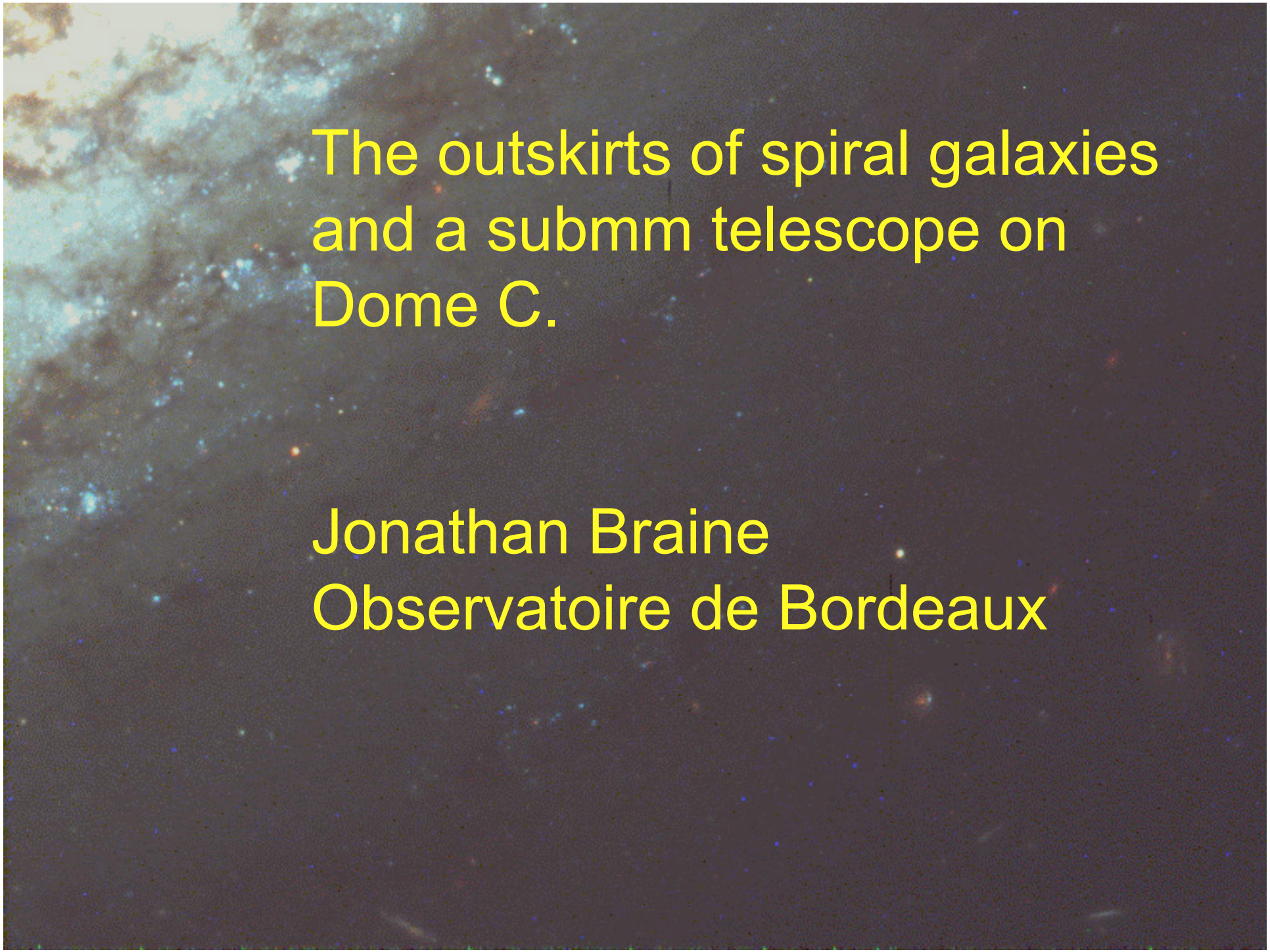
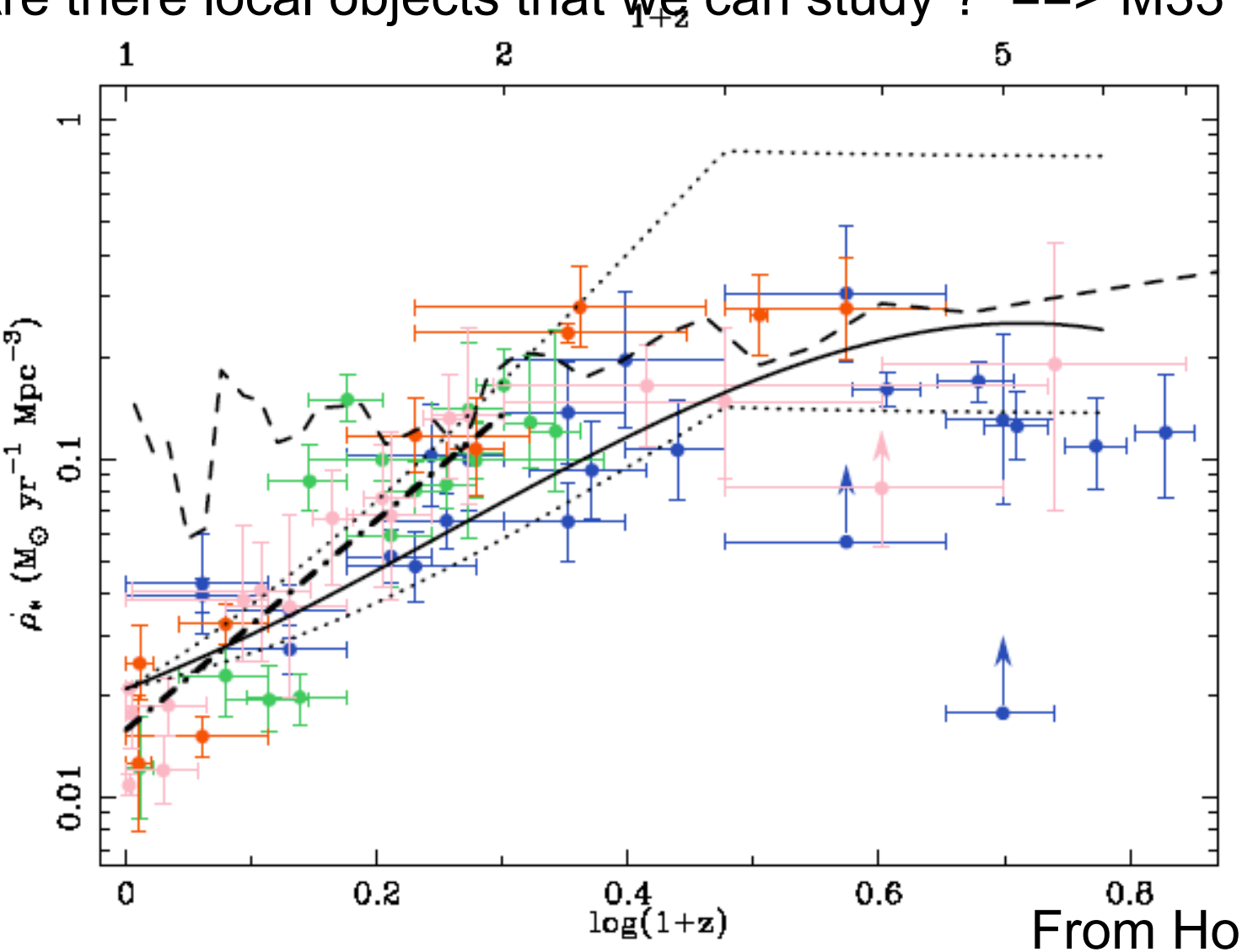

