# The Core Mass Function in NGC 6357


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# The Initial Mass Function

**Fundamental ingredient for study of star formation and galaxy evolution**

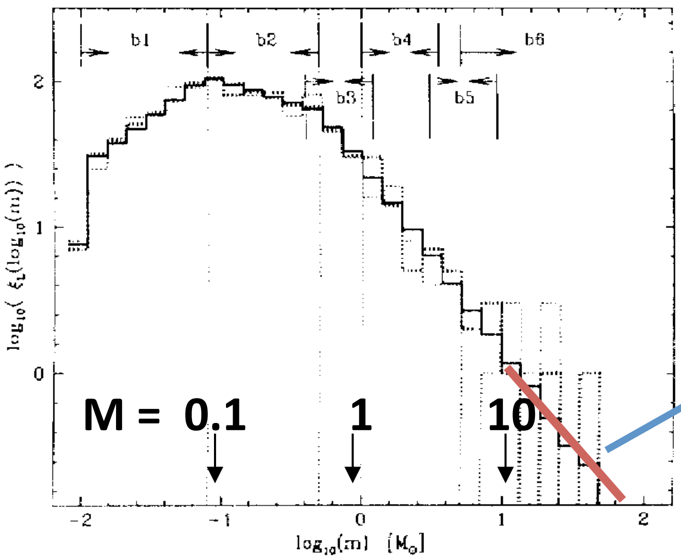
**IMF: Frequency distribution of stellar masses at birth**

**Number of stars per unit of (logarithmic) mass:**

$\xi(\log m) \propto m^{\Gamma}$ or $\xi(m) \propto m^{\gamma}$

$\xi(\log m) = (\ln 10).m\,\xi(m)$

**log[ ξ(logm) ] vs. logm**




**Scalo (1998):** $\Gamma = -0.2 \pm 0.3$ for $0.1 < M < 1\,M_{\odot}$

$= -1.7 \pm 0.3$ for $1 < M < 10\,M_{\odot}$

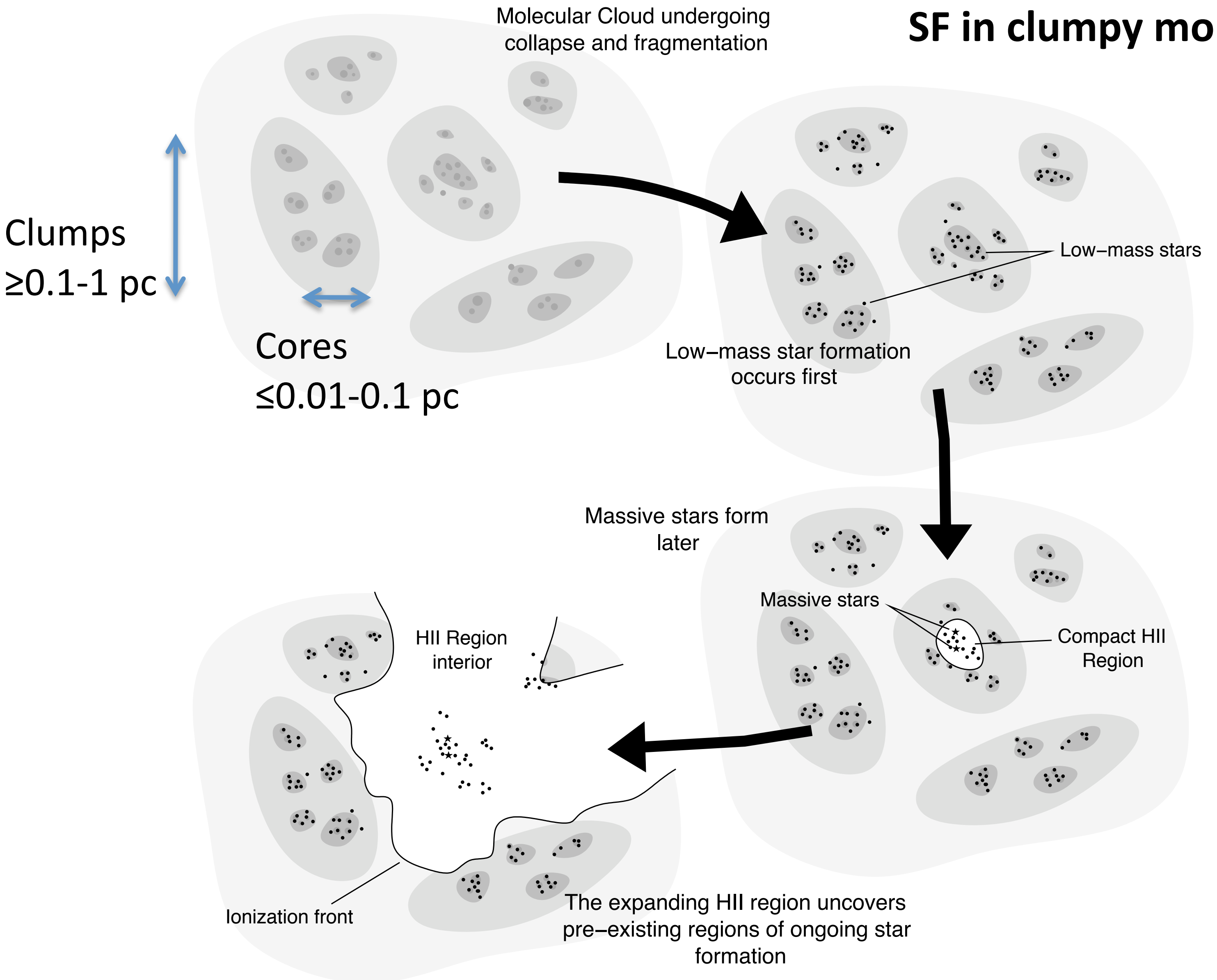
$= -1.3 \pm 0.3$ for $10 < M < 100\,M_{\odot}$

**i.e.:** $\gamma = -1.2 \pm 0.3$ for $0.1 < M < 1\,M_{\odot}$

$= -2.7 \pm 0.3$ for $1 < M < 10\,M_{\odot}$

$= -2.3 \pm 0.3$ for $10 < M < 100\,M_{\odot}$

# SF in clumpy molecular clouds I

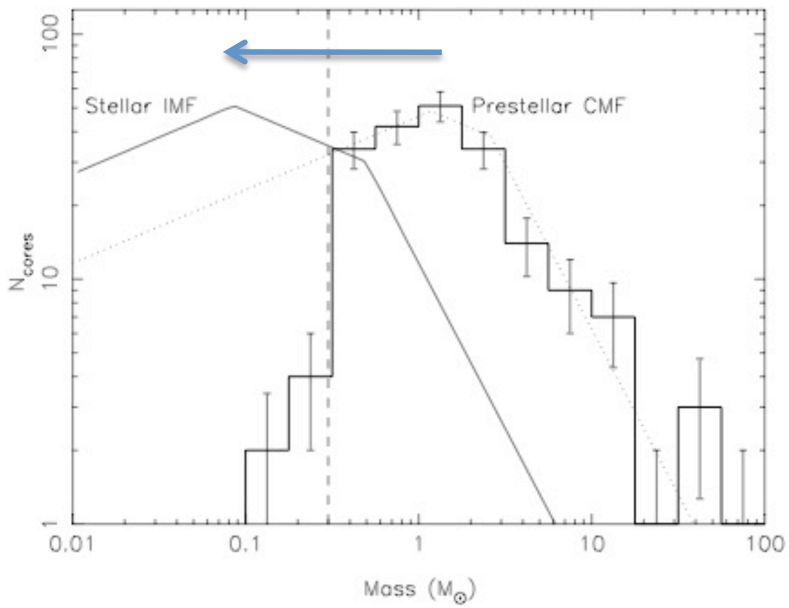



Hester & Desch ASP 341, 2005

# IN A NUTSHELL:

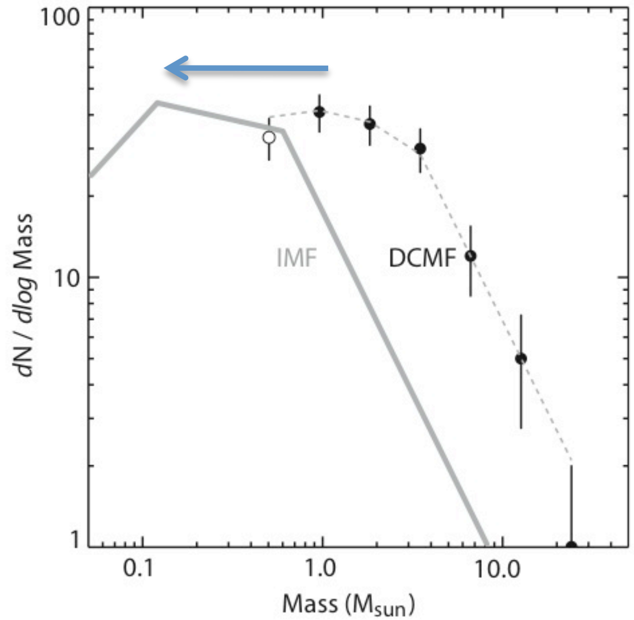
Stars form in cores.
Mass distribution cores (CMF) resembles that of stars (e.g. in Ophiuchus, Serpens, Orion, Pipe Neb.)
IMF determined early on, during the formation of clumps and cores in molecular clouds
CMF is thus fundamental. May depend on environment. Different CMFs may lead to different IMFs, or do you somehow always get same IMF?

Orion, SFE ≈ 6%



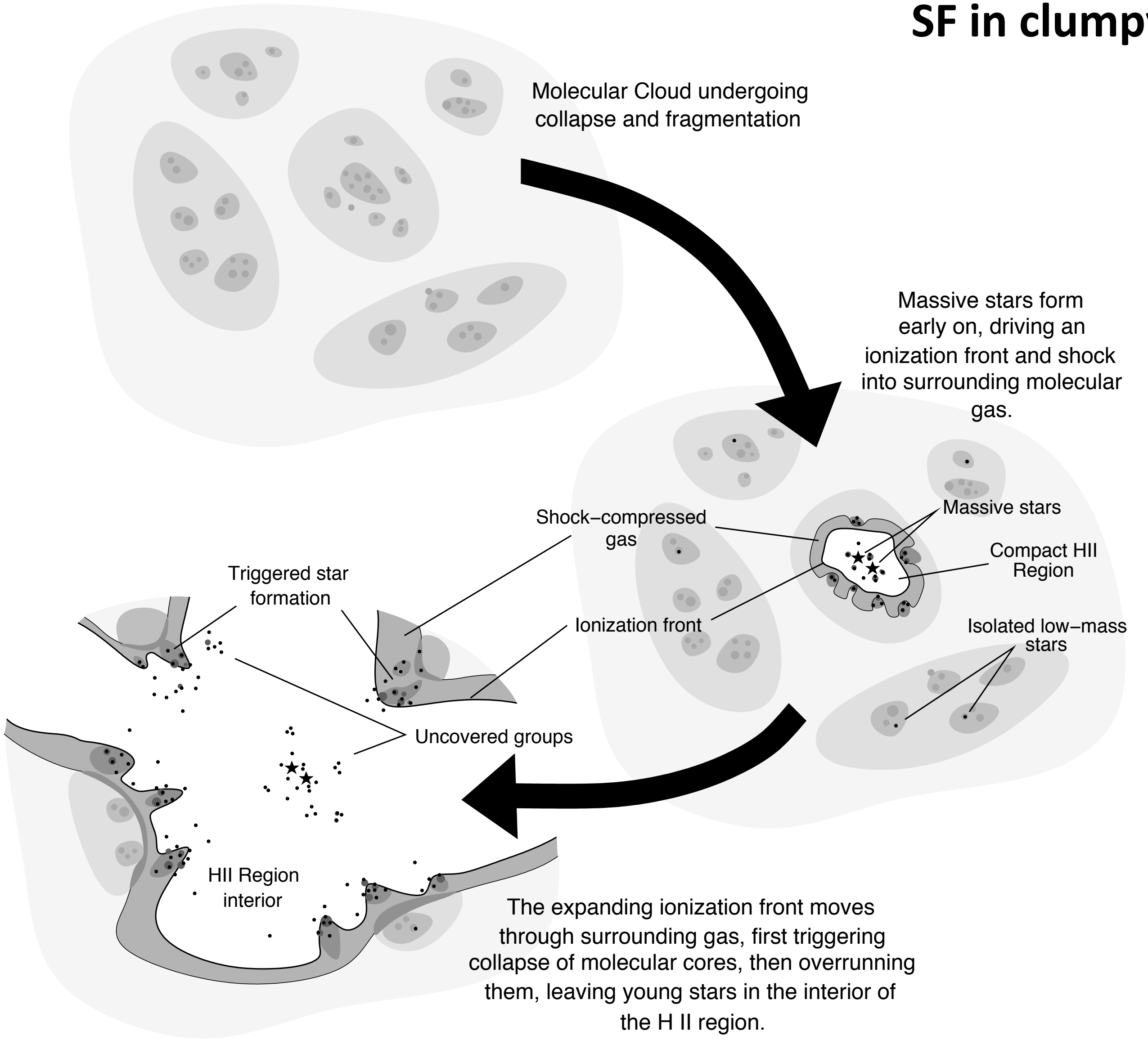

Nutter & Ward-Thompson 2007

Pipe Neb, SFE ≈ 30%




Alves et al. 2007

# SF in clumpy molecular clouds II




Hester & Desch ASP 341, 2005

# Massive stars ($M > 8\ M_o$):

- Produce large amounts of ionizing radiation that creates PDR in nearby molecular cloud

