The Perseus star-forming region before and after Herschel

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Outline

- Core mass function (CMF)
  - what was known before *Herschel*
  - importance of PACS and SPIRE
  - the Herschel-derived CMF

- Welcome in the realm of First Hydrostatic Core (FHSC)

Nomenclature

Core: a local overdensity of gas and dust embedded in the cloud diffuse medium

Starless core: no compact object inside

Bound starless (prestellar) core: internal gravitation stronger than thermal/magnetic pressure → collapsing to form a star

Unbound starless core: internal gravitation not enough to collapse → transient structure

Protostellar core: core with a compact object (newly formed star) inside

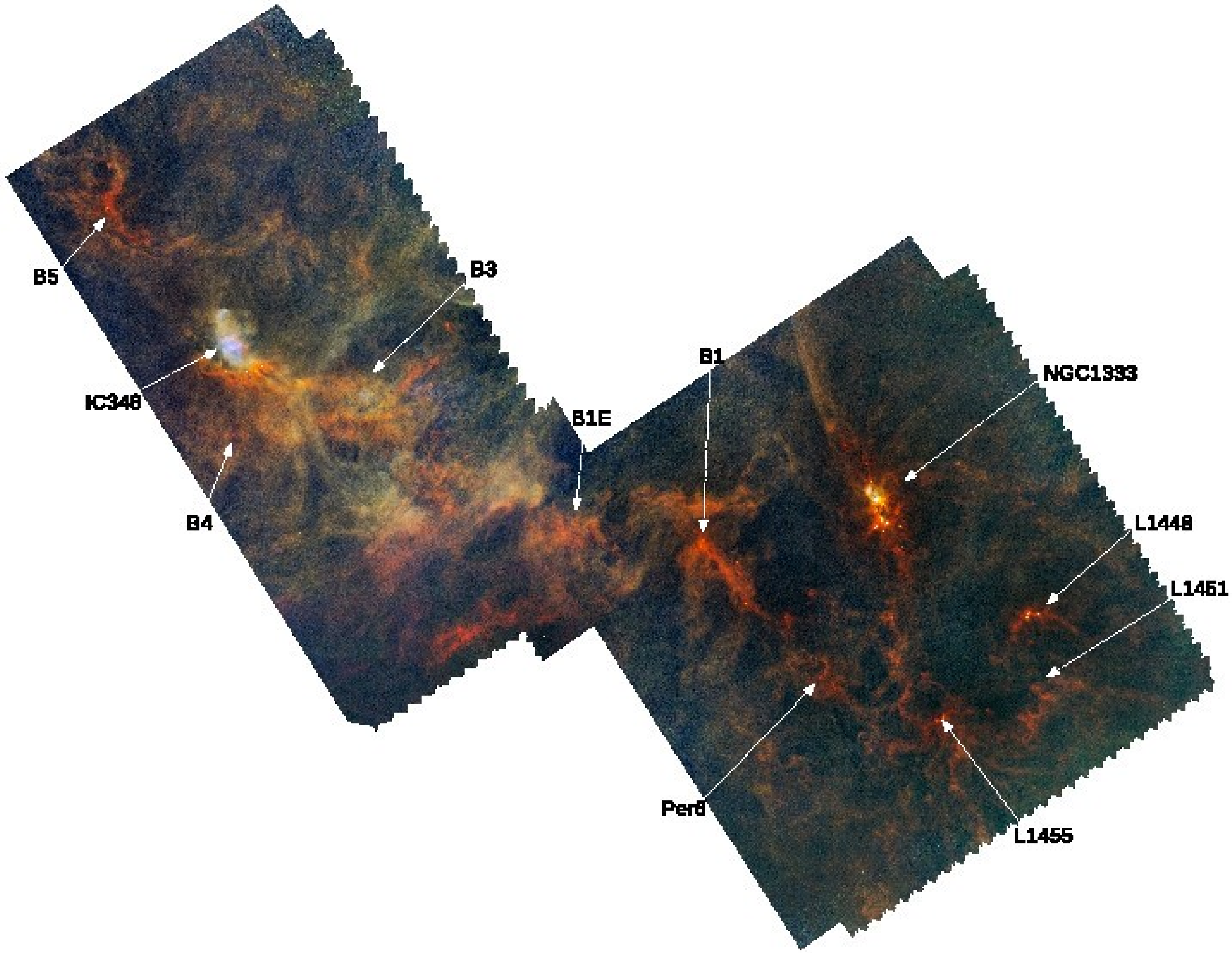
Core Mass Function

CMF: number of (prestellar) cores per unit mass

Related to the Initial Mass Function for field stars

CMFs in different star-forming regions appear similar each other and have same shape of IMF for field stars → **one common large-scale mechanism** (e.g., turbulence) drives star formation

Perseus star-forming region



Distance: ~300 pc with West side closer and East side farther

Many active sites of star formation

Different ages: IC348 older, B1E possibly starting to form stars
(Sadavoy et al. 2012)

CFM in Perseus: 2006 (i)

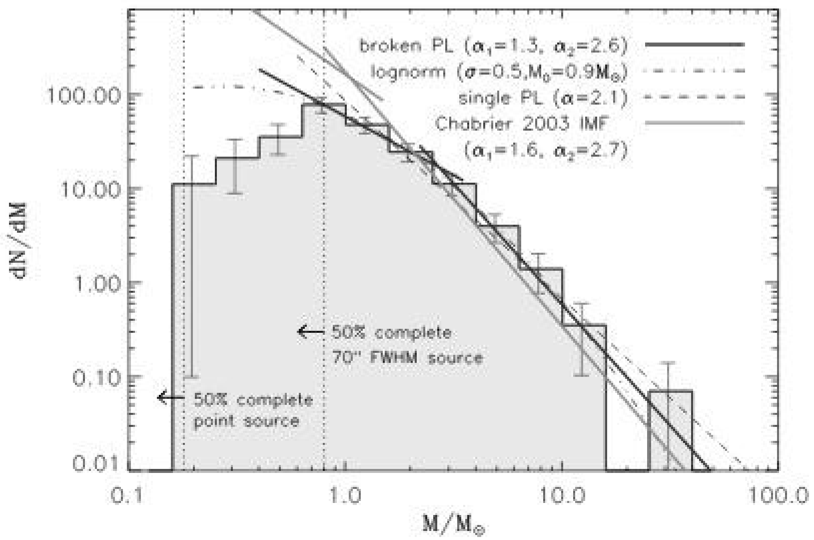
Previous survey of cores in Perseus: Enoch et al. (2006) with BOLOCAM at 1.1 mm

