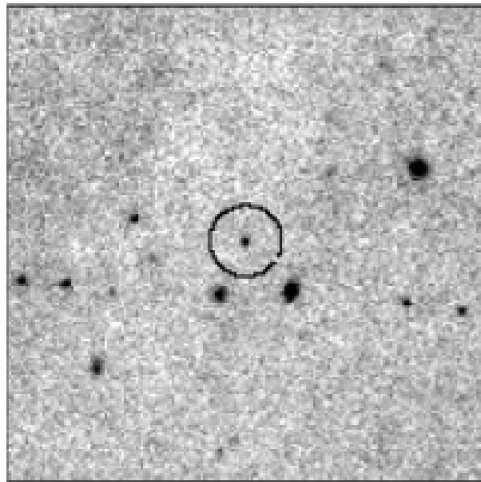




Low-Mass Brown Dwarfs and the Initial Mass Function

Andrew Burgess

aburgess@obs.ujf-grenoble.fr



LAOG, Grenoble
Laboratoire d'AstrOphysique de Grenoble



Jerome Bouvier & Estelle Moraux

Research supported by the Marie Curie Research Training Network “CONSTELLATION” under grant no. MRTN-CT-2006-035890

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Tenerife



Overview

- Episode 1: IC 348
 - Selection and Candidates
 - Membership and Initial Mass Function
- Episode 2: IC 4665
 - Calibration and Analysis
- Summary



Objective

- Constrain the low mass end of the Initial Mass Function in IC 348 and IC 4665:
 - IC 348 – star forming region:
 - T dwarfs later than spectral type $\sim T3$
 - IC 4665 – open cluster:
 - low mass objects earlier than spectral type $\sim L3$
- How do the lowest mass objects form?
- Why are different clusters observed?



