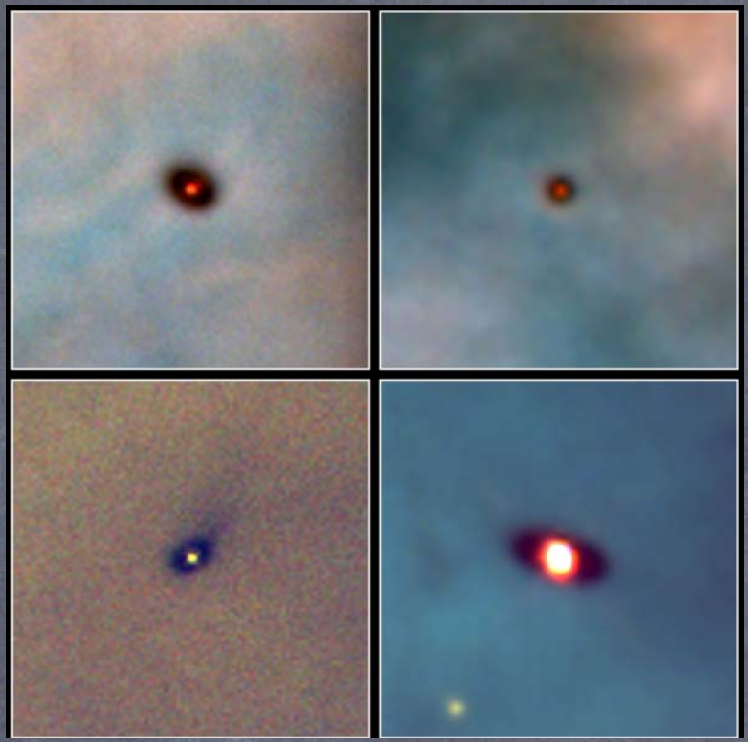
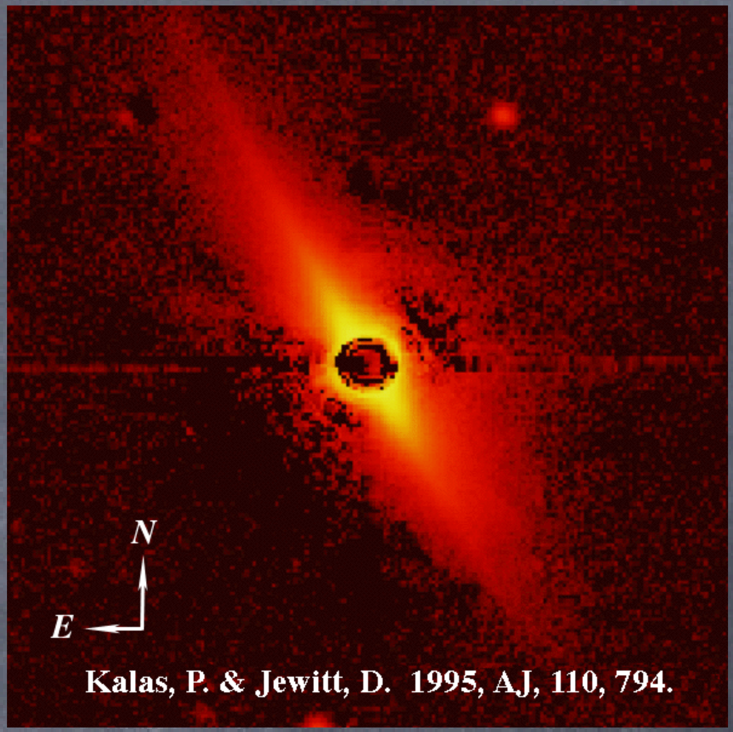
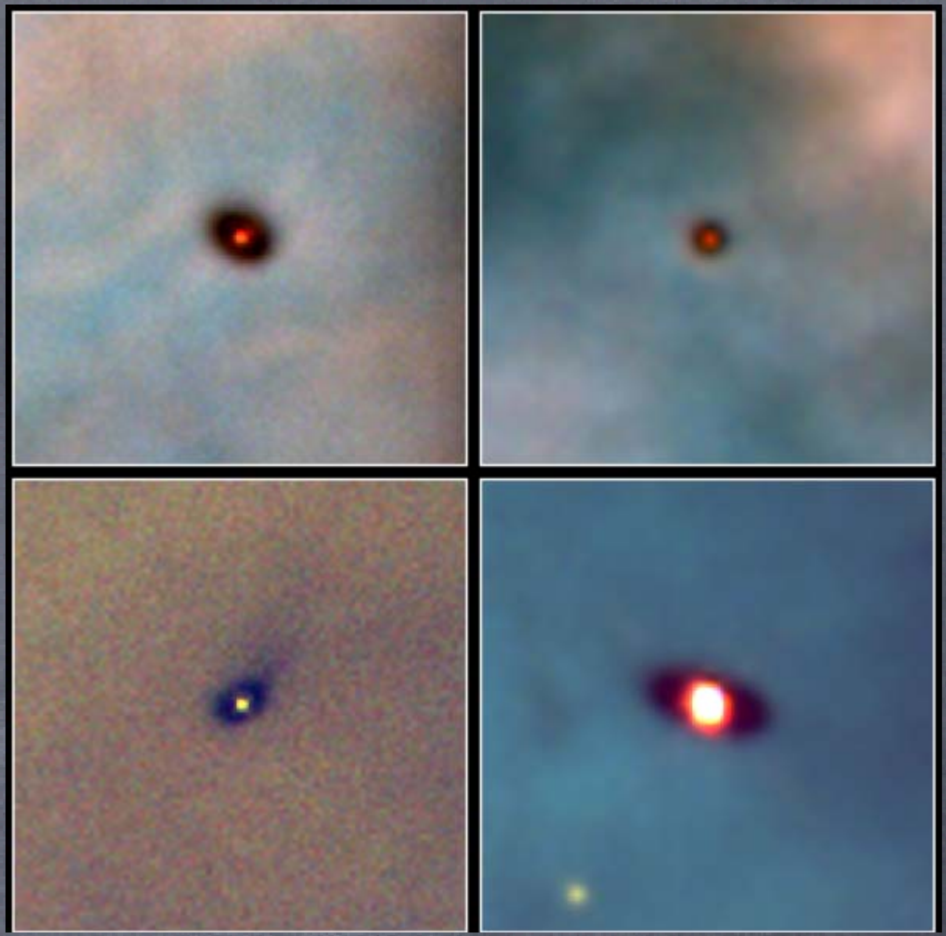
Probing Planet Formation with CCAT Observations of Circumstellar Disks

John Carpenter
California Institute of Technology

Formation of Stars and Planets

Dense cores	"Primordial" disks	"Debris" disks
		
0.1 Myr	1 Myr	> 5 Myr (?)

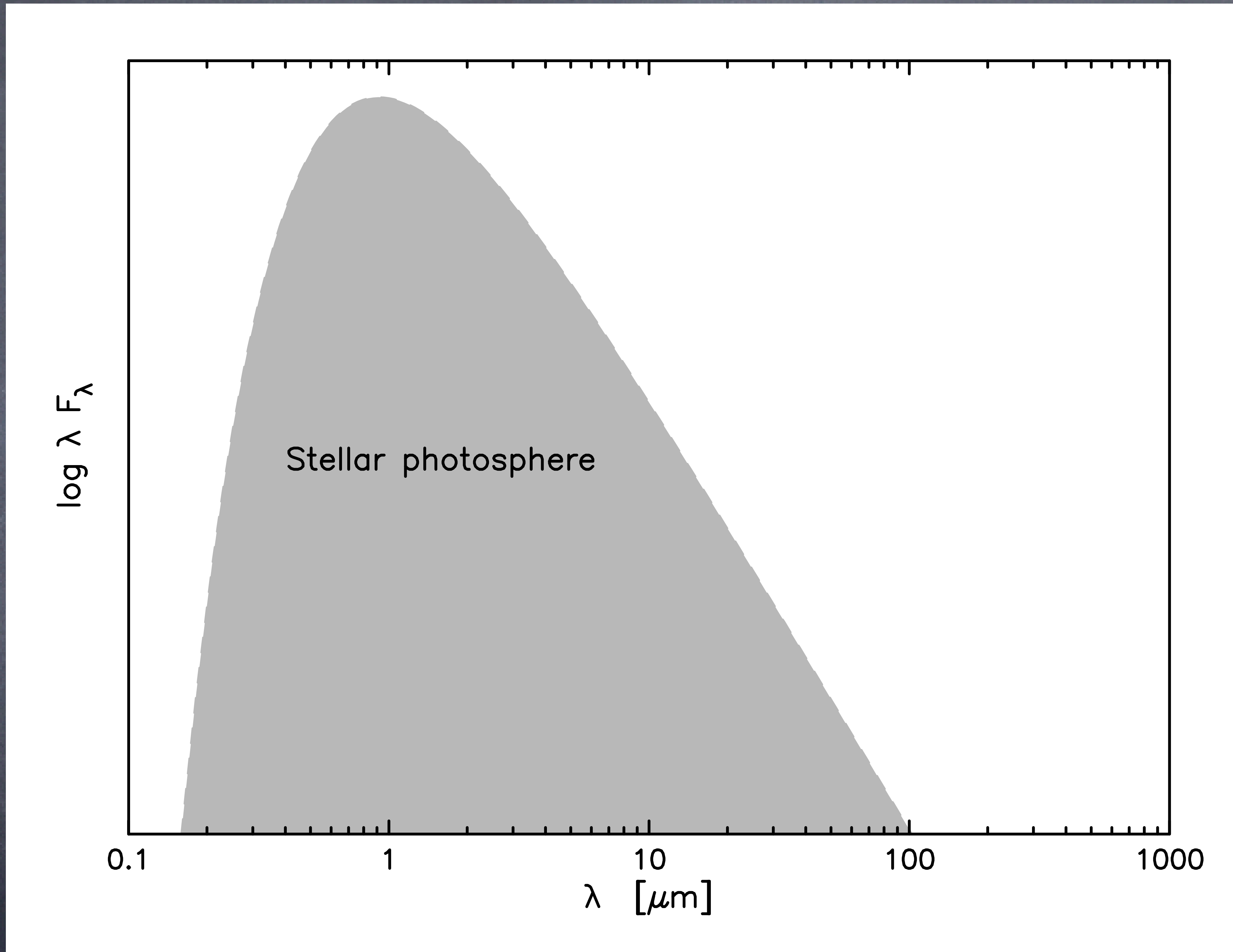
Why study circumstellar disks?



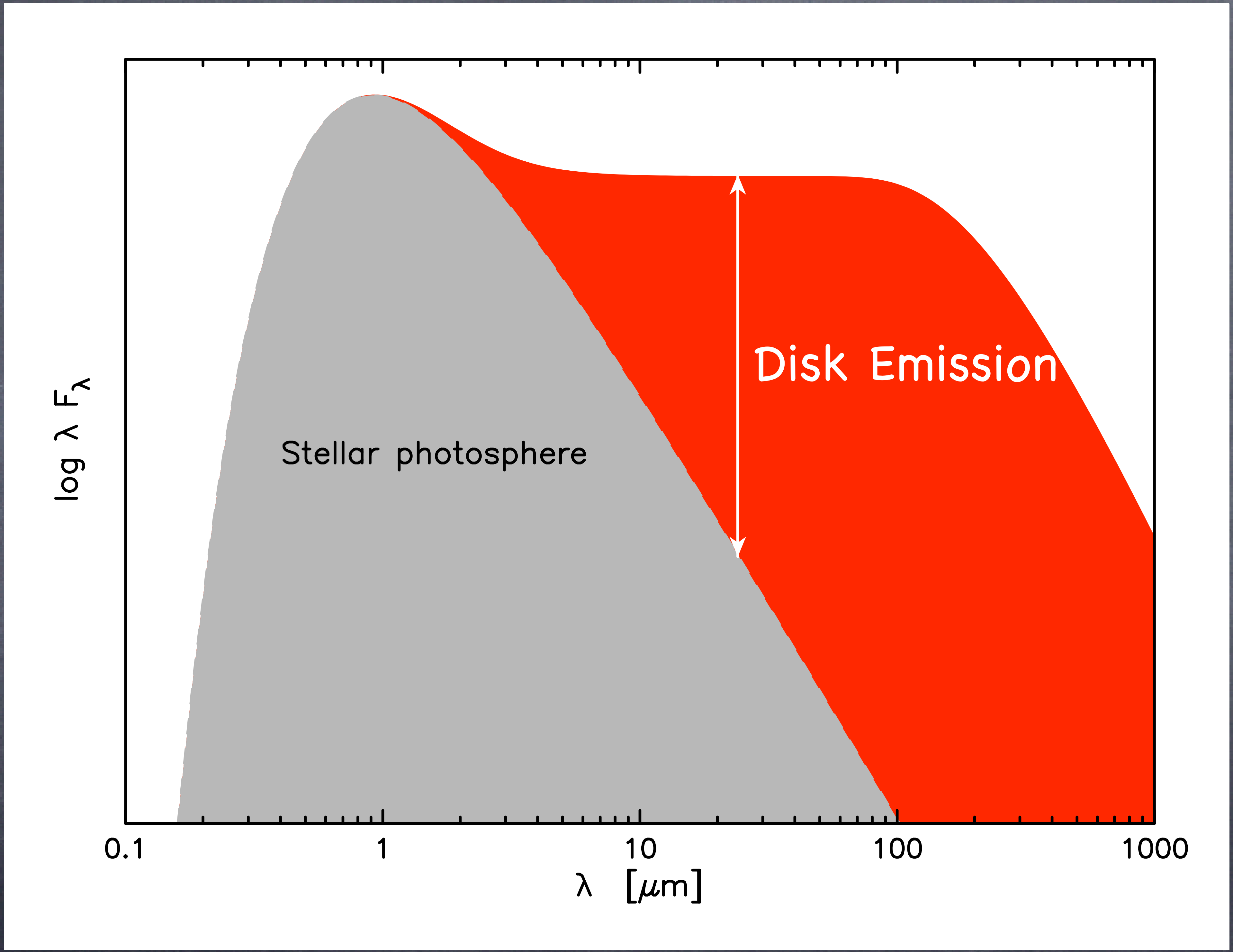
- Progenitors of planetary systems
  - rich in gas and dust
  - sizes of ≈ 100 AU
  - median mass of ≈ 1 Jupiter mass

