

# « Young brown dwarfs and the Initial Mass Function (IMF) »

J. Bouvier, C. Dougados, S. Guieu, T. Kendall,  
F. Menard, J.-L. Monin, E. Moraux, W.-J. de Wit

**Equipe FOST, LAOG**



# The lower IMF and the origin of (sub)stellar masses

## Issues

- How do substellar objects form ( $M < 0.072 M_{\odot}$ ) ?
- What is their mass distribution (IMF) ?
- Is there a lower mass limit to the IMF (Free Floating Giant Planets) ?
- Does BD formation and IMF properties depend on environmental conditions ?
- Or is substellar (and stellar) IMF « universal » ?

# The lower IMF of young clusters

## Why Young Clusters (1-100 Myr) ?

- Large samples ( $> 1000$  stars)
- 2 to 3 decades of masses ( $\sim 10M_{\text{jup}}-10M_{\text{sun}}$ )
- Homogeneous populations (same age, metallicity, distance)
- Young « bright » BDs at an age of 1-100 Myr
- Limited extent on the sky : wide field surveys

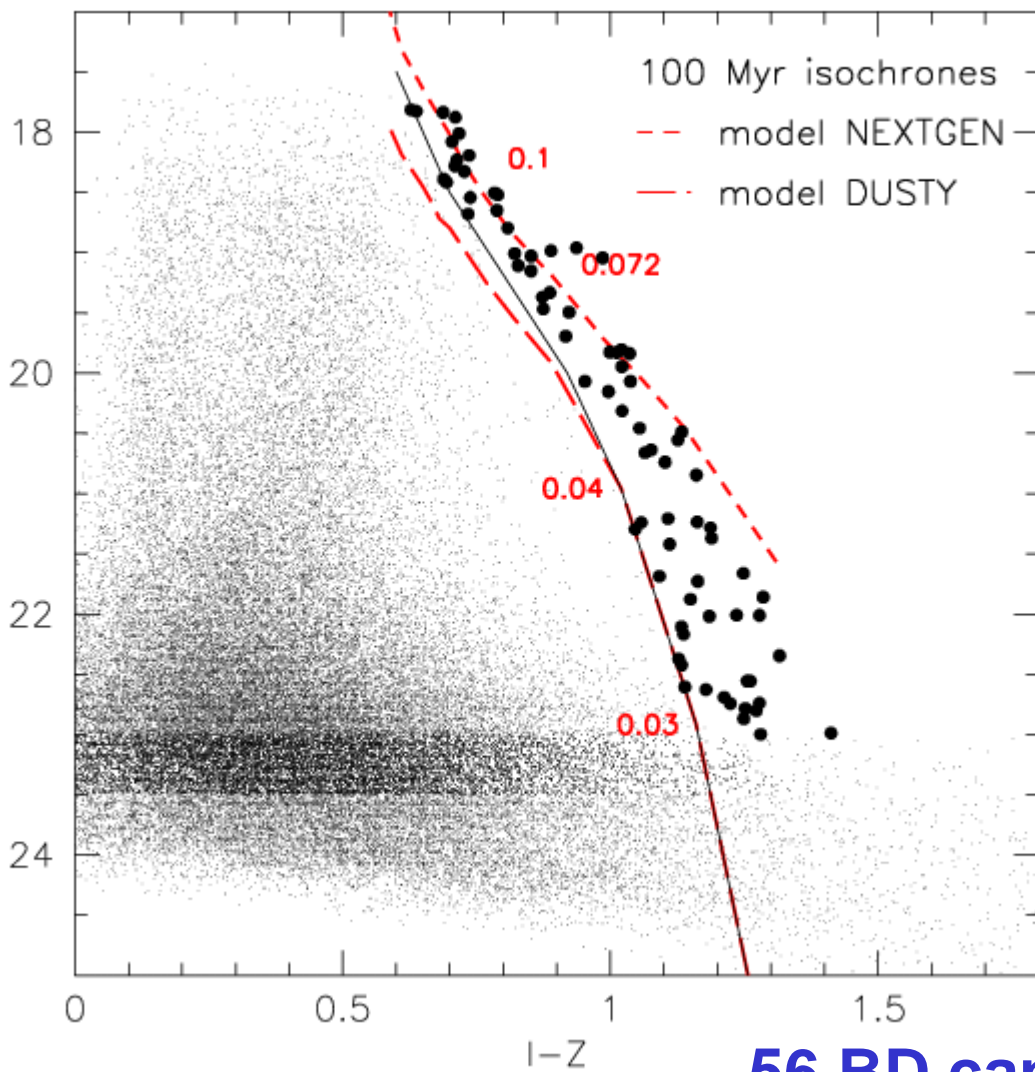
# CFHT 12K + MEGACAM

- CFHT Large Program : 2002A-2003B
- Deep, wide field I,z surveys
- Selected star forming regions and young open clusters
- 100+ square degrees
- I,z filters down to 24 mag
- Detect BDs down to  $\sim 30 M_{\text{Jupiter}}$  in young open clusters (0.03 Mo)

# Young open clusters : photometric surveys

<b>Cluster</b>	Age	[Fe/H]	Richness
<b>Blanco 1</b>	100 Myr	+0.1/0.2	> 200 *
<b>Pleiades</b>	120 Myr	0.0	~ 1200 *
<b>NGC 2516</b>	150 Myr	-0.3/0.0	~2000 *
<b>Hyades</b>	625 Myr	+0.14	> 300 *

