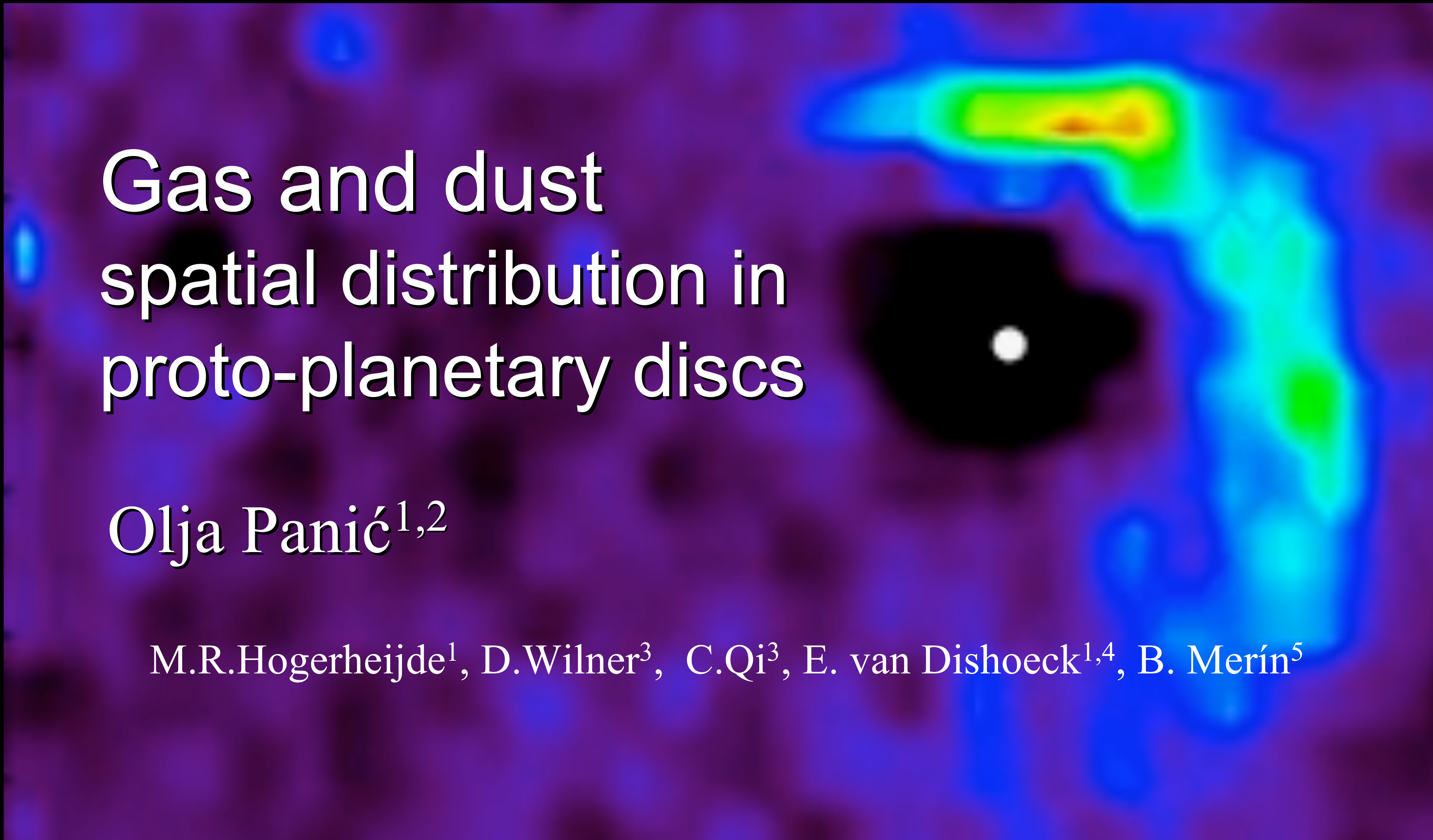

Gas and dust spatial distribution in proto-planetary discs

Olja Panić[1,2]

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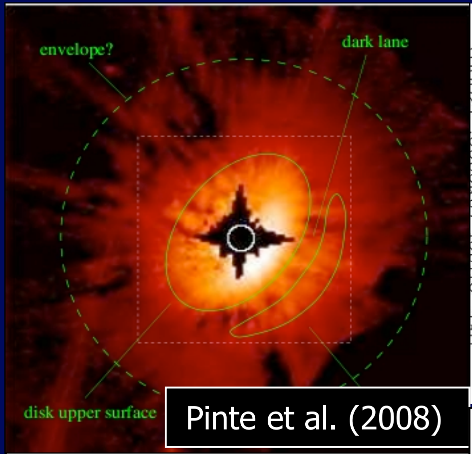
Why study the gas and dust distribution in discs:

