Constraining the structure of the transition disk around HD 135344B

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cnrs dépasser les frontières

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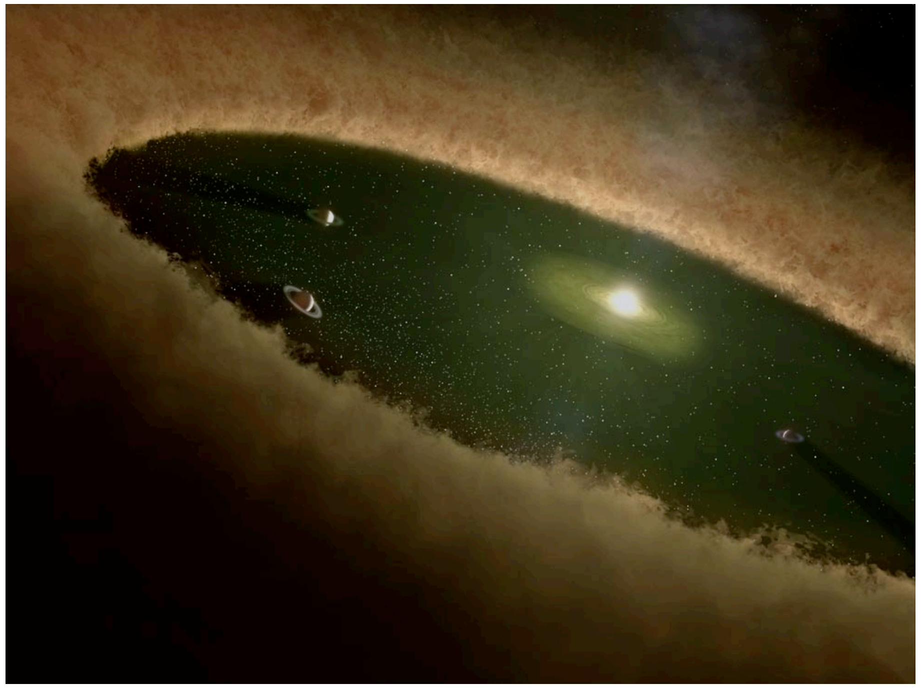
Origin of holes/gap in transition disk ?

- planets
- dust growth
- photoevaporation
- ??



Origin of holes/gap in transition disk ?

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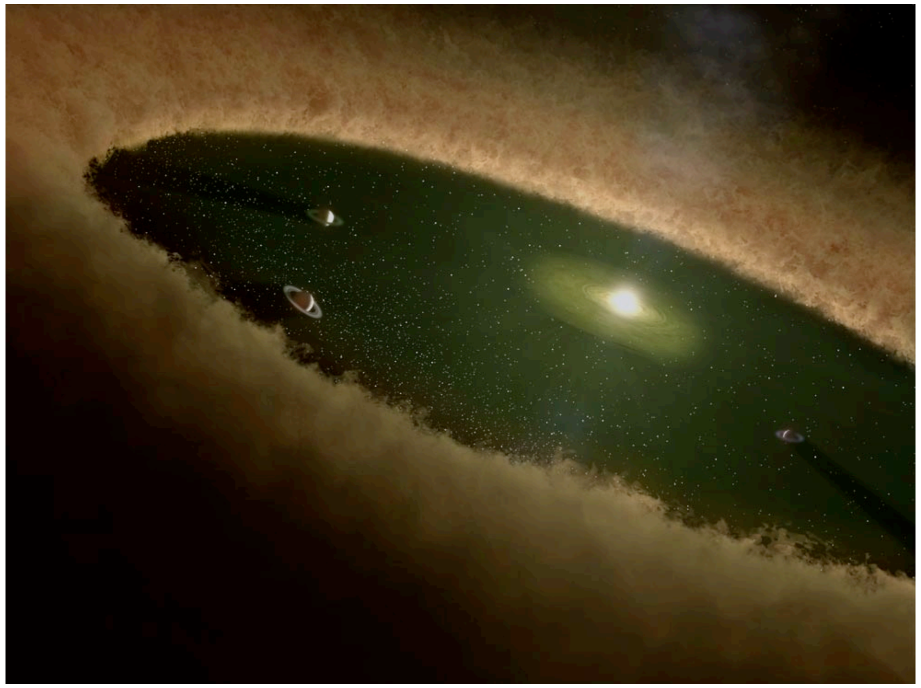
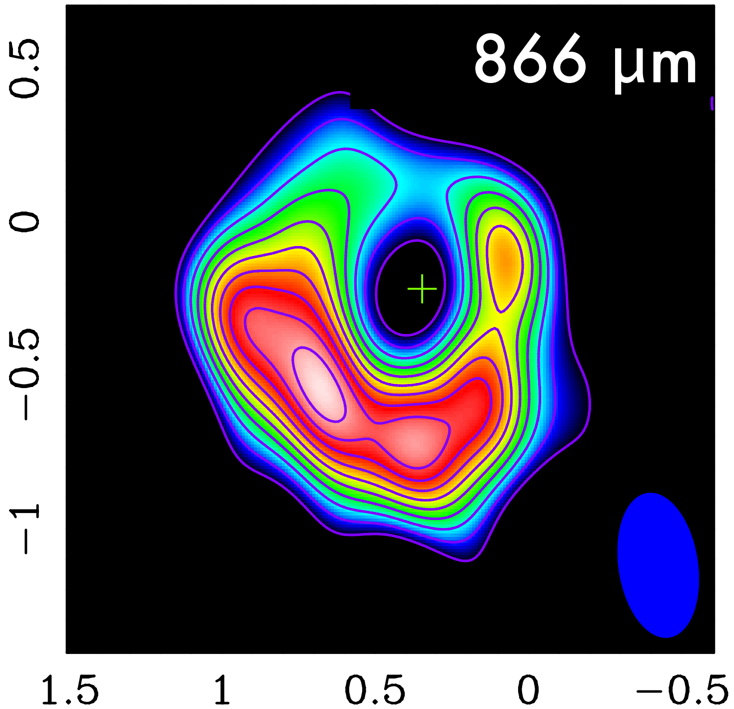


We need to constrain both the dust & gas structure

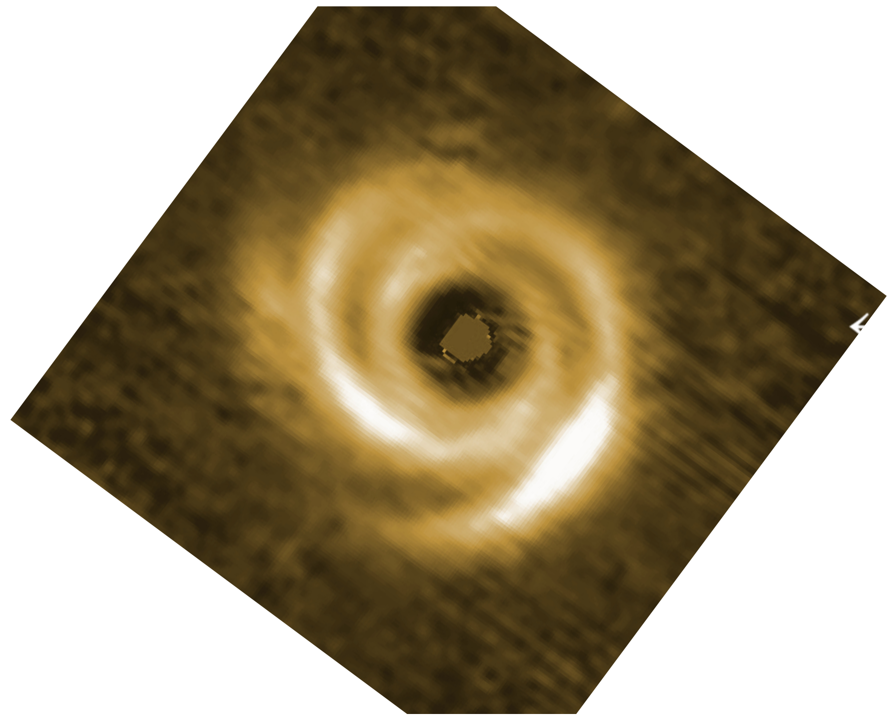
➪ multi-λ and multi-technique modelling

What is the gas & dust structure?

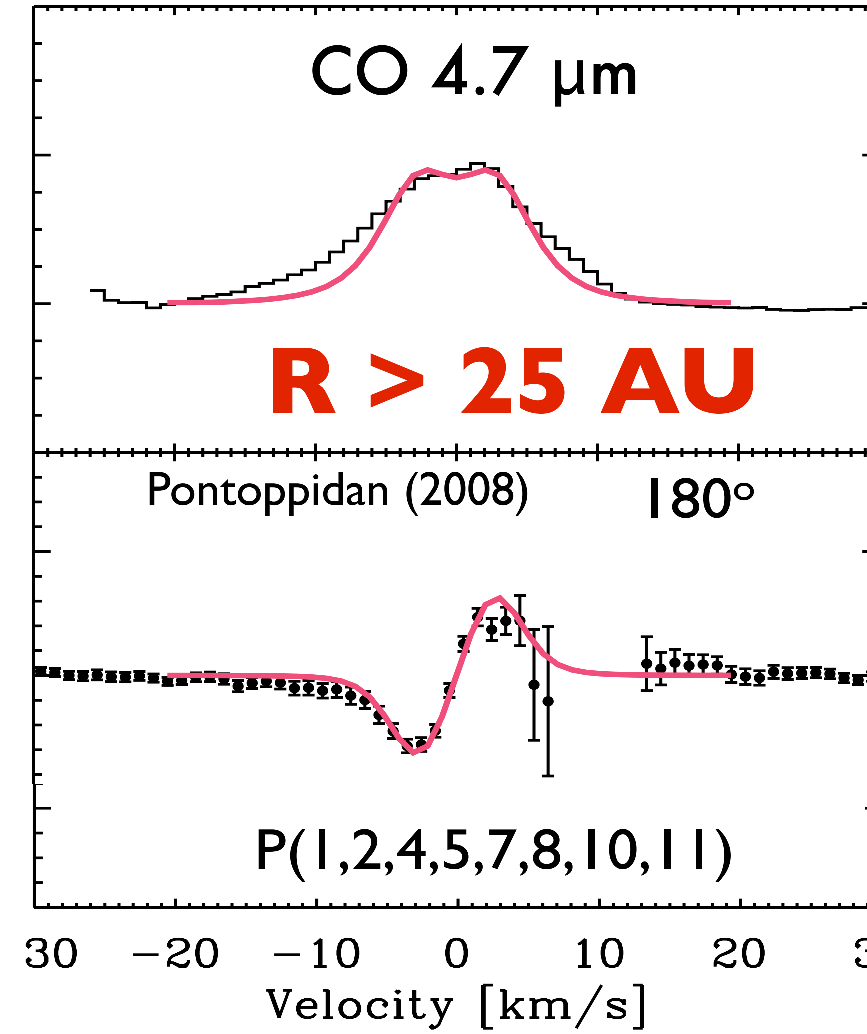
HD135344B data set

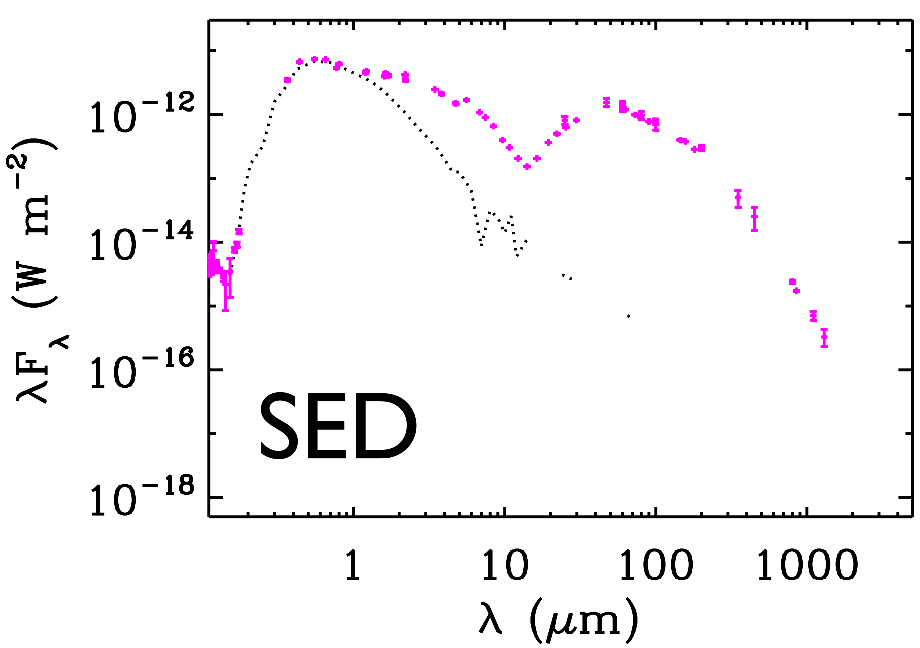


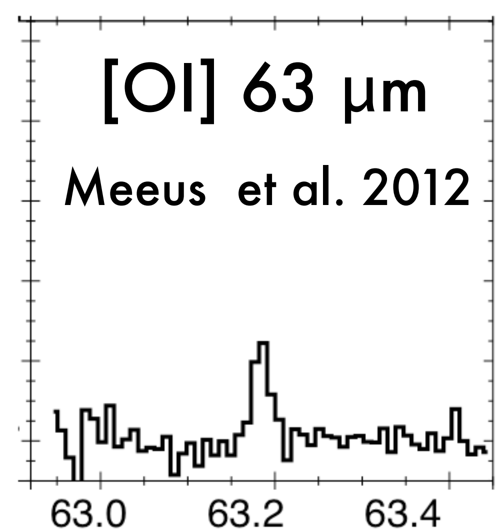
large dust
Rin ~ 40 AU
Brown et al. 2009; Andrews et al. (2011)



