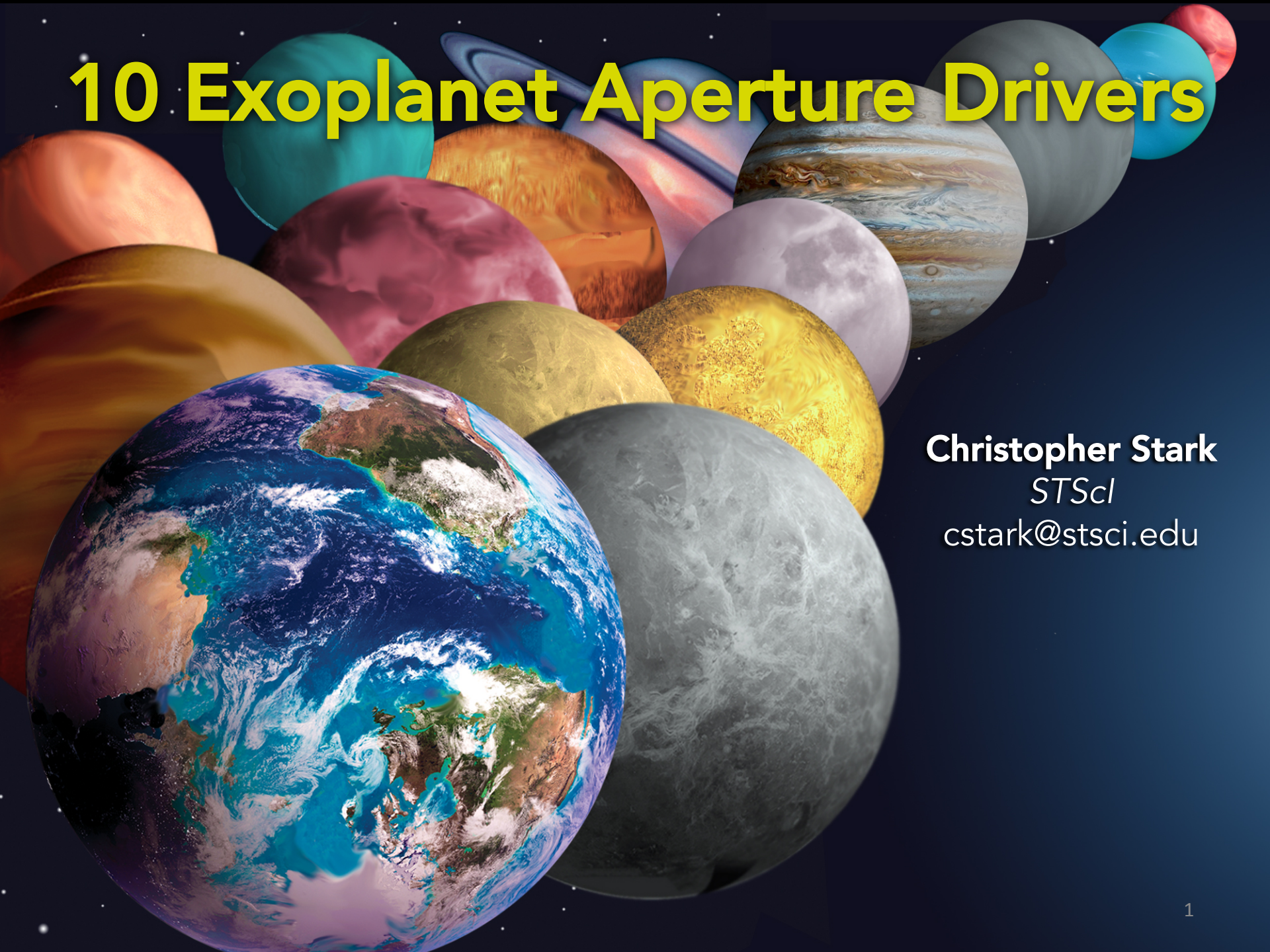
10 Exoplanet Aperture Drivers



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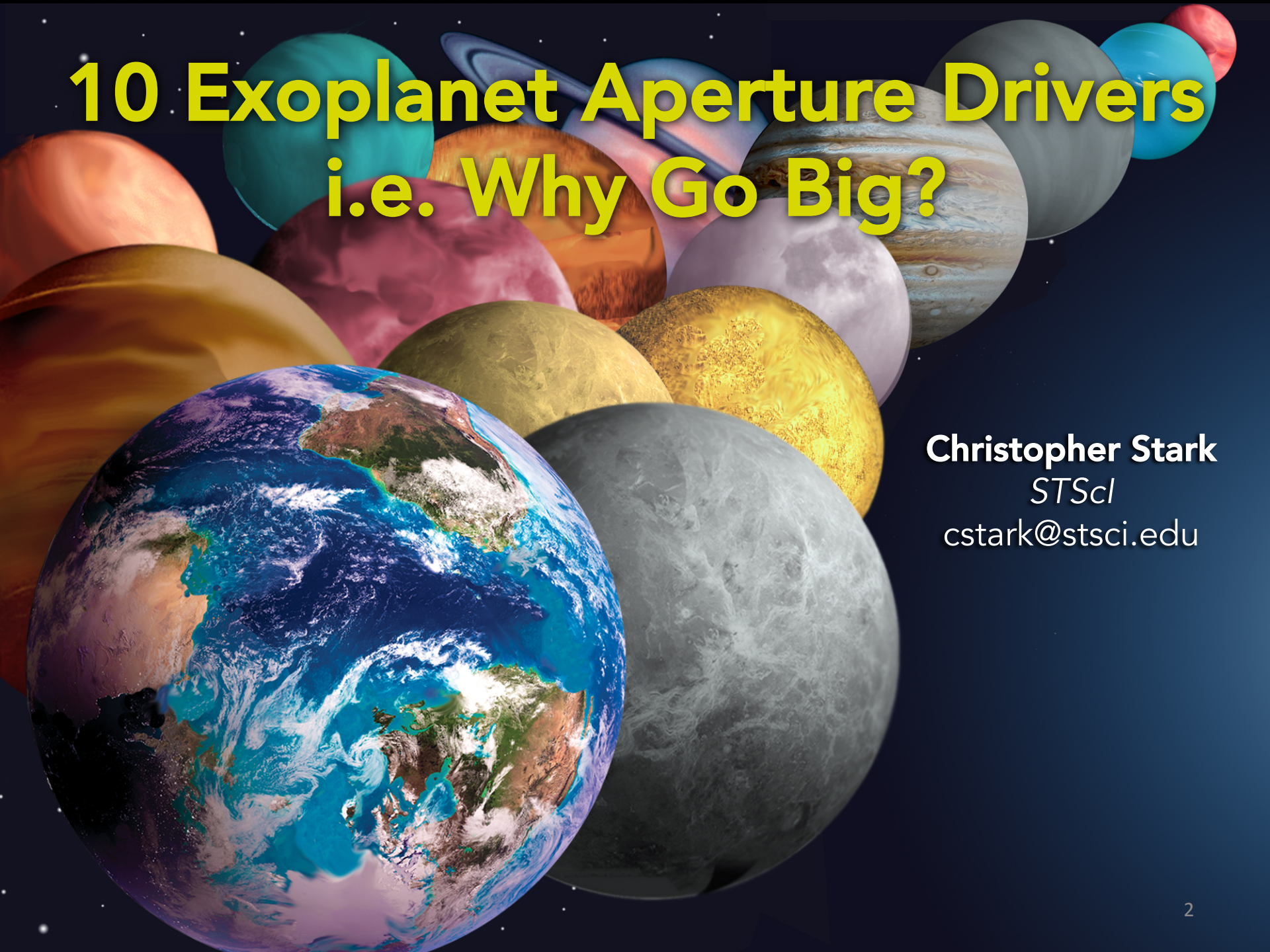
10 Exoplanet Aperture Drivers i.e. Why Go Big?



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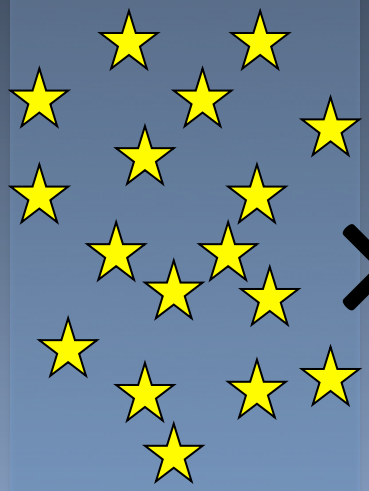
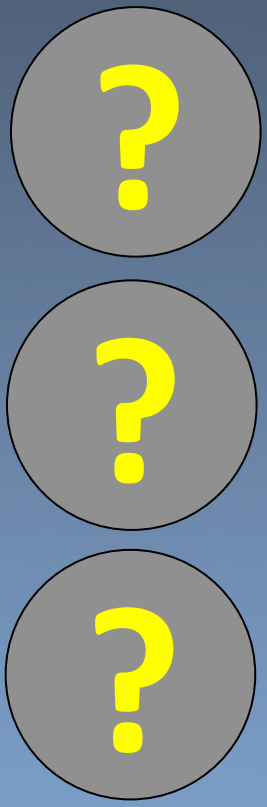
1. Enables a Powerful Null Result in the Search for Life

