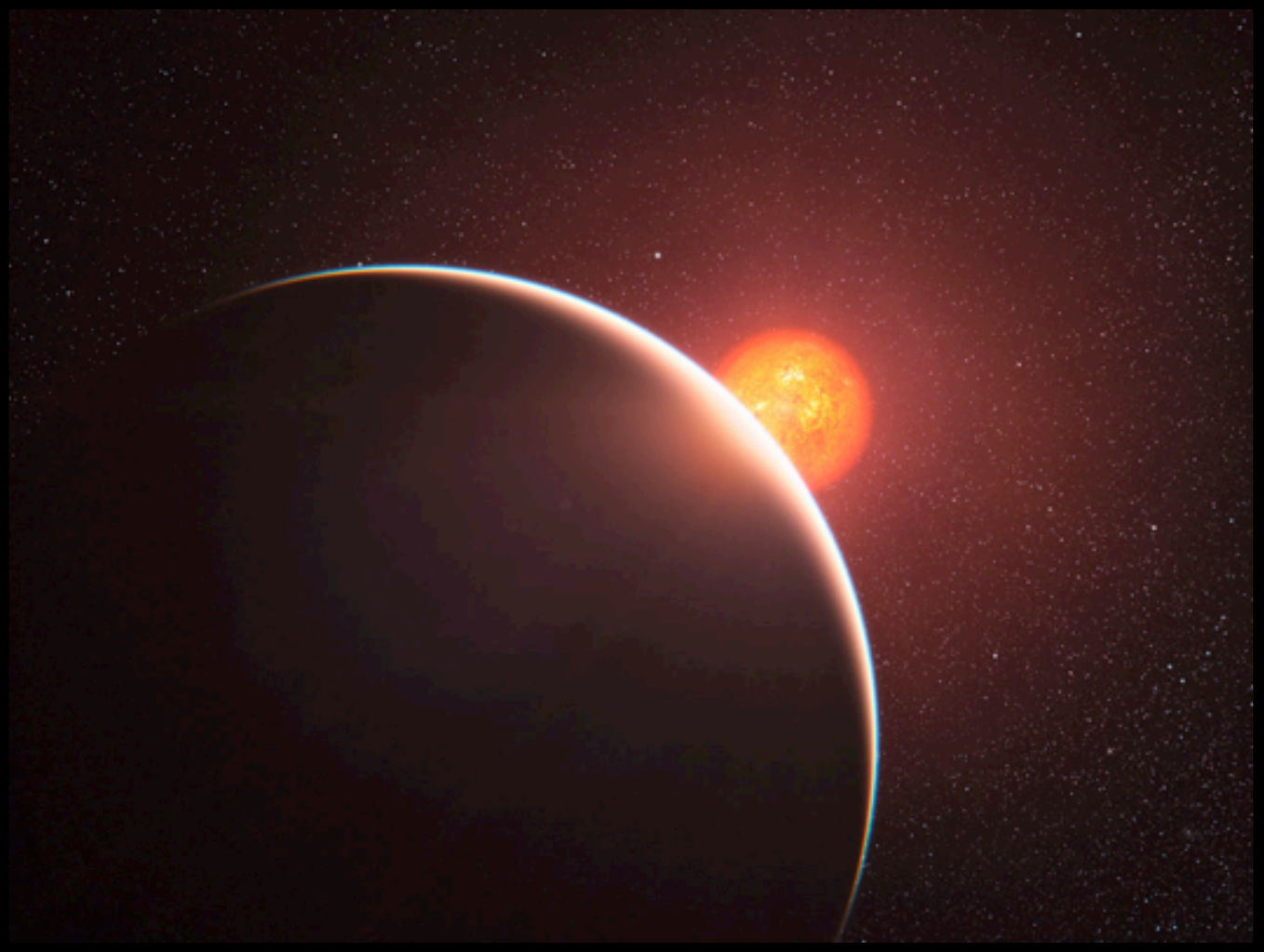
Atmospheric Characterization of Transiting Extrasolar Planets



