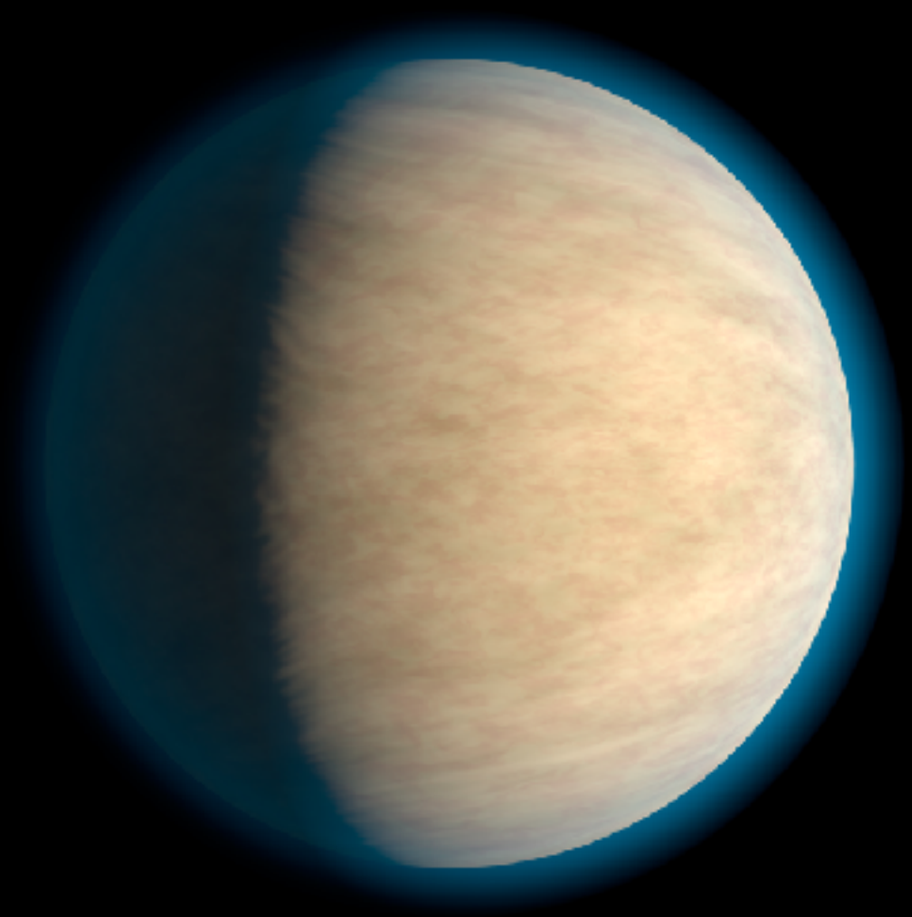
Space-Like Infrared Photometry and Spectroscopy of Transiting Exoplanets with WIRC



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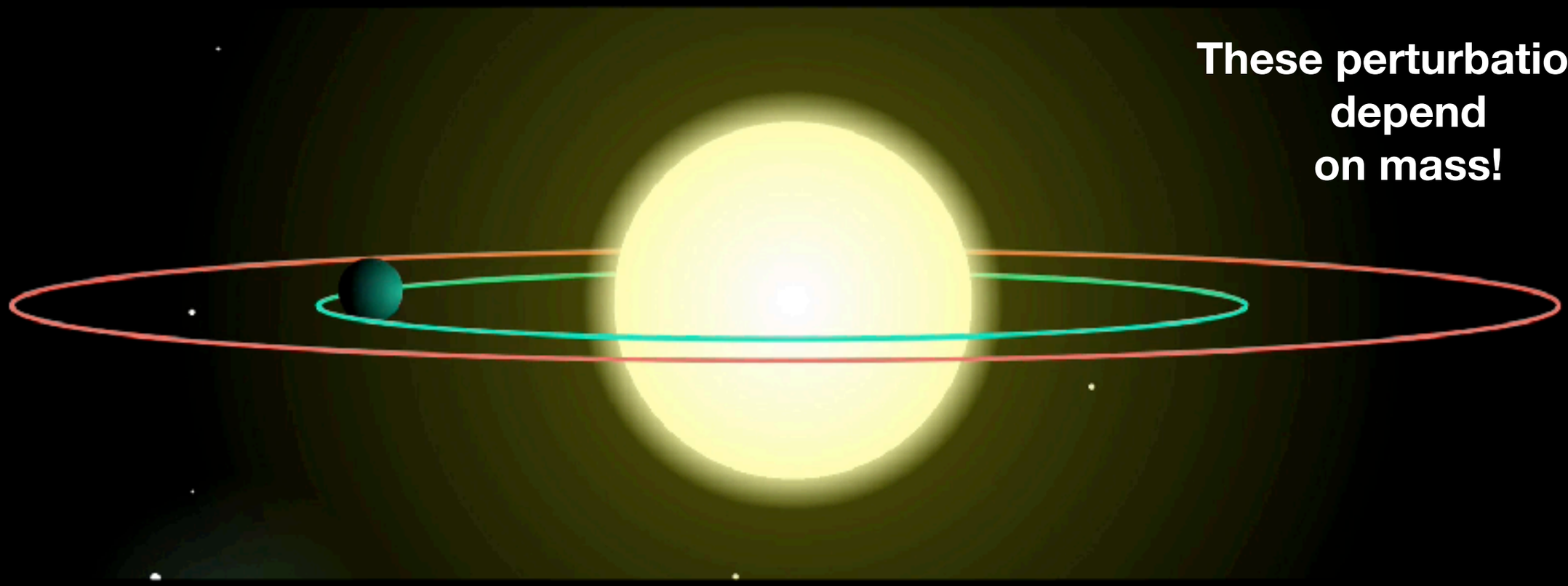
@astroshrey

Image Credit: NASA/JPL-Caltech

Space-Like Infrared Photometry and Spectroscopy of Transiting Exoplanets with WIRC

*for transit-timing variation (TTV) science

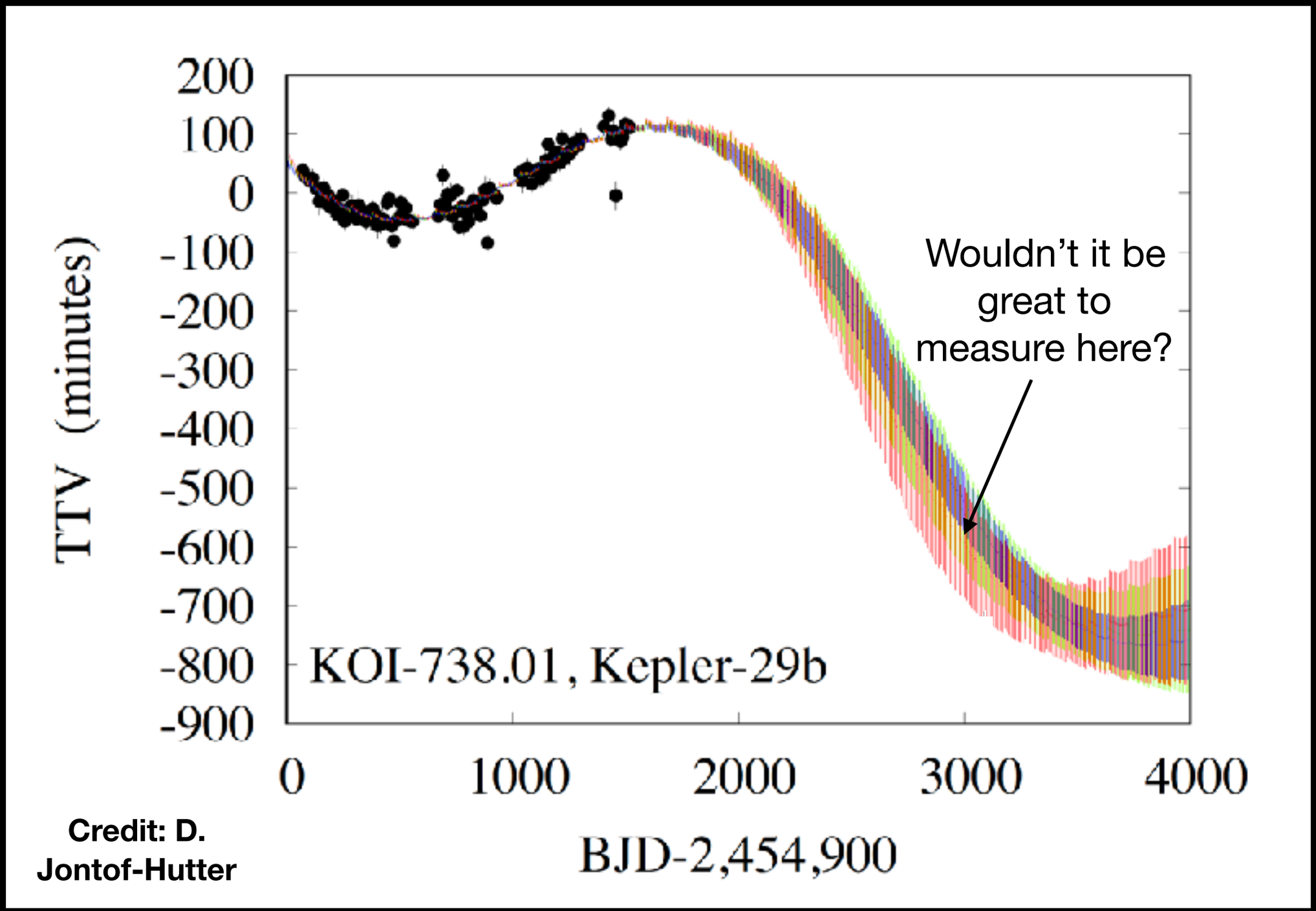
Transit times in multi-planet systems can come early or late from perturbations



These perturbations depend on mass!