small dust
Rin ~ 28 AU
Muto 2012, Garufi 2013







warm gas
inside cavity

Herbig F4Ve, 1.65 Msun, 140 pc, i = 14°; PA=55°

Methodology

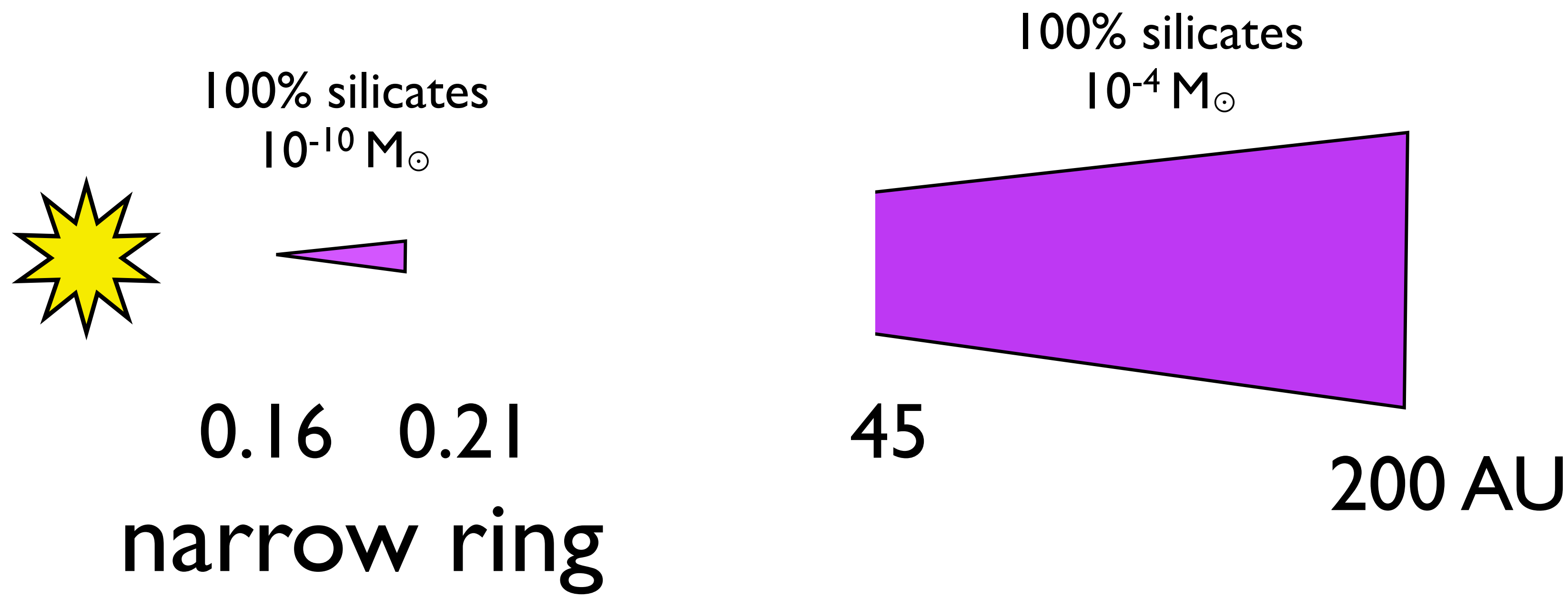
MCFOST ⟷ PRODIMO

Carmona et al 2014

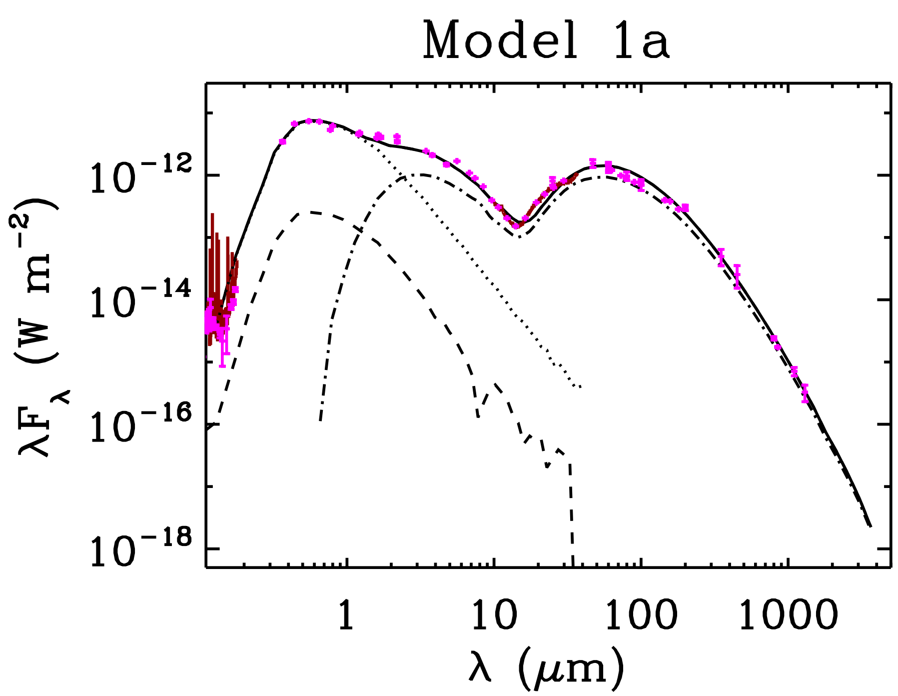
- SED
- CO P(10) ro-vibrational line profile
- PIONIER nIR visibilities
- dust cavity at 870 µm
- [OI] 63 µm
- good agreement with other line fluxes
- scattered light images (2D !)

SIMPLE → COMPLEX MODELS

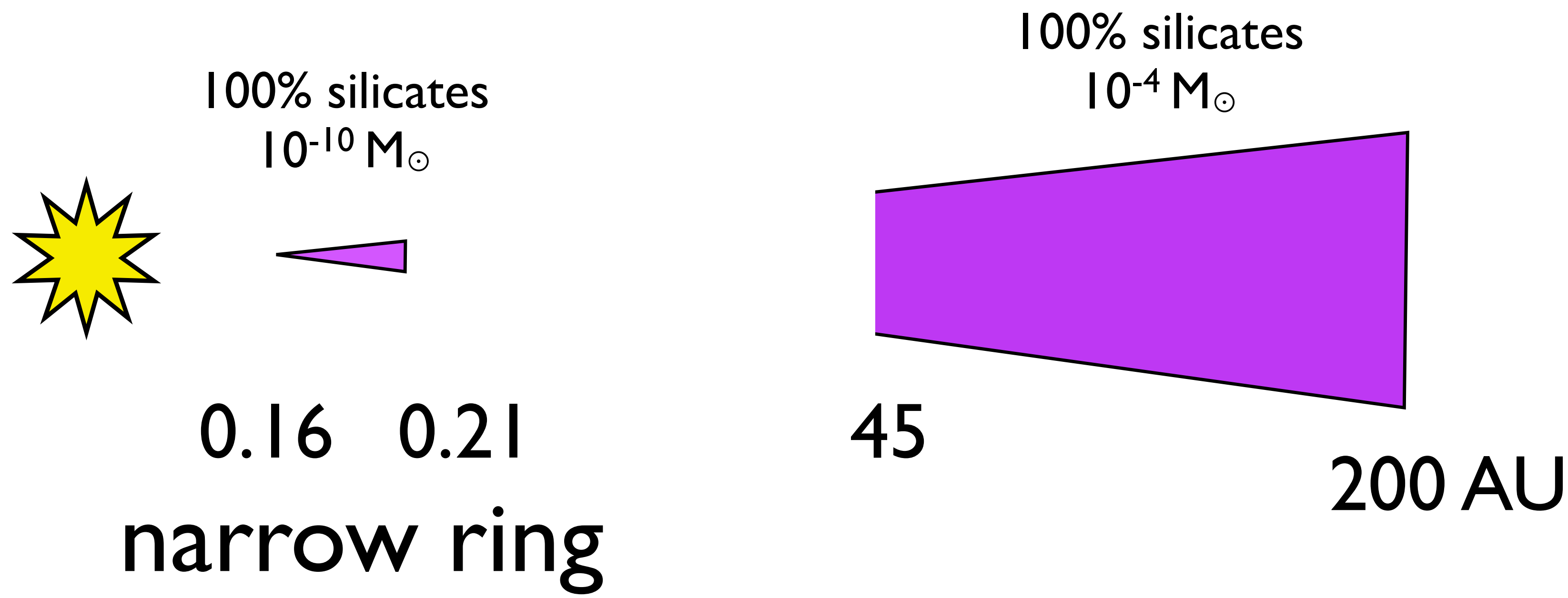
100% astronomical silicates



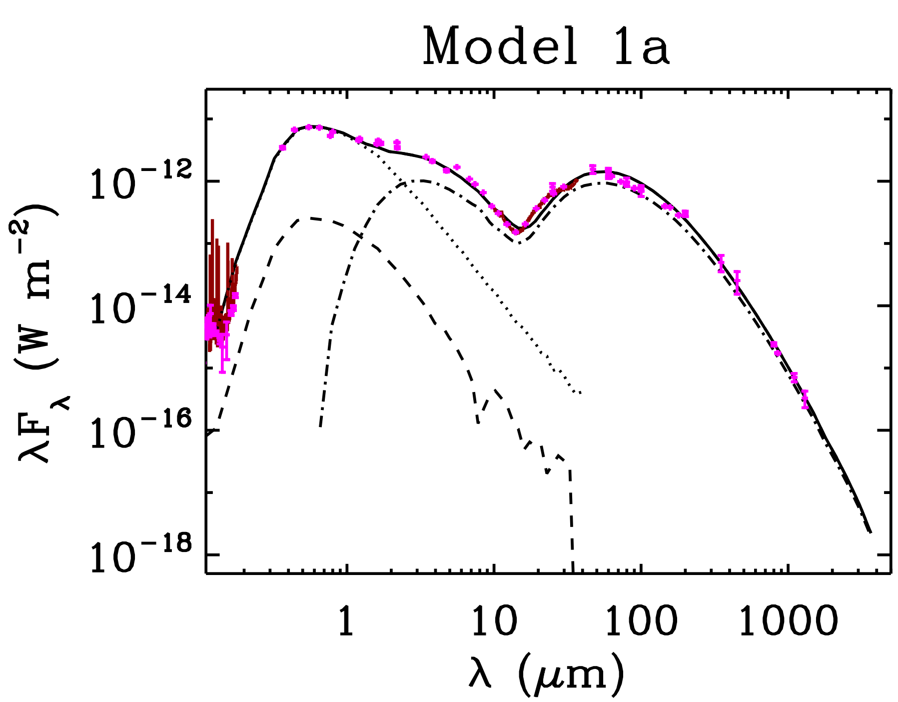
SED OK!



