Detecting Potential Biosignatures in super-Earth Atmospheres with JWST

Caprice Phillips

Pronouns: She/her/hers

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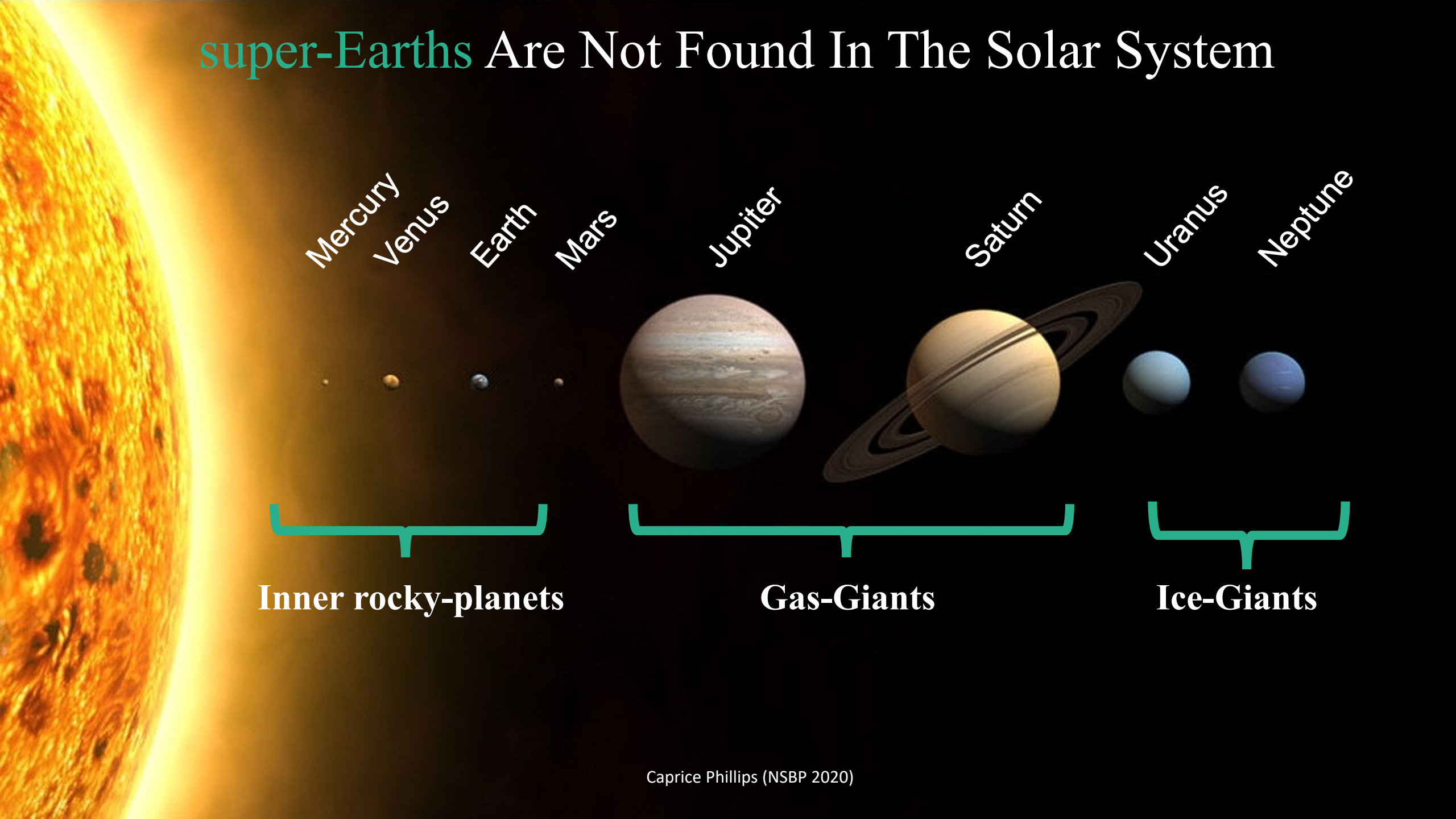
super-Earths Are Not Found In The Solar System



