

# IMPACT OF EXOZODI ON EARTH-LIKE PLANET IMAGING TELESCOPES

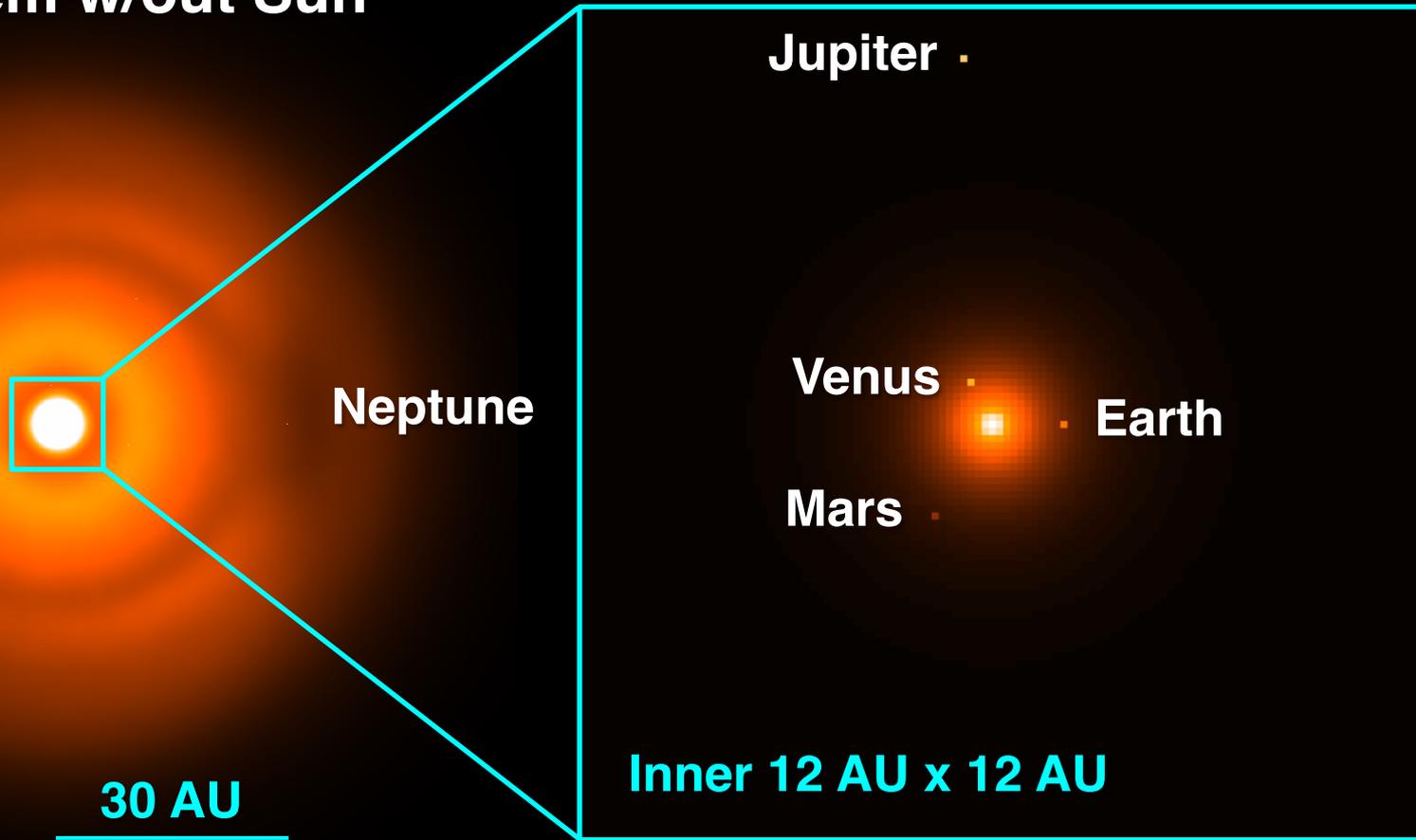
**Aki Roberge (NASA GSFC)**

**Chris Stark (STScI)**

# The exozodi problem

## Solar System w/out Sun

$\lambda = 0.55 \mu\text{m}$



*Credit: A. Roberge & the Haystacks team*