Disk evolution probes timescale for planet formation

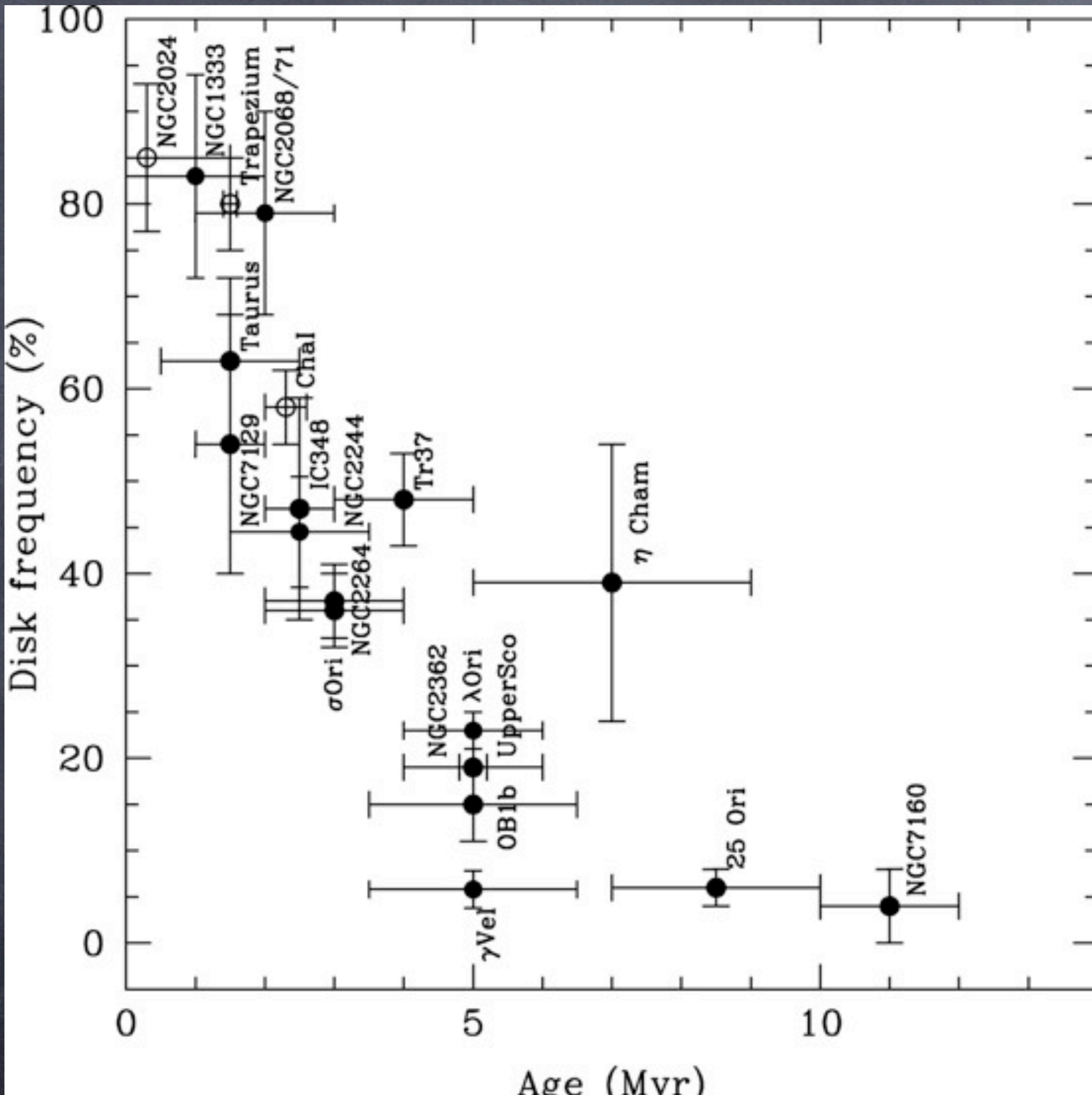
Identifying disks with photometry



Identifying disks with photometry



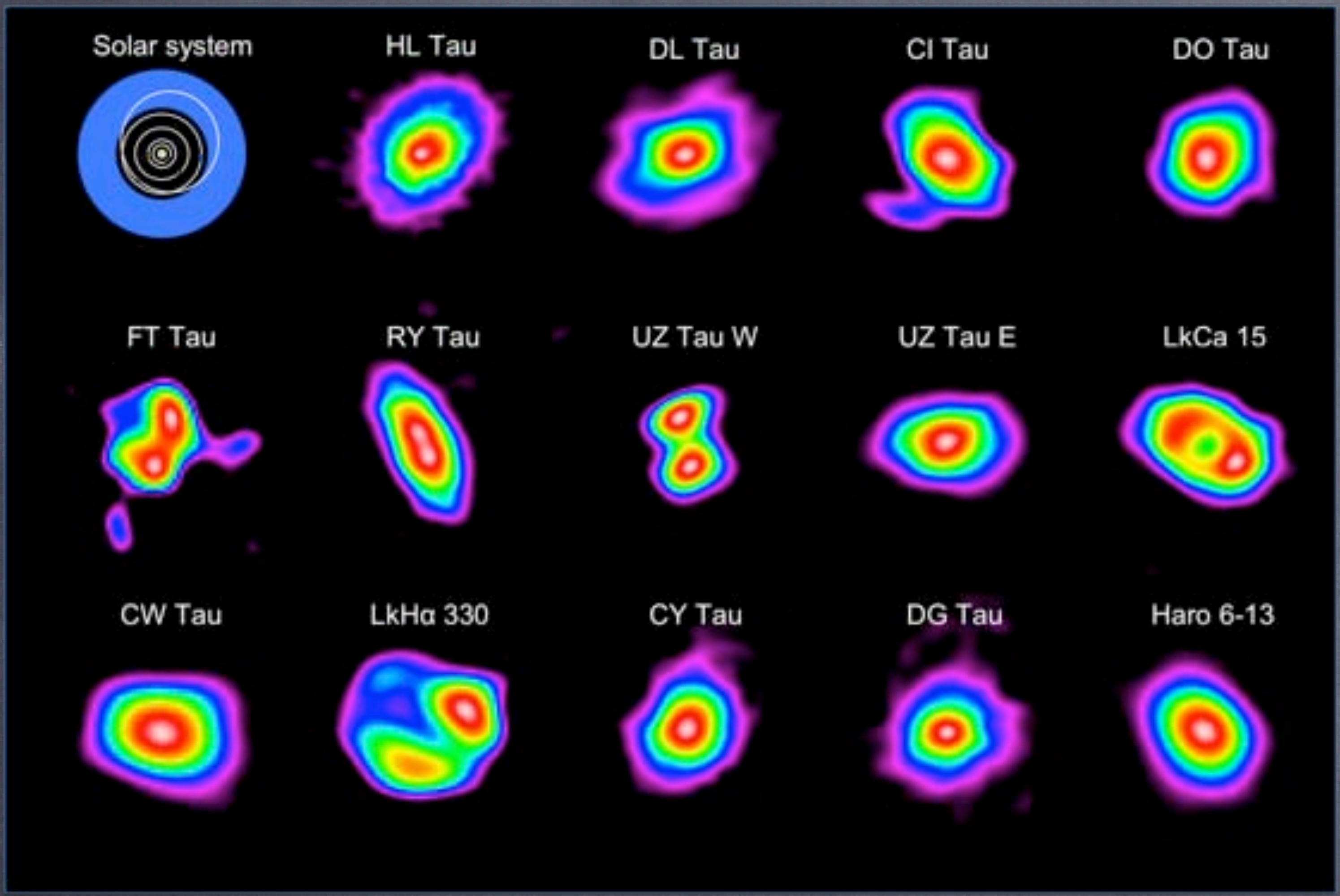
Timescales for disk dissipation



Hernandez et al. 2008, ApJ, 585, 1195

- 90% of gas-rich disks dissipate in ≈ 10 Myr

But disk evolution is far more interesting...



CARMA 1.3 mm continuum images of disks

- dissipation times vary by 10x
- dissipations times vary with stellar mass
- disk masses vary by > 100x
- holes, gaps in disks
- multiple pathways for disk evolution

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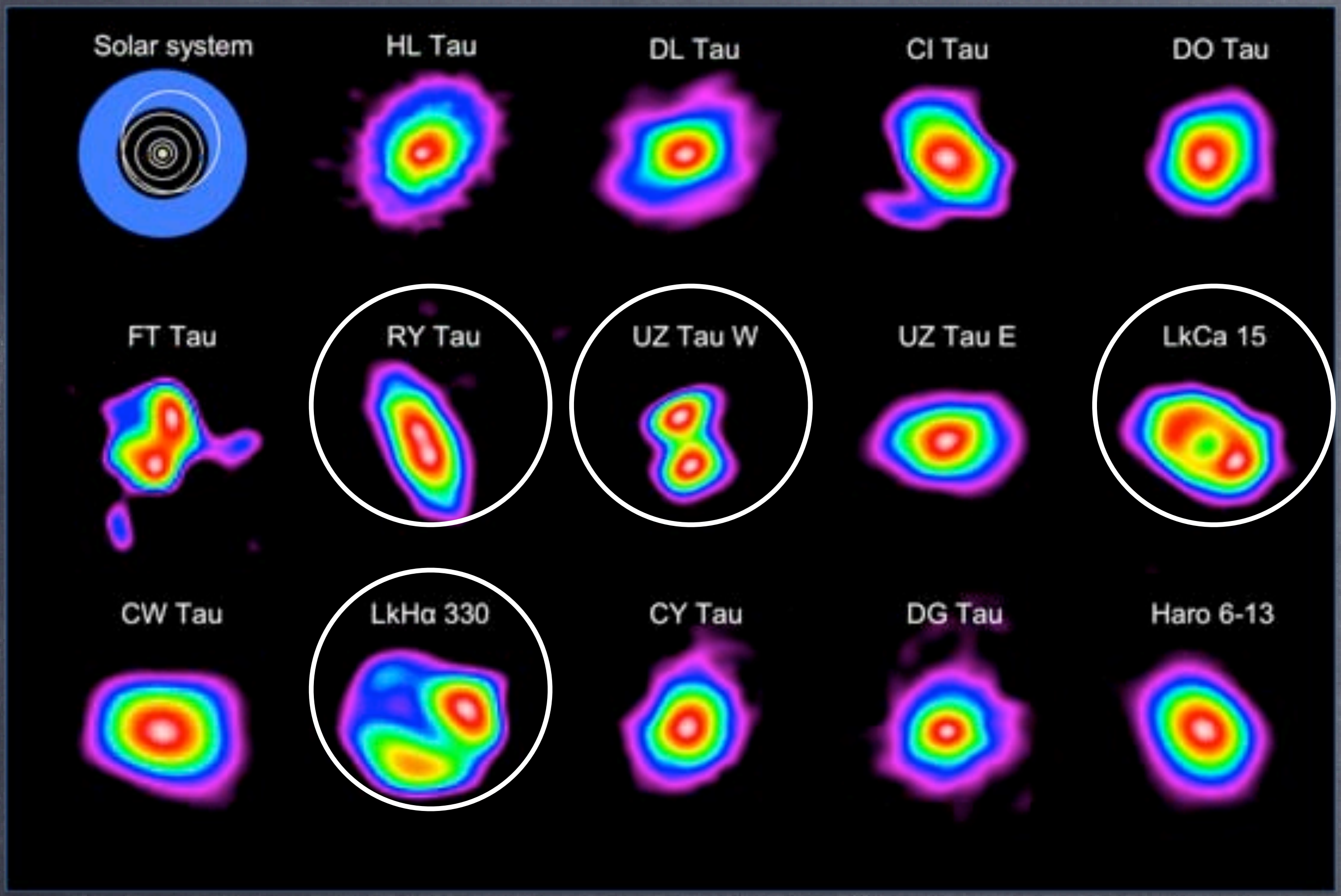