### (I, I-z) CMD

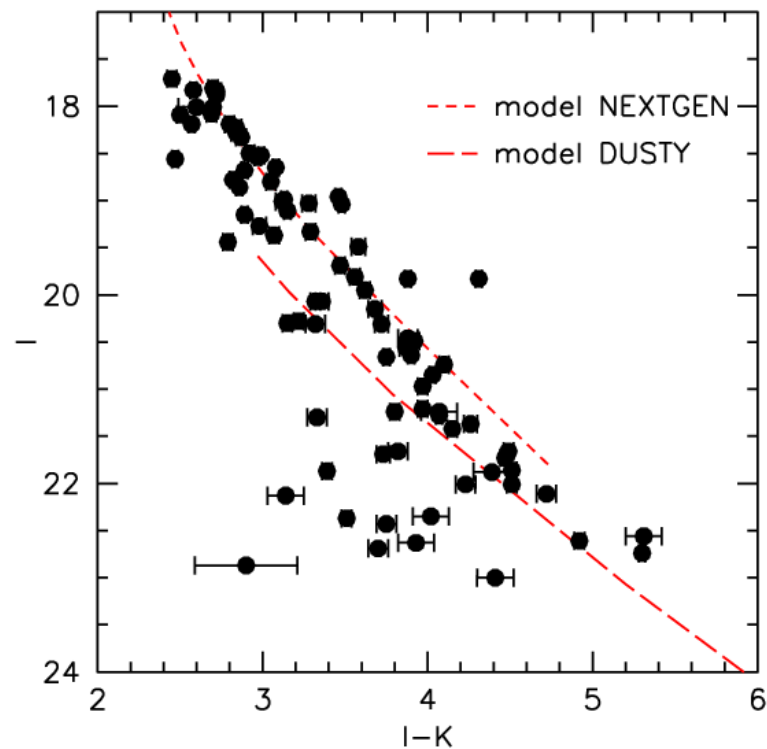


**56 BD candidates**

# Blanco 1

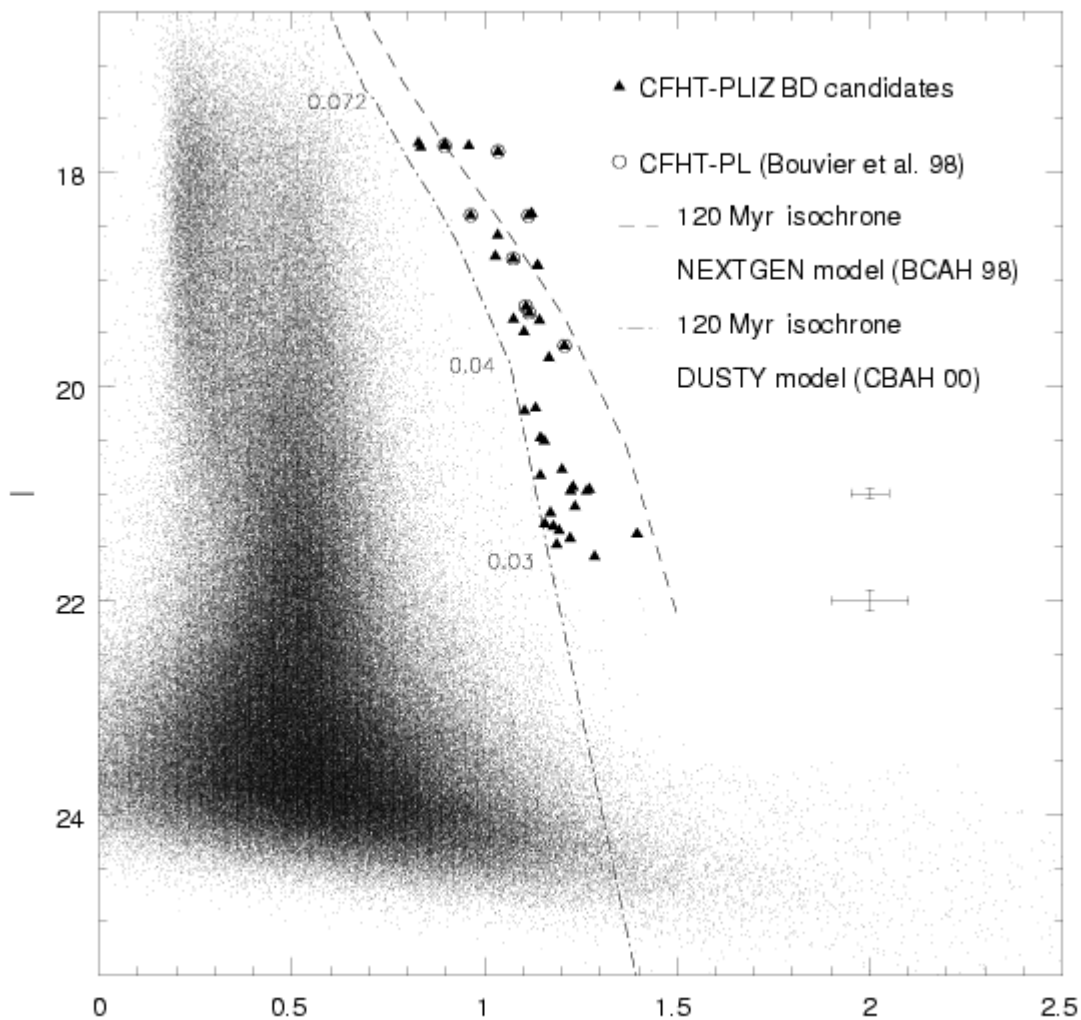
**Galactic latitude = +89**

### (I, I-K) CMD



