Transits: Group 1
Effect of Stellar SNR and Spectral Resolution

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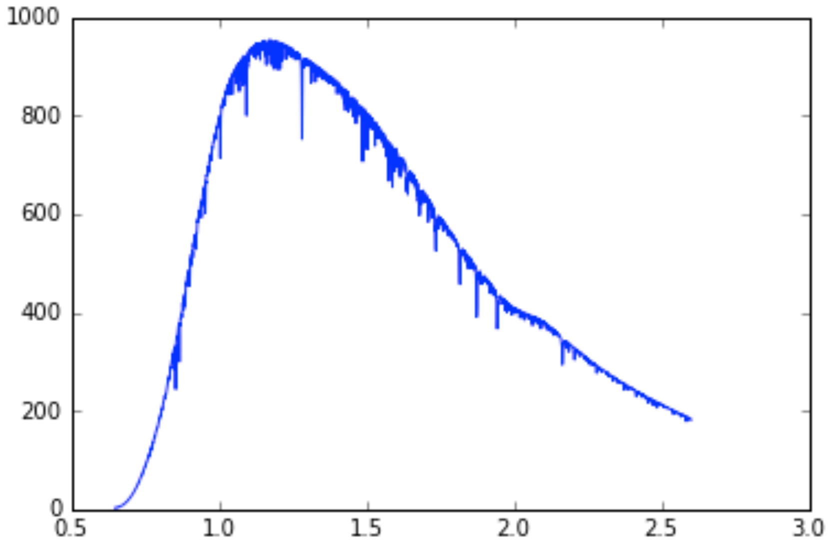
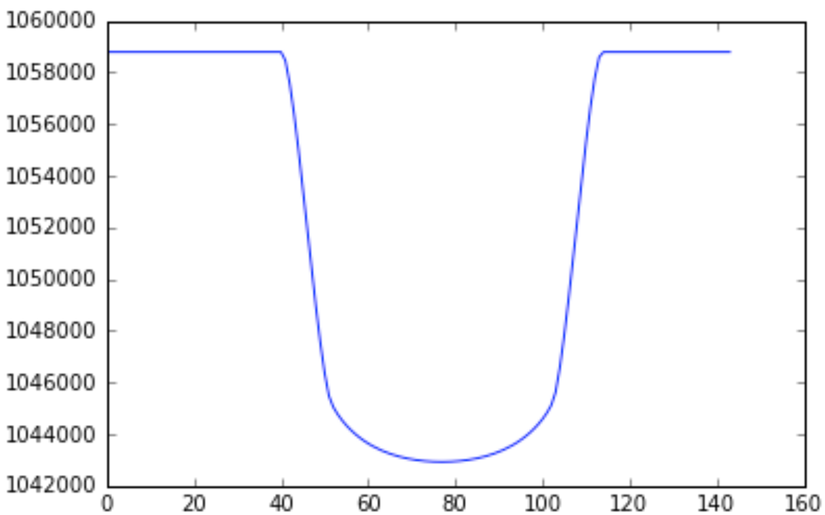
Image Credit: CHRISTINE DANILOFF/MIT, JULIEN DE WIT

Motivation

- Given the information in the FITS headers, what are the SNR and achievable precision as a function of wavelength?
- How does binning the data change these numbers?
- Trades between spectral resolution and SNR/ achievable precision
- Effect of scale height and planet radius in the context of detection of spectral features

