



The spectroscopic mass function in the Upper Scorpius association

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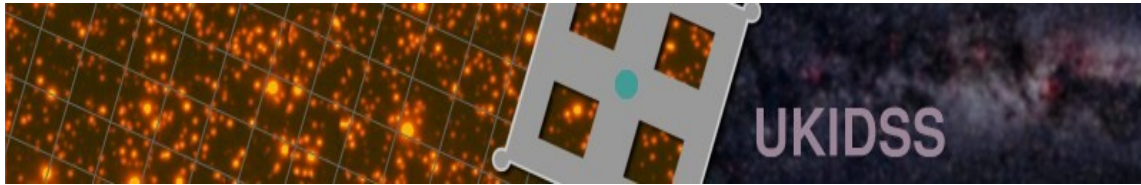
(1) Instituto de Astrofísica de Canarias (IAC, Tenerife)

(2) Ramón y Cajal fellow

Results presented in Lodieu, Dobbie & Hambly 2011, submitted to A&A

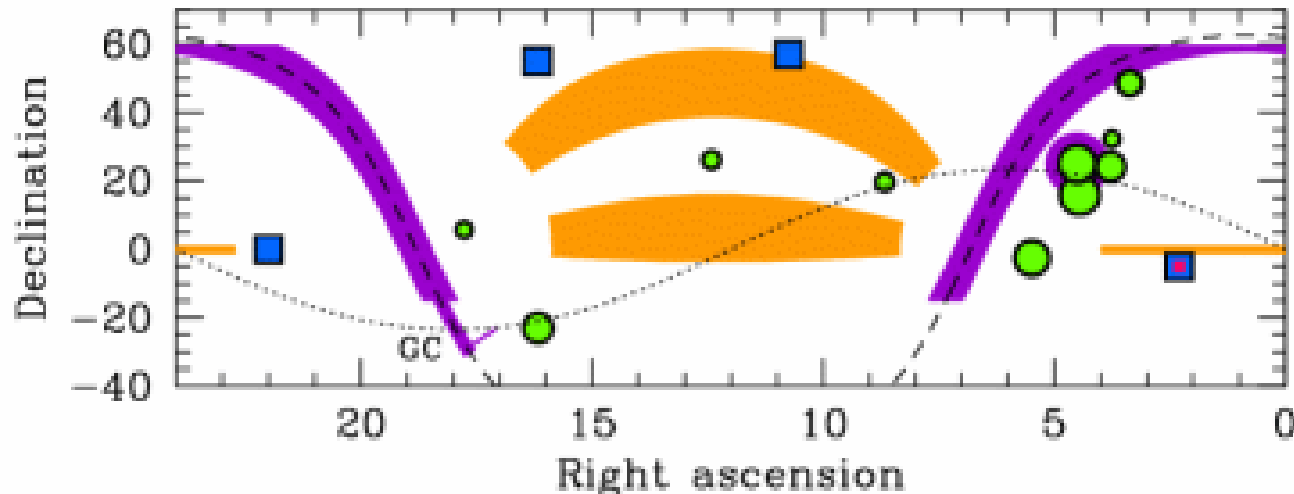


Talk @ CONSTELLATION workshop
Hotel Antheia, Tenerife, October 2010



UKIDSS

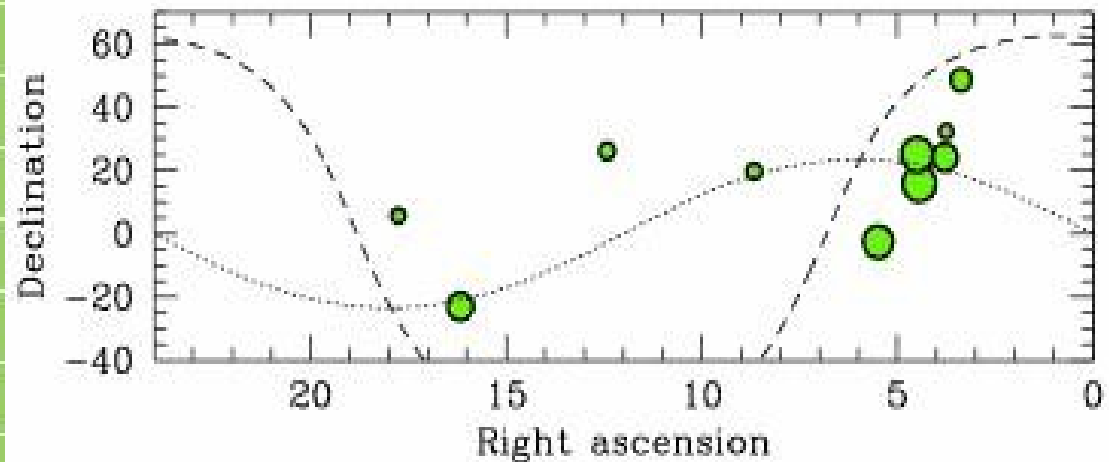
- Wide-field NIR survey with WFCAM on UKIRT (*Lawrence et al. 2007*)
- Pipeline-processed by CASU in Cambridge (*Irwin et al. 2008, in prep*)
- WFCAM Science Archive (*Hambly et al. 2008*)
- 5 components: LAS, GCS, GPS, DXS, and UDS
- Typical 5σ completeness limit is $K = 18.1$ mag (Vega)
- EDR, DR1-4 in July 2006 now WR4 (*Dye et al. 2006; Warren et al. 2007a*)
- DR5 (April 2009) and DR8 (September 2009)



