Constraint on brown dwarf formation: radial variation of the stellar and sub-stellar mass function of IC 2391 (and mass function of Praesepe)

Steve Boudreault

Coryn Bailer-Jones, Bertrand Goldman, Thomas Henning and Wei Wang (*Max-Planck-Institut für Astronomie*)

José Caballero (*Universidad Complutense de Madrid*)

Constraint on brown dwarf formation: radial variation of the stellar and sub-stellar mass function of IC 2391 (and mass function of Praesepe)

→ Background (*justification of project*)

→ Photometric Survey

→ Results

→ Future work

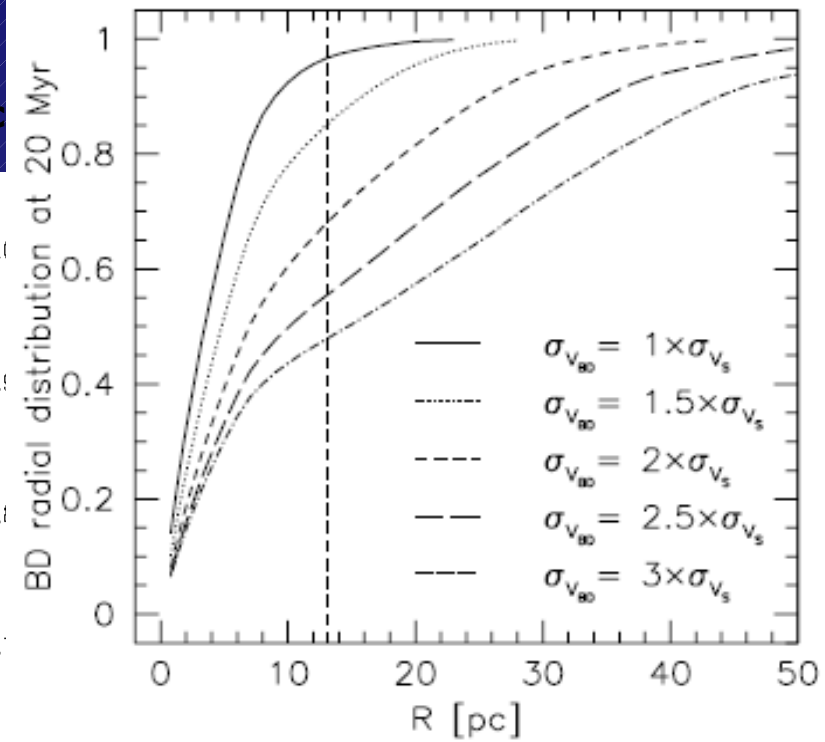
Background : previous radial/spatial study of cluster(s)

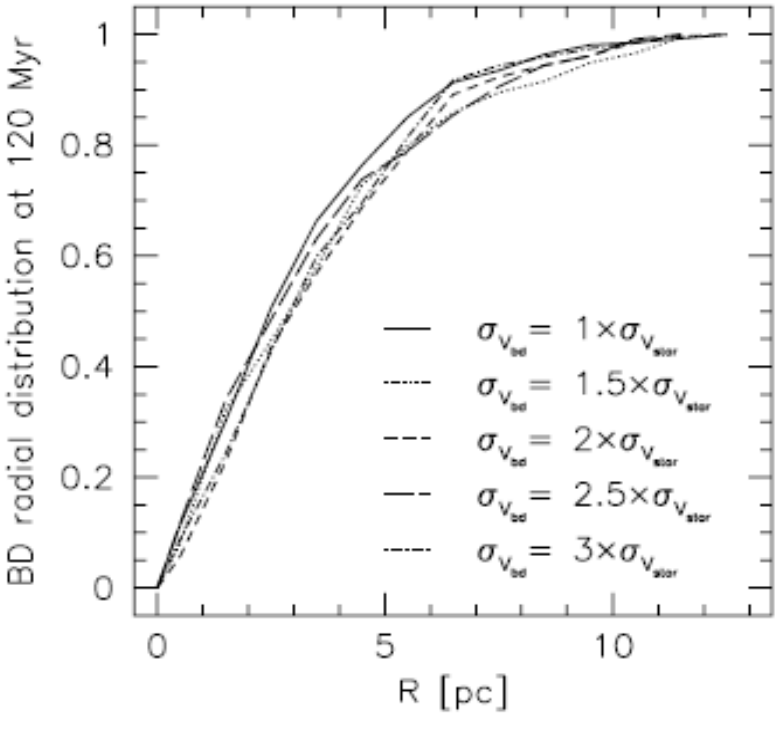
BDs with $v > v_e$ ⇨ these BDs would have escaped after a few t_c

BDs v_δ and spatial distribution *very* similar to stars

ench et al. (2002)

Moraux & Clarke (2005)





limiting magnitude (K)

0.5

if v_δ~2-3km/s Kroupa & Bouvier (2003)

⇨ in favor of ejection scenario

Future Work

80 - 25M_J : 14% in core / 16% in halo (+/- 10%)

⇨ whether IMF variation primordial or via dynamical evolution, does not acting on substellar population

Background : why survey in IC2391 ?

