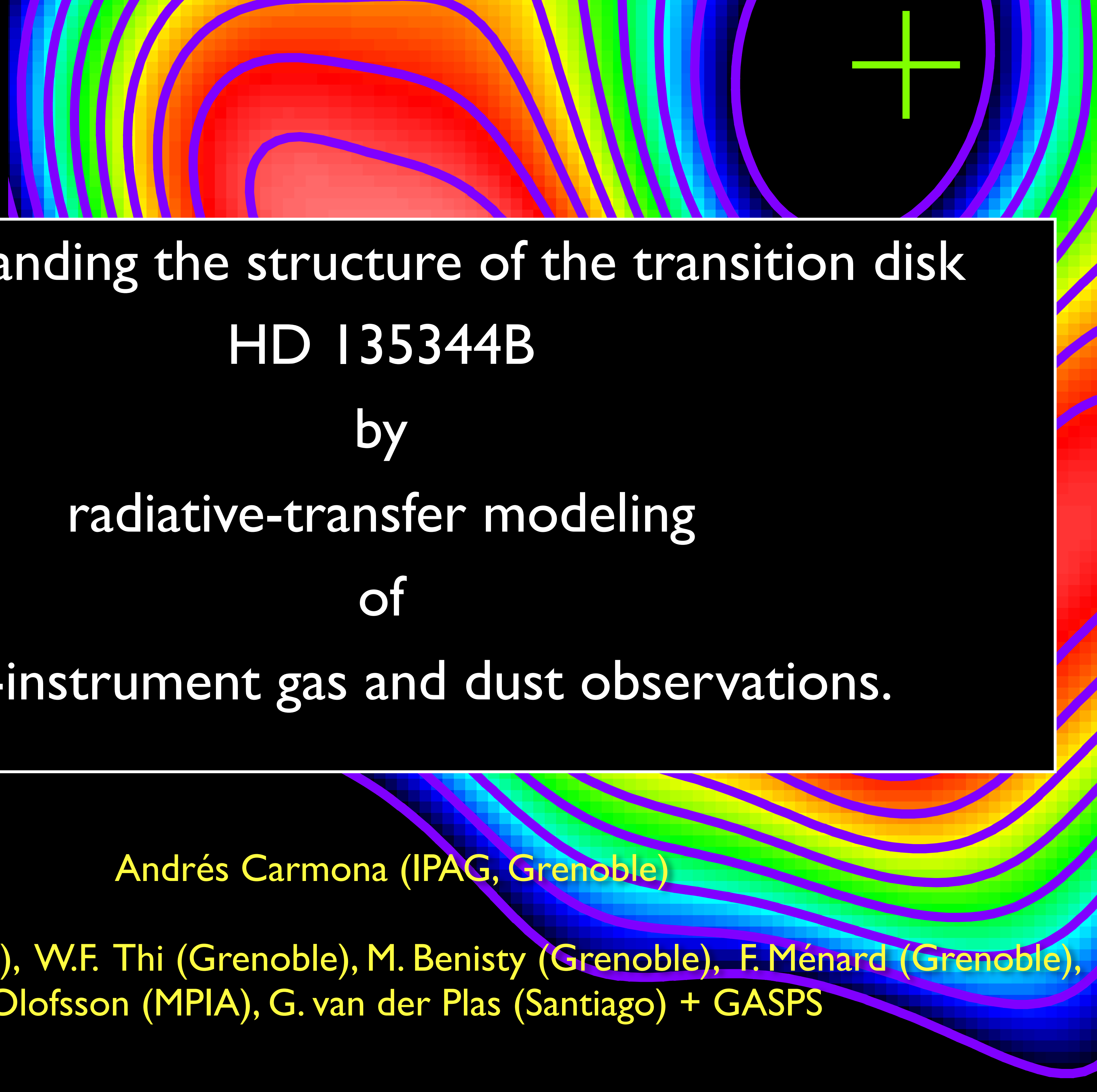
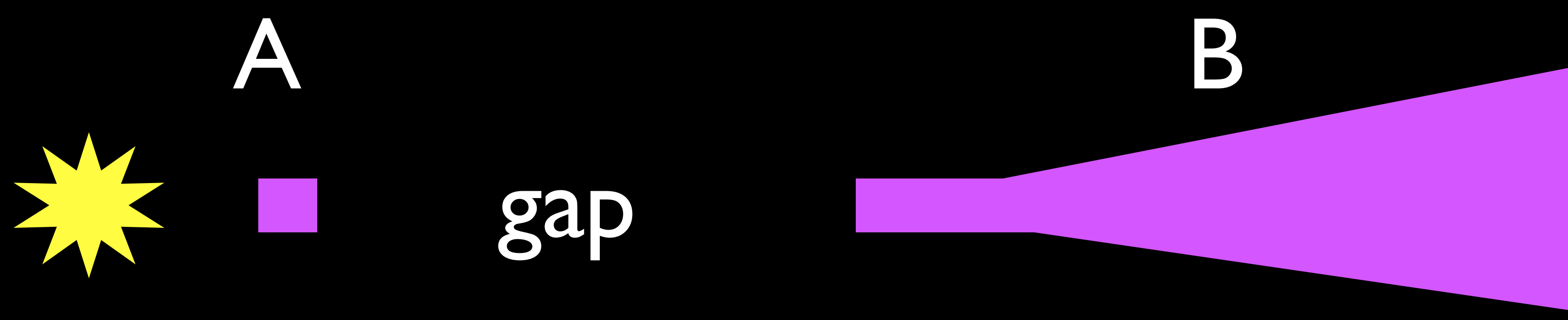


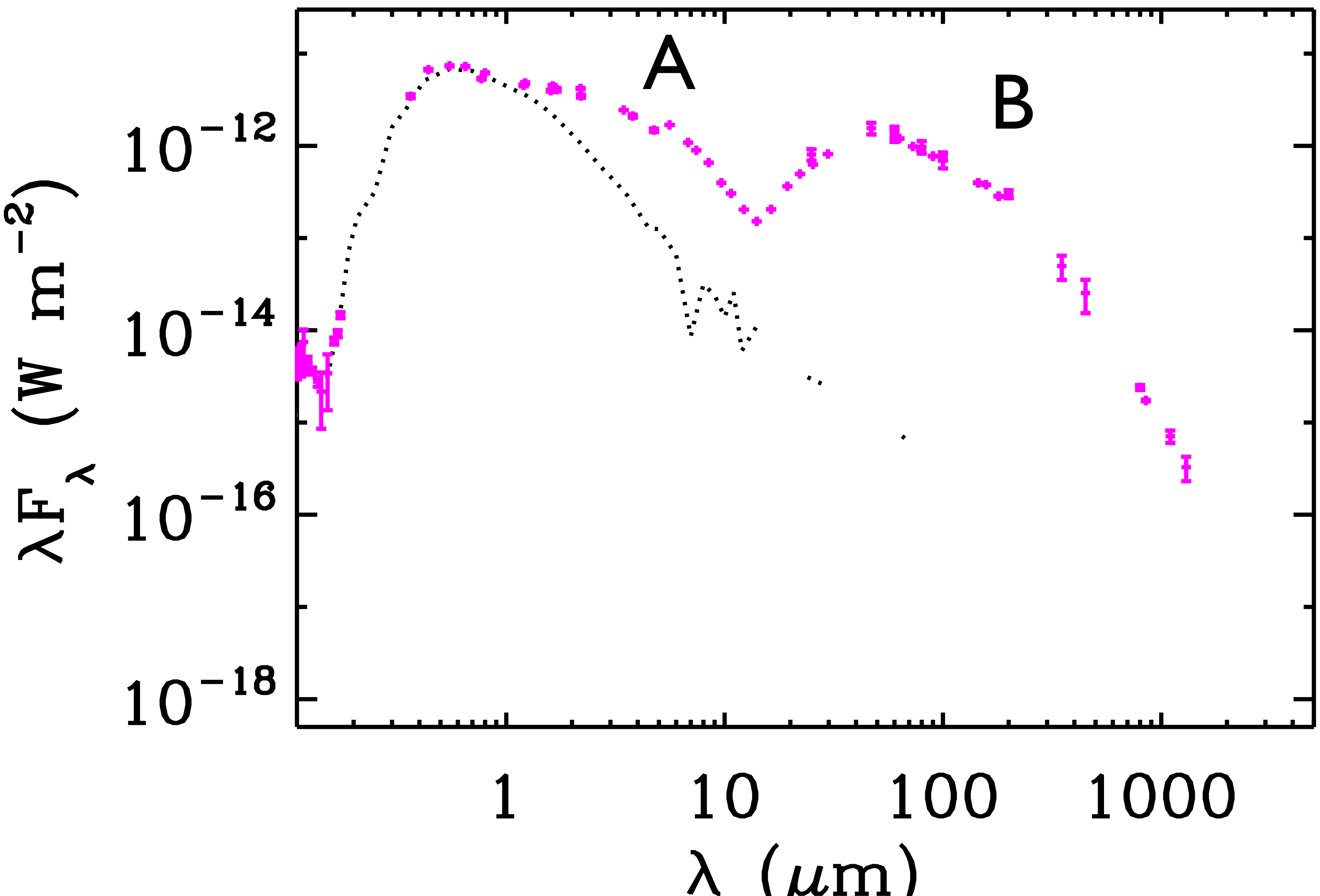
Understanding the structure of the transition disk HD 135344B by radiative-transfer modeling of multi-instrument gas and dust observations.

Andrés Carmona (IPAG, Grenoble)

C. Pinte (Grenoble), W.F. Thi (Grenoble), M. Benisty (Grenoble), F. Ménard (Grenoble), J. Olofsson (MPIA), G. van der Plas (Santiago) + GASPS