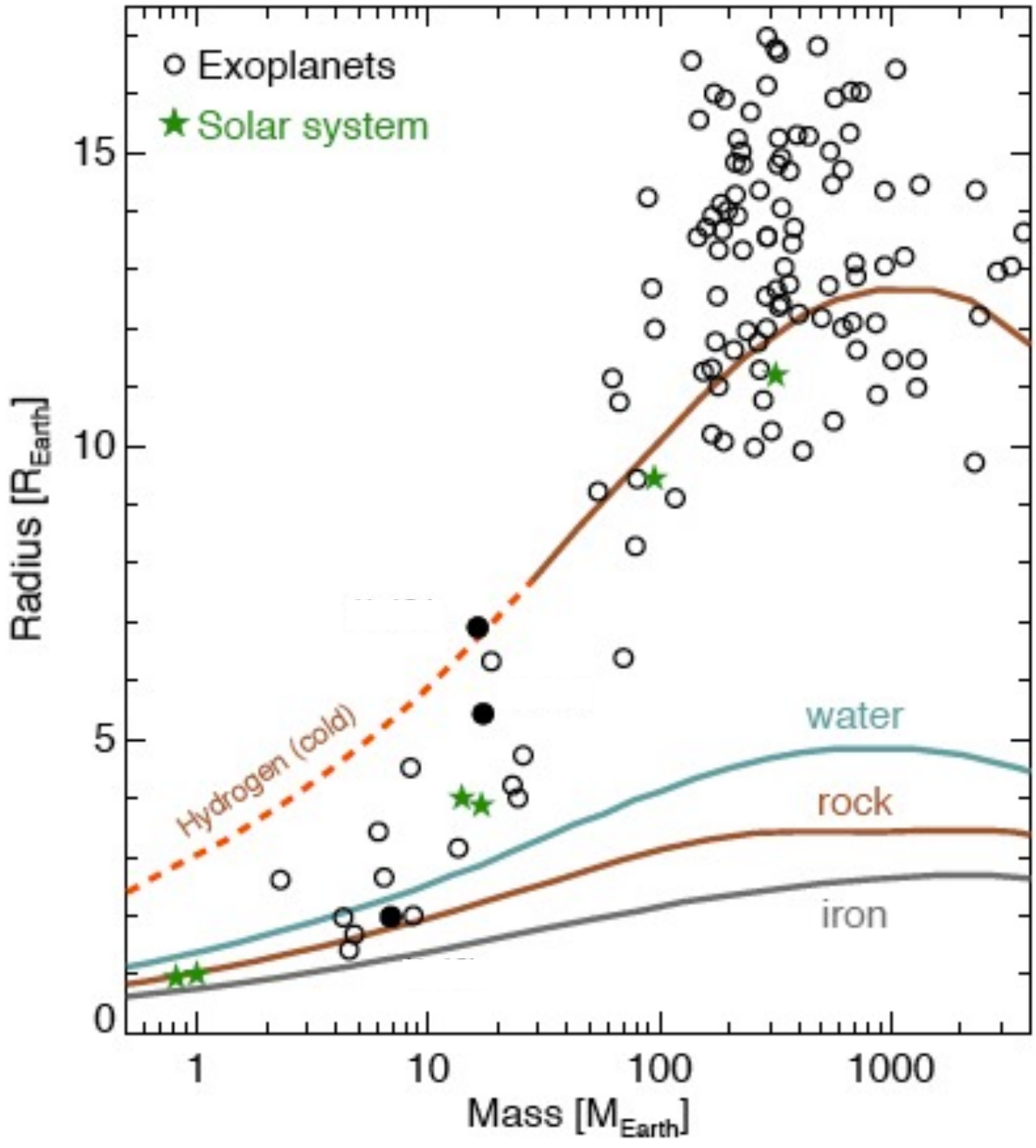
Jean-Michel Désert

Caltech - Sagan Fellow

2012 Sagan/Michelson Fellows Symposium

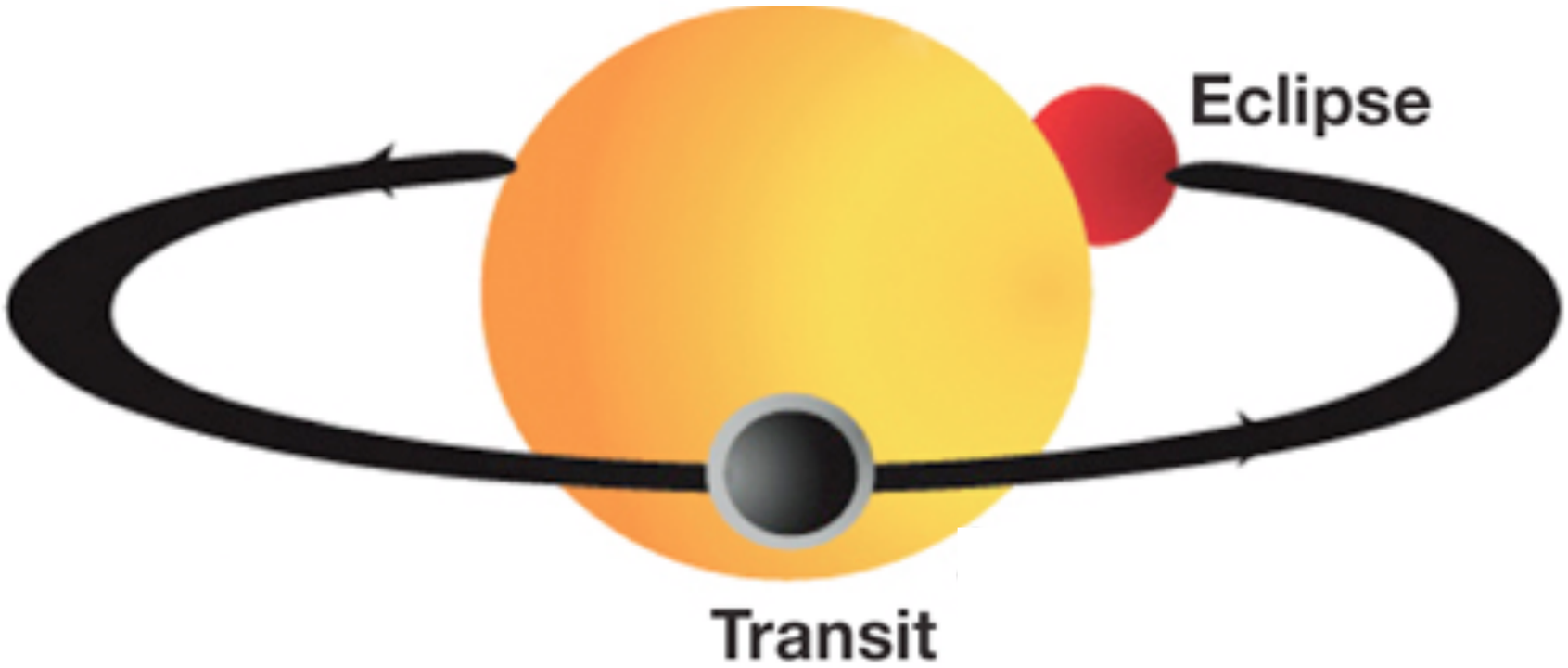
Caltech, November 9th 2012

Diversity of Transiting Exoplanets

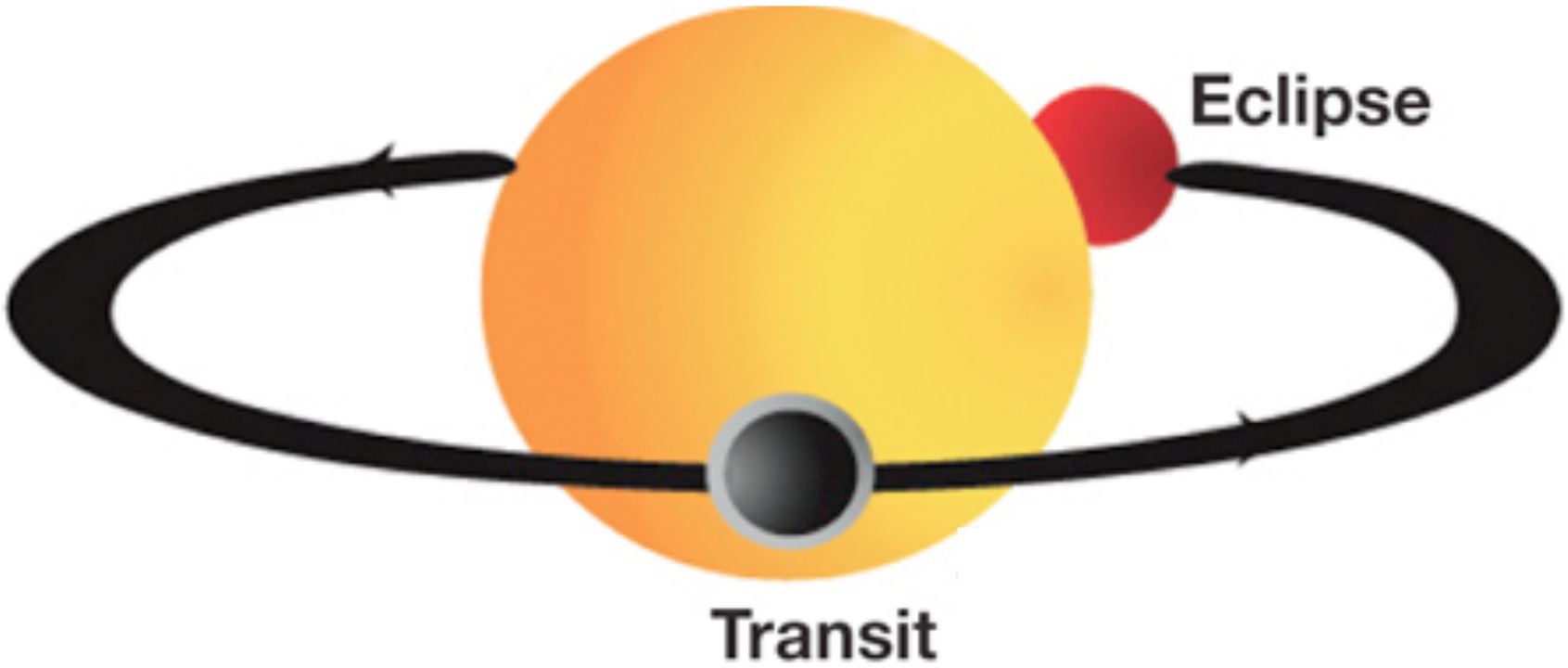


From Cochran et al. (2011)

Transits Allow Studies of Atmospheres That Are Not Possible for Non-Transiting Exoplanets



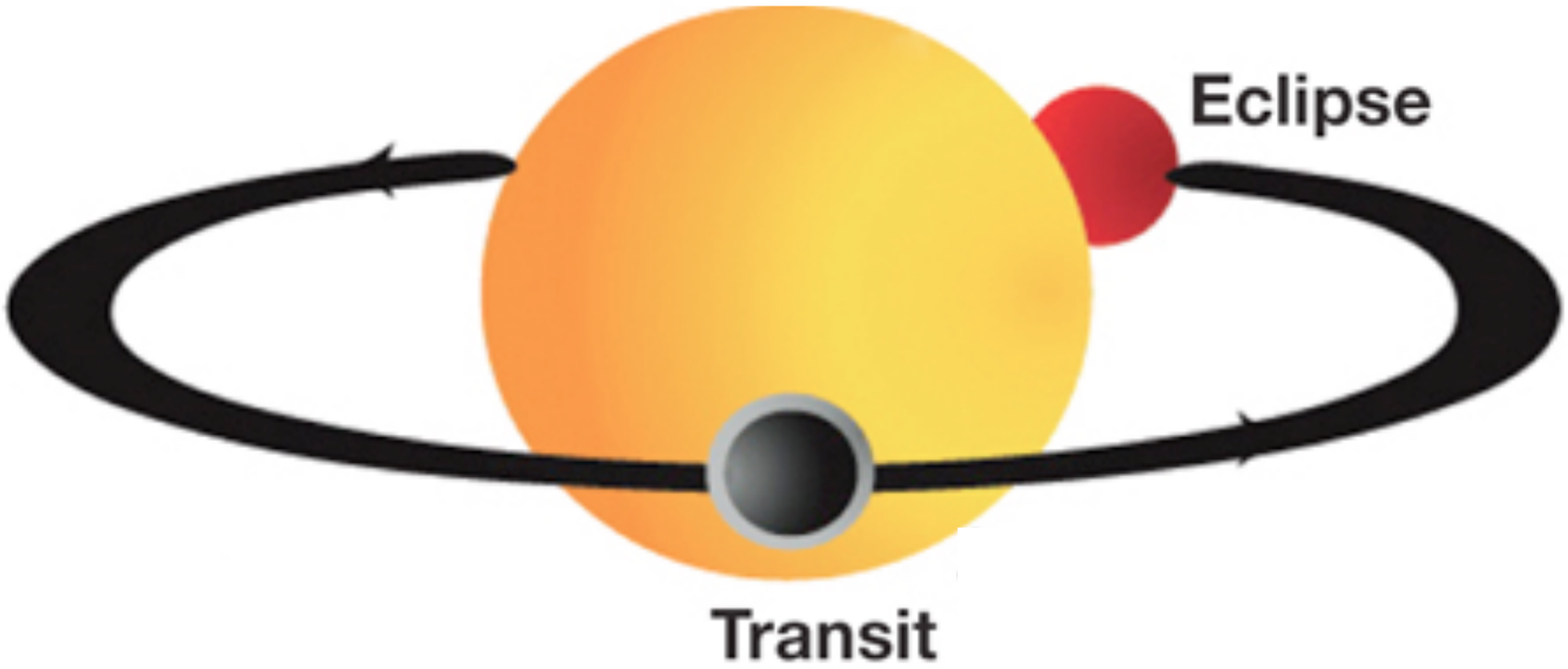
Transits Allow Studies of Atmospheres That Are Not Possible for Non-Transiting Exoplanets



Transmitted: $\Delta D \sim \frac{2 H R_{\rm pl}}{R_*^2}$

$$H = \frac{kT}{\mu_m g}$$

Transits Allow Studies of Atmospheres That Are Not Possible for Non-Transiting Exoplanets



Transmitted: $\Delta D \sim \frac{2 H R_{\rm pl}}{R_*^2}$

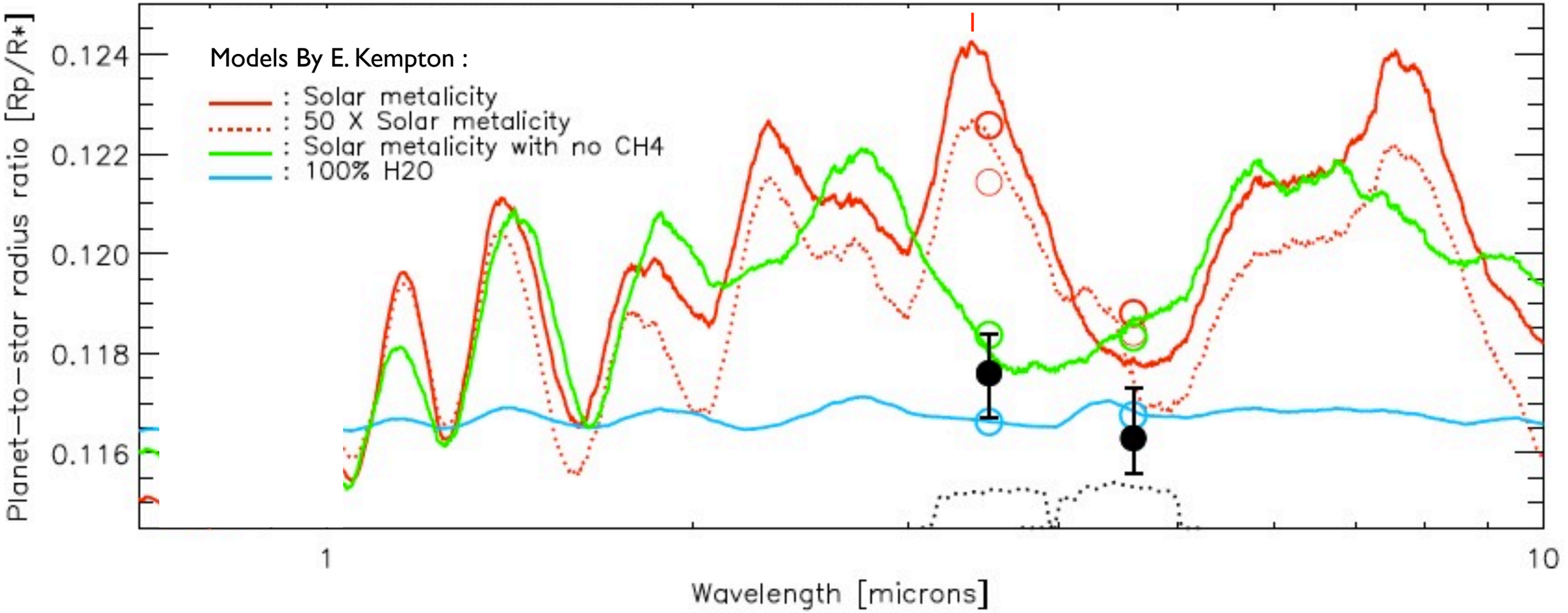
R_{Jup} ~1 % **~0.01 %**

$R_\oplus$ ~0.01 % **~10^{-5}**

$$H = \frac{kT}{\mu_m g}$$

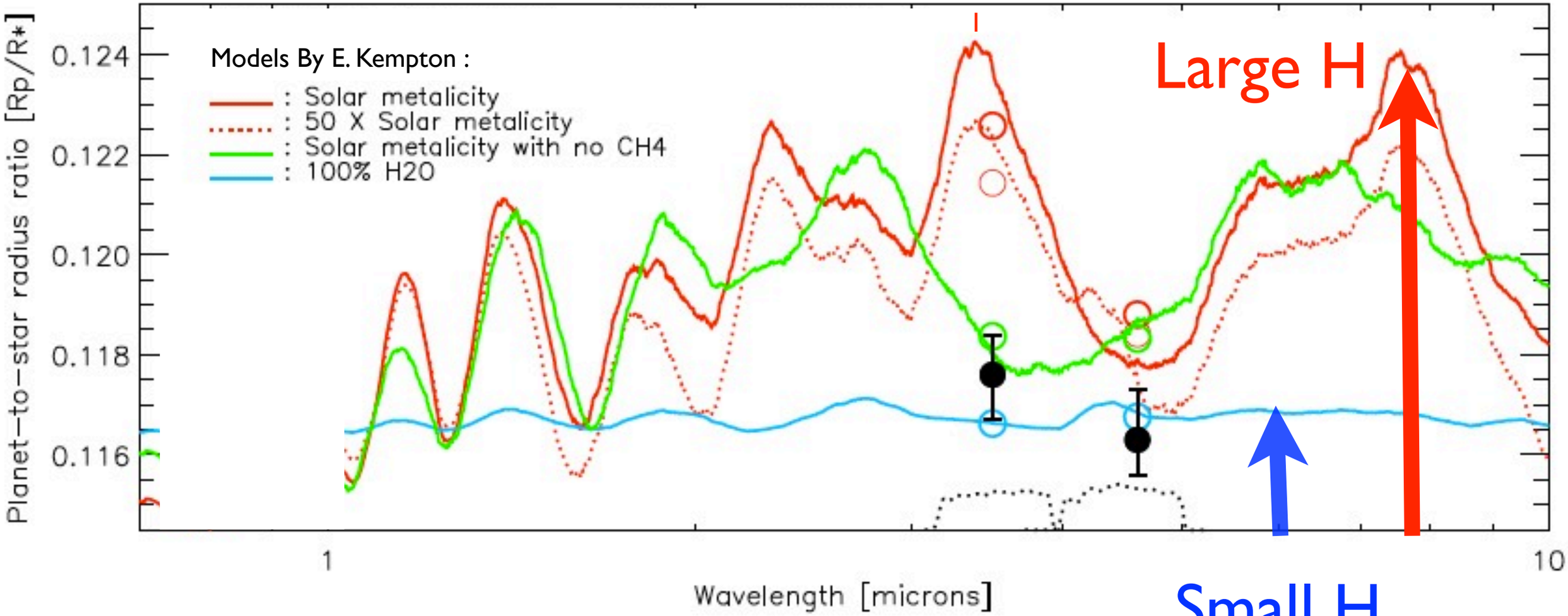
Transmission Spectroscopy of GJ1214b

Désert et al. (2011)



