ESO Herbig Ae/Be Workshop (Faulty) Summary

Nuria Calvet
University of Michigan

Astronomy

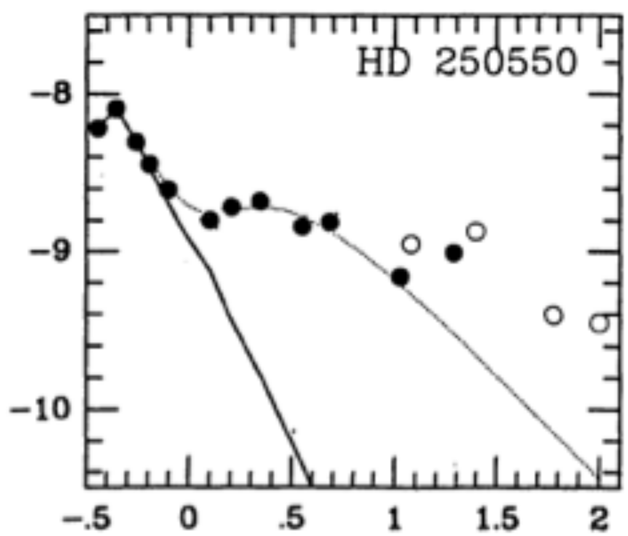
1992 Conference in Amsterdam

Disks or Envelopes?

Hillenbrand et al. 1992

Massive circumstellar disks

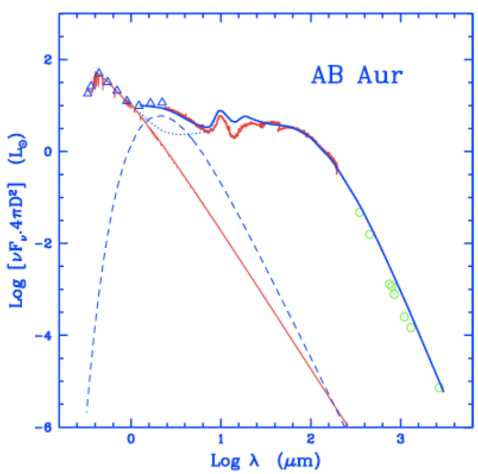
Near-IR "bump" at ~ 2.2-3 μm, R_{hole} ~ 3-25 R_*

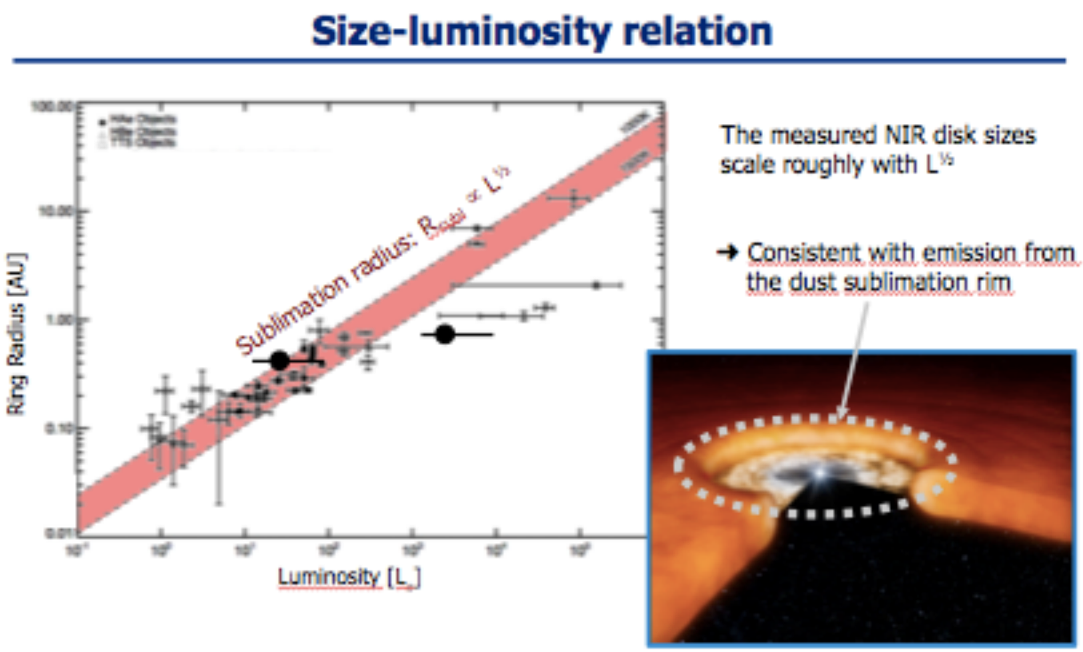


Dust sublimation radius

Emission from inner disk wall

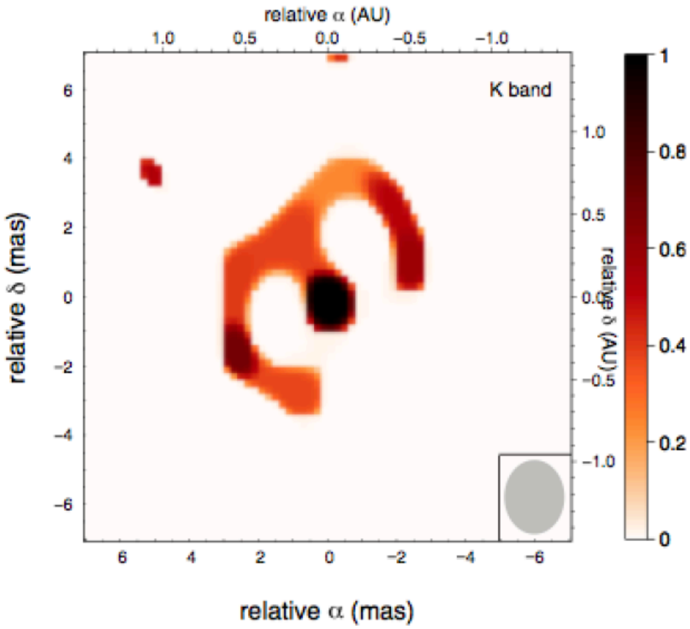
Natta et al 2001; Tuthill et al. 2001

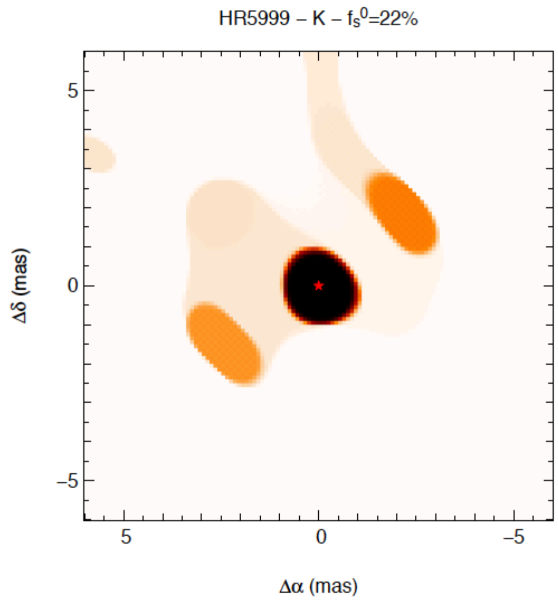


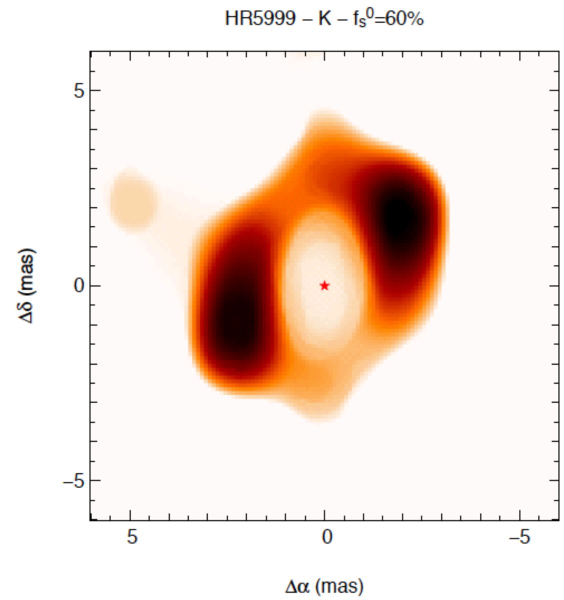


Kraus

Evidence for a puffed-up inner rim: Imaging







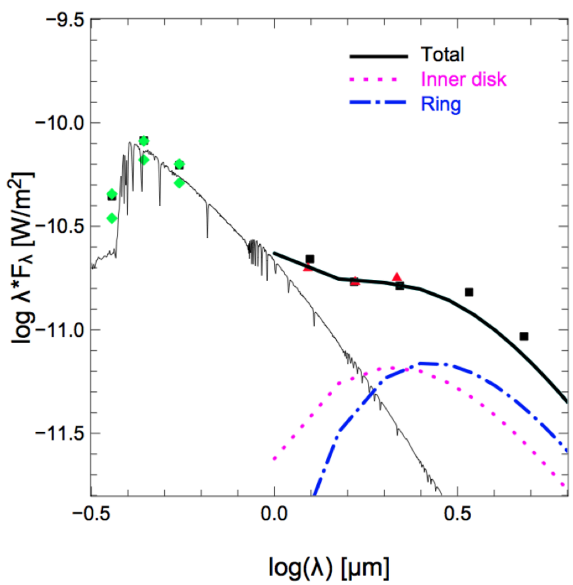
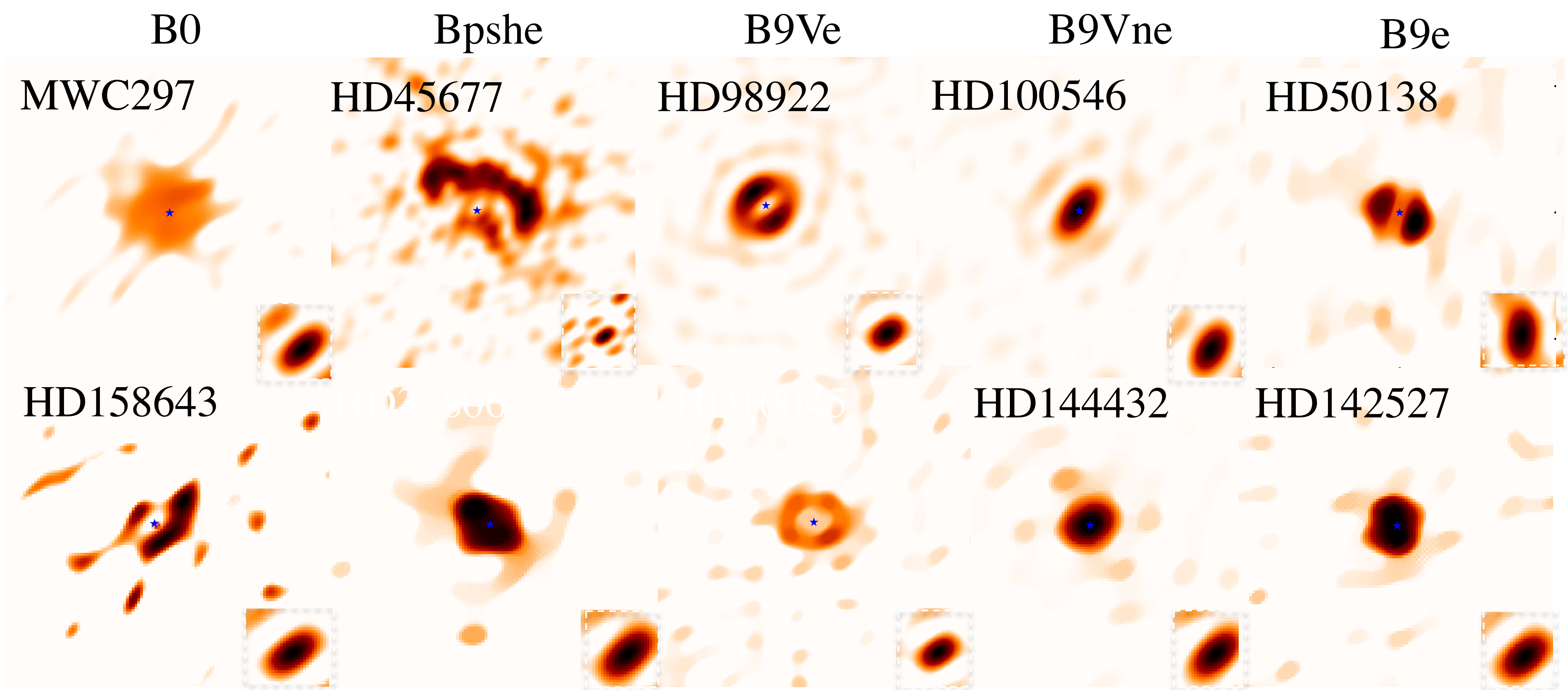


