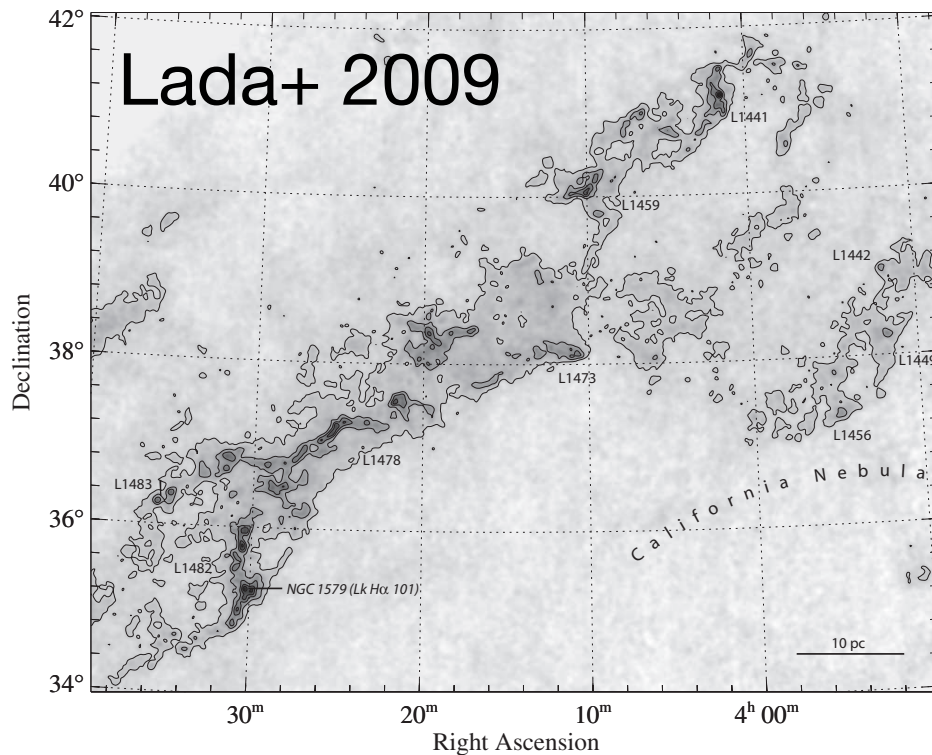10 pc

Herschel
Harvey et al. 2013

Protoplanetary disks in the
Auriga-California Molecular Cloud

Hannah Broekhoven-Fiene, Brenda Matthews, Paul Harvey, Gaspard Duchêne, Rita Mann, James DiFrancesco, and JCMT GBS collaboration
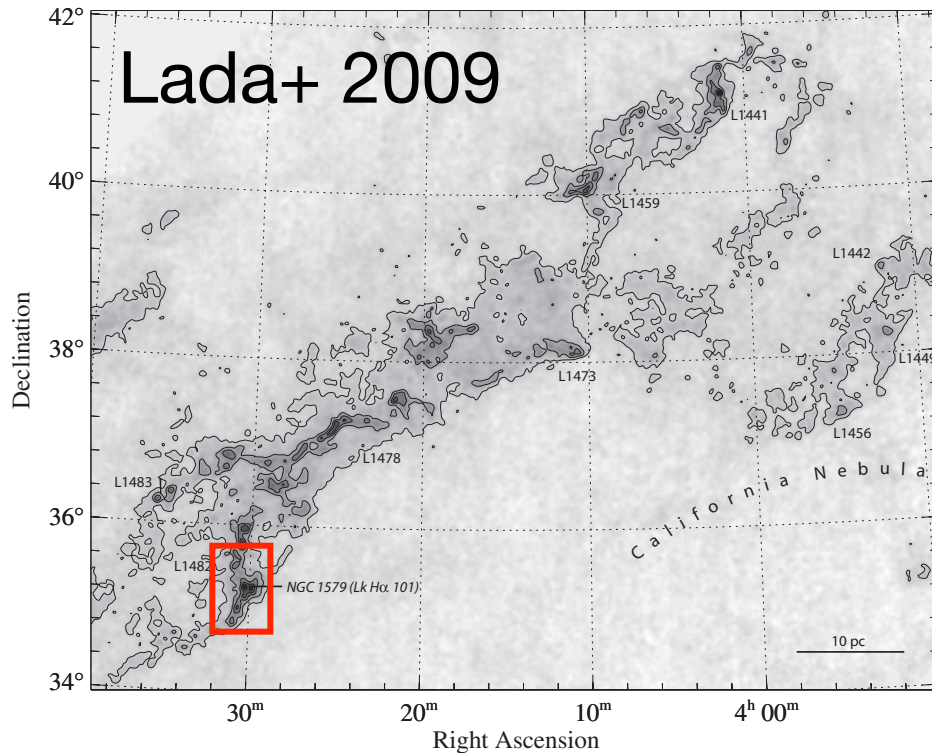
The Auriga-California Molecular Cloud

Lada+ 2009

Herbig+ 2004

- LkHα 101 - early B star

- NGC 1579 - young stellar cluster

- ~1arcmin HII region

	Auriga
Distance	450 pc
Size	80 pc
Mass	$\sim 10^5 \, M_{solar}$

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Environment of the AMC

Auriga-Cal

Spitzer Survey of
Interstellar Clouds
(PI L. Allen)

Class I ○
Class F +
Class II ×
Class III △
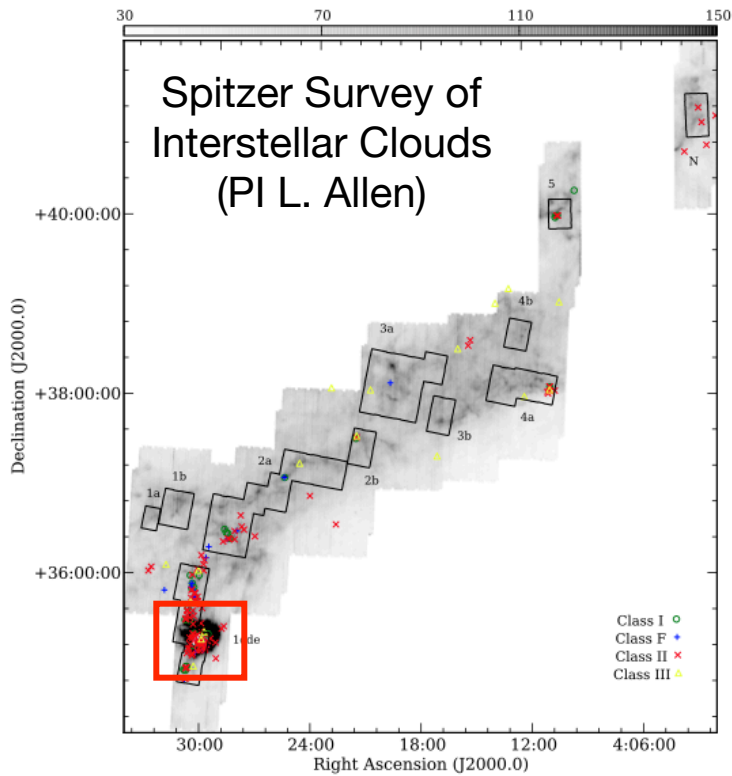
Broekhoven-Fiene+ 2014