The outskirts of spiral galaxies
and a submm telescope on
Dome C.
Jonathan Braine
Observatoire de Bordeaux

Factor 10-20 increase in SFR from now to z=1 ==> higher SFE unless 10-20 times more molecular gas than today.
Why? Doing real physics on these near point sources difficult.
Are there local objects that we can study ? ==> M33



"Madau" plot of the Cosmic Star Formation Rate (SFR)

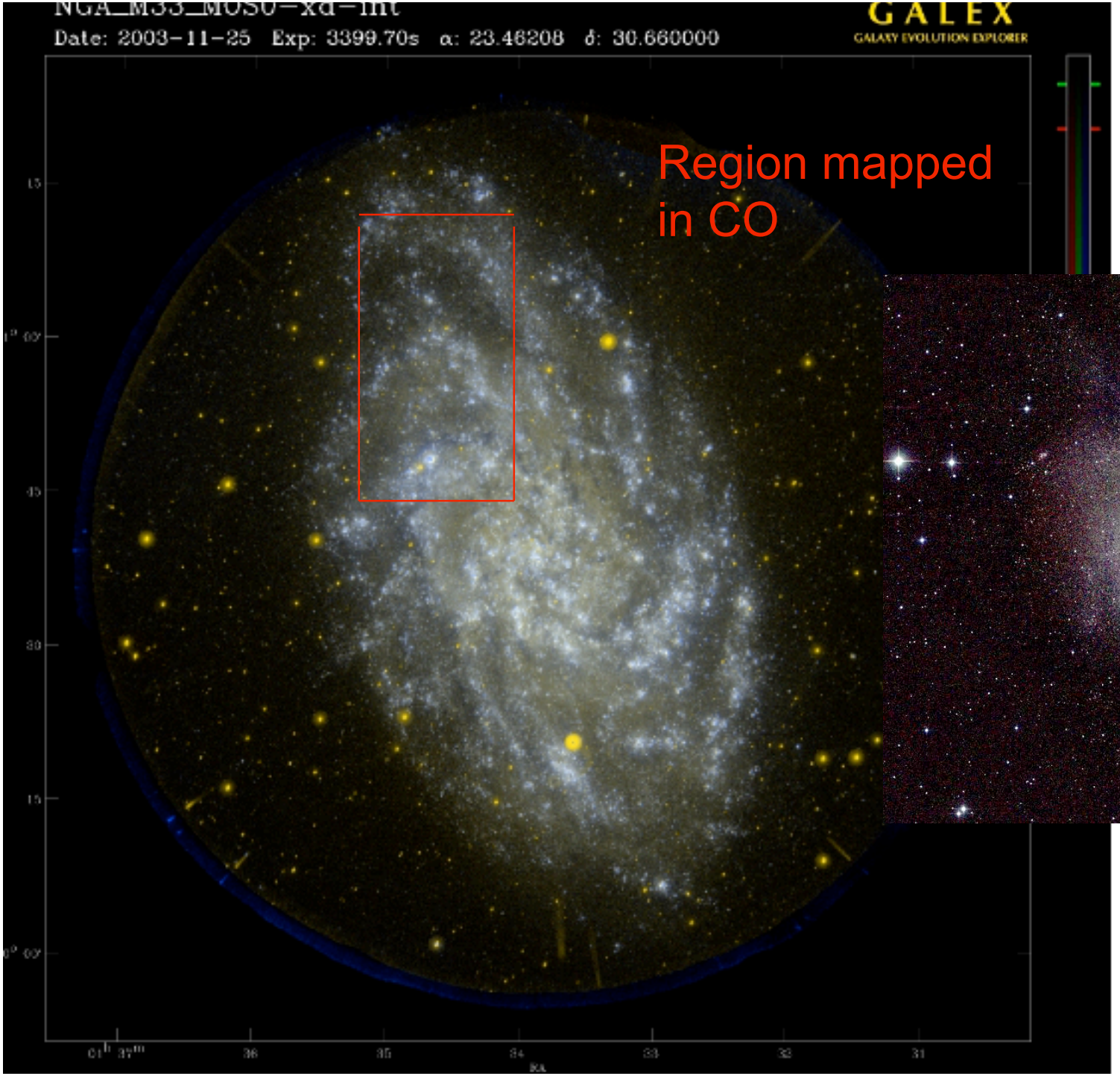
From Hopkins 2004

Why M33 ?