Simulation Credit: GravityKit

TTV dynamical masses can be uncertain, and solution uncertainties grow with time



Credit: D. Jontof-Hutter

The goal: precisely constrain exoplanet mass ratios + ephemerides with TTV measurements

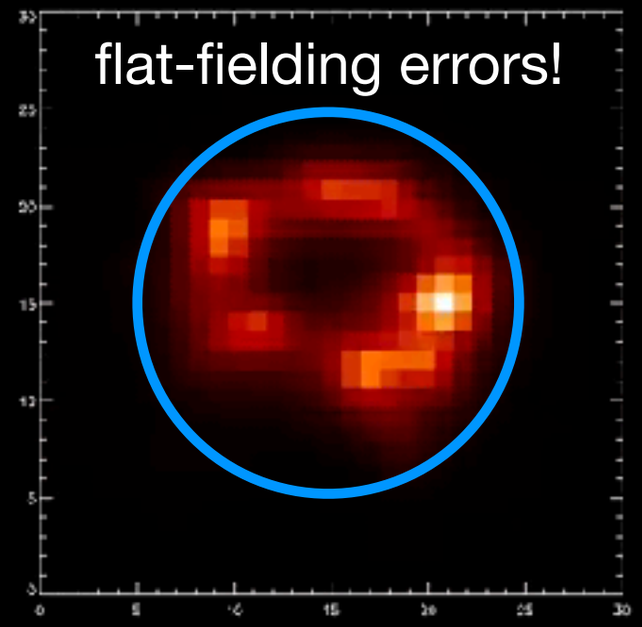
The instrument: Wide-field InfraRed Camera (WIRC) on the Hale 200” telescope at Palomar Observatory

Image Credit: Caltech/
Palomar Observatory

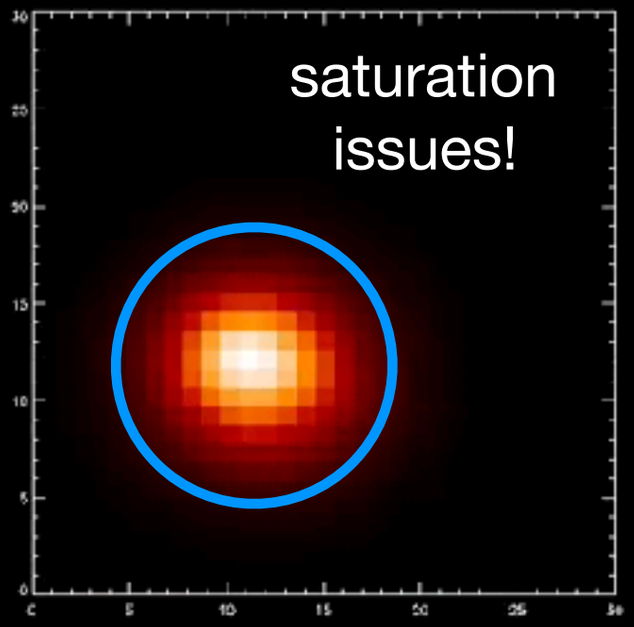
The method: diffuser-assisted photometry (to limit time-correlated noise)

