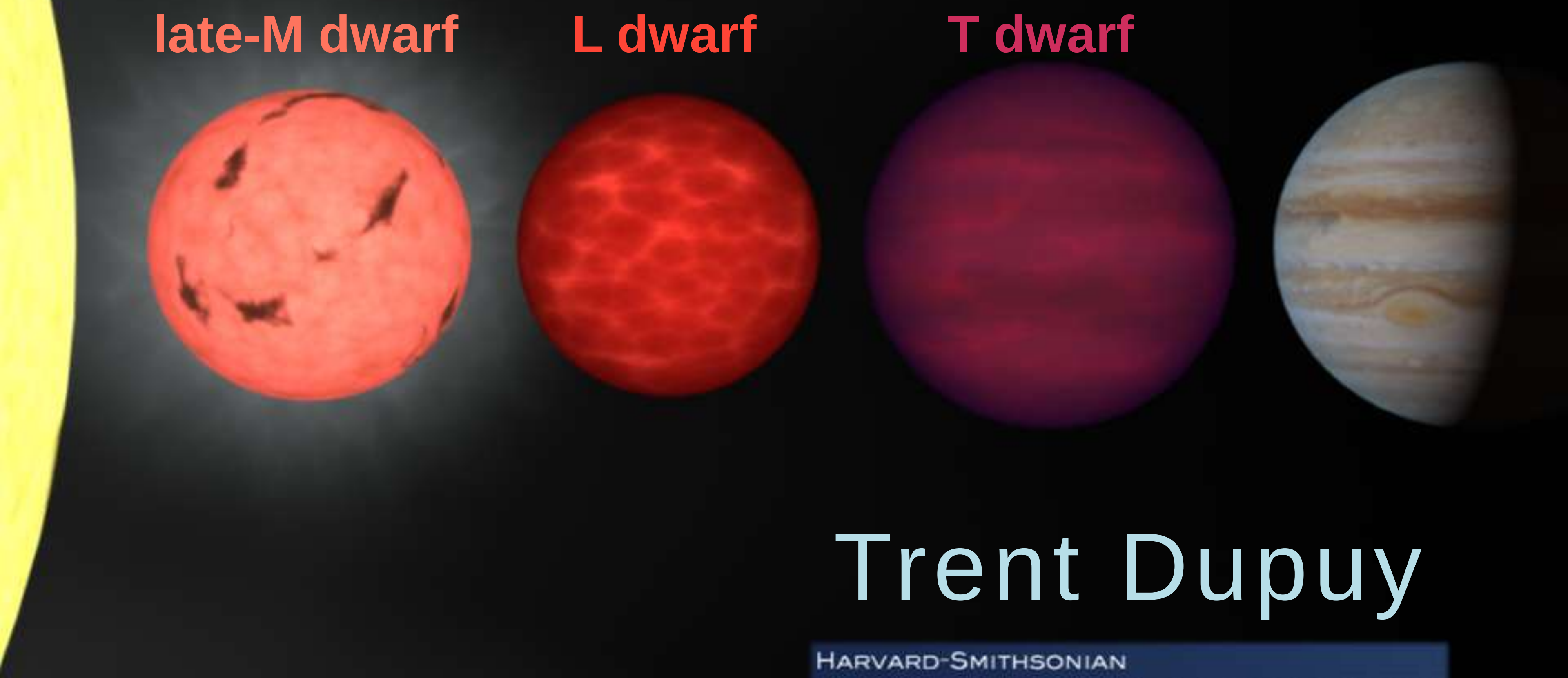
Hawaii Infrared Parallax Program



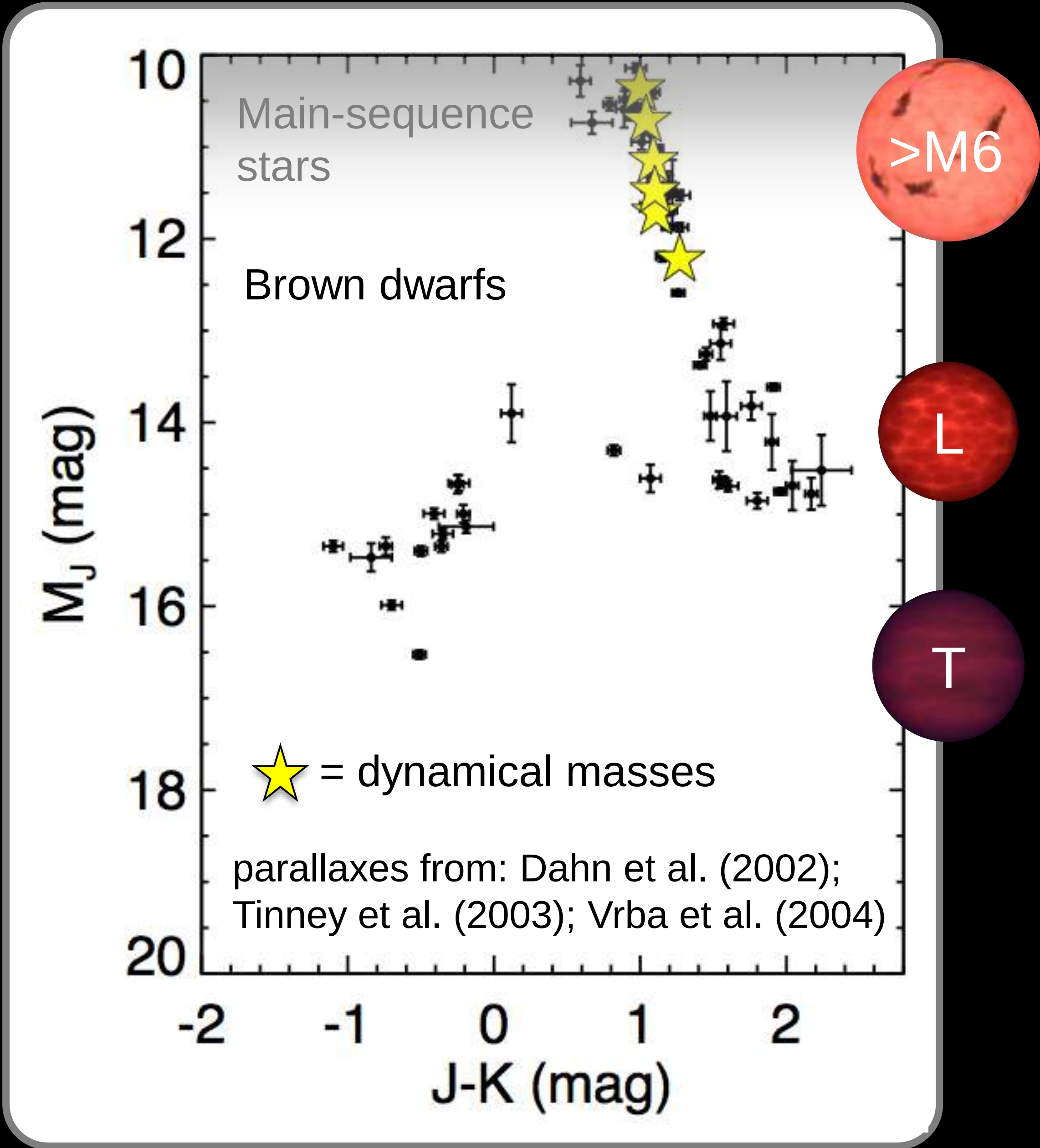
Trent Dupuy

HARVARD-SMITHSONIAN CENTER FOR ASTROPHYSICS

Michael Liu

INSTITUTE FOR ASTRONOMY UNIVERSITY OF HAWAII

Credit: Robert Hurt (IPAC)

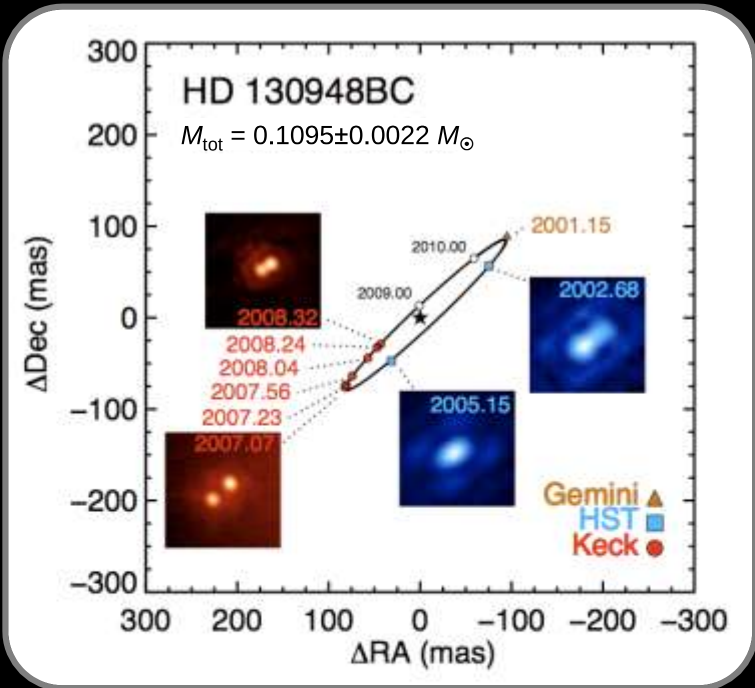


M8.5+M9.5
(Leinert et al. 2001)