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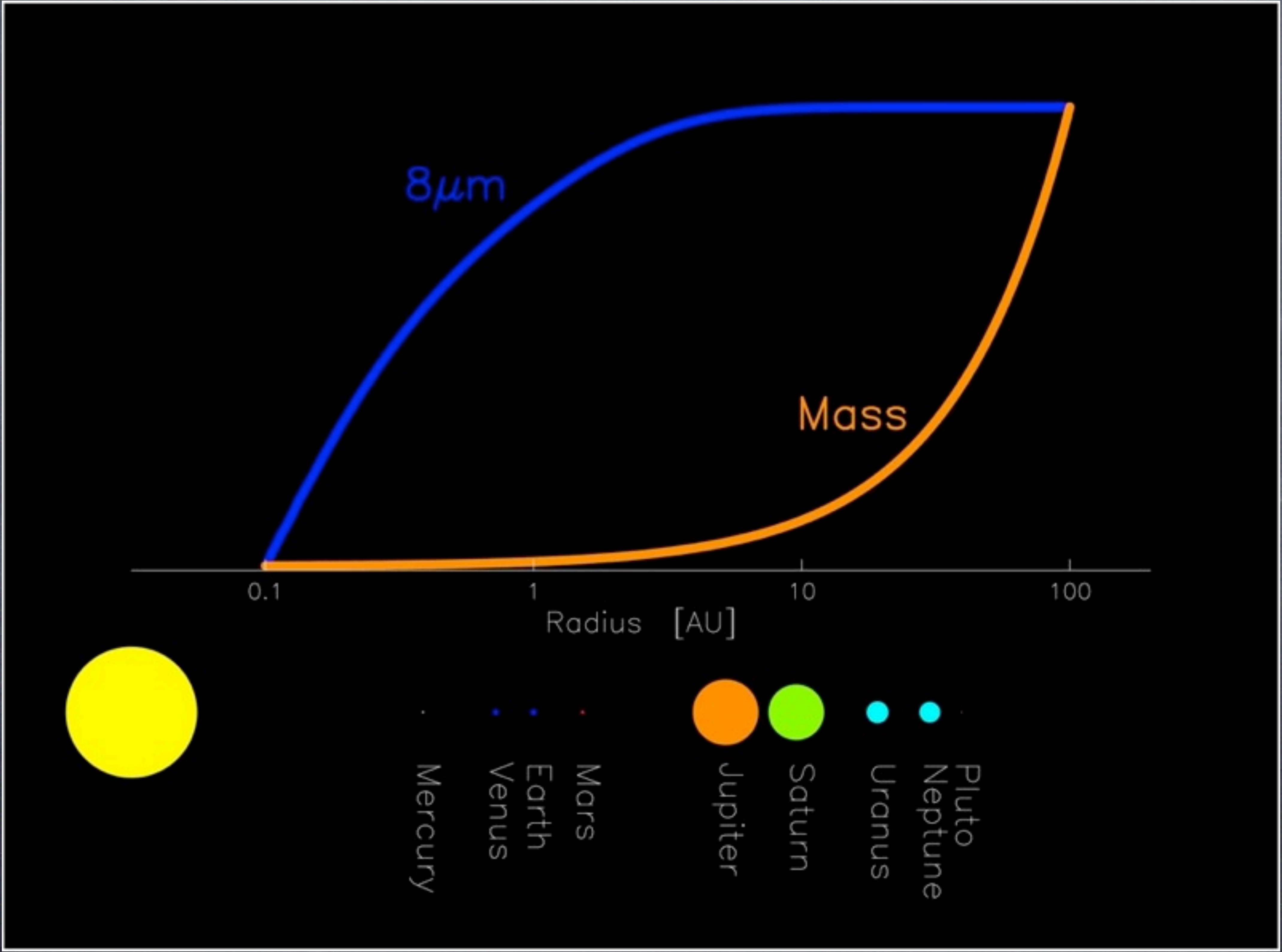
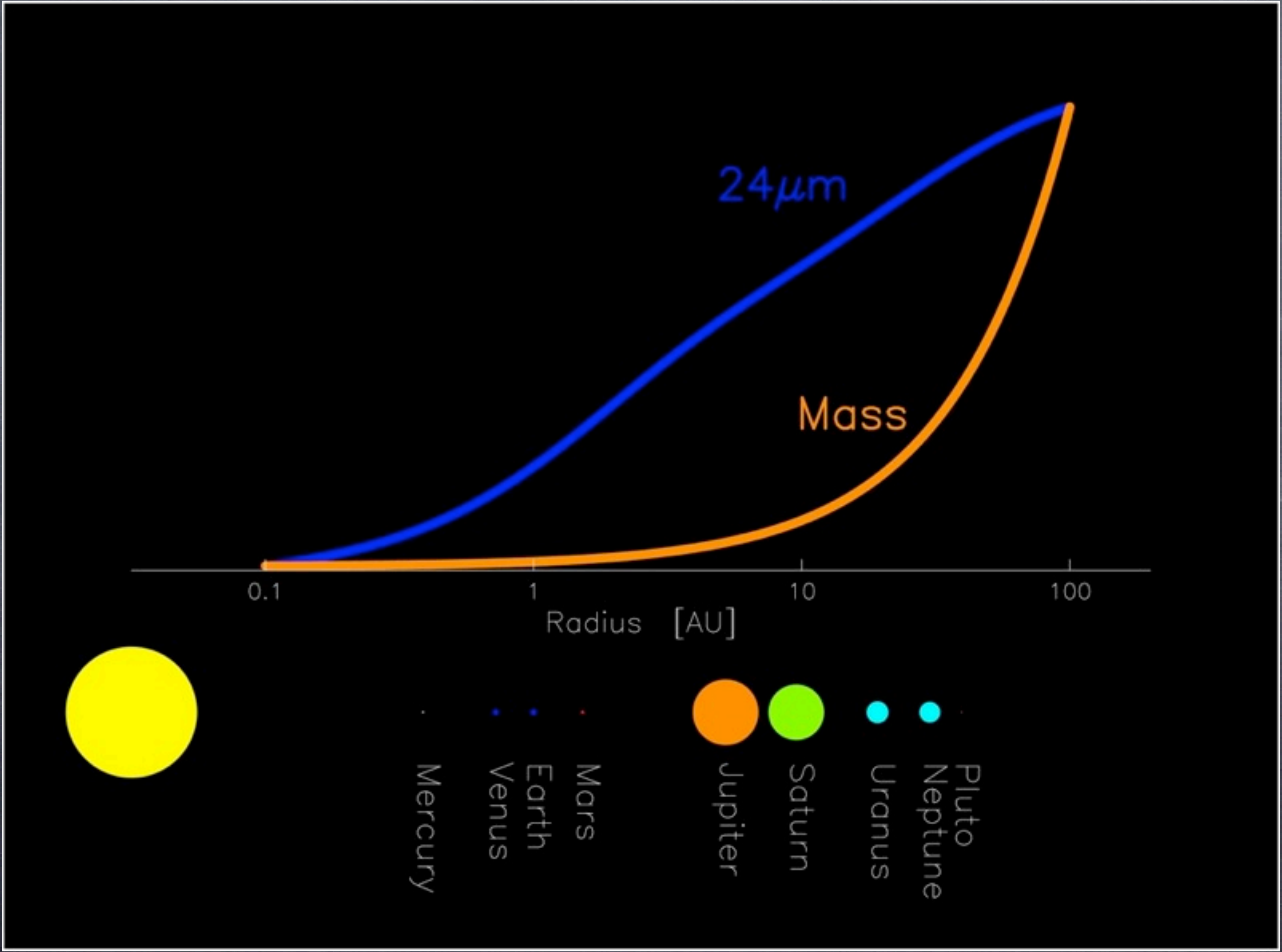
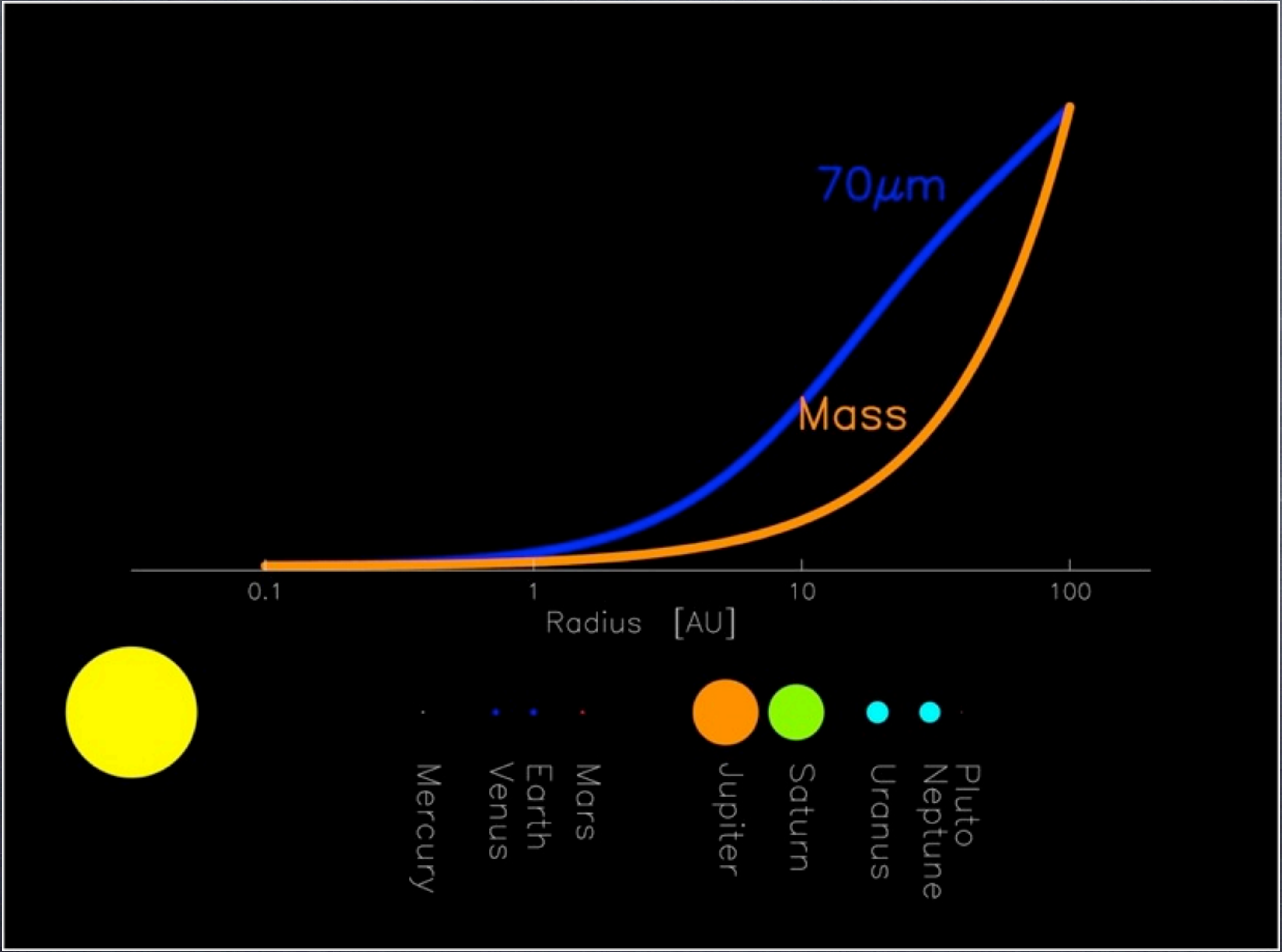
Probing disk masses



