MAD

Millenium Nucleus For Disk Research with Alma

VORTEX

Transition Disks

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Vortex yearly meeting - Aug. 15, 2016

UNIVERSIDAD DE CHILE

Université de Liège

Outline

1. What is a transition(al) disk? Why should we observe them?

2. First results of the AGPM on transition disks

3. Current transition disk programs with the AGPMs

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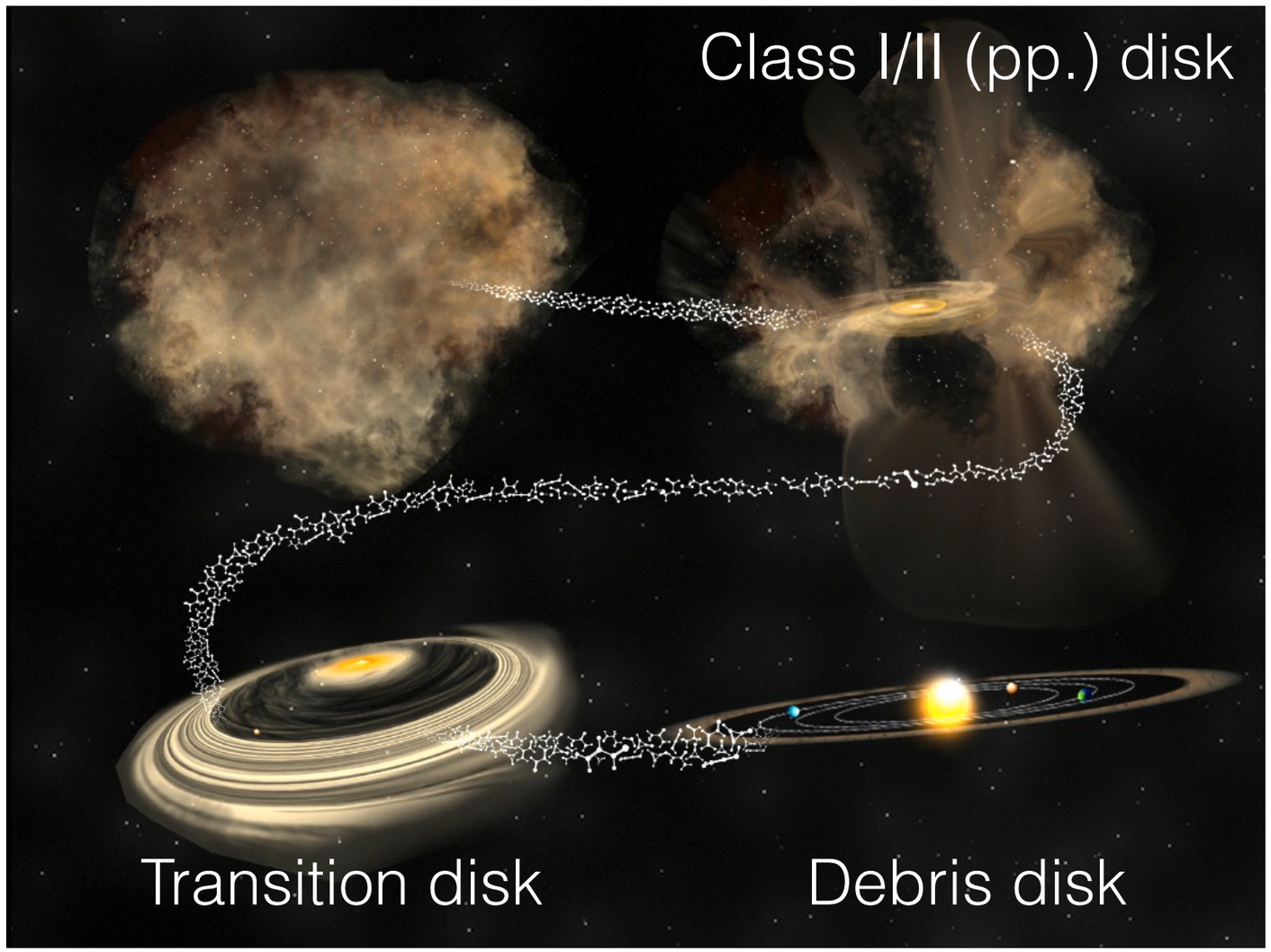
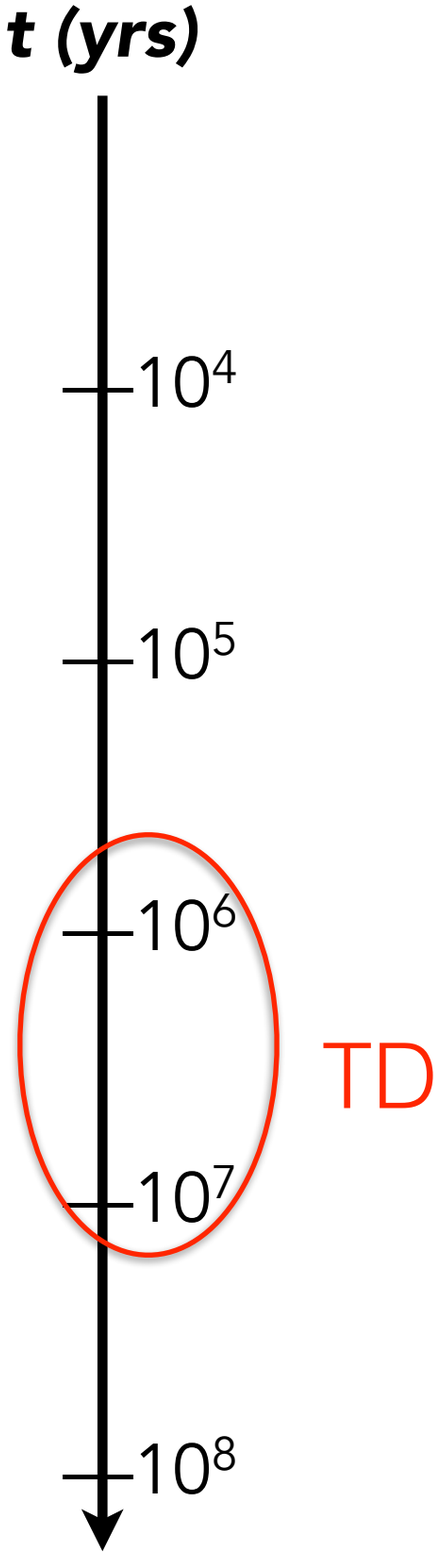
Transition Disks (TDs)