- Physical processes during disc evolution may alter the relative distribution of gas and dust
- Disc size is a key parameter when assessing disc mass
- To understand where the emission arises from is necessary to interpret a wealth of (spatially unresolved) observations that are available (e.g. SEDs)

Olja Panić

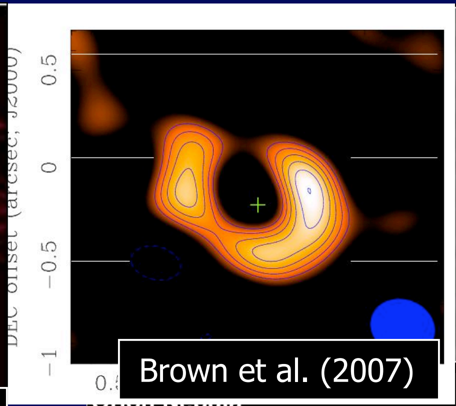
Leiden Observatory, Leiden University

Disc imaging from nIR to mm



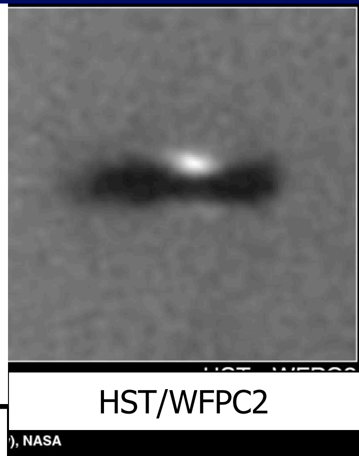
Pinte et al. (2008)

HST/NICMOS

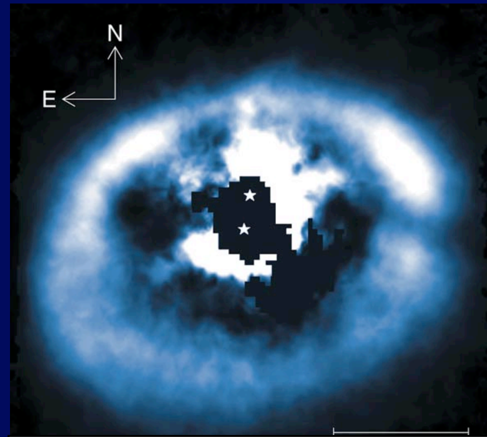


Brown et al. (2007)

Submillimeter Array



HST/WFPC2



Gemini

University of Hawaii, IfA

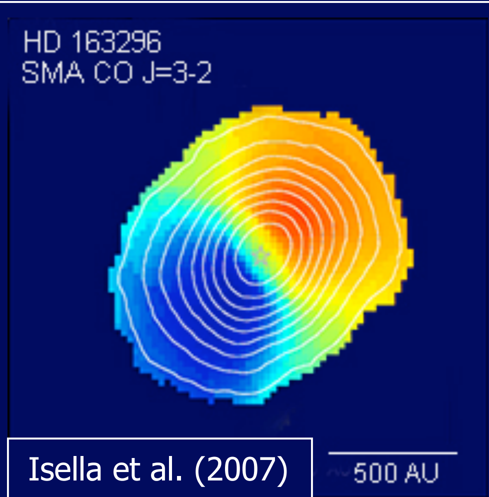
Young gas rich discs:

$R \approx 100\text{-}1000$ AU

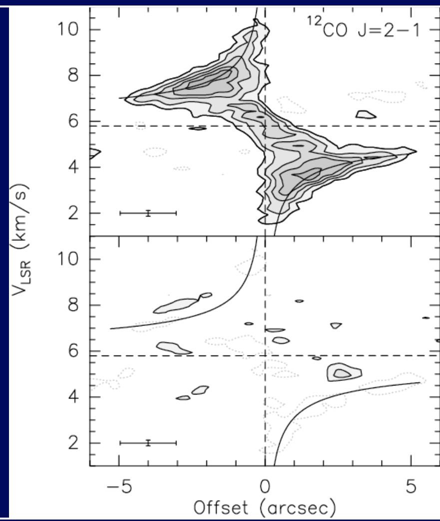
$M_{disc} \approx 10^{-3} M_{\odot} \sim 10^{-1} M_{\odot}$

