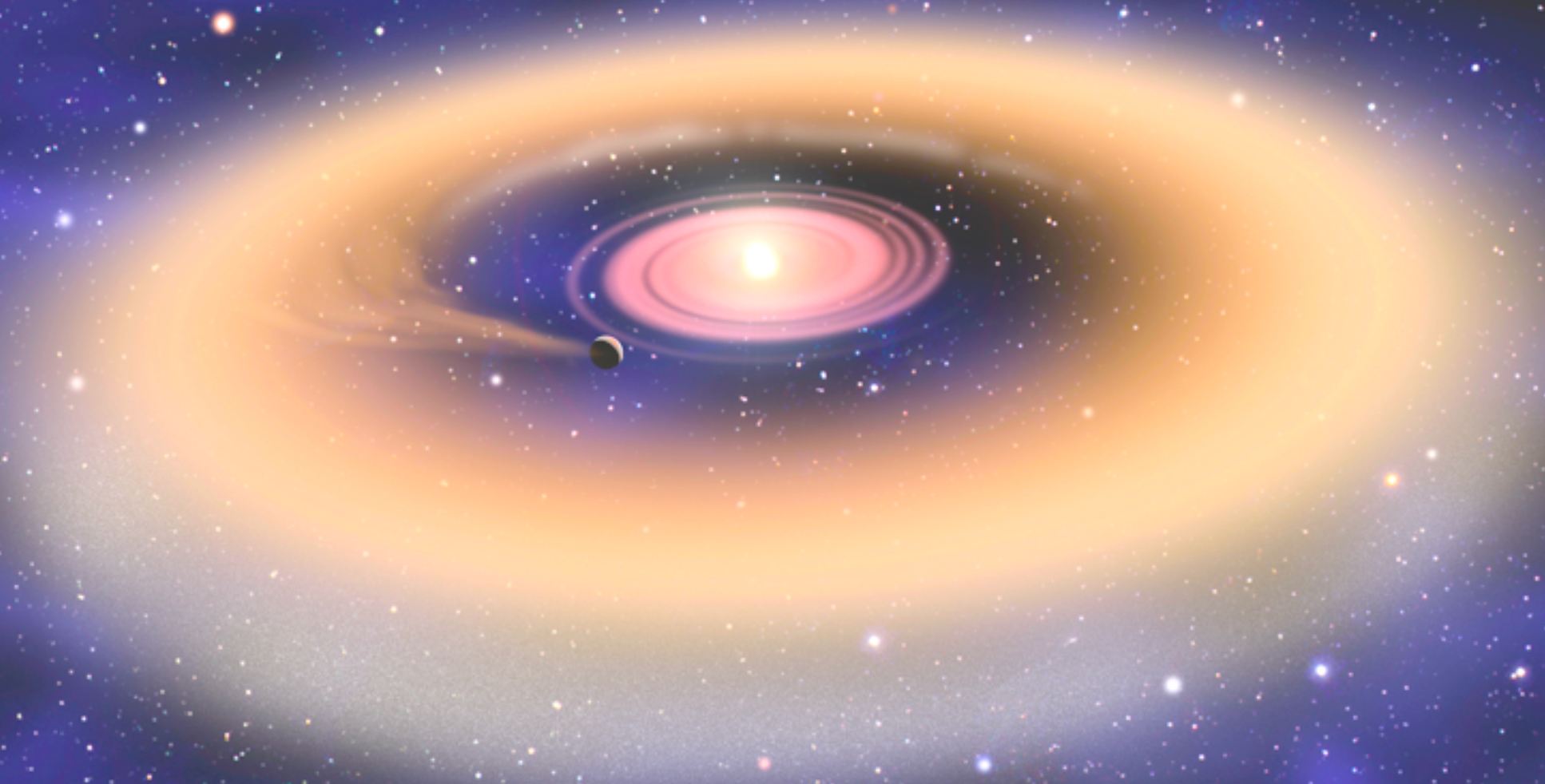


# OBSERVATIONAL EVIDENCE OF DISK DISPERSAL MECHANISMS FROM OPTICAL TO MID-IR WAVELENGTHS



Elisabetta Rigliaco

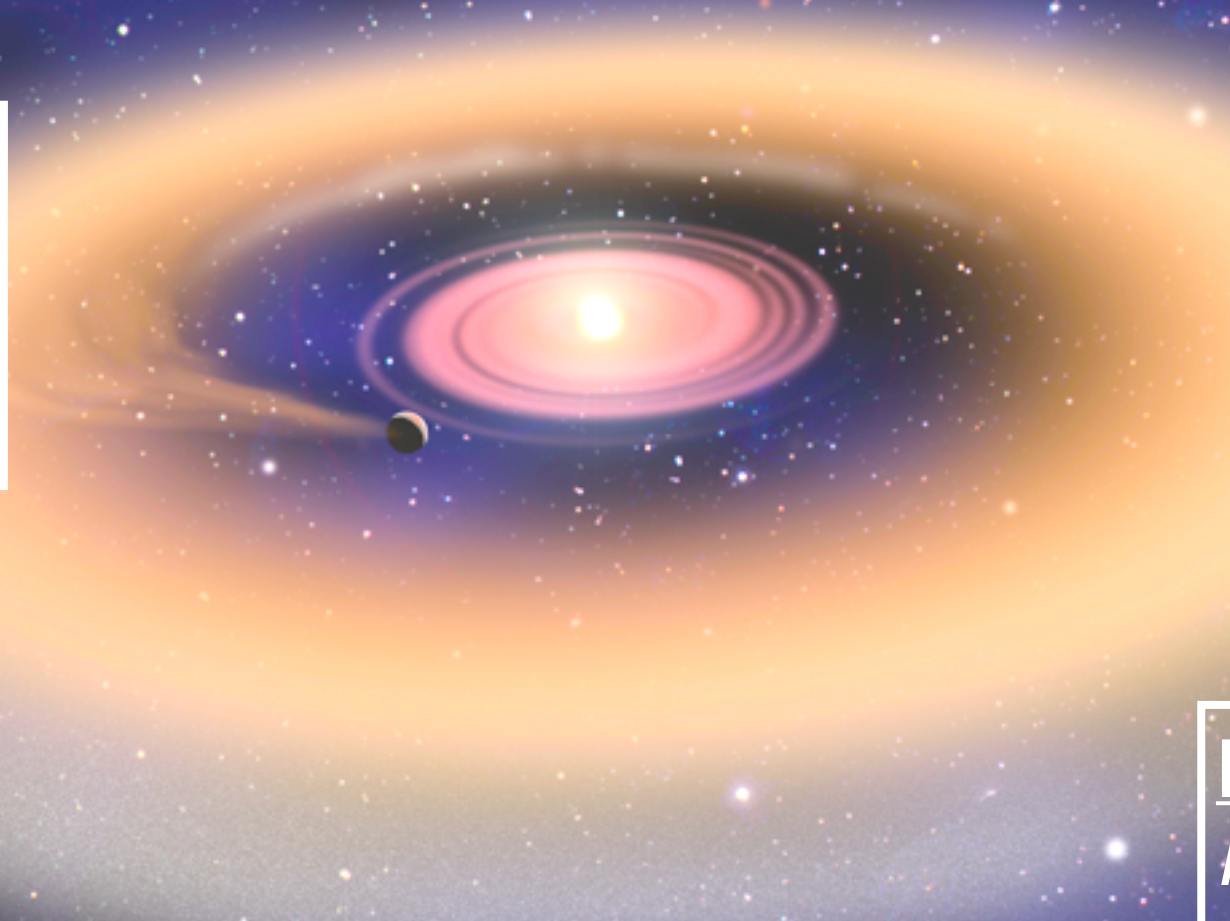
**ETH** zürich



# OBSERVATIONAL EVIDENCE OF DISK DISPERSAL MECHANISMS FROM OPTICAL TO