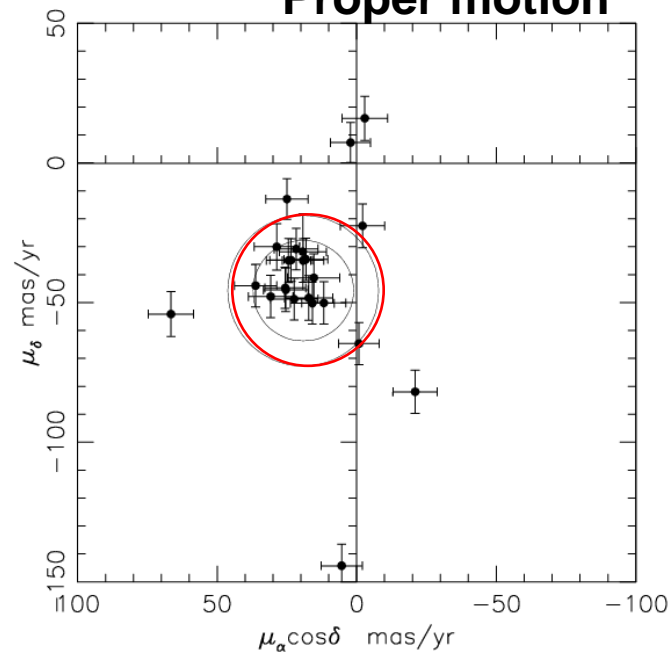
# Pleiades

(I, I-z) CMD

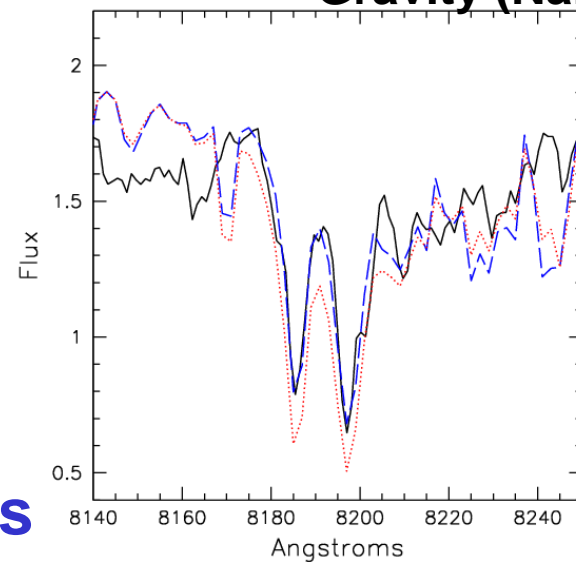


**40 BD candidates**

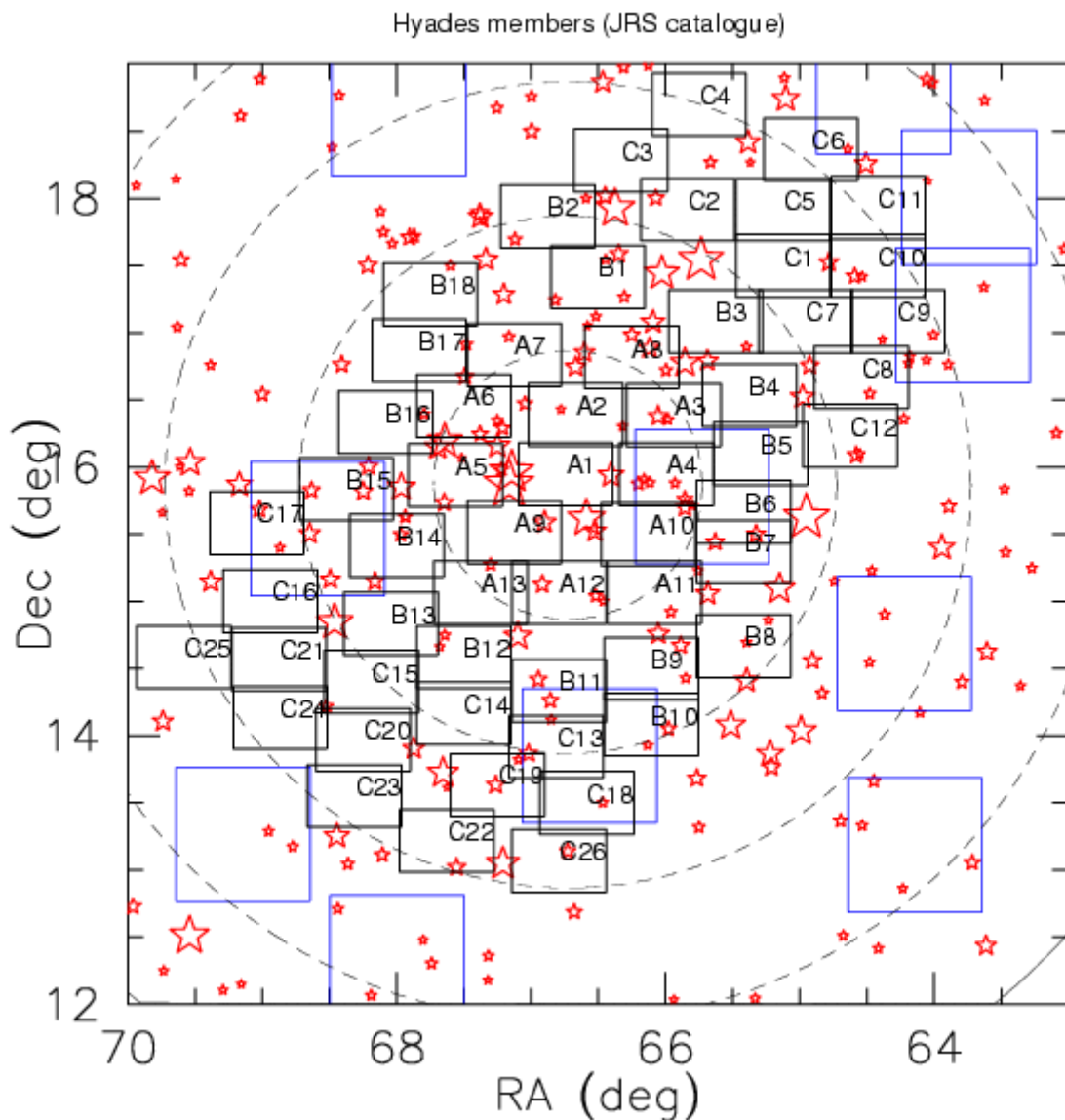
Proper motion



Gravity (NaD)



