The WFCAM Transit Survey

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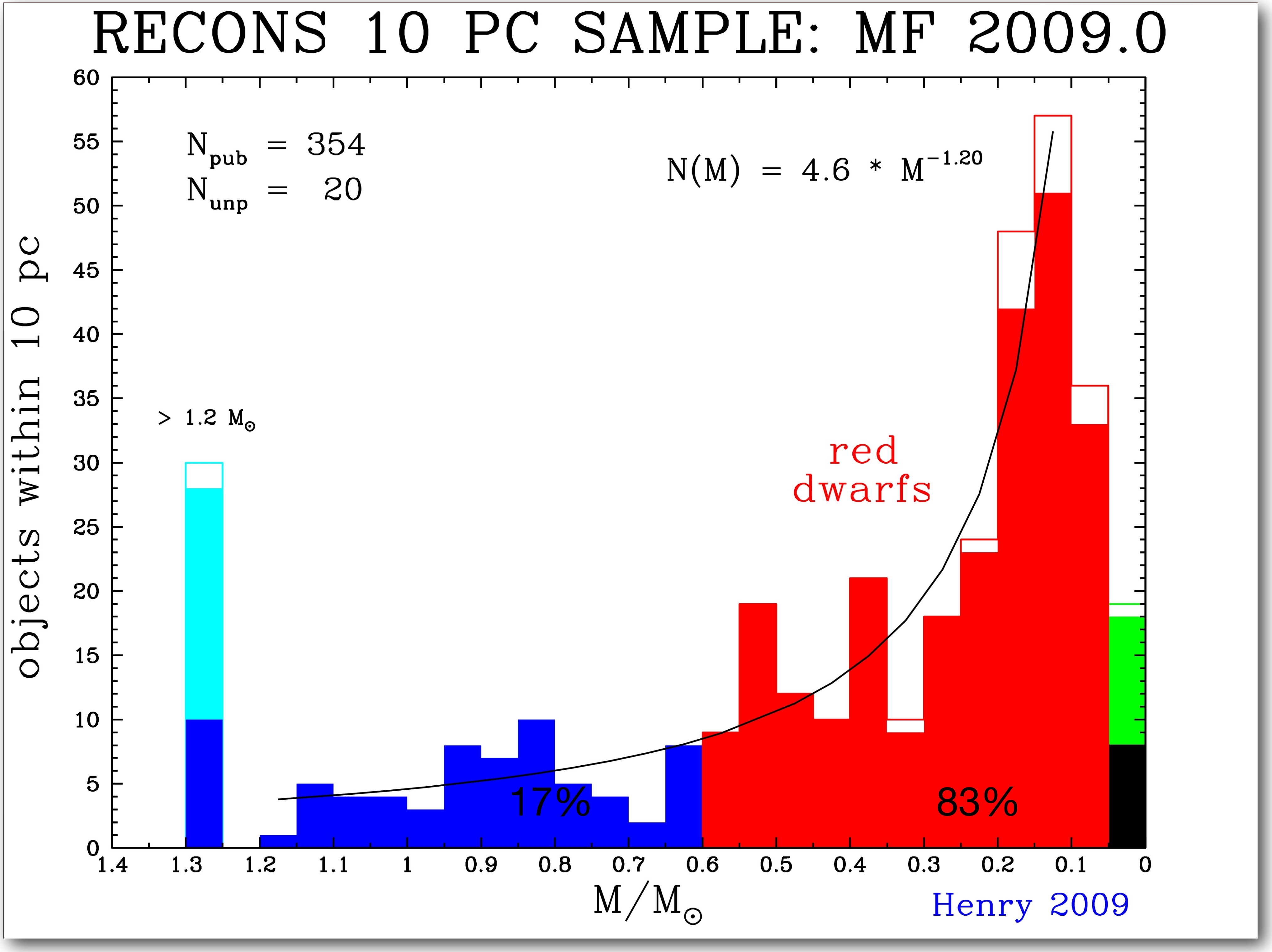
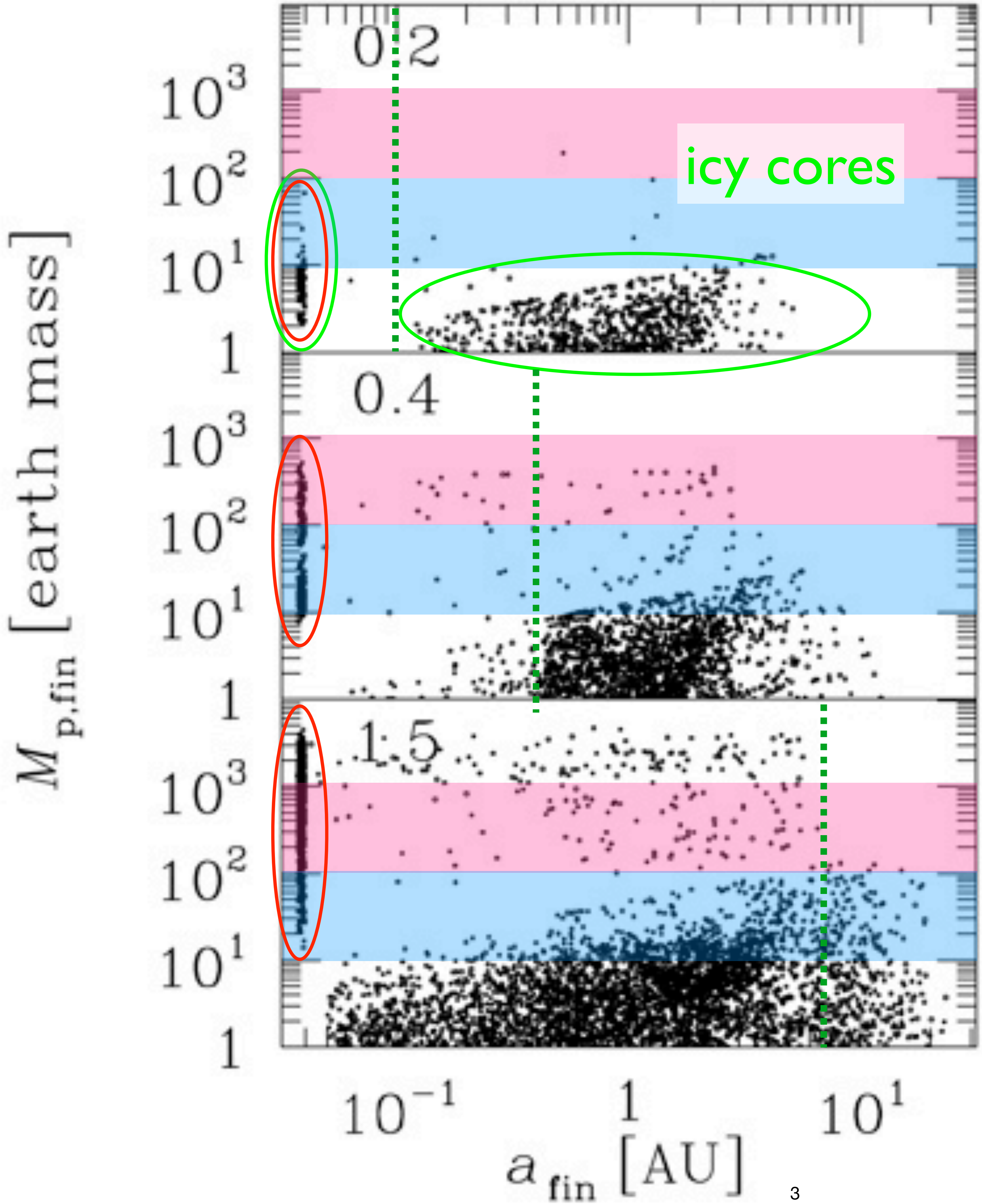
Mdwarf mass funtion



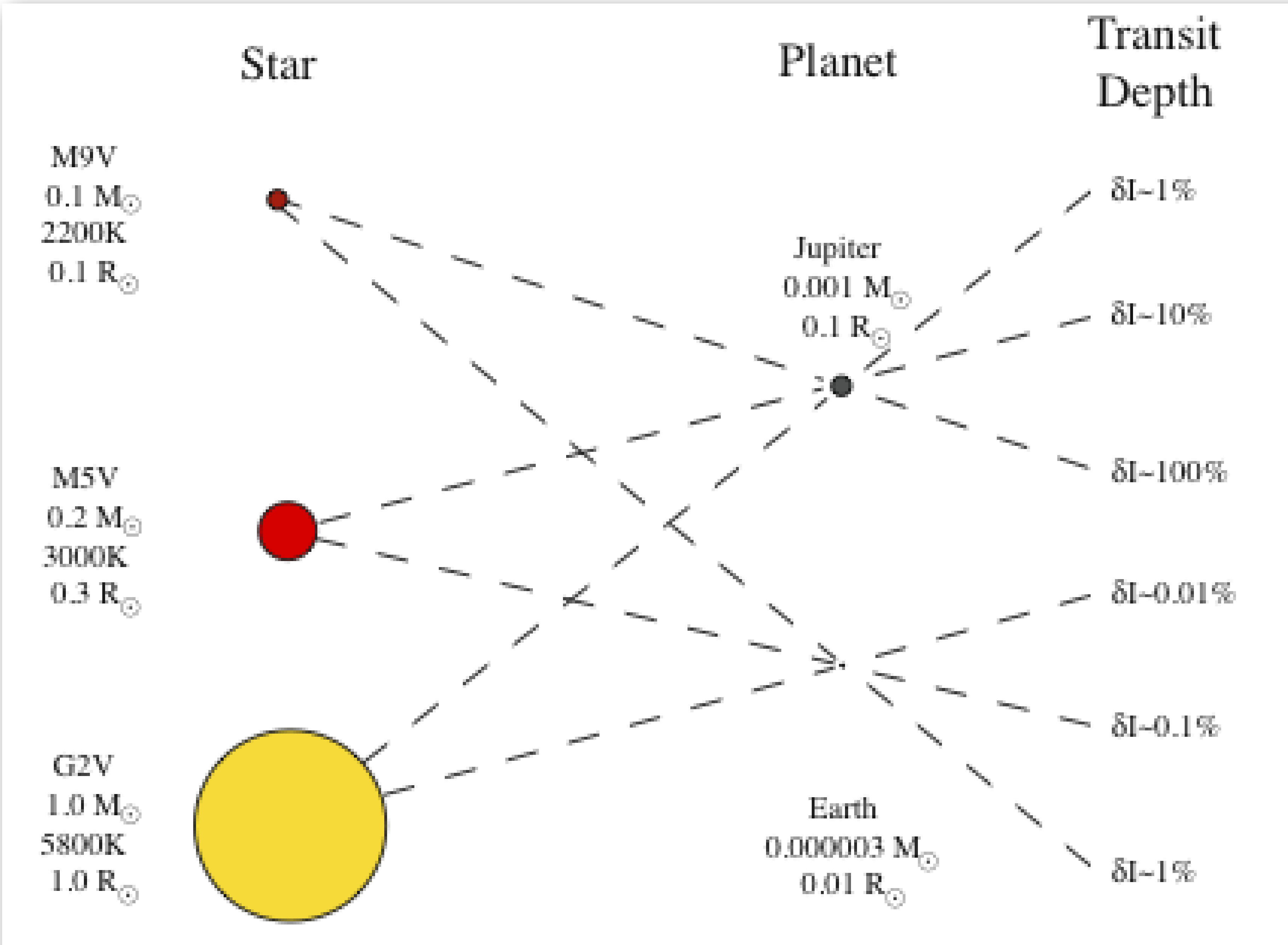


Distributions of a and M of planets predicted by the Monte Carlo simulations of Ida & Lin (2005) for a range of primary masses (model includes migration and disk evolution).