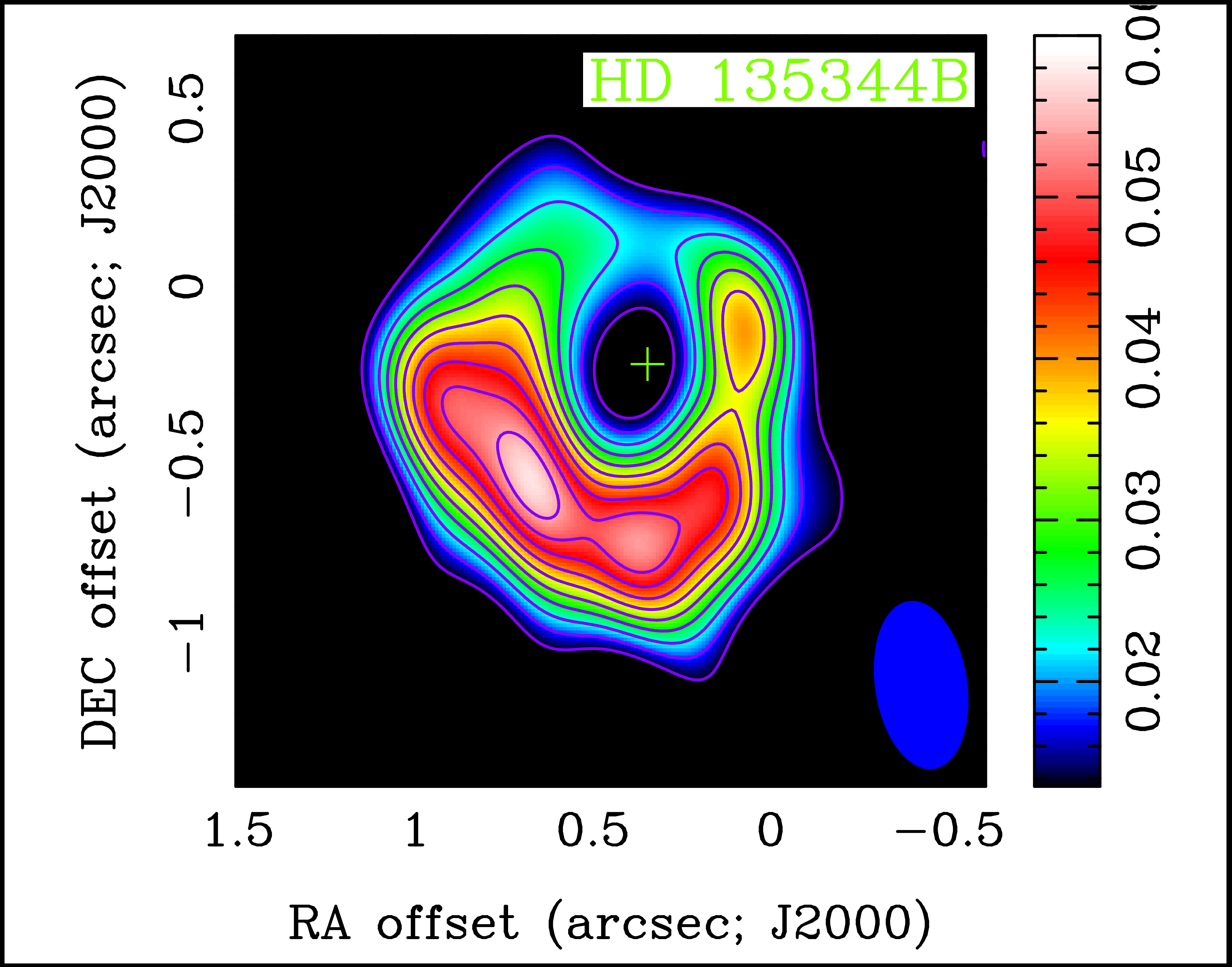


Transition Disk: Herbig F4Ve, 2 Msun, 140pc



Spatially resolved sub-mm observations

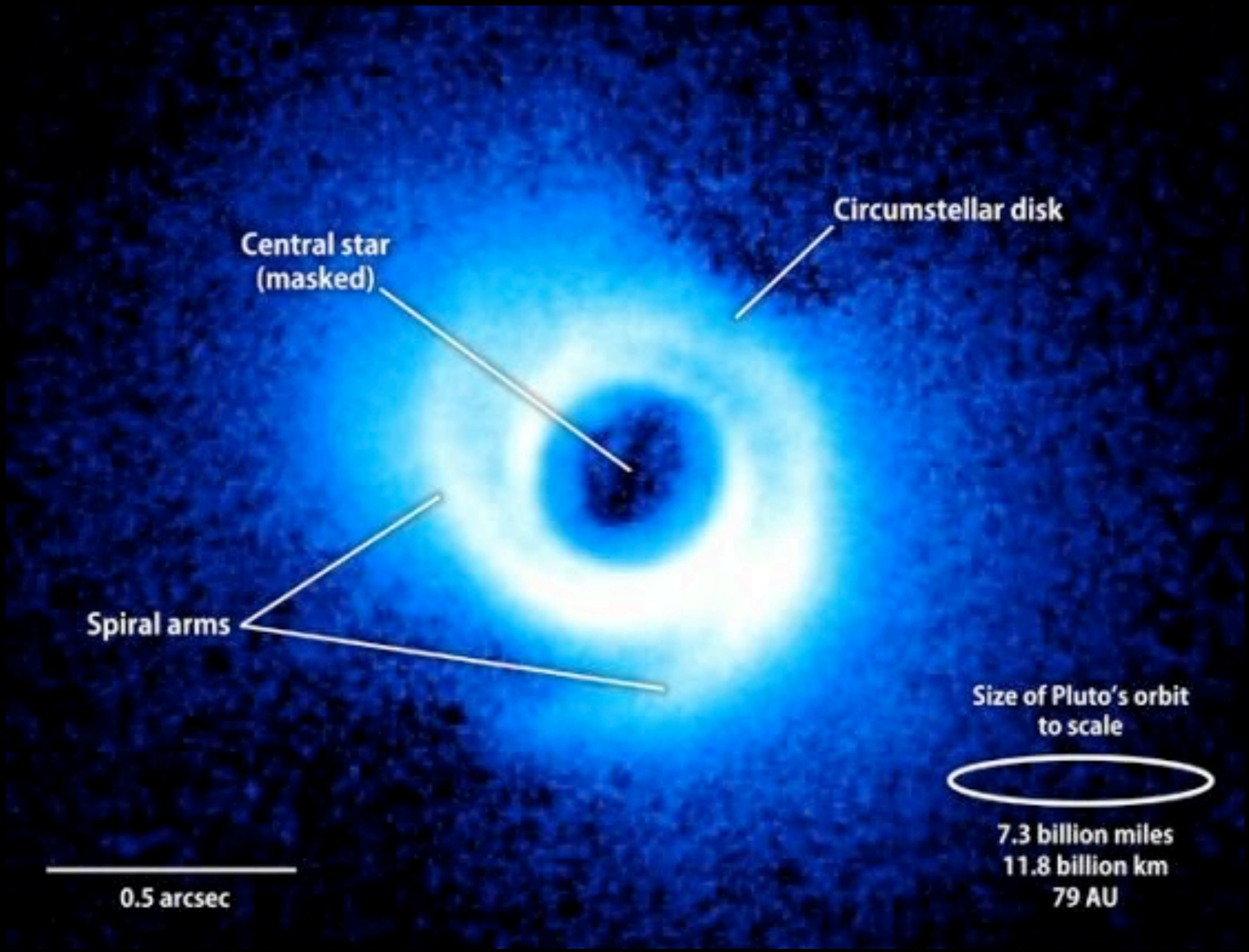
(cold dust)



Rin ~ 40 AU; i = 21°; Rdisk>120 AU; PA=55°

Brown et al. 2009; Andrews et al. (2011)

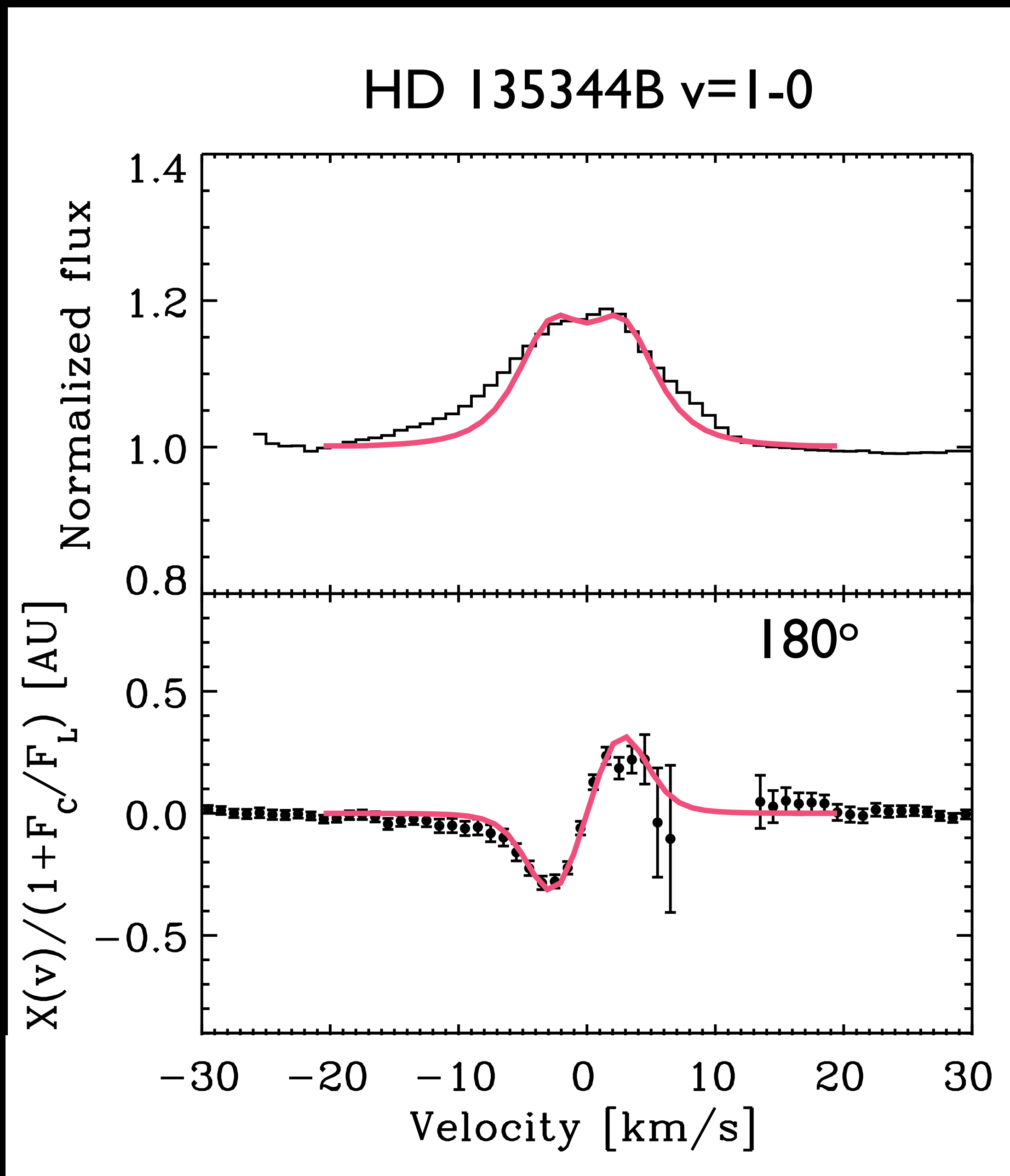
Scattered light imaging:
Spiral arms + Dust inside the Gap!!



Muto et al. 2012 (H-band)

scattered light **down to ~28 AU**

CO 4.7 micron spectro-astrometry
(Pontoppidan et al. 2008)



warm gas "inside the gap"

TABLE 2
BEST FIT MODEL PARAMETERS

Star	R_{in} [AU]	R_{out} [AU]	PA	i
HD 135344B $v = 1$-0	0.3±0.3	> 15	56±2°	14±4°[c]

Rout > 15 AU !!!

Observational Data Sets

Dust diagnostics

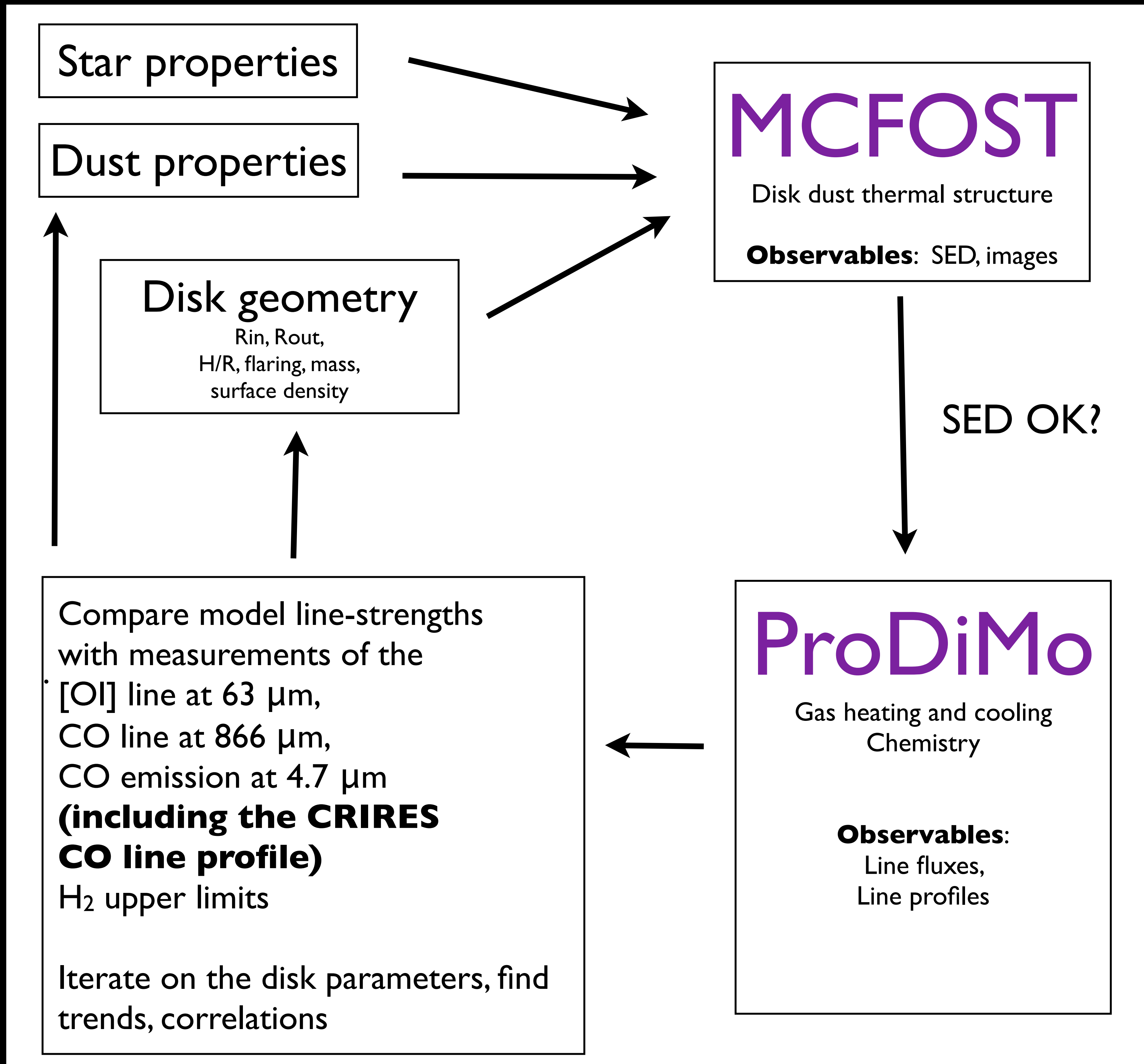
- Dust scattering imaging [1,2]
- Spitzer IRS spectrum [3]
  No silicate feature,
  weak 11.2 micron PAH
- mid-IR Q-band imaging [4]
- sub-mm interferometry [5]
- mm interferometry [6]
- near-IR interferometry from PIONIER [7]
- Herschel-PACS continuum [8]

Gas diagnostics

- H_2 near and mid-IR upper limits [9,10]
- Spectroastrometry of CO 4.7 μm emission [11]
- Herschel [OI] 63 μm emission [8]
- CO 866 μm emission [12]
- High res. spectra of the [OI] 6300 Å line [13]

References : [1] Muto et al. 2012; [2] Grady et al. (2009) ; [3] Brown et al. 2007; [4] Pantin et al. (in prep); [5] Brown et al. 2009; [6] Lyo et al. 2011; [7] Benisty et al. In prep; [8] Meeus et al. (in prep), [9,10] Carmona et al. 2008, 2011; [11] Pontopiddan et al. (2008); [12] Dent 2005; [13] van der Plas (2008);

Methodology



“free” parameters

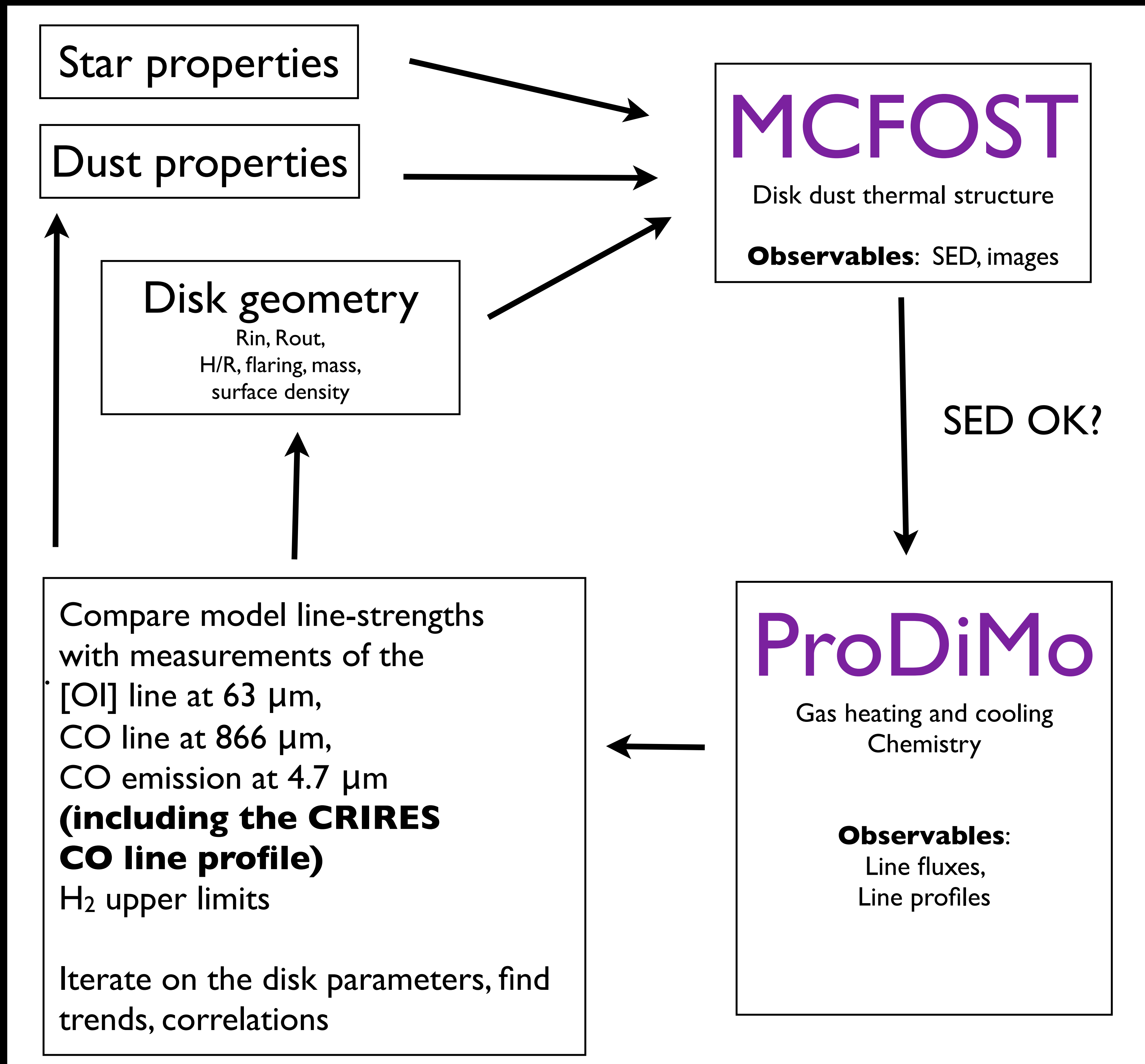
Geometry

Flaring exponent
Rin
Rout
edge
surface density exponent
H/R scale height

Dust Properties

Silicates (+ Carbon?)
amin
amax
exponent = -3.5 (?)
Heating: Rad. Eq. + LTE
PAH = Non. Rad. E
T < 1500 K

