Mapping water in protostellar outflows:

first results from the WISH-KP

Brunella Nisini (INAF-Osservatorio Astronomico di Roma),

Rene Liseau, Mario Tafalla, Milena Benedettini, Per Bjerkeli, Claudio Codella, Teresa Giannini, Greg Herzog, David Neufeld, Ewine van Dishoeck, and the WISH team.

Scientific motivations to observe water in outflows

- Among the main coolant of dense molecular shocks:
- The most sensitive to local physical conditions:

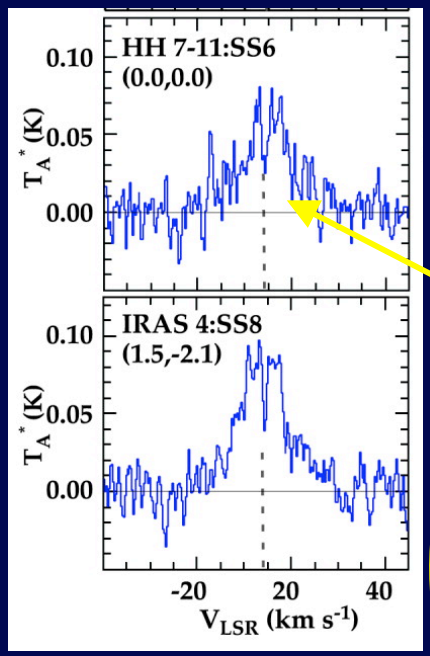
  → large abundance variations with shock conditions and evolution:
- Key molecule for the oxygen chemistry in shocks:

  → oxygen reservoir in the dense warm gas
- Trace grain surface chemical processes

Observing water in protostellar outflows

SWAS H_2O $1_{1,0}$-$1_{0,1}$

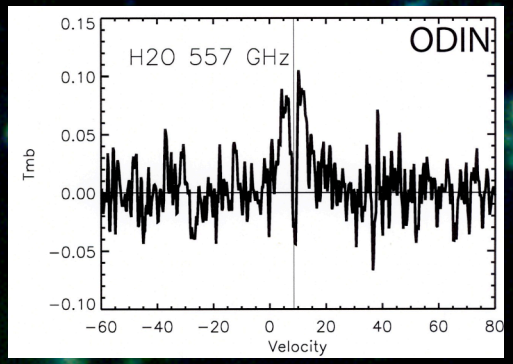
Ø = 3.3′x4.5′



(Bergin et al. 2004)

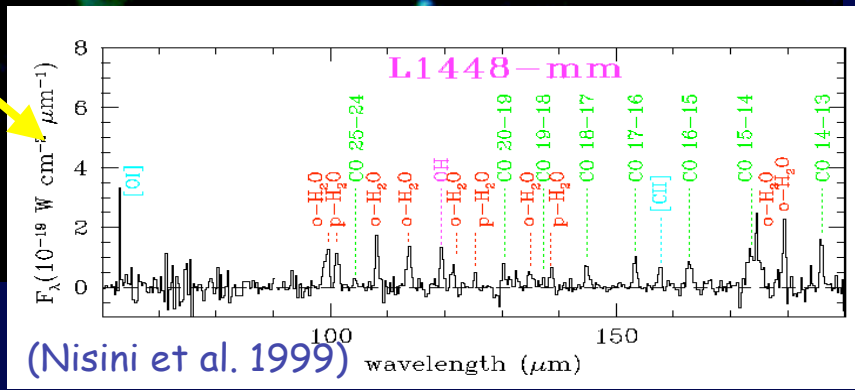
ODIN H_2O $1_{1,0}$-$1_{0,1}$

Ø = 126″



(Olberg et al. 2006)

ISO-LWS 55-180 μm Ø = 80″



(Nisini et al. 1999)

Herschel Ø = 9.4″ - 40″

⇒ provides the spatial resolution to probe water on spatial scales comparable to ground-based mm observations