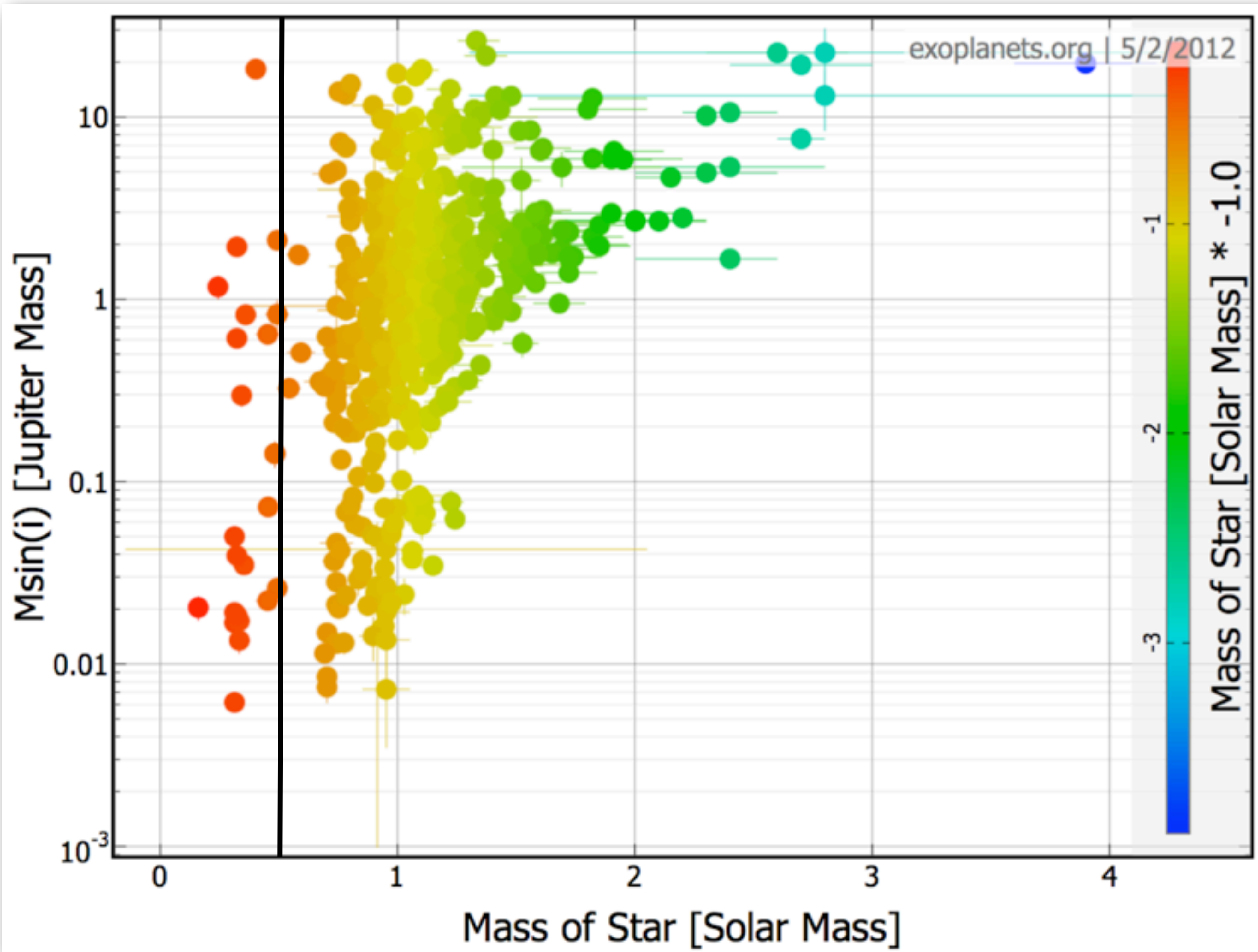
Rocky planets are common around all spectral types, whilst gas giants are only predicted in large numbers around high mass stars.

(see also Lodato et al. 2006)

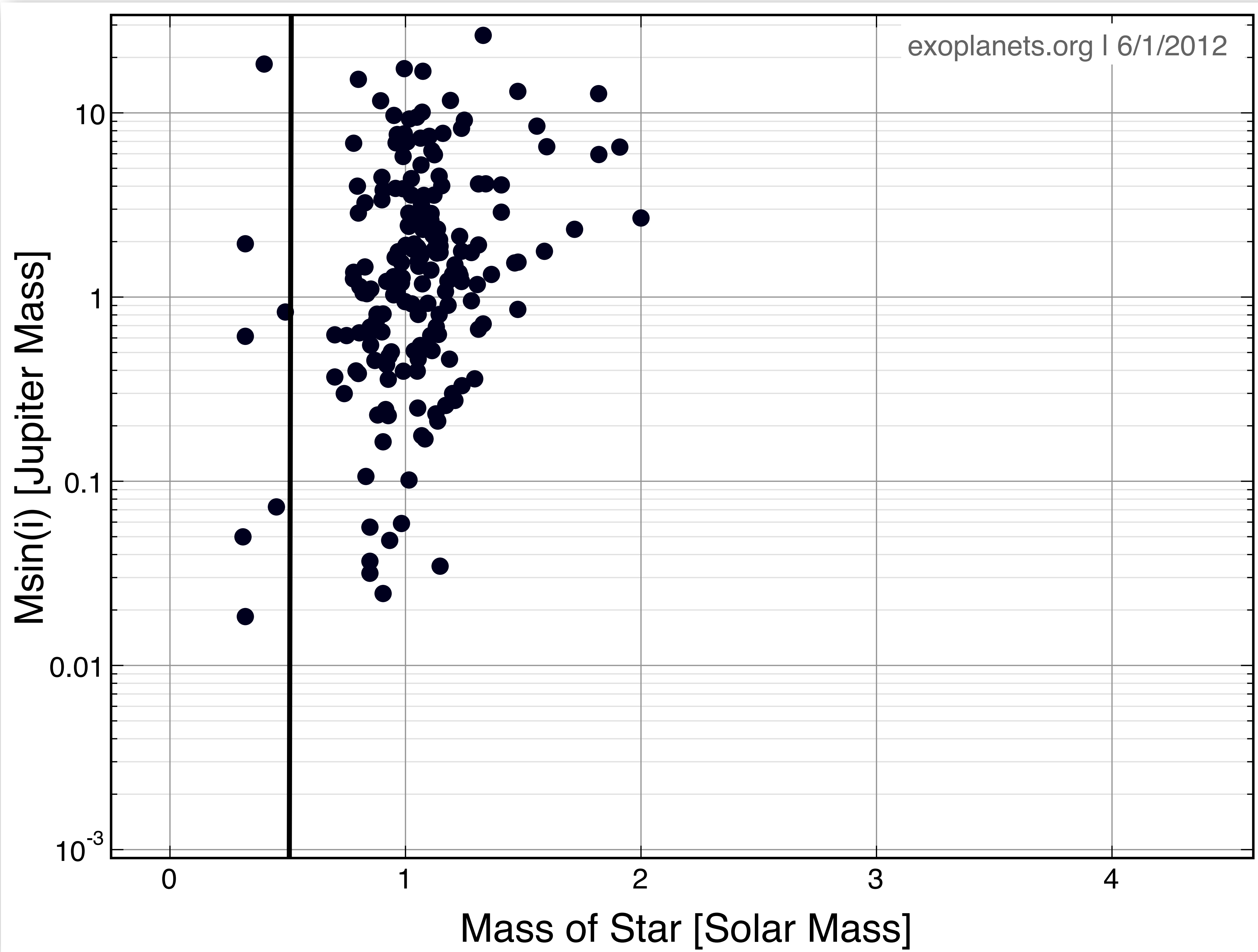
the transit method: sensitivity



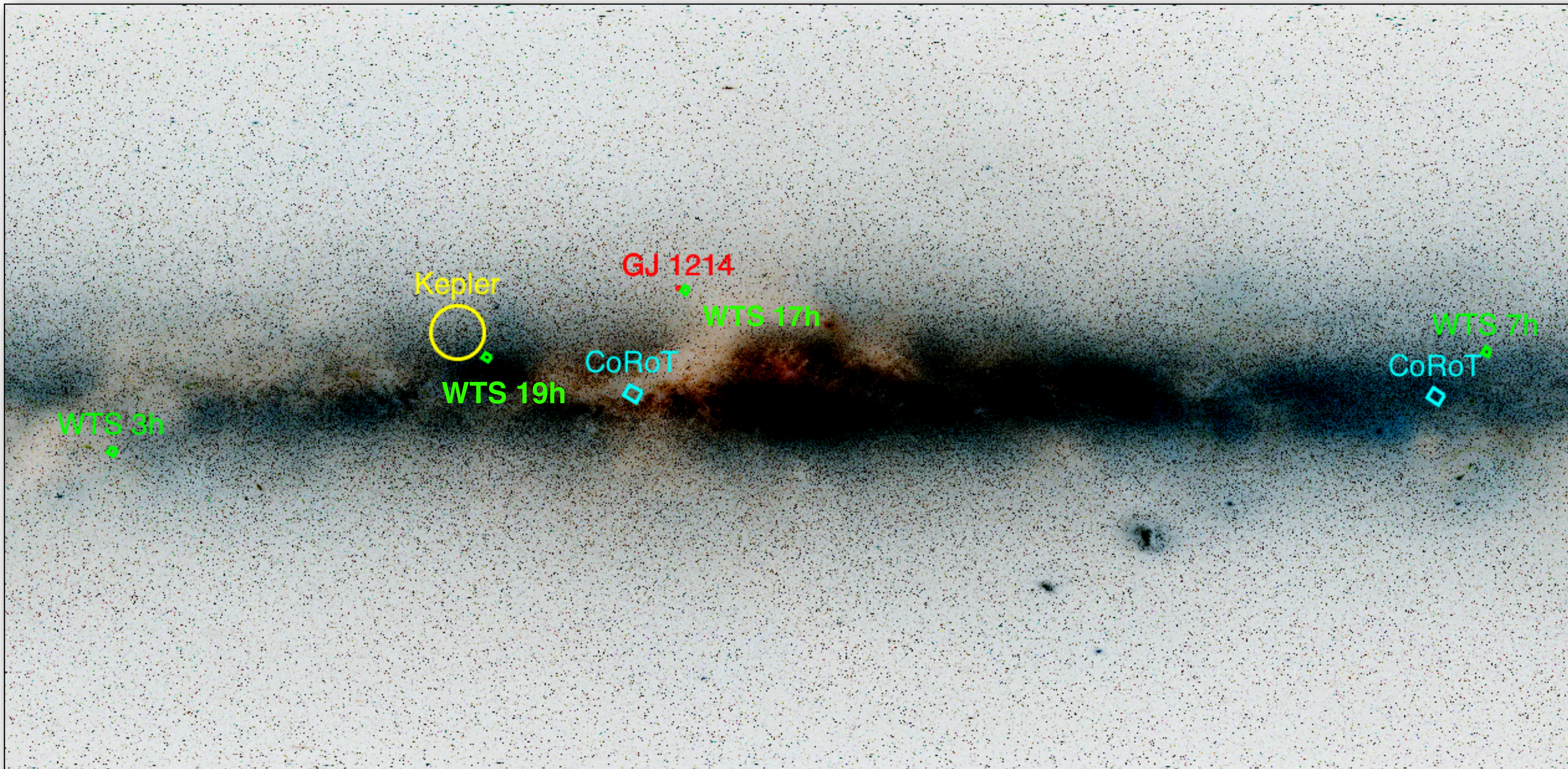
Mass of Planet hosts



Mass of Planet hosts pre-2007



4 fields with 8º<b<23º



E(B-V)<0.1
uniform RA coverage
poor seeing backup programme

requires queue-scheduling
long-term status
patience !

