# Scheduling and Target Selection Optimization for Exoplanet Imaging Spacecraft

Dean Keithly[1,3], Daniel Garrett[1], Christian Delacroix[2], Dmitry Savransky[1,3]

[1]Sibley School of Mechanical and Aerospace Engineering, Cornell University, Ithaca NY, United States
[2]Princeton University, Princeton NJ, United States
[3]Carl Sagan Institute, Cornell University, Ithaca NY, United States

WFIRST — WIDE-FIELD INFRARED SURVEY TELESCOPE
ASTROPHYSICS • DARK ENERGY • EXOPLANETS

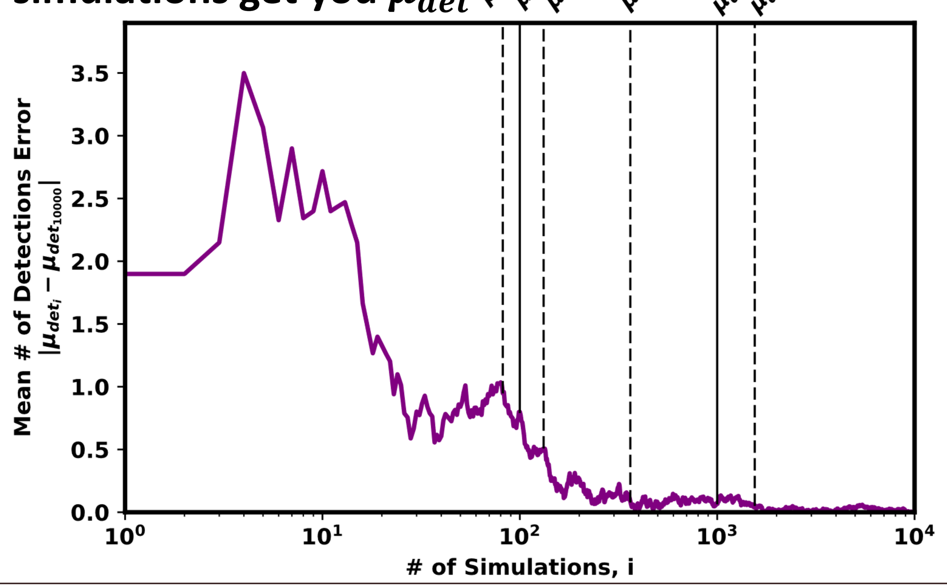
## Objectives

Analyze the projected performance of the Sequential Least-Squares Quadratic Programming (SLSQP) scheduling of the WFIRST coronagraph. Compare how variations in: **planet population priors, mission length, overhead time, observing blocks, and observation selection metrics** effect projected exoplanet detection yield.