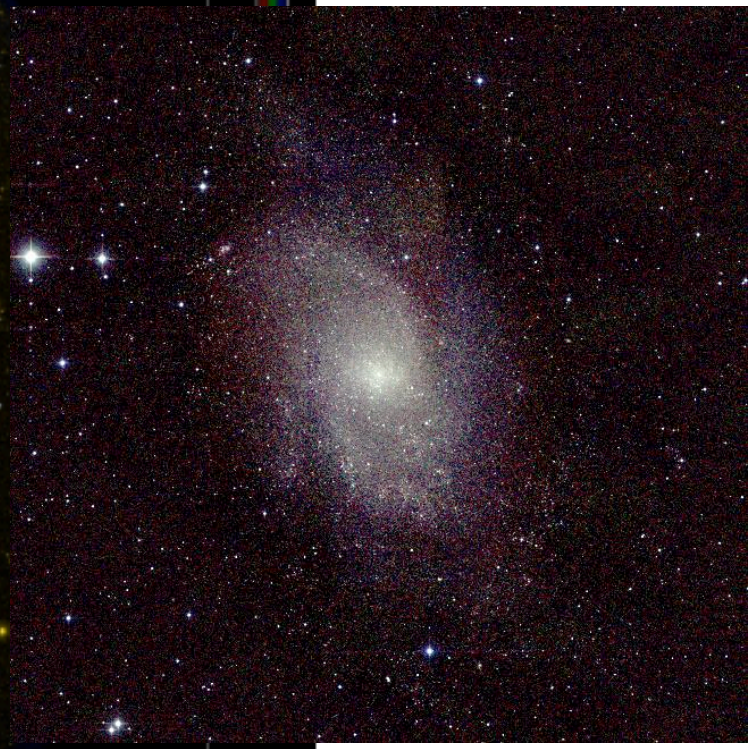
M33 is a small spiral with little sign of a halo formed through mergers like M31.
M33 has a young stellar population and a subsolar metallicity.
M33 has a high gas mass fraction.
M33 is very nearby, part of the Local Group.

M33 is a dynamically and chemically young spiral.
Is it like the intermediate redshift population?

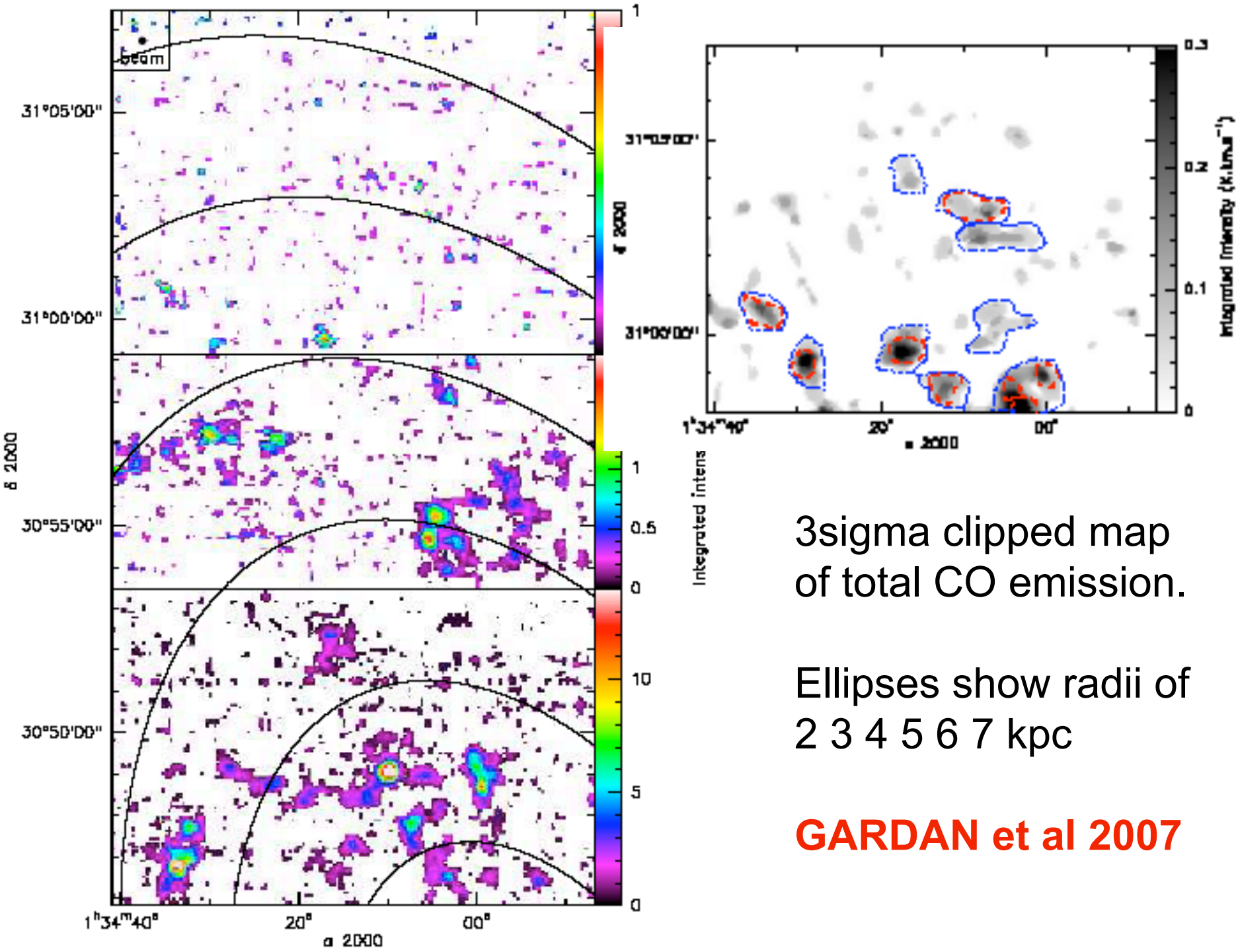
Close enough to study individual molecular clouds.
Possible to constrain NH2/Ico ratio.
Geometry well known, lots of complementary data.



