

A 2 EPOCH PROPER MOTION CATALOGUE FROM THE UKIDSS LARGE AREA SURVEY

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PROPER MOTION CATALOGUES

- LHS (Luyten, 1979a)
 - 4470 sources
 - Proper motion greater than 240mas/yr
- NLTT (Luyten, 1979b)
 - 58,845 sources; Vmag limit ~18 (rNLTT)
 - Proper motion greater than 180mas/yr
- Hipparcos & Tycho (Perryman & ESA, 1997)
 - 118,218 & 1,058,332 sources respectively
 - Tycho 2 revision 99% complete to Vmag = 11 (Hog et al., 2000)
- USNO-B1.0 (Monet et al., 2003)
 - 1 Billion sources; Complete to approximately Vmag = 21
- LSPM
 - Largely complete in northern hemisphere; Vmag limit = 21
 - Low false detection contamination

PROPER MOTION CATALOGUES

- Pan STARRS
 - PS1 survey: 30000 square degrees of northern sky
 - High quality proper motions and parallaxes
- SuperCOSMOS Sky Survey (SSS)
 - SuperCOSMOS scanned Schmidt plates, 2 epochs of R band
 - Absolute proper motions with errors of $\sim 10 \text{ mas yr}^{-1}$ at $R \sim 18$
- GAIA
 - Very accurate astrometry, photometry, radial velocities
 - 2016

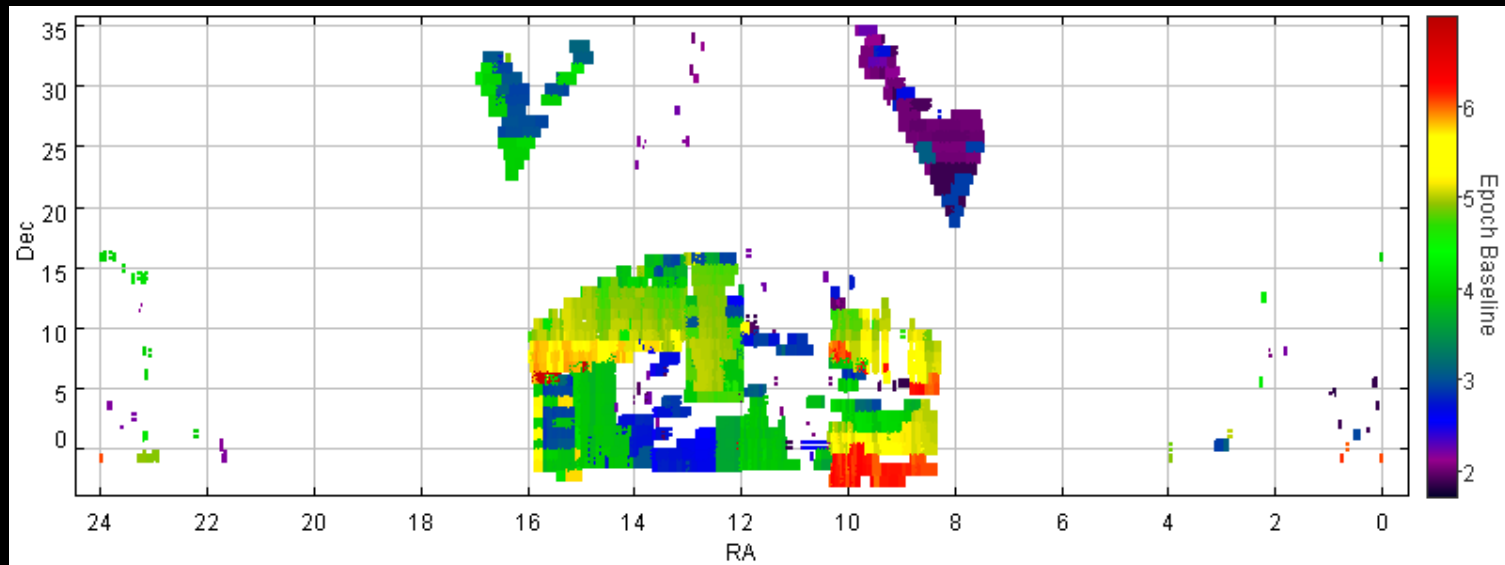
Some have IR components or IR photometry included but all are primarily optical.

MOTIVATION

- Identification of nearby objects
 - Census of objects in the solar neighbourhood.
 - Common proper motion companions
 - Companions to Hipparcos stars are benchmark objects with known age, metallicity, distance.
 - Test late T dwarf model ages
 - Models suggest the latest T dwarfs are old and low mass, population kinematics can be used to test this.
 - White dwarf discovery
 - Cool white dwarfs can exhibit relatively large space velocities and are needed to understand the dynamical evolution of the Galaxy.
 - Finding genuine members of nearby moving groups
 - Moving group members have well constrained ages and metallicities and provide benchmarks for testing of stellar models.
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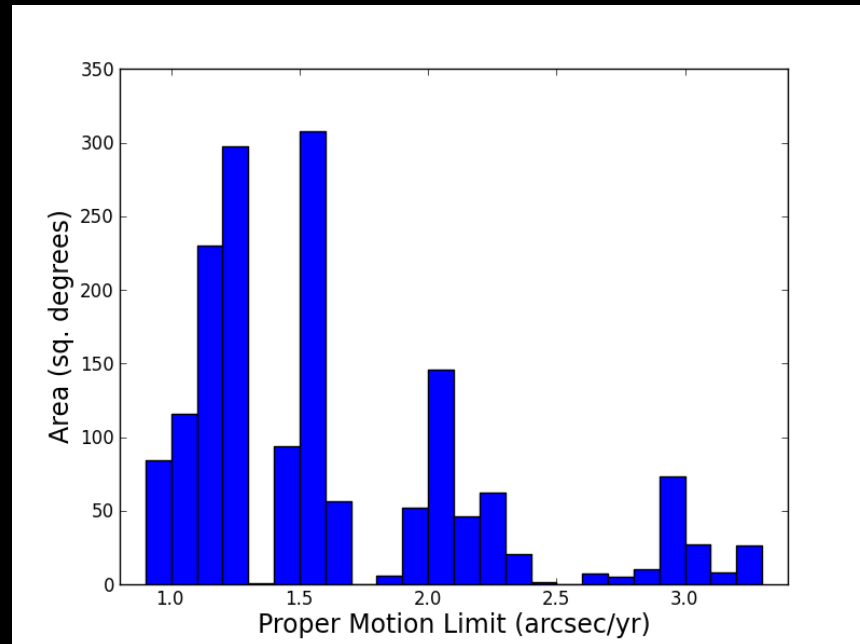
DATA SET

