Extremely High Velocity gas from high-mass YSOs in IRAS17233-3606

C. Codella

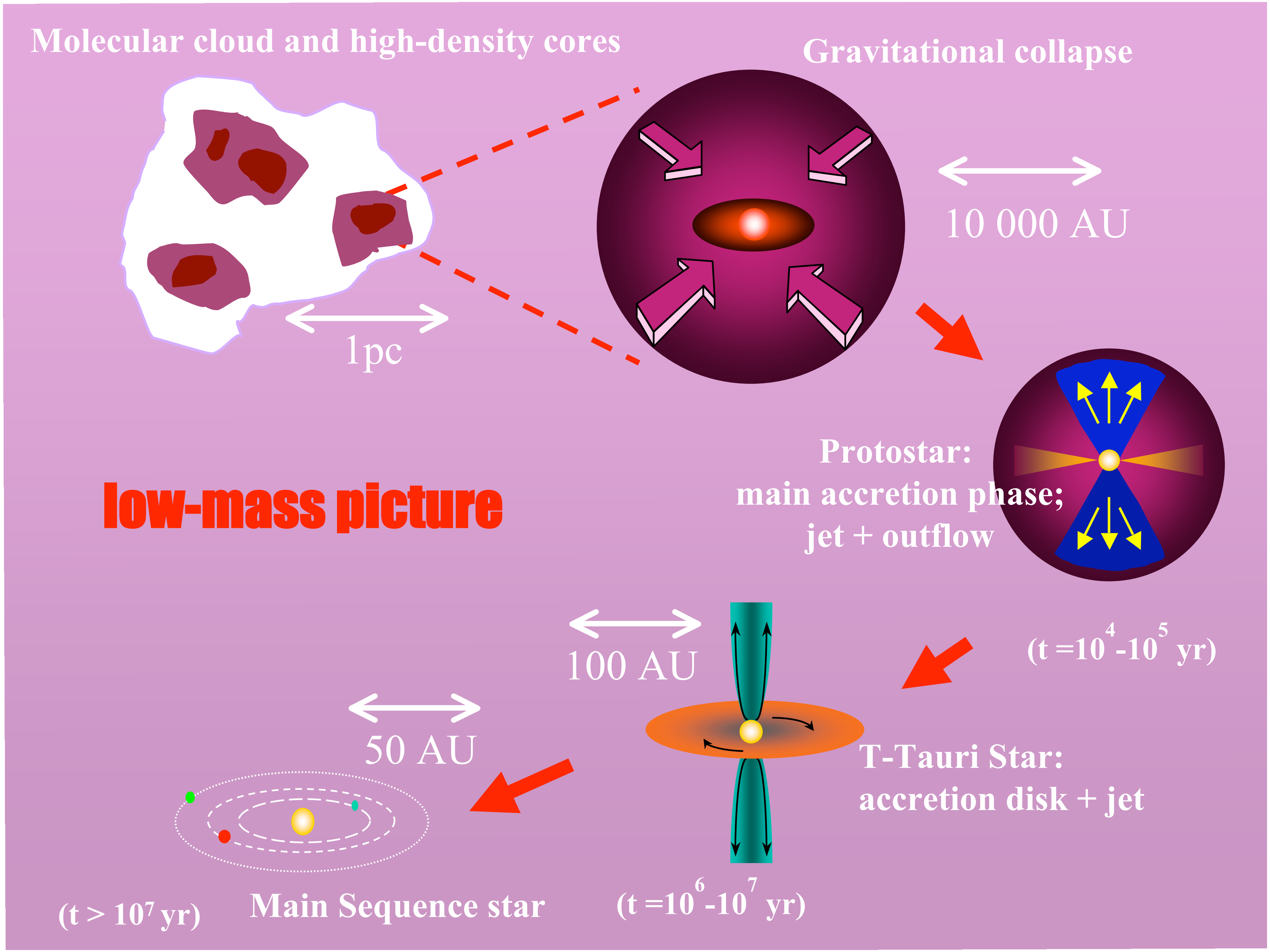
(INAF, OAA, Firenze, Italy)

Co-Authors:

S. Leurini, T. Stanke (ESO, Germany)

F. Wyrowski, K.M. Menten, R. Güsten, A. Belloche, L.A. Zapata (MPIfR, Germany)

P. Schilke (Universitat zu Köln, Germany)



Molecular cloud and high-density cores
1pc
Gravitational collapse
10 000 AU
low-mass picture
Protostar:
main accretion phase;
jet + outflow
(t =10^4-10^5 yr)
100 AU
T-Tauri Star:
accretion disk + jet
50 AU
(t > 10^7 yr)
Main Sequence star
(t =10^6-10^7 yr)

High-mass star formation: possible scenarios

Coalescence of lower masses stars

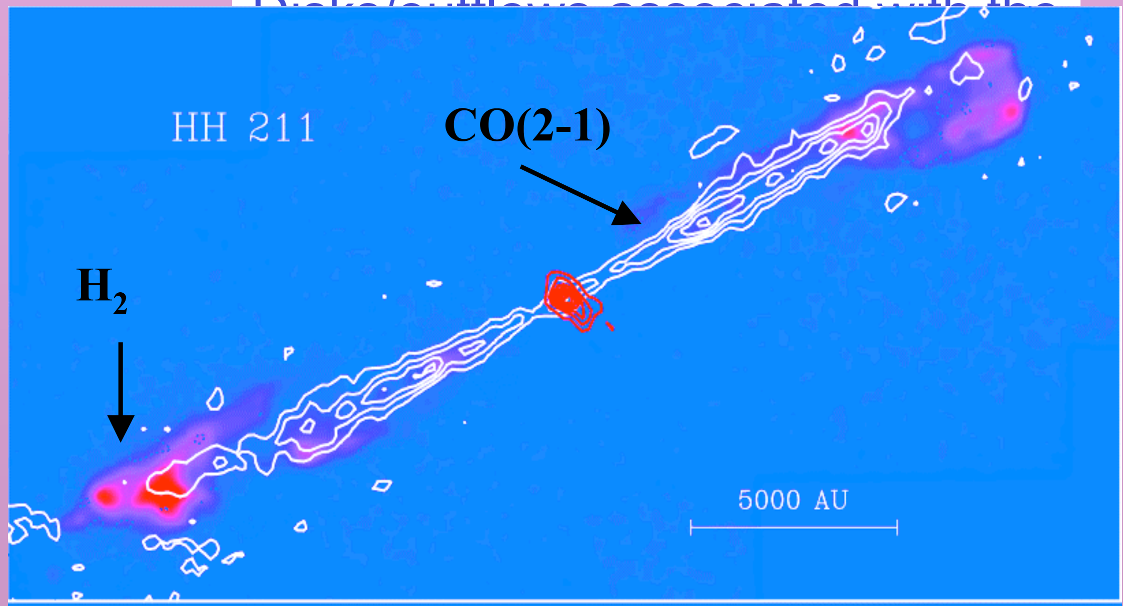
Disks/outflows associated with the low-mass stars destroyed during merging

