Unveiling the dust dissipation geometry and properties in the inner regions of pre-transitional disks : an interferometric view of the Herbig star HD139614

Alexis Matter *Institut de Planétologie et d'Astrophysique de Grenoble*

Collaborators : L. Labadie, J.-C. Augereau, M. Benisty, A.Kreplin, B. Lopez, G. Weigelt, J.-U. Pott, W.C. Danchi, Wing-Fai Thi

Planet Formation And Evolution 2014

Kiel, 08/09/2014

Outline

- Dust evolution and dissipation processes
  - ↳ Which observational signatures ?
- The pre-transitional disk around HD139614
  - ↳ How/where circumstellar dust is dissipating ?
- Summary / Outlook

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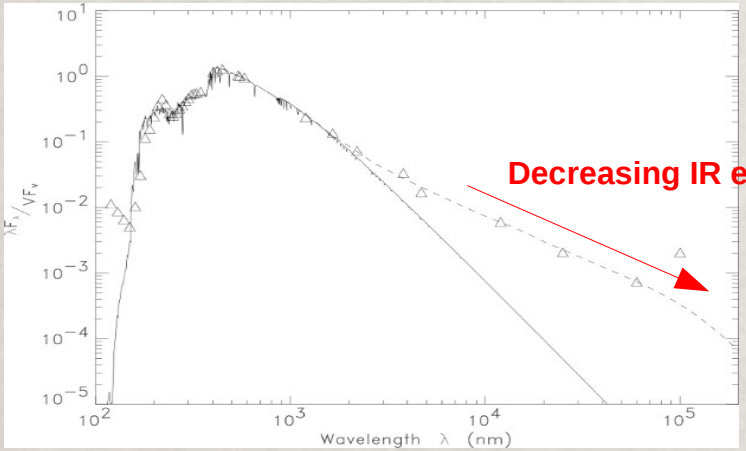
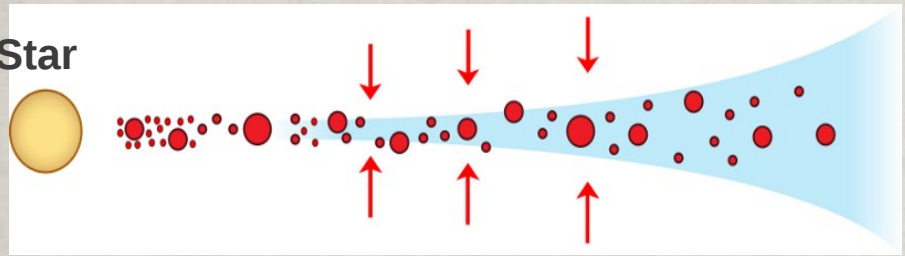
Dust evolution and dissipation processes : Observational signatures ?

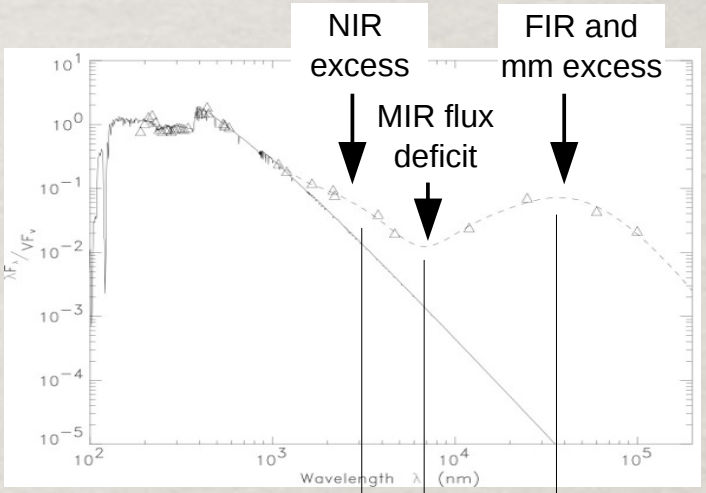
SED

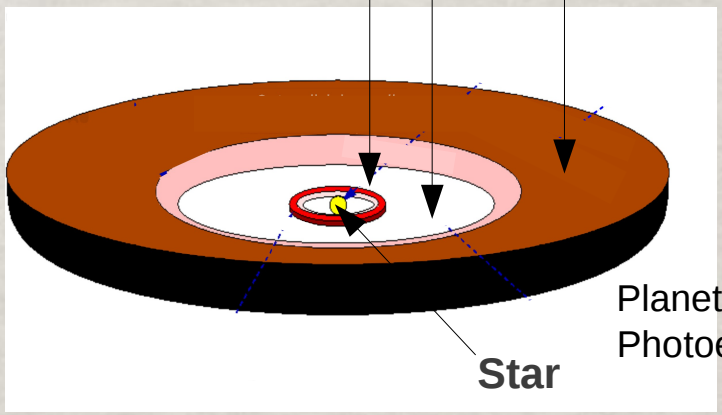
Signatures of dust evolution





Global grain growth/dust settling ?





Planet formation ?
Photoevaporation ?

Dust evolution and dissipation processes : Observational signatures ?