MID-IR WAVELENGTHS

## Part I

*[OI] lines as  
photoevaporative  
wind indicators*

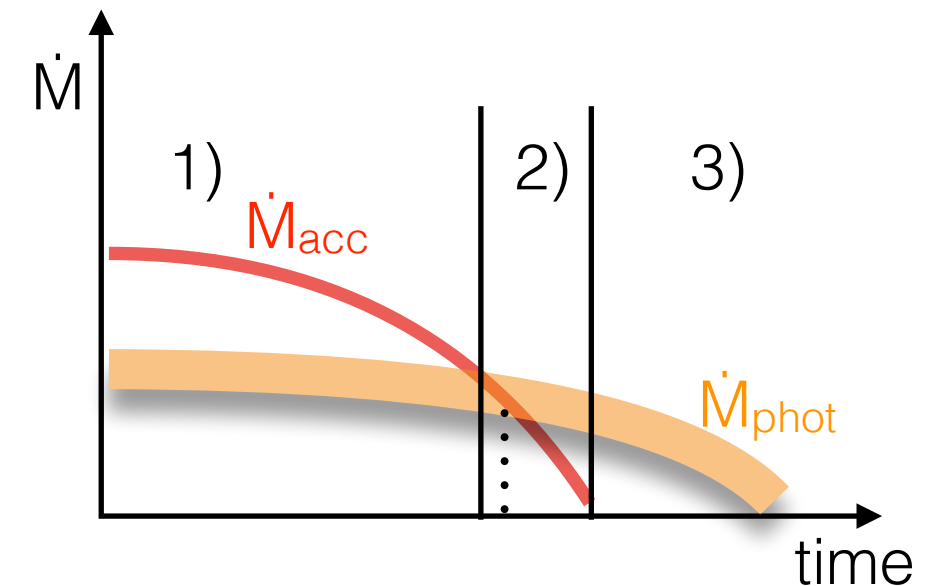
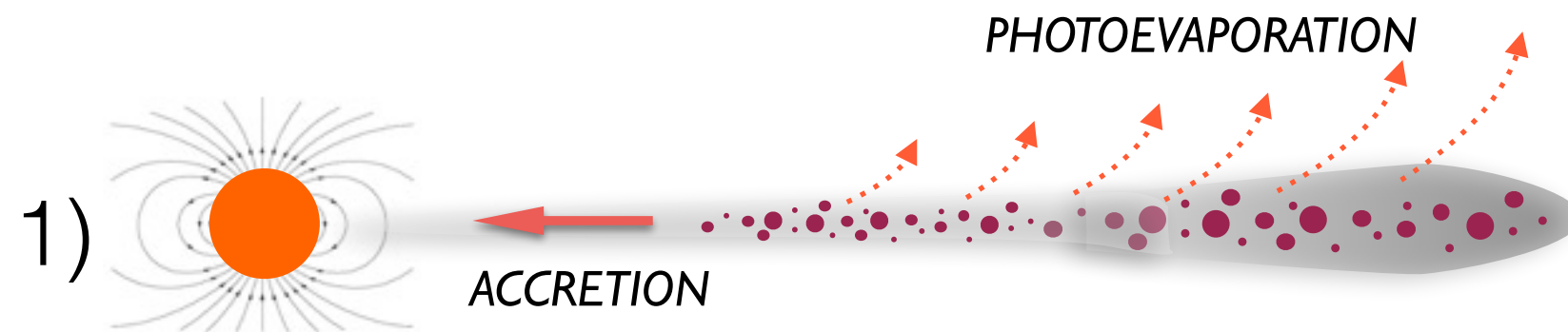


## Part II

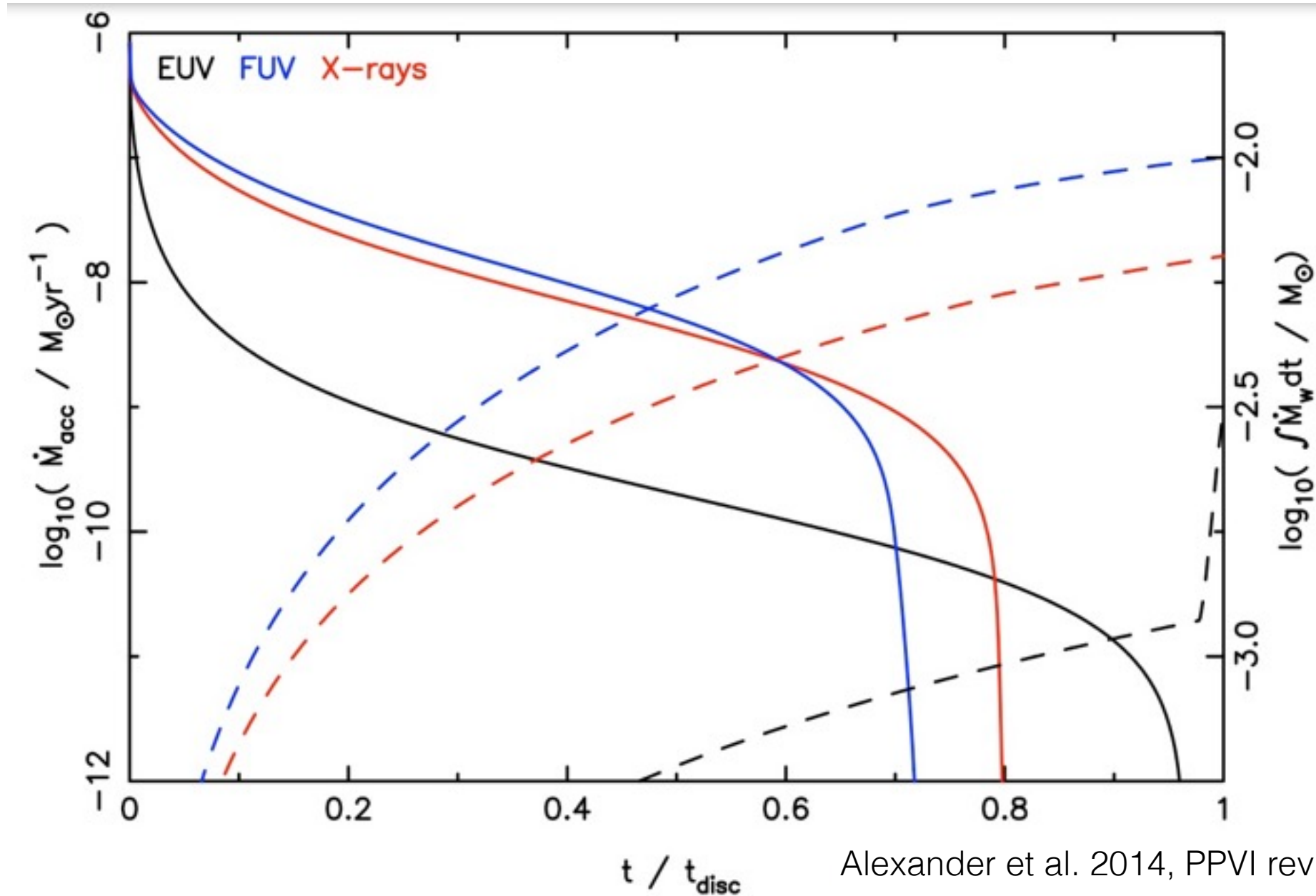
*Hydrogen lines in the  
mid-IR as accretion  
indicators*