Dusty envelopes are optically thin

$$M = \frac{d^2 S_\nu}{B_\nu(T_D)\kappa_\nu},$$

One only S_ν → assumption on T_D

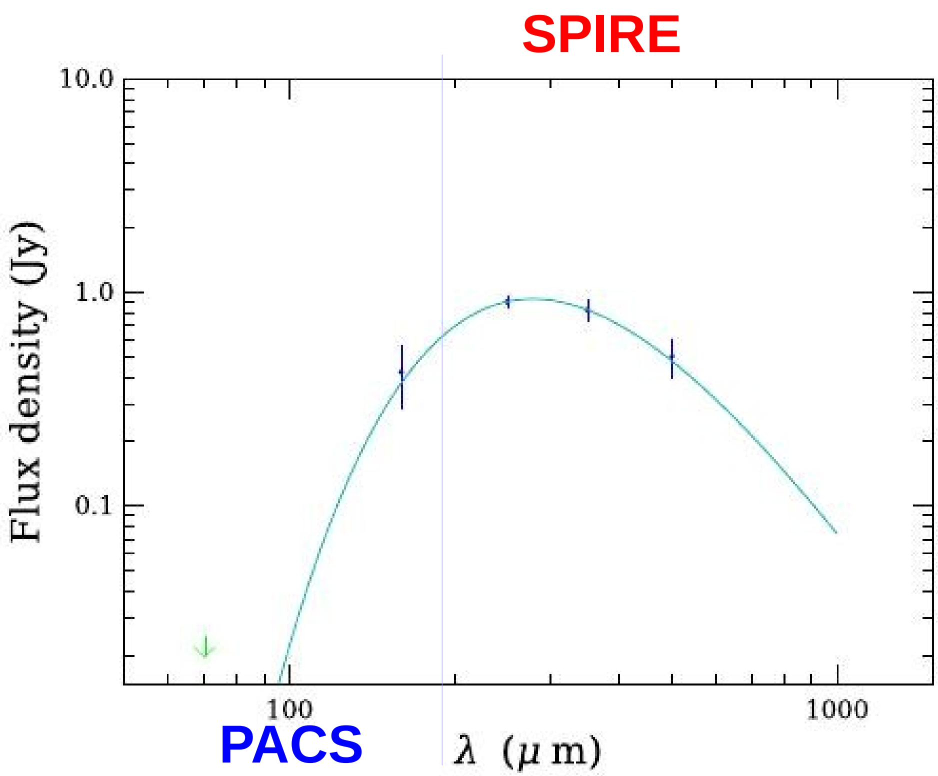
CFM in Perseus: 2006 (ii)



Same *T* for all sources
No distinction between bound and unbound cores
No information on evolutionary status

High-mass tail: two power laws with α=1.3 and 2.6; or one power law (worse fit) wih α=2.1

The importance of being *Herschel*



Pezzuto et al., to be submitted

Physical properties of the source

$T = 10.41 \pm 0.10$ K

$M = (2.65 \pm 0.16) \cdot 10^{-1}\, M_\odot$

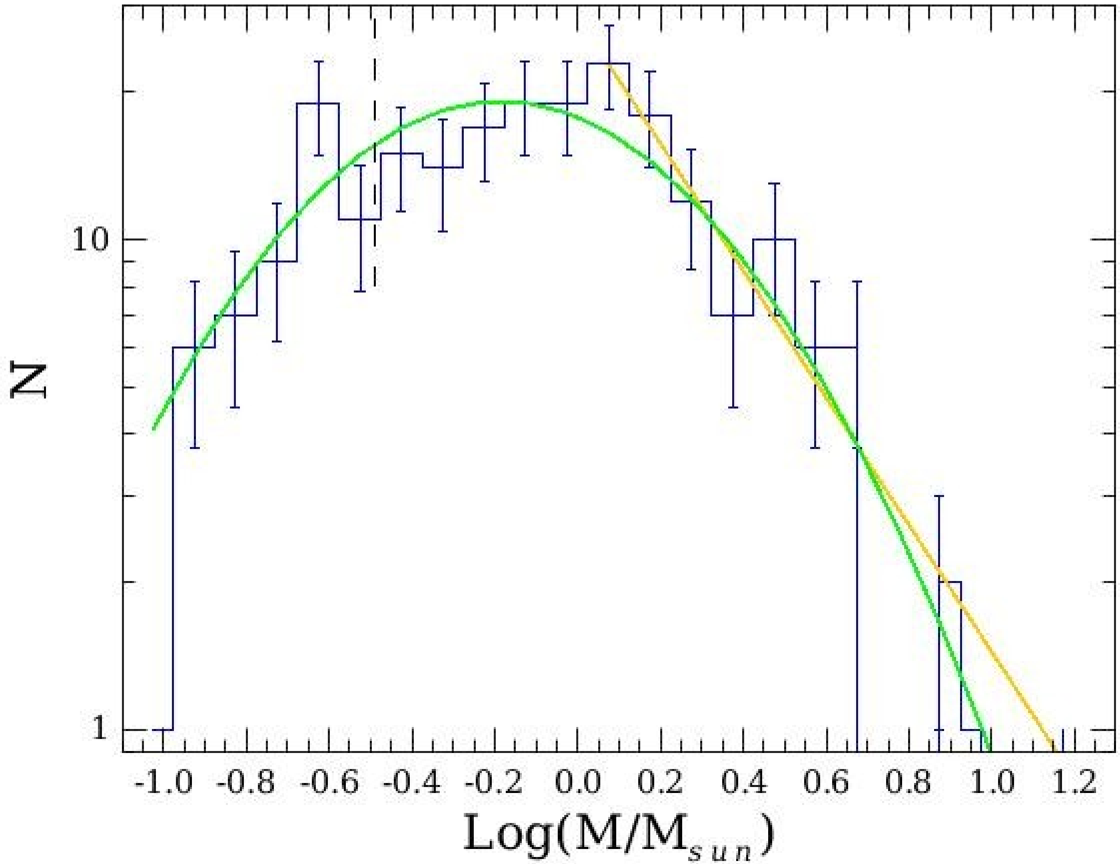
$$R = \begin{cases} 21''.4 \\ 11''.3 \\ 1.64 \cdot 10^{-2}\ \text{pc} \end{cases}$$

