

WFIRST Coronagraphic Instrument Science Yield Modeling

Dmitry Savransky^{1,2}, Daniel Garrett¹, Christian Delacroix^{1,2}



Cornell University



March 3, 2016



- 1 Describe the **range** of potential science yields of the WFIRST coronagraph and determine:
 - What is the optimal proportion of coronagraph time that should be devoted to searching for new planets versus attempting to image known exoplanets?
 - What are the best targets and optimal observation times for potential new detections and followup observations?
 - What are the permissible false positive rates as a function of angular separation and how does this affect the required integration time for each target?
- 2 Develop and release an open source toolkit for the modeling of space-based planet finders



- Build models of the instrument and observatory
- Build models of the exoplanet population
- Generate simulations of entire missions
 - Each simulation draws a random sample of planets from a single population and populates exosystems about a fixed target list (but not all stars will necessarily be observed in any one simulation)
 - The output of each simulation is an ordered list of observations and simulated outcomes
- Generate ensembles of simulations and mine them for statistics on mission yield

Create a software architecture where every model component can be independently upgraded

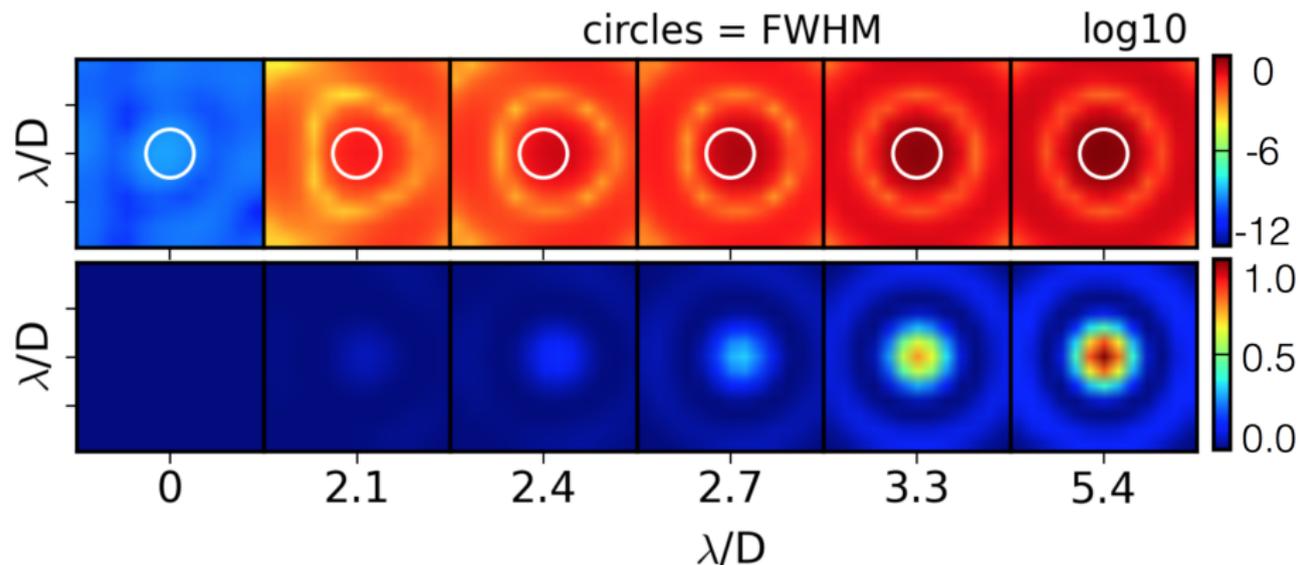
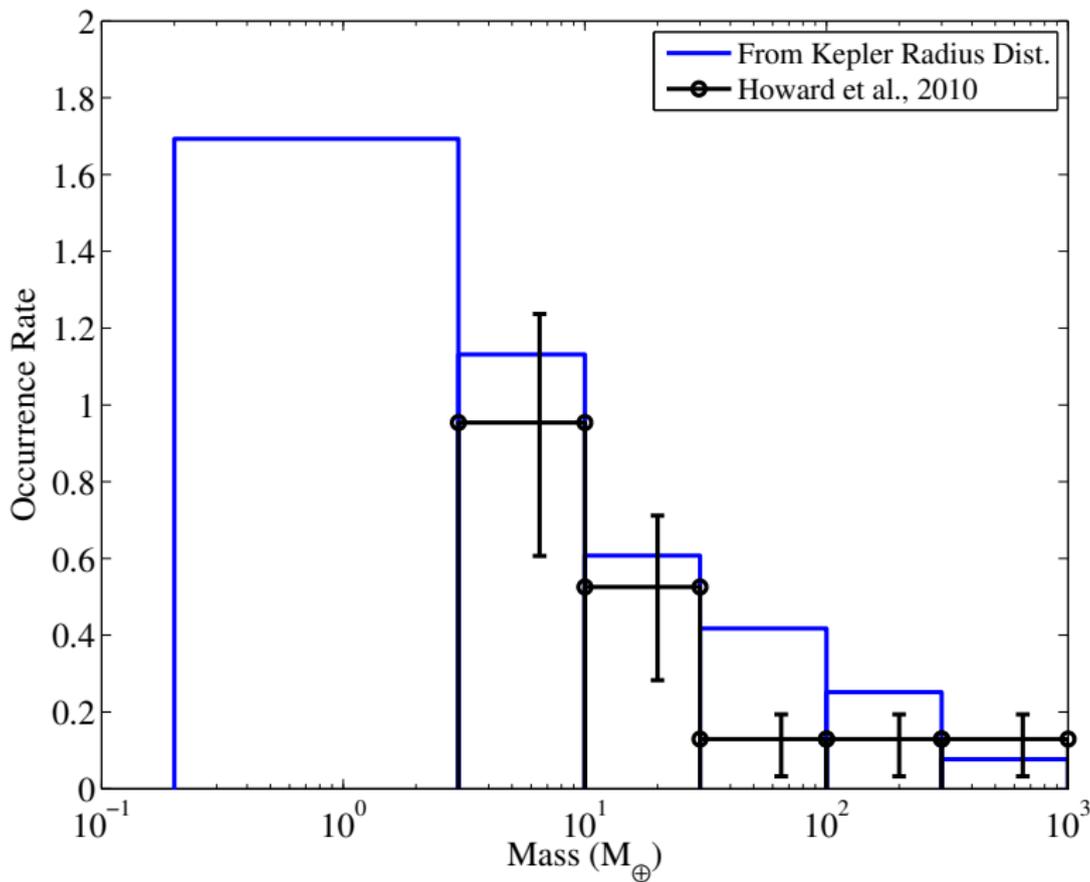
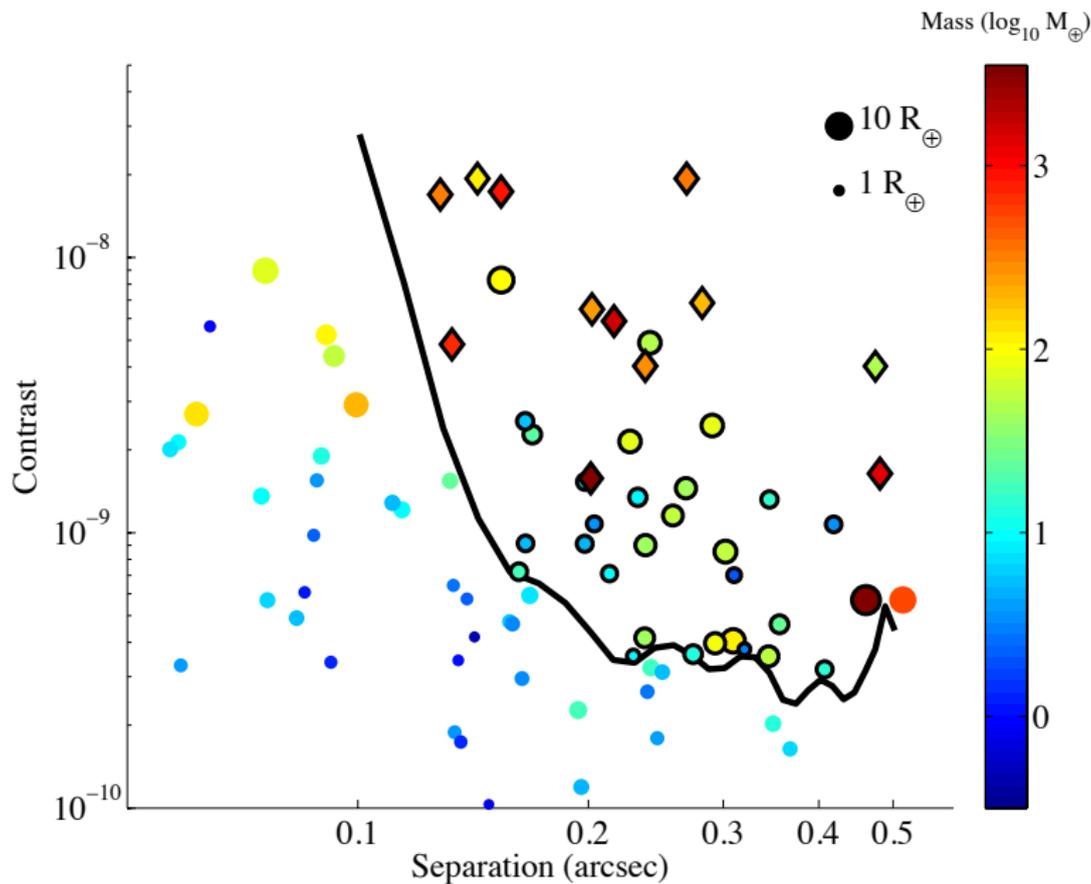


Figure: Inputs are full diffraction models from JPL using PROPER. See Krist et al. (2015) for details.