# Disk Dispersal due to the interplay of Accretion and Photoevaporation

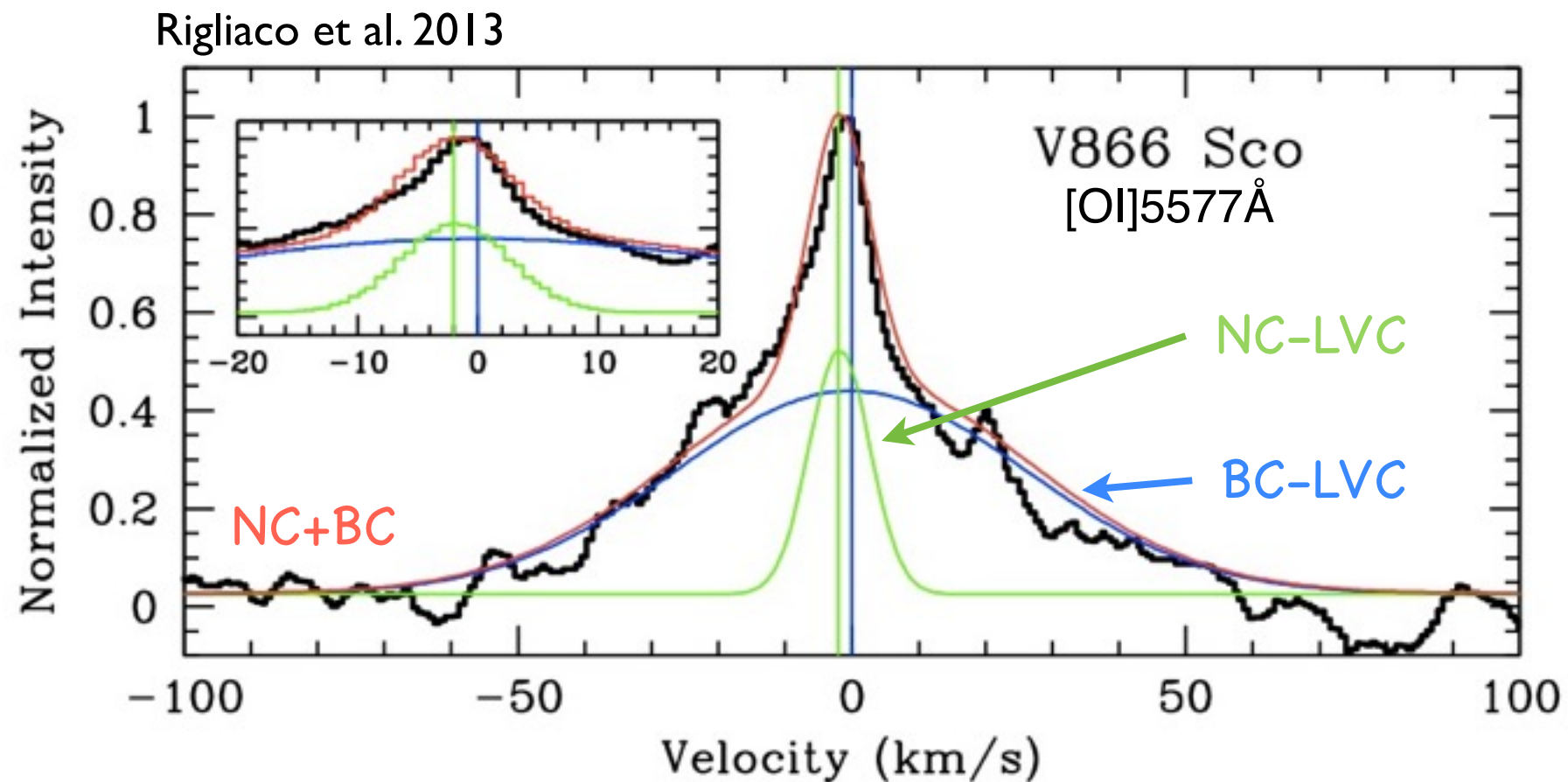


# Disk Dispersal due to the interplay of Accretion and Photoevaporation



Alexander et al. 2014, PPVI review chapter

# [OI] as photoevaporation indicator



Broad Component (BC):  
centrally peaked and broad  
⇒ bound gas

Narrow Component (NC)  
slightly blueshifted and narrow  
⇒ unbound gas

*The unbound component is tracing **Photoevaporative wind***

# [OI] as photoevaporation indicator

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Questions to be addressed:

- Is the NC of the LVC confirmed to be a photoevaporative wind indicator?
- What is the driving agent of the photoevaporation?
- Can we use these indicators to measure the mass loss rate?

# Is the NC of the LVC confirmed to be a photoevaporative wind indicator?

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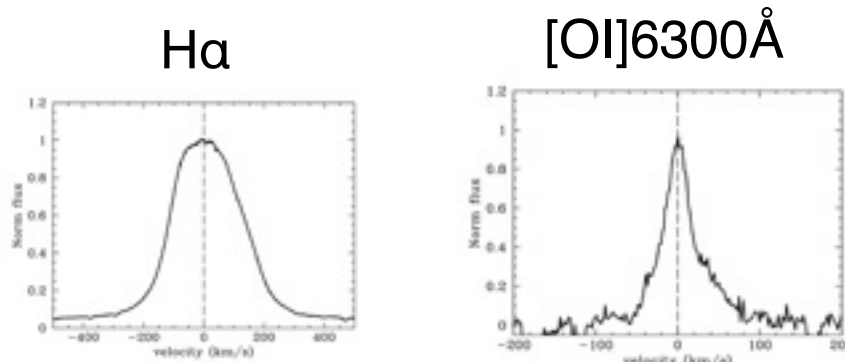
Enlarging the sample where the different components in the LVC can be identified:

- Objects with different  $\dot{M}_{\text{acc}}$
- Objects in different evolutionary stages
- Results presented by Suzan Edwards

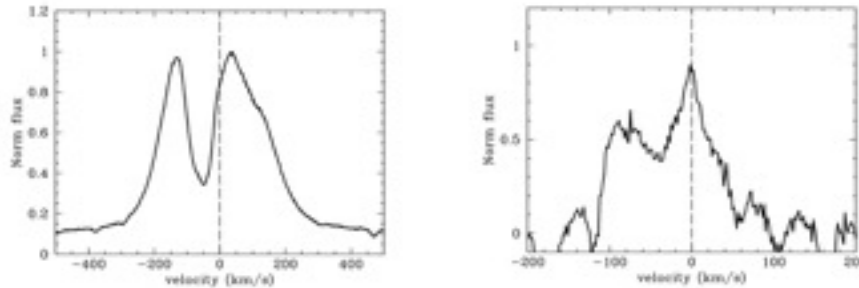
# Is the NC of the LVC confirmed to be a photoevaporative wind indicator?

**Objects with different  $\dot{M}_{\text{acc}}$**

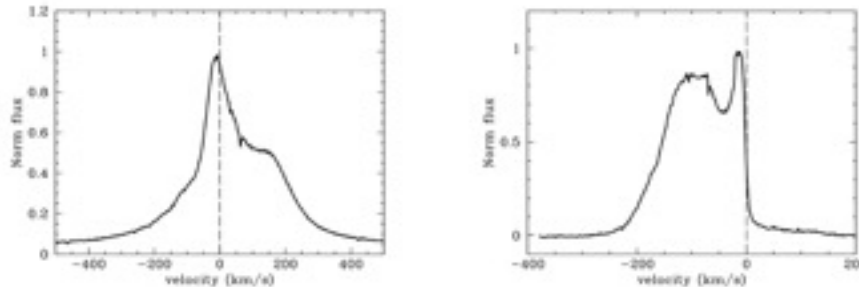
**BPTau**  
 $\dot{M}_{\text{acc}} = 2.4 \times 10^{-8} M_{\odot}/\text{yr}$



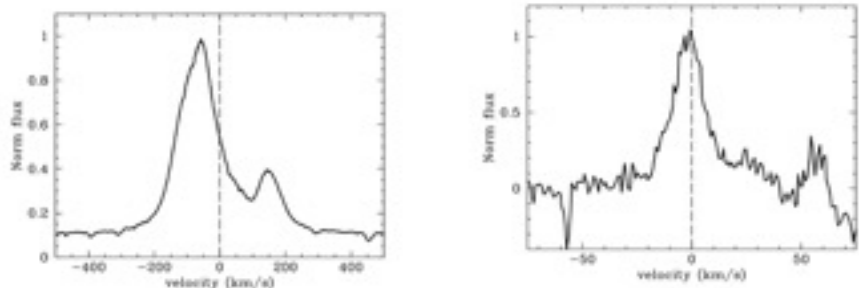
**DKTau**  
 $\dot{M}_{\text{acc}} = 7.5 \times 10^{-9} M_{\odot}/\text{yr}$



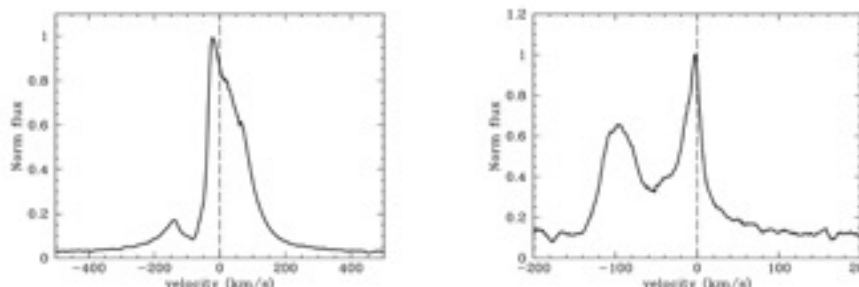
**DGTau**  
 $\dot{M}_{\text{acc}} = 7.0 \times 10^{-9} M_{\odot}/\text{yr}$



**CSCha**  
 $\dot{M}_{\text{acc}} = 4.7 \times 10^{-9} M_{\odot}/\text{yr}$



**XX Cha**  
 $\dot{M}_{\text{acc}} = 1.5 \times 10^{-9} M_{\odot}/\text{yr}$

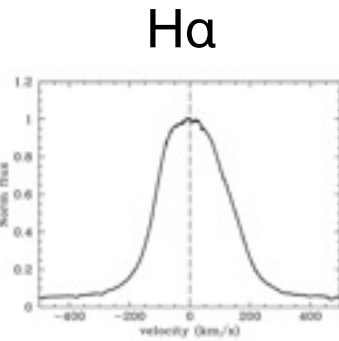


Decreasing  $\dot{M}_{\text{acc}}$

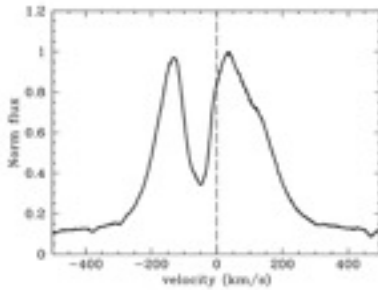


# Is the NC of the LVC confirmed to be a photoevaporative wind indicator?

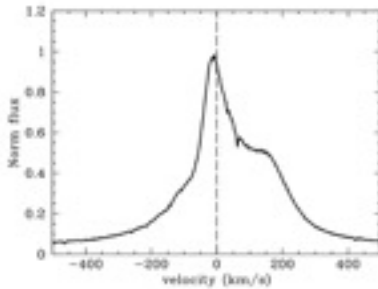
**BPTau**  
 $\dot{M}_{\text{acc}} = 2.4 \times 10^{-8} M_{\odot}/\text{yr}$