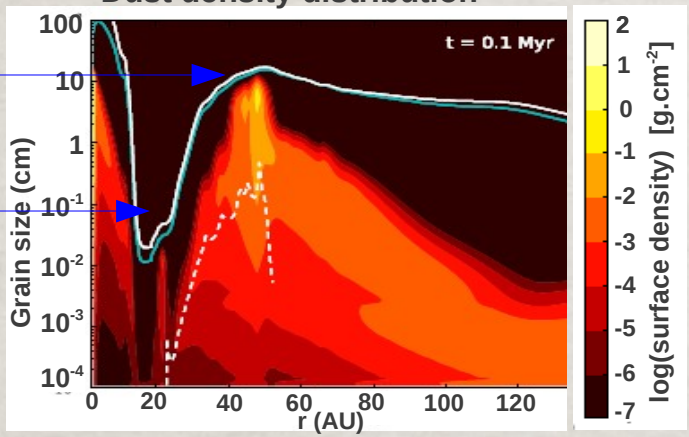
Spatially resolved observations

Planet formation

Dust density distribution

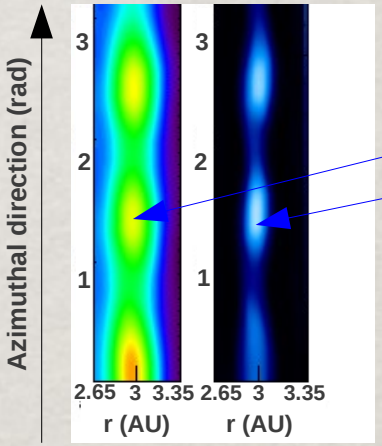
Axisymmetric over-density

Gap



Pinilla et al. (2012)

Anticyclonic Vortex



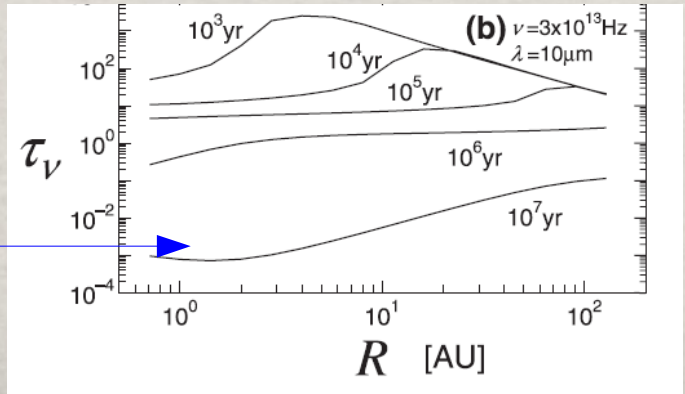
Vortex (gaz)

Local over-density (Dust)

Méheut et al. (2012)

Faster grain growth and settling in the inner region

Optical depth radial profile



Positive optical depth radial profile

Tanaka et al. (2005)

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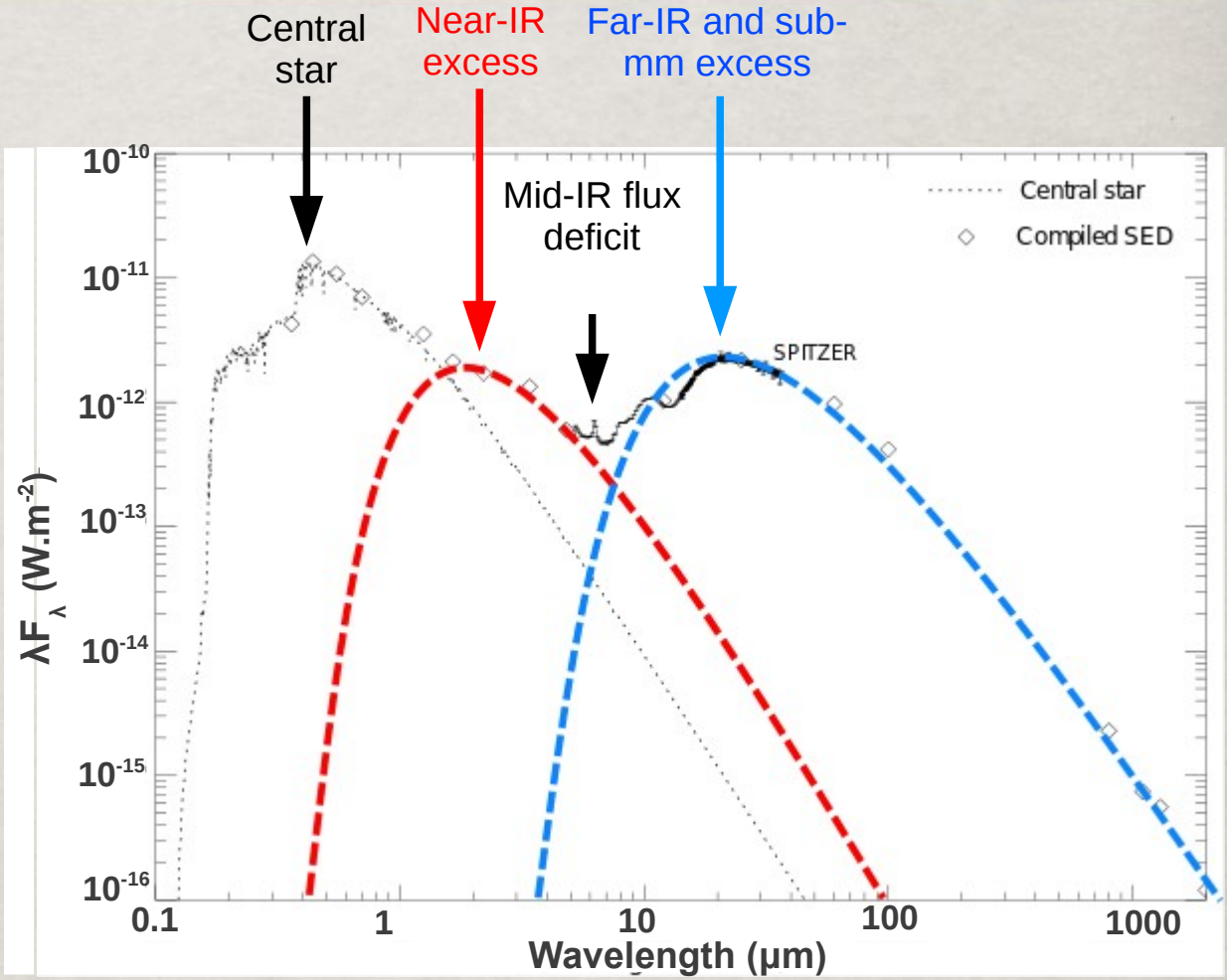
The pre-transitional disk around HD139614

HD 139614

Intermediate mass (~ 2 M_{sun}) pre-main sequence star(≤ 10 Myr)

Group Ib object :
Two-component SED +
no distinct silicate features
(Meeus et al., 2001)



Geometry of dust dissipation ?

