YSO studies in context

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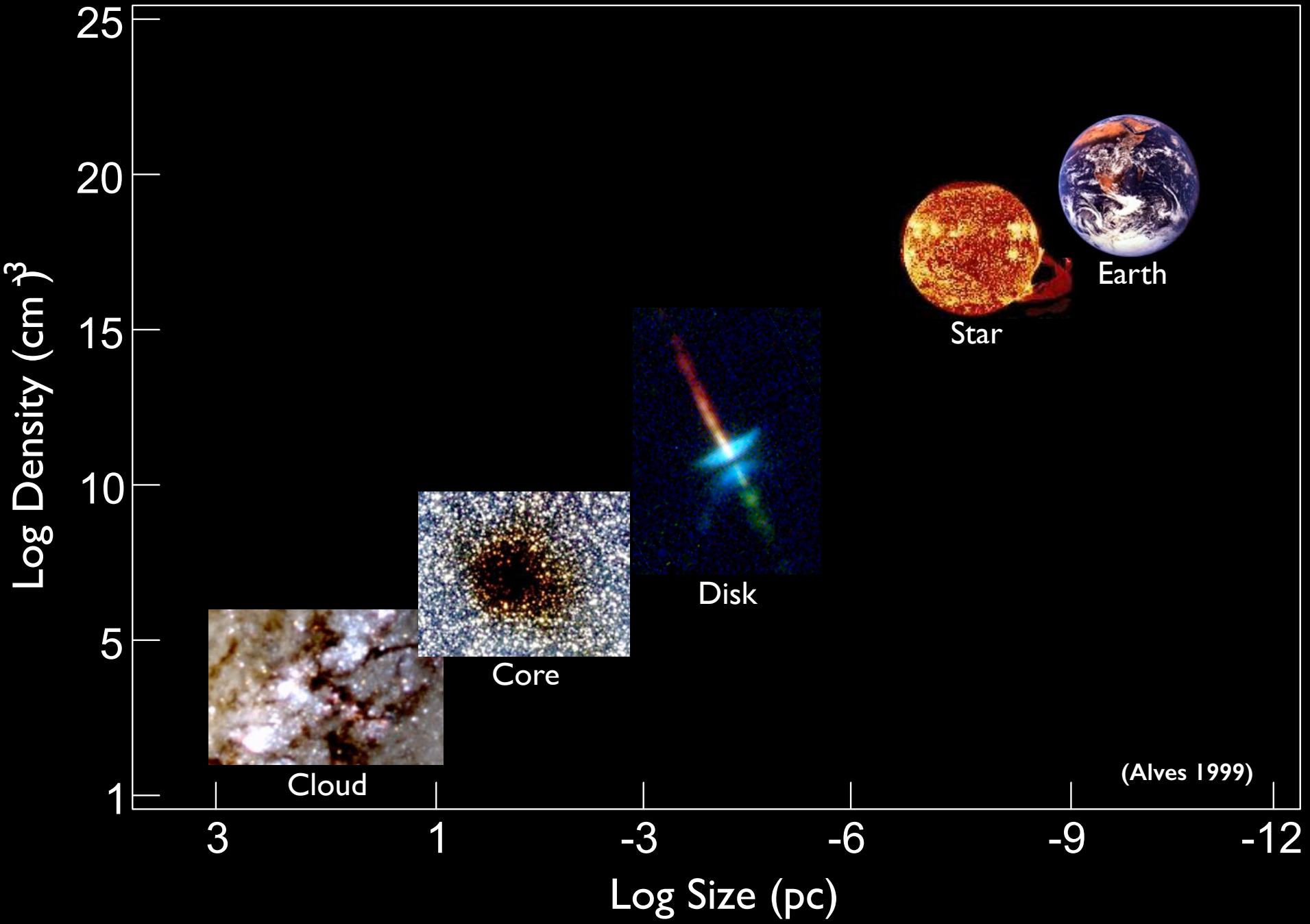
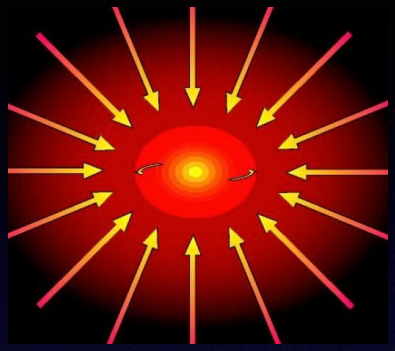
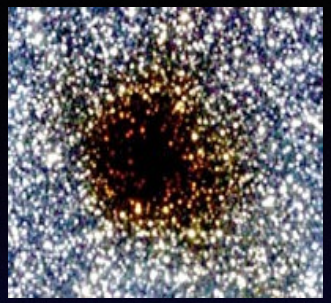
- Focus on (proto-)star-disk interactions
- Issues and potential contributions from VLTI
- I will not cover: High mass stars/multiplicity/disks

