Mapping the Inner Disk Gas around Young Stars in the Lupus Complex

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Take a Closer Look

October 16th, 2018

Outline

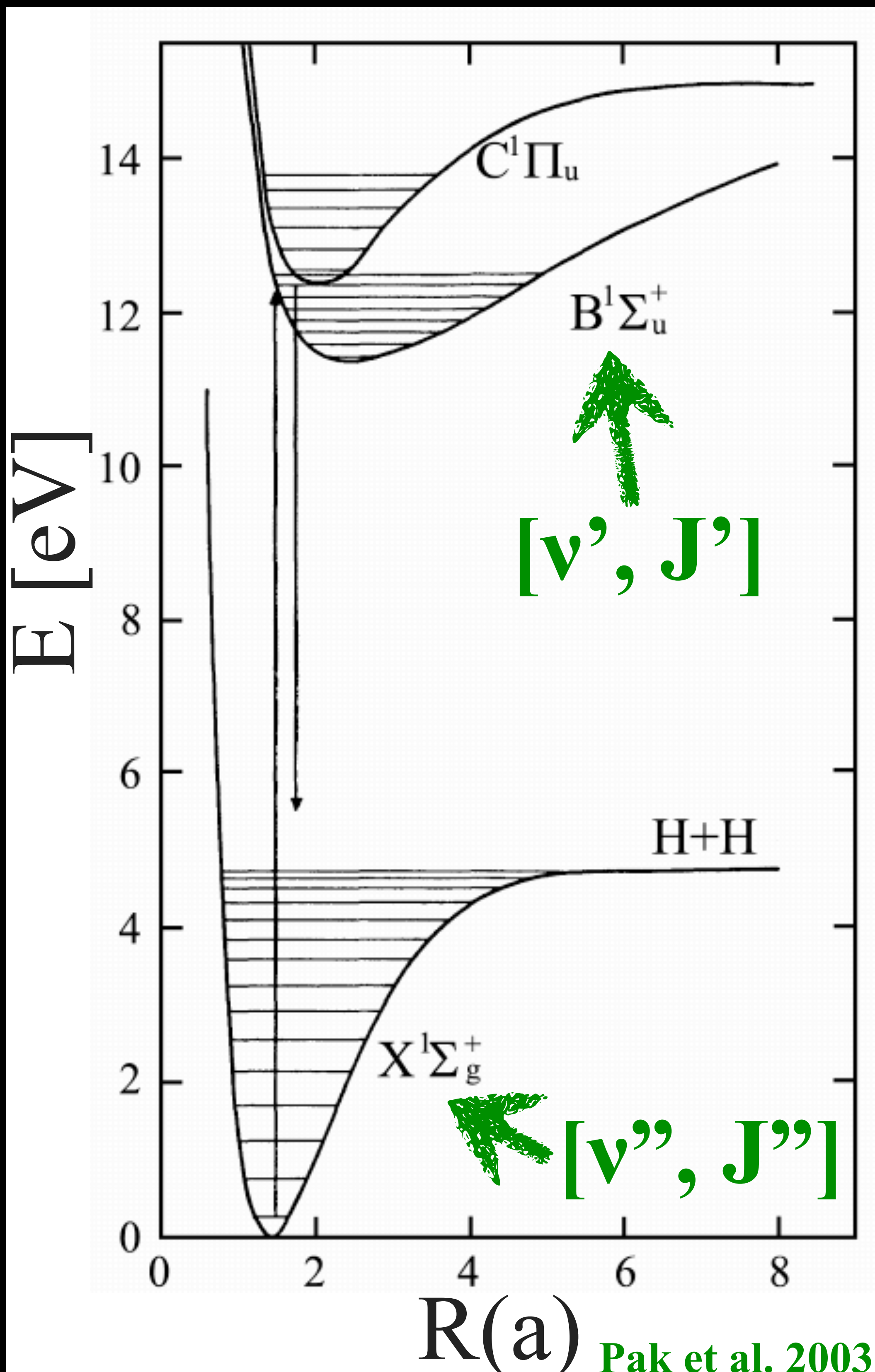
1) Overview of relevant molecular spectroscopy

2) Where in the inner disk are we looking?

3) RY Lupi as a prototype for combining inner/outer disk tracers

4) Extending analysis to a sample of “evolved” disks in the Lupus complex

Electronic transitions of H_2 are observed in the UV with *HST*-COS



Example: The group of emission lines cascading from an upper state with

v' = 1,

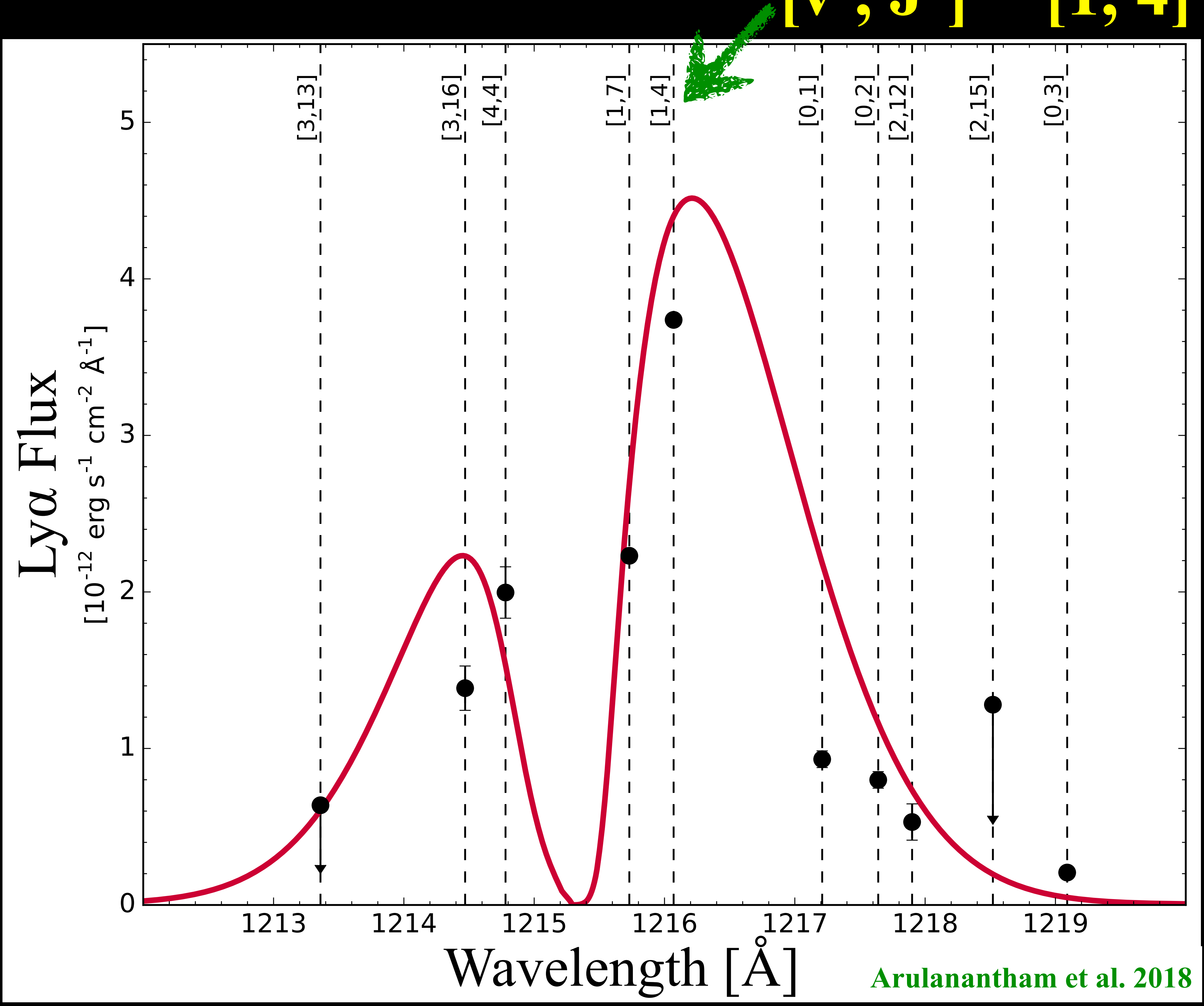
J' = 4

in the **$B^+\Sigma_u^+$** electronic state is known as the

[1, 4] progression.

H_2 is pumped into $B^{+}\Sigma_u^{+}$ by photons with wavelengths spanning the entire Lyα profile

