Genesis of Low-Mass Stars and Brown Dwarfs: APEX as a piece of the jigsaw

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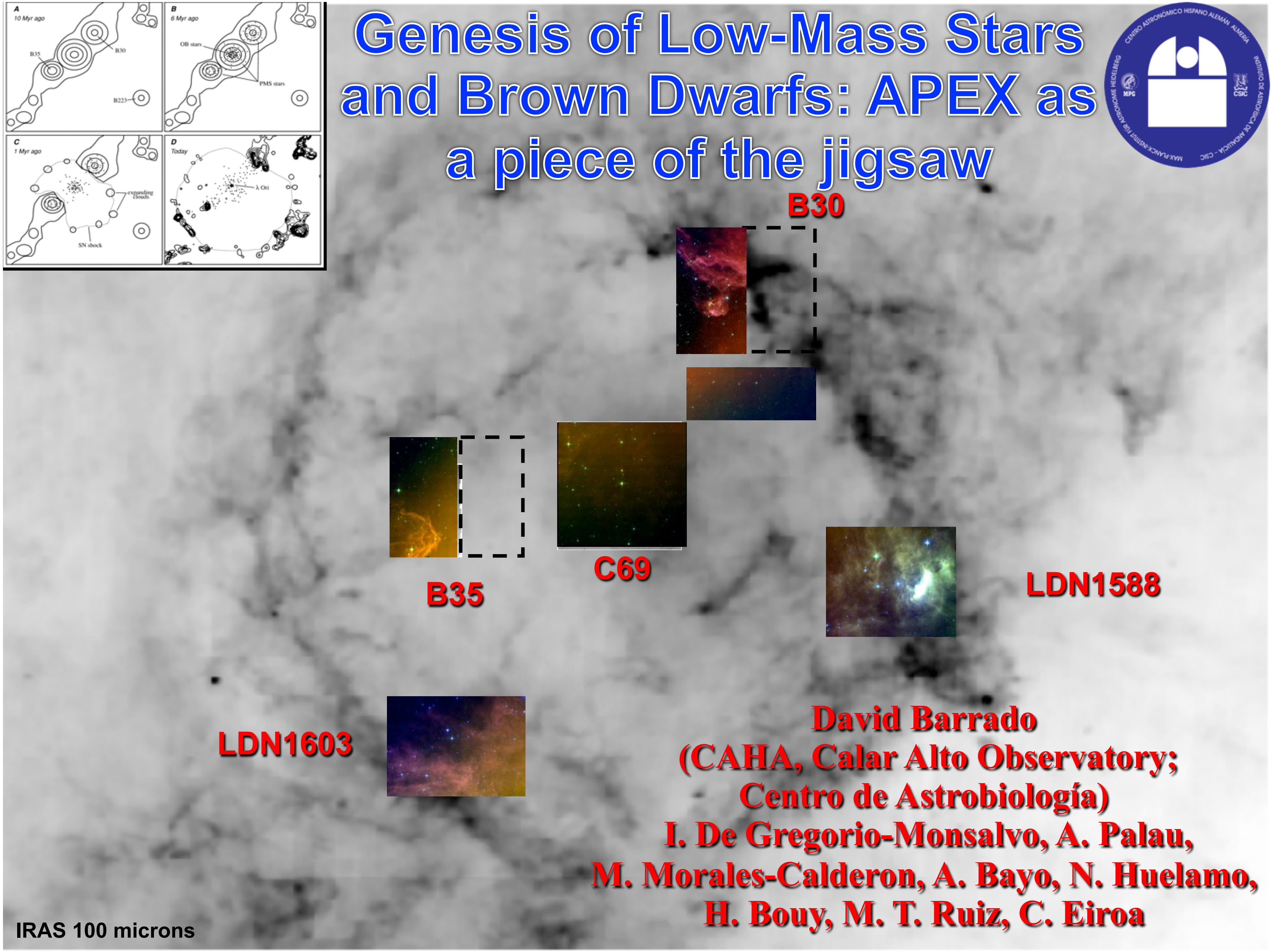
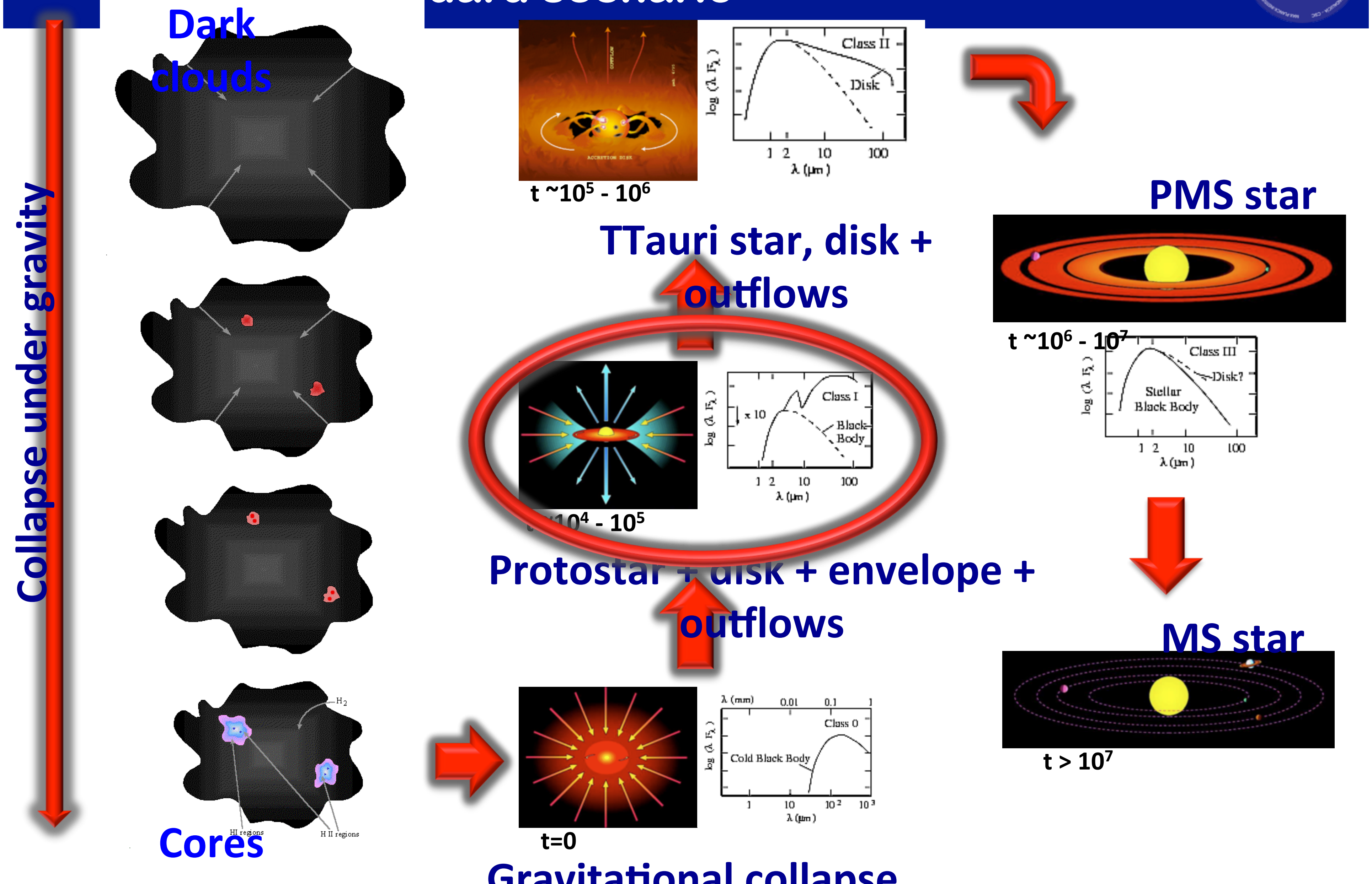
M. Morales-Calderon, A. Bayo, N. Huelamo,
H. Bouy, M. T. Ruiz, C. Eiroa



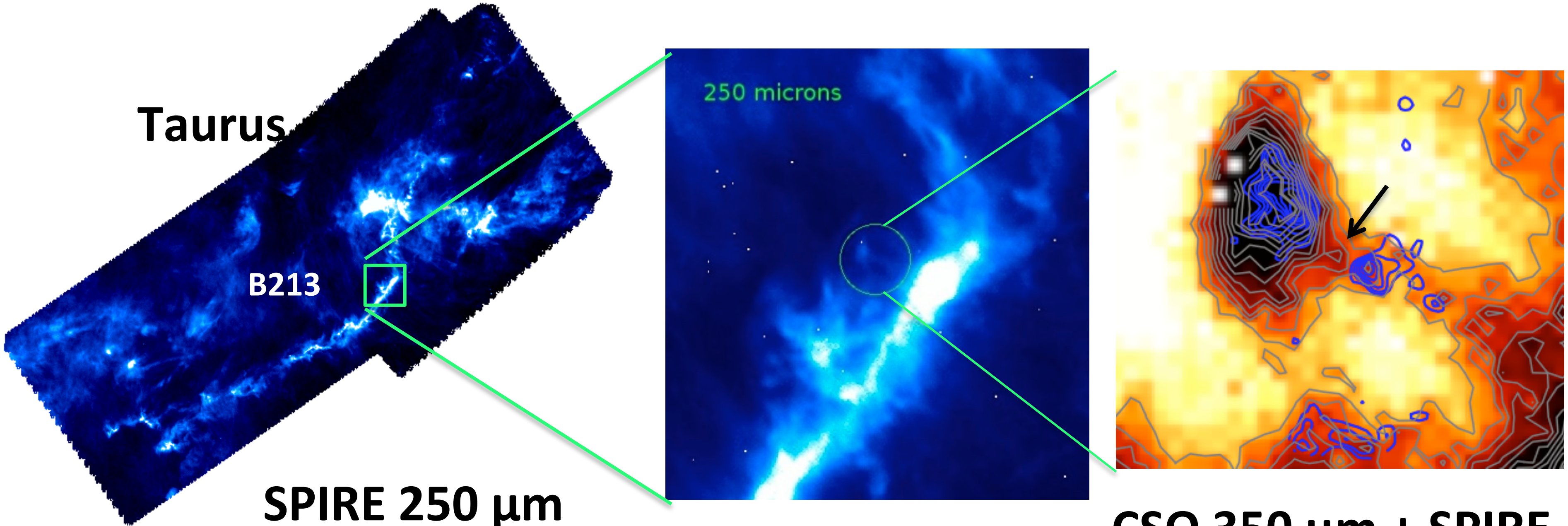
INTRODUCTION: The low-mass star formation standard scenario



The goals

- Search for brown-dwarfs “in the making”
- Environmental effects
- Try to shed some light on the formation mechanism of low-mass stars and brown dwarfs by looking at the IMF and the disk properties (looking for a Class 0/I BDs).

A Proto-BD candidate in Taurus



SPIRE 250 µm

CSO 350 µm + SPIRE

- Multiwavelength study (cm, mm, near/mid IR, optical).