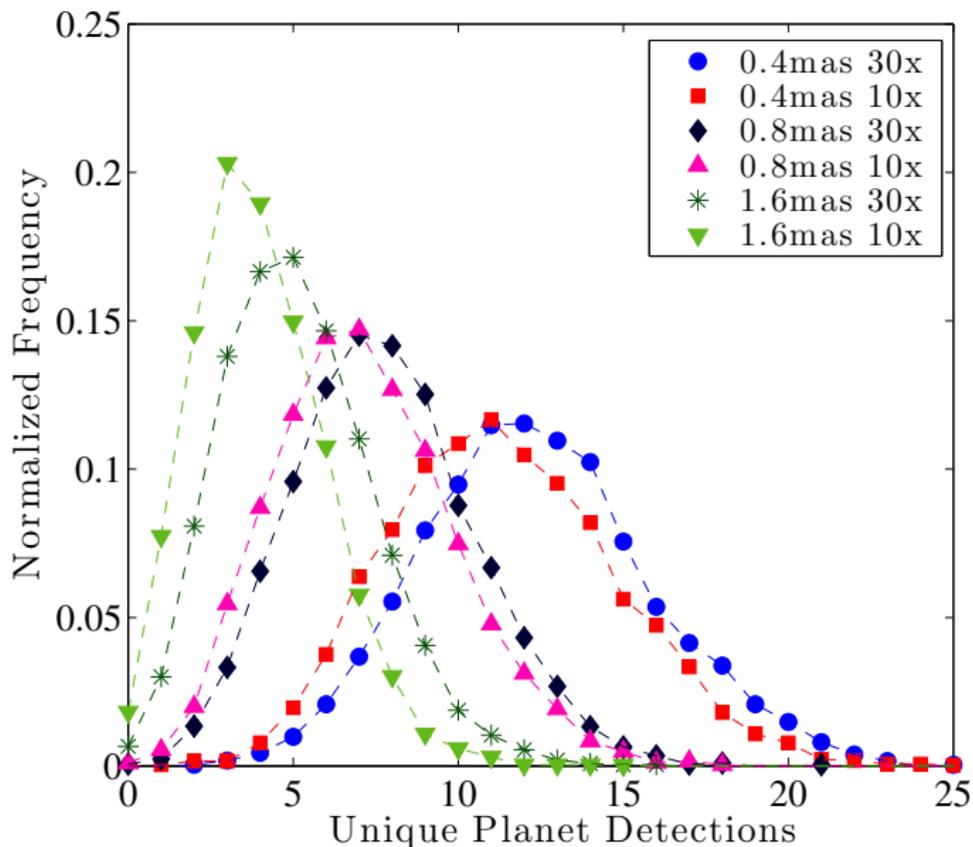


Single Simulation Results



Simulation Ensembles

Savransky and Garrett, 2015



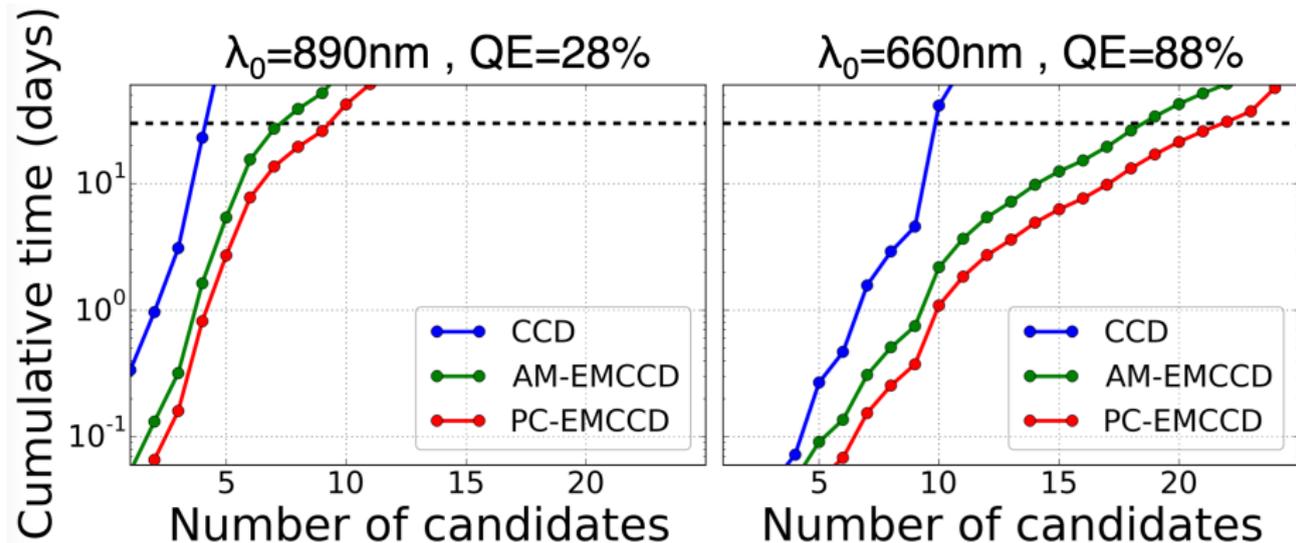