Orion A
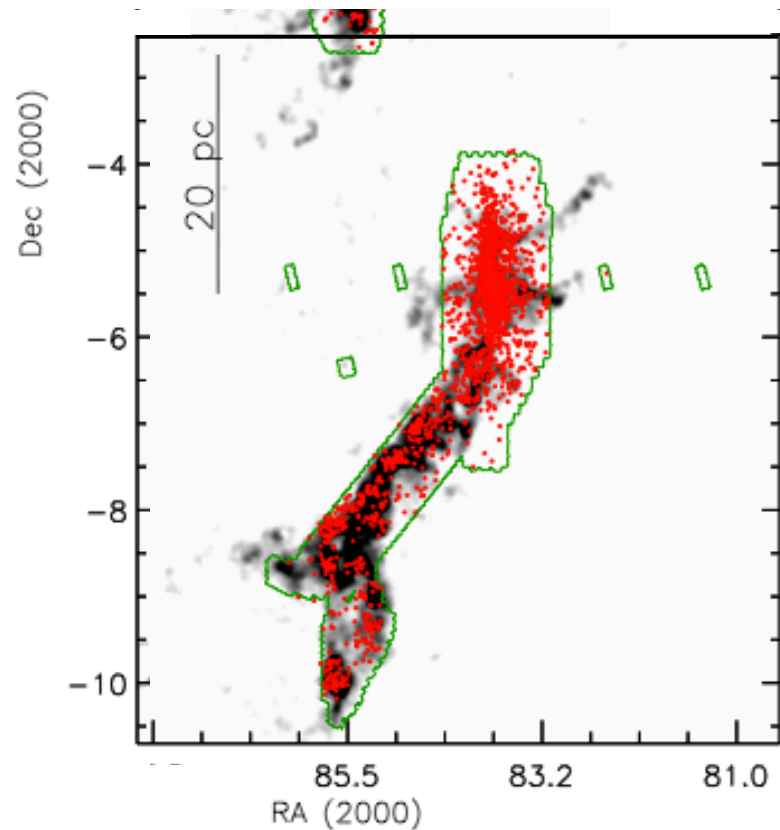
Megeath+ 2012

AMC
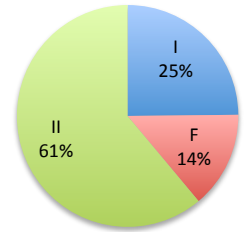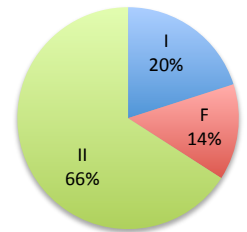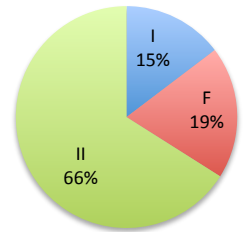
I 25%
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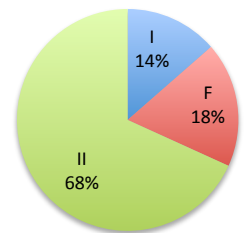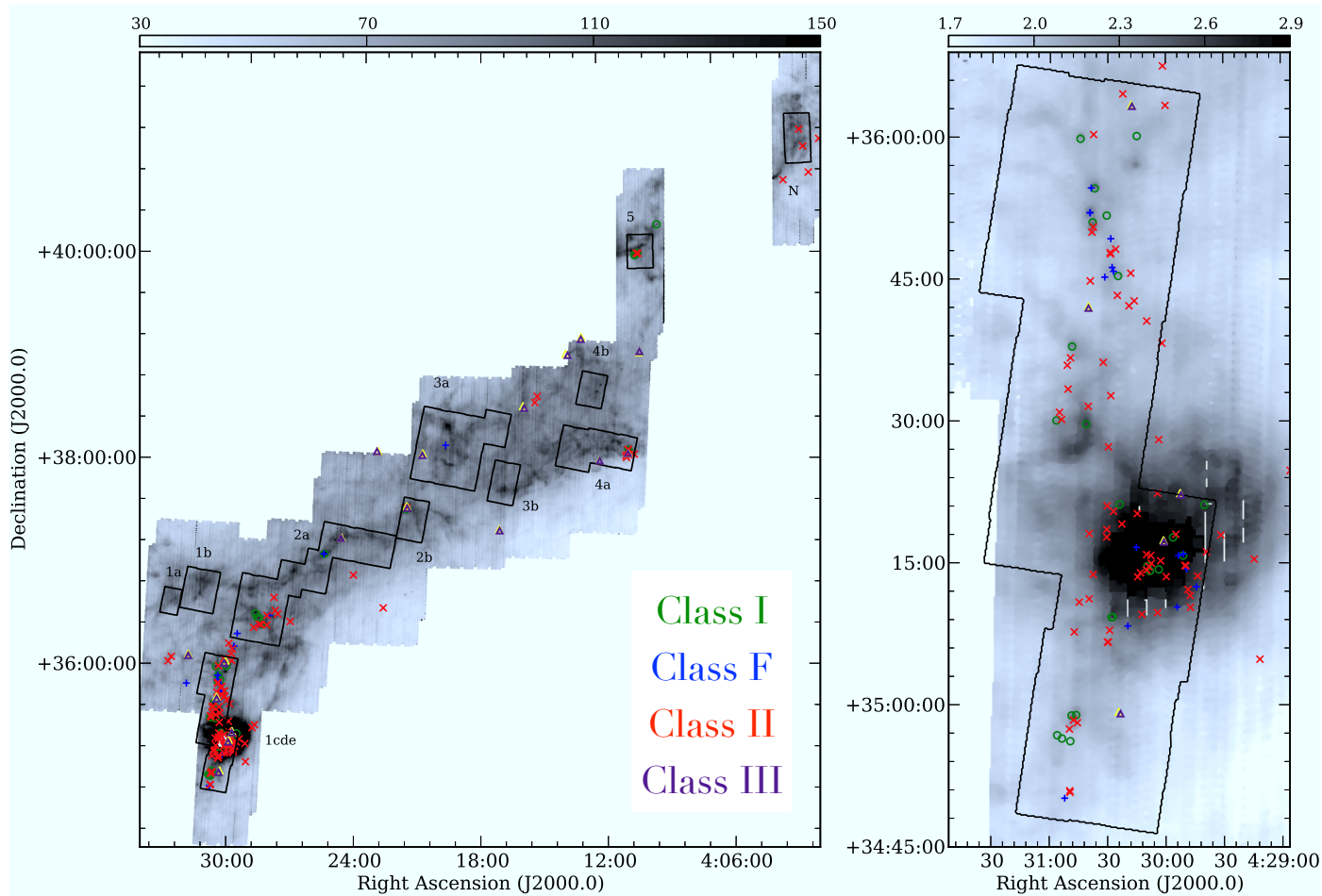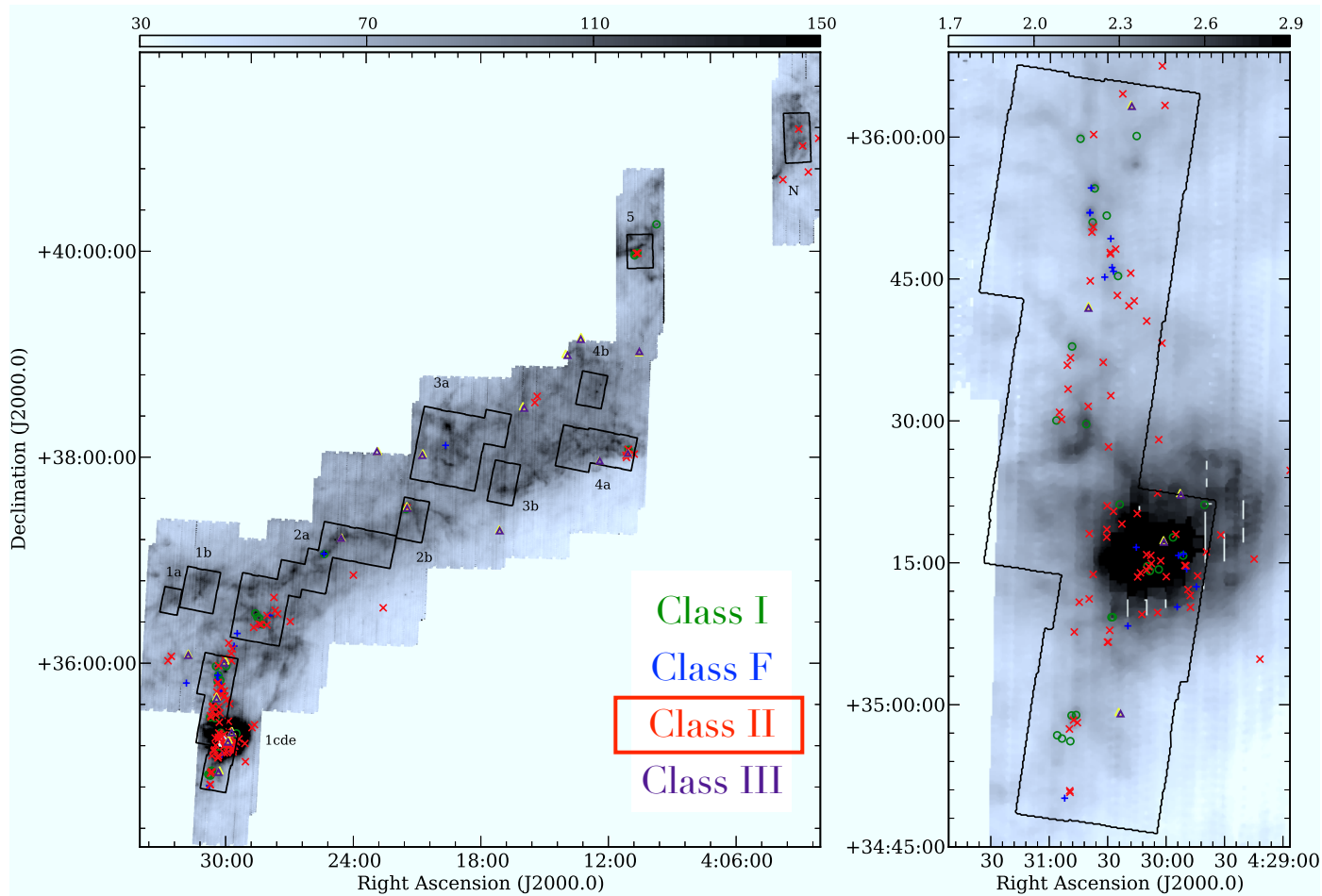
Identifying the protoplanetary disk sample - Spitzer

Spitzer Survey
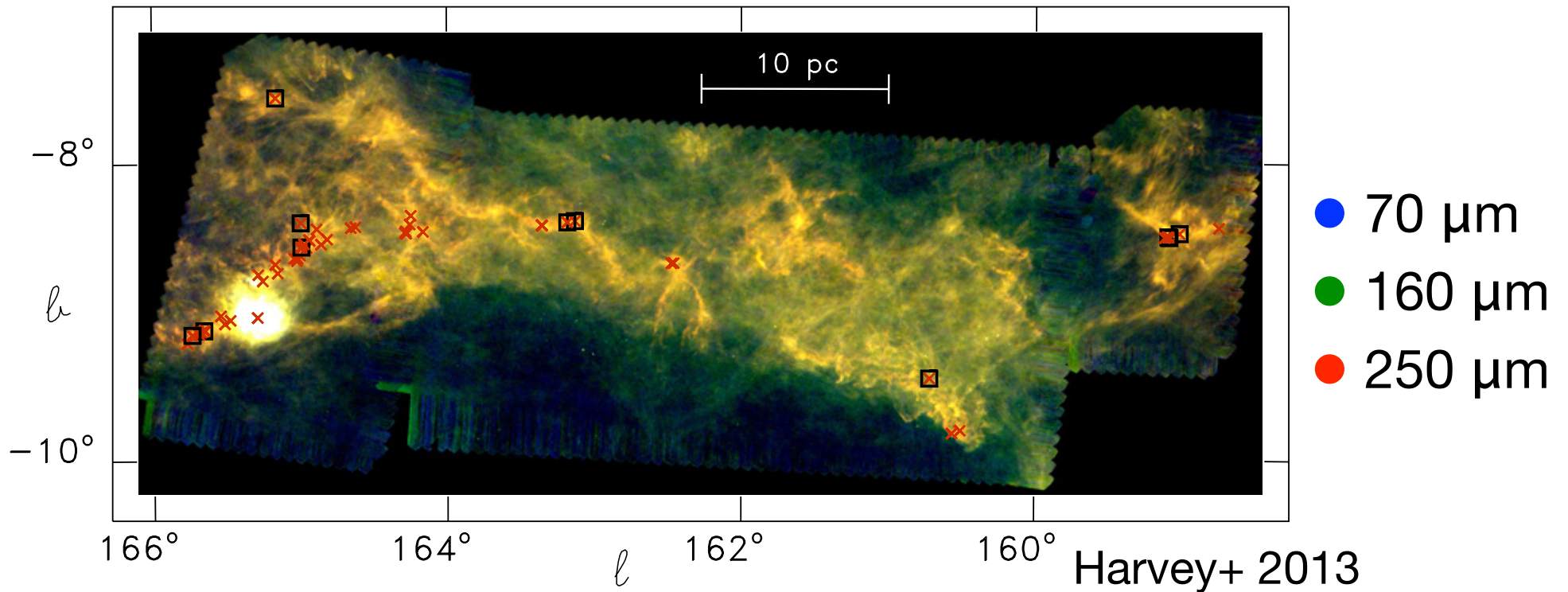of Interstellar
Clouds
(PI L. Allen)