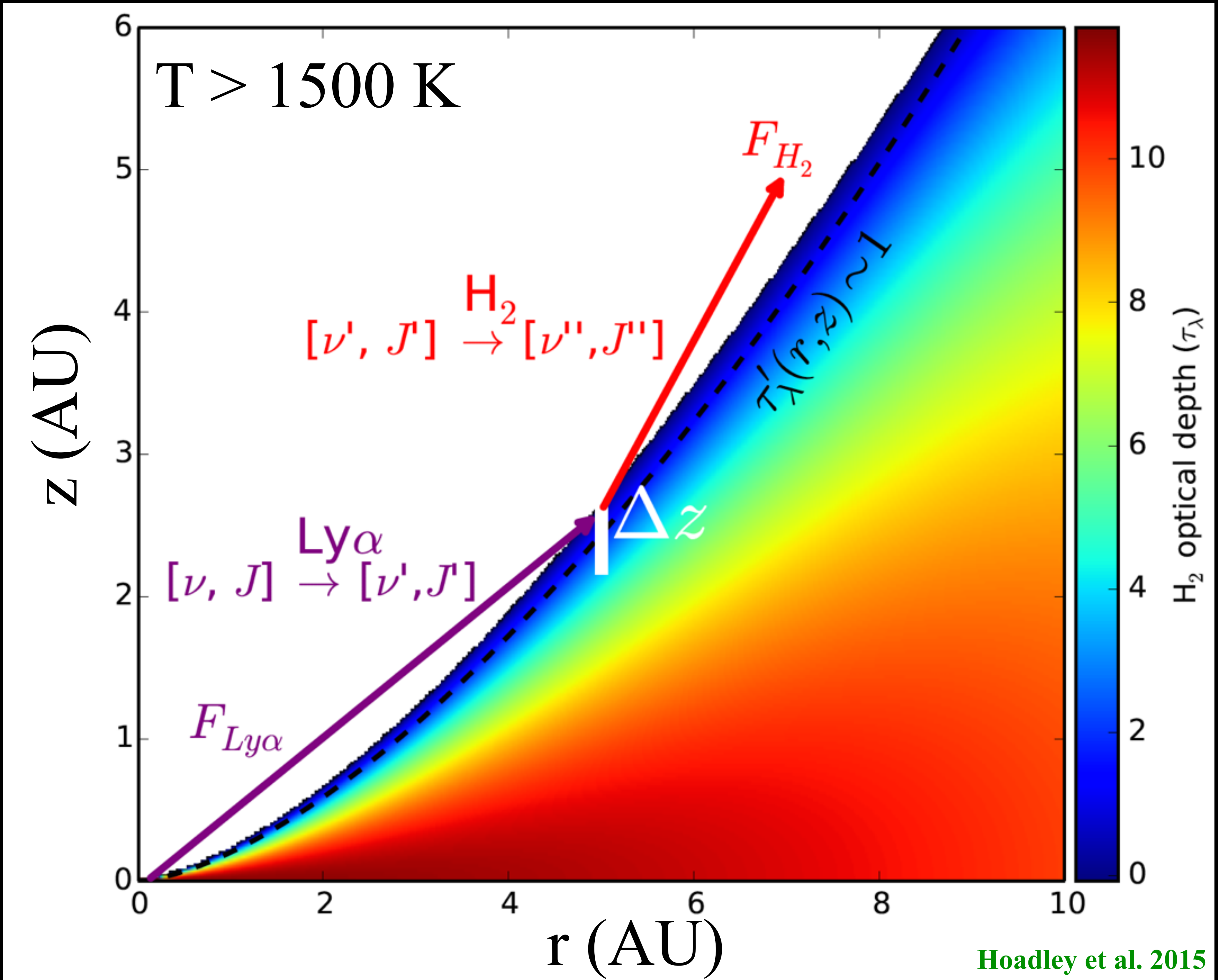
[v', J'] = [1, 4]



Arulanantham et al. 2018

Example: H_2 molecules are "pumped" into the [1, 4] state by photons with λ= 1216.07 Å

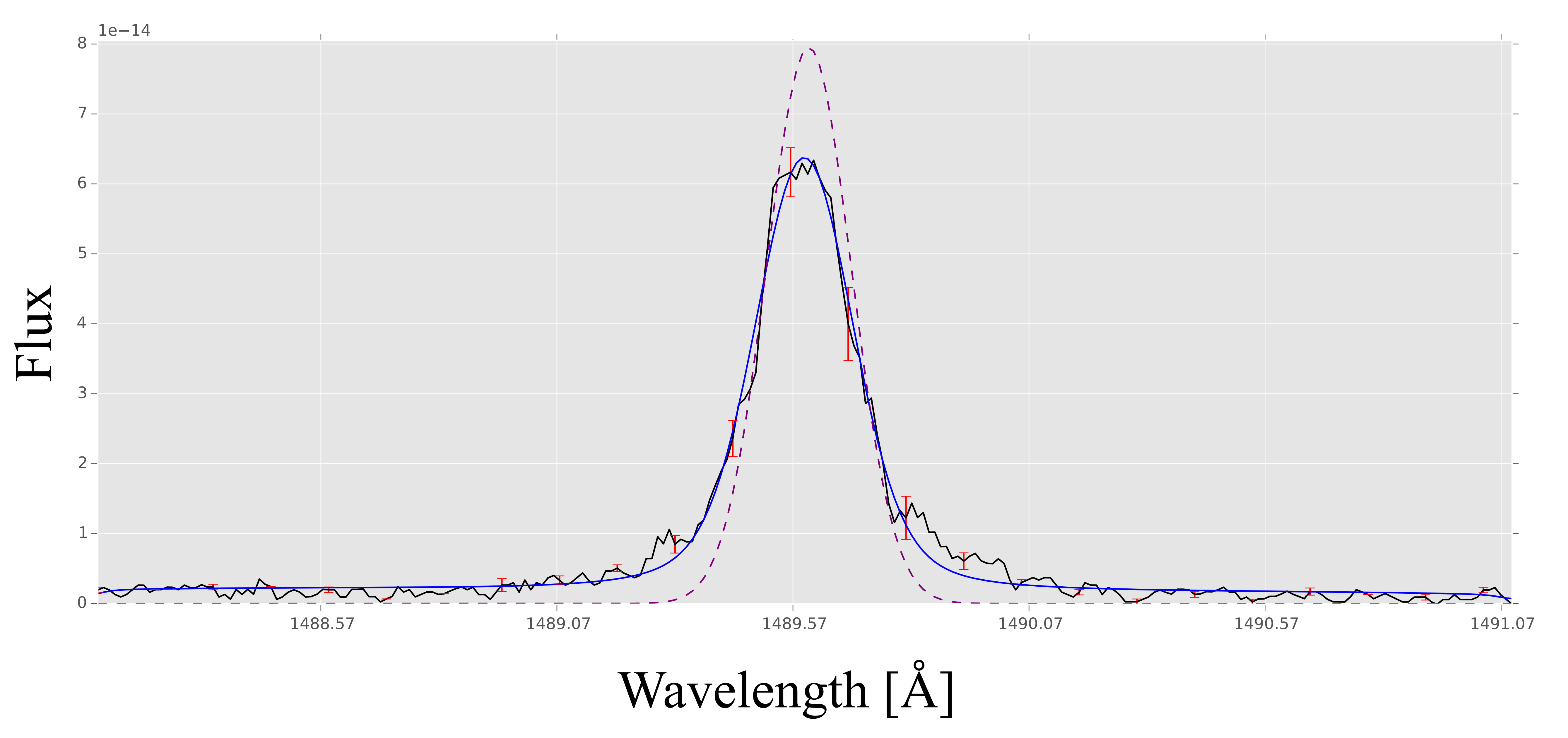
UV-H_2 fluorescence takes place in a thin layer at the disk surface



Hoadley et al. 2015

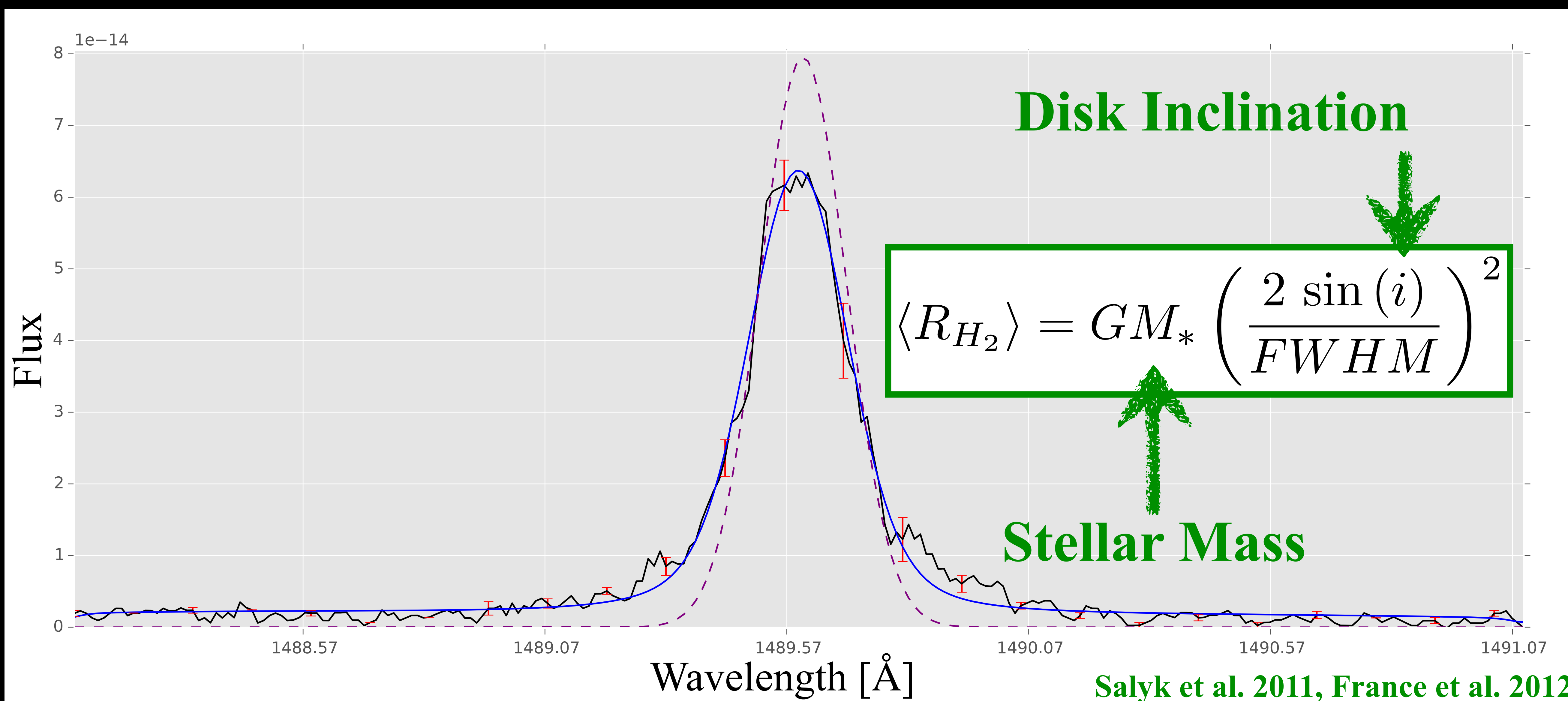
Spectrally resolved UV-H_2 emission traces inner disk structure