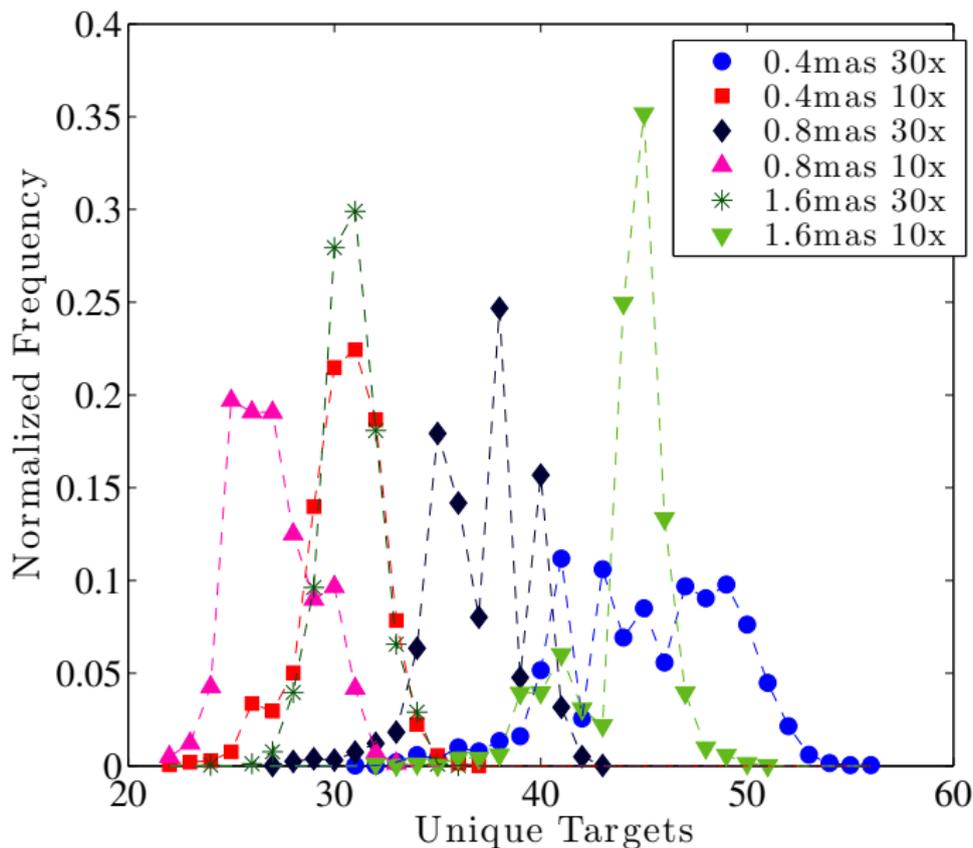


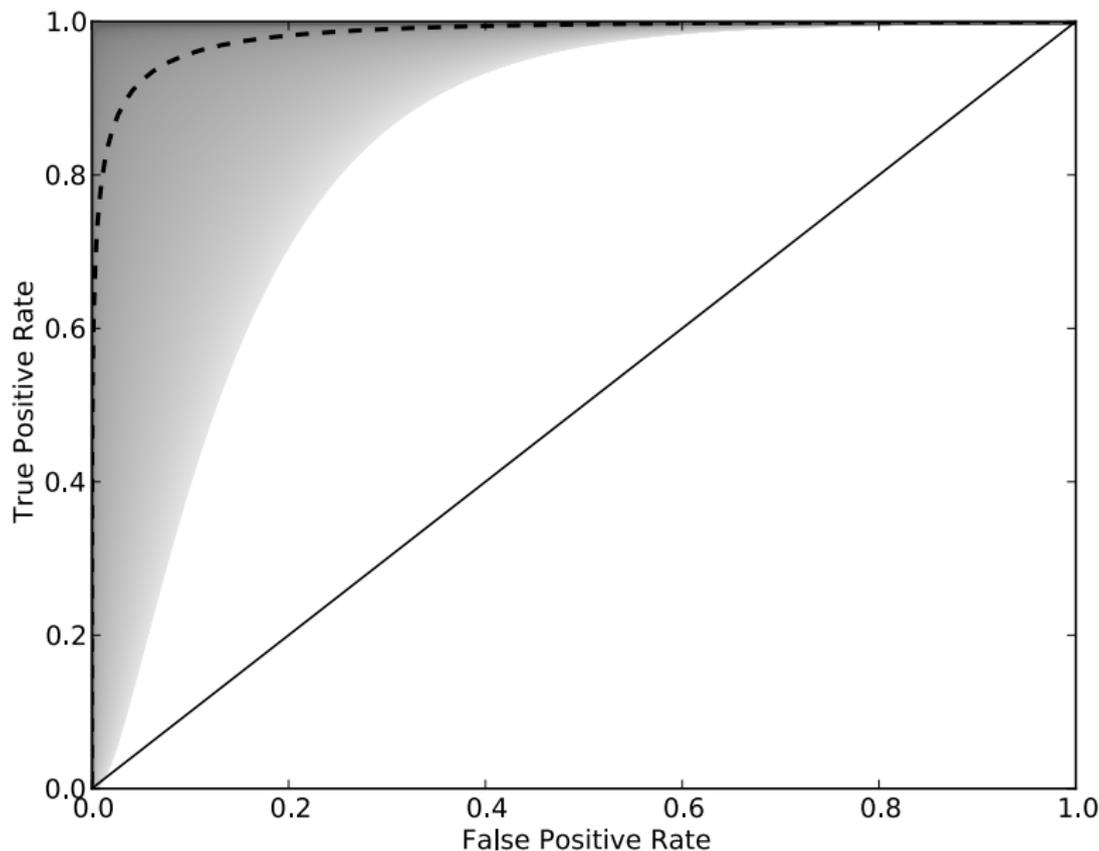
Figure: Cumulative detection integration time for different detectors, based on Nemati (2014).

