The Core Mass Function in NGC 6357

Jan Brand[1,2], Andrea Giannetti[1,2,3,4]
Chiara Verdirame[1,3], Jan Wouterloot[5], Fabrizio Massi[6]

1. INAF-Istituto di Radioastronomia, Bologna
2. ALMA Regional Centre, Italian node, Bologna
3. Dept. of Physics and Astronomy, University of Bologna
4. Max-Planck-Institut für Radioastronomie, Bonn
5. Joint Astronomy Centre, Hilo, Hawaii
6. Osservatorio Astrofisico di Arcetri, Florence

The Initial Mass Function

Fundamental ingredient for study of star formation and galaxy evolution

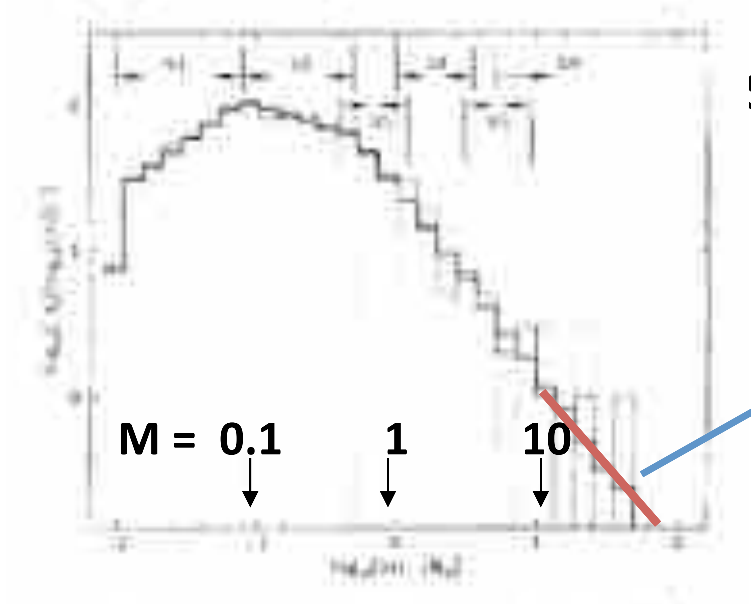
IMF: Frequency distribution of stellar masses at birth

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 $1 < M < 10\ M_{\odot}$

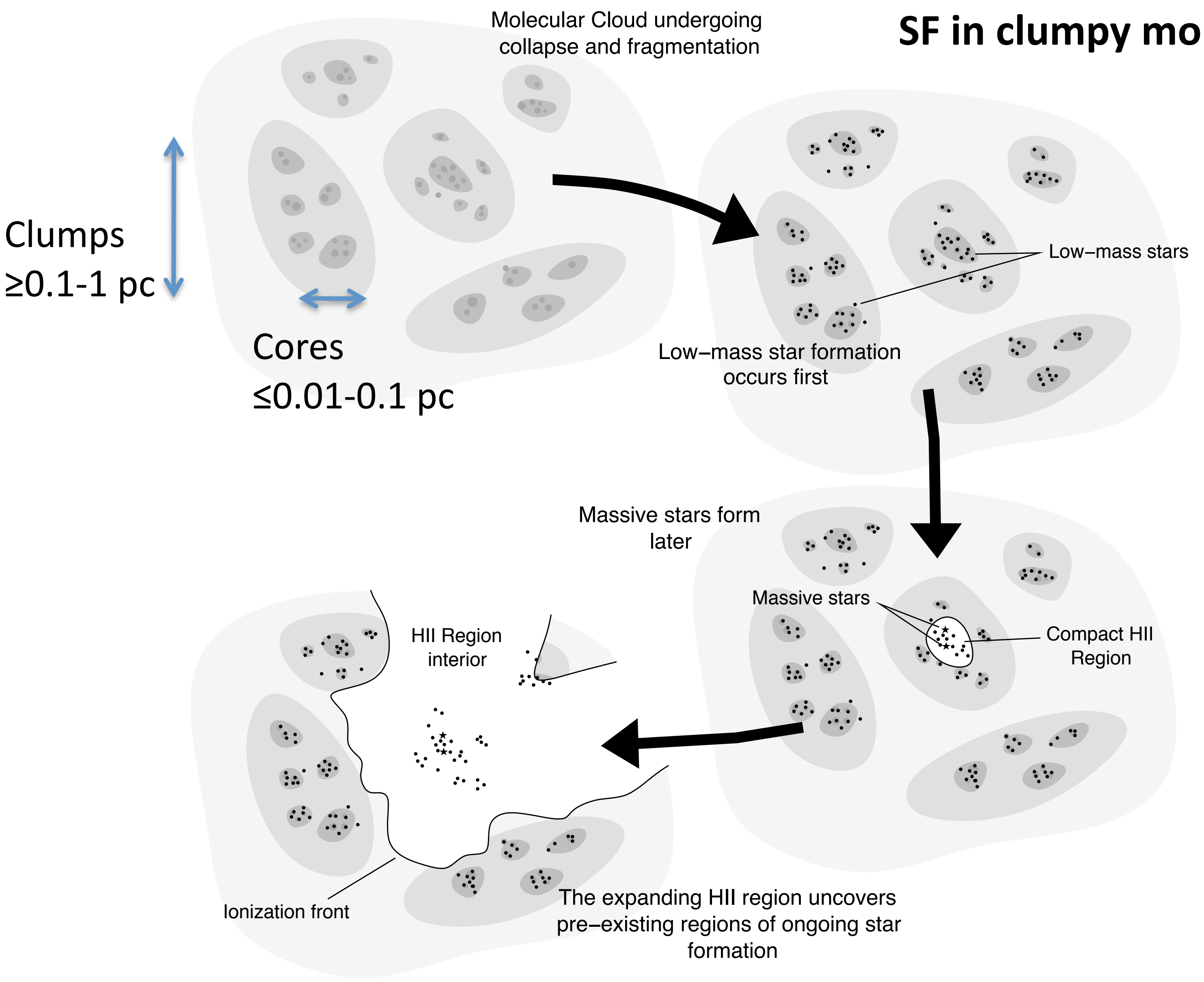
$= -1.3 \pm 0.3$ for $10 < M < 100\ M_{\odot}$

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

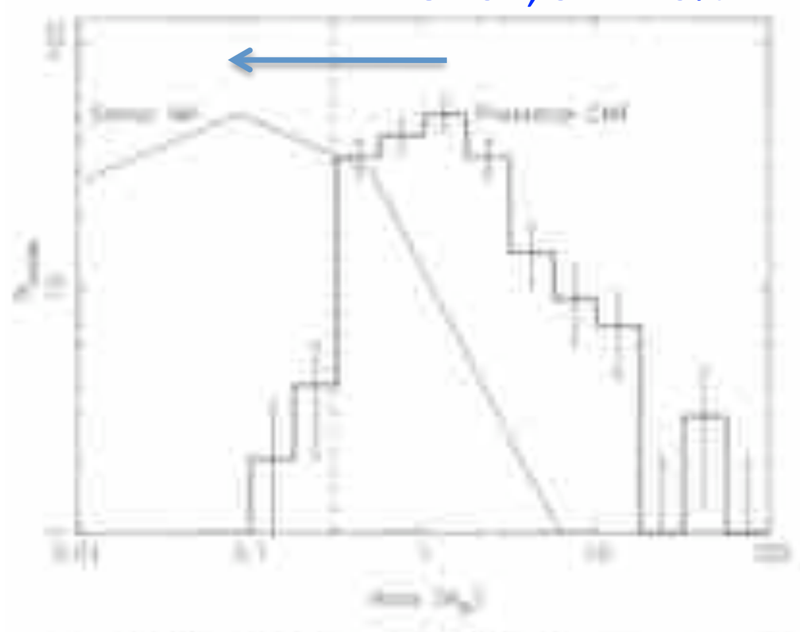


Hester & Desch ASP 341, 2005

IN A NUTSHELL:

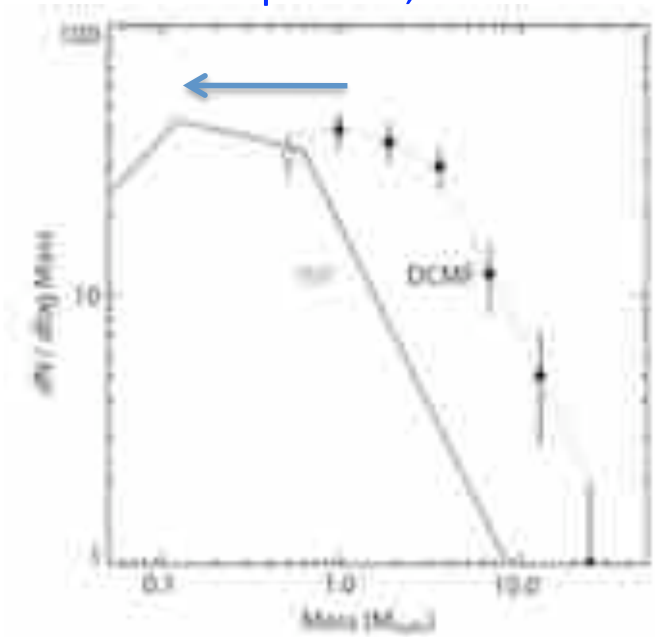
Stars form in cores.
Mass distribution cores (CMF) resembles that of stars (e.g. in Ophiuchus, Serpens, Orion, Pipe Neb.)
IMF determined early on, during the formation of clumps and cores in molecular clouds
CMF is thus fundamental. May depend on environment. Different CMFs may lead to different IMFs,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

Orion, SFE ≈ 6%



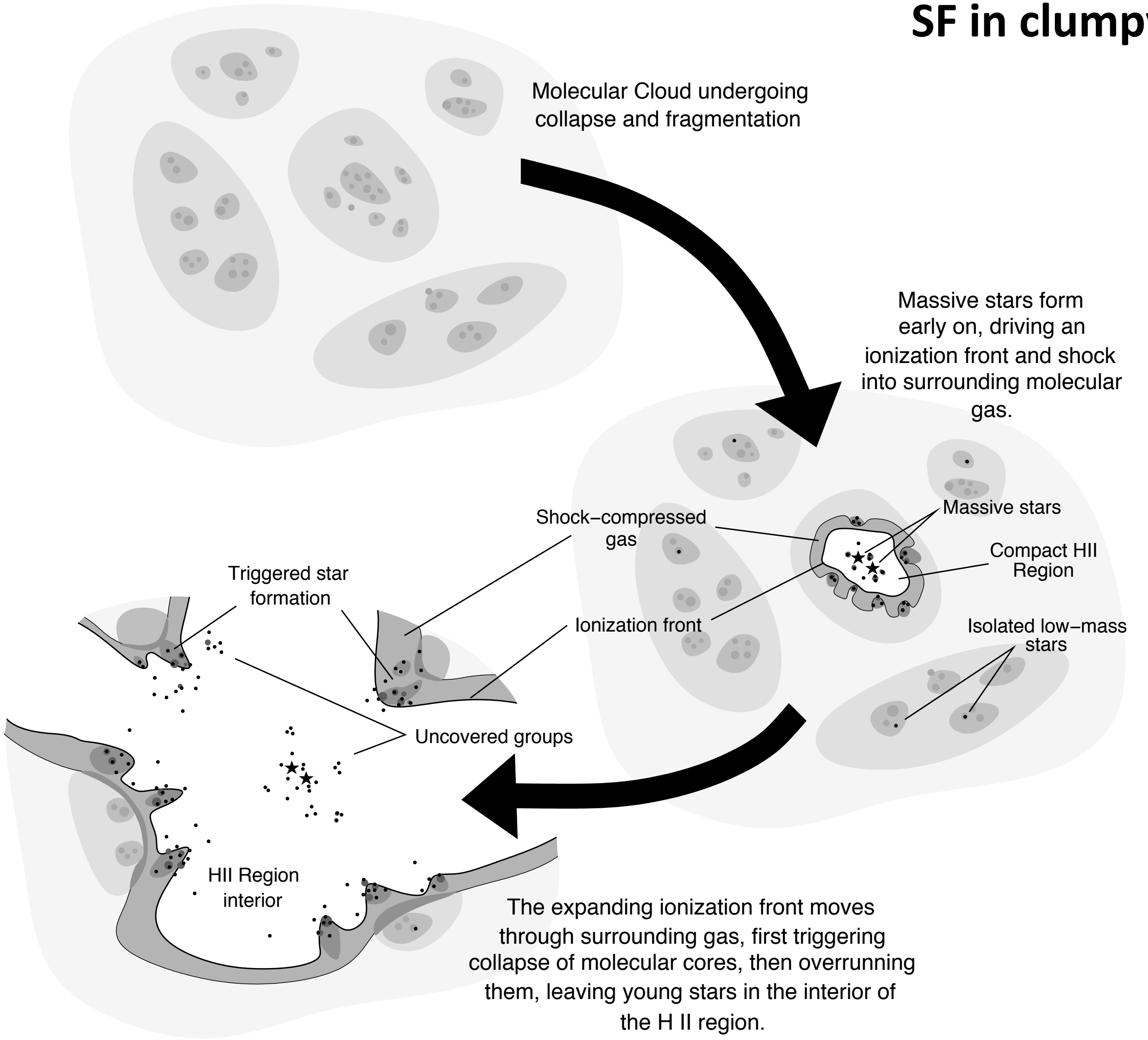
Nutter & Ward-Thompson 2007

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;

