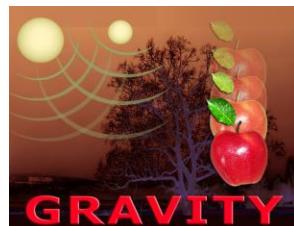


# Characterising dust and gas at the inner rim of protoplanetary disks with GRAVITY

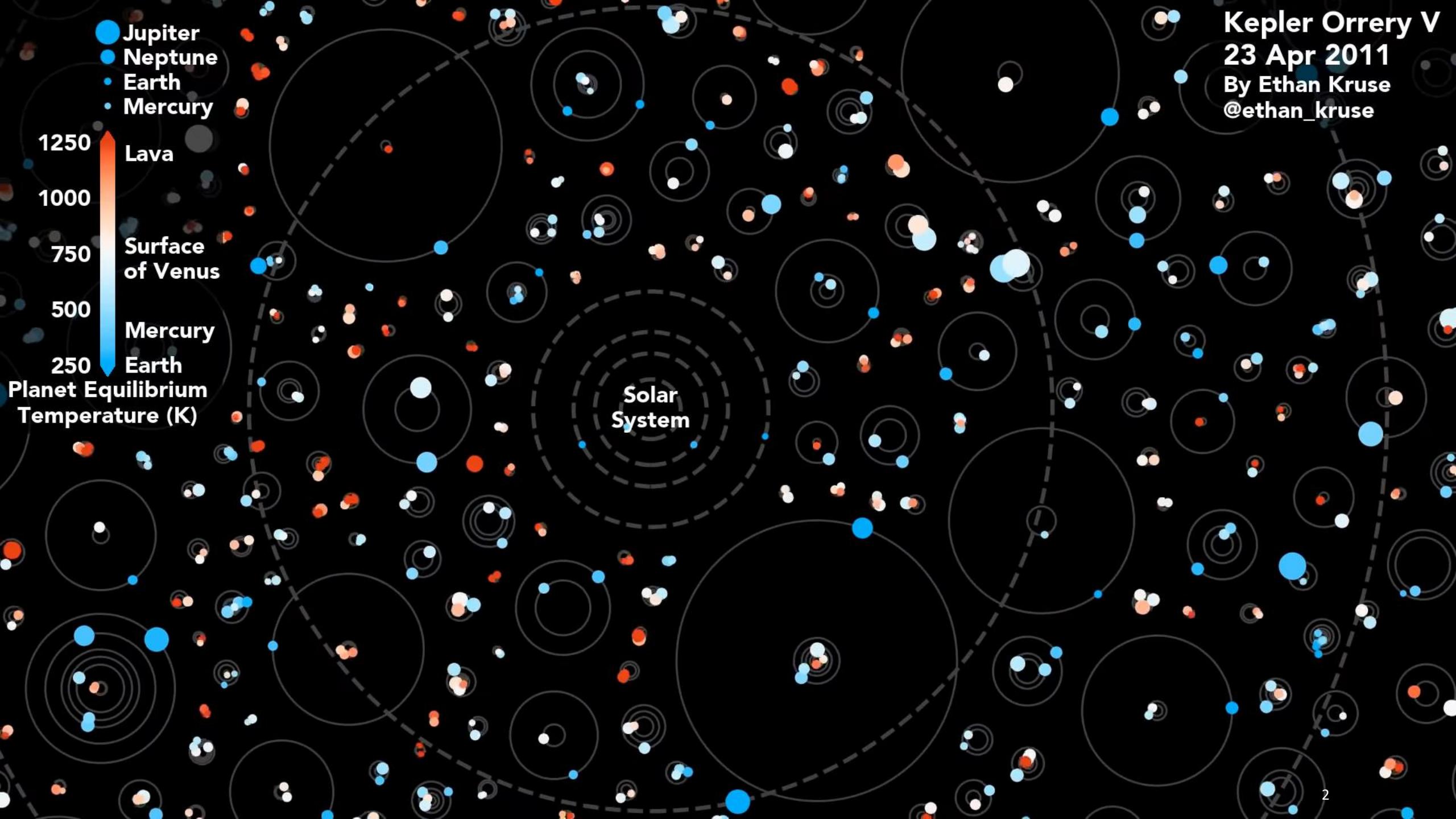
Lucia Klarmann - Great Barriers in Planet Formation - 23.07.19

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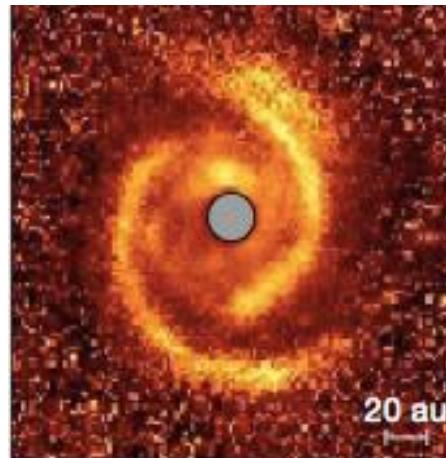
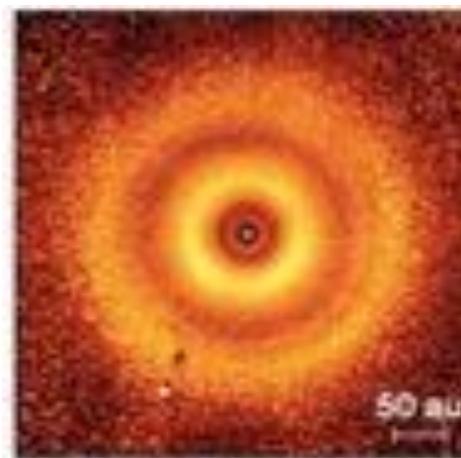
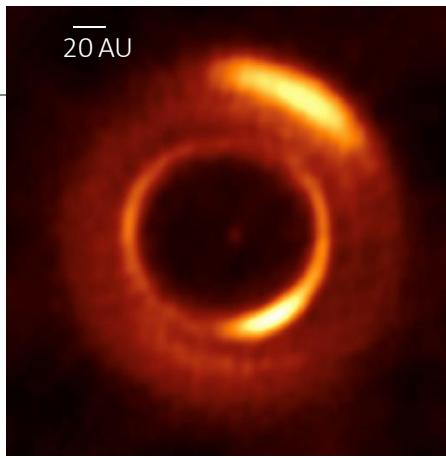
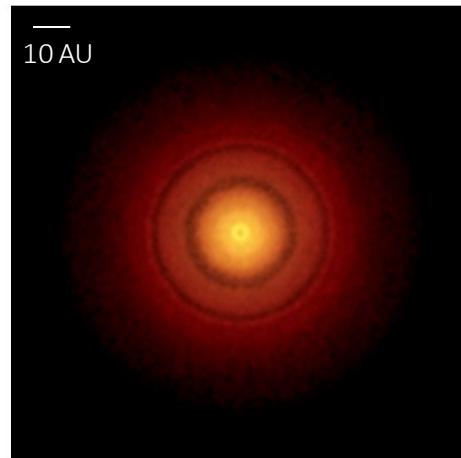
GRAVITY Consortium, K. Perraut, L. Labadie , B. Lazareff, M. Min, **M. Benisty**,  
C. Dominik, W. Brandner, T. Henning, D. Segura-Cox , M. Benisty, J. Bouvier,  
A. Caratti o Garatti, **C. Dougados**, P. Garcia, R. Garcia-Lopez, M. Koutoulaki



Kepler Orrery V  
23 Apr 2011  
By Ethan Kruse  
[@ethan\\_kruse](https://twitter.com/ethan_kruse)

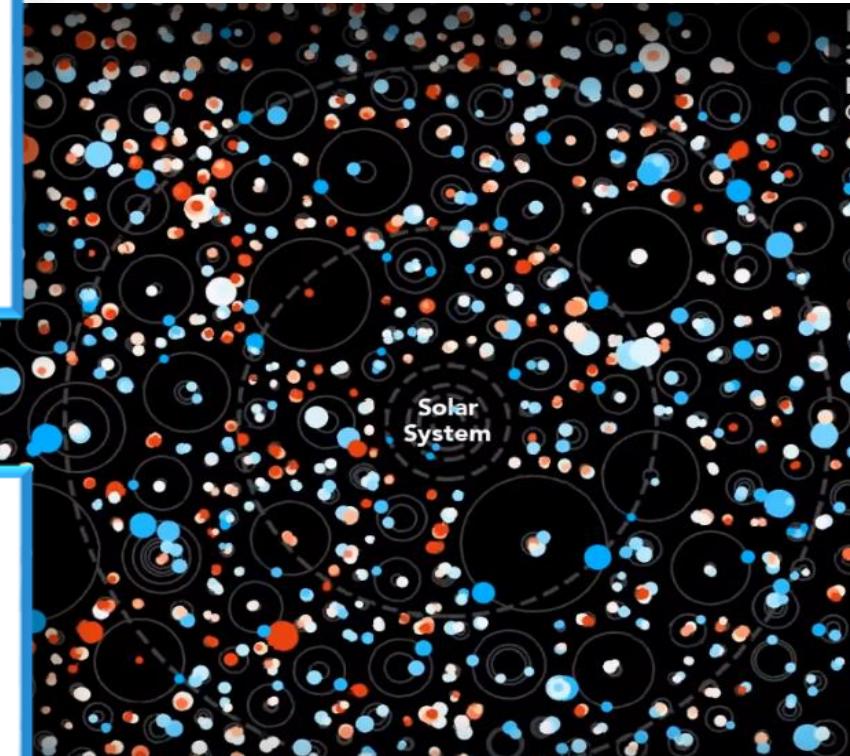
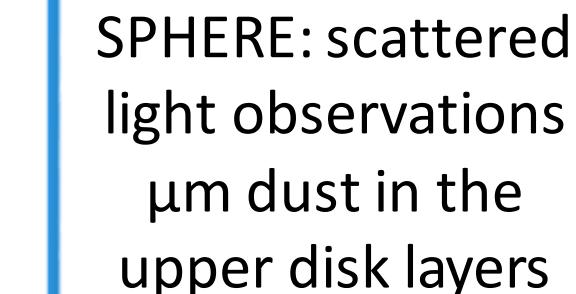
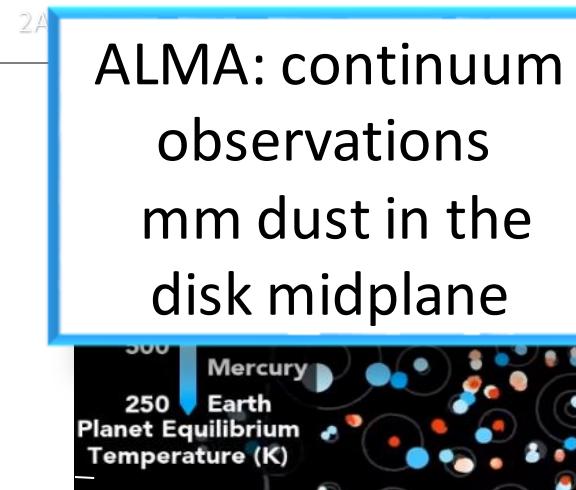


# Diversity of disks and exoplanetary systems



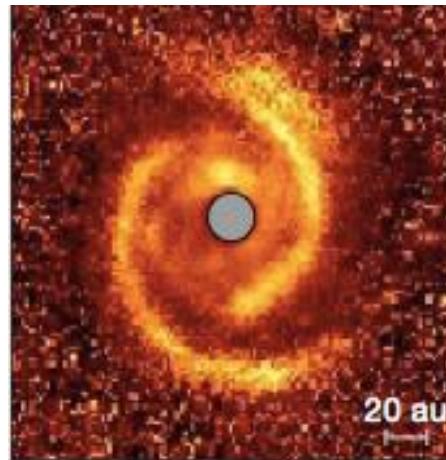
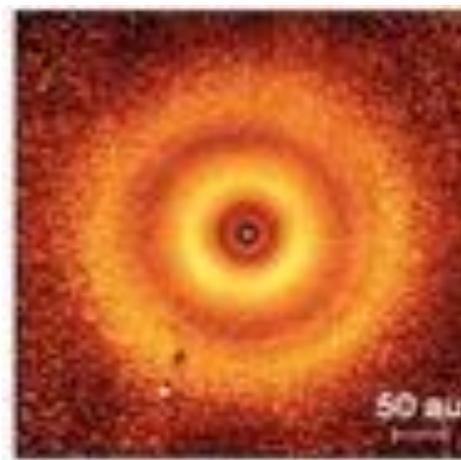
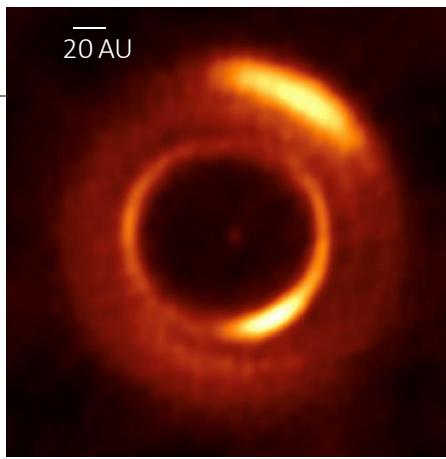
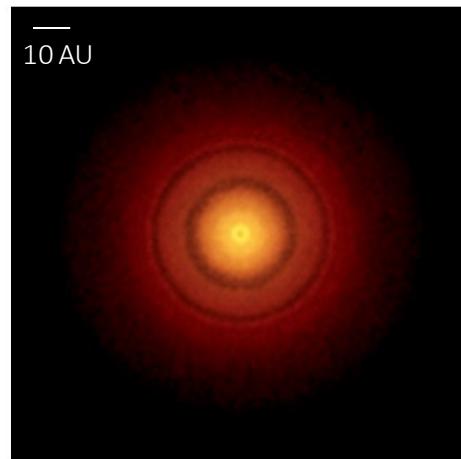
TW Hya