$M_{BE} = (2.80) \cdot 10^{-1}\, M_\odot$

SPIRE: peak of SED → **Temperature**
PACS+SPIRE: shape → **Mass**
PACS: 70 μm detection → **Protostar**

} Stability → **bound/unbound core**

CFM in Perseus: 2019

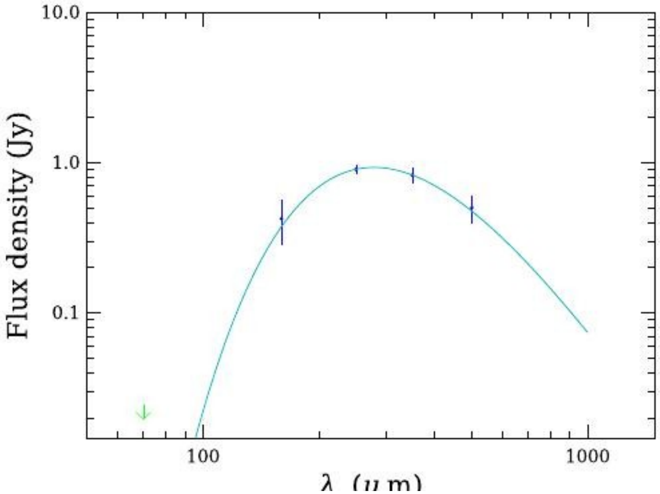


High-mass tail: one power law with α=2.3

Only prestellar cores

No protostars: three most massive cores in Enoch et al’s CFM detected at 70 µm → **protostars!**

FHSC (i)



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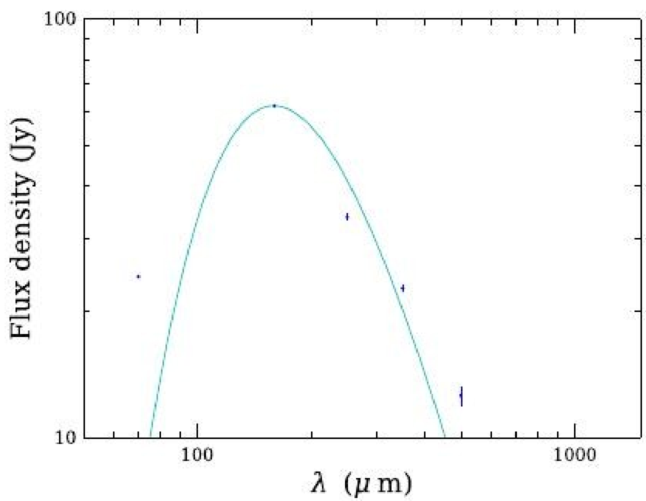


Physical properties of the source

$T = 18.14 \pm 0.09$ K

$M = 1.105^{+0.027}_{-0.026}\, M_\odot$

$$R = \begin{cases} 18''.6 \\ < 6''.1 \\ < 8.87 \cdot 10^{-3}\ \text{pc} \end{cases}$$

$M_{\rm BE} < (2.65) \cdot 10^{-1}\, M_\odot$

Prestellar

What in between?