Broekhoven-Fiene+ 2014

Identifying the protoplanetary disk sample - Spitzer

Spitzer Survey
of Interstellar
Clouds
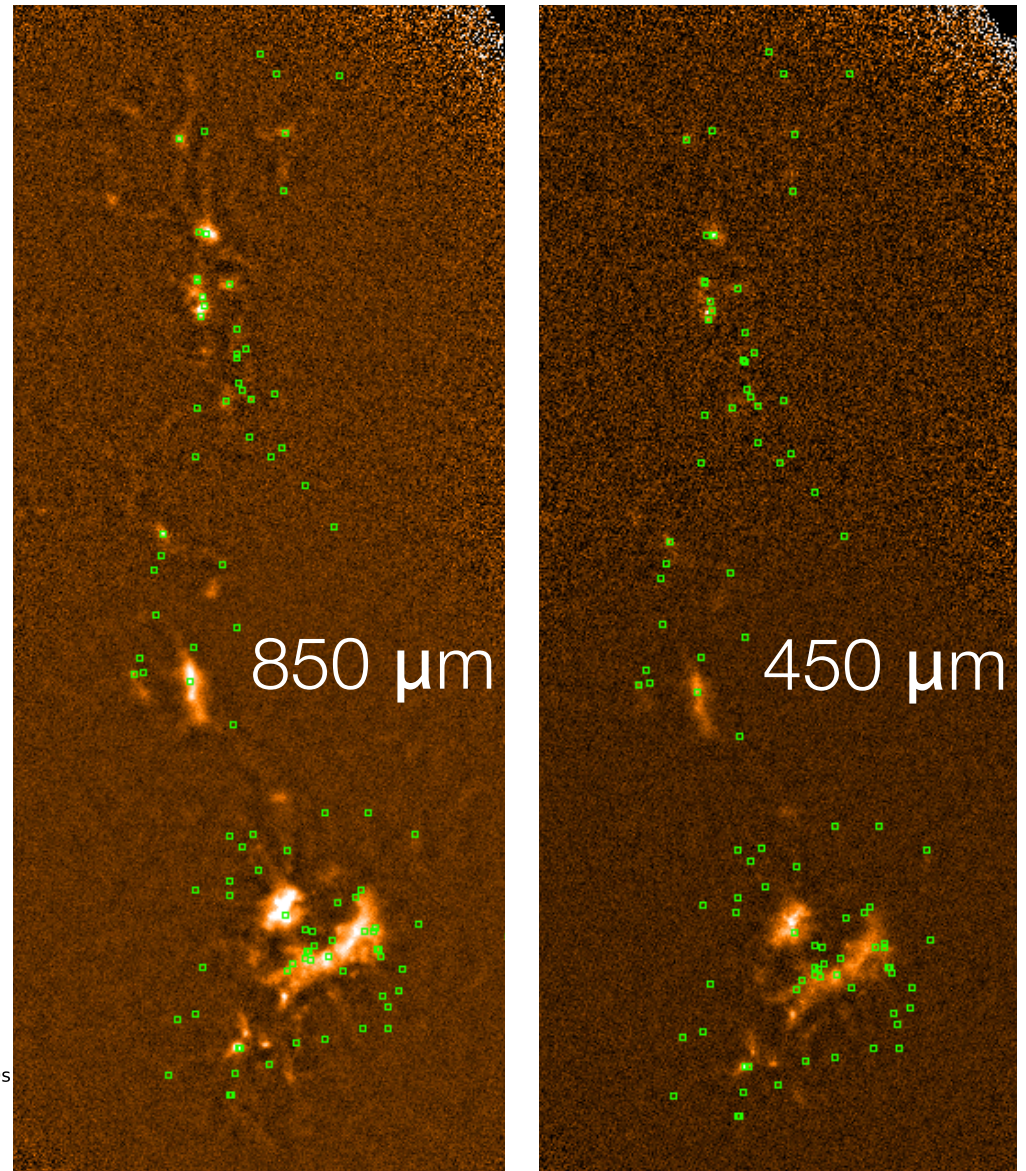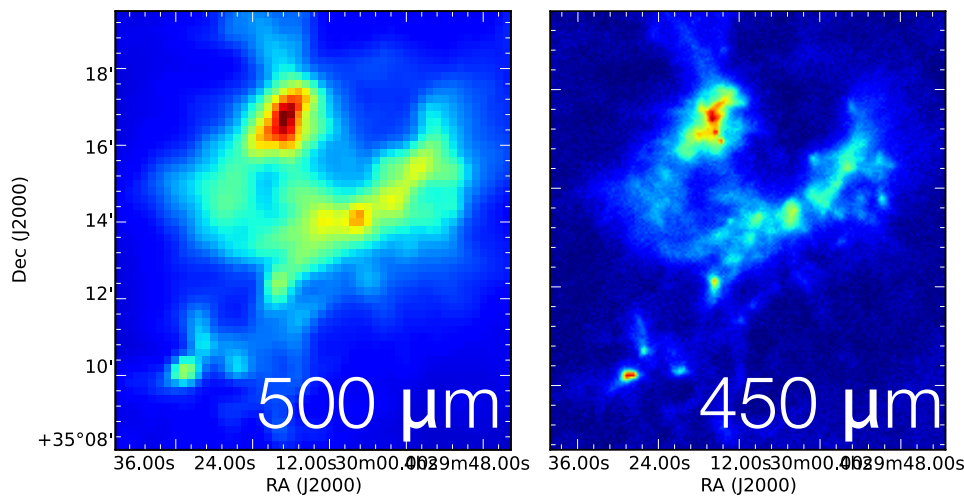(PI L. Allen)

Broekhoven-Fiene+ 2014

Herschel

10 pc

−8°

ℓ

−10°

166°   164° ℓ 162°   160°

● 70 µm

● 160 µm

● 250 µm

Harvey+ 2013

- large scale structure

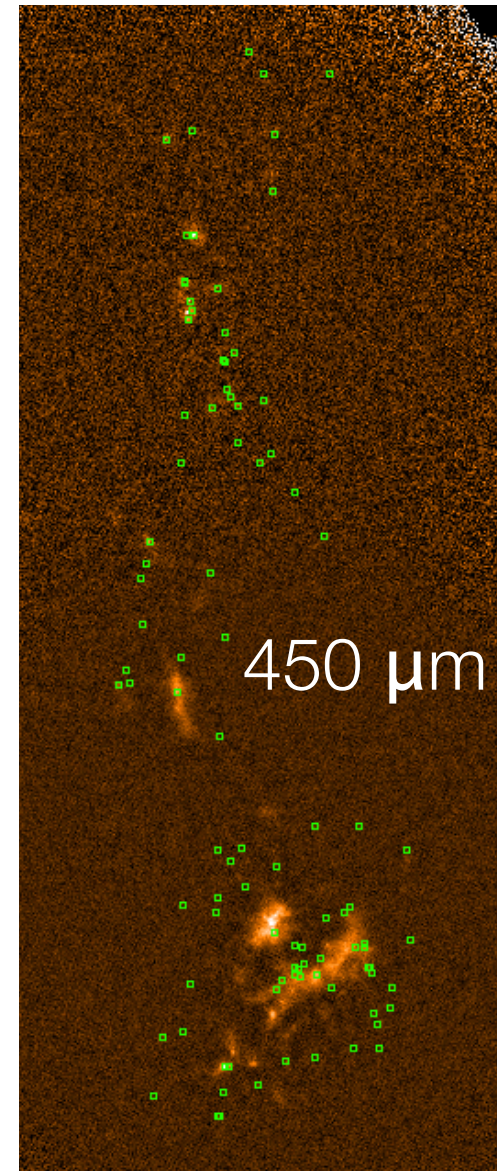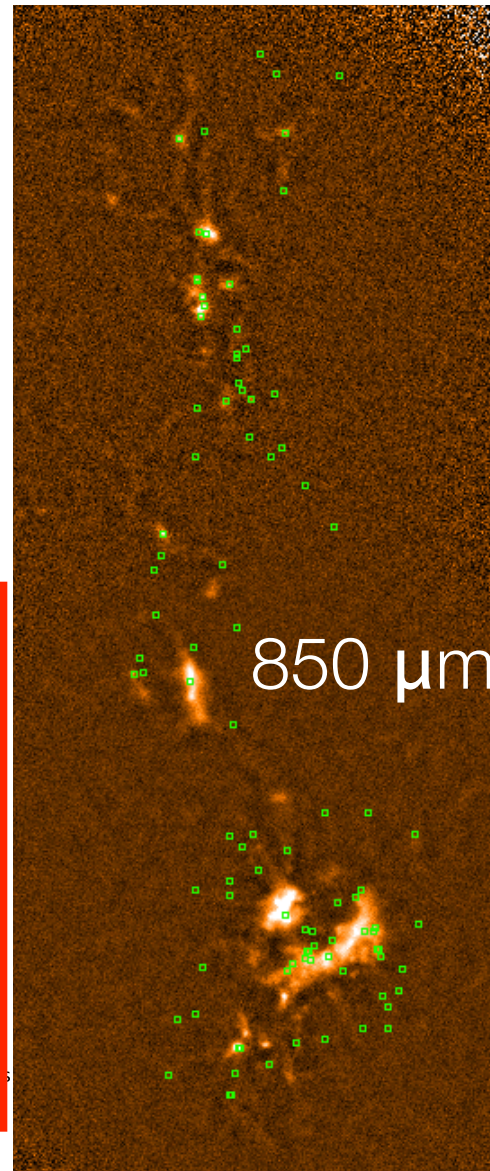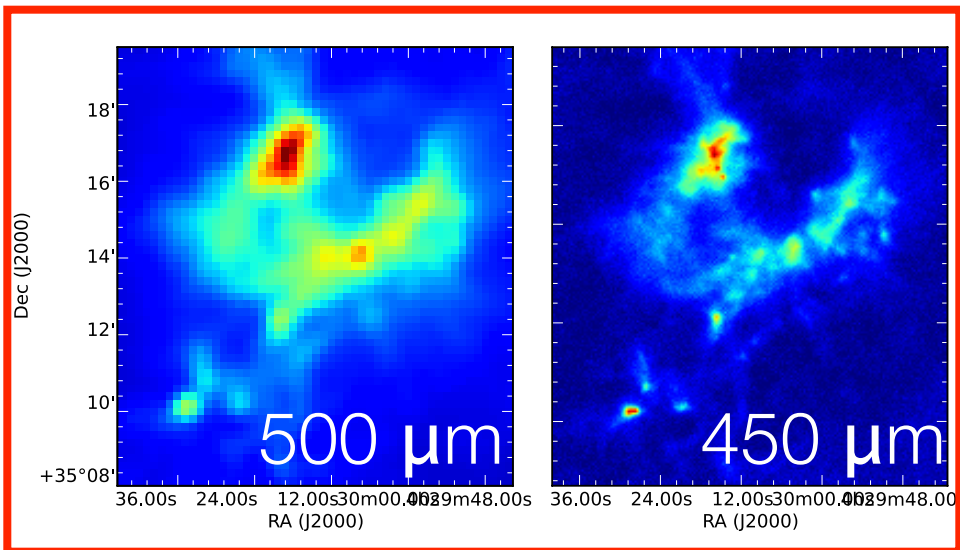- 60 compact sources (12 new)