GJ1214b: Distinguishing H-rich/H-poor atmospheres

Désert et al. (2011)



$$H = \frac{kT}{\mu_m g}$$

Necessity of a Multi-Wavelength Approach

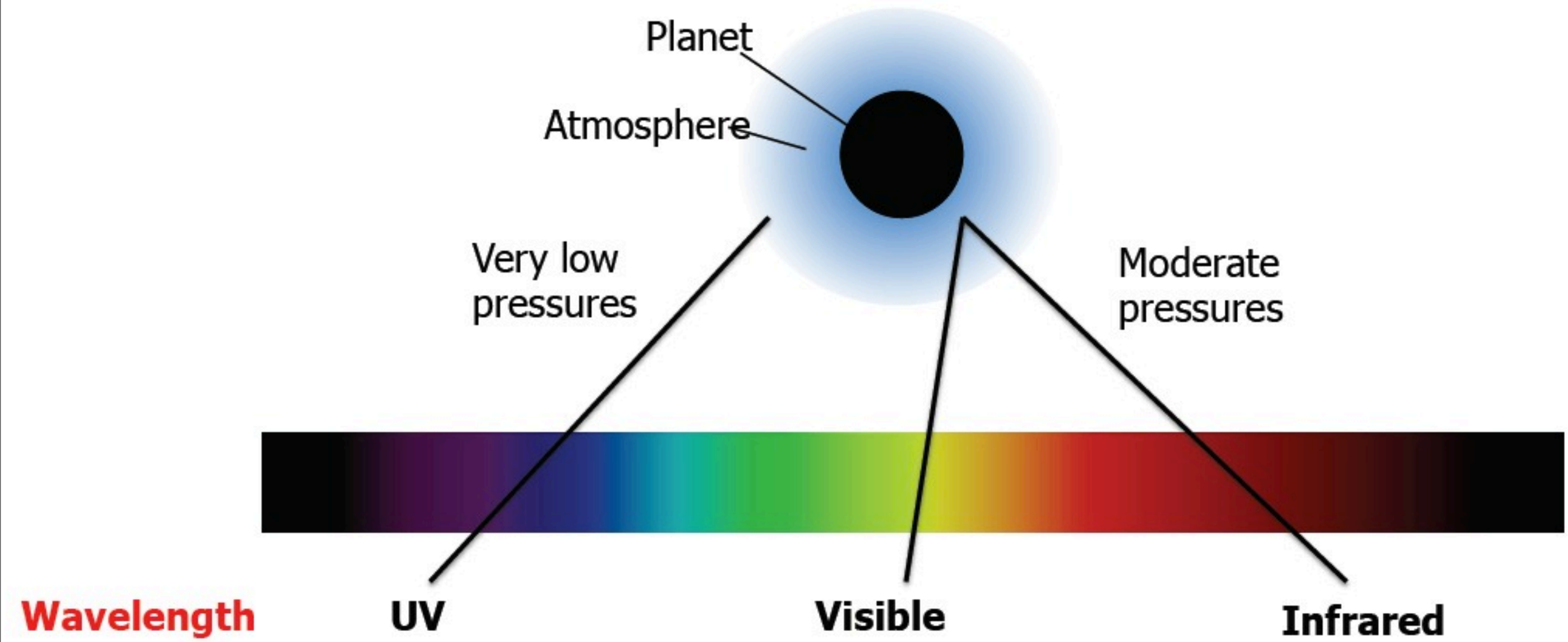
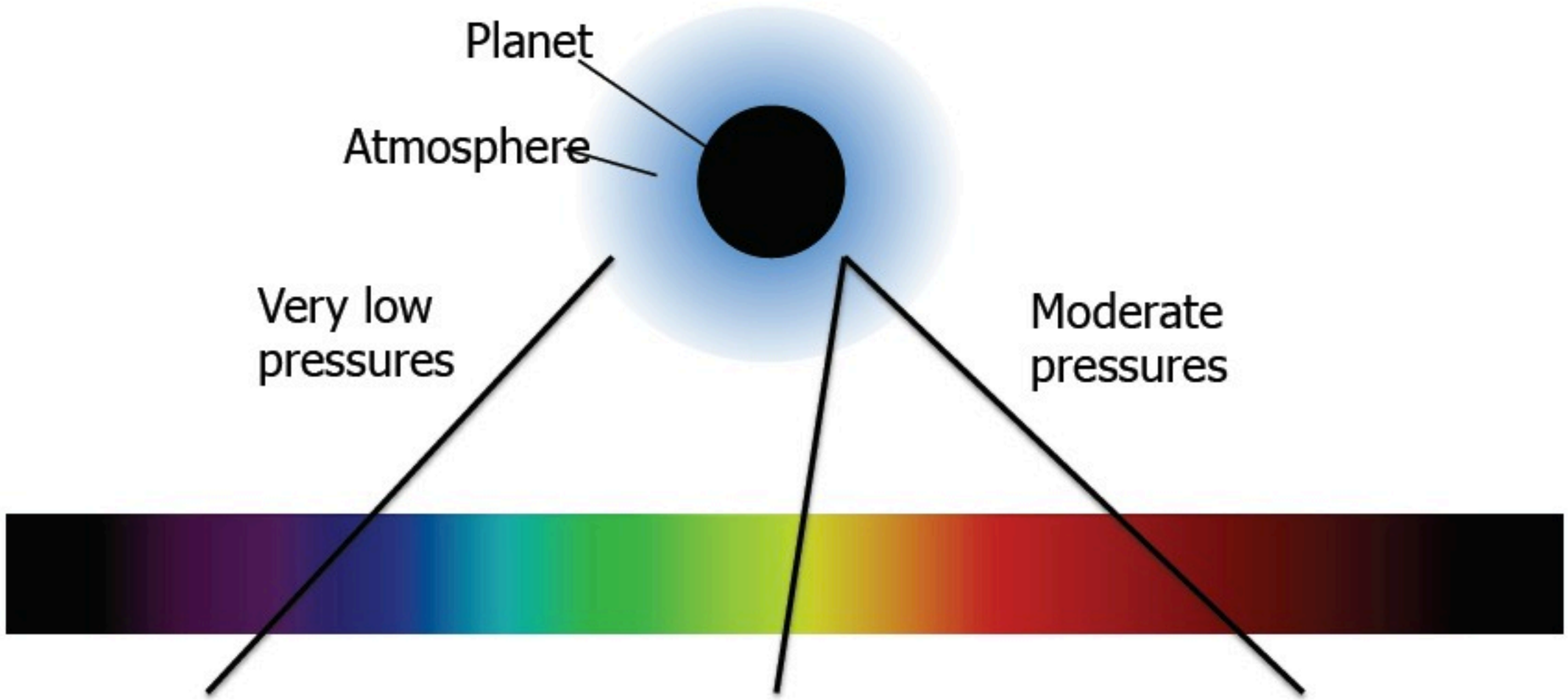


Figure Courtesy H. Knutson

Necessity of a Multi-Wavelength Approach



What do we measure?	Lyman alpha, ionized metals	Sodium, potassium, TiO	Water, methane, CO, CO_2
	[Vidal-Madjar *et al.* 2003]	[Charbonneau *et al.* 2002]	[Deming *et al.* 2005] [Charbonneau *et al.* 2005]

Figure Courtesy H. Knutson

Diversity of hot-Jupiter atmospheres

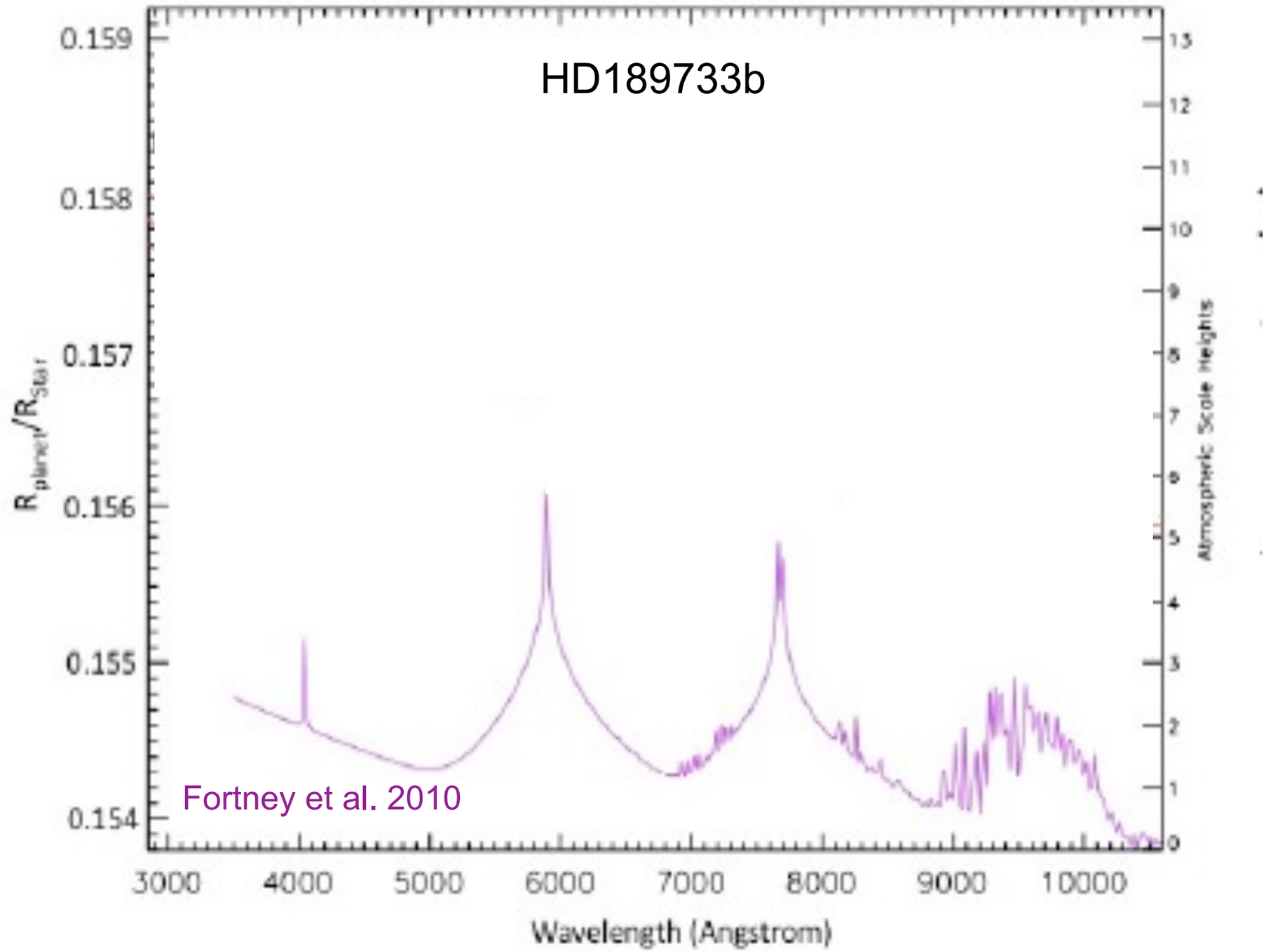
- Temperature and Thermal inversion for a subset of planets