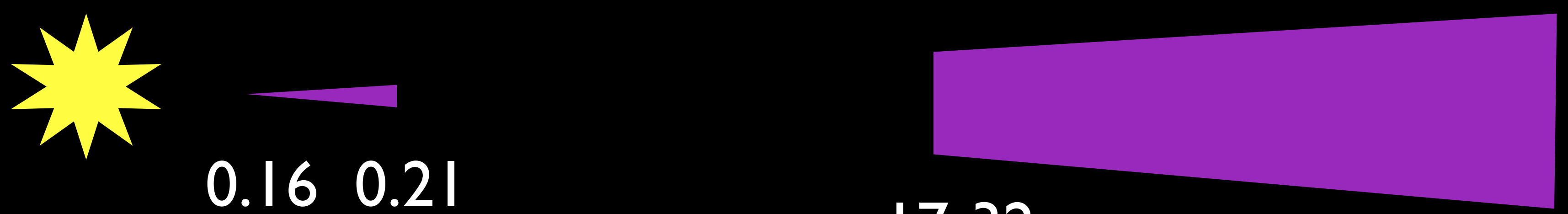
Methodology



Step 1

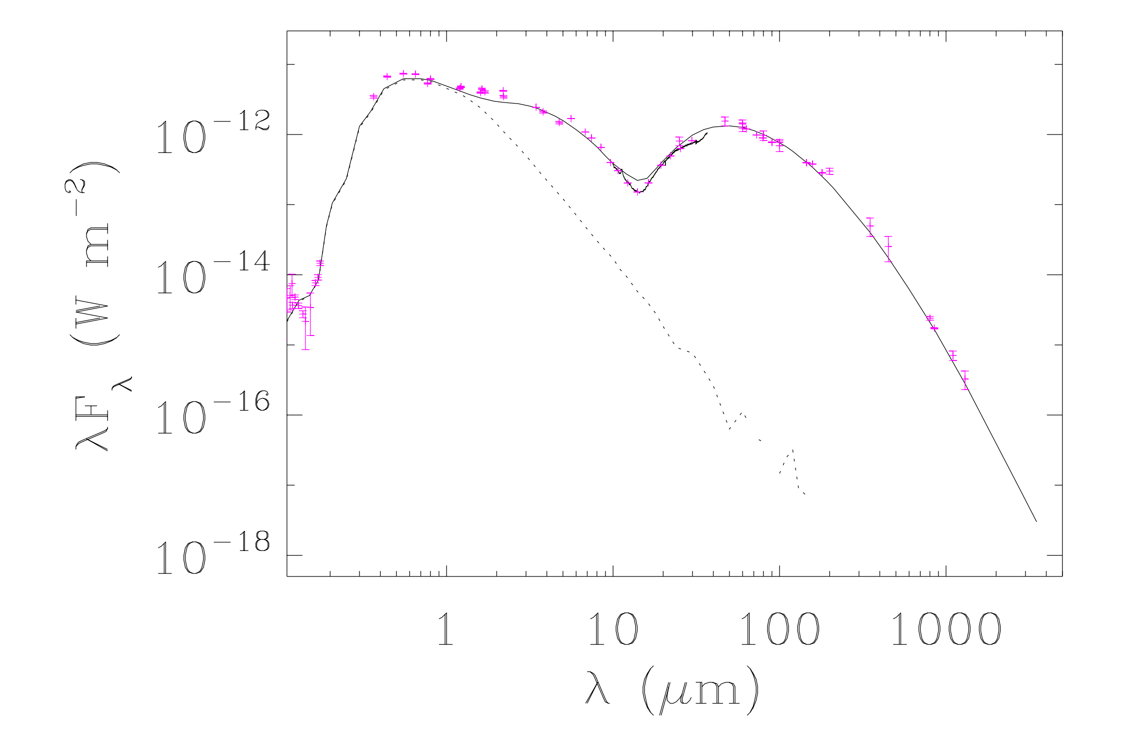
Assume only Silicates

Solution: Narrow Ring



	[OI] 63 μm (1)	CO J3-2 866 μm (2)	CO v =1-0 P(10) 4.7545 μm (3)	H_2 1-0S(1) 2.12 μm (4)	H_2 0-0S(1) 17.03 μm (5)
Observed	4.6E-17	1.2E-19	1.4E-17	<1.6E-17	< 1.0E-17
Model 46	5.7E-17	1.7E-19	4.7E-17	9.0E-20	7.7E-19

Line Fluxes OK

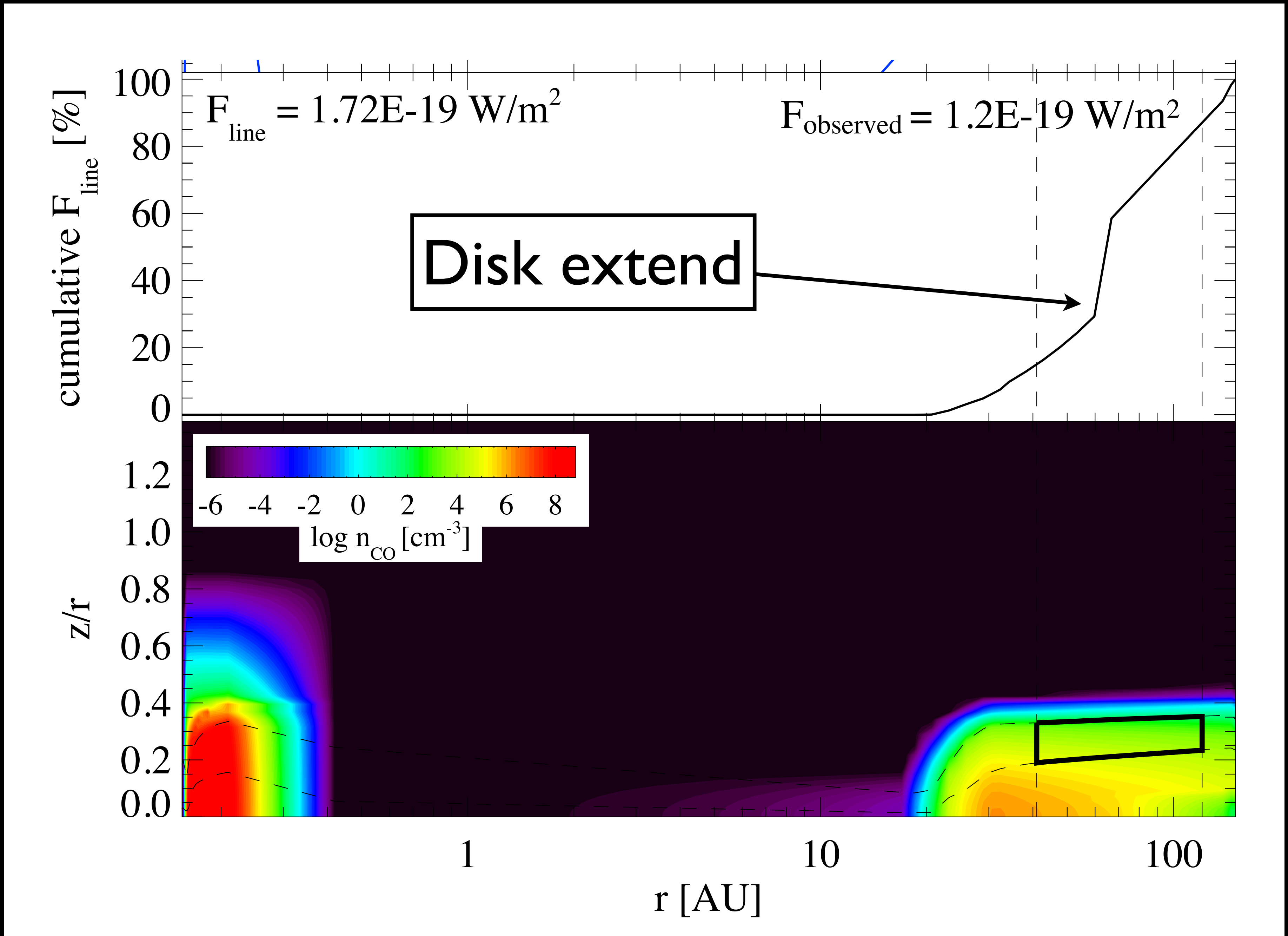


SED OK:

- Large silicates >10 µm
- Large PAH (NC > 100)

