The Herschel first look at protostars

Gould Belt and HOBYS key programmes

On the behalf of the SPIRE SAG3 consortium

Sylvain Bontemps

special thanks to
Ph. André, A. Men'shchikov , M. Hennemann , V. Könyves, N. Schneider, D. Arzoumanian, F. Motte

Herschel imaging survey of OB Young Stellar objects
A guaranteed time key programme with Herschel Space Observatory esa

Objectives

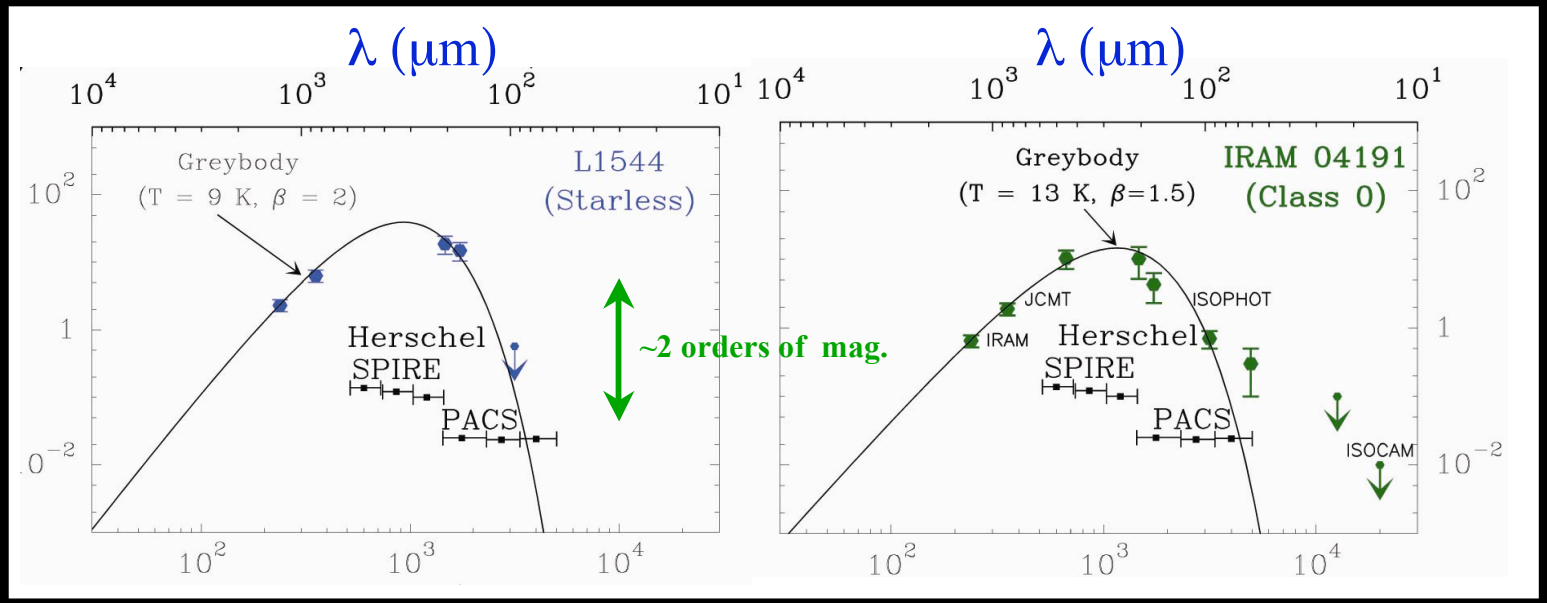
- Probe the earliest stages of star formation.
- Timescale for proto-stellar evolution.
- Initial conditions for planet/disk formation.
- Discriminate between accretion histories.

The (long) quest for protostars

- The Class I , I and III YSOs after IRAS (80's)
- The Class 0 and pre-stellar cores after MM range surveys (90's)
- Much more complete surveys with ISO and Spitzer (00's)
- What about Herschel? … let's try to guess a little … (10's)

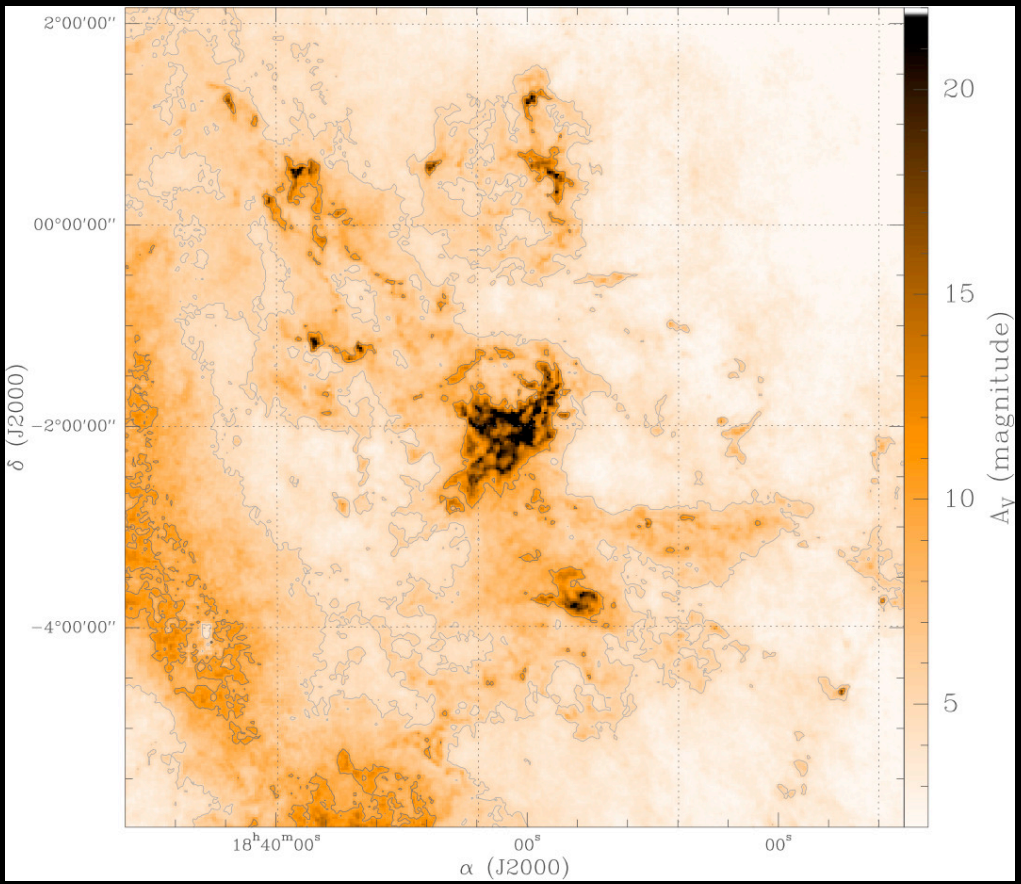
The power of Herschel

- full coverage of the peak of the SEDs.
- Spatial resolution in the FIR.
- Sensitivity: down to sub-stellar range.
- Both pre-stellar and protostars at the same time.
- Unprecedented statistics … up to high-mass stars in HOBYS.

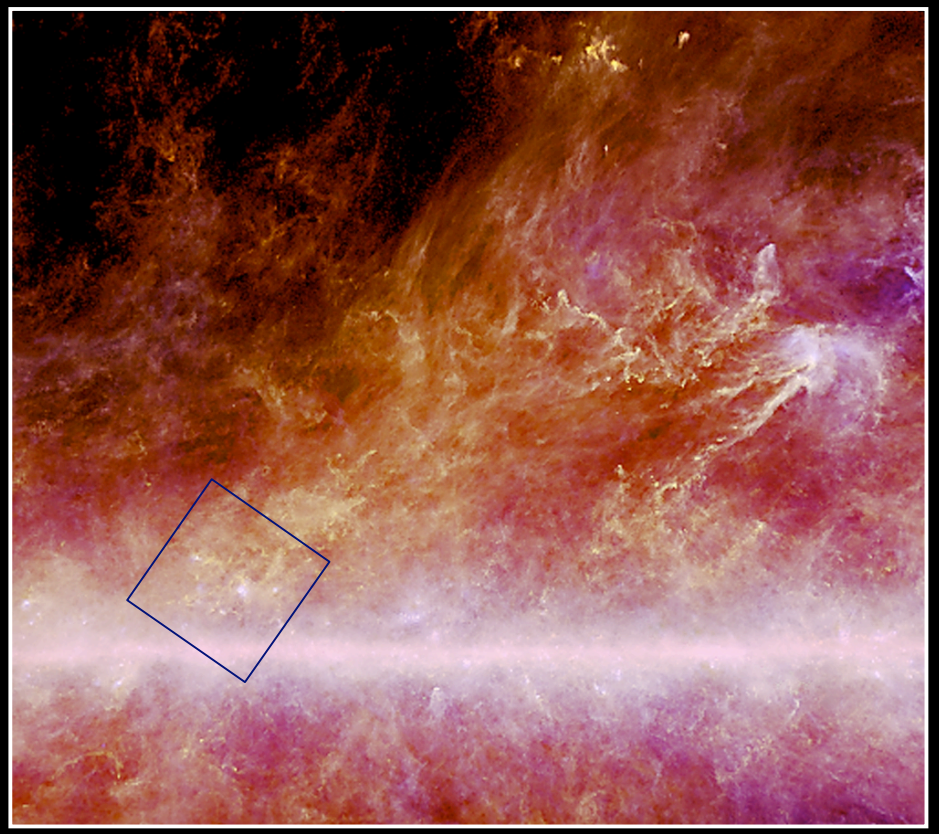


The Aquila Rift / Serpens region

as part of the Gould Belt key programme (André et al.)
Talk on Monday and André et al. (2010)



2MASS extinction map - Bontemps et al.

