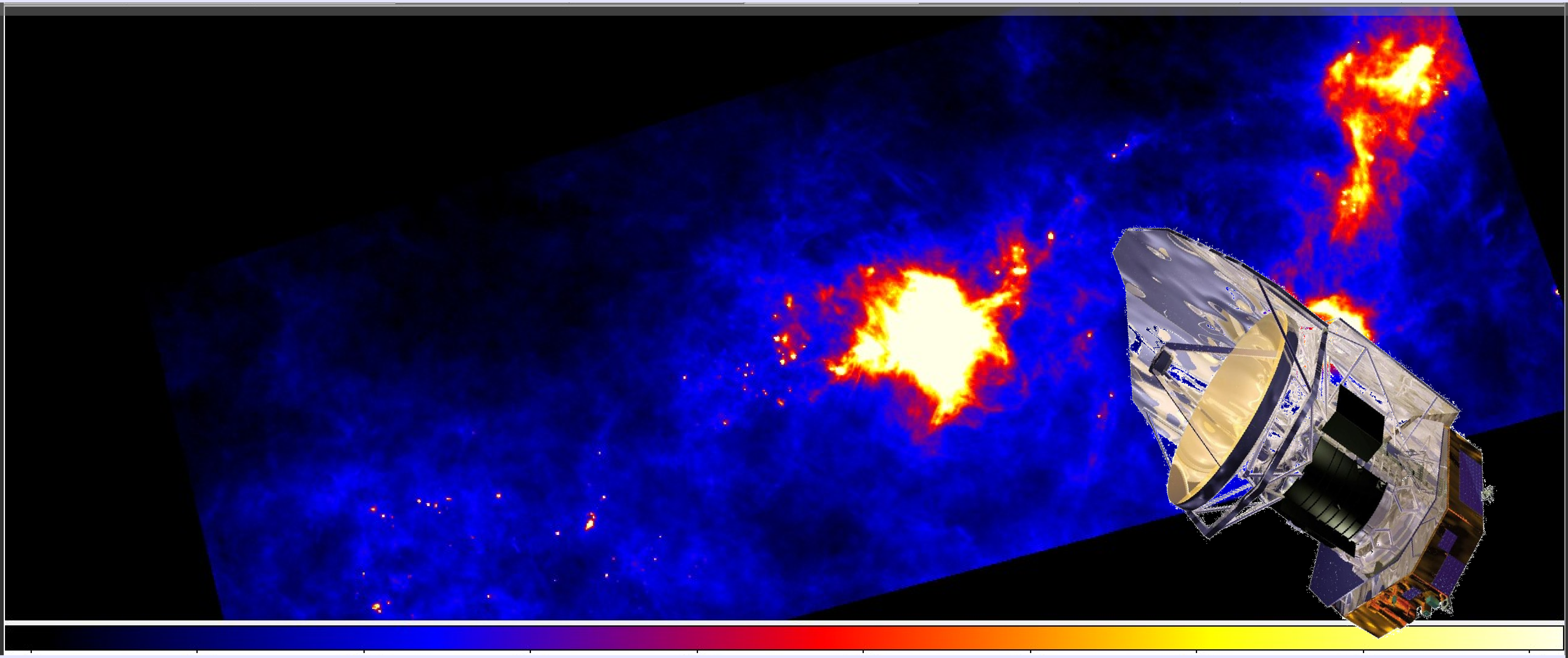
The Herschel view of the on-going star formation in the Vela-C molecular cloud



