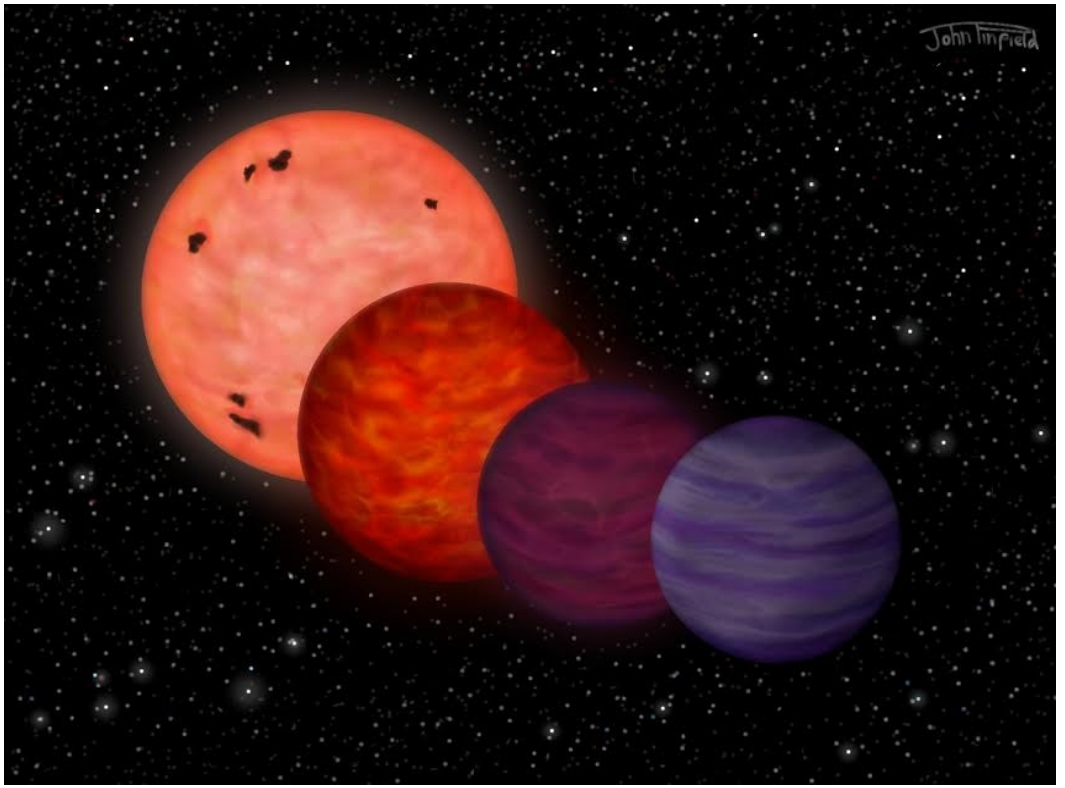
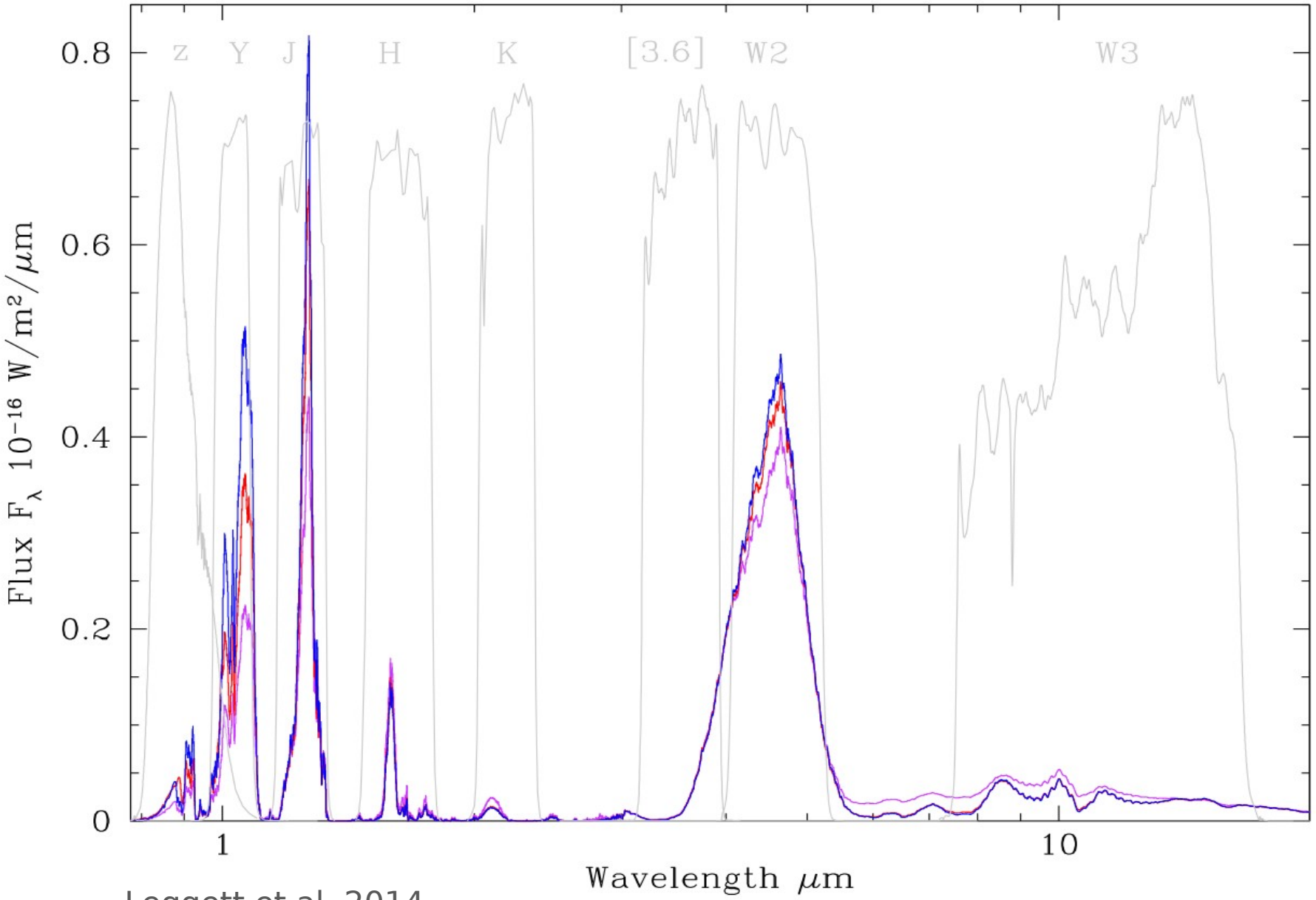
Mariusz Gromadzki

A deep search for very late type objects



Collaboration: D. Pinfield, S. Leggett, M. T. Ruiz, R. Kurtev, N. Lodieu, A. Day-Jones, J. Gomes, and others.

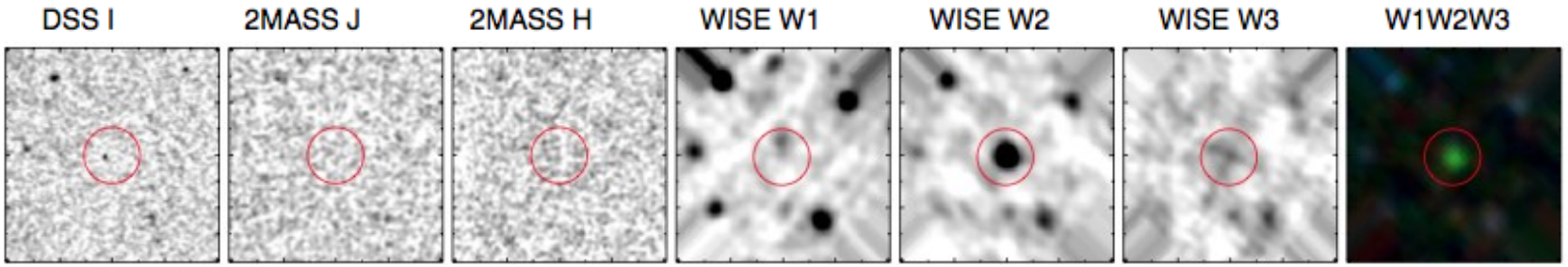
How to find really cool object ?



Leggett et al. 2014

WISE and Y dwarfs

- Cool dwarf (>T8) show temperatures ;
  T8~750 K, T8.5~600K, T9~500 K , Y0~400K
- Record holder is WISE0855 with ~250 K
- 20 Y dwarfs was discovered on WISE W2 images.
- 19 has W2>15.2 and one W2=15.6
- 21st Y dwarf was found by Spitzer (companion to WD)



Cushing et al. 2011

Selection criteria

6067 sources

1. Select W2 detections with S/N ≥ 10. In WISE this corresponds to W2 = [15 – 15.7]. Taking into account Y colours:

4673 sources

$$W1 - W2 > 3.9$$
$$W2 - W3 = [1.7\text{-}2.6]$$
$$W2 - W4 \geq 5$$

it means we do not expect detections, at a level of 2σ, in the W1,W3 and W4 bands.