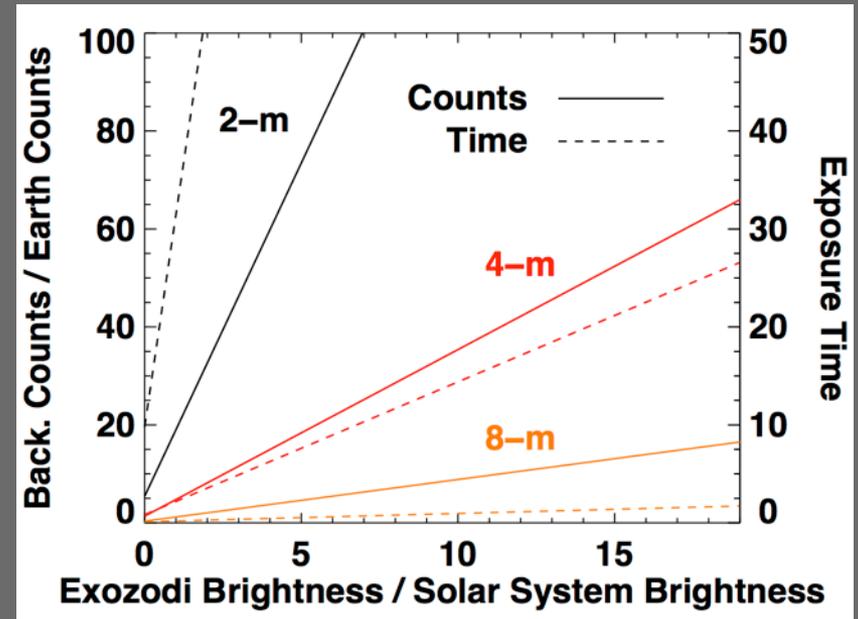
# Old view of the problem

1. Background linearly increases imaging & spectroscopy **exposure times**

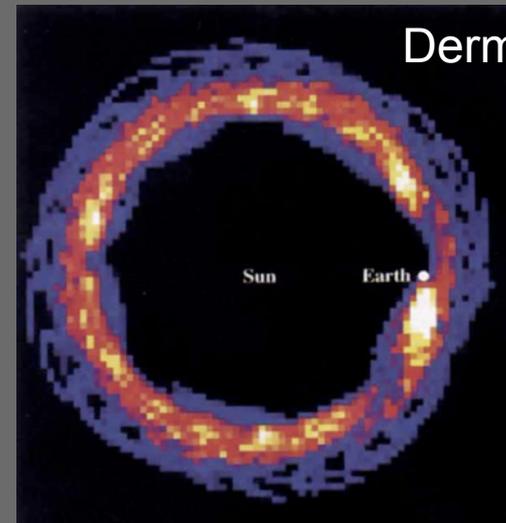
- In background-limited case,  $t_{\text{exp}} \propto D^{-4}$

