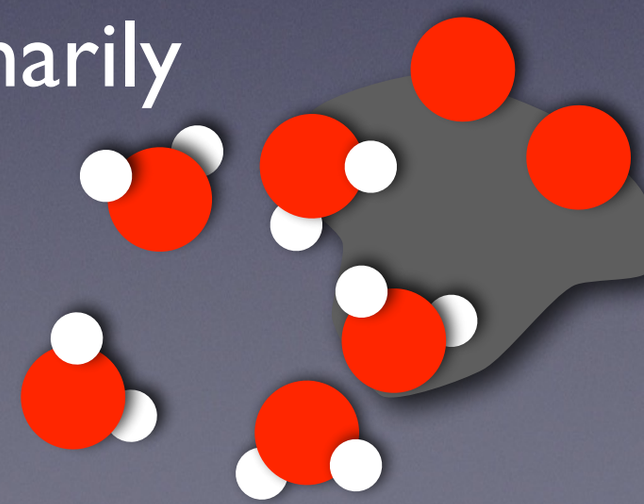
Hot water in disks: inner hot disk, or wind?

Lars E. Kristensen
SMA Fellow

Joanna Brown (former SMA fellow, now Boston Fusion),
David Wilner (SAO/CfA), Colette Salyk (NOAO),
Mark Gurwell (SAO/CfA)

H_2O: why?

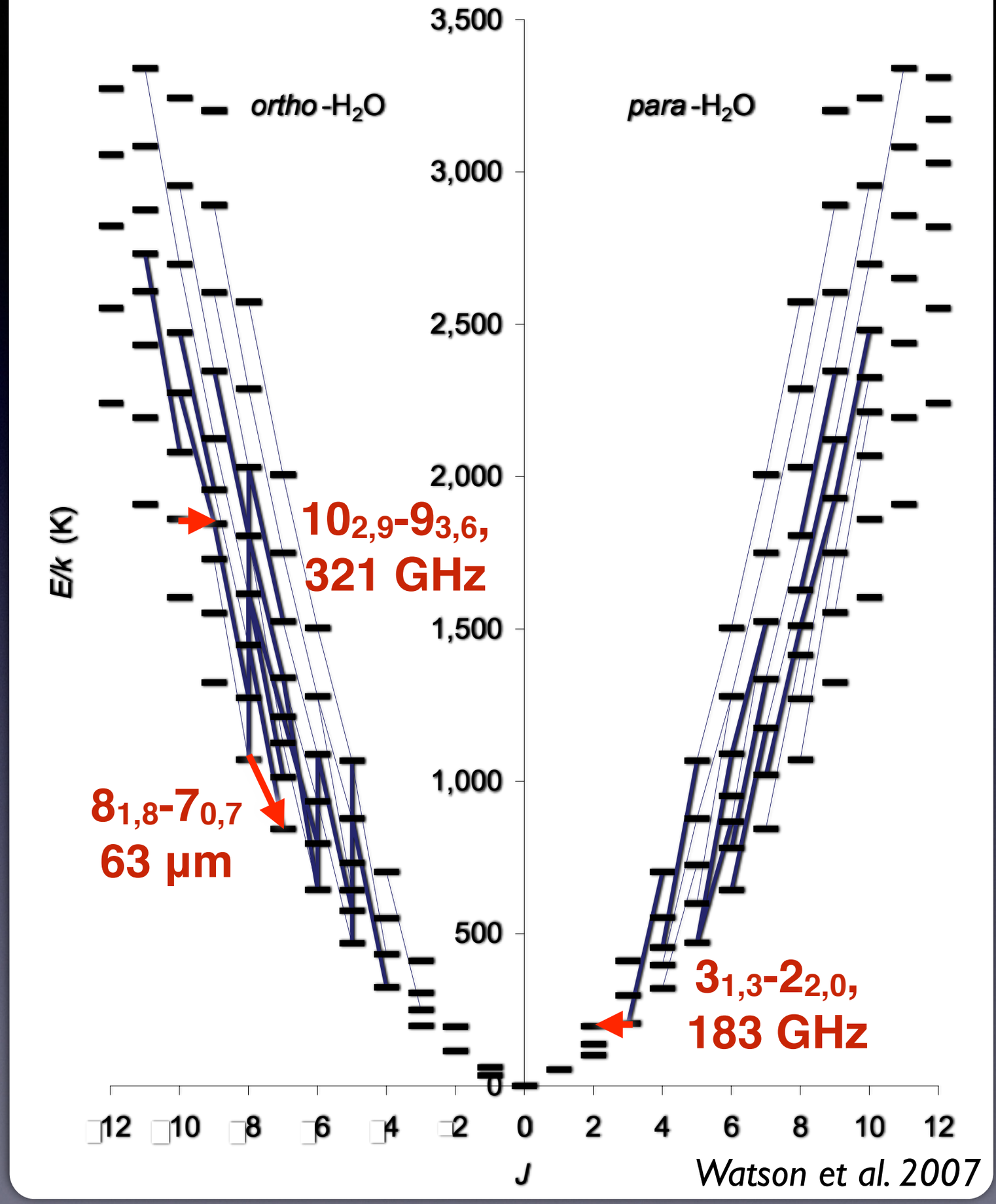
- Main O reservoir in molecular gas
- Linking gas/grain chemistry and interactions
- Important interstellar coolant
- However, nearly impossible to observe from the ground: opaque atmosphere
- Ground-based $H_2{}^{16}O$ observations primarily masers