U/CMP/2 Progress

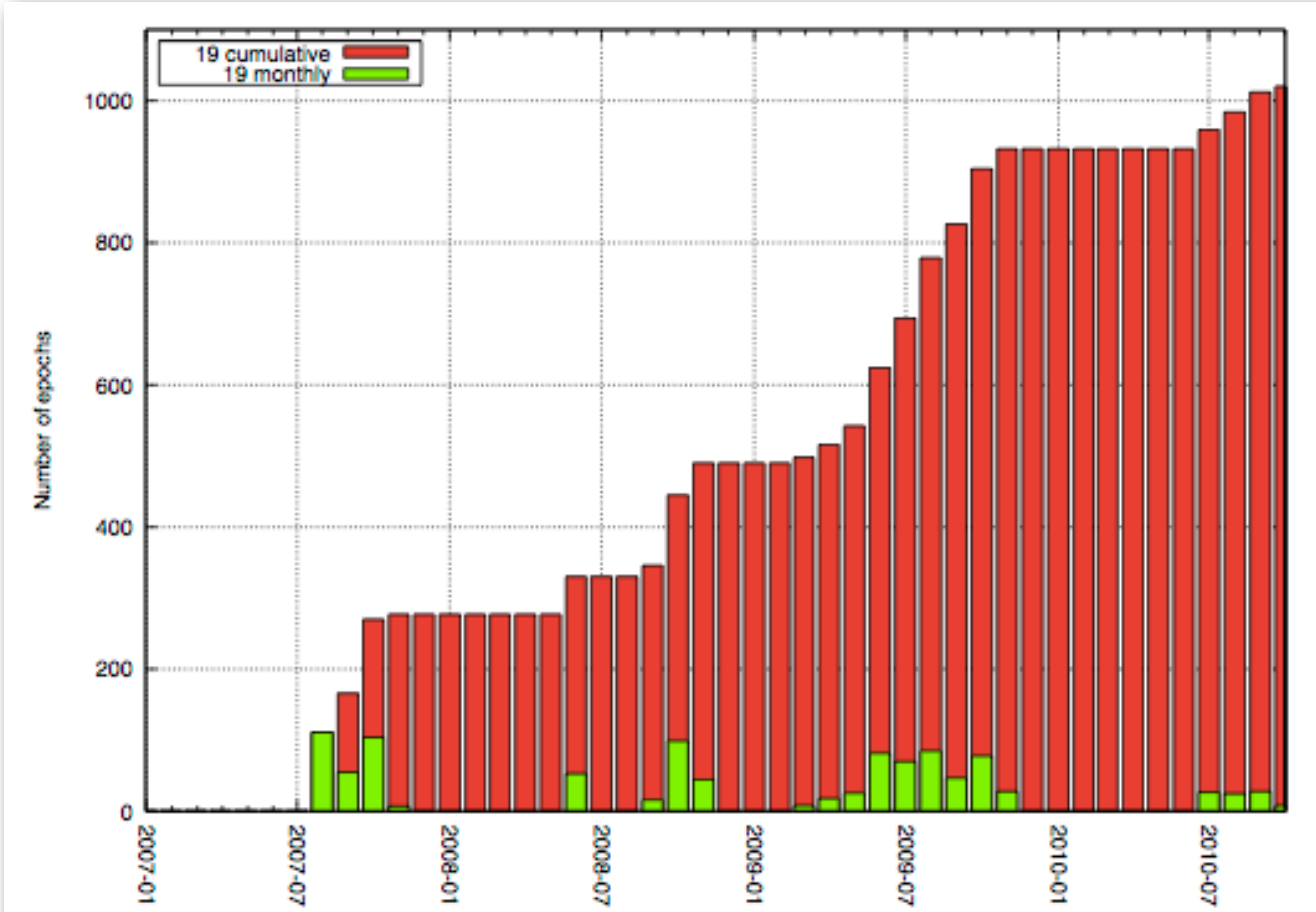
Release 4

As of ~1 month ago:

Field	Nep	ΔNep
03hr:	581	[194]
07hr:	765	[142]
17hr:	828	[122]
19hr:	1196	[52]

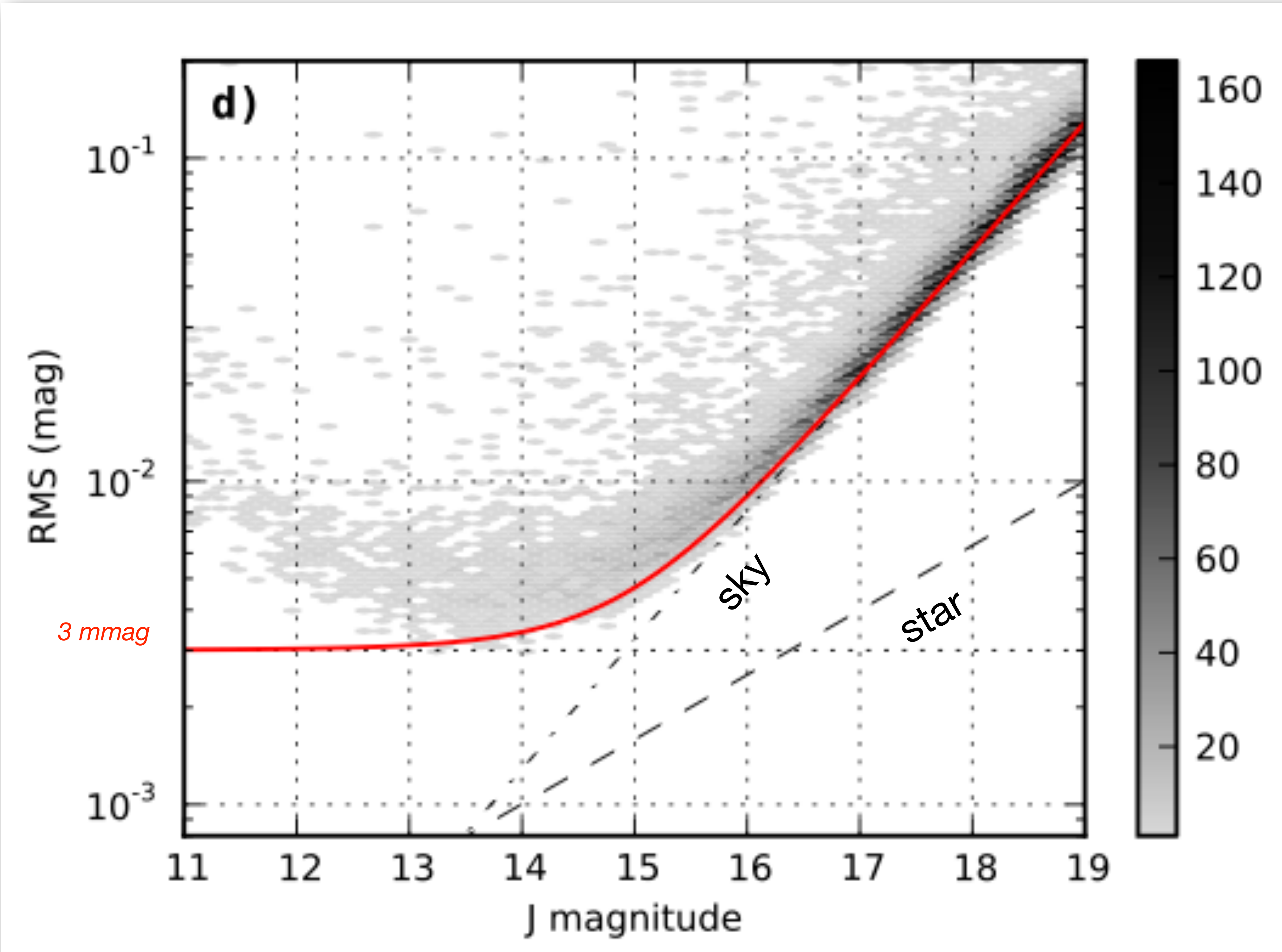
1.56 sq degs

Field	Exp/star
03hr:	14.5h
07hr:	19h
17hr:	21h
19hr:	30h



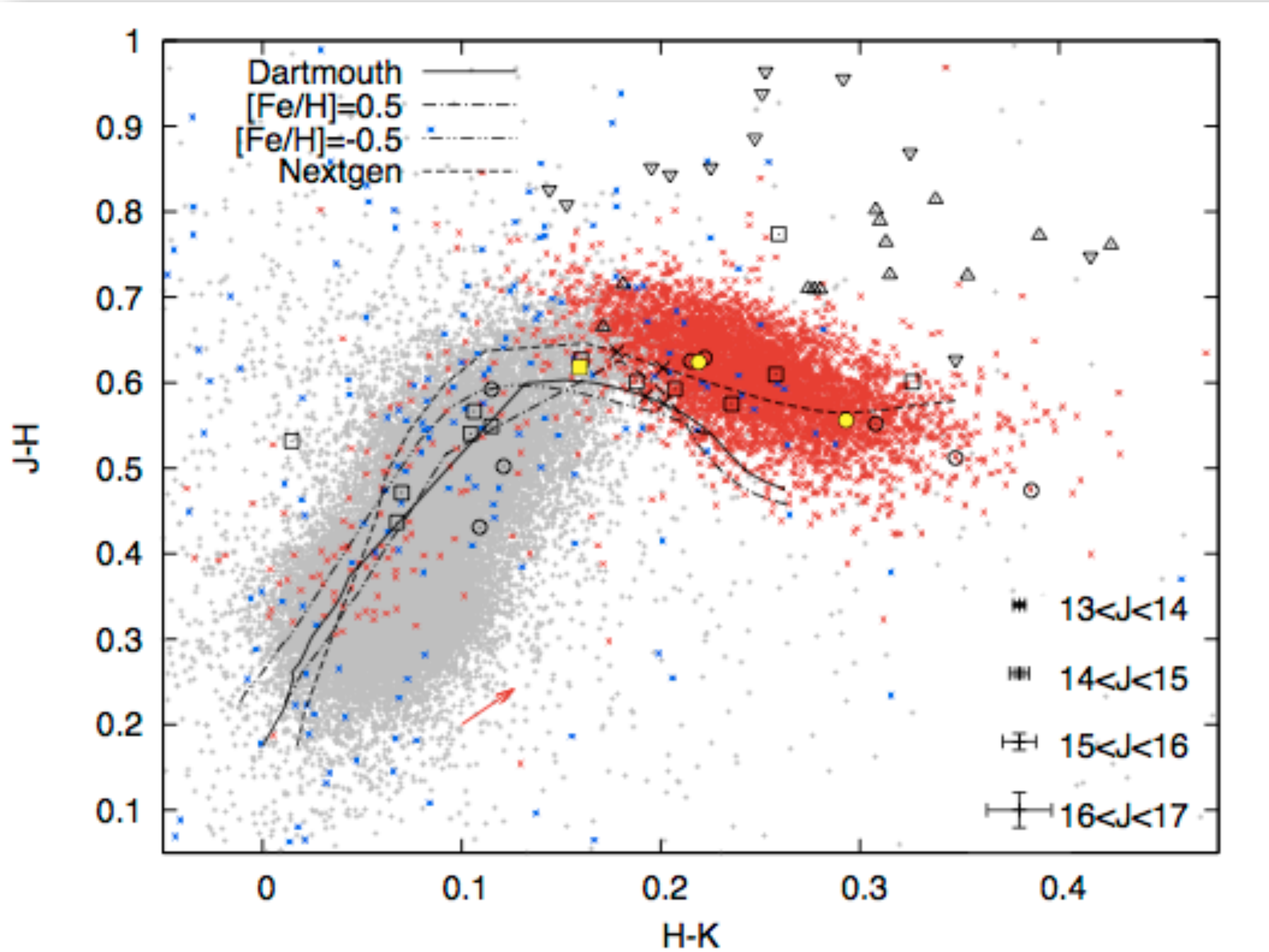
WTS total on sky exposure: 84.5h x 8 = 676h
WTS total time used = 898.6h (75% efficient)