2. Dust structures (produced by exoplanets) can cause **confusion**

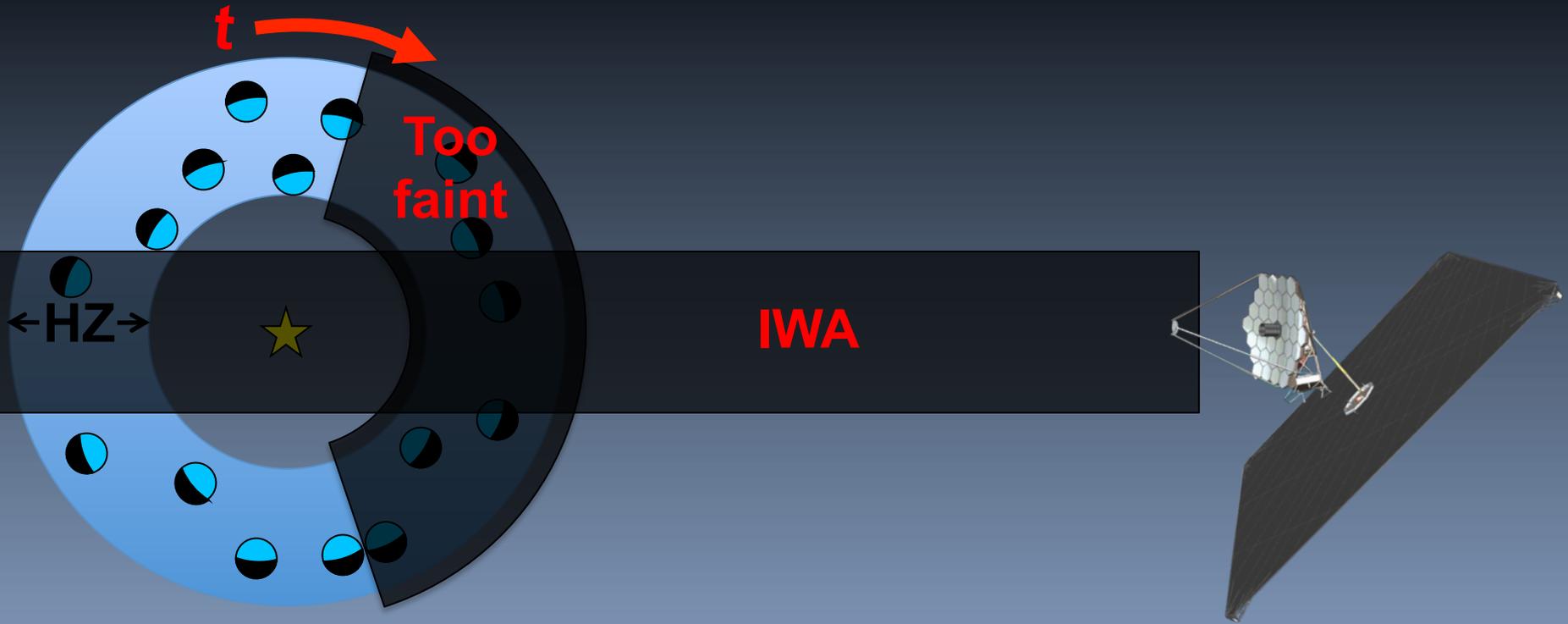
Roberge et al. (2012)



Dermott et al. (1994)