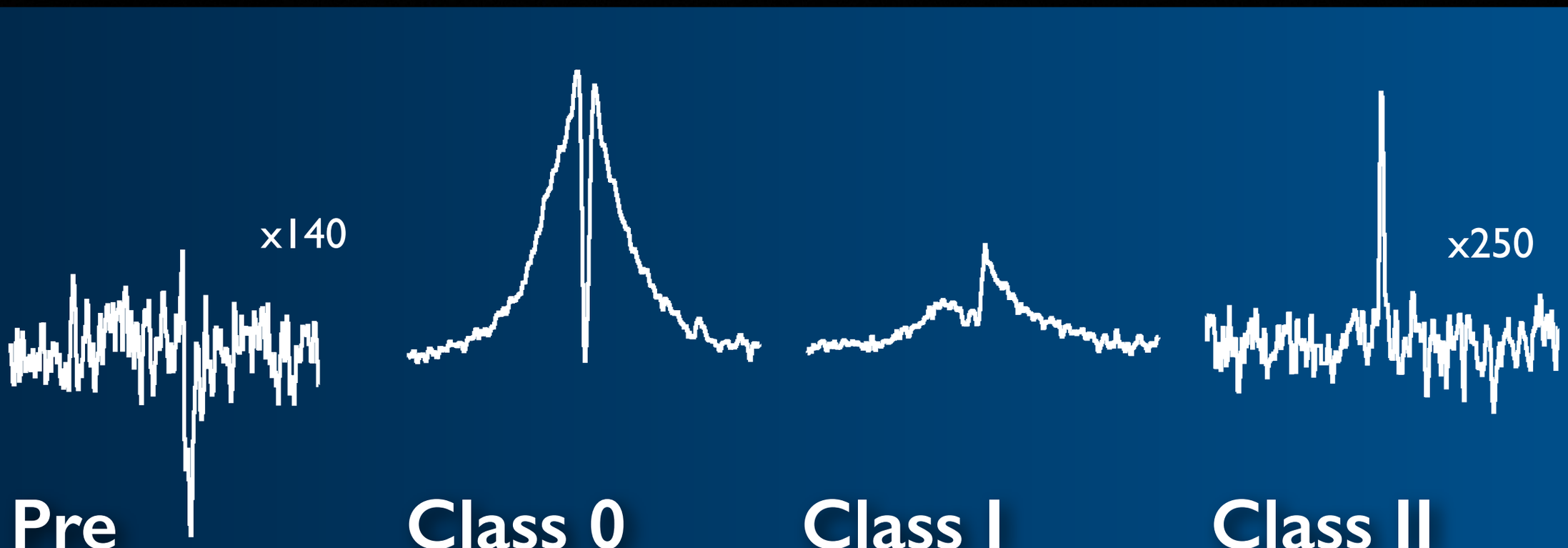
SMA & H_2O

- 183 and 321 GHz lines available (plus others toward AGB stars)
- Detected as masers toward galaxies, AGB stars, high- and low-mass protostars

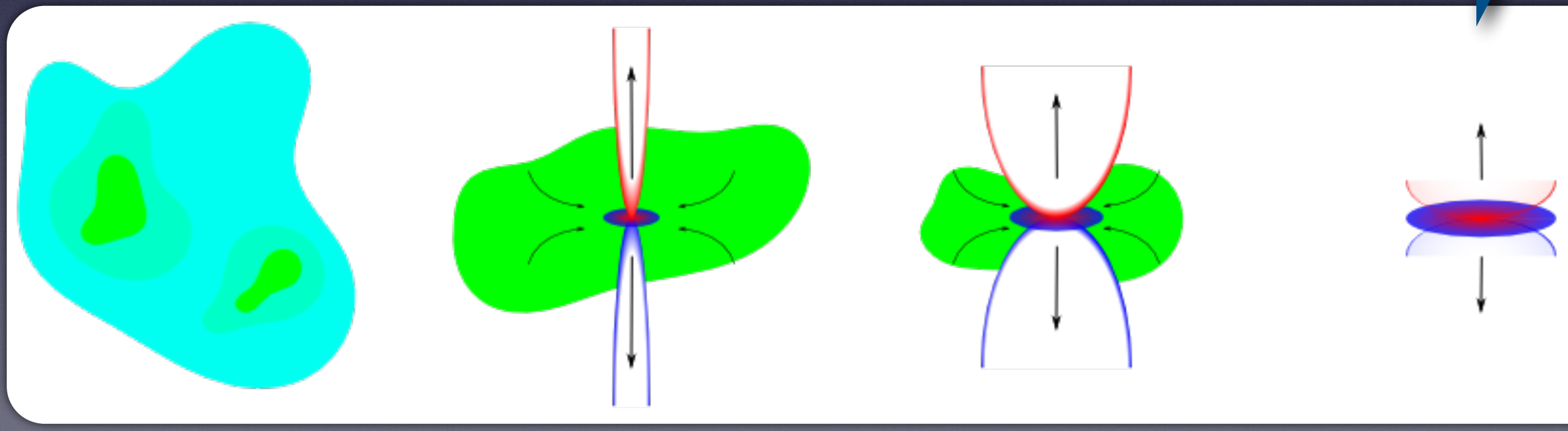
e.g., Humphreys et al. 2005, Patel et al. 2007, van Kempen et al. 2009, Kaminski et al. 2013



