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Laboratorio de Astrofísica Estelar y Exoplanetas

Properties of low-mass stars and brown dwarfs: a multiwavelenght approach

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N. Huélamo, A. Palau, A. Bayo,
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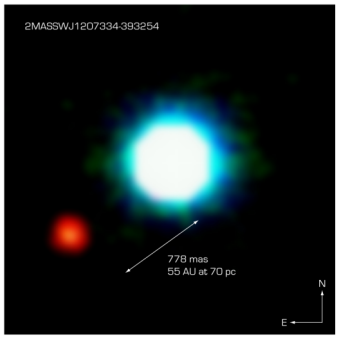
Star Formation and Disk evolution

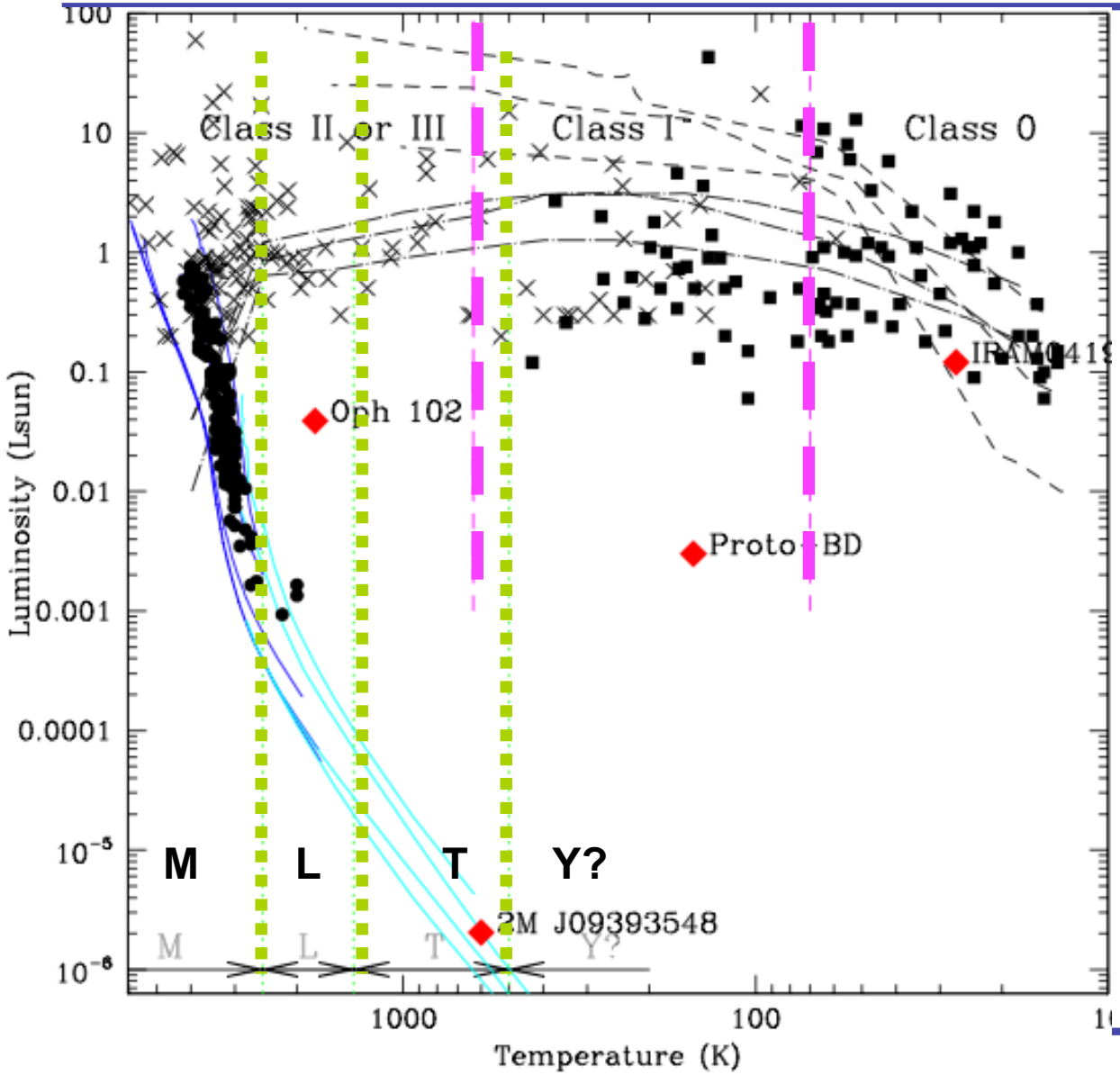


NACO Image of the Brown Dwarf Object 2M1207 and GPCC

ESO PR Photo 26a/04 (10 September 2004) © European Southern Observatory

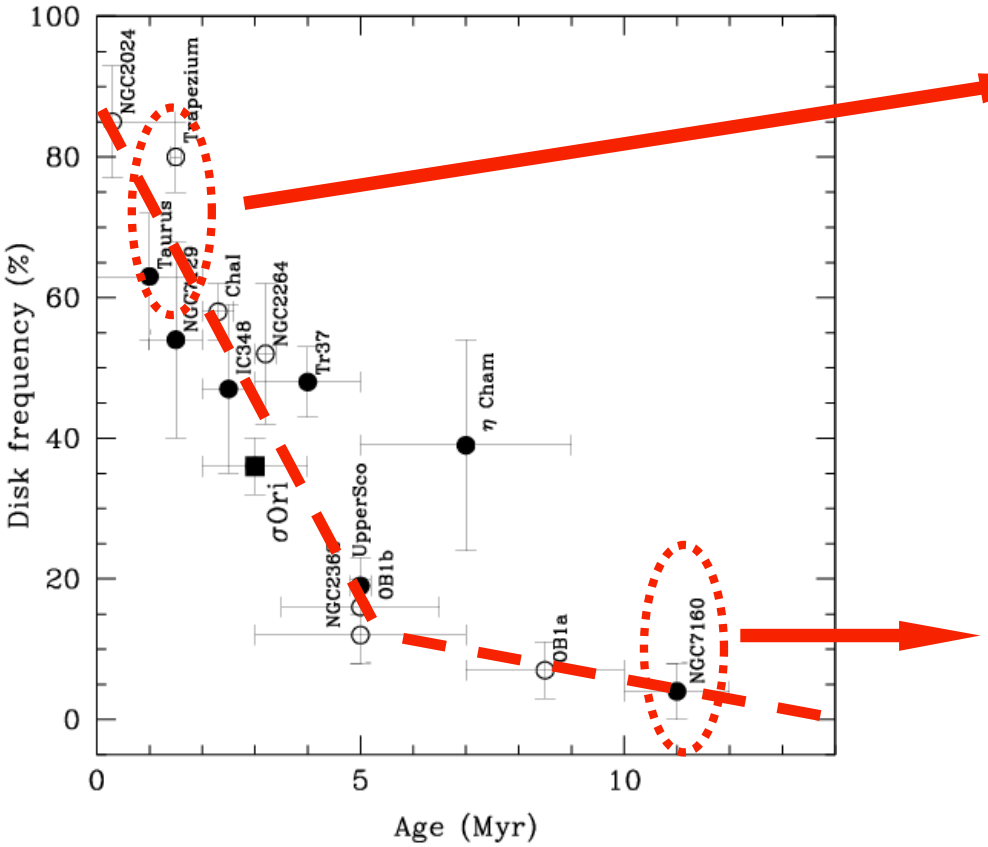
- Properties of Class III
- Disk evolution (and planet formation)
- Brown Dwarfs

From Protostars to the MS

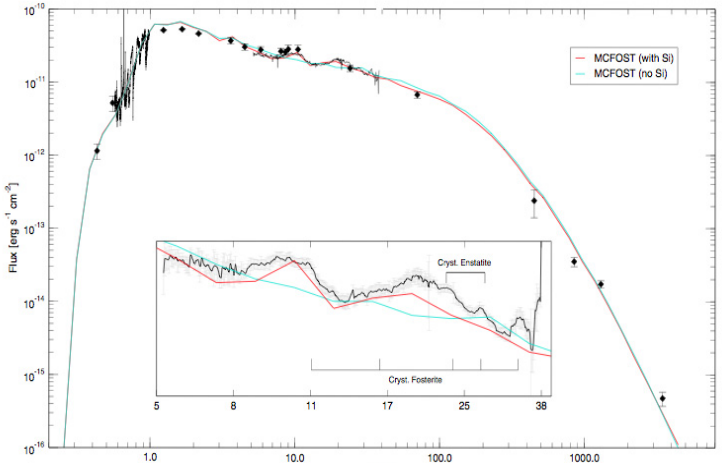


Bolometric luminosity versus the temperature. The 50 sources compiled by Durham et al., showing some evidence for being embedded low luminosity sources, are shown as solid black squares. Class 0 VeLLO IRAM04191, the proto-brown dwarf candidate B213-I1119, and the brown dwarfs Oph 102 (Class II, young) 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 0l and Class III boundaries, or the temperature limits for M, L, T dwarfs (and the postulated Y).