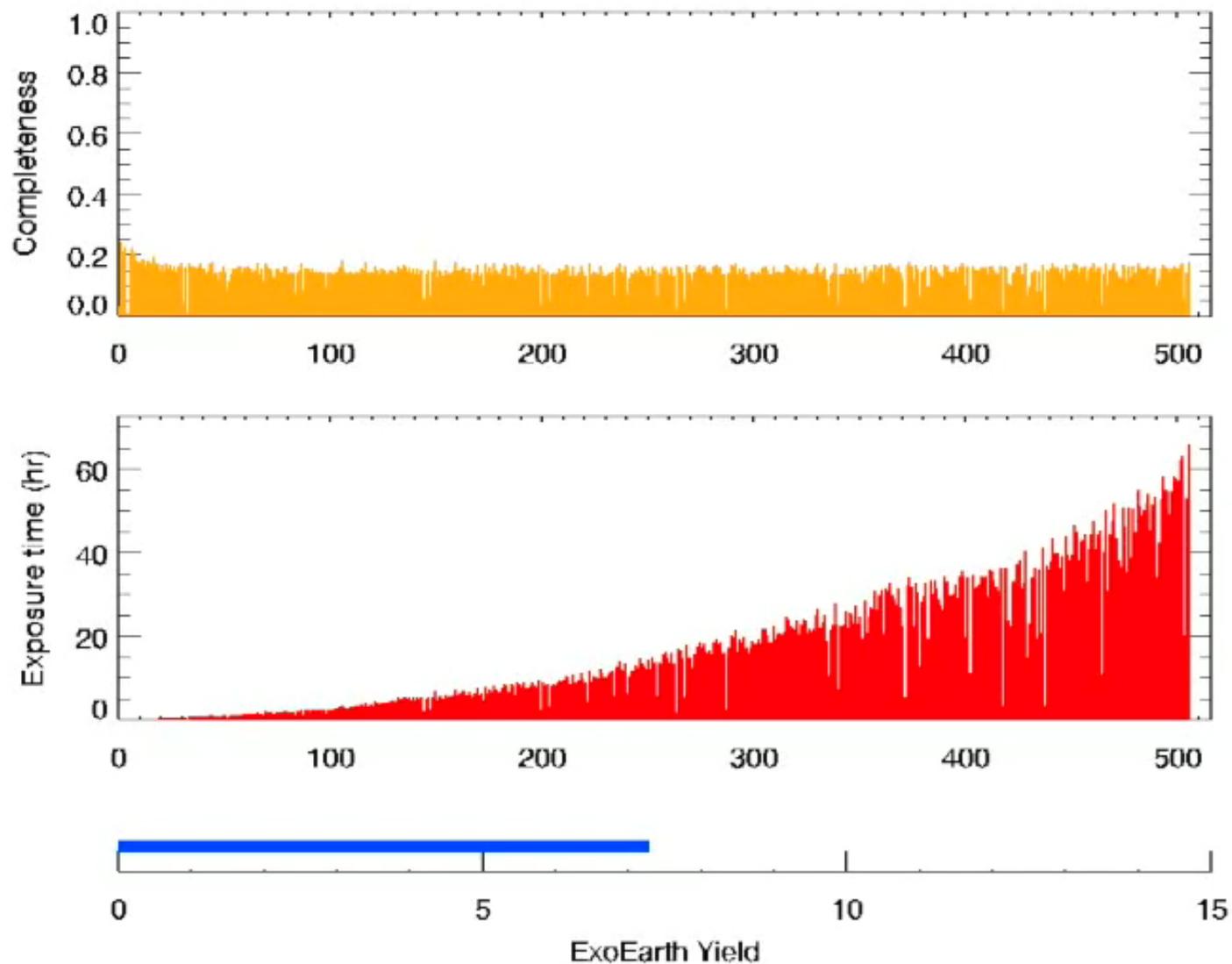
# New exoEarth yield estimations



- Completeness,  $C_i$  = the chance of observing a given planet around a given star if that planet exists (Brown 2004)
- Yield =  $\eta_{\text{Earth}} \sum C_i$
- Calculated via a Monte Carlo simulation with synthetic planets
- Can revisit same star multiple times to increase total completeness

