Initial Highlights from the Gould Belt Survey

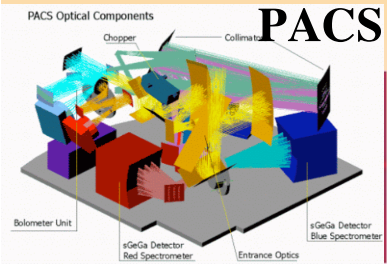
Philippe André, CEA/SAp Saclay

A.Men'shchikov, S.Bontemps, V. Könyves, F. Motte, N. Schneider, P. Didelon, V. Minier, P. Saraceno, D.Ward-Thompson, J. Di Francesco, G. White, S. Molinari, L. Testi, A. Abergel, M. Griffin, T. Henning, P. Royer, B. Merin, R. Vavrek, M. Attard, D. Arzoumanian, C.D. Wilson, P. Martin, and the Gould Belt KP Consortium

Main groups : SPIRE SAG 3
(eg. J.Kirk, M. Huang, G. Olofsson)

PACS Institutes
- **CEA Saclay, IFSI Rome & INAF Arcetri**
- **OAMP Marseille** (A. Zavagno)
- **KU Leuven** (J. Blommaert & C. Waelkens)
- **MPIA Heidelberg** (O. Krause, R. Launhardt)

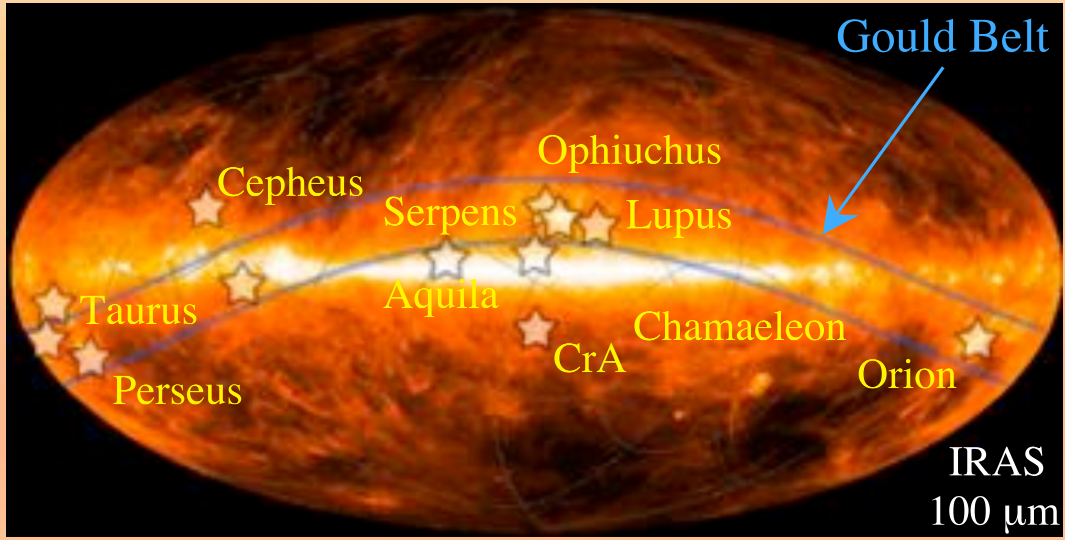
+ ESA HSC



The *Herschel* Gould Belt Survey

http://gouldbelt-herschel.cea.fr/

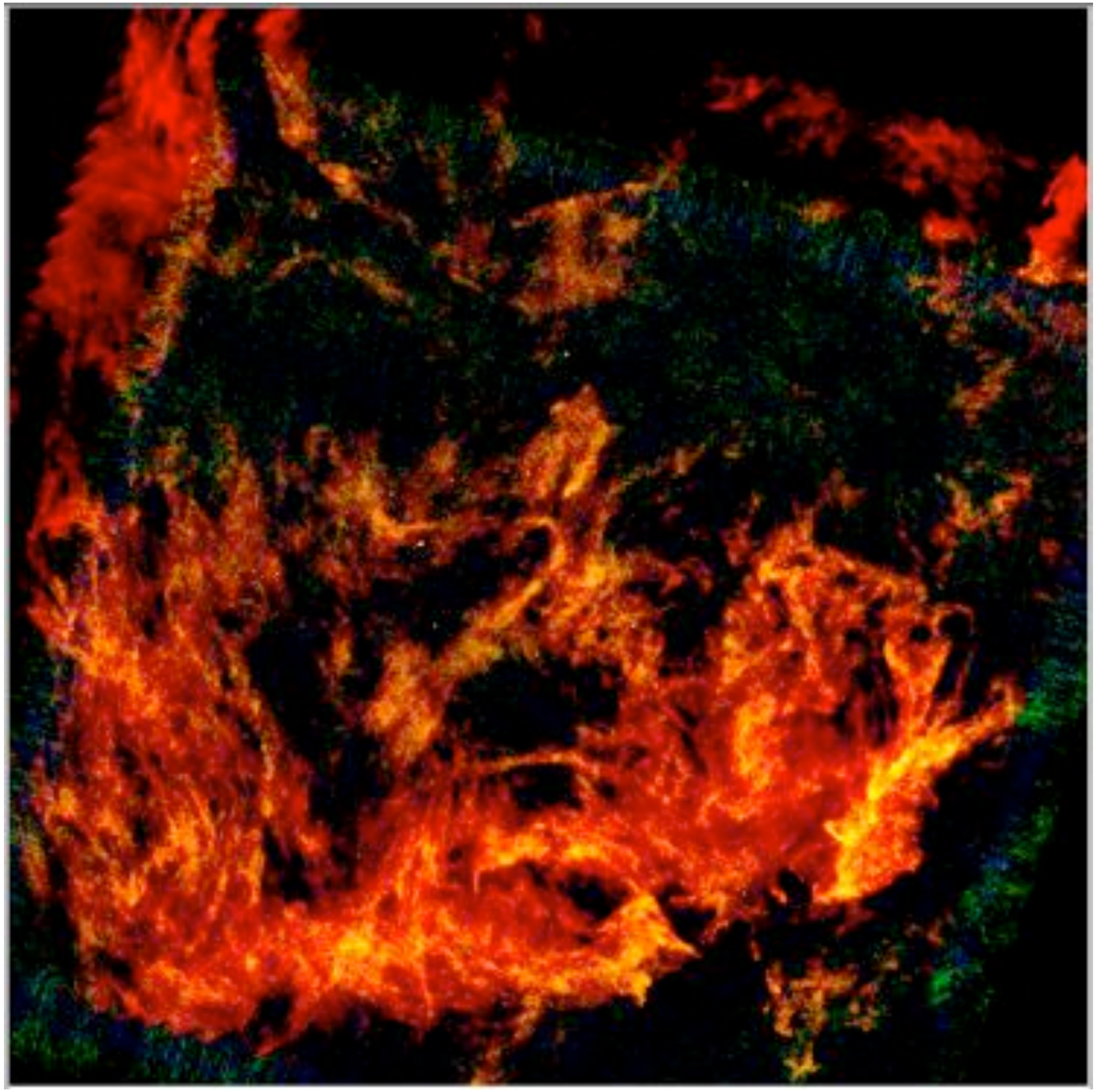
SPIRE/PACS 70-500 μm imaging of the bulk of nearby (d < 0.5 kpc) molecular clouds (~ 160 deg^2), mostly located in Gould's Belt.



Motivation: Key issues on the early stages of star formation

- What determines the distribution of stellar masses = the IMF ?
- What generates prestellar cores and what governs their evolution to protostars and proto-brown dwarfs ?

"First images" from the Gould Belt Survey



1) Polaris translucent cloud
(d ~ 150 pc)

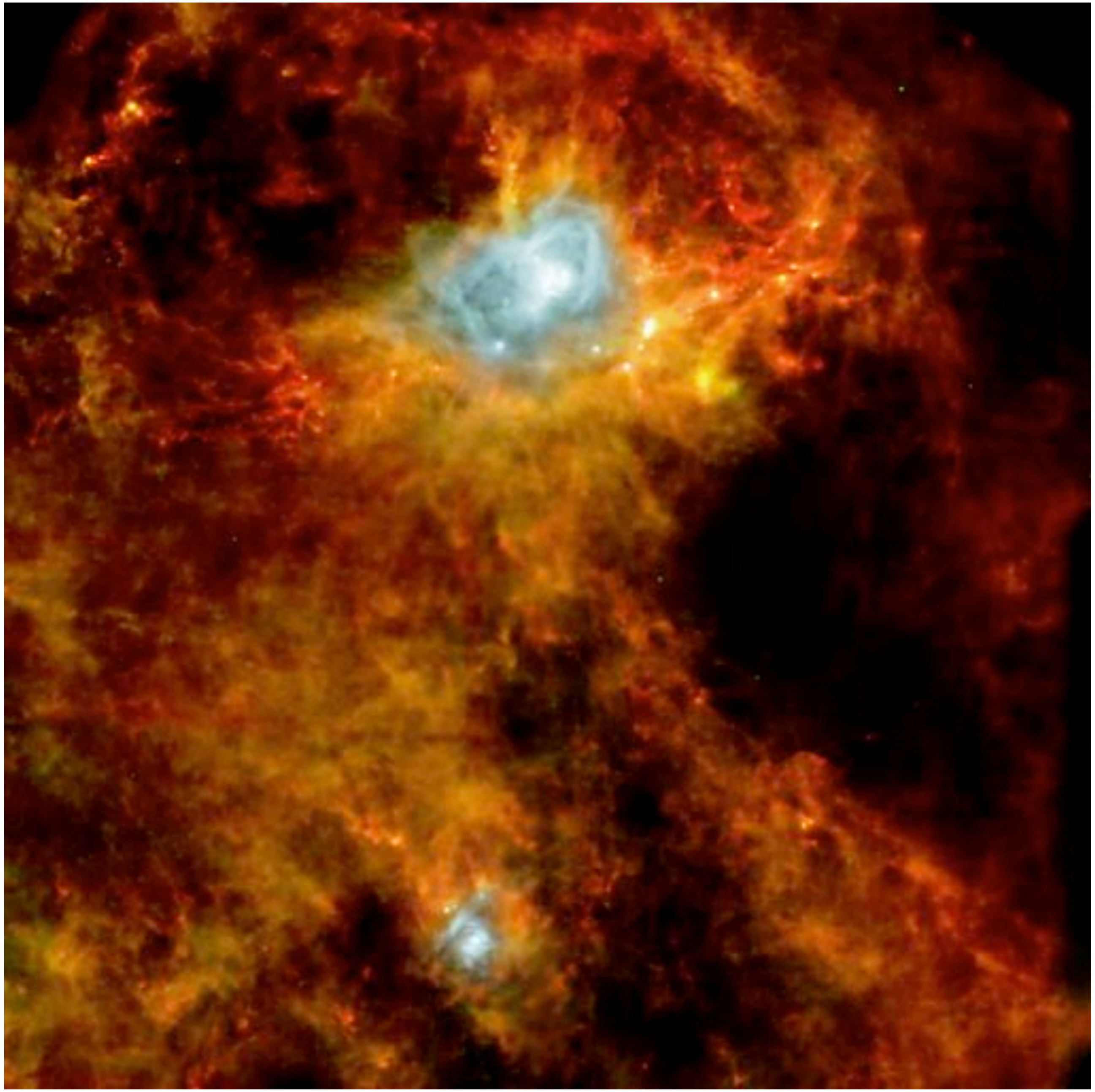
23 Oct 2009

Red : SPIRE 500 μm
Green : SPIRE 250 μm
Blue : PACS 160 μm

~ 7 deg^2 field

Ward-Thompson et al. 2010
Miville-Deschênes et al. 2010
A&A special issue

"First images" from the Gould Belt Survey



2) Aquila Rift star-forming cloud (d ~ 260 pc)