IC 348



Image: Adam Block and Tim Puckett

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IC 348

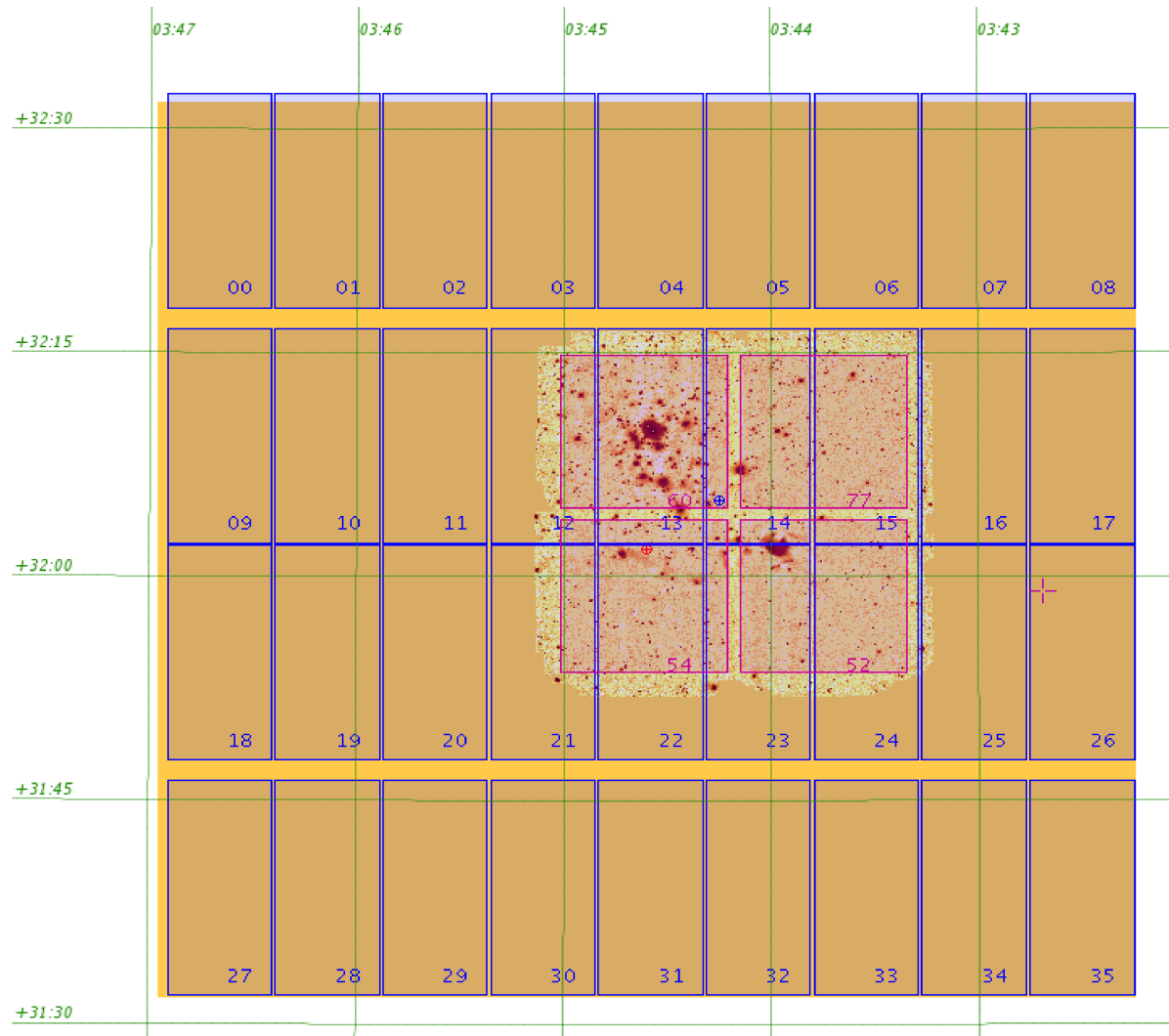
Clustered star forming region

- $03^{\text{h}}44^{\text{m}}34^{\text{s}} +32^{\circ}09'8''$ (J2000) in Perseus
- 300+/-15pc, ~40pc in front of Per OB2 association
- ~1-3Myr, low proper motion; $\sim 2 < A_v < 20$ mags
- IMF complete to $\sim 35M_{\text{Jup}}$ (though for $A_v < 4$ mag)
- **WIRCam IR survey to find the lowest mass objects**

Cernis 1993, Herbig 1998, Herbst 2008, Luhman et al. 2003, Muench et al. 2003, Scholz et al. 1999.

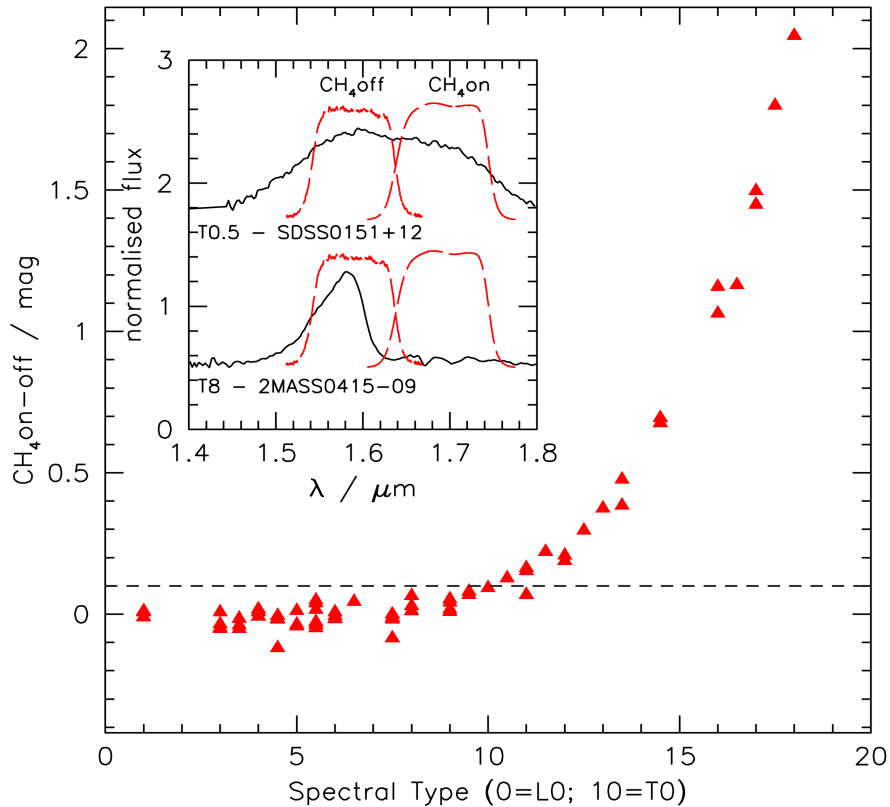


Field of View





Methane Selection



$\text{CH}_4\text{on-CH}_4\text{off}$ colour ($1.69\mu\text{m}-1.58\mu\text{m}$) vs SpT