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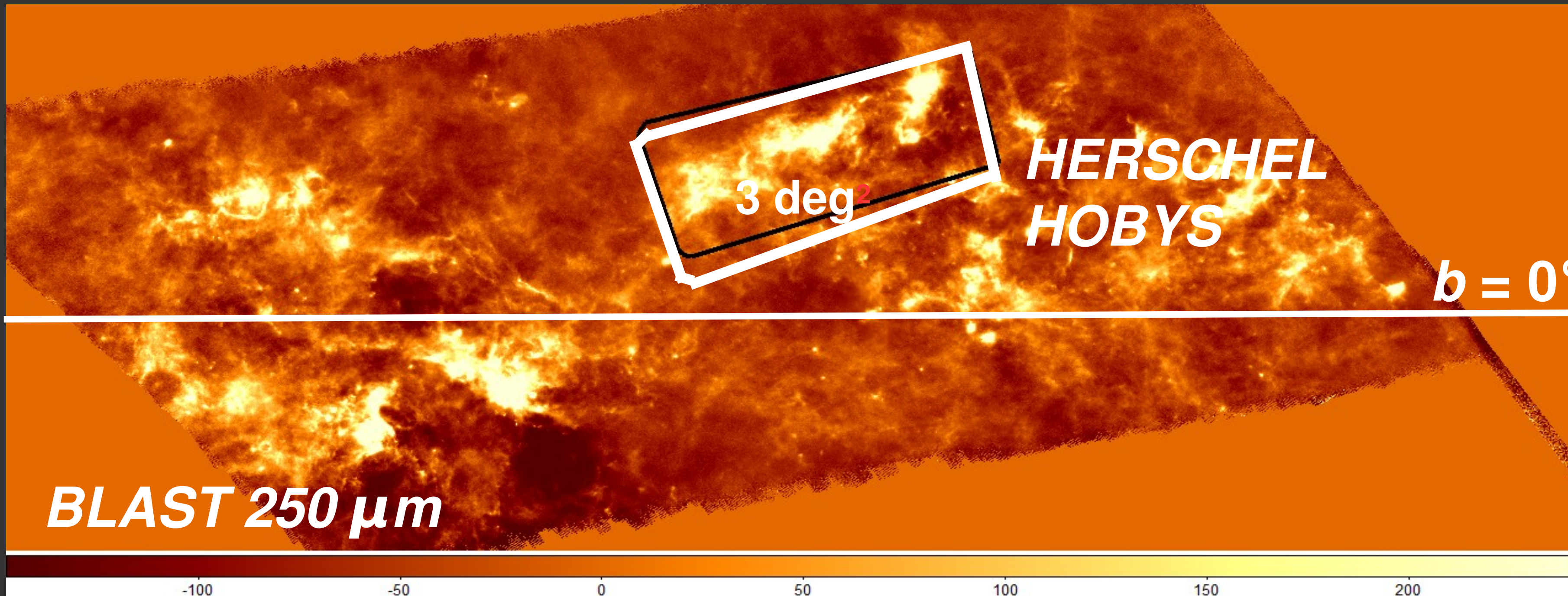
The Vela-C cloud



- it is the cloud "C" of the Vela Molecular Ridge (Murphy & May, 1991) , *l* = 263° - 265° , *b* = 0° - +2°

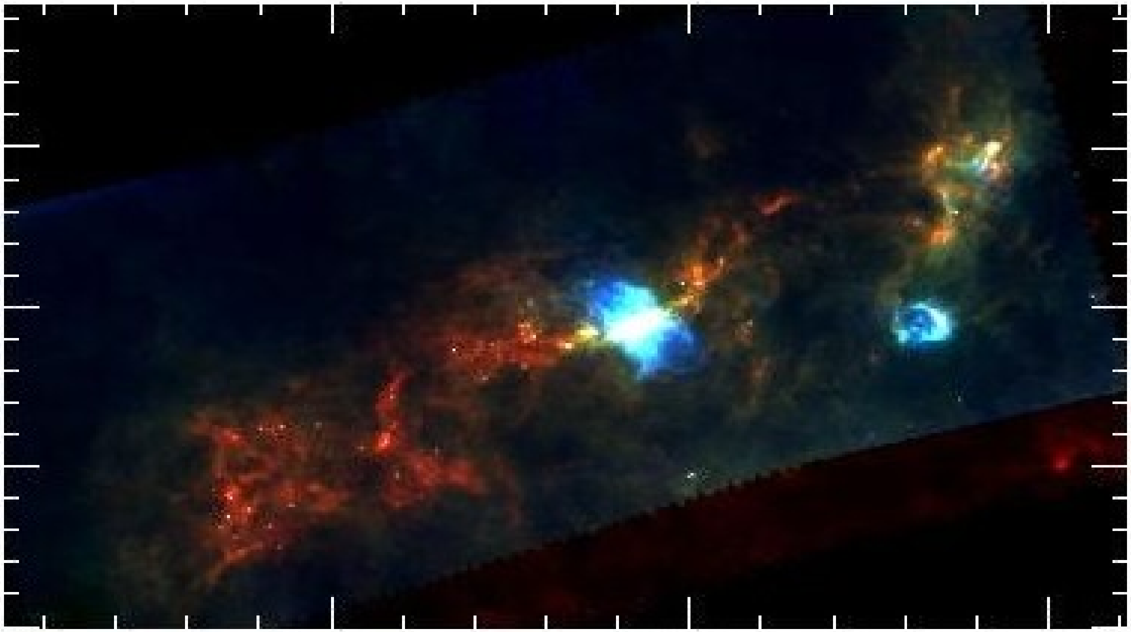
- distance = 700 ± 200 pc (Liseau et al. 1992)