WIRC PSF comparison

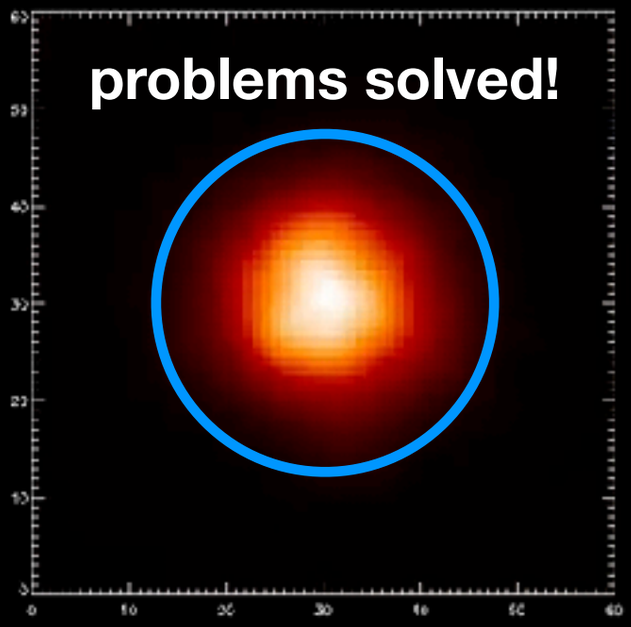
Defocused



Focused

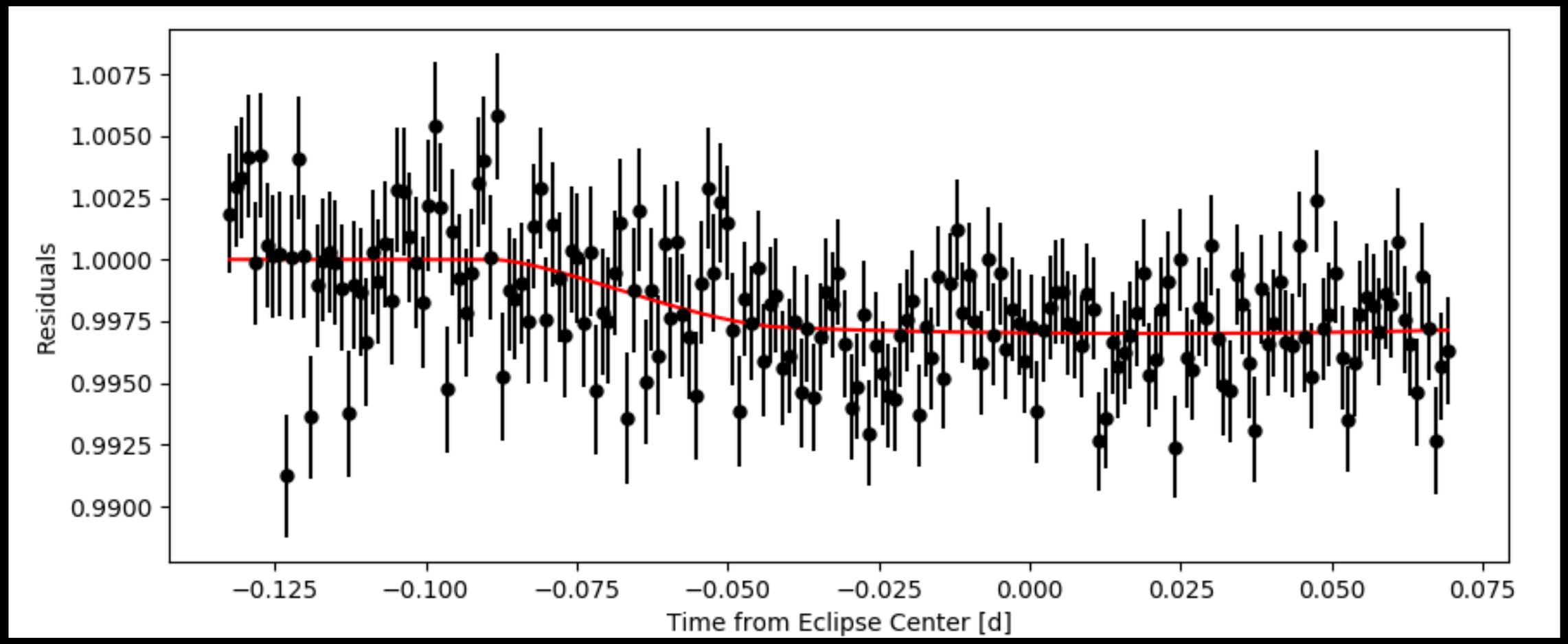


Diffused



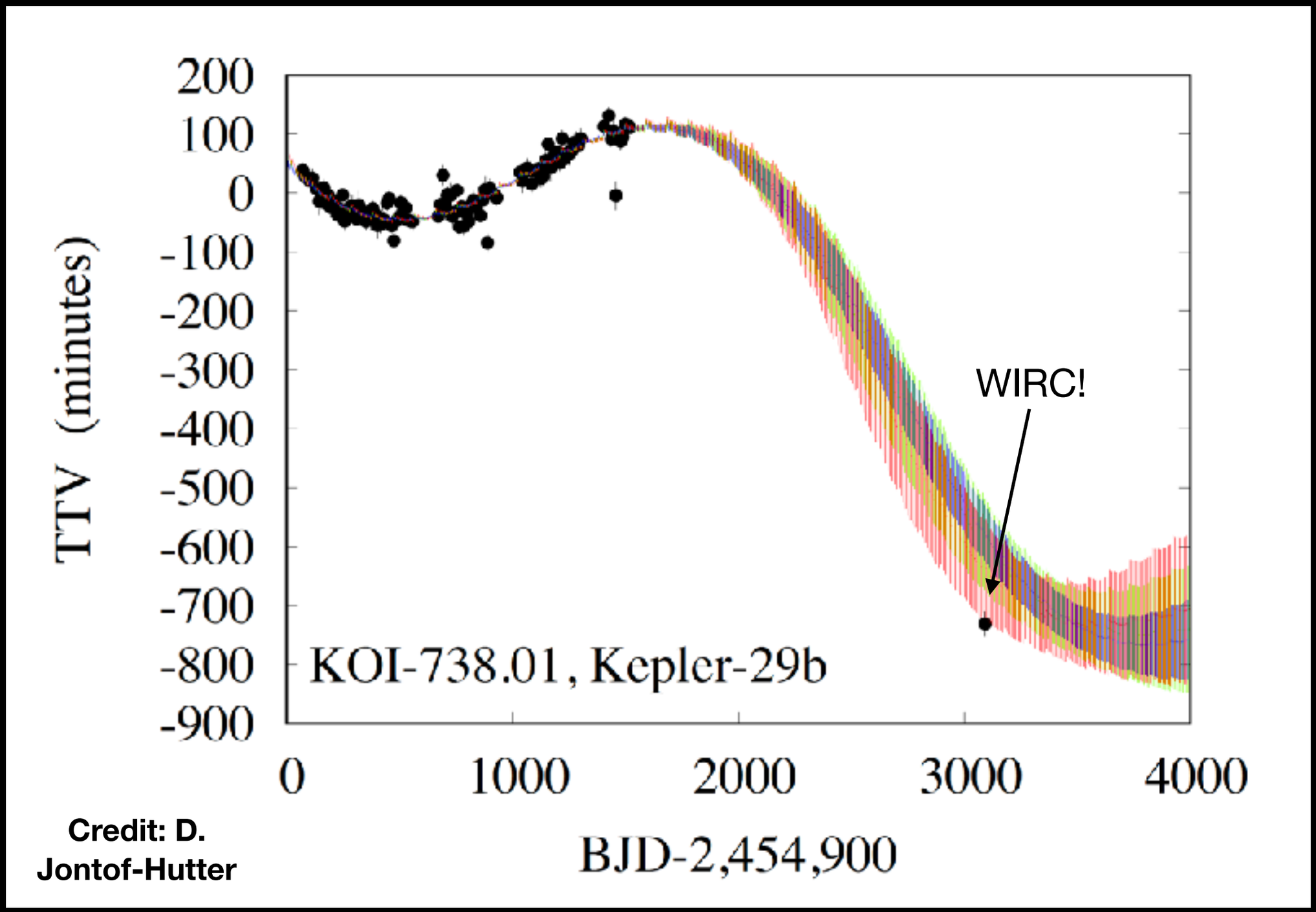
Video Credit: G. Stefansson; M. Zhao

A representative result: Kepler-177c



14th magnitude in J band, 4 sigma detection, timing precision of ~15 mins, 18% above photon noise lim!

Our TTV measurements can help lessen uncertainties!

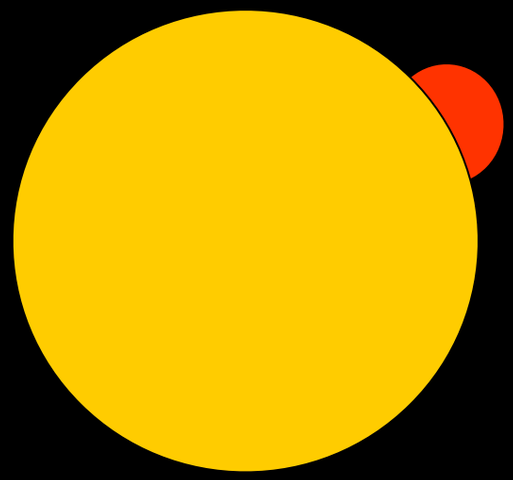


Credit: D. Jontof-Hutter

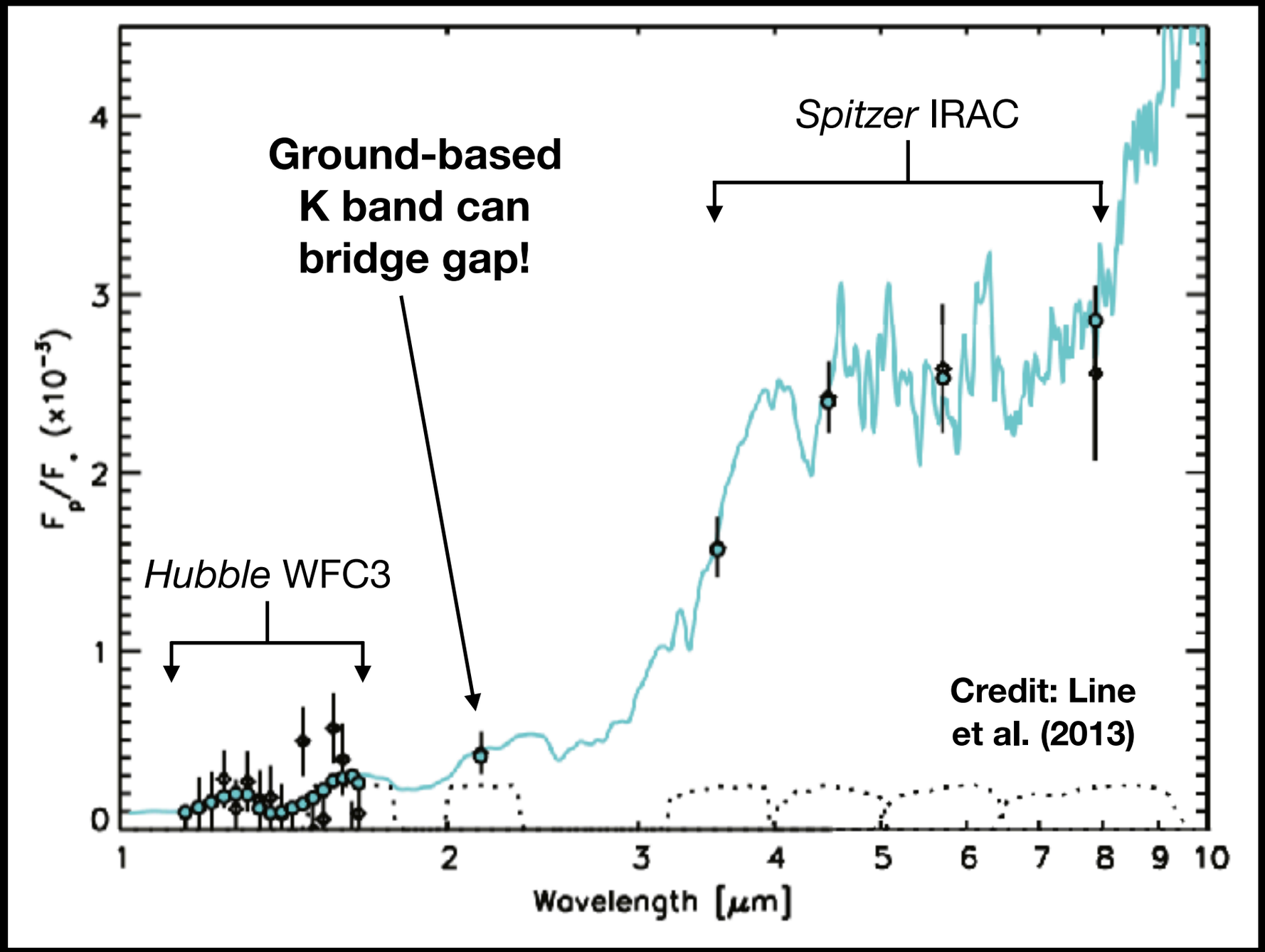
Space-Like Infrared Photometry and Spectroscopy of Transiting Exoplanets with WIRC

*for secondary eclipse science

Ground-based data can fill in gaps between space-based observations

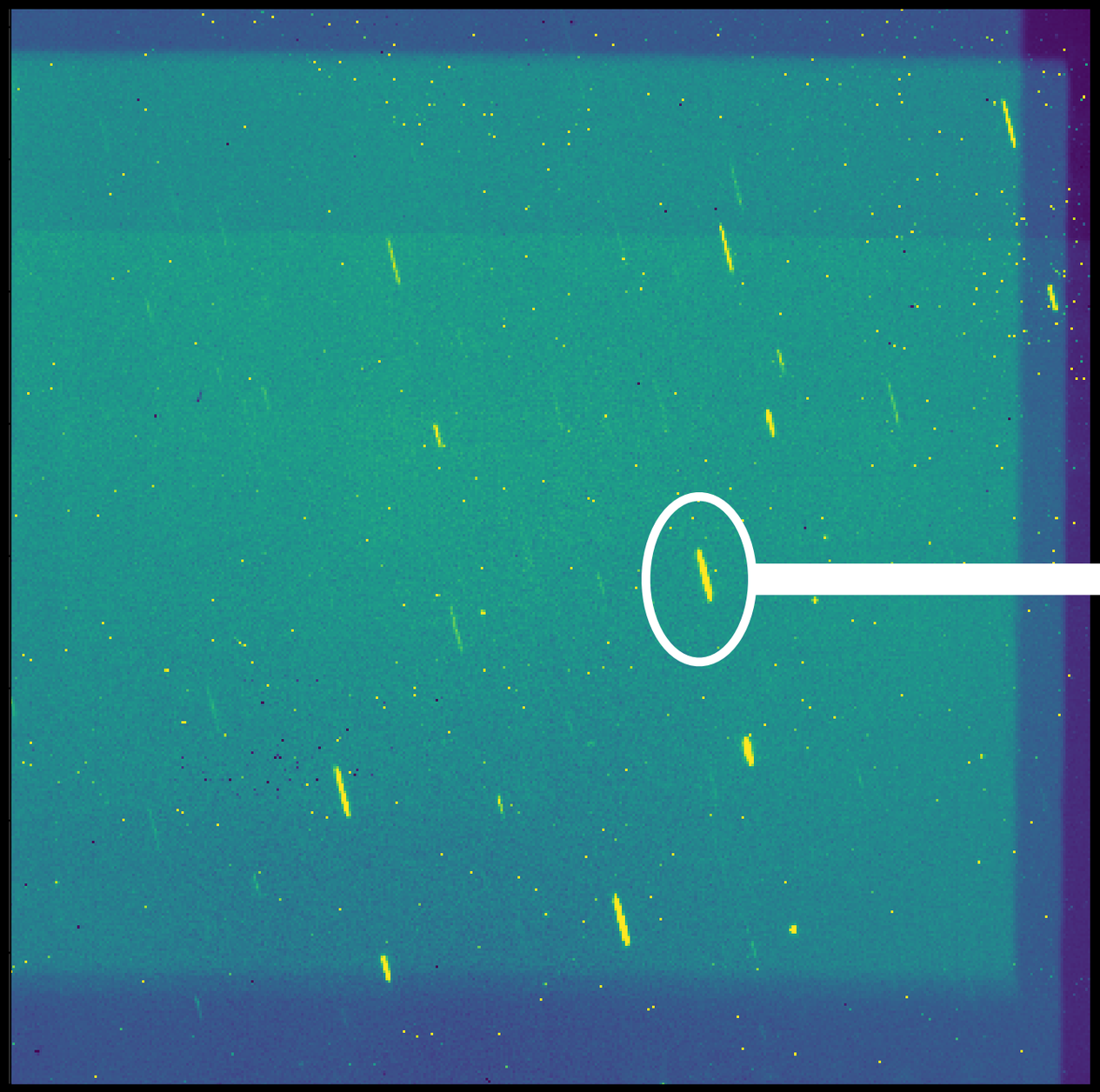


(on secondary eclipse, you see the atmosphere in emission)