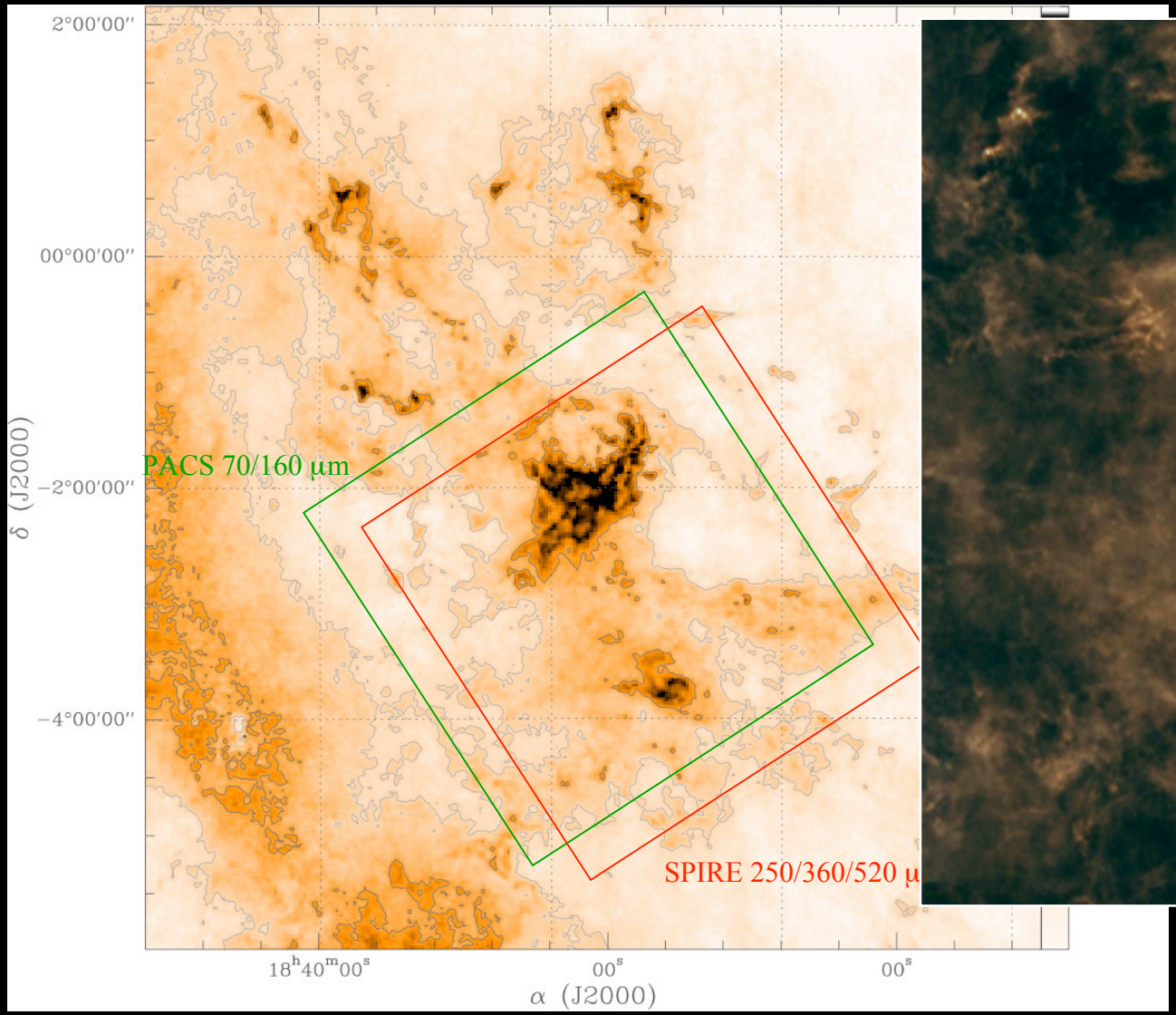


ESA Press Release - Planck consortium

Cloud complex	Area (deg^2)	Distance (pc)	IRAS B_{100} (MJy/sr)	(1σ) Cirrus Noise at 250μm (mJy/beam)	Required $rms_{250\mu}$ (mJy/beam)	(10σ) Mass Sensitivity[1] ($M_\odot$)	Required Time (hr)
Taurus	20	140	35	10	20	0.02	19.5
Taurus	5	140	35	10	10	0.01	19.5
Ophiuchus	10	140	80	35	20	0.02	9.7
Pipe Nebula	3	140	80	35	20	0.02	2.9
Polaris flare	4	150	10	3	10	0.01	15.6
Lupus	3	100	50	15	20	0.01	2.9
Coalsack	1.5	150	150	90	20	0.02	1.5
Cham I/III + Musca	4	160	20	5	10	0.01	15.6
Corona Australis	3	170	30	10	10	0.01	11.7
Serpens/Aquila Rift	25	260	70-150	30-90	20	0.07	24.3
Perseus	4	300	20-50	5-15	10	0.04	15.6
IC 5146	1	400	90	25	20	0.15	1.0
Cepheus flare	20	440	20	5	20	0.2	19.5
Orion (A+B)	20	450	75	20	20	0.2	19.5

Target list - Gould Belt survey

- 200' x 200' scan map in **parallel mode** at 60"/sec.
- A nearby complex at **260 pc**; **3.1 x 10^4 $M_\odot$**



pc

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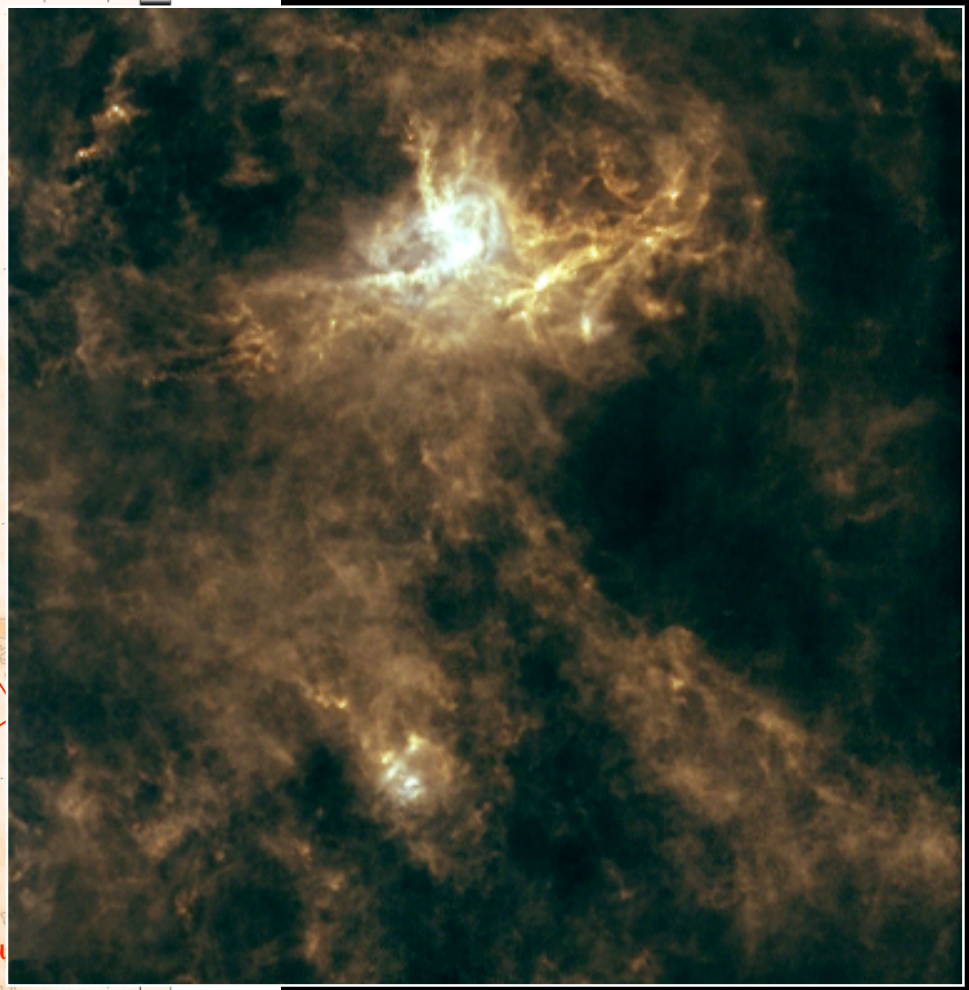
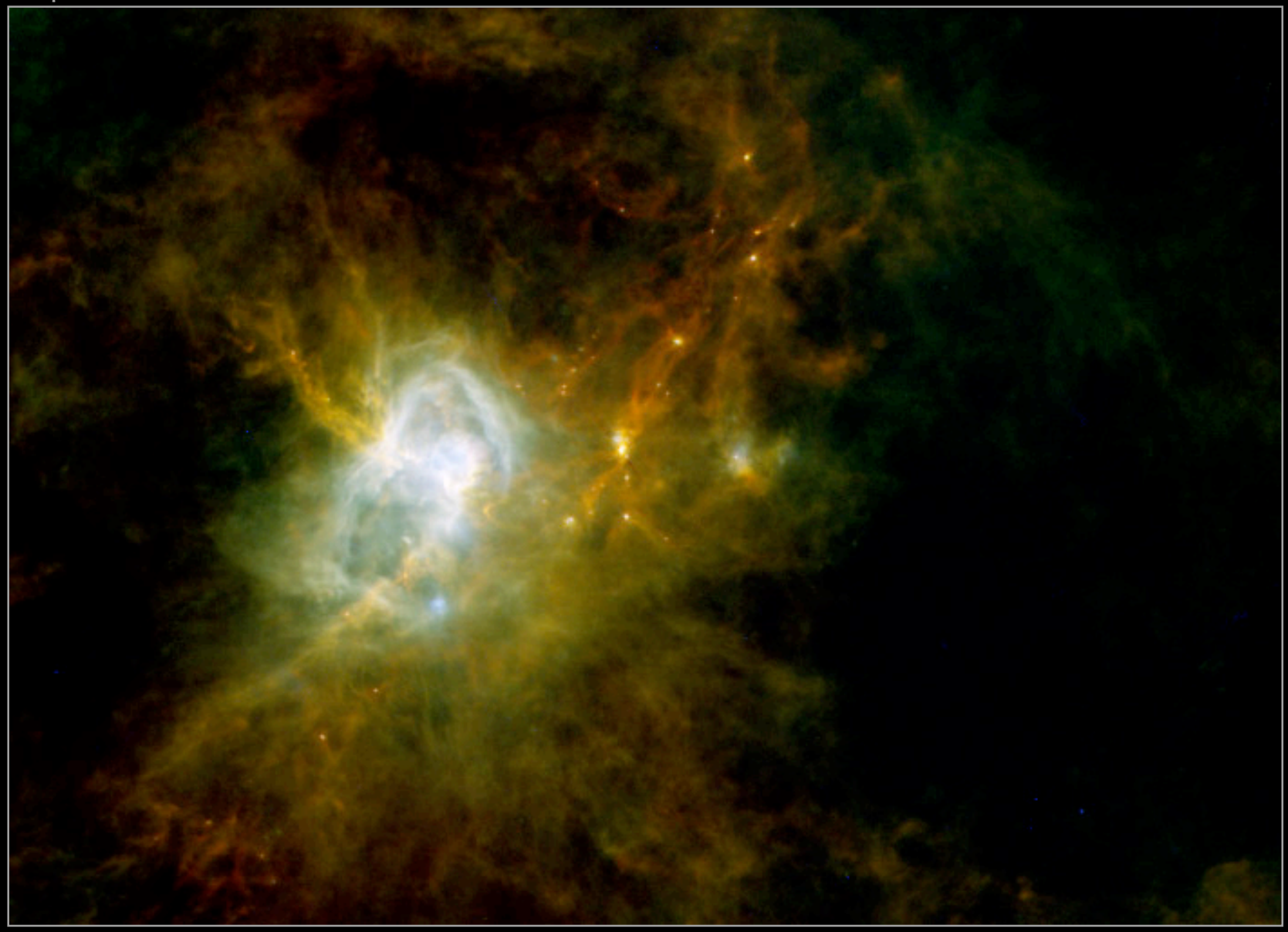