IC239 … nuse …

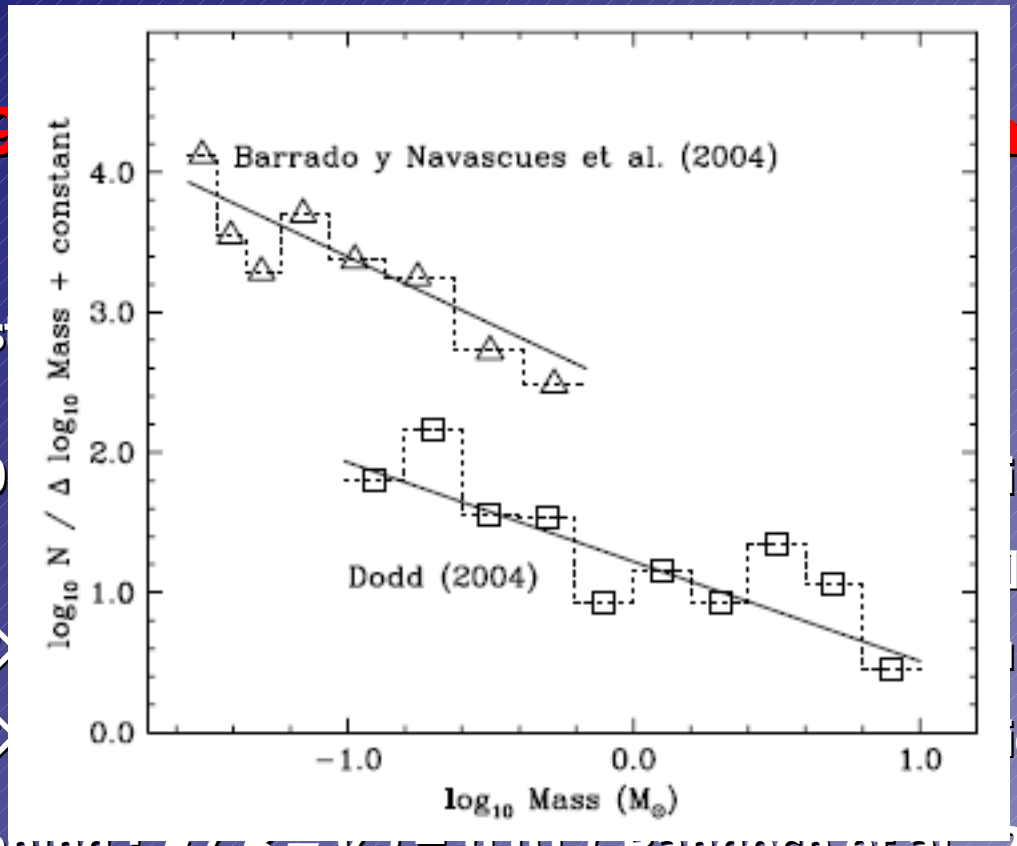
near : dis

age of 50 **i])**

])

lar gaz, models)

ical data)

