The chemistry of water in the ultracompact HII (UCHII) Monoceros R2

A. Fuente, P. Pilleri, J. Cernicharo, O. Berné, Rizzo, J.R, González-García, M., Goicoechea, J.R., Ossenkopf, V., Gerin, M. and the WADI KP team

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Monoceros R2

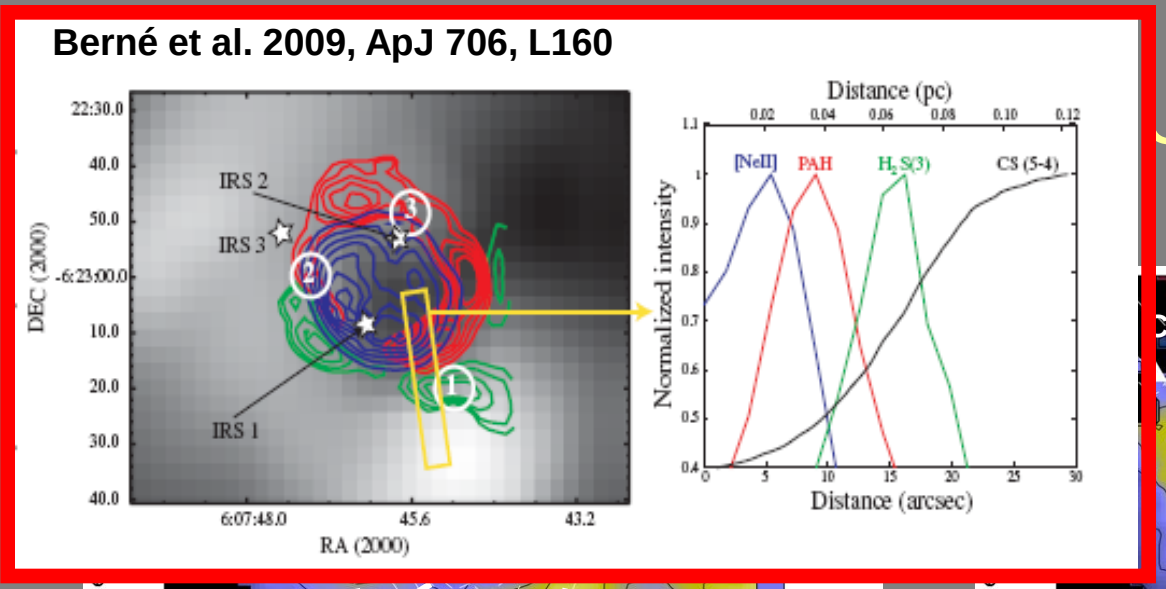
- The closest UC HII region (d=830pc)

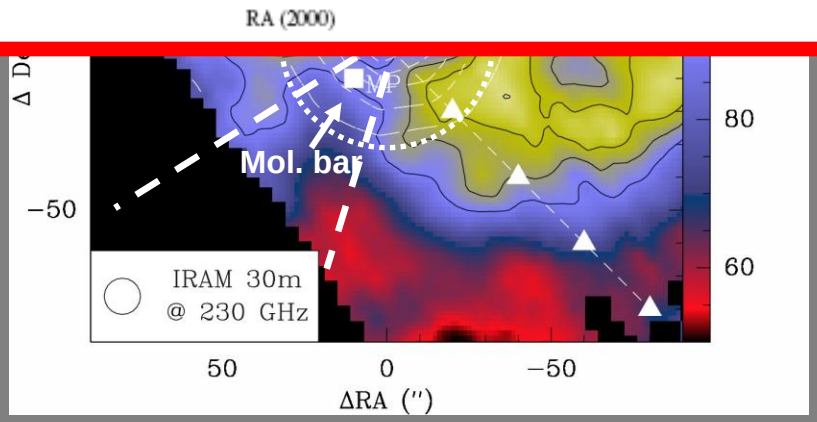
- The best target to investigate this evolutionary stage in the formation of massive stars

