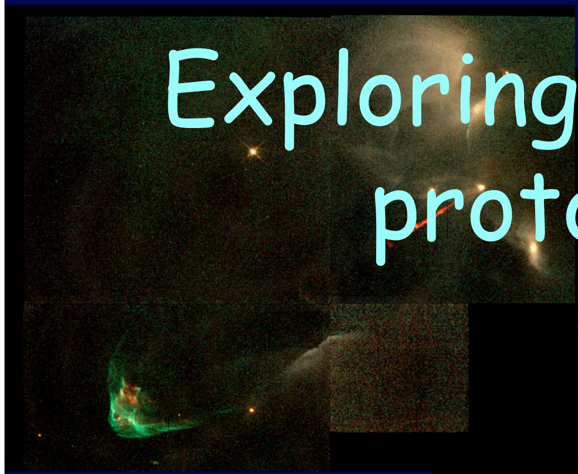
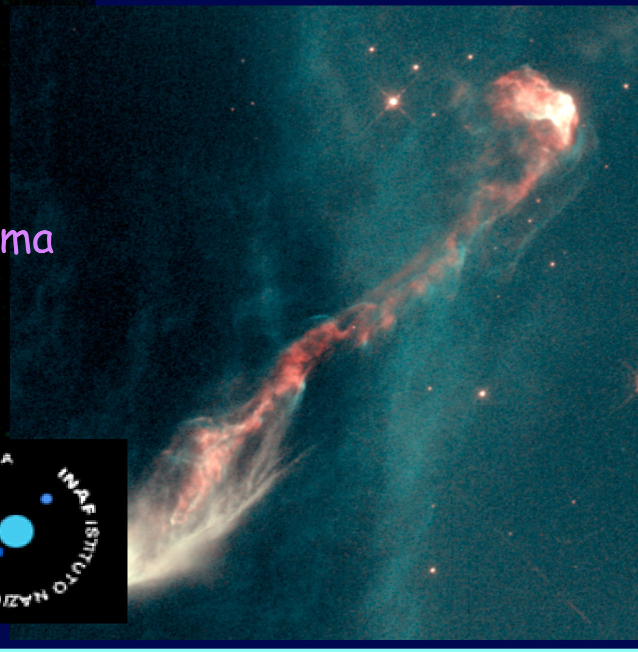
Exploring the origin of jets in embedded protostars with ELT and ALMA



Brunella Nisini

INAF-Osservatorio Astronomico di Roma



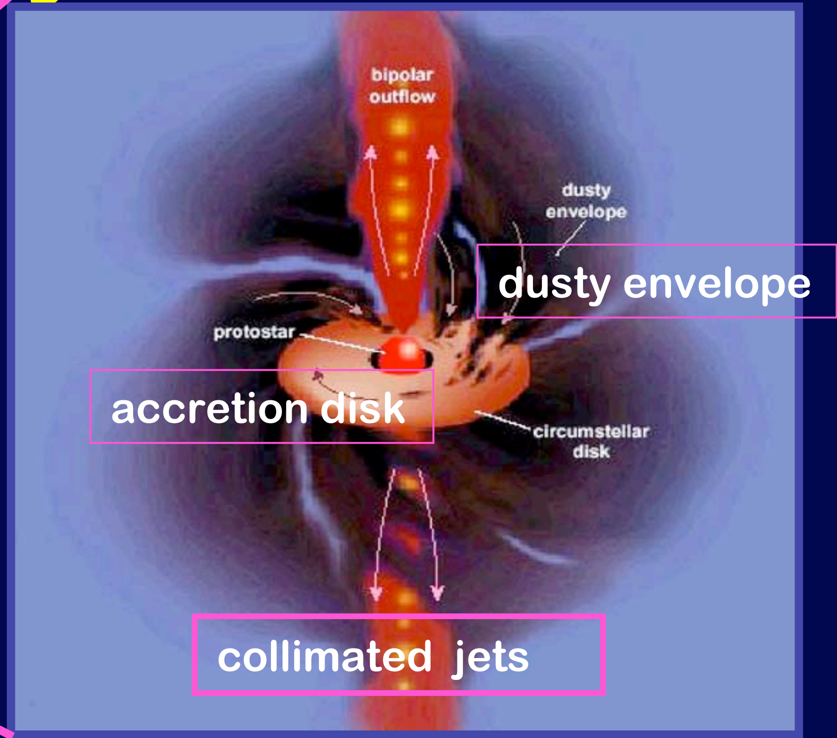
Paradigm for solar-mass star formation

$t=0-10^4$ yr
(pre-stellar core)

