The Ophiuchus DIsk Survey Employing ALMA (ODISEA)

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Great Barriers in Planet Formation

Palm Cove, Australia

NÚCLEO DE ASTRONOMÍA udp
FACULTAD DE INGENIERÍA Y CIENCIAS

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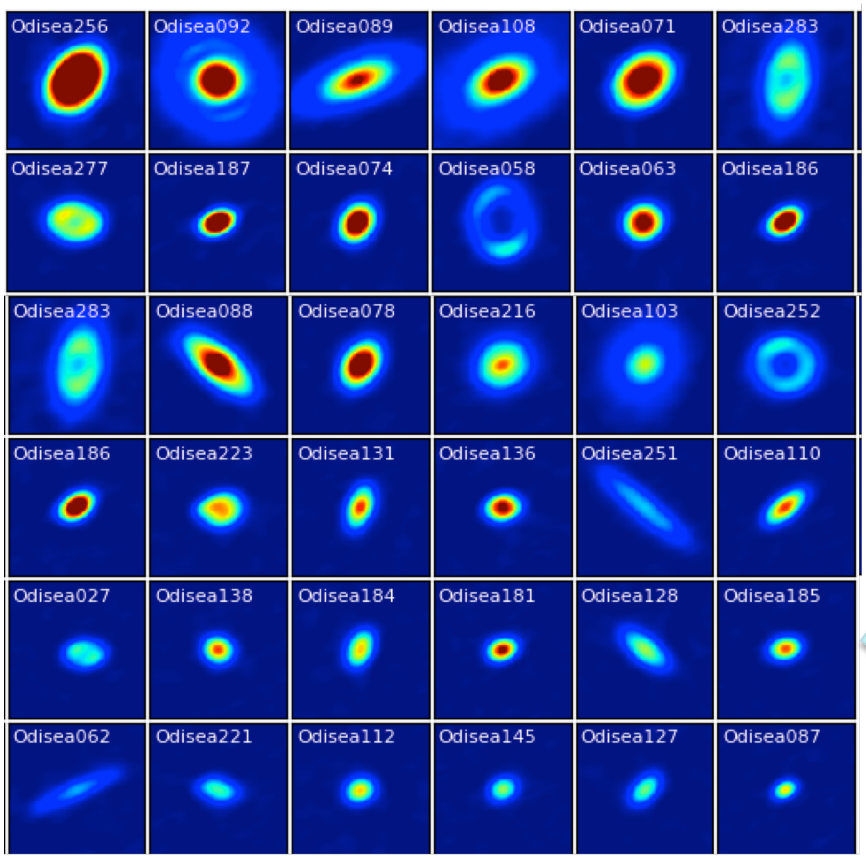
Cycle-4/5 program:

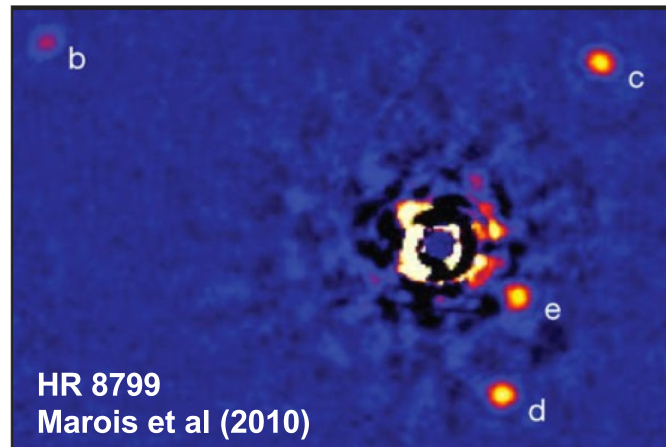
Goal: image entire disk population in Ophiuchus: ~ 300 disks (140 pc).

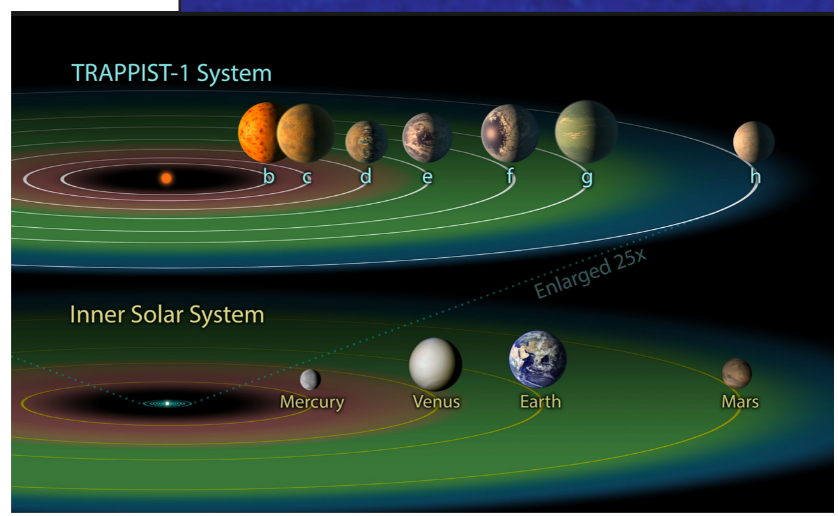
1.3 mm continuum + CO

High-resolution (~3 au) follow-up of 10 targets in Cycle-6



"How the diversity of disk relates to the diversity of planets "