From diffuse gas to Stars and Planets

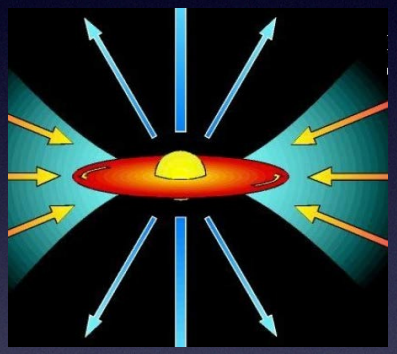


From Cores to Planetary Systems

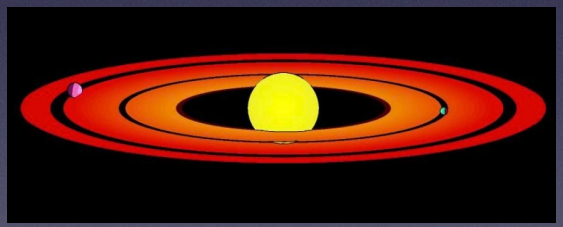


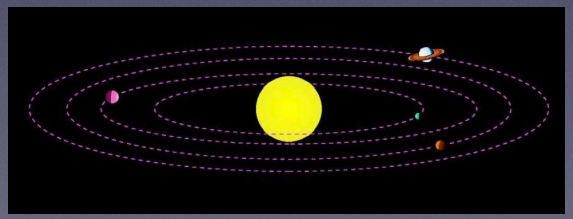


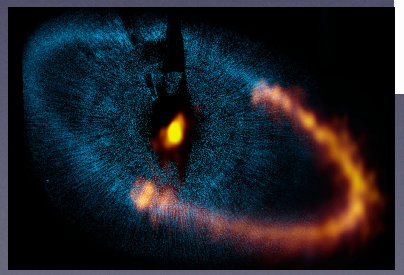
Core



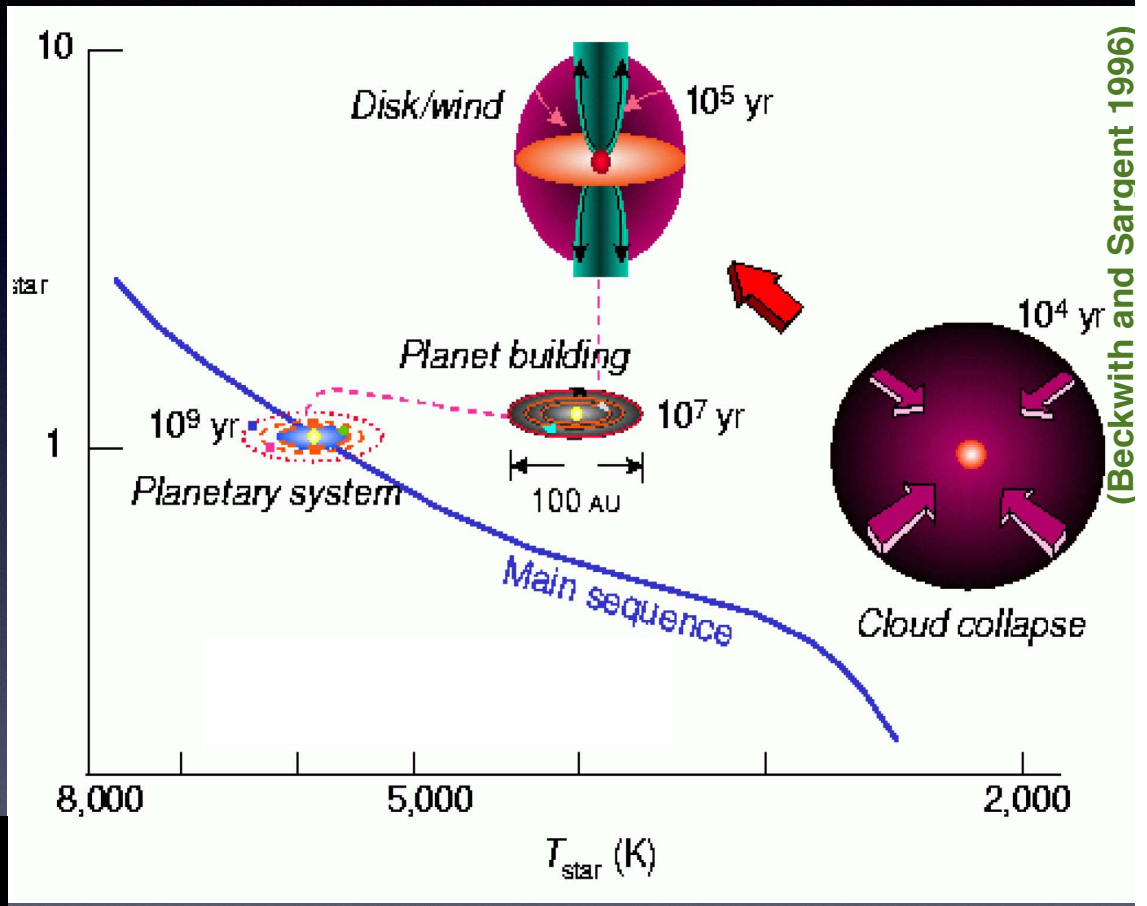
Disk





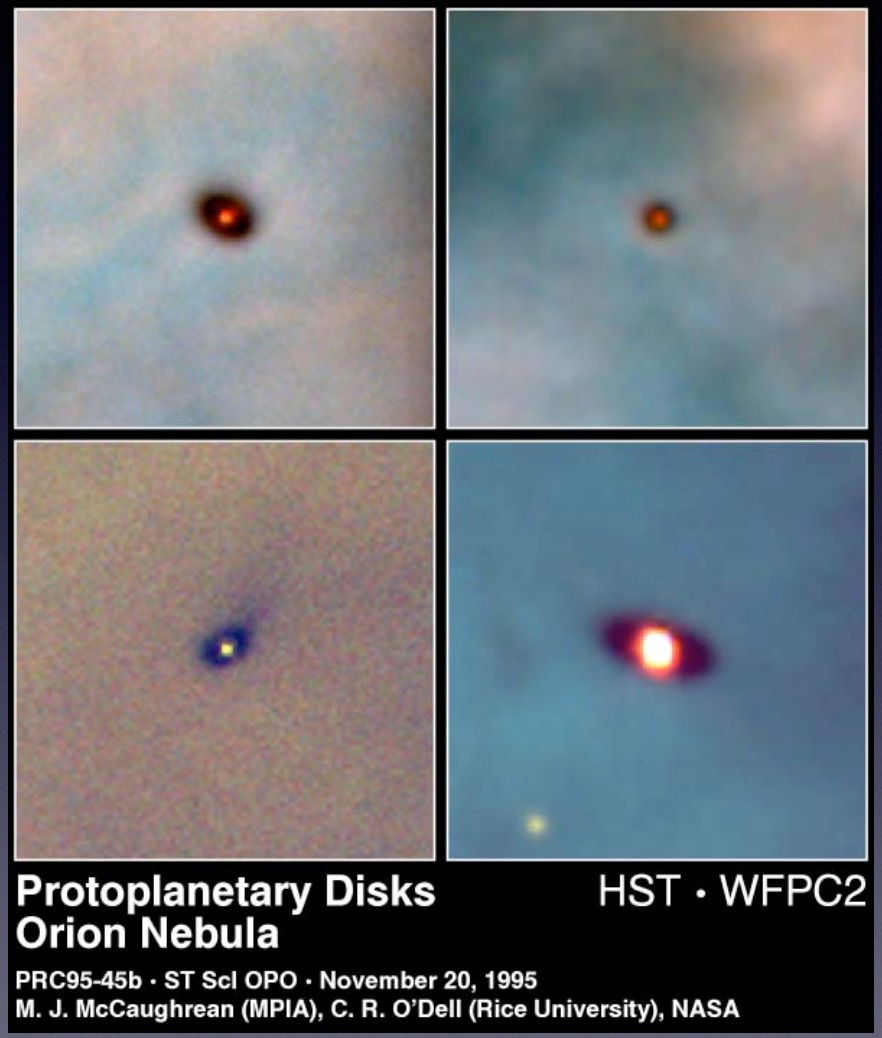


Debris Disk

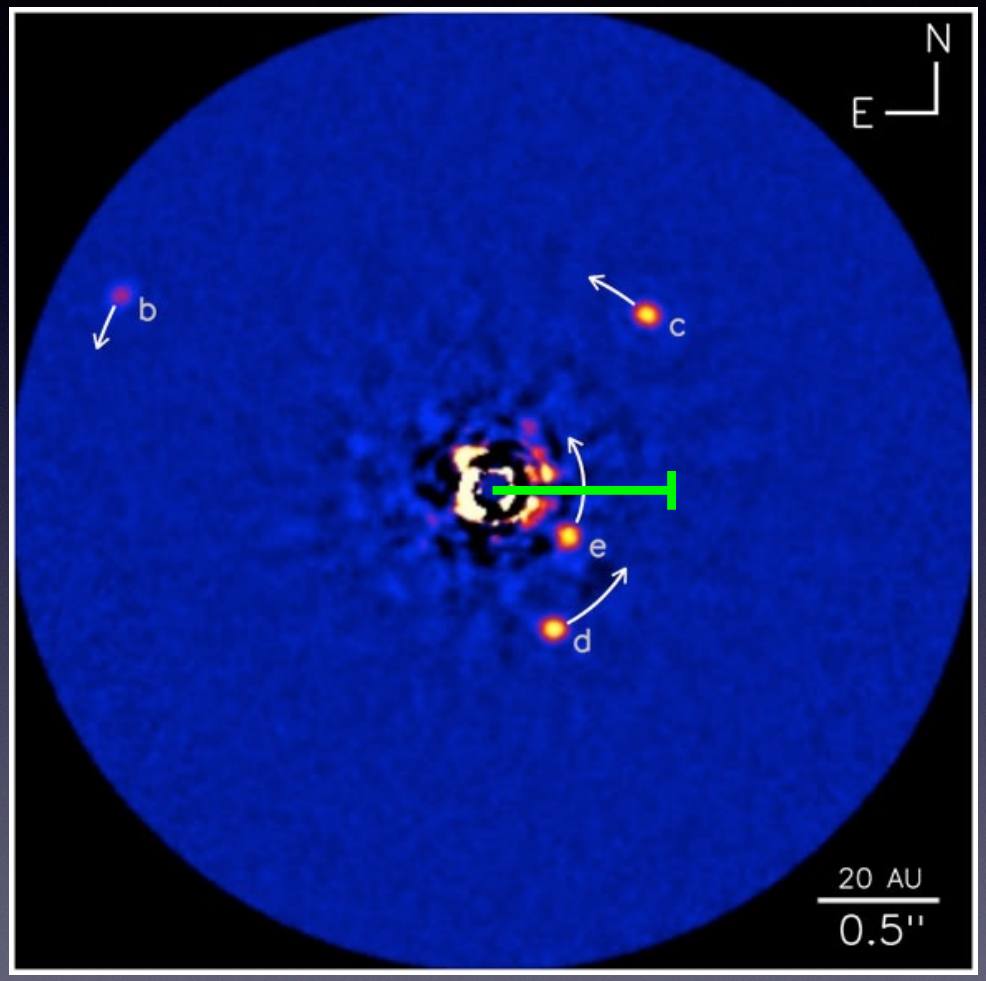


(Beckwith and Sargent 1996)

Origins of Planetary Systems

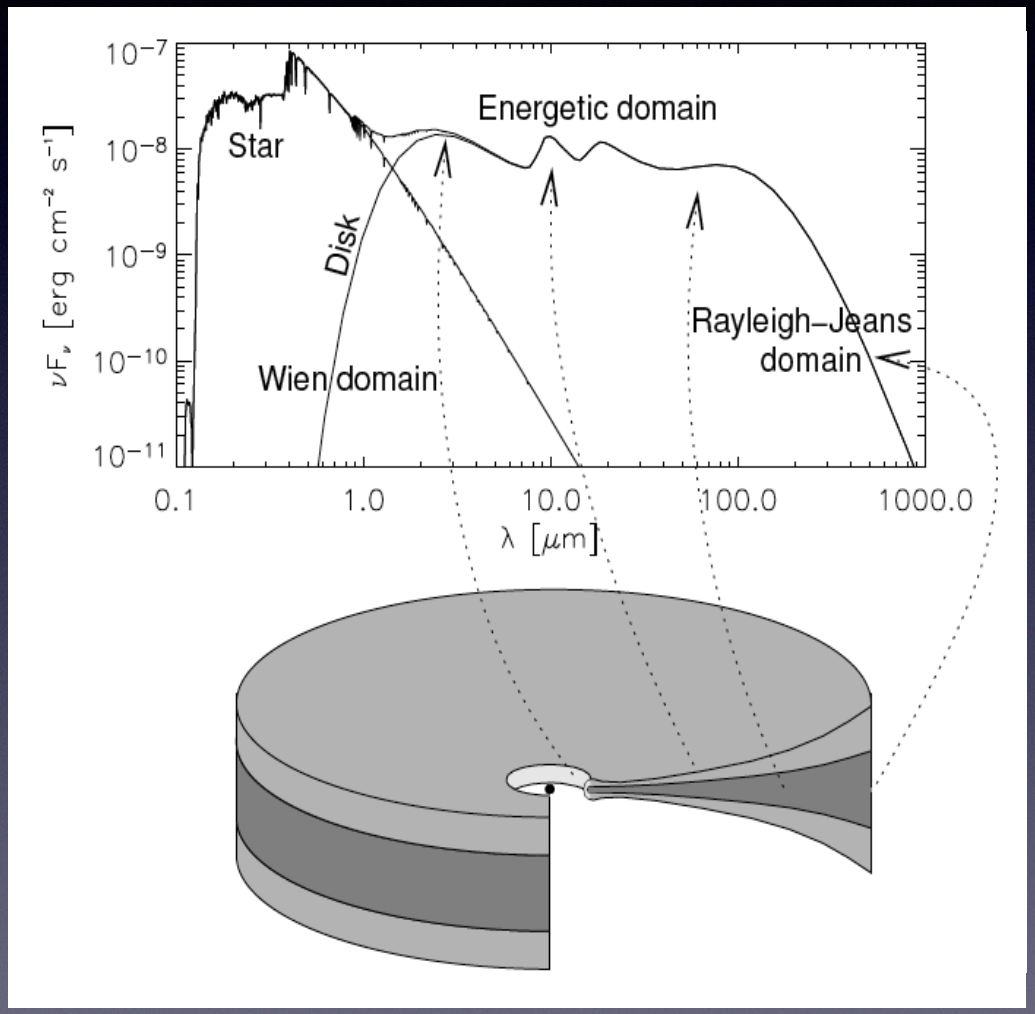


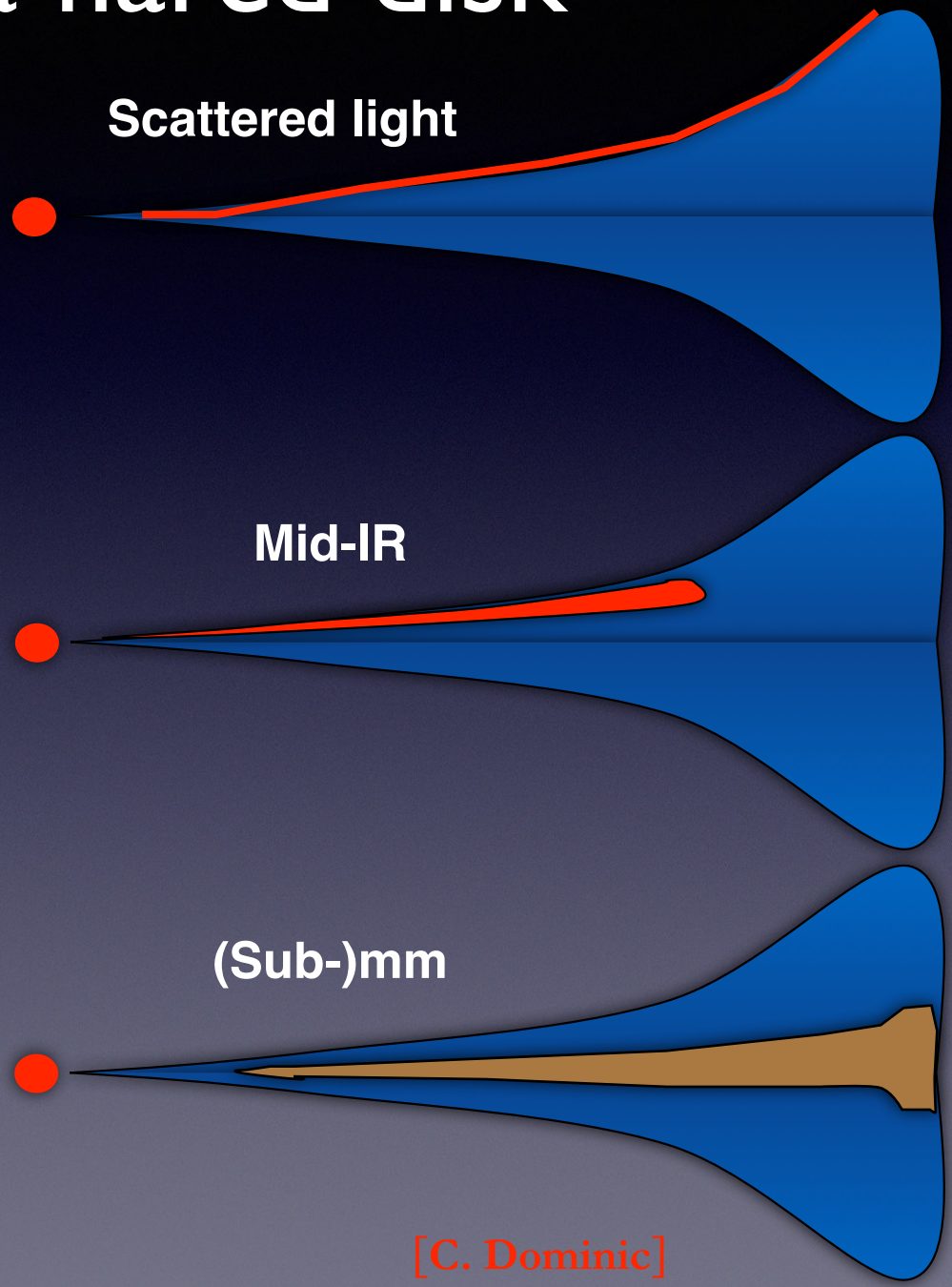
(McCaughrean & O'Dell 1995)