3263 sources

2. No 2MASS source within 3 arcseconds of WISE source

904 sources

3. Measured in at least 8 individual exposures

4. Removed sources towards redenned regions of sky

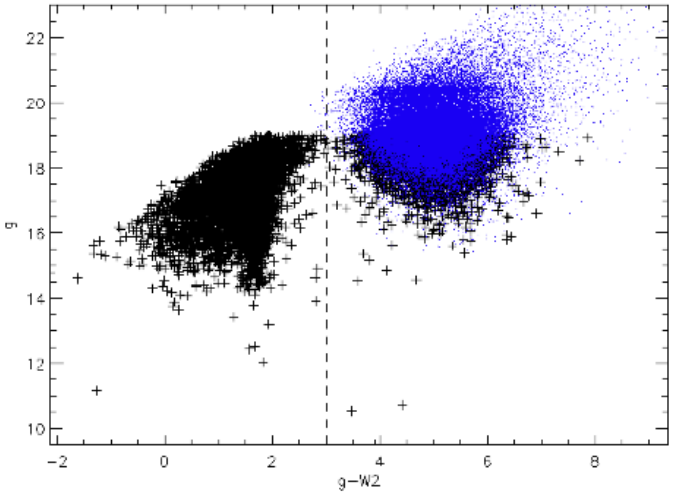
52 sources

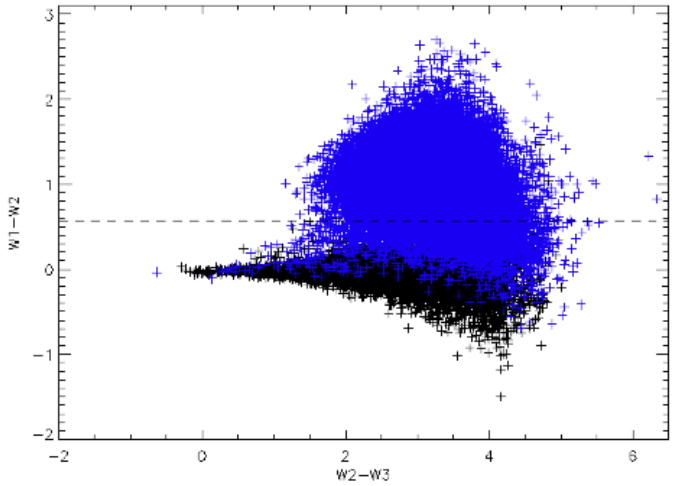
Control sample

Control sample of isolated, point-like, non-variable and non-moving sources.

Combination of SDSS and WISE:

- Avoided galactic latitudes
- g < 20
- g – r < 0.3
- proper motions > 20 mas yr^{-1}
- cross-match with 1 arcsecond to avoid mis-matches
- avoid quasars with colour cuts



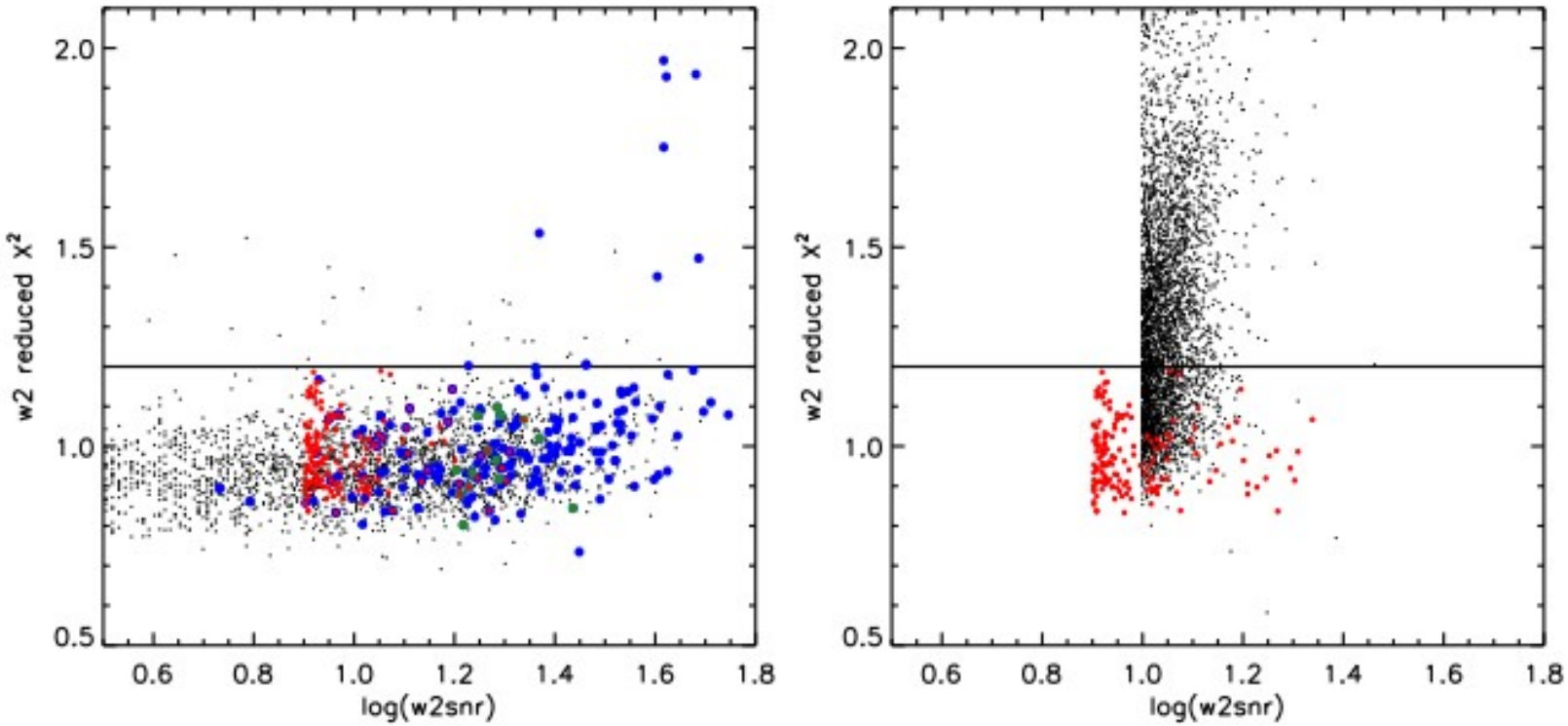


Wu et al. 2012

Rejection method 1

1 – Profile fit photometry rejection method

Assess how point-like each source is.



6067 sources

4673 sources

3263 sources

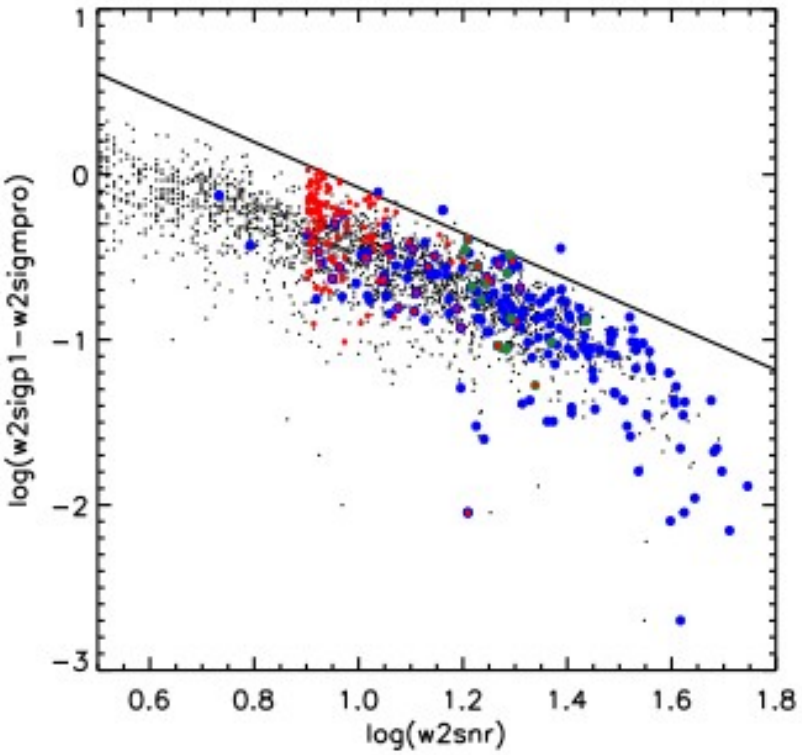
904 sources

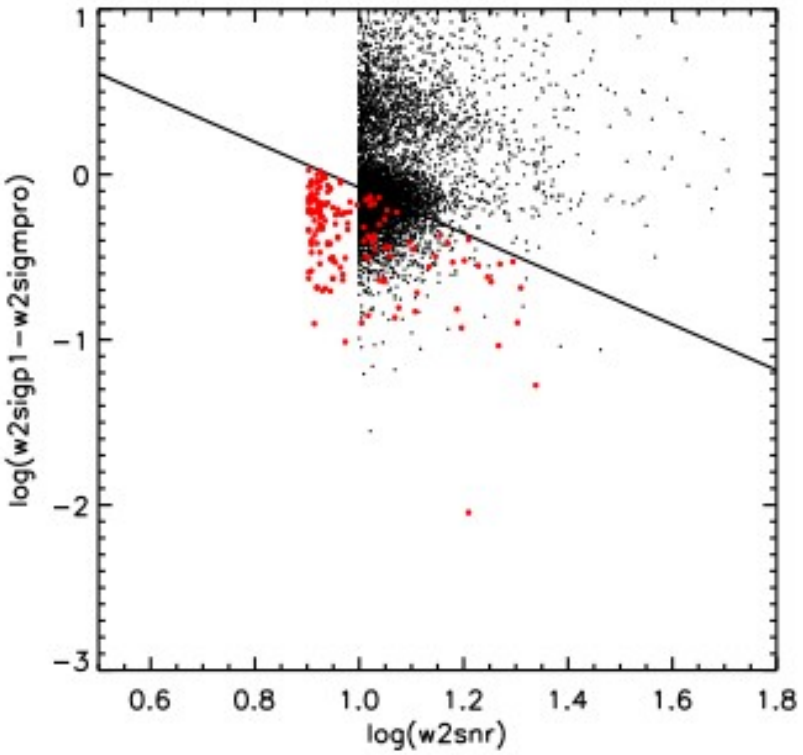
52 sources

Rejection method 2

2 –Photometric uncertainty rejection method

Compares the integrated flux uncertainty (w2sigmpro) with the standard deviation of W2 fluxes from the individual exposures (w2sip1)