M8.5+M9
(Lane et al. 2001; Zapatero Osorio et al. 2004; Simon et al. 2006)

L0+L1.5
(Bouy et al. 2004)

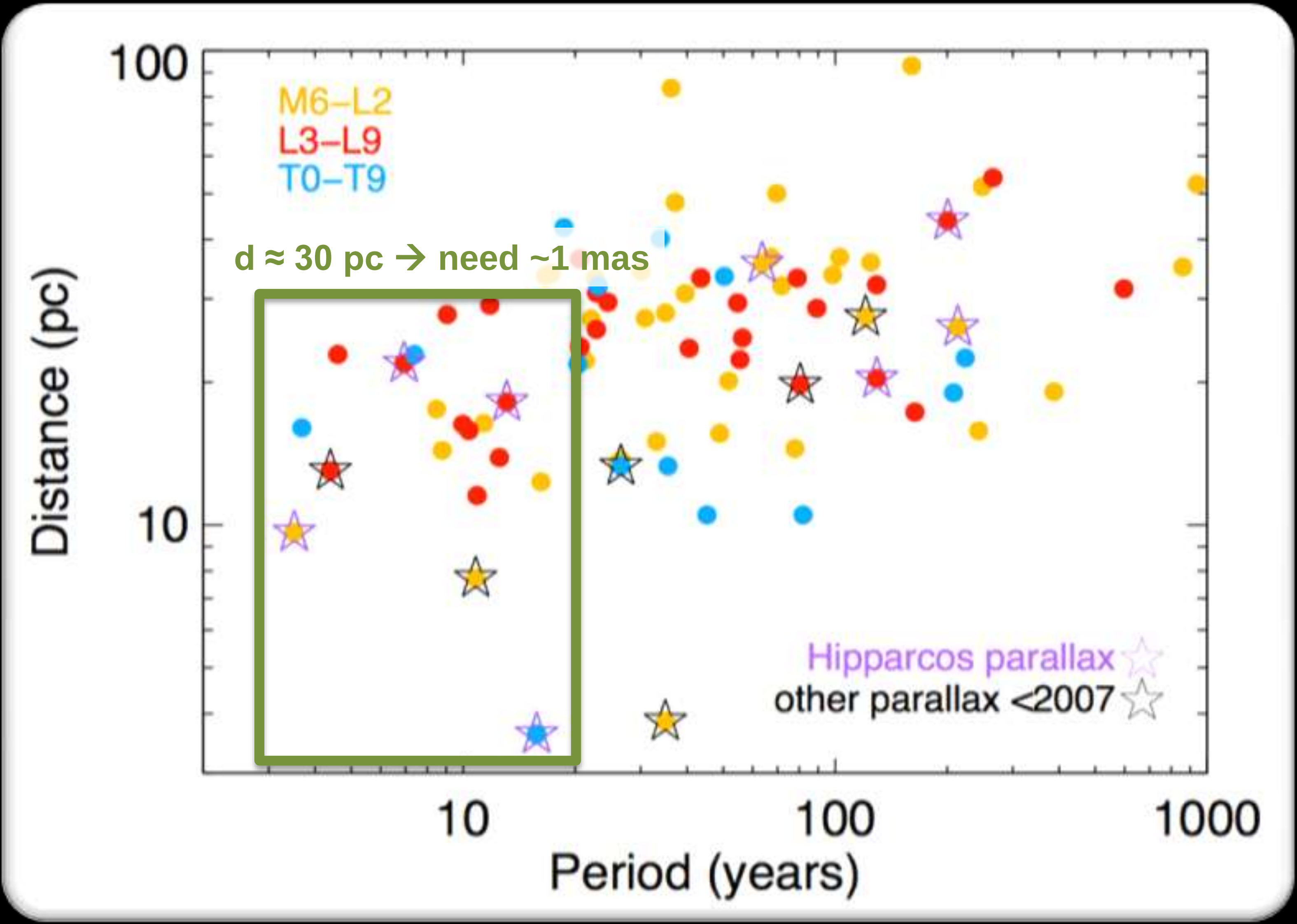
Dupuy et al. (2009b)



$$M_{tot} = \frac{\alpha^3 d^3}{P^2}$$

3% distance error → 9% mass error

All known ultracool binaries

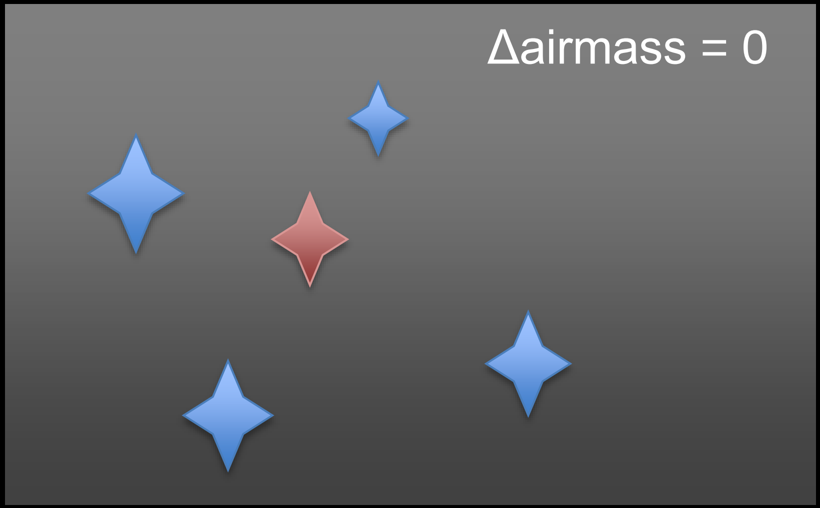


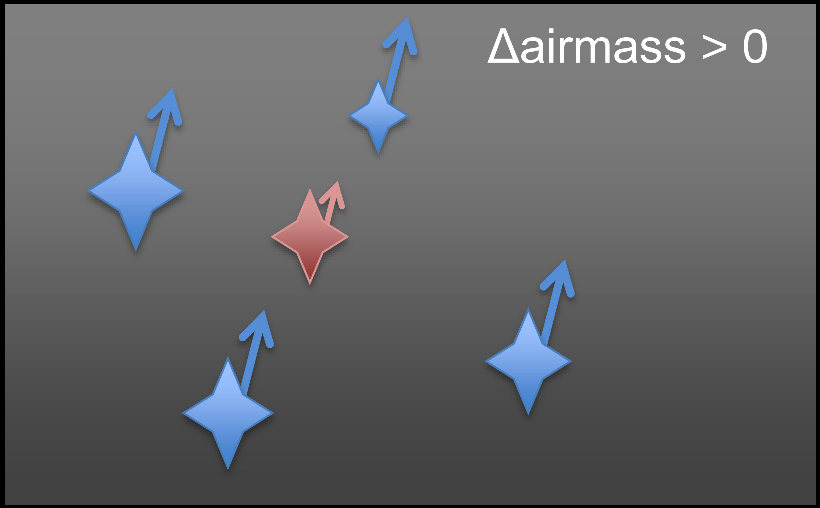
Credit: J.-C. Cuillandre (CFHT)