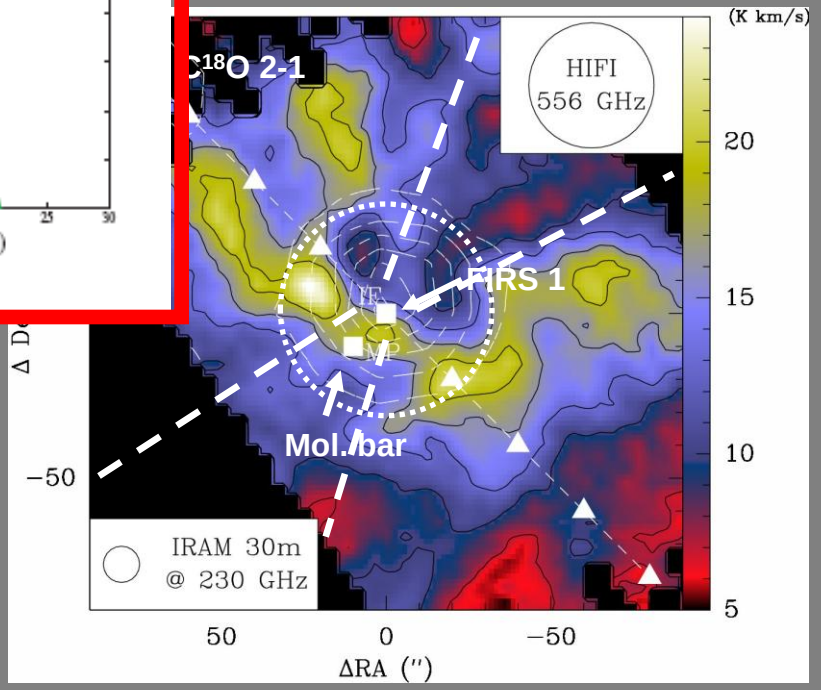
- Good target to investigate the chemistry of dense ($n>10^5$ cm^{-3}) photon-dissociation regions with high UV fluxes (G_0=5 10^5 Habing field)

- Very simple geometry which allows detailed modeling.