SPIRE 250, 350, 500 μm

Details in Könyves and André talks

Aquila Rift - W40/Sh2-64

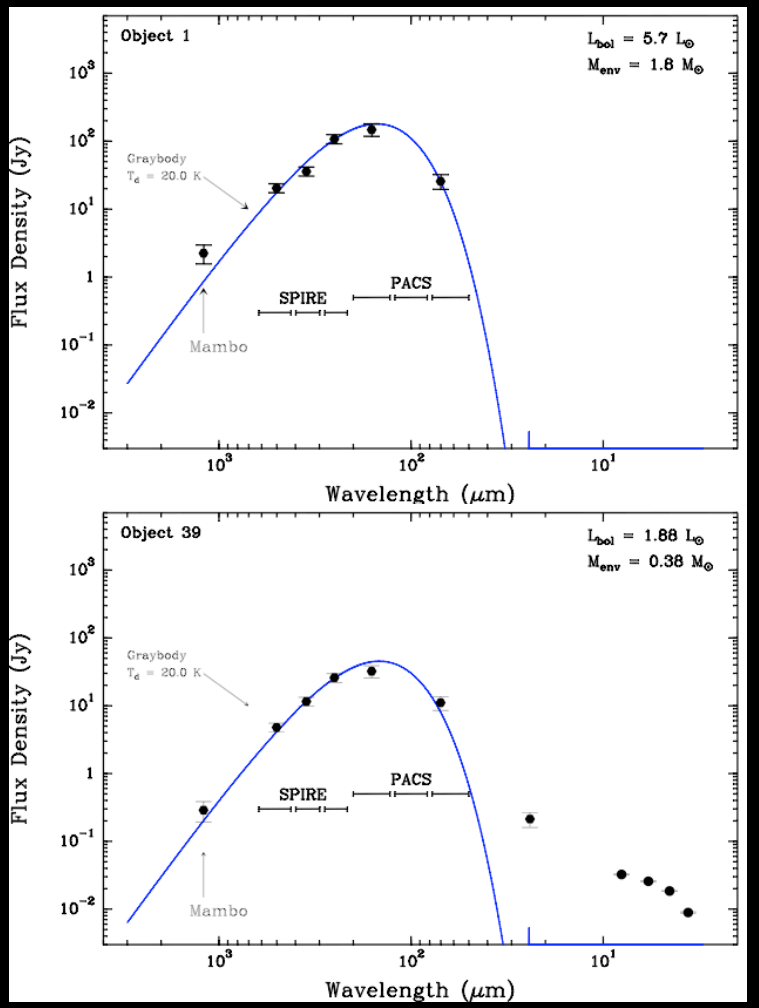


Gould Belt key programme

PACS+SPIRE 160, 250, 350 μm

How to recognize protostars?

- Systematic getsources extraction (Men'shchikov et al. 2010; Könyves's talk).
- + 24 or 70 μm point-like.
- Graybody fits of the SEDs.
- Physical sizes ~ 4000 AU (radius).
- Individual protostars resolved out.



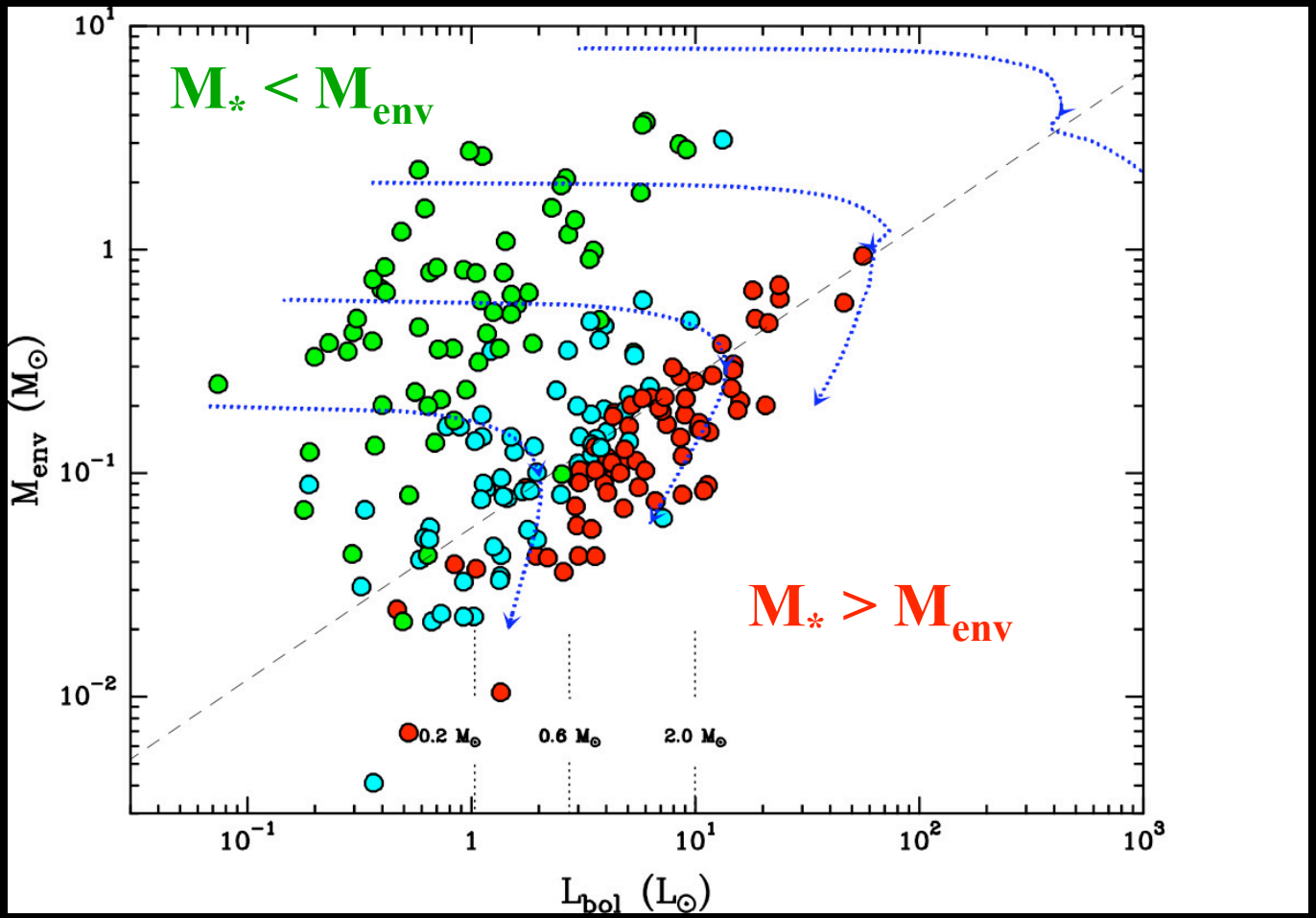
Bontemps et al. (2010) A&A special issue

Fundamental properties:

- Luminosities.
- Envelope masses.

First attempt for an evolutionary diagram

- In the whole Aquila region 201 protostars; 90% completeness at 0.2 $L_\odot$
- An evolutionary diagram with $L_{70\text{-}500\mu m}$ for the whole sample.
- $L_{>350\mu m}/L_{70\text{-}500\mu m} > 3$ % (green dots); $L_{>350\mu m}/L_{70\text{-}500\mu m} < 1$ % (red dots). to discriminate Class 0 from Class I YSOs (see André et al. 2000).