- In clumpy clouds UV radiation can penetrate deeply and affect large part of cloud.
  UV radiation may thus affect the CMF in the exposed cloud:

    by dispersing or partially evaporating parental molecular cloud via ionization, winds, supernova explosions, thus possibly preventing subsequent SF;

    by accumulation of gas, swept up by expanding HII region; creation of cores; subsequent collapse leads to new generation of stars;

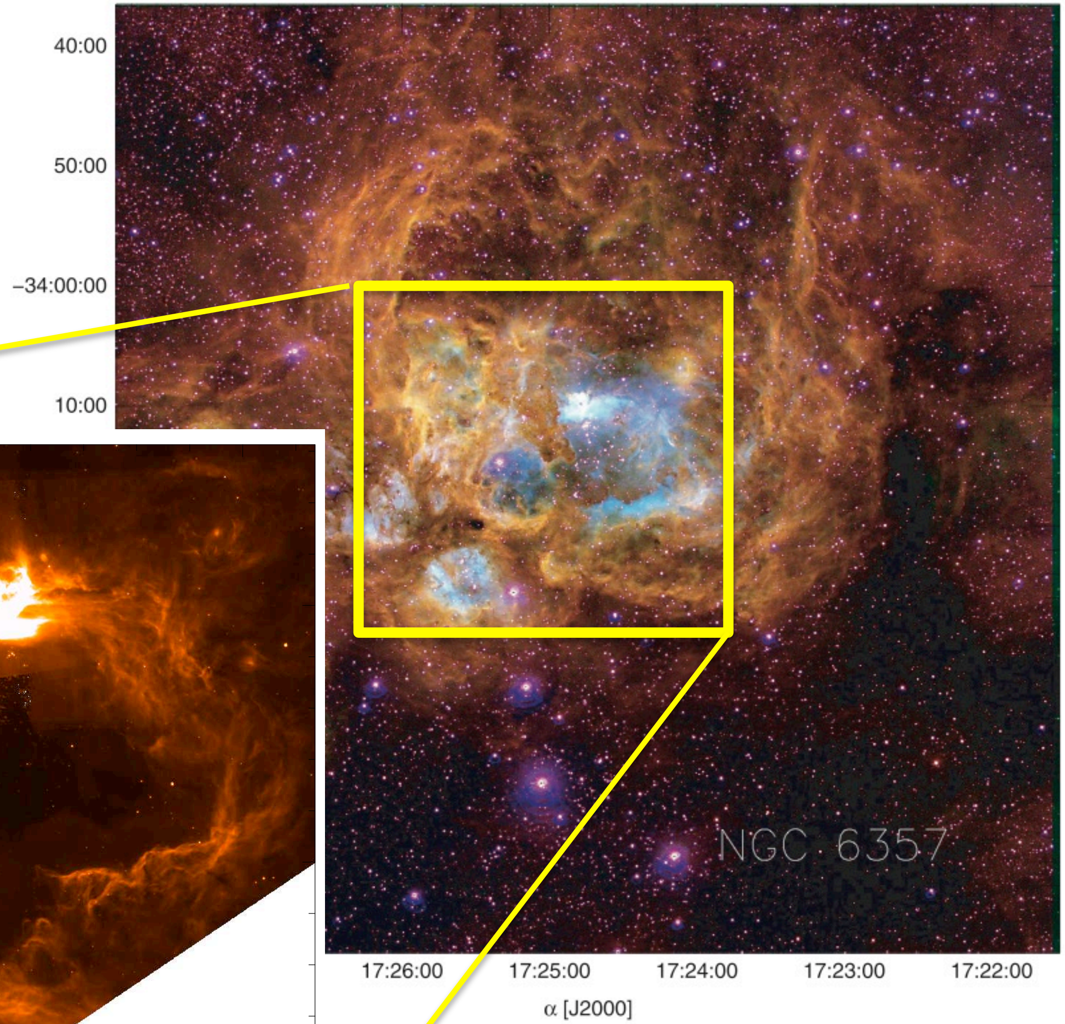
    by compressing existing dense condensations, triggering SF.

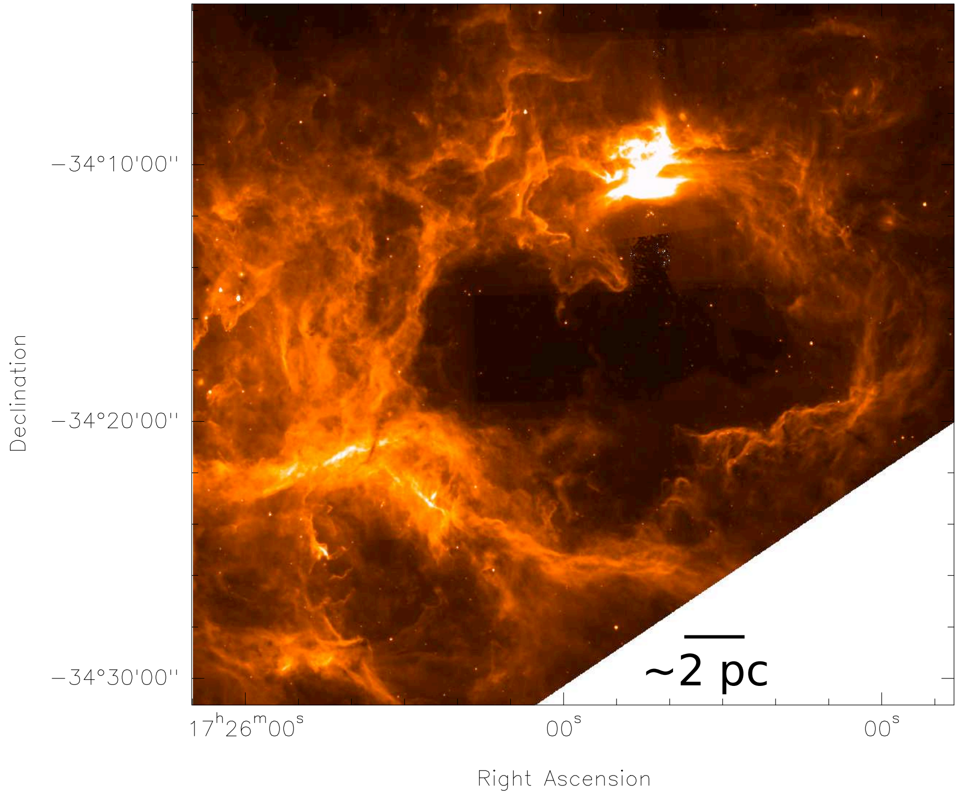
A way of assessing these effects is to determine whether the CMF near to a PDR significantly departs from those observed in more quiescent (less exposed to intense stellar UV radiation) star forming regions.

# NGC 6357

Distance = 1.7 ± 0.2 kpc

8 µm (GLIMPSE survey)



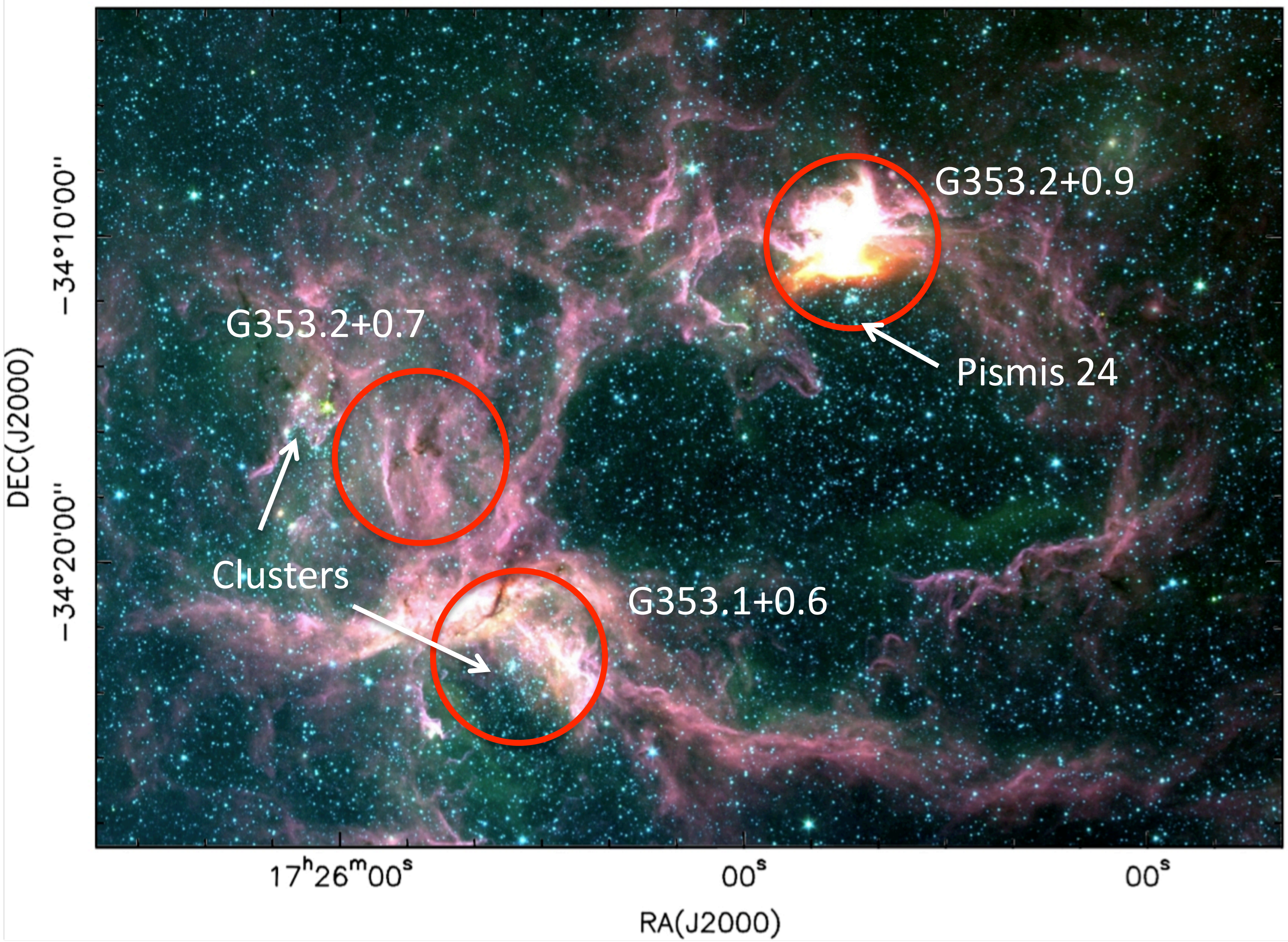




RGB: [SII], Hα, [OIII]