UC HII region

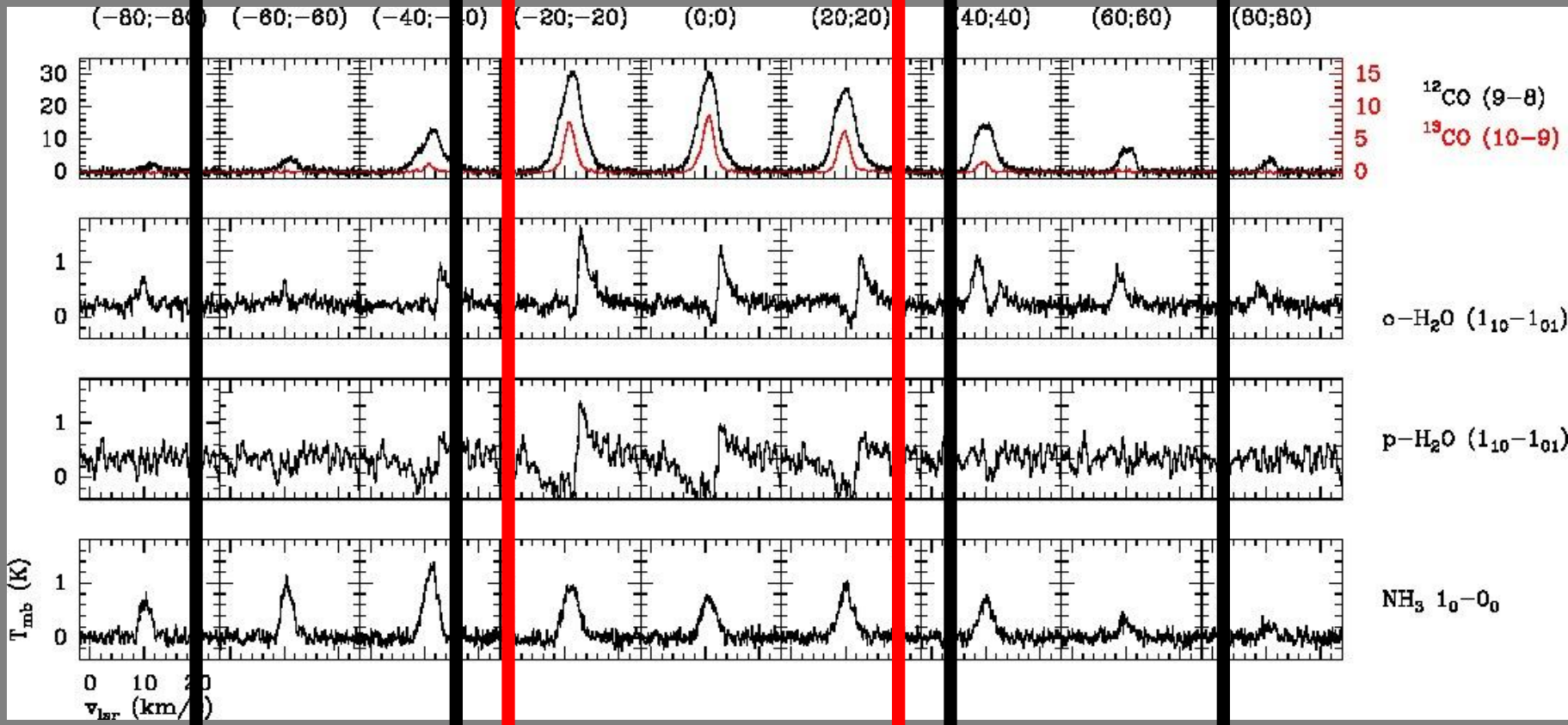




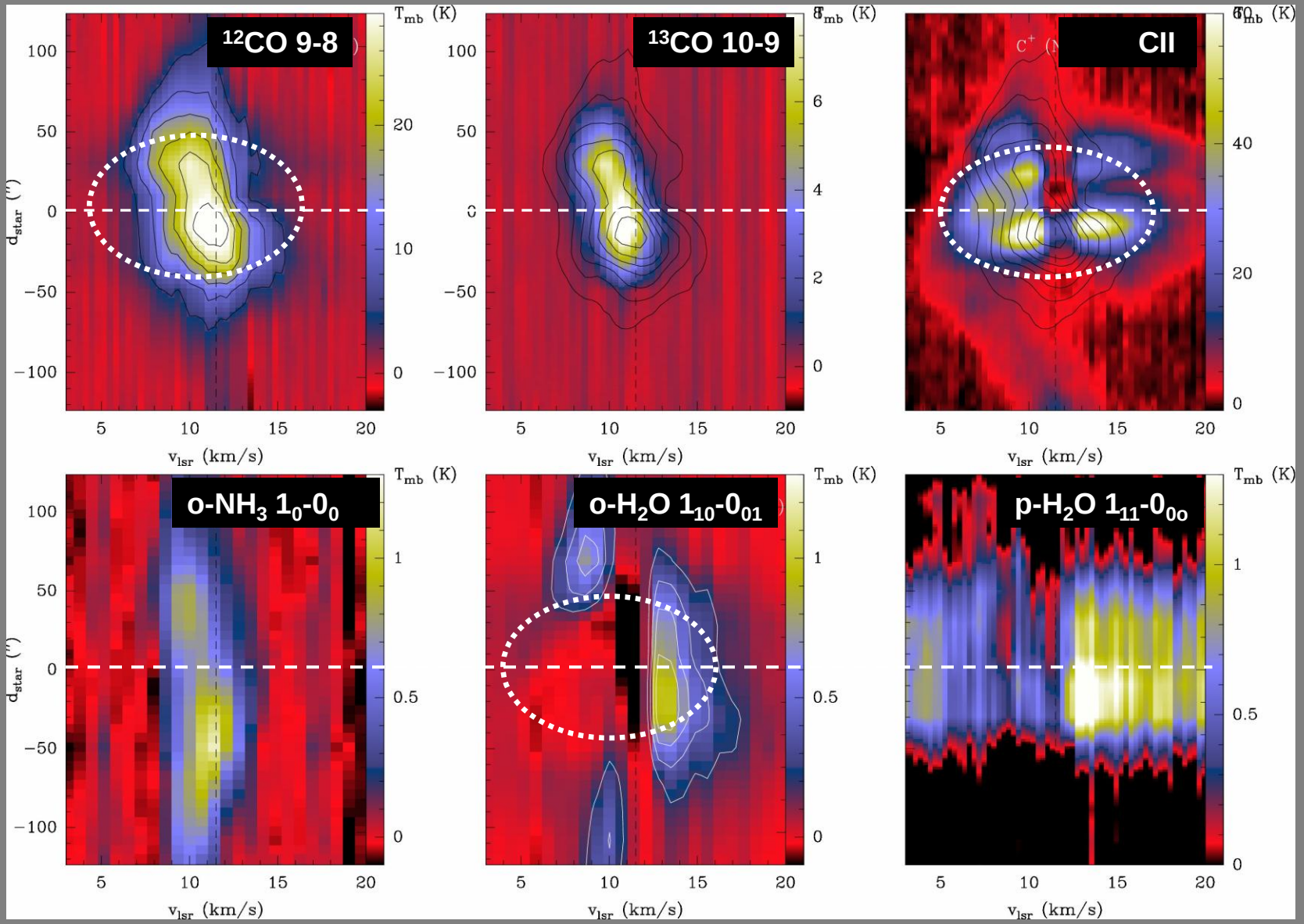


- A small cluster of young stars (FIRS 1, 2, 3, 4, 5) is in the center of the HII region. The UC HII region is ionized by the more massive young B star FIRS 1 (Henning, Chini and Pfau 1992)
- Observational study using the IRAM 30m telescope and Herschel (Mon R2 is one of the sources of the HSO Guarantee Time Key Project WADI (PI: Volker Ossenkopf)