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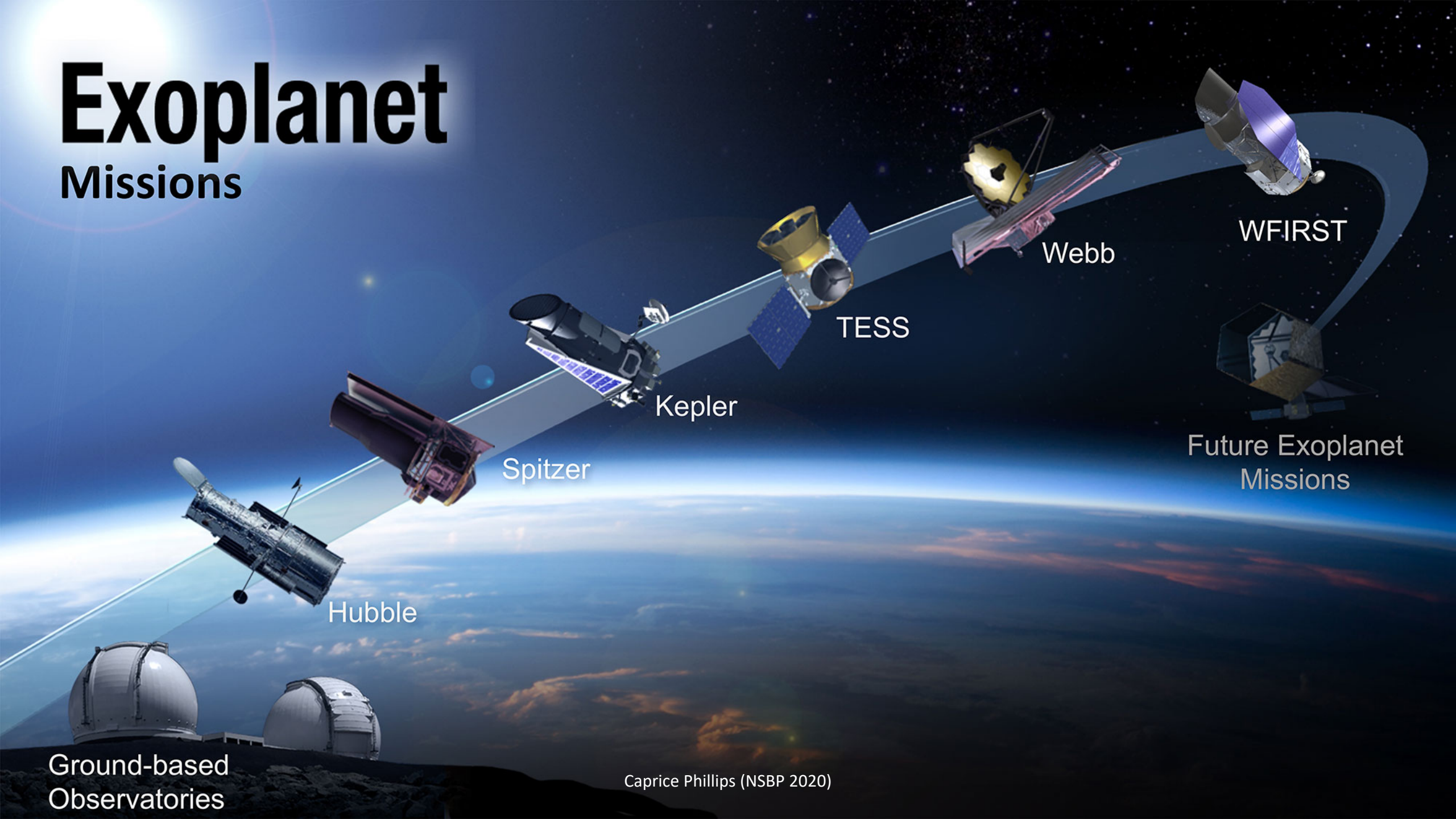
What is a Biosignature?

- An atmospheric biosignature is a gas whose presence in a planetary atmosphere indicates that the planet likely harbors life

Criteria
• Generated by life
• Build up in planetary atmosphere to be detectable
• Present/active in wavelength range being observed



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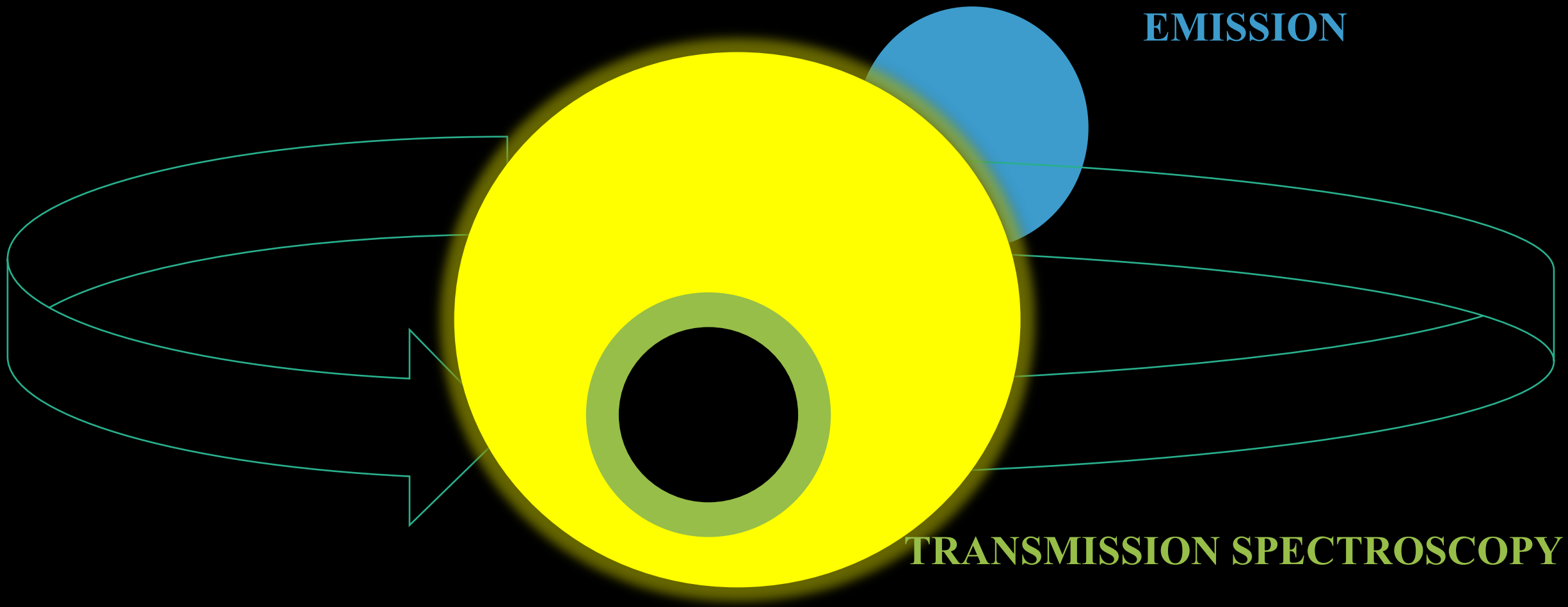
JWST Will Probe super-Earth Atmospheres