## Methods & Convergence

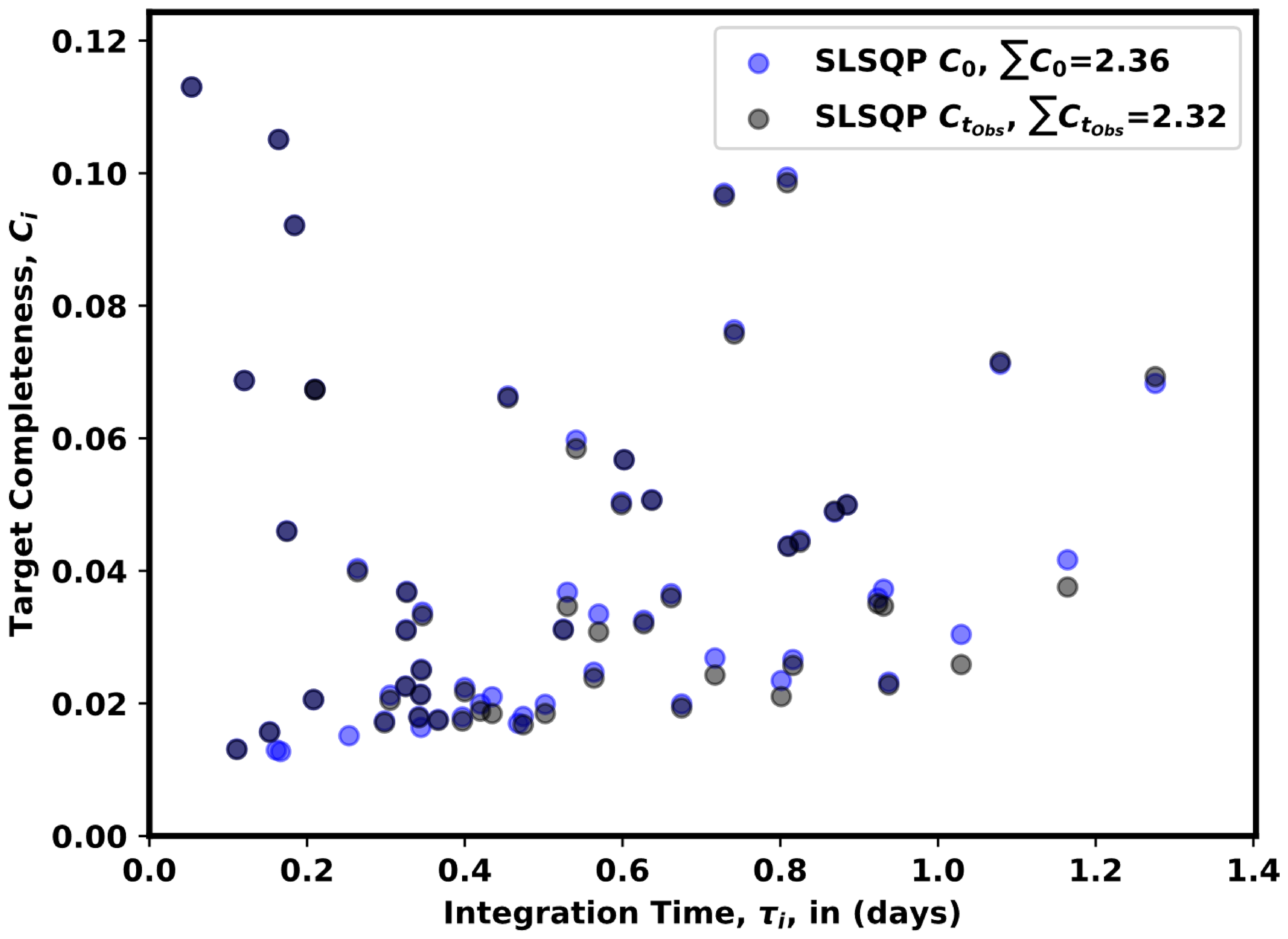
- ran >100,000 survey simulations of the **WFIRST CGI** over differing planet populations, target selection metrics, and temporal parameters
- Each run type was executed **1,000** times. We ran a sim. for 10,000 iterations to verify convergence.

**Takeaways: 100 simulations gets you $\hat{\mu}_{det}$, 1000 simulations get you $\mu_{det}$**




## $C_0$ vs $C_{t_{observed}}$

How does the initially optimized completeness $C_0$ compare to C at the time of observation for the 3 month mission?



