Progress and results from the UKIDSS GPS

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and
the GPS working group

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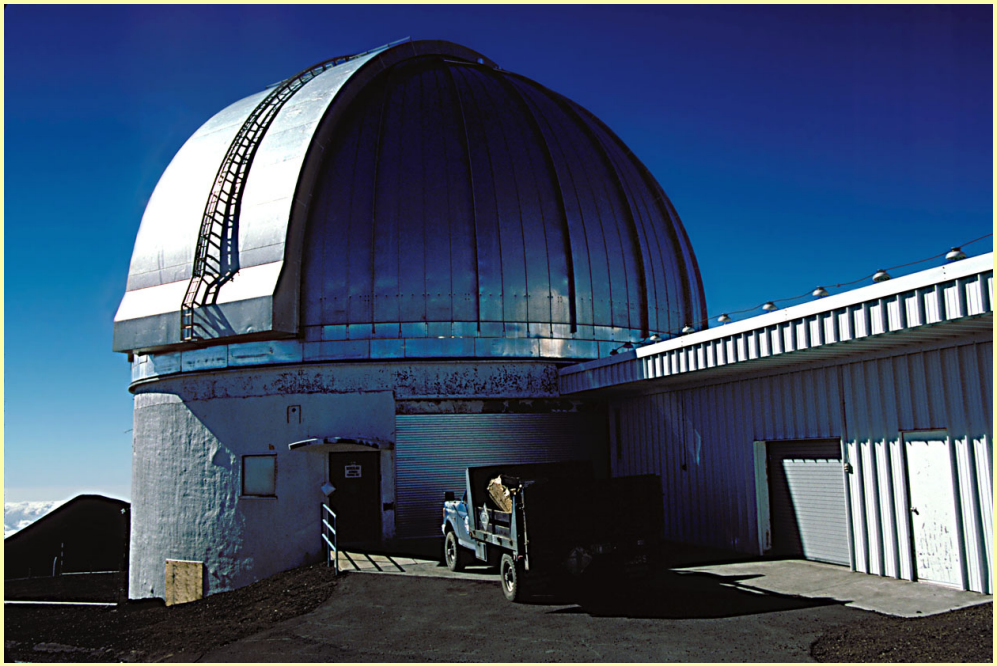
Outline

1) Survey progress
2) Complementary datasets
3) Recent highlights from rare object searches
   - The coolest brown dwarfs
   - New high amplitude variables
4) Plans for the future

UKIRT is still there!



GPS Observations

- JHK imaging in photometric conditions. Typical seeing 0.8” at K.
  All 3 bands observed within a 20 minute period.

  Integration times are 80s, 80s, 40s at JHK.
  2x2 microstepping is used to improve resolution, giving 0.2” pixels.

  5 sigma depths in uncrowded fields

  J=19.8

  H=19.0

  K=18.1

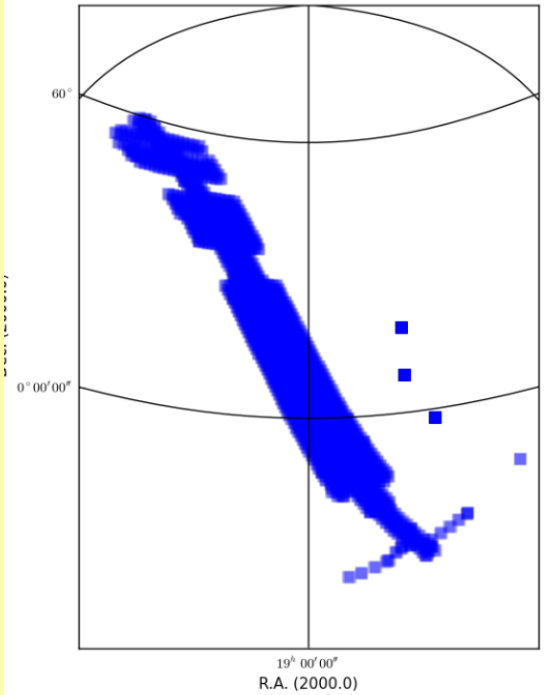
  2nd epoch imaging at K is also underway, for proper motions and variability.

