THE STRUCTURES OF EMBEDDED DISKS WITH ALMA

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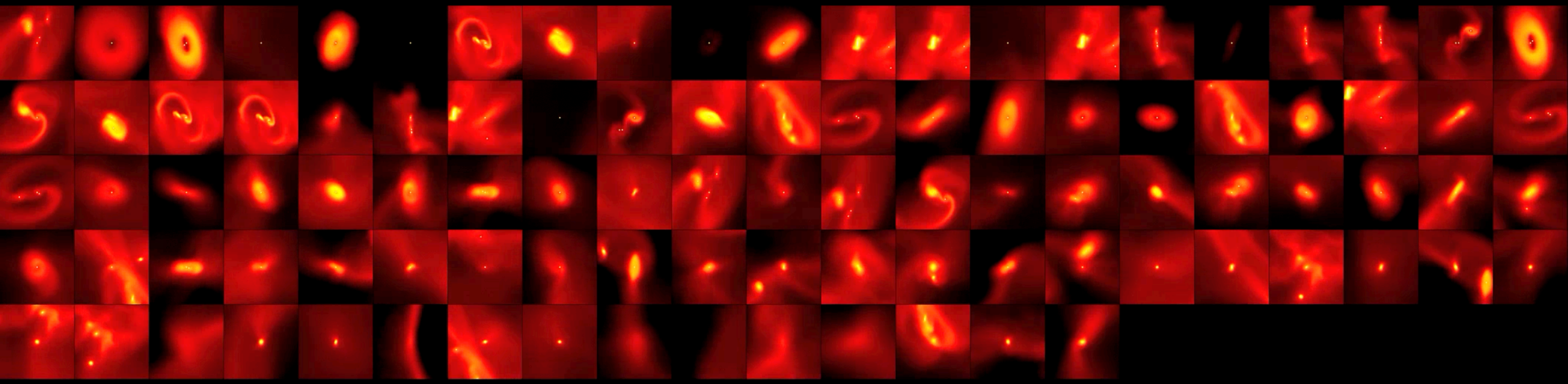
CIERA FELLOW
GREAT BARRIERS IN PLANET FORMATION
JULY 22, 2019

COLLABORATORS:
JOHN TOBIN
JOSH EISNER

Image credit: Reynolds et al., in prep.

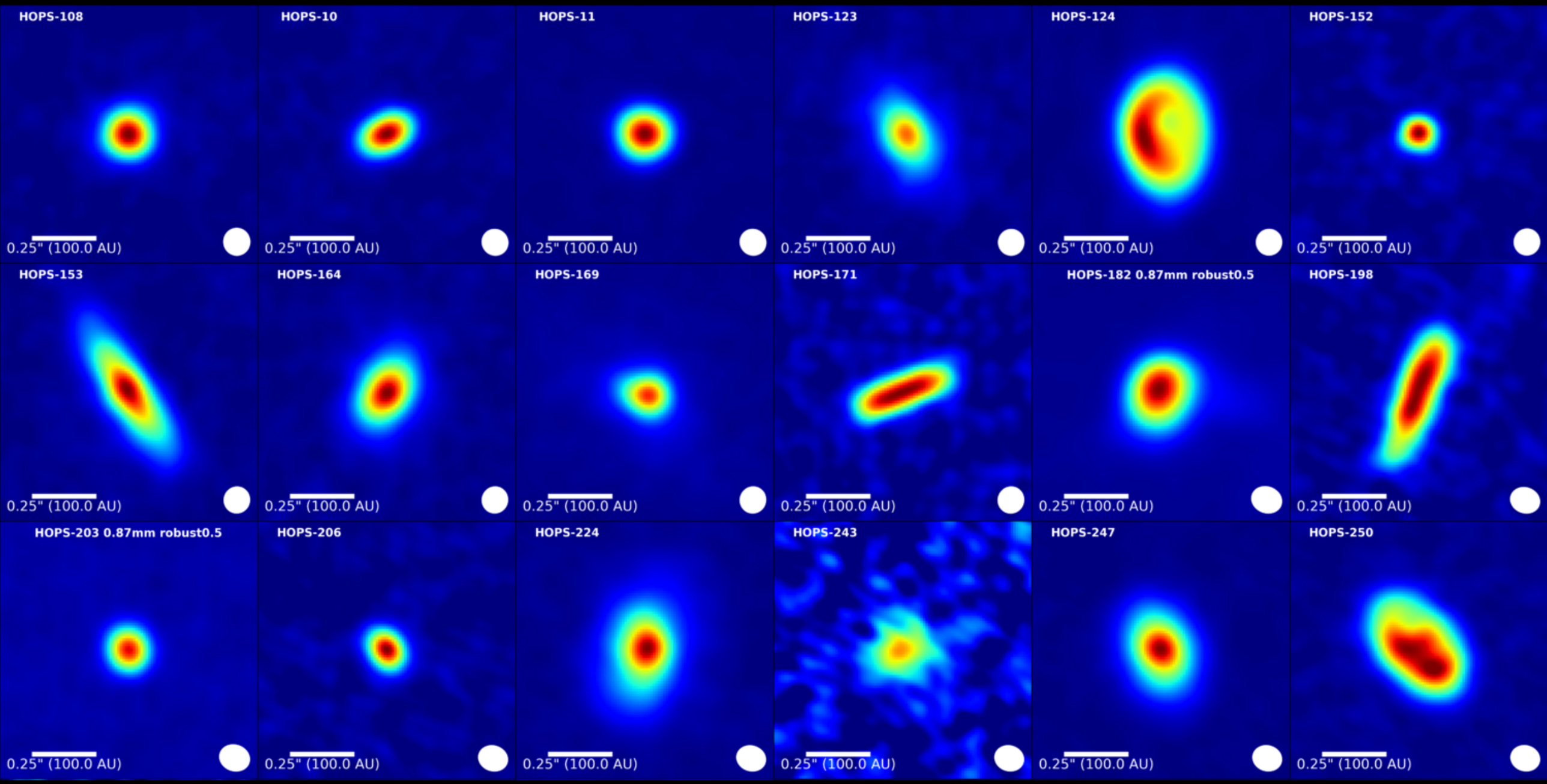
Protostellar disk formation



184833 yr
Z=3 $Z_\odot$

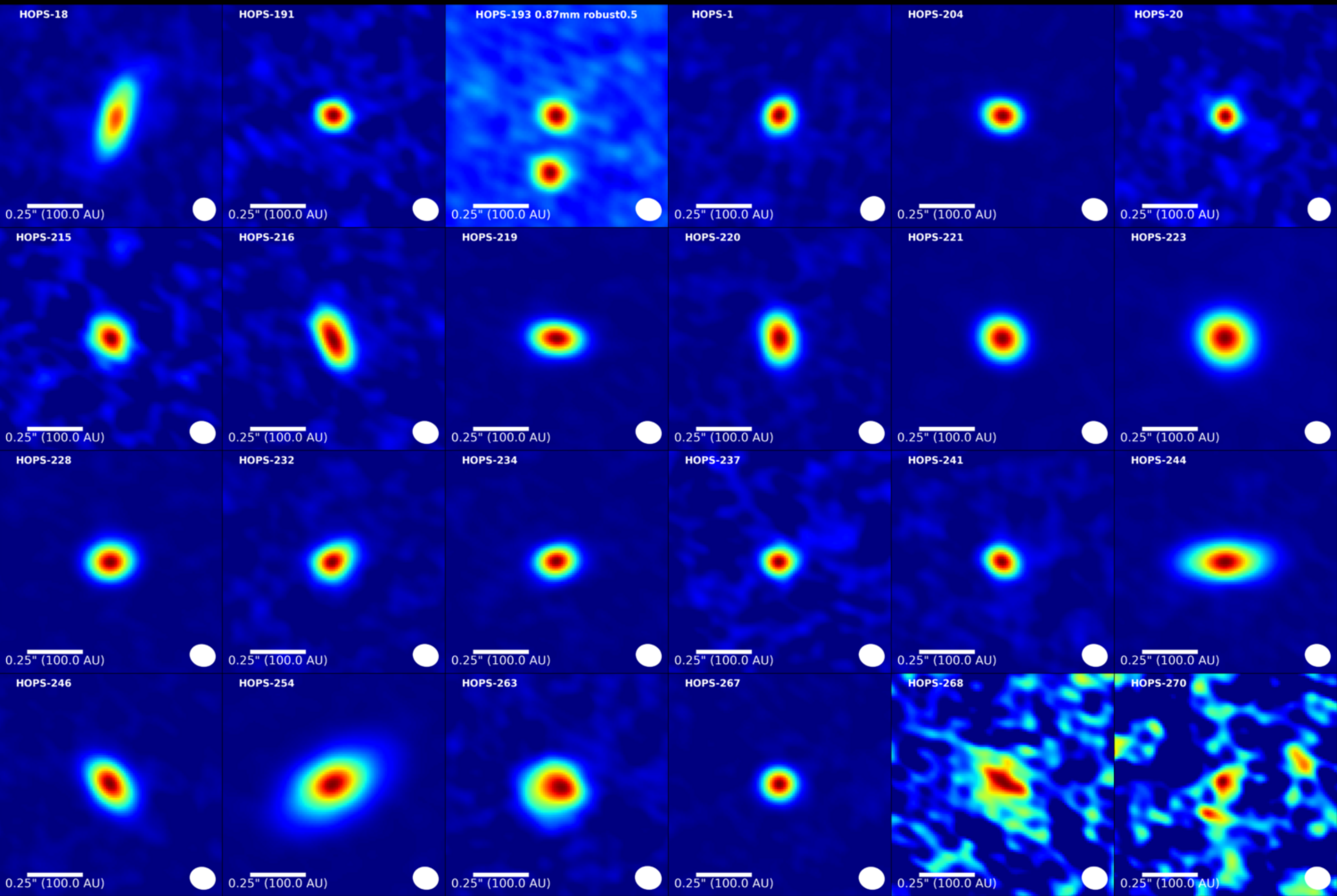
Matthew Bate
University of Exeter

VANDAM: Orion Class 0 - ALMA

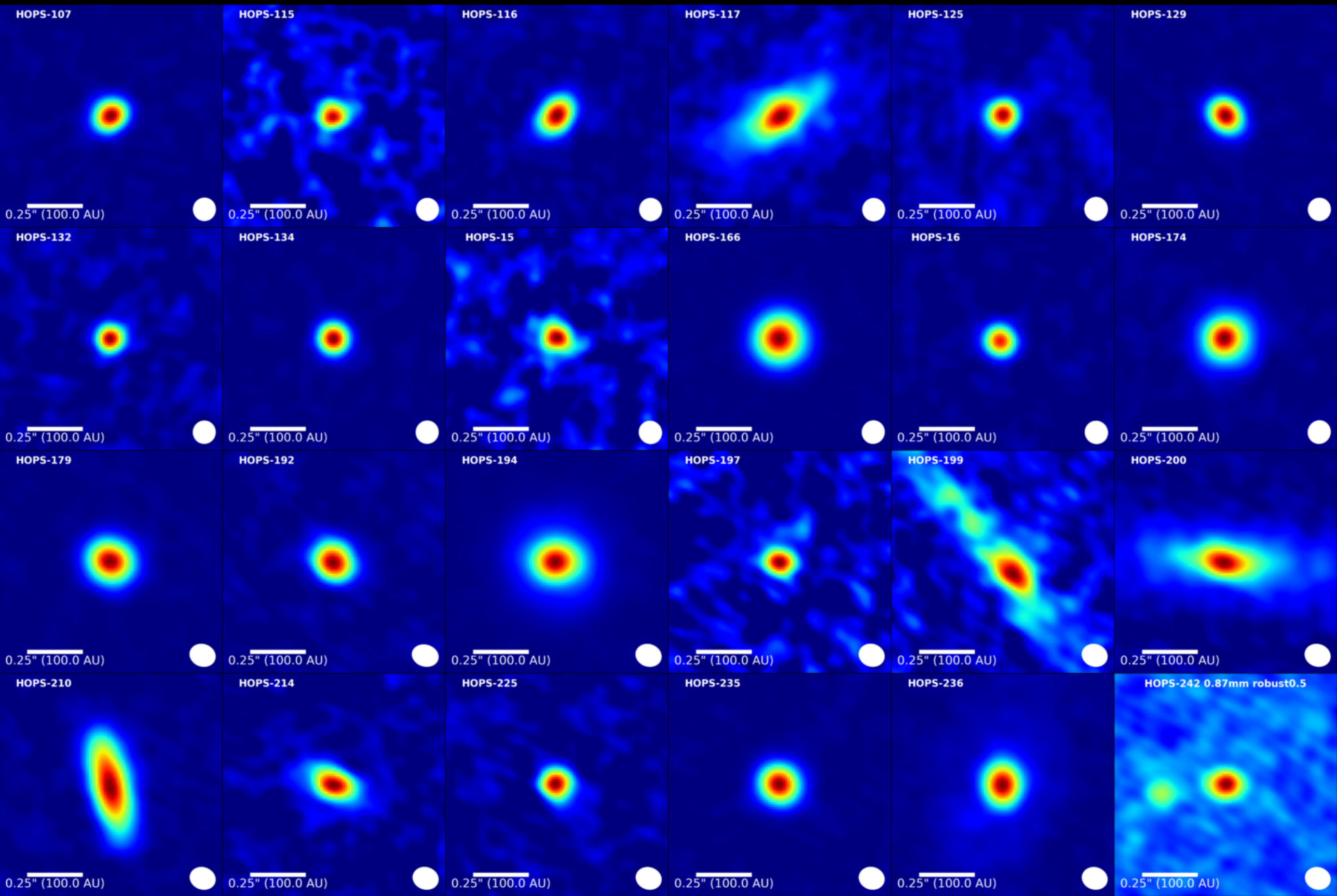


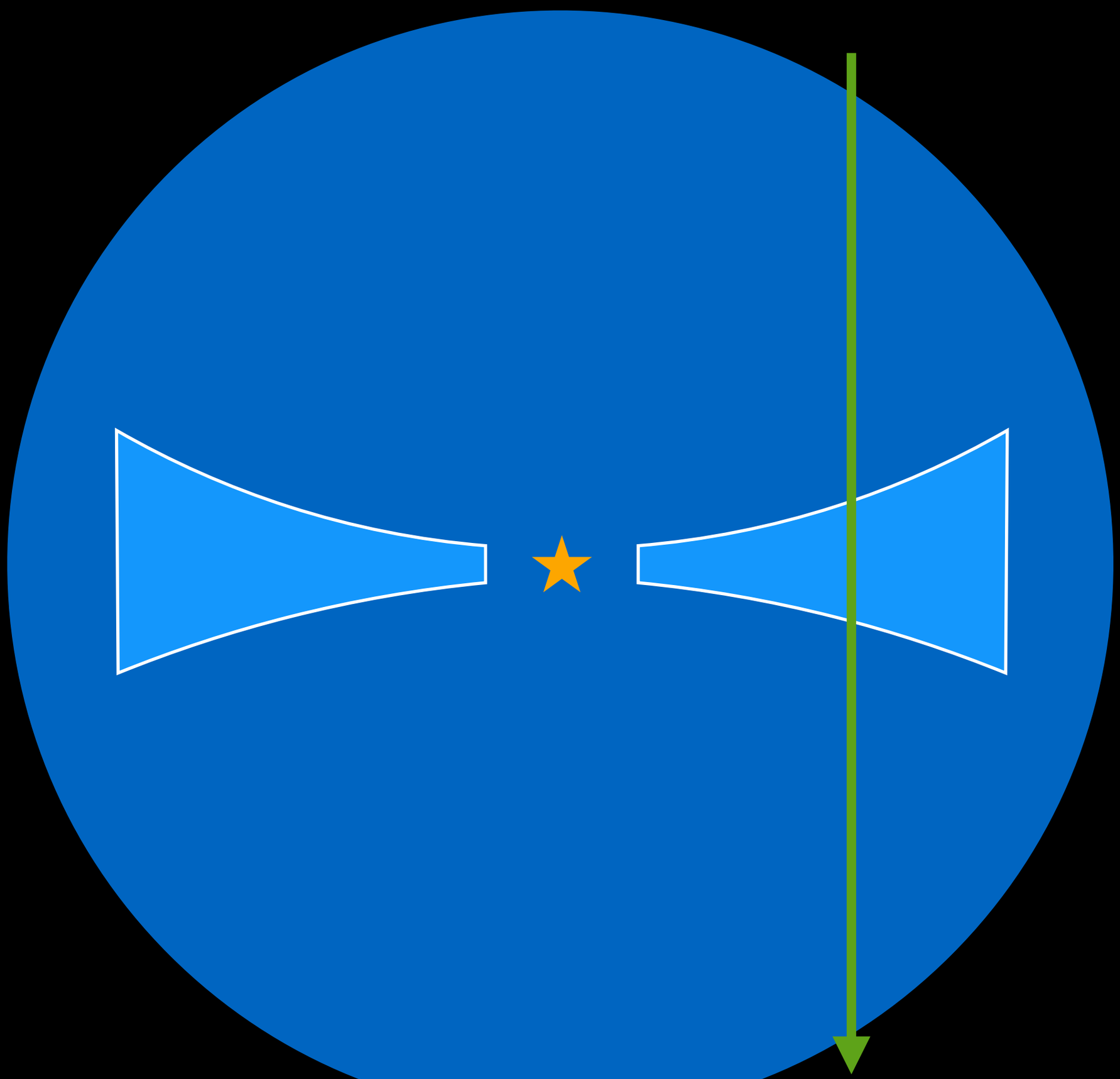
- >300 protostellar disks in Orion with ~40 au resolution at 345 GHz
- ~100 Class 0's, ~200 Class I's/Flat Spectrum
- PI: John Tobin