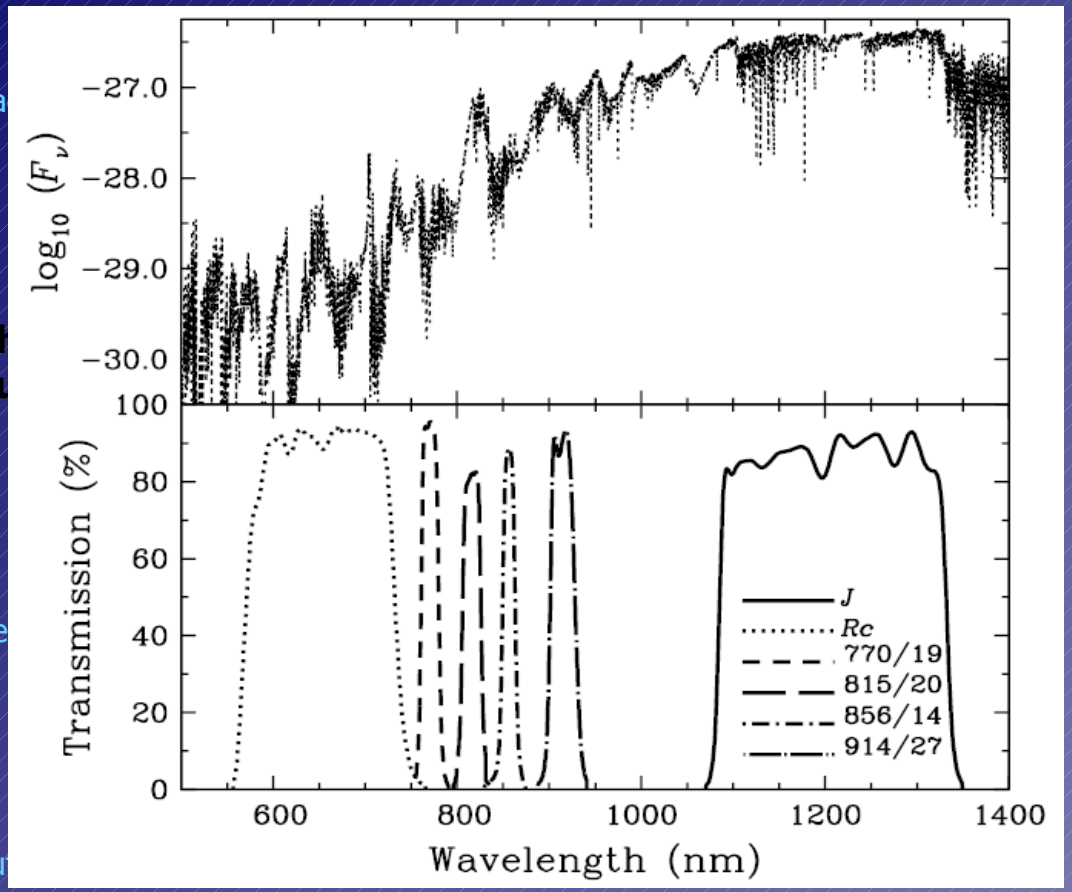


low reddening : $E(B-V) = 0.01$ (Randoch et al., 2001)

previous study of MF : completness limit of 0.072$M_\odot$

no radial study of IC 2391 yet

Photometric Survey : determination of the mass function for very low mass stars and brown dwarfs population in IC 2391



Wide bands R_c and J

Medium bands at 770, 815, 856 and 914 nm

(~ 10.9 sq. deg.)

➪ ESO/WFI (optical data)

➪ CTIO/CPAPIR (IR data)

10δ detection limit at ~0.03M⊙

Fields chosen to …

➪ avoid bright stars

Those bands were chosen …

➪ avoid MF gradient due to

➪ to sample spectra of M and low galactic latitude *b*~-6º L-dwarfs

➪ to minimize Earth-sky background

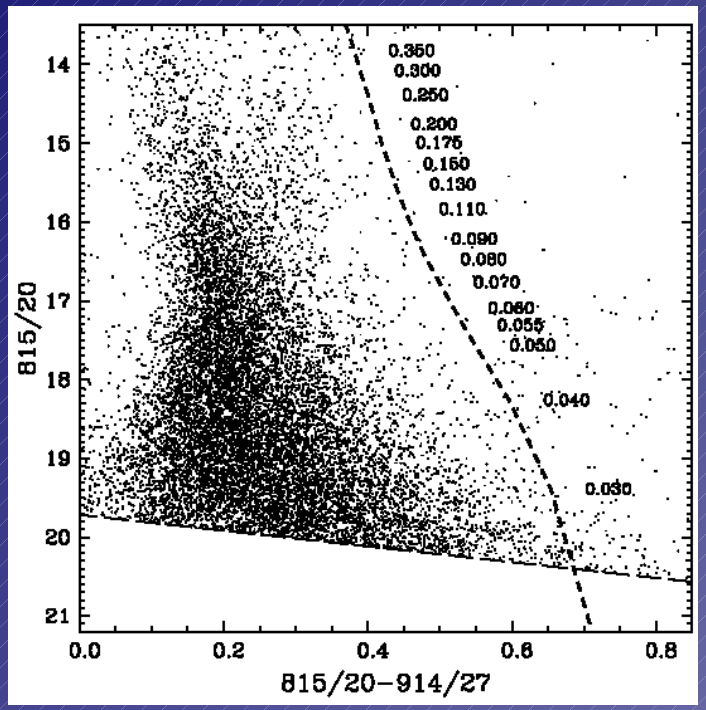
Photometric Survey : determination of the mass function for very low mass stars and brown dwarfs population in IC 2391

