Model-Generated Inputs for Yield Calculations

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Input specifications to yield calculator

Standardized Coronagraph Parameters for Input into Yield Calculations

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To estimate the science yields of future telescopes, yield modeling codes must adopt parameters describing the performance of the telescope-instrument combination. Adopting standard parameters and file formats would help streamline this process, both for those modeling the yield and those modeling the instruments. As such, this document details a set of instrument model files that would form a useful set of standard inputs for yield codes.

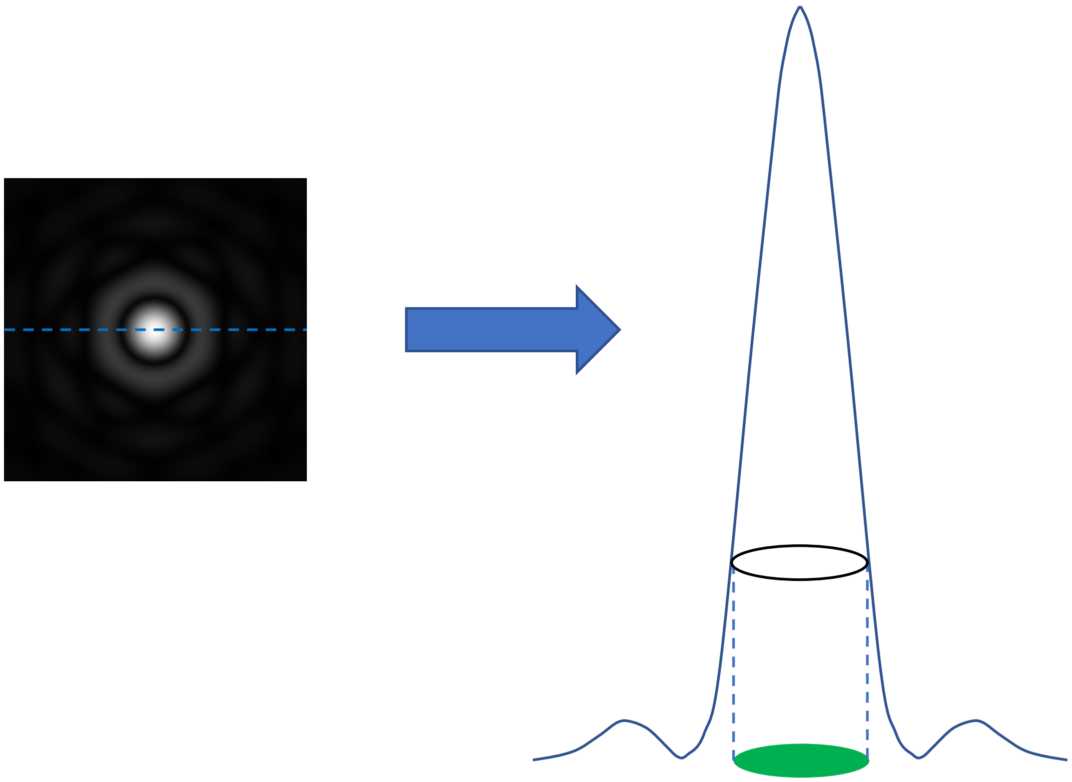
https://starkspace.com/yield_standards.pdf

Numerical Simulation of the Coronagraph

- Surface-to-surface wavefront propagation
  - typically Fourier-based methods (angular spectrum, Fresnel)
- Aberrated optics
  - polishing errors, coating defects, polarization-induced aberrations
- Coronagraph masks
  - focal plane mask, Lyot stop, shaped pupil/apodizer
- Wavefront control using deformable mirrors
  - iterative algorithms to dig dark hole around star (e.g., EFC)
  - can also compenstate for obscurations (e.g., Hybrid Lyot)
- Broadband images
  - sum of multiple monochromatic images
- Pointing jitter & finite-diameter star
  - weighted combination of many source offset images

Fundamental input parameters to a yield calculator:

How much light is in the core of the exoplanet's PSF and how much is in the background beneath it?



