HIFISTARS :
The physical and chemical properties of circumstellar environments around evolved stars

A GUARANTEED TIME KEY PROJECT

Systematic observations of molecular lines from evolved stars using HIFI

by the HIFISTARS team:

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SCIENTIFIC GOALS

INTERMEDIATE EXCITATION COMPONENTS + H_2O.

Very interesting physics and chemistry

Inner AGB shells: acceleration is still active and AGB mass ejection takes place.

Wind shock interaction: responsible for PN evolution and shaping.

mm-wave lines properly probe regions T $\lesssim$ 100 K

observations in the visible or NIR select T $\gtrsim$ 1000 K

Herschel/HIFI NECESARY

FIR lines $\equiv$ warm layers, basic in many processes.

High spectral resolution, dynamics is important!

PROPOSED OBSERVATIONS

H_2O: $\sim$ 25 lines of ortho- and para-H_2O. + H_2O^*, $H_2{}^{18}O$, $H_2{}^{17}O$ and HDO.
All kinds of excitation conditions, line strengths, species, etc.
14 tunings.
5 sources: IK Tau, W Hya, IRC +10011, χ Cyg, VY CMa.

H_2O: $\sim$ 13 lines. + H_2O^*, $H_2{}^{18}O$, $H_2{}^{17}O$ and HDO.
Basic excitation regimes.
7 tunings.
18 sources: O-rich AGB stars, PPNe, young PNe, red/yellow super/hypergiants.

H_2O in IRC +10216: $\sim$ 10 lines. **7 tunings.**
+ search for H_2O in other C-rich AGB stars
9 sources, 2 lines.

^{12}CO lines:

J=6-5 (434 μ), J=10-9 (260 μ), J=16-15 (163 μ)

Sometimes simultaneously with H_2O lines

In the total sample: 38 selected sources:

AGB stars (O-rich, C-rich), PPNe, PNe, red/yellow super/hypergiants.

^{13}CO lines:

J=6-5 (454 μ), J=10-9 (272 μ), J=16-15 (170 μ)

Almost always simultaneously with H_2O lines

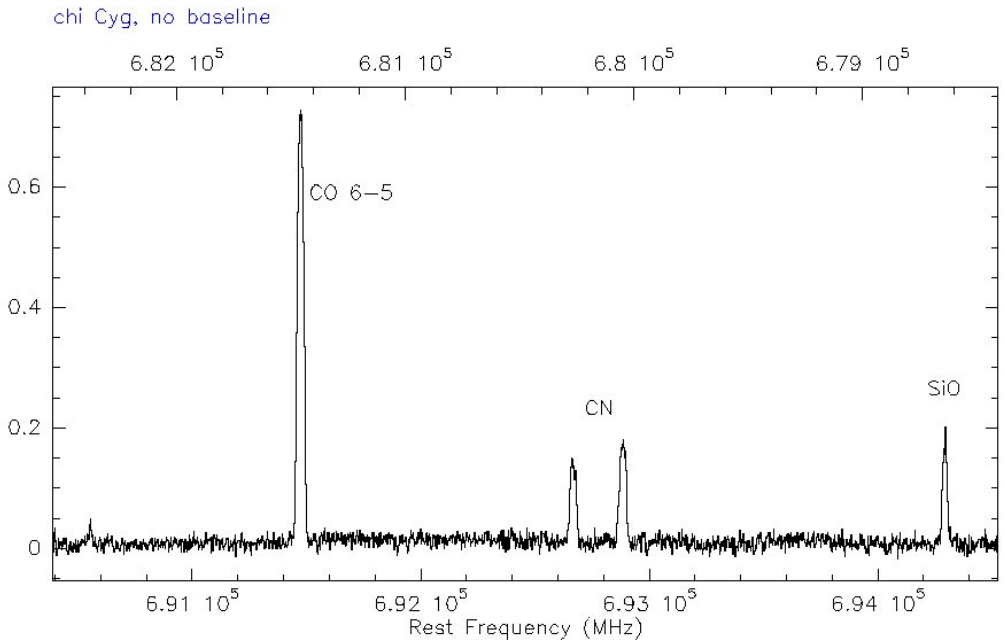
In the total sample: 38 selected sources:

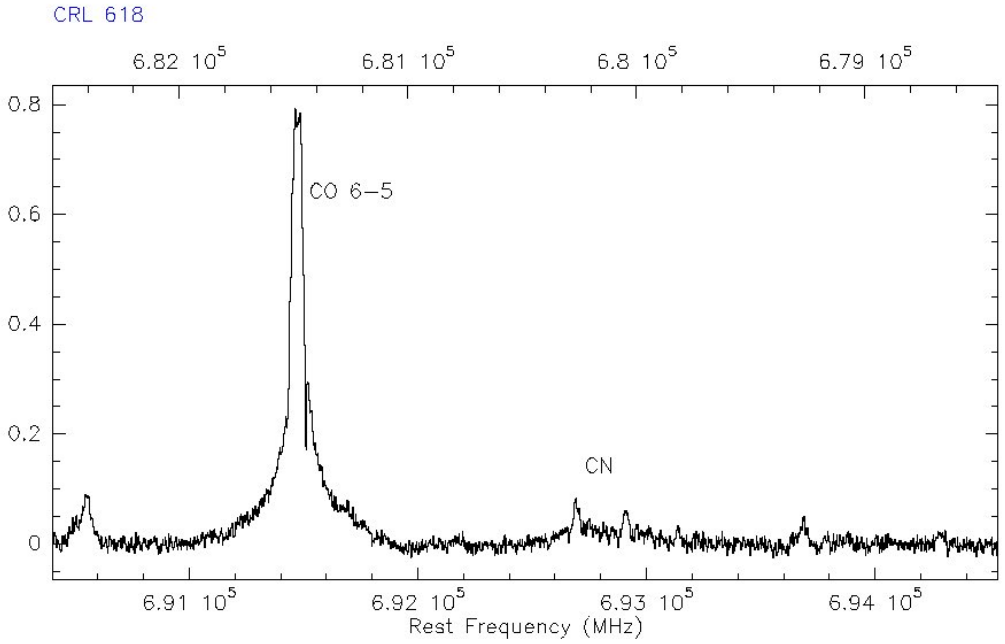
+ PACS full freq. surveys:

Mostly performed by the PACS GT group. Wide collaboration agreement.

About 90% of the sources are in common.

116 observations performed until now. Examples: dependence on dynamics.