GPS update

Area covered at JHK: ~1570 deg^2 in the plane (not counting TAP region). Survey aim is 1844 deg^2 at JHK, so we are ~85% complete.

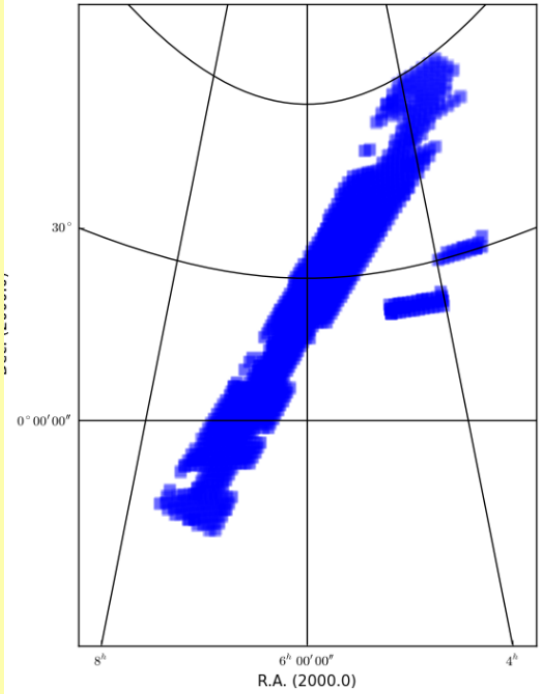
~500 deg^2 of "2nd epoch" K band data has also been taken.