Background=
Dark hole
(speckles)

Signal=
Exoplanet
(field PSF)

Image

Dependencies:
- *Coronagraph masks*
- *Optical errors*
- *Polarization aberrations*
- *Wavefront correction (DMs)*
- *Pointing errors (jitter)*
- *Finite-diameter star*

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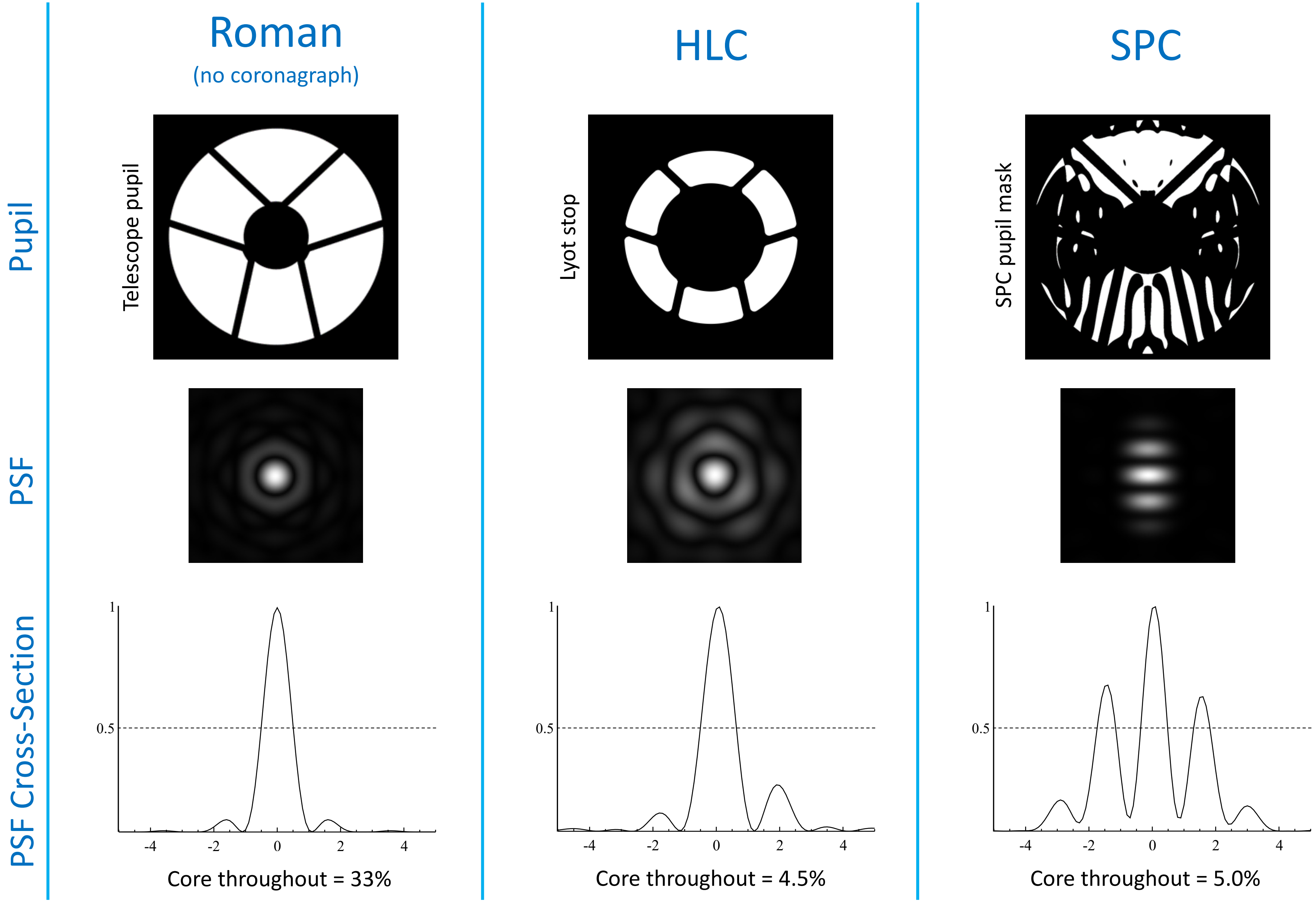
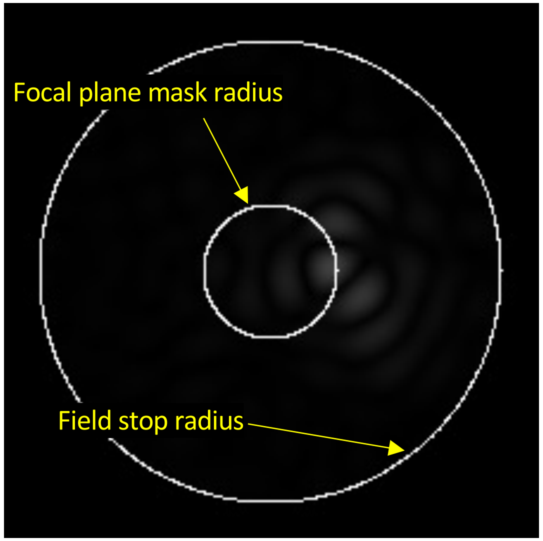