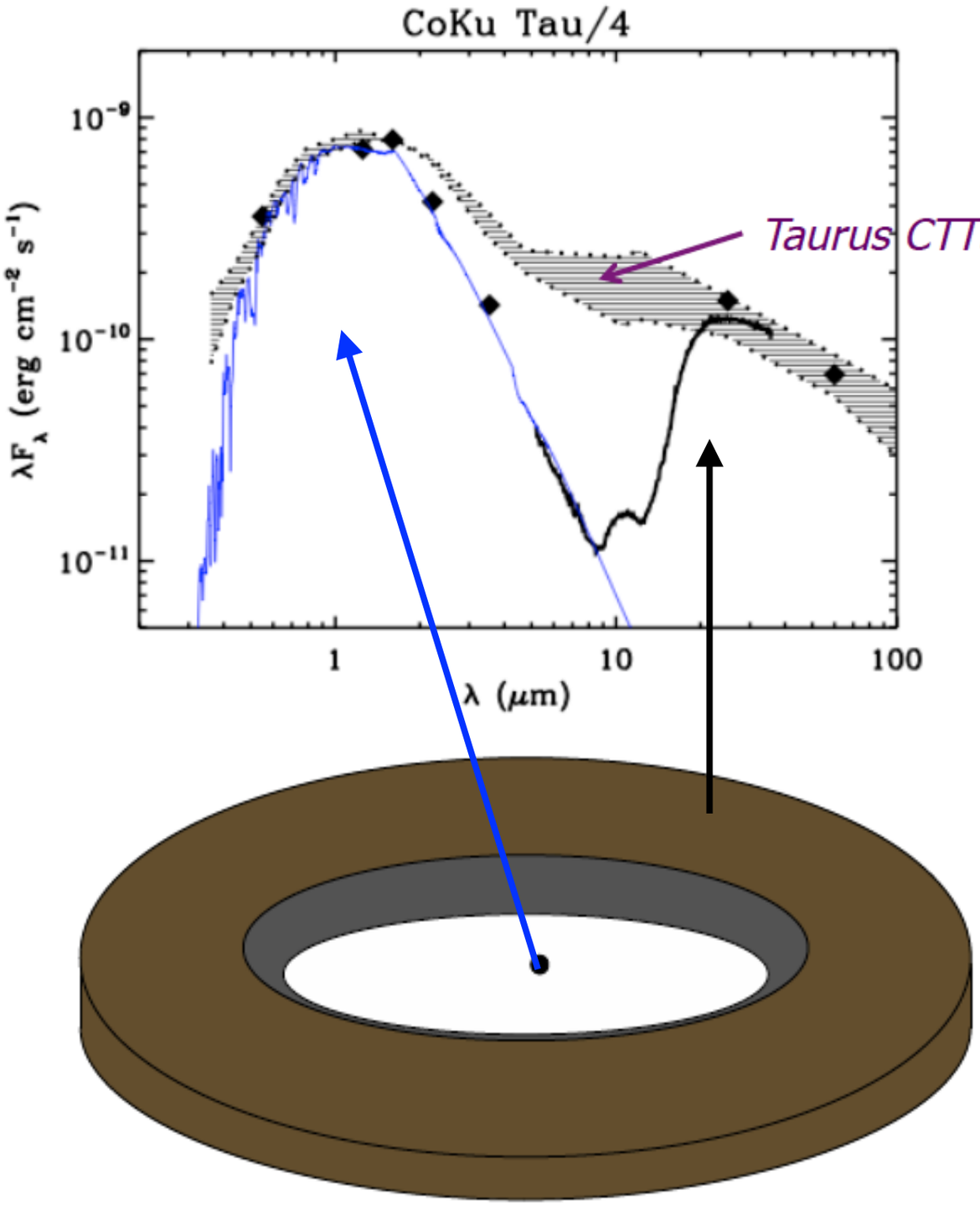


credit: L. Pérez

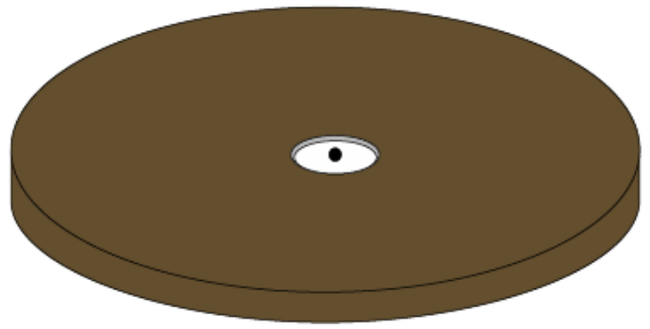


- **Short definition of TD:**
  Protoplanetary disk (still has gas!) showing evidence for a gap/cavity in the dust distribution
- **Why are they so interesting?**
  Giant planet formation must occur before the gas in the disk gets dissipated (max. ~10Myr)

First observational identification



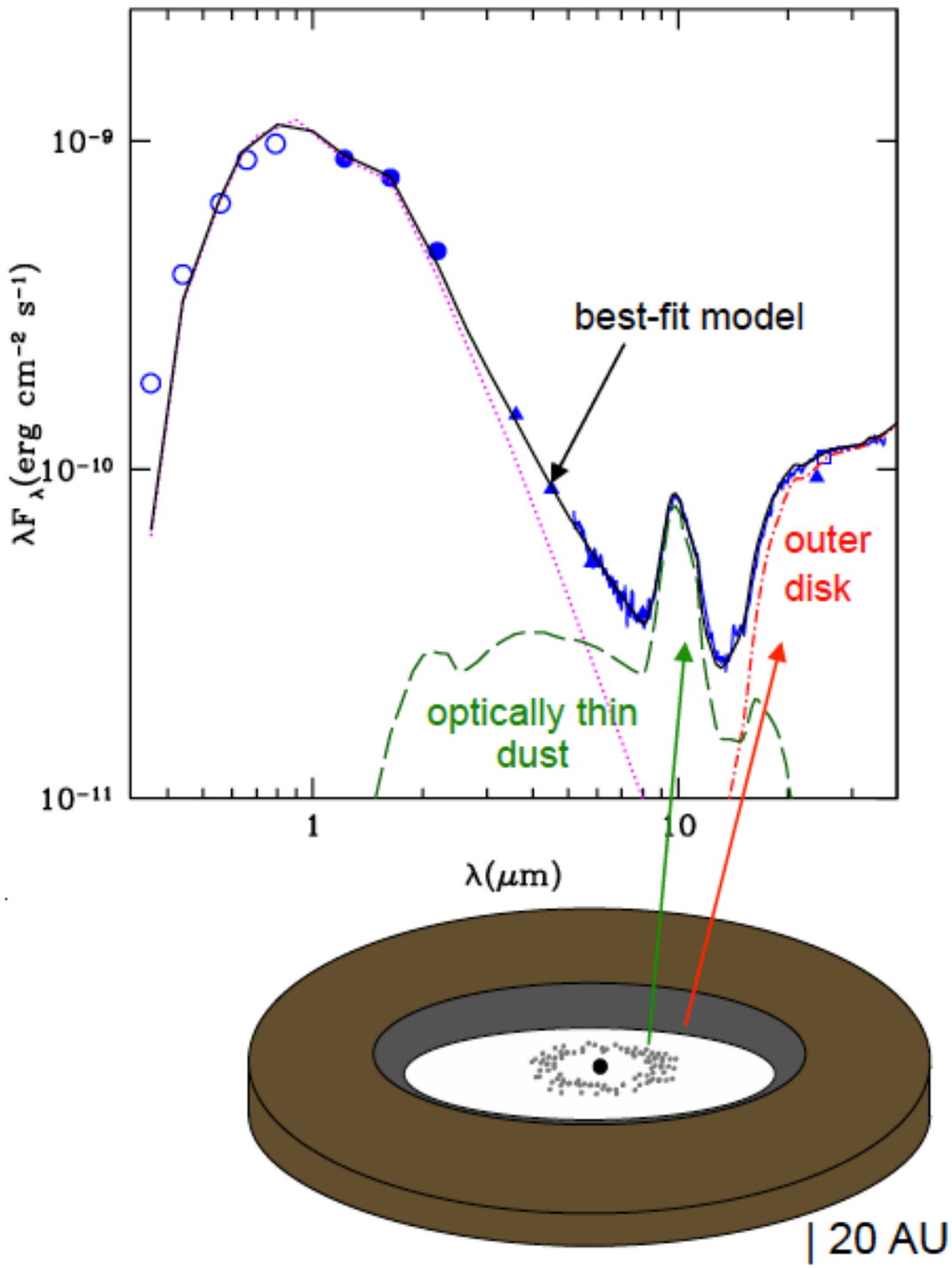
Taurus CTTS median :



Espaillat+14 (PPVI)