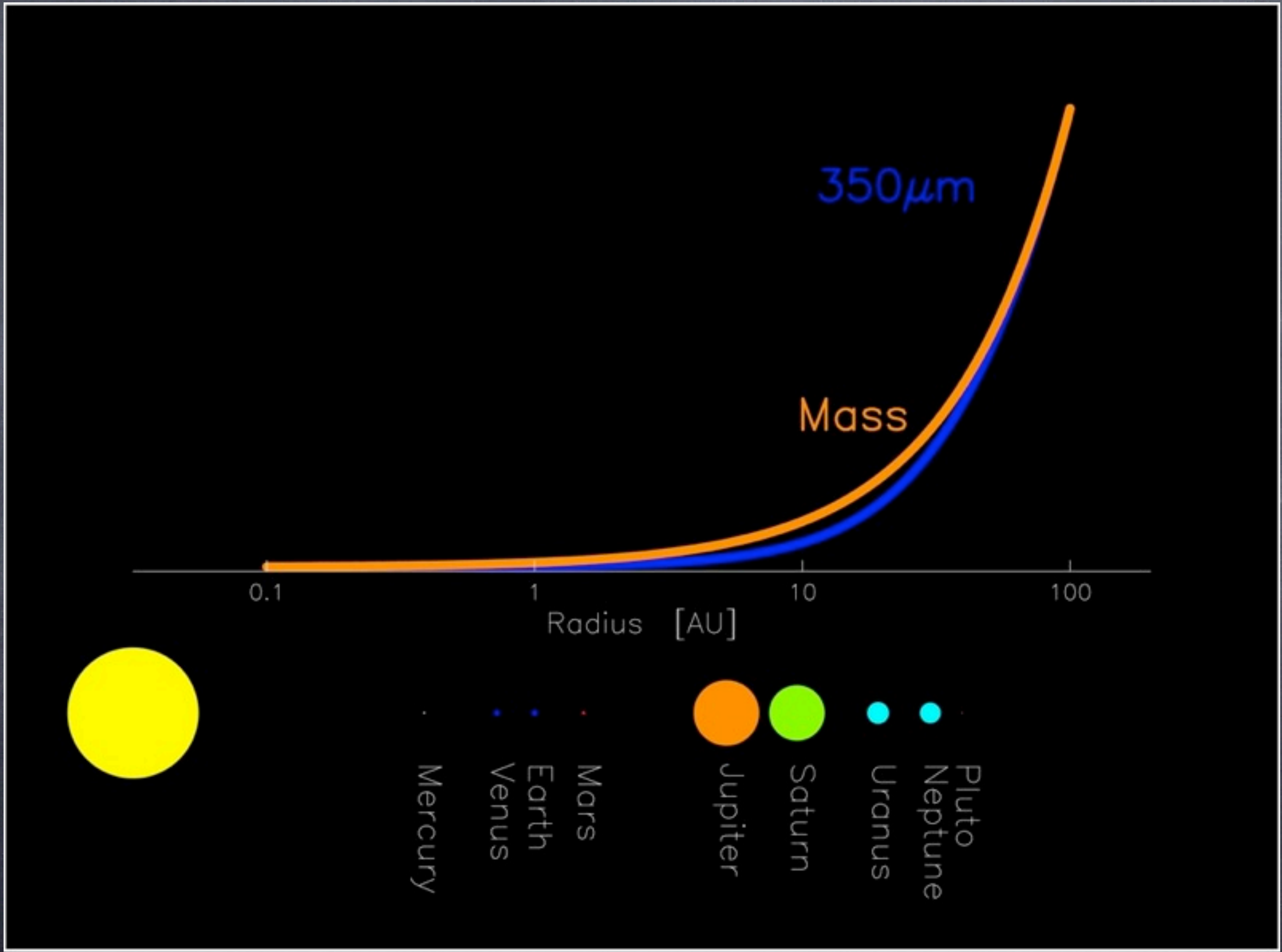
Probing disk masses



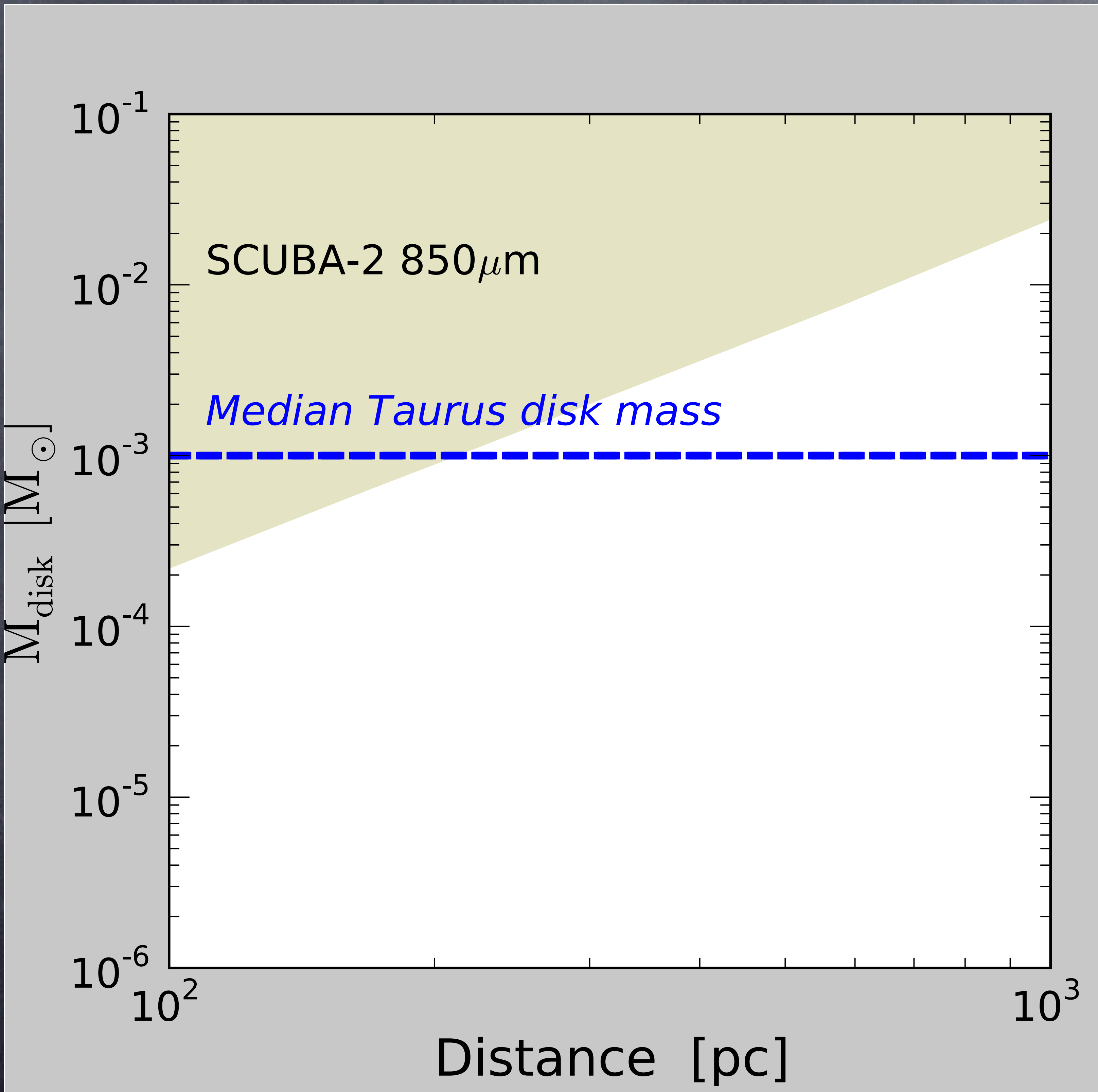
Probing disk masses



Probing disk masses

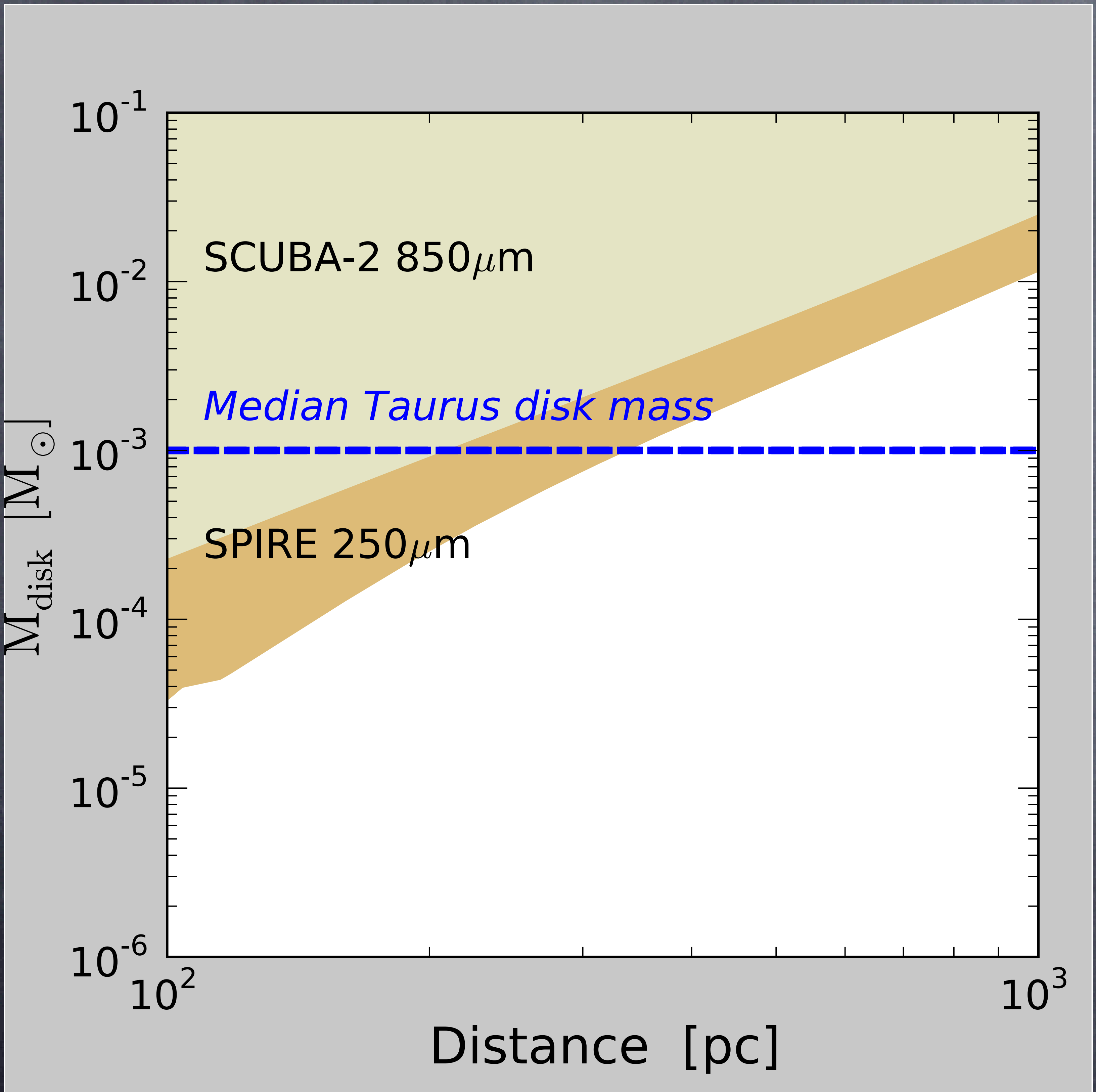


Sensitivity to Disk Mass with CCAT



- median mass of ≈10^{-3} M_{sun} in Taurus

Sensitivity to Disk Mass with CCAT



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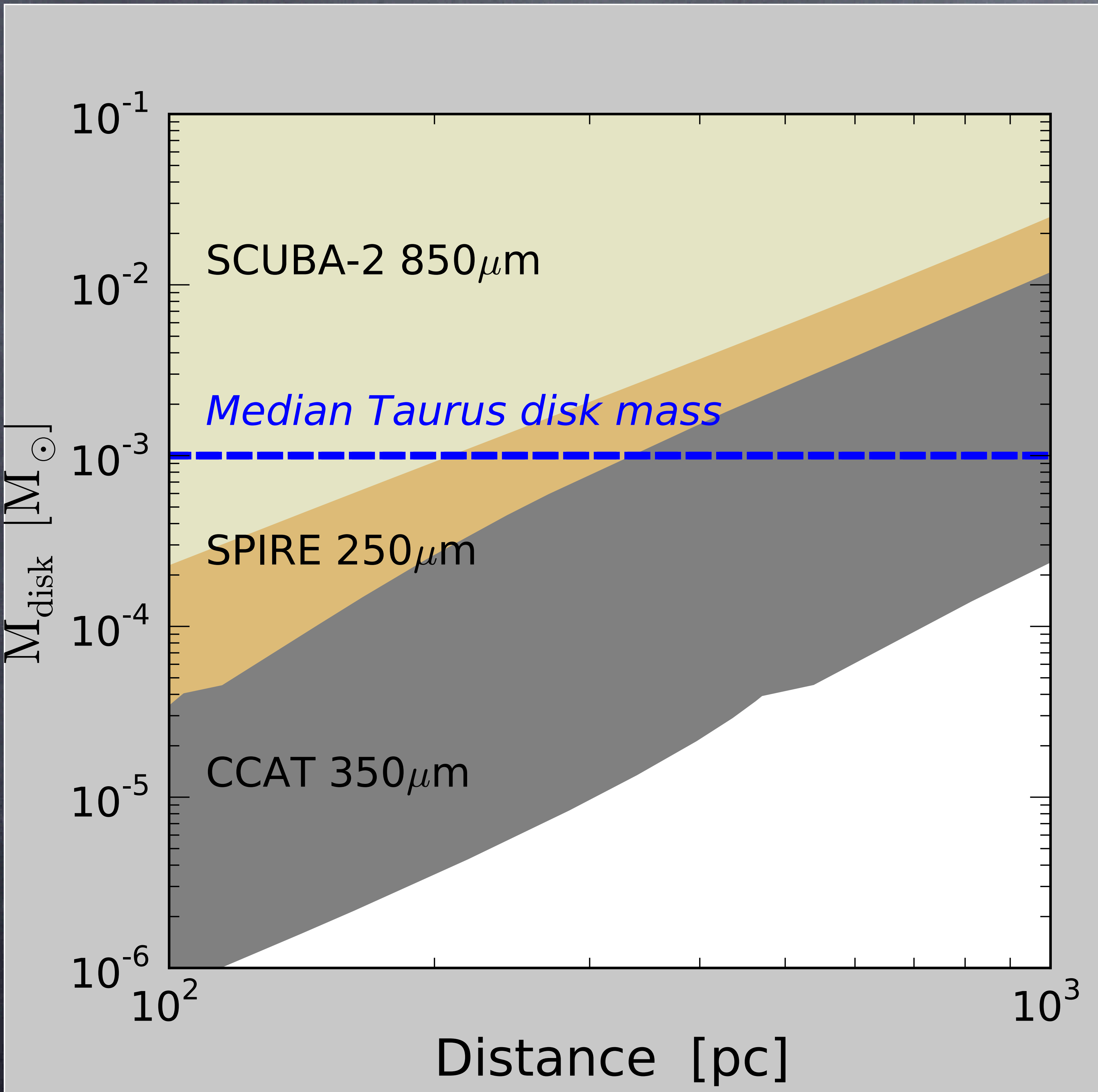
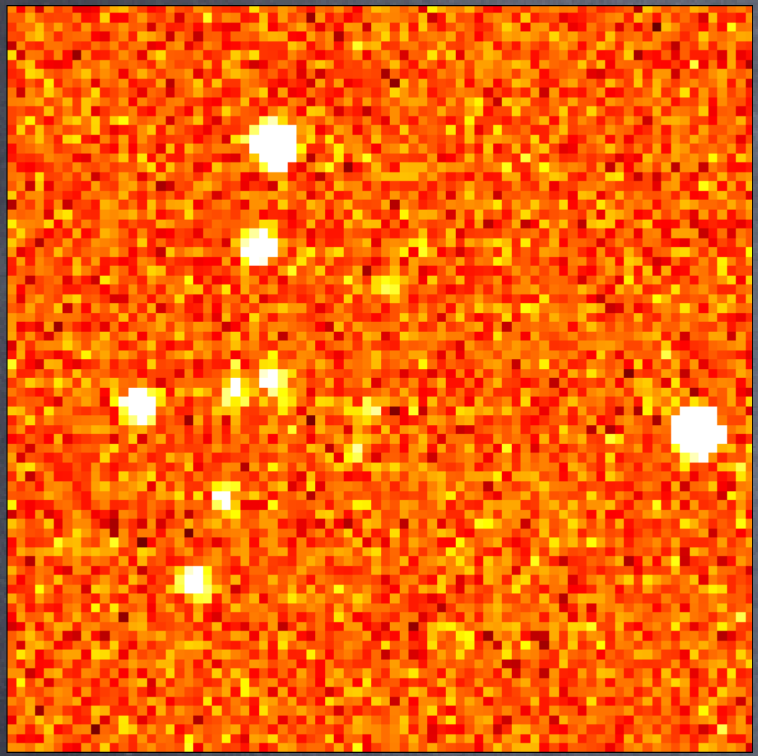
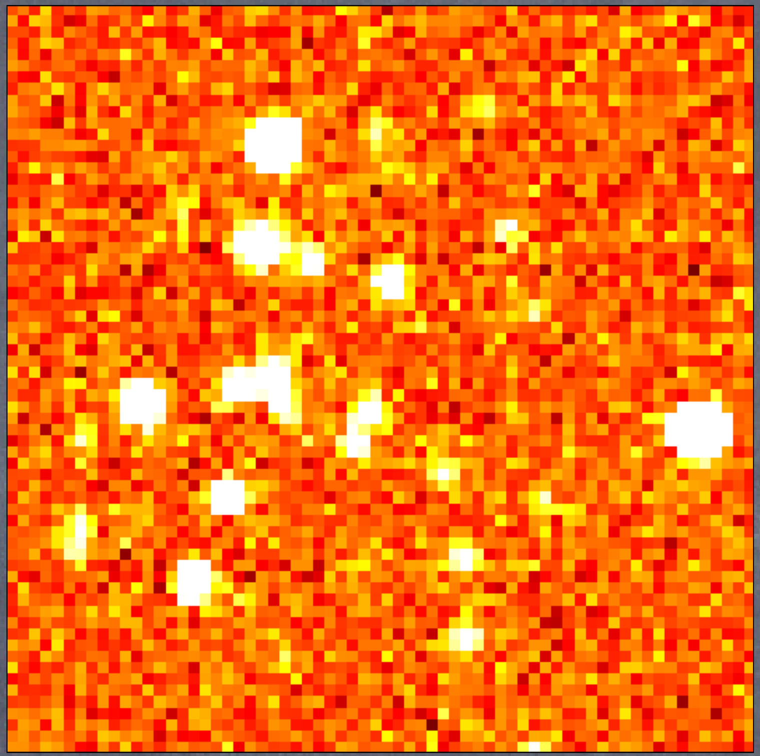
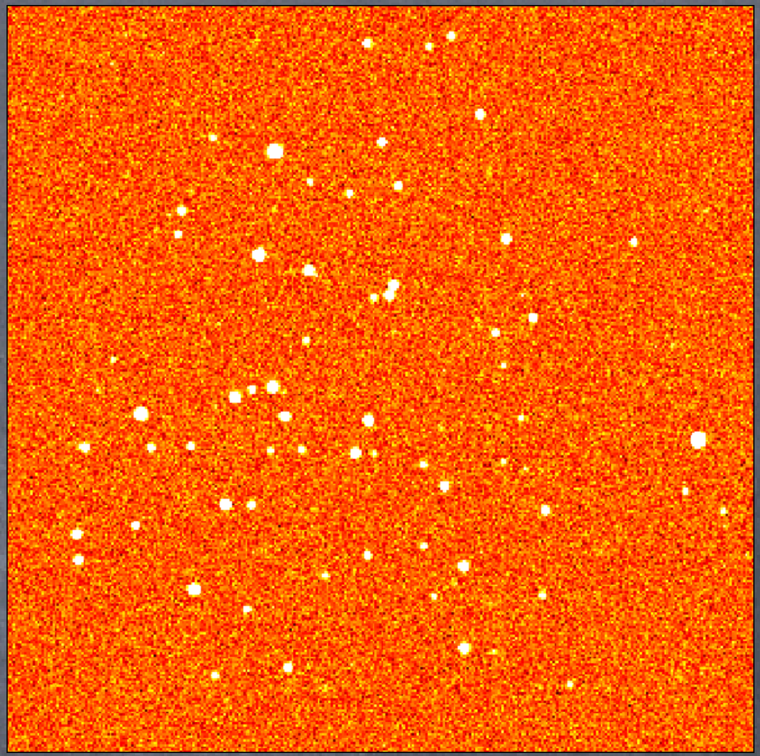
Sensitivity to Disk Mass with CCAT