Compact, intense sources => “Easy” observations

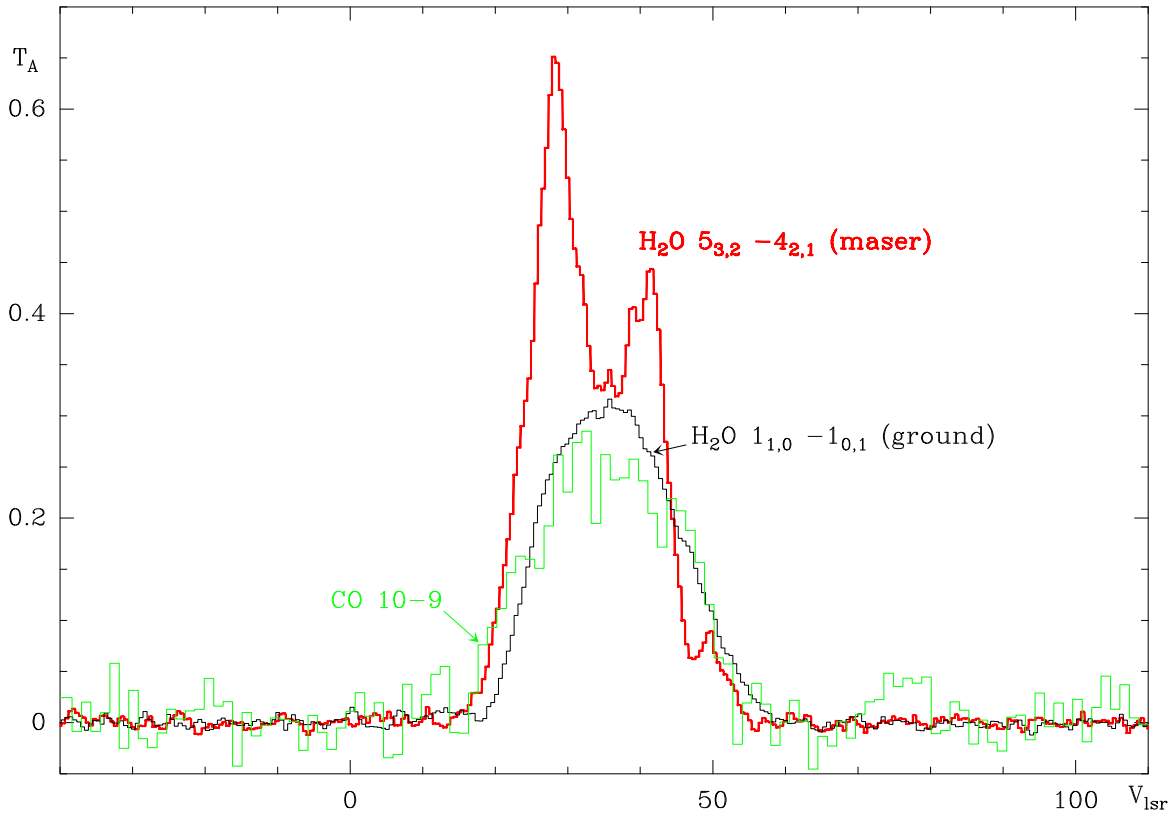
Single-point, DBS, WBS

A lot of information in the data, in particular, on dynamics

Examples: CO and H_2O lines in IK Tau

Intense lines of abundant species.

1st detection of H_2O $5_{3,2} - 4_{2,1}$ maser (predicted by models)



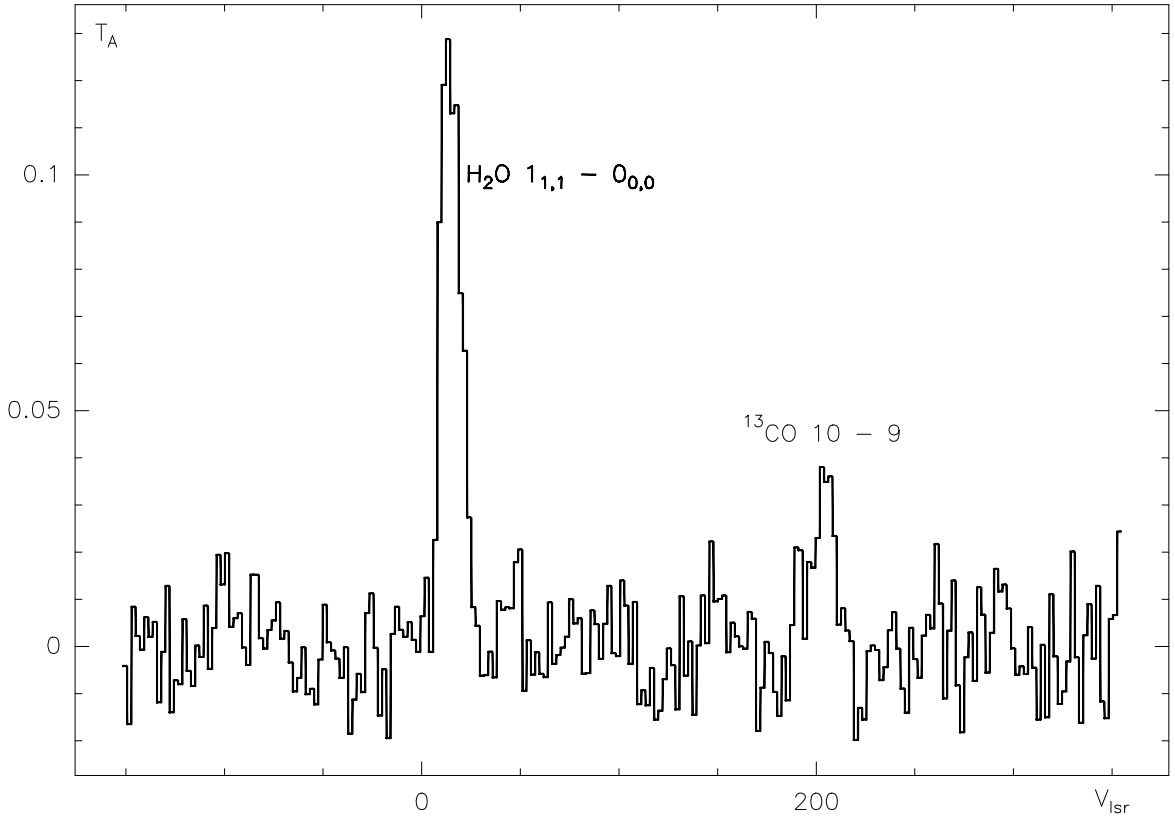
See all details in poster P1.32, by E. De Beck, L. Decin, and the HIFISTARS team

Examples: Detection of H_2O emission from the C-rich AGB star V Cyg

H_2O seems often present in C-rich AGB stars !

$\sim$ 100 times higher anbundance than in IRC+10216 (from SWAS data)

We will search for water vapor in 8 more carbon-rich AGB stars



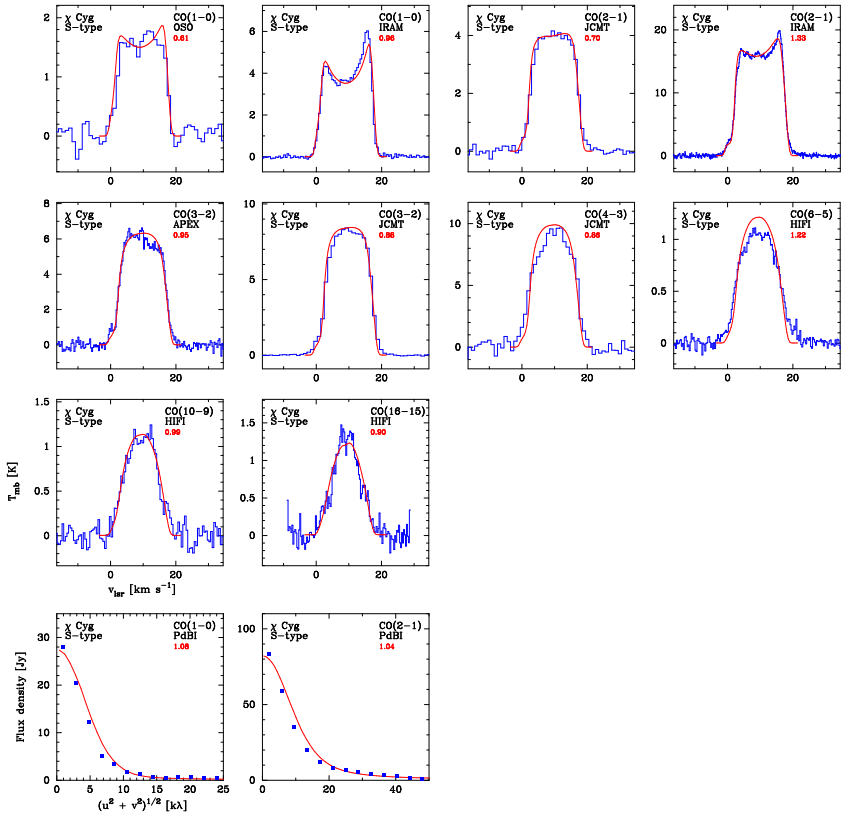
See all details in poster P2.28, by D. Neufeld, E. González-Alfonso, and the HIFISTARS team

