Direct Imaging of Newborn Planets

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Phantom Workshop

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MONASH University

exoALMA

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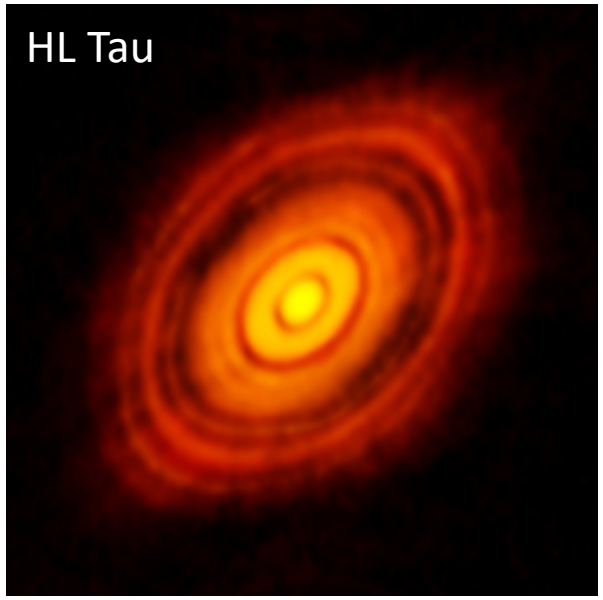
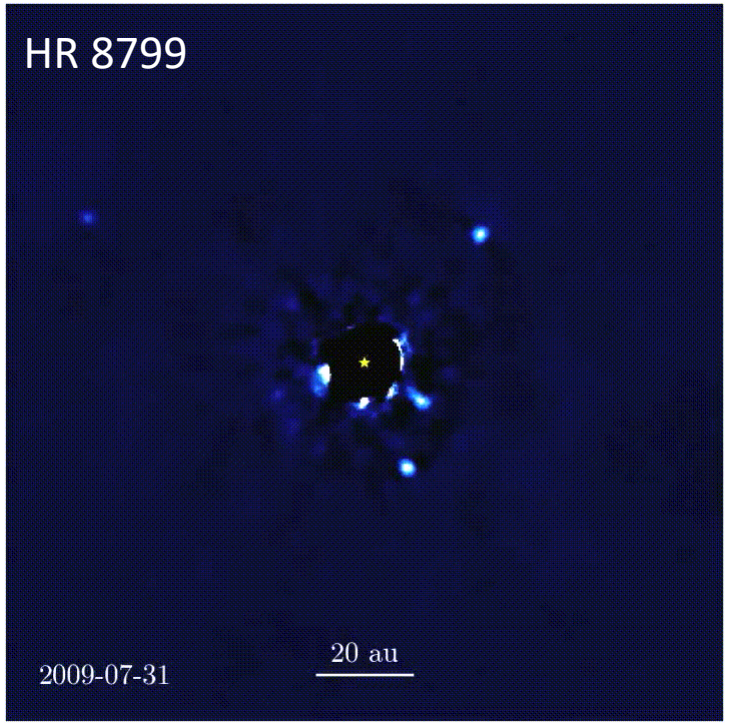
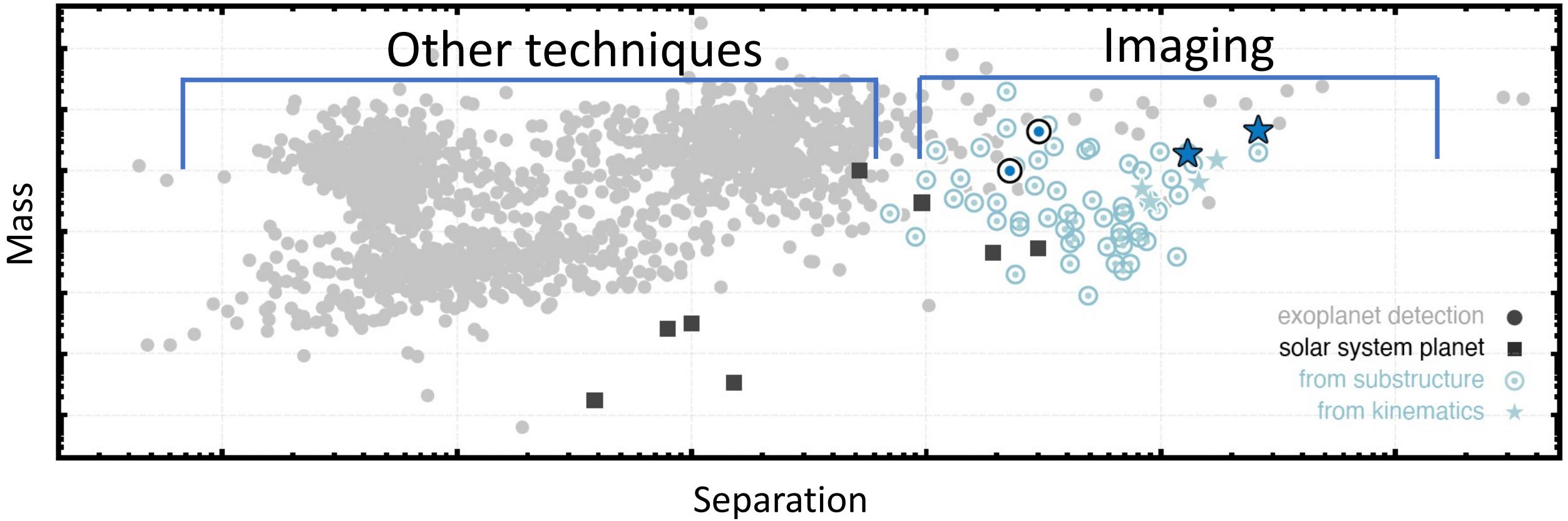
Why directly image discs?

