Uncovering inner disk asymmetries with VLTI/MATISSE: the case of HD 163296

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Uncovering inner disk asymmetries with VLTI/MATISSE: the case of HD163296

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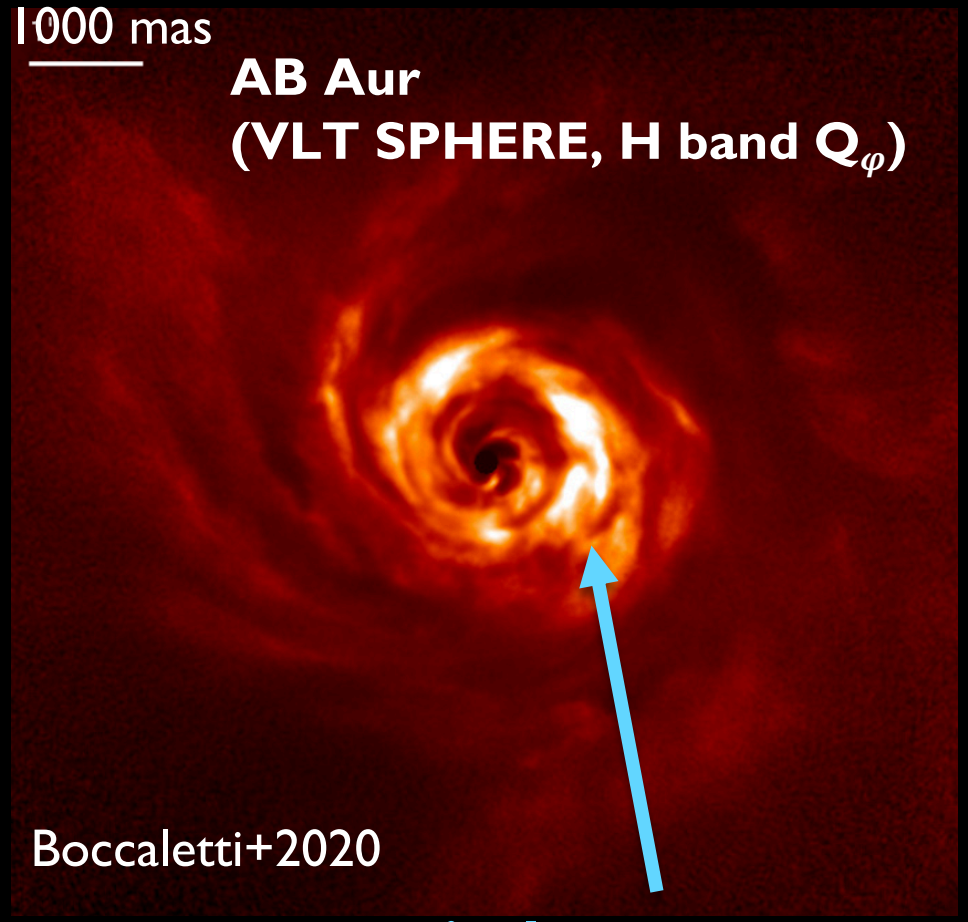
Ground-based thermal infrared astronomy – past, present and future