(1-7)R(3) 1489.57 Å



Spectrally resolved UV-H_2 emission traces inner disk structure

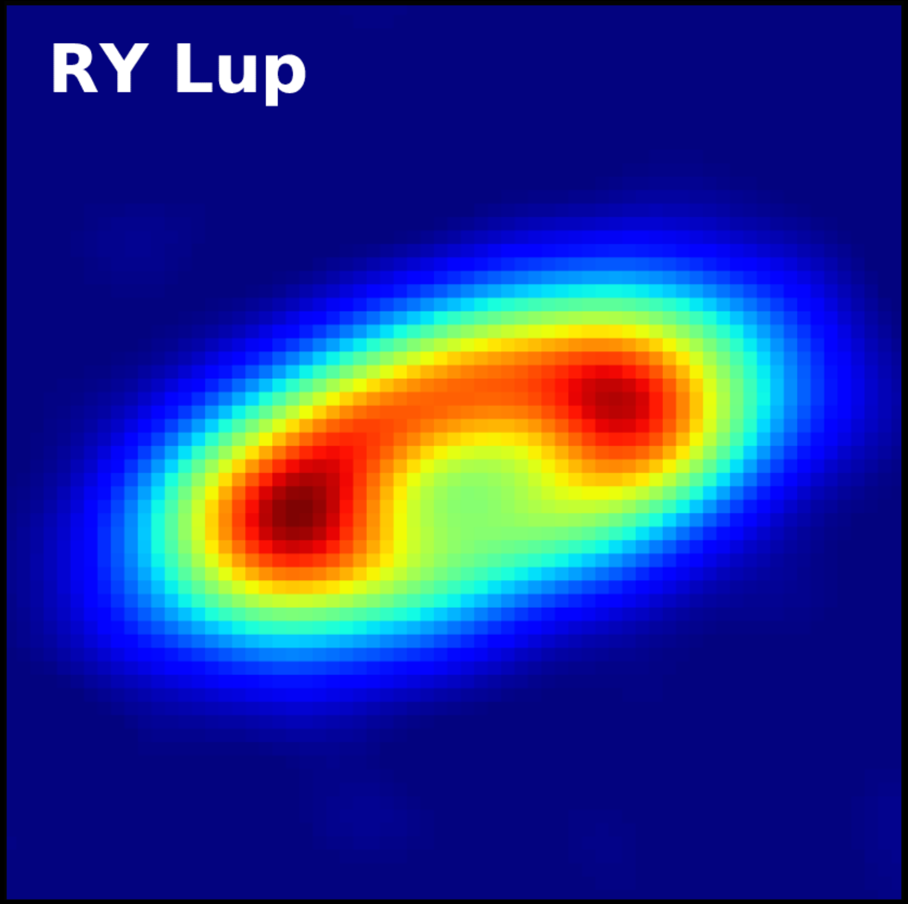
Determine Gaussian line widths → **Infer average emission radius from FWHM**



$$\langle R_{H_2} \rangle = GM_* \left(\frac{2 \sin(i)}{FWHM} \right)^2$$

Salyk et al. 2011, France et al. 2012

RY Lupi: The Prototype



Ansdell et al. 2016

• Clearing of inner disk seen in 890 µm dust continuum and ^{13}CO ALMA images (Ansdell et al. 2016, van der Marel et al. 2018)

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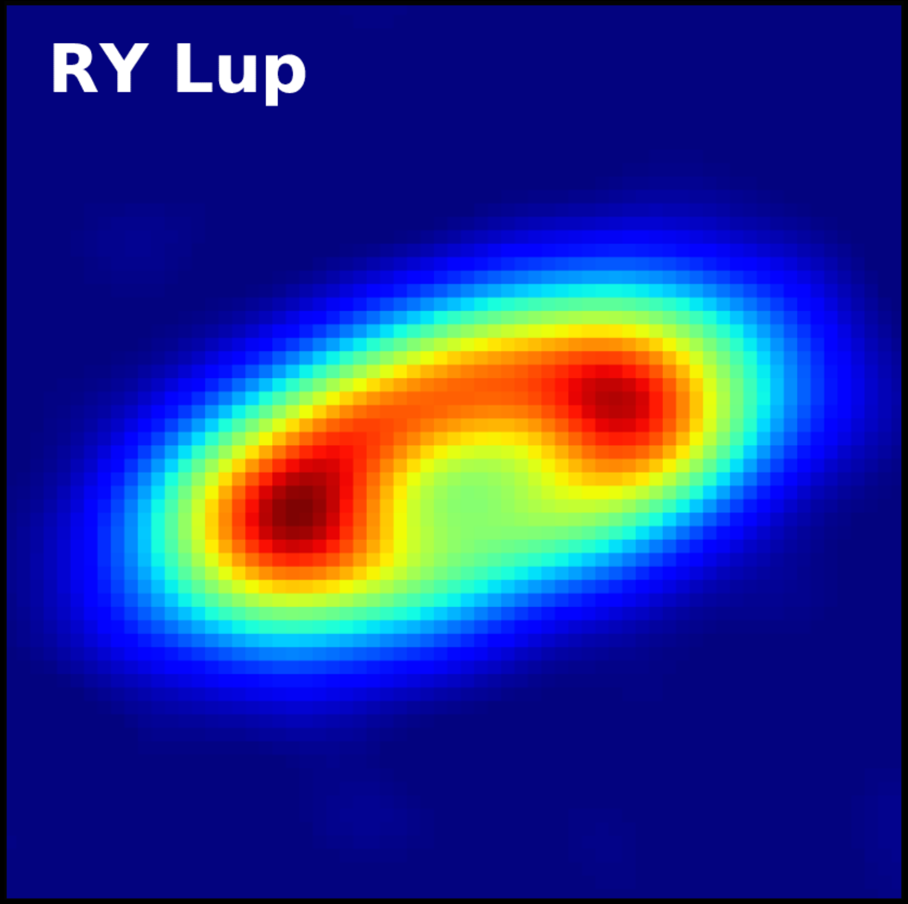

Ansdell et al. 2016

- Clearing of inner disk seen in 890 μm dust continuum and ^{13}CO ALMA images (Ansdell et al. 2016, van der Marel et al. 2018)

- Undergoes photometric (*UBV*) variability over a 3.7 day period (Manset et al. 2009)

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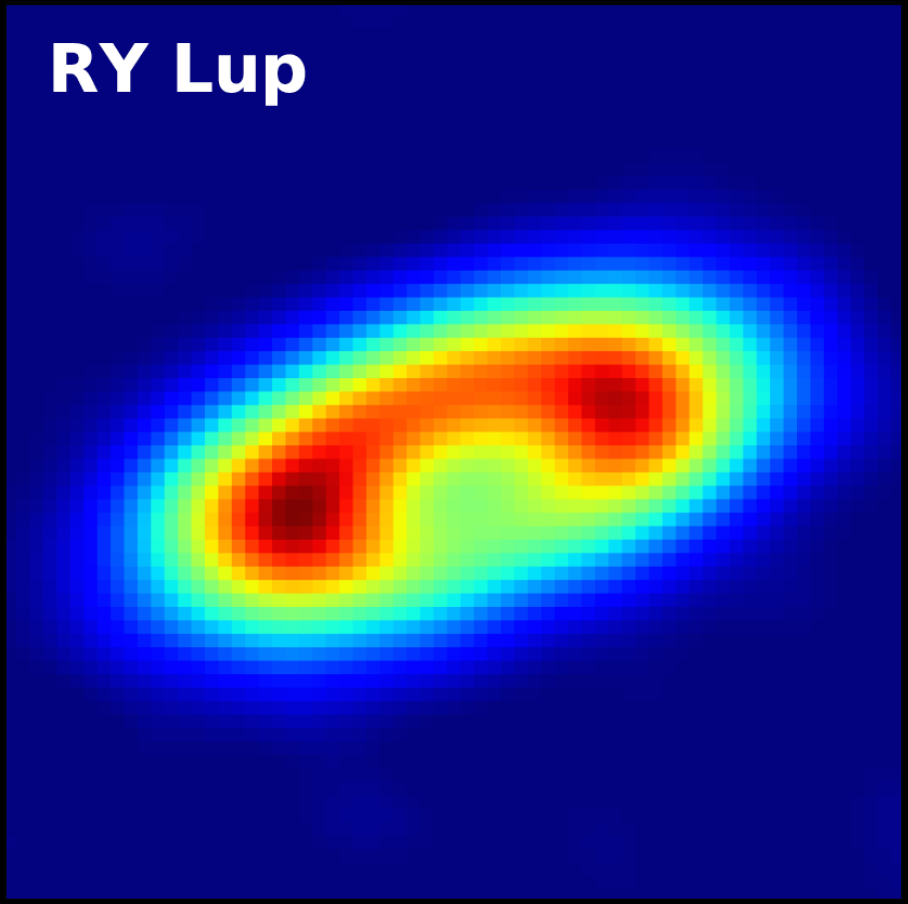
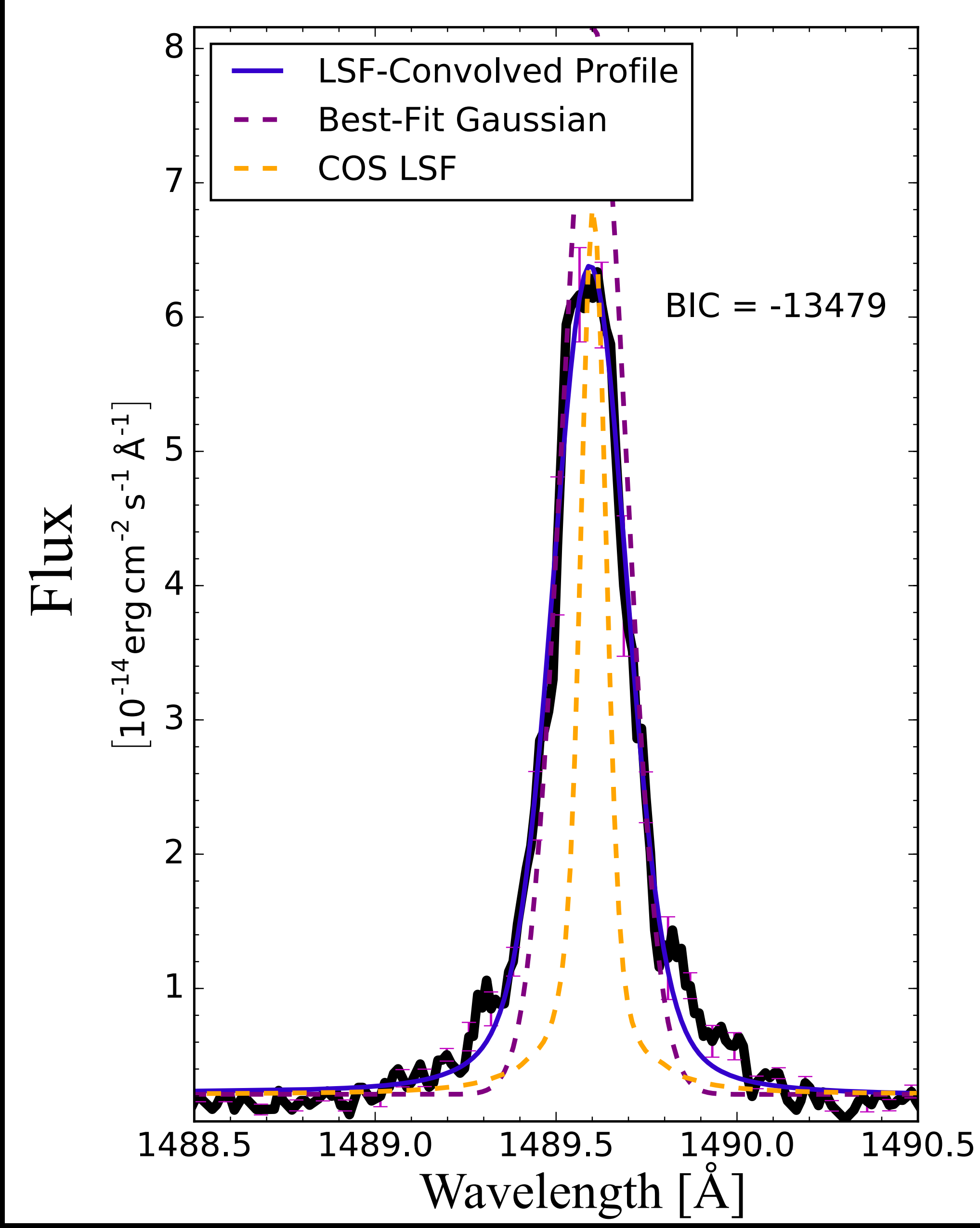