Accretion as in the low-mass case through massive disks and high accretion rates

Well-defined disk/outflow system

High-mass star formation: possible scenarios

Coalescence of lower masses stars

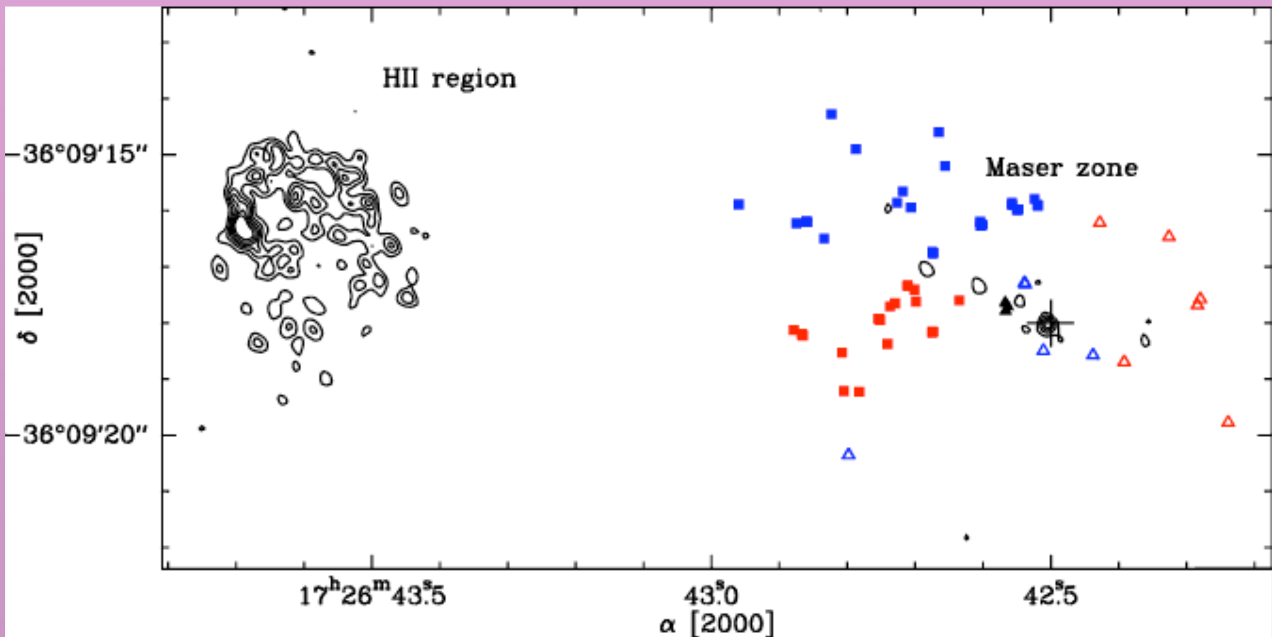


Gueth & Guilloteau (1999)

A limited number of massive disk/outflow systems (e.g. Beltrán et al. 2004, Patel et al. 2005) have been found, supporting the low-mass picture

The IRAS17233-3606 star forming region

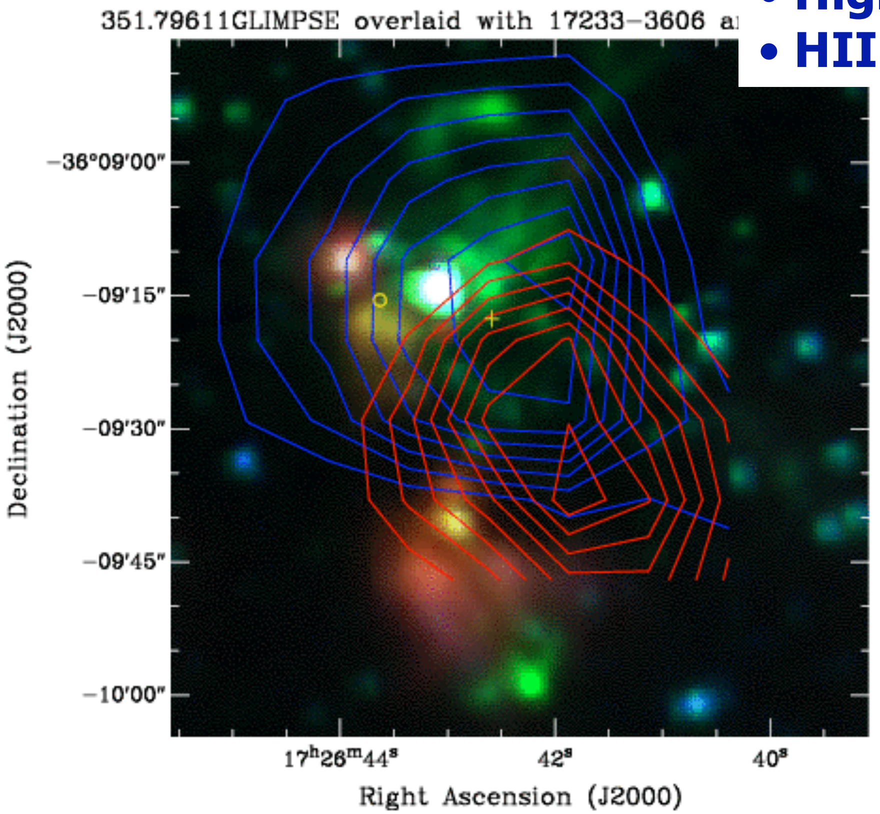
- H_2O, CH_3OH, and OH maser site (e.g. Menten 1991)
- Bipolar CO outflow (Leurini et al. 2008)
- Near kinematic distance (0.7-2.2 kpc; Miettinen et al. 2006)
- High luminosity: 10^4-10^5 L_{sun}
- HII regions (e.g. Zapata et al. 2008)



Leurini et al. (2009)

The IRAS17233-3606 star forming region

CO(3-2)
APEX; HPBW = 18”
Leurini et al. (2008)



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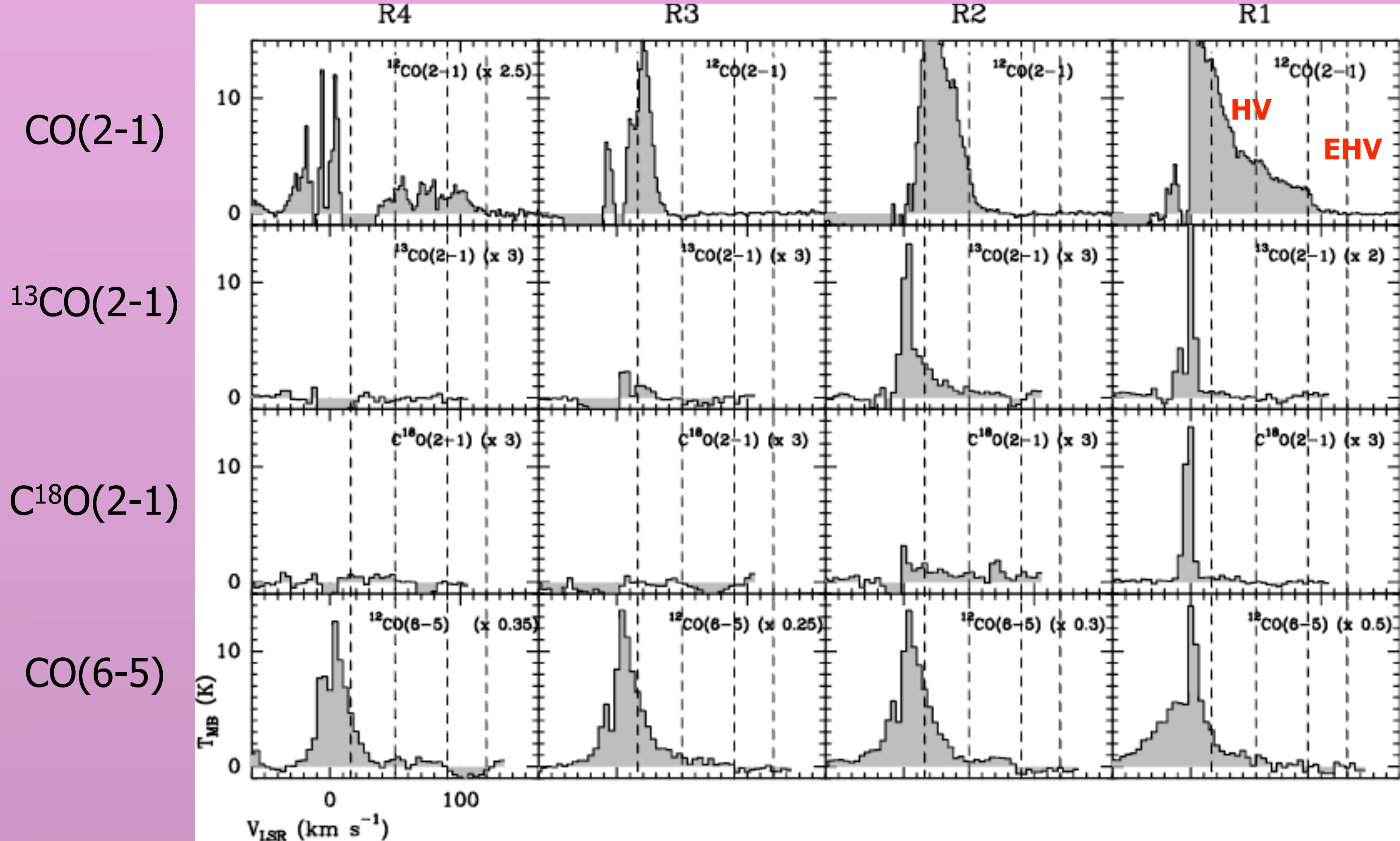
New Observations:
SMA CO(2-1)@231 GHz
HPBW: 5.4" X 1.9"
Also: $^{13}CO(2-1)$, $C^{18}O(2-1)$, $SO(6_5-5_4)$