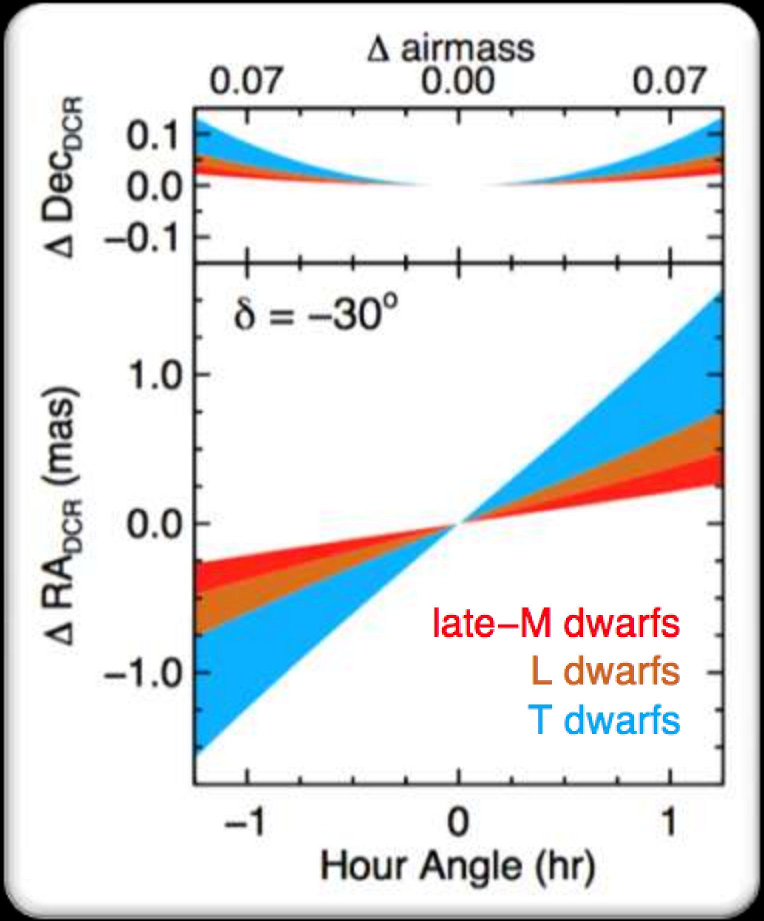
CFHT Parallax Program

- WIRCam 20’x20’ FOV
- Mauna Kea seeing
- ***queue scheduled***

Differential Chromatic Refraction (DCR)

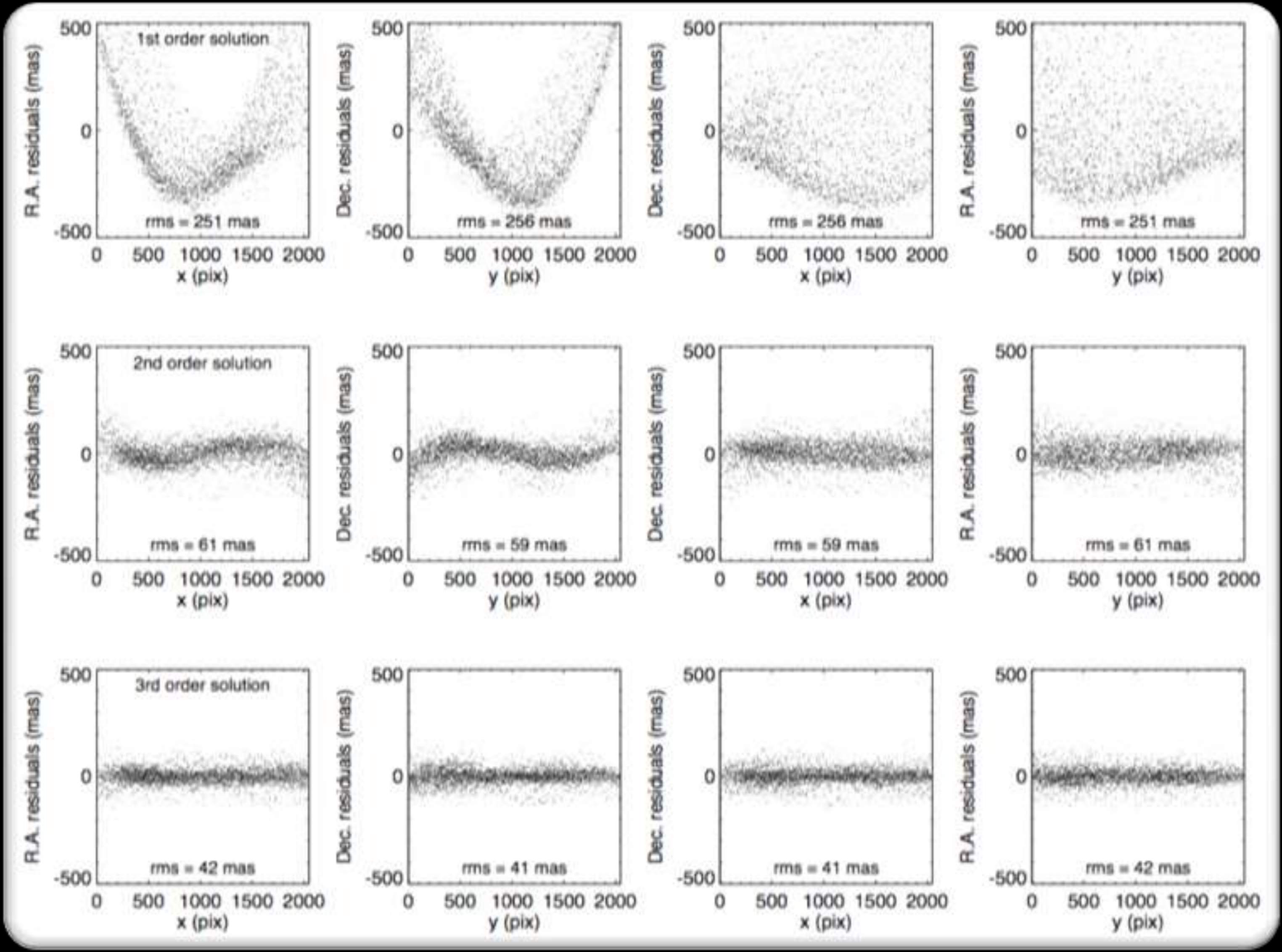






Dupuy & Liu (2012)