# Dynamically evolved open clusters : the Hyades



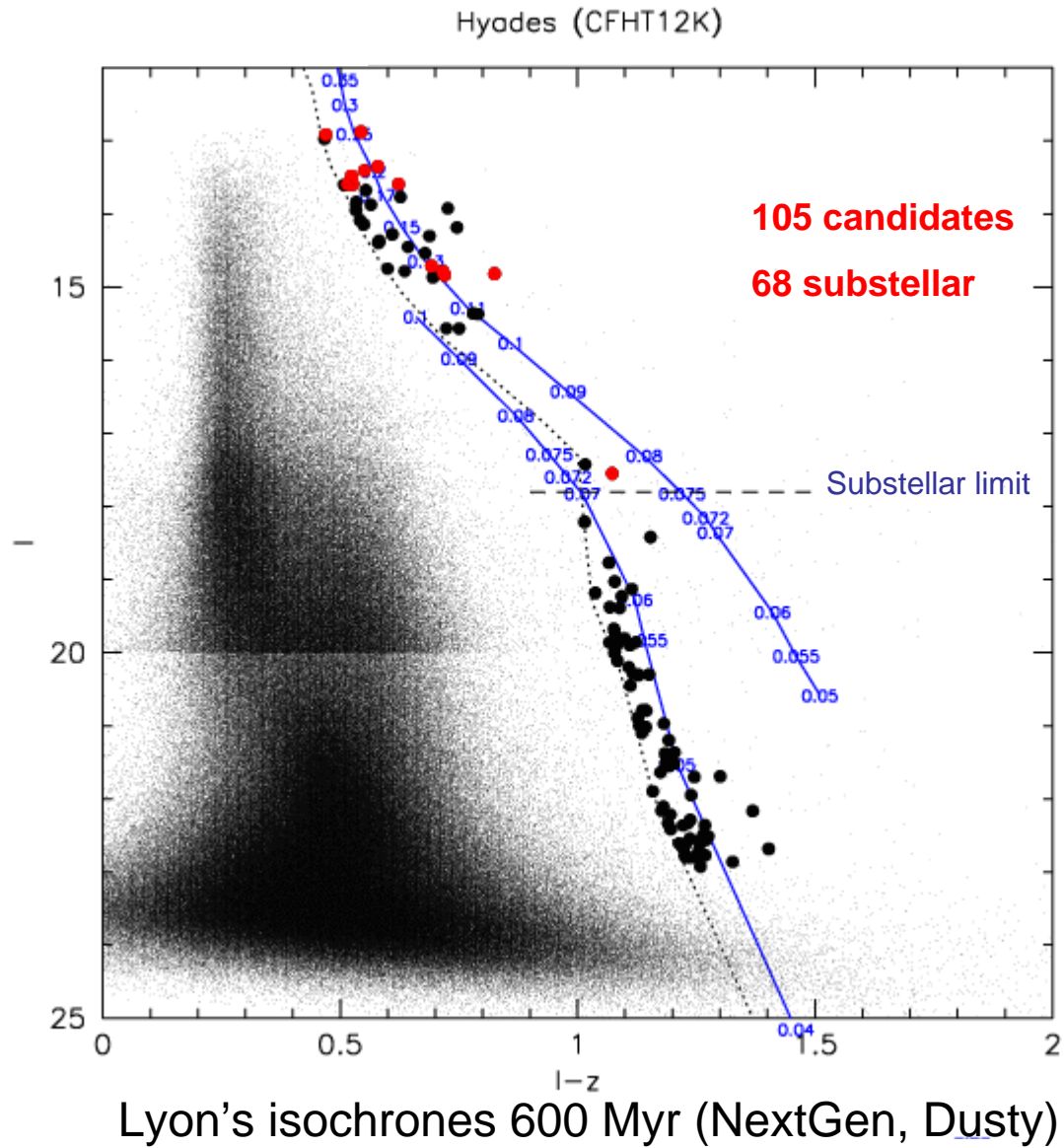
Distance : 43 pc

Age = 625+/-50 Myr

[Fe/H] = 0.14

**CFHT survey**  
**17.4 sq.deg.**  
**I,z ~24.**



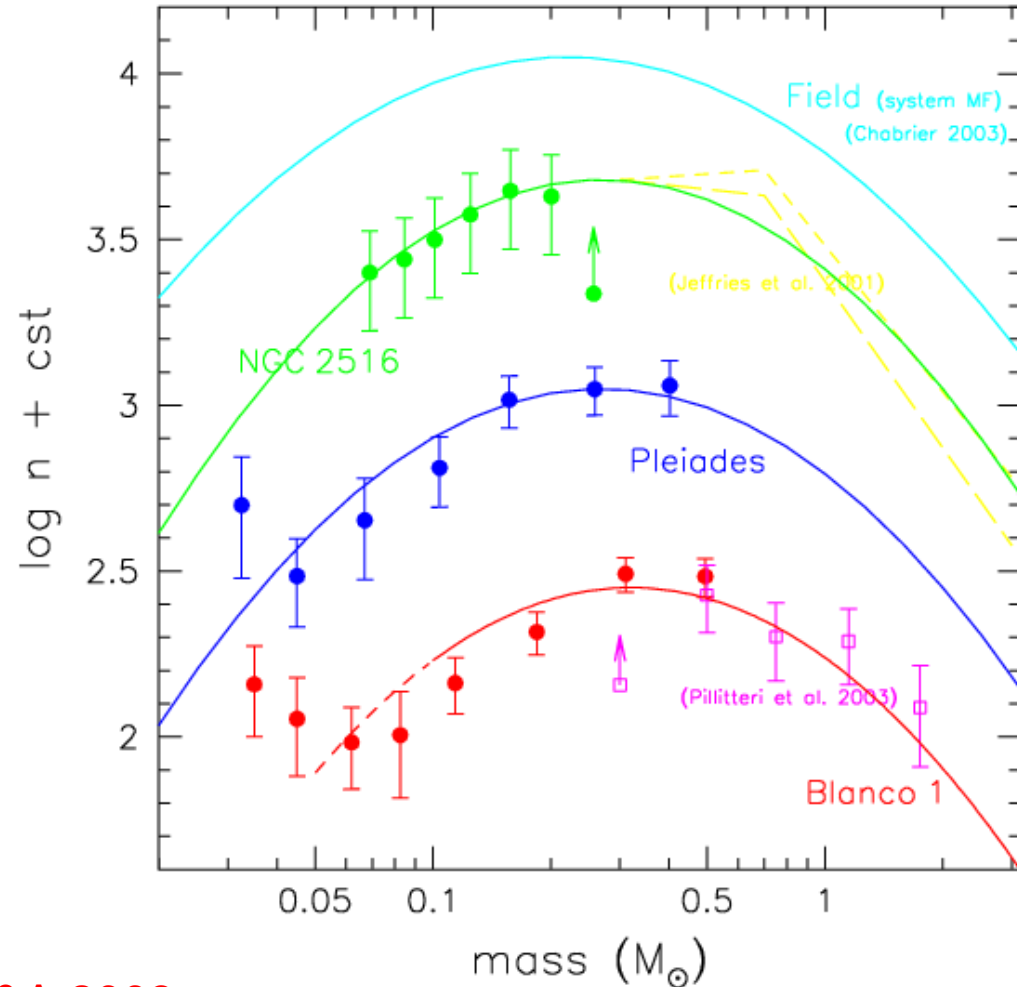
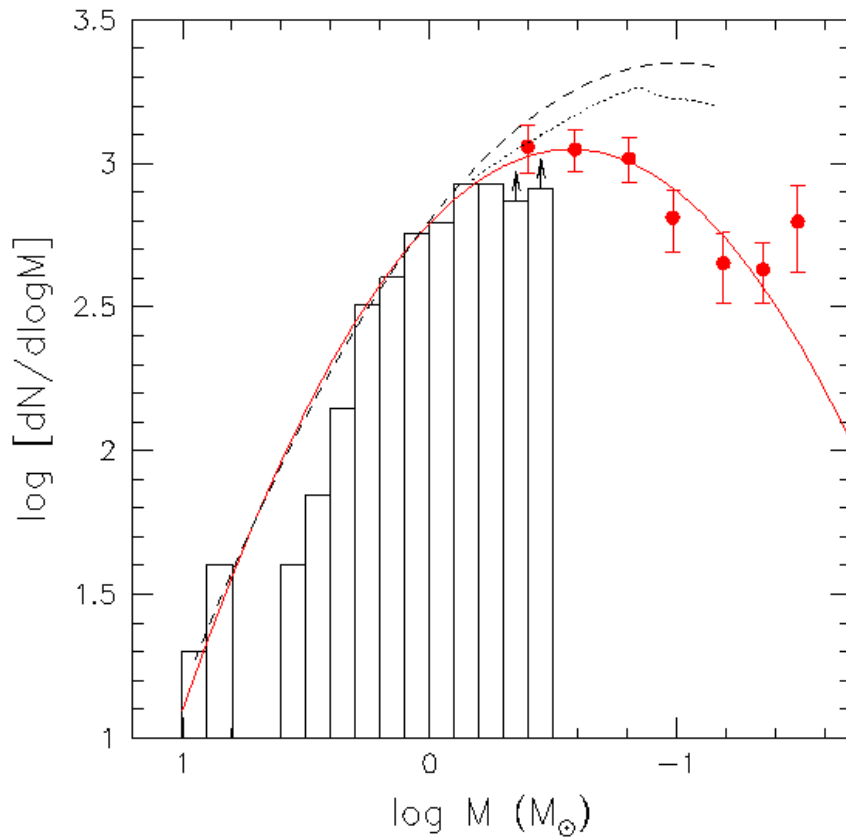