~99% molecular gas

~1% dust

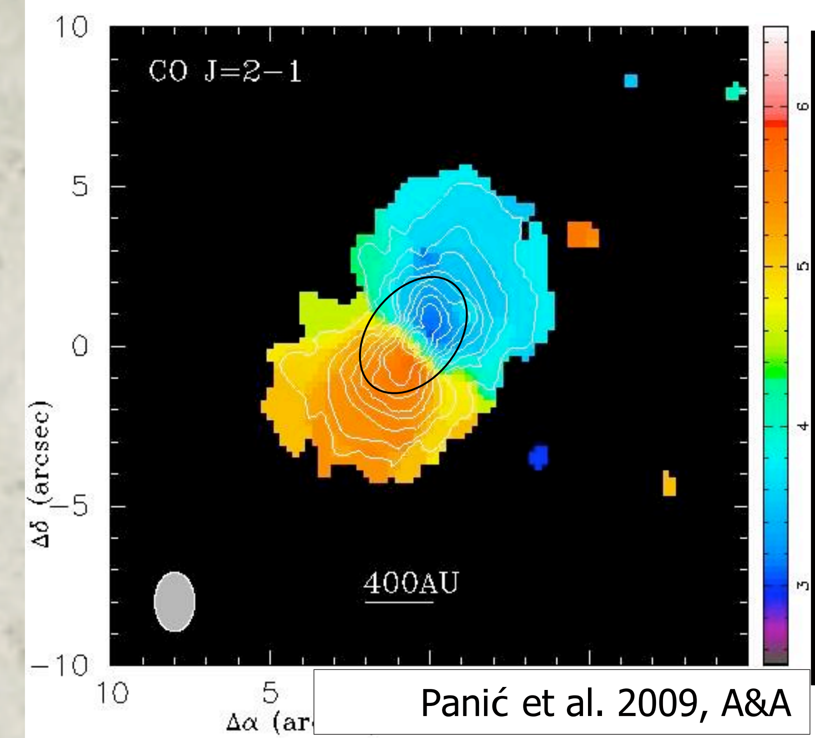


Isella et al. (2007)

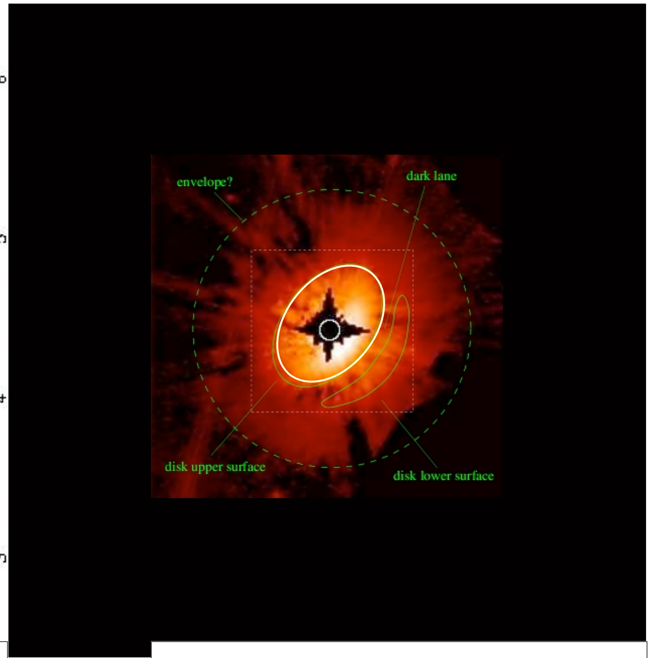


Disc around the T Tauri star IM Lup:

Larger by 500 AU than expected from detailed dust modelling



Panić et al. 2009, A&A



Pinte et al. 2008, A&A

CO observations

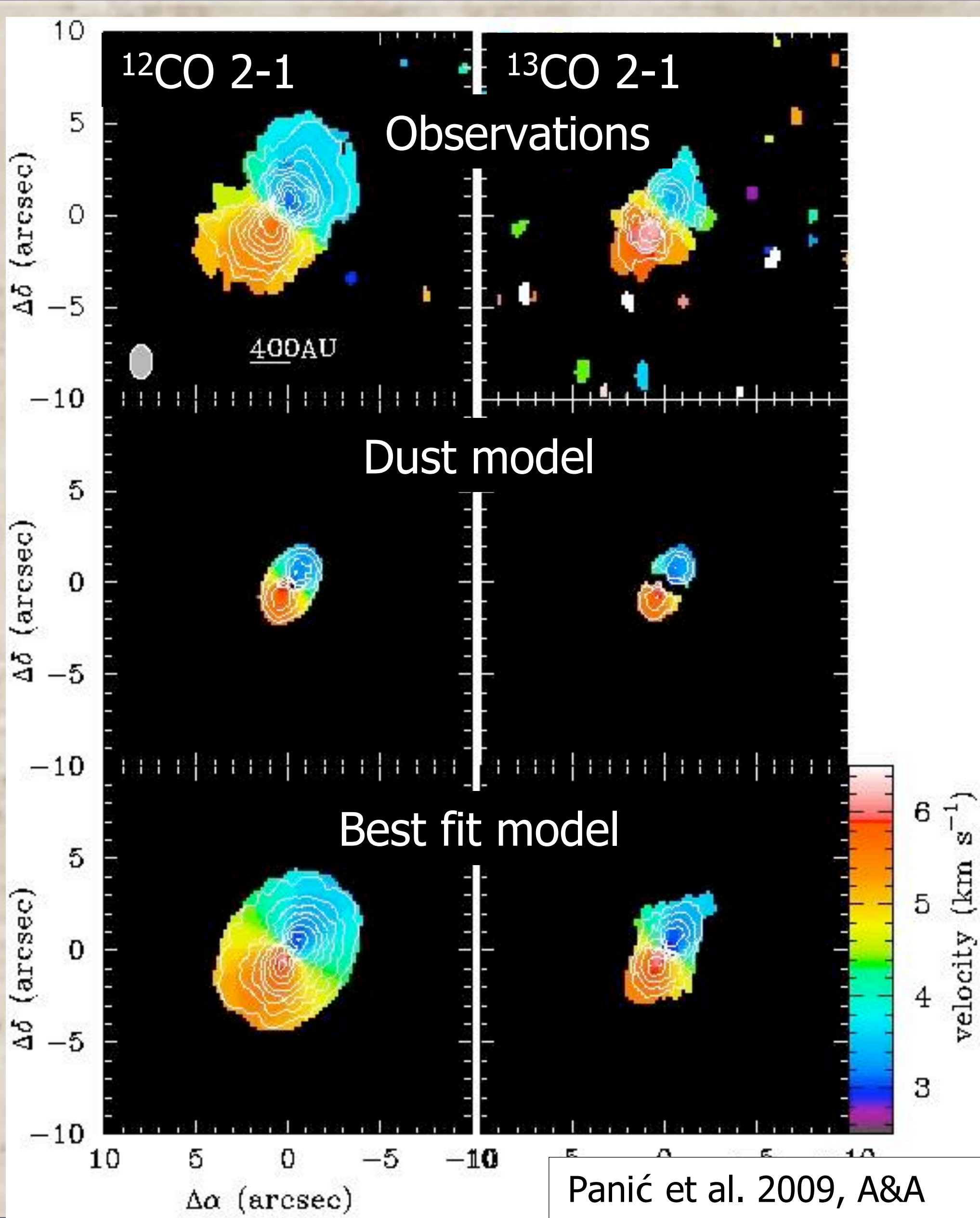
→ $R_{out} = 900\,AU$

(at ~1.5″ resolution)

scattered light imaging

→ $R_{out} = 400\,AU$

$\Sigma_{(R \approx 500\,AU)} \leq 10^{-4}\, g_{dust} / cm^2$



Panić et al. 2009, A&A

Observations

SMA observations of ^{12}CO, ^{13}CO, and $C^{18}O$ J=2—1 line (~230GHz,~1.3mm)