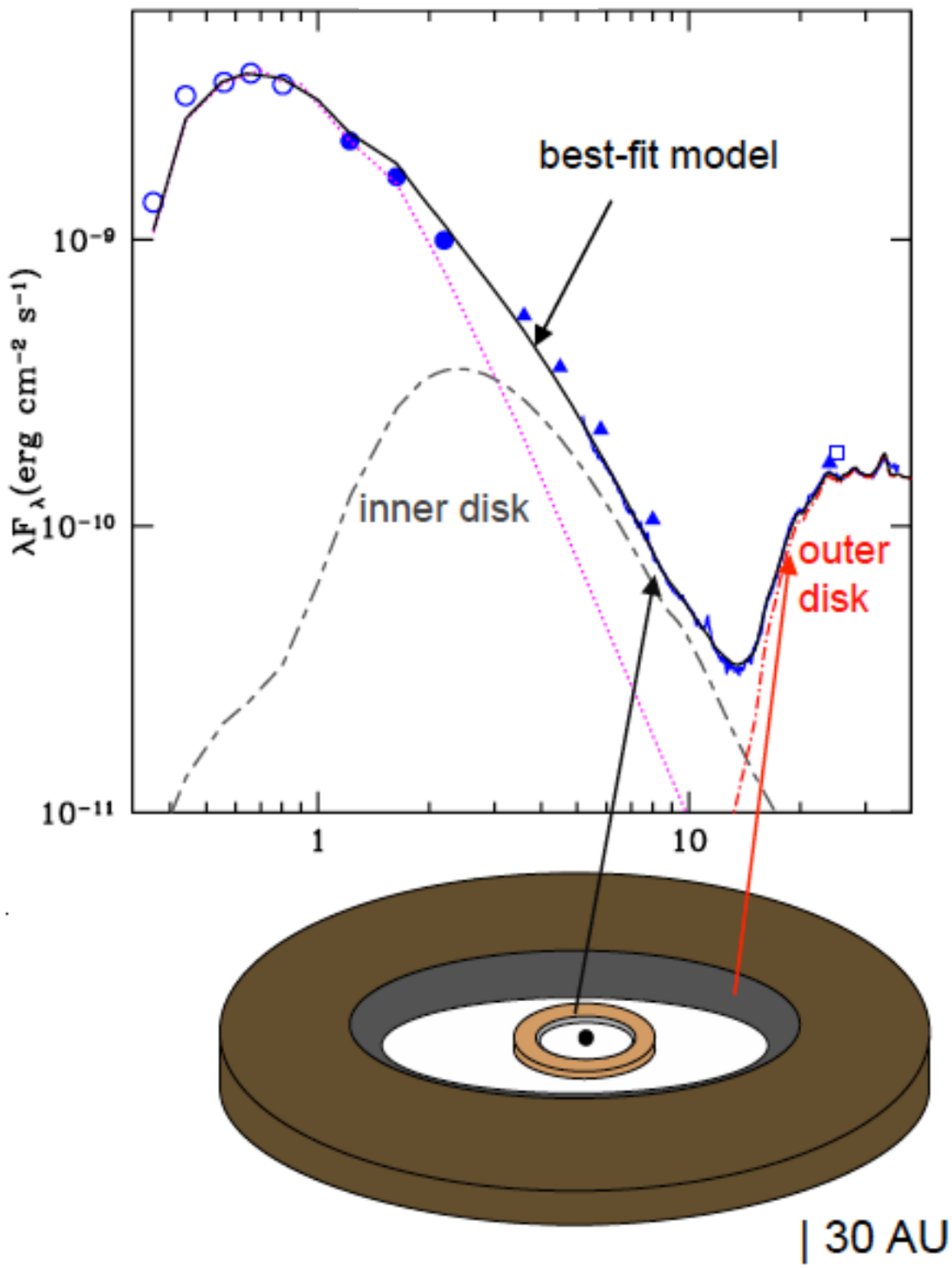
pre-Transitional disks

GM Aur



Espaillat+11

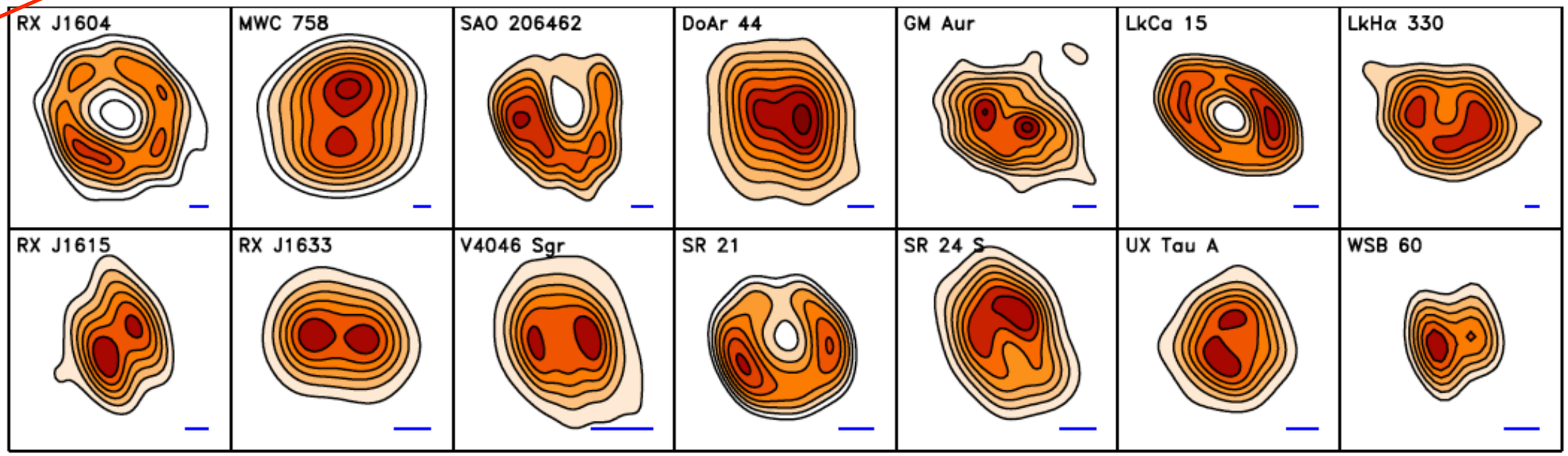
UX Tau A



Espaillat+07

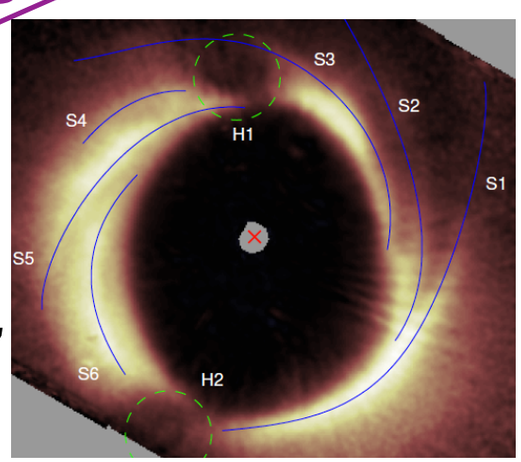
Confirmation with resolved images

sub-mm continuum (large grains)

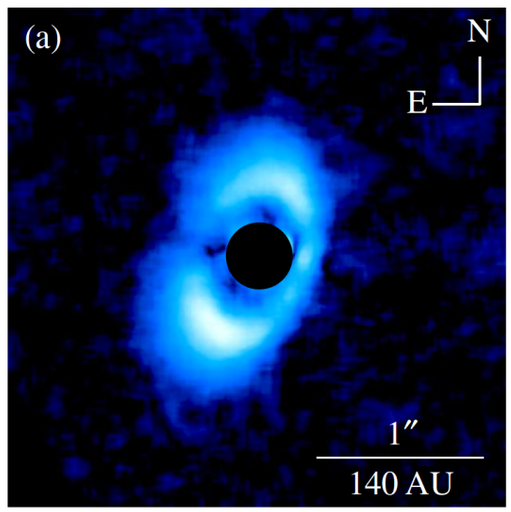


Espaillat+14 (PPVI)

N-IR polarized light (small grains)

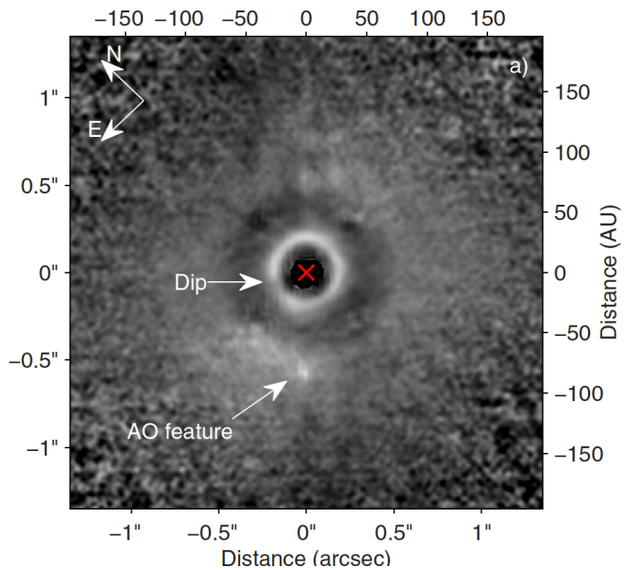


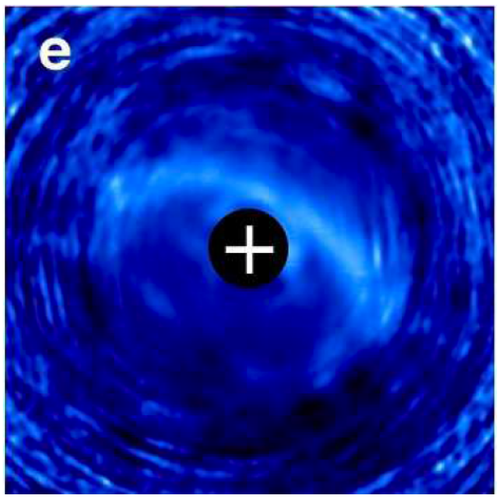
HD 142527
(Avenhaus+13)



PDS 70
(Hashimoto+12)

HD 169142
(Quanz+13)



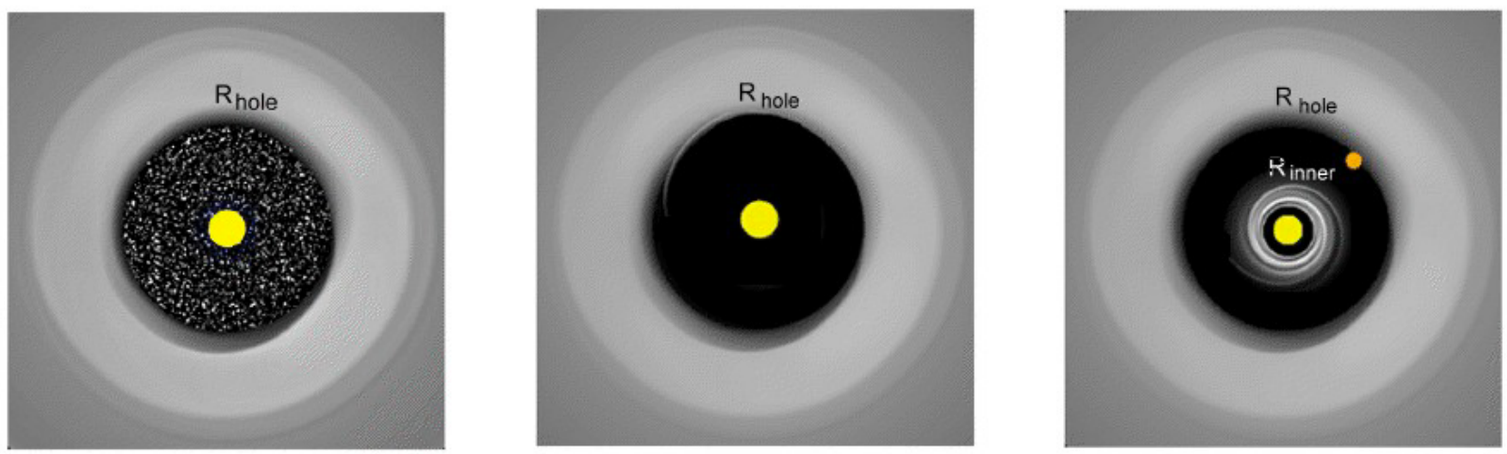


LkCa 15
(Thalmann+14)