Cappa+ 2011 MNRAS 415, 2844

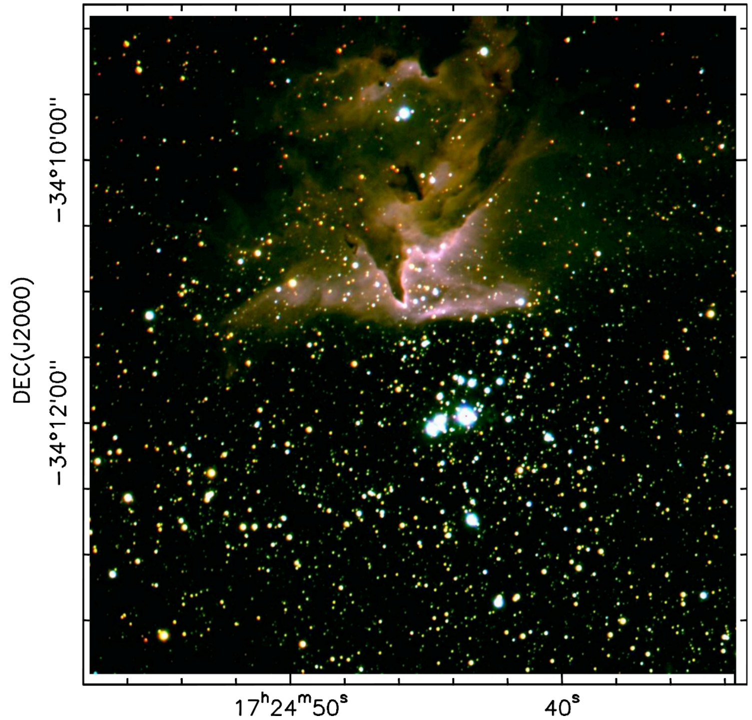
# NGC 6357

NIR (Spitzer) RGB: Red: 8 µm Green: 4.5 µm Blue: 3.6 µm



NGC6357-complex:
G353.2+0.9

HST

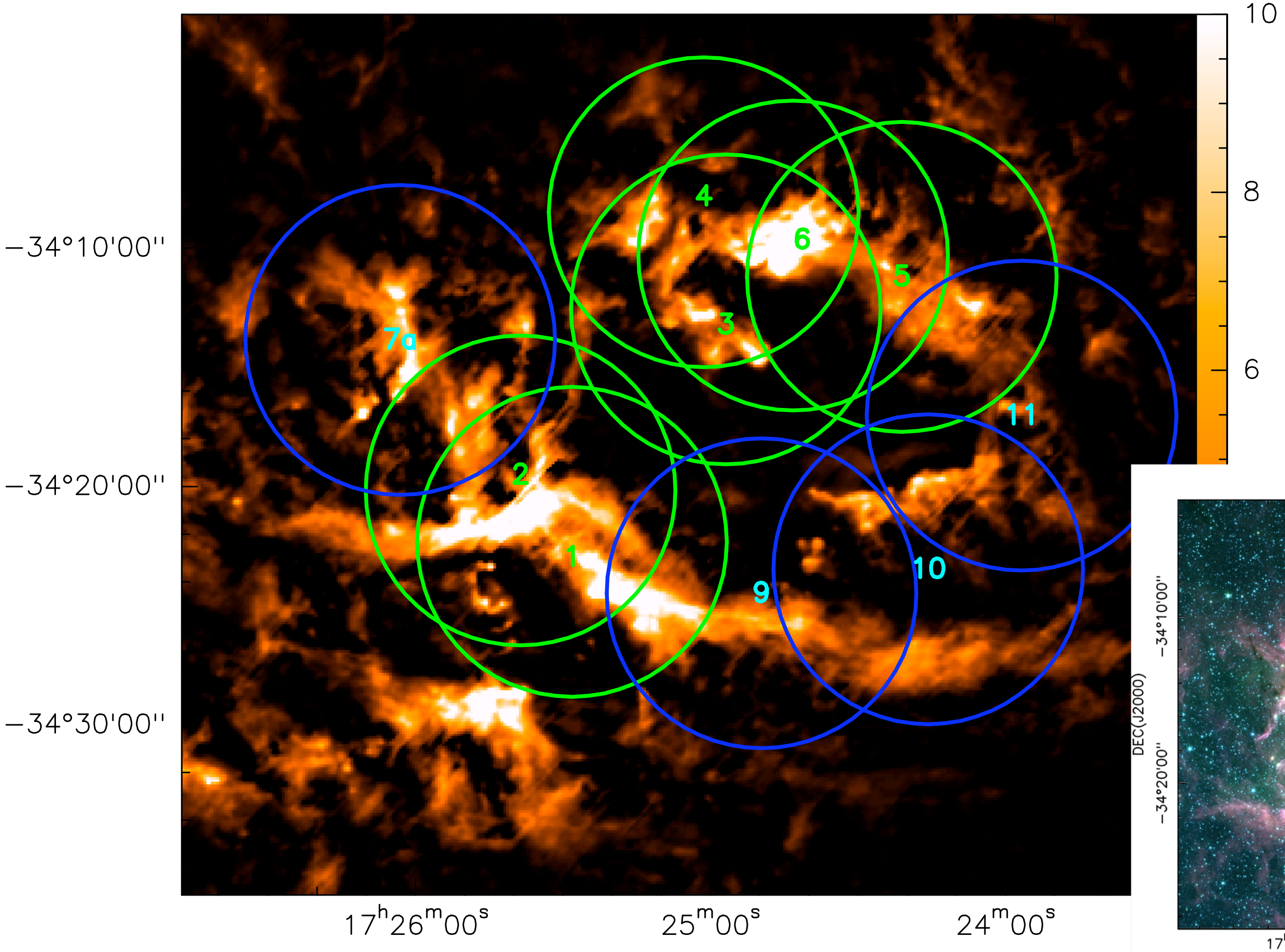



Massi F., Giannetti A., di Carlo E., Brand J., Beltran M.T., Marconi G.
Young open clusters in the Galactic star forming region NGC6357
2015, *Astron. Astroph.* ***573, A95***

Giannetti A., Brand J., Massi F., Tieftrunk A., Beltran M.T.
Molecular clouds under the influence of massive stars in the Galactic HII region G353.2+0.9 2012, *Astron. Astroph.* ***538, A41***

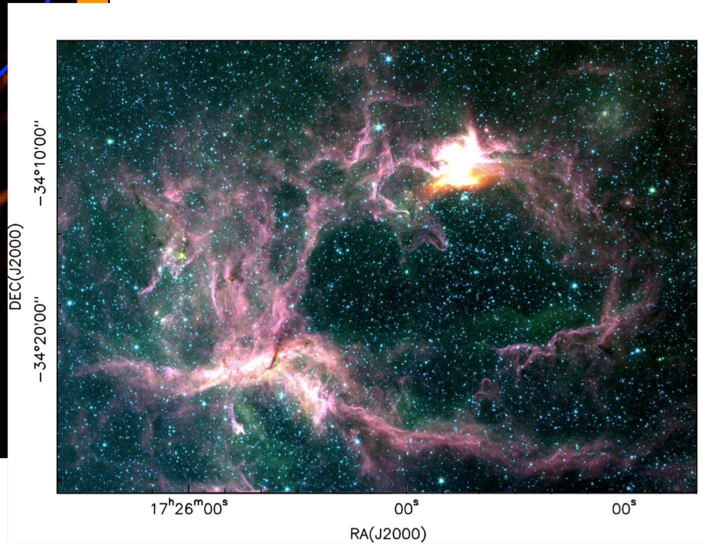
Massi F., Brand J., Felli M.
Molecular Cloud/HII Region Interfaces in the Star Forming Region NGC6357 1997 *Astron. Astroph.* ***320, 972***

Pismis 24:
30-40 OB stars (2 O3.5)



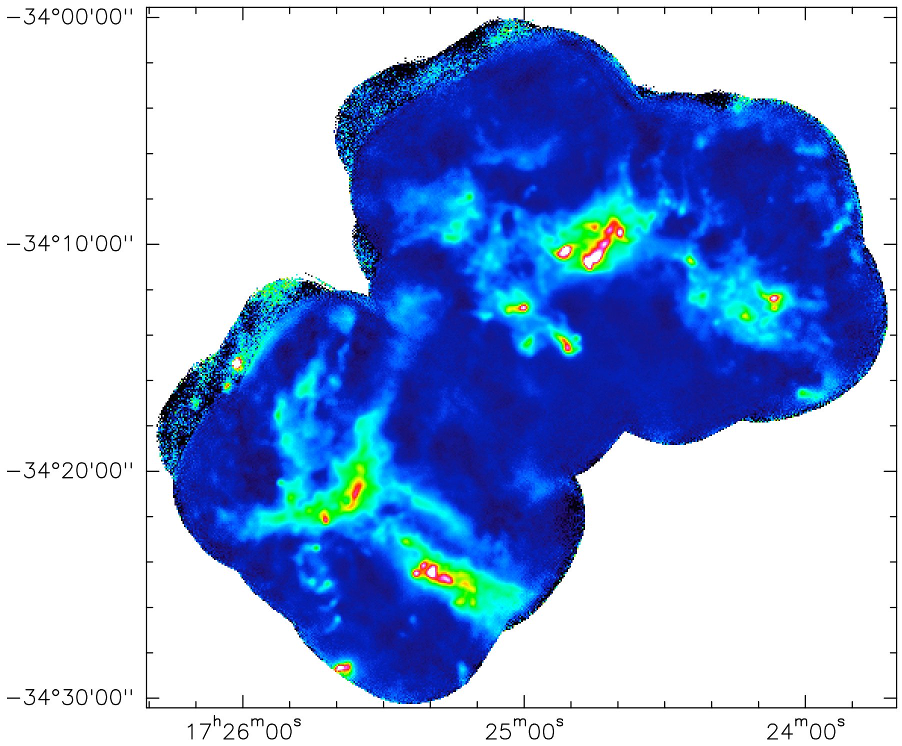

# OBSERVATIONS

Herschel 160 μm map with daisy fields SCUBA2 overlaid.

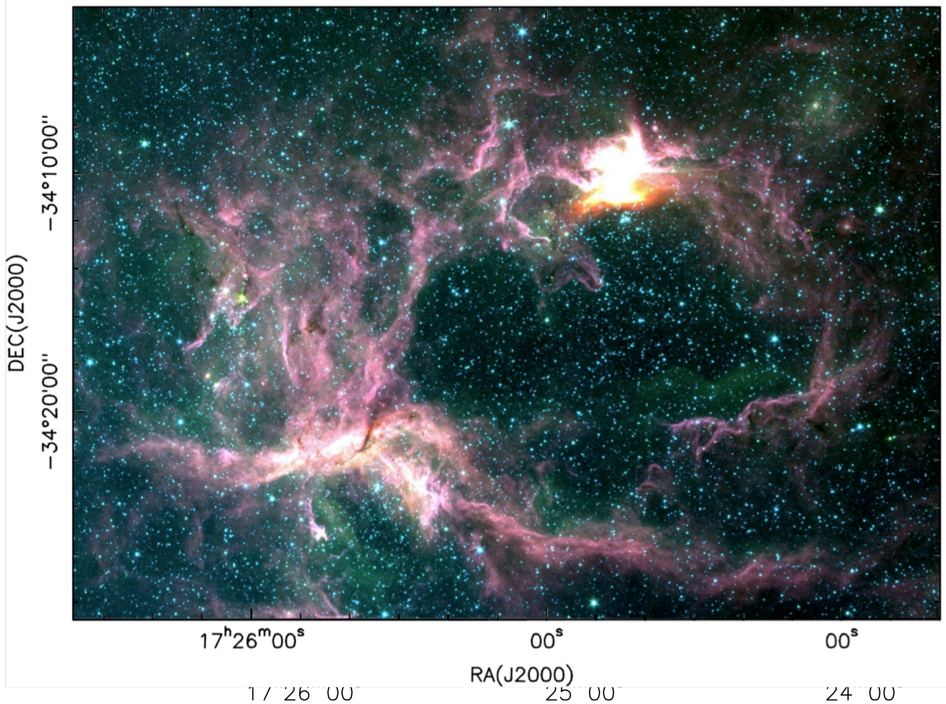



We used SCUBA2 at the JCMT to observe, at 450 μm and 850 μm, the dust associated with the molecular clouds in a 30' x 30' (15 pc x 15 pc) region containing three HII regions. We assess the radiative and mechanical influence of the stars that excite the HII regions on the molecular gas, by determining the CMF near the HII regions and comparing it with that in more quiescent (less exposed to intense stellar feedback) parts of the complex.

# RESULTS: Maps of dust continuum emission

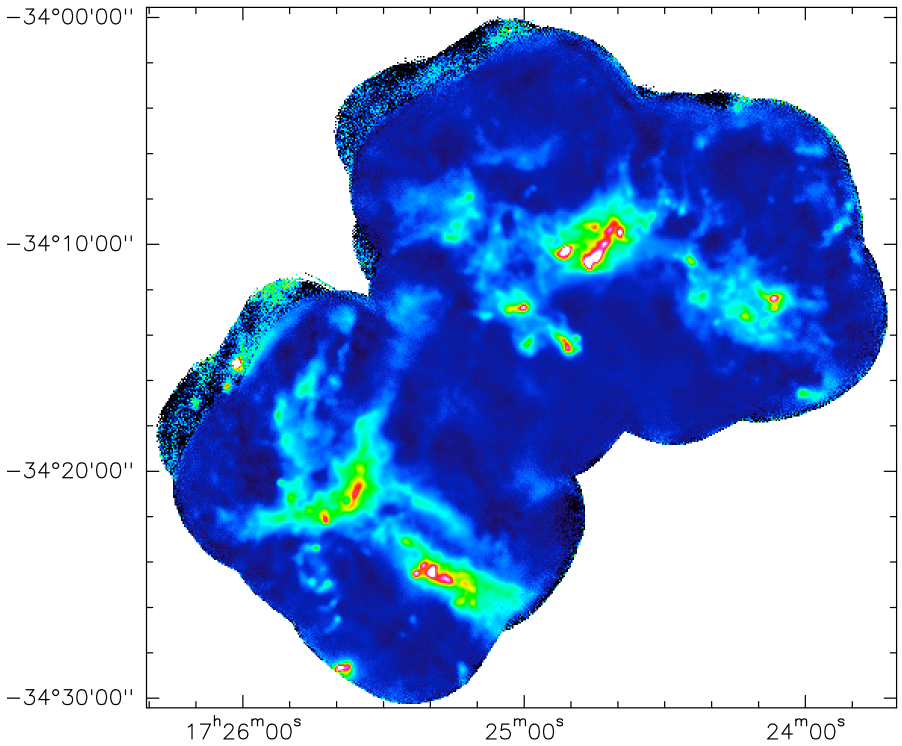



Spitzer NIR RGB

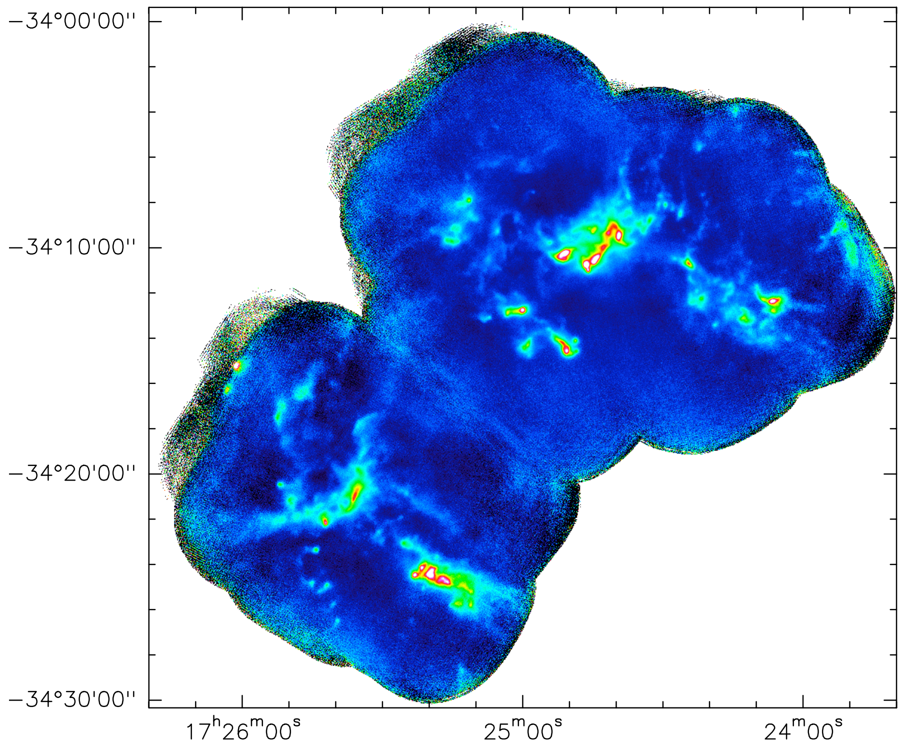



Mosaic at 850 µm; hpbw 14”