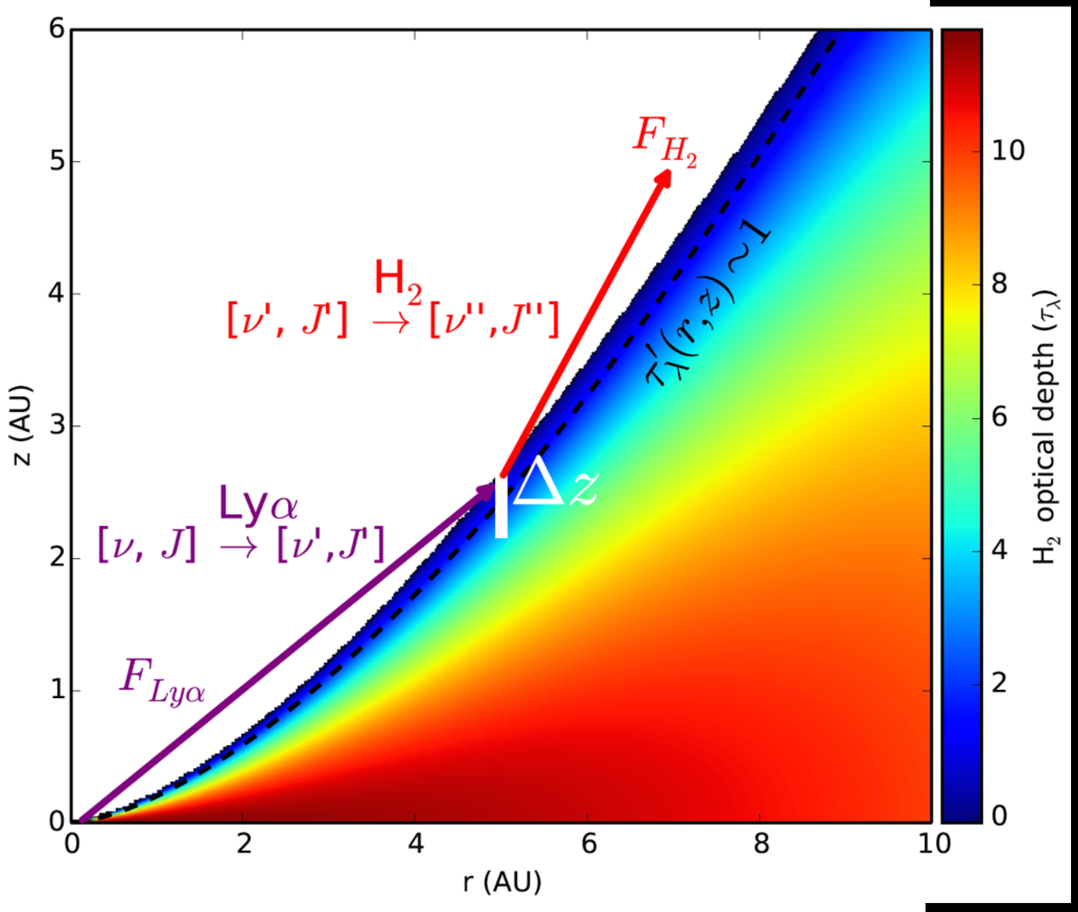
Ansdell et al. 2016

- Clearing of inner disk seen in 890 µm dust continuum and ^{13}CO ALMA images (Ansdell et al. 2016, van der Marel et al. 2018)
- Undergoes photometric (*UBV*) variability over a 3.7 day period (Manset et al. 2009)
- Strong 10 µm silicate emission dominates IR flux (Kessler-Silacci et al. 2006)