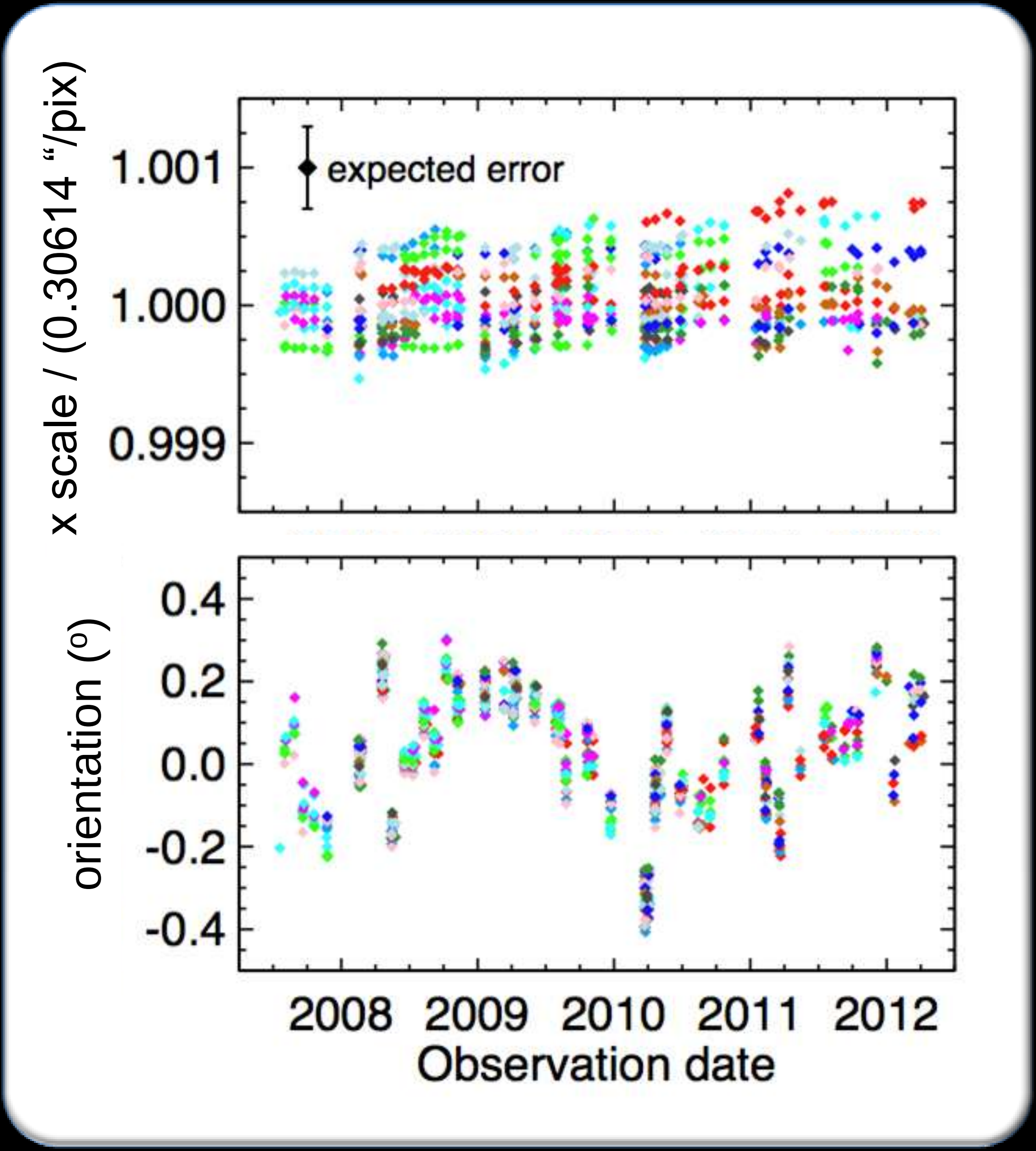
Correcting for WIRCam's Distortion



1st order

2nd order

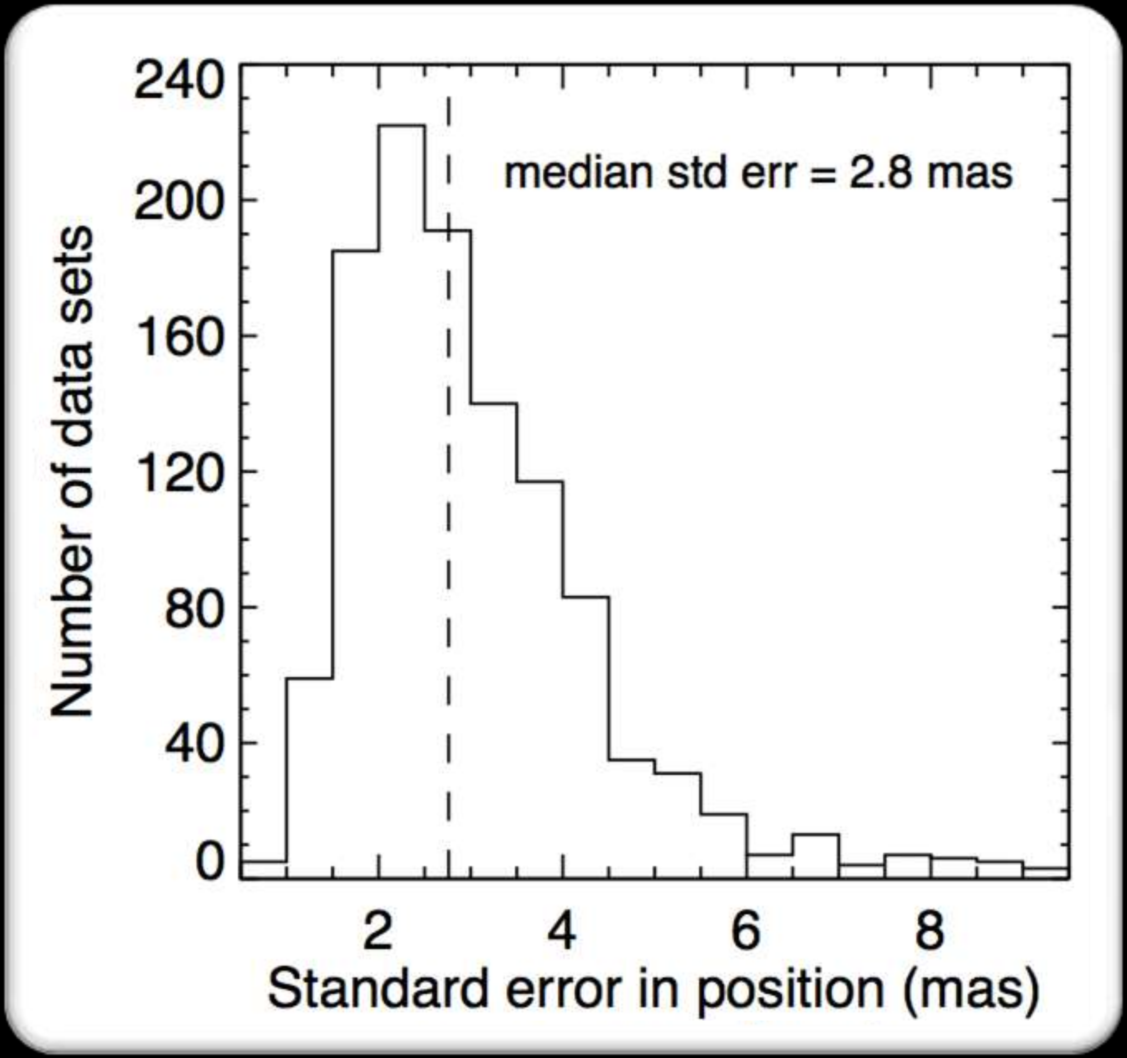
3rd order

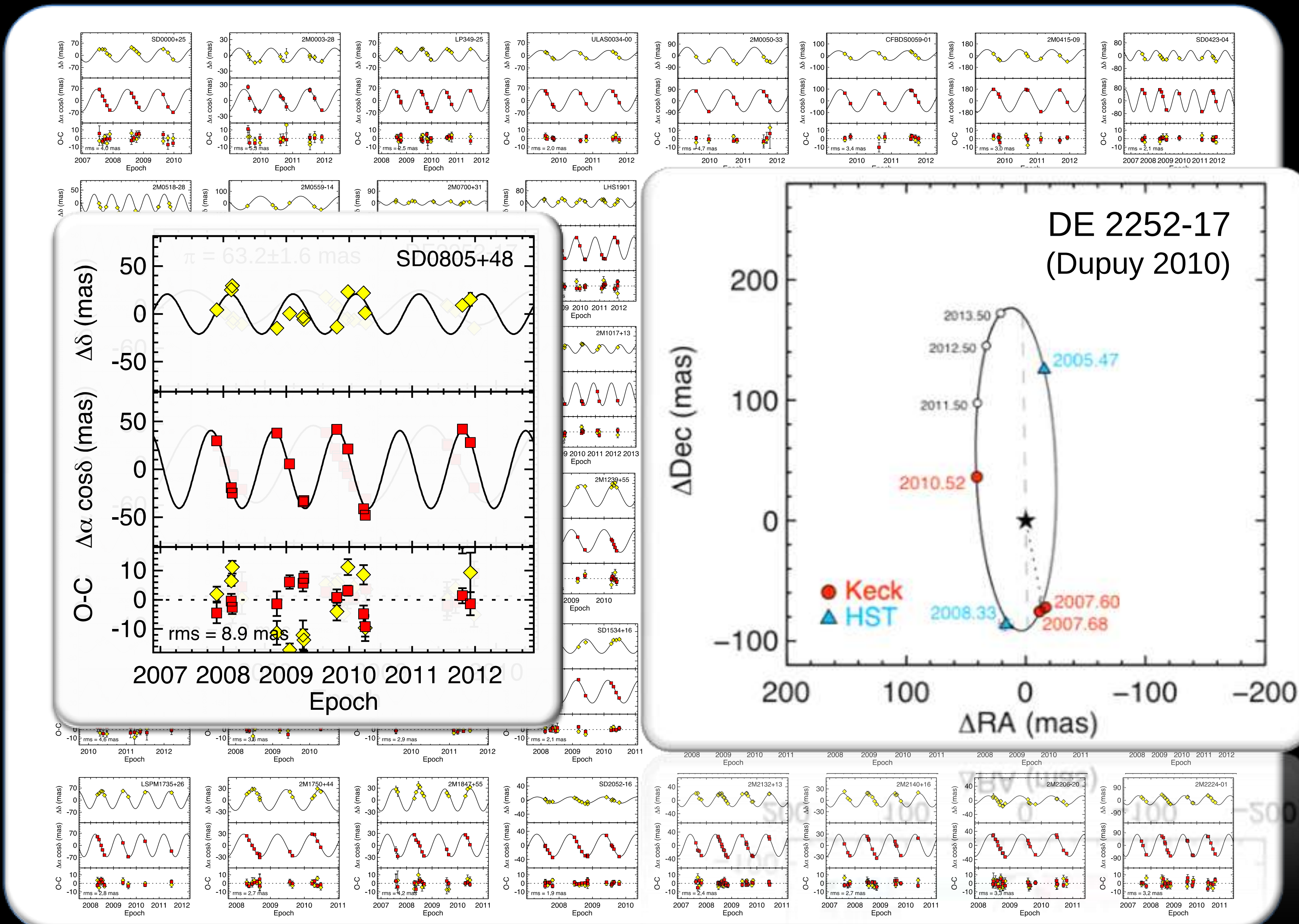


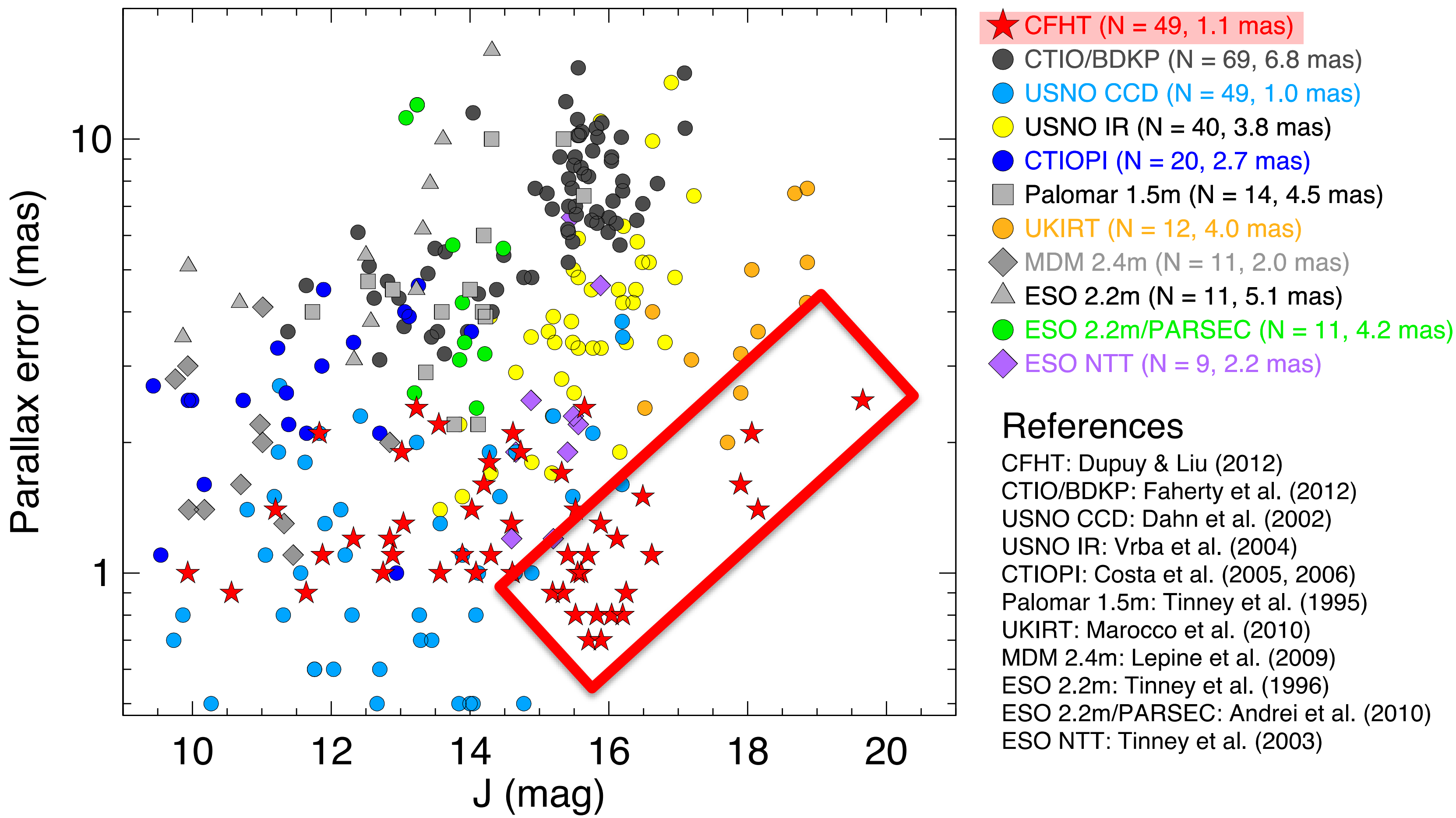
pixelscale of WIRCam appears constant to within ≈ 3×10^{-3}

orientation varies by ±0.3° from run to run

WIRCam Astrometric Precision




SD0000+25
2M0003-28
LP349-25
ULAS0034-00
2M0050-33
CFBDS0059-01
2M0415-09
SD0423-04
2M0518-28
2M0559-14
2M0700+31
LHS1901
2M1017+13
2M1239+55
SD1534+16
LSPM1735+26
2M1750+44
2M1847+55
SD2052-16
2M2132+13
2M2140+16
2M2206-20
2M2224-01
