The open cluster IC4665

Nicolas Lodieu

"Panoramic near-infrared Astronomy", Edinburgh, 10 November 2005

Outline of my talk

1) Brief overview of the IC4665 open cluster

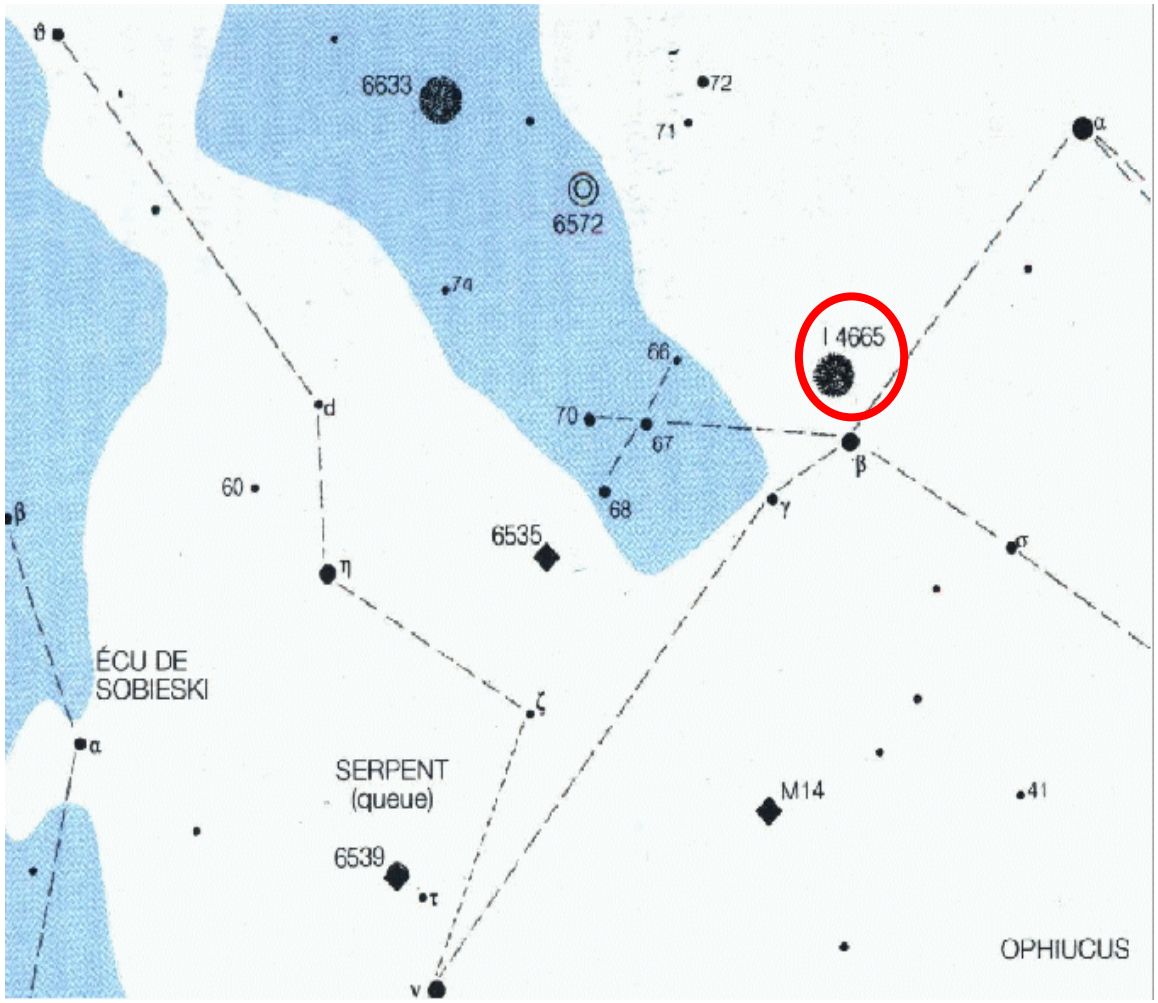
2) A deep wide-field optical survey in IC4665

   a) (*I*,*z*) colour-magnitude diagram
   b) Selection of cluster member candidates
   c) The present-day mass function

3) UKIDSS GCS observations in IC4665

   a) *ZYJHK* observations
   b) Colour-magnitude diagrams
   c) Colour-colour diagrams