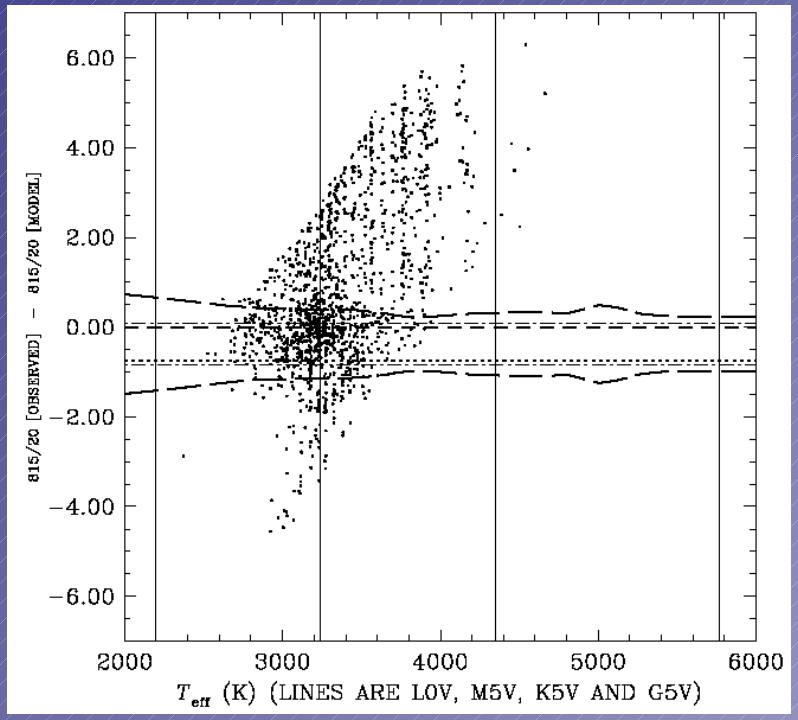
Background

Photometric Survey

Results

Future Work

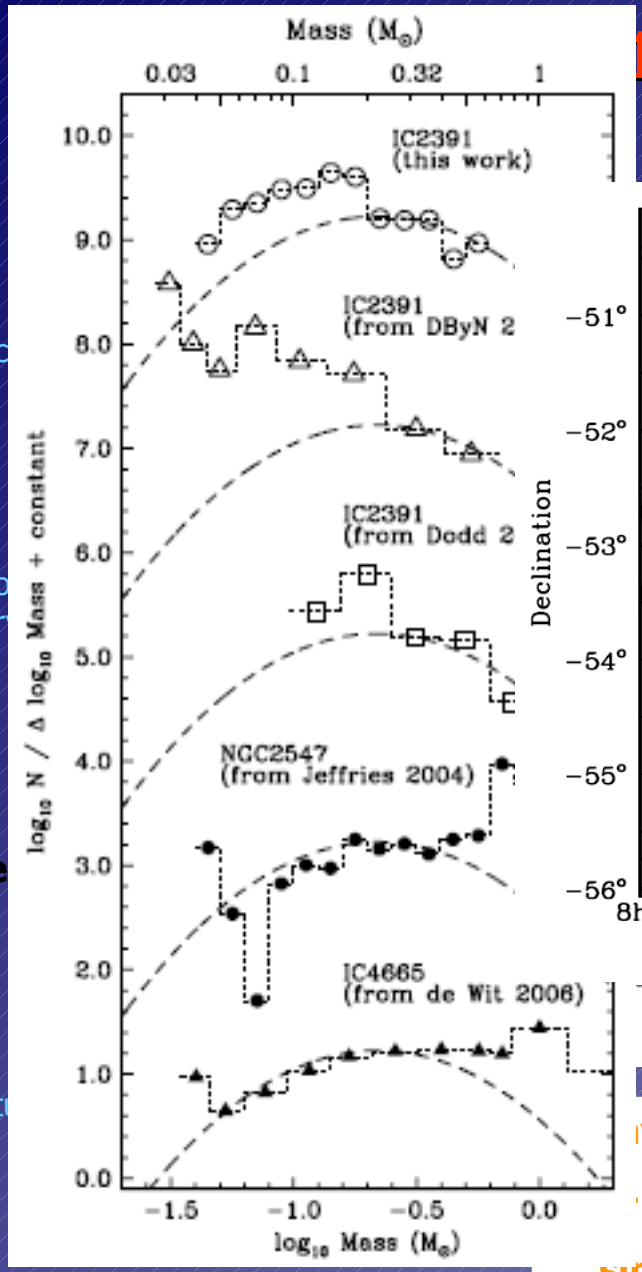


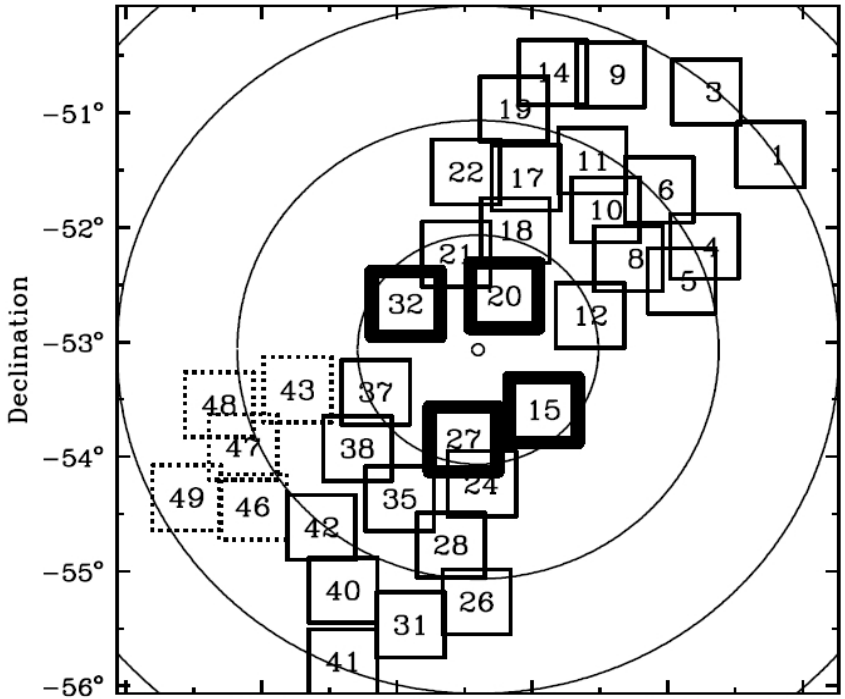


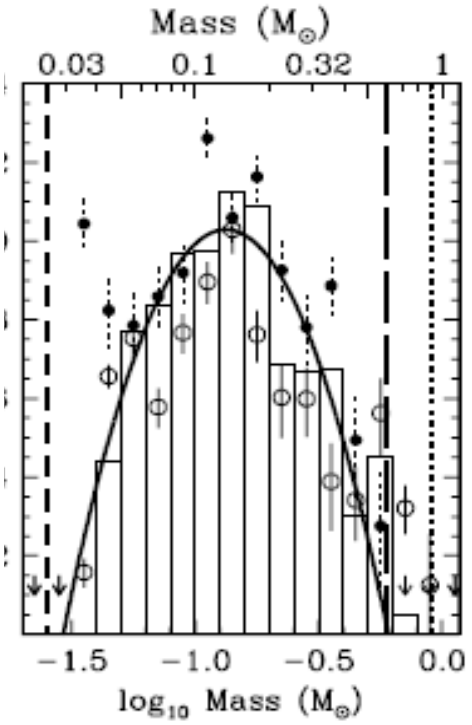
- Colour-magnitude diagrams
- Colour-colour diagrams

- Astrometry
- *M* [obs] VS *M* [model] (from *T*eff and mass)

Results : no radial variation below 0.15 $M_\odot$ of the mass
1, but observed for 0.15 – 0.9 $M_\odot$







$\log_{10}$ Mass ($M_\odot$)

Bac

Pho
Sur

Re

Futu

…vor of $v_{\delta BD} > v_{\delta s}$? (Kroupa & Bouvier 2003)