Diversity of hot-Jupiter atmospheres

- High altitude optical absorbers / transparent atmospheres

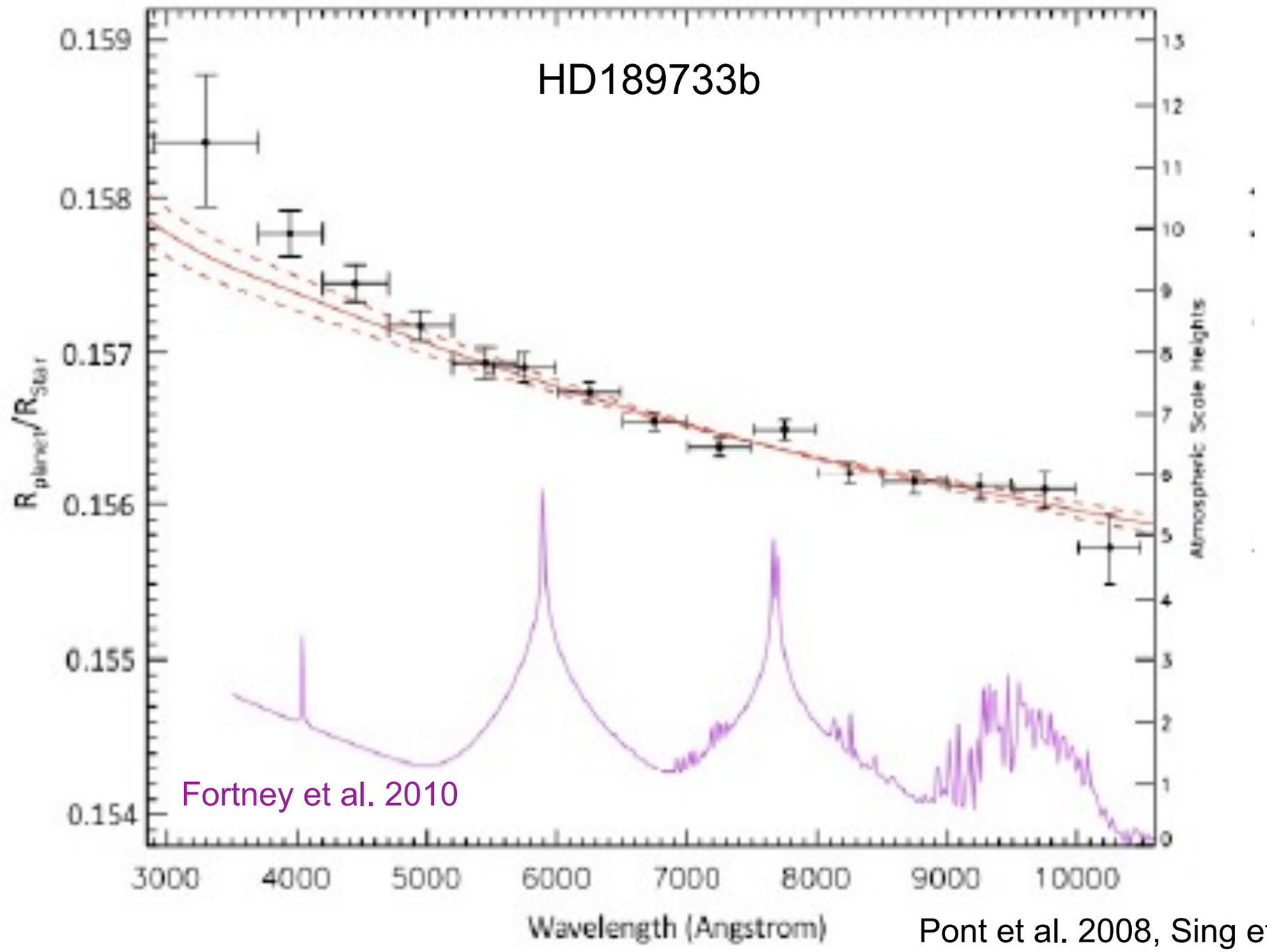
Diversity of hot-Jupiter atmospheres

- High altitude optical absorbers / transparent atmospheres



Diversity of hot-Jupiter atmospheres

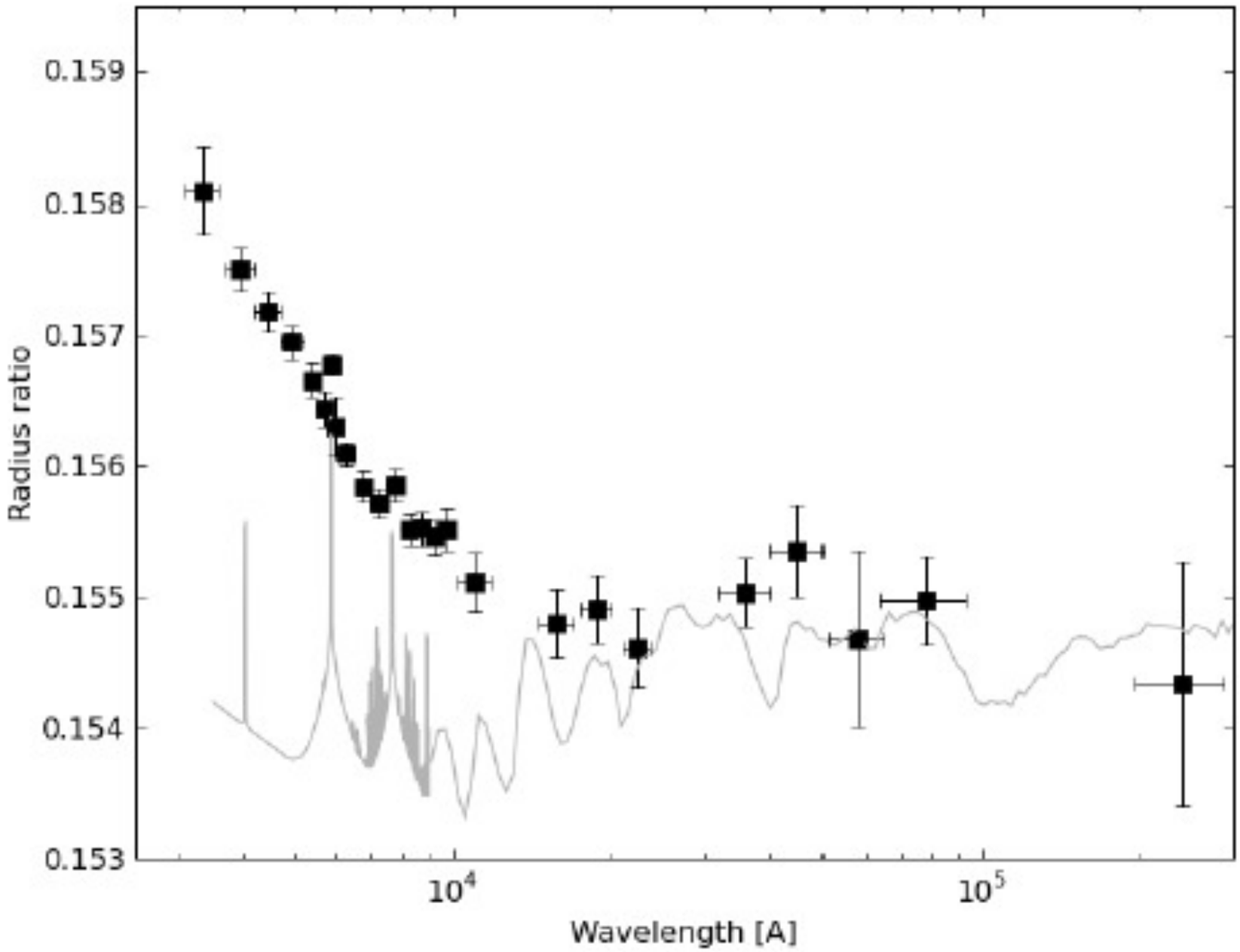
- High altitude optical absorbers / transparent atmospheres



Pont et al. 2008, Sing et al. 2011

Diversity of hot-Jupiter atmospheres

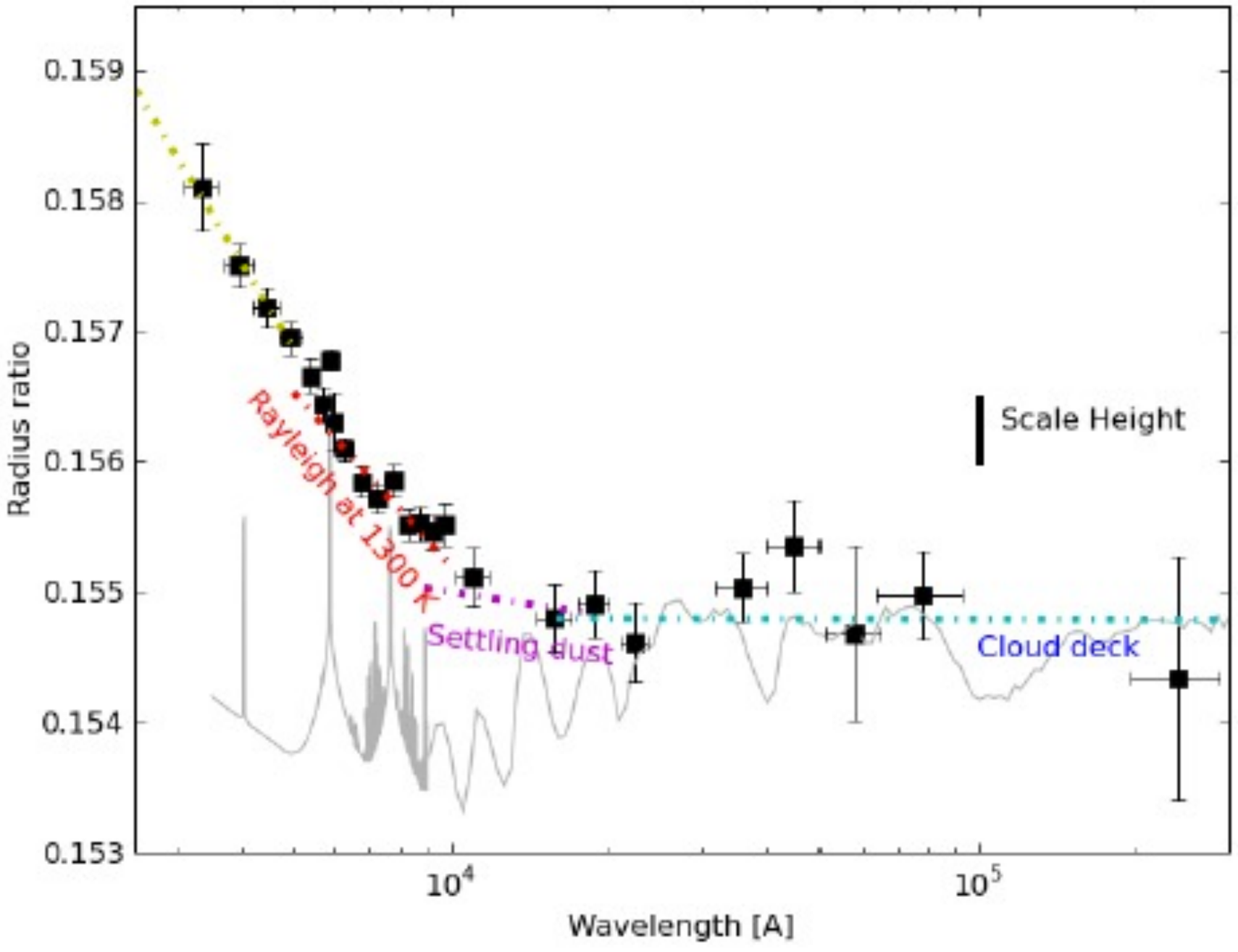
- High altitude optical absorbers / transparent atmospheres