# Results : the IMF of young open clusters

PLEIADES Mass Function

Morax & Bouvier 2004

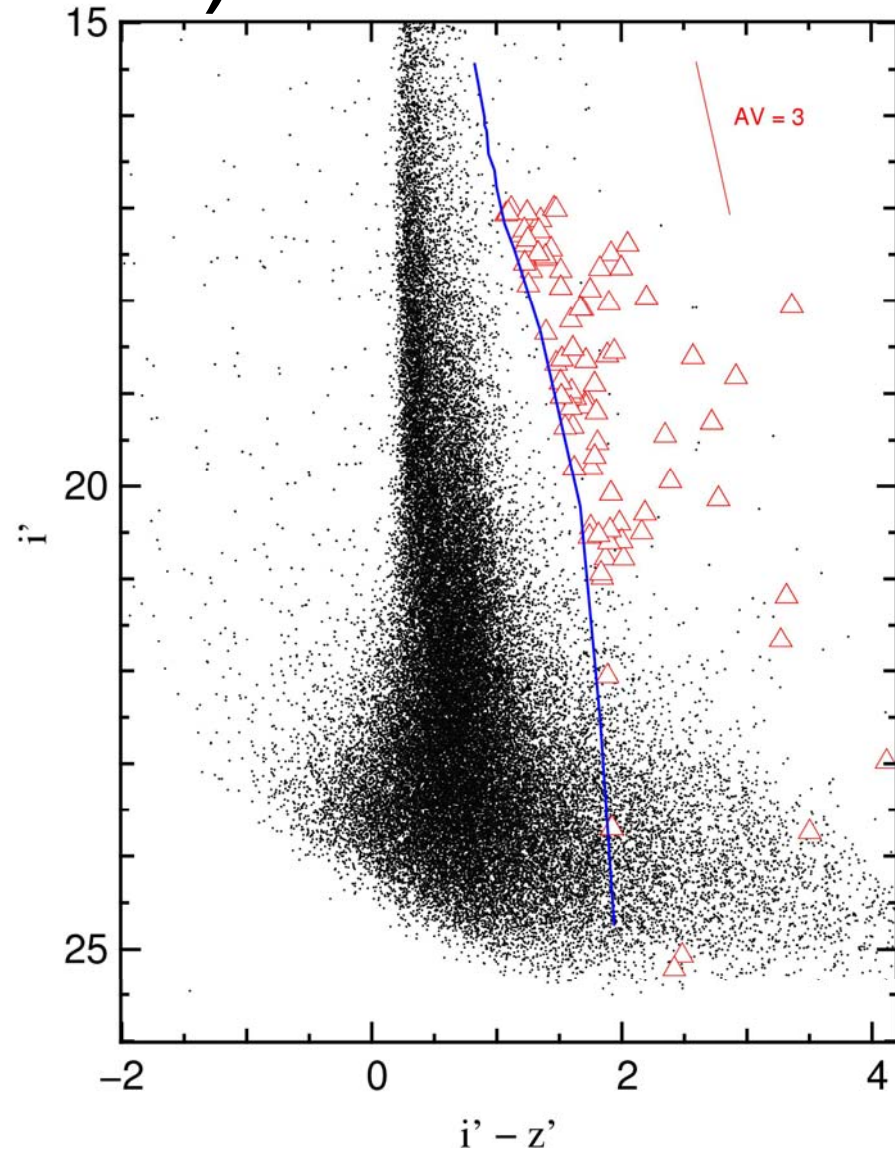
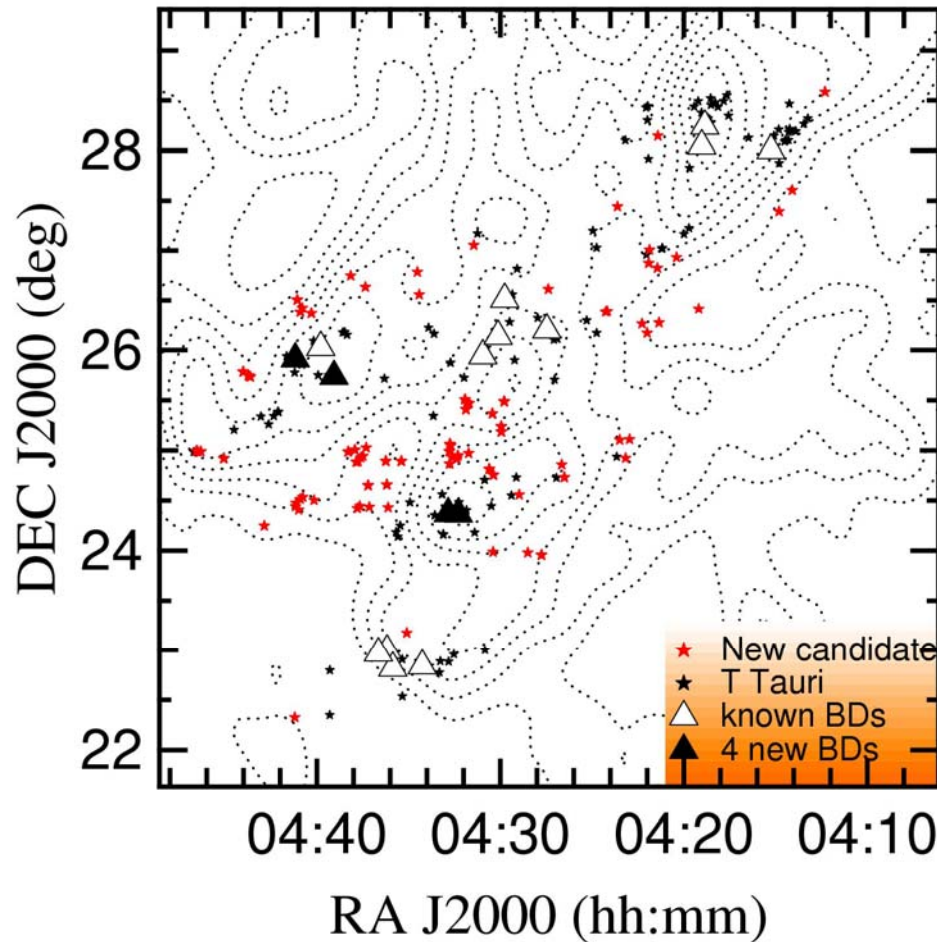
$dN/d\log M = G(\langle 0.25 \rangle, 0.52)$   
from 30 M<sub>Jup</sub> to 10 M<sub>Sun</sub>