24 Oct 2009

cf. http://oshi.esa.int

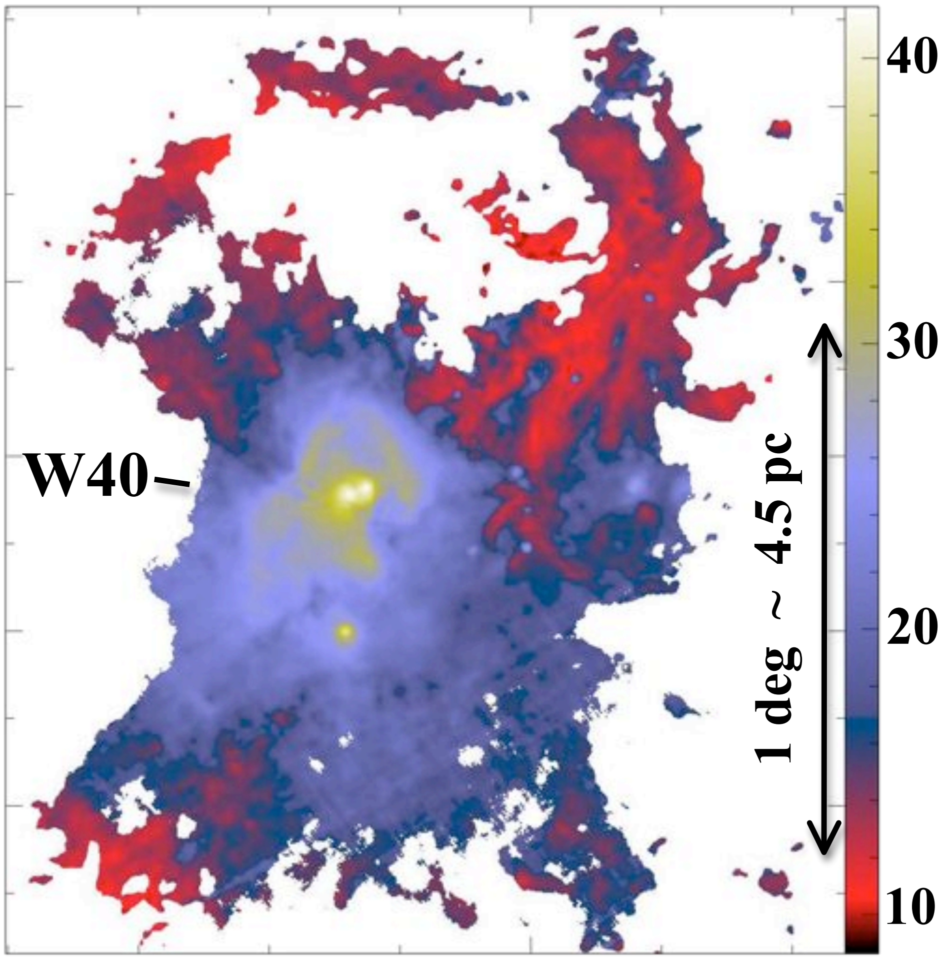
Red : SPIRE 500 μm
Green : SPIRE 160 μm
Blue : PACS 70 μm

~ 3.3 deg x 3.3 deg field

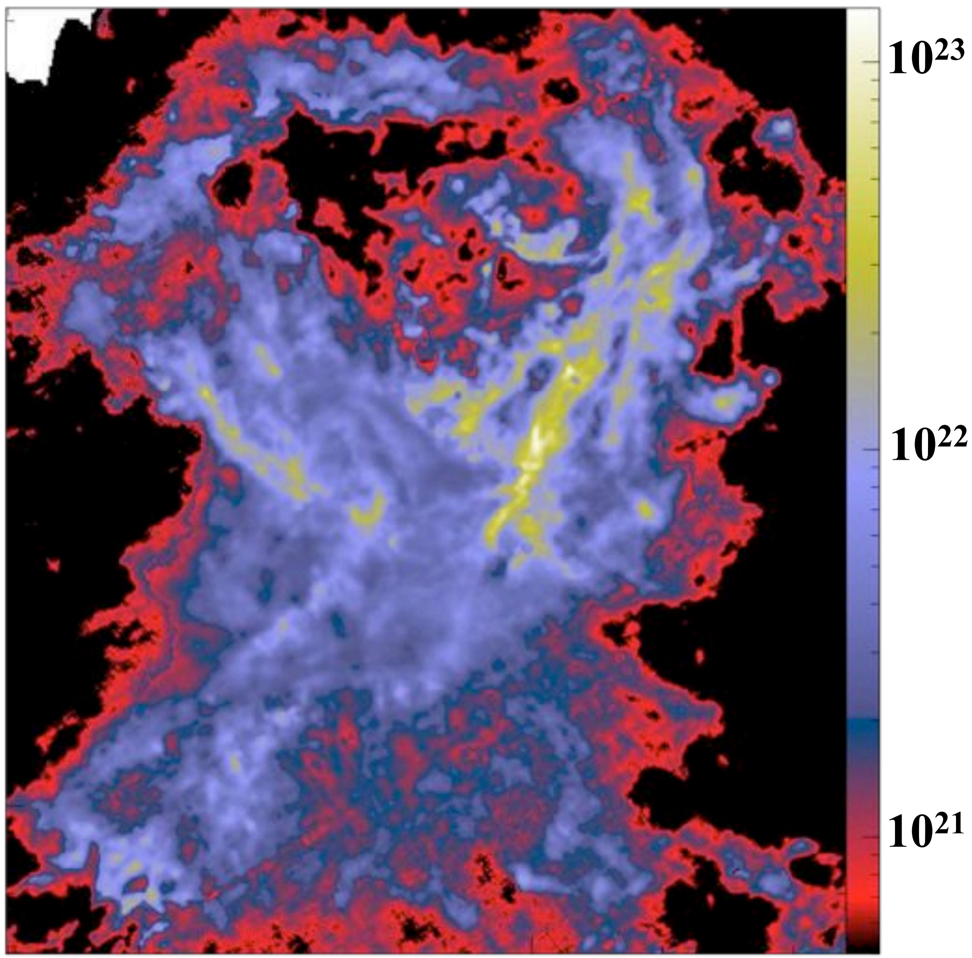
Könyves et al. 2010
Bontemps et al. 2010
André et al. 2010
A&A special issue

Revealing the structure of one of the nearest infrared dark clouds (Aquila Main: d ~ 260 pc)

Herschel (SPIRE+PACS)
Dust temperature map (K)

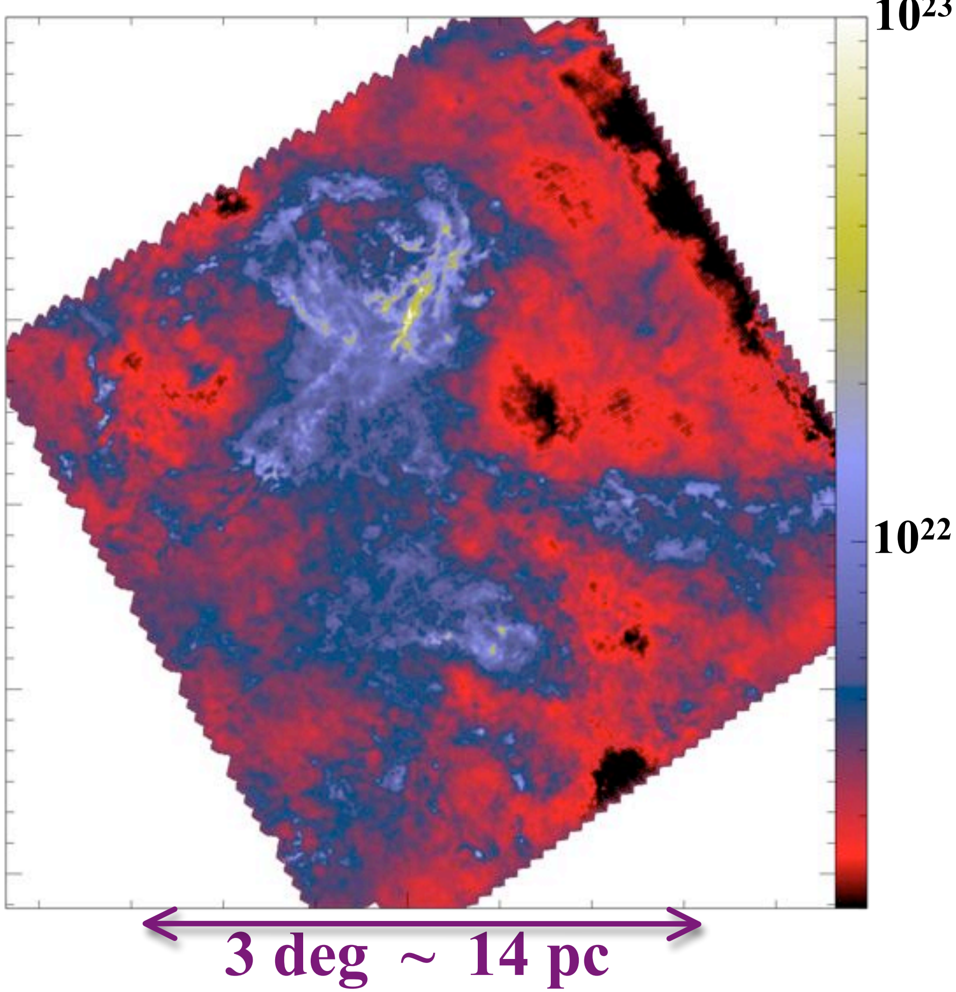


Herschel (SPIRE+PACS)
Column density map (H_2/cm^2)

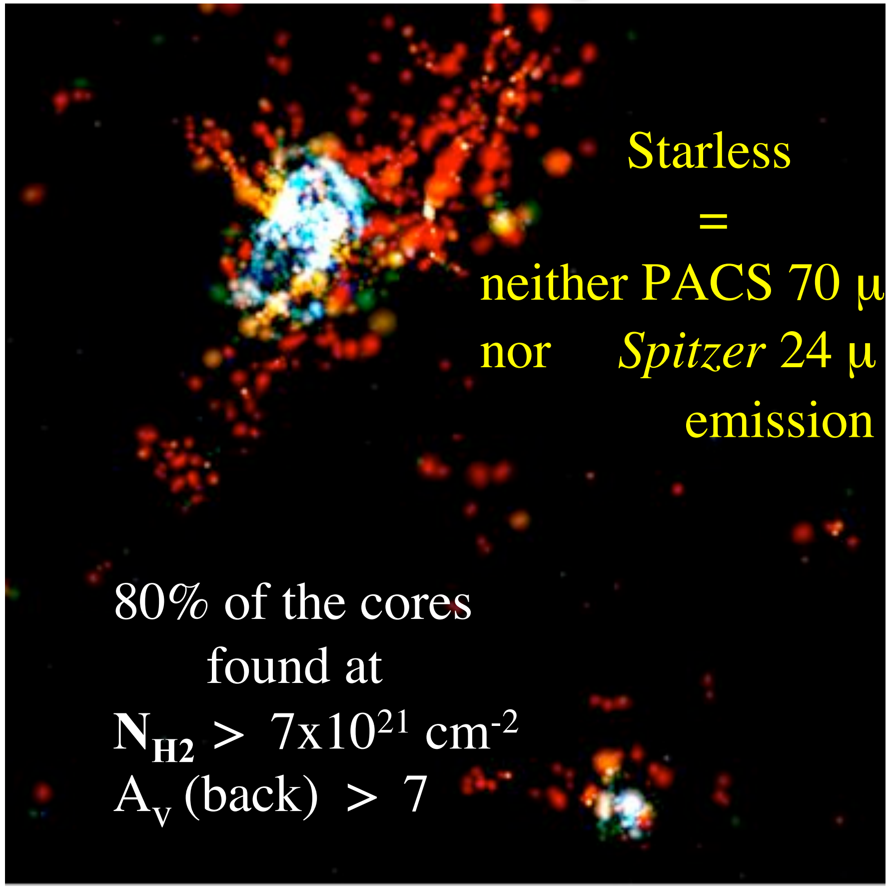


Aquila: `Compact' Source Extraction
(using "getsources" – A. Menshchikov et al. 2010)