Image after removing the photospheric contributions

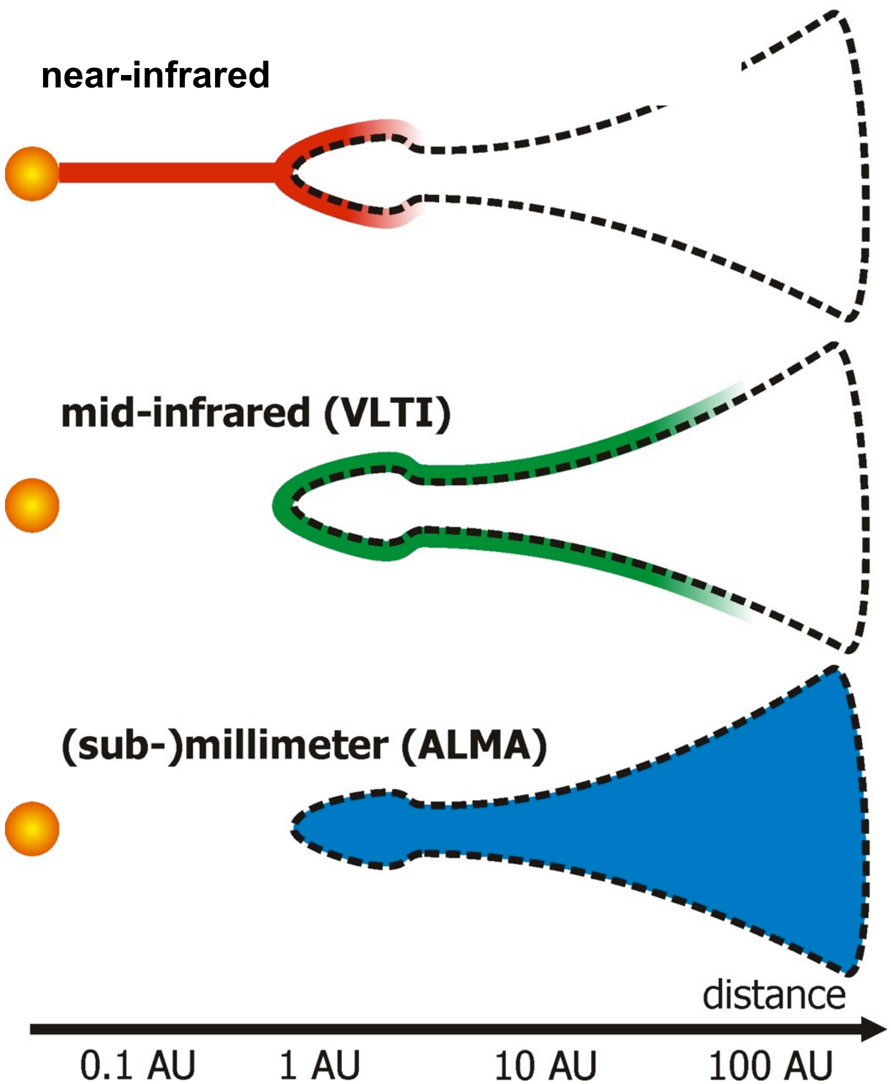
Image after removing photospheric and inner disk contributions

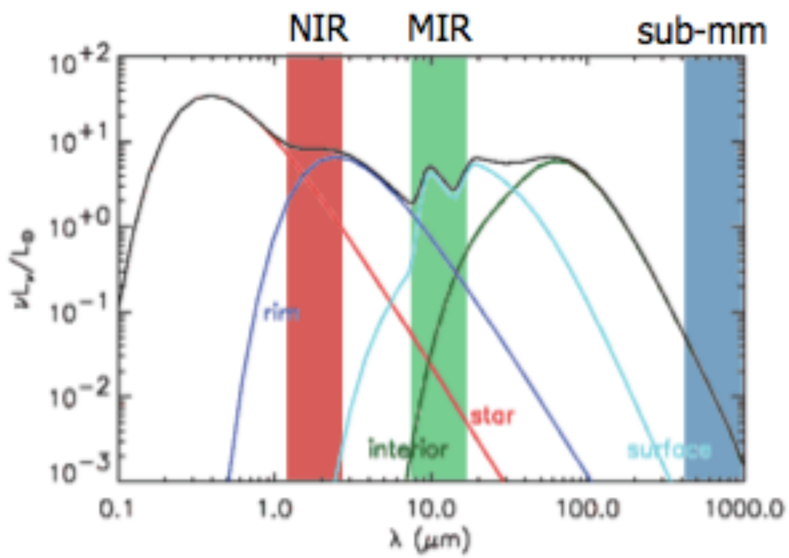
Kruska, Thi

Images from HAeBe survey PIONIER



Multi-wavelength interferometry





NIR/MIR/mm wavelength regimes…

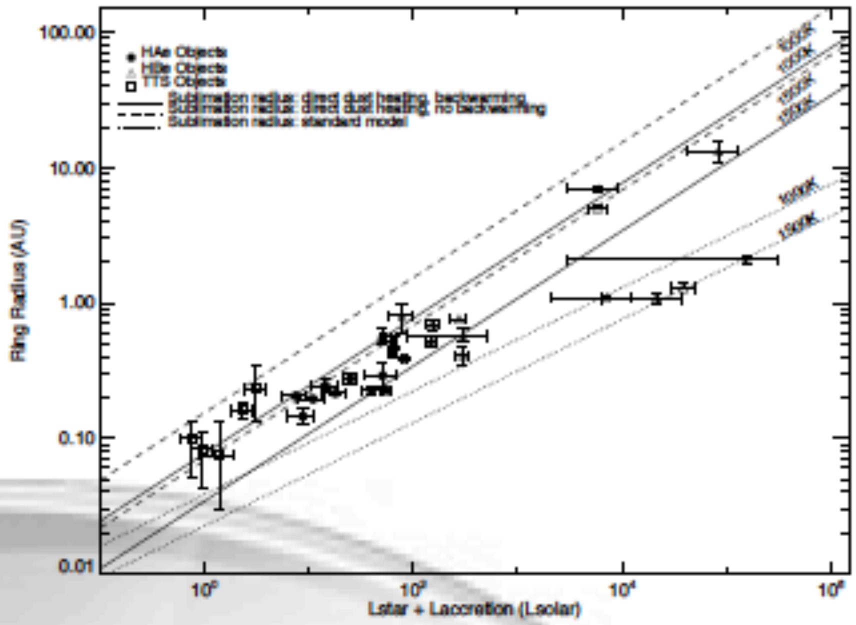
..trace **different disk radii**

…trace **disk surface & interior**

MIDI survey

Menu

Near-IR (Millan-Gabet+ 2007)

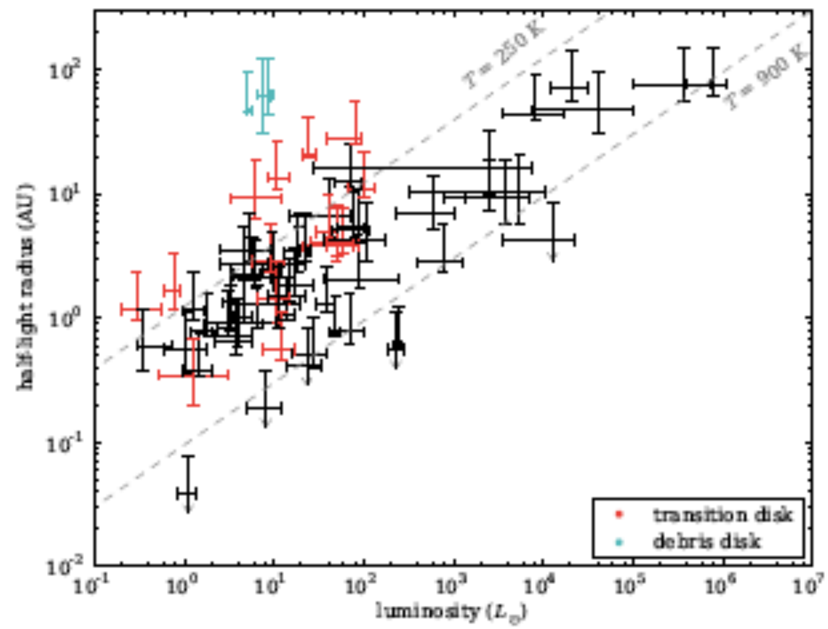


tight relation

Physics: dust sublimation

↔

Mid-IR (our MIDI sample)



loose relation

Physics: **flaring + gaps?**

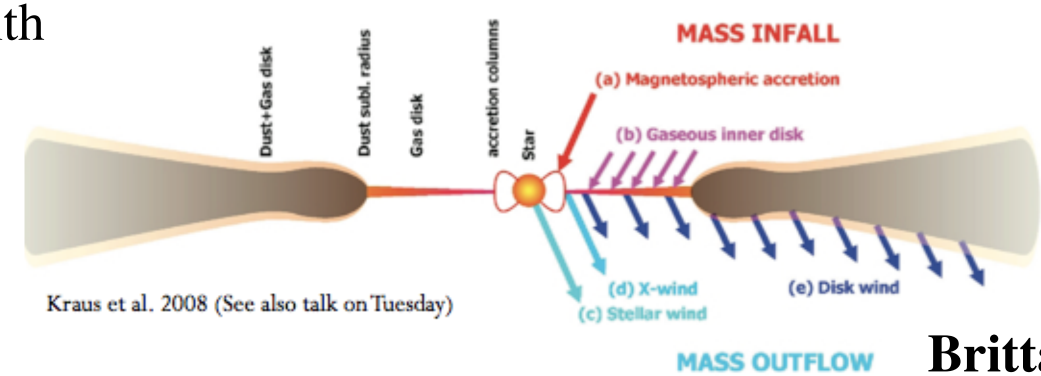
Mid IR analysis of SEDs implies asymmetries: **Jamialahmadi**