Spectrally resolved UV-H_2 emission also traces inner disk structure

$$\langle R_{H_2} \rangle = GM_* \left(\frac{2 \sin(i)}{FWHM} \right)^2$$





Arulanantham et al. 2018;
Hoadley et al. 2015

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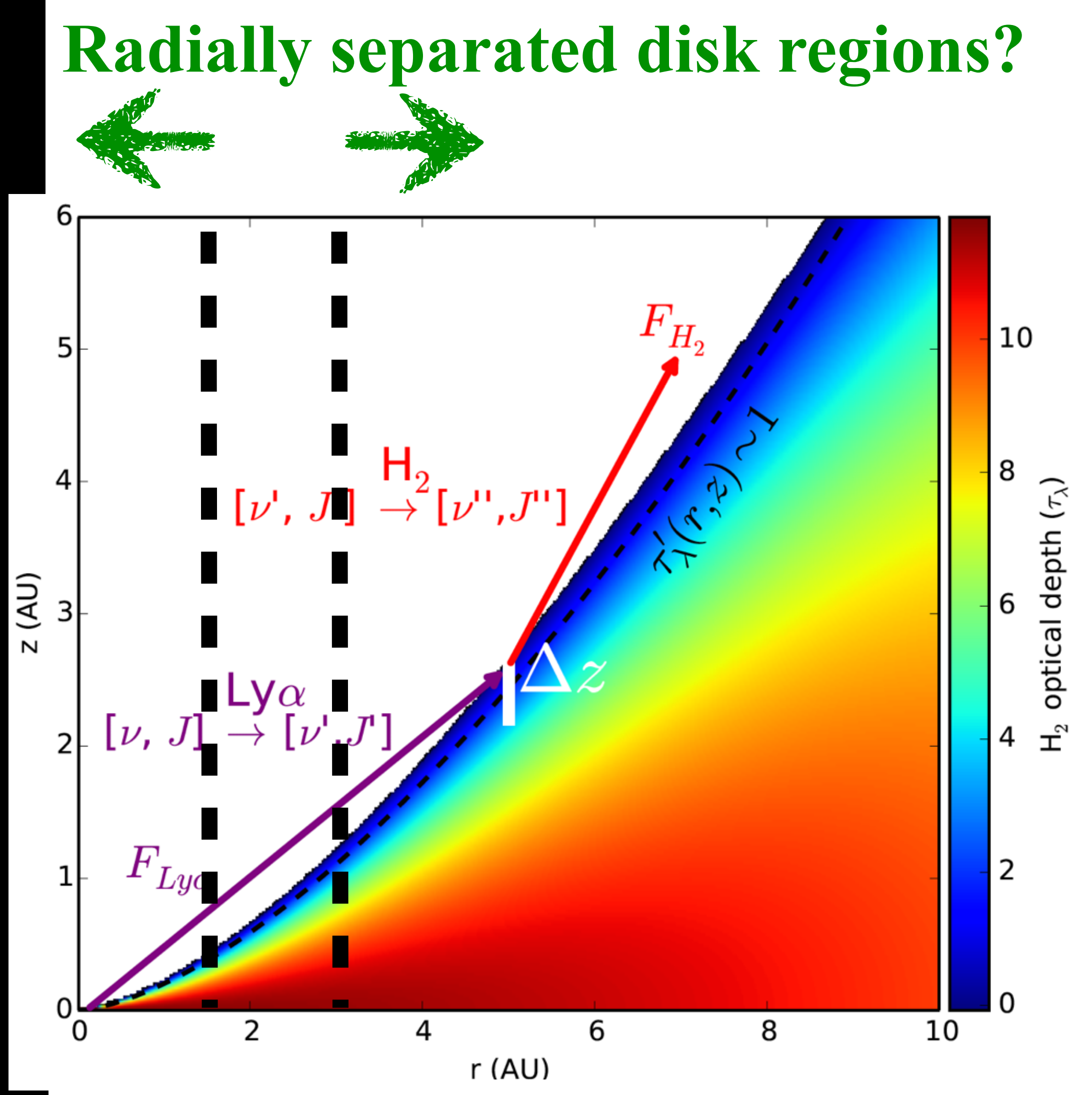
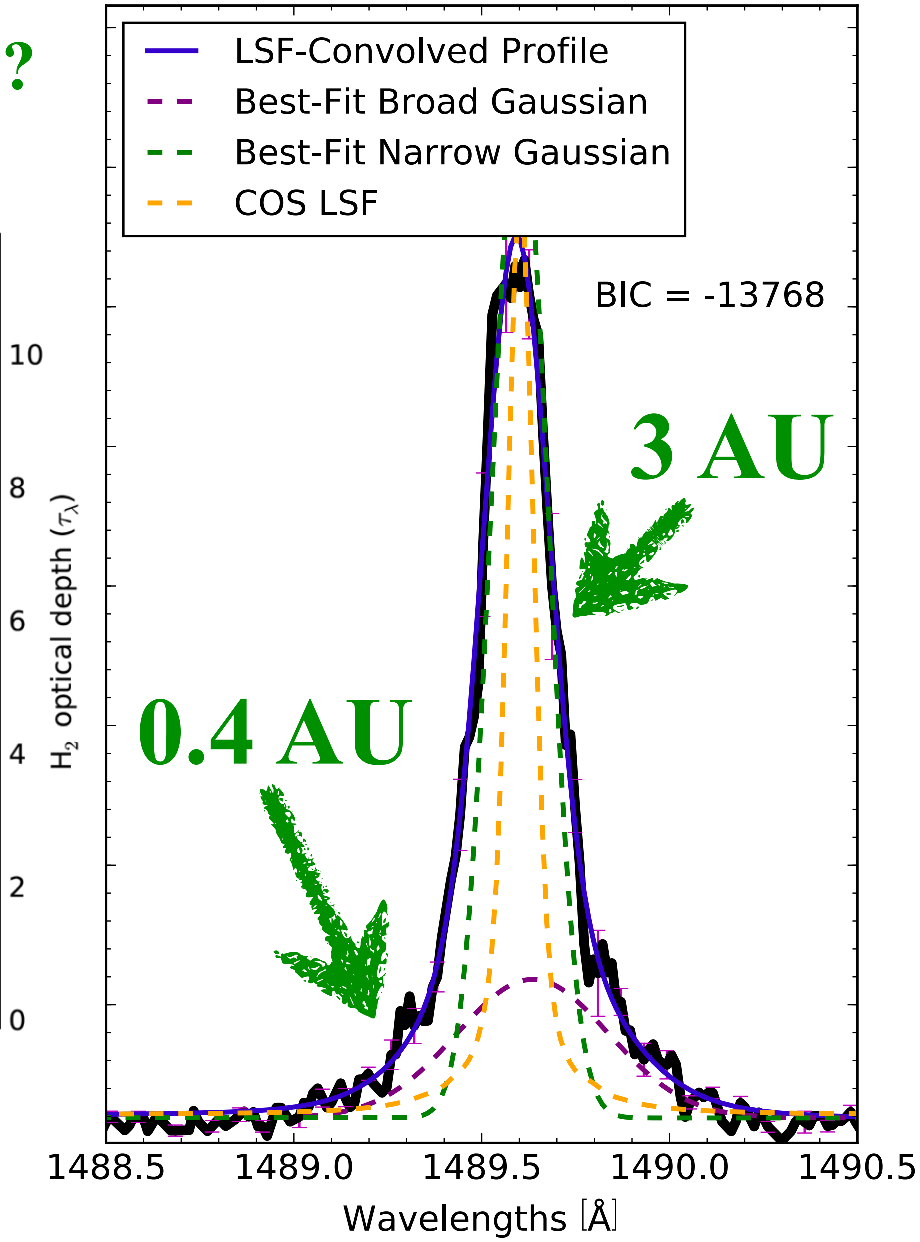
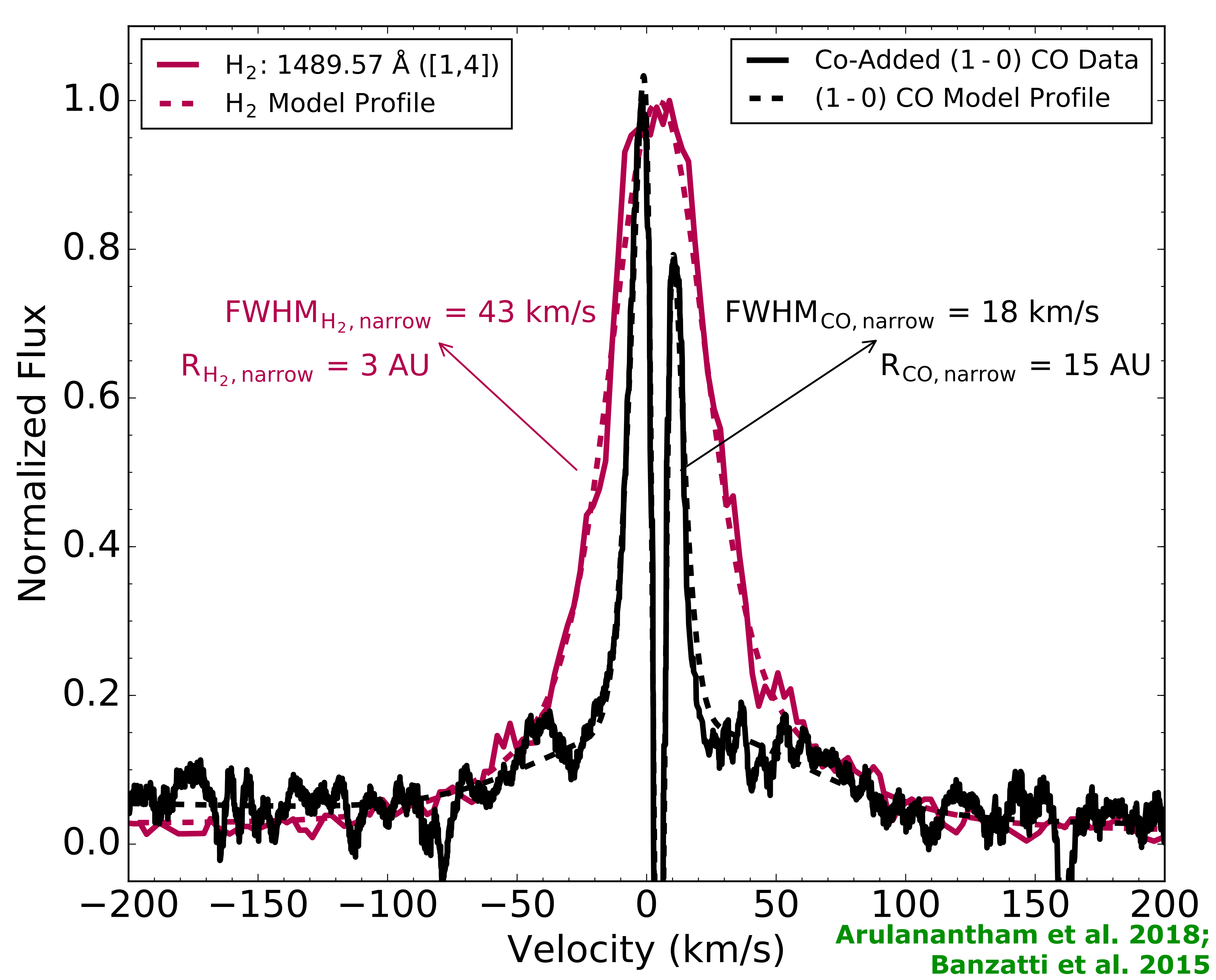