- Planets are most luminous during formation
- Directly imaged planets are young (0.1-10Myrs)
- Orbital constraints
- Visceral satisfaction





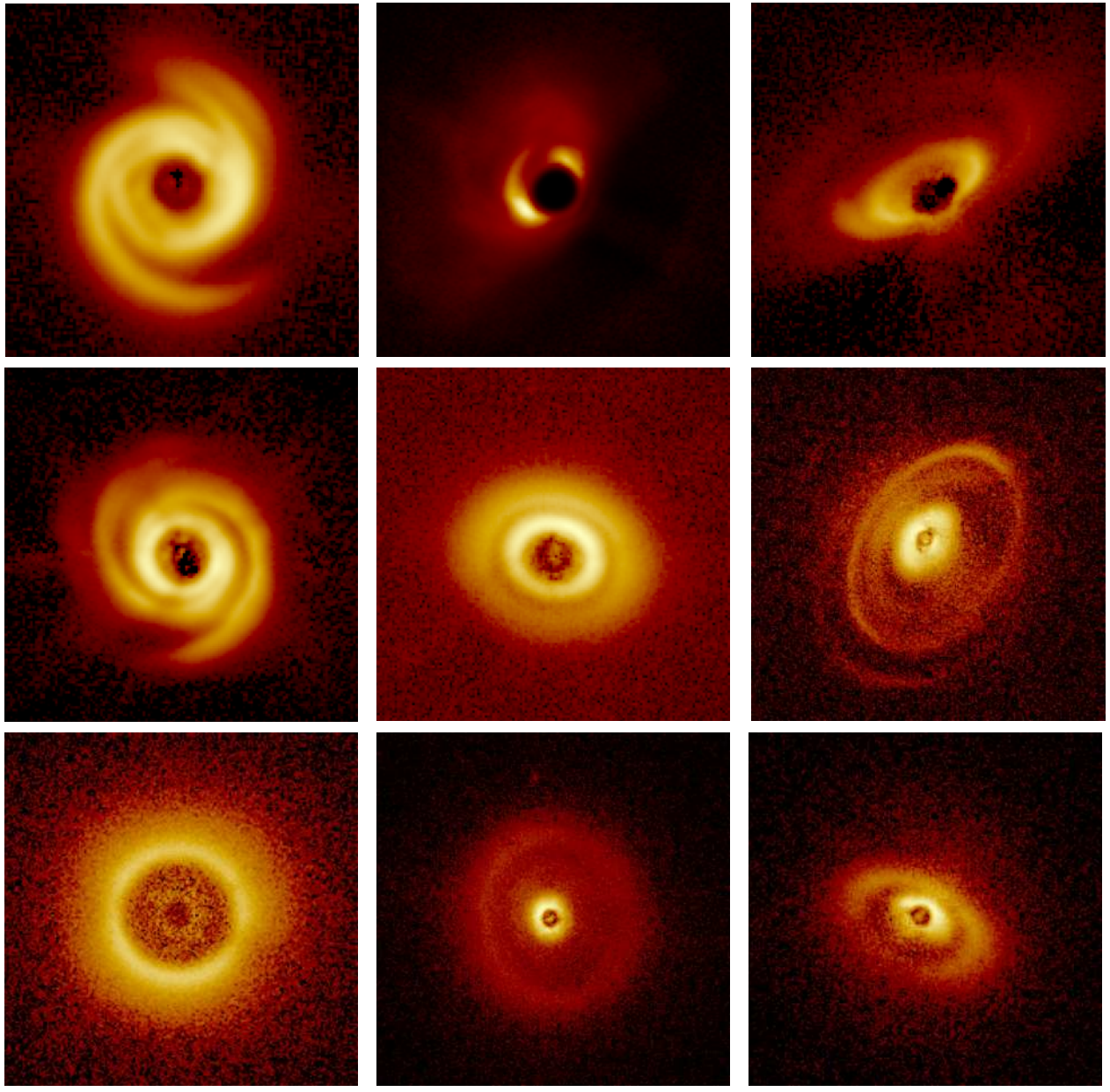
Why directly image discs?



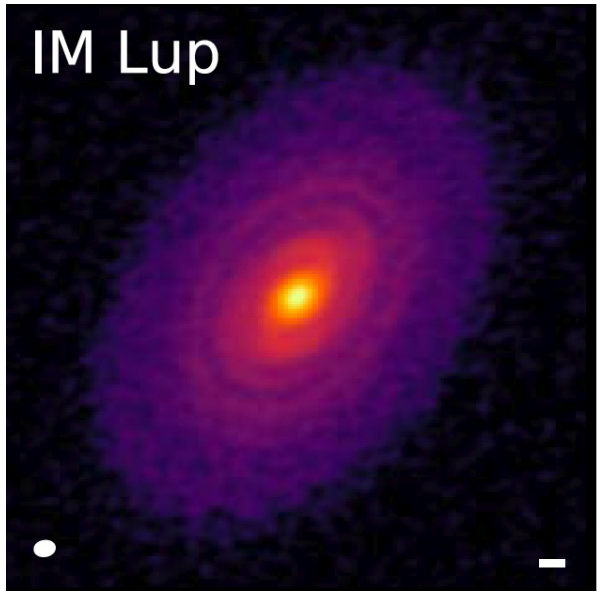
Pinte+22, PPVII

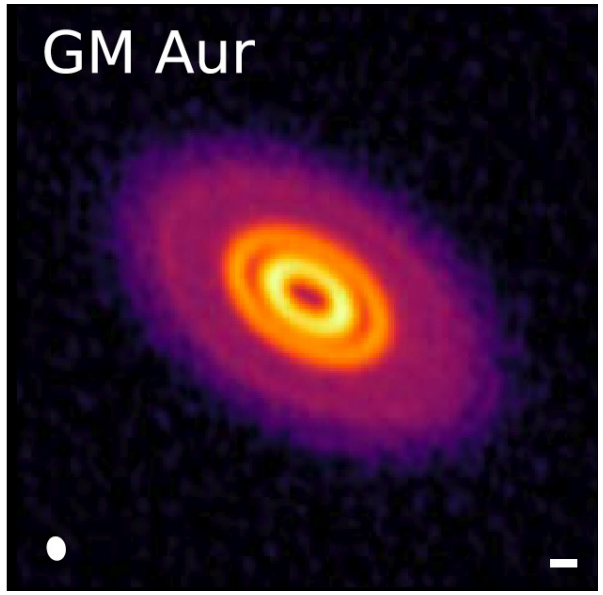
Direct imaging of planet-disc interactions