Gas diagnostics: CO lines

Some transitional disks – disks with inner disk clearings- (i.e HD100546), seem to have non molecular inner regions, ≥ 10 au (**Brittain, van der Plas**)

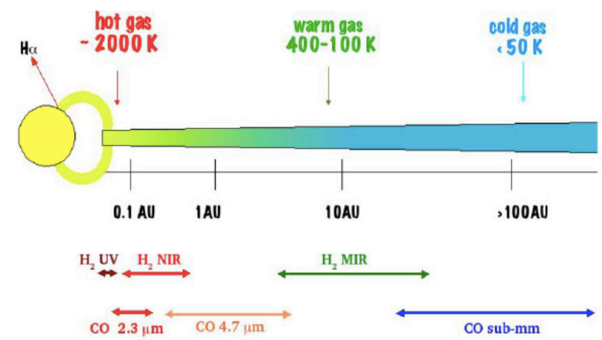
Width of profiles consistent with formation within ~ 2au in HD 163296, HD250550, Hen 2-80 (**Bertelsen**)

Need survey of sources with different SEDs



Kraus et al. 2008 (See also talk on Tuesday)

Brittain



Van der Plas

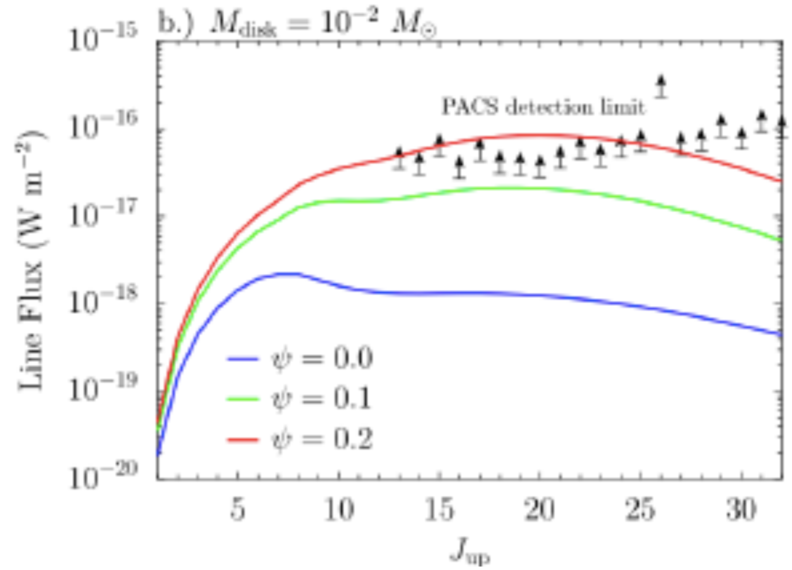
Gas diagnostics: CO lines

PACS + Spires: CO ladder
Groups I flared gas disks
A few Group II
Menard, **Meeus, Woitke**

Scale height at 100 AU to explain low J CO (**Pietu**) higher than dust scale height (**Grady**)

Difficult to explain bright [OI]

Few sources analyzed, need more to draw general conclusions



Very elaborated models, difficult to get general physical conclusions
Woitke, Pinte

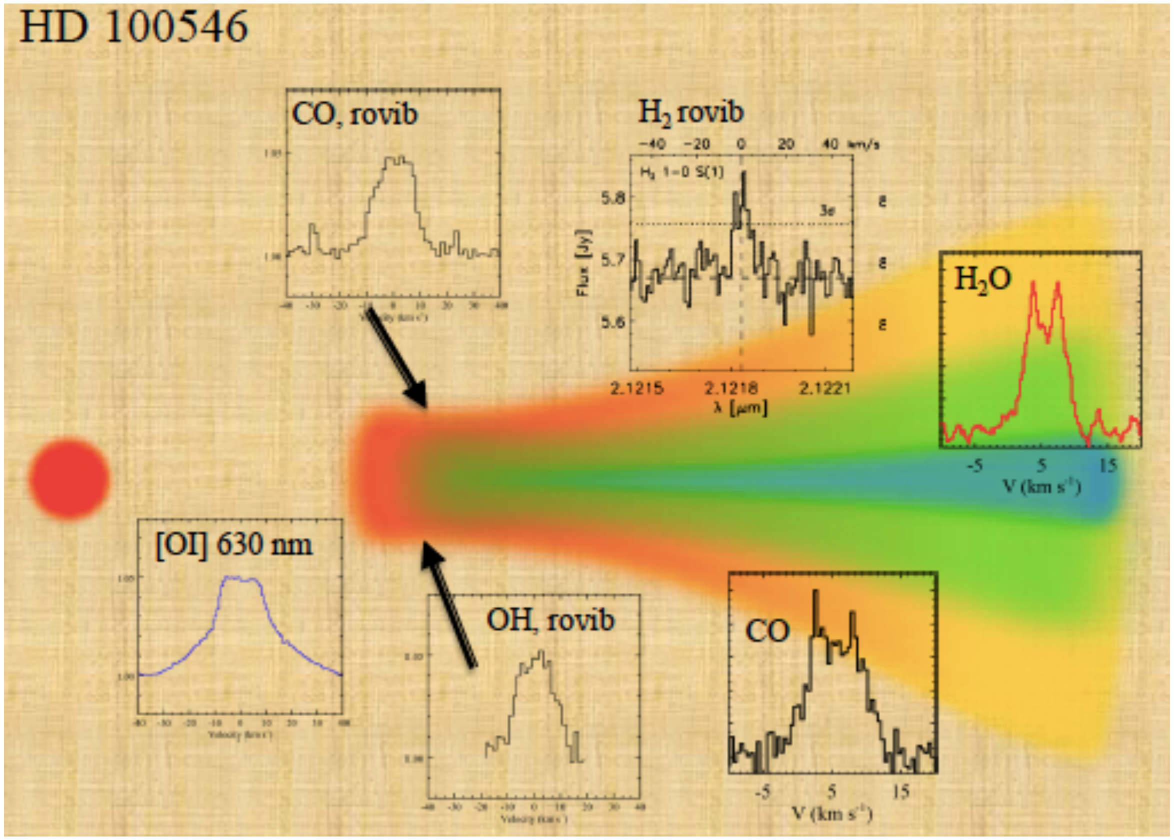
Other gas diagnostics

No hot H_2O – unlike CTTS
OH most common
Warm H_2O

Fedele: hotter disks in HAe

H_2O dependence on dust/gas
Antonellini

Great things to be done by SOFIA
Zinnecker

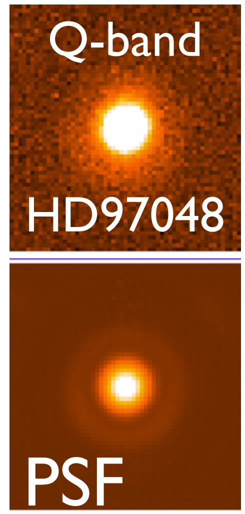


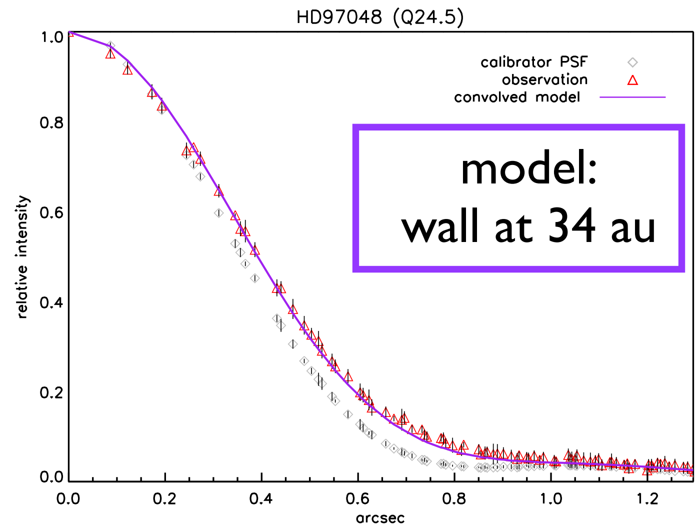
All Group I have gaps?

Maaskant et al. 2013,
Khalafinejad et al. 2014

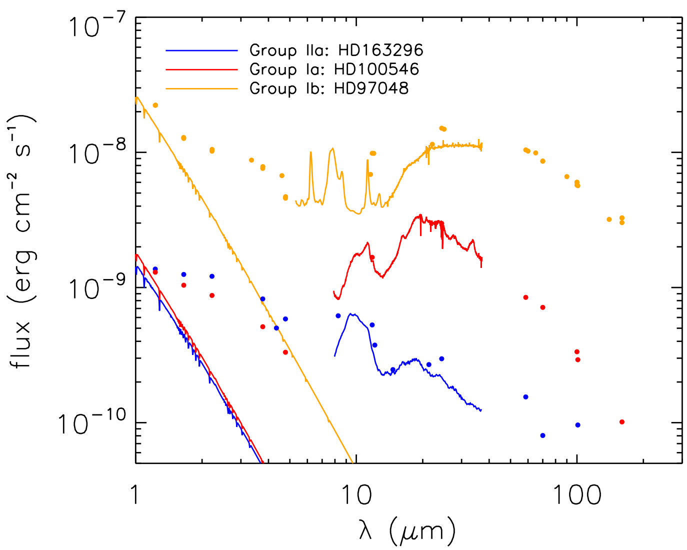
- Connection SEDs, gaps and absence of silicate features.
- New simple Meeus group classification based on F30/F13.5 ratio

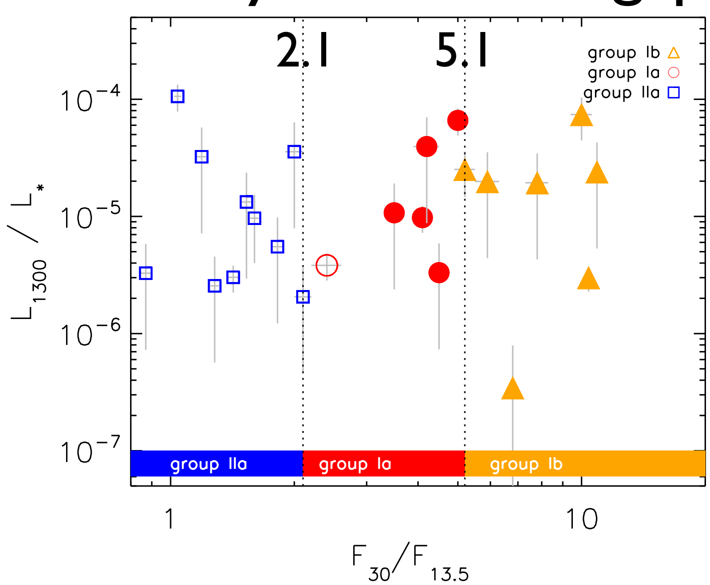
example:

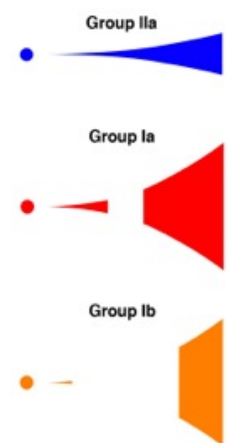




filled symbols have gaps





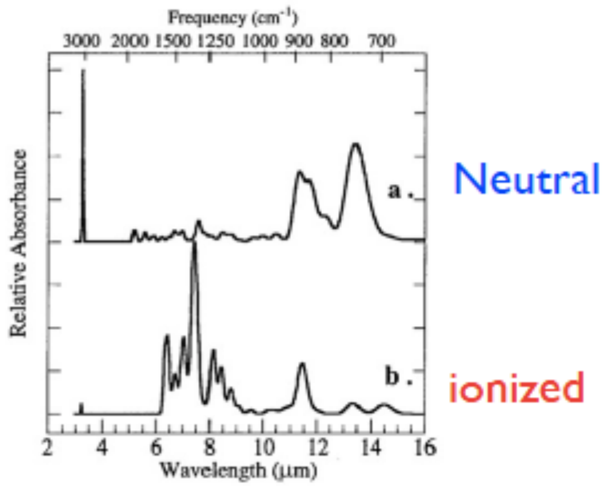


Group I morphologies

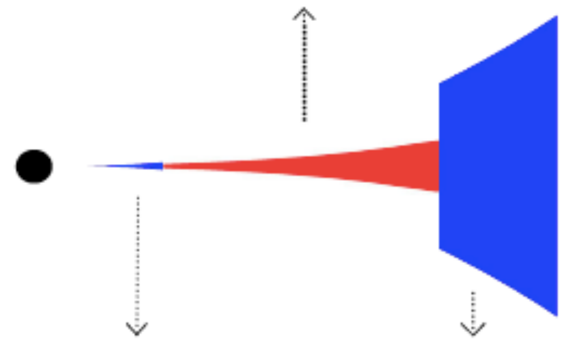
All Group I have SED consistent with being pre-transitional:
Disks with gaps with inner optically thick material

Grady

Gap diagnostics: PAH



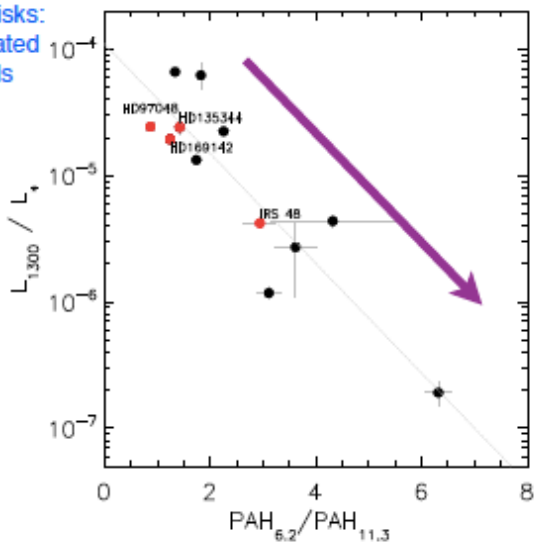
Ionized PAHs in low density, optically thin gas flows through the gap (high UV field, low electron density)



Neutral PAHs in optically thick disk (low UV field, high electron density)

Maaskant

Higher mass disks: spectra dominated by neutral PAHs

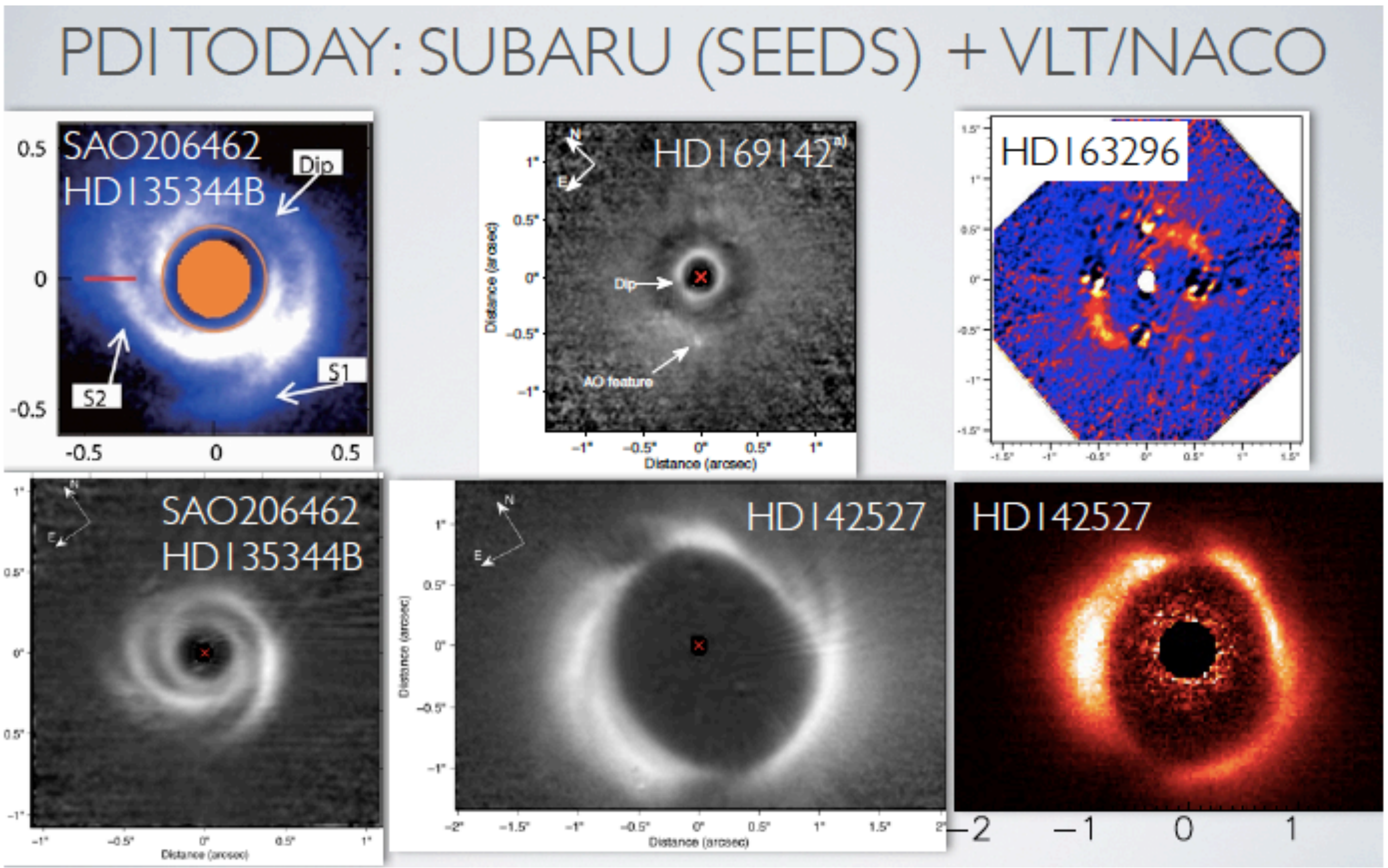


Lower mass disks: spectra dominated by ionized PAHs in gaps

Gaps/Arms/Asymmetries due to planet formation?

Polarimetric Differencial Images

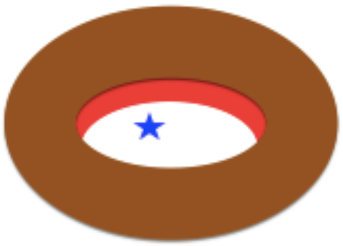
Quanz

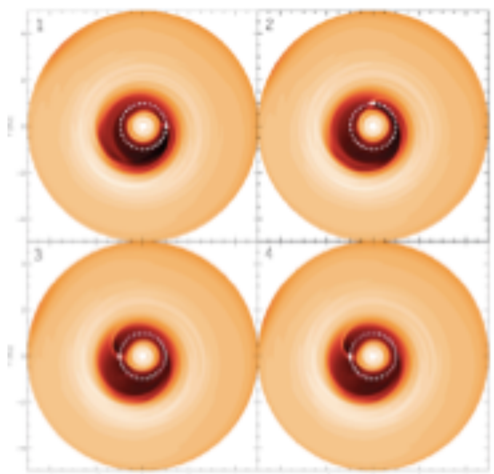


Planet formation?

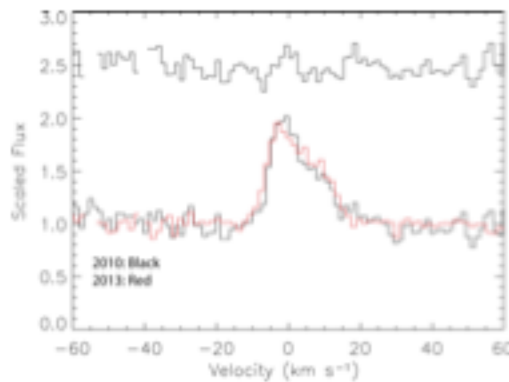
Line asymmetries in HD 100546 caused by companion in excentric orbit