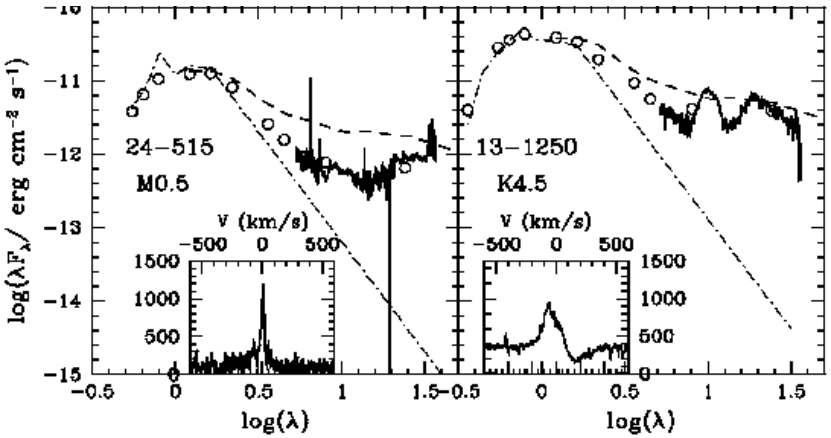
Disk frecuency, SED evolution and planet formation



Fraction of stars with near-infrared disk emission as a function of the age of the stellar group (after Hernández et al. 2007).



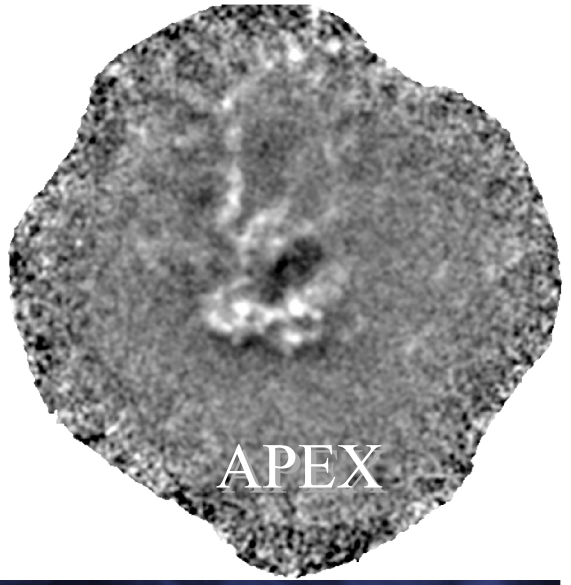
Spectral energy distribution of the target (black) and best fit MCFOST model including the treatment with and withour silicates (blue and red curves). The inset shows a zoom on the IRS spectrum (after Bouy et al. 2008).

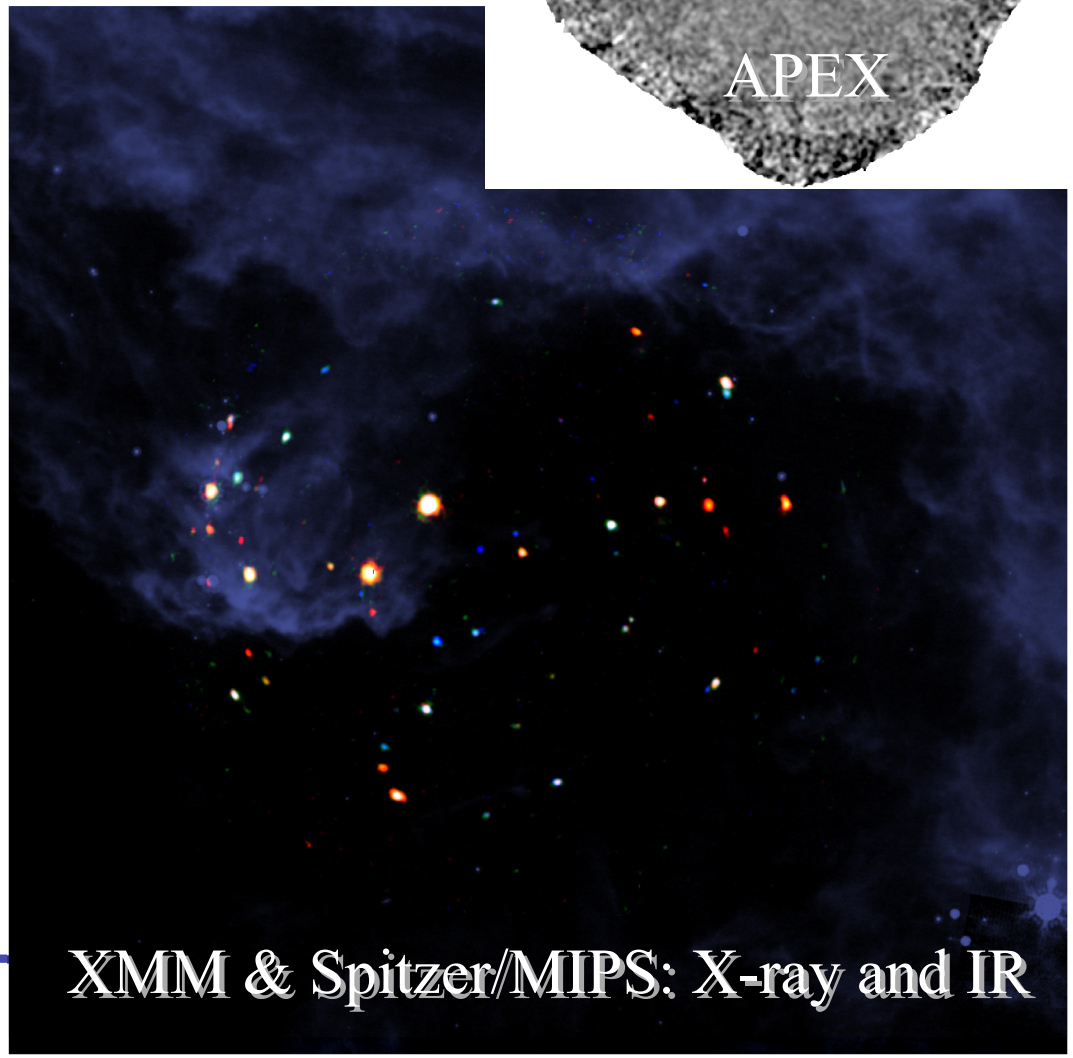


Mid-IR spectra from Spitzer/IRS for several stars belonging to NGC7160 (after Sicilia-Aguilar et al. 2007).