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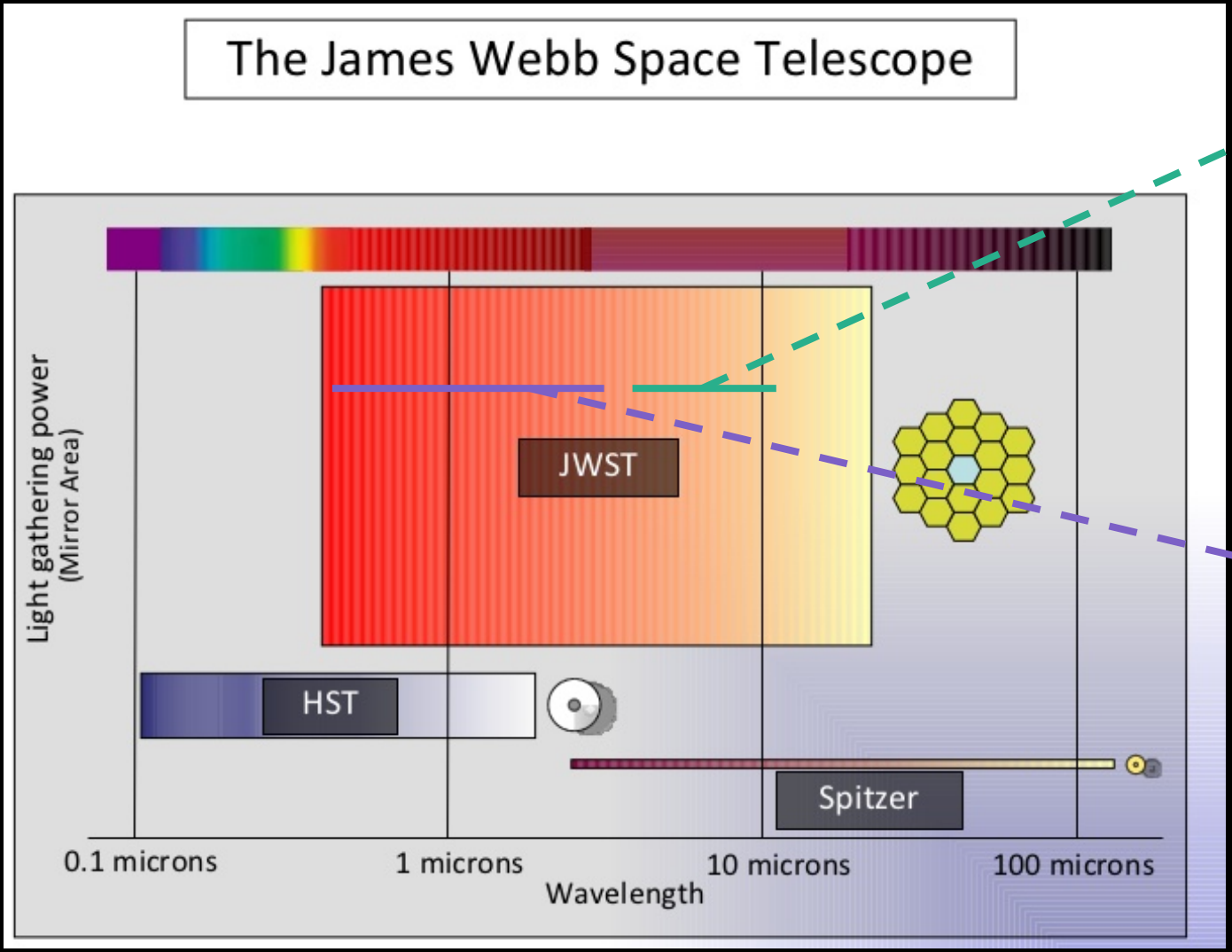
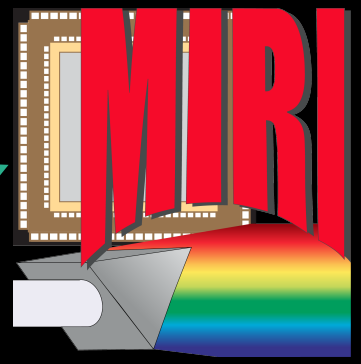
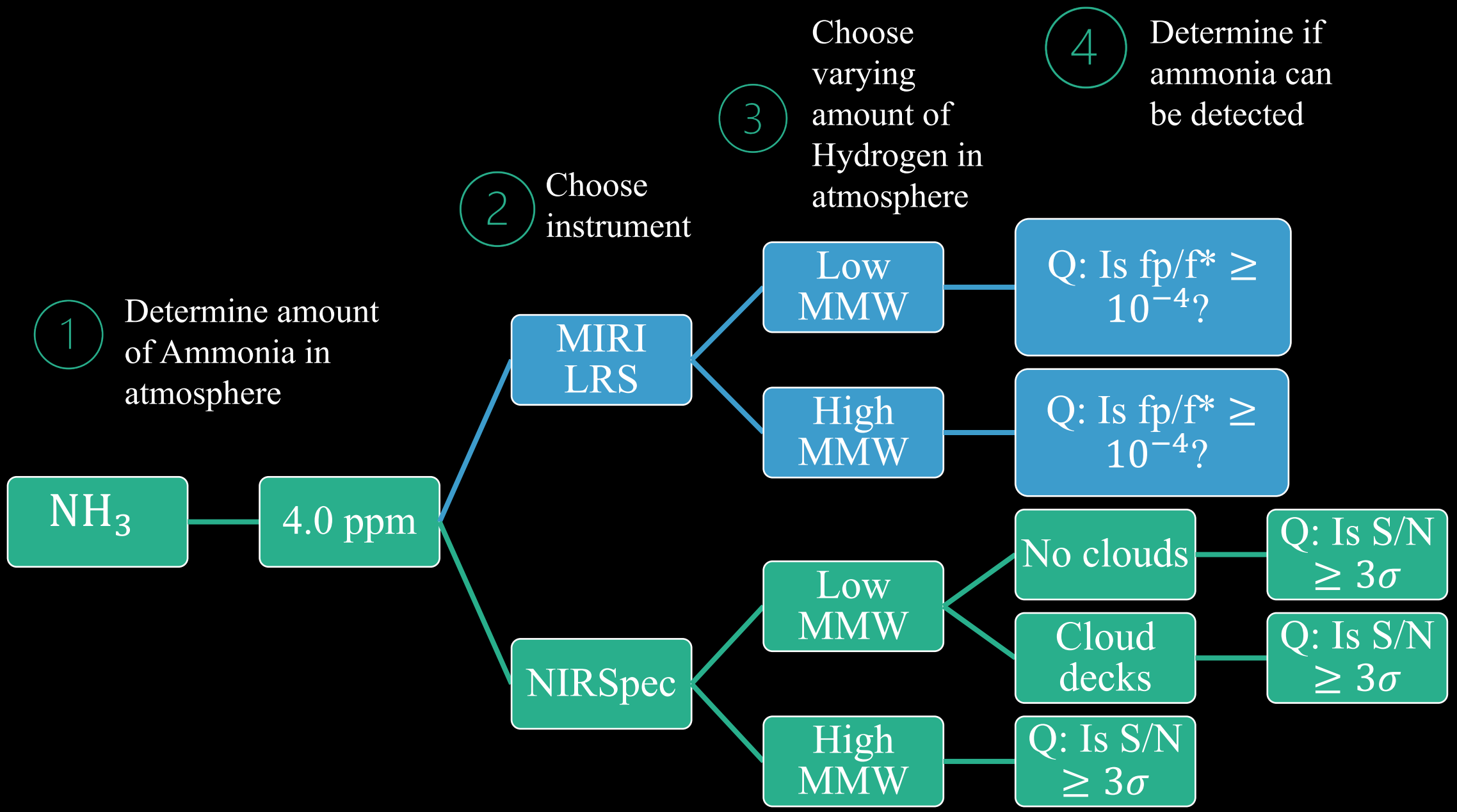
JWST Will Provide Unprecedented Area Collection and Wavelength Coverage



