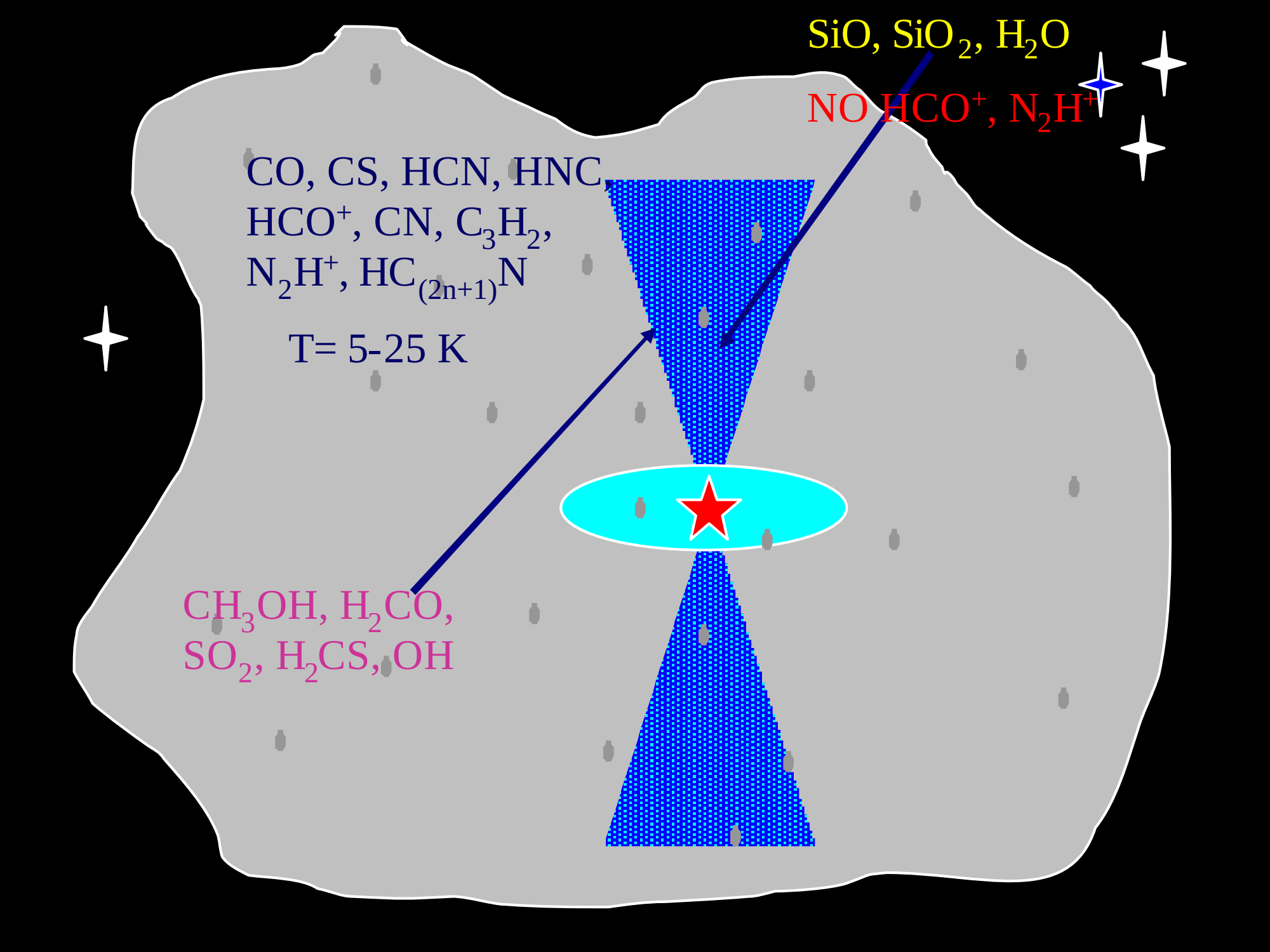
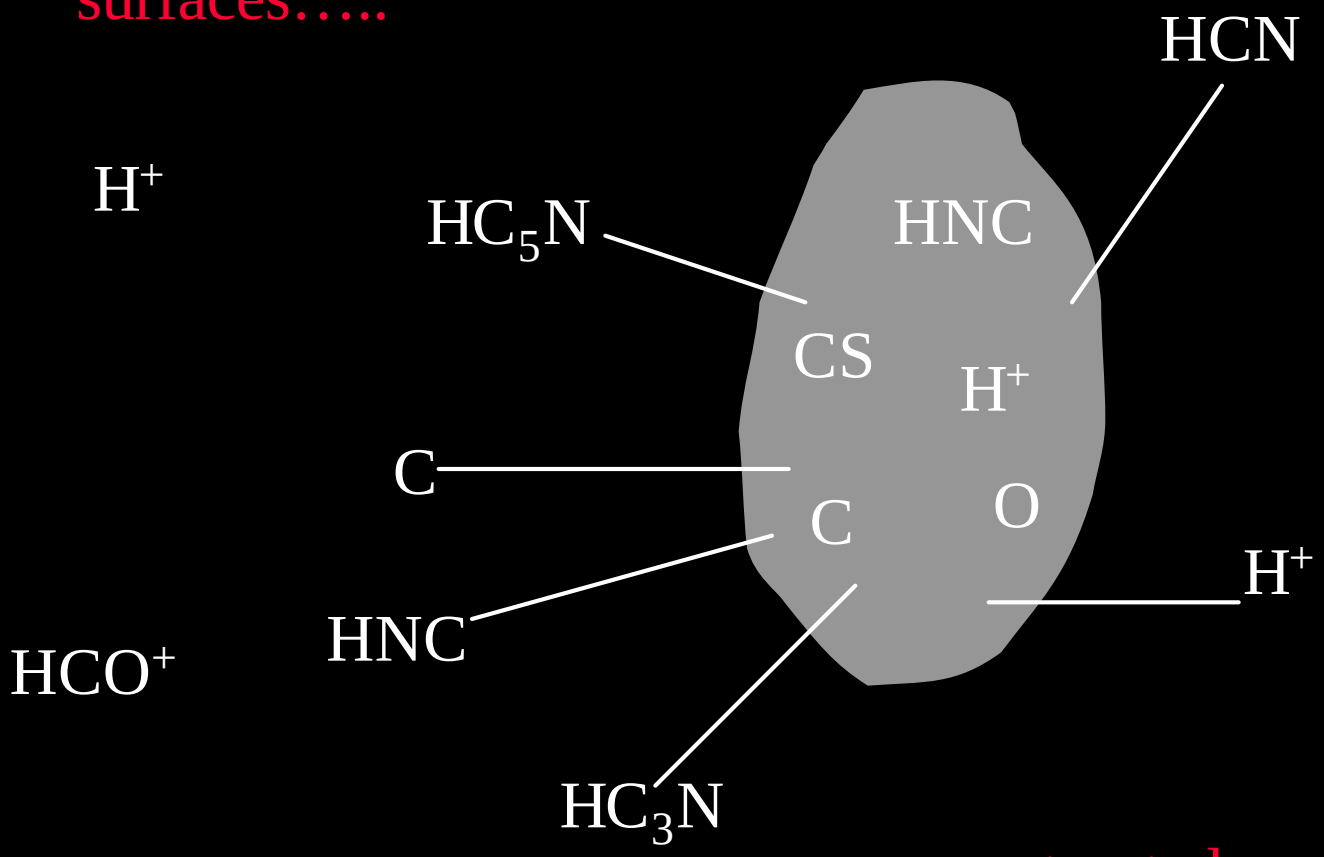
Investigating Star Formation in Southern Dense Molecular Cores