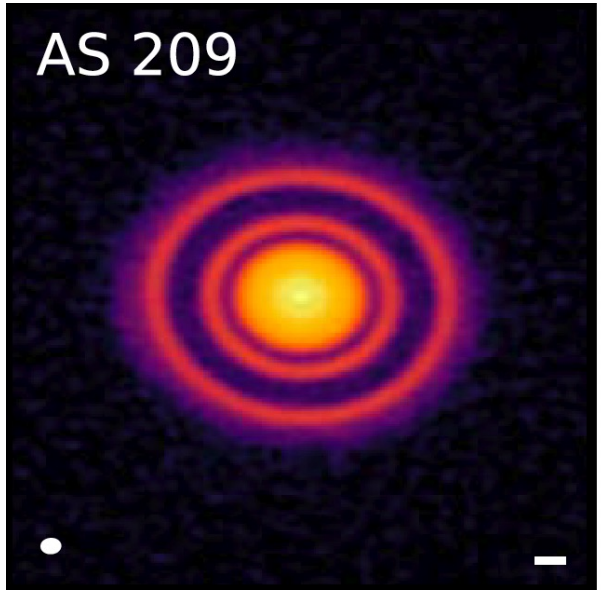
Scattered light

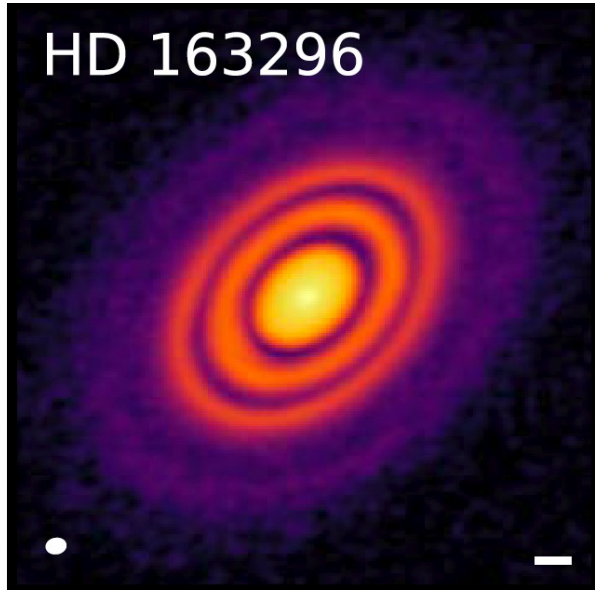


Dust continuum (MAPS, Sierra+21)



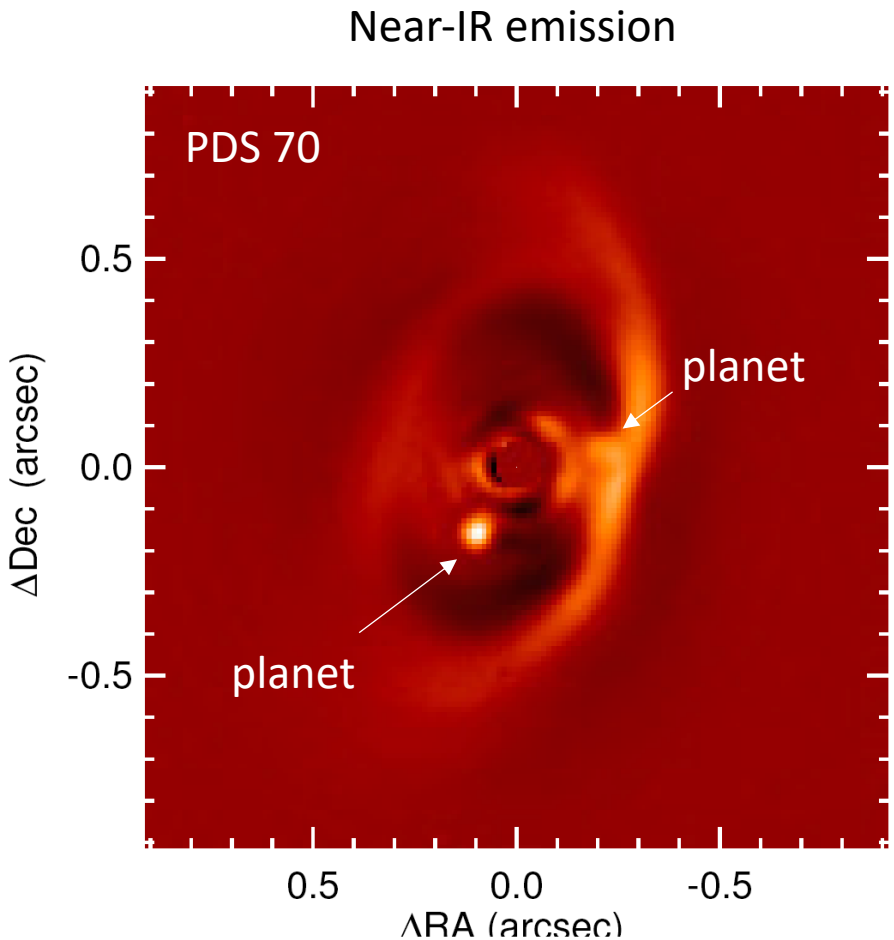






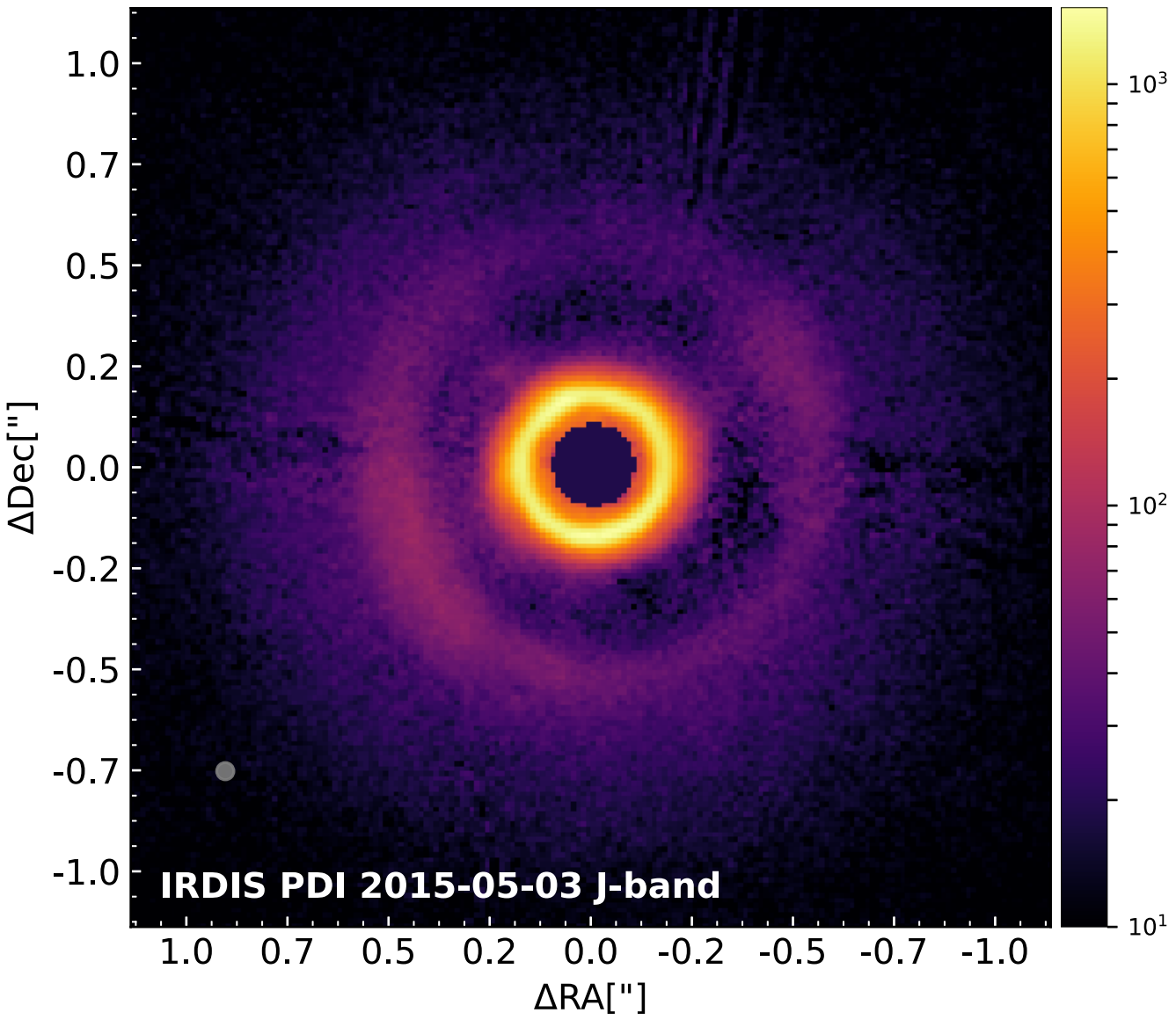
Where are all the planets?