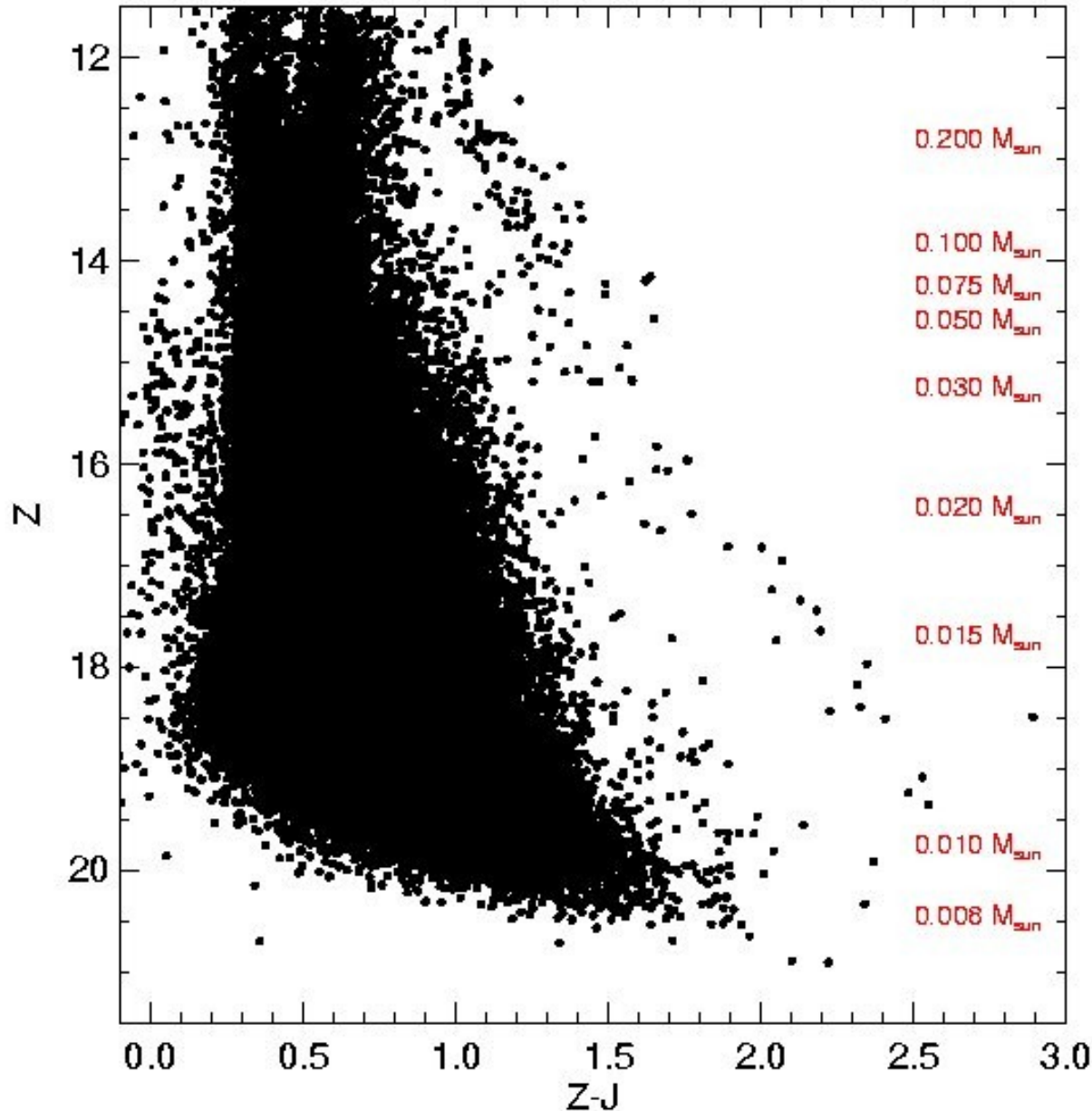
The UKIDSS Galactic Clusters Survey

- *ZYJHK* observations
- 1000 square degrees
- 10 star-forming regions and open clusters
- 2 epochs in the *K*-band for proper motions
- 5 sigma completeness limits: $Z=20.4$, $J = 19.6$, $K = 18.2$ mag