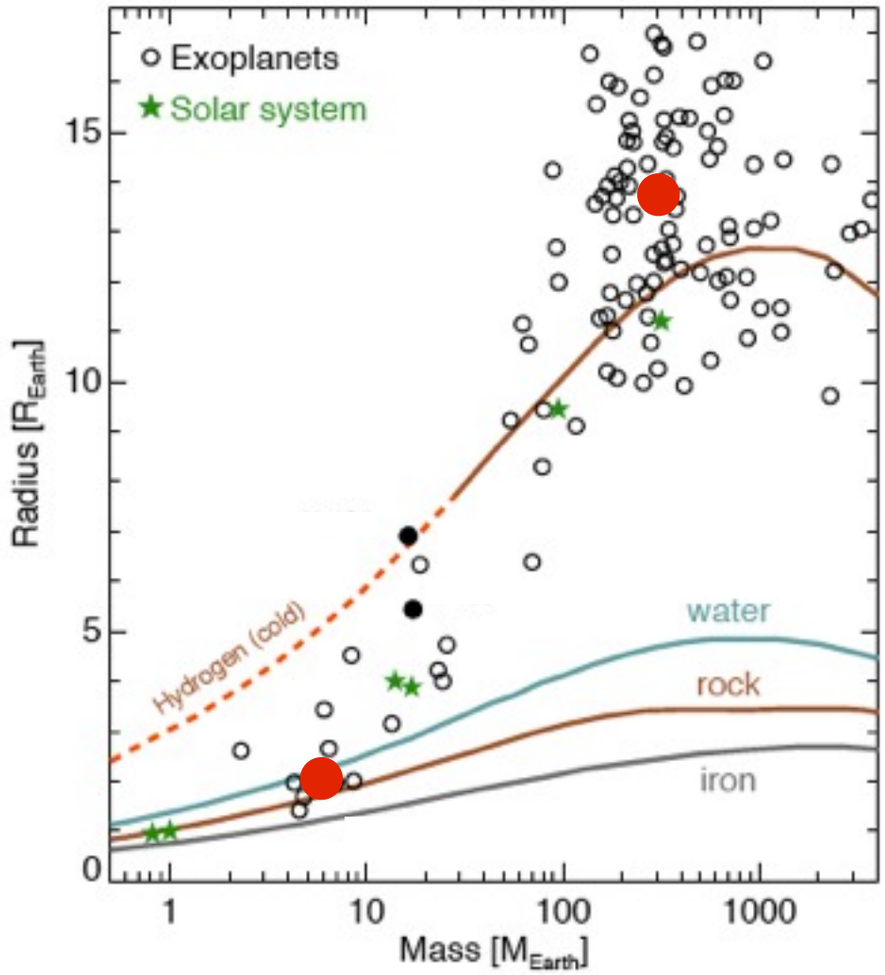
Pont et al. 2012

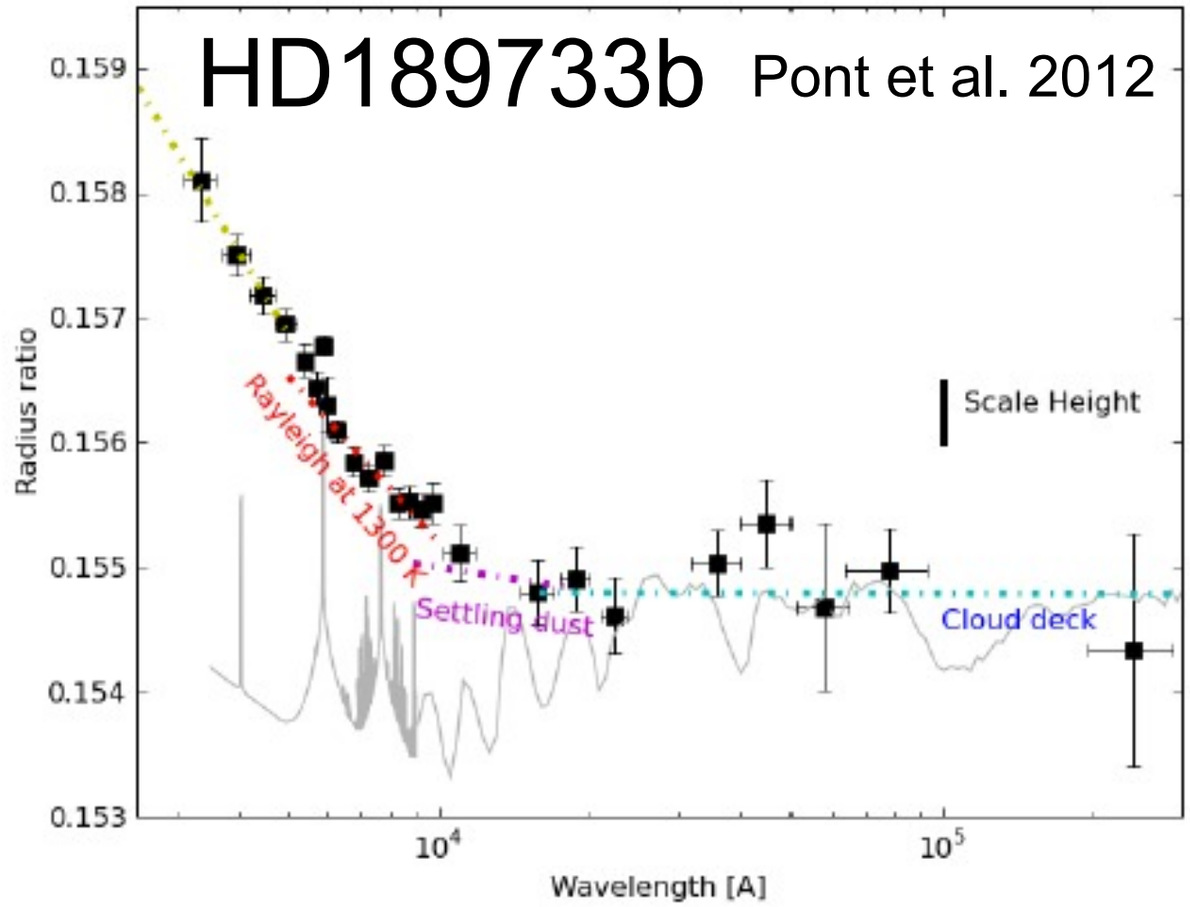
Diversity of hot-Jupiter atmospheres

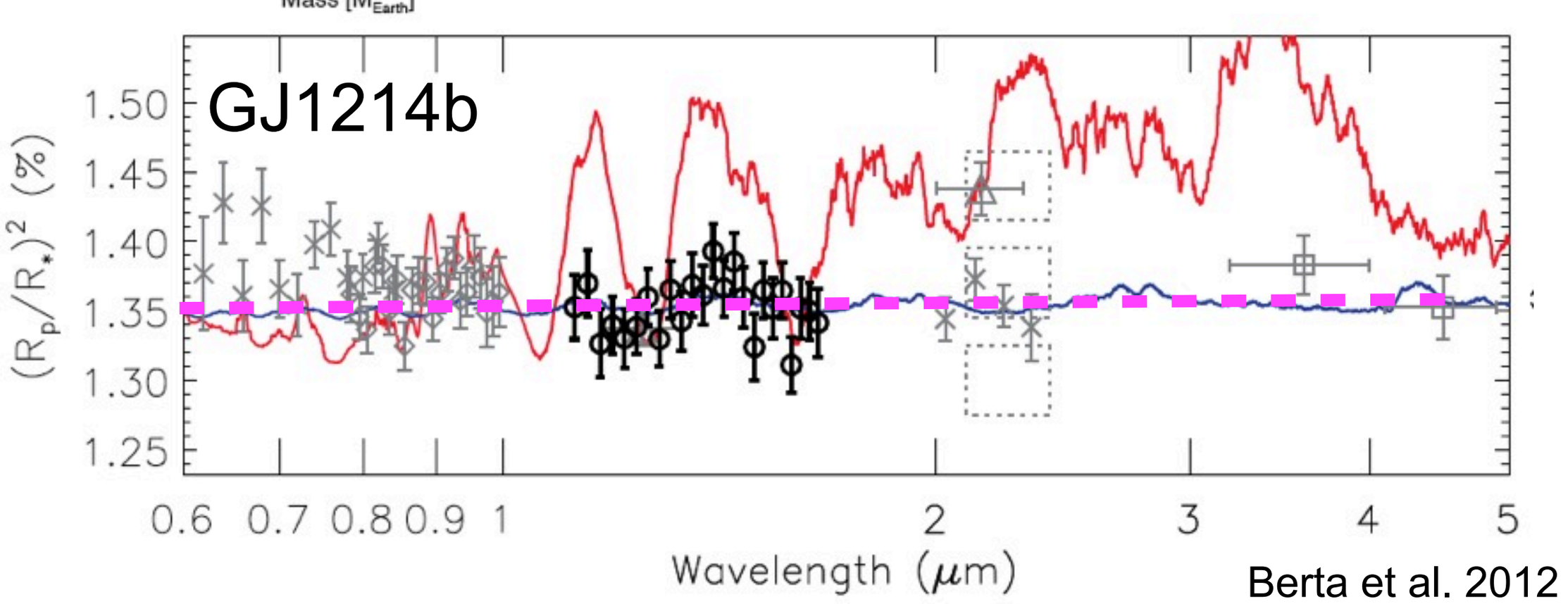
- High altitude optical absorbers / transparent atmospheres