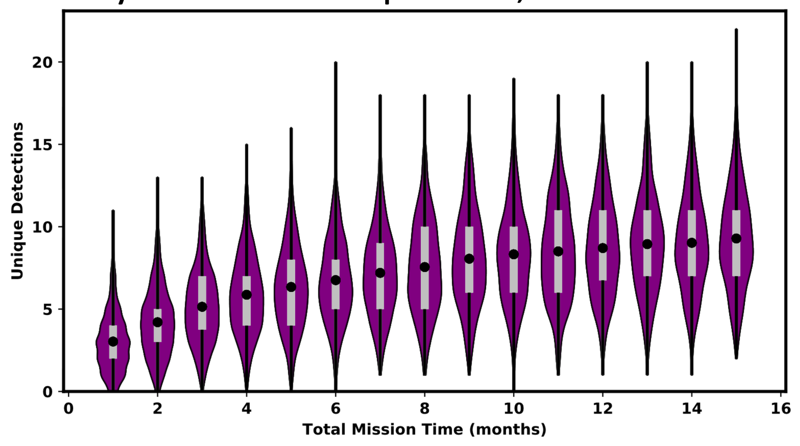

**Takeaway:** $\sum C_0 \approx \sum C_{t_{observed}}$
**Aside:** Longer mission $\sum C$ decrease by 5-10%

## Mission Length & Overhead Time

**Takeaway:** A continuous 3mo mission yields ~5.1 exoplanets, 12 months produce ~8.7 exoplanets

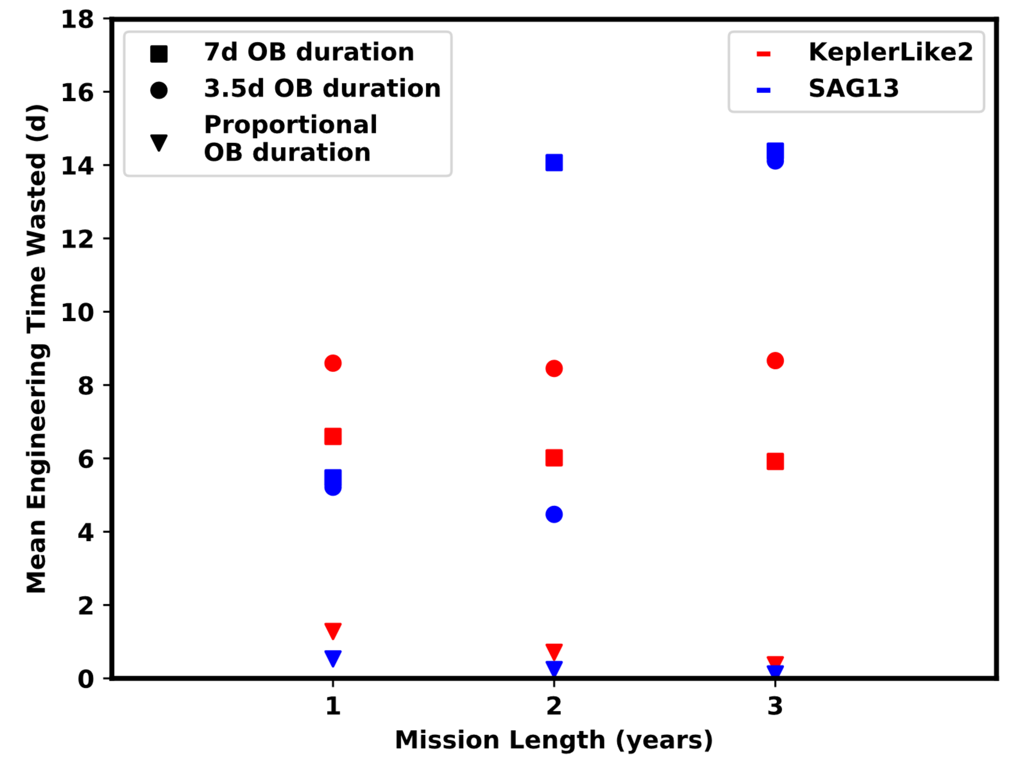
**Takeaway:** A 3mo mission has a 99.6% chance of yielding at least 1 detection