- LAS fits file data
- Matched using a 6" matching radius and a 0.5 J mag variability tolerance
- Approximately 1500 square degrees
- Epoch baselines 1.8 to 7 years
- Proper motion detection limit of 3.3 "/yr

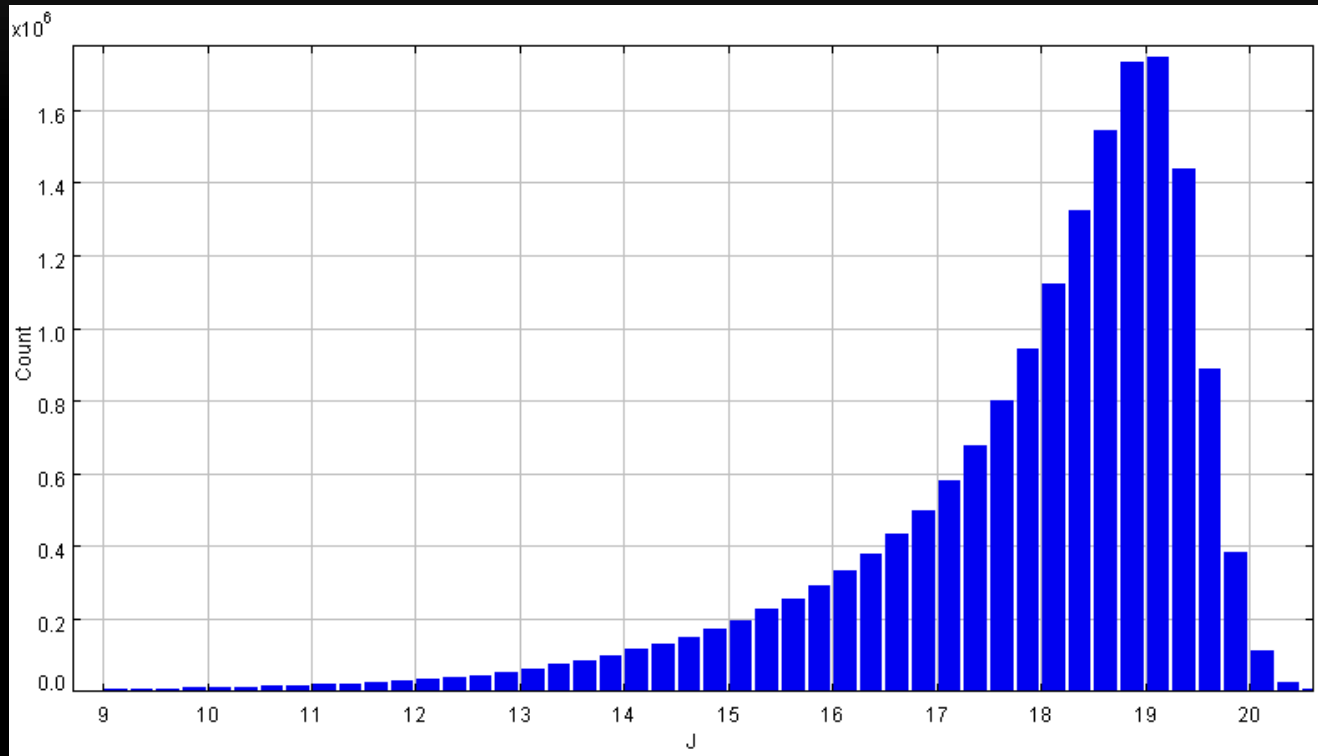


DATA SET

- 16,969,701 sources in 33,278 frames
- 6,997,165 sources classified as stellar at both epochs