(Marois et al. 2010)

Emission of a flared disk

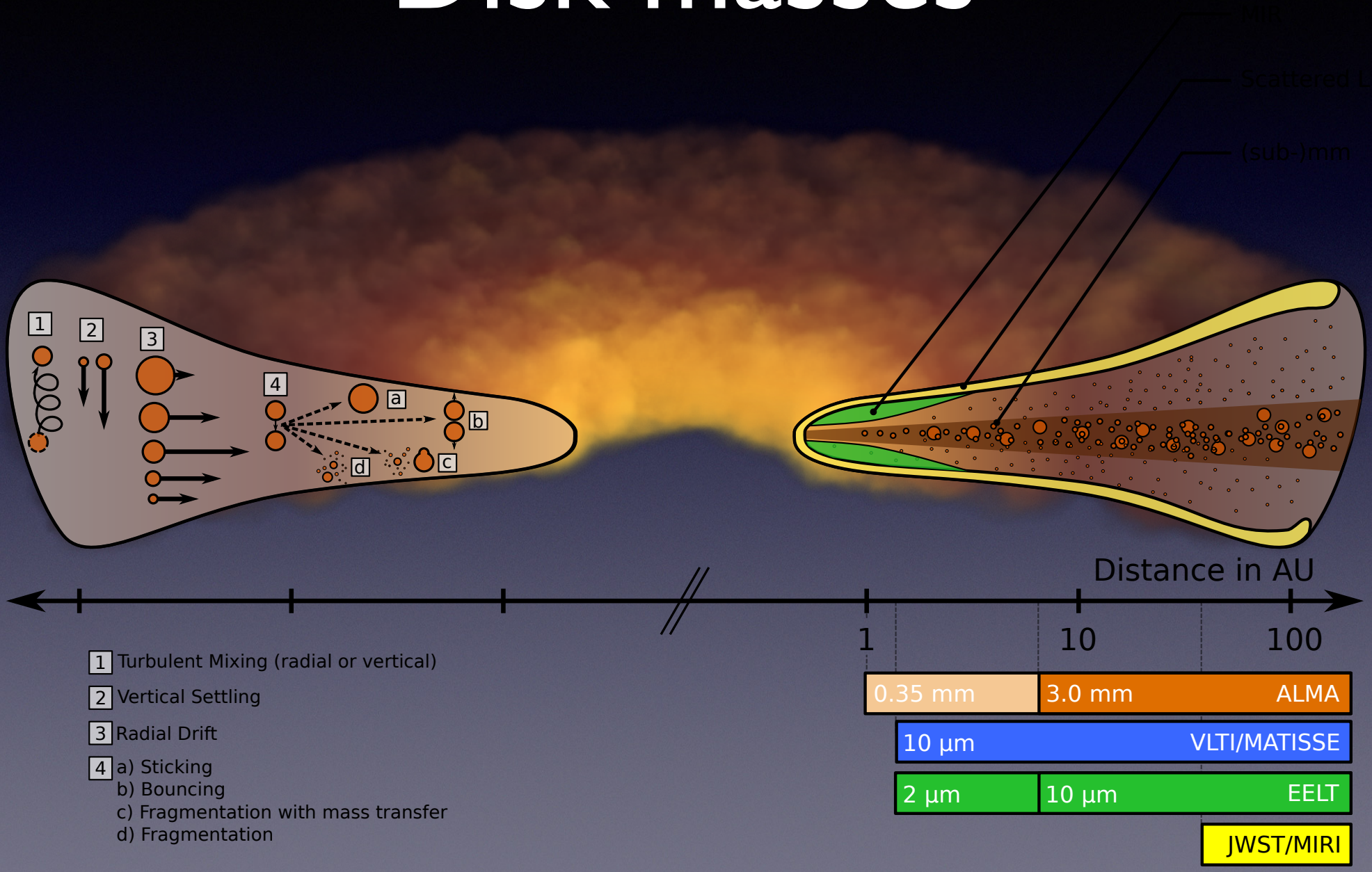




[C. Dullemond]

[C. Dominic]

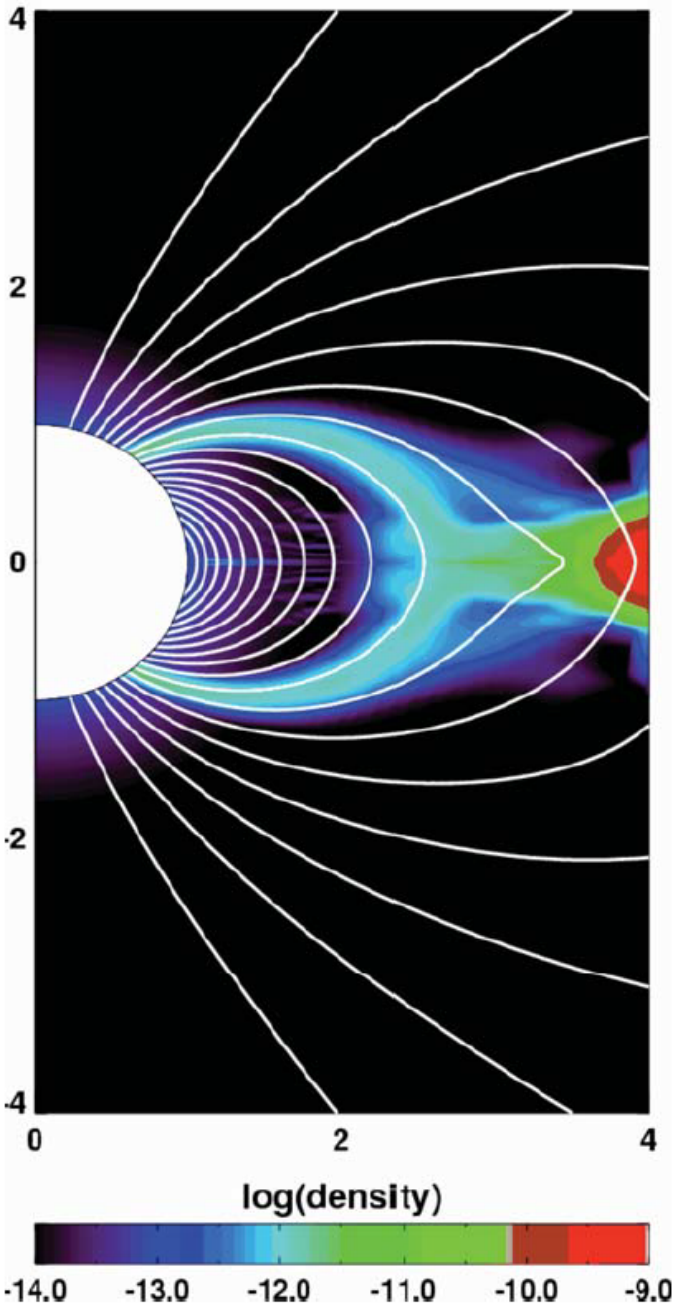
Disk masses


MIR
Scattered Light
(sub-)mm
1
2
3
4
a
b
c
d
Distance in AU
1
10
100
1 Turbulent Mixing (radial or vertical)
2 Vertical Settling
3 Radial Drift
4 a) Sticking
b) Bouncing
c) Fragmentation with mass transfer
d) Fragmentation
0.35 mm
3.0 mm
ALMA
10 µm
VLTI/MATISSE
2 µm
10 µm
EELT
JWST/MIRI

Some key questions

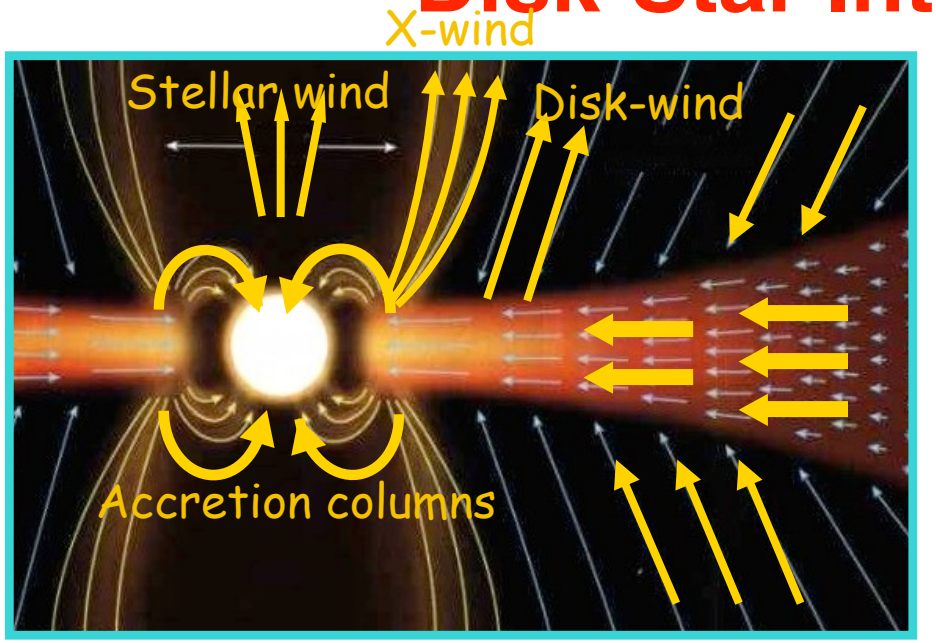
- Detailed structure and evolution of the disk-star interface
    - (Magnetospheric) Accretion
    - Role of jets/winds in disk evolution
    - Evolution of the inner disk during planet formation
- [Evolution of the YSO photosphere]
- Inner disk variability!