APEX CO(6-5)@691 GHz
HPBW: 8.9”

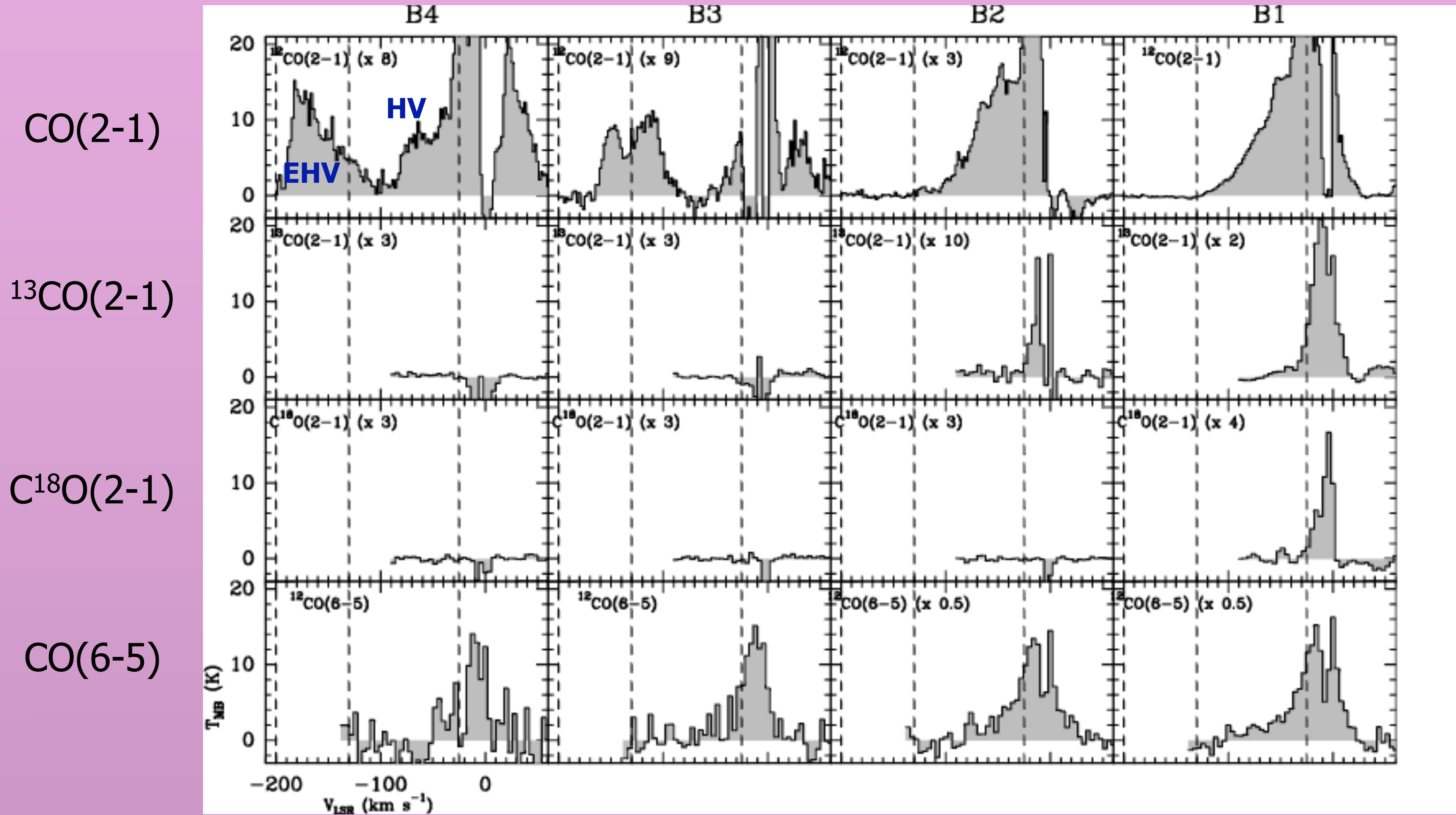
Extremely High Velocity CO emission



Red-shifted emission up to +120 km/s, CO(2-1) and +60 km/s, CO(6-5) (Vsys = -3.4 k/s)