Arulanantham et al. 2018; Hoadley et al. 2015

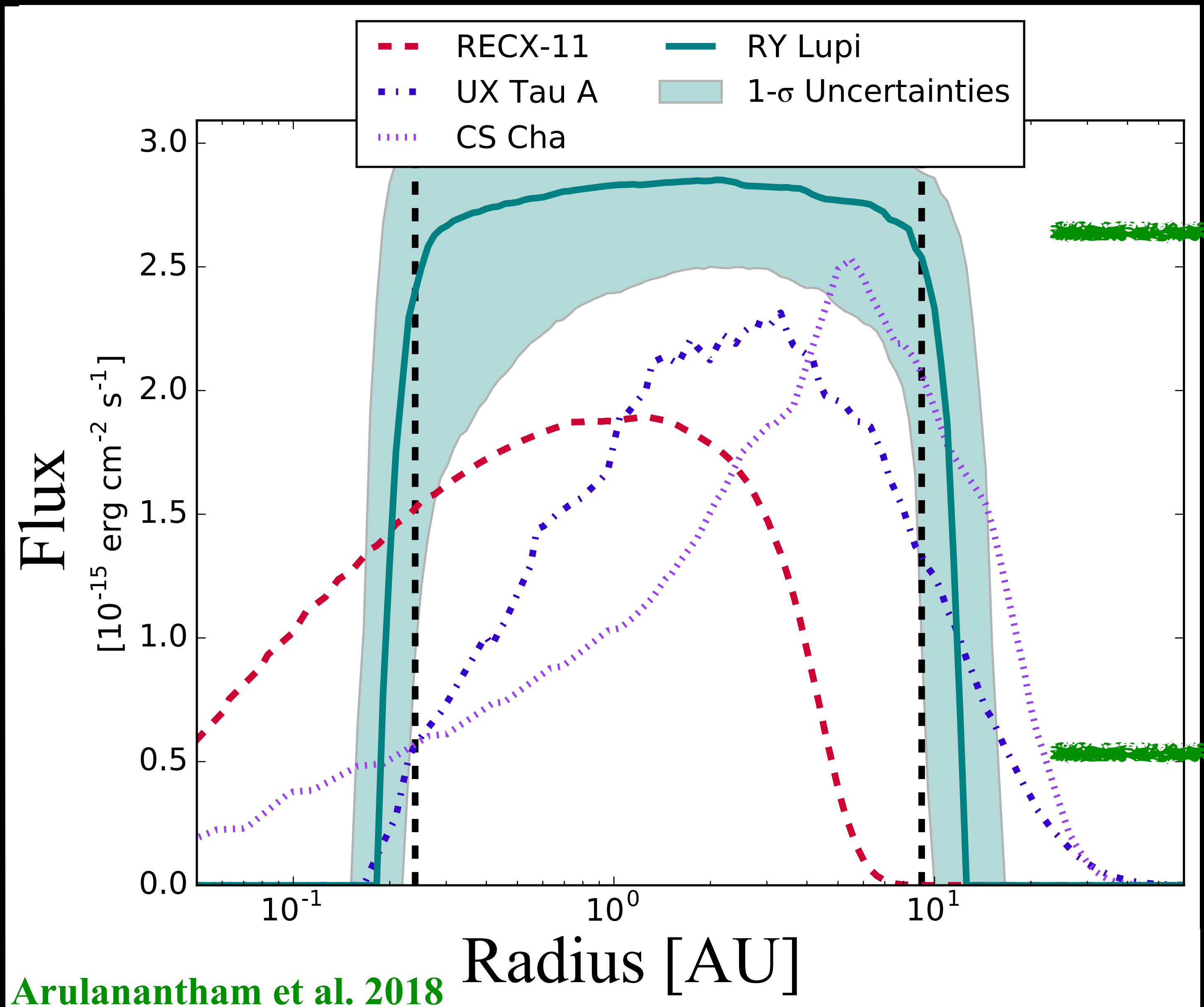
Radial structure inferred from *VLT*-CRIRES IR-CO emission is consistent with the UV-H2



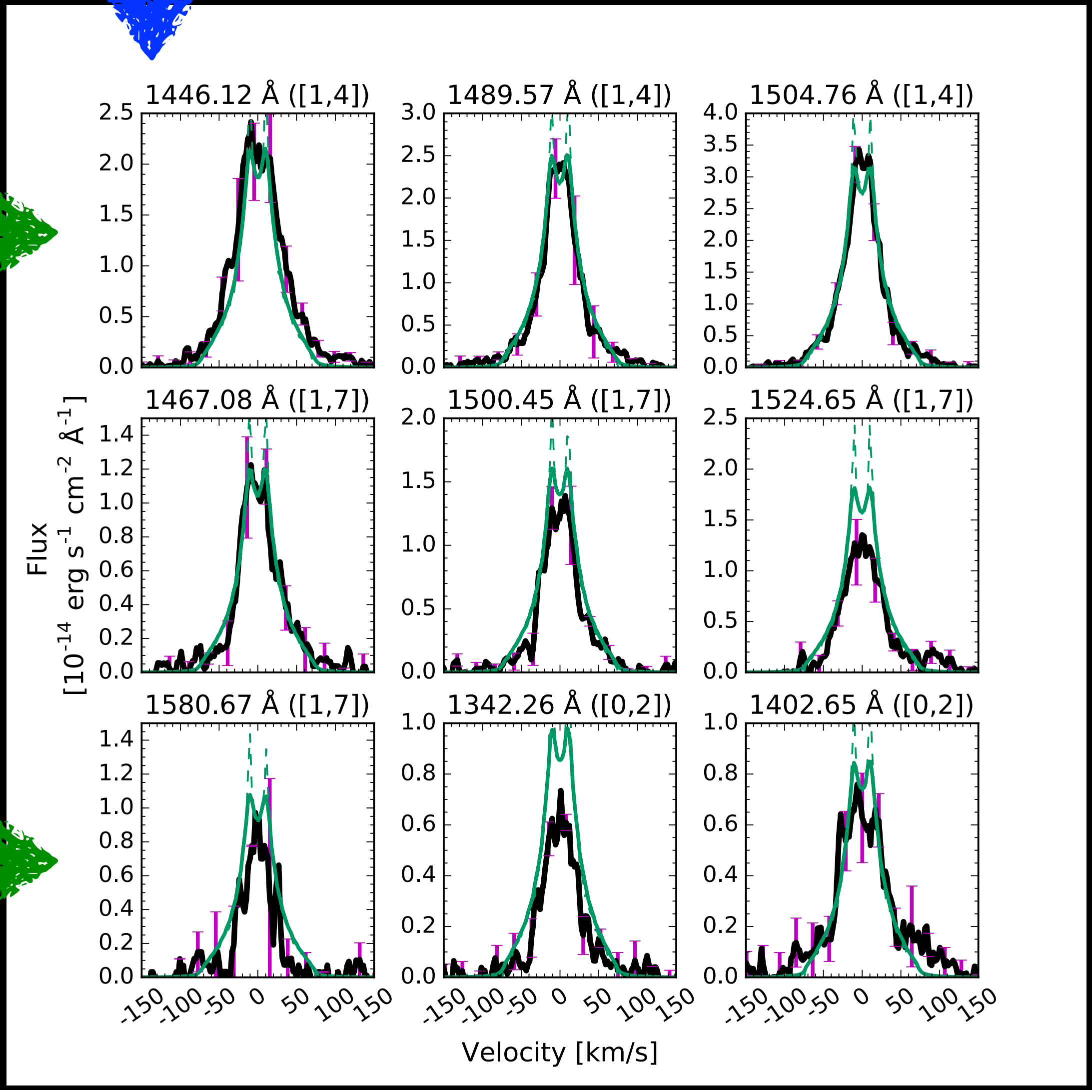
Arulanantham et al. 2018; Banzatti et al. 2015

2-D radiative transfer model (Hoadley et al. 2015) to extract radial distribution of UV-H2 flux

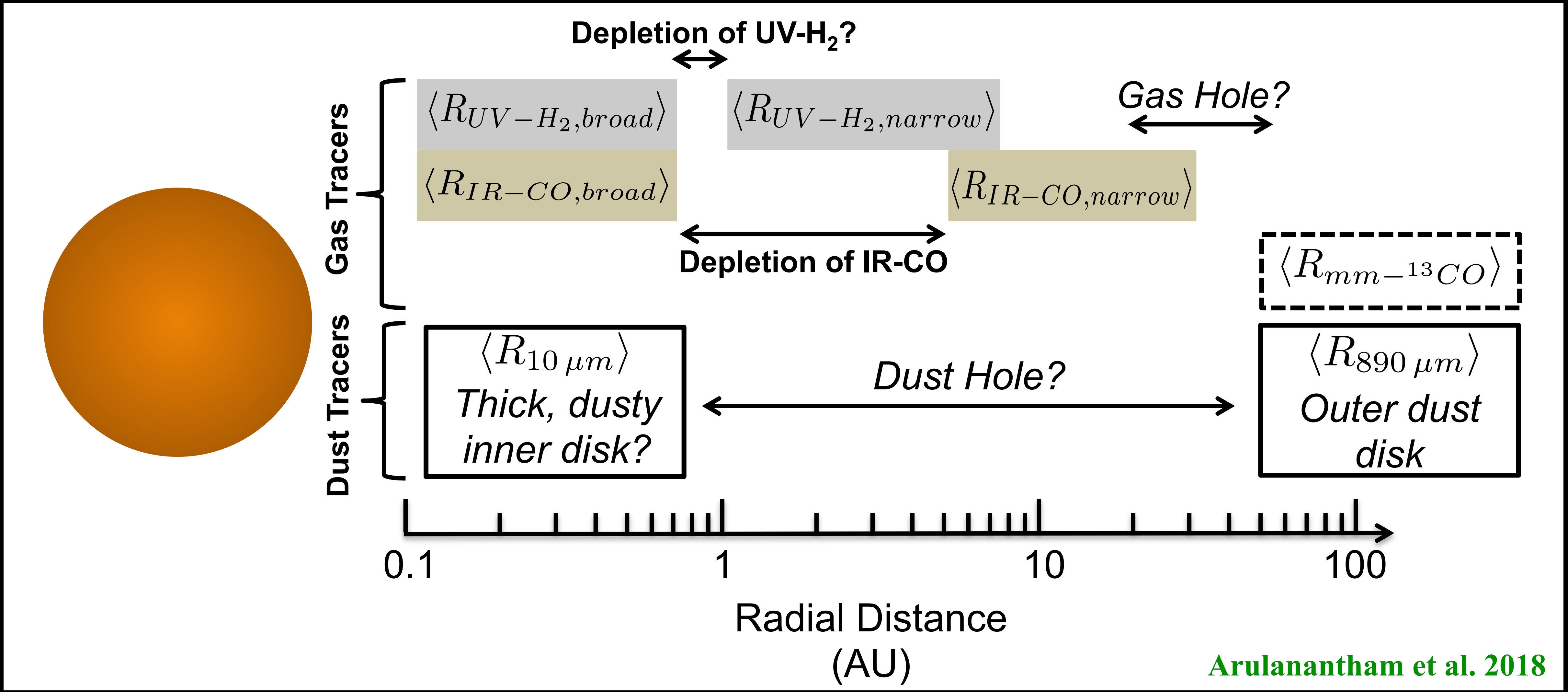
Which **model flux distribution** best reproduces the **observed emission lines**?