Spitzer Map of the Ophiuchus Molecular Cloud

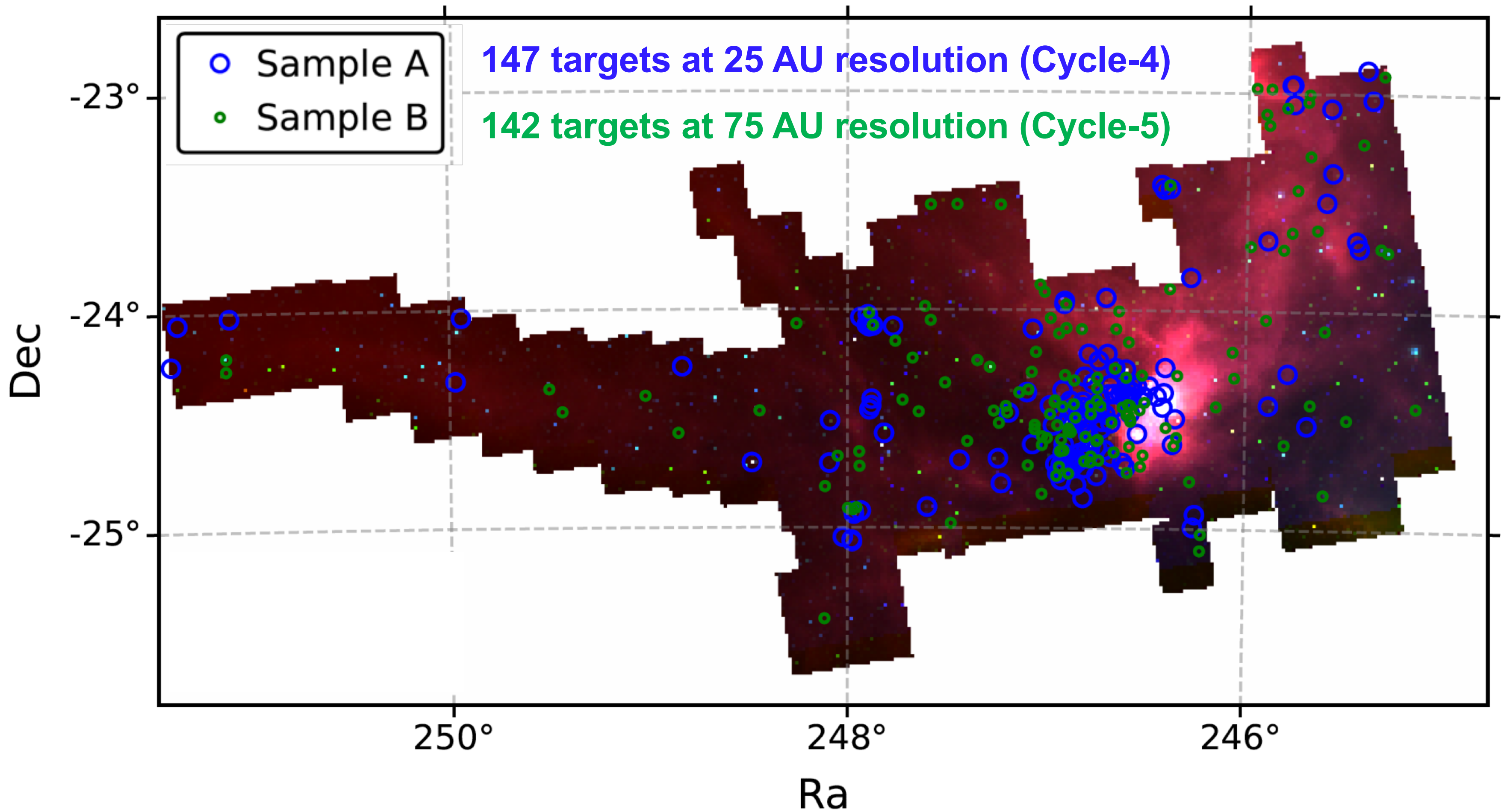
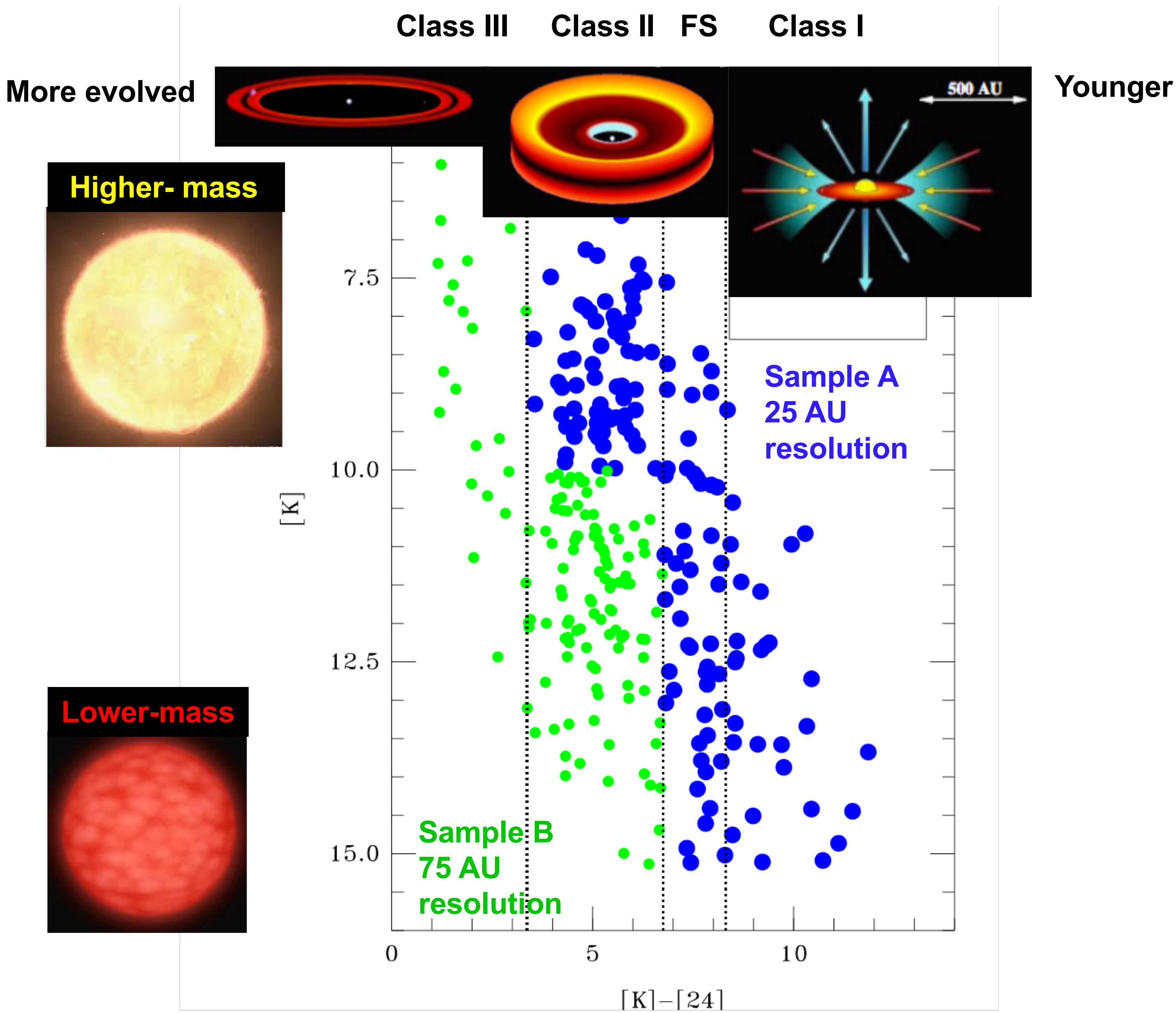
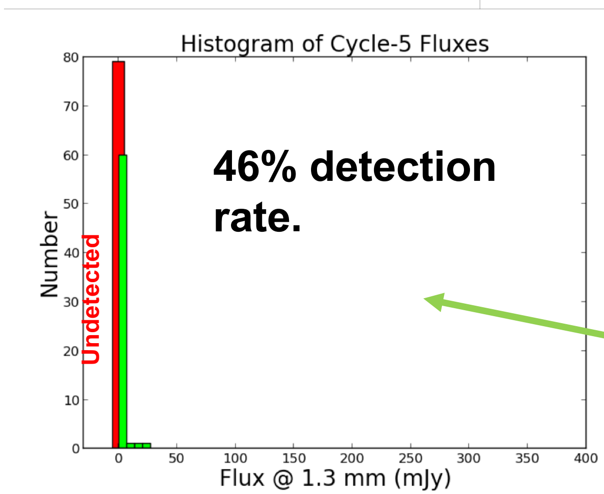


Figure 2. The spatial distribution of the ODISEA targets (both Samples A and B) shown on top of the *Spitzer* map of the Ophiuchus molecular cloud from the "Cores to Discs" Legacy Project.

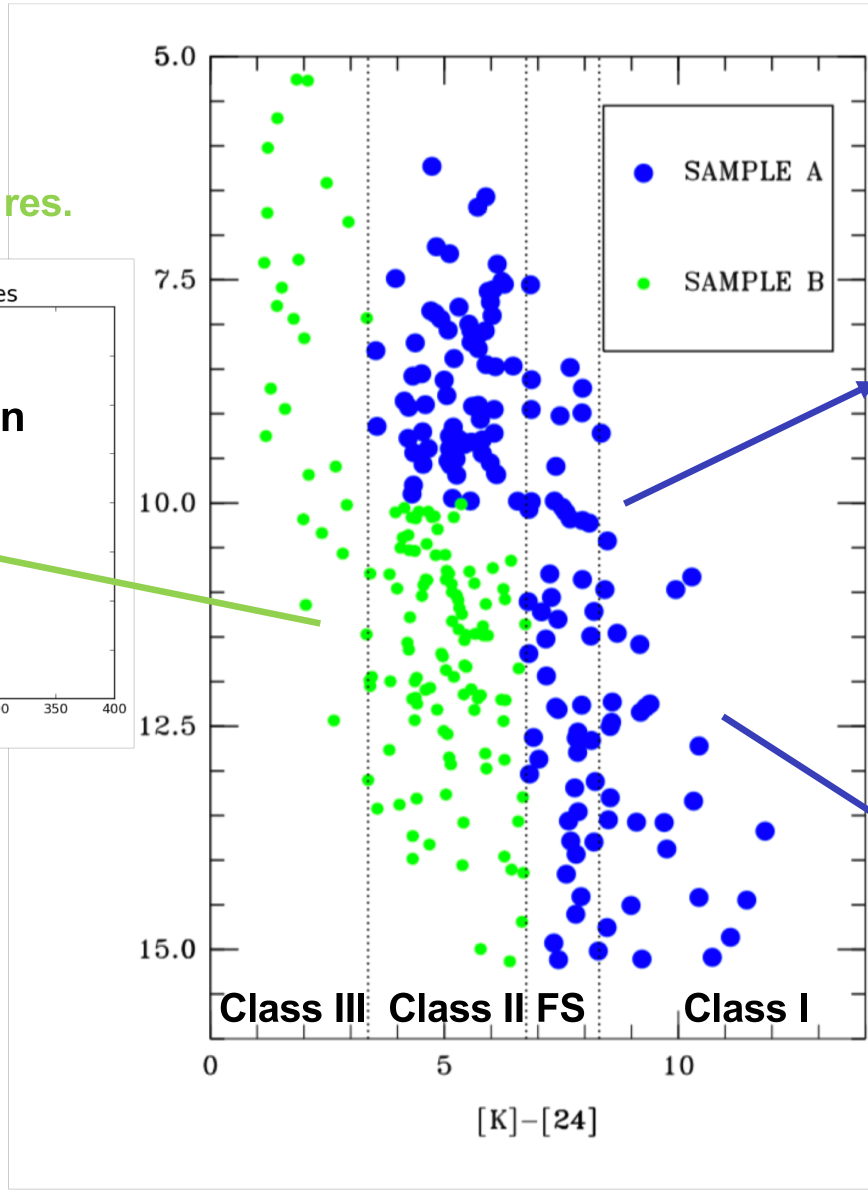

Class III
Class II
FS
Class I
More evolved
Younger
500 AU
Higher- mass
Lower-mass
Sample A
25 AU
resolution
Sample B
75 AU
resolution
7.5
10.0
12.5
15.0
[K]
0
5
10
[K]−[24]