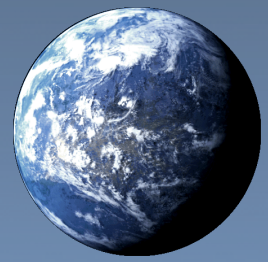
Let's build an experiment, not an instrument



$\times \eta_{\text{Earth}} =$

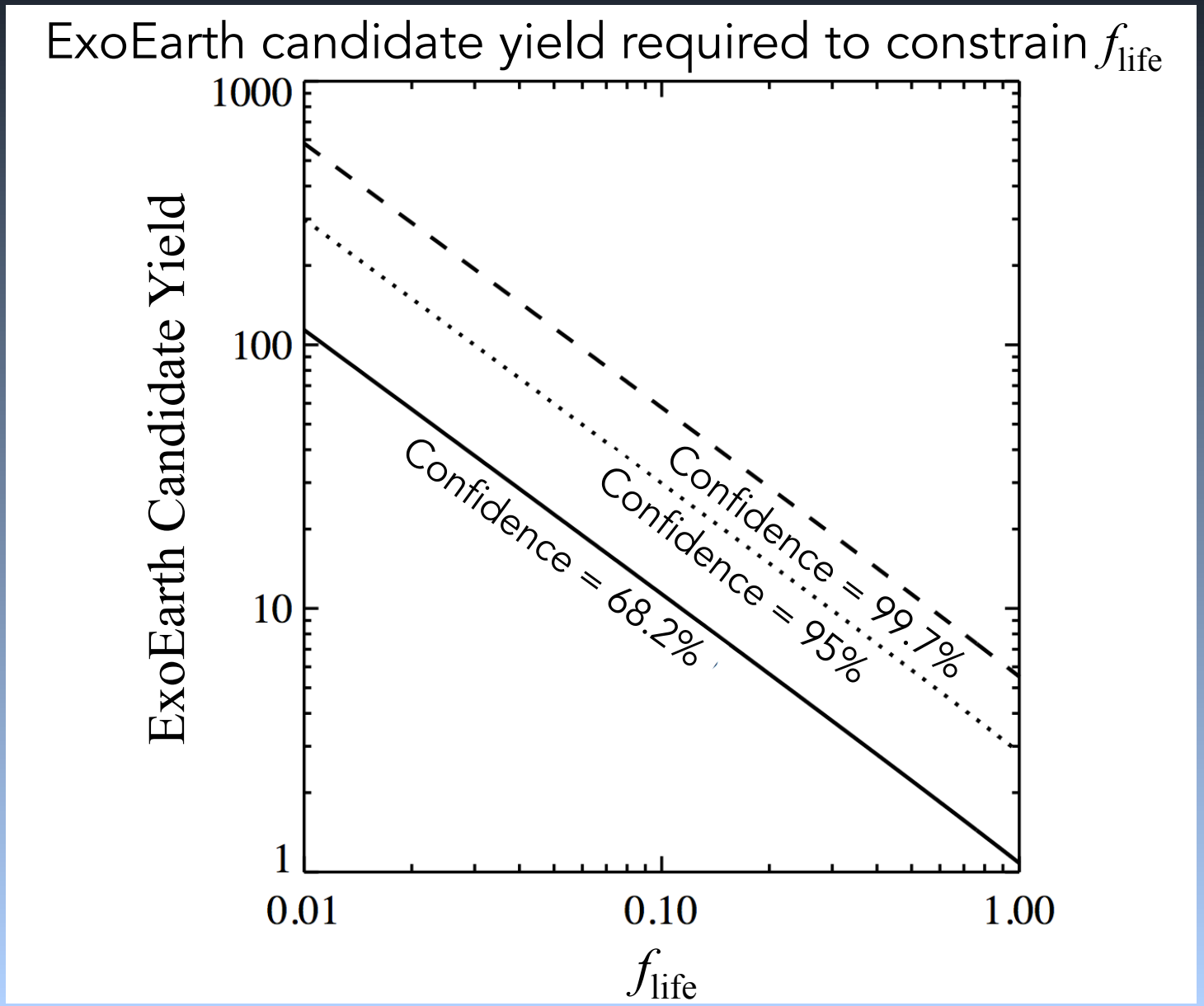


$\times f_{\text{life}} =$

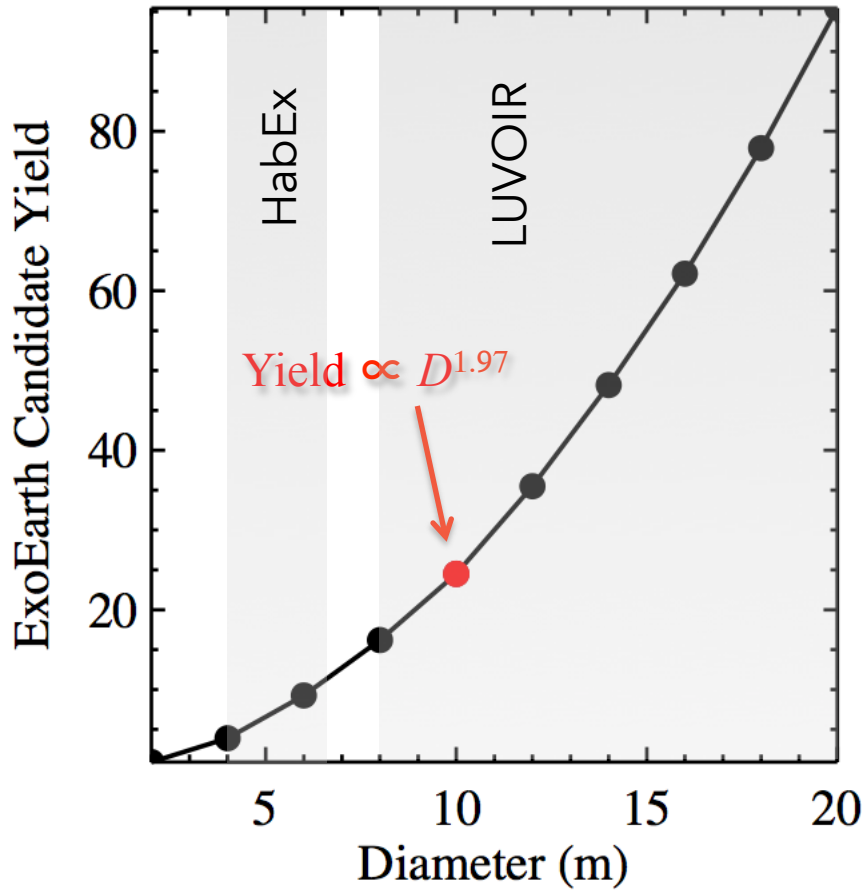


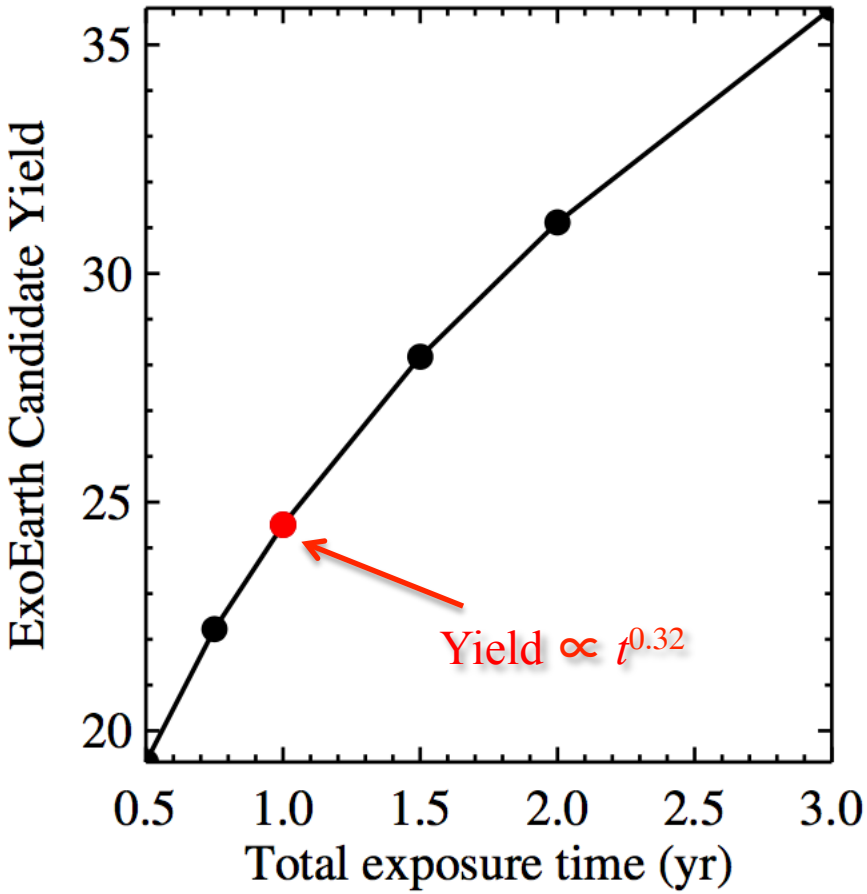
Number of habitable zones (HZs) surveyed	Frequency of Earth-sized rocks in the HZ	Yield of "exoEarth candidates"	Fraction of Earth-sized HZ rocks with life	Yield of living planets