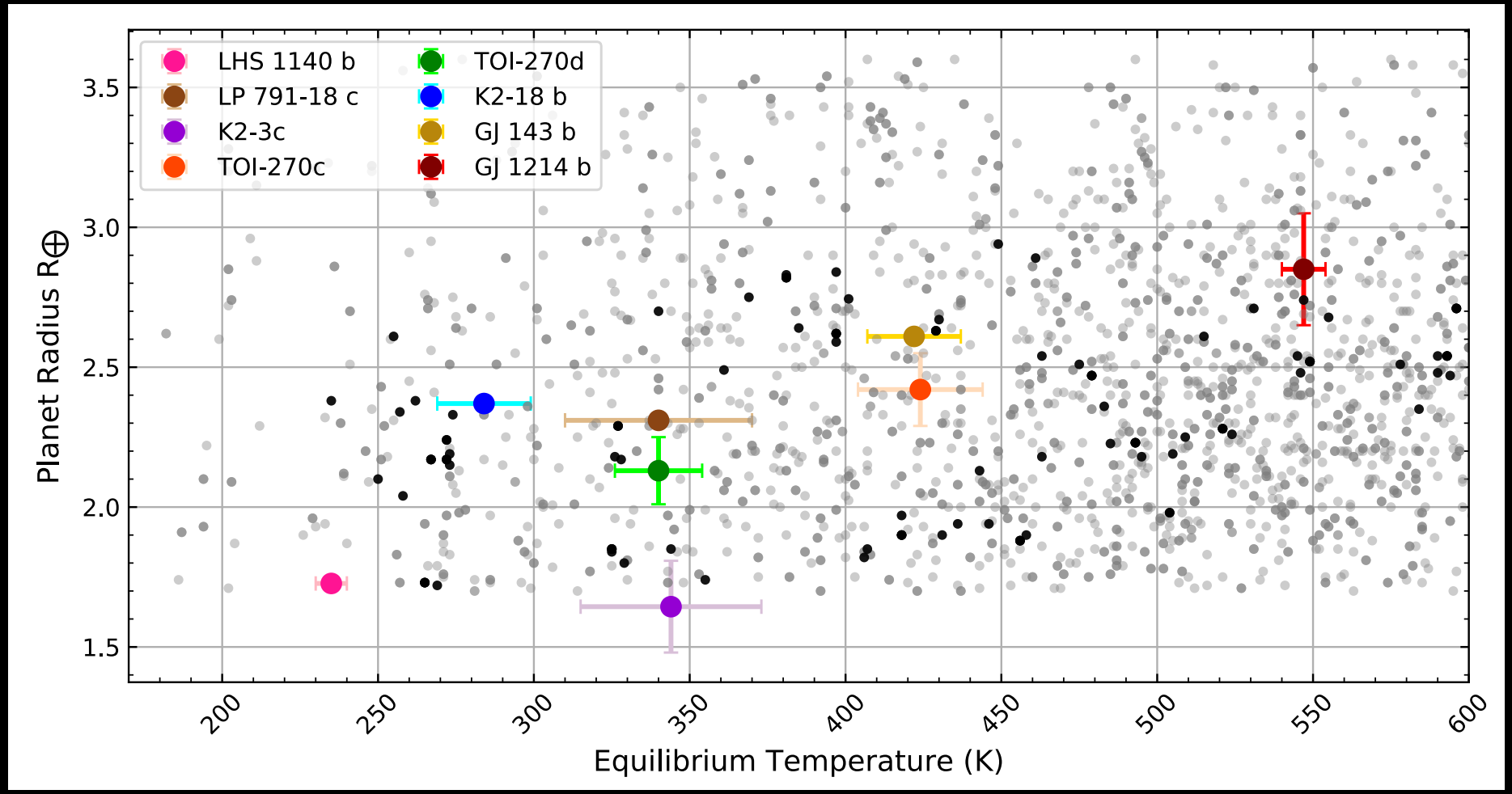


Wavelength Coverage: 5 – 12 microns

Wavelength Coverage: 0.6 – 5 microns


1
Determine amount of Ammonia in atmosphere
2
Choose instrument
3
Choose varying amount of Hydrogen in atmosphere
4
Determine if ammonia can be detected
NH_3
4.0 ppm
MIRI LRS
NIRSpec
Low MMW
High MMW
Low MMW
High MMW
Q: Is $fp/f^* \geq 10^{-4}$?
Q: Is $fp/f^* \geq 10^{-4}$?
No clouds
Cloud decks
Q: Is S/N $\geq 3\sigma$
Q: Is S/N $\geq 3\sigma$
Q: Is S/N $\geq 3\sigma$