Where & How to look

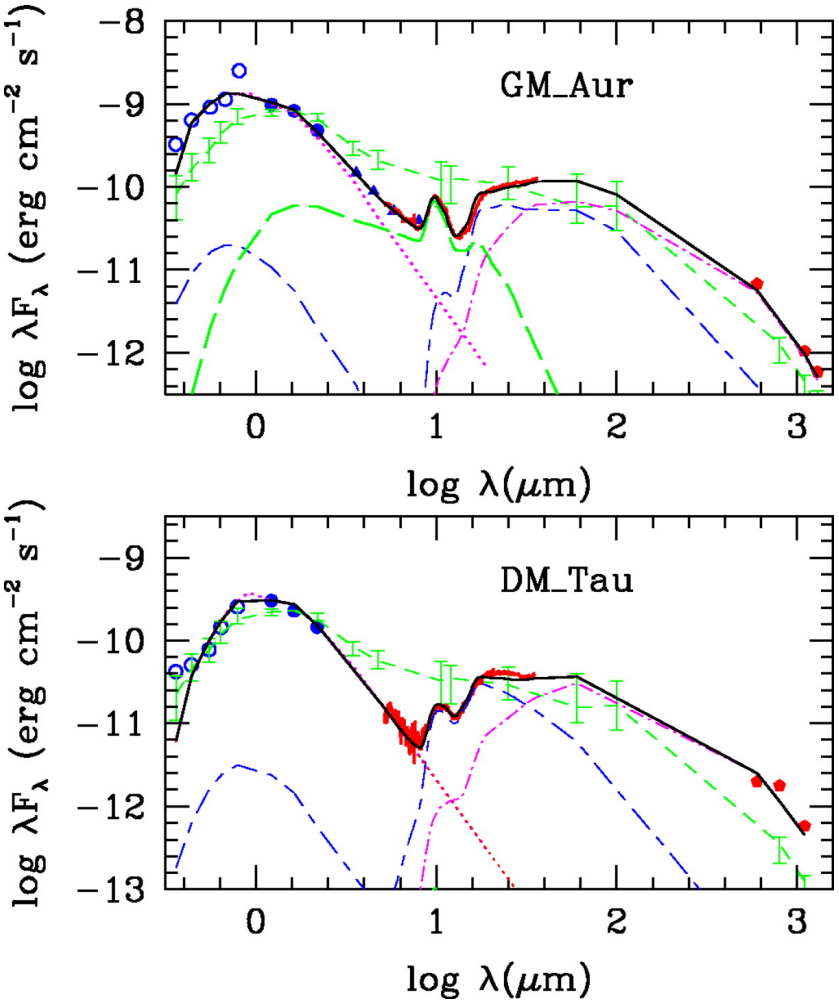
Laboca:
850 micron
10x10 arcmin



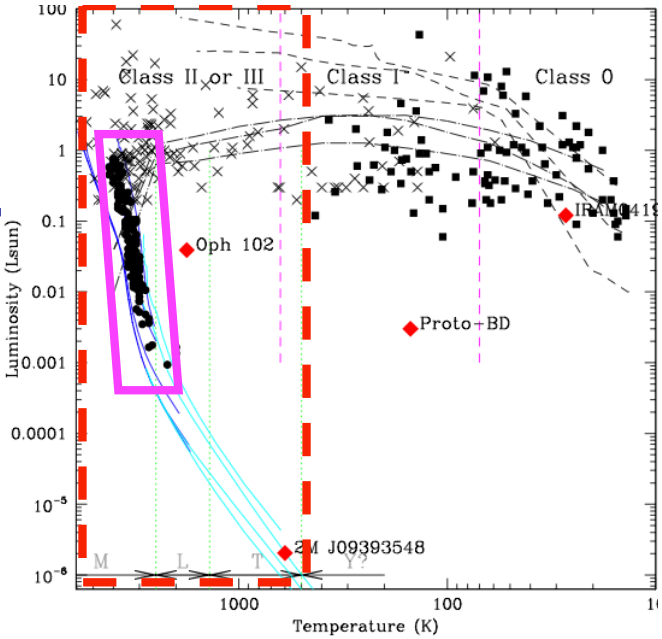


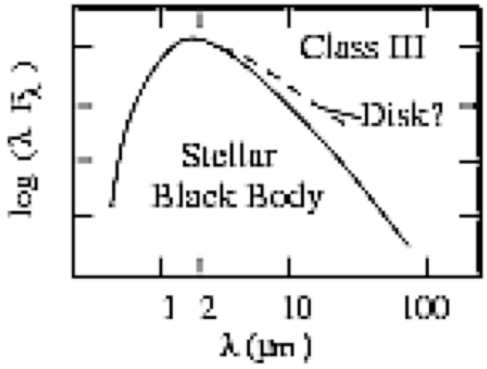
Class III phase

PMS star (Weak-Line TTauri)

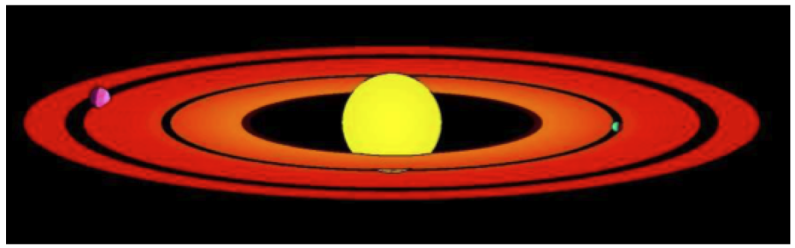


Complete SED, including IRS spectra, of two Taurus stars which have transition disks (Calvet et al. 2005).