MWC 758



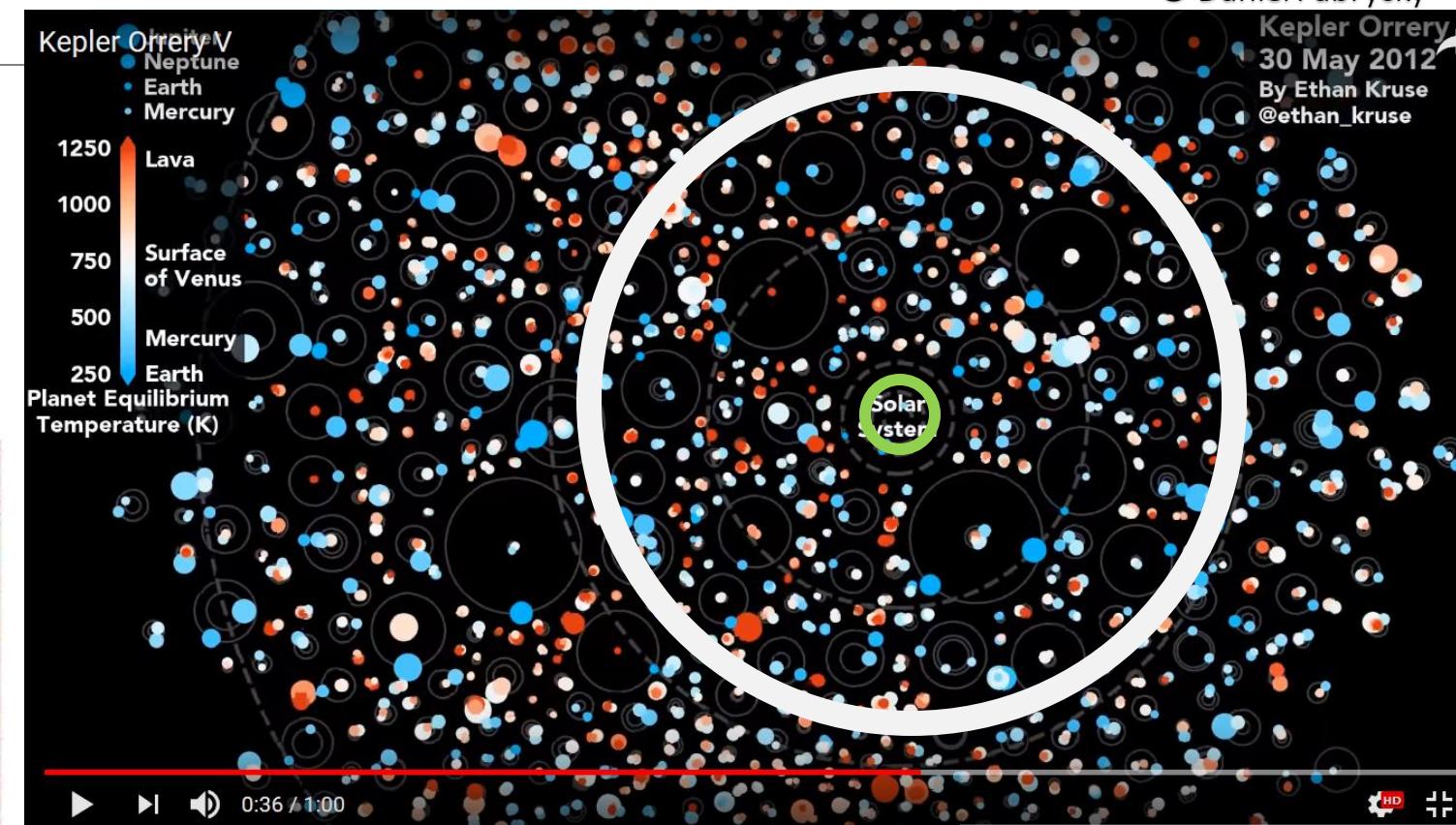
Andrews et al. 2016, Benisty et al. 2015, van Boekel et al. 2016, Dong et al. 2018

# Diversity of disks and exoplanetary systems



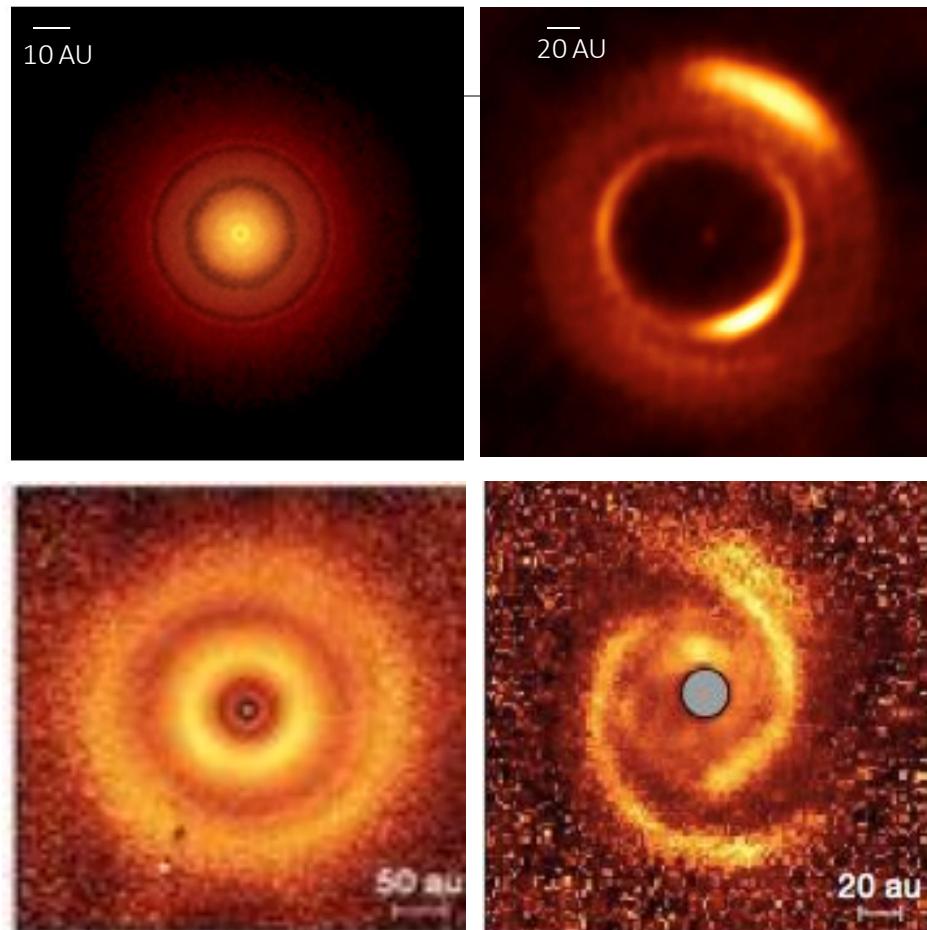
TW Hya

MWC 758



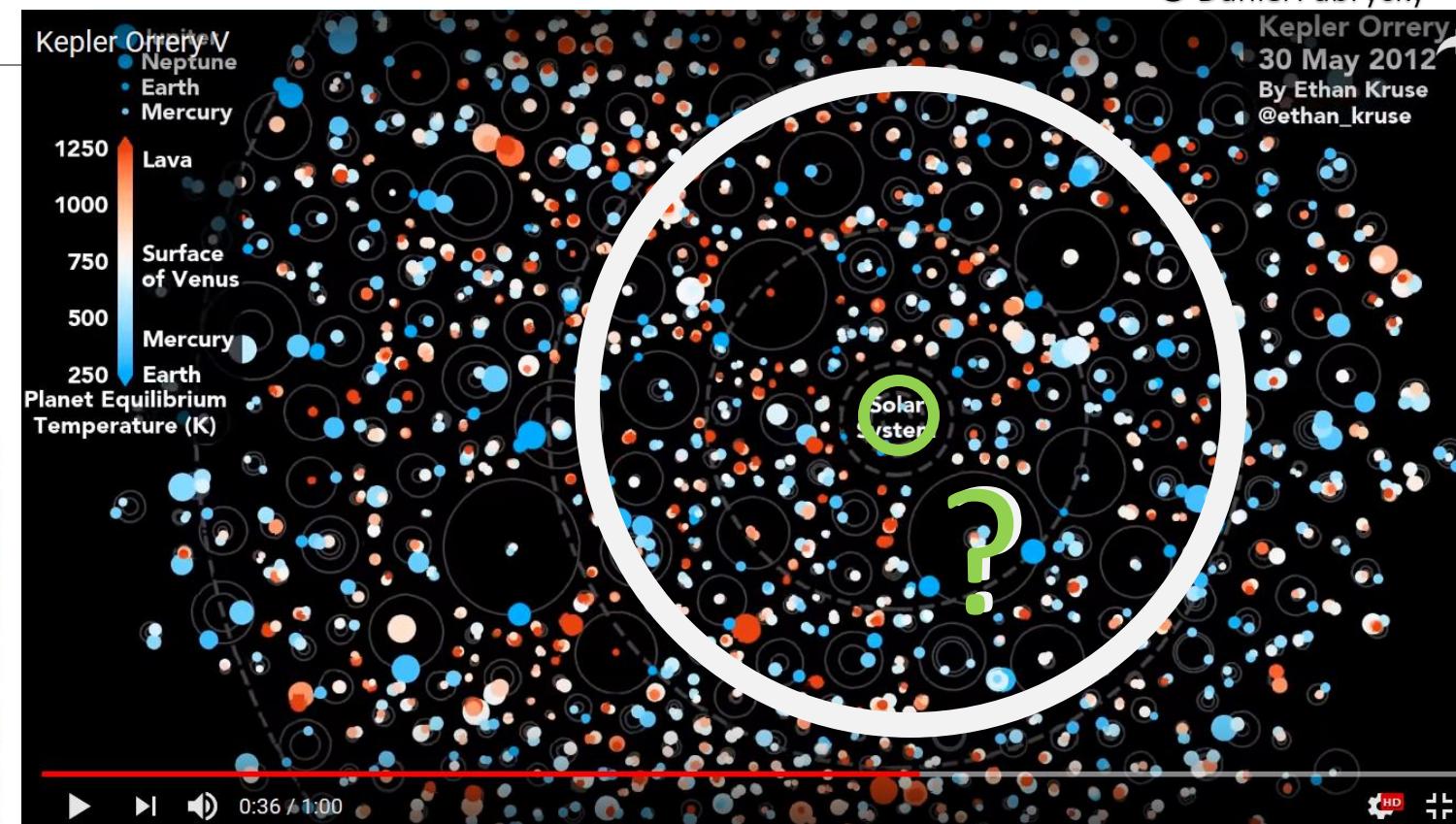
Andrews et al. 2016, Benisty et al. 2015, van Boekel et al. 2016, Dong et al. 2018