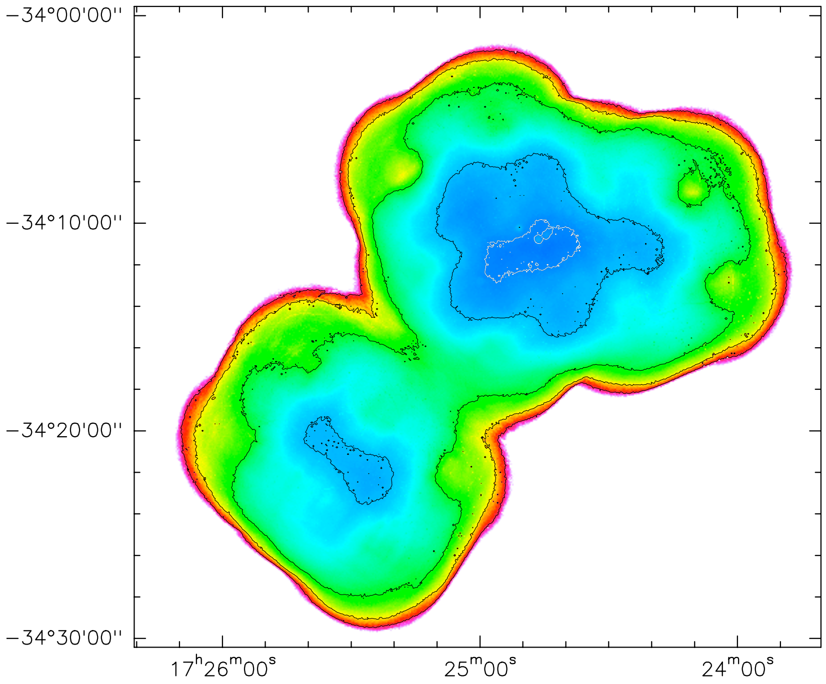
# RESULTS: Maps of dust continuum emission

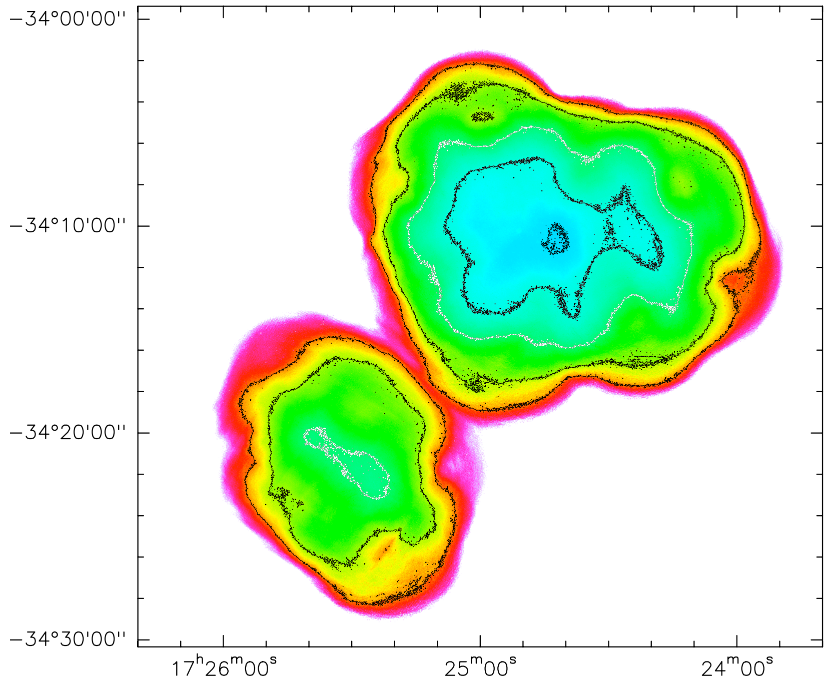



Mosaic at 850 μm; hpbw 14”



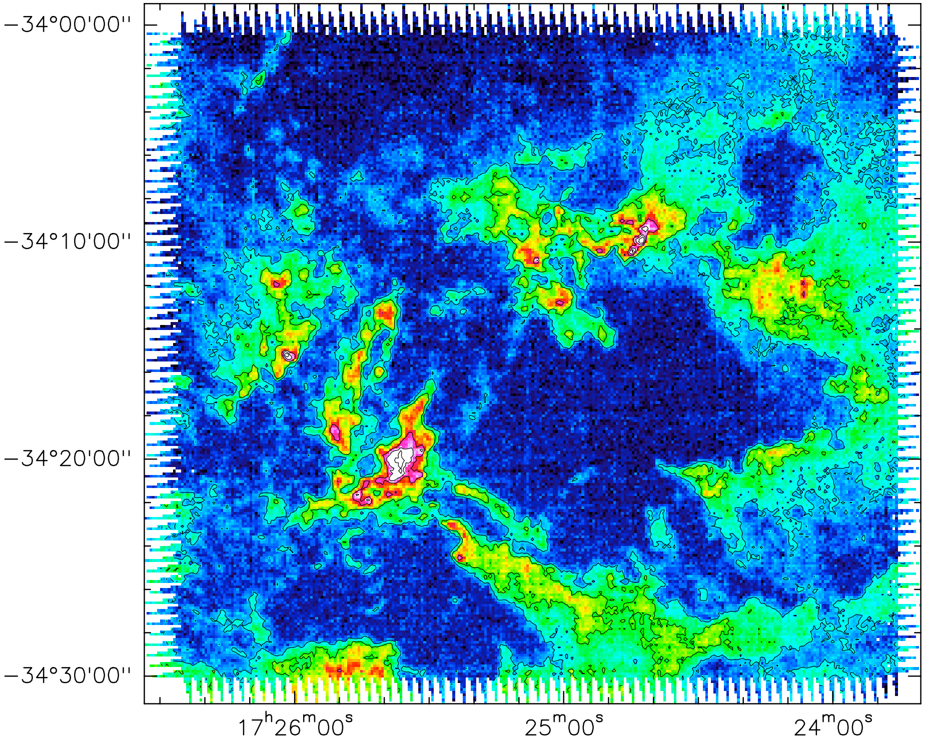

Mosaic at 450 μm; hpbw 7”




**Left:** errormap 850 µm. Levs (mJy/bm): 4 (white), 5, 10, 15, 20

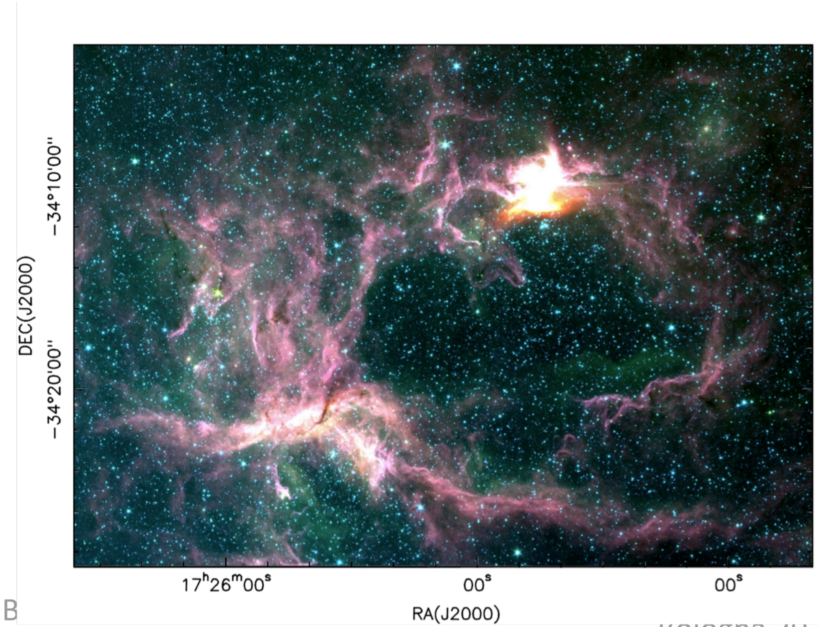
**Right:** errormap 450 µm. Levs (mJy/bm): 60, 75, 100 (white), 150, 200