Herschel (SPIRE+PACS)
Aquila entire field: N_{H_2} (cm^{-2})



Spatial distribution of extracted cores { 541 starless, 201 YSOs }



70/160/500 μm composite image

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Herschel (SPIRE+PACS)
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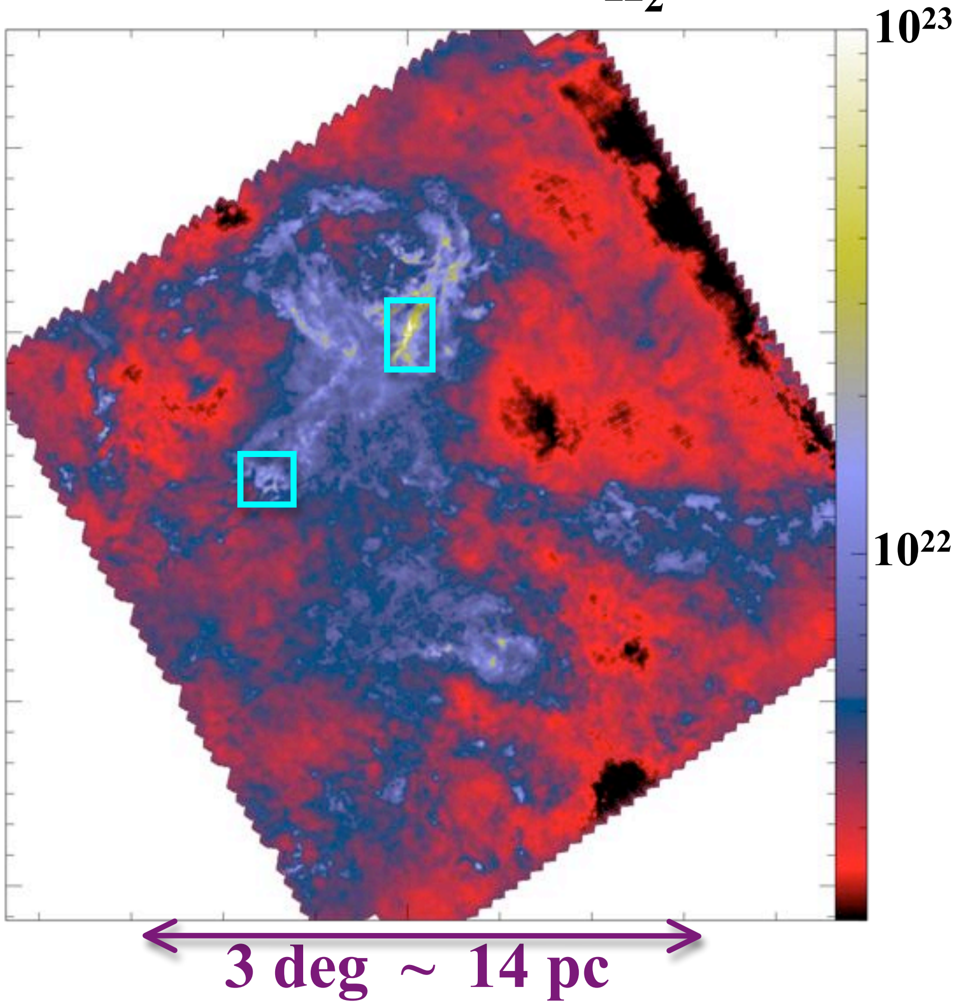

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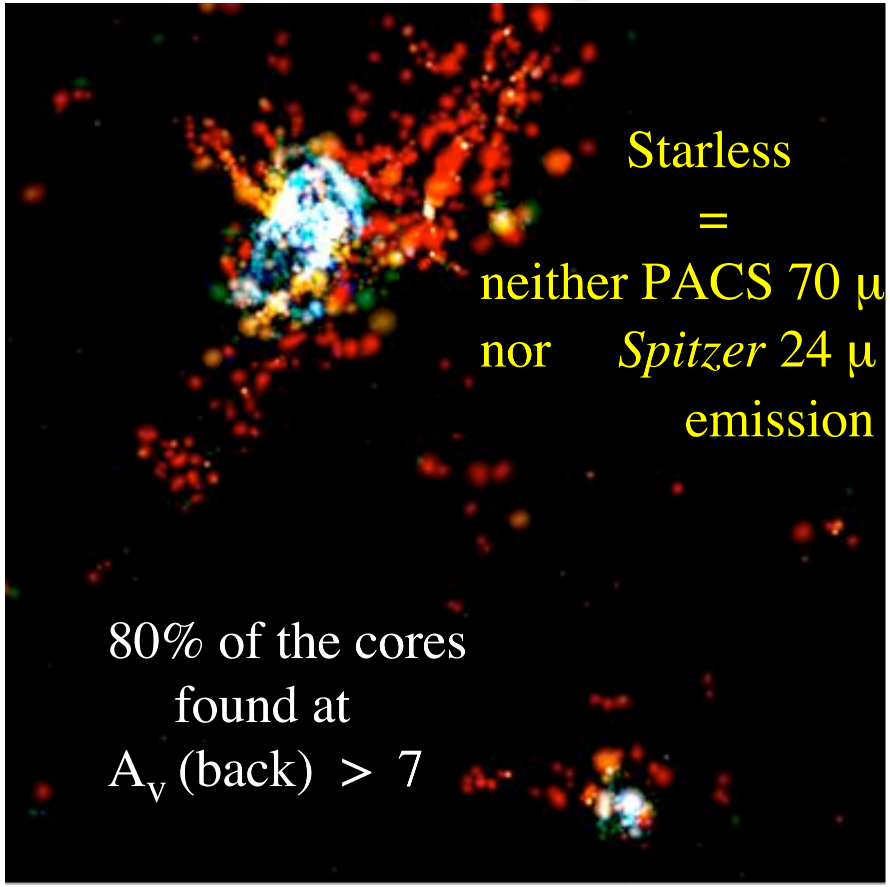
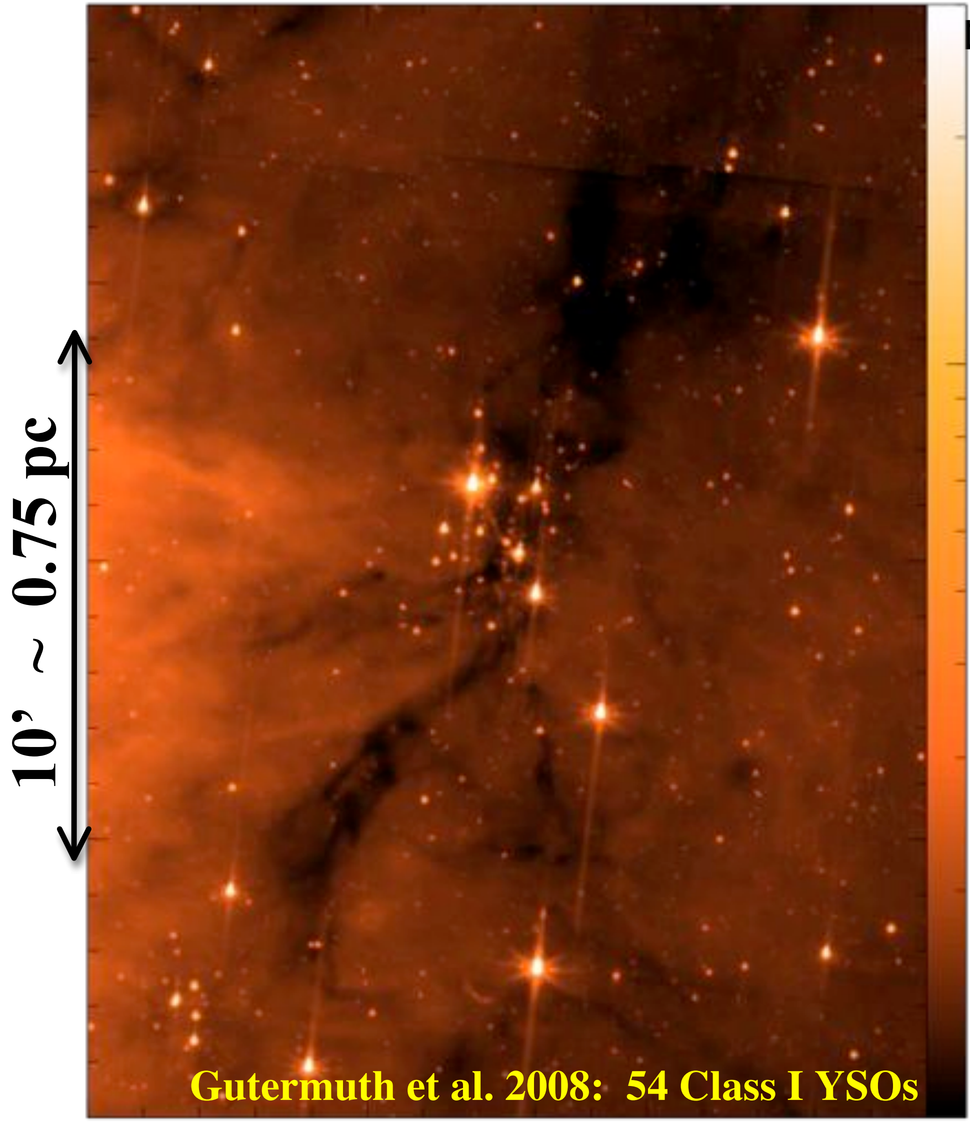