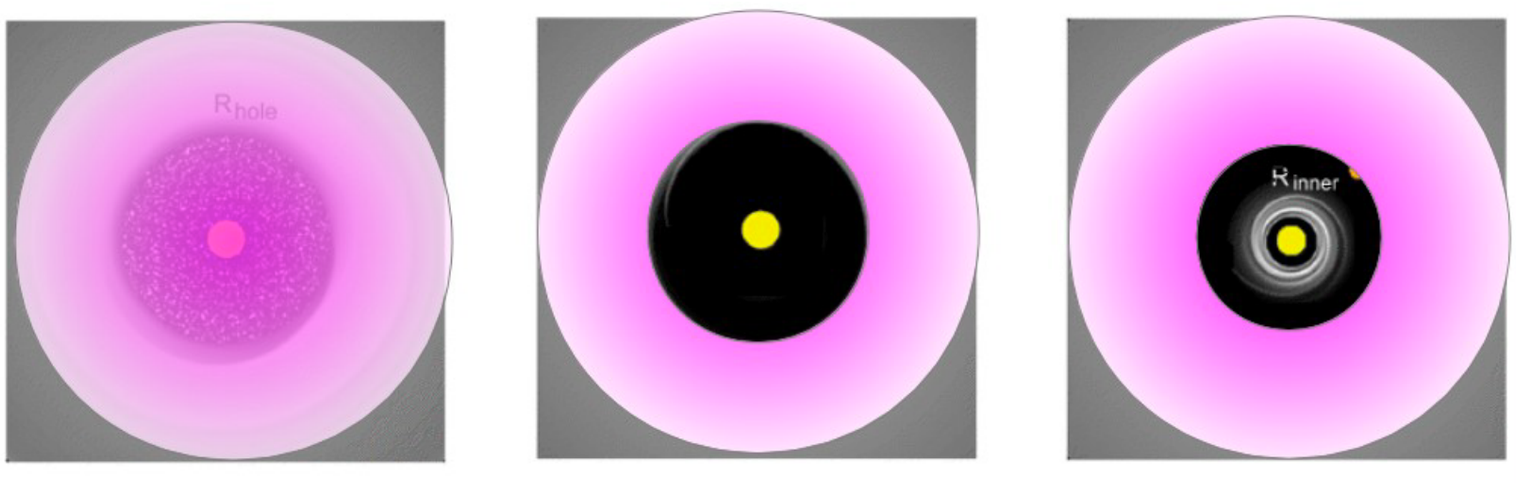
Origin?

Grain growth *Photoevaporation* *Companion*

DUST



GAS



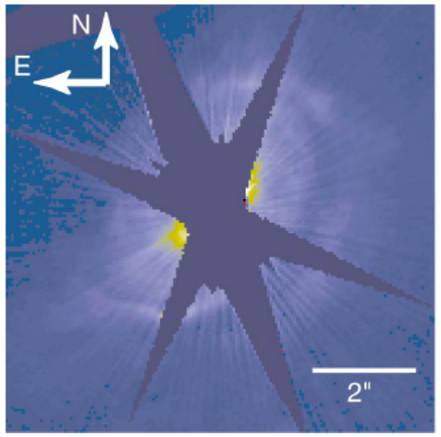
(Strom & Najita)

So far most observations indicate a shallower gap in the gas than in the dust distribution => hint towards a companion origin

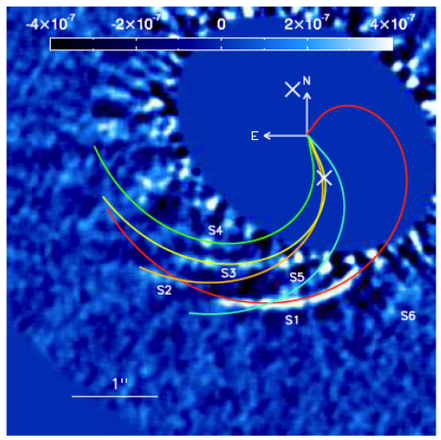
Additional companion signposts

- **Spiral arms**

HD 100546

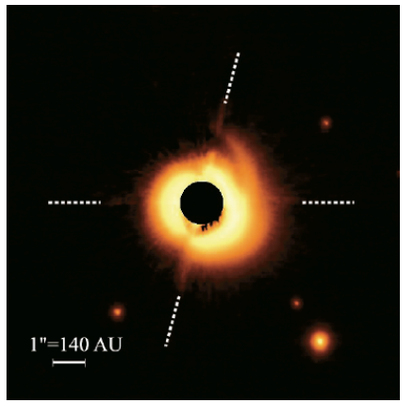


(Grady+01)

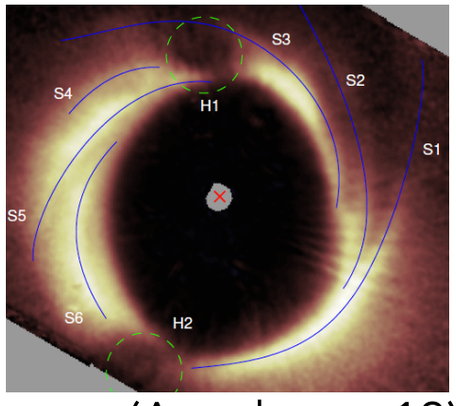


(Boccaletti+13)

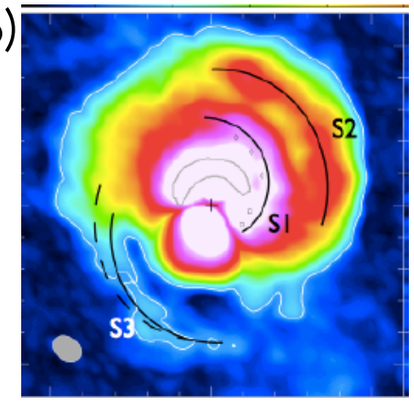
HD 142527



(Fukagawa+06)



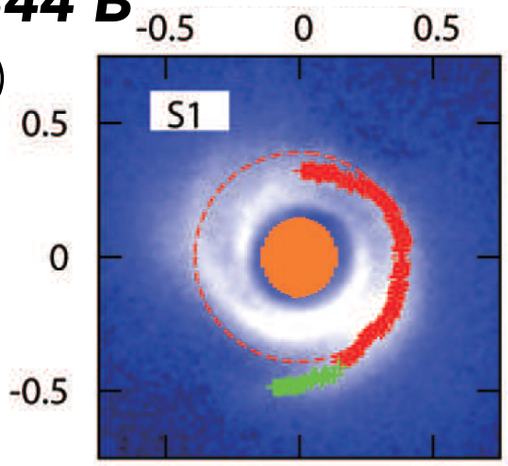
(Avenhaus+13)



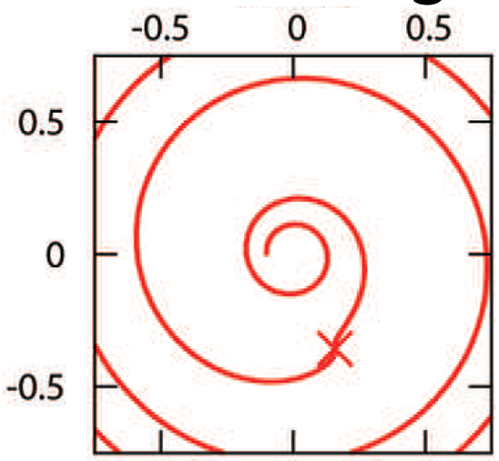
(Christiaens+14)

HD 135344 B

(Muto+12)

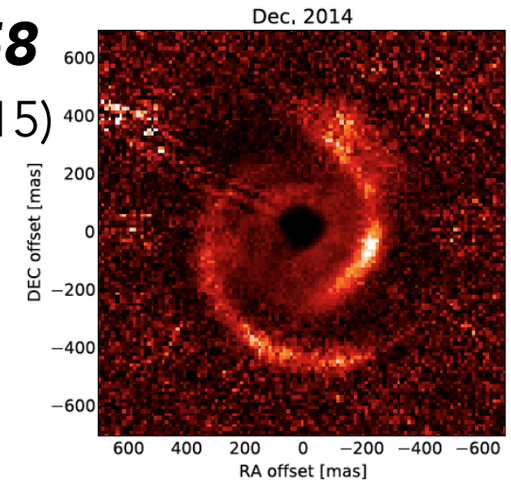


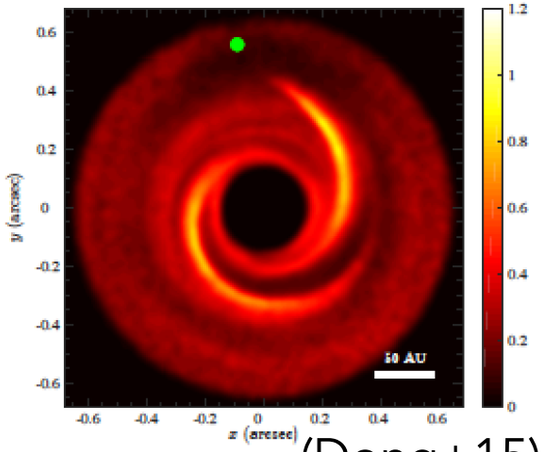
Modelling



MWC 758

(Benisty+15)

