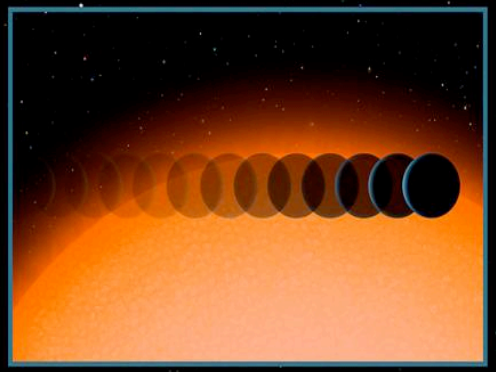
GJ 436

Michaël Gillon (Geneva)

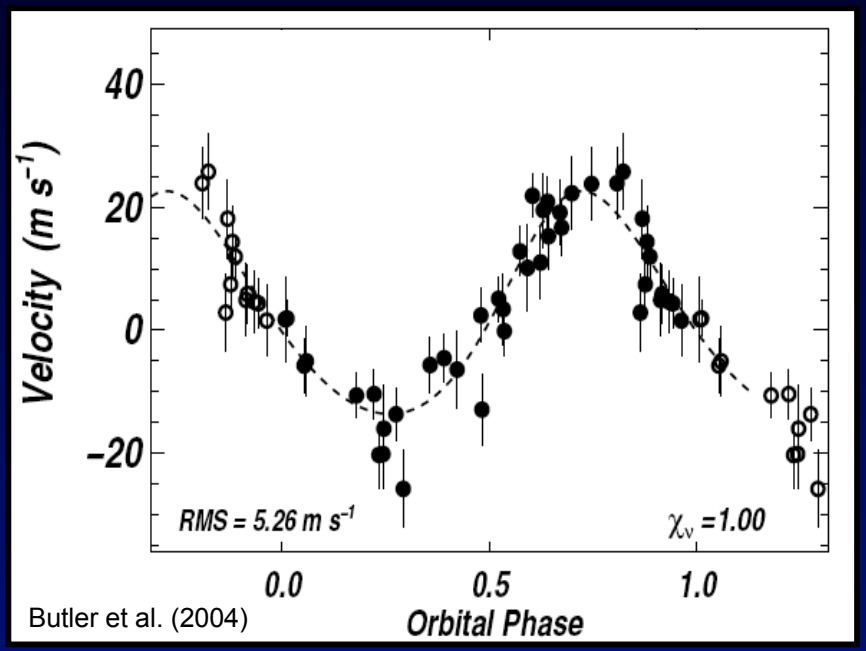


Michelson Summer Workshop - July 25, 2007

2004: first 'hot Neptunes' detected by radial velocity

GJ 436

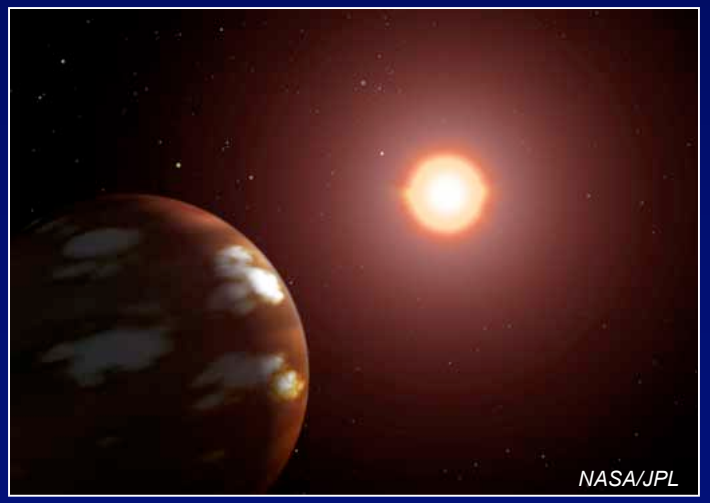
Among them: GJ 436b (Butler et al. 2004, Maness et al. 2007)



Butler et al. (2004)

$M_* \sim 0.44\ M_{Sun}$ (M2.5V)
$R_* \sim 0.44\ R_{sun}$
d = 10.2 pc
V = 10.67

P = 2.64385 days
a = 0.0278 AU
e = 0.16
$M_p \sin i$ = 22.6 M_{Earth}
= 1.32 $M_{Neptune}$



M-dwarfs and RV planets

GJ 436

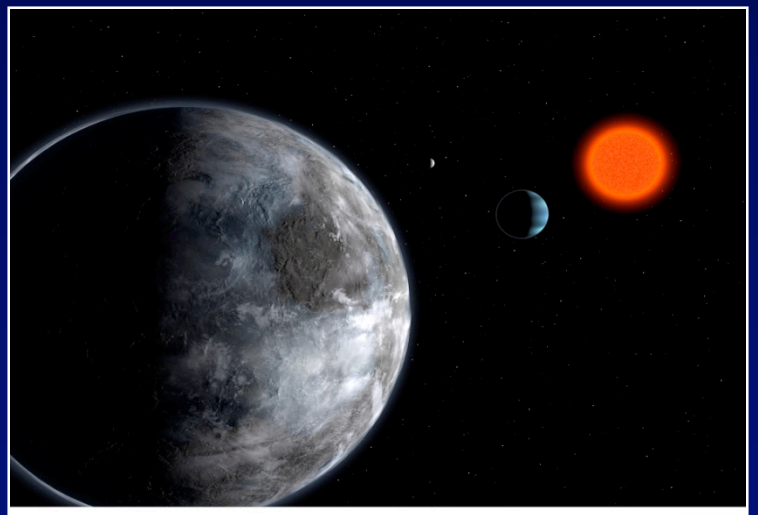
Planet	Mass ($M_{Jupiter}$)	Period (days)	Detection paper
Gl 876*b*	1.935	60.94	*Delfosse et al. 1998; Marcy et al. 1998*
Gl 876*c*	0.56	30.1	*Marcy et al. 2001*
Gl 876*d*	0.018	1.93776	*Rivera et al. 2005*
Gl 581*b*	0.049	5.3683	*Bonfils et al. 2005*
Gl 581*c*	0.016	12.932	*Udry et al. 2007*
Gl 581*d*	0.024	83.6	*Udry et al. 2007*
GJ 436*b*	0.071	2.64385	*Butler et al. 2004*
GJ 674*b*	0.037	4.6938	*Bonfils et al. 2007*
GJ 849*b*	0.82	1890	*Butler et al. 2006*
GJ 317*b*	1.2	692.9	*Johnson et al. 2007*

HARPS search for planets around M-dwarfs

GJ 436

Aim: investigate the dependence of planet formation on the mass of the parent star.