6067 sources

4673 sources

3263 sources

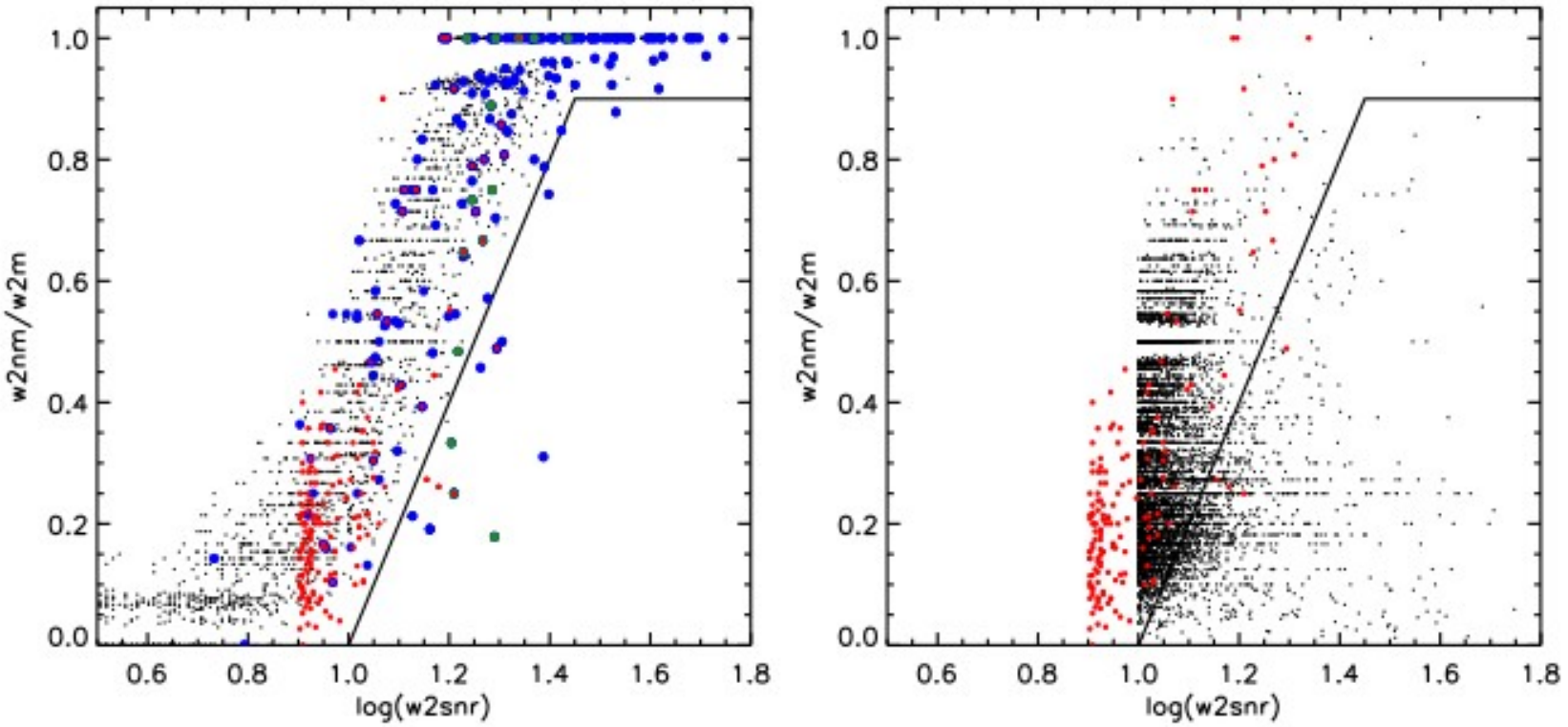
904 sources

52 sources

Rejection method 3

3 – Detection number rejection method

Fraction of individual W2 frames in which the source is detected



6067 sources

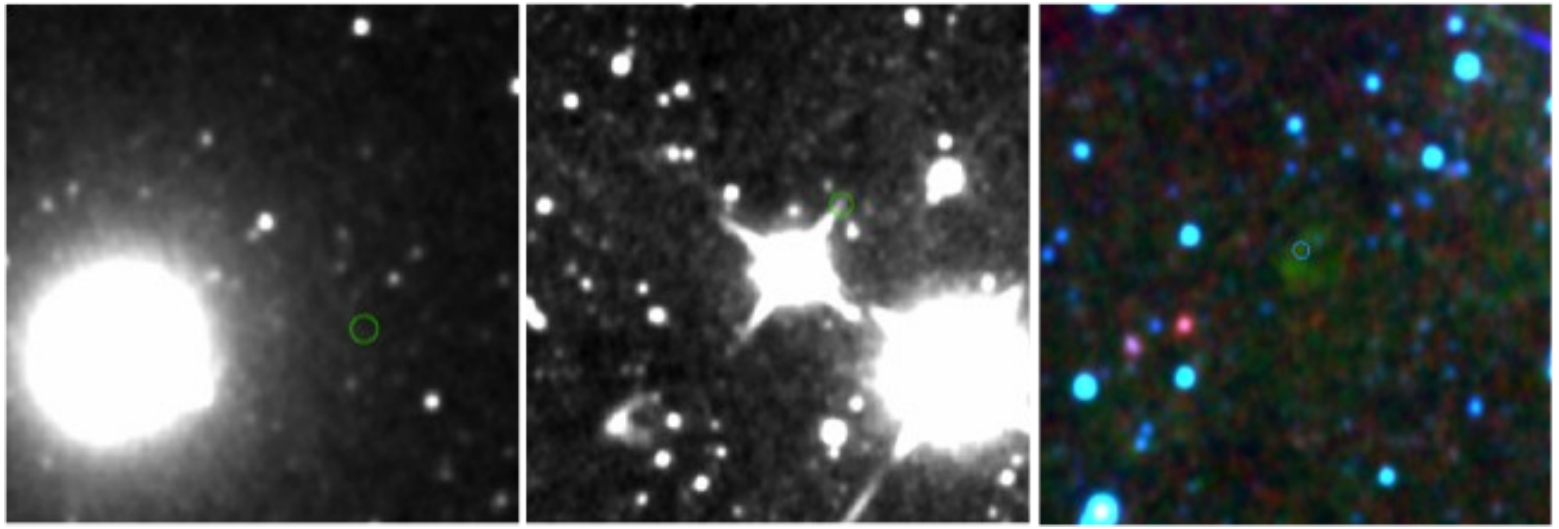
4673 sources

3263 sources

904 sources

52 sources

Visual inspection



6067 sources

4673 sources

3263 sources

Excluded:
• artefacts (such as diffraction spikes, optical ghosts, glints, halo associations)
• blended sources
• extended structures (galaxies, nebulae)

904 sources

52 sources

Extended sample

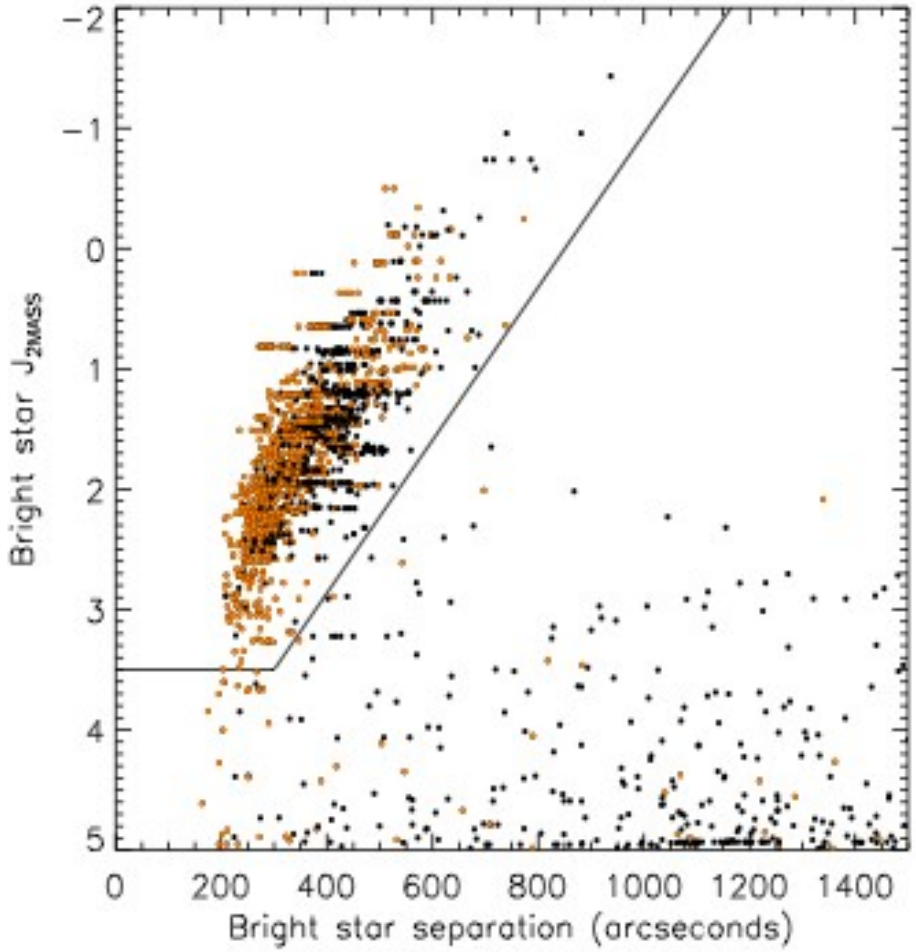
Extended the analysis to S/N = [8 – 10]

After applying rejection methods – 3252 sou

Compare the separation of the sources with the proximity to a 2MASS bright source – most of the sources are halo associations.