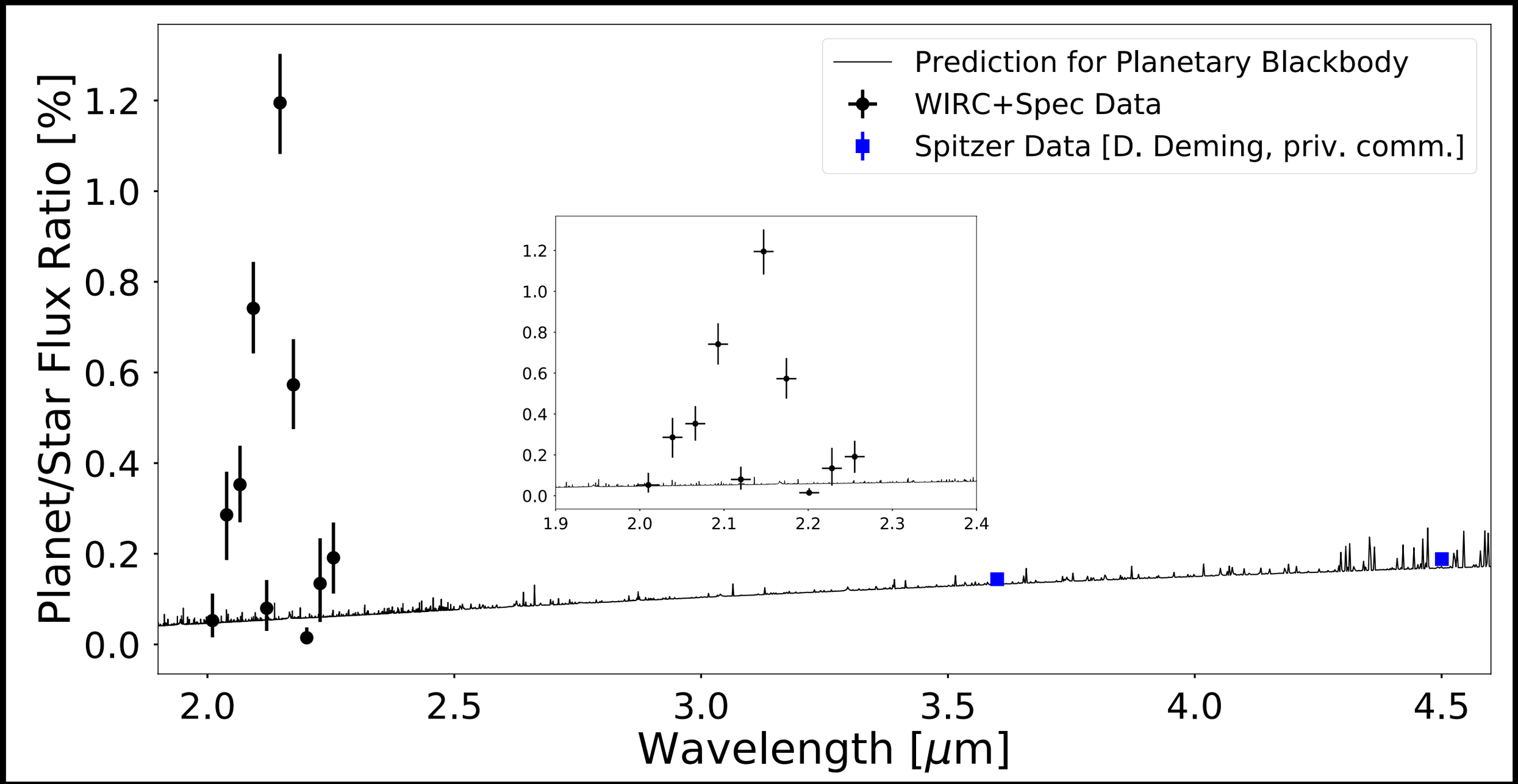
The goal: secondary eclipse *spectroscopy* from the ground in K_s band

The method: grism spectroscopy

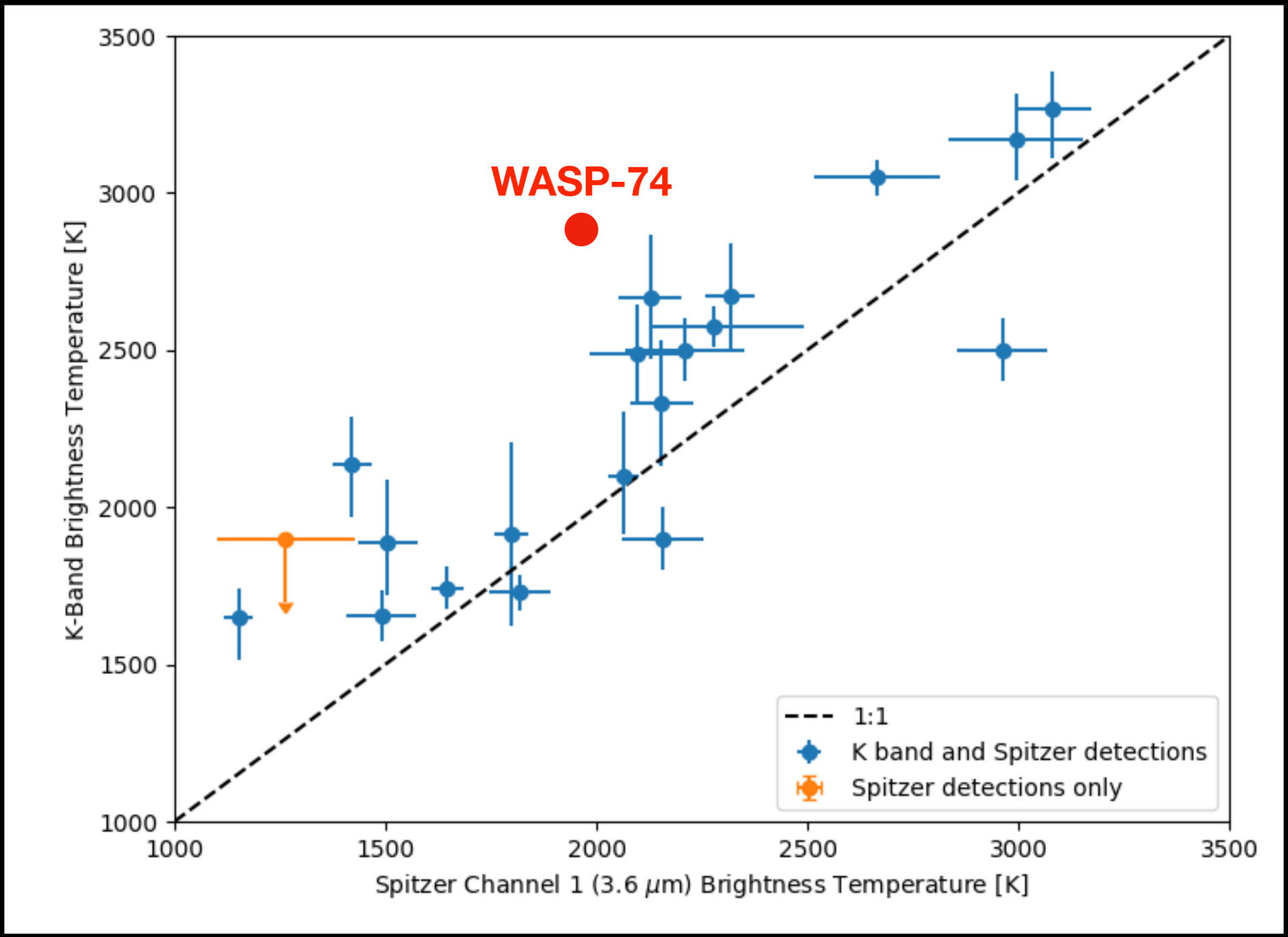


(Example image from J band)

A curious result: WASP-74b emission spectrum



What is going on in K band?