Protostar

FHSC (ii)

First phase of collapse: whole condensation is optically thin → isothermal

Density gradually increases until central part becomes optically thick and reaches hydrostatic equilibrium: **a star is borne!**

Temperature increases and around 2000K H2 dissociates → opacity decreases, second collapse → Class 0

FHSC phase lasts few hundreds/thousands years, difficult to catch an object in this phase

A serendipitous discovery (i)

In September 2011 first Via Lactea conference was planned

Main topic on high-mass star formation: what to do with Perseus, a low-intermediate mass star-forming region?

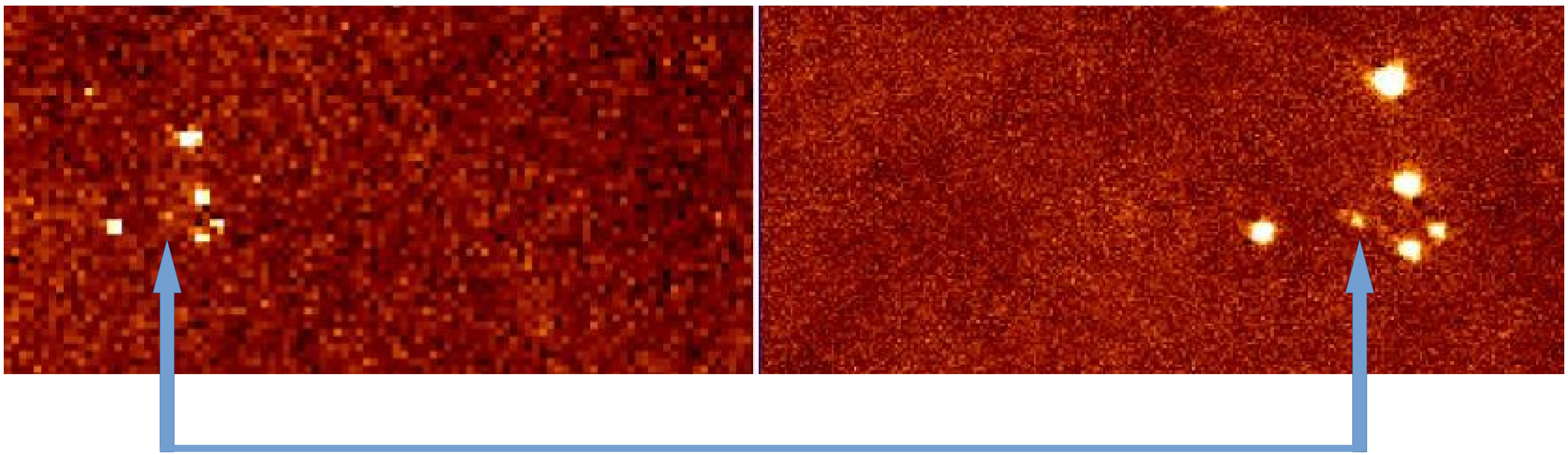
Idea: what happens if Perseus is put at 1kpc? How it appears due to the lack of spatial resolution?

The result of this simulation was presented as a poster "**The Perseus star forming region at 1 kpc distance: what we can learn for the distant high mass star forming clouds**" (Pezzuto et al. 2011)
This idea had two consequences:

- one student took his PhD at IAPS exploiting this idea: Baldeschi et al. 2017 a,b
- while preparing the poster one object appeared in the rebinned, and less noisy, map!