Cold gas

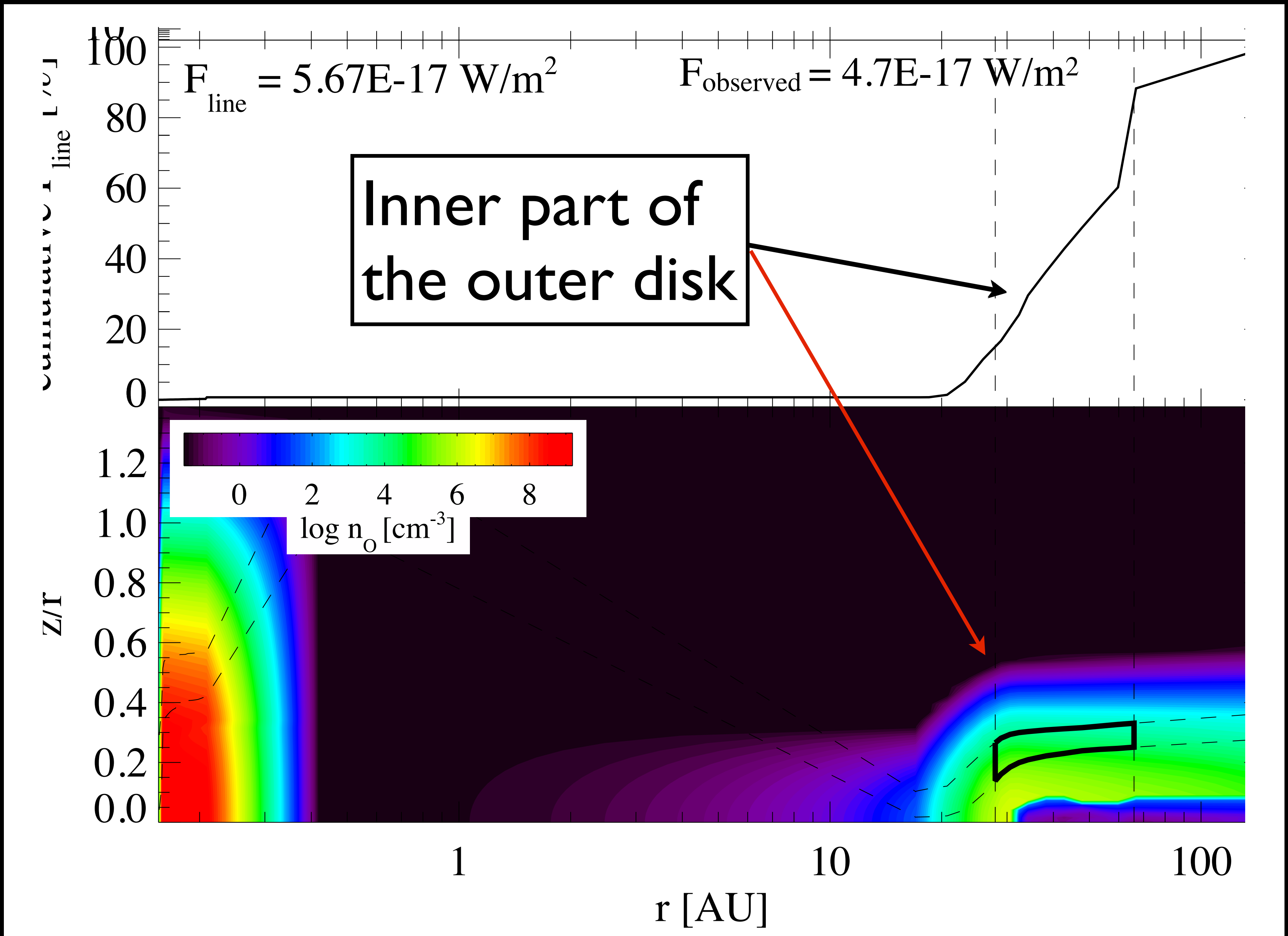
CO 866 µm



Op. thick emission: larger disk → higher CO 3-2 fluxes

Surface Density → Rout constraint

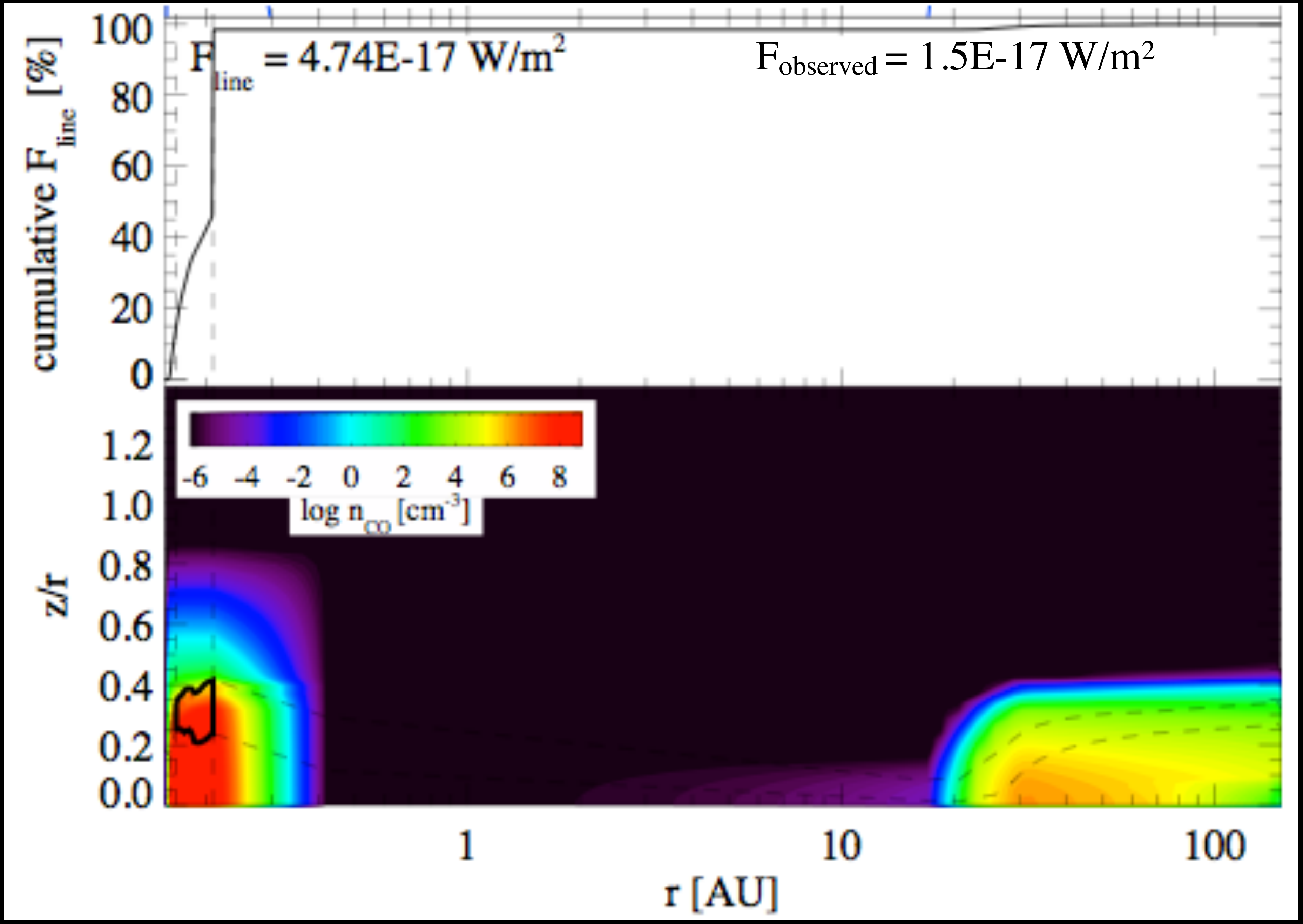
[OI] 63.18 µm



higher inner disk scale height → lower [OI] fluxes

larger PAH size → lower [OI] fluxes

CO 4.7 μm

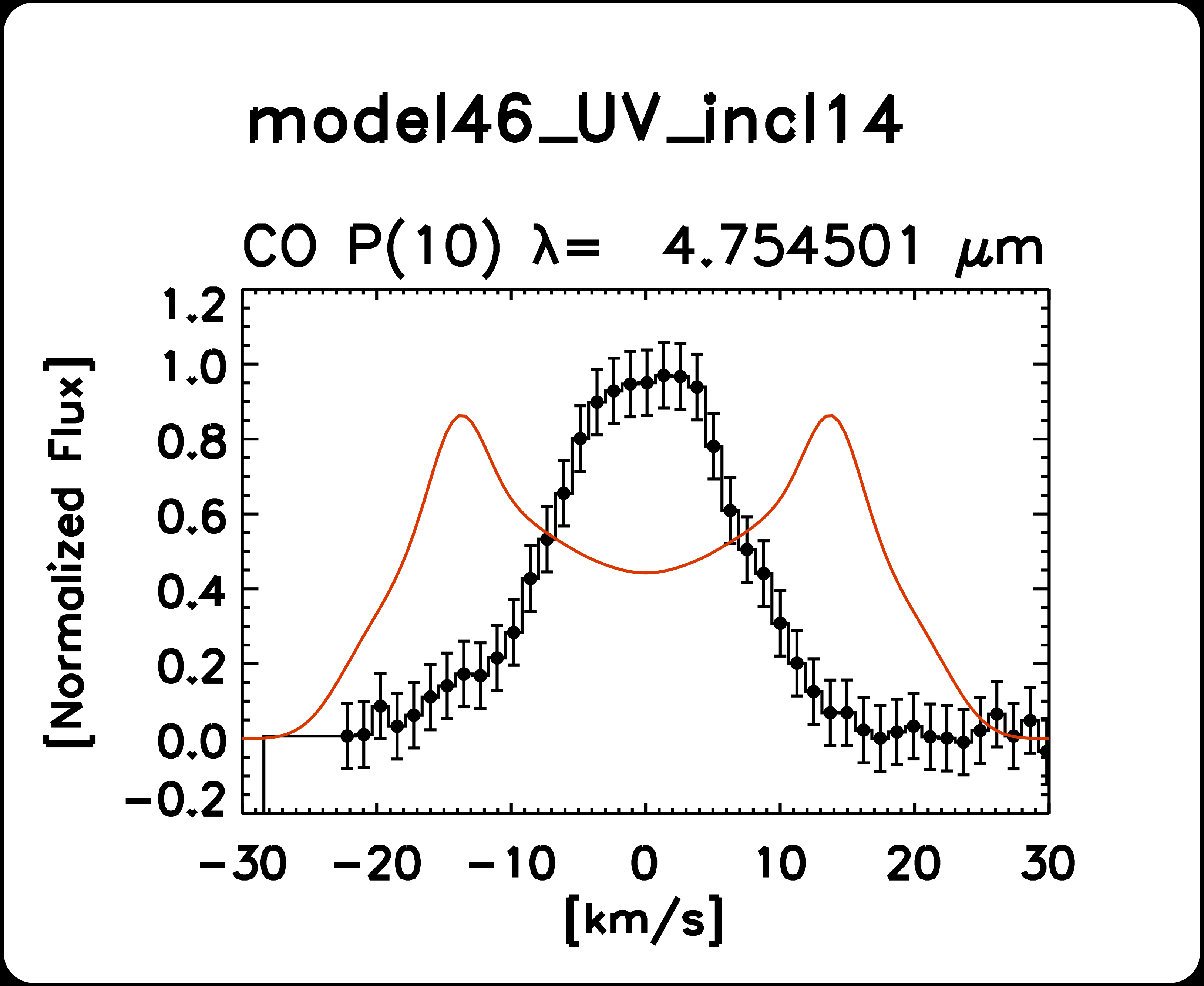


★ The CO 4.7 μm emission is produced in the inner disk at a fraction of AU.

Crucial parameters

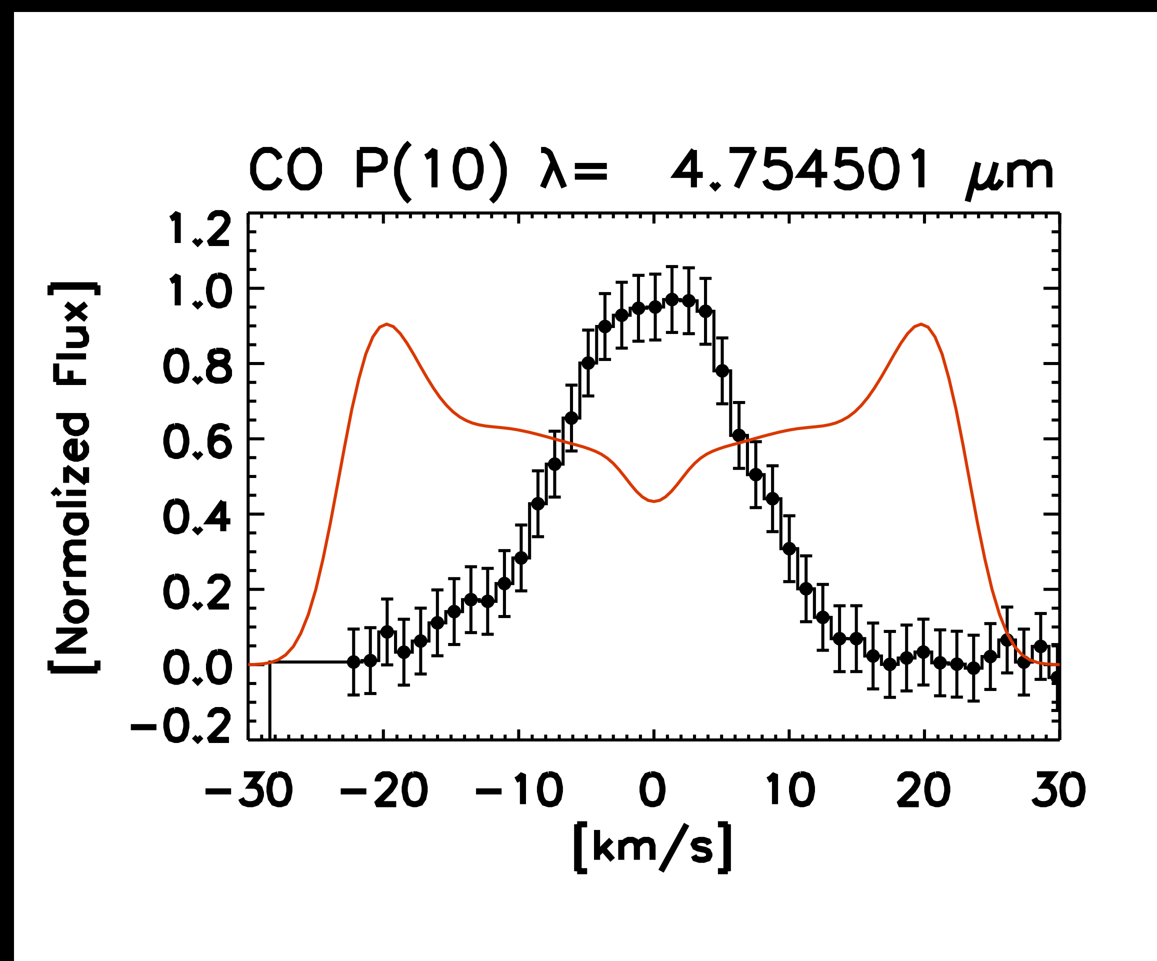
edge of the inner disk

extend of the inner disk



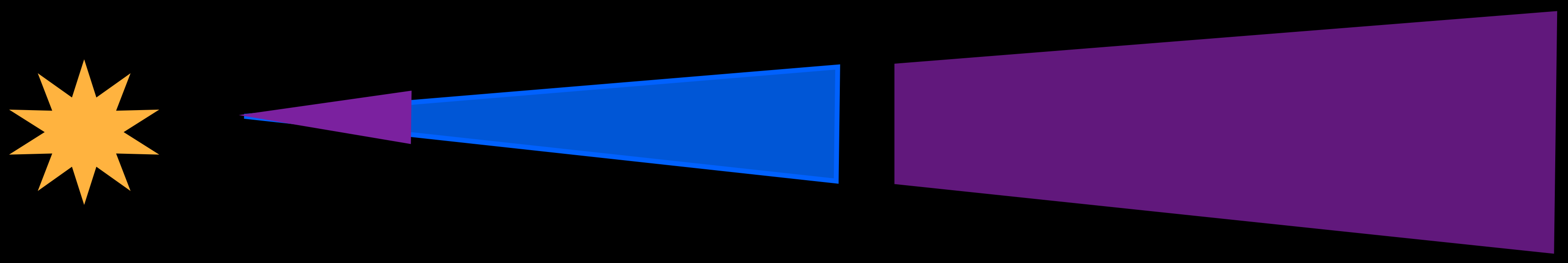
Naturally the expected CO 4.7 micron line profile does not fit !

A flat disk

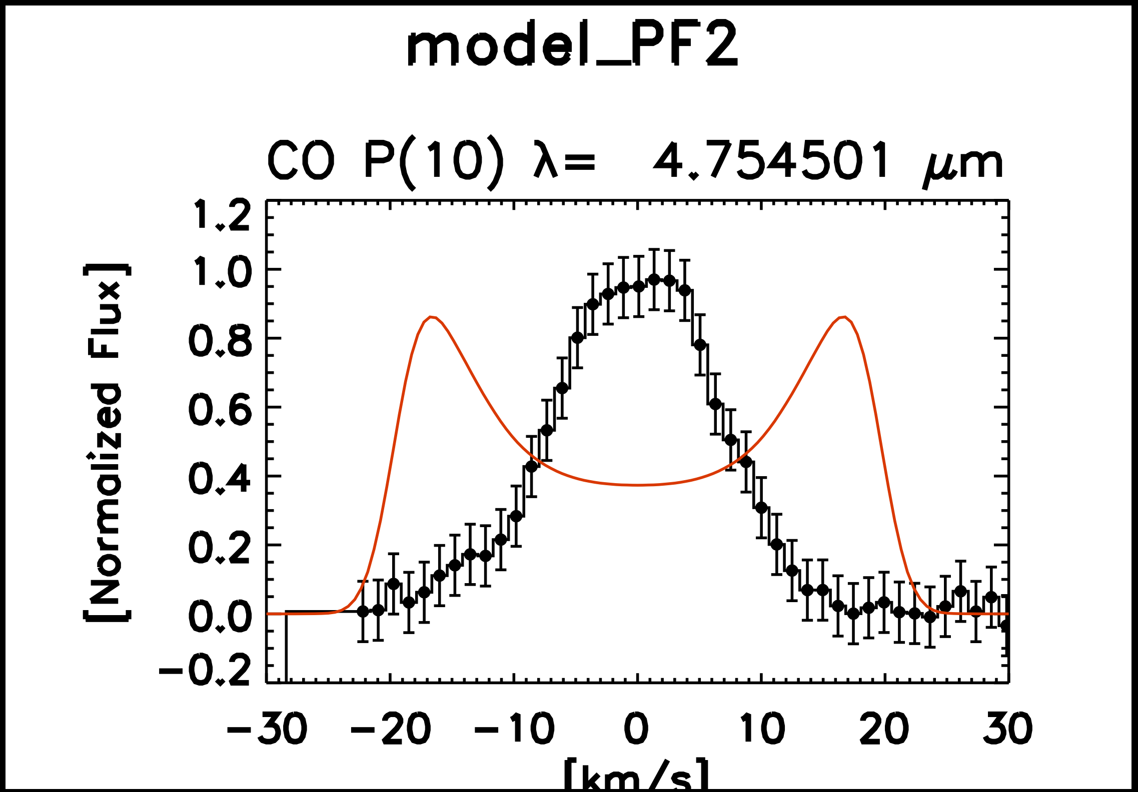


Does not work the inner ring gets most of the radiation and dominates the emission

Flaring Disk?