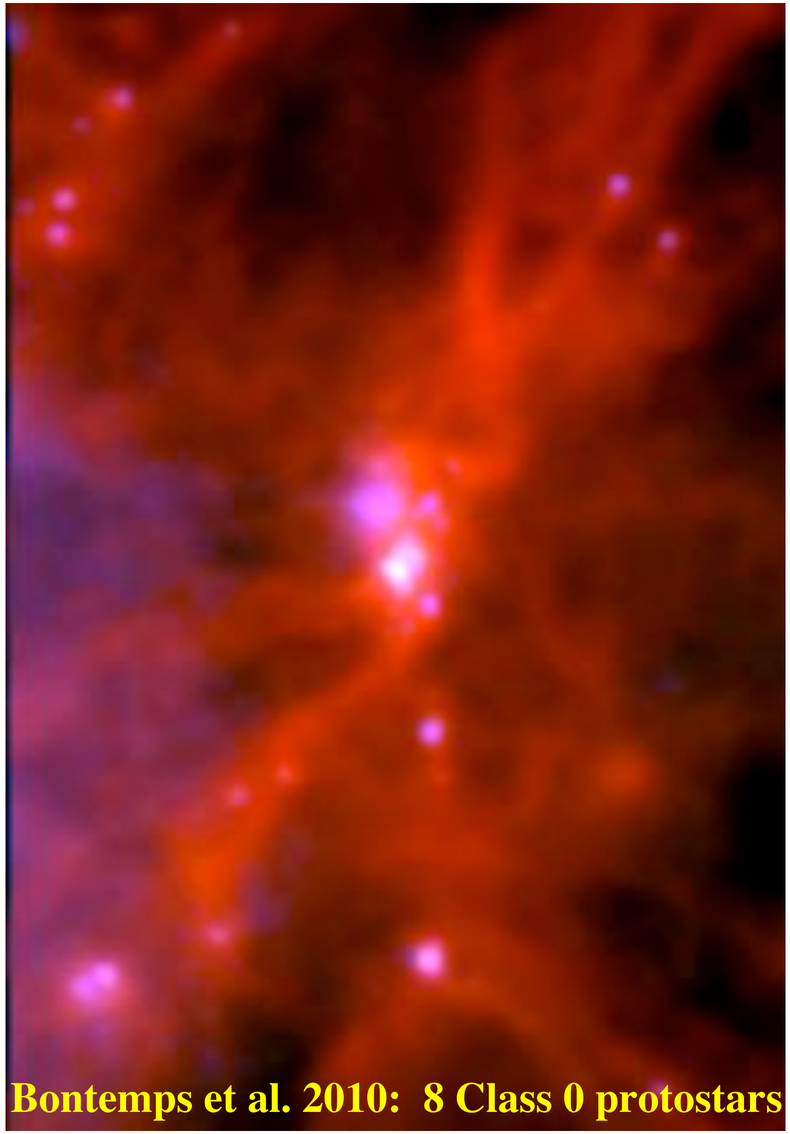
70/160/500 μm composite image

Aquila/Serpens-South dark filament:
A rich protocluster in the making

Spitzer/IRAC 8 µm

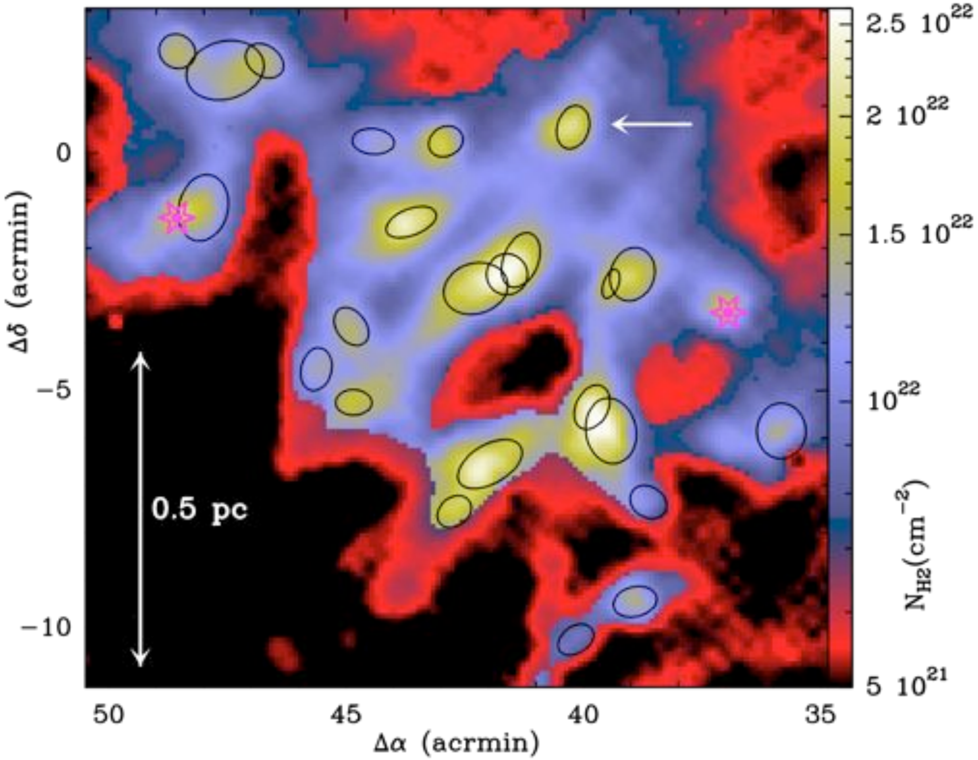


SPIRE 250 µm + PACS 160/70 µm

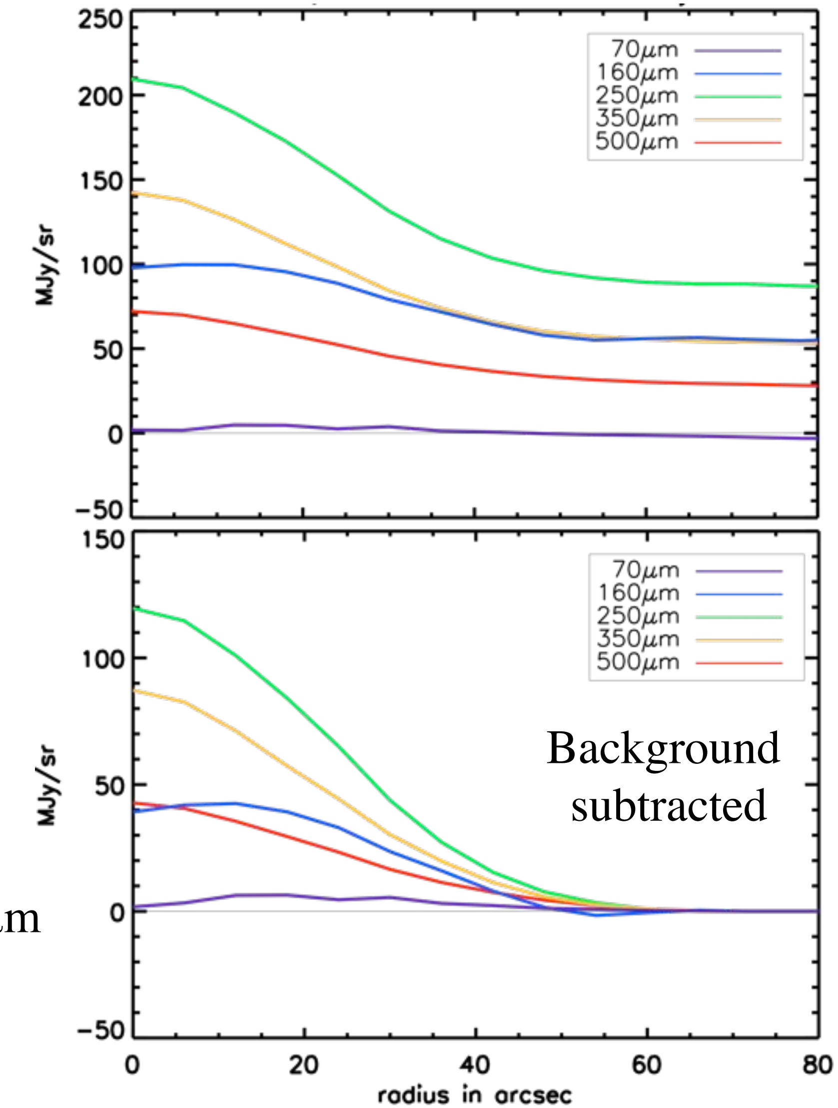


A group of starless cores in Aquila-East

Herschel (SPIRE+PACS) N_{H_2} map (cm^{-2})



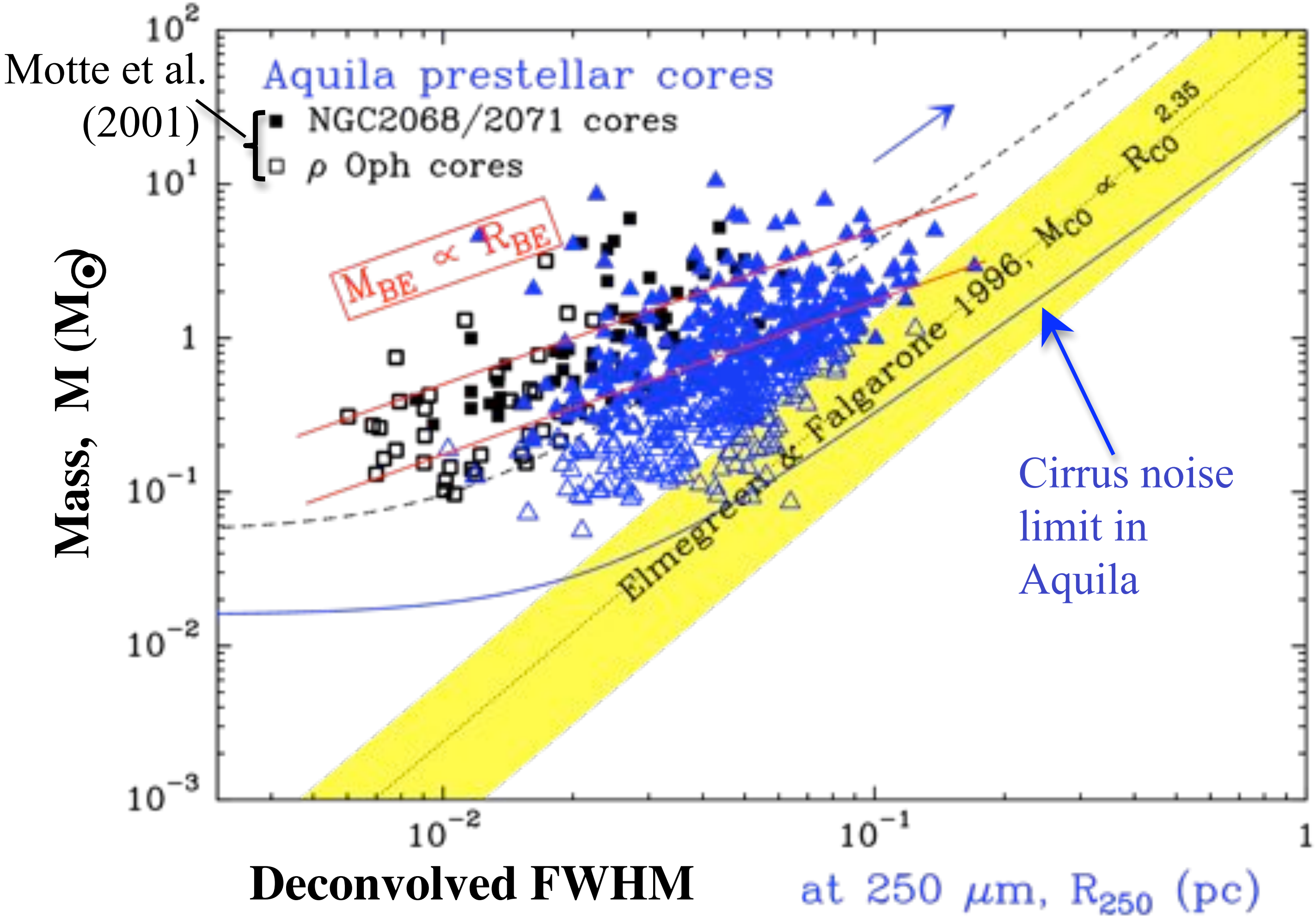
Radial intensity profiles



Ellipses: FWHM sizes of 24 starless cores at 250 µm
Stars (☆) : Two candidate Class 0 protostars