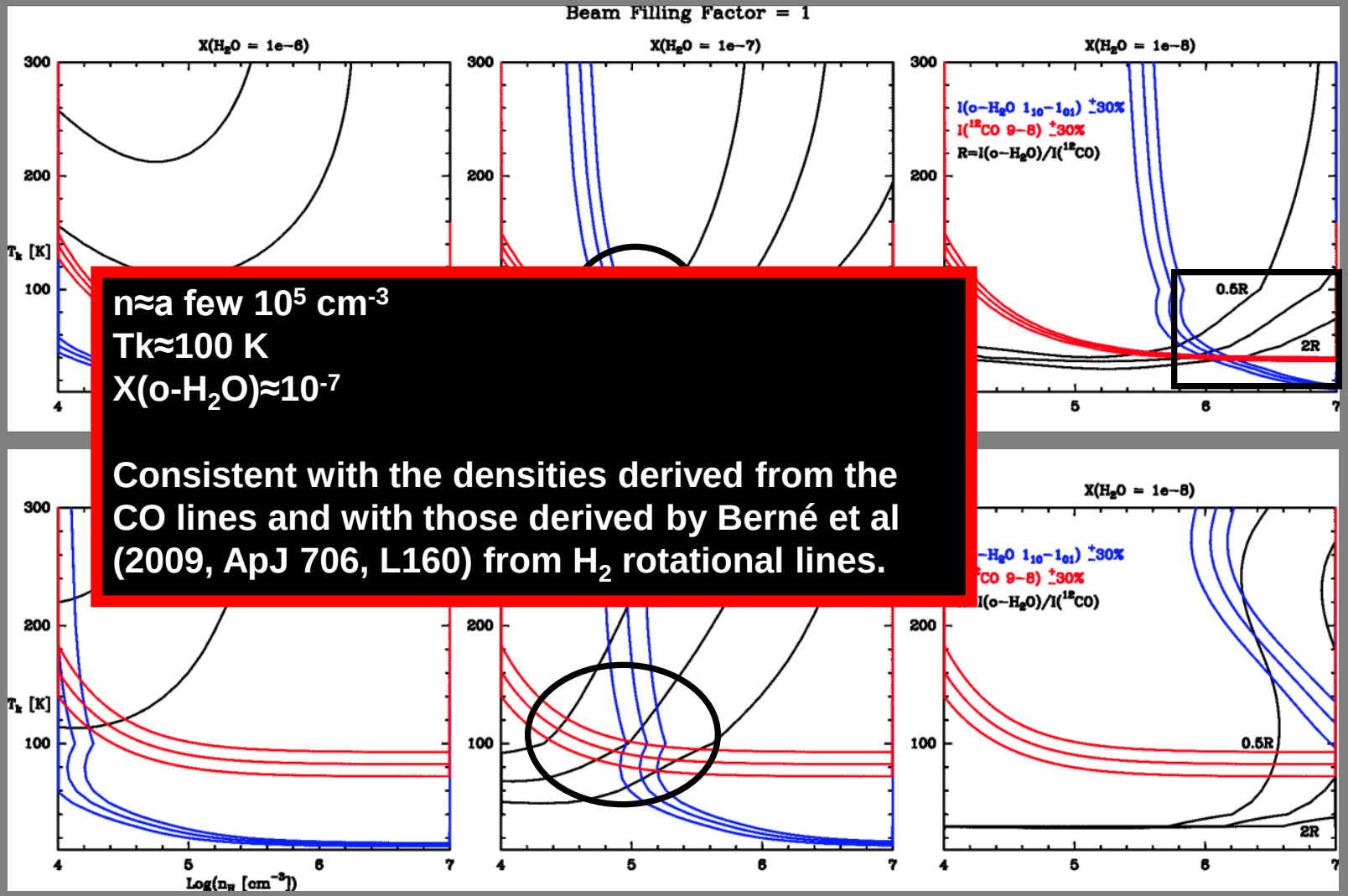
Massive star forming region



Massive star forming region



Inner High Velocity layer

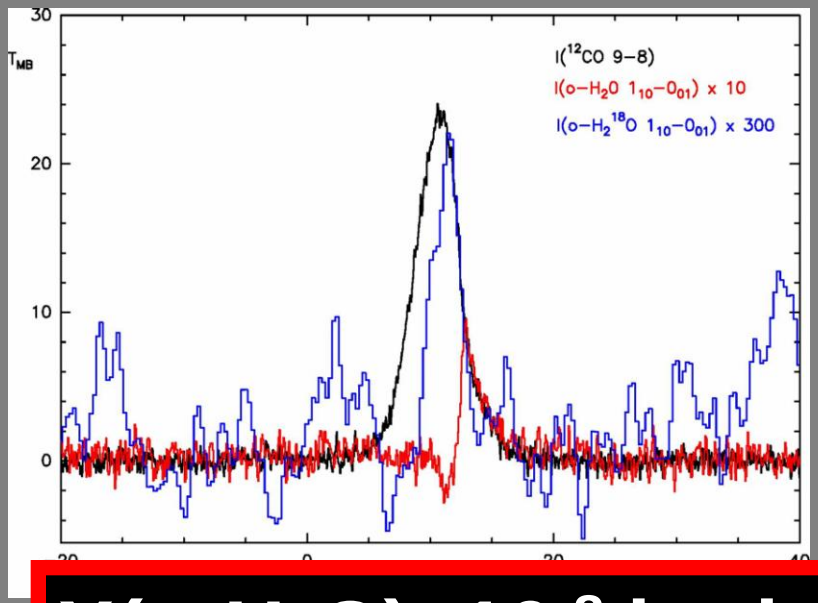


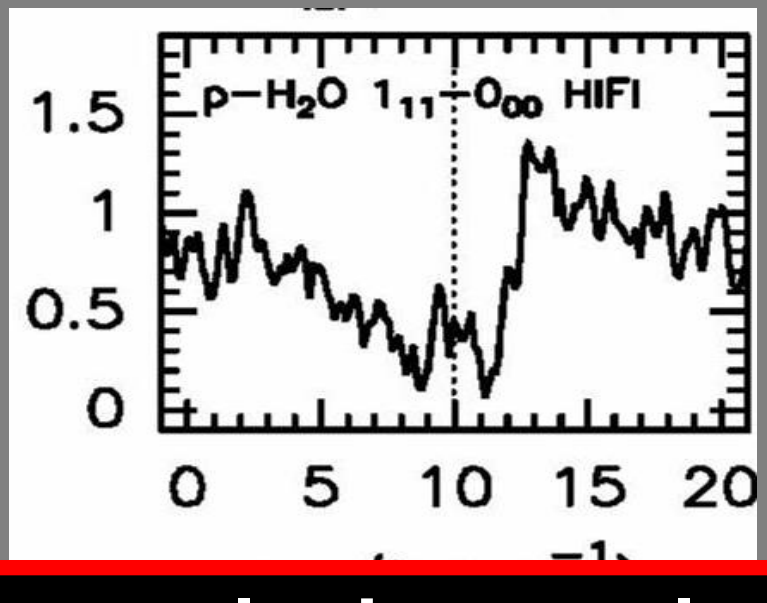
n≈a few 10^5 cm^{-3}
Tk≈100 K
X(o-H_2O)≈10^{-7}

Consistent with the densities derived from the CO lines and with those derived by Berné et al (2009, ApJ 706, L160) from H_2 rotational lines.