Selection Criteria for Targets



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petit RADTRANS

Mollière et al. 2019

Abundances

Pressure Bar

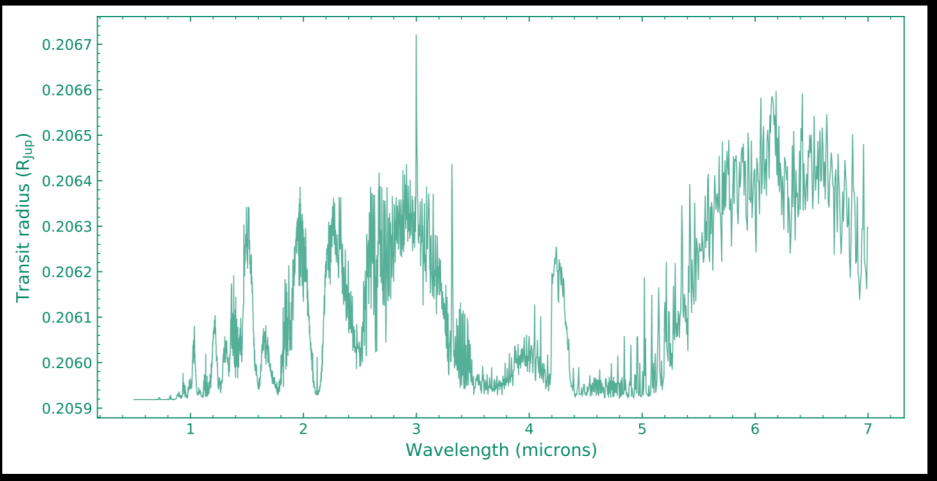
Cloud Decks