Disk-Star Interaction Region

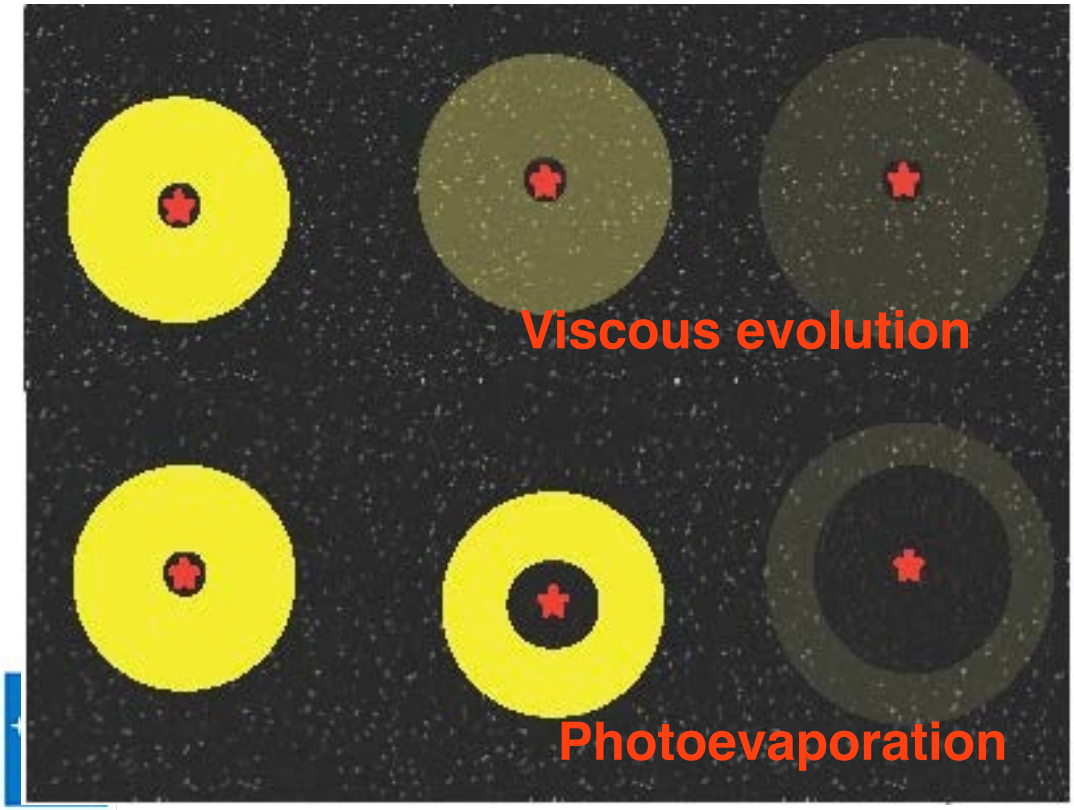


- Ingredients:
  - Young (evolving) stellar photosphere
  - Magnetic Field
  - Dusty disk evolving
  - Gaseous inner disk accreting/outflowing
- What we know:
  - Evolution of the star is tightly coupled to the disk and vice versa
  - Very little on magnetic fields
  - Gas (chemistry) and dust (size distribution) evolve with time and are affected by the star
  - Structure (and its evolution) of the inner disk is critical for outcome of planet formation (planets in habitable zone and their characteristics)
- 1 AU @ 150pc = 7 mas

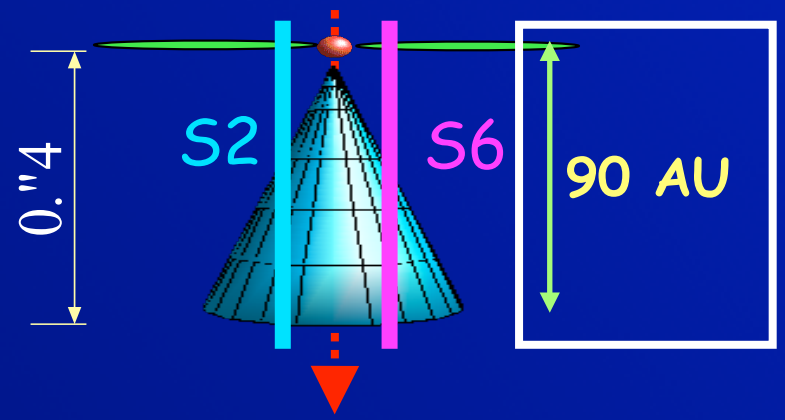
Disk-Star Interaction Region



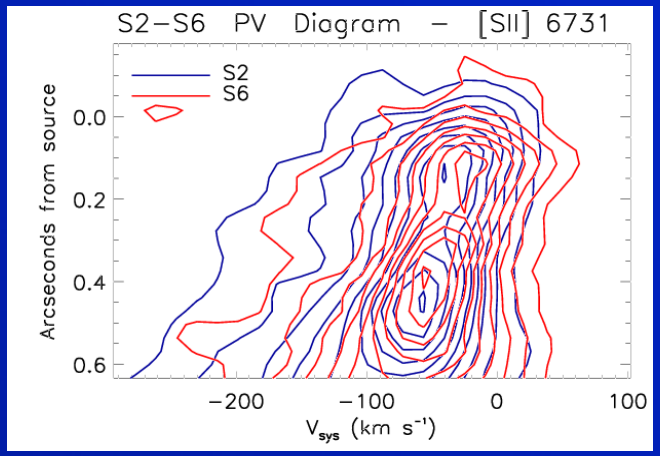
- Accretion is driven by viscosity
  - Accretion is linked to the inner stelalr and/or “X-”wind.
- What we know:
  - Photoevaporation removes the disk inside-out
- Planet formation “competes” for resources with these two processes and interacts with them

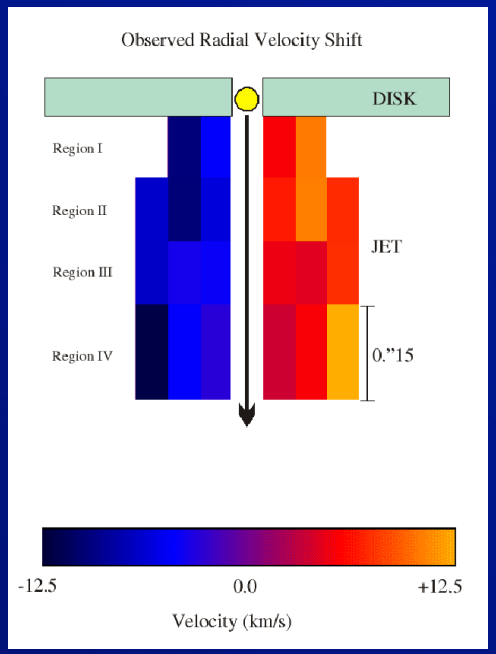


First detections of jet base rotation : DG TAU, RW AUR



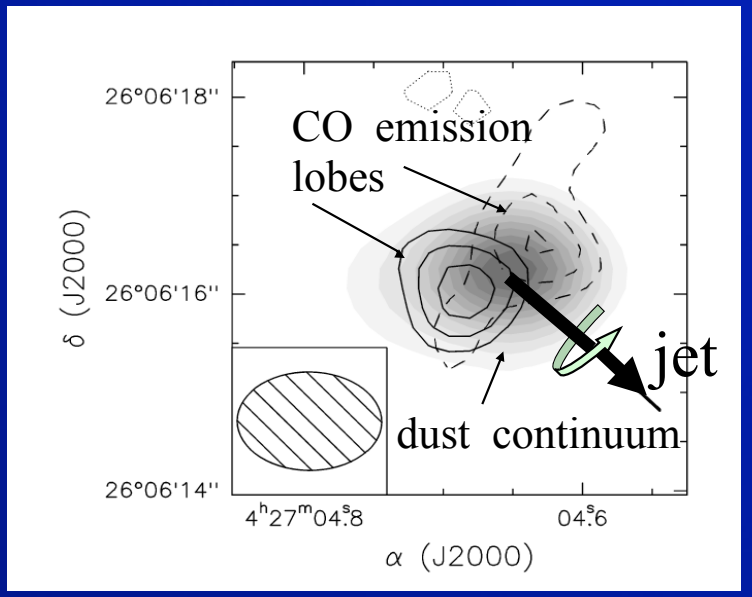
Small VELOCITY SHIFT
in symmetrically opposed slits (in all lines, corrected for uneven slit illumination)