- site of star formation on a wide range of masses (Massi et al. 2003; Baba et al. 2006)

Herschel observations

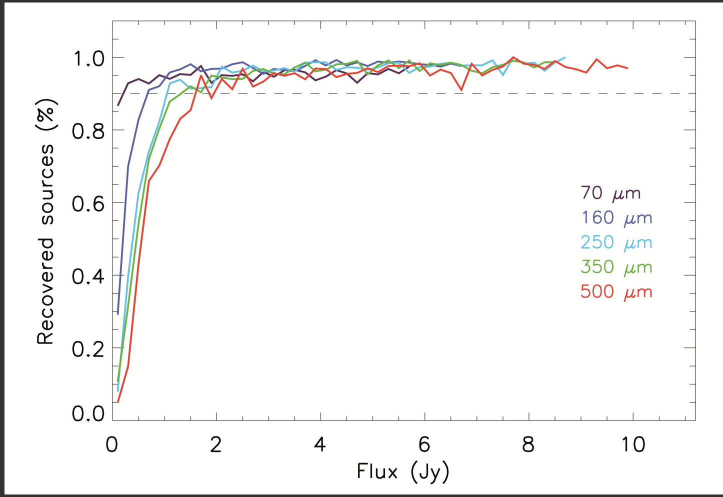
- Vela – C observed with *PACS* and *SPIRE* in parallel mode as part of the Herschel key-program *HOBYS* (Herschel imaging survey of OB Young Stellar OBjects

- Simultaneous photometry at five wavelengths between 70 μm and 500 μm



Giannini et al. 2012 A&A, 539, 156

Catalogue building



Band	N	Sens. limit (Jy)	90% Compl. limit (Jy)
All	1686		
70 μm	658	0.04	0.21
160 μm	871	0.09	0.67
250 μm	966	0.11	1.07 (BLAST : 17)
350 μm	697	0.33	1.32 (BLAST : 22)
500 μm	416	0.46	1.95

- *SPIRE* sensitivity ~ 20 times better than *BLAST*
- catalogue of 1686 sources (5σ)
- sources spatially associated to obtain a band merged catalogue
- peak of source number at 250 μm (loss of sensitivity at longer wavelengths)
- multiple associations at λ ≥ 160 μm