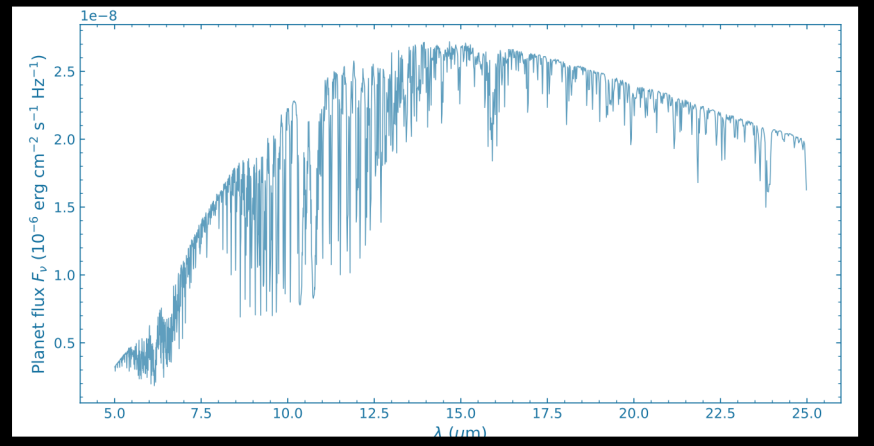
surface gravity

P-T Profile

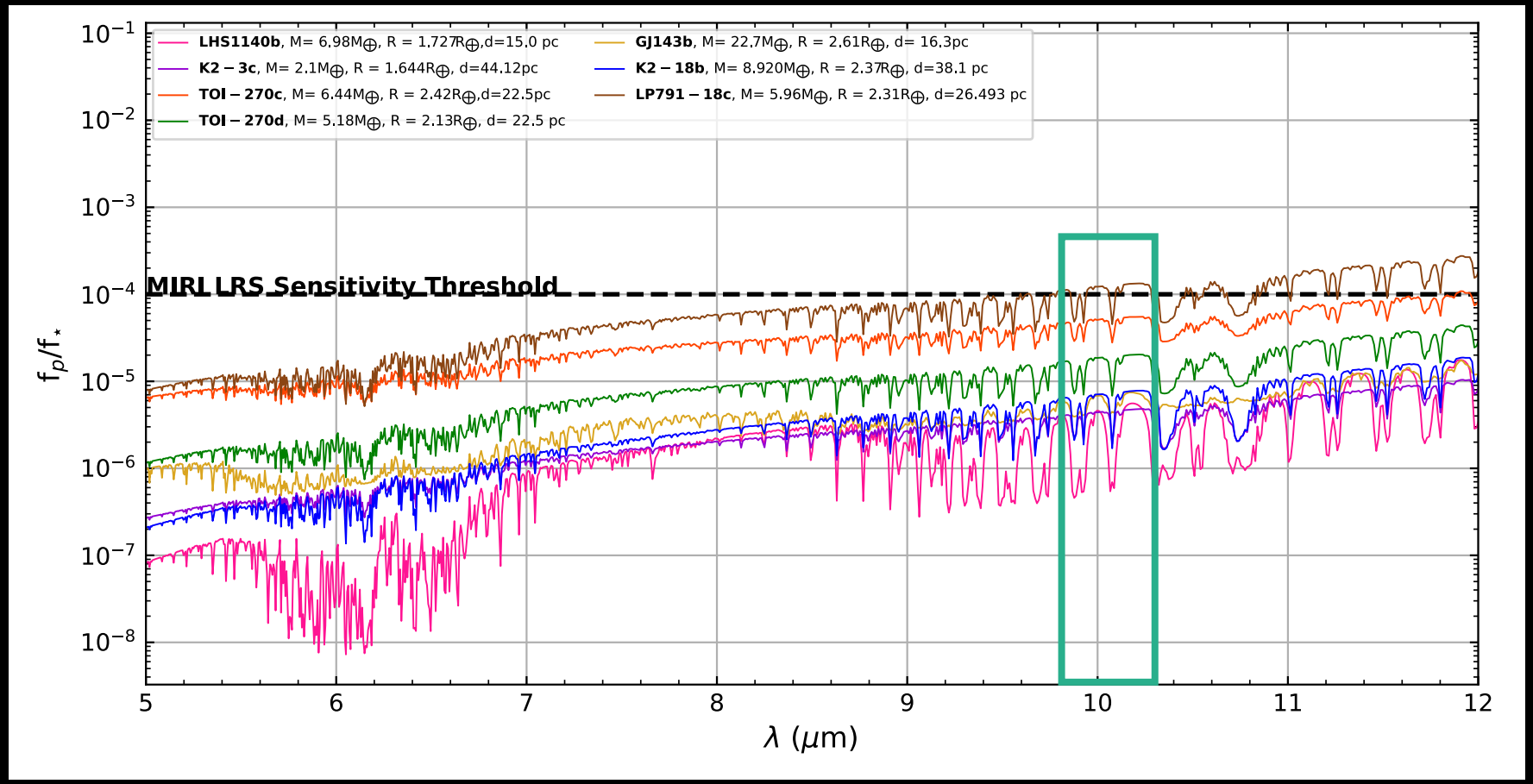
Radius/ T_{eq}/μ

Simulated Transmission/Emission Spectra





10μm Ammonia Feature Is Difficult to Detect with MIRI LRS