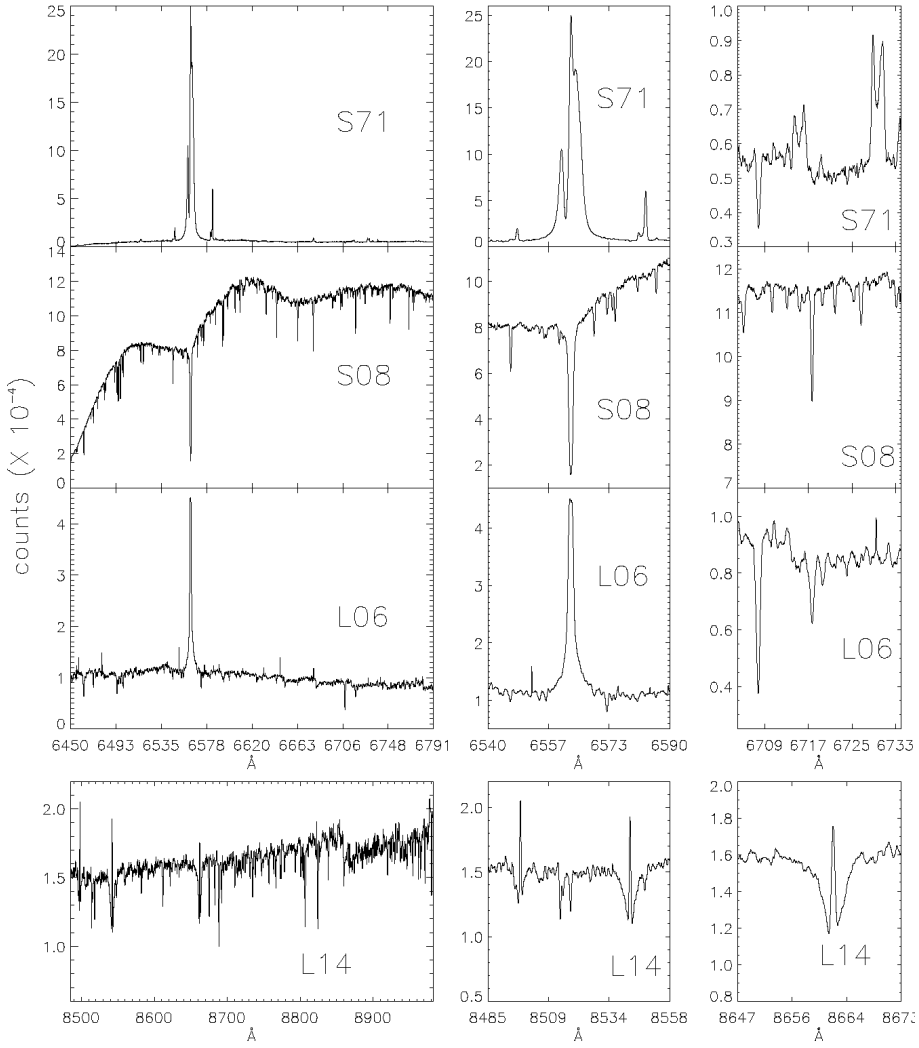


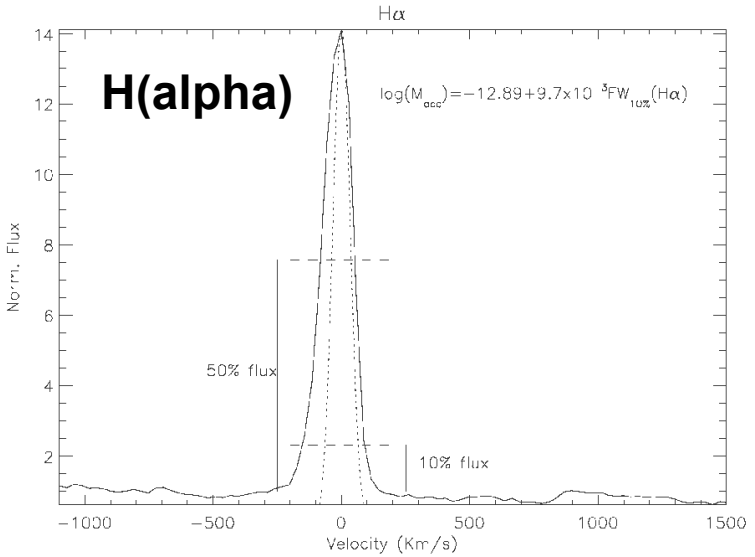


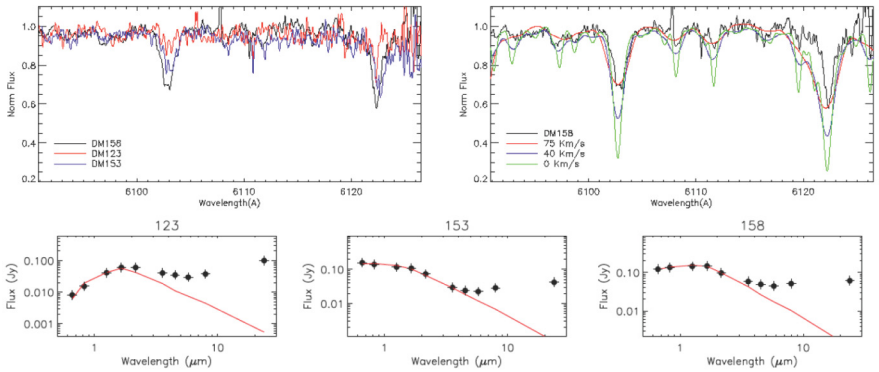
t ~10^6 - 10^7



Flames optical spectra

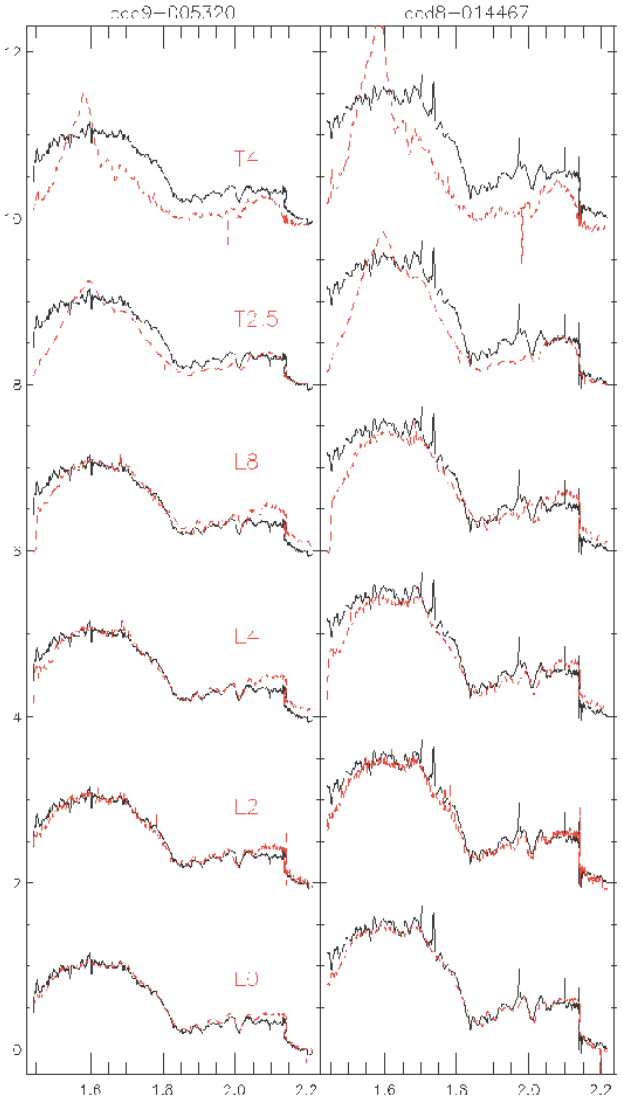


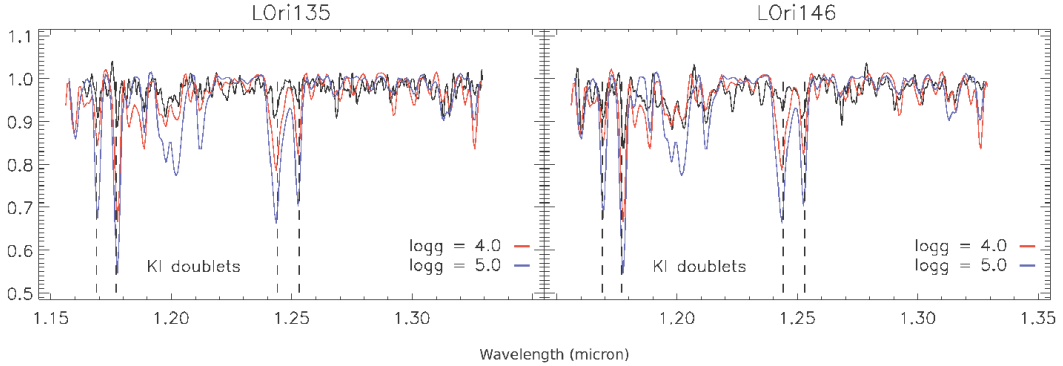


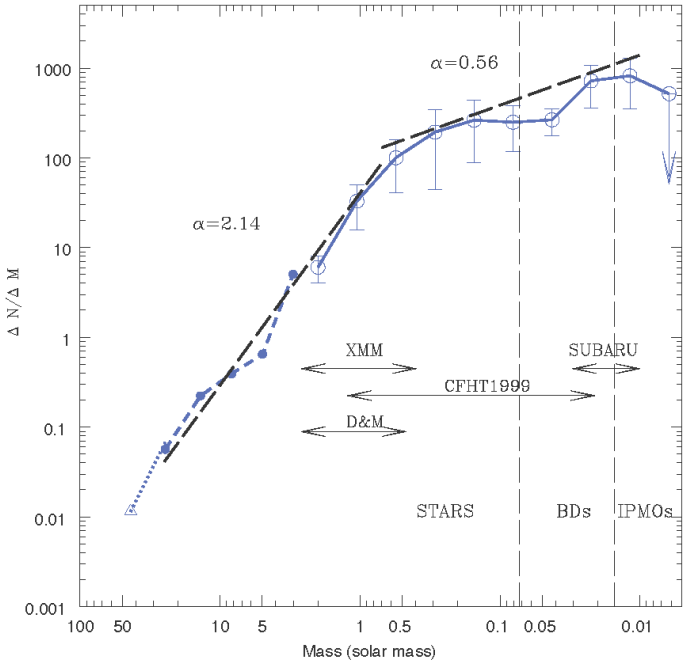


Rotational velocities

Near-IR spectra: ISAAC and Sofi



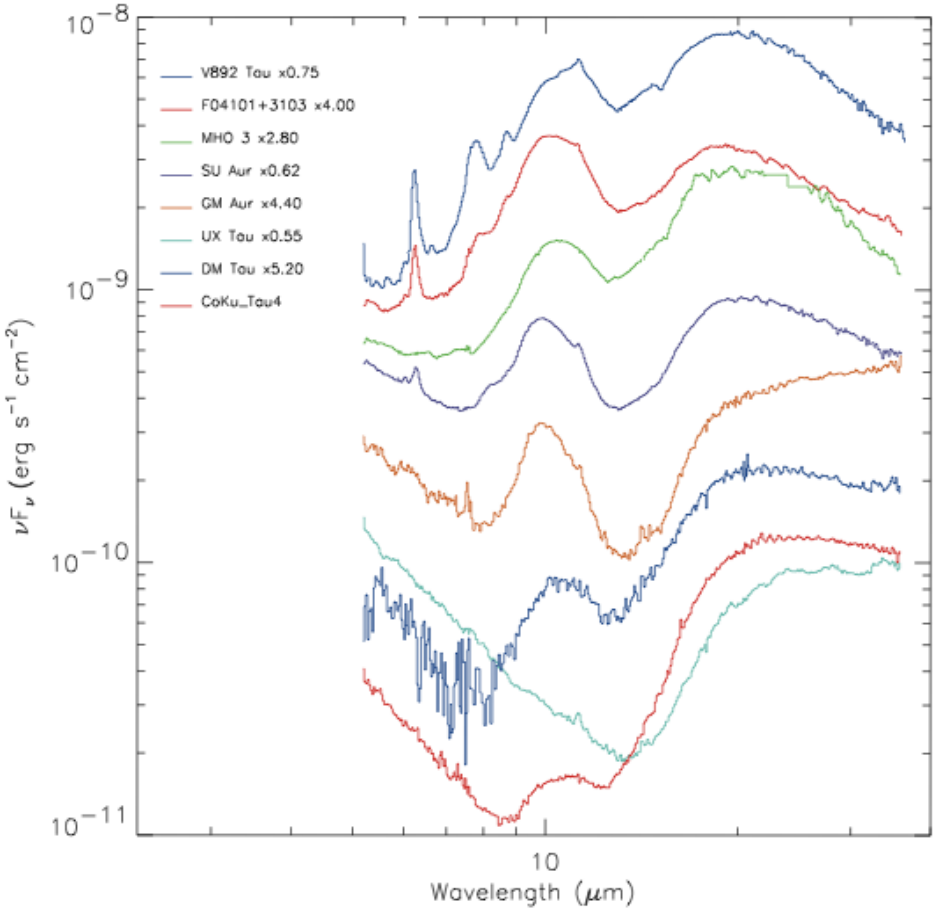


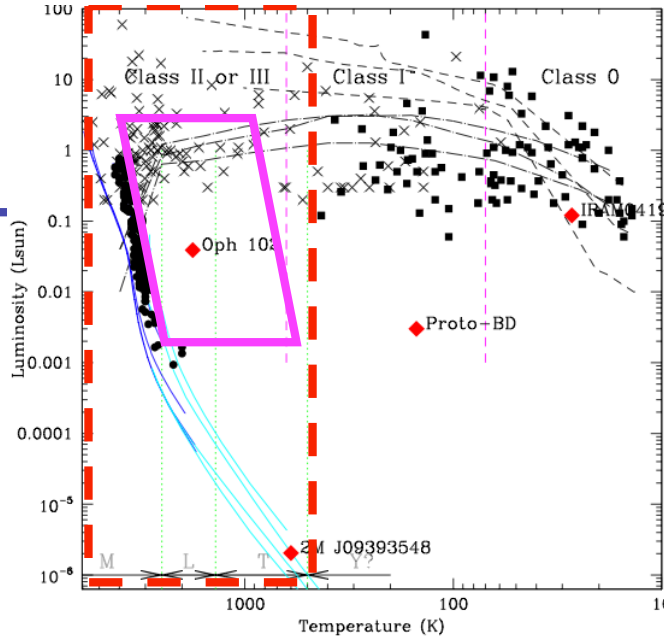


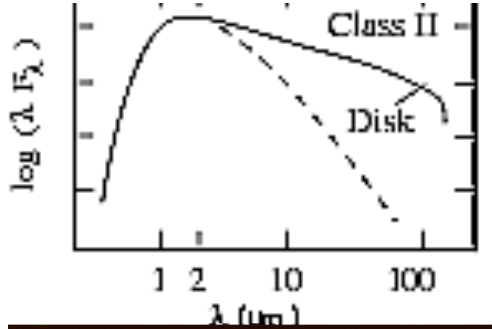
Class II phase

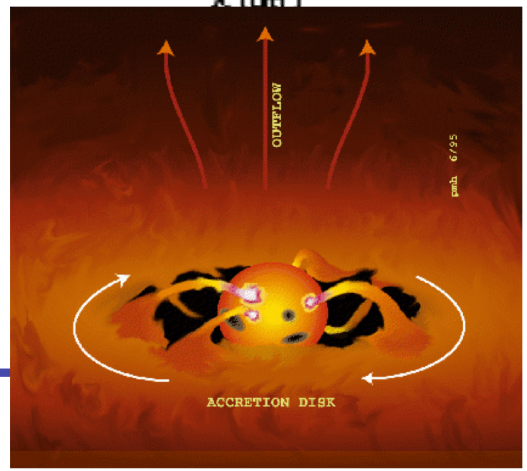
t ~10^5 - 10^6

TTauri star, disk + outflows









Morphological sequence of Class II objects; some of the "outliers" of the morphological sequence: Herbig Ae/Be stars, Class II objects with rising SEDs over the IRS spectral range, and the so-called transitional disks (Furlan et al. 2006).