Coverage in all 3 filters at June 2011



Summer fields

Winter fields

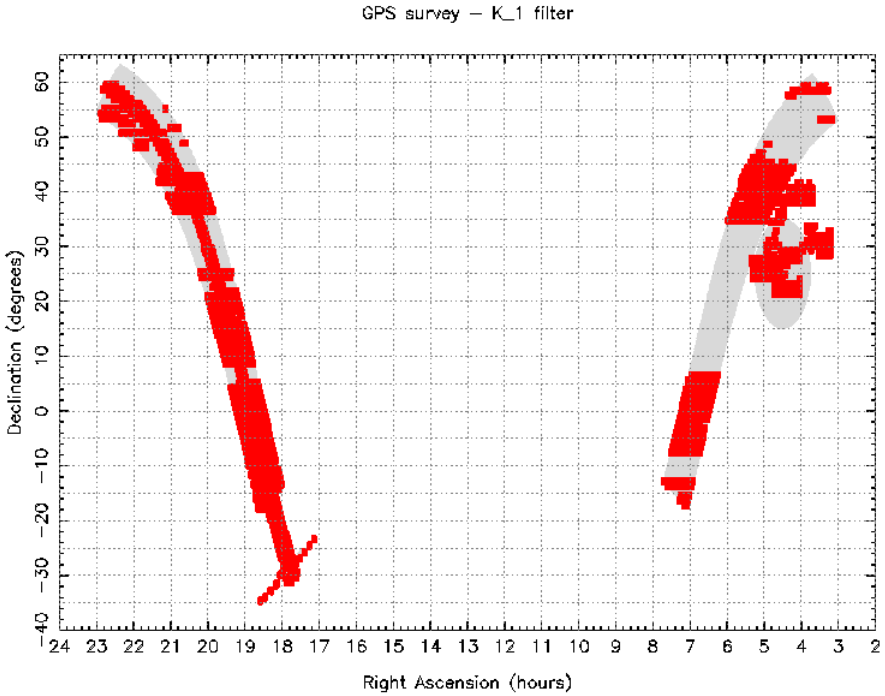


Releases

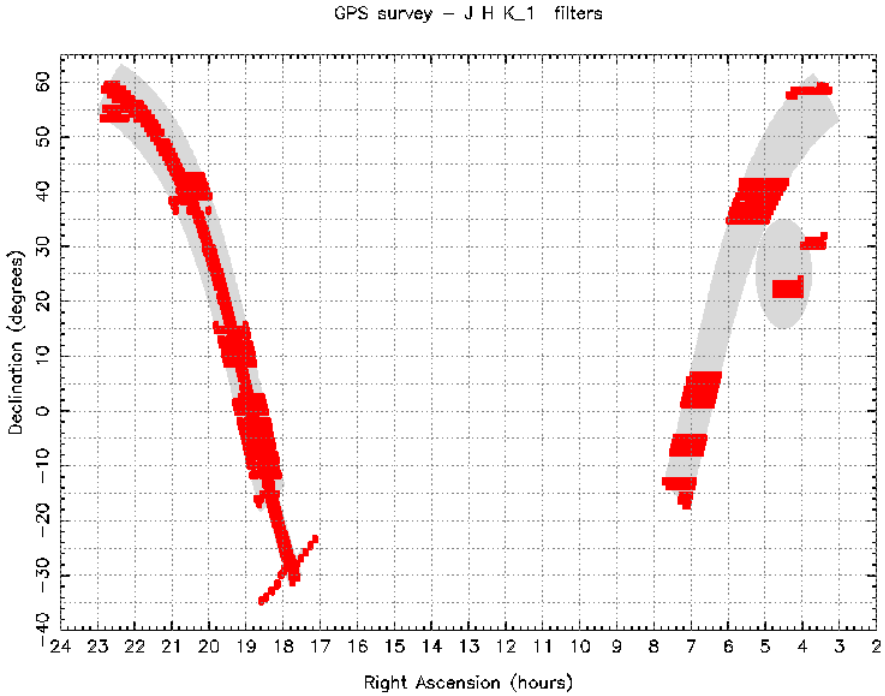
DR7 released in Sep 2010.

DR8 (09B data) is expected to be released later this summer. It will benefit from improved photometric calibration and improved astrometry.

DR7 K band coverage (1302 deg^2)



Full JHK coverage (802 deg^2)



Complementary northern/equatorial datasets

- Optical: IPHAS (r', i', Hα) & UVEX in the north, VPHAS+ in the south.
- Near IR: UWISH2 2.12 μm imaging survey with UKIRT.

- Mid-infrared: Spitzer and now WISE
  - GLIMPSE (3.6, 4.5, 5.8, 8.0 μm) and MIPSGAL (24 μm) were a core part of the GPS star formation science case, covering longitudes -65° < l < 65° at |b|<1°
  - GLIMPSE360 (3.6, 4.5 μm) now extends the spatial coverage to the entire mid-plane, with greater depth. CYGNUS-X (3.6, 4.5, 5.8, 8.0, 24 μm) covers 24 sq.deg.
  - WISE (3.3, 4.6, 12, 23 μm) covers the entire sky fairly deeply, with ~6" resolution.

- Far IR/submm
  - HERSCHEL/Hi-Gal (70, 160, 250, 350, 500 μm) covered -60° < l < 60° at |b|<1°. It is now being extended to cover the anti-centre.
  - JCMT/JPS (450, 850 μm) and SASSy (850 μm) should start soon with SCUBA2.

- Millimetre: CSO/BOLOCAM GPS 1.1mm survey covers -10° < l < 90.5° at |b|<0.5°
  BU-FCRAO ^{13}CO (J=1-0) Galactic Ring Survey covers -15° < l < 56° at |b|<1°

- Radio: MMB class II methanol maser survey with the Parkes radio dish. l<40°, |b|<2°
  CORNISH VLA 5 GHz survey (6 cm) covered the Glimpse-north region.

Recent results from multiwaveband combination with the GPS

- The GPS/Spitzer combination is invaluable to detect YSO discs in very large numbers. The ratio of Class I/Class II YSOs can be used to determine the relative ages of clusters in a molecular cloud complex.

- E.g. Beerer et al.(2010, ApJ, 720, 679) did this for a 4 sq. deg. portion of Cygnus-X. Massive star formation was traced using OB stars with optical data.

- Cygnus-X + 2MASS found 12,000 YSO discs in 24 sq. deg.
- Cygnus-X + GPS raised this to 25,000 (Gutermuth, private comm.)
  - The GPS adds most of the Class I sources since these are faint at JHK.

- Mark Gallaway (2011 PhD thesis) found that only 5% of MMB methanol masers are in GPS clusters.

- This suggests that massive star formation happens first, though sensitivity issues remain to be addressed.