1. Enables a Powerful Null Result in the Search for Life



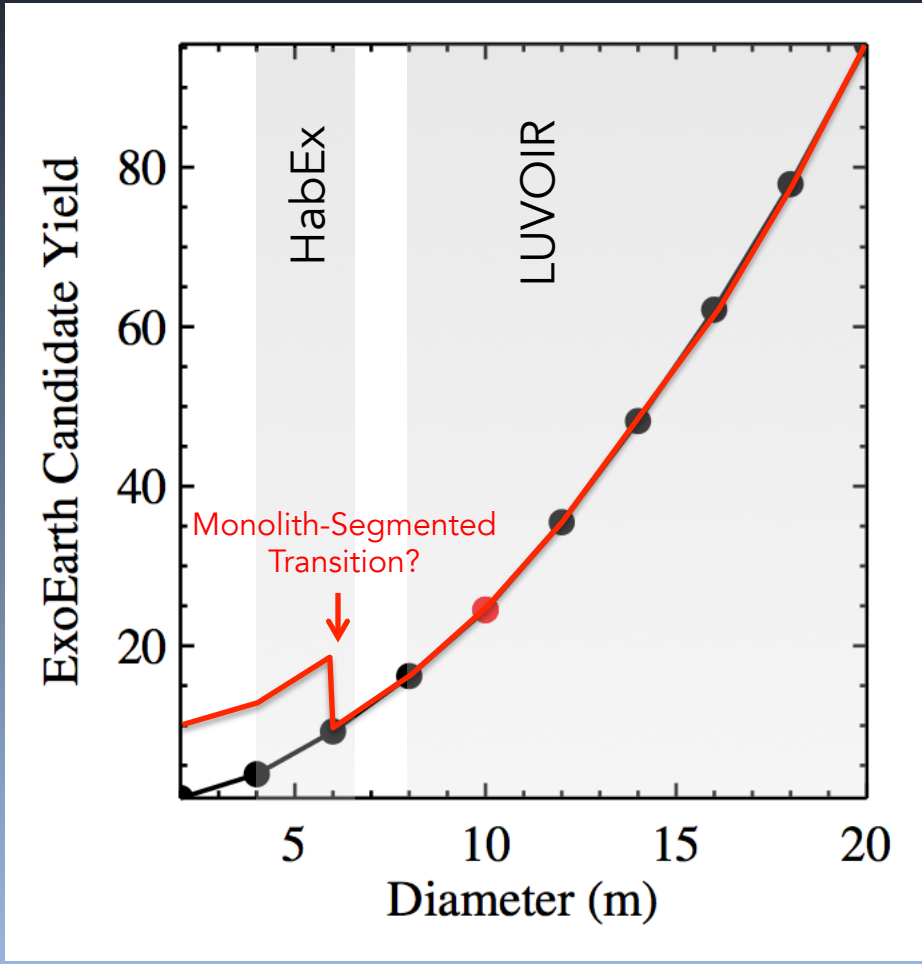
1. Enables a Powerful Null Result in the Search for Life





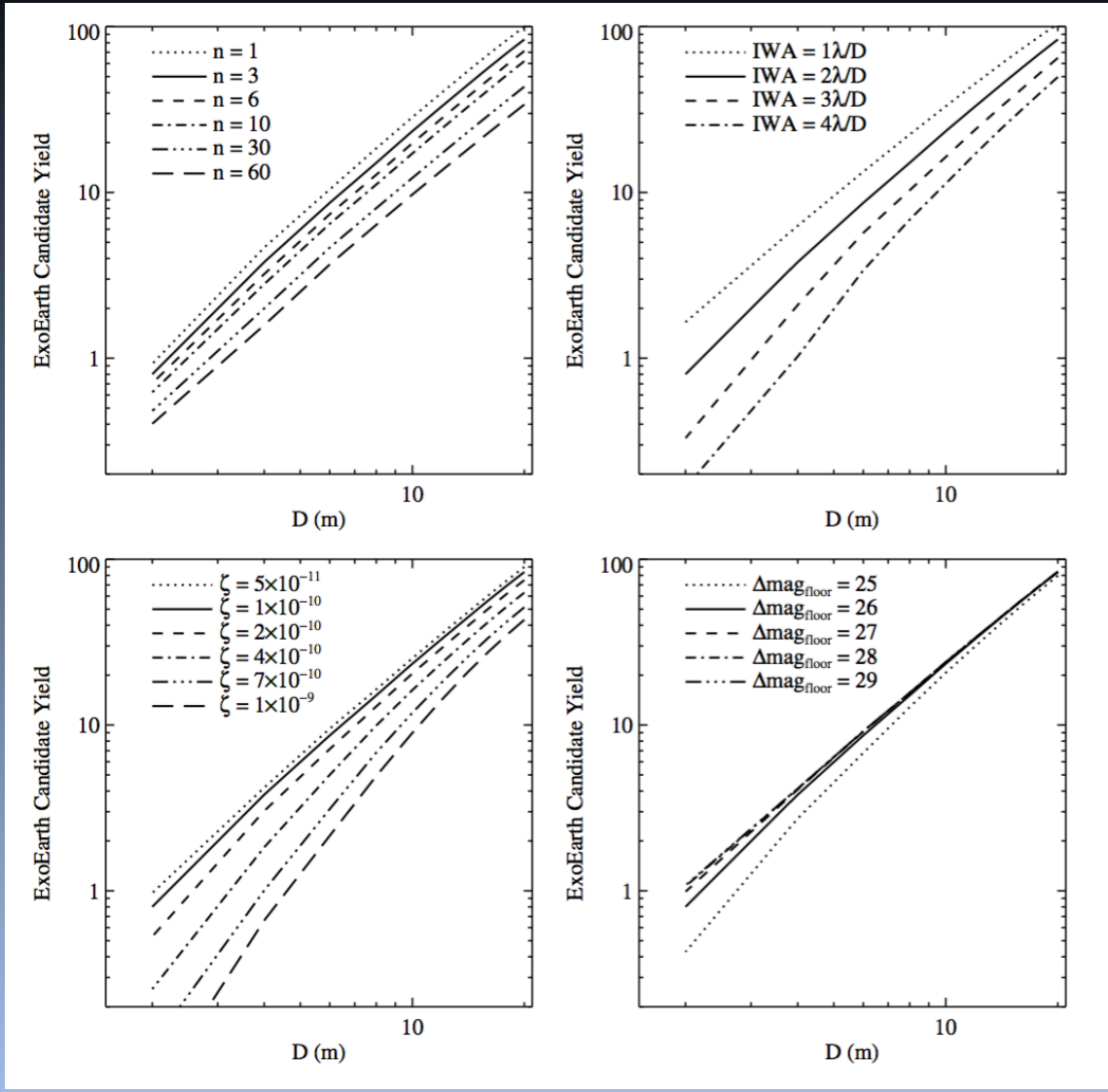
Yield is more sensitive to aperture than any other instrument, mission, telescope, or astrophysical parameter.

2. Must get past segmentation "penalty"



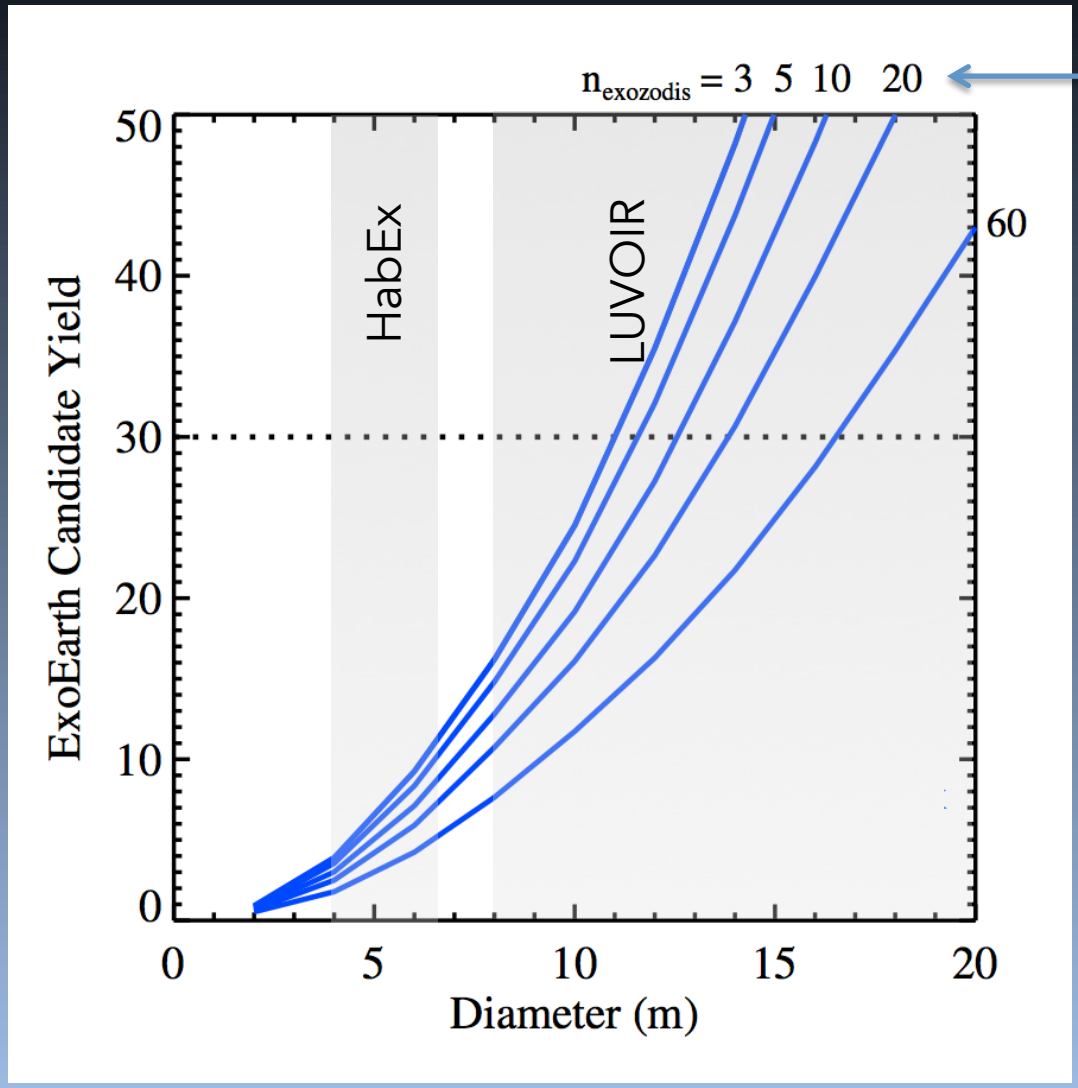
For **some** coronagraphs, monoliths will have larger yields than their segmented counterparts.