- If confirmed by ALMA, it would be the lowest mass object forming in-situ

Selection criteria

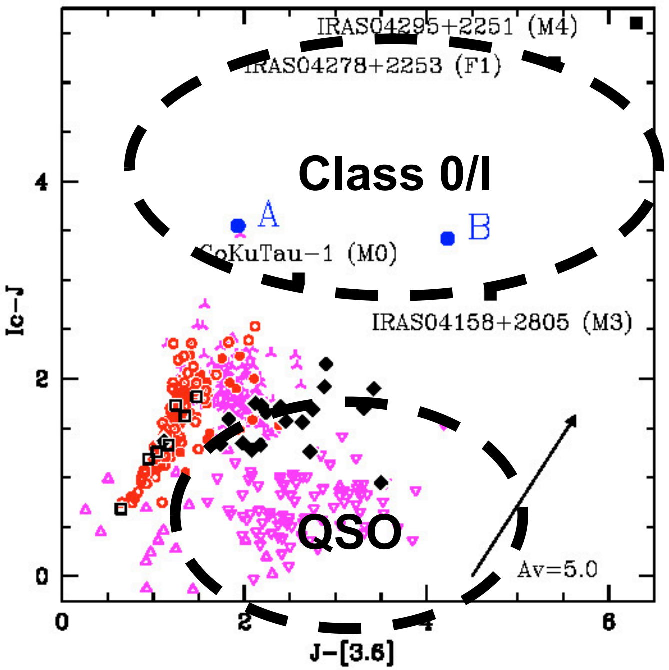
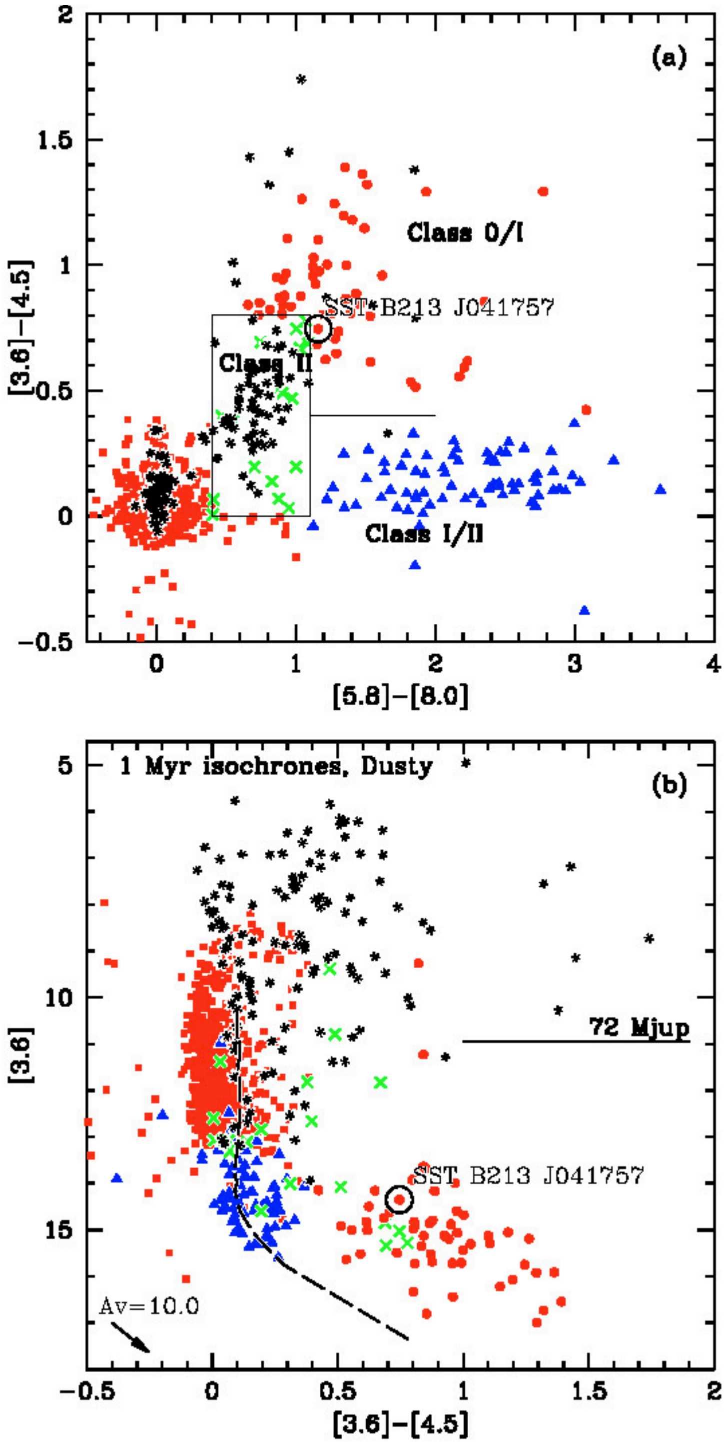
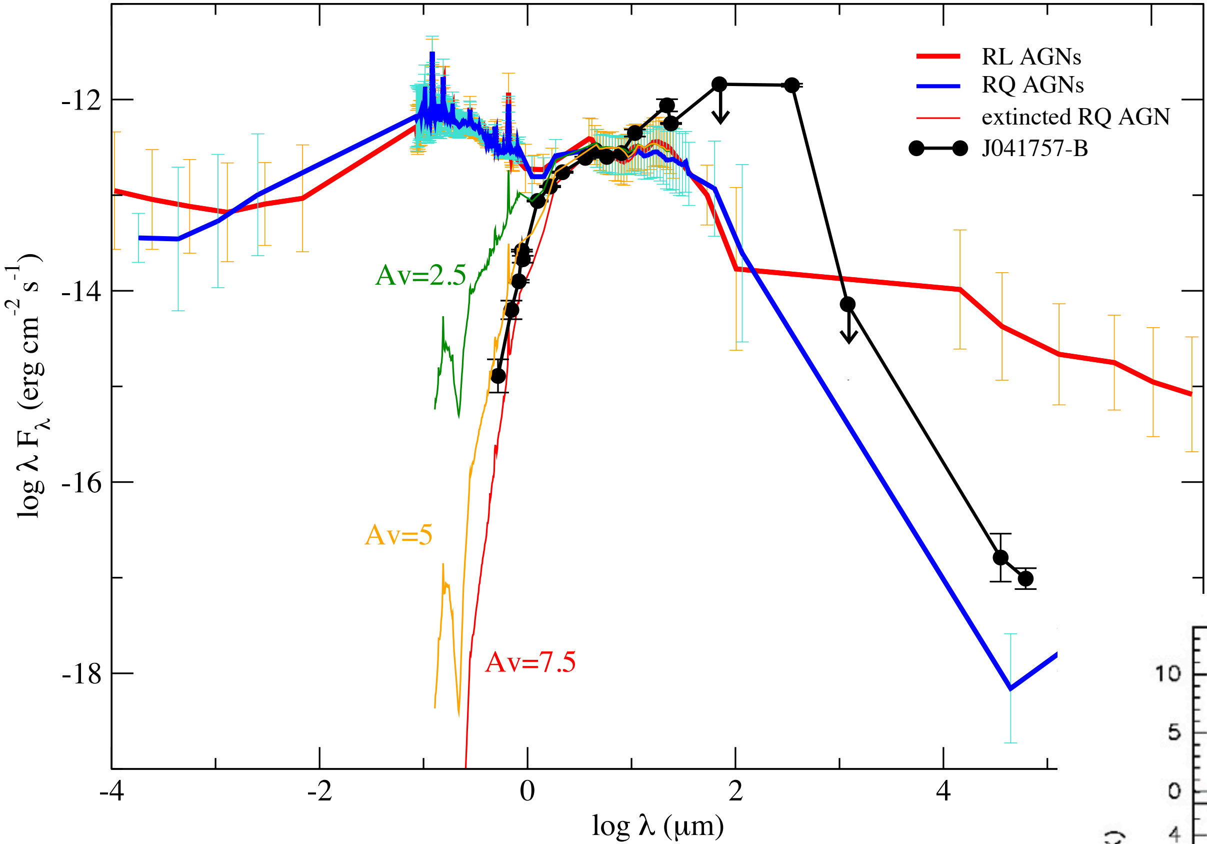


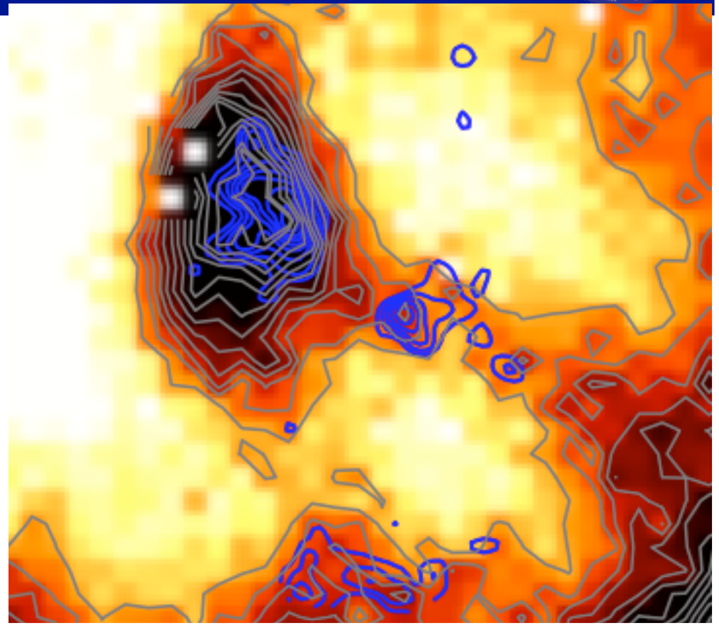
Fig. 6. Optical-infrared colour–colour diagram, after Bouy et al. (2009a). It includes quasars from SWIRE (open magenta triangles, pointing downwards; Hatziminaoglou et al. 2008); AGNs from GOODS-MUSIC (open green triangles, pointing upwards; Grazian et al. 2006); a comparison with the stellar and substellar population of the 5 Myr Collinder 69 cluster (open and solid red circles for Class III and II, respectively; Dolan & Mathieu 1999, Barrado y Navascués et al. 2007); and Taurus members (open squares, solid diamonds and solid squares (cyan) for Class III, II and I, respectively; Kenyon & Hartmann 1995, Luhman et al. 2006, and this work).