Time



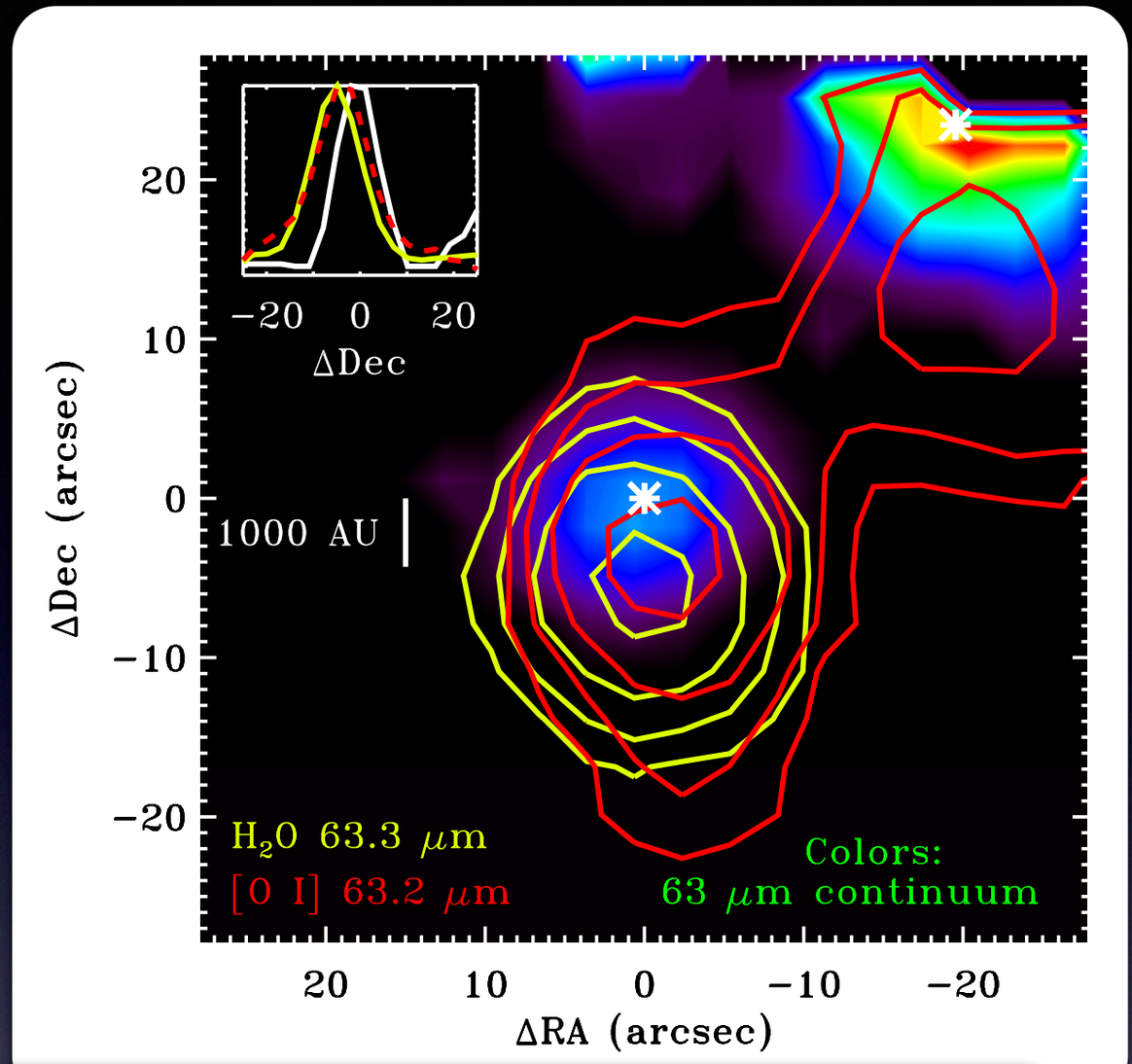
Same velocity range: 100 km s^{-1}

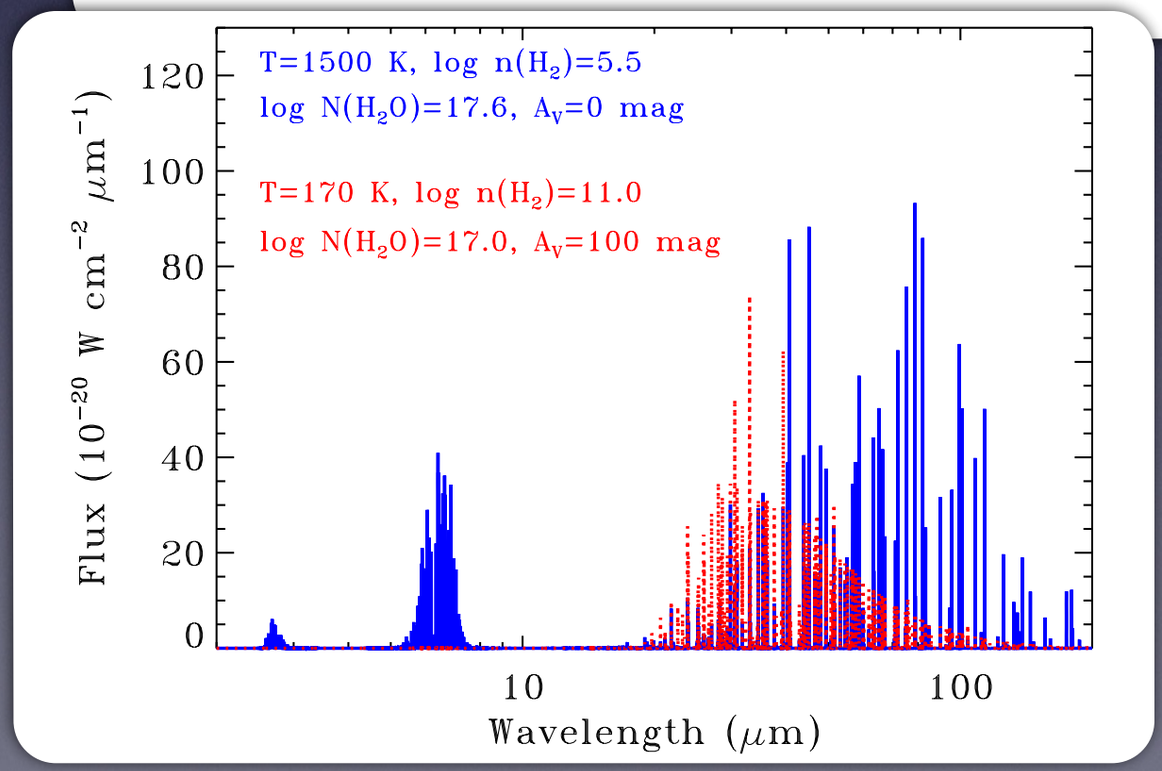


WISH observations: Caselli et al. (2012), Kristensen et al. (2012), Hogerheijde et al. (2011)

Hot H_2O: PACS

- Herschel-PACS observations at 4.5" resolution
- Hot H_2O emission offset from "disk" by > 1000 AU
- *Origin: outflow (wind/jet)*