VISIR

Imaging

spectral range [µm]	pixel field of view [arcsec]	total field of view [arcsec^2]	filter
8 - 13	0.075	19.2 x 19.2	broad and narrow band filters
17 - 24	0.127	32.3 x 32.3	

pfov is selectable for both wavelength regions

Spectroscopy

grating	offered central wavelengths [µm]	resolving power
low resolution (LR)	8.1, 8.5, 8.8, 9.8, 11.4, 12.2 and 12.4 µm	R ~ 350 at 10 µm
medium resolution (MR)	7.5 to 9.3 ?m, 10.2 to 13.0 µm, 17.1 to 19.0 µm, 20.12 µm	R ~ 3200 at 10 µm
high resolution - long slit (HR)	8.02, 12.81 and 17.03 µm	R ~ 25000 at 10 µm
HR - cross dispersed (HRX)	8.970 - 9.140 µm, 9.360 - 9.690 µm, 10.480 - 10.540 µm, 11.540 - 11.570 µm, 11.762 µm, 12.210 - 12.760 µm, 12.814 - 13.364 µm, 16.390 µm, 16.925 µm, 17.790 - 17.980 µm, 18.246 µm, 18.680 - 18.960 µm, 21.295 µm	R ~ 25000 at 10 µm

The slits offered have selectable widths of 0.4", 0.75" and 1", and a length of 32.3".
In high-resolution, cross-dispersed mode, the slit length is 4.1".

VLT/VISIR: mid-IR photometry

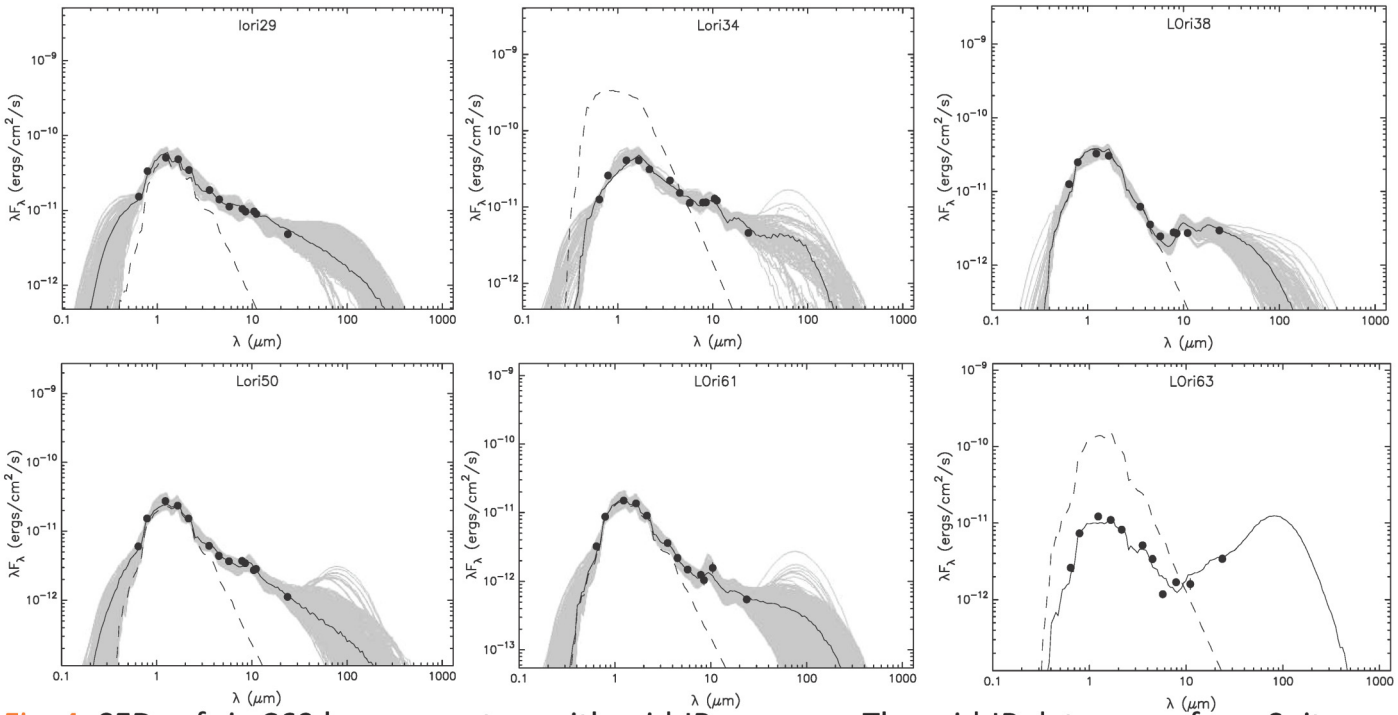
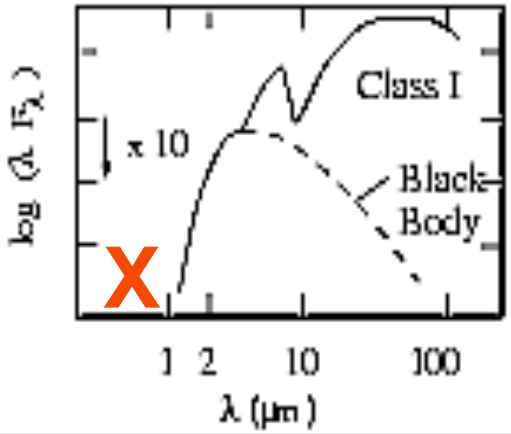


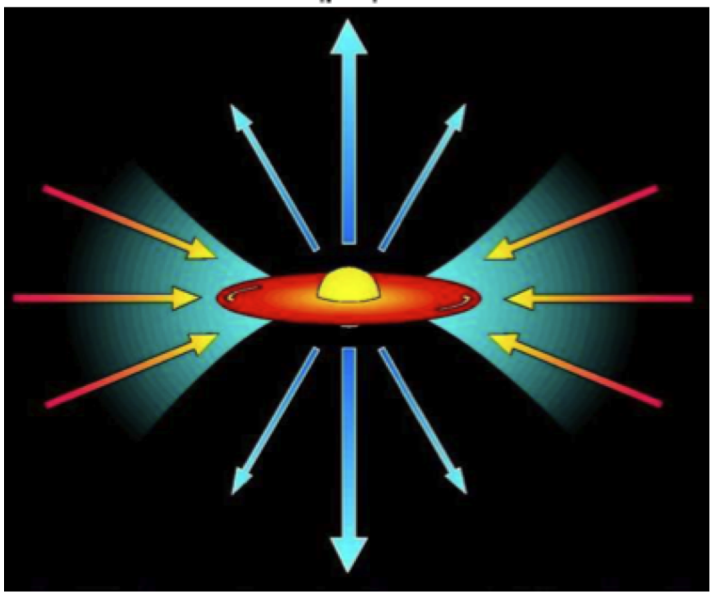
Fig. 4: SEDs of six C69 low-mass stars with mid-IR excesses. The mid-IR data come from Spitzer and VISIR/VLT. The solid line represents the best fit to the data (Robitaille et al. 2007). The dashed lines represent the expected photospheric flux.

- We have studied the SEDs of 13 low-mass stars and BDs with excesses at 24 microns.
- The modeling of the SEDs (see Fig. 4) will provide us with parameters related with the disk geometry (e.g. inclination, flaring), and will allow to study if they show dust settlingto the disk midplane. A detailed anaylis will be presented in Hu.lamo et al. (in prep.).

