Looking for Carbon-Rich Giant Planets: Ground-based Observations of the Extremely Hot Jupiter WASP-12b

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w/Brad Hansen & Travis Barman

How are heavy elements distributed in (giant) planets?

Table 1. Elemental and Isotopic Abundances [(a)]

Elements

Elements	Sun	Jupiter/Sun	Saturn/Sun
He/H	0.0975	0.807±0.02	0.56-0.85
Ne/H	1.23×10^{-4}	0.10±0.01	
Ar/H	3.62×10^{-6}	2.5±0.5	
Kr/H	1.61×10^{-9}	2.7±0.5	
Xe/H	1.68×10^{-10}	2.6±0.5	
C/H	3.62×10^{-4}	2.9±0.5	~6
N/H	1.12×10^{-4}	3.0±1.1 (hotspot, 9-12 bar)	2–4 (uncertain)
O/H	8.51×10^{-4}	0.033±0.015 (hotspot, 12 bar) 0.30±0.1 (hotspot, 19 bar)	
S/H	1.62×10^{-5}	2.75±0.66 (hotspot, 16 bar)	
P/H	3.73×10^{-7}	0.82	5–10

Atreya+2004

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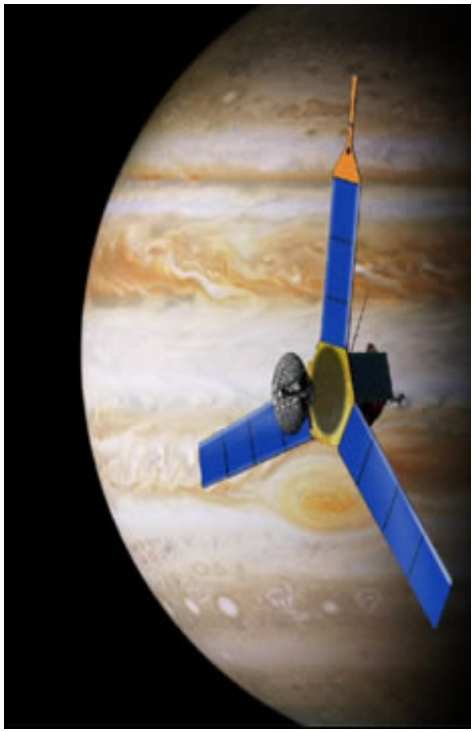

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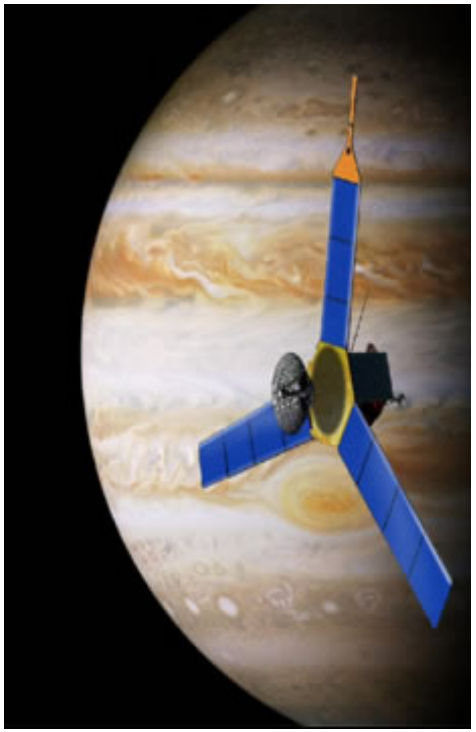
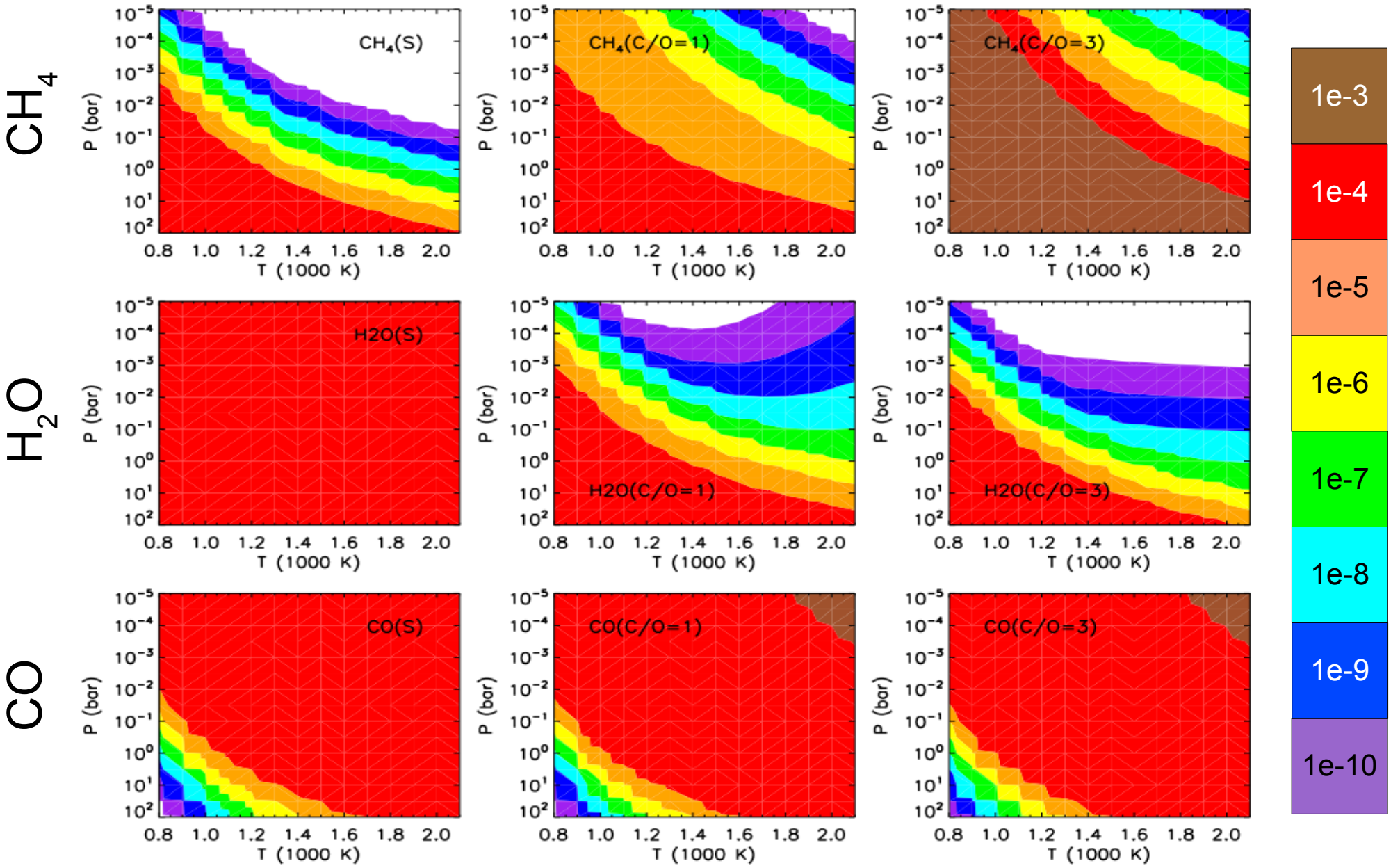


Atreya+2004

Remote sensing of exoplanets can help answer this question!

Atmospheric C/O ratio influences abundances of observable species.