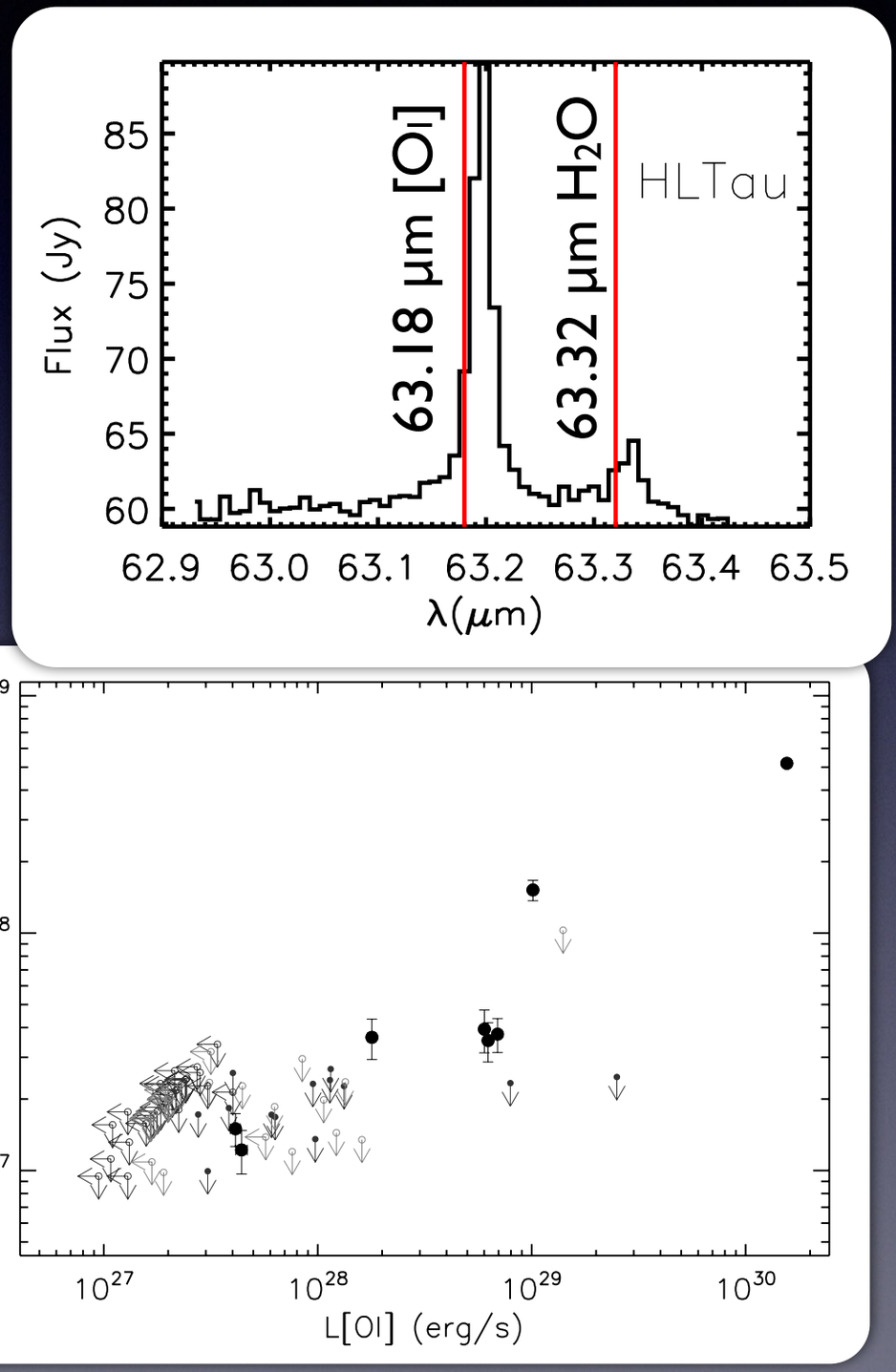




Herczeg et al. 2012

PACS hot water in disks

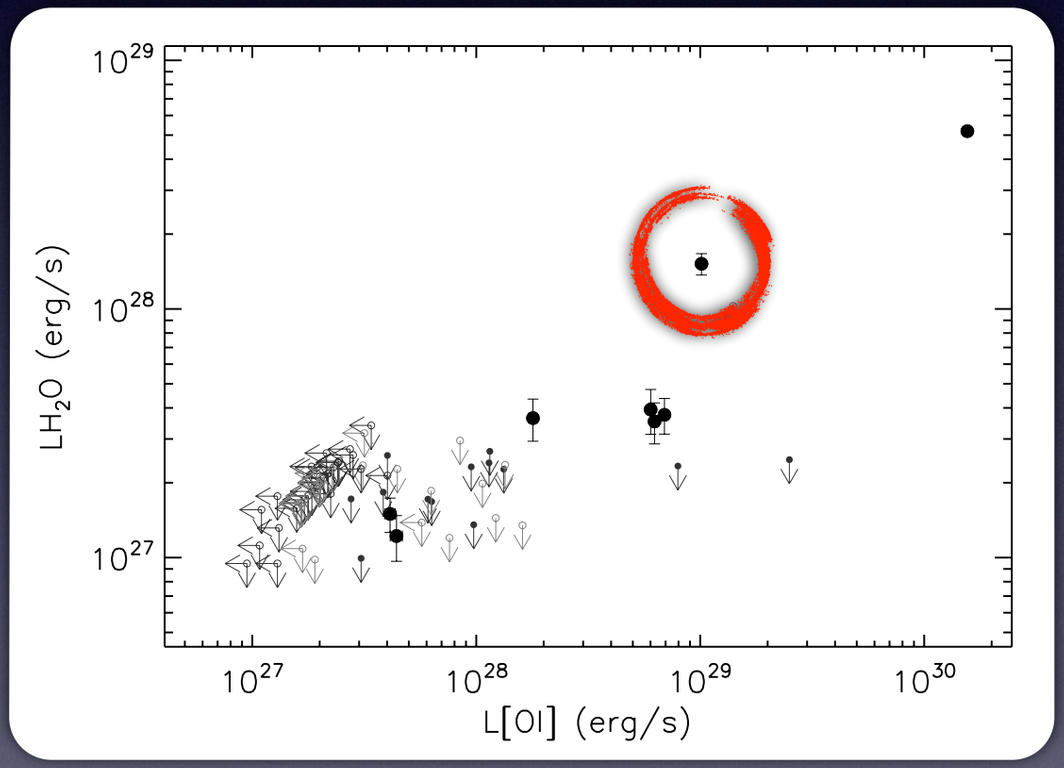
- Observed the H_2O 63 μm line
- Emission correlates with the known jet-tracer [OI] also at 63 μm
- Compact emission (< 9.4”)
- *Origin: disk or wind?*