VANDAM: Orion Class I



VANDAM: Orion Flat Spectrum/Class I

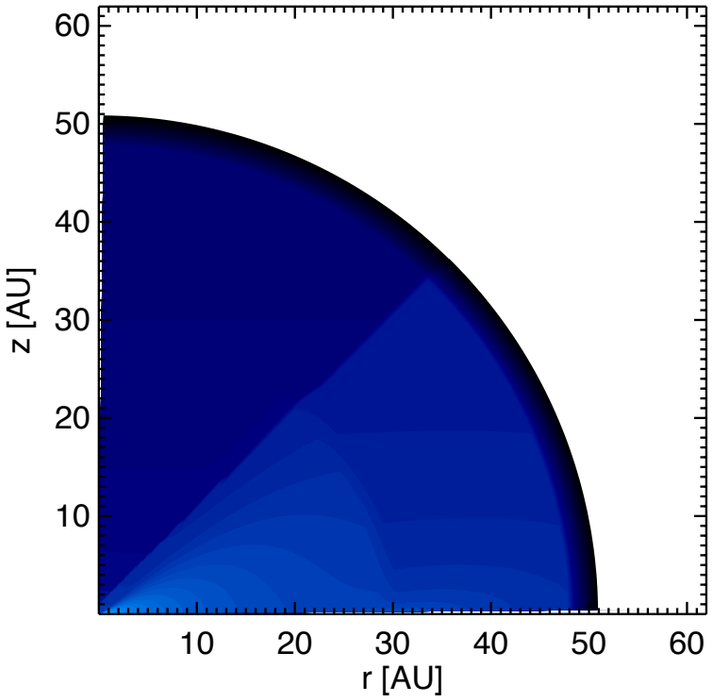




Radiative transfer forward modeling

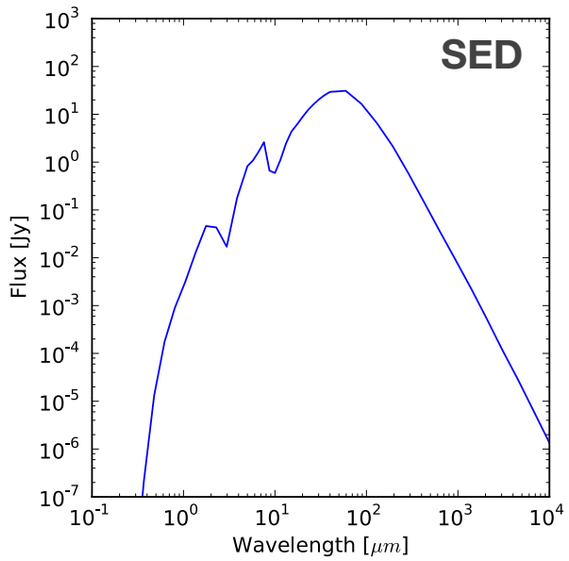
parametric density distribution

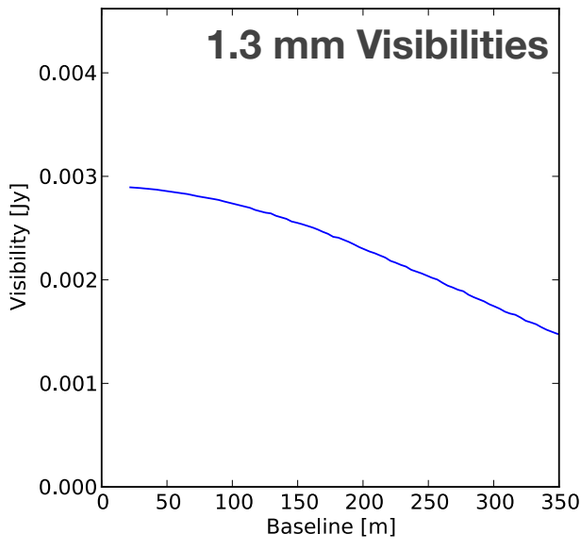
disk + envelope + outflow cavity



RADMC-3D

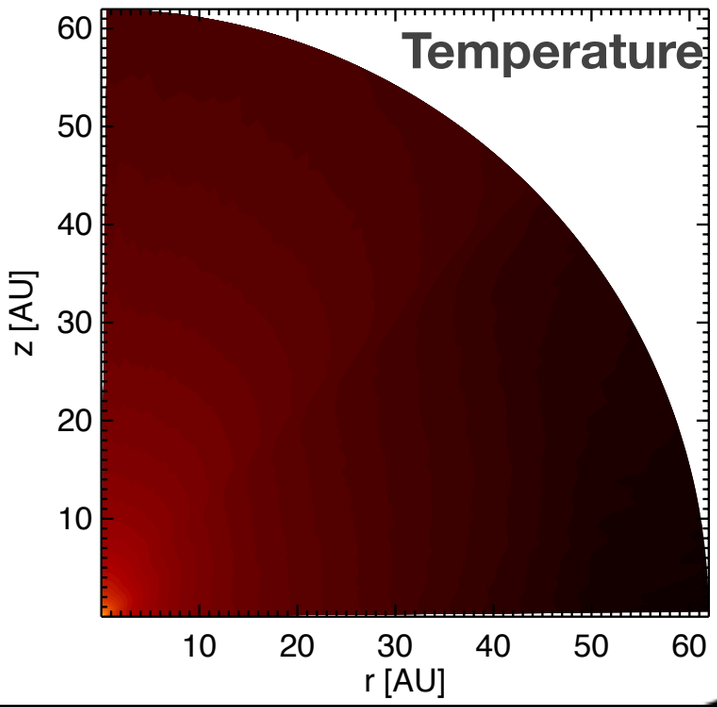
synthetic observations



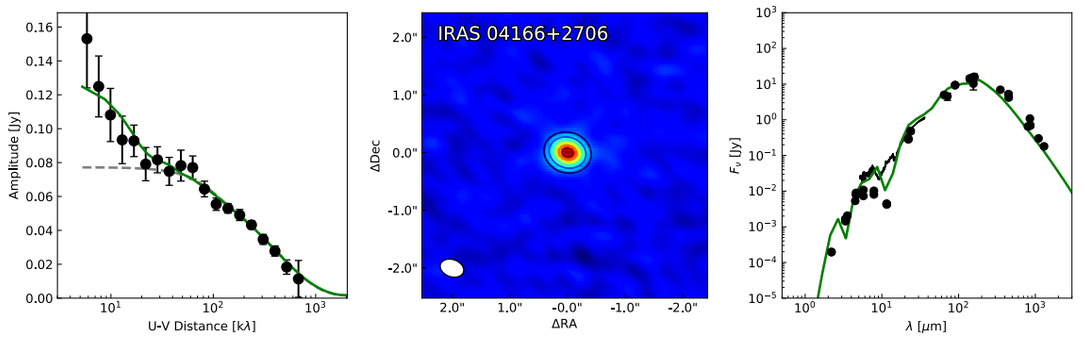


emcee

RADMC-3D



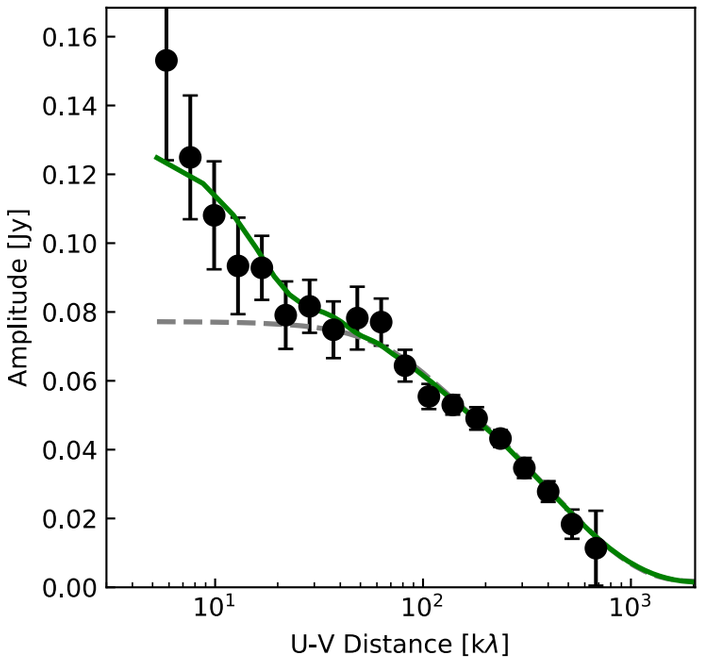
best fit model

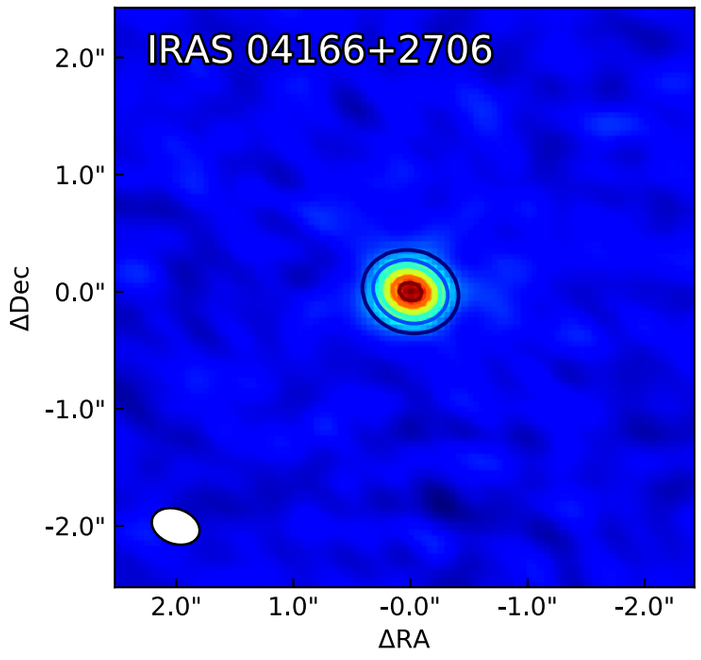


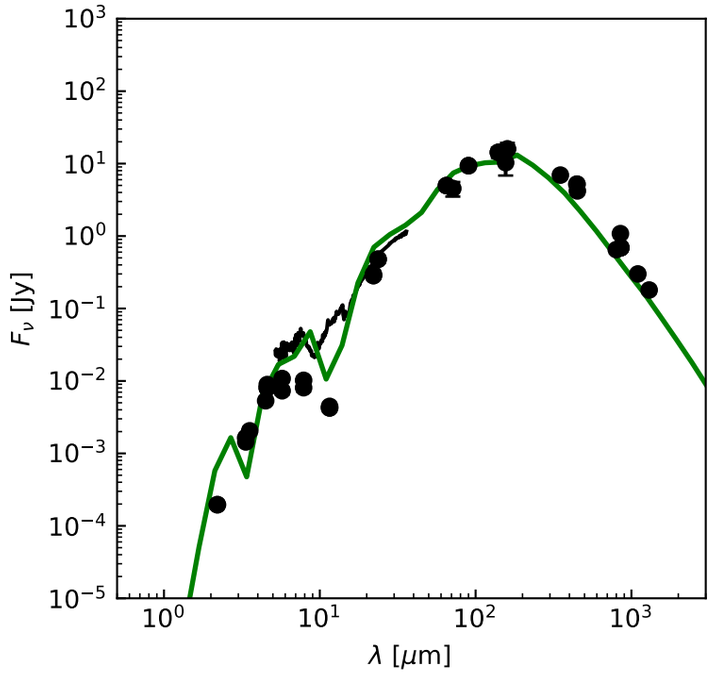
pdspy: Available on GitHub now! Documentation sparse, but more coming soon.