Dust model

$$\sum \propto R^{-1}$$

$$R = 400\,AU$$

Our model

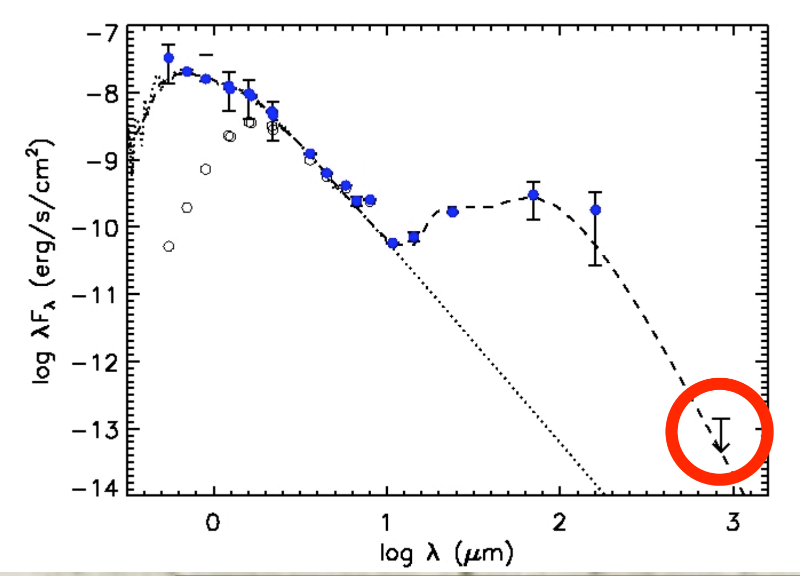
Drop in density close to 400AU

20-30K temperature beyond 400AU

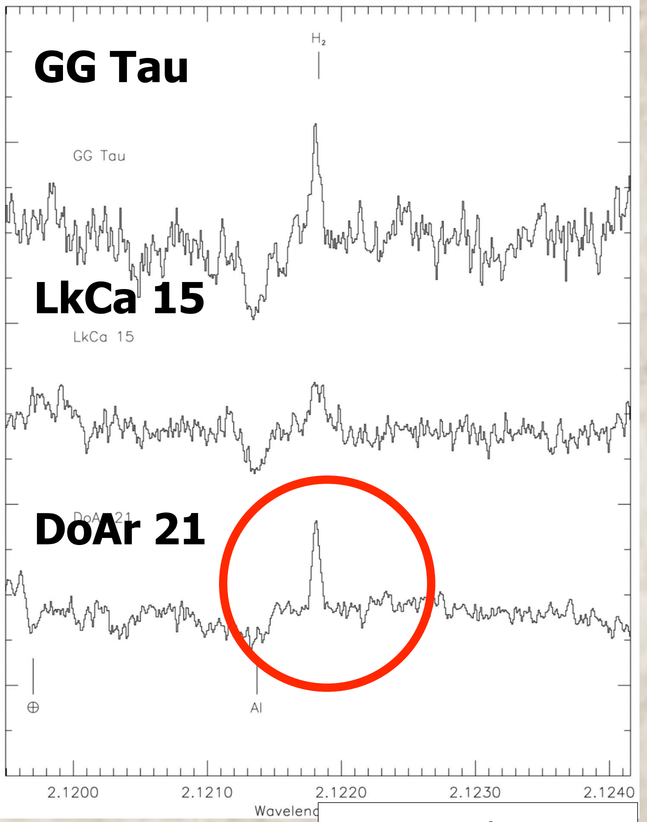
Possible astrophysical implications:

- Efficient radial drift of small dust in the outer disc (talk by C.Dullemond) + photodissociation
- Presence of a companion at 400 AU
- Outermost disc material did not participate in the viscous spreading?

Weak line T Tauri star DoAr21: transitional SED, weak mm fluxes but strong H_2



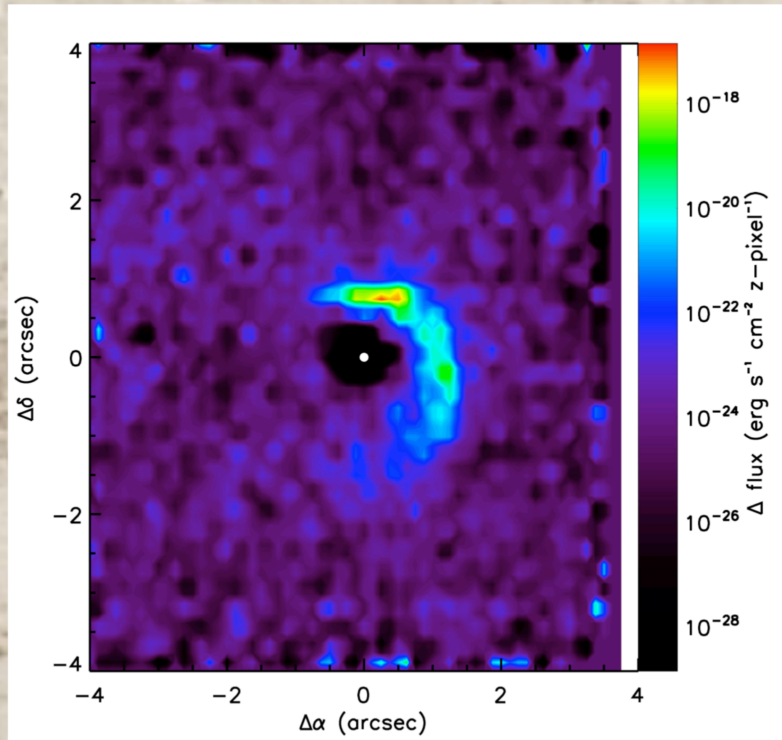
Hogerheijde, Schouten, Panić and Merín (2009), A&A submitted



Bary et al. (2003)