⇒ 268 objects selected for SED fitting

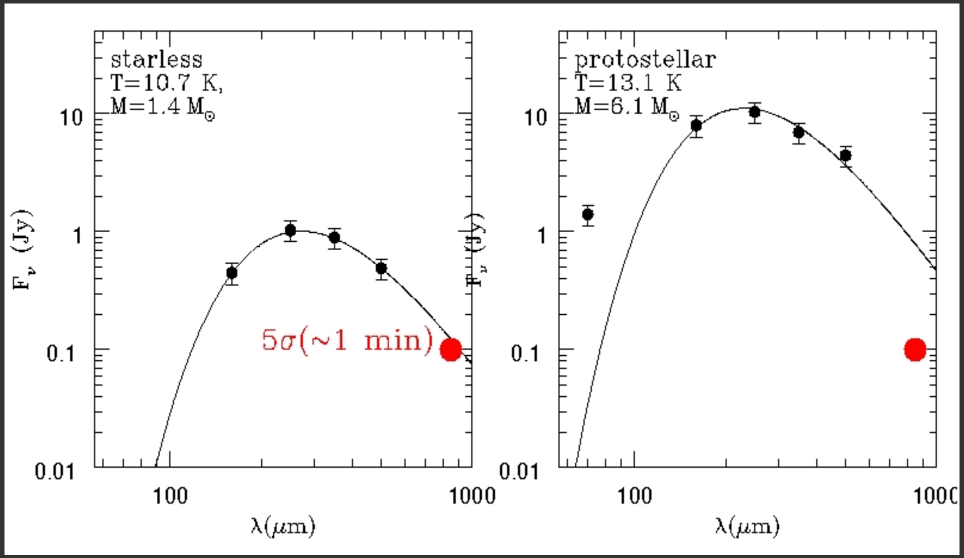
- Herschel HPBW (500 μm) = 35.7”, ALMA (870 μm) : FoV = 18”, ang.res. : 0.45”-1.55”
- ALMA sensitivity at 870 μm : ~ 0.1 Jy (5σ , 1 min)

SED fitting

- SED fitted with a modified black-body function
- Grid of models : 8 K ≤ T ≤ 40 K; 10 μm ≤ λ_0 ≤ 40 μm, nfor $\lambda > \lambda_0$
- the emission is optically thin
- Derived parameters: T,M,d, L

STARLESS:
- sources not detected at 70 μm

PROTOSTELLAR:
- sources with a 70 μm flux above the best fit by more than 3 σ or
- detected at λ < 70 μm by other surveys