Rare Object Highlights
UGPS 0722-0540 – the coolest brown dwarf

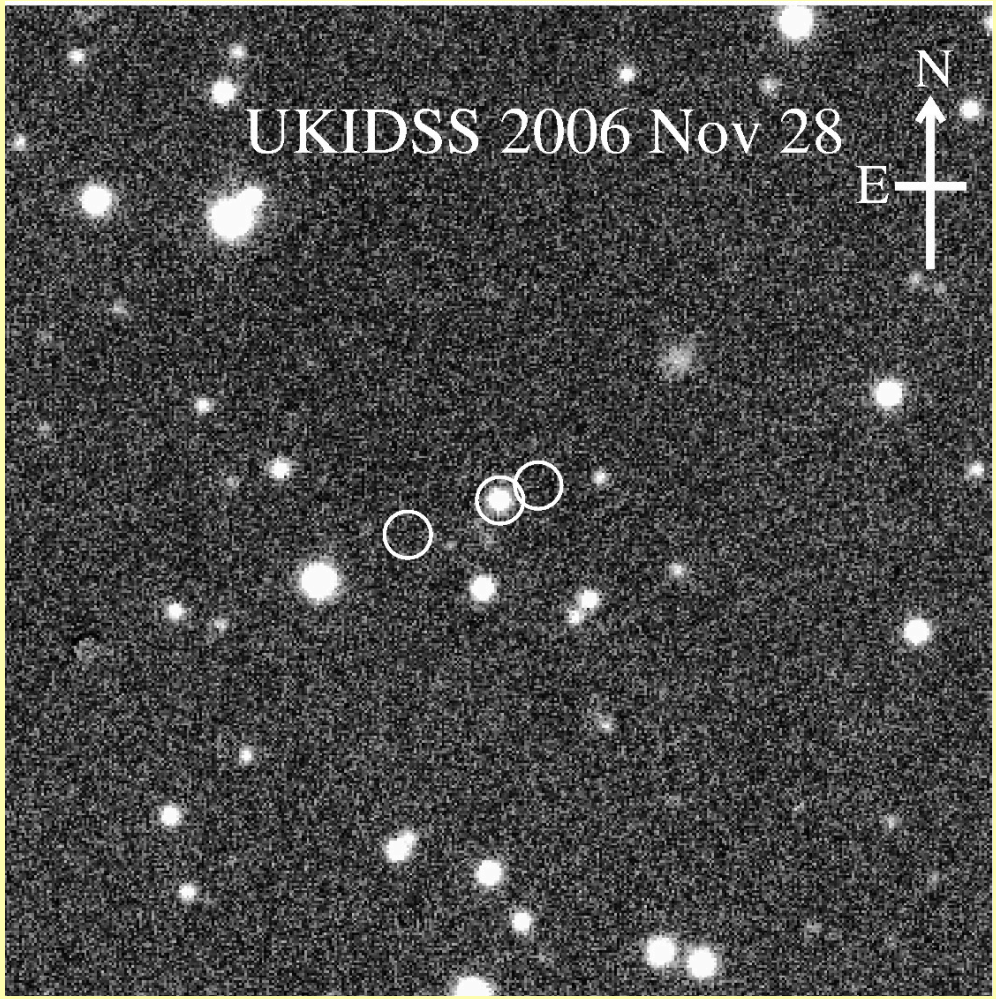
- Searched the gpsSource table in UKIDSS DR6 at longitudes l=60-230° (134 million primary sources in ~400 deg^2 of sky).
- Selected sources with J-H < -0.2 and H-K < -0.1 and uncertainties <0.3 mag in these colours.

- Then use quality flags:
  - ppErrbits<256 at JHK (photometric quality flag)
  - pstar > 0.9 (point source image profile required)
  - ellipticity < 0.3 at JHK
  - Coordinate shifts between passbands <0.3 arcsec

- Result: 6 candidates in the catalogue.
- Inspecting the image ruled out 4 of these (blends or bad pixels).
- One of the remaining 2 was in USNO B1.0 (a white dwarf candidate).
- That left only UGPS 0722-0540, a relatively bright source at J=16.5, which was immediately queued for Gemini/NIRI spectroscopy.