Low Velocity molecular cloud

(Fuente et al. 2010, A&A 521, L23)





X(o-H_2O)≈10^{-8} in the low velocity envelope

T_k=50K

n=4 10^6 cm^{-3}

N(o-$H_2{}^{18}O$)=2.7 10^{12} cm^{-2}

N(o-H_2O)=1.3 10^{14} cm^{-2}

X(o-H_2O)=2 10^{-8}

T_L/T_c=0.9

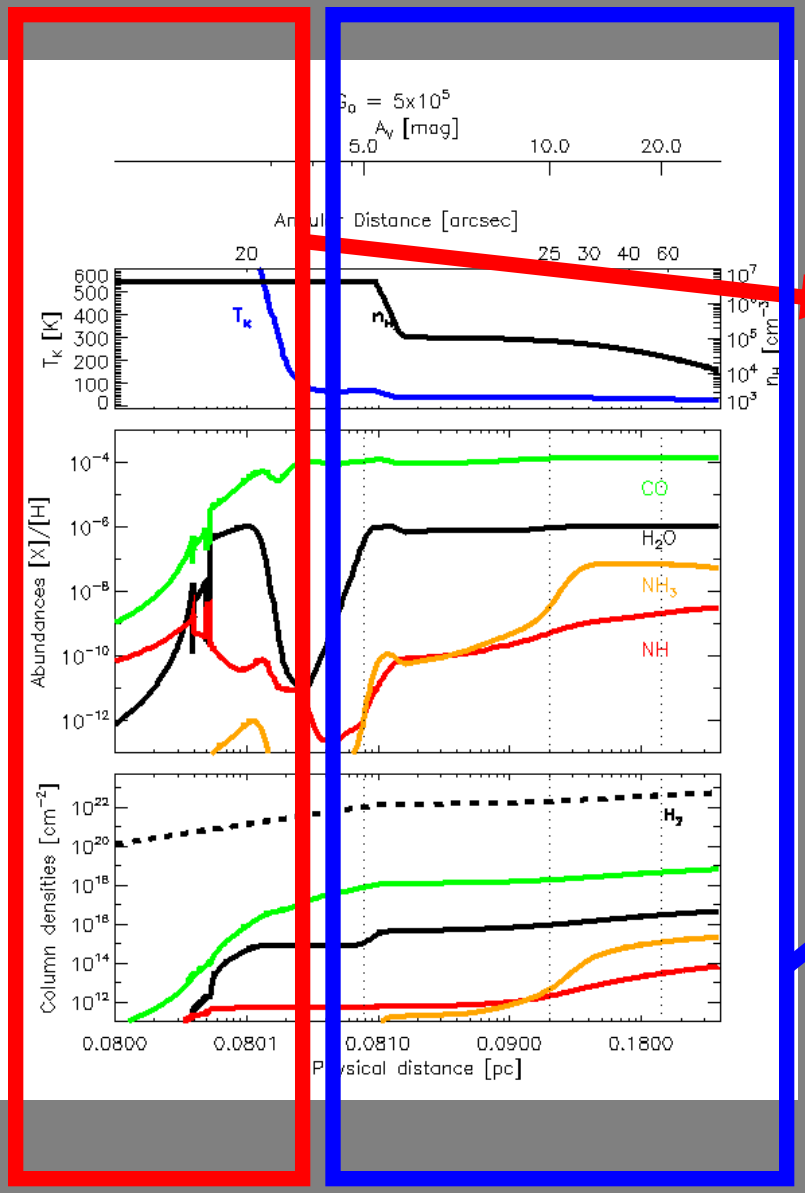
Tex=10 K

N(p-H_2O)=5.0 10^{13} cm^{-2}

X(o-H_2O)=7 10^{13} cm^{-2}

X(o-H_2O)=10^{-8}

Water chemisry in Mon R2



Meudon PDR code v1.4.1 (Bourlot et al. 2006)