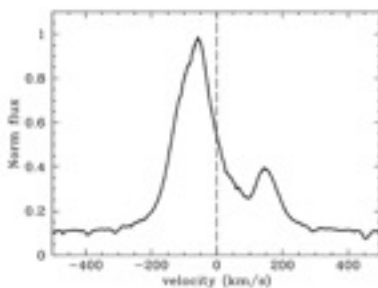
**DKTau**  
 $\dot{M}_{\text{acc}} = 7.5 \times 10^{-9} M_{\odot}/\text{yr}$



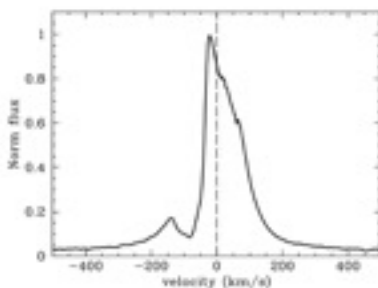
**DGTau**  
 $\dot{M}_{\text{acc}} = 7.0 \times 10^{-9} M_{\odot}/\text{yr}$



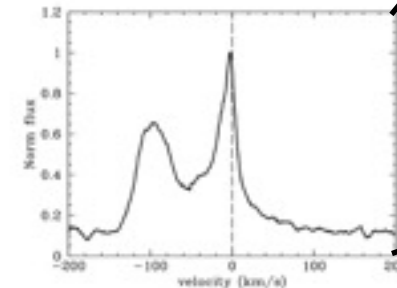
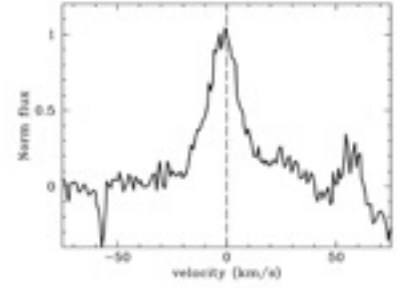
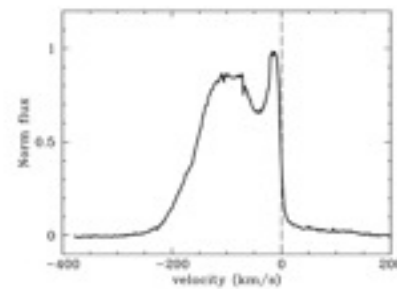
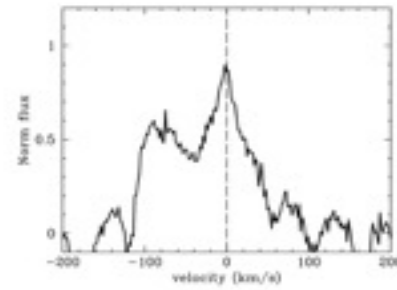
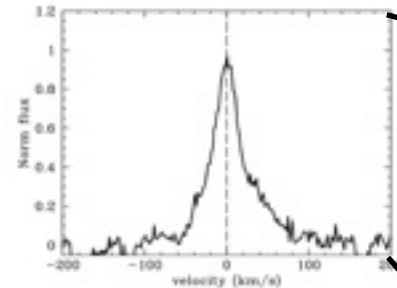
**CSCha**  
 $\dot{M}_{\text{acc}} = 4.7 \times 10^{-9} M_{\odot}/\text{yr}$



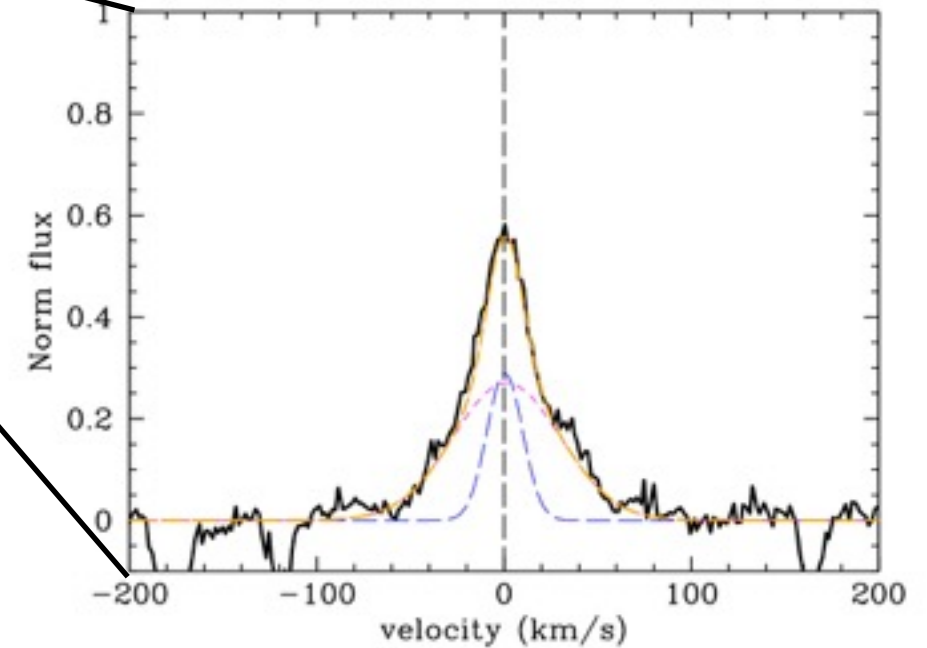
**XX Cha**  
 $\dot{M}_{\text{acc}} = 1.5 \times 10^{-9} M_{\odot}/\text{yr}$



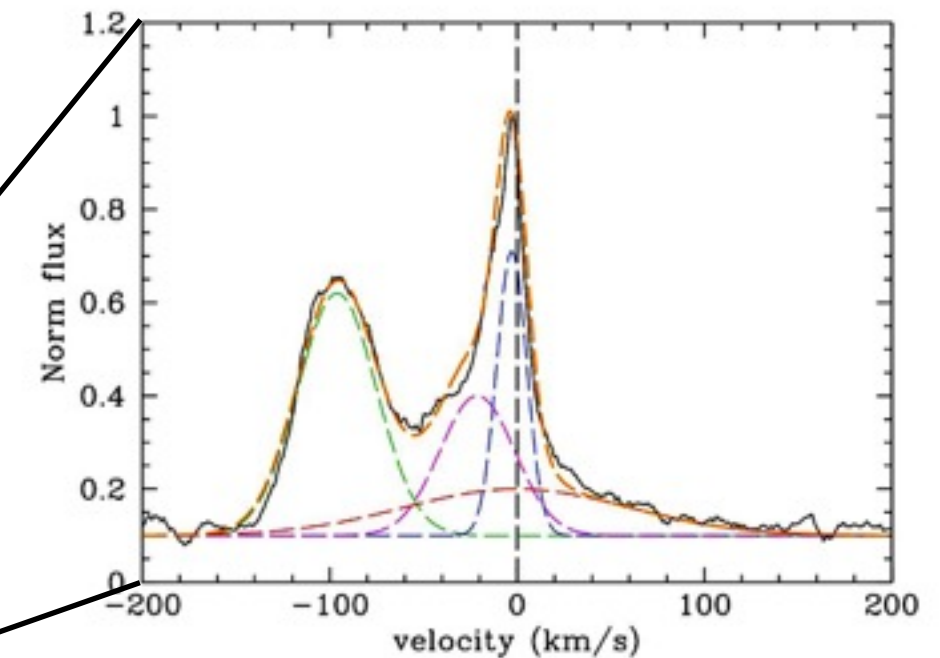
[OI]6300Å



**Objects with different  $\dot{M}_{\text{acc}}$**



Decreasing  $\dot{M}_{\text{acc}}$



# Is the NC of the LVC confirmed to be a photoevaporative wind indicator?

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Objects with HVC show a slightly blueshifted LVC:

If the accretion is sufficient to “power” a jet, it might produce enough FUV radiation to drive a photoevaporative wind