12 October 2020

Planet-forming disks – substructure everywhere

Infrared

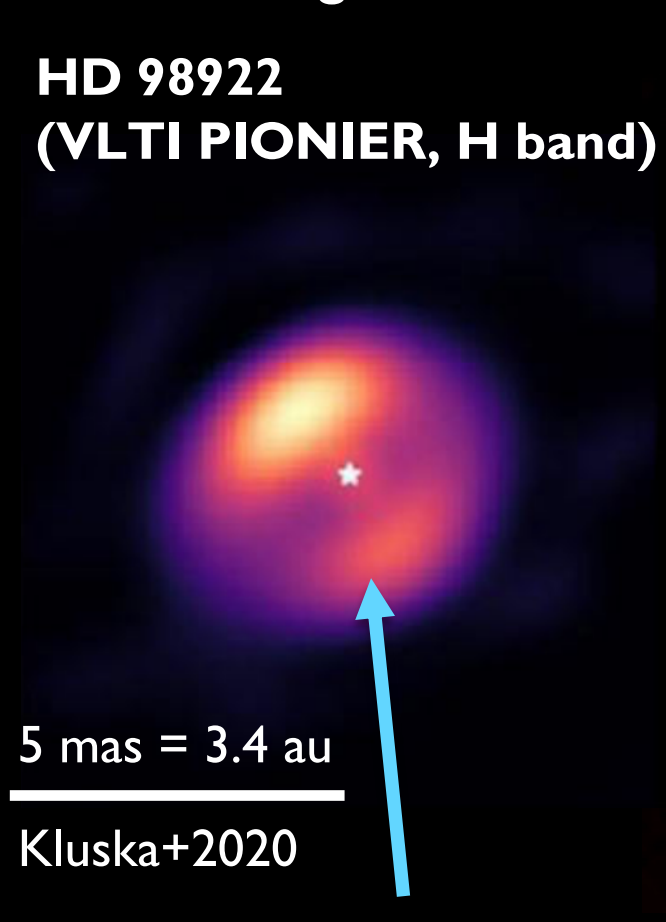
- scattered light



spiral structure

Infrared

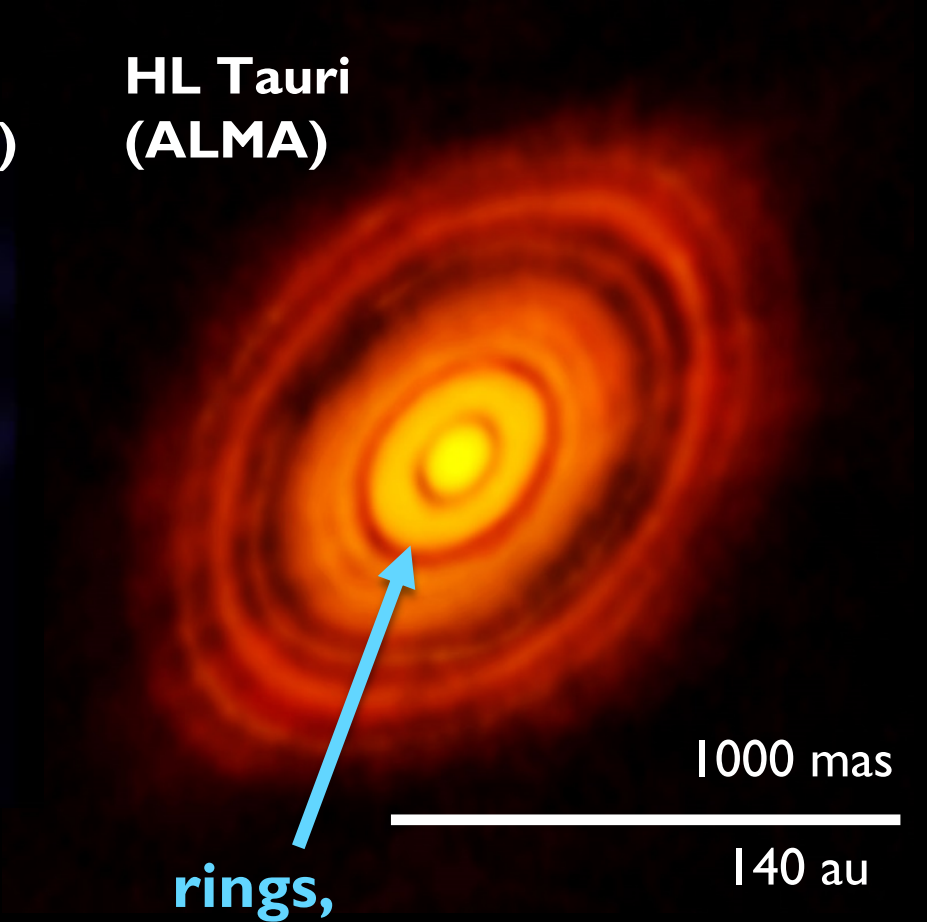
- thermal emission from small grains



inner rim

mm

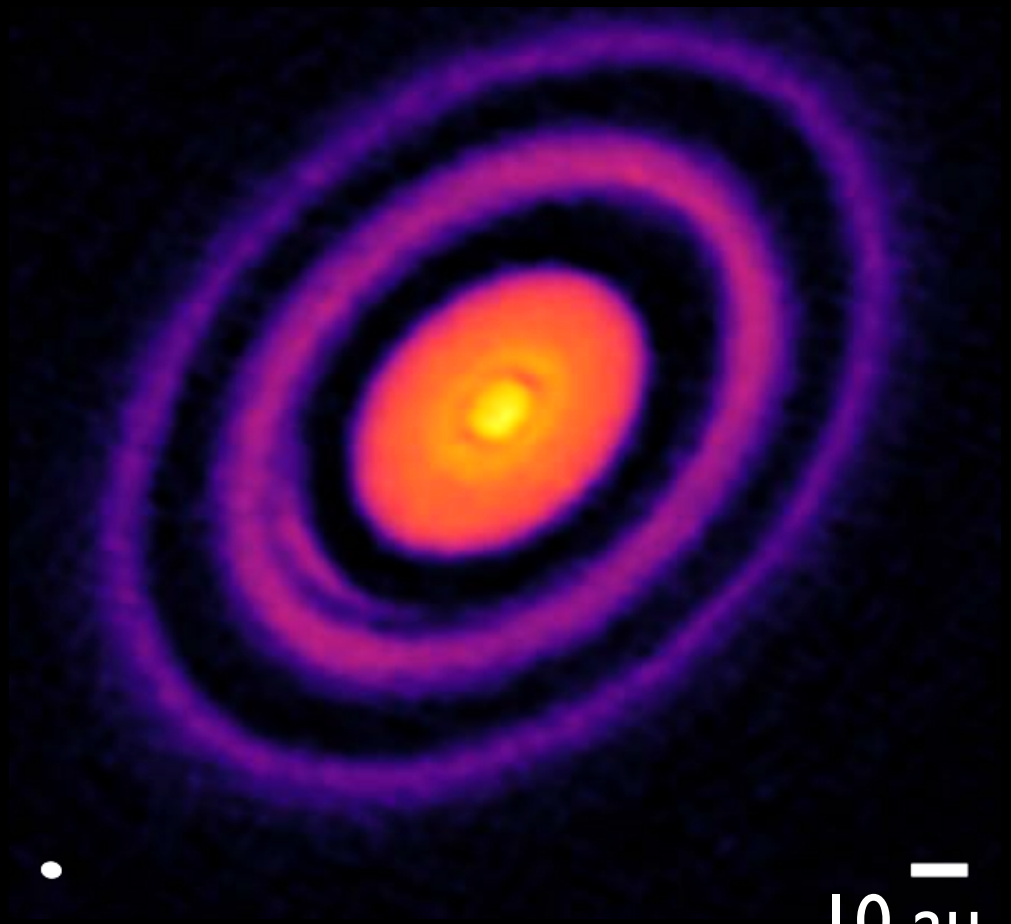
- thermal emission from large grains



rings, gaps

HD 163296 – a Herbig Ae disk in high resolution

ALMA
1250 μm
Andrews+2018



- Herbig Ae star
- d = 101 pc,
- Age = 7 – 10 Myr
- $L_\star = 16\ L_\odot$
- A1Vep spectral type
- disk
  - i = 47°
  - PA = 133°
  - outer radius = 169 au