DATA SET

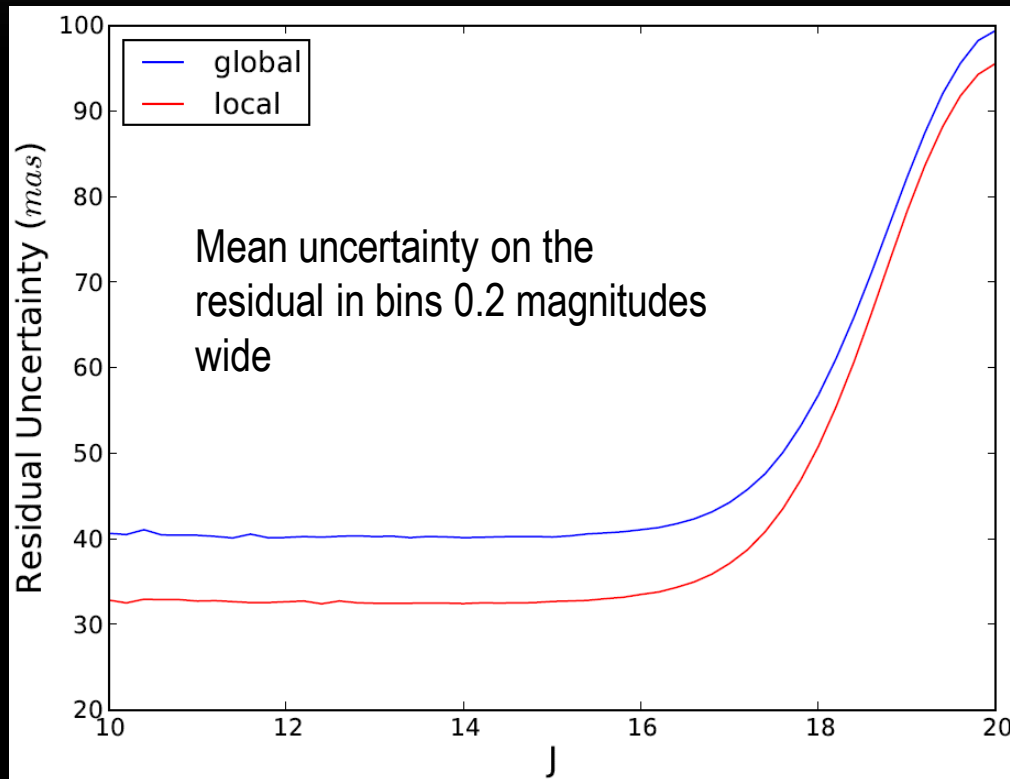


METHOD

- *On a frame by frame basis:*
- Selection of suitable reference stars based on photometry and preliminary astrometry
- `Global' 2nd order polynomial fits of second epoch reference star positions to first epoch reference star positions
- Apply transform to all second epoch positions and calculate positional differences
- Unique `local' 2nd order polynomial fit of selected nearby reference stars to first epoch positions
- Apply one of these local polynomials to each source (where possible...) and calculation of positional differences
- Median proper motion of suitable reference galaxies subtracted from relative proper motions of all sources to produce absolute proper motions

RESULTS

- So why bother with the (computationally more intensive) unique local transforms?

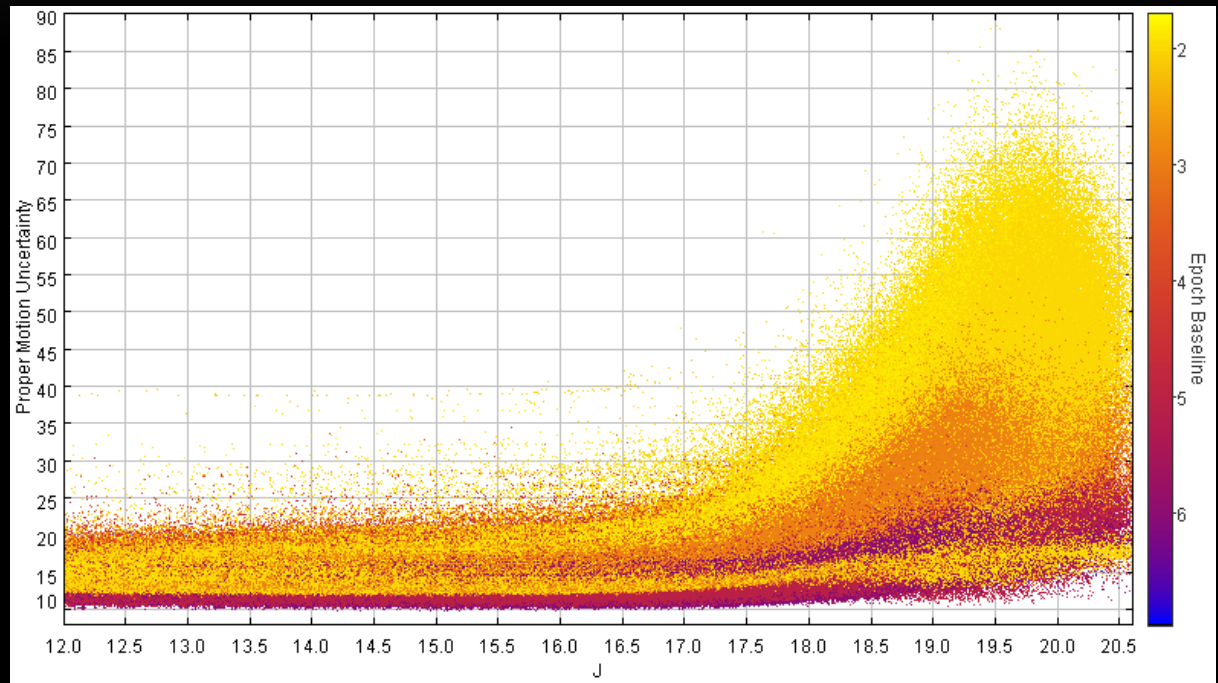


Simply more accurate results!

RESULTS

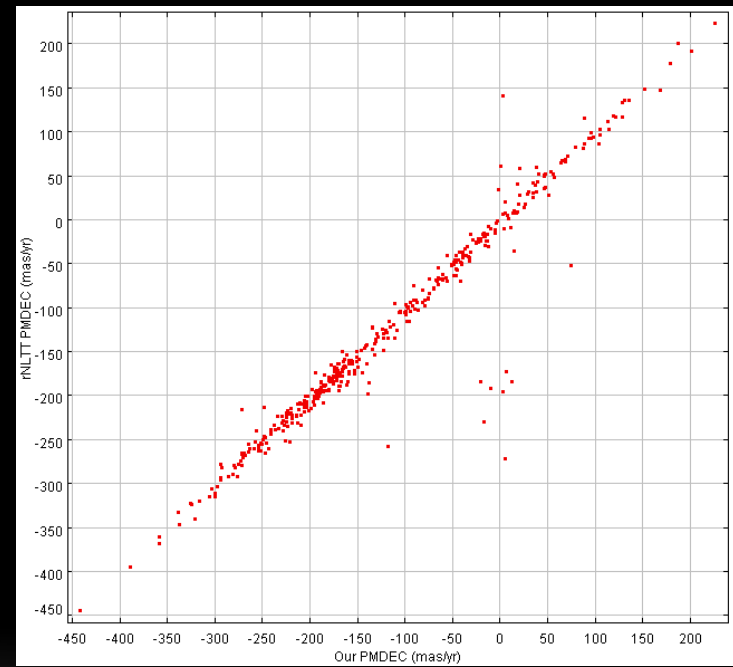
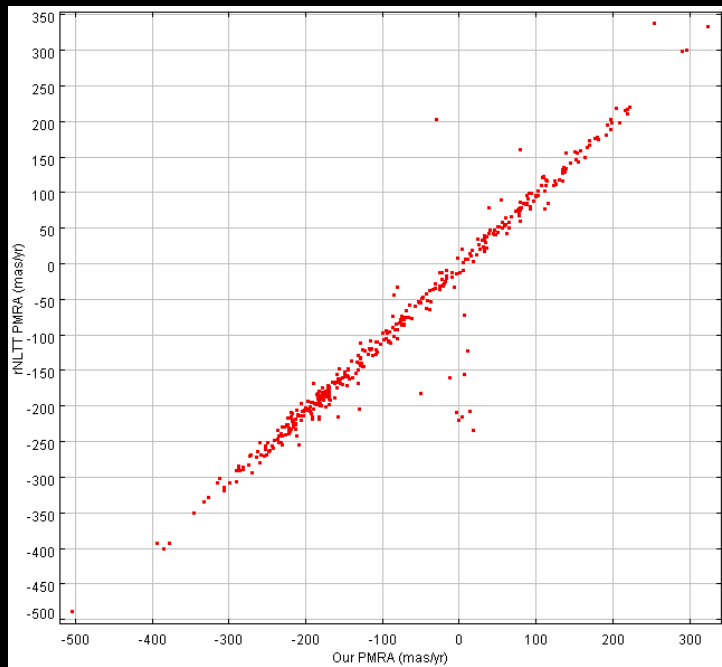
- Absolute proper motion uncertainties:

177,806 sources
classified as stellar at
both epochs with
greater than 5σ pm
measured, 27,892
greater than 10σ



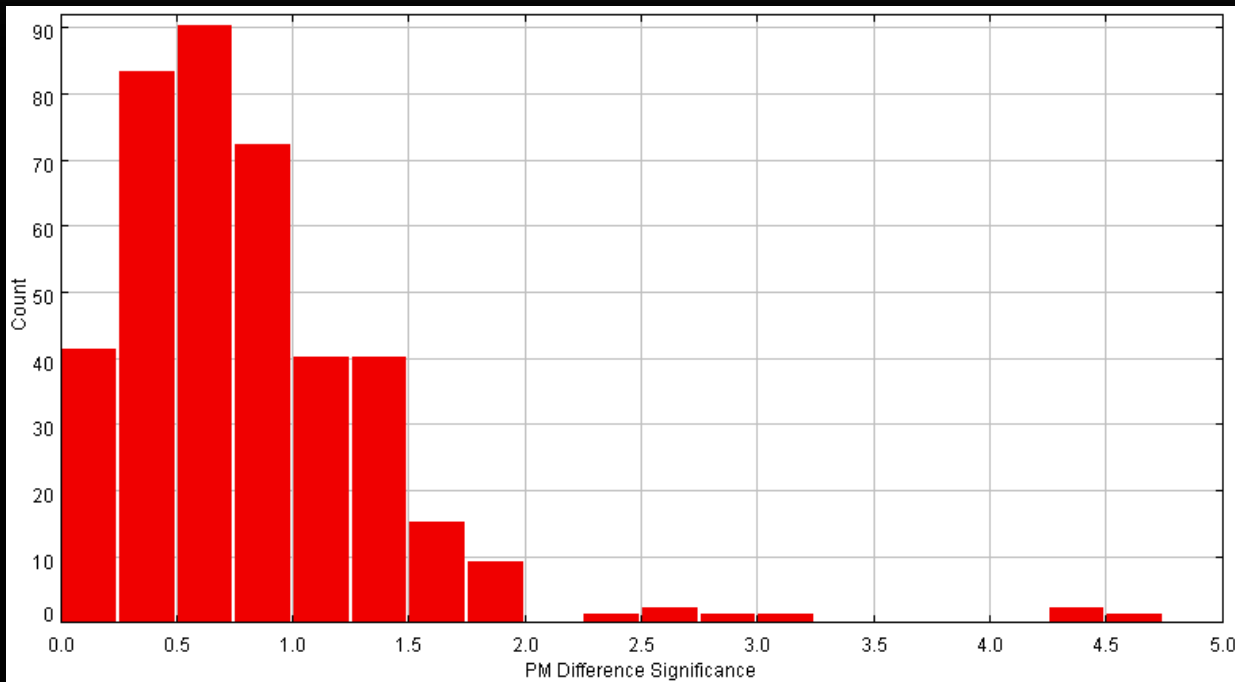
RESULTS

- Comparison to rNLTT



RESULTS

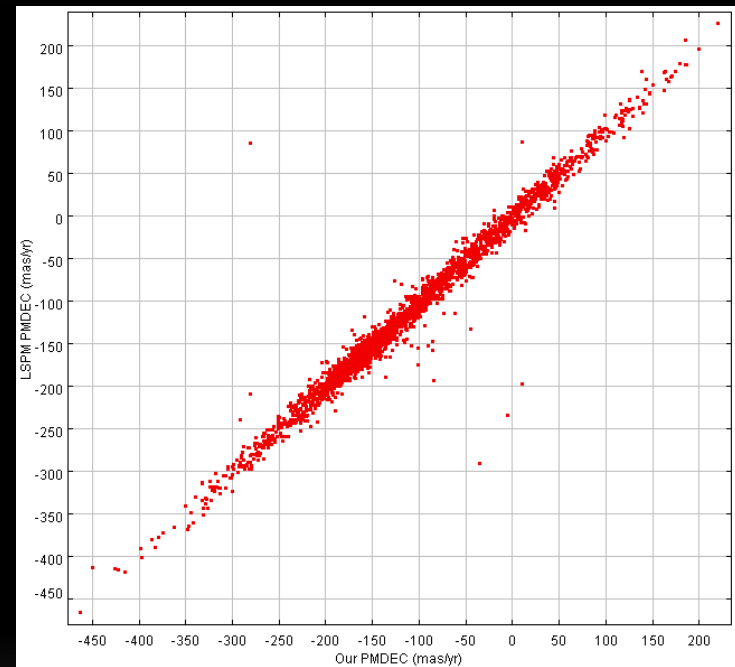
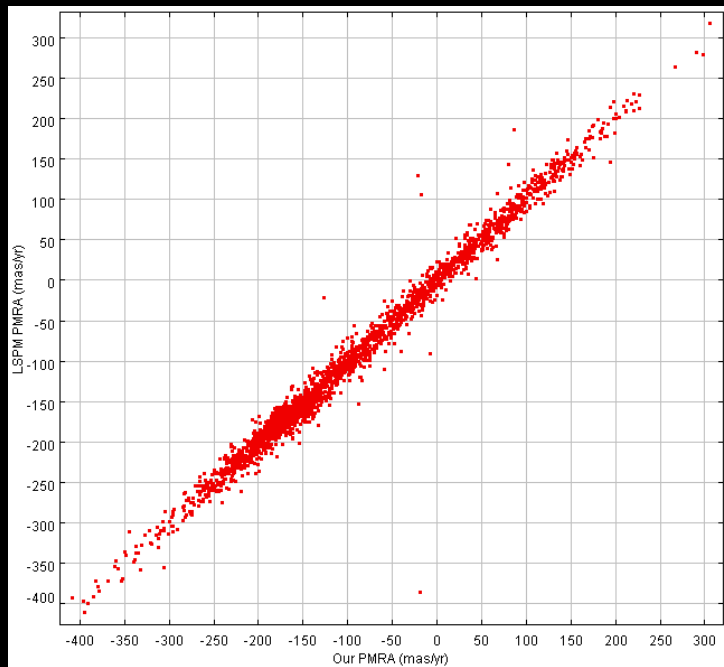
- Comparison to rNLTT