SD0805+48
Δδ (mas)
Δα cosδ (mas)
O-C
rms = 8.9 mas
2007 2008 2009 2010 2011 2012
Epoch
DE 2252-17
(Dupuy 2010)
ΔDec (mas)
ΔRA (mas)
2013.50
2012.50
2011.50
2005.47
2010.52
2008.33
2007.60
2007.68
Keck
HST

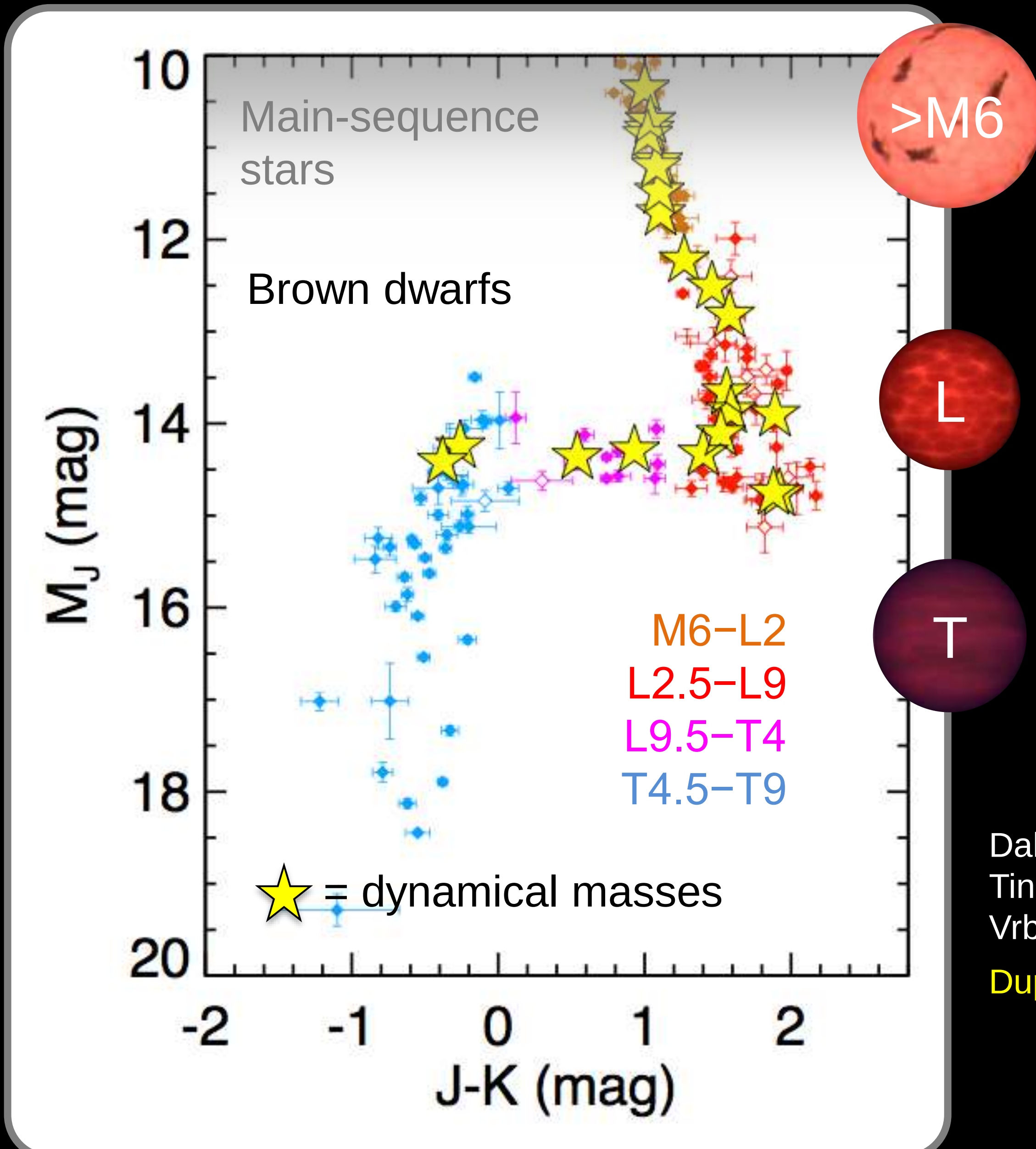


References

CFHT: Dupuy & Liu (2012)
CTIO/BDKP: Faherty et al. (2012)
USNO CCD: Dahn et al. (2002)
USNO IR: Vrba et al. (2004)
CTIOPI: Costa et al. (2005, 2006)
Palomar 1.5m: Tinney et al. (1995)
UKIRT: Marocco et al. (2010)
MDM 2.4m: Lepine et al. (2009)
ESO 2.2m: Tinney et al. (1996)
ESO 2.2m/PARSEC: Andrei et al. (2010)
ESO NTT: Tinney et al. (2003)