Pont et al. 2012

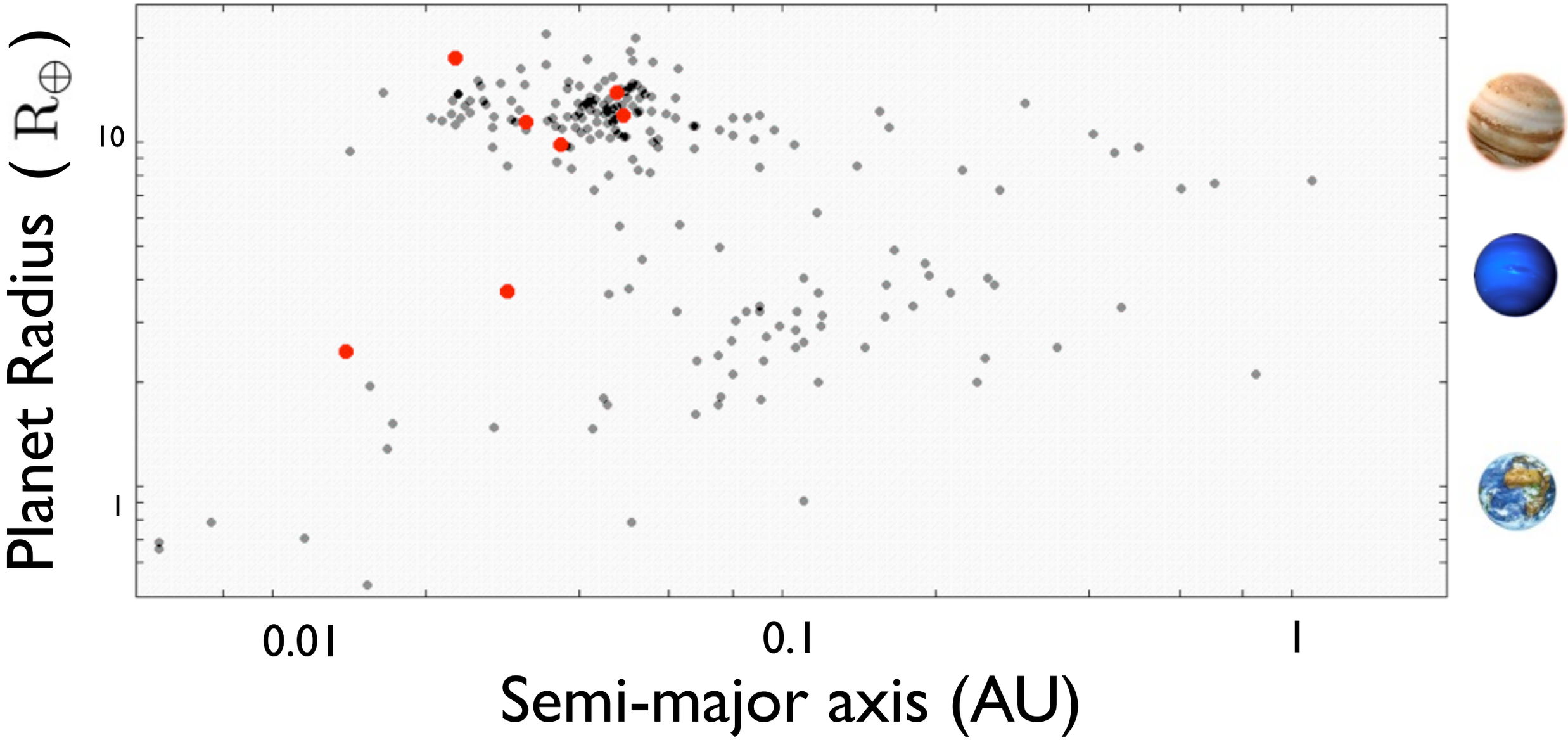






Berta et al. 2012

Transmission Measurements (XEUV -> IR)



Hot-Jupiters Survey

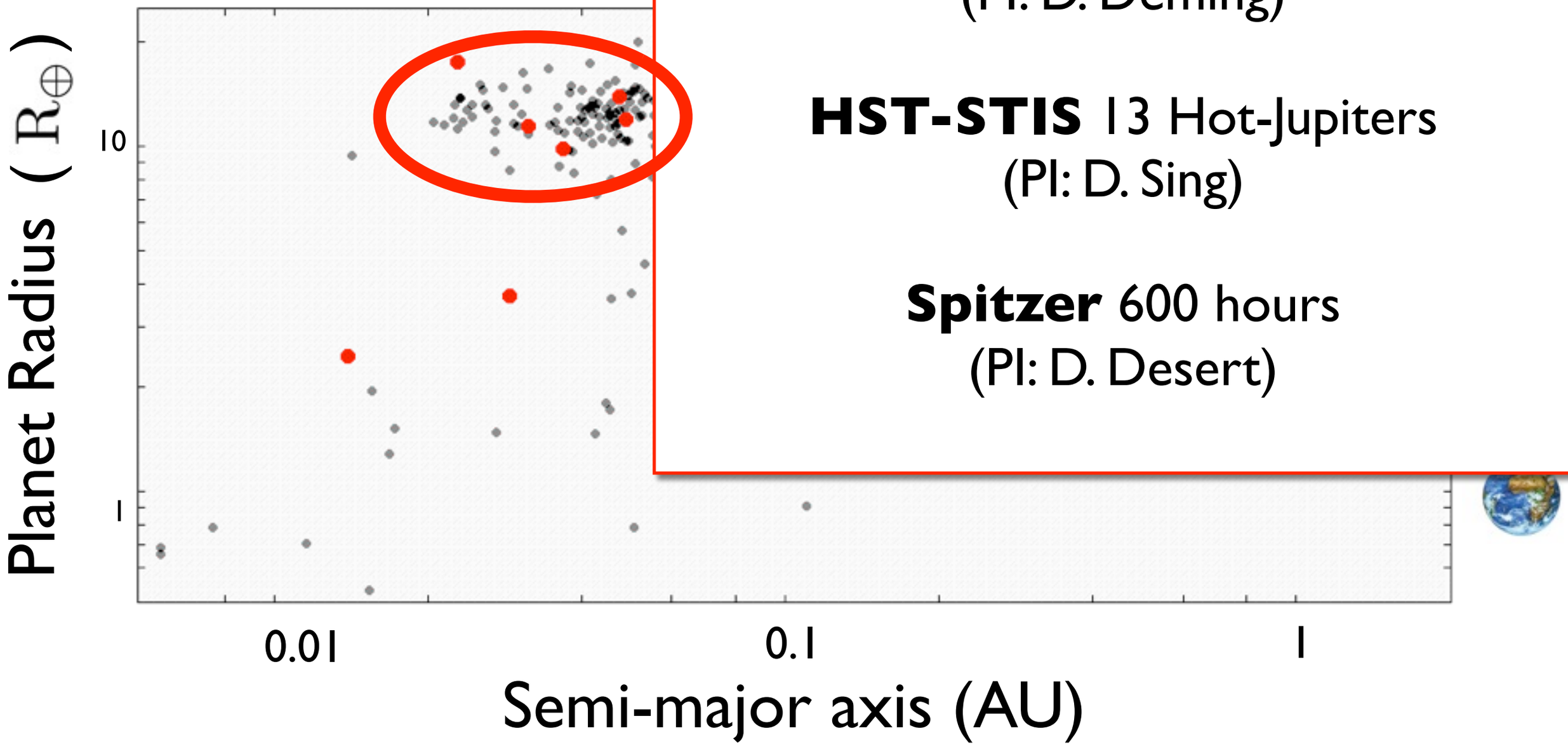
Transmis

Space-based Surveys:

HST-WFC3 13 Hot-Jupiters
(PI: D. Deming)

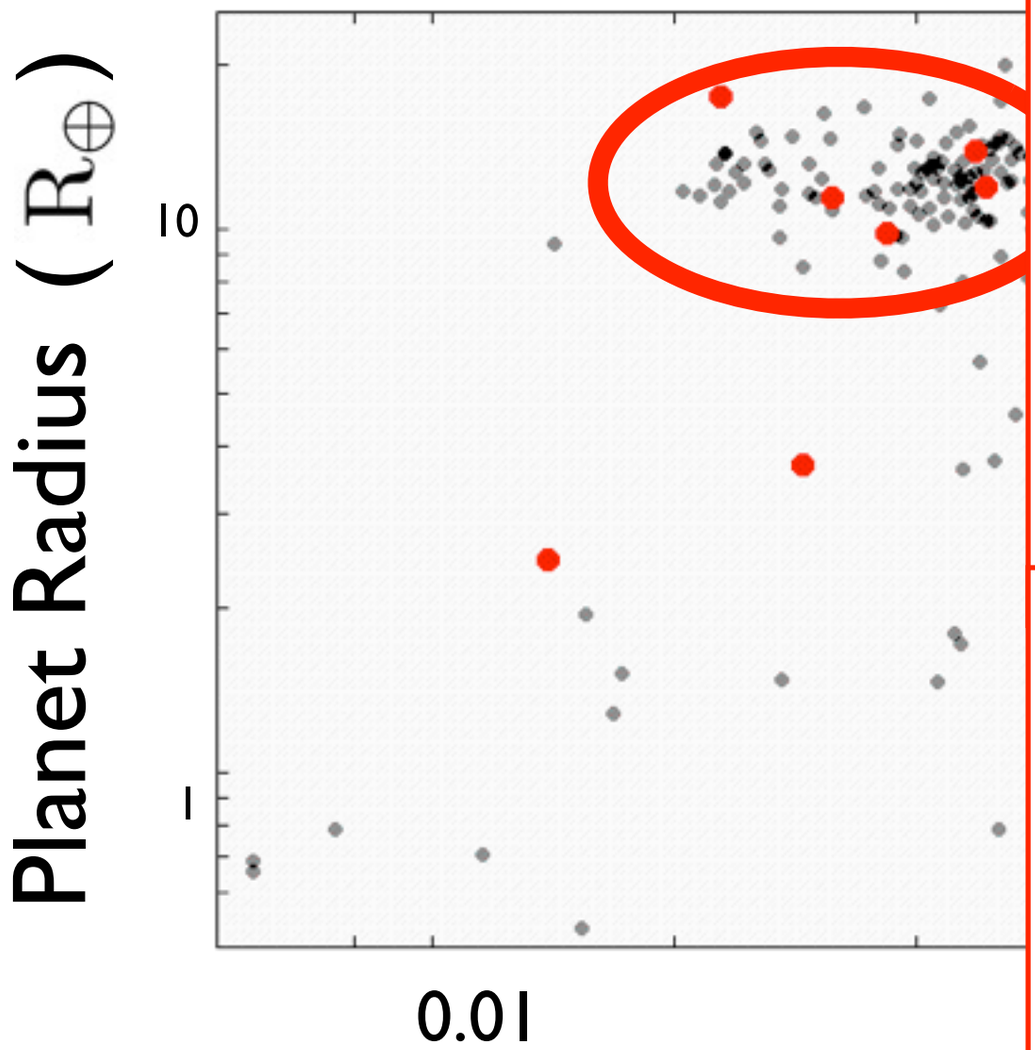
HST-STIS 13 Hot-Jupiters
(PI: D. Sing)

Spitzer 600 hours
(PI: D. Desert)



Hot-Ju

Transmis



Space-based Surveys:

HST-WFC3 13 Hot-Jupiters
(PI: D. Deming)

HST-STIS 13 Hot-Jupiters
(PI: D. Sing)

Spitzer 600 hours
(PI: JM. Désert)

Ground-based Surveys:

NIR: Magellan (PI: JM Désert/Bean)