S/N > 10 = 52
S/N = [8-10] = 106

Total = 158 candidates

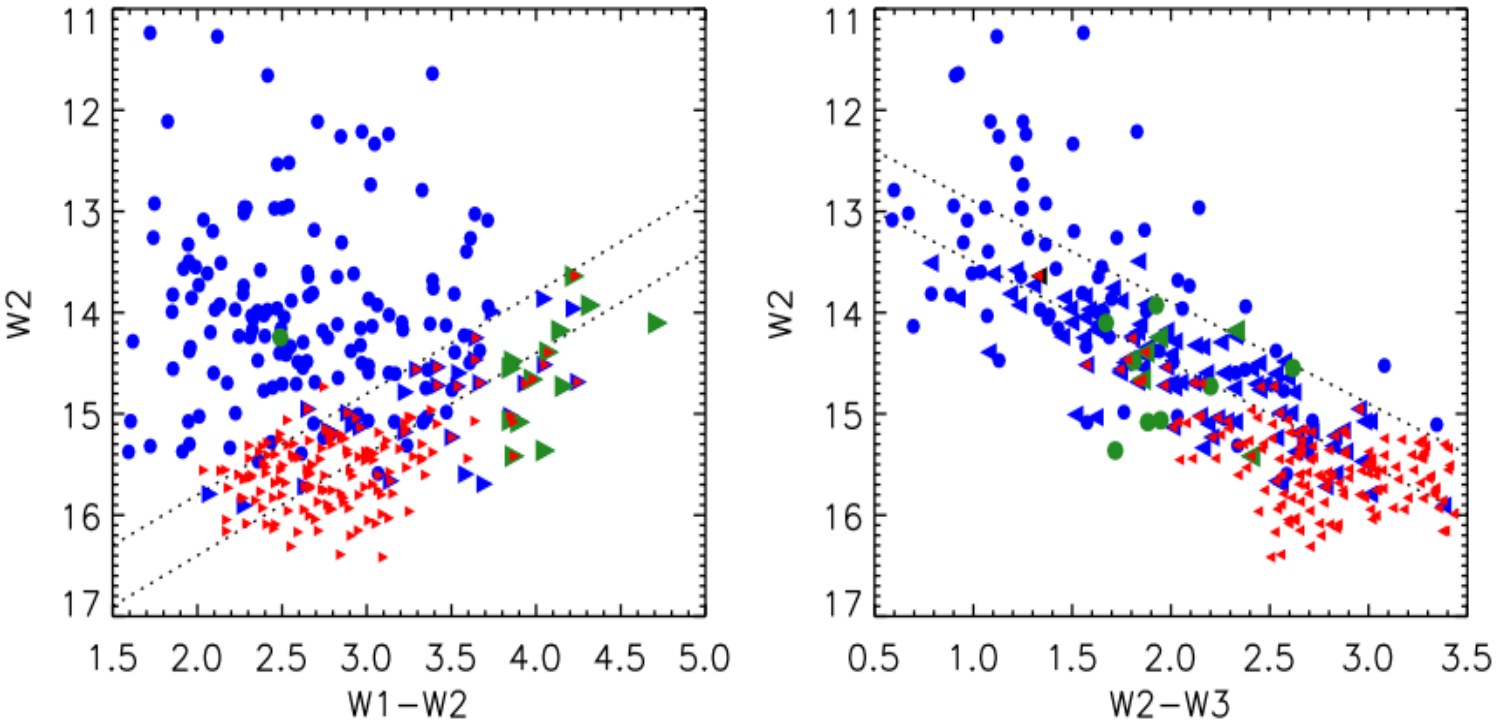


Extended sample

S/N > 10 - 29 out of 52 candidates in Kirkpatrick et al 2012

S/N = [8-10] - only 8 out of 106 in Kirkpatrick et al 2012

Difference comes from the criterion that defines the minimum number of individual exposures where the source should be detected.



Follow-up observations

We have used multiple facilities in our ongoing follow-up campaign.

•UKIDSS/UHS and VISTA surveys

- J,J2,J3-band at FourStar, Magellan telescope
- J,H-bands at NIRI, FLAMINGOS-2, Gemini
- J-band at NICS, TNG telescope
- J-band SofI, NTT
- J-band at HAWK-I, VLT

- Low-RES spectroscopy, with FIRE, Magellan telescope
- Low-RES spectroscopy, with Flamingos-2, GNIRS, Gemini

- Mid-IR obtained at the Spitzer, [3.6] and [4.5] bands

Conclusion

• We developed a new method to identify late T and Y dwarfs in the WISE database.

• Identified 158 candidates, with 90% falling outside the K12 criteria in the lowest S/N sample

• We got data for 78 objects.

• Discovery of 5 new T8-9 (3 of them show thick disk/halo kinematics)

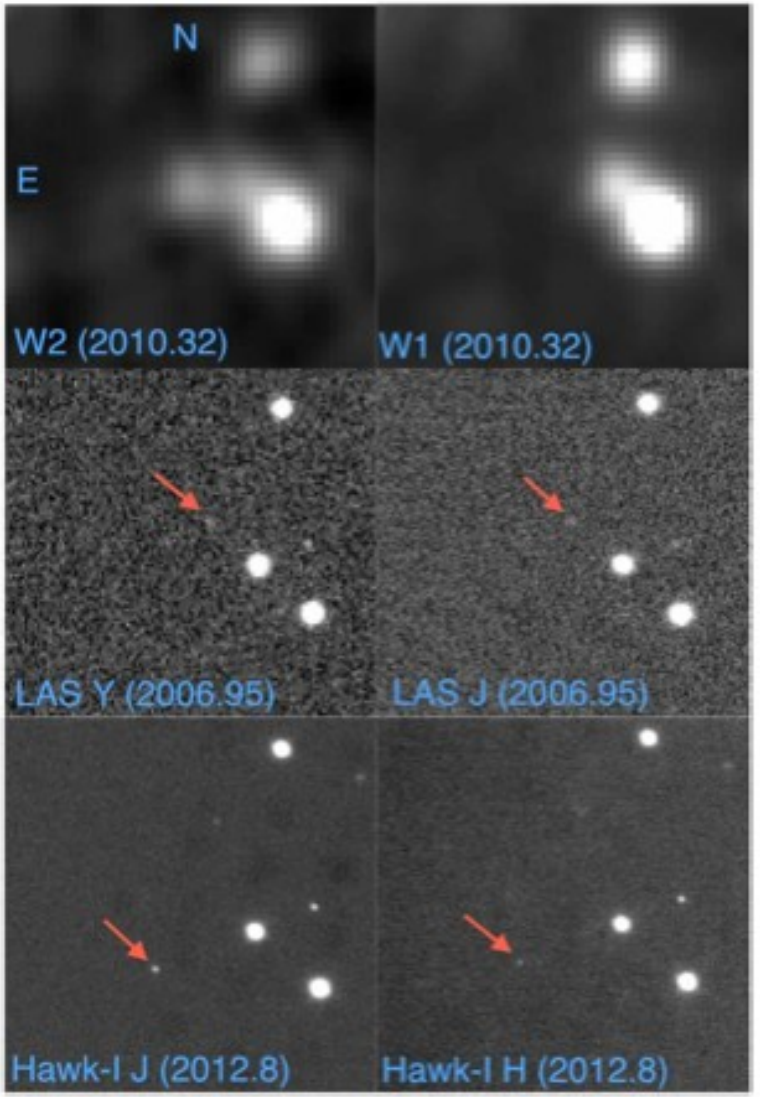
• Discovery of one new Y0p dwarf

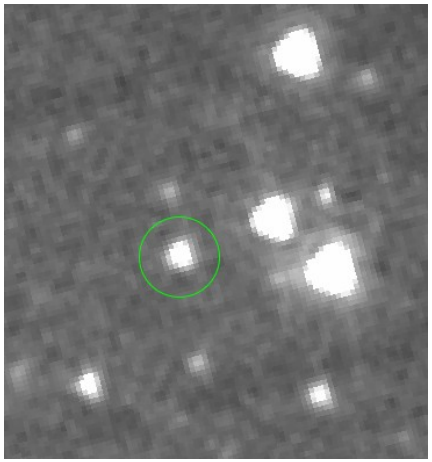
WISE 0833+0052

The brightest new object in the sample with W2 = 14.96

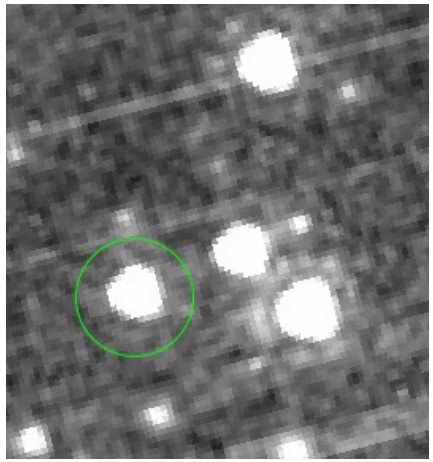
Proper motion estimated with different combinations of epochs. Final result obtained with UKIDSS and HAWK-I images.