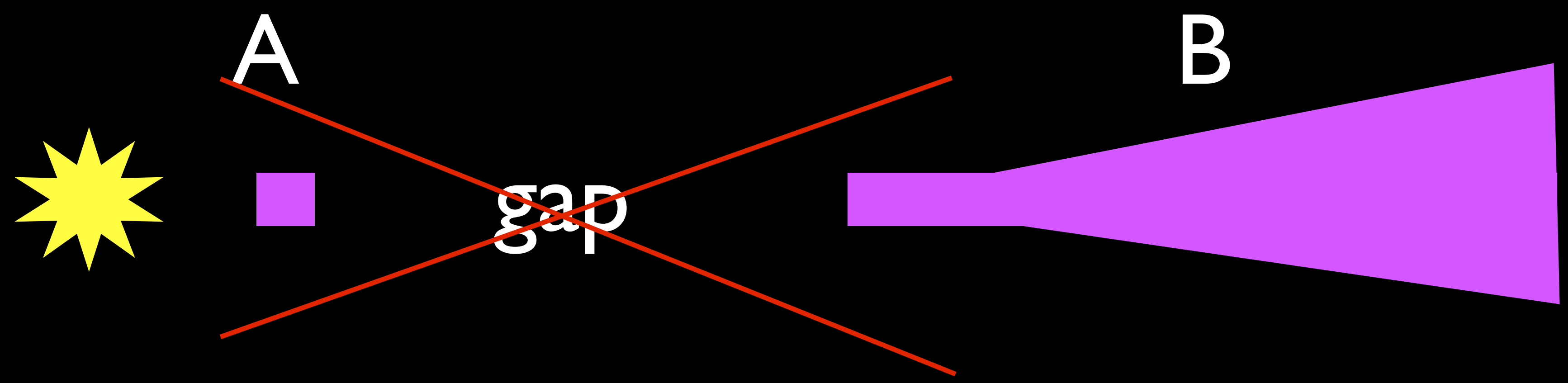


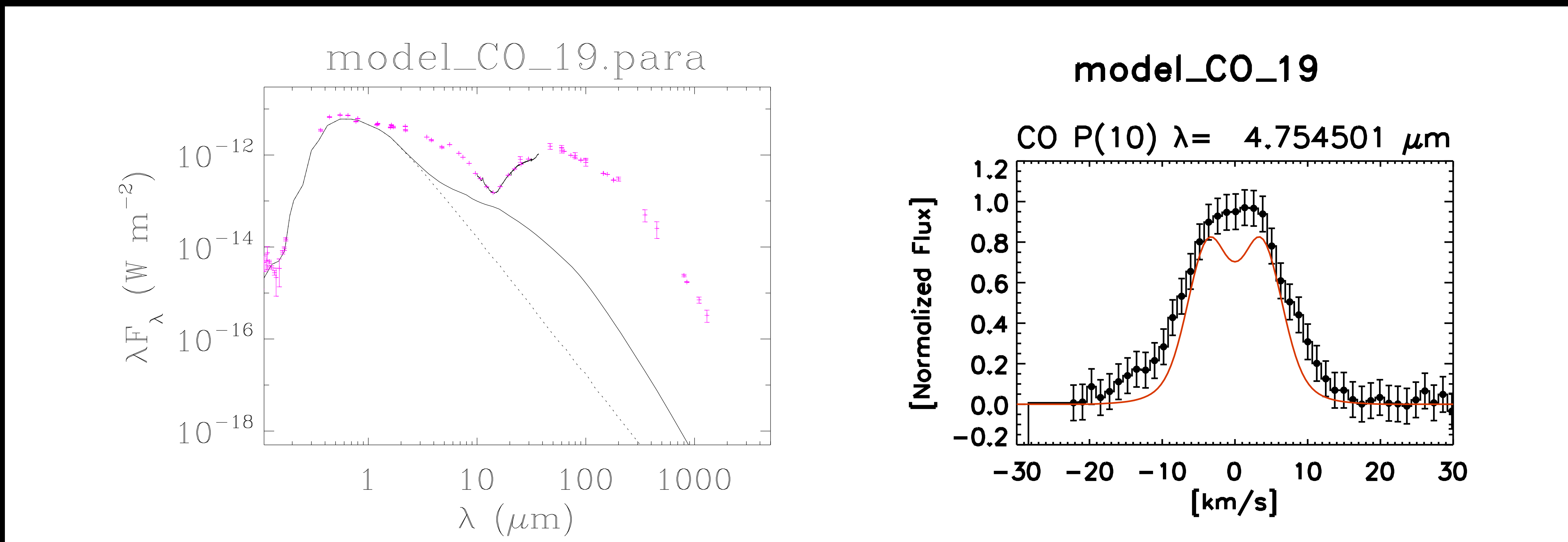
does not
work neither



The Wall is the problem!

if we want to describe the CO 4.7 micron emission
this model needs to be abandon





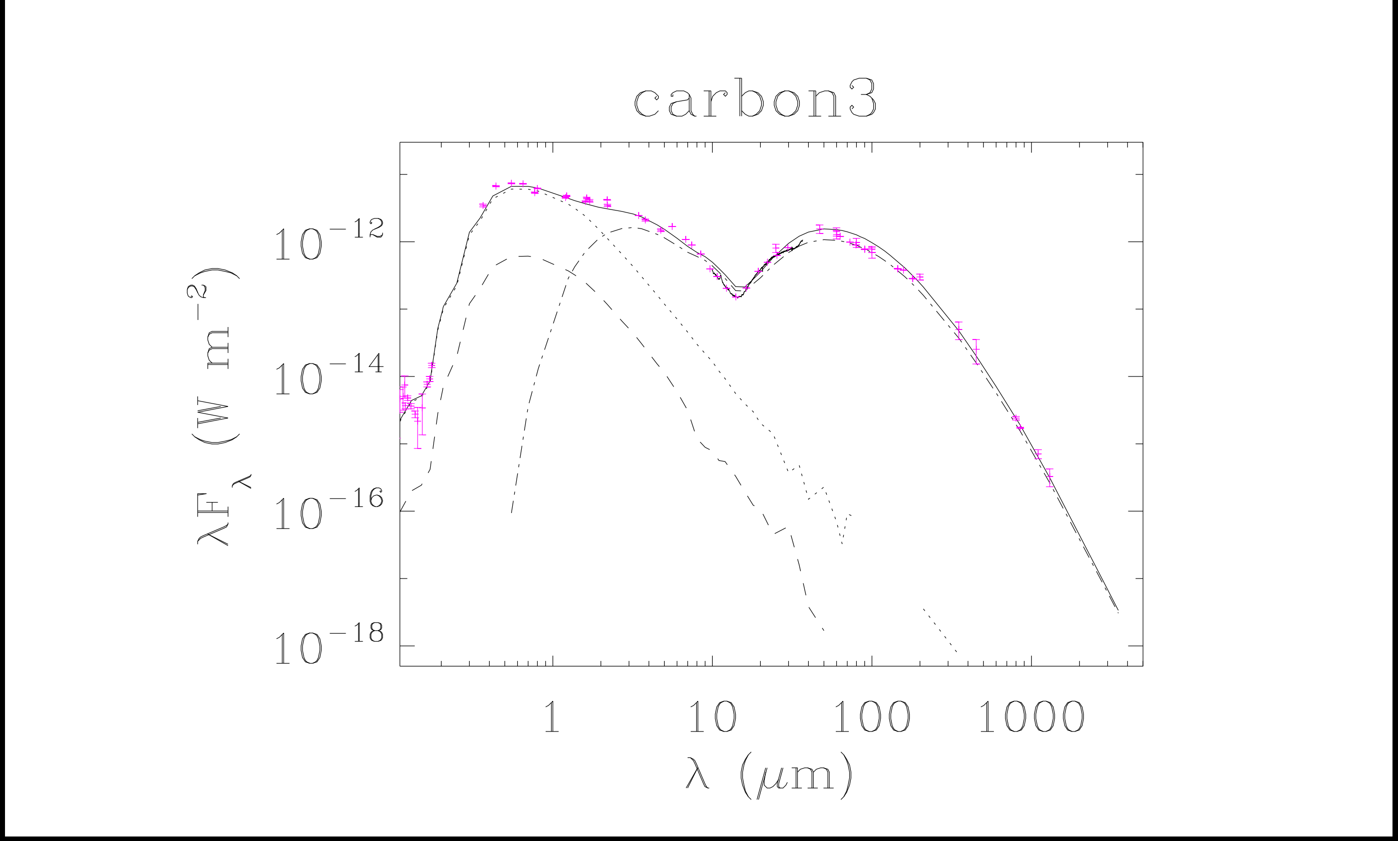
a disk with dust 100% silicates does not make it
(we tried settling does not help neither)

Step II
Add Carbon to the Mix

Idea 1:
Uniform Mixture Carbon + Silicates

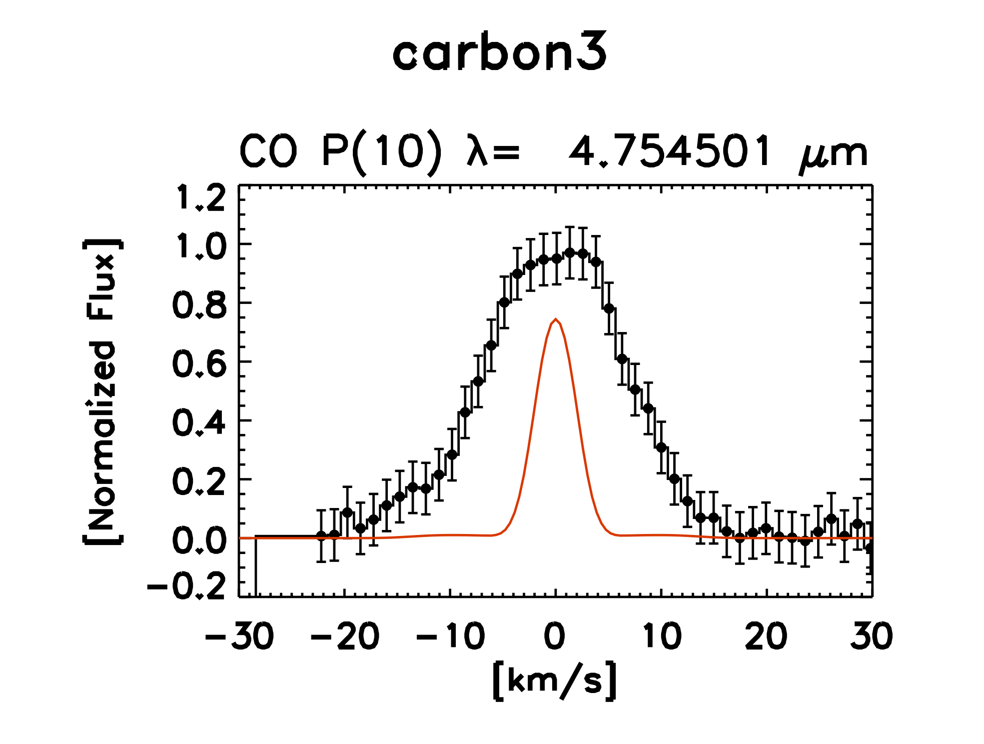
0.18 < R < 20 AU

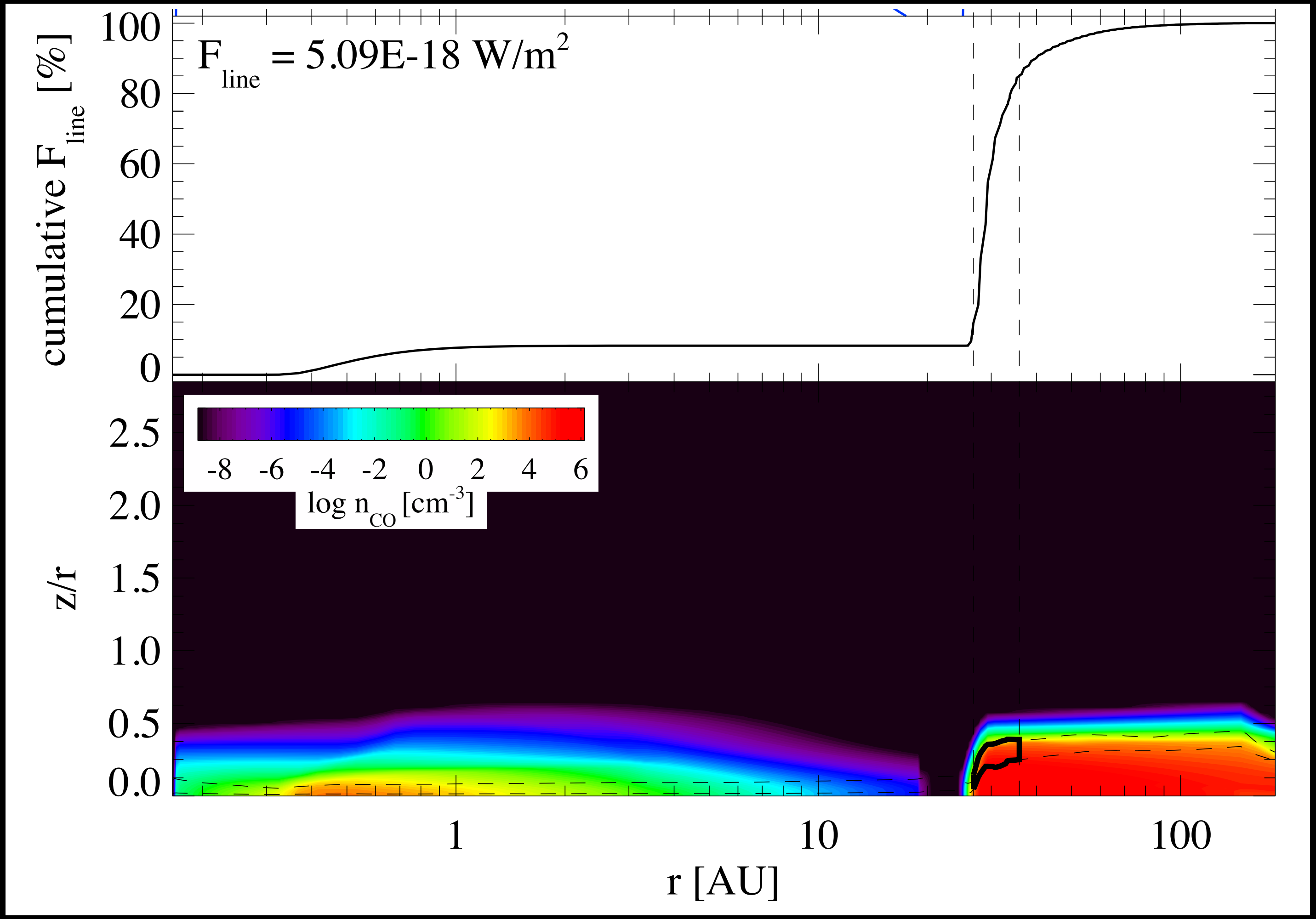
inner disk:
25% carbon
75% silicate
(dust: $2X10^{-10}$ Msun)