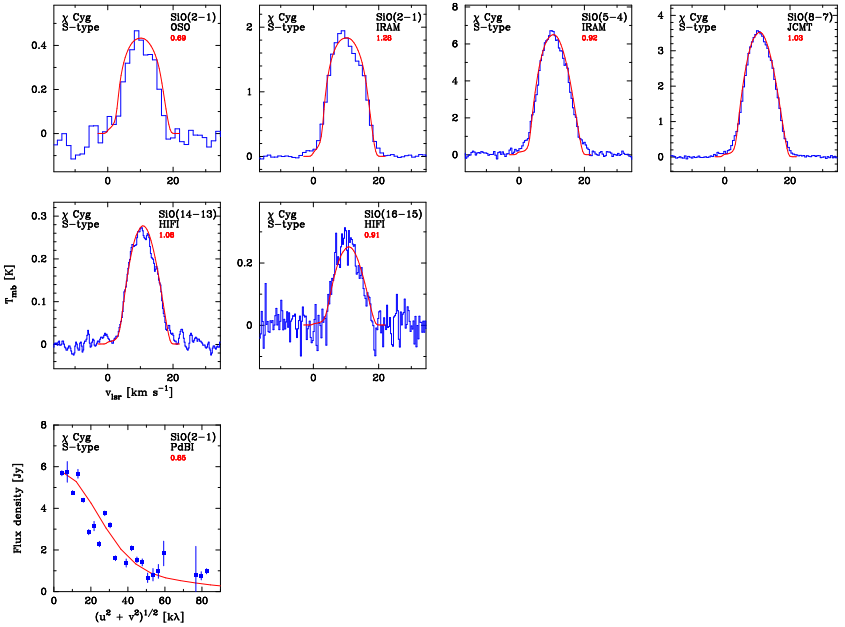
χ Cyg: observations and modeling

HIFI (+ ground based) observations of CO and SiO :

Measurement of V_{exp} and T_k in inner circumstellar regions ($< 10^{15}$ cm)

Models: non-local radiative transfer, “theoretically” consistent calculation of T_k and V_{exp}



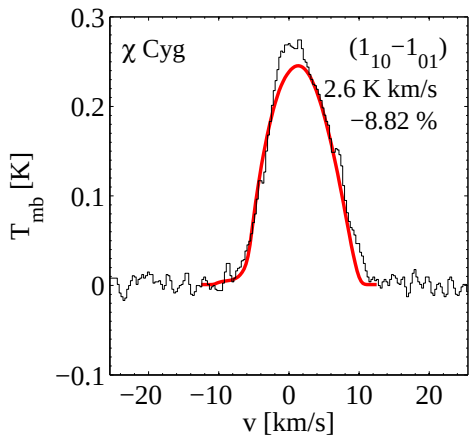


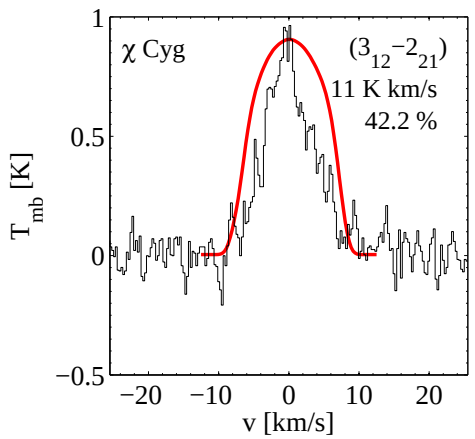
Subtopic leaders: K. Justtanont, F. Schöier, M. Maercker, L. Decin

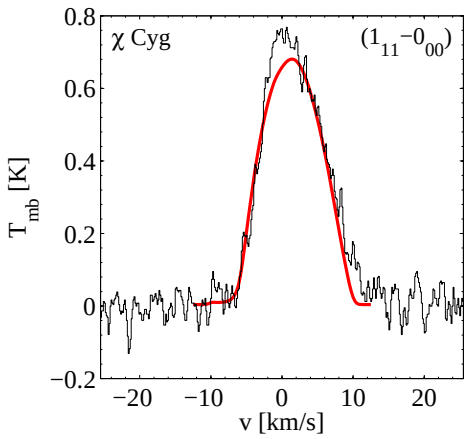
χ Cyg: observations and modeling: H_2O

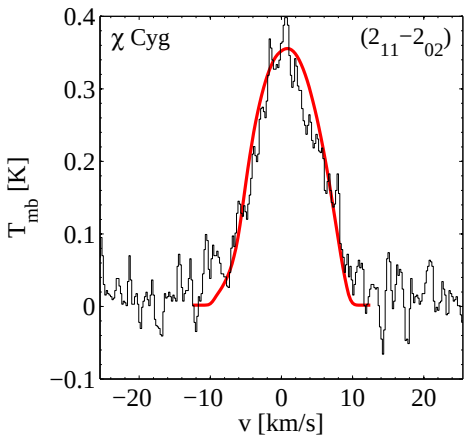
Same model as for CO, o-H_2O/H_2 abundance ratio is deduced to be $\sim 10^{-5}$

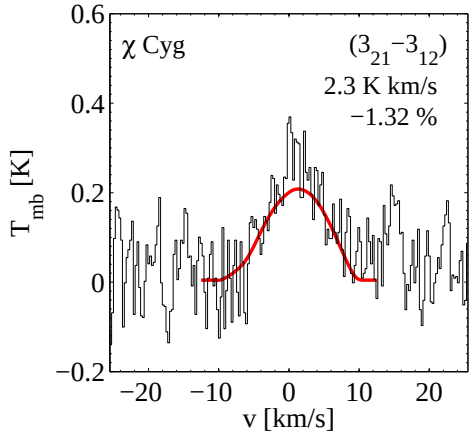
Outer H_2O radius of 3.6 10^{15} cm, compatible with photodissociation predictions

