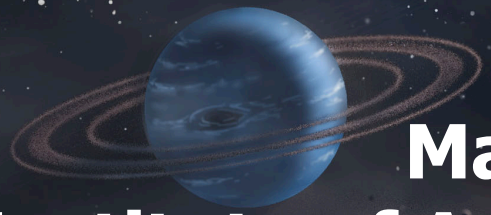
Debris Disk Science
in the M5 SPICA SPFE Proposal



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With help from: Grant Kennedy (IoA), Inga Kamp (Groningen), SPFE team

HARDY

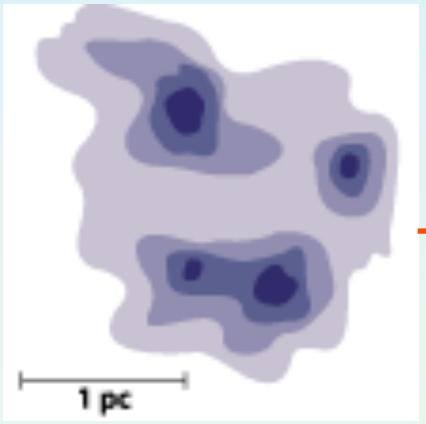
SPFE = “Star and Planet Formation and Evolution”

- SPFE Proposal very open to be discussed by community

- Sign up to SPFE mailing list by contacting Peter Roelfsema **P.R.Roelfsema@sron.nl** or Bruce Sibthorpe **b.sibthorpe@sron.nl**

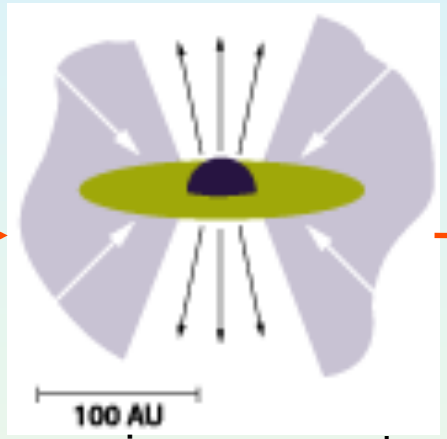
- Proposal is based on “use cases” – if your science is missing, send one in a.s.a.p.