The open cluster IC4665



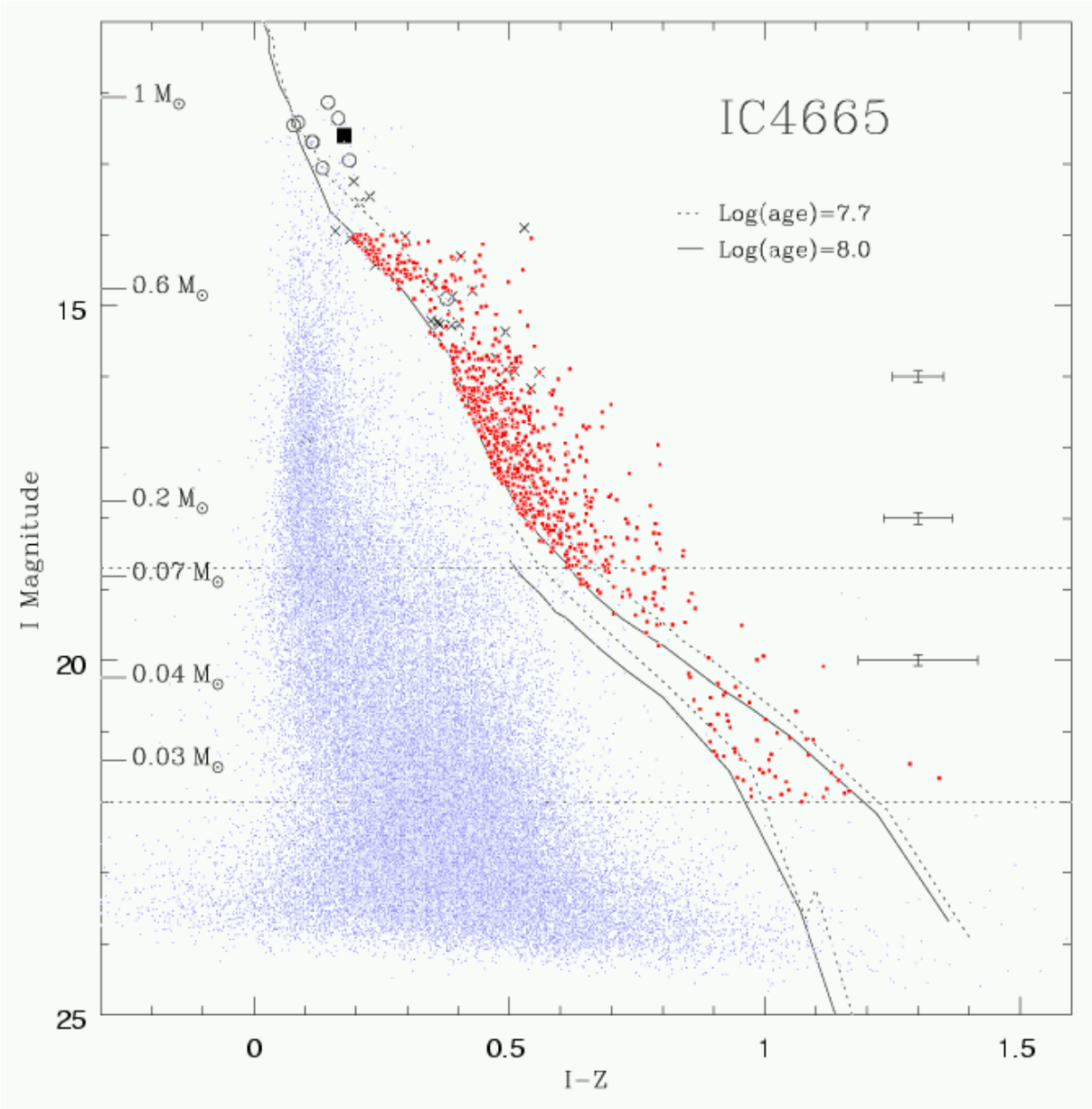
- In the Ophiuchus constellation
- D_{Hipp} = 350 pc *(Hoogerwerf et al. 2001)*
- Age = 50-100 Myr *(Prosser 1993)*
- One of few nearby young clusters
- Low Reddening *(Mathis 1990)*
- Galactic latitude: $b = +17°$
- Previous work from 1990 on
  - Spectral types
  - Lithium abundances
  - Proper motion
  - Radial velocities
  - Hα emission
  - X-ray studies

Prosser 1993; Prosser & Giampapa 1994;
Martín & Montes 1997;
Giampapa, Prosser & Fleming 1998

The CFHT Key Programme

- CFHTKP: wide-field optical observations:
  - PI: Bouvier in collaboration with the EC network
  - 30 nights over 2 years
  - CFH12K camera offers a 42'x28' FOV with 0.206 arcsec/pix
  - *I* and *z* CFH12K filters
  - Completeness and detection limits of 22 and 24 mag in *I* and *z* filters
- Targets (age < 200 Myr, d < 500 pc, visible from Hawai'i)
  - SFRs: Perseus, Taurus, Ophiuchus, and Serpens
  - PMS clusters: IC4665, Collinder 359, Stephenson 1
  - The Hyades
- Main goals of the CFHTKP programme:
  - How do brown dwarfs form and at which rate?
  - Is the Initial Mass Function sensitive to the environment?
  - How do substellar objects evolve with time?
  - What is the mass distribution of low-mass stars and brown dwarfs?