25 % Carbon : Emission from the outer disk

0.18 < R < 20 AU



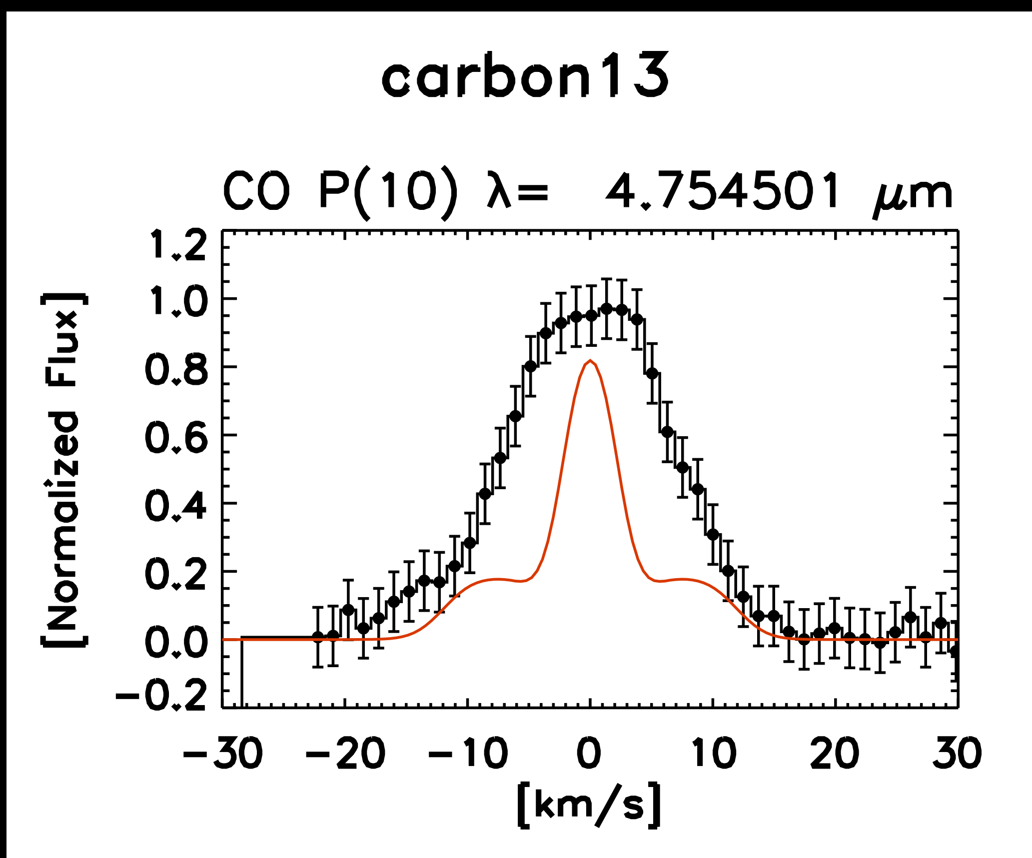


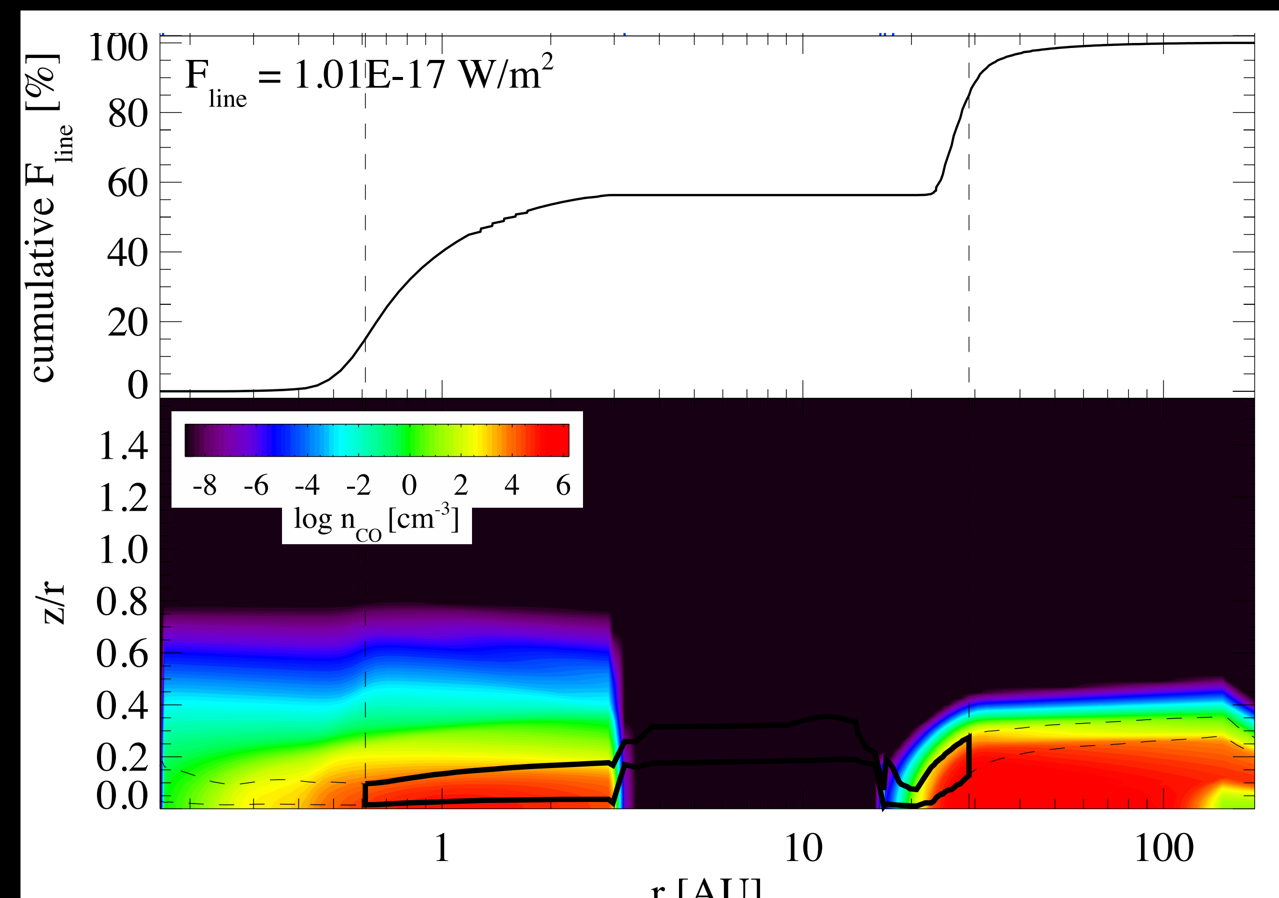
	[OI] 63 μm (1)	CO J3-2 866 μm (2)	CO v =1-0 P(10) 4.7545 μm (3)	H_2 1-0S(1) 2.12 μm (4)	H_2 0-0S(1) 17.03μm (5)
Observed	4.6E-17	1.2E-19	1.5E-17	<1.6E-17	< 1.0E-17
carbon3	7.0E-17	1.7E-19	5.1E-18	2.5E-19	4.3E-19

Too faint !

5% carbon

8×10^{-10} Msun

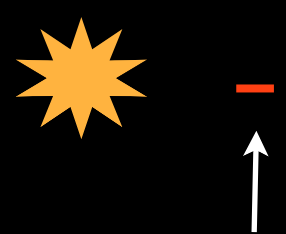




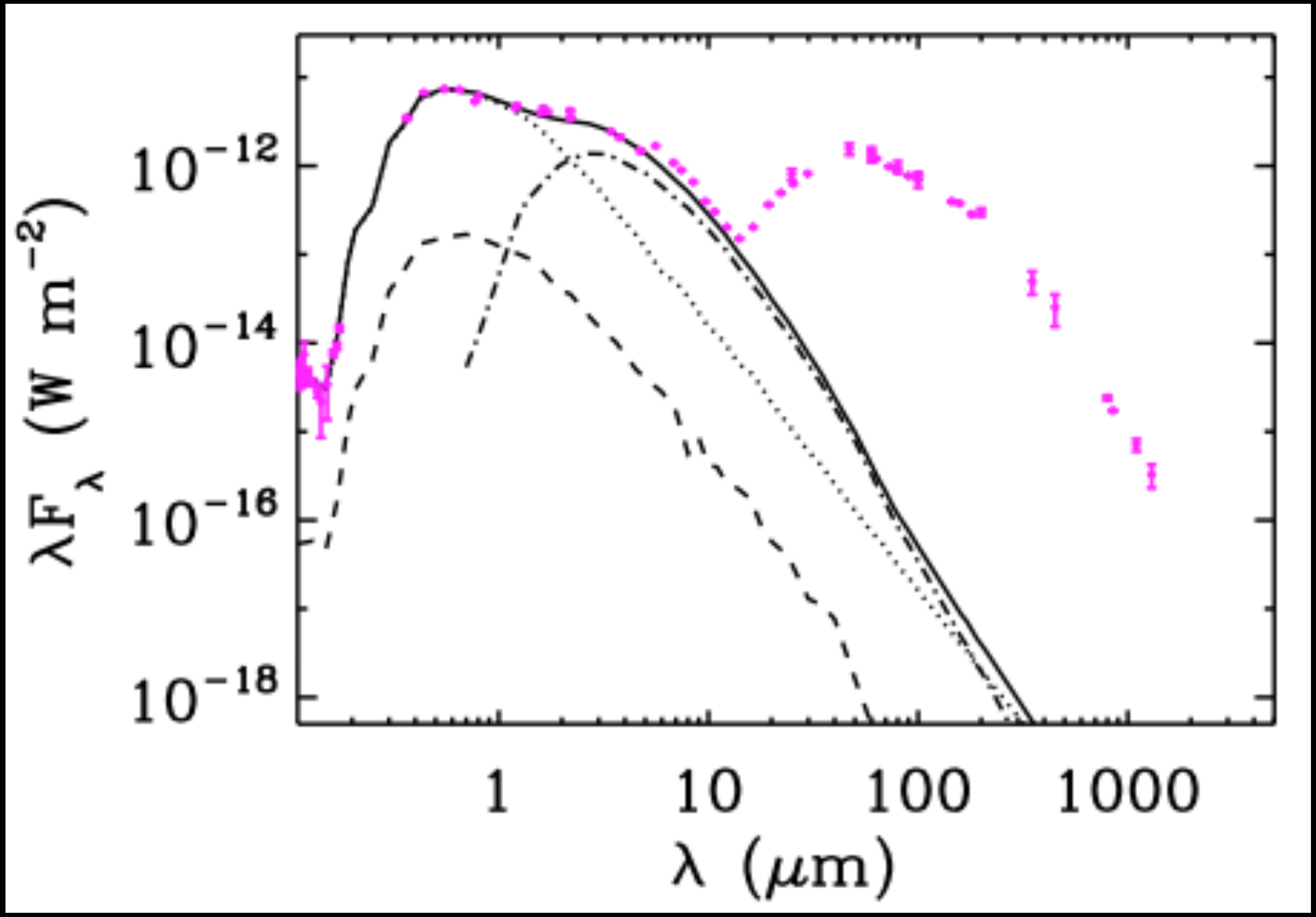
Less extended carbon allows for larger masses

	[OI] 63 μm (1)	CO J3-2 866 μm (2)	CO ν =1-0 P(10) 4.7545 μm (3)
Observed	4.6E-17	1.2E-19	1.5E-17
model carbon 13	9.2E-17	1.8E-19	1.0E-17

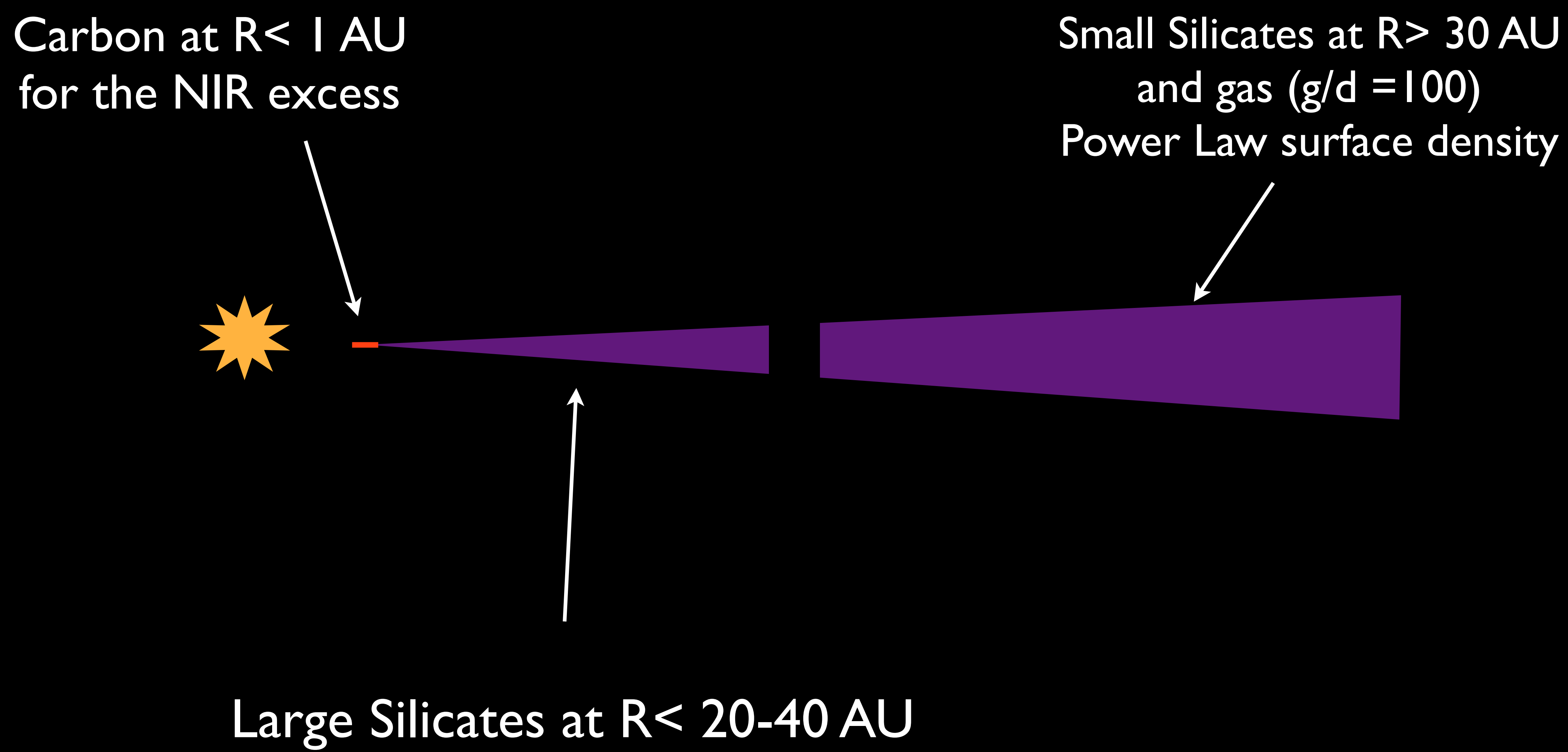
near-IR emission:
dominated by the carbon dust emission in the inner disk
we have large freedom choosing the dust in the
extended inner disk