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



Photometric selection



★ GCS Science Verification

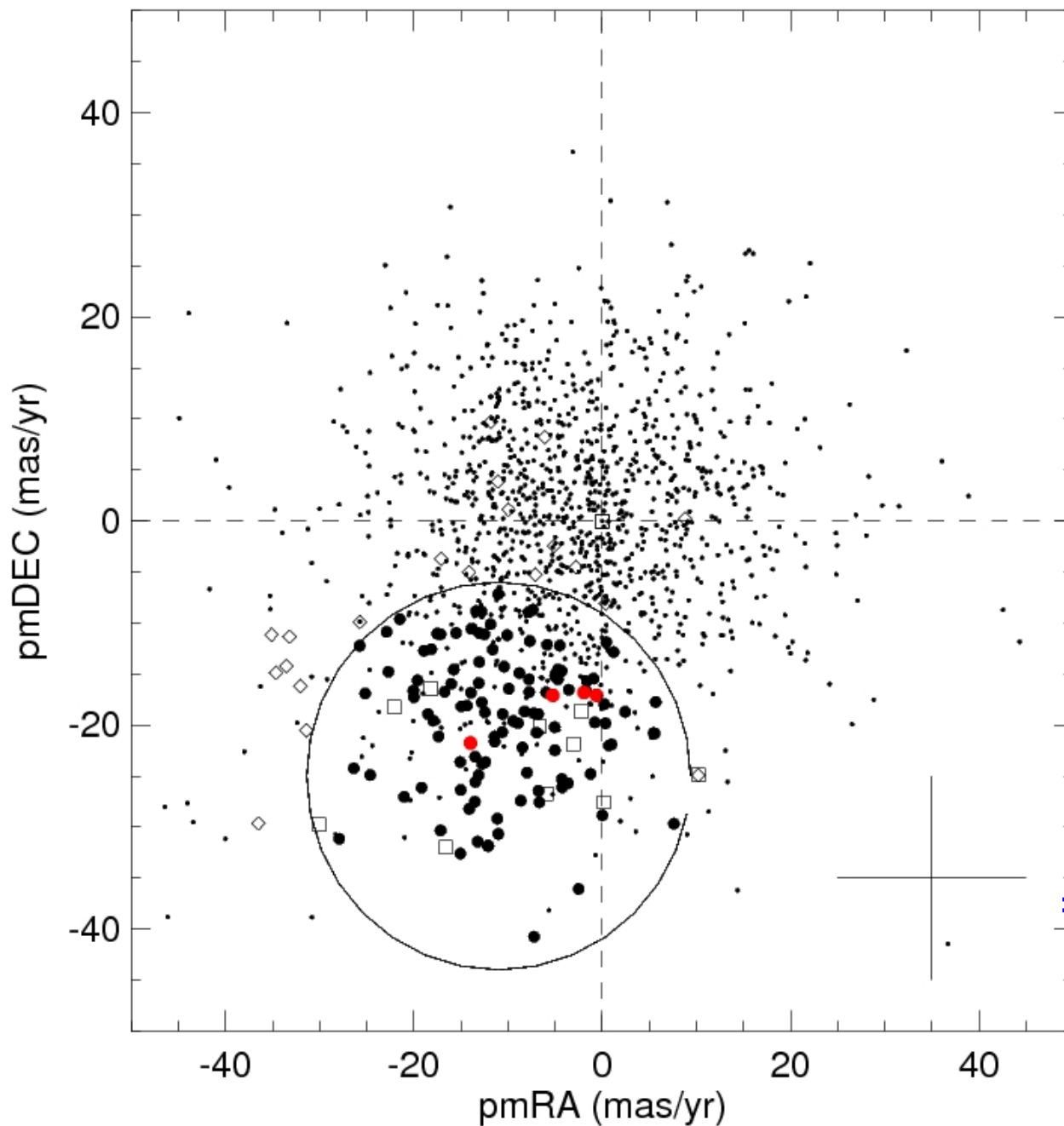
★ Depth $J \sim 18.7$ mag

★ 6.5 sq. deg. covered

★ 30% coverage in DR8

- Cluster sequence well separated from field stars
- Various colour cuts applied
- 164 candidates selected
- Mass scale: NextGen and DUSTY models