Könyves et al. 2010, A&A special issue

Most of the Aquila starless cores are bound



➢ Likely prestellar in nature

Könyves et al. 2010

Talk by V. Könyves on Thursday

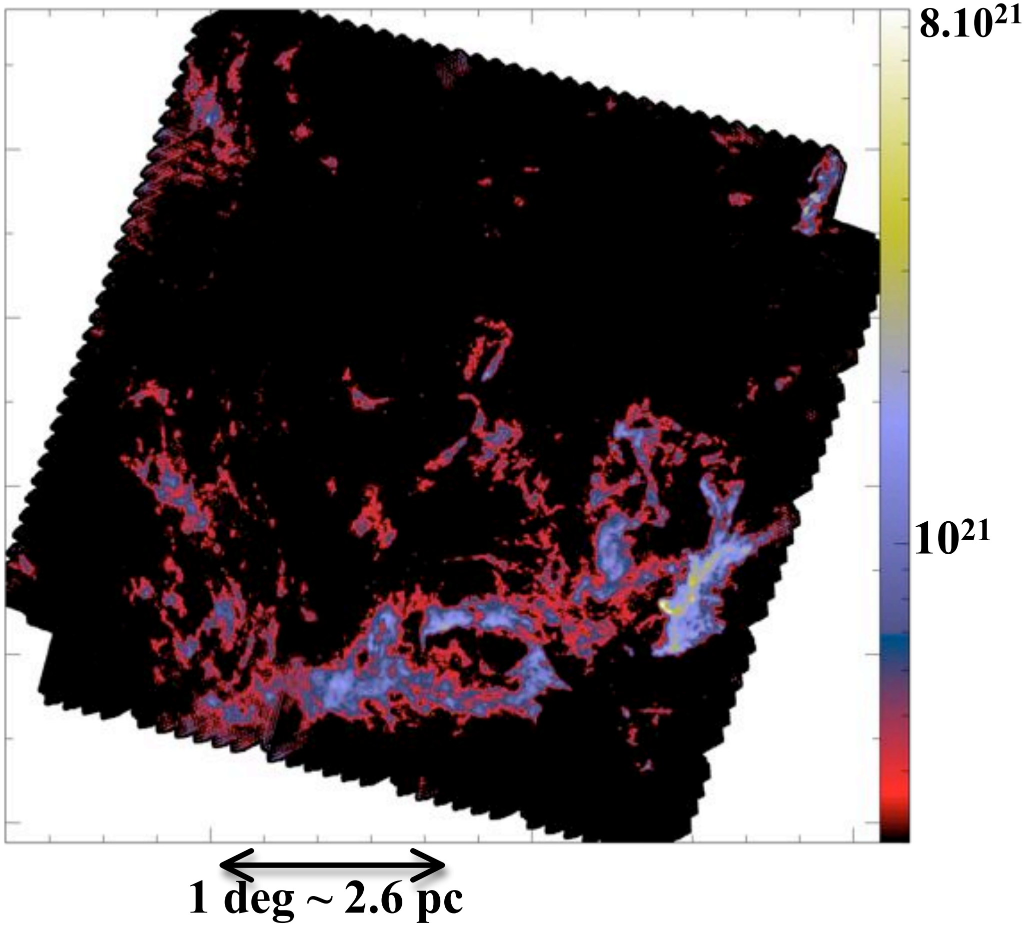
➢ Location in mass vs. size diagram, consistent with BE spheroids

➢ High degree of concentration: $N_{H2}^{peak}/\langle N_{H2}\rangle \sim 4$ on average

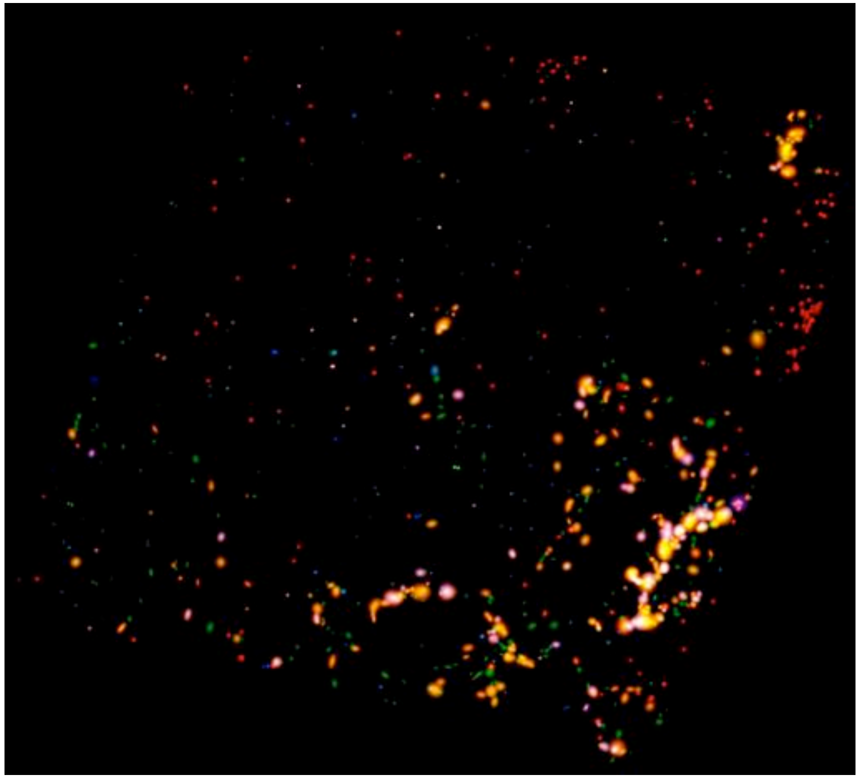
➢ Median column density contrast over the background ~ 1.5

Polaris: `Compact' Source Extraction
(using "getsources" – A. Menshchikov et al. 2010)

Herschel (SPIRE+PACS)
Column density map (H_2/cm^2)

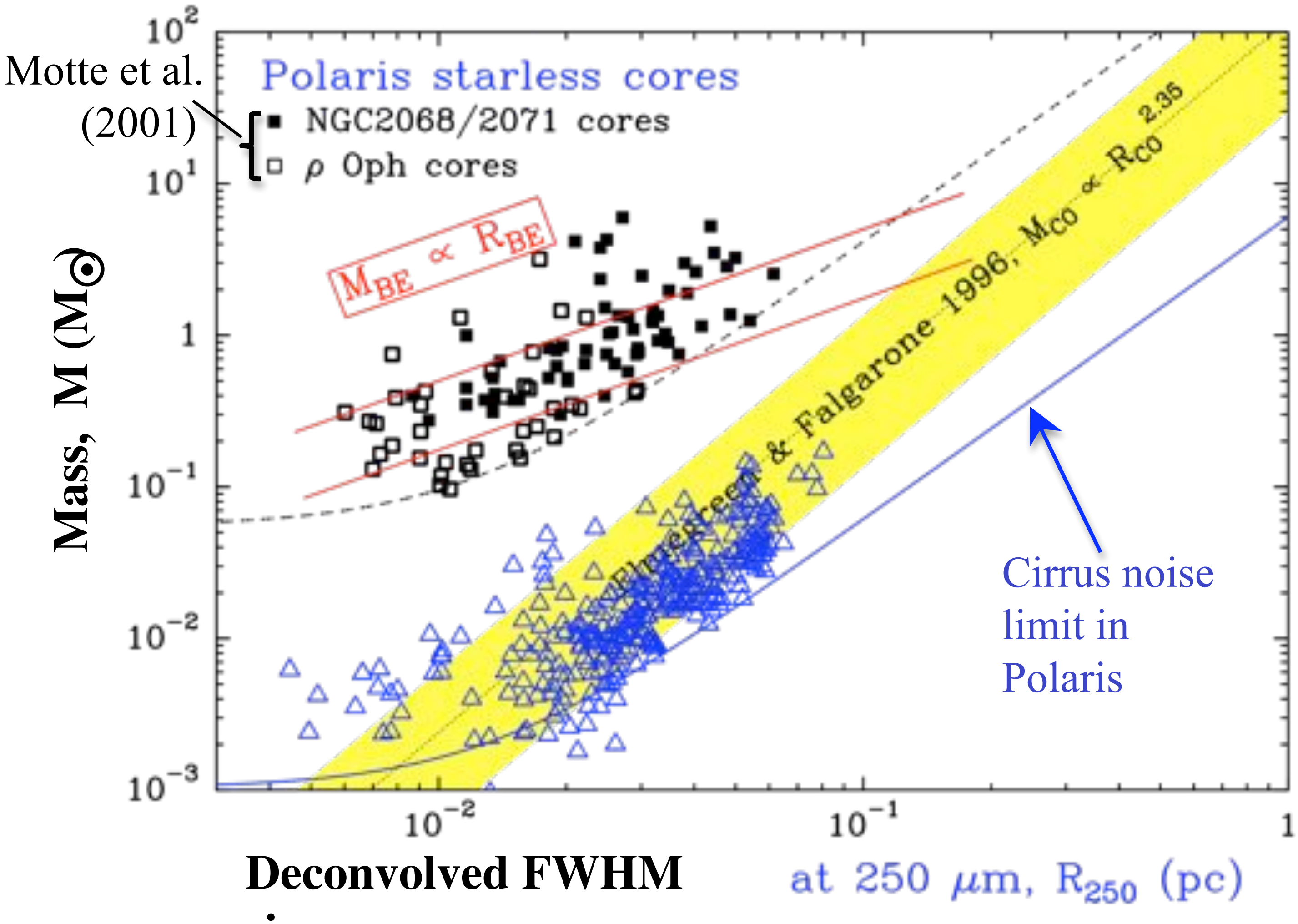


Spatial distribution of
~ 300 extracted cores
(all starless) + galaxies (!)



160/250/500 μm composite image

Most of the Polaris starless cores are unbound



- not (yet ?) prestellar

André et al. 2010
Ward-Thompson et al. 2010

Talk by D. Ward-Thompson on Wednesday

- **Location in mass vs. size diagram:** 2 orders of magnitude below the density of self-gravitating Bonnor-Ebert isothermal spheres

Confirming the link between the prestellar CMF & the IMF

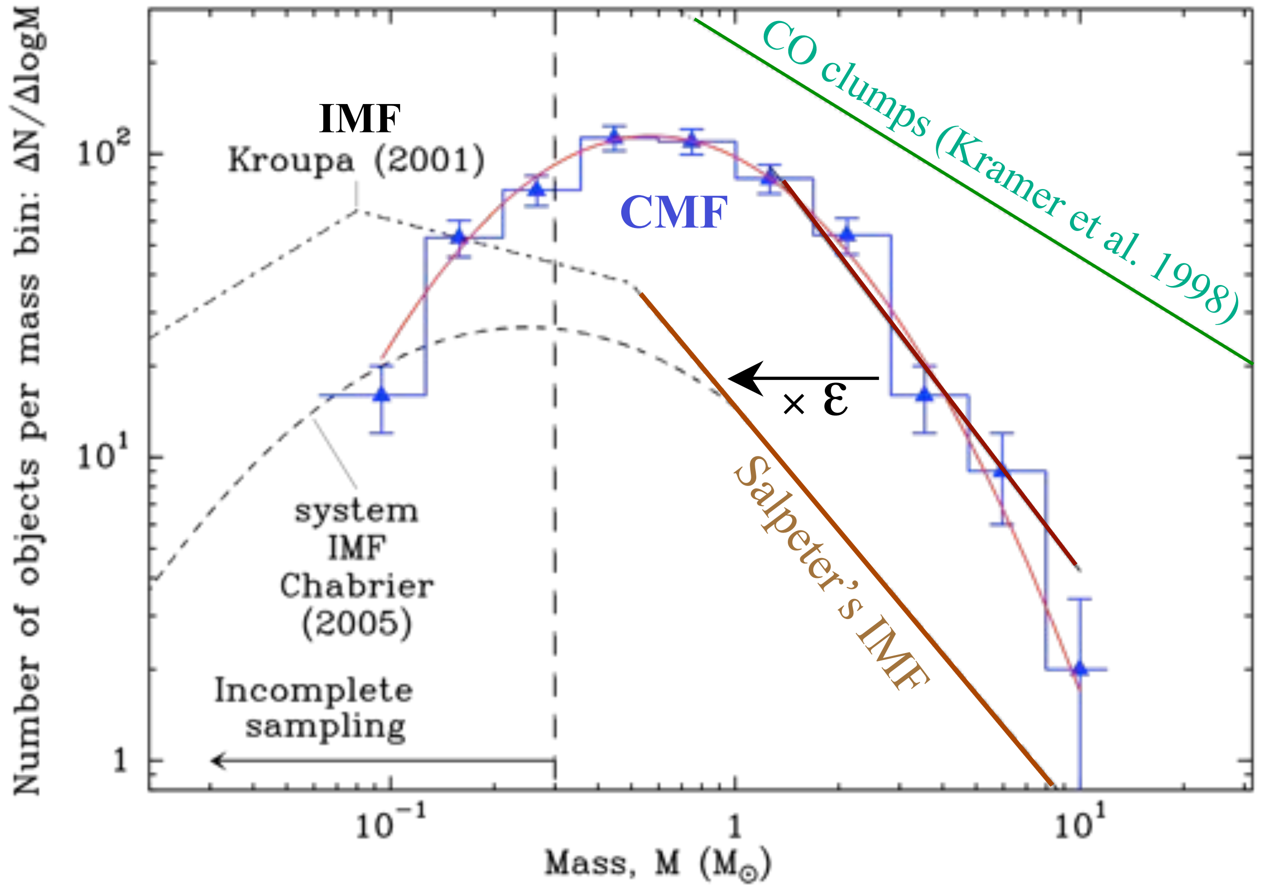
Könyves et al. 2010
André et al. 2010
A&A special issue

