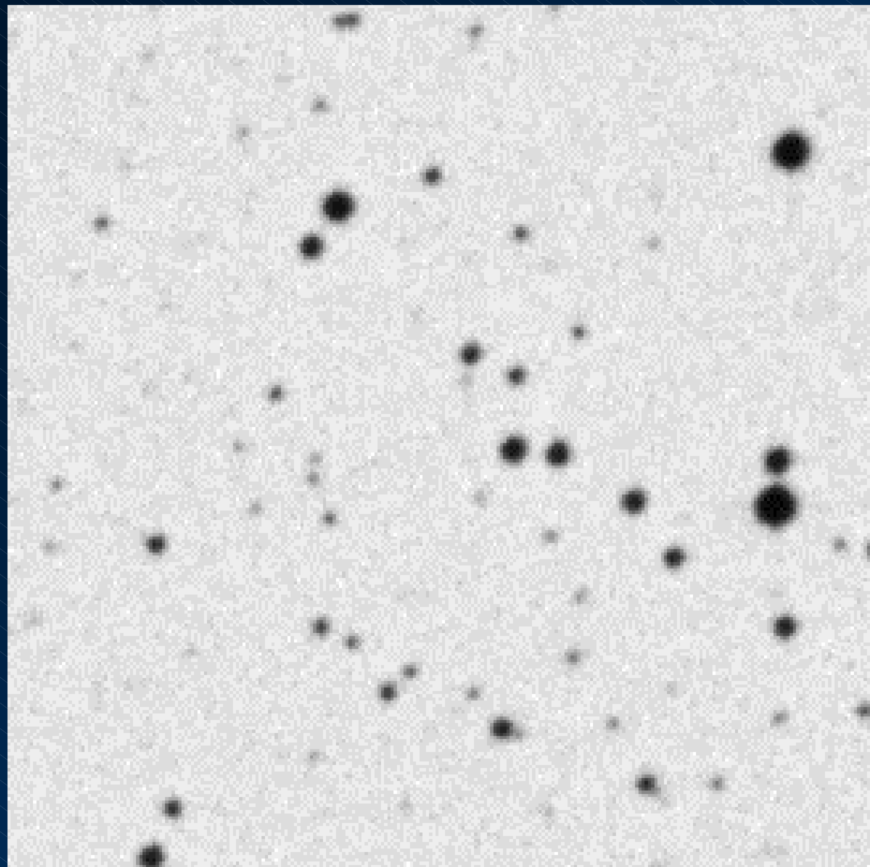
Proper motion surveys in the infrared



Nigel Hambly & Niall Deacon
University of Edinburgh

Institute for Astronomy

Centroiding accuracy

Following: King, 1983, PASP, 95, 163
Irwin, 1985, MNRAS, 214, 575

$$\sigma_x / a \sim \sigma_I / I$$

where:
a **is the (well-sampled) image scale size (~pixel size)**
x **is either co-ordinate**
I **is the intensity**

$\Rightarrow$ **a 5-sigma detection will have centroid accuracy of** ***one fifth*** **of a pixel, etc.**

Panoramic (near) infrared surveys currently available

Legacy (first epoch) :

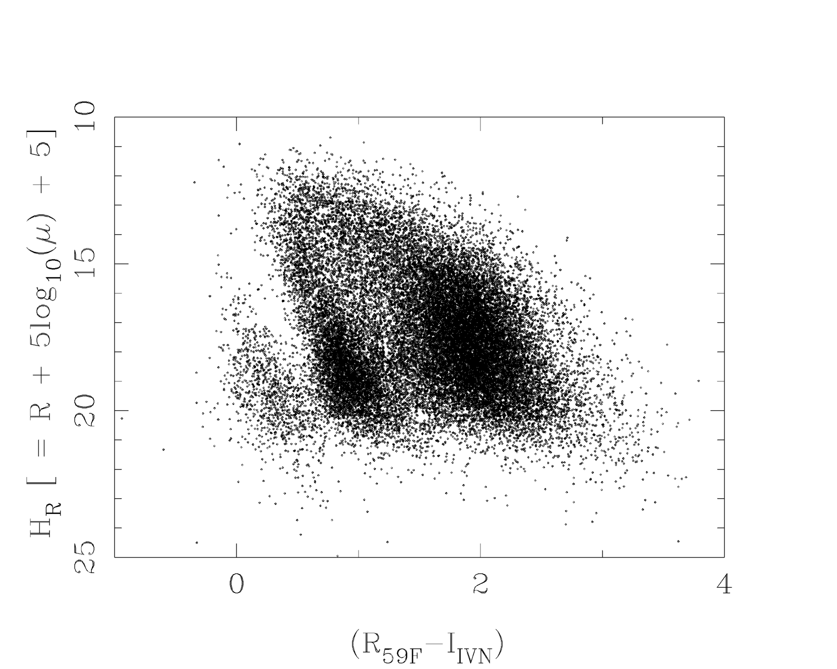
- **Schmidt photographic digitised sky surveys:**
  - **I ~ 18.5**
  - **USNO-B, GSC-II, SuperCOSMOS Sky Survey (SSS)**

Recent (second epoch):

- **Two-micron all-sky survey (2MASS):**
  - **J~15.8 ; H~15.1 ; K~14.3**
- **Deep near-infrared southern sky survey (DENIS):**
  - **I~18.5 ; J~16.5; K~14.0**
- **Sloan Digital Sky Survey:**
  - **i~21.3 ; z~20.5**

⇒ all provide relative astrometry to ~0.1 arcsec, and hence a combined pm accuracy ~10 mas/yr

Proper motion as an indicator of absolute luminosity



Following Hertzsprung:

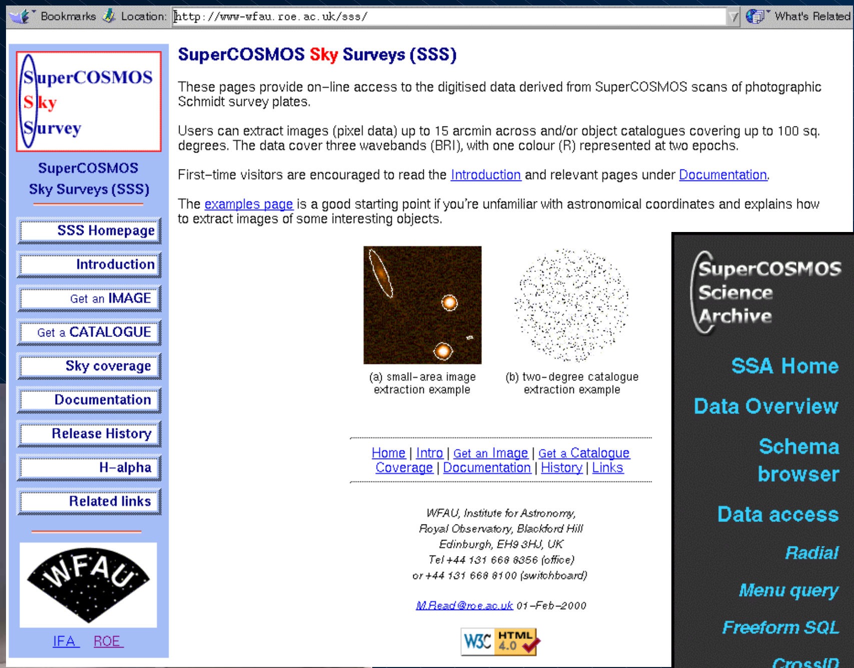
$$M = m - 5\log_{10} d + 5$$

$$\mu = v_T / 4.74d$$

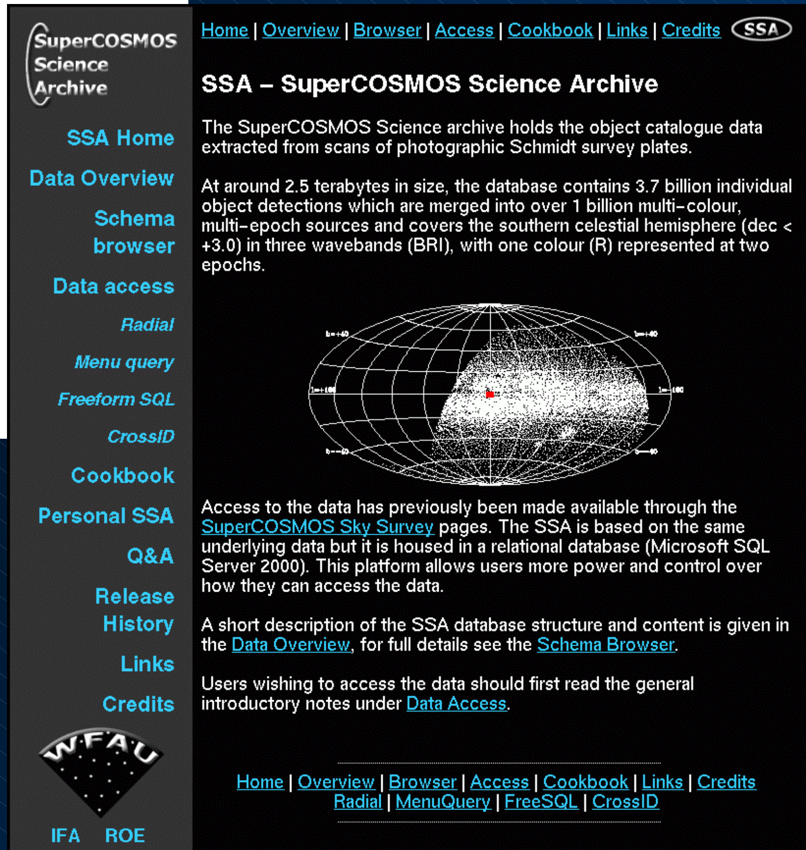
$$\therefore M = m + 5\log_{10} \mu + 5 + c$$

⇒ **5-sigma proper motions are required for clear population separation in reduced proper motion.**