p.m. = 1.89 ± 0.04 arcsec yr^{-1}



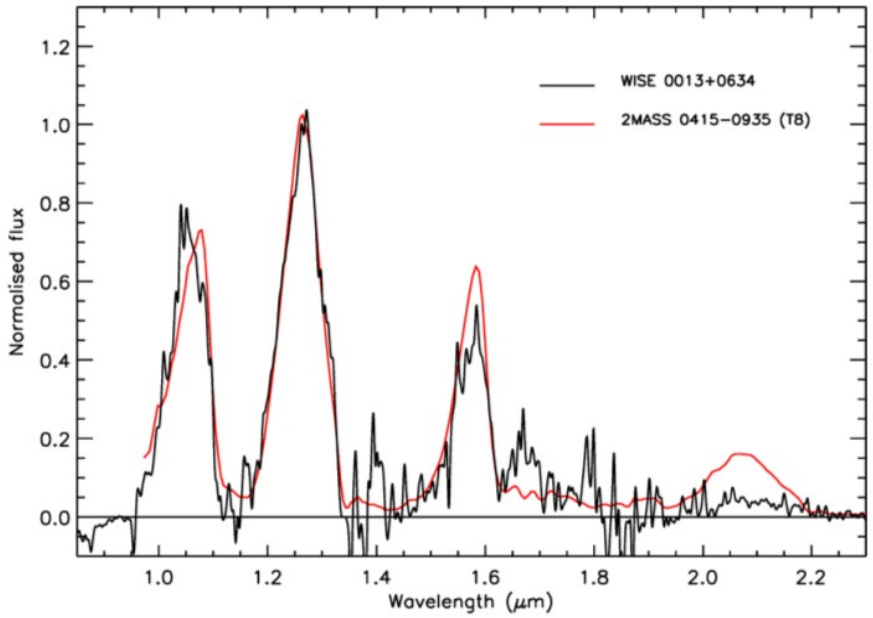


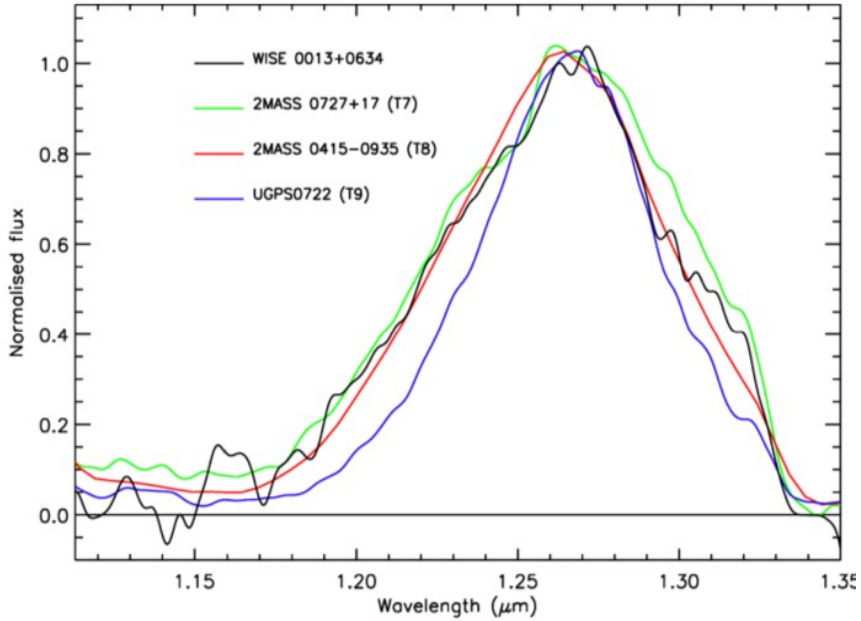
Spitzer ch1 (2013.1)

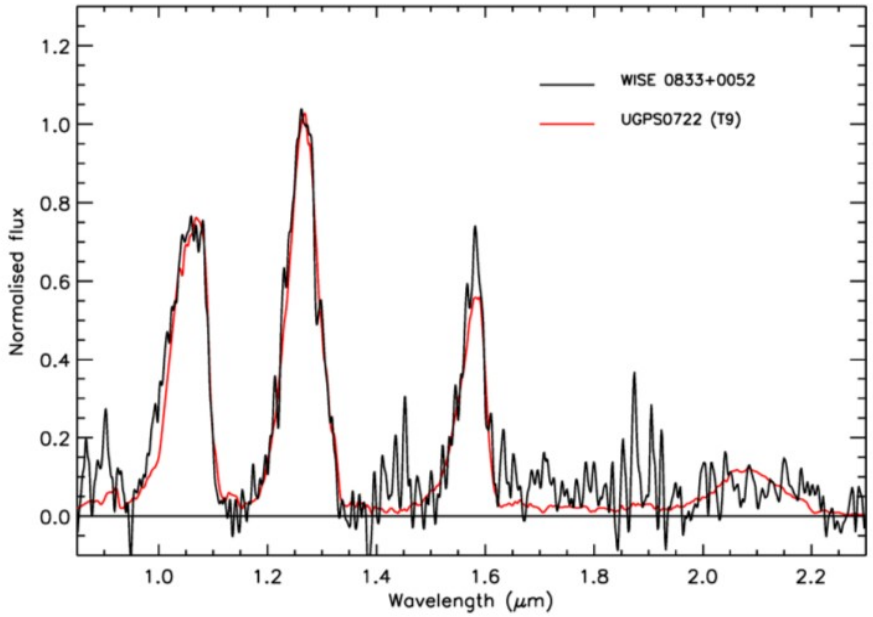


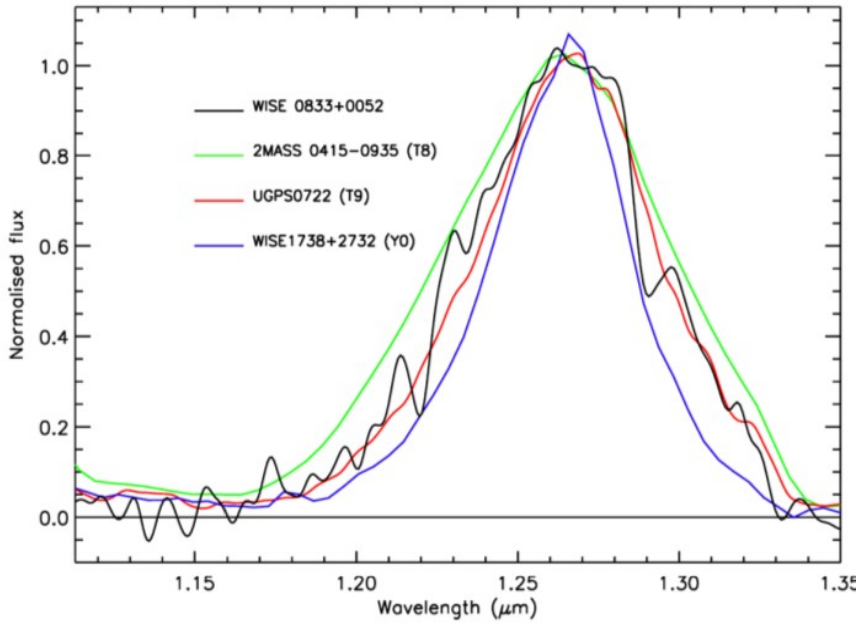
Spitzer ch2 (2013.1)

WISE 0013+0634 and WISE 0833+0052









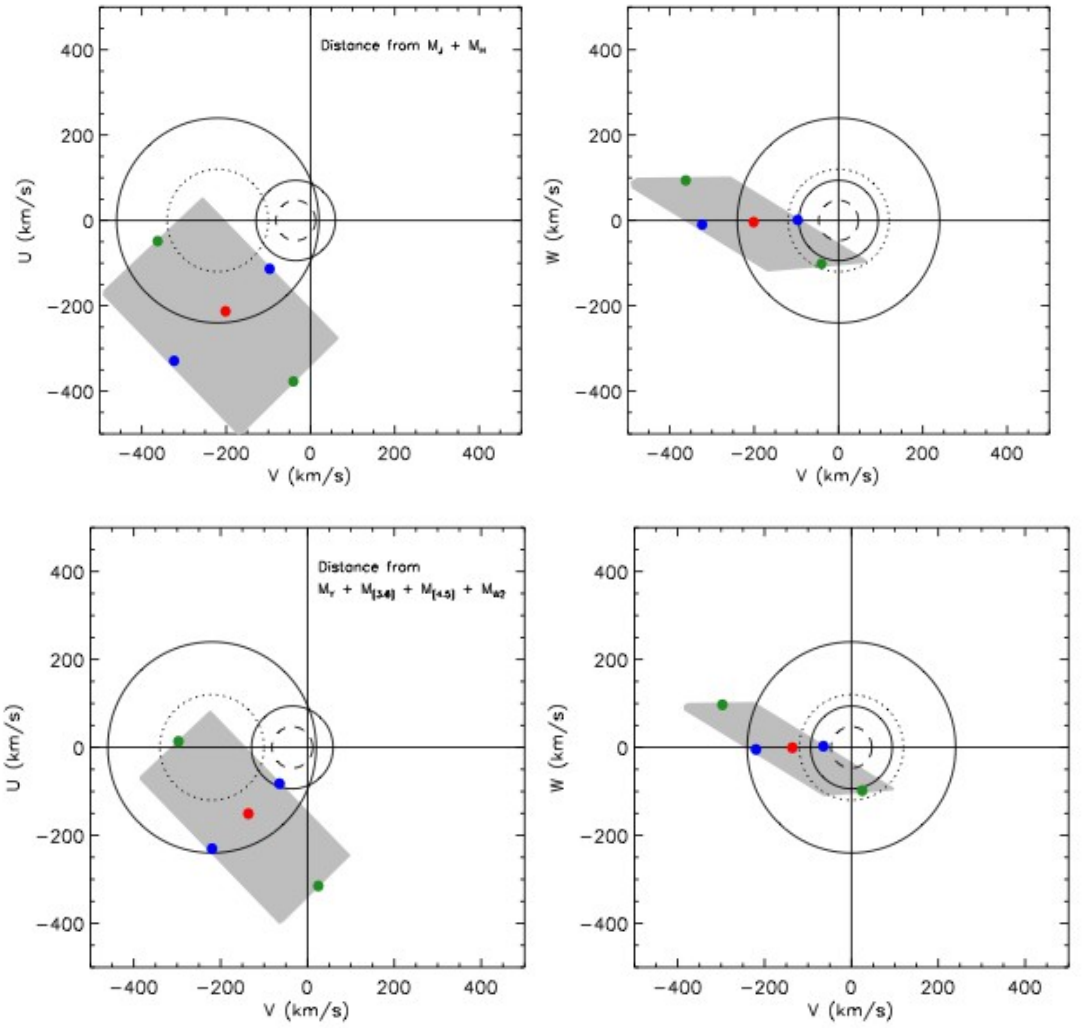
Kinematics

Distances estimated with the relations between absolute magnitude and spectral type considering single object and binarity.