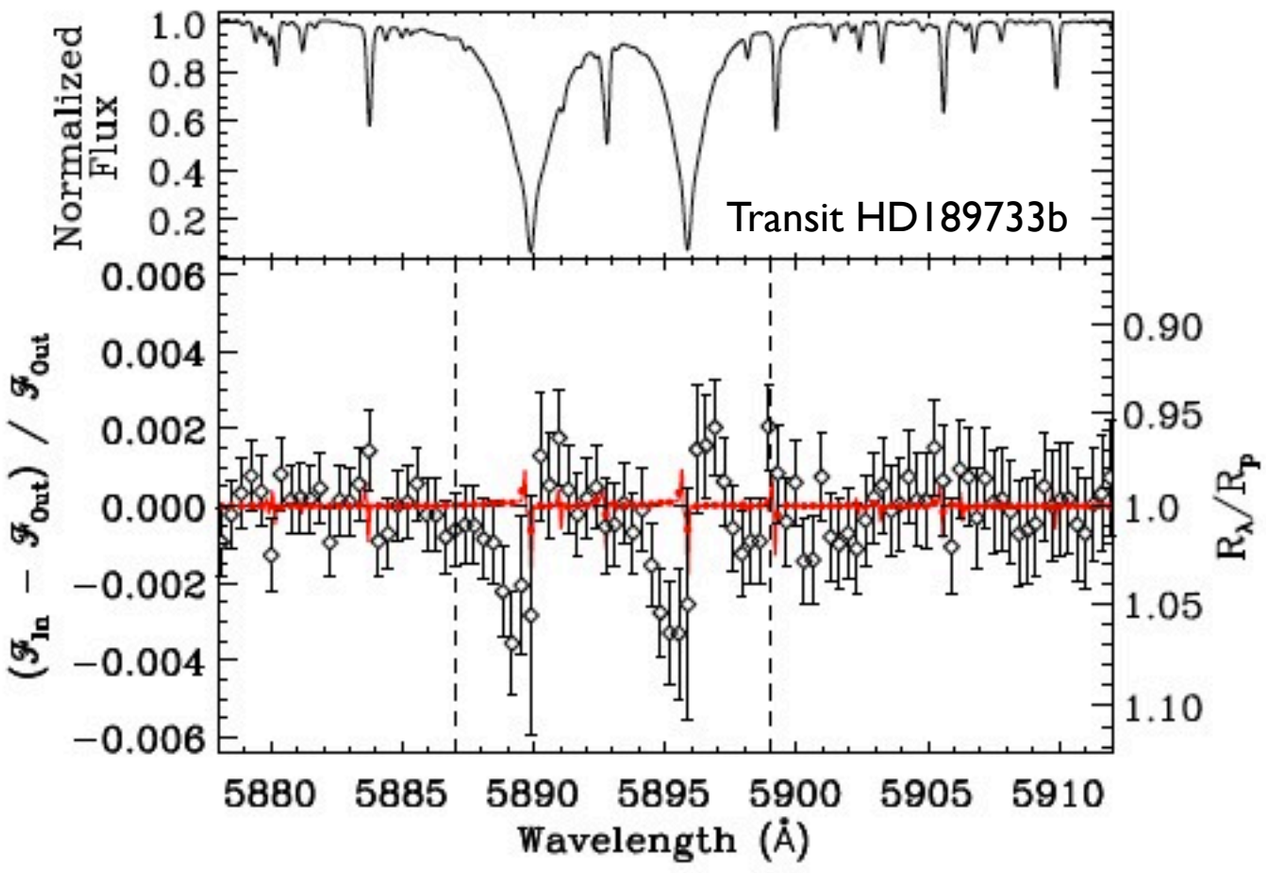
Optical: Gemini (PI: JM Désert)

Ground-based Survey Of hot-Jupiters

- **Optical:** Gemini
- **NIR:** Magellan

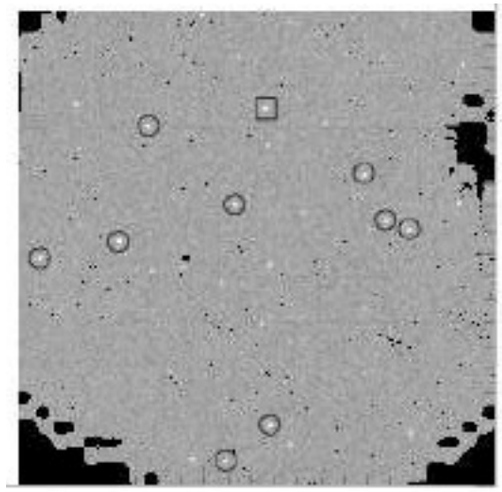
Ground-Based Observations

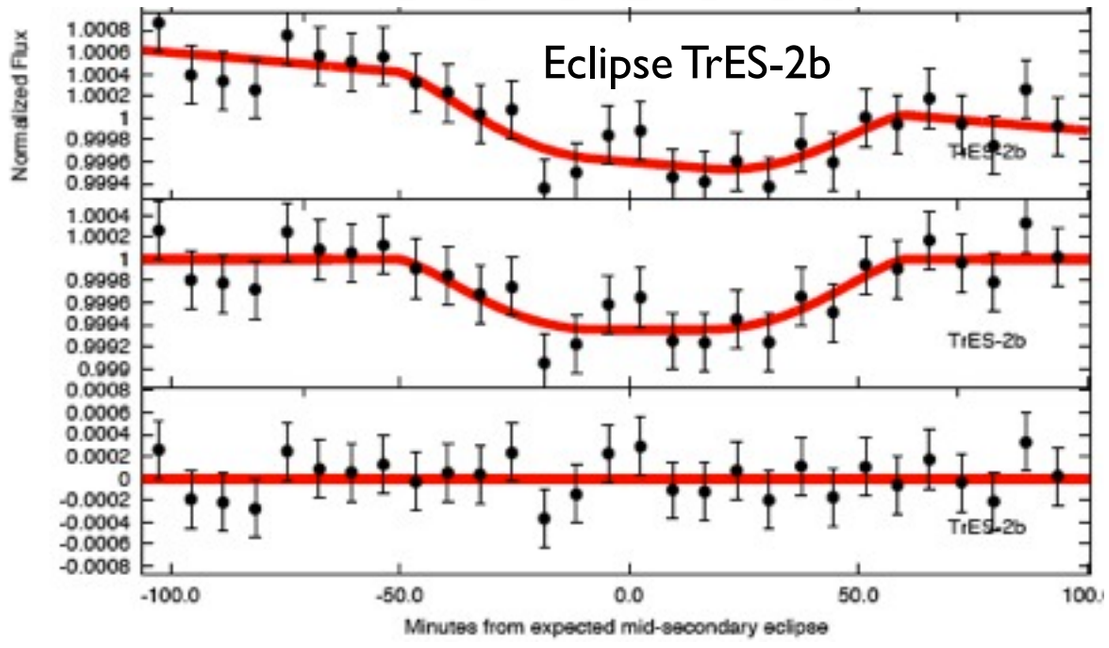
High Resolution Spectroscopy



Redfield et al. (2008)

Wide Field Photometry

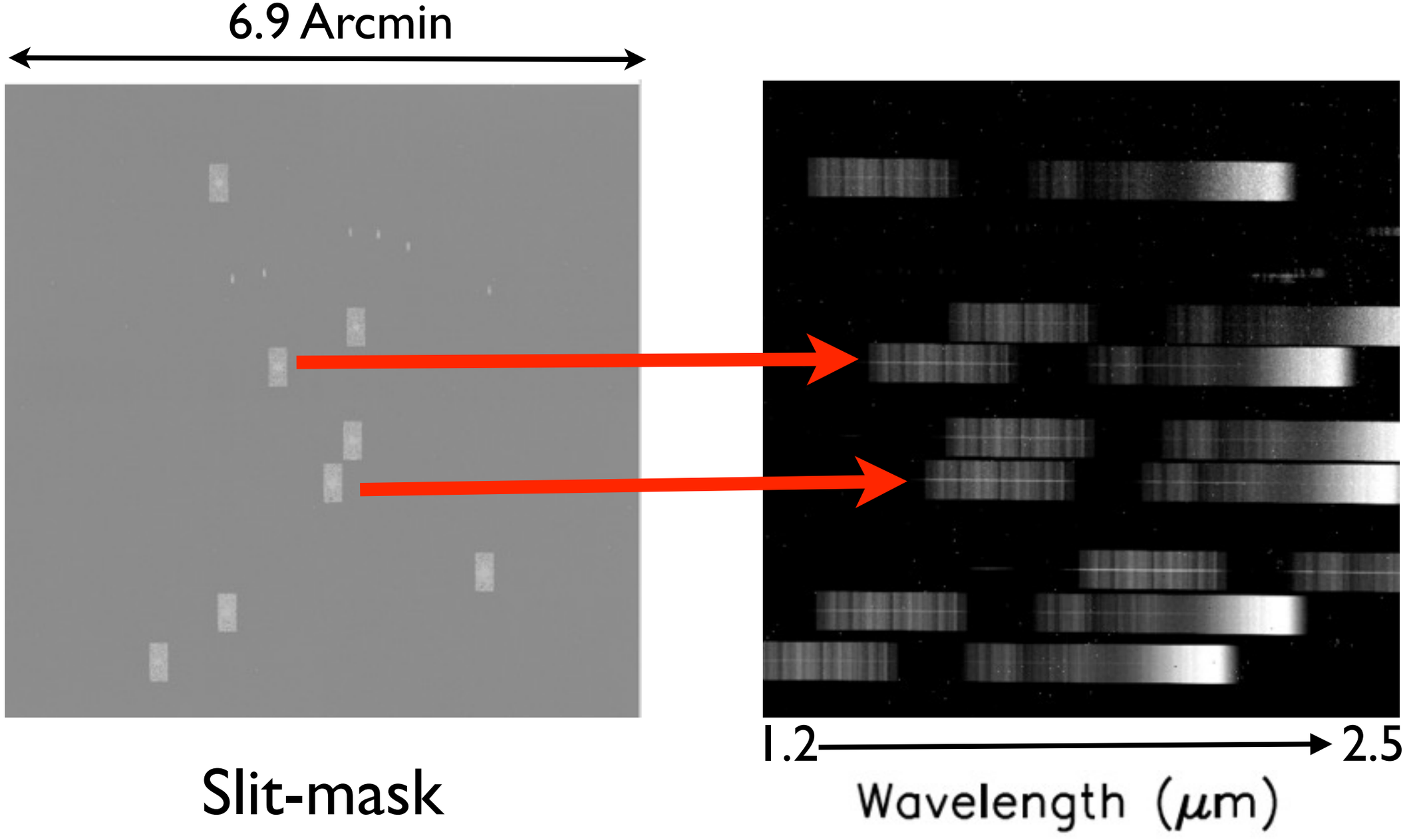




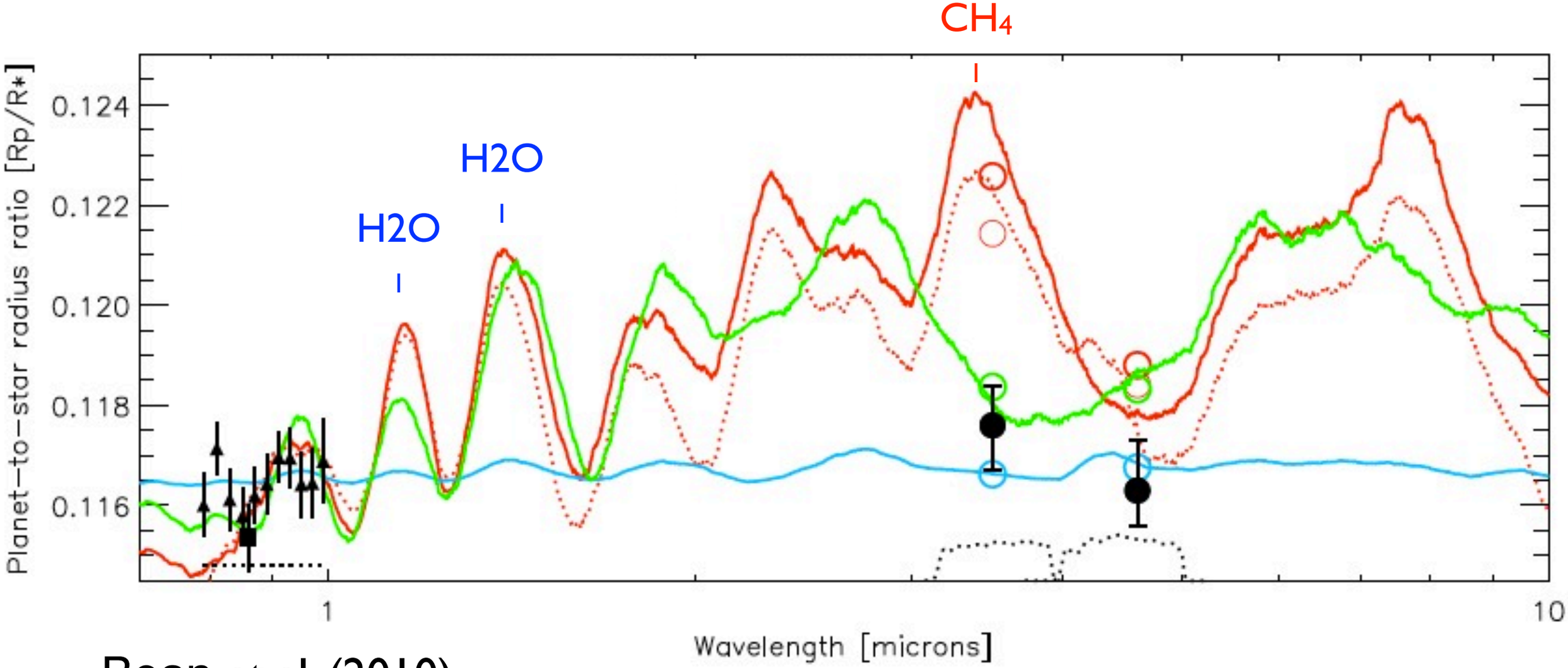
Croll et al. (2010)