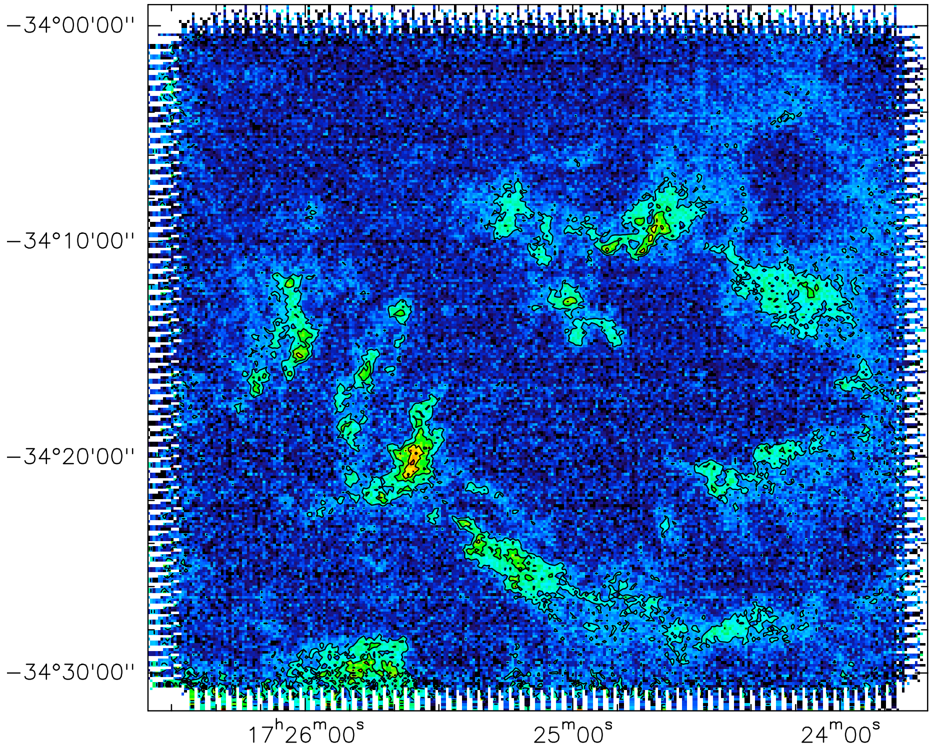


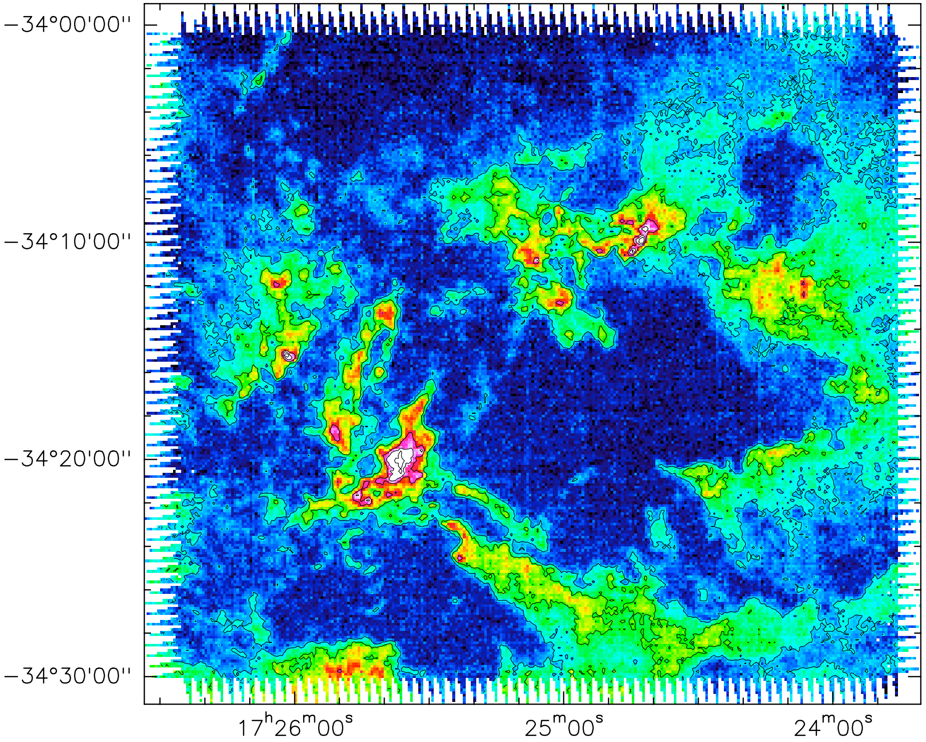

# CONTAMINATION

$^{12}$CO(3-2) map, JCMT. Used to correct 850 µm dust continuum

Typical contamination <10-25%





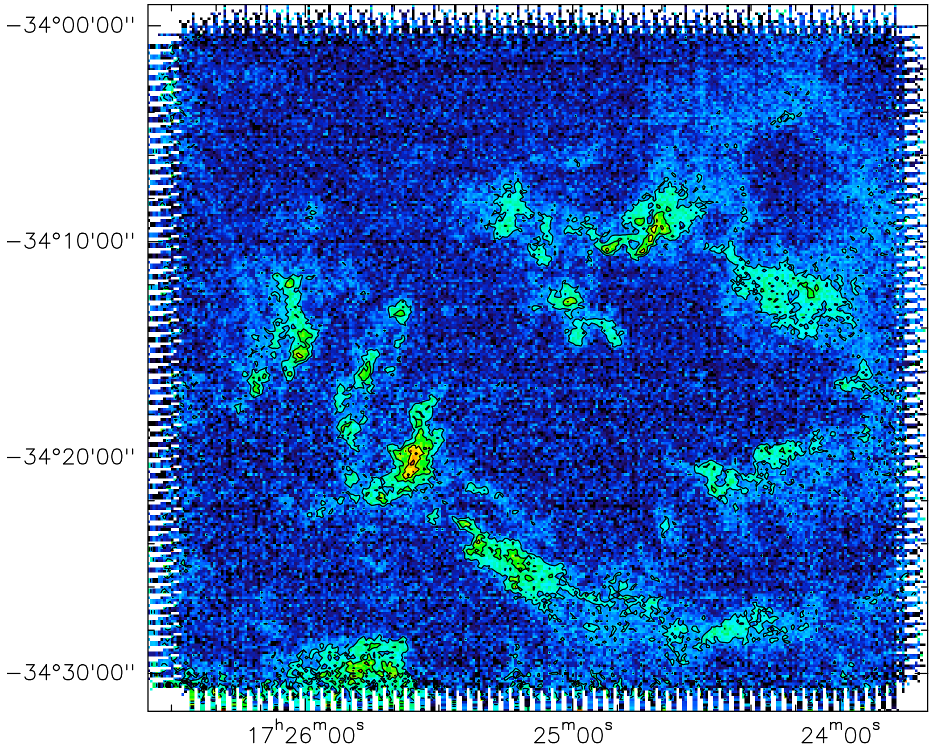

# CONTAMINATION

$^{12}CO(3-2)$ map, JCMT. Used to correct 850 µm dust continuum

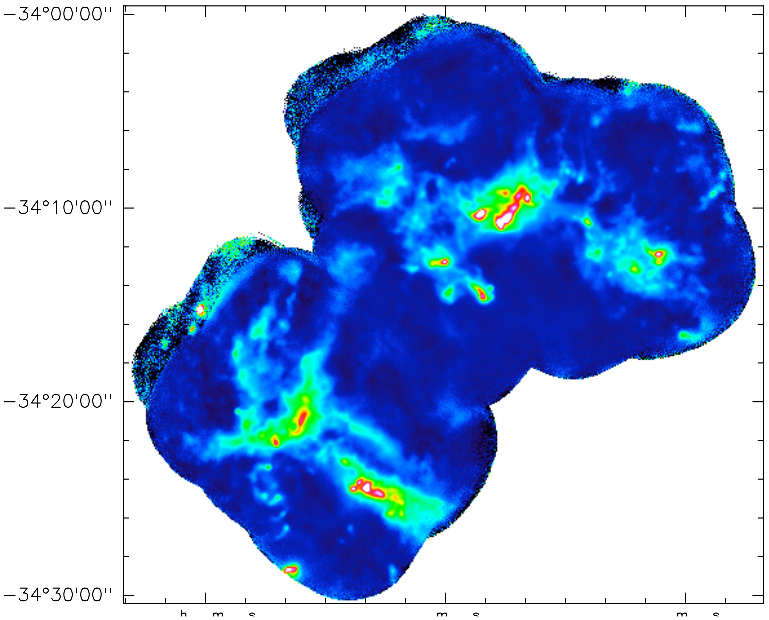
Typical contamination <10-25%

Also have $^{13}CO(3-2)$ map

$^{13}CO(3-2)$

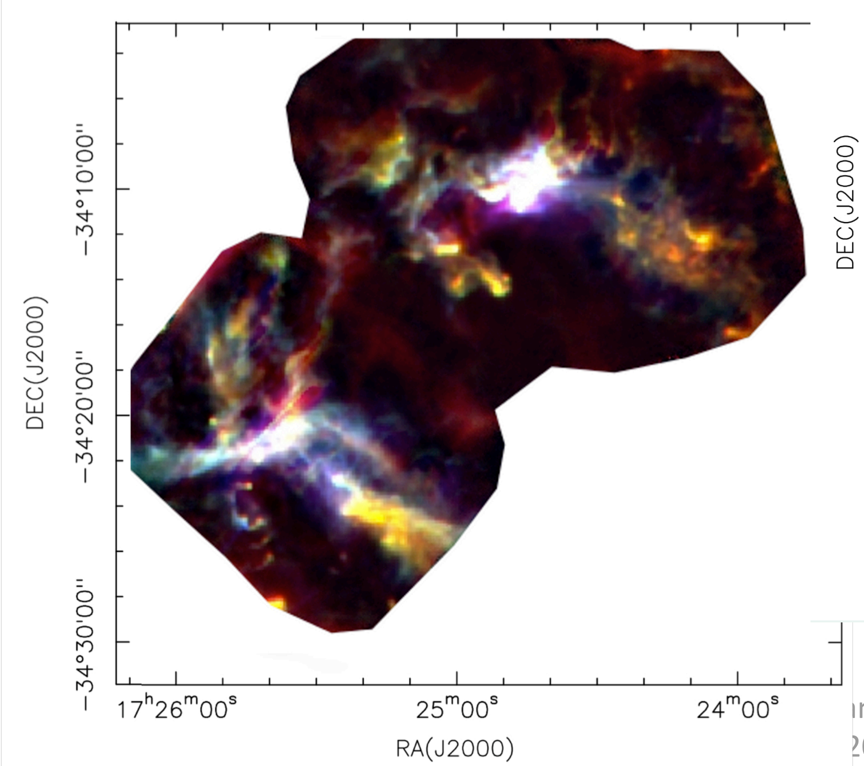


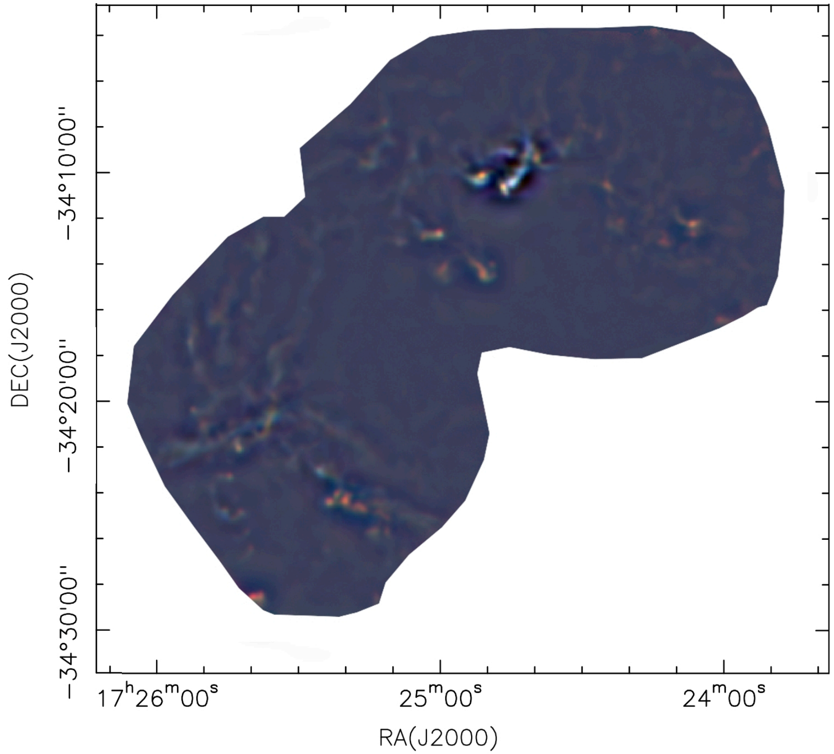
# REMOVING DIFFUSE EMISSION




SCUBA2 850 µm

RGB: Herschel 70, 160, SCUBA2 850 µm




RGB, background removed

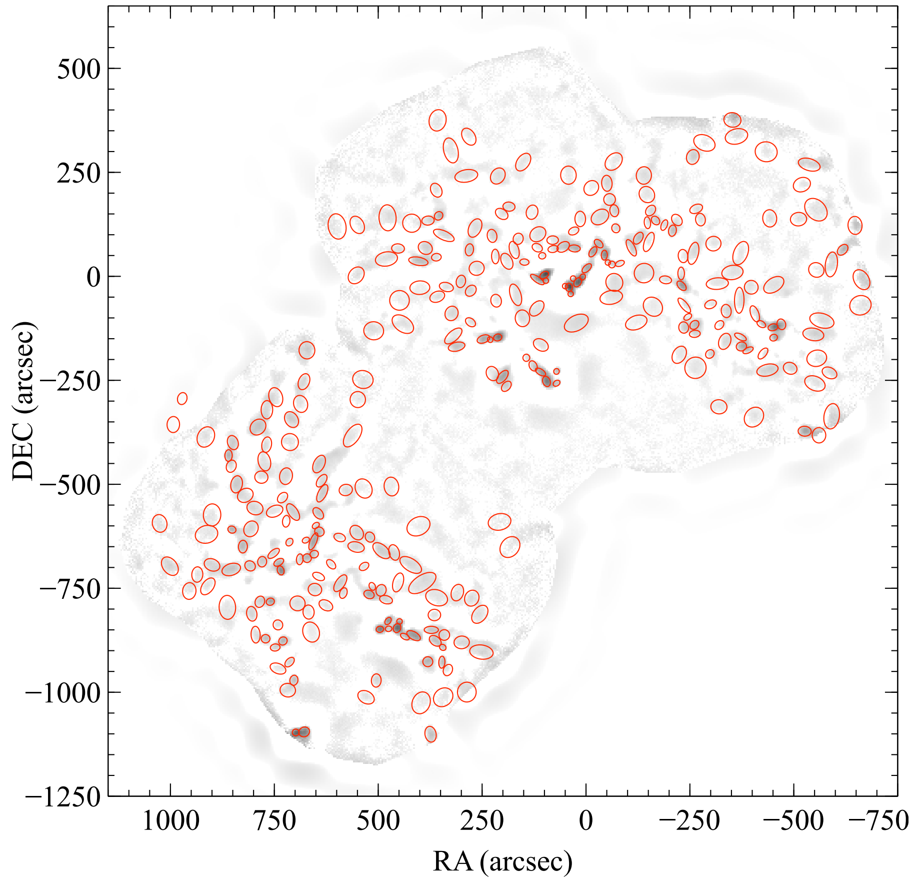
# CORE IDENTIFICATION

We identified 361 *bona fide* cores in the background-subtracted 850 μm image.
**Masses: $M = \gamma \ (S\, d^2) / (k_\nu\, B[\nu,T])$**, where
*S*: integrated flux of the (Gaussian) core
*d* : distance
*B[ν,T]:* Planck function at (dust) temperature *T* and frequency *ν*
$k_\nu$ : dust absorption coefficient: $k_\nu = k_0(\nu/\nu_0)^\beta$.

We use $k_\nu = 1.93\ cm^2\ g^{-1}$, derived from
$k_0 = 1.85\ cm^2\ g^{-1}$ at $\nu_0 = 345\ GHz$ and $\beta=1.8$.