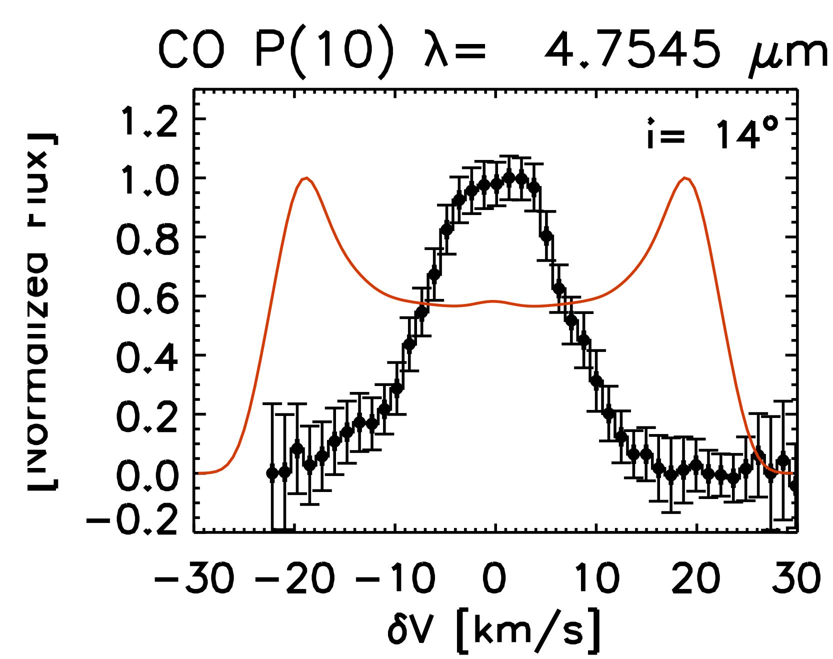
100% astronomical silicates



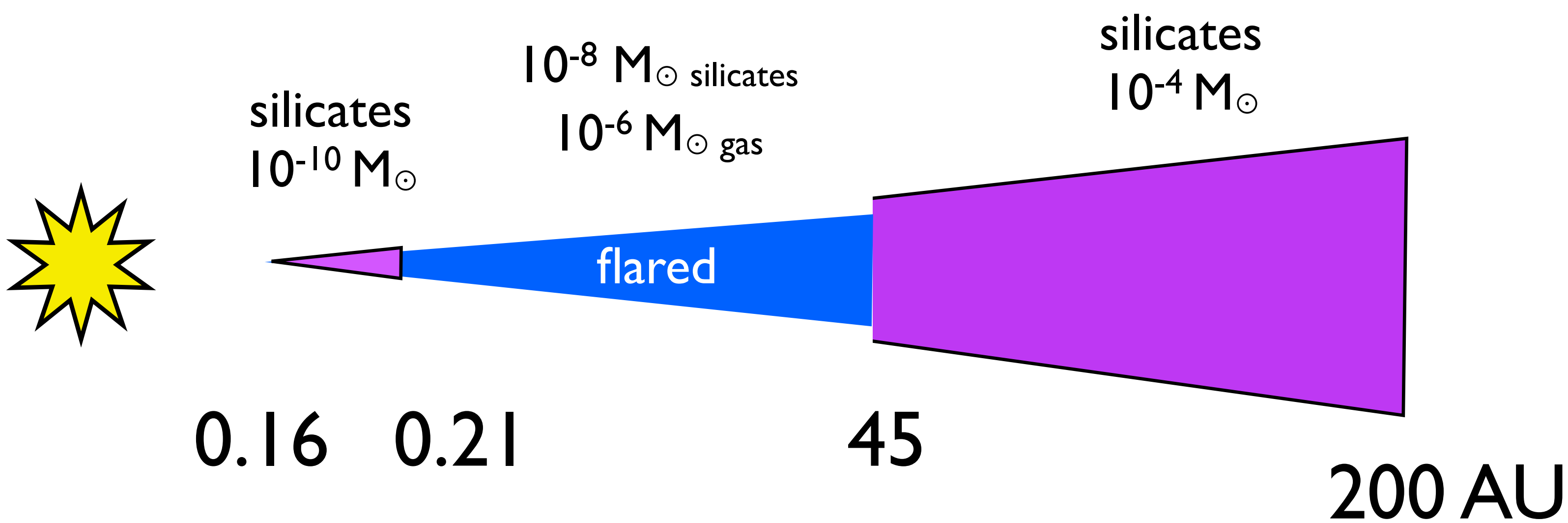
SED OK!

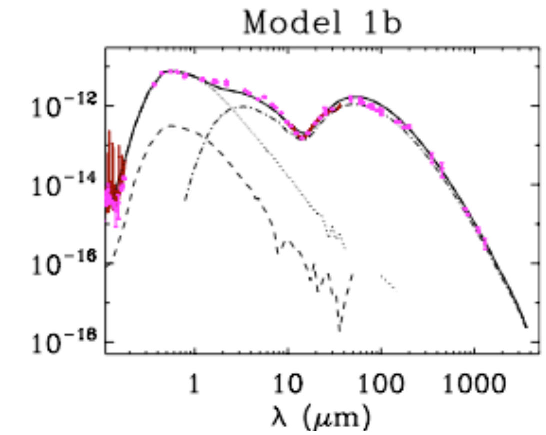


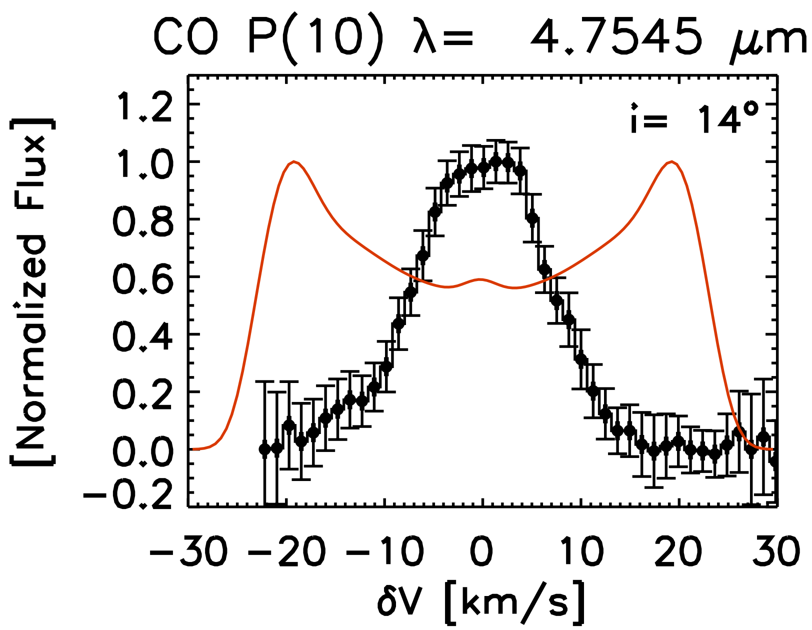
BAD CO ro-vib



Adding gas in the gap



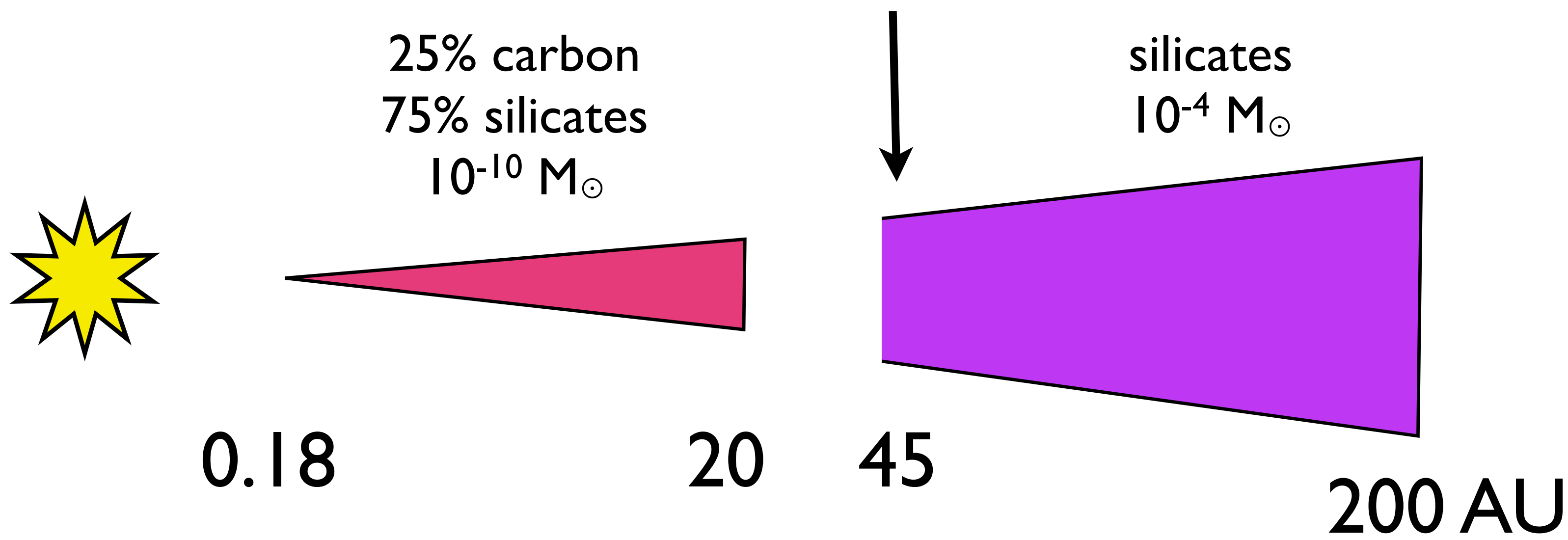


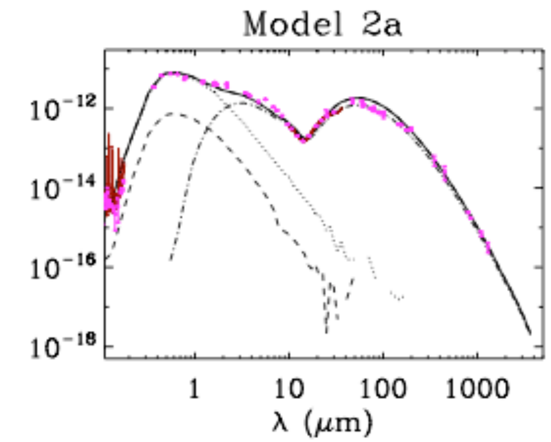


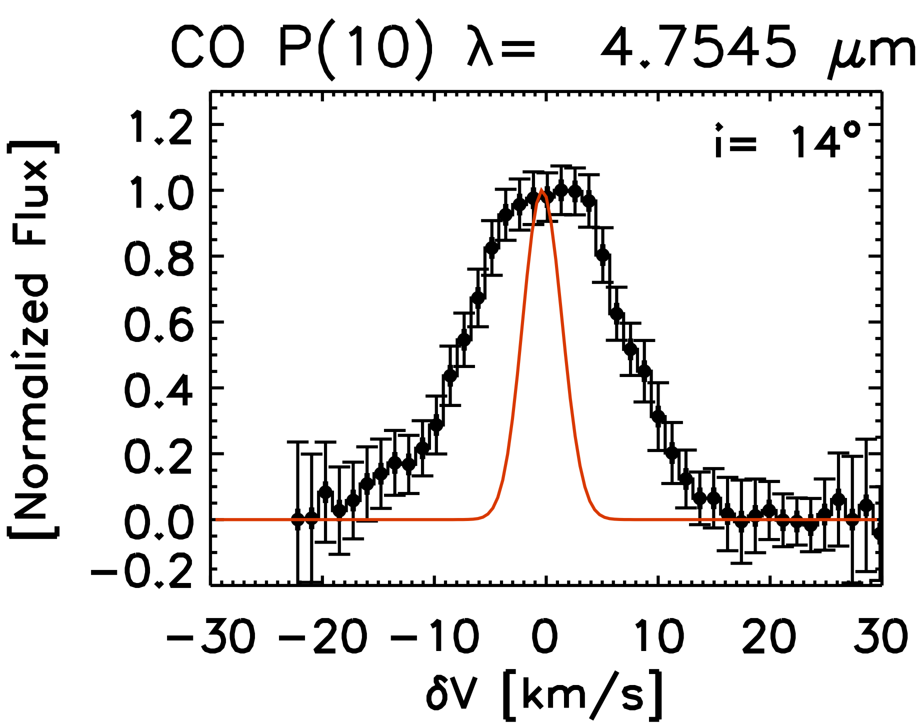
CO ro-vib emission dominated by the inner-most disk