Morax, Bouvier, Stauffer, Cuillandre A&A 2003

# TAURUS : 200+ New candidates (MEGACAM)

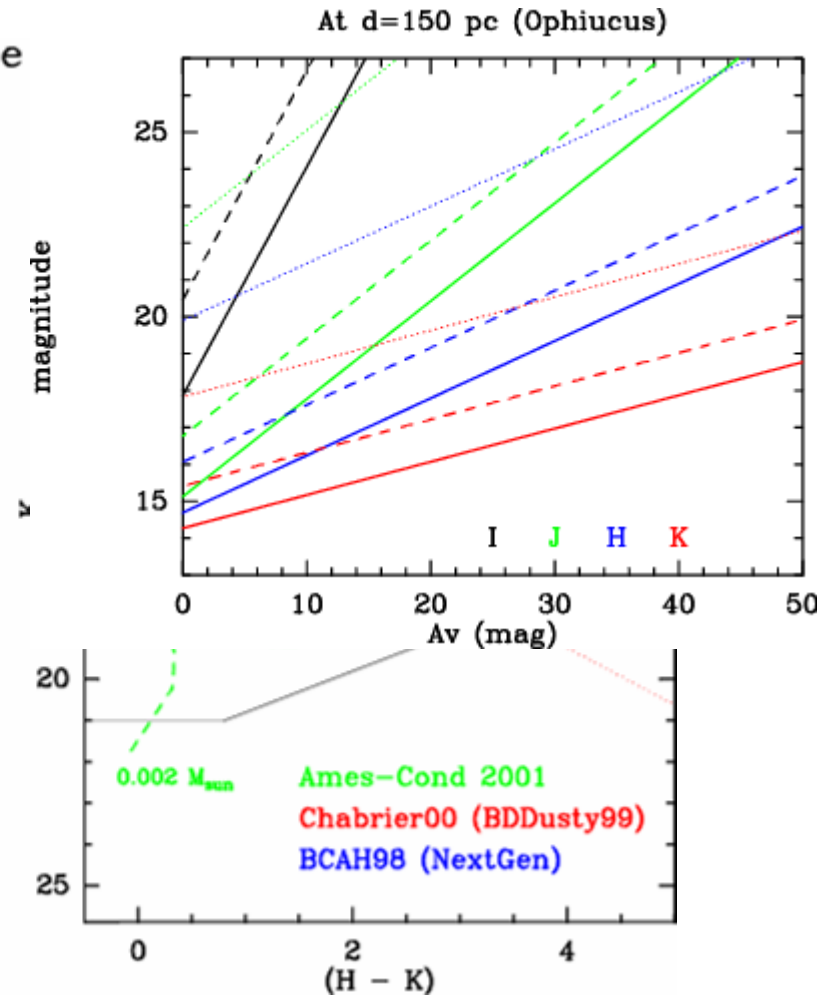
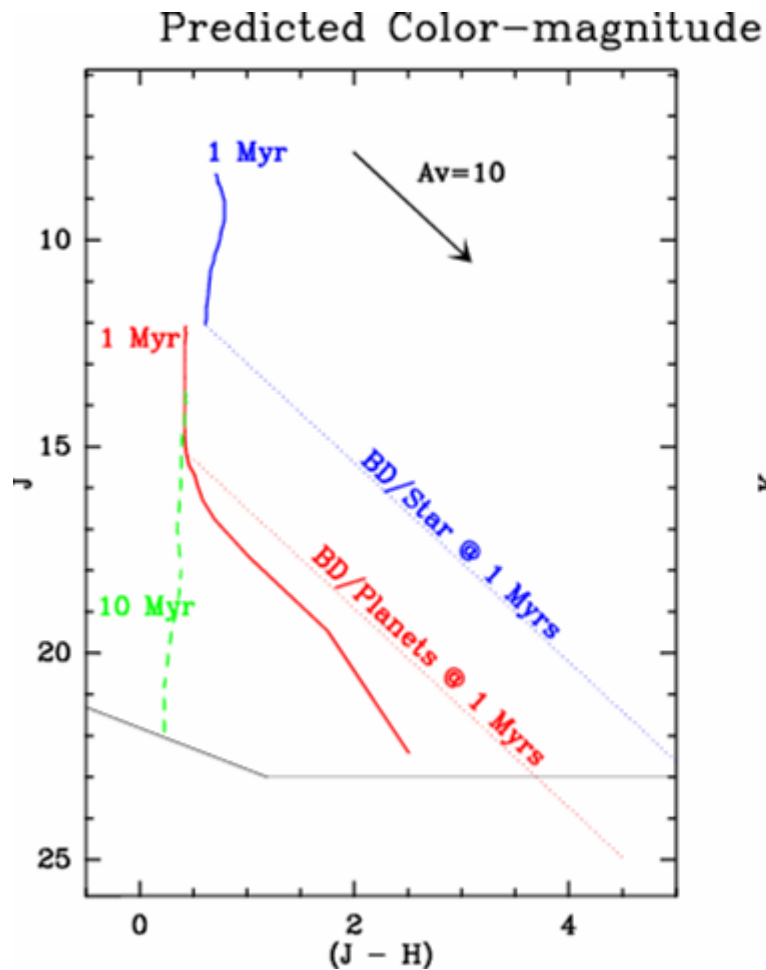
S. Guieu et al., in prep.