Catalog of 120 close, single M-dwarfs followed at the 1 - 3 ms^{-1} precision level.



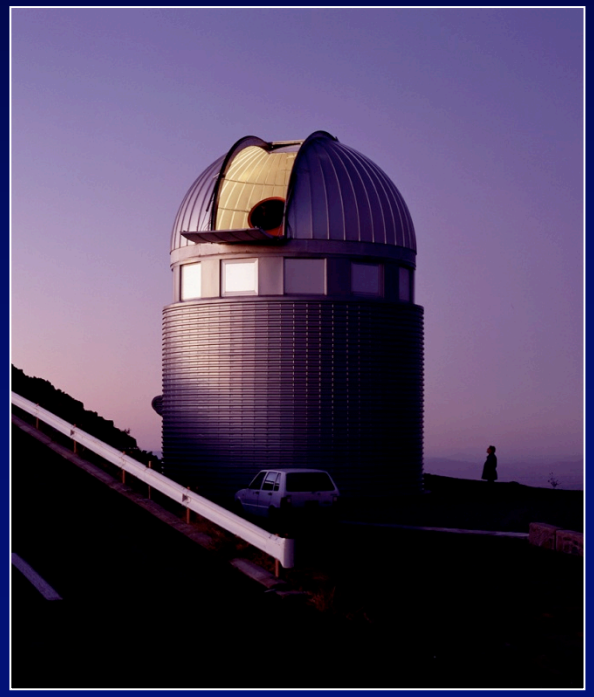
The Planetary System in Gliese 581
(Artist's Impression)
ESO Press Photo 22a/07 (25 April 2007)

Photometric follow-up of the HARPS M-dwarfs candidates

GJ 436

Aim 1: to verify that the Doppler signal has not a stellar origin

Aim 2: to reject or detect the transits (only for short-period planets)



South: Euler 1.2m, La Silla (Chili)

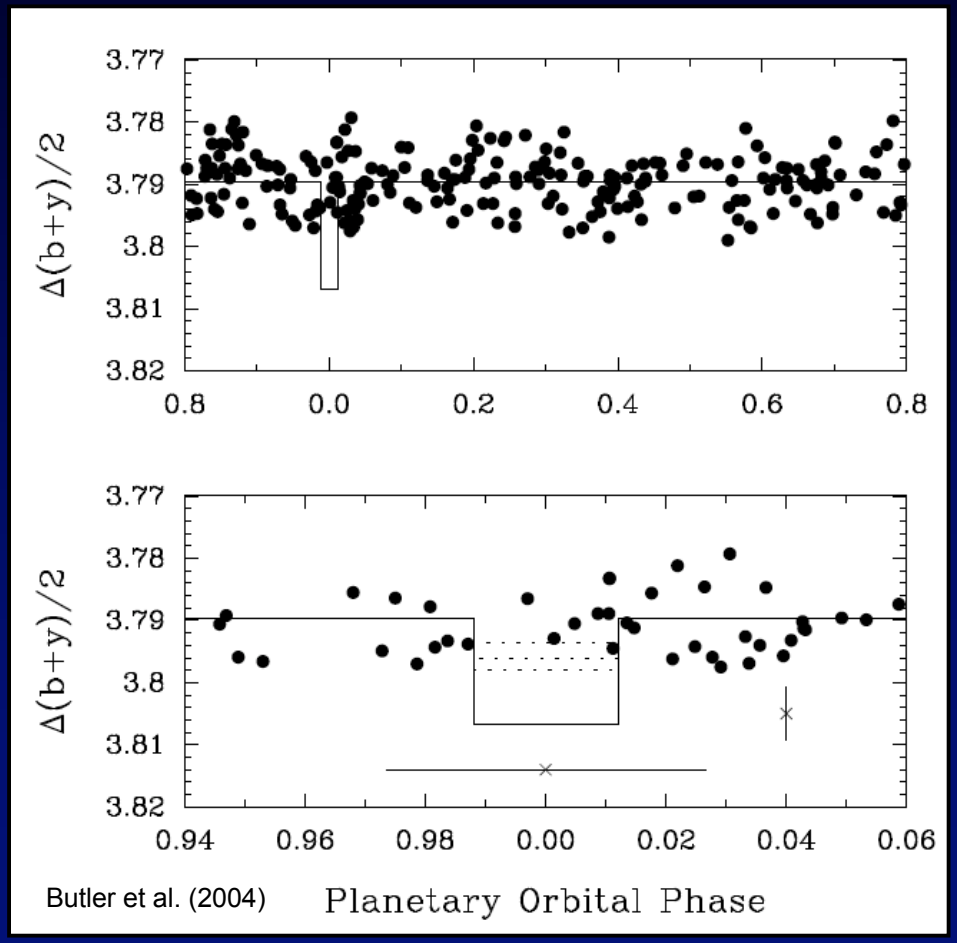
North: OFXB 0.6m, St-Luc (Switzerland)

GJ 436: first search for transits in 2004

Photometry using T12 APT 0.8m two-channel photometer 226 measurements from 2003 November to 2004 June