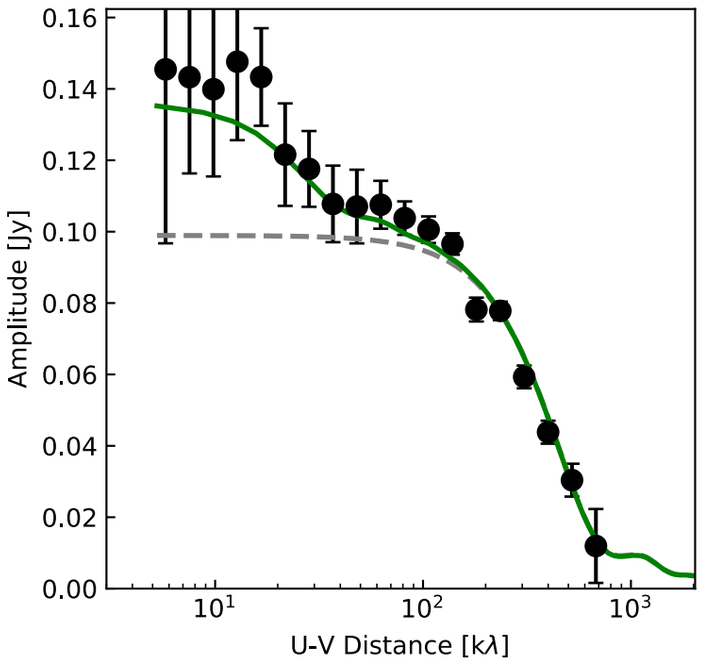
Class I protostars in Taurus

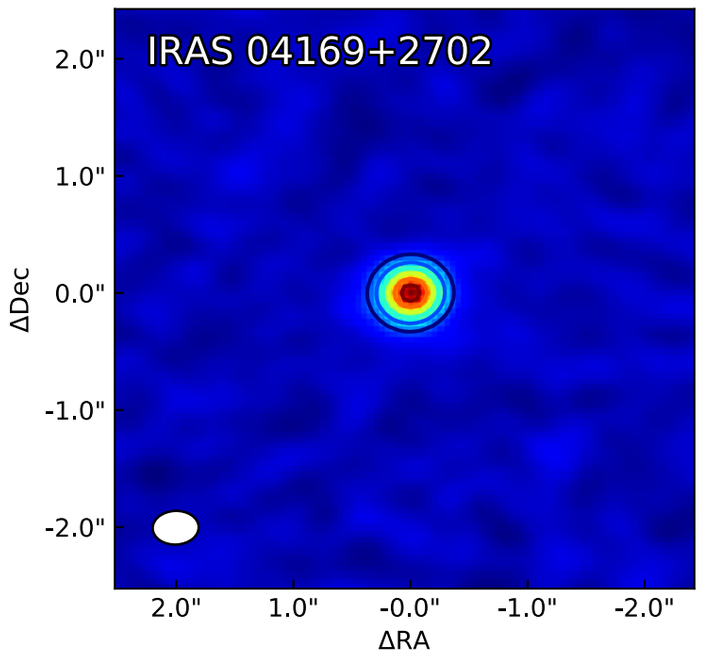
Sheehan & Eisner 2017b

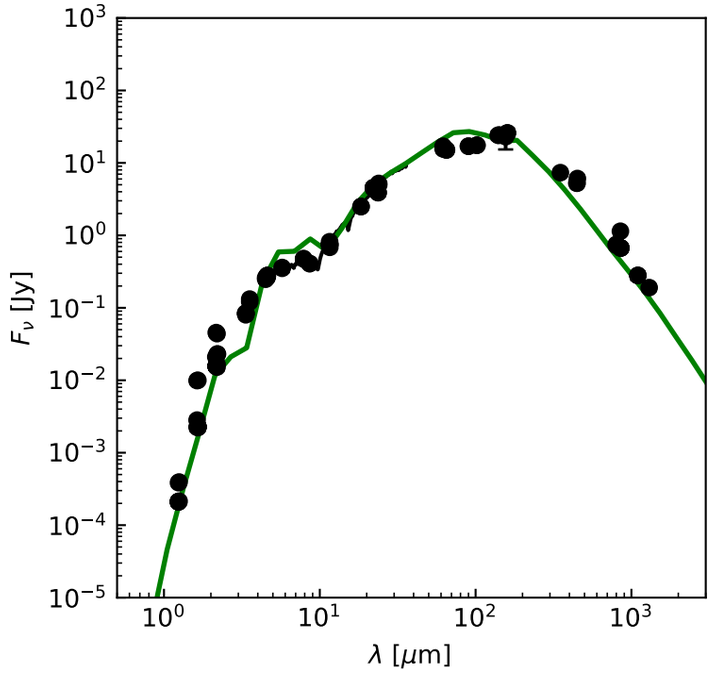




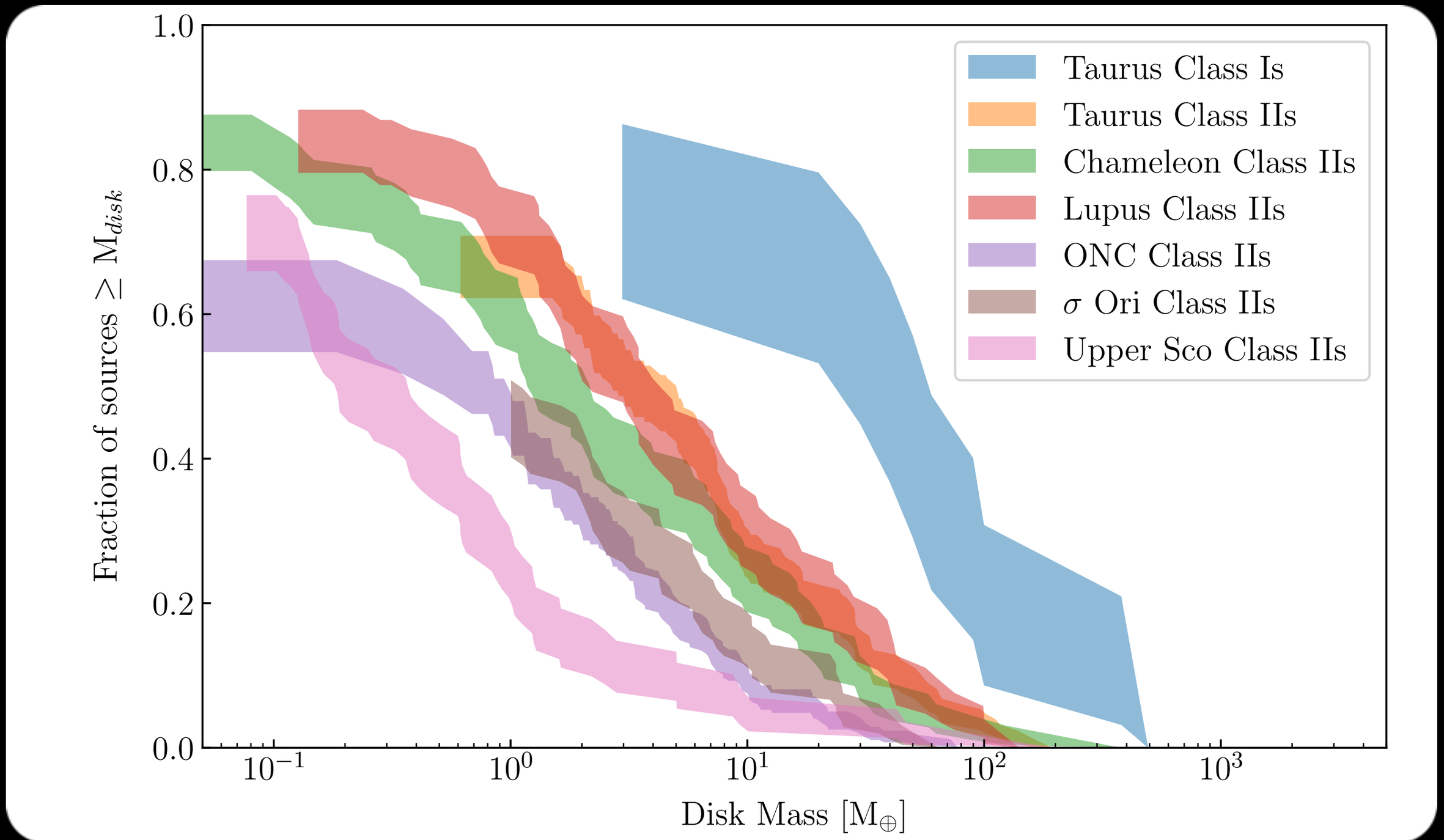








The Initial Mass Budget for Forming Planets?

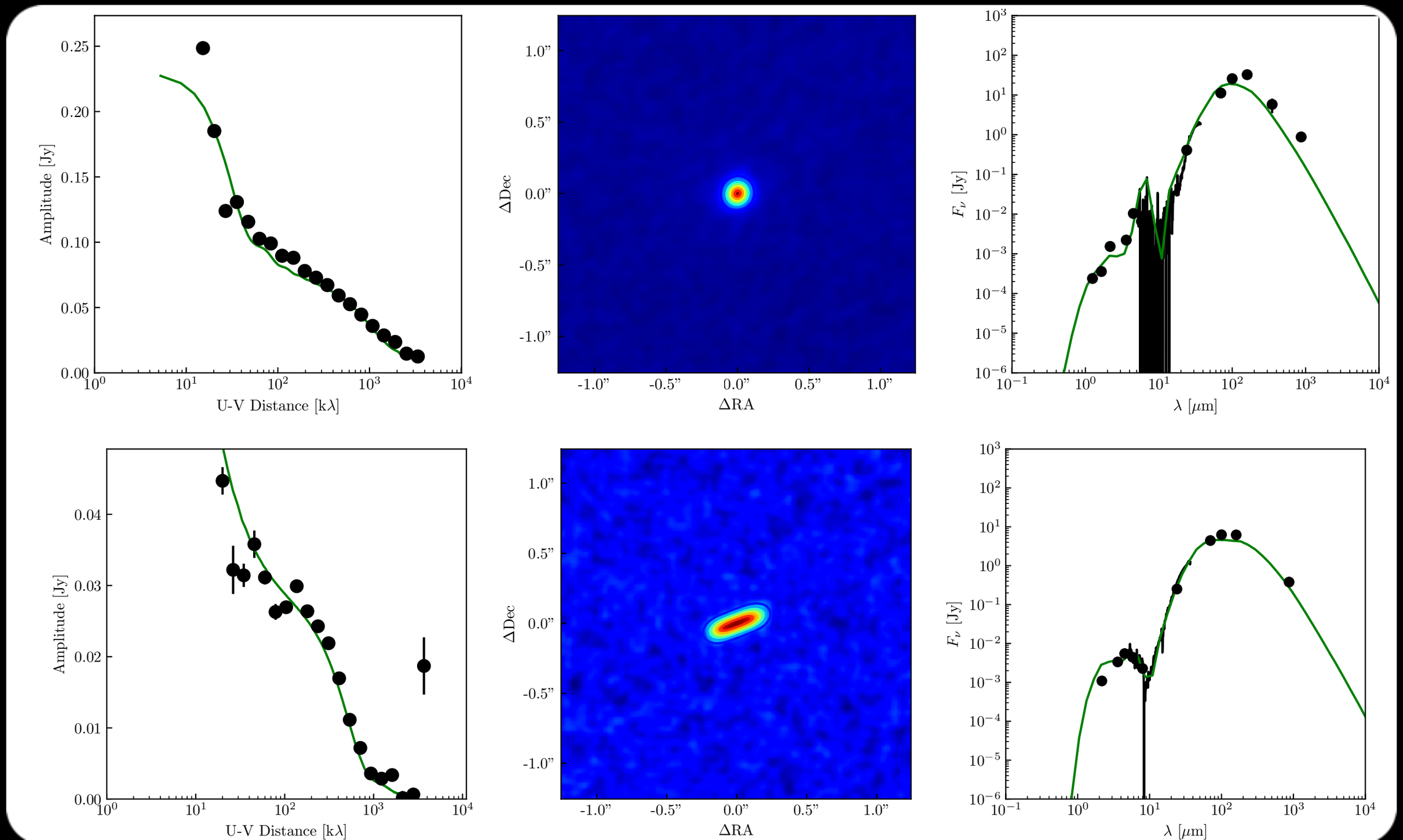


Sheehan & Eisner 2017b

- With 10 sources, only a ~2.5σ result => need a bigger sample!

Modeling Class protostellar disks in Orion

- 5,000,000 core-hour allocation to model all 200 single protostars in the VANDAM: Orion survey with NSF XSEDE supercomputers



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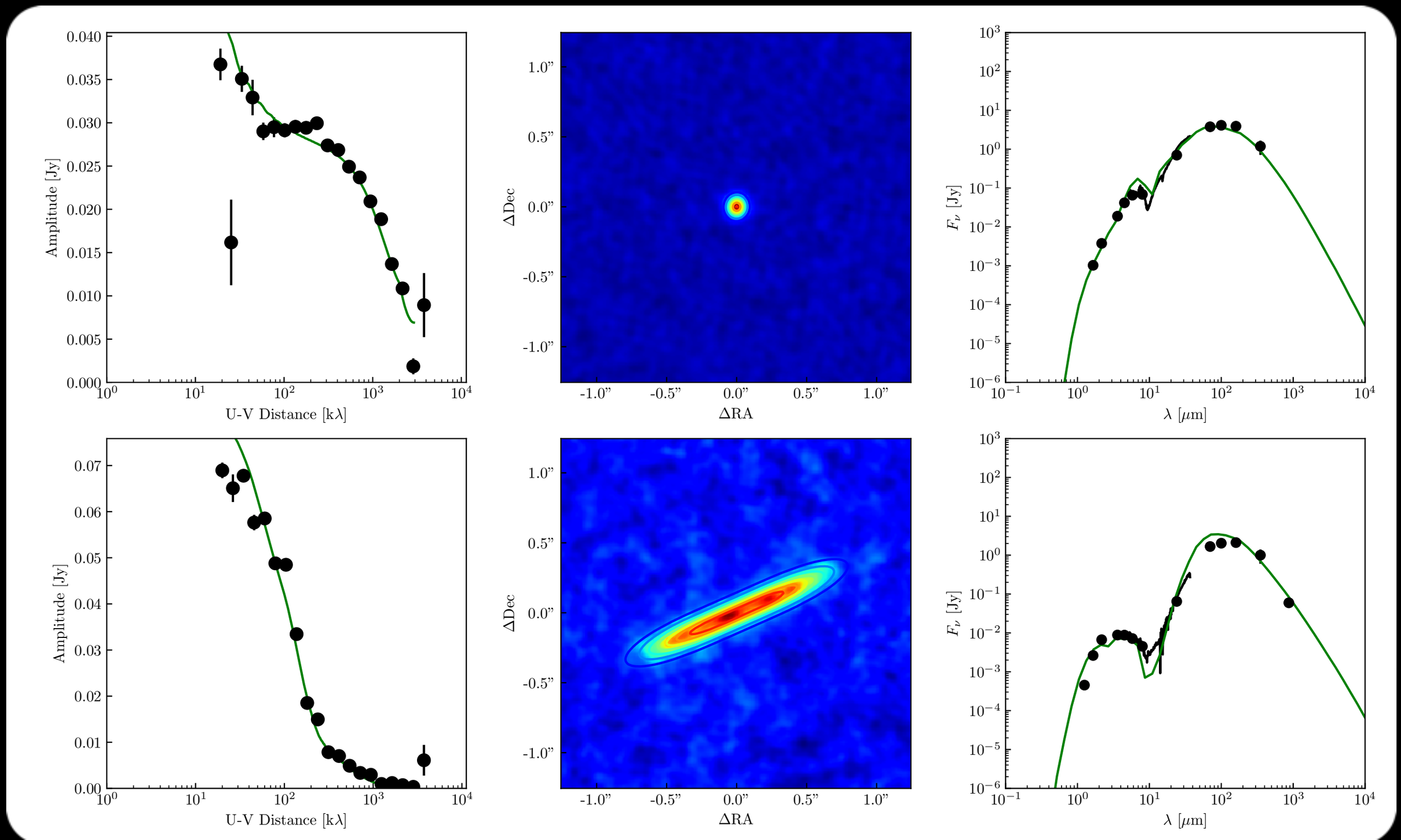