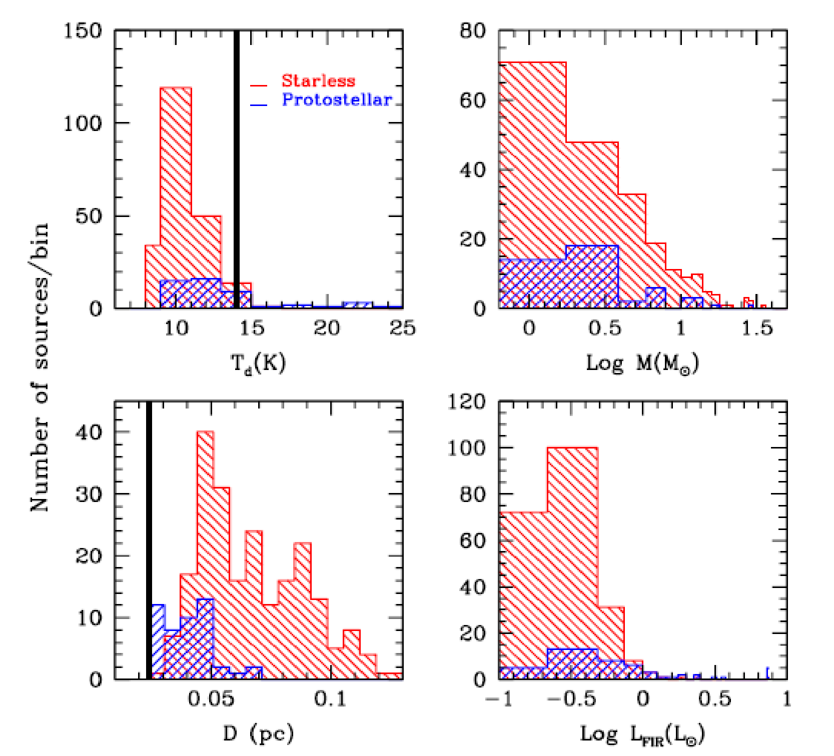


⇒ 218 starless sources
⇒ 48 protostellar sources

Physical parameters

Parameter	Starless (218)			Protostellar (48)		
	median	average	min-max	median	average	min-max
M ($M_\odot$)	3.3	5.5	0.13-55.8	2.7	4.8	0.15-29.1
T_d (K)	10.0	10.3	8.0-15.2	11.4	12.8	9.0-24.2
D (pc)	0.064	0.067	0.025-0.13	0.040	0.040	0.025-0.07
L_{FIR} ($L_\odot$)	0.17	0.22	0.04-4.8	0.6	8.0	0.08-138

RED: starless
BLUE : protostellar



- **Sizes from 0.025 pc to 0.13 pc: mixture of cores and clumps**
- **On average, protostellar sources are more compact and warmer than the starless ones. Both colder than interstellar medium (T~ 14 K, Hill et al. 2011)**
- **Wide range of masses; 8 sources have M > 20 $M_\odot$**

Prestellar sources

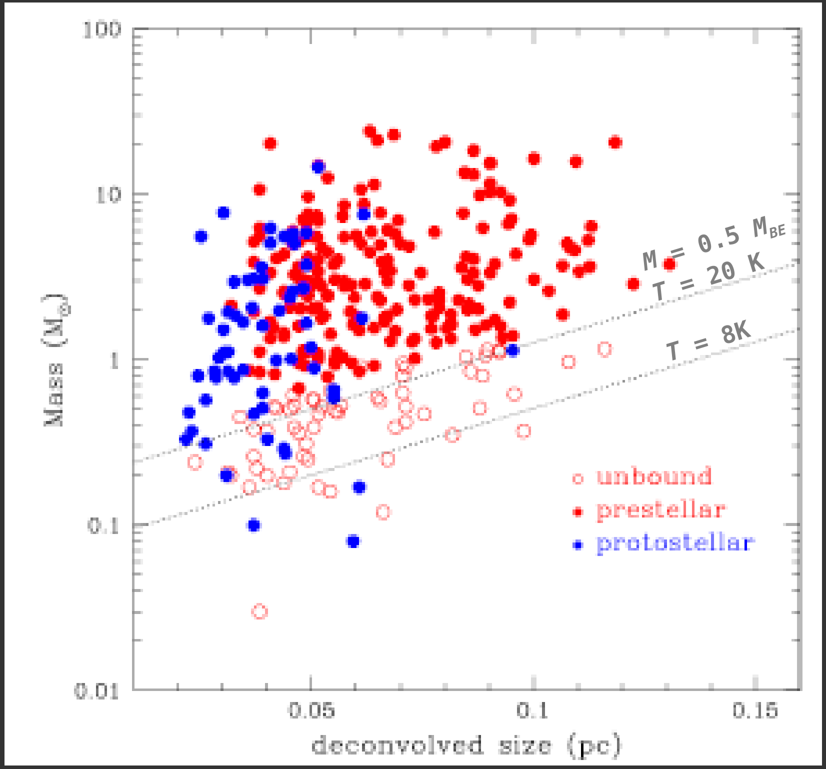
- To determine if a starless core is gravitationally bound (then pre-stellar), a comparison of its mass with the corresponding Bonnor- Ebert mass has been performed ($M_{pre} > 0.5M_{BE}$)

- Effects of turbulence and magnetic field discarded

- 206 out of 218 (~94%) starless cores have been recognized as pre-stellar, (69% in the Aquila Rift)

- in a mass vs size plot, all the unbound sources are close to the mass detection limit (~0.05 $M_{\odot}$)

⇒need of much higher sensitivity to effectively probe the ratio of the bound/unbound sources