L & T 5Gyr field dwarf spectra - convolved

Distance corrected

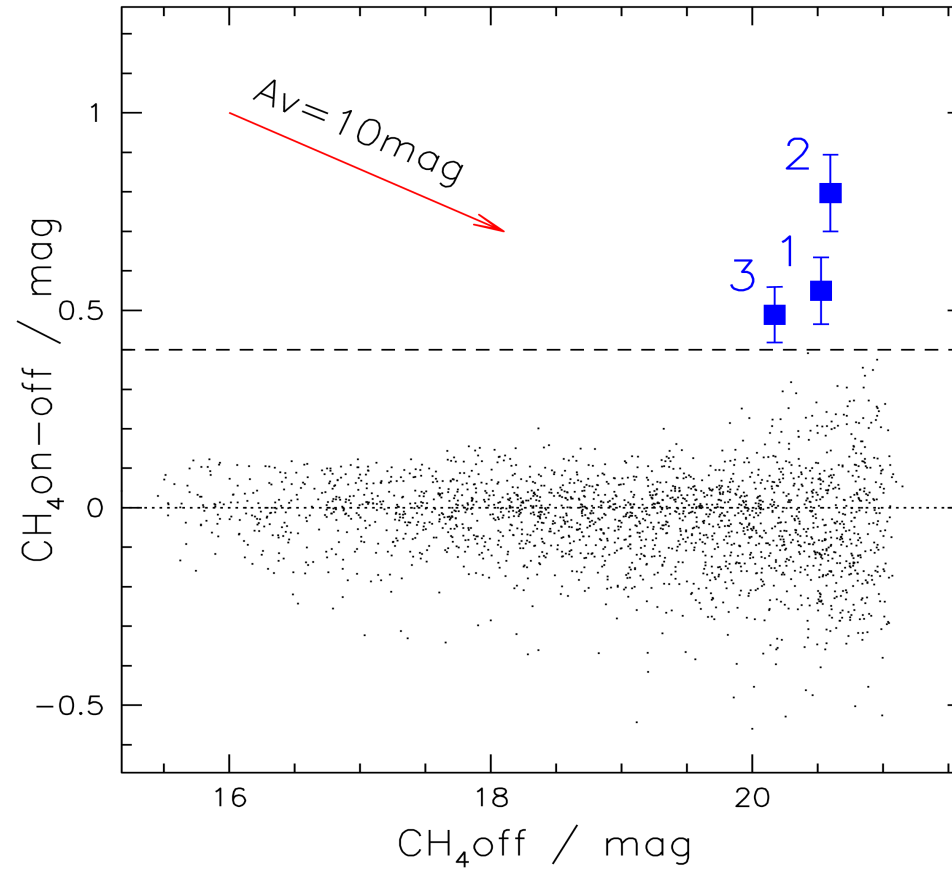
SpT latens with colour

e.g. T3 => $\sim 0.4\text{mag}$

3 selected candidates



Methane Candidates





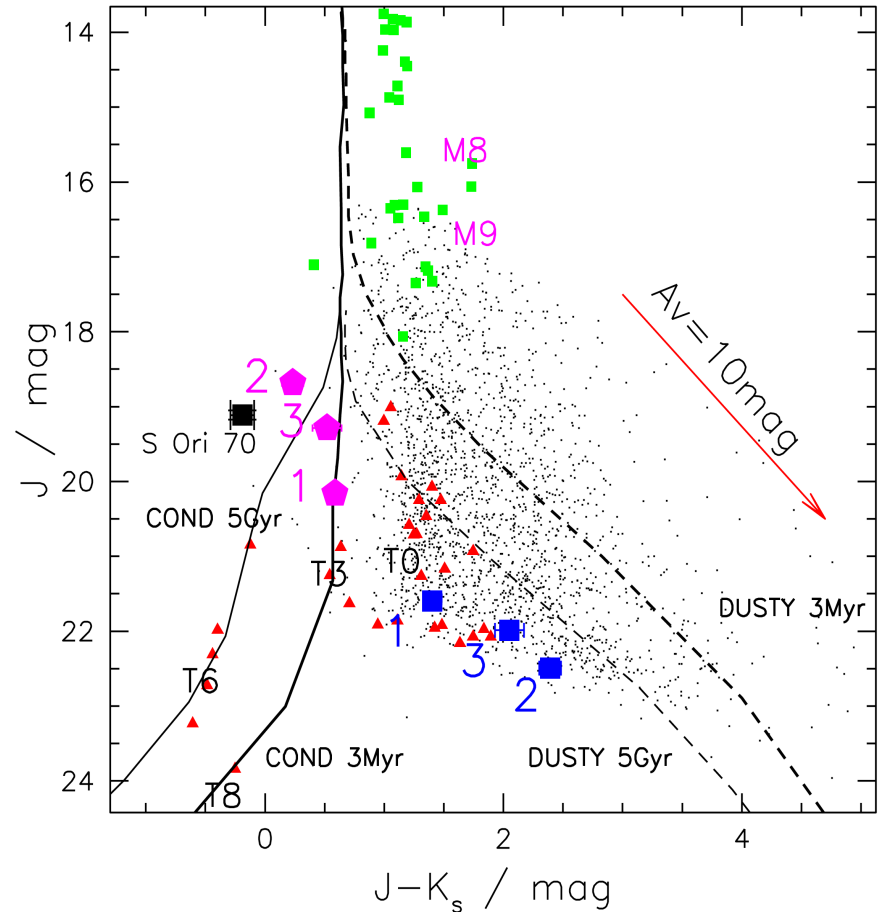
Methane Candidates

Dereddened to 3Myr COND model

Younger objects are brighter than field objects from larger radii

Comparison: ~T6 S Ori 70, 1-8Myr, 350pc

IC348_2 close to S Ori 70





Candidate Rejection

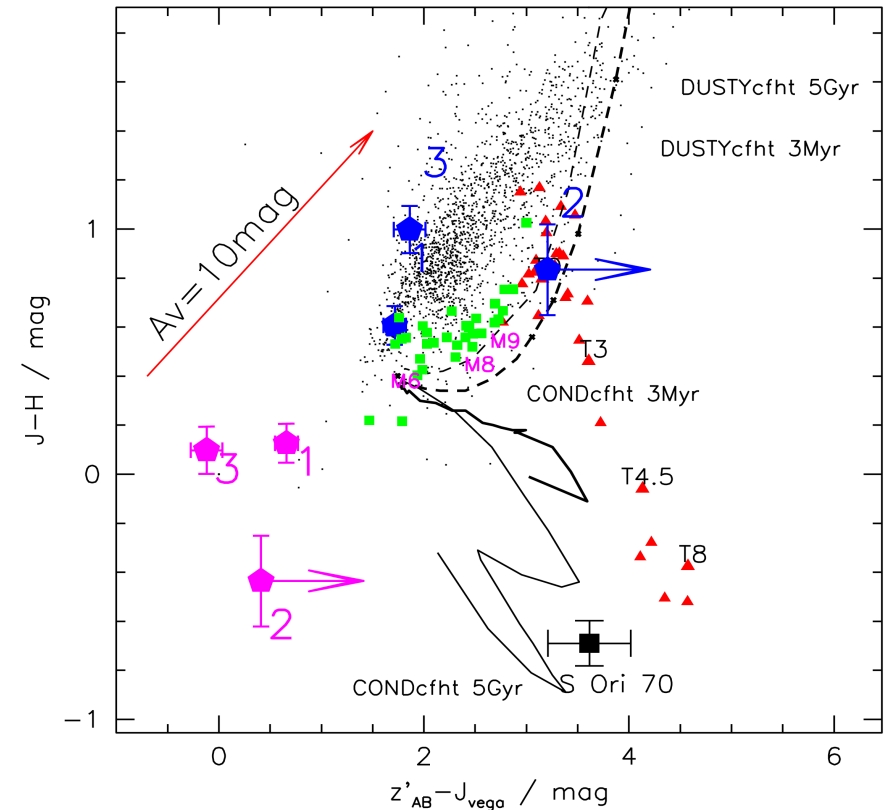
Inconsistent location

IC348_CH4_1 & 3 rejected

Far too blue in $z'-J$

IC348_CH4_2 upper limit

Identity unknown for rejected candidates



Luhman et al 2006, Zapatero Osorio et al. 2002, 2008.



IMF

- One candidate with mass estimated $<7M_{\text{Jup}}$ ($\pm 50\%$)
- ~420 members in IC 348
- Used log-normal and power law IMF extrapolated to $1-10M_{\text{Jup}}$ (1.6-4 expected)
- Power law overestimates $\sim x10$ for IC 348 (25 ± 16 expected)
- This candidate is consistent with lognormal extrapolation to low mass domain for IC 348



IC 348 Summary

“Young T-Dwarf Candidates in IC 348” published: Burgess et al. 2009 (2009A&A...508..823)

- Three objects based on methane colours detected
- Two rejected by too blue z'-J colours – unknown identifications
- One very likely a member of IC 348 and consistent for a 3Myr old, ~T6 Dwarf
- Among lowest-mass T-dwarf detected so far

