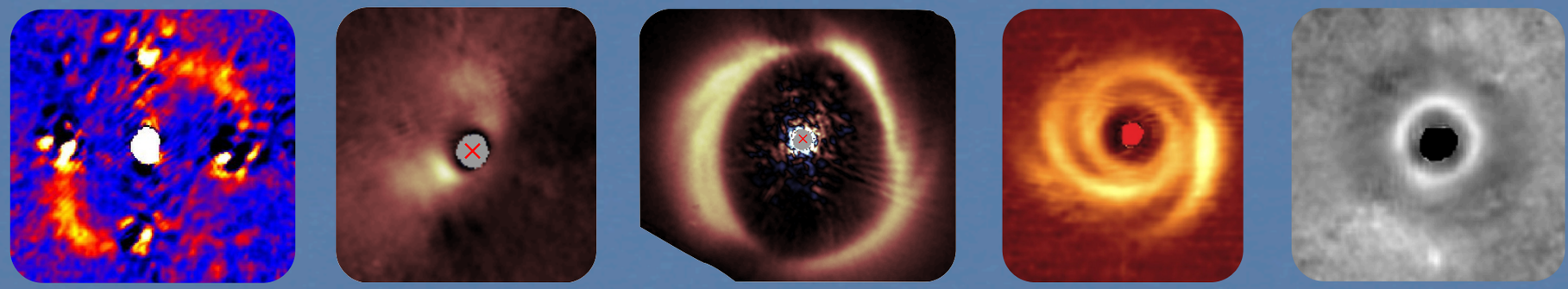
Small vs large dust grains in transitional disks (maybe...) from VLT/NACO and ALMA



Antonio Garufi

(PhD student @ ETH Zürich)

S. Quanz, H. Avenhaus, H.M. Schmid, M. Meyer, C. Dominik,
F. Meru, E. Buenzli, P. Pinilla, and S. Wolf

Motivations

Observe planet formation in the act...

Forming planets
(e.g. Quanz et al. 2013, Reggiani et al. 2014, Biller et al. 2014...)

Forming planets' environment

Need to look at the disk stage when planet formation is favored

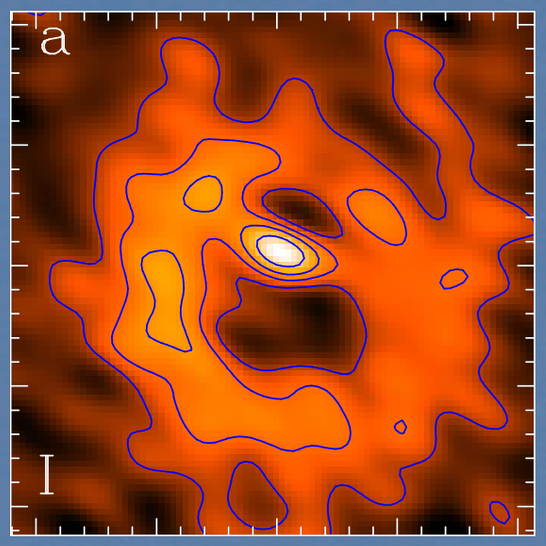
TRANSITIONAL DISKS
(and their peculiar features, possibly signposts of planets)

Transitional disks

Peculiar spatial distributions generated by planet action, grain growth, photoevaporation, gravitational instability...

These processes differentiate the dynamics of components

Gas
NIR-mm imaging, NIR-mm spectroscopy...

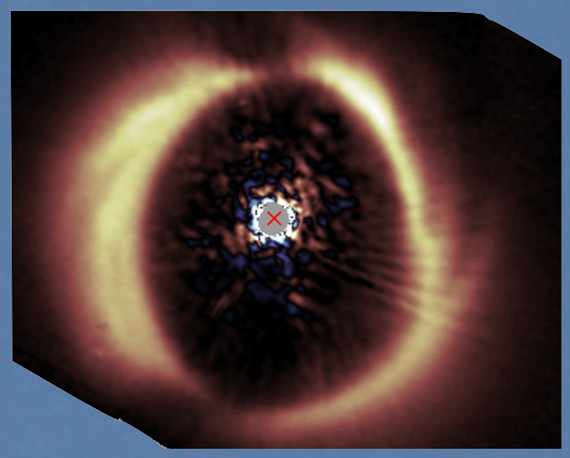


HD142527
HCO^+ (4-3) (ALMA)
Casassus et al. (2013)

Small grains
Opt-NIR scattered light, NIR-MIR interferometry...

ETH zürich

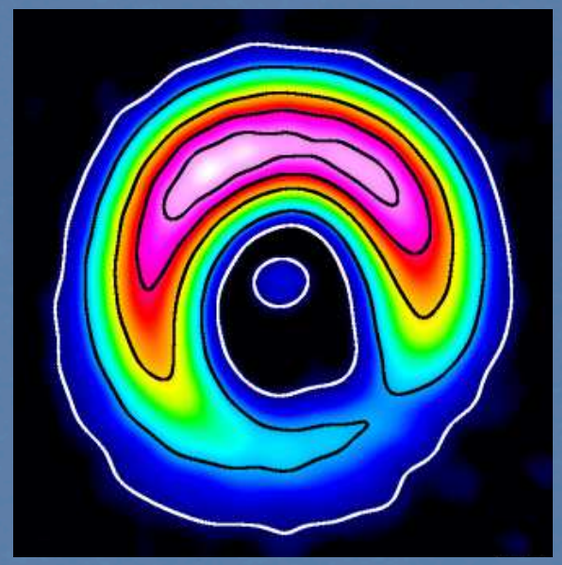
≠



HD142527
1.6 µm scattered light (VLT/NACO)
Avenhaus et al. (2014)

Large grains
(Sub-)mm imaging

≠



HD142527
890 µm continuum (ALMA)
Fukagawa et al. (2013)

Near-IR scattered light

Ground telescopes + AO : $\theta \simeq 0.1''$

And with Polarimetric Differential Imaging : IWA $\simeq$ 0.1″

$\Rightarrow$ imaging the planet formation region!

But...