Core throughput = Flux in ≥50% peak region of PSF /
total flux over infinite extent without masks

Point source vs. Field offset



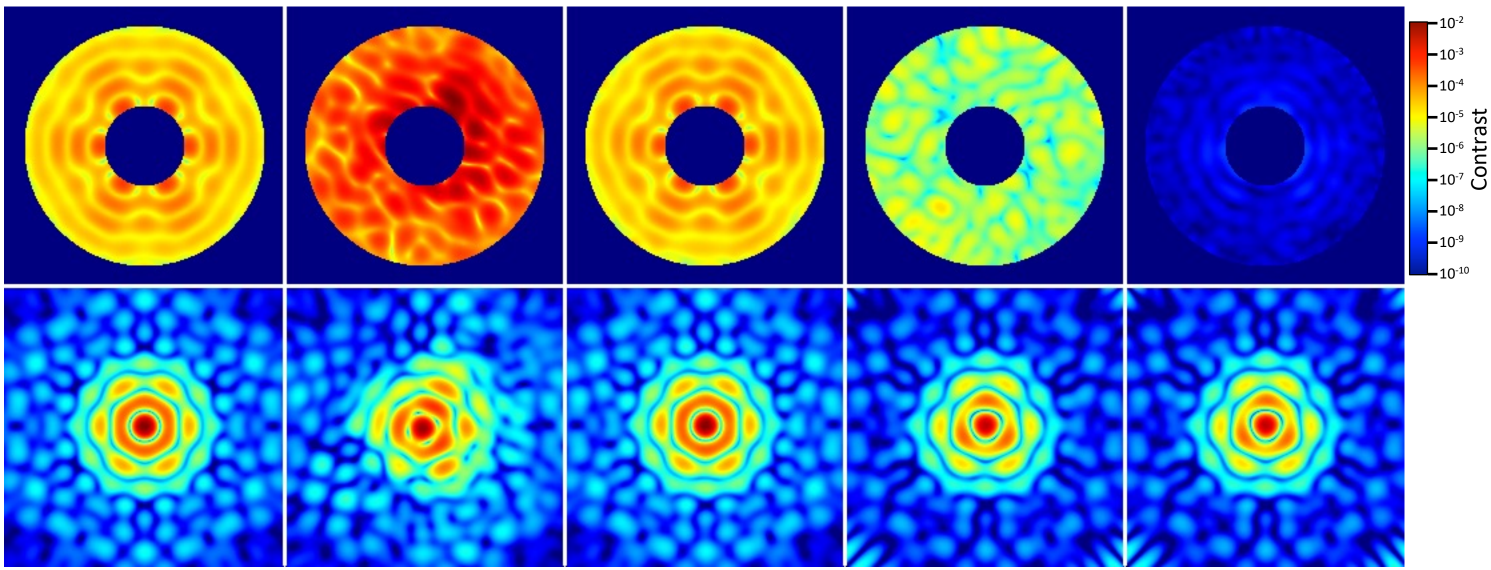
Dark hole before & after wavefront control