High velocity expanding layer

T_k >100 K

X(o-H_2O) ≈10^{-7}

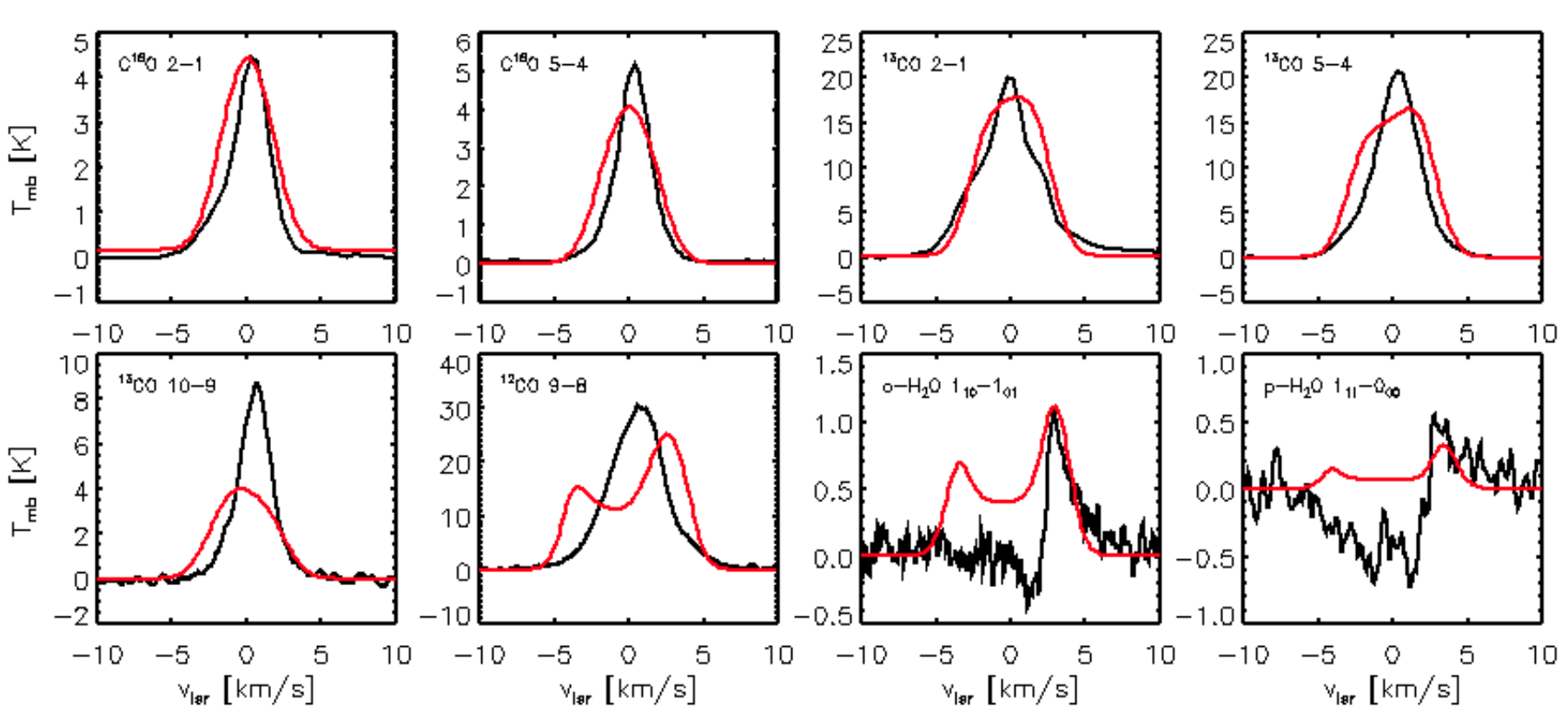
Low velocity molecular cloud

T_k <100 K

X(o-H_2O)≈ 10^{-8}

Non-local ALI model

Spherical model
Non local radiative transfer (Cernicharo et al. 2006, ApJ 642, 940)



Comparison with star forming regions

Pre-stellar cores:

- $X(H_2O) < 10^{-9}$ Caselli et al. 2010, A&A 521, L1

Bipolar outflows:

- $H_2O/CO = 0.01 - 1$ (increasing at the higher velocity)
  Lefloch et al. 2010, A&A 518, L113
  Kristensen et al. 2010, A&A 521, L30
  Kristensen et al. 2011, ArXiv.1105.4884v1