3. Potentially Less Sensitive to Instrument Degradation



However, more sensitive to stellar diameter-induced contrast degradation.

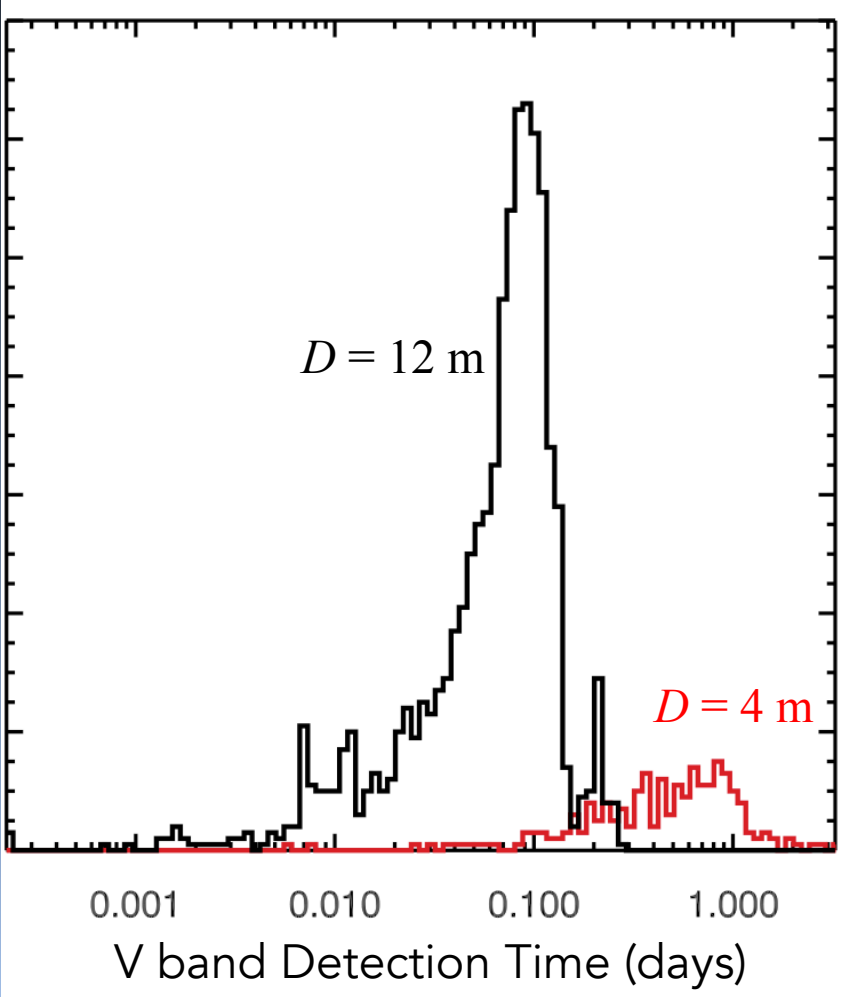
4. More Robust to Astrophysical Uncertainty

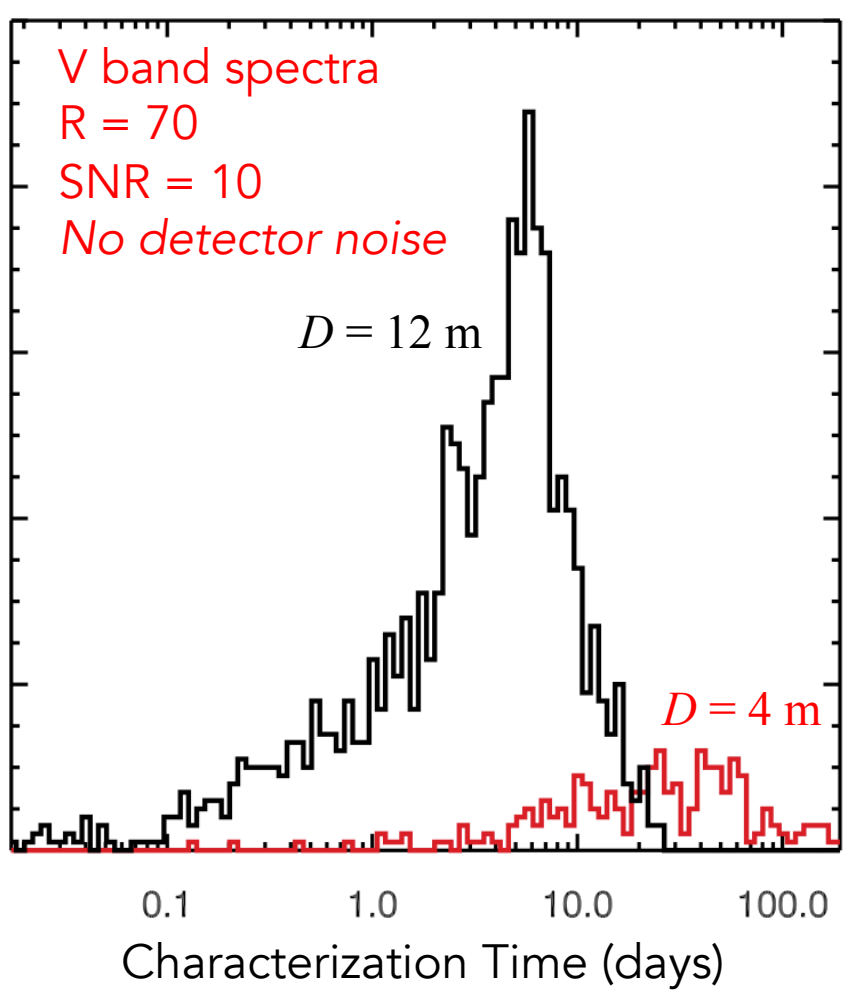


Amount of exozodiacal dust (× solar zodiacal amount)

We will only get what nature provides. Budget for uncertainty.