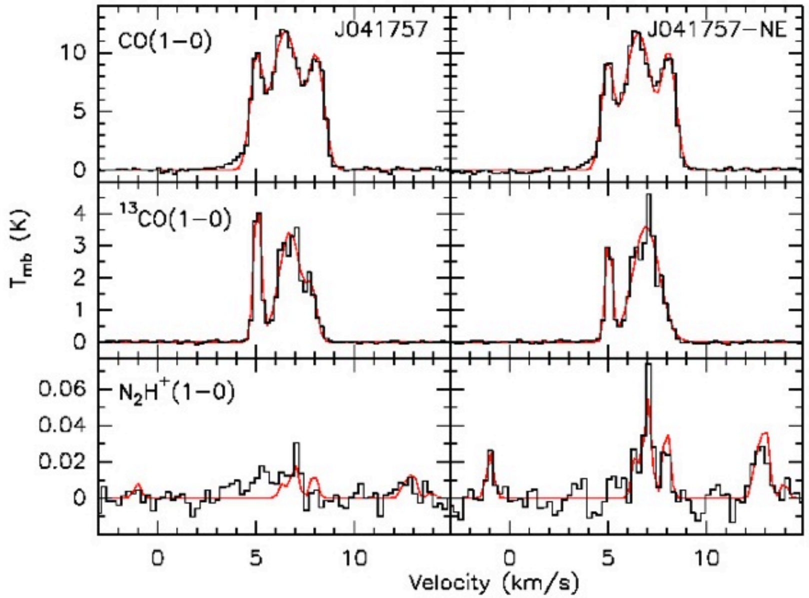
Barrado et al. 2009



A proto-BD in Taurus

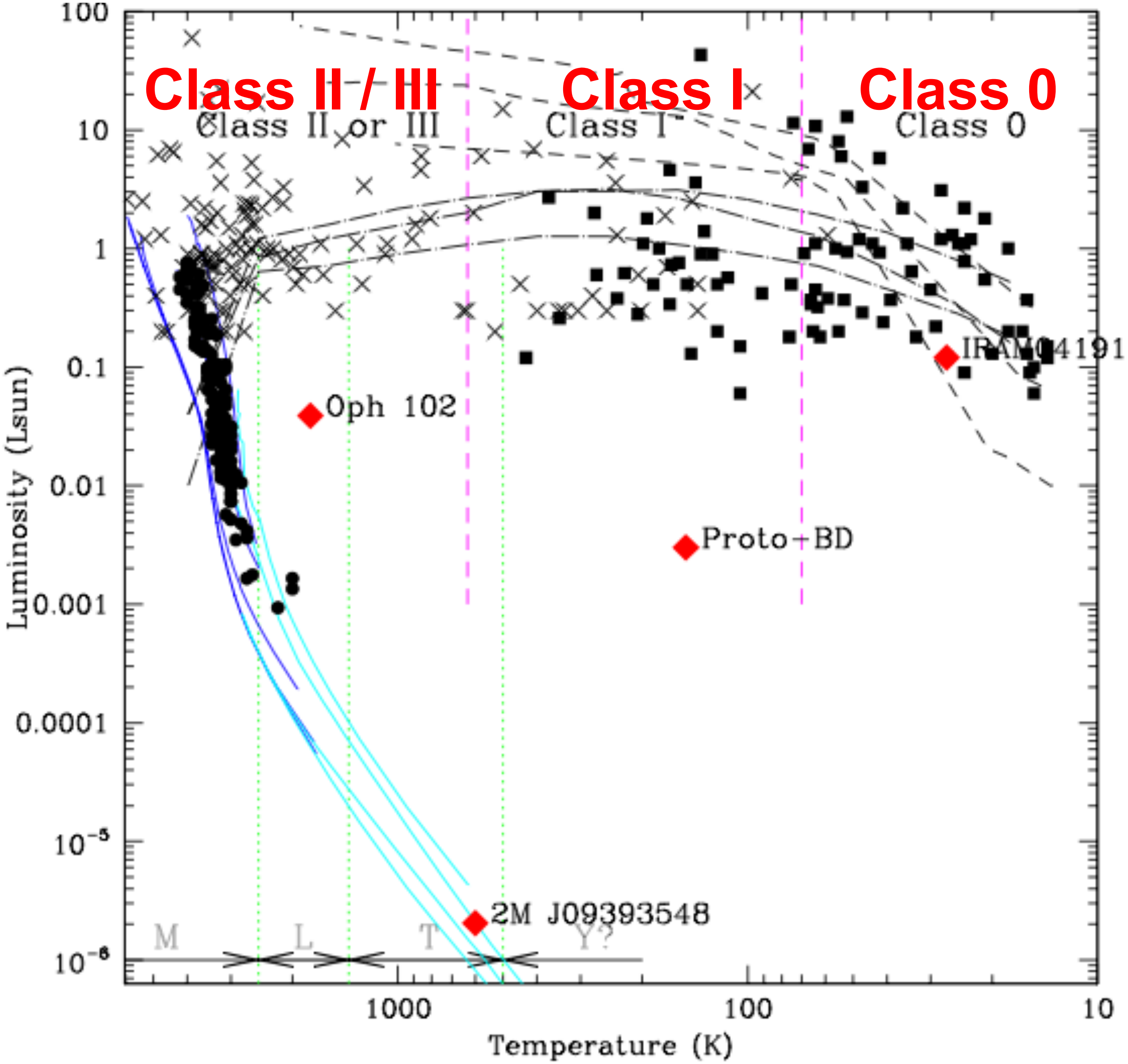




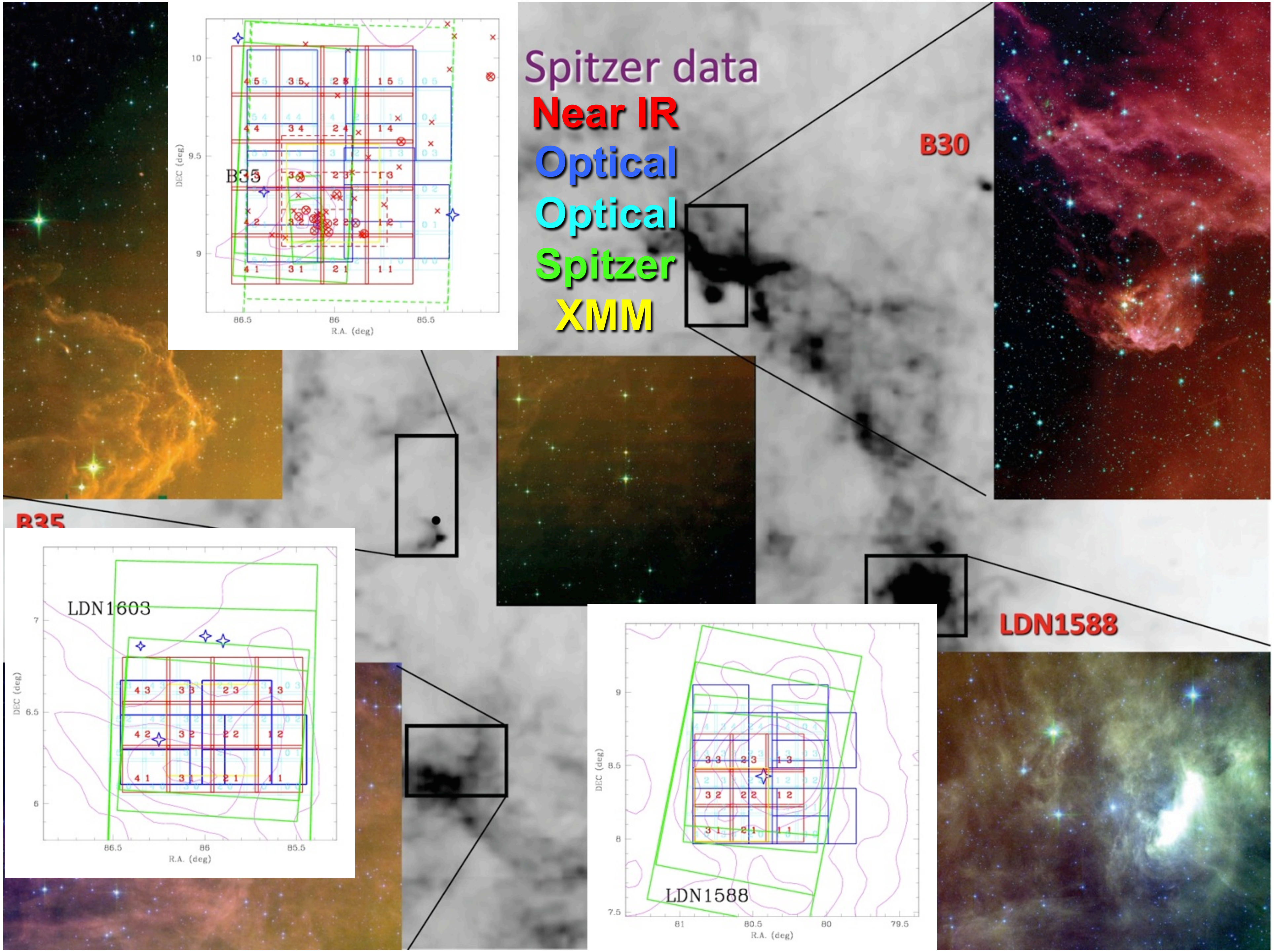


Palau et al. 2012, in prep

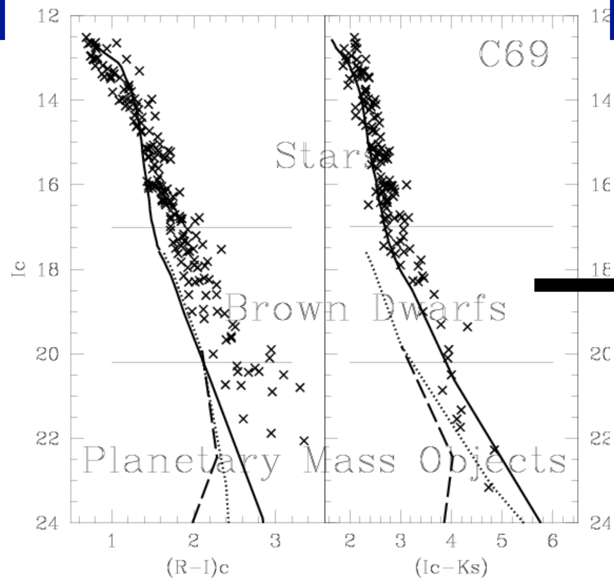
From Protostars to the Main Sequence

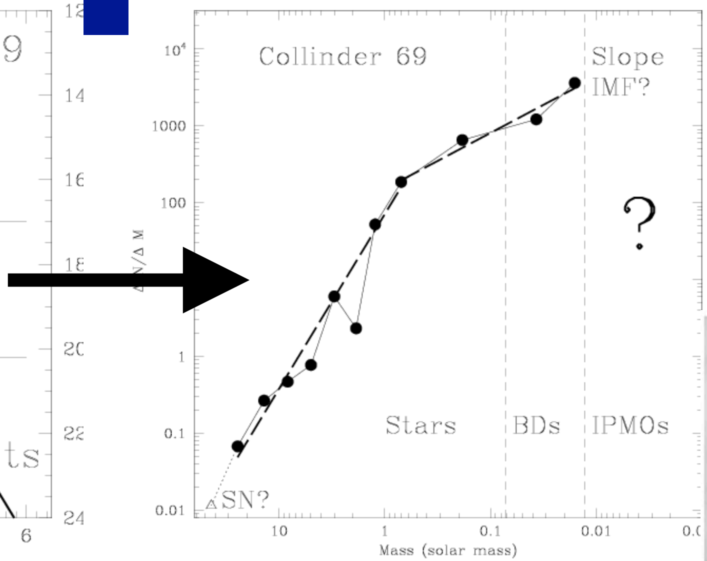


Bolometric luminosity versus the temperature. The 50 sources compiled by Durham et al., showing some evidence for being embedded low luminosity sources, are shown as solid black squares. Class 0 VeLLO IRAM04191, the proto-brown dwarf candidate B213-I1119, and the brown dwarfs Oph 102 (Class II, young) and 2M J09393548 (the extremmely cool and old) are displayed as red solid diamonds. The short-dashed and long-dashed lines show the evolutionary tracks for the three models with different masses (in solar masses). Pre- and Main Sequence models from the Lyon group are also included as solid lines (1, 10, 100, 1000, 10,000 Myr). The crosses and solid circles are data from Taurus (1 Myr) and Collinder 69 (5 Myr). The vertical dashed lines show the Class 0I and Class III boundaries, or the temperature limits for M, L, T dwarfs (and the postulated Y).

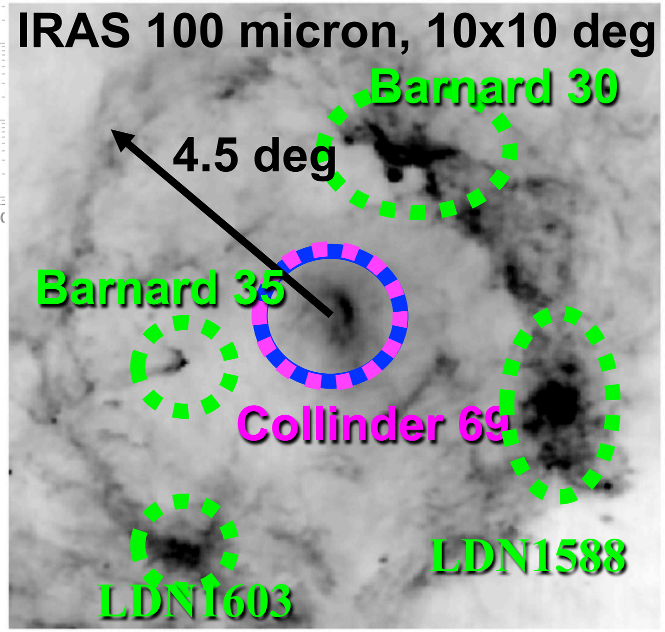

Spitzer data
Near IR
Optical
Optical
Spitzer
XMM
B30
B35
LDN1588
B35
LDN1603
LDN1588
DEC (deg)
R.A. (deg)