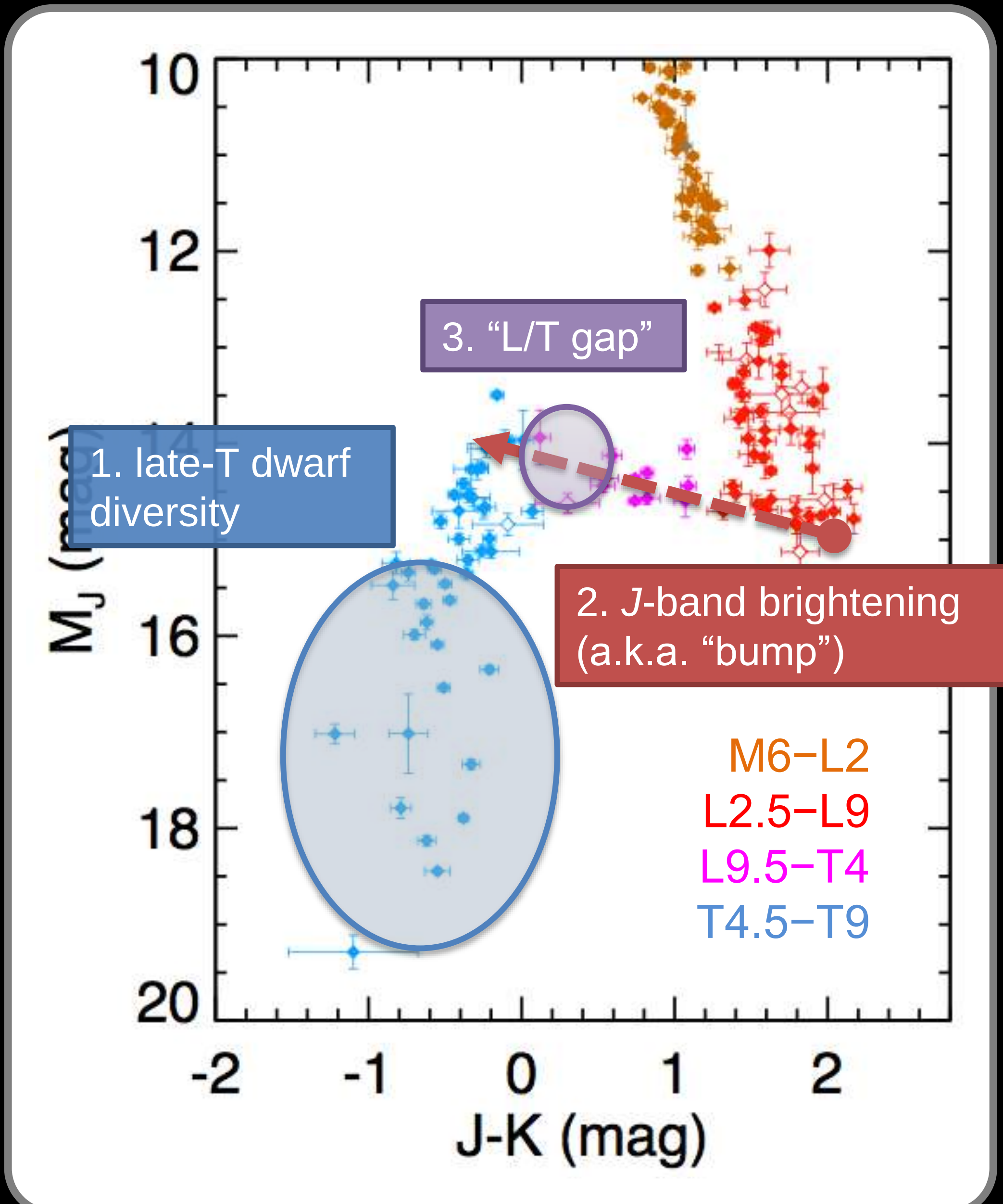
parallaxes
2004
2012

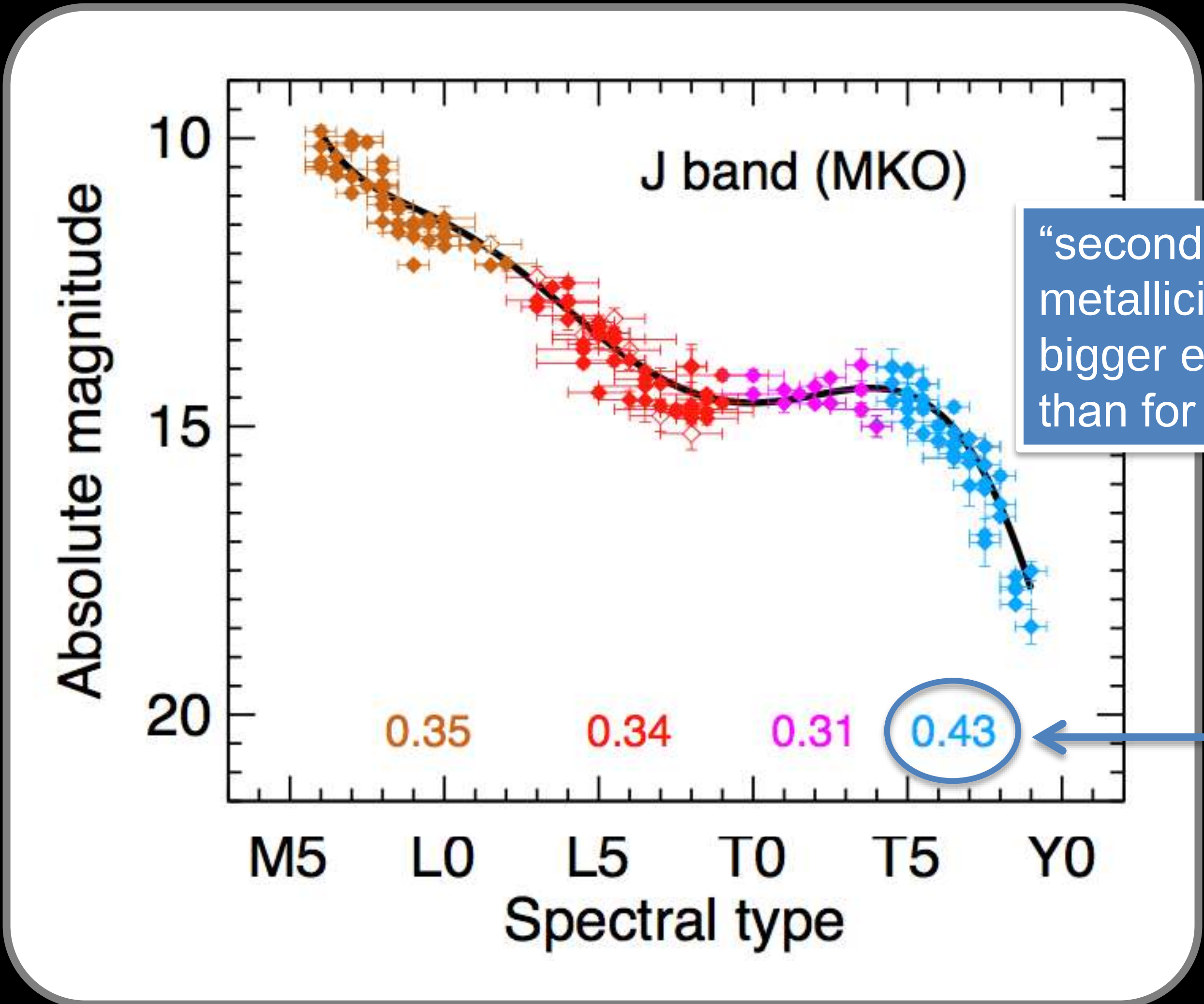
dynamical masses
2004
2012



Dahn et al. (2002);
Tinney et al. (2003);
Vrba et al. (2004)

Dupuy & Liu (2012)