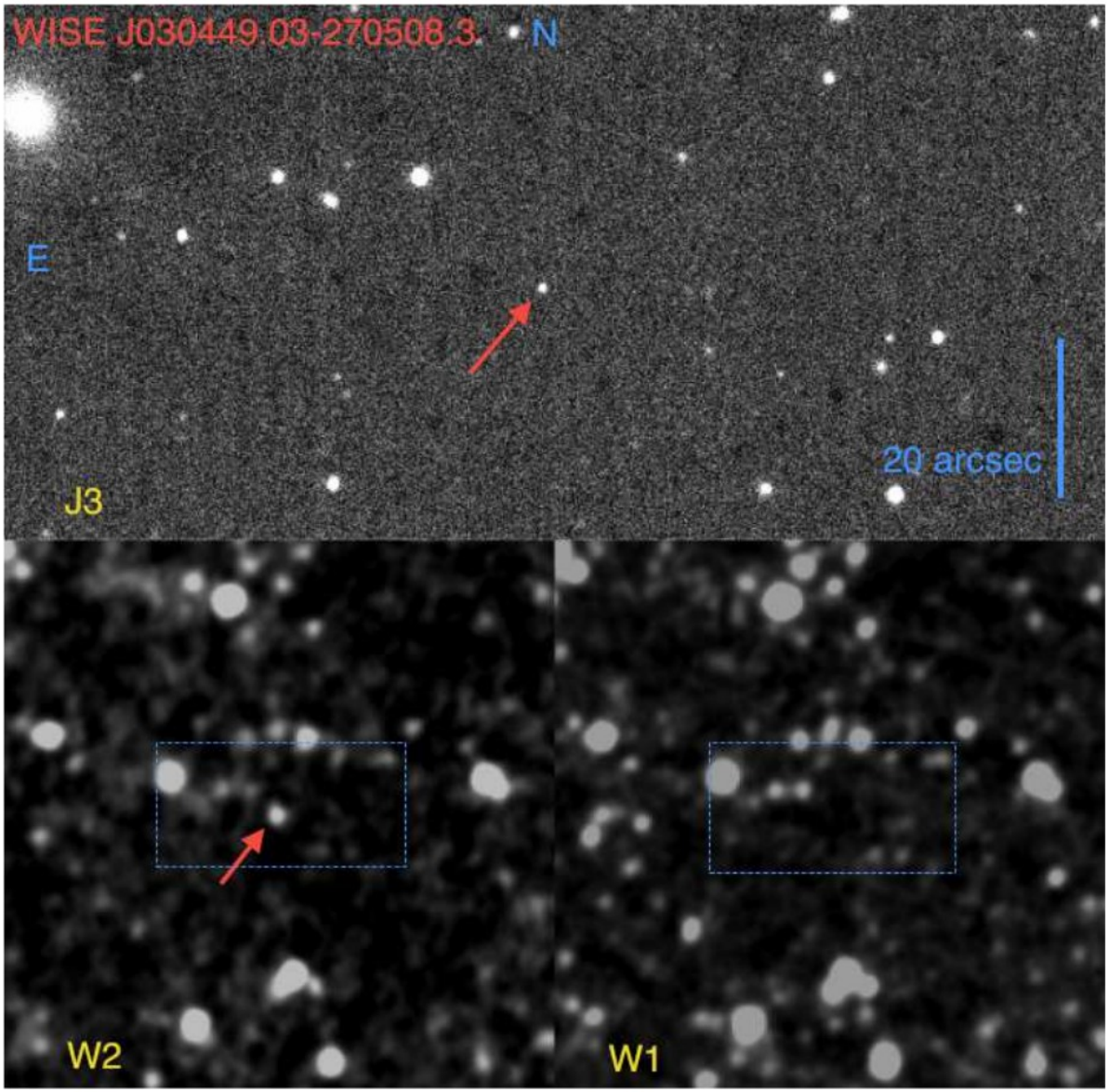
J + H band distances – 17-52 pc

Y + mid-IR distances 13-23 pc

Space motion suggesting it's a thick disk/halo candidate.