Results support the extrapolation
of the log-normal IMF down to a
few M_J



IC 4665



Image: Stefan Binnewies and Josef Pöpsel



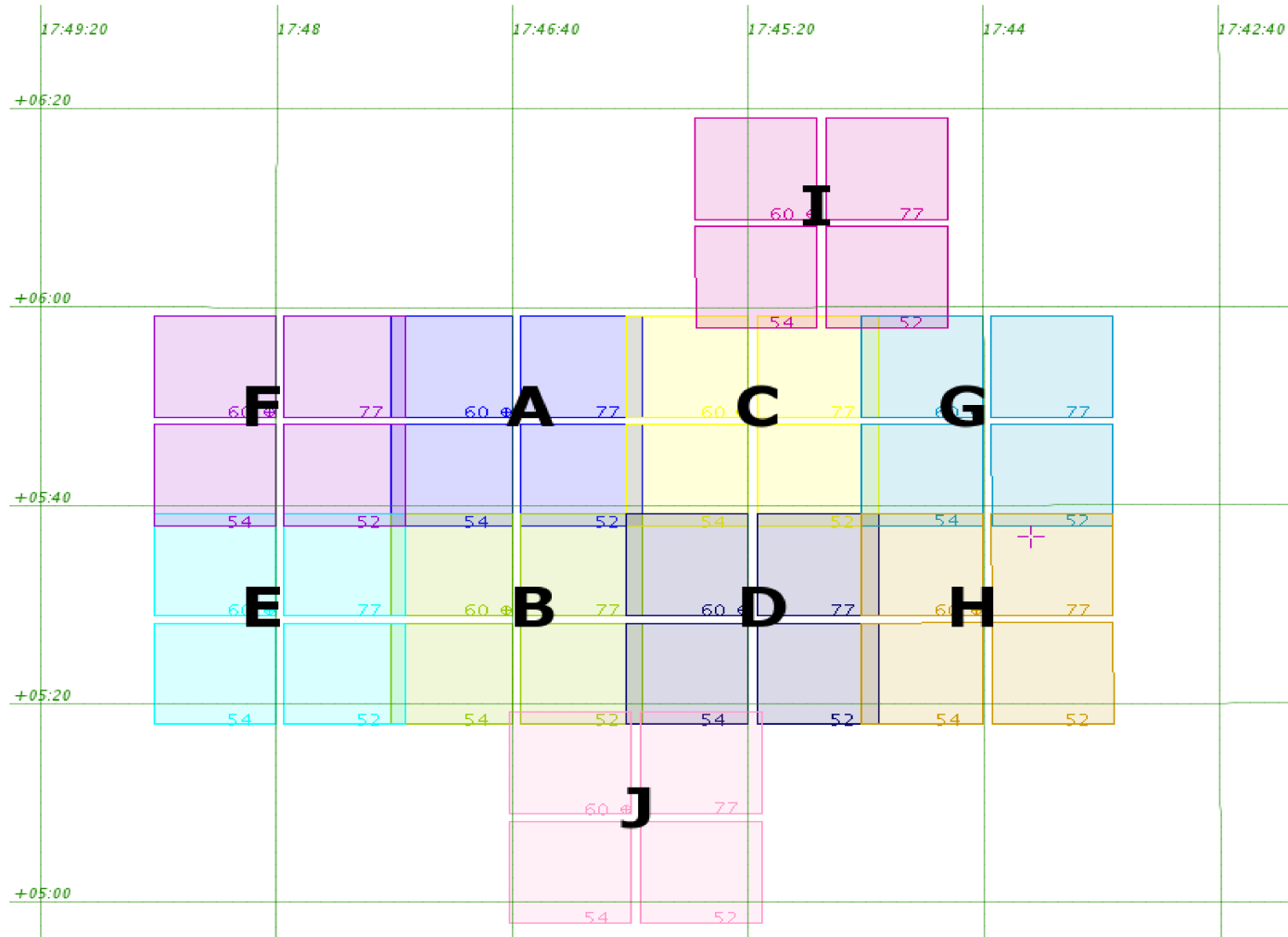
IC 4665

Open cluster

- $17^{\text{h}}46^{\text{m}}18^{\text{s}} +05^{\circ}43'0''$ (J2000)
- 350+/-15pc
- ~30-40Myr, low proper motion
- Average extinction $A_v \sim 0.17$ mags
- Good place to study the IMF