WISH outflow program

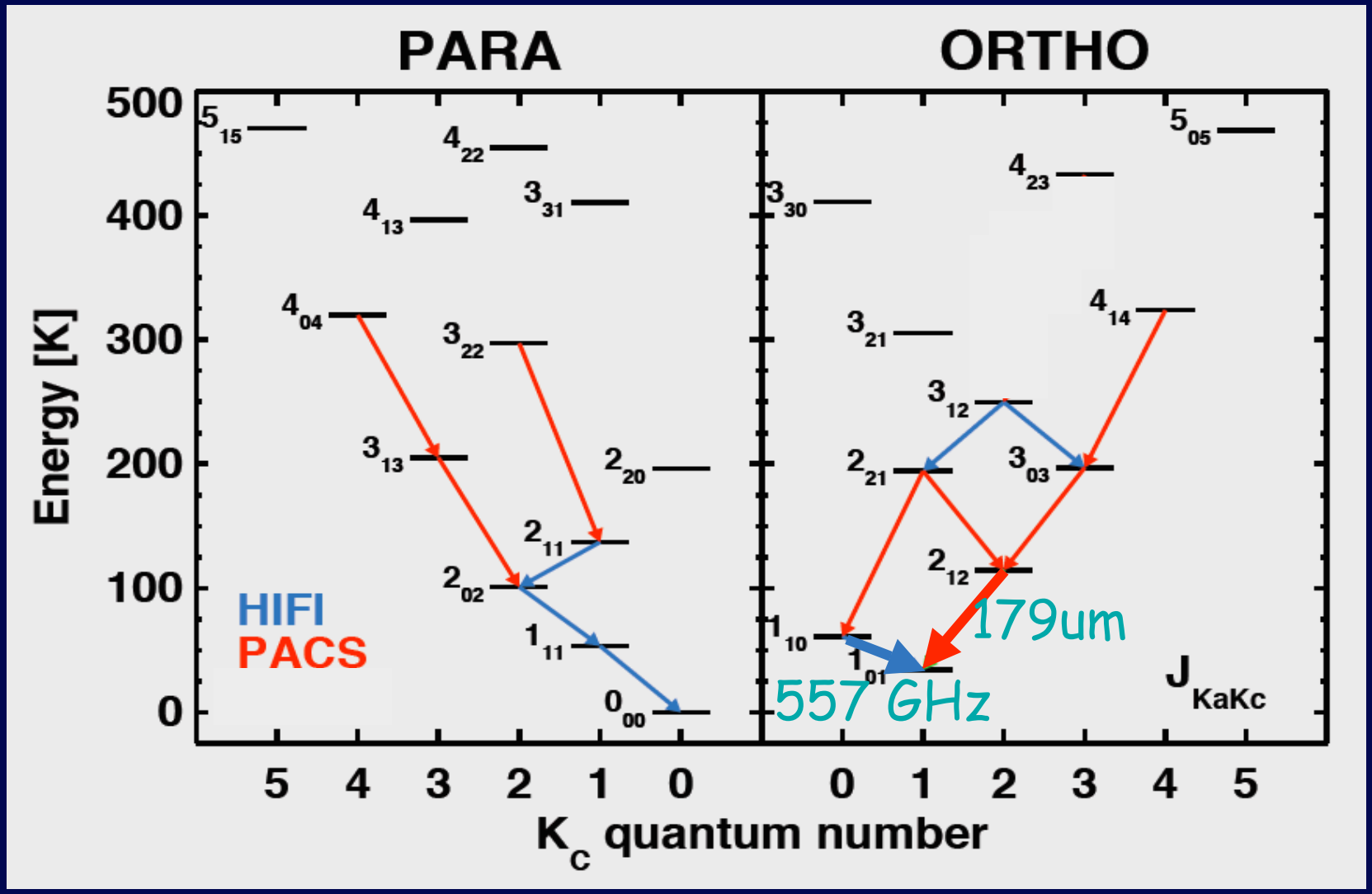
Observations of outflows from low mass objects

→ Observing strategy:

1. Survey of the oH_2O 557 GHz (HIFI) and 179μm (PACS) emission in 25 Class 0/I outflows with L between 0.5 to 100 Lo
   → H_2O cycle in outflows/ chemical complexity

2. PACS/HIFI observations of several H_2O lines (+ complementary OI/CO and OH) in few shock spots
   → H_2O excitation - test of oxygen chemistry in shocks

3. maps of oH_2O 557 GHz (HIFI) and 179μm (PACS)
   → morphology of water emission vs other tracers/ variations in abundance