341-541 prestellar cores in Aquila

Factor ~ 2-9 better statistics than earlier studies:

e.g. Motte, André, Neri 1998; Johnstone et al. 2000; Beuther & Schilke 2004; Stanke et al. 2006; Enoch et al. 2006; Alves et al. 2007; Nutter & Ward-Thompson 07

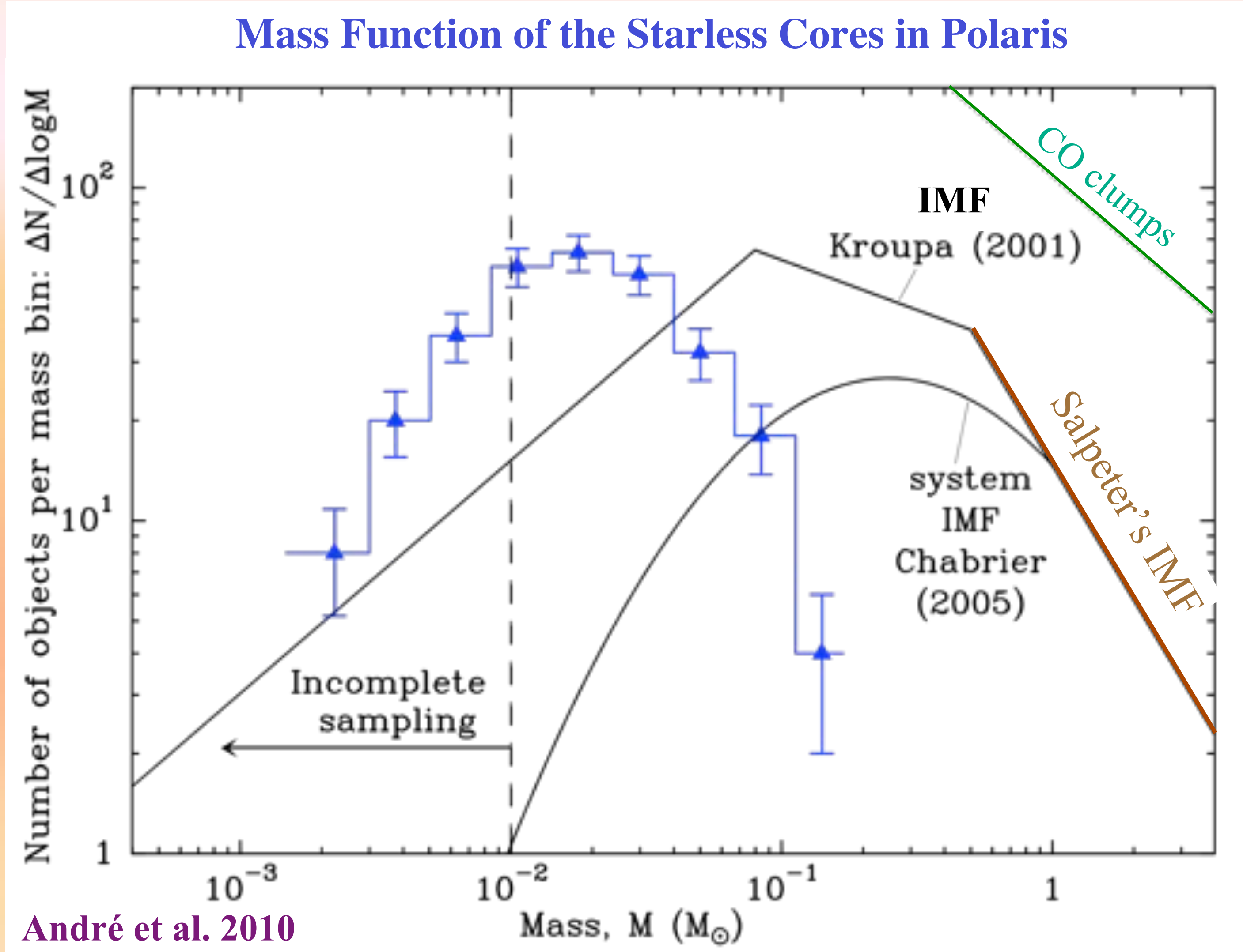
Prestellar Core Mass Function (CMF) in Aquila Complex



➢ **Good (~ one-to-one) correspondence between core mass and system mass: $M_* = \varepsilon\, M_{core}$ with $\varepsilon \sim 0.2$-0.4 in Aquila**

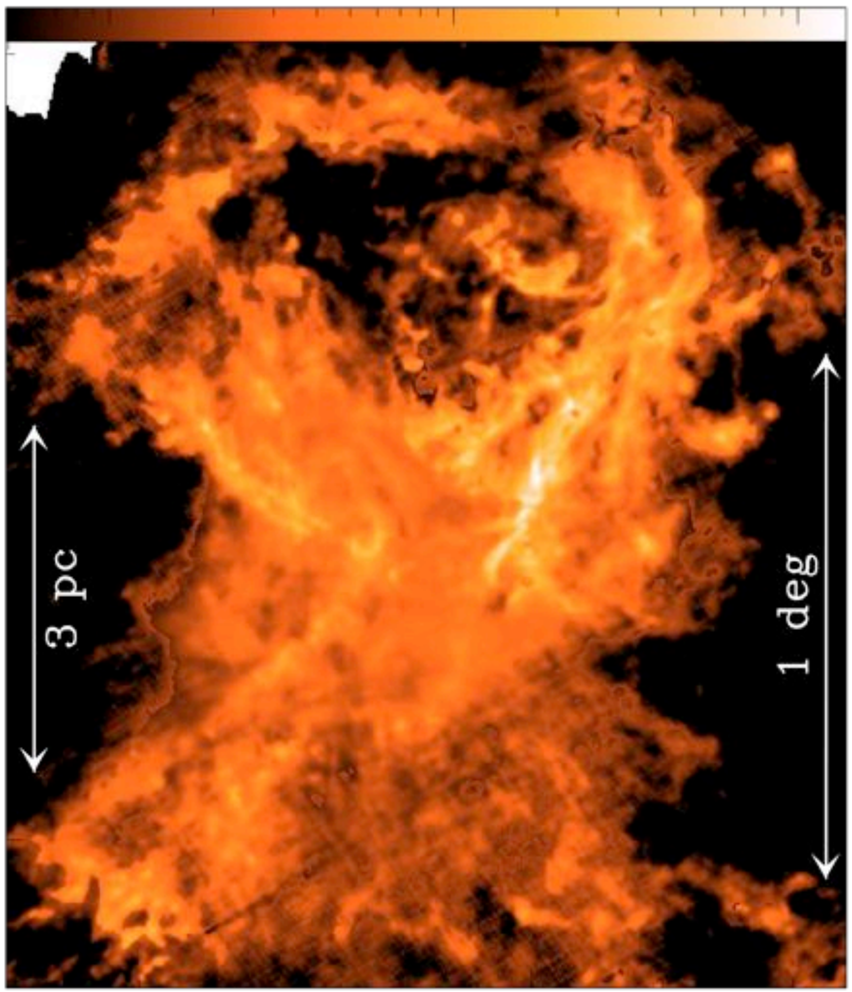
➢ **The IMF is at least partly determined by pre-collapse cloud fragmentation** (cf. models by Padoan & Nordlund 2002, Hennebelle & Chabrier 2008)

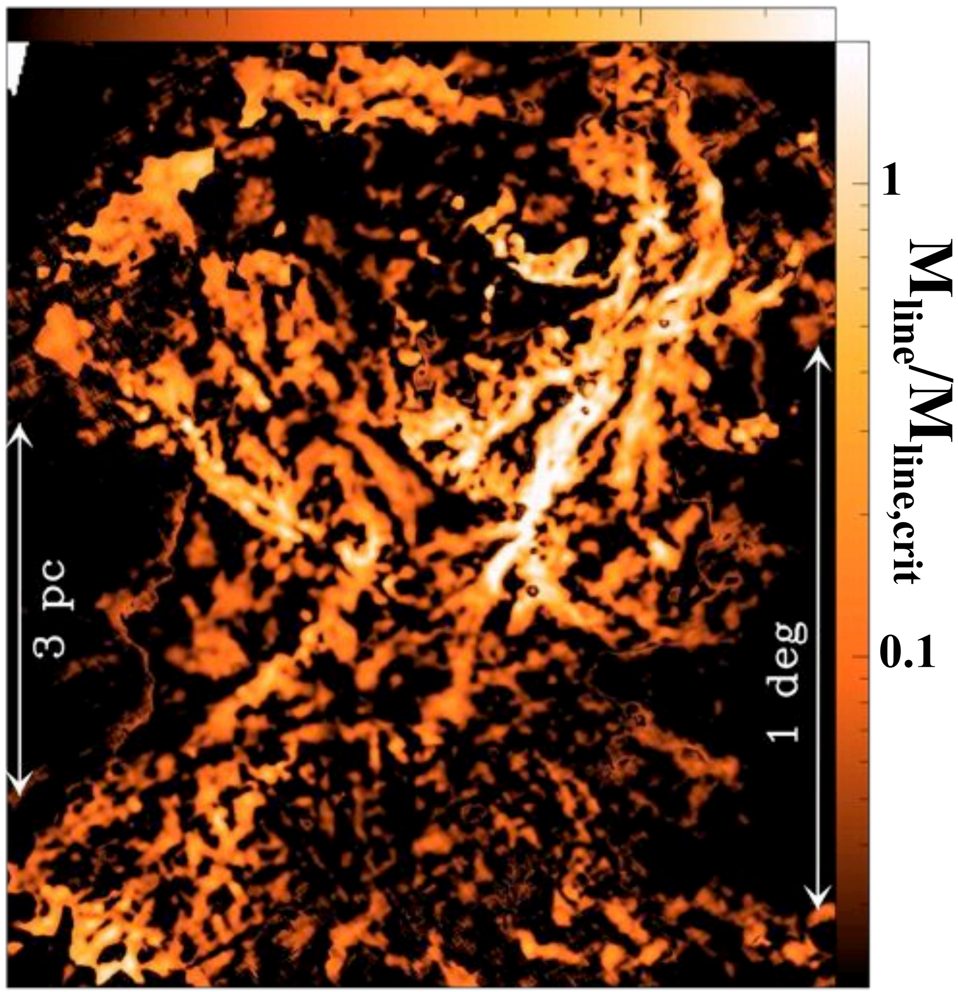
The Polaris starless cores are not massive enough to form stars