# Breaking through the resolution barrier



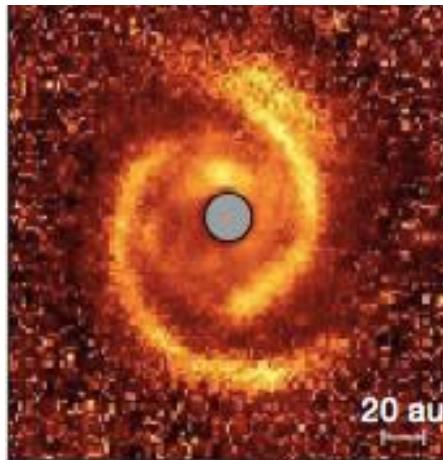
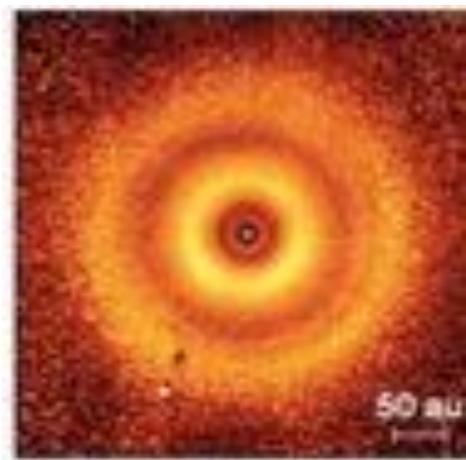
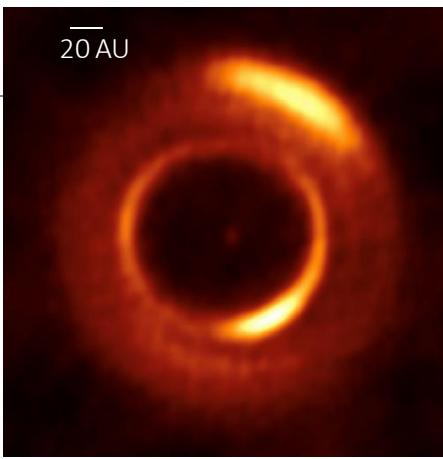
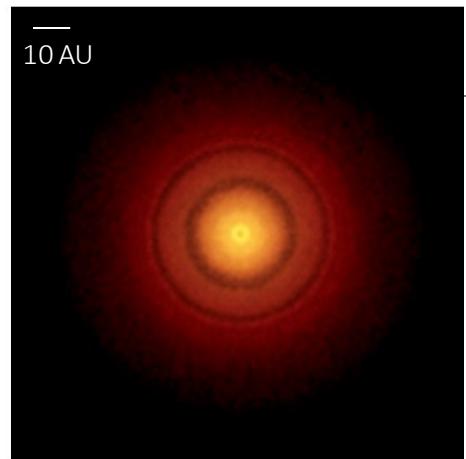
TW Hya

MWC 758



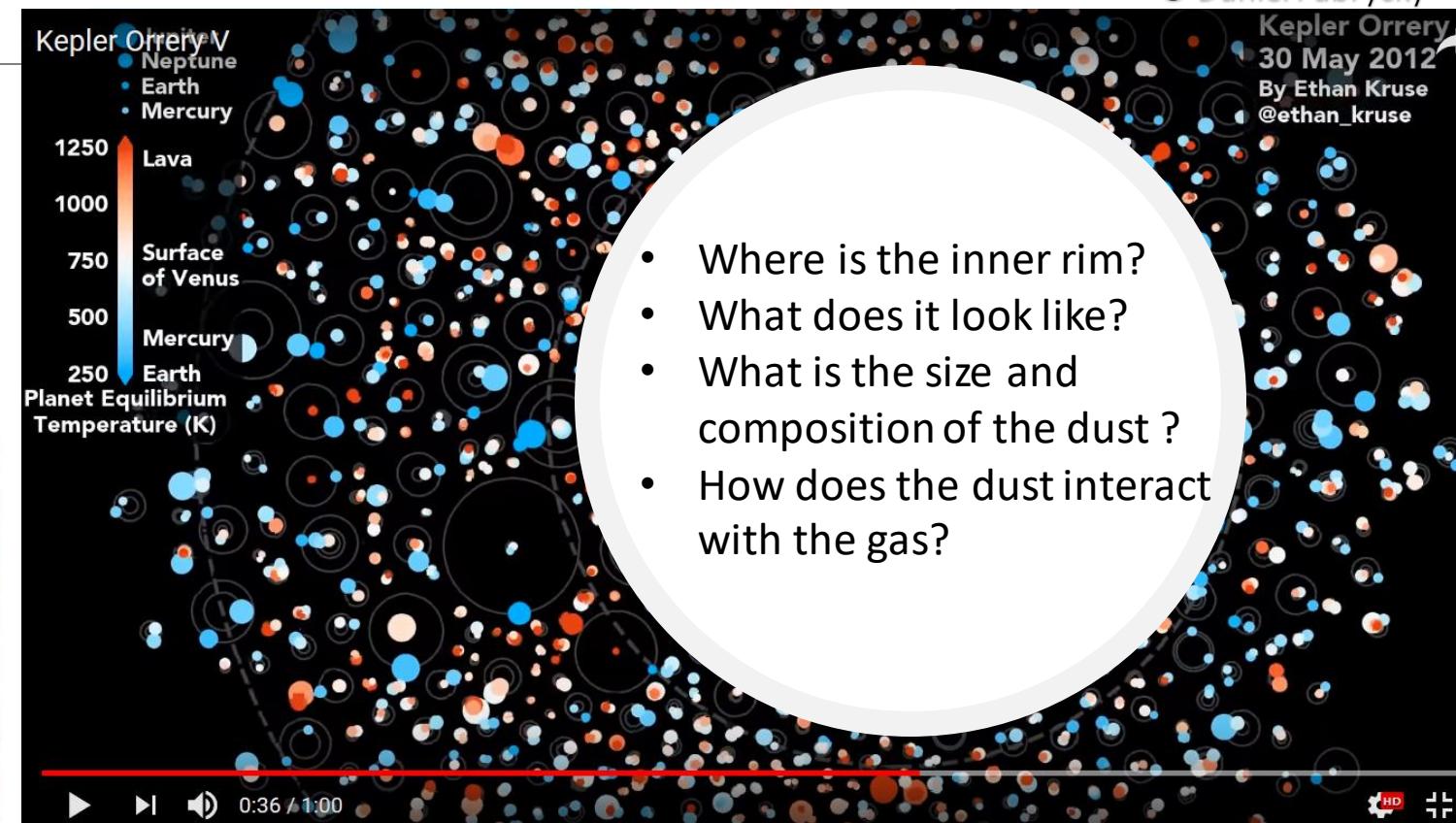
Andrews et al. 2016, Benisty et al. 2015, van Boekel et al. 2016, Dong et al. 2018

# Breaking through the resolution barrier



TW Hya

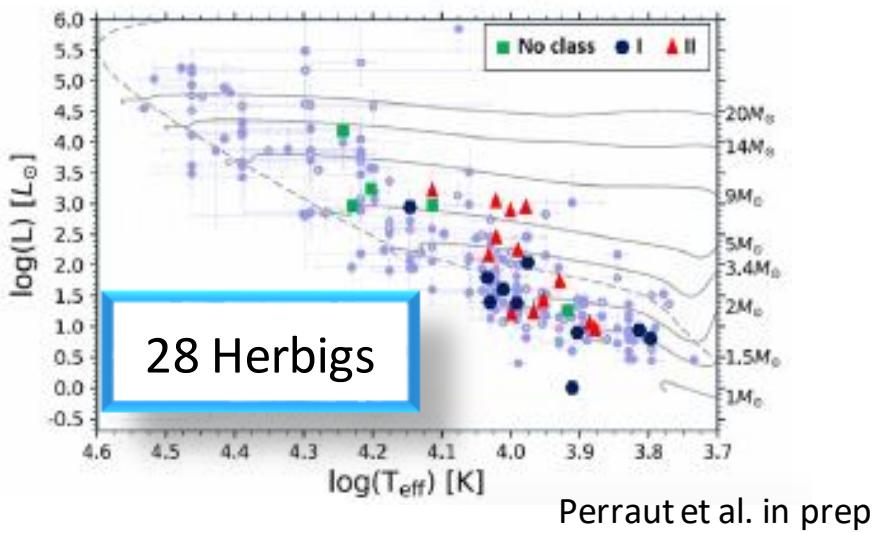
MWC 758



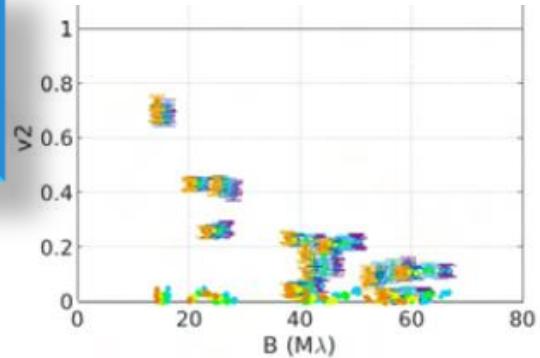
Andrews et al. 2016, Benisty et al. 2015, van Boekel et al. 2016, Dong et al. 2018

# GRAVITY: Observations and interpretation

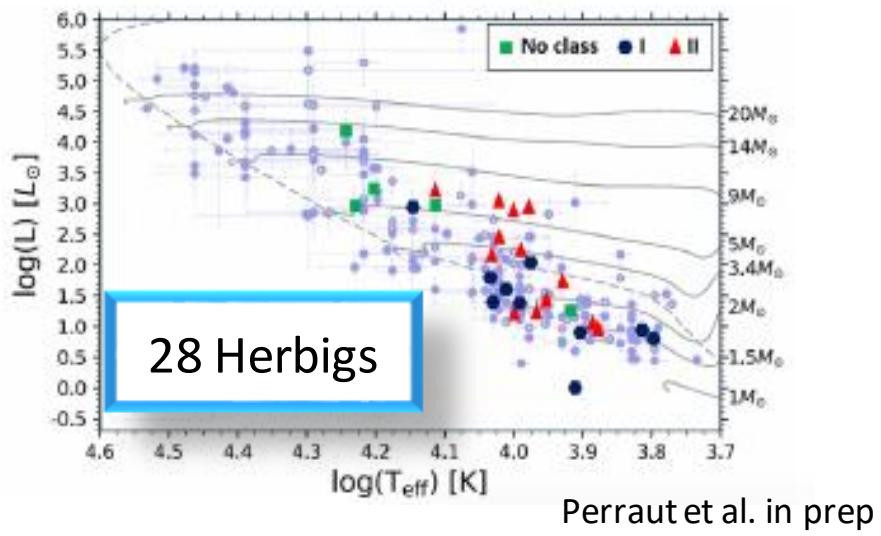
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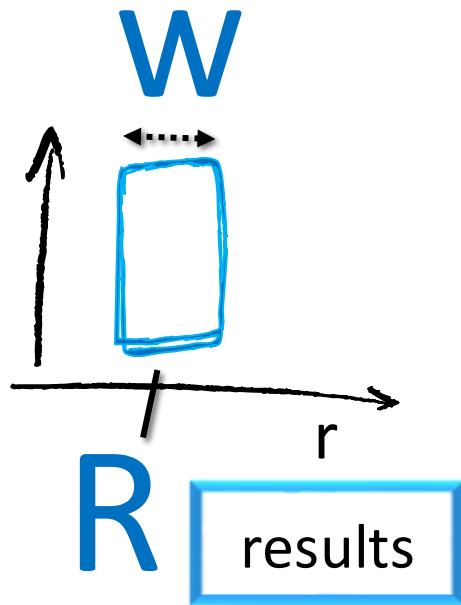
observation



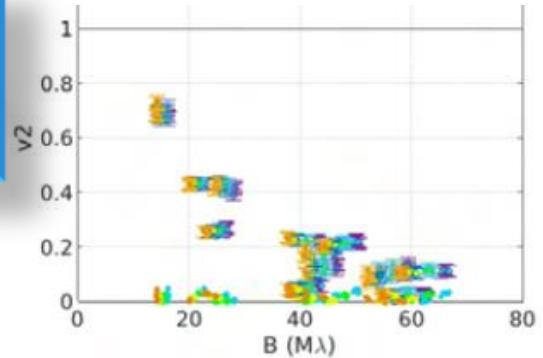
GRAVITY  
observation



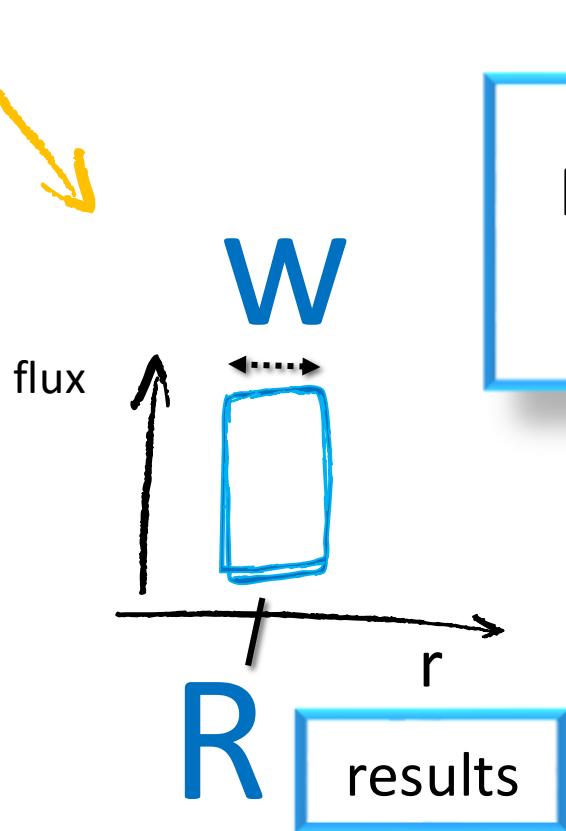
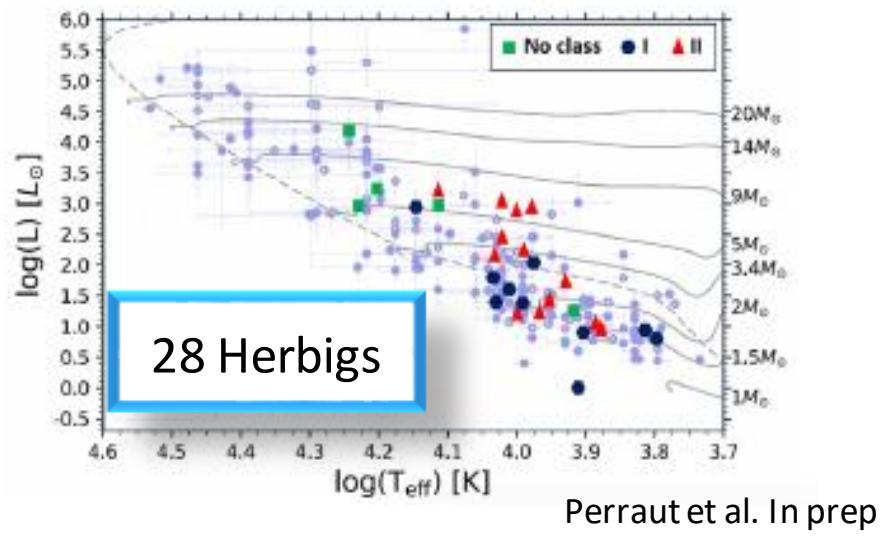
fit



