Herschel observations of The Carina Nebula Complex

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Outline

- Introduction
- Clusters in Carina
- Herschel survey
  - ✓ Point Source analysis
  - ✓ Cloud structure
  - ✓ Pillars
- Conclusions

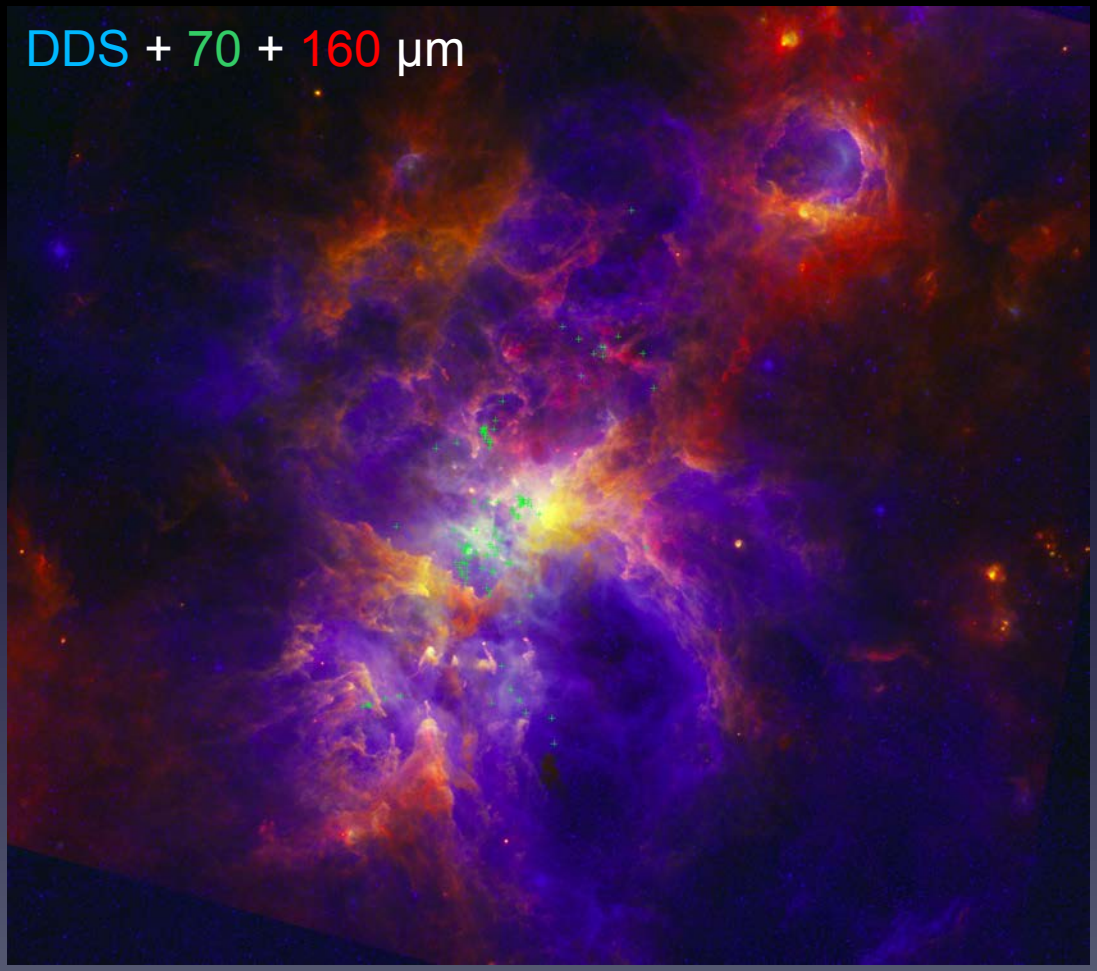
Why the Carina Nebula Complex?

① **@ 2.3kpc**
1" = 2300 AU = 0.01 pc

② **>70 O** + 4 WR **stars**

③ $M_{\star,max}$ **~ 100** $M_{\odot}$

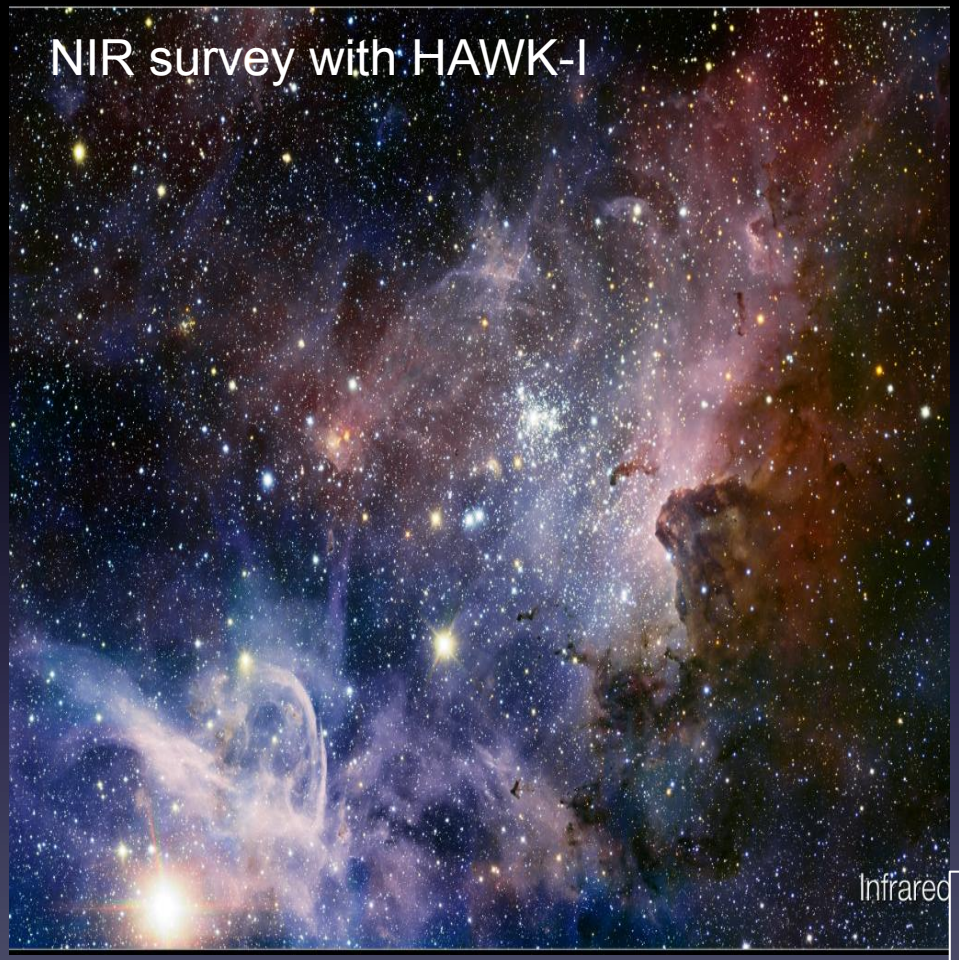
④ **Clusters at different ages: <1Myr to ~8Myr**