Full Cycle-4/5 ODISEA sample

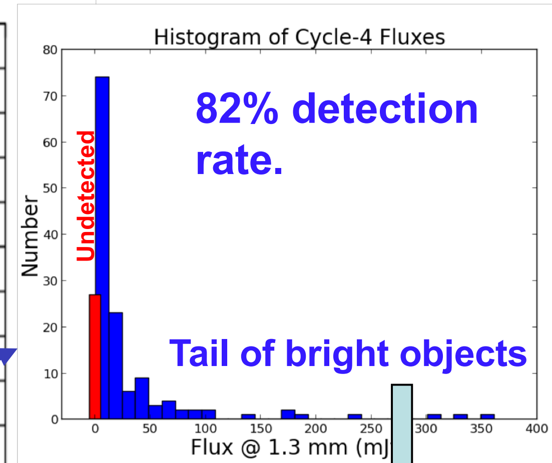
Cycle-5 Sample B: 0.6” res.



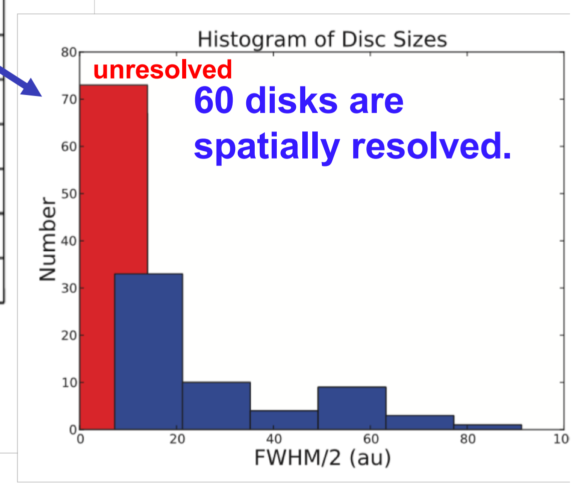
(Williams et al. 2019)



Cycle-4 Sample A: 0.25” res.

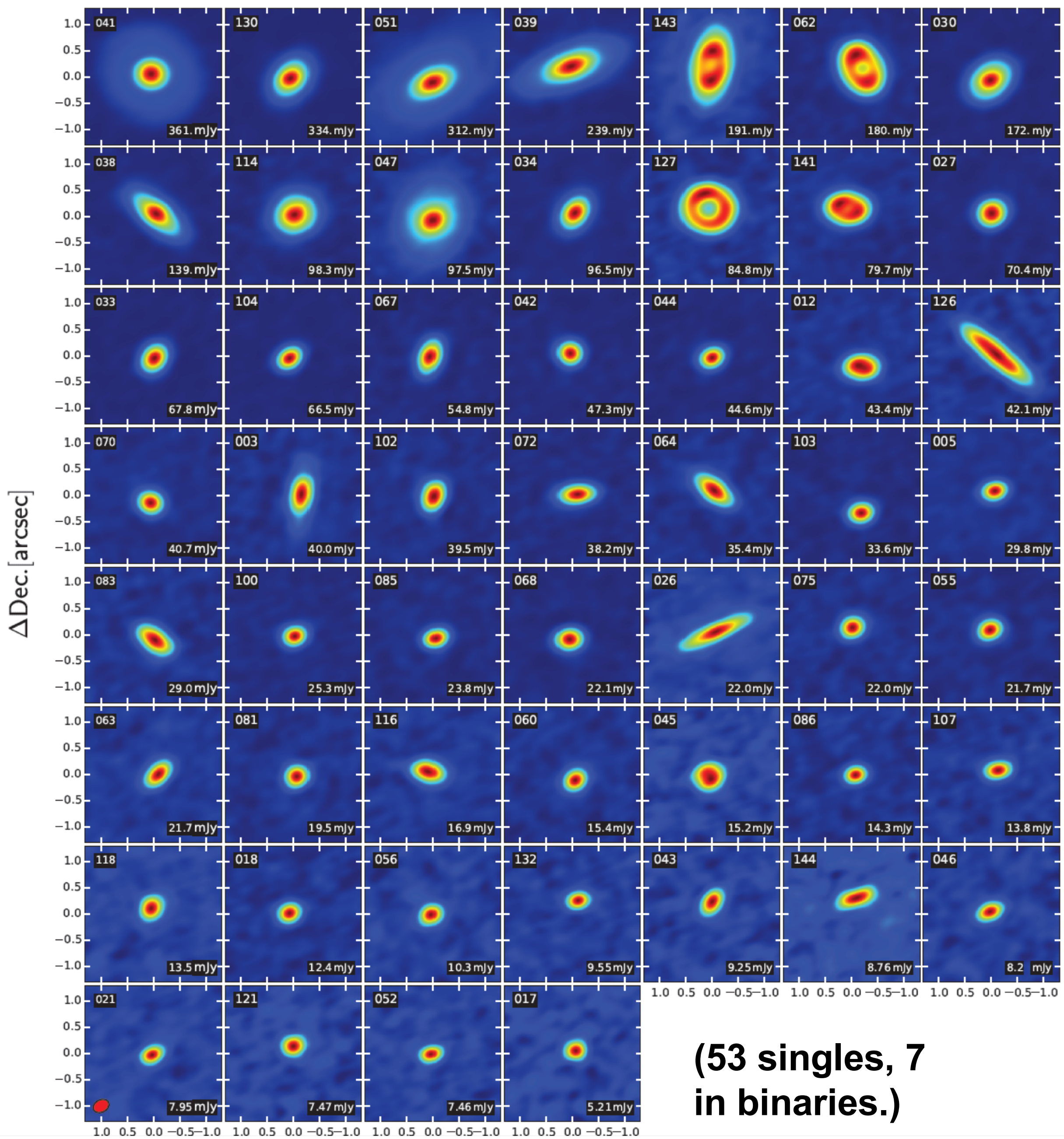


Very high-resolution



(Cieza et al. 2019)

Spatially resolved disks (at 0.25” res.)