The Initial Mass Functions of different groups

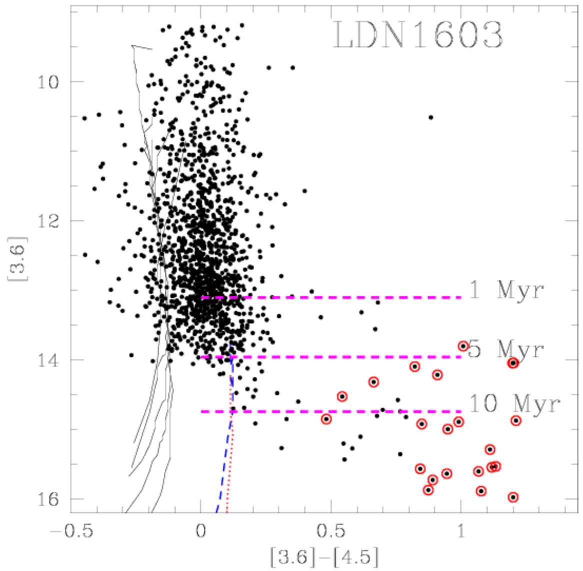


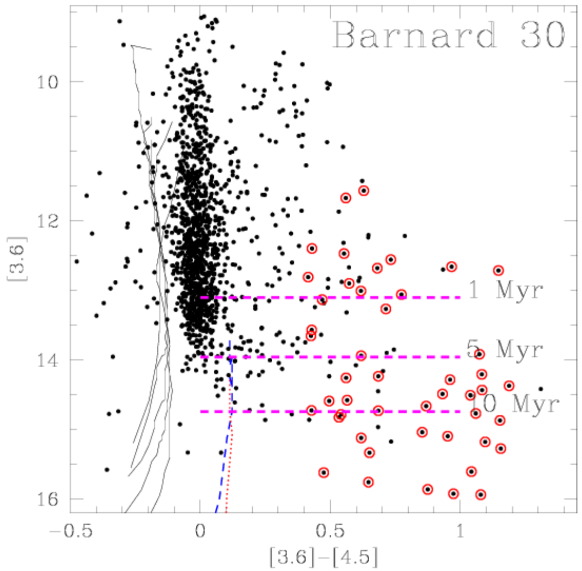


C69
- **Slope IMF?**
- **Planetary Mass?**
- **Cut-off?**



Barrado et al. 2004, 2005, 2007a

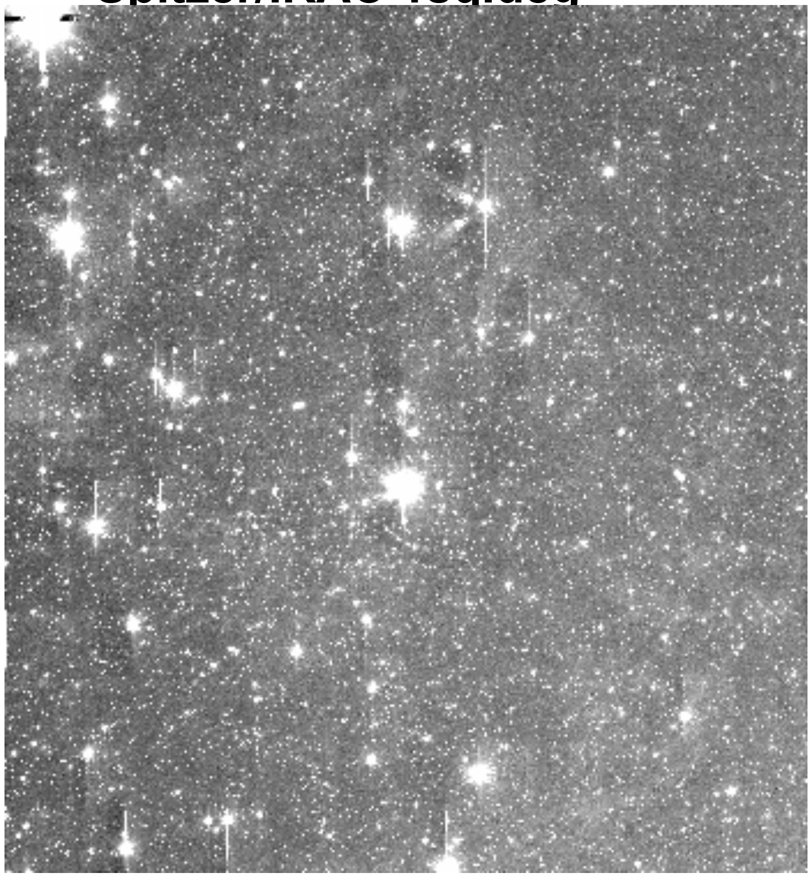


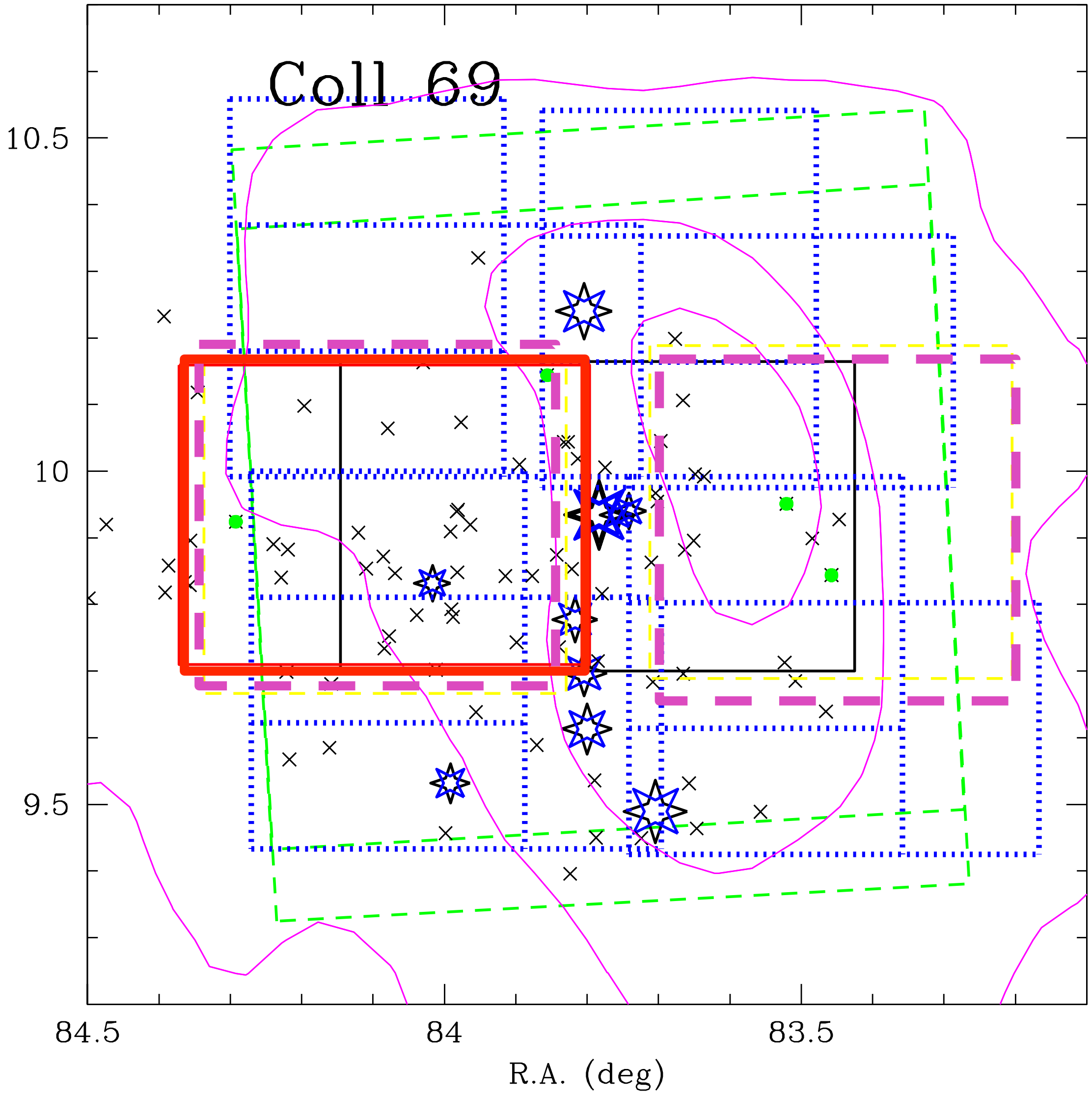


All SFRs
- **IMFs?**
- **Environmental effects?**

Photometric Searches
Morales-Calderón´s PhD

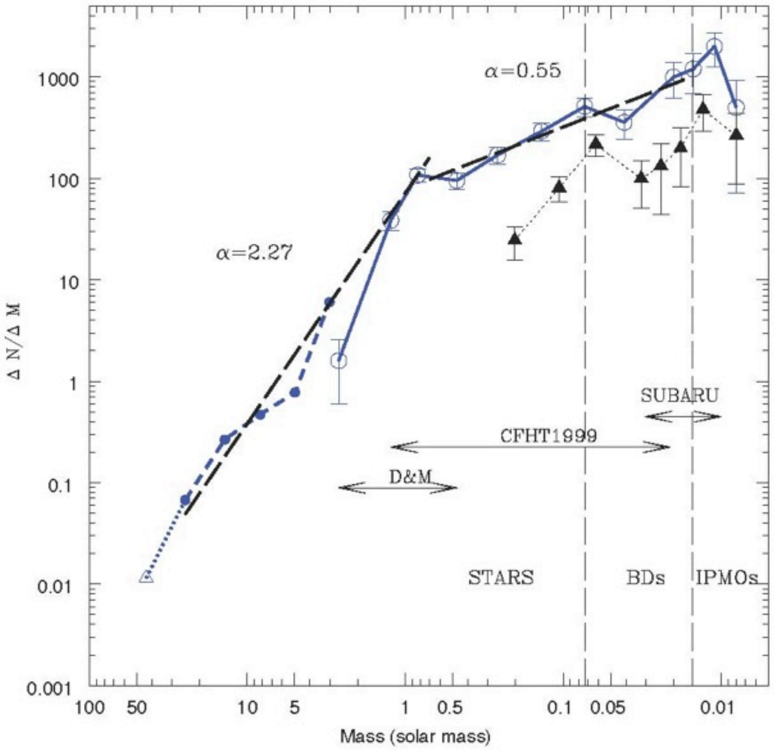
Spitzer/IRAC 1sq.deg



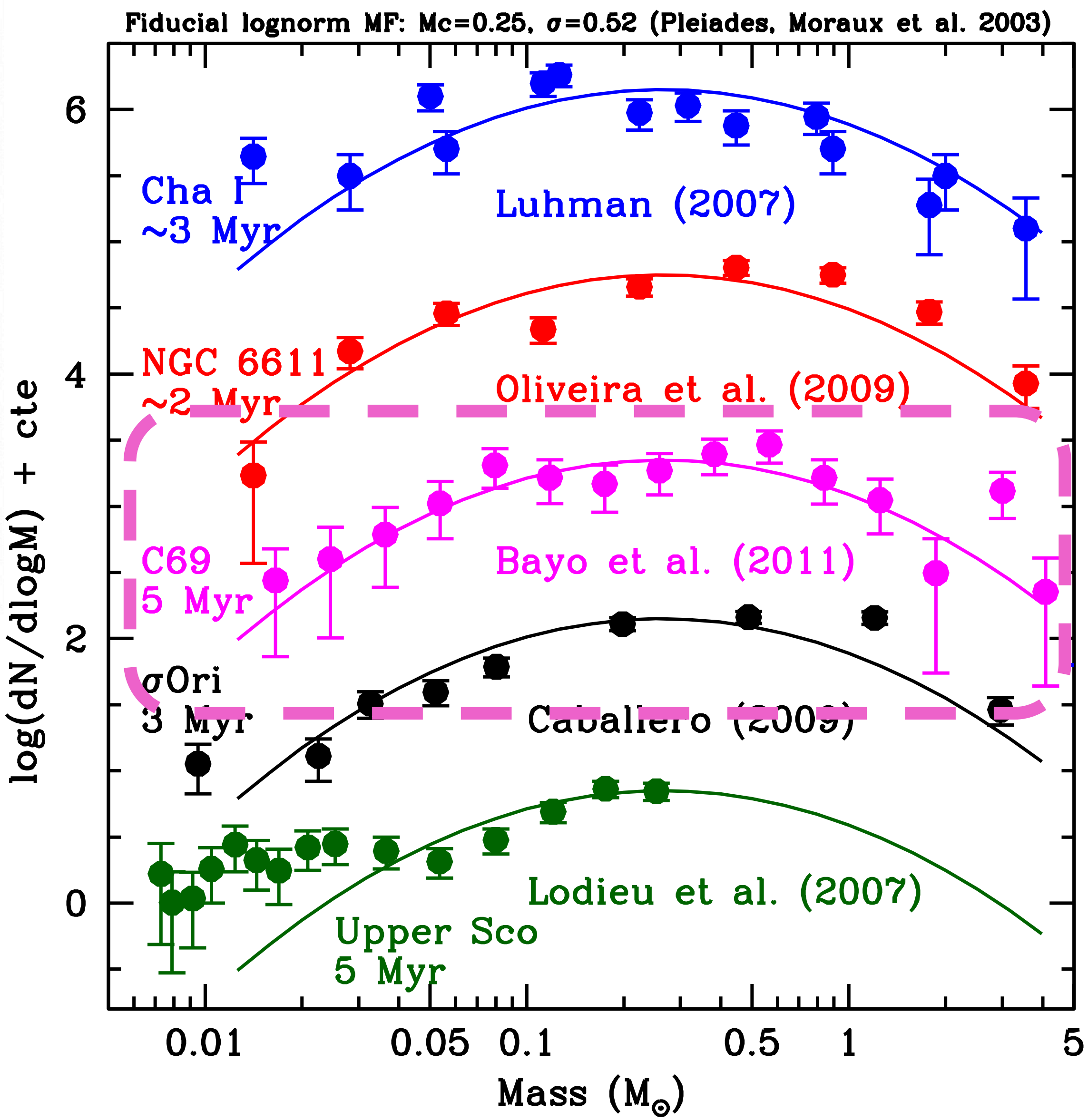


Morales-Calderón 2008 (PhD dissertation)
Morales-Calderón et al. 2012

C69: A spectroscopic IMF

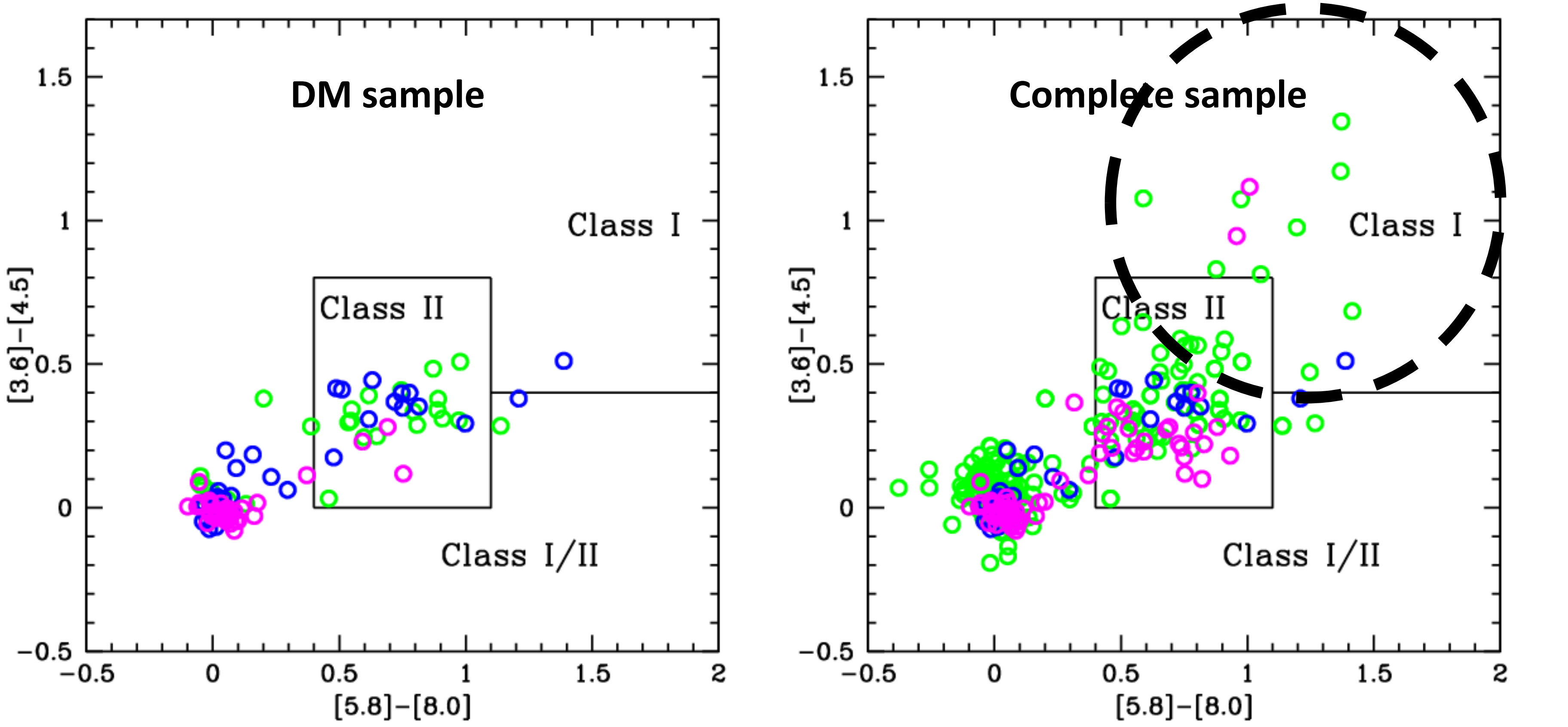