- iden

SCUBA-2: JCMT Gould Belt Legacy Survey

- sources less blended

- probing optically thin emission

- sensitive to younger sources

SCUBA-2: JCMT Gould Belt Legacy Survey

- sources less blended

- probing optically thin emission
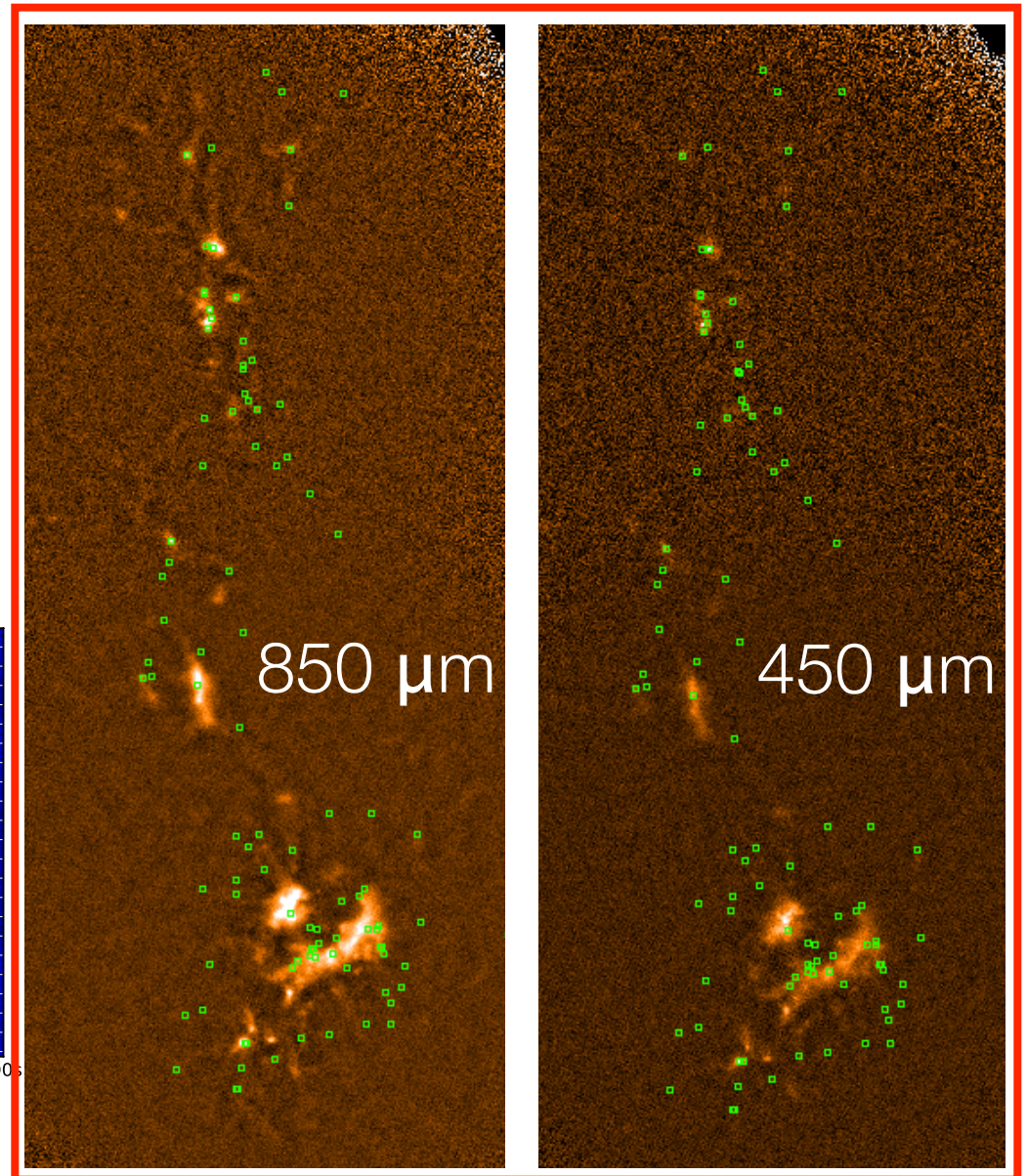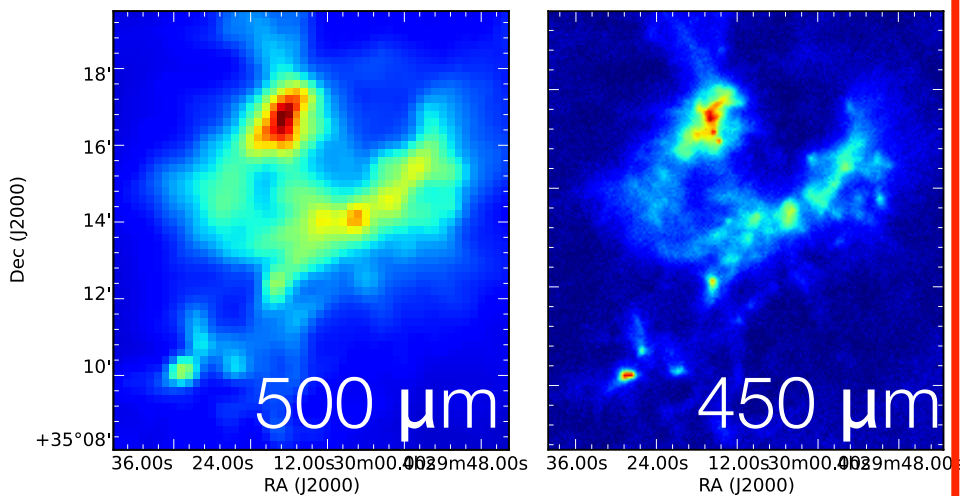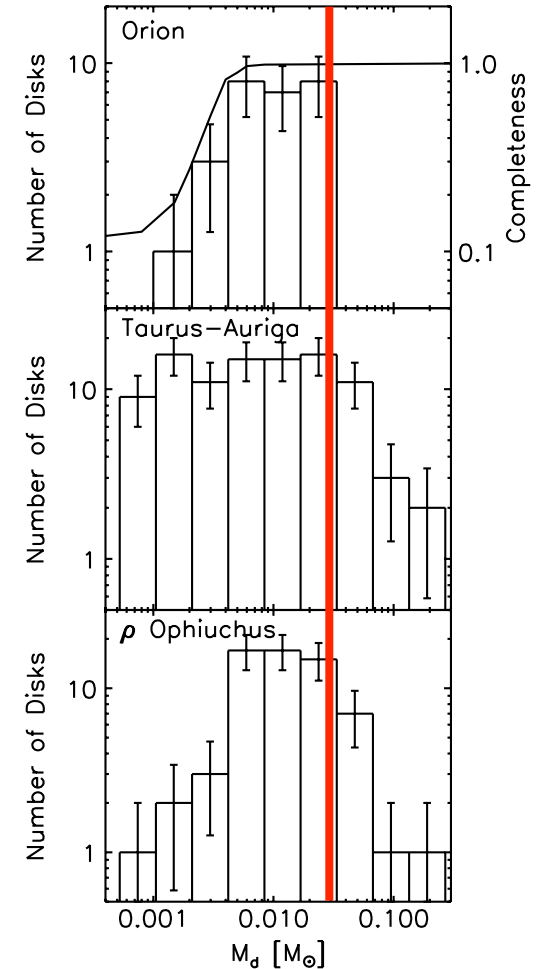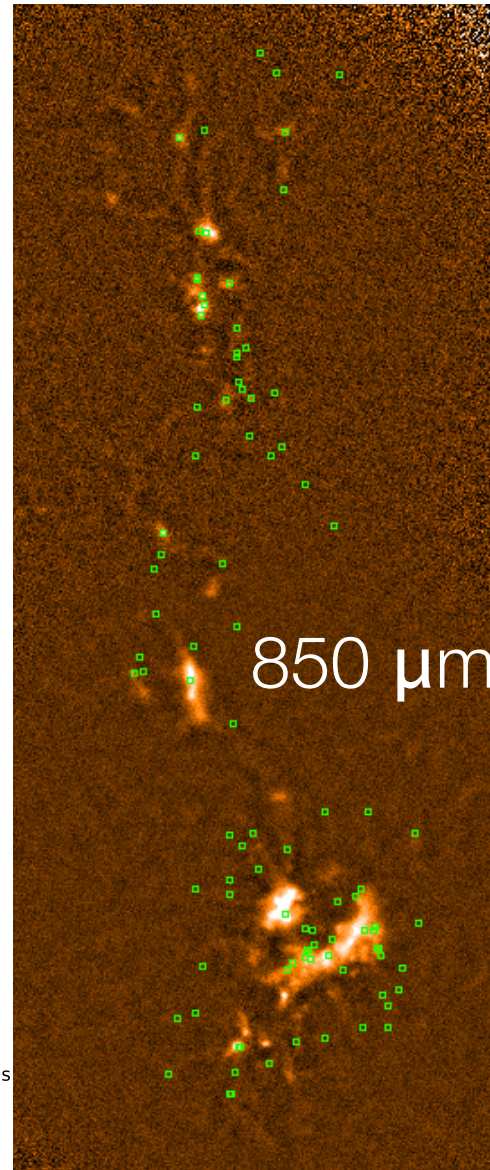
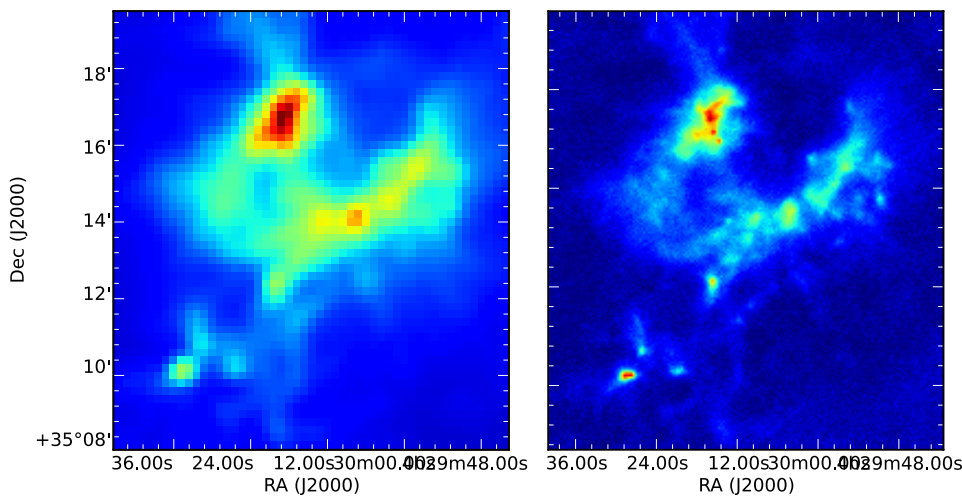- sensitive to younger sources

SCUBA-2: JCMT Gould Belt Legacy Survey

- sources less blended

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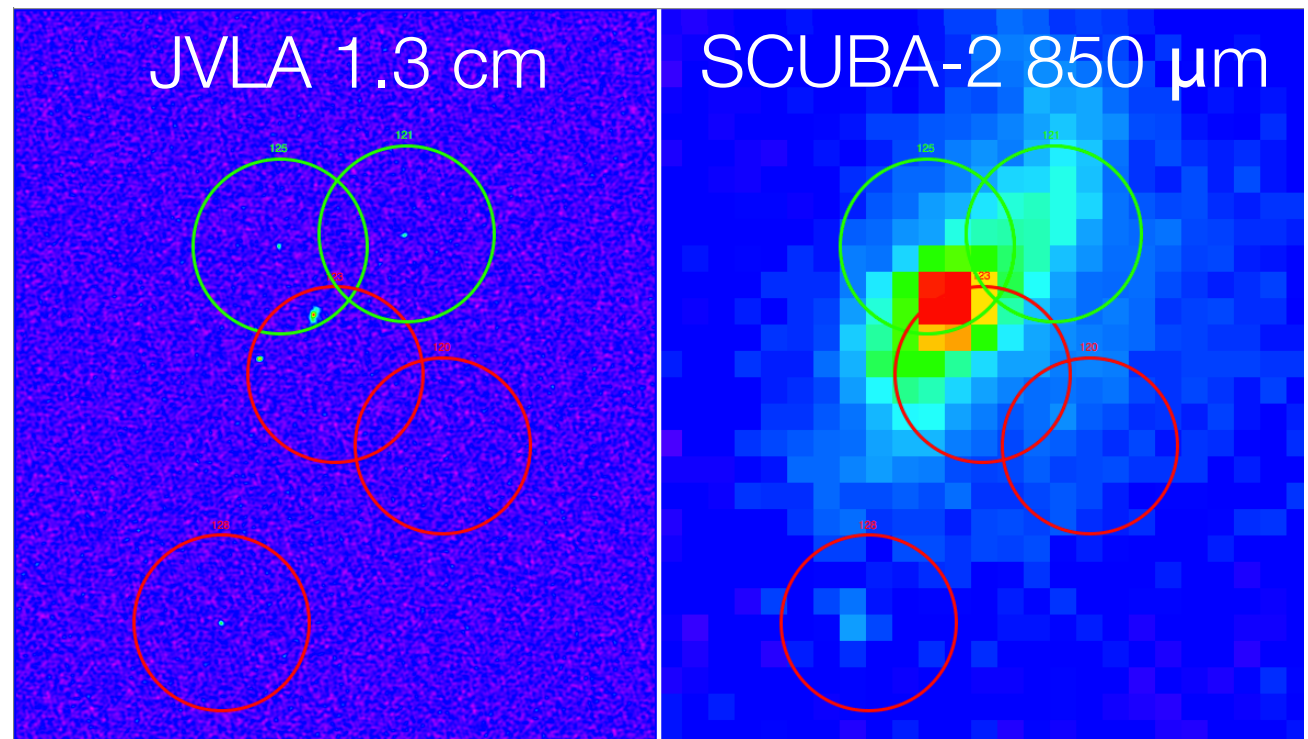# SCUBA-2: JCMT Gould Belt Legacy Survey

- sources less blended

- probing optically thin emission

- sensitive to younger sources

850 μm

Mann & Williams 2009

# The power of radio interferometry

- Longer wavelengths with better resolution

- isolating sources from each other and surrounding cloud emission

| YSO	SMA 1.3 mm (measured)	SMA 0.88 mm (expected)	SCUBA-2 0.85 mm (peak)
108 - blended with YSOs and cloud	20 mJy	55 mJy	240 mJy
128 - more isolated	36 mJy	100 mJy	120 mJy

Jansky VLA observations

- Trace cm-sized grains

- Constrain the level of contamination from free-free emission to the thermal dust emission

- Comparison to Disks@EVLA (PI Claire Chandler) program that targets disks in nearby clouds