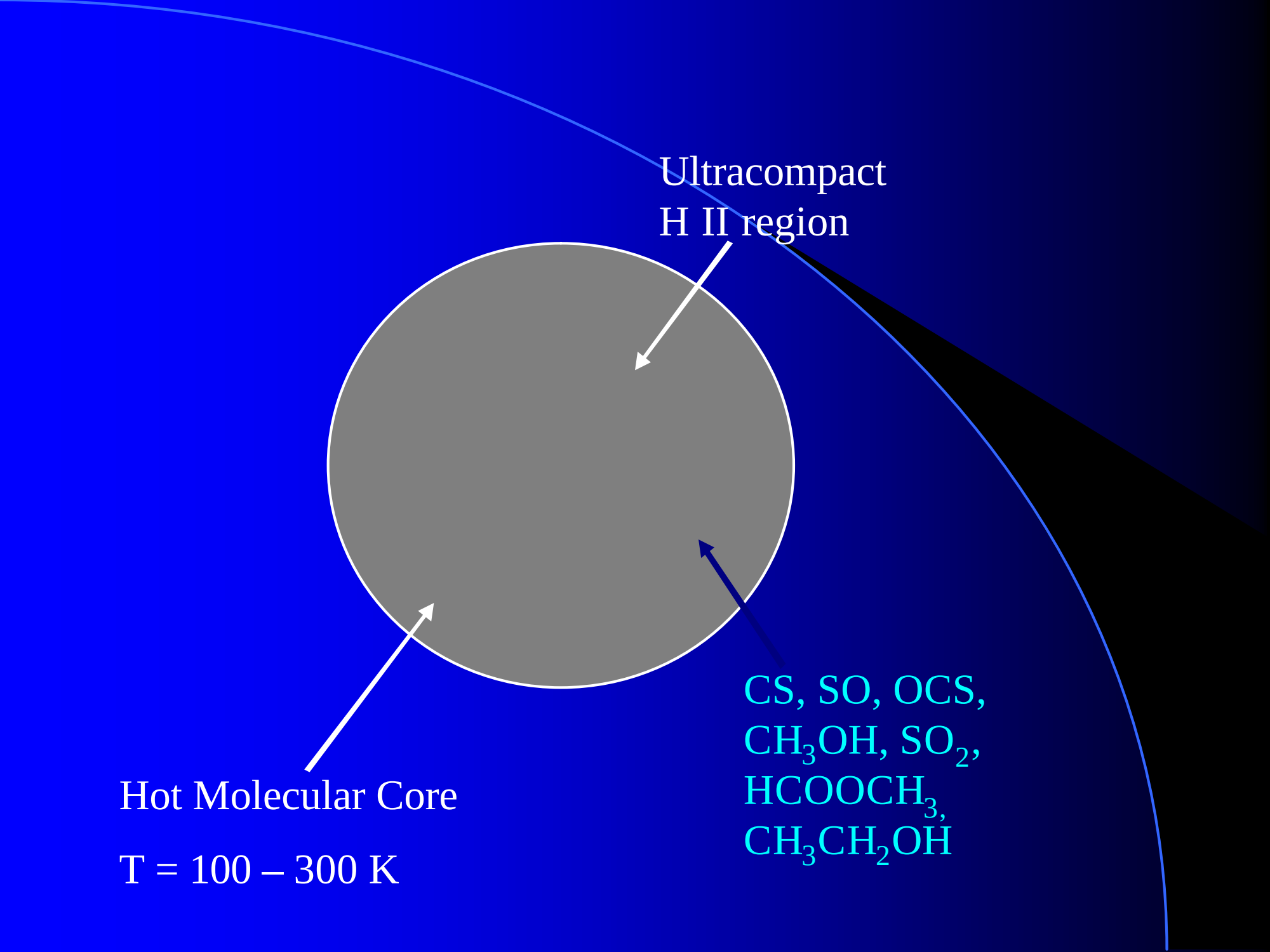
- How?
  - Mopra and SEST observations of molecular transitions between 1 and 3 mm.
  - Kinematic information from line profiles.
  - Temperatures and abundances from modelling of line emission.
- Why?
  - To produce a statistical database of molecular emission and abundances in southern molecular clouds.
  - To test theoretical predictions for molecular abundances in different physical regions of molecular clouds