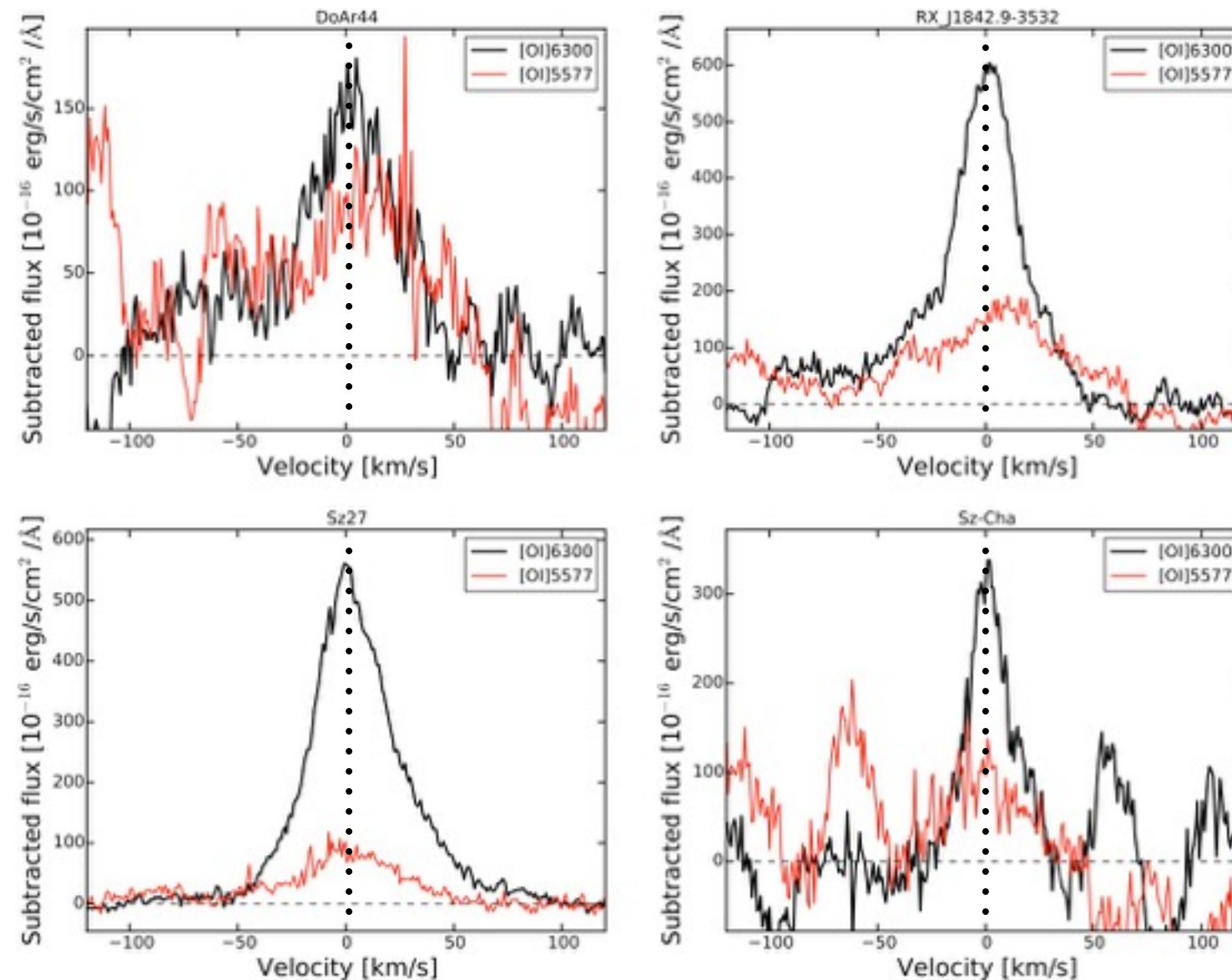
The HVC might deform the LVC, making it appears artificially blueshifted, therefore **no photoevaporation!**

In objects with no HVC, the LVC appears centered to the rest velocity of the star

Gaps in the disk, and we are seeing through? Disk inclination?  
No photoevaporation at all? Gas bound?

# Is the NC of the LVC confirmed to be a photoevaporative wind indicator?

## Objects in different evolutionary stages



Manara et al. in prep.

Carlo Manara's poster



# [OI] as photoevaporation indicator

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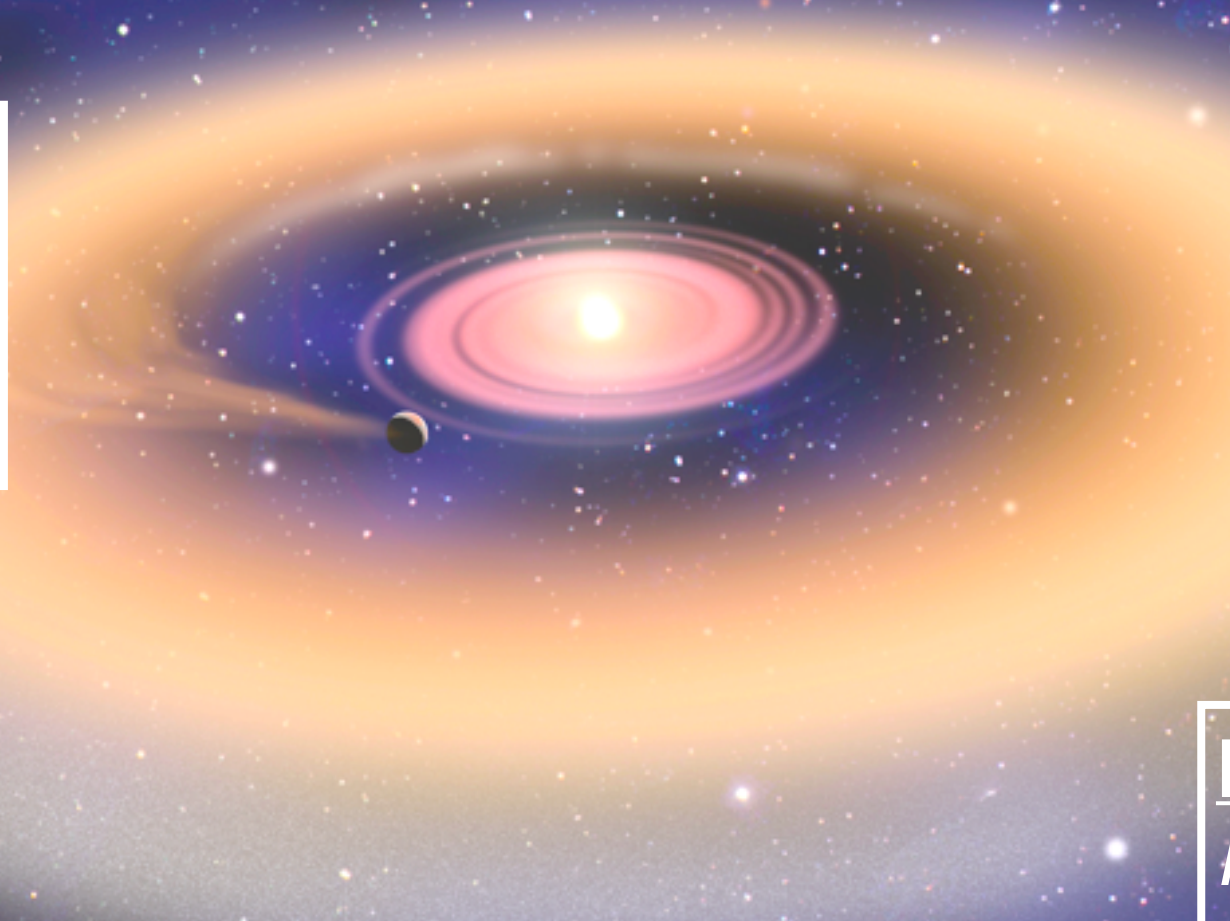
Questions to be addressed:

- Is the NC of the LVC confirmed to be a photoevaporative wind indicator? **Objects with jets show a slightly blueshifted LVC, objects with no jets have a LVC centered to zero (small sample analyzed so far...)**
- What is the driving agent of the photoevaporation? **TBD once we answer the first question.**
- Can we use these indicators to measure the mass loss rate?  
**Next talk!**