Problem: Dust in inner disk shields the gas in the gap

Uniform carbon/silicate ratio

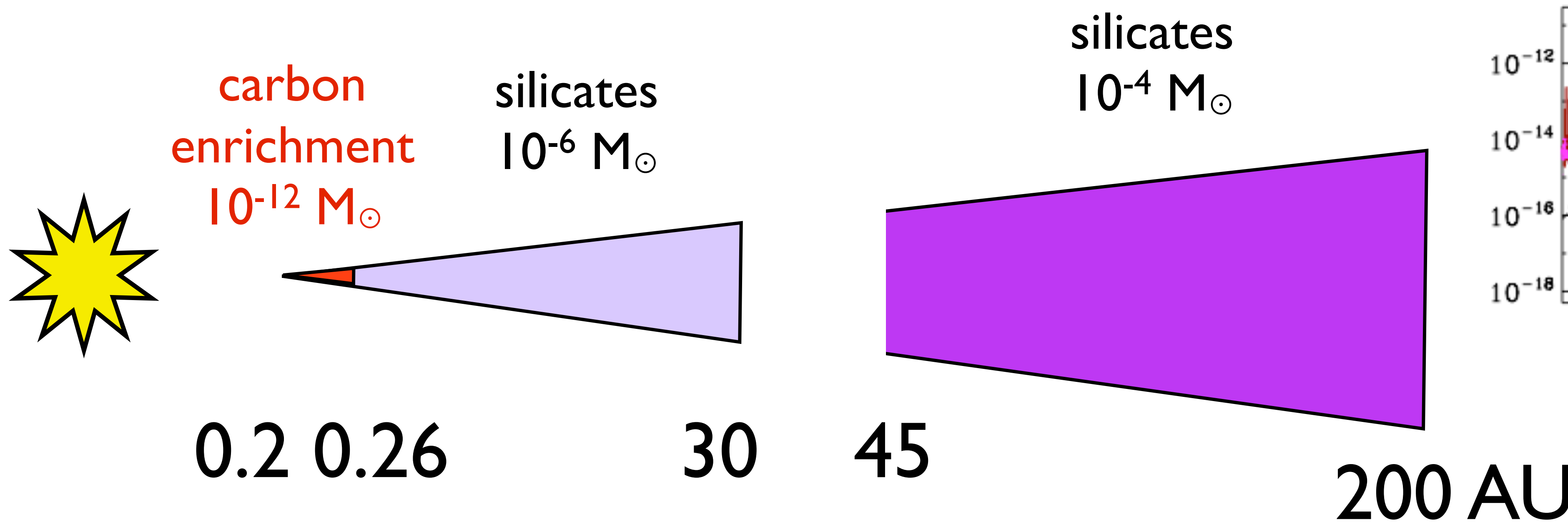


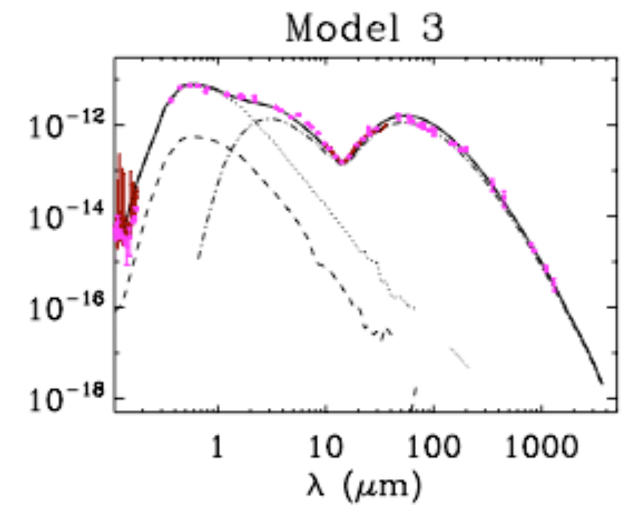


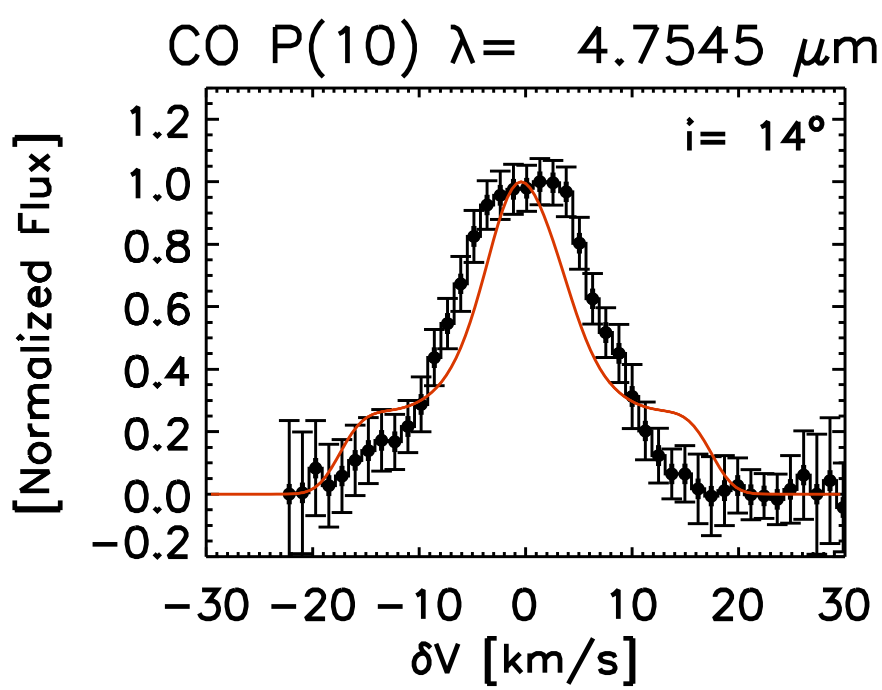


Too much carbon, CO ro-vib emission dominated by the inner rim of the outer disk

Carbon-enriched inner disk



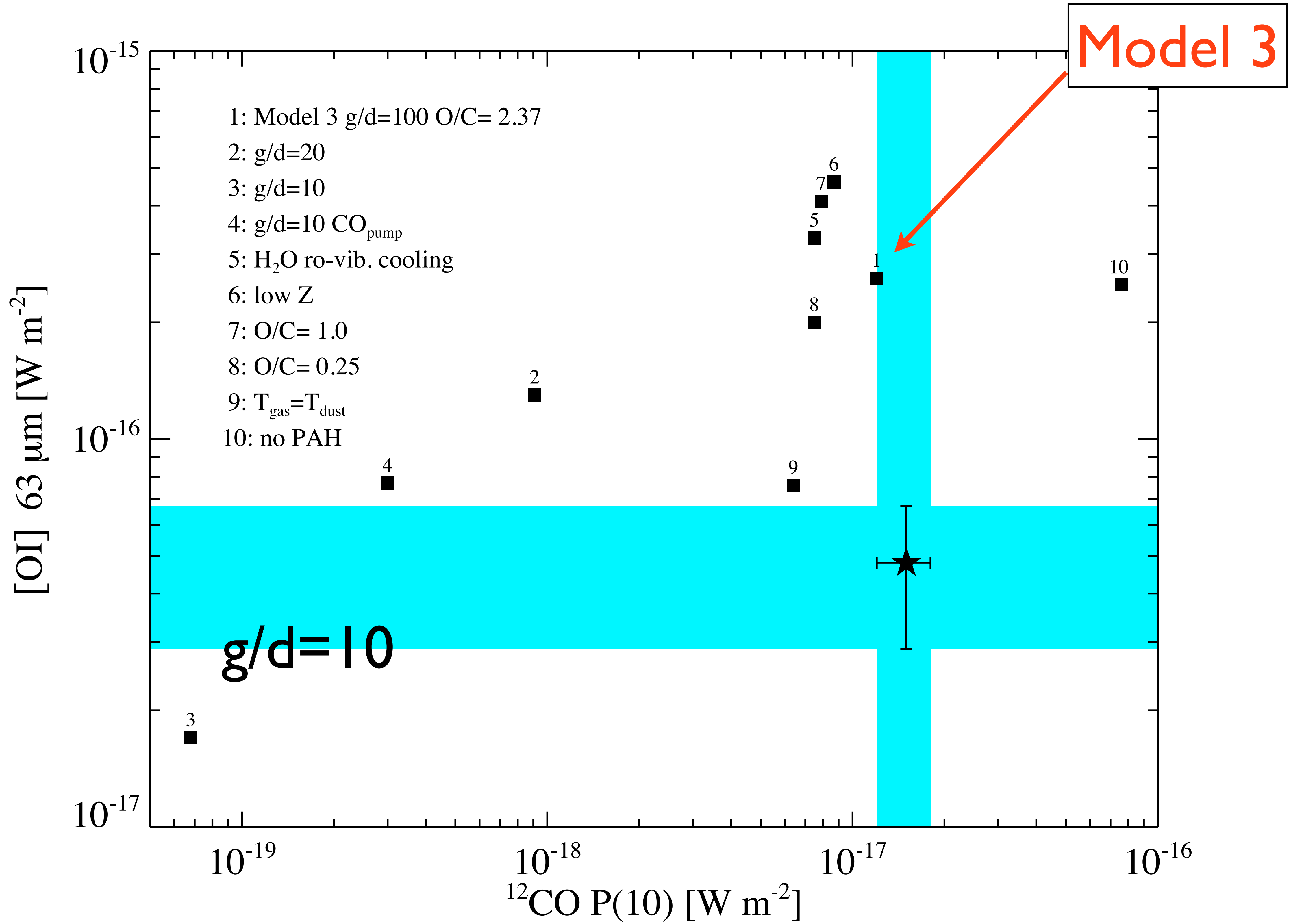




Simultaneous fit of the SED + CO ro-vib profile

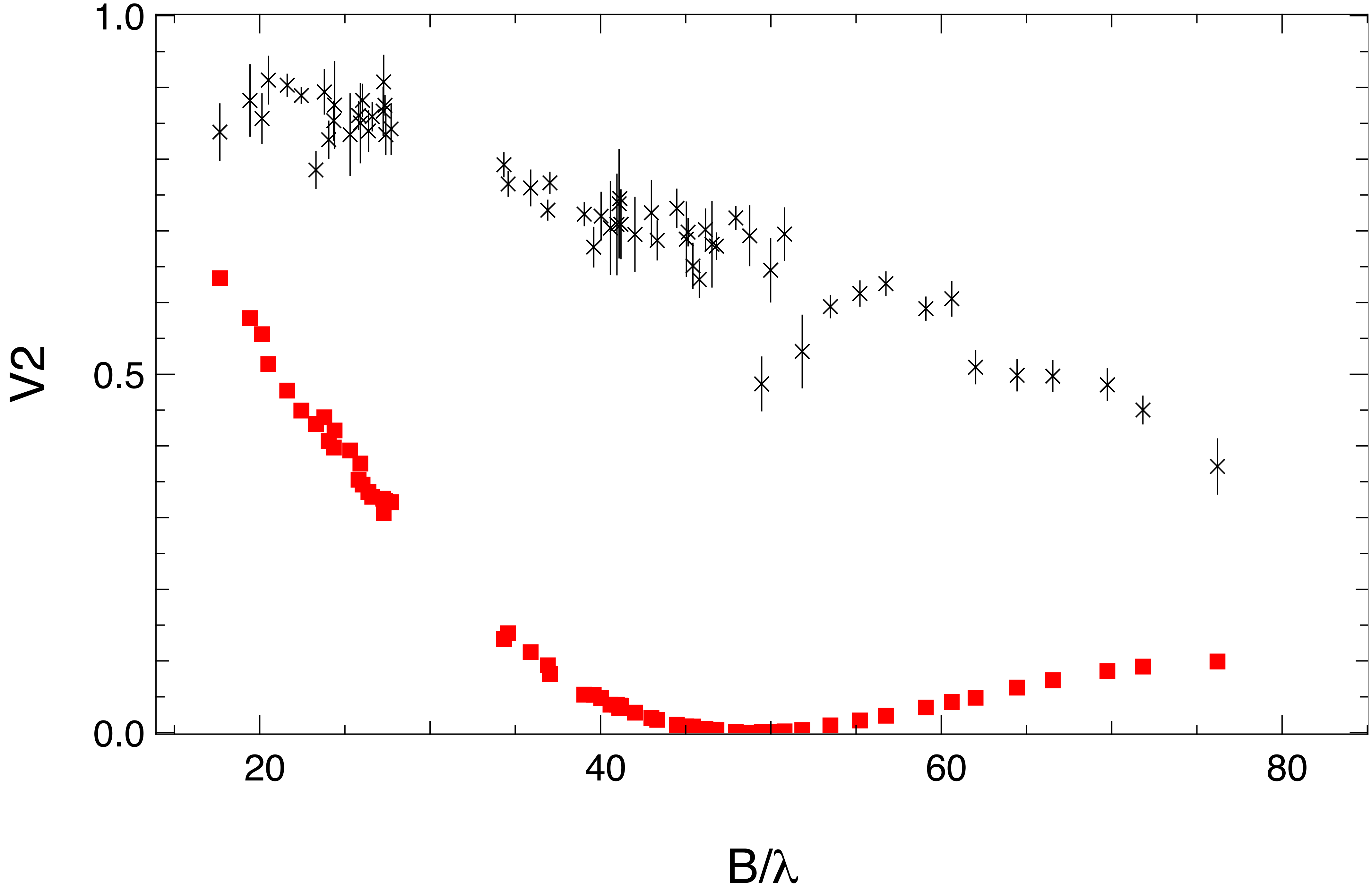
Problem 1: too strong [OI] 63 μm

Only way to reduce line flux : lower gas/dust ratio



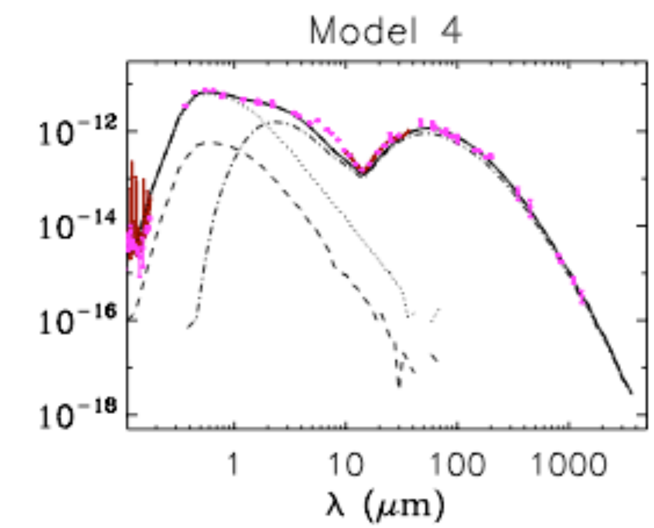
Problem II: near-IR visibilities do not fit