SiO, SiO_2, H_2O
NO HCO^+, N_2H^+
CO, CS, HCN, HNC,
HCO^+, CN, C_3H_2,
N_2H^+, $HC_{(2n+1)}N$
T= 5-25 K
CH_3OH, H_2CO,
SO_2, H_2CS, OH

As the gas density increases, molecules collide with and stick to the grain surfaces…..



…new saturated molecules form on the grain surfaces such as CH3OH, OCS, NH3, H2CO ….


Ultracompact
H II region
CS, SO, OCS,
CH_3OH, SO_2,
$HCOOCH_3$,
CH_3CH_2OH
Hot Molecular Core
T = 100 – 300 K

Observed Sample

- 27 bright galactic-plane molecular clouds with declinations south of -30^{o}
  - $(250^{o} < l < 2^{o})$.
- Telescopes
  - The Mopra Telescope (86-116 GHz)
  - The SEST (84-250 GHz)

The Mopra Telescope ..

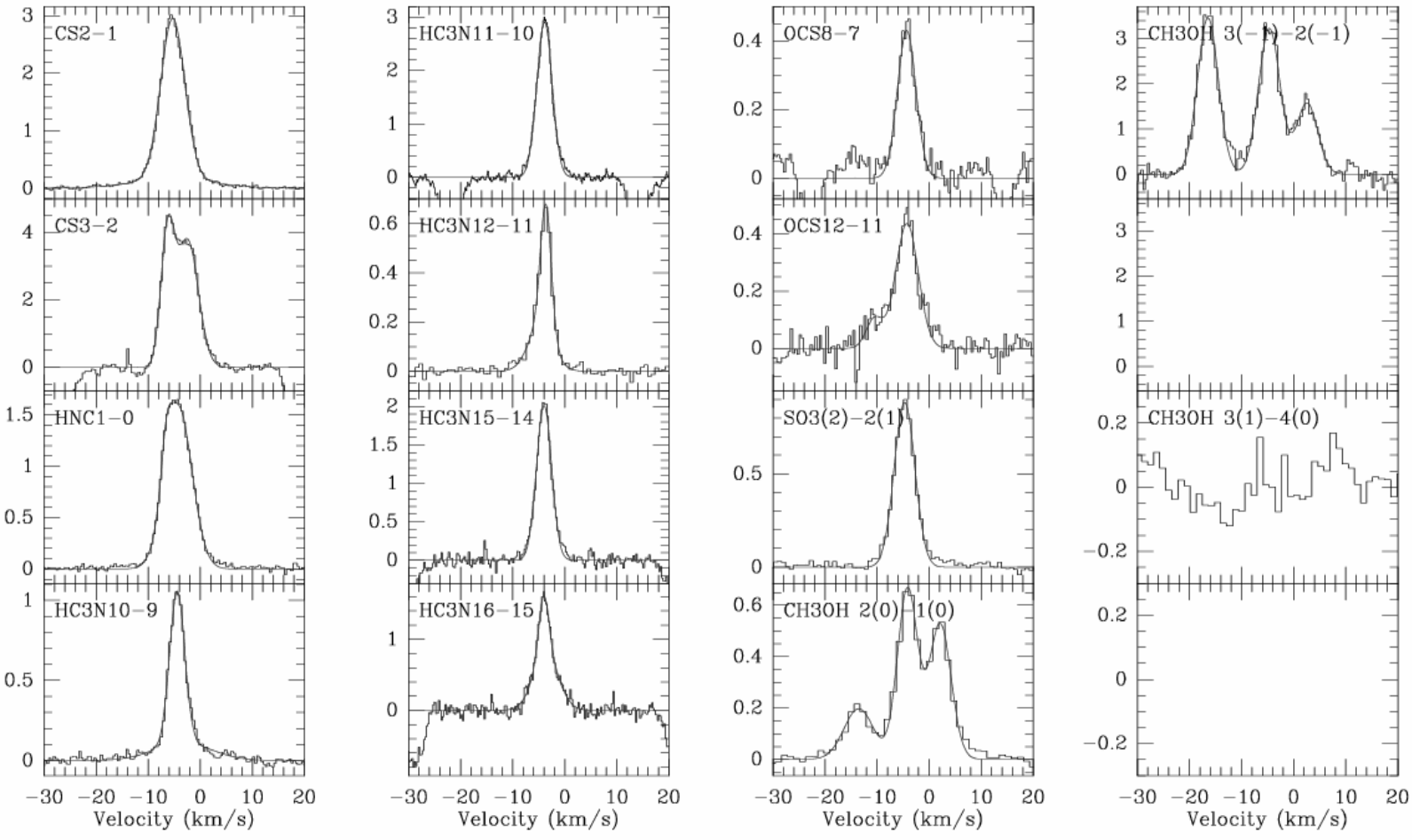
- Diameter 15 m (until 1999), 22 m (after 1999).
- 86 GHz – 116 GHz
- UNSW, ATNF
- Coonabarabran, NSW, Australia

Molecules

- Transitions of the molecules CO, CS, HCN, HNC, HCO^+, HC_3N, OCS, CH_3OH and SO and several of their isotopomers with frequencies from 86 - 240 GHz