HD 163296 – a Herbig Ae disk in high resolution

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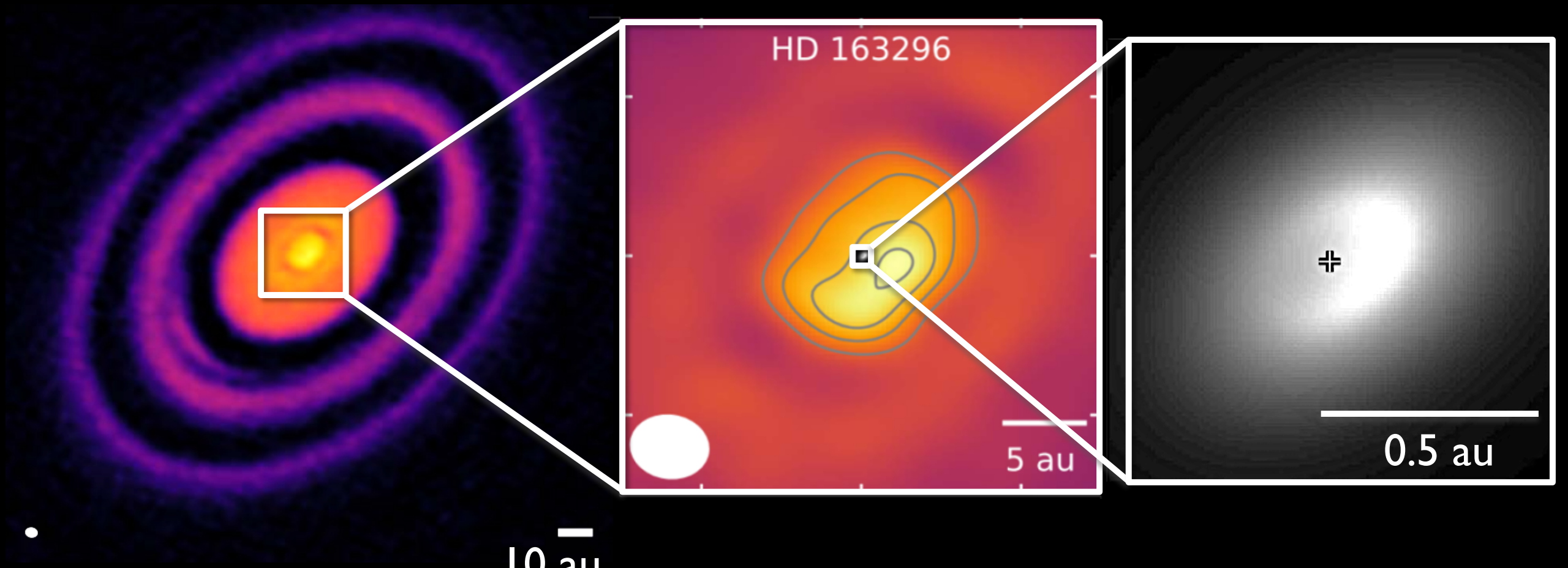
Huang+2018

VLTI PIONIER
1.6 μm
Lazareff+2017



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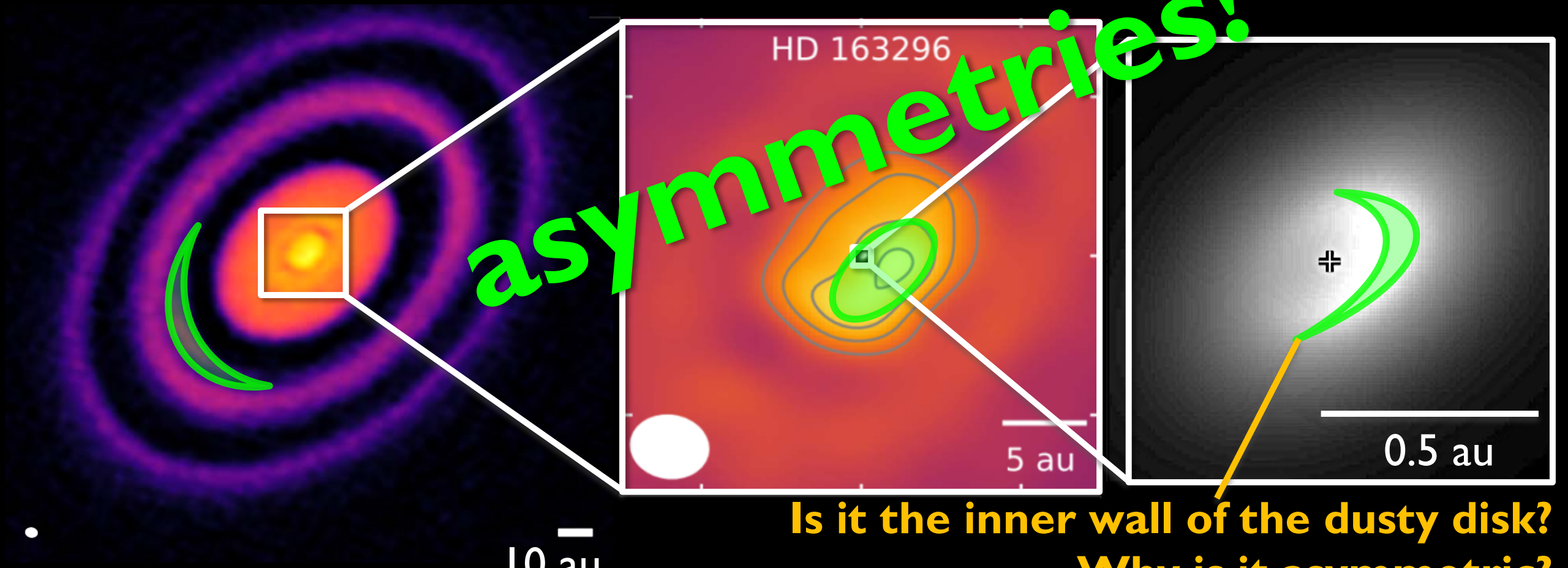
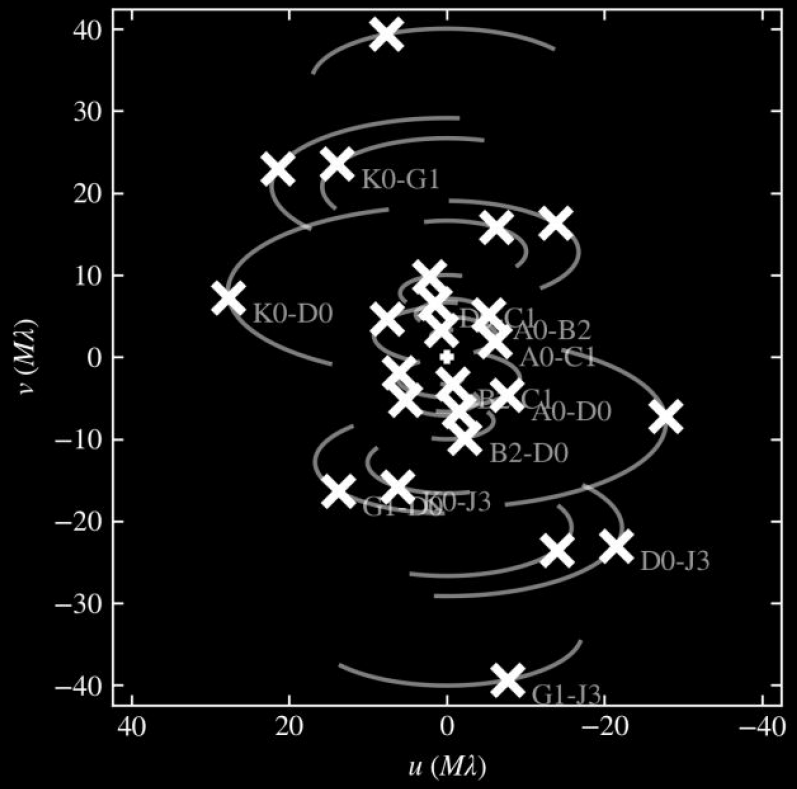