2MASS image at same scale



Disk is obviously young.

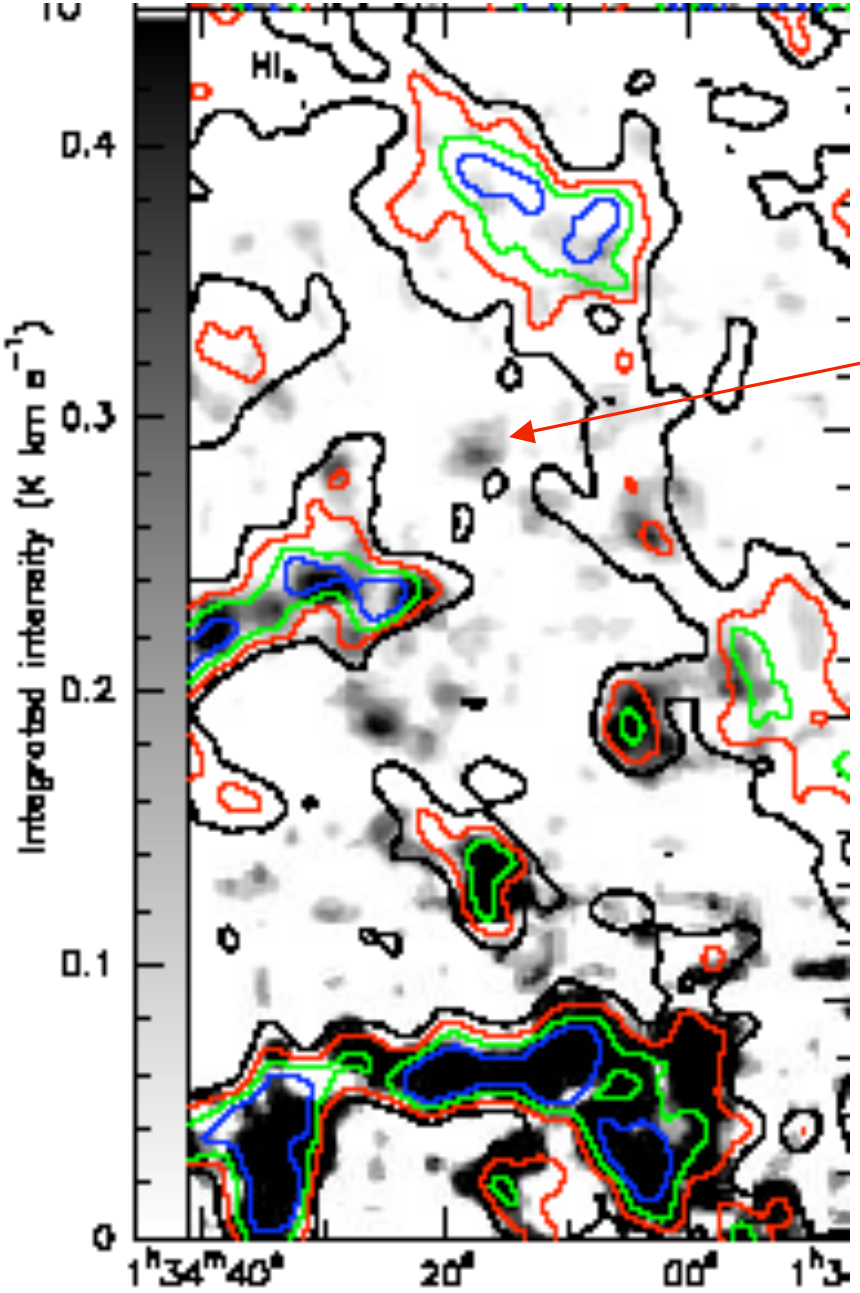


3sigma clipped map of total CO emission.