Noise



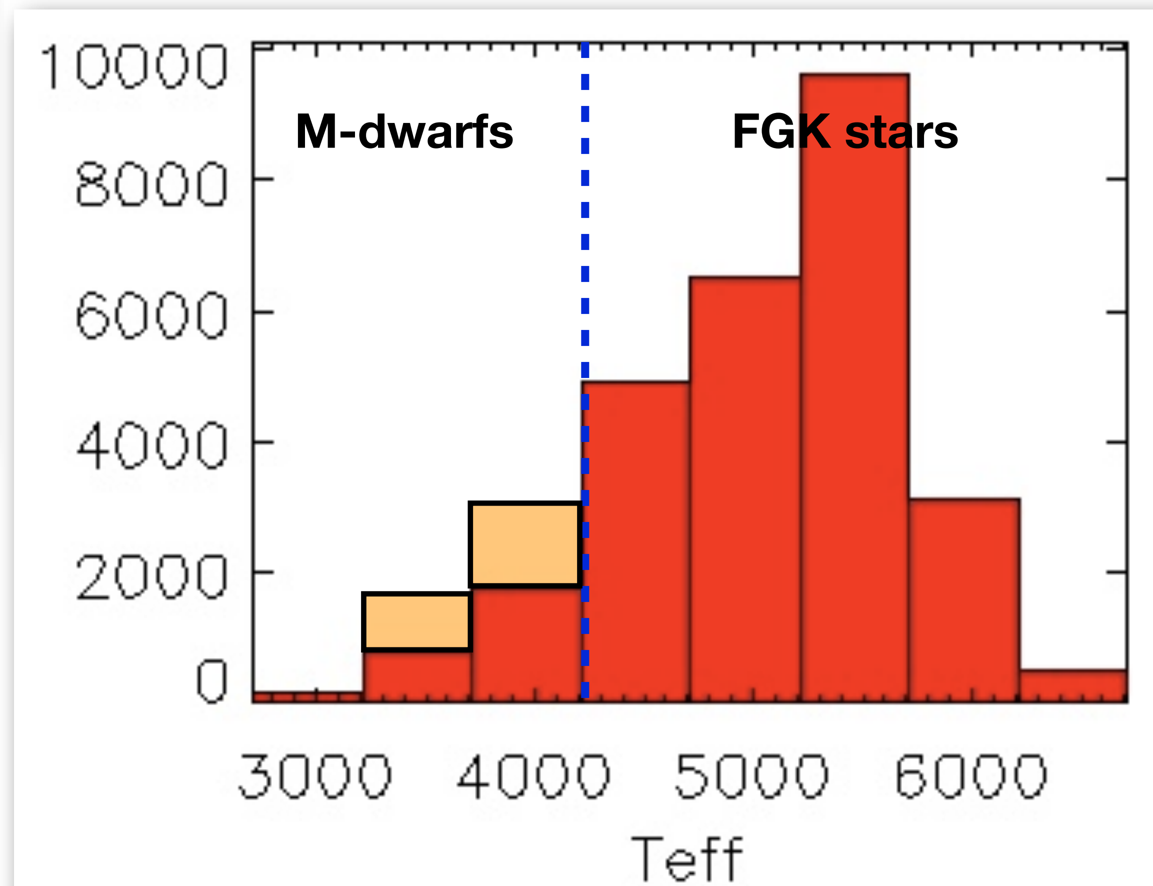
d)
10^{-1}
10^{-2}
10^{-3}
RMS (mag)
3 mmag
sky
star
11
12
13
14
15
16
17
18
19
J magnitude
160
140
120
100
80
60
40
20

M Dwarf selection in WTS



Temp (K)	N_{stars}	corr.	N_{pl}	N_{aug}	f	$f_{95\%}$
3600–4100	1086	1.00	0	0		.04
4100–4600	1773	0.88	0	0		.027
4600–5100	6029	0.79	1	14.5	.003	
5100–5600	18935	1.00	6	55.2	.003	
5600–6100	31407	1.00	20	197.0	.006	
6100–6600	11808	0.88	3	24.9	.002	
6600–7100	2302	0.76	1	3.0	.002	

Table 7. Total number of stars (N_{stars}) in Kepler Q2 temperature bins, their corresponding correction (corr.) factors (see text), number of Jupiter size short period planets (N_{pl}), their augmented contribution (Naug) and the occurrence ratio (f) or upper limit ($f_{95\%}$).



4600 Mdwarfs to J=17 in 19hr field
Teff based on SED fitting to *ugriz*ZYJHK photometry (NextGEN, Dartmouth)

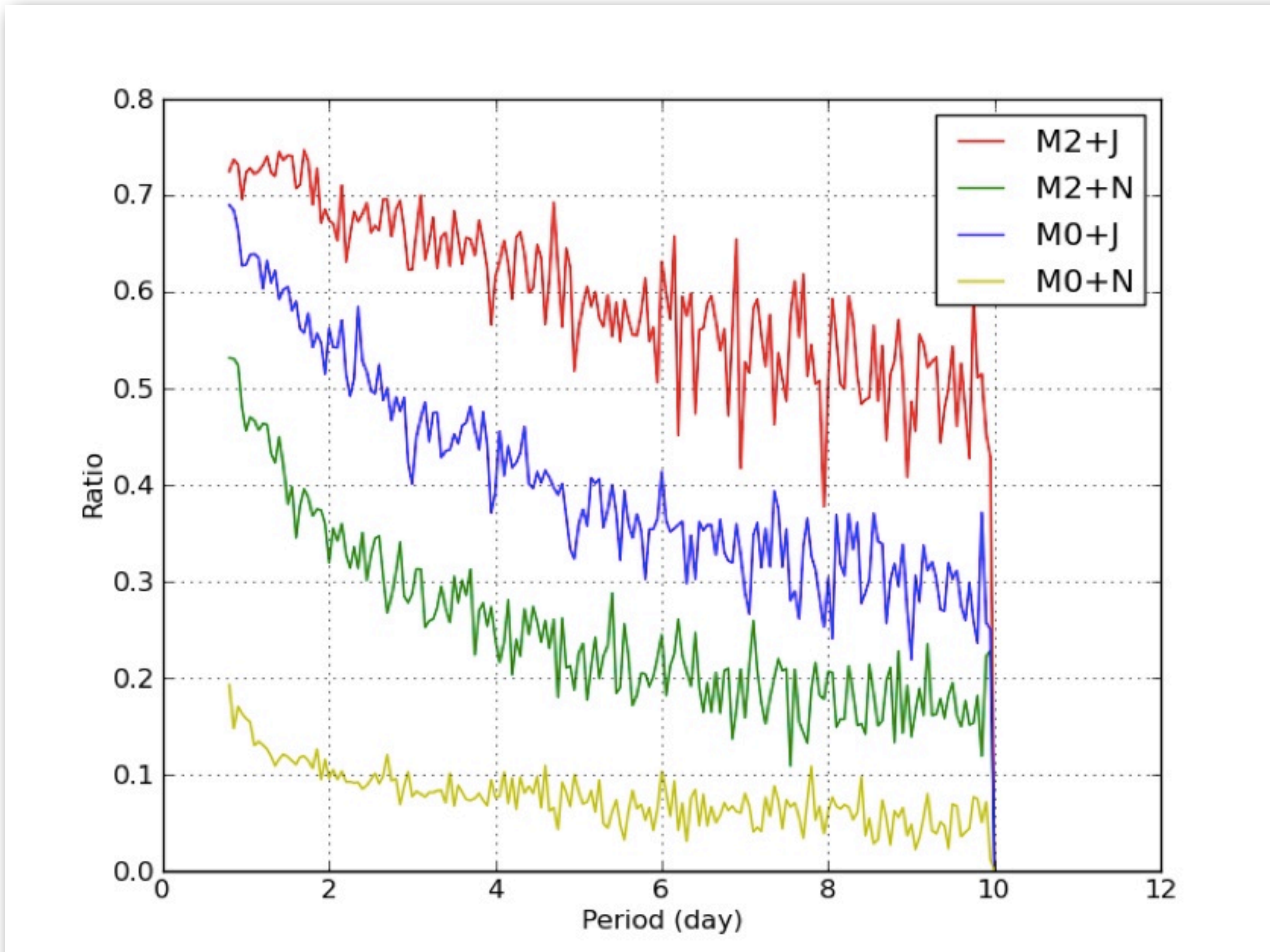
Sensitivity Analysis

Insert transit signals into real data

Includes all the noise, systematics, detection difficulties

Monte Carlo approach:

- sample of flat M dwarf lightcurves
- drawing system parameters (lc, period, offset, inclination)
- calculate transit shape, add to lightcurve