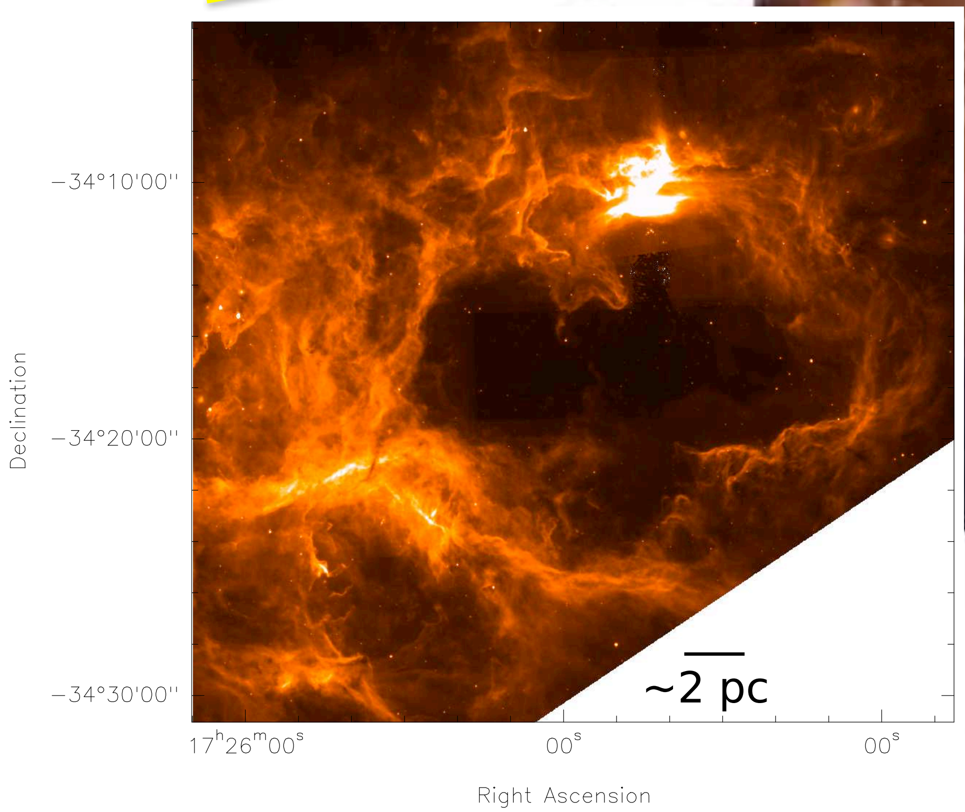
  by compressing existing dense condensations, triggering SF.

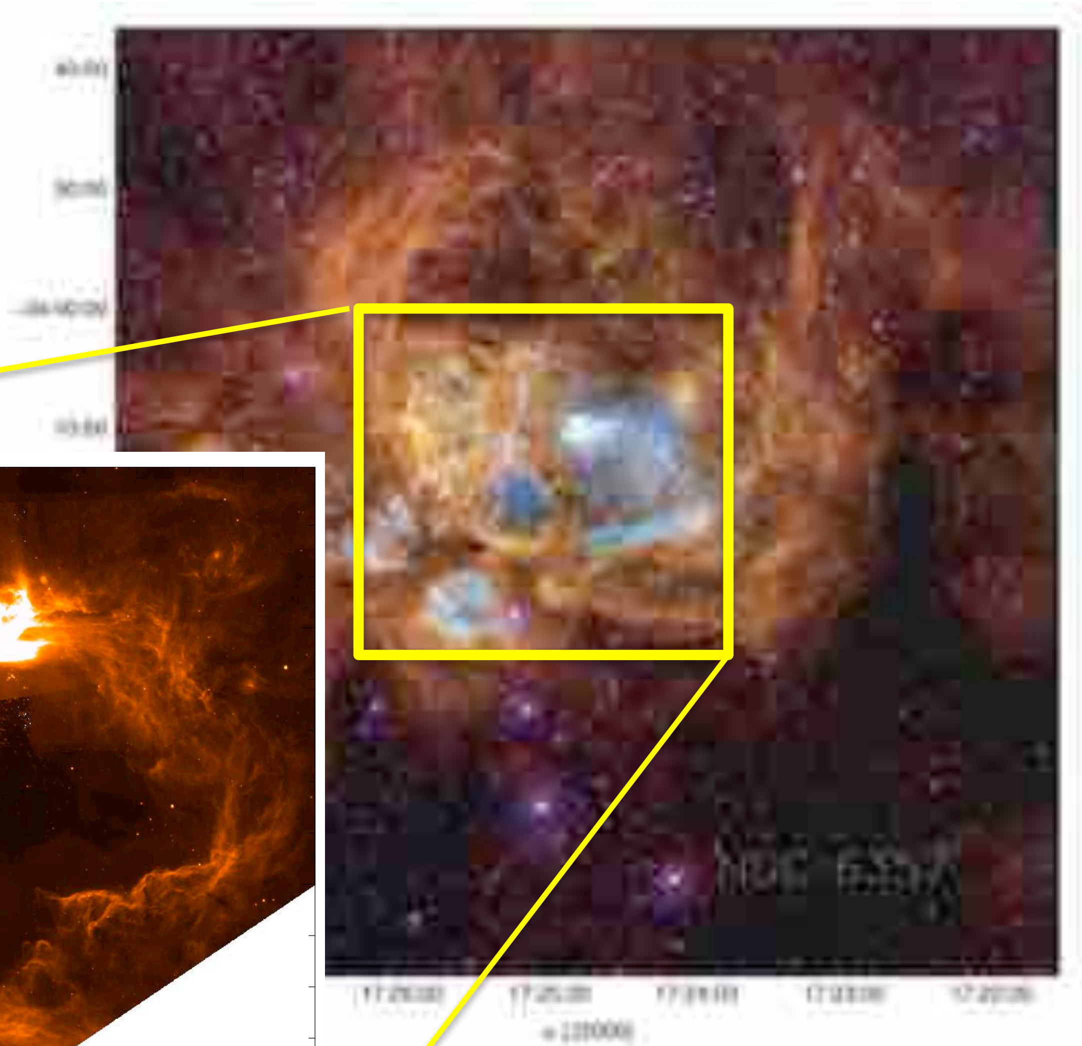
A way of assessing these effects is to determine whether the CMF near to a PDR significantly departs from those observed in more quiescent (less exposed to intense stellar UV radiation) star forming regions.

NGC 6357

Distance = 1.7 ± 0.2 kpc

8 µm (GLIMPSE survey)



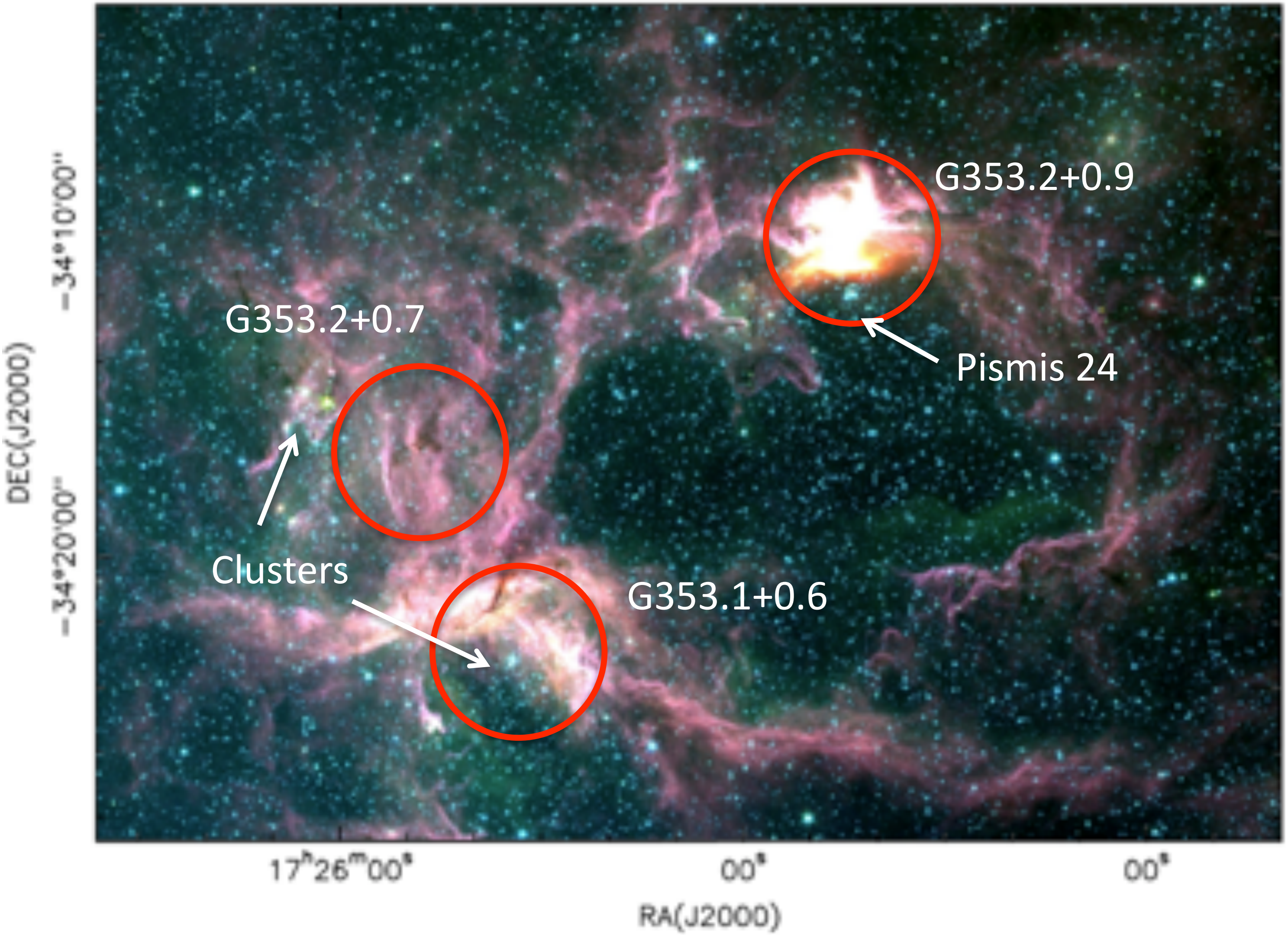


RGB: [SII], Hα, [OIII]

Cappa+ 2011 MNRAS 415, 2844

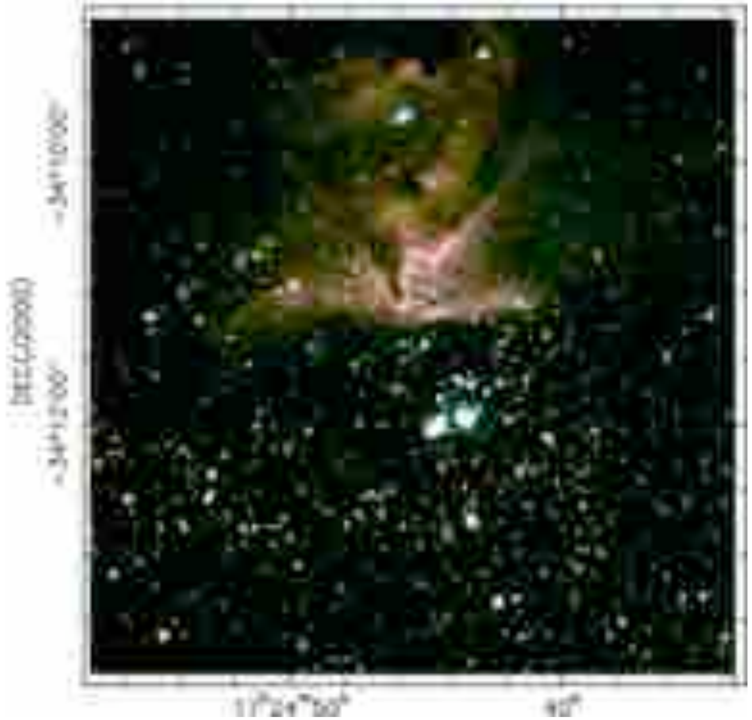
NGC 6357

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***]