Preibisch et al. 2012

2.9°x2.6°

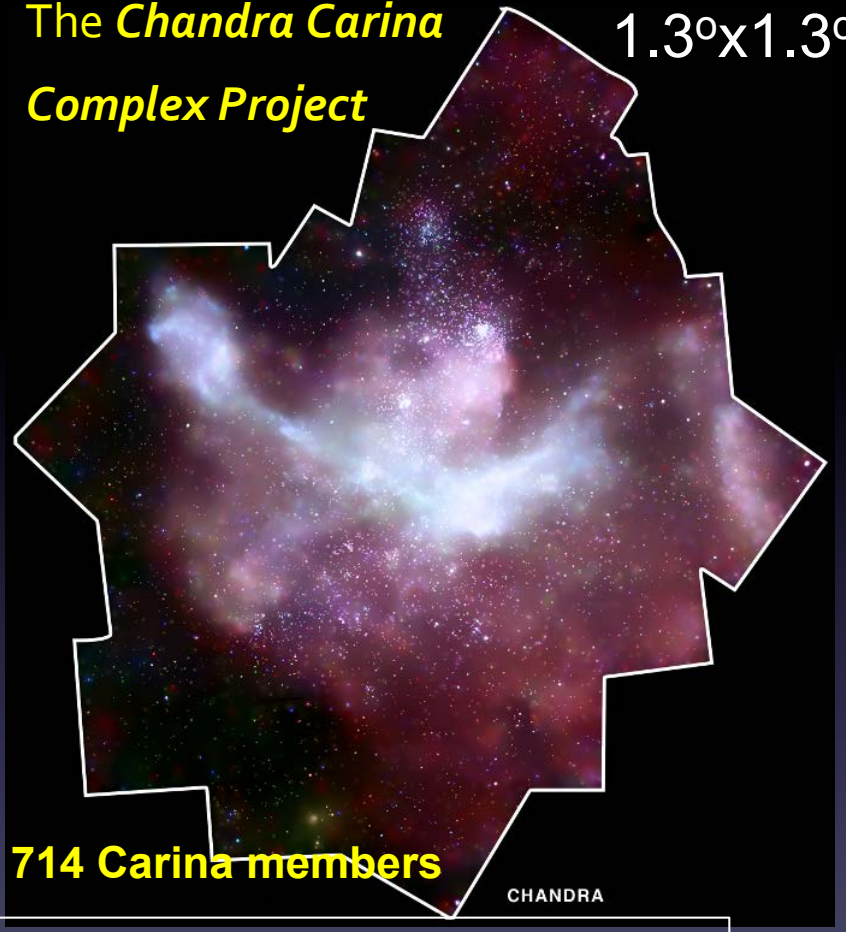
The young stellar population



Preibisch et al. 2011

The ***Chandra Carina Complex Project***

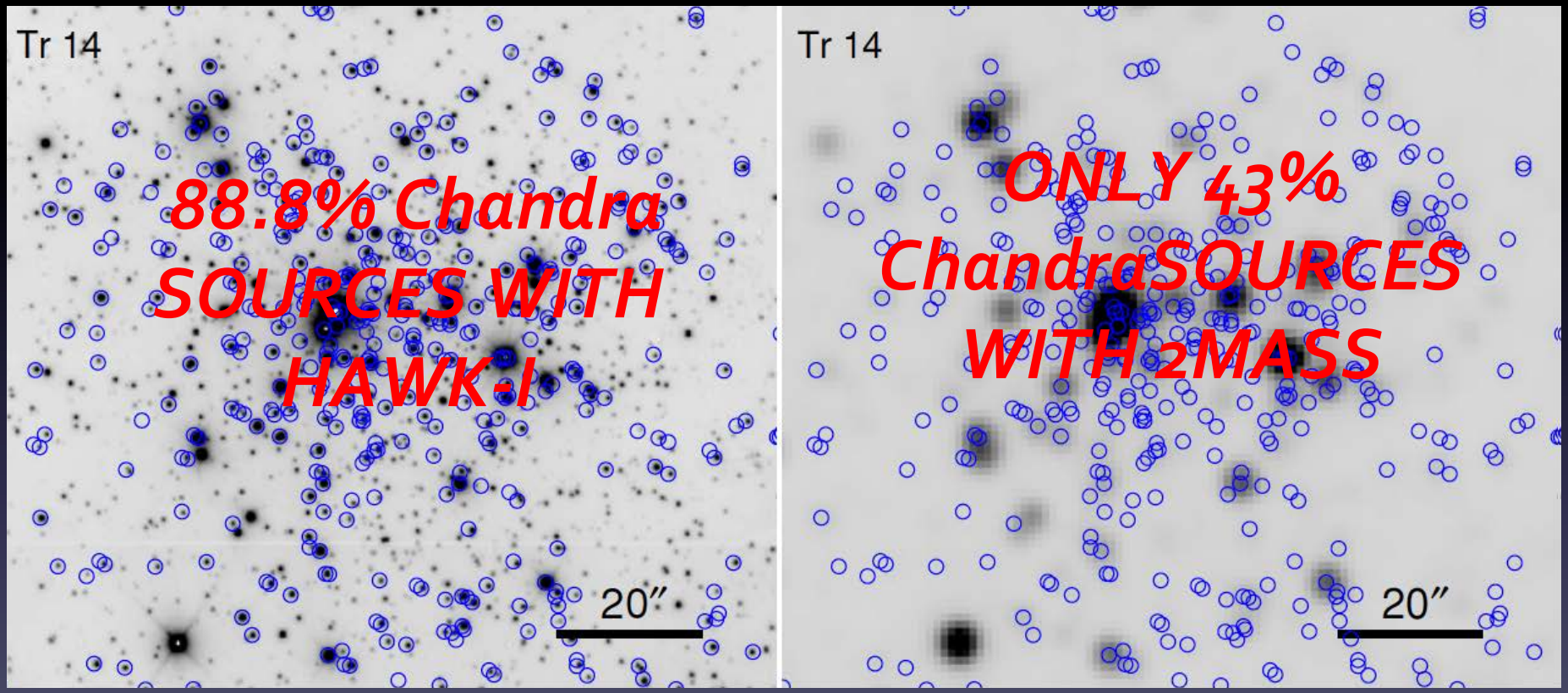
1.3°x1.3°



- **10 714 Carina members**

The first unbiased sample of the low-mass stellar population.
≥ 80% (50%) complete at ~ 1 $M_{\odot}$ (0.5 $M_{\odot}$)