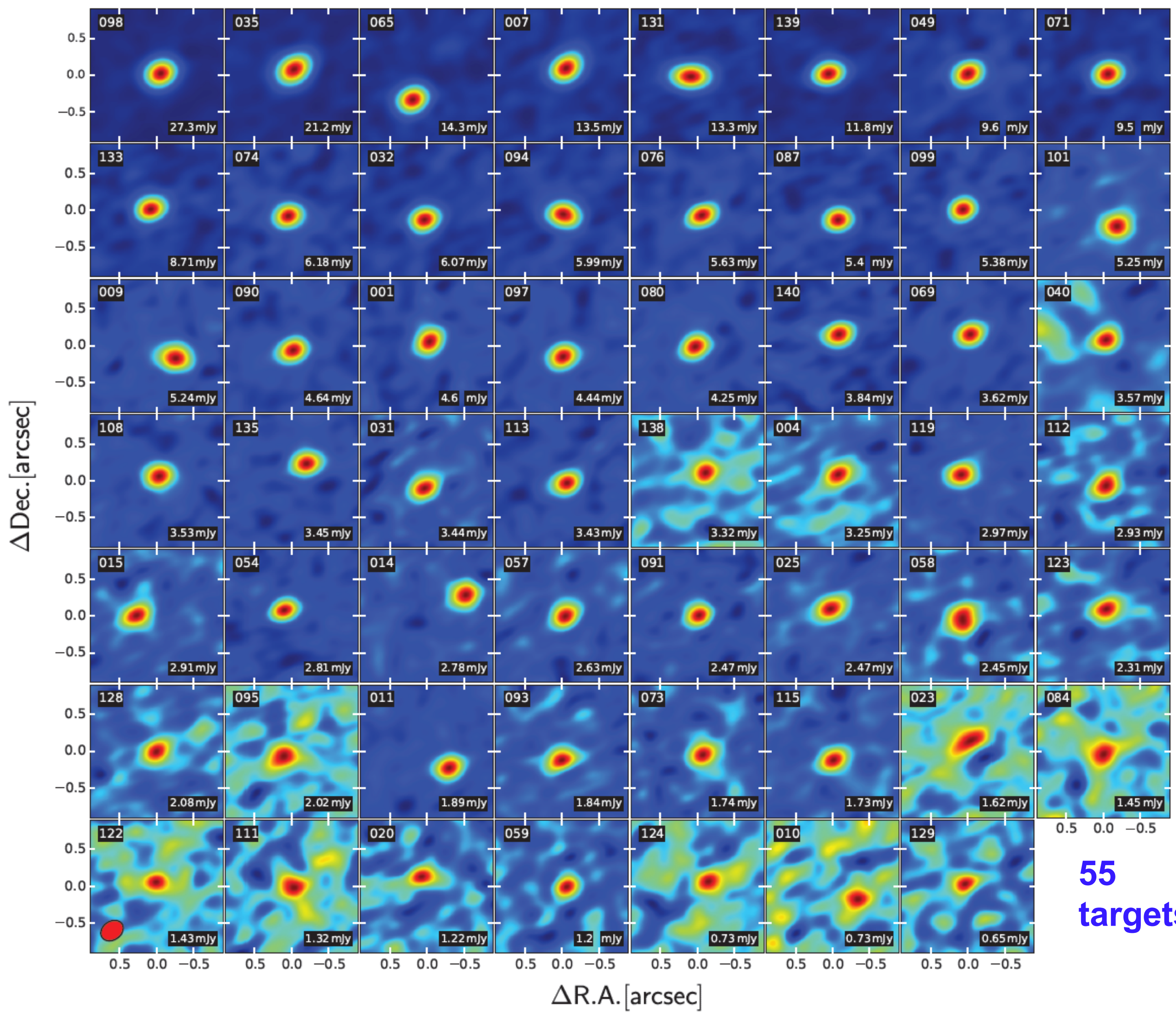


Massive large disks (many with inner holes)

Small disks with no obvious structures.

(53 singles, 7 in binaries.)

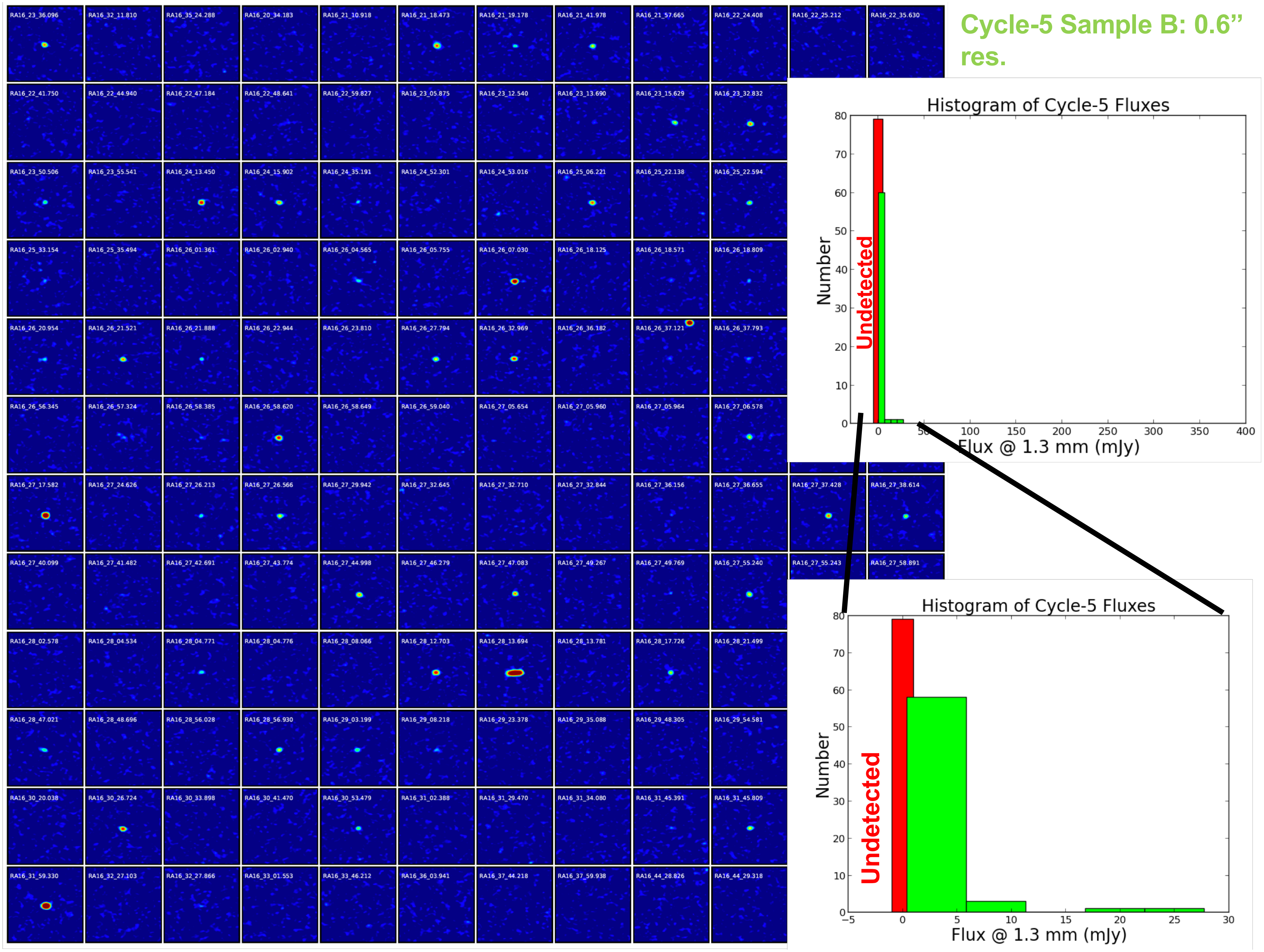
Unresolved disks 0.2” res.



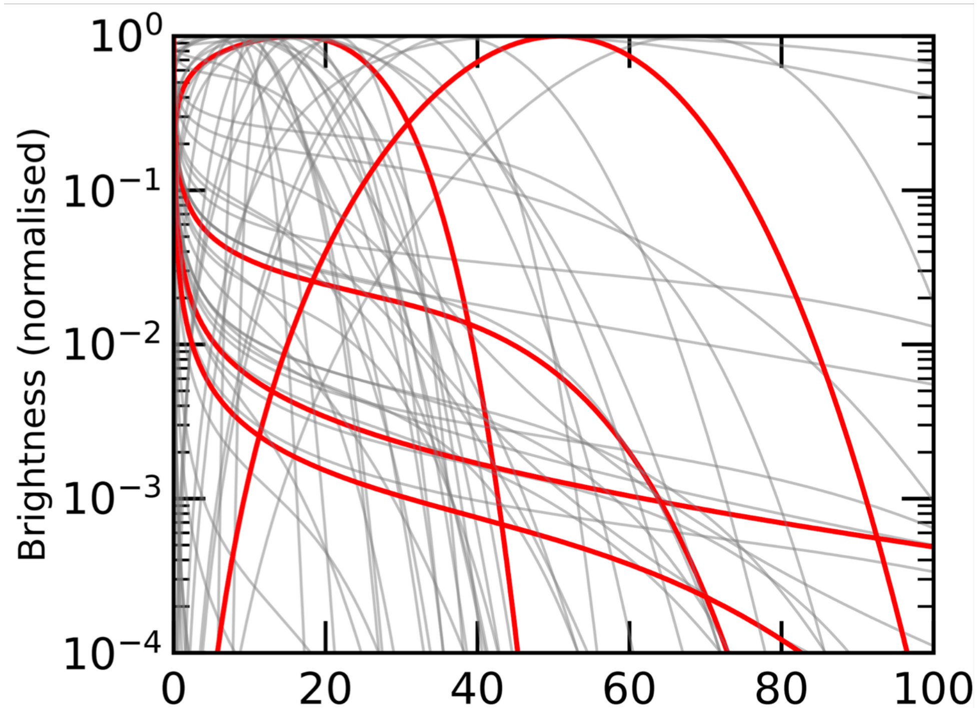
R < 15 au

55 targets

Cycle-5 Sample B: 0.6” res.