Roman CGI HLC Example

	No aberrations, Flat DMs	Aberrated, Flat DMs	Aberrated, +Phase-flat DMs	Aberrated, +HLC DM Patterns	Aberrated, +EFC solution
Mean contrast =	3.6×10^{-5}	6.4×10^{-4}	3.7×10^{-5}	2.1×10^{-6}	$<10^{-9}$

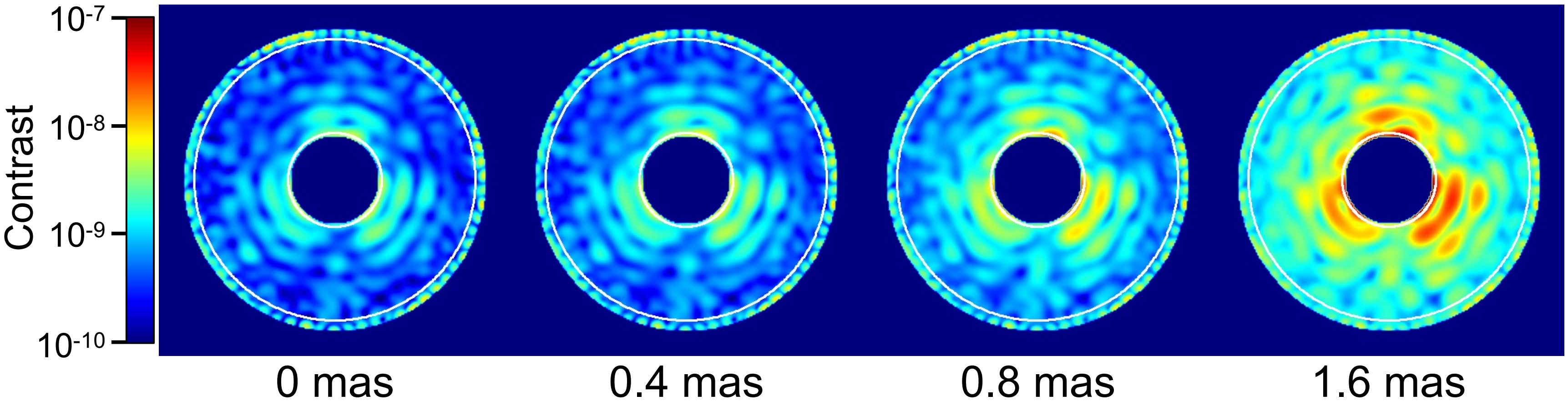
Dark hole

Unocculted PSF



Core throughput =	7.5%	6.1%	7.5%	4.7%	4.5%
Core area =	2242 mas^2				2368 mas^2

Dark hole vs Jitter/stellar diameter

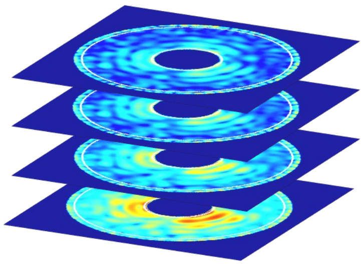


Rule of thumb:

Dark hole for θ diameter star ≈ Dark hole for ¼ θ RMS jitter

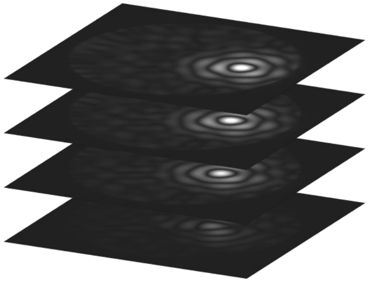
Model outputs = Yield calculator inputs

Background = Dark holes



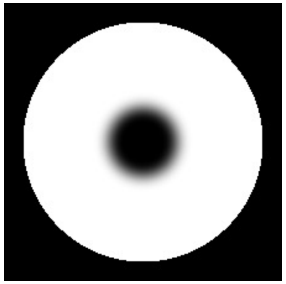
3-D FITS file:
Dark holes for a variety of stellar diameters

Exoplanets = Field PSFs



3-D FITS file:
Source offset by various amounts in one direction from center of focal plane mask (use small offsets near inner working angle)

Sky transmission



2-D FITS file:
Sky transmission, applied to extended sources
(focal plane mask transmission convolved by Lyot stop PSF, then multiplied by field stop)

The End