Optimal Target Selection

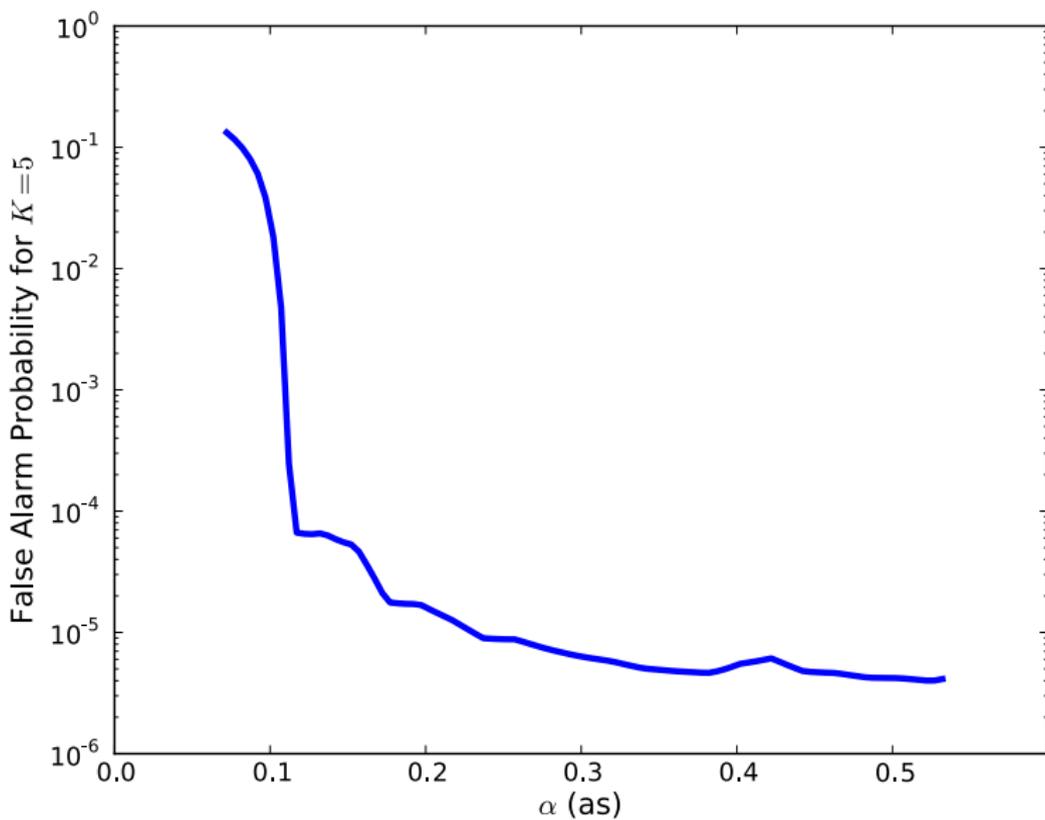
Savransky and Garrett, 2015



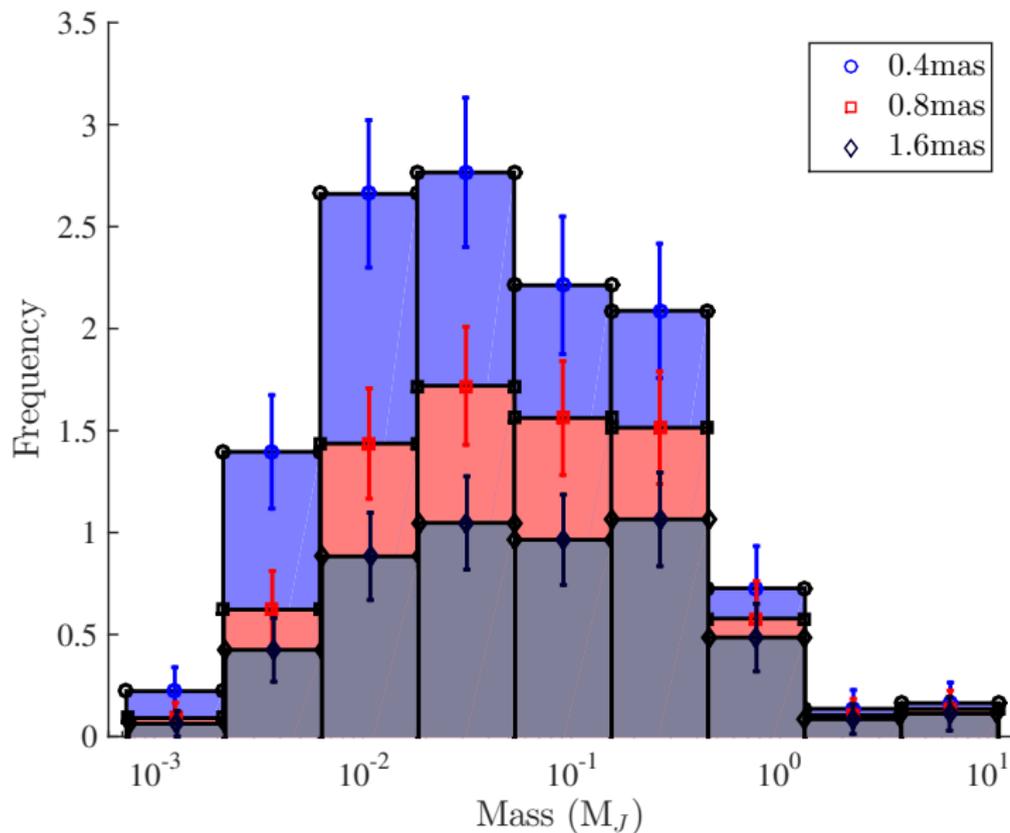