# Altruistic yield optimization (AYO)

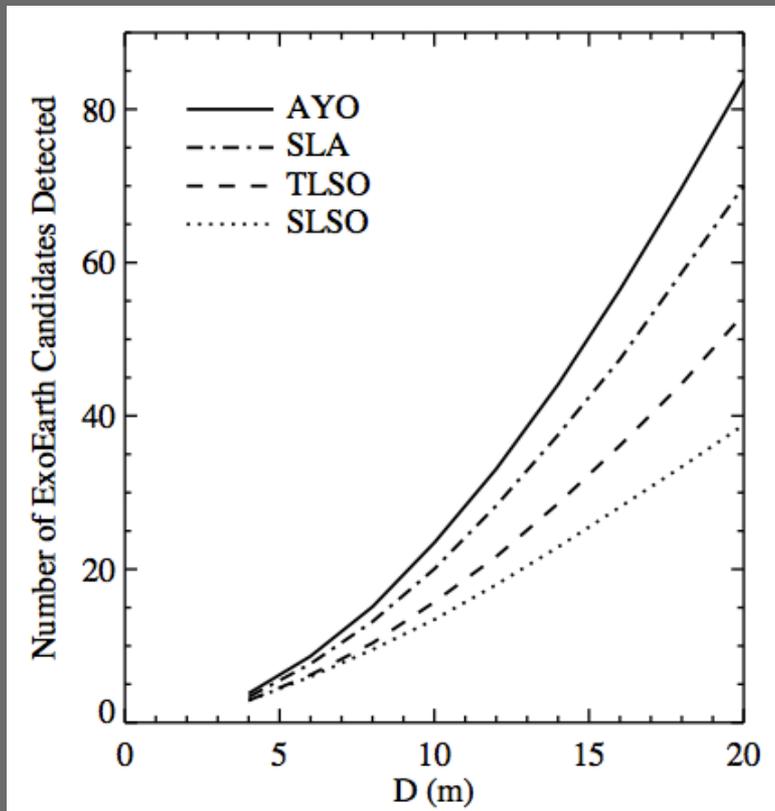
Credit: C. Stark



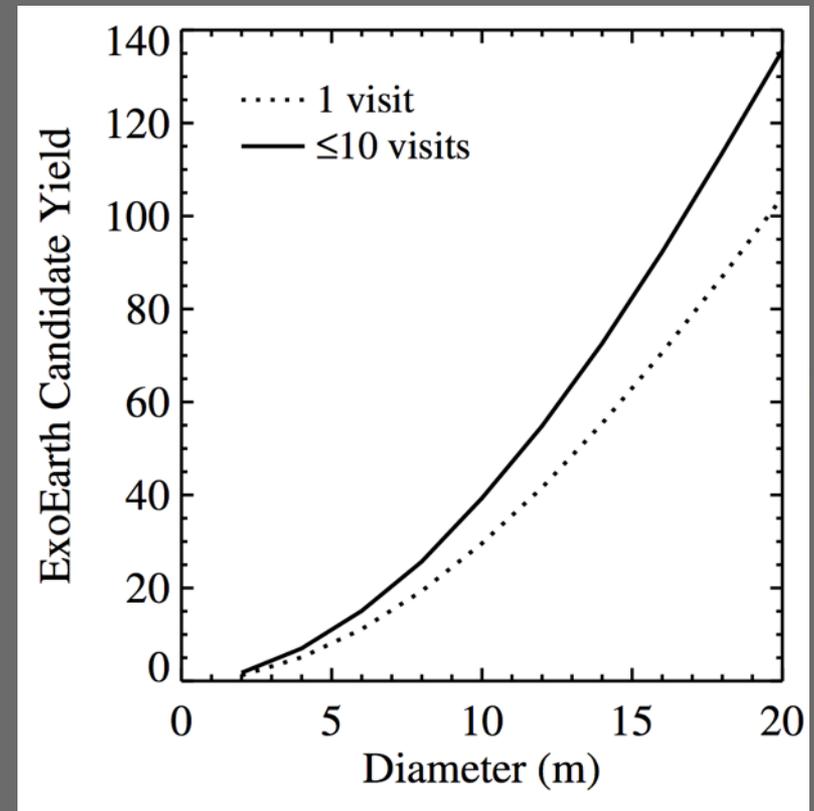
# Maximizing yield by optimizing observations

Optimizing **exposure times** can potentially double yield

Optimizing **revisits** can increase yield by additional 35 – 75%



Stark et al. (2014)

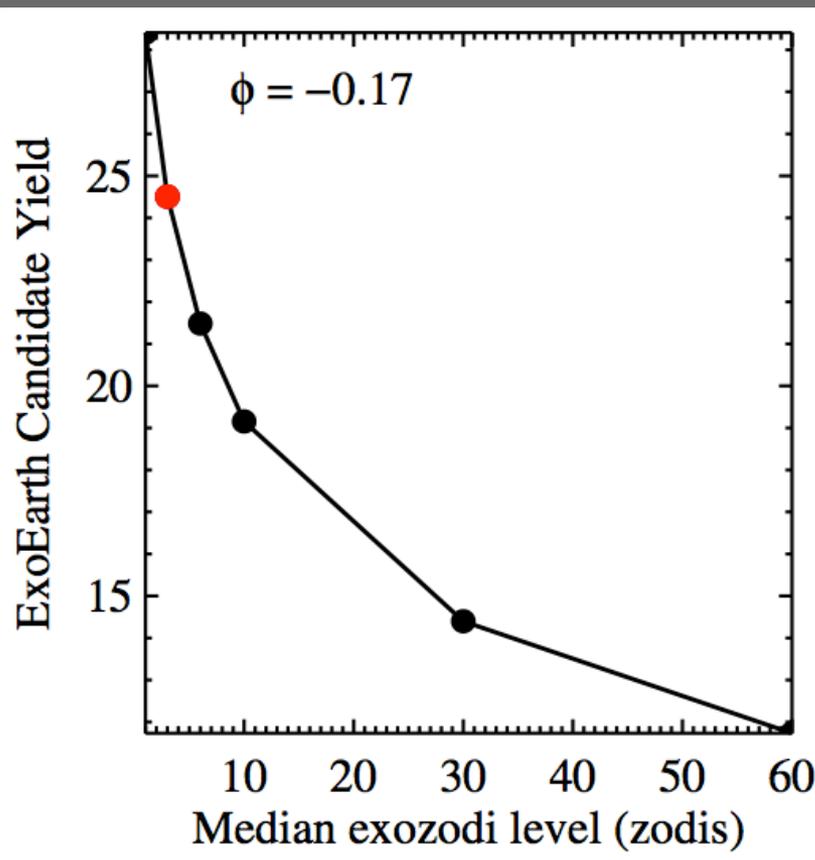


Stark et al. (2015)