30 AU

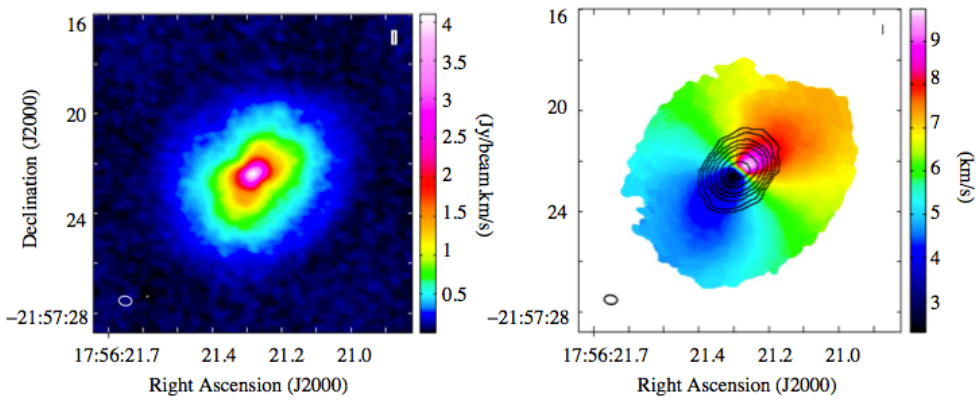
Bacciotti et al, 2002 ApJ

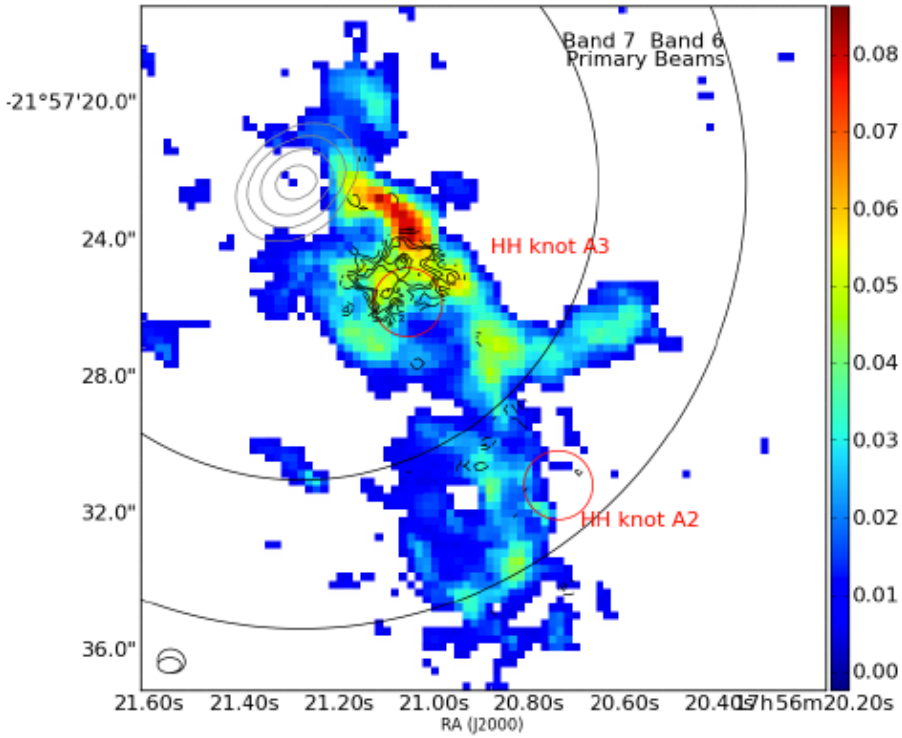


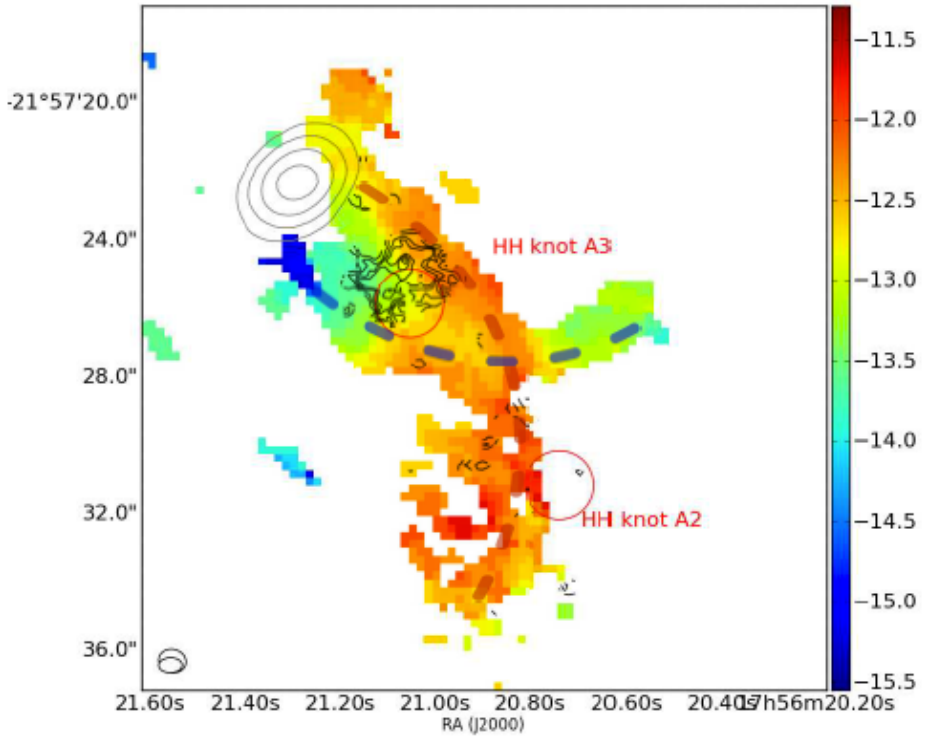
DG Tau disk rotates in the same sense and along the same rotation axis

Testi, Bacciotti et al. 2002, A&A

HD163296 as seen by ALMA





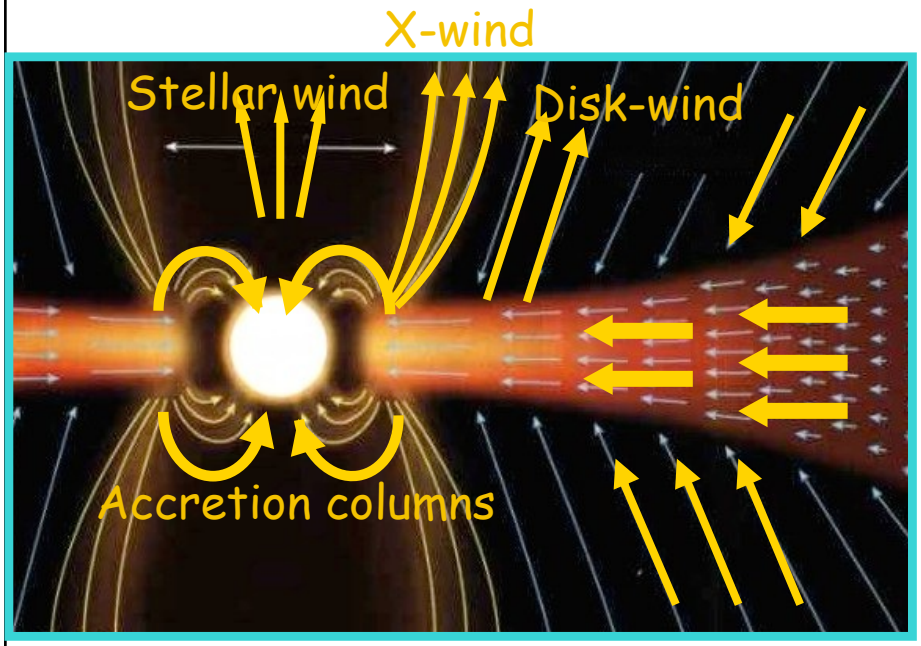


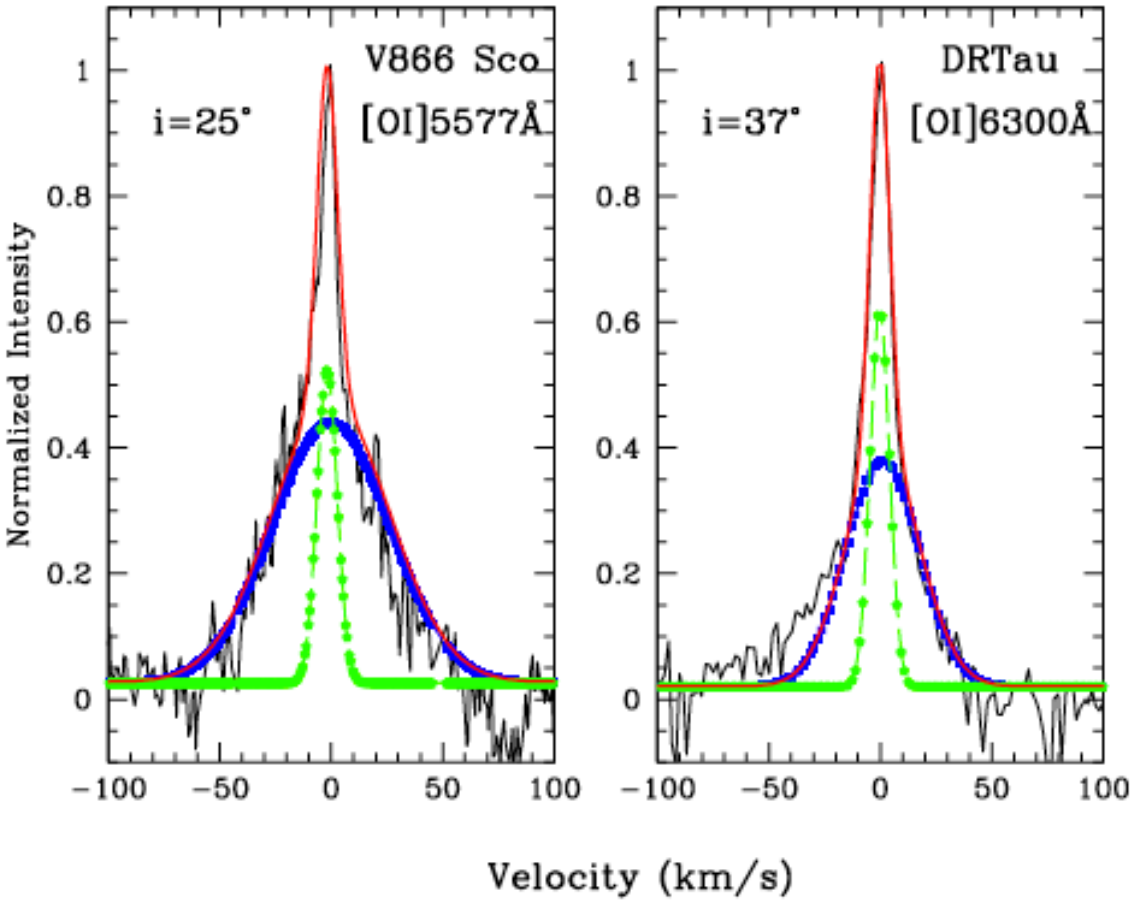
(Klaassen et al. 2013)

- CO disk wind

Winds in optical forbidden lines

Low Velocity Component





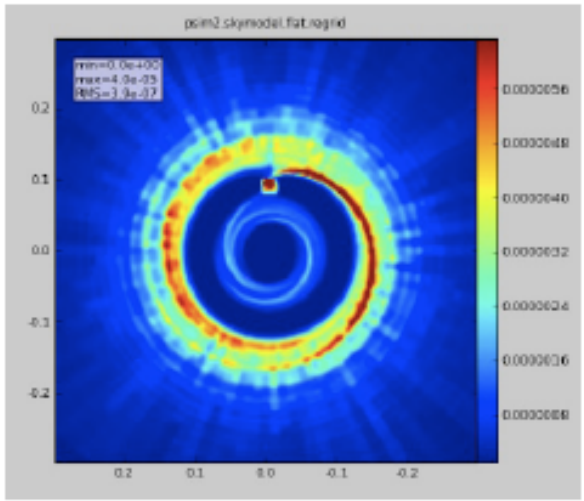
(Rigliaco et al. 2013)

- Working hypothesis:
  - Narrow component is the real wind from outer disk
  - broad component is photodissociated upper layer of the inner disk