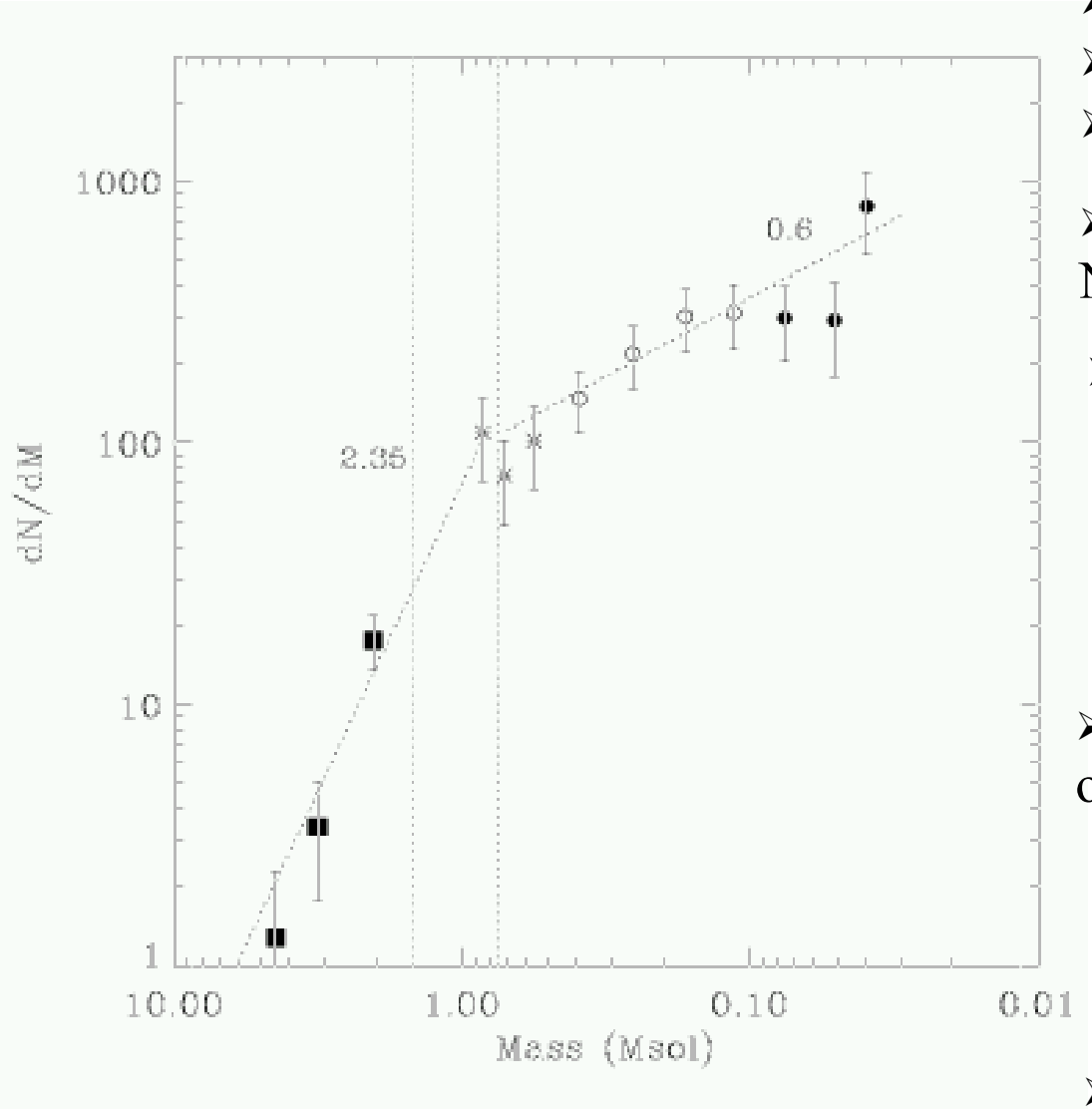
Deep wide-field optical survey



- 13 CFH12K pointings
  => about 3.8 sq. deg. covered
- Overlap between fields
- 2 Control fields to estimate the contamination
- Theoretical isochrones
  - NextGen down to 0.05 $M_\odot$
  - DUSTY for lower masses
  - Distance = 350 pc
  - Age = 50 and 100 Myr
- New cluster members selected with masses between 1 and 0.03 $M_\odot$

de Wit et al. 2005, accepted to A&A

The cluster mass function



- Members within 1° tidal radius
- Starring symbols = short exp.
- Open circles = medium exp.
- Filled circles = long exp.

- Conversion to mass with NextGen+DUSTY models

- Error bars = statistical uncertainty

- Mass function: $dN/dM \alpha M^{-0.6}$
- Mass range = 1.0–0.03 $M_{\odot}$

de Wit et al. 2005, accepted to A&A

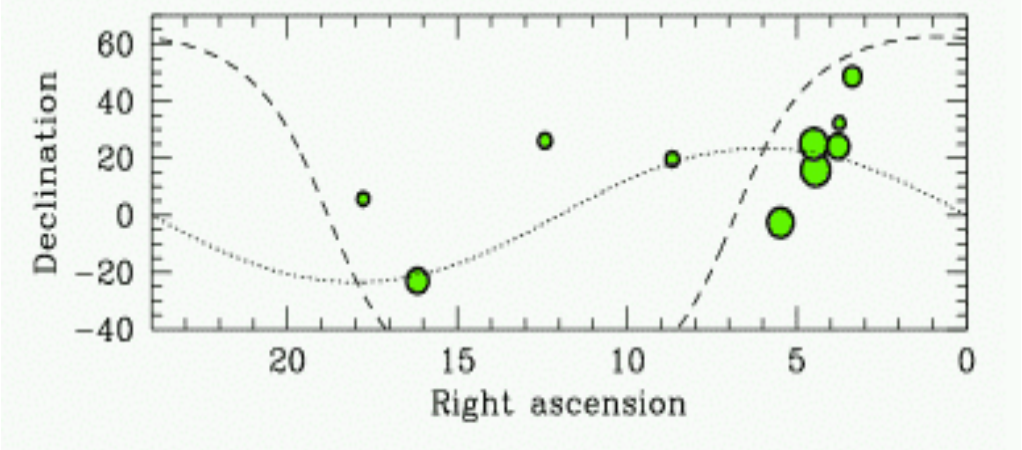
- Slope consistent with other studies over the same mass range
  - Pleiades: *Moraux et al. (2003)*
  - α Per: *Barrado y Navascués et al. (2002)*

- Dip observed around 0.07 $M_{\odot}$

Dobbie et al. 2002, MNRAS,335, 79

The UKIDSS Galactic Cluster Survey

Priority	Name	Type	RA	Dec	Area sq. degs
			J2000		
1	Pleiades	open cluster	03 47	+24 07	79
2	Alpha Per	open cluster	03 22	+48 37	50
3	Praesepe	open cluster	08 40	+19 40	28
4	IC 4665	open cluster	17 46	+05 43	0.8
5	Taurus-Auriga	SF assoc.	04 30	+25 00	386
6	Orion	SF assoc.	05 29	-02 36	314.2
7	Sco	SF assoc.	16 10	-23 00	154
8	Per-OB2	SF assoc.	03 45	+32 17	12.6
9	Hyades	open cluster	04 27	+15 52	292
10	Coma-Ber	open cluster	12 25	+26 06	78.5