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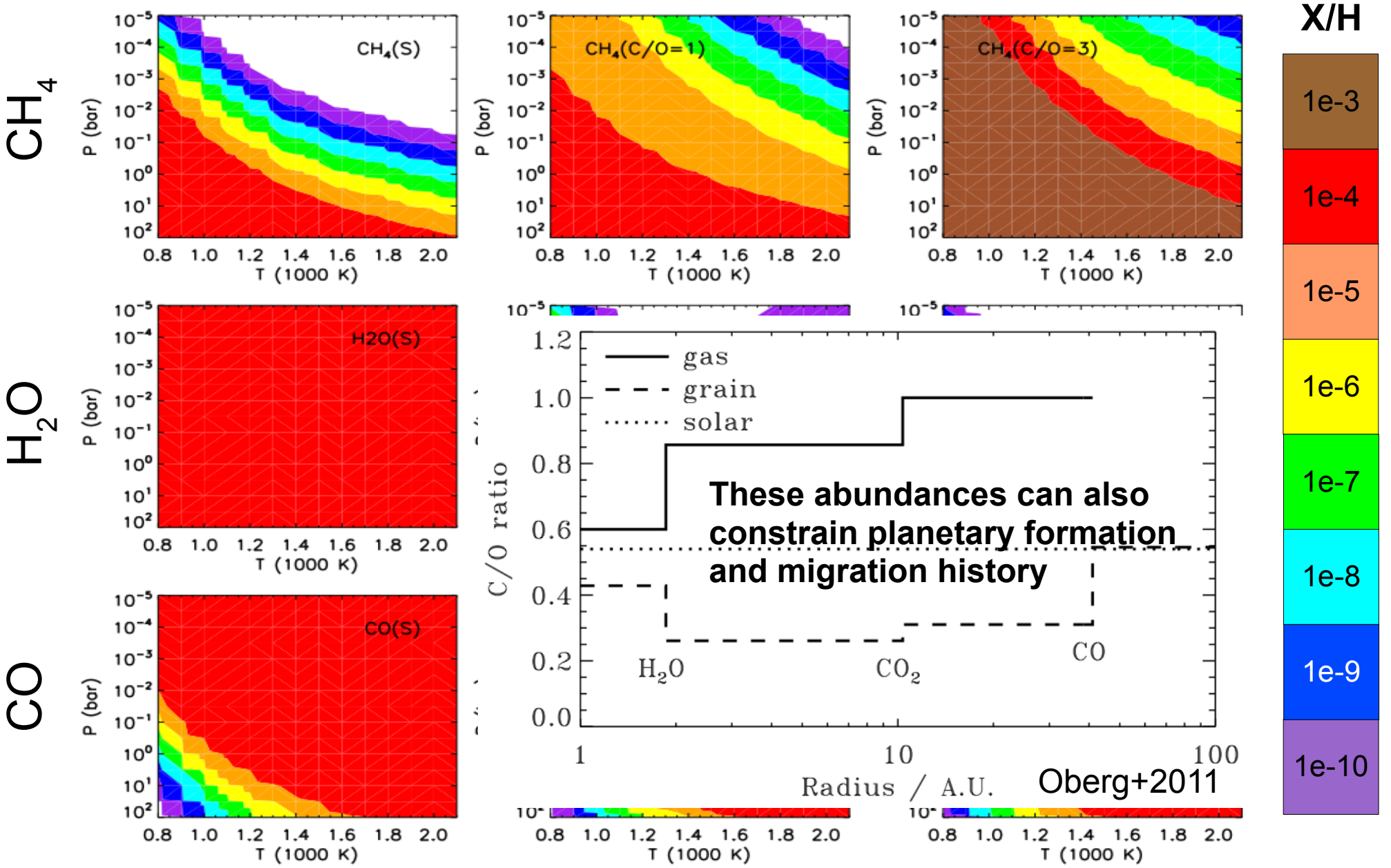
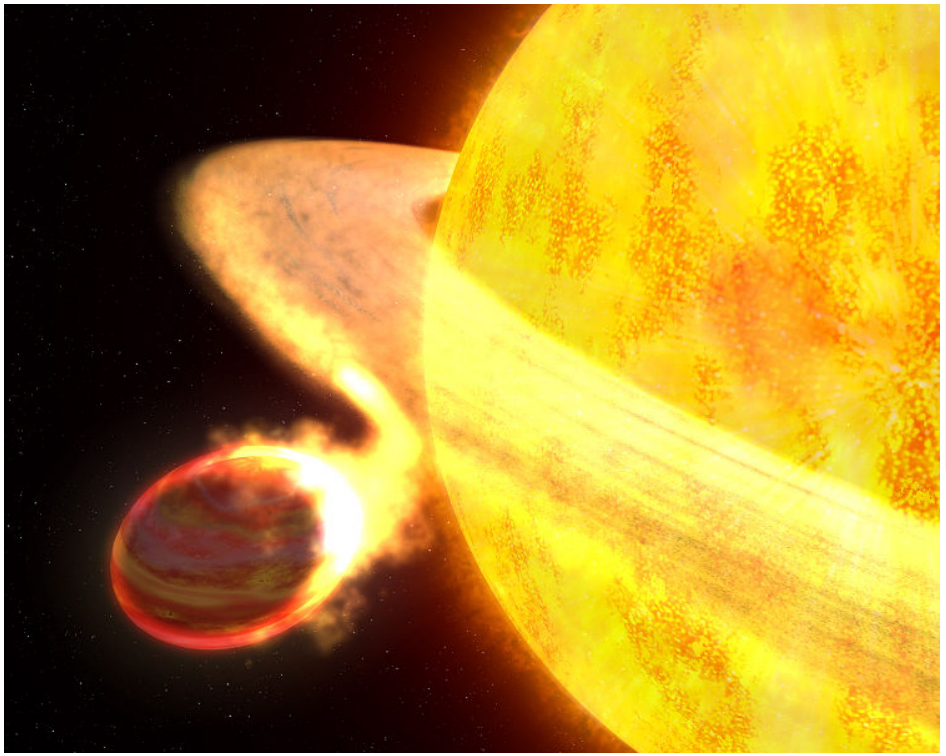
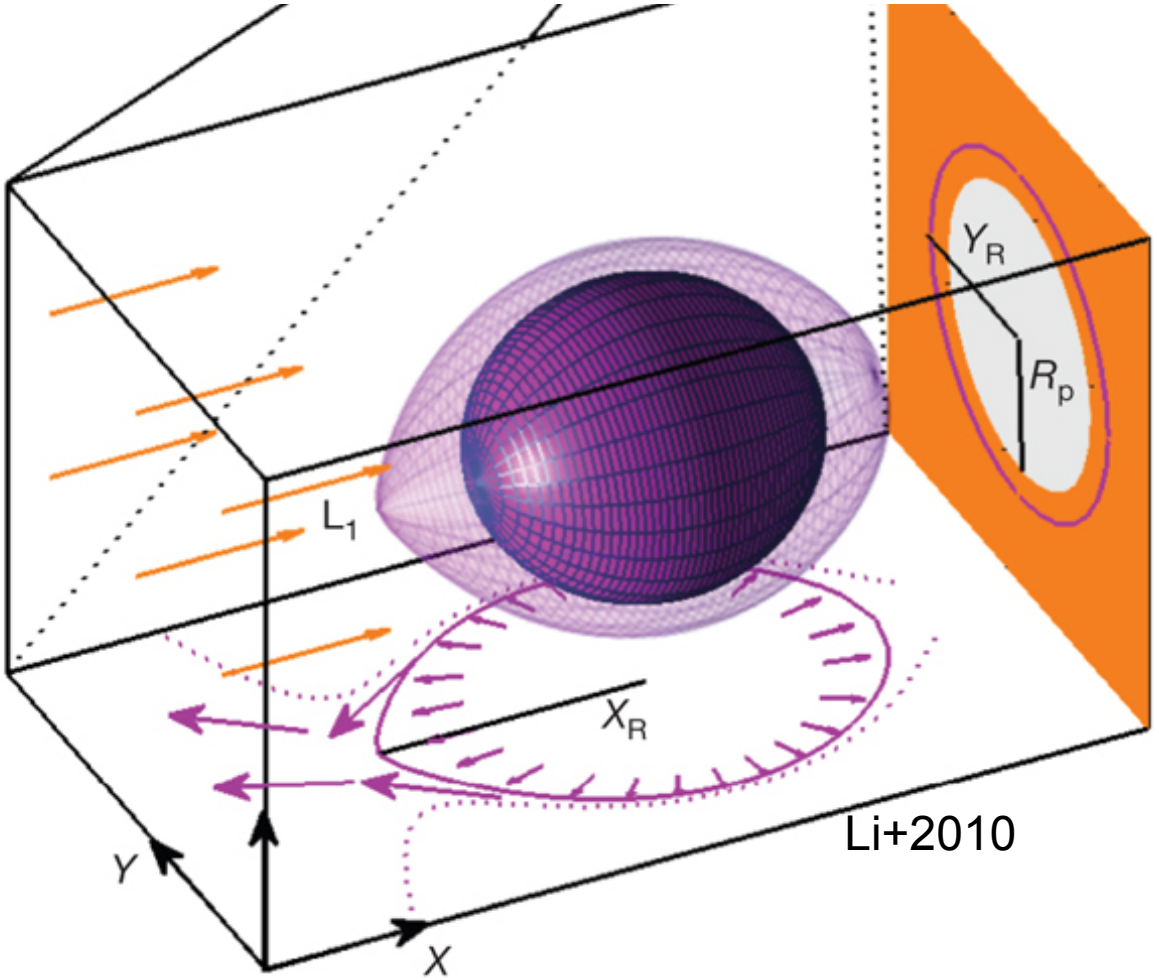


Our current observations focus on testing the claim of Carbon-rich planets.

WASP-12b: An Extreme Giant Planet

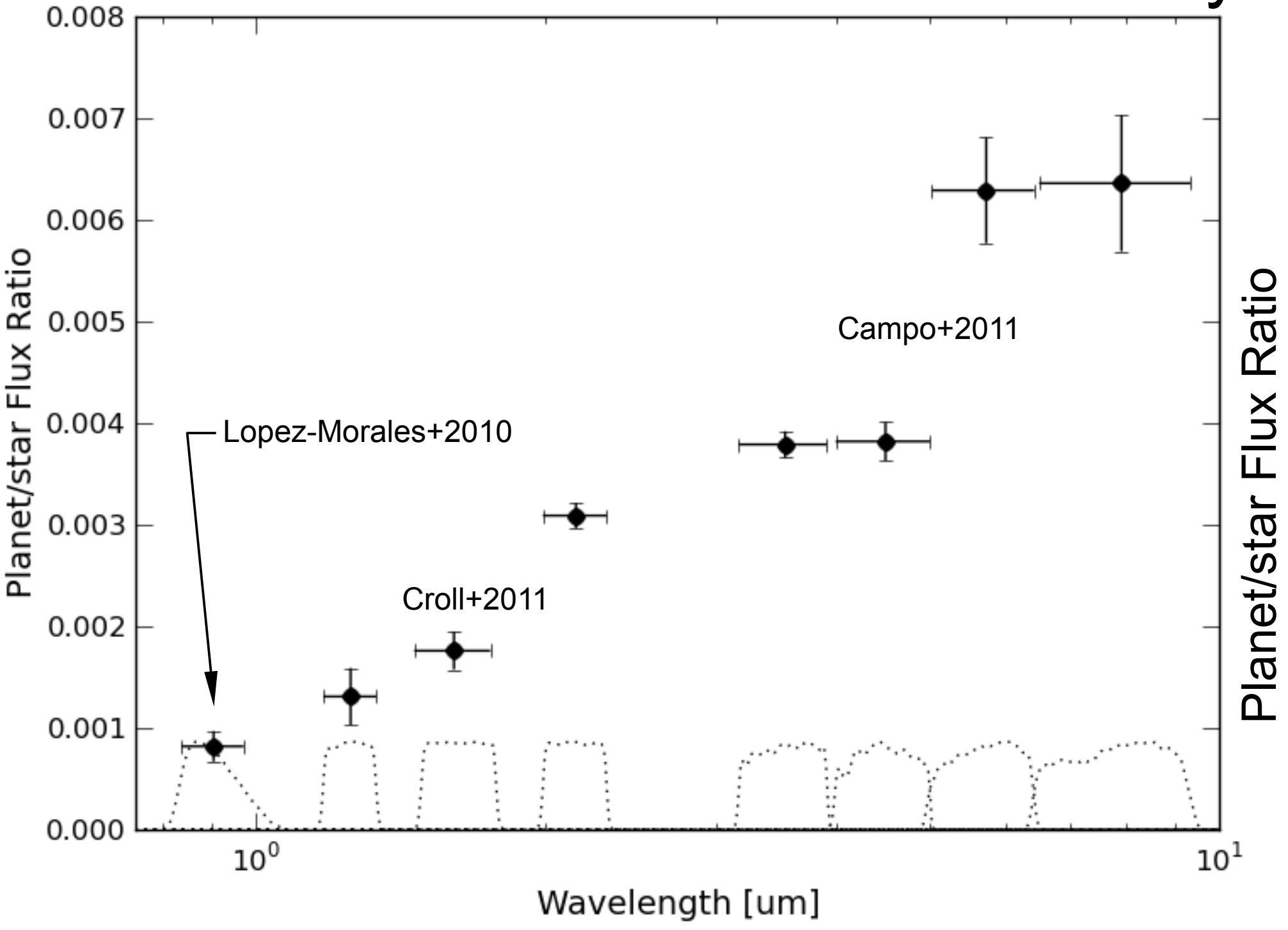
Period ~ 1 day
Eq. Temp. ~ 3,000 K
Radius ~ 1.7 R_Jup
Density ~ 0.3 g/cc