Hot cores:

- $X(H_2O) = 10^{-5}$ Chavarría et al. 2010, A&A 521, L37

Protostellar envelopes of massive stars:

- $X(H_2O) = 10^{-10} – 10^{-8}$
  Chavarría et al. 2010, A&A 521, L37

PDRs:

- $X(H_2O) = 10^{-8} – 10^{-7}$ (this work)

WADI & HEXOS

I. Physikalisches Institut, Universität zu Köln

Carbon fractionation in photon-dominated regions

V. Ossenkopf, M. Röllig, A. Fuente, R. Simon, C. Kramer, E. Bergin

T. Bell, A. Benz, O. Berné, F. Boulanger, J. Le Bourlot, S. Bruderer, E. Caux, C. Ceccarelli, J. Cernicharo, C. Comito, N. Crocket, F. Daniel, C. Dedes, M.-L. Dubernet, M. Emprechtinger, P. Encrenaz, M. Gerin, T. Giesen, J. Goicoechea, P. Goldsmit… Klein, D. Lis, S. Lord, S. Maret, P. Martin, G. Melnick, K. Menten, B. Mookerjea, P. Mor… leri, T. Phillips, R. Plume, S. Qin, P. Schilke, S. Schlemmer, J. Stutzki, D. Teyssier, N…

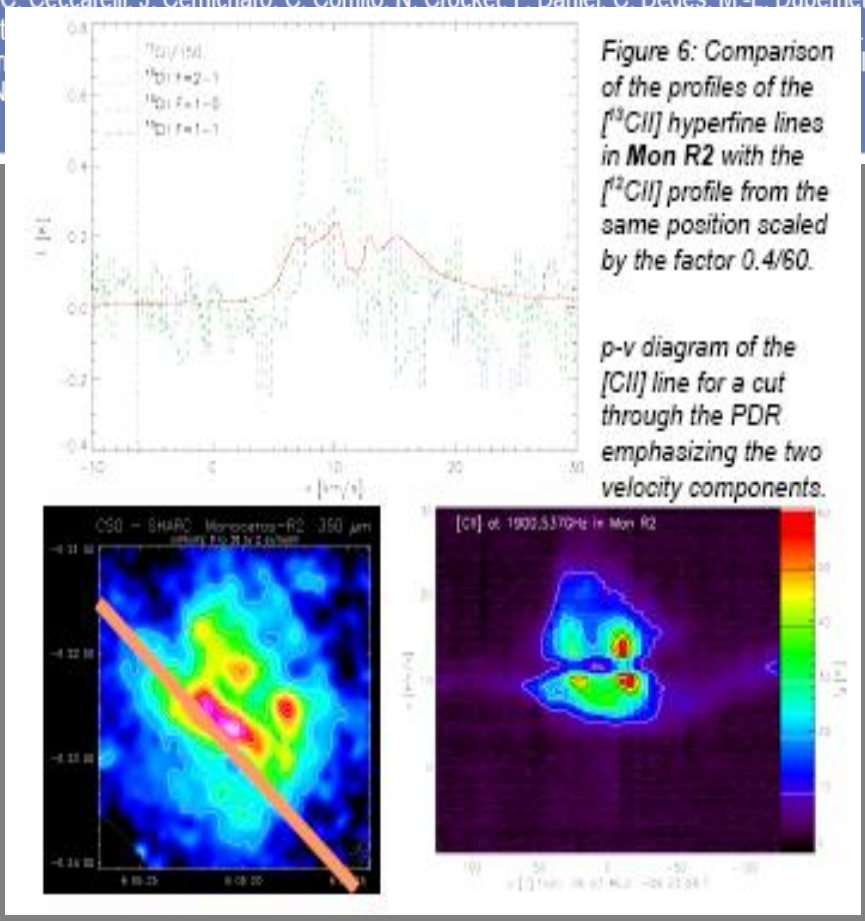


*Figure 6: Comparison of the profiles of the [^{13}CII] hyperfine lines in **Mon R2** with the [^{12}CII] profile from the same position scaled by the factor 0.4/60.*

p-v diagram of the [CII] line for a cut through the PDR emphasizing the two velocity components.