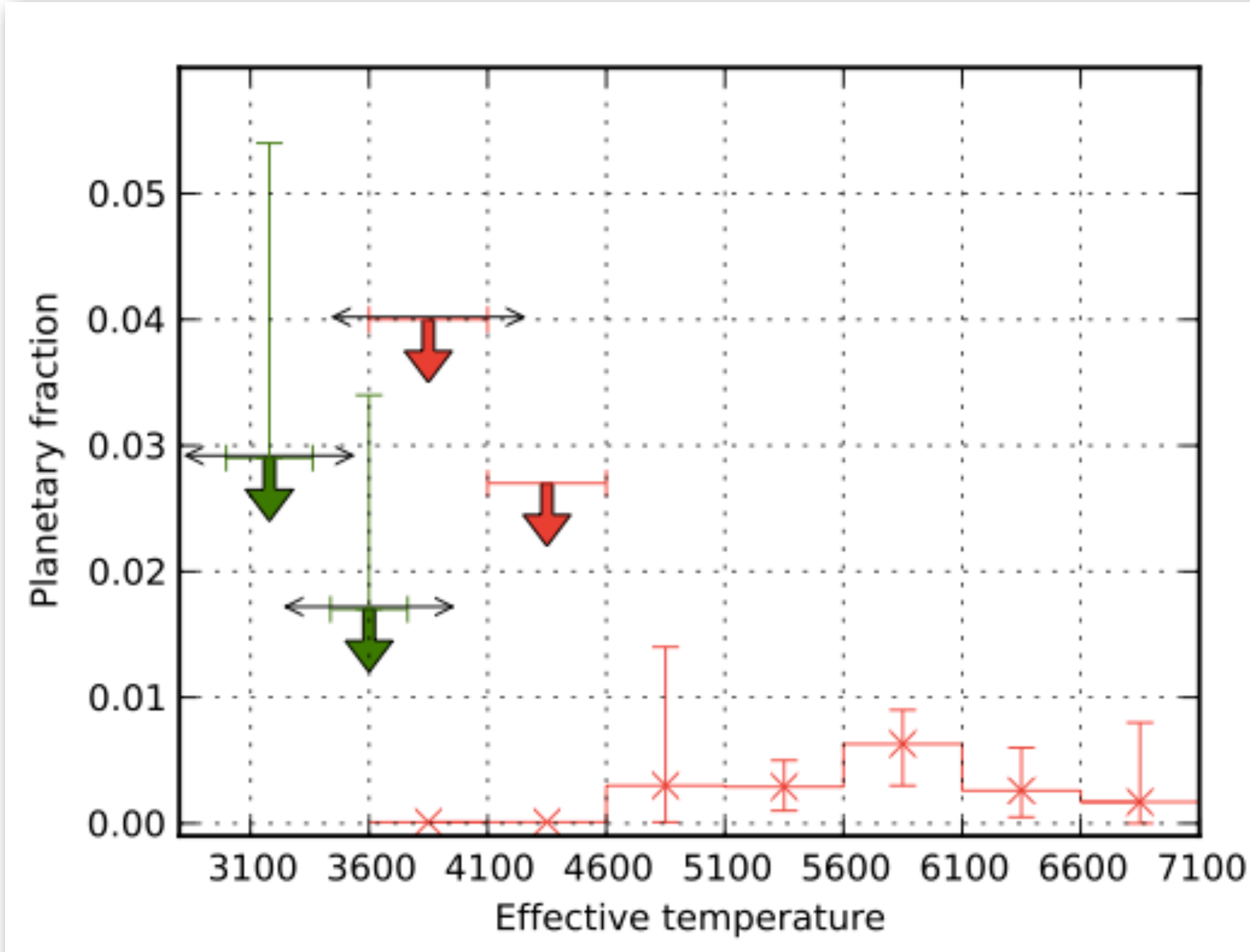


Sensitivity Analysis Results

P<10 days
J<17
Optimistic*

M0+Jup: <0.03
M2+Jup: <0.04

M0+Nep: <0.16
M2+Nep: <0.11

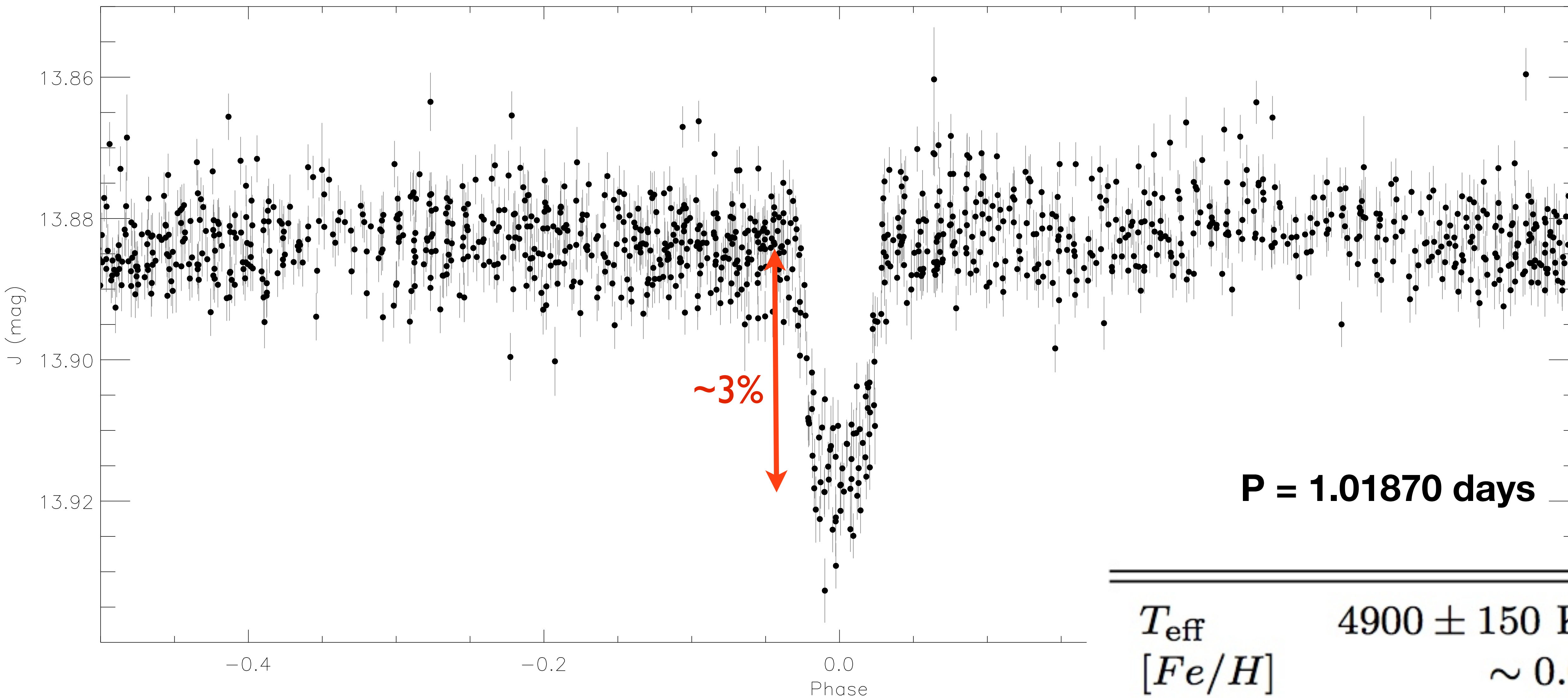


*Assumptions: precise recovered period not required, Prior N(*p*) uniform in *p*.
Note figure shows *N(p)* α *1/p*

Discovery of a short period planet

WTS-2 b (J =13.87 mag, i =15.15 mag, ~K3V)

Birkby et al. in prep

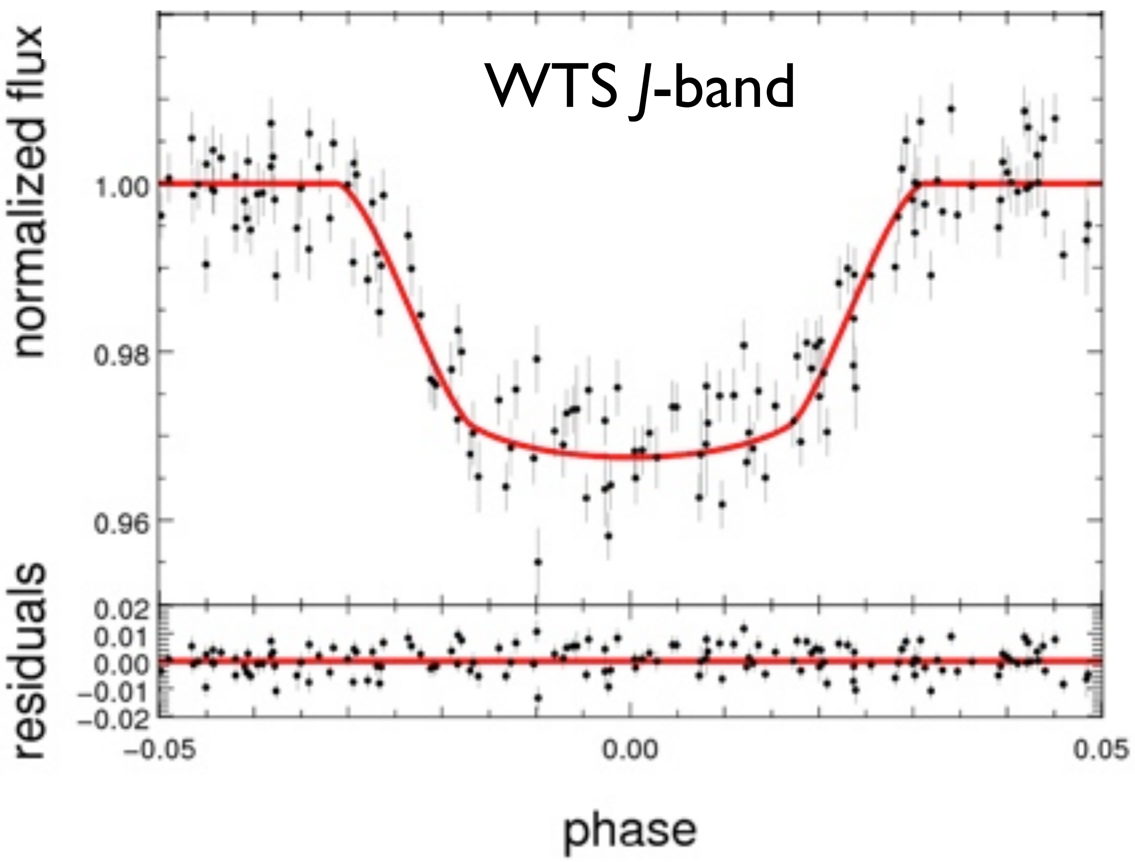


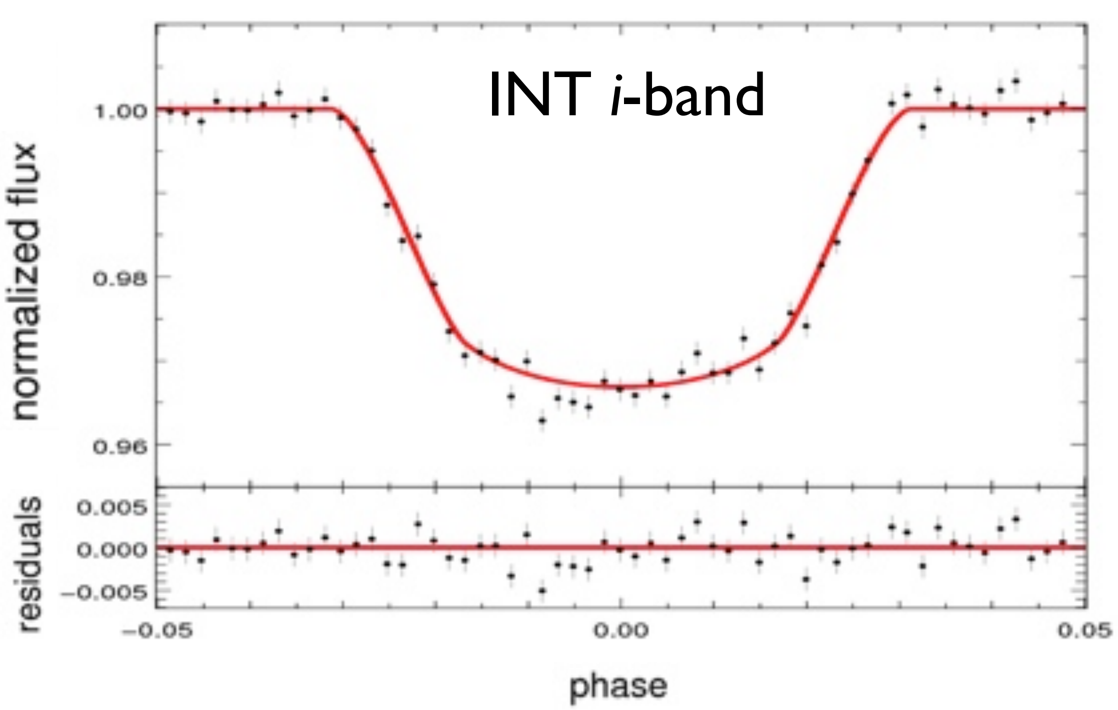
$T_{\rm eff}$	4900 ± 150 K
$[Fe/H]$	~ 0.0
$\log(g)$	4.4
$v \sin i$	$\lesssim 5$ km/s
$P_{\rm rot}$	$\gtrsim 8$ days

$\rho_\star$ = 2.1 g/cm^3 (Seager & Mallen-Ornelas, 2003)

$\rho_{0.85M_\odot}$ = 2.2 g/cm^3 (Baraffe et al. 1998)