# Sensitivity of yield to exozodi

## What is “one zodi”?

- Different things to different people (Roberge et al. 2012)
- Here, 1 zodi = 22 mag/arcsec<sup>2</sup> at V band



$$\phi_x = \frac{\% \text{ change in yield}}{\% \text{ change in parameter } x}$$

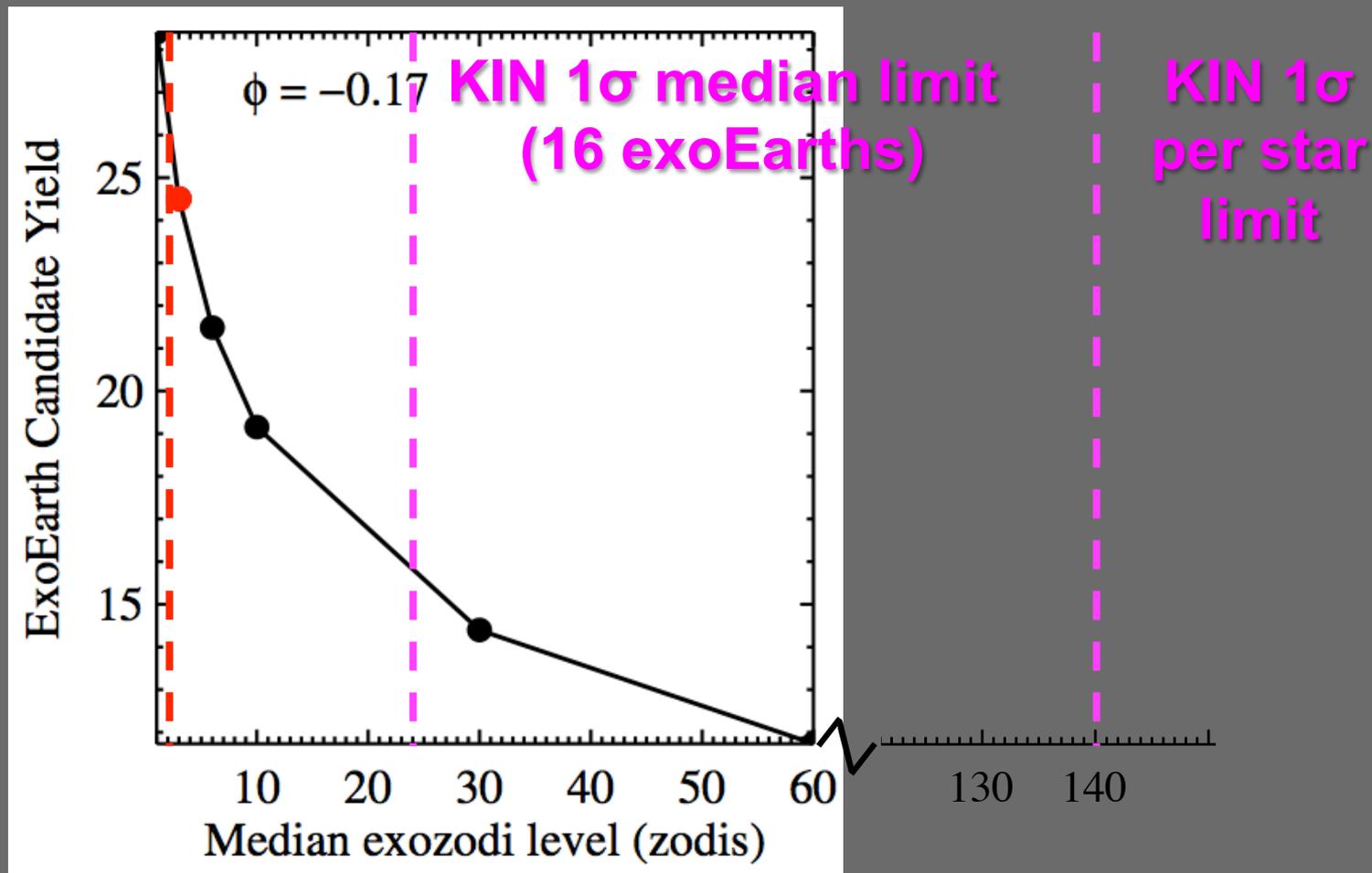
Weak function of exozodi  
(reduce exozodi by 10x,  
increase yield by ~ 2x)