Future (or, current) Work

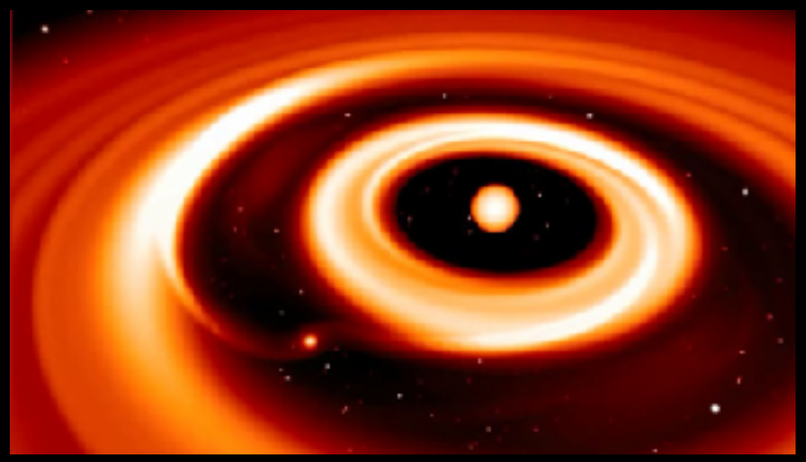
Continue to make TTV measurements

Investigate the mysterious K band emission spectrum

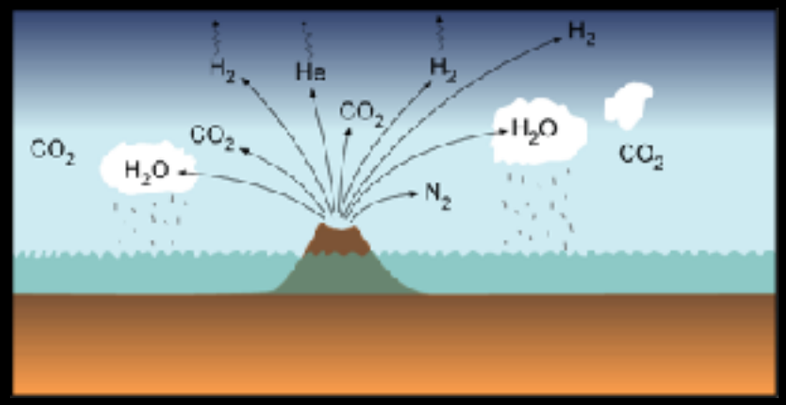
Also measure transmission spectra!

Backup slides

Atmospheric composition can inform us about many things



Planet formation!

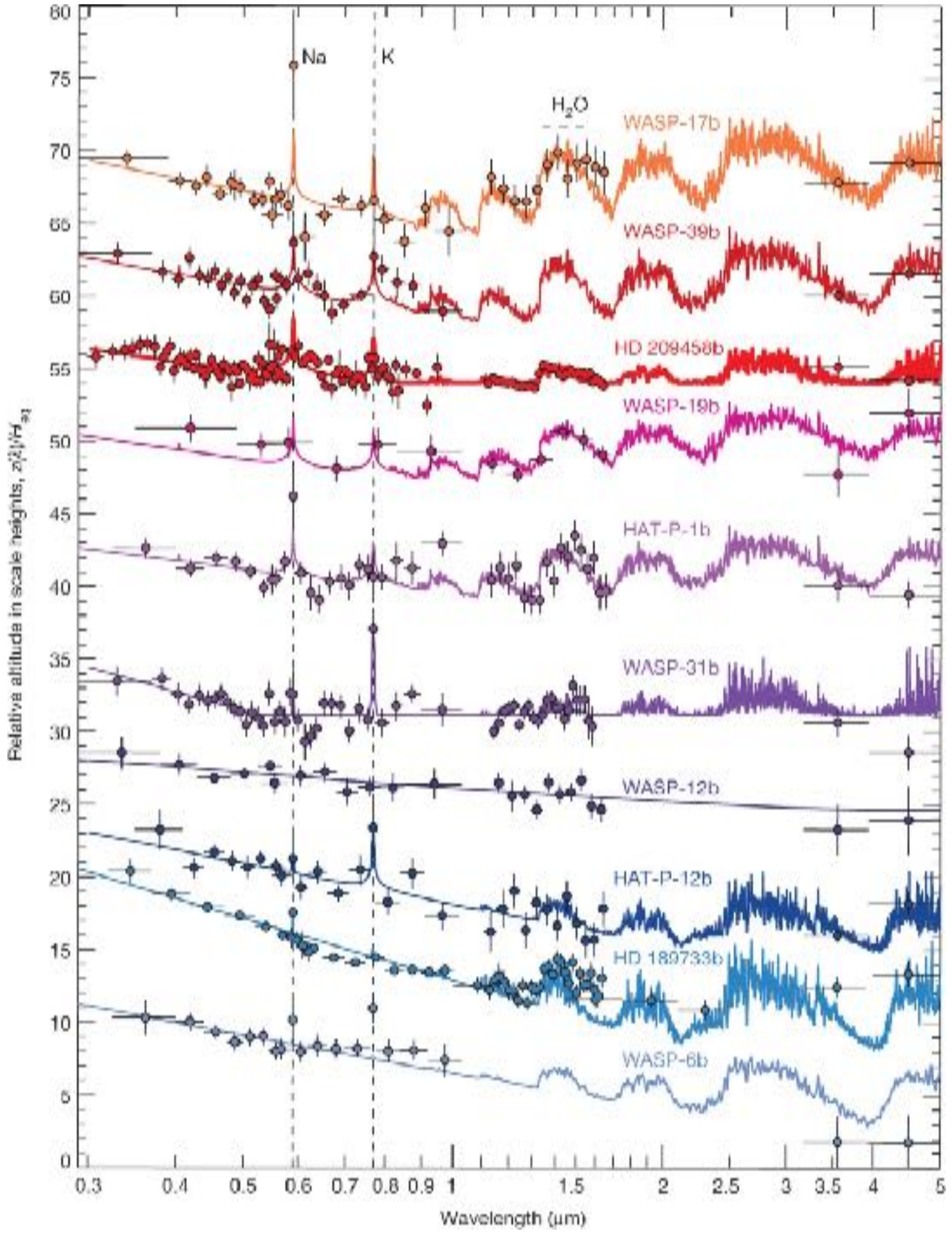


Interior-atmosphere interactions!

Biosignatures!

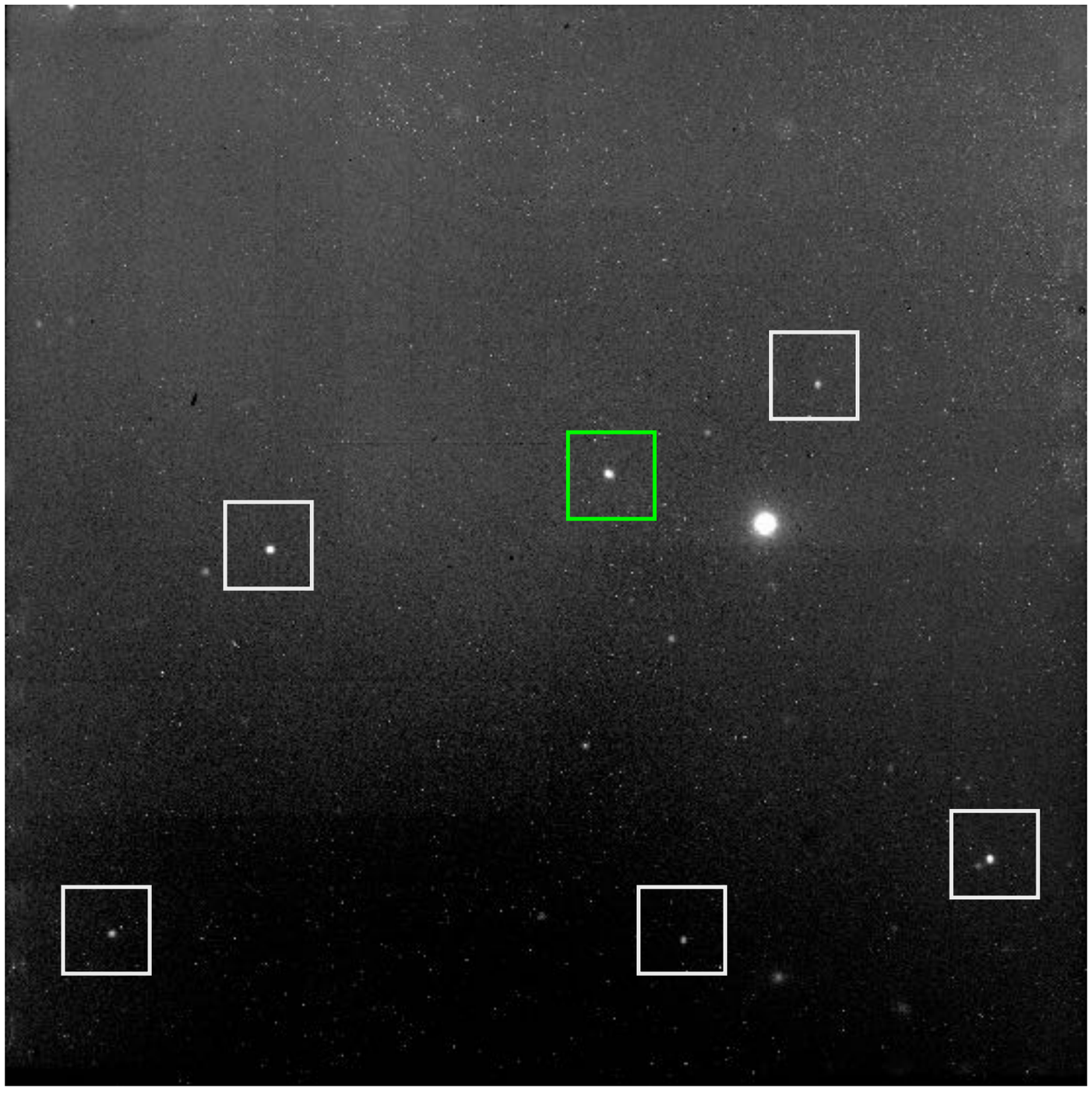
Clouds are a reality for all planetary size ranges

Meaning that, at all observed sizes, clouds can obscure the stuff you want to see!