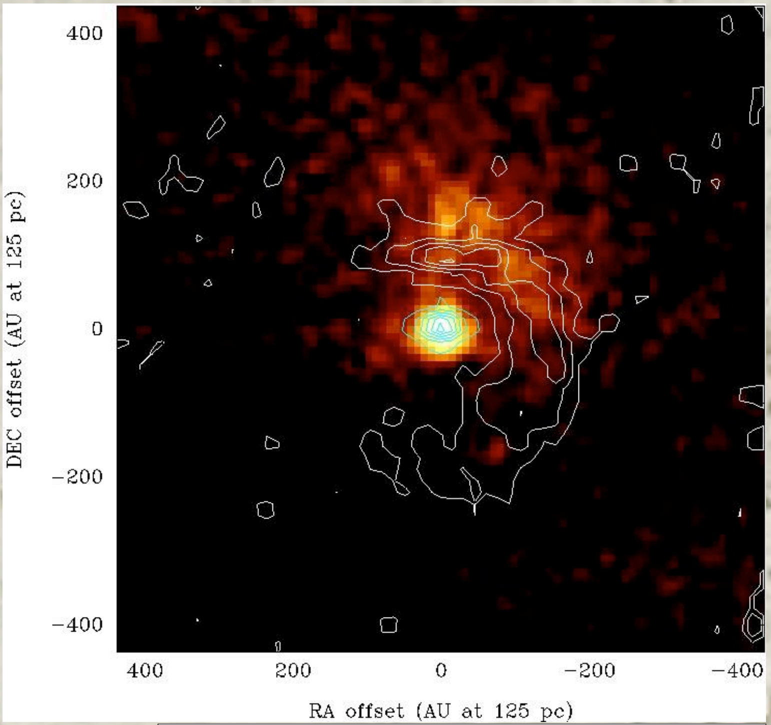
VLT/SINFONI imaging of the H_2 2.12 μm emission reveals a surprising structure

- Inner 70 AU appear to be devoid of gas
- Emission confined to an arc on the NW side of the star



Hogerheijde, Schouten, Panić and Merín (2009), A&A submitted.

VLT/VISIR warm dust imaging at 18 μm confirms the asymmetric distribution



Hogerheijde, Schouten, Panić and Merín (2009), A&A submitted.

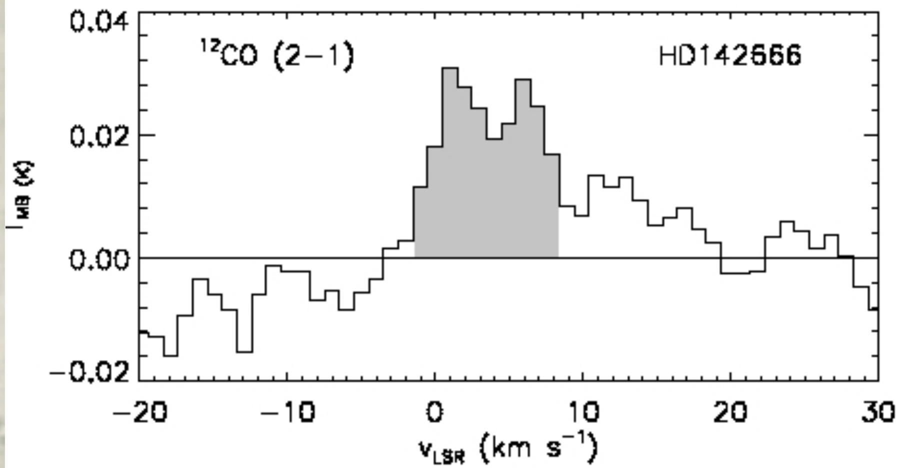
- 100-200 K warm dust
- Emission distribution coincident with that of the H_2
- Star photosphere is also detected (~50/50%)

Astrophysical implications:

- nIR H_2 lines can be efficiently excited up to 200 AU from the star

  → In low-mass discs, near-IR H2 lines may provide means to image the gas.
- Imaging is necessary to confirm the presence and size of a hole inferred from a "transitional" SED