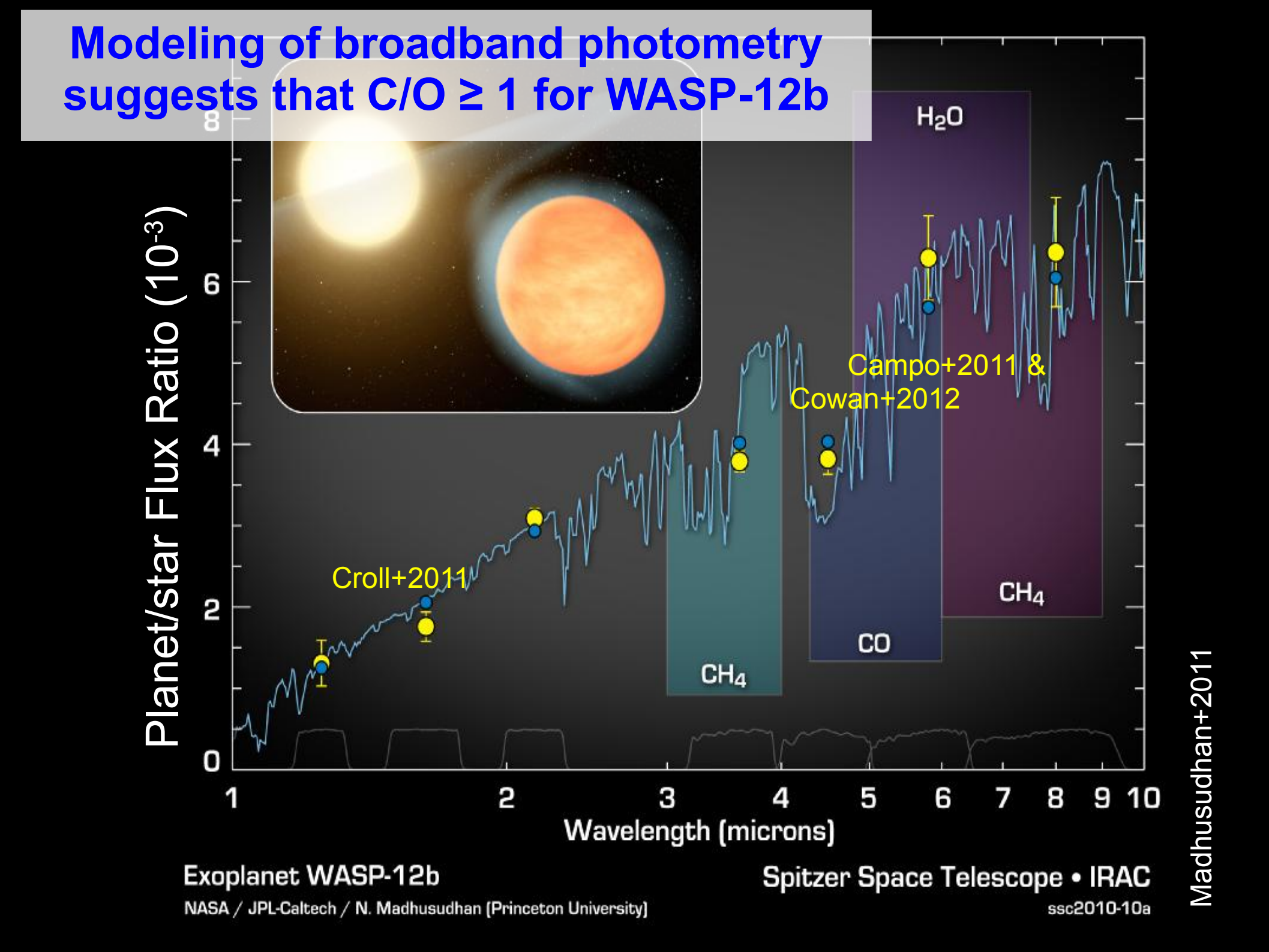


Li+2010

WASP-12b Broadband Photometry:

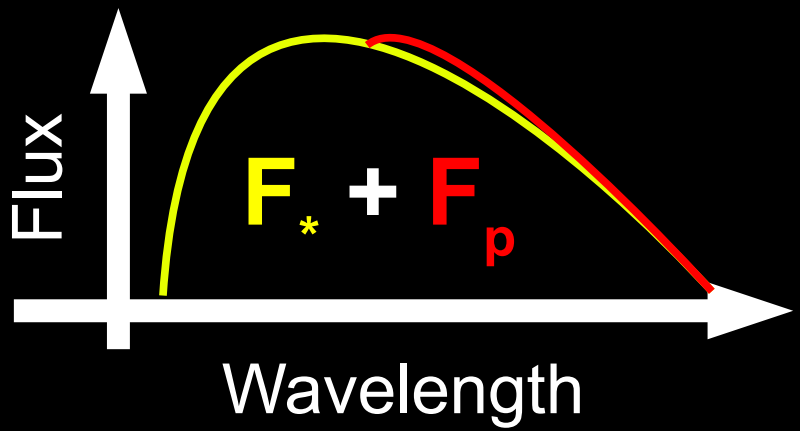


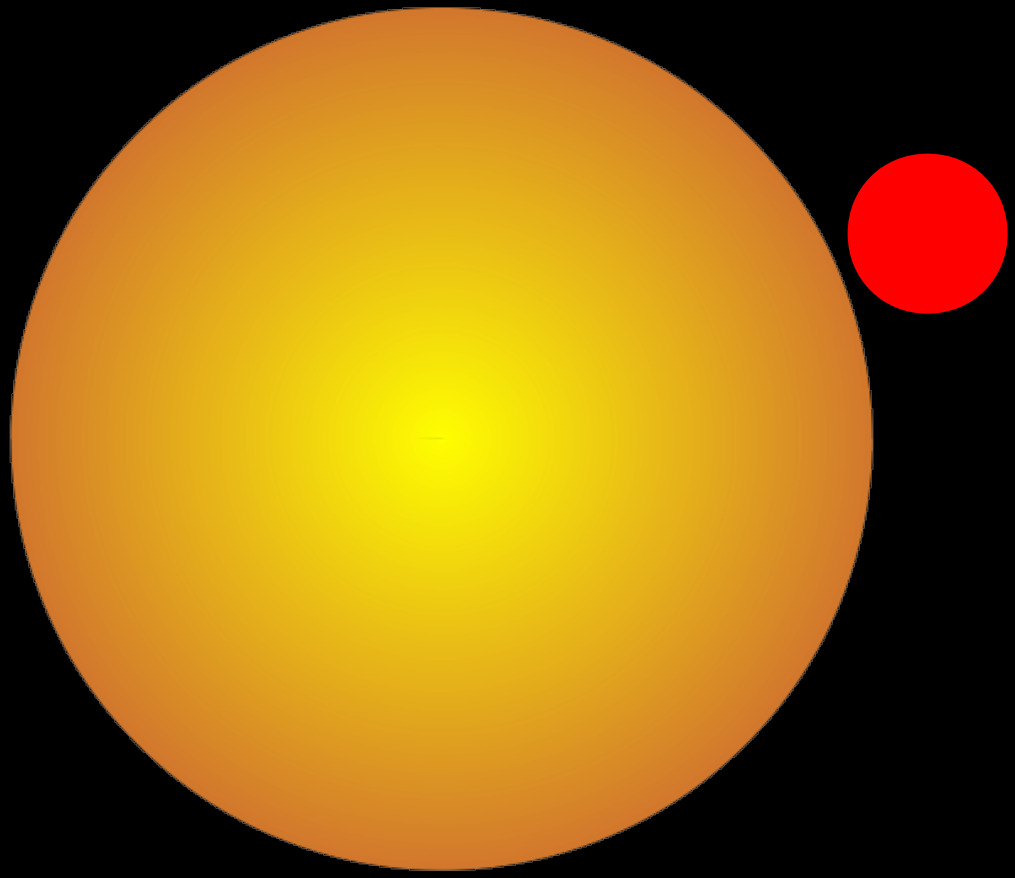
Modeling of broadband photometry suggests that C/O ≥ 1 for WASP-12b