Probing the disk surface only (disk geometry counts)

Dust scatters and polarizes anisotropically (grain properties count)

Polarized light distribution is not necessarily representative of the dust distribution

How PDI works

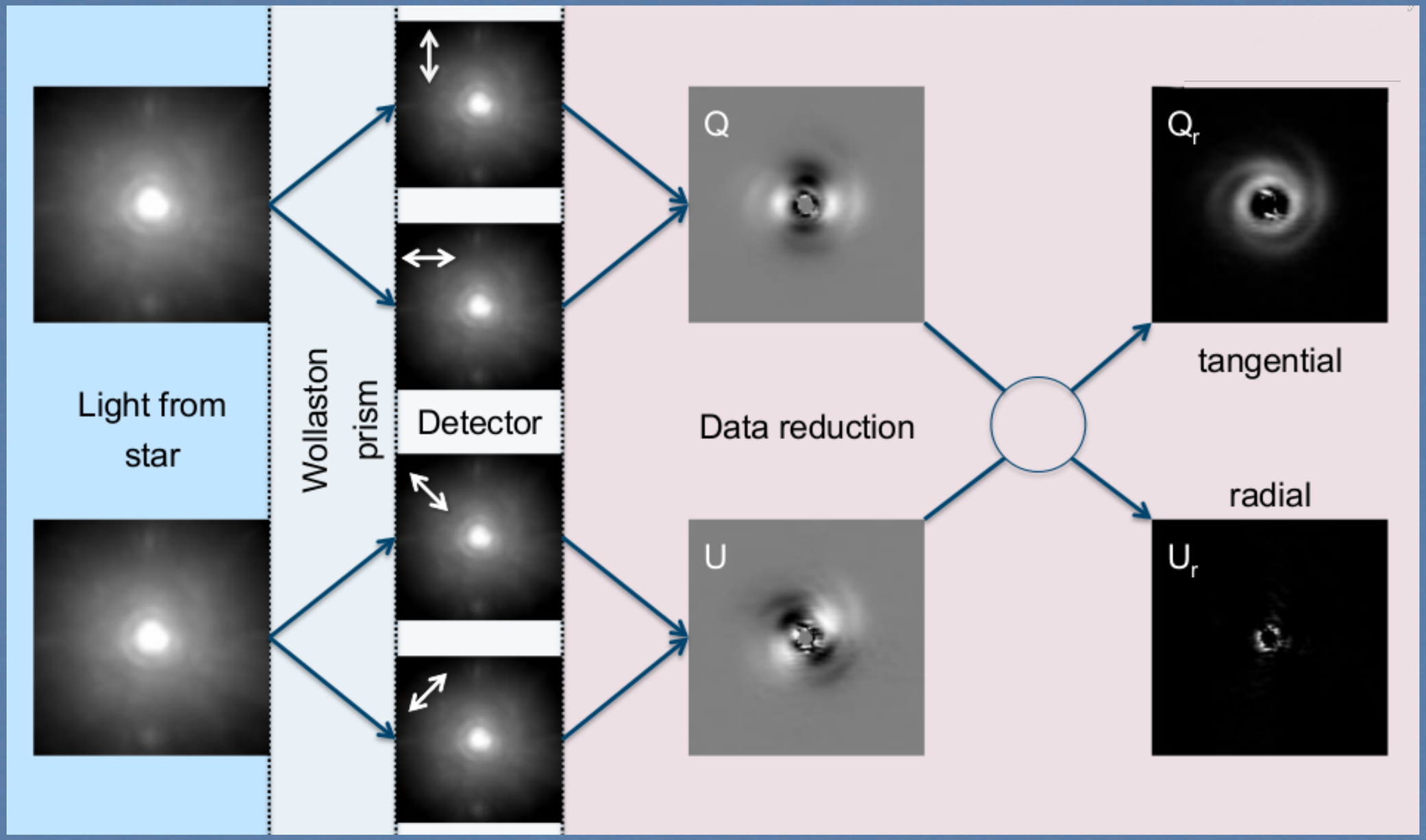
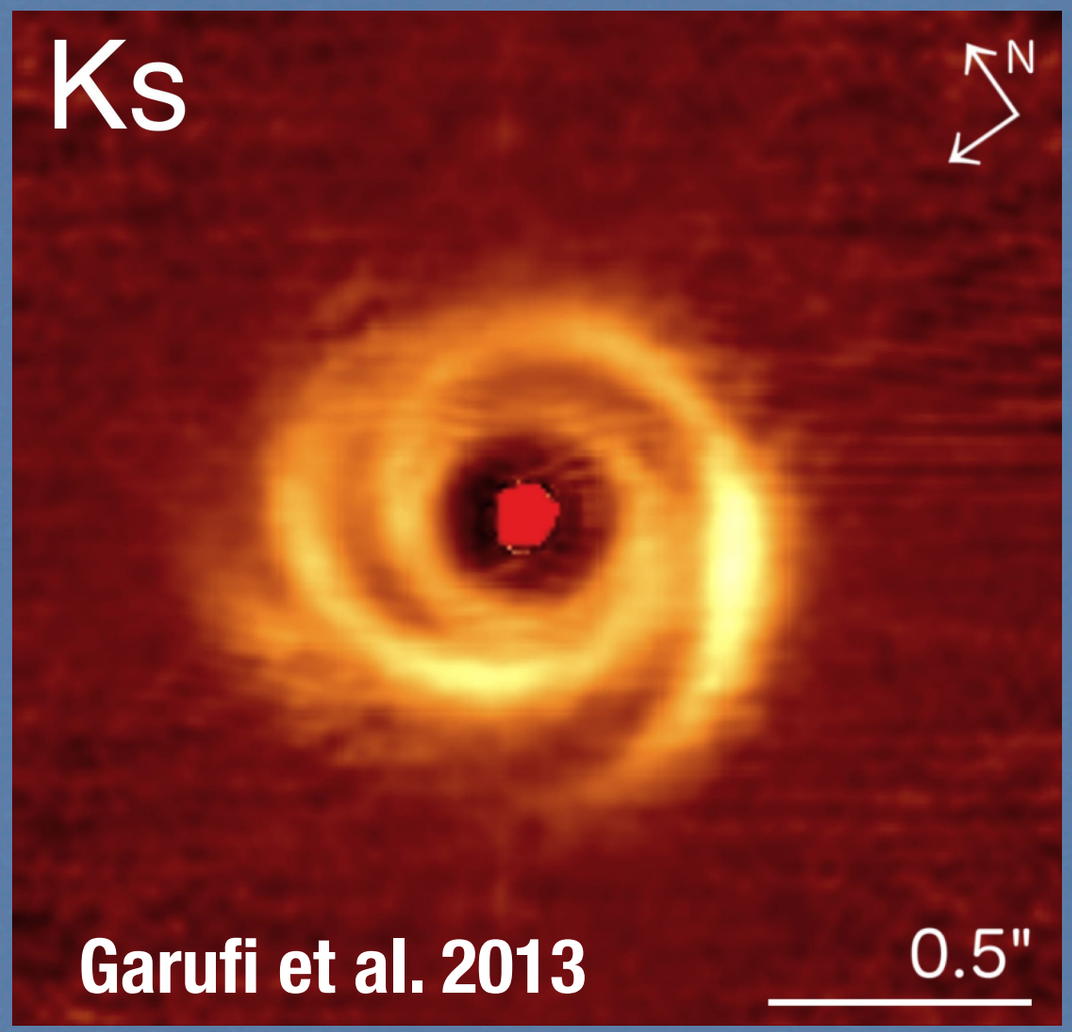