Modelling of low-J CO lines in discs around Herbig Ae stars



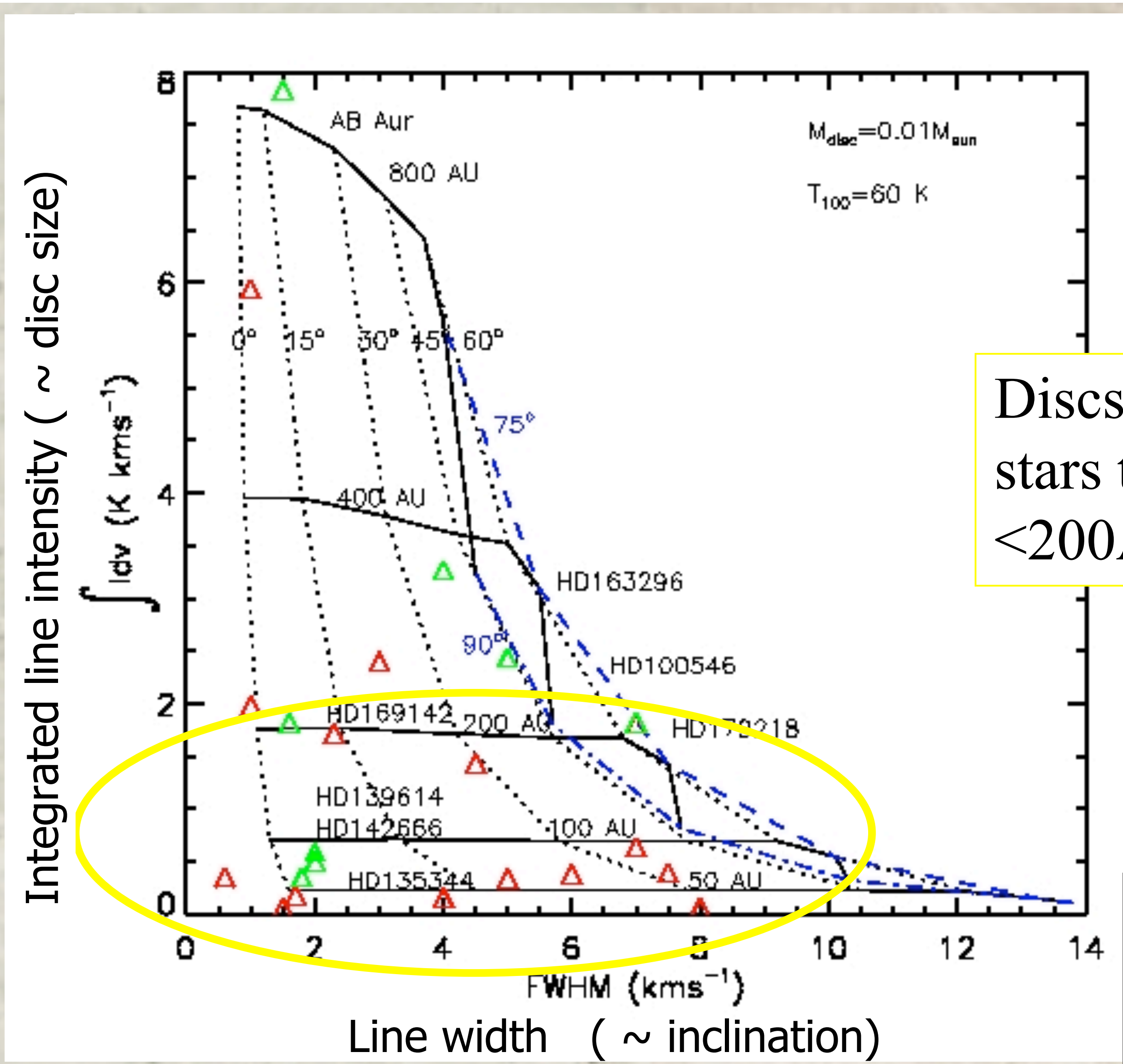
$$T(R) = T_{100}\left(R/100AU\right)^{-q}$$
$$q = 0.5$$
$$T_{100} = 60K$$
$$\Sigma(R) = \Sigma_{100}\left(R/100AU\right)^{-p}$$
$$p = 1$$

$$FWHM = f\left(M_*, i, R\right)$$
$$\int I dv = f\left(T, R, N\right)$$

free parameters: R, i

We use a sample of 25 gas-rich discs around Herbig Ae stars and their CO 3-2 spectra from Dent et al. 2005.