Expected transit depth from 3 to 16 mmag

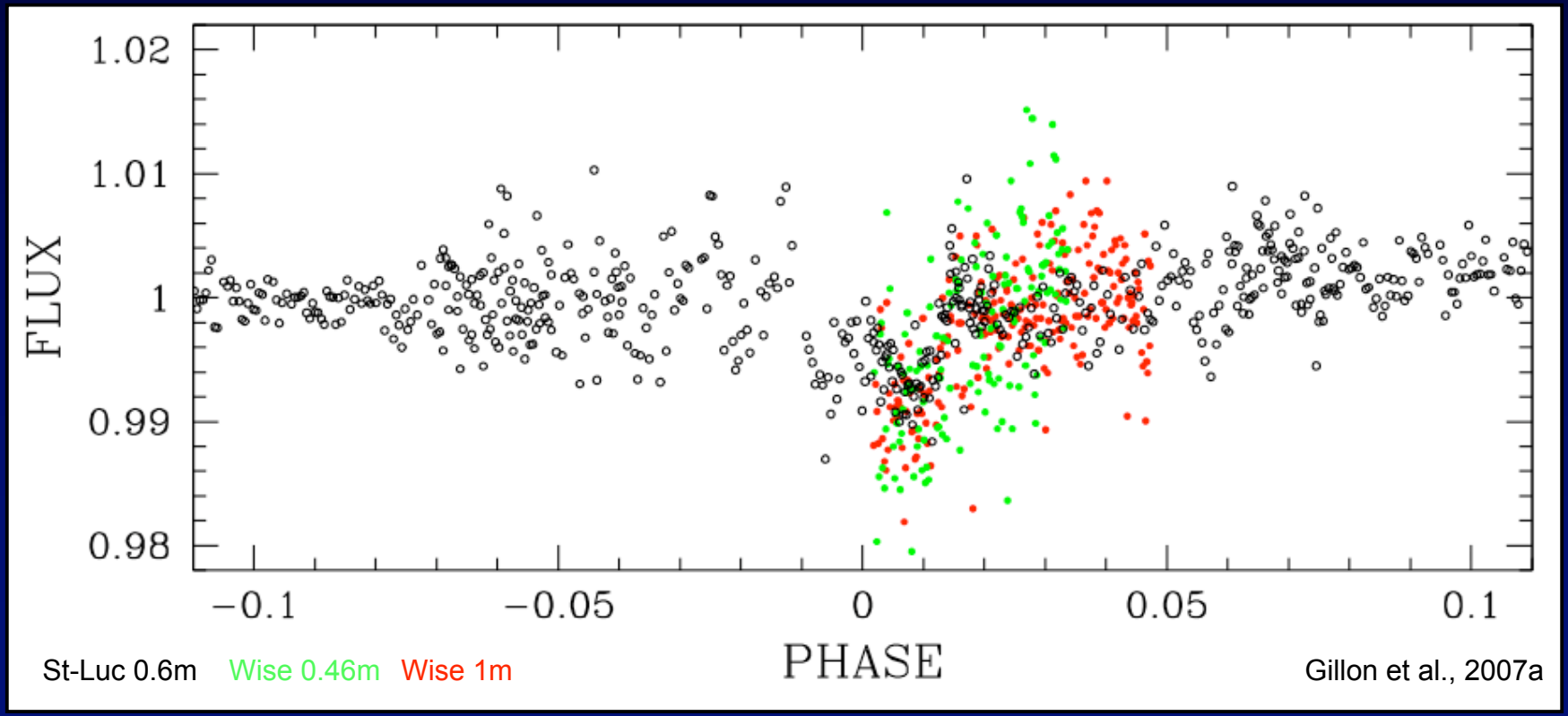
Result: *'Photometric transits of the planet across the star are ruled out for gas giant compositions and are also unlikely for solid compositions'* (Butler et al. 2004)



Butler et al. (2004)

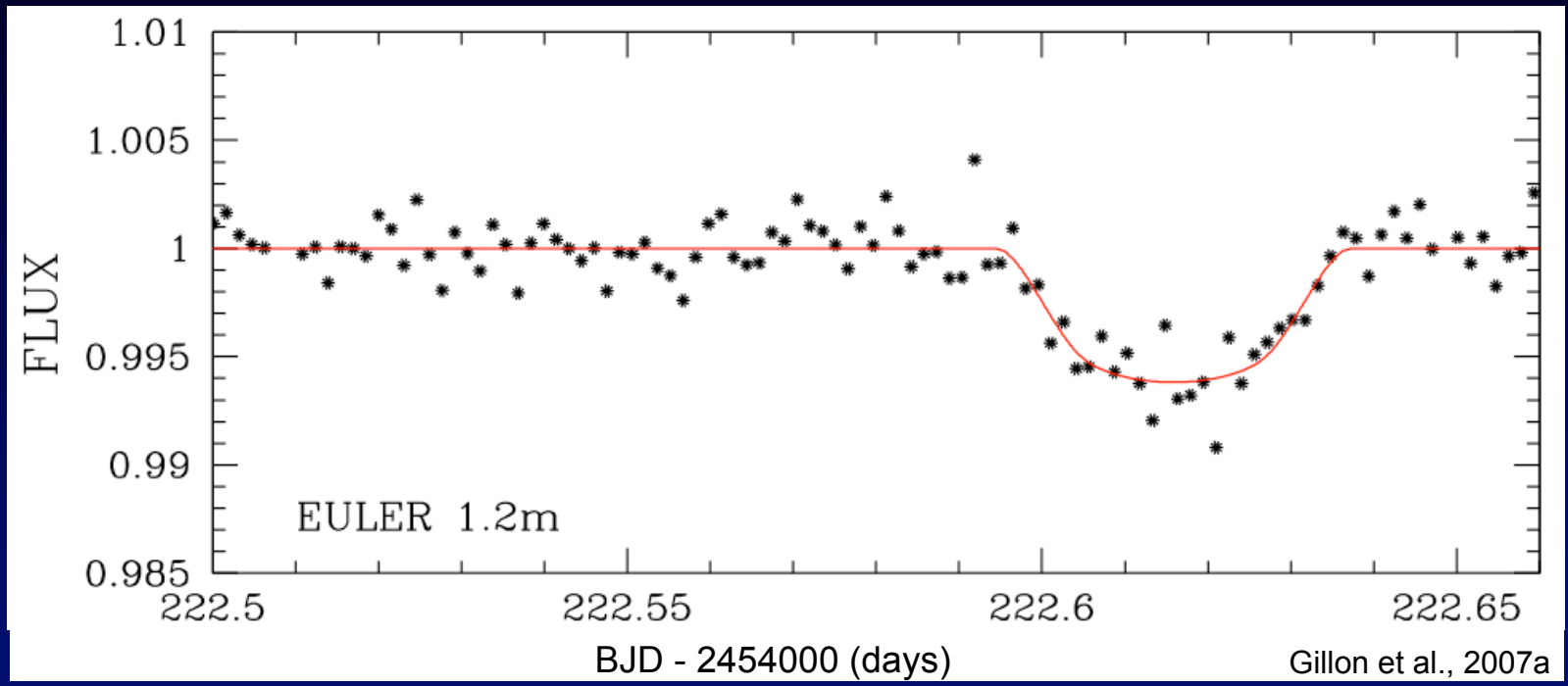
GJ 436: second try in 2007

Covering of the whole transit window with OFXB 0.6m (Switzerland)
1108 V-band measurements during 8 nights
Confirmation with Wise 1m and 0.46m telescopes (Israel)