Bayo 2009 PhD Dissertation
Bayo et al. 2011, 2012



Amelia's talk

THE λ ORIONIS SFR AS A WHOLE DISKS



Collinder 69 Barnard 30
Barnard 35

Best for very young objects!!!

Morales-Calderón (2008)
Morales-Calderón et al. (2012)

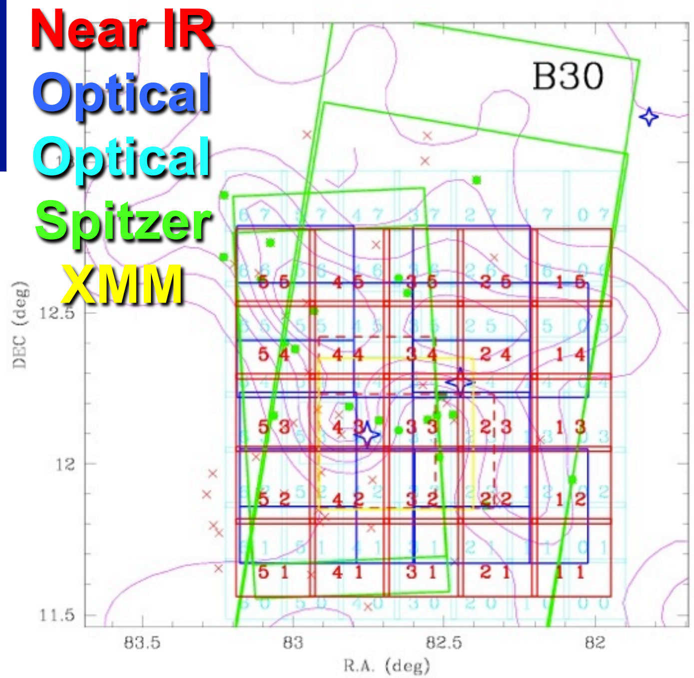
David Barrado, OPS II, Santiago March 2012

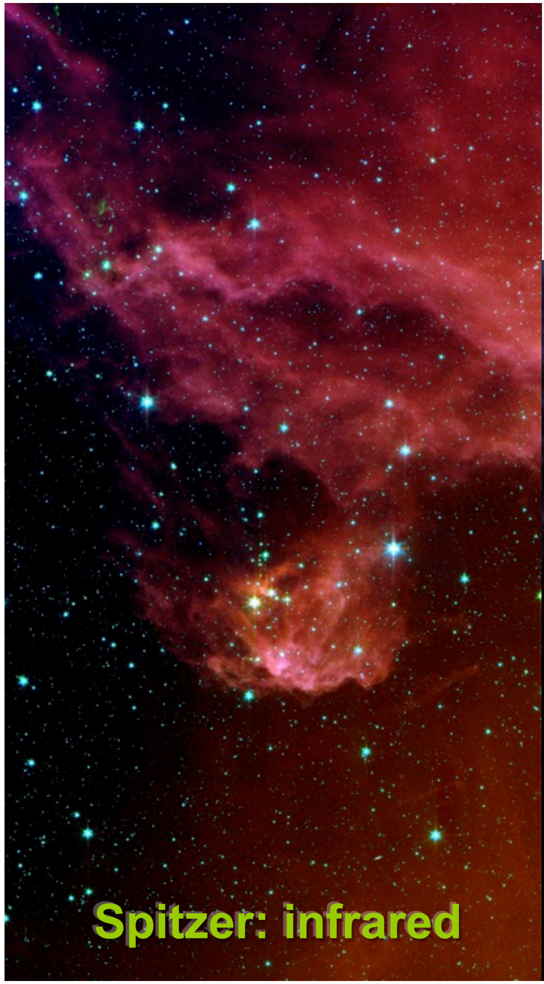
Searching for Class 0/I objects in Barnard 30

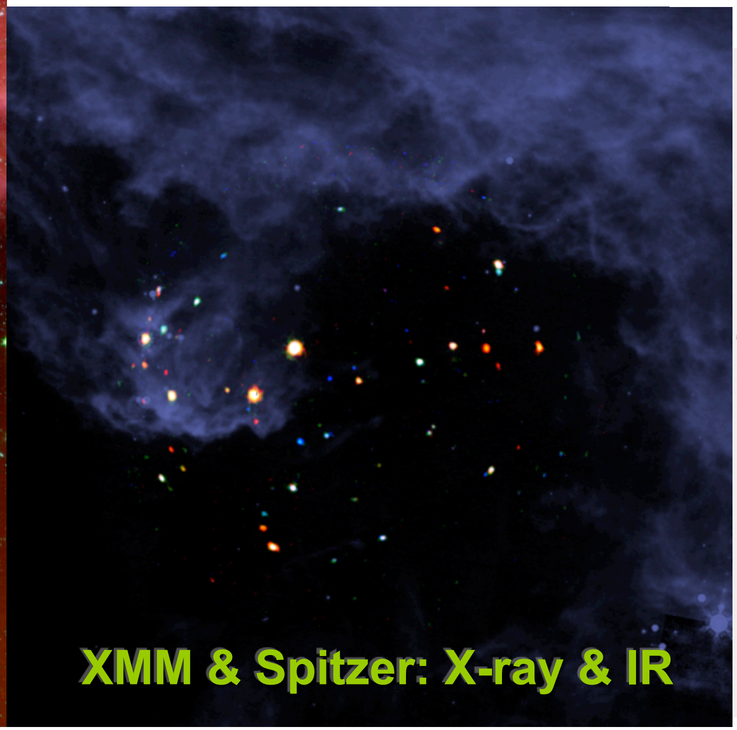
Barnard 30:
Class 0 / I / II / III

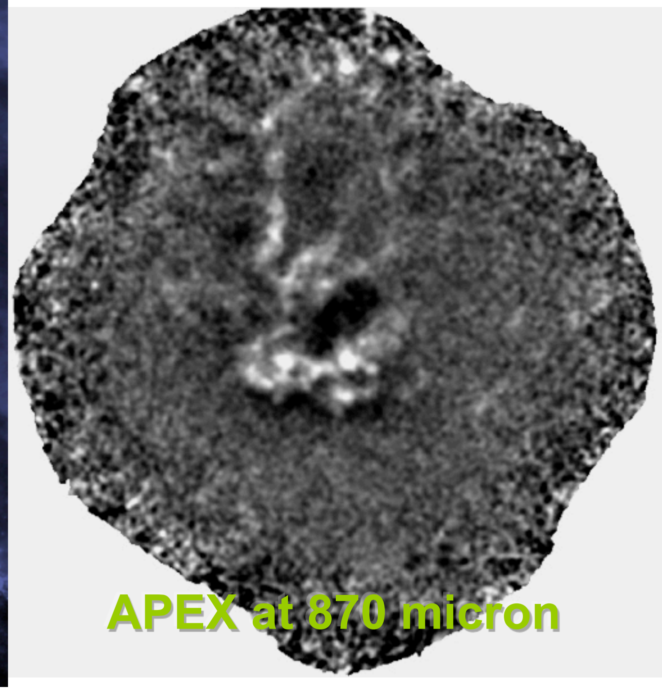
Dependence on mass

Morales-Calderon 2008
Bayo (2009)
De Gregorio et al. (2012)
Barrado et al. (2012)
Bayo et al. (2012)