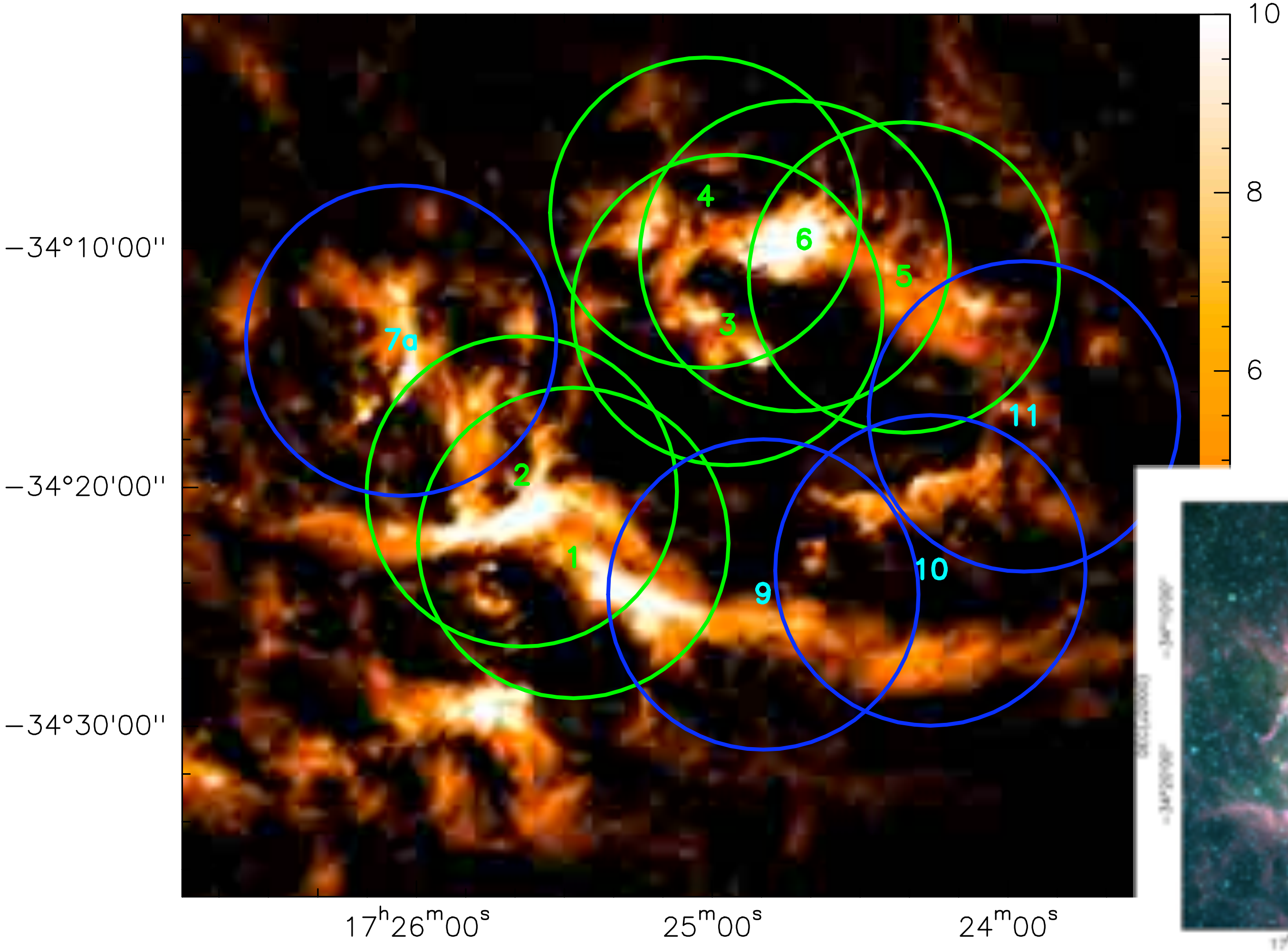
Giannetti A., Brand J., Massi F., Tieftrunk A., Beltran M.T.
Molecular clouds under the influence of massive stars in the Galactic HII region G353.2+0.9 [2012, *Astron. Astroph.* ***538, A41***]

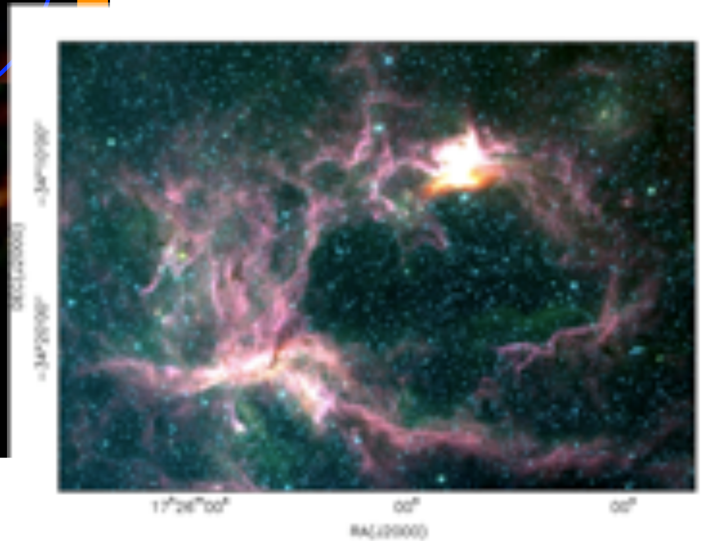
Massi F., Brand J., Felli M.
Molecular Cloud/HII Region Interfaces in the Star Forming Region NGC6357 [1997 *Astron. Astroph.* ***320, 972***]

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

OBSERVATIONS

Herschel 160 µm map with daisy fields SCUBA2 overlaid.

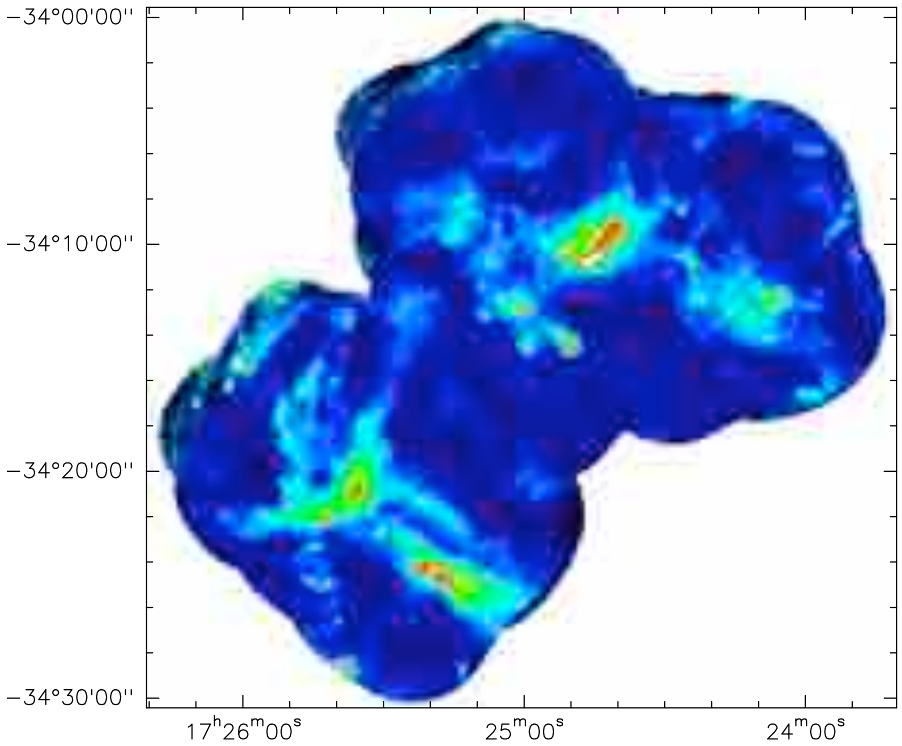


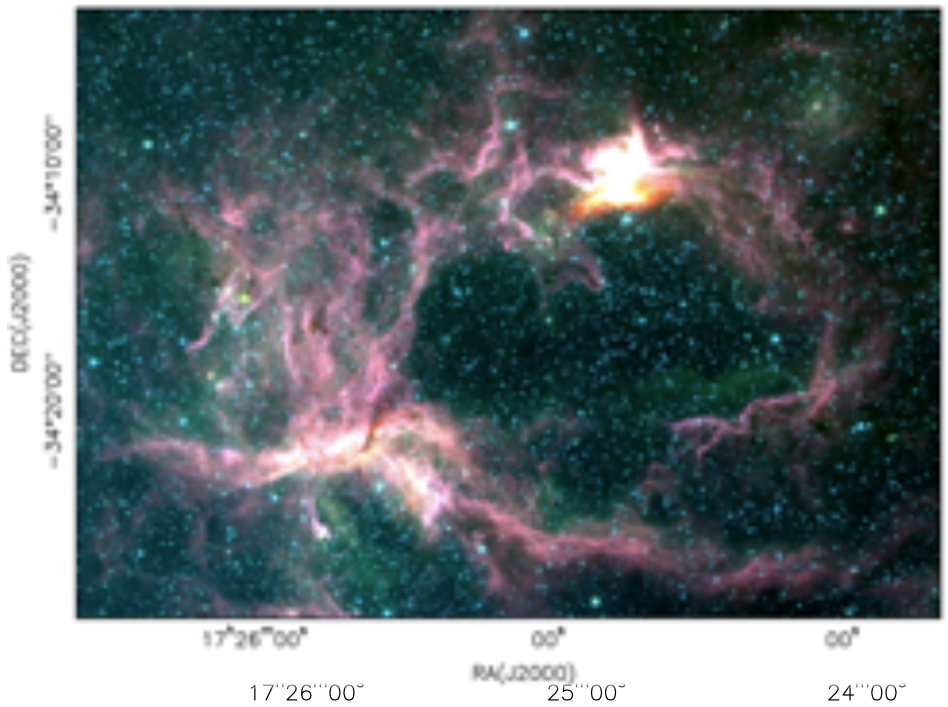


We used SCUBA2 at the JCMT to observe, at 450 µm and 850 µm, the dust associated with the molecular clouds in a 30’ x 30’ (15 pc x 15 pc) region containing three HII regions. We assess the radiative and mechanical influence of the stars that excite the HII regions on the molecular gas, by determining 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