Melis+ 2011
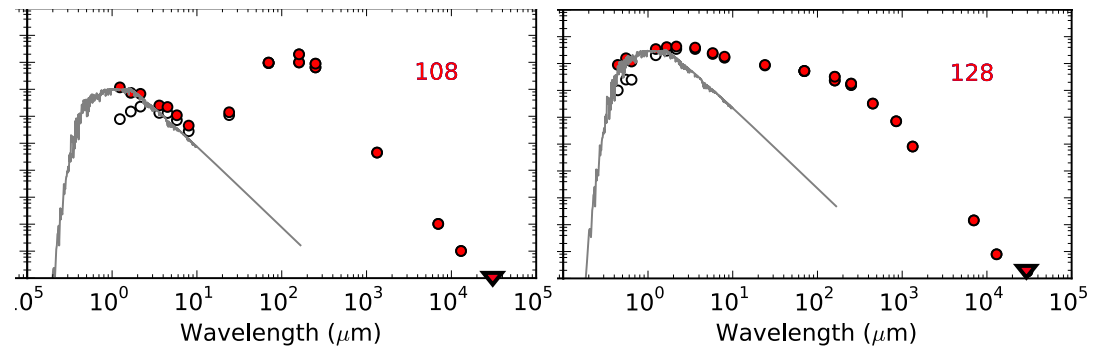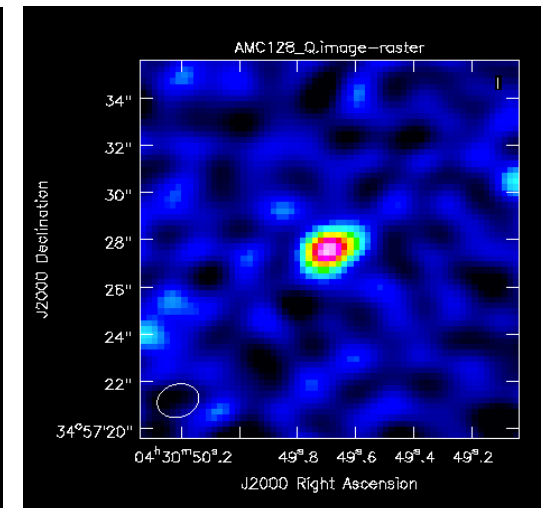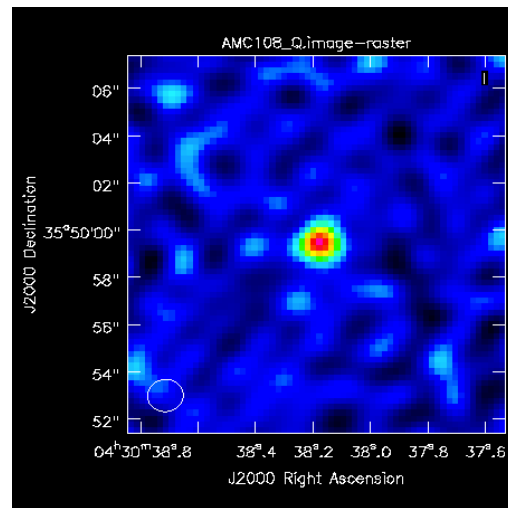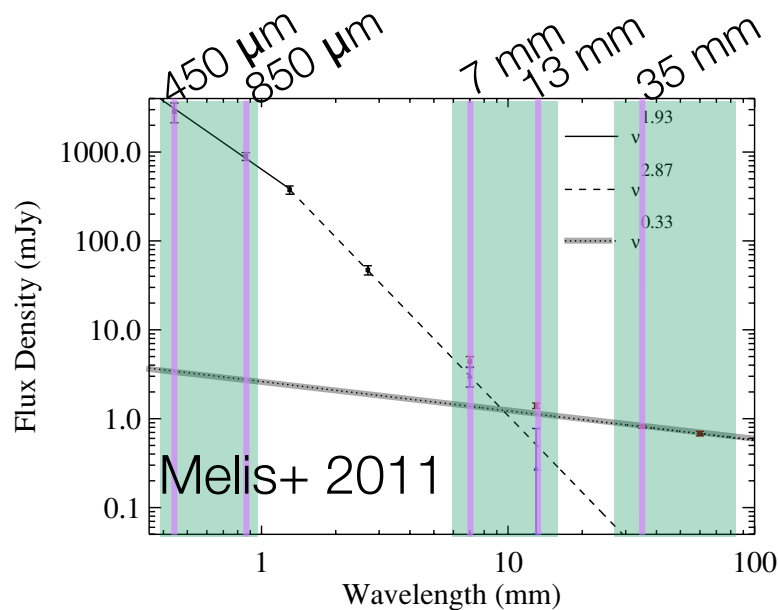
Conclusions/Summary

- ACMC is a nearby GMC similar in mass, extent, and distance to the Orion A MC, however, with a startling contrast in environment.

- Detections at both submm and wavelengths used to investigate the global grain size distribution.

- Next step is to compile catalogues from the various data sets and SEDs for individual objects.

- Follow-up high-resolution observations of detected disks can investigate disk and dust properties further, such as disk sizes and radial grain size distribution within the disk.
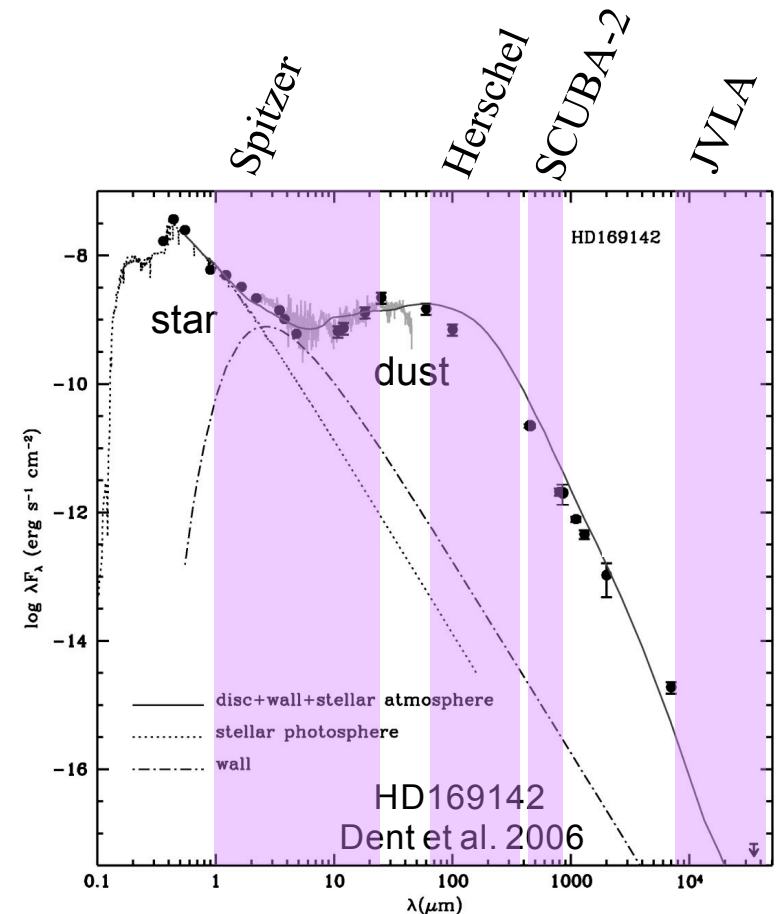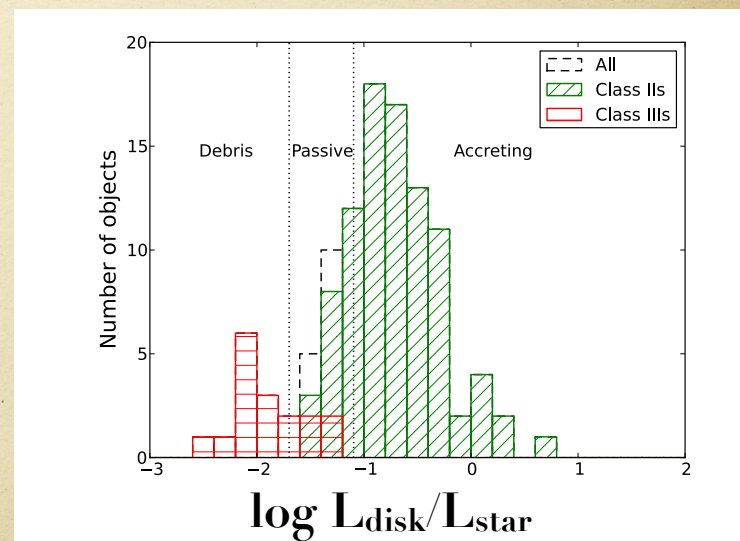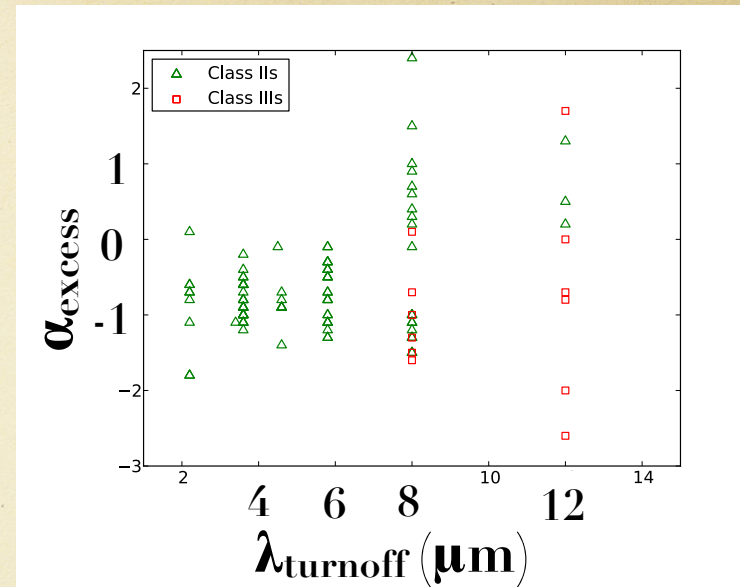
Thank you!