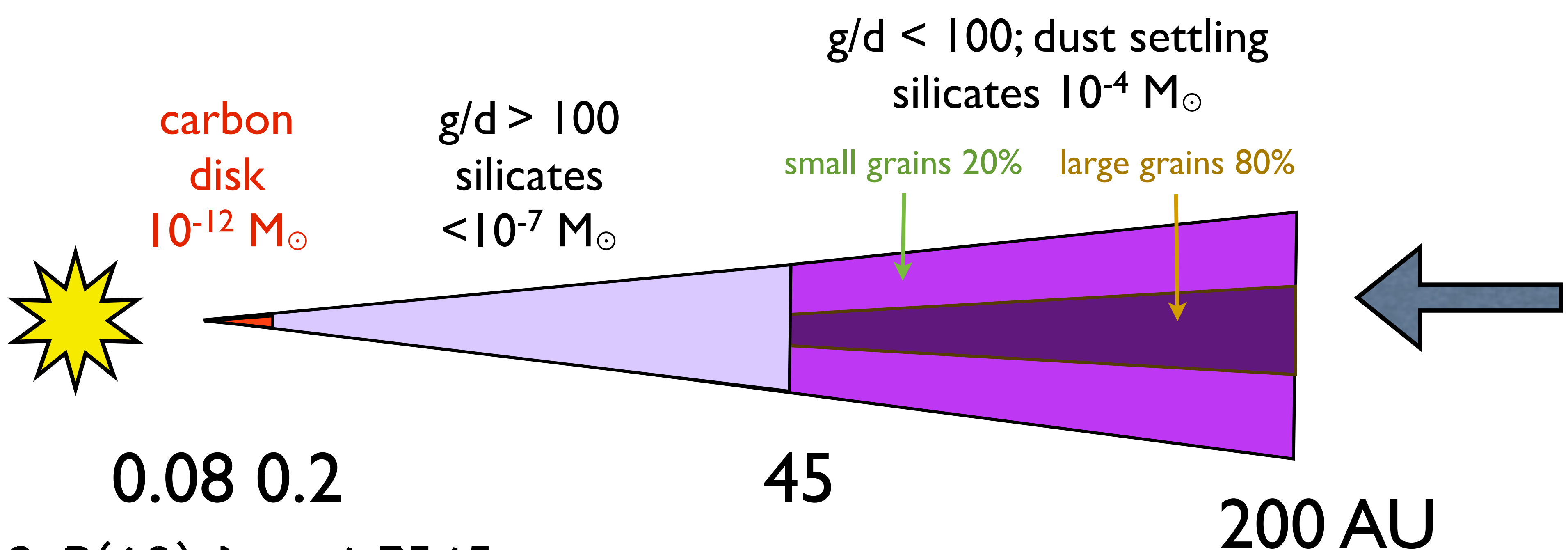
Rin = 0.2 AU is too far out !



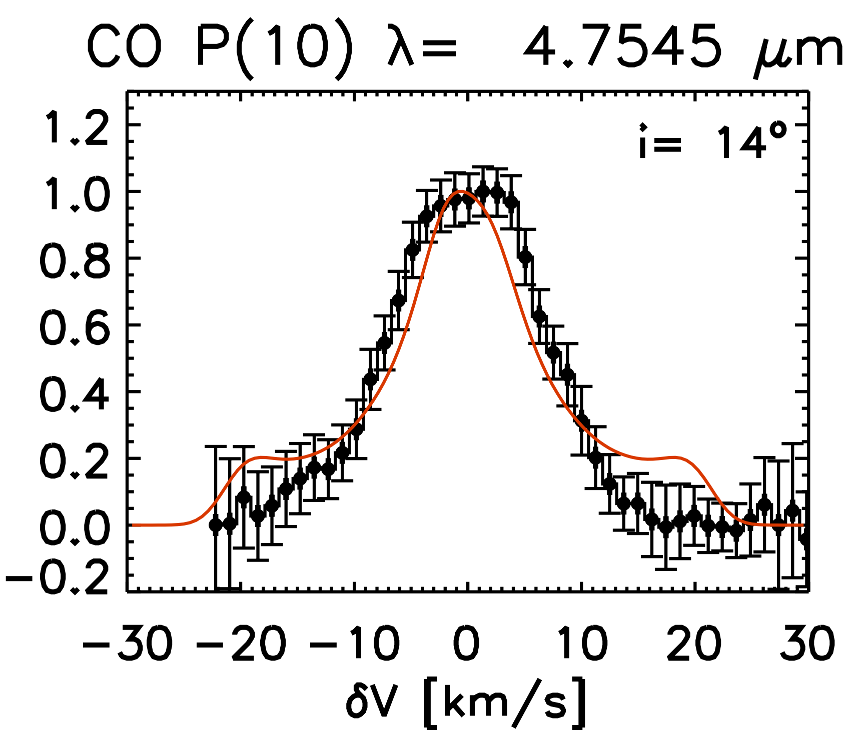
Spatial differentiation of dust

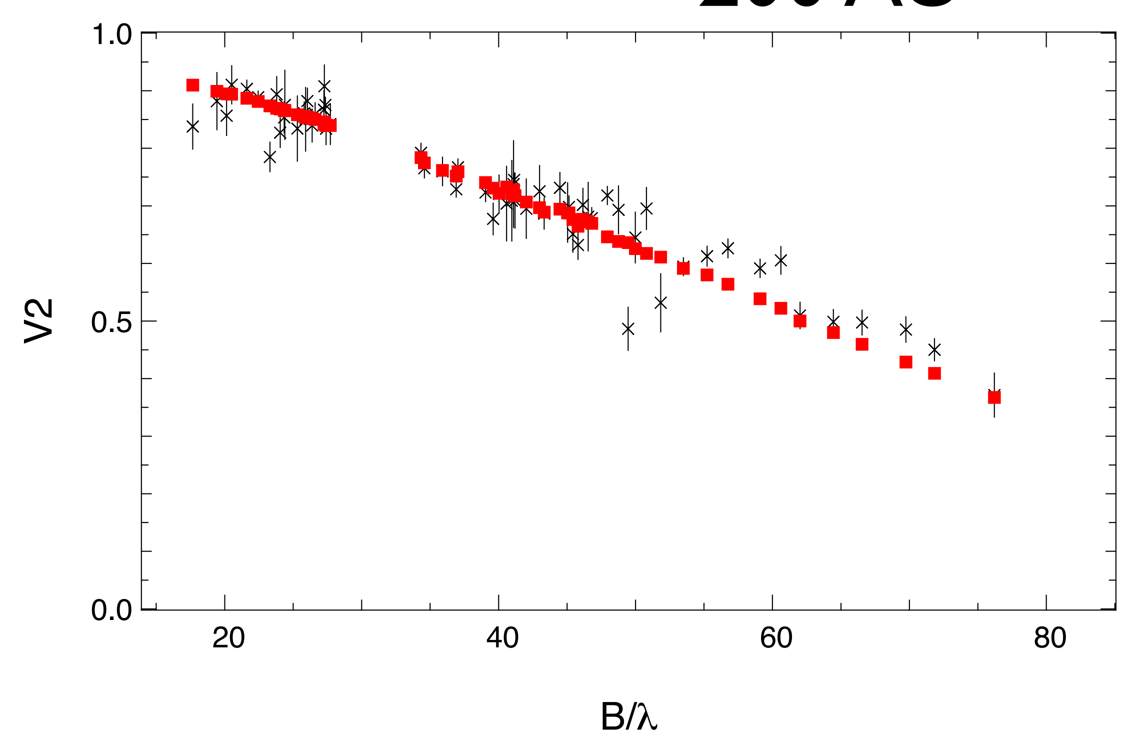
1. carbon inside silicate sublimation radius
2. gas to dust ratio < 100 in the outer disk





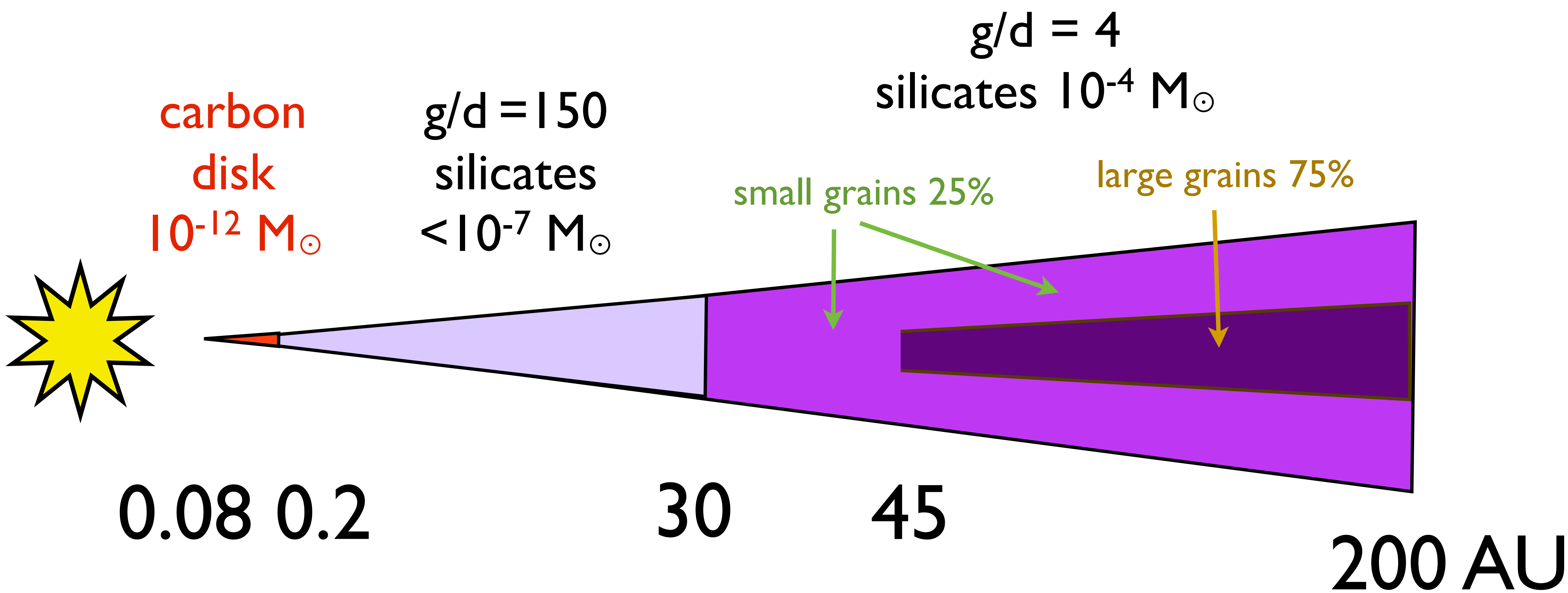
3.

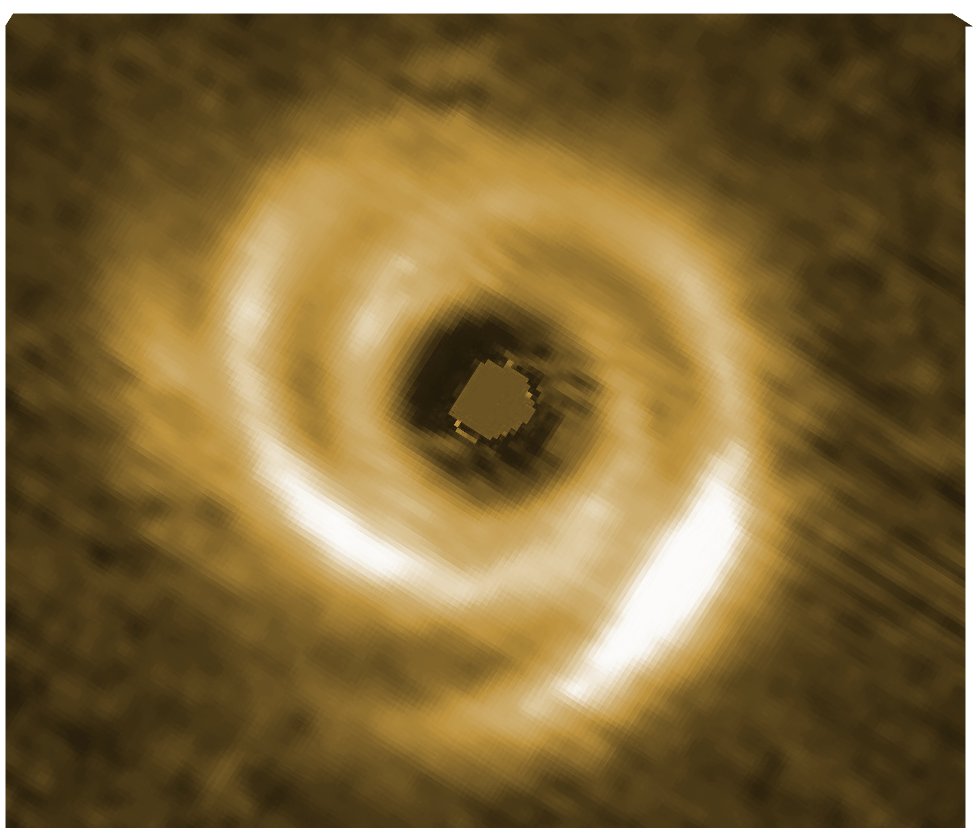




[OI] 63μm
OK!

Spatial differentiation of dust



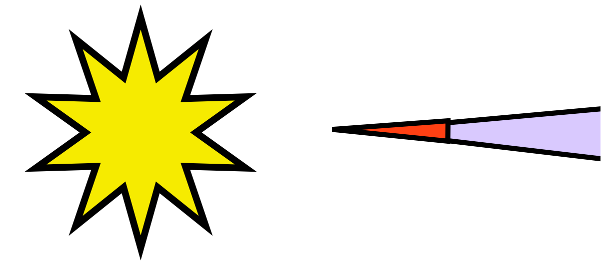


Rin ~ 28 AU

Muto 2012, Garufi 2013

What did we learn ?