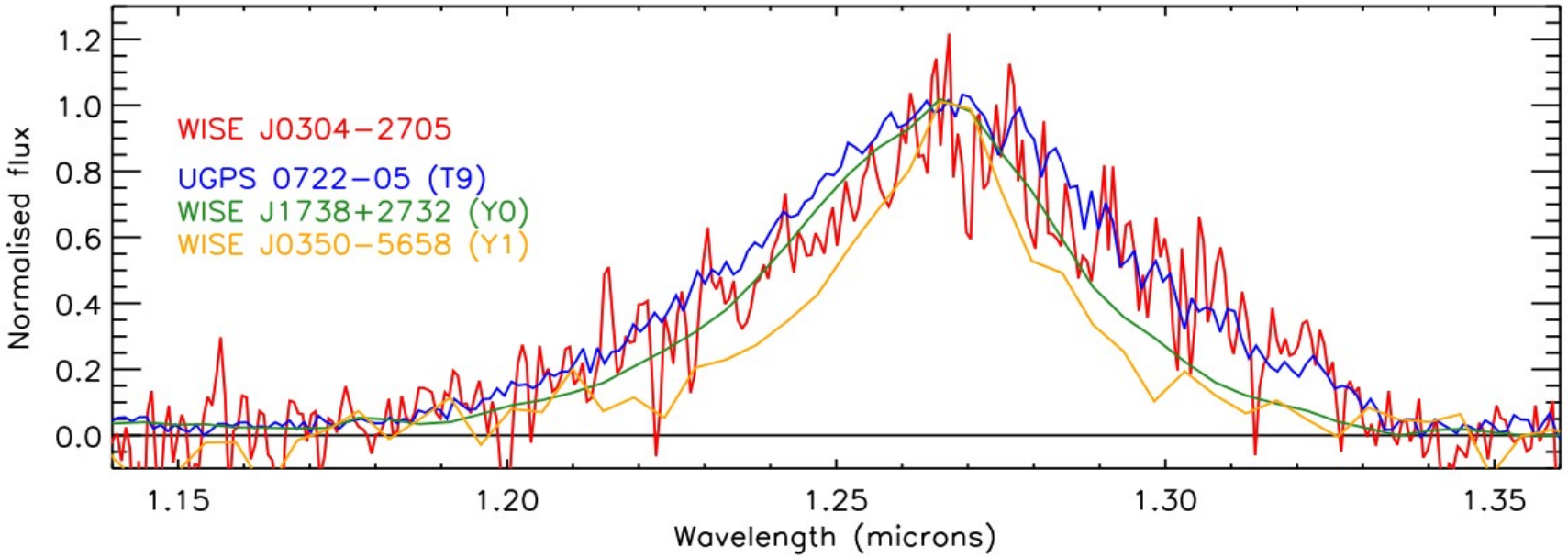
WISE 0304-2705

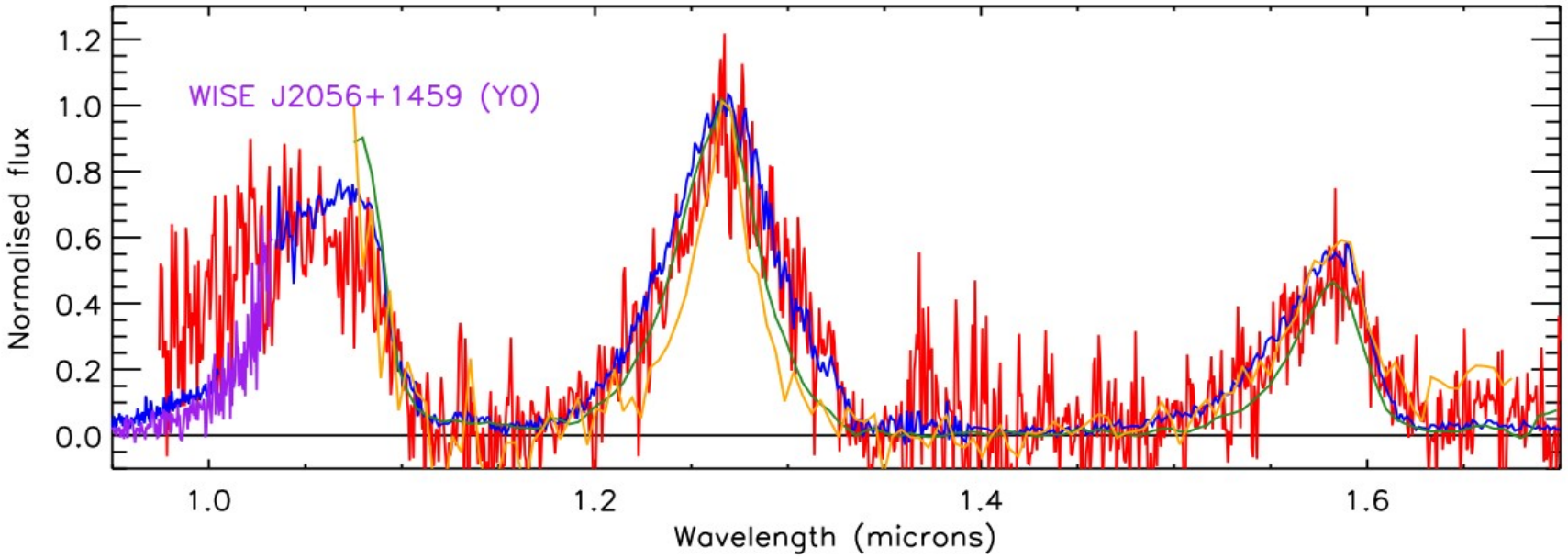


The faintest Y dwarf in W2 = 15.6

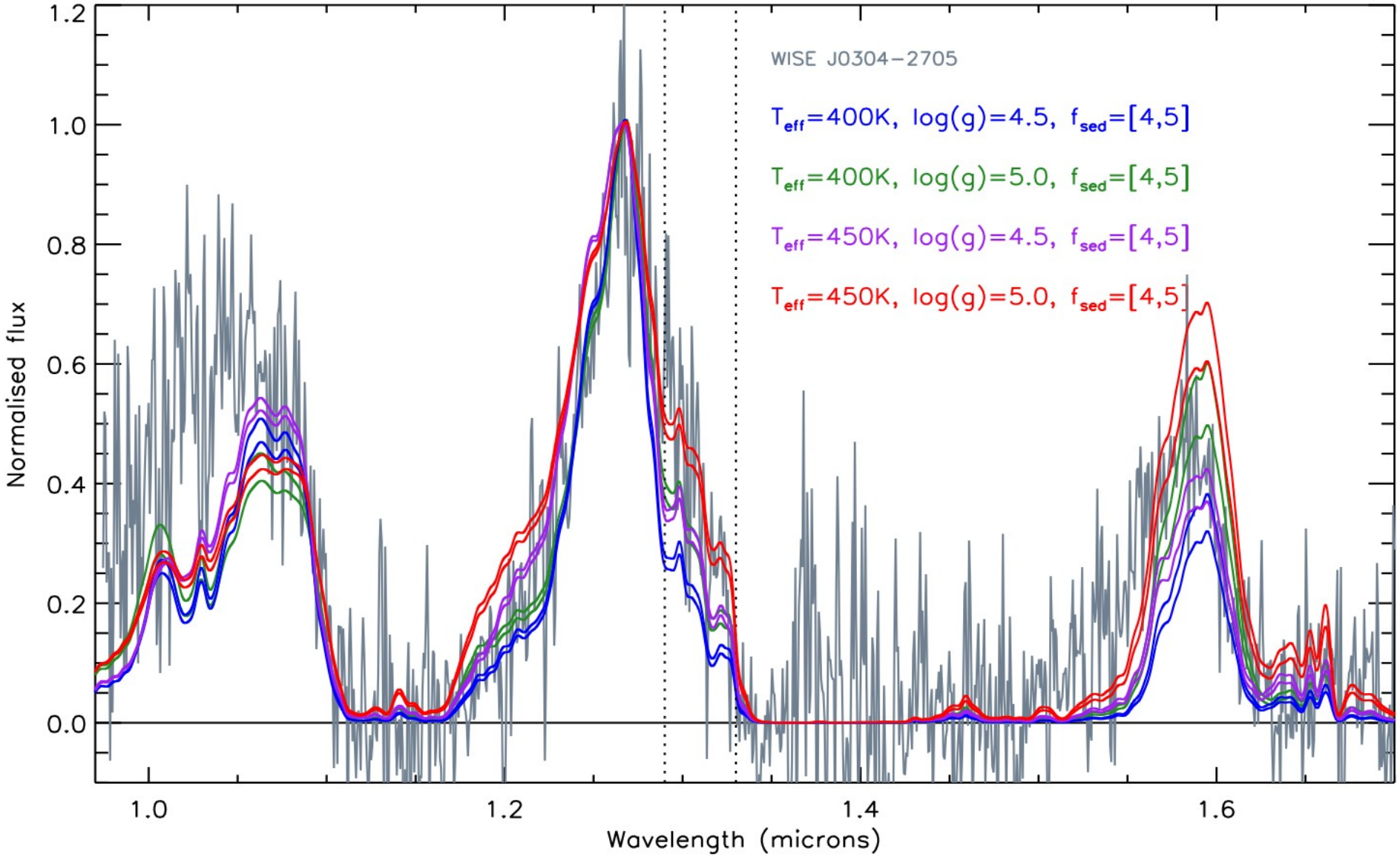
p.m. = 0.65 ± 0.14 arcsec yr^{-1}

WISE 0304-2705

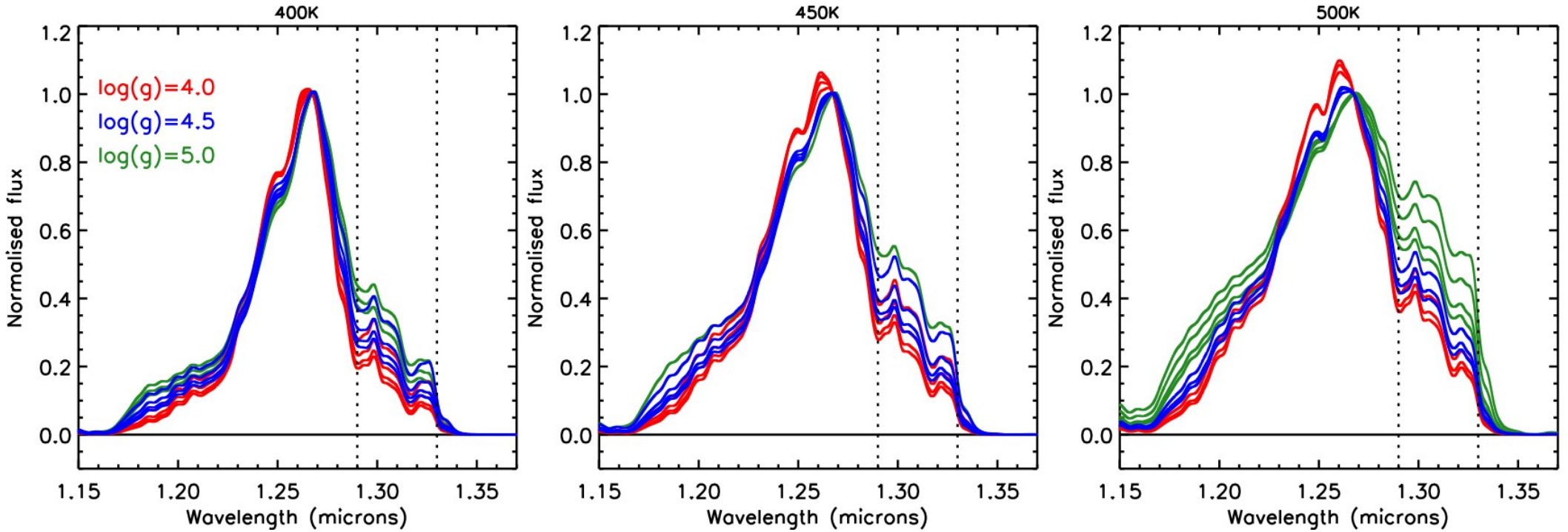




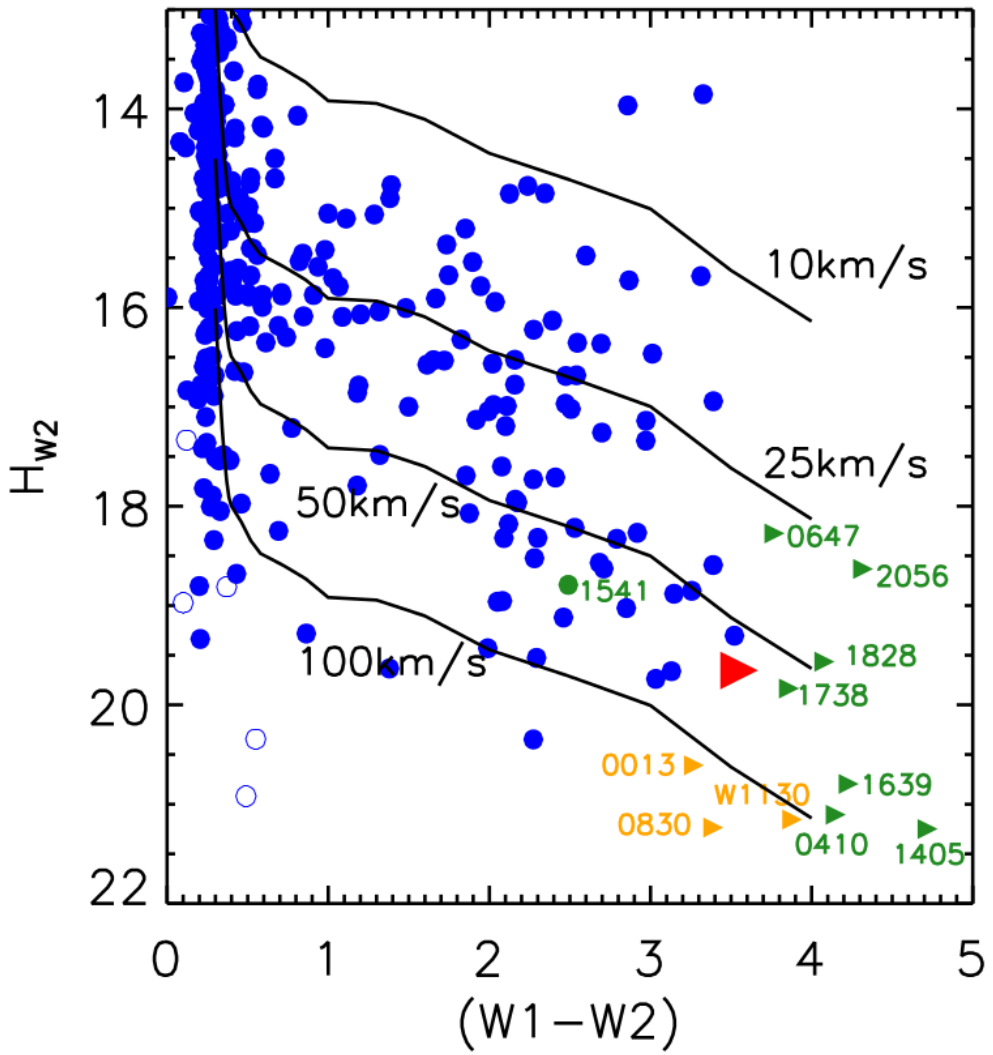
WISE 0304-2705

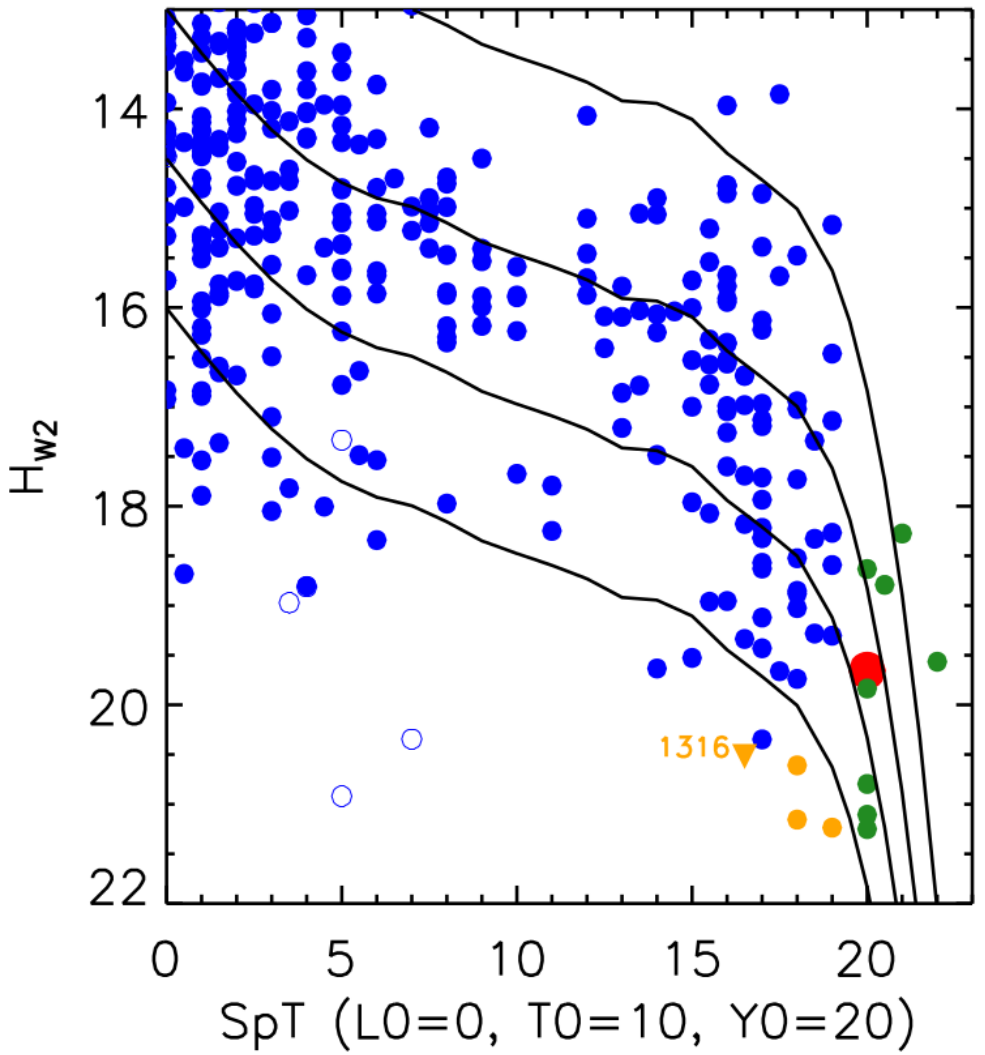


Models

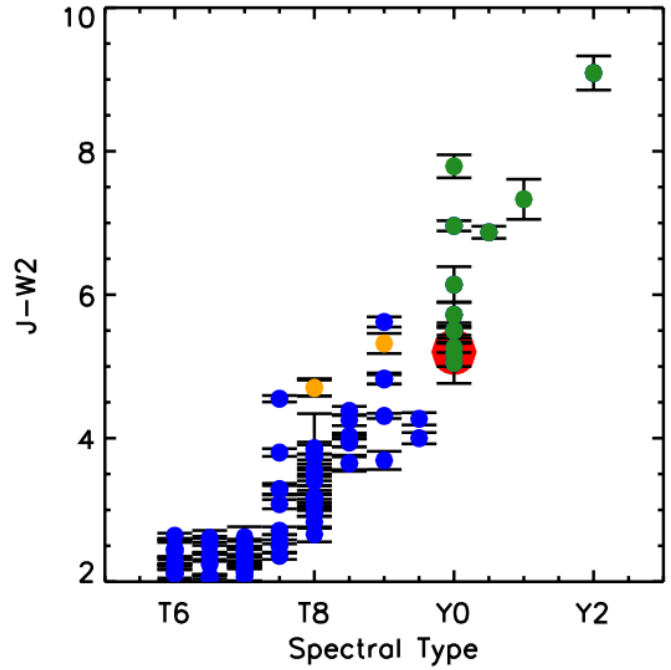

400K
450K
500K
log(g)=4.0
log(g)=4.5
log(g)=5.0
Normalised flux
Wavelength (microns)
1.15
1.20
1.25
1.30
1.35
0.0
0.2