Image credit: H. Avenhaus

Selected PDI ref.: Apai et al. 2004, Quanz et al. 2011, Avenhaus et al. 2014

SAO 206462 (with VLT/NACO)



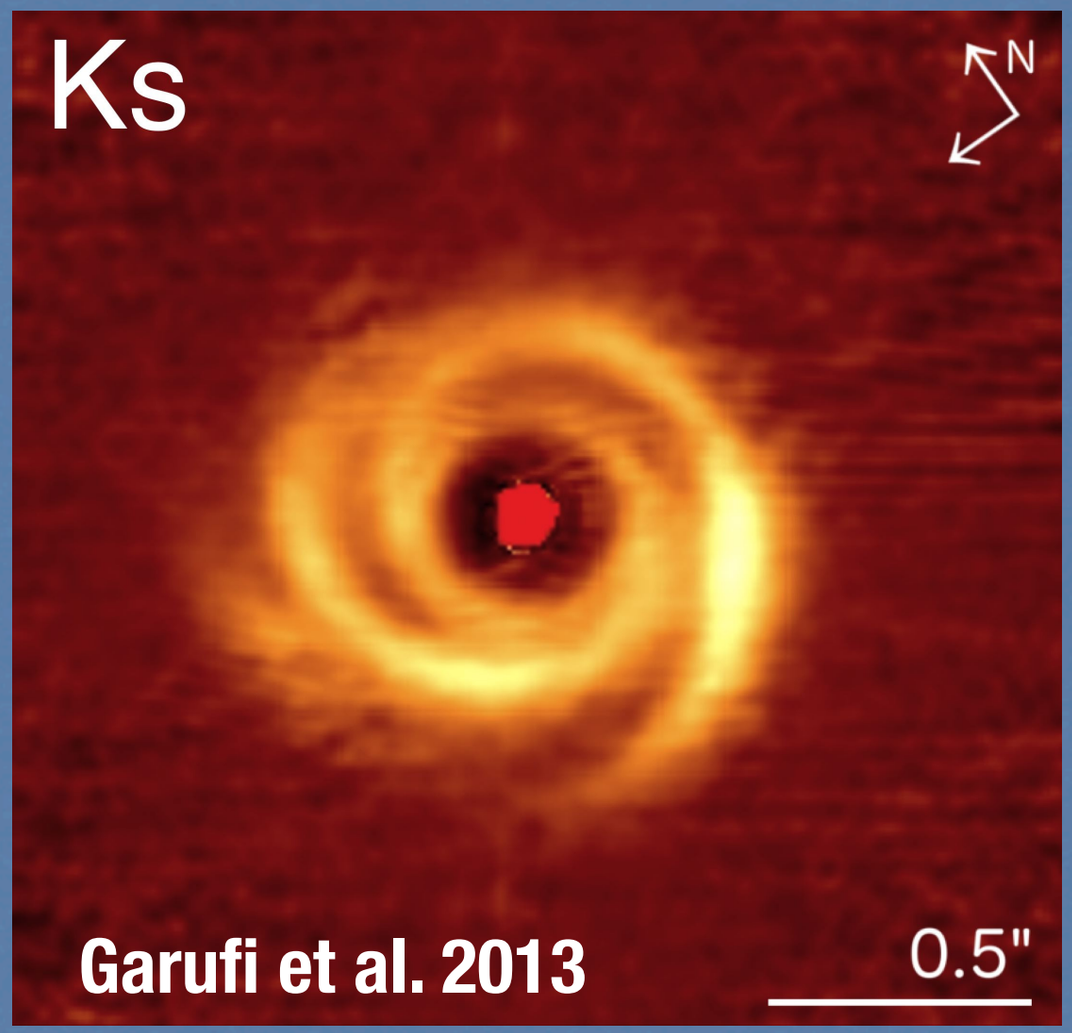
1. Double spiral structure
(also Muto et al. 2012)

2. Bright unresolved rim

3. Cavity inside 28 AU

However...

SAO 206462 (with VLT/NACO)



1. Double spiral structure
(also Muto et al. 2012)

2. Bright unresolved rim

3. Cavity inside 28 AU

However...

Sub-mm cavity size = 39 AU
(Brown et al. 2009)

Filtration of small grains (Rice et al. 2006, Dong et al. 2012) **is not enough...**

In a giant planet scenario:

r_{cavity} (large dust) > r_{cavity} (gas, small dust)
(Pinilla et al. 2012)

See Pinilla's talk

SAO 206462 (and the potential planet)

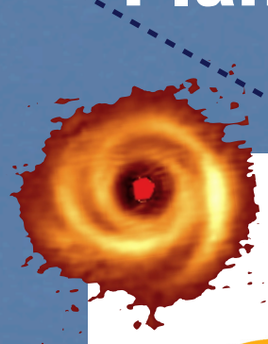
Cavity sizes for small and large grains depend on planet mass and location.

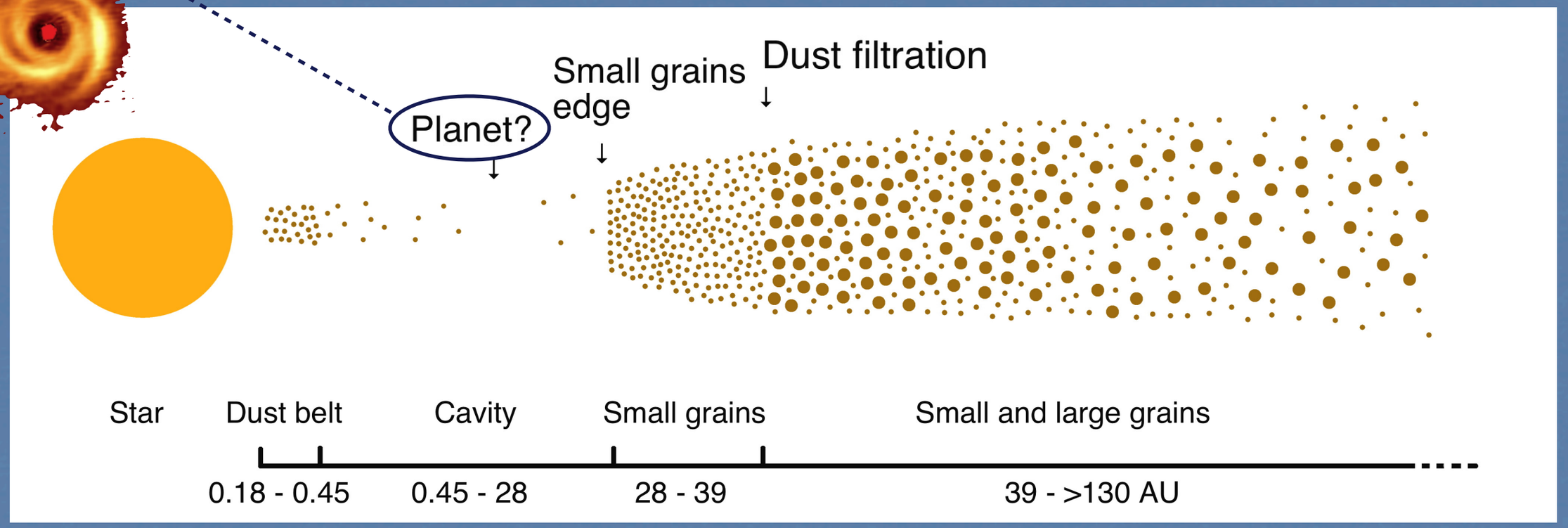
(Pinilla et al. 2012, de Juan Ovelar et al. 2013)