Is it the inner wall of the dusty disk?
Why is it asymmetric?

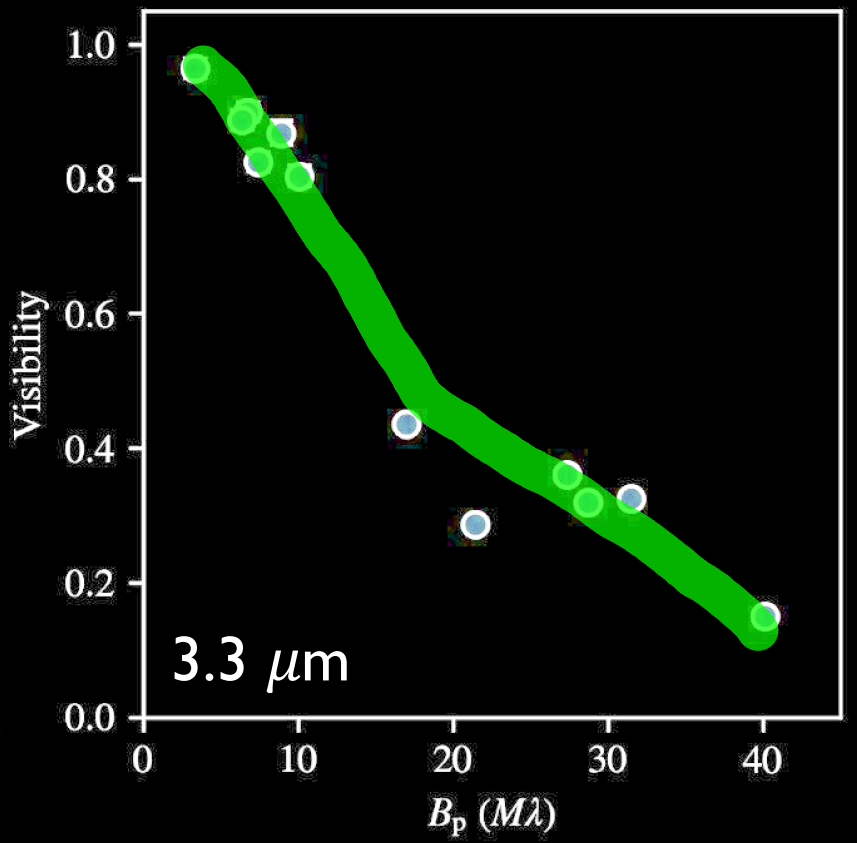
HD 163296: L band MATISSE GTO observations

baseline coverage



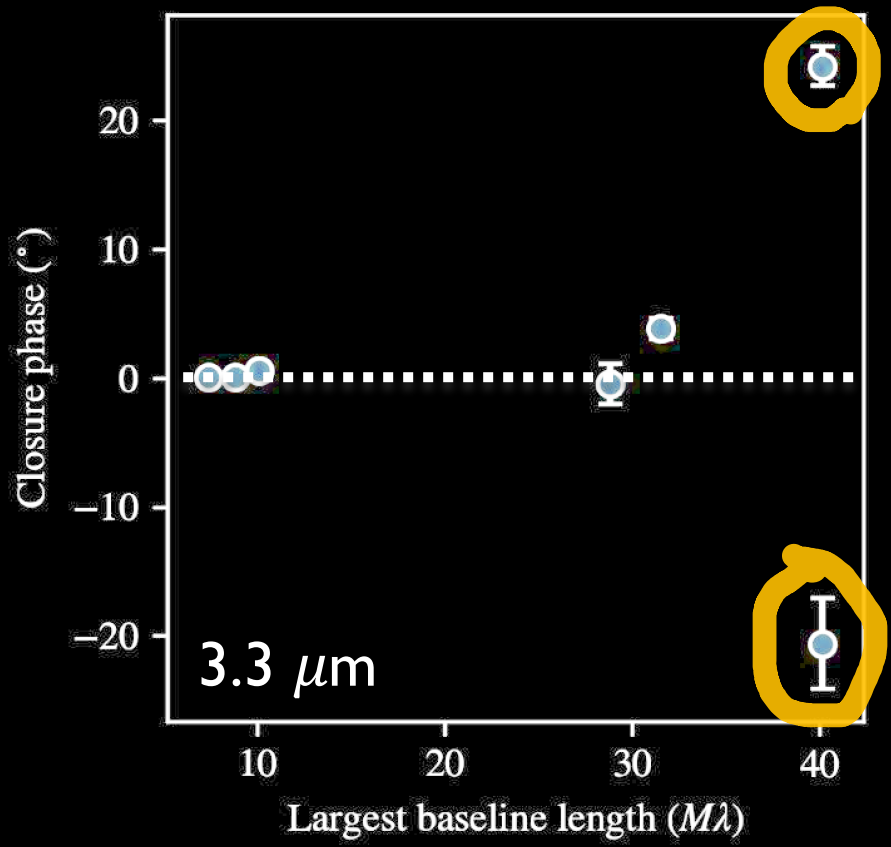
– max. resolution:
~2.6 mas (0.26 au)