Arulanantham et al. 2018



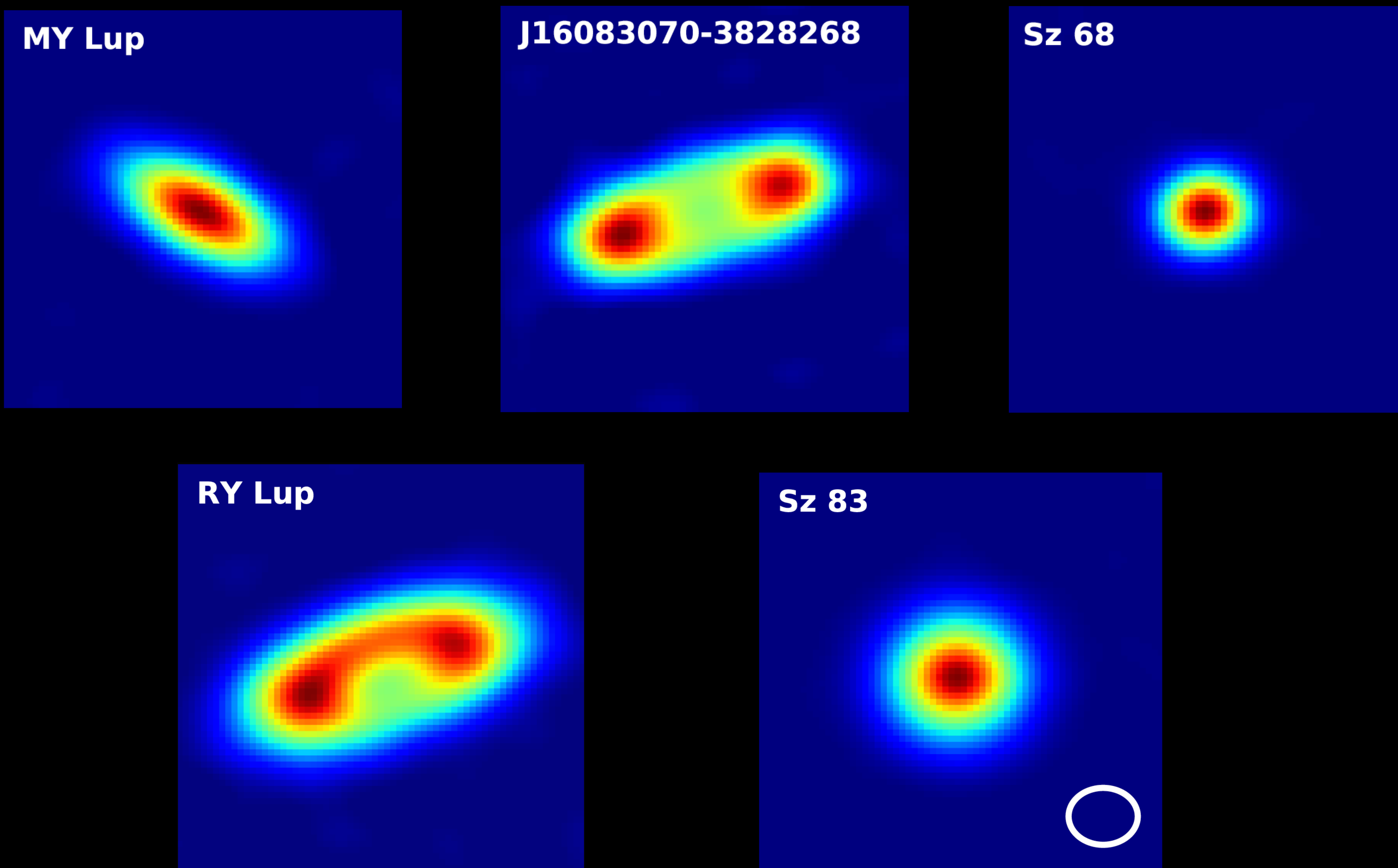
Added other disk tracers to provide a more complete picture of the whole disk



Arulanantham et al. 2018

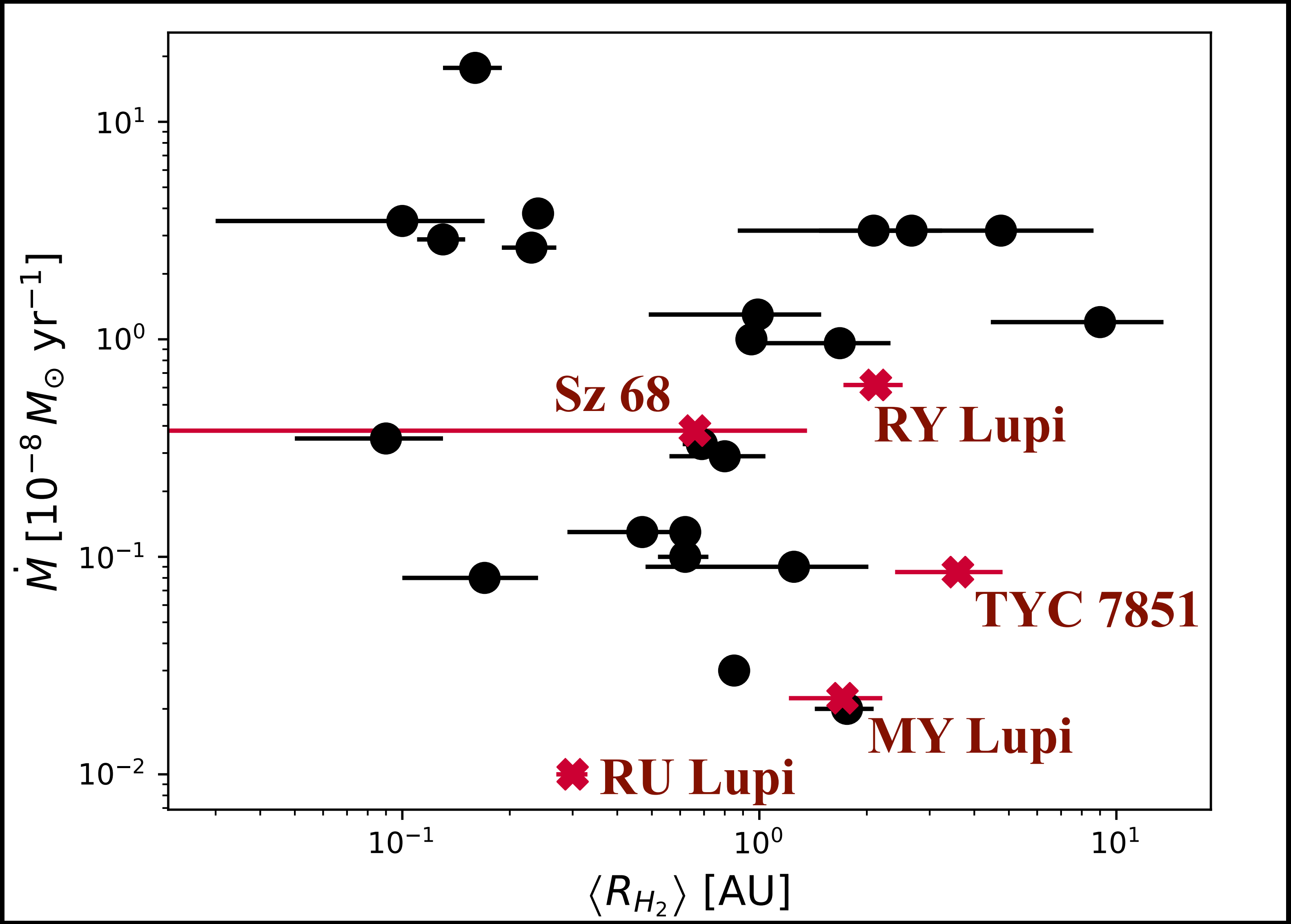
Extending analysis to broader sample of "evolved" Lupus disks