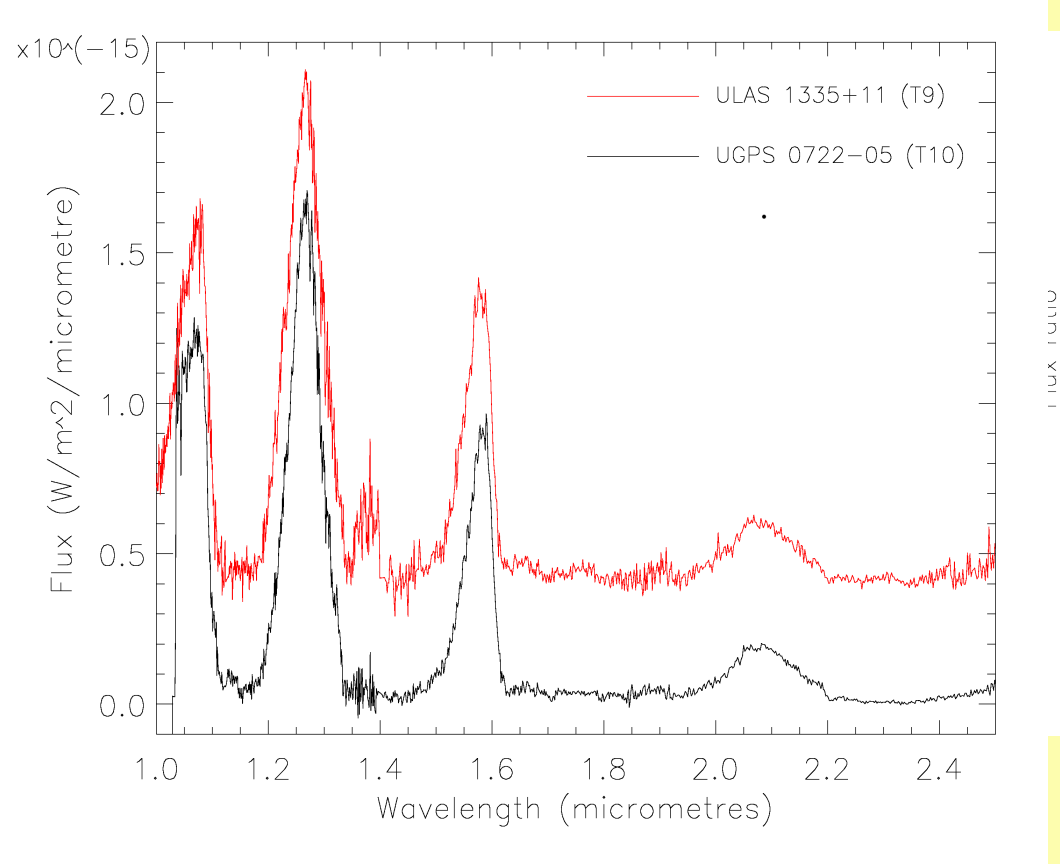
UGPS0722-0540 discovery image

- White circles show the ~11 arcsec motion over 11 years.
- First epoch is from an uncatalogued noise feature in 2MASS.