We measure WASP-12b's emission via eclipse spectroscopy:

$$F_p(\lambda) = (F_* + F_p) - F_*$$





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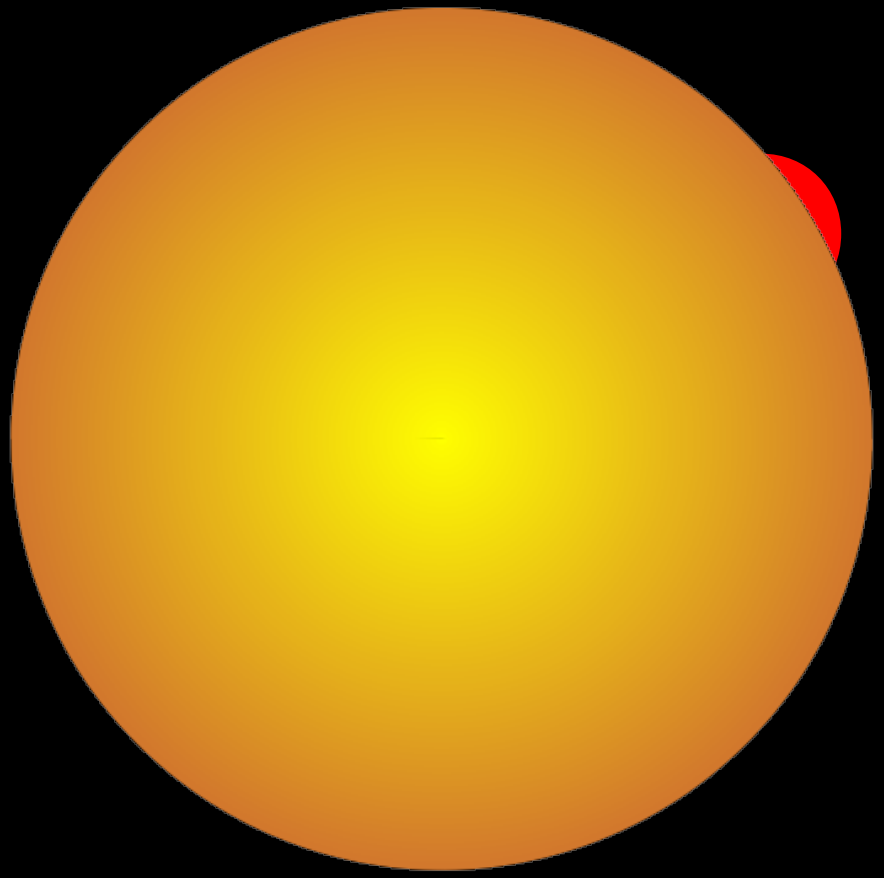

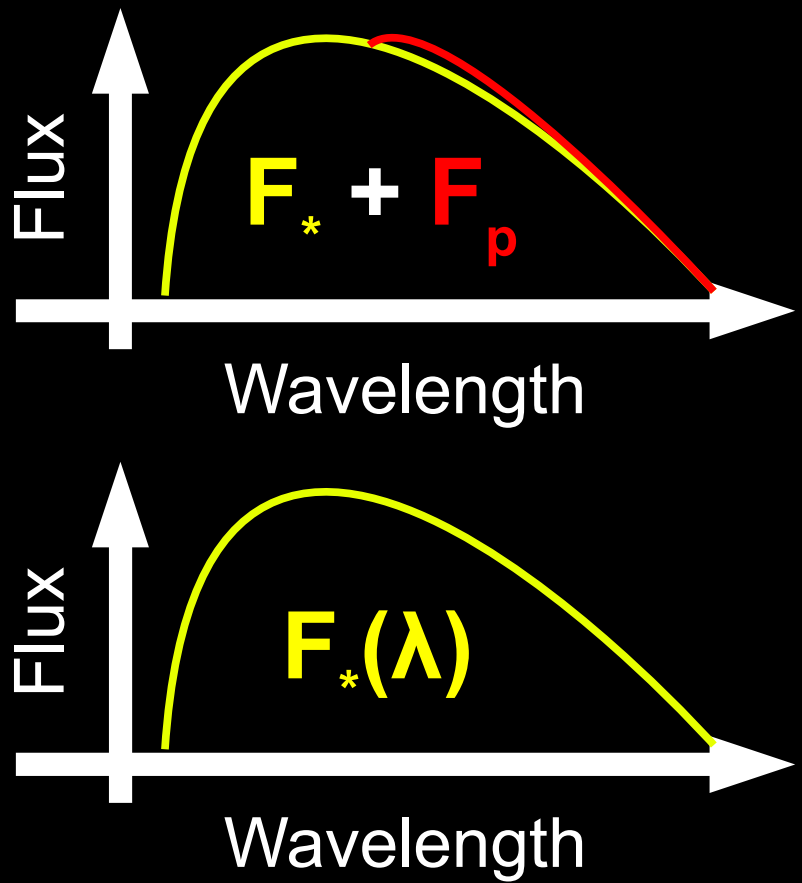

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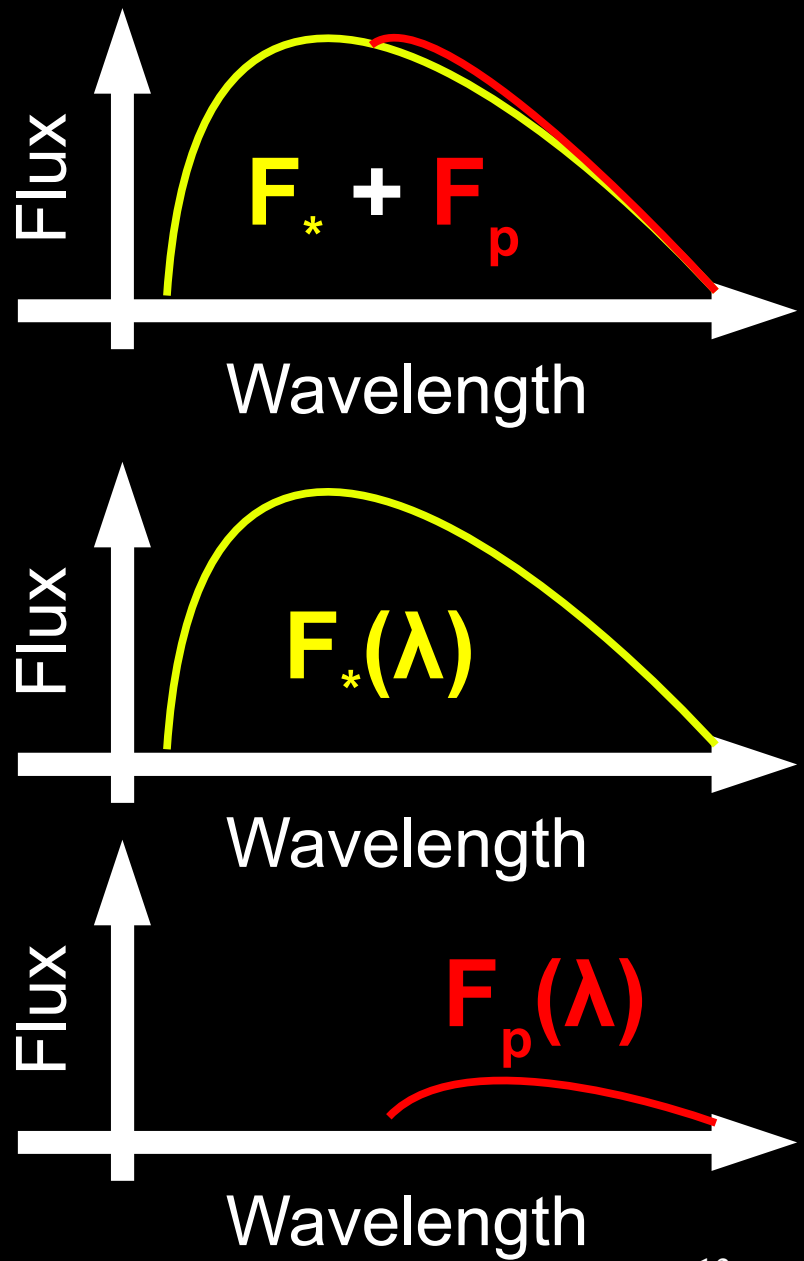