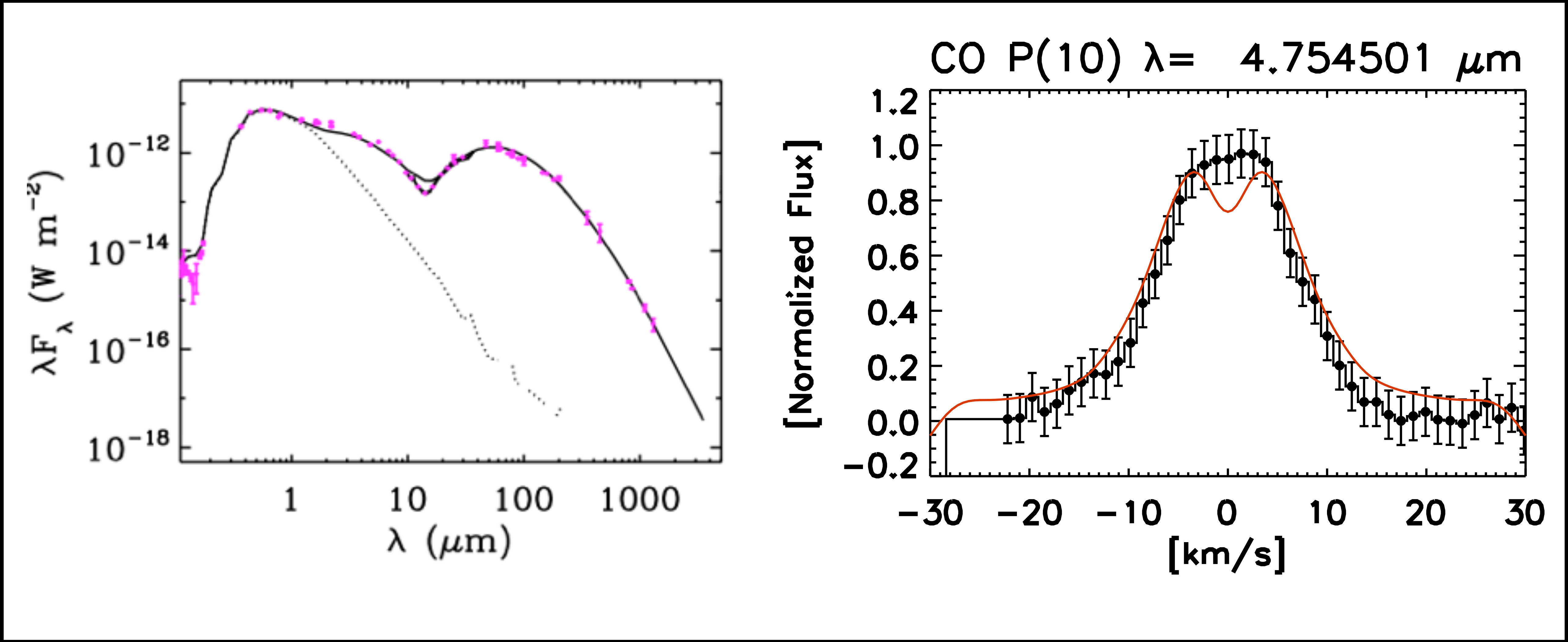


6×10^{-12} Msun
0.2-0.25 AU



Idea II
Just put the Carbon in the inner-most disk



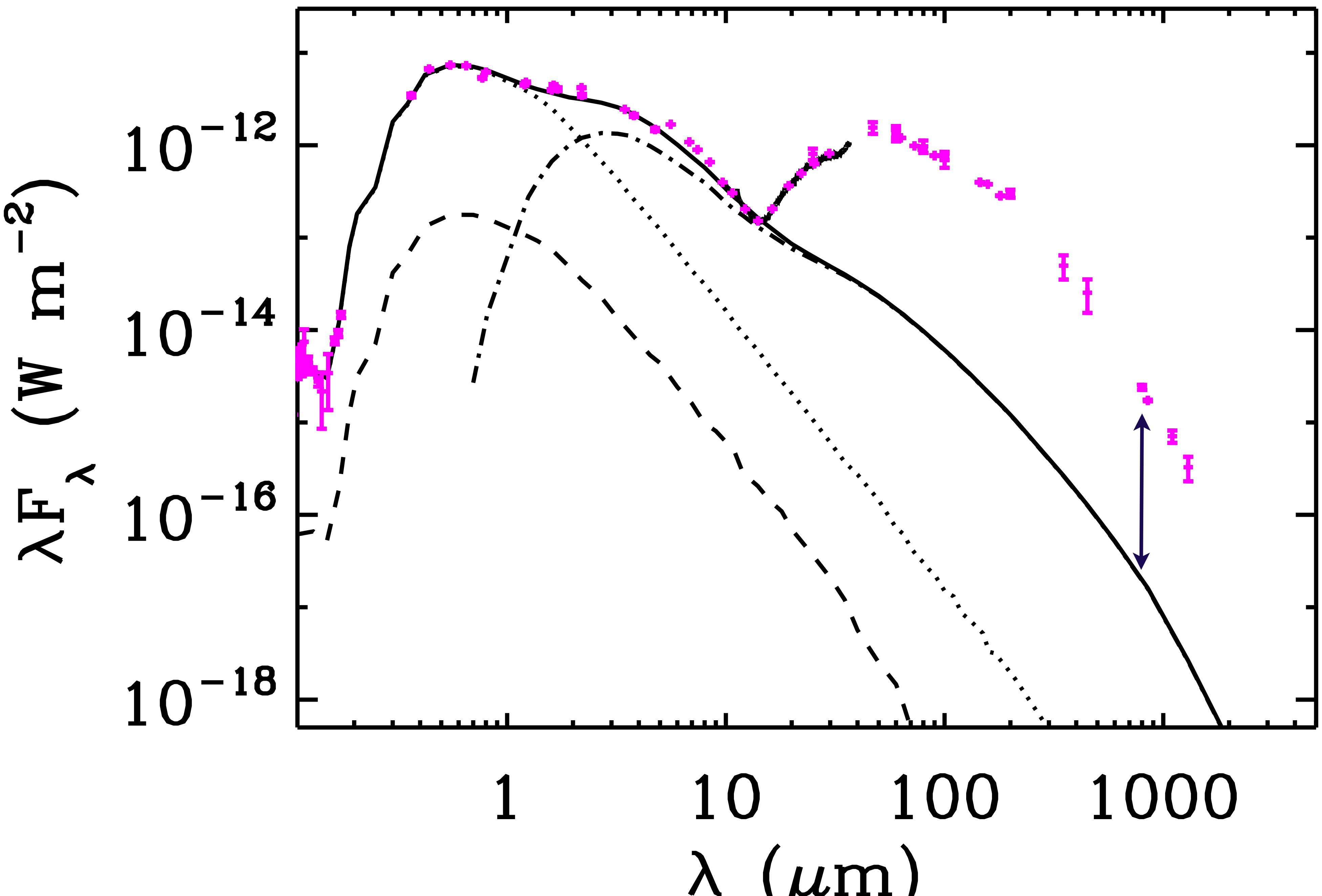


it works !

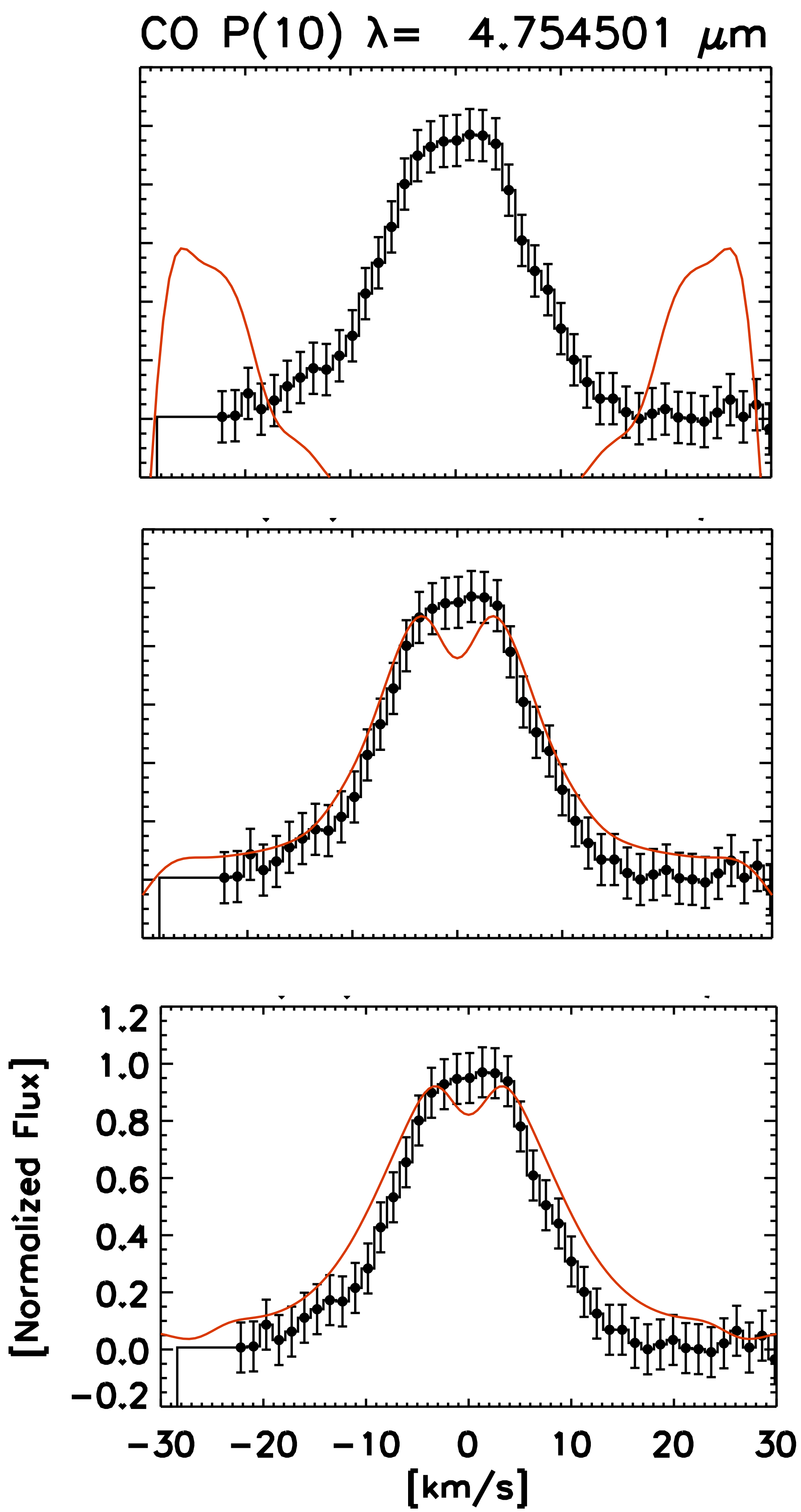
I. Gas surface density must be flat

Do you fit the sub-mm images?