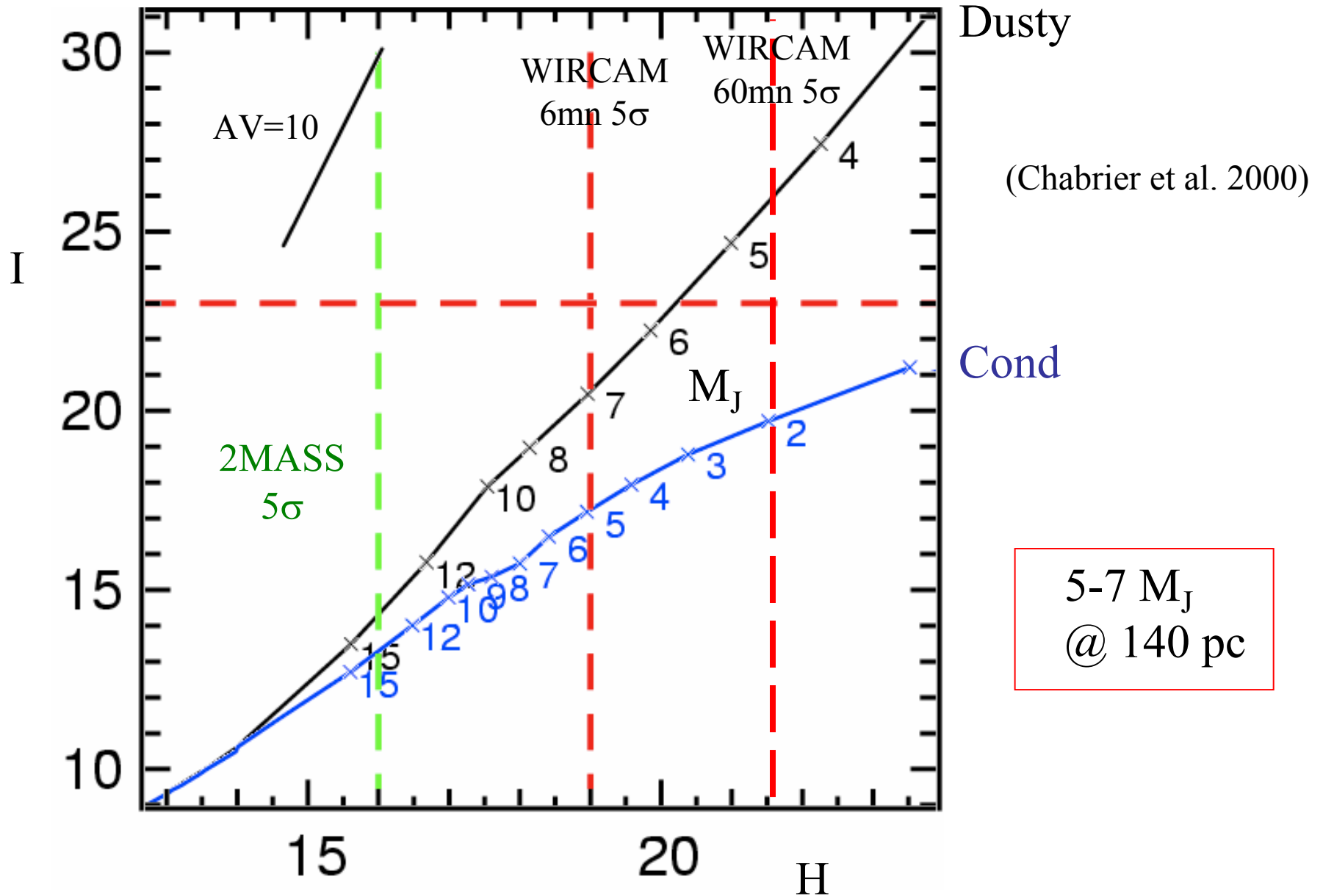
# WIRCAM surveys

- **I. Ultra-deep (Y)JHK surveys of young clusters**
    - JHK down to  $K \sim 21.5$  (5 sigma, 1h)
    - Reach  $\sim 8 M_{\text{Jup}}$  in Young Open Clusters (Pleiades, IC 4665)
    - Reach  $\sim 2 M_{\text{Jup}}$  in Star Forming Regions (e.g. NGC2264, Taurus)
      - **LOWER END OF THE IMF : 10-30  $M_{\text{Jup}}$**
  - **II. Methane (CH<sub>4</sub> on/off) search for young T dwarfs**
    - on promising young T dwarfs candidates ( $< 10 M_{\text{Jup}}$ )
    - survey mode in selected Star Forming Regions (e.g. IC 348)
      - **FREE FLOATING GIANT PLANETS : 2-10  $M_{\text{Jup}}$**
- N.B. :** complementary very-wide, shallow surveys ( $K \sim 18.4$ ) are performed by UKIDSS GCS