Proper motion selection



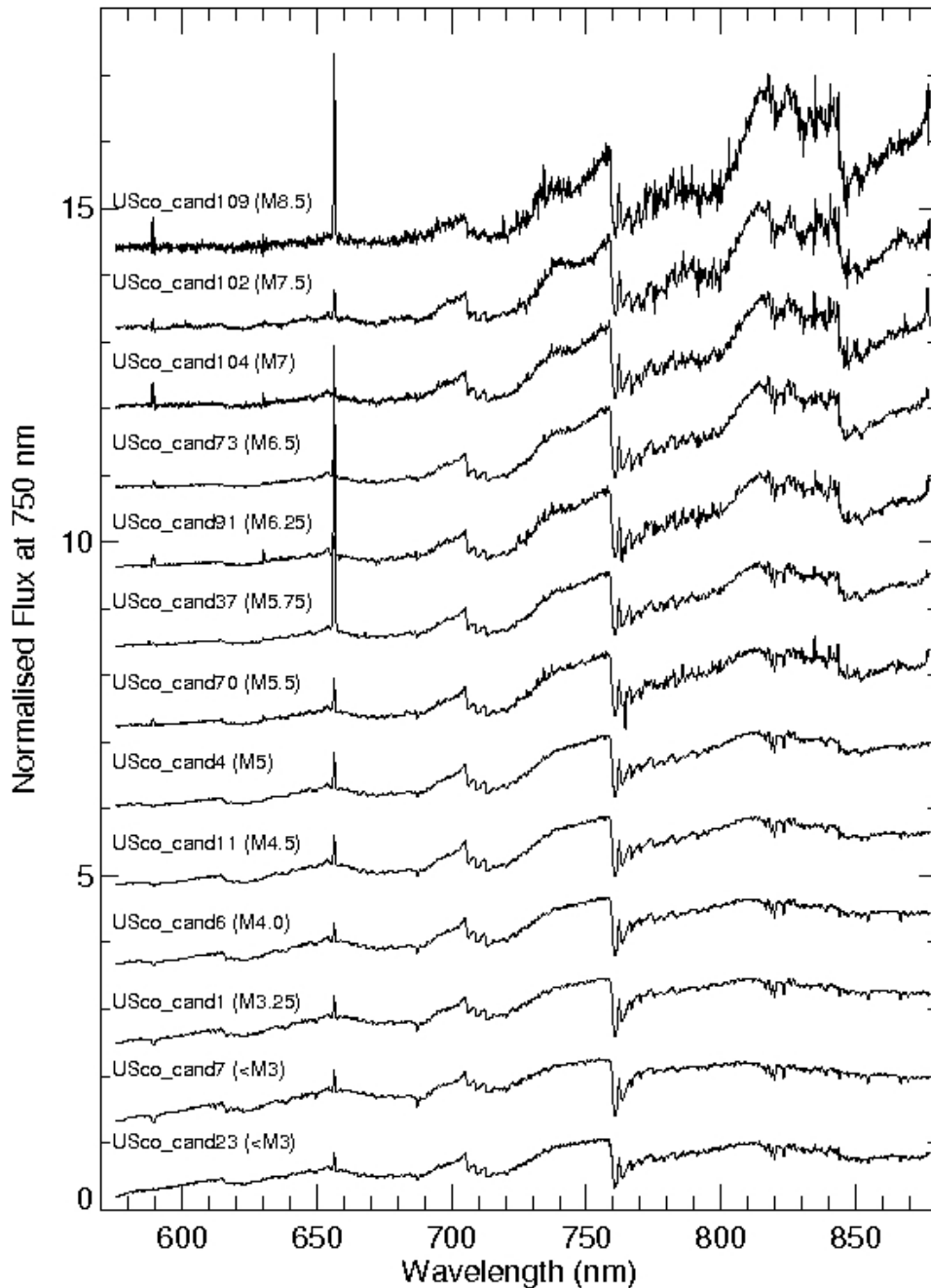
Upper Sco mean PM
(-11, -25) mas/yr

- 2MASS/GCS cross-match
- PM selection: 2σ circle
- Limit at $J = 15.5$ mag

- ✓ 23 rejected as PM NM
- ✓ 129 good candidates

=> Level of contamination: 25%

Optical spectroscopy



★ AAT/AAOmega multi-fibre spectroscopy

★ Wavelength range: 5700-8800 Å

★ Resolution $R \sim 1350$

★ Blue spectra (3740-5720 Å) available

★ 94 candidates observed

➤ 90/94 phot+PM candidates confirmed

➤ H α + NaI & KI equivalent widths

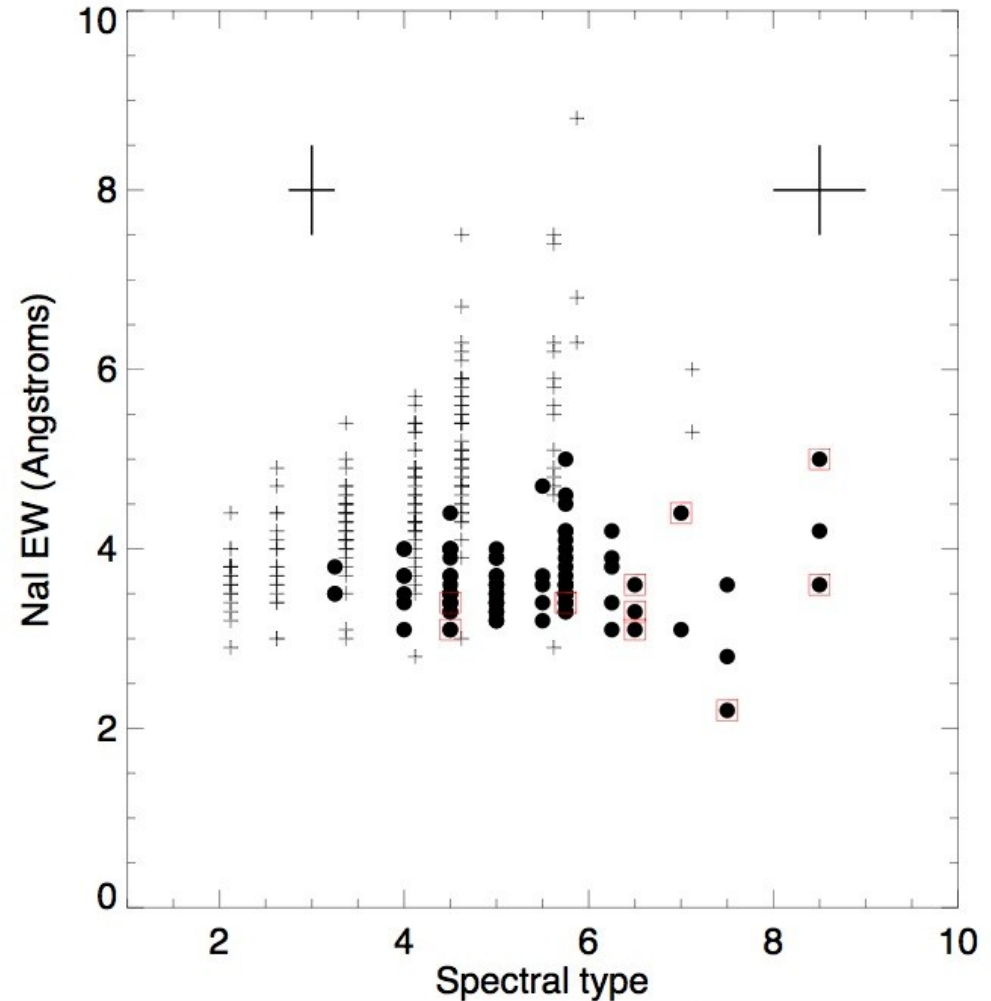
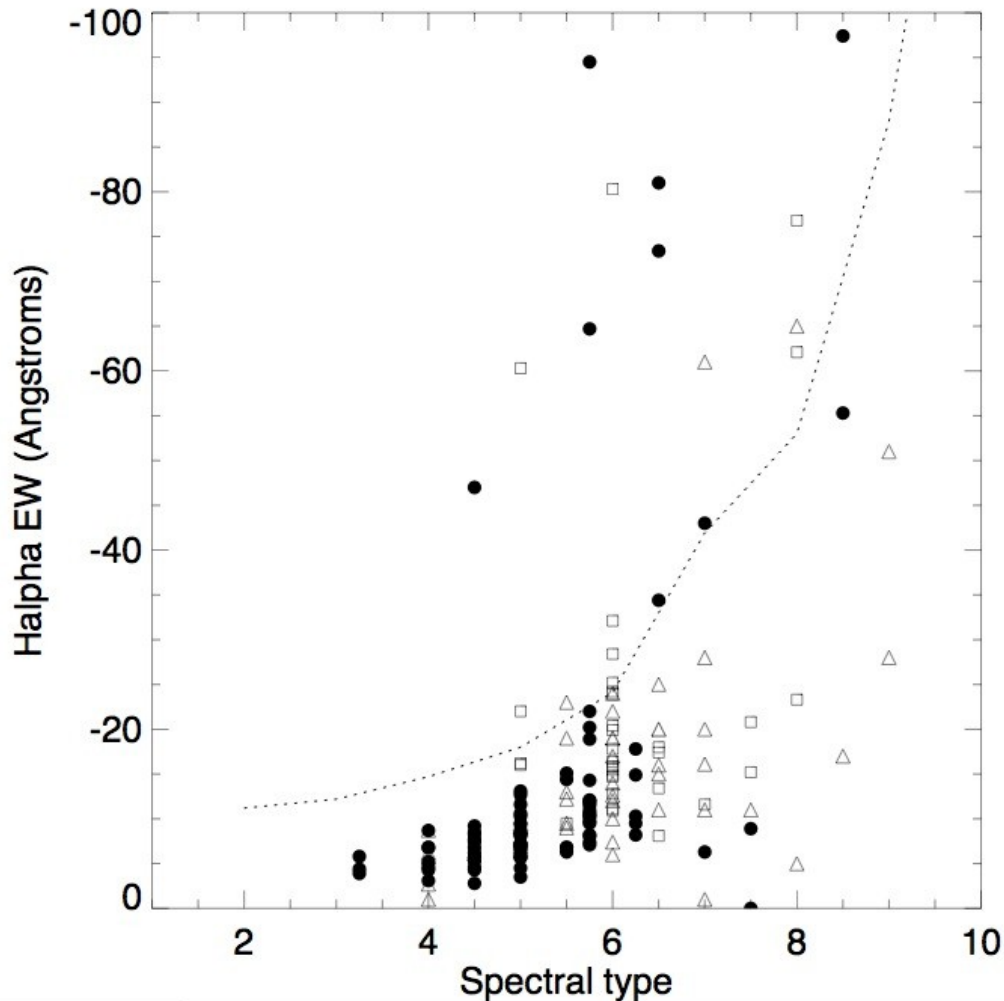
➤ Spectral types: M3.5-M8.5

➤ $T_{\text{eff}} = 3340\text{-}2250$ Kelvins

➤ Mass = 0.4-0.004 M_{\odot}

Youth features

Pseudo-equivalent widths (EWs) for the H α (left) and NaI (right)