Overview of star and planet formation



molecular cloud
0Myr

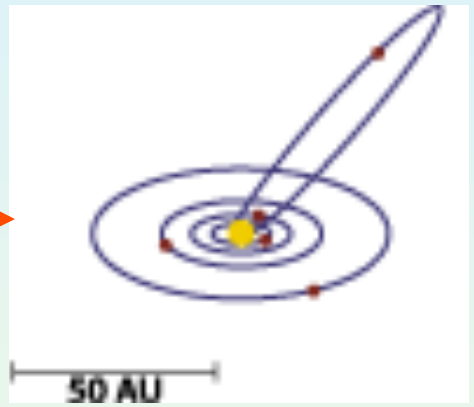
star formation



pre-main sequence star
+ protoplanetary disk
1-10Myr

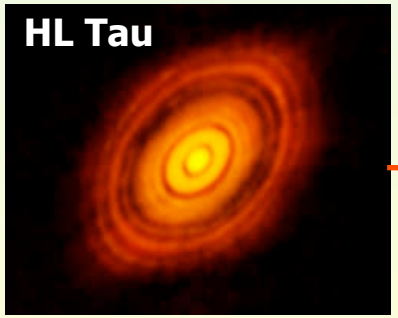
planet formation

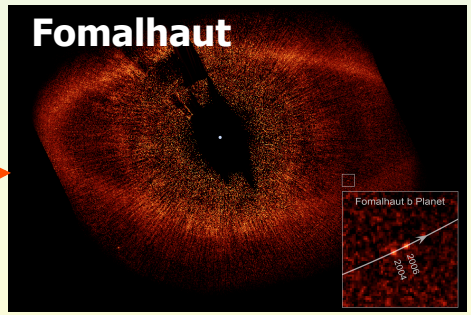
& disk dispersal



main sequence star
+ planetary system
and/or debris disk
10Myr-10Gyr

e.g.,

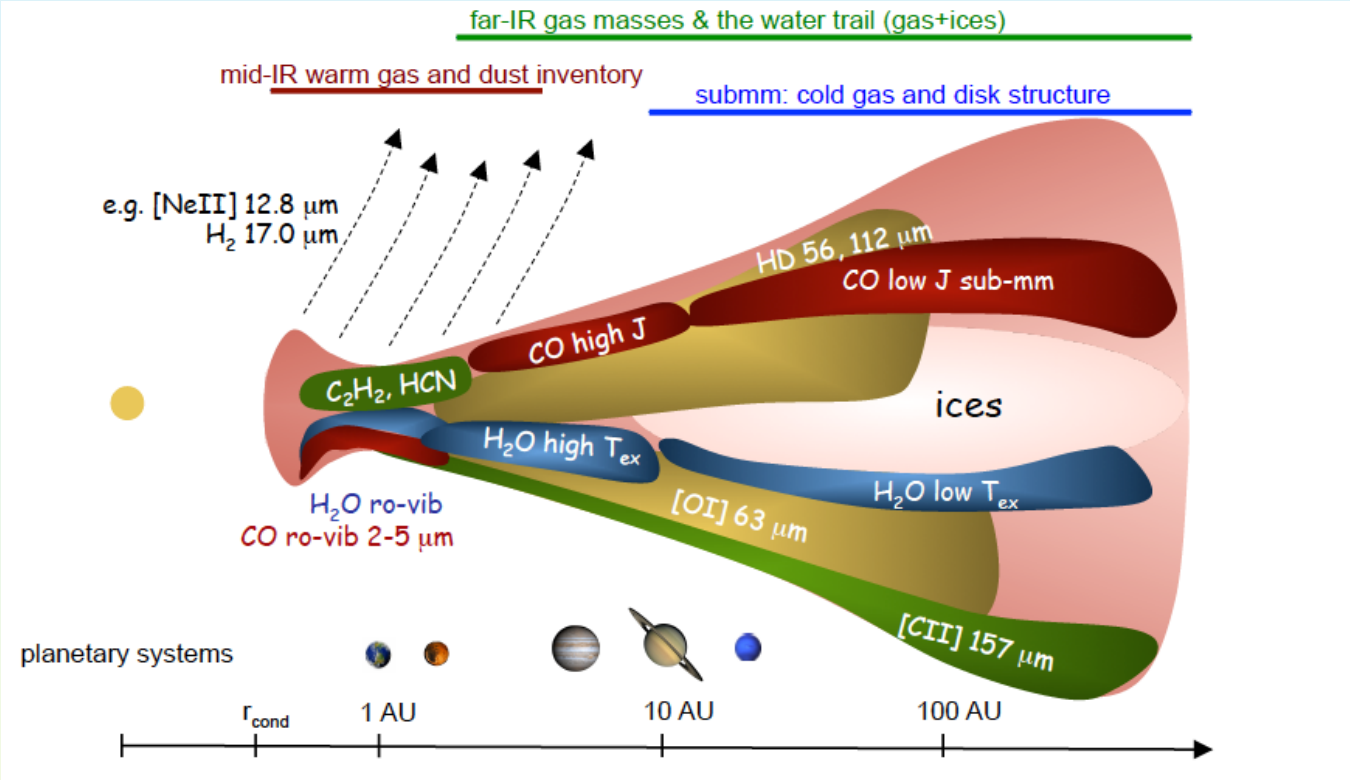




Spica's role in SPFE

Mid-IR and far-IR have some unique tracers (HD, CO, H_2, NeII, H_2O, ice, forsterite) that enables unique science

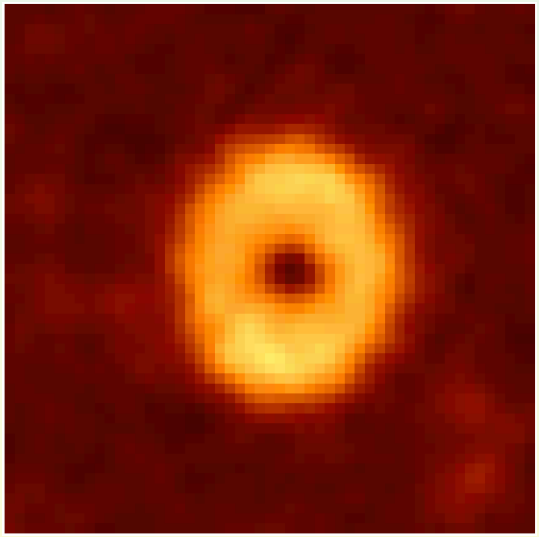
Key science questions (from Inga's presentation):



1. How is water delivered to the planets?
2. How do solids evolve from pristine dust to differentiated bodies, and what is the link with our own Solar System?
3. When does the gas supply exhaust during the planet forming phase?
4. How does gas dissipation and photo-evaporation set the clock for planet formation?