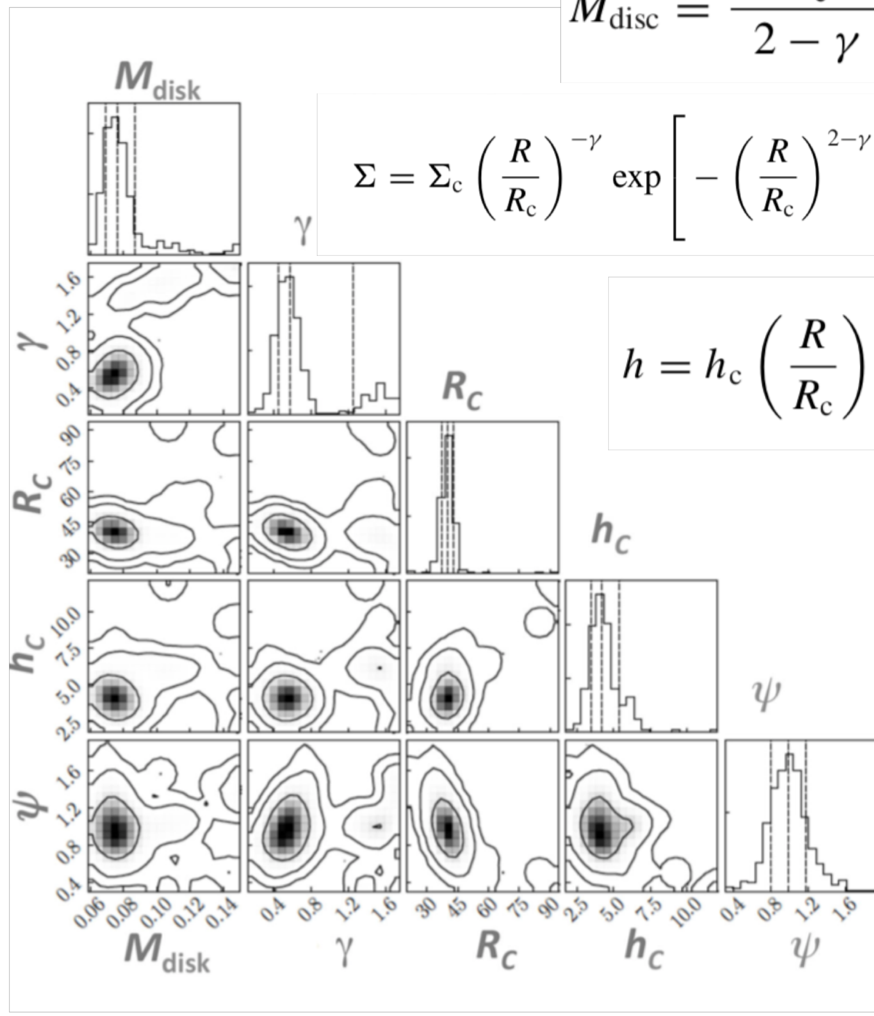
50 ODISEA brightness profiles at 0.25” res.



Perez et al. in prep.

Very diverse brightness profiles!

MCMC Radiative Transfer modeling



$$M_{\rm disc} = \frac{2\pi R_{\rm c}^2 \Sigma_{\rm c}}{2-\gamma}$$

$$\Sigma = \Sigma_{\rm c}\left(\frac{R}{R_{\rm c}}\right)^{-\gamma} \exp\left[-\left(\frac{R}{R_{\rm c}}\right)^{2-\gamma}\right]$$

$$h = h_{\rm c}\left(\frac{R}{R_{\rm c}}\right)^{\Psi}$$

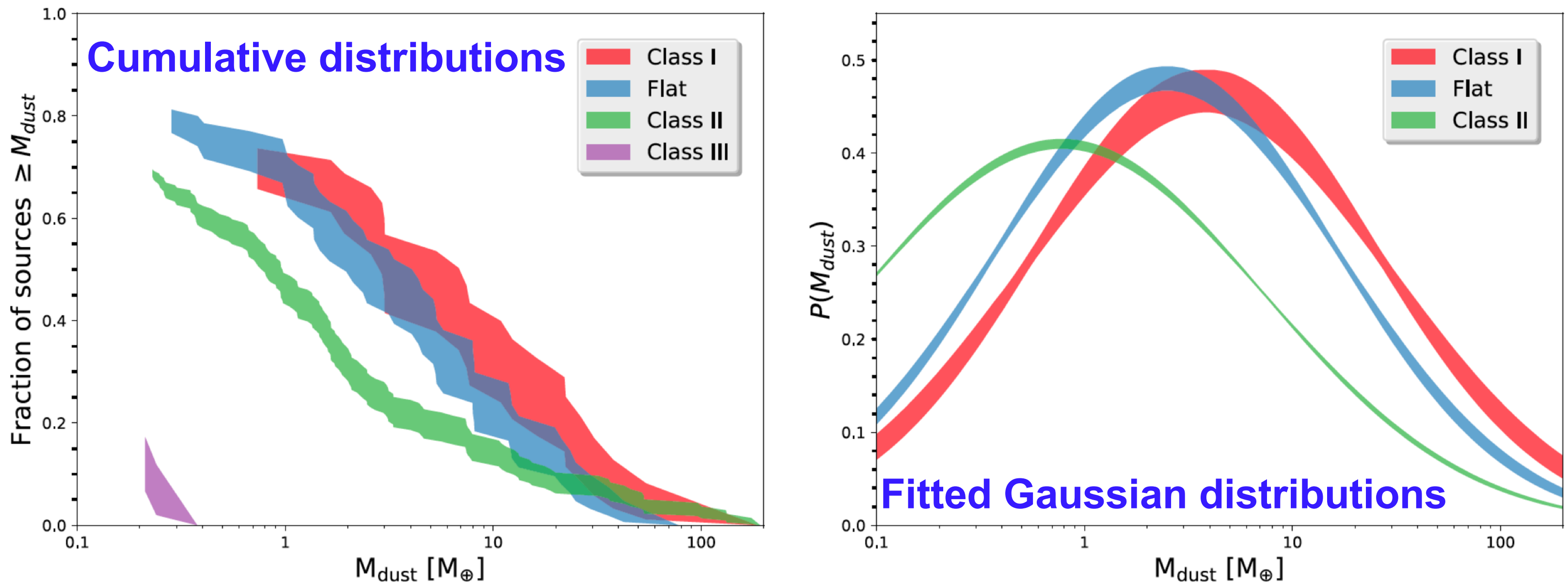
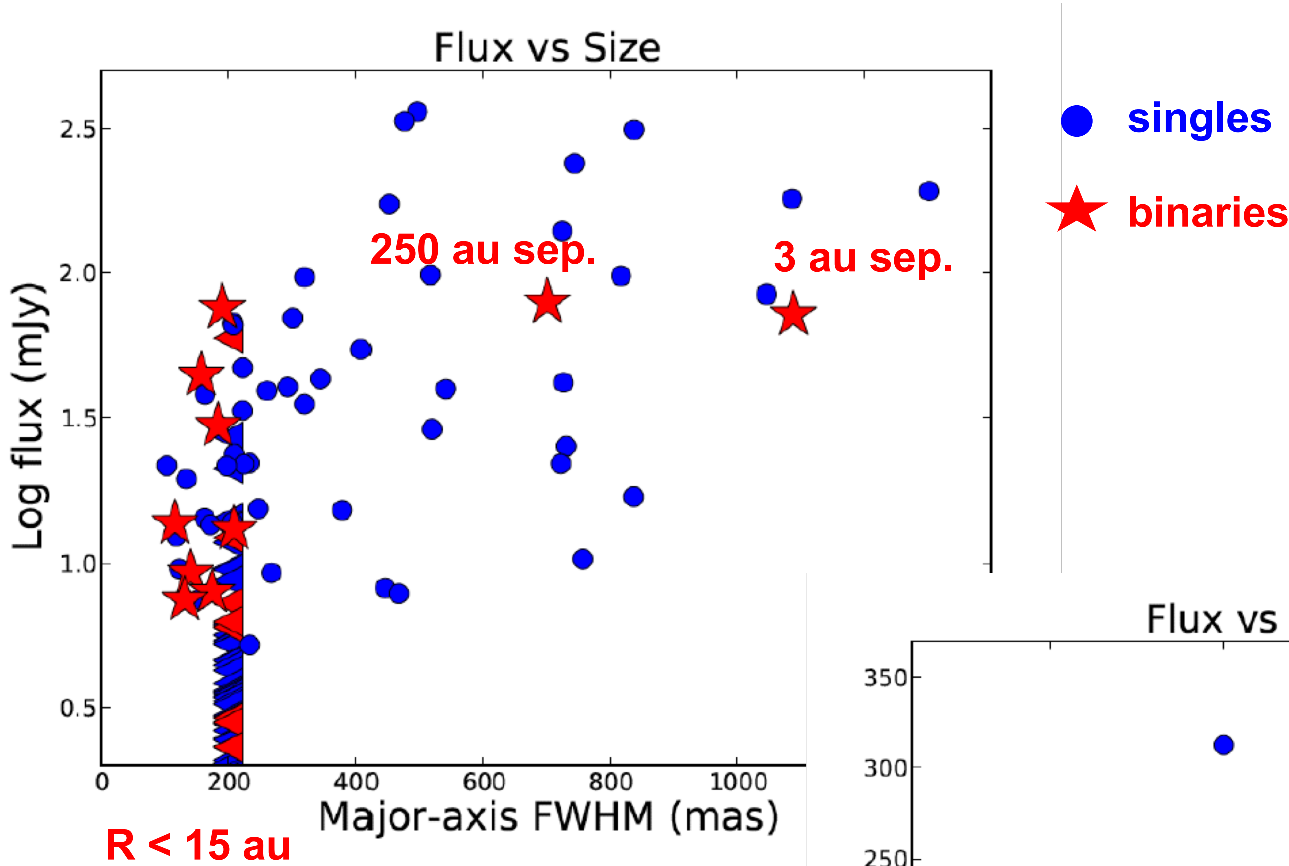
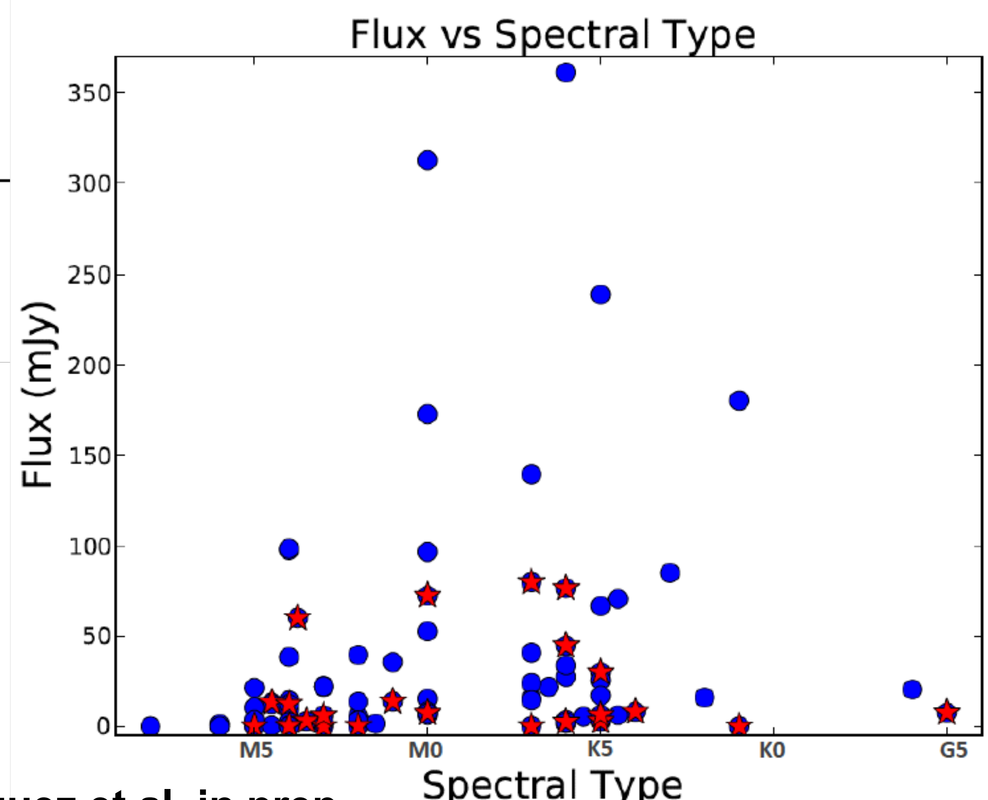