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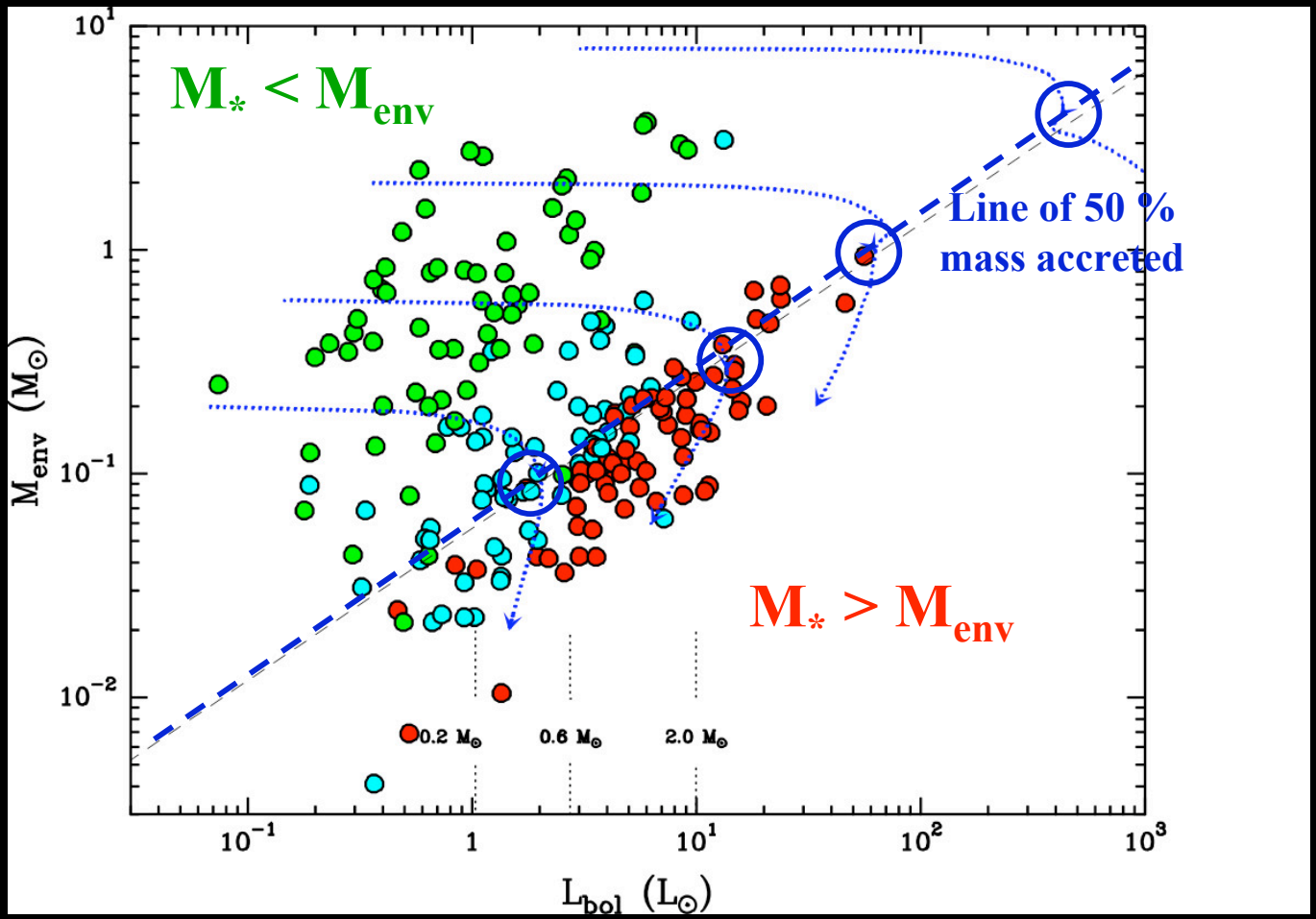

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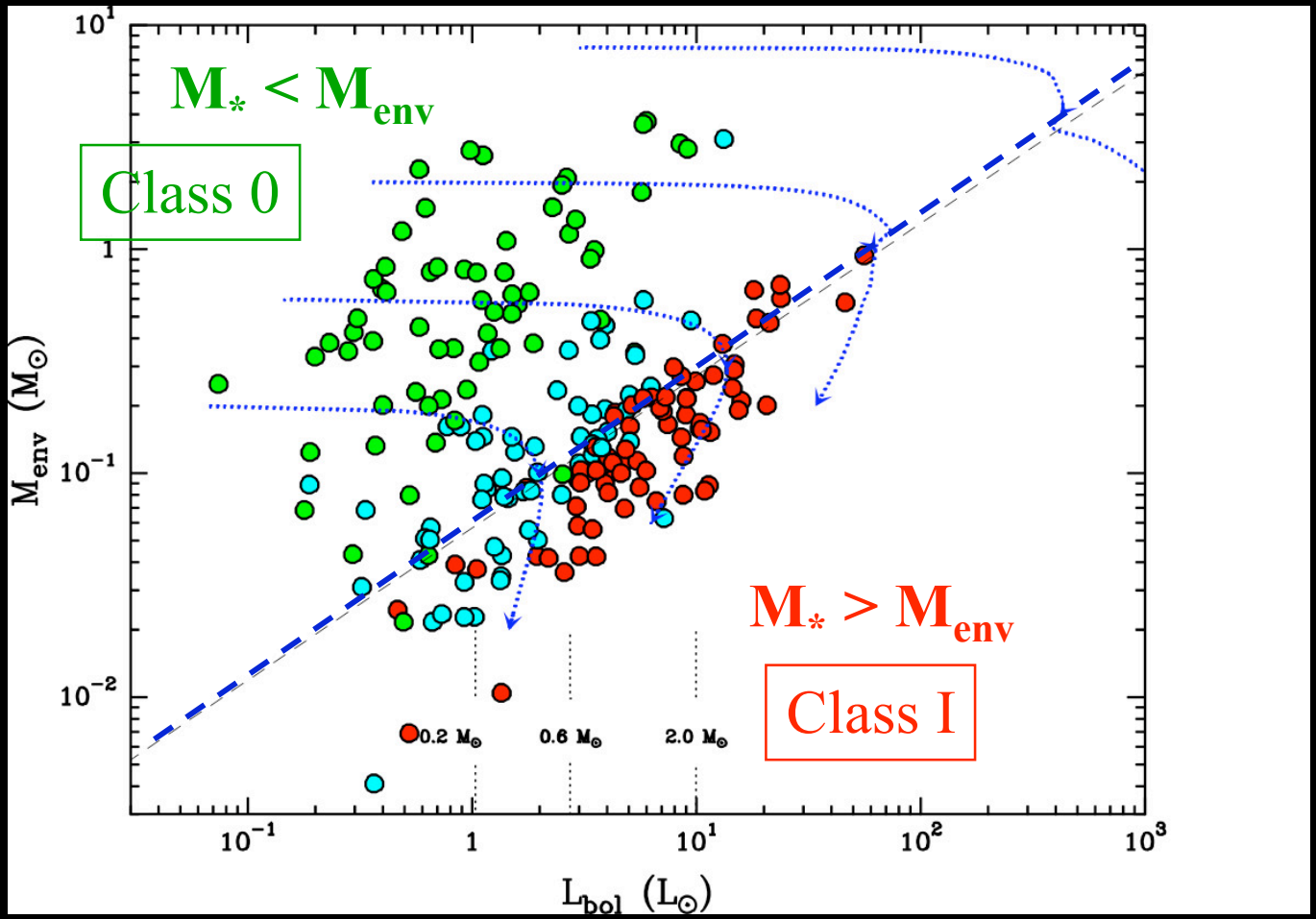

45 - 60 Class 0s

Bontemps et al. (2010) A&A special issue

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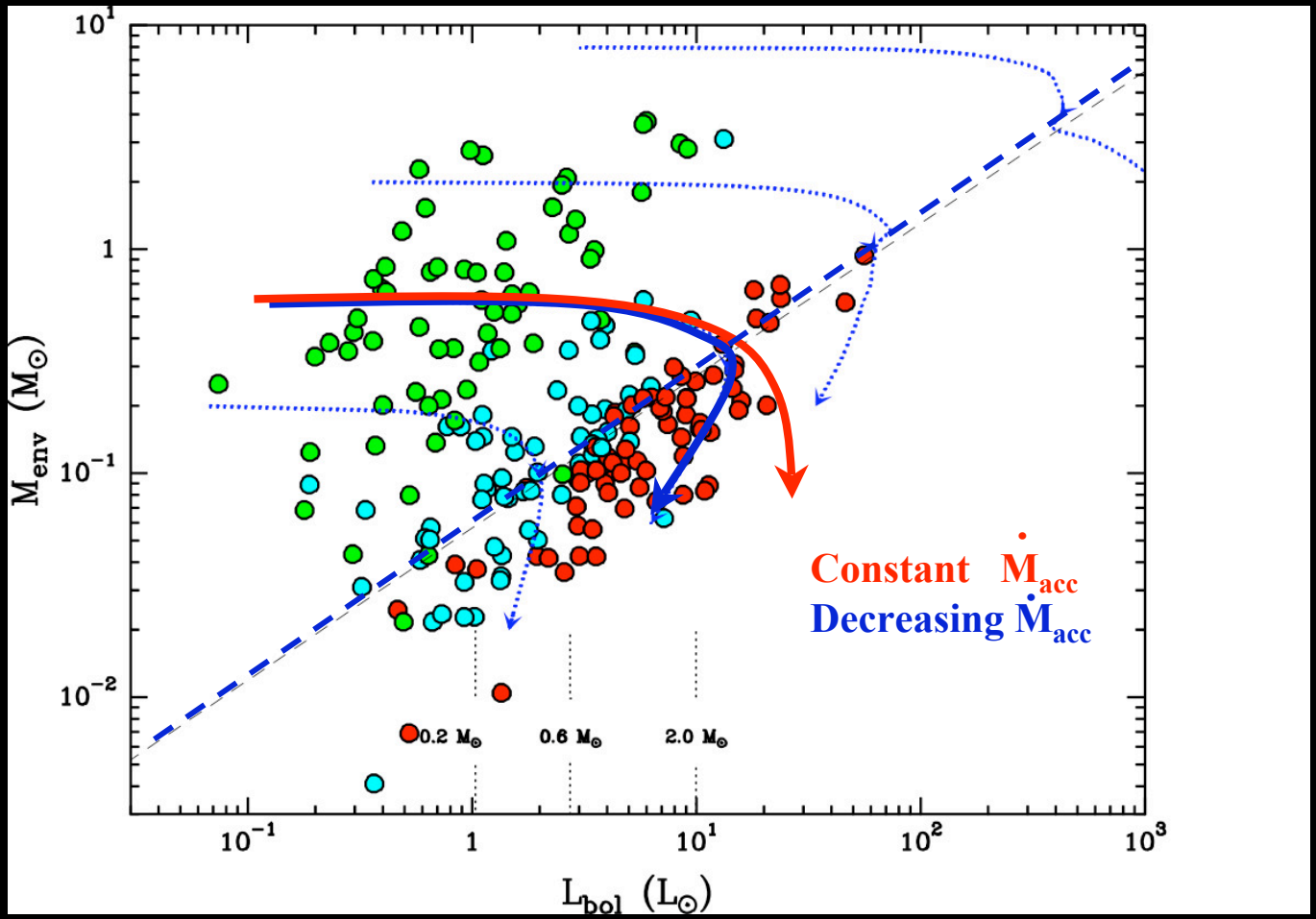