SuperCOSMOS Sky Survey



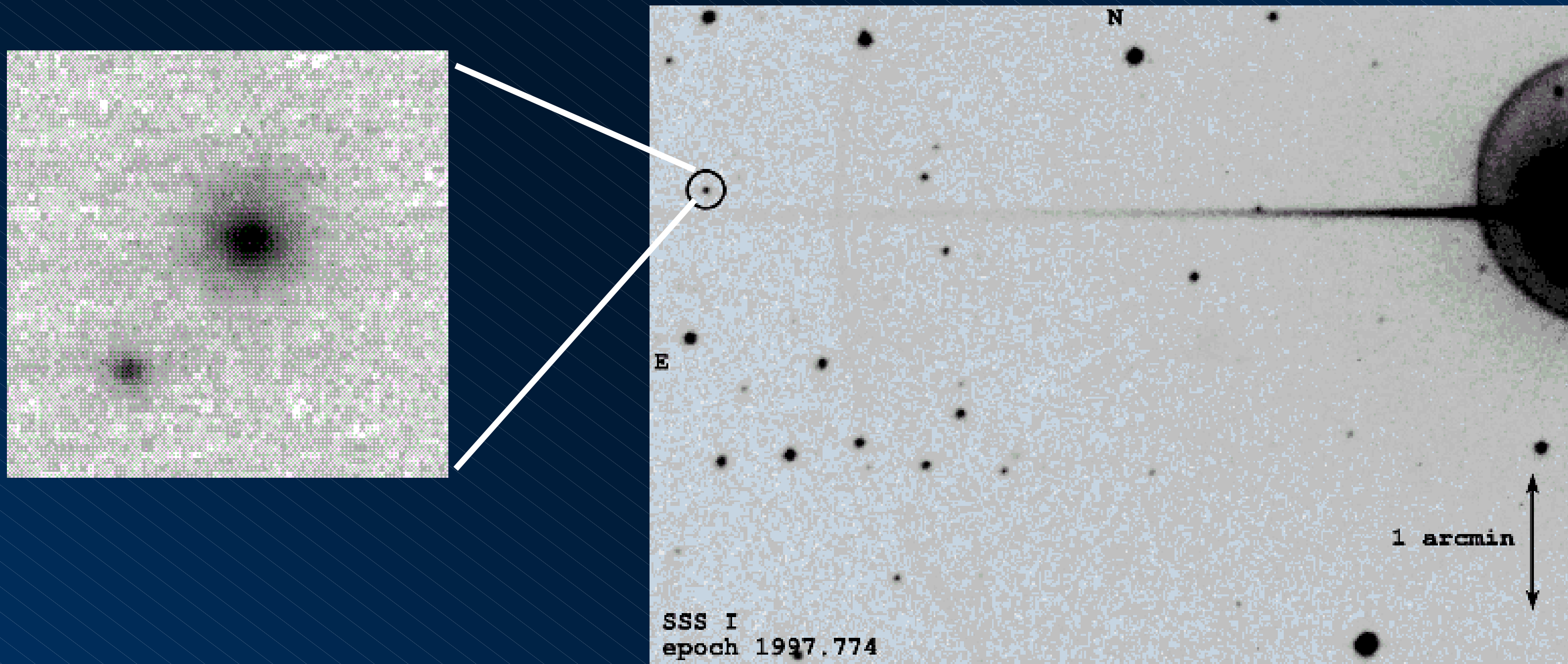
http://www-wfau.roe.ac.uk/sss



http://surveys.roe.ac.uk/ssa

e.g. Scholz et al., 2003, A&A, 398, L29

- **SSS and 2MASS**
- **common proper motion T dwarf companion to Epsilon Indi**



- **McCaughrean et al., 2004, A&A, 413, 1029 : T1 / T6 binary !**
- **work being extended/completed by Scholz, Lodieu, et al.**

Southern hemisphere Infrared Proper motion survey (SIPS)

- **Employing SSS I-band and 2MASS**

- **all sky except most crowded regions**
  - **Schmidt data cannot be used at low |b| or M.C.s**

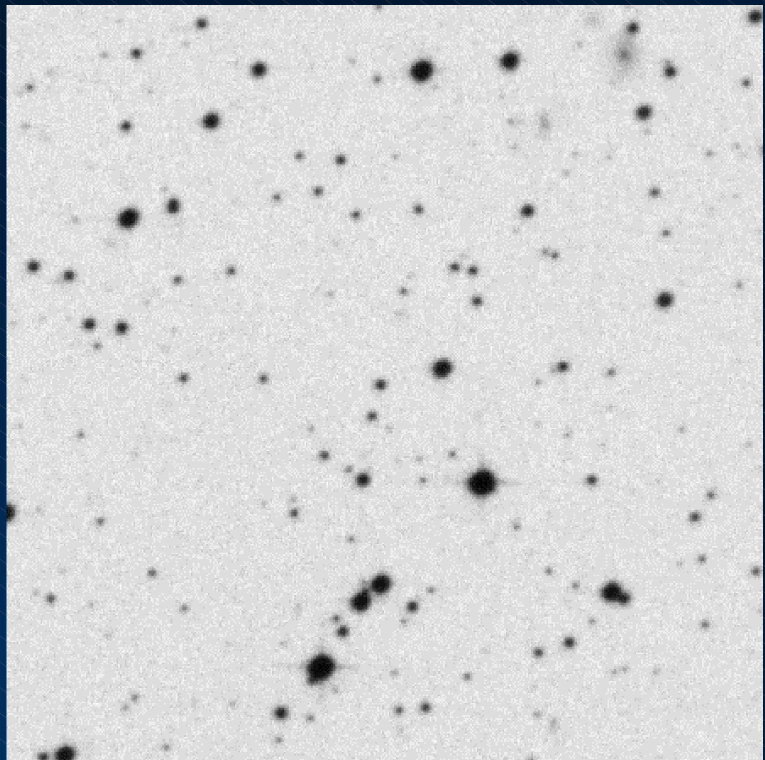
- **currently limiting pm mu > 0.5 arcsec/yr**

- **extending work in progress:**
  - **lower proper motion limit**
  - **northern hemisphere**