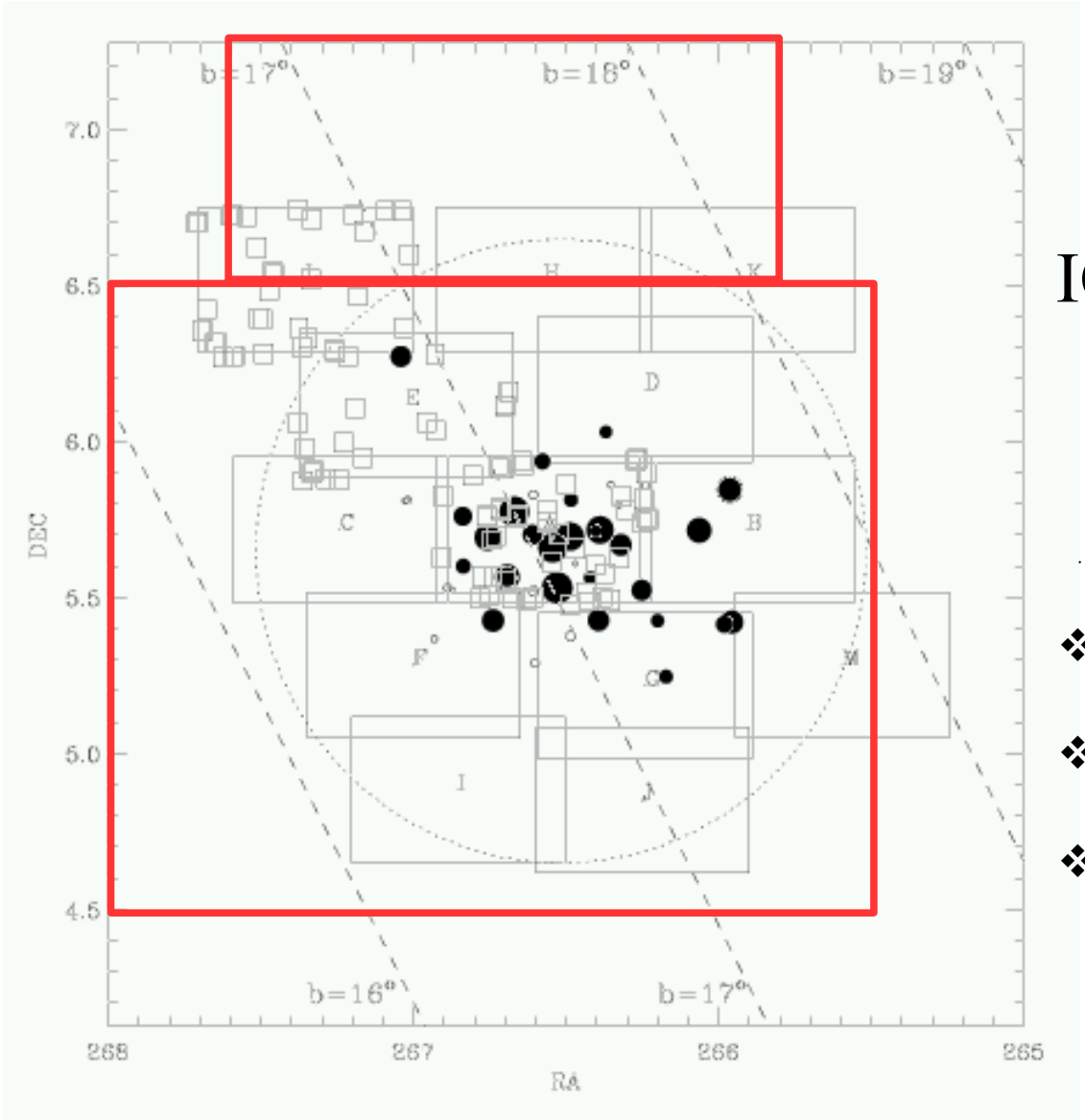


- 10 open clusters & SFRs
- 1400 square degrees
- 25 M_{Jup} in most regions

- 5-sigma detection limits:
  - ✓ *Z* @ 0.87μm $m_Z = 20.0$
  - ✓ *Y* @ 1.02μm $m_Y = 19.5$
  - ✓ *J* @ 1.25μm $m_J = 19.7$
  - ✓ *H* @ 1.65μm $m_H = 18.8$
  - ✓ *K* @ 2.2μm $m_K = 18.7$