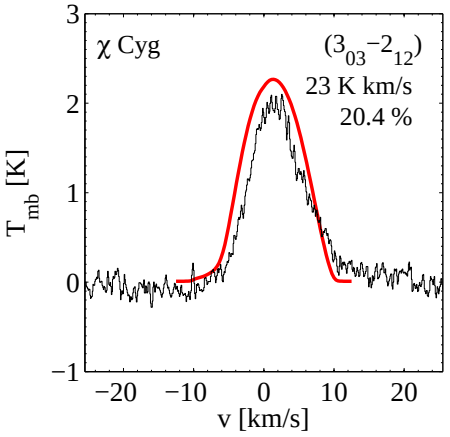


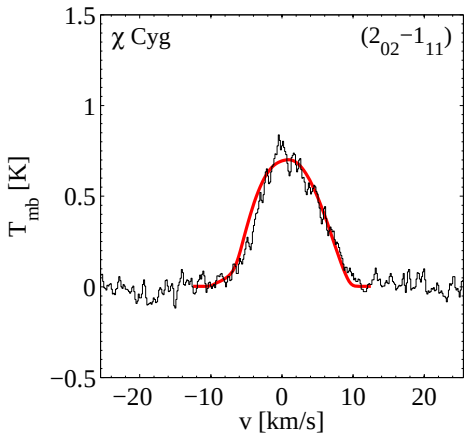




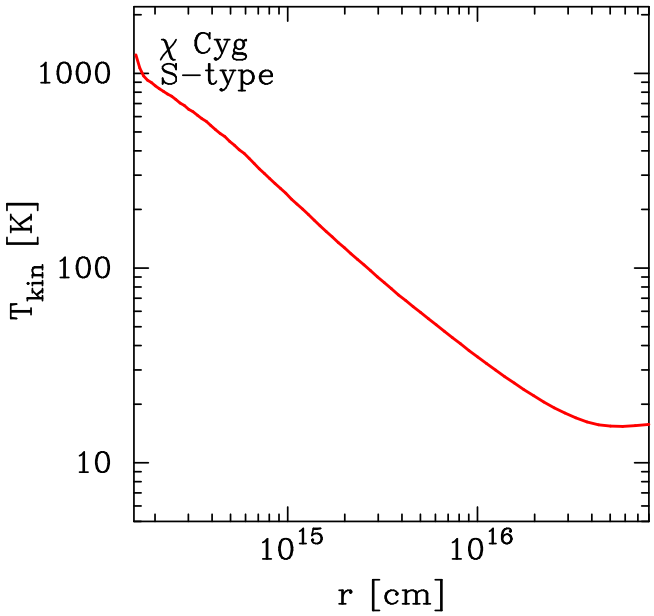


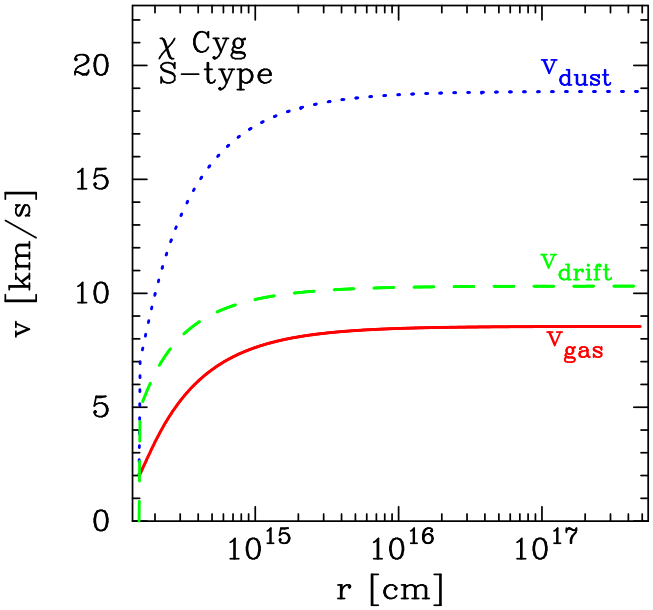


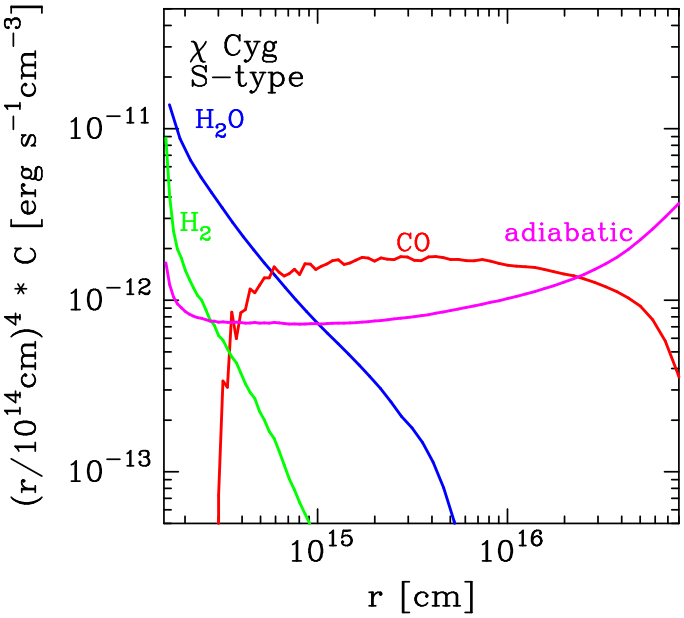




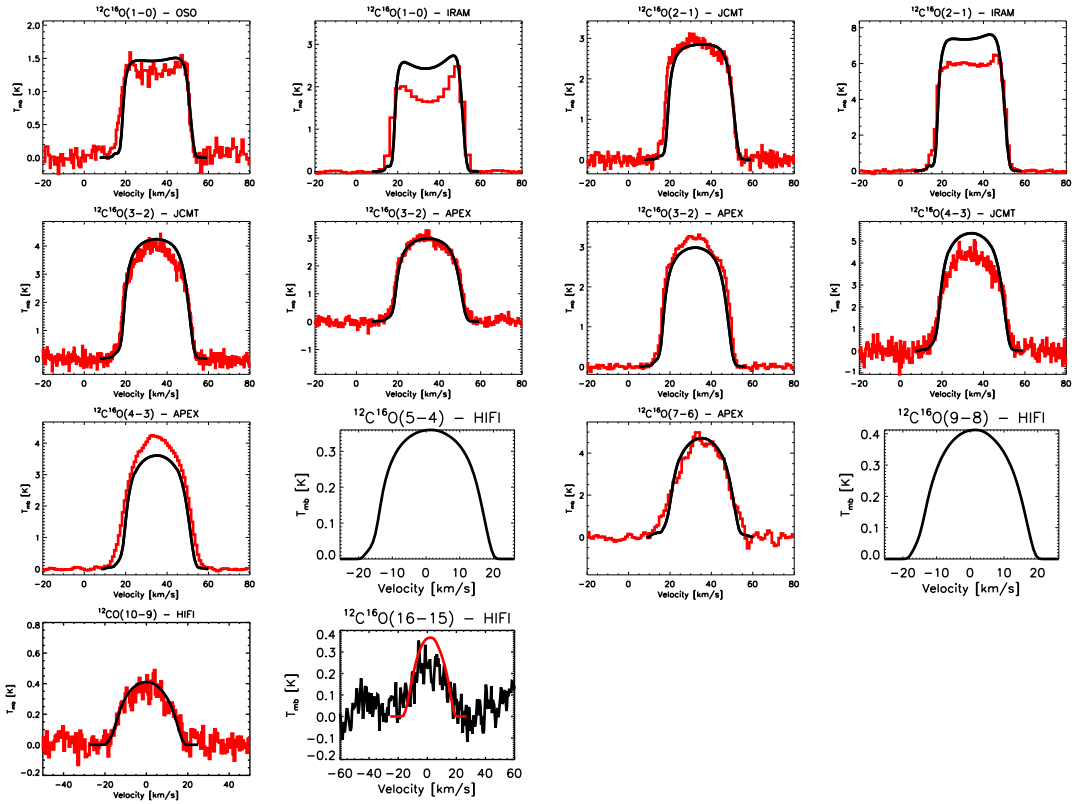
χ Cyg: results from models

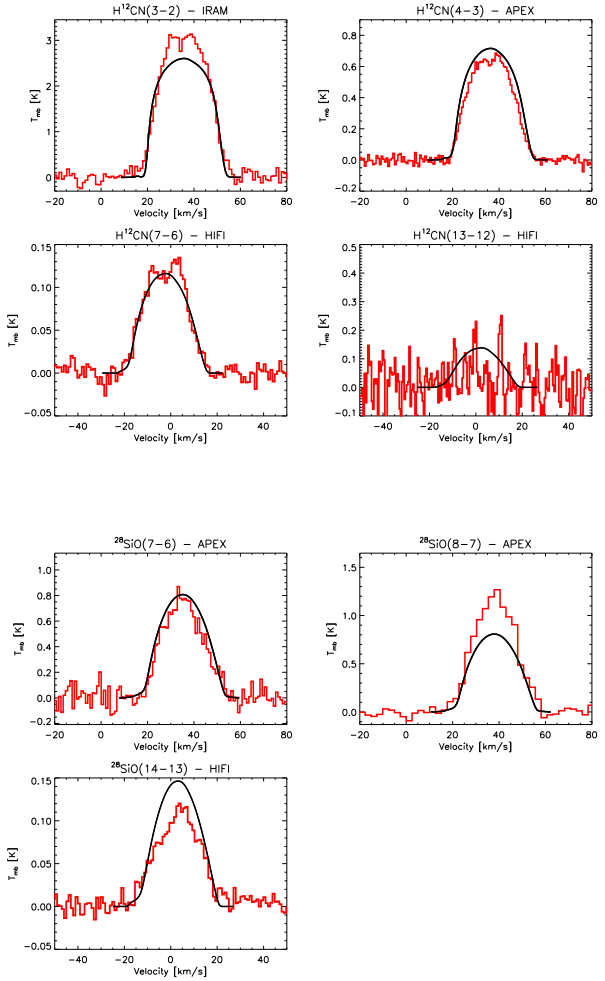






IK Tau: observations and modeling





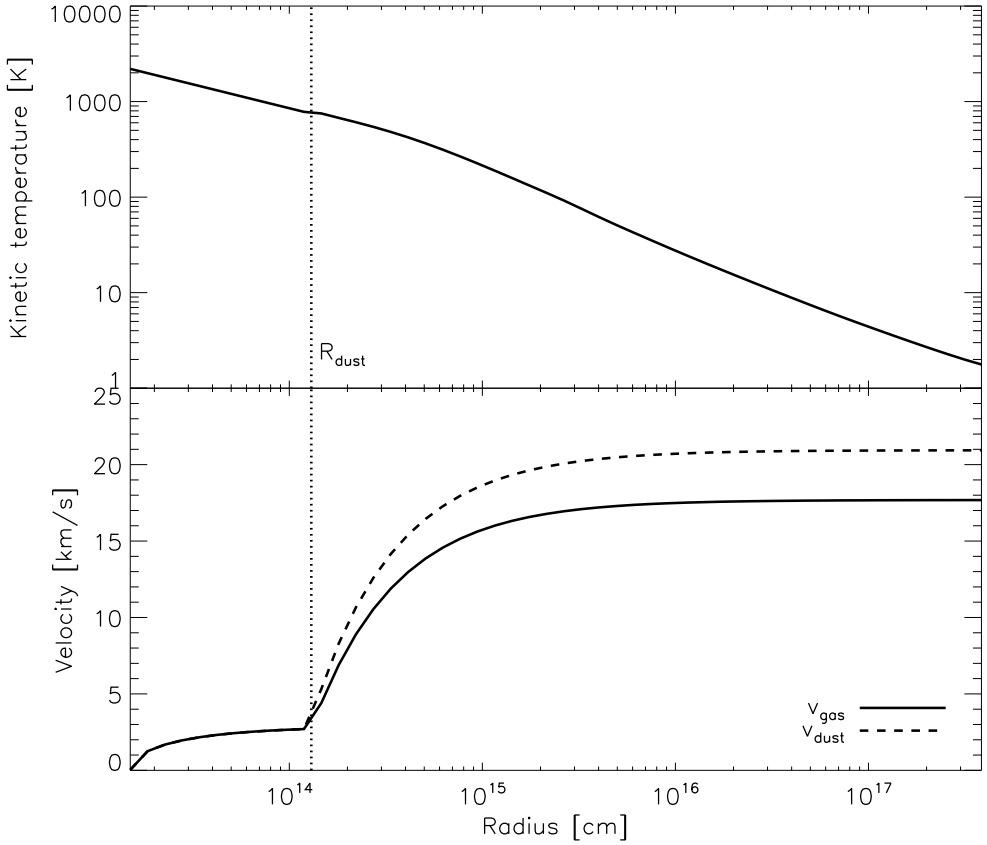
Subtopic leaders: L. Decin, E. De Beck, R. Lombaert, K. Justtanont

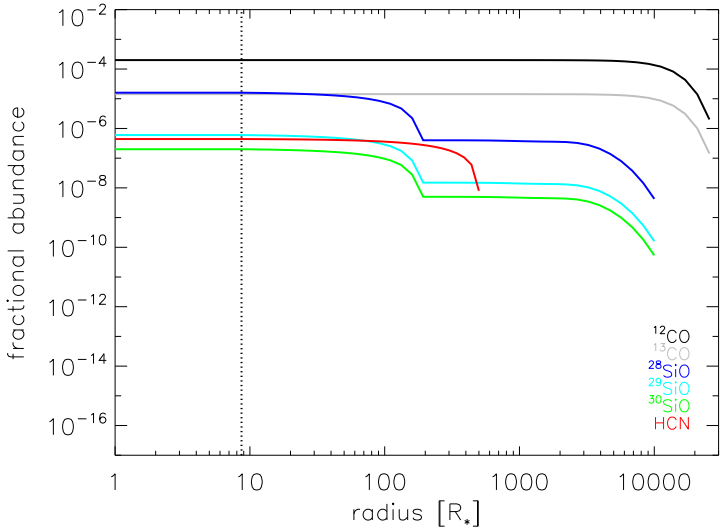