- Planets are highly embedded
- Circumplanetary material increases extinction
- 10^6 - 10^8 orders of magnitude in contrast
- Extremely short separation (~0.3” for 30 au planet at 100pc)

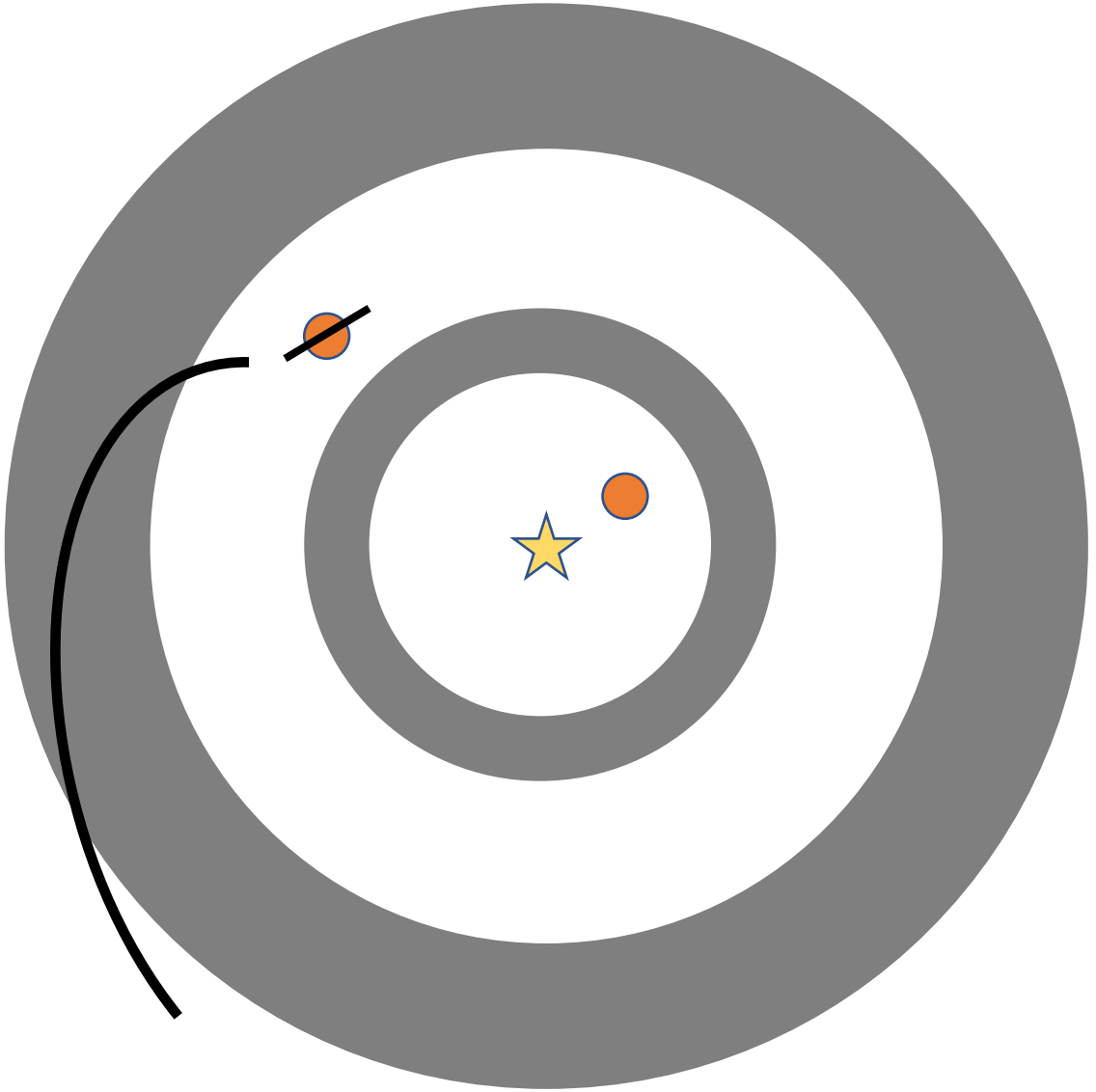


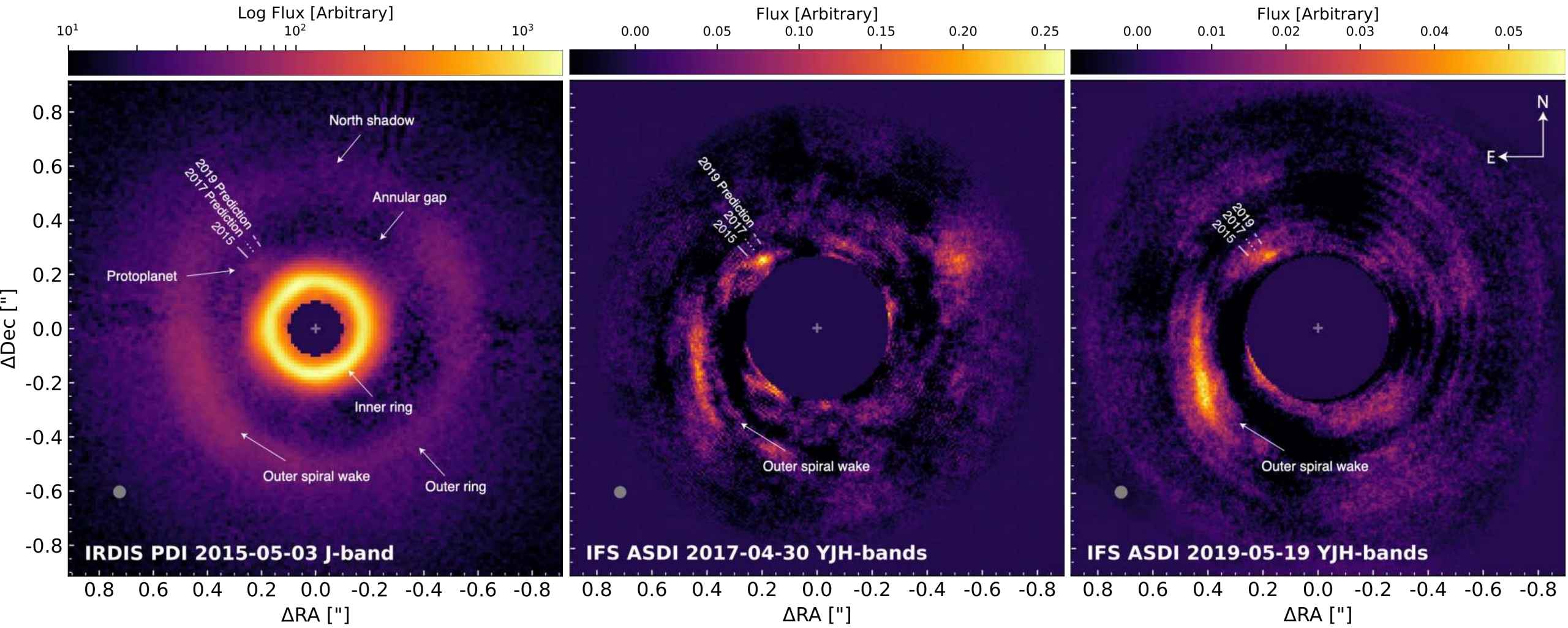
Keppler+18: First confirmed embedded protoplanet(s)