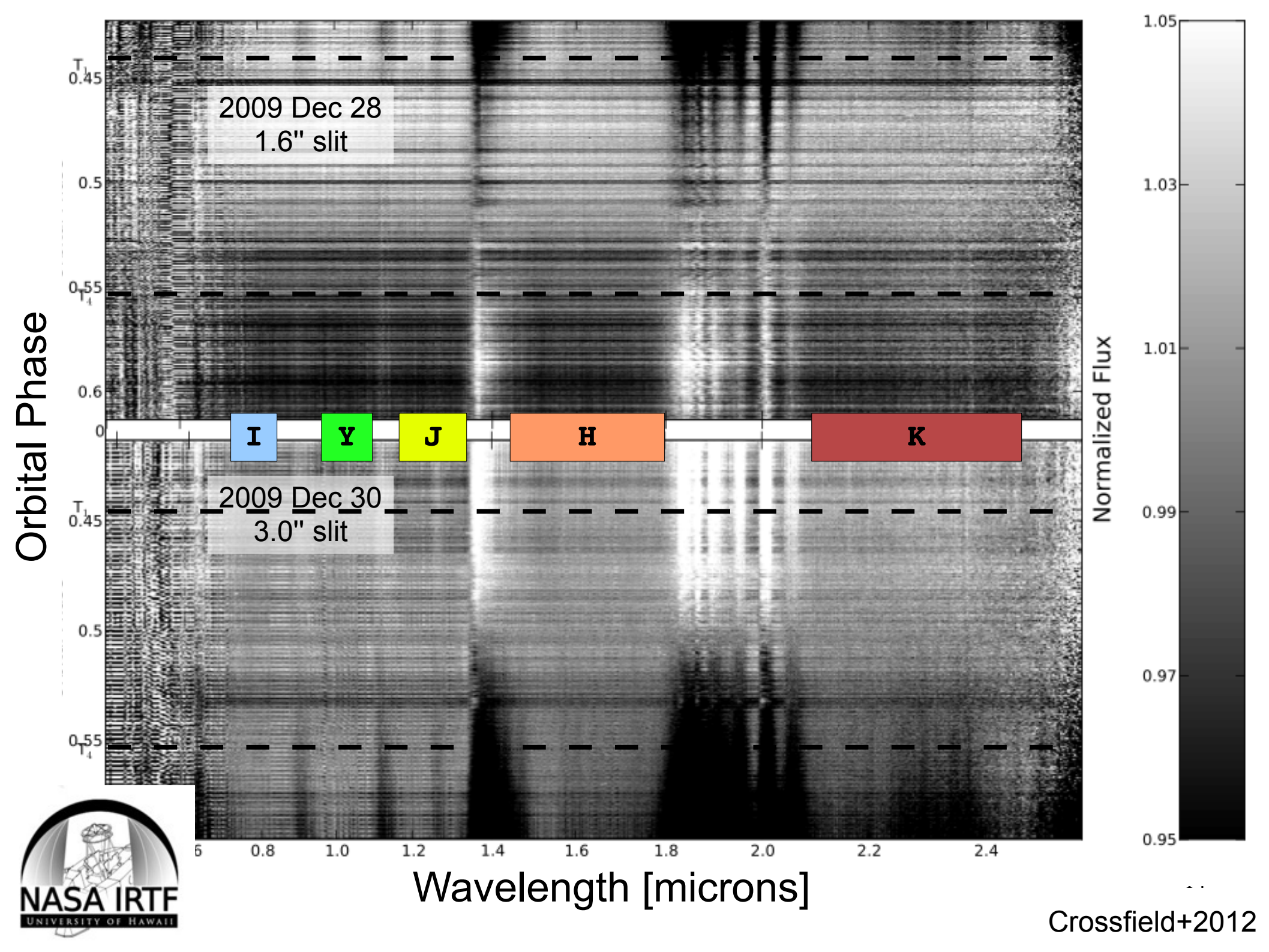
2009 Dec 28
1.6" slit
2009 Dec 30
3.0" slit
I
Y
J
H
K
Orbital Phase
0.45
0.5
0.55
0.6
0
0.45
0.5
0.55
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
Wavelength [microns]
Normalized Flux
1.05
1.03
1.01
0.99
0.97
0.95
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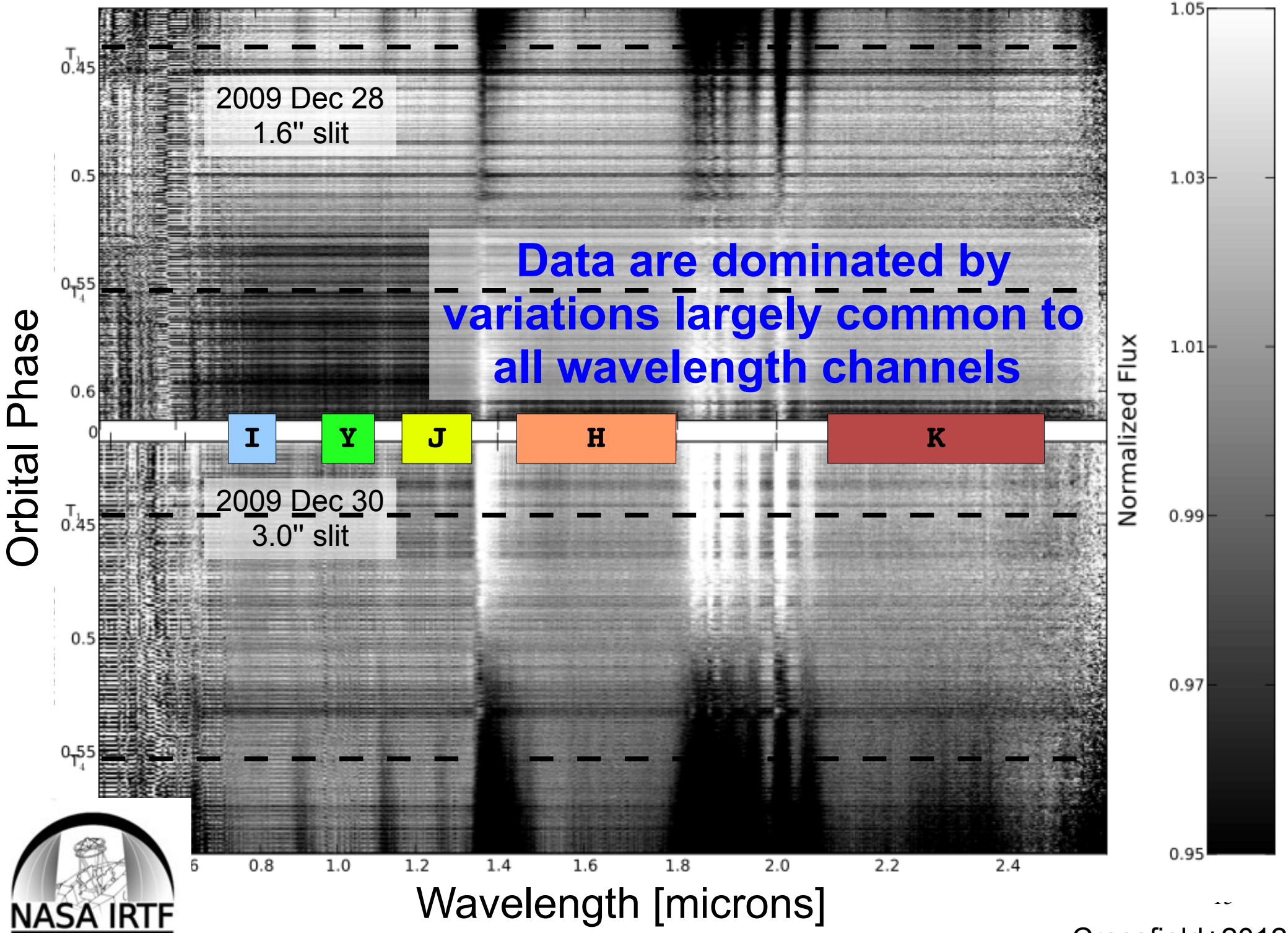
UNIVERSITY OF HAWAII
Crossfield+2012



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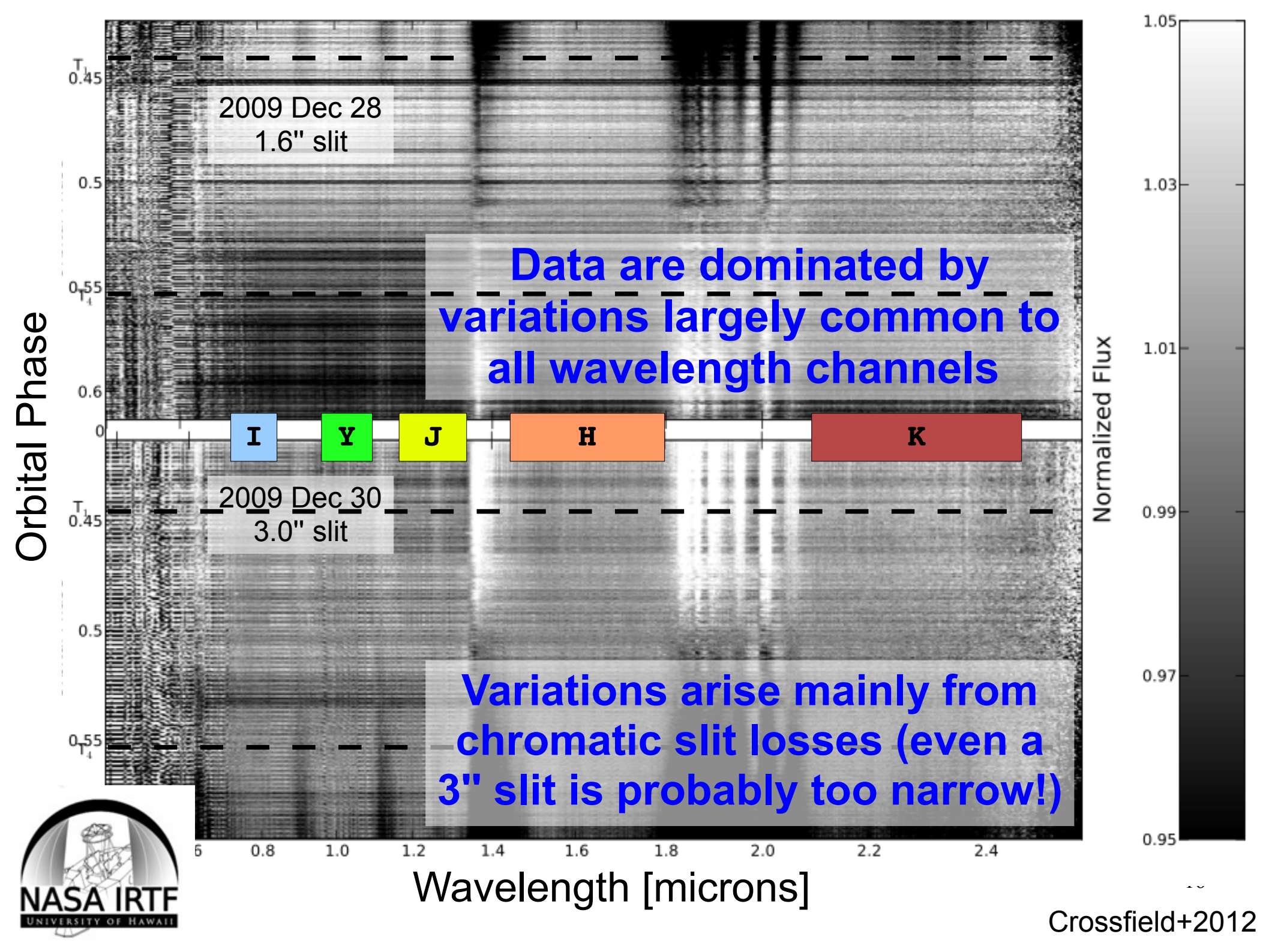