5. Larger Apertures Provide Shorter Integration Times (Even Though They Observe More Distant Stars)

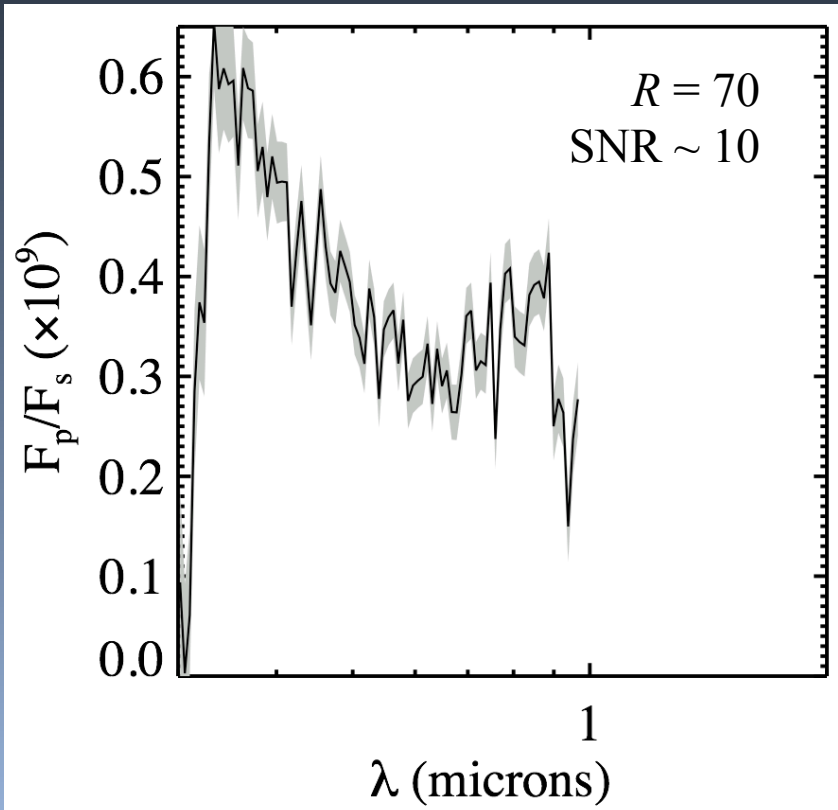




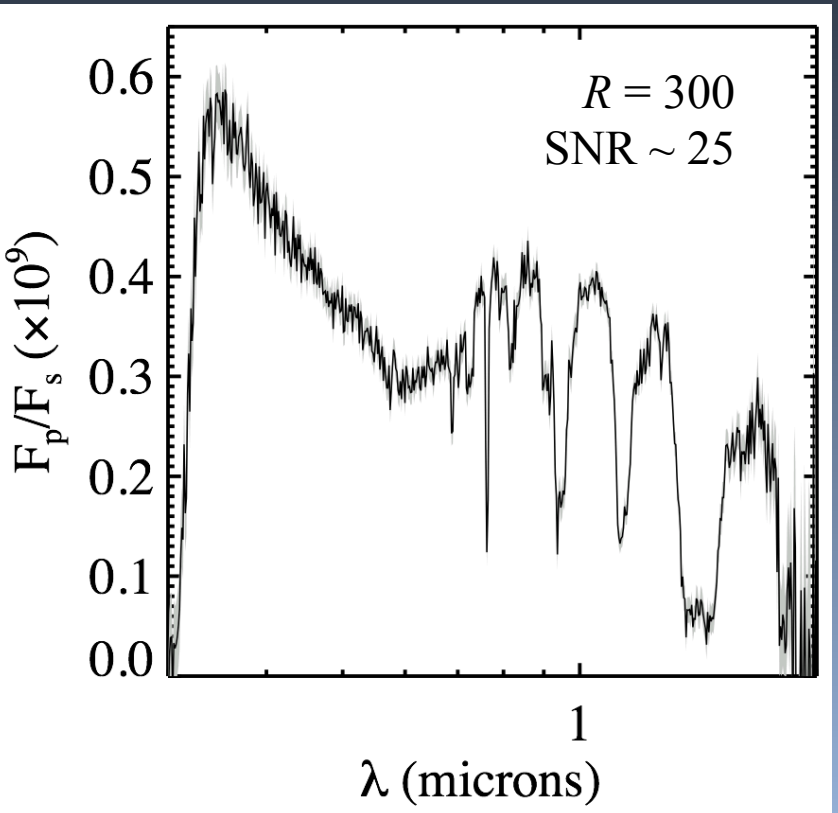
5. Larger Apertures Provide Shorter Integration Times Higher R & SNR is Possible

200 hr observations of Earth @ 10 pc

D = 4 m



D = 12 m



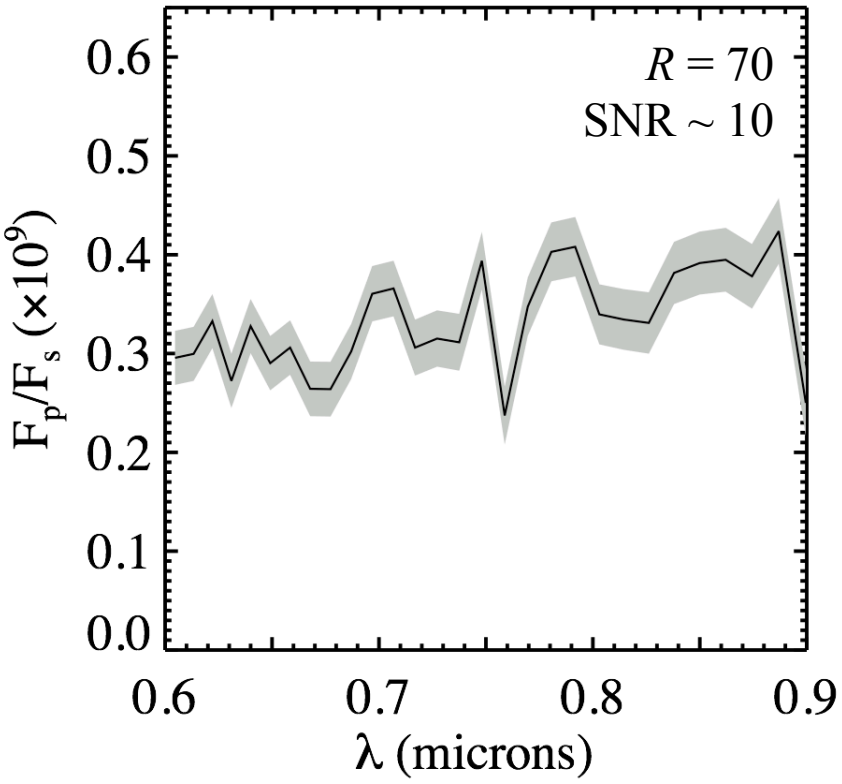
Tumlinson's Online Spectra Tool (Tumlinson, Robinson, Arney, et al)

In background-limited regime, characterization time of a given planet ~ D^{-4}; 12 m apertures can achieve R ~ **80 x** that of 4 m apertures in same exposure time.

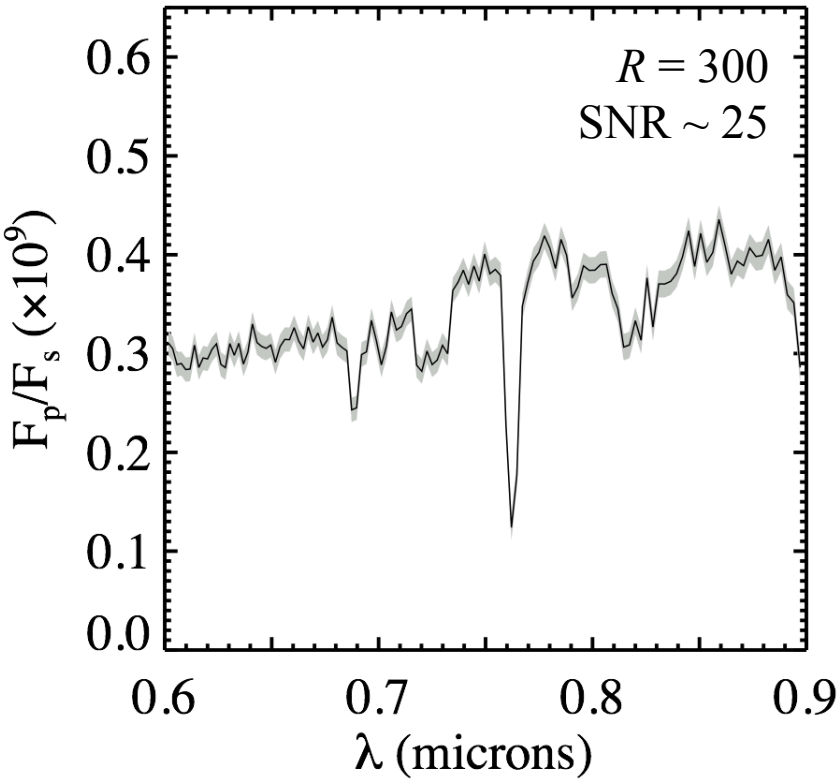
5. Larger Apertures Provide Shorter Integration Times Higher R & SNR is Possible

200 hr observations of Earth @ 10 pc

D = 4 m



D = 12 m

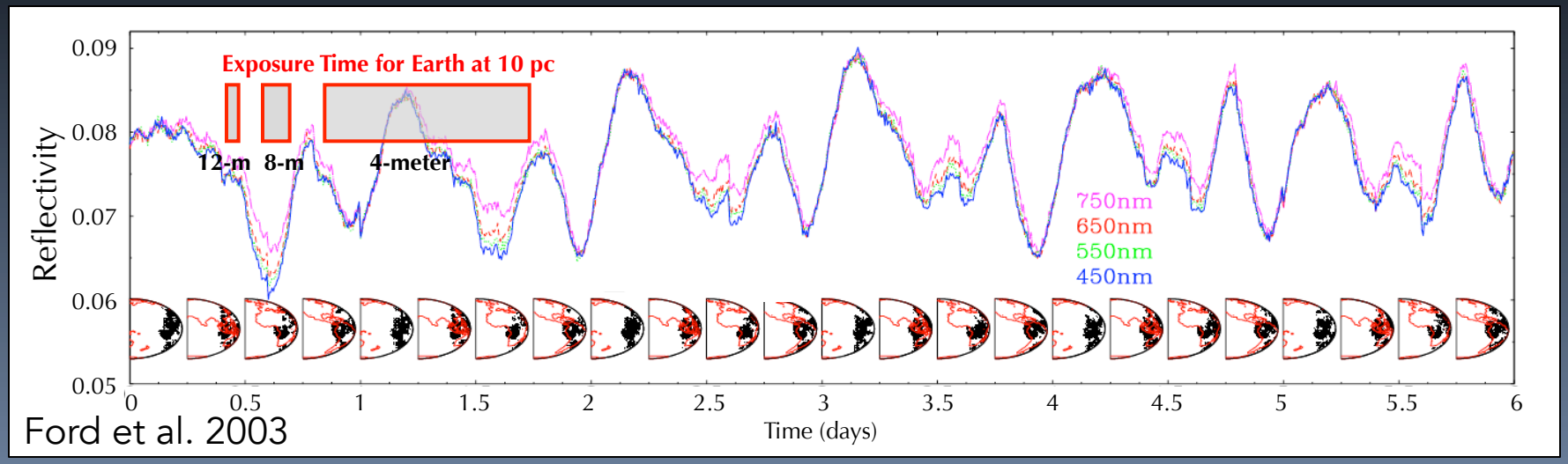


Tumlinson's Online Spectra Tool (Tumlinson, Robinson, Arney, et al)

Will the unresolved O_2 line on the left be sufficient for the most profound discovery NASA has ever made?