⬍

Planet properties: 5 M_J < *M* < 15 M_J at 17 AU < *r* < 20 AU

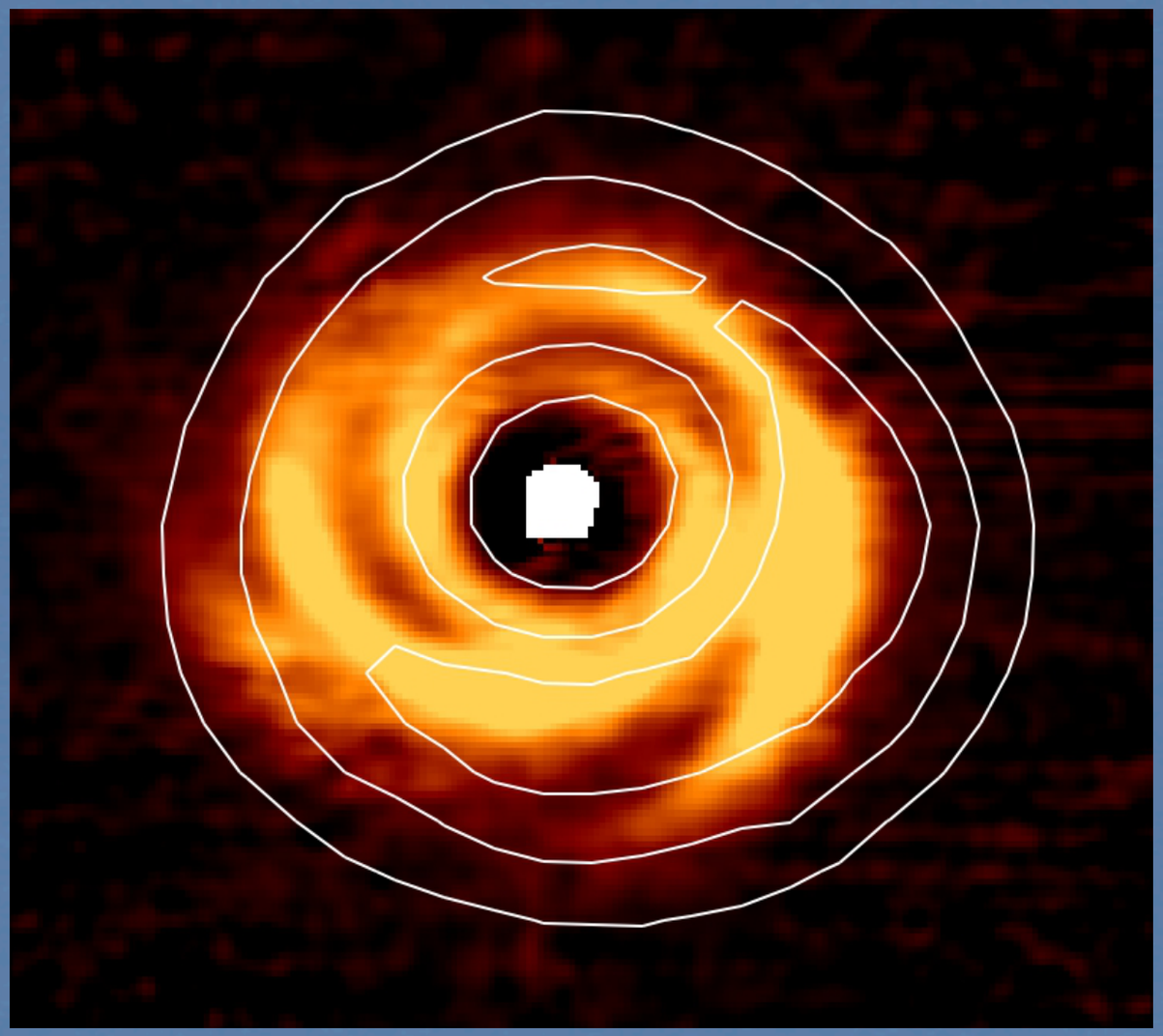
Planet hunters will tell...





Garufi, Quanz, Pinilla et al. 2013

SAO 206462 (with ALMA)



690 GHz continuum: low-contrast asymmetries ascribed to a vortex (Pérez et al. 2014).

← The brightness peak lies on the same side as the polarimetric peak

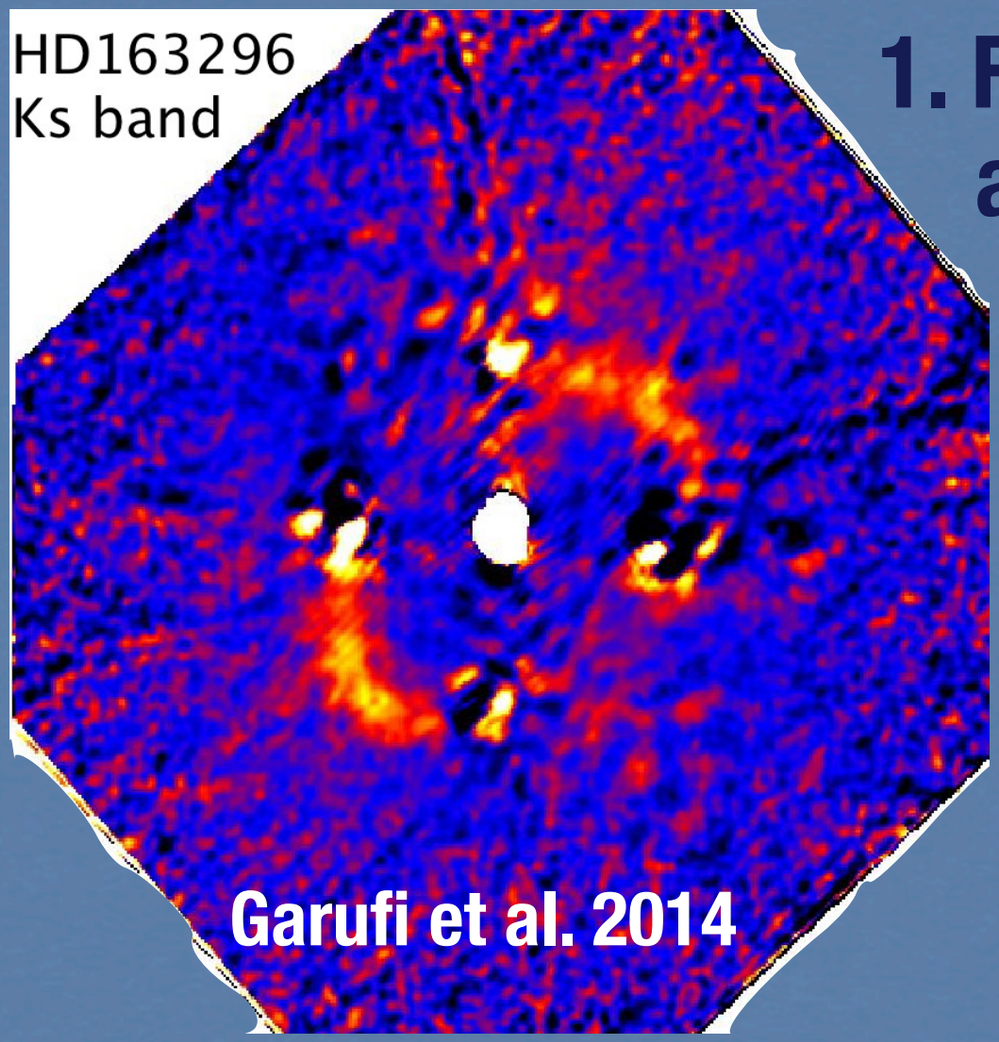
Unresolved ALMA spirals? ⇒ PDI spirals are real dust concentration?