See all details in poster P1.32, by E. De Beck and the HIFISTARS team

IK Tau: observations and modeling of several molecules

Theoretically consistent calculation of the temperature and velocity profiles

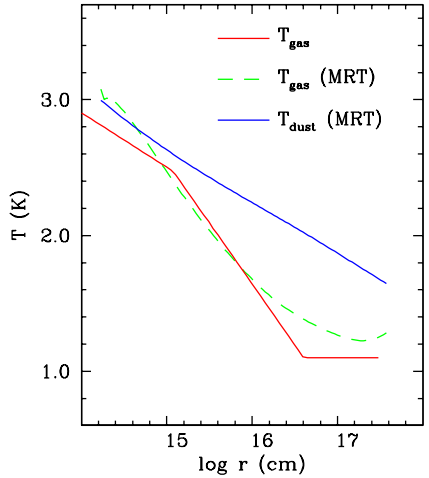
\+ estimate of the abundances

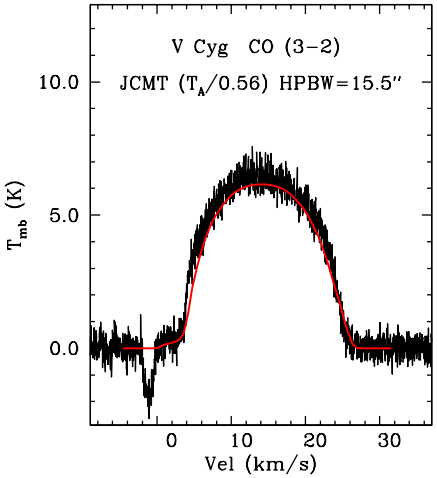


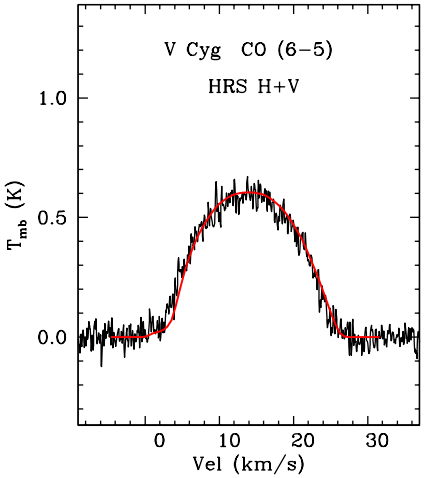


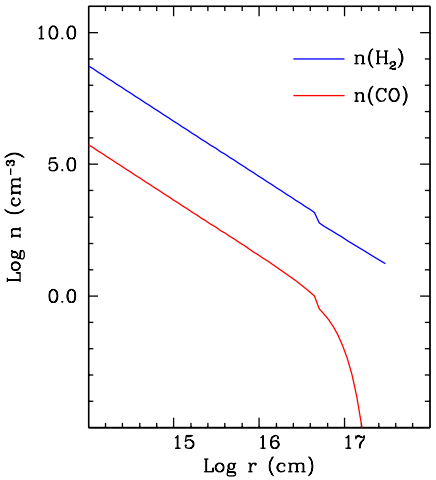
CO emission from V Cyg

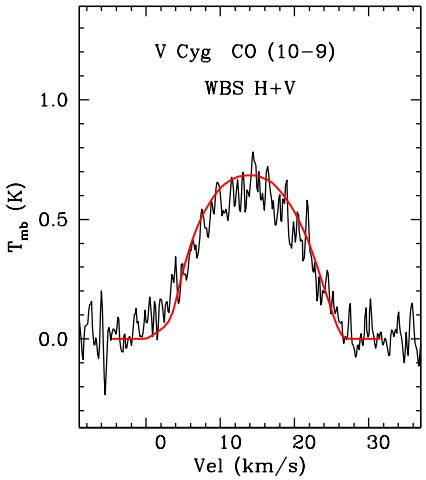
Basic determination of physical parameters, used in particular to better derive $X(H_2O)$