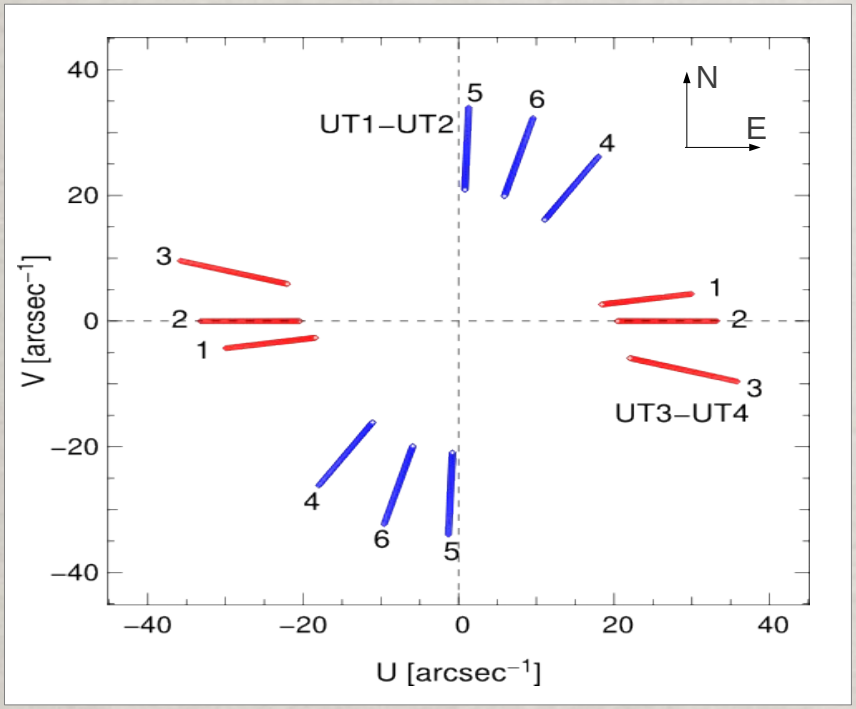
Physical characteristics of the inner region (~ 0.1-10 AUs) ?

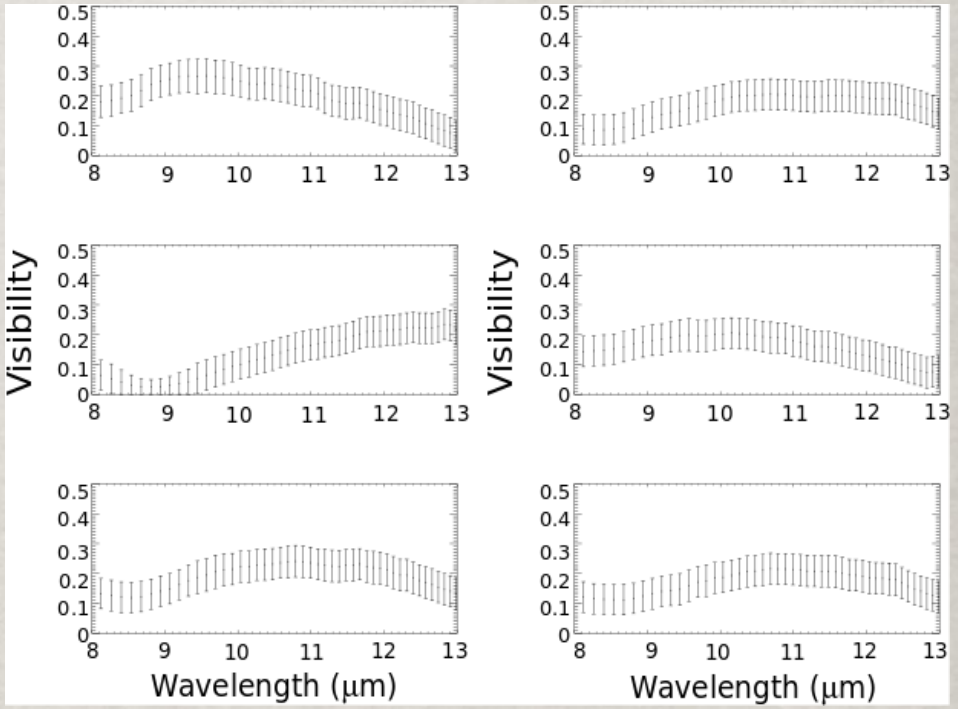
The pre-transitional disk around HD139614

First set of observations

Mid-infrared interferometry

Warm disk atmosphere
(~ 1 – 10 AU)





MIDI (N band)

(Baseline ~ 50 m → Resolution ~ 35 mas)

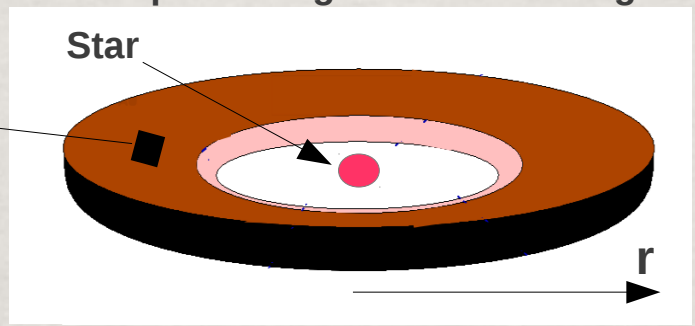
The pre-transitional disk around HD139614