- Y J H Ks (short+long) (21,20.5,19.75,18.5mag)
- 0.012M/Ms (YJH) and 0.015M/Ms (Ks)
- 10 fields + 2 control fields



Field of View



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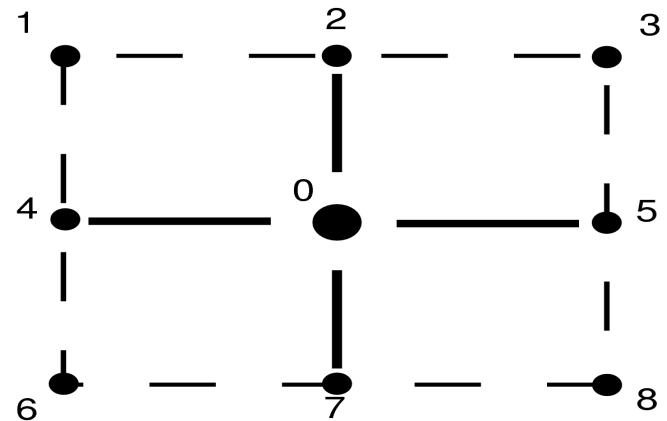
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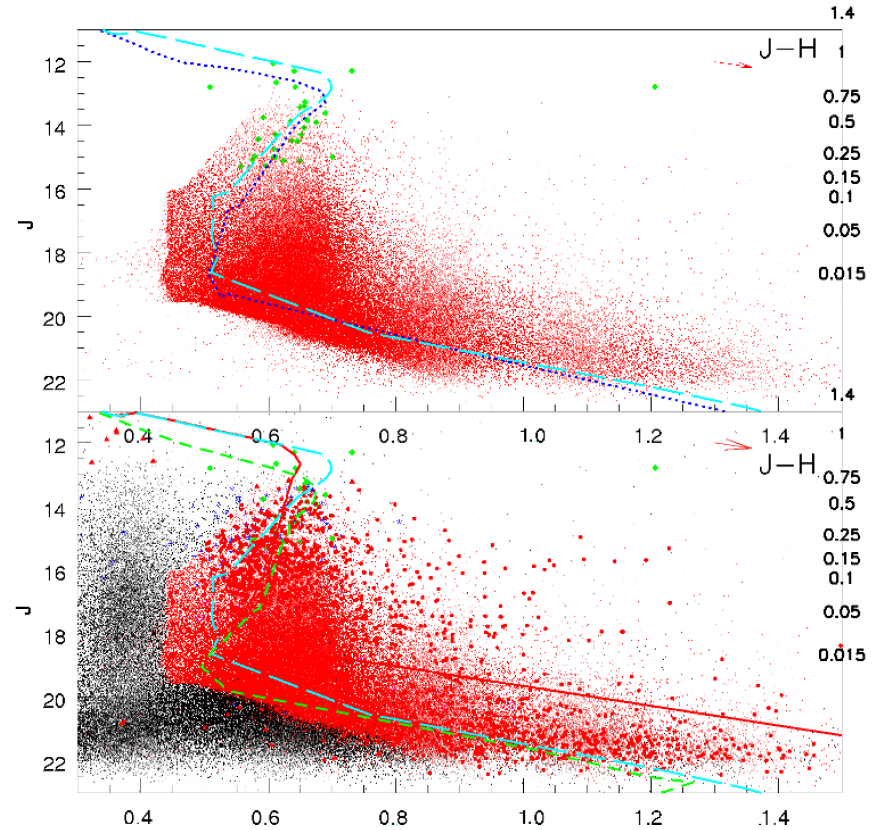
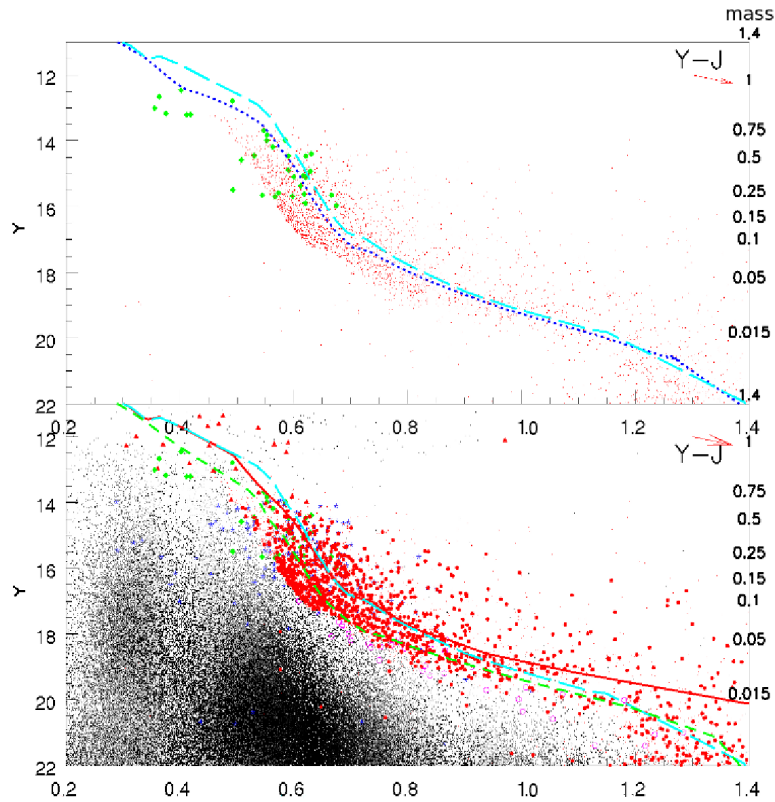
Candidates