Riviere-Marichalar et al. 2012

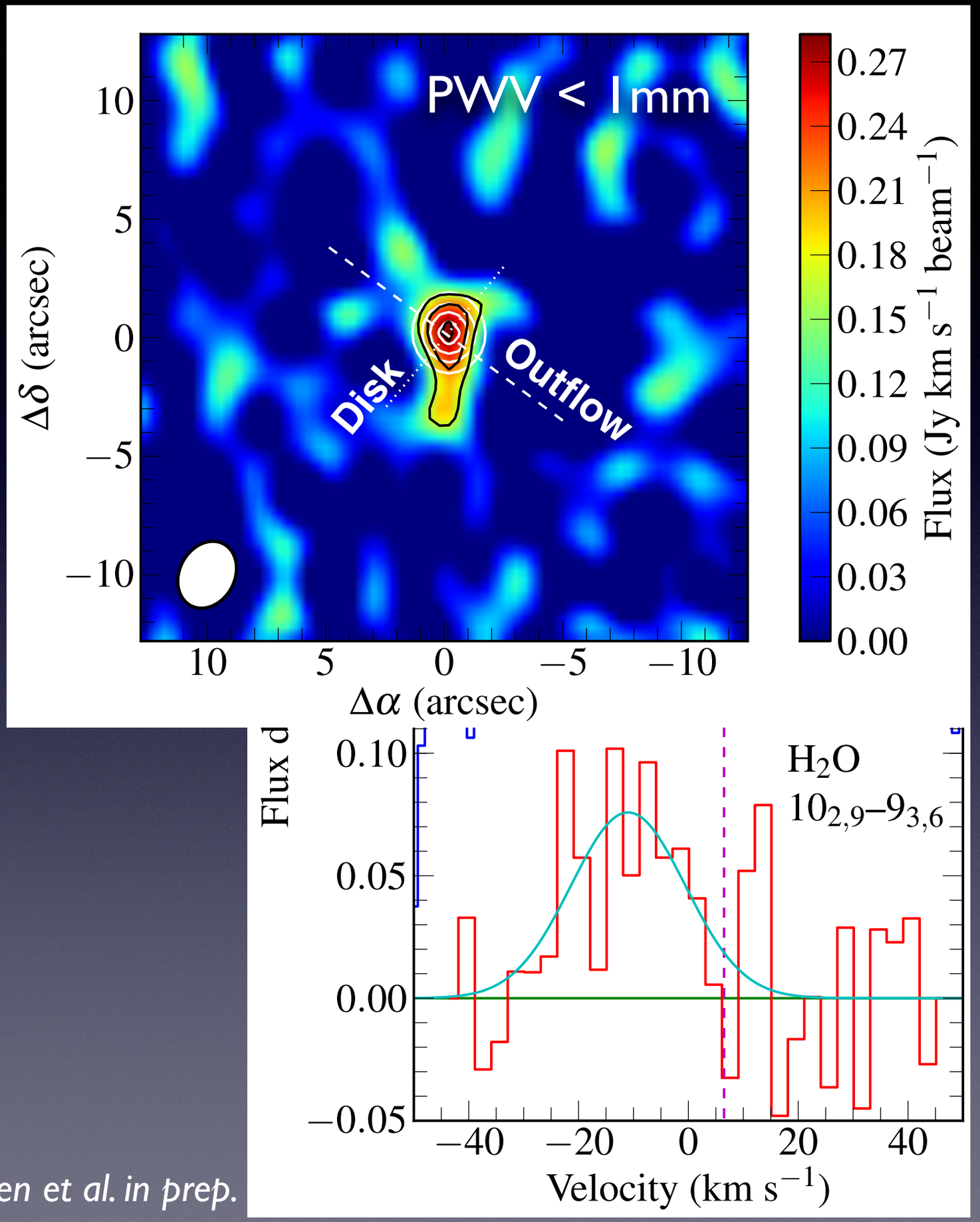
SMA observations

- Test interpretation: warm inner disk, or outflow/wind?
- Target: HL Tau, one of the brightest hot H_2O emitters
- Observed: Dec 18 2013, COM (2" beam ~ 300 AU @ 321 GHz)