# OBSERVATIONAL EVIDENCE OF DISK DISPERSAL MECHANISMS FROM OPTICAL TO MID-IR WAVELENGTHS

## Part I

*[OI] lines as  
photoevaporative  
wind indicators*



## Part II

*Hydrogen lines in the  
mid-IR as accretion  
indicators*

# Probing Stellar accretion with mid-IR Hydrogen lines

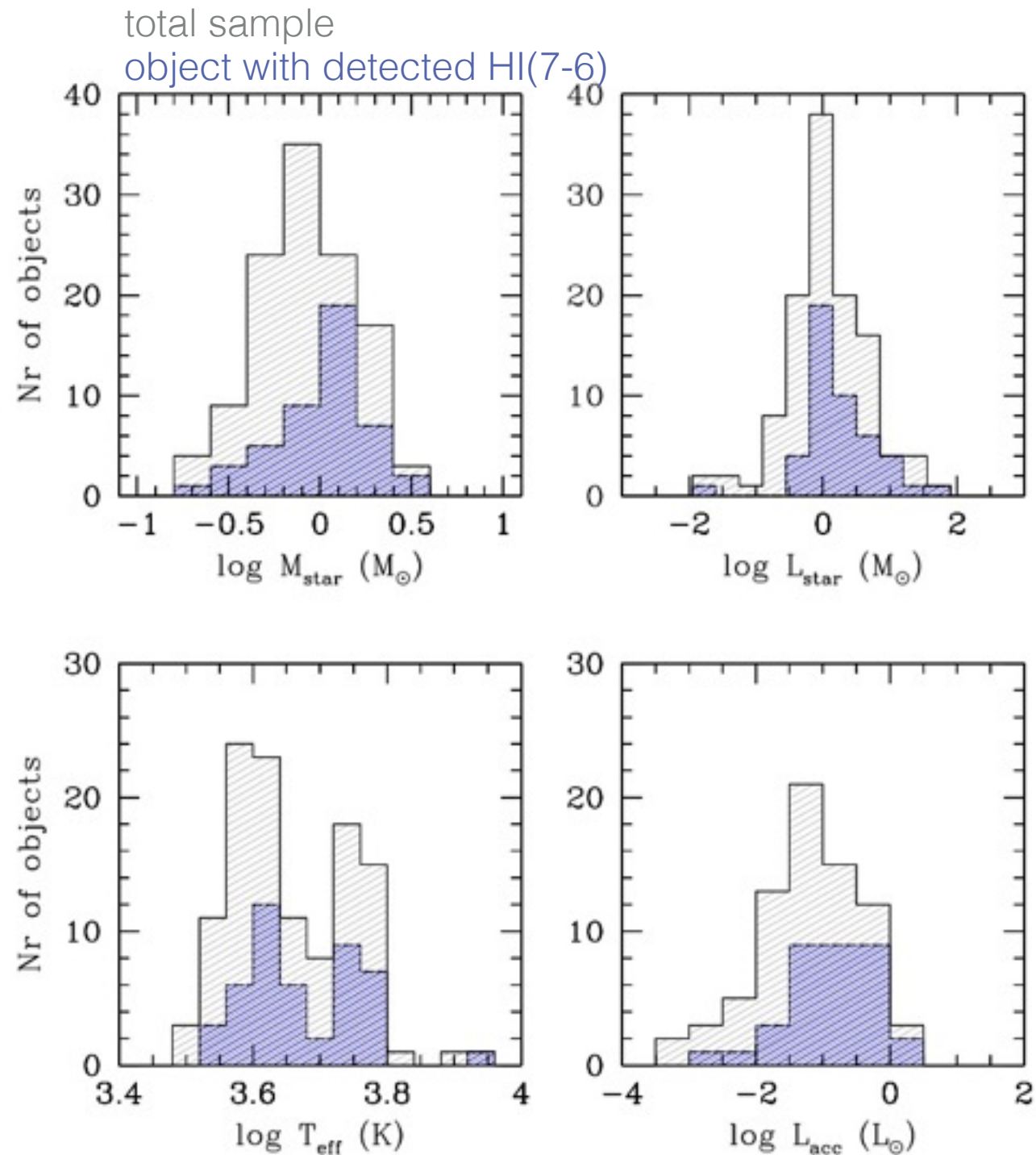
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Analysis of Spitzer spectra to constrain the origin of the observed Hydrogen lines  $\text{HI}(7-6)$ @ $12.37\mu\text{m}$  and  $\text{HI}(9-7)$ @ $11.32\mu\text{m}$

- Are those lines tracing accretion?
- What for?



# Probing Stellar accretion with mid-IR Hydrogen lines



Spitzer spectra of disk-bearing young stars of 114 objects:

68 **Full**, 21 **Transitional** and  
25 **Debris** Disks

40% show evidence of the  
HI(7-6)@12.37 $\mu\text{m}$  line in their spectra

# Probing Stellar accretion with mid-IR Hydrogen lines

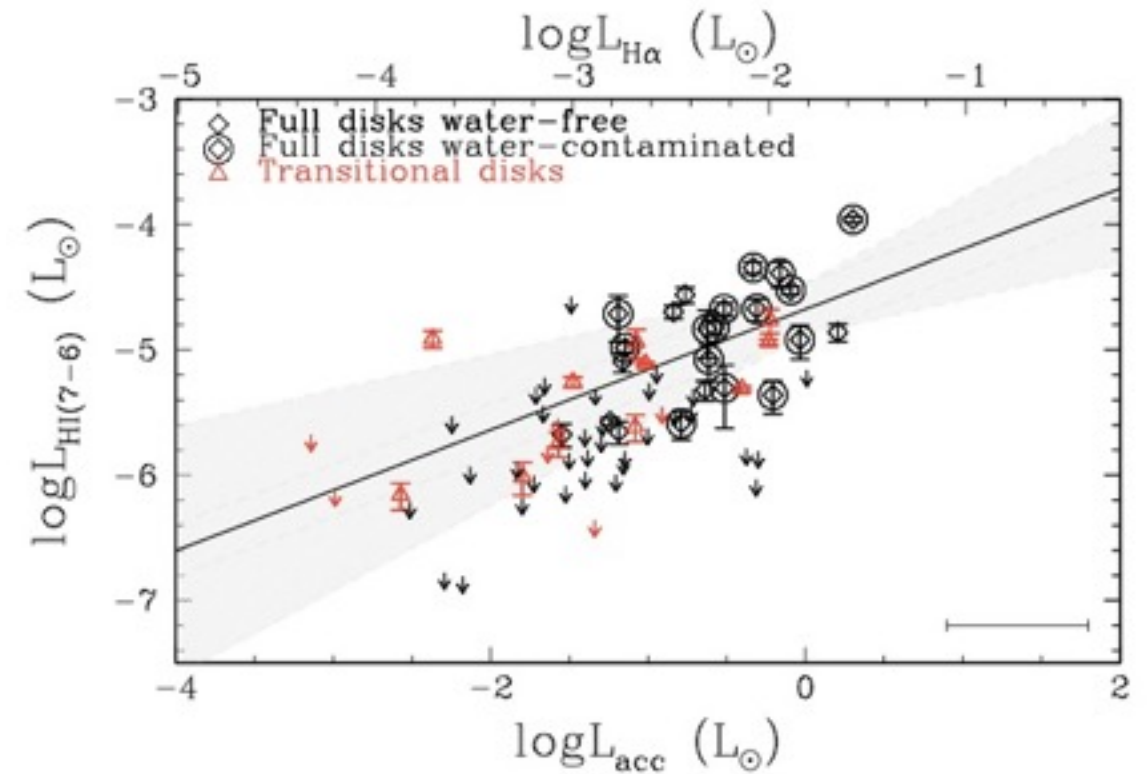
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Could mid-IR H I lines trace accretion as  
other Hydrogen lines?

# Probing Stellar accretion with mid-IR Hydrogen lines

Could mid-IR HI lines trace accretion as other Hydrogen lines?

- HI(7-6), H $\alpha$  and  $L_{\text{acc}}$  are correlated;