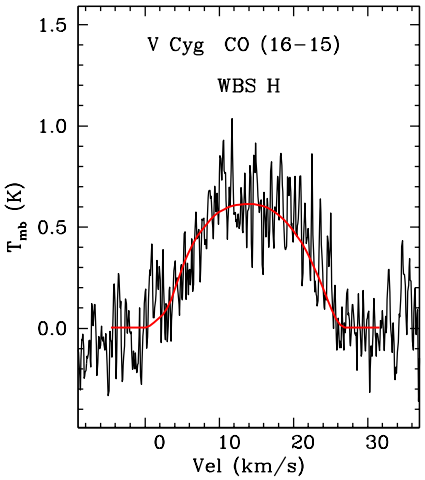








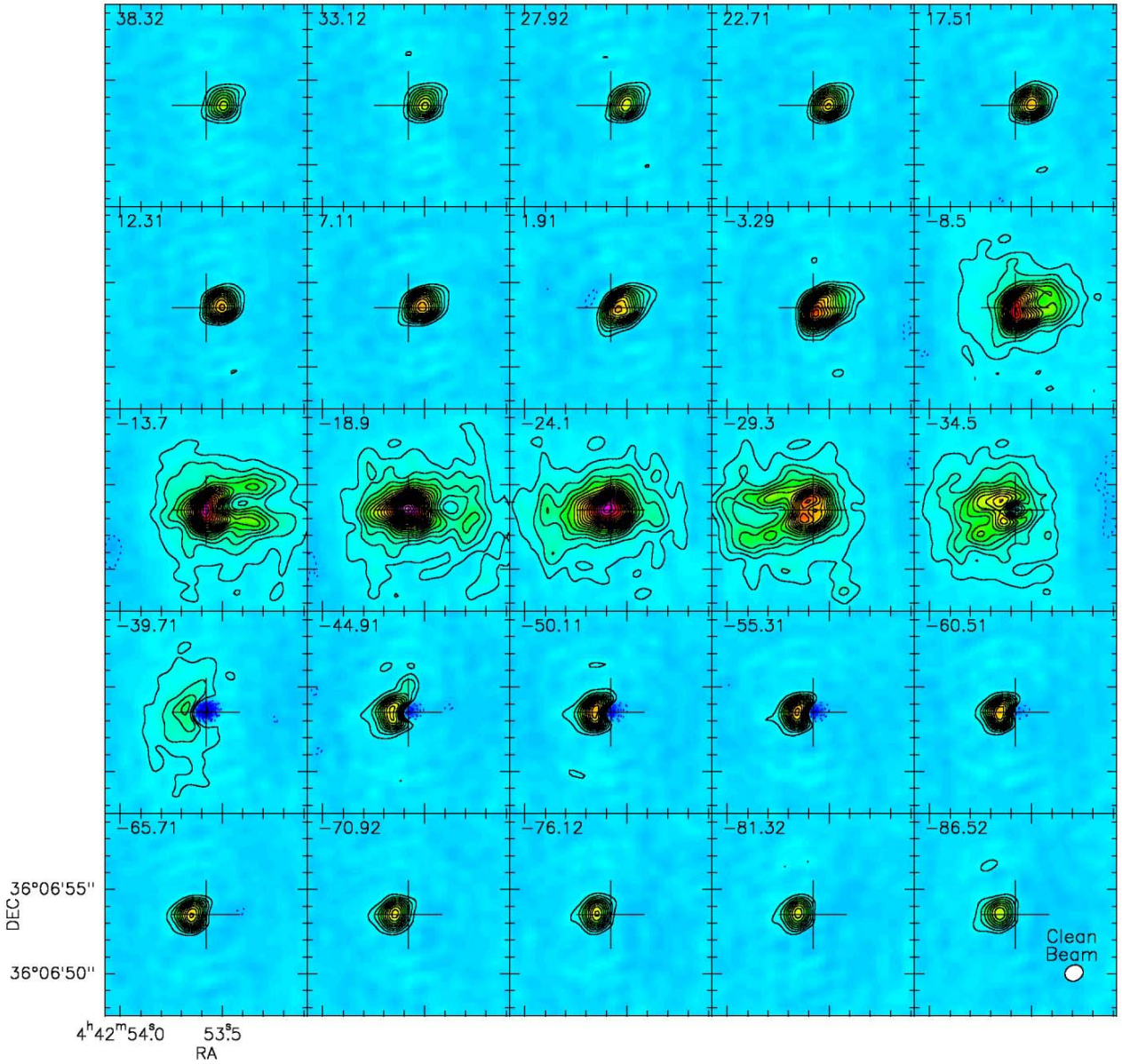




Subtopic leaders: R. Szczerba and D. Neufeld

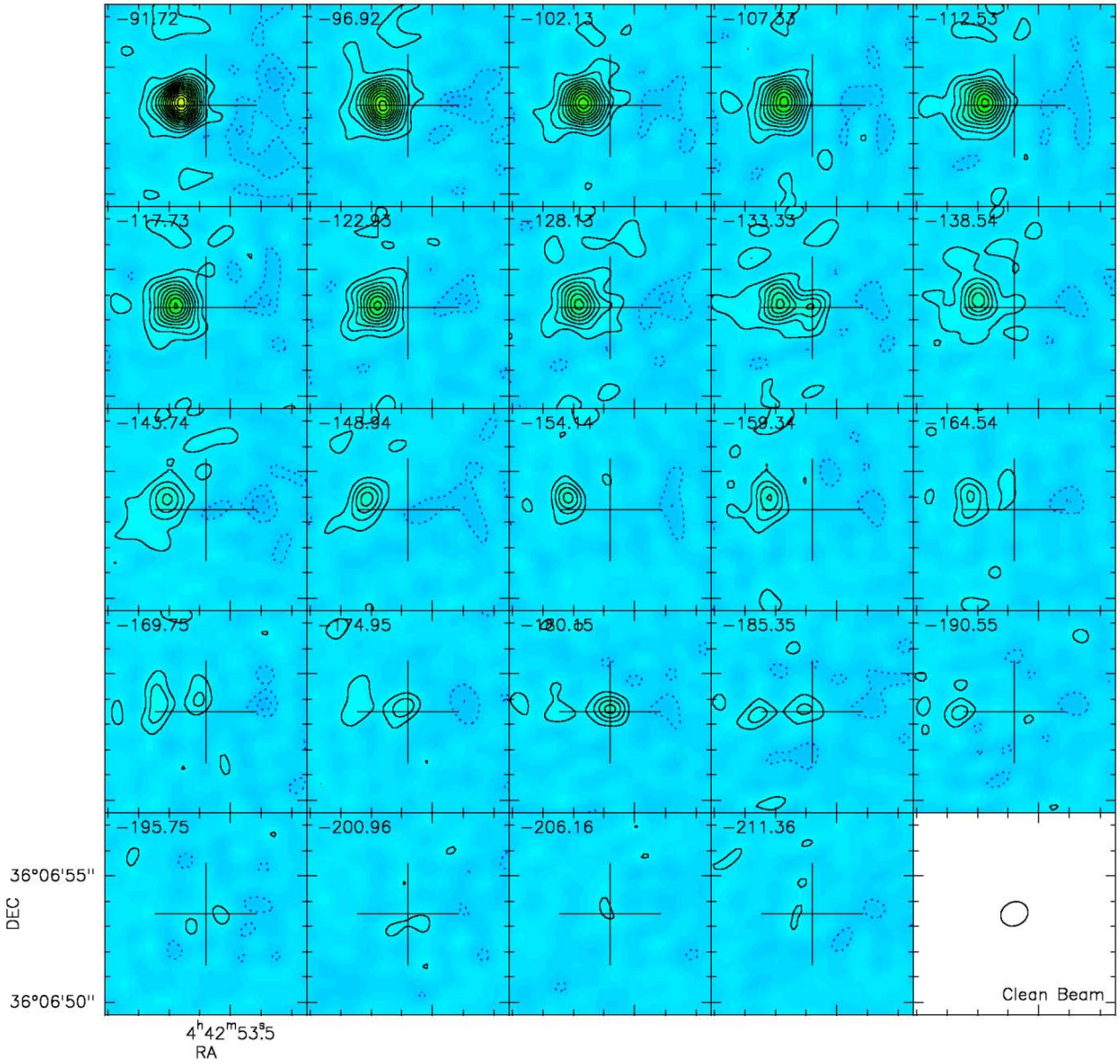
See all details in poster P2.34, by R. Szczerba, M.R. Schmidt, and the HIFISTARS team