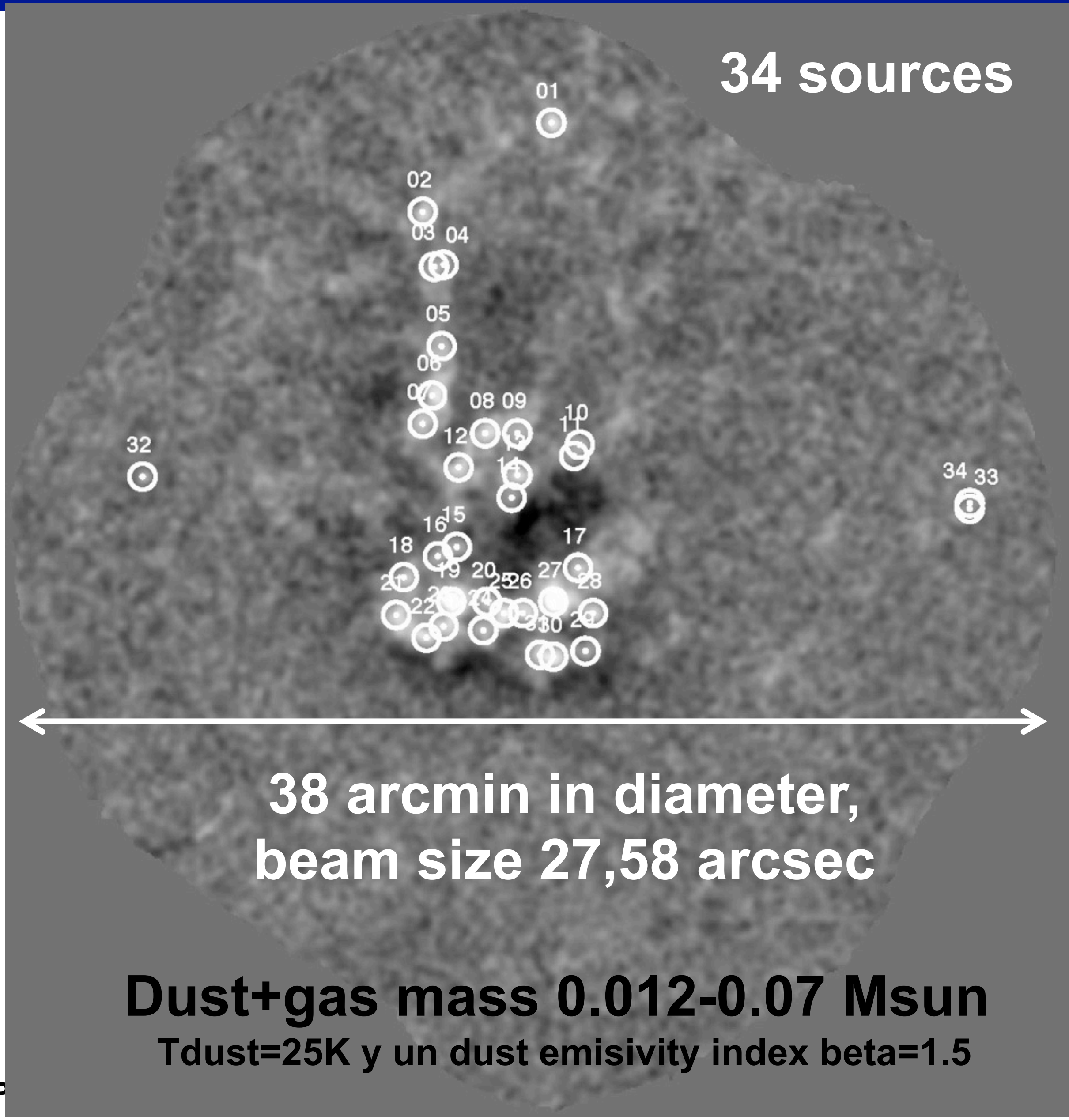



Spitzer: infrared


XMM & Spitzer: X-ray & IR


APEX at 870 micron

APEX/LABOCA map at 870 micron



Ancillary data for identification and characterization

- ✓ **INT/WFC RI**
- ✓ **CAHA/O2000 JHK**
- ✓ **Spitzer/IRAC and MIPS.-**

3.6, 4.5, 5.8, 8.0, 24 micron with
1.7-2.0 and 5.9 arcsec FWHM

- ✓ **WISE.-**

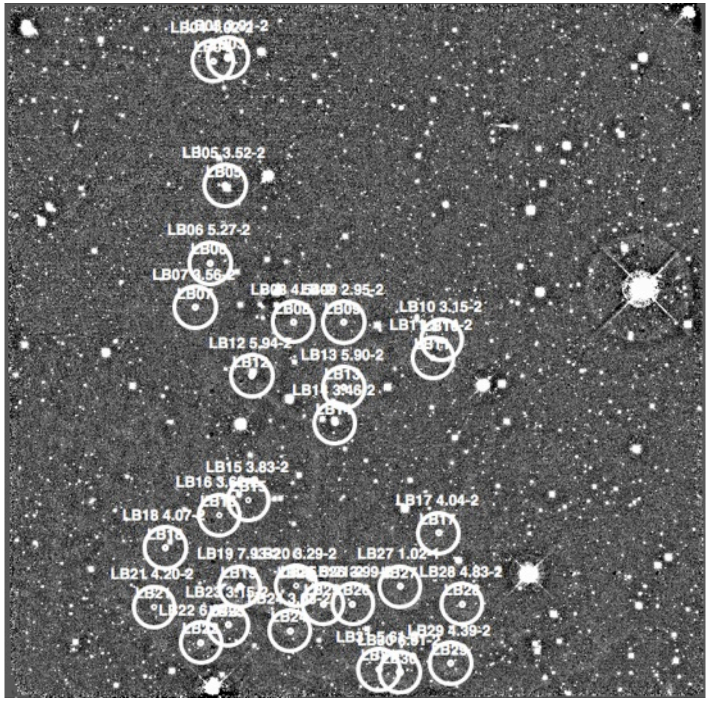
3.4, 4.6, 12, 22 micron with
5.8, 6.5, 6.7 and 11.8 arcsec PSF

- ✓ **Akari.-**

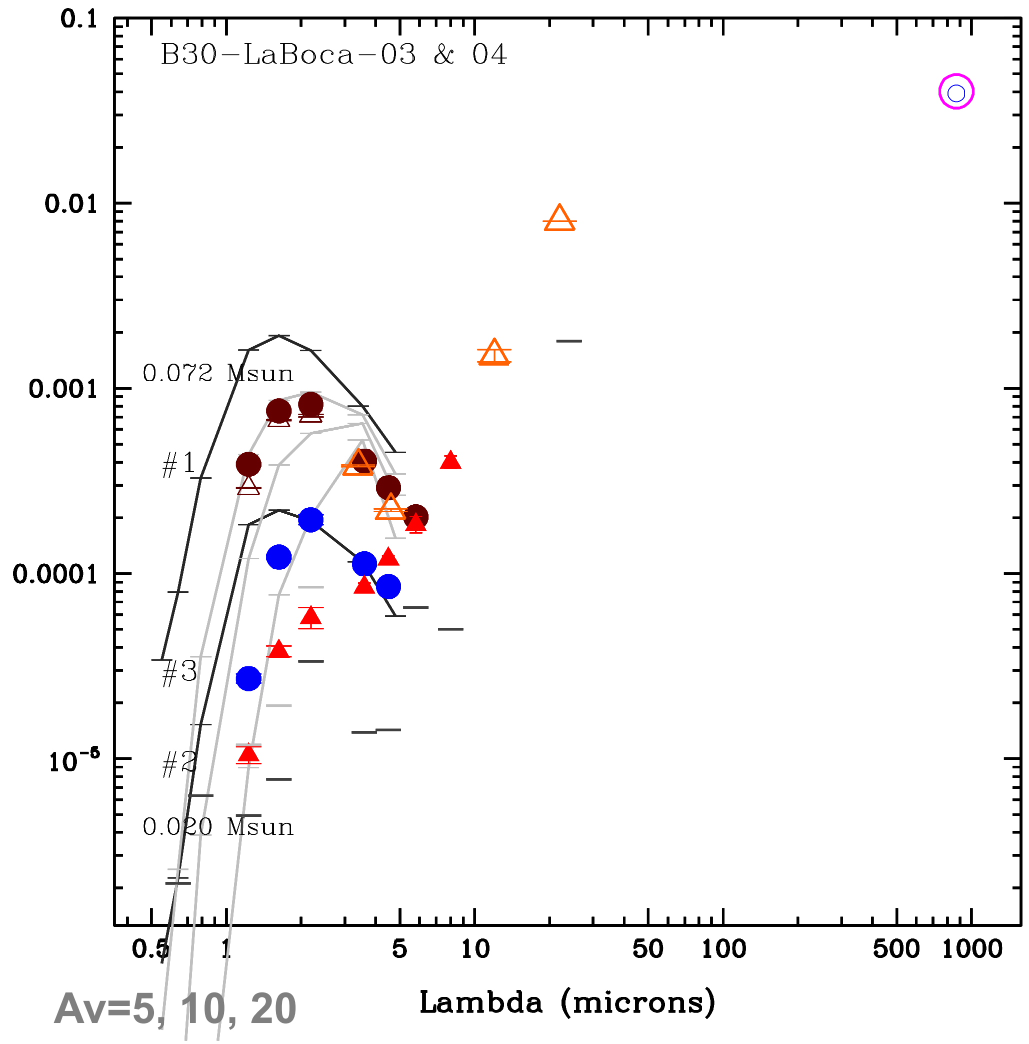
IRC at 9 and 18 micron, with
5.5 and 5.7 arcsec FWHM
FIS at 65, 90, 140, 160 micron with
37, 39, 58, 61 arcsec PSF