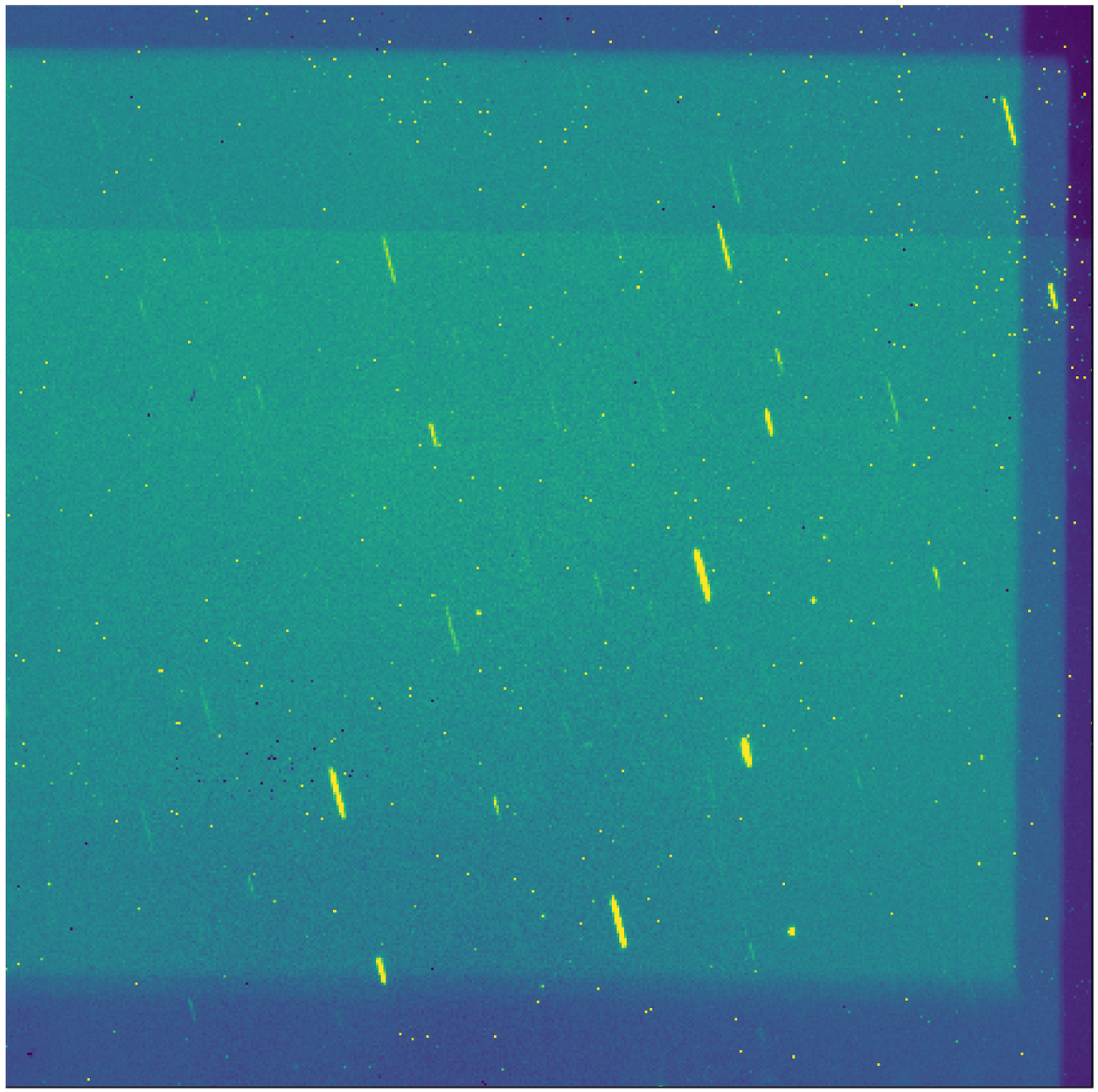


Sing et al. (2016)

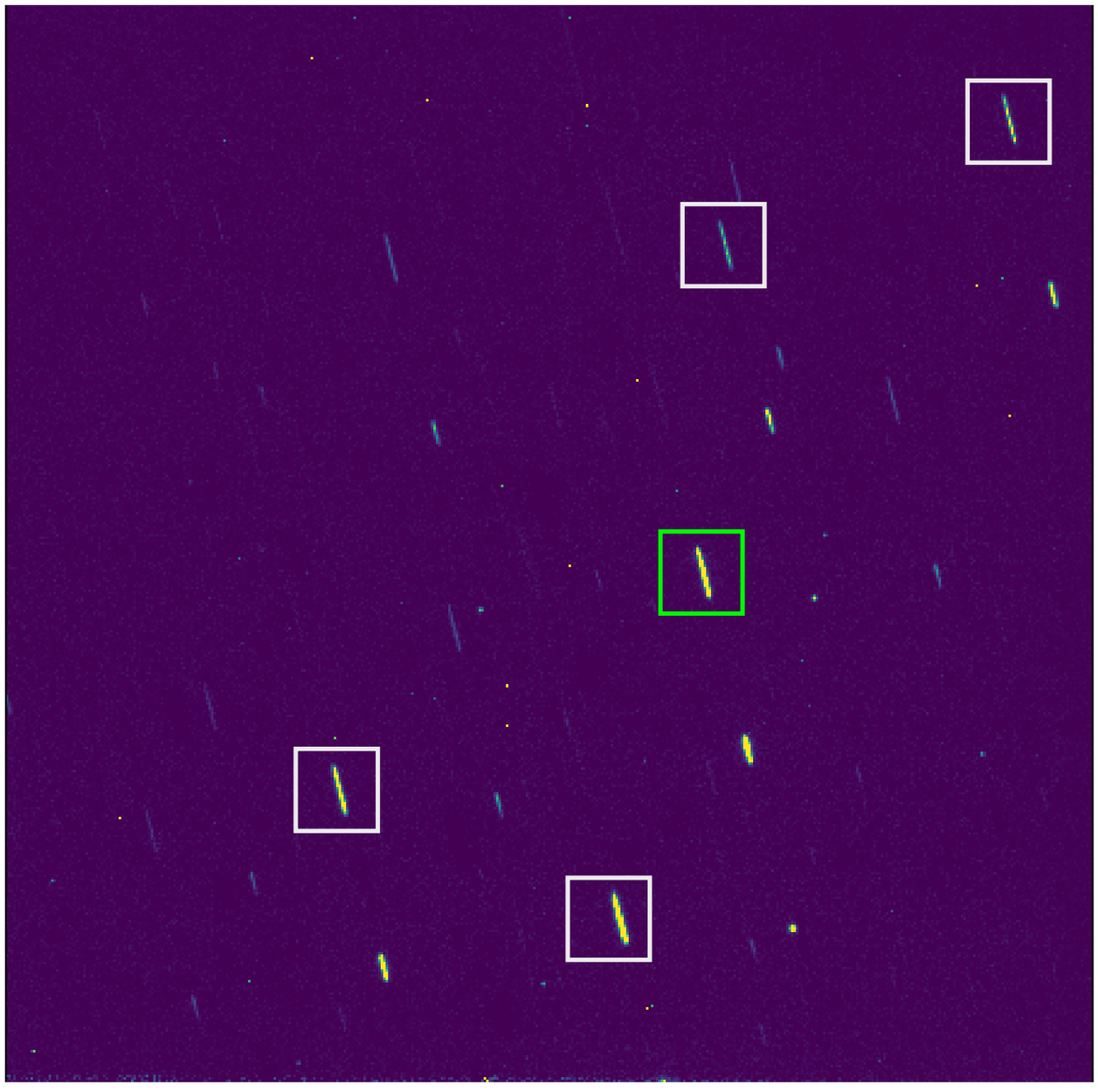
Sample WIRC+Phot image (K2-22, diffuser on)