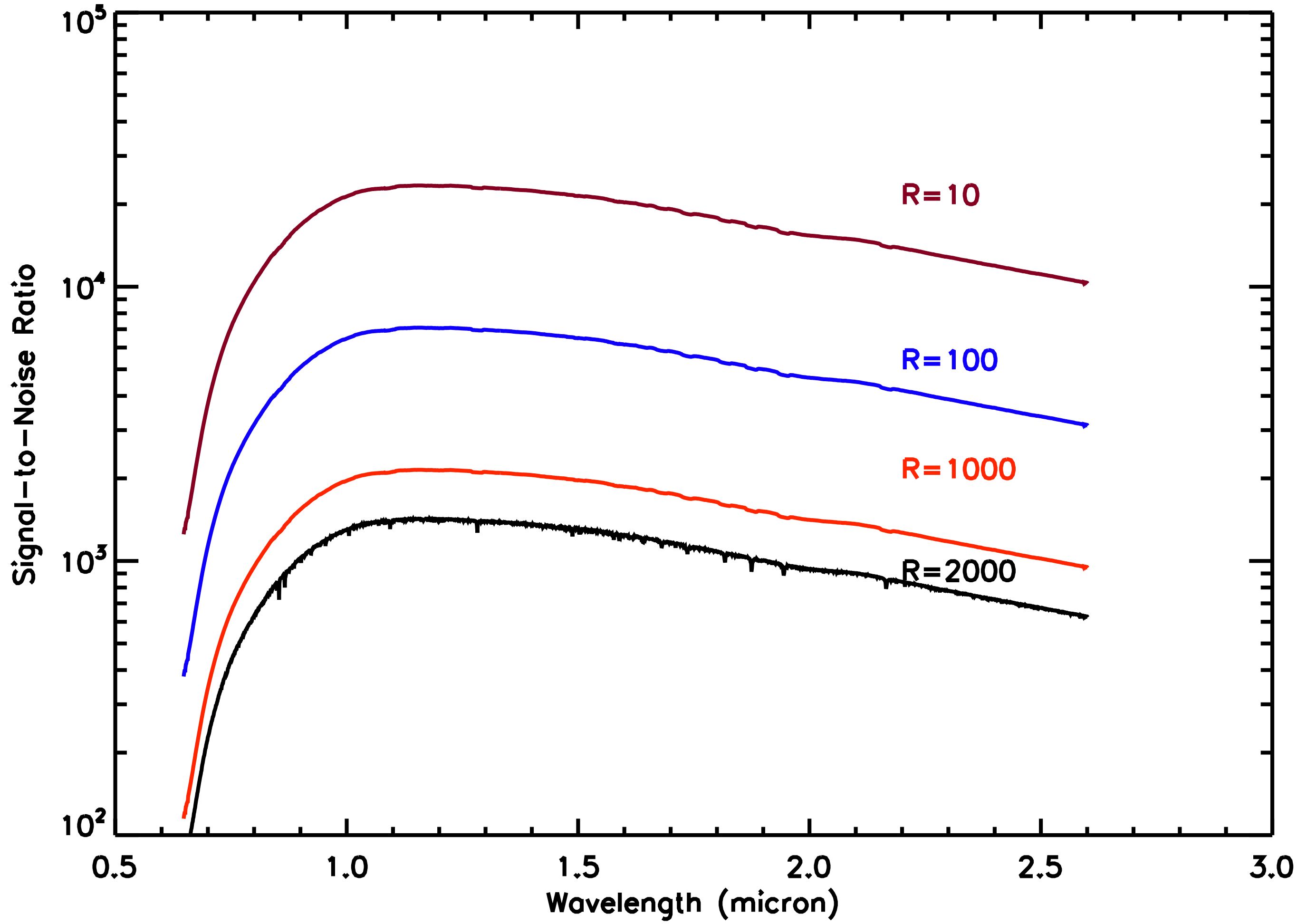
Input Data



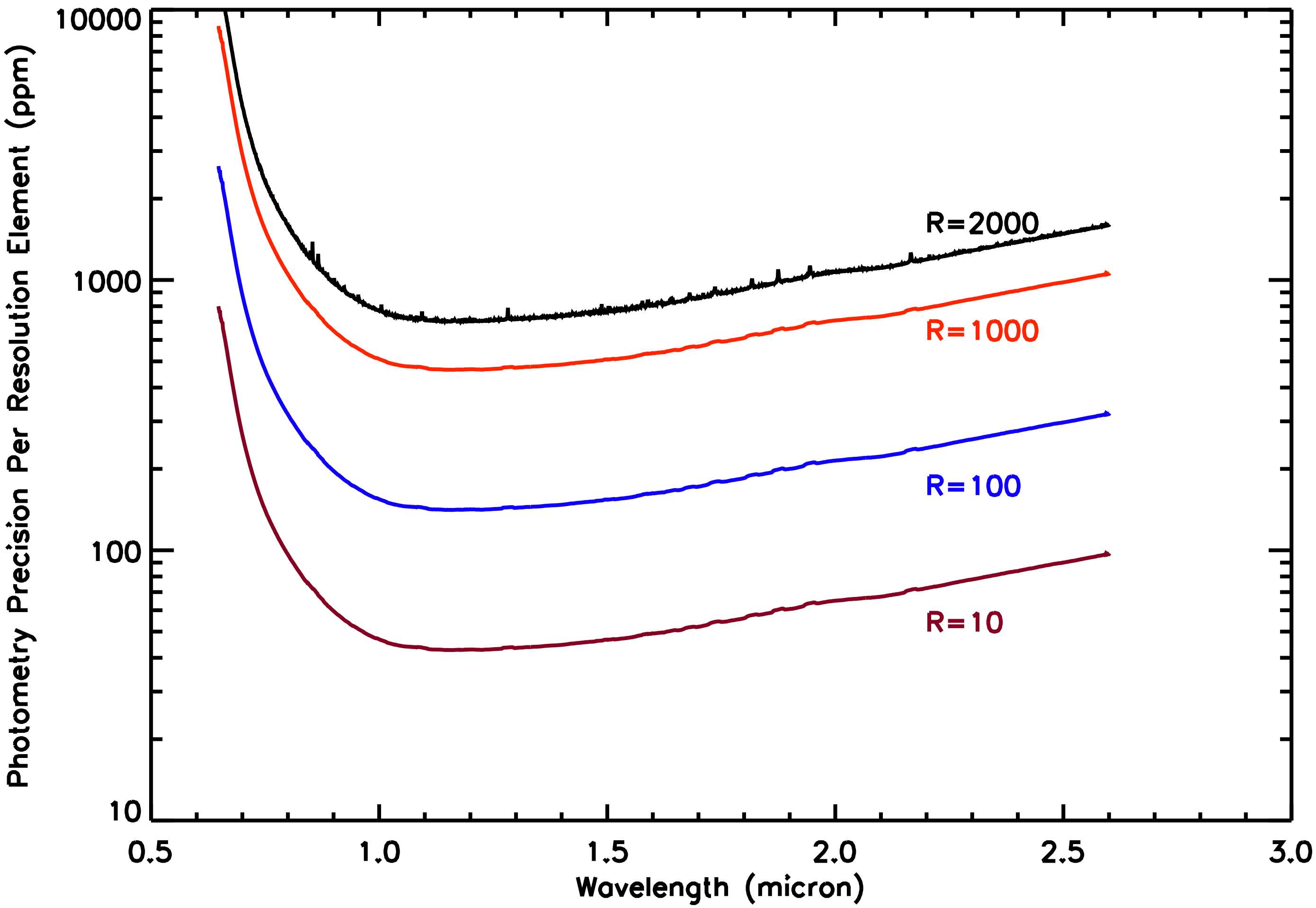


- JWST level 3 time-series data delivered as 2048 x 2 spectra tables
- Number of integrations = 144
- Effective integration time = 33 s
- NIRISS detector gain = 1.5 e^-/DN

SNR as a function of wavelength (at different spectral resolutions)



Achievable precision as a function of wavelength (at different spectral resolutions)



Detection of Spectral Features

Optical Depth along tangent ray at some Z

$$\tau_\lambda(z) = \sigma_\lambda(T,P)\frac{P(z)}{k_B T}\sqrt{2\pi R_p H}$$

Larger the planet radius, easier to detect.