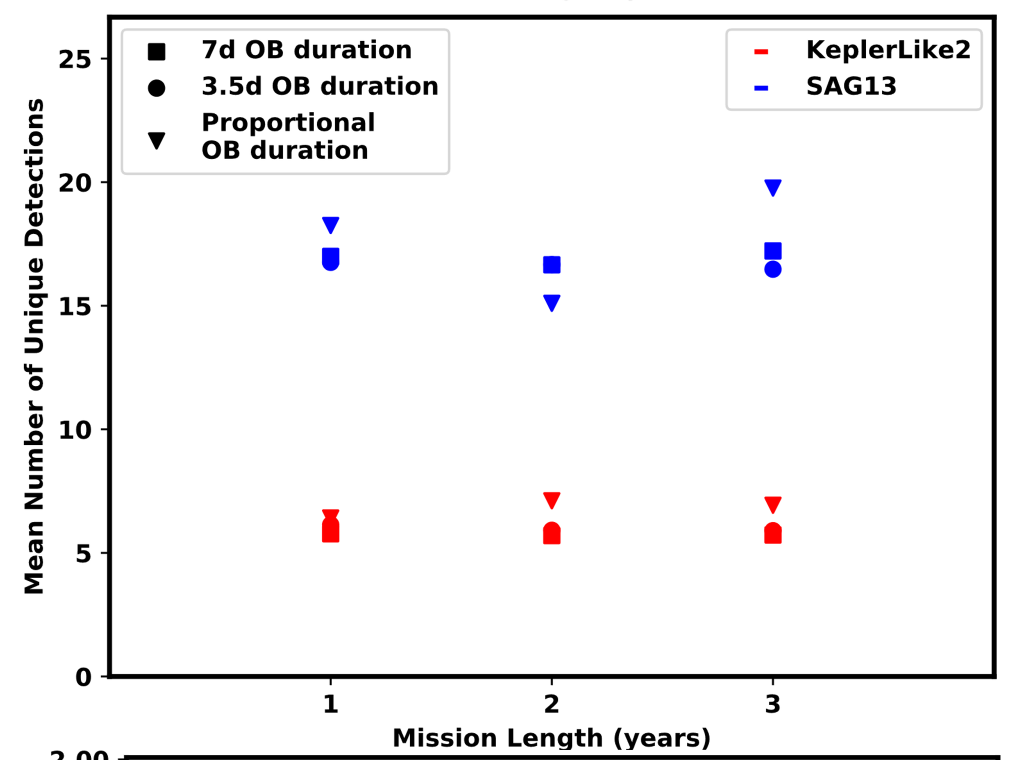
**Takeaway:** Variations in the overhead time have a negligible impact on yield for a 1 year mission

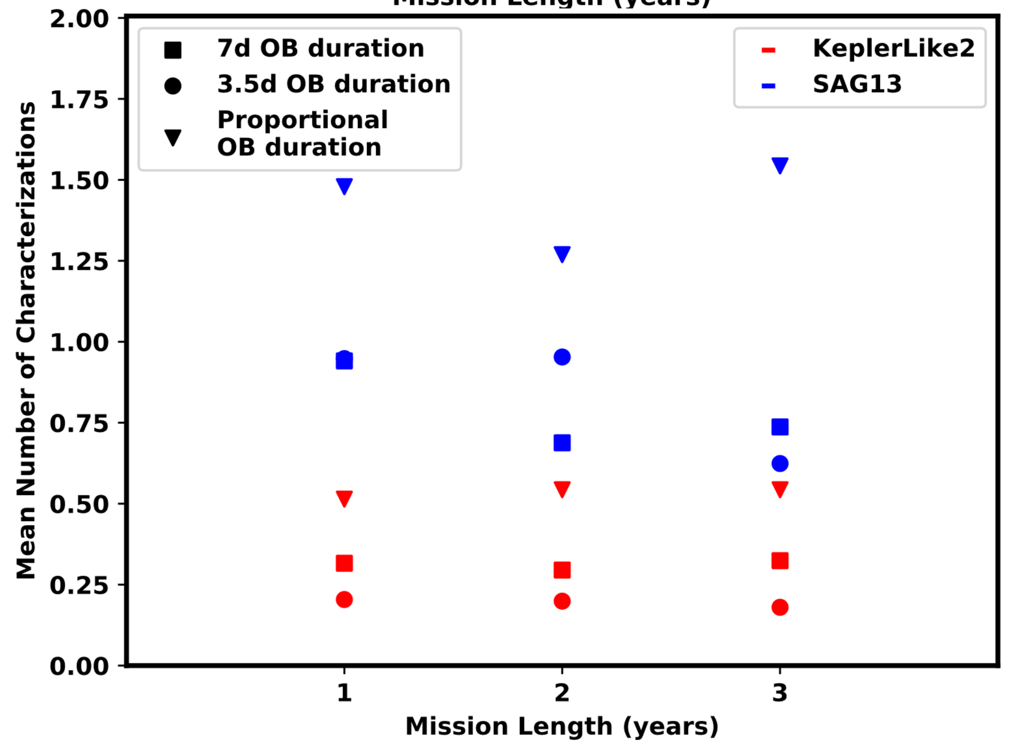



## Observing Blocks

How should Observing Blocks be spaced for coronagraph observations in a 3mo (91.3125d) mission?