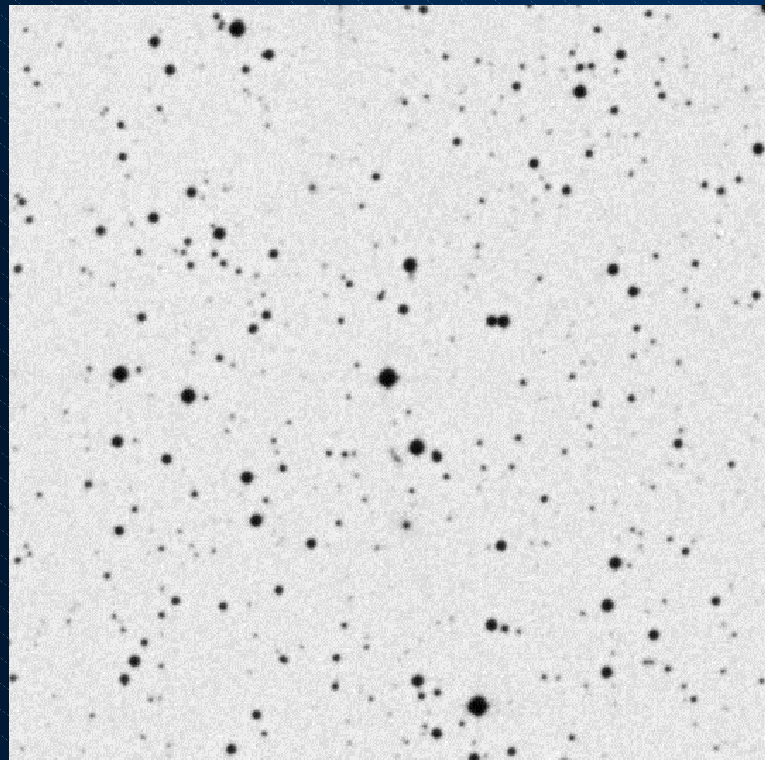
- **identifying new, nearby stars**

⇒ see Deacon, Hambly & Cooke, 2005, A&A 435, 363 (astro-ph / 0412127)

New high proper motion stars:

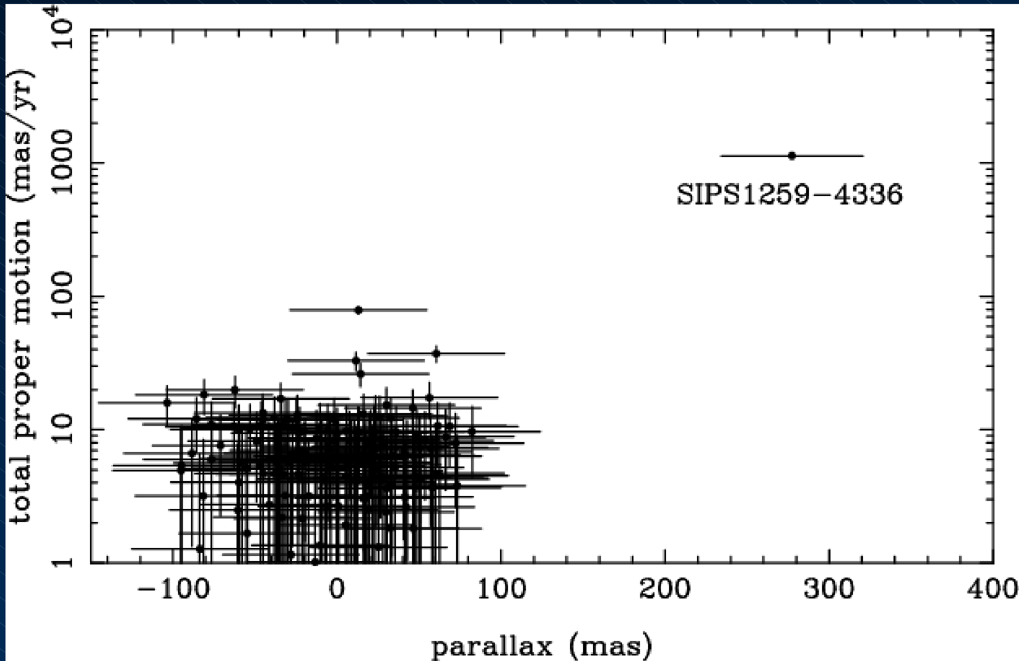


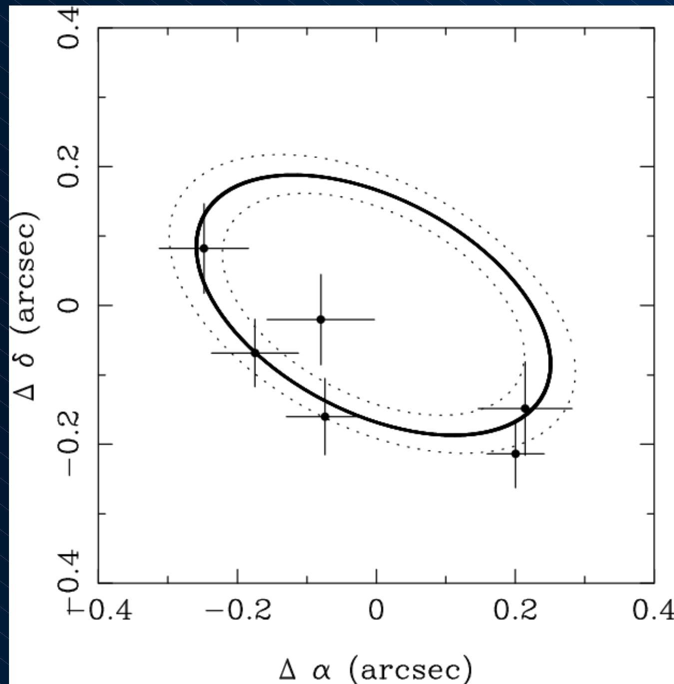
SIPS 1259 - 4336



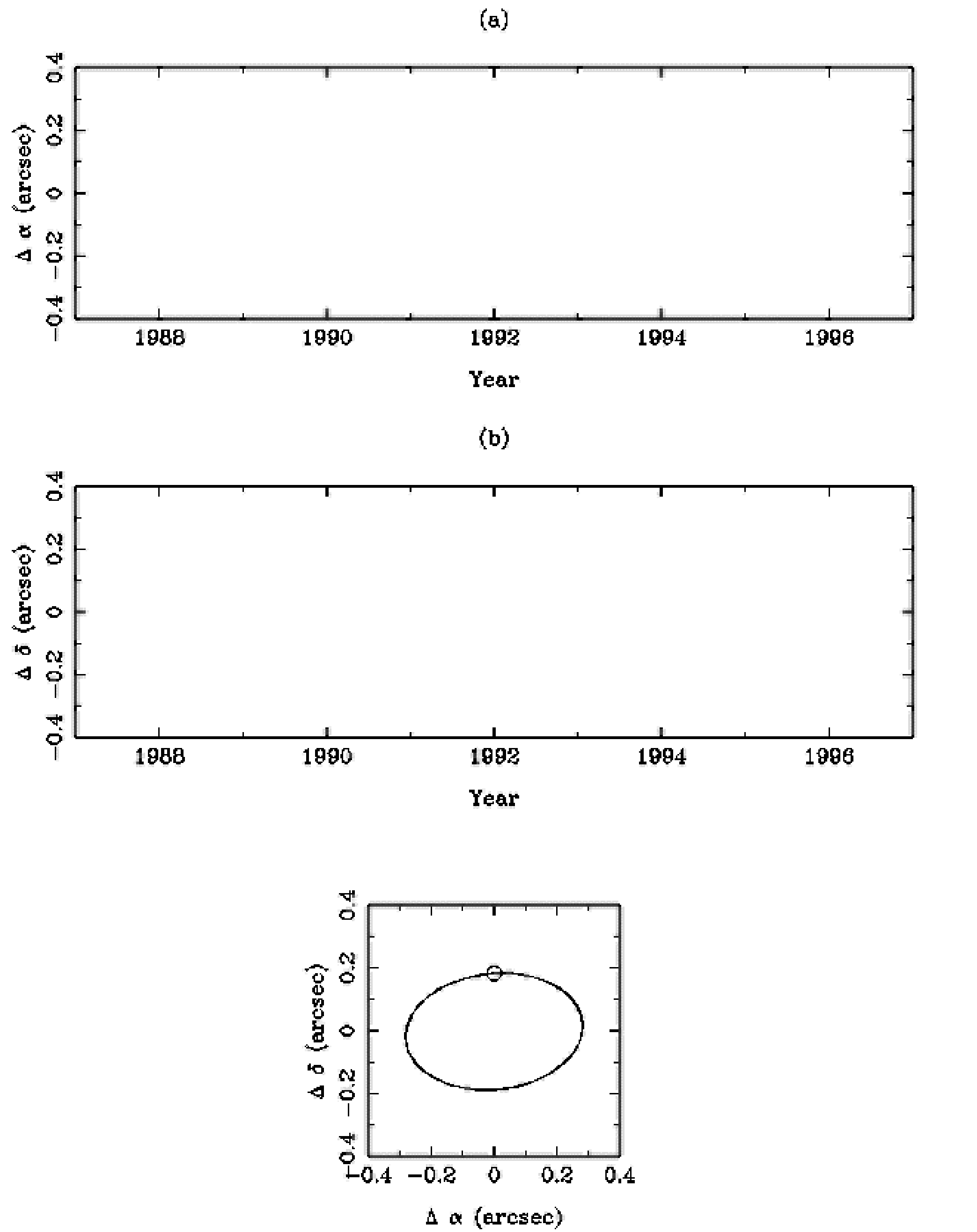
SIPS 1910 - 4132

SIPS 1259 parallax / proper motion





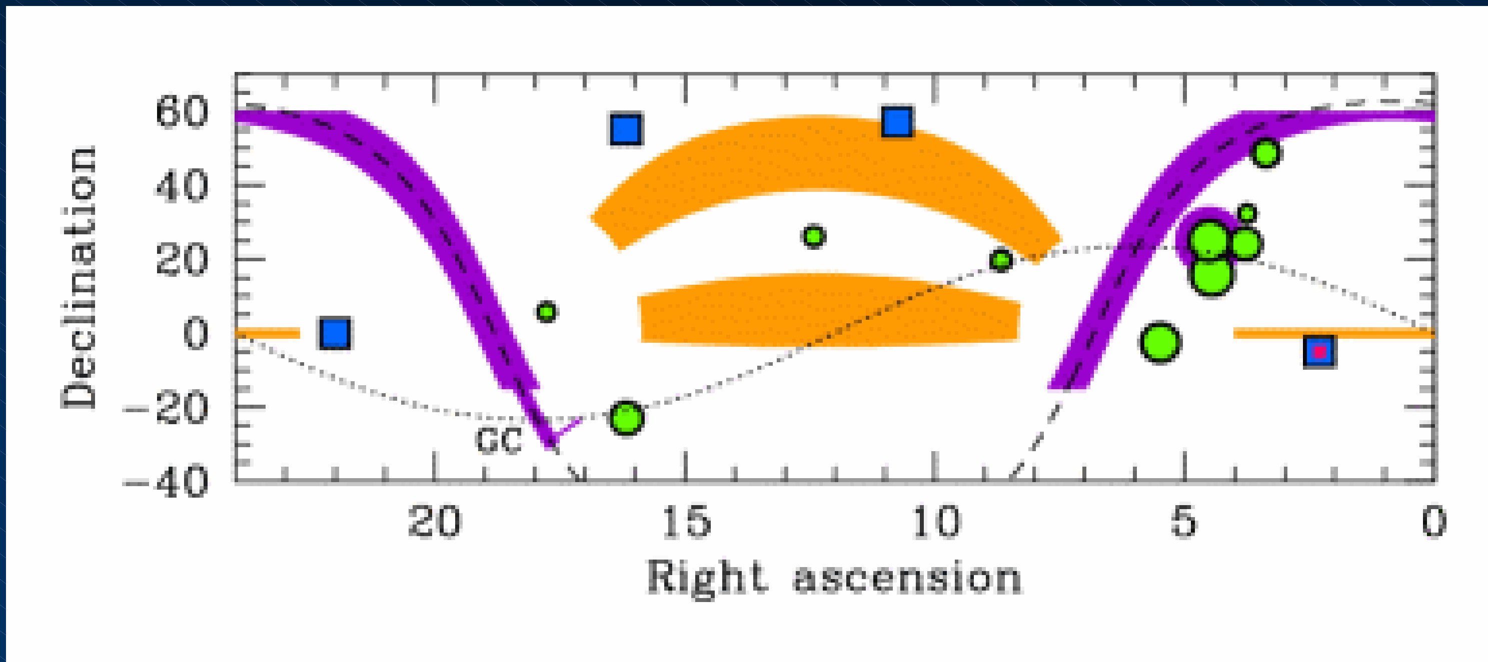
- **parallax = 276 +/- 41 mas**
- ***d* = 3.6 +/- 0.5 pc**