Debris disk science with Spica

Debris disks reside in fully formed planetary systems; e.g., ε Eri at 160μm shows a 60au "exo-Kuiper belt" ring
(Greaves et al. 2014)



Some key questions and how Spica observations may help:

(1) How unique is the Solar System?
- Detect Kuiper (and asteroid?) belt analogs

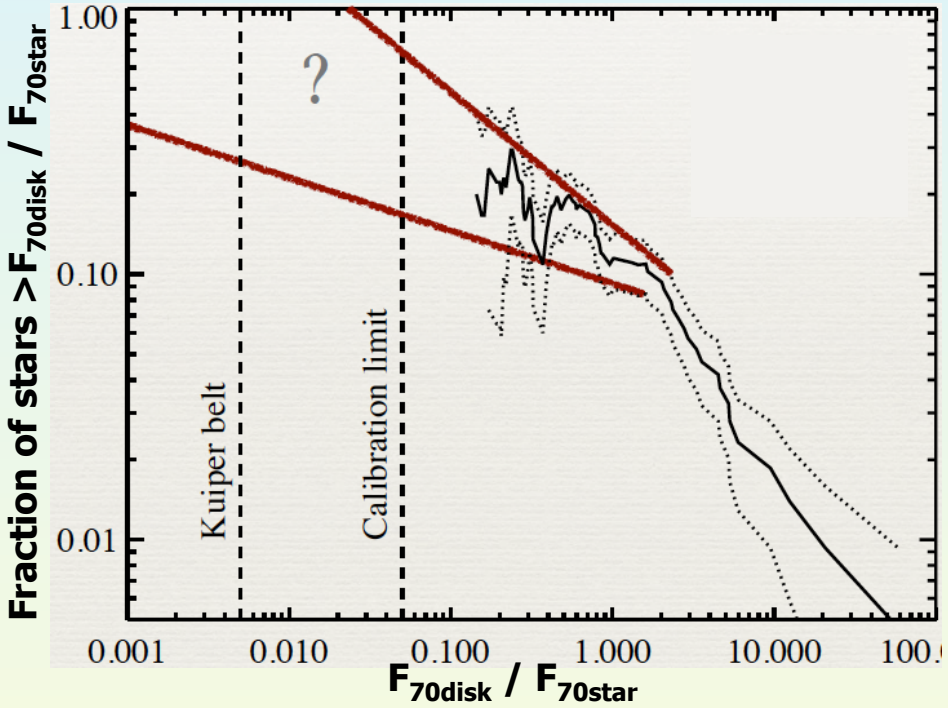
(2) How does disk structure correlate with planet system?
- Survey large numbers of stars

(3) How do protoplanetary disks disperse / how are debris disks born?
- Detect debris disk levels of dust at <10Myr
- Search for evolution of gas tracers

(4) What is composition of planetesimals?
- Look for continuum spectral features
- Detect OI, CII from photodissociation of volatiles

(1) Detection of Kuiper belt analogues is hard due to a fundamental calibration limit