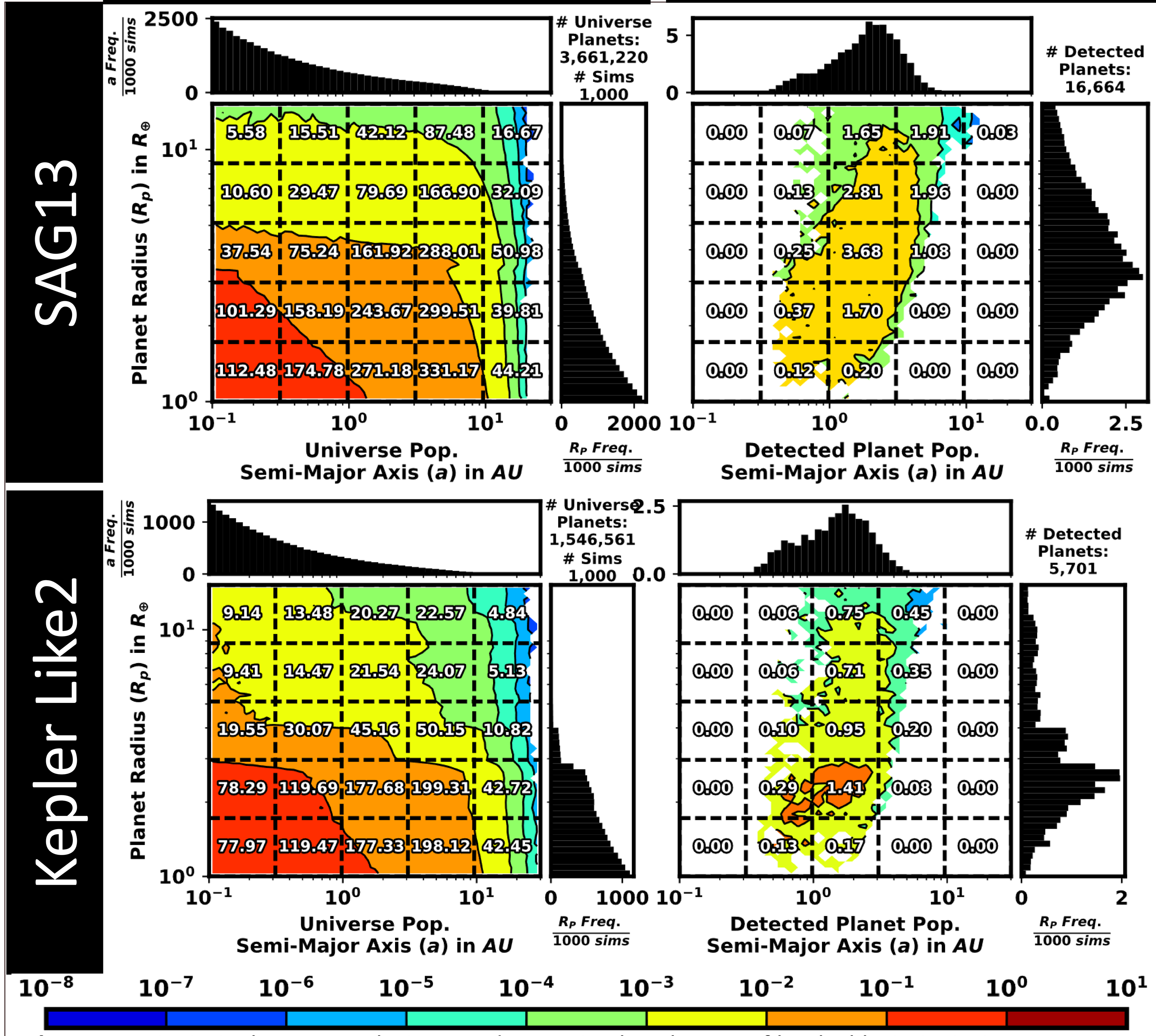




**Takeaway:** Dynamic scheduling (proportional observing block duration) wastes strictly less observation time, generally yields more unique detections, and produces strictly more characterizations.