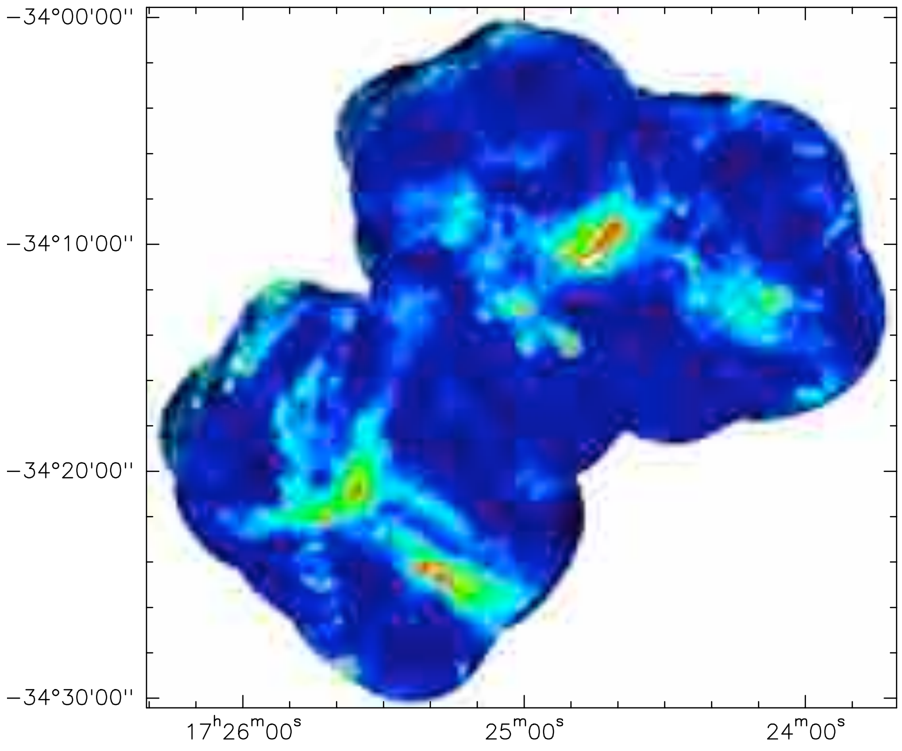
Spitzer NIR RGB



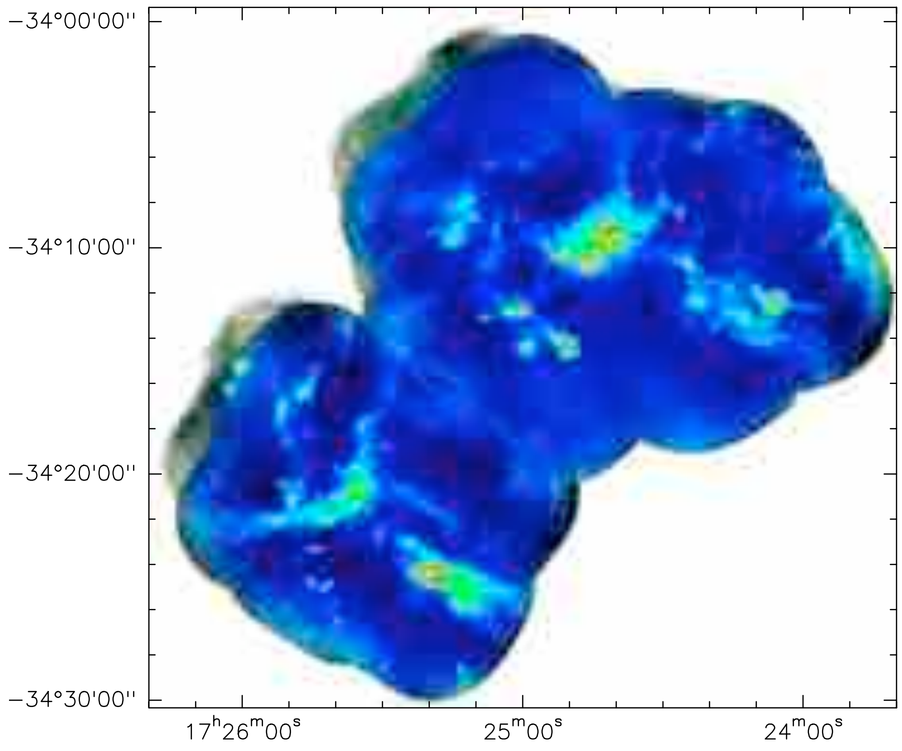


Mosaic at 850 µm; hpbw 14”

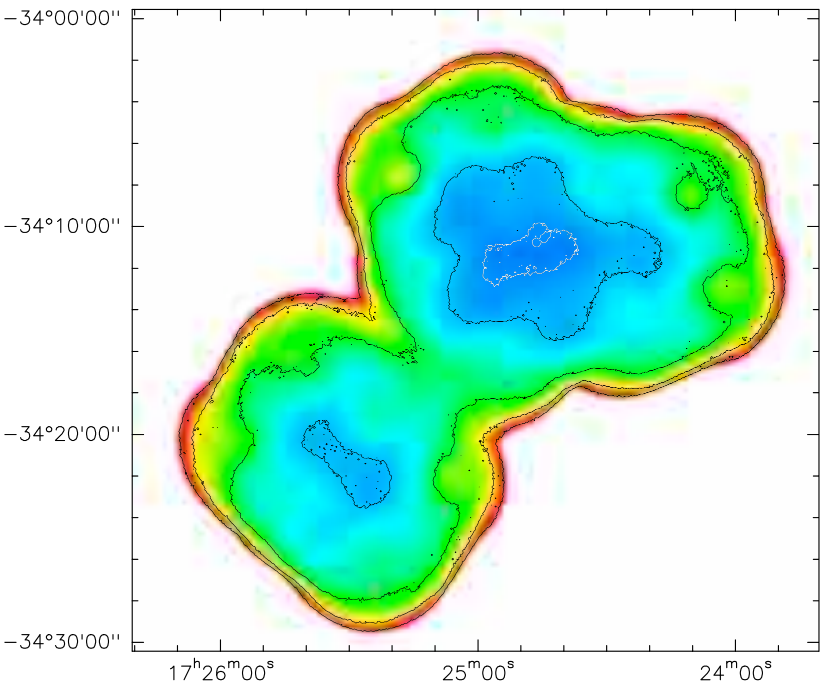
RESULTS: Maps of dust continuum emission

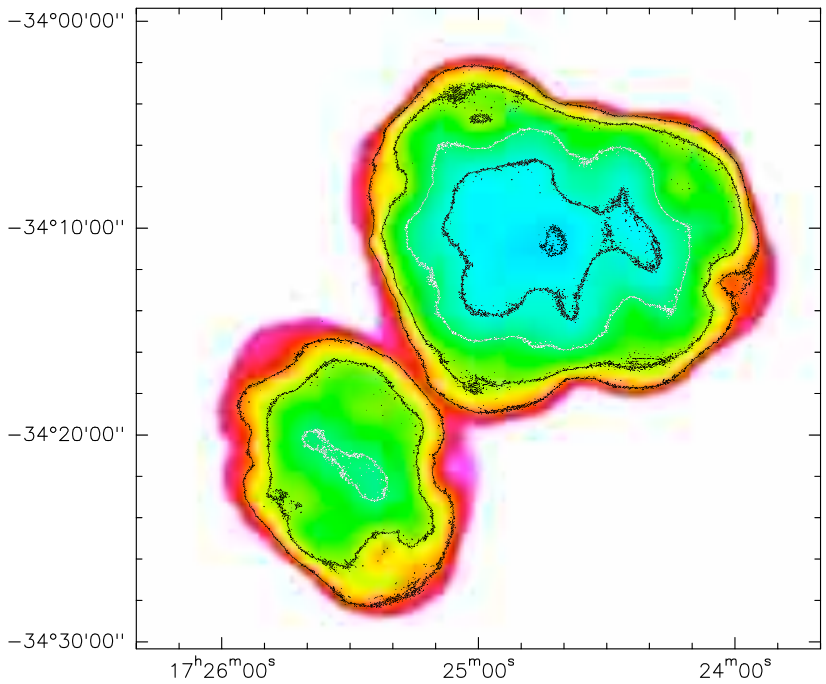


Mosaic at 850 µm; hpbw 14”



Mosaic at 450 µm; hpbw 7”

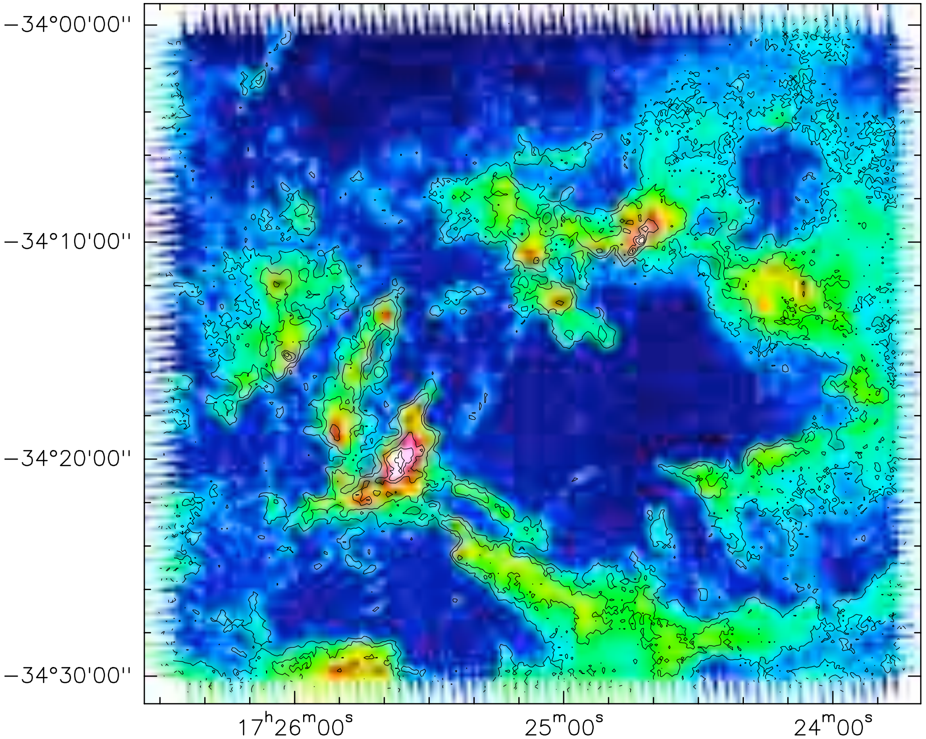




Left: errormap 850 μm. Levs (mJy/bm): 4 (white), 5, 10, 15, 20

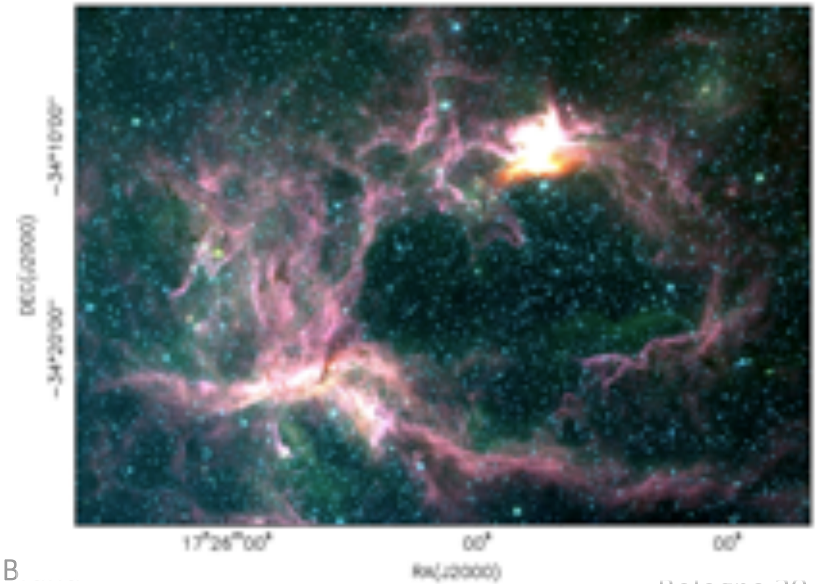
Right: errormap 450 μm. Levs (mJy/bm): 60, 75, 100 (white), 150, 200