10^4 - 10^5 yr
(proto-star)

10^6 - 10^7 yr
(T Tauri star)

10^8 yr
(debris disk
ZAMS star)



Class 0/ I objects

Highly embedded accreting sources

$\dot{M}\_jet / \dot{M}\_acc \sim 0.05 - 0.1$

Protostellar jets

Class 0 (Av > 100 mag)

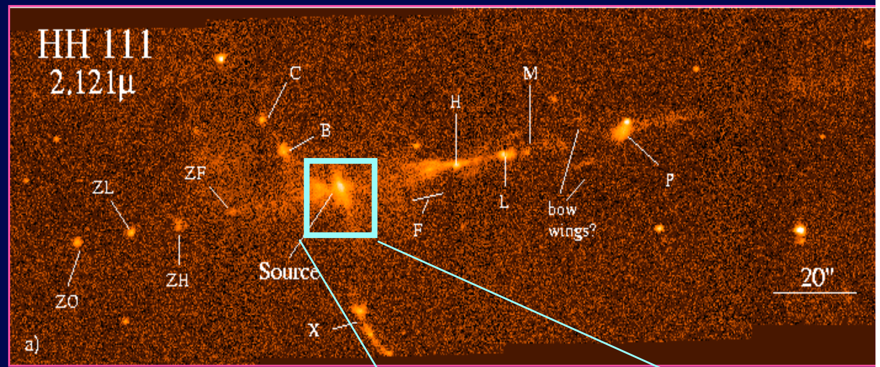
- molecular flows

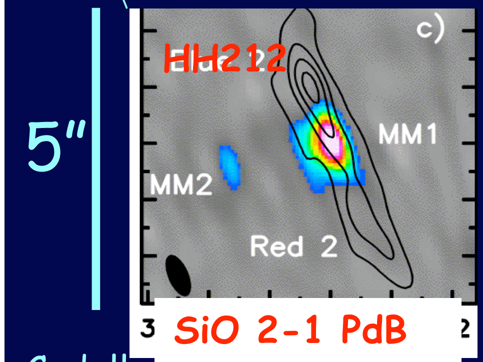
- tracers:CO,SiO

Class I (Av ~ 20-50 mag)