(a)
Δ α (arcsec)
0.4
0.2
0
−0.2
−0.4
1988
1990
1992
1994
1996
Year
(b)
Δ δ (arcsec)
0.4
0.2
0
−0.2
−0.4
1988
1990
1992
1994
1996
Year
Δ δ (arcsec)
Δ α (arcsec)
−0.4
−0.2
0
0.2
0.4

The new generation of IR surveys

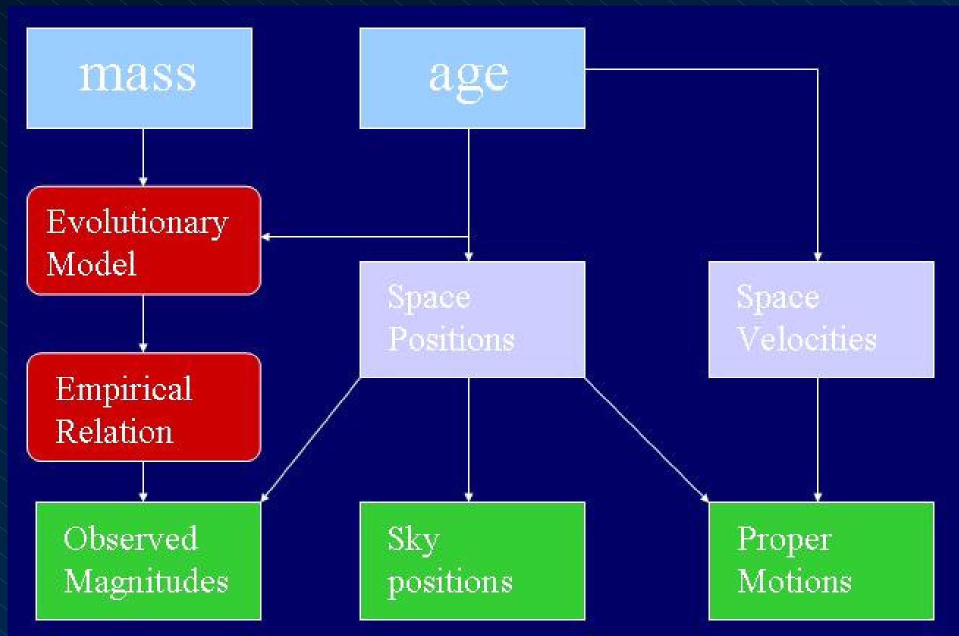
- **United Kingdom Infrared Deep Sky Survey (UKIDSS) Large Area Survey:**

  - **up to 4000 sq. degrees over ~5 yr**
  - **Y~20.5 ; J~19.7 ; H~18.8 ; K~18.4**
  - ***with J at two epochs!***



Simulated populations

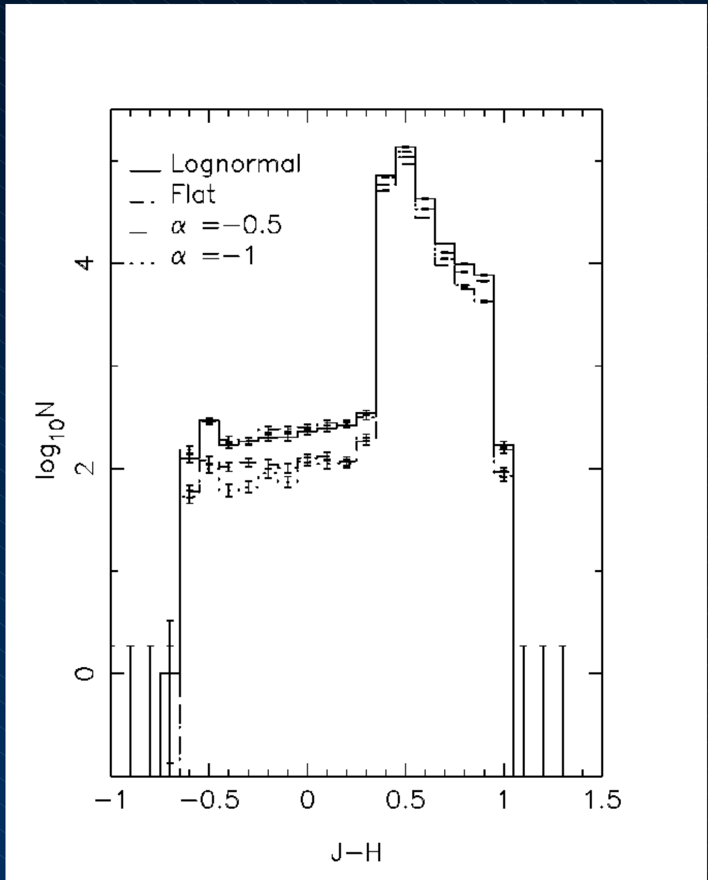
- **Assumed mass and age distributions**
  - **MF: power law & log-normal (logMc=-1.1; width=0.79)**
  - **BR: exponential; characteristic timescale tau**