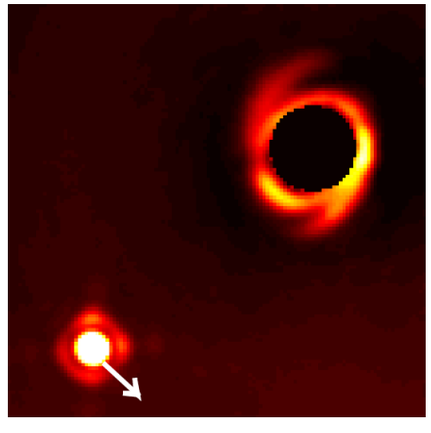


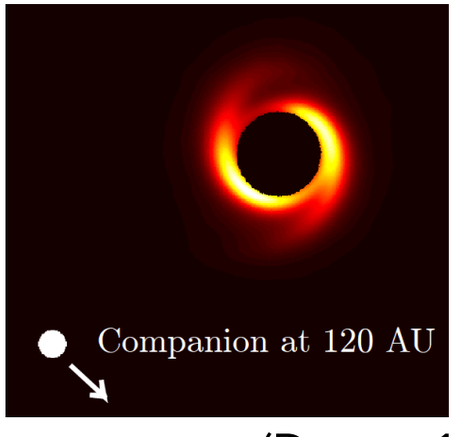


(Dong+15)

HD 100453

(Wagner+15)





(Dong+16)

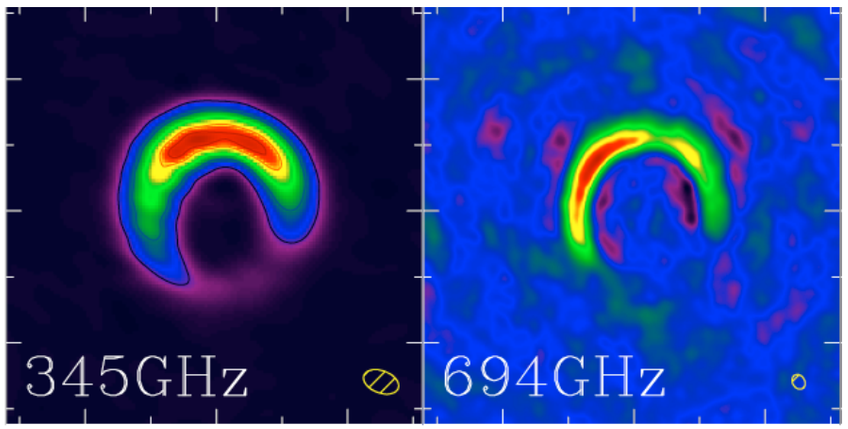
BUT alternative origins: gravitational instability, recent fly-by, shadowing from inner disk

Additional companion signposts

- Spiral arms
- **Dust traps**

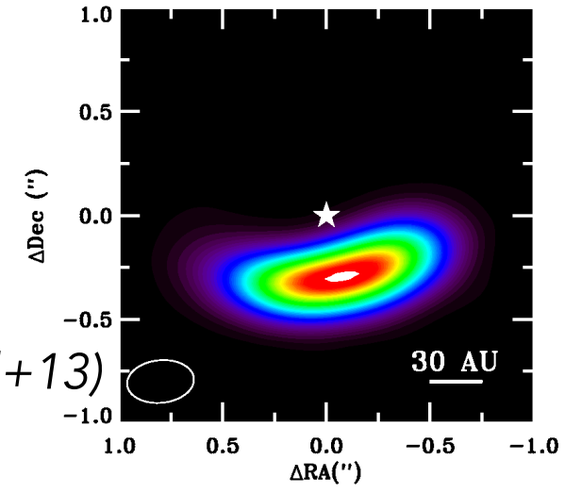
HD 142527

(Casassus+13,+15)



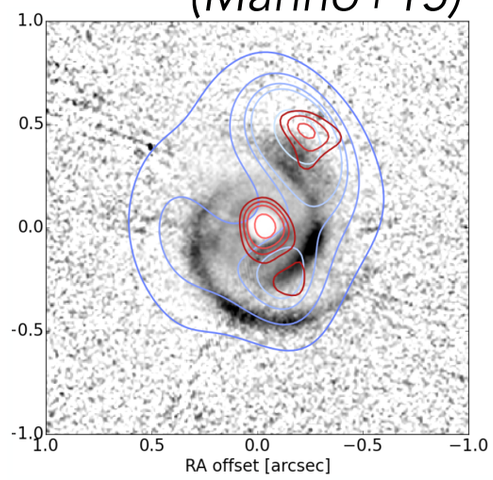
IRS 48

(van der Marel+13)

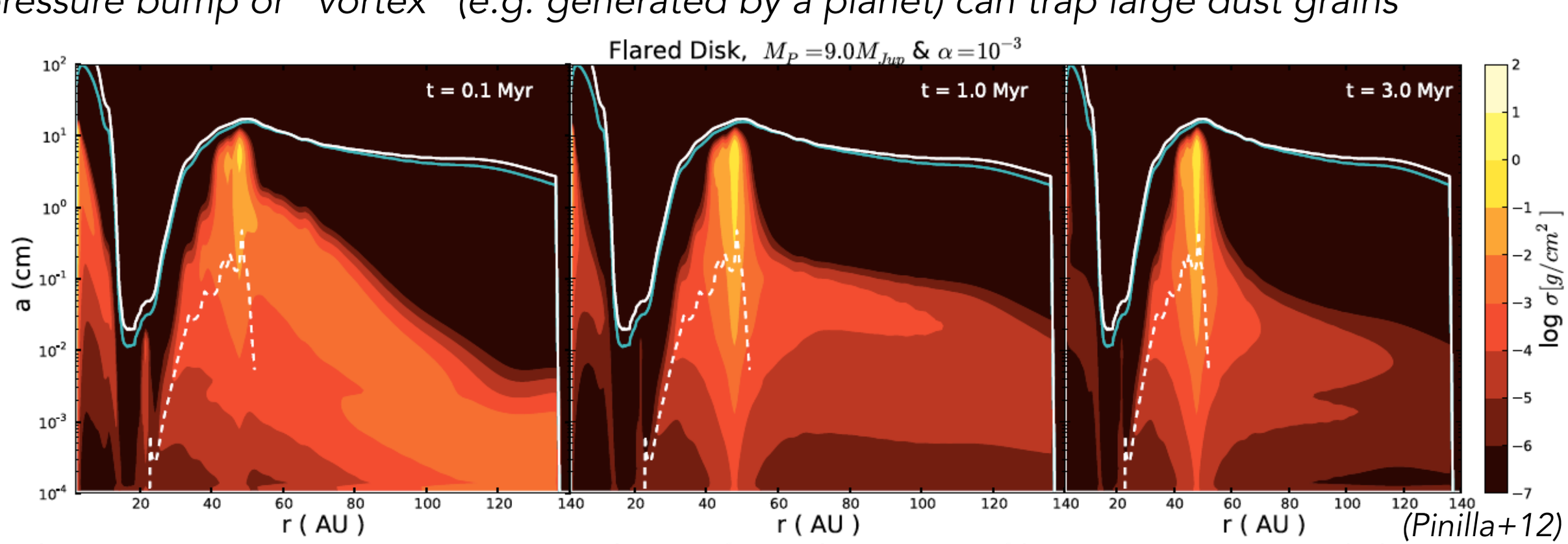


MWC 758

(Marino+15)



A pressure bump or "vortex" (e.g. generated by a planet) can trap large dust grains



(Pinilla+12)

BUT alternative origin: any extrema in the surface density profile can trigger instabilities leading to the formation of a vortex and hence to a dust trap

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   - It is a primordial disk with some evidence for gap/cavity
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   => TDs are prime targets to look for forming planets
   - Most TDs might reveal remarkable disk features given enough angular resolution and sensitivity