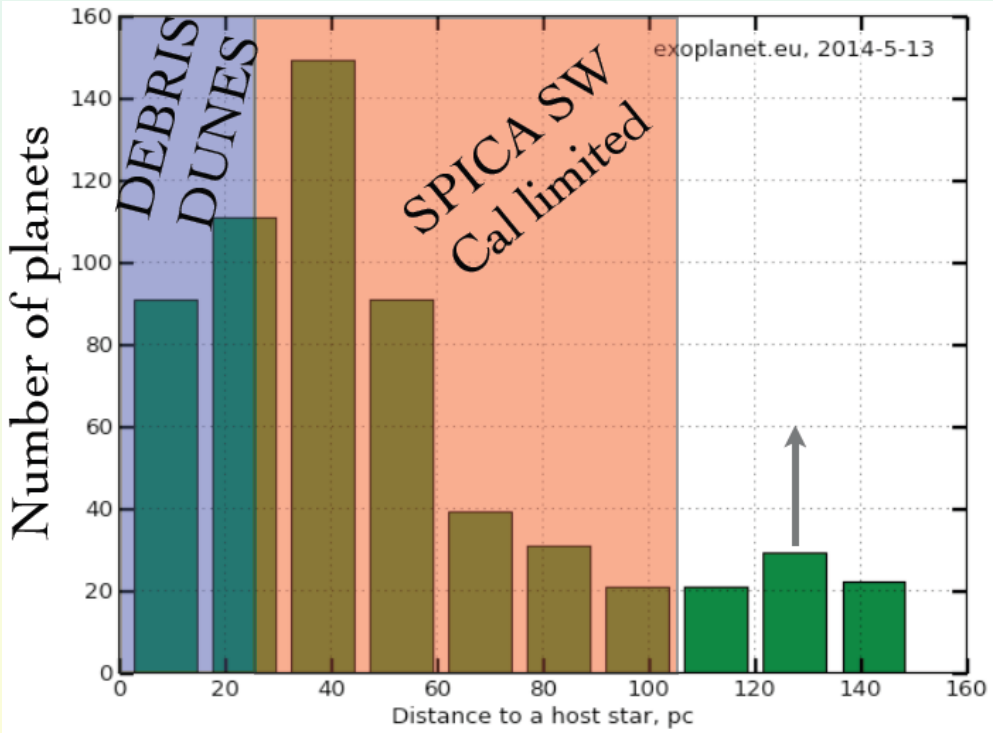
- Herschel already characterised the fraction of ~300 nearby (<20pc) stars with bright disks
- Spica can't improve much for these stars



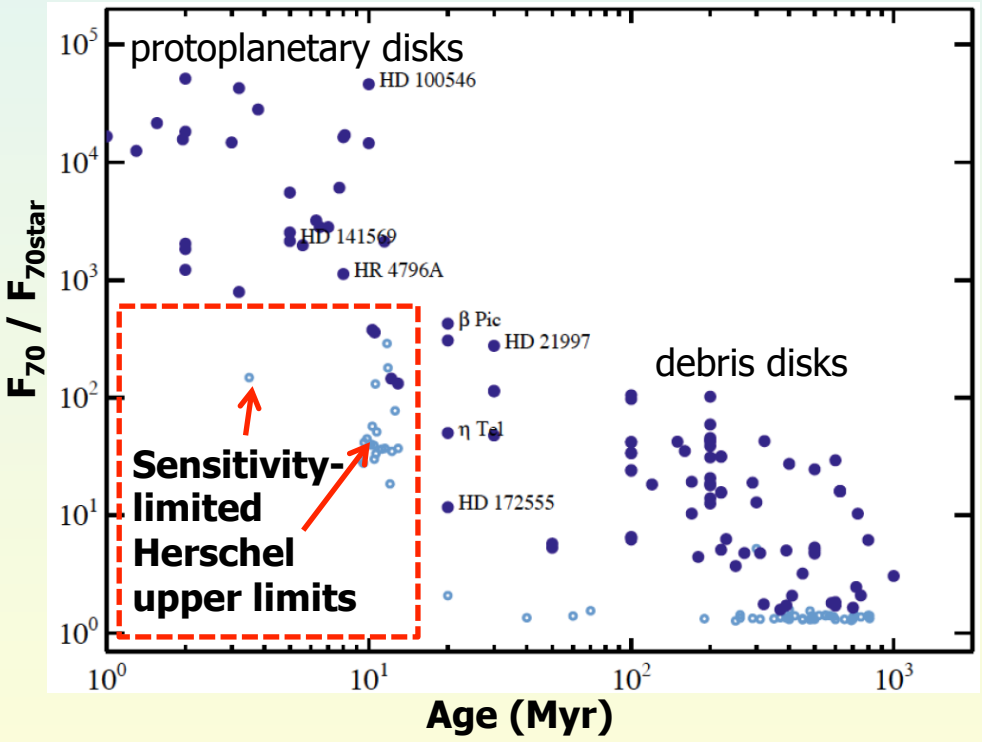
- KB at 10pc is ~1mJy at 70μm in 4" ring; Spica has sensitivity, but must resolve star and use sky motion to disentangle from background –> need imaging
- Improved calibration limit of 0.1% if spectral slope well characterised?