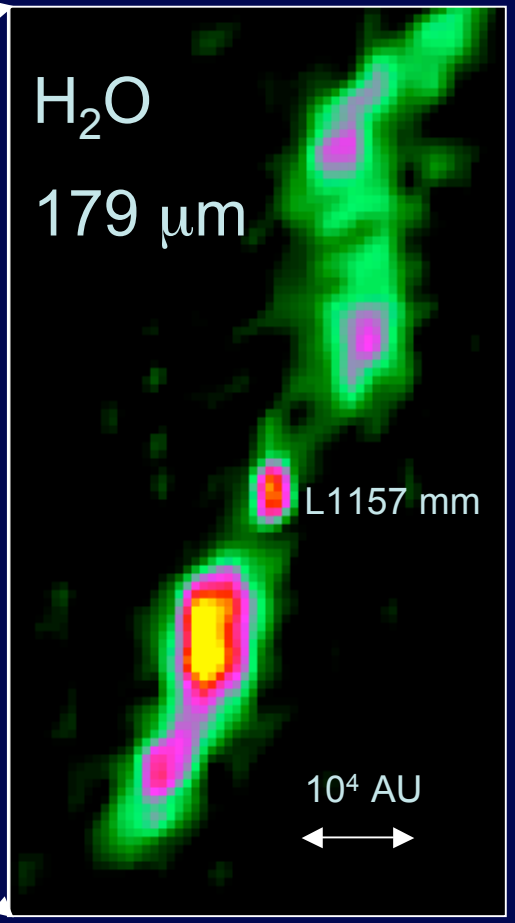


➔ FIRST results on the PACS mapping of the 179μm line will be presented here…

PACS map of 179μm line in L1157

Spitzer IRAC

Herschel PACS



L1157, D=440 pc

Class 0, L = 8 Lo

•Proto-type of chemically active flows

PACS observations:

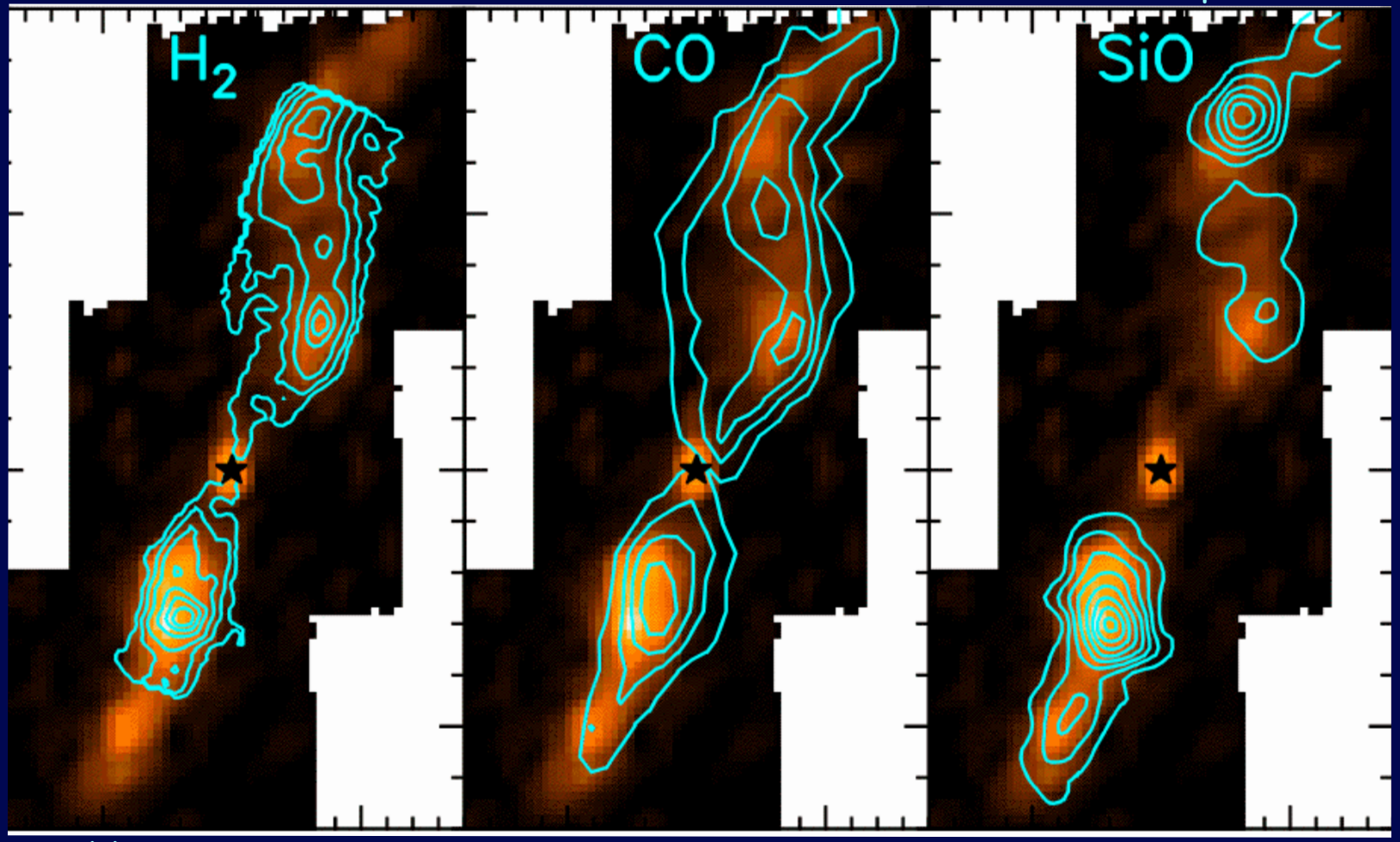
9.4"/pixel

6'x2' raster map

R(179 μm) ~ 1500

- Strong water emission from the embedded protostar
- Emission peaks trace the shock interaction regions

A&A Herschel special issue



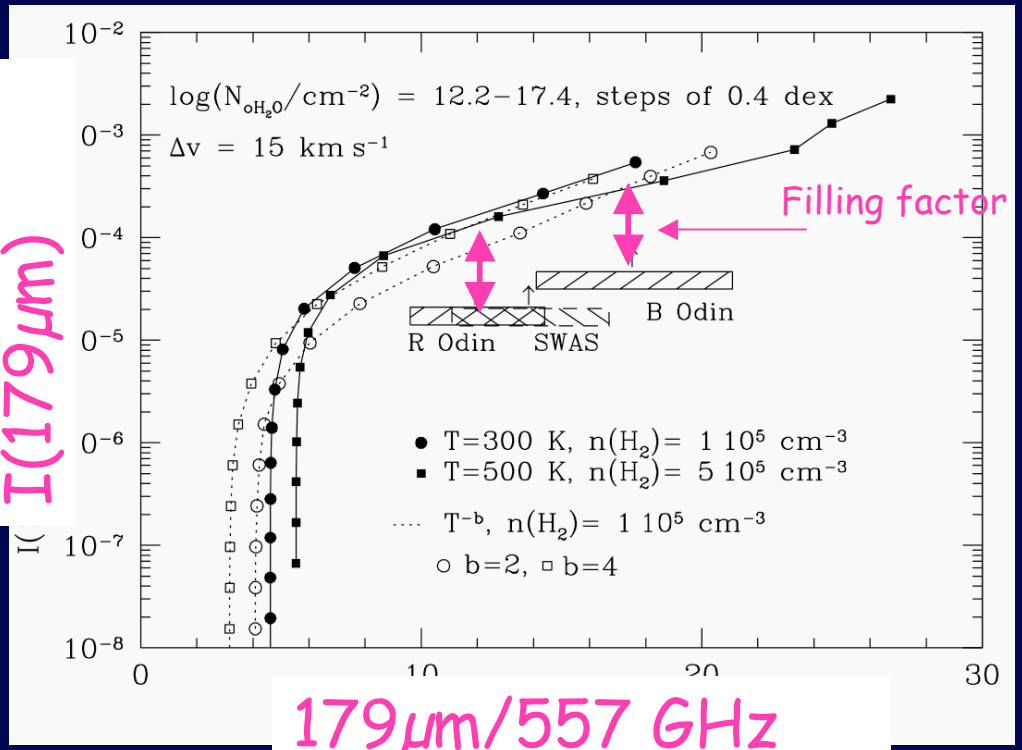
$H_2S(1)$ 17μm
Neufeld et al. 2009

CO 2-1 Bachiller et al. 2001

SiO 3-2 Bachiller et al. 2001

- H_2O localized on the CO peaks of the precessing jet
- Correlation between H_2O and H_2 warm gas at T ~ 300 K
- H_2O follows SiO --> tracer of high density shocks with v_s > ~ 20 km/s