observation



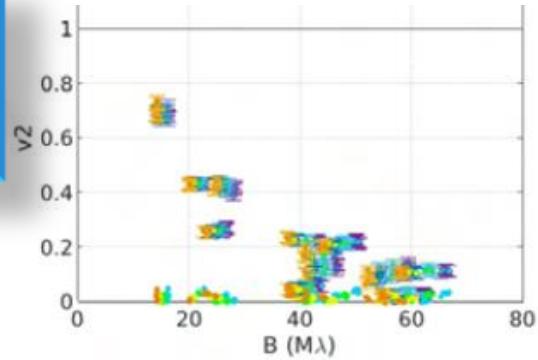
GRAVITY  
observation



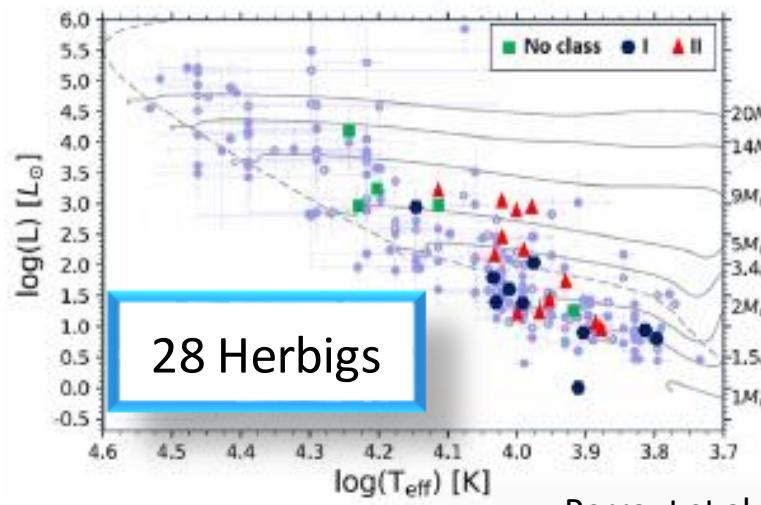
Rim position determined by  
dust composition and size