Analytical modeling
Interferometry (mid-IR) + IR SED

(See Matter et al., 2014, A&A)

Temperature-gradient modeling

$$dF_\lambda = B_\lambda(T_r)(1-e^{\tau_r})$$



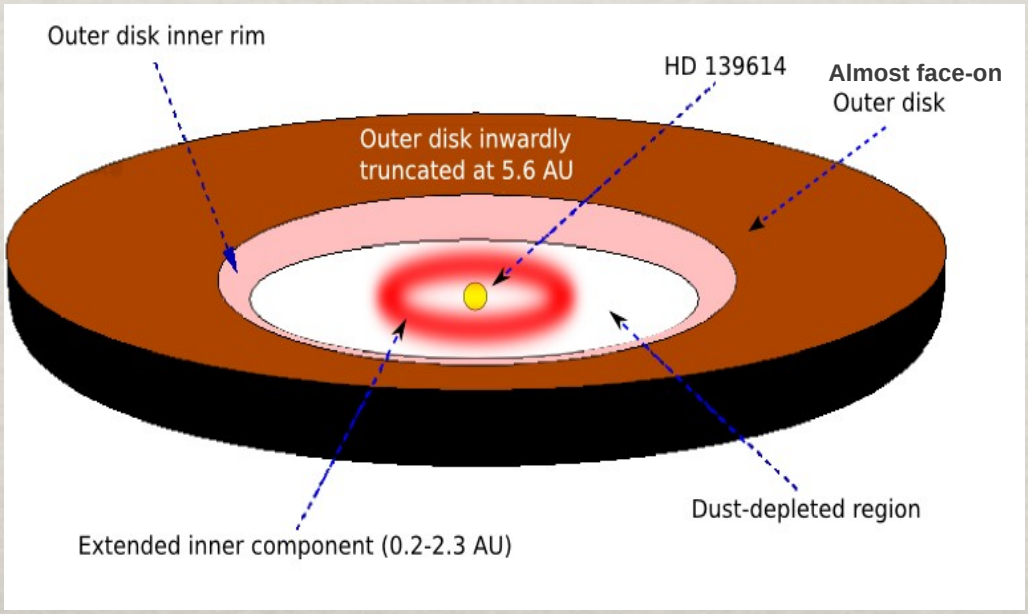
Surface density profile

$$\Sigma_r = \Sigma_0 r^{-p}$$

Temperature profile

$$T_r = T_0 r^{-q}$$

Best-fit model representation

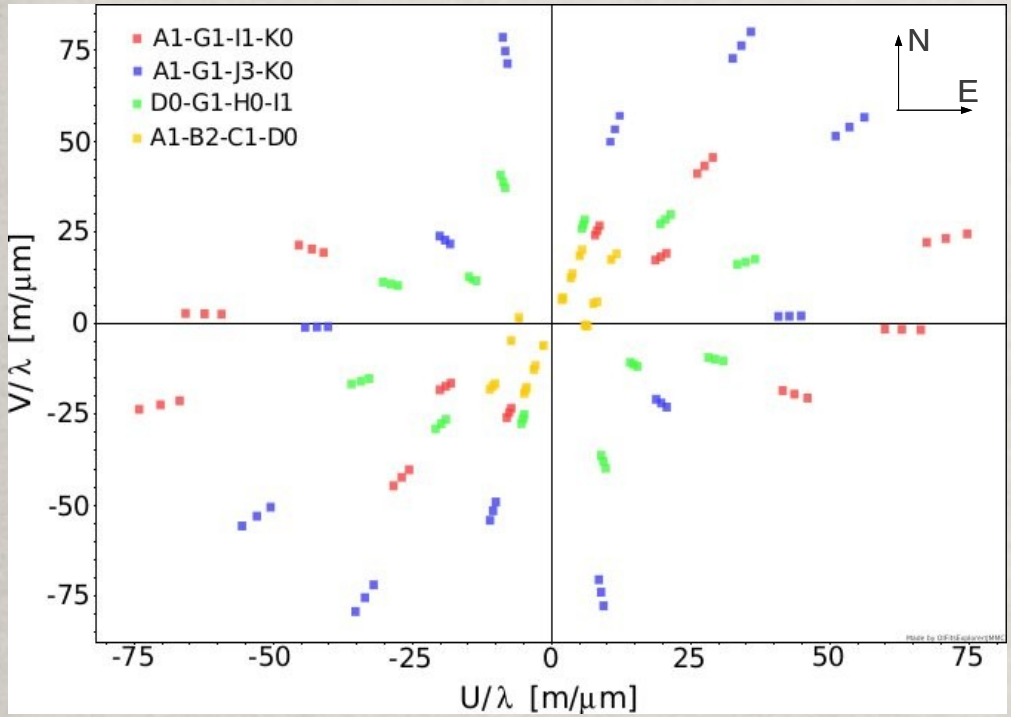


The pre-transitional disk around HD139614

Second set of observations

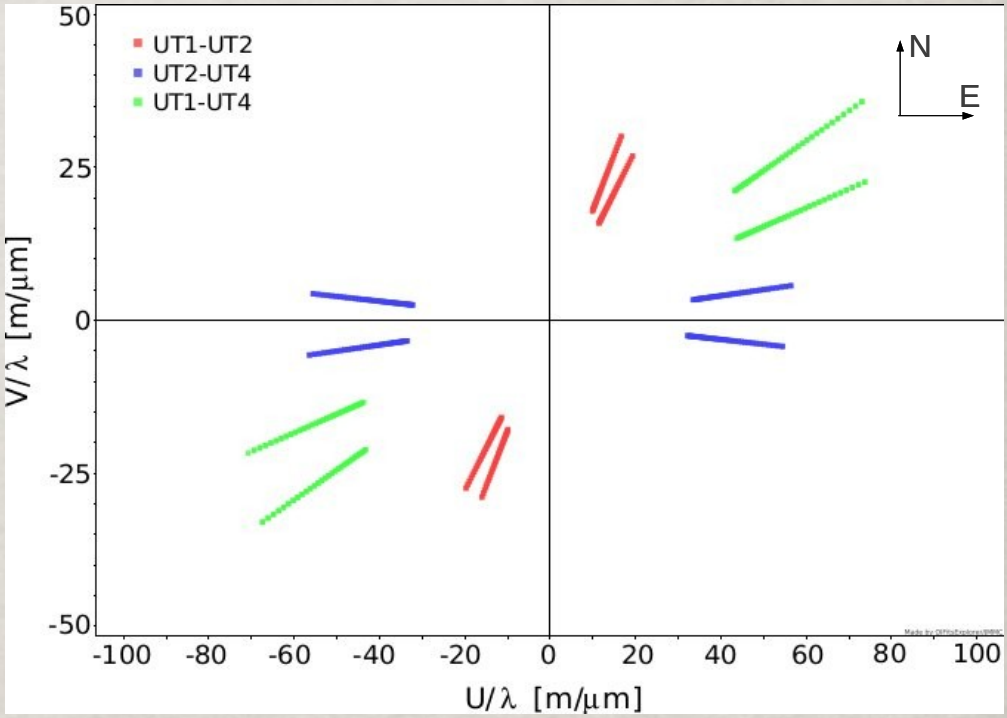
Near-infrared interferometry