## Universe Distributions

## Detected Planet Distributions




**Takeaways:** SAG13 planet population produces >2x the planets of keplerlike2, SAG13 generates larger planets than KeplerLike2, SAG13 produces 3x the detections of Keplerlike2

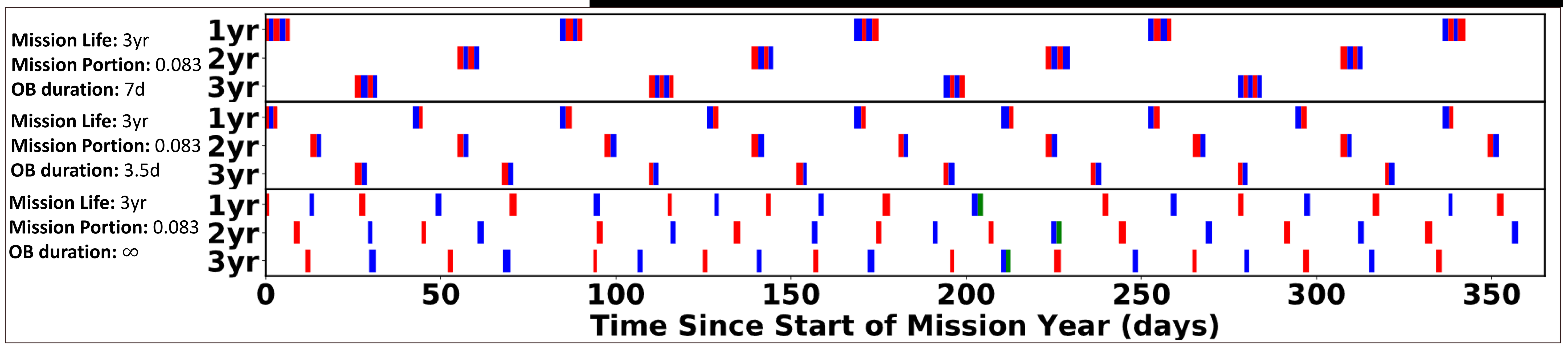
## Overfitting

Completeness is based off an assumed planet population. How does the SLSQP Scheduler perform if optimized for SAG13 but the actual planet population is KeplerLike2?

| Unique Detection Yield/sim. | | Completeness Based On: SAG13 | Completeness Based On: KeplerLike2 |
|---|---|---|---|
| Actual Planet Pop. | SAG13 | 16.664 | 16.758 |
| | KeplerLike2 | 4.901 | 5.701 |

**Takeaway:** Optimizing using completeness based on KeplerLike2 produces strictly more unique detections (although 0.1 detections is within error)

## Observation Schedules




## Acknowledgements & References

Research funded under the NASA Space Grant Graduate Fellowship from the New York Space Grant Consortium, NASA Grant Nos. NNX14AD99G (GSFC), NNX15AJ67G (WPS) and NNG16PJ24C (Science Investigation Team)

[1] C. Stark, A. Roberge, A. Mandell, T. Robinson, *Maximizing the ExoEarth Candidate Yield from a Future Direct Imaging Mission*, ApJ, 2014
[2] D. Savransky, C. Delacroix, D. Garrett, *Multi-Mission Modeling for Space-Based Exoplanet Imagers*, SPIE, 2017
[3] D. Garrett, D. Savransky, *Analytical Formulation of the Single-visit Completeness Joint Probability Density Function*, ApJ, 2016
[4] B. Nemati, *Detector Selection for the WFIRST-AFTA Coronagraph Integral Field Spectrograph*, SPIE 2014

Dean Keithly
drk94@cornell.edu

EXOSIMS

SIOS LABORATORY