Not an issue, emission of the inner disk is below SMA sensitivity



0.2 < R < 25 AU



Dust 0.01 - 10 micron
g/d =10000
flux too low

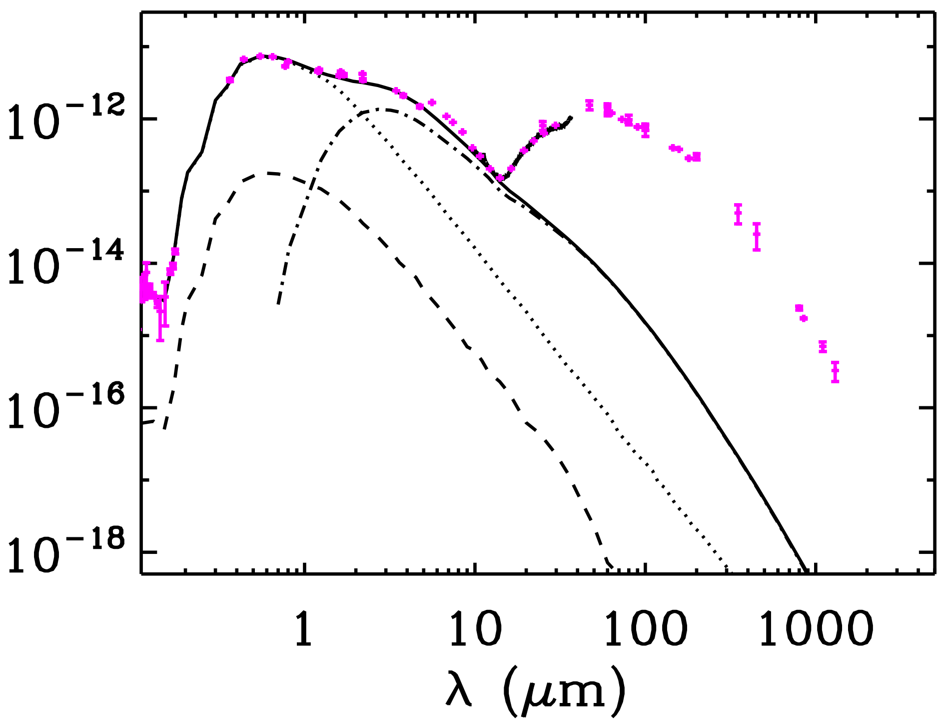
Dust 10 - 1000 micron
g/d =1000 flux OK

Dust 100 - 1000 micron
g/d =100 flux OK

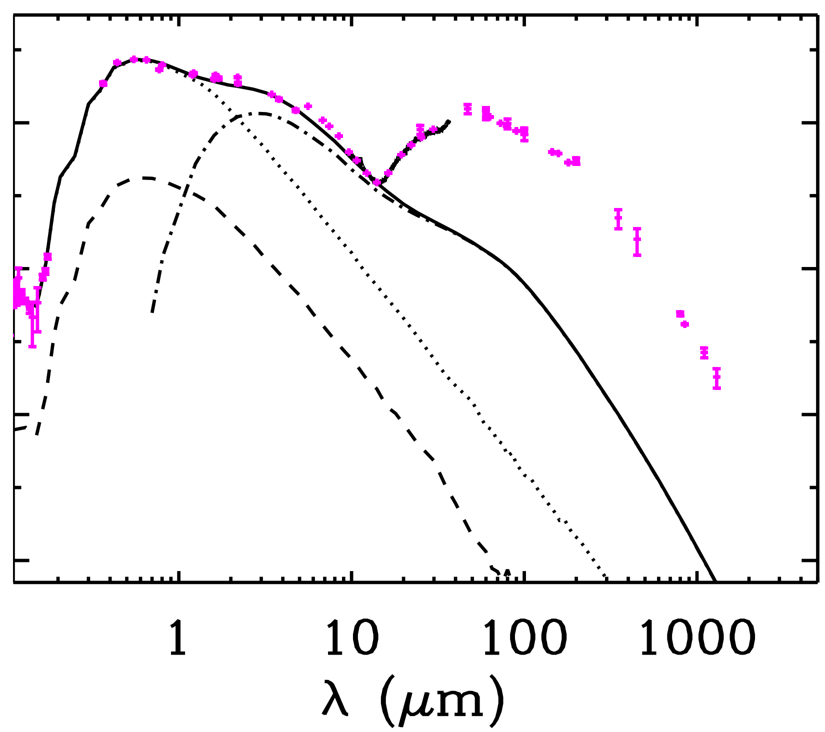
degeneracy Dust Size, g/d, disk size

How we will know? Spatially resolved observations: ALMA + EVLA

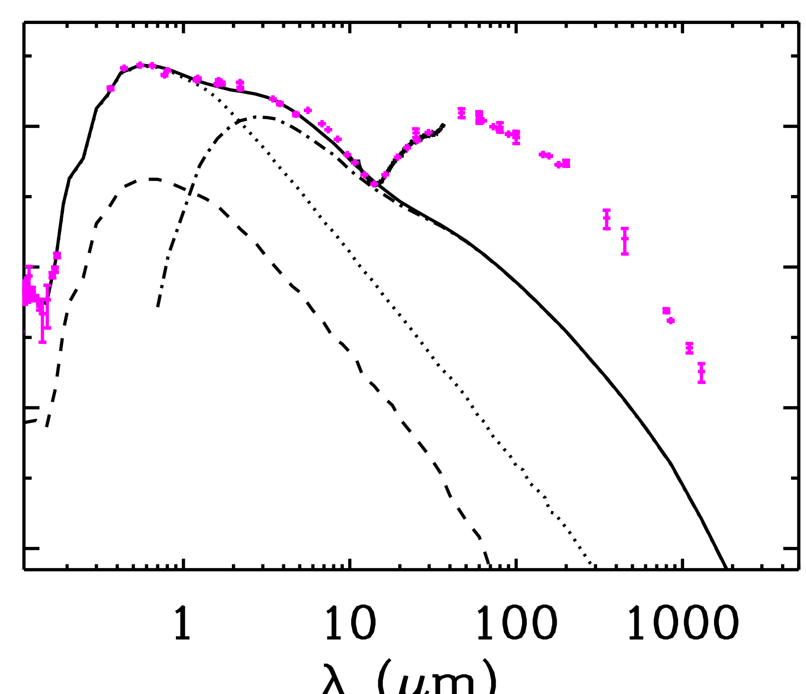
1 - 1000



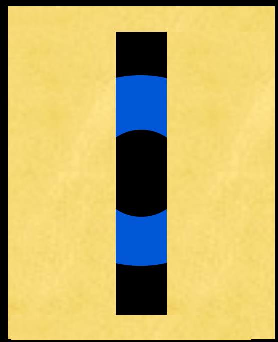
10 - 1000



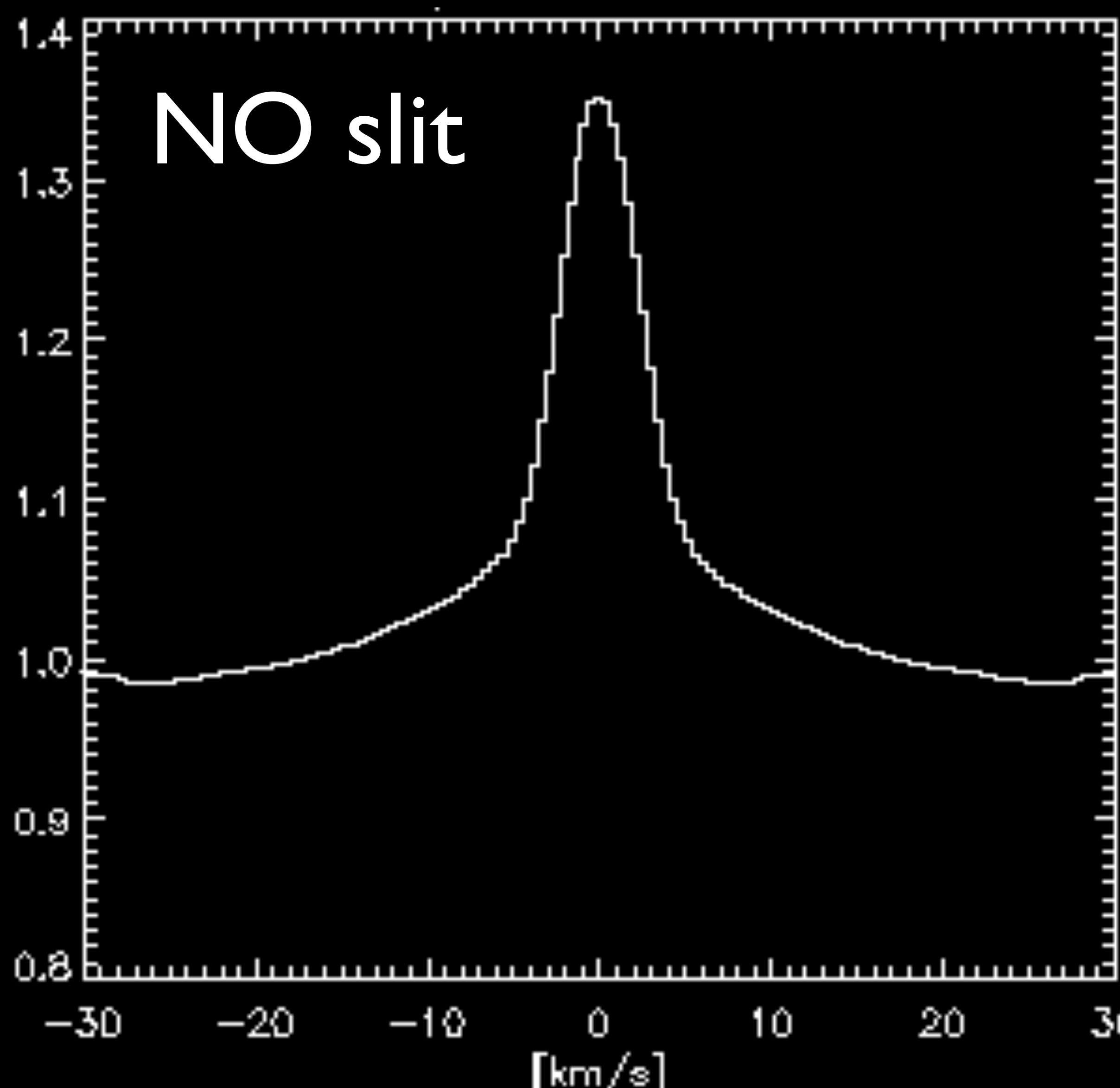
100 - 1000

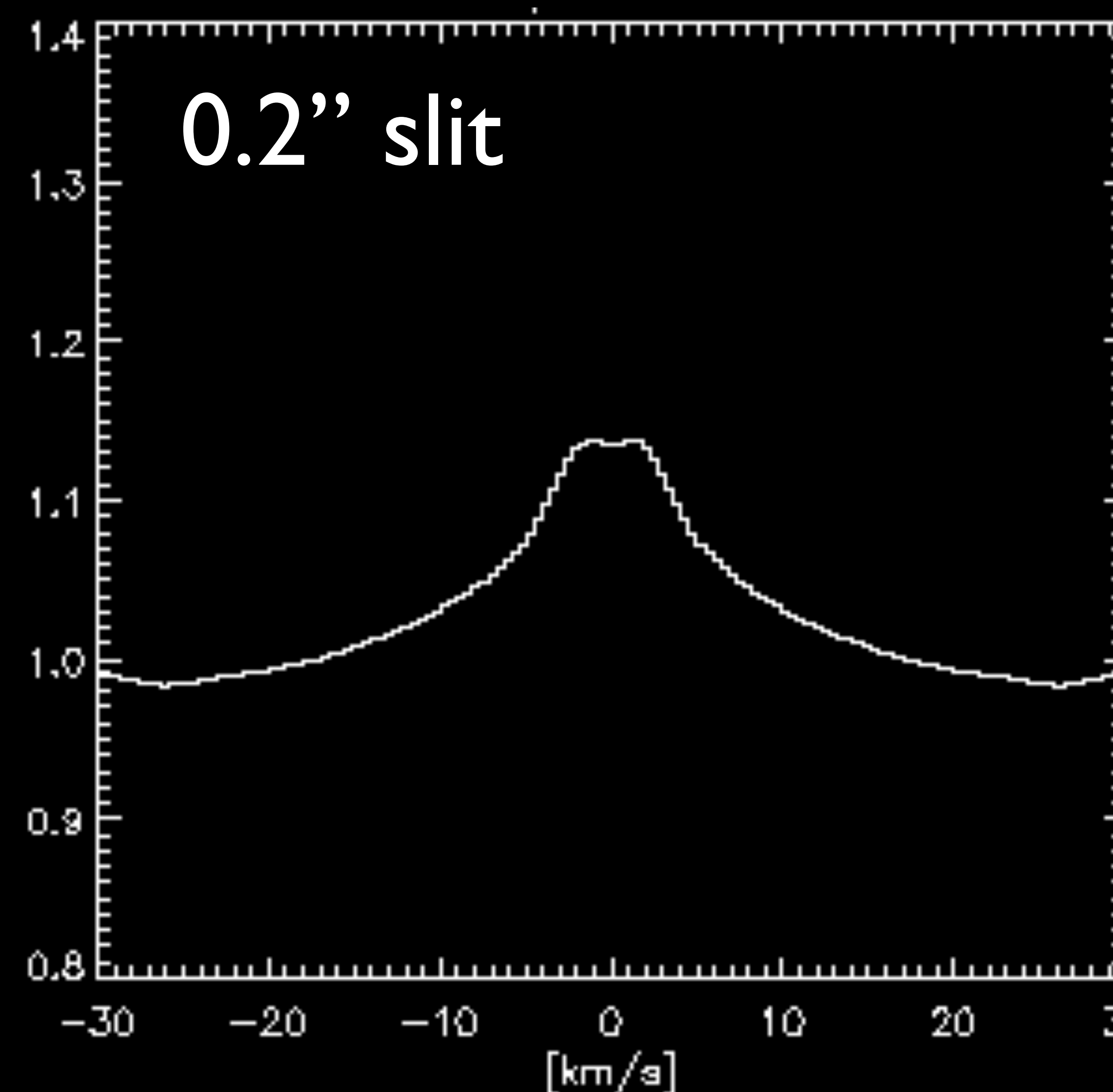


Different slopes!!!

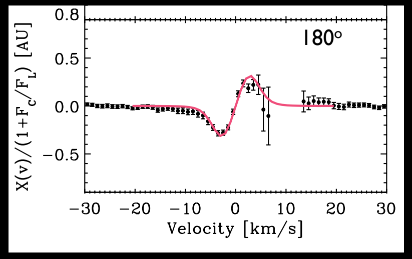


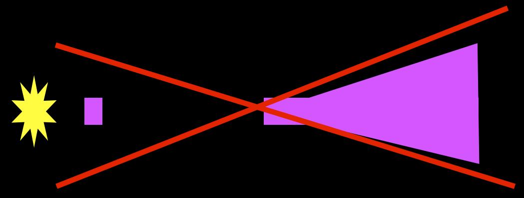
The slit effect is important



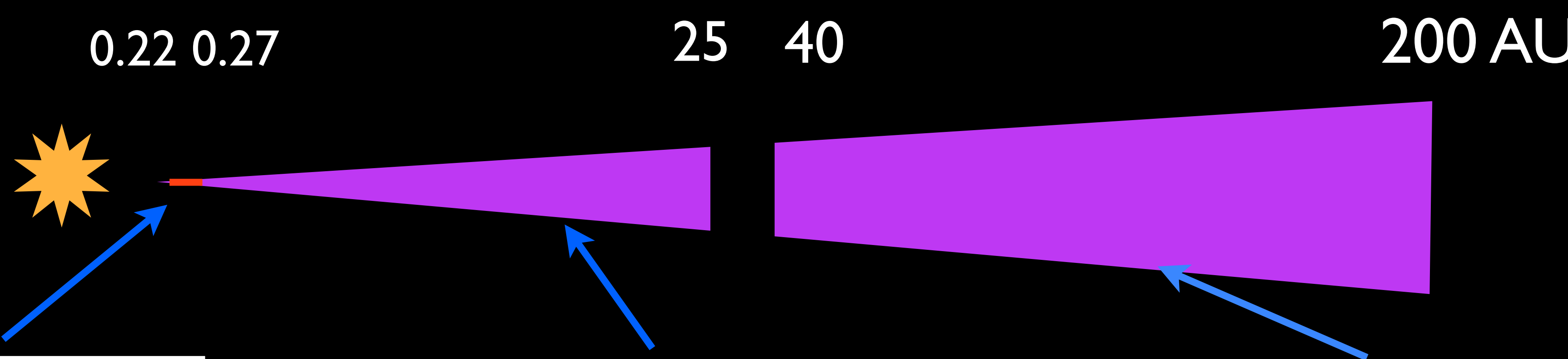


need to fit the spectroastrometry signal





Interplay GAS and DUST diagnostics is crucial to break degeneracies of the modeling process



0.2 - 0.27 AU
0.1-10 μm carbon
10^{-12} M_{sun}

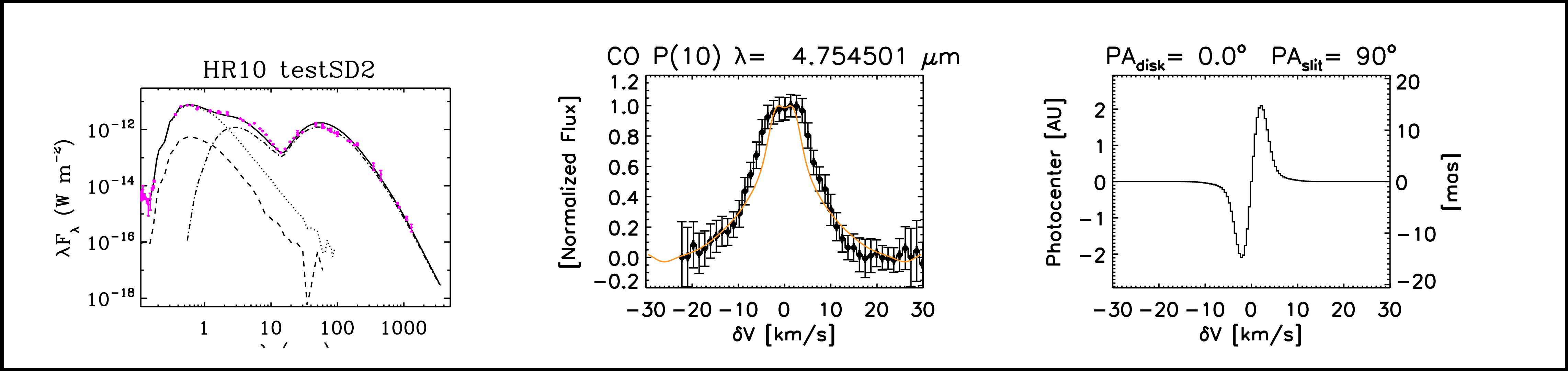
This small region is responsible for the IR-excess at <10 μm

0.20 - 25 AU
100 - 2000 μm silicates
10^{-7} M_{sun}
Flat surface density

This region is responsible for the CO 4.7 μm emission

30 - 200 AU
0.05 -1000 μm silicates
10^{-4} M_{sun}

This region is responsible for the [OI] 63 μm and cold dust and gas emission



END