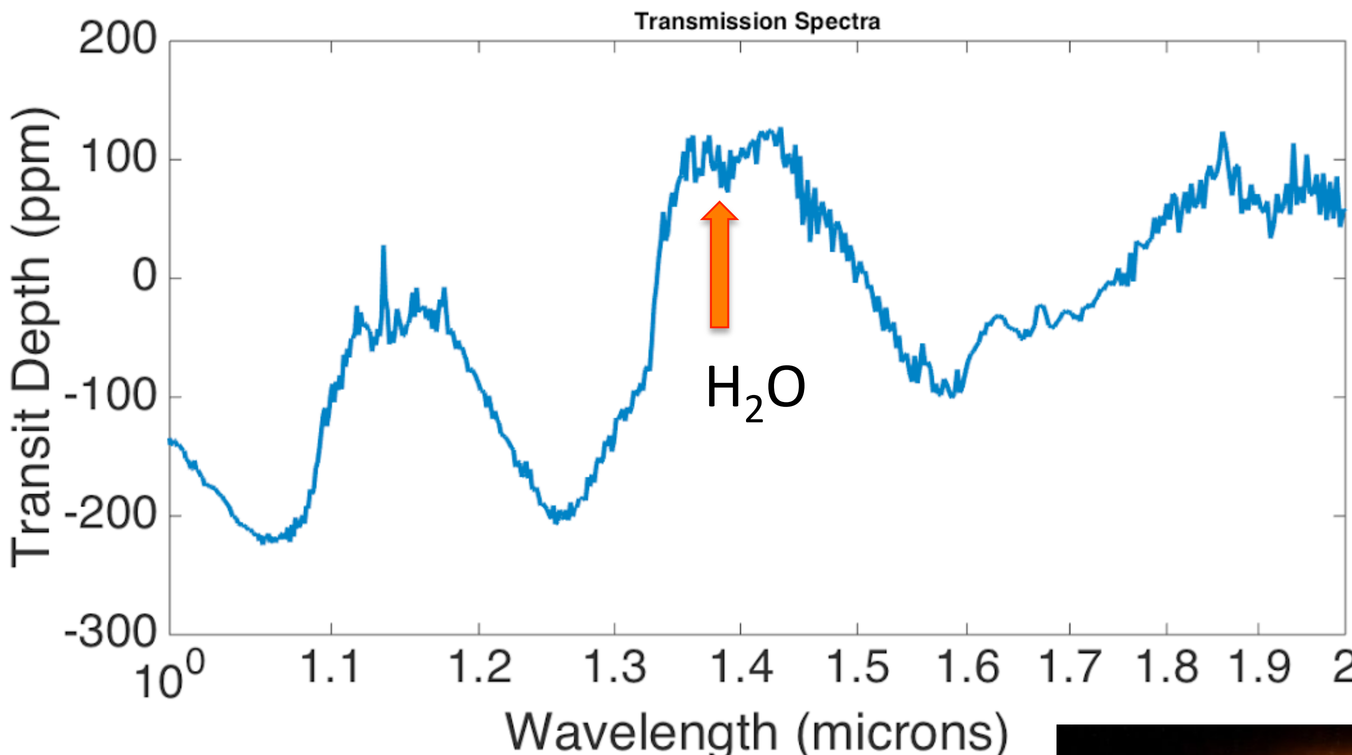
Variation of scale height with temperature

$$H = \frac{k_b T}{\mu g}$$

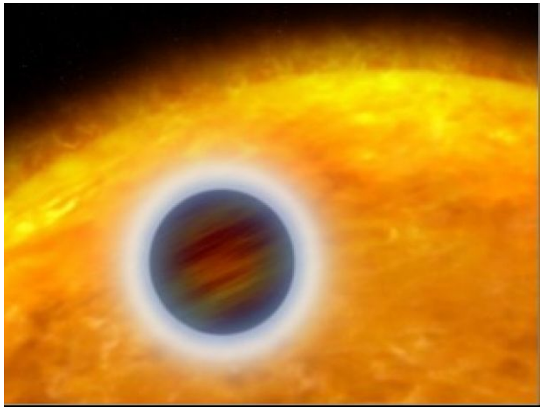
Larger the scale height, easier to detect.