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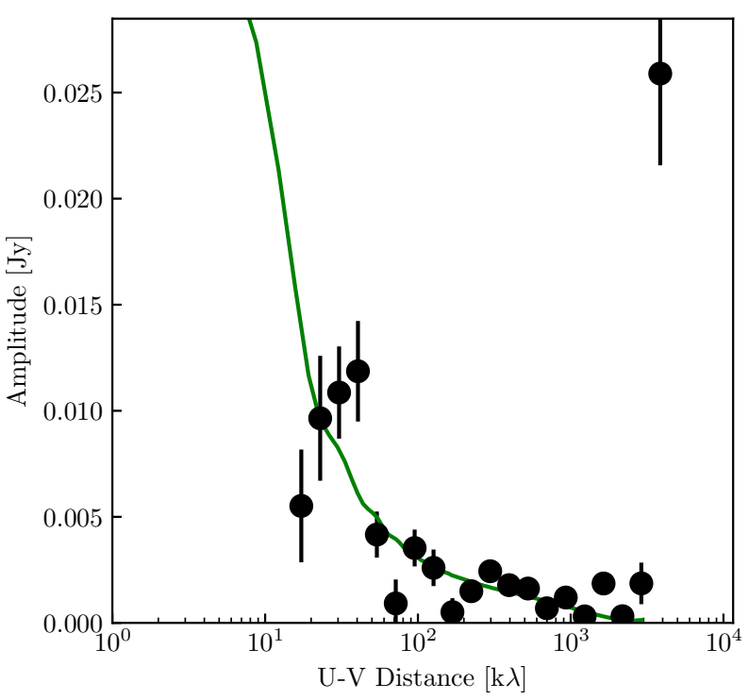

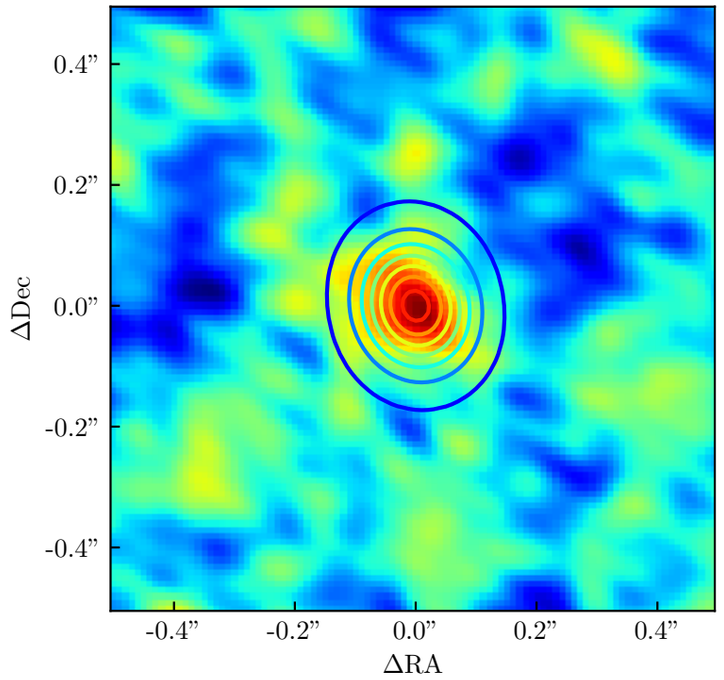

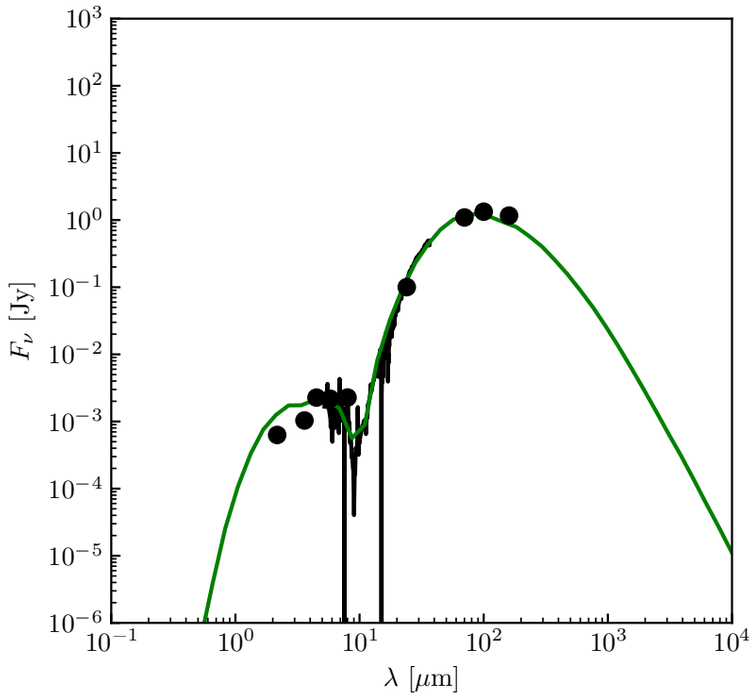

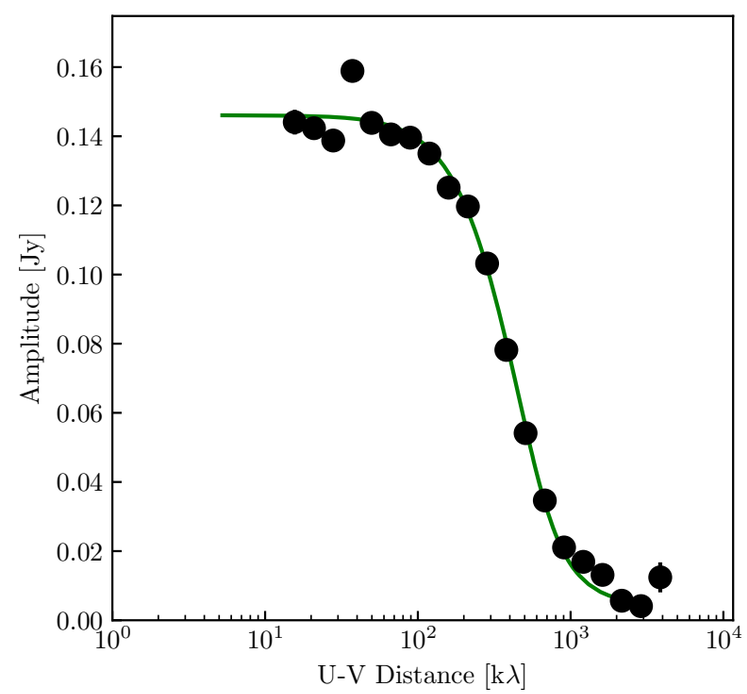

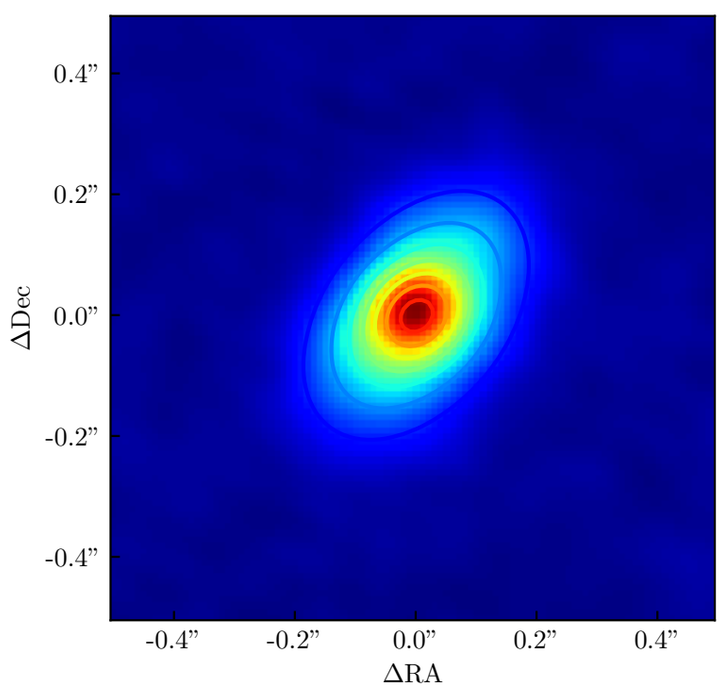

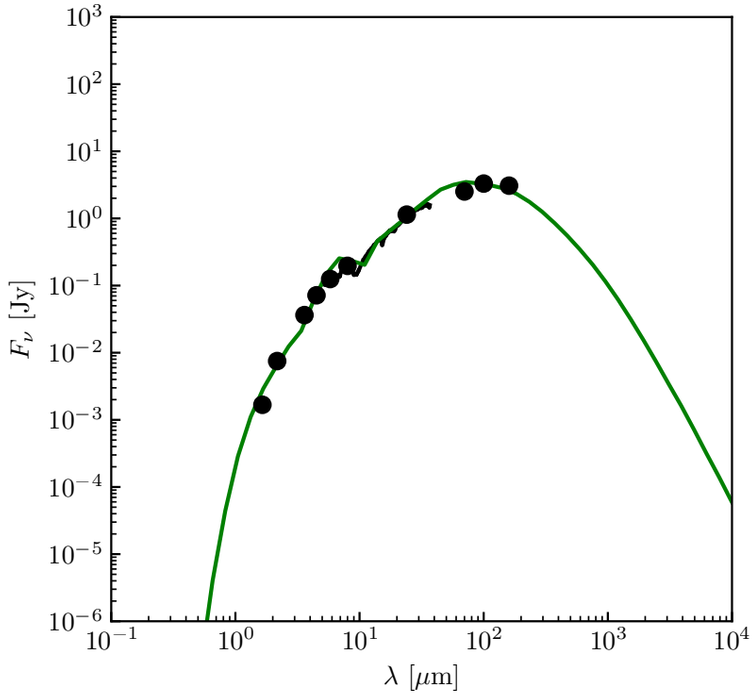

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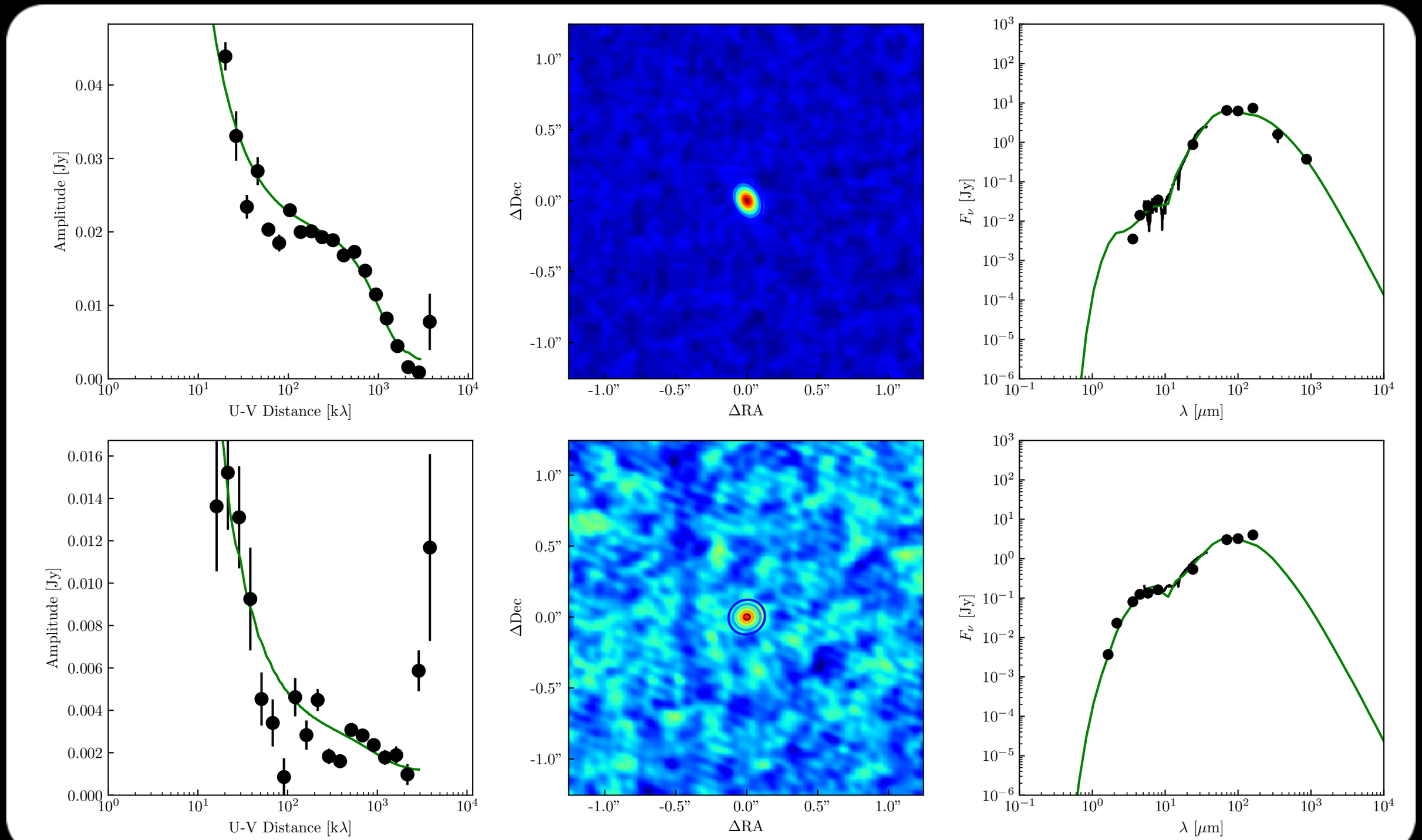
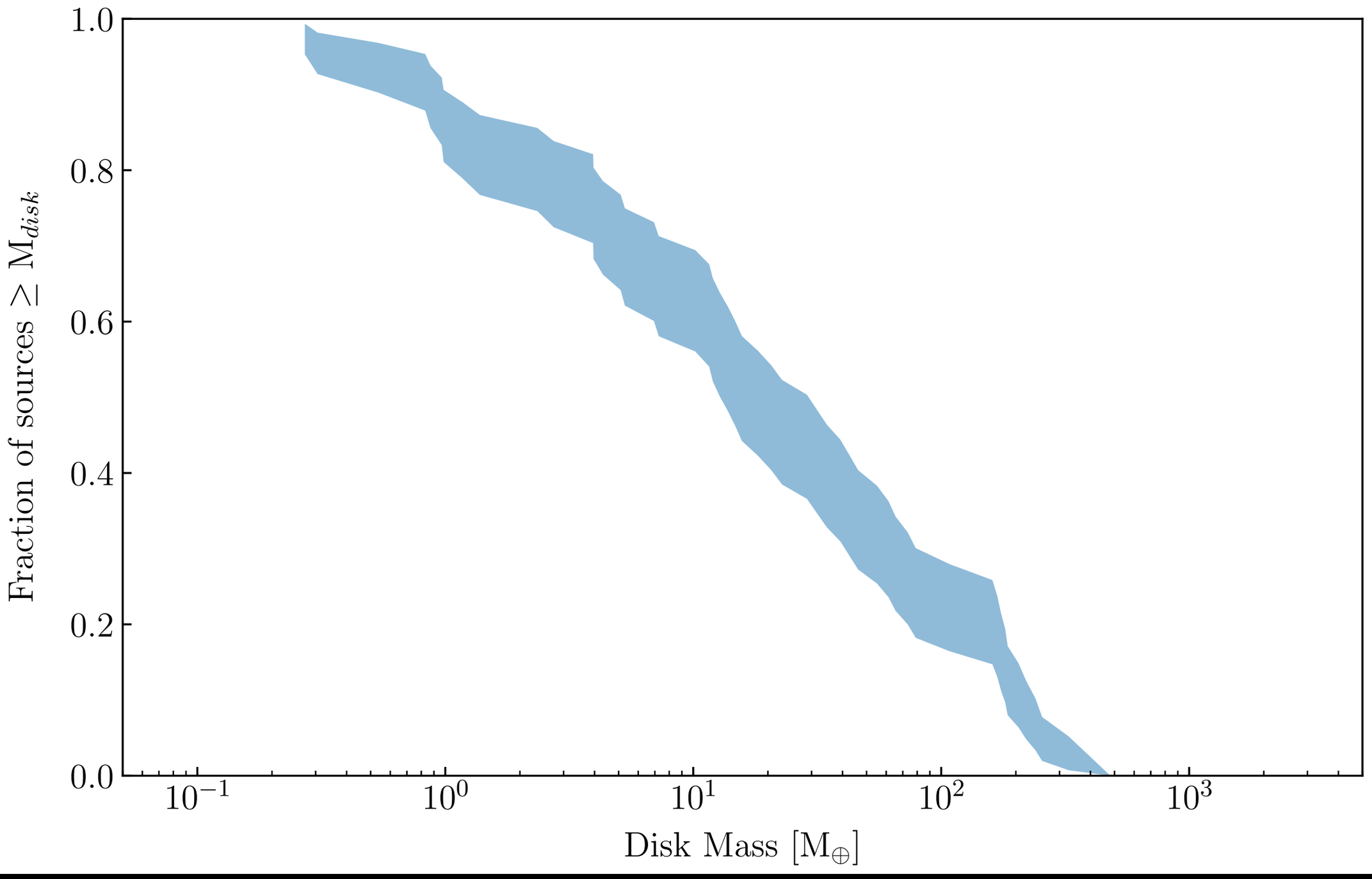
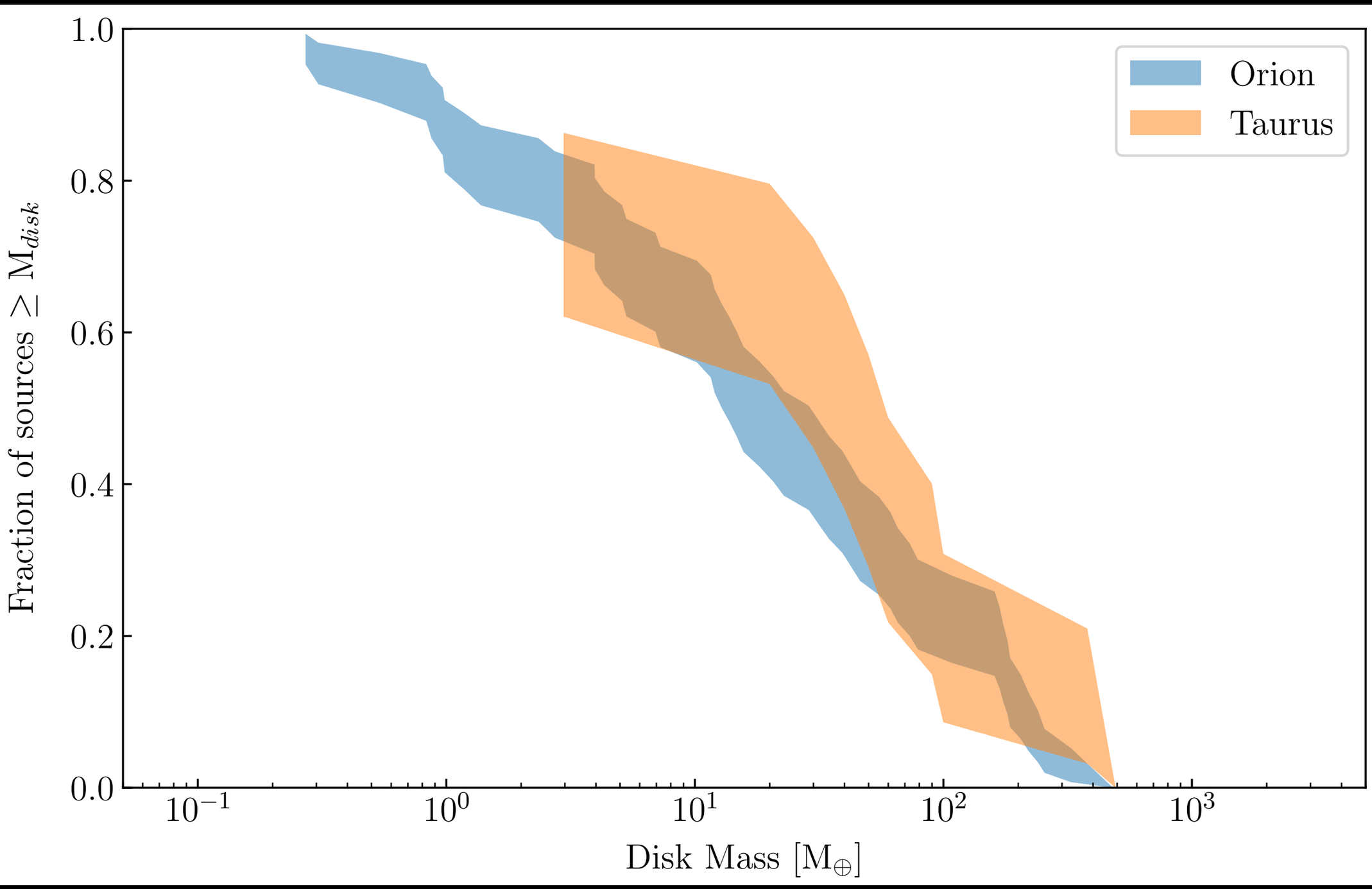