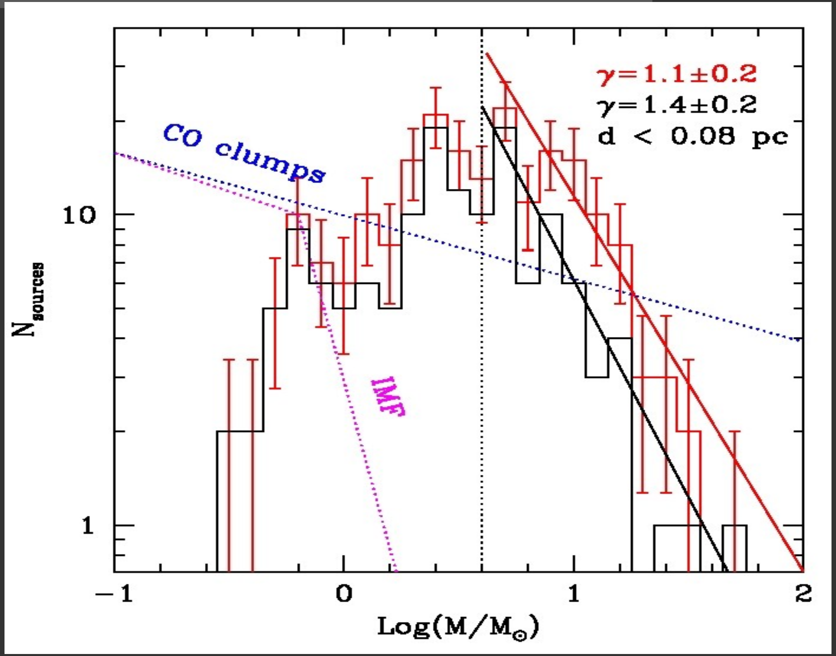


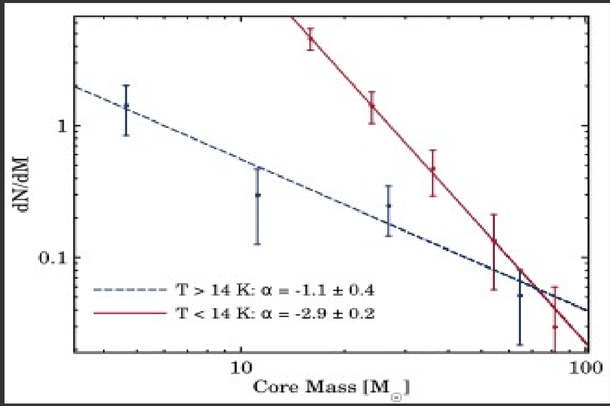
The Source Mass Distribution

- The prestellar source mass distribution was fitted as N(log M)$\propto$ $M^{-\gamma}$

- Fit from the completeness mass limit of $4M_{\odot} \Rightarrow \gamma = 1.1\pm0.2$

- With BLAST : $\gamma = 1.9\pm0.2$ for M > 14 $M_{\odot}$ (Netterfield et al. 2009)





- This value is intermediate between $\gamma = 0.7$ of large CO clumps (Kramer et al. 1998) and $\gamma = 1.3$ of the IMF ... but if we consider only sources with d<0.08pc $\Rightarrow \gamma = 1.4$

- Possible flattening at masses close to the completeness limit?

$\Rightarrow$ at the Vela-C distance the Herschel spatial resolution is not sufficient to probe cloud cores

First Conclusions

- The Herschel-HOBYS survey of Vela-C in the FIR has revealed a numerous population of pre- and proto-stellar cores ....

.....but

- need of higher sensitivity to :
  - probe the faintest and much numerous population
  - understand whether or not the very high percentage of bound cores is real or not
  - probe the mass distribution up to subsolar masses

- need of higher spatial resolution to :
  - resolve the high degree of multiplicity in the largest Herschel beams
  - probe the core mass distribution without contamination of larger structures