Credit: Mike Line

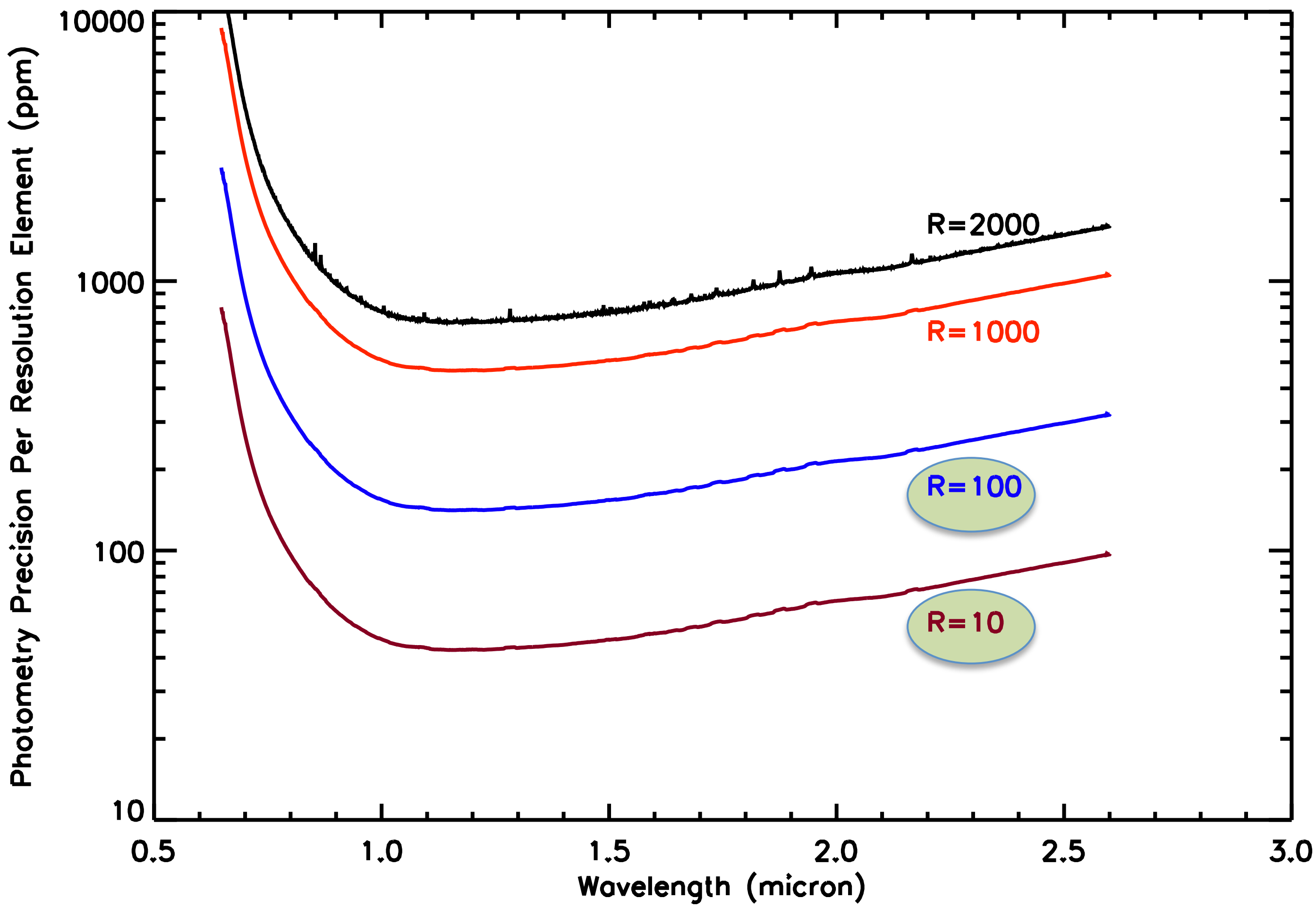
Transmission Spectrum for a typical hot Jupiter