1. Refractory grains at R< 0.2 AU (we suggest carbon)

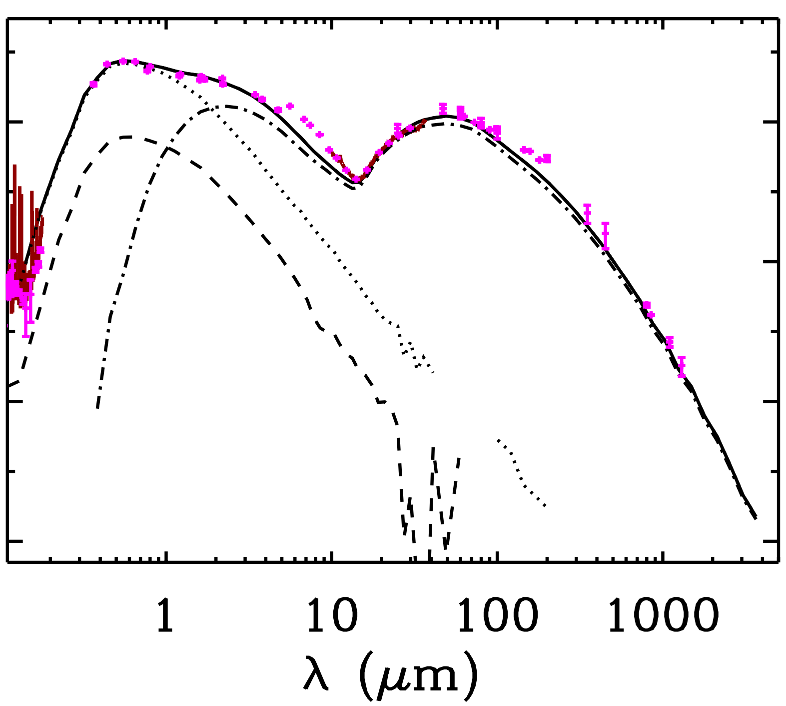


0.08 0.2

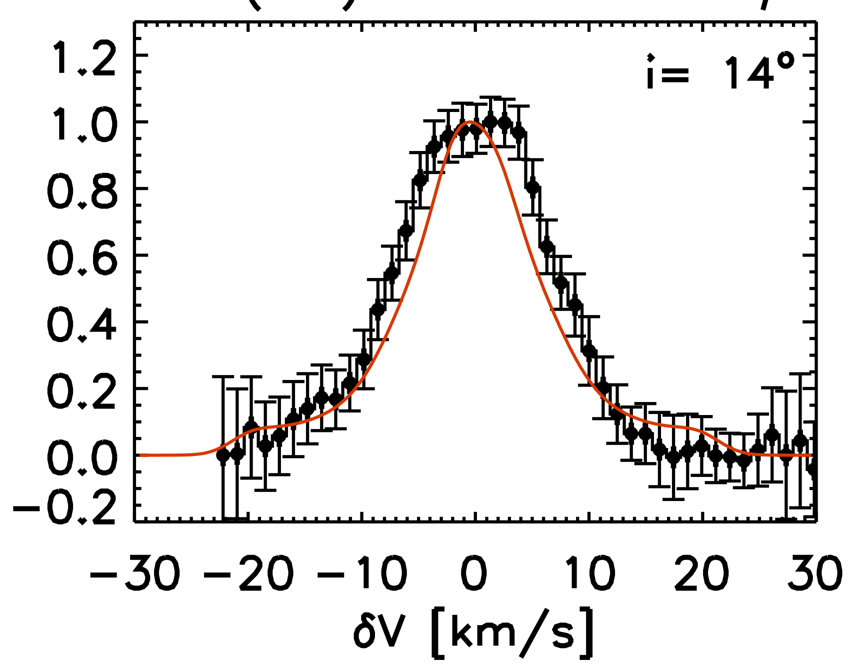
~ $10^{-12} M_\odot$

Required to fit simultaneously the

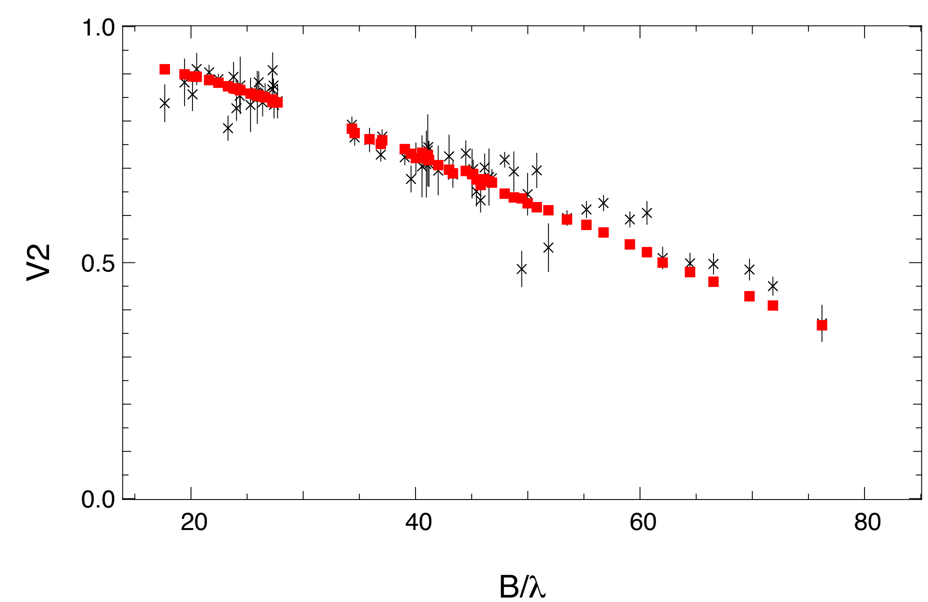
SED



CO ro-vibrational profile



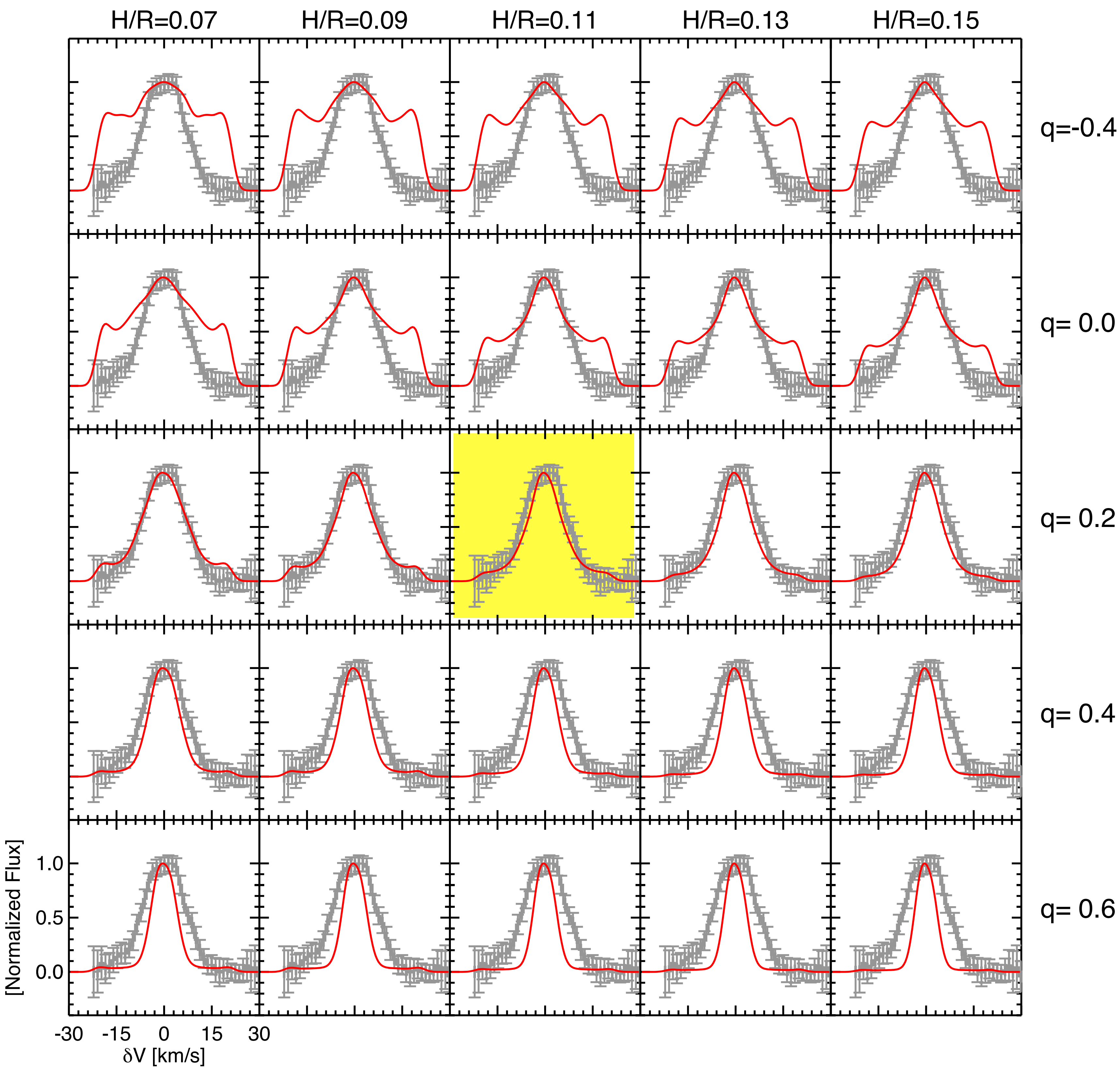
near-IR visibilities

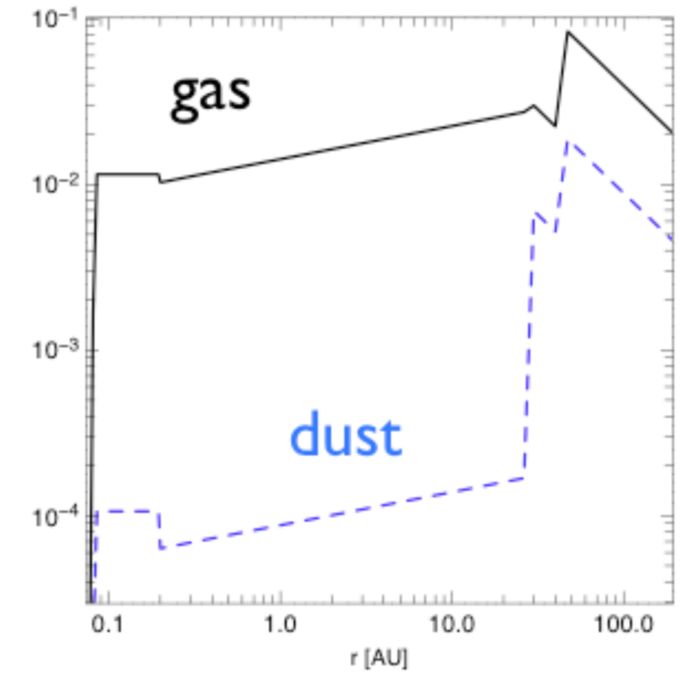


II. Surface density should increase with radius in the inner disk

Required to fit CO ro-vibrational profile

CO (P10) λ= 4.7545 μm