-molecular and atomic flows

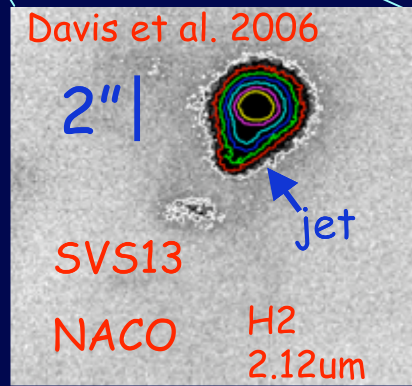
-tracers: H_2, FeII

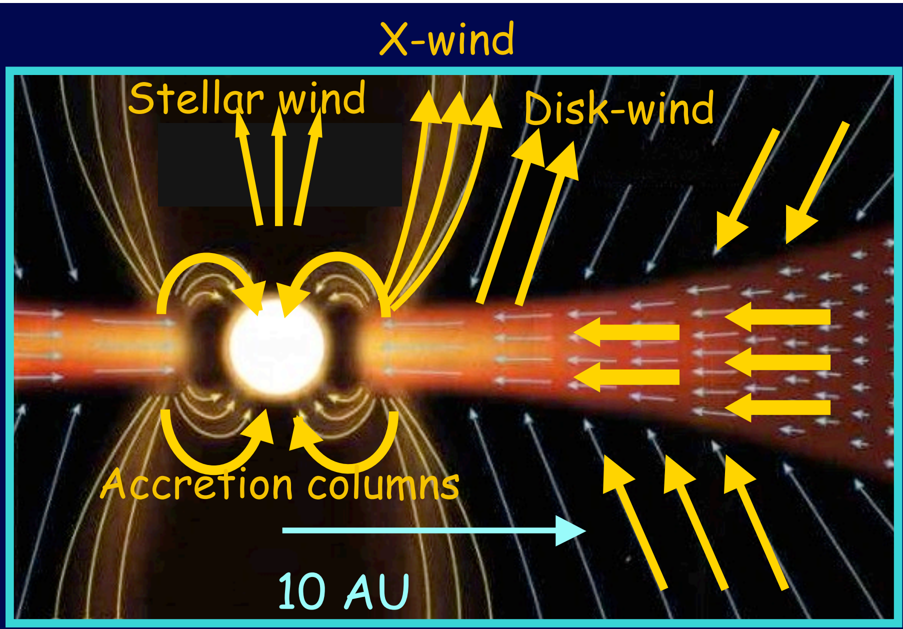




Codella et al. 2008

- How the jets are launched and collimated
- How angular momentum is transferred from the accretion disk to the jet
- Which is the initial heating process

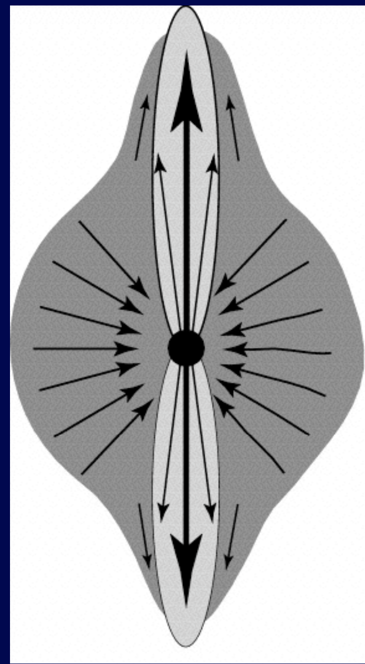




MODELS BASED ON OBSERVATIONS ON T TAURI STARS:

- jet launching zone within 10 AU

- jet acceleration/collimation zones 10-100 AU (~70-700 mas at 150 pc)



CAVEAT TO EXPORT THESE RESULTS ON YOUNGER SOURCES

-different mass accretion/mass ejection rates

- thick massive envelopes and disks

-Large densities --> large B and low Xe

Role of ELT and ALMA to give observational constraints resolving the collimation scales

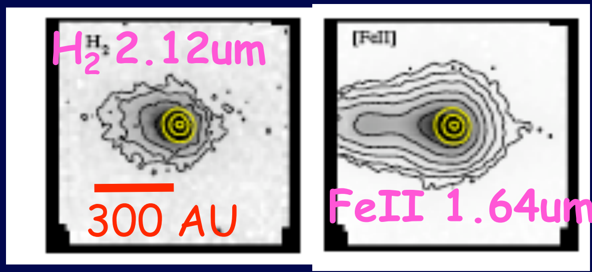
Excitation structure in the inner 100 AU region

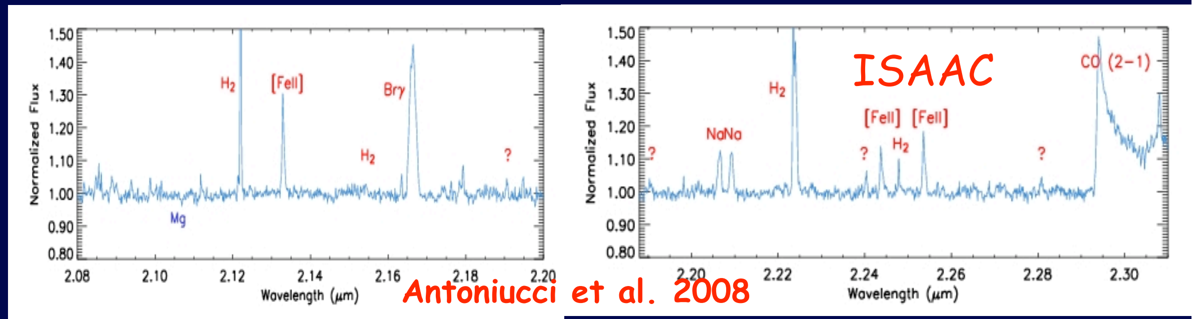
Probe excitation mechanisms: steady shocks, X-rays, ambipolar diffusion..