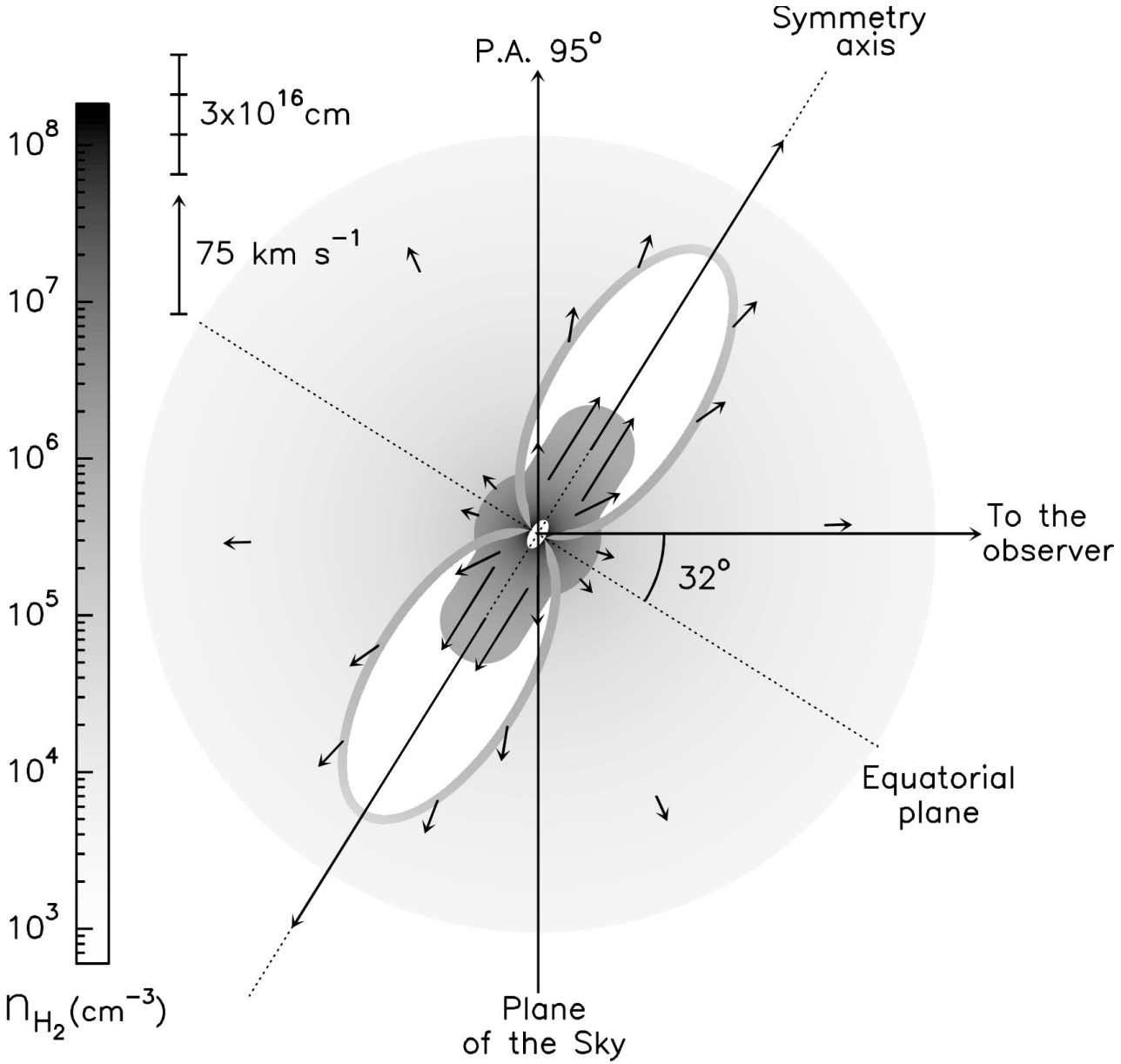
CRL 618: FROM mm TO submm AND FIR



CRL 618, CO J=2–1 (Sánchez Contreras et al. 2004, ApJ 617, 1142)

CRL 618: FROM mm TO submm AND FIR





Total molecular mass: 0.3 $M_\odot$

Diffuse, slow envelope:

$\dot{M} \sim 10^{-5}$ $M_\odot$ yr^{-1}, during 2500 yr

T_k: from 50 to 15 K

Dense, slow envelope:

$\dot{M} \sim 2\ 10^{-4}$ $M_\odot$ yr^{-1}, during 500 yr

T_k: from 350 to 50 K

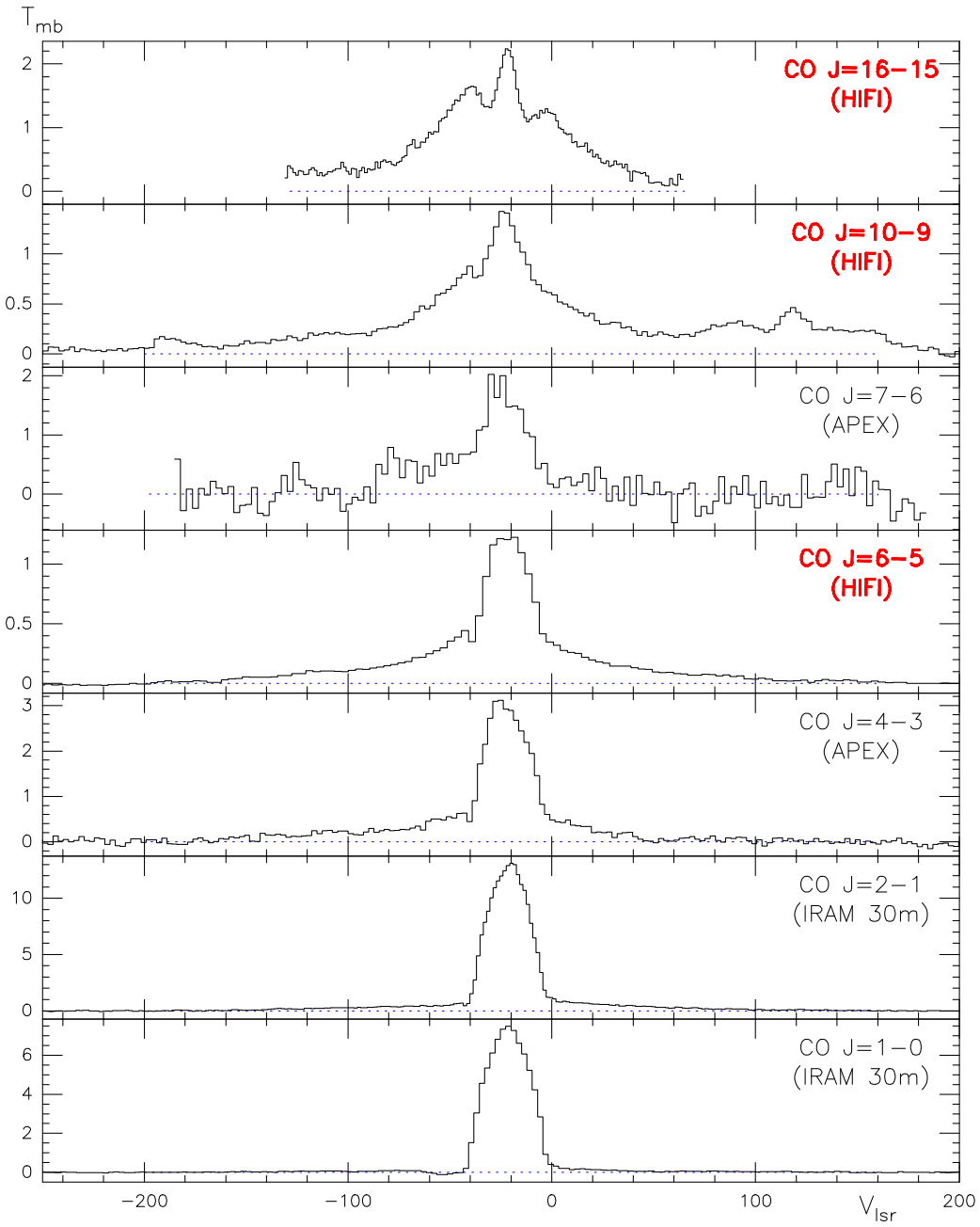
Double hollow shells:

T_k = 200 K

Very fast outflow:

T_k: from 500 to 50 K

ground and HIFI CO observations of CRL 618: impressive high-velocity emission



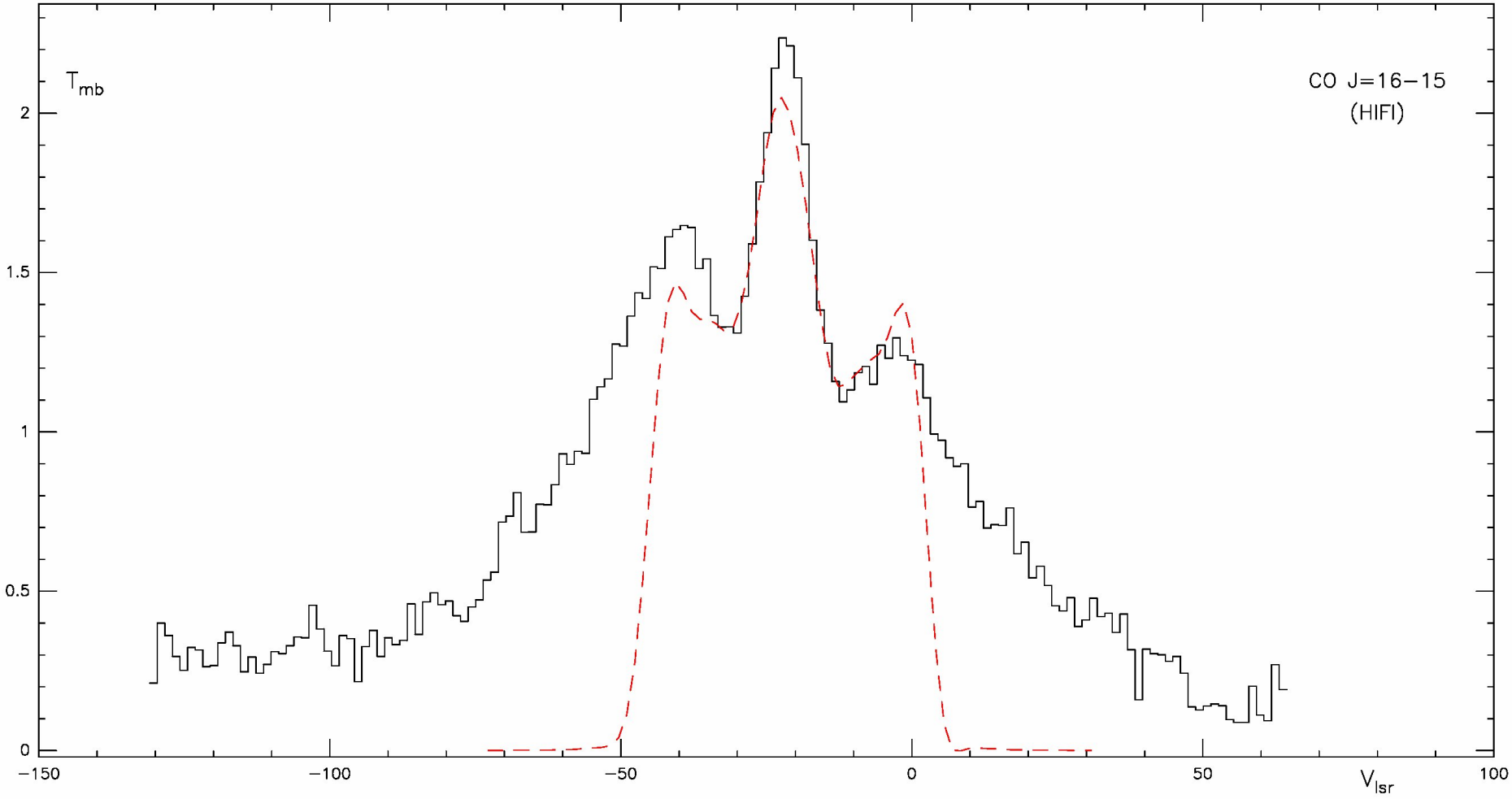
(similar telescope times in HIFI and ground tel.)

subtopic leaders: V. Bujarrabal, J. Alcolea, R. Soria

HIFI CO observations of CRL 618: predictions of initial model

Model from mm-wave maps predicts reasonable intensities, except for the very fast jet

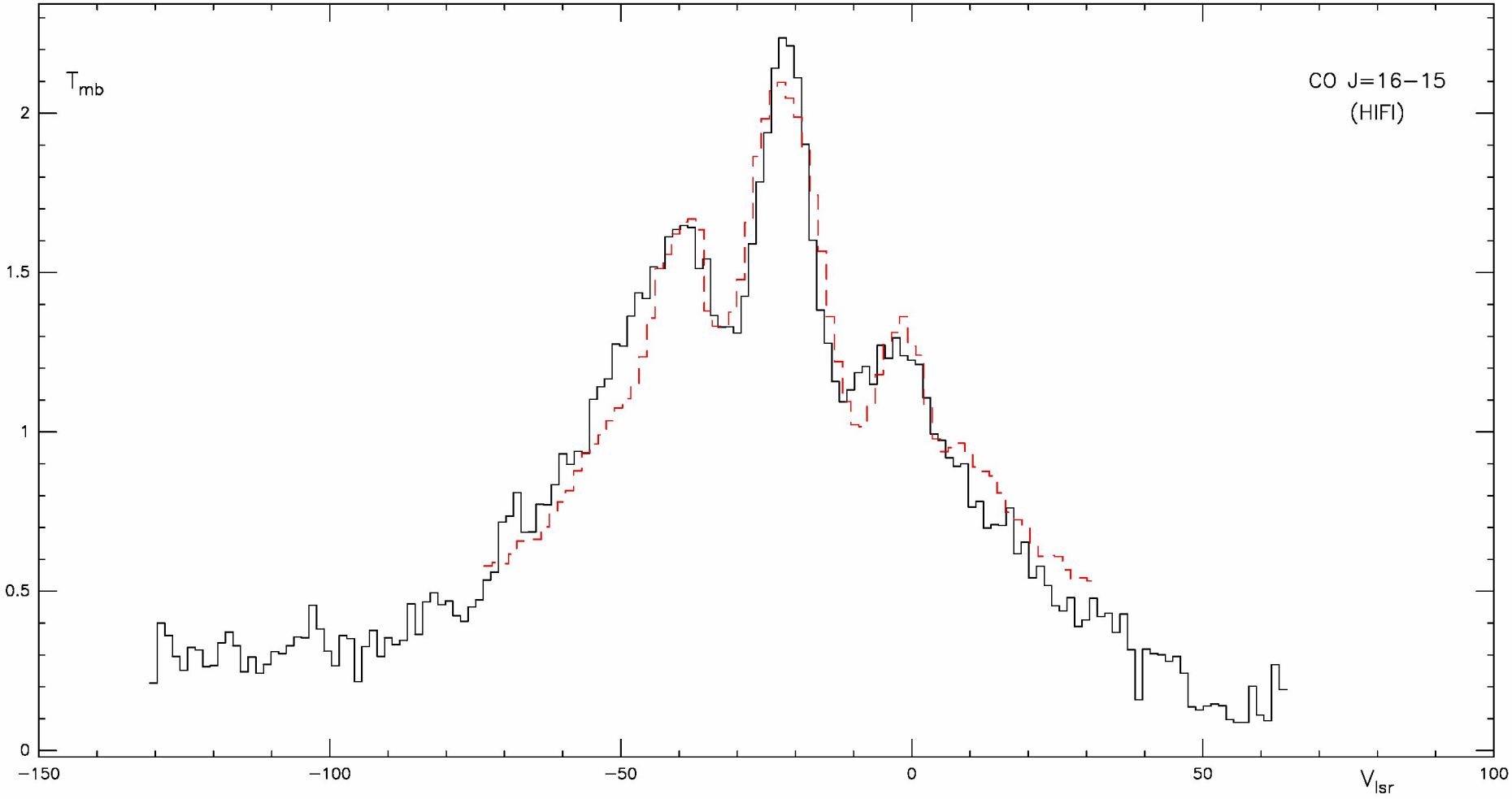
=> very low velocities in inner regions (momentum from radiation), bubbles are hot, ...



HIFI CO observations of CRL 618: new modeling

Very fast jet: temperature must be higher at least by a factor 2

remember: very preliminary modeling !!



FIRST RESULTS FROM HIFISTARS: CONCLUSIONS

- Very good results, lots of astrophysical information !!

- Lines are intense (as expected), noise levels also $\sim$ expectations in general

- Results (still preliminary modeling) :
  - Study of inner circumstellar shells around AGB stars
    Acceleration and temperature
  - Study of H_2O in O-rich stars: chemistry, cooling
  - Origin of H_2O in C-rich environments: comet vaporization, shocks, ...
  - Study of warm inner regions and shocks in young PNe
    Hot and cold shocked gas

- Some technical problems at high frequency: ripples
  can improve with careful analysis, and will certainly improve in the future