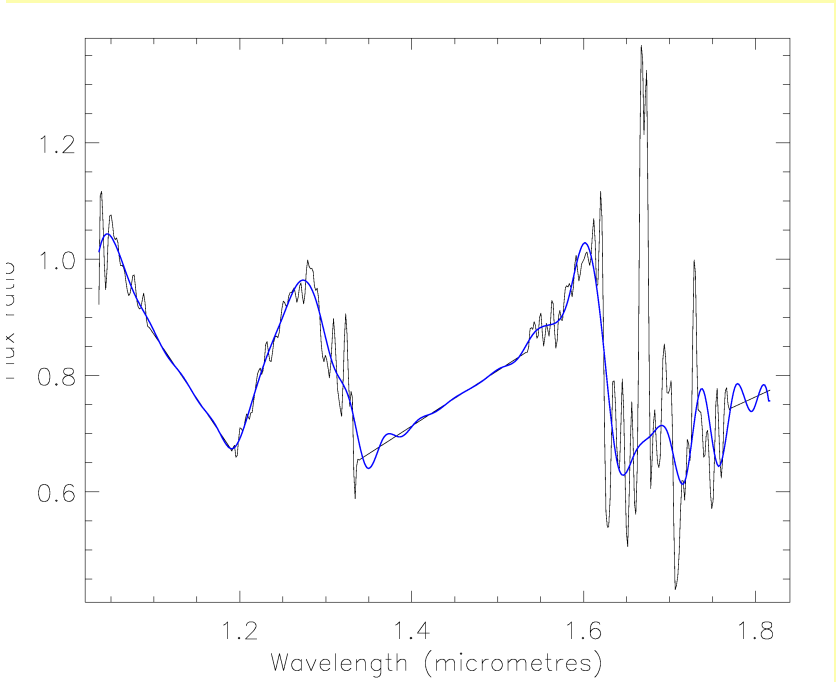


Spectrum: T10 classification

1 to 2.5 micron spectrum



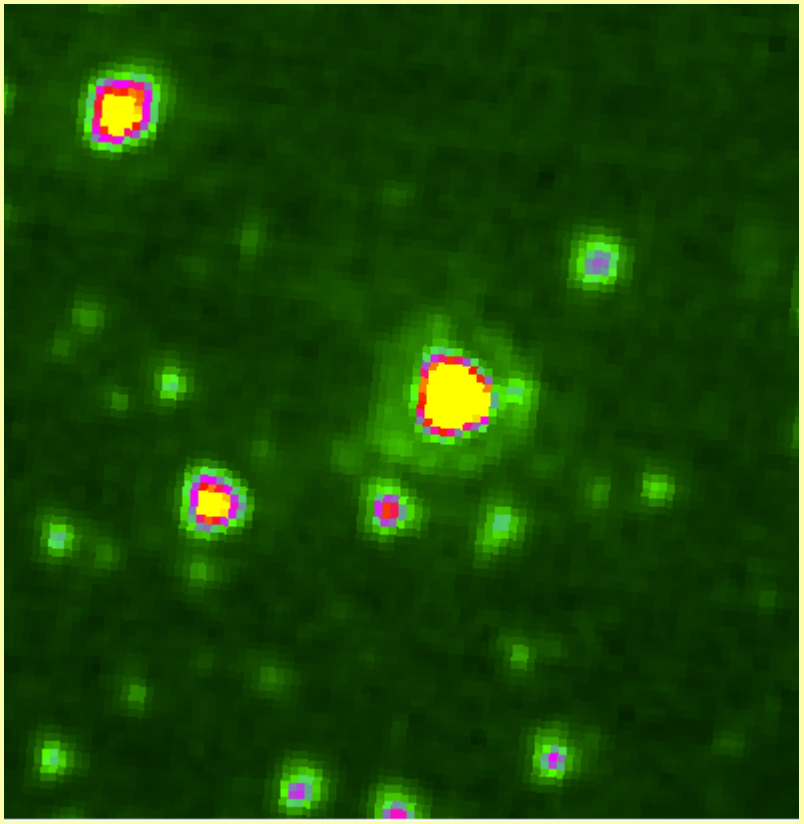
Ratio spectrum: T10/(T9 average)



~80% of the flux is emitted at $\lambda > 3$ μm.

JHK image

4.5 um IRAC



UGPS 0722-0540 … and two more

Parallax measurement gives d ≈ 4.1 pc – the closest isolated brown dwarf.

Derived T_{eff} = 520 ± 40 K for UGPS 0722-0540.

Saumon & Marley 2008 model isochrones then suggest M = 5 – 15 M_{jup},
age = 0.2 - 2Gyr, log(g)=4.0 – 4.5.