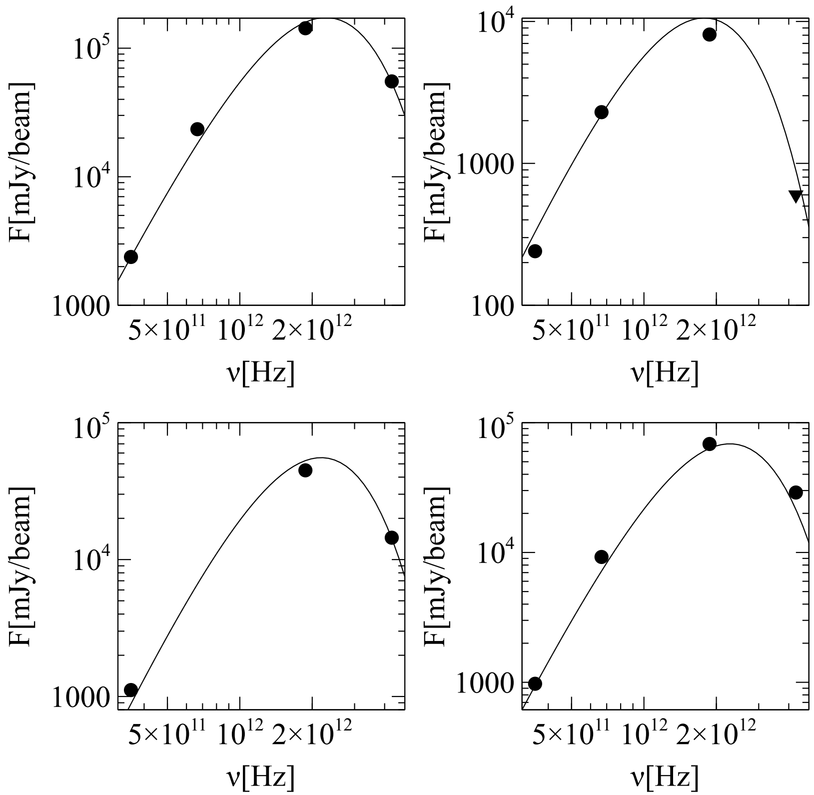
The gas-to-dust ratio $\gamma = 100$.

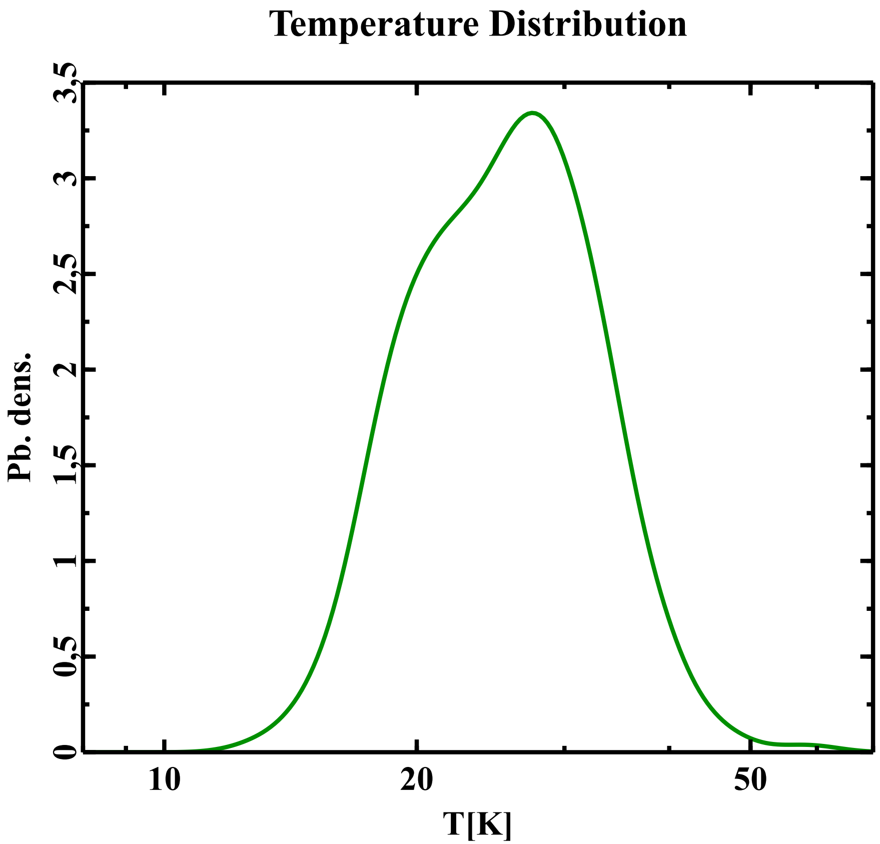
Need the dust temperature:
use Herschel Hi-GAL data

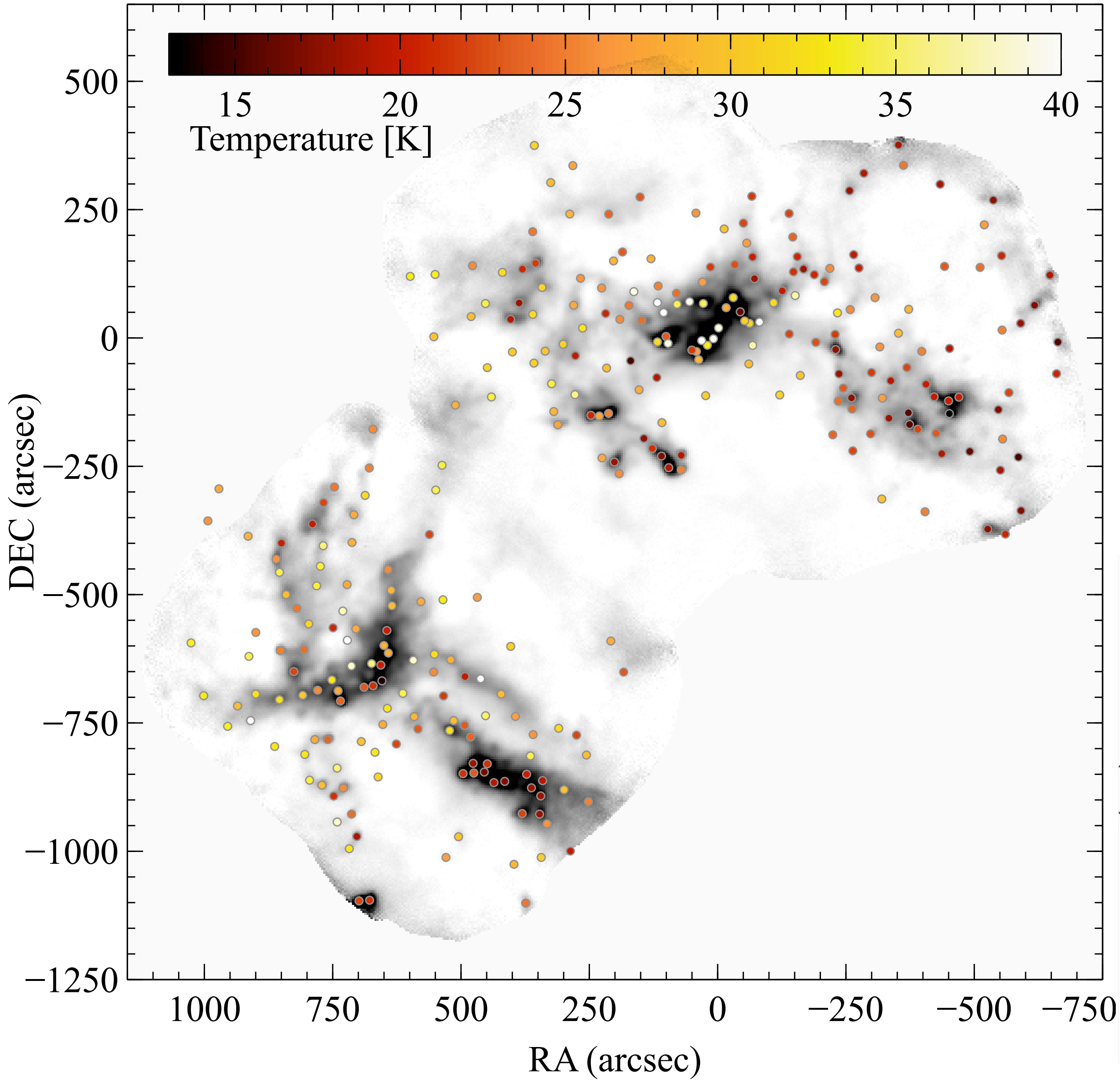


# TEMPERATURE OF CORES

from SED fit to fluxes at 70, 160 μm (Herschel Hi-GAL)
and 450, 850 μm (SCUBA2)

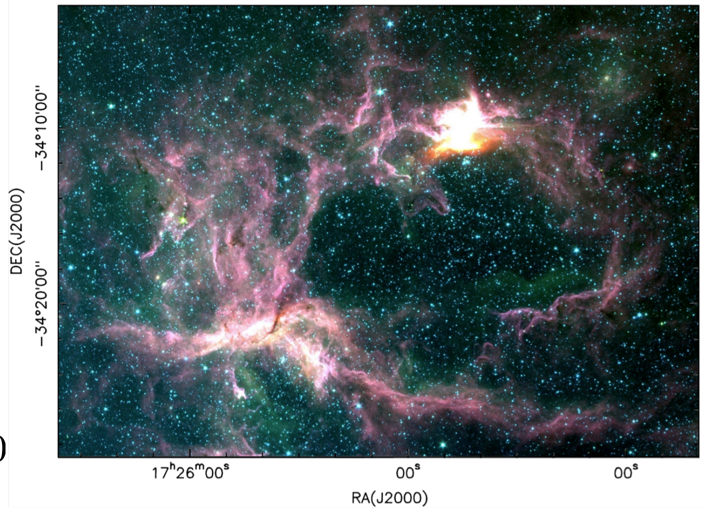


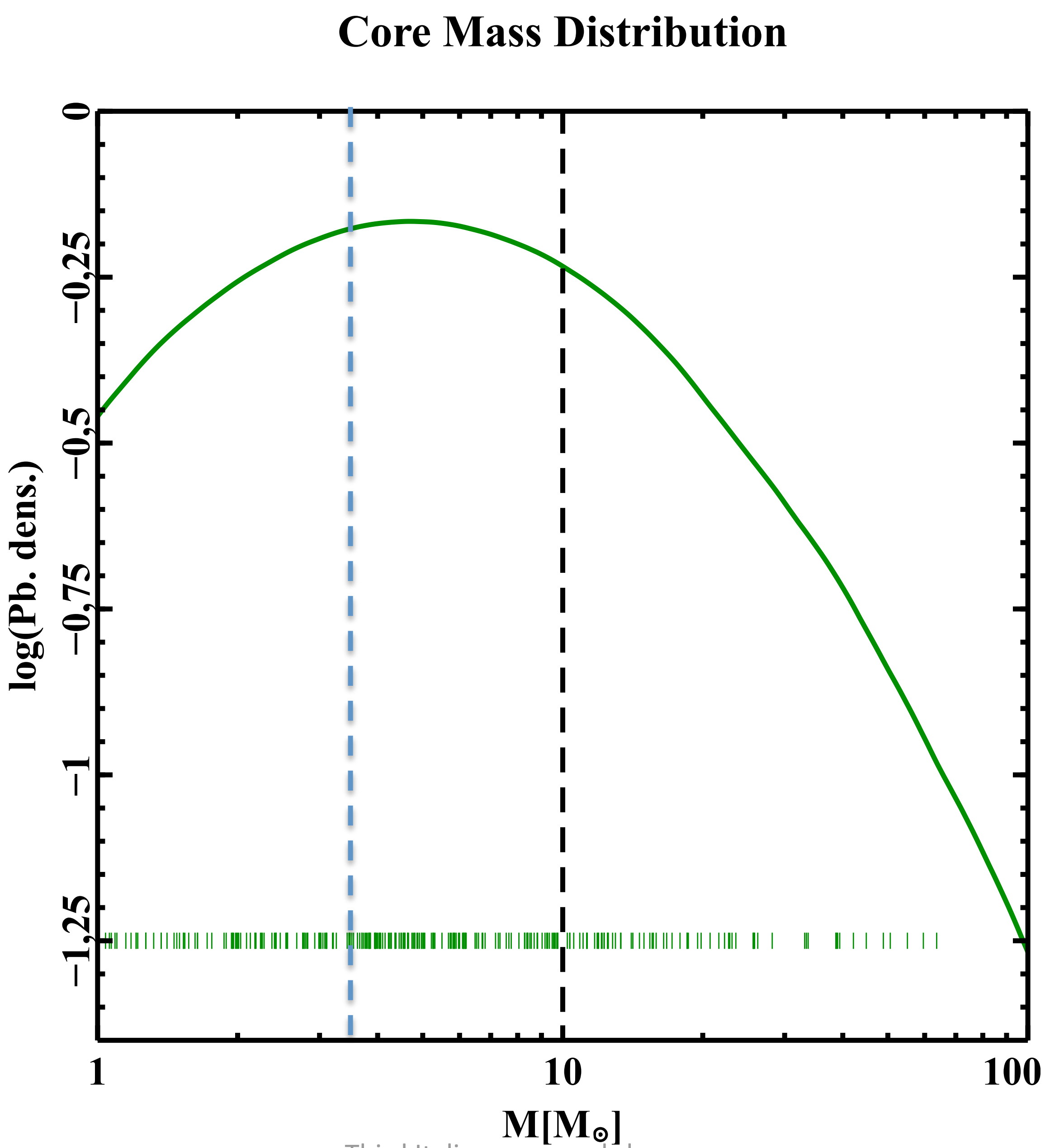






# TEMPERATURE MAP

302 cores

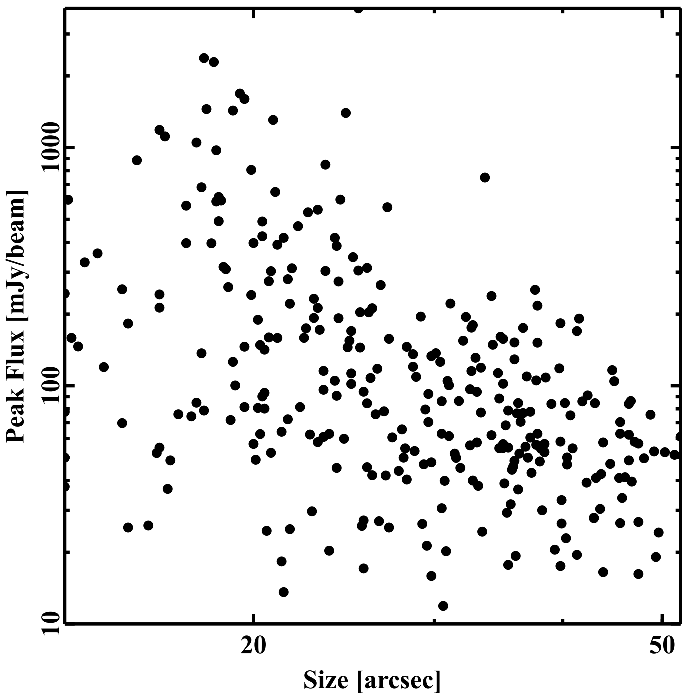




Core Mass Distribution
log(Pb. dens.)
0
−0,25
−0,5
−0,75
−1
−1,25
1
10
100
M[M⊙]