(2) But increased sensitivity means Spica will detect debris disks to greater distance

Calibration limited survey to >100pc of >1000 stars to look for correlations of disk properties with exoplanet architecture

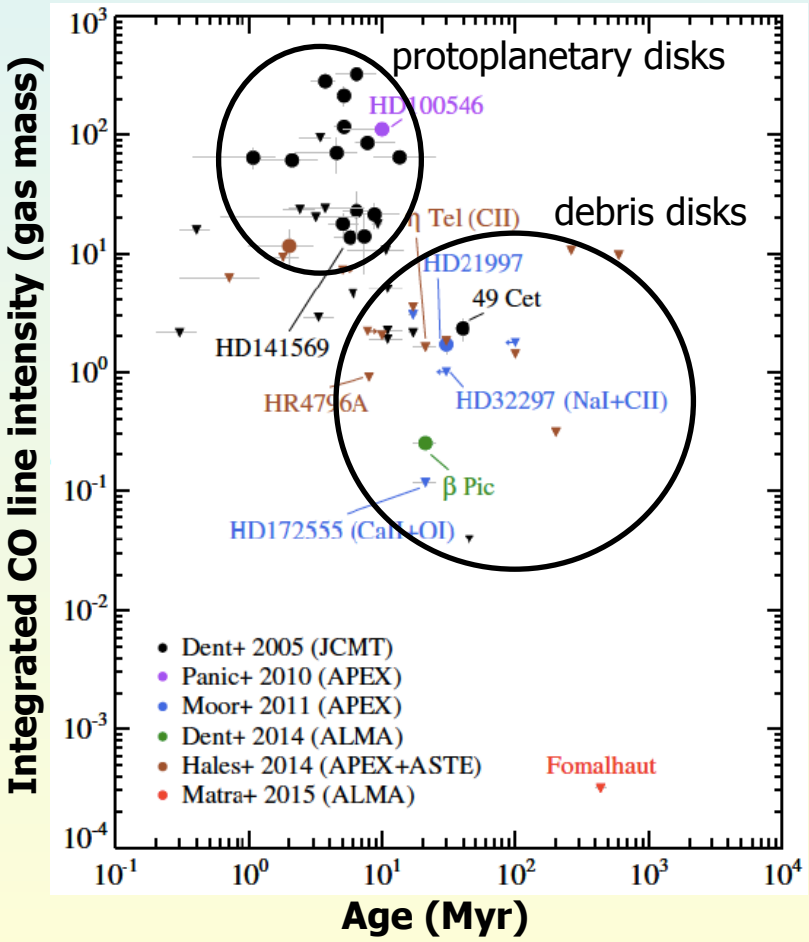


Search for debris disk levels of dust in young star forming regions



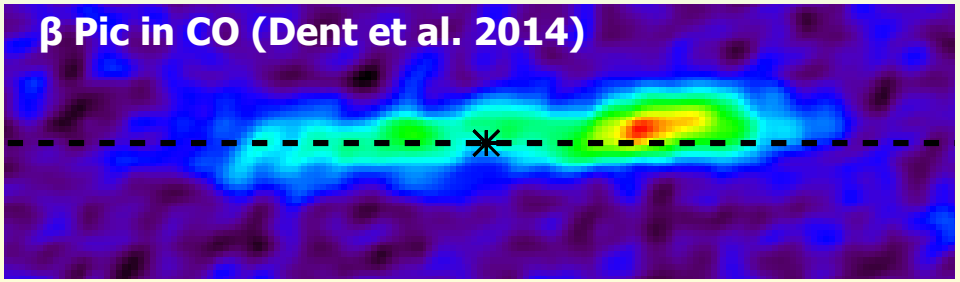
(3) Debris disk gas is a fast-growing topic