# Reasons for weak dependence on exozodi

- ◎ AYO code partially compensates for increased individual exposure times
  1. Preferentially eliminates poor targets
    - Distant stars with lower completeness and longer times
  2. Adjusts exposure times to observe some stars more shallowly
    - Avoids wasting time searching for dimmest planets (doesn't push as far into crescent phase)

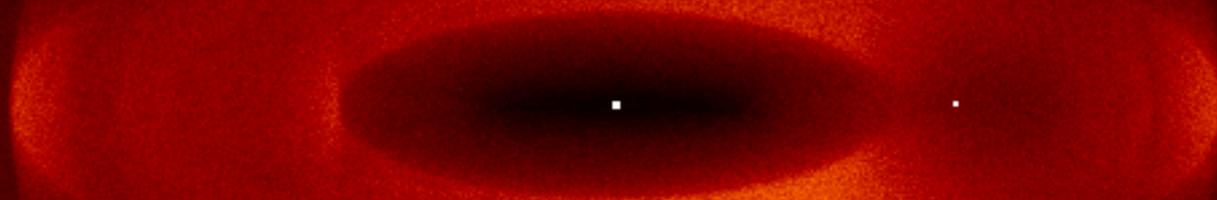
# So why does exozodi still matter? Big room for improvement in knowledge