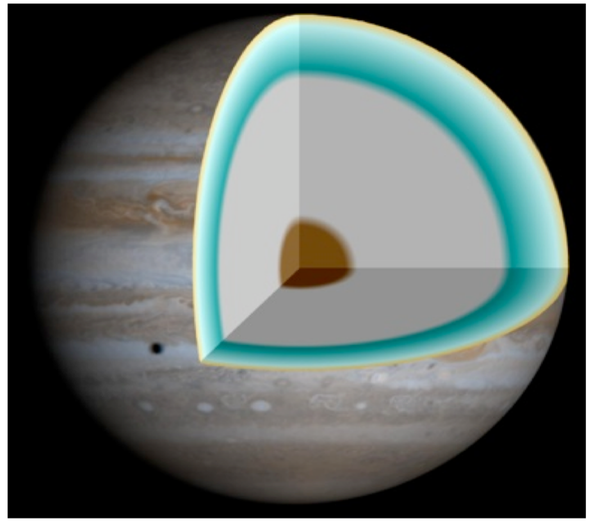
Figure 1. Dust mass distributions for Ophiuchus disks around protostars of different infrared evolutionary states. The cumulative distributions derived from the censored data are shown in the left-hand plot, where the shading illustrates the 1σ uncertainty at each mass and the colors indicate protostellar class. The corresponding Gaussian distributions for the probability distribution function for the Class I, Flat, and Class II sources is shown in the right panel, where the shading now illustrates the range of allowed fits.

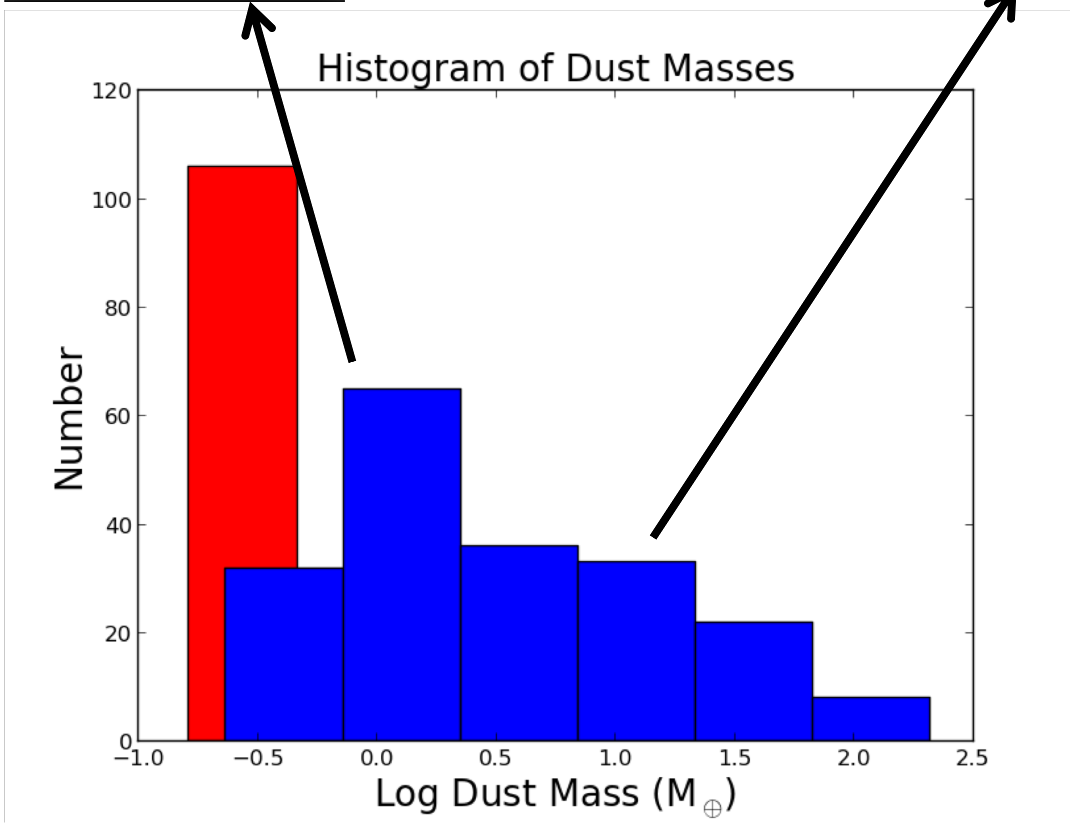


Cieza et al. 2019, Zurlo et al. in prep.



Ruiz-Rodriguez et al. in prep.