Brittain





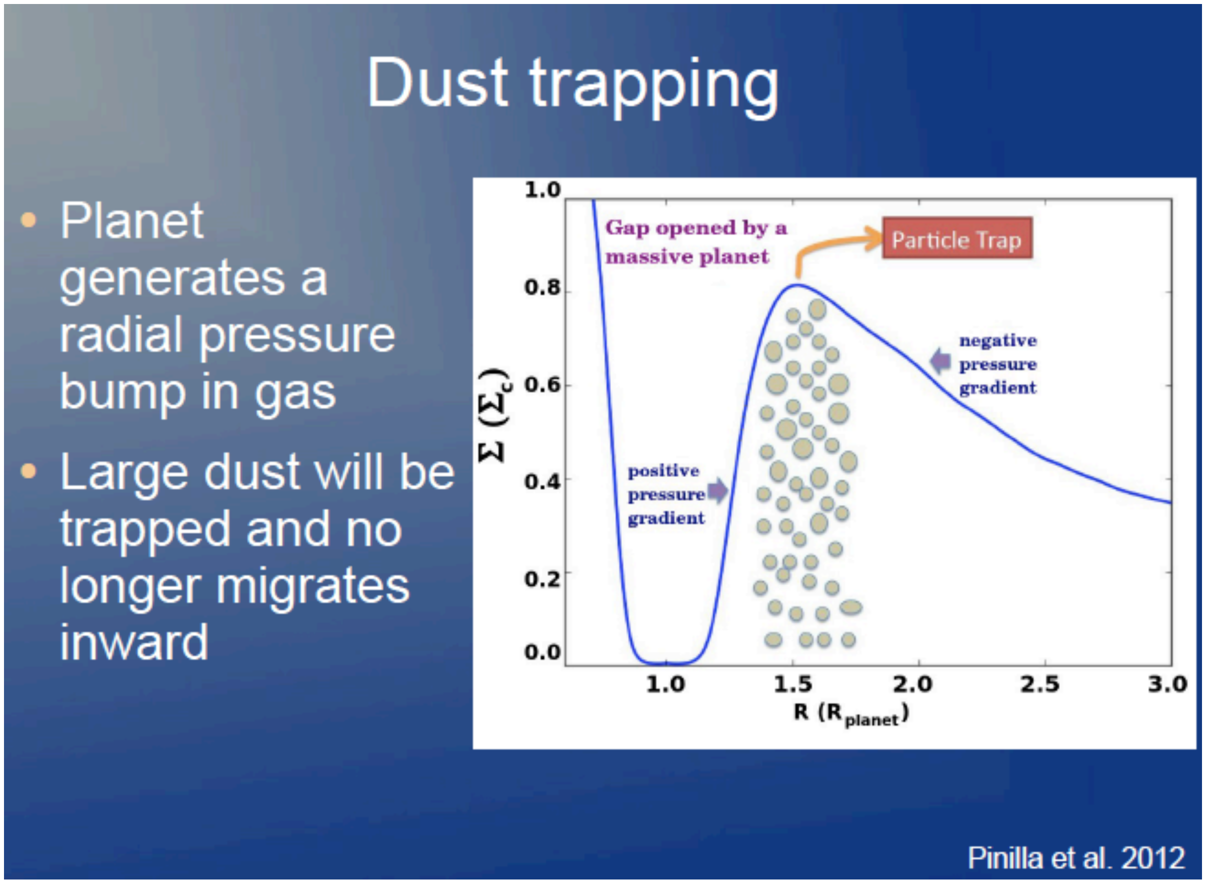
Regaly et al. 2011; also Kley & Dirksen 2006; Papaloizou et al. 2001)



Brittain et al. 2014

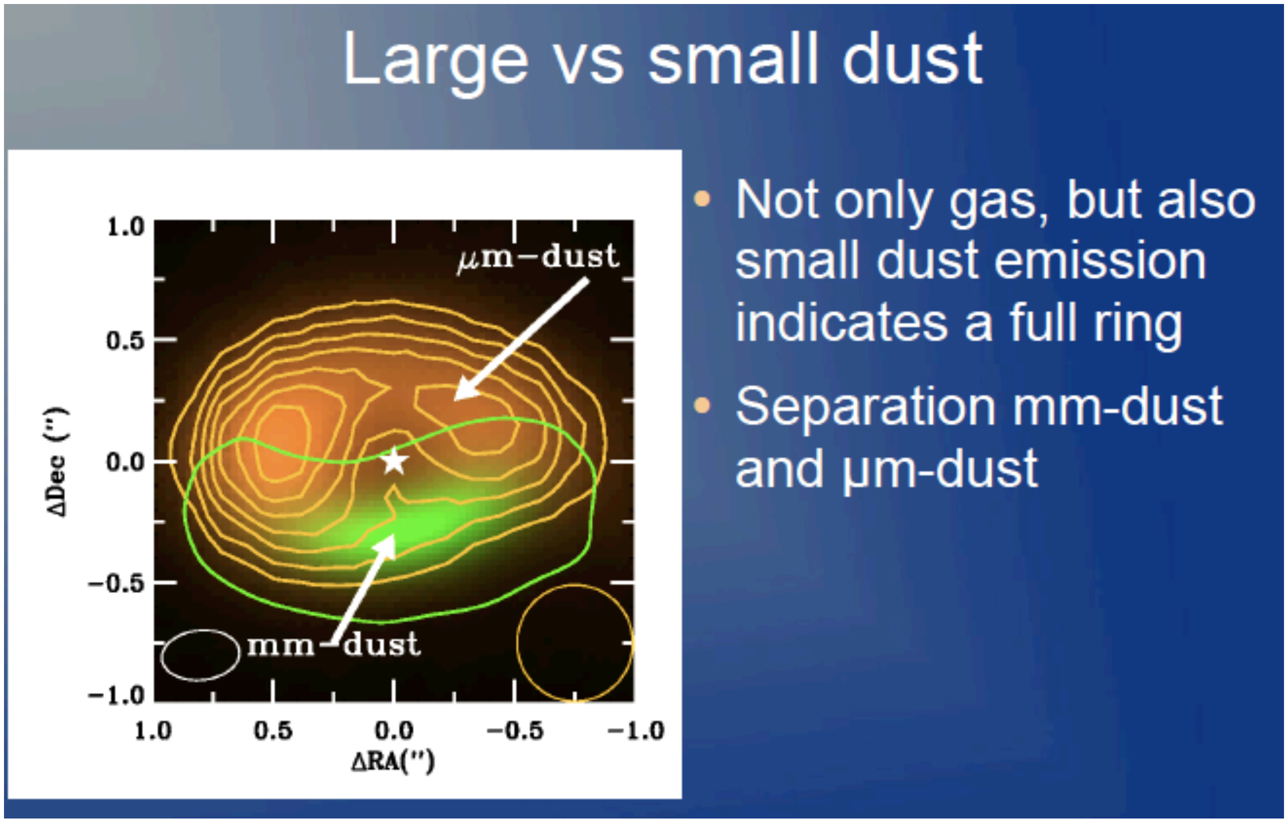
Gaps/Arms/Asymmetries due to planet formation?

Van der Marel



Gaps/Arms/Asymmetries due to planet formation?

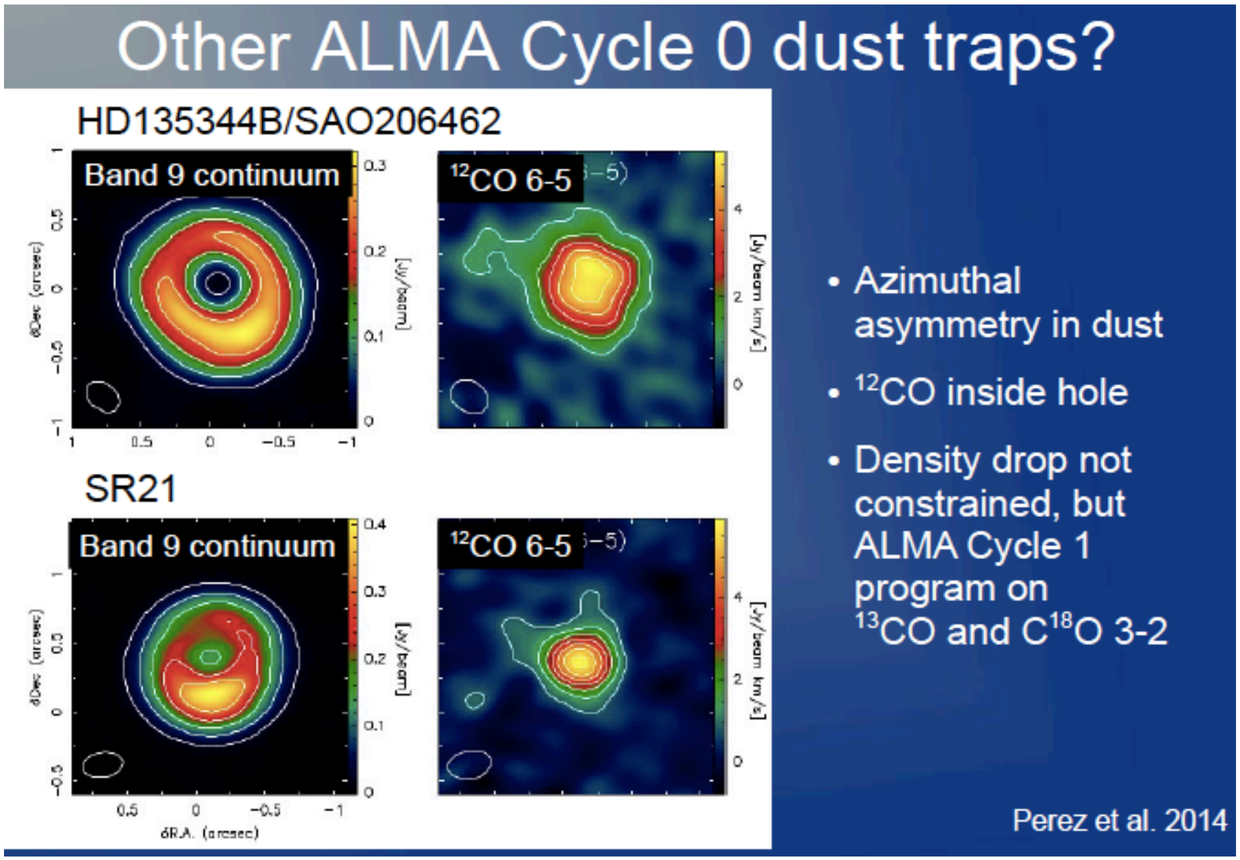
Van der Marel



Gaps/Arms/Asymmetries due to planet formation?

Transitional disks may be dust traps
indicating planet formation - ALMA

Van der Marel

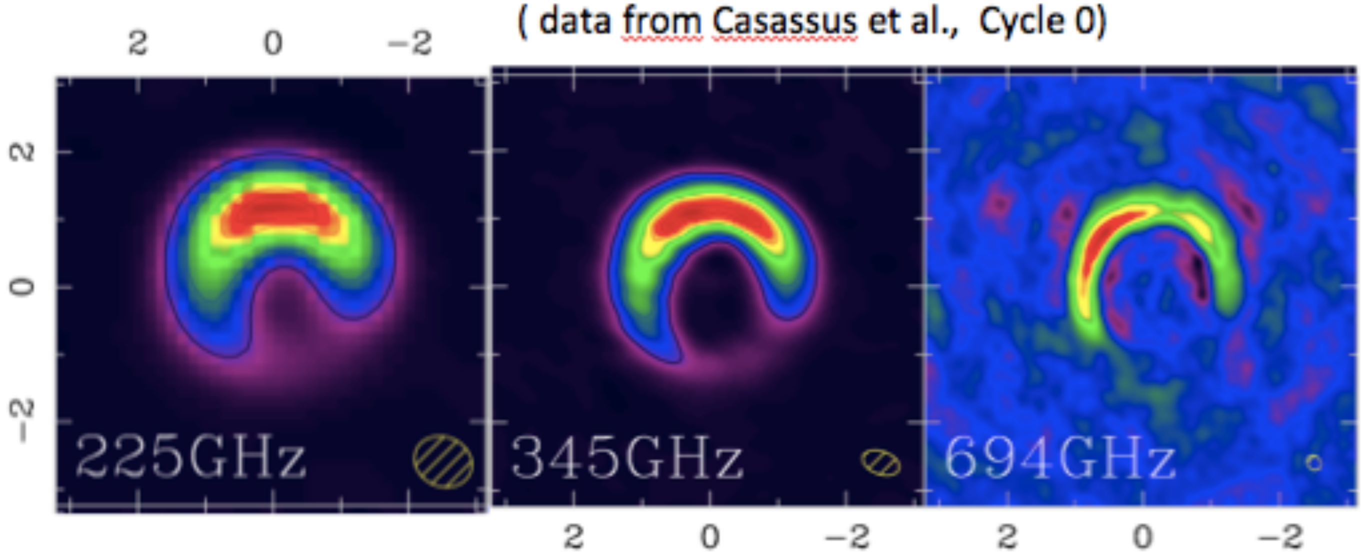


Gaps/Arms/Asymmetries due to planet formation?