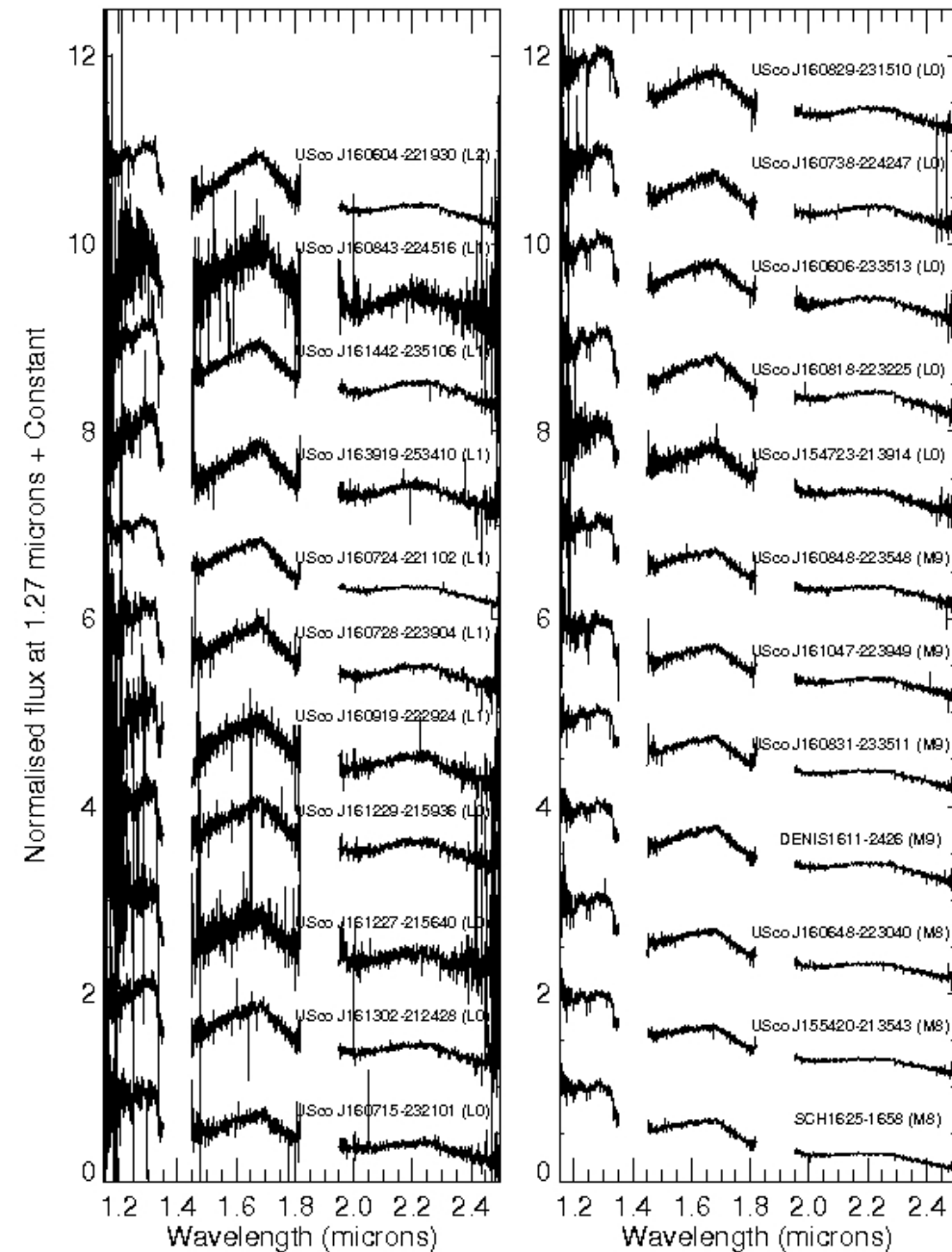


- Increase of H α EWs with cooler temperatures
- Several accretors above the empirical boundary

- NaI doublet sensitive to gravity
- Weak features and EWs

==> Young objects members of the Upper Sco association

Near-infrared spectroscopy (I)