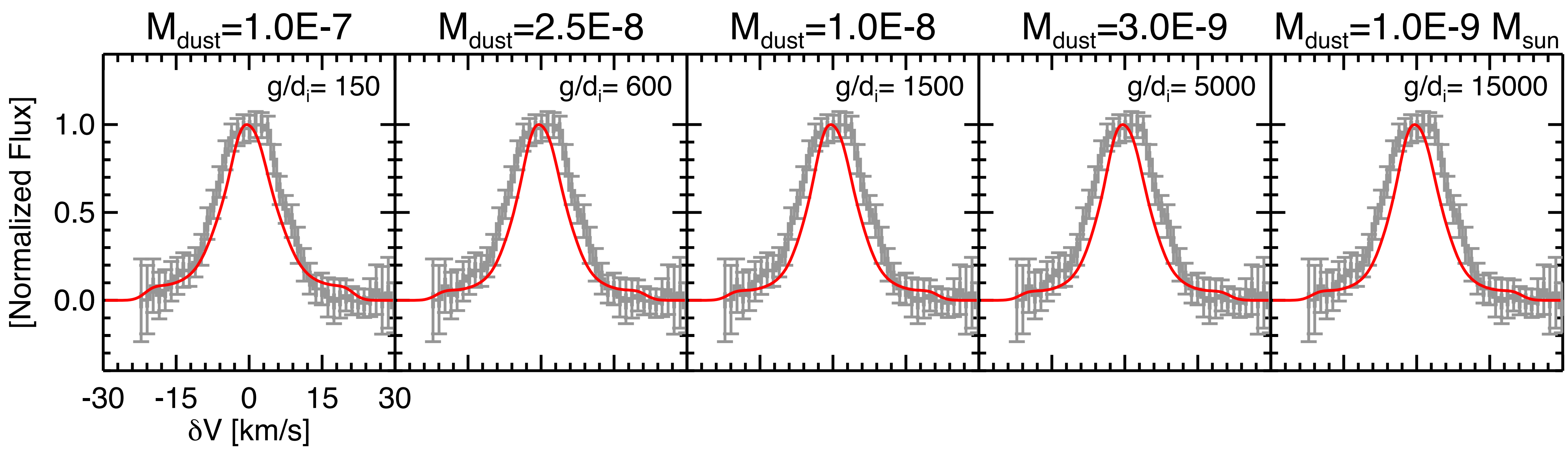




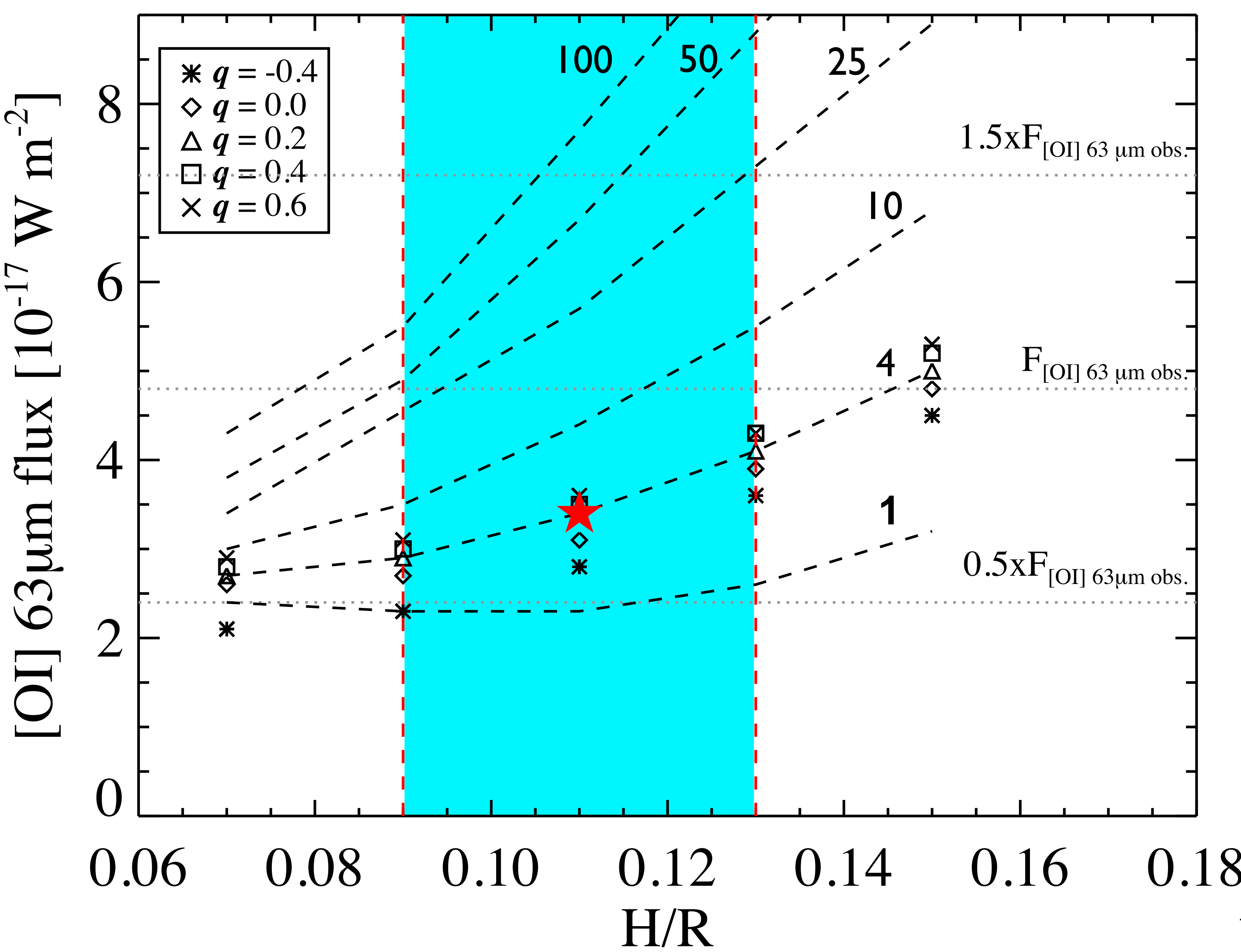
III. gas/dust > 100 inside the cavity (R<30 AU)

maximum dust mass ↓

100 lower ↓



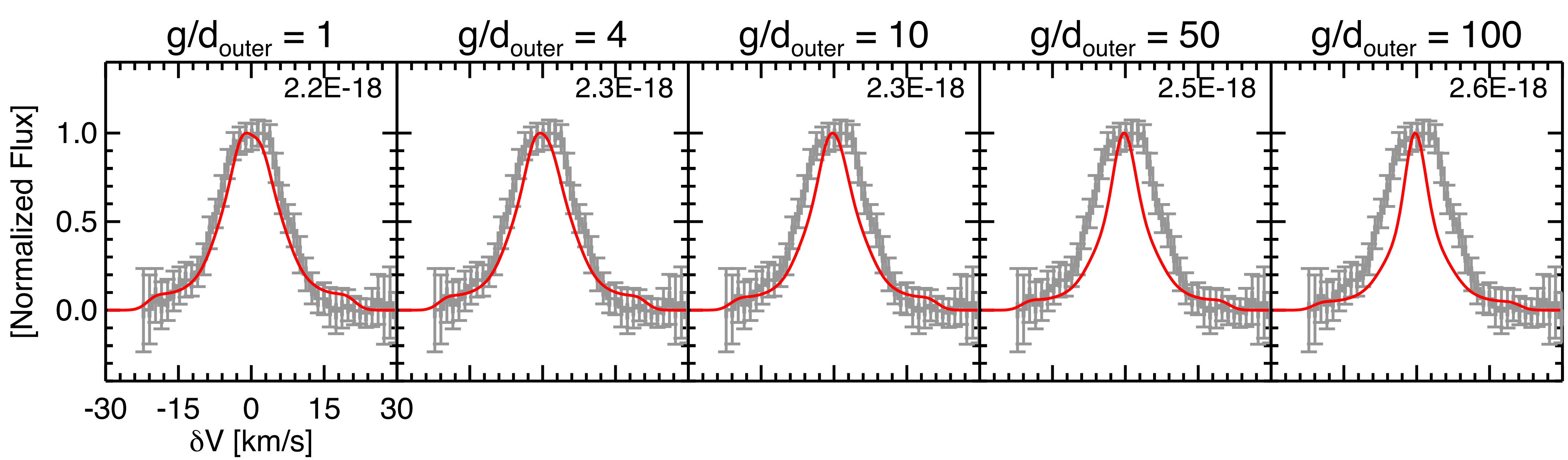
* Constant Mgas 10^{-5} Msun (Required for the CO P(10) flux)
* 10^{-9} < Mdust < 10^{-7} Msun



IV. outer disk: Gas/dust < 100

Required to fit [OI] 63 µm flux and the CO P(10) profile.

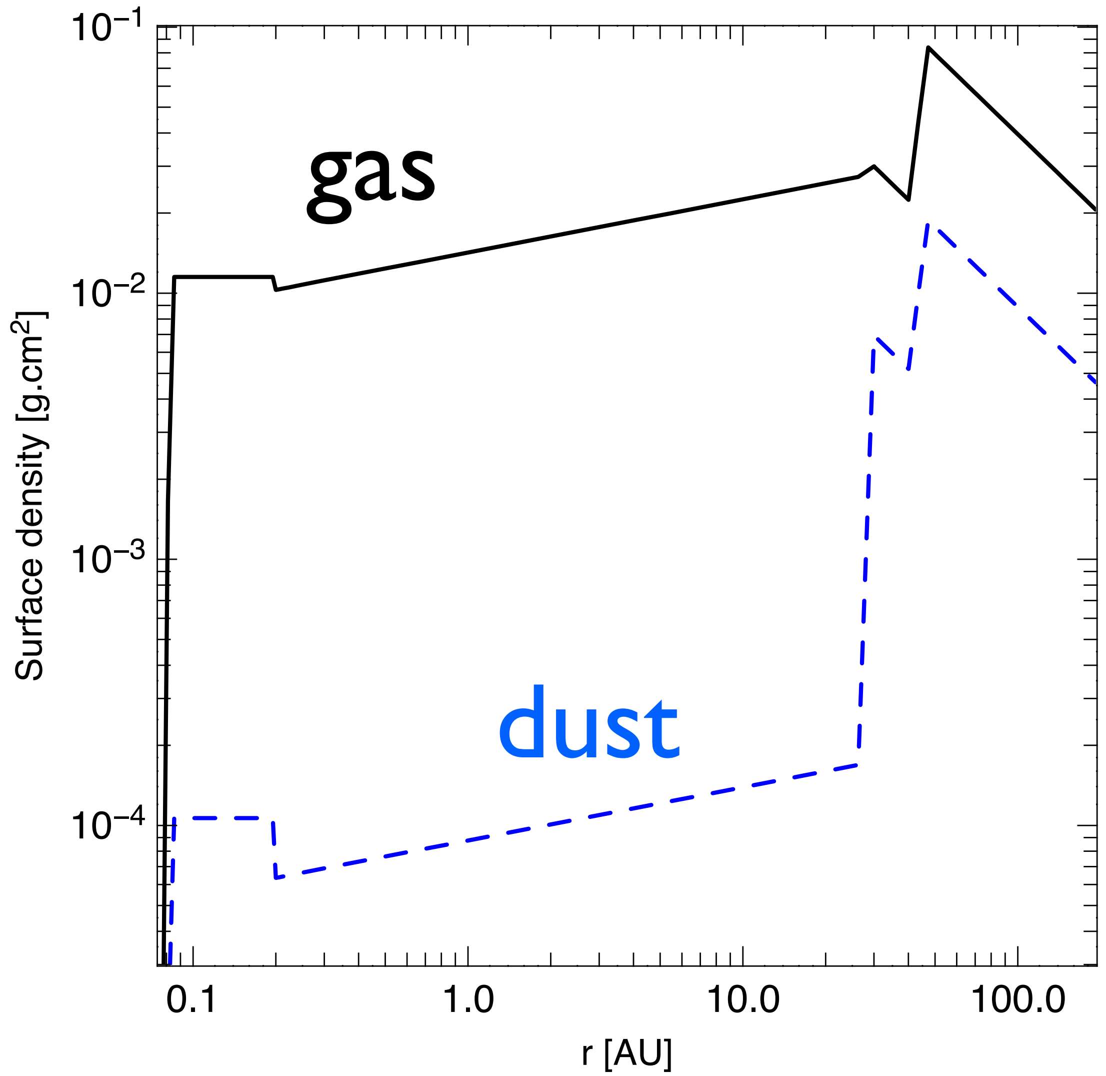
too narrow →



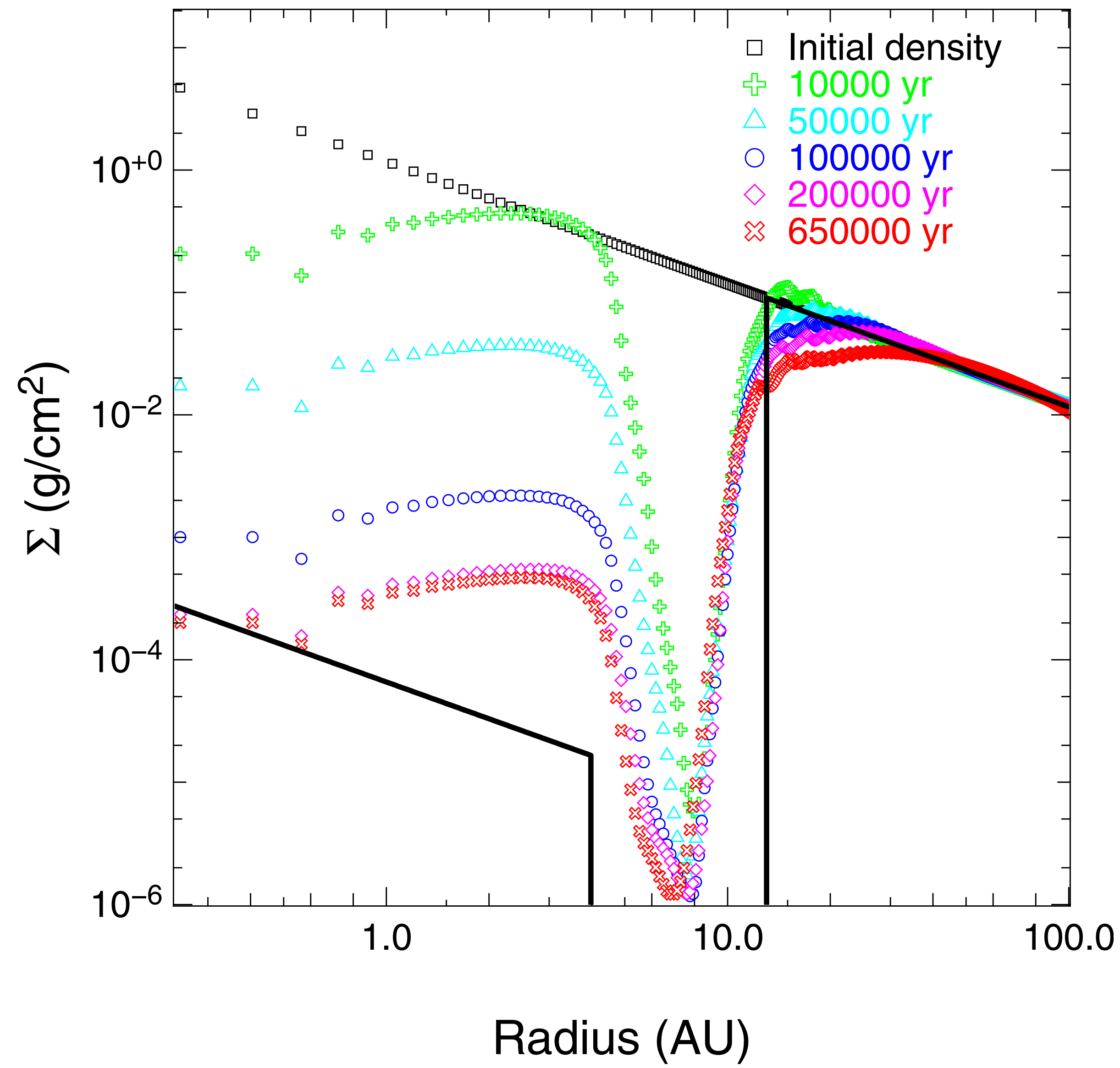
Cleaning by planetary system ?