results

## observation

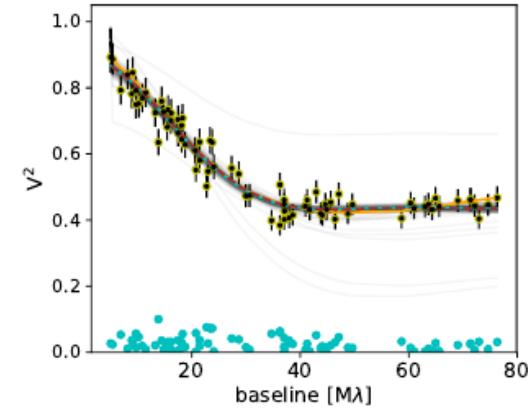


GRAVITY  
observation

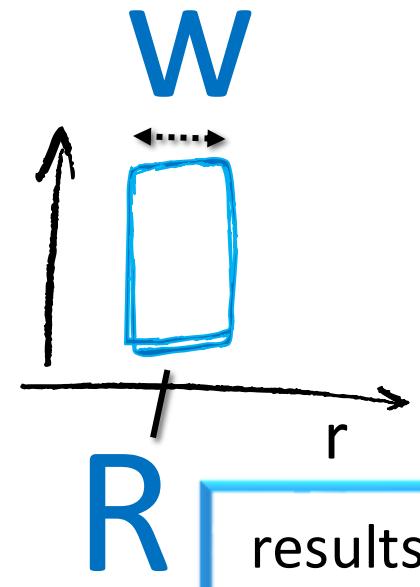


Perraut et al. in prep

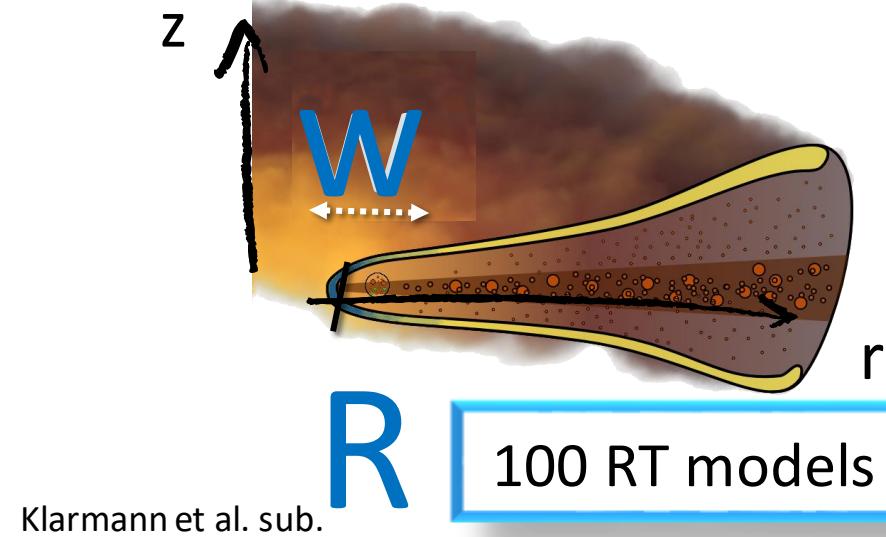
## modelling



synthetic  
observation

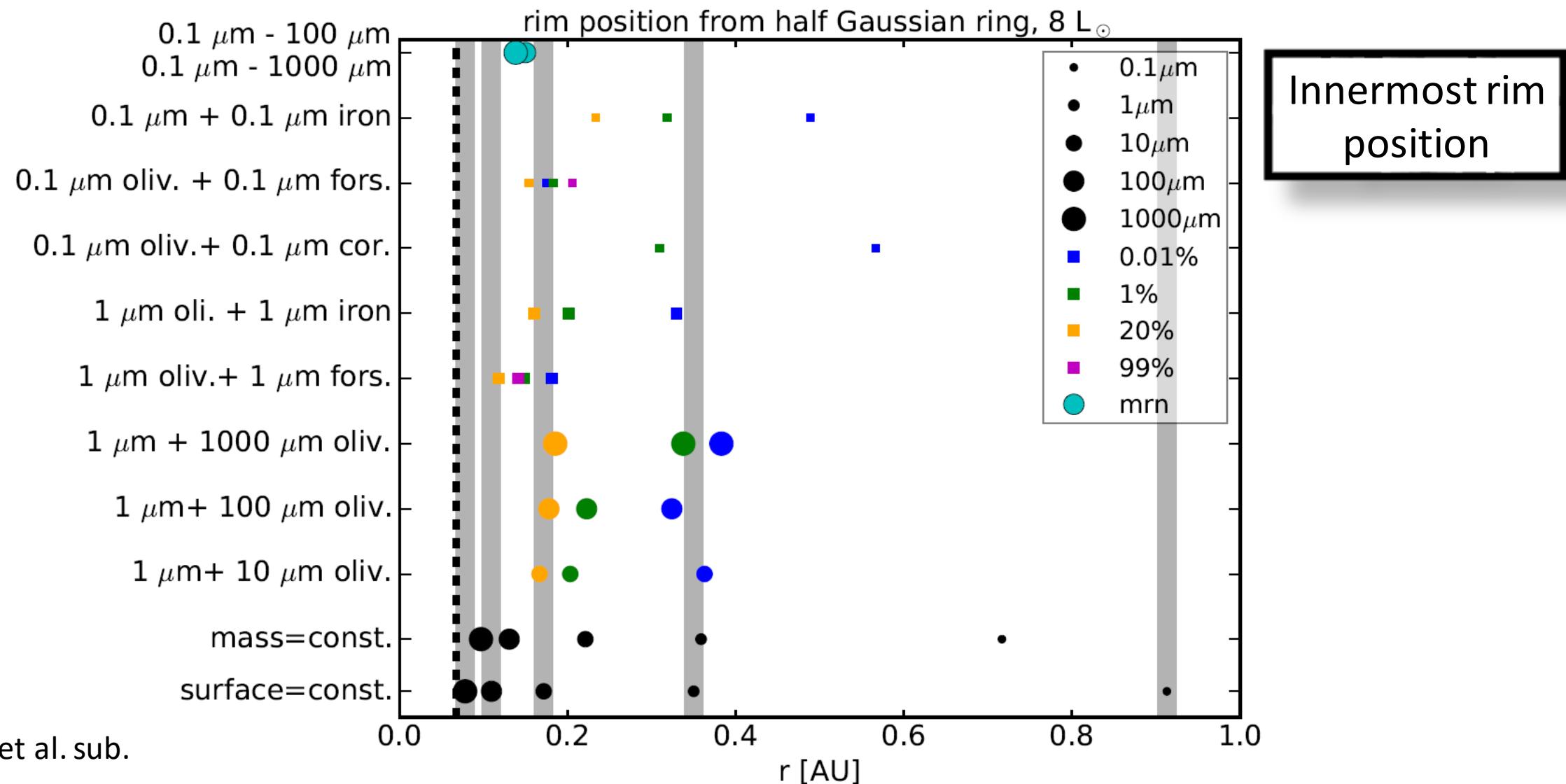


results

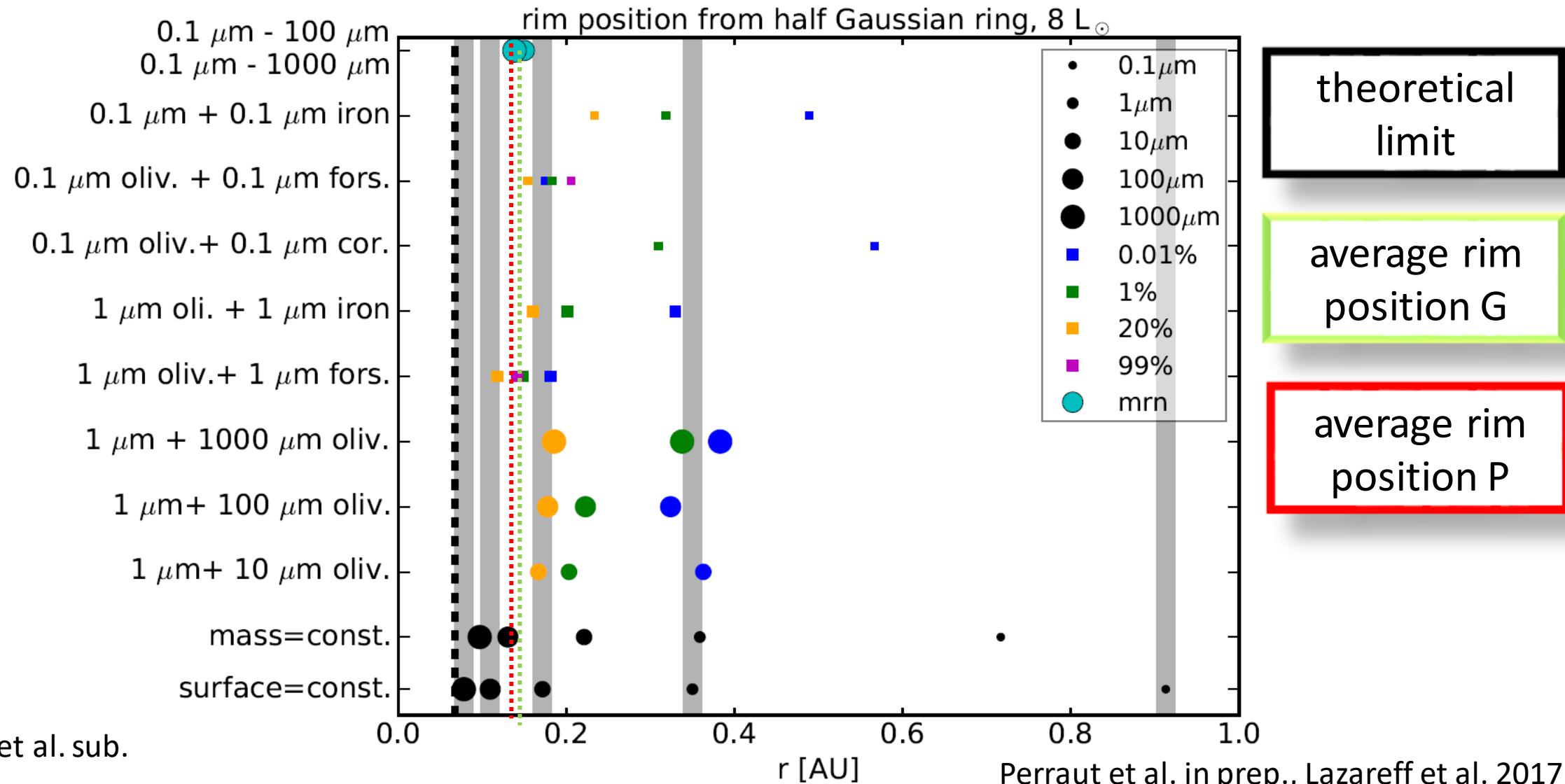


100 RT models

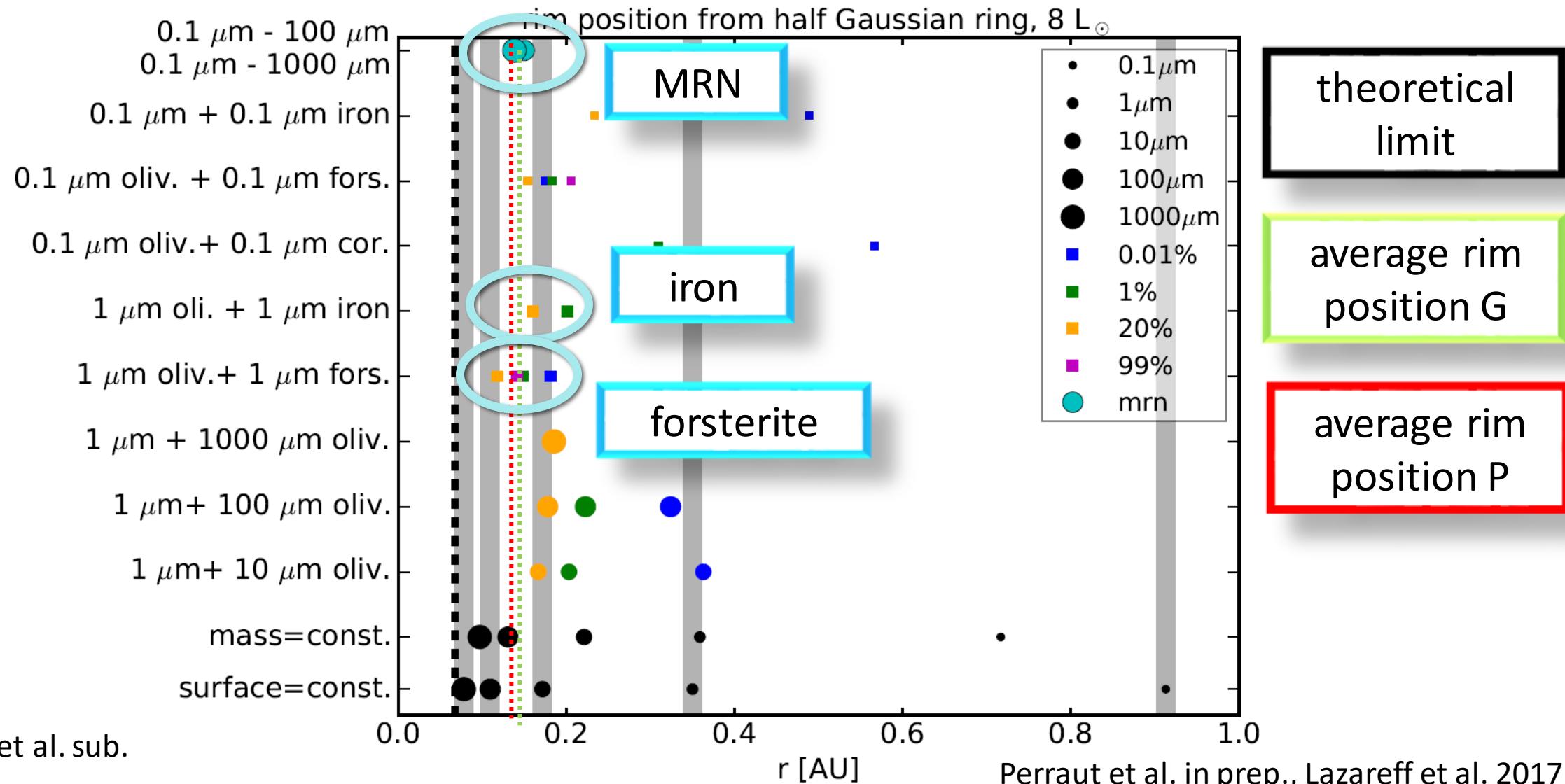
# What does the rim position tell us about the rim composition?



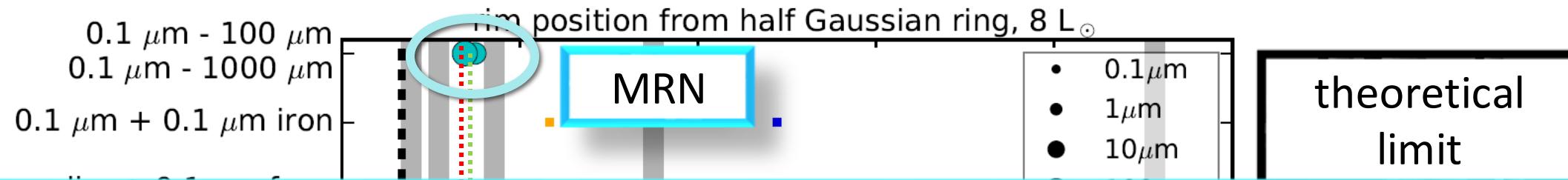
# What does the rim position tell us about the rim composition?



# What does the rim position tell us about the rim composition?

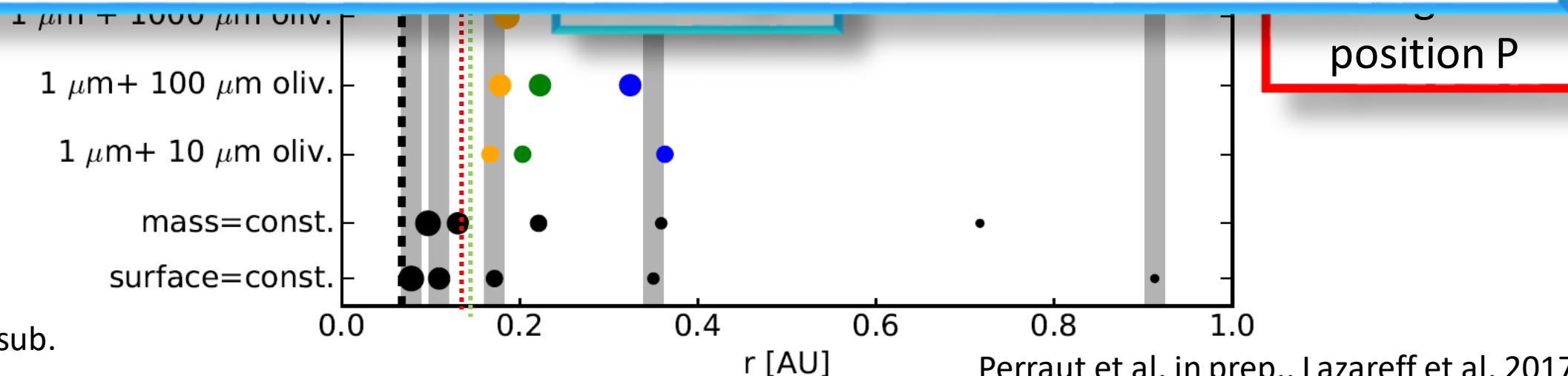


# What does the rim position tell us about the rim composition?

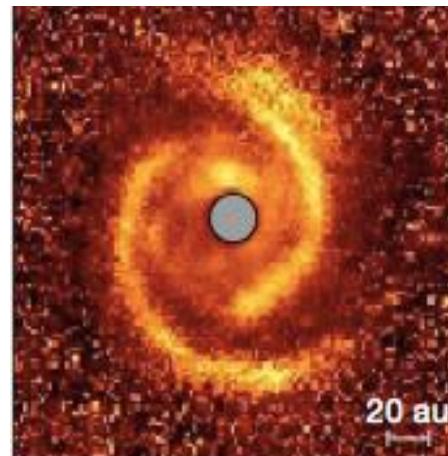
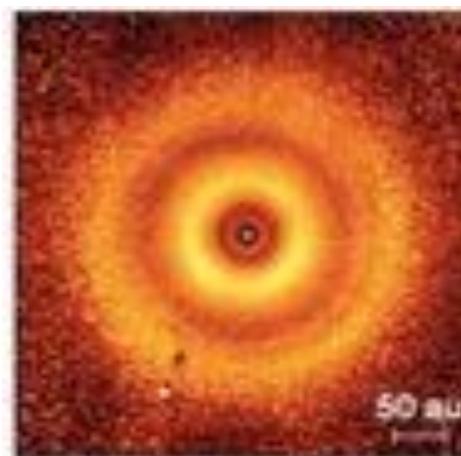
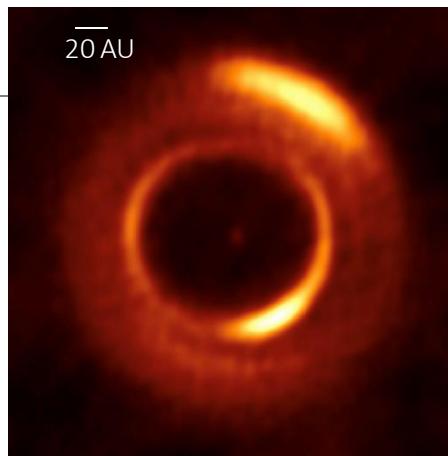
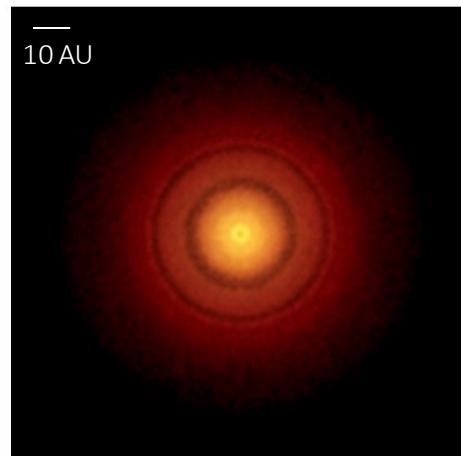


Result:

Grain growth has a similar effect on the position of the inner rim as the presence of highly refractory grains