**Current LBTI  $1\sigma$  median limit (27 exoEarths)**



# What about confusion?

Optical depth movie



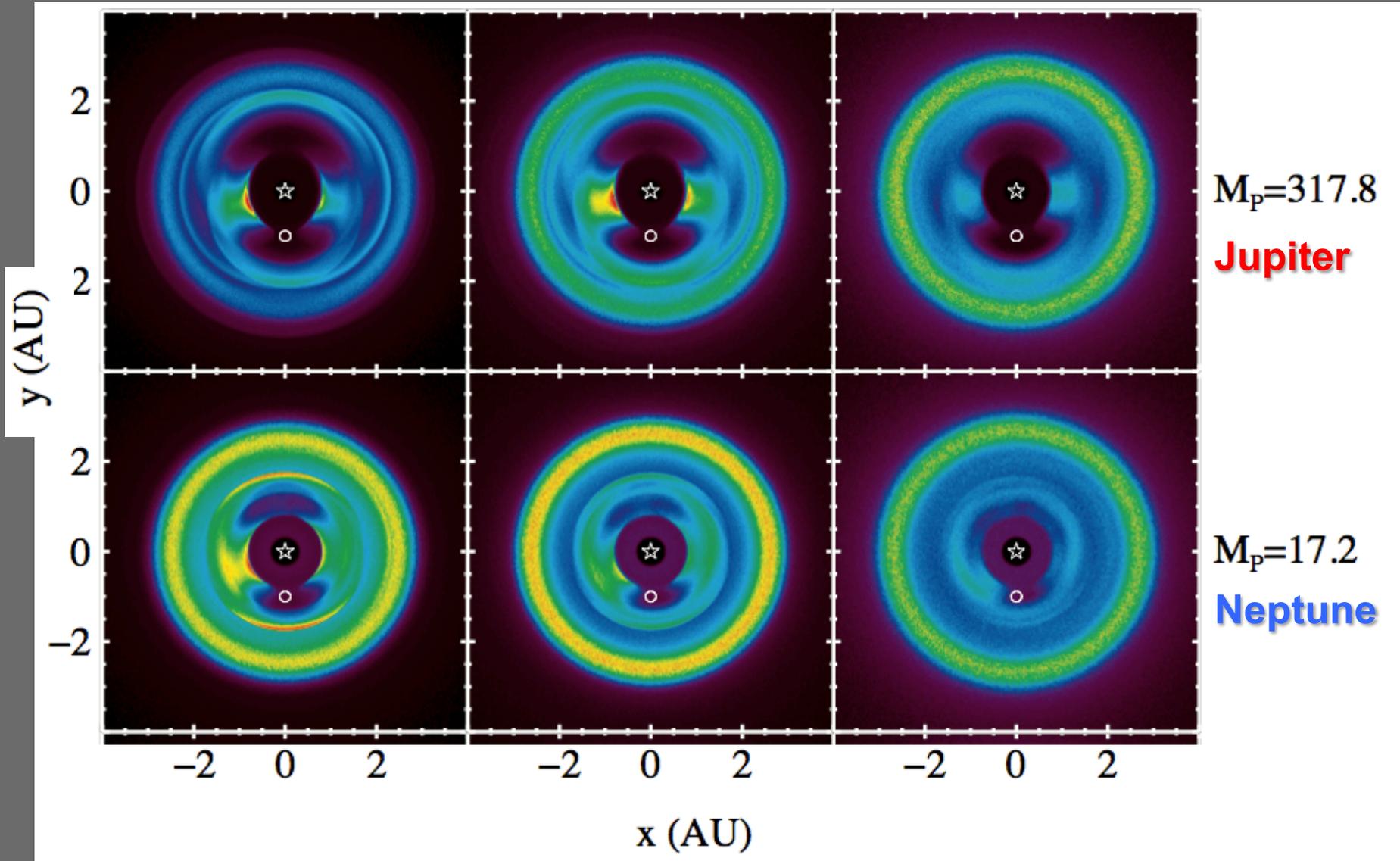
Credit: C. Stark

# Worst case scenarios for exozodi structure

1 zodi

10 zodis

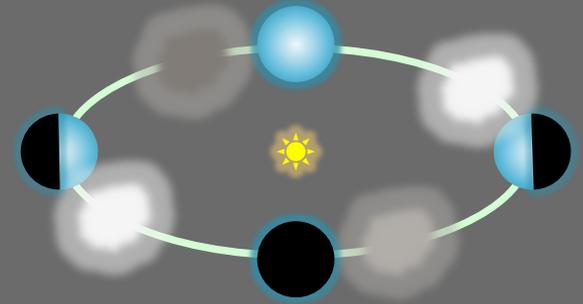
100 zodis



# Confusion mitigation strategies

- Phase curve of a dust clump different from that of a planet

- Possibly effective, observationally costly



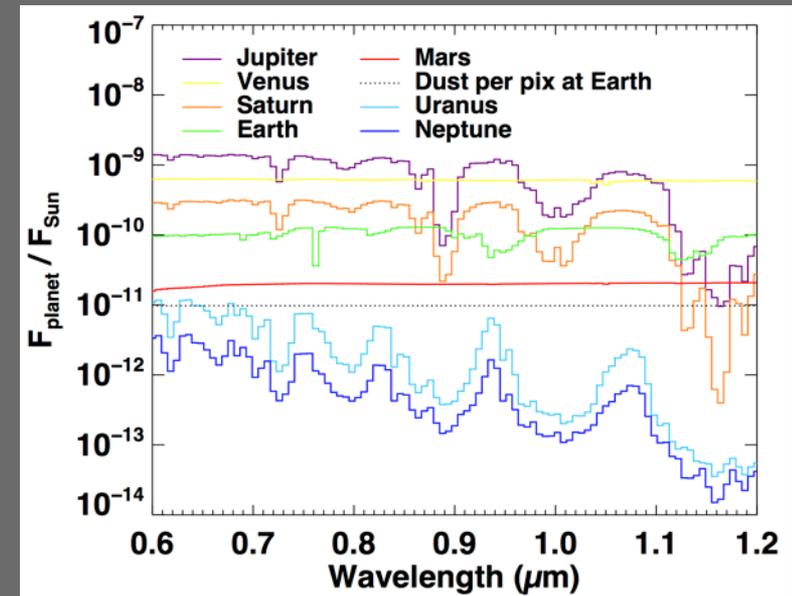
- Spectroscopy

- Planet with atmosphere has absorption lines, dust clumps don't

- Likely effective but costly

- Color

- Uncertain effectiveness, observationally inexpensive



A. Roberge

# Summary

- ⦿ Exozodi can have weaker effect on exoplanet yield than previously thought
- ⦿ But much room for improvement in exozodi knowledge
- ⦿ Impact of confusion uncertain
  - Need detailed study of observational strategies