HV: +16 < V < +50 km/s; EHV: +90 < V < +120 km/s

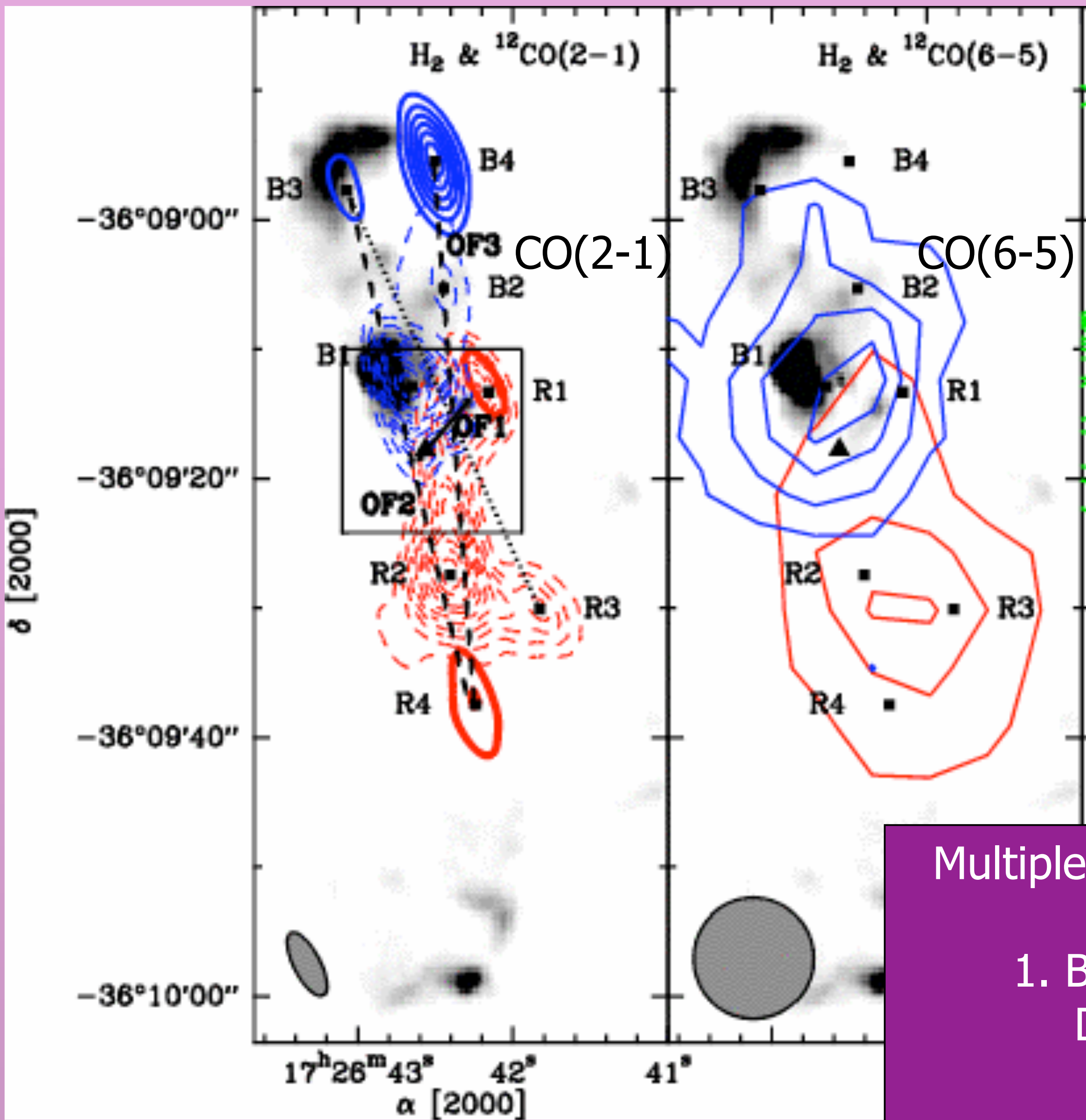
Extremely High Velocity CO emission



Blue-shifted emission up to -200 km/s, CO(2-1) and -80 km/s, CO(6-5) (Vsys = -3.4 k/s)

HV: -130 < V < -25 km/s; EHV: -200 < V < -130 km/s

Multiple outflows



Leurini et al. (2009)

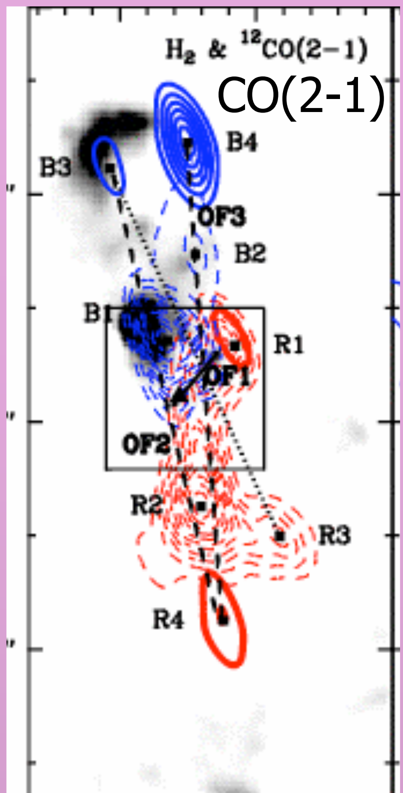
CO(2-1): very collimated flow;
Size: 0.2-0.3 pc

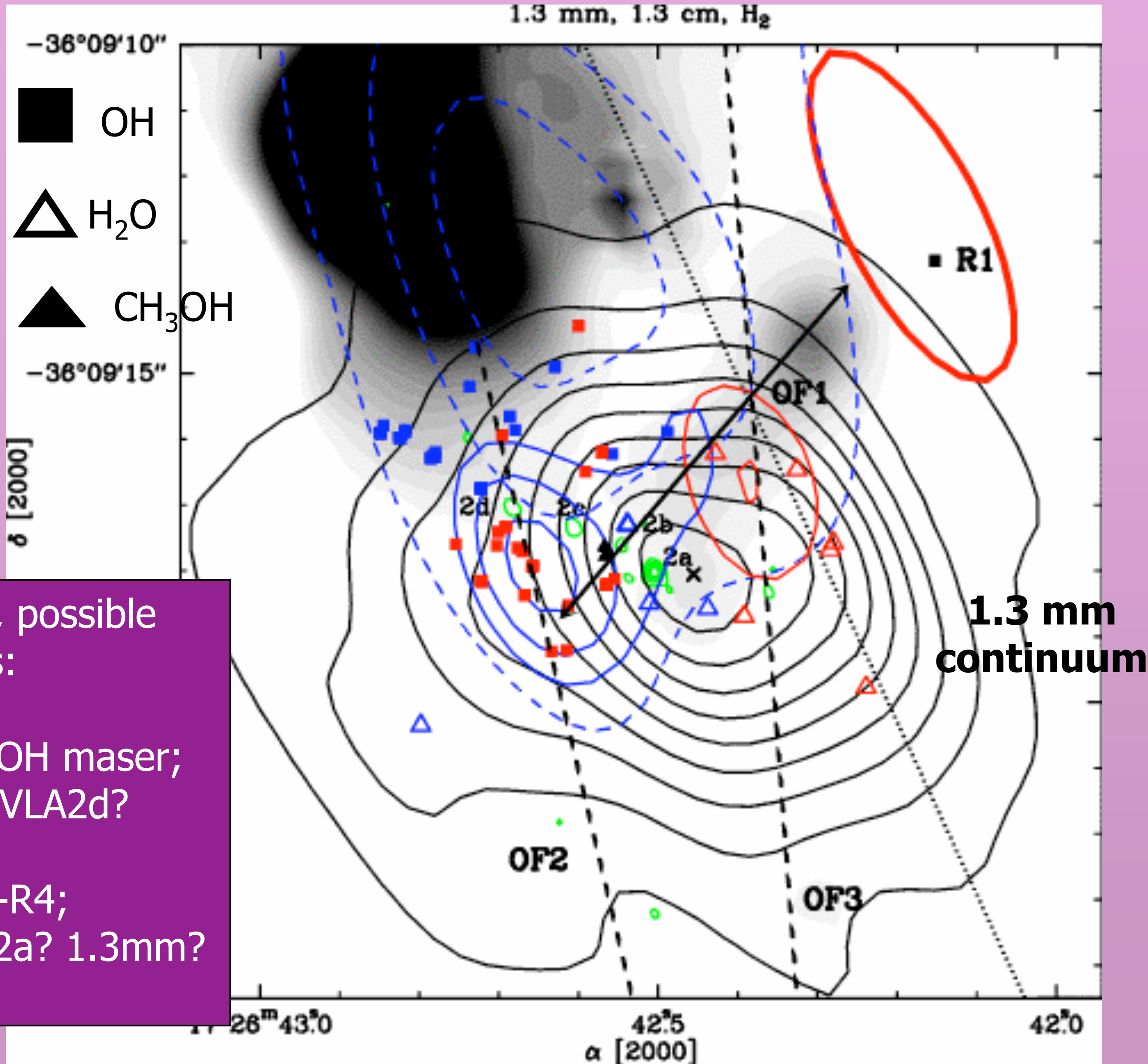
Multiple outflows, possible directions:

1. B3-B1-R2-R4 + OH maser;
Driving source VLA2d?

2. B4-B2-R2-R4;
Driving source: VLA2a? 1.3mm?

The central region





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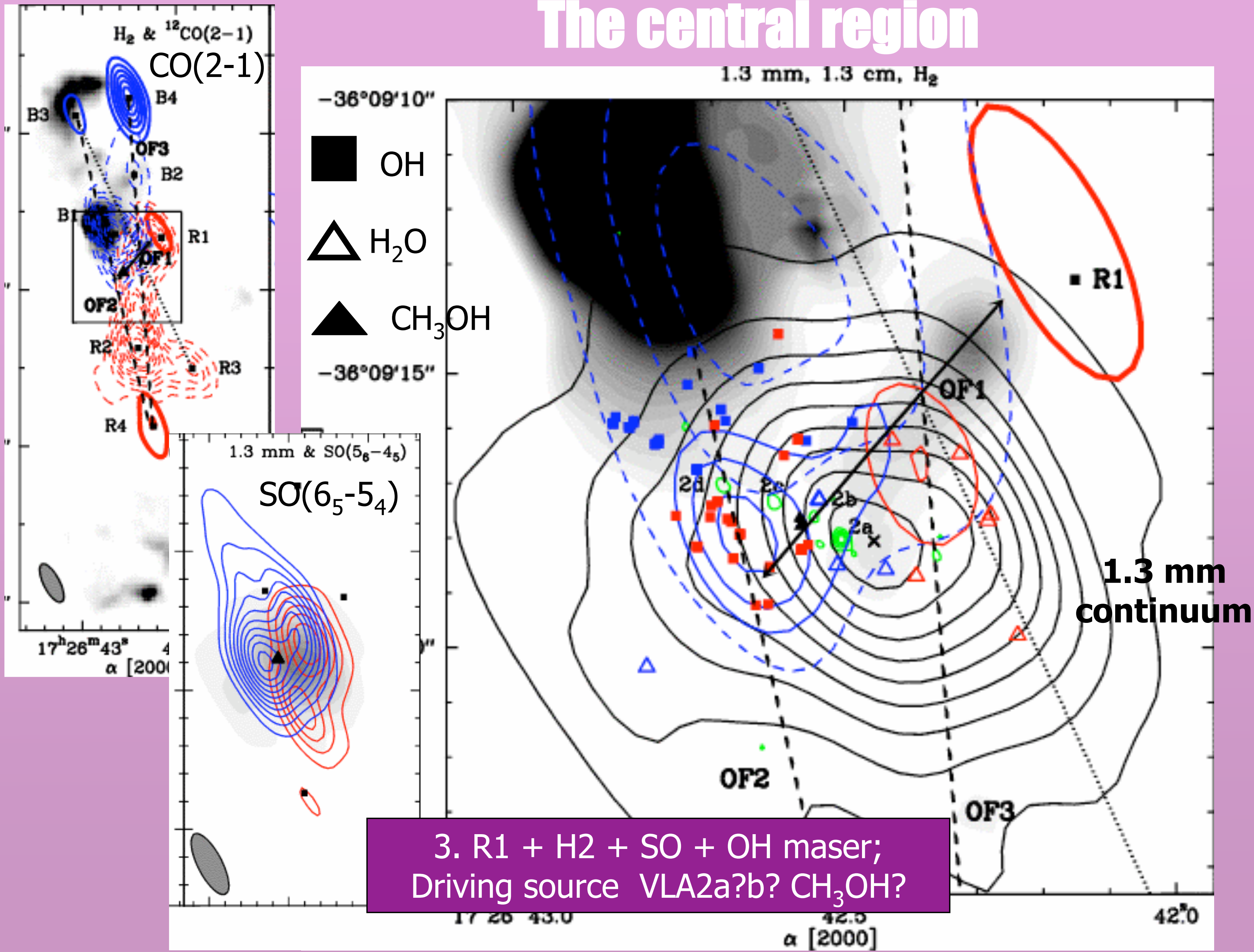
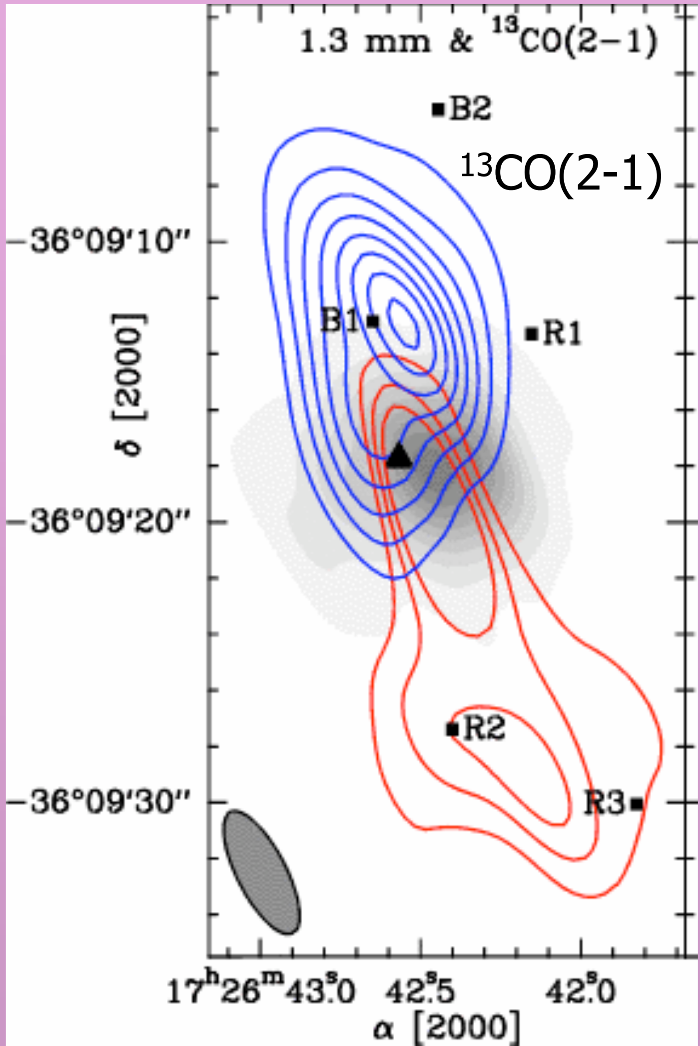
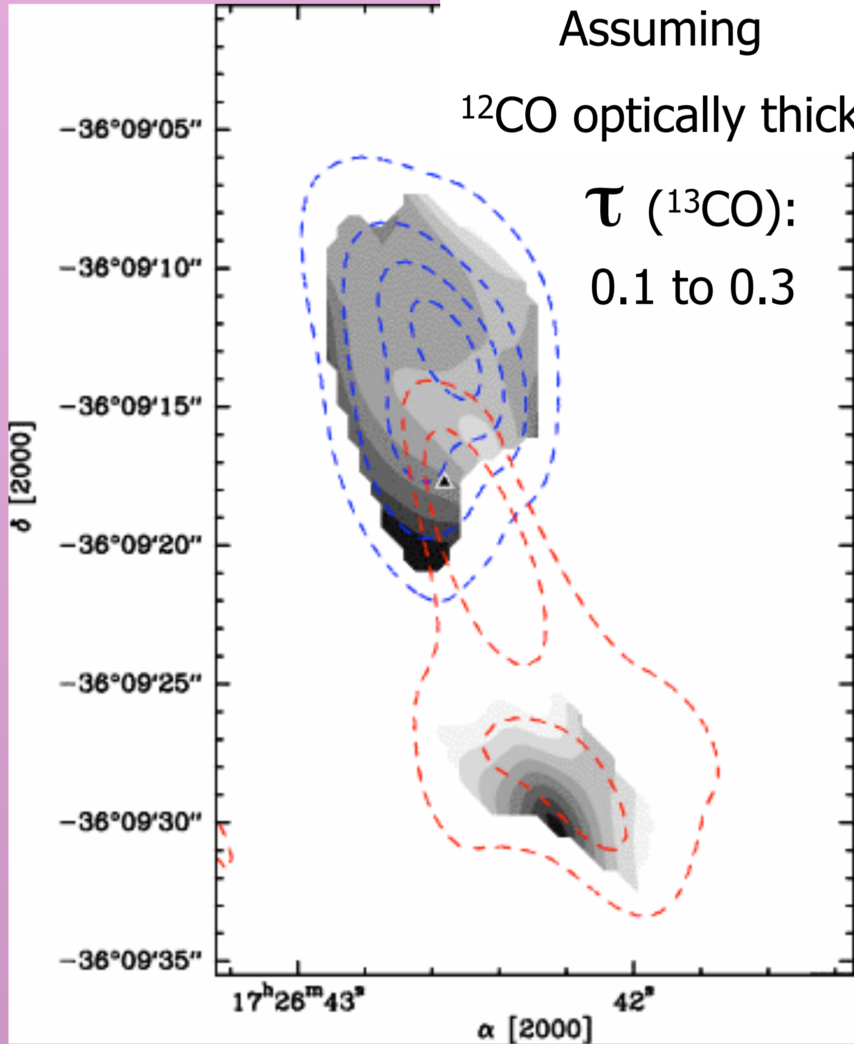