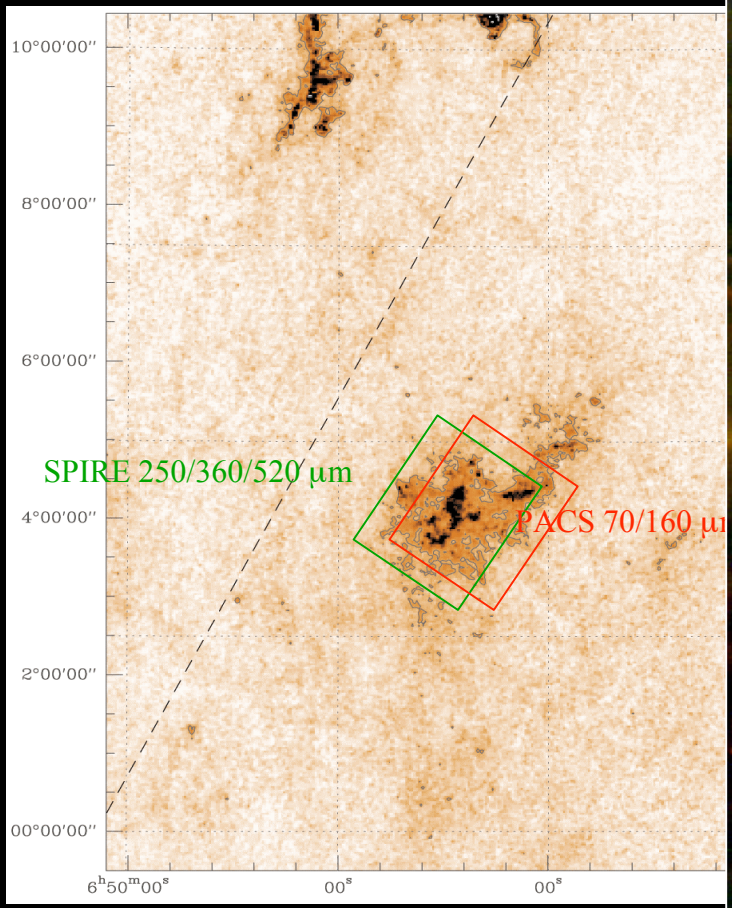
Bontemps et al. (2010) A&A special issue

The Rosette Molecular Cloud:

- 60' x 80' scan map in parallel mode at 20"/sec.
- More distant cloud at 1600 pc; 3.5 x 10^5 $M_\odot$

as part of HOBYS (Motte et al.)
Talk on Friday and Motte et al. (2010)

Higher mass protostars in HOBYS



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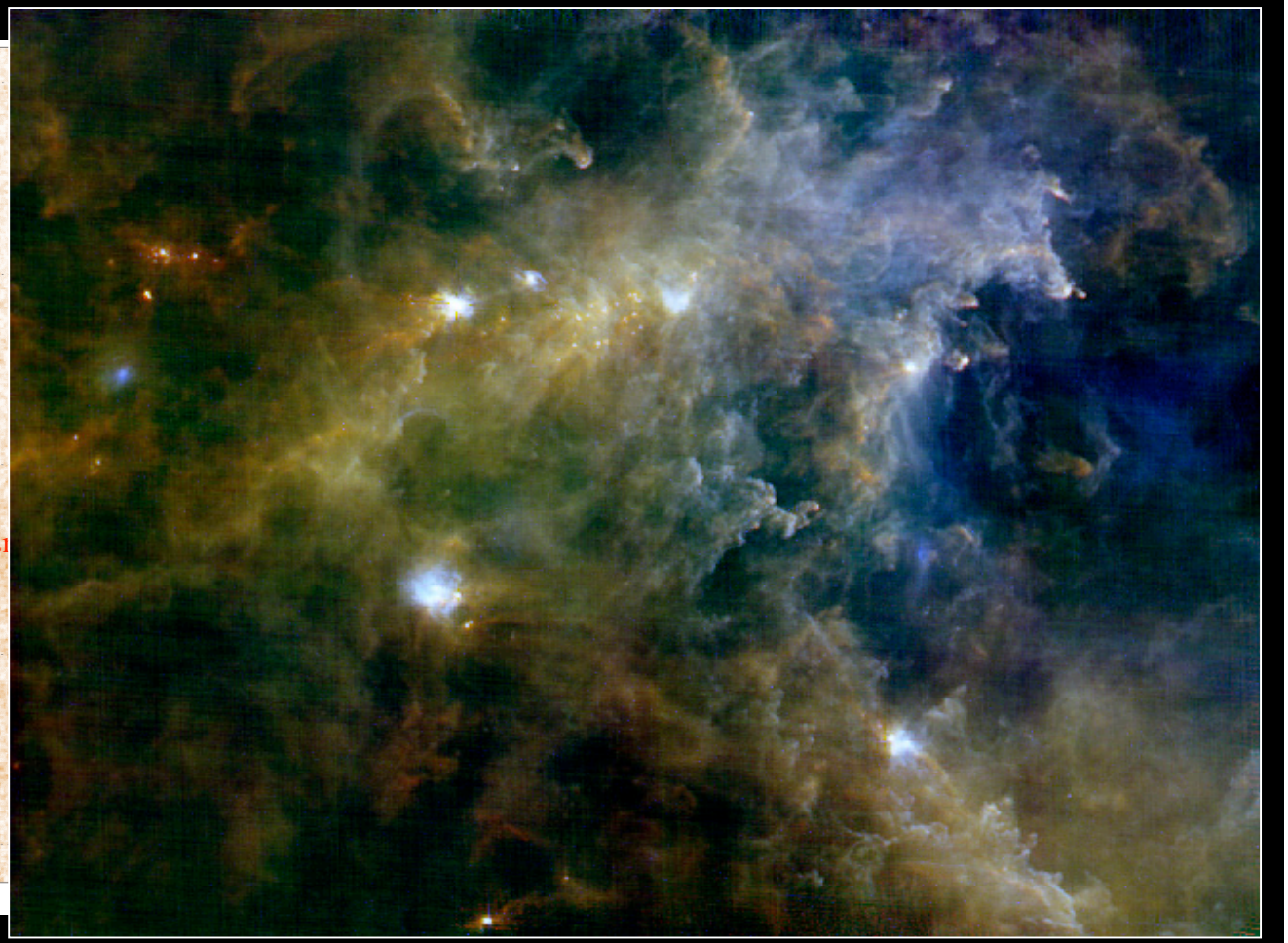
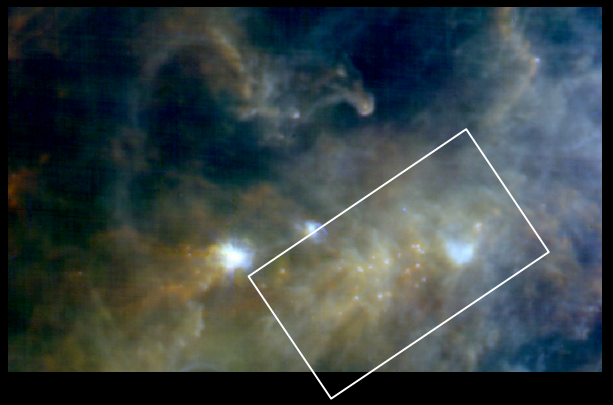