Data

- Reduced with CASA 4.2
- H_2O detected at 8σ
- Matches disk position, tentative (3-4σ) extended emission
- *Profile: blue-shifted and broad!*

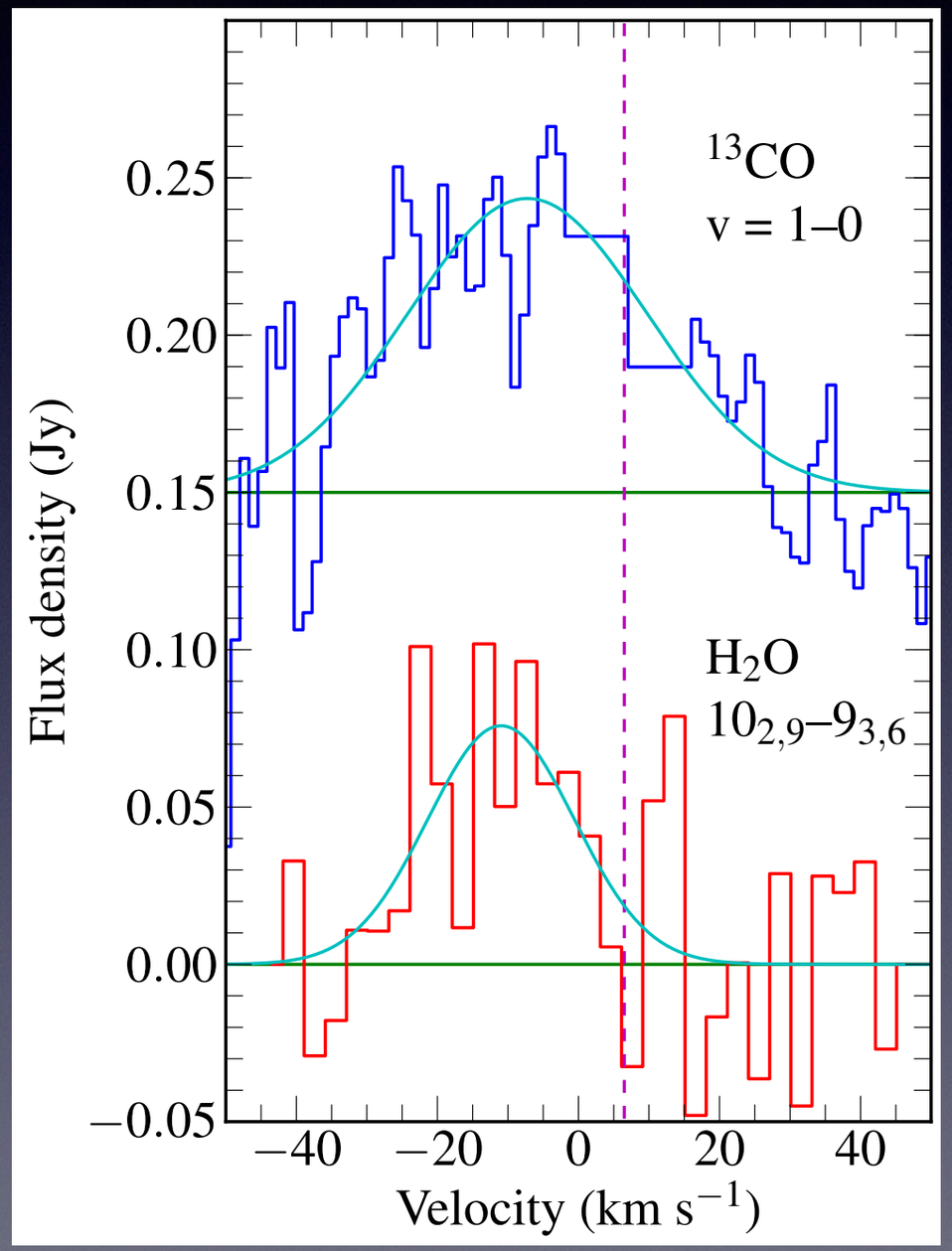


Kristensen et al. in prep.