Disk innermost region
(~ 0.1 – 1 AU)



PIONIER (H band)

24 visibility measurements
(Baseline ~ 15-120 m)



AMBER (K band)

6 visibility measurements
(Baseline ~ 40-120 m)

The pre-transitional disk around HD139614

Radiative transfer modeling
IR Interferometry + broadband SED

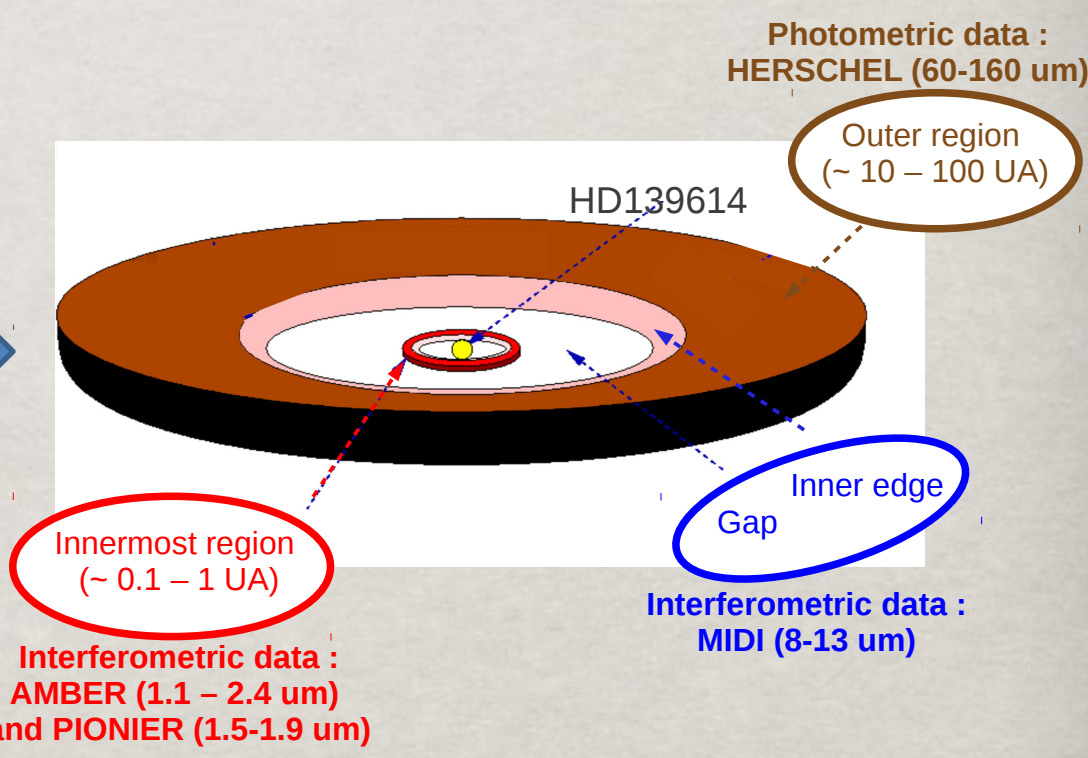
What ?

- **Dust geometry (inner and outer regions)**
- **Dust temperature profile**
- **Dust properties (composition, grain size)**

How ?

Radiative transfer modeling (RADMC3D)

Observational data ?