- Calibration onto UKIDSS – Y offset range 0.33mag
- Selection (from 360,000)
 - Use BT-Settl 30 & 50 Myr isochrones
 - 6 CMDs
 - 15 COLDs Y-J/J-H etc
 - Y-J colour most constraining (~4500 objects)
 - J-H least (~140k objects)





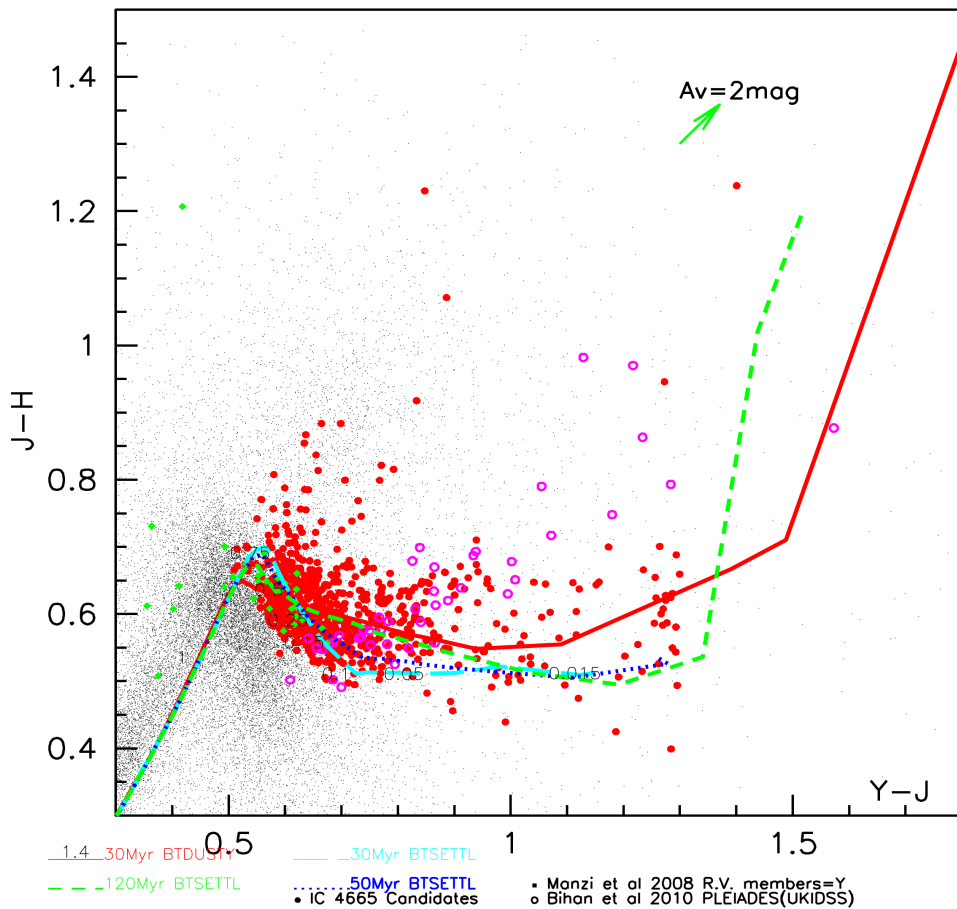
CMD Selection - 2278