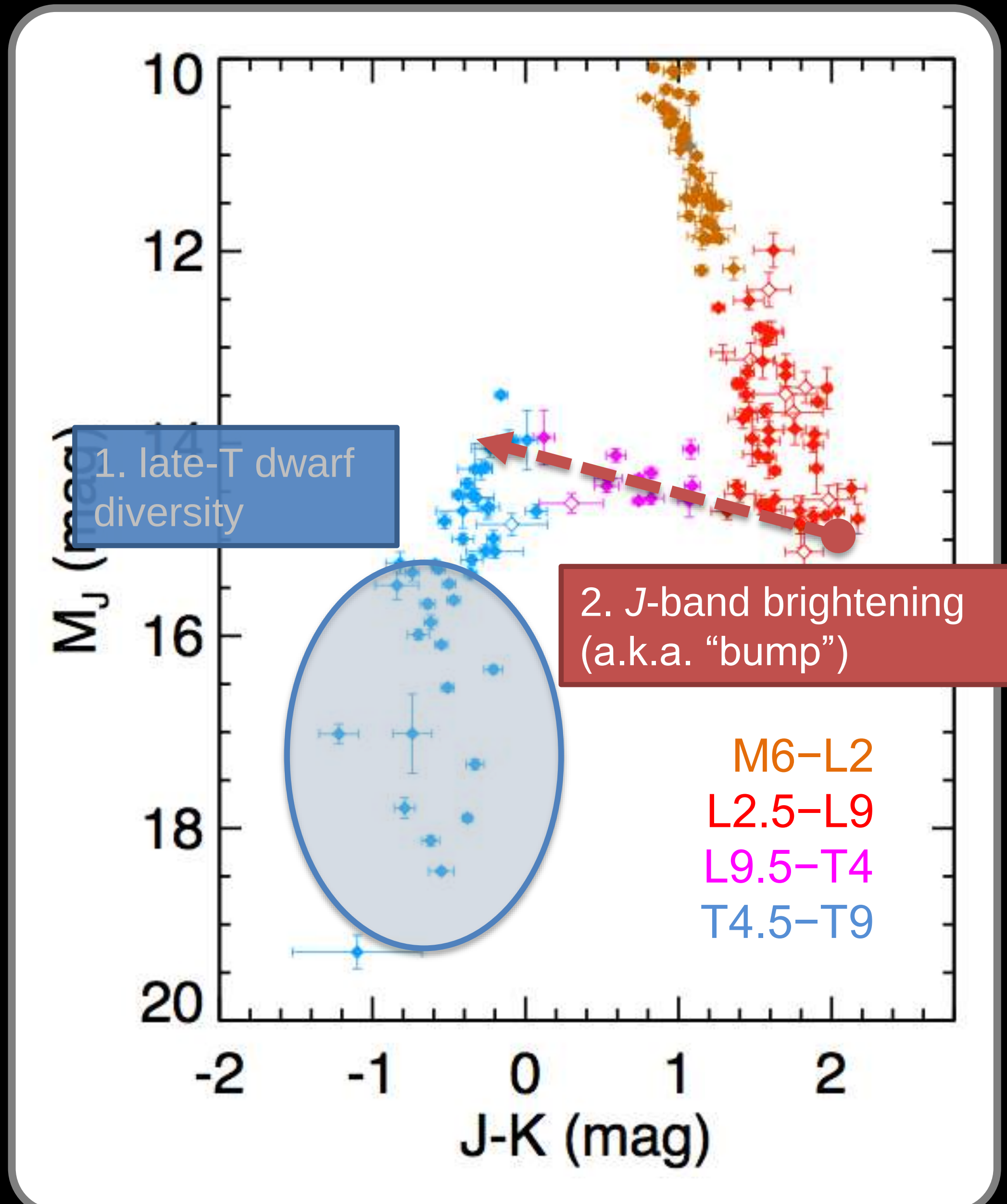

10
12
14
16
18
20
-2
-1
0
1
2
J-K (mag)
M_J (mag)
3. "L/T gap"
1. late-T dwarf diversity
2. J-band brightening (a.k.a. "bump")
M6−L2
L2.5−L9
L9.5−T4
T4.5−T9



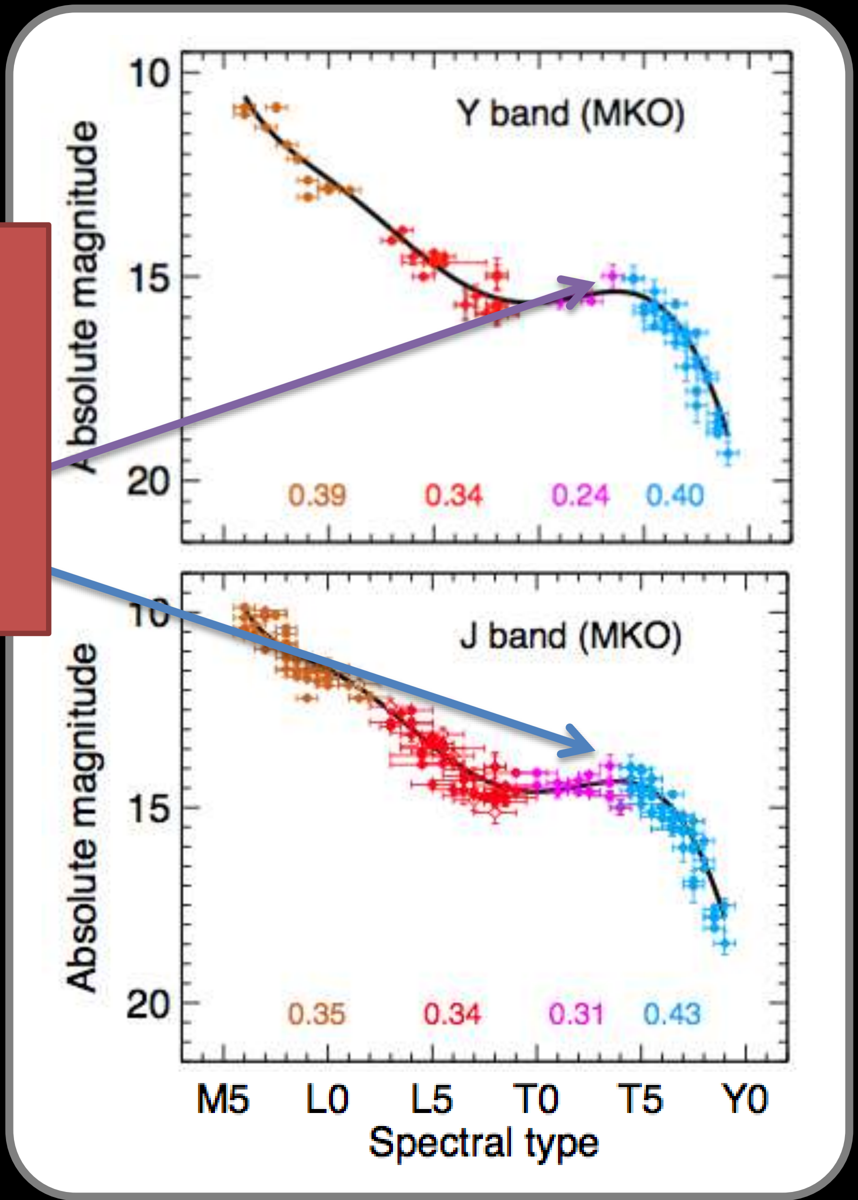
“second” parameters like metallicity, gravity have bigger effect on T dwarfs than for earlier types…

rms about the polynomial fit in mags

Dupuy & Liu (2012)


1. late-T dwarf diversity
2. J-band brightening (a.k.a. “bump”)
M6−L2
L2.5−L9
L9.5−T4
T4.5−T9
10
12
16
18
20
-2
-1
0
1
2
J-K (mag)

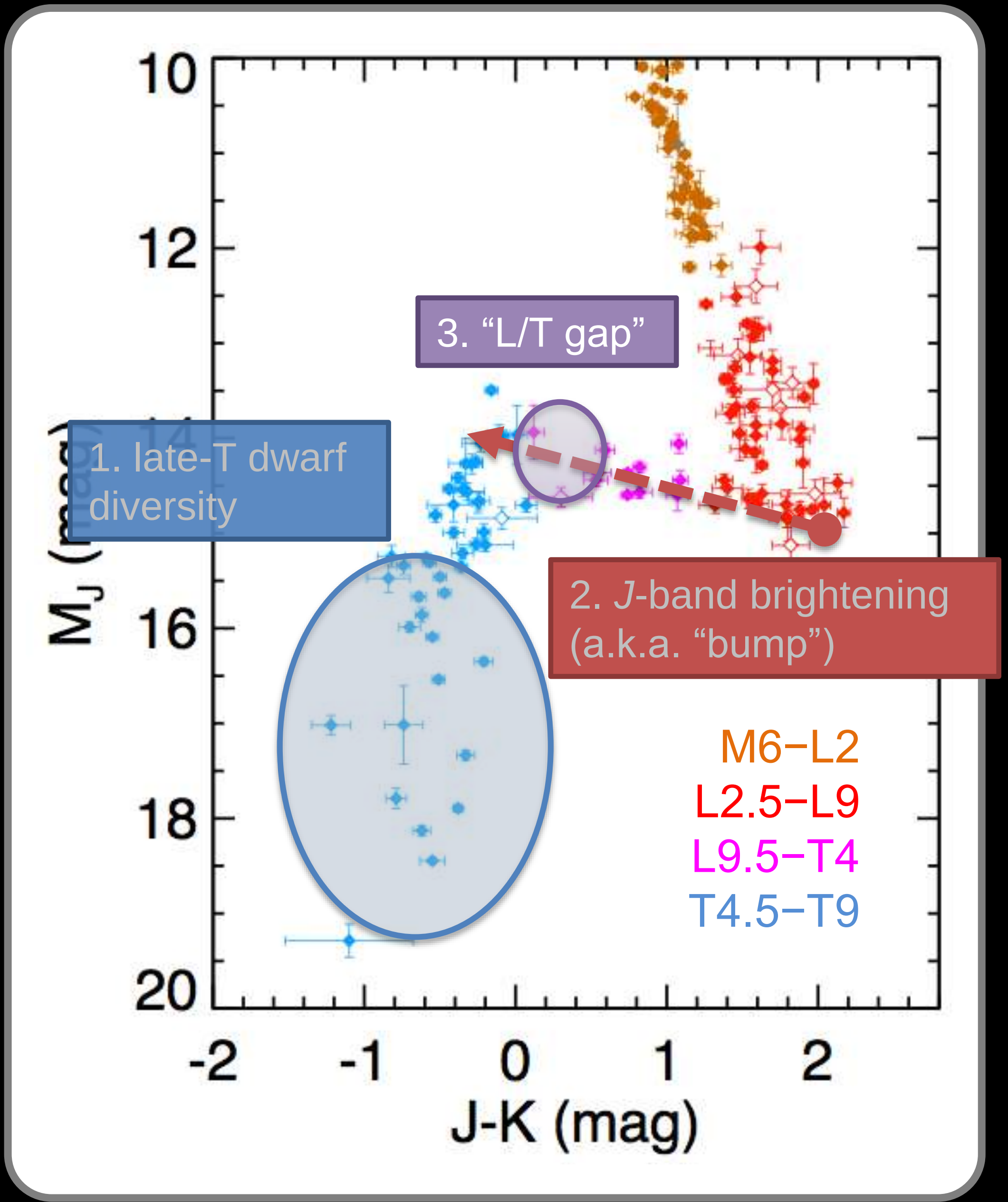
Dust clearing has an even bigger effect at ≈1.0 mm than at ≈1.2 mm