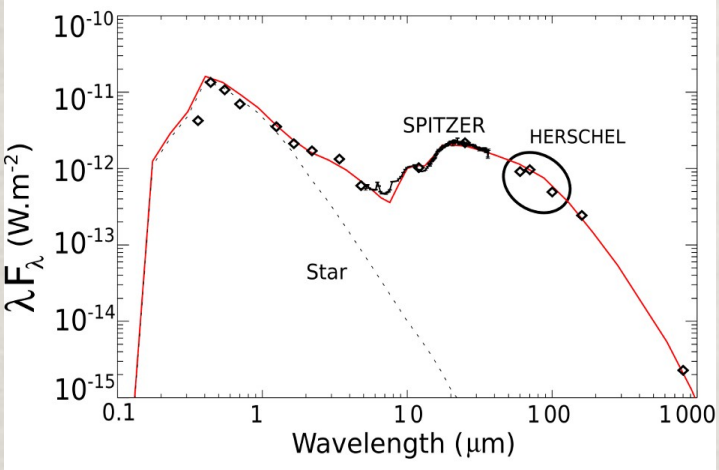


The pre-transitional disk around HD139614

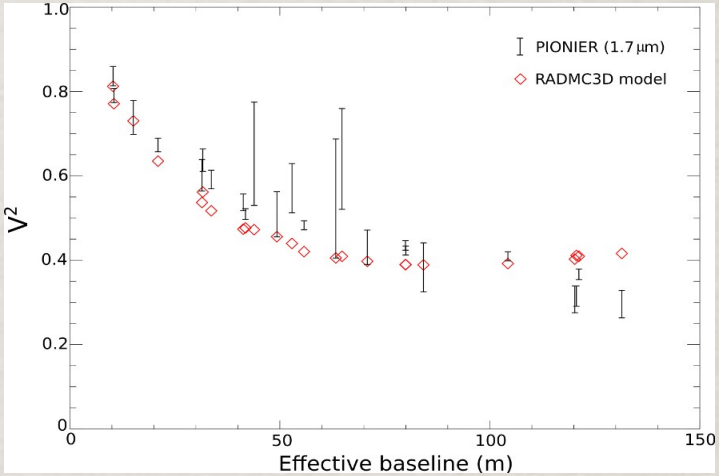
Radiative transfer modeling

IR Interferometry + broadband SED

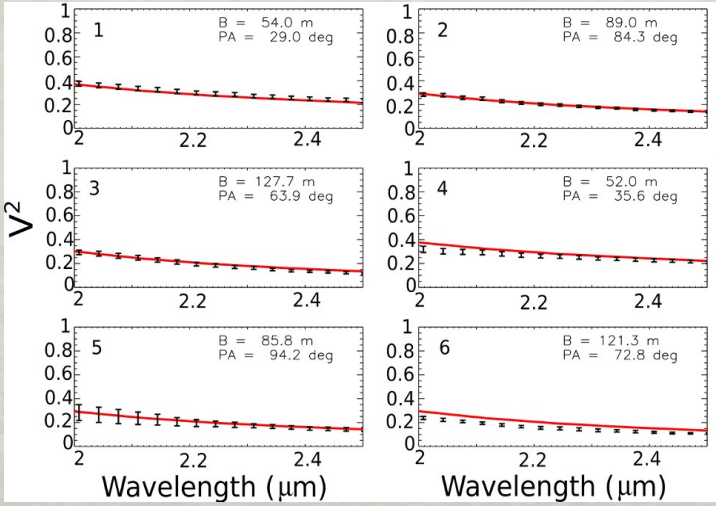
Broadband SED



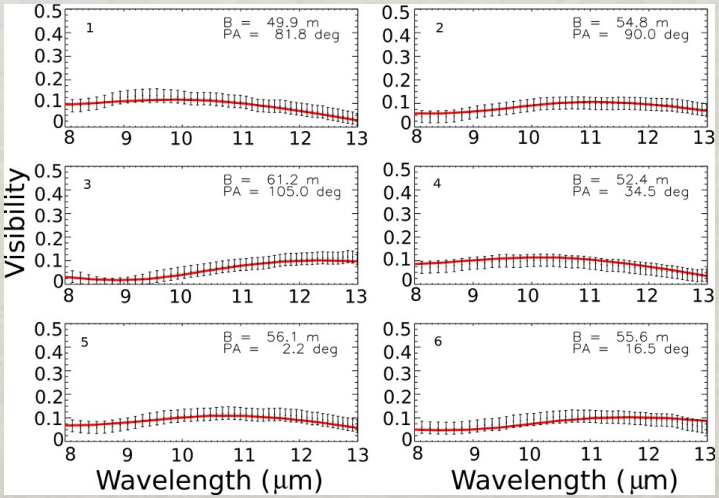
H-band V²



K-band V²



N-band V

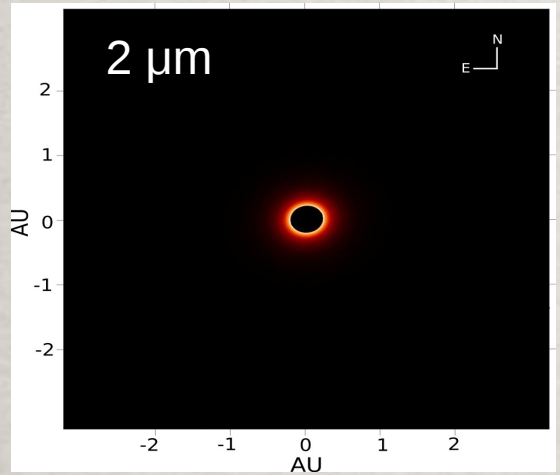


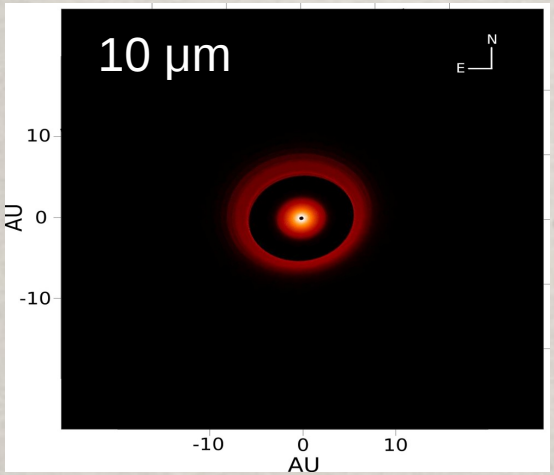
The pre-transitional disk around HD139614

Radiative transfer modeling
IR Interferometry + broadband SED

(Matter et al., in prep.)