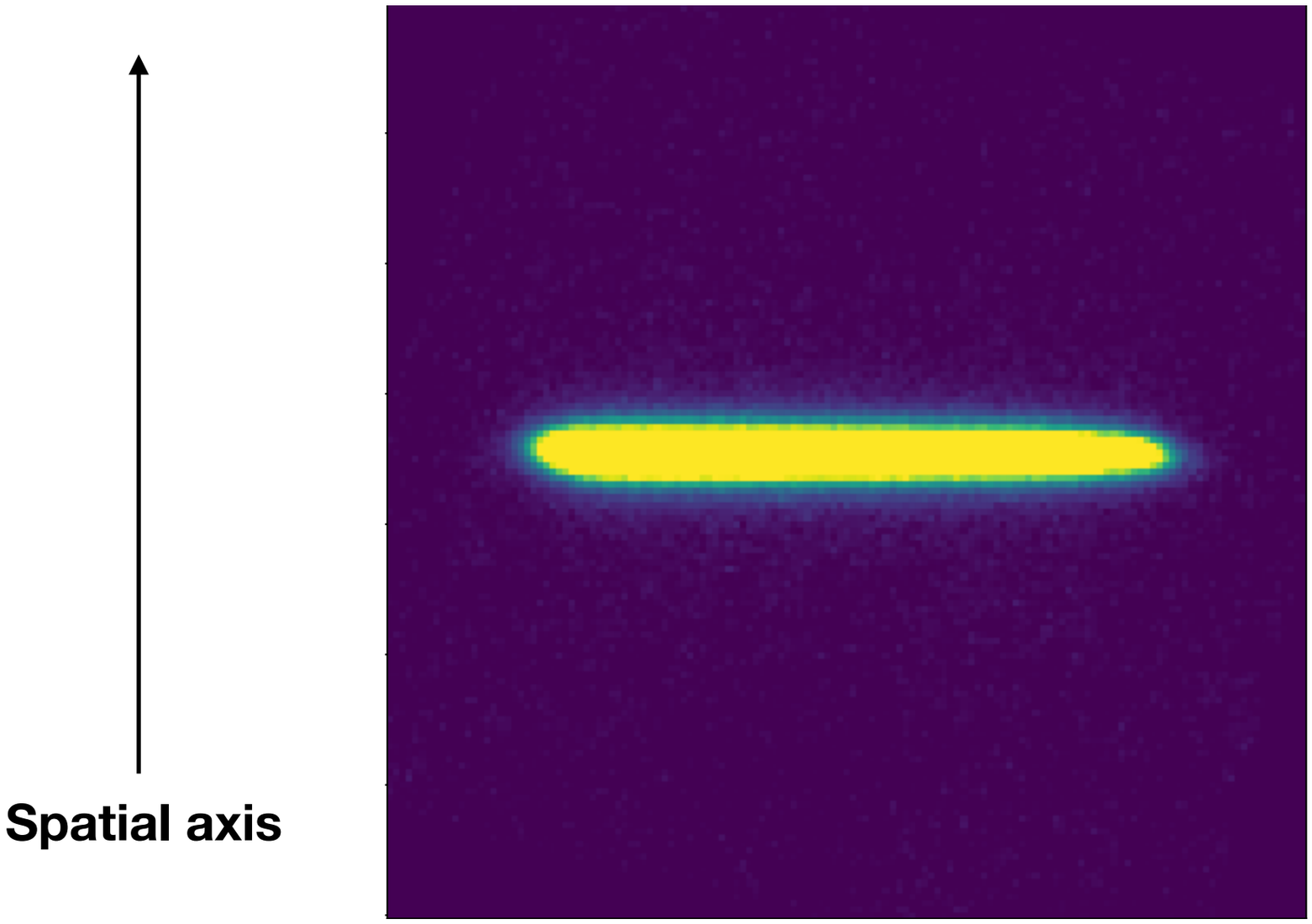
Let’s get spectra for WASP-74 b



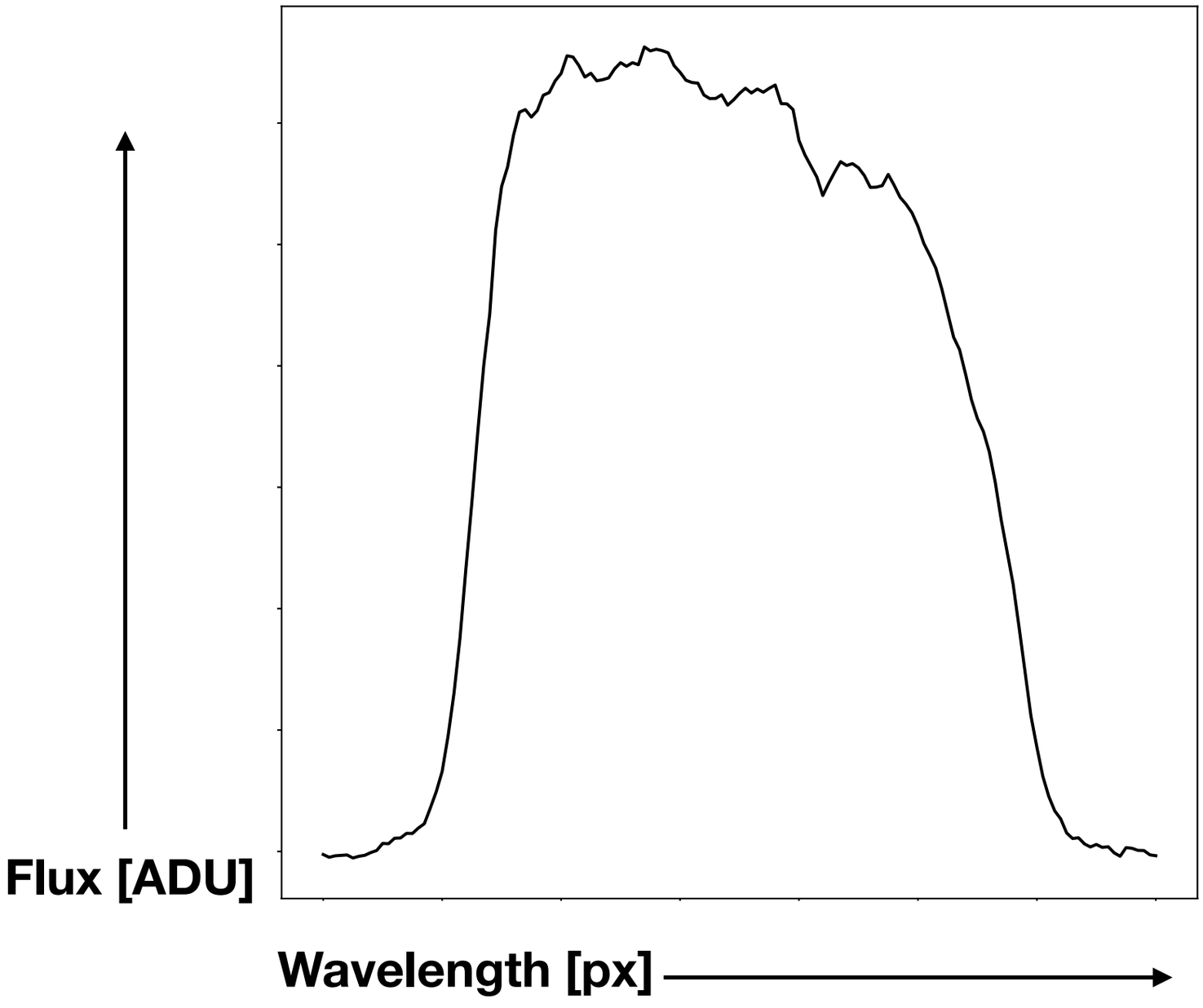
After dark, flat, bad pixel, and background correction



Zooming in on a (rotated) trace



Summing across the spatial direction gives you a spectrum

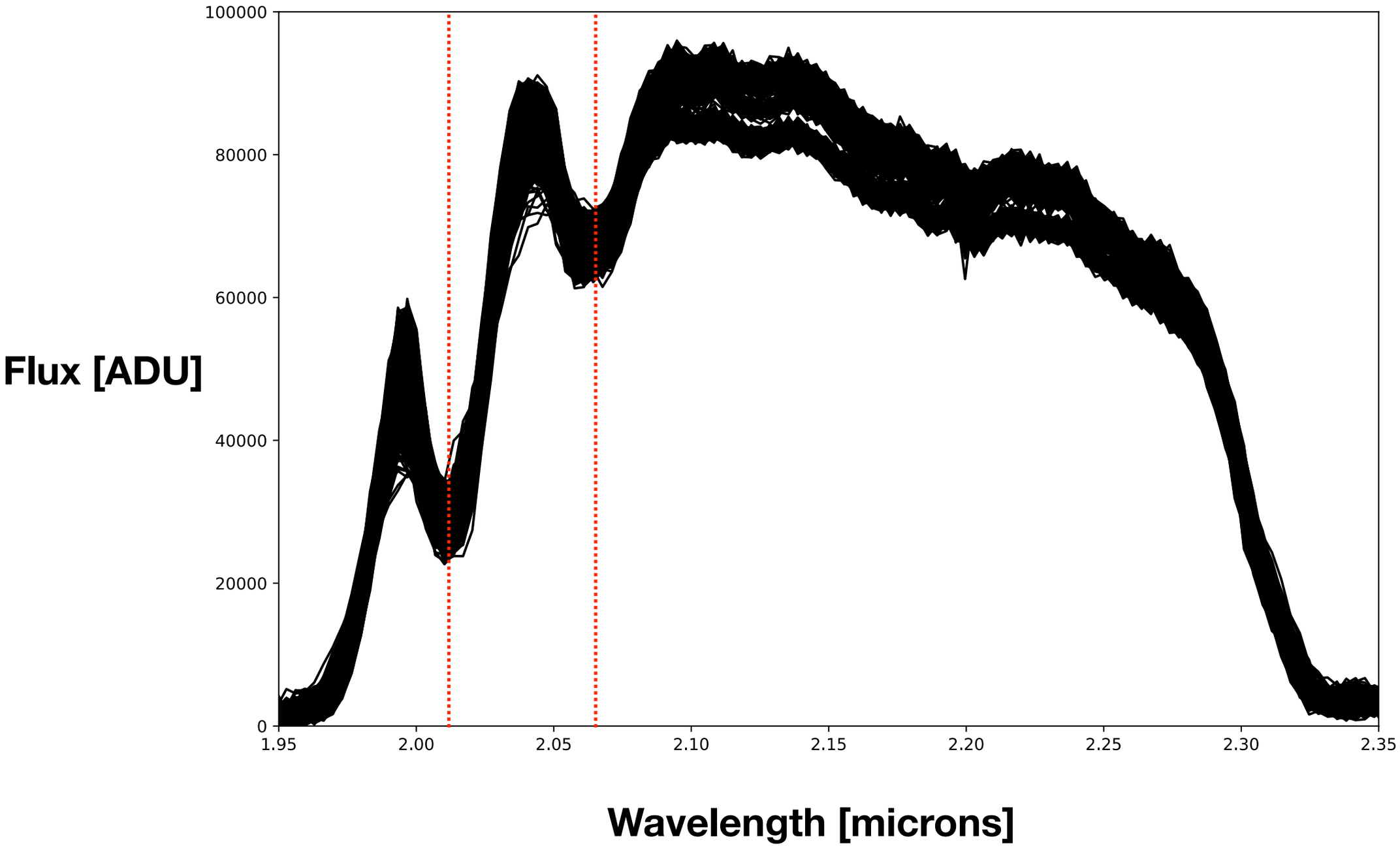


We use an algorithm (Horne 1986) that optimally constructs the spatial profile of the light while rejecting bad pixels