- 2nd epoch in the *K*-band with a baseline > 2 years

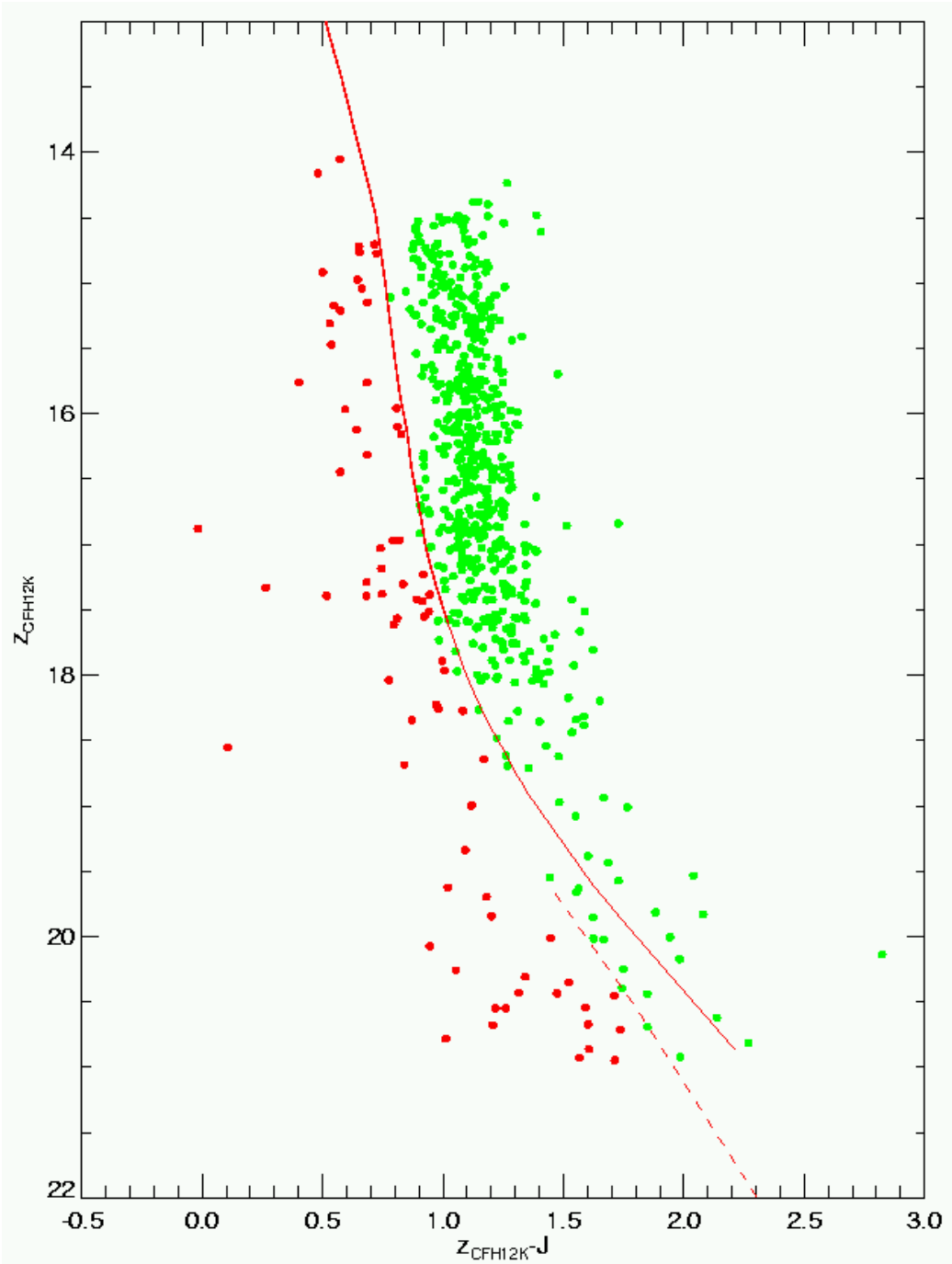
UKIDSS GCS: IC4665

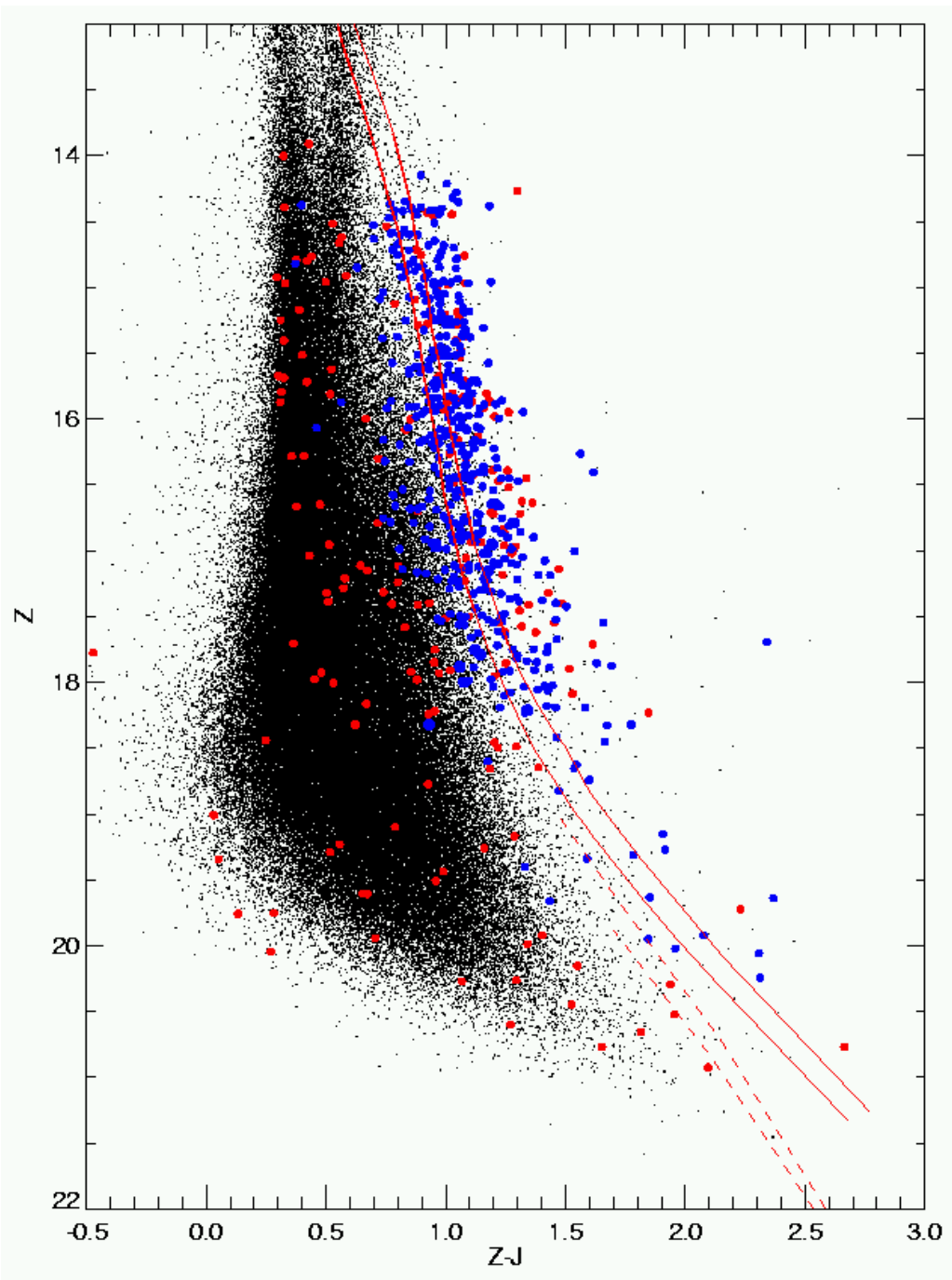


IC4665
- Age = 50–100 Myr
- Distance = 350 pc
- Low reddening
- PM = (0.0,-9.0) mas/yr