WTS-2b: Light Curves





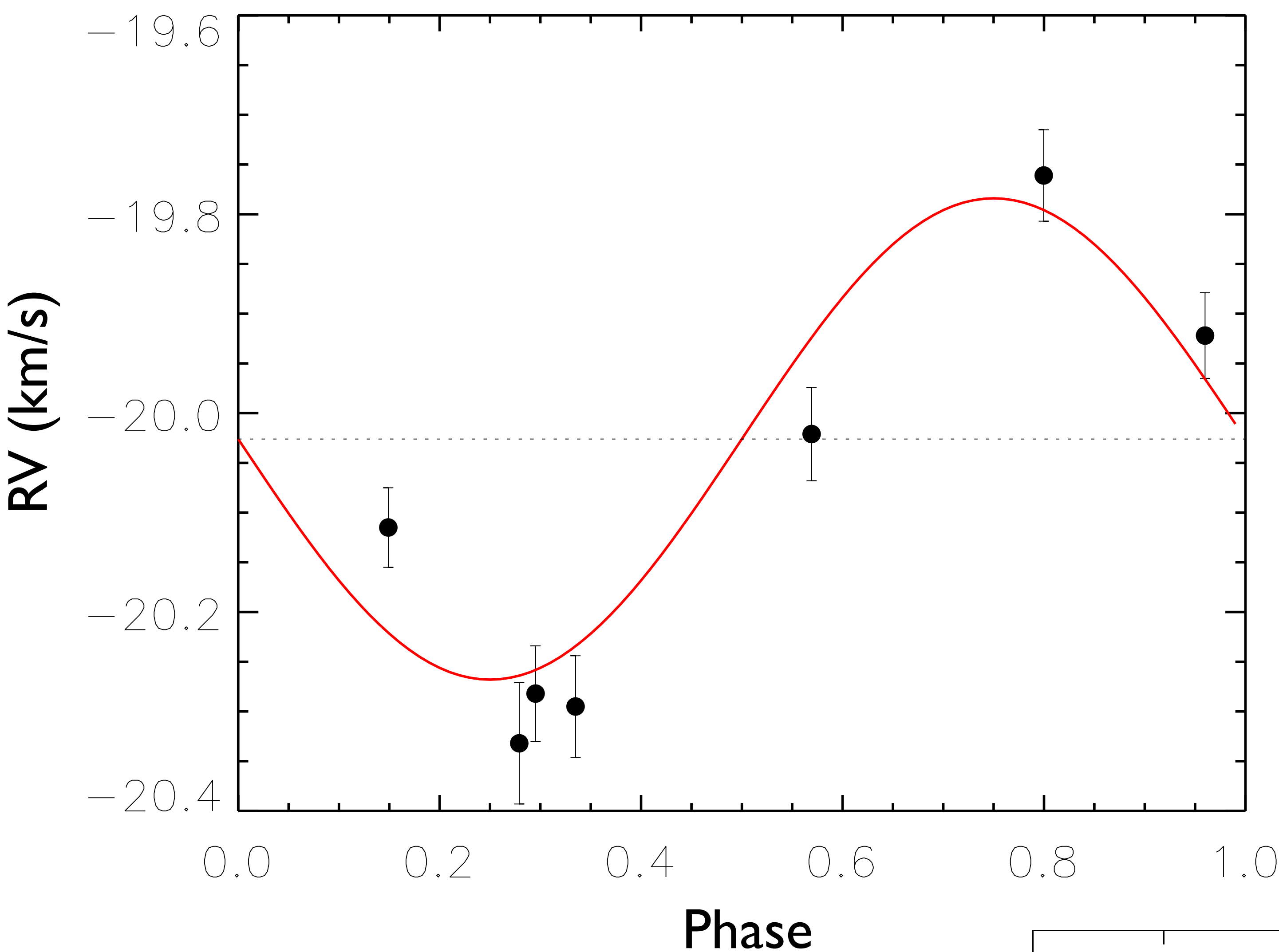
Simultaneous MCMC fitting of *J* and *i*-band with the Mandel & Agol models

Parameter	
P (days)	$1.0187070^{+4.10e-07}_{-5.07e-07}$
T_0 (HJD)	$2454317.81308^{+0.00048}_{-0.00039}$
e	0 (fixed)
i (°)	$82.99^{+0.41}_{-0.36}$
$R_P/R_\star$	$0.1751^{+0.0013}_{-0.0014}$
R_P (R_J)	$1.3564^{+0.0361}_{-0.0384}$
$R_\star$ ($R_\odot$)	$0.794^{+0.016}_{-0.017}$
$\bar{\rho}_\star$ ($\rho_\odot$)	$1.697^{+0.117}_{-0.101}$
b	$0.617^{+0.019}_{-0.023}$
a(AU)	0.01877
Duration (hrs)	1.540
$M_\star$ ($M_\odot$)	0.85 (fixed)

Evidence *against* a blended background eclipsing binary:
- Consistent transit depths between J and *i*-band
- Consistent stellar density from the light curve and spectroscopy

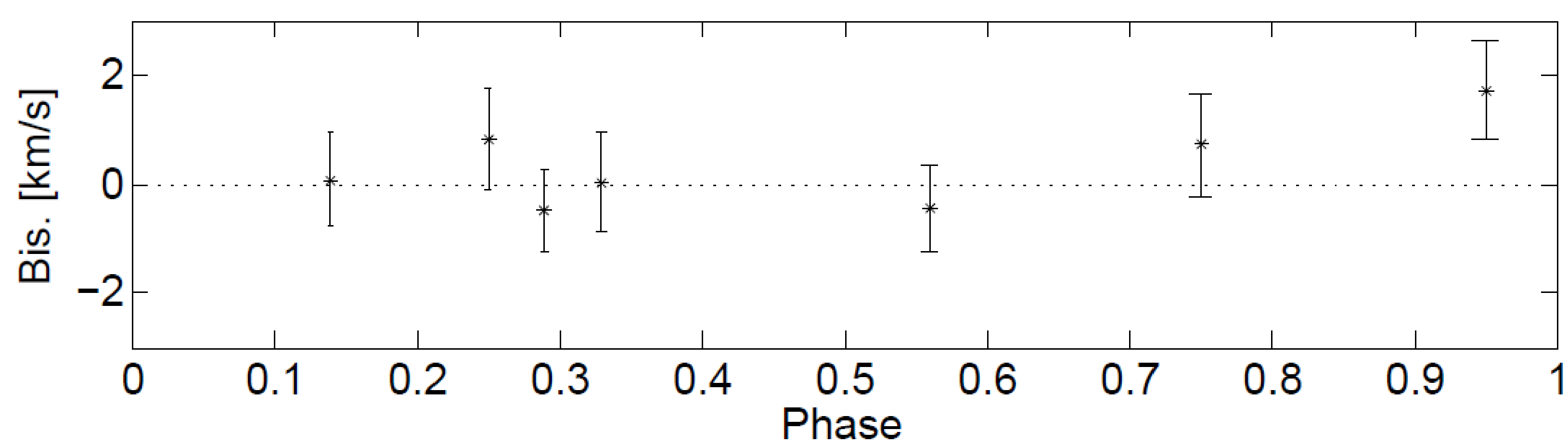
WTS-2b: Radial Velocities

HET Spectroscopy

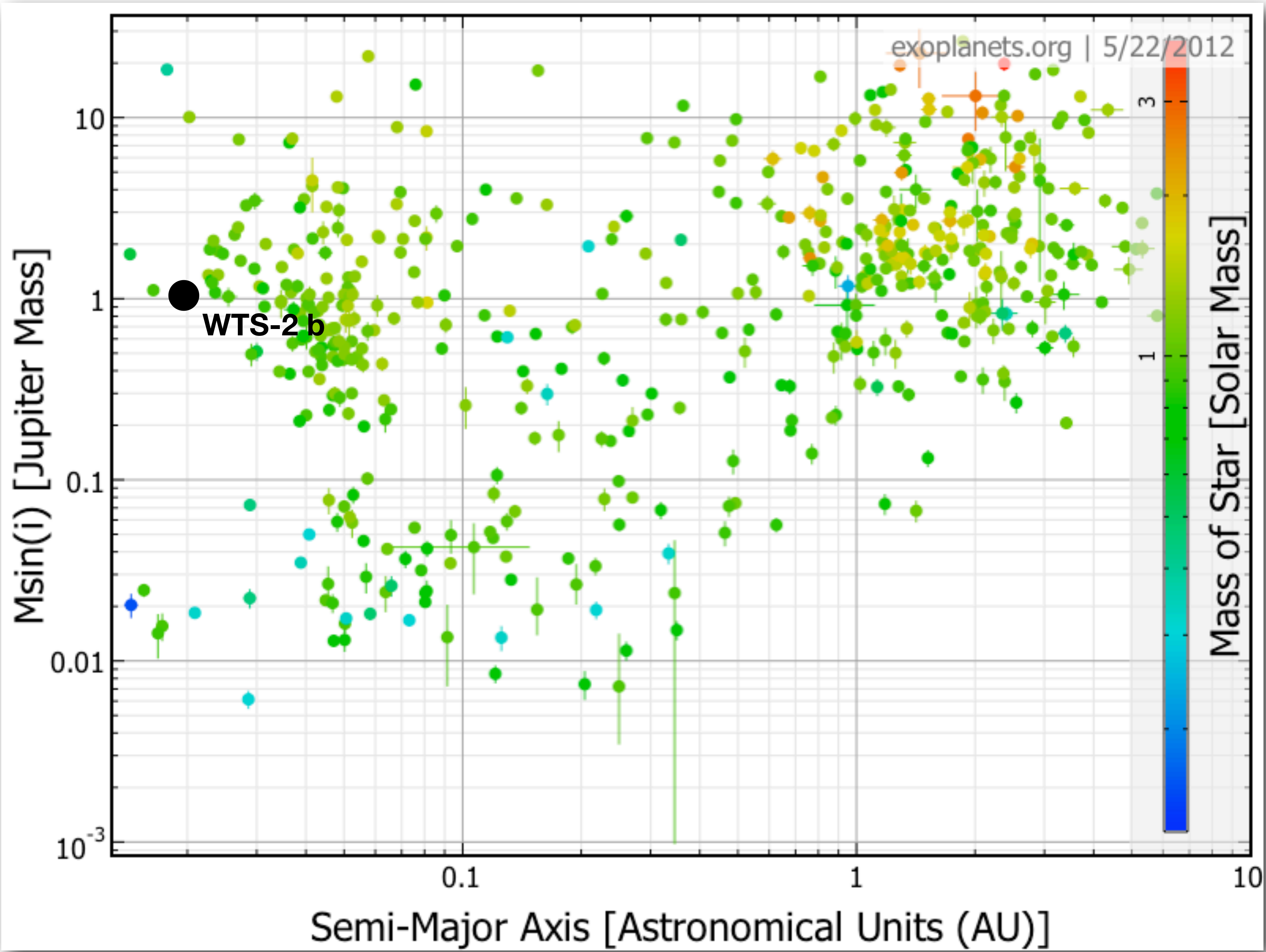


Parameter	
K (km/s)	-0.242 ± 0.027
$V_{\rm sys}$ (km/s)	-20.026 ± 0.021
e	0 (fixed)
$M_{\rm P}$ ($M_{\rm J}$)	1.08 ± 0.11
$\rho_{\rm P}$	$0.43\rho_{\rm J}$
χ^2_ν	1.46

No correlation between bisectors and phase within the errors - further evidence *against* a blended background eclipsing binary



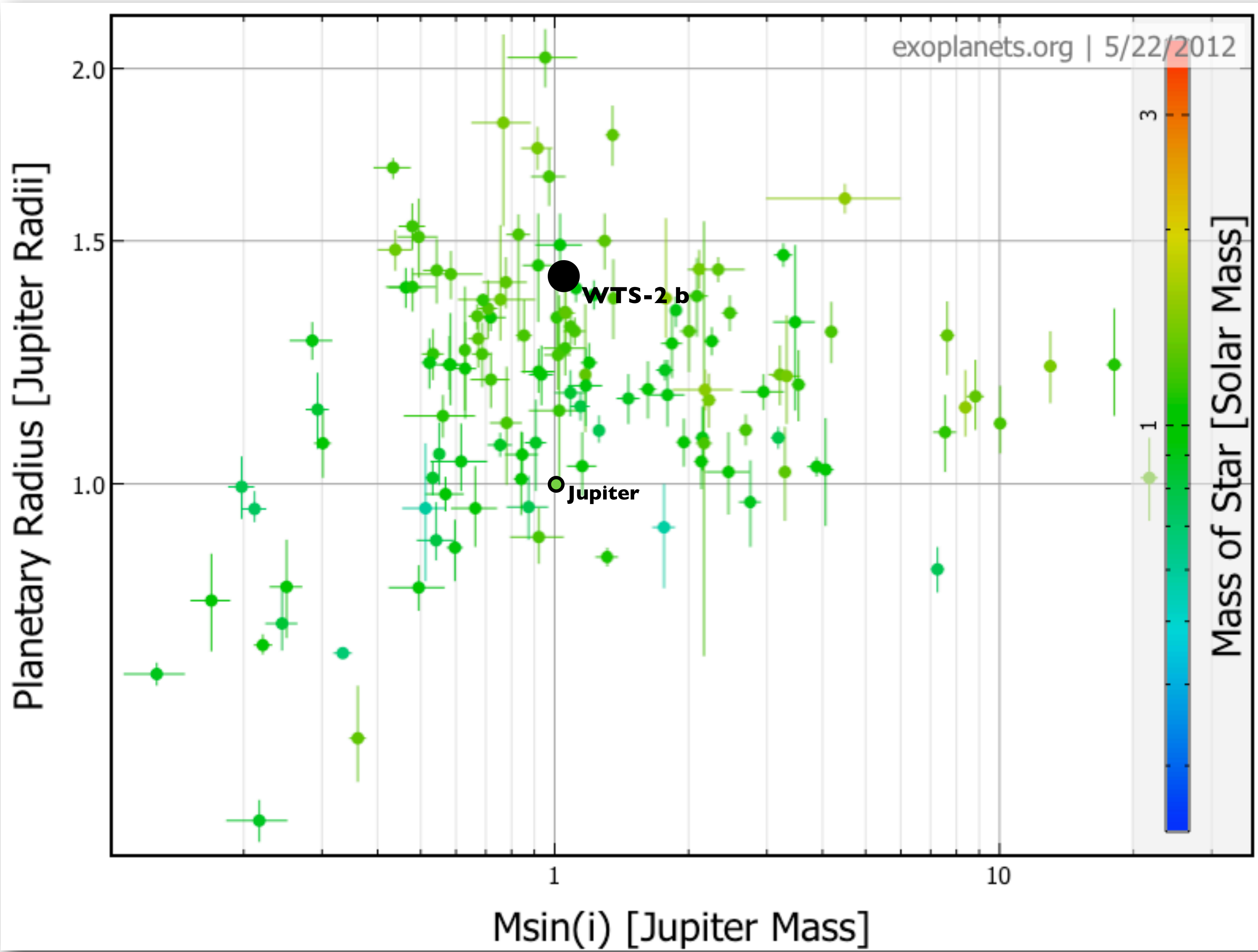
WTS-2b: close in



WTS-2 b

$R_P = 1.3564\ R_J$
$M_P = 1.08\ M_J$
$\rho_P = 0.43\ \rho_J$
$P = 1.018707$ days
$a = 0.01877$ AU