Results: ^{13}CO optical depth





Assuming

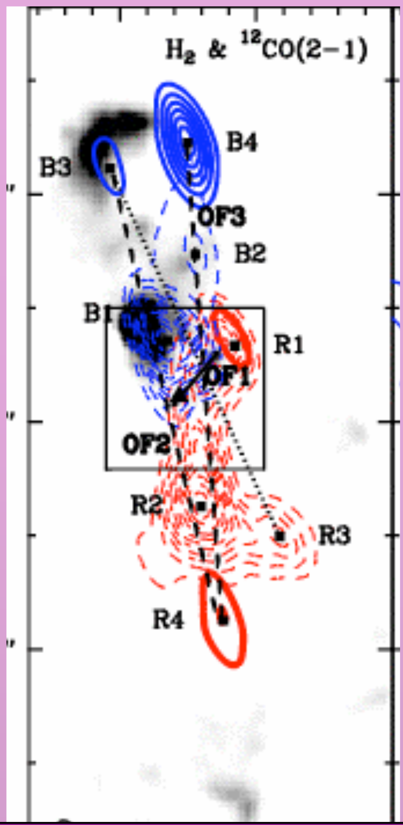
^{12}CO optically thick:

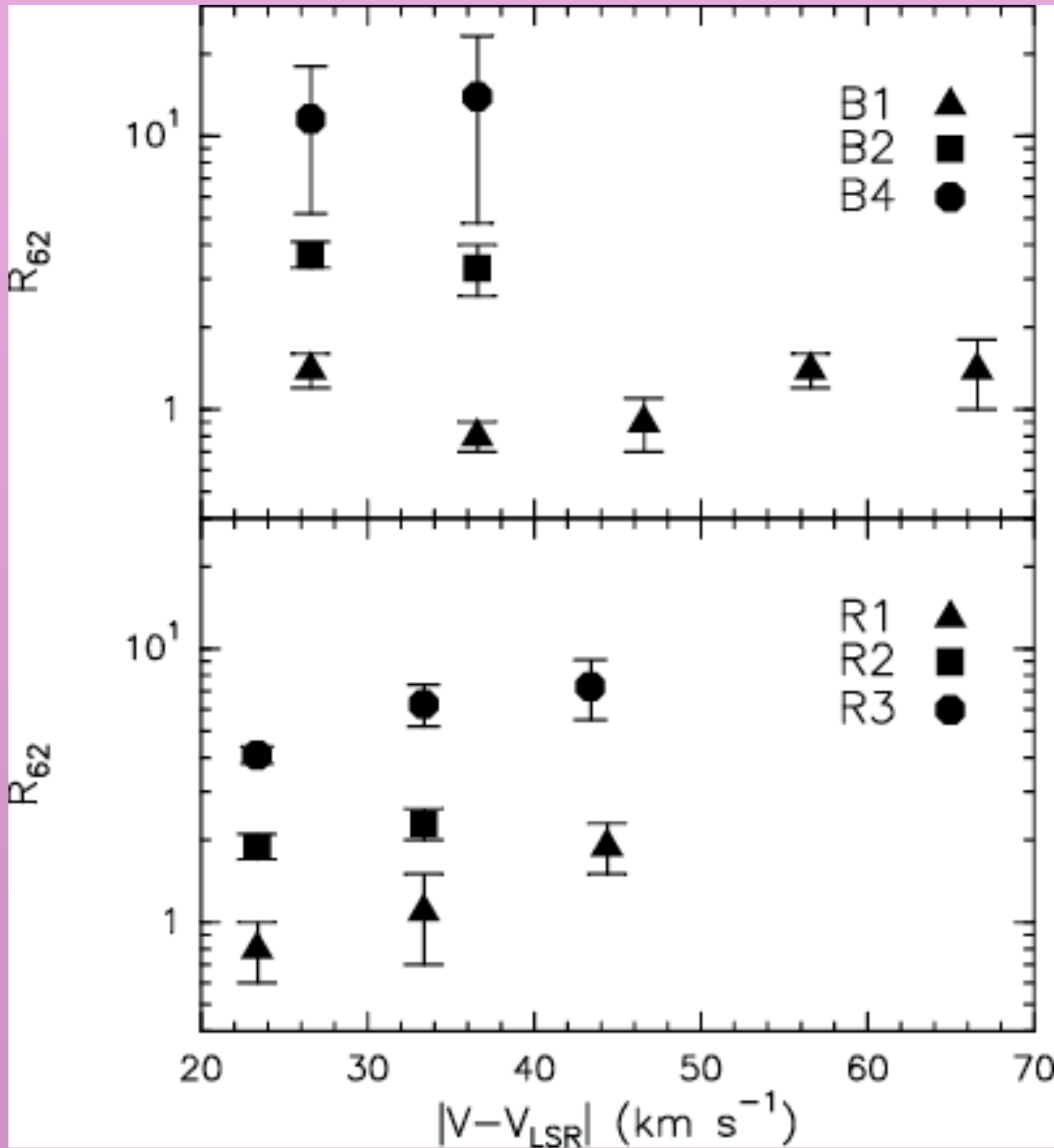
τ (^{13}CO):

0.1 to 0.3

→ τ (^{12}CO): ~10-30

CO excitations vs. velocity & position



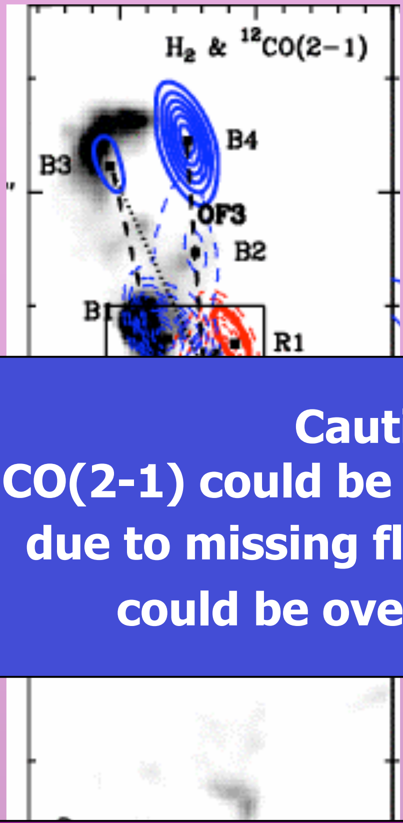


$R62 = CO(6\text{-}5)/CO(2\text{-}1)$

The higher the distance of the clump rhe higher is the R62 ratio (excitation);

Red clumps suggest an increase of excitation at the highest velocities.

CO excitations vs. velocity & position



Caution!
CO(2-1) could be underestimated due to missing flux; τ, R62, Tkin could be overestimated.