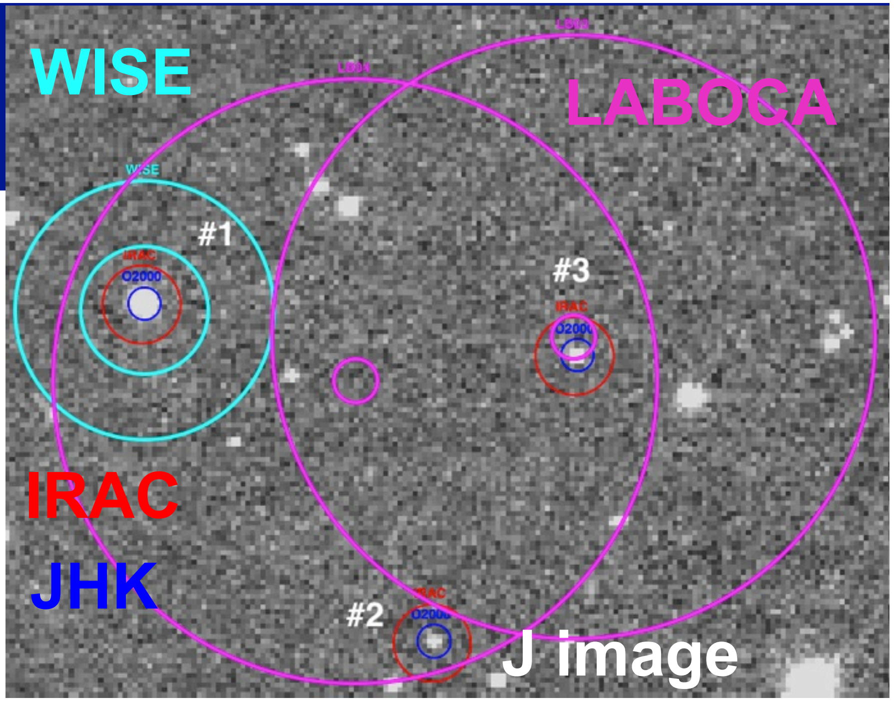
- ✓ **APEX/LABOCA.-**

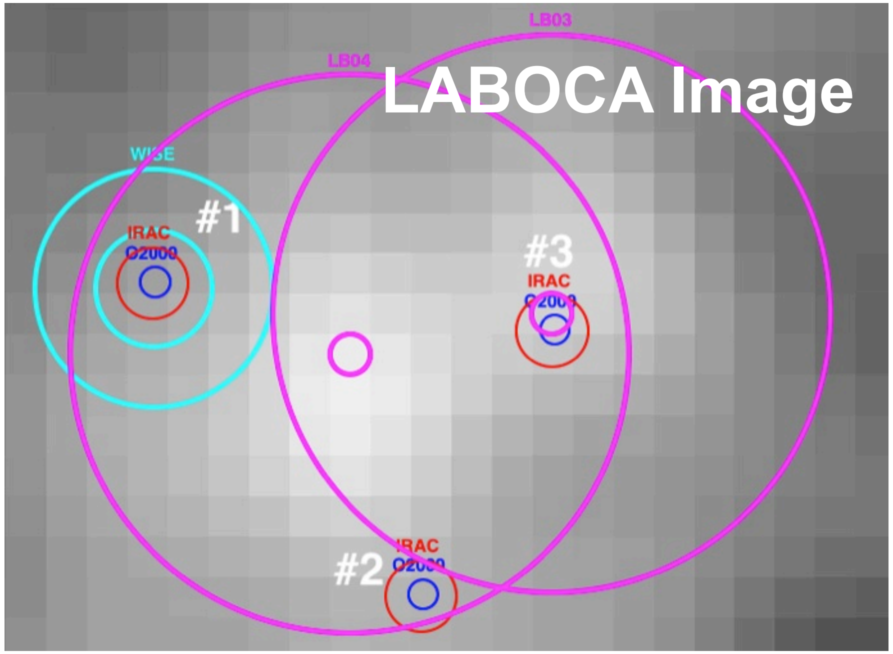
870 micron with 27.6 arcsec PSF



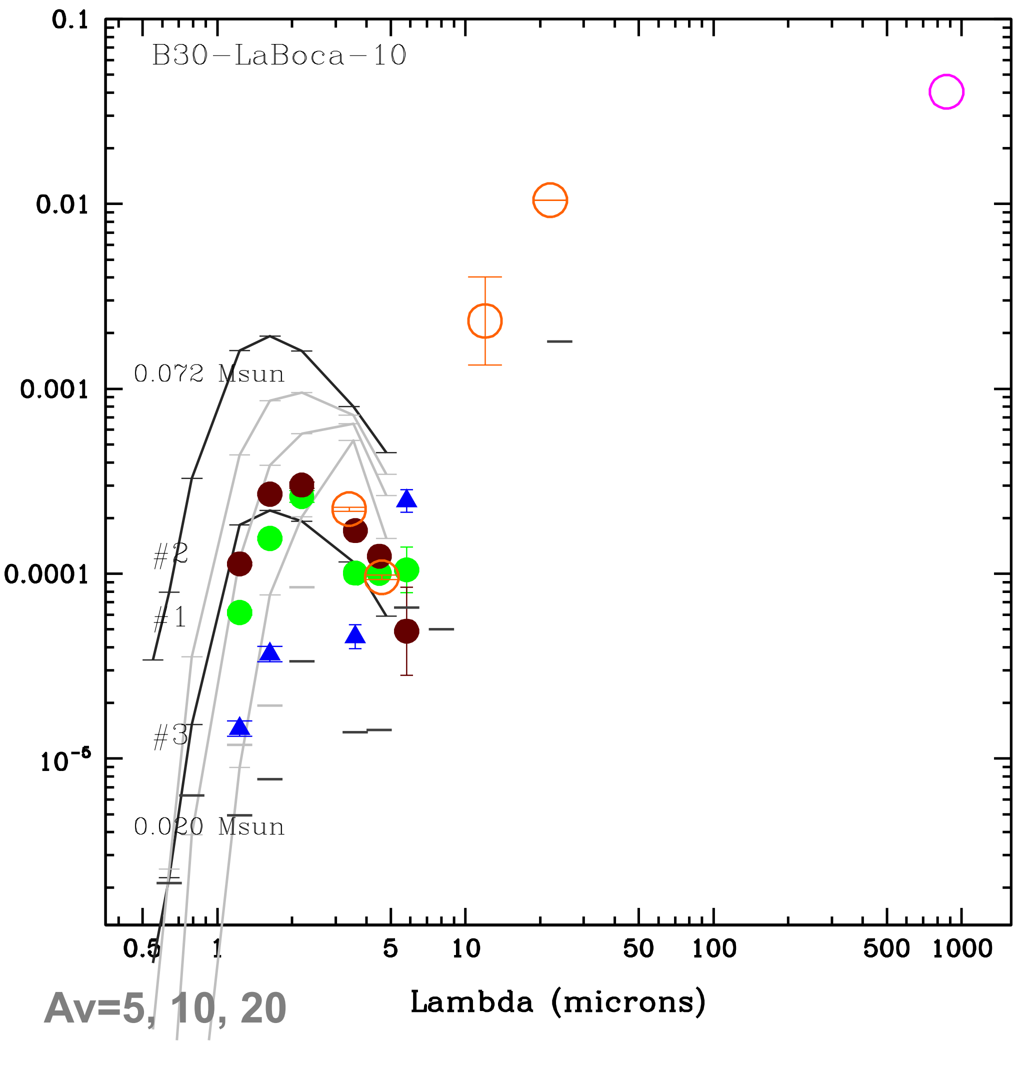
An example (I)

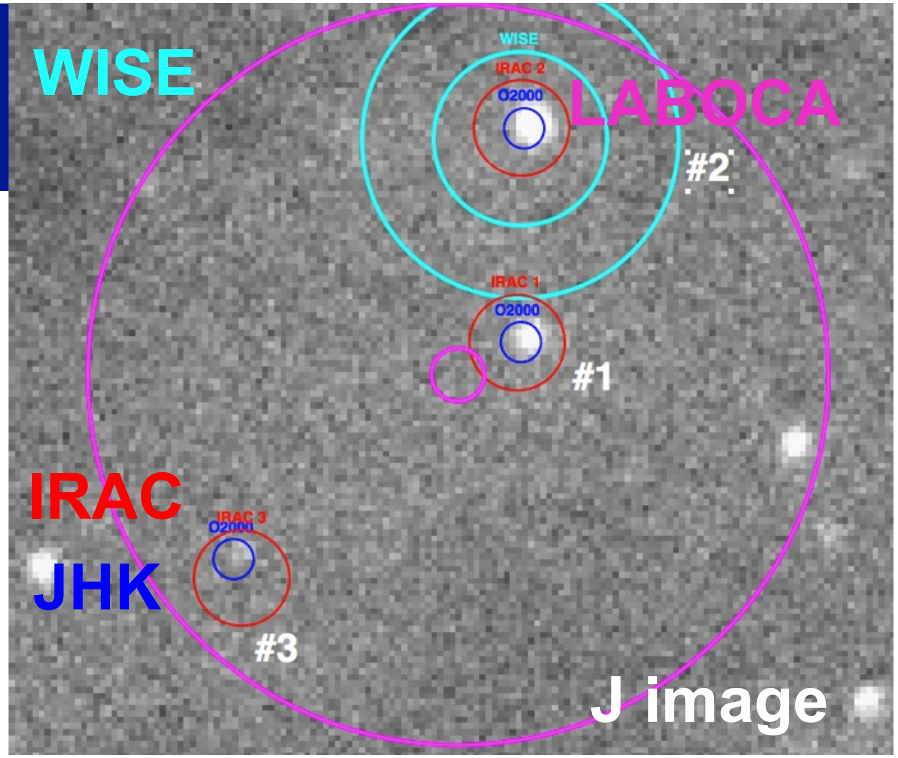

B30−LaBoca−03 & 04
0.1
0.01
0.001
0.0001
10^{-5}
0.072 Msun
#1
#3
#2
0.020 Msun
0.5
1
5
10
50
100
500
1000
Lambda (microns)
Av=5, 10, 20

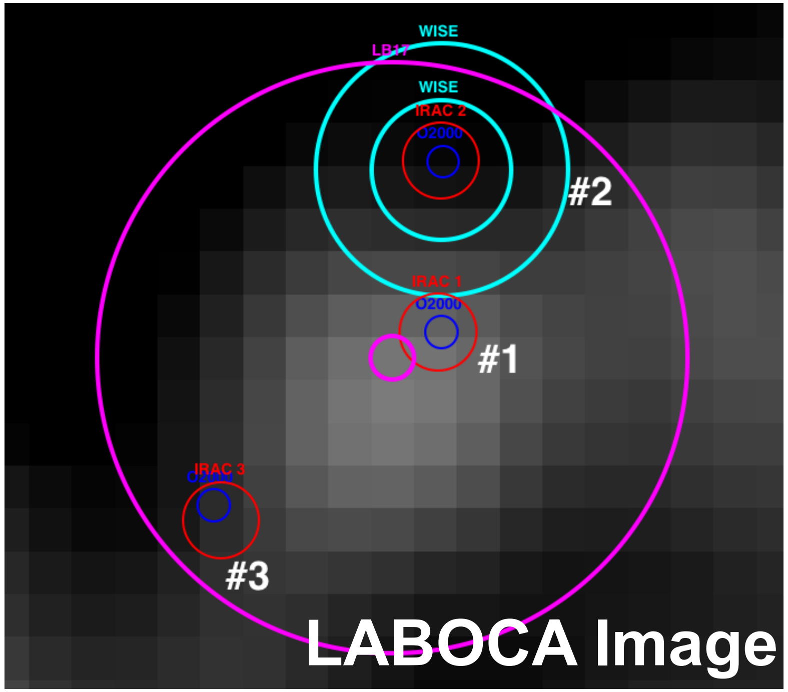

WISE
LABOCA
#1
#3
#2
IRAC
JHK
J image


LB03
LB04
LABOCA Image
WISE
#1
IRAC
O2000
#3
IRAC
#2
IRAC

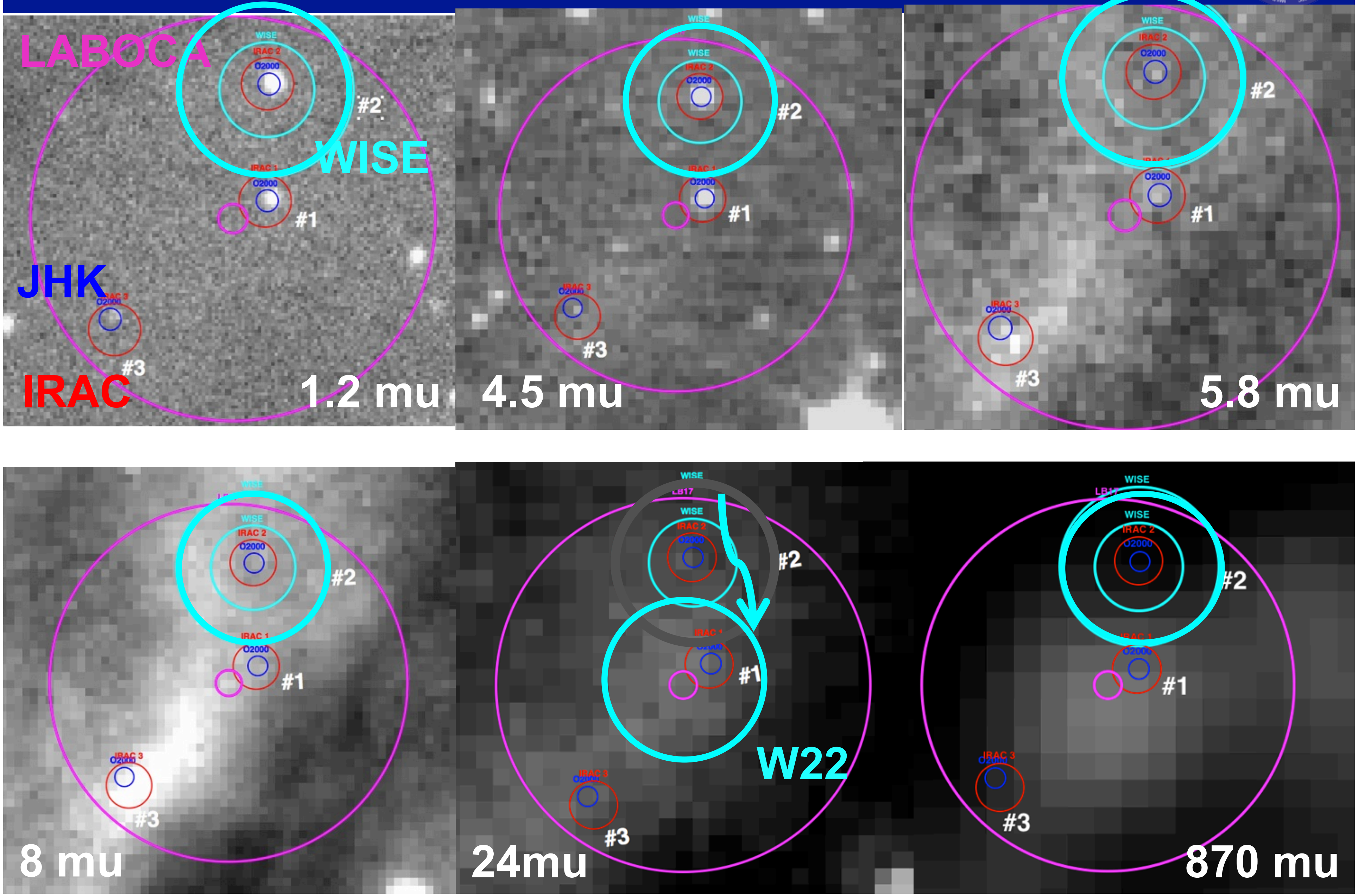
An example (II)