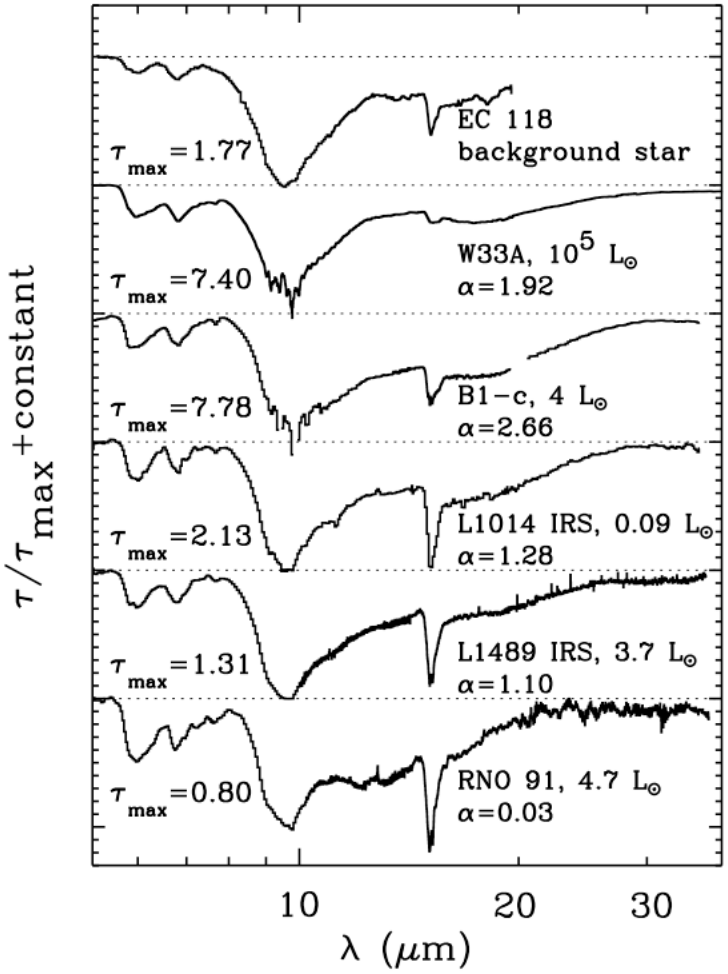
Class I phase



t ~10^4 - 10^5



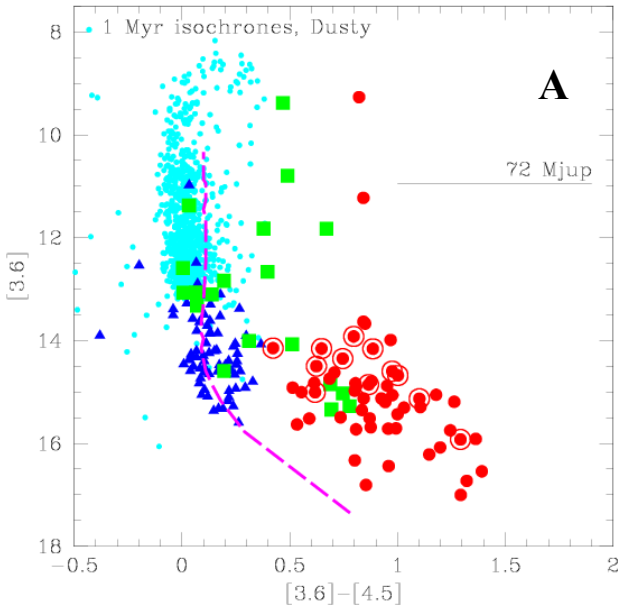
Protostar + disk + envelope + outflows

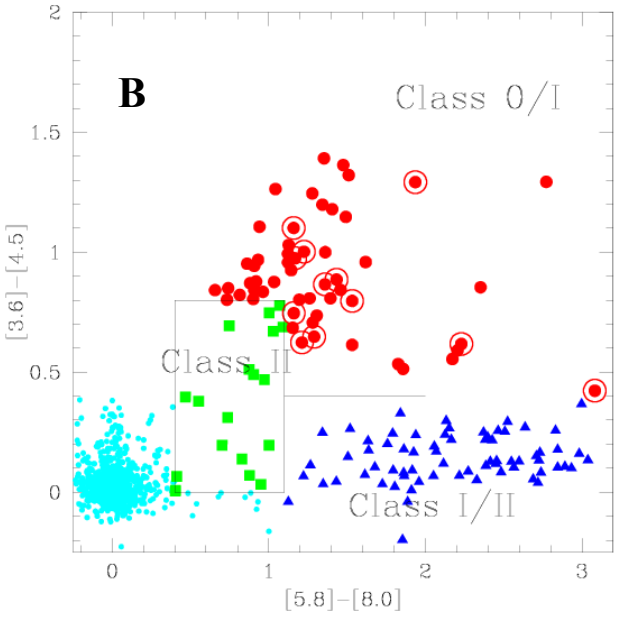


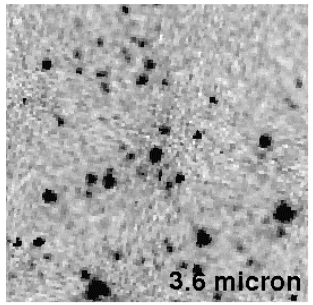
Mid-IR spectra of YSO by Boogert et al. 2008, which show different features corresponding to ices.