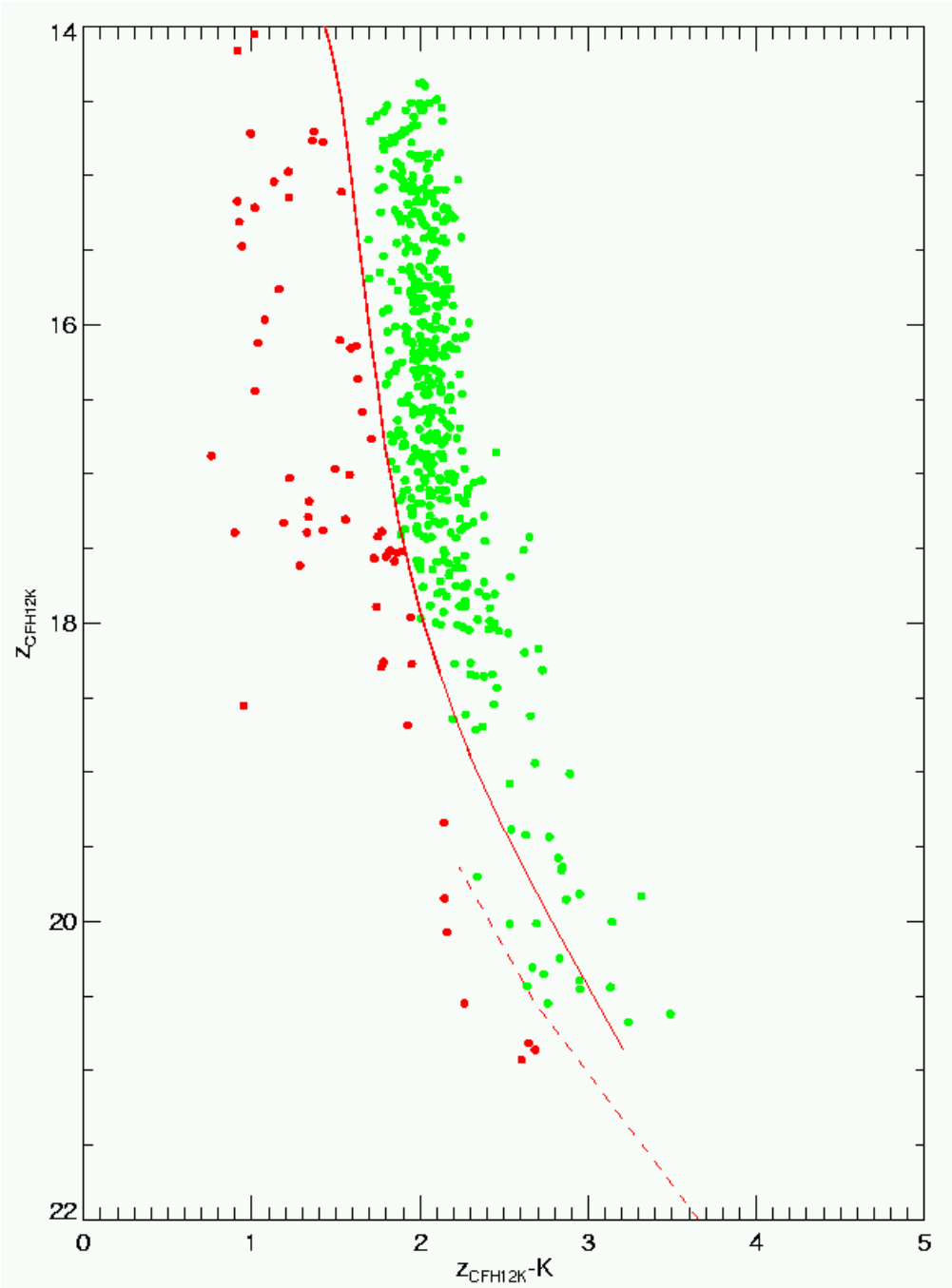
- 13 CFH12K pointings
- Thick red rectangles = IR coverage
- Filled circles = high-mass members