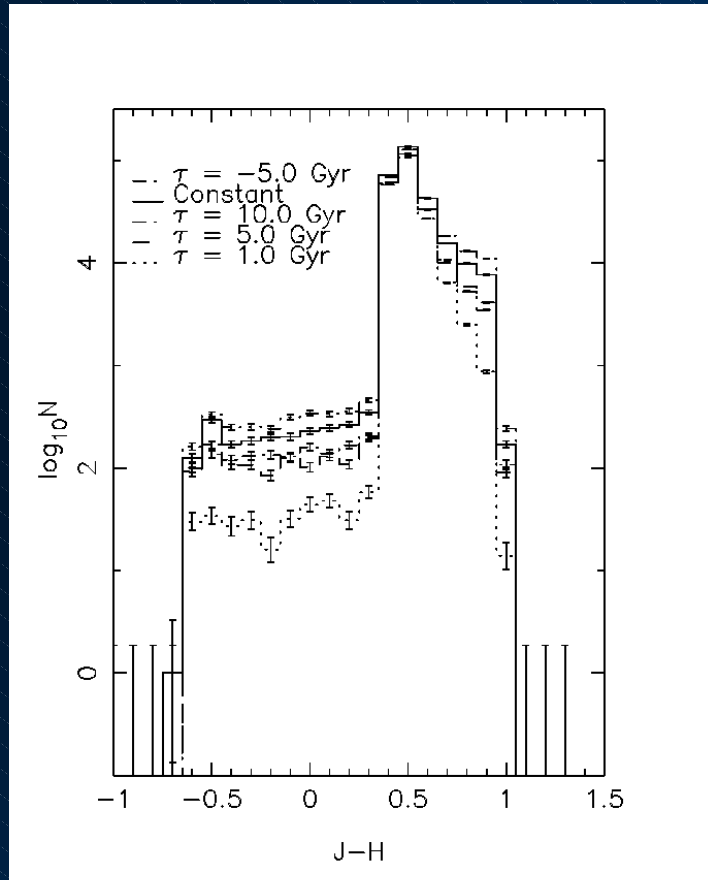
- **Disk scale height and velocity dispersions modelled as increasing with age; also model photometric errors**

$\Rightarrow$ **some preliminary results follow**

Distributions in (J-H) colour



- **constant birth rate, varying the mass function**

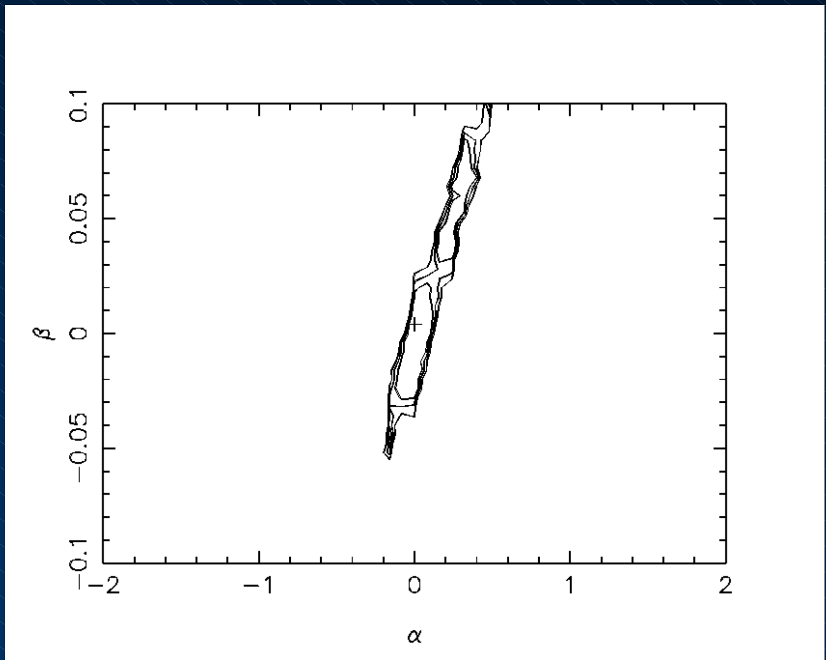


- **constant mass function varying the birth rate**

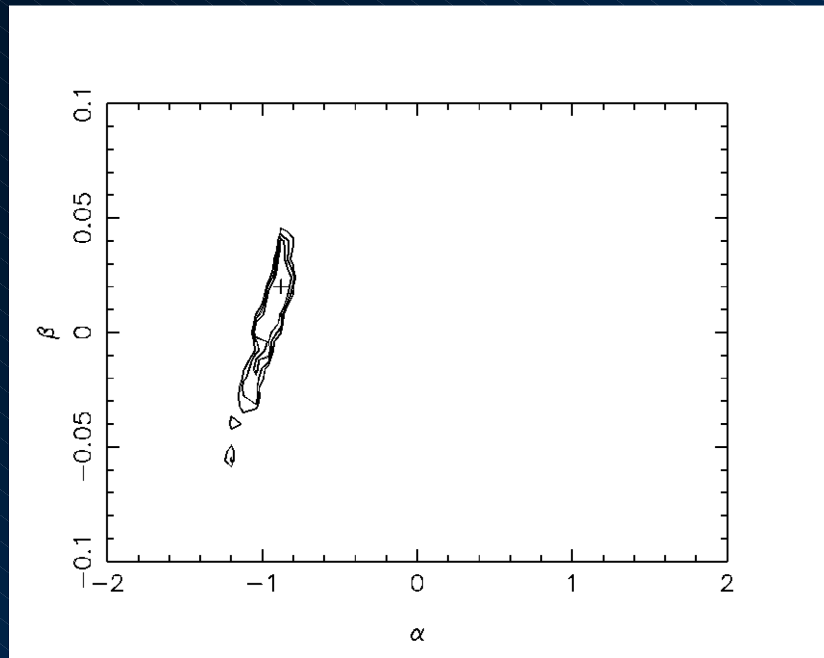
Constraining the birth rate and MF

Using a grid of simulated (J-H) distributions; compare a single model realisation (incl. errors) against the grid