411 matches
70% agree within their 1
sigma uncertainties
95% agree within their 2
sigma uncertainties

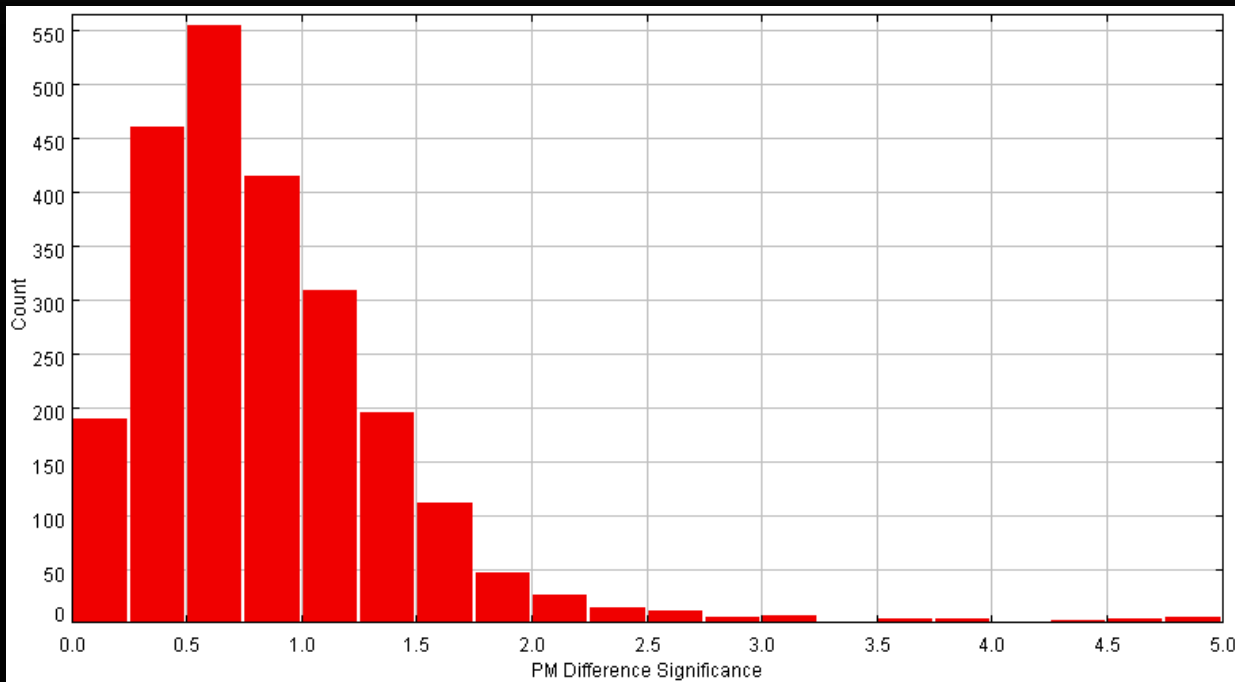
RESULTS

- Comparison to LSPM



RESULTS

- Comparison to LSPM



2341 matches

69% agree within their 1
sigma uncertainties

97% agree within their 2
sigma uncertainties

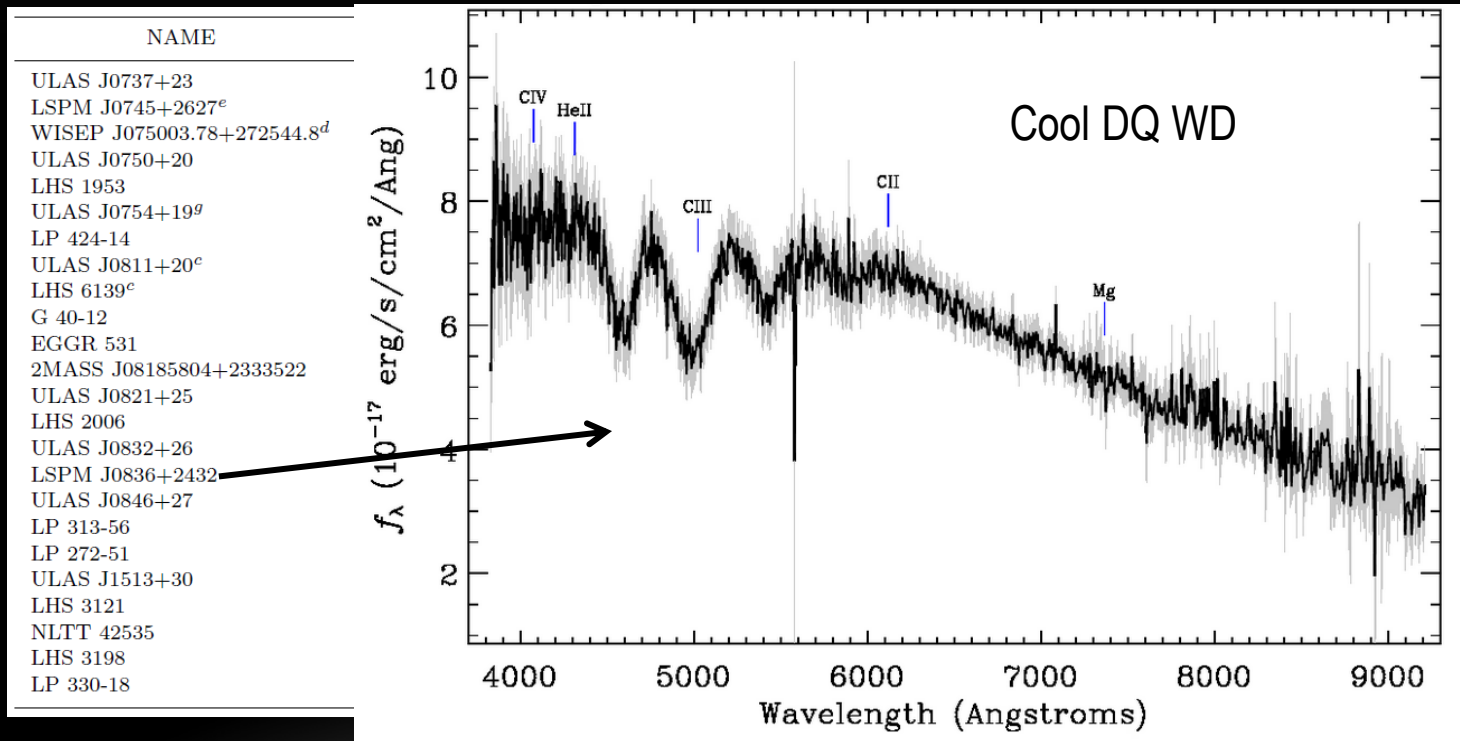
RESULTS

A sample of high PM (>400mas/yr) stars from within the DR9 footprint

NAME	Spectral Type Estimate	Distance Estimate (pc)	Vtan Estimate	Simbad Entry
ULAS J0737+23	M8 ^b	20	46	...
LSPM J0745+2627 ^e	WD	35	148	hpm
WISEP J075003.78+272544.8 ^d	T9 ^h	15	53	BD
ULAS J0750+20	M6/7 ^{b,g}	36 ^g	86	...
LHS 1953	M dwarf ^f	...	...	hpm