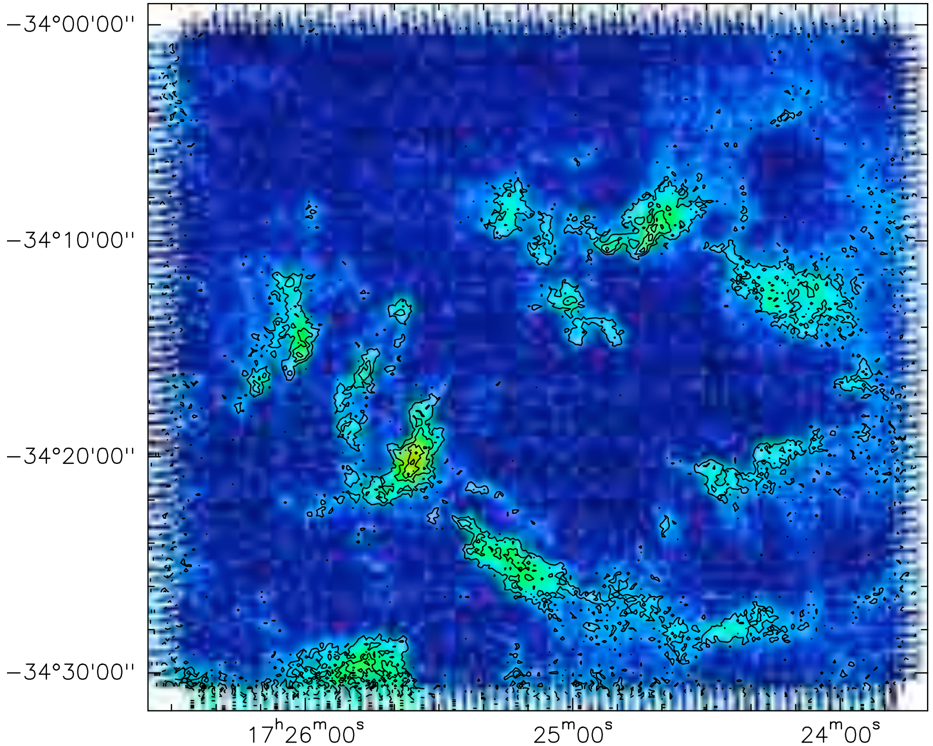
CONTAMINATION

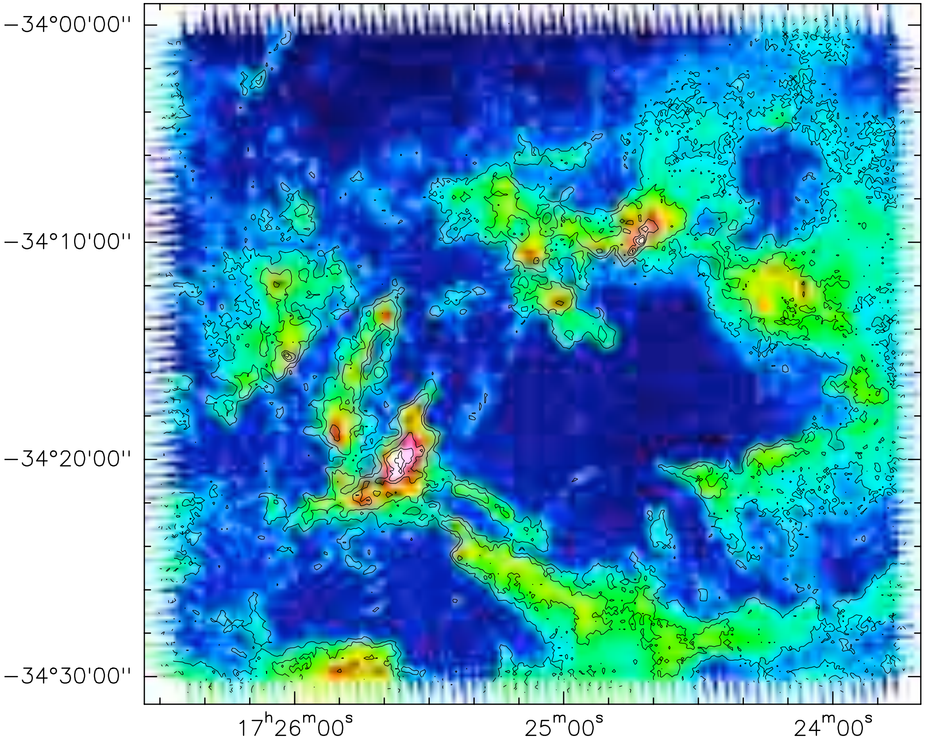


$^{12}CO(3\text{-}2)$ map, JCMT. Used to correct 850 µm dust continuum

Typical contamination <10-25%





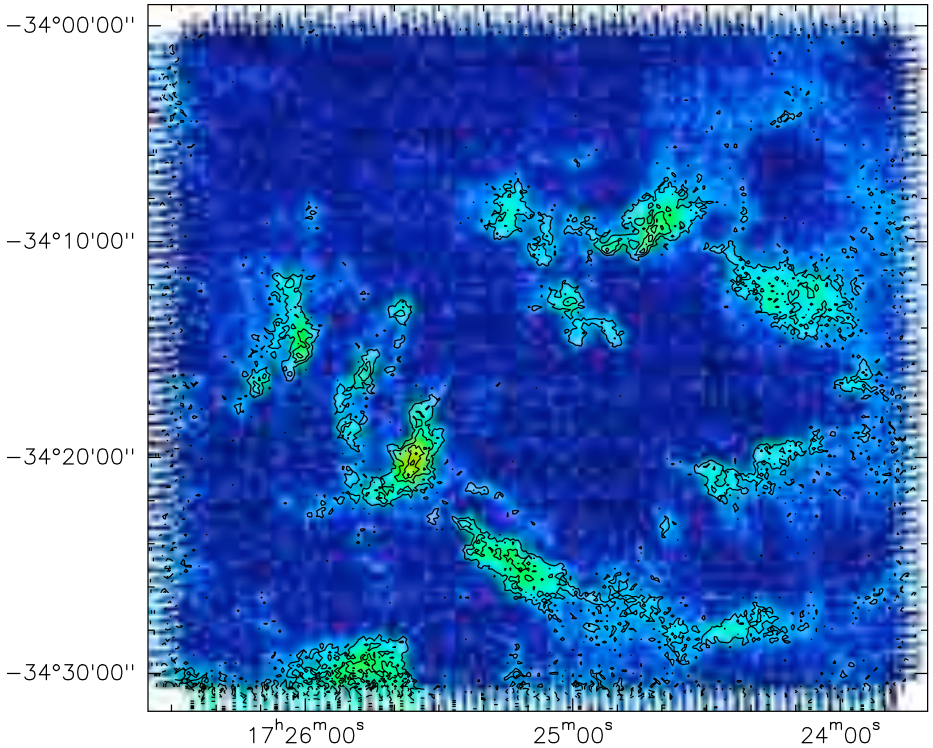


CONTAMINATION

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

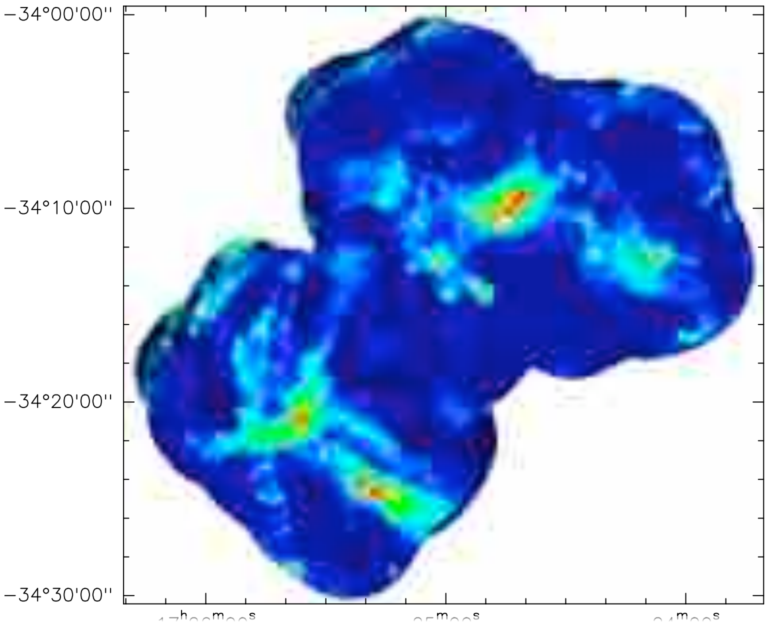
Typical contamination <10-25%

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



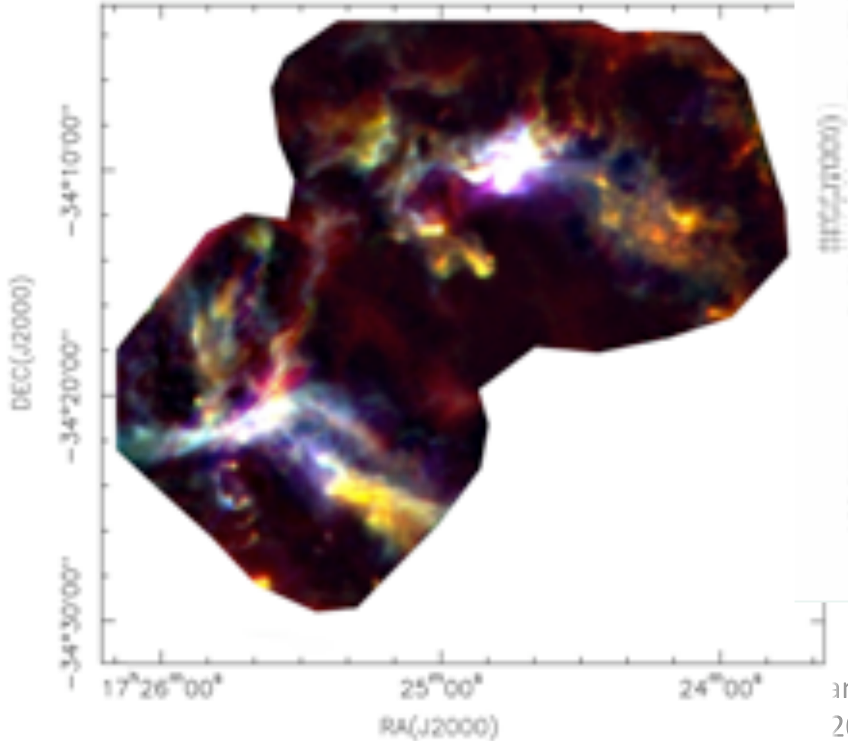
$^{13}CO(3-2)$

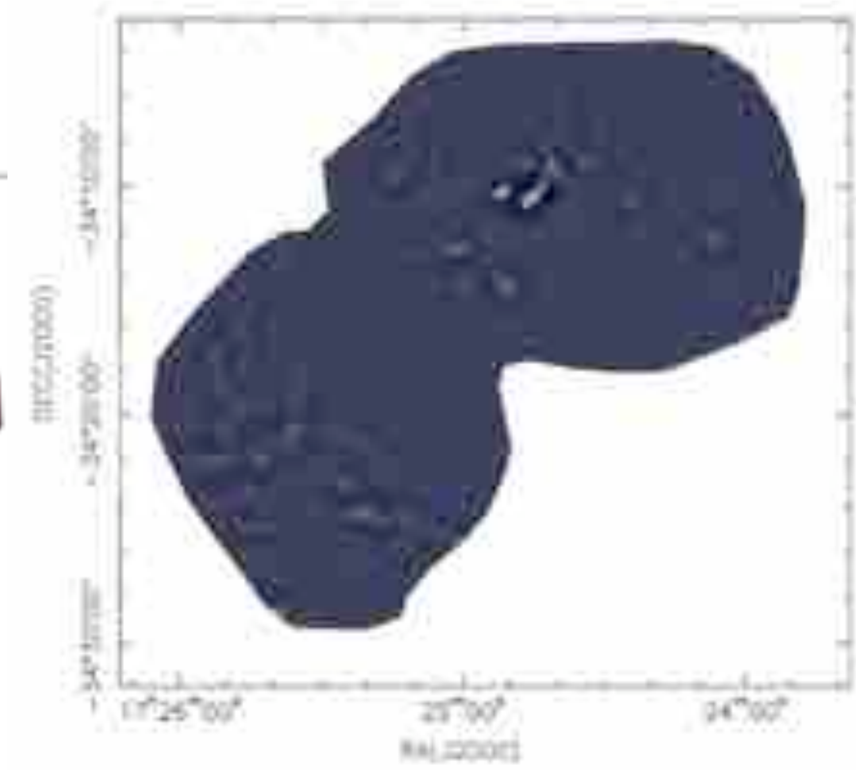
REMOVING DIFFUSE EMISSION



SCUBA2 850 μm

RGB: Herschel 70, 160, SCUBA2 850 μm





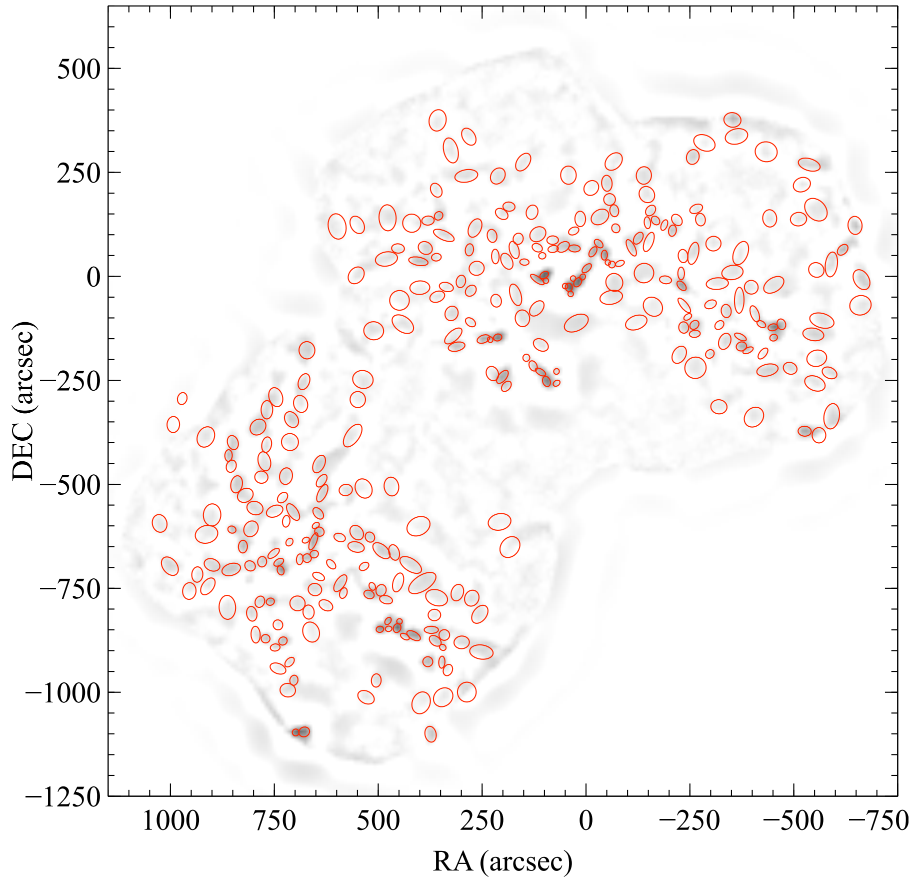
RGB, background removed

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_ν : 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 $\beta=1.8$.