… BDs are already gone (Moraux & Clarke 2005) ?

… simply other formation process involved ?

Future work : spectroscopic follow-up to confirm/refute the radial variation of the mass function of IC 2391

To confirm the radial variation of the MF of IC 2391

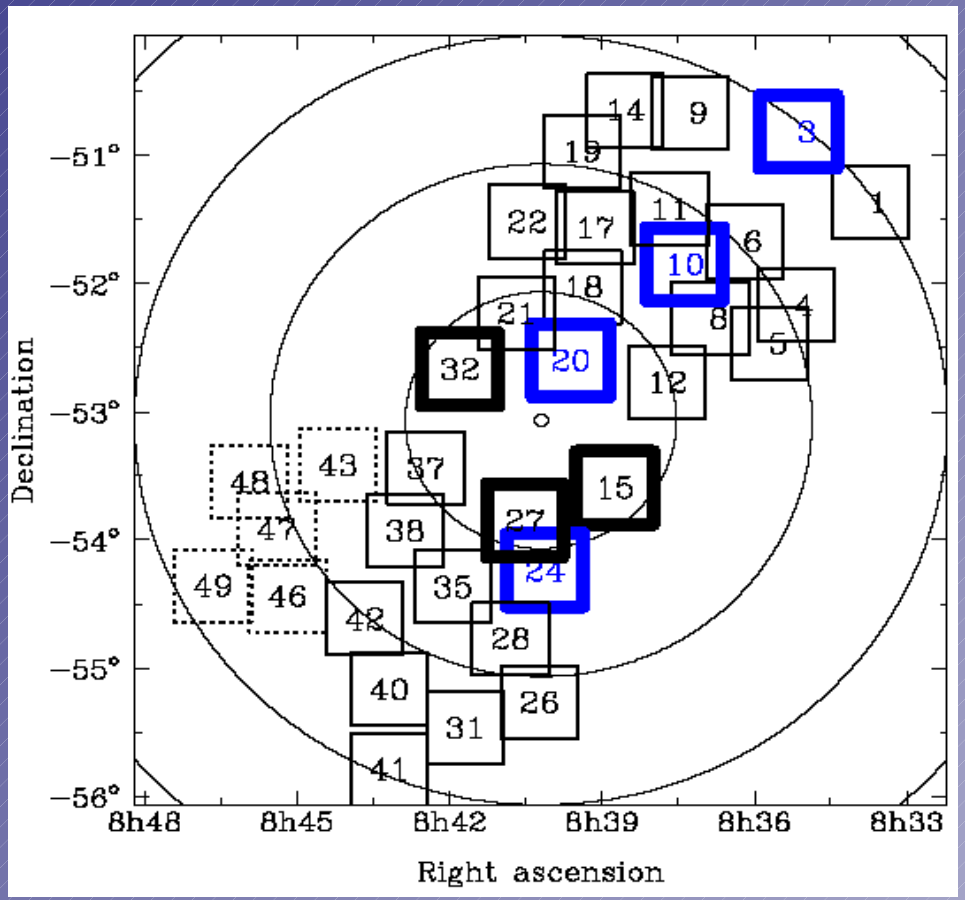
⇨ **VLT/VIMOS for IC2391 (from 0.045 up to 0.9$M_{\odot}$)**

Background

Photometric Survey

Results

Future Work



Background : why survey in Praesepe ?

Background

Photometric Survey

Results

Future Work

Praesepe is an interesting target because ...