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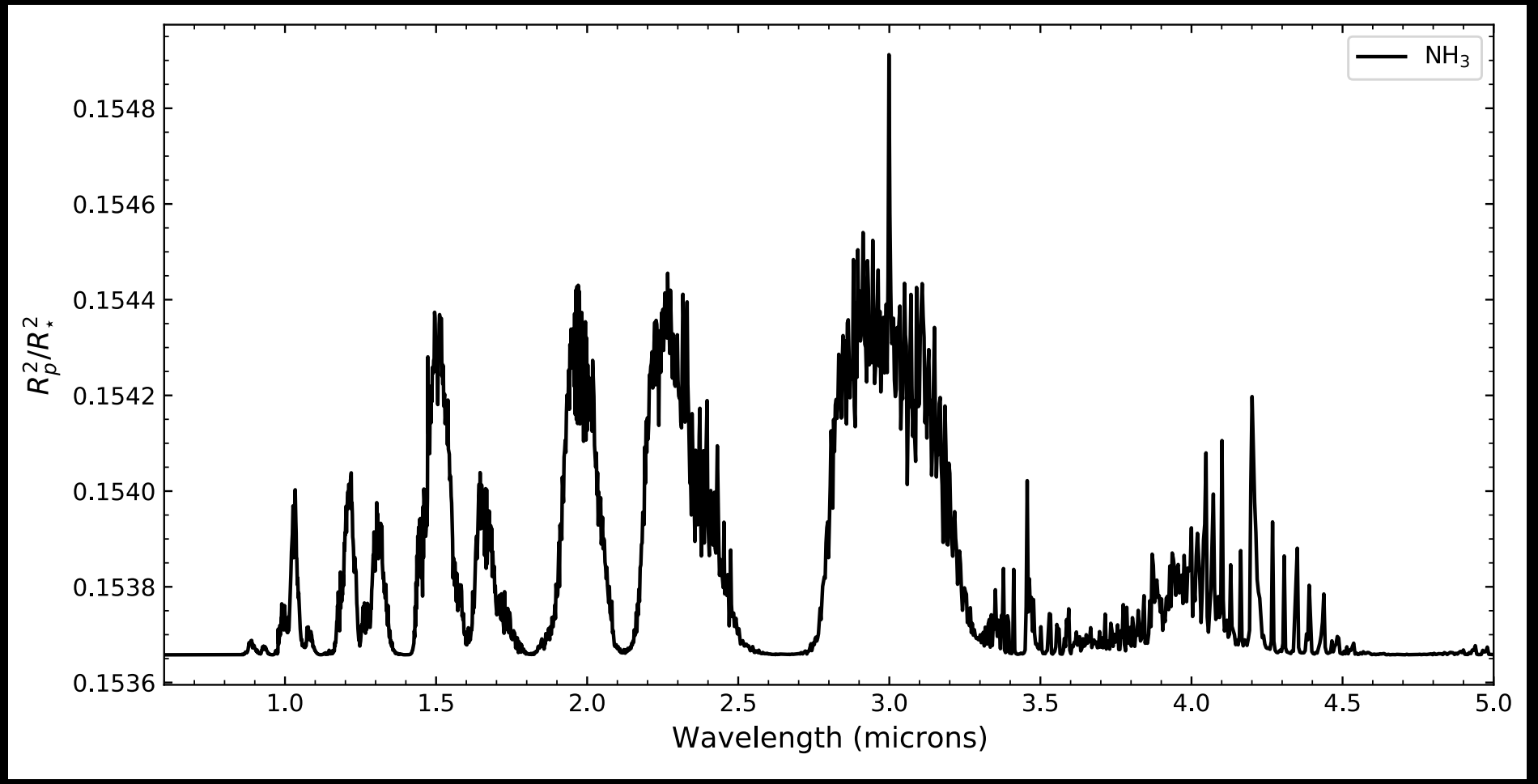
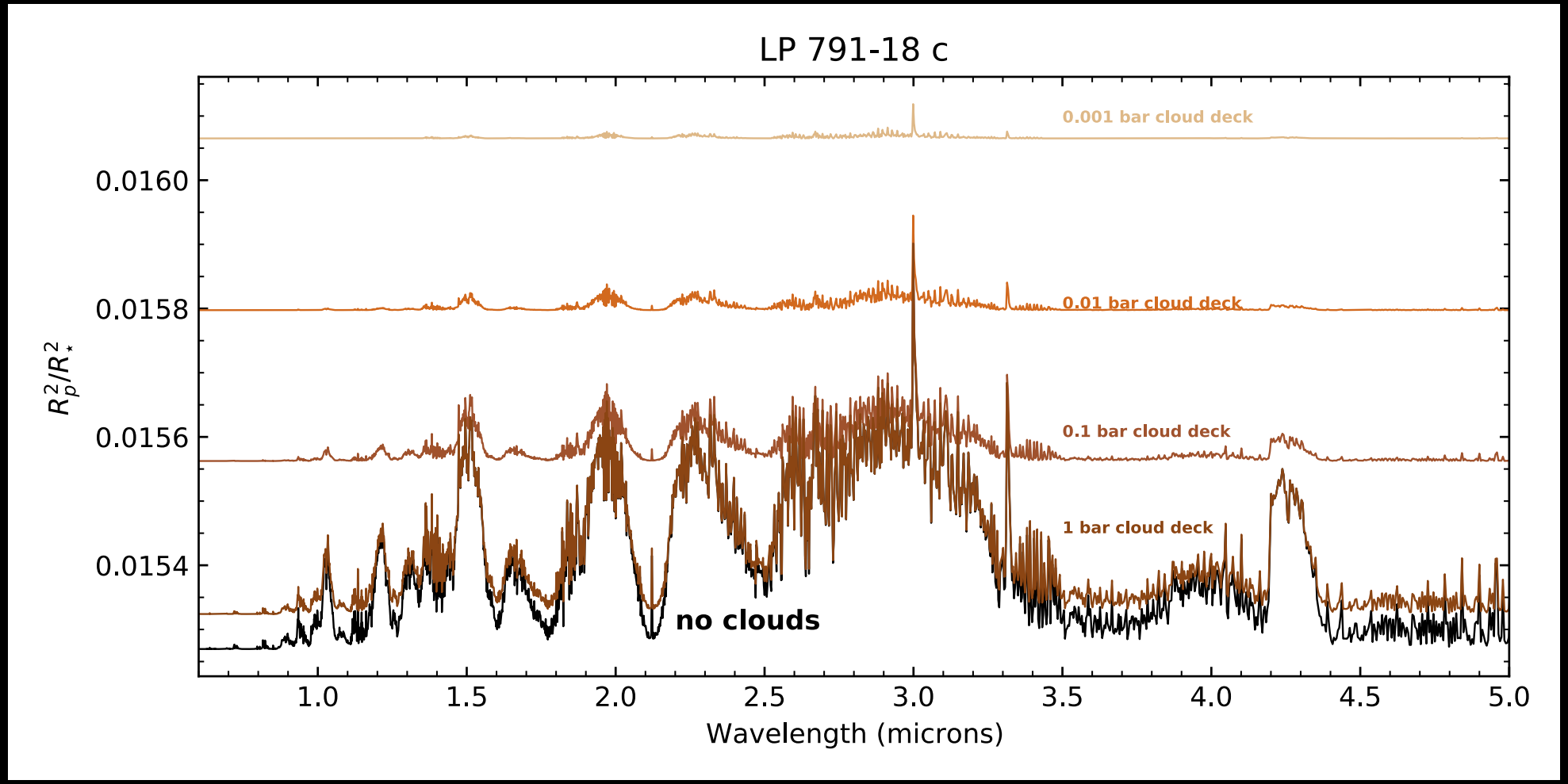
Ammonia has many features in the NIR