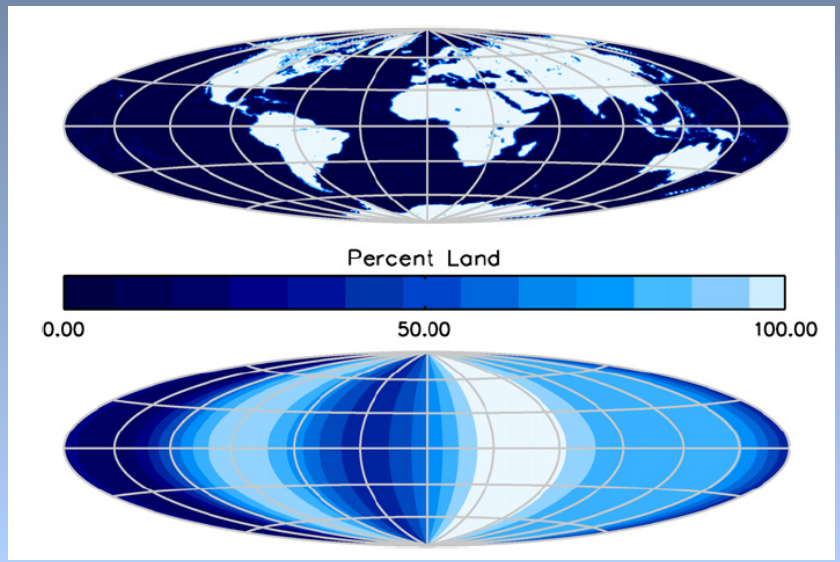
6. Enables New Kinds of Exoplanet Science

E.g., mapping planets, resolving circumplanetary material…

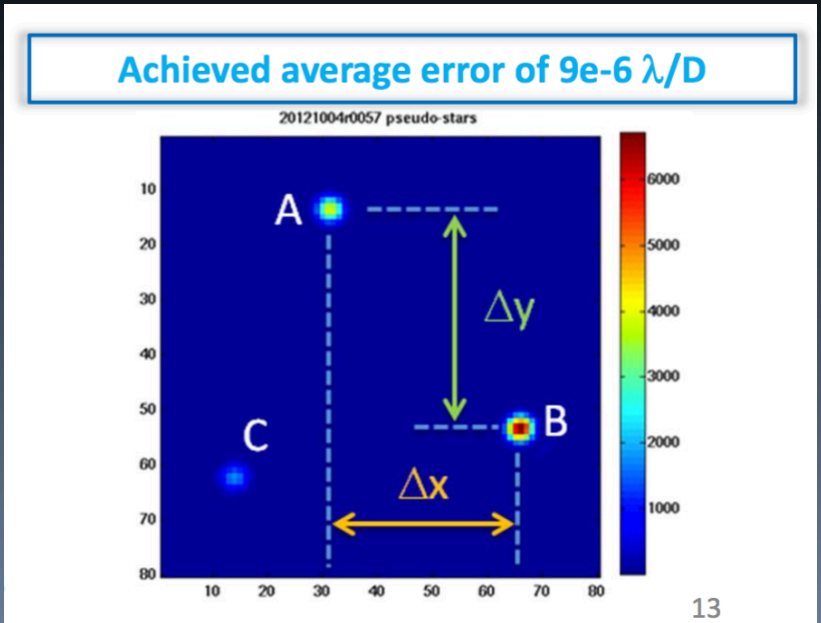


Require S/N~20 (5% photometry) to detect ~20% variations in reflectivity.

Reconstruction of Earth's land:sea ratio from disk-averaged time-resolved EPOXI observations.



7. Enable New Exoplanet Discovery Techniques



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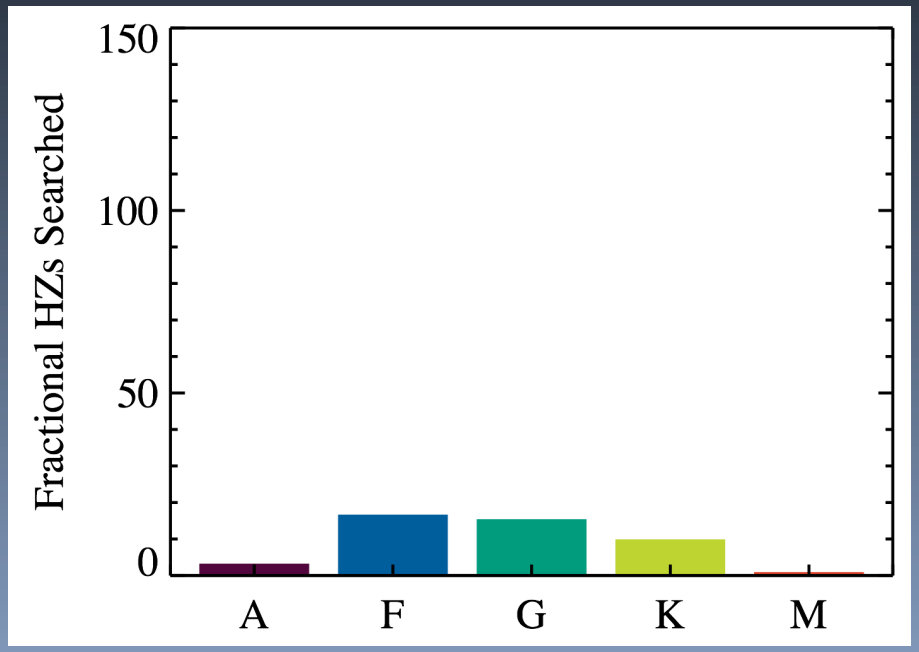
- How many Exo-Earths can be found?
  - How many hours of LUVOIR time (not including slew) would it take to survey the easiest (nearby) **100 stars** for an EXO-Earth (1 Mearth, 1 AU scaled to Star's luminosity)? **Answer 150 hrs**
  - We sorted the Hipparcos catalog for all FGK stars < 30pc. (double stars where a HZ orbit was not stable were removed) We found 384 stars. It would take **~1500 hrs** or LUVOIR integration time to search all of them.

M. Shao (presentation to LUVOIR HDI Team)

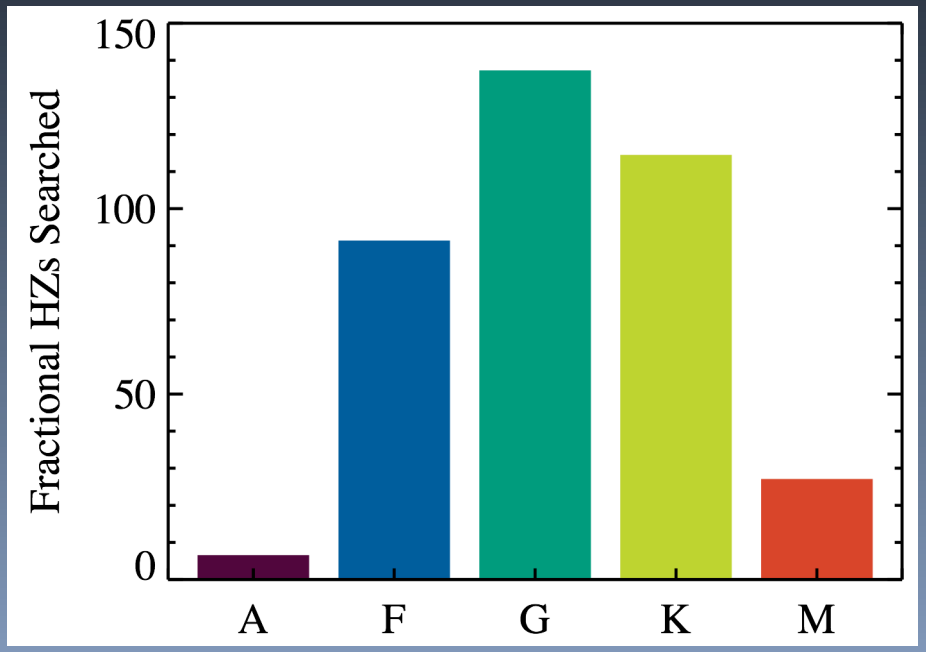
Astrometry of ExoEarths may be possible in fraction of time it would take to directly image