visibility vs. baseline



– the trend is related to spatial structure

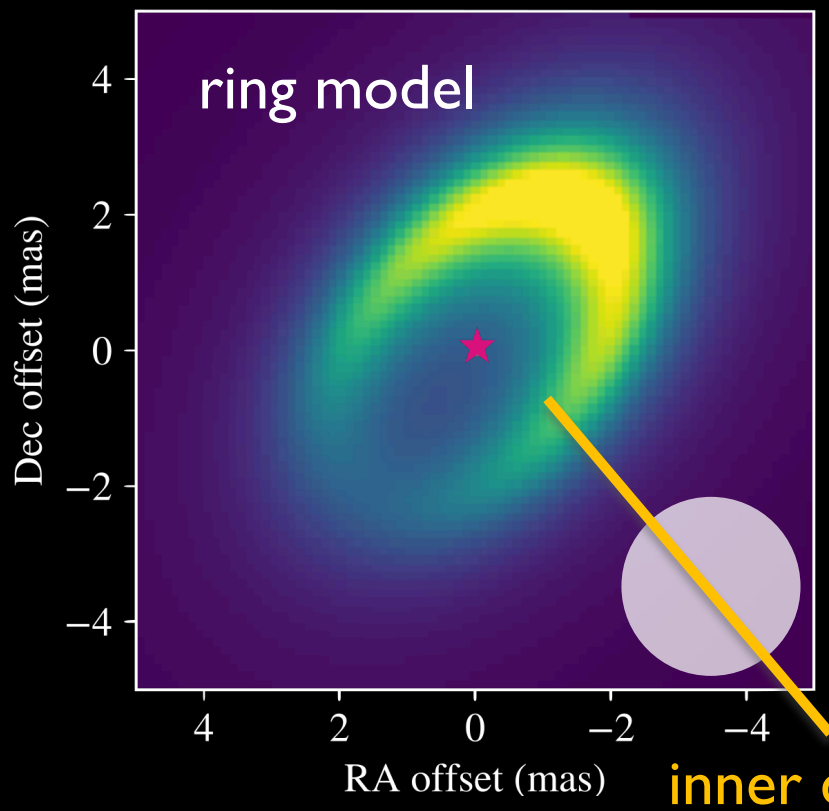
closure phase

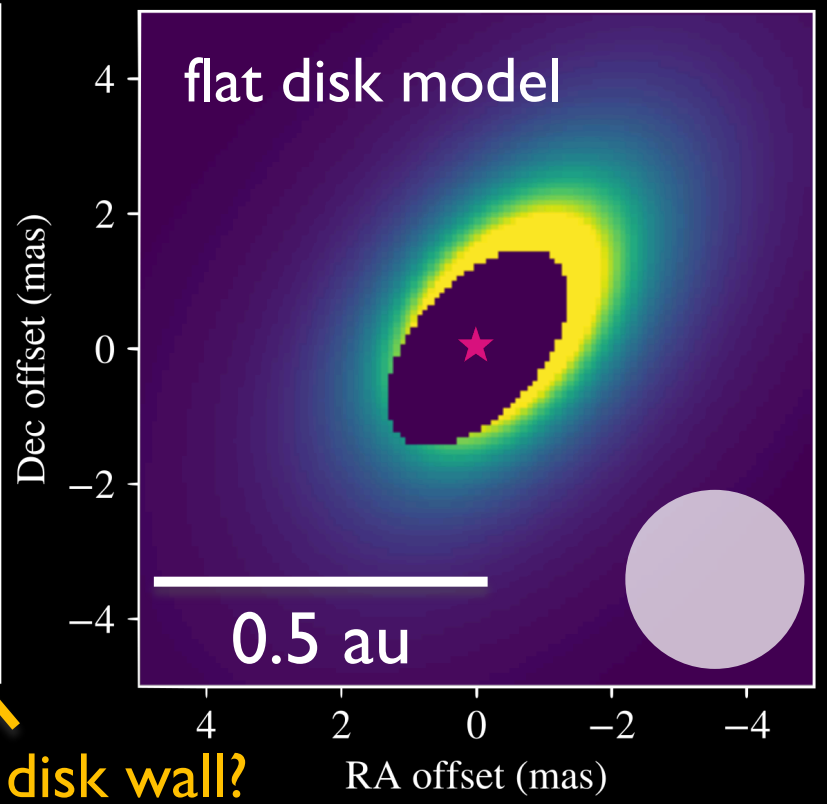


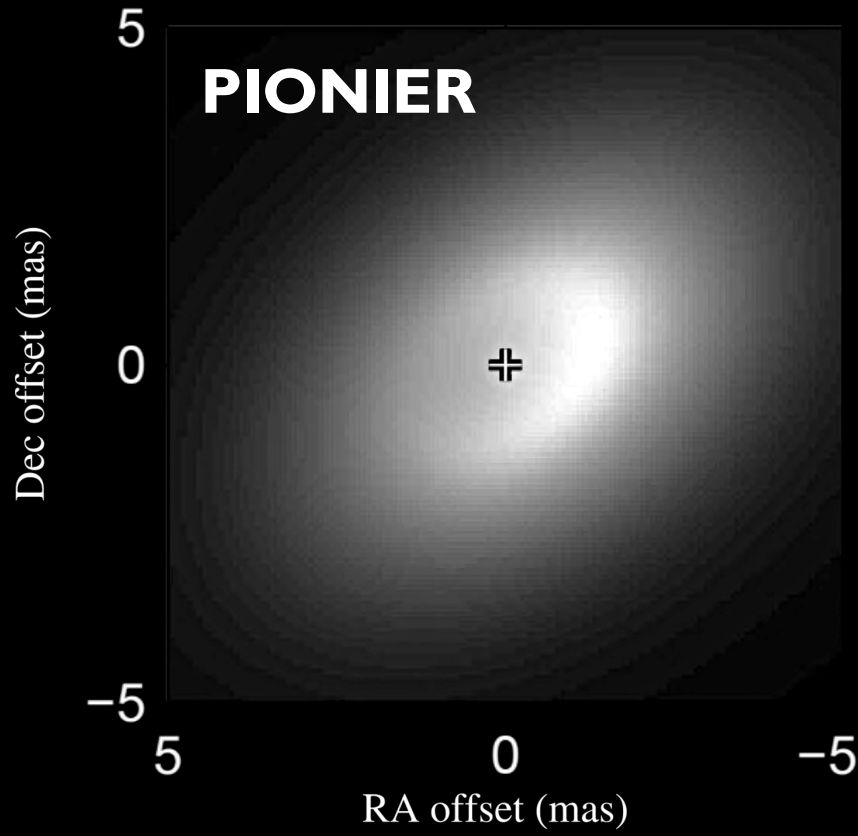
– indicates asymmetry
– max: ≈ 25°
> PIONIER closure phases

Modelling results (Varga et al., submitted)