First radius measurement for a hot Neptune

GJ 436



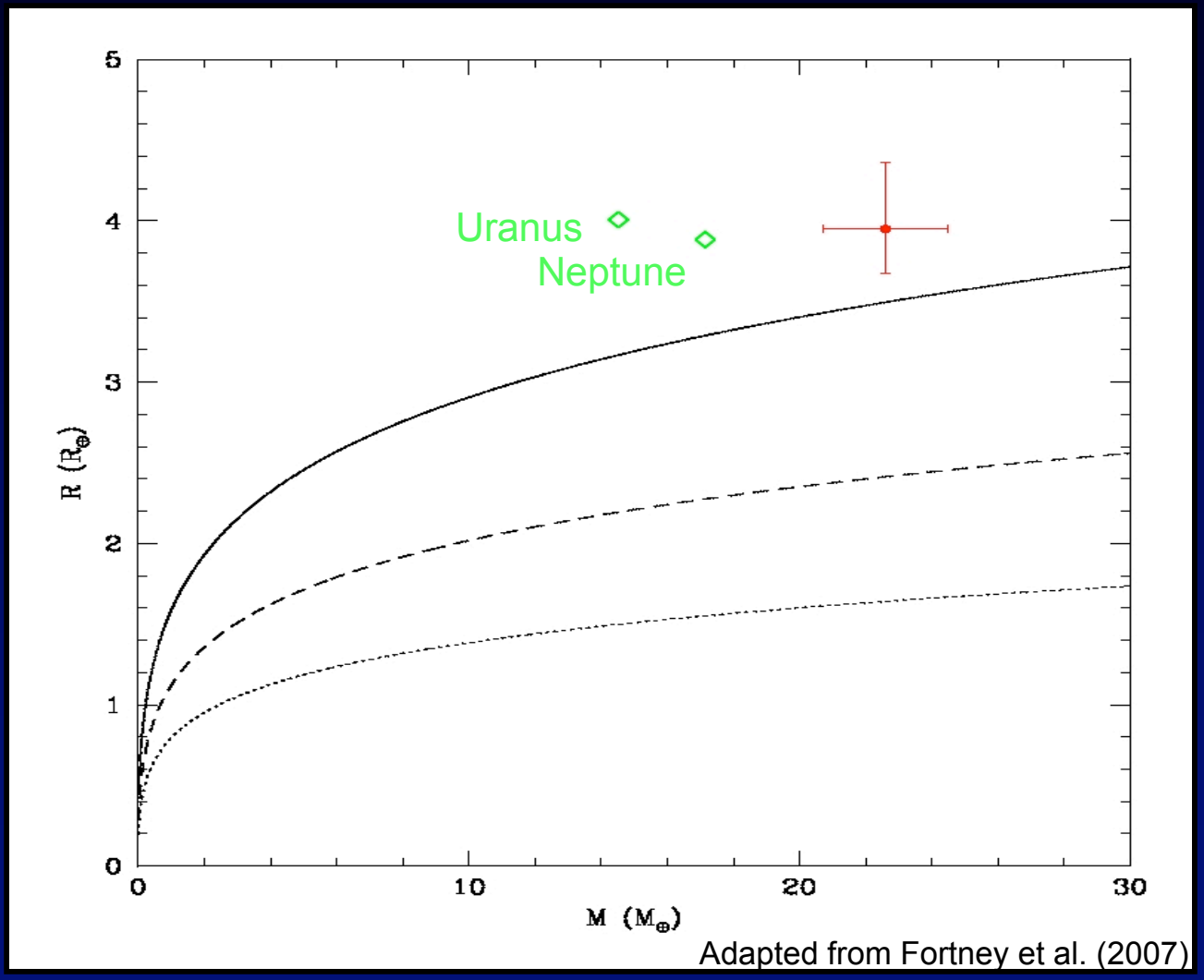
Assuming $M_* = 0.44\ M_{Sun}$ and $R_* = 0.44\ R_{Sun}$:

$i = 86.5° (\pm 0.2)$

$Rp = 3.95\ R_{Earth}$ (+0.41 -0.28)