- median mass of $\approx 10^{-3}$ M_{sun} in Taurus
- CCAT will provide $\approx$100x better mass sensitivity
- CCAT will detect median disk mass out to > 1 kpc.

Simulated Observations of a Young Cluster

SCUBA2 850μm
SPIRE 250μm
CCAT 350μm

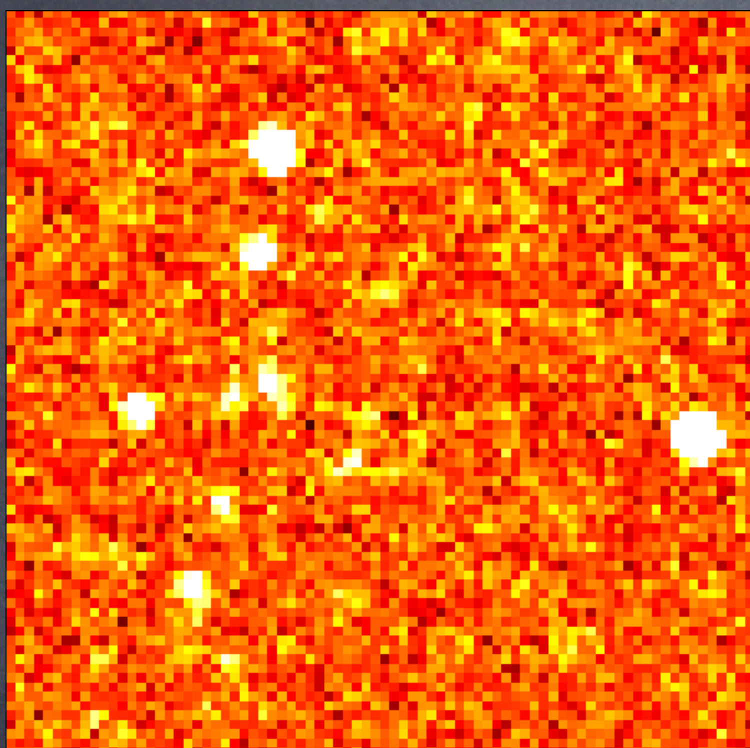
stars only

FOV = 100 $arcmin^2$

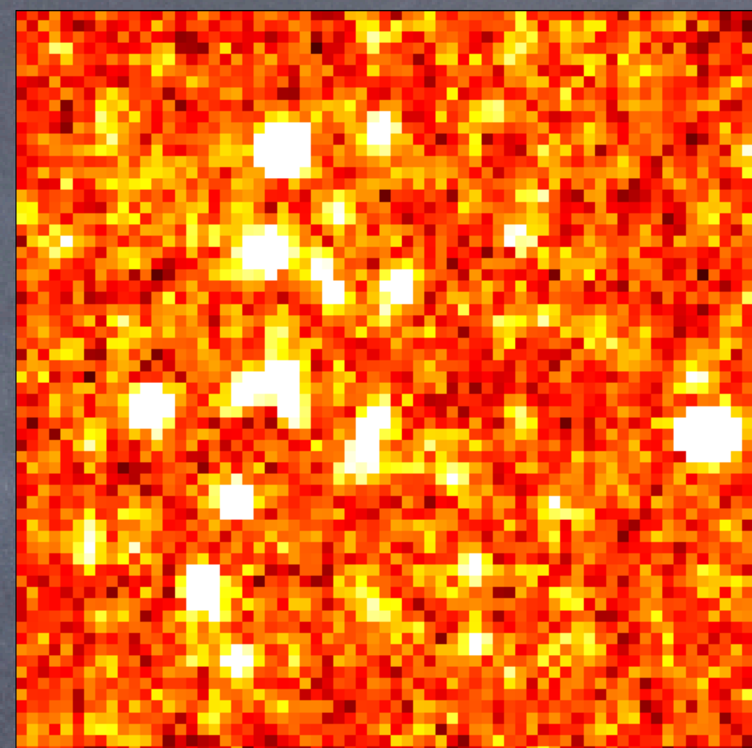
mean disk mass = 10^{-5} M_{sun}

Simulated Observations of a Young Cluster

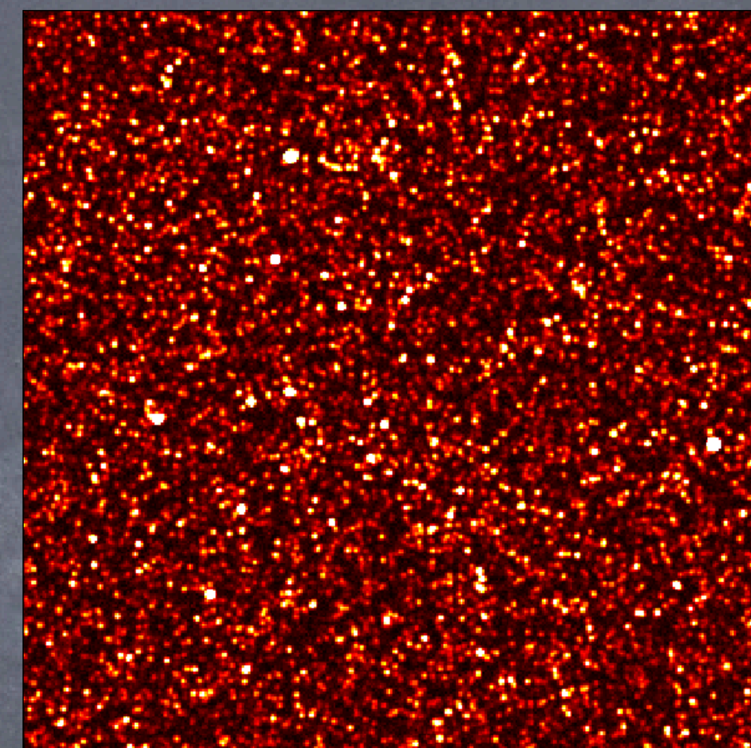
SCUBA2 850µm



SPIRE 250µm



CCAT 350µm