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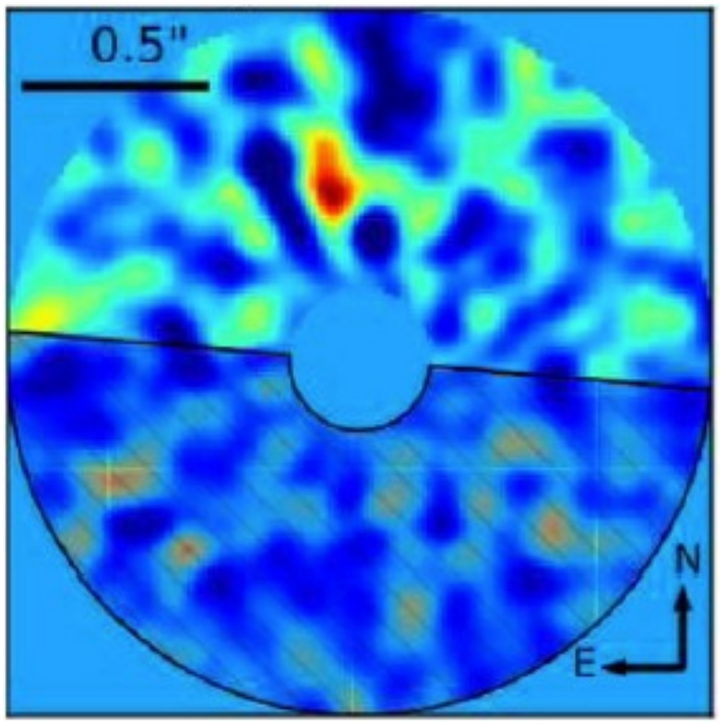
Protoplanet candidates

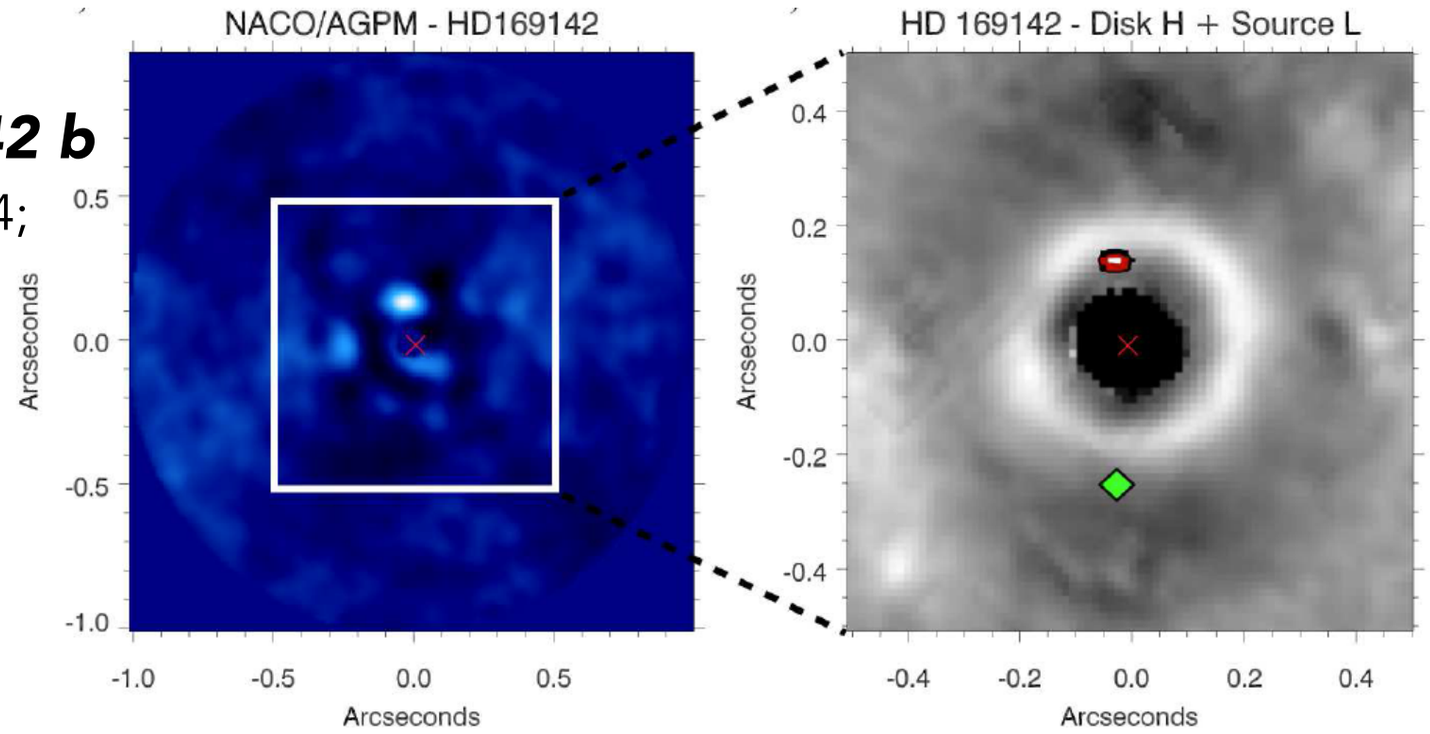
HD 100546 b

(Quanz+13,+15; Currie+14)



HD 169142 b

(Reggiani+14; Biller+14)

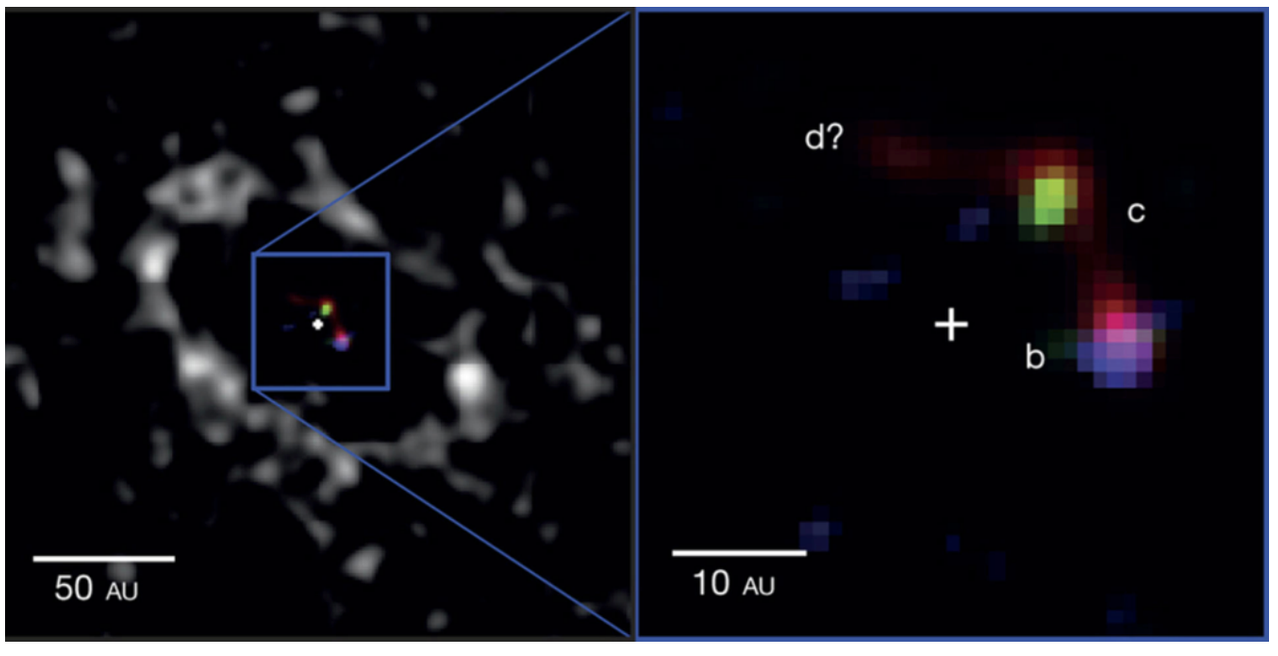


- If photospheric, the L-band mag of these detections would correspond to brown dwarfs (>15-28 M_{Jup})
- The morphology of the disk would be different for such objects
- Very faint H and K band counterparts

=> Most likely explanation: accreting protoplanets heating circum-planetary disk (e.g. Montesinos+15)

LkCa 15 b

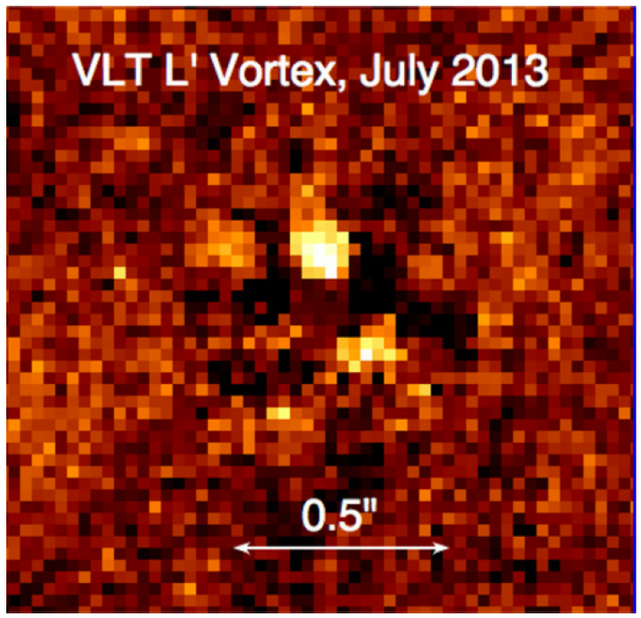
(Kraus & Ireland 12; Sallum+15)