⇨ **with age 500 My – 1 Gy (like IC2391 ; no interstellar gaz , model)**

... 590^{+150}_{-120} My (Fossati et al. 2008) and Hyades at 625±50 My (Bouvier et al. 2008)

⇨ **not too far : $190^{+6.0}_{-5.8}$ pc , van Leeuwen (2009)**

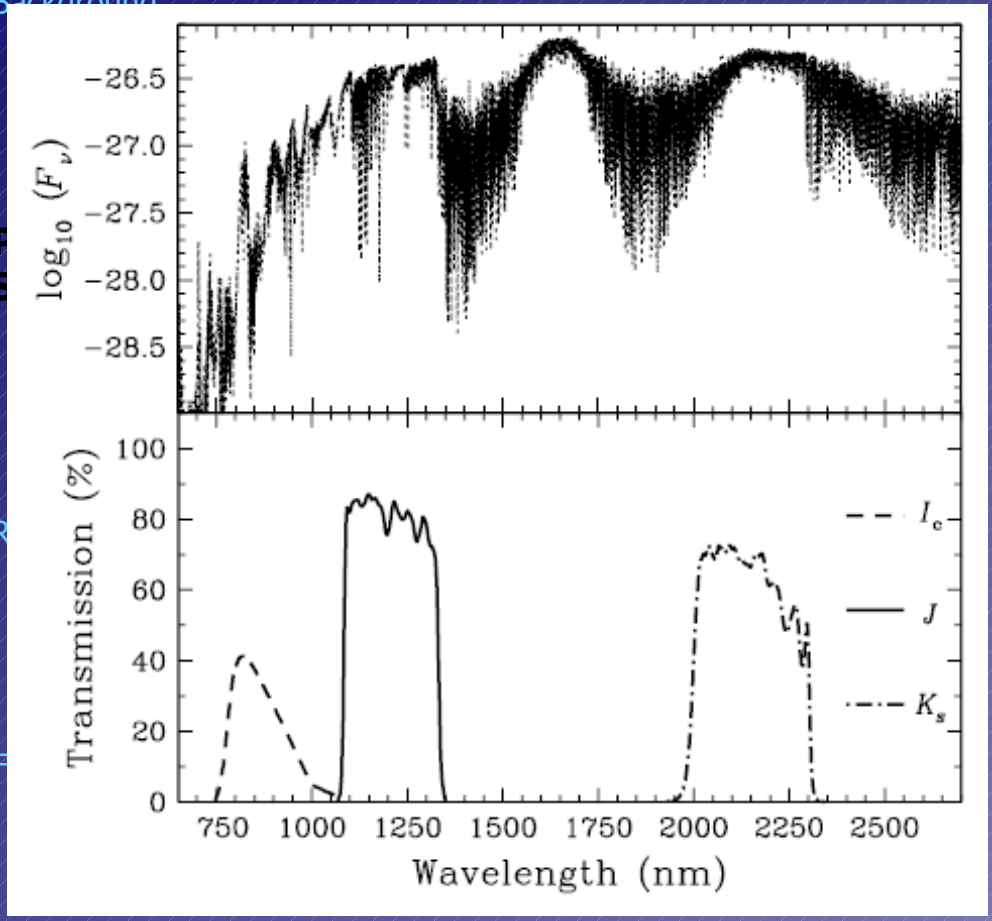
⇨ **low reddening : $E(B-V) = 0.027 \pm 0.004$ (Taylor 2006)**

⇨ **we may investigate how the BDs and population itself evolves**

(e.g. efficiency with which BDs are evaporated and populate the field)

Photometric Survey : determination of the mass function for very low mass stars and brown dwarfs population in Praesepe

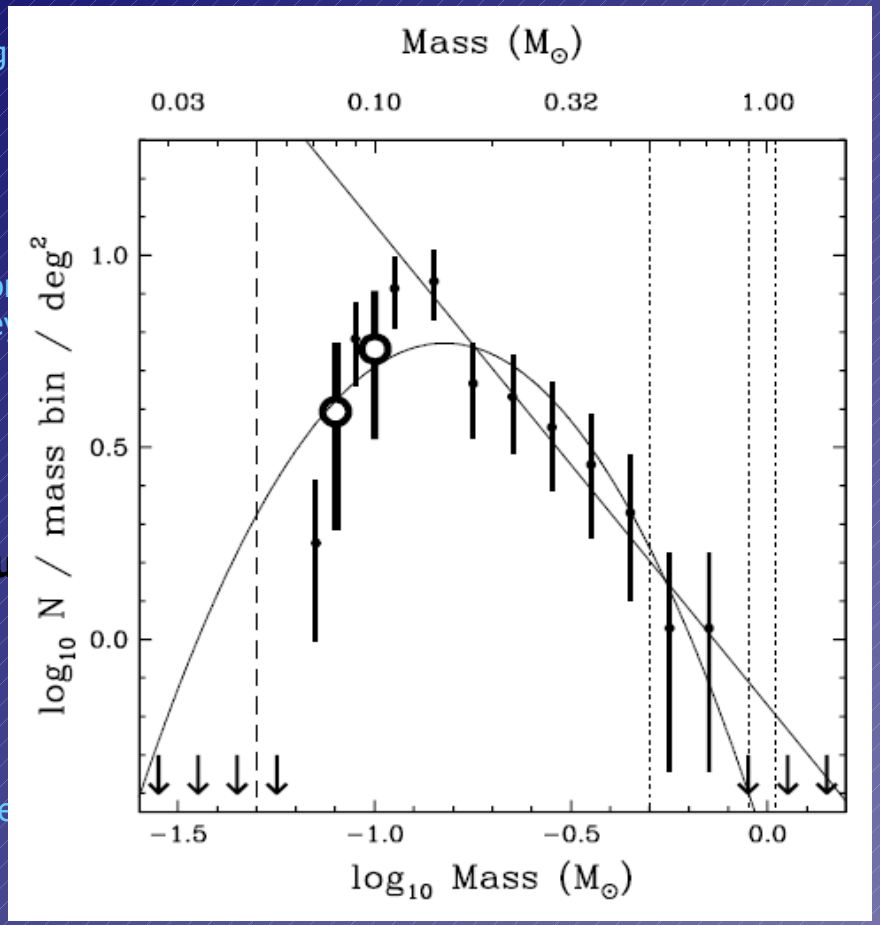
Fields and area of the survey ...