Menard, Perez, Casassus, Christiaens

HD142527 in ALMA bands 6, 7, and 9

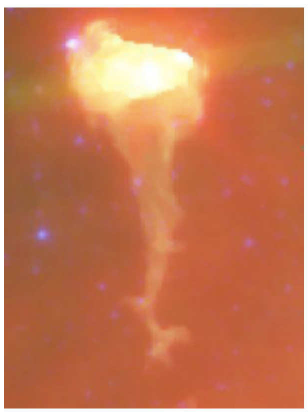
(data from Casassus et al., Cycle 0)



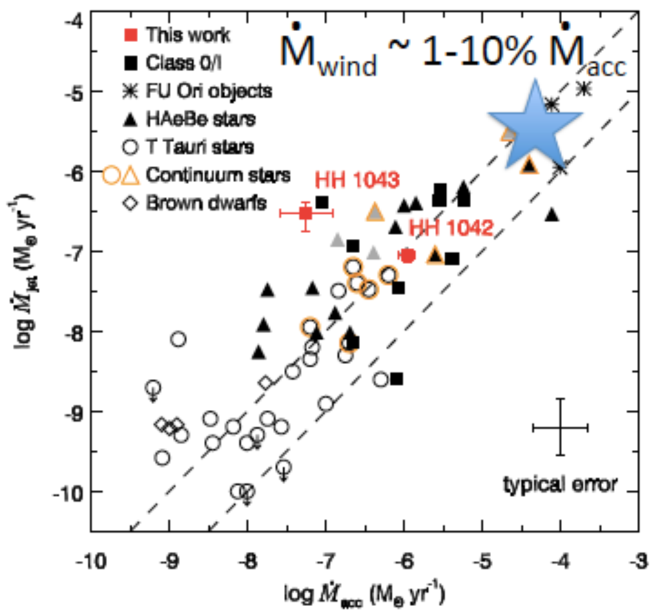
Evolution

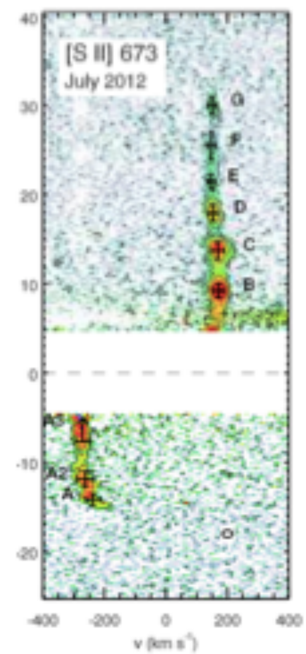
IM protostars form as low mass protostars. Disks and collimated outflows with similar properties to low mass protostars (**Beltran, Wu, Comeron**)
Jets in Herbig rare but selection effect but similar to low mass protostar (**Dougados**). Soft X-rays from jets (**Schneider**)

Comeron



Reiter



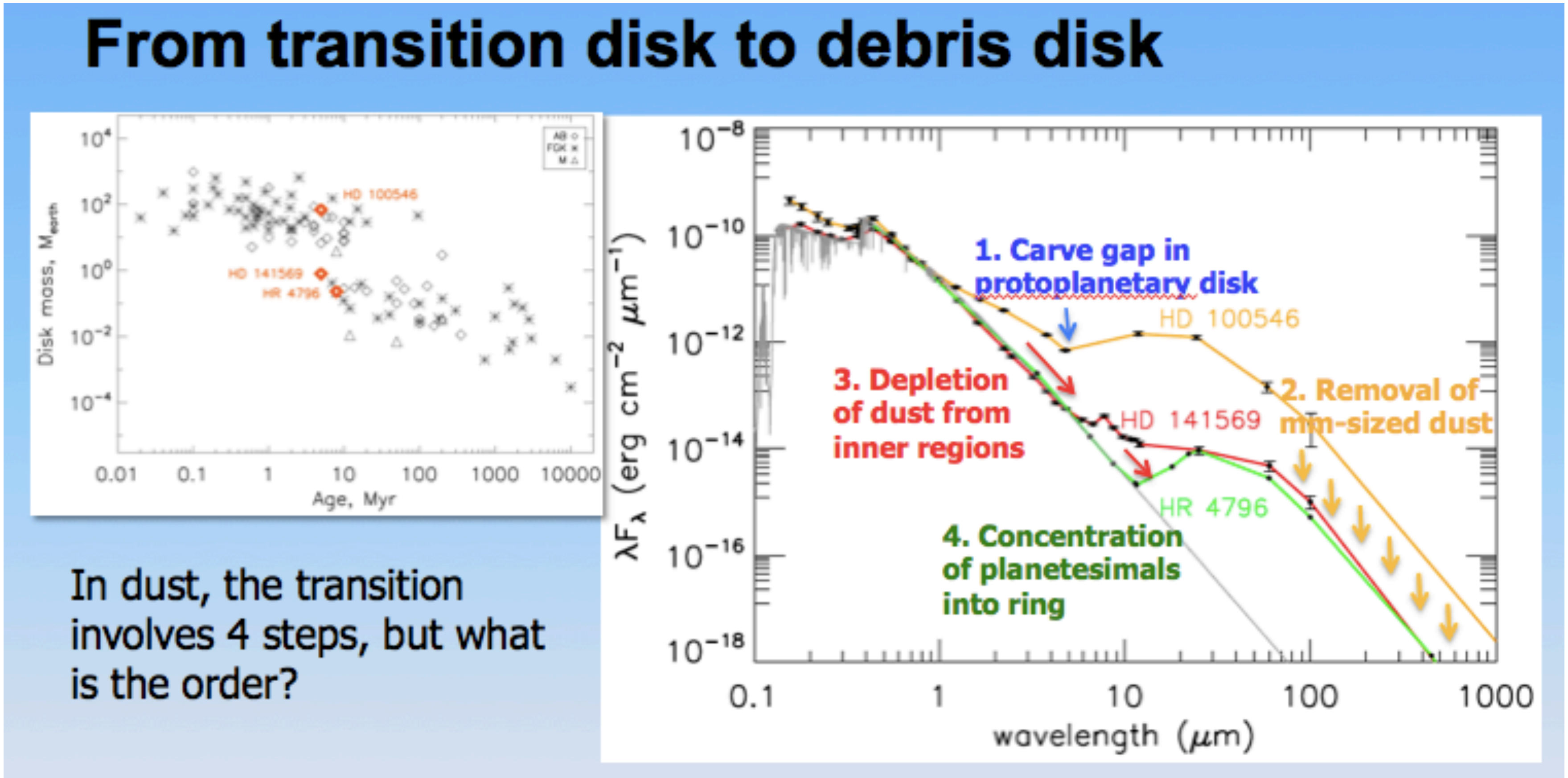


HD163296
Ellerbroek et al. 2014

All molecular outflows are collimated (**Beltran, Dougados**) and jets can produce (soft) cosmic rays (**Ray**)

Evolution

Wyatt



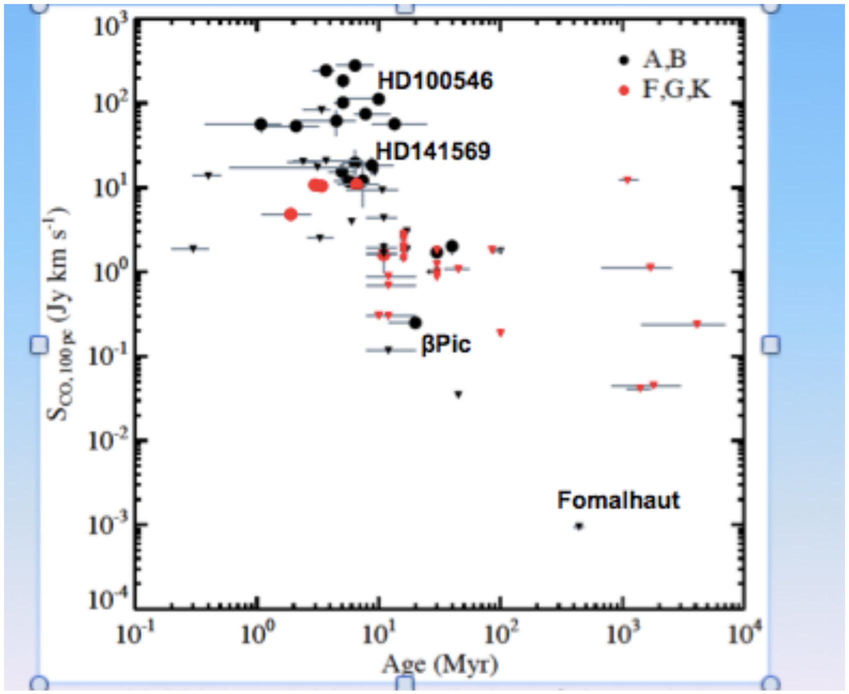
Pristine or secondary dust in TD?