L'-AGPM hunting trophies in TDs

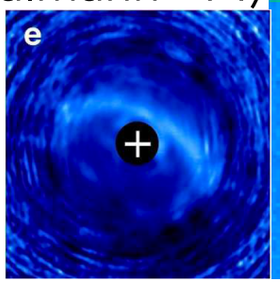
HD 169142 b

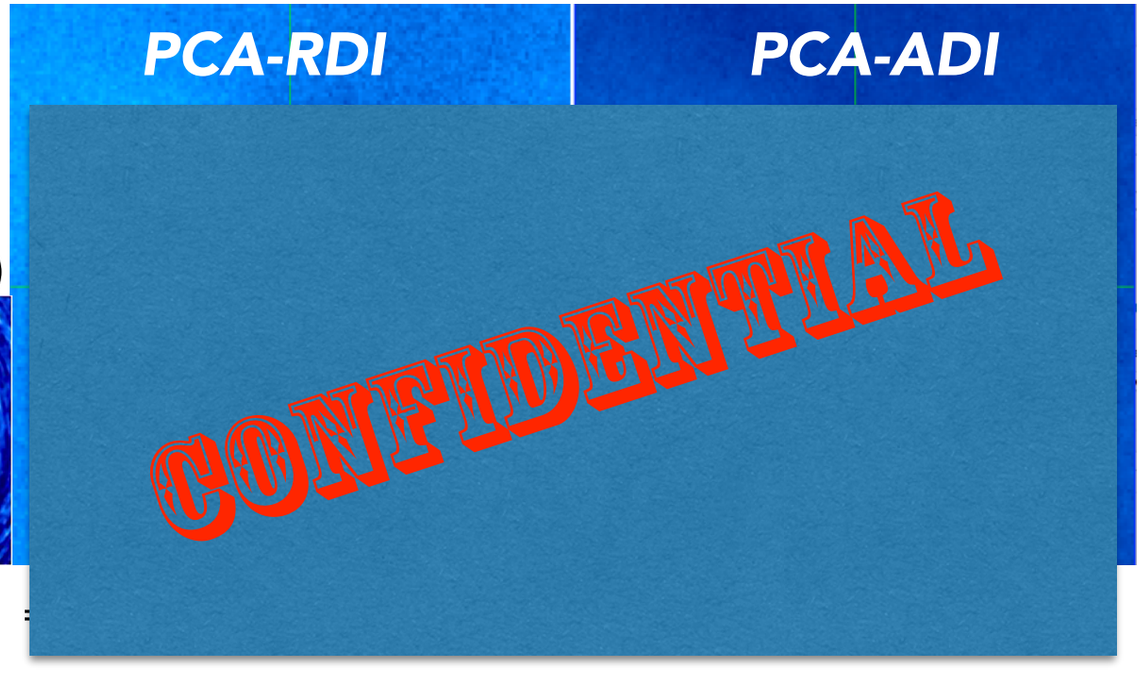
(Biller+14)

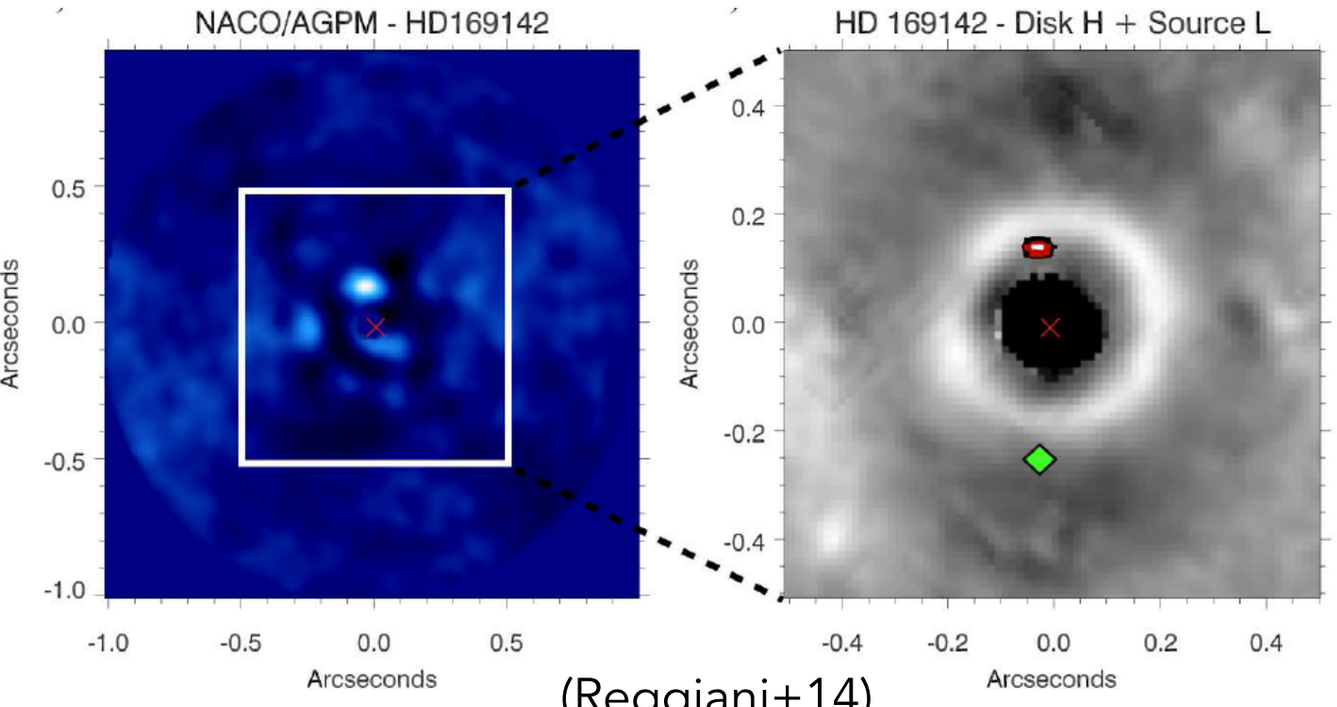


LkCa 15 (Absil+in prep)

(Thalmann+14)

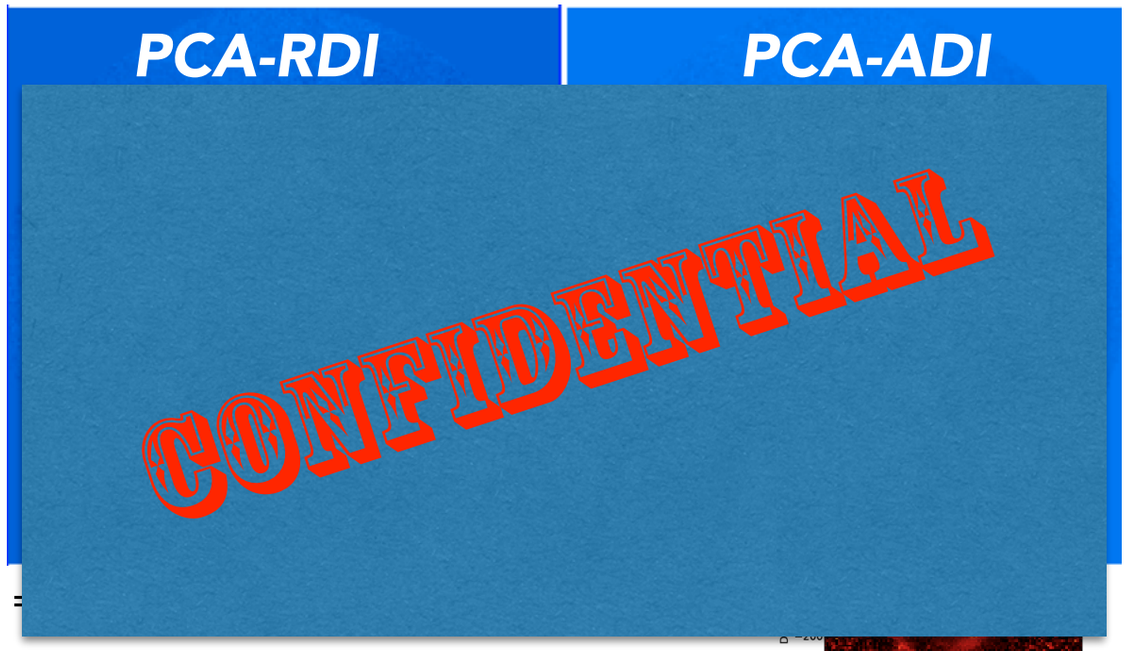






(Reggiani+14)

MWC 758 (Reggiani/Christiaens+ in prep)



(Benisty+15)

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2. First results of the AGPM on transition disks
   - L'-AGPM ideal to look for protoplanets
   - L'-AGPM also allows to probe disk features

3. Current transition disk programs with the AGPMs

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NACO+AGPM (mini-)mini-survey (PI: Christiaens)