- MATISSE 3.3 μm
  - asymmetric ring
  - modulation along major axis
- PIONIER 1.6 μm
  - Lazareff+2017
  - model image







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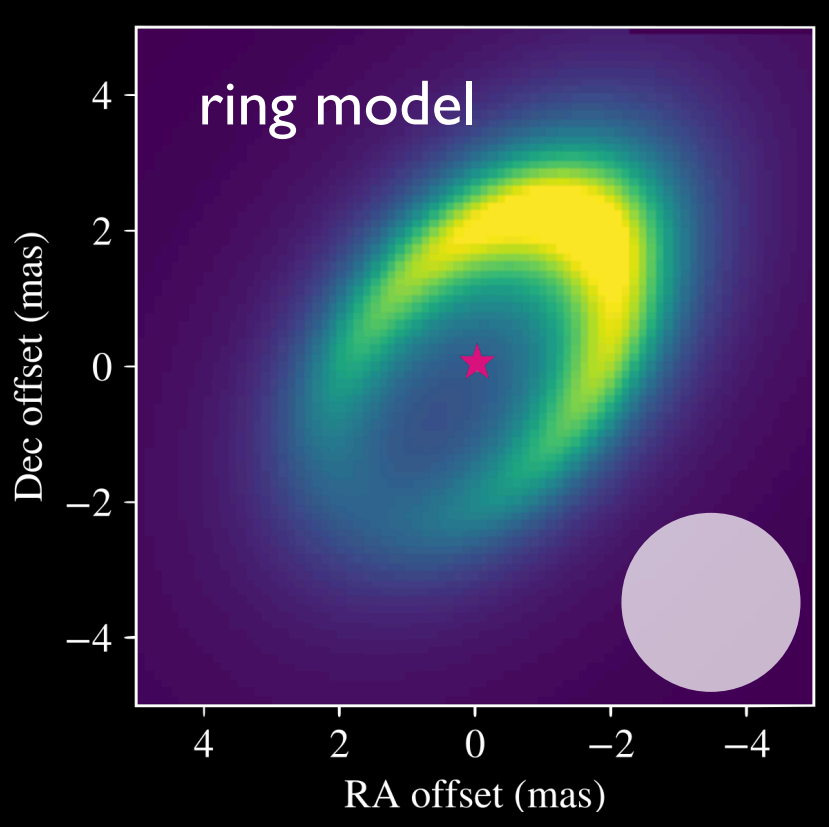
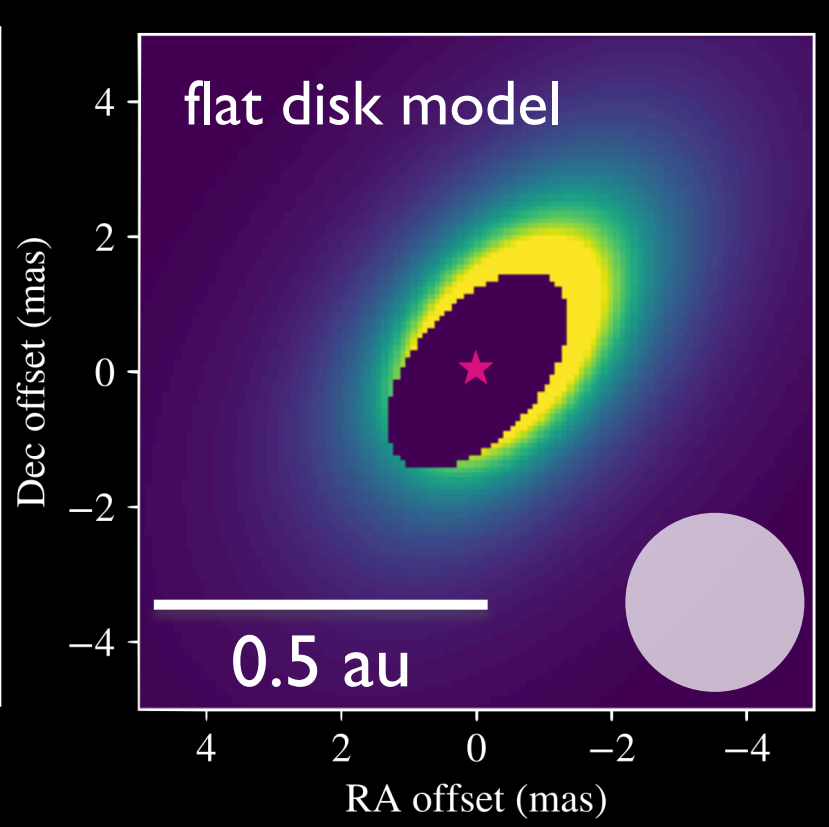
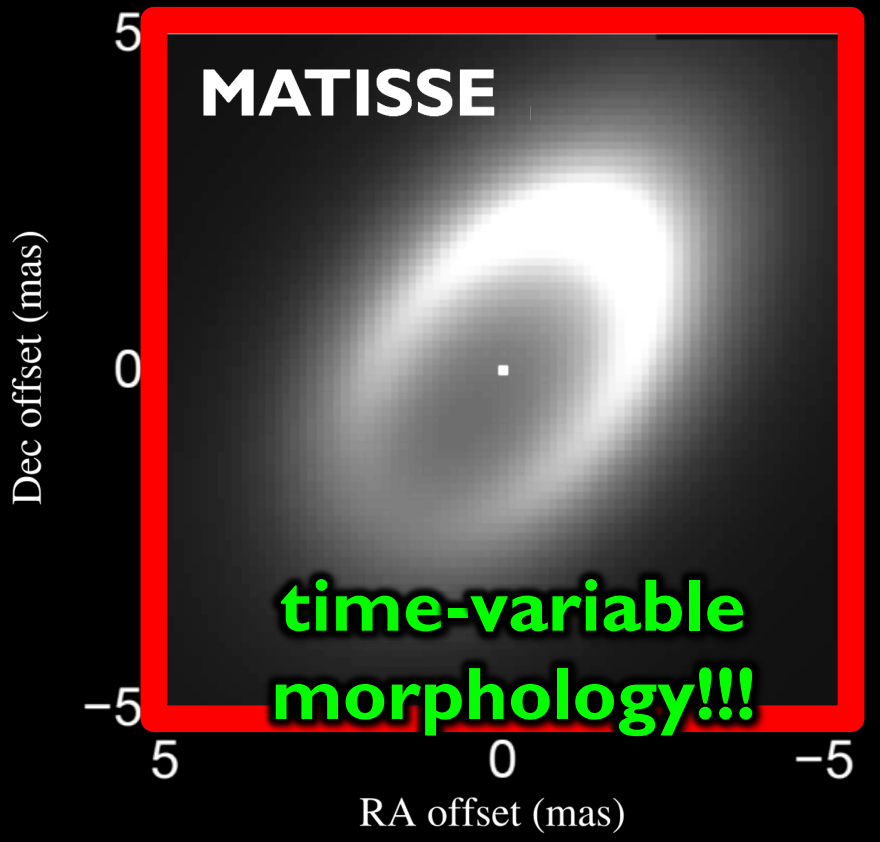