# WIRCAM & Star Forming Regions

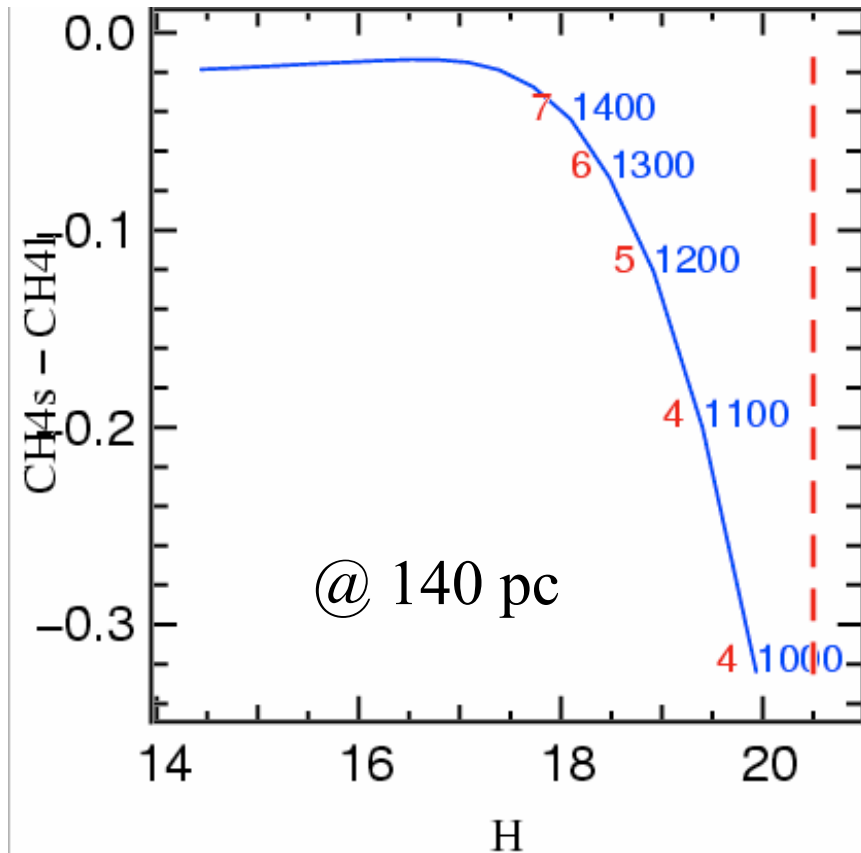


# I mag vs H mag for various Masses ( $M_{\text{Jup}}$ )



# Young T Dwarfs == Free Floating Giant Planets (< 12 M<sub>Jup</sub>)

CH<sub>4</sub> on- CH<sub>4</sub> off



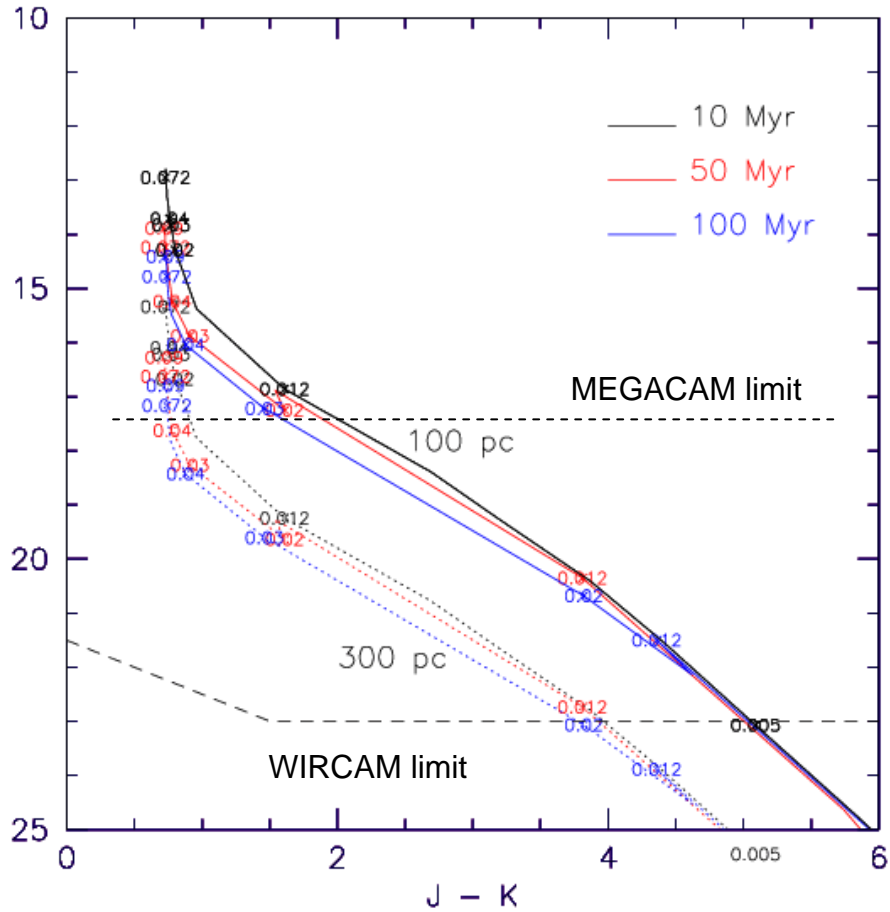
Methane filter

T<sub>eff</sub> < 1400 K

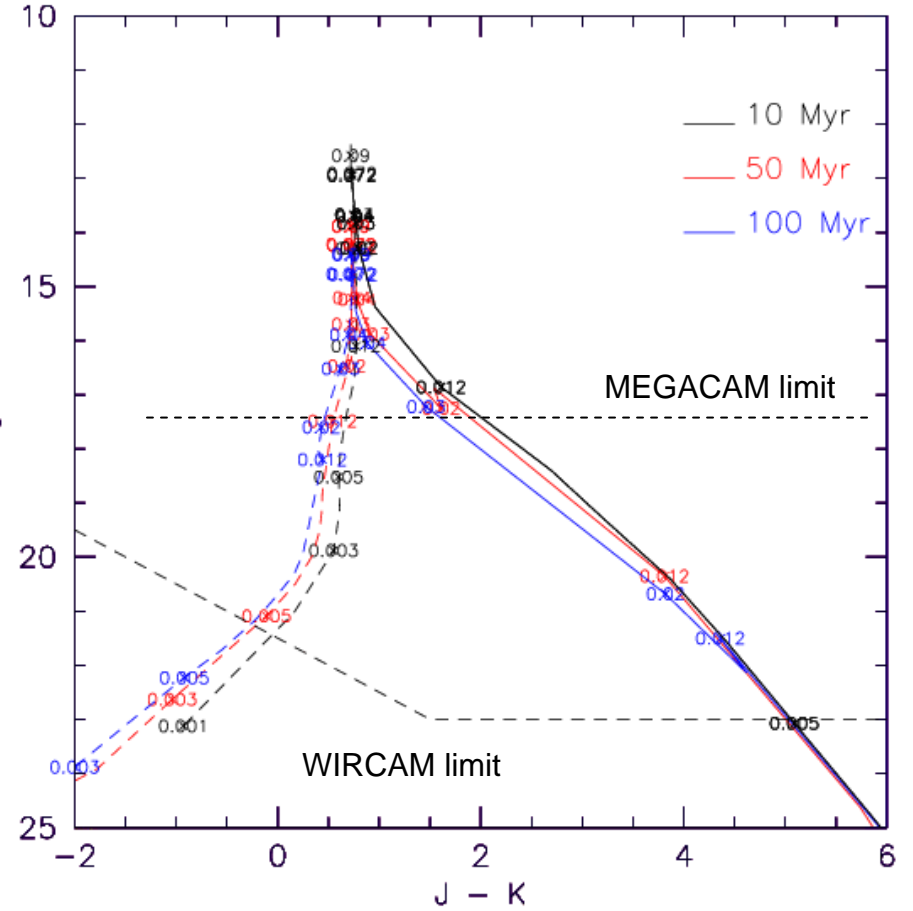
CH<sub>4</sub> absorption band @ 1.7 μm

# WIRCAM & Young Open Clusters

Young Open Clusters : Dusty Models



Young Open Clusters : Dusty & Cond Models (d=100pc)





# Summary

- **CFHT12K + MEGACAM** : very low mass stars and brown dwarfs : 0.03-0.3  $M_{\text{sun}}$  (**substellar IMF**)
- **WIRCAM** : low mass brown dwarfs and free floating giant planets : 2-30  $M_{\text{Jup}}$  (**lower end of the IMF**)
  - **Complete IMF from 1  $M_{\text{Jup}}$  to 10  $M_{\text{sun}}$**
- **Coordination WIRCAM / UKIDSS**
  - UKIDSS : wide, shallow surveys (GCS)
  - WIRCAM : focussed, ultra-deep surveys(ongoing discussions since Sept.03; E. Moraux @Cambridge)

# Large program requirements

- 3 Star Forming Regions (1-10 Myr)
  - 3 Young Open Clusters (10-100 Myr)
  - ~ 1.5 sq.deg. ultra-deep surveys (15 FOV)
  - (Y)JHK + CH4 on/off
  - 1h per filter = 5h per WIRCAM field
  - $15\text{FOV} * 5\text{h} * 6 \text{ clusters} = 450 \text{ hours}$
- **65 nights** for the expected detection of a few hundred young low mass BDs and FFGP (~2 -- 30 Jupiter masses)