Choosing Operating Points



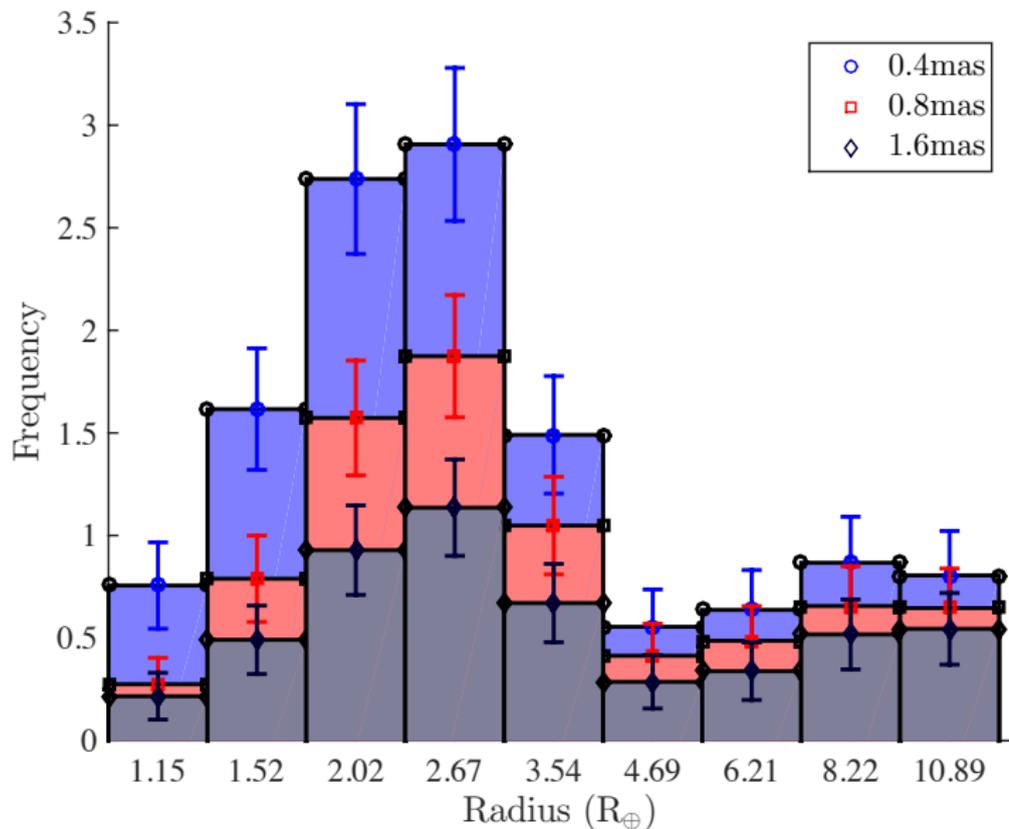
Detection Statistics Change with Separation!