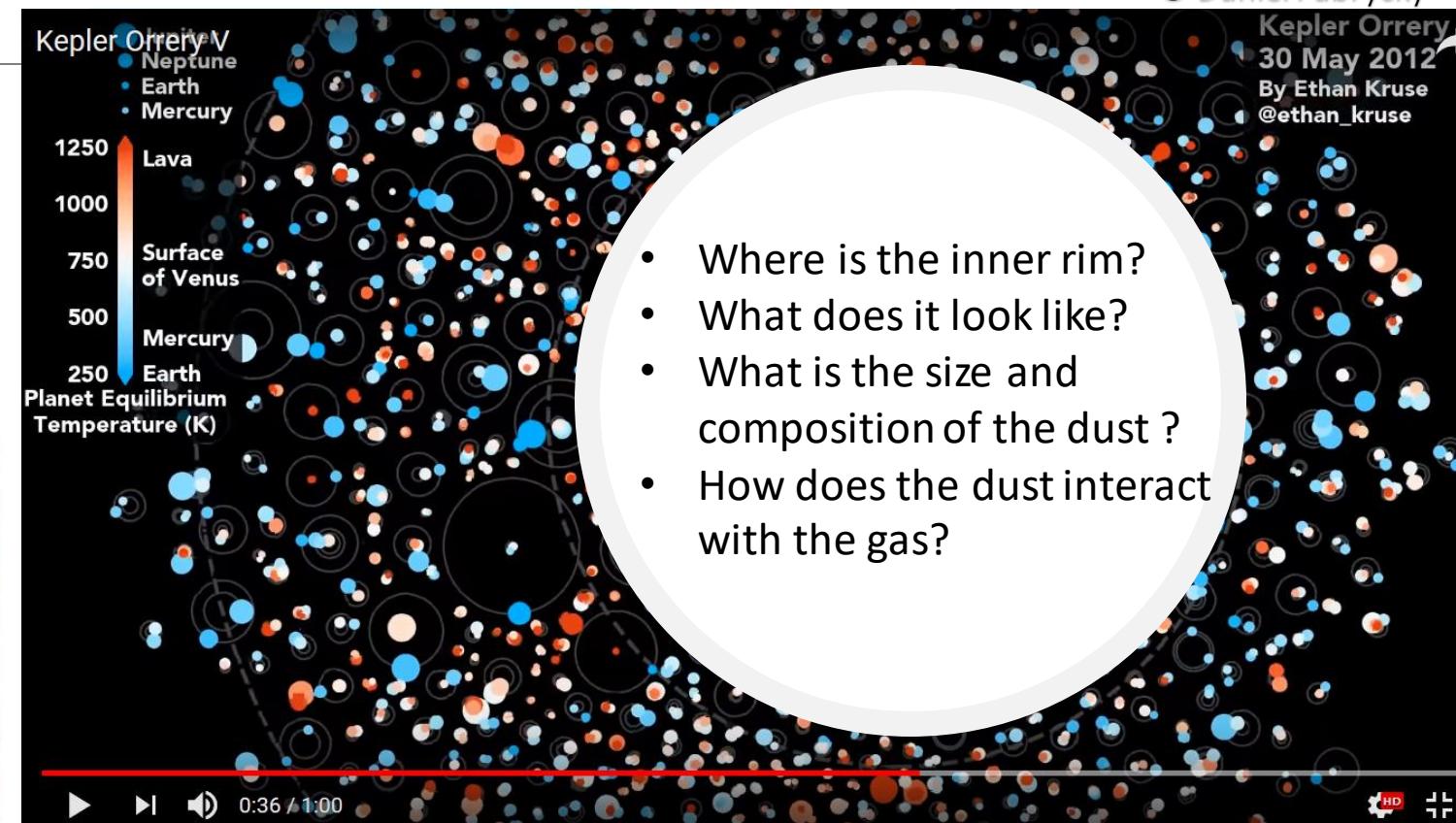


# Diversity of disks and exoplanetary systems



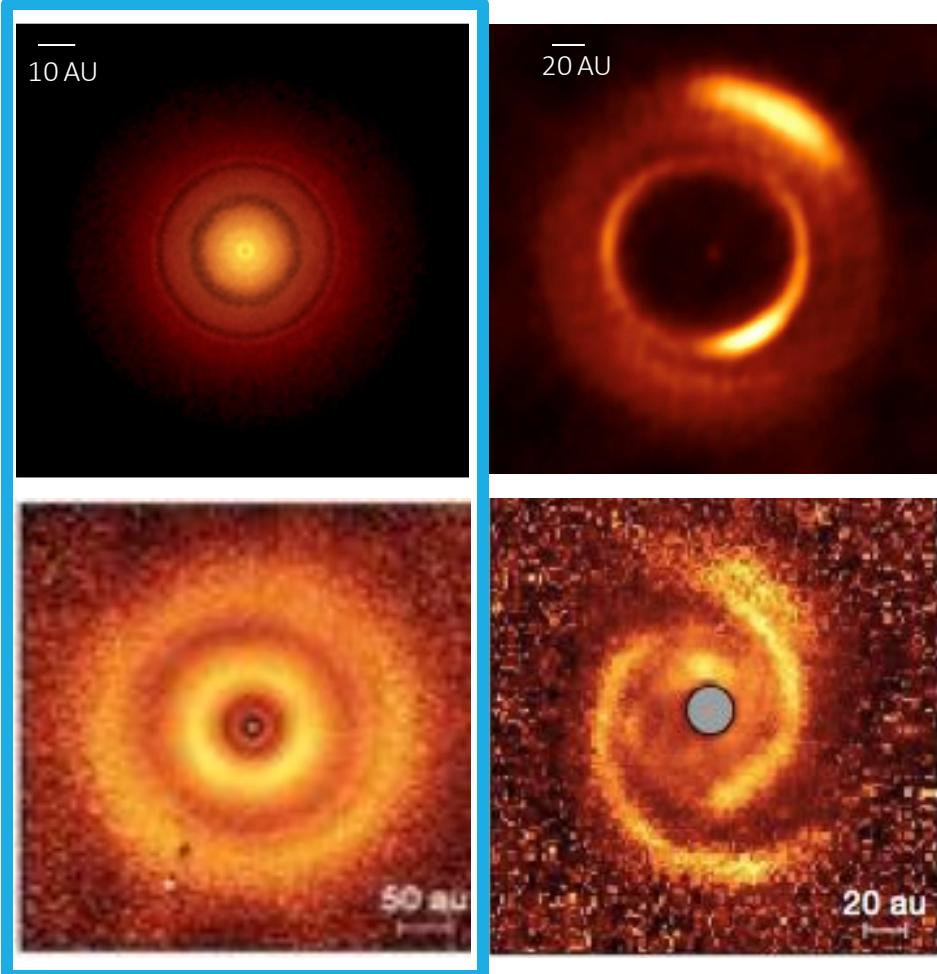
TW Hya

MWC 758



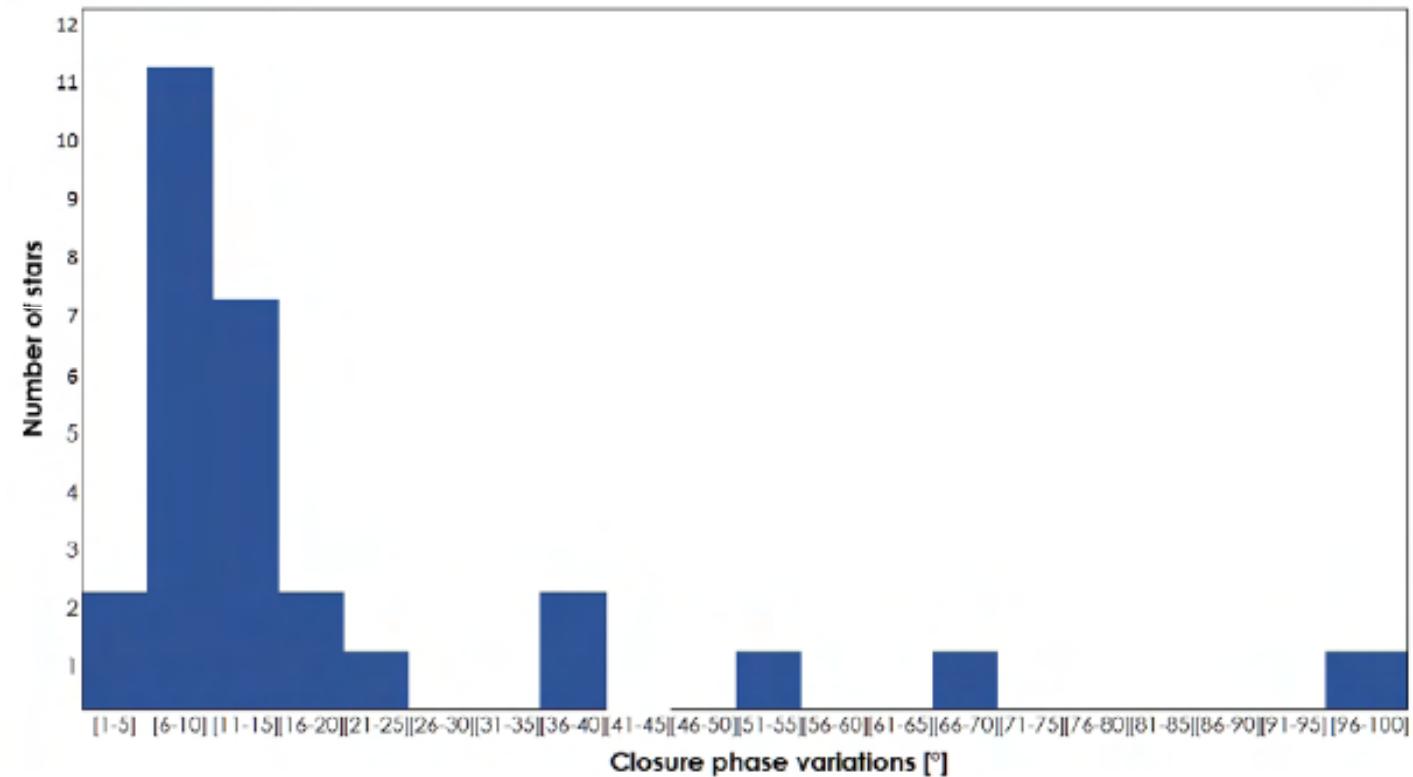
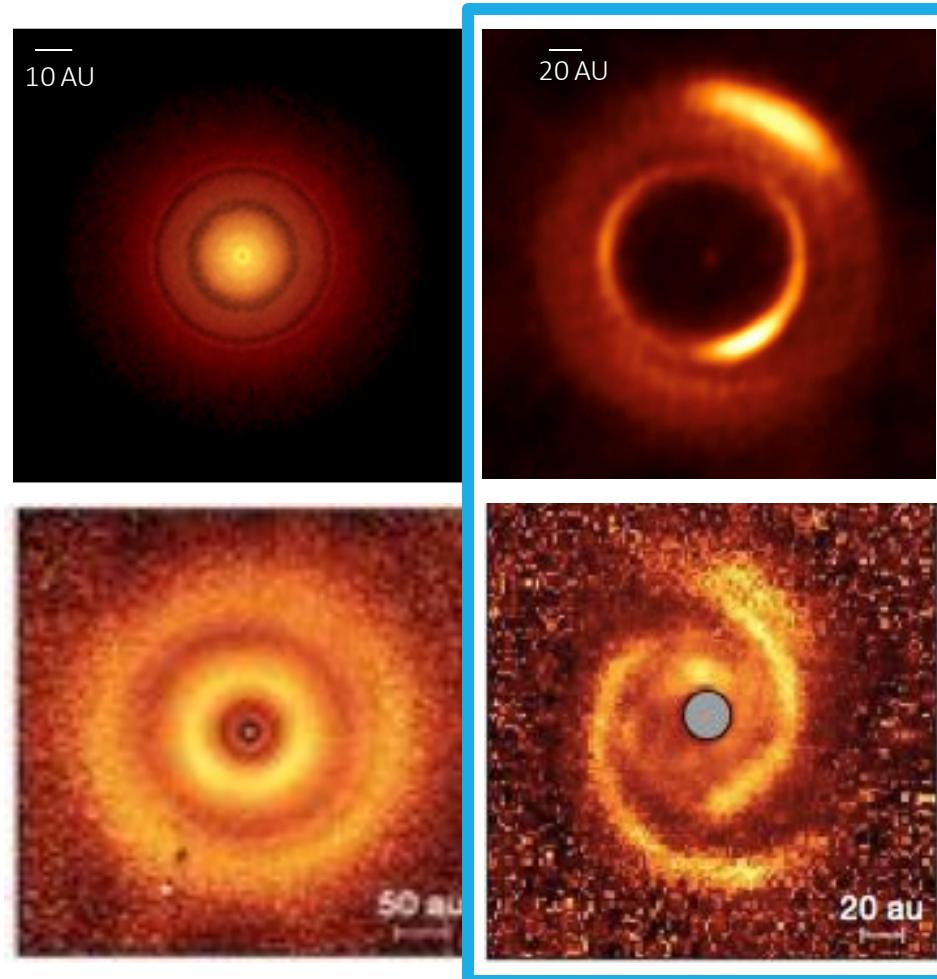
Andrews et al. 2016, Benisty et al. 2015, van Boekel et al. 2016, Dong et al. 2018