- Search for protoplanets using direct imaging in L'-band
  - Initial plan: mini-survey of 16 transition disks with NACO+AGPM

    …but severe streak of bad luck
  - Targets observed so far:

Source	Type	Instrument	Obs. strategy
PDS 66	TD	NACO (+AGPM)	RDI
RU Lup	TD	NACO (+AGPM)	ADI
HD 98800B	TD or circum-binary gap?	NACO	BDI
DoAr 21	TD?	NACO (+AGPM)	ADI+RDI
TWA 7	Debris disk	NACO (+AGPM)	ADI
gamma doradus	Debris disk	MagAO/Clio2	ADI
HD 35650	Debris disk	MagAO/Clio2	ADI

- Data reduction in progress

NIRC2+AGPM mini-survey (PI: Ruane)

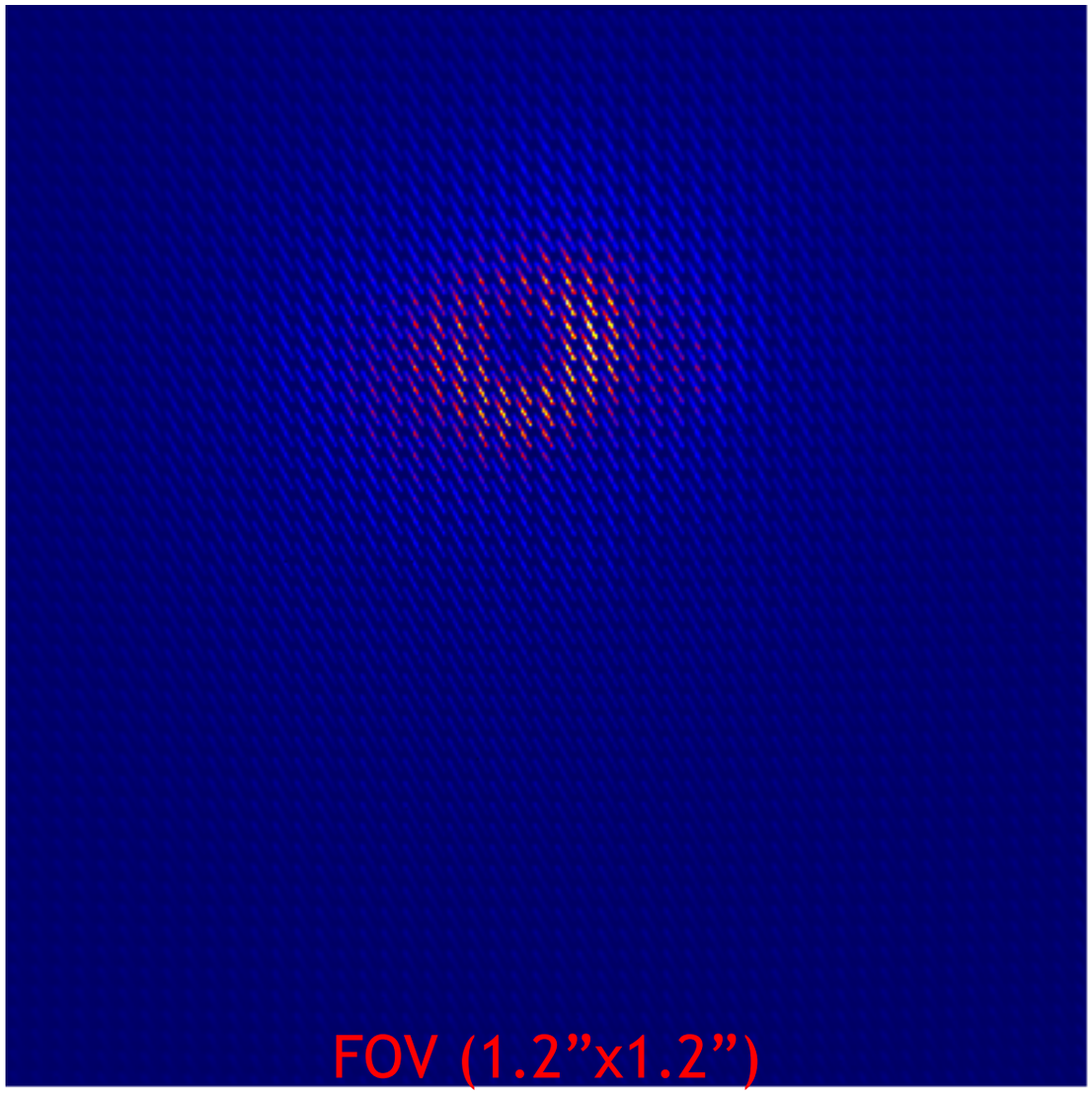
- Search for protoplanets using direct imaging in L'-band
  - Beginning of the observations last Saturday
  - First result:

LMIRCam+AGPM mini-survey (PI: Defrère)

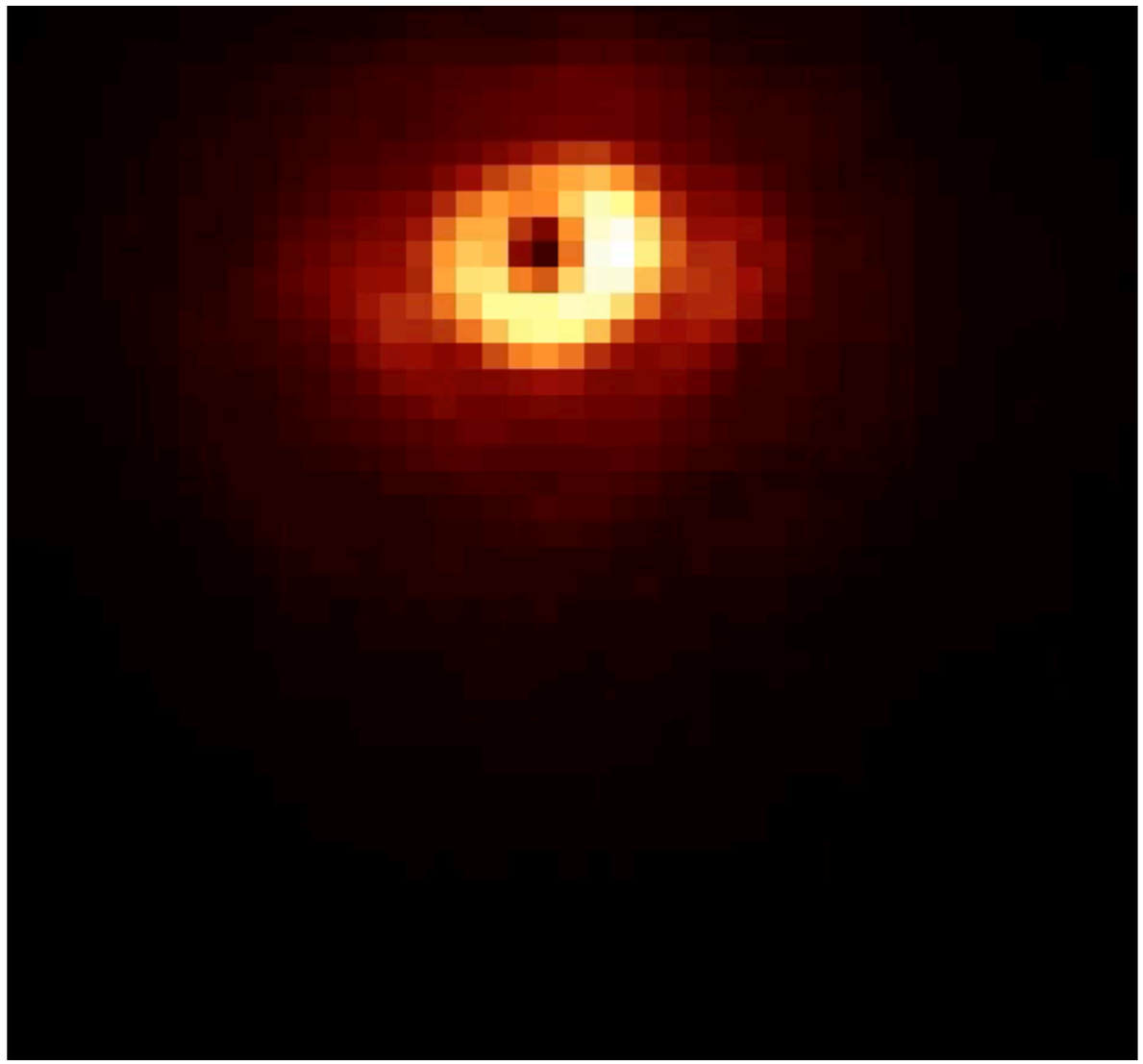
- Weather loss for TDs => commissioning of ALES+AGPM

First ALES+AGPM images

First AGPM+IFU image (beta Aur)



Spectral image cube (2.8 – 4.2 microns, R~20)



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3. Current transition disk programs with the AGPMs
   - VLT: results for the NACO+AGPM mini-survey will arrive soon
   - Keck: promising start for the NIRC2+AGPM mini-survey
   - LBT: LMIRCam+AGPM mini-survey delayed