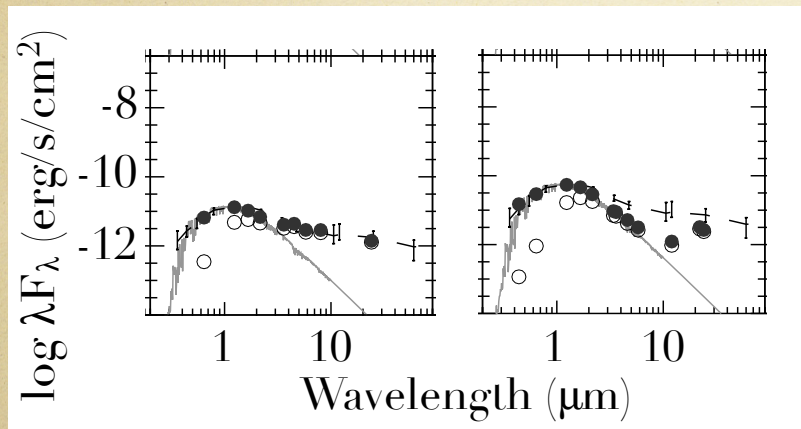# EXTRA SLIDES

Disk population
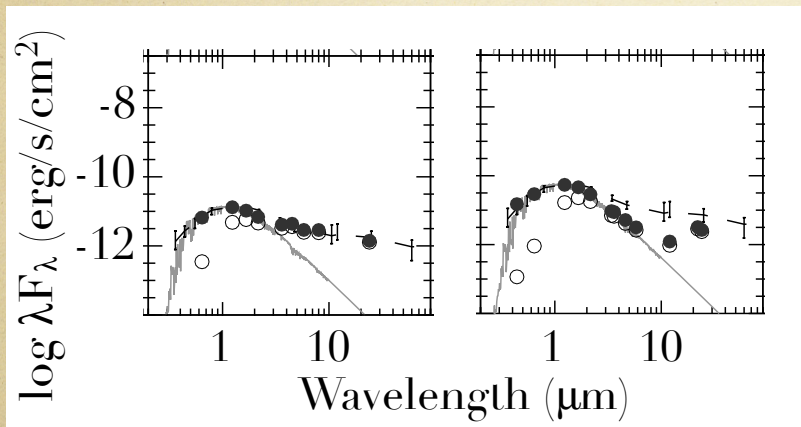
- estimate where excess begins and the slope of the excess
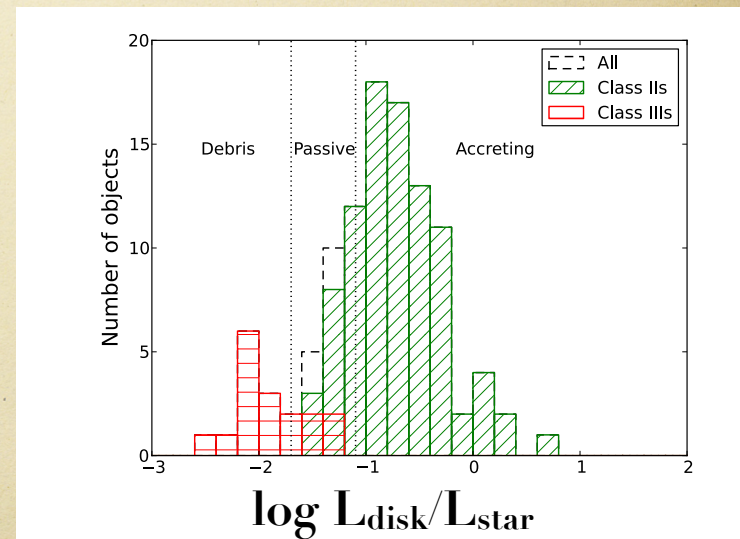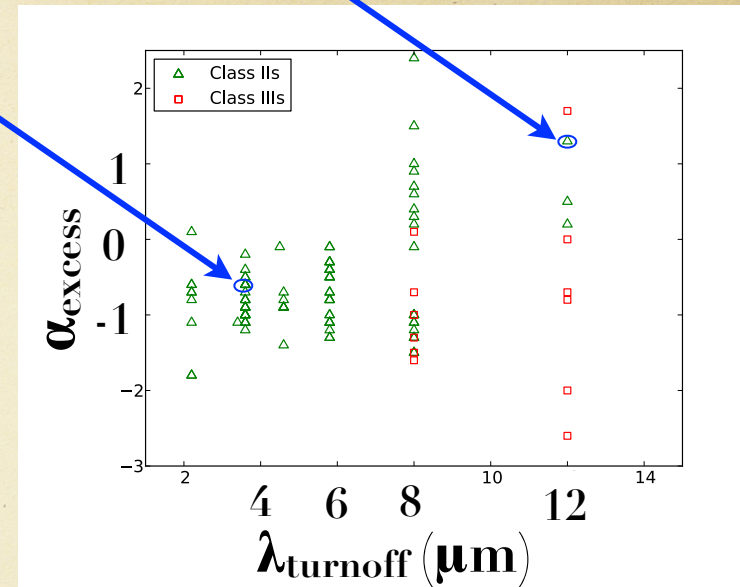
- estimate disk luminosity

Broekhoven-Fiene+, subm.

Disk population

- estimate where excess begins and the slope of the excess
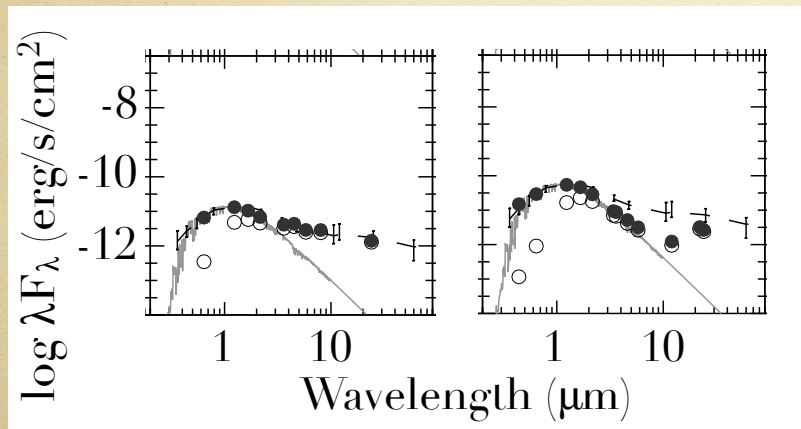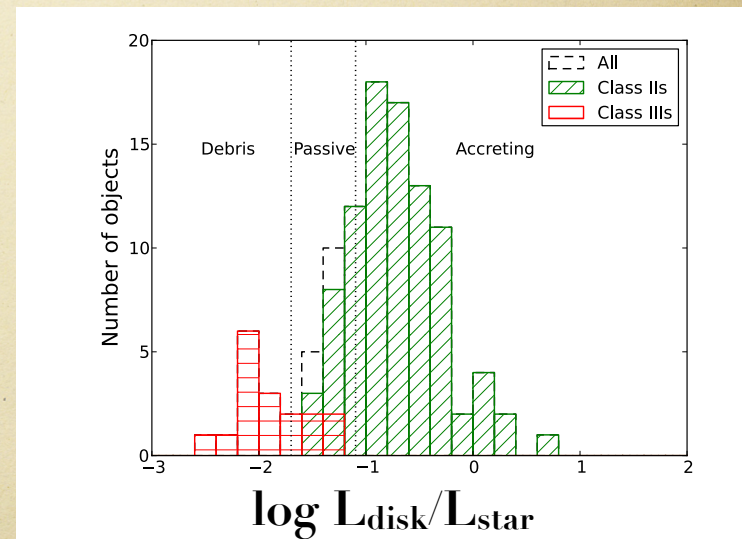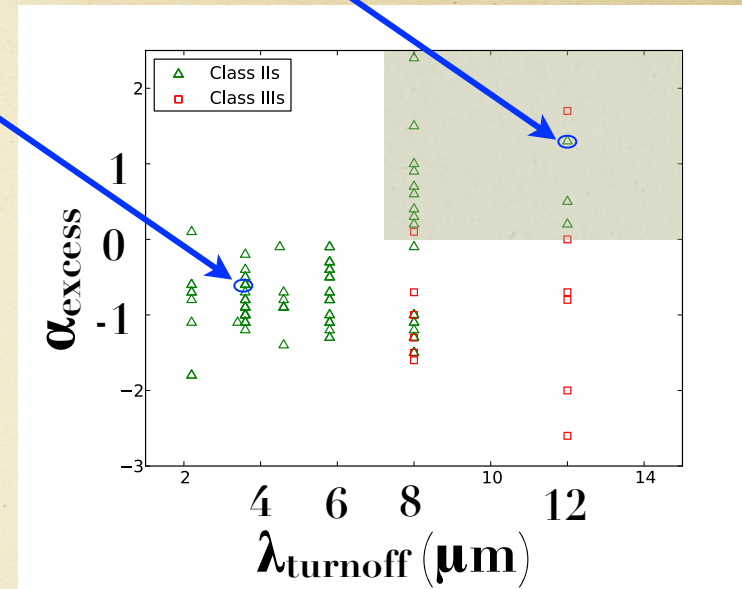
- estimate disk luminosity

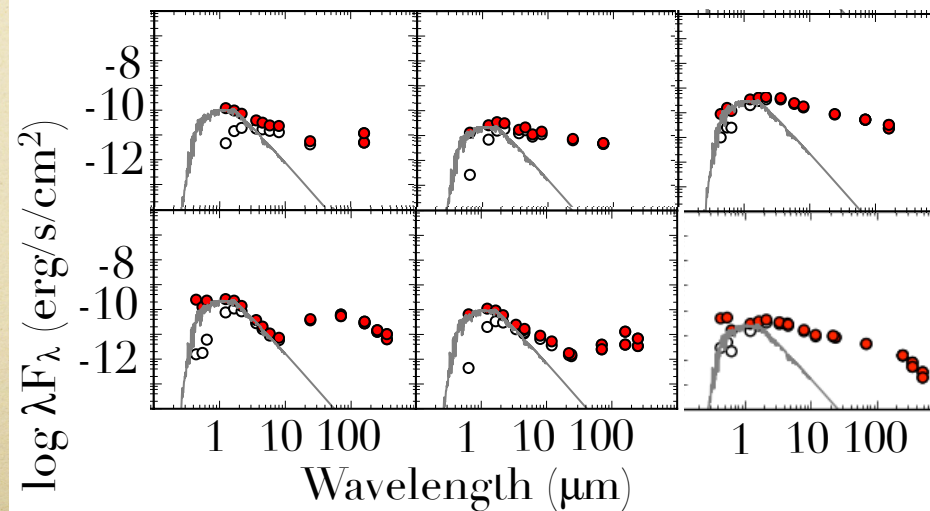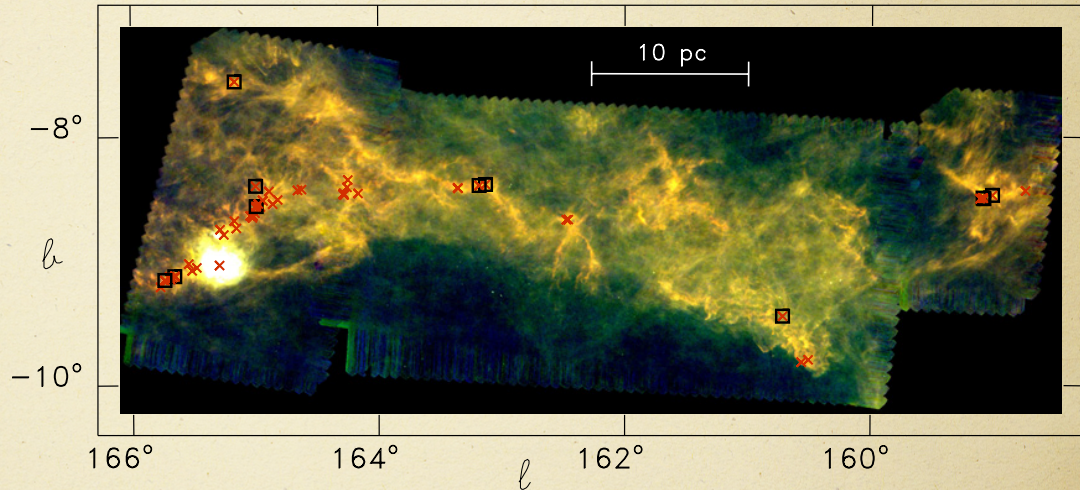Broekhoven-Fiene+, subm.