Fe-rich dust in warm debris disk (**Henning**)

Compare to PPD – 10 mm spectroscopic studies (**Boekel, Vieria**)

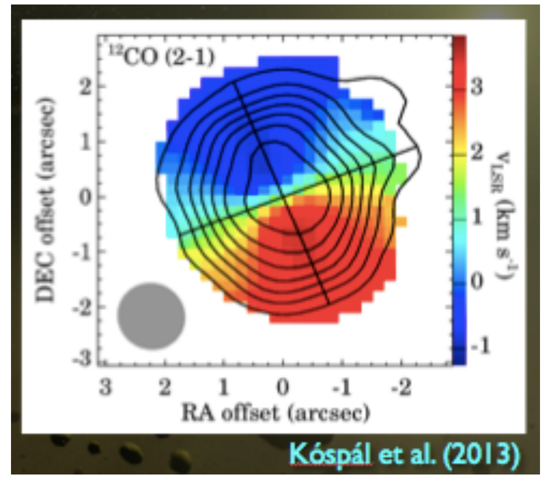
Evolution of gas

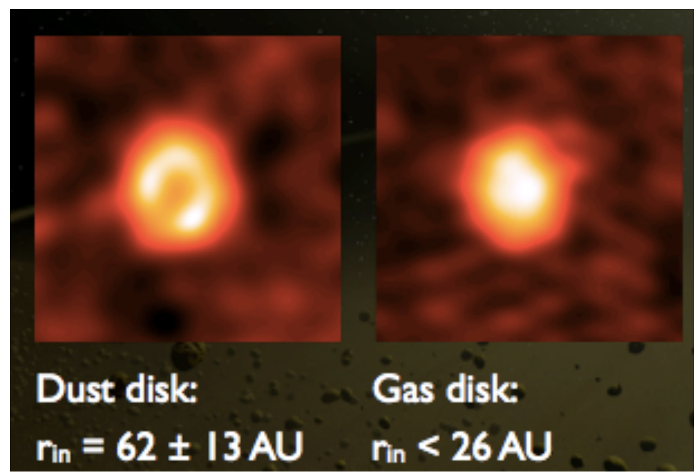
Wyatt



β Pic gas is secondary
Dent

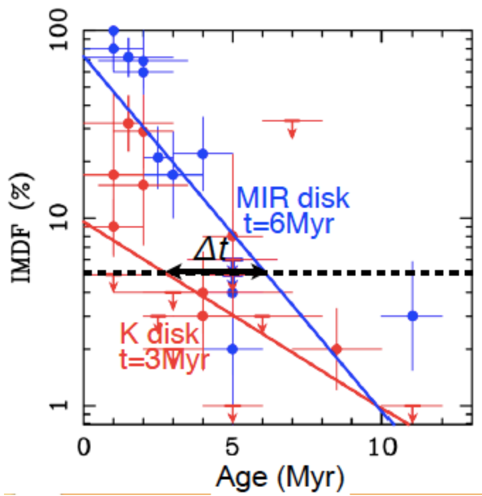
30 Myr old HD 21997: gas primordial
Kospal





Disk evolution in clusters

Yasui



Lifetimes shorter in IM than in LM (**Yasui**)
Mechanism not understood (**Kunimoto**)

Longer lifetime for mid-IR disk

Z-dependence of mass accretion rate (**Beccari**)

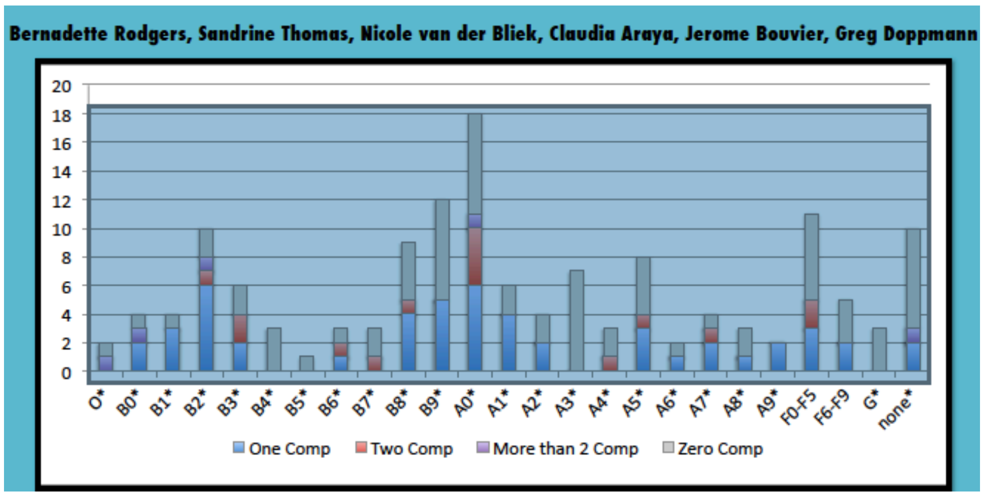
Searches

Ae/Be in the LMC (**Mathew**)
Fe/Ge in Ori OB1 (**Hernandez**)

Binaries

For every star there is a companion at some separation **Duchene**

Rodgers



Also
Briceno
Csepany

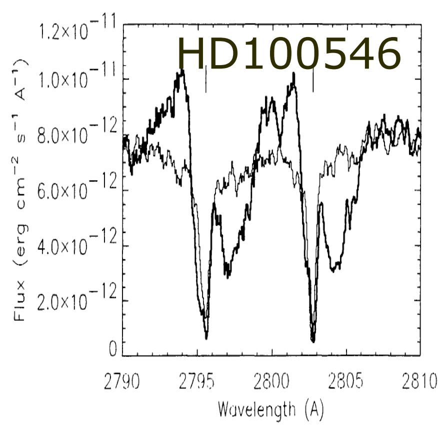
Accreting? How?

Hillenbrand et al. 1992

Massive circumstellar disks

$6x10^{-7} < Mdot_{acc} < 8x10^{-5}$ Msol/yr

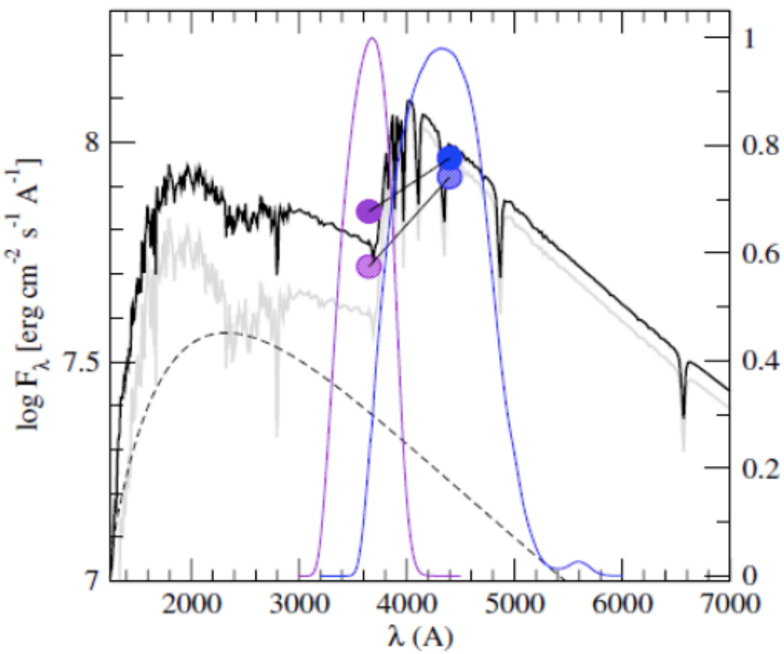
Accreting? What are the mass accretion rates?



Grady et al. (1996)

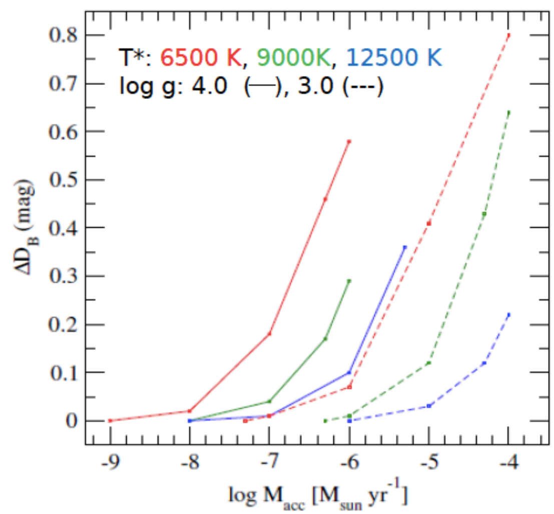
Magnetospheric Accretion: shock emission