IFU Sinfoni seeing limited

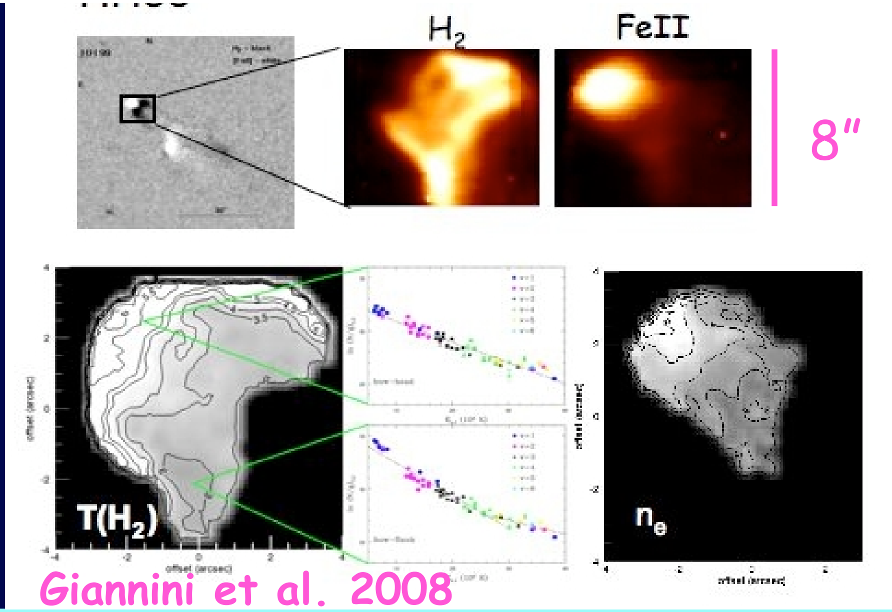
(Davis et al. in prep.)

HH34 IRS jet





Sinfoni 2D maps of the HH99 bow-shock



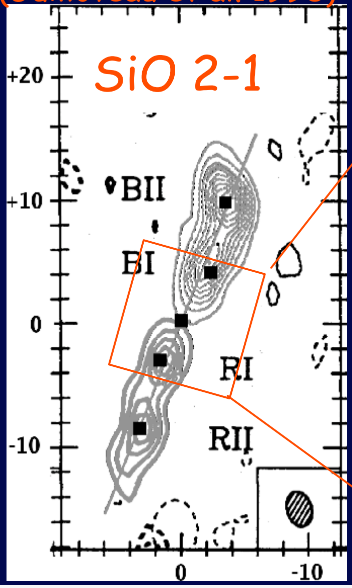
More than 140 diagnostic emission lines detected in HH99 (mainly H2, HI, FeII, PII..)

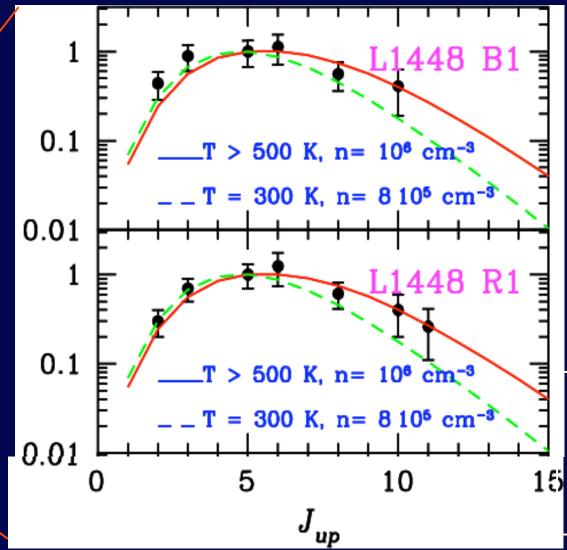
--> maps of molecular and atomic gas physical parameters:

T,n,x_e, Av, dust depletion…

Excitation studies in Class 0 molecular jets

(Guilloteau et al. 1998)