Model images
(linear scale / star removed)





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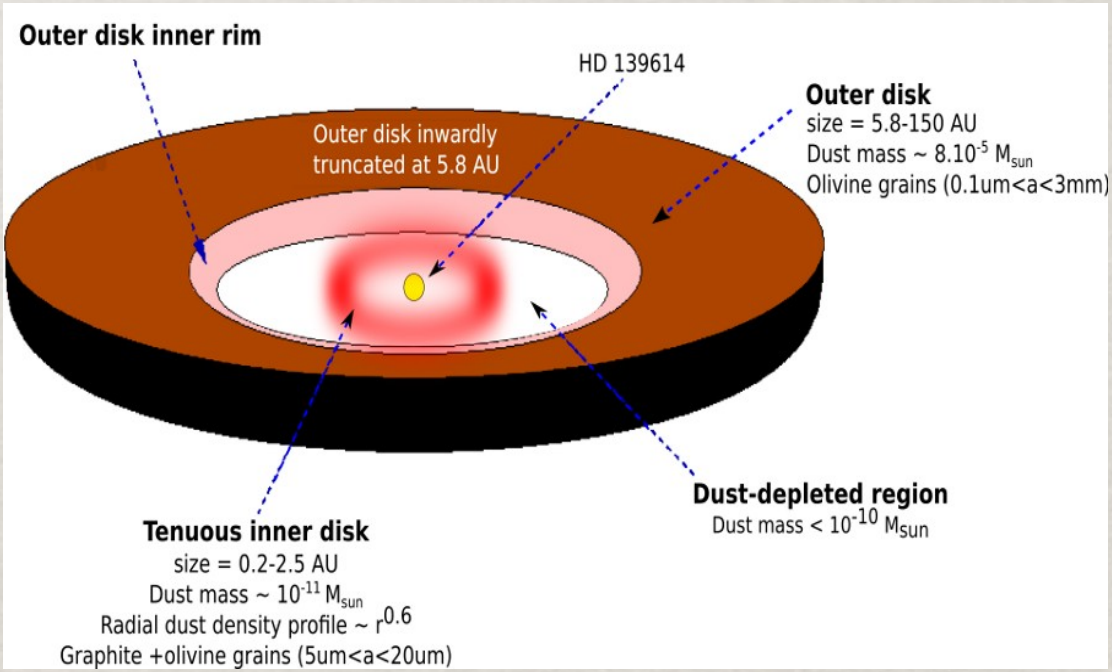
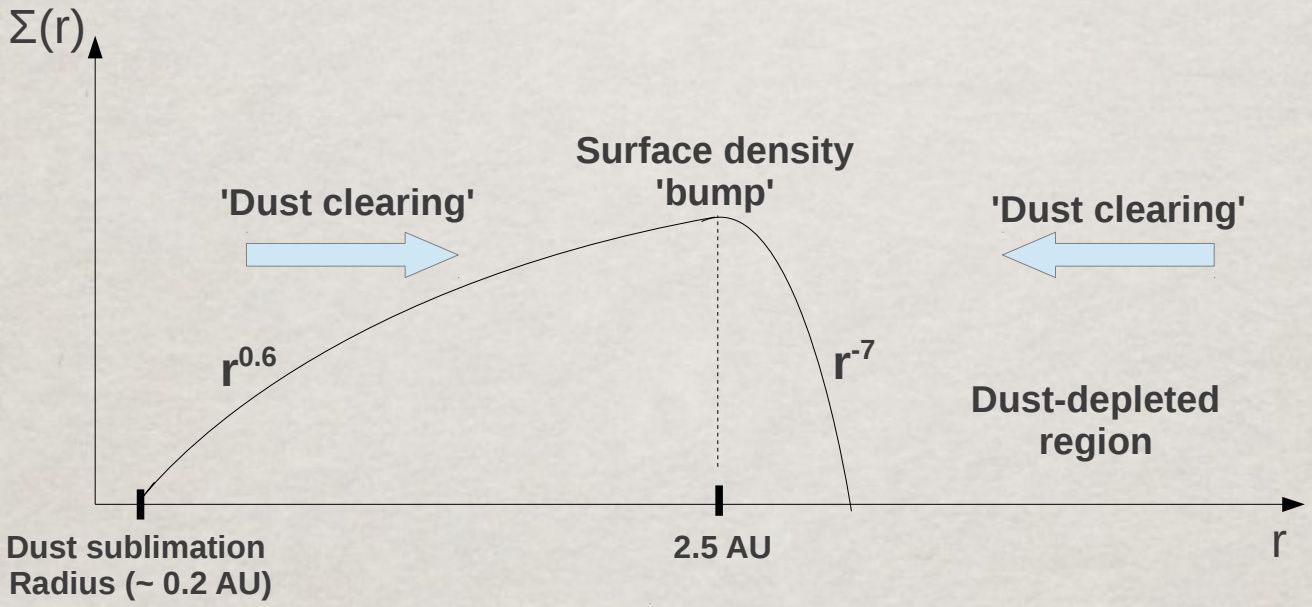


The pre-transitional disk around HD139614

Results analysis

Inner disk



Inside-out 'clearing' mechanism ?