Excess due to shock emission to estimate mass accretion rates



Mendigutia

Warning: excess very dependent on spectral type



Magnetospheric Accretion: shock emission

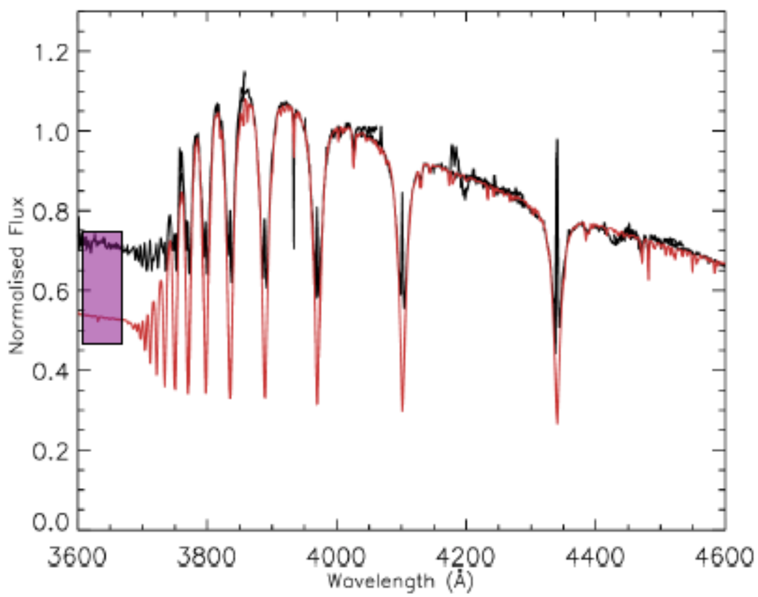
Large X-shooter study

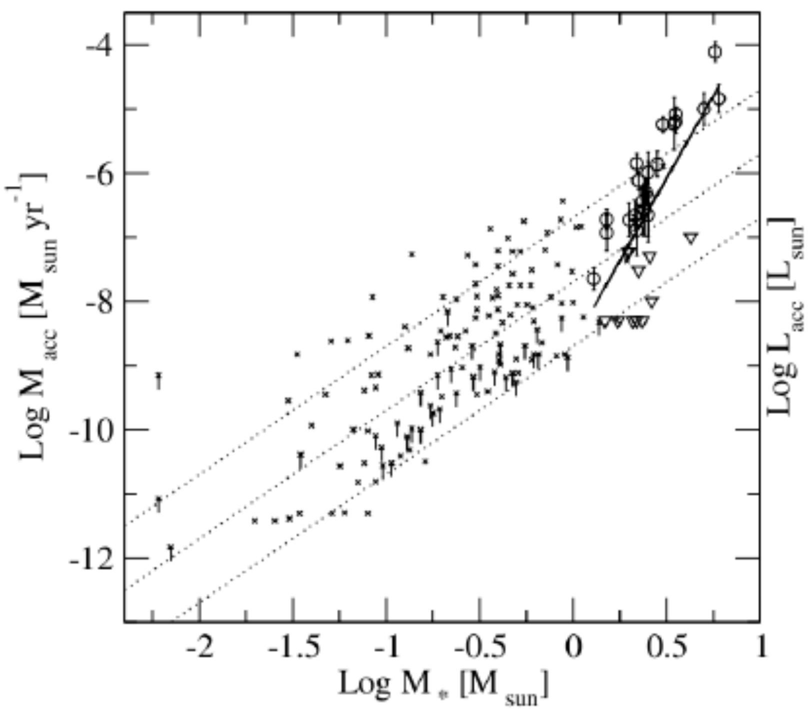
Fairlamb

Extend relation from brown dwarfs to CTTS to Herbig Ae

MA does not fit strong UV excess in early B stars

Also **Vink**



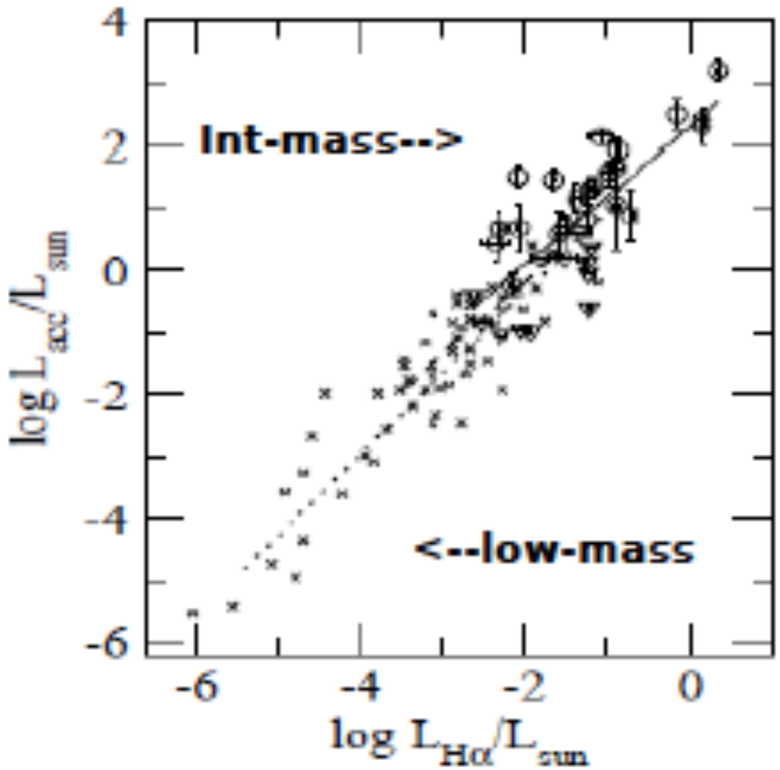


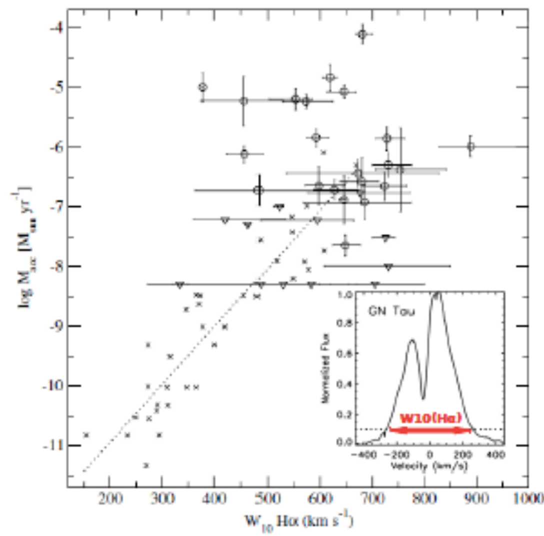
Mendigutía et al. (2011)

Calibration of line indicators

Mendigutia, Fairlamb

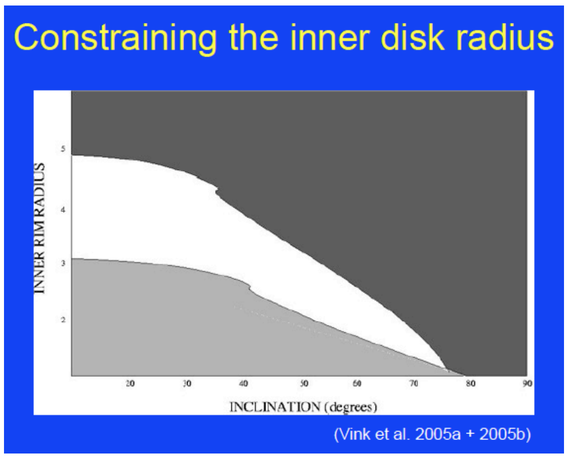
Warning: Not all work:

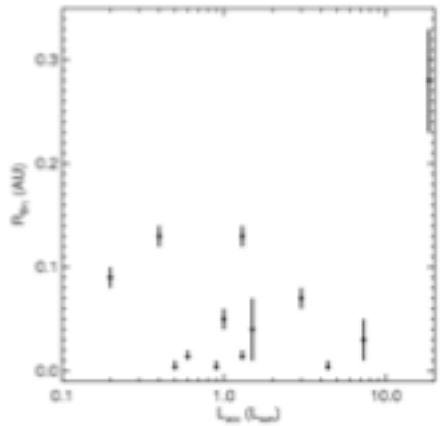




Support MA

Vink
Linear Polarization
Rotating disk geometry
Similar for HAeBe and CTTS
Inner disk radius





Kraus
Compact Brγ emitting region in most low L sources

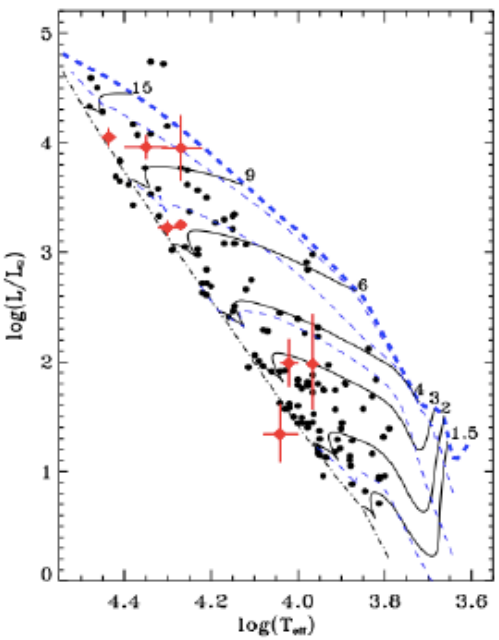
Many (statistics?) H line profiles consistent with MA
Brittain, Arnio, Ramirez, Gotzens, Van den Ancker

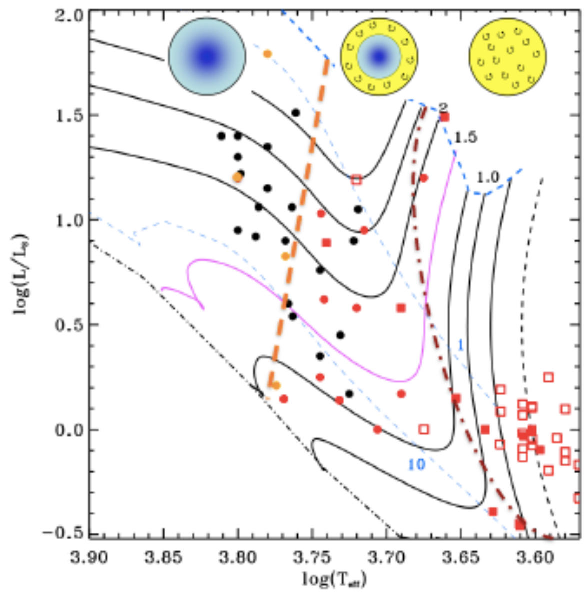
Although few redshifted absorptions, and some extended

Against MA: weak/absent magnetic fields

Alecian
128 stars, 1.5-20 Msun
8 stars detected (6%) strong
Others ≤ 100 G

Hussain
IMTTS, dipole component gets weaker with increasing radiative core



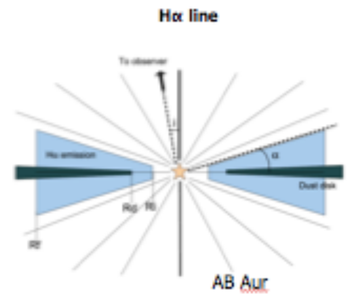


Also **Petr-Gotzens**, **Ababakr**

Question: Where does the excess come from?

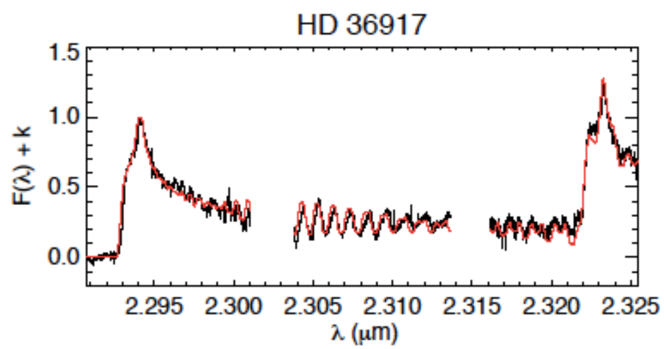
Boundary layer?
MA profiles

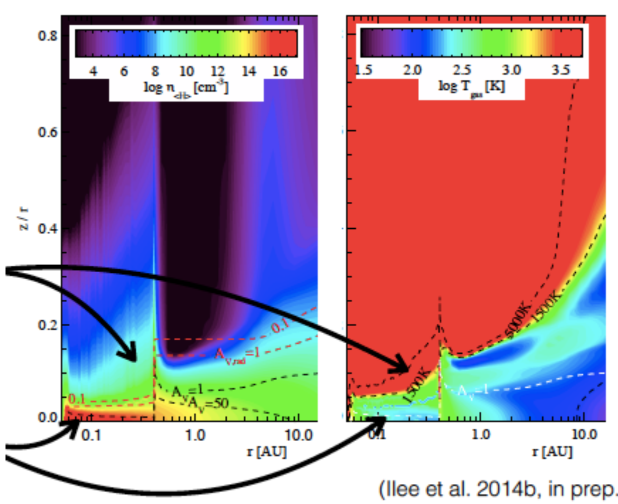
Inner gas disk?
Too cold?



Kraus
Dougados

Ilee





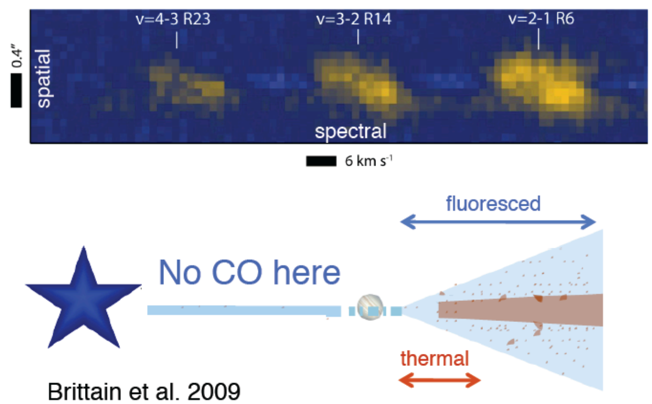
(Ilee et al. 2014b, in prep.)

Hot inner disk?

Brittain

HD100546: rovib CO

- CO hot bands (dv = 1, $v_{low} > 0$)
  UV fluoresced
- CO v=1-0 also has thermal
  (excited by collisions)
- R(CO) =13 AU to ~100 AU



Brittain et al. 2009

Kratter, Lobato

Summary of the summary

- Images: New view on the nature of disks around Herbig Ae/Be
- Group I may all have cavities/gaps and outer disks are very structured
- Need statistics
- Generalized dust traps may indicate planet formation
- Are early Be to be included in the class?
- Stars are accreting – excess, outflows – but weak, multipolar magnetic fields
- How are they accreting?

- Great conference!

And don’t forget

~~AU~~ au