8. Greater Diversity of Exoplanet Host Stars

$D = 4$ m



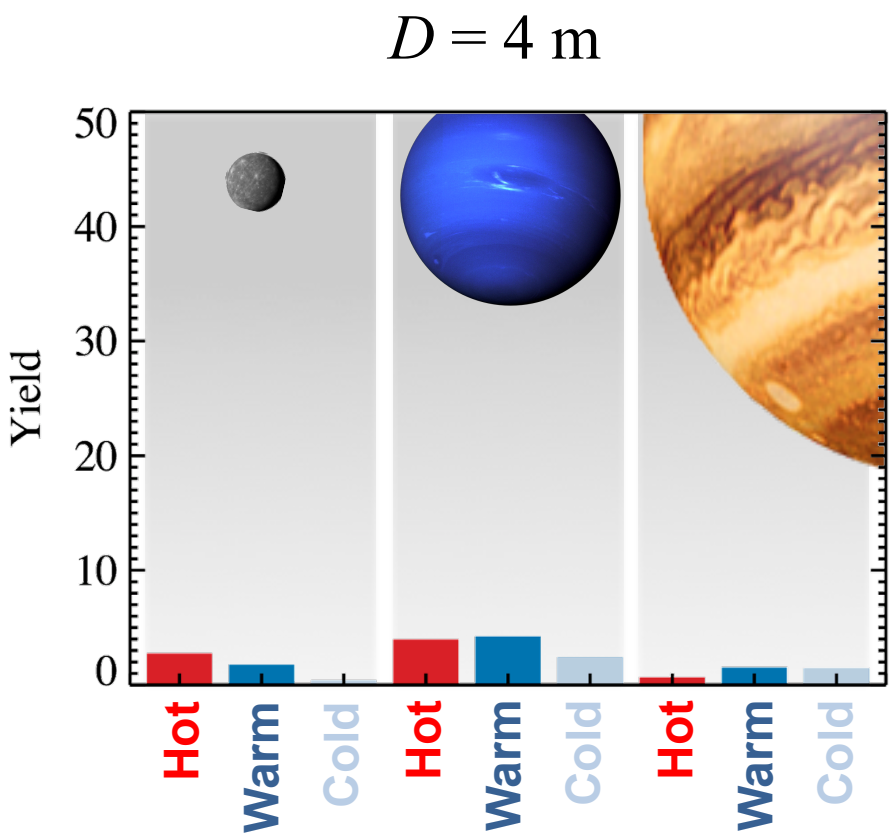
$D = 12$ m

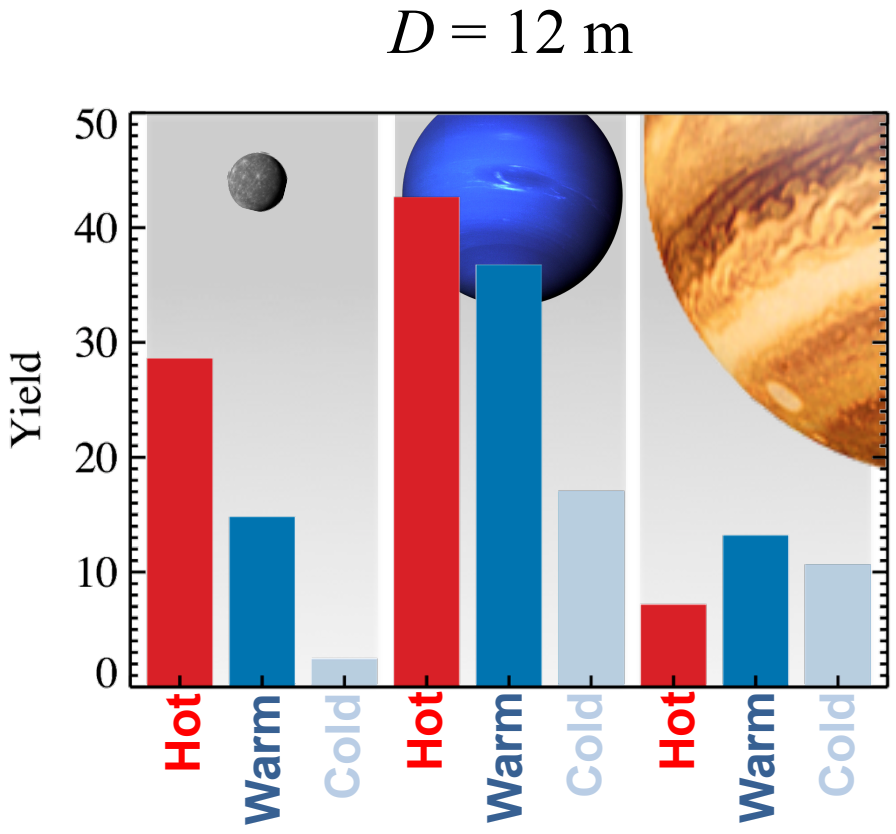


Smaller apertures skewed toward earlier stellar types. Little overlap with ground.

9. Greater Diversity of Exoplanets

Blind Planet Search Yields When Optimizing for Earths

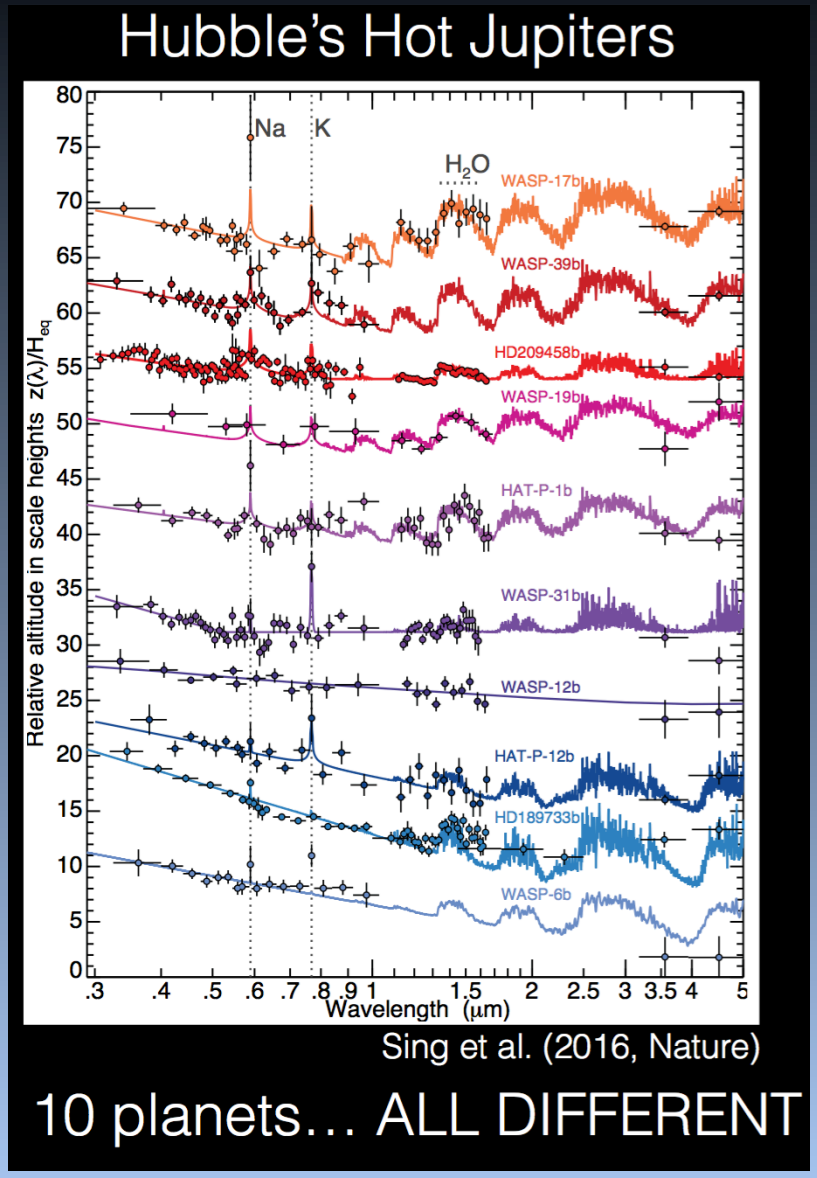




Kopparapu et al. (in prep)
Yields adopt Kopparapu's occurrence rates

Smaller apertures may not discover many Jupiters!