The grazing transits of a Neptune-like planet

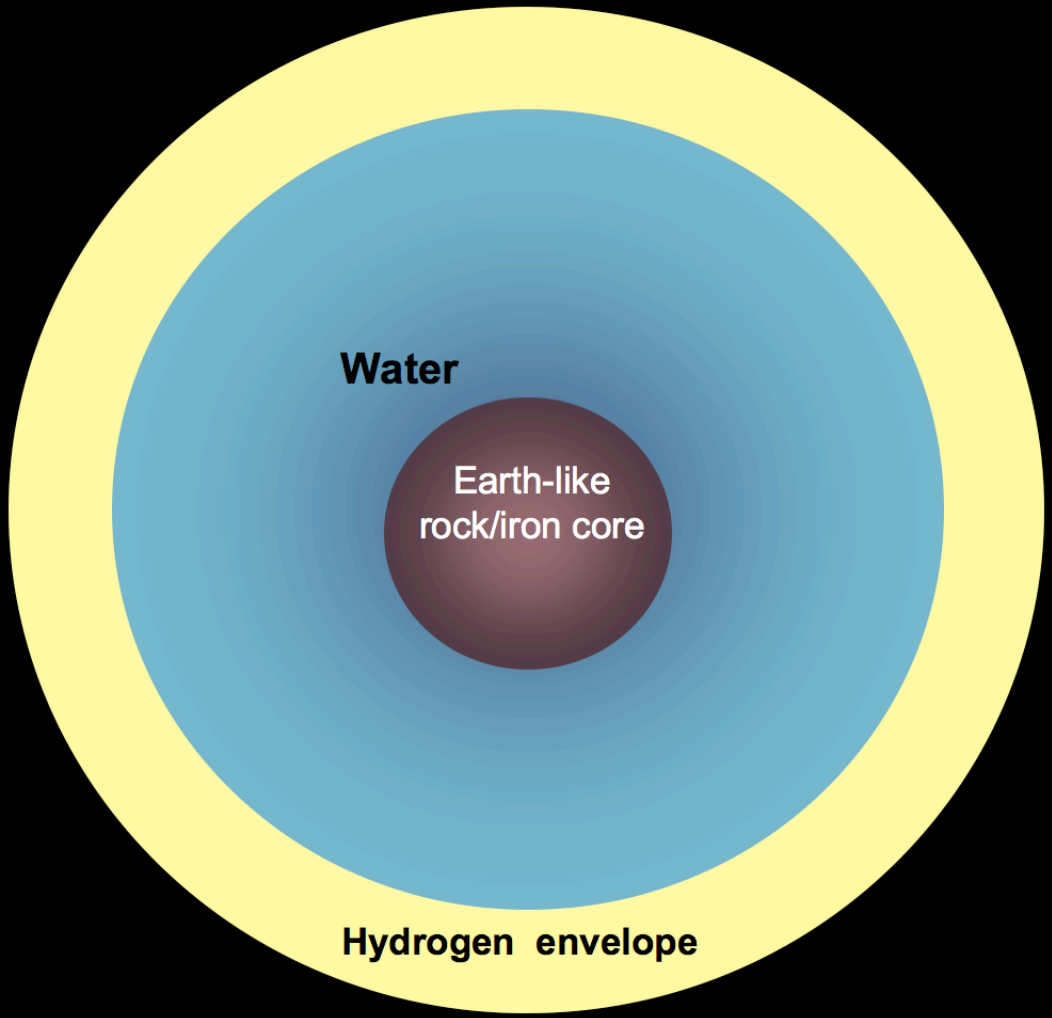
GJ 436



Adapted from Fortney et al. (2007)