# Disk gaps



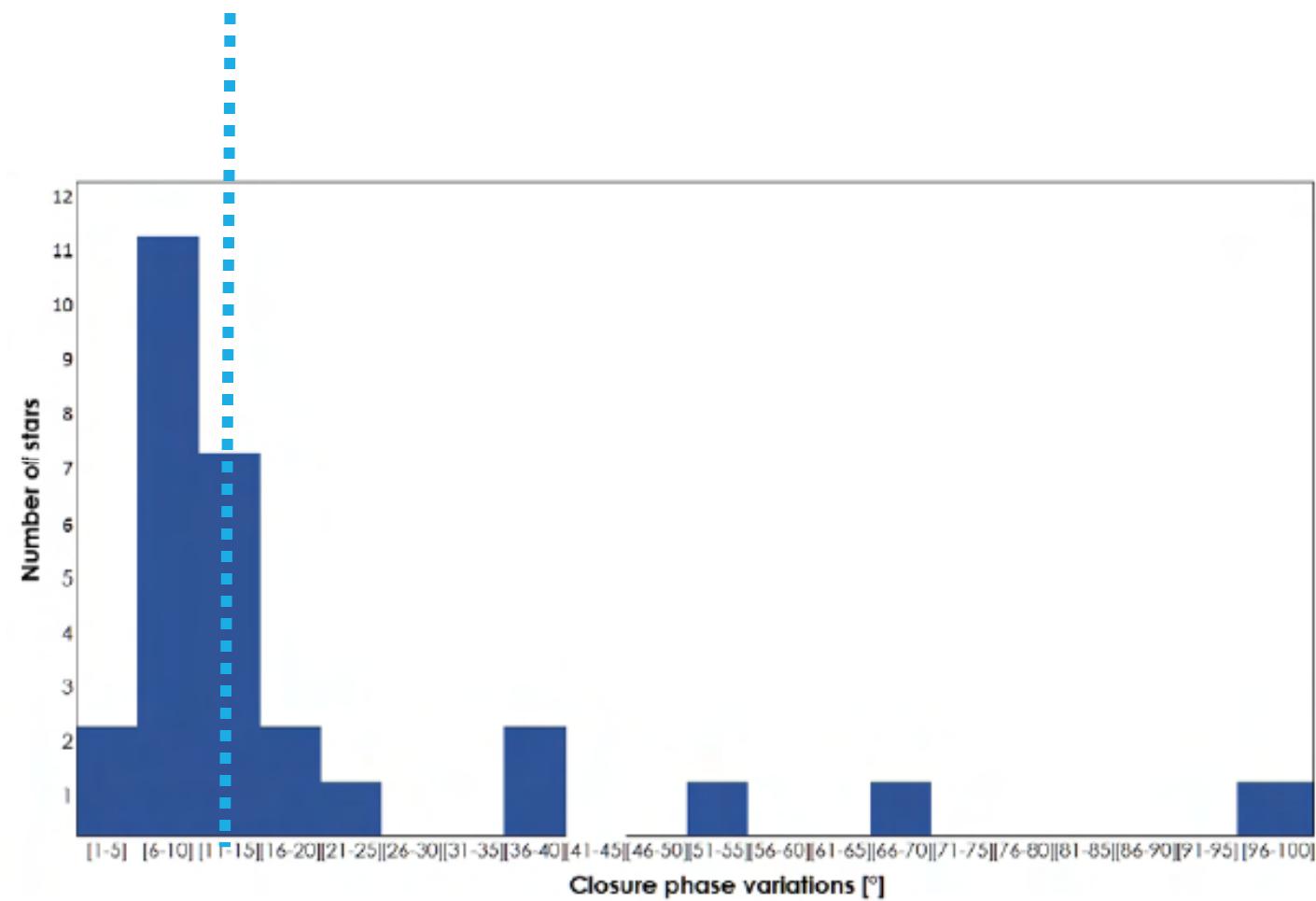
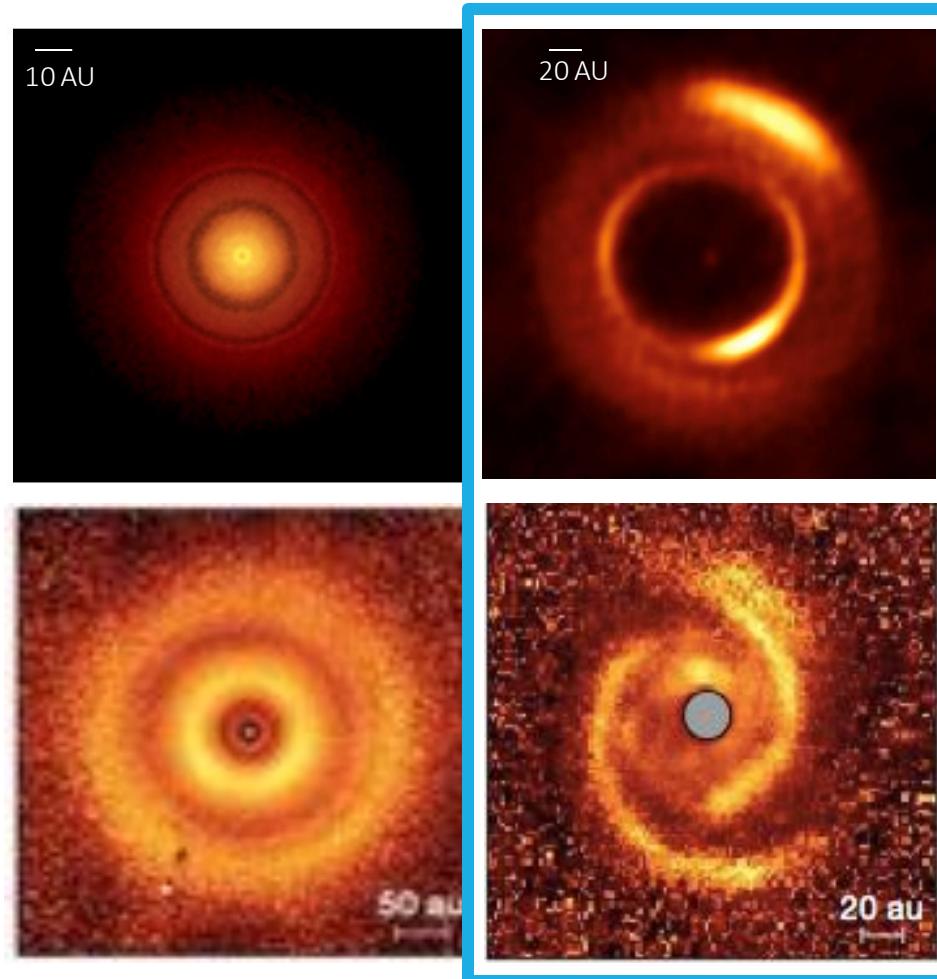
=> MATISSE observations

# Disk asymmetry from closure phase



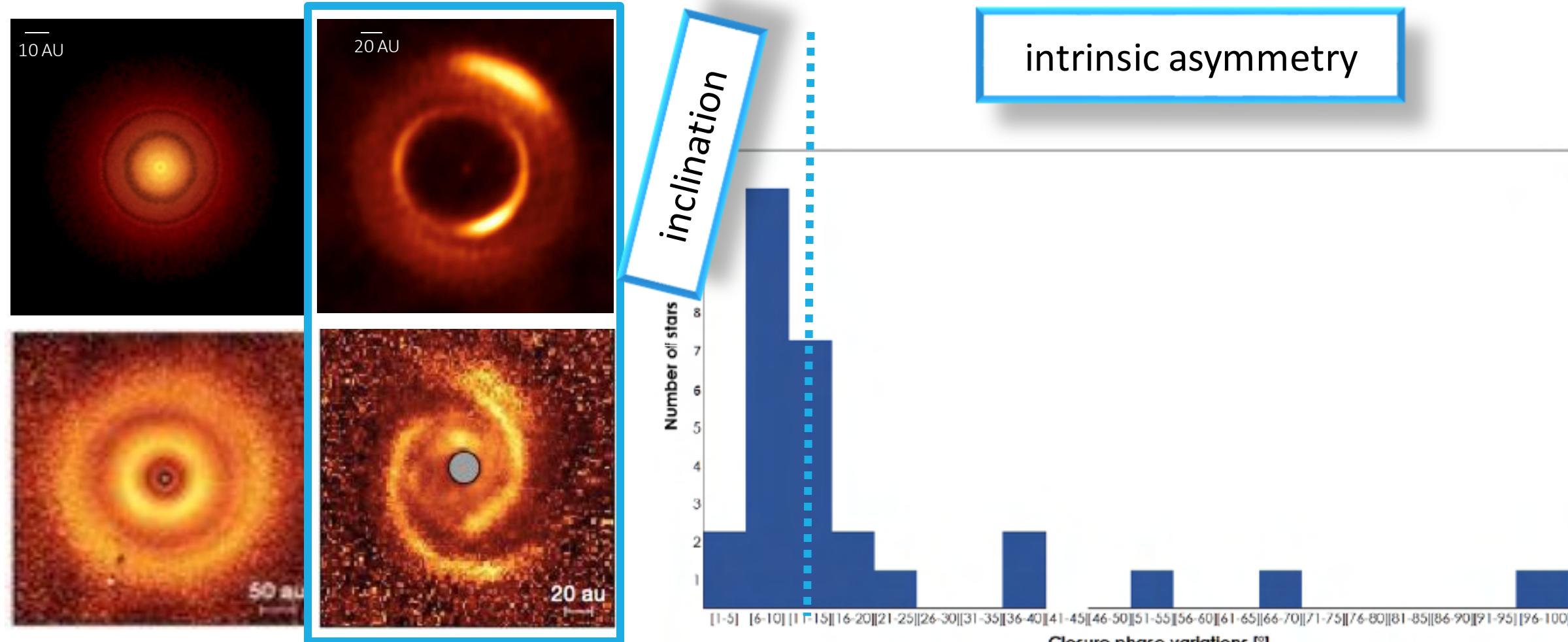
Perraut et al. in prep.

# Disk asymmetry from closure phase



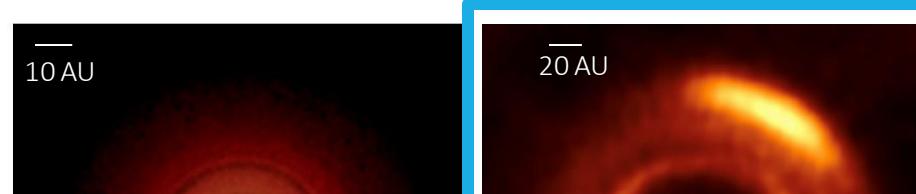
Perraut et al. in prep.

# Disk asymmetry from closure phase



Perraut et al. in prep.

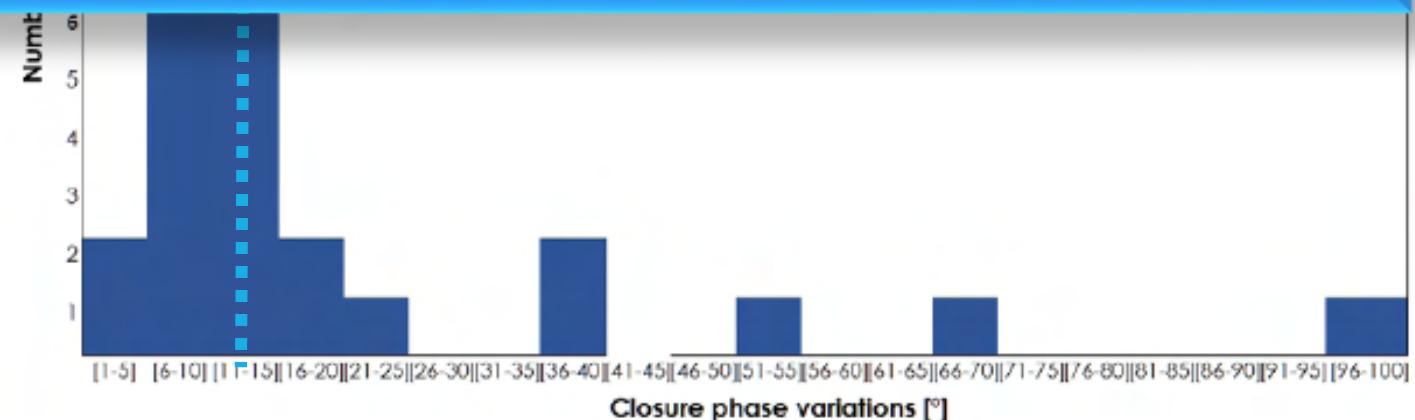
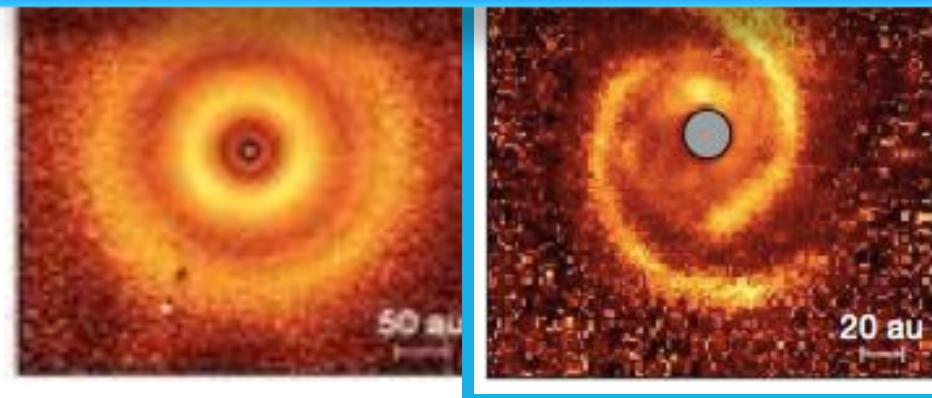
# Disk asymmetry from closure phase



tion

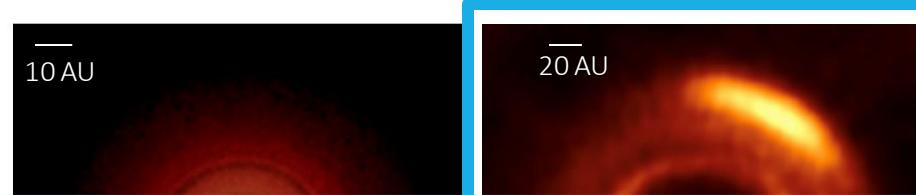
intrinsic asymmetry

Result:  
Half of our observed disks have an asymmetric inner rim structure.