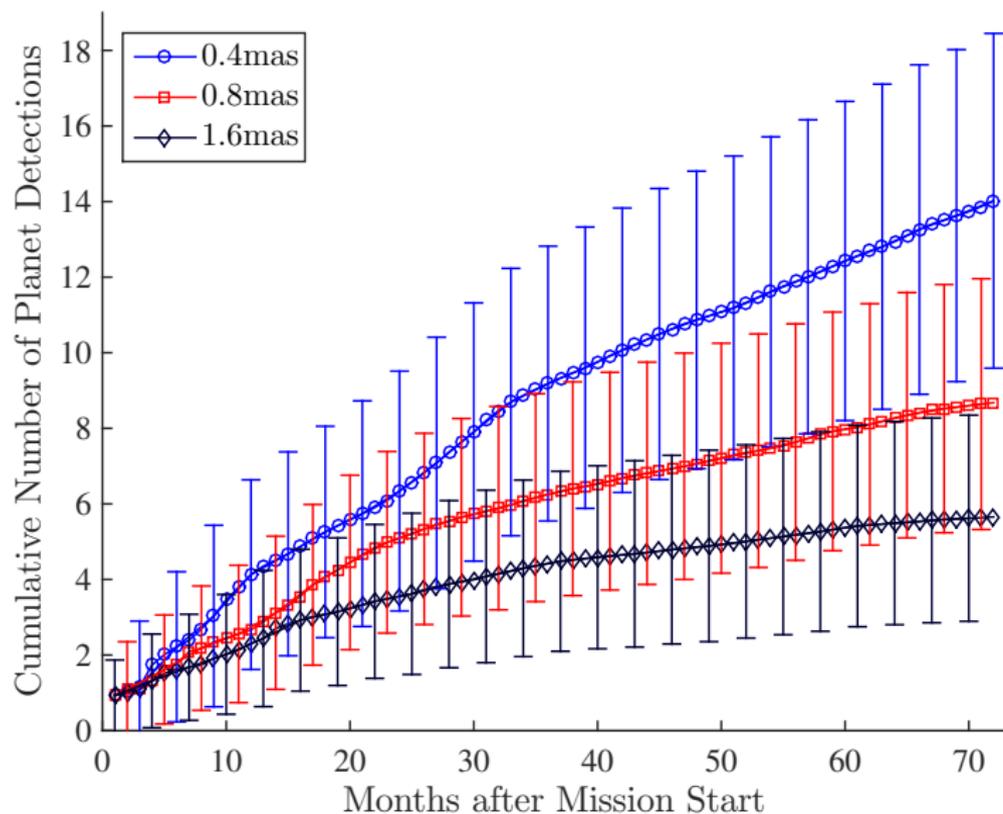
Other Ensemble Results: Instrument Biasing



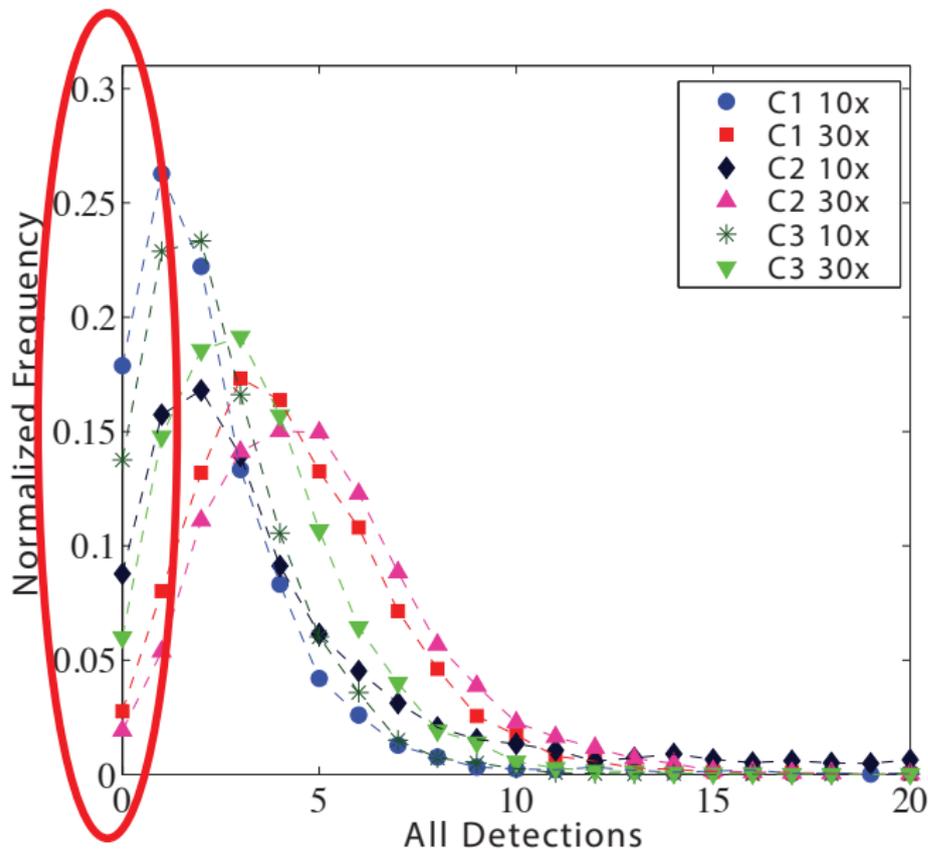
Other Ensemble Results: Instrument Biasing