Ansdell et al. 2016



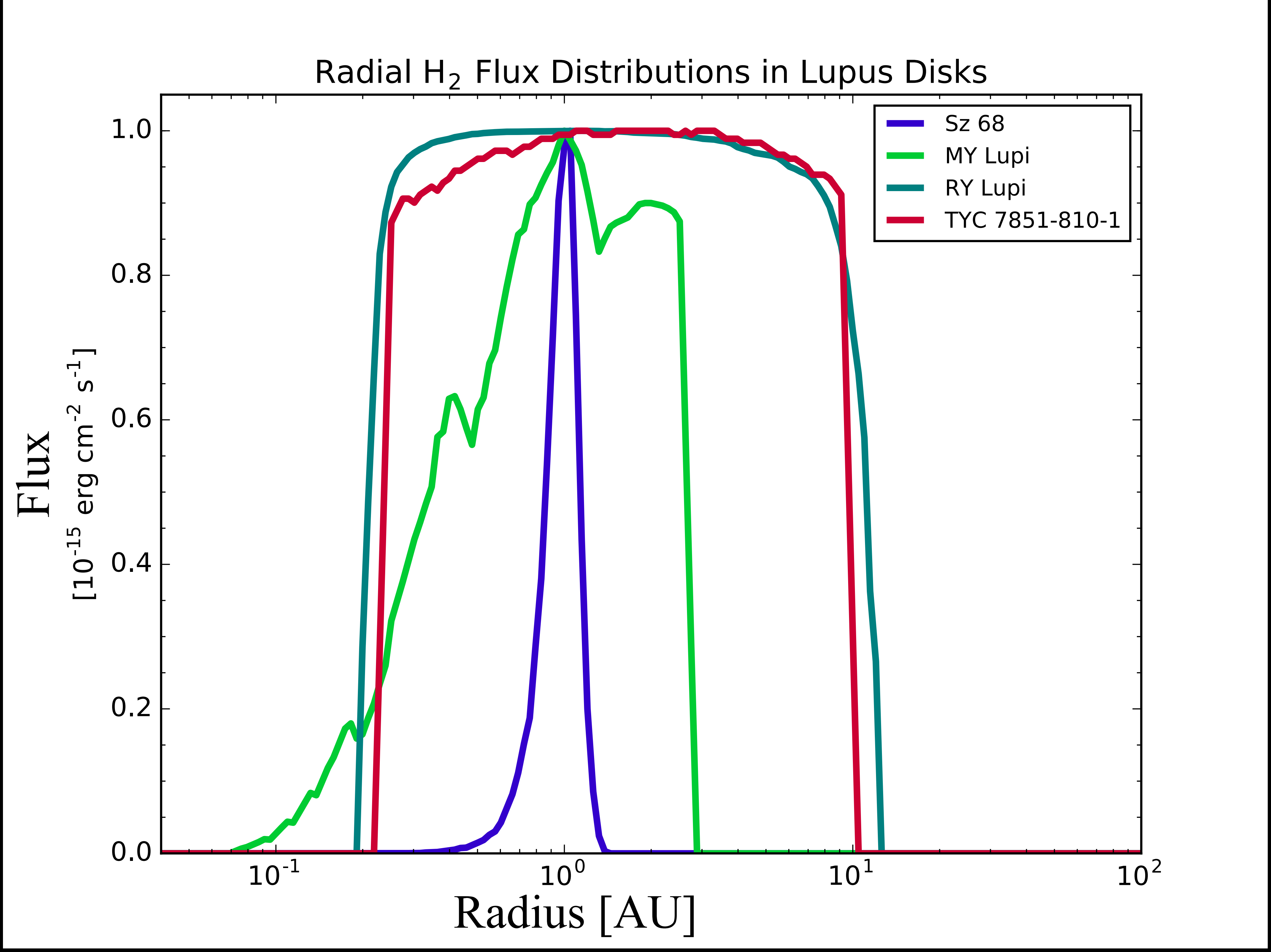
Average radius of UV-H2 emission is similar for all five Lupus complex systems...

$$\langle R_{H_2} \rangle = GM_* \left(\frac{2 \sin(i)}{FWHM} \right)^2$$

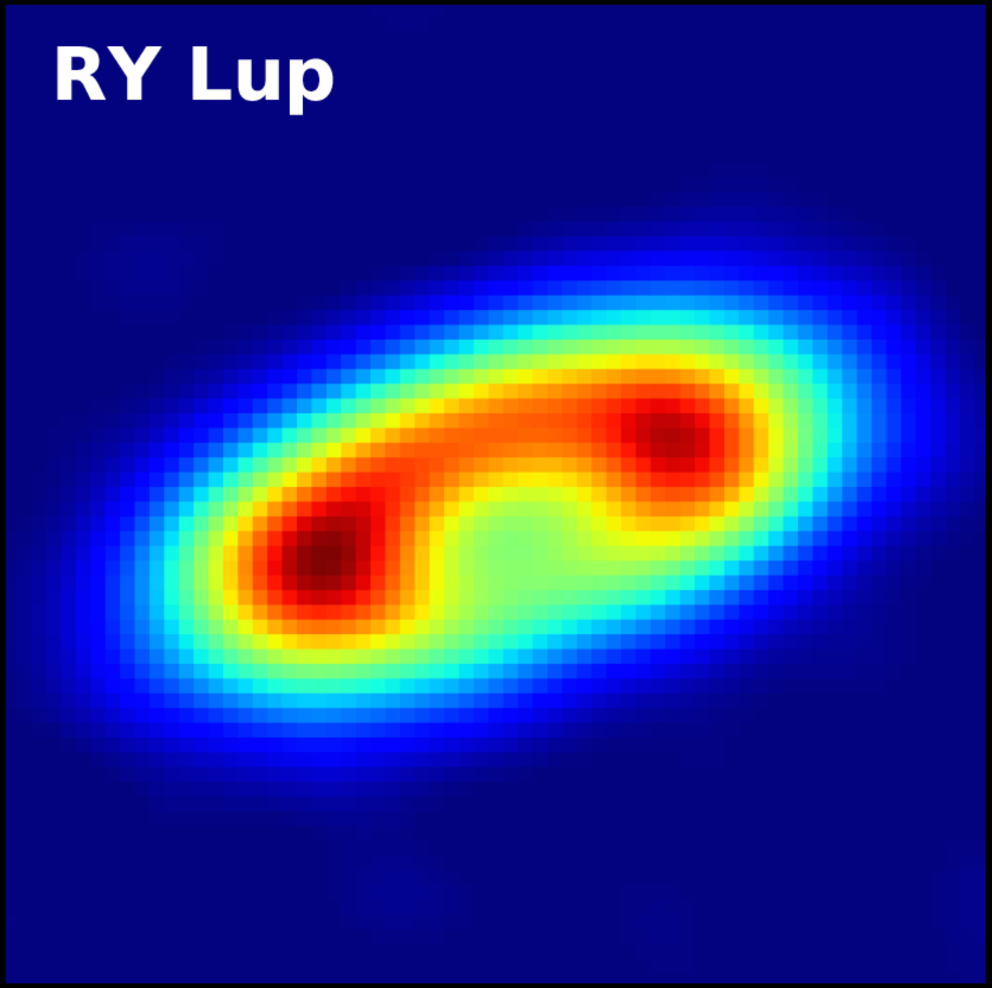


Accretion rates from Alcalá et al. 2017

...but the shapes of the radial flux distributions look quite different



Future Work:
Exploring link between inner and outer disks



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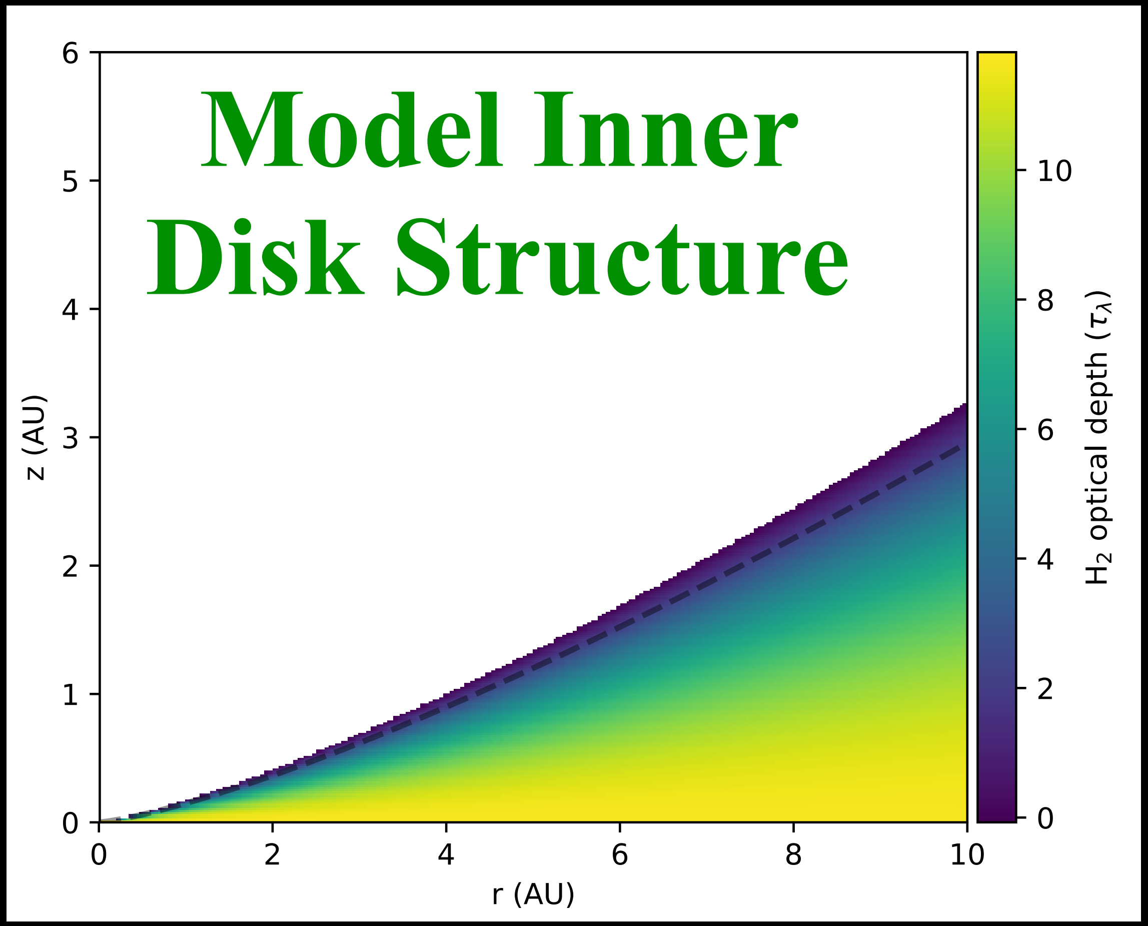

Also incorporating UV-CO radiative transfer models to strengthen our understanding of inner disk structure

Summary/Conclusions

- Emission from hot, fluorescent UV-H_2 in the inner disk is a tracer of radial structure.

- We can form a more complete picture of disk structure by combining UV-H_2 emission with other inner/outer disk tracers (see e.g. RY Lupi).

- Extending this analysis to a sample of "evolved" disks in the Lupus complex will allow us to start connecting the inner and outer disks.