Positive surface density slope in inner disk

Our model



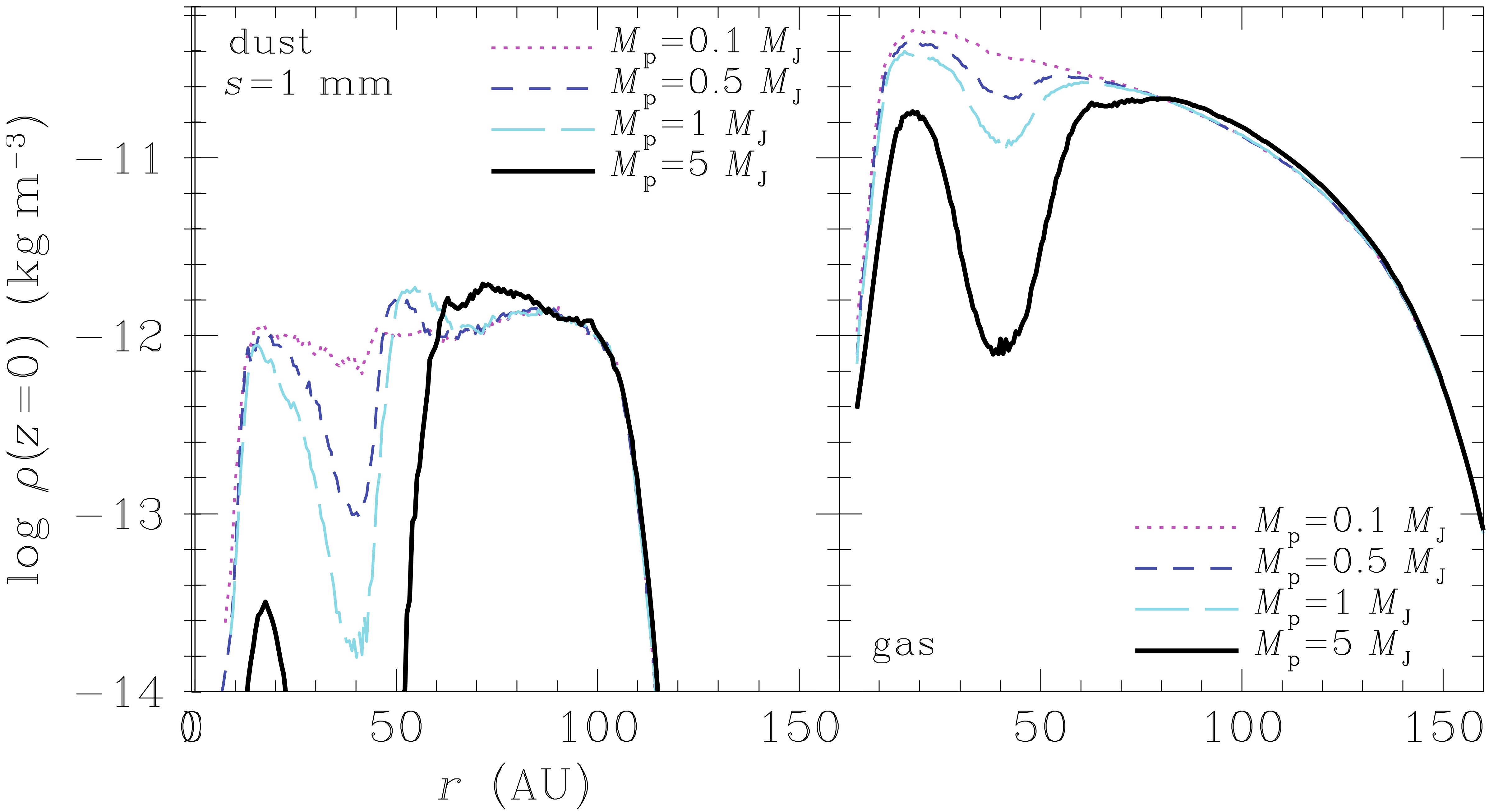
Disk-planet interaction



Tatulli et al 2011

Cleaning by planetary system ?

Dust filtering by planetary gap



Fouchet et al 2010

Conclusions

A variety of disk observations = finer disk models

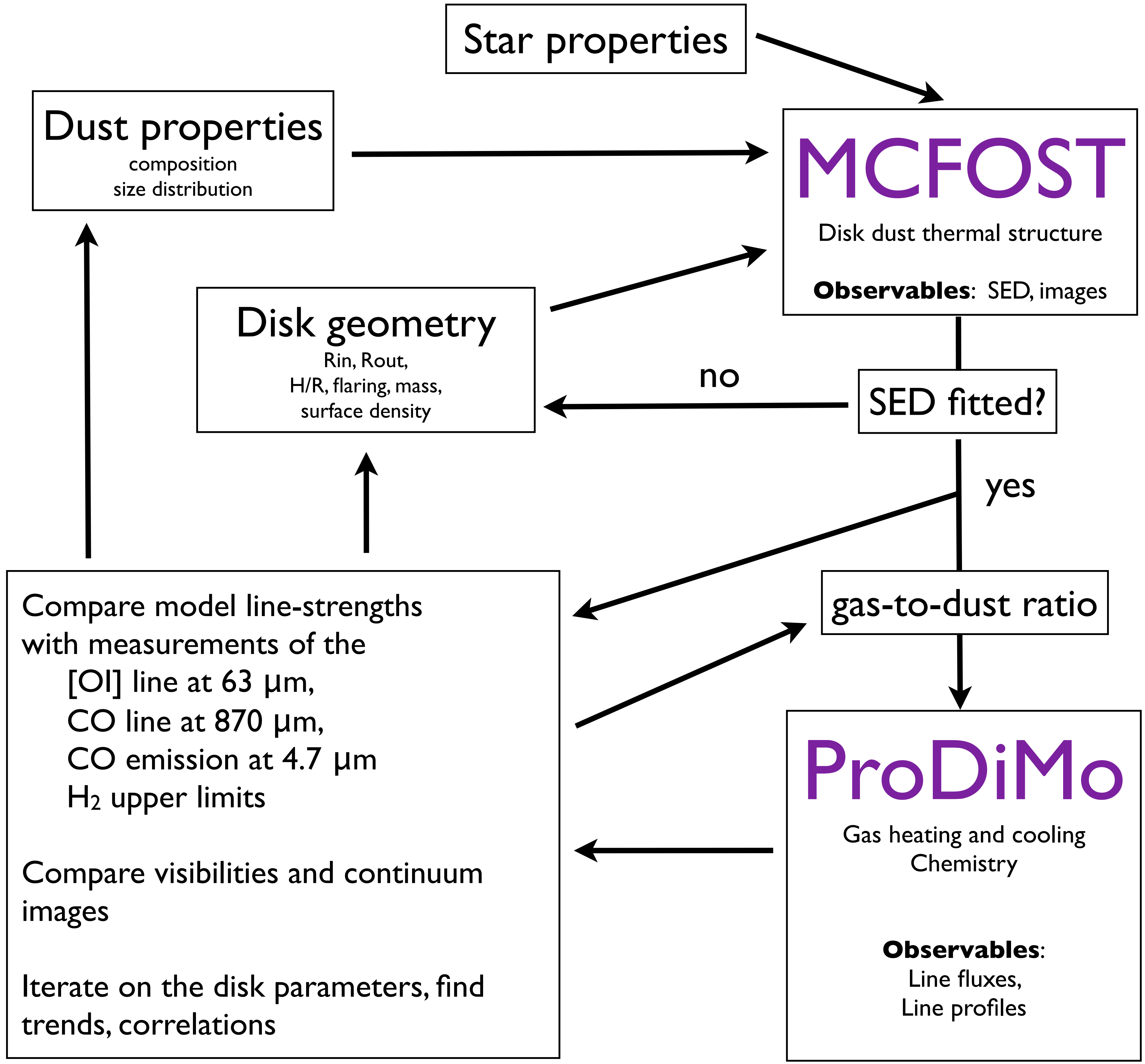
• Surface density & change in gas/dust ratio : compatible with the planet scenario

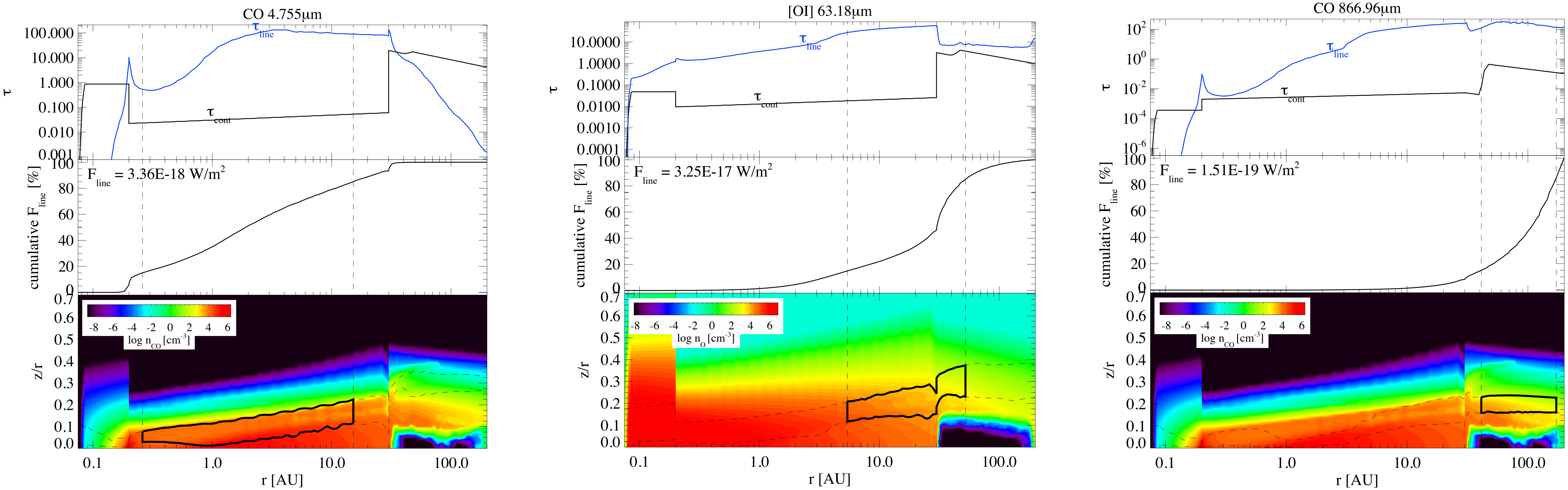
• Small gaps of few AU in the gas are compatible with the data

• gas mass is lower than expected for the amount of dust observed: HD 135344B is an evolved object

• Dust segregation (in size & in composition)

Carmona et al 2014


Star properties
Dust properties
composition
size distribution
MCFOST
Disk dust thermal structure
Observables: SED, images
Disk geometry
Rin, Rout,
H/R, flaring, mass,
surface density
no
SED fitted?
yes
gas-to-dust ratio
Compare model line-strengths with measurements of the
[OI] line at 63 µm,
CO line at 870 µm,
CO emission at 4.7 µm
H2 upper limits
Compare visibilities and continuum images
Iterate on the disk parameters, find trends, correlations
ProDiMo
Gas heating and cooling
Chemistry
Observables:
Line fluxes,
Line profiles


CO 4.755μm
[OI] 63.18μm
CO 866.96μm
τ
τ_line
τ_cont
cumulative F_line [%]
F_line = 3.36E-18 W/m²
F_line = 3.25E-17 W/m²
F_line = 1.51E-19 W/m²
z/r
log n_CO [cm⁻³]
log n_O [cm⁻³]
r [AU]