HAWK-I 2MASS

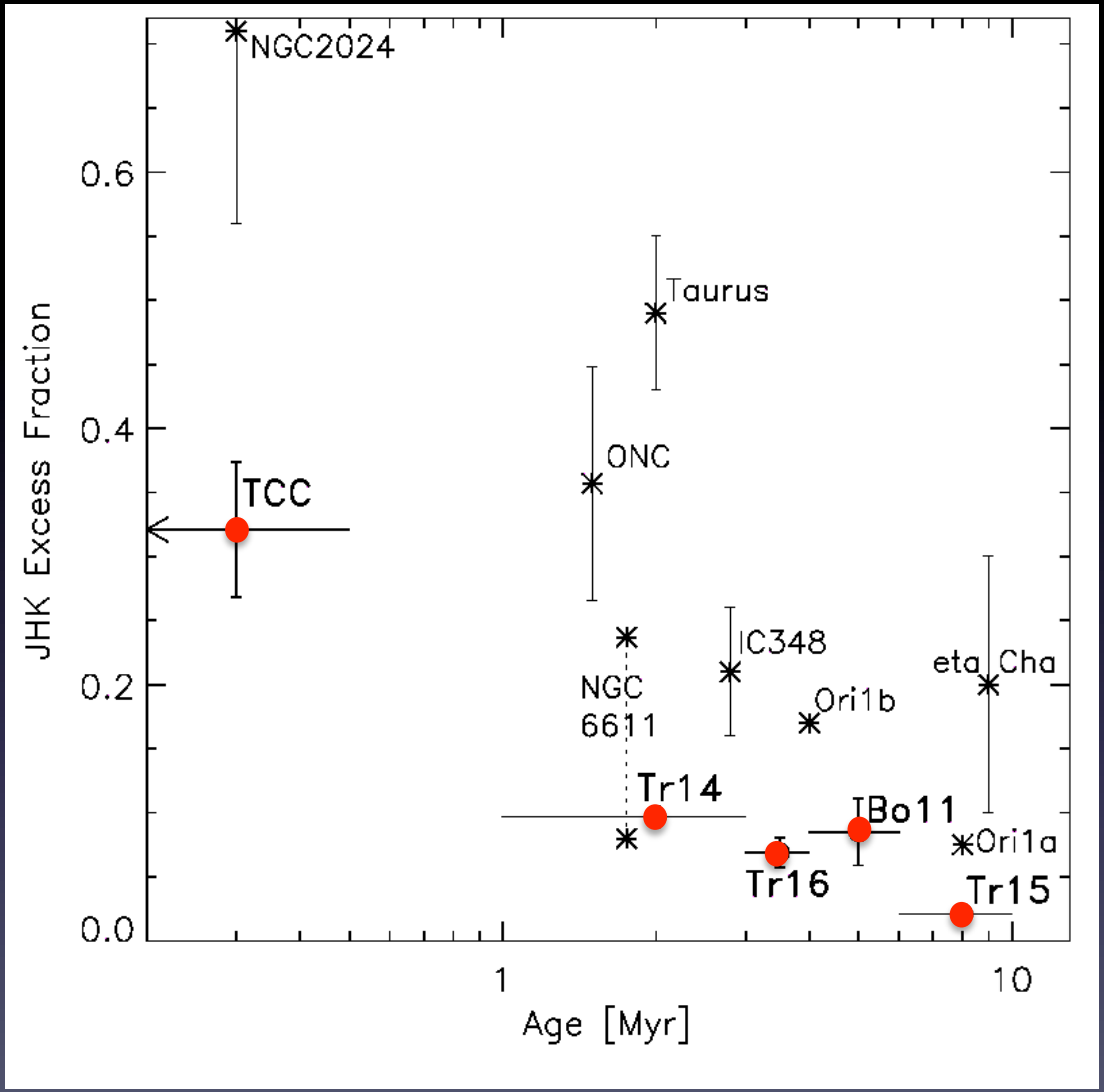


Preibisch et al. 2011 , ApJSS194, 10

Completeness: J=21mag (23)
K=19mag (21)

J=14.8 mag
K=13.3 mag
(Skrutskie et al. 2006)

Inner Disk dispersion



Preibisch et al. 2011 , A&A 530, A34

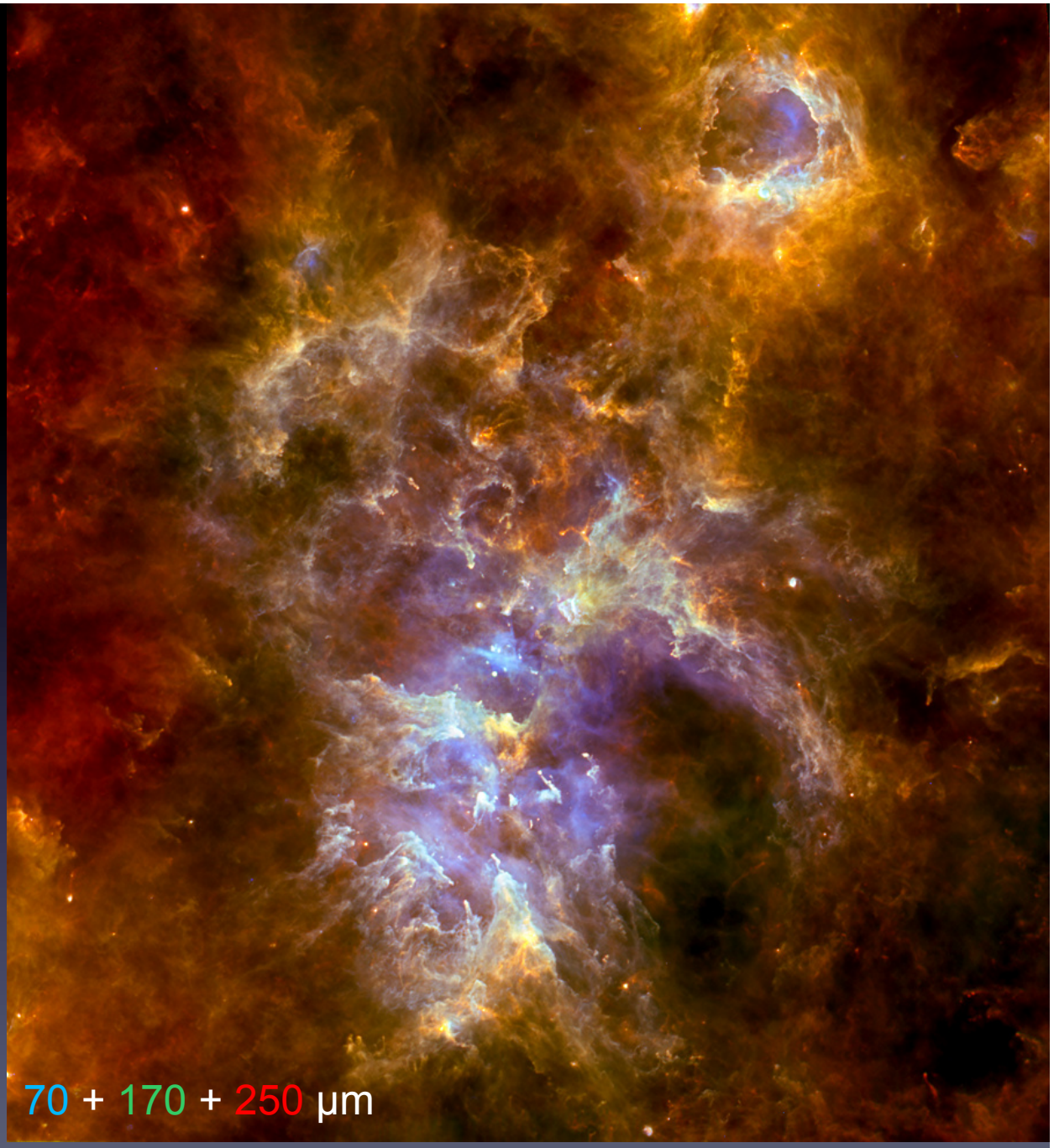
Herschel

far-infrared survey

70 + 170 + 250 + 350 + 500 μm

PACS+SPIRE in parallel mode

Covered area: 2.3°x2.3°



Preibisch+ 2012, A&A 541, A132
Gaczkowski+ 2013, A&A 549, A167
Roccatagliata+ 2013, A&A 554, A6
Ohlendorf+ 2013, A&A, 552, 14

Point Herschel source: 267 YSOs

Nature of point sources

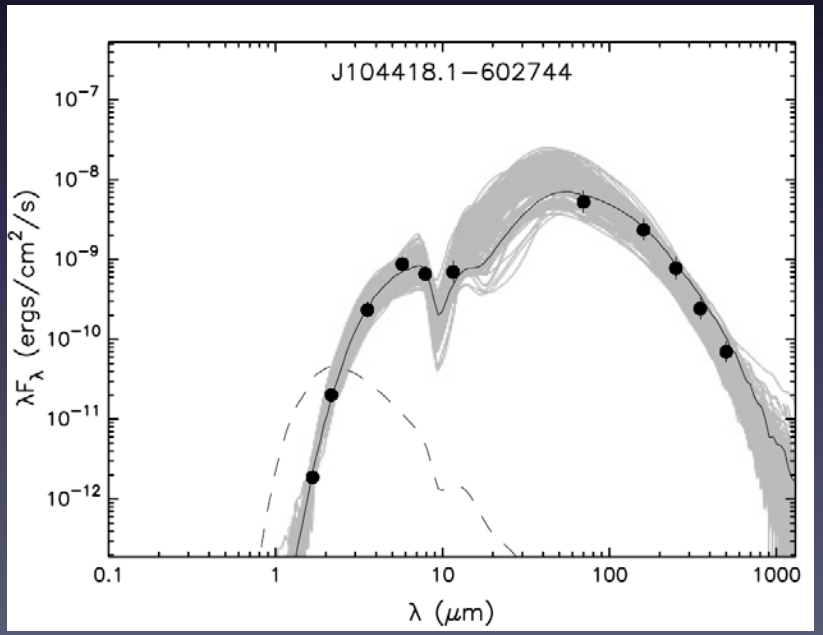
- Pre-stellar cores
- Embedded protostars
- Detection limit: $1M_{sun}$