ULAS J0754+19 ^g	M6/7 ^b	21 ^f	44	...
LP 424-14	M0-4 ⁱ	125	240	hpm
ULAS J0811+20 ^c	...	...	...	...
LHS 6139 ^c	M dwarf ^f	...	...	hpm
G 40-12	M0-4 ^b	10	20	hpm
EGGR 531	DA8 ^a	33	63	WD
2MASS J08185804+2333522	M7 ^b	19	38	BD M7
ULAS J0821+25	T4	23	49	...
LHS 2006	M dwarf	...	...	hpm
ULAS J0832+26	...	...	...	...
LSPM J0836+2432	WD	85	221	hpm
ULAS J0846+27	M dwarf ^b	...	...	...
LP 313-56	WD	41	81	hpm
LP 272-51	M5/6	38	80	hpm
ULAS J1513+30	M7	41	85	...
LHS 3121	M6	29	87	hpm
NLTT 42535	M0-4 ^b	124	243	hpm
LHS 3198	M dwarf	...	...	hpm
LP 330-18	M4/5	42	89	hpm

RESULTS

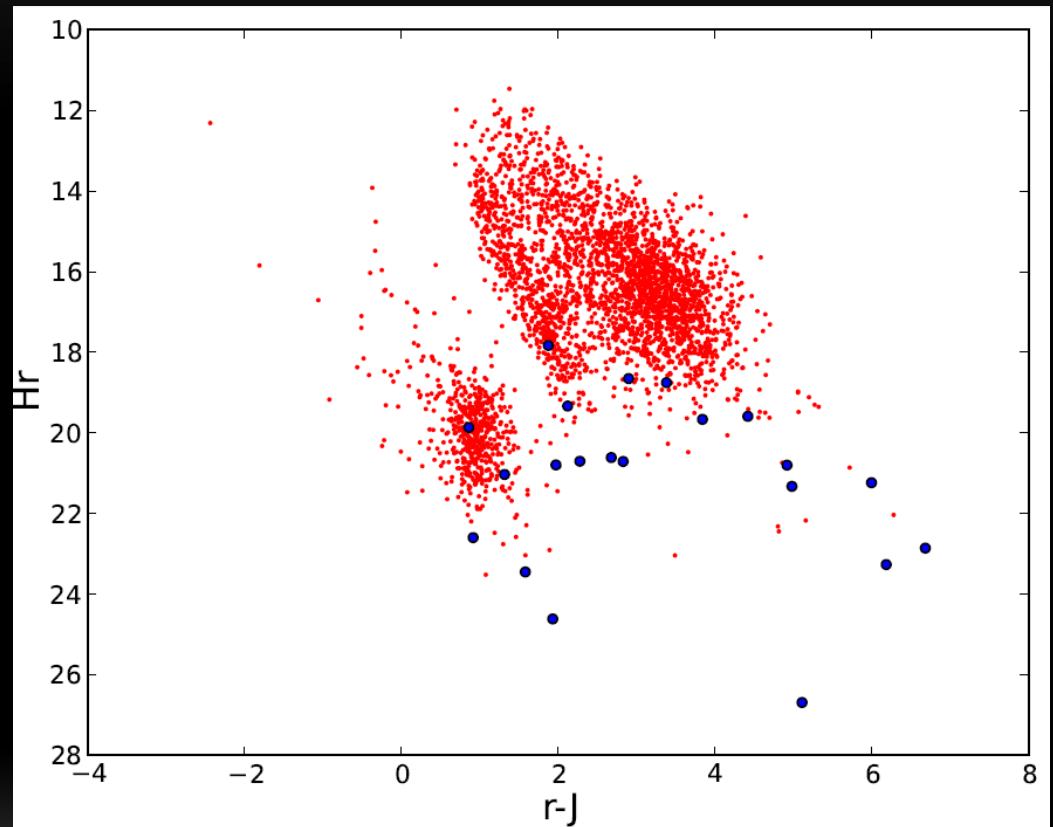
A sample of high PM ($>400\text{mas/yr}$) stars from within the DR9 footprint