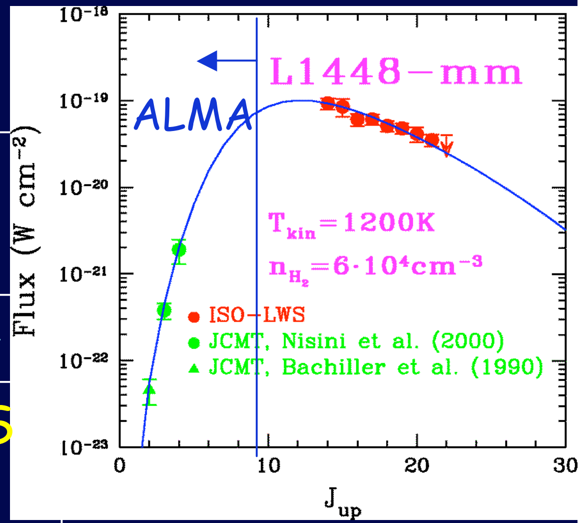
Nisini et al. 2007

IRAM, JCMT

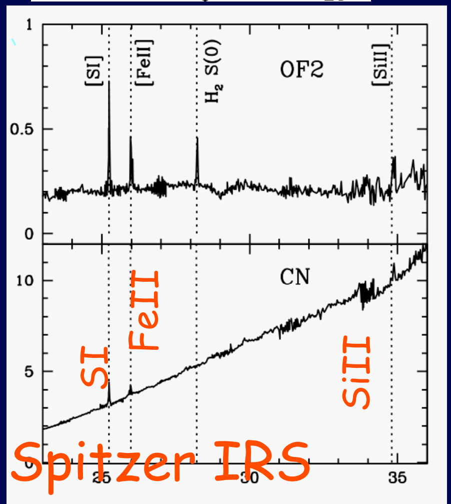
SiO J from 2 to 11

JCMT, ISO-LWS

CO J from 2 to 22



Nisini et al. 2000



Dionatos et al. 2008

The molecular jets are 'warm':

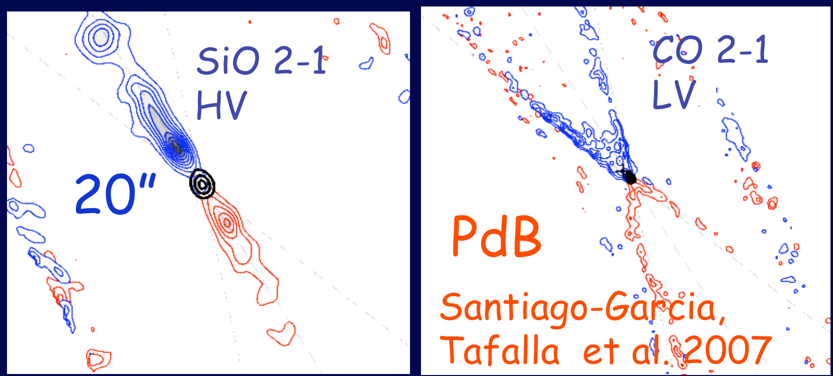
Excitation conditions at the base can be probed through ALMA multiline analysis

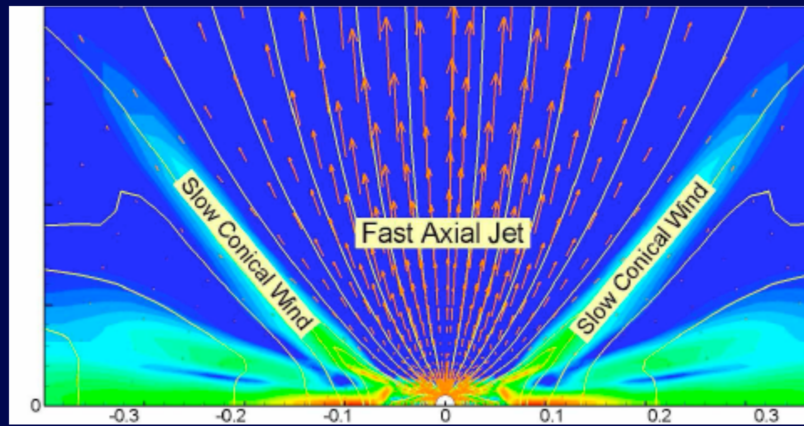
- tracers: CO, SiO

- synergy with ELT mid-IR observations

Velocity structure as a test for ejection models
ALMA and ELT may provide a unified picture