Ellipses show radii of 2 3 4 5 6 7 kpc

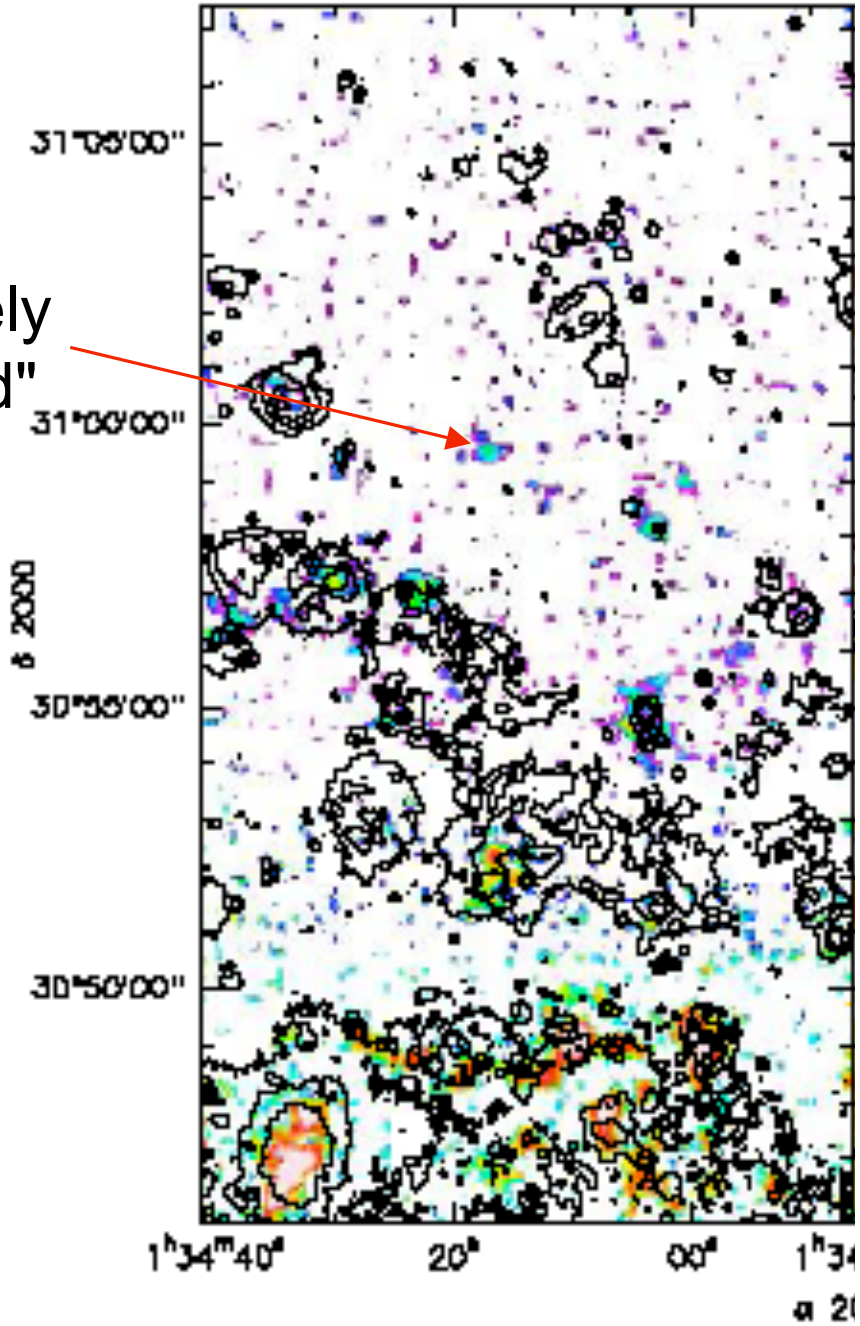
GARDAN et al 2007

HI contours on CO



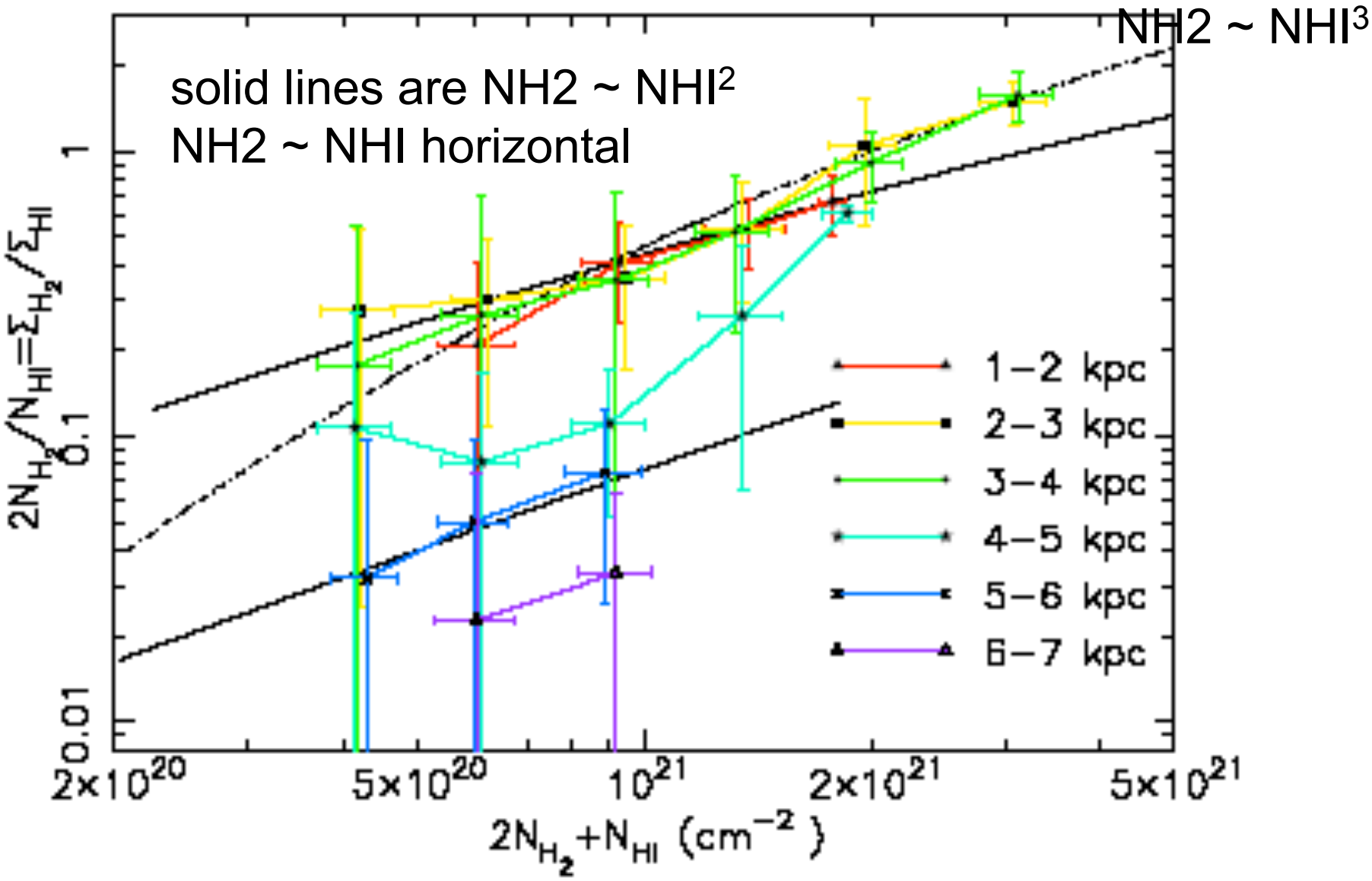
"lonely cloud"