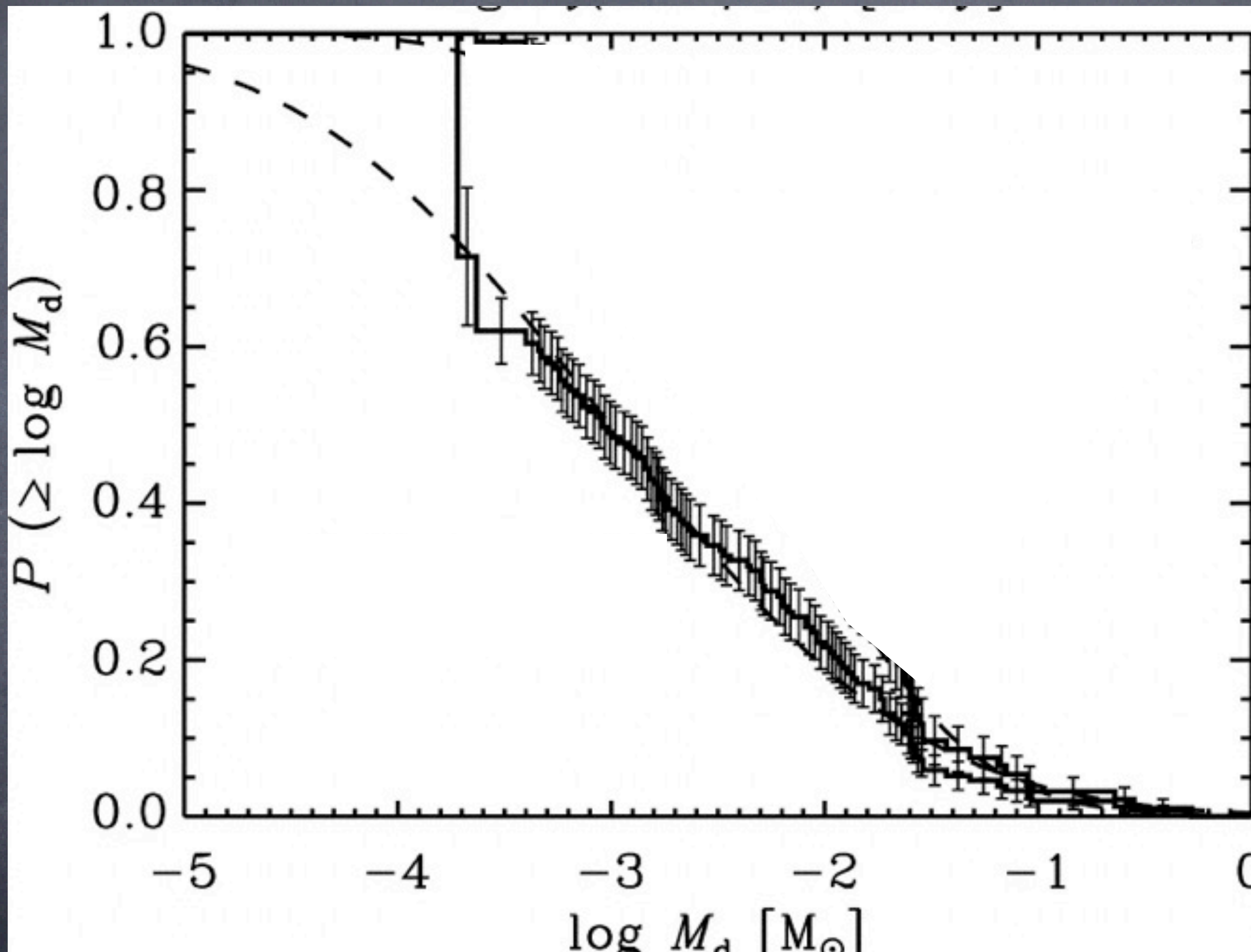
stars + galaxies

FOV = 100 arcmin^2

mean disk mass = 10^{-5} M_{sun}

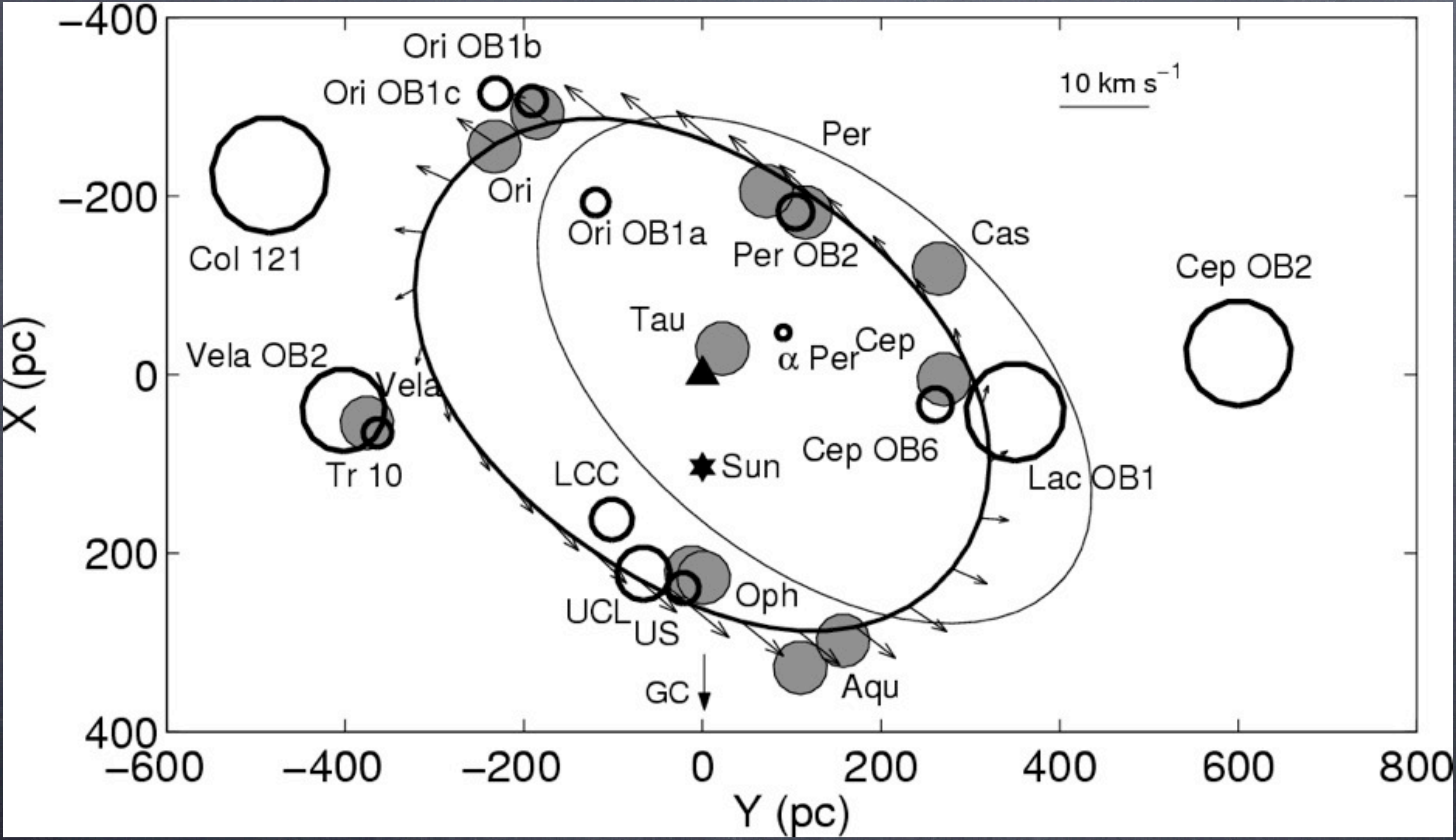
Disk Masses in Taurus

CCAT 5σ



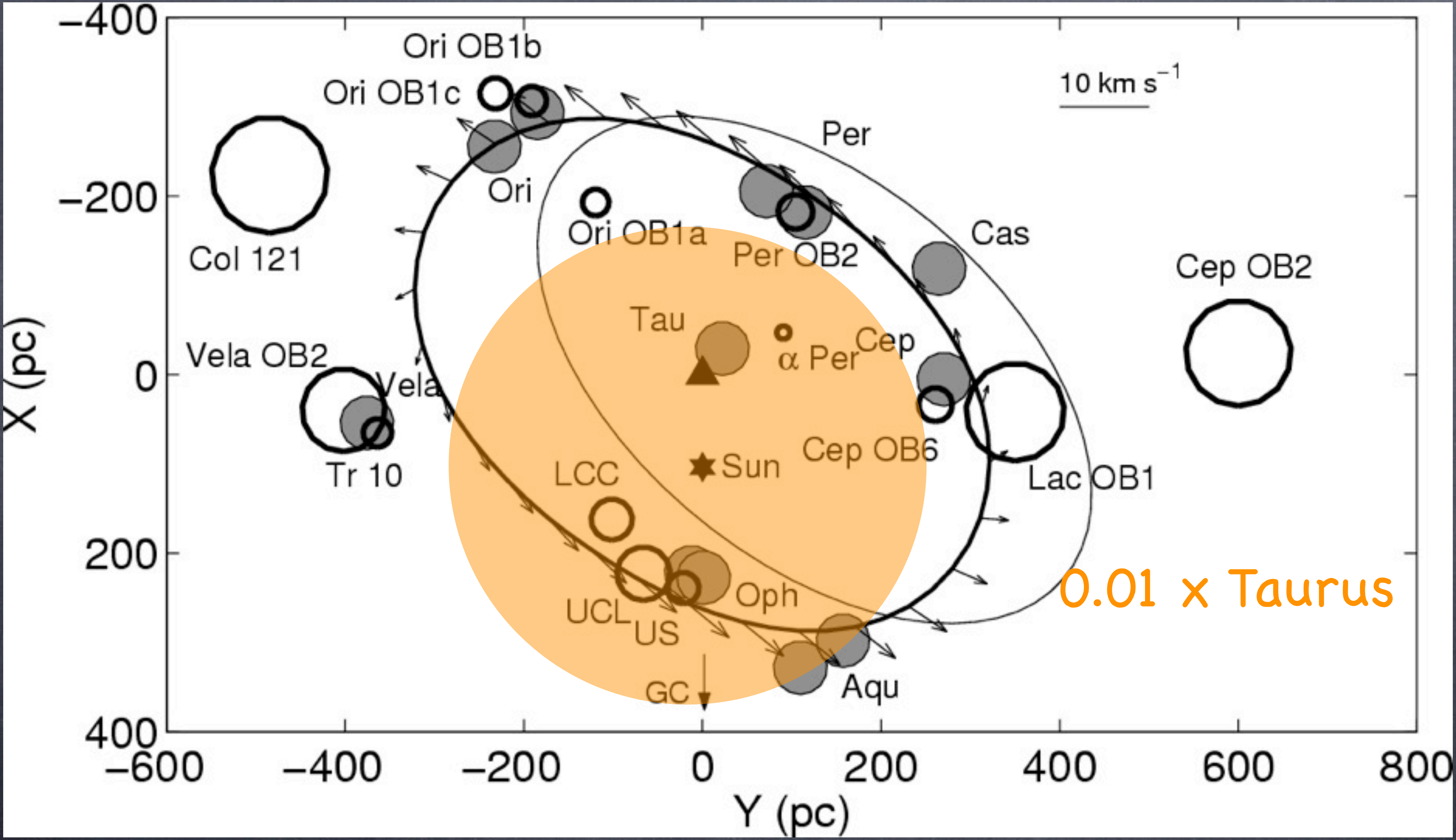
Andrews & Williams 2005, ApJ, 631, 1134

Nearby Stellar Associations



Perrot & Grenier (2003, A&A, 404, 519)

Nearby Stellar Associations



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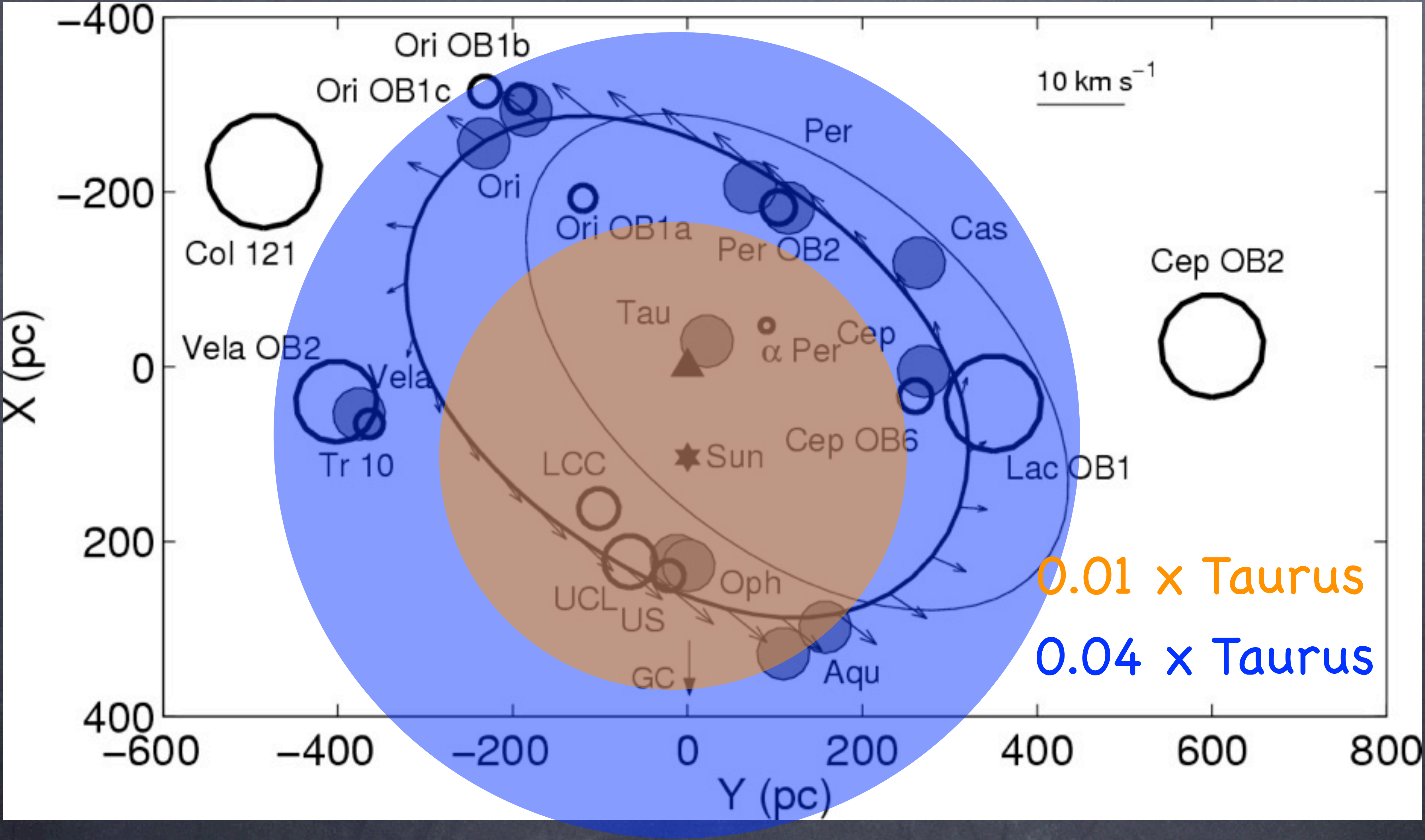
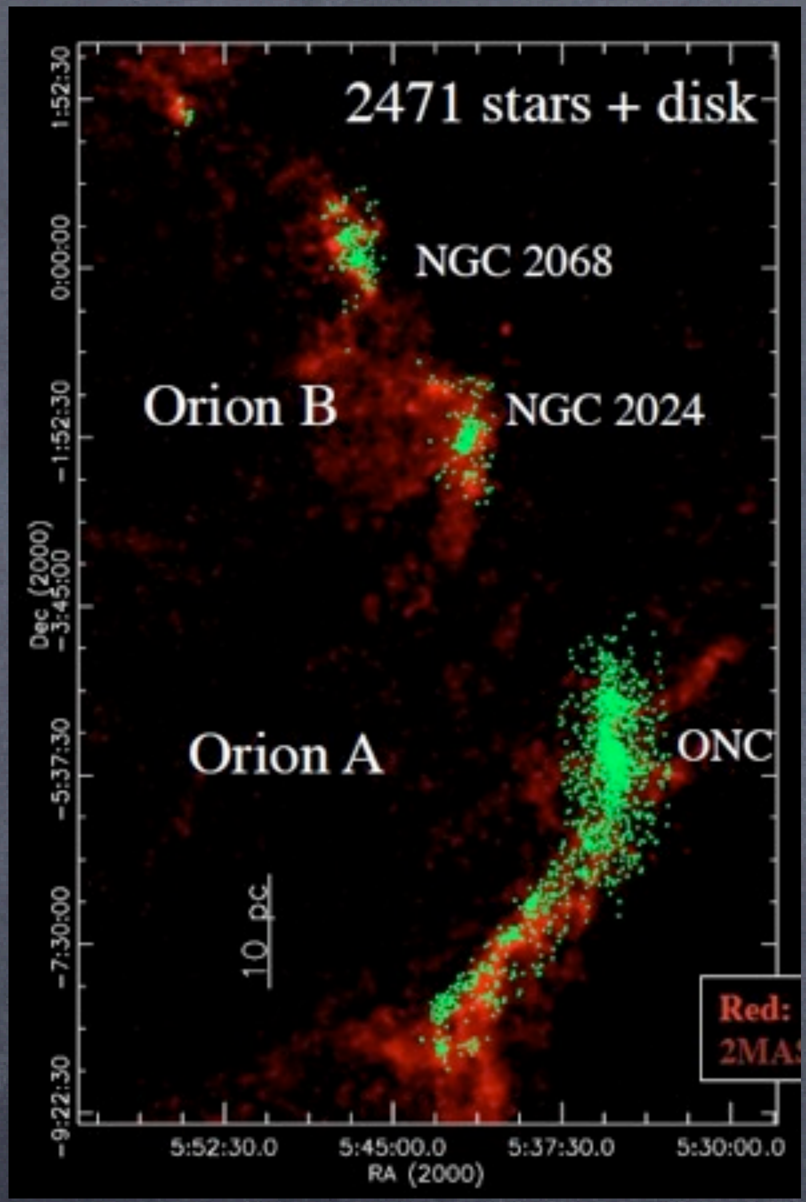
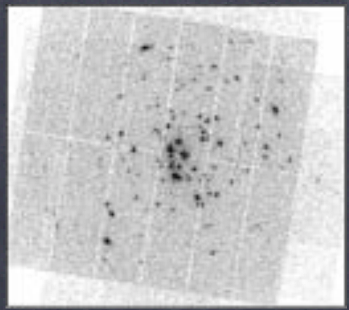