The composition of an extrasolar Neptune-mass planet

GJ 436

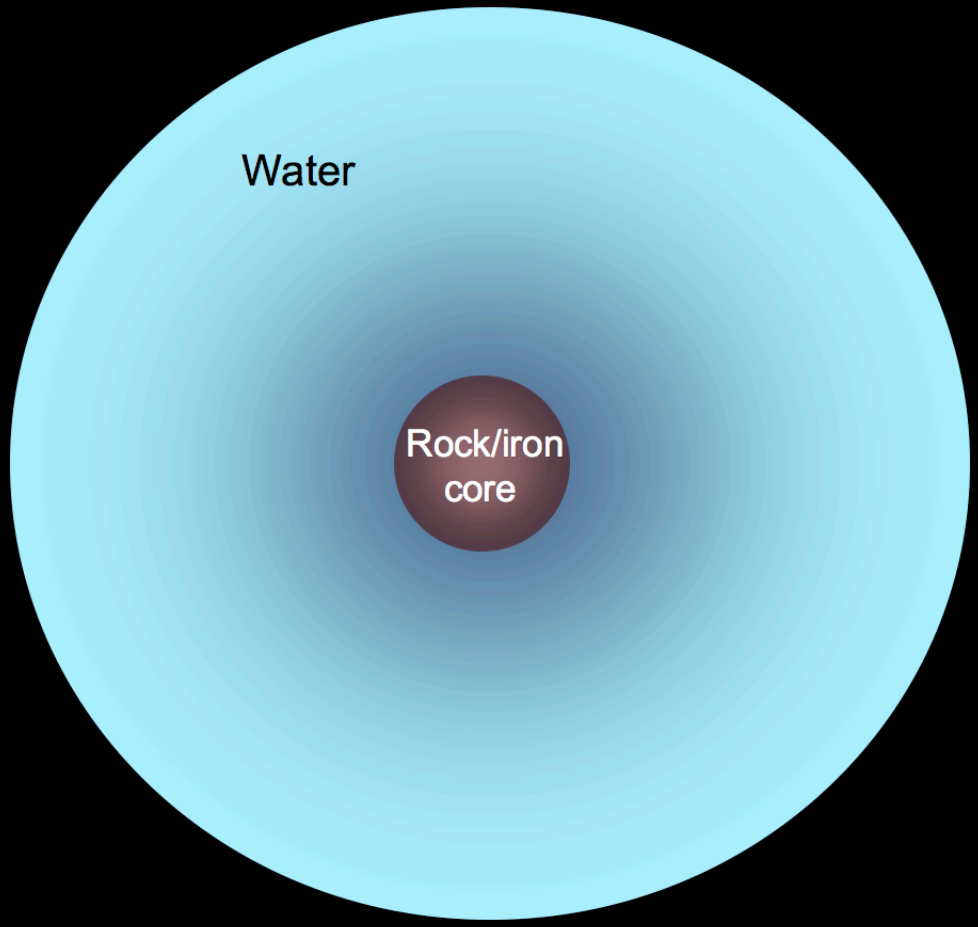


Model 1 : hot Neptune

Earth diameter

The composition of an extrasolar Neptune-mass planet

GJ 436



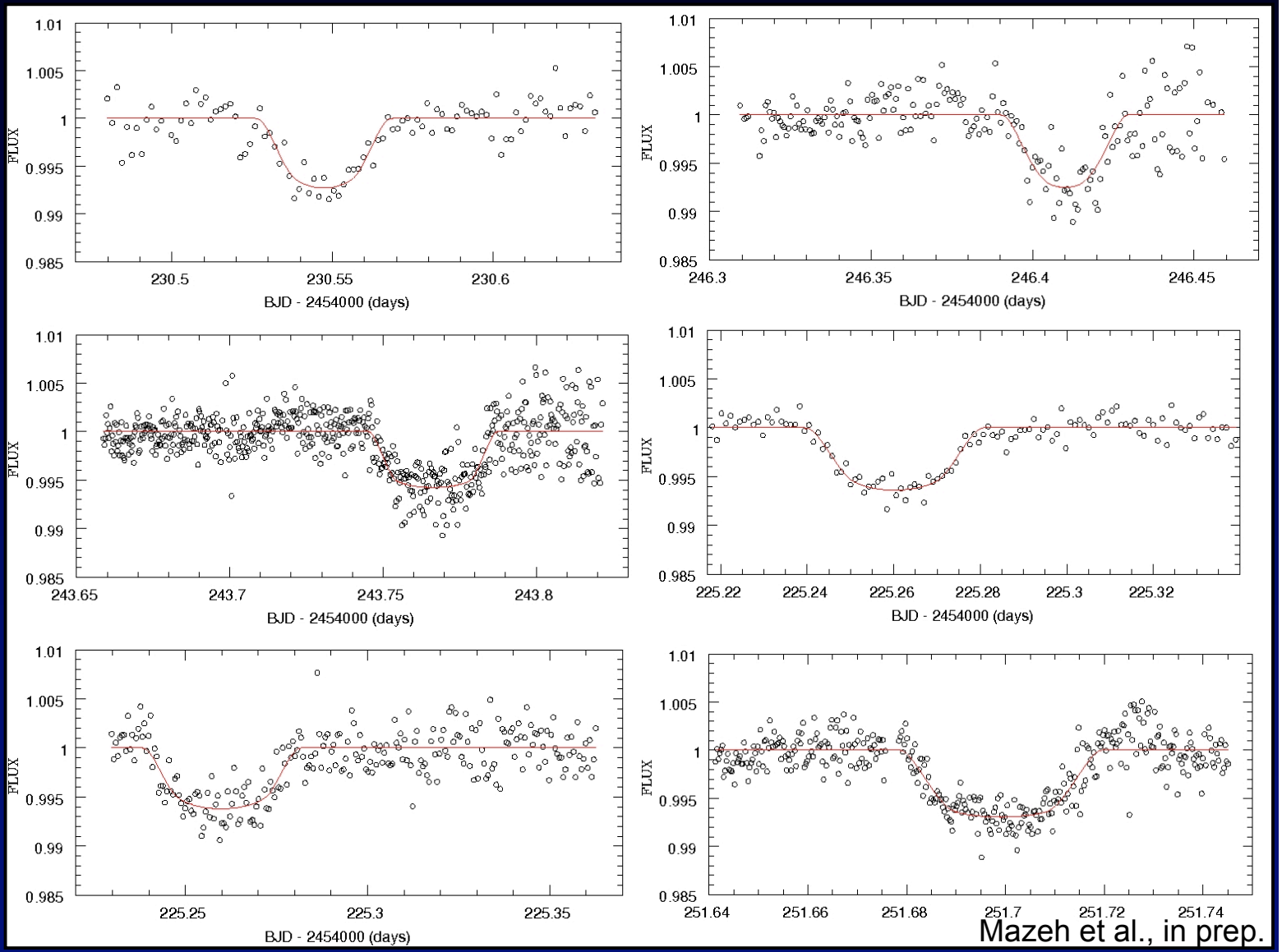
Model 1 : Ocean Planet

Earth diameter

Characterization of a hot Neptune

GJ 436

Constraining the composition with accurate ground-based …



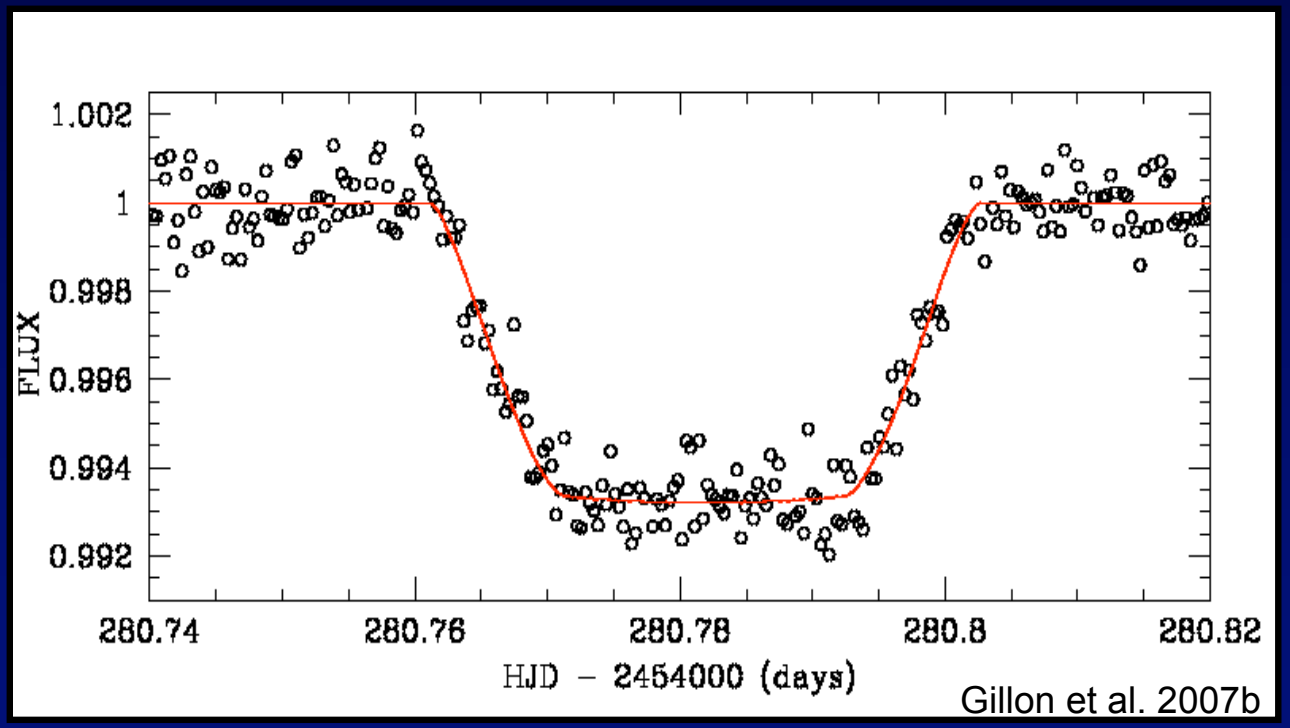
Mazeh et al., in prep.