Contaminations:

- **Evolved stars**
- **Extragalactic**

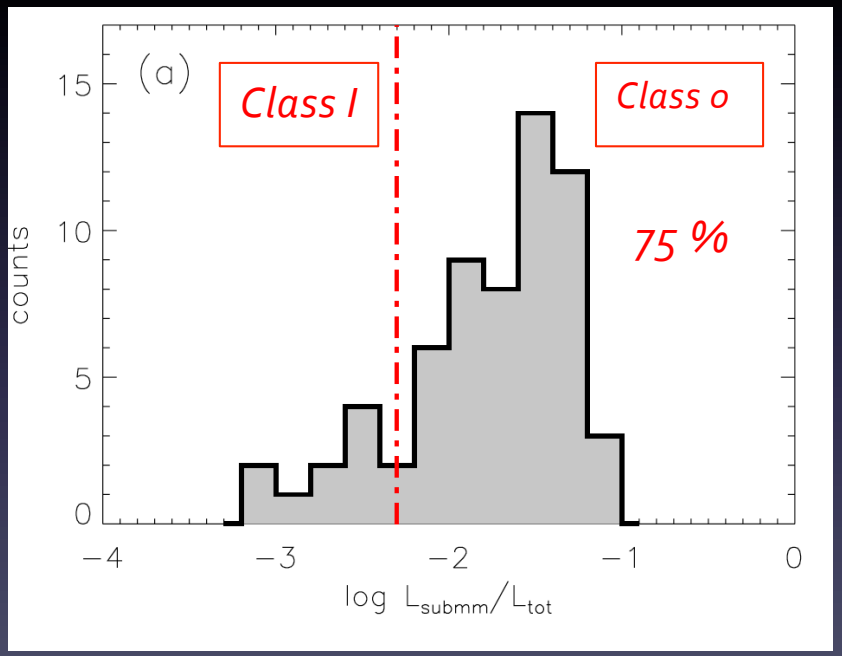
Analysis via Robitaille models for:

- Total luminosity
- Stellar mass
- Mass of circumstellar disk
- Mass of circumstellar envelope

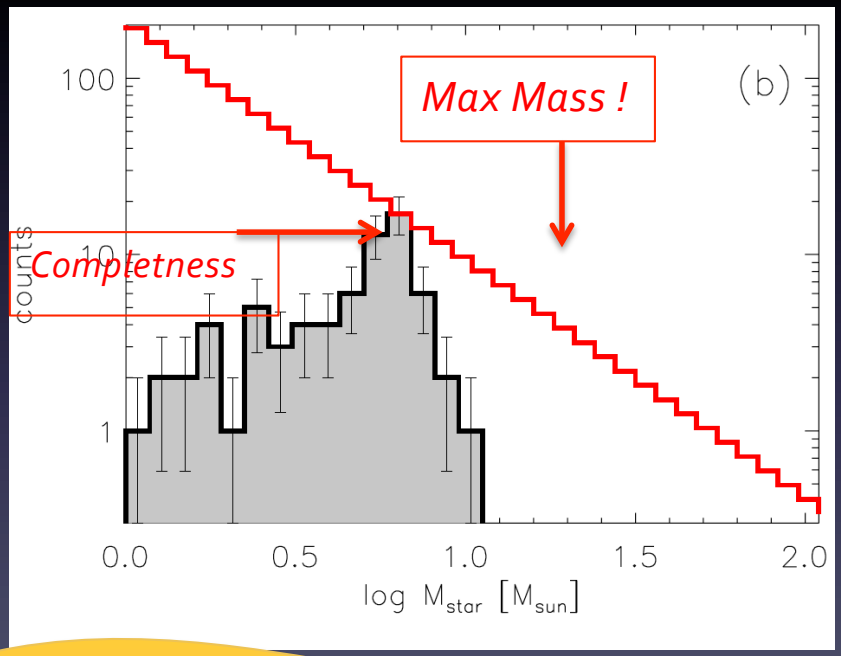


Results of point source analysis:

Class I & Classo



Stellar Mass



ONLY low- and intermediate mass YSOs!

Star Formation rate in Carina

- Herschel Completeness+ extrapolating down to 0.1M_{sun}:

⇨ 0.029 ★/yr ⇨ 0.017 M_{sun}/yr

Cloud structure analysis

- Nebula -> optically thin from 70 to 500 μm:
- SED fit px by px

  free parameters: *T* & Σ [g/cm²]

$$N_H = \frac{2\Sigma R}{m_H \mu_{H_2}}$$

UV flux map G_0

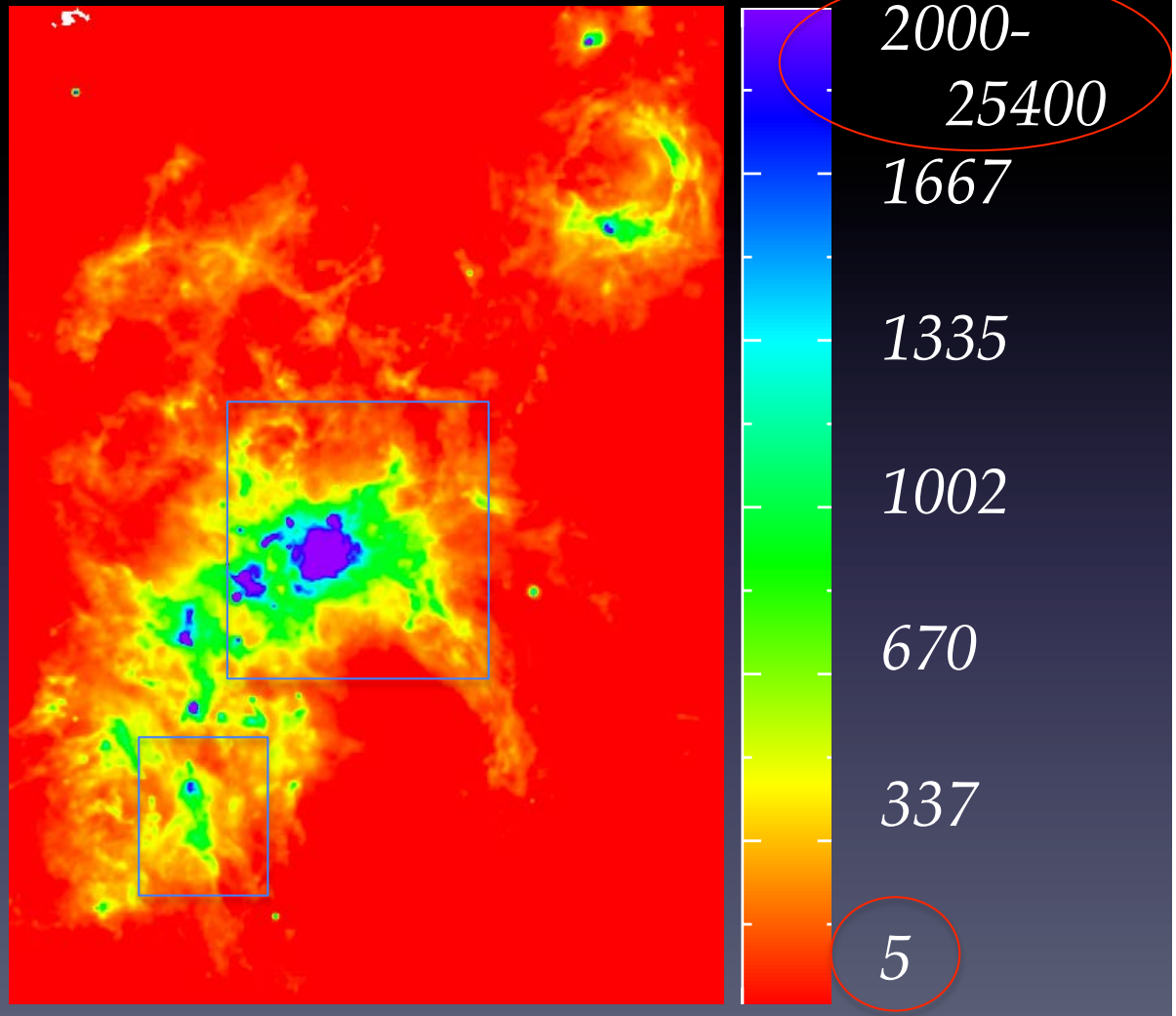
$$\frac{4\pi I_{FIR}}{1.6\cdot 10^{-3} ergcm^{-2}s^{-1}}$$