RESULTS

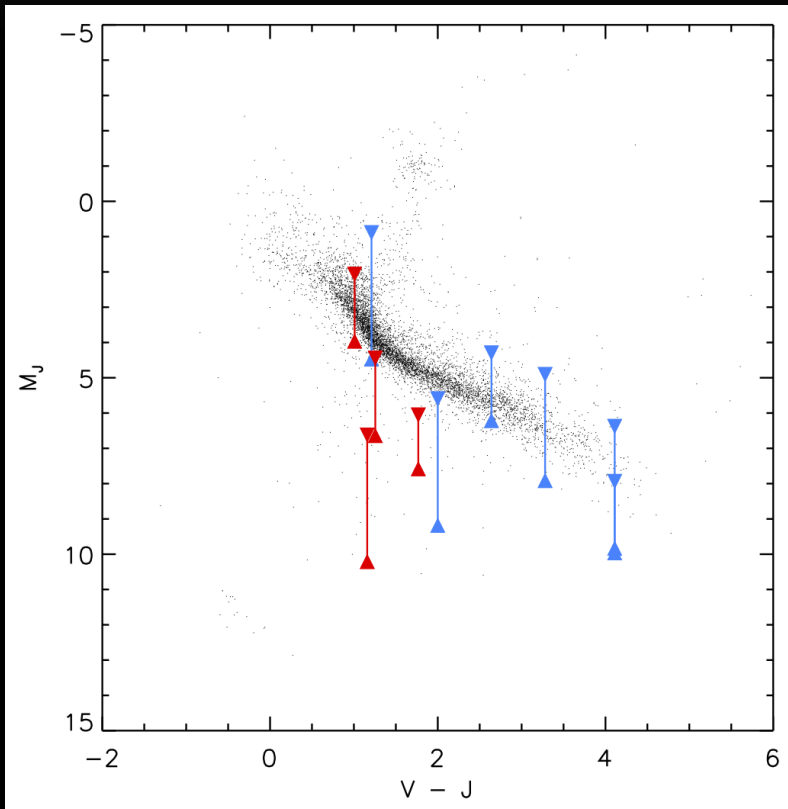
A sample of stars with proper motions greater than 50mas/yr (red points)

The same high proper motion (>400mas/yr) sample from the previous slide (blue points)



WE ARE USING IT FOR...

Finding T dwarf benchmarks



Provided proper motions for 124 ULTS T dwarfs

Crossmatch against Hipparcos, Gliese, LSPM, NOMAD

20,000 AU projected separation limit

100 mas/yr lower pm limit

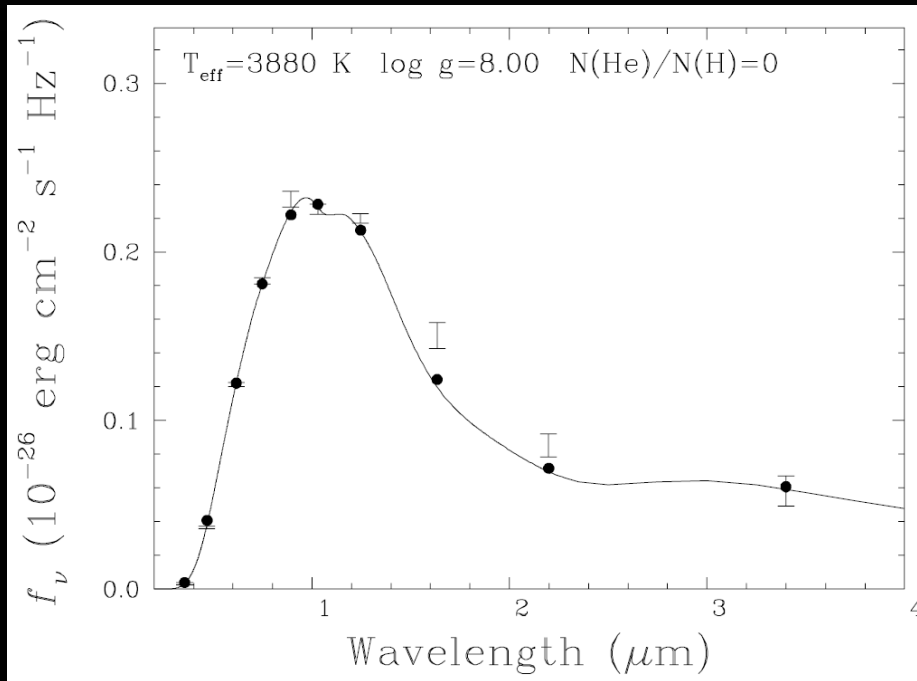
3σ pm difference tolerance

10 potential benchmarks

Burningham et al. (2012)

WE ARE USING IT FOR...

Finding cool white dwarfs



LSR J0745+2627
 $\mu = 890 \text{ mas yr}^{-1}$
Pure H composition
 $T_{\text{eff}} = 3880 \pm 90 \text{ K}$
 $J = 17.12$

Brightest pure-H ultracool WD
ever identified

Catalan et al. (2012)

WE ARE USING IT FOR...