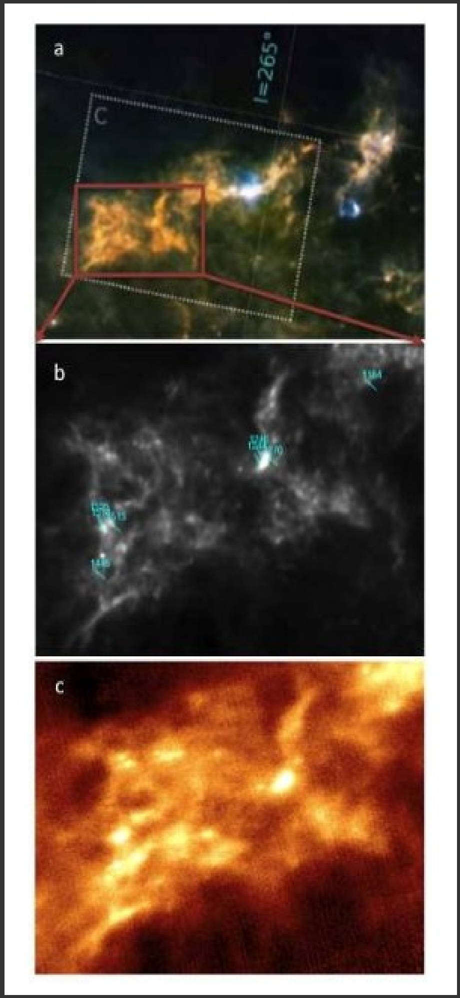
Joint ALMA and BLAST-Pol

Collaboration with Northwestern University, Osservatorio di Arcetri

- Aim: to study the role of the magnetic field in the gravitational collapse through similarities between cloud magnetic fields (30000 AU) and infall morphologies (1000 AU).

- In a magnetically dominated scenario a flattened inner core forms with its symmetric axis parallel to the local B-field.

- The 'Axehead' in Vela-C is the ideal target since it was observed with BLAST-Pol at 250 μm (50 hr, data under reduction)



Project feasibility

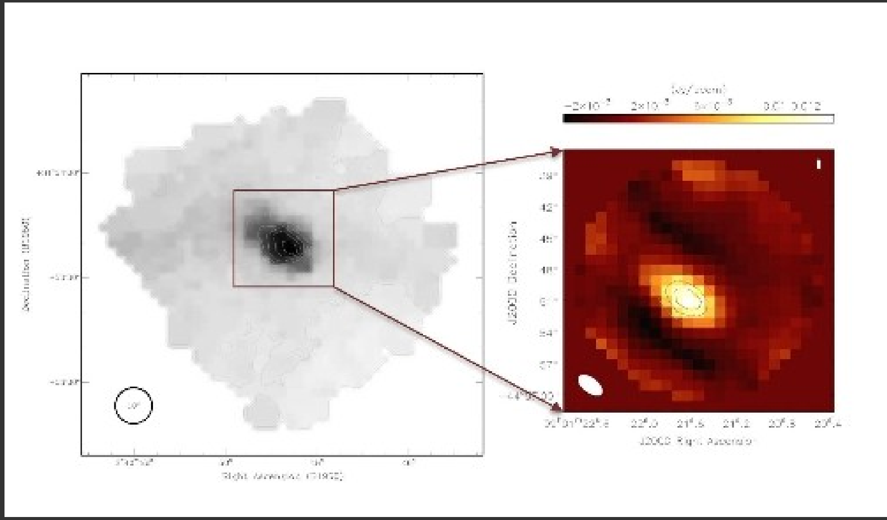
- **Method: sample of Herschel selected prestellar and protostellar cores : sources in different evolutionary stages selected based on the 250 μ m/mid-IR flux (Akari, MSX, Wise) (e.g. F(250 μm /F(9 μm) > 100 ⇒ Class 0 protostar, Enoch et al. 2009)**

- **Direction of the B-field from BLAST-Pol**

- **Core morphology from ALMA observations at 345 GHZ**

- ***CASA* simulation of a Class 0:**

- left: **original 350 μm data (from SHARC-II of the B-field/SHARP at CSO);**
- right: **simulated ALMA 345 GHz image at the distance of Vela-C.**



⇒ Despite some artifacts, the position angle of the inner core's major and minor axes are preserved.

....Grazie !!