I_{FIR} = 60–200 μm

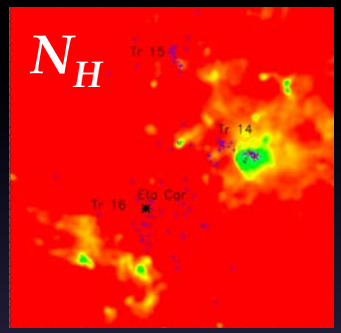
FIR intensity

Smith et al. (2006):

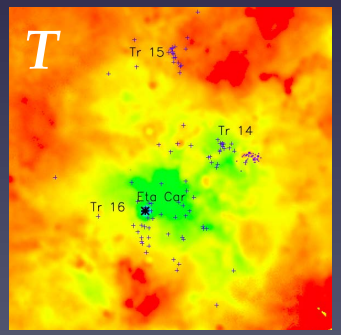
UV flux from the stars



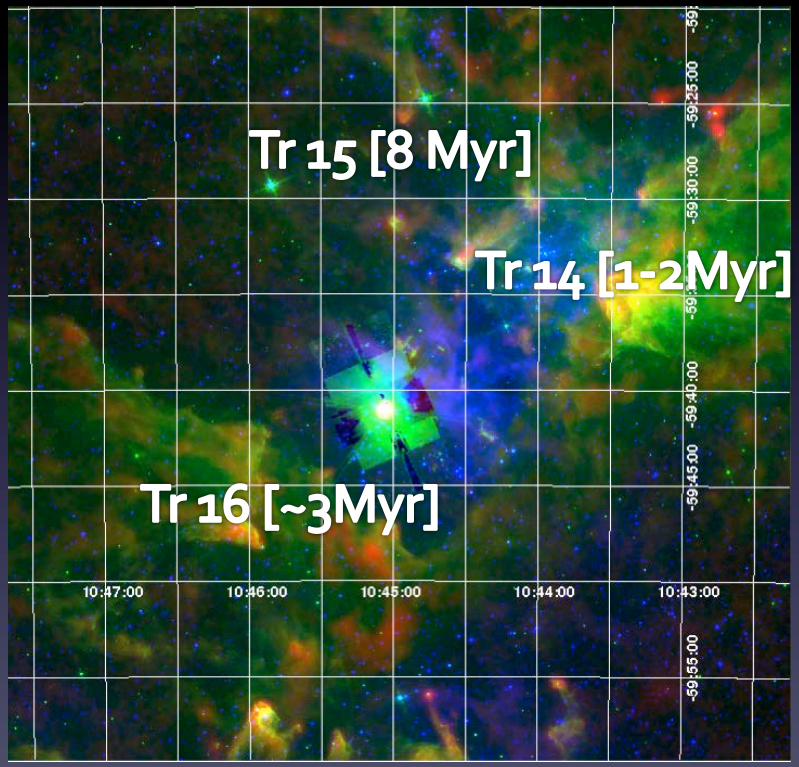
Central region around η Car



$1.0\text{-}4.9 \times 10^{23}$
8.5×10^{21}
7.0×10^{21}
5.4×10^{21}
3.9×10^{21}
2.4×10^{21}
9.0×10^{20}



60.0
53.7
47.3
41.0
34.7
28.3
22.0

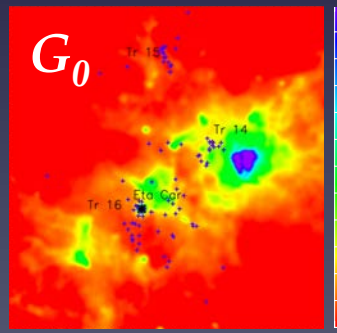


23pc x 26pc

Spitzer 3.6 μm

Herschel 70 μm

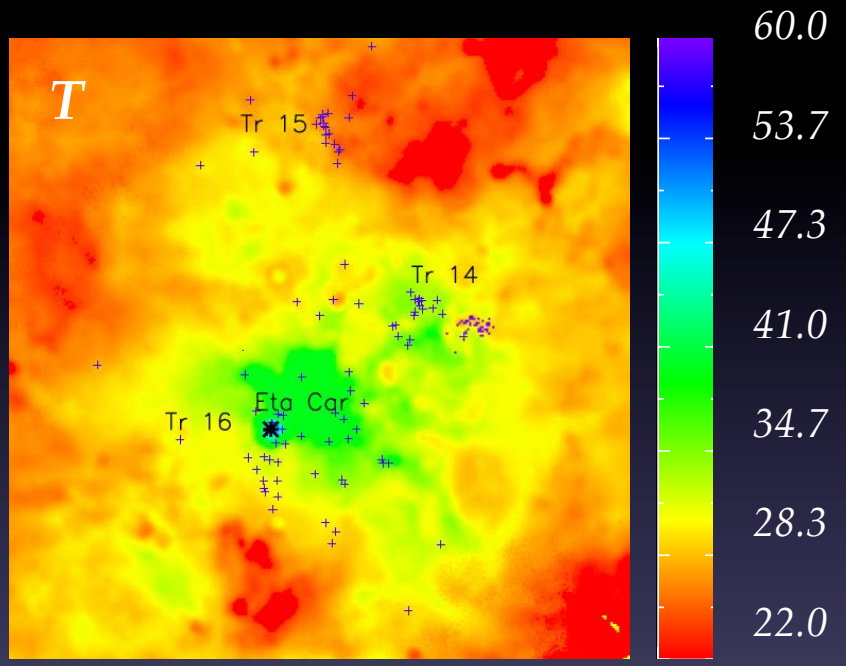
APEX 870 μm



6000-25400
5009
4018
3026
2035
1044
53

Temperature of the clouds

- Tr 14: 1-2 Myr
- Tr 16: 3 Myr
- Tr 15: 8 Myr



Cloud T ⟷ number of high-mass stars in the cluster!