. Different dust sublimation radii (different grain sizes)

. Faster grain growth and settling in the innermost region (Tanaka et al., 2005)

. Photophoresis effect (Krauss&Wurm, 2005)

. Radiation pressure (Dullemond et al., 2011)

+

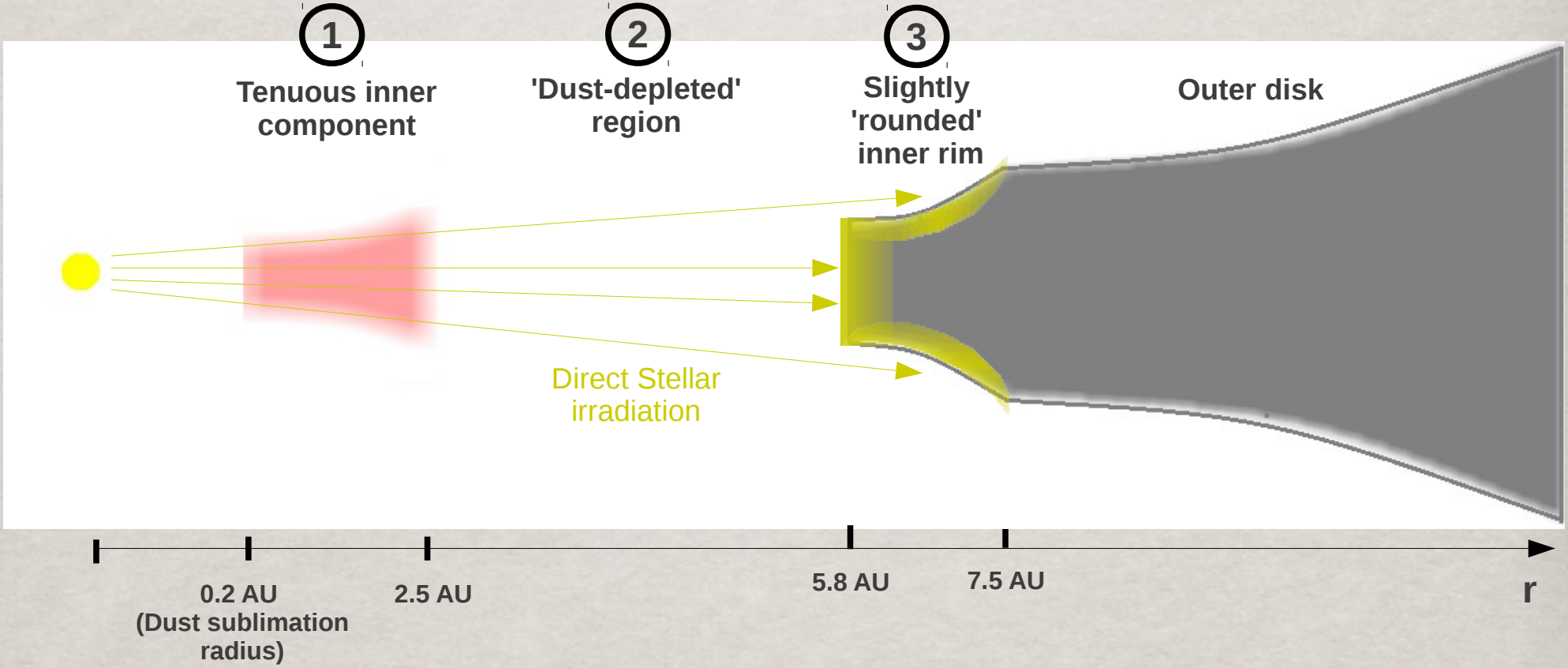
Density bump + sharp transition in opacity/density ?

Dynamical clearing by a substellar companion (see e.g. Zhu et al., 2011)

The pre-transitional disk around HD139614

Results analysis

Outer disk



3 → **Hydro simulations** → Hypothetical substellar companion mass + disk viscosity
(see the case of HD100546, Mulders et al., 2013)

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Summary / Outlook

Dust

Inner disk

- ✔ Tenuous and spatially extended
- ✔ Positive surface density profile

Gap

- ✔ Only about 4 AU wide
- ✔ Depleted in sub-μm and μm-sized grains

Outer disk

- ✔ Flared and massive
- ✔ Slightly rounded inner rim

Status of gas and mm-sized dust in the inner region?

Gas

On-going analysis of CO emission in L band from CRIRES data

Gas detection in the ~ 1-30 AU region including the gap (Carmona et al., in prep)

mm-sized dust

Need of resolved observations in mm

Spatial discrimination of dust grain sizes in the inner region (~ 1-10 AU) ?

Summary / Outlook

Results analysis

Observed pre-transitional disks

		Age (Myr)	Spectral type	r_i (AU)	r_{out} (AU)	D (pc)	Gap size (AU)
Herbig stars (Group I)	HD 139614	8	A7	0.2	2.6	140	3.7
	HD 100546	10	B9	0.26	~4	103	9
	HD 169142	13.5	A5V	~0.1	0.2(?)	145	<23(?)
	IRS 48	15	A0	~0.1	0.3	120	<63
	HD 97048	-	B9.5	0.3	2.5	158	<34
T Tauri stars	HD 135344B	6	F4V	~0.1	0.3(?)	140	<30(?)
	T Cha	7	K0-G8	0.07	0.11	100	12
	LkCa 15	3-5	K5-K3	0.015	0.19	140	58
	Rox 44		K3	0.25	0.4	120	36
	UX Tau	1	G8	0.15	0.4	120	36

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Inner disk size

Very narrow NIR-emitting region ($\Delta r < 0.3$ AU)

Spatially extended NIR-emitting region ($\Delta r > 2$ AU)

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Gap size

Narrow gaps (size < 10 AU)

Very large gaps (size > 25 AU)