Protostellar disk demographics

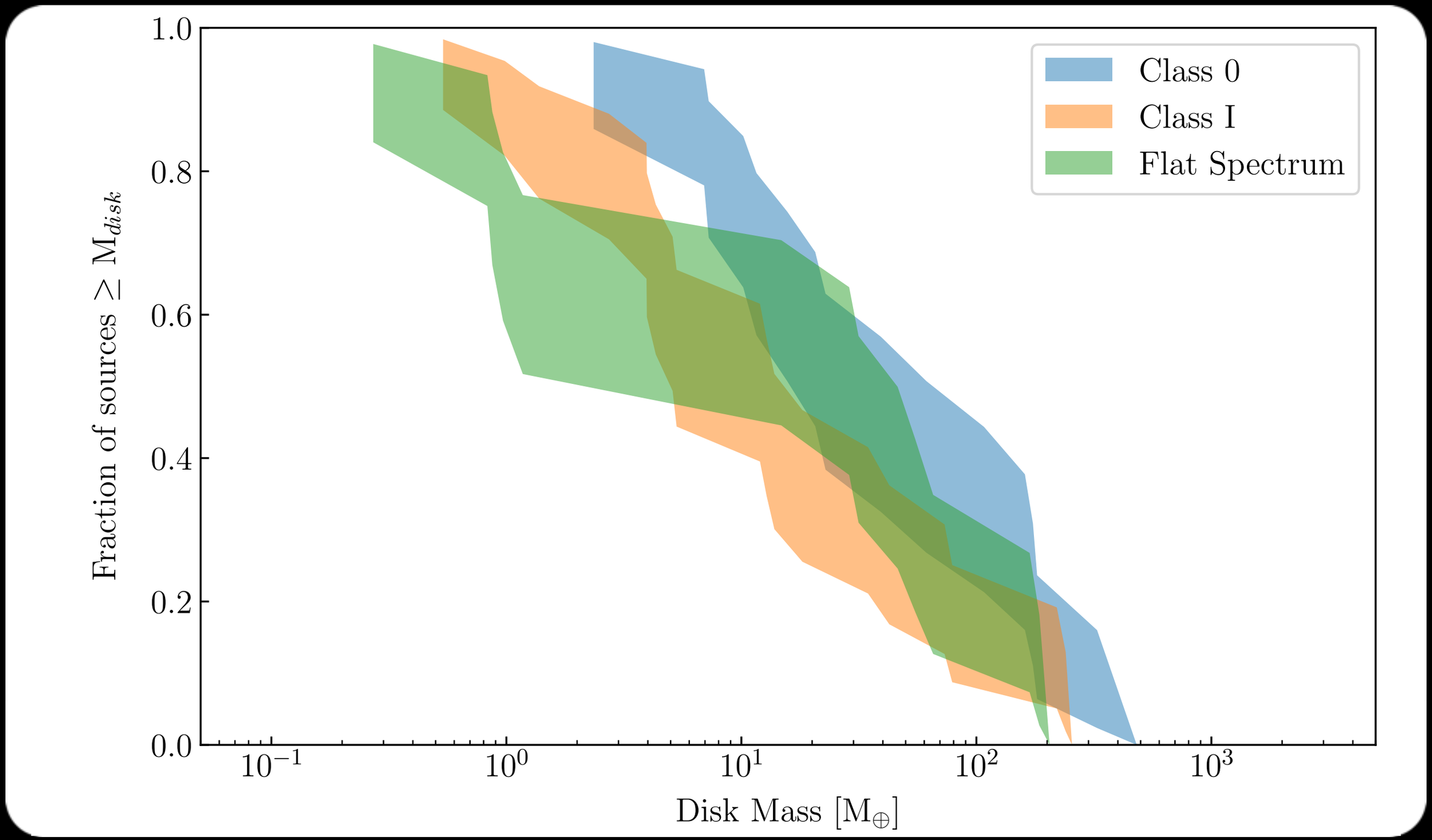


- About 50 radiative transfer models done so far

Protostellar disk demographics



Protostellar disk demographics



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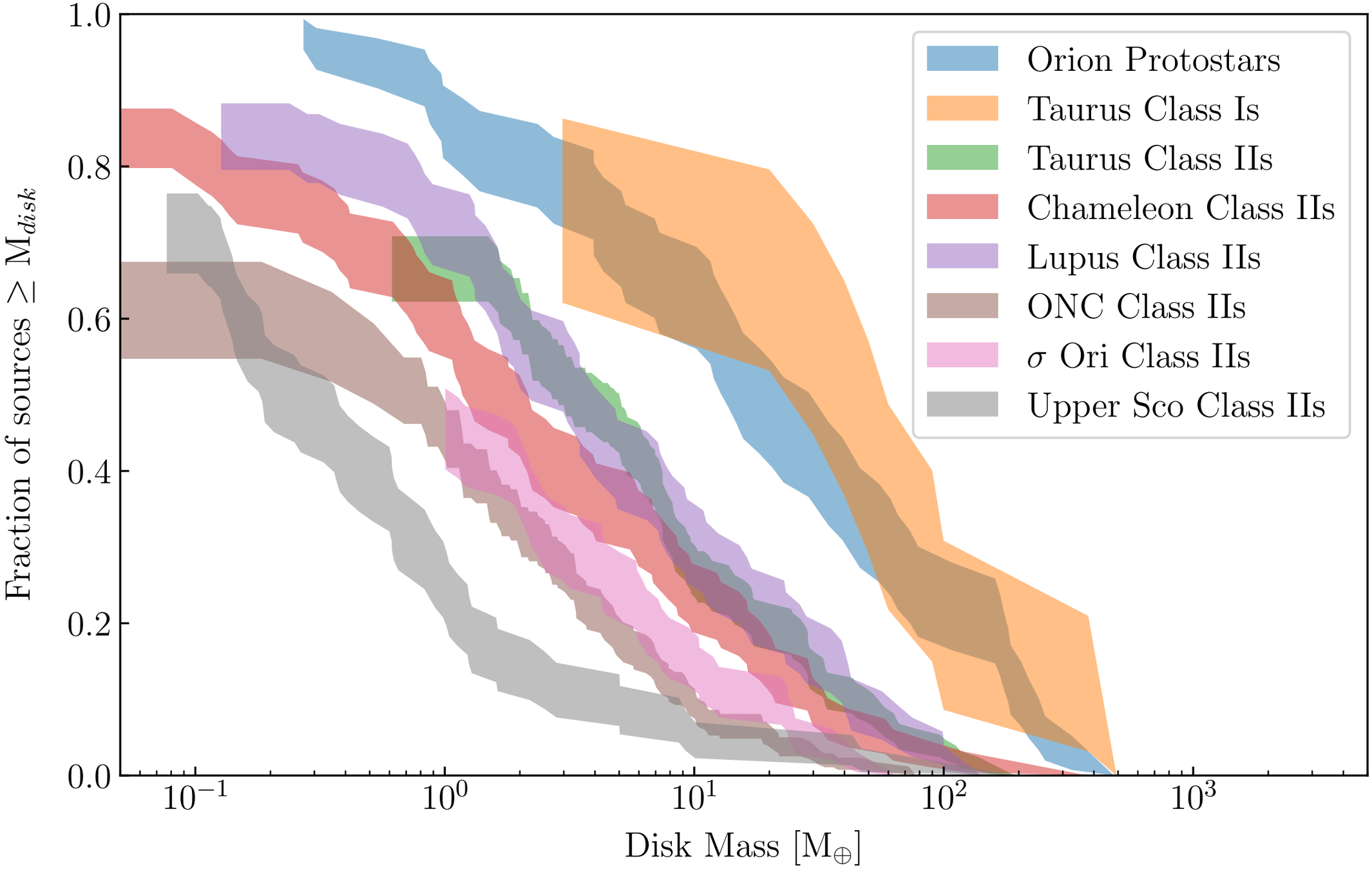

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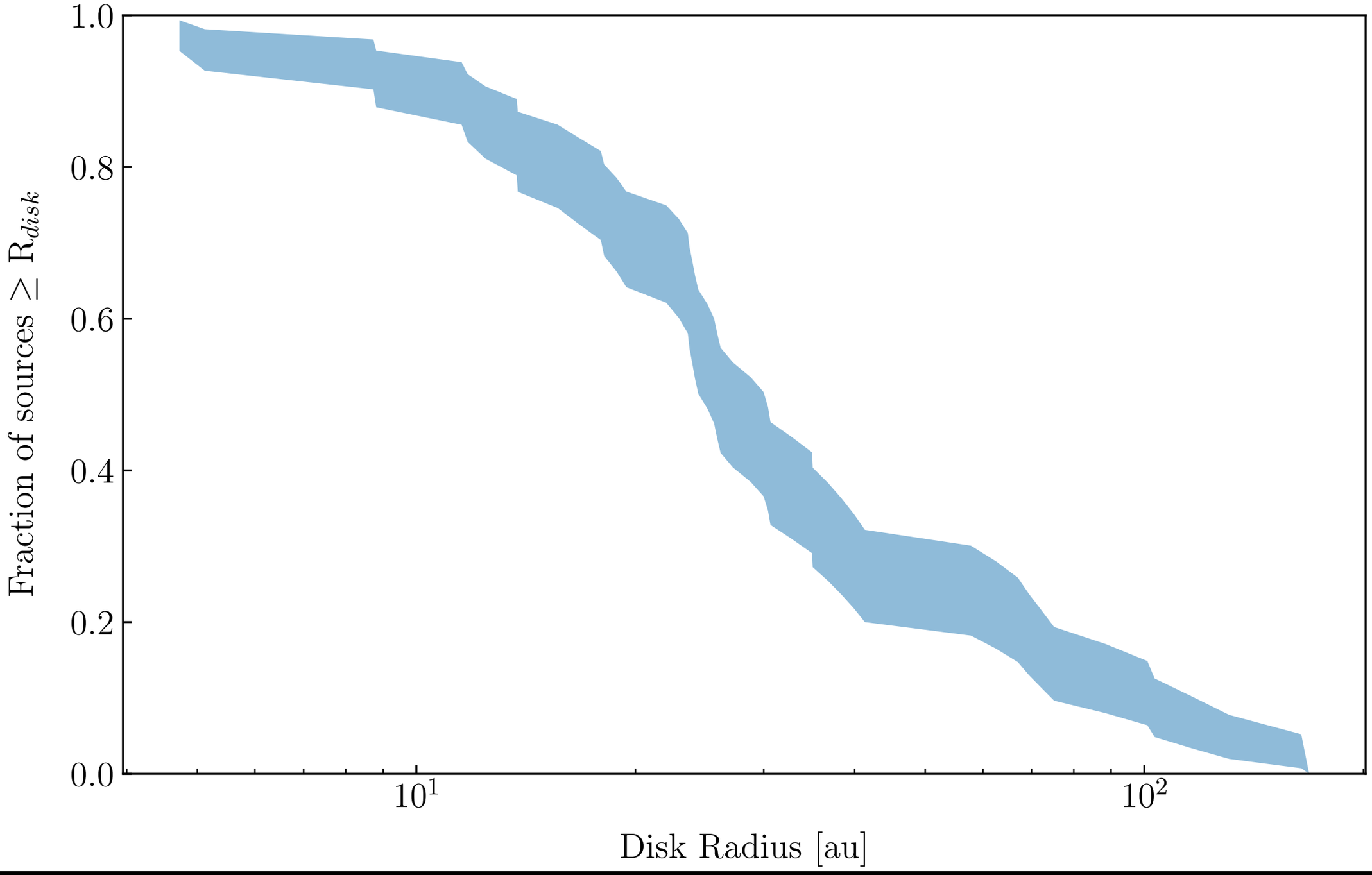