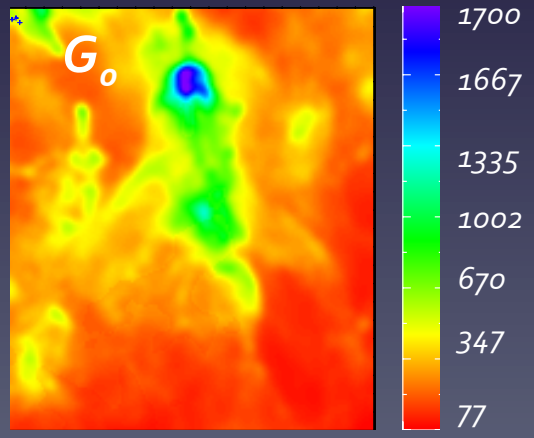
Young stars in the pillars

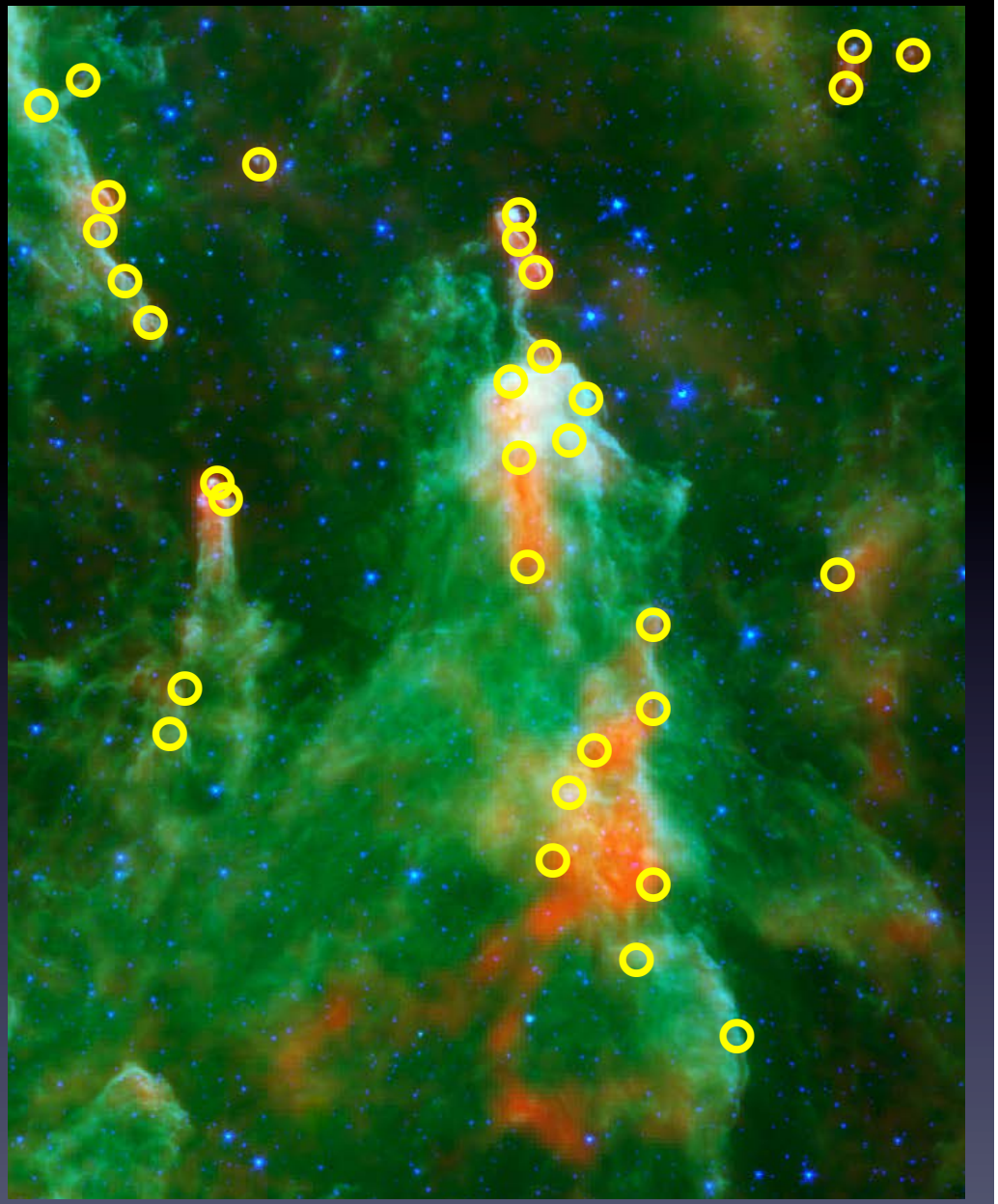
Spitzer
3.6 μm

Herschel
70 μm

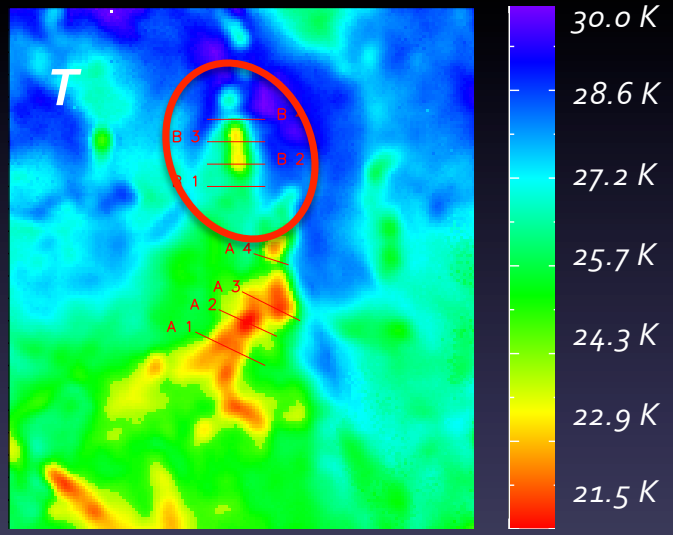
APEX
870 μm

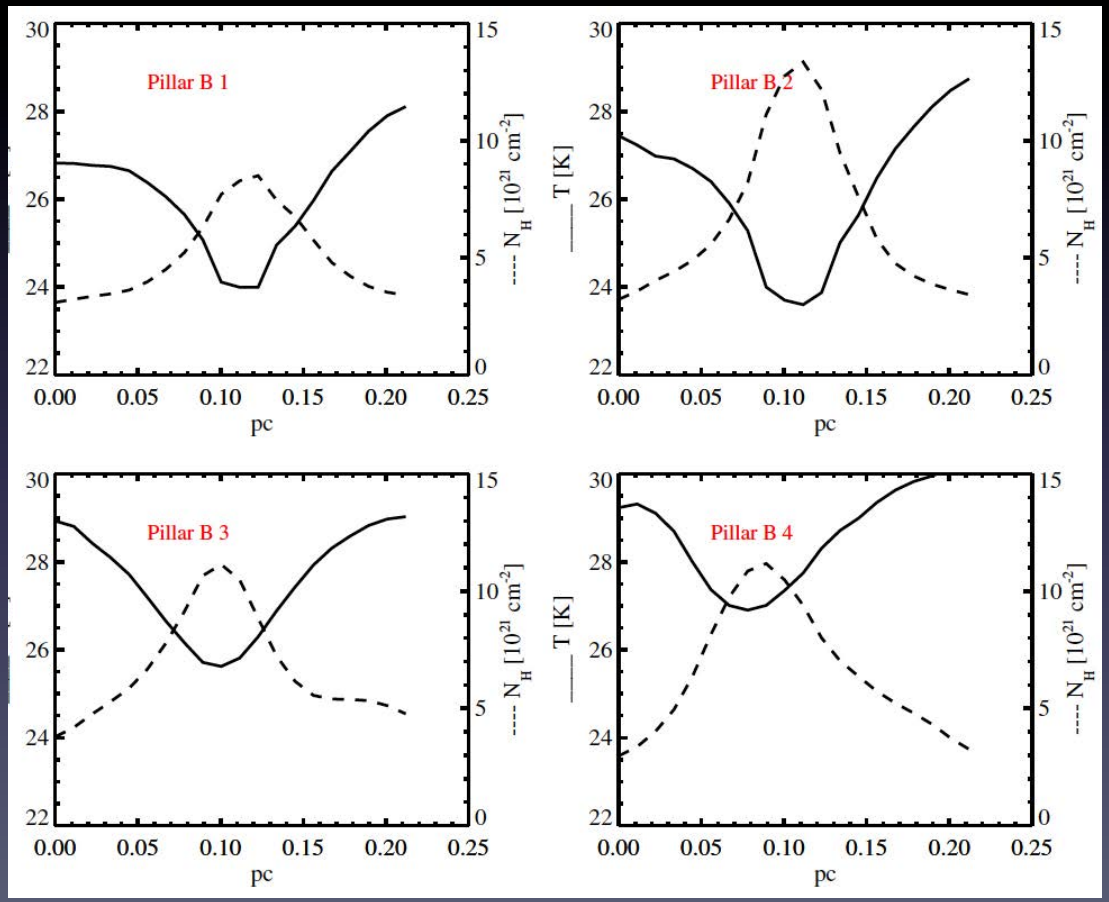