H_2O abundance



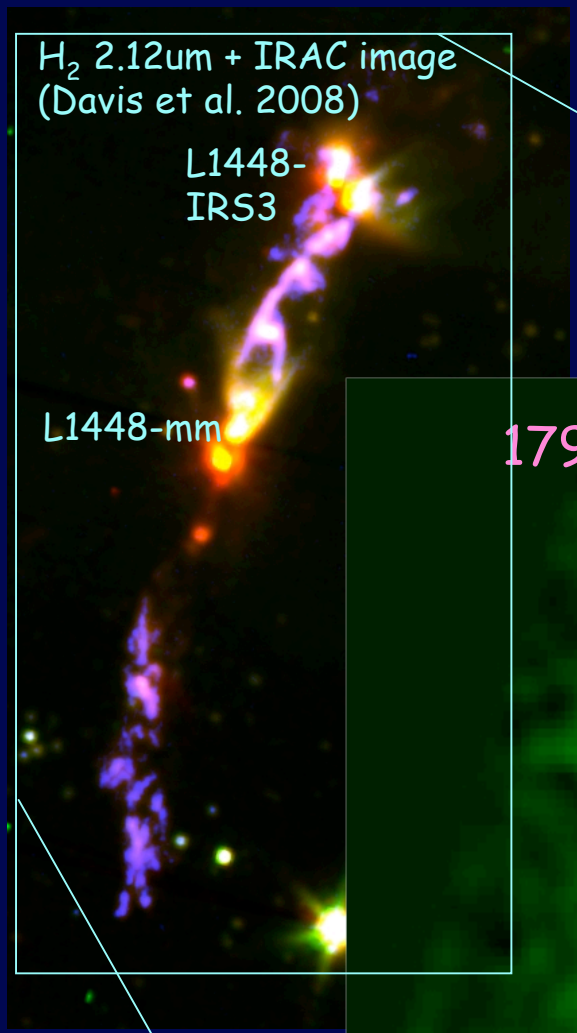
Comparison with Odin/SWAS observations of the 557GHz line

(Franklin et al. 2008, Bjerkeli et al. 2009)

Main results:

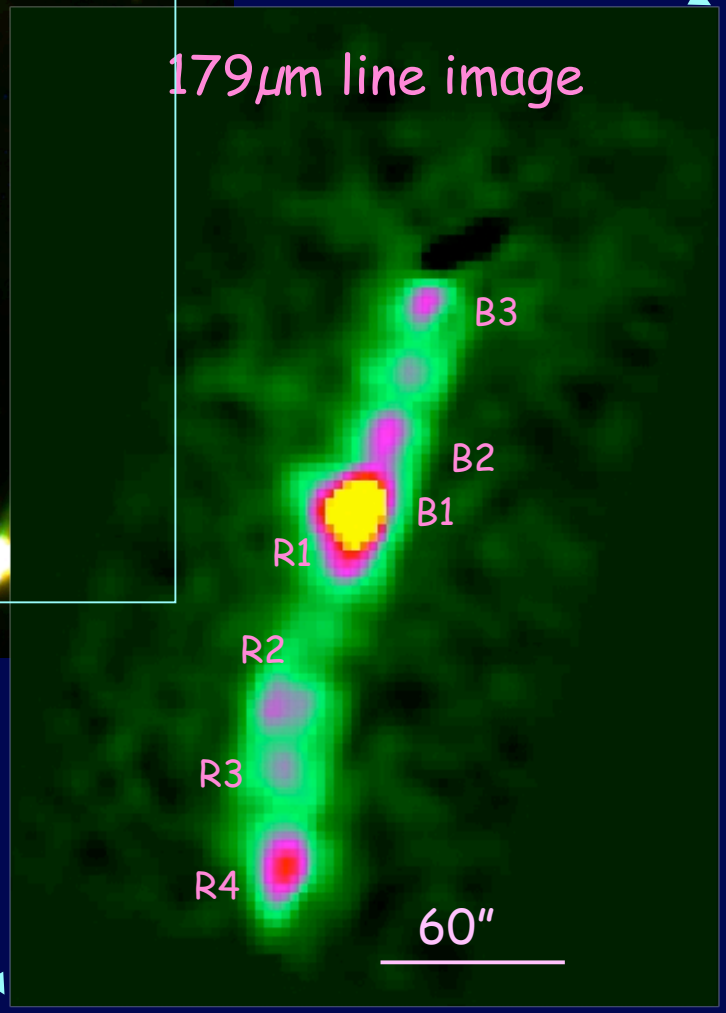
- emission from PACS not resolved clumps with few arcsec of size and $N(H_2O) \sim 5 \times 10^{16}$ cm^{-2}
- $H_2O/H_2 = (0.6\text{-}3)\ 10^{-4}$: complete conversion of OI into H_2O
- $L(179\mu m) \sim 30\text{-}40\%\ L(H_2O)$; $L(H_2O) \sim 15\%$ total cooling