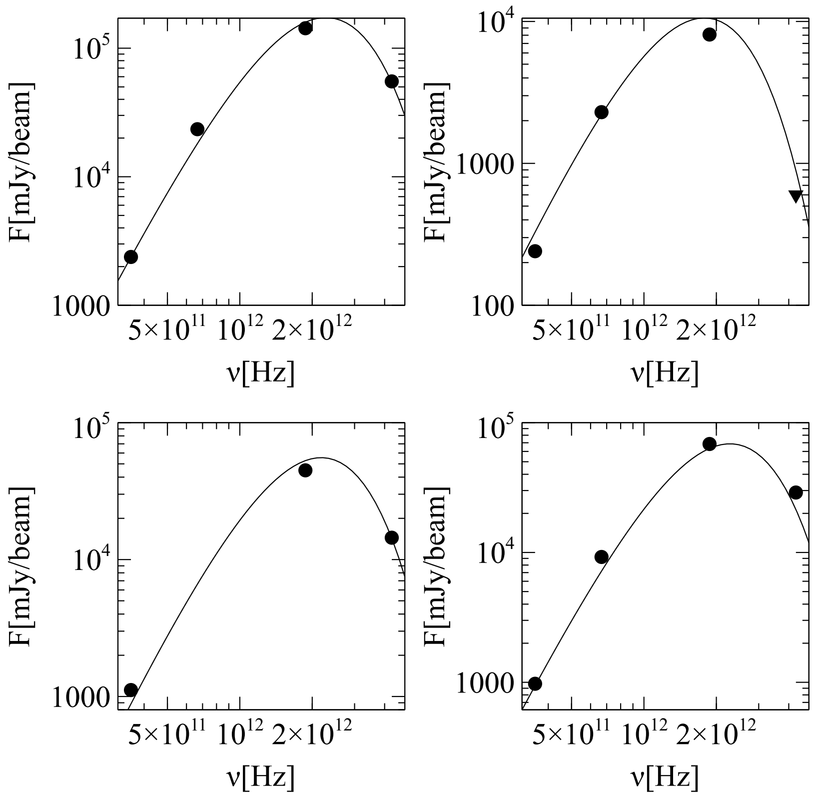
The gas-to-dust ratio $\gamma = 100$.

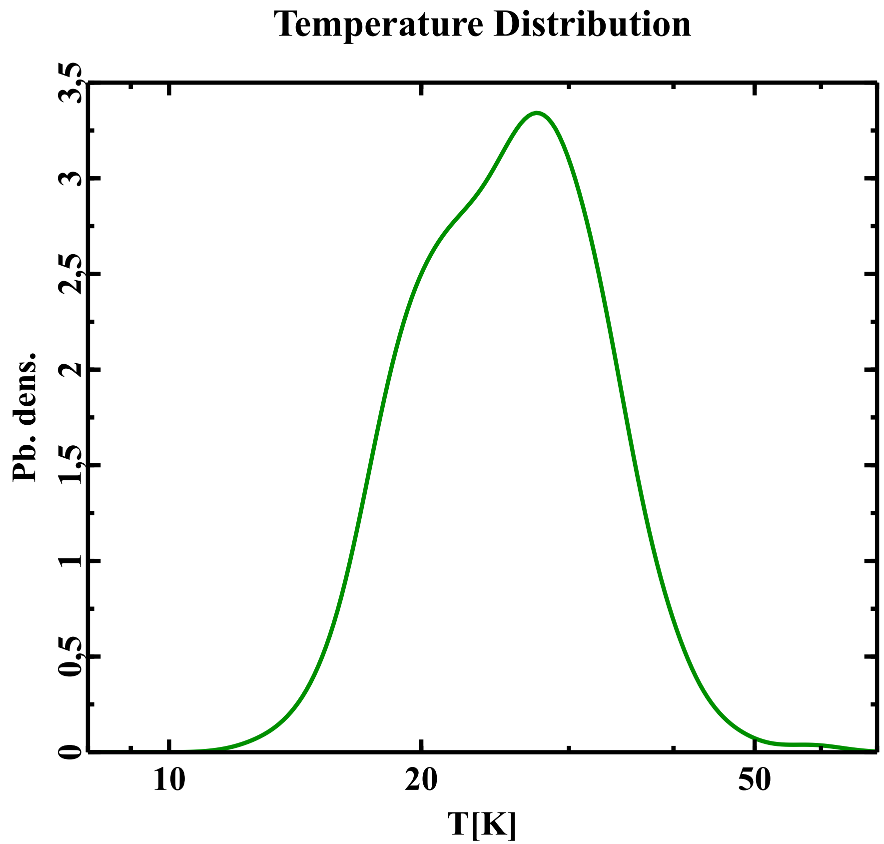


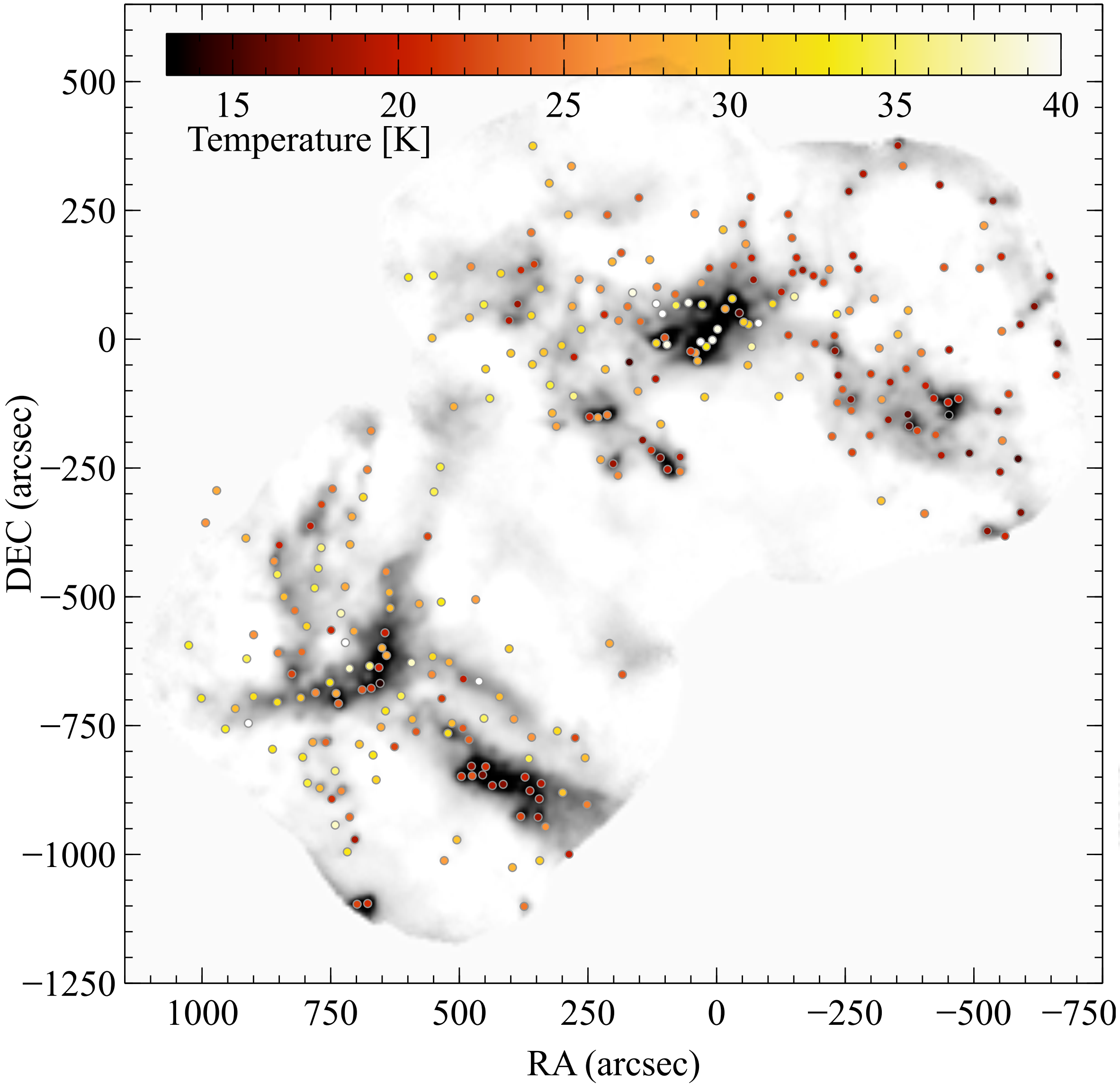
Need the dust temperature:
use Herschel Hi-GAL data