The mass function of Polaris starless cores peaks at ~ 0.02 $M_\odot$ i.e., ~ one order of magnitude below the peak of the stellar IMF

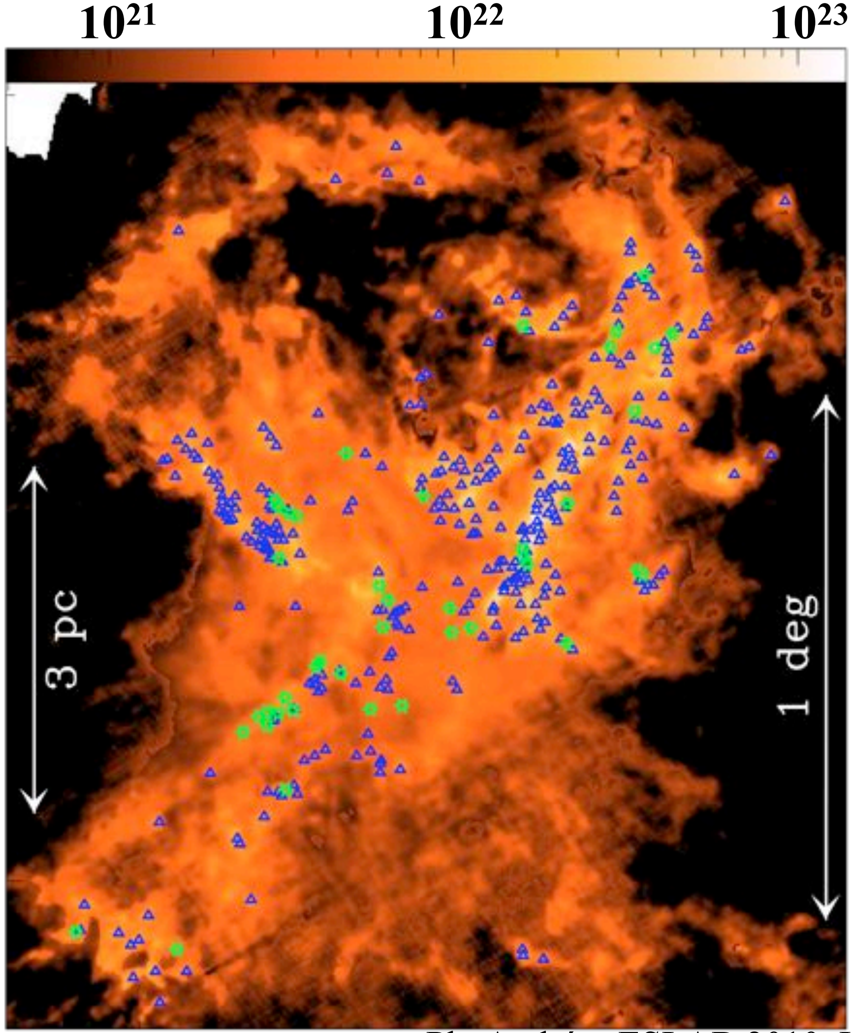
Prestellar cores form out of a filamentary background

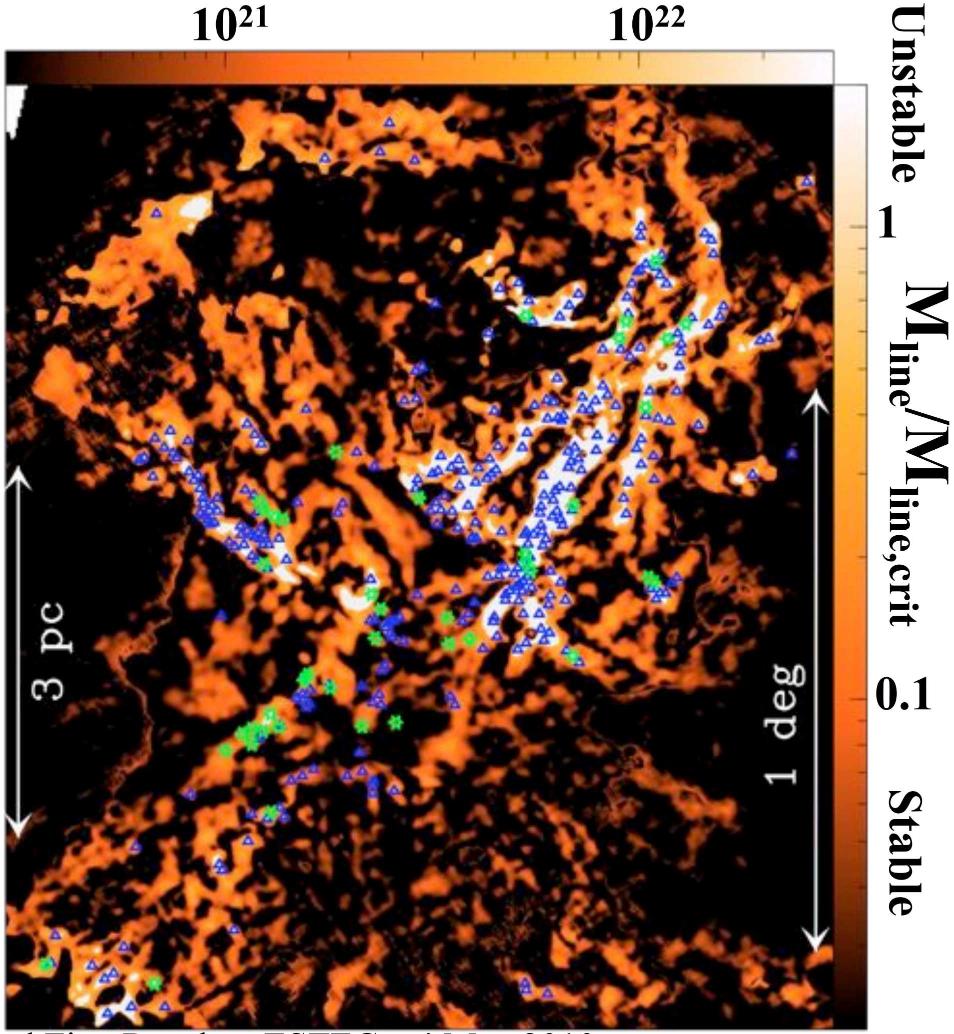




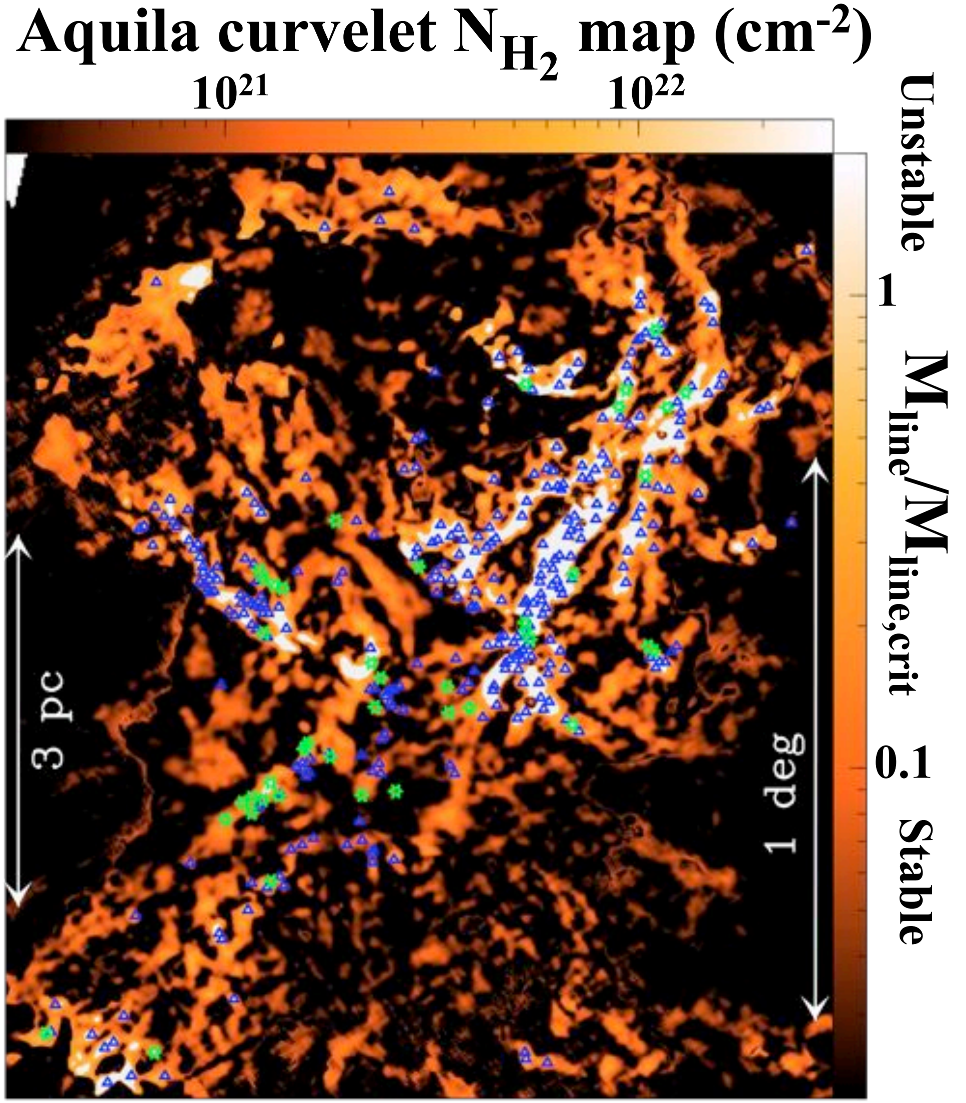
Prestellar cores form out of a filamentary background

★ : Class 0 protostars △ : Prestellar cores - 80% found at A_V(back) > 7





Only the densest filaments are gravitationally unstable and contain prestellar cores (△)