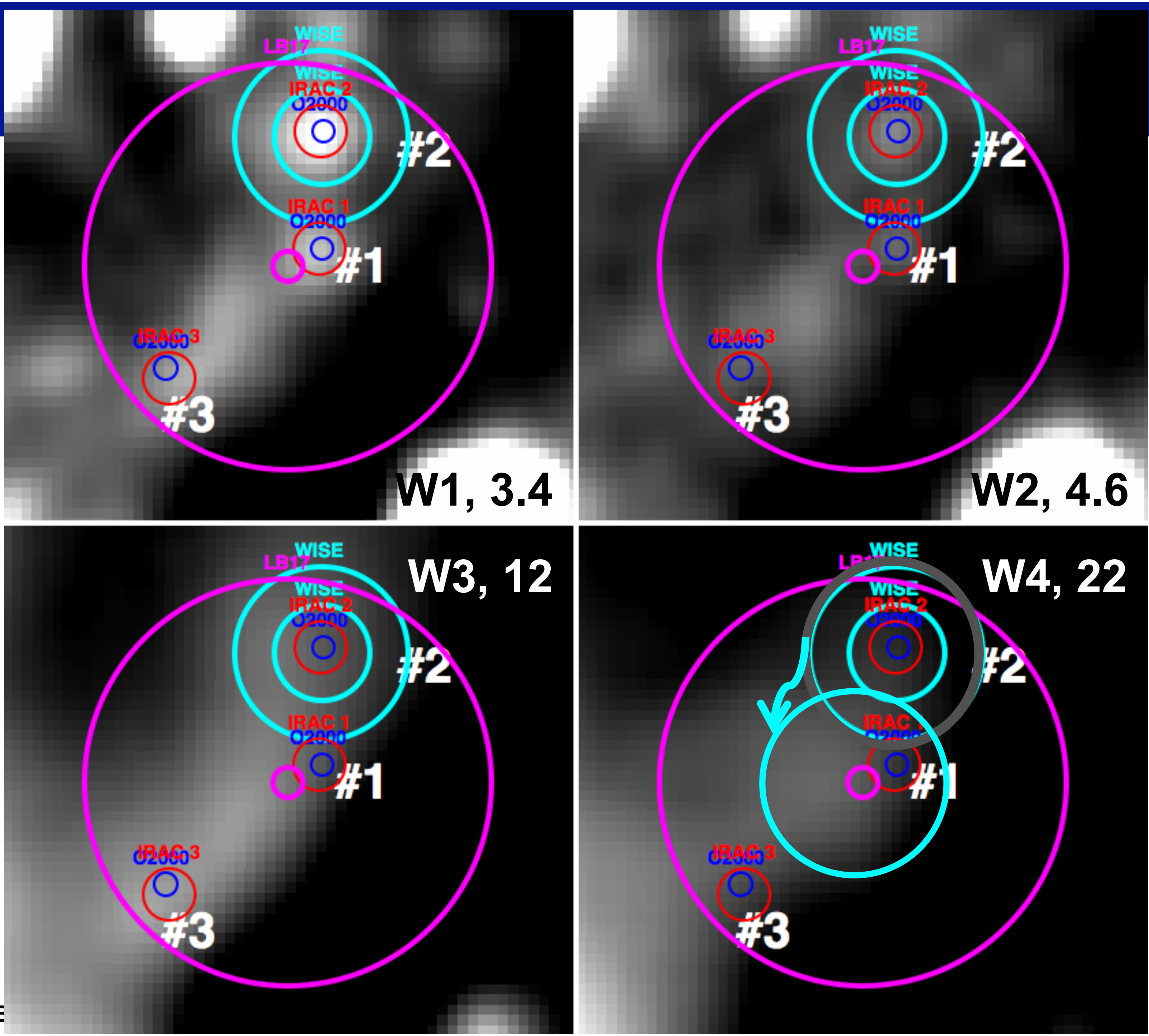




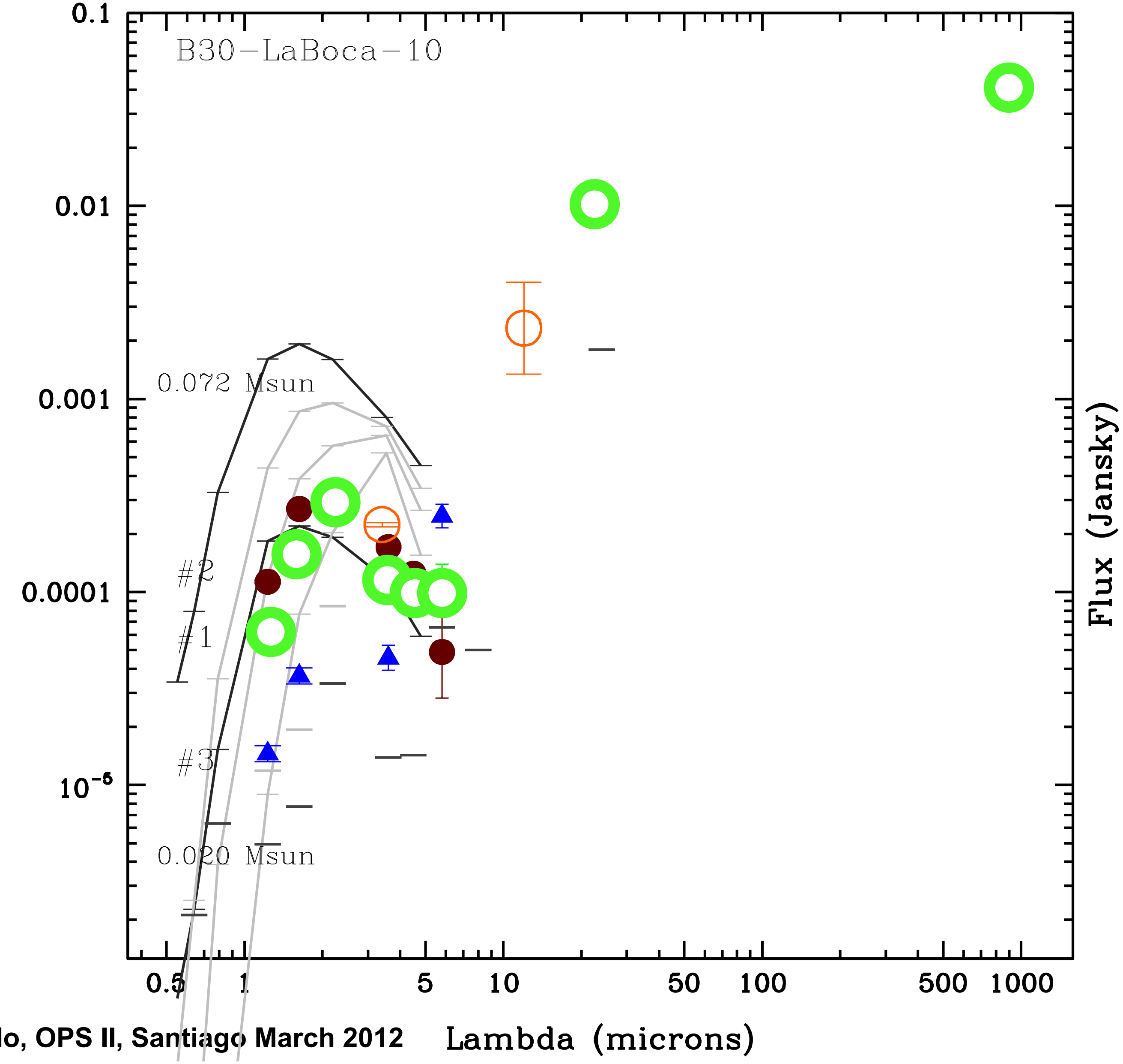


WISE identifications? Filaments





David B


B30−LaBoca−10
0.072 Msun
#2
#1
#3
0.020 Msun
0.1
0.01
0.001
0.0001
10^{-5}
0.5
1
5
10
50
100
500
1000
Flux (Jansky)
Lambda (microns)

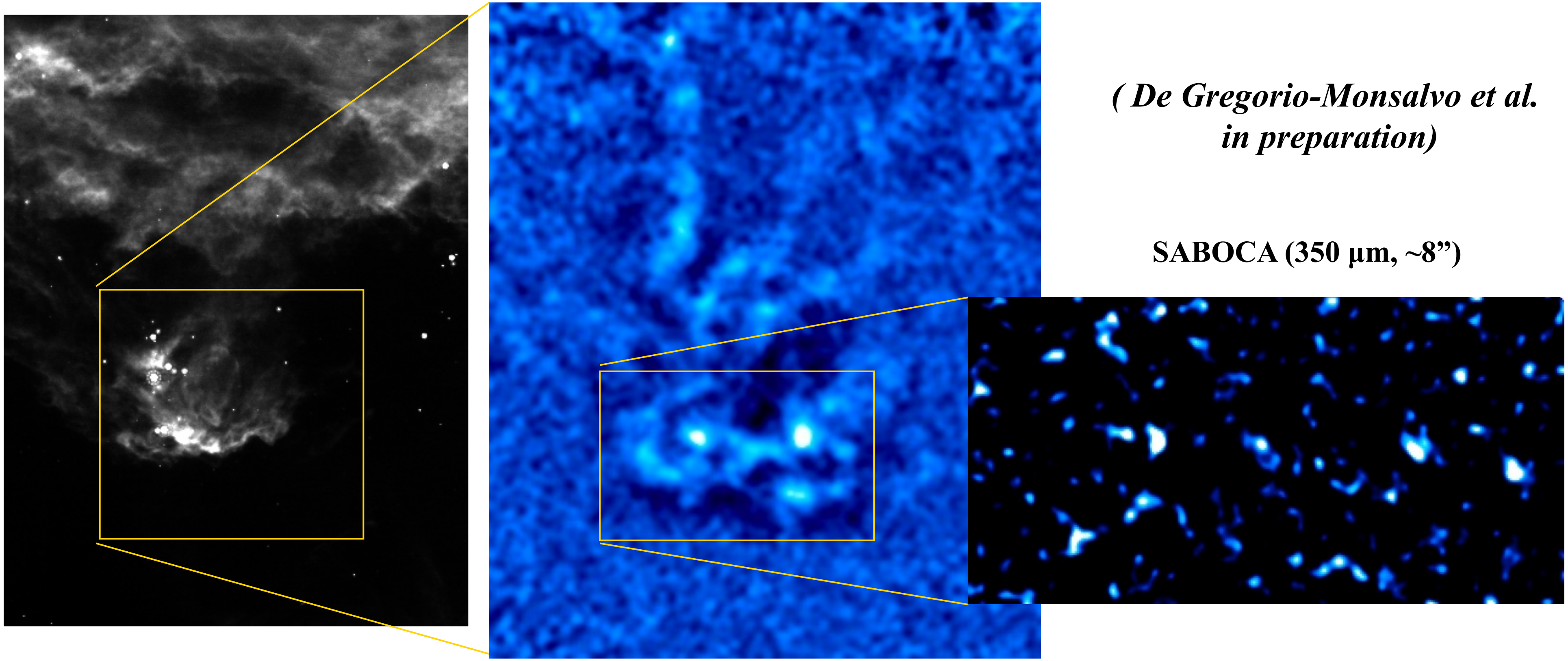
What Is Next?

B30: A proto-brown dwarf nursery?

Spitzer/MIPS 24 µm

APEX/LABOCA (870 µm, ~19")

SABOCA (350 µm, ~8")



(De Gregorio-Monsalvo et al. in preparation)

- A region with multiple young low and very low mass objects.
- ALMA Cycle 0 filler project accepted
- We need VISIR and ISAAC

Thank you very much for your attention!!!