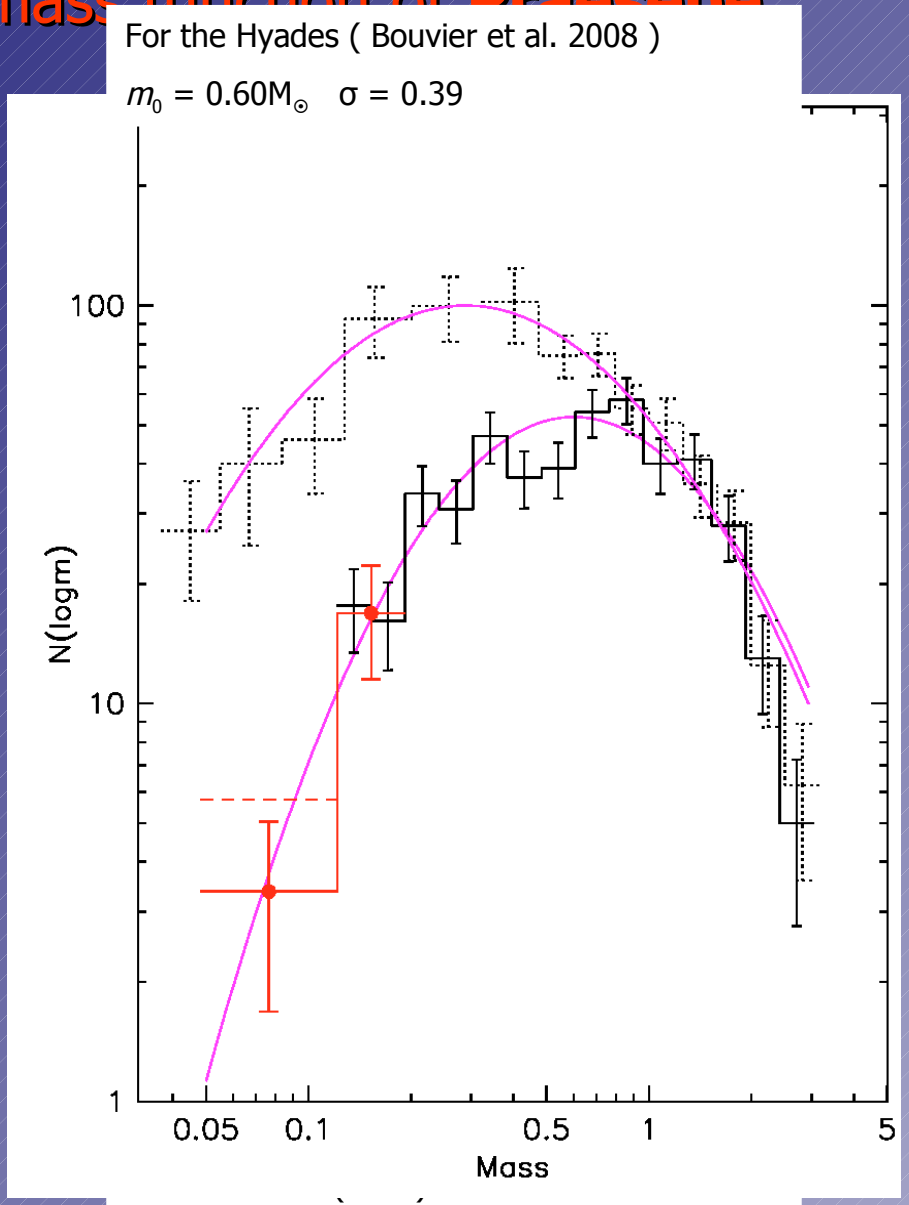


- total coverage of ~3.2 sq. deg.
  - 47 fields of Omega 2000
- 7 x 7 fields of Omega 2000 (14.5' x 14.5')
  ⇨ J and K_s (3.1 sq. deg.)
- centred on α=08:40:04 and δ=+19:40:00
- other fields from
  - 9 fields of WFI
  ⇨ I_c (2.8 sq. deg.)
  ~0.3 sq. deg. (Gonzalez-Garcia et al. 2006)
- >30σ detection limit of 0.045-0.05$M_\odot$

Results : VLMS and BDs mass function of Praesepe

What we have ...