0.4
0.6
0.8
1.0
1.2

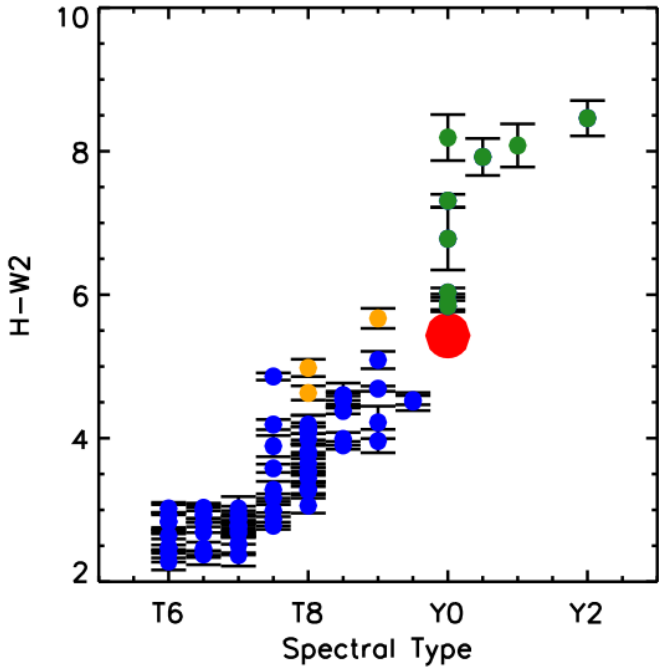
Reduce pm diagram

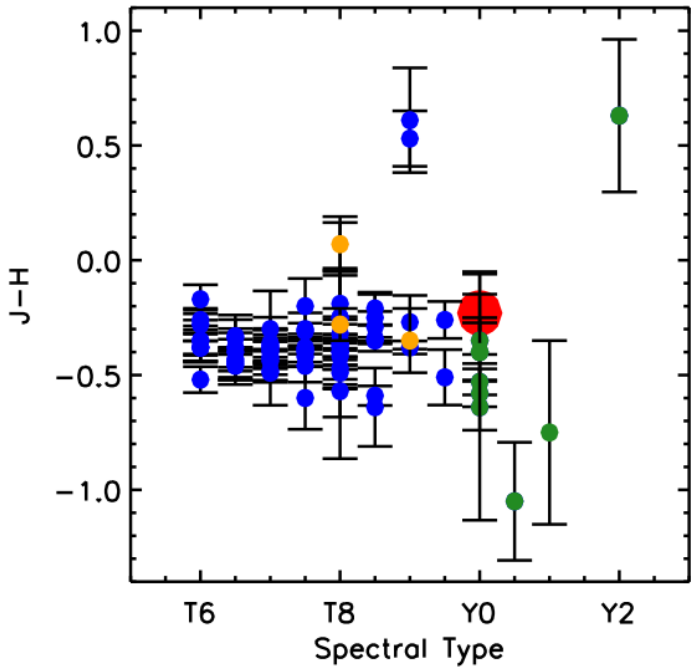




Colours


J−W2
10
8
6
4
2
T6
T8
Y0
Y2
Spectral Type


H−W2
10
8
6
4
2
T6
T8
Y0
Y2
Spectral Type


J−H
1.0
0.5
0.0
−0.5
−1.0
T6
T8
Y0
Y2
Spectral Type

Feature works

- Obtain spectra of other candidates

- Obtain parallaxes measurements for our candidates in order to put better constraints on distance.

- Spitzer observations of candidates not detected on deep J-band images.

- Construct new sample base on AllWISE.