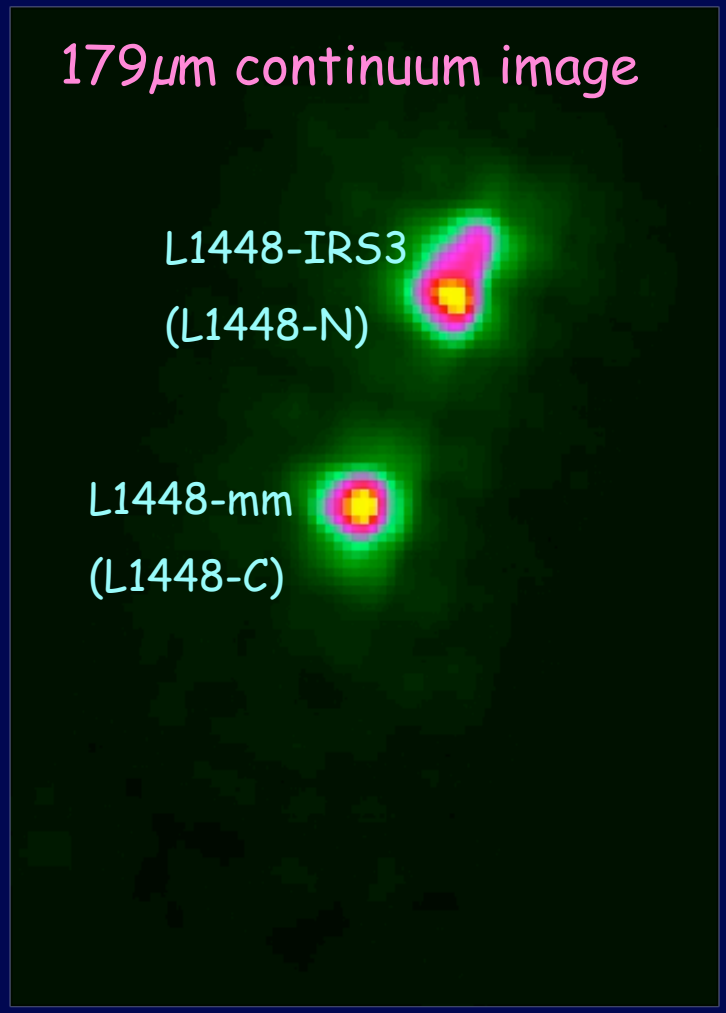
179μm PACS map of L1448



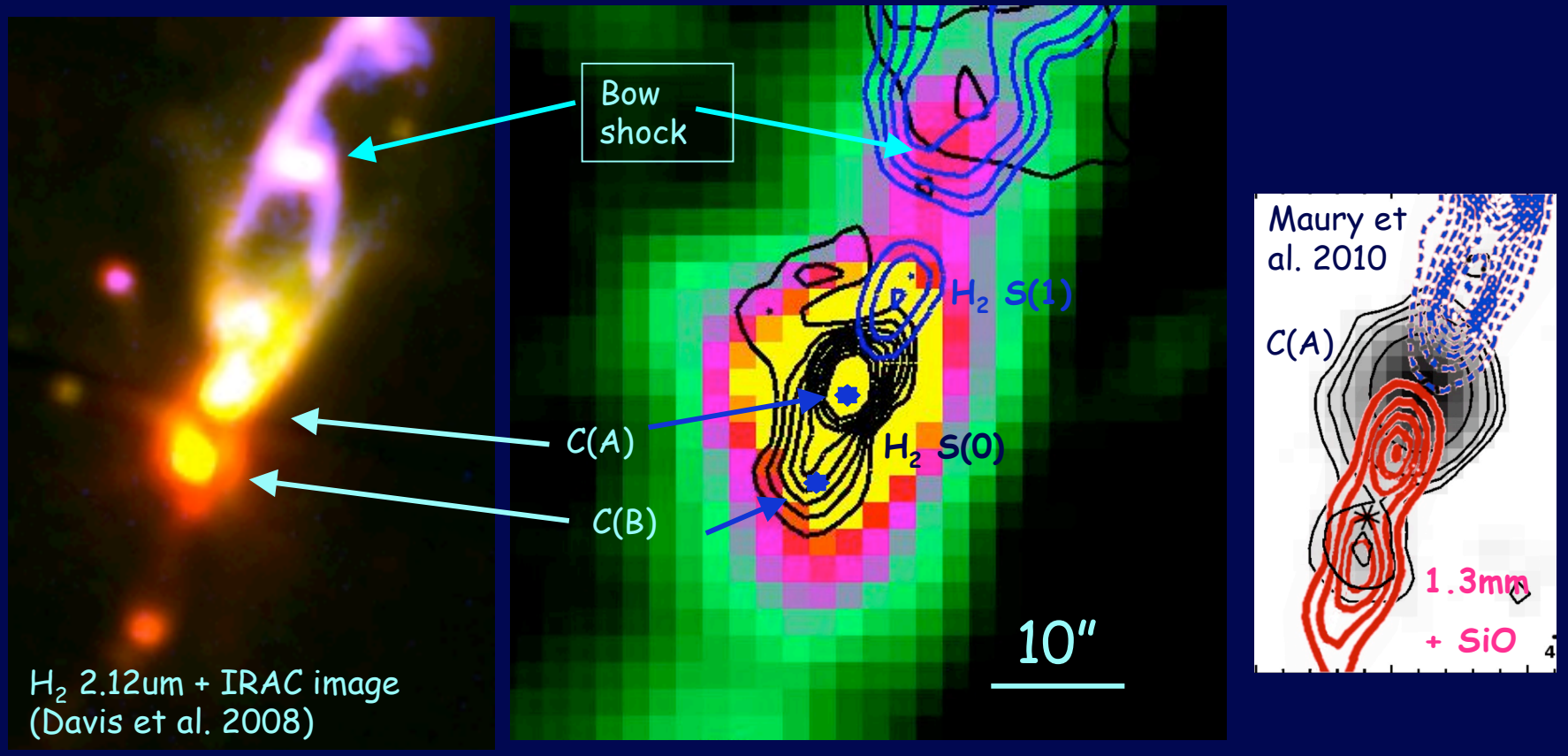
D=300 pc, Class 0

L(mm) = 8.4 Lo, L(IRS3) =10 Lo



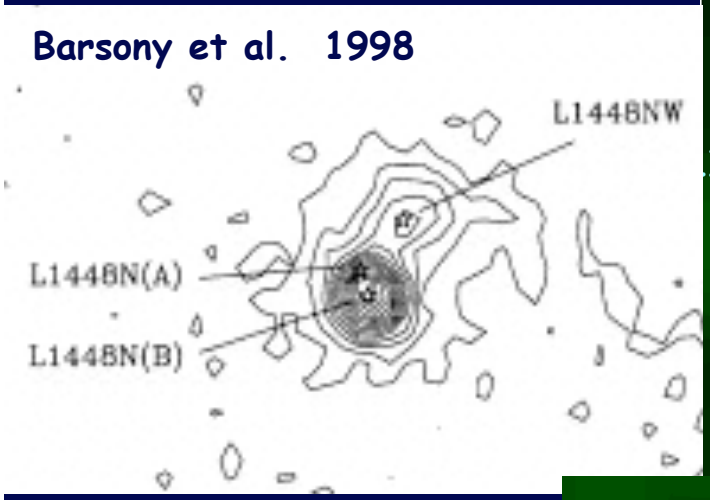


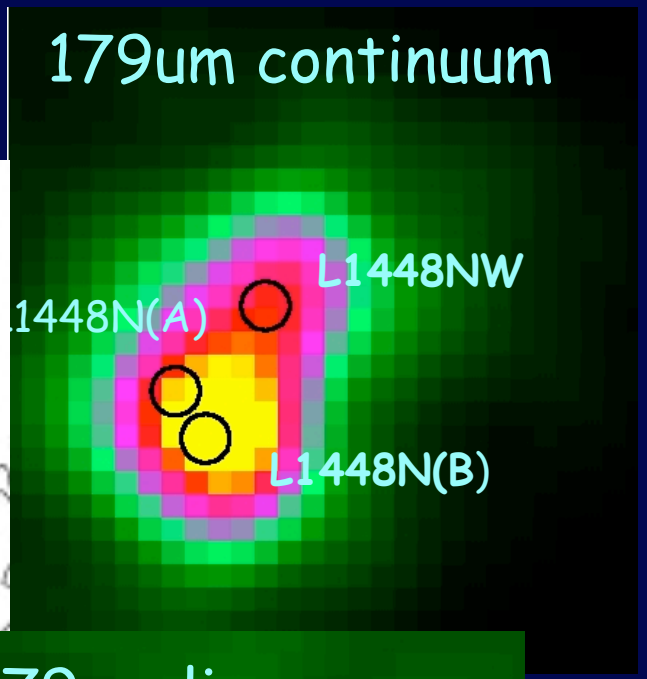
Region around L1448-mm



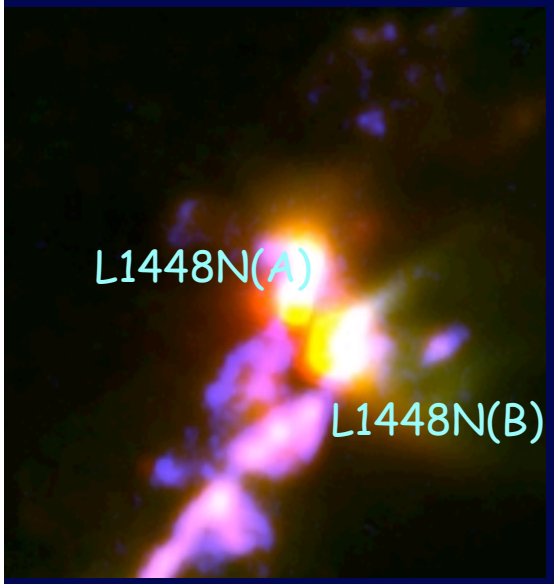
- Strong unresolved emission from central source + collimated SiO/H_2 jet