HD 169142



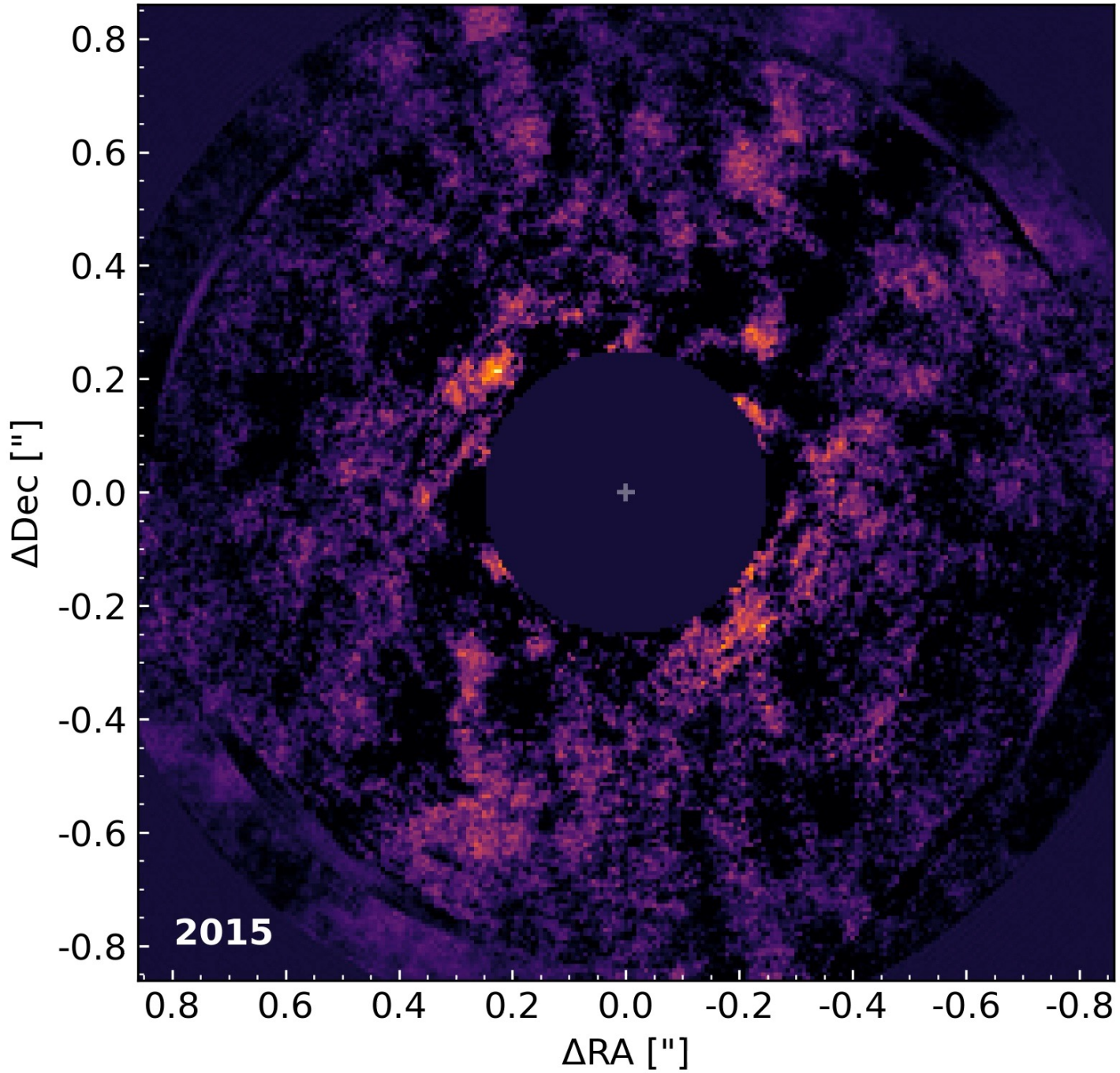
High res model

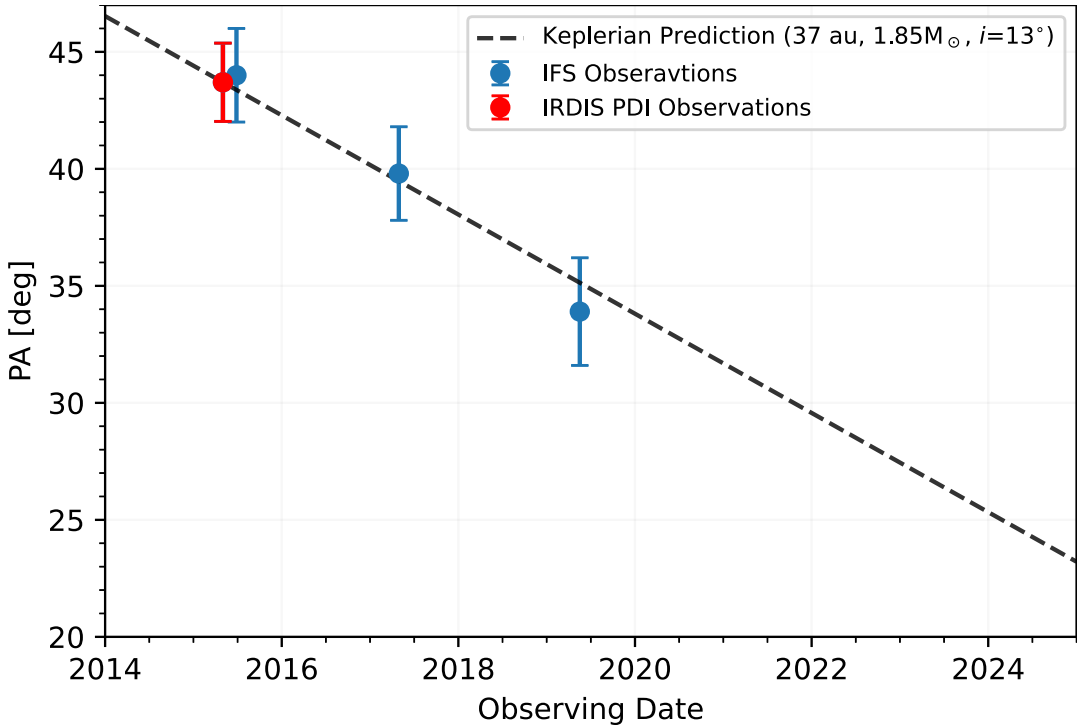




Light scattered off dust grains

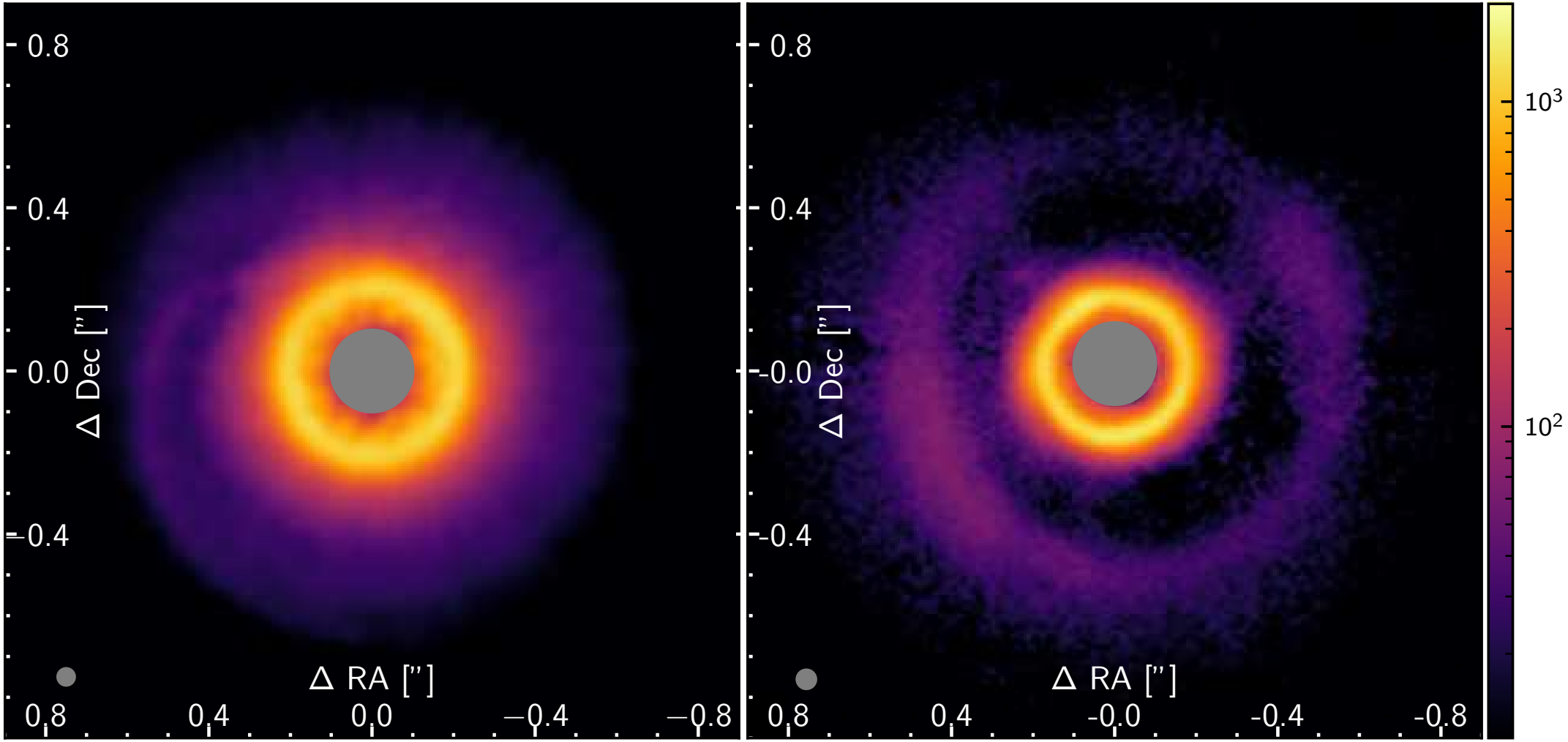
Thermal near-IR emission


2015
ΔDec ["]
ΔRA ["]
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8


Keplerian Prediction (37 au, 1.85M⊙, i=13°)
IFS Obseravtions
IRDIS PDI Observations
PA [deg]
Observing Date
45
40
35
30
25
20
2014
2016
2018
2020
2022
2024