Gravitational instability or stellar fly-by? Not realistic (Garufi et al. 2013).

A perturbing giant planet? (Muto et al. 2012)

See de Boer's poster

HD163296 (with VLT/NACO)



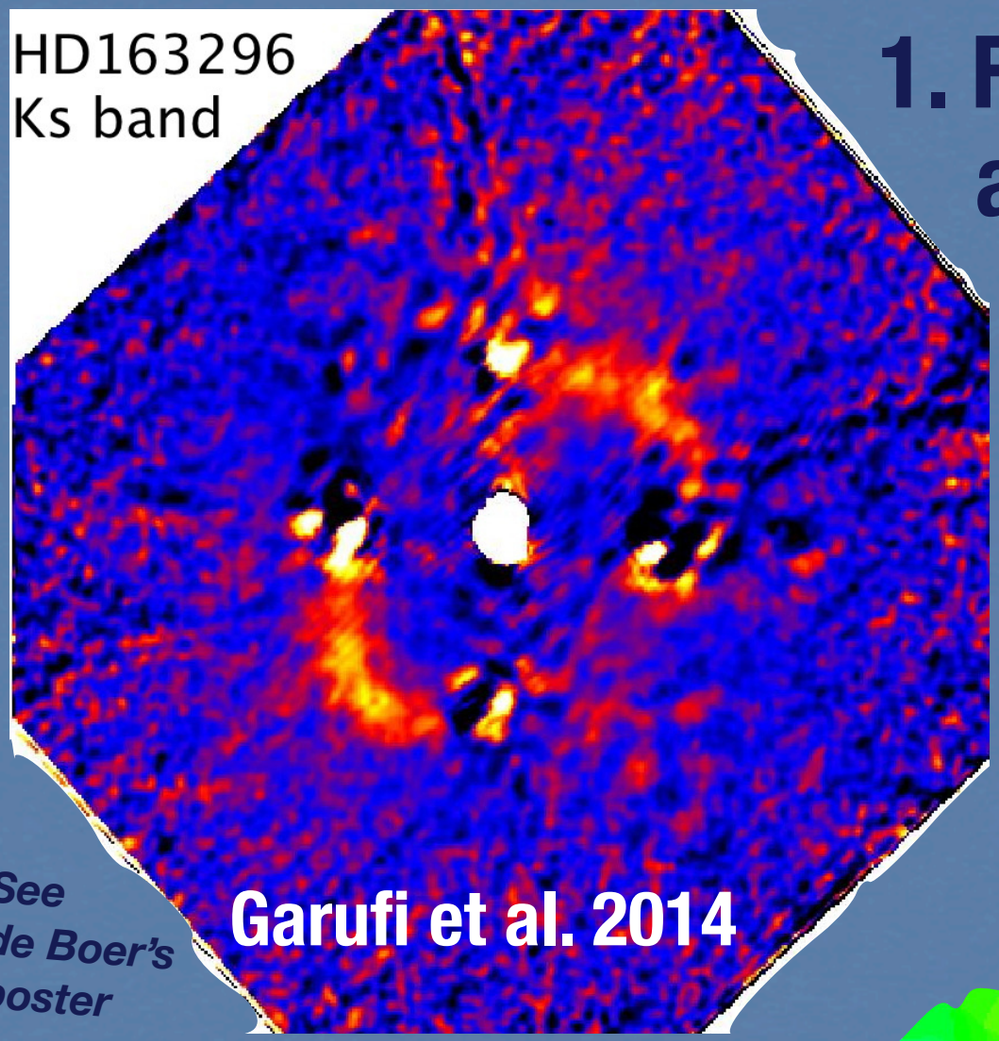
1. Firm detection along the major axis and marginal along the minor

2. Smooth decrease of polarized flux inward of ≃ 70 AU

However...

See de Boer's poster

HD163296 (with VLT/NACO)