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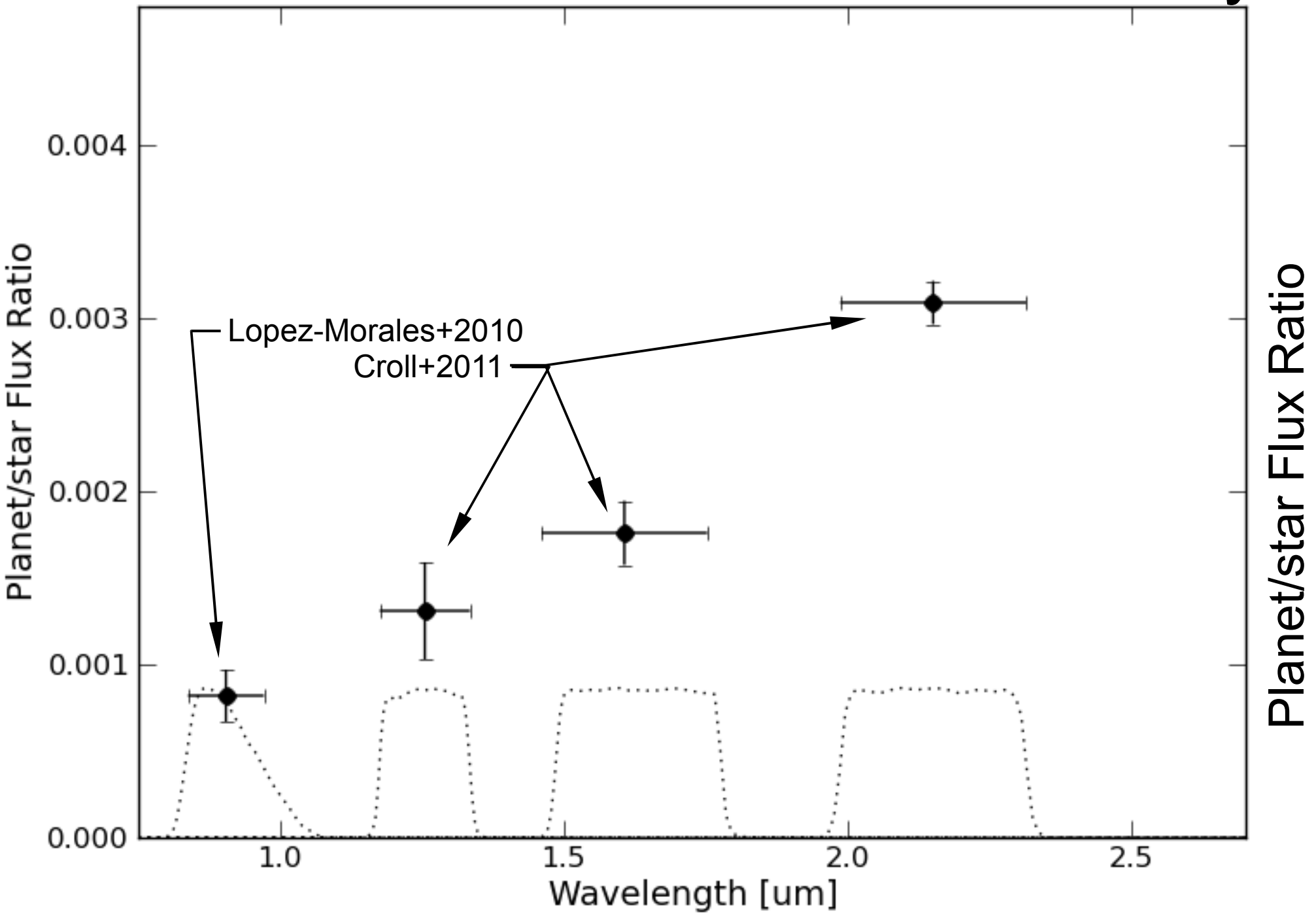
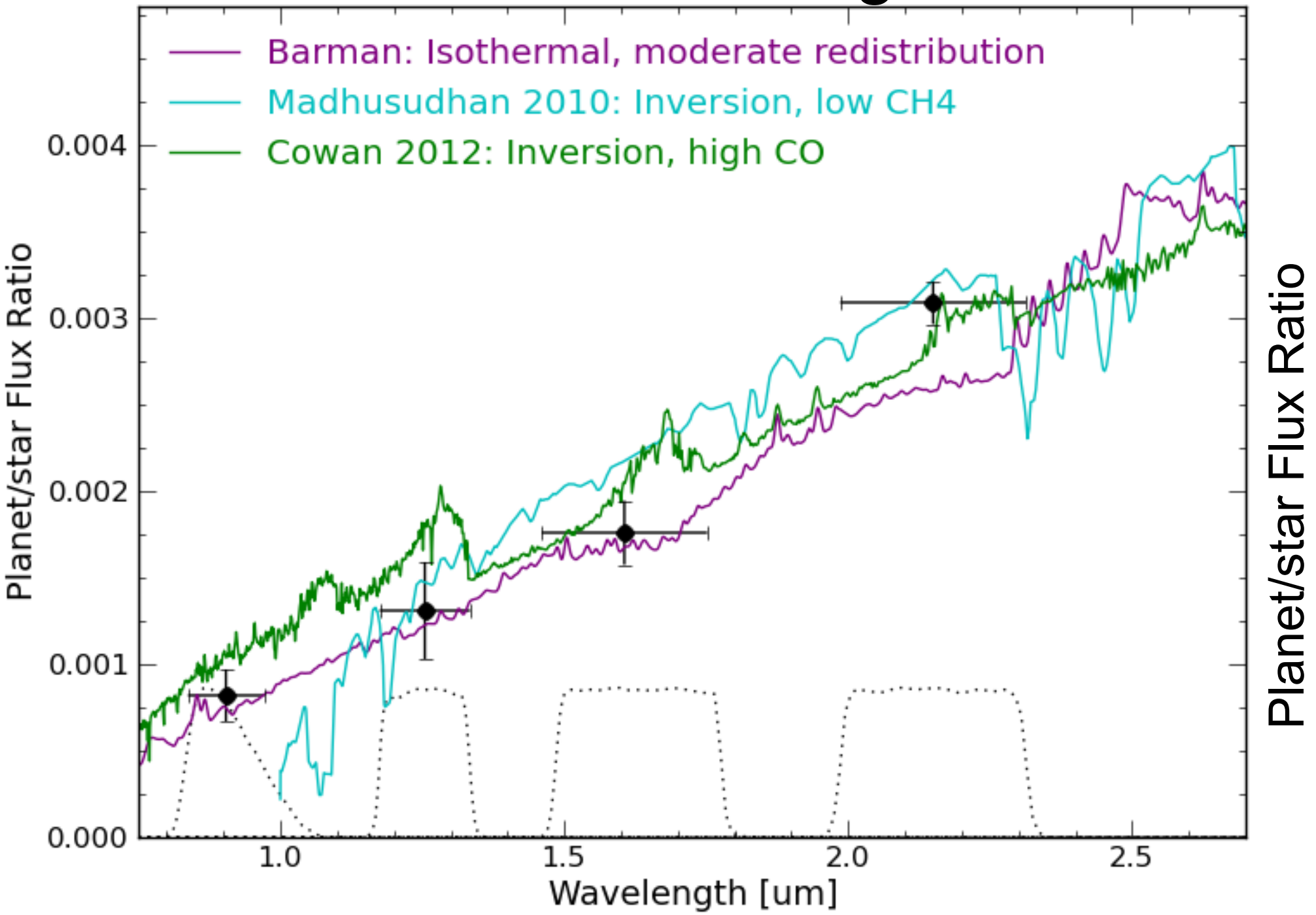
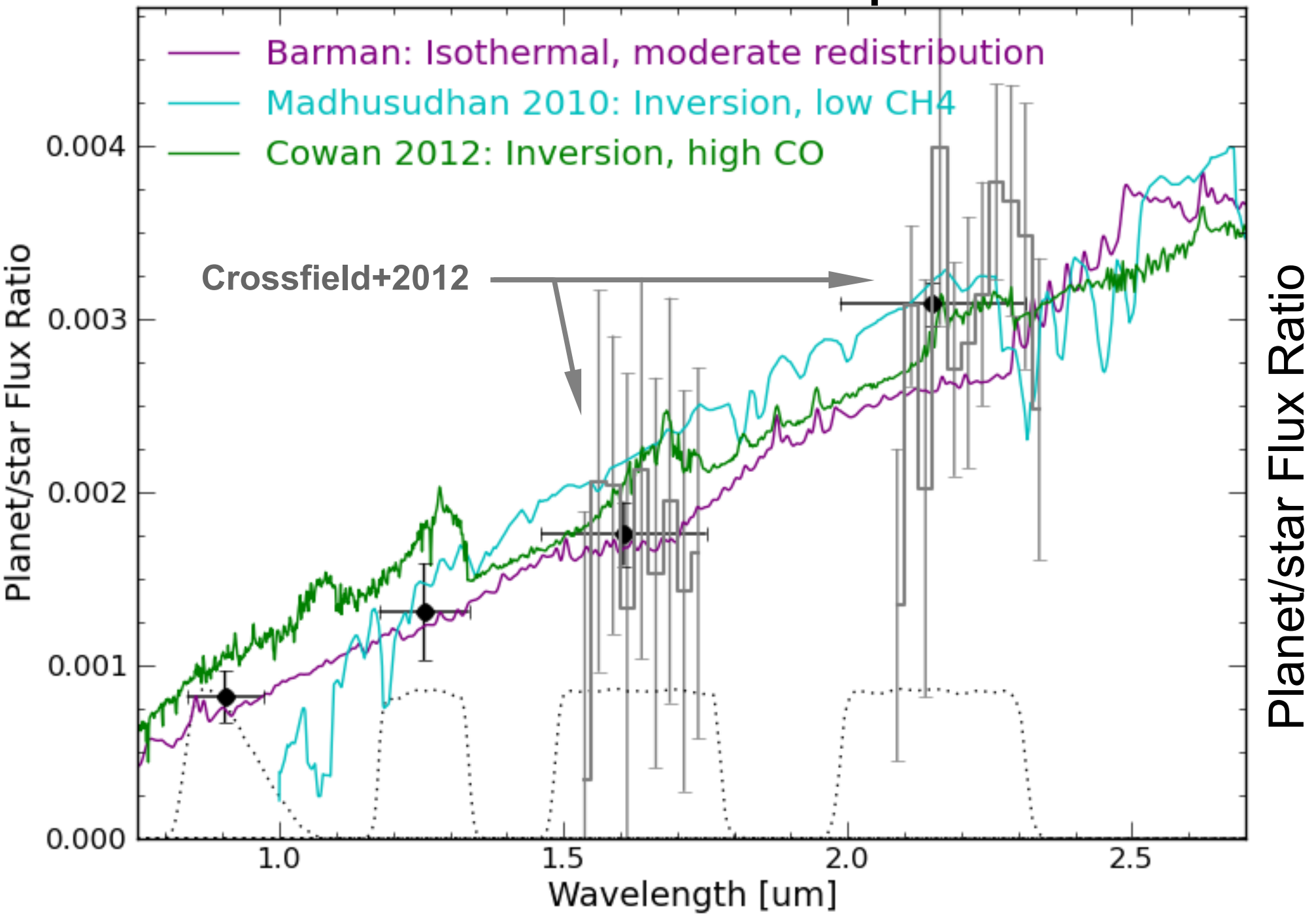