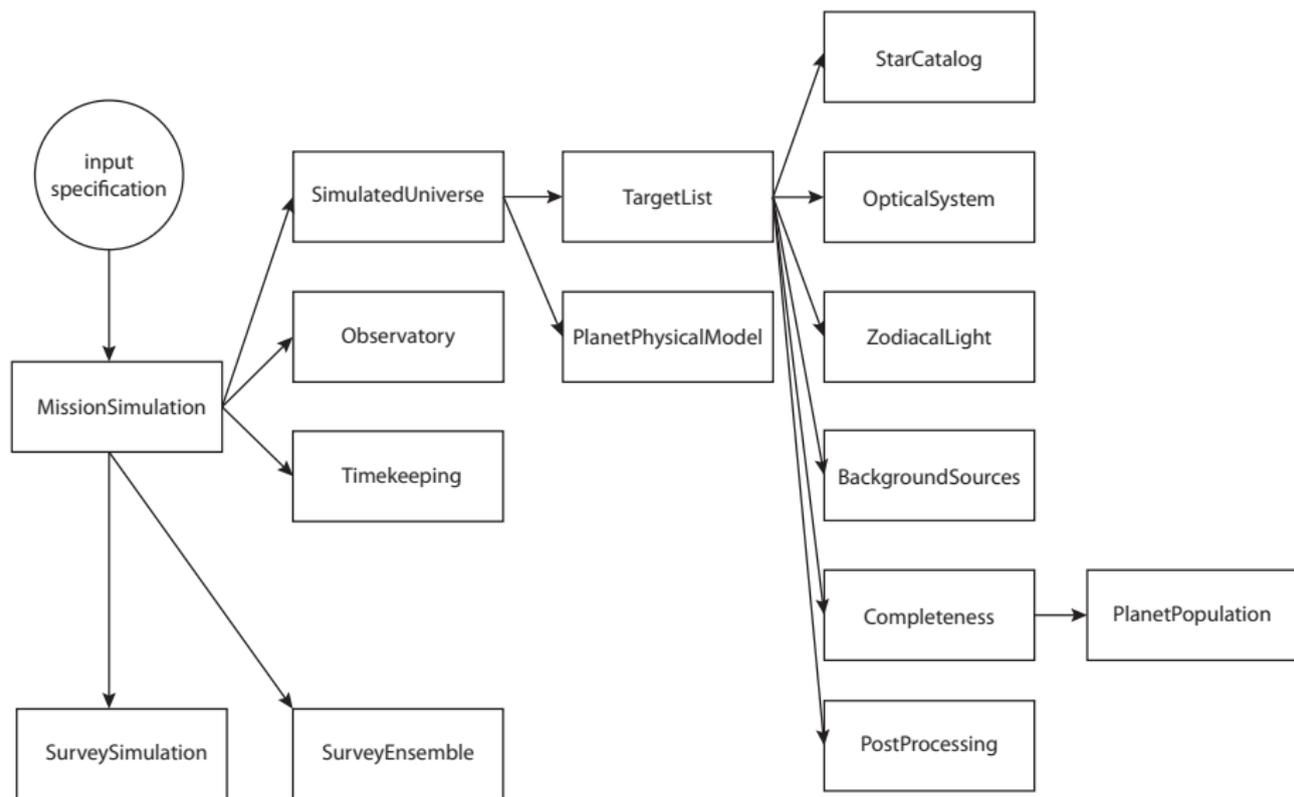


Other Ensemble Results: Mission Execution



Other Ensemble Results: Mission Failure Modes







- Mission Simulation Ensembles are a hugely powerful tool for answering practically any question about mission yields
- *But: you have to trust your simulation* - Achieve this by releasing all simulation code, having independent verification, and iterating on all simulation components with subject matter experts
- Can (and will) incorporate all of the fantastic results from the other WPS projects and (soon) the SITs
- EXOSIMS is under active development and is continuously being updated
 - Please see <https://github.com/dsavransky/EXOSIMS> - in particular the ICD and as-built documentation
 - Comments and pull requests very very welcome