★ Gemini/GNIRS near-infrared cross-dispersed spectroscopy

★ Wavelength range: 1.15-2.49 microns

★ Resolution $R \sim 1700$ with 0.3 arcsec slit

★ 23 candidates observed

➤ 21/23 candidates confirmed

➤ Gravity-sensitive features EWs

➤ Peaked-shaped *H*-band spectrum

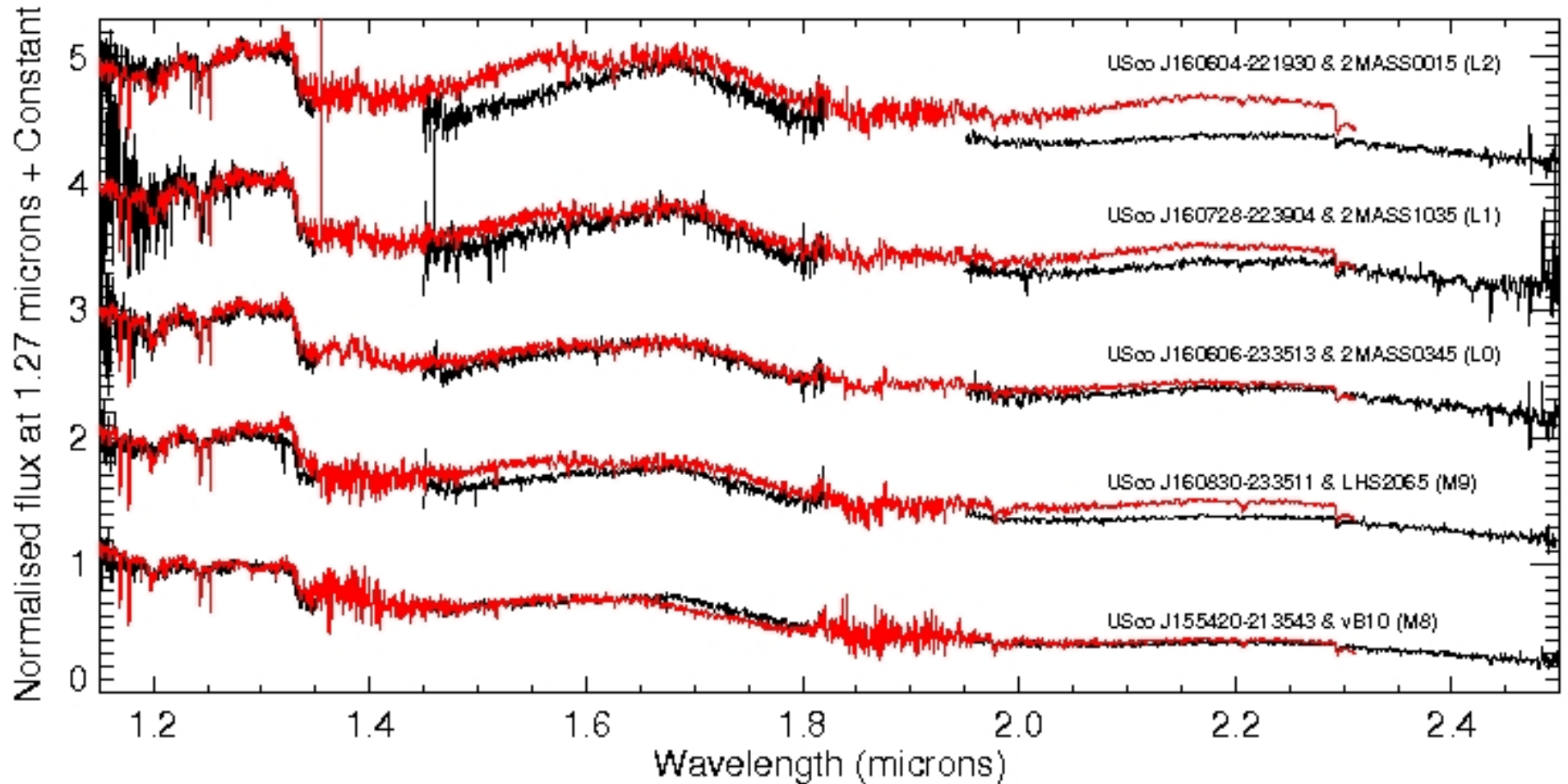
➤ Spectral types: M8-L2

➤ $T_{\text{eff}} = 2700\text{-}1800$ Kelvins

➤ Mass = $0.03\text{-}0.008 M_{\odot}$

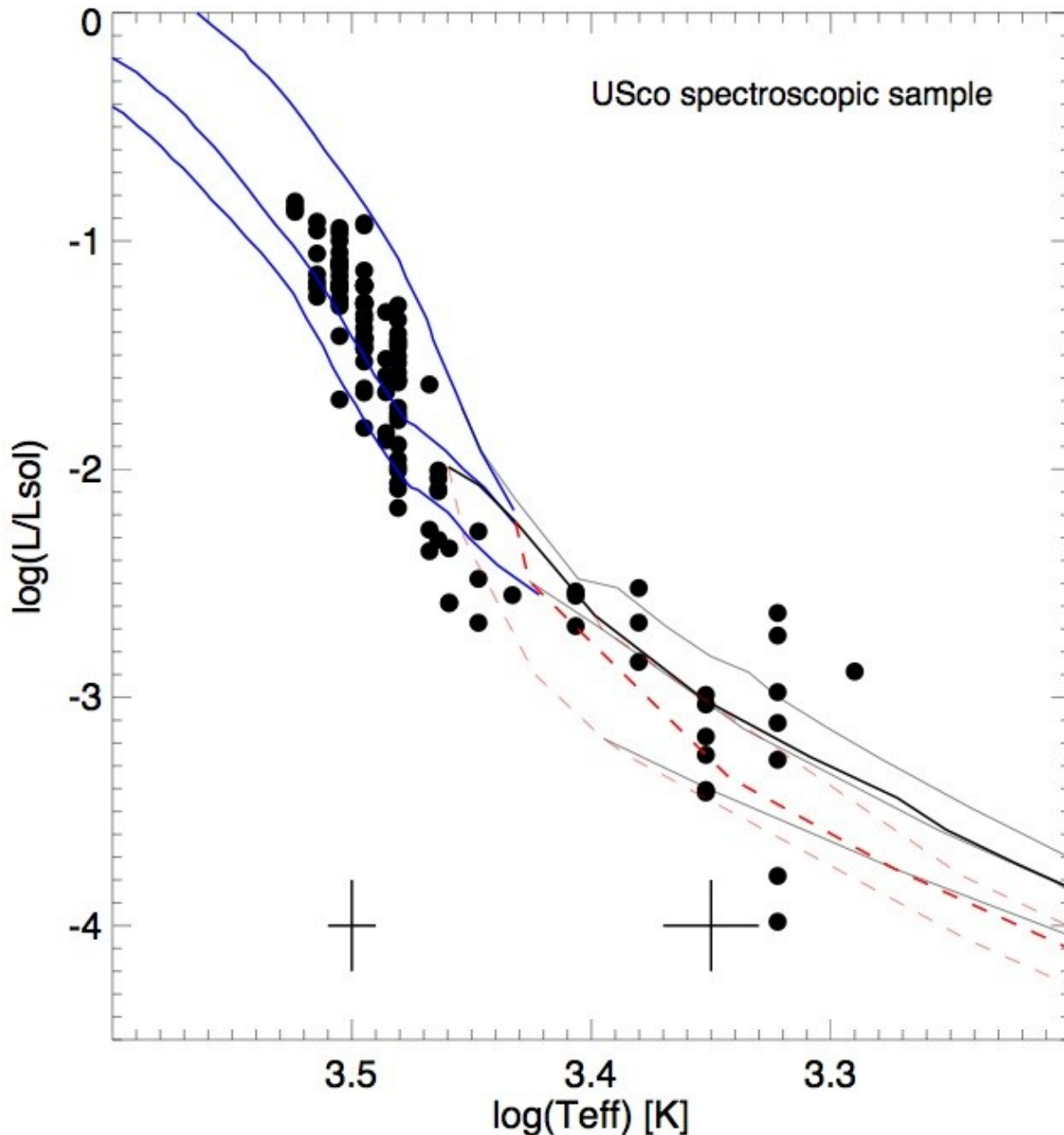
➤ First L dwarfs in the USco association

Near-infrared spectroscopy (II)



Gemini/GNIRS near-infrared cross-dispersed spectroscopy:
Comparison between **USco members** and old field dwarfs
with spectral types ranging from M8 to L2