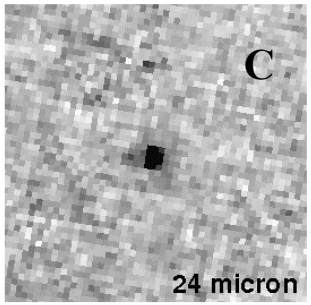
Searching for proto-brown dwarfs

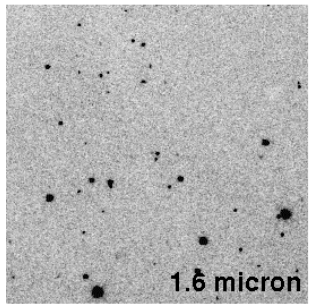
Barrado et al. 2009

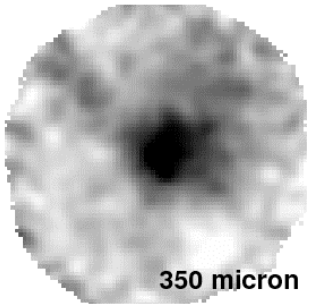


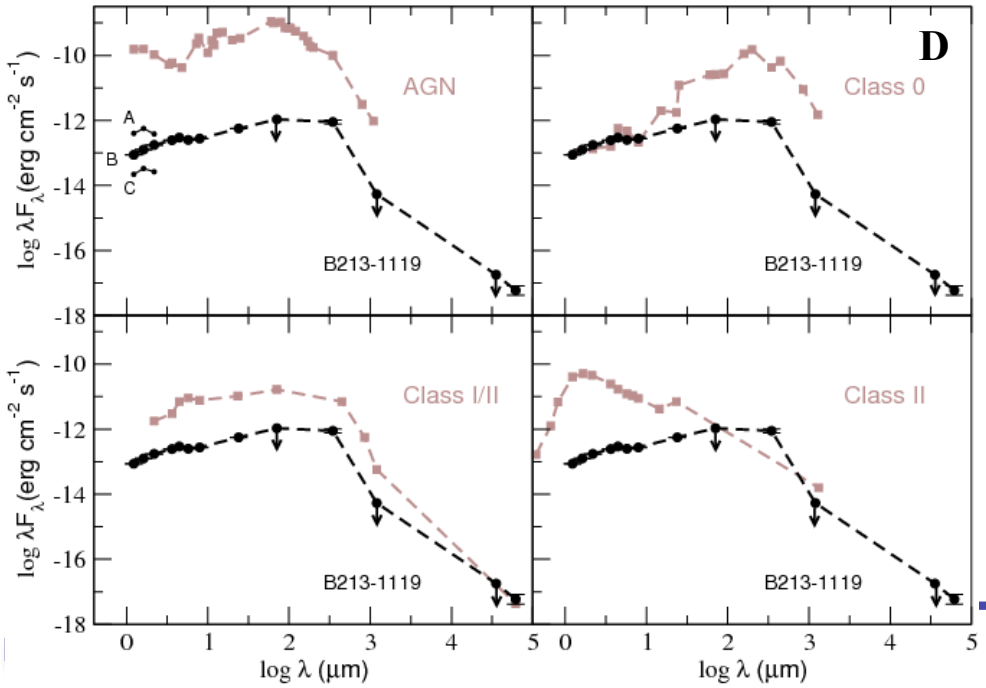


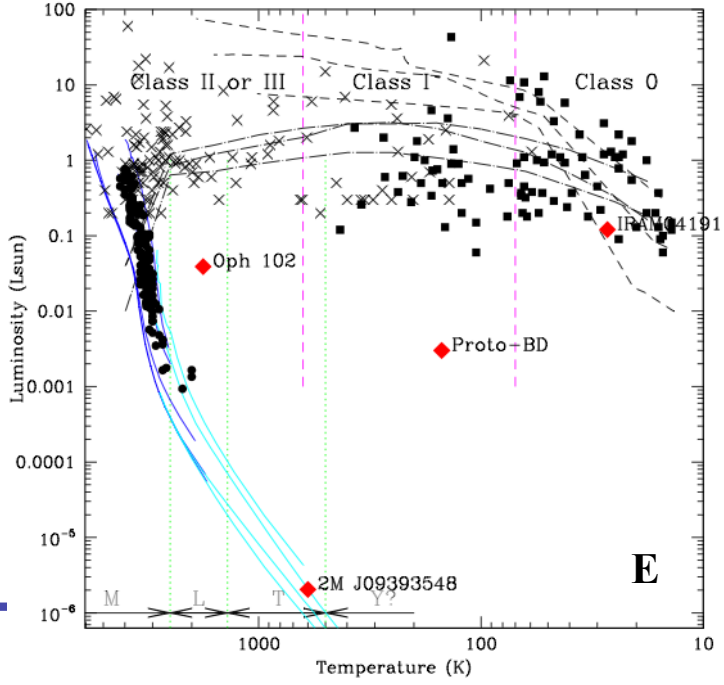




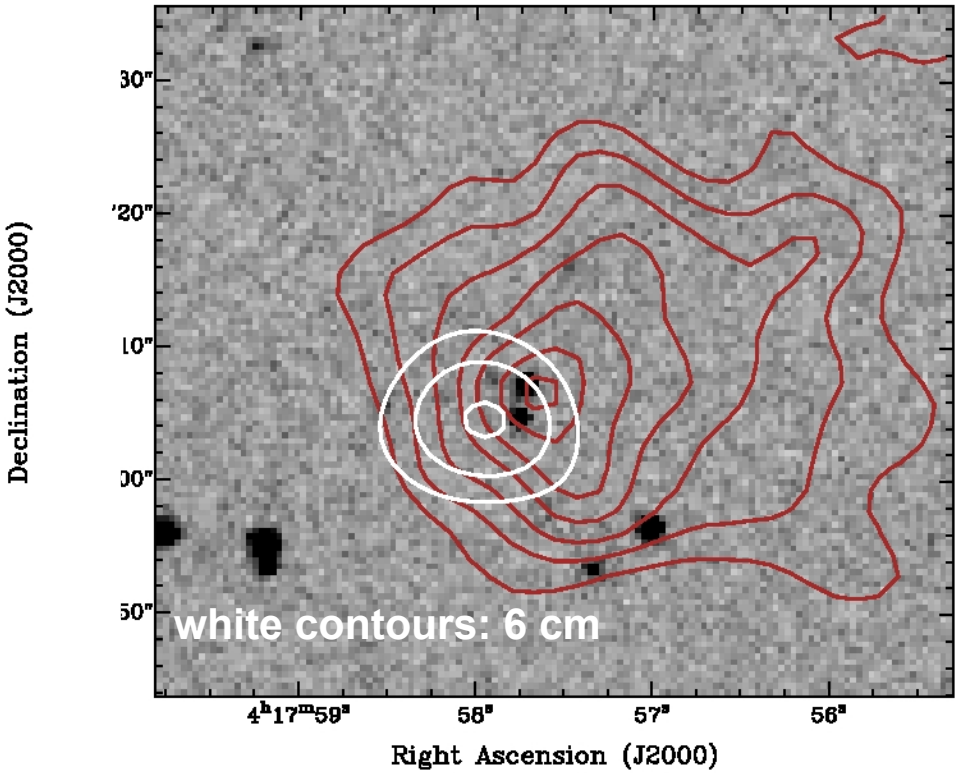






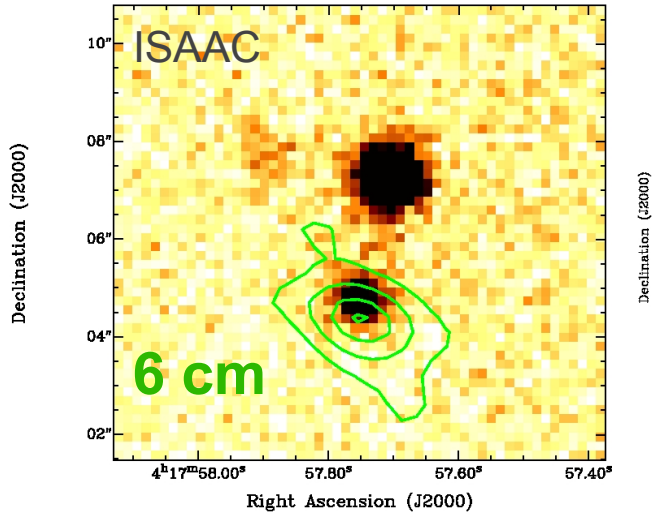


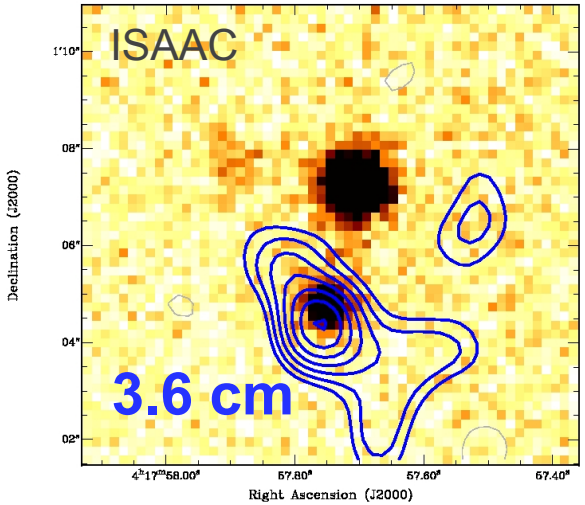
A proto-BD candidate



VLA D-config observations:
Imaging at 6 cm, beam ~ 16":
Compact cm source...
VLA B-config observations:
Imaging at 6 and 3.6 cm, beams ~ 2"
Compact cm sources assoc with B!

ISAAC also 2.19 μm (cont): is C an H2 knot?
must be confirmed spectroscopically (time allocated)





spectral index: -0.7 +/- 0.8 --> does not discriminate btw thermal/non-thermal
cm also in L1014-IRS VeLLO (Shirley et al. 2007)

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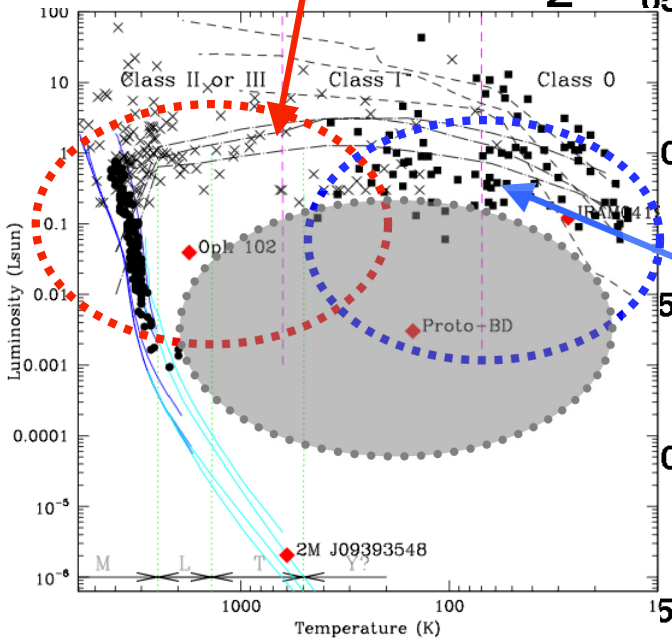
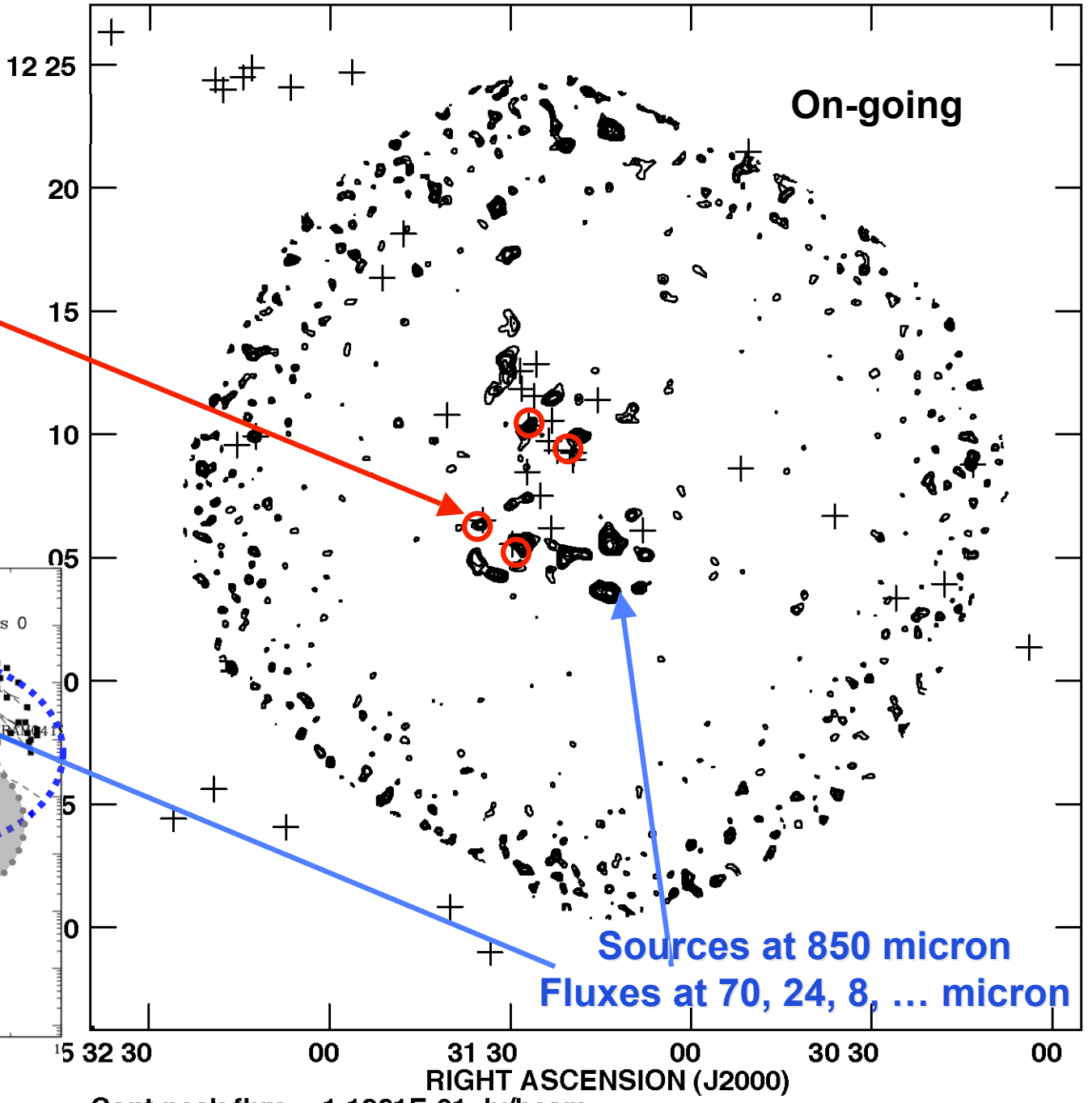
IRAC 4 bands
+ 850 micron