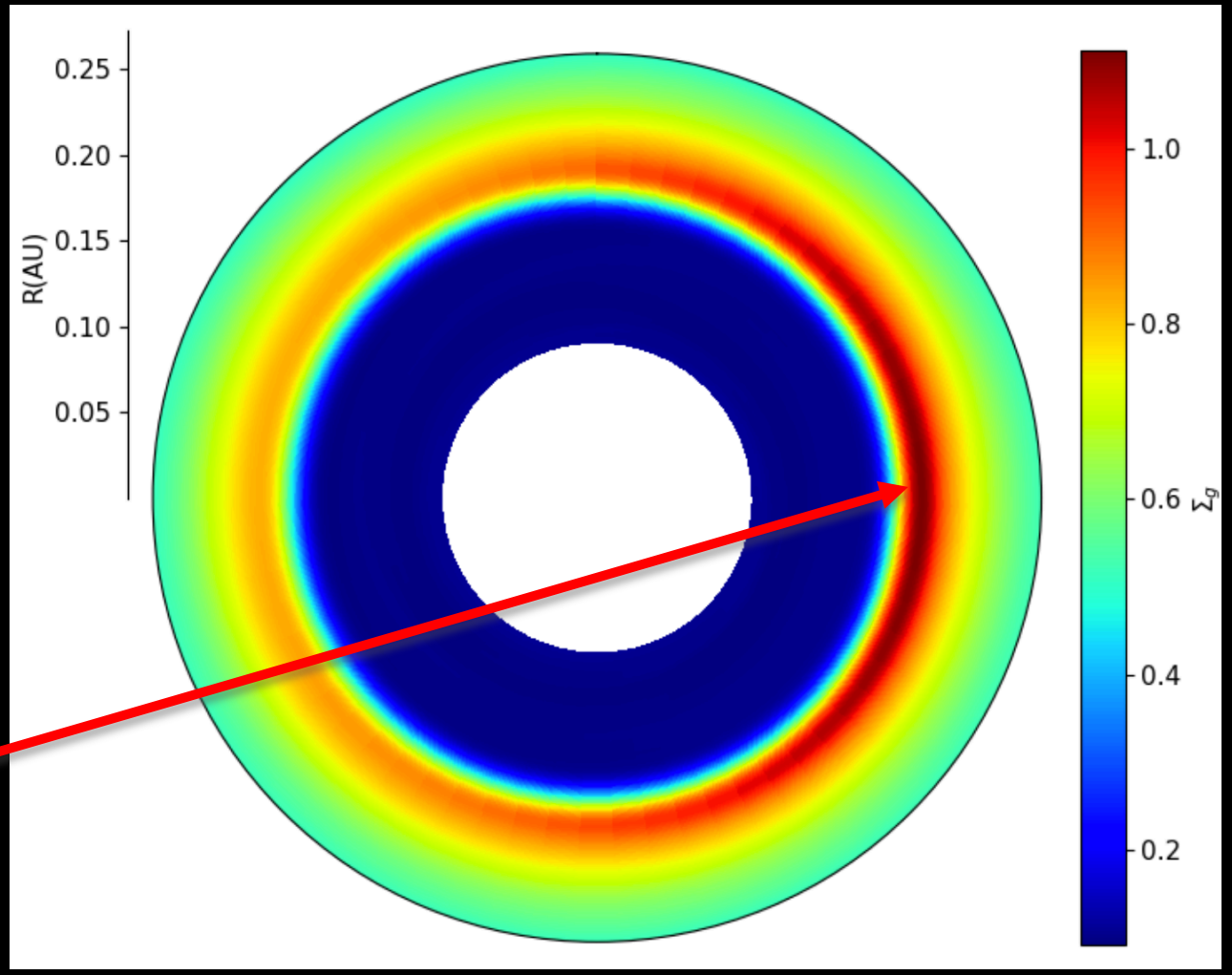


Nature of the asymmetry: vortex scenario

- could it be a rotating clump?
  - radius ~ 0.2 – 0.3 au
  - period should be P ~ 20-50 days
- numerical hydrodynamic simulation
- density gradient at the inner edge
  - Rossby-wave instability

  → formation of a unique large-scale **vortex**

gas surface density map – face-on view

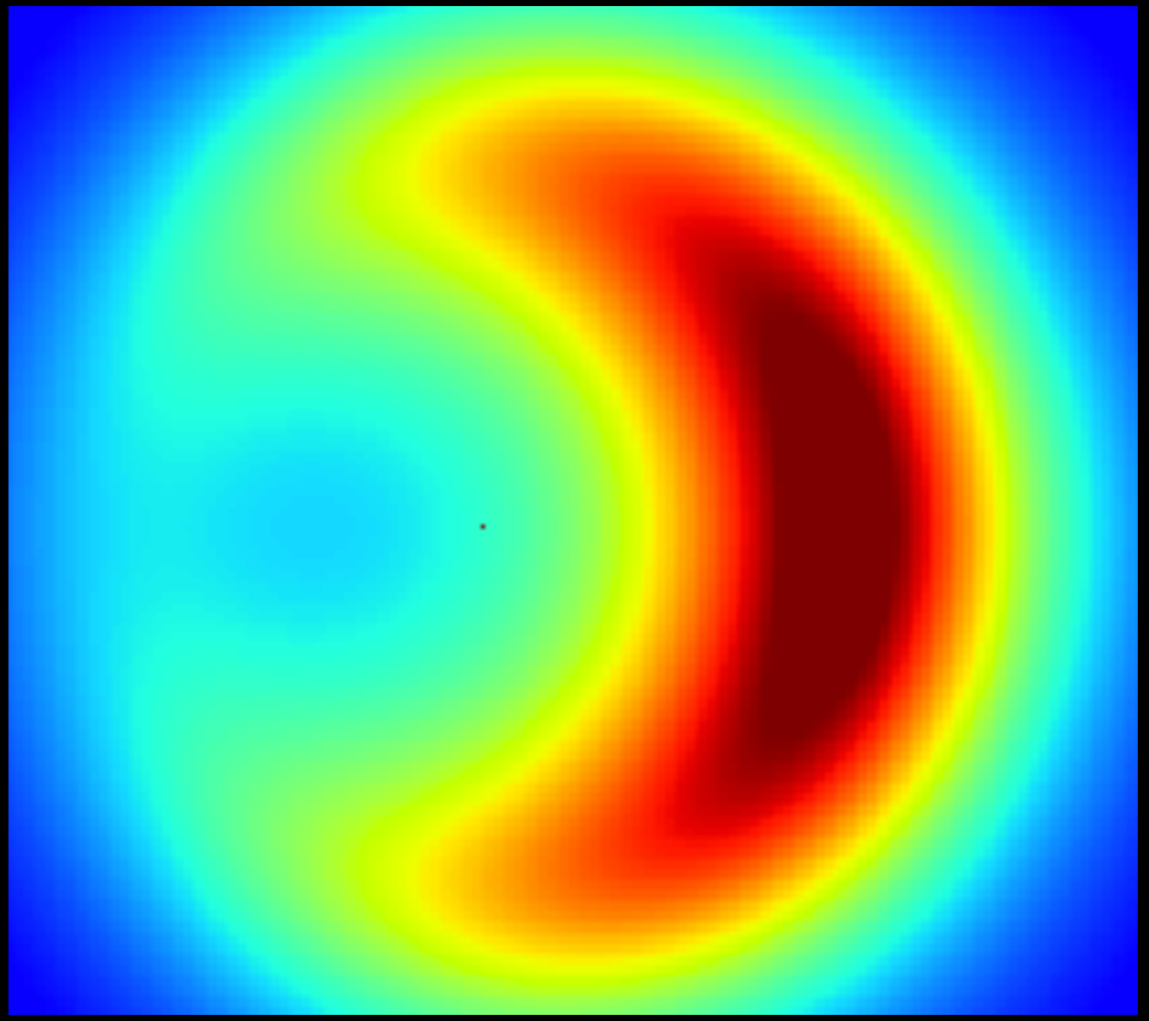


Nature of the asymmetry: vortex scenario

- possible dust trap → grain growth
  - potential site for planet formation
- why is it brighter?
  - grinding down part of the dust

  → production of small grains
- full simulation including dust dynamics + radiative transfer needed

MATISSE surface brightness – face-on view



Summary

- new MATISSE observations of HD 163296
- we observed an asymmetric structure in the inner r=0.3 au
  - strong indications for **variable morphology**
  - could be a rotating clump
    - P ~ 20-42 days
    - possible dust trap
- we tested a scenario for the physical origin
  - vortex formation by Rossby wave instability
- follow-up (monitoring) observations required