- Beam 30 – 60 arcsec

NGC 6334 North



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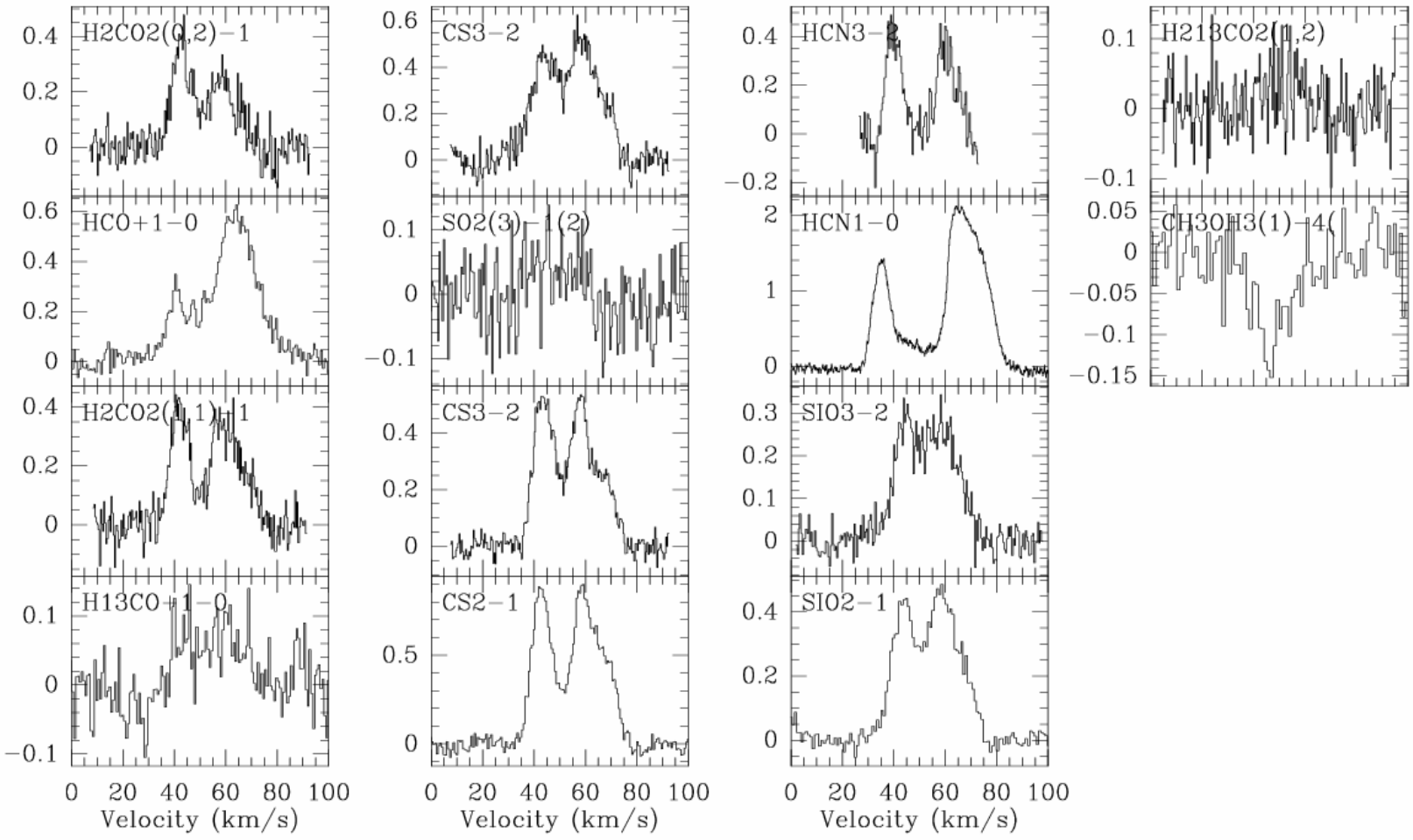
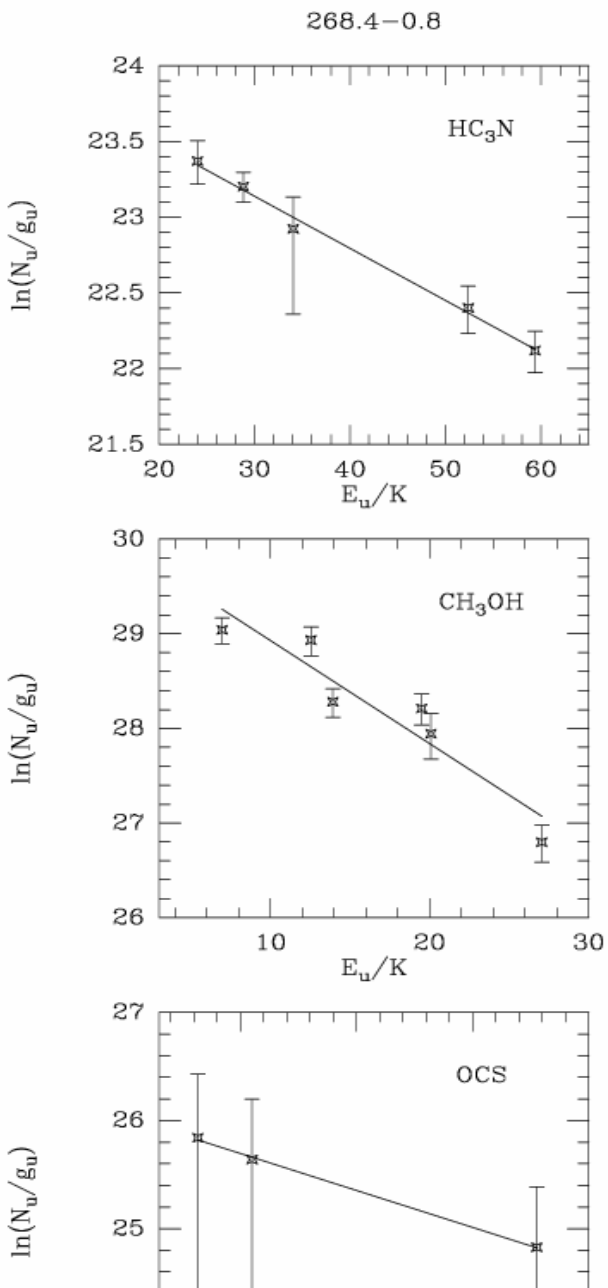
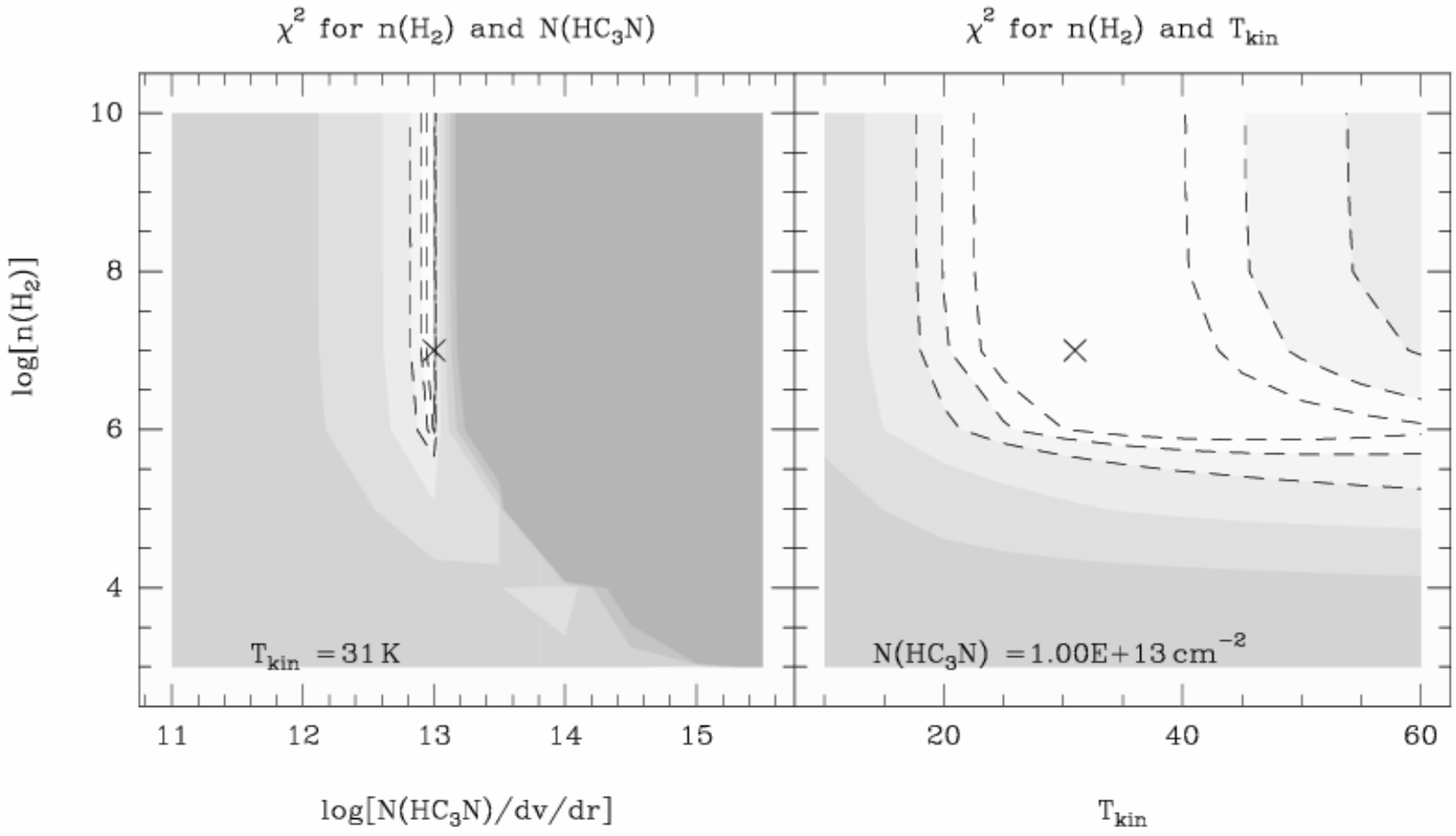