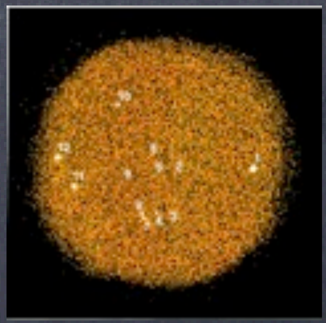
Perrot & Grenier (2003, A&A, 404, 519)

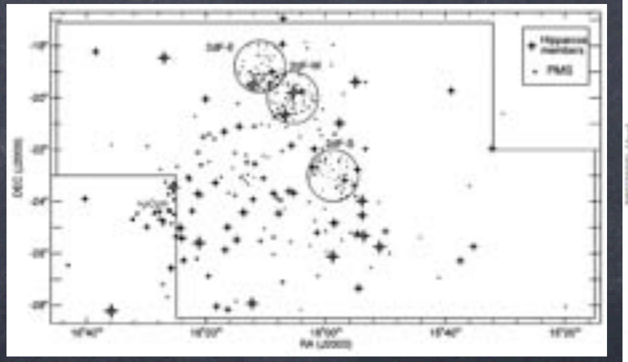
Nearby Clusters and Associations

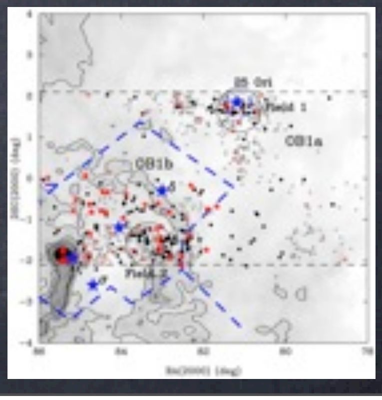
Molecular clouds span degrees on the sky





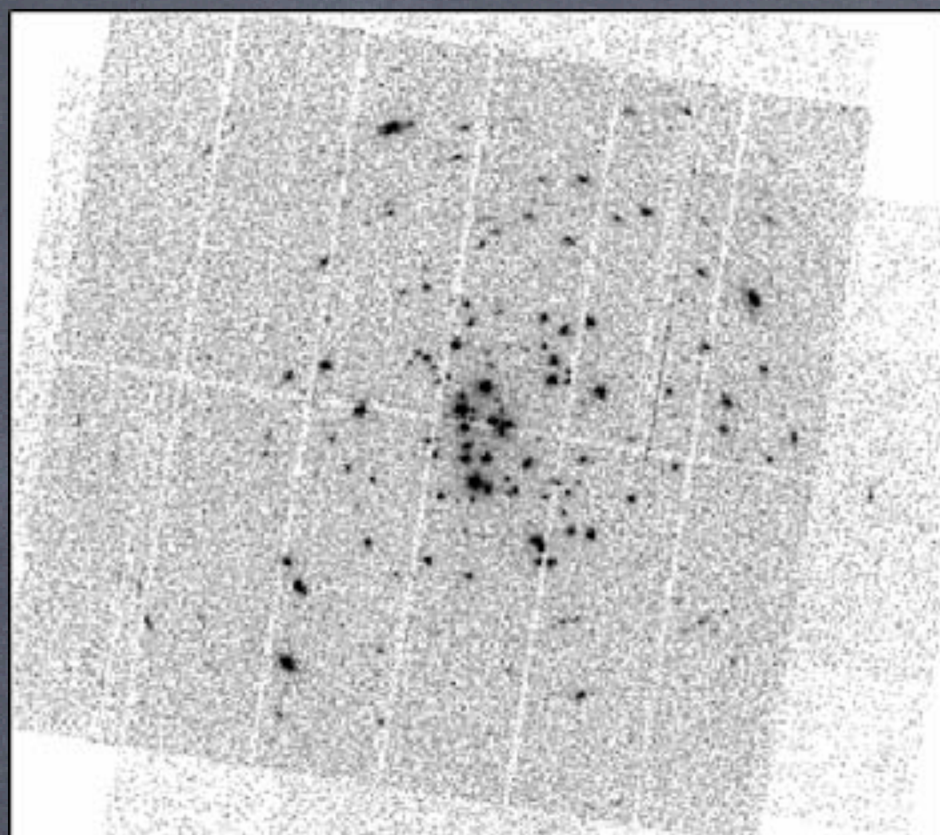


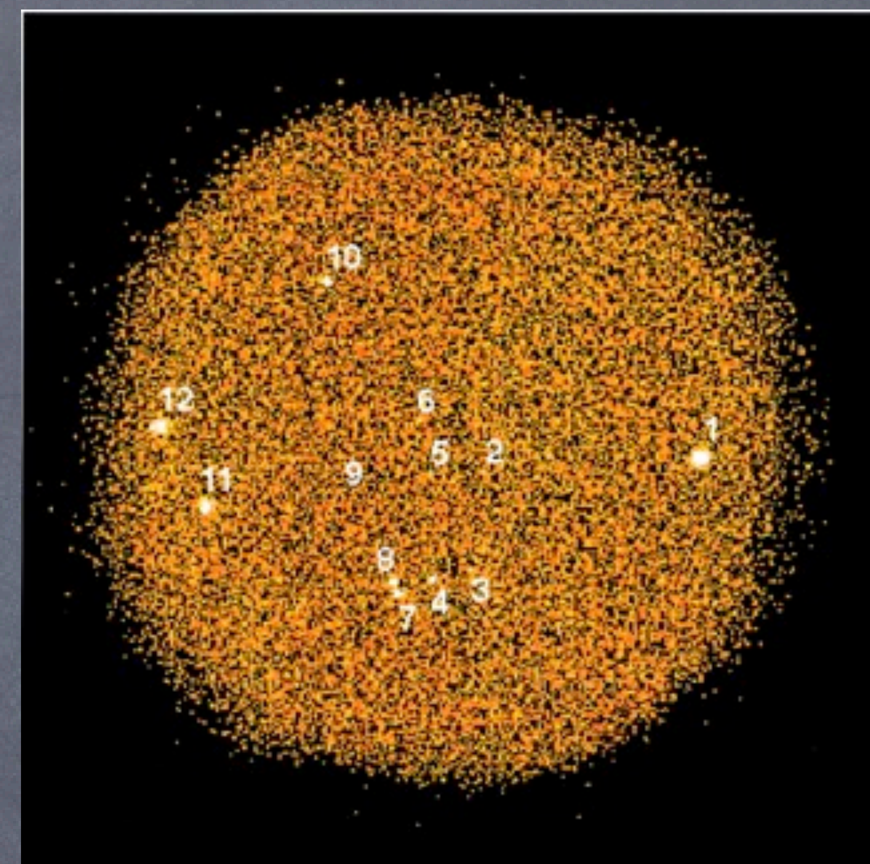


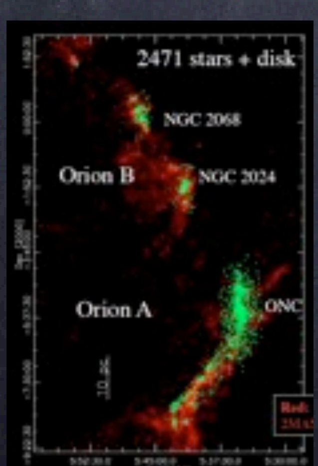


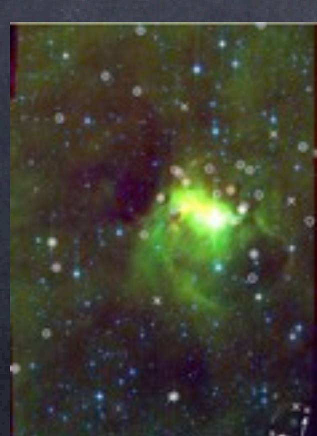
Nearby Clusters and Associations

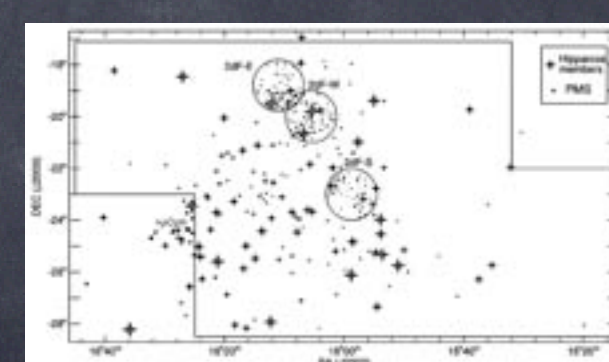
Nearby young clusters are ≈ 5-40′ in diameter