Sources at 850 micron
Fluxes at 70, 24, 8, … micron

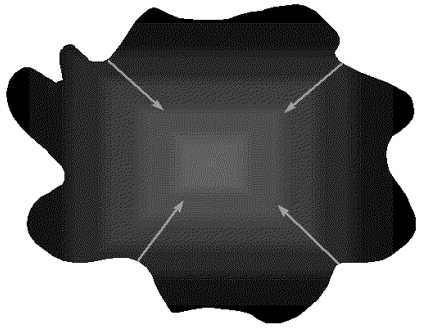
Cont peak flux = 1.1361E-01 Jy/beam
Levs = 7.018E-03 * (3, 4, 5, 6, 7, 8, 9, 12, 15)

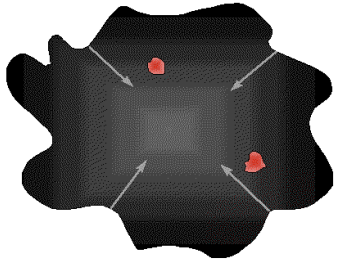
David Barrrado, Jornada ESO,

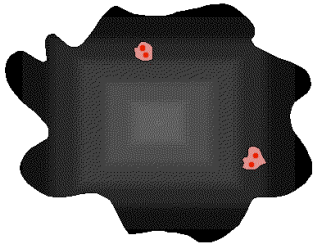
Star Formation: from clouds to planetary systems

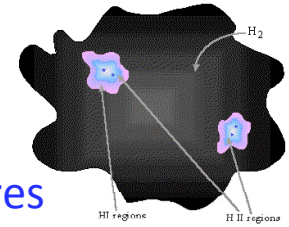
Collapse under gravity

Dark clouds

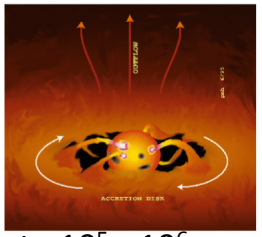


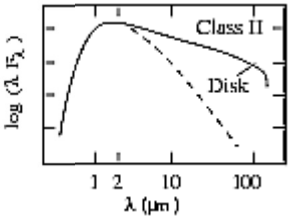






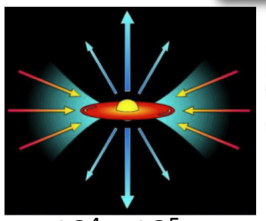
Cores

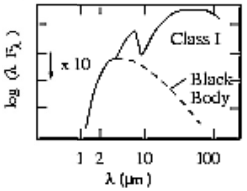




t ~10^5 - 10^6

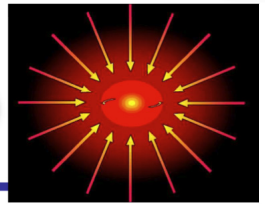
TTauri star, disk + outflows

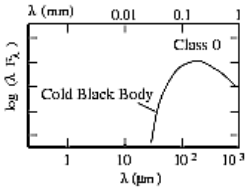




t ~10^4 - 10^5

Protostar + disk + envelope + outflows

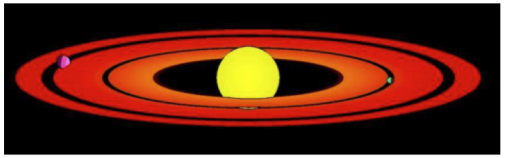




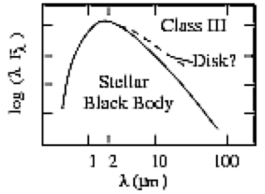
t=0

Gravitational collapse

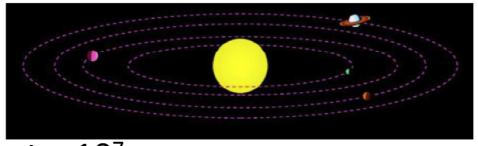
PMS star



t ~10^6 - 10^7

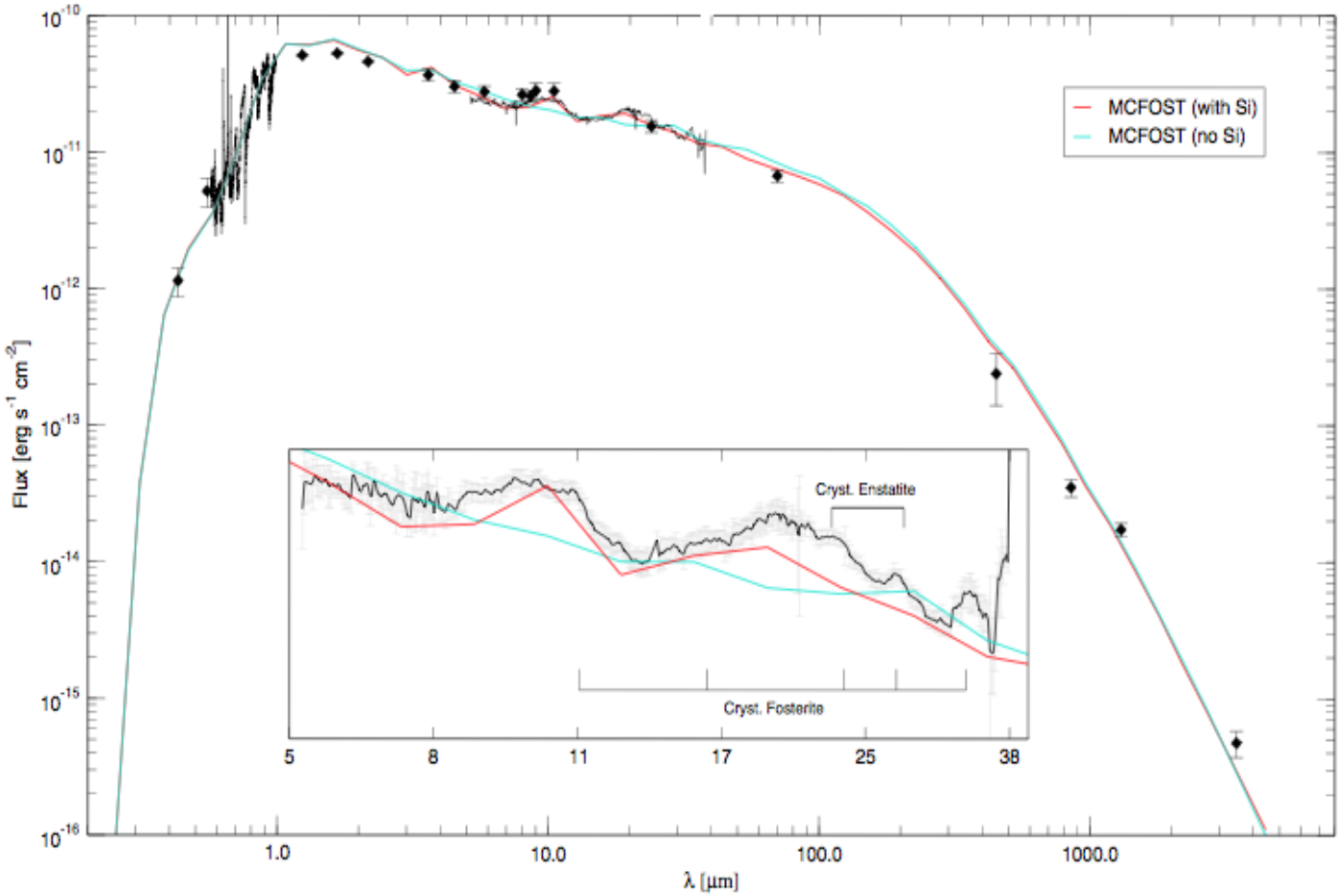


MS star



t > 10^7

Disks around Class II BDs



Spectral energy distribution of the target (black) and best fit MCFOST model including the treatment of silicates (blue curve) and without silicates (red curve). The inset shows a zoom on the IRS spectrum. Some crystalline silicate features are indicated (After Bouy et al. 2008).