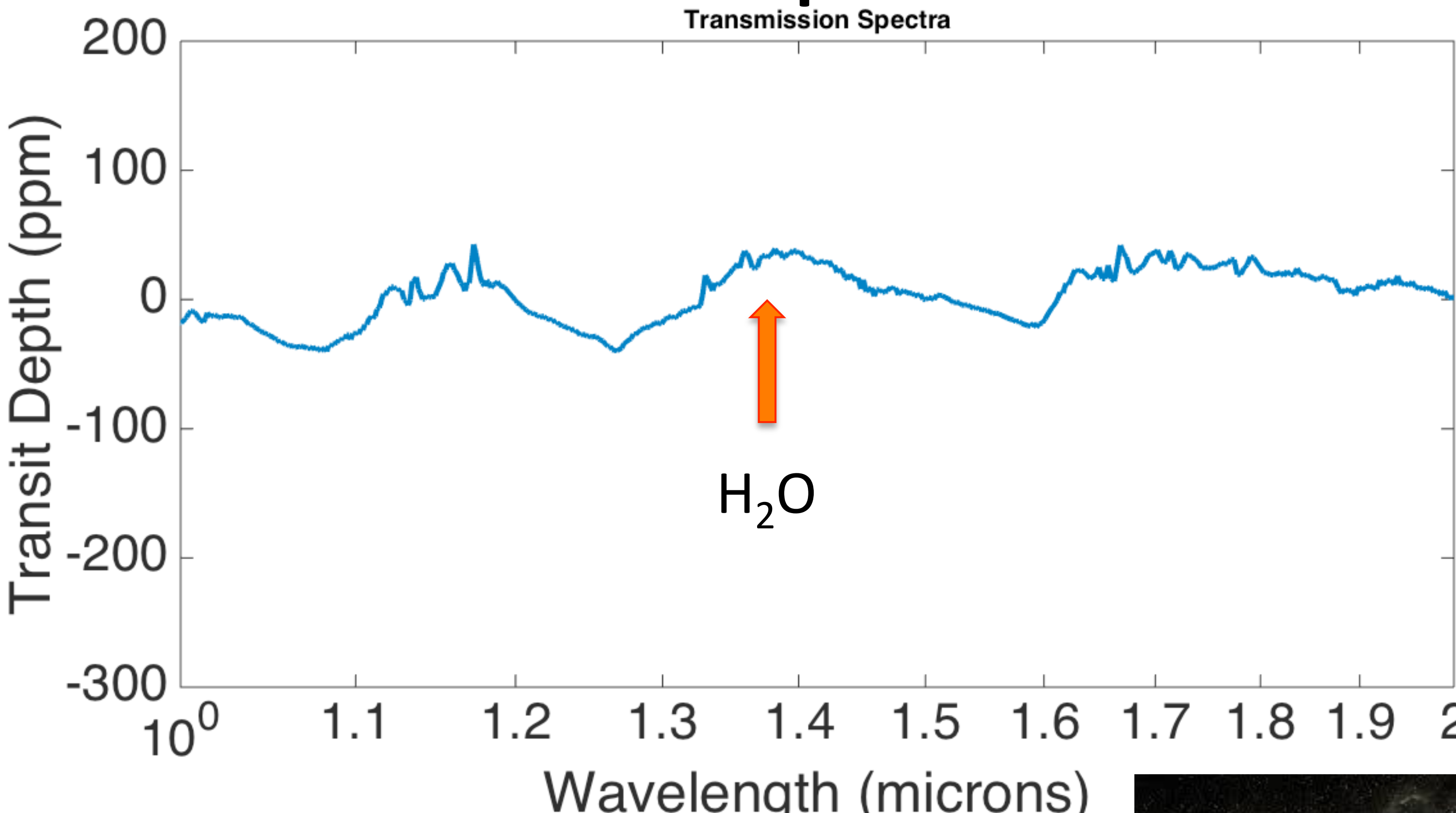
Need 100 ppm for 3-sigma detection.