Halpha contours on CO



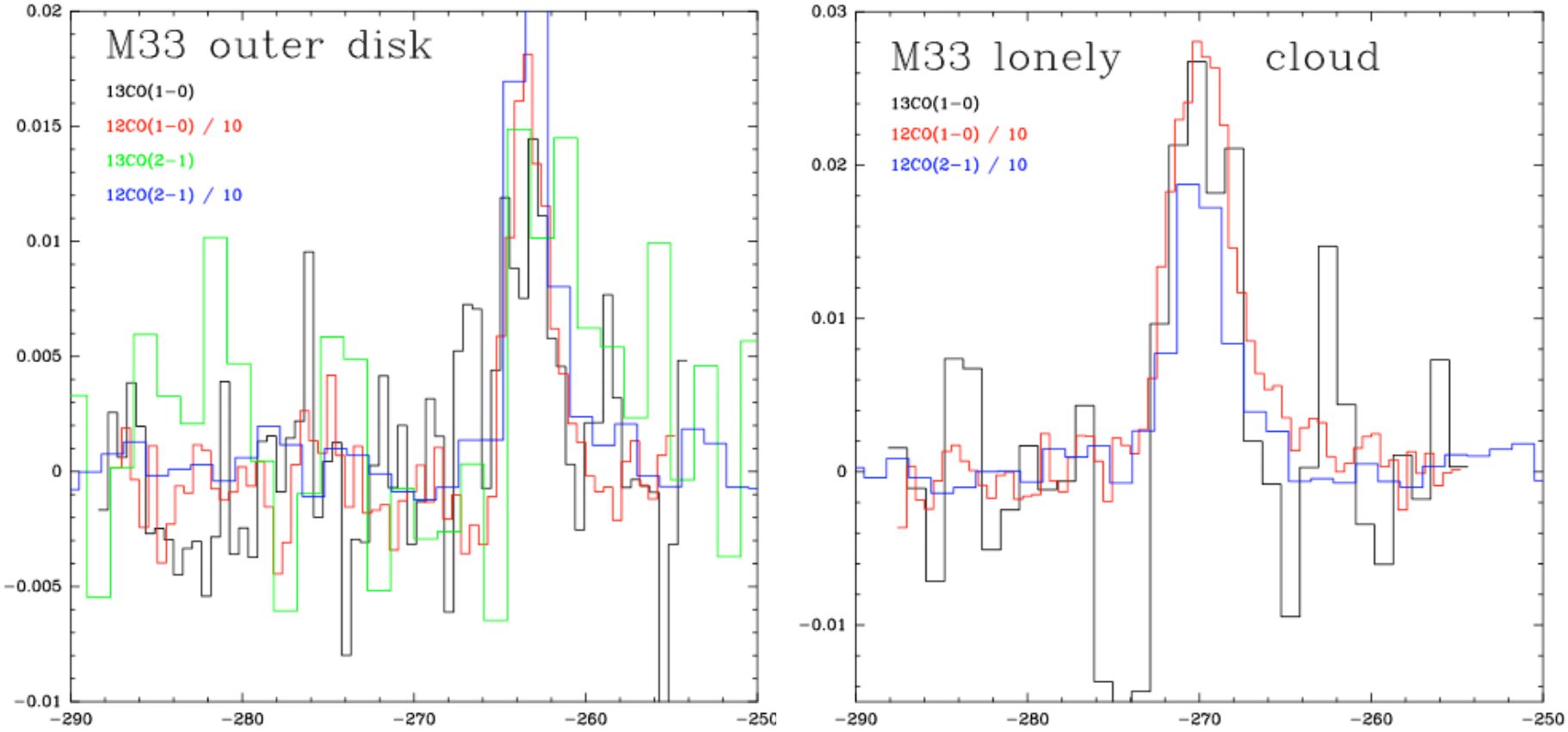
H2 fraction increases with NH==>efficient H2 formation?

But decreases with radius at same NH



13CO observations of M33

Even beyond R25 ("outer disk" cloud), the 13CO is detected with a line ratio ~10, showing that the gas is quite optically thick in 12CO.



"Virial" theorem suggests NH2/Ico ~ 4 x 10^{20} cm^{-2}/(Kkm/s)

Main results of M33 study

Molecular clouds found far out, beyond R25.

Not always in spiral arms or on HI or Halpha peaks.

Even beyond R25 in a subsolar metallicity galaxy we detect 13CO.

Narrow CO lines ==> constraint on NH2/Ico so molecular gas mass is reasonably well known.

The Star Formation Efficiency (SFR/MH2) is higher than in typical local universe spirals. Resemblance to z~1 galaxies confirmed. Further study in progress.

Submm astronomy in Bordeaux

Bordeaux heavily involved in HSO/HIFI and ALMA.
A large submm antenna on e.g. Dome C would provide a sort of high-resolution HIFI except for water lines.

Major science cases

- pre-stellar cores -- para H2D+, 200/450 continuum
  - IMF of pre-stellar cores
- High-Mass Protostellar objects --
  - para H2D+, hi-J CO, 200/450 continuum

- individual clouds in nearby galaxies --
  - CI lines, 200/450 continuum ideal for cool dust
  - detection possible to Tdust ~ 6-8 K
  - pc resolution in LMC/SMC, 15pc M31, M33