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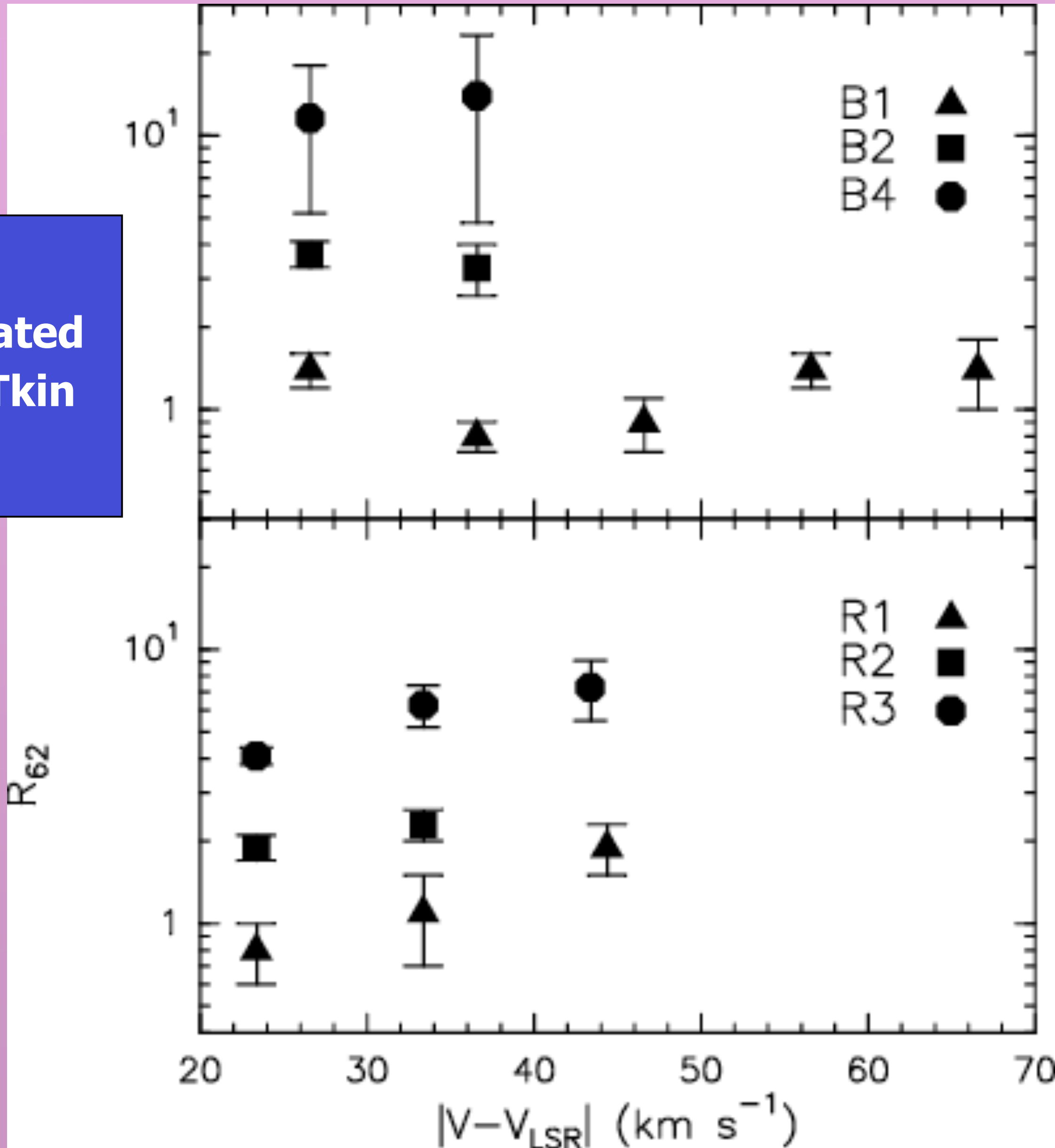
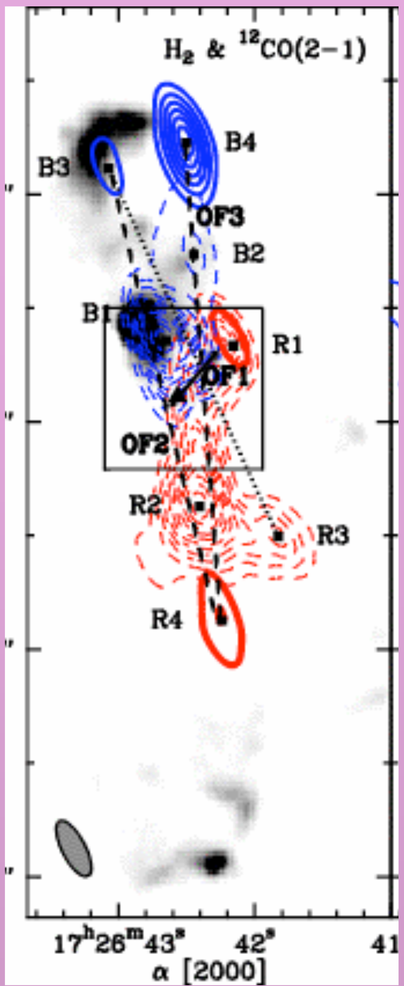
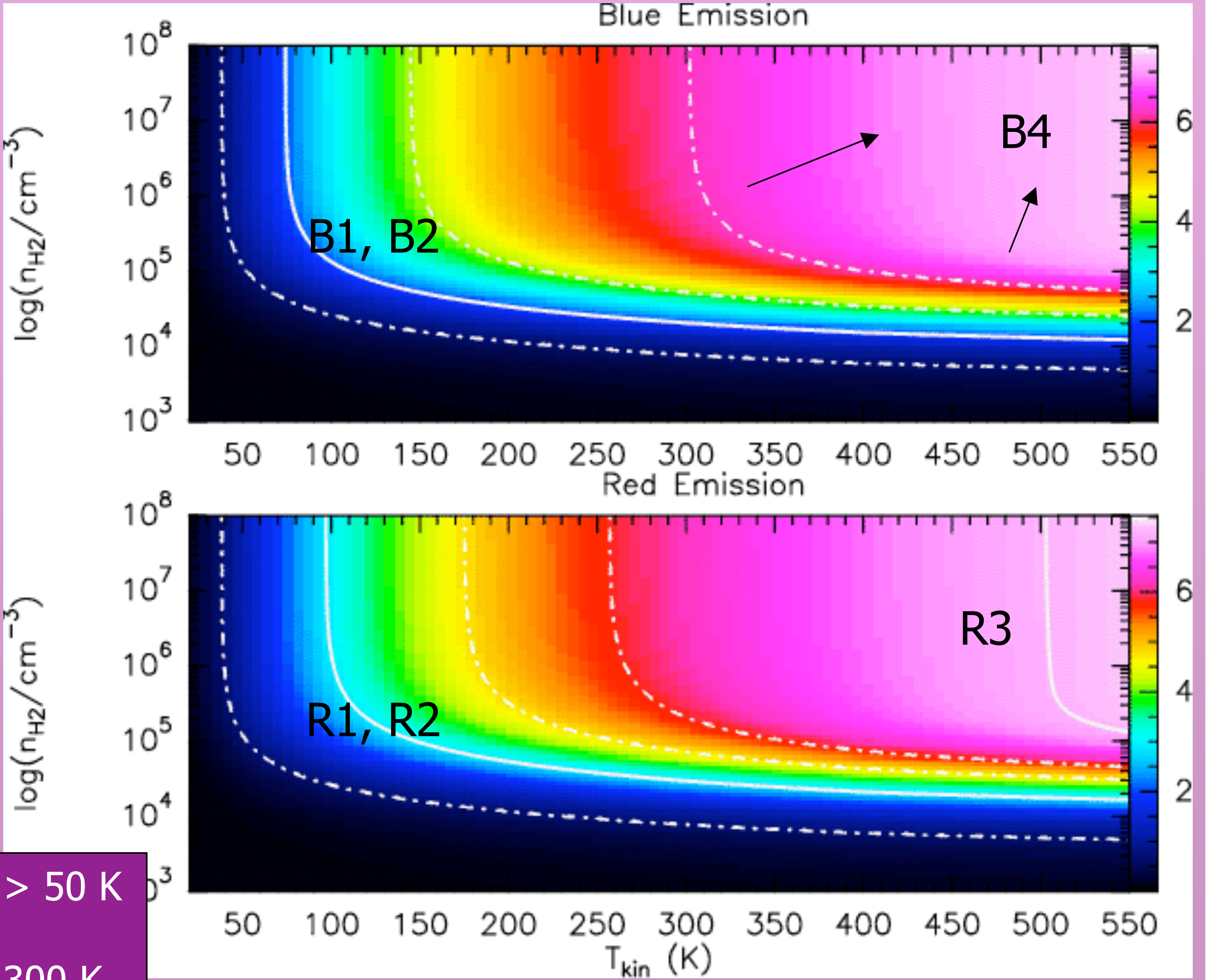