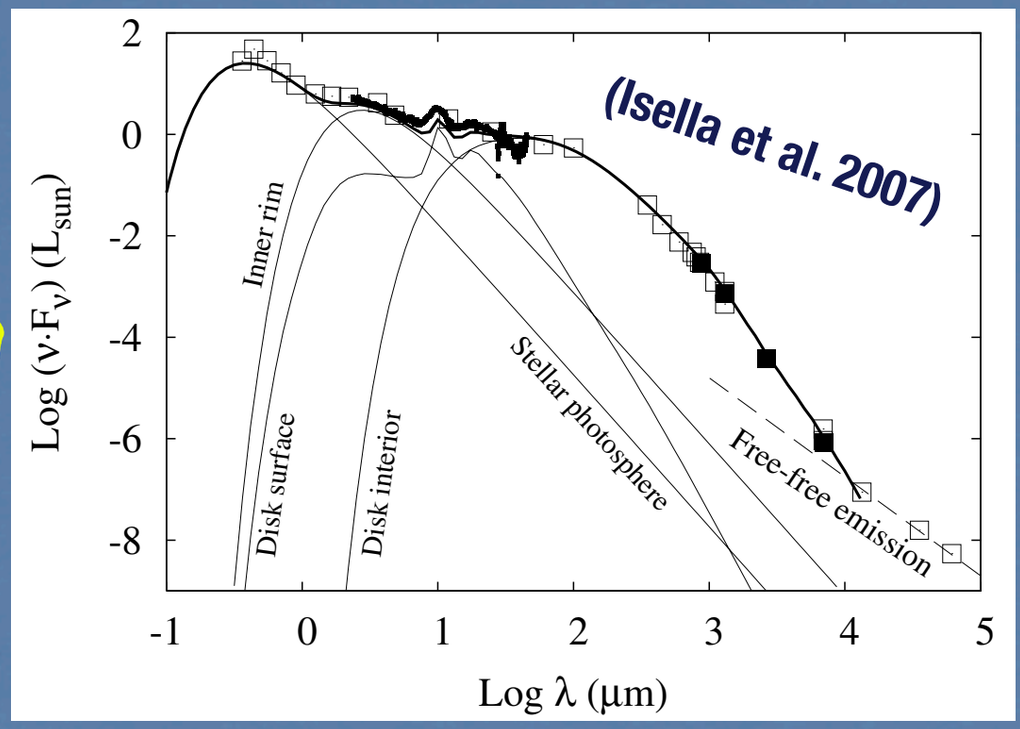
Garufi et al. 2014

See de Boer's poster

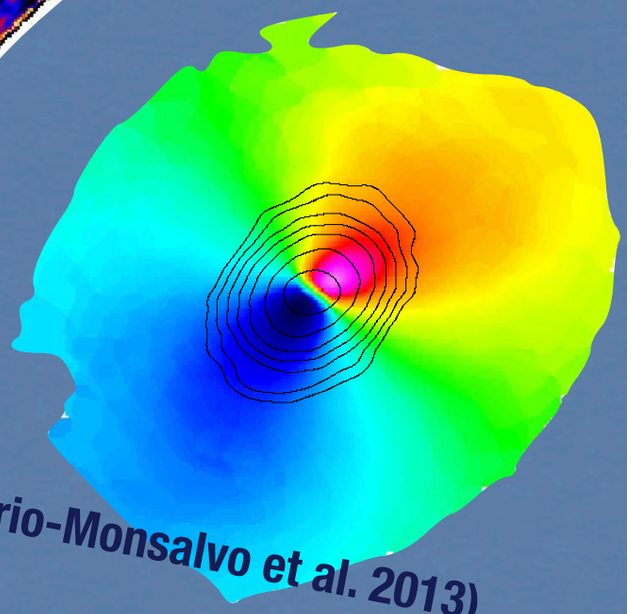
1. Firm detection along the major axis and marginal along the minor

2. Smooth decrease of polarized flux inward of ≃ 70 AU

However, no evidence of a cavity neither from SED... ↴

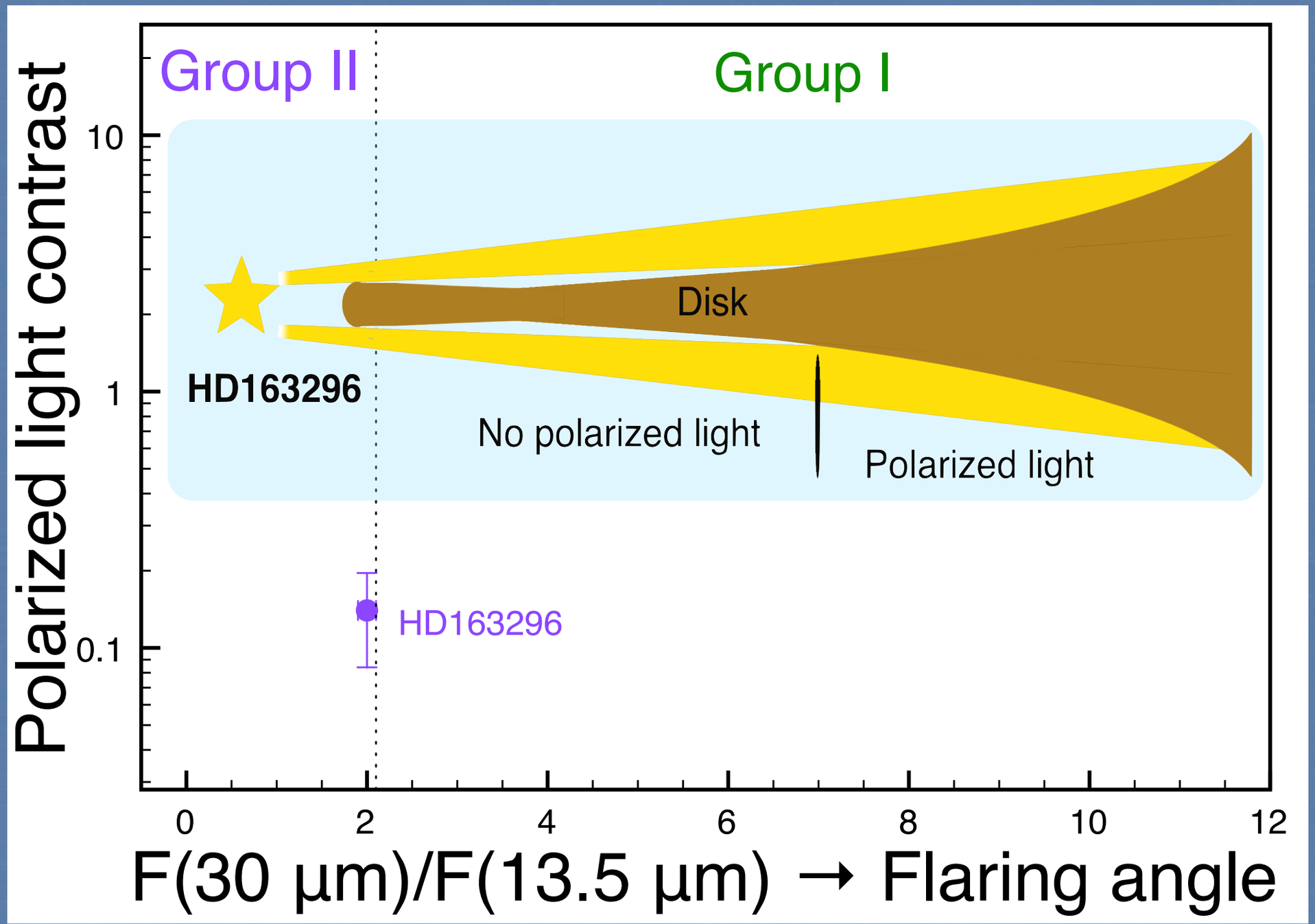


...nor from ALMA ↦



(de Gregorio-Monsalvo et al. 2013)