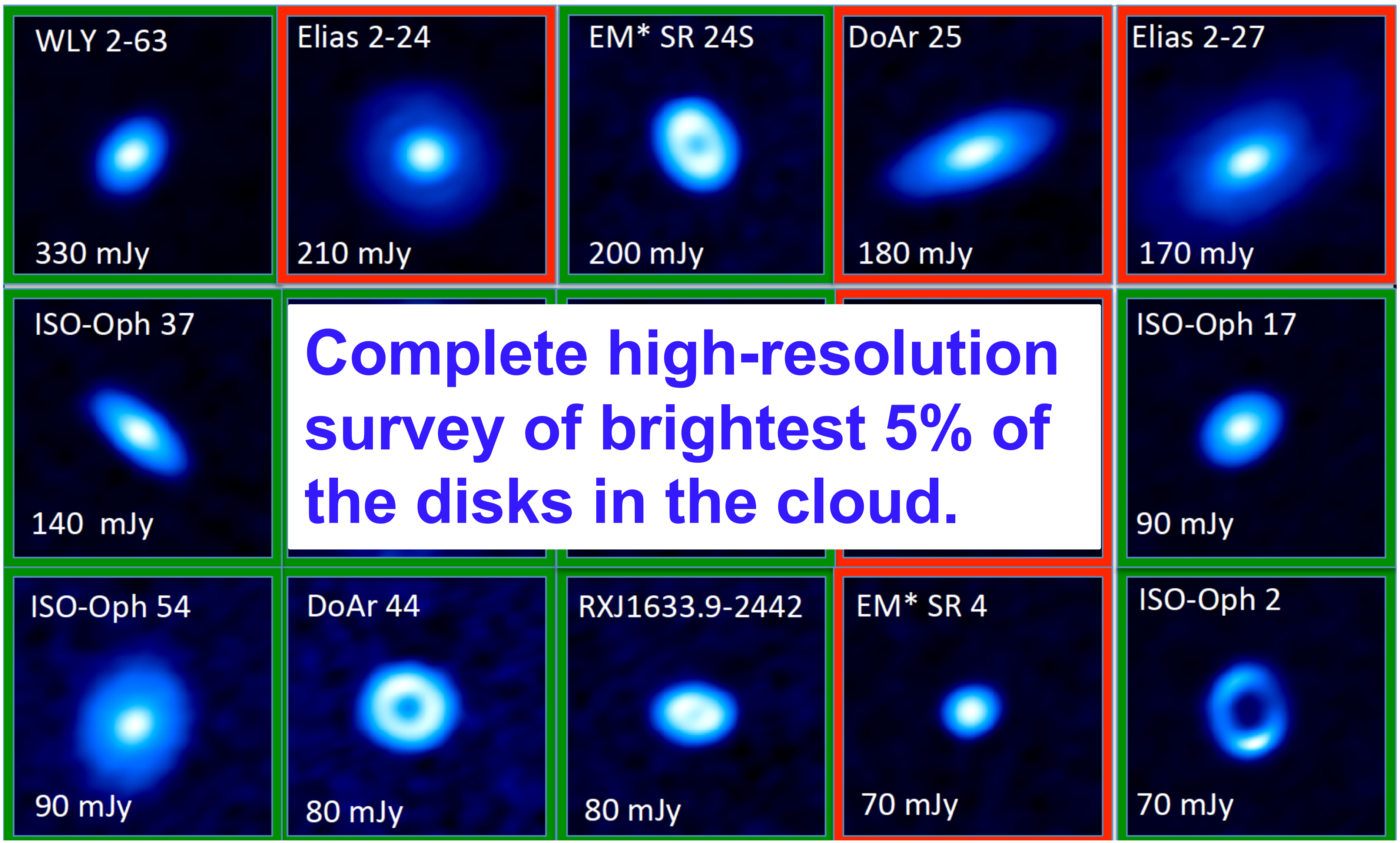


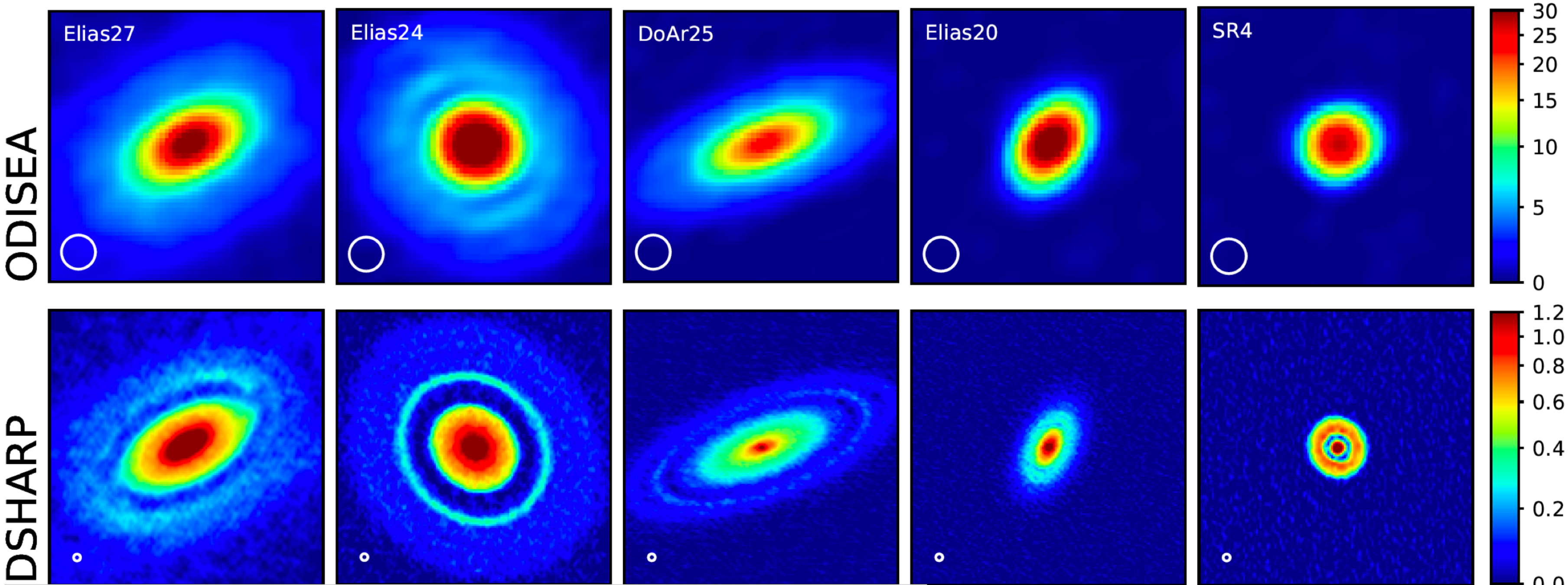
~15% disk population has enough mass to form core of Jupiter.

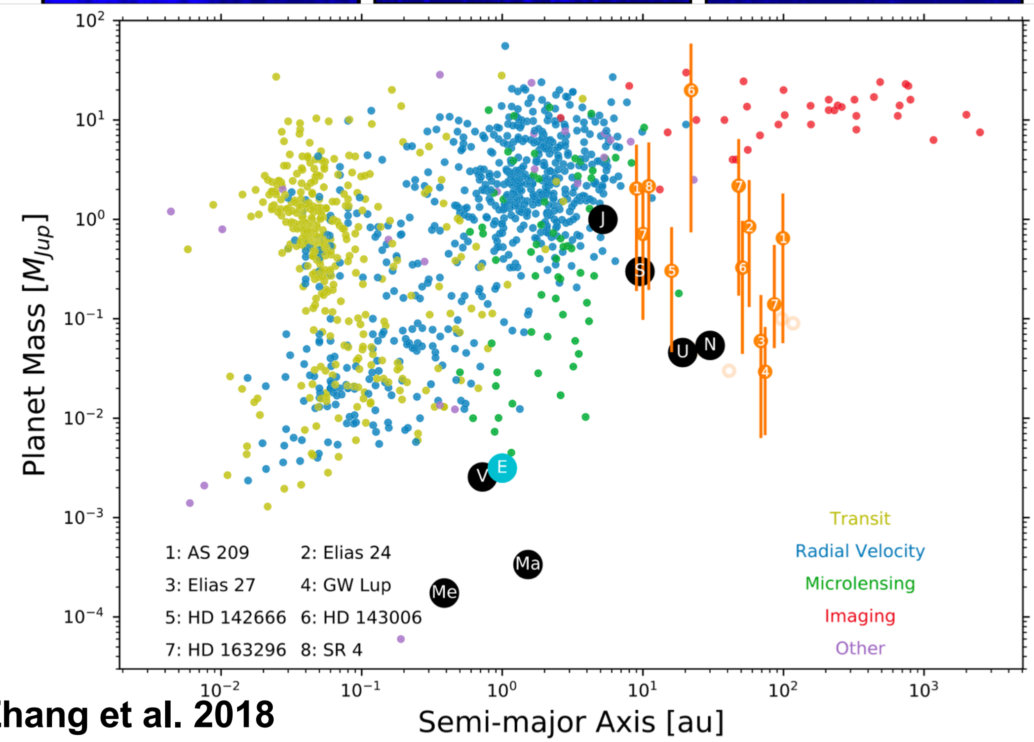
High-resolution follow-up of brightest sources

DSHARP (PI = S. Andrews)

Our Cycle-6 program (PI= L. Cieza)