Hertzprung-Russell diagram

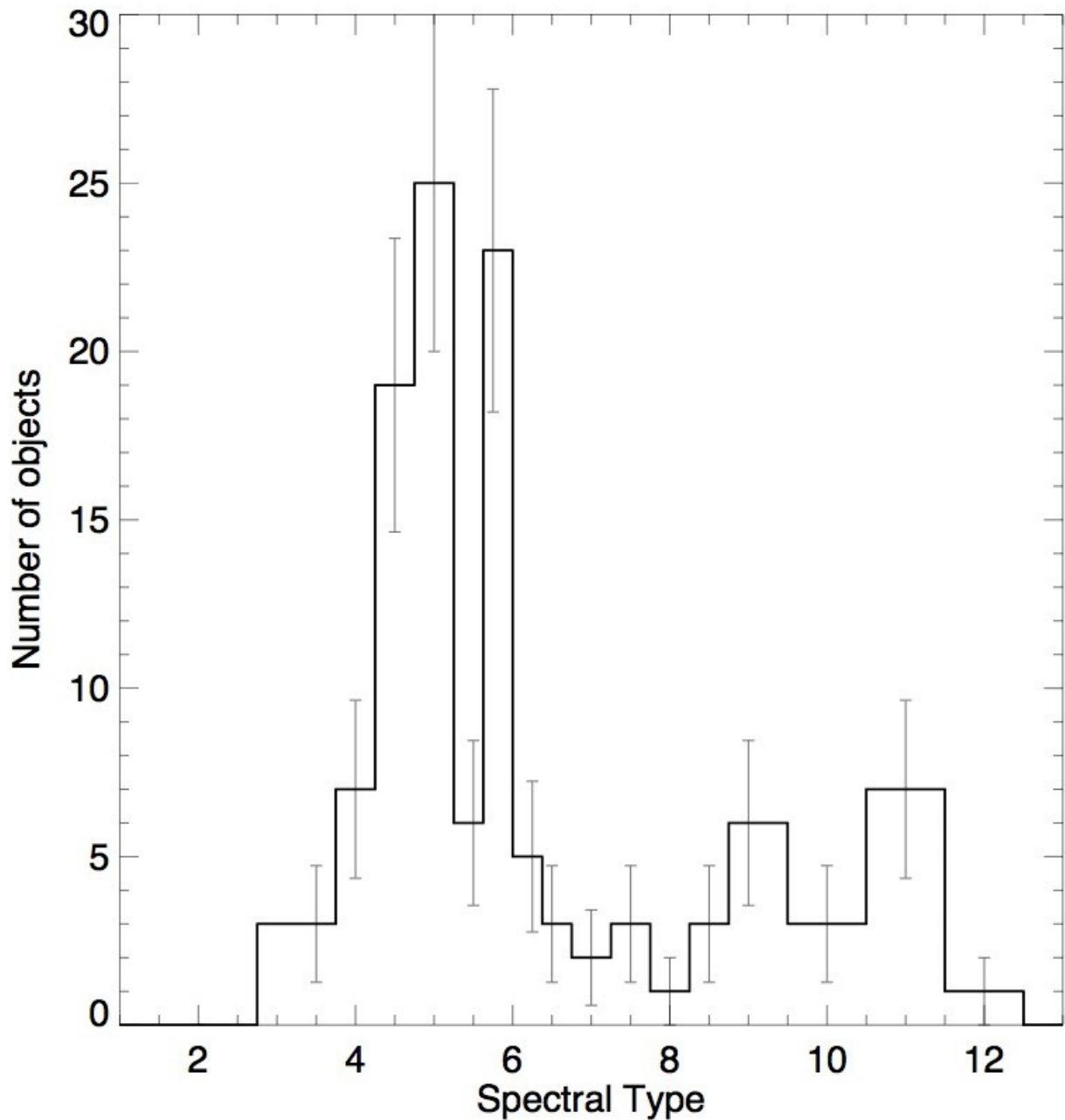


Effective temperatures derived using the scale from Luhman et al. (2003) for young objects

J-band bolometric corrections from old late-M and L dwarfs with trigonometric parallaxes

- Mean USco age: **5 Myr**
- Age dispersion: **1-10 Myr**
- Results similar to Slesnick et al. (2008)