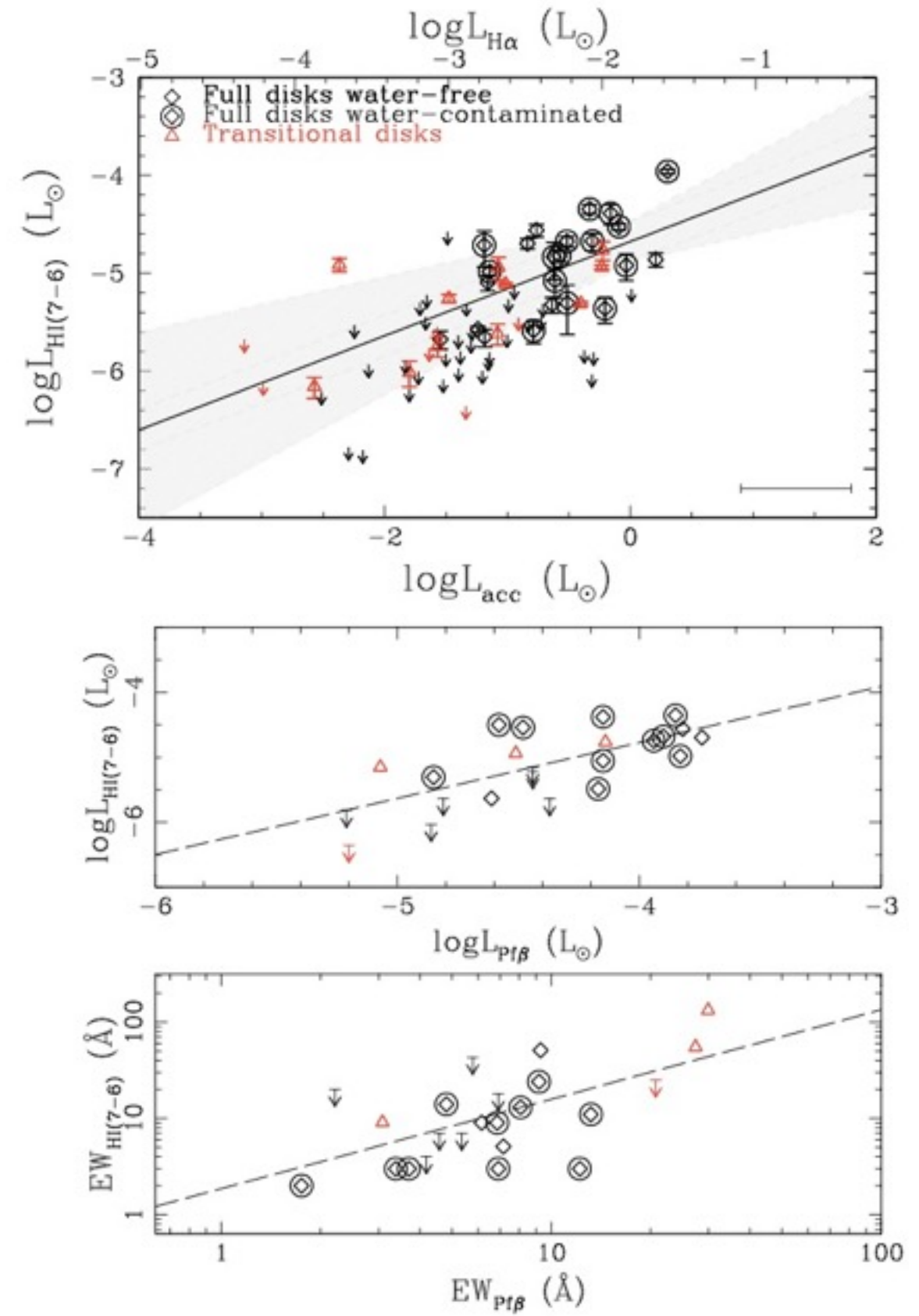




# Probing Stellar accretion with mid-IR Hydrogen lines

## Could mid-IR HI lines trace accretion as other Hydrogen lines?

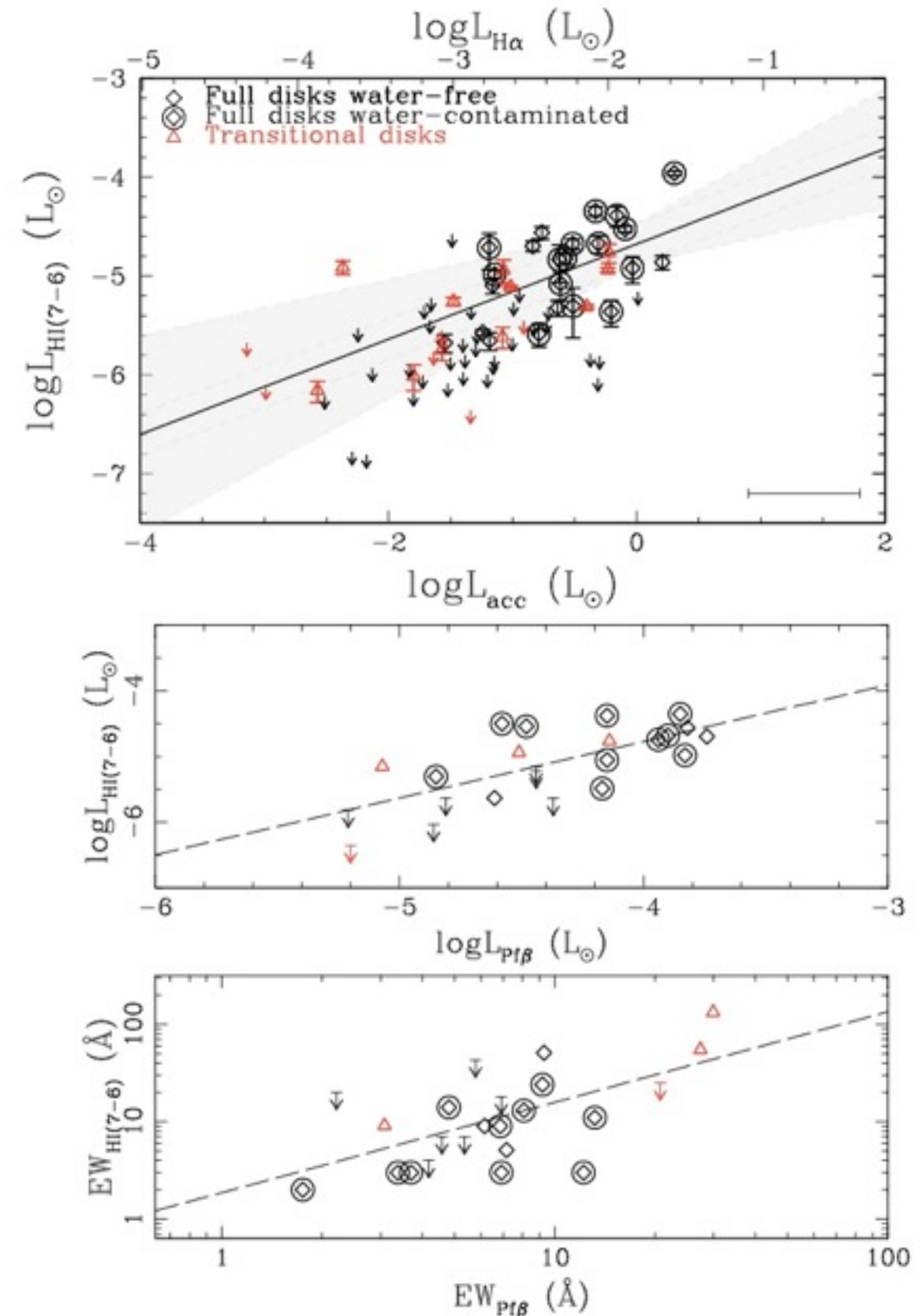
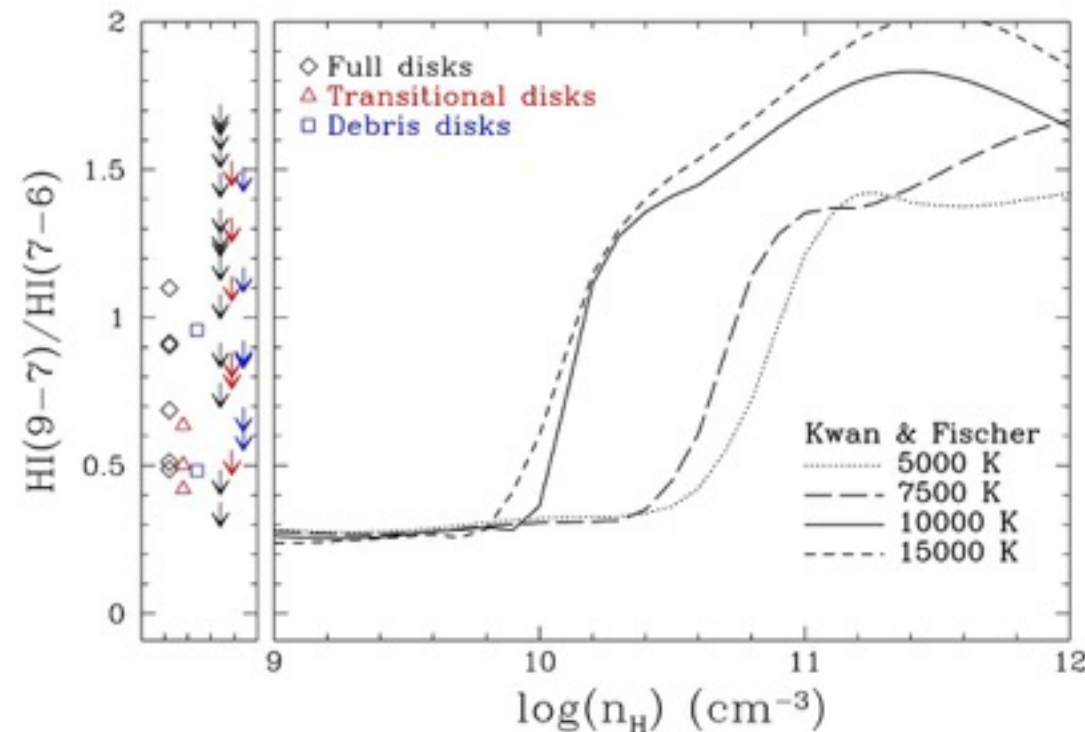
- HI(7-6), H $\alpha$  and  $L_{\text{acc}}$  are correlated;
- Equivalent widths and line luminosities are both correlated;