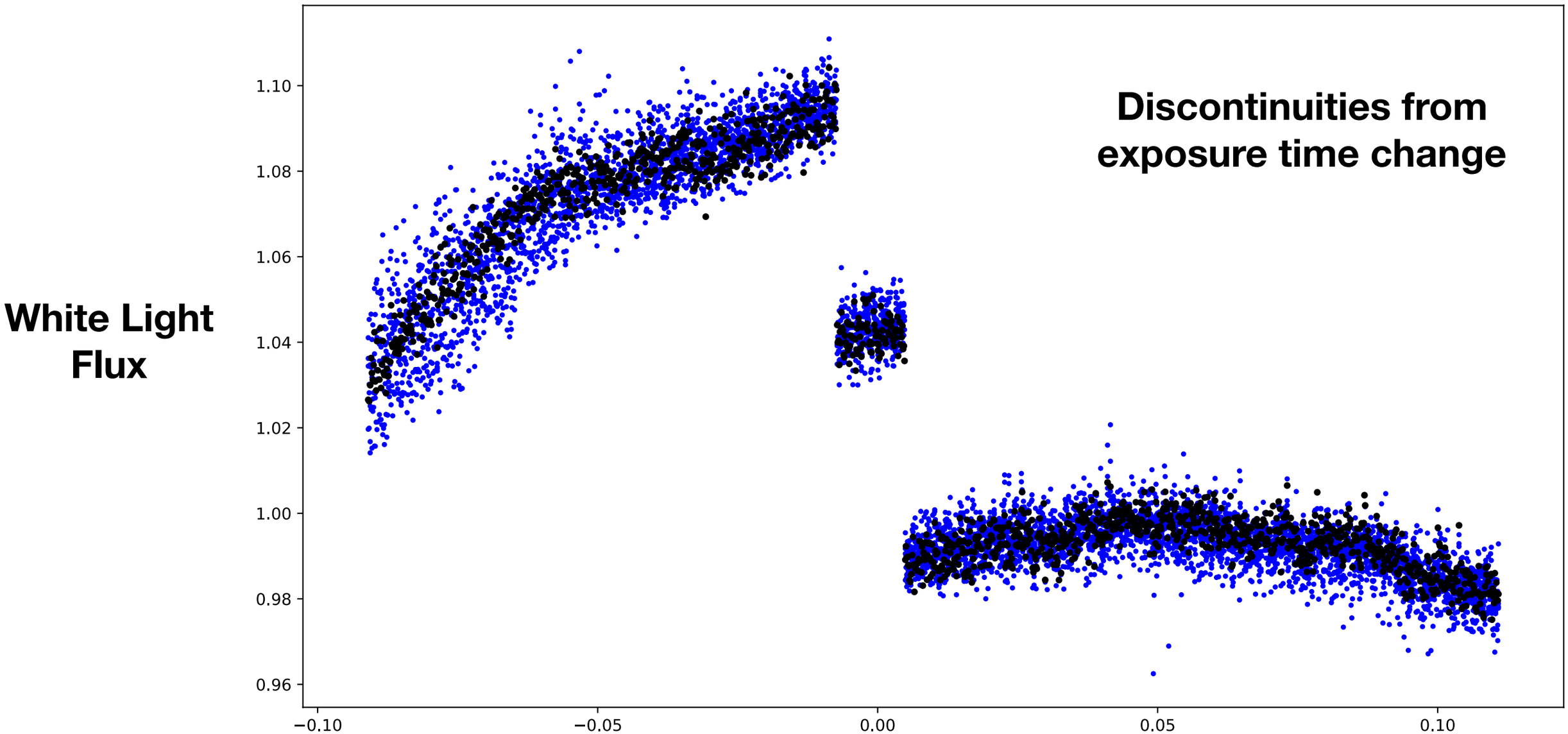
Can obtain “white light” flux by summing across wavelength space

We also require a wavelength solution to go from px to microns

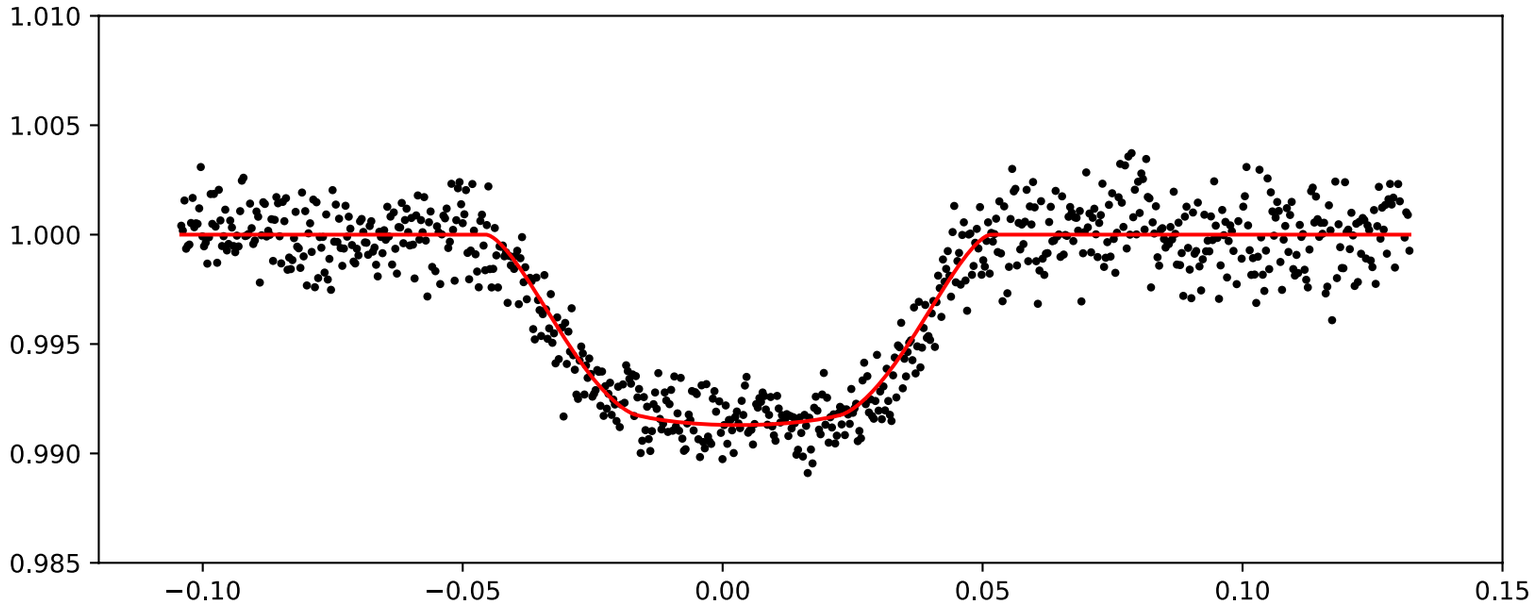
Sample K-band spectra (post-alignment)



And we can look at this over time

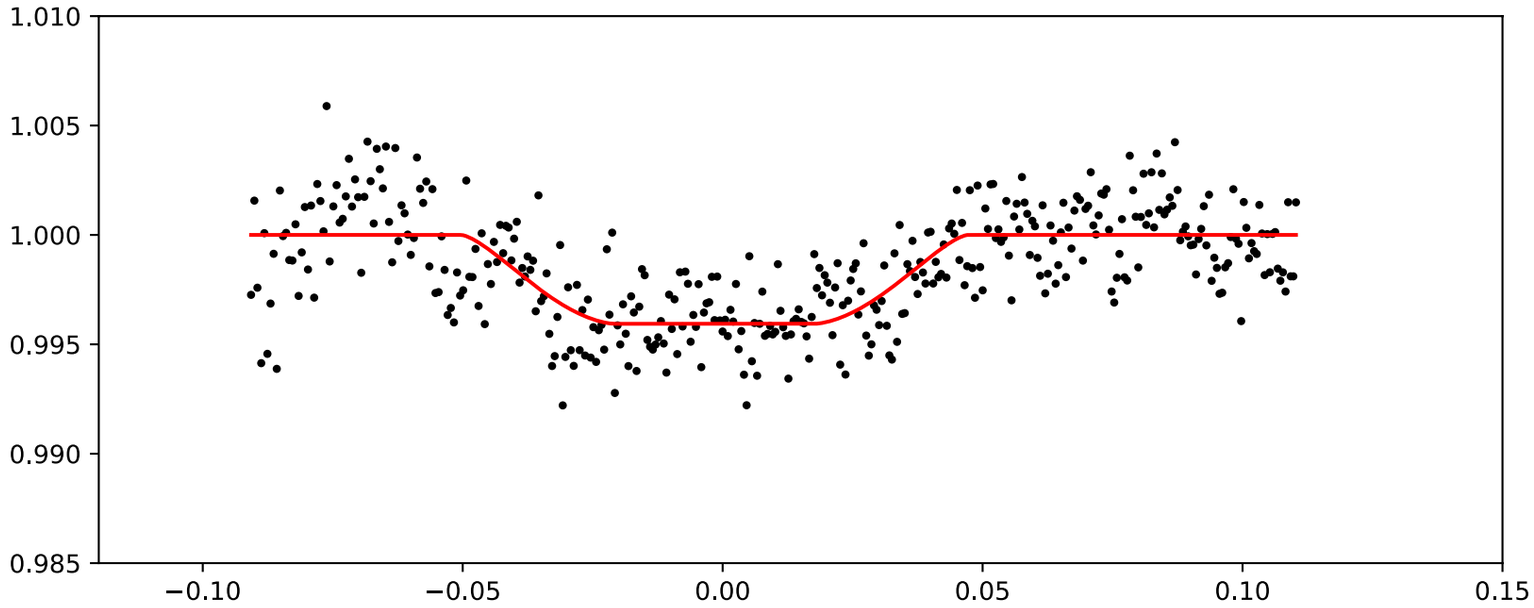


We can fit the transit



Primary Transit

Residuals (from target/ model)



Secondary Eclipse

Time from transit center [days]