Integrated Coronagraph Design and Science Yield Modeling

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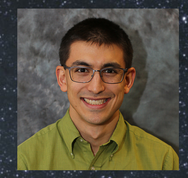


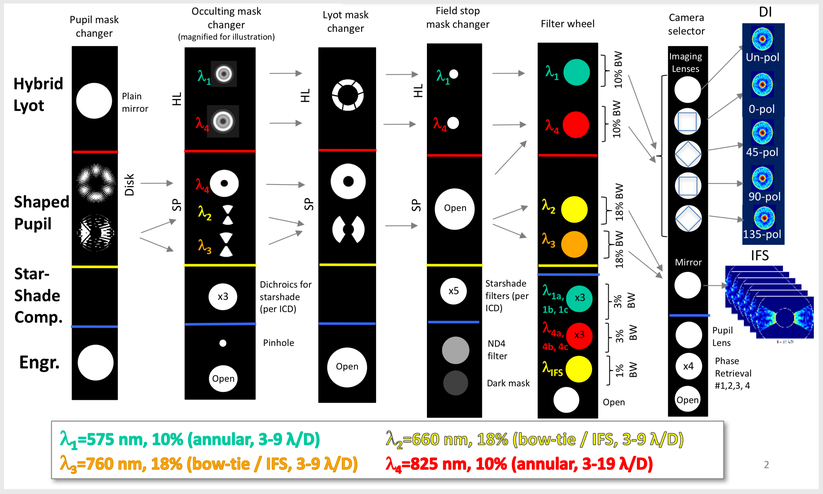
Introduction

The WFIRST CGI would be the first instrument to directly image and characterize cool gas giant exoplanets. The CGI is planned to carry both the shaped pupil coronagraph (SPC) and hybrid Lyot coronagraph (HLC). Ongoing design work is focused on 1) increasing the science yield in the presence of telescope dynamics and primary mirror polarization and 2) simplifying the instrument.

CGI Modes in Phase A

The final design for Phase A has 3 types of modes:

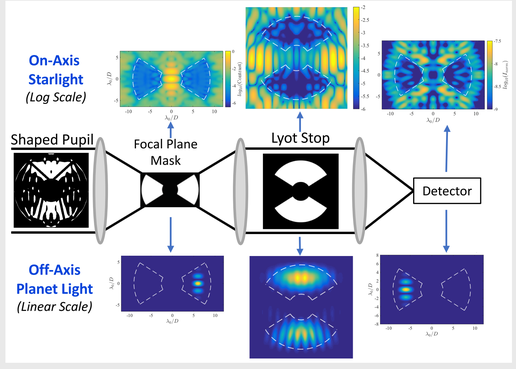
a) Hybrid Lyot (HLC): imaging of exoplanets and inner debris disks
b) Shaped Pupil (SPC): outer disk imaging
c) SPC: exoplanet spectroscopy with an IFS



Current SPC-IFS Design

The current SPC designs generate high-contrast with three binary-amplitude masks.

The SPC is now directly optimized to be less sensitive to tip/tilt and other low-order Zernike aberrations.



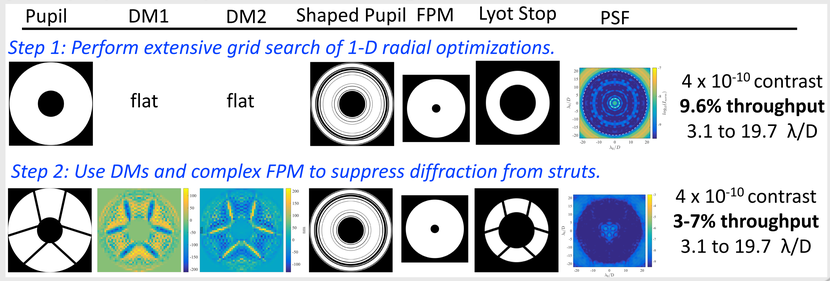
~2x10^{-9} raw contrast

3.8% core throughput

Potential Hybrid Designs: SPHLC

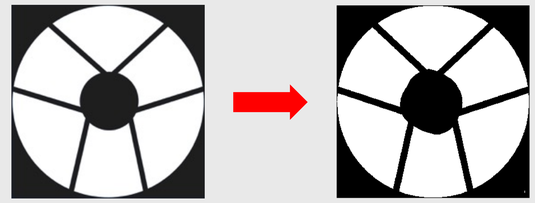
For Phase B, we are investigating hybridized designs that combine the best features of the SPC and HLC into an SPHLC. The potential new benefits are:

- much better sensitivity to pupil-to-apodizer misalignment
- higher throughput
- larger field of view
- fewer overall modes.

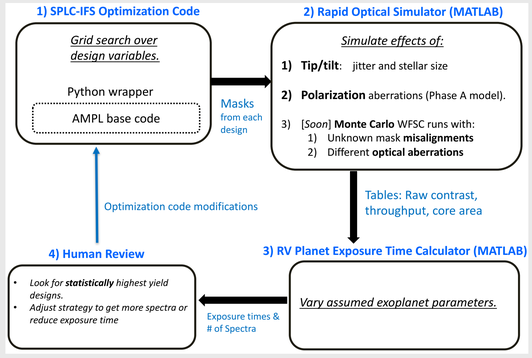


Telescope Pupil Change in Phase B

In Phase B, the obscurations of the secondary mirror and its struts will be larger and degrade CGI performance.



Design Pipeline: Integrated Design and Yield Modeling



Our overall goal is to **maximize the science yield** given the shape, dynamics, and polarization of the telescope.

We are developing a design pipeline to compute the best of many possible designs:

1. Generate and evaluate many designs with a simple model of the telescope and instrument.
2. Compute science yields with either the known RV exoplanets or statistical exoplanet models.

References

- Riggs et al., *Proc. of SPIE*, Vol. 10400, 104000O-1. 2017.
- Zimmerman et al., *JATIS*, 2(1), 011012. 2016.
- Trauger et al., *JATIS*, 2(1), 011013. 2016.
- Nemati, Krist, & Mennesson, *Proc. of SPIE*, Vol. 10400, 1040007. 2017.
- Krist et al., *Proc. of SPIE*, Vol. 10400, 1040004. 2017.

This work was performed at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.