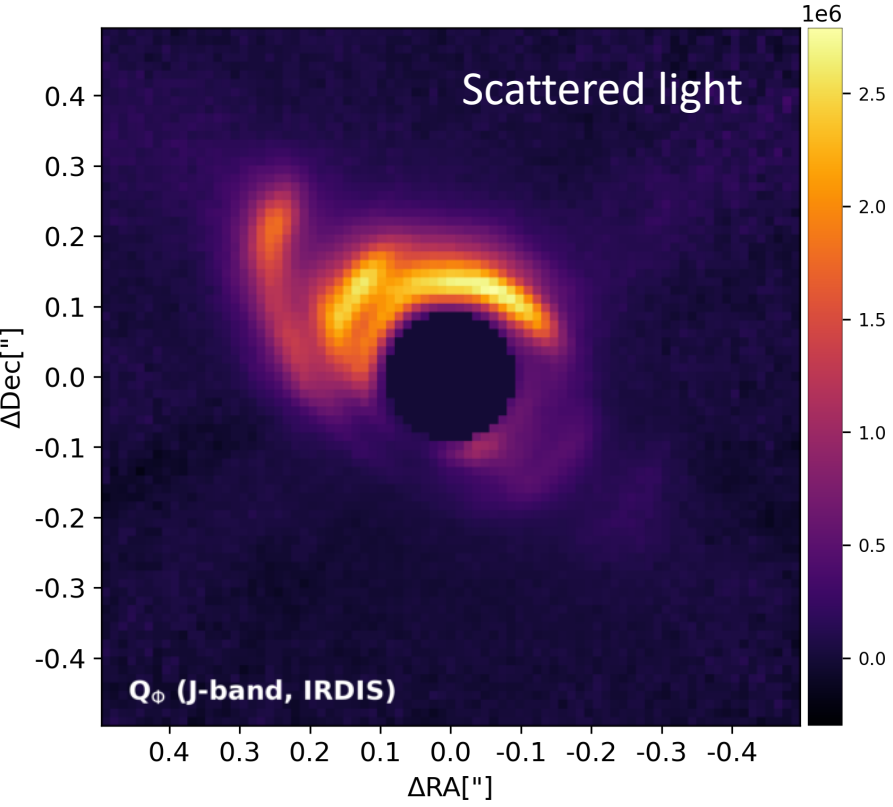
+ MCFOST logo here

Observation

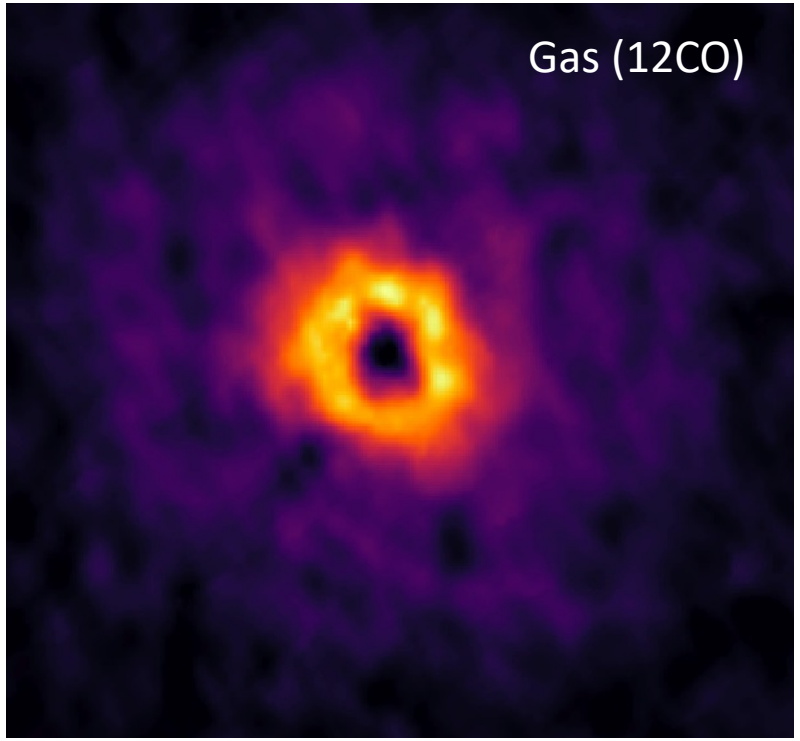


Simulation by Claudia Toci (ESO)