André et al. 2010, A&A special issue

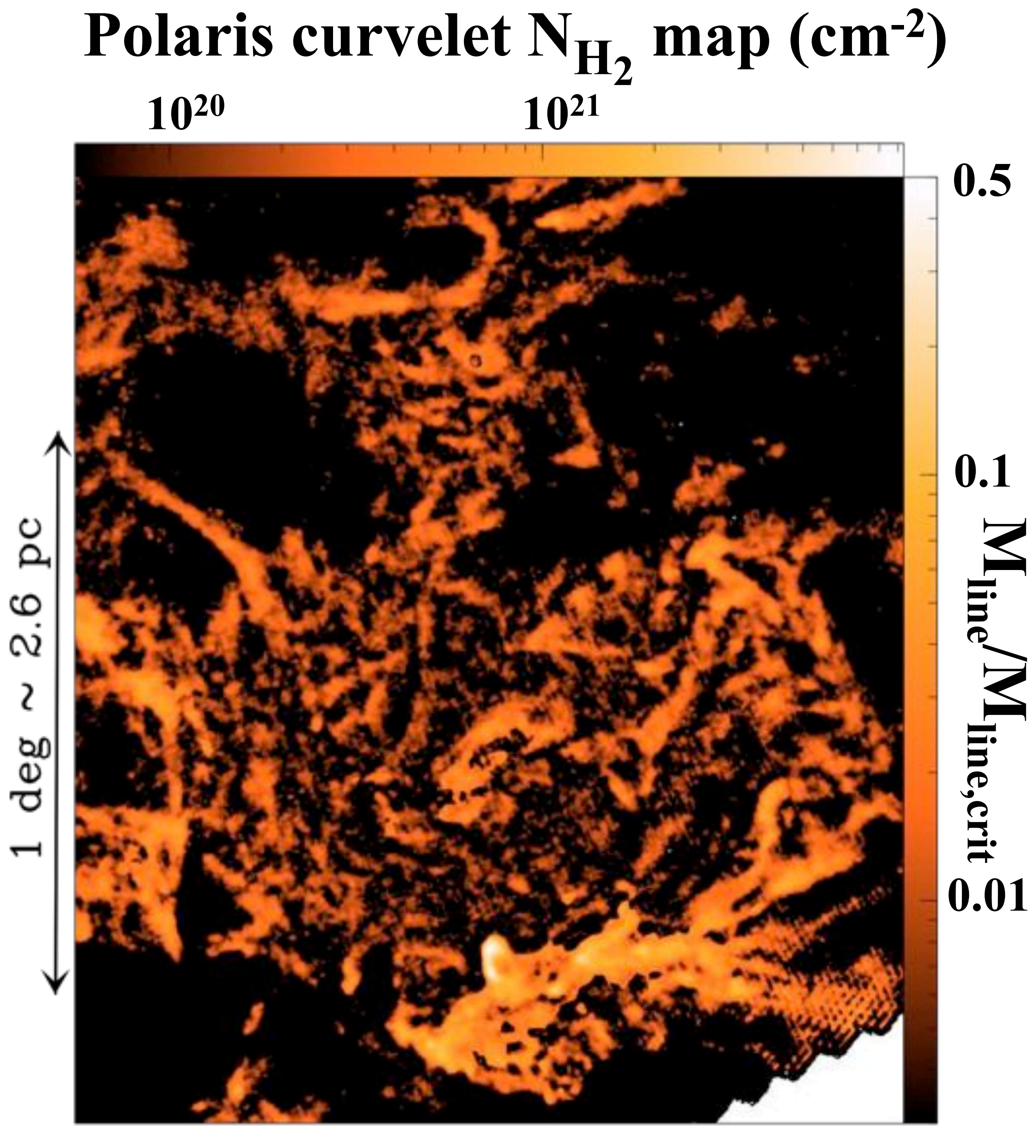
- ➢ The gravitational instability of filaments is controlled by the value of their mass per unit length M_{line} (cf. Ostriker 1964, Inutsuka & Miyama 1997):

- • unstable if $M_{line} > M_{line, crit}$
- • stable if $M_{line} < M_{line, crit}$
- • $M_{line, crit} = c_s^2/G \sim 15\ M_\odot/pc$ for T = 10K

- ➢ Simple estimate:

$M_{line} \propto N_{H2}$ x Width Unstable filaments highlighted in white in the N_{H2} map

Polaris (d ~ 150 pc): Structure of the cold ISM prior to any star formation



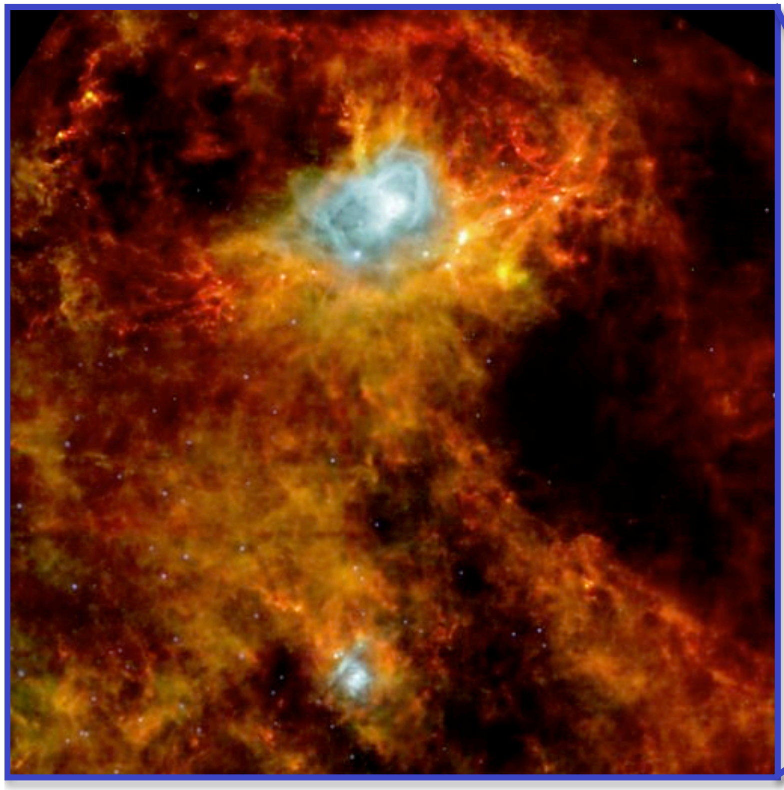
André et al. 2010, A&A special issue

No prestellar cores (yet ?) in Polaris

- Filaments are already widespread prior to star formation
- The maximum value of $M_{line}/M_{line, crit}$ observed in the Polaris filaments is ~ 0.5
- The Polaris filaments are gravitationally stable and unable to form prestellar cores and protostars at present

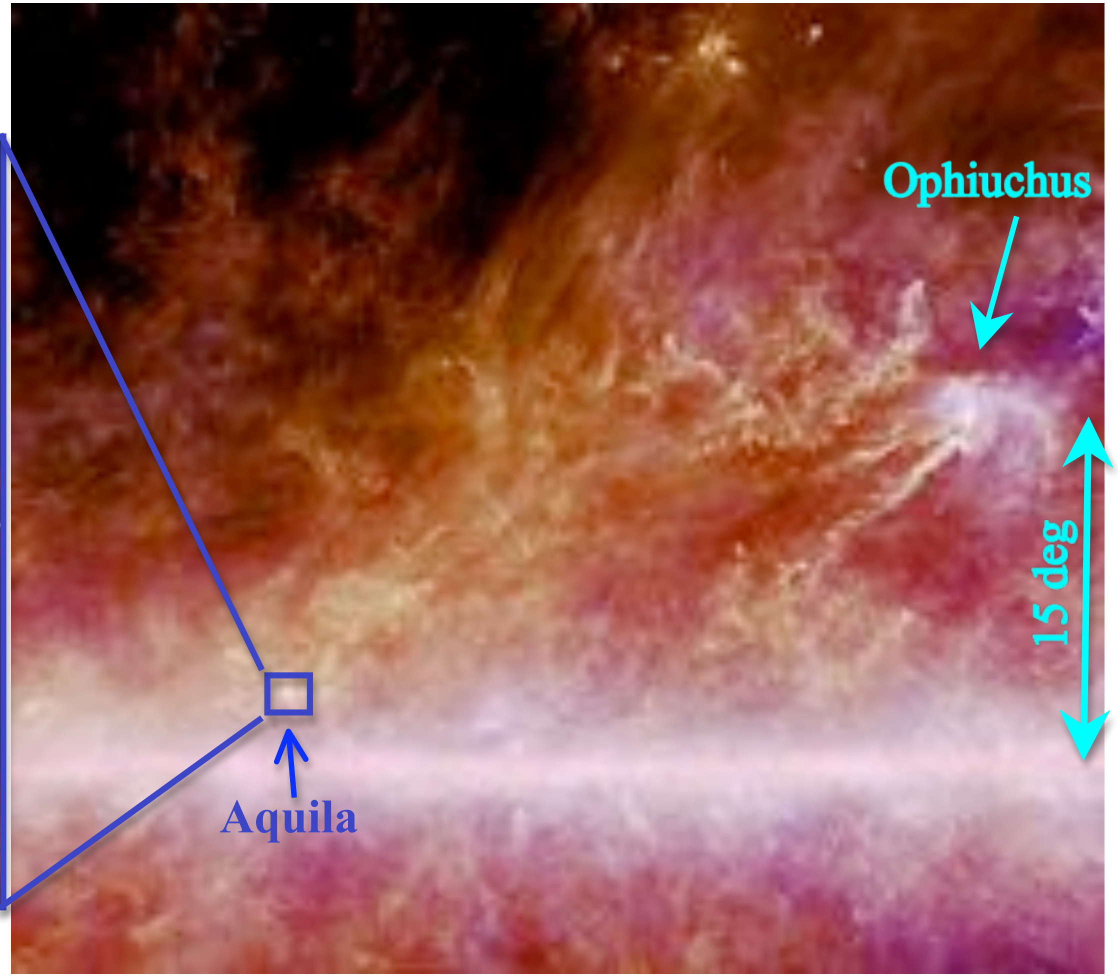
Filaments permeate the ISM on all scales

Herschel
SPIRE 500 μm
+
PACS 160/70 μm



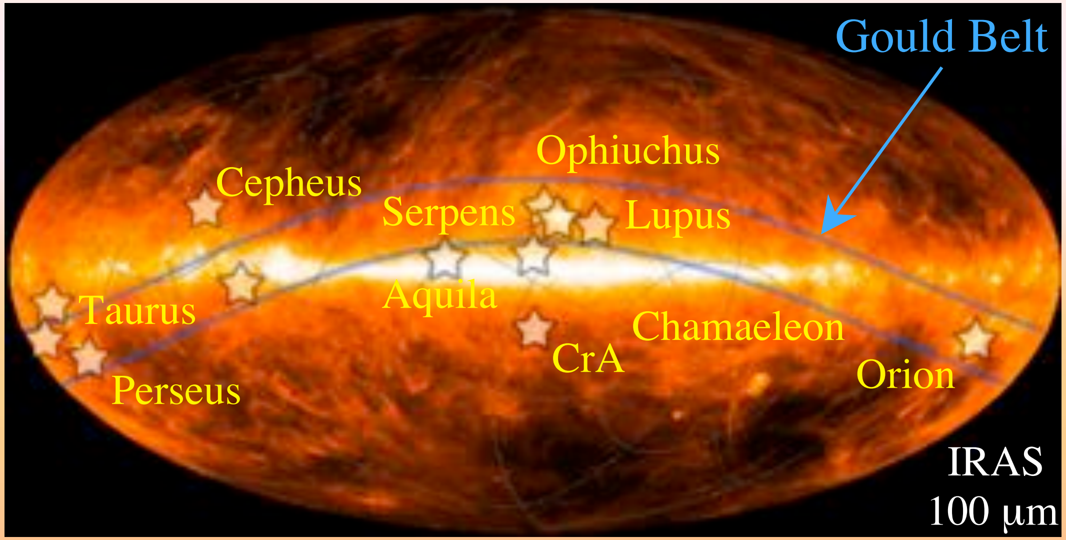
ESA and the Gould Belt KP

Planck
HFI 540/350 μm + IRAS 100 μm



ESA and the HFI Consortium

Conclusions



Our first results are extremely promising; exceed expectations !

- Confirm the close link between the prestellar CMF and the IMF
- Suggest an **observationally-driven scenario of core formation**: 1) Filaments form first in the cold ISM, possibly as a result of interstellar MHD turbulence; 2) The densest filaments then fragment into prestellar cores via gravitational instability.

MANY THANKS TO ESA HSC + SPIRE & PACS ICCs