Modelling low-J CO lines from Herbig Ae discs

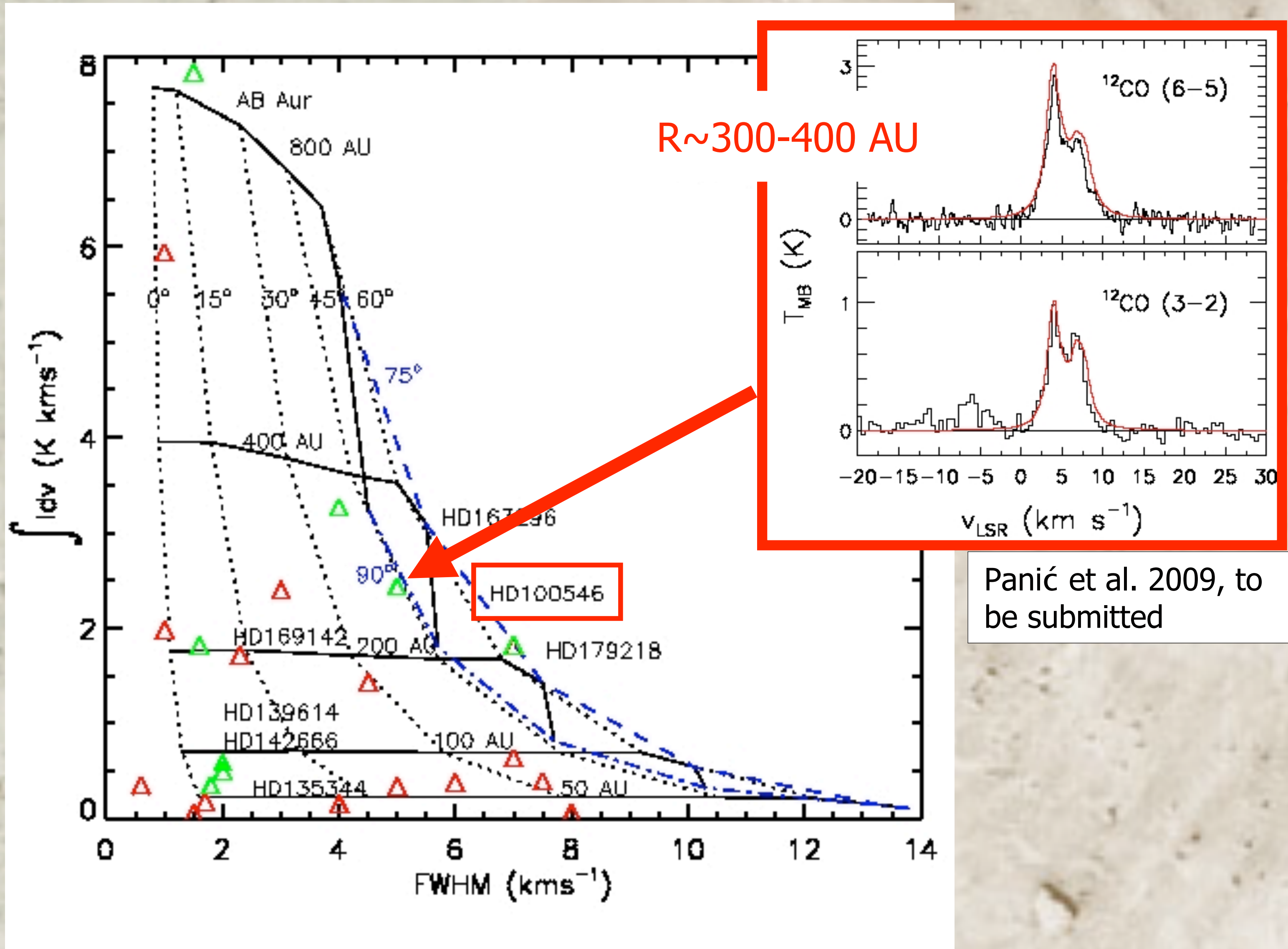


Discs around HAe stars typically <200AU in size

Panić & Hogerheijde 2009, A&A in press

-based on data from Dent et al. 2005

HD100546: CO line spectrum and disc size

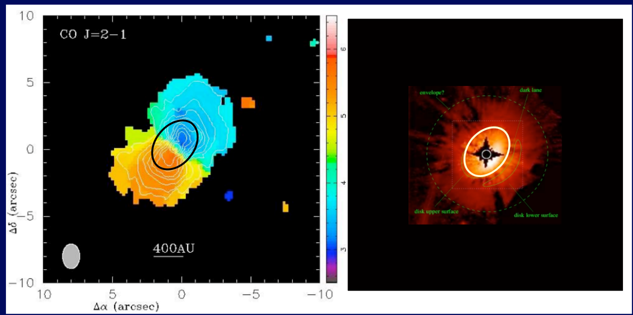


Panić et al. 2009, to be submitted

Astrophysical implications:

- Most discs around HAe stars are small (<200 AU)
  → warm enough to prevent CO freeze-out
  → CO may be used to measure the gas mass directly (as in Panić et al. 2008)

Main conclusions

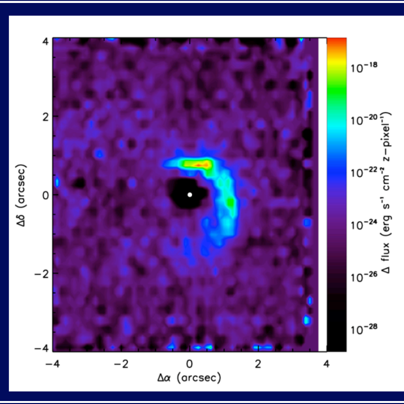


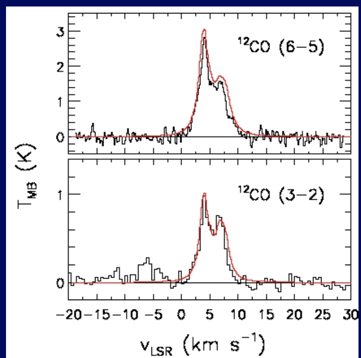
- The spatial distribution of the gas cannot be inferred from dust observations alone, and may be much more extended.

  Panić et al. 2009, A&A

- Fluorescent H_2 2.12μm line can be used to trace disc geometry.

  Hogerheijde et al. 2009, A&A subm.





- Gas mass can be constrained in discs that are sufficiently small (~200 AU) and warm (>20 K, most Herbig Ae stars).

  Panić et al. 2008, A&A,

  Panić et al. 2009 in press, A&A