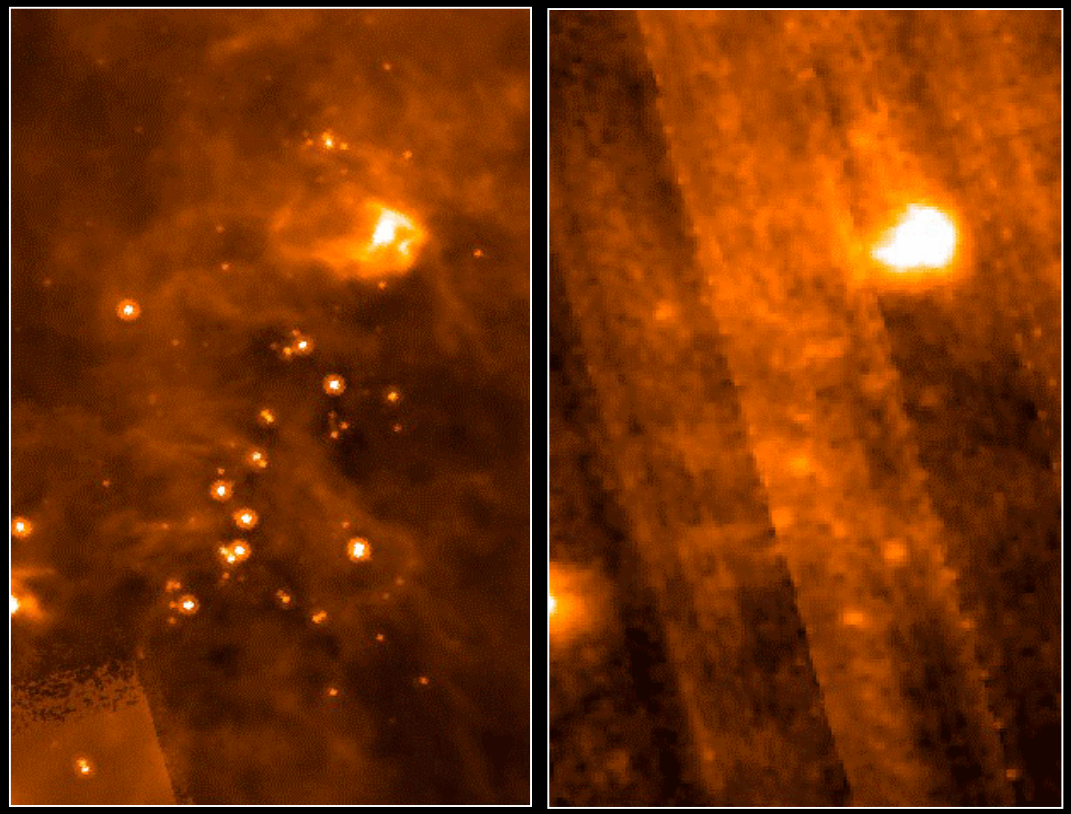
PACS + SPIRE 70, 160, 250 µm

Individual Protostars In Rosette (1.6 kpc)



Spitzer
24 μm

70 μm



0.5 pc

Rosette Molecular Cloud - HOBYS - Hennemann et al. (2010)

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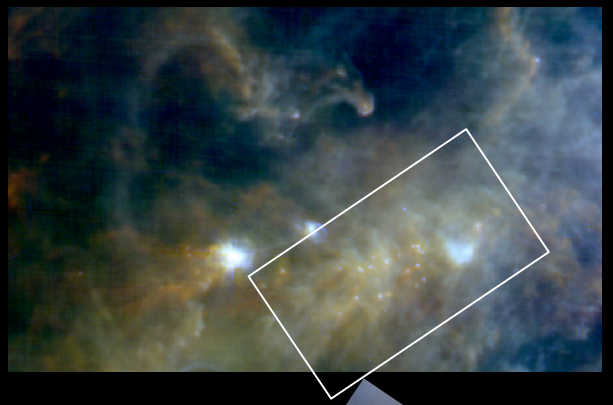
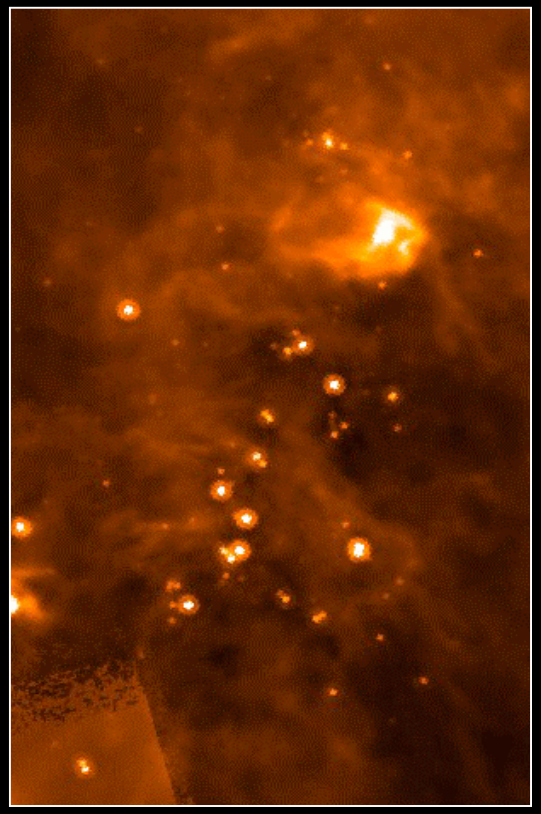
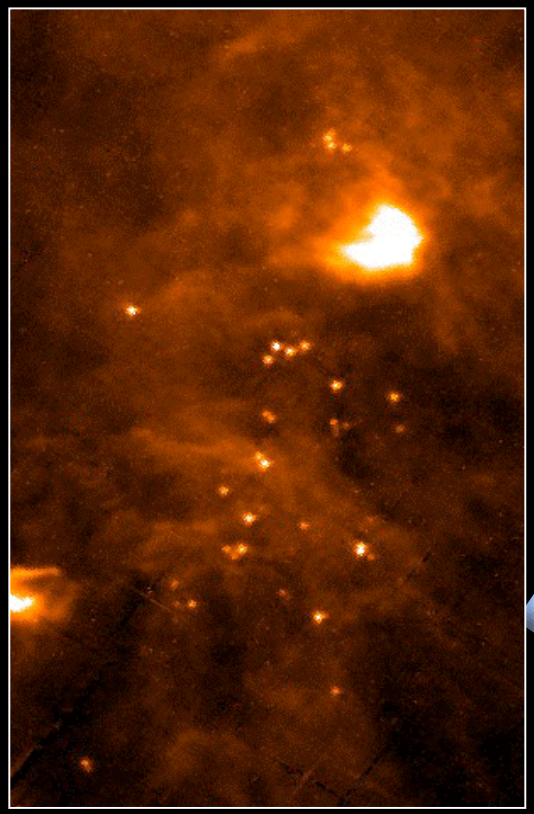


Spitzer
24 μm

Herschel
70 μm





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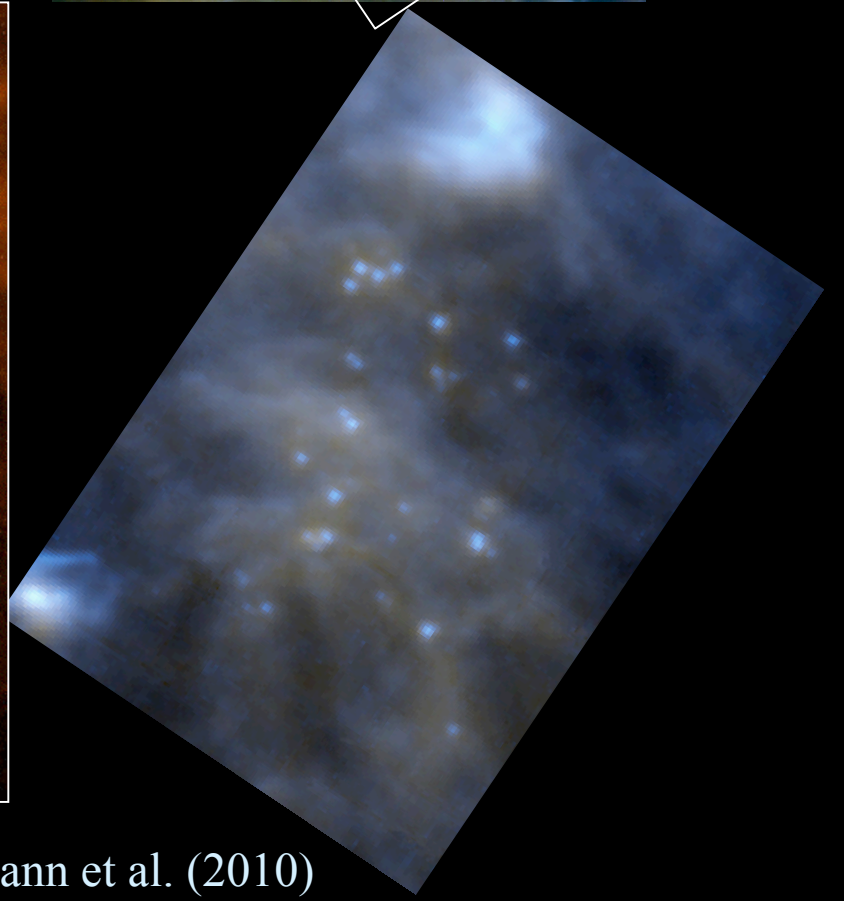
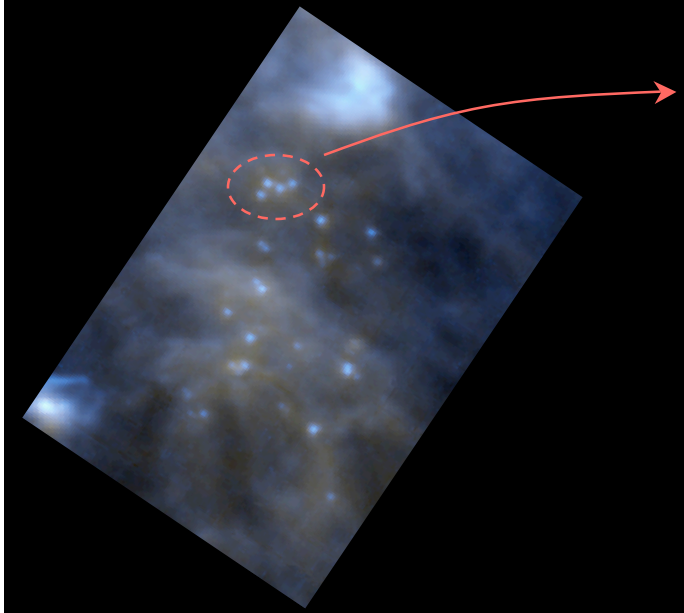
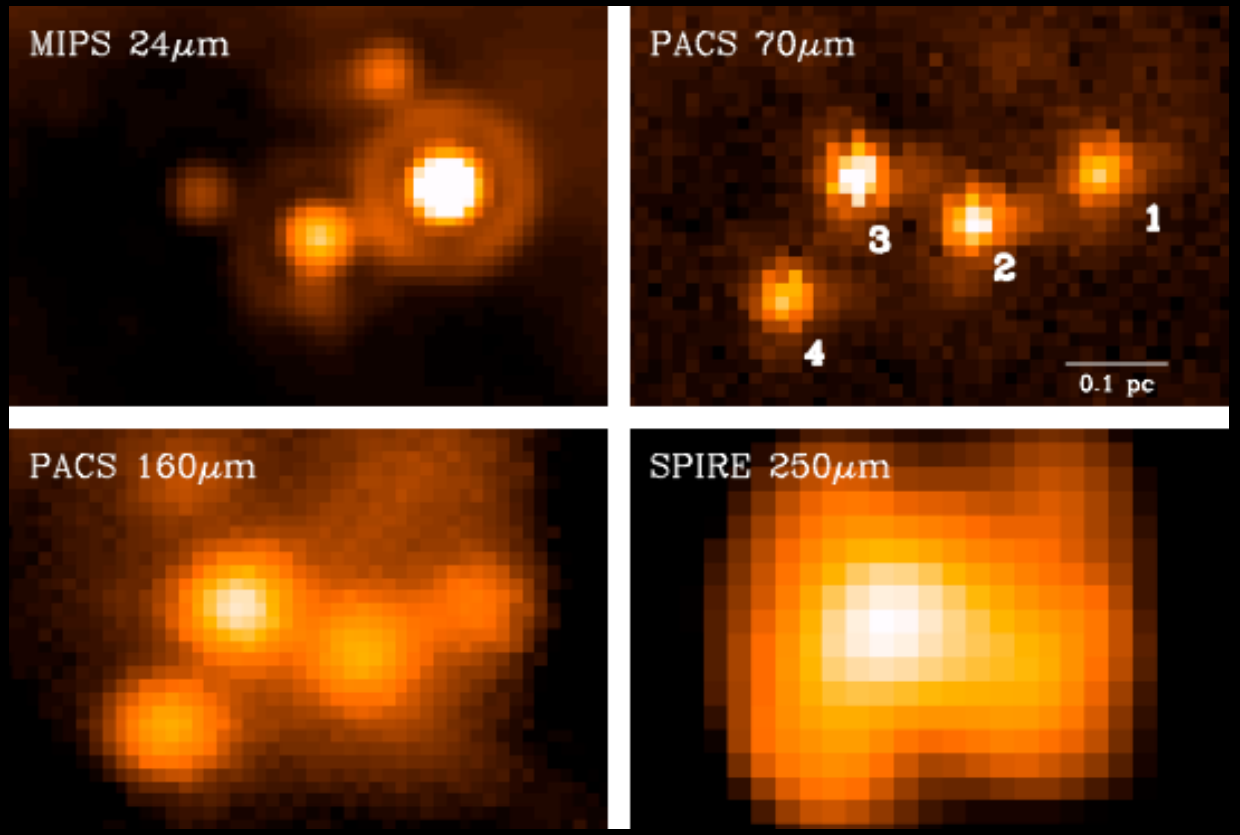