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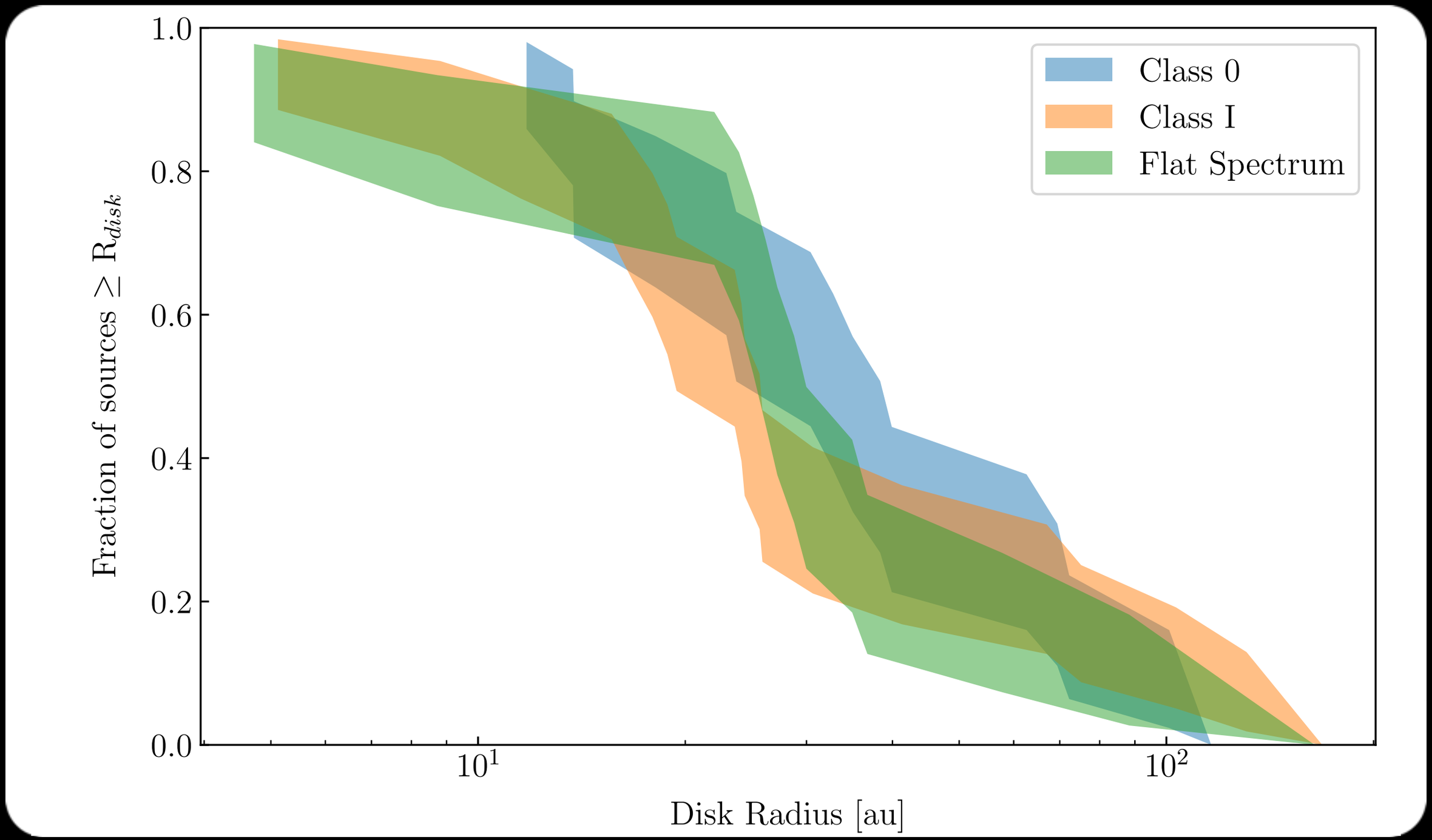

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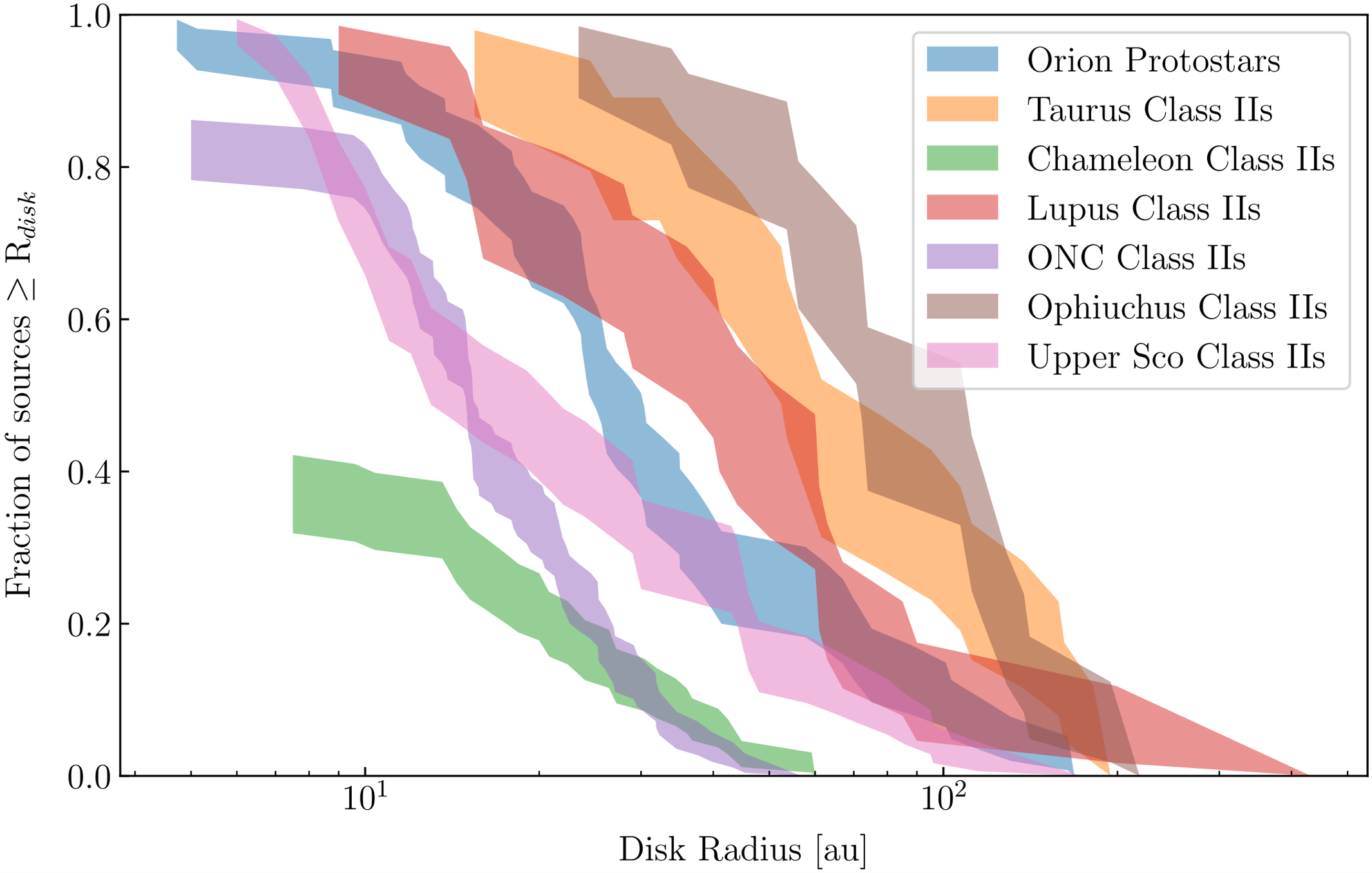
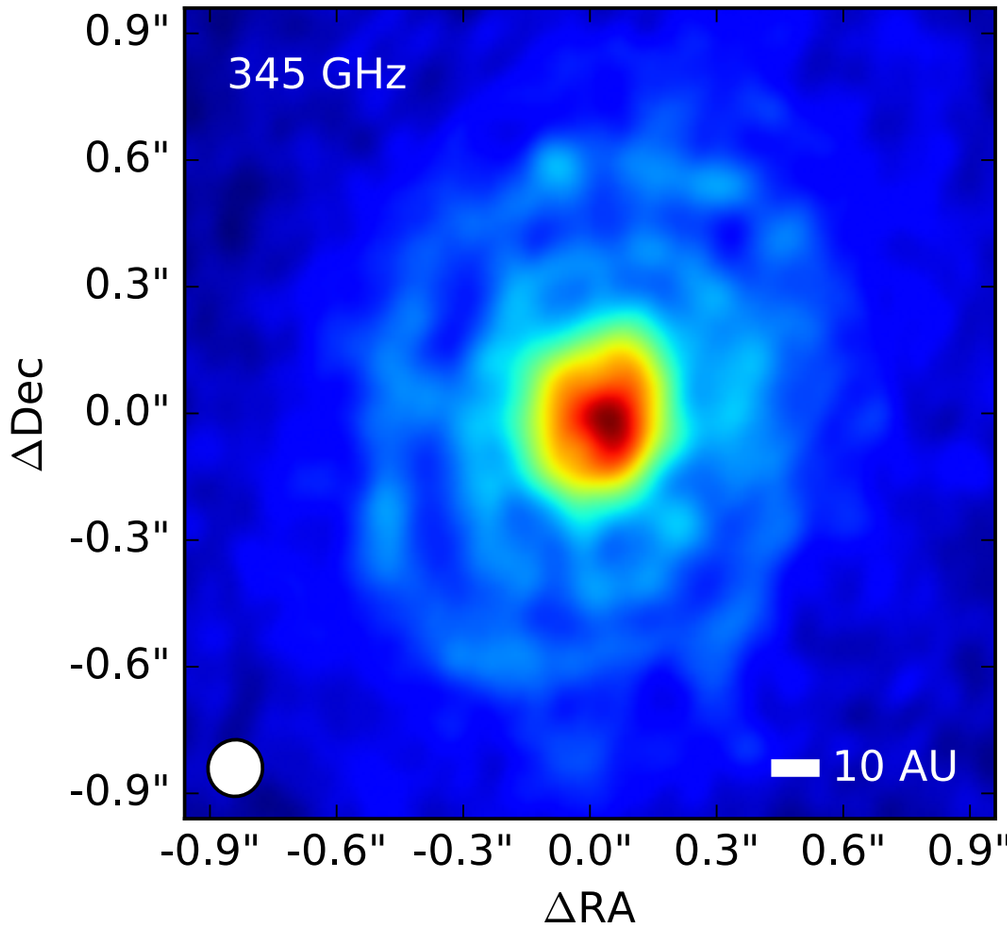
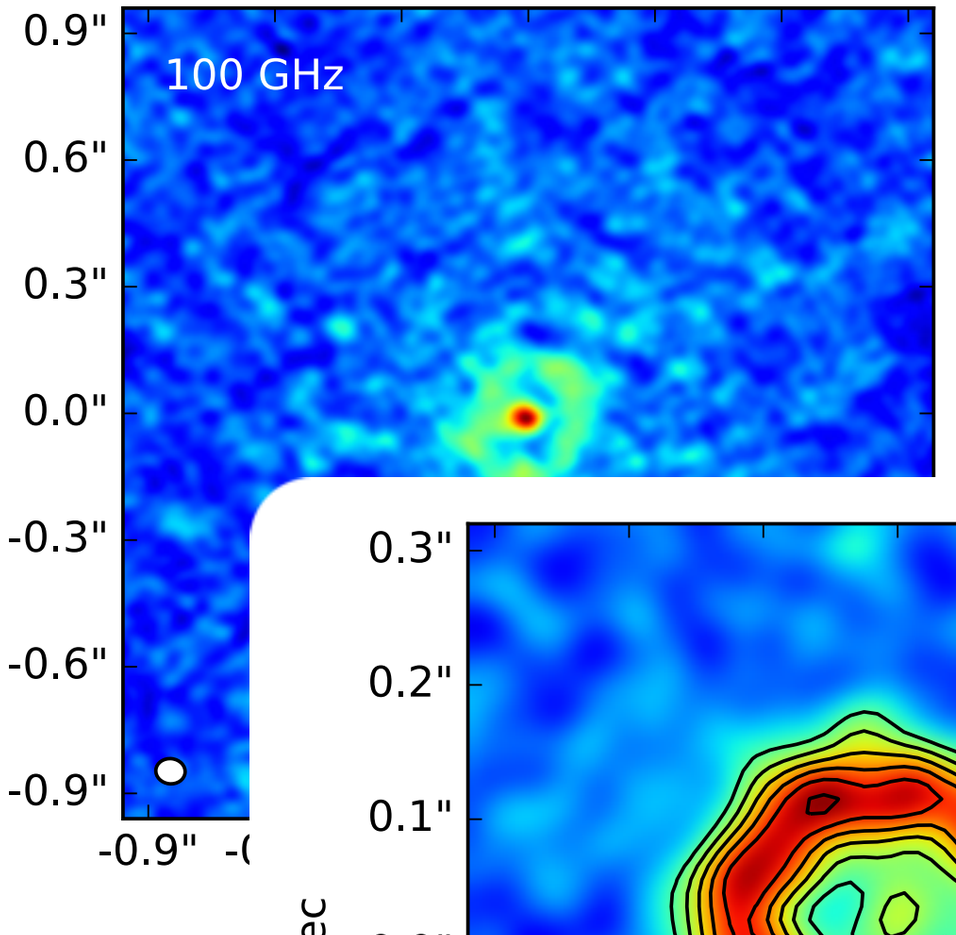


- Only 50% done => stay tuned!