Cloud Decks Weaken Spectral Features



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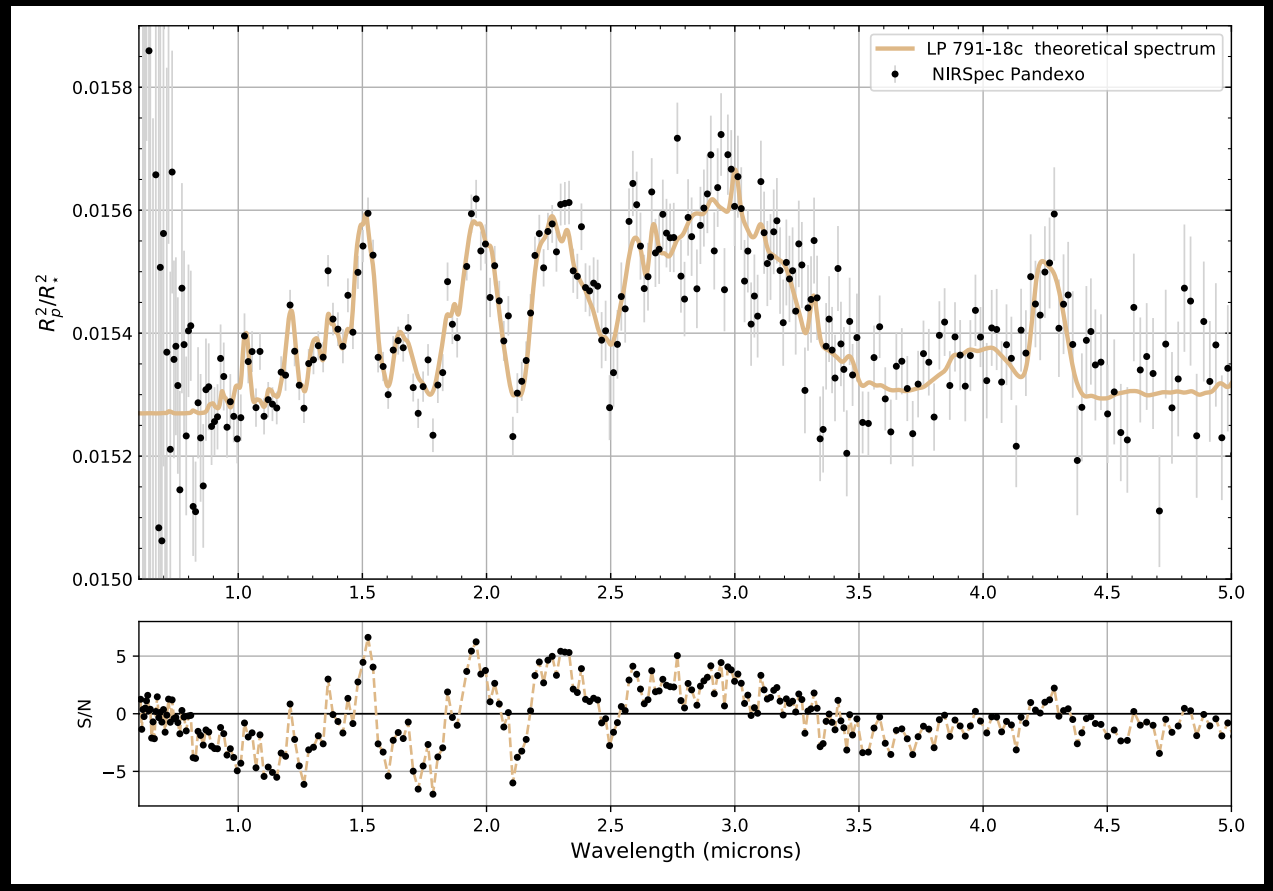
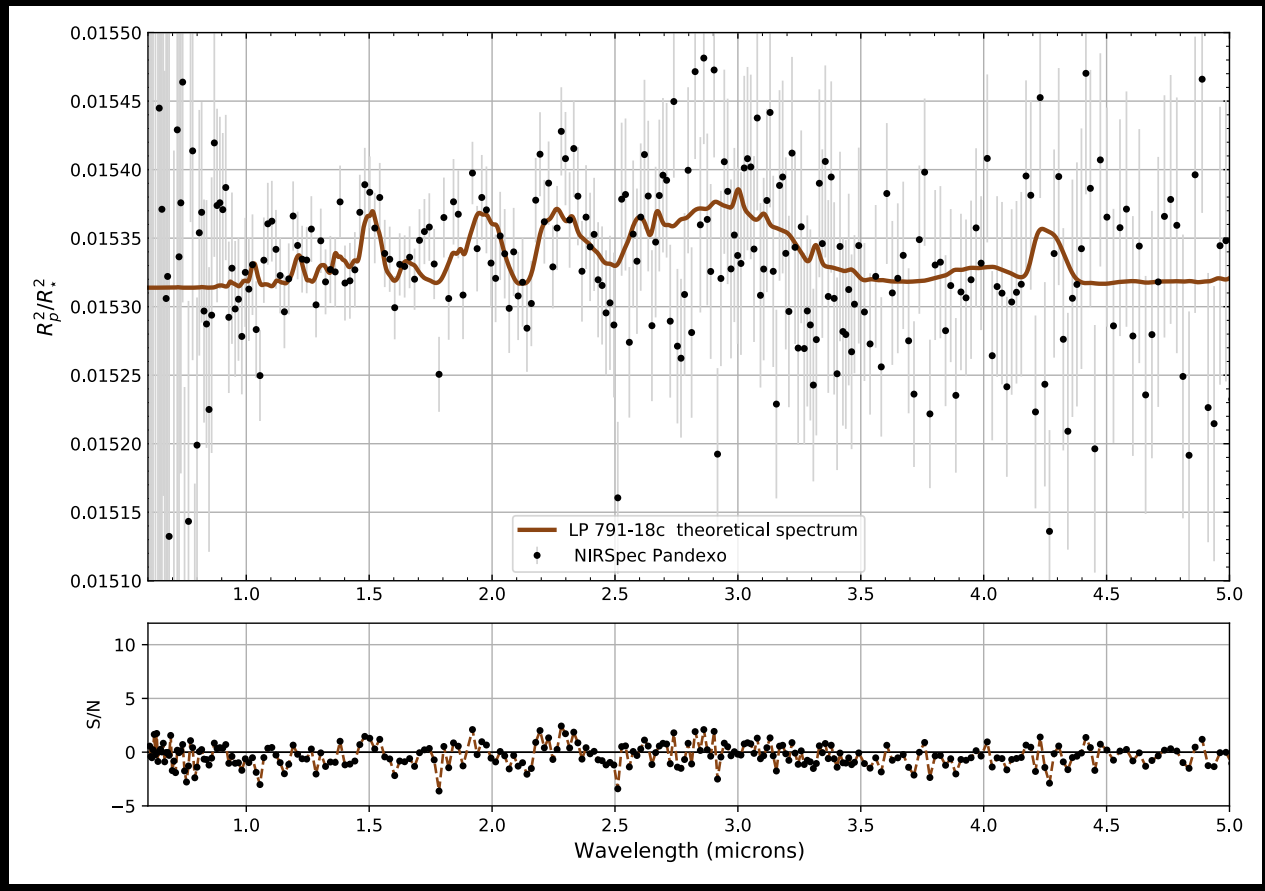
Signal-To-Noise Scales with $\frac{1}{\mu}$

Lower MMW (90% H_2)



Higher MMW (25% H_2)



Rank List of Targets

1. GJ 1214 b

2. LP 791-18 c

3. TOI-270 c

4. LHS 1140 b

5. GJ 143 b

6. TOI-270 d

7. K2-18 b

8. K2-3c

Takeaways

- super-Earths are more massive/common than Earth and are promising sites to look for signs of life
- Ammonia is a biosignature unique to a hydrogen dominated atmosphere
- The 10μm Ammonia feature is difficult to detect with the MIRI LRS instrument
- A lower mean molecular weight atmosphere produces stronger features with transmission spectroscopy
- NIRSpec may be a better tool than MIRI LRS to detect Ammonia in the atmosphere of super-Earths