10. Sample Size!



Even with UVOIR spectra measured for 10 Hot Jupiters:

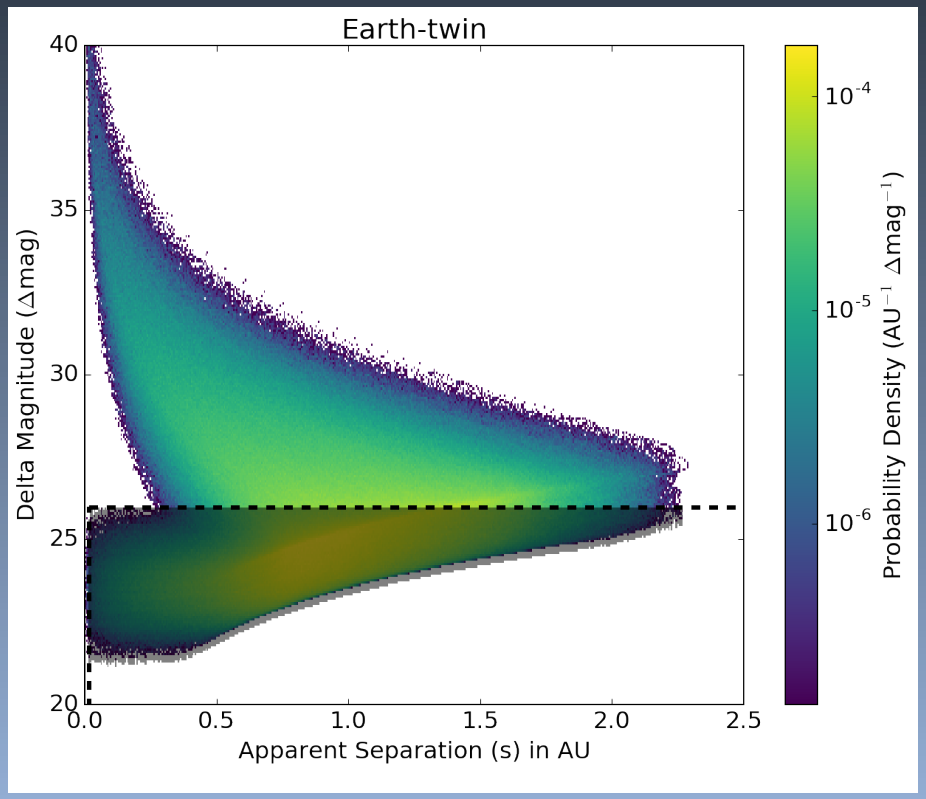
"The atmospheric chemistry of cloud/haze formation and atmospheric mass-loss are a major outstanding issues in the field of exoplanets, and we seek to make progress gaining insight into their underlying physical process through comparative studies."

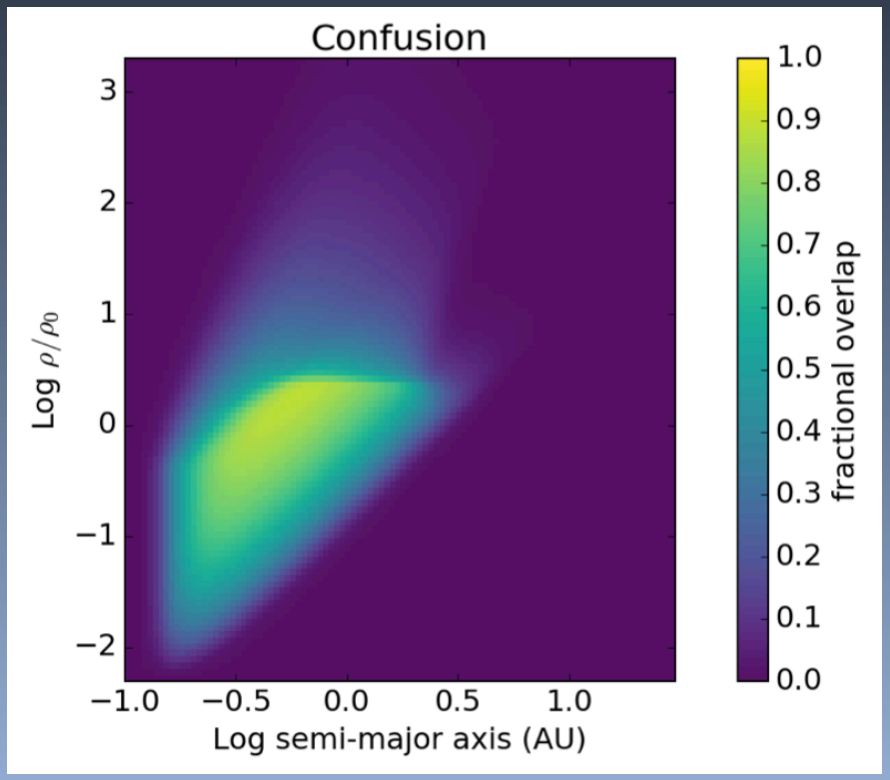
- Sing et al
HST GO Proposal 14767
Awarded 498 HST orbits

Astronomy is an observational science. Sample size is critical.

Planet-Planet Confusion: Overlapping Bird Diagrams

Van Gorkom & Stark (in prep)

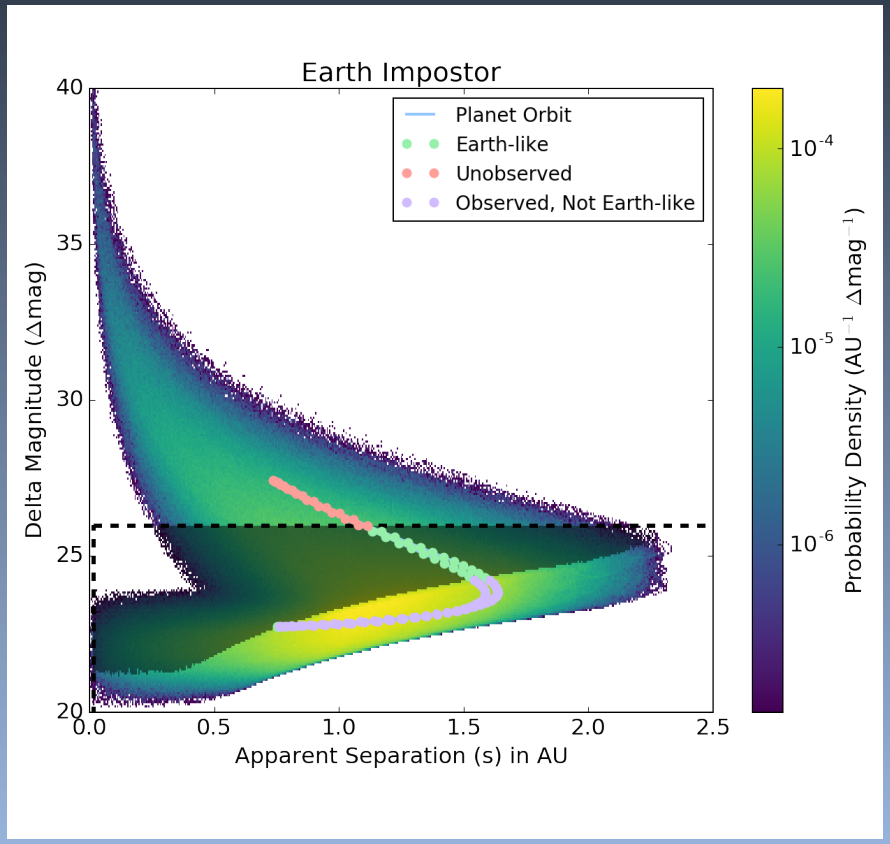


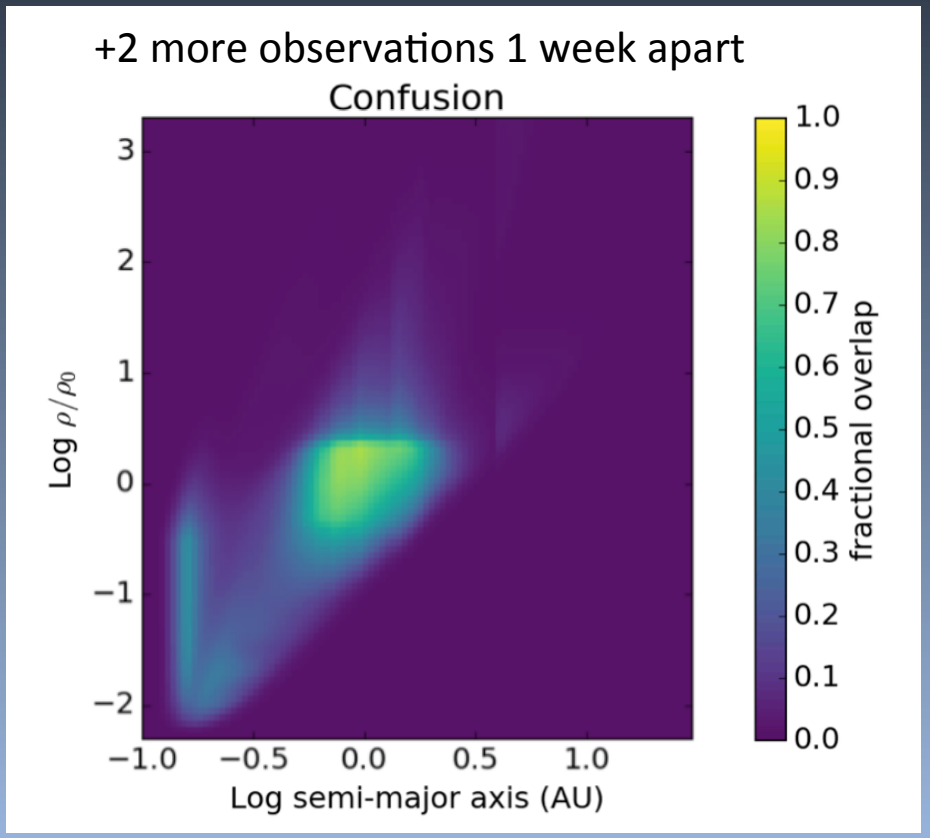


The likelihood of mistaking a Jupiter for an Earth is very low.
We will be confused by smaller planets on smaller orbits.

Planet-Planet Confusion
How to Clarify Without Taking Spectra

Van Gorkom & Stark (in prep)





Multi-epoch imaging can help clarify, but we will always have an albedo-radius degeneracy.

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