Rosette Molecular Cloud - HOBYS - Hennemann et al. (2010)

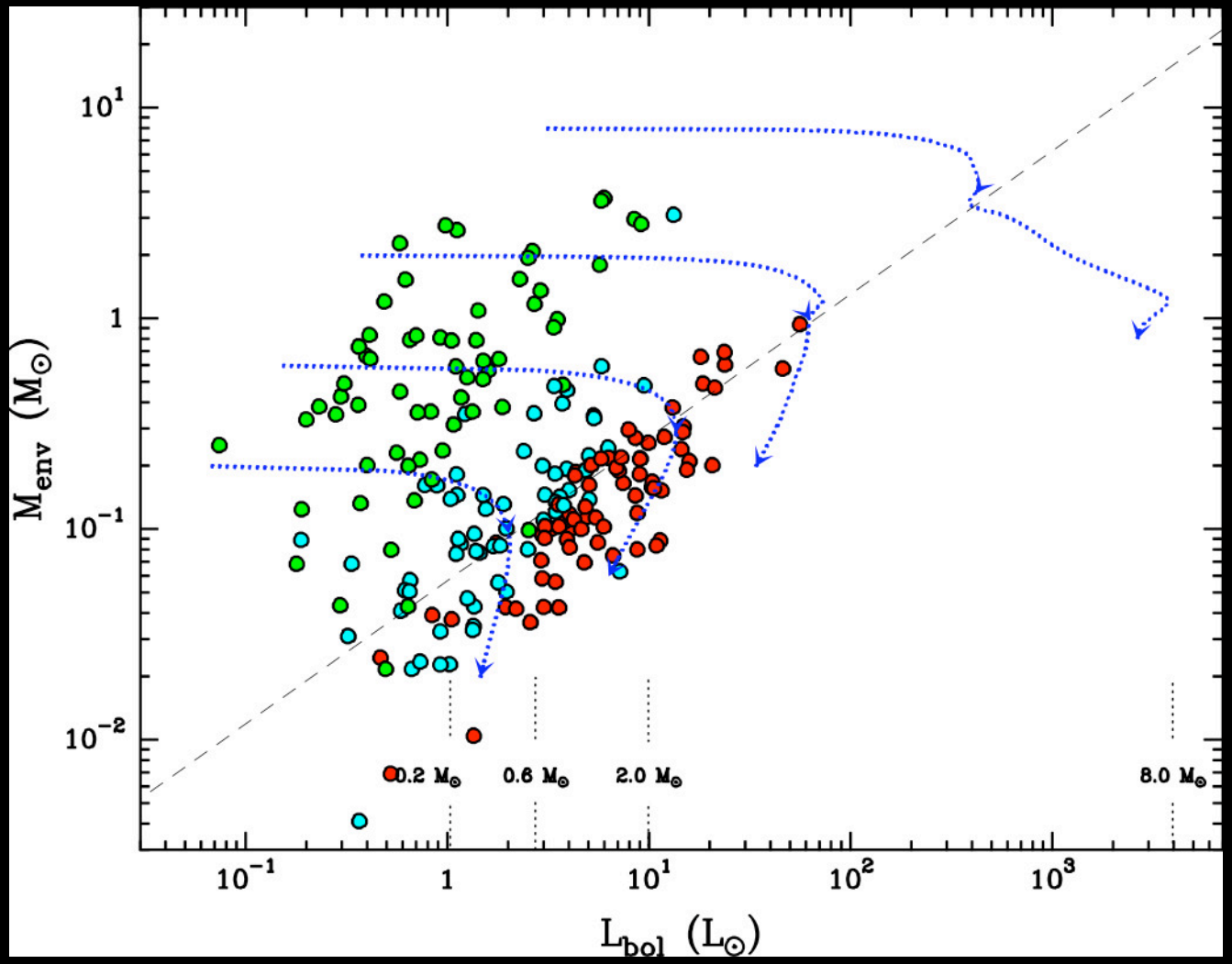
Herschel-only protostars





Rosette HOBYS - Hennemann et al. (2010)