Dupuy & Liu (2012)

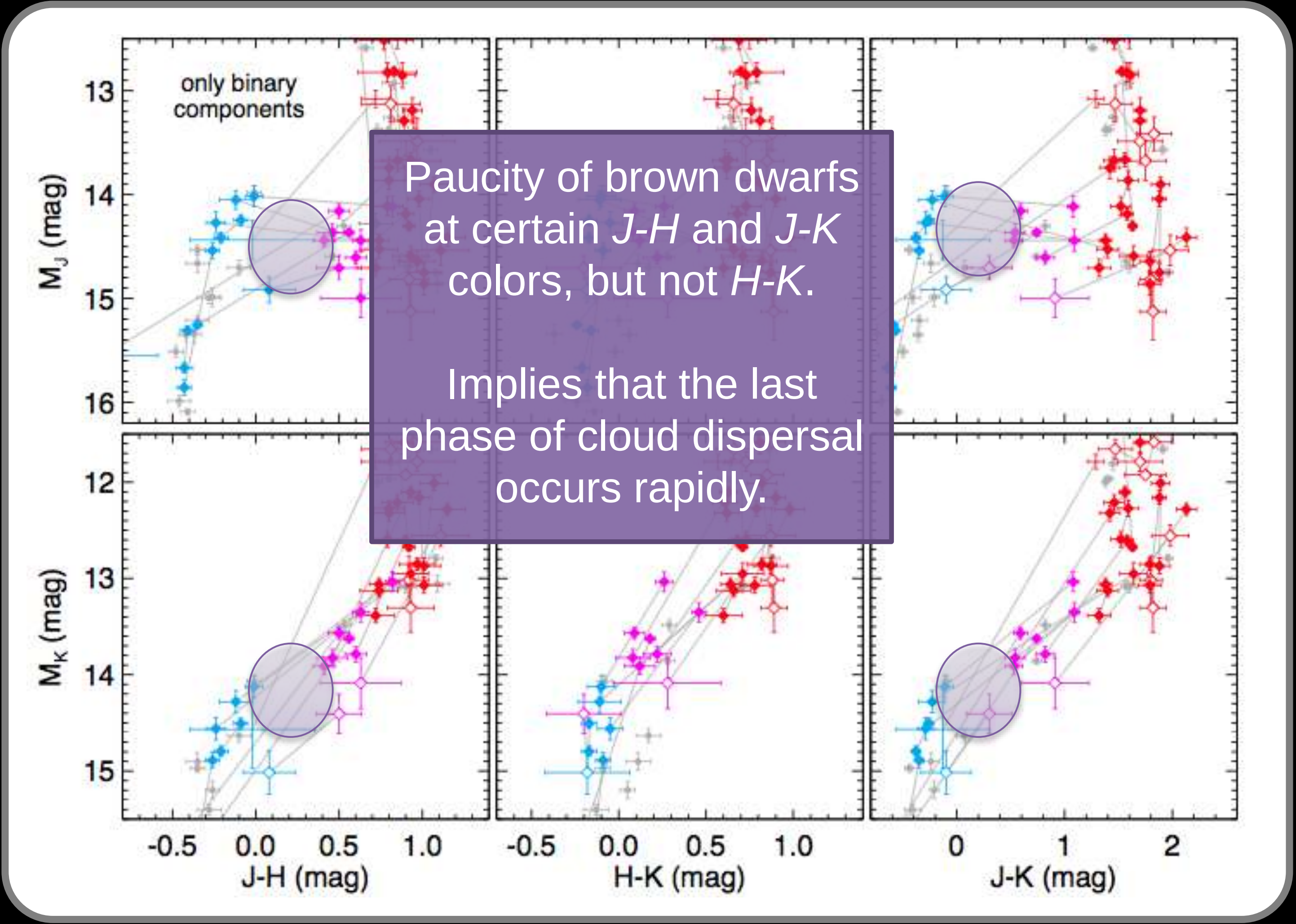
Y-band "bump"
≈0.7 mag

J-band "bump"
≈0.5 mag



10
12
14
16
18
20
-2
-1
0
1
2
J-K (mag)
M_J (mag)
3. “L/T gap”
1. late-T dwarf diversity
2. J-band brightening (a.k.a. “bump”)
M6−L2
L2.5−L9
L9.5−T4
T4.5−T9

The L / T "gap"



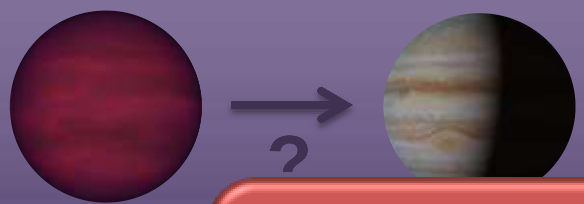
Paucity of brown dwarfs at certain *J-H* and *J-K* colors, but not *H-K*.

Implies that the last phase of cloud dispersal occurs rapidly.

Dupuy & Liu (2012)

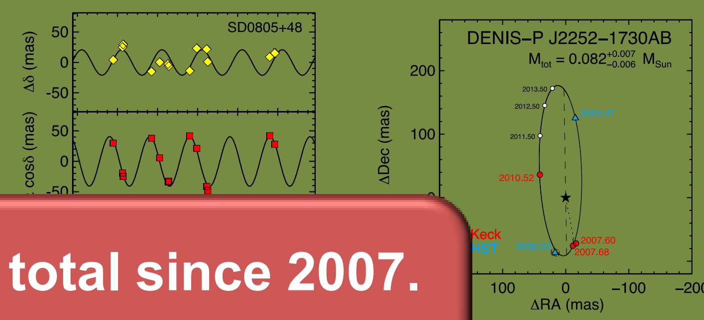
Future / Ongoing Work

Late-T and Y dwarfs



CFHT (Liu)
VLT (Forvei

Long-term orbit monitoring

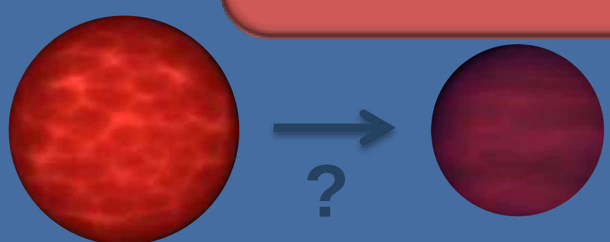


AO = m_1, m_2

Observed ≈250 targets total since 2007.

- ≈4× more than any other program targeting ultracool dwarfs
- vast majority will be too faint to have Gaia parallaxes

Young



CFHT (Liu), Magellan (Dupuy)

Stars

co-I: Muirhead, Johnson

Hawaii Infrared Parallax Program

Established CFHT as an excellent infrared parallax platform – no other facility produces such high-quality measurements for objects so faint. (Thank you QSO.)

Distances enable high-precision *dynamical masses* and *absolute magnitudes* providing strong tests of substellar evolution models. First discovery of substellar binaries using only astrometric perturbations.

Expanding to new samples for which CFHT is uniquely capable of strengthening the connection between brown dwarfs and exoplanets.