Vibrational CO: wind

Herczeg et al. 2011

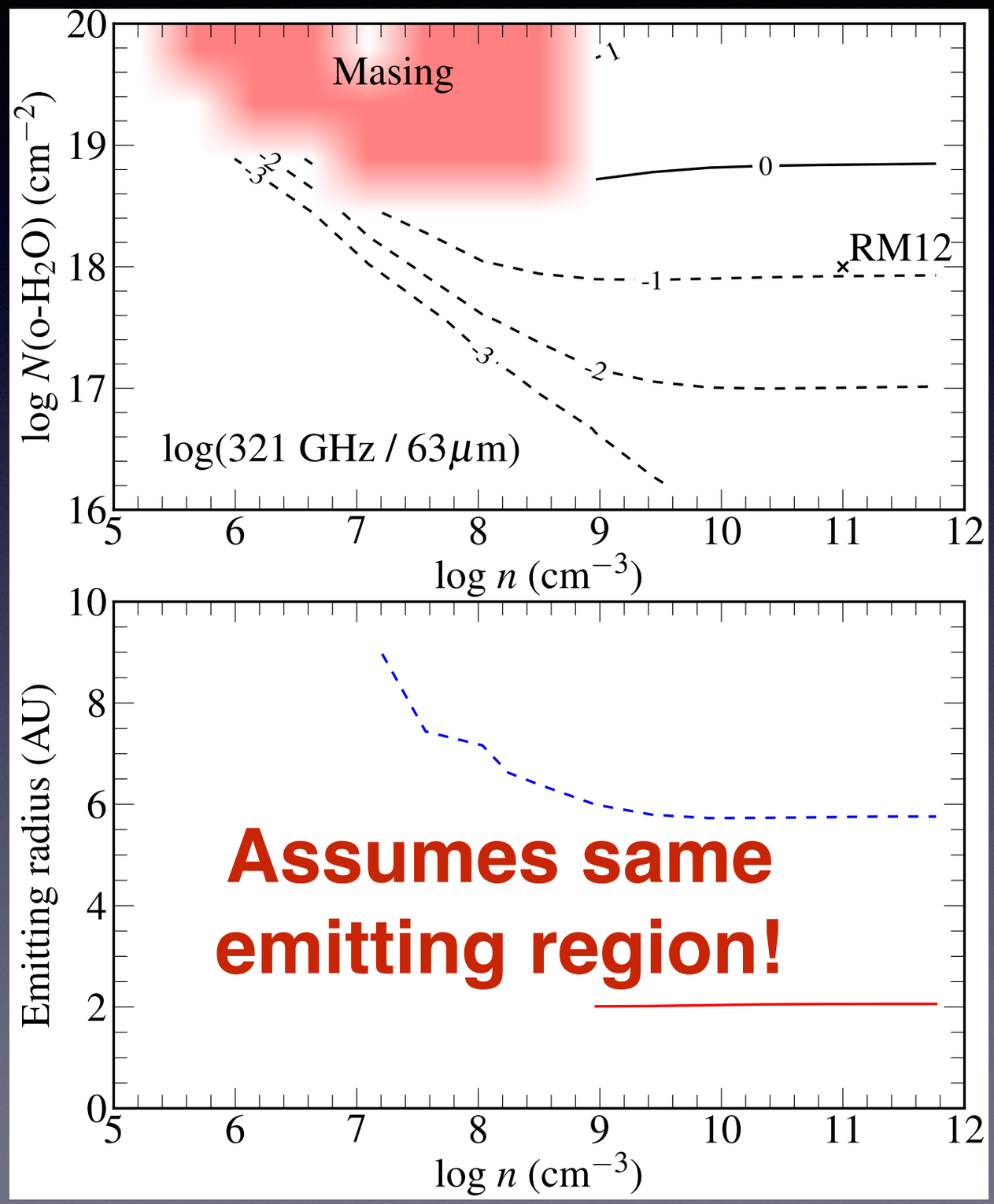
- 4.7 mu rovibrational emission from CO supports wind hypothesis
- Identical line profiles (within uncertainty)
- CO emission unresolved at 0.2” resolution (30 AU)