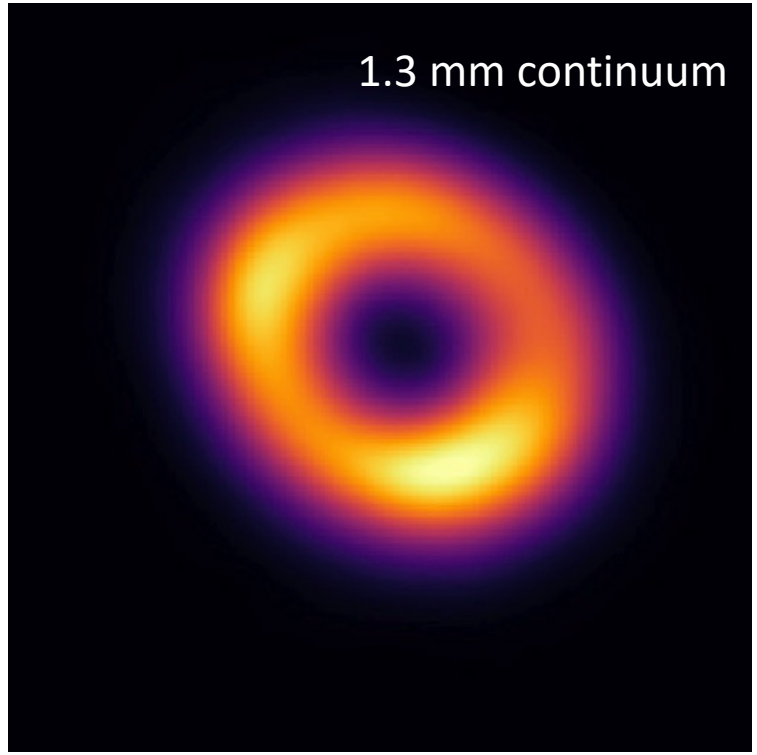
The case of CQ Tau



SPHERE/VLT, Hammond+22

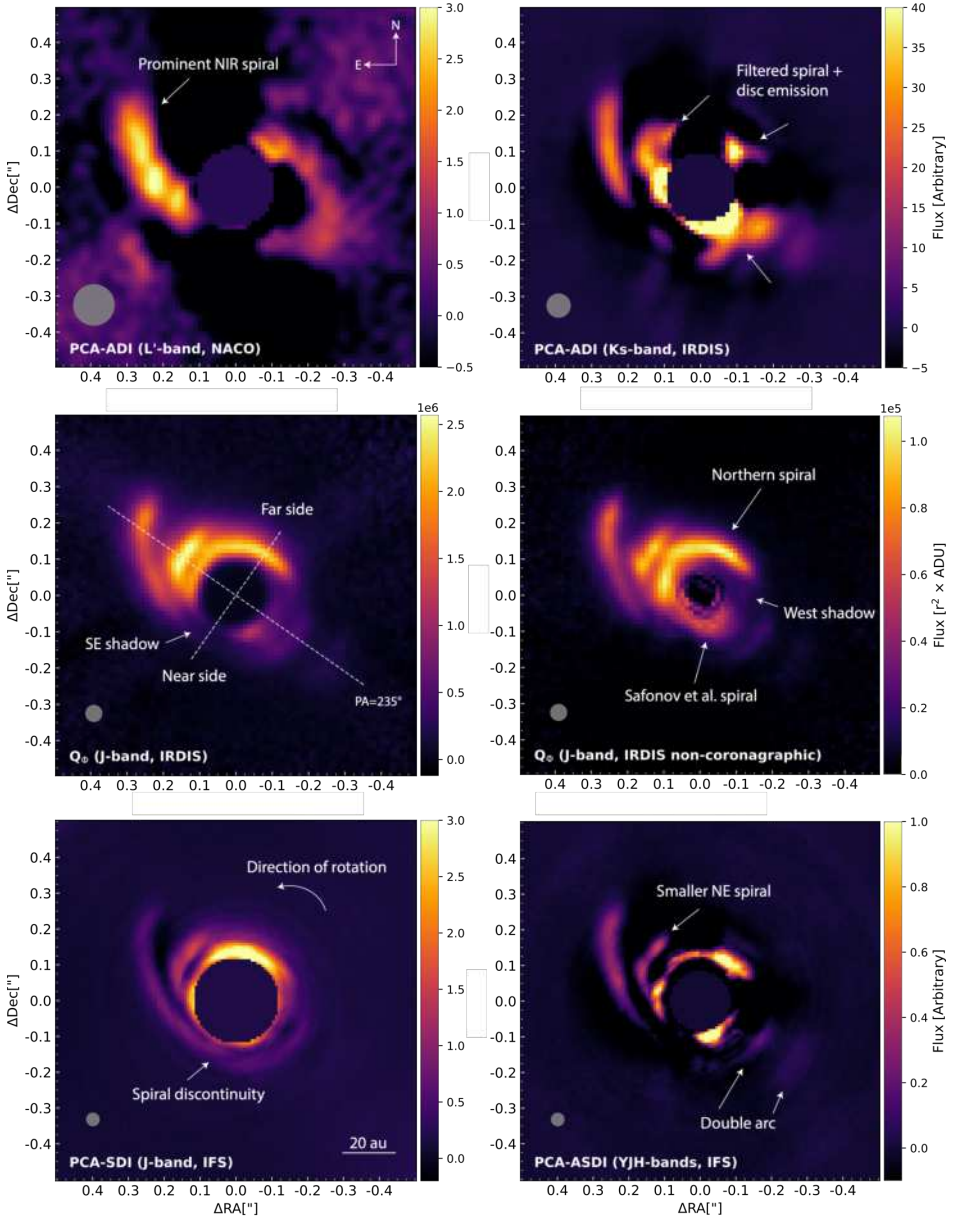


ALMA, Wolfer+21



ALMA, Ubeira Gabellini+19

An unseen companion exciting the spiral arms in CQ Tau



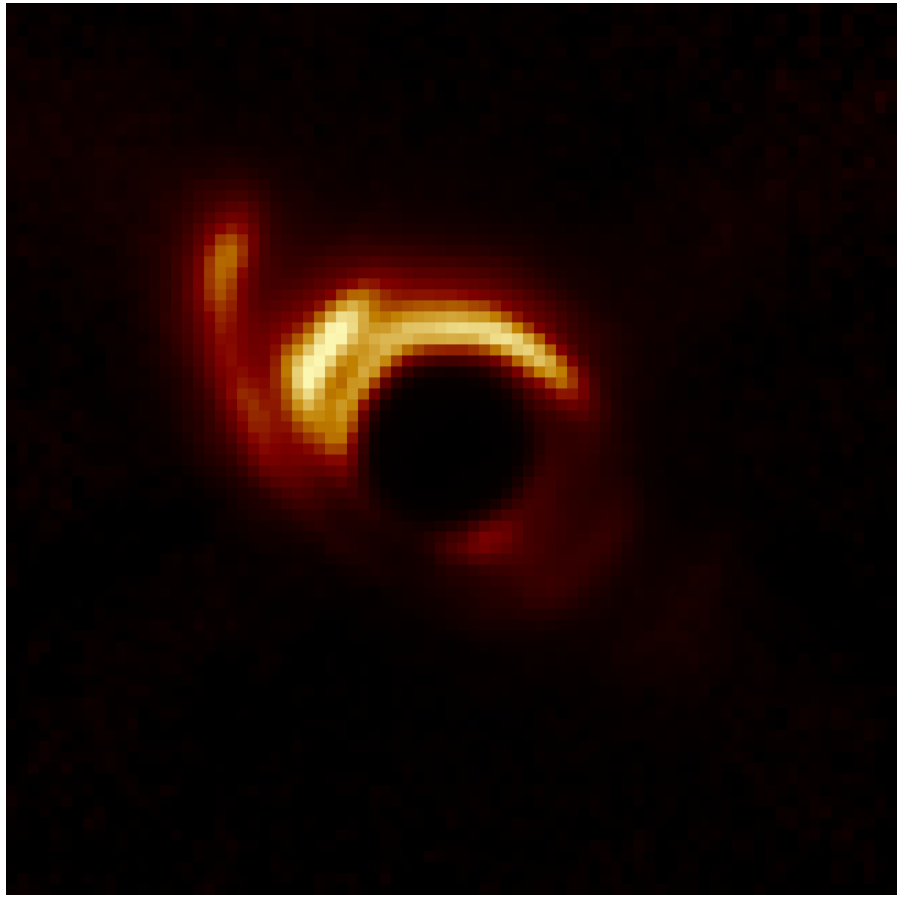
Five data sets, no clear planet detection

However:

- High radial velocity of the star in GAIA
- Highly non-Keplerian gas kinematics
- Massive spiral arms
- A depleted cavity
- Shadowing effects

-> a binary?

An unseen companion exciting the spiral arms in CQ Tau



Observations

Inclined, eccentric 0.2Msun companion model

Conclusions

- Directly imaging embedded planets is hard, but possible
- We have a new discovery – HD 169142 b
- Models help us interpret observations
- Observations inform models