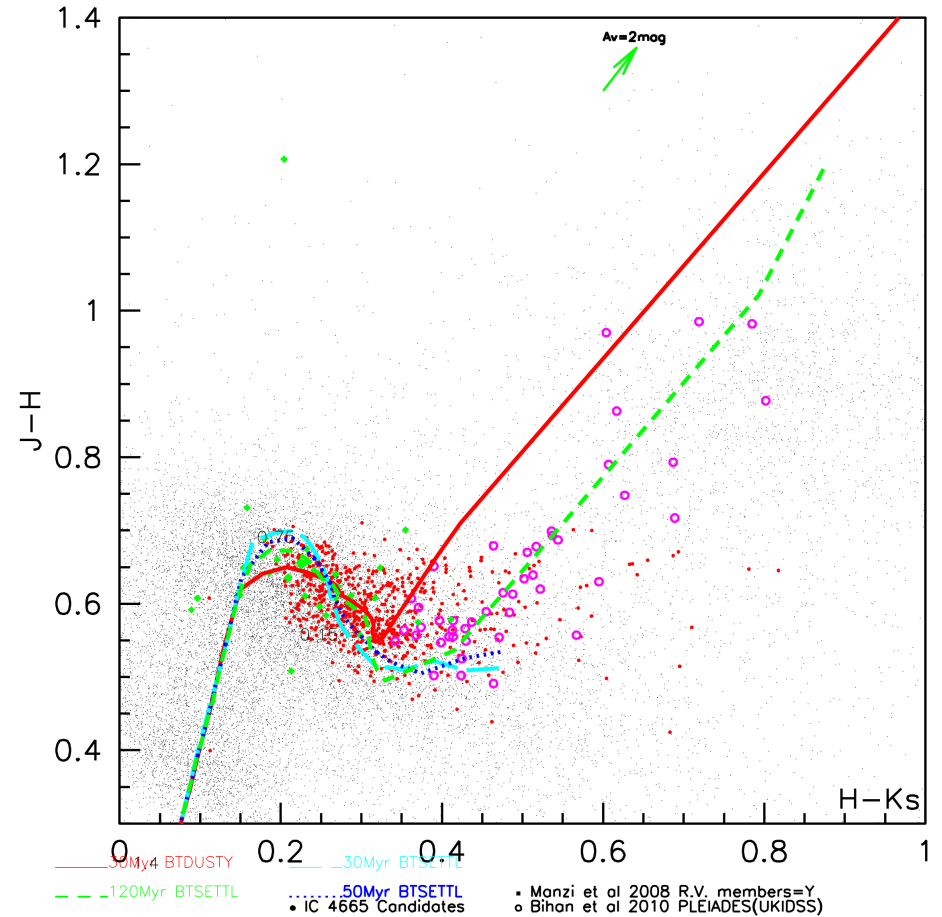


COLD Selection - 1107

YJ..vs..JH plot; CANDIDATES SELECTED FROM CMD and COLDS



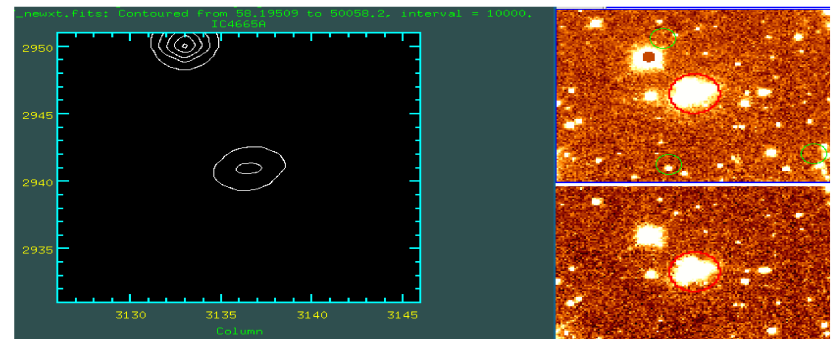
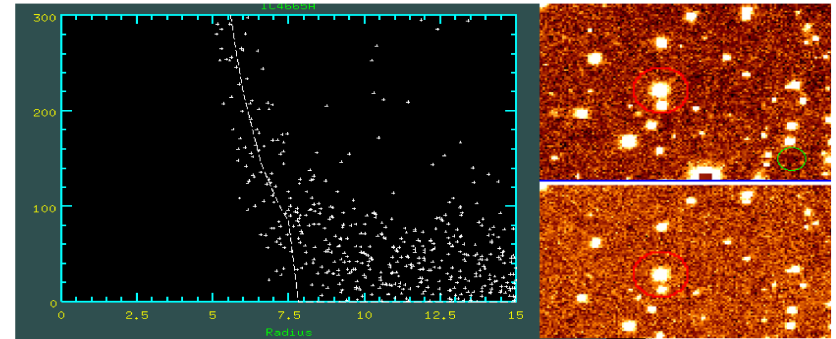
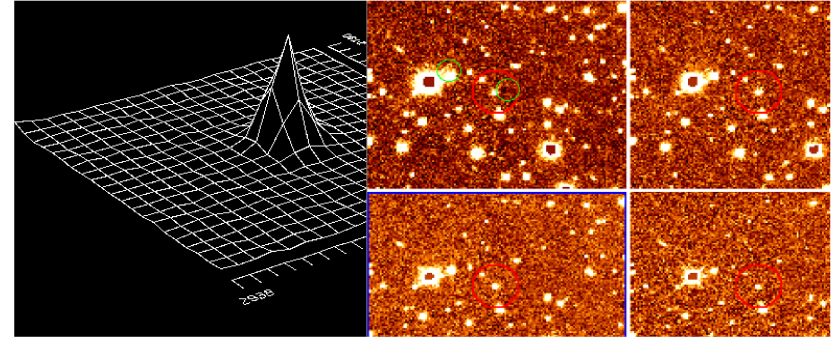
HKs..vs..JH plot; CANDIDATES SELECTED FROM CMDs and COLDS