Characterization of a hot Neptune

GJ 436

… and space-based photometry (1) with Spitzer Space Telescope

IRAC 8 microns primary transit → $R_p = 4.2\ R_{Earth}$

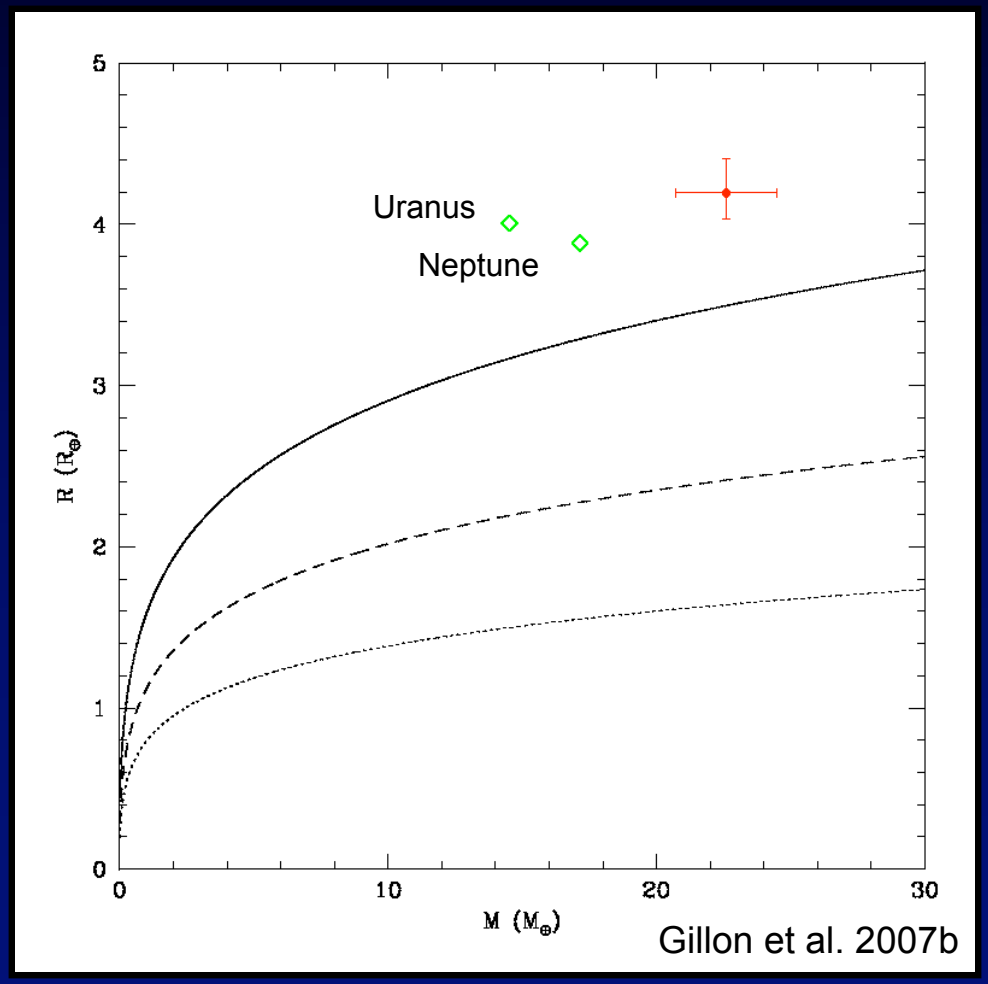


Gillon et al. 2007b

Characterization of a hot Neptune

GJ 436

… and space-based photometry (1) with Spitzer Space Telescope



An H/HE envelope is needed.

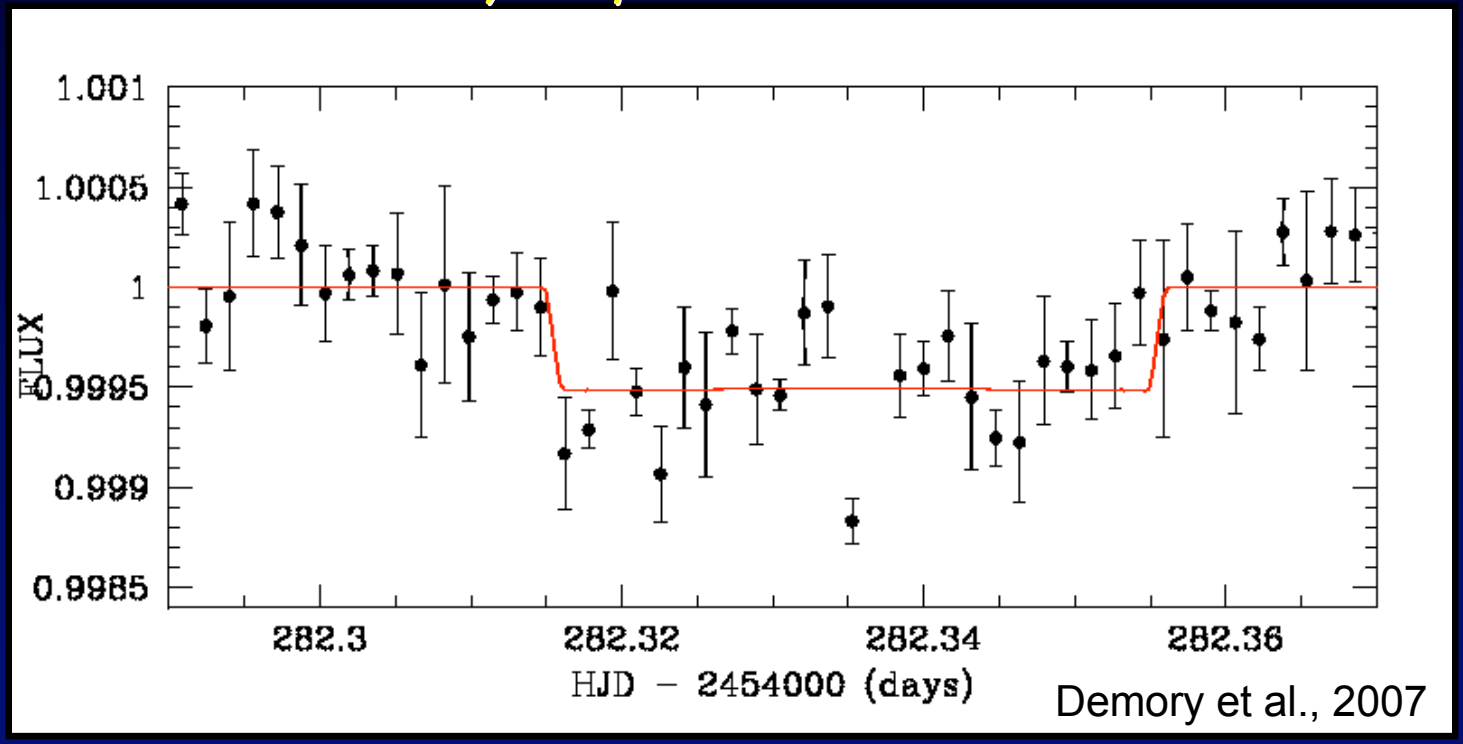
GJ 436b is clearly a hot Neptune.