Disk population

- estimate where excess begins and the slope of the excess

- estimate disk luminosity
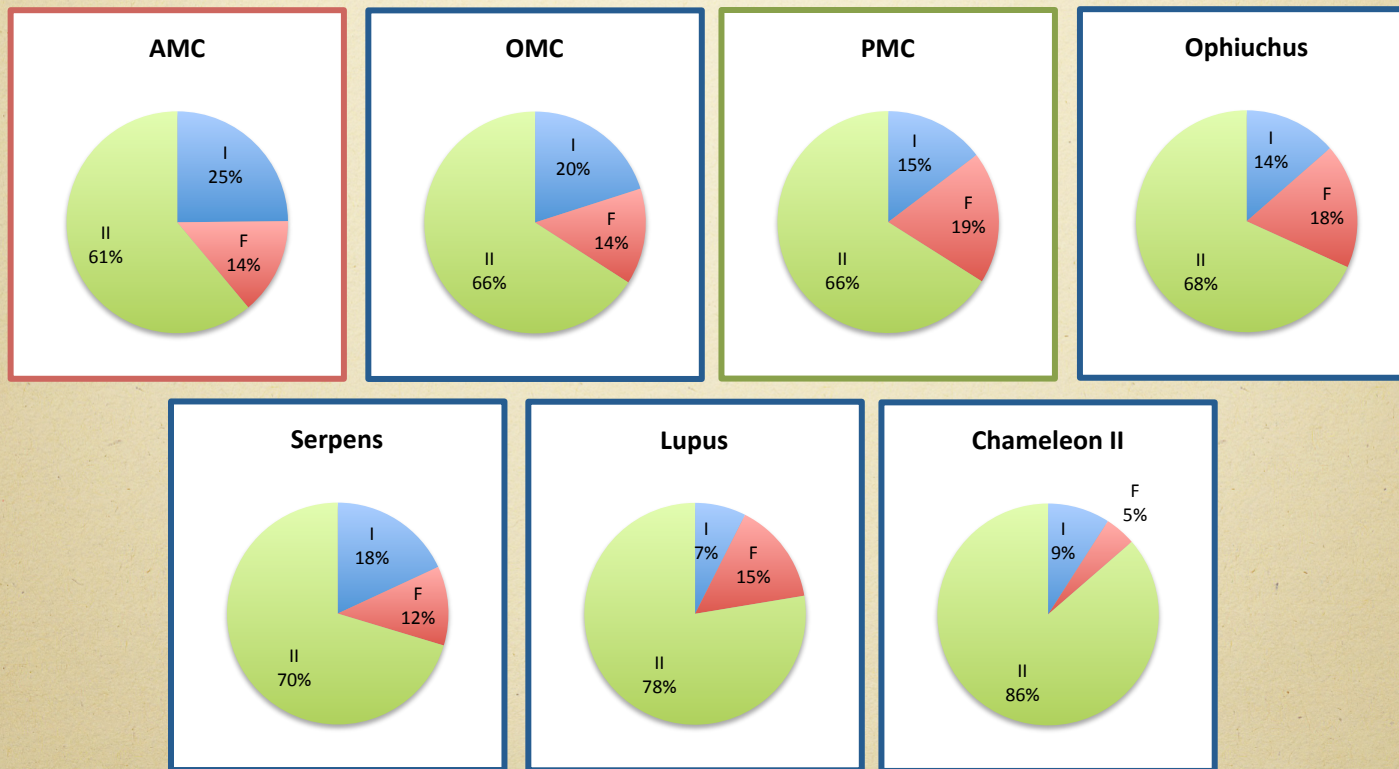
Broekhoven-Fiene+, subm.

Herschel fluxes

- Herschel maps at 70, 160, 250, 350, and 500 um (PI Paul Harvey)

- SPIRE fluxes (250 - 500 μm) measured at positions of known YSOs

- PRELIMINARY masses: 0.003 - 0.6 M$_{sun}$

+JCMT JLS!

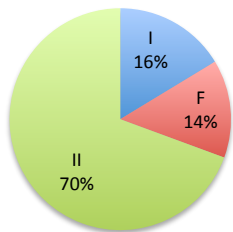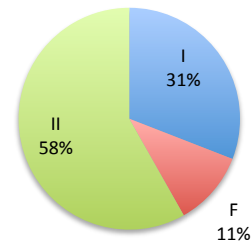# Class breakdowns for different clouds

AMC

I 25%
F 14%
II 61%

OMC

I 20%
F 14%
II 66%

PMC

I 15%
F 19%
II 66%

Ophiuchus

I 14%
F 18%
II 68%

Serpens

I 18%
F 12%
II 70%

Lupus

I 7%
F 15%
II 78%

Chameleon II

F 5%
I 9%
II 86%

Class breakdowns for groups within AMC and Perseus

Group 1 (LkHa 101)
- I 16%
- F 14%
- II 70%

AMC - extended
- I 31%
- F 11%
- II 58%

PMC - NGC 1333
- I 11%
- F 27%
- II 62%

PMC - IC 348
- I 8%
- F 8%
- II 84%

PMC - extended
- I 24%
- F 26%
- II 50%

Dust distribution in disks

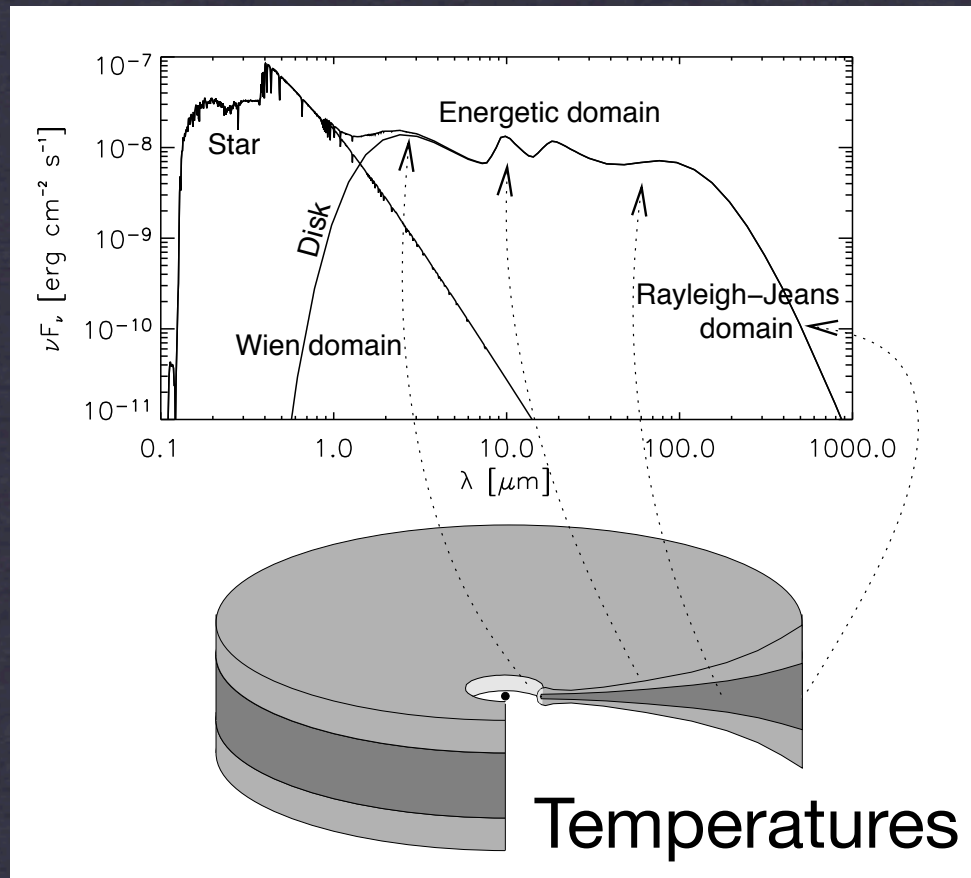Temperatures

Dullemond et al. 2006

Large dust grains

Dust settling

Williams & Cieza 2011

Optically thin dust

$$F_\nu \approx \kappa(\nu) M_d B_\nu(T_d) d^{-2}$$

Dust distribution in disks

νF_ν [erg cm^{-2} s^{-1}]

Star

Energetic domain

Disk

Wien domain

Rayleigh–Jeans domain

λ [μm]

Temperatures
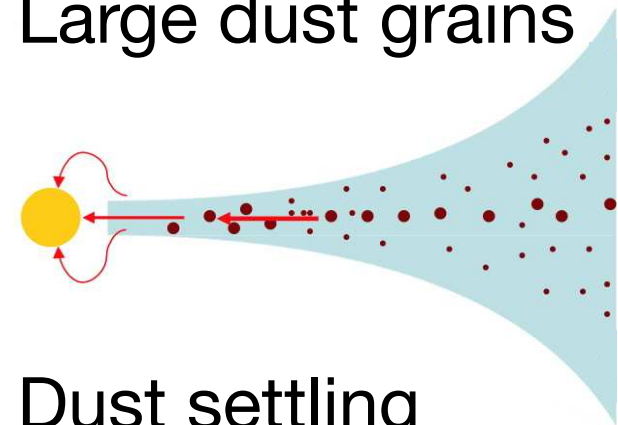
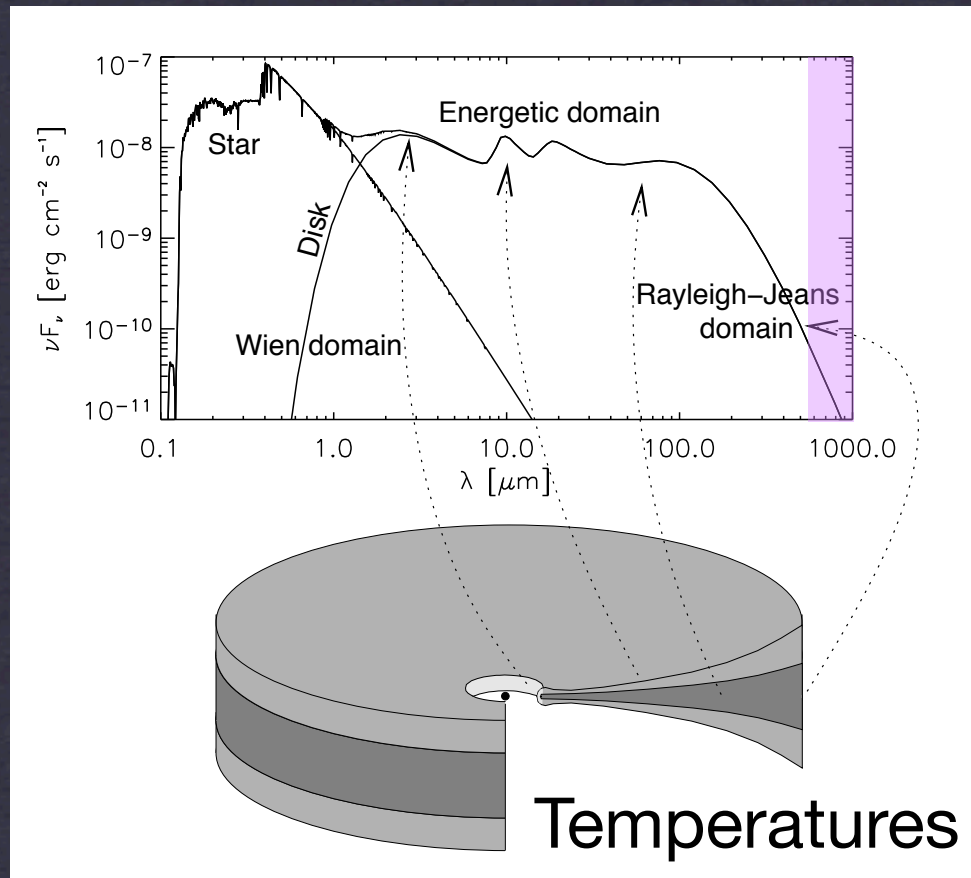Dullemond et al. 2006