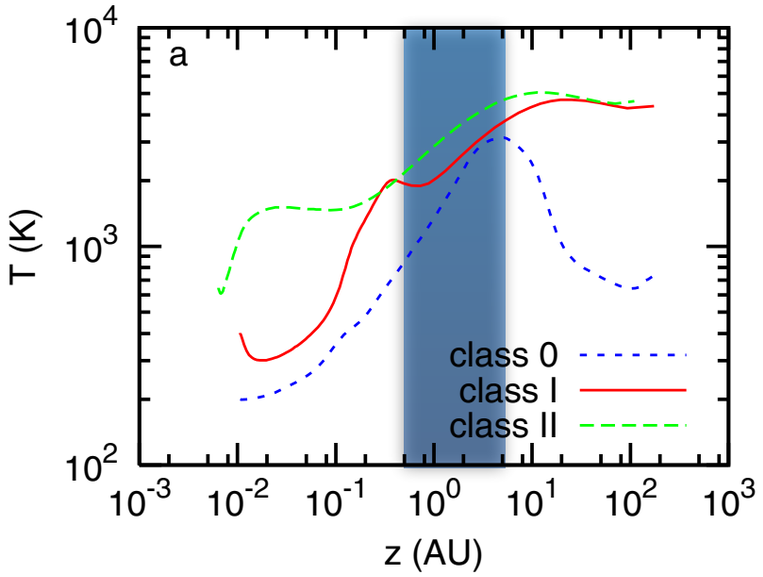
Excitation conditions

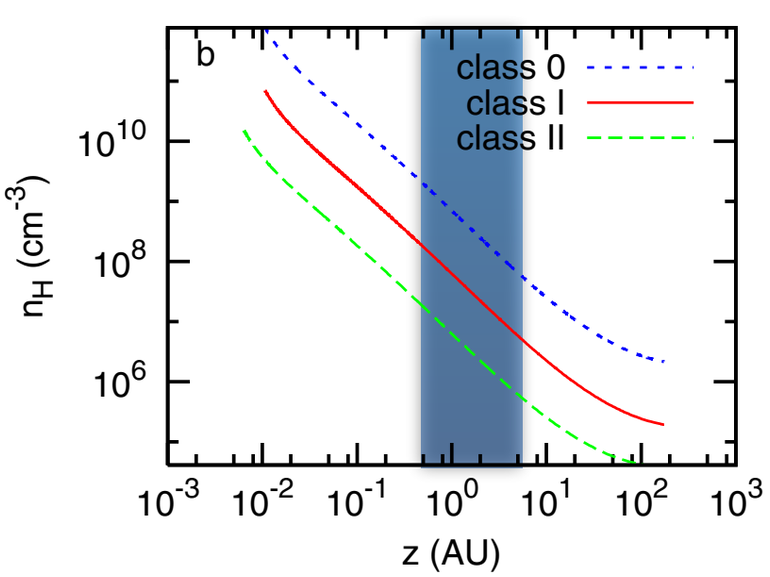
- Use 321 GHz and 63 μm lines to estimate excitation conditions, *n*, *T*, *N*(H_2O)

- Highly degenerate
- *N*(H_2O) ~ 10^{19} cm^{-2}, *n*(H_2) ~ 10^{9}-10^{12} cm^{-3}, *T* ~ 500-1500 K, *r*(H_2O) ~ 2 AU

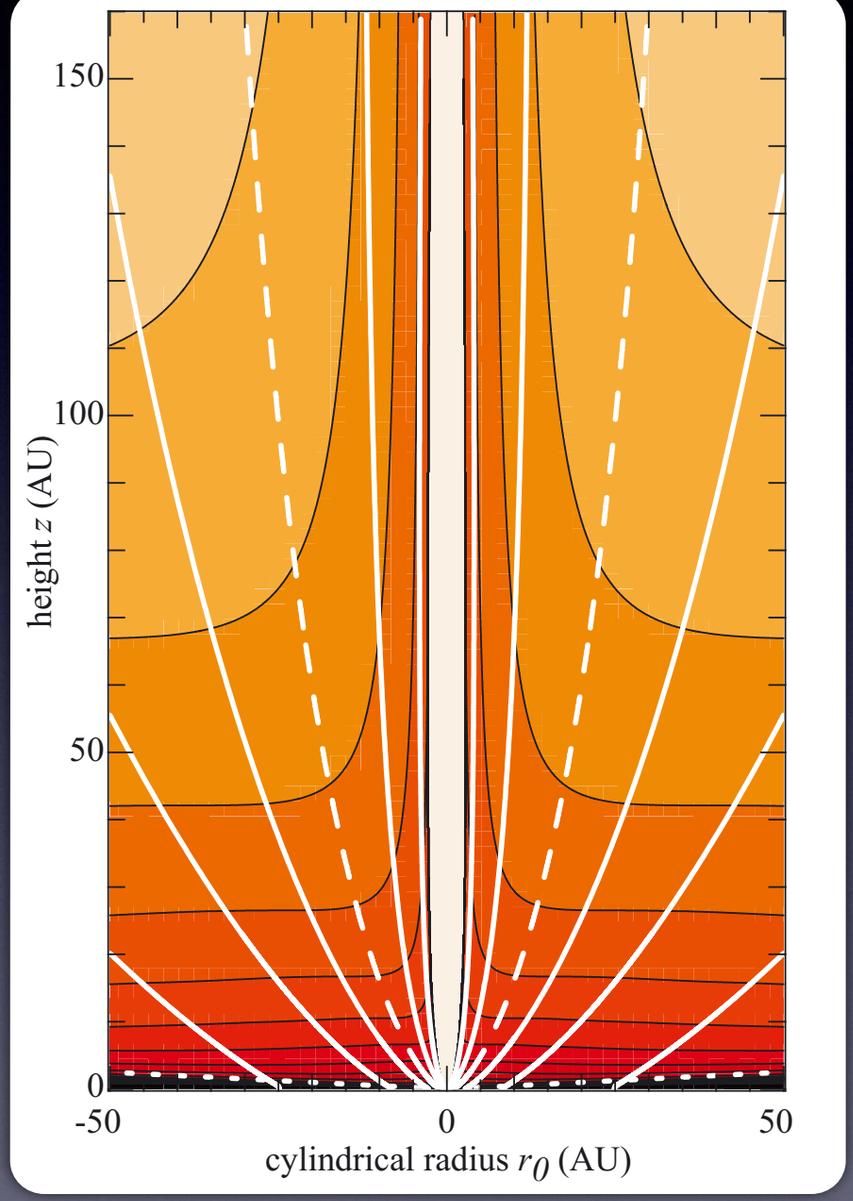


Molecular protostellar winds





- Model calculations show molecules survive launching in MHD winds
- *Physical conditions in wind close to what is inferred from radiative transfer*



Panoglou et al. 2012

Implications / conclusions

- Hot PACS H_2O toward HL Tau originates in wind, not inner disk: a unique SMA result

- HL Tau is Class I/II, uncertain what implications for Class II/III sources are: needs to be tested

- 321 GHz H_2O emission appears to probe winds, need to test on sources with stronger winds / jets (Class 0's) with the SMA