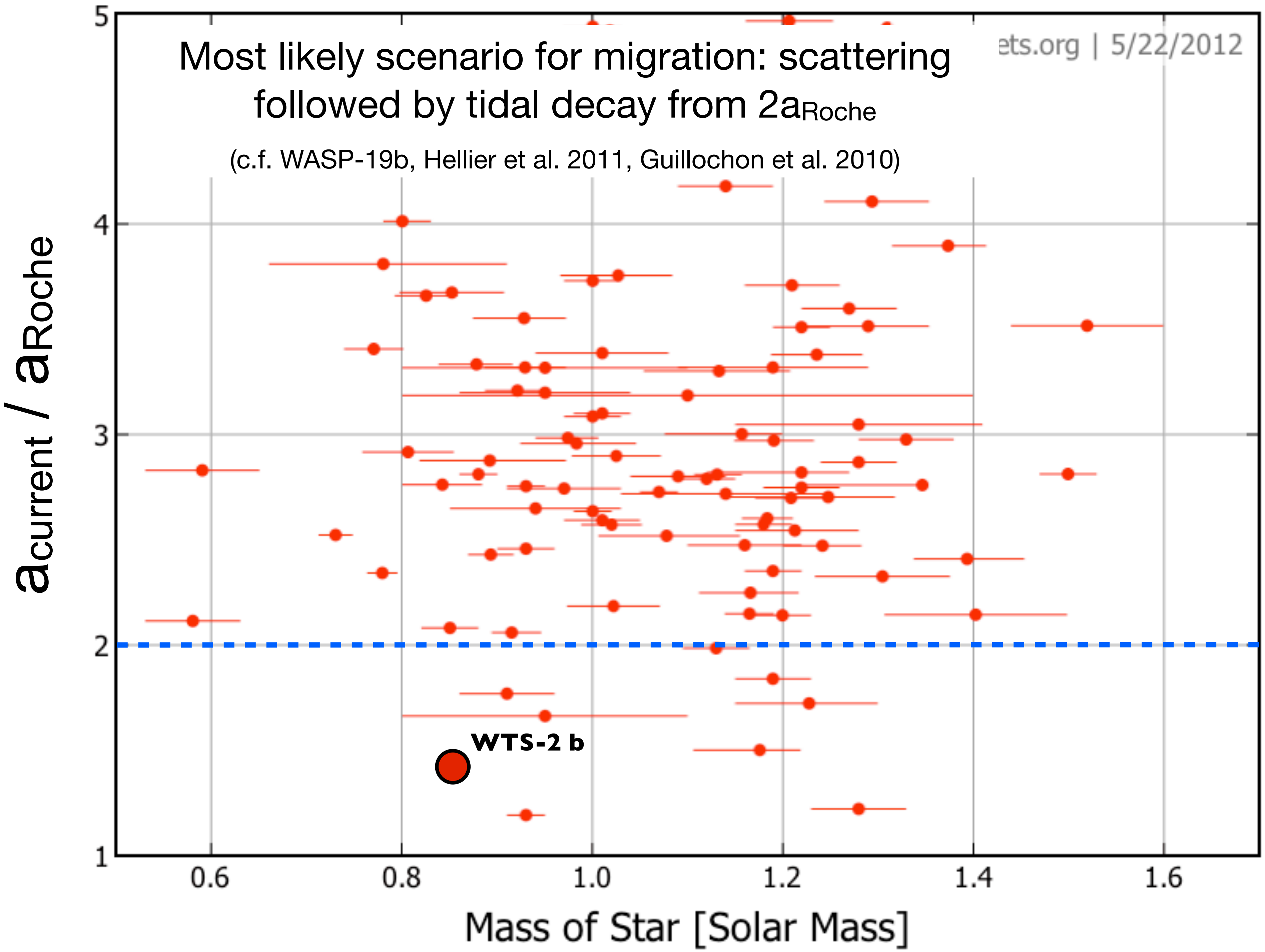
WTS-2b: inflated radius



WTS-2 b

$R_P = 1.3564\ R_J$
$M_P = 1.08\ M_J$
$\rho_P = 0.43\ \rho_J$
$P = 1.018707$ days
$a = 0.01877$ AU

Planetary Parameter Space

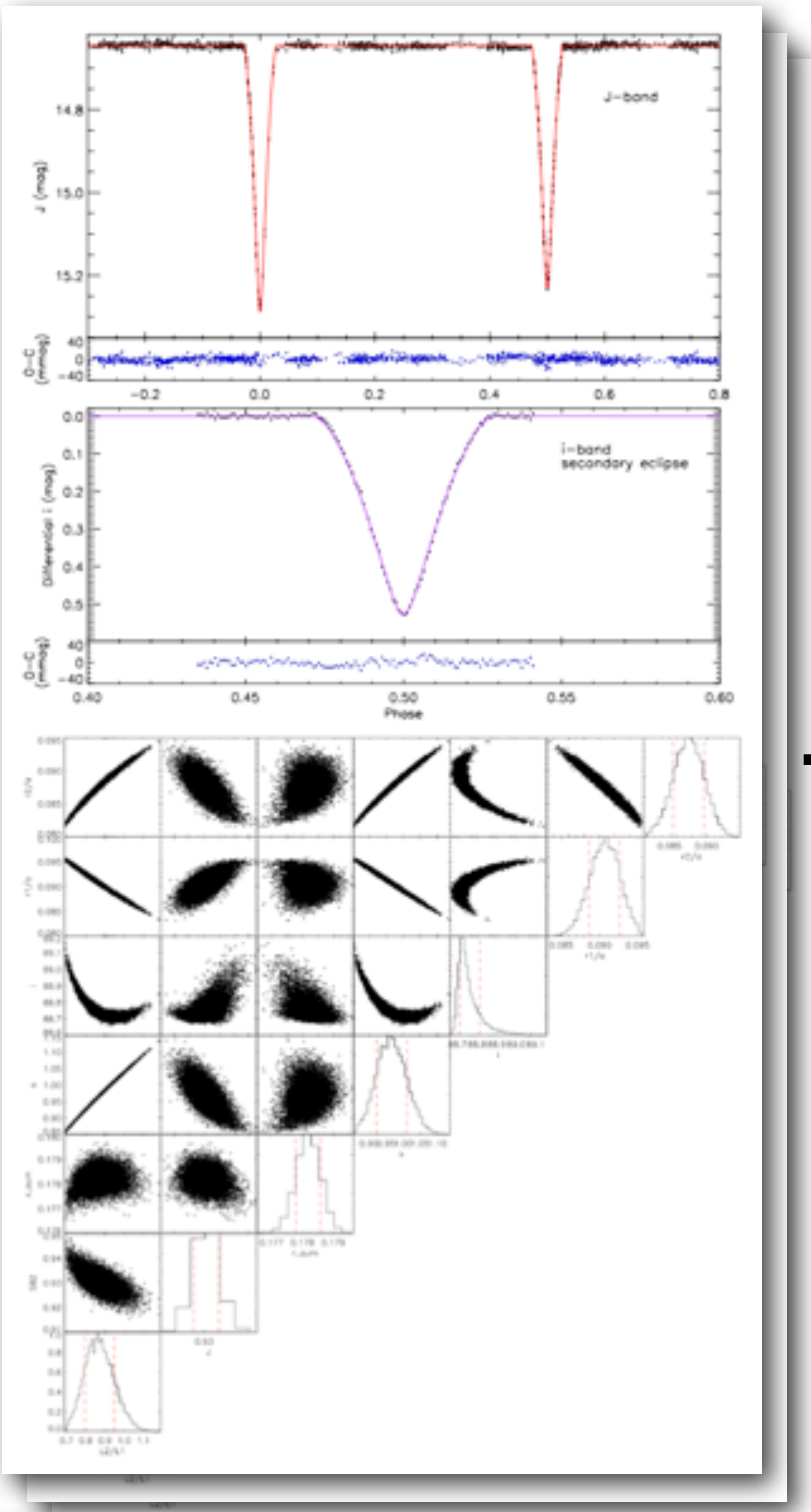


WTS-2 b

$$R_P = 1.3564\ R_J$$
$$M_P = 1.08\ M_J$$
$$\rho_P = 0.43\ \rho_J$$
$$P = 1.018707 \text{ days}$$
$$a = 0.01877 \text{ AU}$$