Characterization of a hot Neptune

GJ 436

… and space-based photometry (1) with Spitzer Space Telescope

IRAC 8 microns secondary eclipse: → T_b = 709 +-17 K



Demory et al., 2007

To come: 3.6, 4.5, 5.8 (IRAC), 16 (IRS) and 24 (MIPS) microns

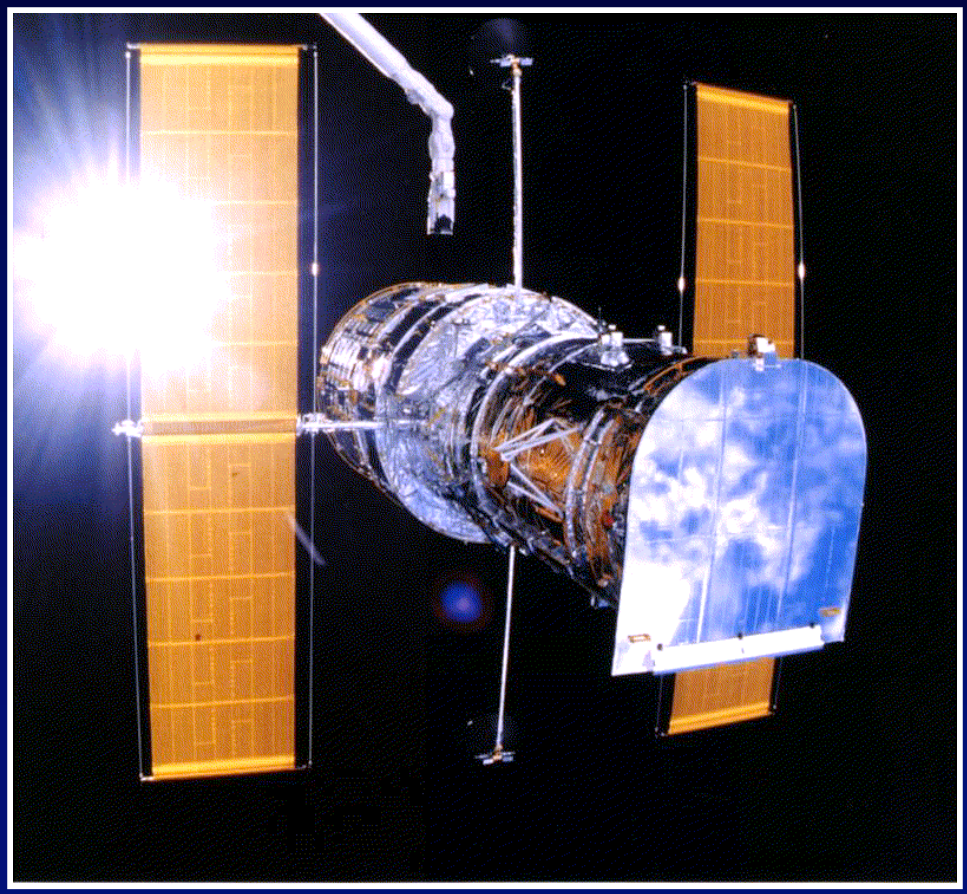
Will constraint the atmospheric composition of this hot Neptune

Characterization of a hot Neptune

GJ 436

… and space-based photometry (2) with Hubble Space Telescope

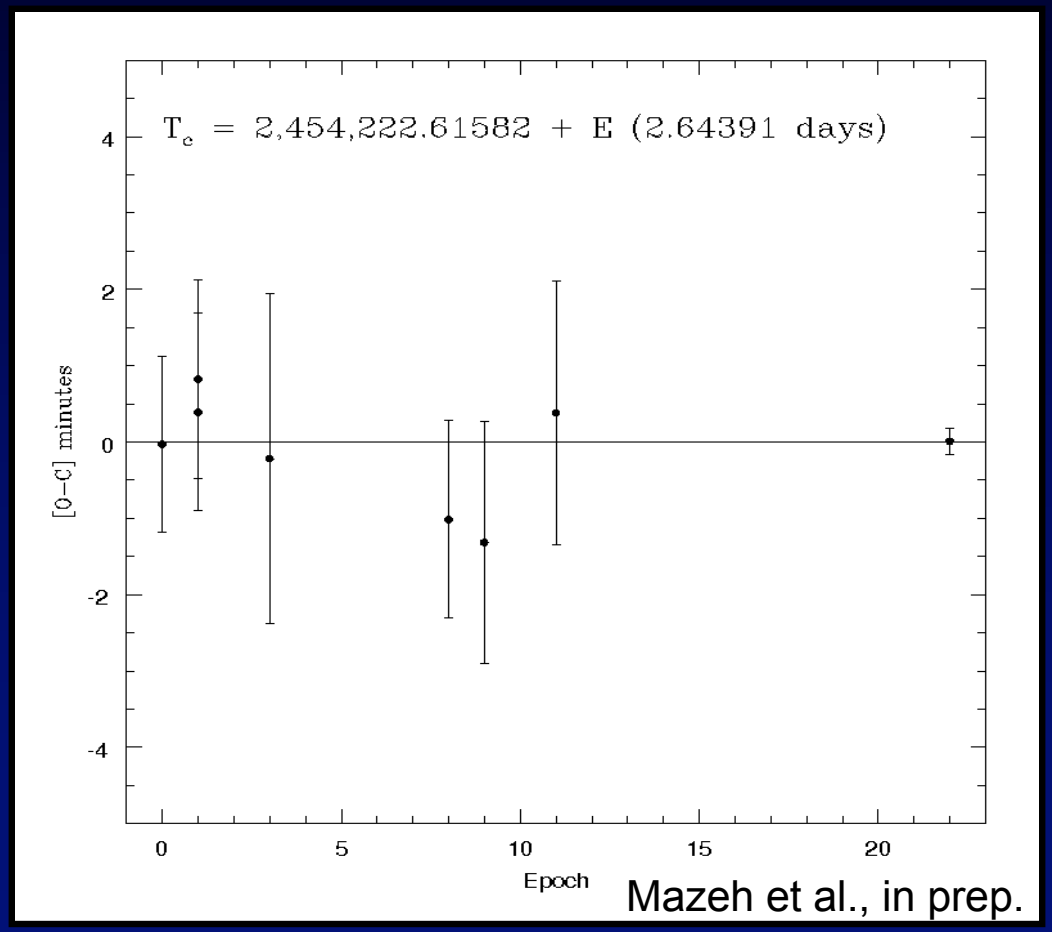
NICMOS observations of the primary transit (PI: F. Pont)



Characterization of a hot Neptune

GJ 436

e = 0.14 +- 0.01 (Demory et al. 2007): what is the cause ?



Mazeh et al., in prep.

No obvious Transit Timing Variations (TTV) nor clear hint for another close planet in the RV data…

See Demory et al. (2007) and Mazeh et al. (in prep.)

GJ 436b

… appears to be a Neptune-like planet,

… but a very hot one.

Its atmospheric composition will be investigated with Spitzer at the end of the year.

Its weird orbital eccentricity is not yet solved,

… and the presence of another planet is not obvious.

The transits of small RV planets around nearby M-dwarfs can be detected from the ground,

… and these planets can be characterized much more thoroughly than the small planets that will be detected by Kepler.

Search for the transits of the HARPS M-dwarfs candidates

GJ 436

Example: GJ 674