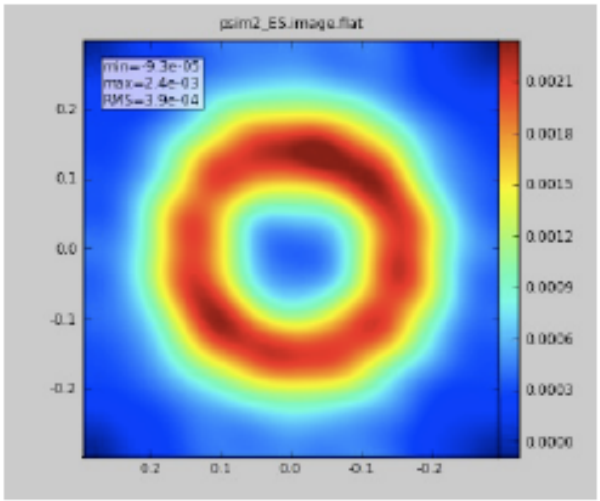
Observing gaps with ALMA

Proto-planetary disk (ALMA band 9)

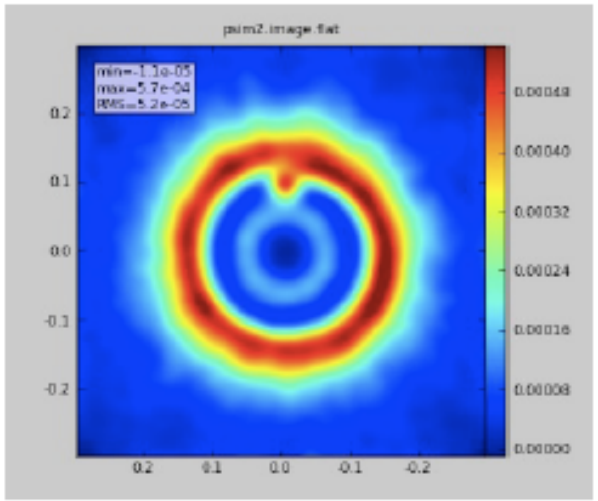
A simulation by Sebastian Wolf (Wolf and D'Angelo 2005)



Skymodel

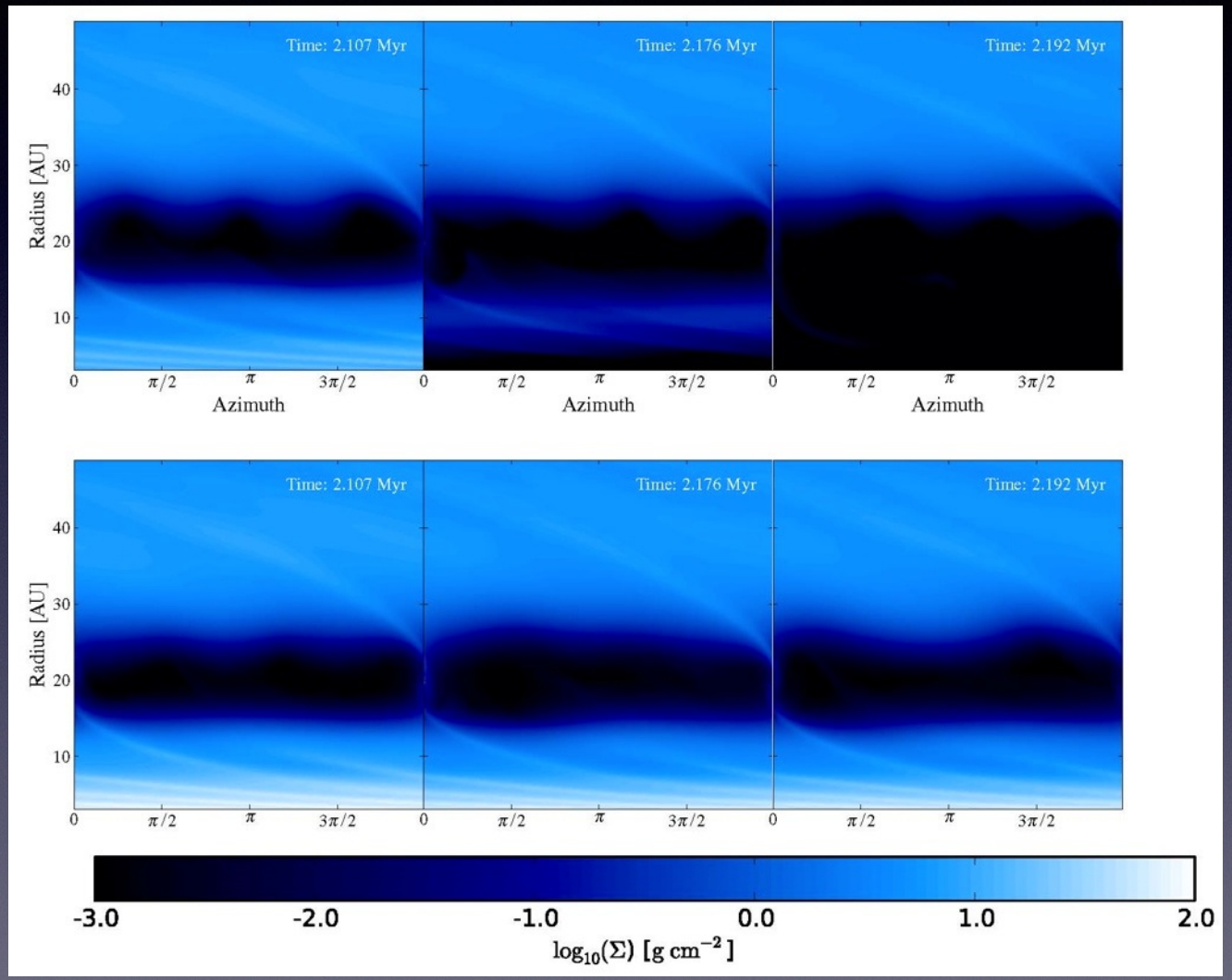


Early Science
(30 mins)



Full Array
(10 mins)

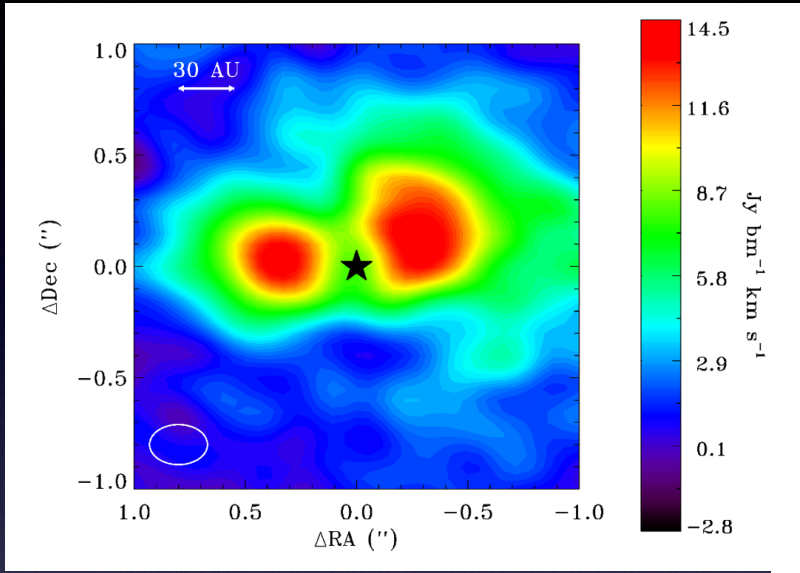
Are gaps long-lived?



(Rosotti et al. 2013)

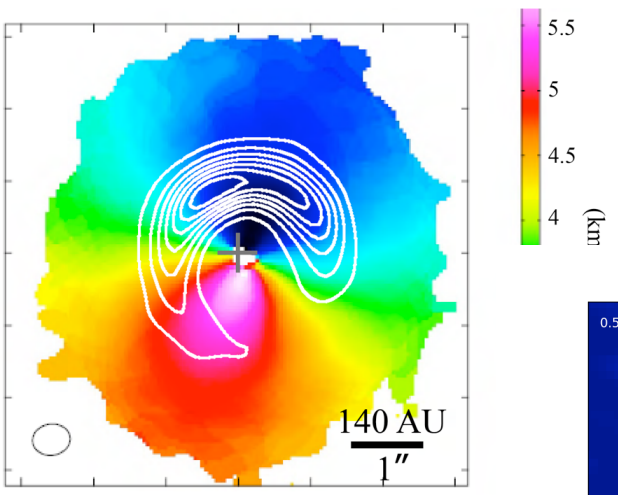
- Disk-Planets-Photoevaporation: initial simulations