Herschel detected protostars





Temperature & density of the southern pillars





Molecular Cloud Mass – Star formation Rate

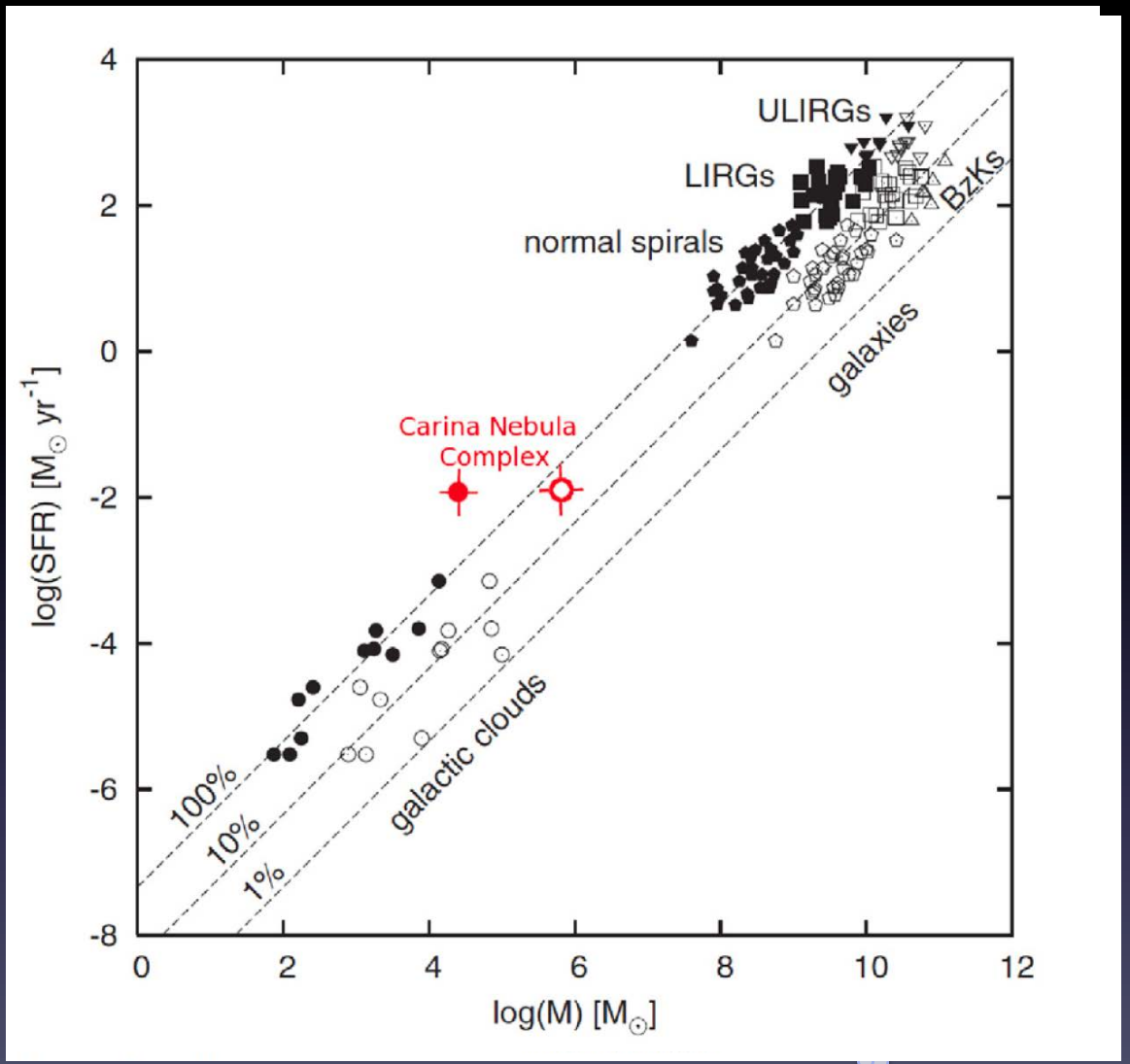
Lada et al.2012:

SFR ~ 4.6 x 10^{-8} M_G [M_{sun} yr^{-1}]