TEMPERATURE OF CORES

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

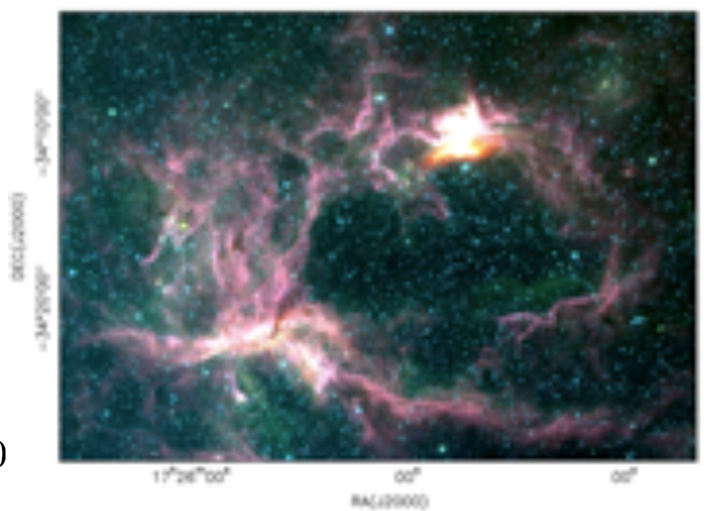




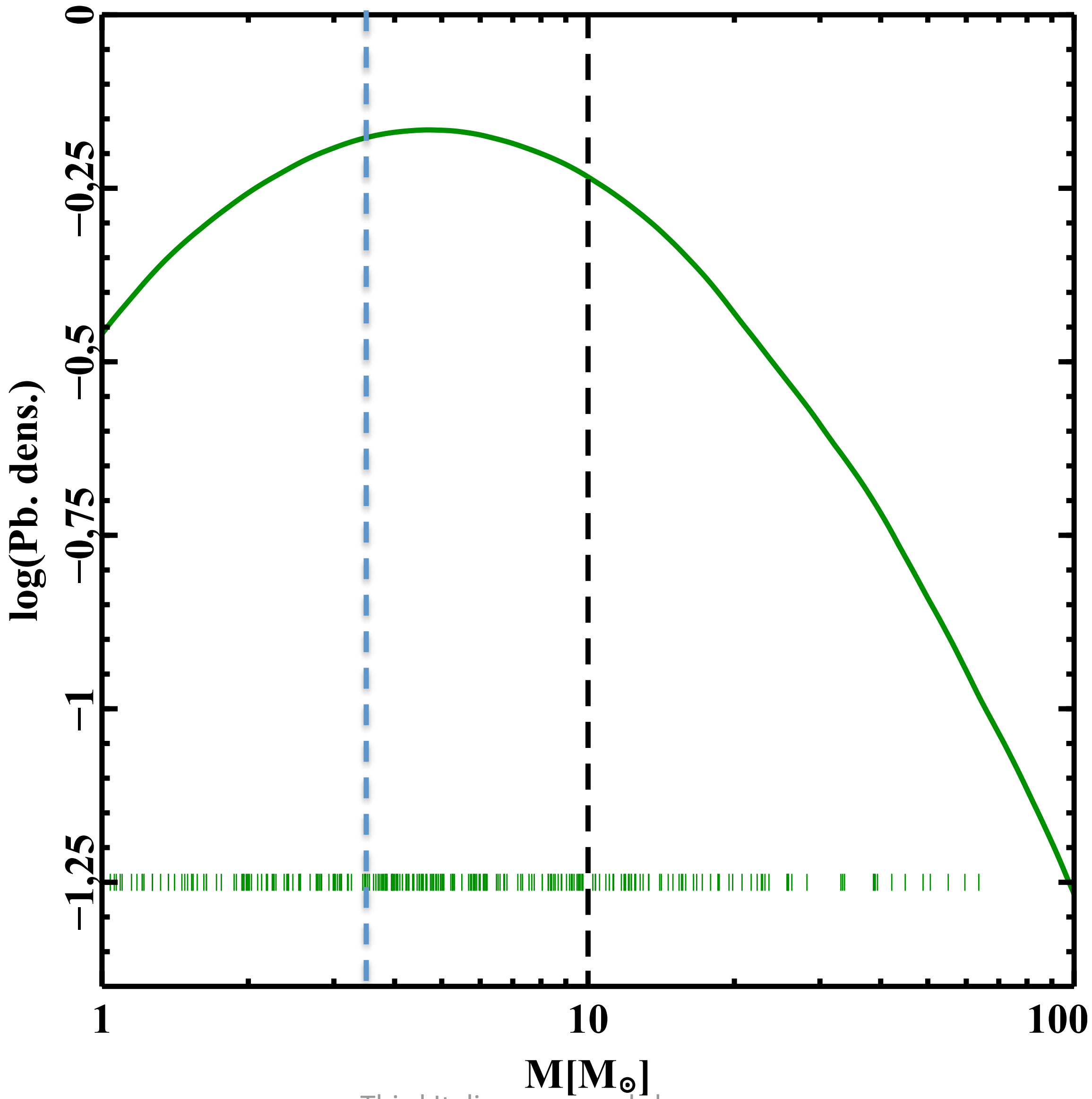


TEMPERATURE MAP

302 cores

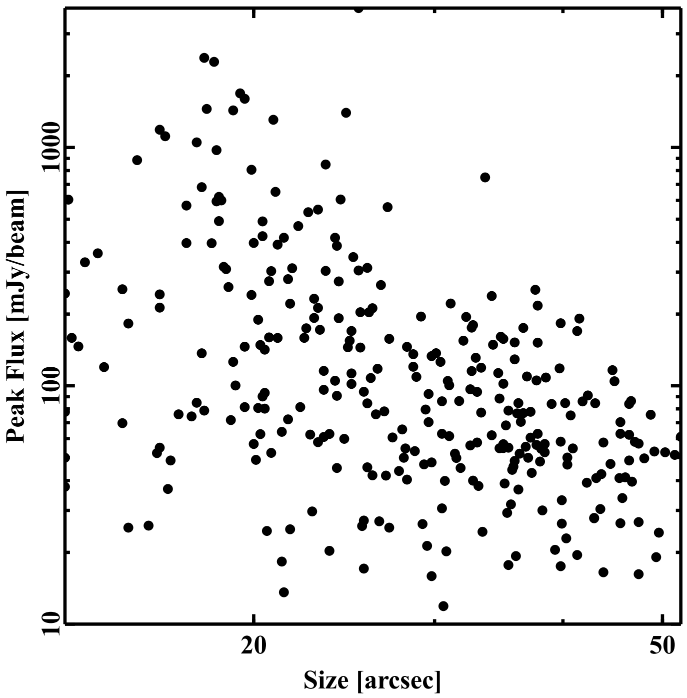


Core Mass Distribution

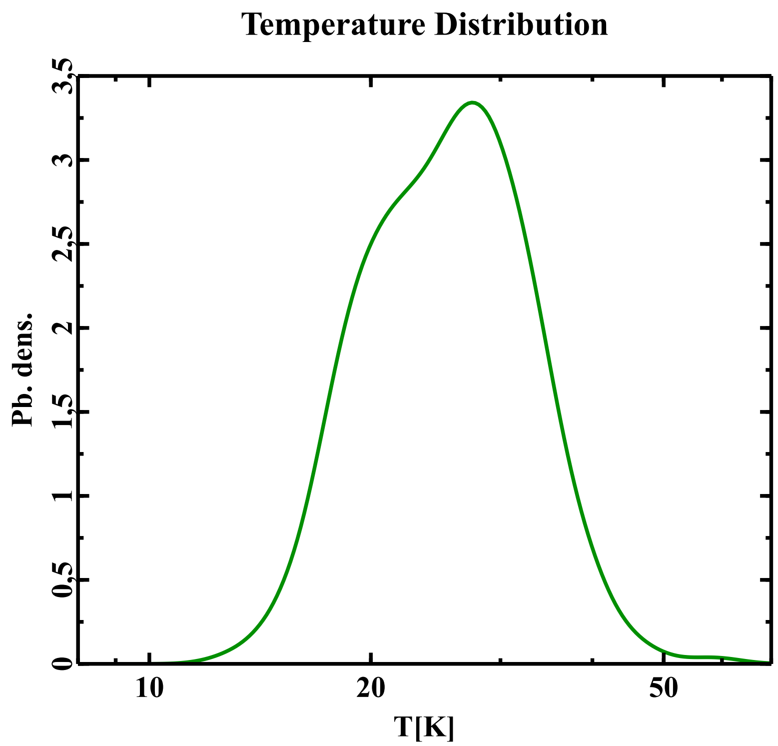


COMPLETENESS I

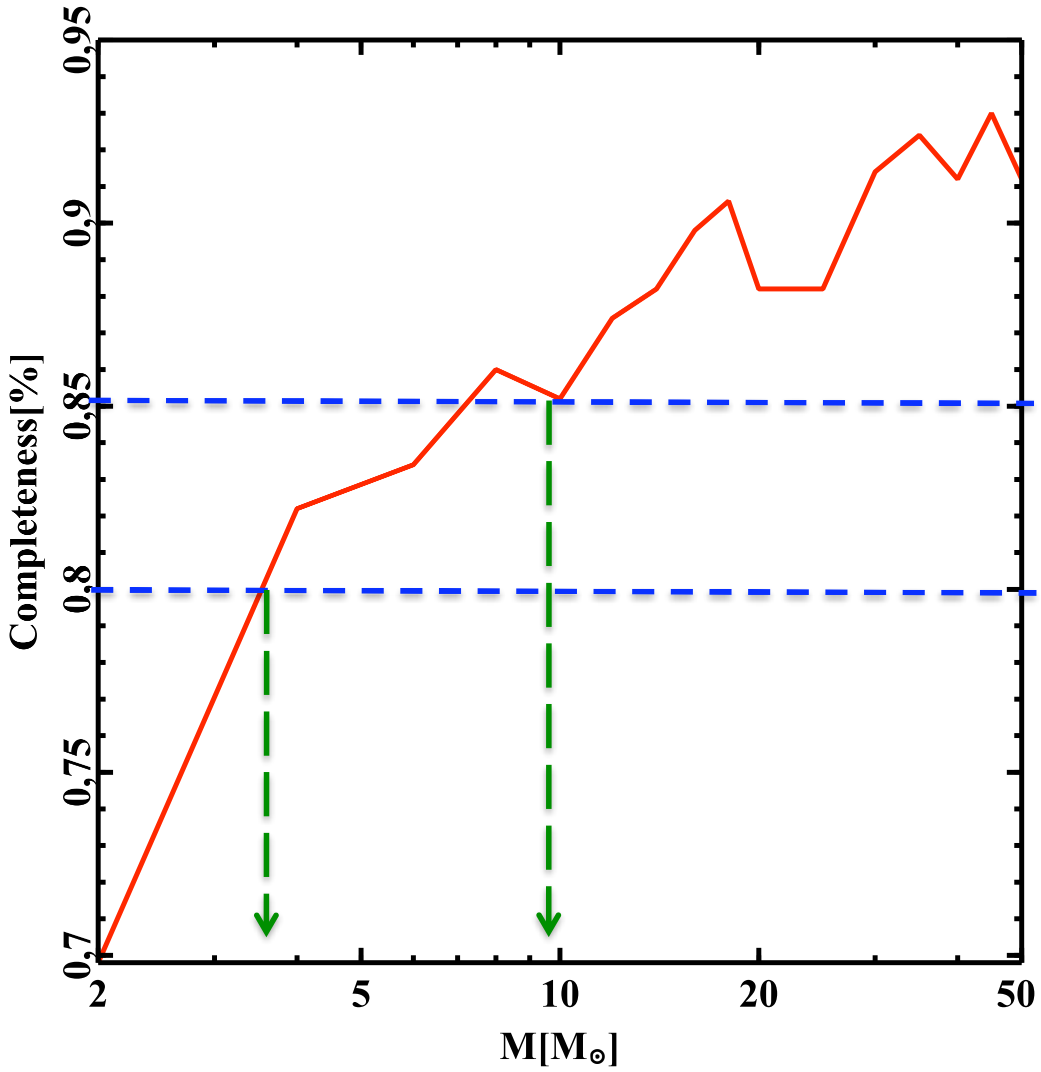
For range of masses (2 – 50 $M_\odot$) create artificial cores, using parameter space of cores actually found.

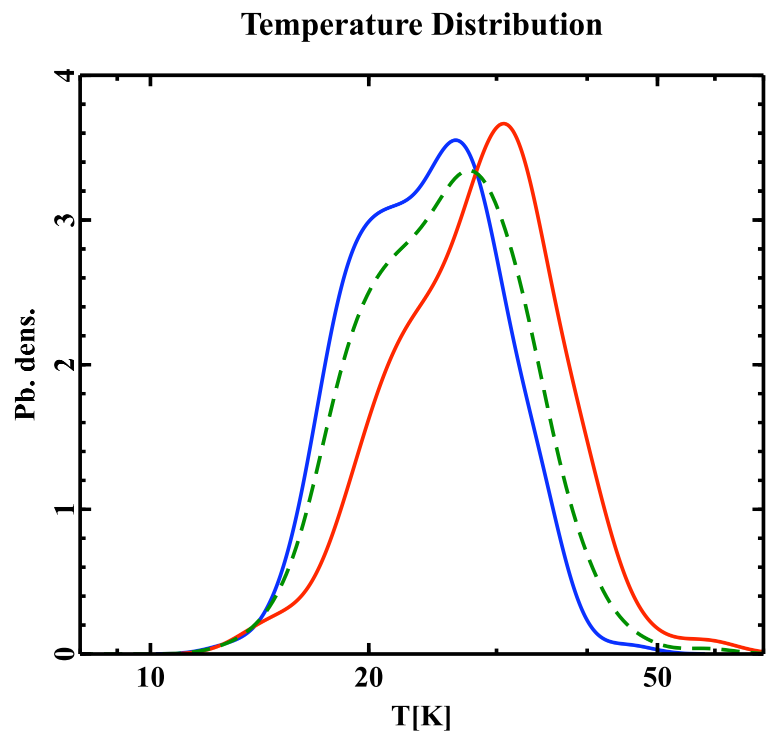


Insert artificial cores into original data, then proceed as before, and see how many are found. Repeat many times for each mass.



COMPLETENESS II



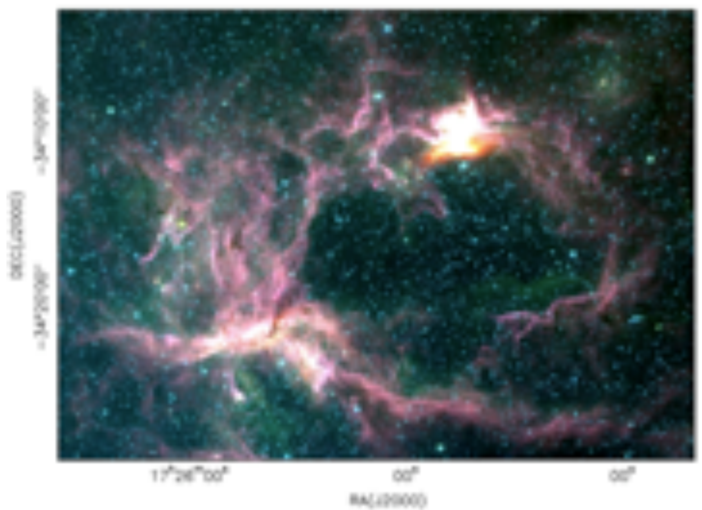


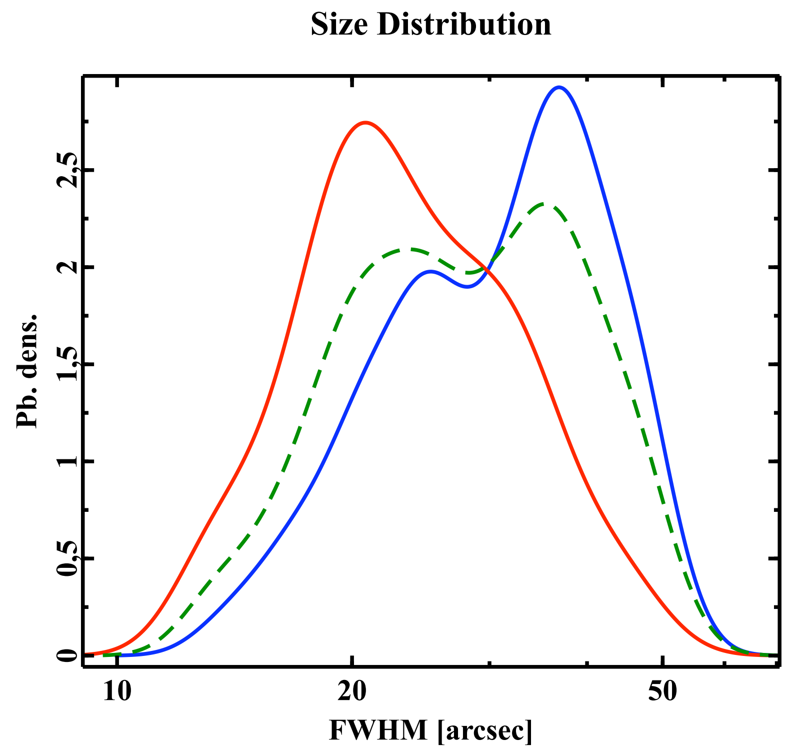
Divide sample into:

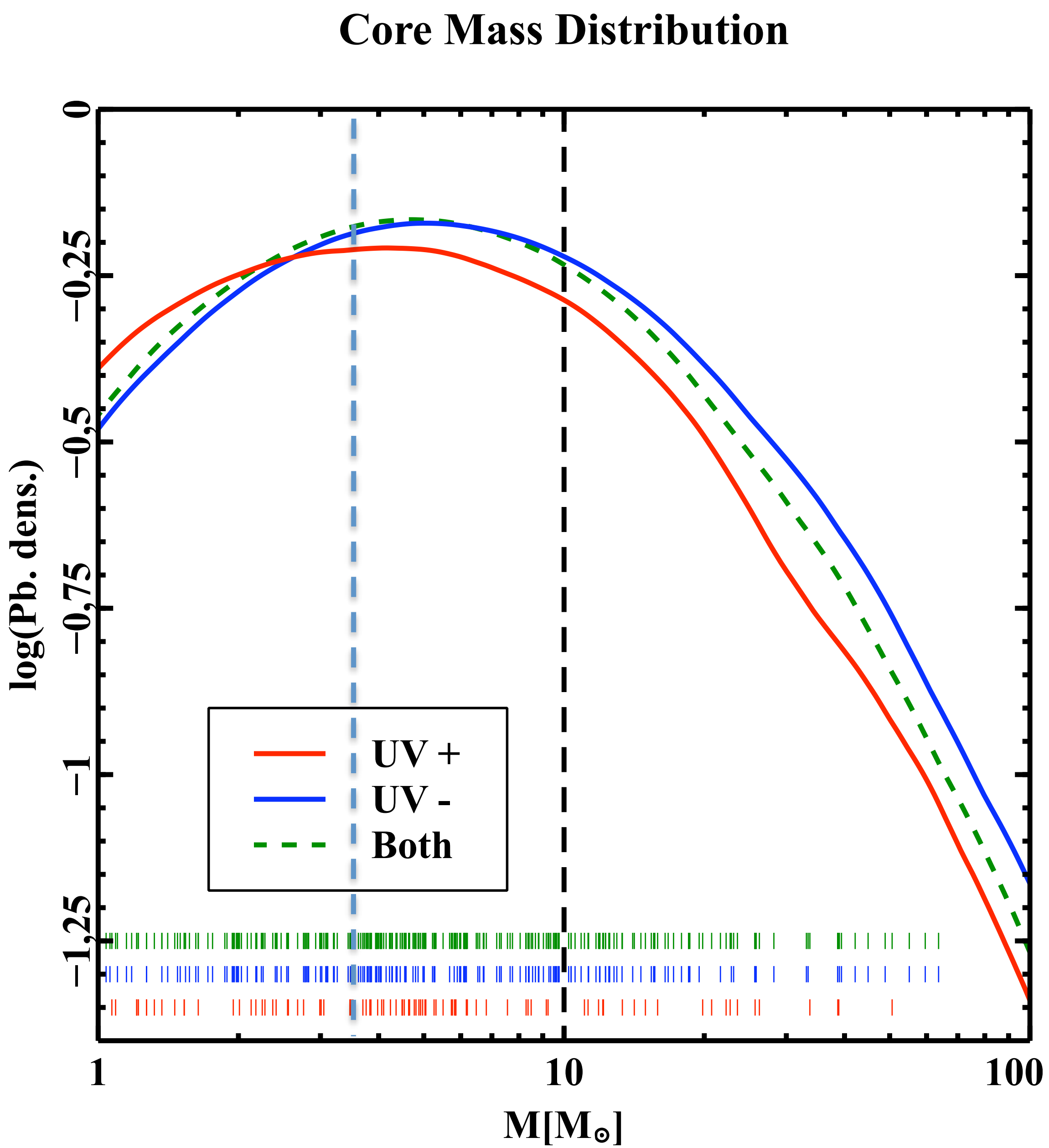
cores near star clusters (**UV+ ; N = 108**)

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

UV+ warmer and more compact





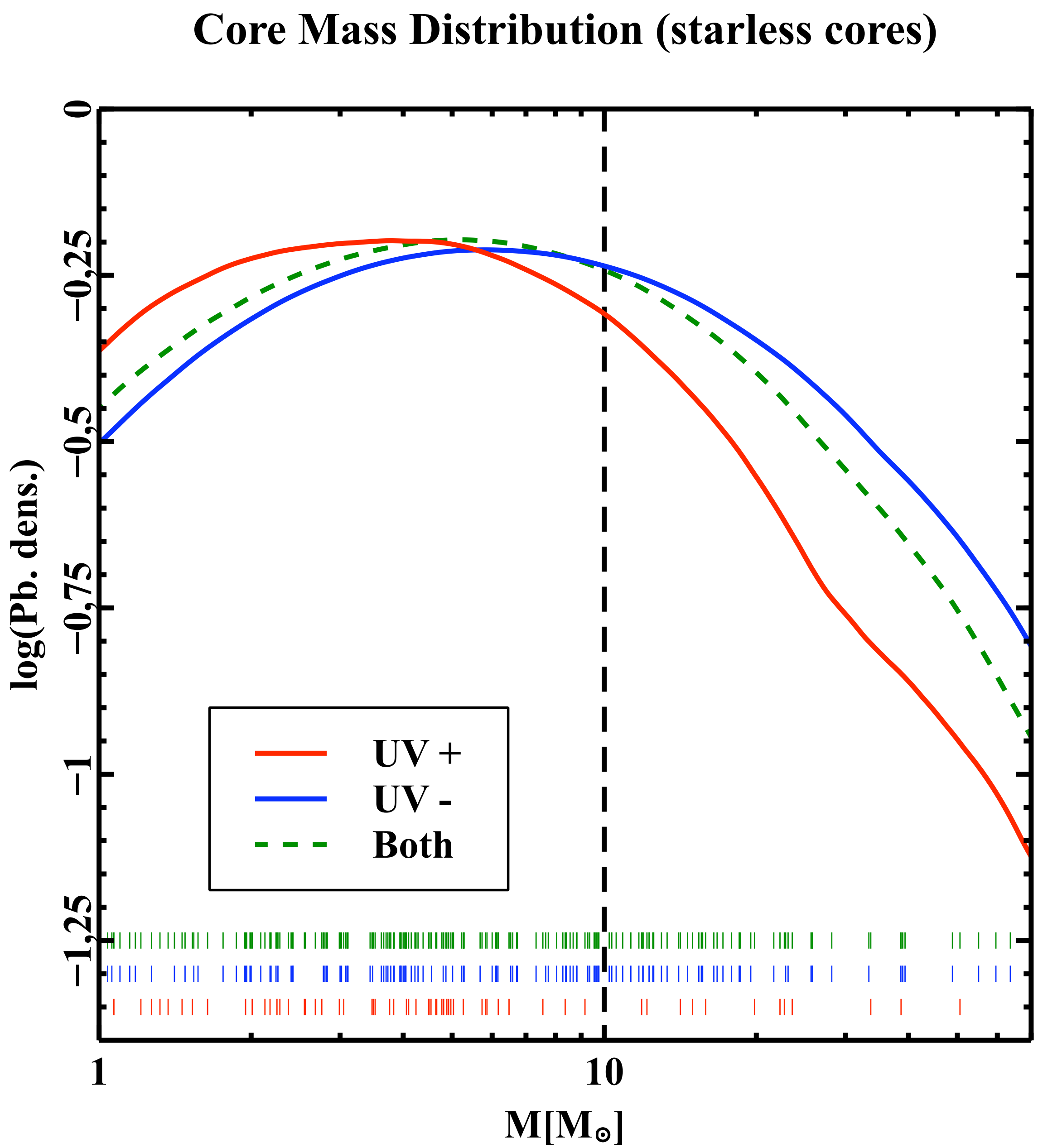


No difference between CMFs:

* 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

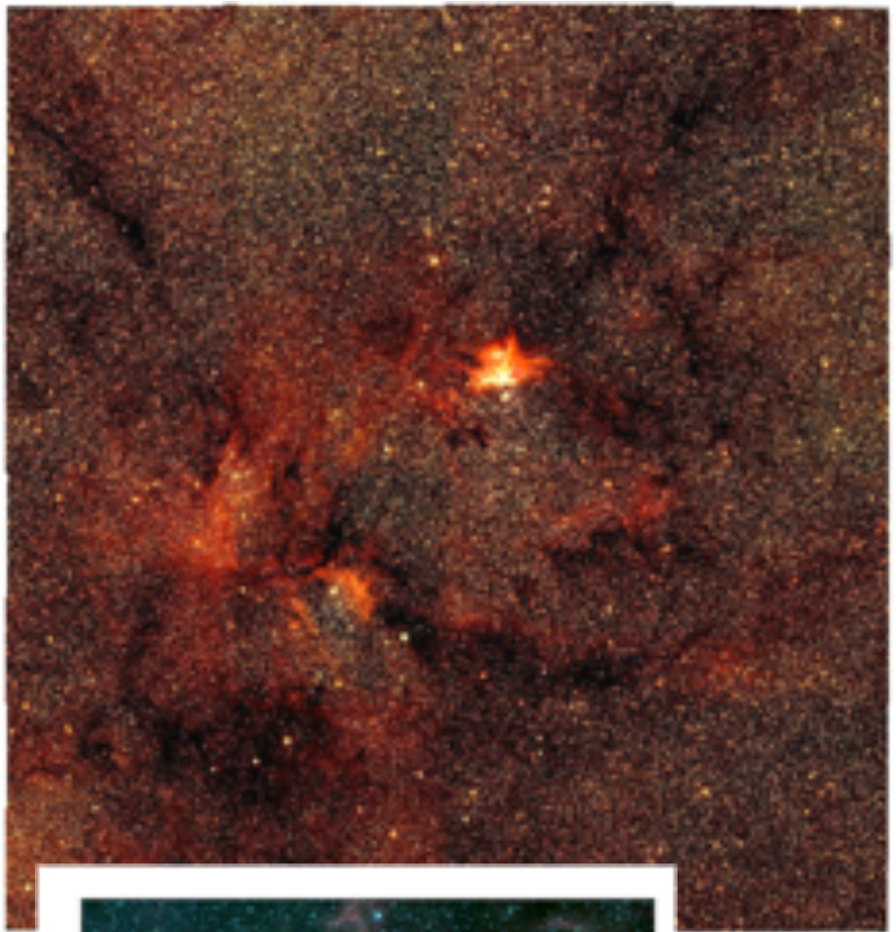


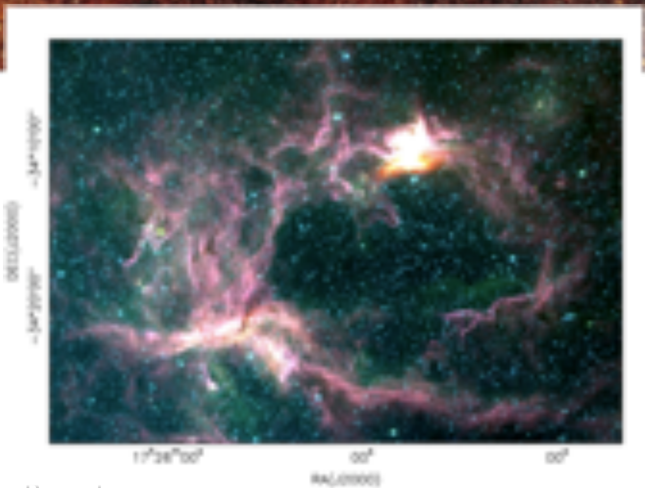
But wait…

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!