Selection

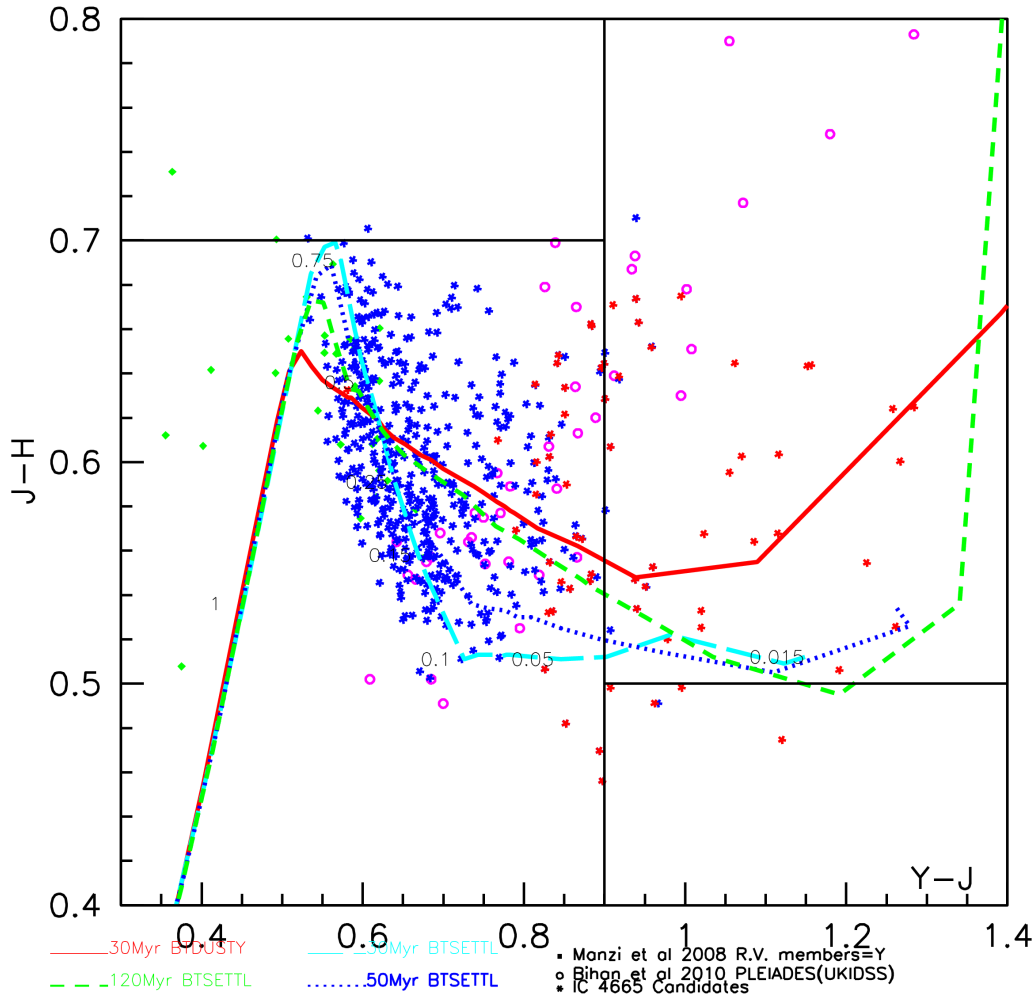
- Filtering 608:
 - Flux radius < 5.0
 - Completeness
 - No sat/IMA flags
 - No duplicates
- 590
 - Visually inspected with criteria
 - 510 'OK'
 - 178 'GOOD'





Selection

YJ..vs..JH plot; M/L DWARF SELECTION



- Empirical selection (Hewett+2008)
 - YJ/JH and JH/HK empirical locations
 - 63 L, 485 M-dwarf 'OK'
 - 3 L, 164 M-dwarf 'GOOD'



Further Prospects

- IC4665:
 - Contamination (at least 20%), further spectral type analysis, IMF, *Spitzer* data, spectroscopy
 - Collaboration with the IAC, N. Lodieu
- IC 348:
 - Spectroscopy of all three candidates
 - Ascertain identity of 2 rejected
 - Full census using zJHK data to extend confirmed IMF to masses $< 30M_j$



Conclusions:

IC348: 1 good T5.5 candidate: supports the extrapolation of the log-normal IMF down to a few M_{\odot}

IC 4665: Empirical candidate selection also required and further analysis