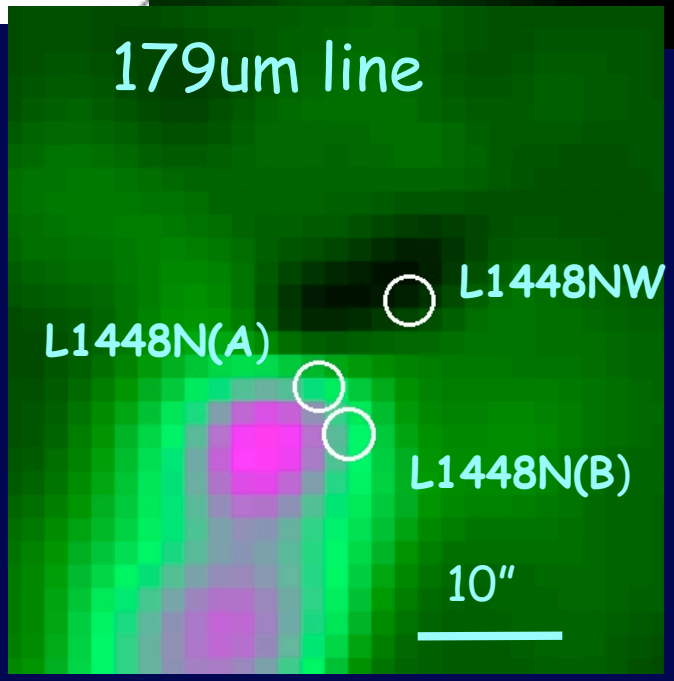
Region around L1448-IRS3

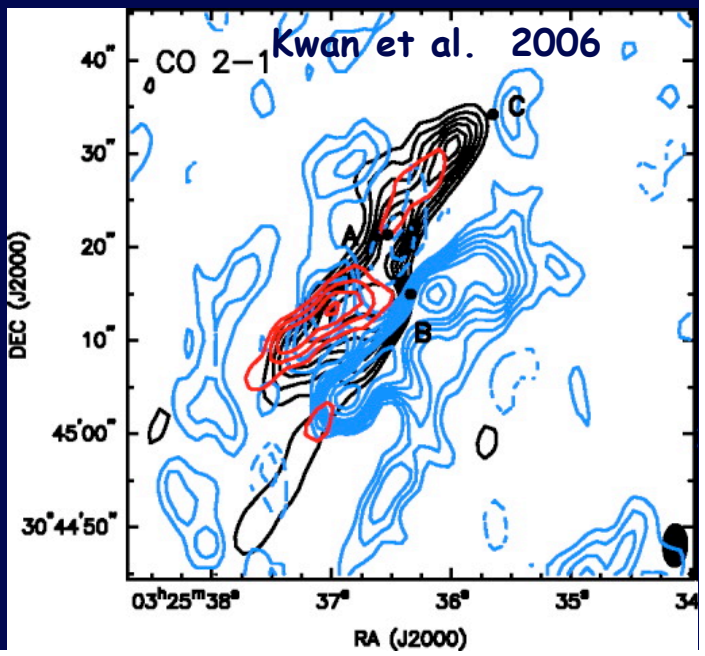




At variance with the other class 0 no H_2O is associated to the central source position







Summary

- PACS 179μm emission in outflows is localized in non resolved regions associated with warm and active knots

- H_2O Abundance in the L1157 outflow is ~10^{-4}

- Emission close to source varies significantly and does not correlate with luminosity

What's next in WISH

- HIFI maps of the same regions in the 557 GHz line
  - kinematical information and abundance variations

- Multi-line analysis on different shock locations
  - excitation vs distance-kinematics-chemistry