There is growing evidence for low levels of gas in debris disks



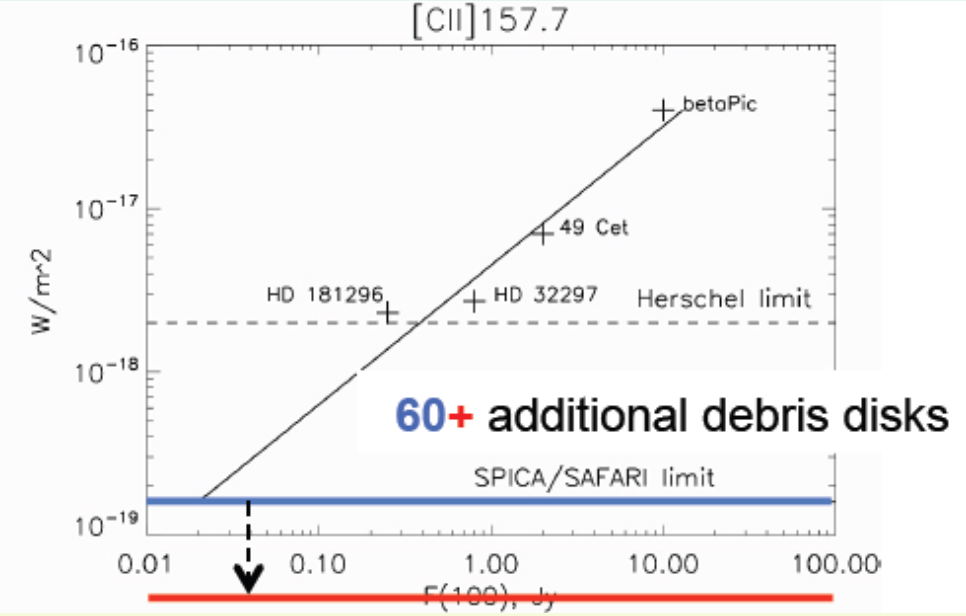
In some cases this is inferred to be a remnant of the protoplanetary disk

In others, the gas is secondary, produced in the break-up of icy planetesimals

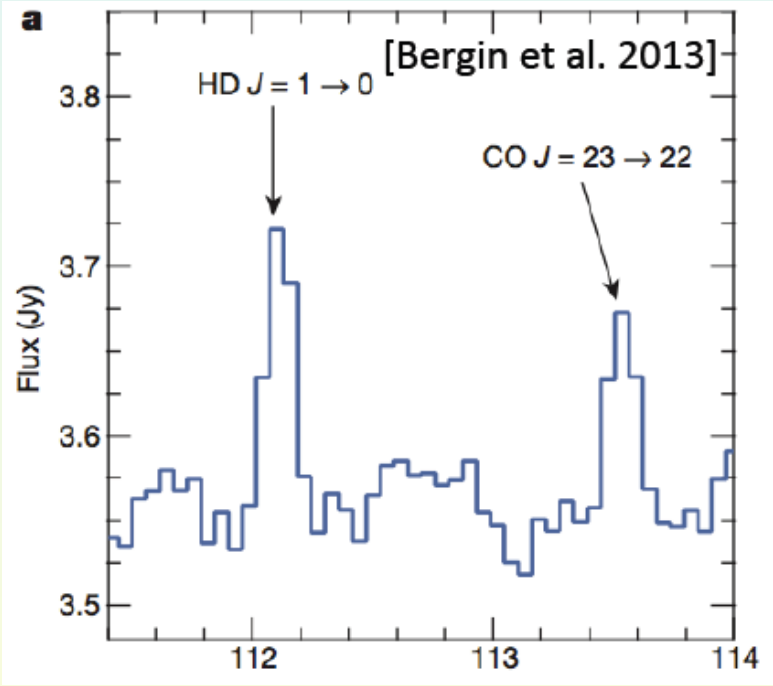


(4) Spica covers unique gas tracers

Many gas lines such as CII, OI, SiII, H_2O, OH, FeII, CO, some of which already detected by Herschel (Alexis Brandeker, Goeran Olafsson)