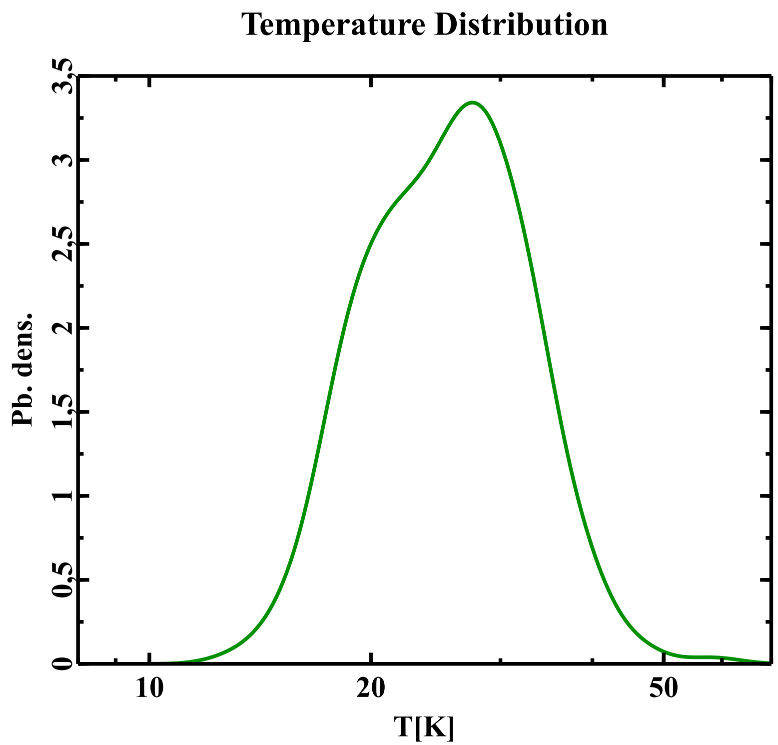

Jan Brand

# COMPLETENESS I

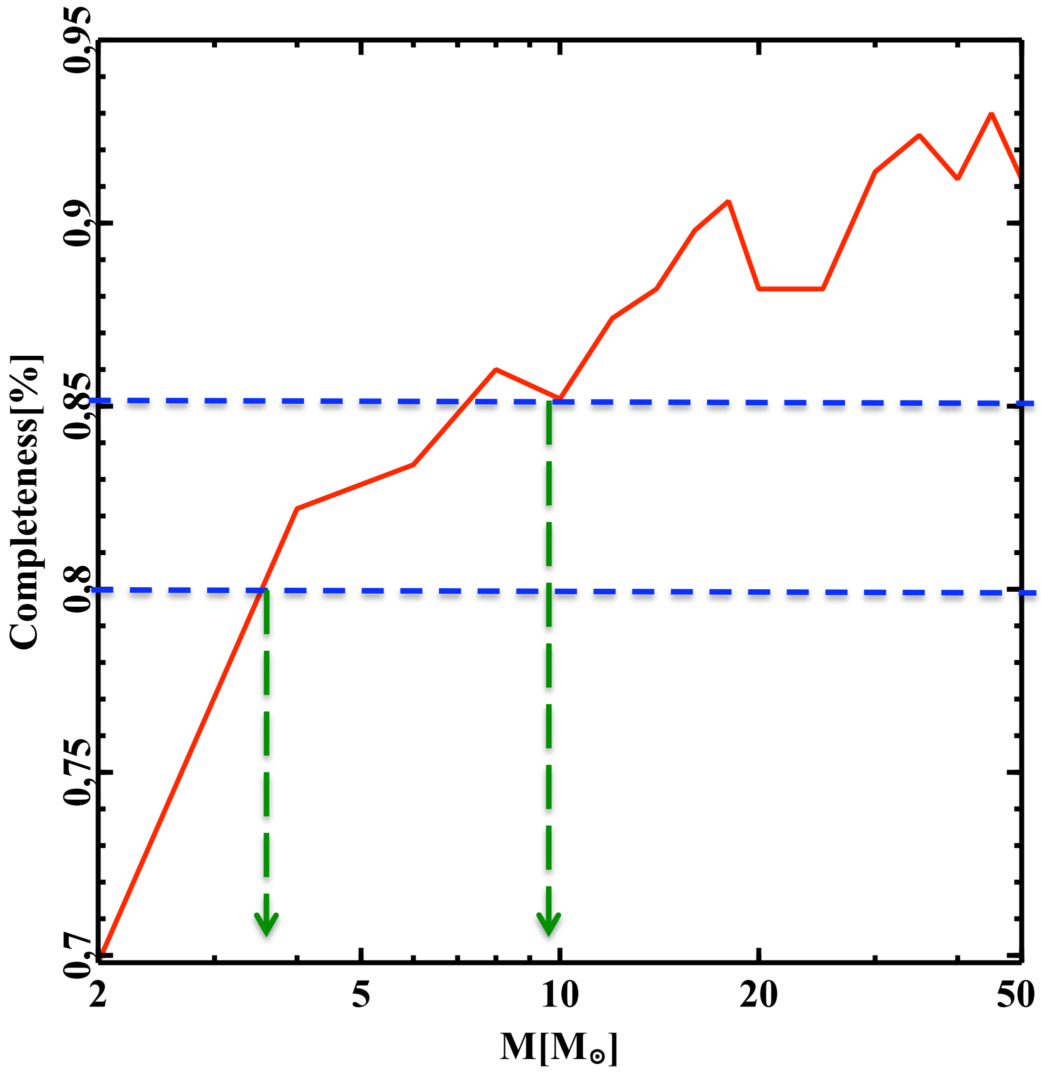


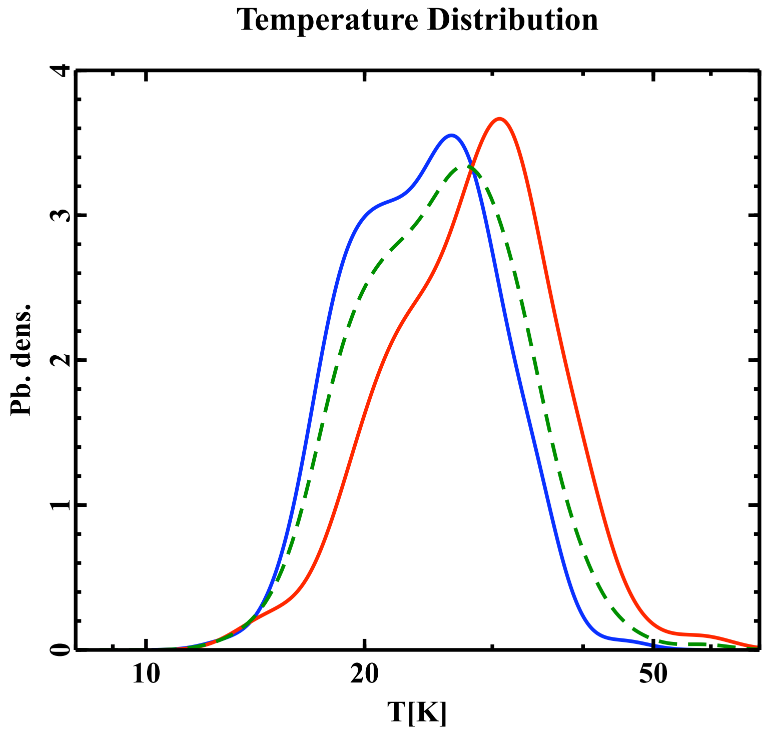

For range of masses (2 – 50 $M_{\odot}$) create artificial cores, using parameter space of cores actually found.

Insert artificial cores into original data, then proceed as before, and see how many are found. Repeat many times for each mass.



# COMPLETENESS II



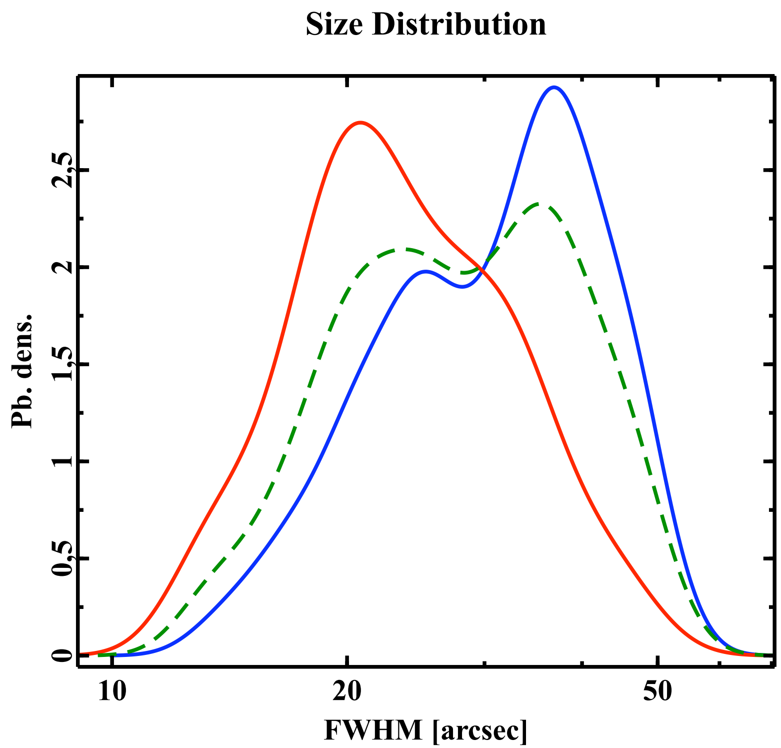


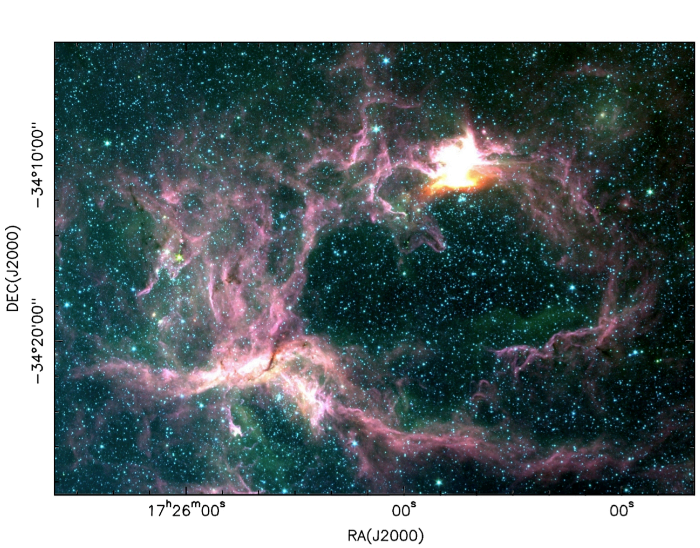

Divide sample into:

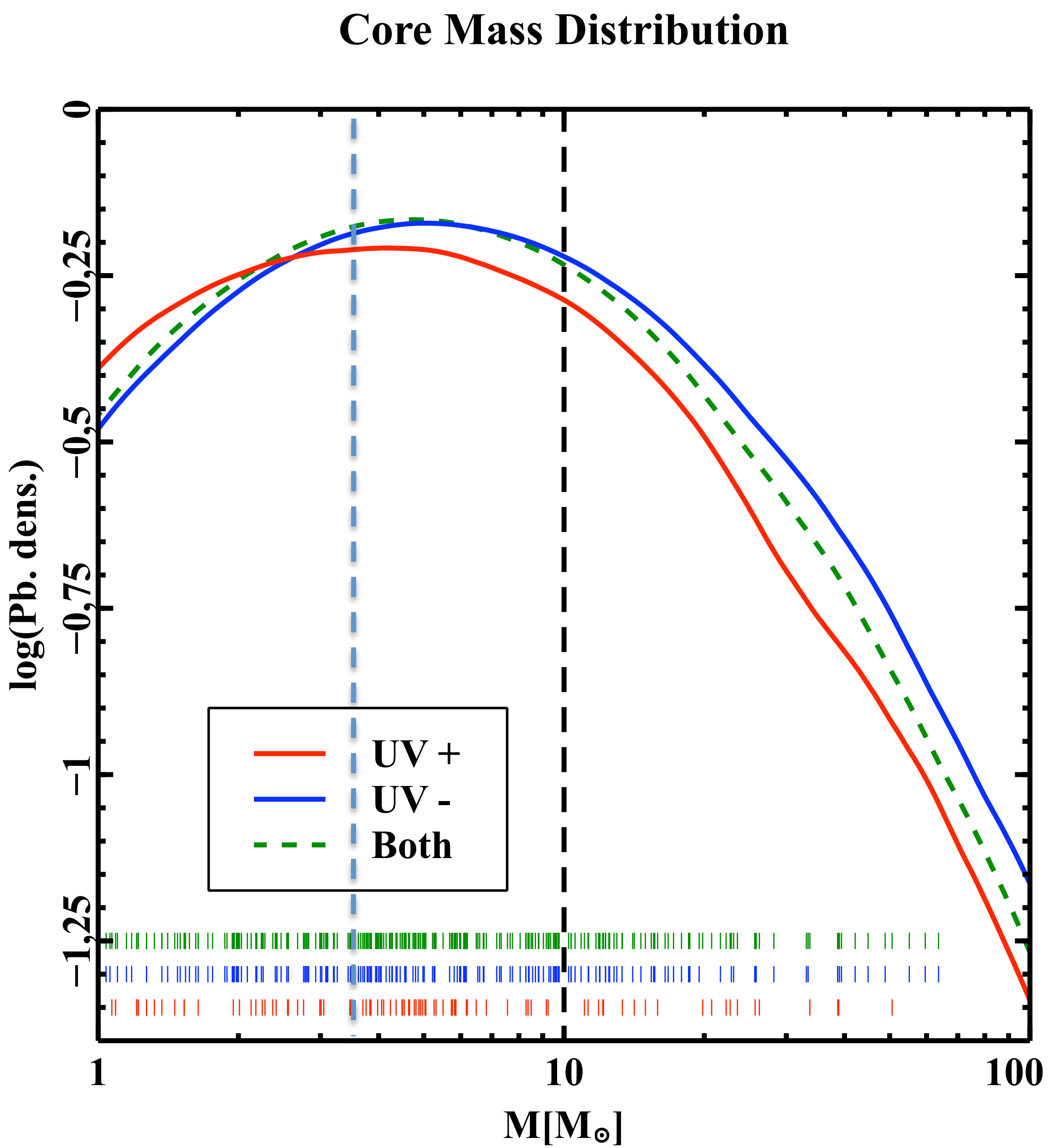
cores near star clusters (**UV+ ; N = 108**)

cores away from clusters (**UV- ; N = 194**)

**UV+** warmer and more compact



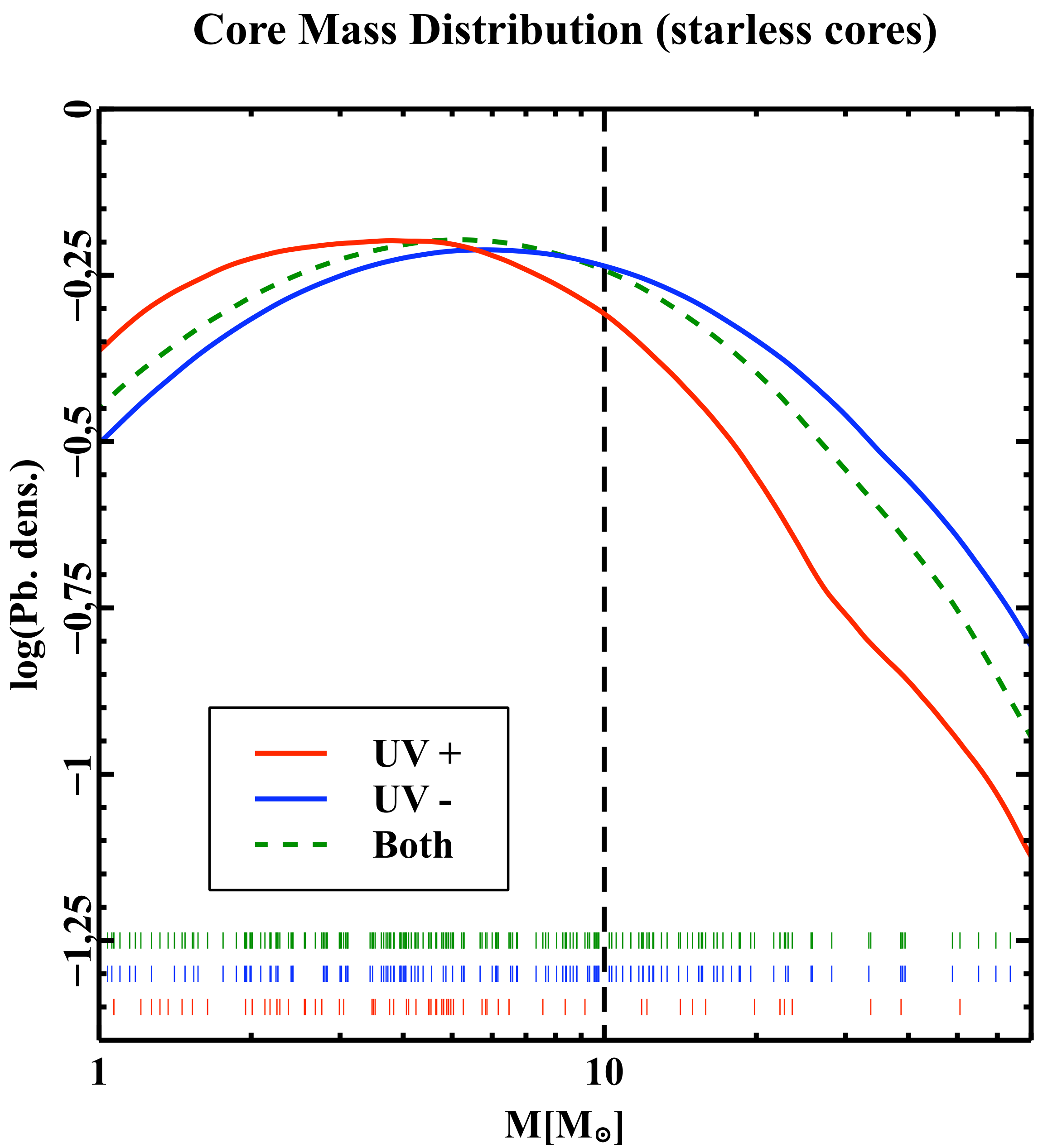



No difference between CMFs:

* Influence of UV field on CMF is not that great

or

* UV-field is so pervasive that being near or far from cluster makes no difference

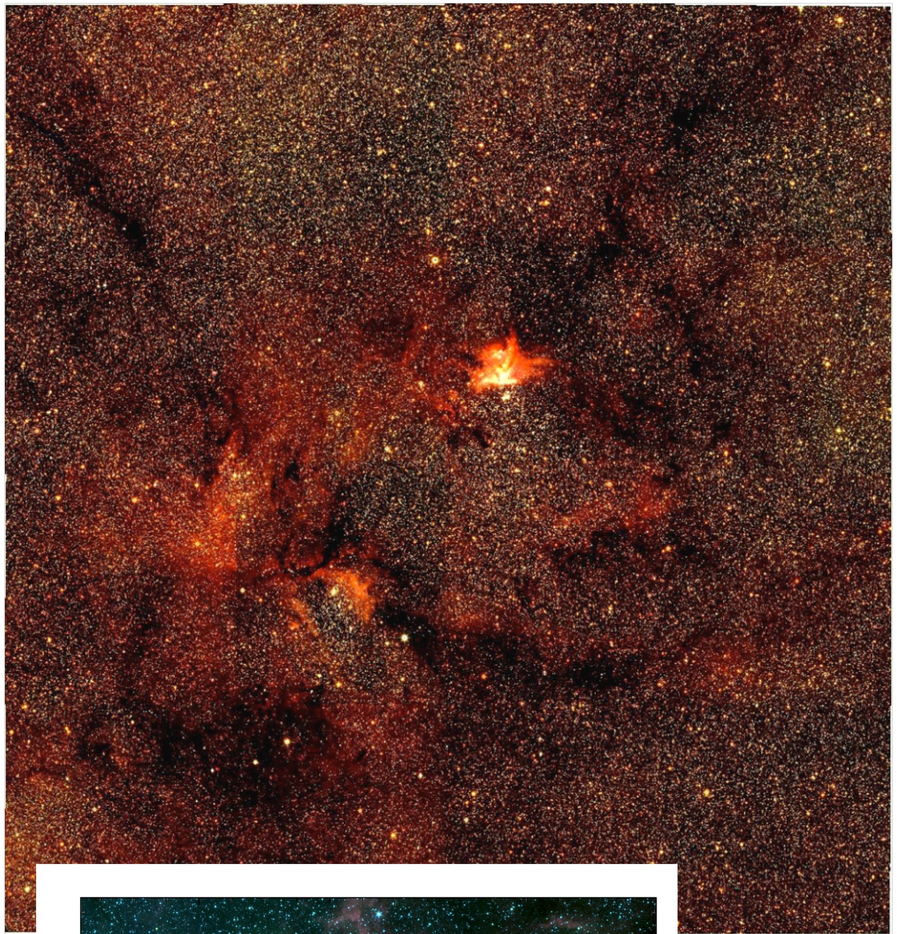


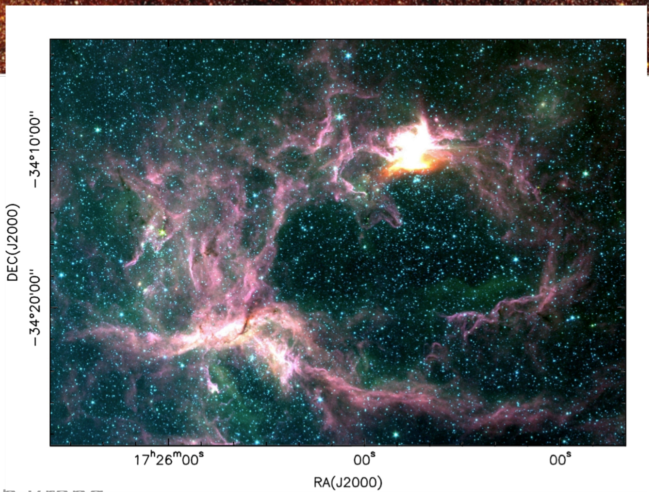

But wait…

Starless cores do show a difference?

(UV+ N = 73; UV- N = 143)

# UKIRT JHK,$H_2$ data WFCAM






G353.2+0.9

# 2 (rejected) ALMA Cycle 2 proposals on this subject.

The core mass function of a cloud in the far-outer Galaxy

In 20%-40% range

| JAN BRAND | | | | | 2013.1.01018.S |
|---|---|---|---|---|---|
| PROJECT TITLE: | The core mass function of a cloud in the far-outer Galaxy | | | | |
| PRINCIPAL INVESTIGATOR NAME: | Jan Brand | PROJECT CODE: | 2013.1.01018.S | | |
| SCIENCE CATEGORY: | ISM, star formation and astrochemistry | ESTIMATED 12M TIME: | 5.3 h | ESTIMATED ACA TIME: | 0.0 h |
| CO-PI NAME(S): (Large Proposals only) | | | | | |
| CO-INVESTIGATOR NAME(S): | Andrea Giannetti; Loris Magnani; Luca Olmi; Sergio Molinari; Jan Wouterloot; Davide Elia | | | | |
| EXECUTIVE SHARES[%]: | NA : EU : EA : CL : OTHER : | 0 100 0 0 0 | STUDENT PROJECT? (Yes/No) | No | |
| | | | RESUBMISSION? (Yes/No) | No | |

| LUCA OLMI | | | | | None Assigned |
|---|---|---|---|---|---|
| PROJECT TITLE: | Identifying the transition phase of the clump mass function toward the IMF | | | | |
| PRINCIPAL INVESTIGATOR NAME: | Luca Olmi | PROJECT CODE: | None Assigned | | |
| SCIENCE CATEGORY: | ISM, star formation and astrochemistry | ESTIMATED 12M TIME: | 7.3 h | ESTIMATED ACA TIME: | 0.0 h |
| CO-PI NAME(S): (Large Proposals only) | | | | | |
| CO-INVESTIGATOR NAME(S): | Davide Elia; Sergio Molinari; Jan Brand; Alvaro Sanchez-Monge; Michele Pestalozzi | | | | |
| EXECUTIVE SHARES[%]: | NA : EU : EA : CL : OTHER : | 0 100 0 0 0 | STUDENT PROJECT? (Yes/No) | No | |
| | | | RESUBMISSION? (Yes/No) | No | |

Identifying the transition phase of the clump mass function to the IMF

In bottom 30%

But we try again in Cycle 3!