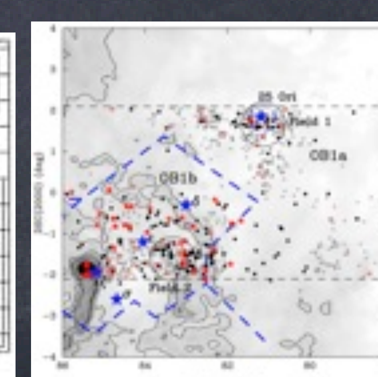






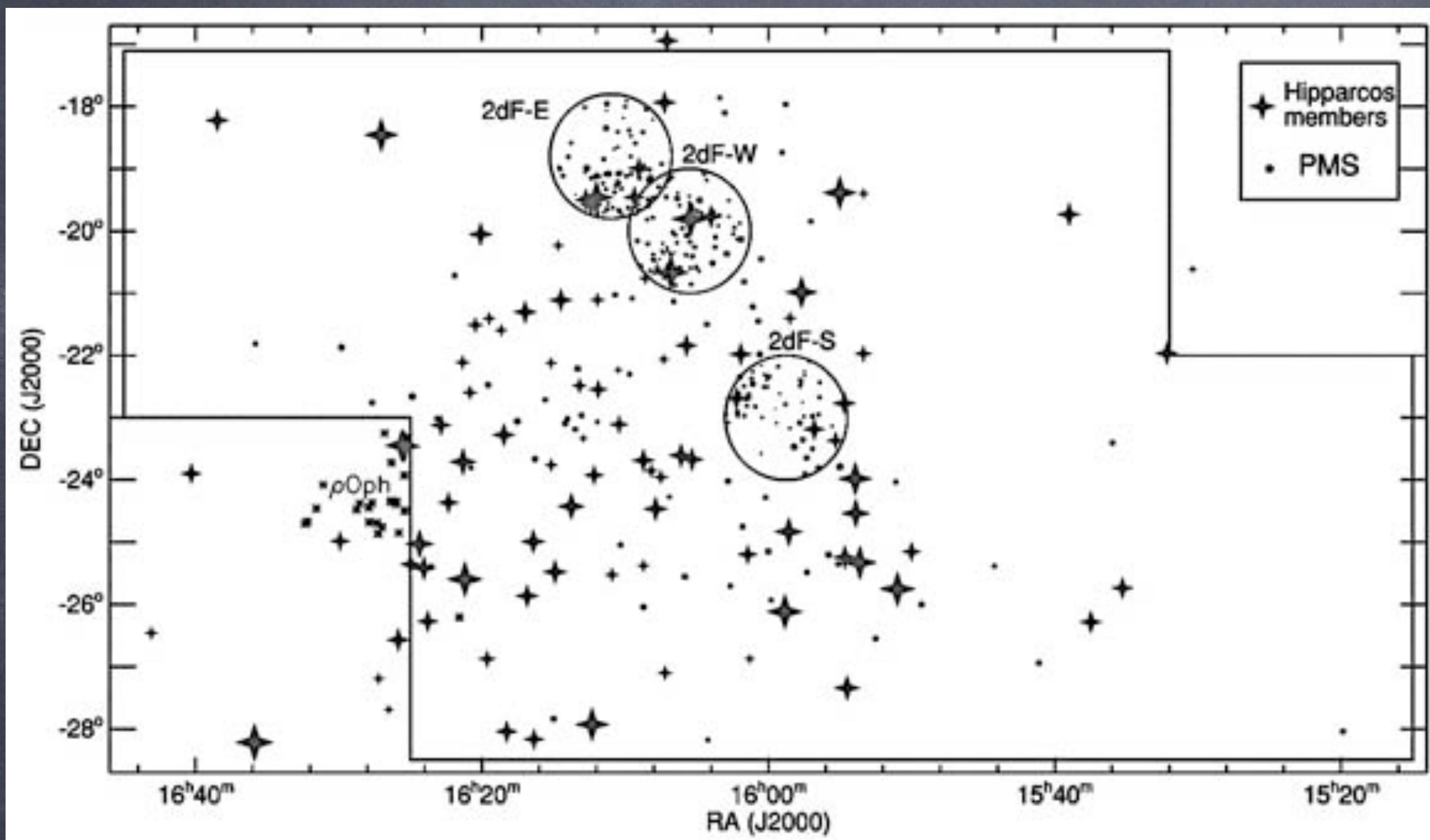


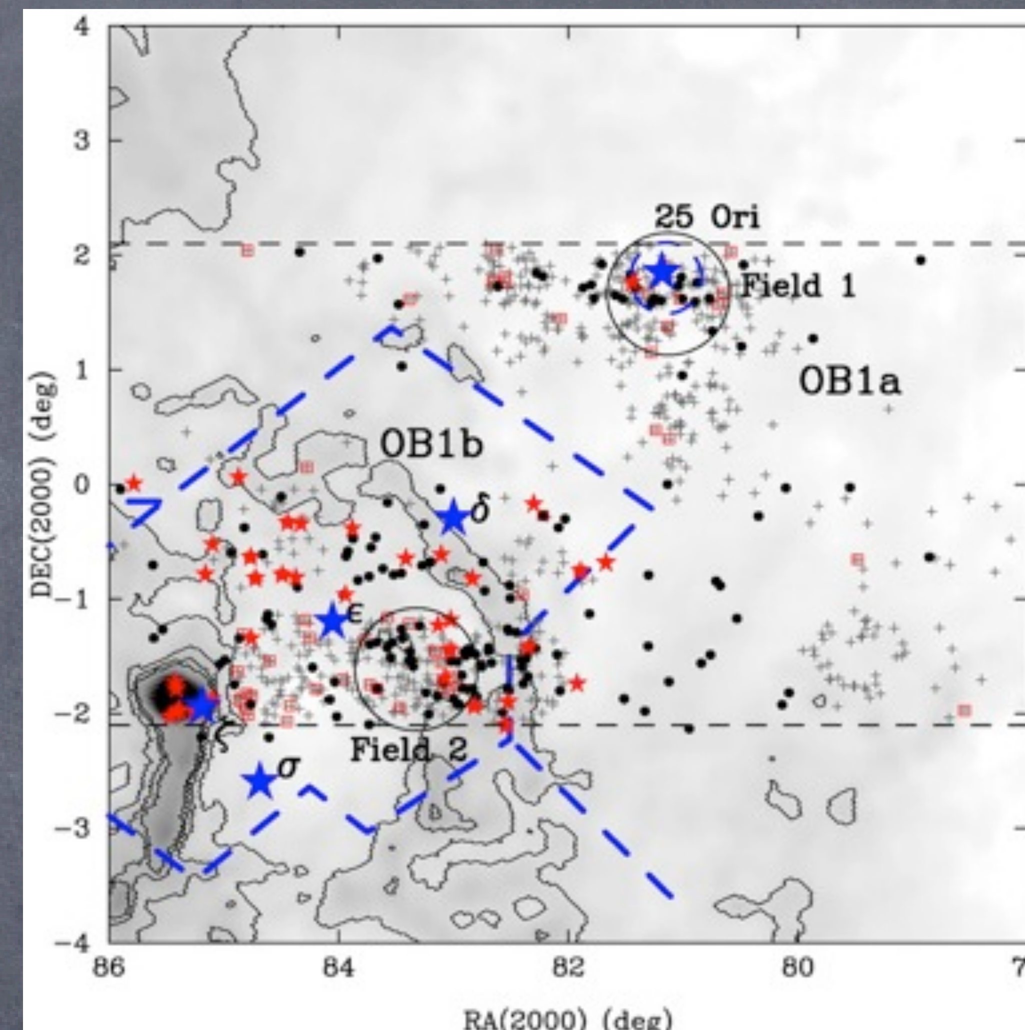


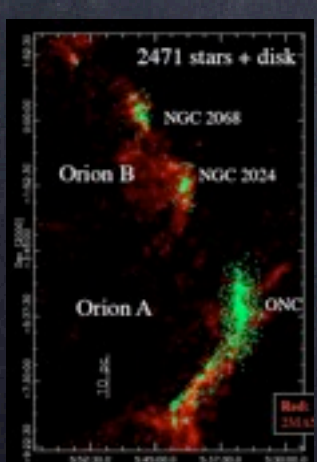


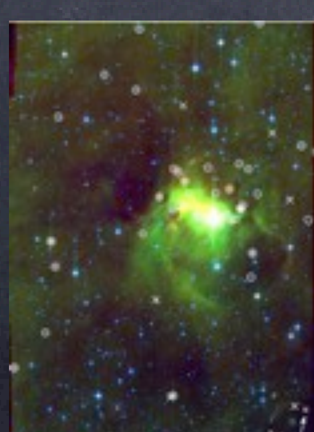
Nearby Clusters and Associations

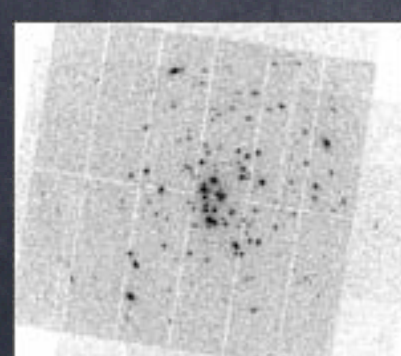
OB associations span degrees, with ≈1–2 deg subgroups



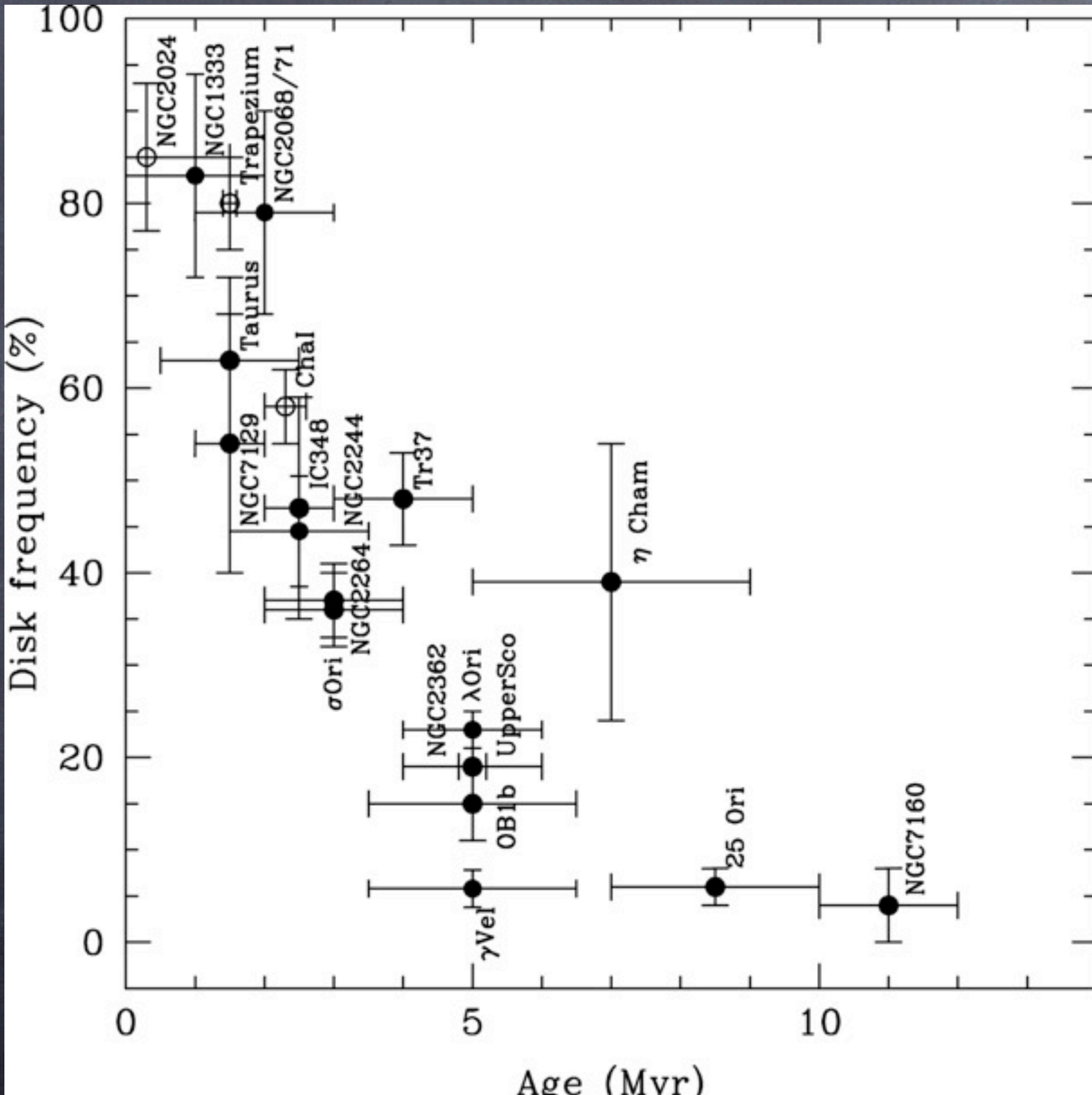






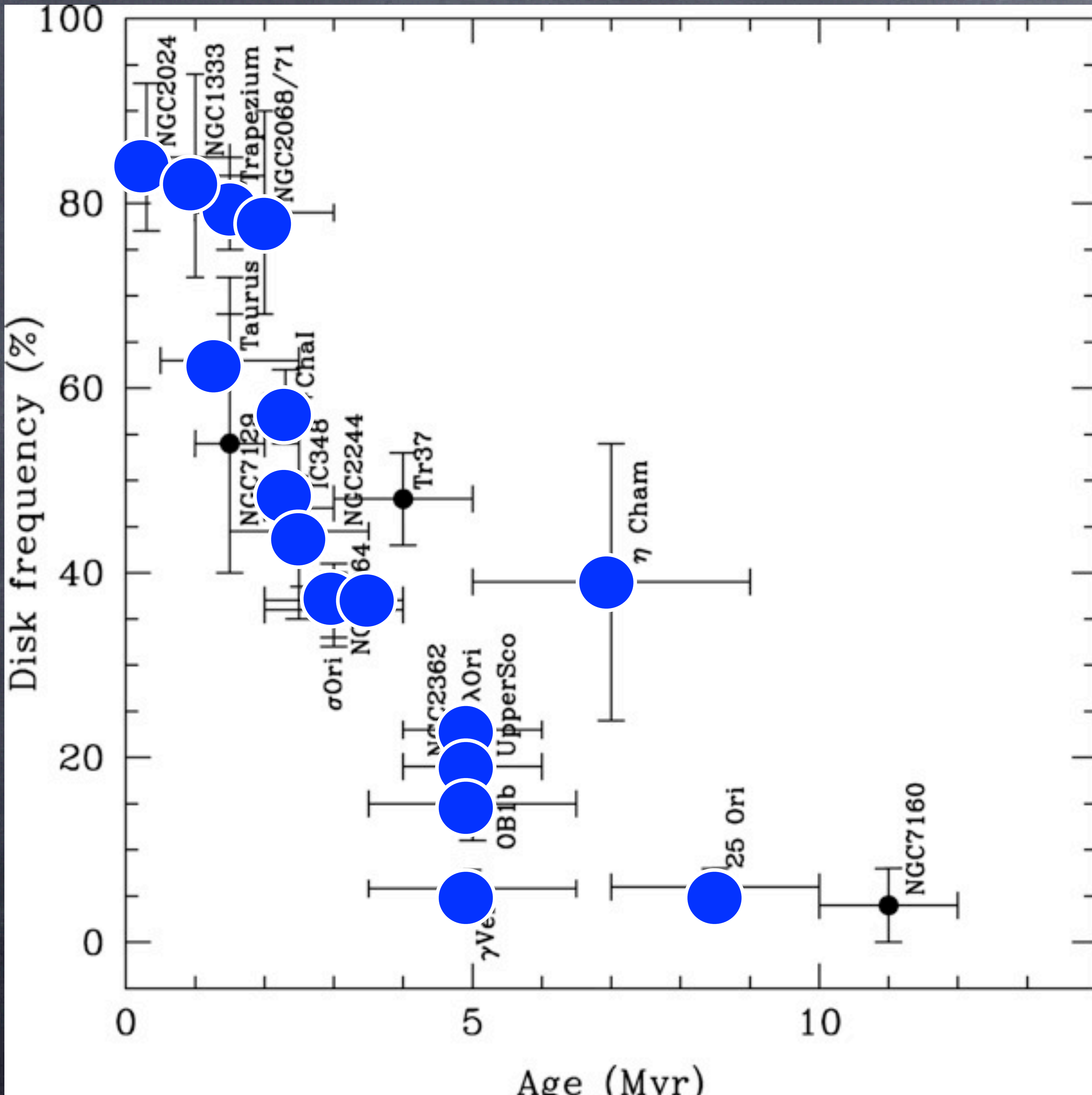


Summary



Disk frequency (%)
Age (Myr)
0
20
40
60
80
100
0
5
10
NGC2024
NGC1333
Trapezium
NGC2068/71
Taurus
ChaI
NGC7129
IC348
NGC2244
Tr37
η Cham
NGC2264
σOri
NGC2362
λOri
UpperSco
OB1b
γVel
25 Ori
NGC7160

Summary



- With 1 deg^2 camera at 350μm, need ≈ 35 pointings (35 hours)
- Measure disk-mass evolution vs. stellar age and mass
- Measure evolution of disk structure (with Spitzer/Herschel)