Long night an important advantage at high frequency

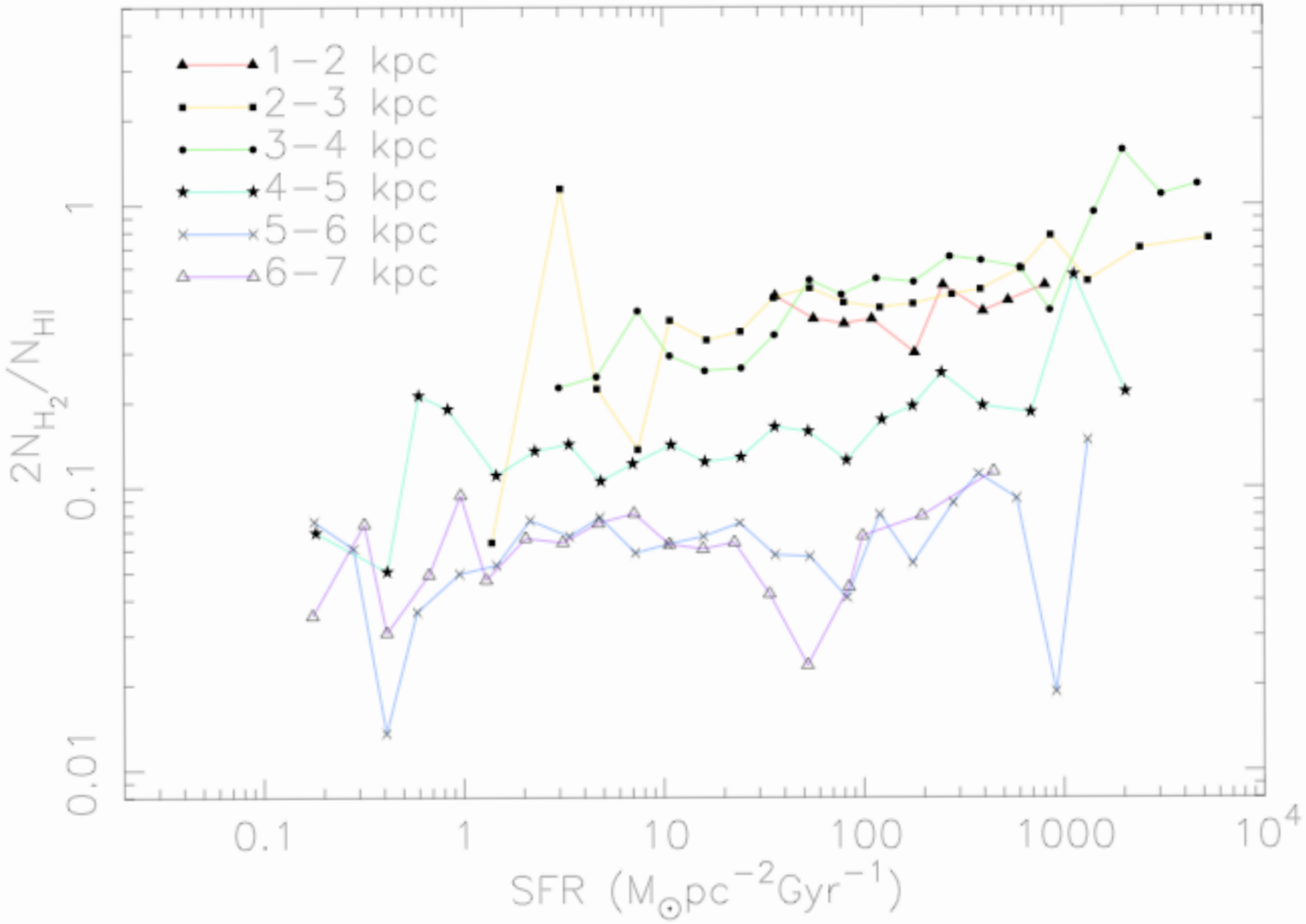
Lack of day/night on 24 hour timescale means that the telescope dish can fully relax and remain at high surface accuracy for long periods.
Even at 350 microns, the surface accuracy of ALMA antennas will probably be poor and at least several hours of the night will be necessary for the dish to stabilize. At 200, this is much more important.

A major advantage of Antarctica is the lack of daily illumination (and thus deformation) of the telescope surface.

Dish: the bigger the better (sensitivity, beamsize)

THE END

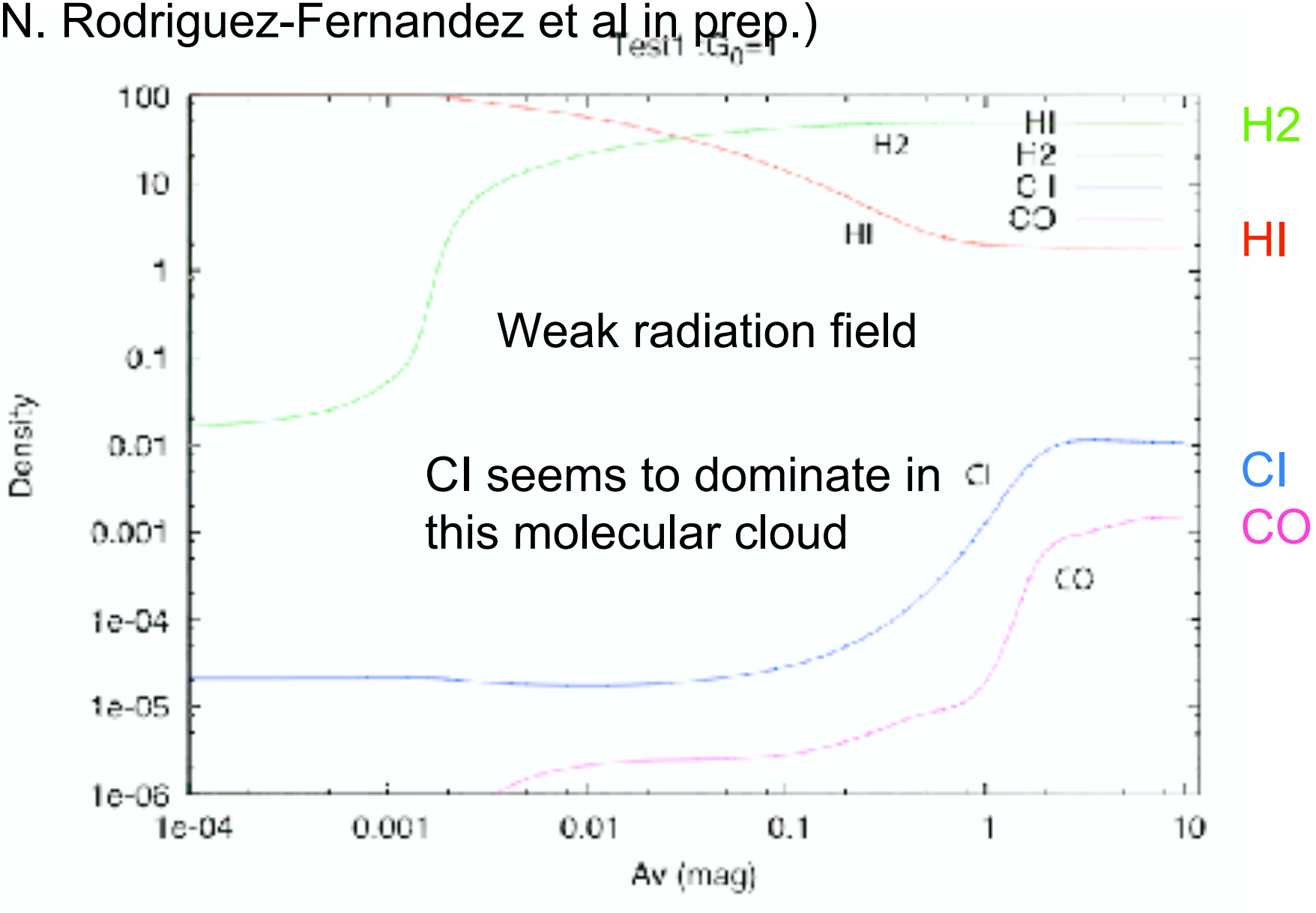
Even at a given star formation rate, the molecular fraction decreases with radius.