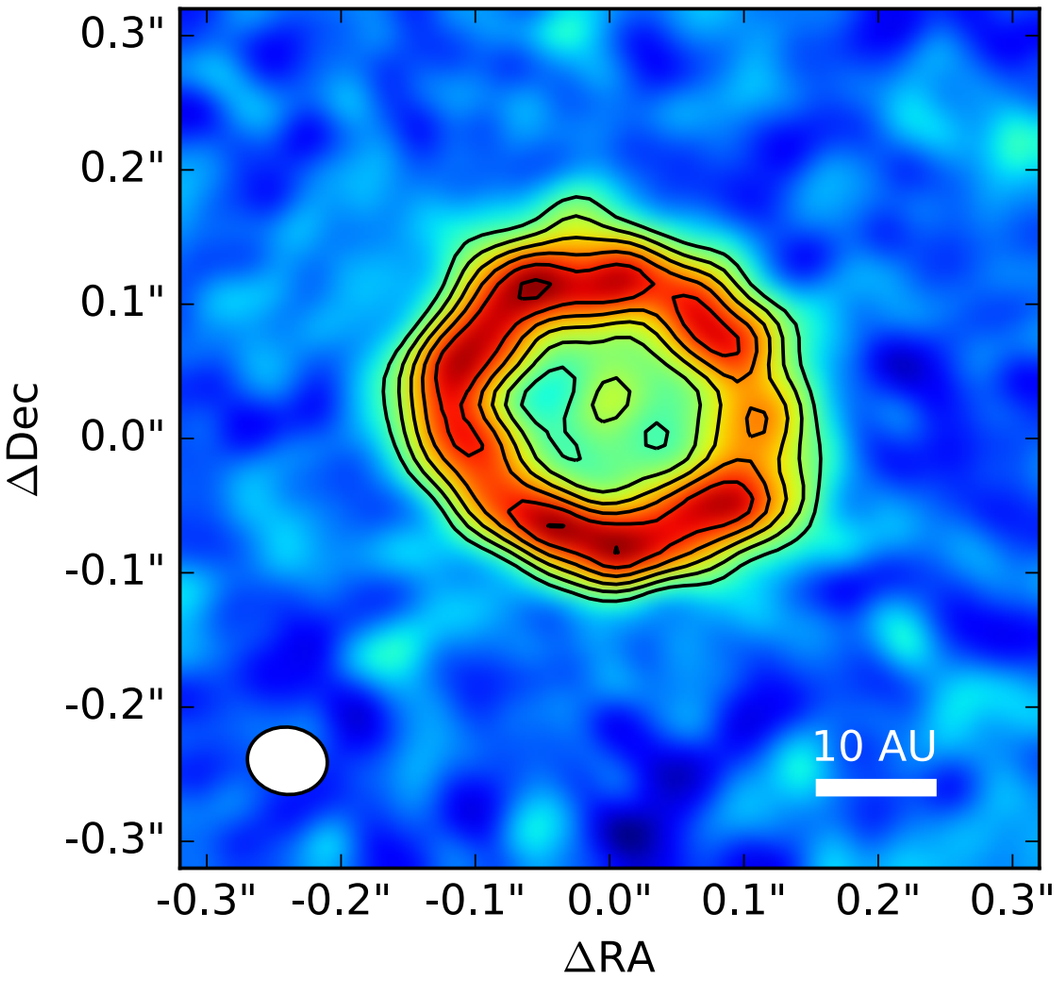
Sub-structures In Embedded Disks

Sheehan & Eisner 2018

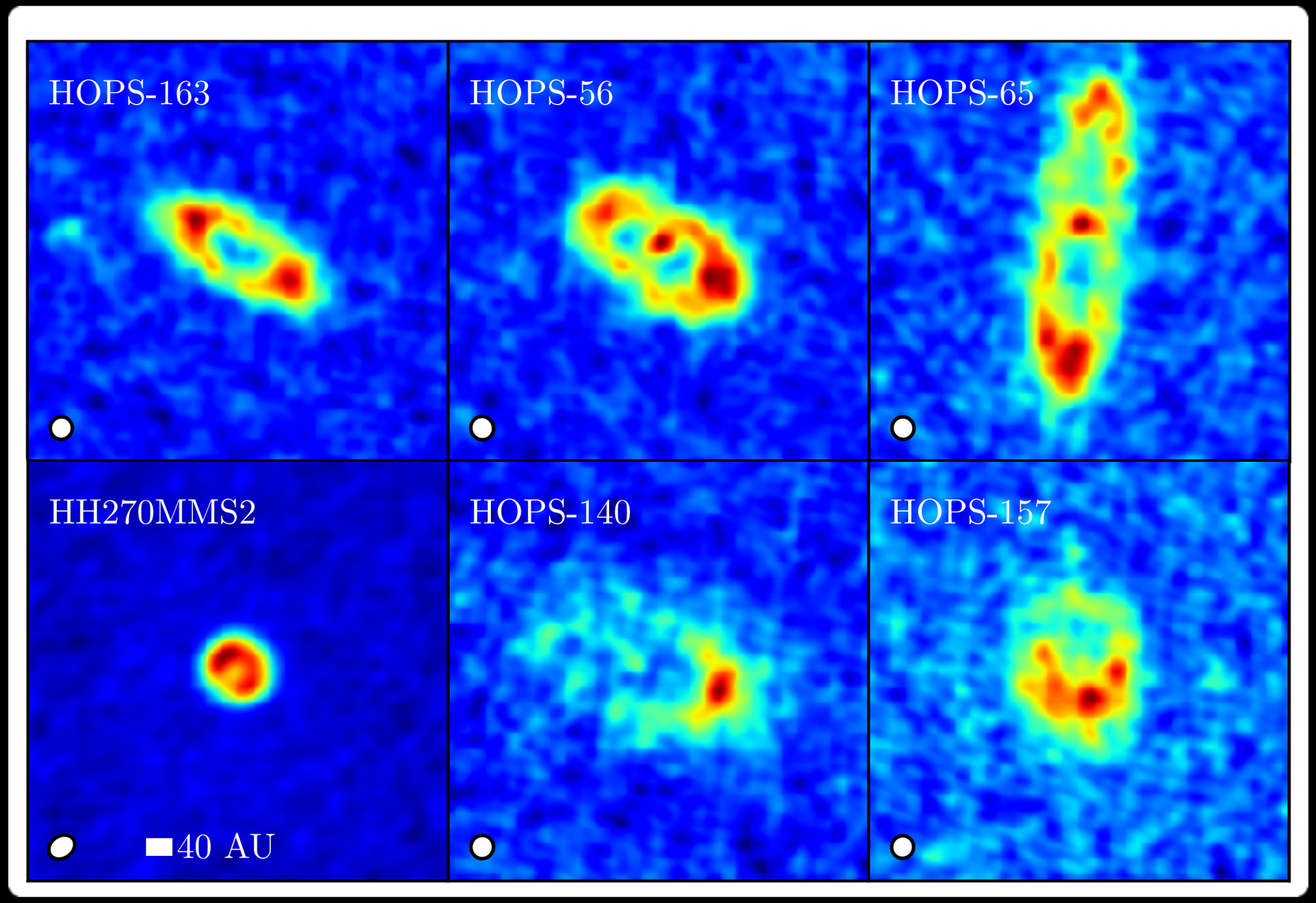




Sheehan & Eisner 2017a

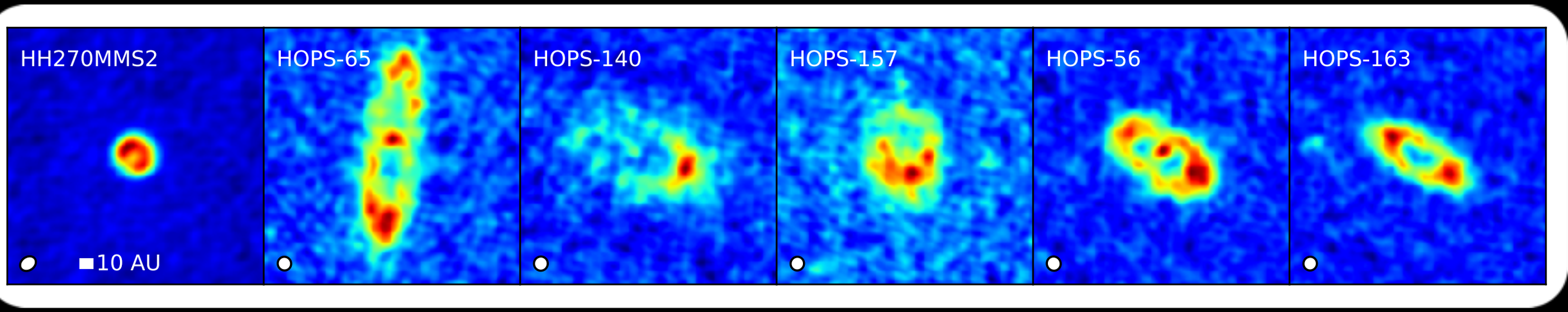


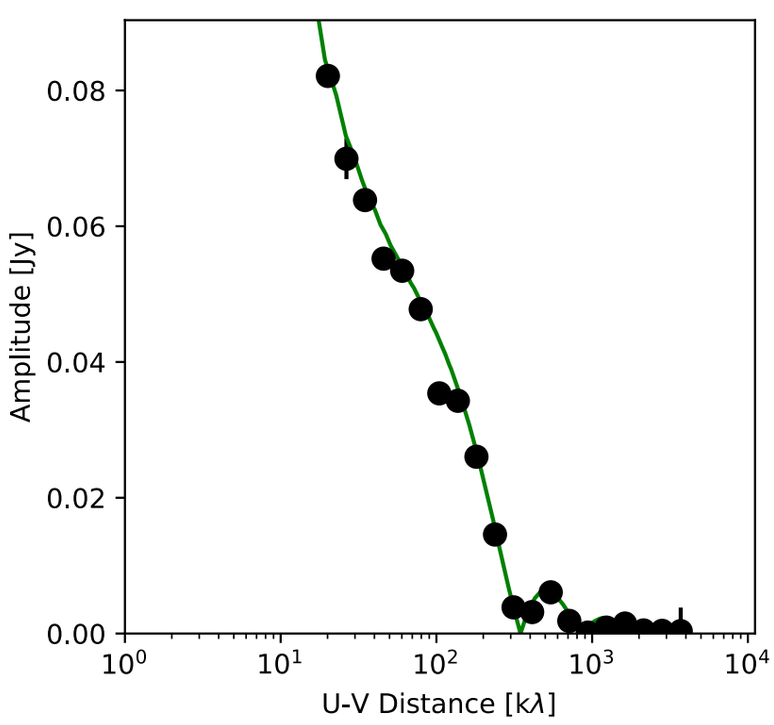
Sub-structures In Embedded Disks

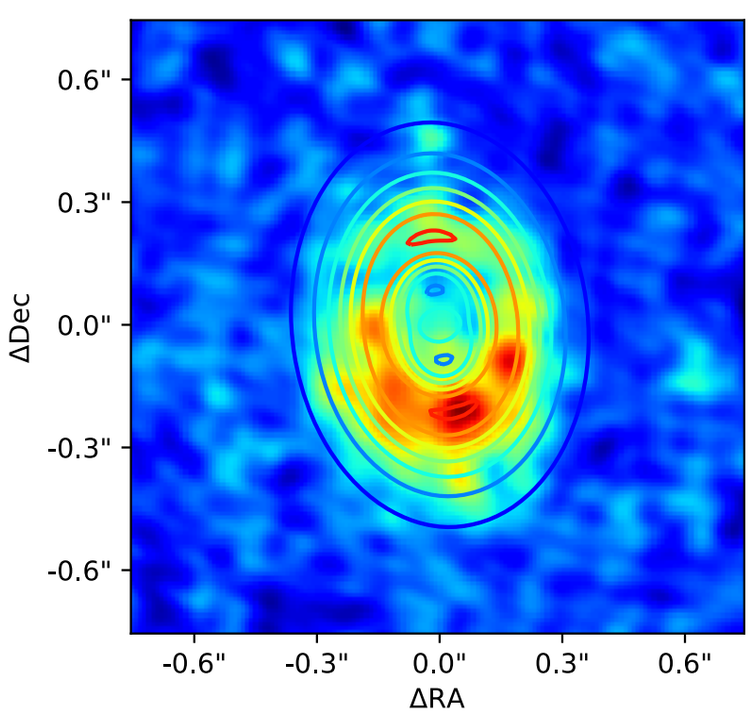


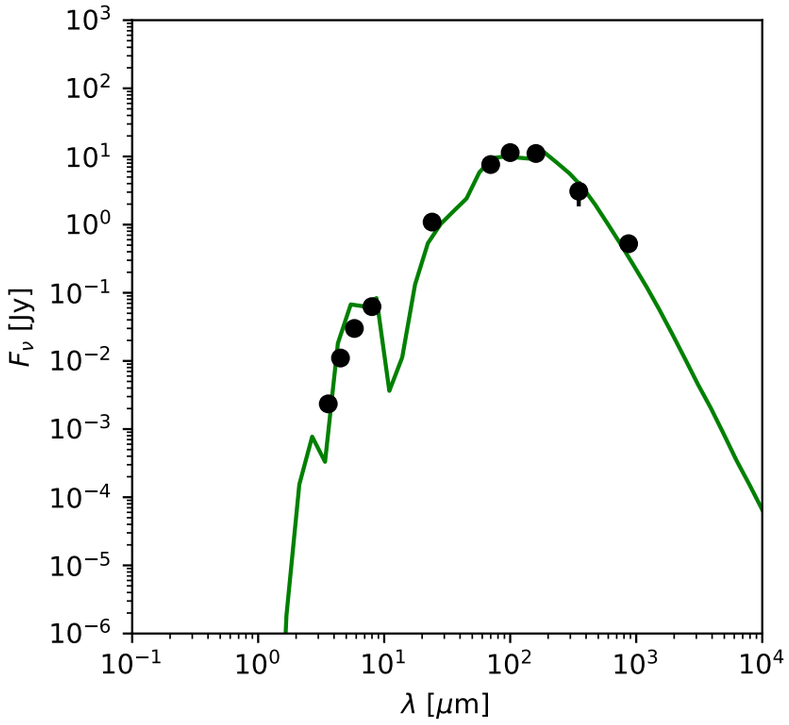
- Gap widths from 17 — 200 au
- Azimuthal asymmetries in many of the “transition disk” sources
- Several have inner disks