Perraut et al. in prep.

# Disk asymmetry from closure phase

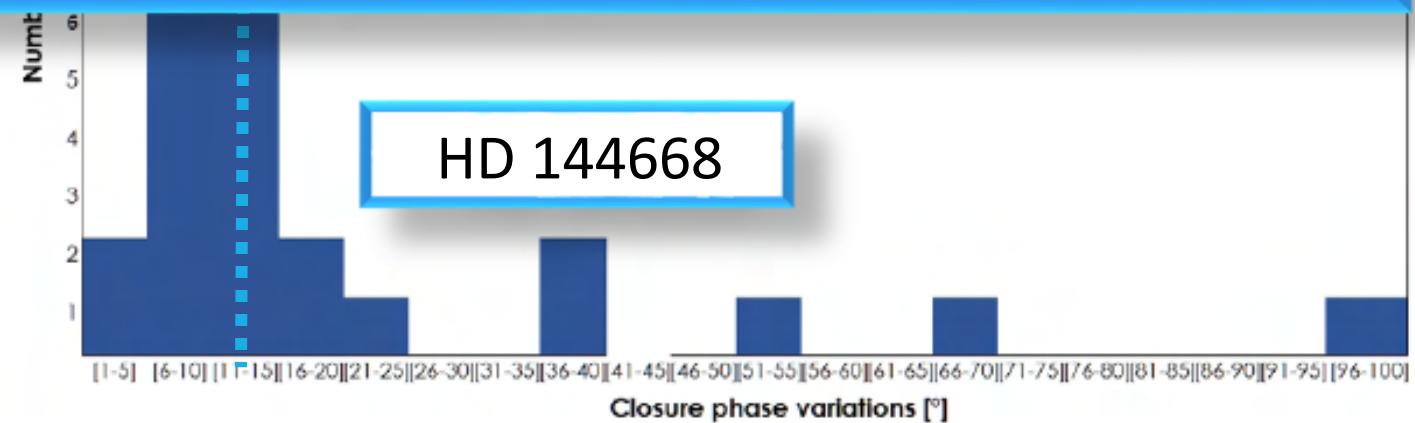
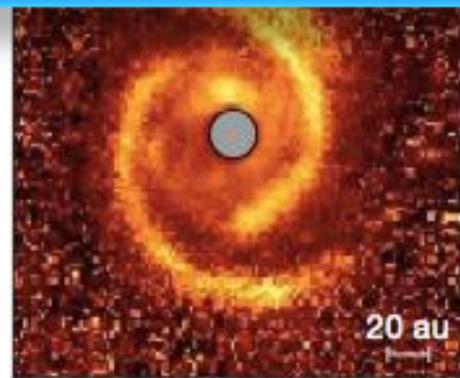


tion

intrinsic asymmetry

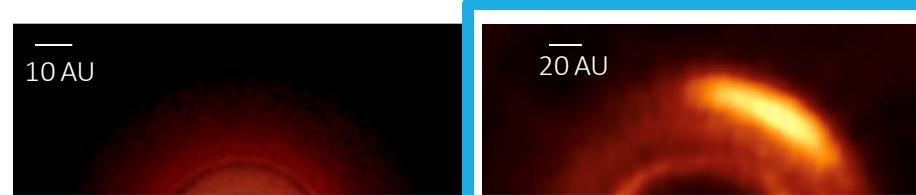
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Perraut et al. in prep.

# Disk asymmetry from closure phase

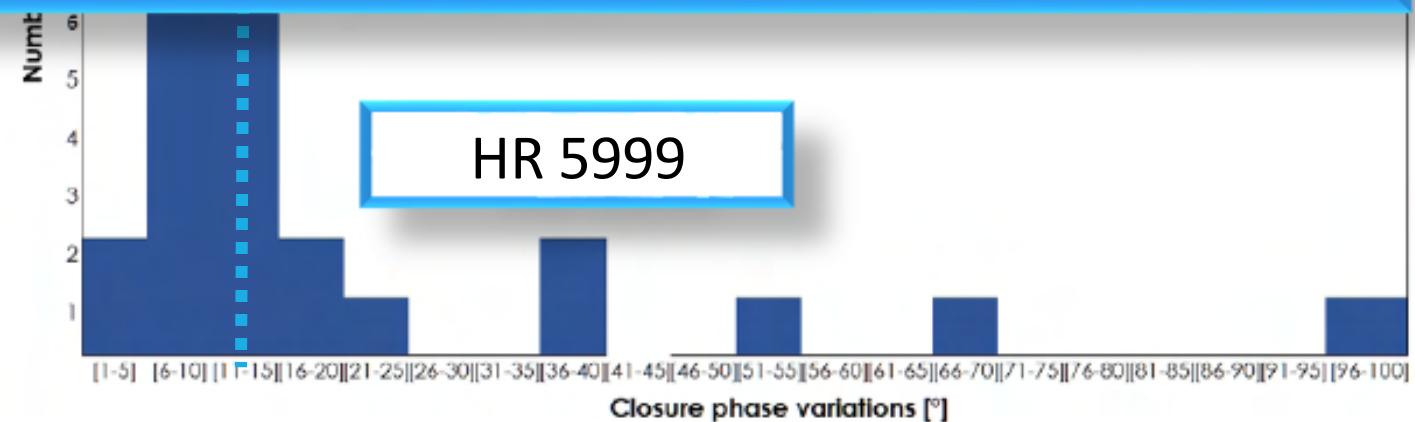
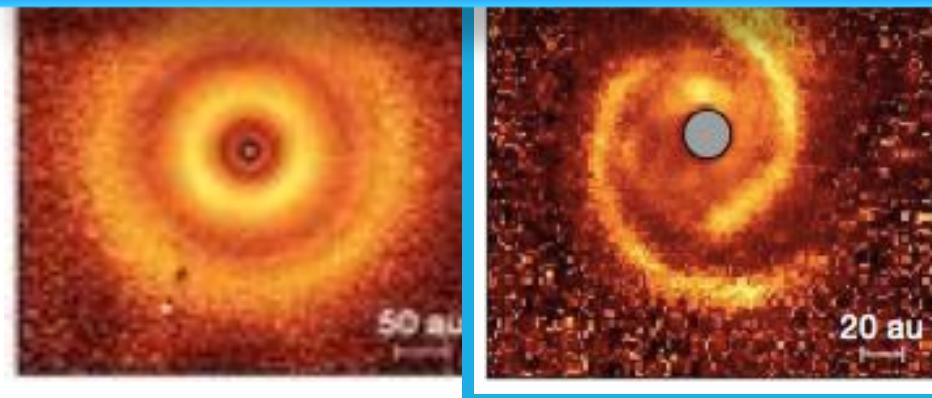


tion

intrinsic asymmetry

Result:

Half of our observed disks have an asymmetric inner rim structure.



Perraut et al. in prep.

# GRAVITY observations of HD144668

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- $T=8500$  K,  $L=53 L_\odot$ ,  $d=161$  pc
- small disk (2-3 au)
- variable in UV and optical
- $\dot{M}_{\text{acc}} : -6.25 \pm 0.2 M_\odot / \text{yr}$ , variable
- double peaked H $\alpha$  and MgII
- $R_{\text{rim}}$ : 0.35 au (K), 0.32 au (H)
- optically thin region inside inner rim (0.08 & 0.5 au)

March, 20th

- $f_{\text{disk}}=0.84 \pm 0.02$ ,  $R_{\text{rim}}=0.33 \pm 0.01$ au
- CP variation: 15 deg
- Bry emission (P-Cyg profile)
- Bry in visibility and differential phase

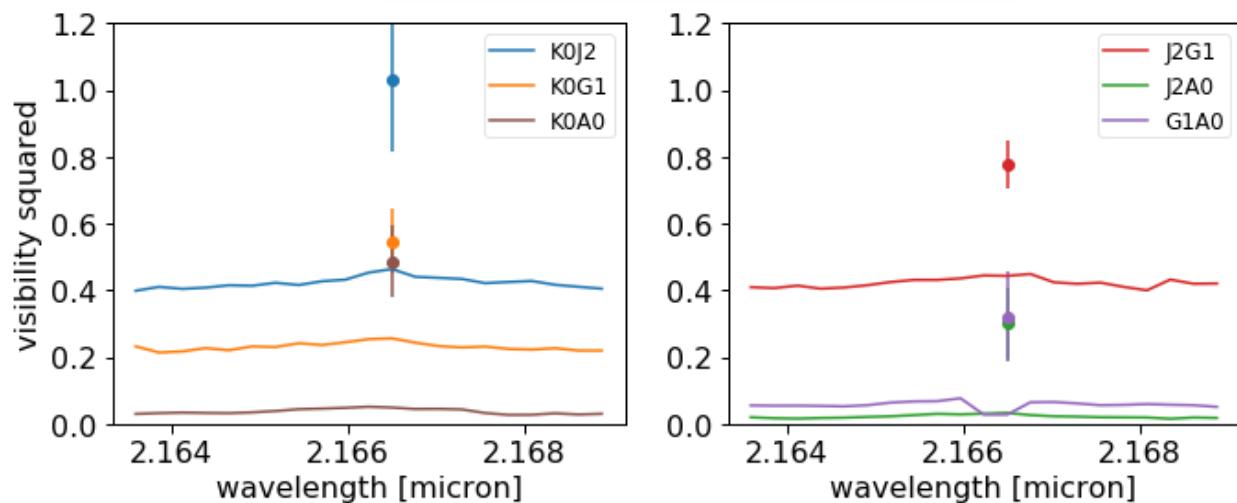
May, 30th

- $f_{\text{disk}}=0.79 \pm 0.01$ ,  $R_{\text{rim}}=0.34 \pm 0.01$ au
- CP variation: 20 deg
- no Bry

Vioque et al 18, Lazareff et al. 17, Fairlamb et al. 15,  
Benisty et al. 11, Preibisch et al. 06, Perez et al. 92, 93

# The origin of Br<sub>y</sub> in HD144668

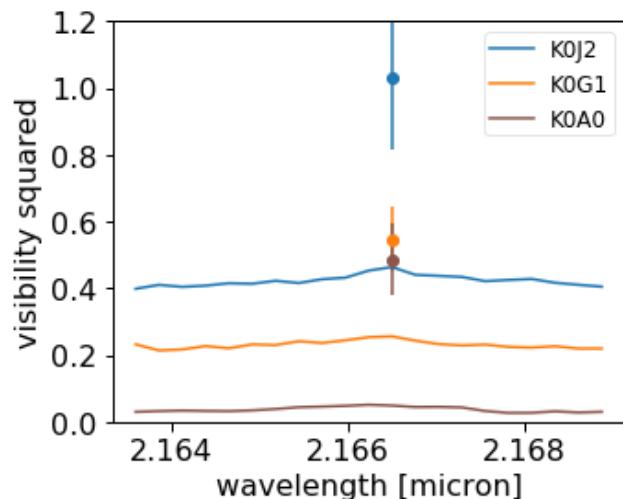
line and total visibility



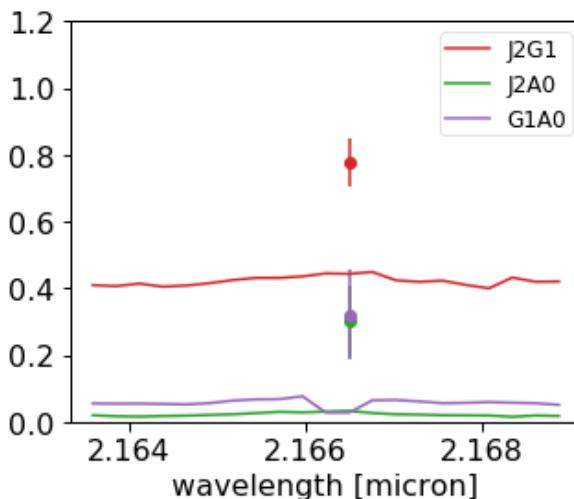
- $R_{Br_y} < 0.1 \text{ au}$
- $R_{Br_y}/R_{\text{rim}} < 0.3$
- $R_{Br_y}/R_{\text{trunc}} < 7$

# The origin of Br<sub>y</sub> in HD144668

## line and total visibility



- $R_{Br_y} < 0.1$  au
- $R_{Br_y}/R_{rim} < 0.3$
- $R_{Br_y}/R_{trunc} < 7$



## line origin

### accretion flow:

- emission radius
- high accretion rate
- P-Cyg profile

### inner gas disk:

- emission radius
- high accretion rate
- double-peaked H $\alpha$
- optically thin inner region
- relative stellar flux is lower

-> talk by C. Dougados

## Results:

- Interferometric observations determine the position of the inner disk rim well, but not the rim width
- Grain growth can explain the average position of the inner rim as well as the presence of highly refractory grains
- Half of the disks in our GRAVITY Herbig sample have an asymmetric inner rim structure.
- GRAVITY can constrain accretion and outflow processes, for example variable accretion in HD144668