# Probing Stellar accretion with mid-IR Hydrogen lines

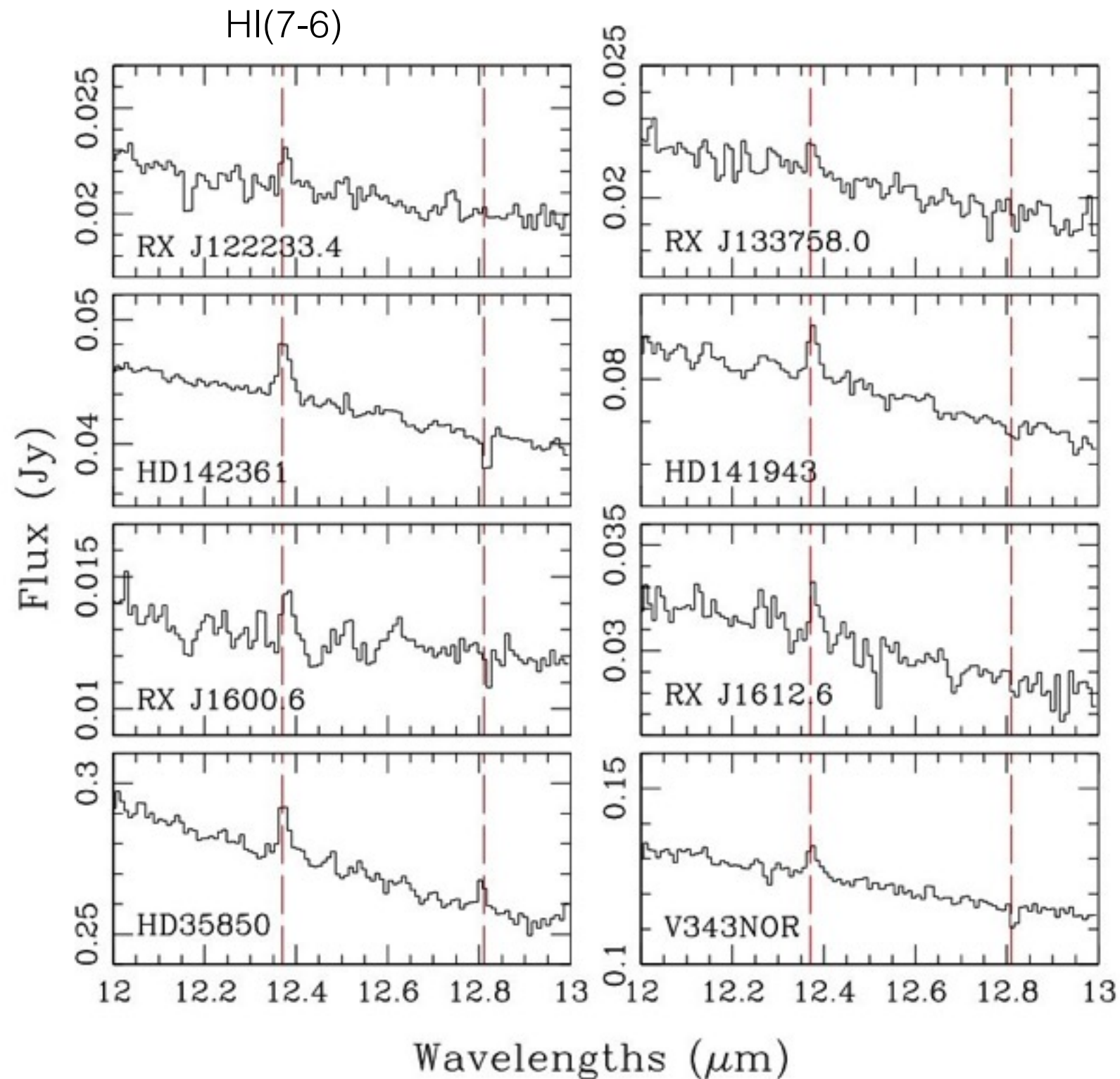
## Could mid-IR HI lines trace accretion as other Hydrogen lines?

- HI(7-6), H $\alpha$  and  $L_{\text{acc}}$  are correlated;
- Equivalent widths and line luminosities are both correlated;
- Physical conditions of the emitting gas are in many cases consistent with accretion



# Probing Stellar accretion with mid-IR Hydrogen lines ... in Debris Disks

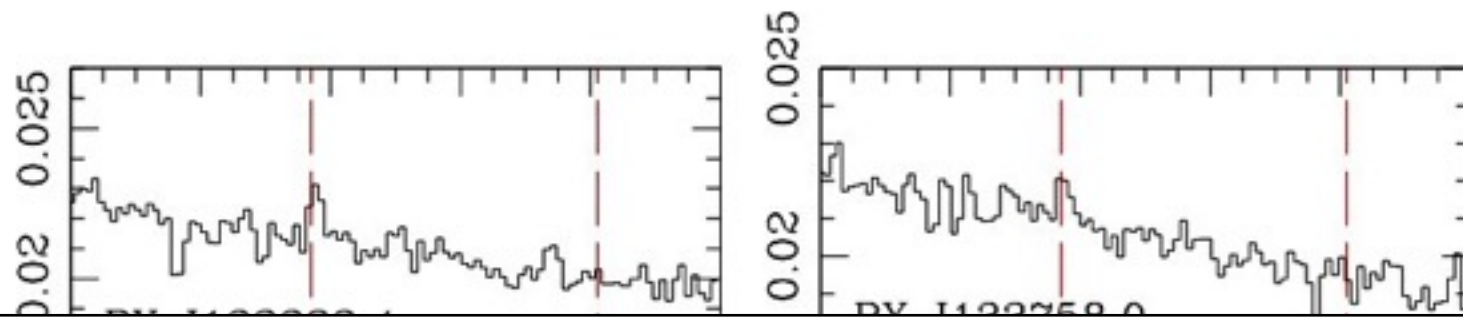
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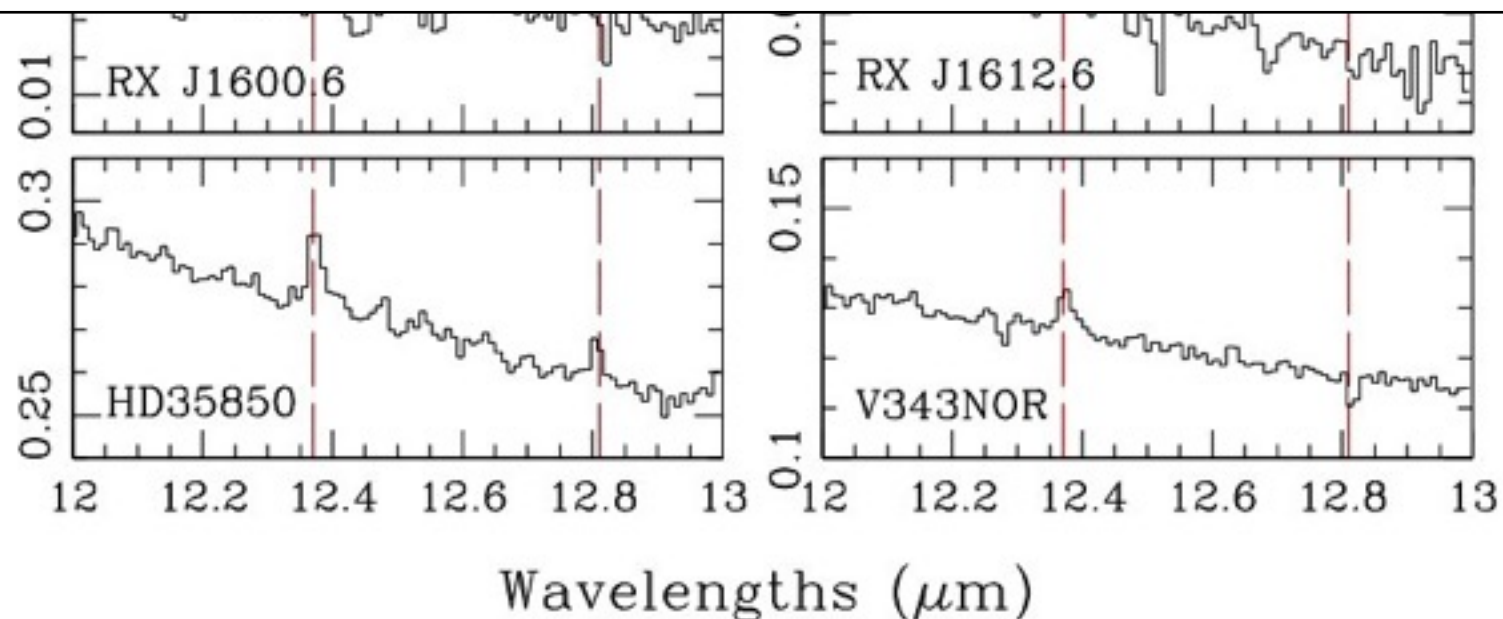
# Probing Stellar accretion with mid-IR Hydrogen lines ... in Debris Disks

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We cannot say yet if the H<sub>I</sub>(7-6) lines detected in DD are tracing long-lasting low level of accretion or chromospheric activity.

Higher-resolution spectroscopy is needed  
(ground-based, e.g., VISIR, or space-based, e.g., JWST)



# Probing Stellar accretion with mid-IR Hydrogen lines

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Analysis of Spitzer spectra to constrain the origin of the observed Hydrogen lines HI(7-6)@12.37 $\mu$ m and HI(9-7)@11.32 $\mu$ m

- Are those lines tracing accretion? **Yes in Full and TD, not sure in DD**
- What for?
  - We can overcome the problem of extinction and measure accretion in embedded (class I) objects
  - IF mid-IR HI lines are tracing accretion in DD, we could measure accretion rates  $< 10^{-10} M_{\odot}/\text{yr}$ , where optical and near-IR indicators are not sensitive
  - Enable simultaneous observation of accretion (HI) and photoevaporation ([NeII]) indicators

# Summary & Discussion

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## **OBSERVATIONAL EVIDENCE OF DISK DISPERSAL MECHANISMS FROM OPTICAL TO MID-IR WAVELENGTHS**

- Is the low-velocity component seen in forbidden lines tracing photoevaporation?

*Observations show that the LVC is blueshifted if you have an associated HVC*

- What is the driving agent of the photoevaporation?
- Are the mid-IR Hydrogen lines tracing accretion in debris disks?  
*If yes, is it long-lasting gas or second generation gas?*