Multi-Object Spectroscopy

Case of GJ1214b Magellan/MMIRS (Bean, Desert, et al. 2011)

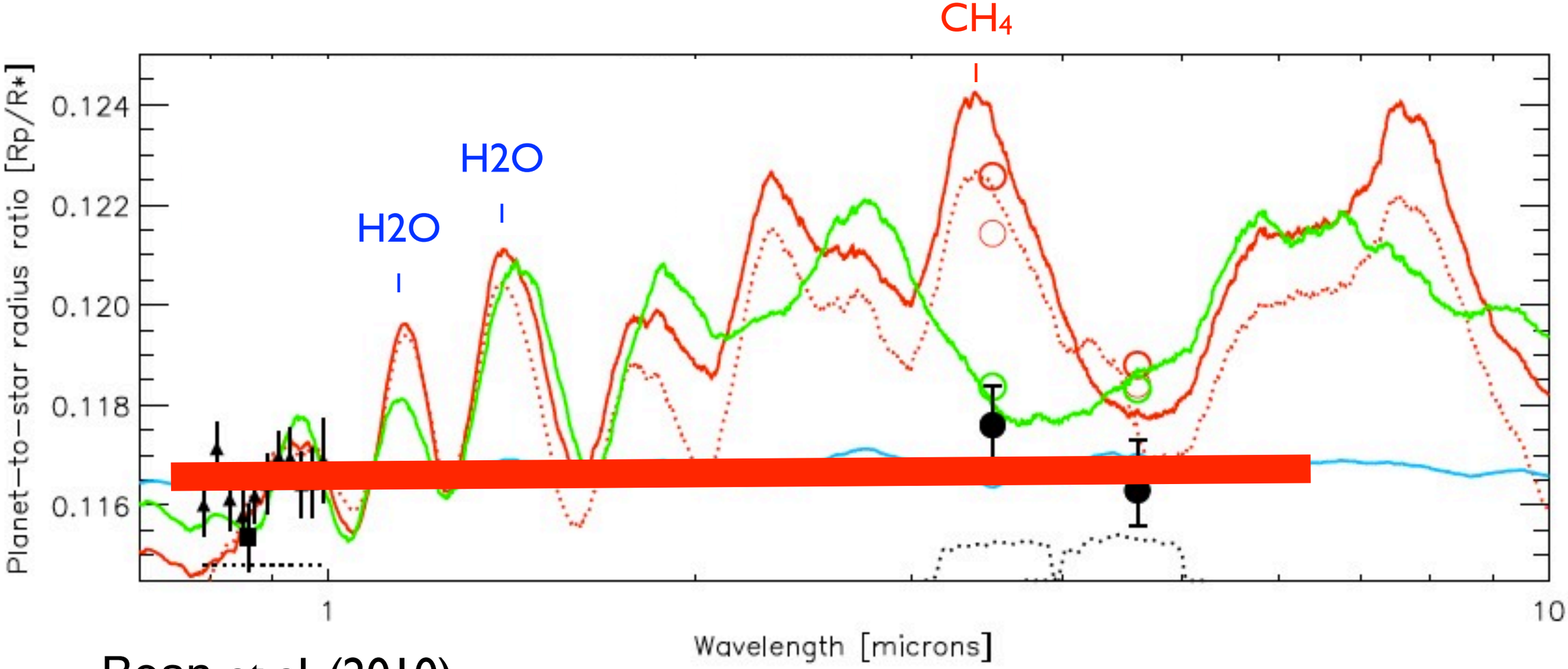


Transmission Spectroscopy of GJ1214b



Bean et al. (2010)

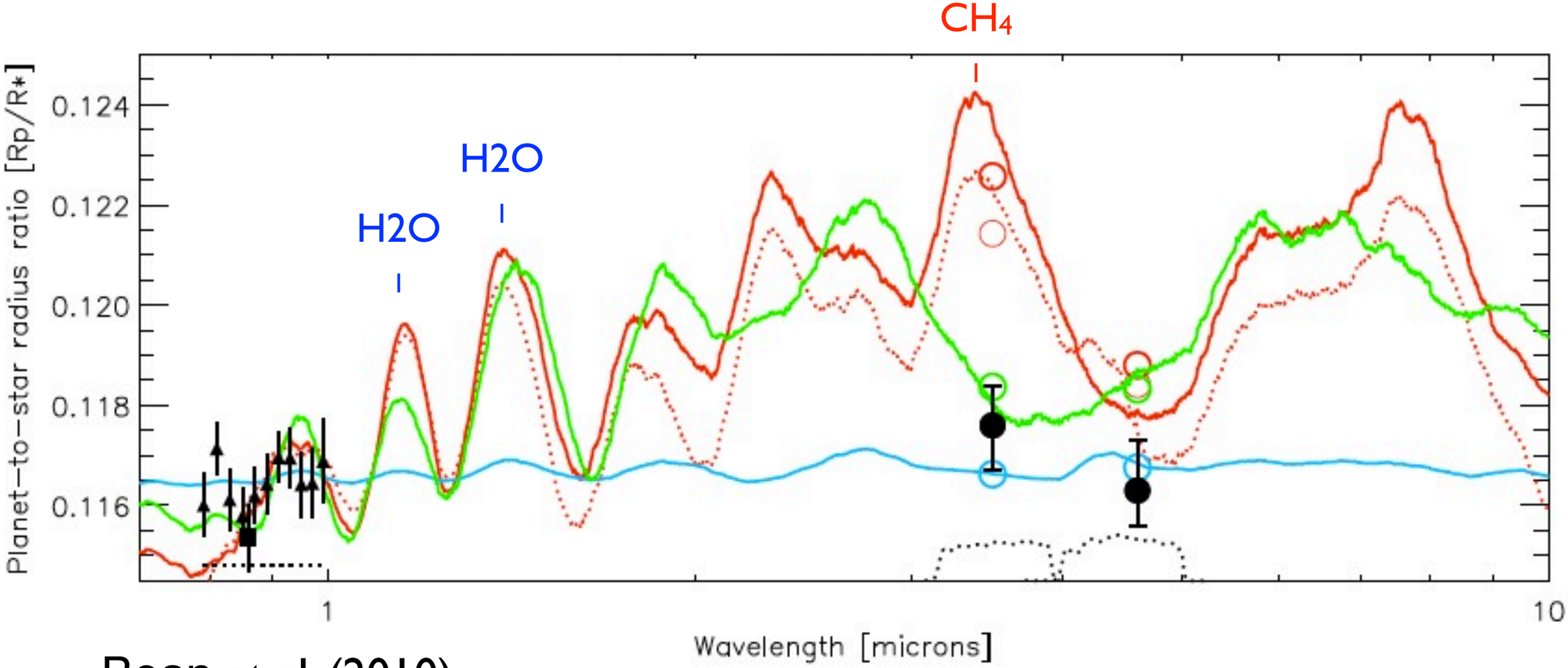
Transmission Spectroscopy of GJ1214b



Bean et al. (2010)

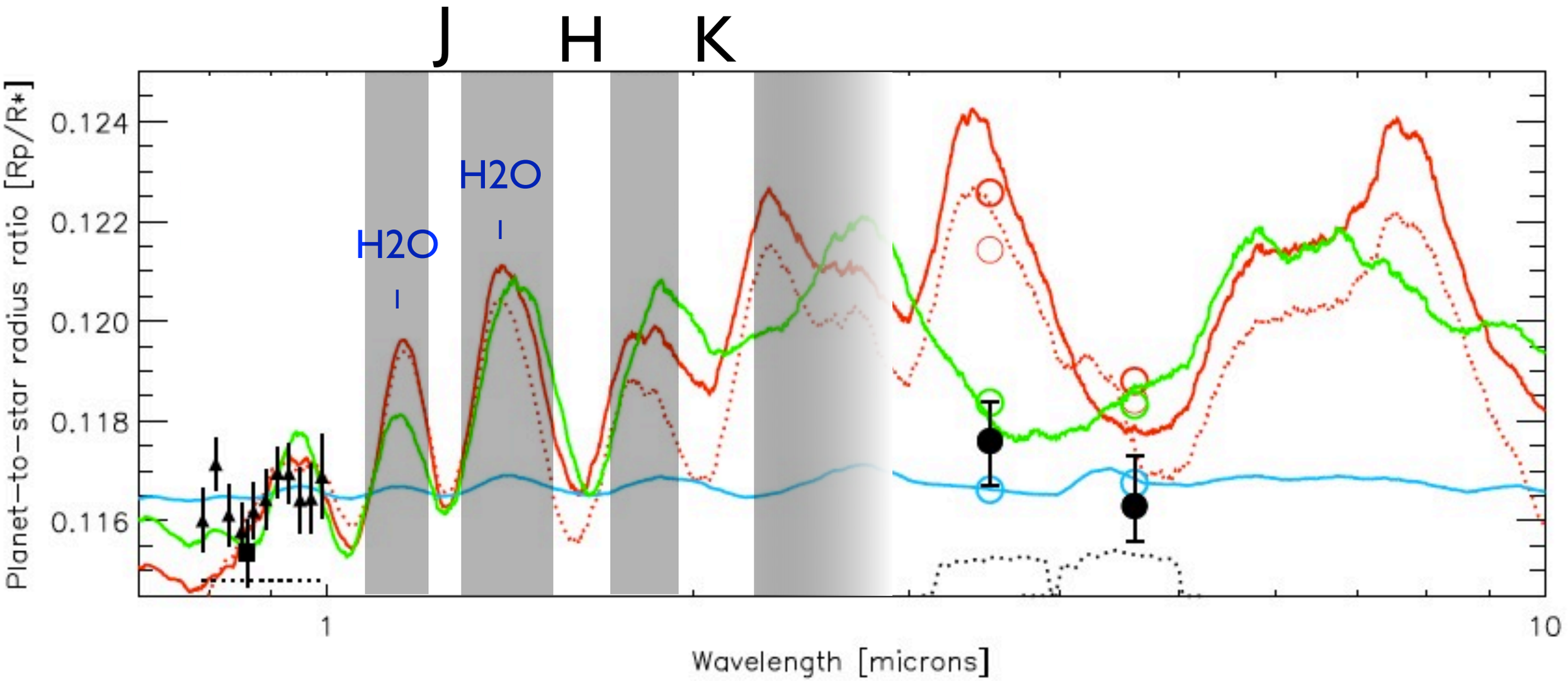
Flat

Transmission Spectroscopy of GJ1214b



Bean et al. (2010)

Transmission Spectroscopy of GJ1214b



Conclusion

- Multi-wavelength transmission spectrocopy to probe exoplanet atmospheres

- Comparative exoplanetology programs to understand the diversity of exoplanet atmospheres

- Ultimate goal: low mass planets around low mass stars

- Main Challenges: Understanding and Controlling Instrumental and Astrophysical Systematics.