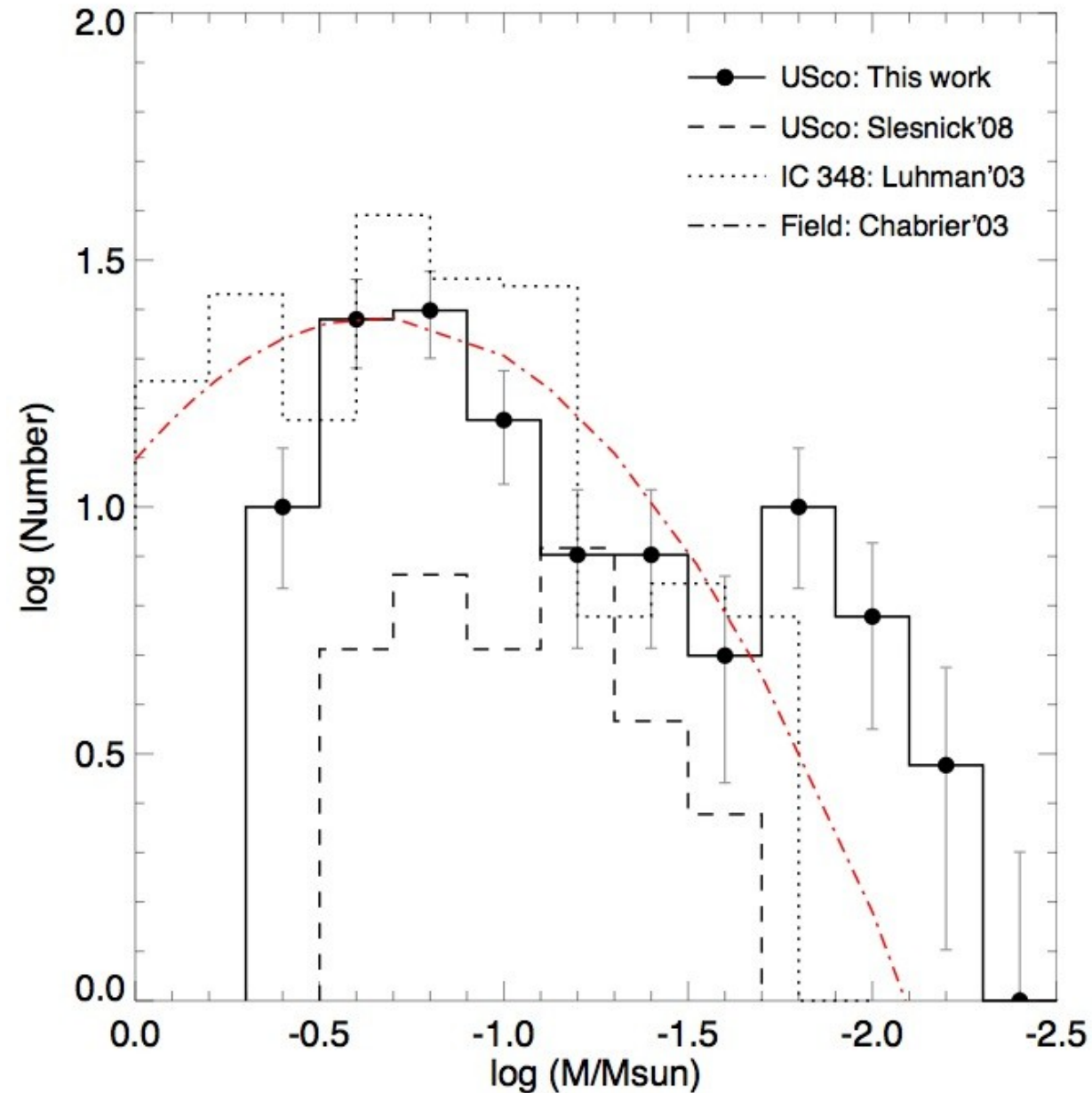
The Luminosity Function



Numbers of spectroscopic members per spectral type bin

- Spectral types: M3.5-L2
- M7/M8 gap detected

The Mass Function

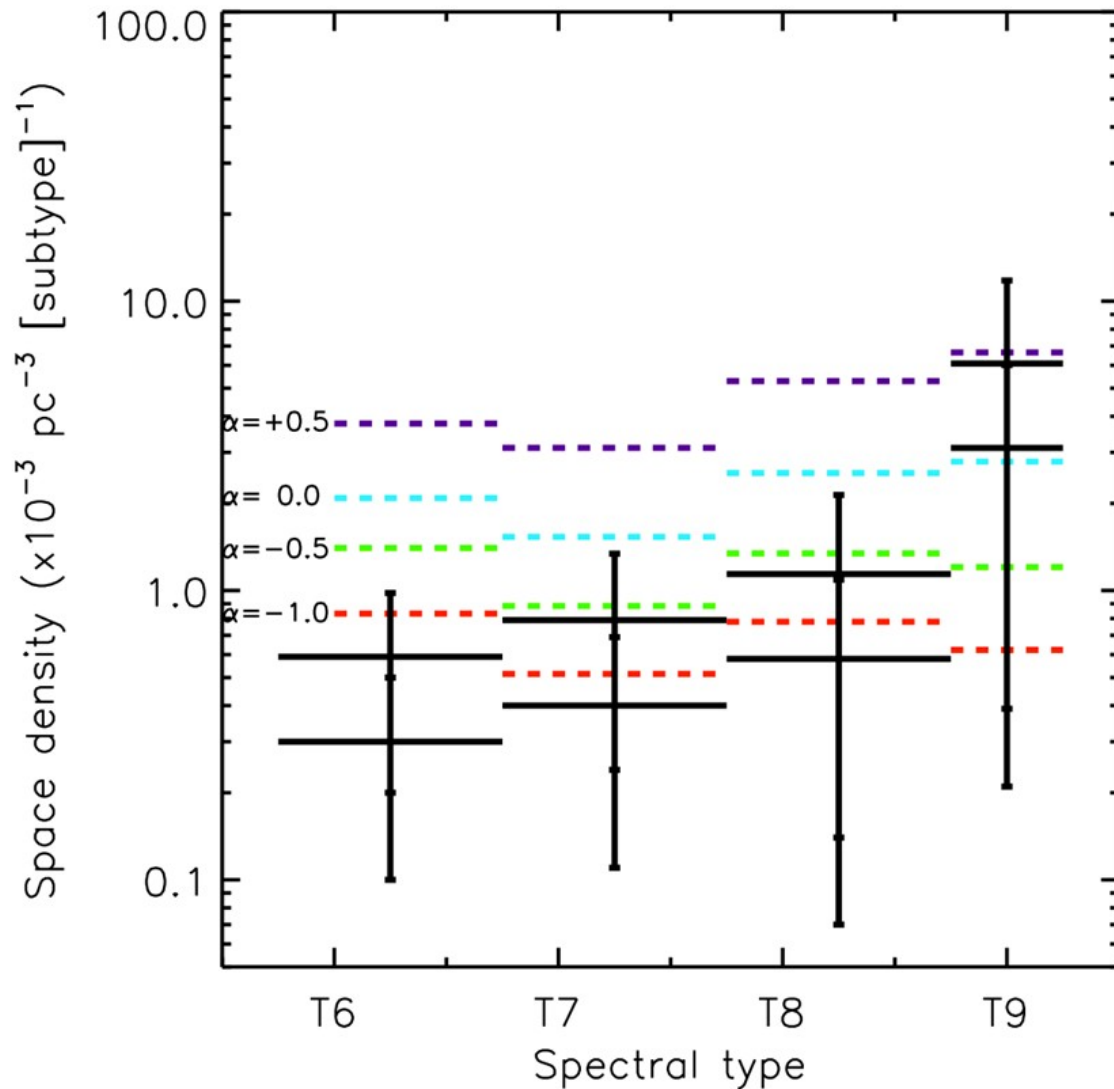


- ★ Age = 5 Myr
- ★ Distance = 145 pc
- ★ 117 spectroscopic members
- ★ Mass range: 0.4-0.01 M_{\odot}

- USco spectroscopic MF similar to IC 348
- Possible excess of low-mass brown dwarfs in USco

Comparison with the field

Field mass function from T dwarfs identified in the UKIDSS Large Area Survey



UKIDSS LAS DR4
we found 11-22 T6+ dwarfs
(Burningham et al. 2010)

IMF $\text{dn/dm} \propto m^{-\alpha}$	# \geq T6 dwarfs
$\alpha = -1.0$	24 ± 2
$\alpha = -0.5$	37 ± 2
$\alpha = 0.0$	56 ± 3
$\alpha = +0.5$	112 ± 4

Slide kindly provided by Ben Burningham

Conclusions & outlook

Conclusions:

- Selection of stellar, substellar and planetary-mass members
- Proper motion measurements using 2MASS as first epoch
- Chromospheric activity and youth features
- First L dwarfs in the Upper Sco association
- Determination of the IMF down to $0.01 M_{\odot}$

Outlook:

- Full coverage of the association in *ZYJHK*
- Second epoch in the *K*-band for proper motions
- Deep Upper Sco *zJ+CH₄* survey underway
- Binarity in the planetary-mass regime
- GAIA 3D space motions of brightest members

Discussion: questions?

Q1: Is the IMF universal?

Q2: Can we explain this discrepancy?