Statistics towards high-mass stars in HOBYS



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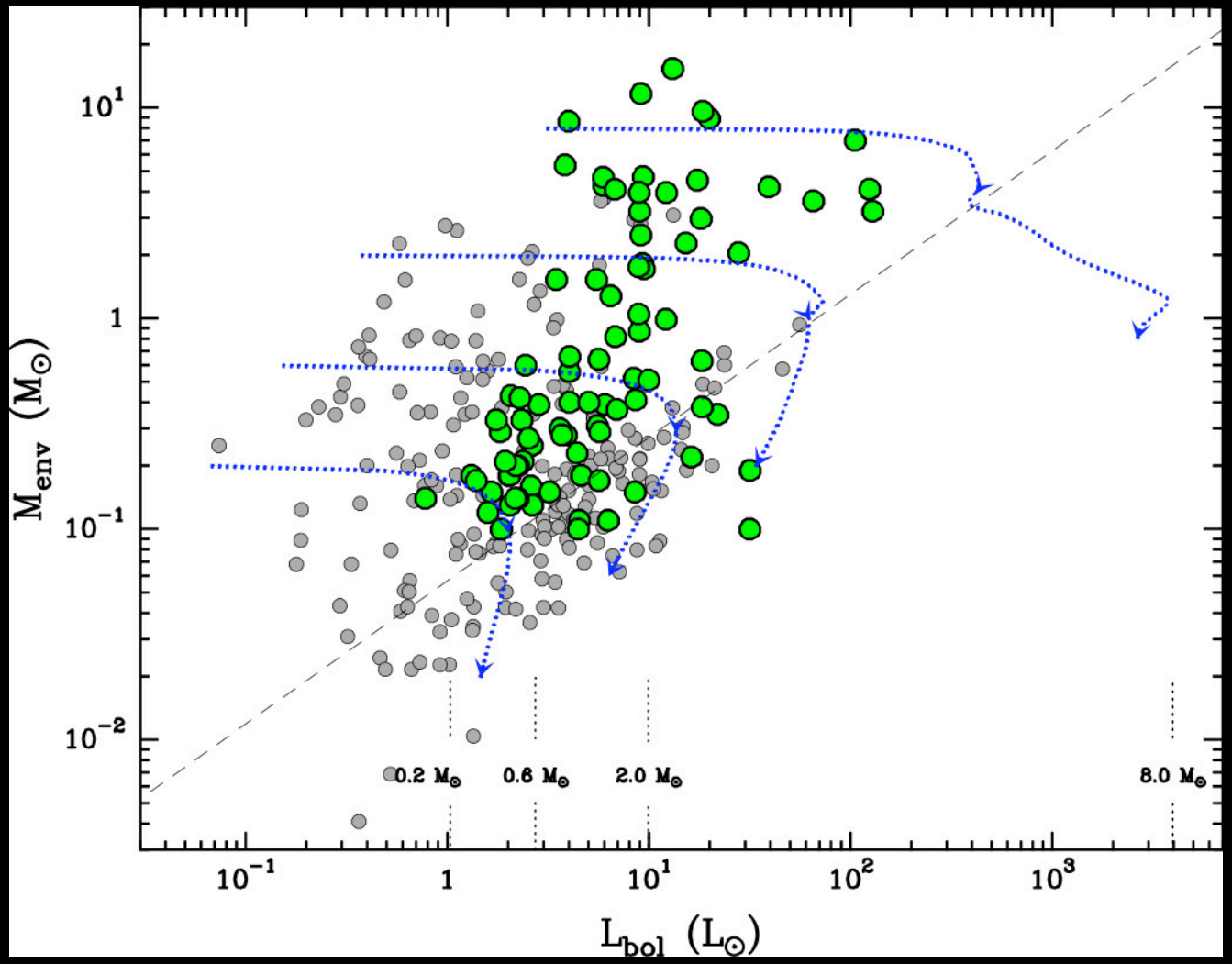
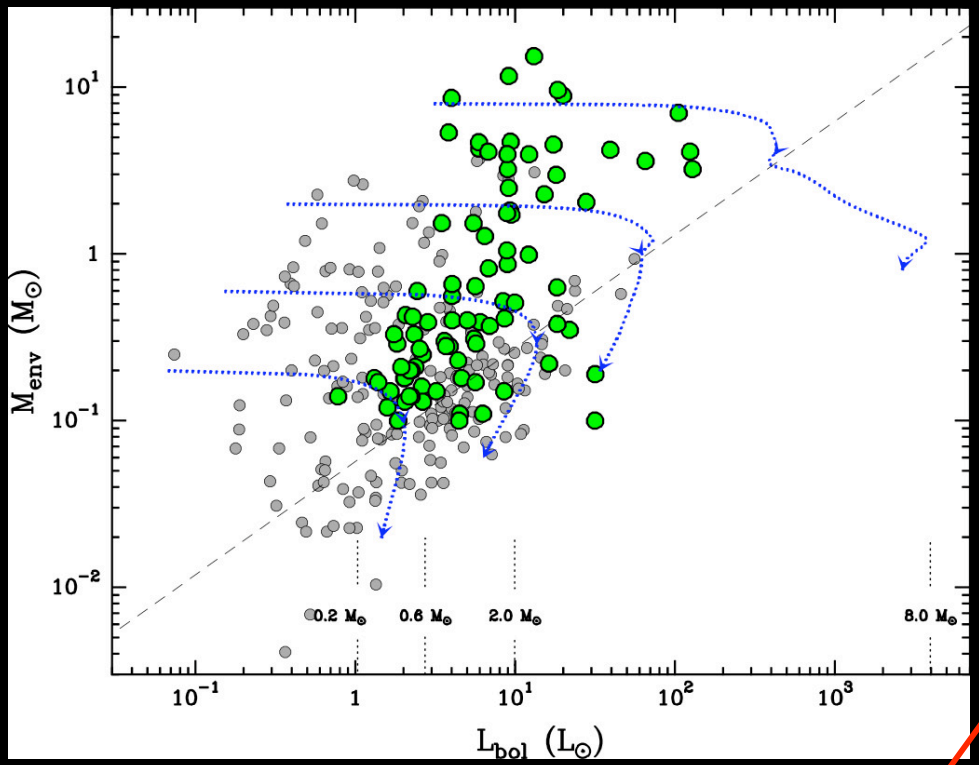
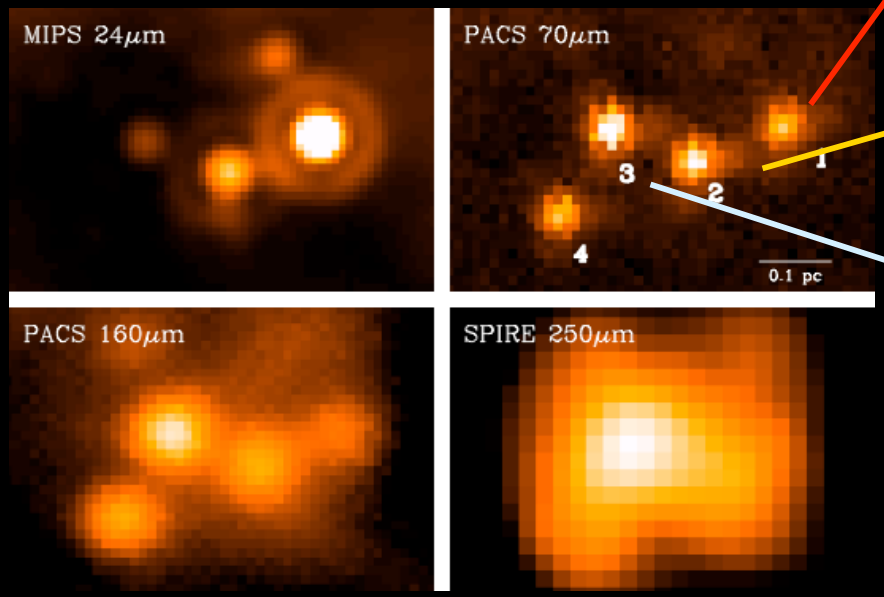
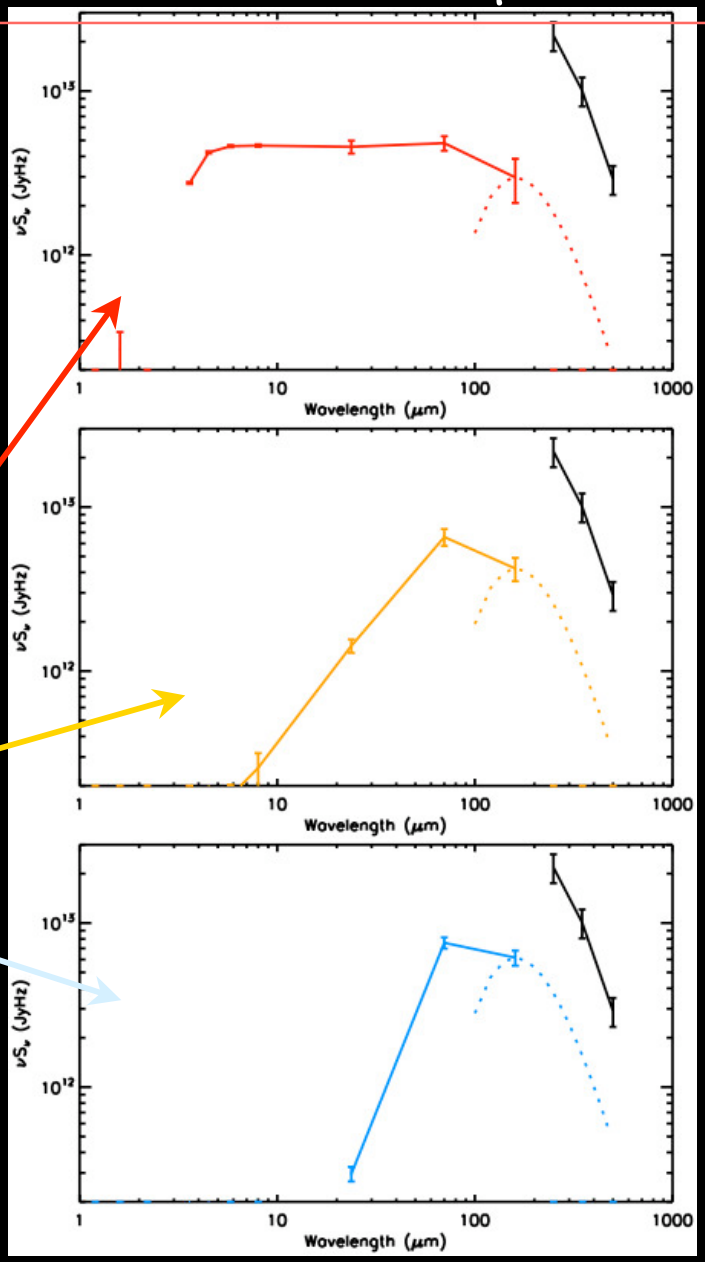


Hennemann et al. (2010) and see his poster.

Unresolved protostars for λ > 160 μm

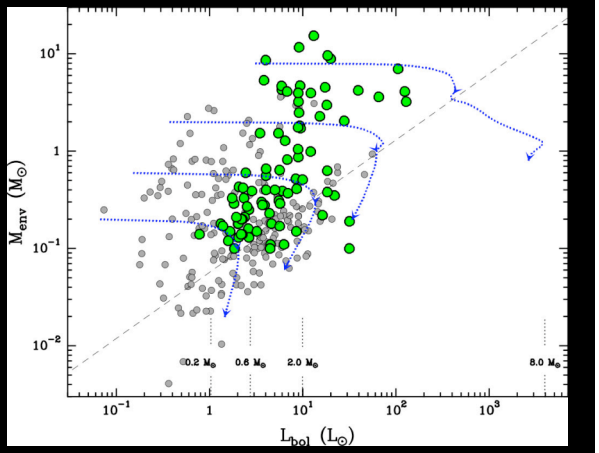






Conclusions

- A large number of protostars.
- Individual protostars in nearby regions.
- Between 45 and 60 Class 0s in Aquila
- Hundreds expected in the whole survey.



- Herschel-only protostars discovered.
- Huge statistics to constrain models.
- Decreasing accretion rate?
- ~50 Class 0s, 200 protostars, 550 PSCs…

… many thanks to the
Herschel teams for the wonderful telescope
the SPIRE and PACS technical teams for two great instruments.