- **MF: dN/dlogm power-law with index -alpha**



- **alpha = 0.0; const. BR (beta = 1/tau = 0.0)**

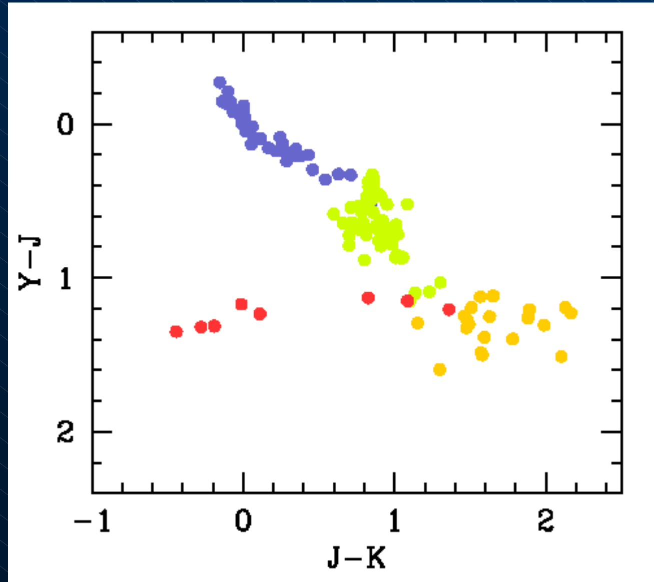


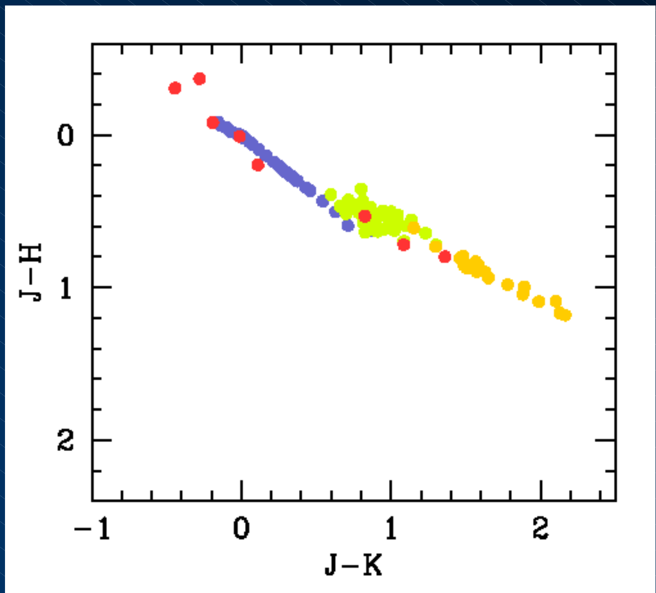
- **alpha = -1.0; const. BR**

Ultracool field dwarfs: the problem

- The coolest objects (e.g. “Y” dwarfs) may only be detected in a few bands (e.g. Y / J / H)

- Optical upper limits, and (weak) K upper limits, may not be sufficient to uniquely identify ultracool dwarfs



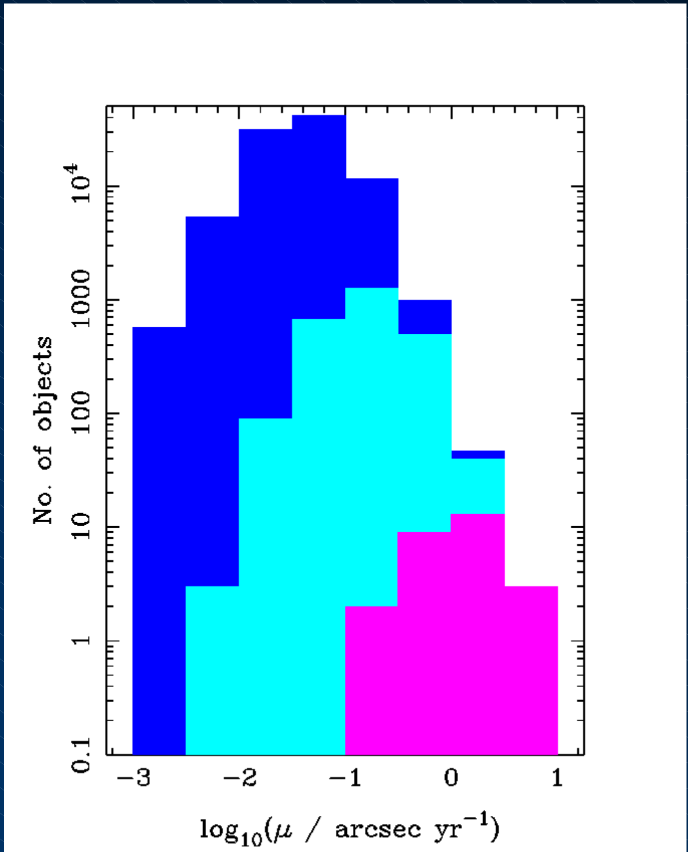


- earlier spectral types may cause significant contamination

⇒ photometric techniques alone may be insufficient to uncover the coolest objects

Distribution of proper motions

- **For a UKIDSS LAS-like survey, with**
  - **log-normal mass function**
  - **constant birth rate**
  - **detection in K band not required for coolest objects**



NOTE:

- **the coolest objects are the faintest**
- **the faintest objects will only be observable *nearby***

⇒ ***the coolest objects will all exhibit significant proper motions***

Conclusions

- **Infrared proper motion surveys may be the easiest way to reliably select samples of the coolest objects**
- **The UKIDSS LAS should contain ~ 10s of "Y" dwarfs**
- **Proper motion measurements yield kinematic information also**
- **Modelling indicates that UKIDSS LAS will constrain ULM MF & BR.**