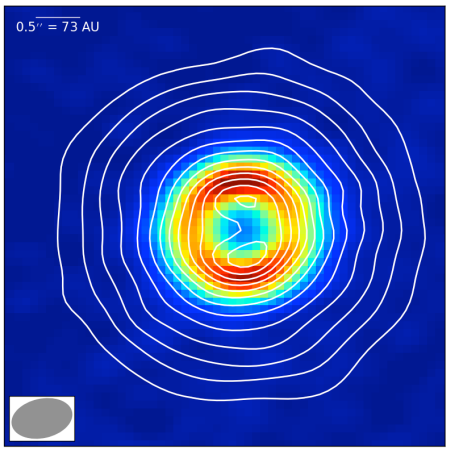
Transitional disks



IRS48: dust and gas

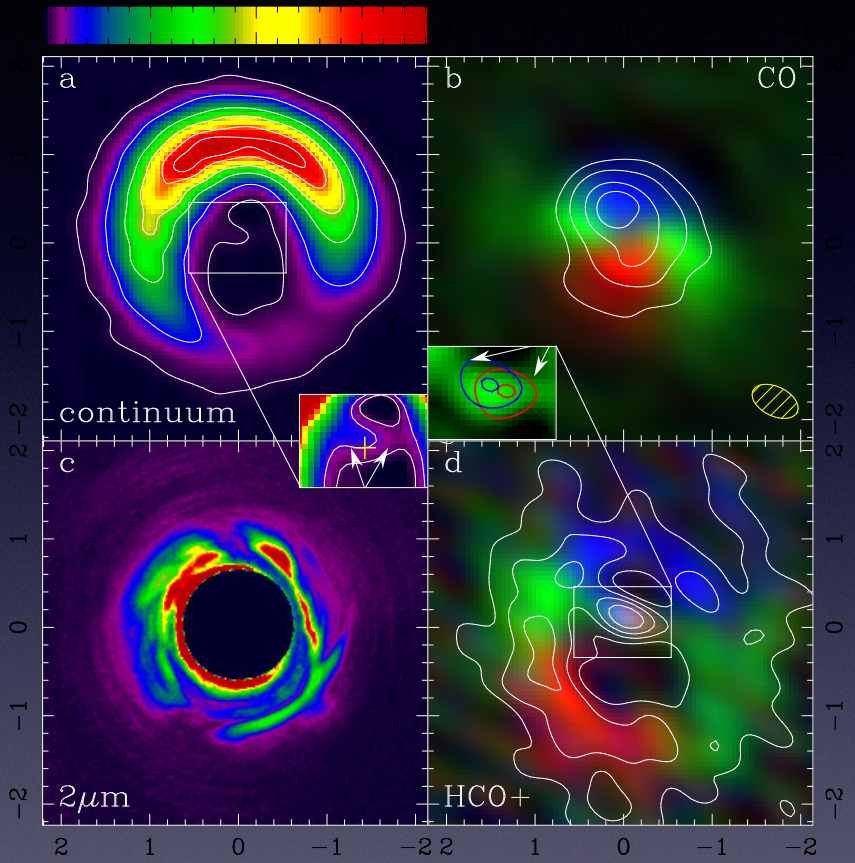
HD142527: dust and gas



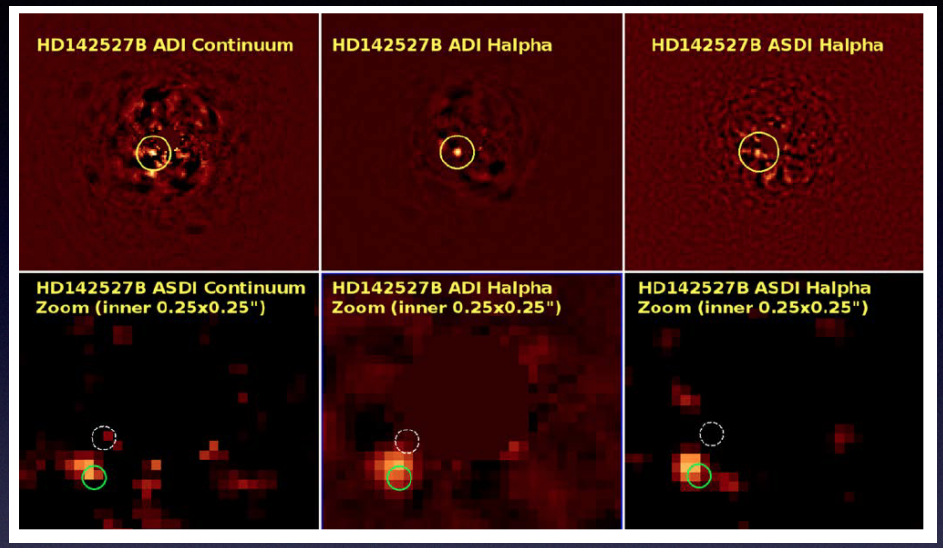


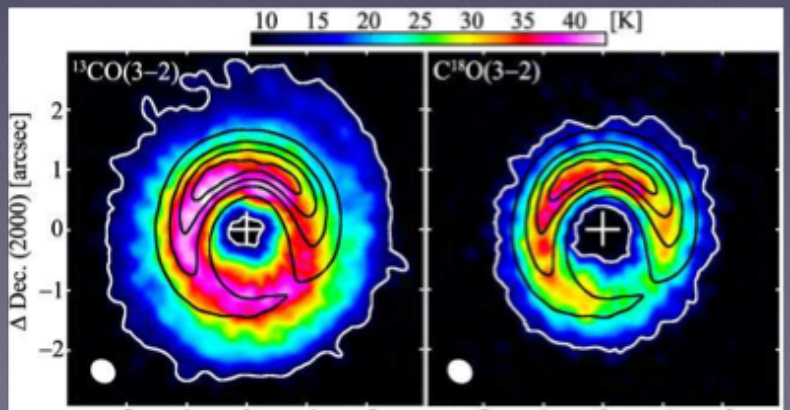
J160421.7 (Carpenter; see also Mathews et al. 2012)

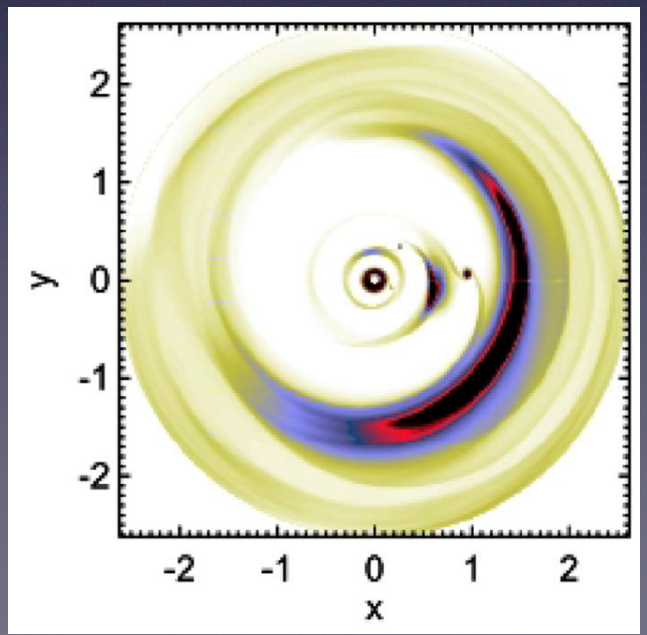
Example: HD142527



(Casassus et al. 2013; Fukagawa et al. 2013)

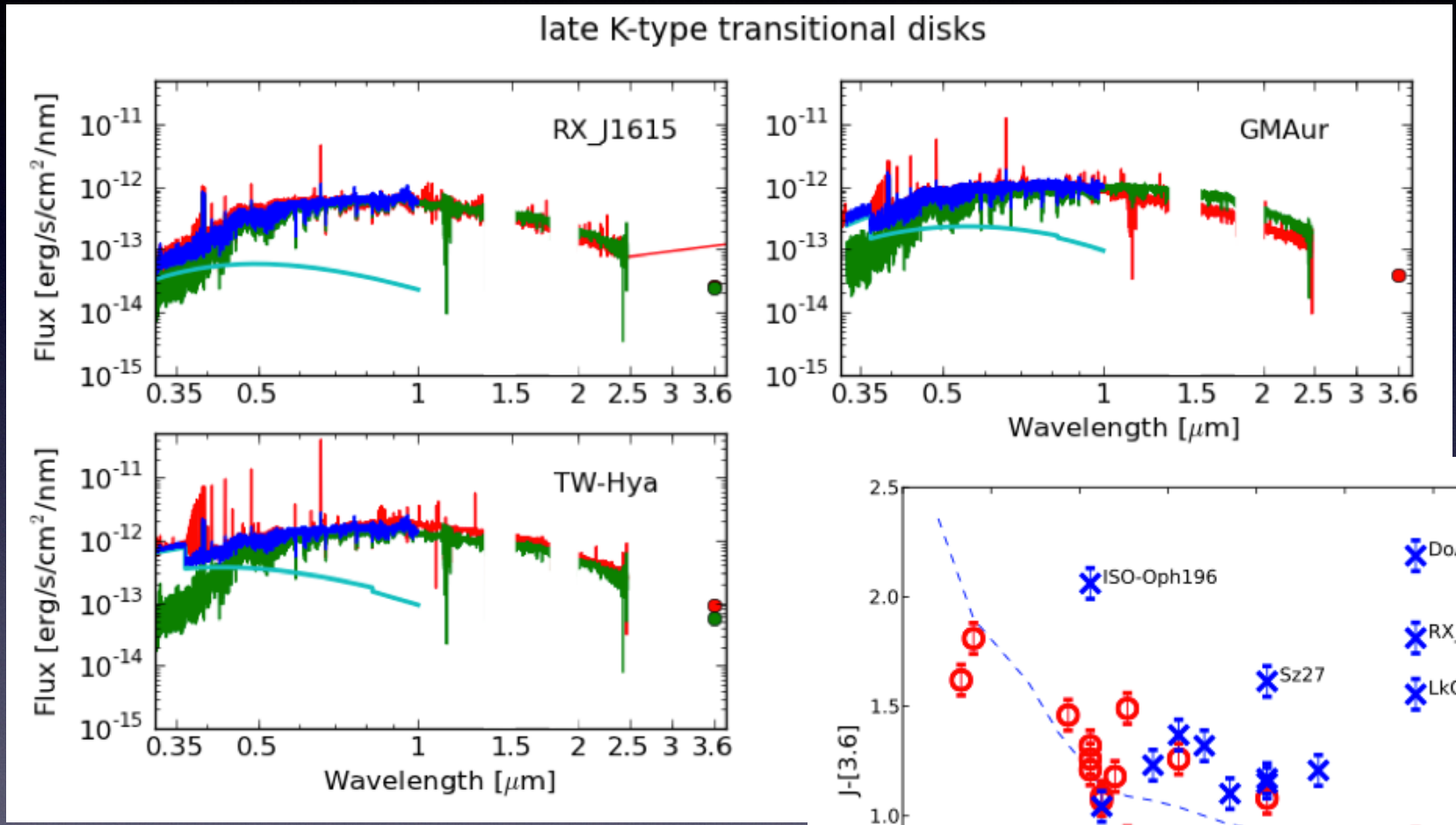


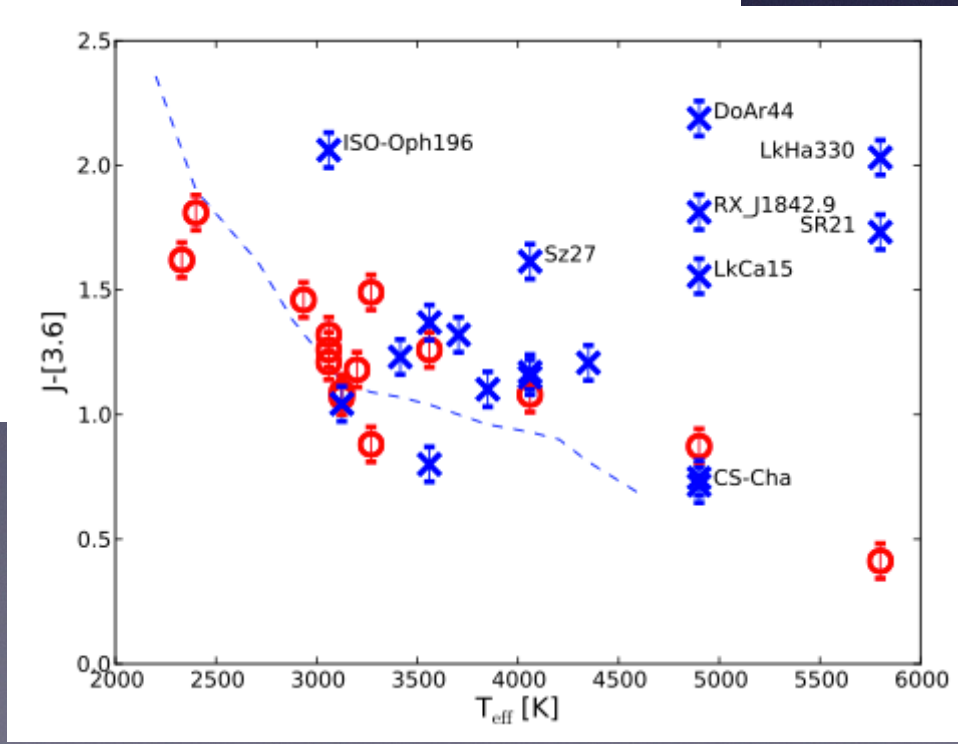




(Close et al. 2014)