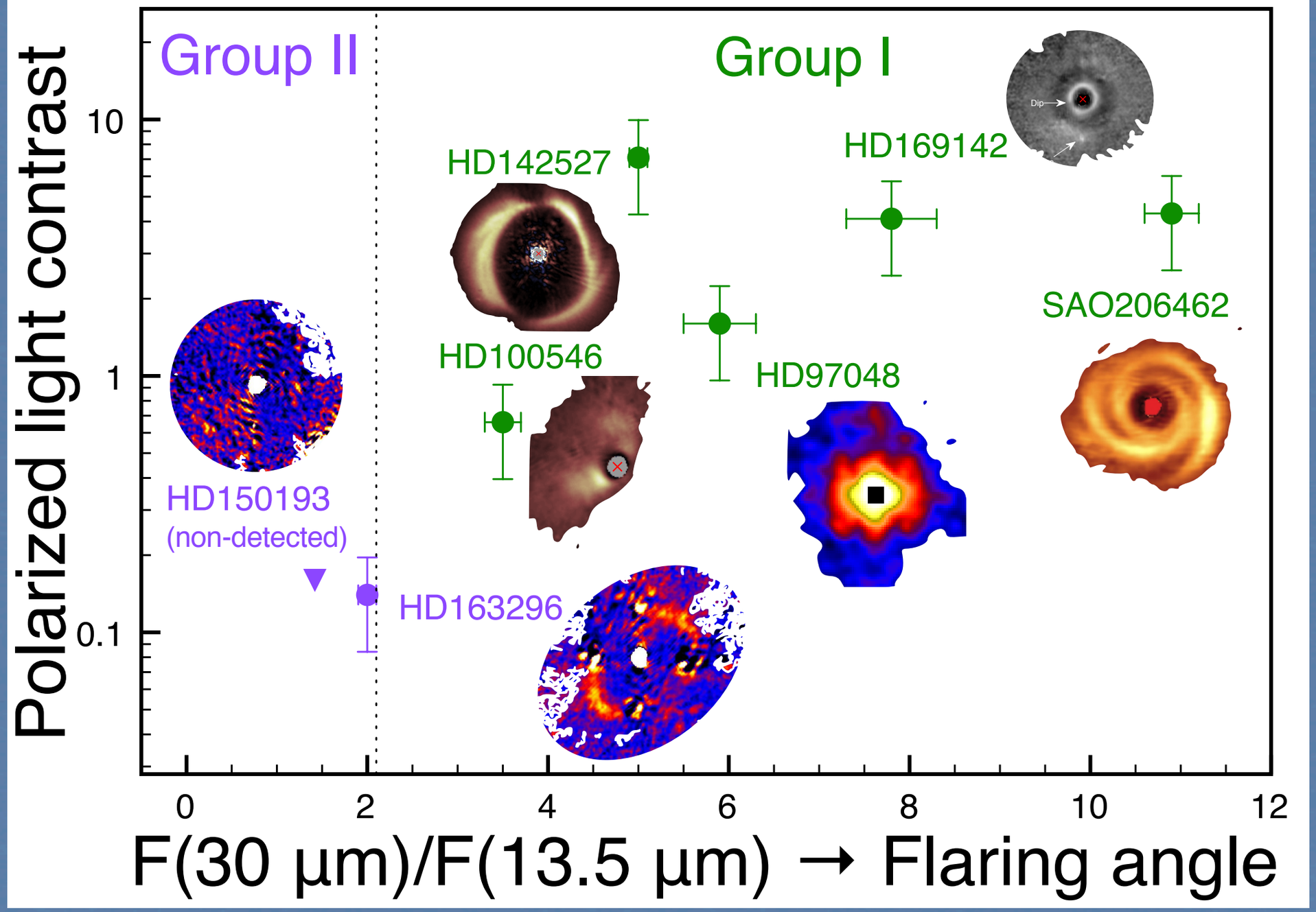
HD163296 (and the disk geometry)



Selected flaring angle ref.: Meeus et al. 2001, Maaskant et al. 2013, Khalafinejad et al. 2014

MIR color: Acke et al. 2010. PDI fluxes: Quanz et al. 2011, 2012, 2013, Avenhaus et al. 2014, Garufi et al. 2013, 2014

HD163296 (and the disk geometry)



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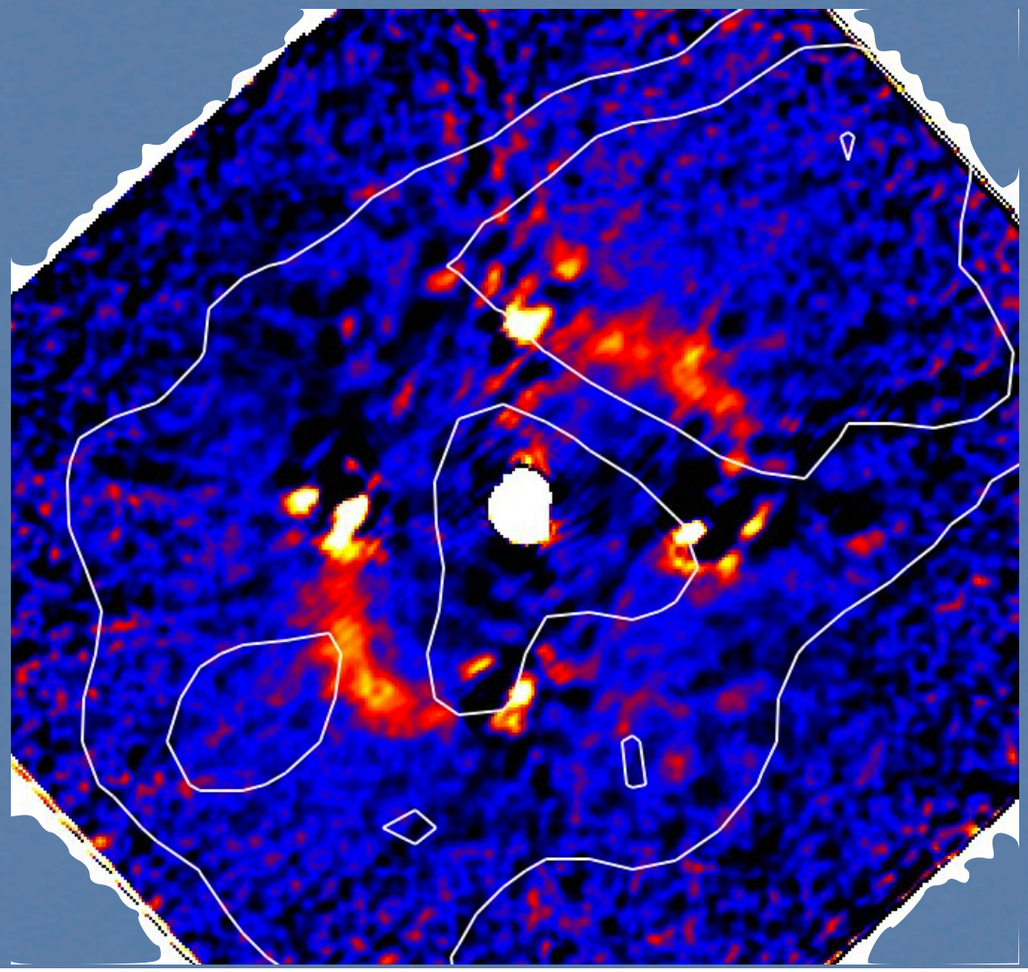
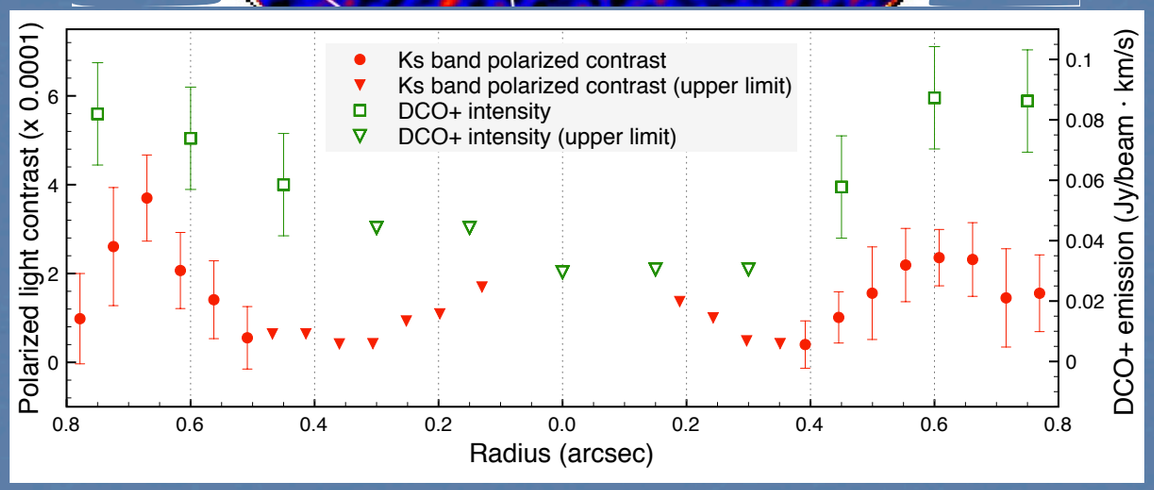
MIR color: Acke et al. 2010. PDI fluxes: Quanz et al. 2011, 2012, 2013, Avenhaus et al. 2014, Garufi et al. 2013, 2014