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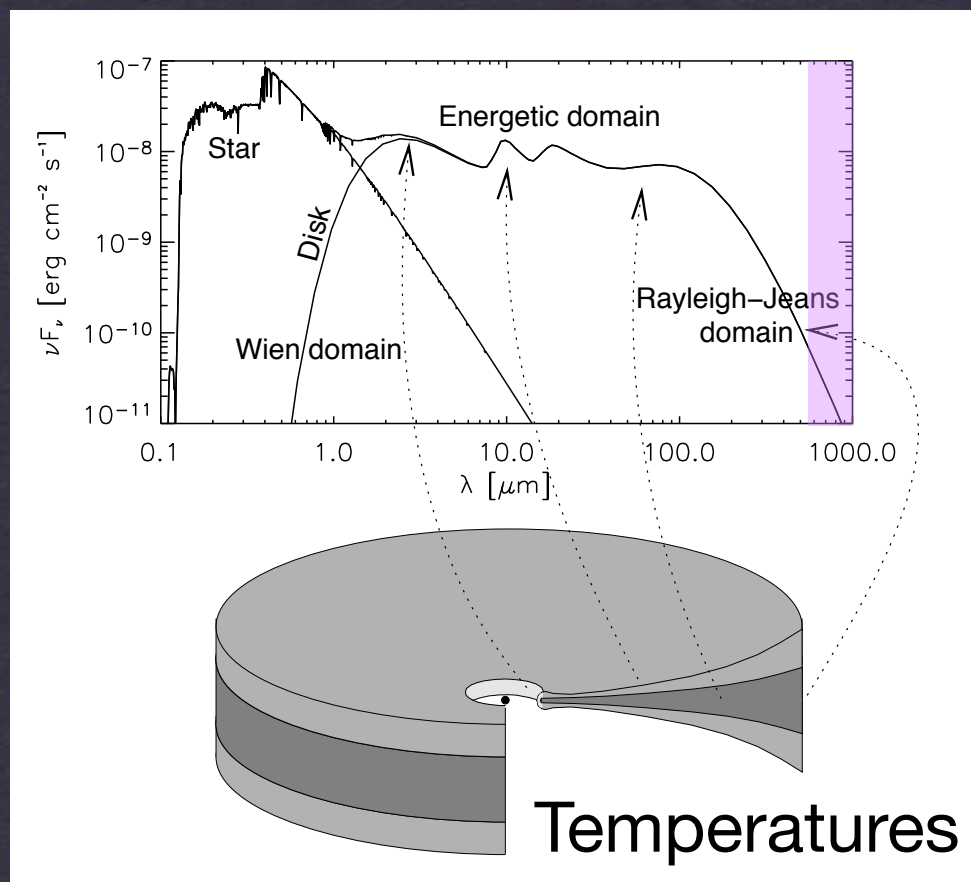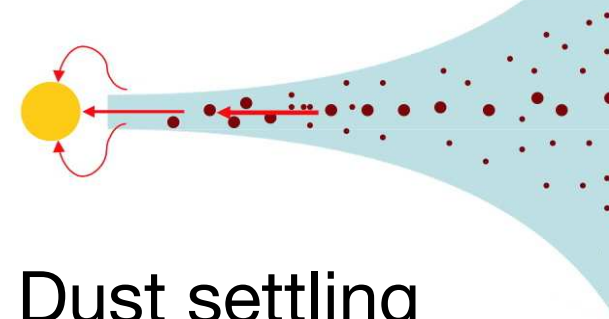
$$F_\nu \approx \kappa(\nu) M_d B_\nu(T_d) d^{-2}$$

Signatures of grain growth

Recall:

$$F_\nu \approx \kappa(\nu) M_d B_\nu(T_d) d^{-2}$$

Submm/mm observations:

$$B_\nu(T_d) \propto \nu^2 \qquad \kappa(\nu) \propto \nu^\beta$$

$$F_\nu \propto \nu^\alpha, \text{ with } \alpha = 2 + \beta$$

Draine 2006

Evolution in β suggests evolution in dust grain size
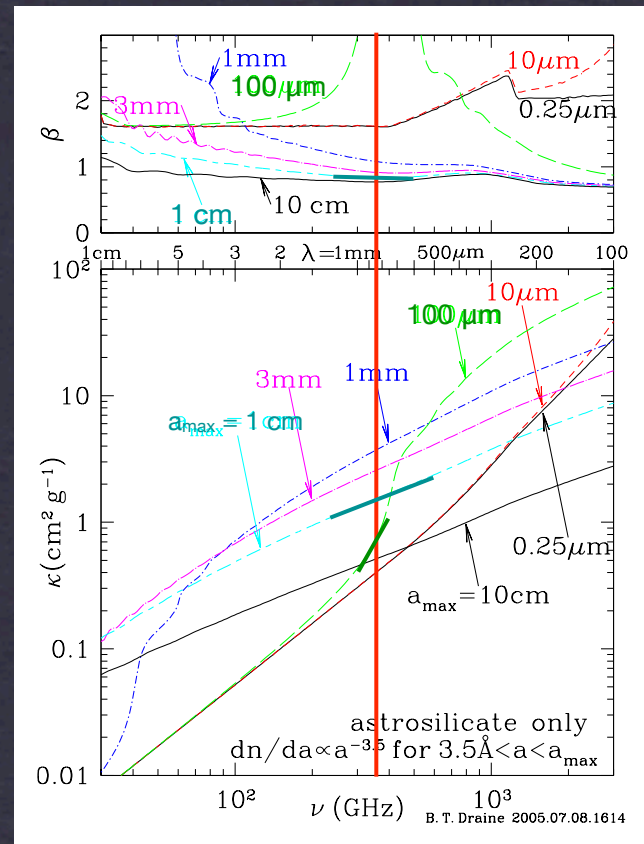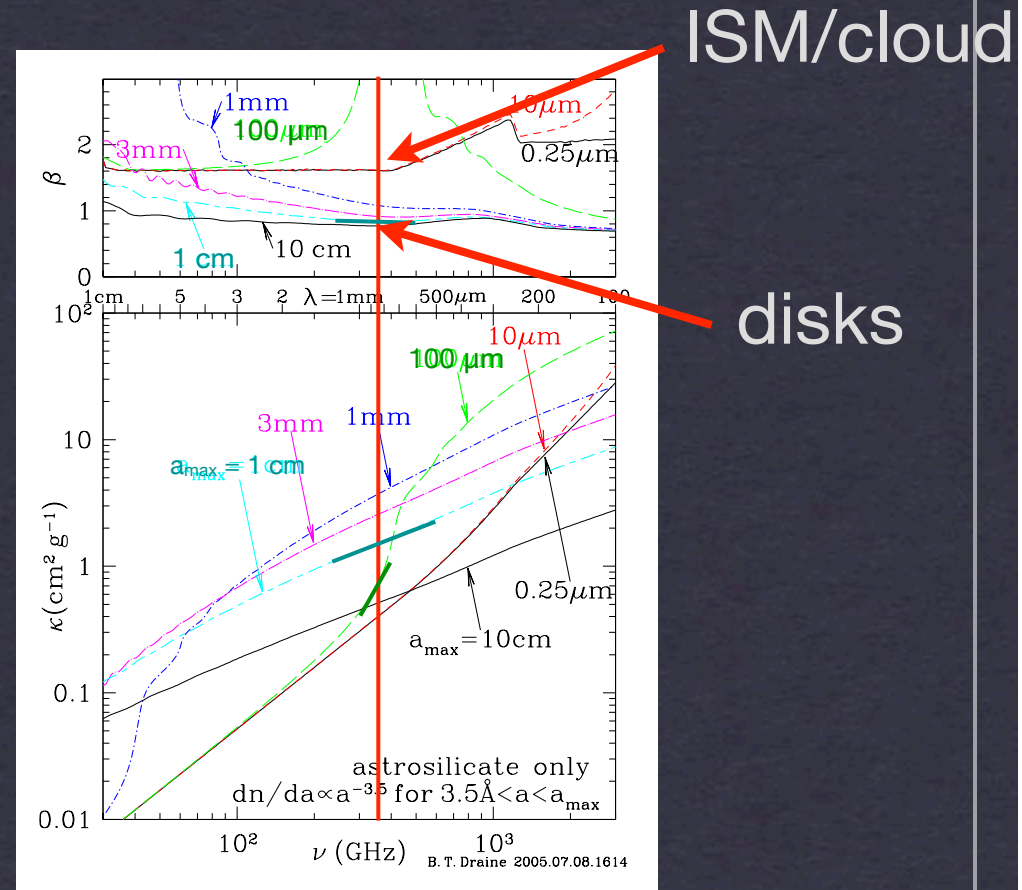
Signatures of grain growth

Recall: $F_\nu \approx \kappa(\nu) M_d B_\nu(T_d) d^{-2}$

Submm/mm observations:

$B_\nu(T_d) \propto \nu^2$ $\kappa(\nu) \propto \nu^\beta$

$F_\nu \propto \nu^\alpha$, with $\alpha = 2 + \beta$

ISM/cloud

disks

Draine 2006

Evolution in β suggests evolution in dust grain size

Case study: ONC

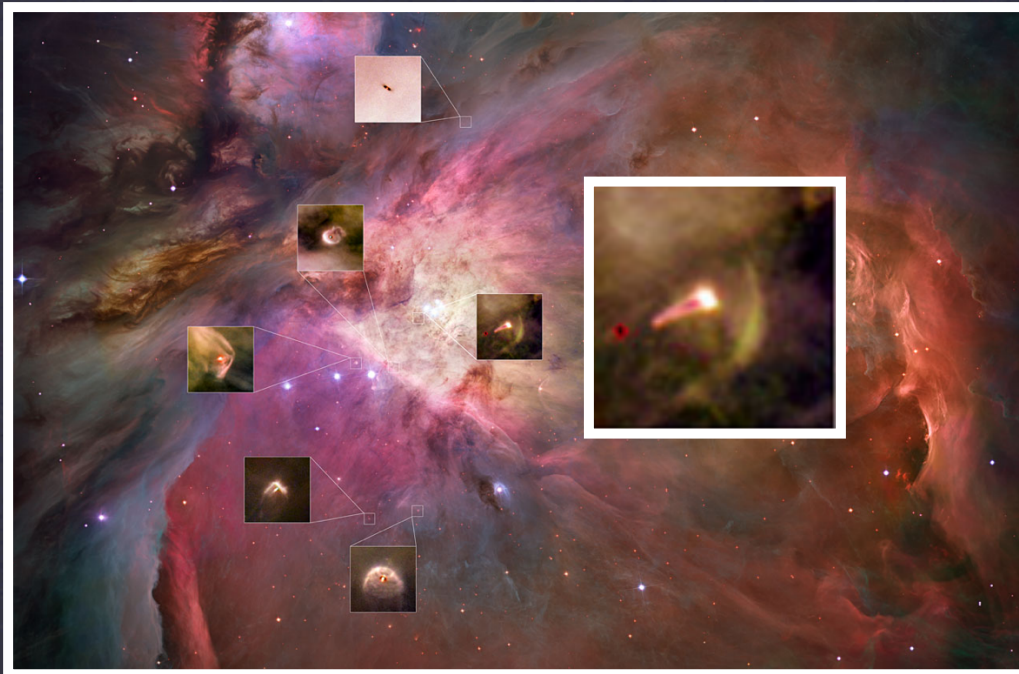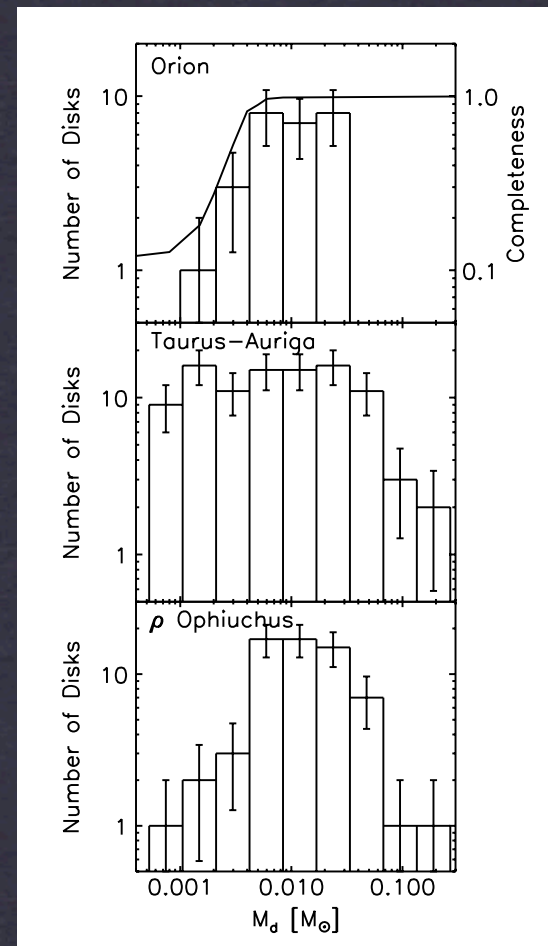Image credit: Space Telescope Science Institute

Mann & Williams 2009

Identify disk host candidates