LVG Analysis: R62, T_{kin}, & n_{H2}





B1, B2, R1, R2: T > 50 K

R3, B4: T > 250-300 K

N_{CO}/FWHM = 10^{16} cm^{-2}/km/s

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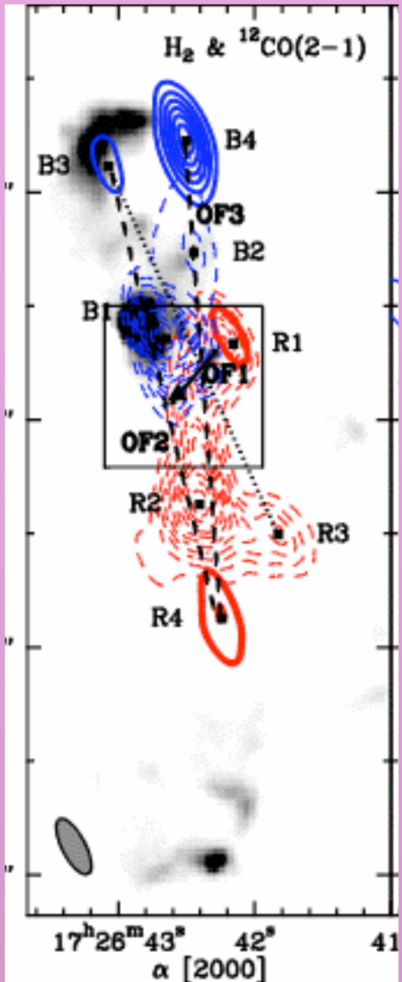

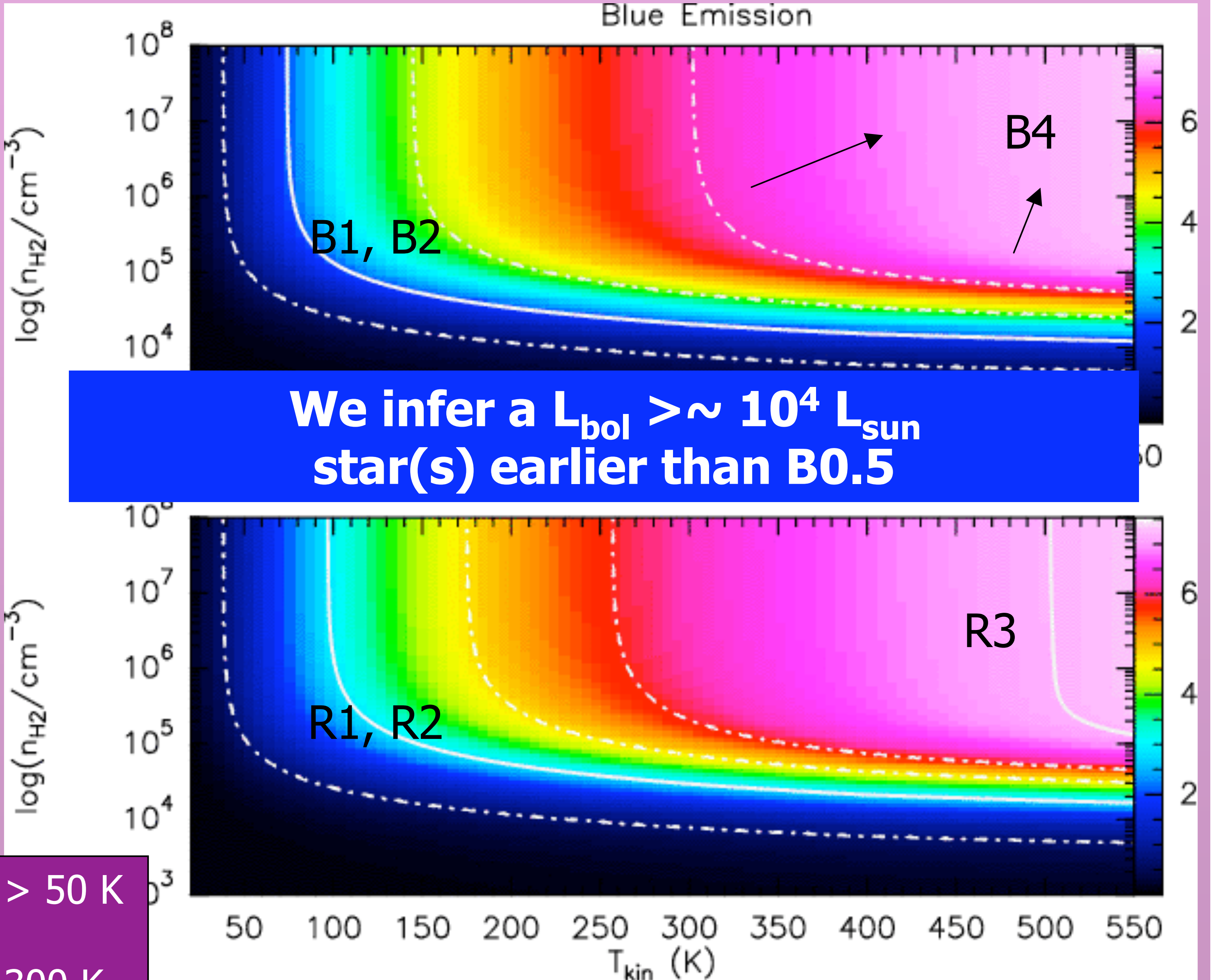

We infer a L_{bol} >~ 10^4 L_{sun}
star(s) earlier than B0.5

B1, B2, R1, R2: T > 50 K

R3, B4: T > 250-300 K

N_{CO}/FWHM = 10^{16} cm^{-2}/km/s

Conclusions

• We mapped the near (~ 1 kpc) IRAS17233 high-mass SFR in (13)CO(2-1) and CO(6-5) using the APEX and SMA telescopes;

• The data reveal well separated blue and red EHV emission along the N-S direction and centred on the maser+HCHII zone. Outflow multiplicity;

• CO thick emission even at outflow velocities ~ 30-60 km/s with respect to the ambient velocity;

• Excitation seems to increase with velocity (association with recently shocked gas). In addition, the higher the distance of the clump from the driving source the higher is the excitation;

• LVG analysis: high temperature conditions (> 50 K);

• Outflow energetics and kinematics typical of massive YSOs ($L_{bol} > 10^4\ L_{sun}$). Kinematical ages in the 10^2-10^3 yr range;

•High collimation (CO) and less collimated wind (OH) seem to coexist. Further high-spatial resolution observations of higher excitation CO lines as well as SiO (sensitive to hot jets) would be instructicve.