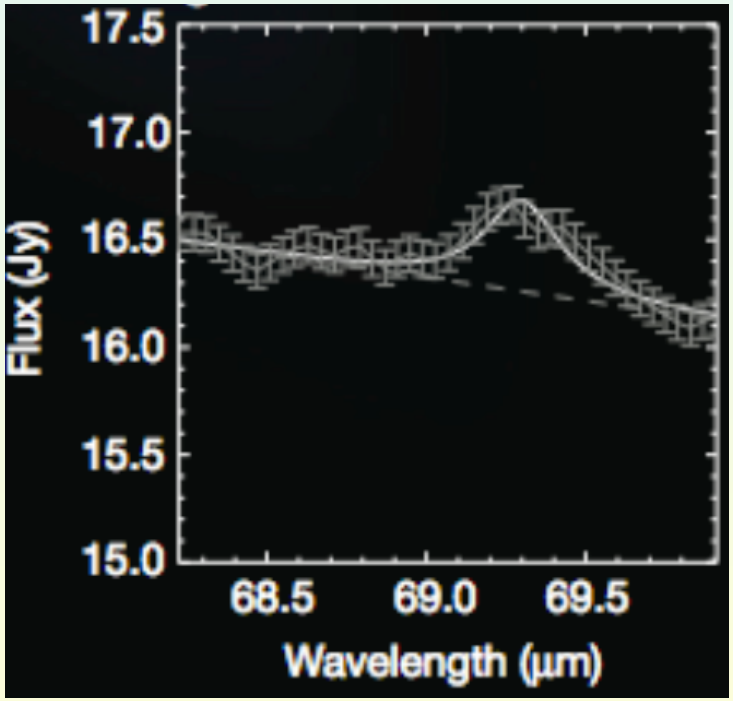


Can also use HD to get direct disk gas mass evolution

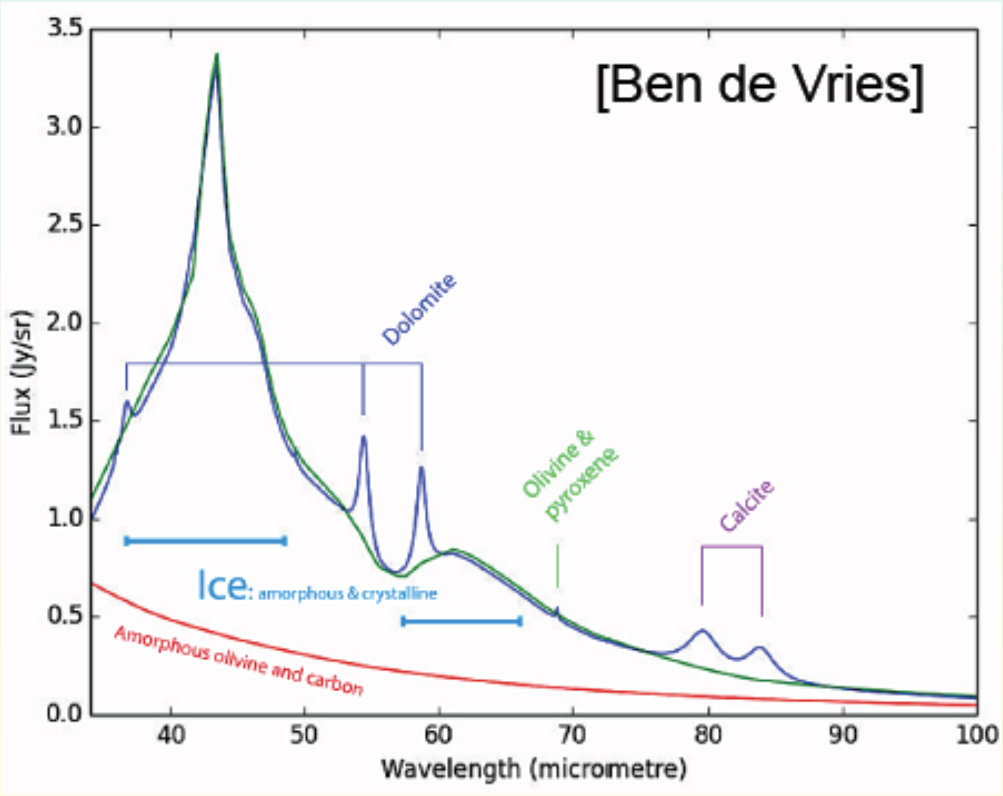


(4) Also unique dust composition tracers

Forsterite feature at 69μm, peak wavelength and width of which gives Fe/Mg ratio in crystalline silicates (de Vries et al. 2012)



And ice feature at 40μm, plus calcite, dolomite, pyroxene



Conclusions

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