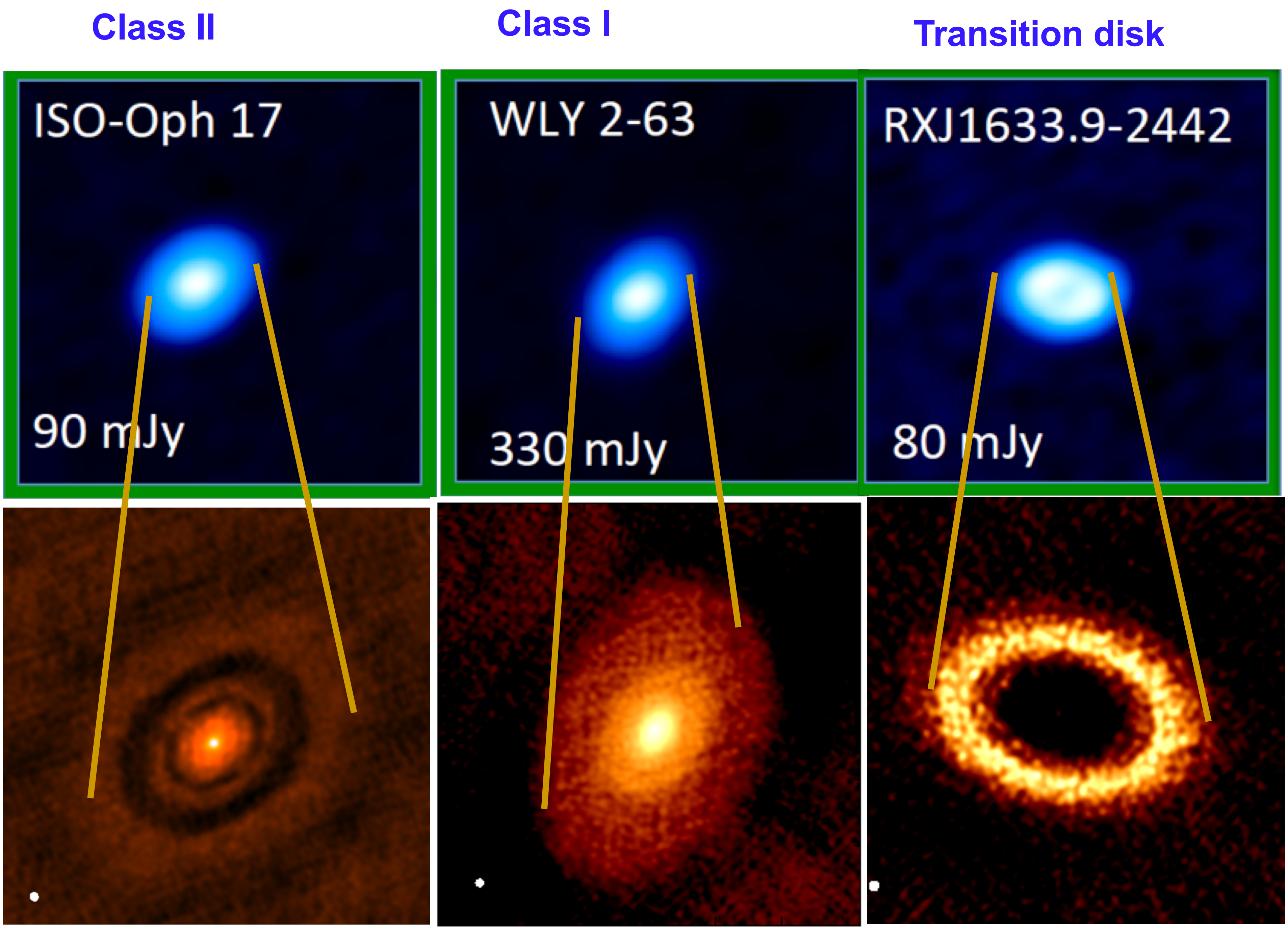






Zhang et al. 2018

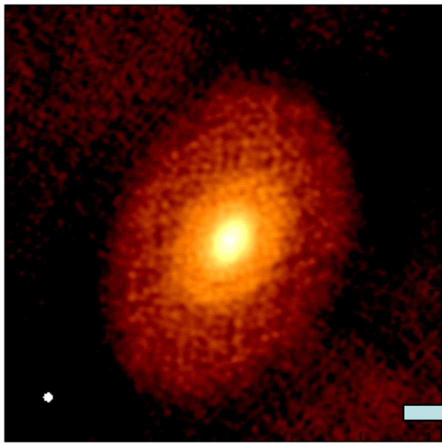
Gaps consistent with planets that can not be detected another way.



Class II
Class I
Transition disk
ISO-Oph 17
90 mJy
WLY 2-63
330 mJy
RXJ1633.9-2442
80 mJy

The evolution of gaps and rings in massive disks?

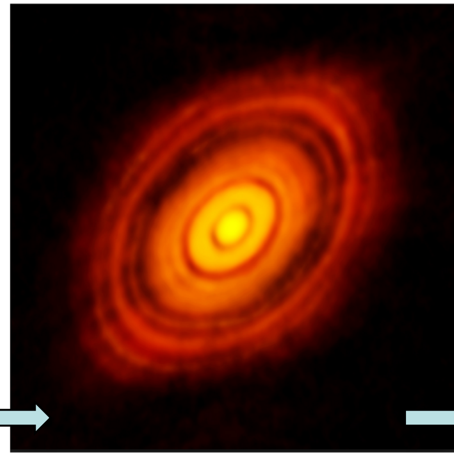
~Class I



WLY 2-63

No obvious gaps

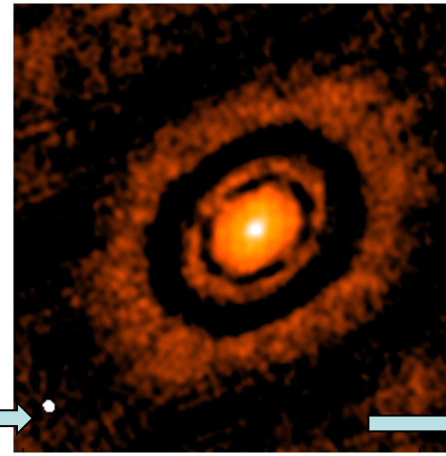
~Flat Spectrum



HL Tau
(ALMA Partnership et al. 2015)

Narrow gaps

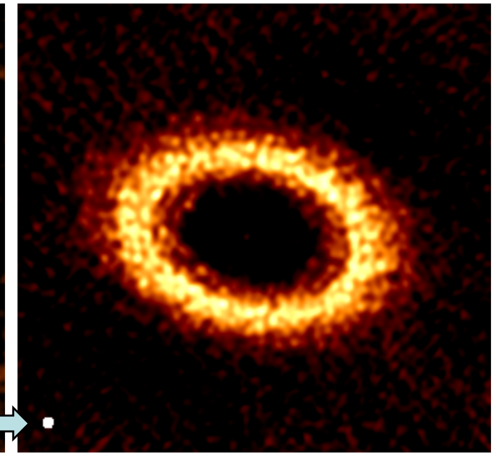
~Class II



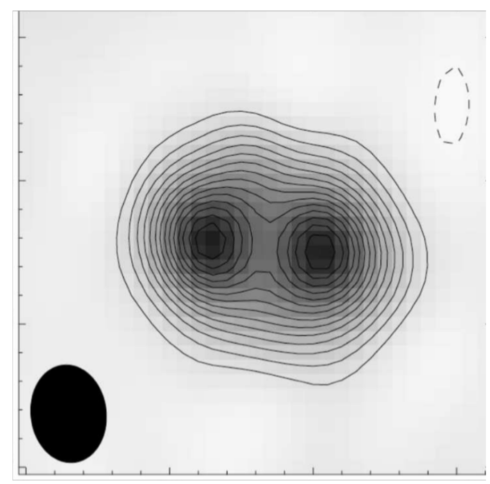
ISO-Oph-17

Wide gaps

~Transition disk



RX J1633.9-2442



Two full tracks with the SMA!
Cieza et al. (2012)

Preliminary Results (Cieza et al. 2019,Williams et al. 2019)

1. Disks are very diverse!

2. Wide range of masses for a given evolutionary class.

3. Most systems are small (r < 15 au) but have enough dust to form rocky planets.
   ~ 15% of the disks have enough mass to form core of Jupiter.

4. Most massive disks are seen around solar-mass stars without stellar companions, disks in binary systems are particularly small and low-mass.

5. High-resolution images might trace the evolution of gaps and rings in massive disks

ODISEA continues…

1. Modeling of all resolved sources (Perez et al. in prep), spectroscopic characterization and disk properties vs stellar properties (Ruiz-Rodriguez et al. in prep). Multiplicity paper and disk properties in binary systems (Zurlo et al. in prep).

2. High-resolution images of 10 brightest sources (Cycle-6). All observed.

3. Measuring disk sizes for disks that remain unresolved, multiwavelength imaging, gas kinematics, etc (Cycle-7/8).