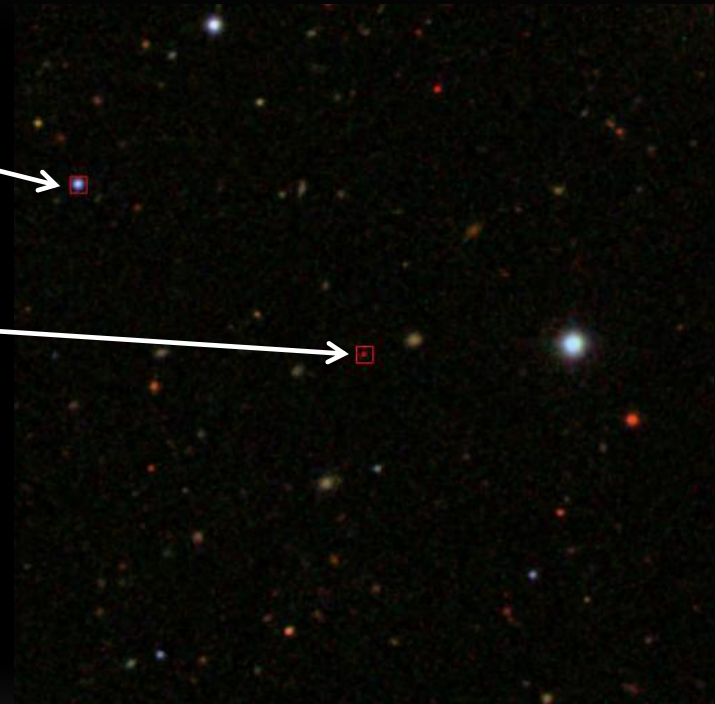
Confirming WD+BD binaries

White dwarf: DA, $T_{\text{eff}} = 6570 \pm 50\text{K}$, $\log g = 8.0$,
mass = $0.591 \pm 0.008 M_{\odot}$, $T_{\text{cool}} = 1.69 \pm 0.04$,
Total age $> 4\text{Gyrs}$.

Brown dwarf: L1, $T_{\text{eff}} \sim 2000\text{K}$.

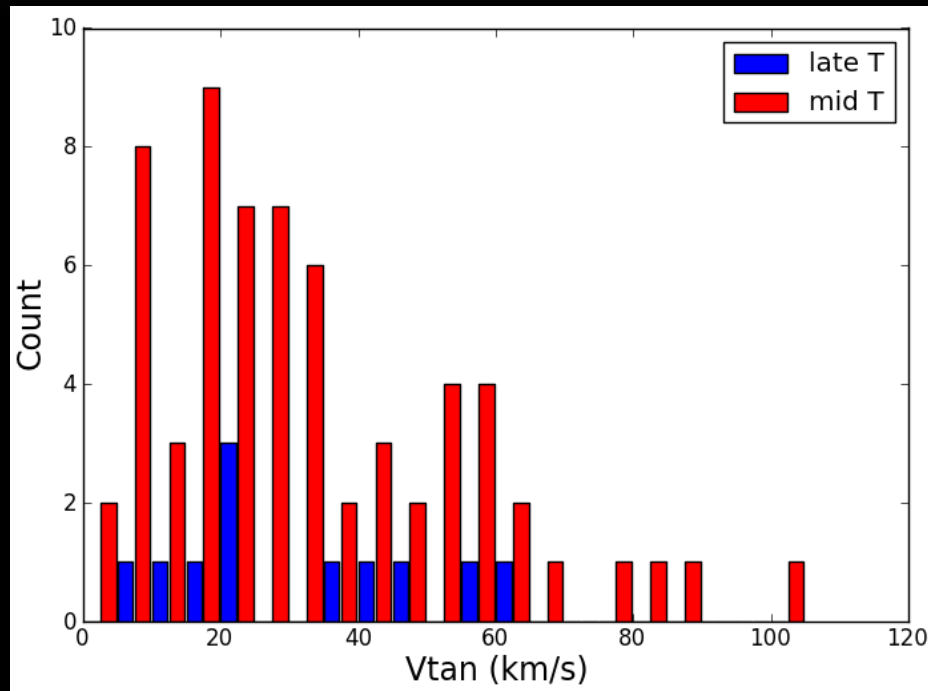
Binary system: separation $98''/3600\text{AU}$.

Discovery of a new benchmark white dwarf + L
dwarf system (Day-Jones et al., in prep)



WE ARE USING IT FOR...

Kinematic age of late T dwarf population



Atmospheric models suggest late T dwarfs are young and low mass

We compared tangential velocities of late (8.5-10) and mid (5.5-8) T dwarfs

Statistical tests suggest they are probably drawn from the same sample

Comparison to Hipparcos stars suggests population age of $>2\text{Gyr}$

(Smith et al., in prep)

WE ARE USING IT FOR...

- Finding ultracool dwarfs in conjunction with WISE photometry (*David Pinfield*)
- Searches for L dwarfs (also in CPM pairs, Phil Lucas)
- Searches for new members of moving groups (David Rodriguez)
- Searches for very nearby (census of solar neighbourhood) or very fast moving (halo?) objects (Sean Ryan)

- ...Ideas?

CAVEATS

- CASU source classification includes a flag for sources with a bad pixel (~20% of sources at 1 or both epochs), this flag is not present in WSA data (calibrated out perhaps?)
 - implications for the selection of reference stars (unnecessary rejection of a number of potentially useful stars)
 - relative to absolute correction (unnecessary rejection of a number of potentially useful galaxies)
- Relative to absolute correction unreliable in isolated frames or frames with a very short epoch baseline
- False detections of sources (in diffraction spikes, etc)
- Duplicate sources
- 'High proper motion' unflagged saturated sources
- 'High proper motion' galaxies!

SUMMARY

- New PM catalogue from the UKIDSS Large Area Survey!
 - 1500 square degrees at NIR, complemented in optical by SDSS and Mid IR by WISE
 - 177,806 sources* with greater than 5σ pm measured, 27,892 greater than 10σ
- Perfect for finding cool objects
- Accuracy is reasonable considering the short epoch baselines
- Agrees with current, accurate proper motion catalogues as one might hope
- Available soon! (now in collaboration, contact me! L.SMITH0607@GMAIL.COM)