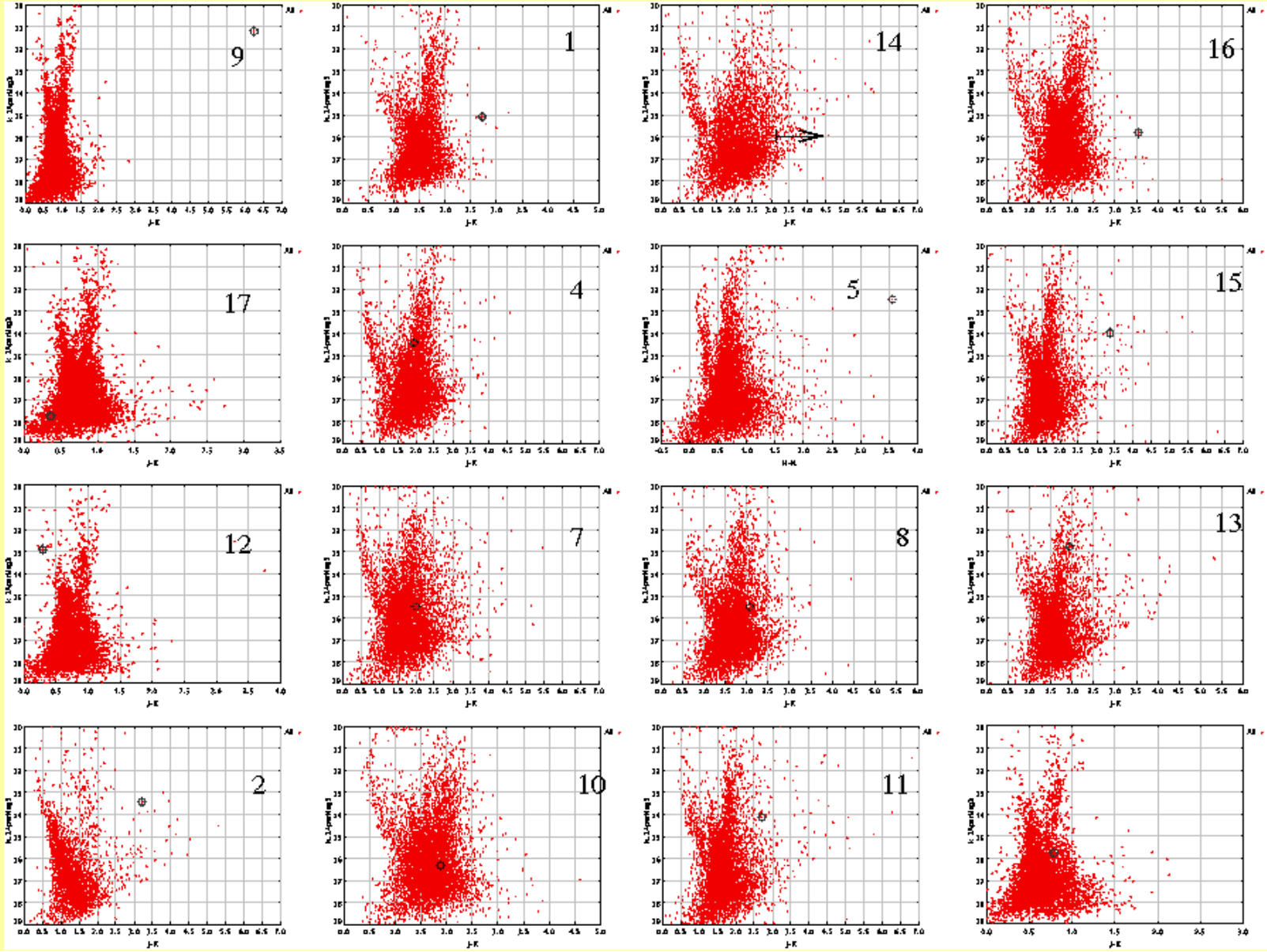
Another young, very low mass UKIDSS late T dwarf, bordering on the planetary mass regime, see **Lucas et al.2010, MNRAS 408, L56**

Two more GPS T dwarfs found recently (Burningham et al.2011, MNRAS 414, L90)

UGPS 0521+3640: a T8.5 dwarf at 7-9 pc, T_{eff} = 600-650 K

UGPS 0652+0324: a T5.5 dwarf at 28-37 pc, T_{eff} ~ 1000 K

Variable stars in the GPS



Future Plans

- UKIDSS will continue in 2013, finishing the GPS JHK survey and doing more of the K band 2nd epoch imaging.
- Proper motion catalogues: GPS^2, GPS-2MASS, GPS-IPHAS.
- Future final data release
  - Improved rejection of occasional fields with e.g. cross-talk artifacts or bad astrometry.
  - Do PSF photometry.
- Create merged optical/near IR/mid IR Galactic database at Herts for GPS, IPHAS, VVV, VPHAS+, OGLE-4, GLIMPSE360 etc.