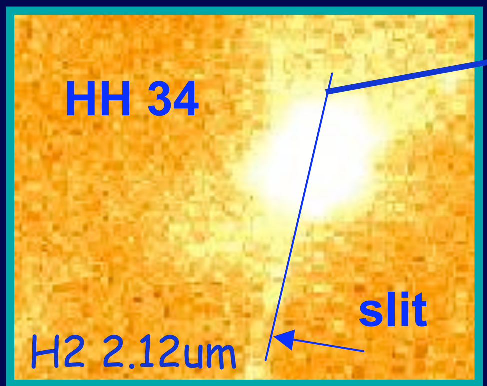
IRAS04166+2706

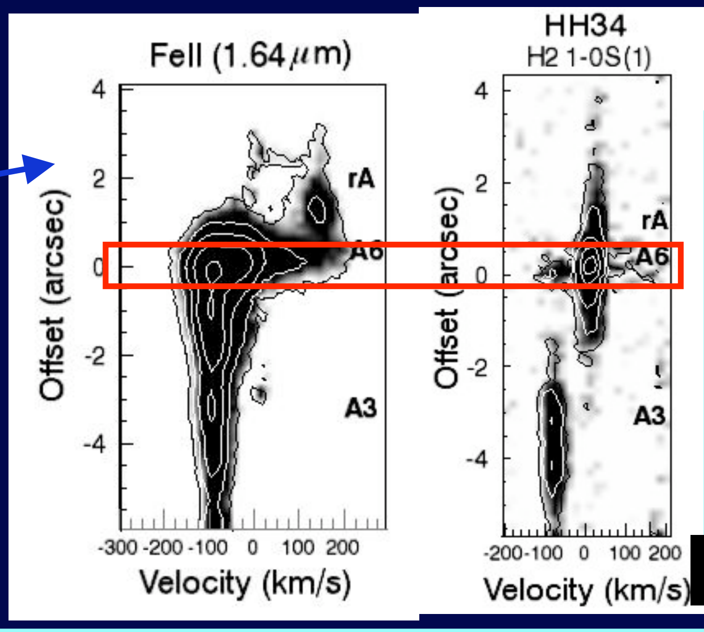




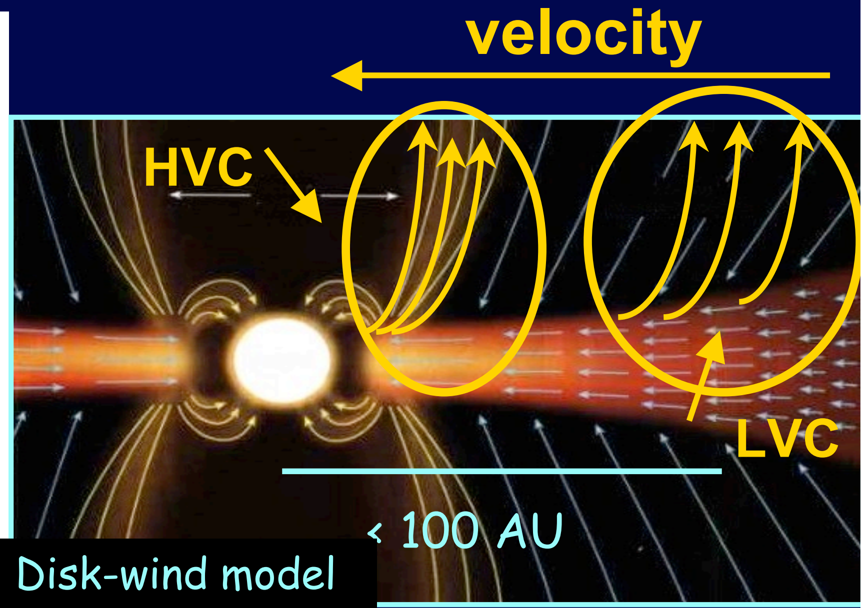
Romanova et al. 2009

ISAAC spectroscopy of class I jets



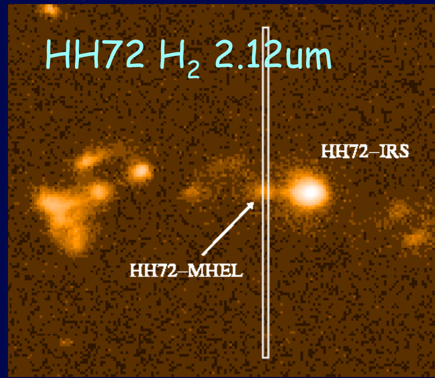


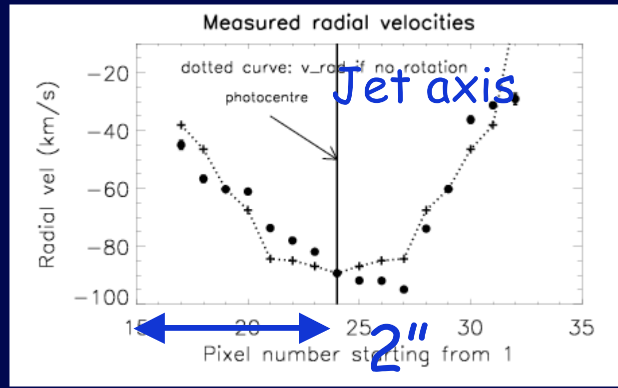
Garcia Lopez, Nisini et al. 2008



Role of jets in removing AM: probing jet rotation

Crysostomou, Bacciotti , Nisini et al. et al. 2007

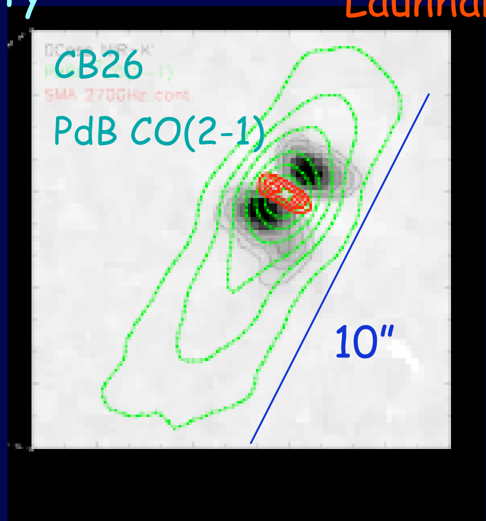


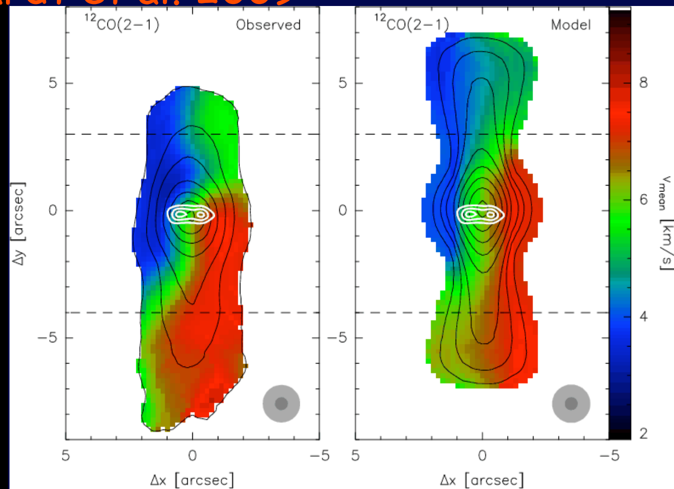


rotation signatures observed in class 0/I objects

- Interaction with ambient medium and/or precession may cause velocity asymmetries
- Need tests as close as possible to the launching zone

Launhardt et al. 2009





vφ ~2-3 km/s --> need for high resolution

- NIR jets -> HARMONI with R>10000, SIMPLE
- (sub-)mm jets --> ALMA 350 GHz SiO (8-7), CO 3-2

ALMA will also test disk rotation

Additional issues

- Proper motion measurements:
  of the order of 0.1"/yr in the nearby clouds
- chemistry
- ALMA polarimetric studies: structure of magnetic field

Summary of requirements

Similar requirements for ELT and ALMA

* For exitation studies at the jet base:

- Angular resolution better than 100 mas
- Spectral resolution 1000-10000
- Integral field (~3x3 arcsec)

E-ELT: e.g. Harmoni

ALMA: Baselines > 1 km, Bands 7/8

* For dynamical studies (rotation/origin of the different gas components):

- Spectral resolution ~ 50000 (e.g. E-ELT/ SIMPLE)

Caveats

E-ELT

AO systems with IR sensors or LGS

- no optical sources in the field
- IR sources usually fainter than m(H) = 12

ALMA

- sensitivity limit for observations with long baselines ?

  expected $T_{MB} \sim$ 10-100 K for resolved emission
- which are the suitable tracers ? SiO 5-4/8-7, high-J CO, CI ?

  chemical models needed...