M_G = molecular mass measured at a particular extinction threshold

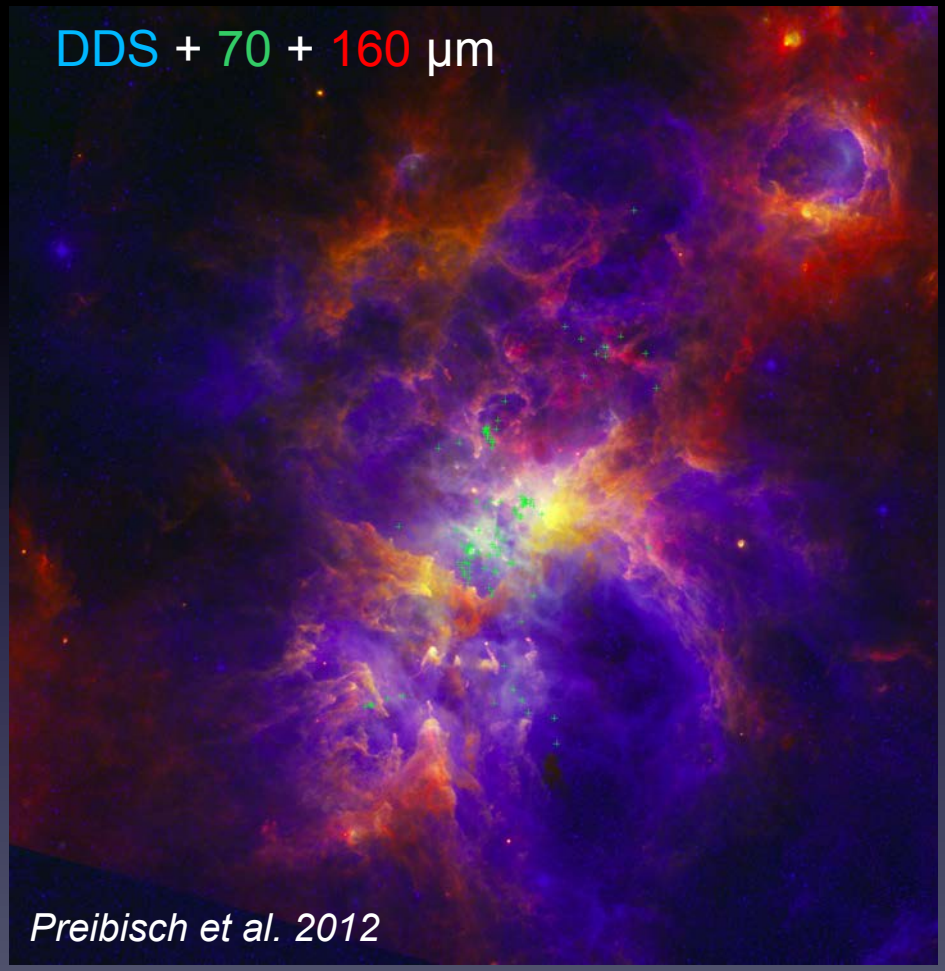
A_K > 0.1 mag: M_{CNC}: 610 000 Msun

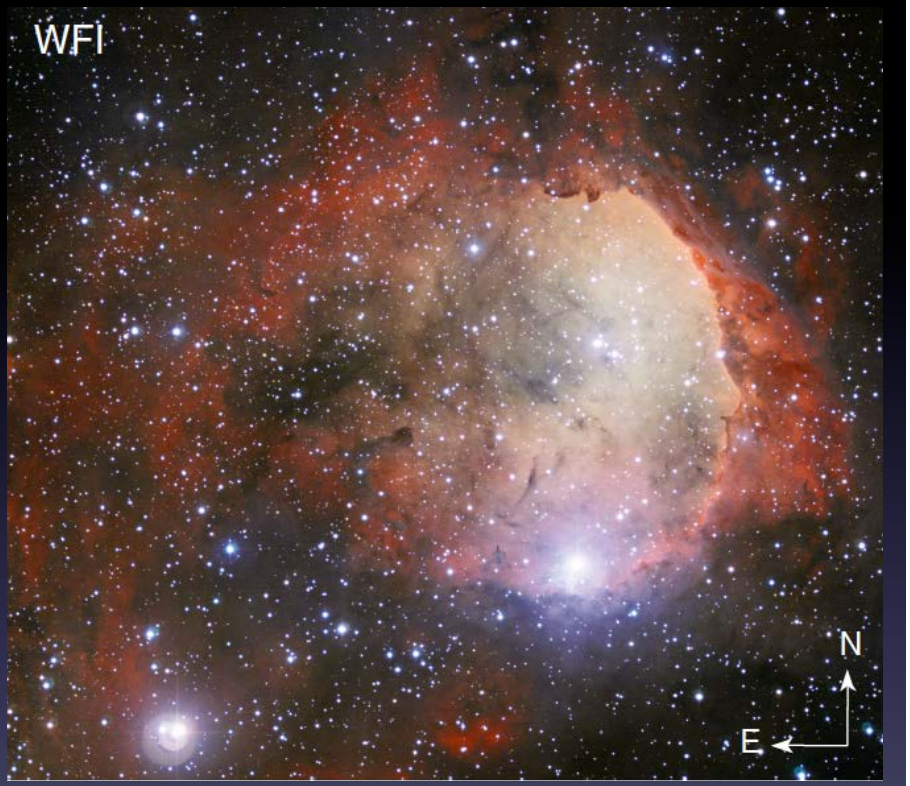
A_K > 0.8 mag : M_{CNC}: 23 000 Msun



The CNC is a `bridge' between local and extragalactic star formation!

Gum 31

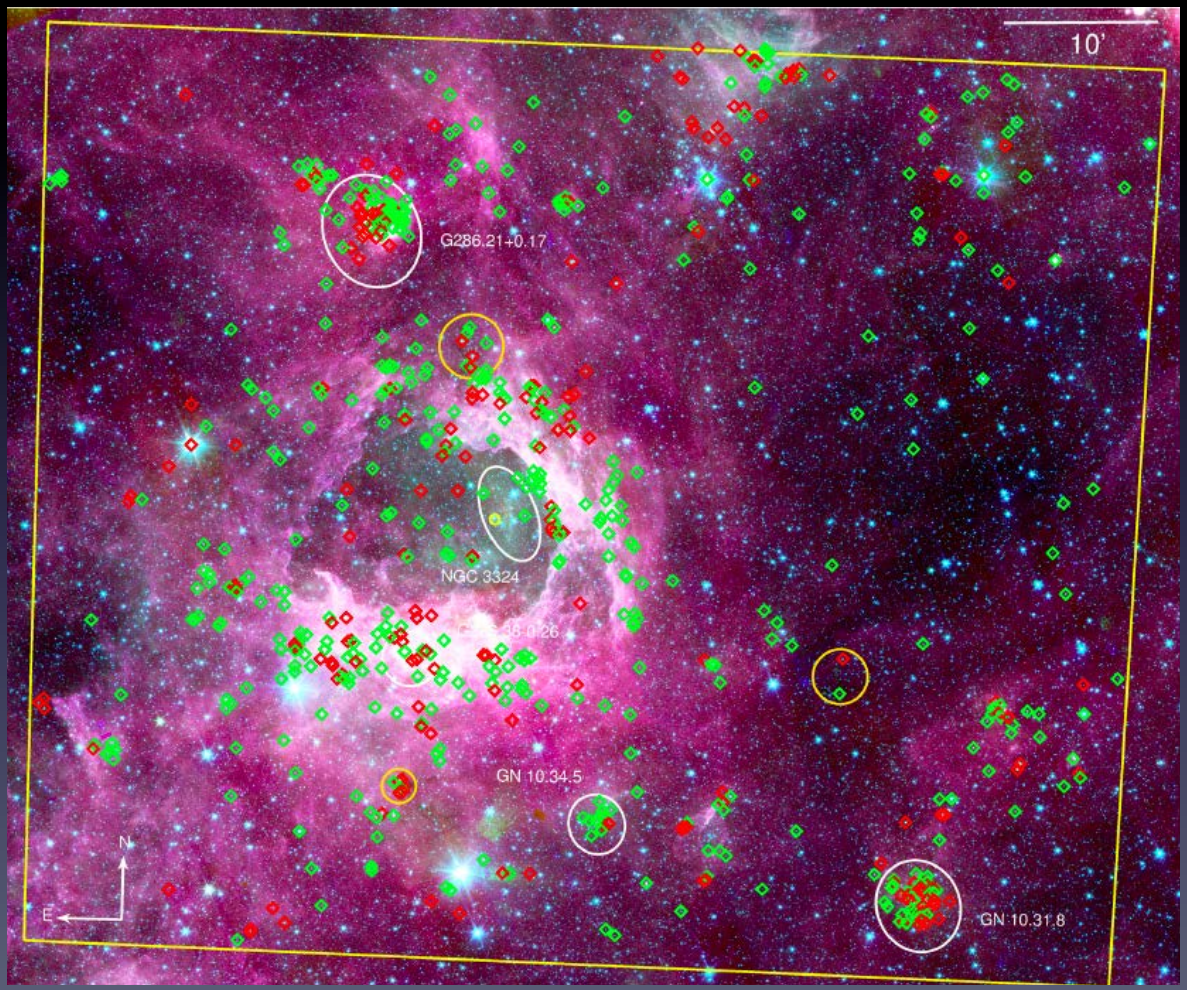




Wide Field Imager:
V Band
OIII 501 nm
Hα

Young stars in Gum 31

- Class I
- Class II



Spitzer/IRAC 3.6 μ m

Spitzer/IRAC 4.5 μ m

Spitzer/IRAC 8.0 μ m

Ohlendorf+ 2013, A&A, 552, 14

Take home messages

- ✓ Disk dissipation faster in high-mass star forming regions
- ✓ The CNC as a bridge between local and extragalactic star formation
- ✓ Evidence of triggering of star formation

Thanks for your attention!