HD163296 (and the CO snow-line with ALMA)





DCO^+ (5-4): annulus emission used as proxy for the CO snow-line (Mathews et al. 2013)

← The two inner edges are approximately coincident

⬇

CO mantles onto the dust grain surface boost albedo?

Any connections CO snow-line / disk thickness?

See Panic's talk

Three messages

✔ PDI allows disk imaging with an incomparable combination of resolution and inner working angle.
But ALMA is having its say...

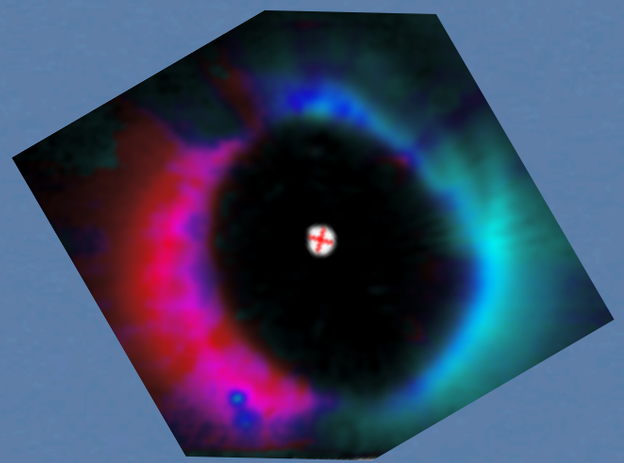
✔ The compared spatial distribution of different disk components can suggest the presence of planets.
And even their properties...

✔ The geometry of the disk surface plays a first-order role in imprinting the scattered light distribution.
So data complementary to PDI are welcome...

THANK YOU

Other works in our group and beyond

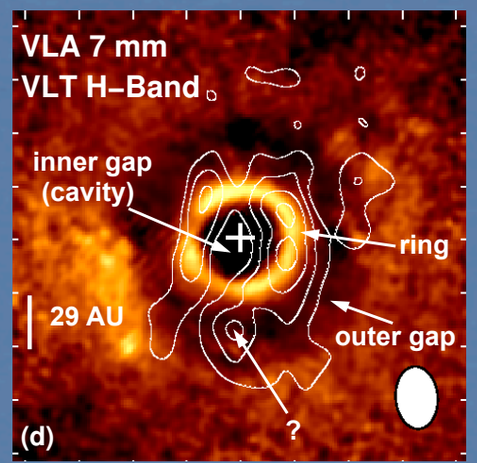
HD142527



Disk cavity and inner wall are huge!

Biller et al. 2012
Canovas et al. 2013
Casassus et al. 2013
Avenhaus et al. 2014a

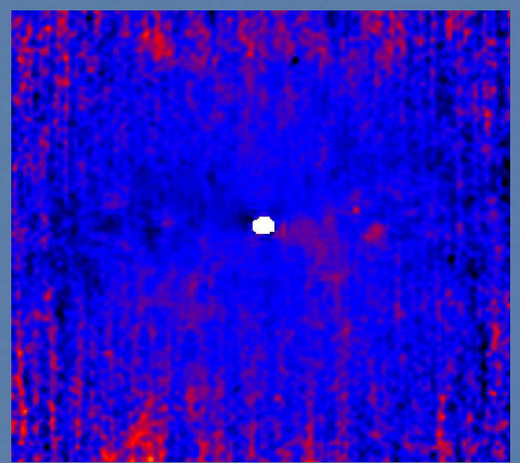
HD169142



A planet candidate, not where expected!

Quanz et al. 2013b
Osorio et al. 2014
Reggiani et al. 2014
Biller et al. 2014

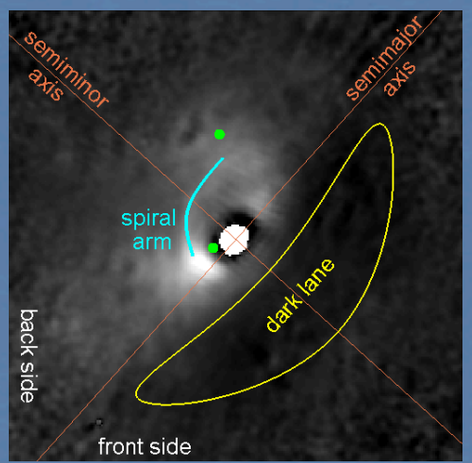
HD141569A



Where has the disk gone?

Moerchen et al. 2010
Garufi et al. 2014
Maaskant et al. 2014a
Maaskant et al. 2014b

HD100546



Dark lanes, planet candidates...

Quanz et al. 2013a
Brittain et al. 2014
Pineda et al. 2014
Avenhaus et al. 2014b