WTS-2 b: $a=1.43\ a_{Roche}$

Eclipsing Binaries



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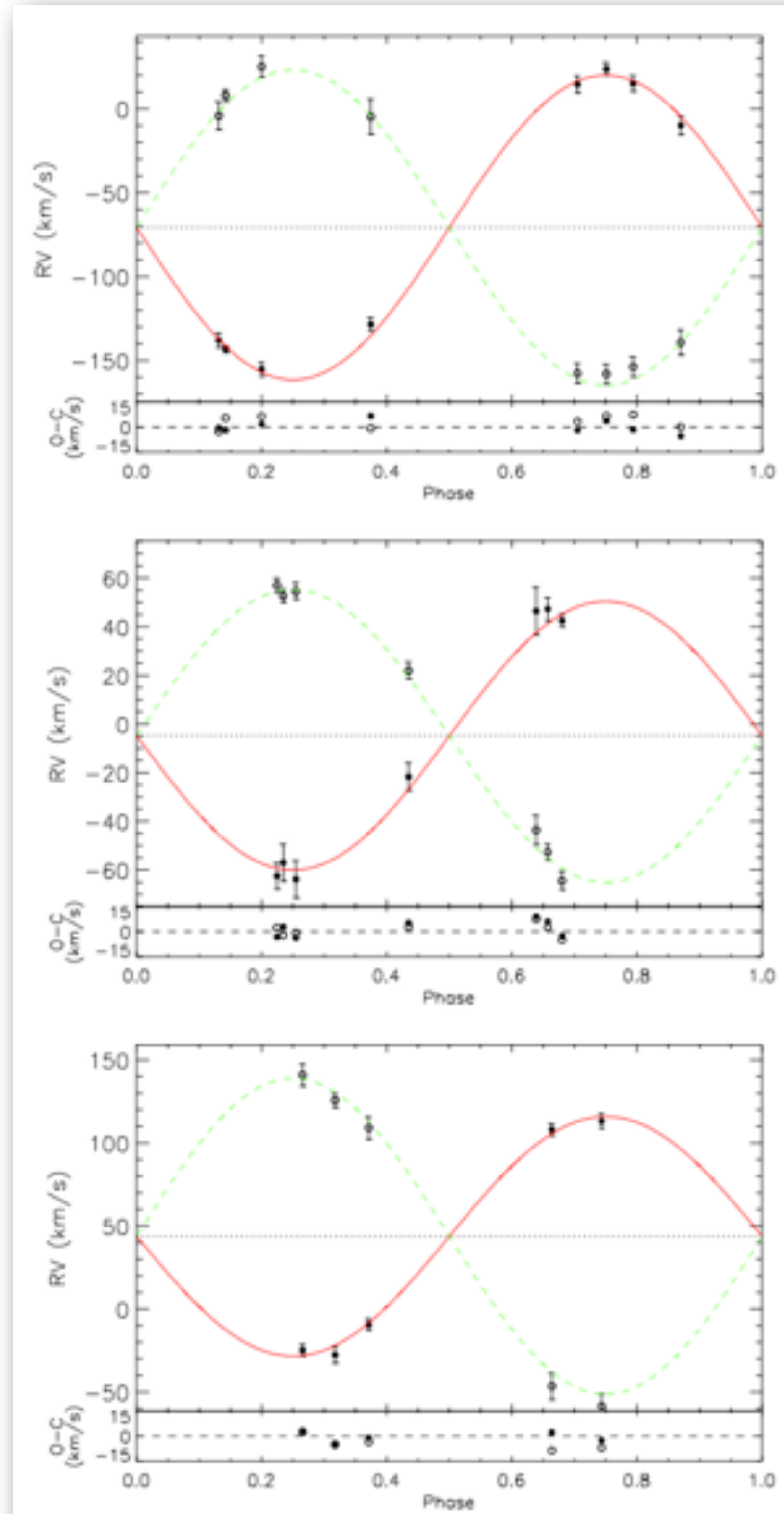

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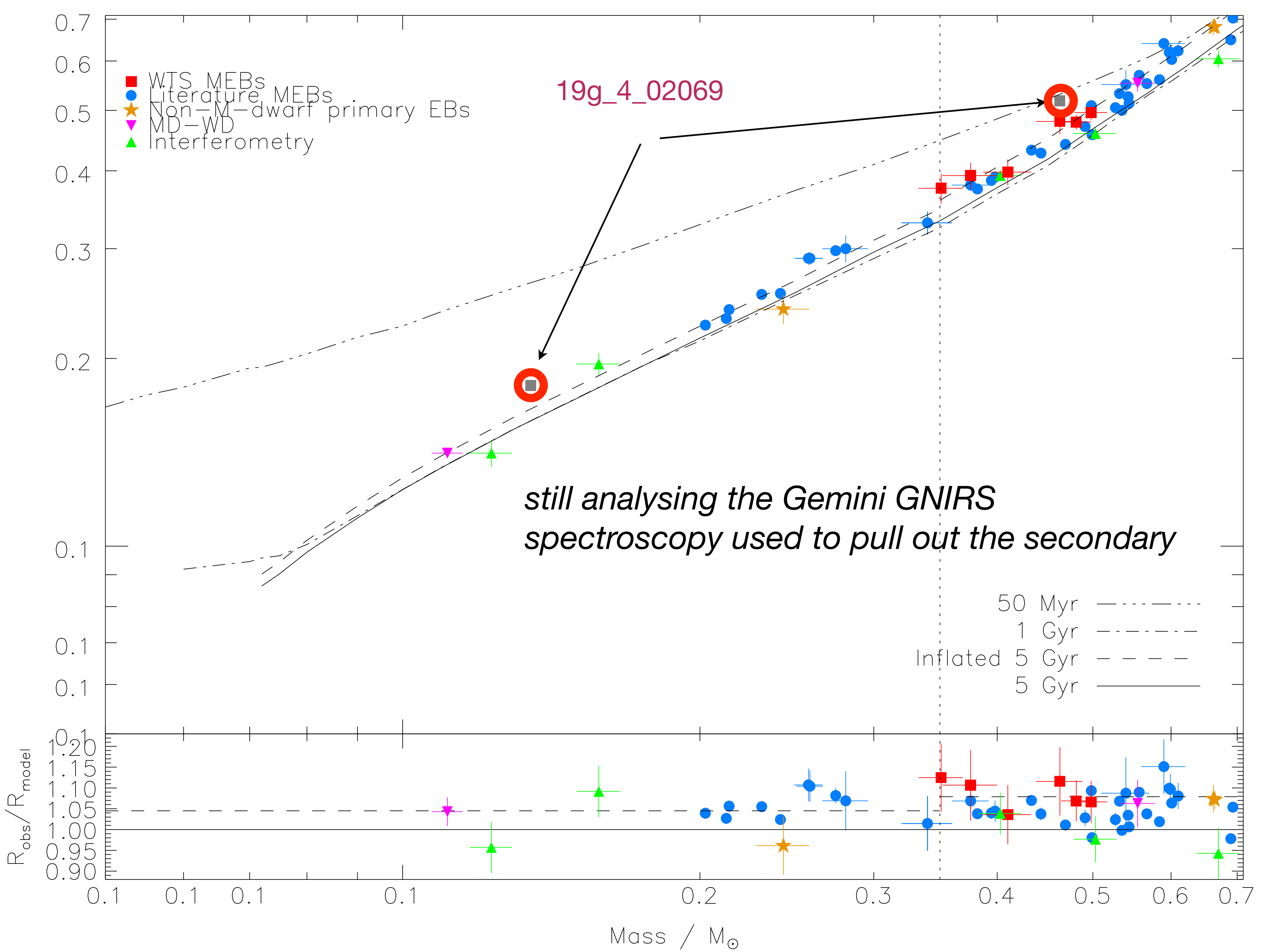
Parameter	19b-2-01387	19c-3-01405	19e-3-08413
M_1 ($M_\odot$)	0.498 ± 0.019	0.410 ± 0.023	0.463 ± 0.025
M_2 ($M_\odot$)	0.481 ± 0.017	0.376 ± 0.024	0.351 ± 0.019
R_1 ($R_\odot$)	0.496 ± 0.013	0.398 ± 0.019	0.480 ± 0.022
R_2 ($R_\odot$)	0.479 ± 0.013	0.393 ± 0.019	0.375 ± 0.020
a ($R_\odot$)	5.474 ± 0.083	11.27 ± 0.27	5.54 ± 0.12
$\log(g_1)$ (cm/s^2)	4.745 ± 0.039	4.851 ± 0.055	4.742 ± 0.053
$\log(g_2)$ (cm/s^2)	4.760 ± 0.035	4.825 ± 0.064	4.834 ± 0.051
$T_{\rm eff,1}$ (K)	3498 ± 100	3309 ± 130	3506 ± 140
$T_{\rm eff,2}$ (K)	3436 ± 100	3305 ± 130	3338 ± 140
$L_{\rm bol,1}$($L_\odot$)	0.0332 ± 0.0042	0.0172 ± 0.0031	0.0314 ± 0.0058
$L_{\rm bol,2}$($L_\odot$)	0.0289 ± 0.0037	0.0166 ± 0.0031	0.0167 ± 0.0033
$M_{1,\rm bol}$	8.45 ± 0.14	9.16 ± 0.20	8.51 ± 0.19
$M_{2,\rm bol}$	8.60 ± 0.14	9.20 ± 0.20	9.26 ± 0.23
$V_{\rm 1rot,sync}$ (km/s)	16.73 ± 0.45	4.08 ± 0.19	14.51 ± 0.55
$V_{\rm 2rot,sync}$ (km/s)	16.73 ± 0.45	4.01 ± 0.20	11.31 ± 0.70
$t_{\rm sync}$ (Myrs)	0.05	6.3	0.1
$t_{\rm circ}$ (Myrs)	2.6	1480	4.0
$d_{\rm adopted}$ (pc)	545 ± 29	645 ± 53	610 ± 52
U (km/s)	-63.6 ± 7.0	-2.4 ± 9.0	30.9 ± 8.6
V (km/s)	1.0 ± 7.8	1.3 ± 12.2	-10.2 ± 11.8
W (km/s)	-37 ± 6.4	-4.2 ± 8.5	30.1 ± 8.1

4 Eclipsing Binaries in the WTS



Papers

Discovery and characterisation of detached M-dwarf eclipsing binaries in the WFCAM Transit Survey

Jayne Birkby[1,2*], Bas Nefs[2], Simon Hodgkin[1], Gabor K
Ignas Snellen[2], Patricia Cruz[4], Niall Goulding[3]
Hristo Stoev[4], David Pinfield[3], David B
Nicolas Lodieu[7], Yakiv Pavlenko[8]

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[2] Leiden Observatory, Leiden U
[3] Centre for Astrophysics
[4] Calar Alto Obser
[5] Max-Planck
[6] Cen

J band Variability of M Dwarfs in the WFCAM Transit Survey

N. T. Goulding[1] et al.
[1] Centre for Astrophysic

A sensitivity analysis of the WFCAM Transit Survey for short-period giant planets around M dwarfs

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rado[3], J. Birkby[4], M. Cappetta[5], P. Cruz[3], J. Koppenhöfer[5], E. Martín[6],
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28850 Torrejón de Ardoz, Madrid, Spain
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Four ultra-short period eclipsing M-dwarf binaries in the WFCAM Transit Survey.

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[1] Leiden Observatory, Leiden University, Niels Bohrweg 2,
[2] Institute of Astronomy, University of Cambridge, Madin

RoPacS network.

ABSTRA
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The first planet detected in the WTS: an inflated hot-Jupiter in a 3.35d orbit around a late F-star

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Accepted XXXX Received XXXX ; in original form XXXX

ABSTRACT
We report the dis
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WTS-2 b: a hot Jupiter in a tight orbit around a mid-K

y[1*] et al.
ry, Leiden University, Niels Bohrweg 2, 2333 CA Leiden, The Netherlands

ABSTRACT
We report the discovery of WTS-2 b, a hot Jupiter orbiting a mid K-dwarf (~K3V) in a tight 1.0187063 day orbit. It is the first planet orbiting a relatively cool star to be found with the WFCAM Transit Survey (WTS). The WTS is a large-scale, infrared photometric monitoring campaign of a vast sample of low-mass stars using the 3.8-m United Kingdom InfraRed Telescope (UKIRT). The survey operates in a unique harmony with the UKIRT observing queue schedule by only observing in relatively poor sky conditions that other programs cannot utilise. WTS-2 b joins a very small but growing sample of giant planets in very close orbits around stars less massive than the Sun, in contrast to the Kepler sample, which finds that the majority of planets around these stars are small Neptune-size objects. The short orbital period of WTS-2 b, coupled with the measured rotation period and low-mass of the host star, provides an important observational constraint on the theory of tidal evolution and the inspiral timescale for hot Jupiters, which are expected to depend on spectral type. This abstract was accepted for a talk at the National Astronomy Meeting (NAM) in Manchester, UK. I will be giving a 10 minute talk about our discovery on 29th March 2012.

Keywords

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Cool white dwarfs candidates found in the WTS fields*

S. Catalán[1], R. Napiwotzki[1], uno[3], dos[2], tres[1], and whooo[1]

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February 16, 2012

ABSTRACT

Context. d
Aims. d
Methods. d
Results. d
Conclusions. d

Key words.

Conclusions

- The WTS contains:
  - a wealth of multi-epoch photometry (3mmag at J>12, 2% at J=17)
  - and astrometry (spanning 5 years, ~10mas per epoch)
  - for 111,000 stars with J<17
  - in 4 sight lines covering 6 sq degs (total).
- Made possible only by a flexibly queue-scheduled telescope, and a community willing to support a long-term variability study
- Ground-based infrared transit surveys with irregular observing patterns are capable of finding exoplanets.
- WTS-2 b is a short-period hot Jupiter around a sub-solar mass star that challenges theory.