Sub-structures In Embedded Disks



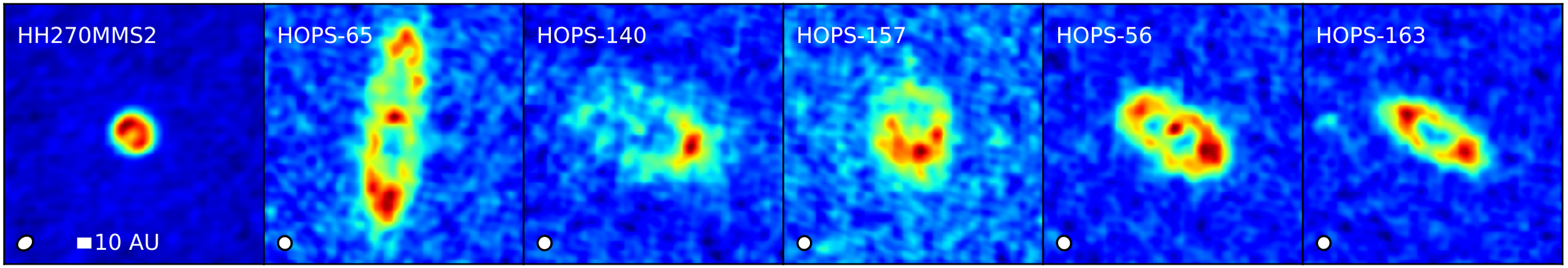


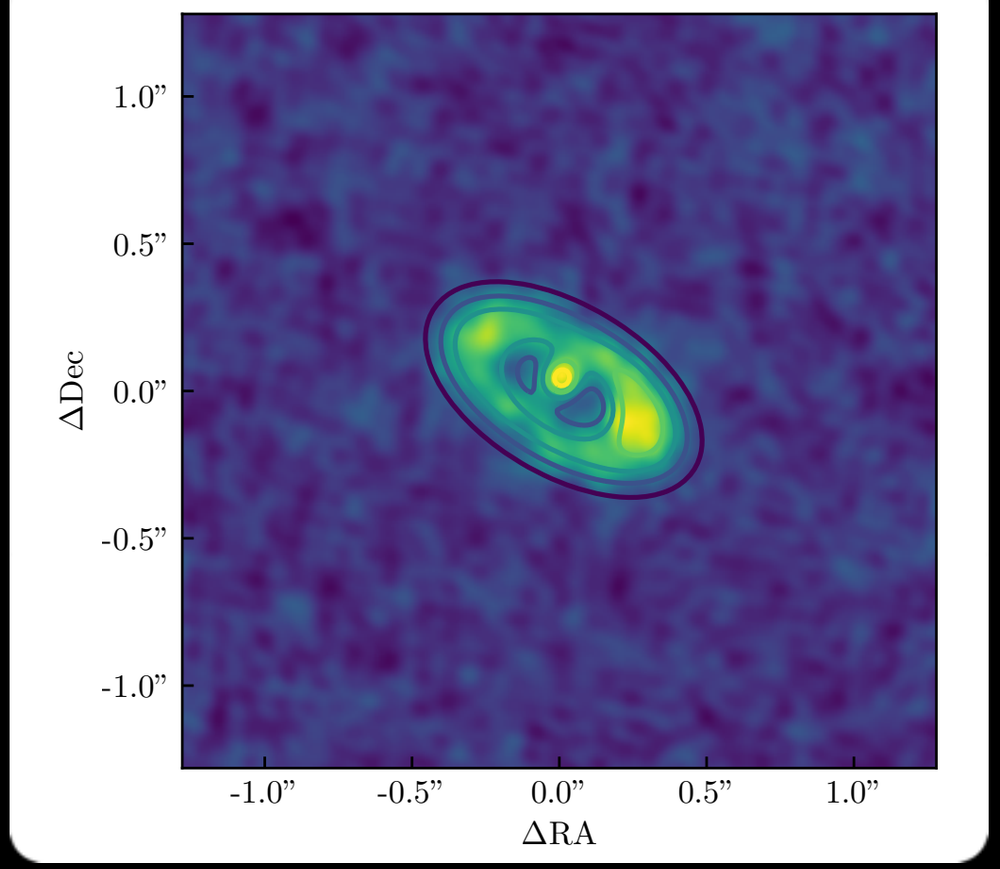


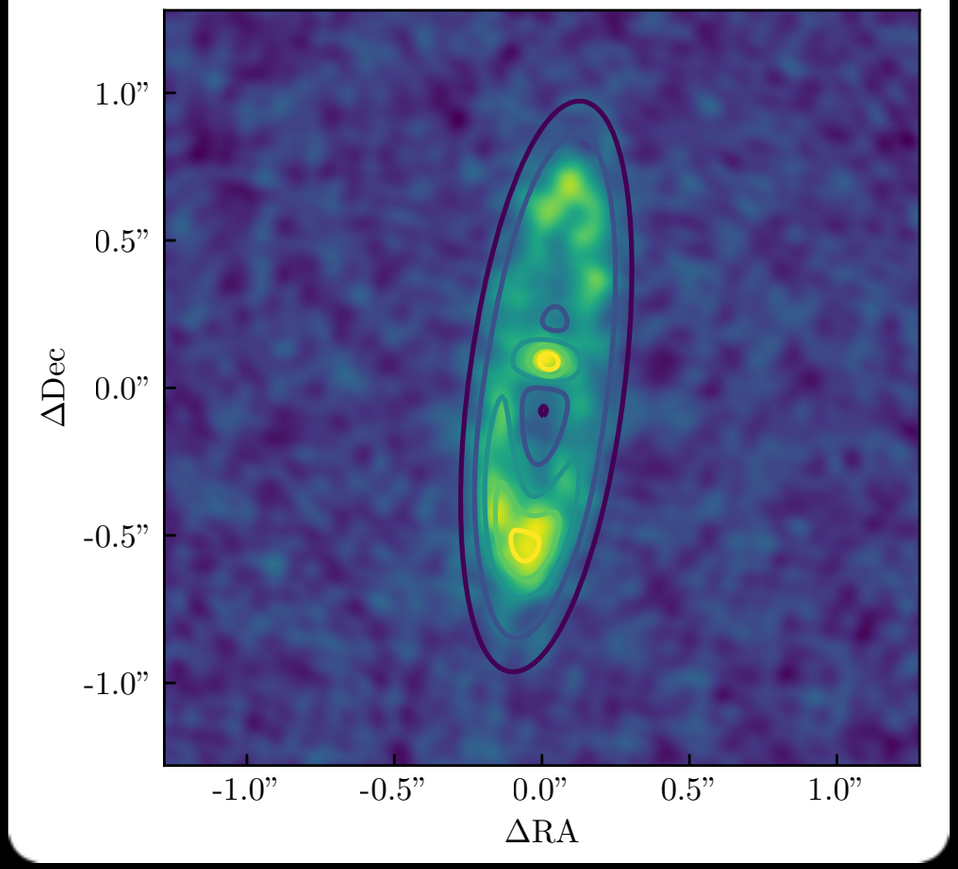


- At least a few of the sources are heavily embedded => young!

Sub-structures In Embedded Disks



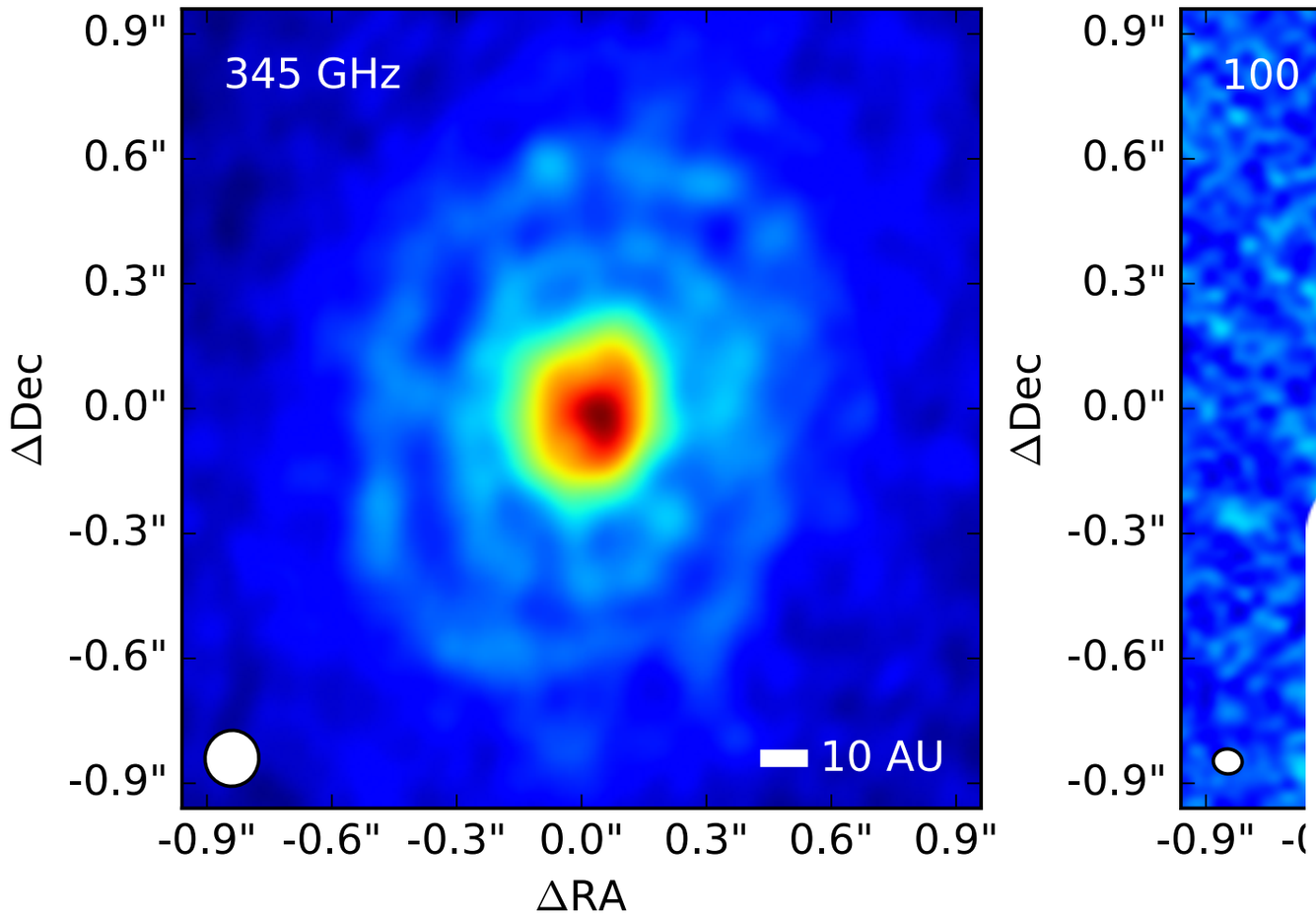


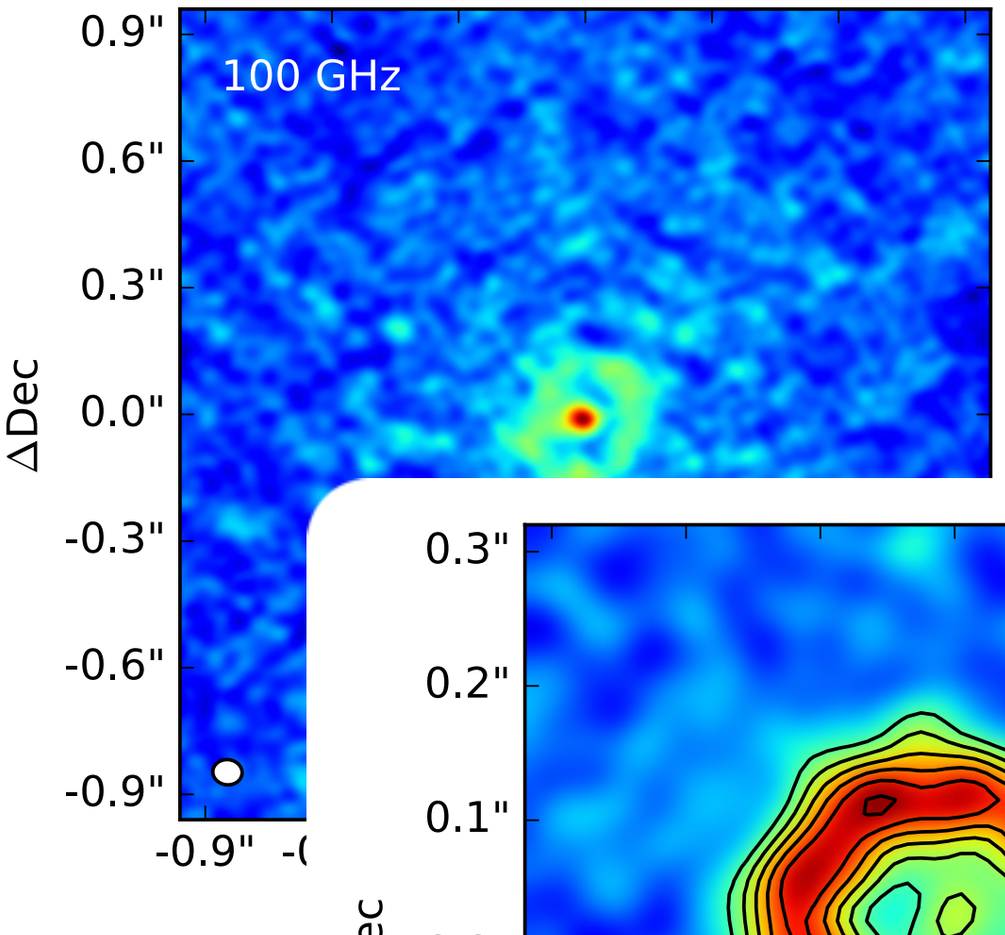


- Some of the inner disks appear to not line up with the center of the outer ring - offset by ~0.05 — 0.1”

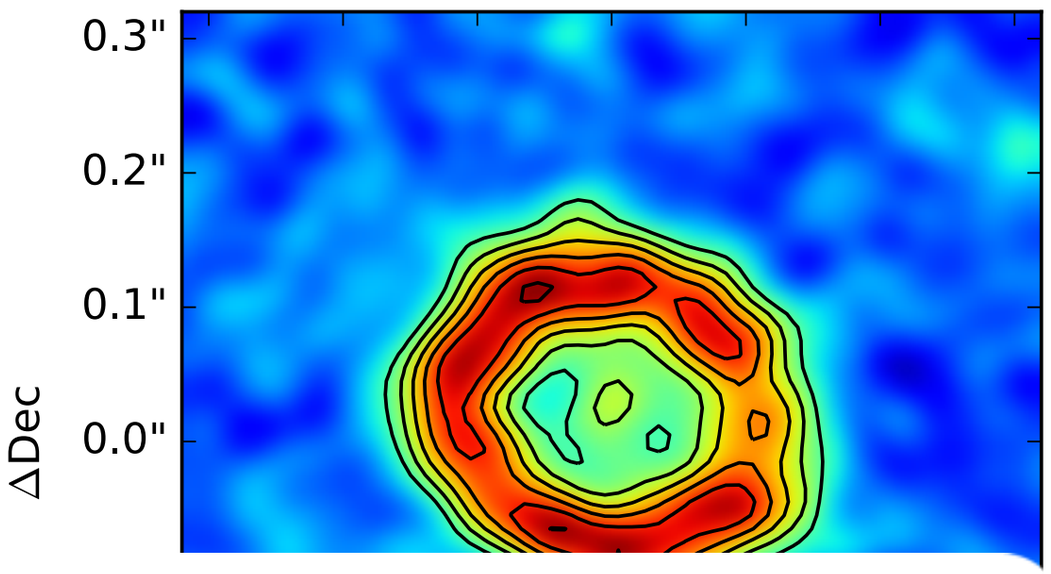
Dynamical sculpting by large bodies?

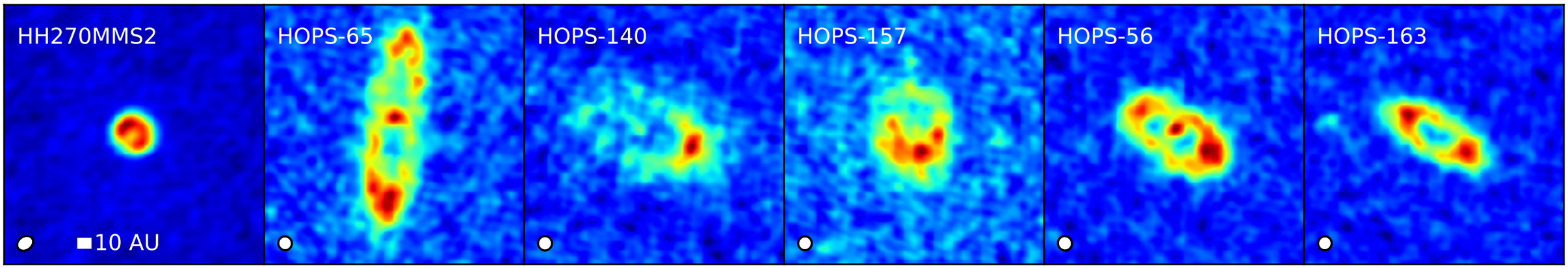
Sheehan & Eisner 2018





Sheehan & Eisner 2017a





Questions?