A serendipitous discovery (ii)

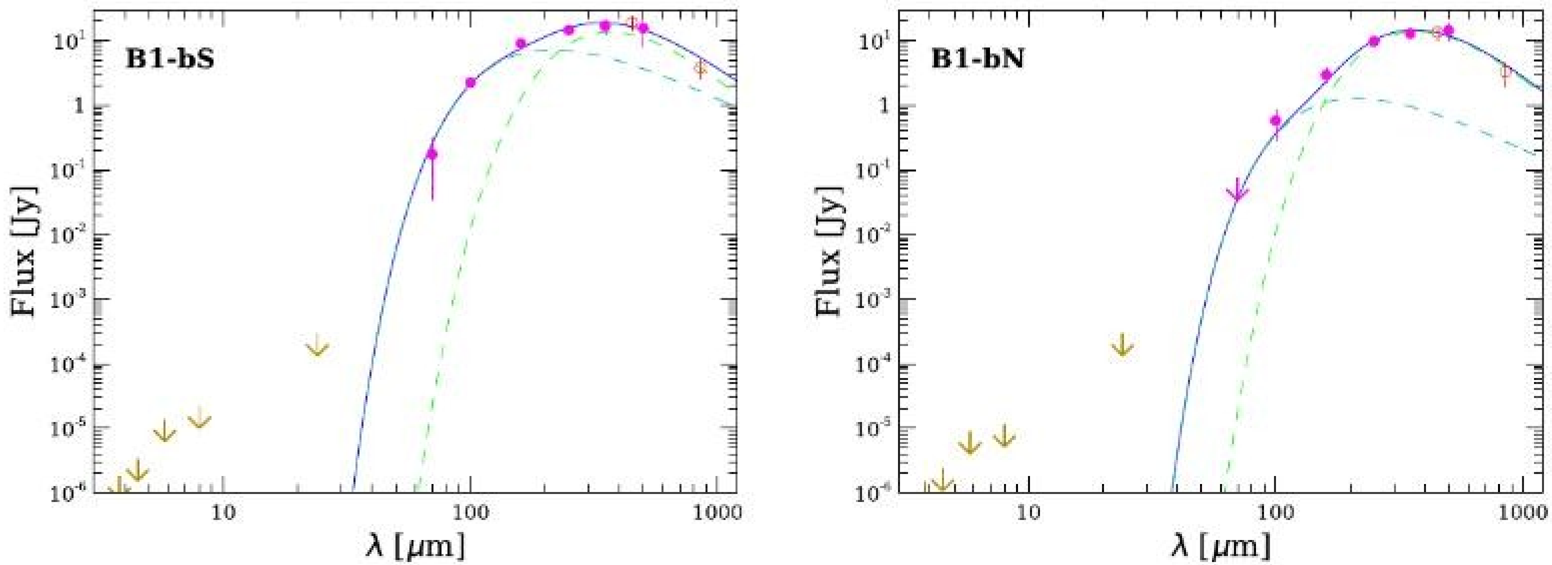
Original map | Rebinned map



This *nova stella* discovered in 1999 by Hirano at 3 mm and named **B1-bS**; few arcseconds to North is **B1-bN**, visible for λ≥100 μm
Both objects classified as Class 0 stars

B1-bS is the only source in our map visible at 70 μm and undetected by *Spitzer* at 24 μm

A serendipitous discovery (iii)



SED not compatible with modified blackbody, and undetected in near infrared → **FHSC candidates** (Pezzuto et al. 2012)

Few months after our work Huang & Hirano published a paper based on SMA observations in 2008 confirming young nature of these two objects

Few doubts today that B1-bN is a genuine FHSC; less clear for B1-bS, maybe a bit more evolved

24 May 2009 @ ESOC
PACS is switched on for the first time after launch

Thanks to the Herschel team

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and to the PACS ICC
♥