Backg

Photor
Survey

Resu

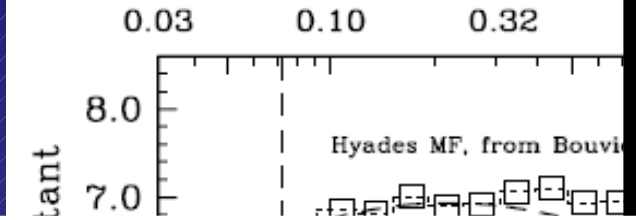
Future

Results : VLMS and BDs mass function of **Praesepe**

Background

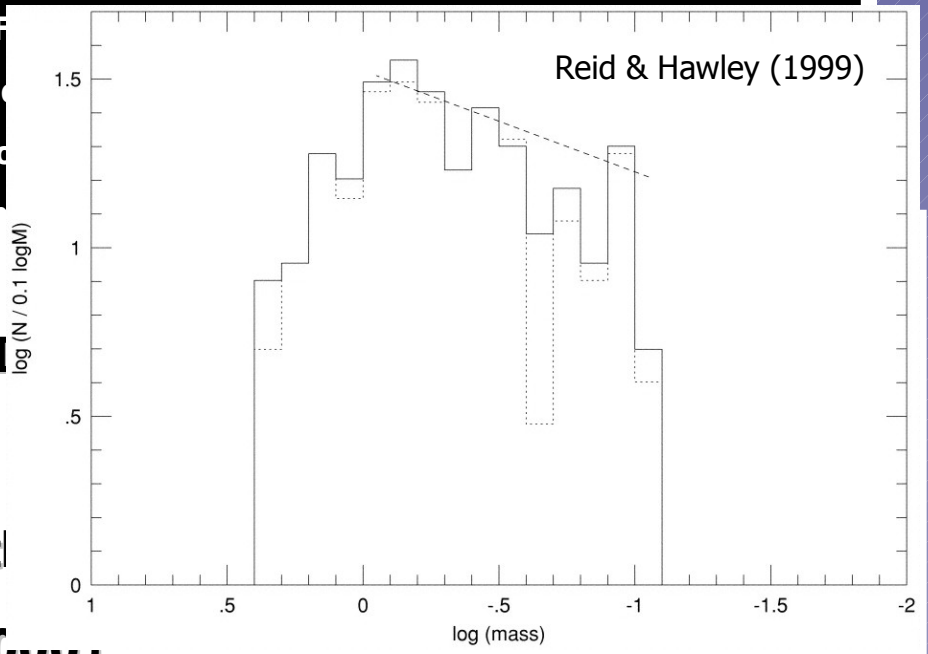
Phot
Surv

Lognormal fit of Galactic field MF from Chabrier (20



For the Hyades we have ...

- **age = 625±50My (Perryman et al. 1997)**
- **[F**
- **ti**
- **co**



THEREFORE ...

... different initial conditions ? (and I

... binaries ? (Thies & Kroupa 2007)

... evolution of Praesepe differ from t

[merged clusters (Holland et al. 2000) ...

... but Adams et al. (2002) find no evidence of subclusters]

Fo

- **a**
- **[Fe/H] = +0.038±0.039 (Friel & Boesgaard 1992) to +0.27±0.10 (Pace et al. 2008)**
- **tidal radii = 11.5±0.3pc (Kraus & Hillenbrand 2007)**
- **core radii = 0.8±0.1pc (Piskunov et al. 2007)**
- **mass = 550±40$M_\odot$ (Kraus & Hillenbrand 2007)**
- **binarity : 31^{+7}_{-6}% for 0.6-0.35$M_\odot$, 44±6% for 0.35-0.2$M_\odot$, 47^{+13}_{-11}% for 0.11-0.09$M_\odot$ (Pinfield et al. 2003)**

Future work : spectroscopic follow-up to confirm/refute the radial variation of the mass function of IC 2391 … and the mass function of Praesepe

To confirm the radial variation of the MF of IC 2391

Background

⇨ **VLT/VIMOS for IC2391 (from 0.045 up to 0.9$M_{\odot}$)**

Photometry from LBTC-red and blue

Photometric Survey

⇨ ***r*** **,** ***i*** **,** ***z*** **and** ***Y*** **band**

⇨ **4 pointing (0.61 sq. deg.) and from 0.1 $M_{\odot}$ down to 0.04 $M_{\odot}$**

Spectroscopic follow up of candidates with I_c < 18.5

Results

⇨ **HYDRA at 3.5m WYIN telescope at KPNO**

⇨ **MOSCA at 3.5m telescope at Calar Alto**

Future Work

⇨ **WHYFOS at 4.2m telescope at La Palma**

CON[illegible]IEW

We want[illegible] of the BD popu[illegible]

- ... radia[illegible])
  - ⇨ usi[illegible]
- ... no si[illegible]
  - ⇨ ejec[illegible]
  - gone [illegible]
  - ⇨ ana[illegible]
- ... photometric surv[illegible]
  - ⇨ using WFI (I_c)
- ... rise down from 0[illegible]ellar regime
  - ⇨ not consistent w[illegible]MF, binaries ratio ?