WASP-12b: Model degeneracies



WASP-12b: Our Spectrum



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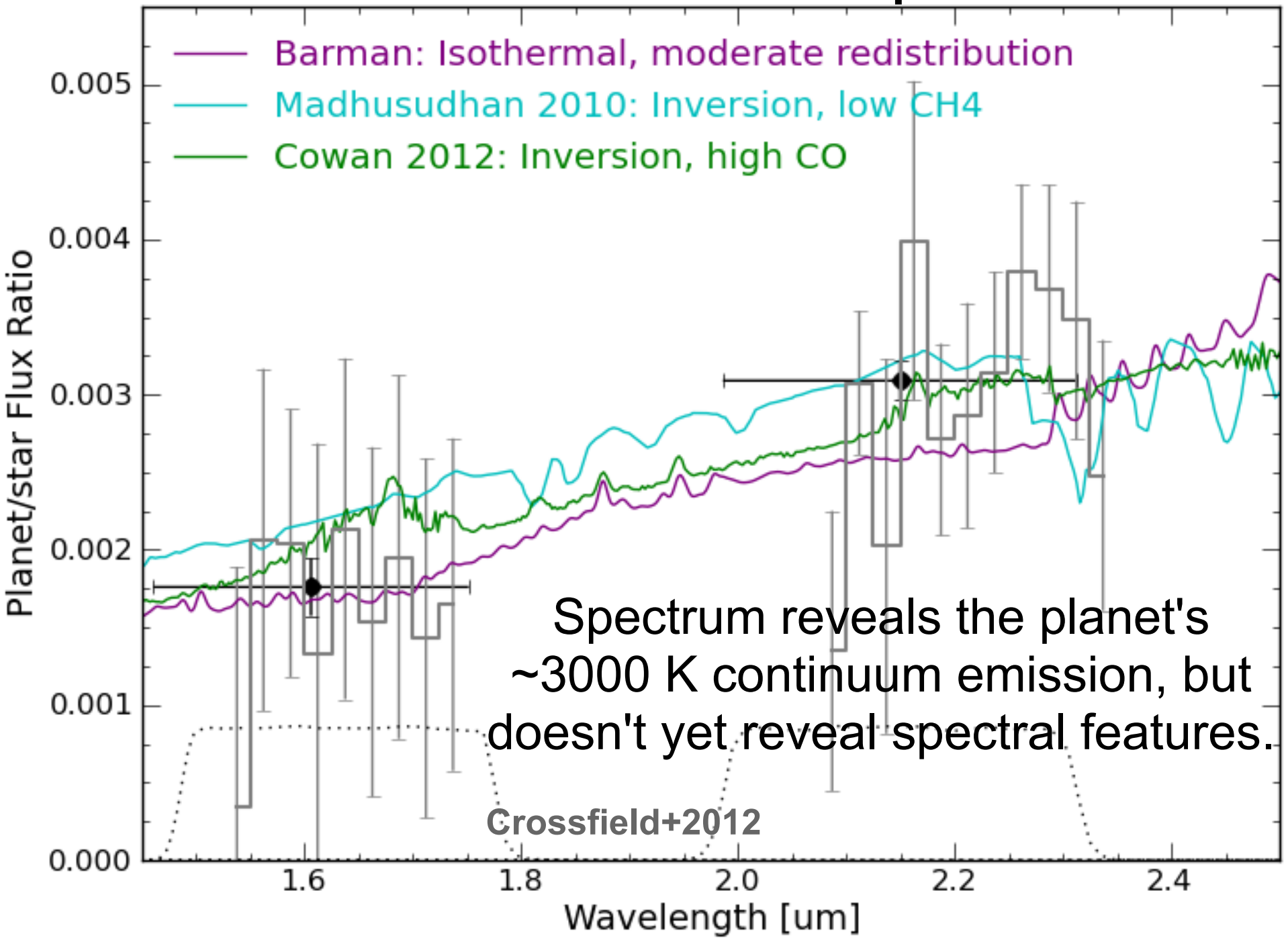

Planet/star Flux Ratio

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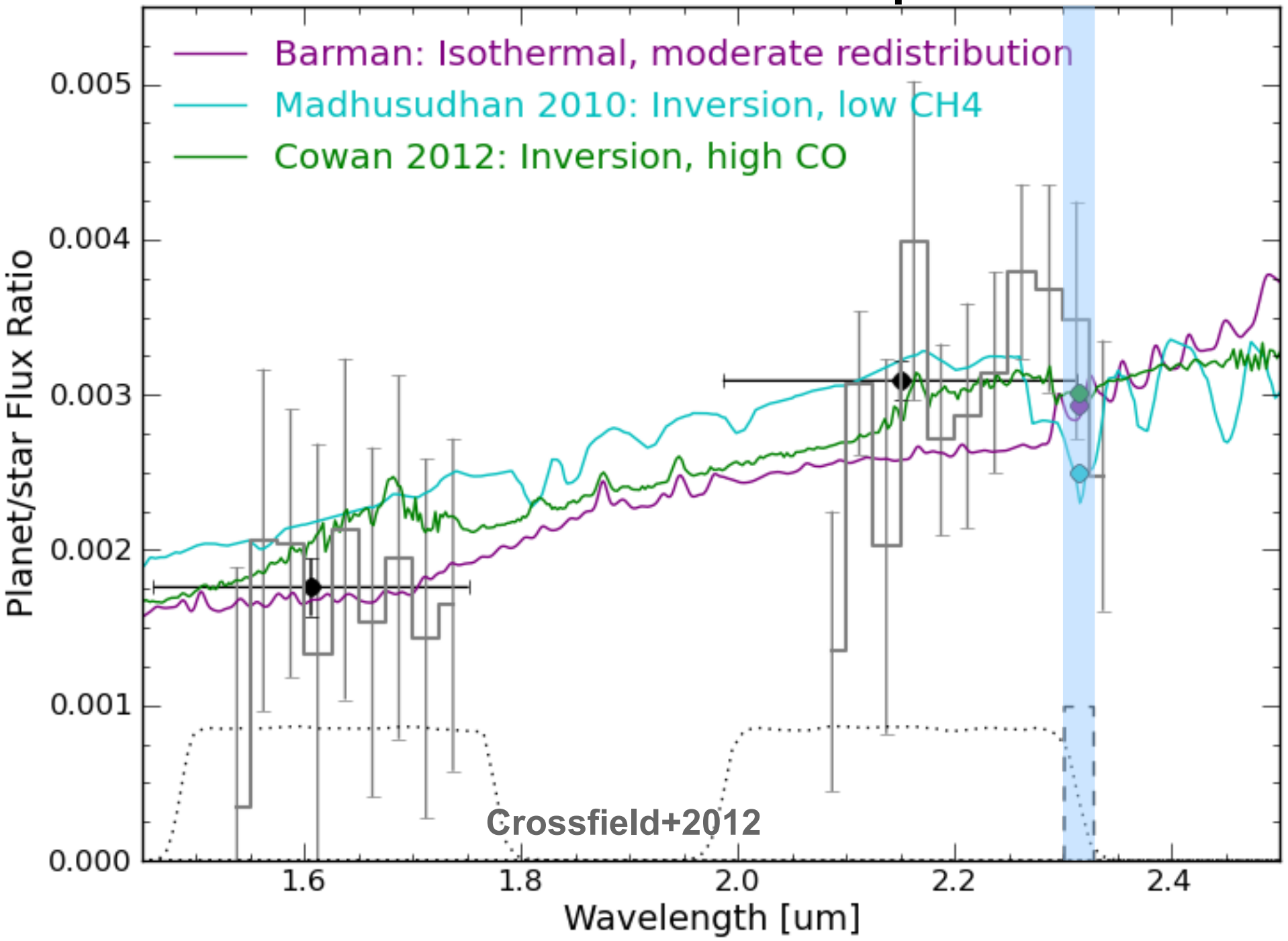
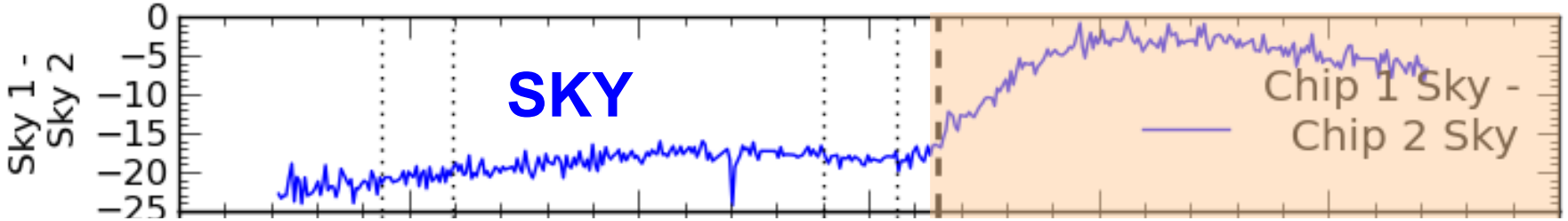