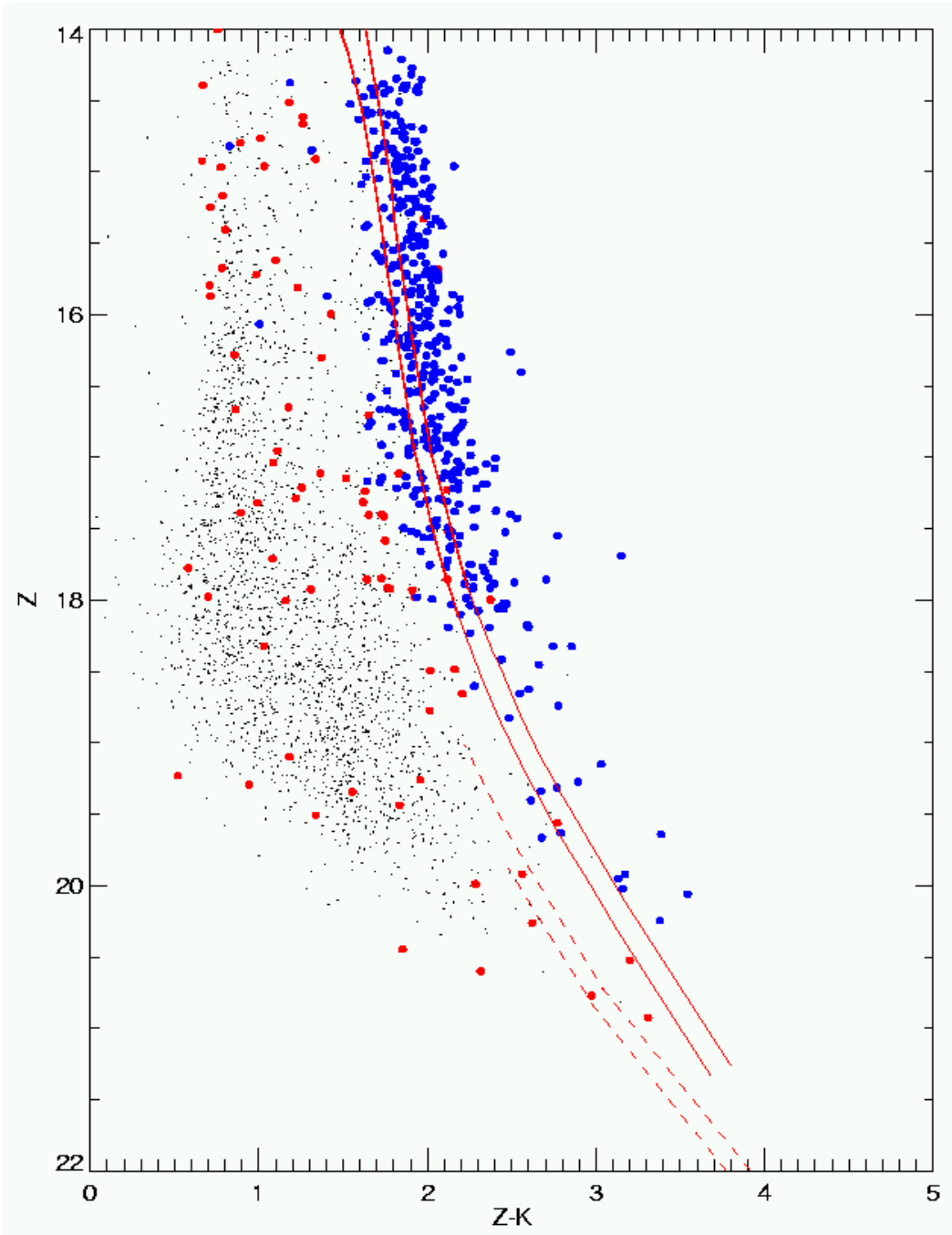
Colour-magnitude diagrams I



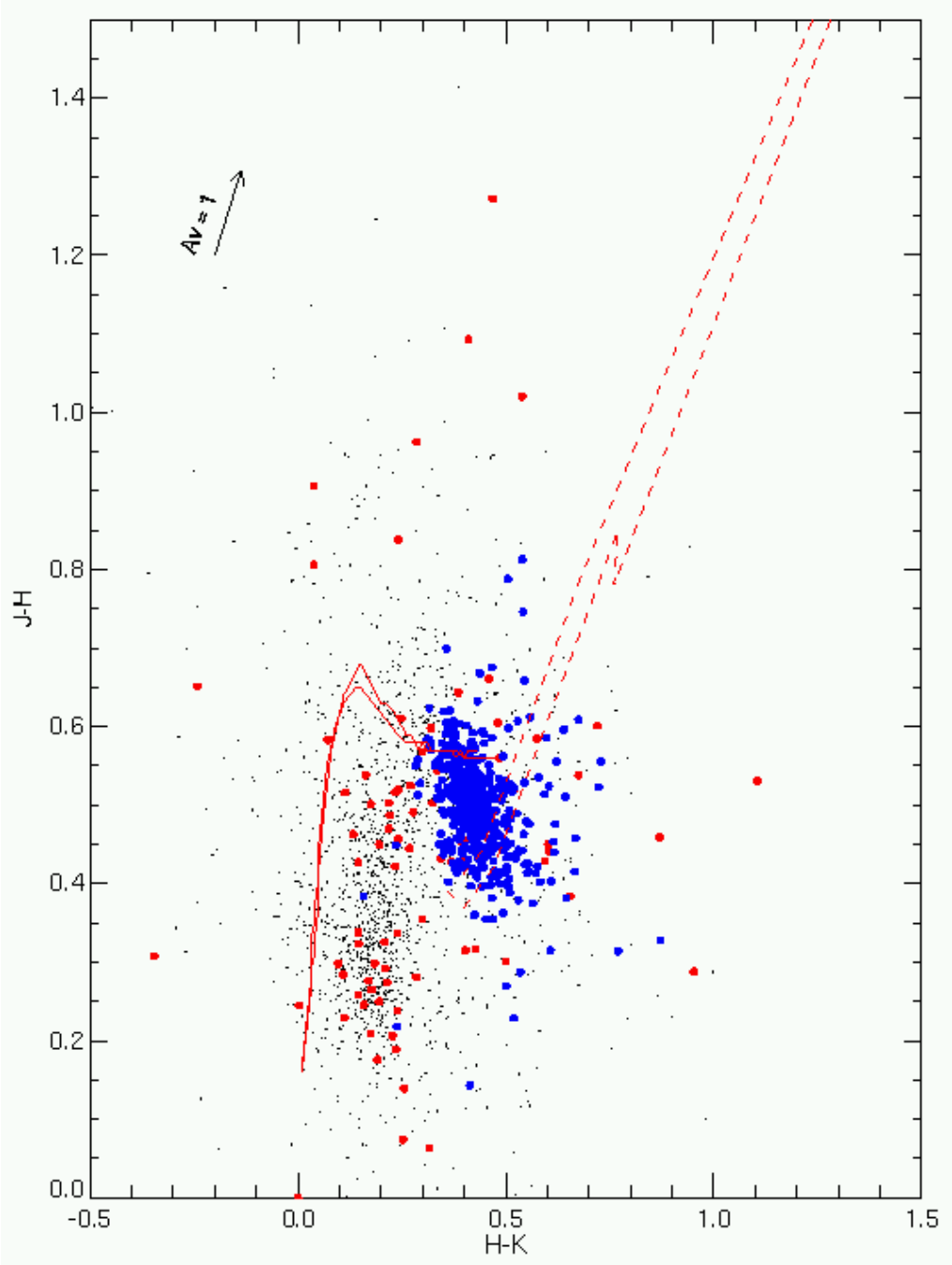


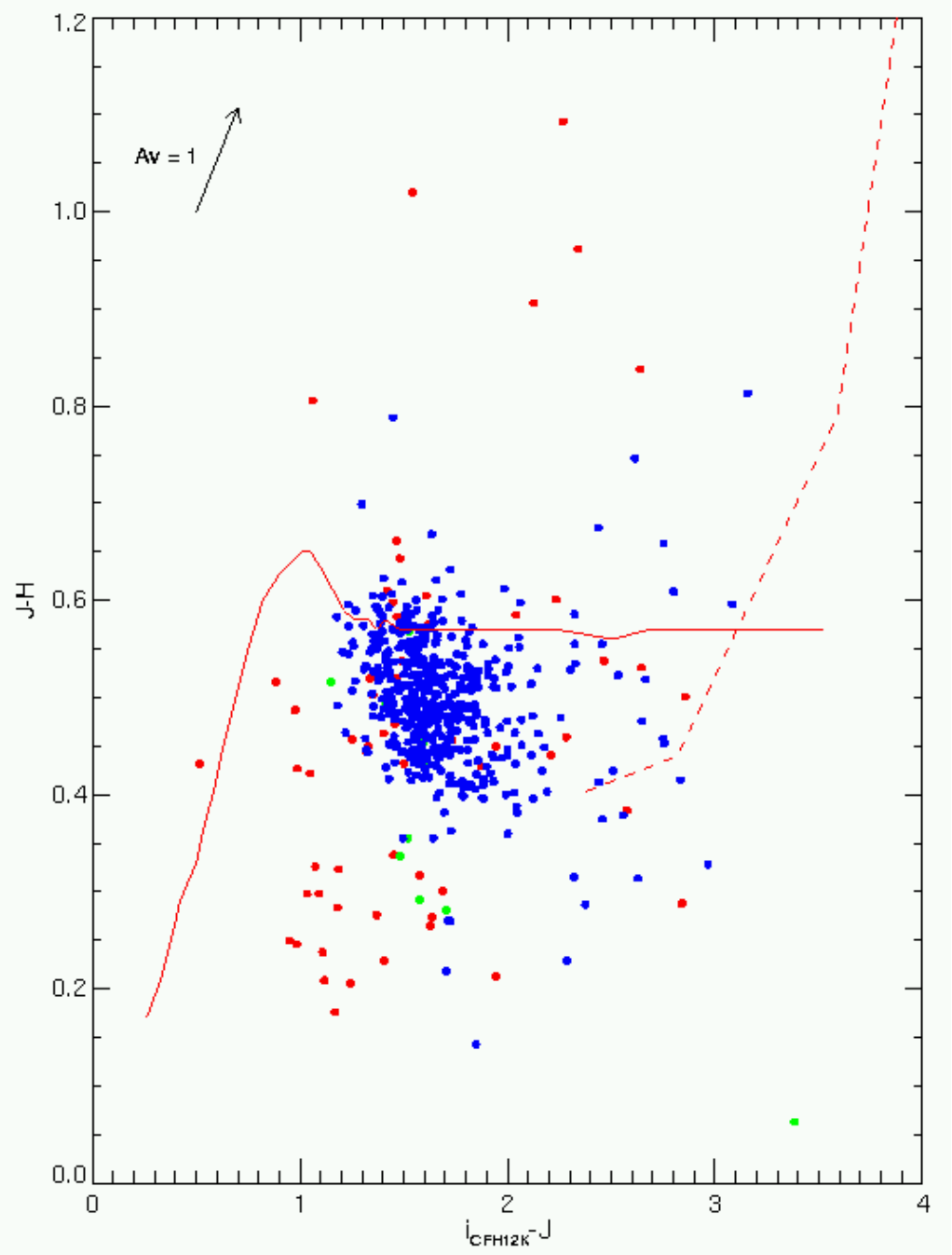
Colour-magnitude diagrams II





Colour-colour diagrams





Conclusions & outlook

1) Conclusions

a) Optical survey:

- Deep (I=z=24 mag) + wide-field (3.8 sq. deg.) survey
- New cluster members with masses between 1 and 0.03 $M_{\odot}$
- Derived mass function consistent with Pleiades-like clusters

b) Infrared survey:

- Membership assessment using multiple colours
- Rejection of some optically-selected candidates

2) Outlook & future prospects

a) Spectroscopy

- Optical spectroscopy: WHT/AF2/WYFFOS & VLT/FORS1
- Near-infrared spectroscopy: VLT/ISAAC
- Future capabilities: KMOS & TNG/GIANO

b) Lithium test to pinpoint the age of the cluster: underway

c) Deeper NIR imaging survey for cooler BDs & planets