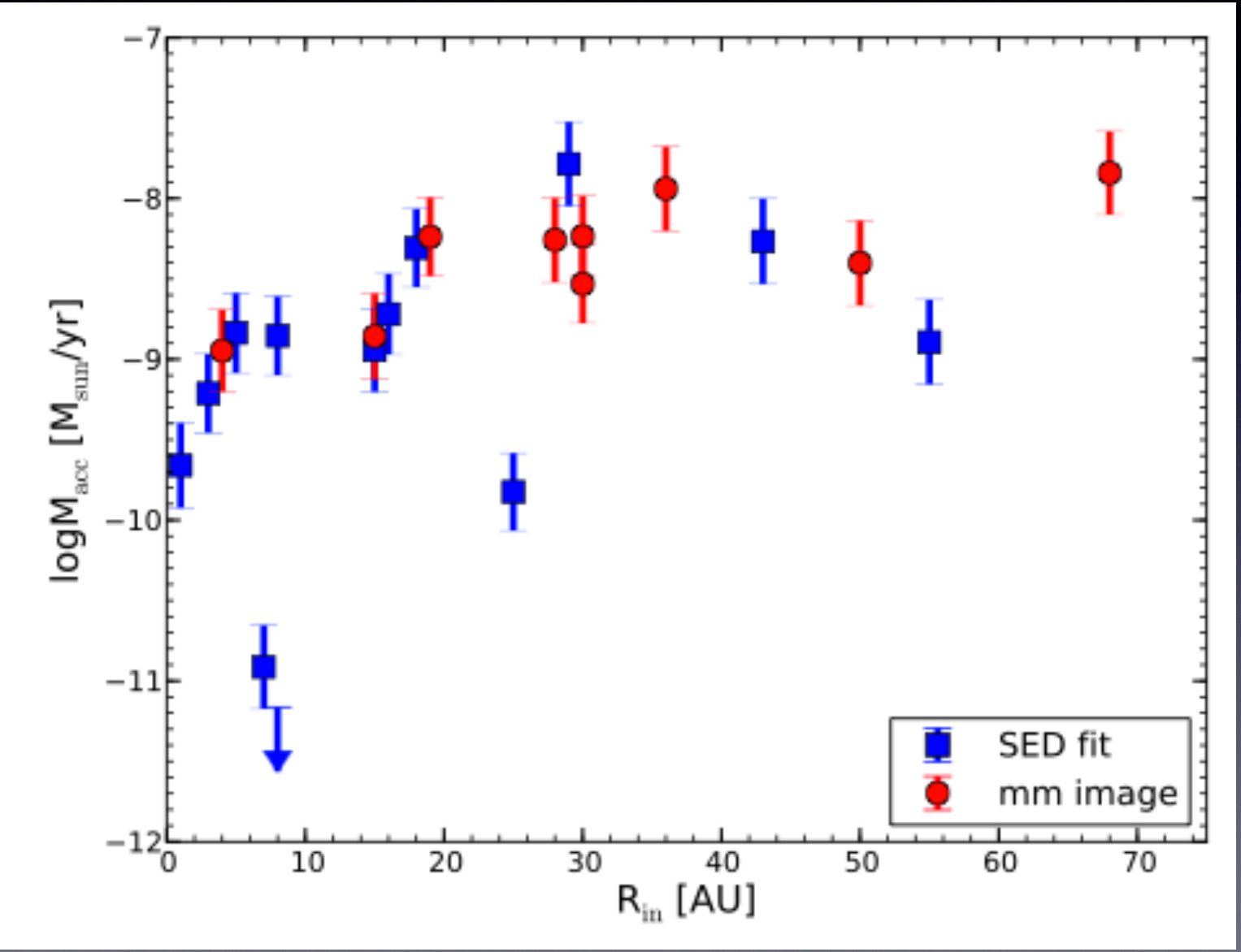
Inner regions of TDs





(Manara et al. 2014)

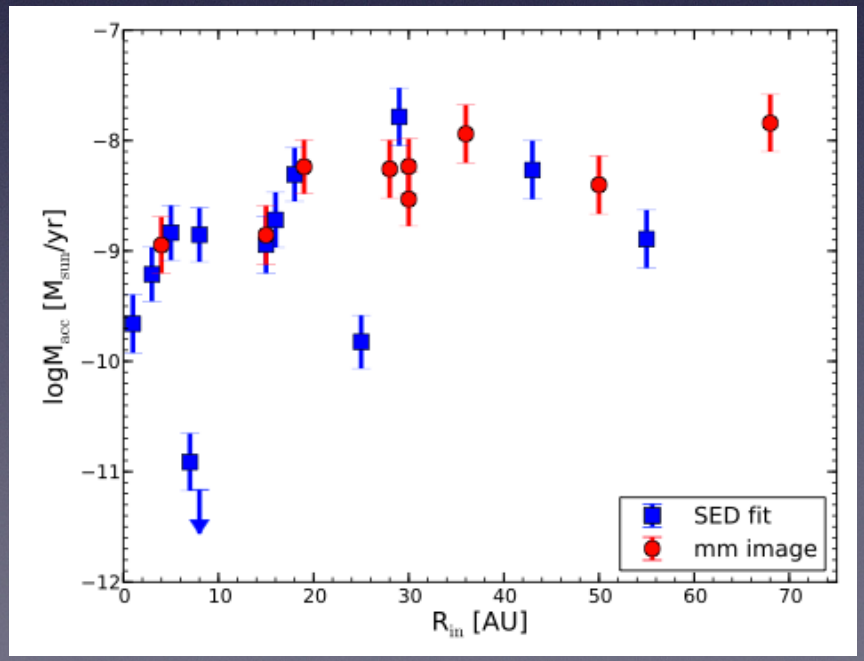
Inner regions of TDs



(Manara et al. 2014)

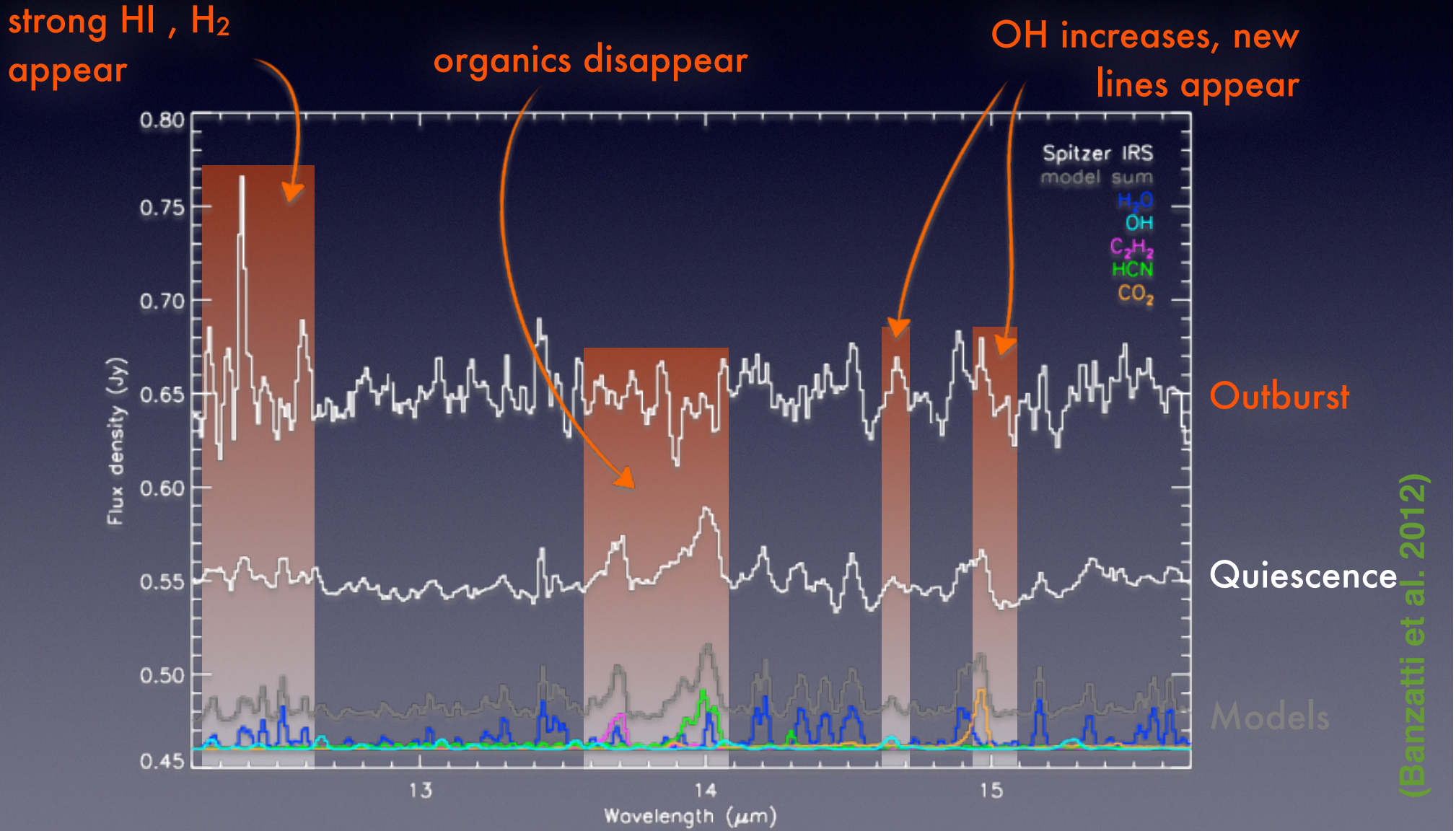
Inner regions of TDs

- Gas rich inner disk?
  - Fast filtration of material through planets?
  - Accumulation in an "inner" disk?
- VLTI!!!



(Manara et al. 2014)

Effects of variable accretion on inner disk chemistry



Summary

- Key questions are related to the disk-star interaction during planet formation
  - Disk inner structure and relation with wind-outflow (and its evolution)
  - Accretion and the interaction between disk and stellar magnetosphere
  - Disk-planet interactions and evolution of inner disk
- What is unique for VLTI?
  - Angular resolution/wavelength coverage (need spectral resolution!)
- Next frontier
  - Spatial-kinematical resolution of the planet formation zone
  - Quantitatively address the effects of variable activity on disk chemistry