Planet/star Flux Ratio

Subaru/MOIRCS Narrowband (2.315 um) Photometry



Variations in sky background suggest an instrumental systematic effect, beginning just after eclipse

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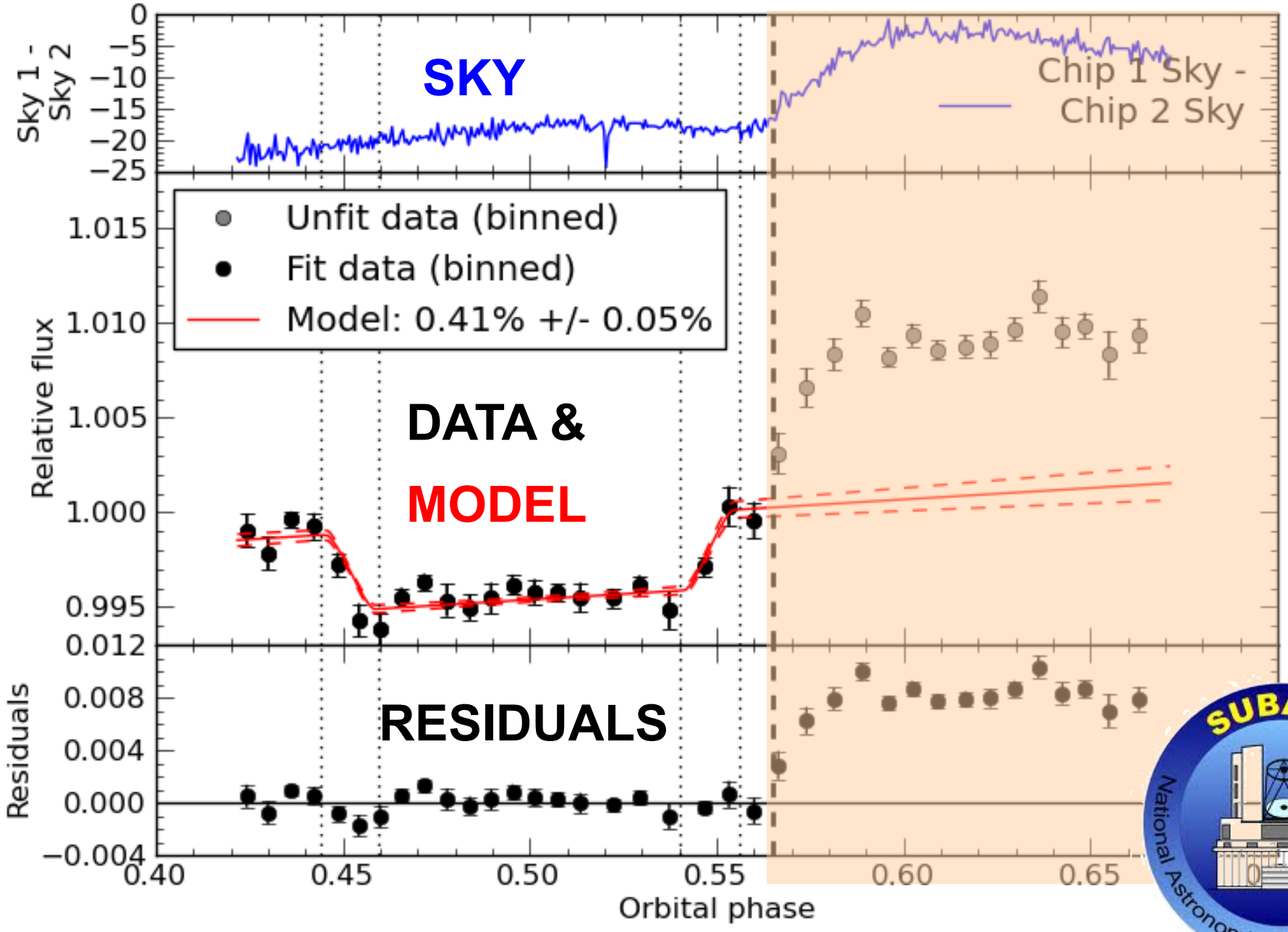

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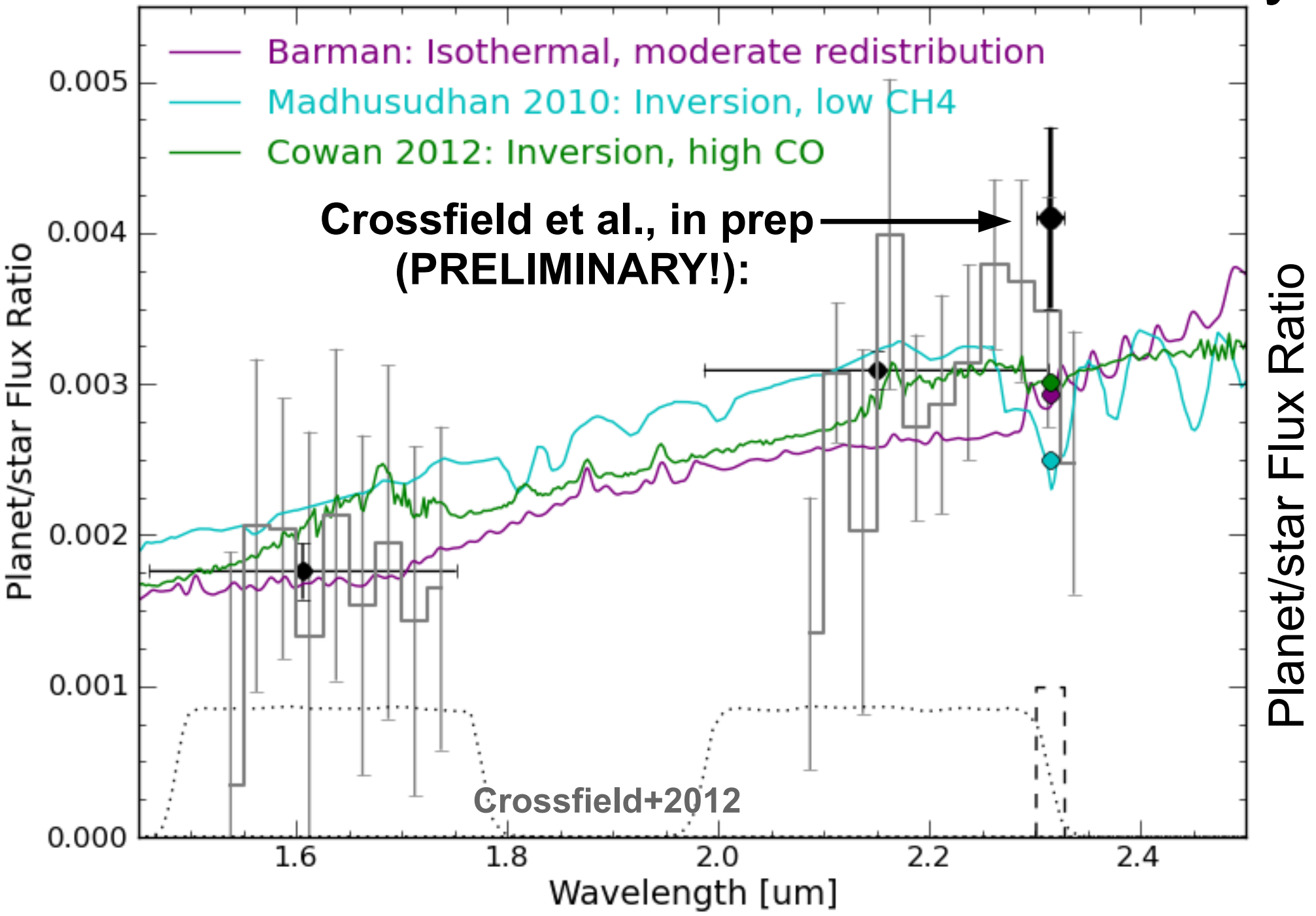

WASP-12b: Conclusions

- Infrared exoplanet spectroscopy is possible with single-slit spectrographs (but use big slits!)
- Multi-object spectrographs perform better (cf. Bean et al.), but can't be used for bright and/or solitary exoplanet systems
- WASP-12b emission is unexpectedly high at 2.32 μm: CO & CH_4 emission, or just a lack of absorption?
- Stay tuned for further spectroscopic results and tighter constraints on C-bearing species.