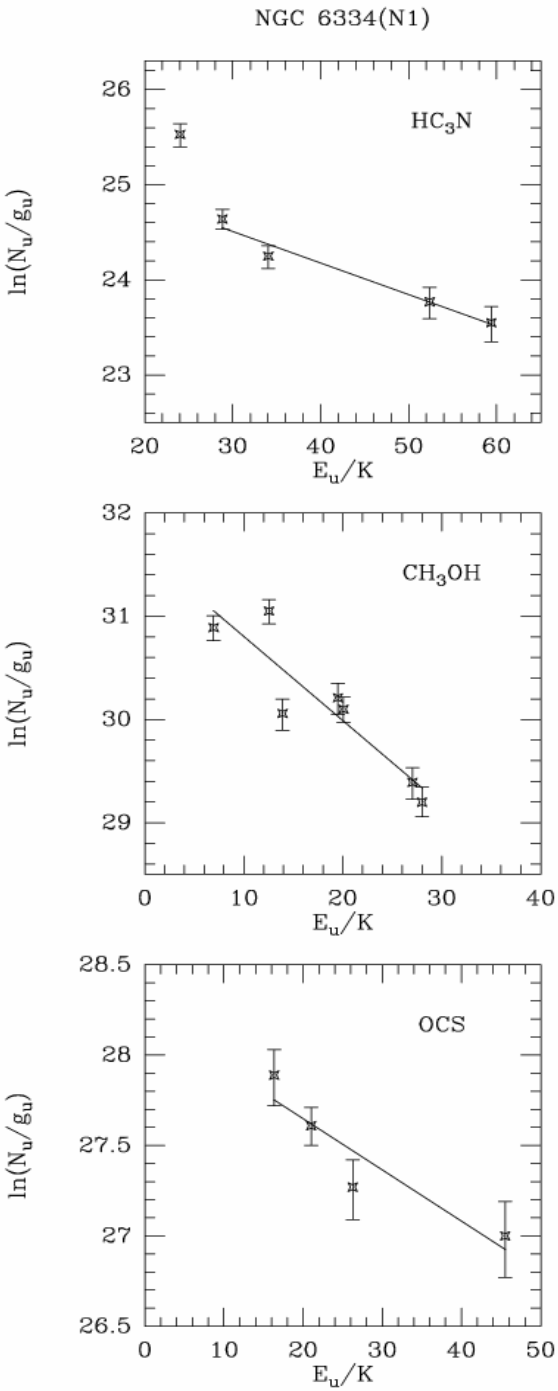
Calculating Abundances

- Rotation Diagrams
  - Goldsmith, P.F. & Langer, W.D., 1999. Ap.J., **517**, 209.
- LVG Modelling
  - LVG code courtesy of Dr Peter Schilke, MPIFR.
  - Extension to LVG code for HC_3N (Maria Hunt).
  - Castor, J.I., 1970. MNRAS, **149**, 111.
  - Lampton, M., Margon, B. & Bowyers, S., 1976. Ap.J., **208**, 177.