But this is not an increase in the SFE because NHI/SFR increases with radius.

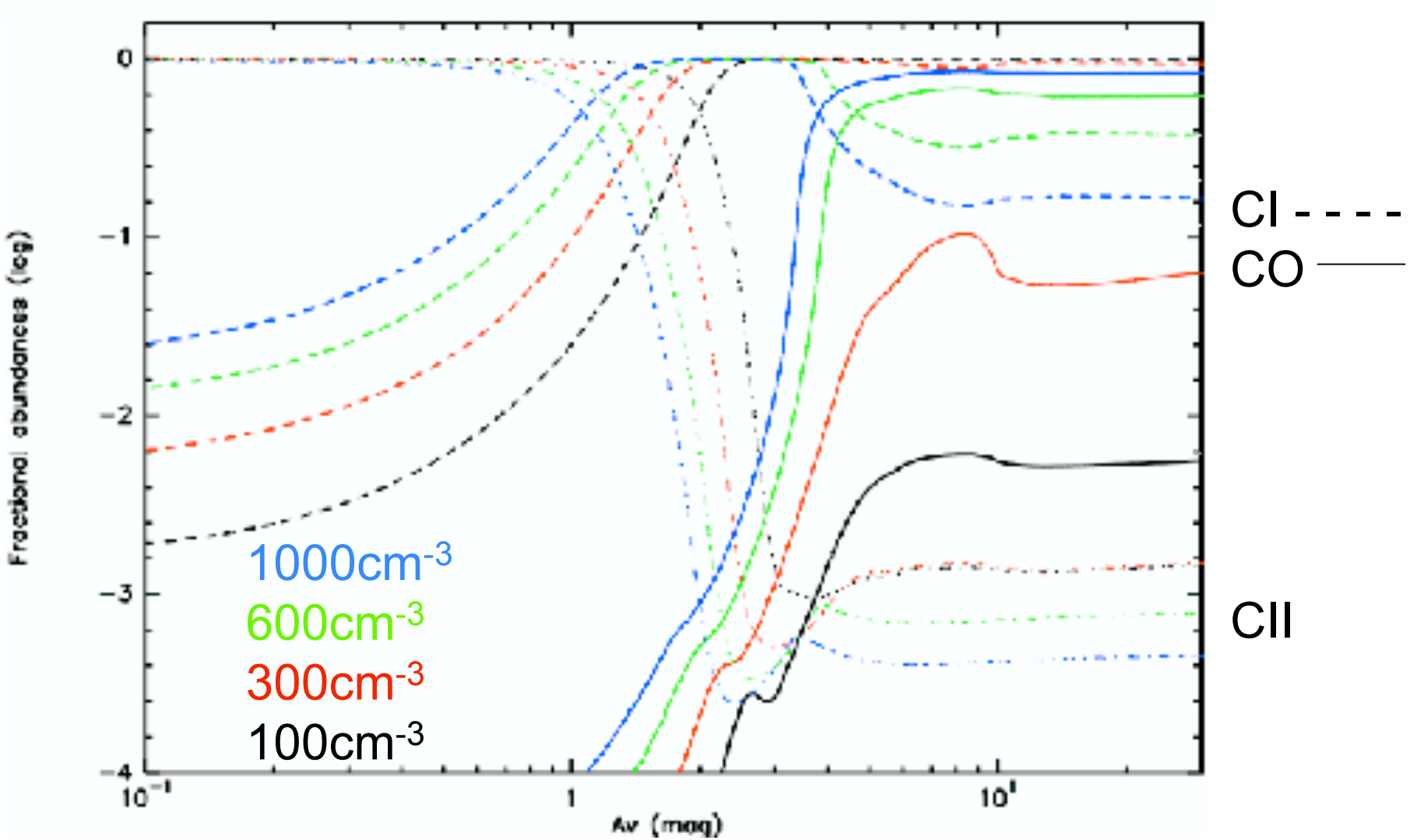
Is CO the best tracer of molecular gas?

Meudon PDR code (Le Bourlot), n = 100 cm^{-3}
(N. Rodriguez-Fernandez et al in prep.)



With CLOUDY (N. R-F)

In this close-up of the CII --> CI --> CO transition, the density varies but the cloud is molecular throughout the region shown. CI stronger than CO when n < 600cm^{-3}



- alma transparency -- LMC stuff as with FIRI, individual clouds further away and at higher resolution.