Transmission Spectrum for a typical hot Jupiter

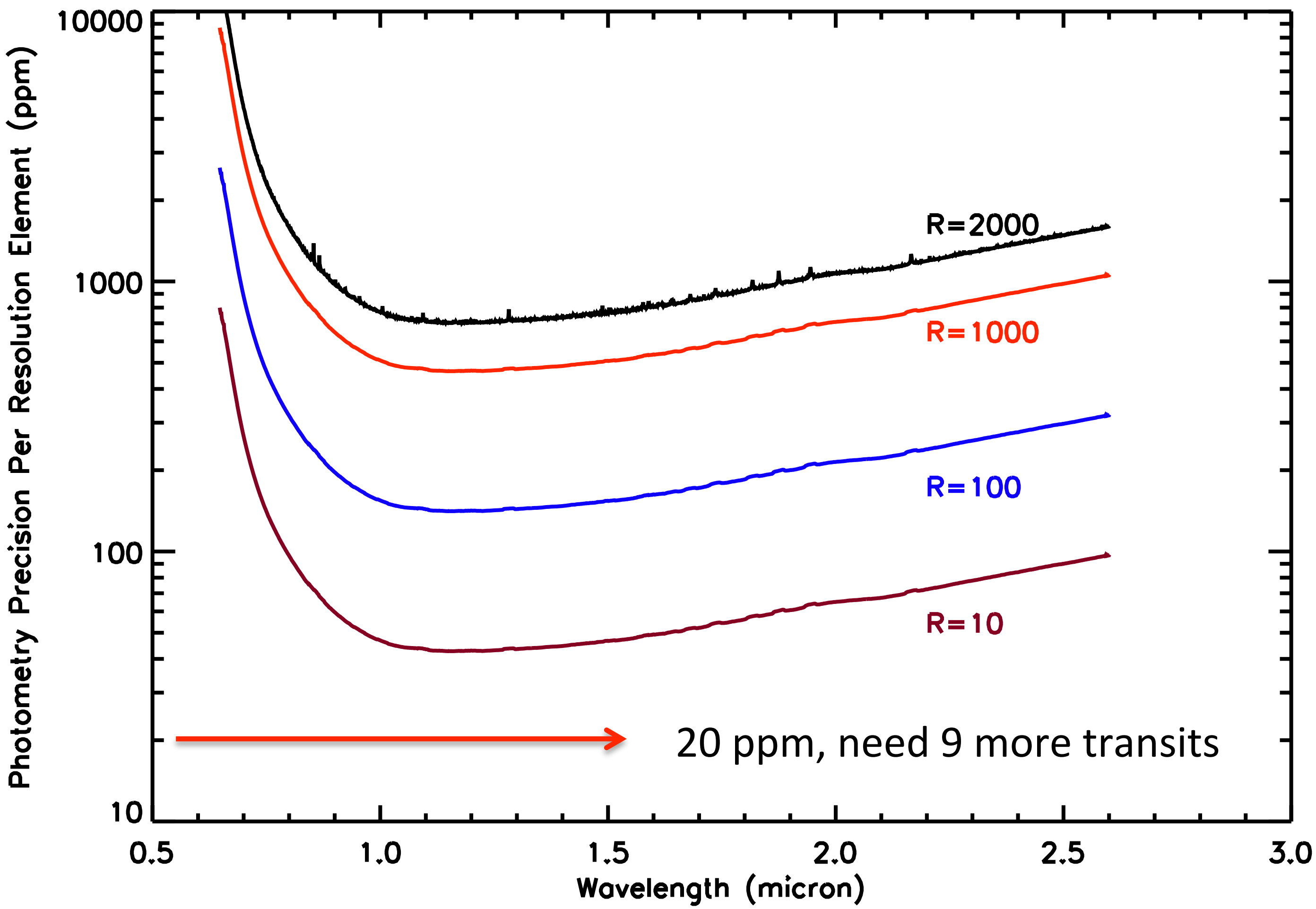


Transmission Spectrum for a typical cool Earth-sized planet



Need 20 ppm for 3-sigma detection.

Transmission Spectrum for a typical cool Earth-sized planets



Conclusion

- Lower spectral resolution results in a higher signal-to-noise ratio of each resolution element.
- Spectral features on planets with higher temperature and larger radius are easier to detect.