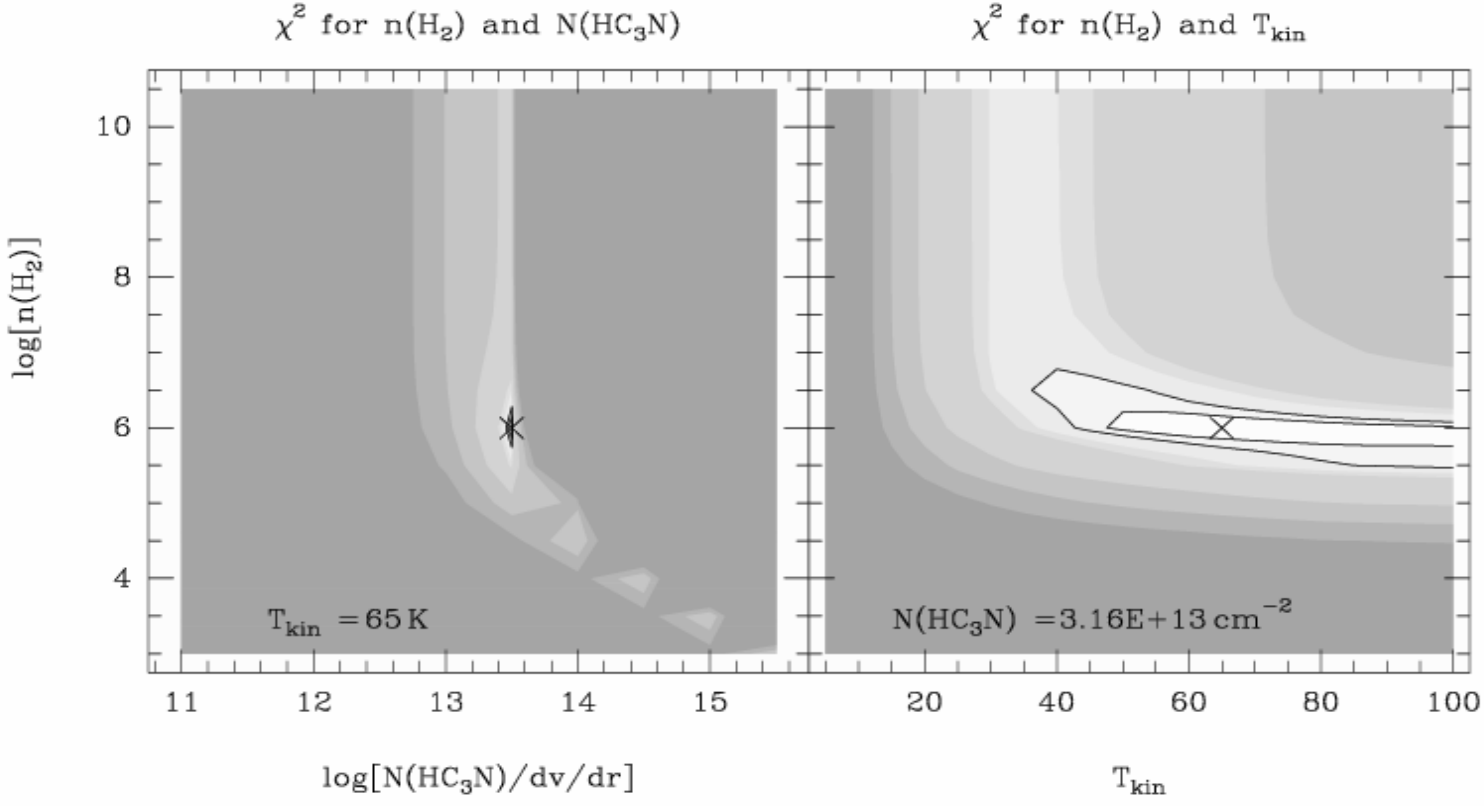

268.4−0.8
HC3N
CH3OH
OCS
ln(Nu/gu)
Eu/K

268.4−0.8


χ² for n(H2) and N(HC3N)
χ² for n(H2) and Tkin
log[n(H2)]
10
8
6
4
Tkin =31 K
N(HC3N) =1.00E+13 cm⁻²
11
12
13
14
15
20
40
60
log[N(HC3N)/dv/dr]
Tkin


NGC 6334(N1)
HC3N
CH3OH
OCS
ln(Nu/gu)
Eu/K

NGC 6334(N1)


χ^2 for n(H_2) and N(HC_3N)
χ^2 for n(H_2) and T_{kin}
log[n(H_2)]
10
8
6
4
T_{kin} = 65 K
N(HC_3N) = 3.16E+13 cm^{-2}
11
12
13
14
15
20
40
60
80
100
log[N(HC_3N)/dv/dr]
T_{kin}

Results

- Most of the dense cores showed some evidence for recent or ongoing star formation:
  - Detection of thermal CH_3OH emission.
  - Detection of OCS emission.
  - Line wings suggestive of outflow.

- G291.3-0.7, G345.5+1.5, NGC 6334(S), NGC 6334(N), NGC 6334(N1), G351.6-1.3 and G353.4-0.4 probably contain hot cores.

More Results

- The Galactic-Centre cloud G1.6-0.025 is probably undergoing a cloud-cloud collision.
- The molecular clouds G265.1+1.5, G291.3-0.7 and G1.6-0.025 have self-absorbed line profiles in many molecules, suggesting a complex cloud structure and kinematics.

ATCA mm-observations

- The higher resolution will enable the observation of more chemically homogeneous regions involved in star-formation.
- Thermal CH_3OH: At least 7 transitions within the 86 –115 GHz range.
- HC_3N and OCS have 3 transitions each accessible with the ATCA.