# AFTA Shaped Pupil + Lyot Stop Modeling Summary

SPC-20140902-1

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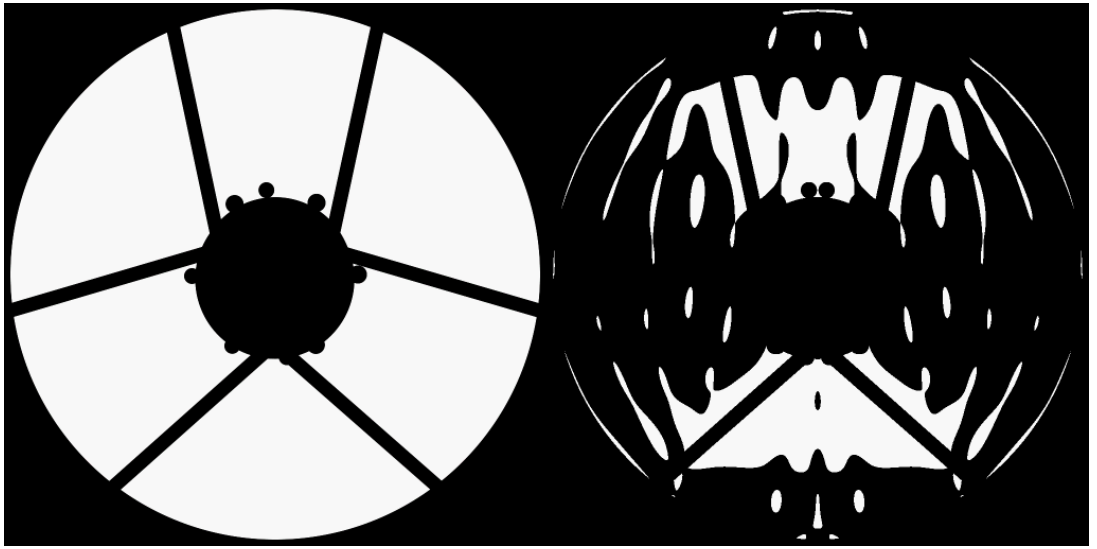
# AFTA Shaped Pupil + Lyot Stop
## Characterization Design SPC-20140902-1

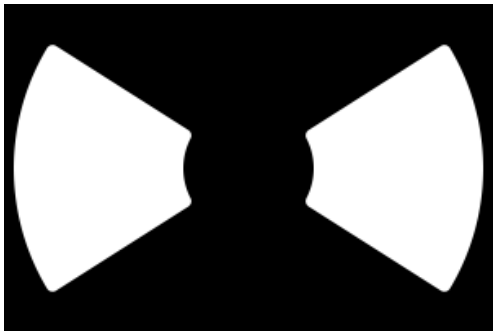
AFTA Pupil

Shaped Pupil



27% mask transmission

Focal plane mask

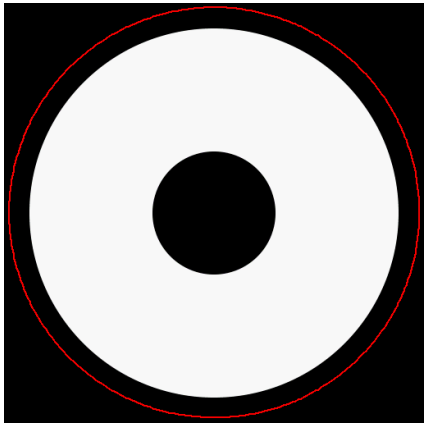


$r = 2.5 – 9\ \lambda_c/D$

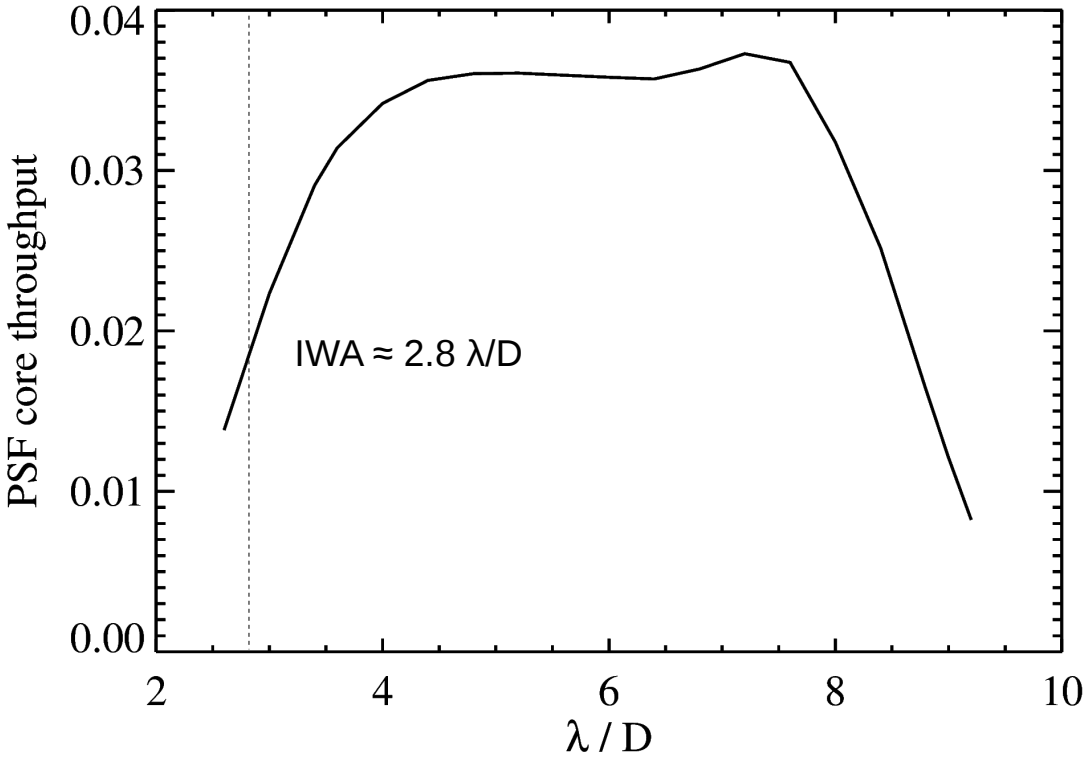
65° opening angle

Lyot stop

$r_{sp} = 0.3 – 0.9\ r_{pup}$



# PSF Core Throughput




PSF core Throughput = Flux inside off-axis PSF FWHM region / Flux at AFTA primary
(for AFTA without a coronagraph this is 0.34)
Peak relative core throughput = 0.037 / 0.34 = 0.11
Off-axis (planet) PSF FWHM region covers ~0.0026 arcsec$^2$
(for AFTA without a coronagraph this is 0.00165 arcsec$^2$)
50% core throughput at ~2.8 λ/D

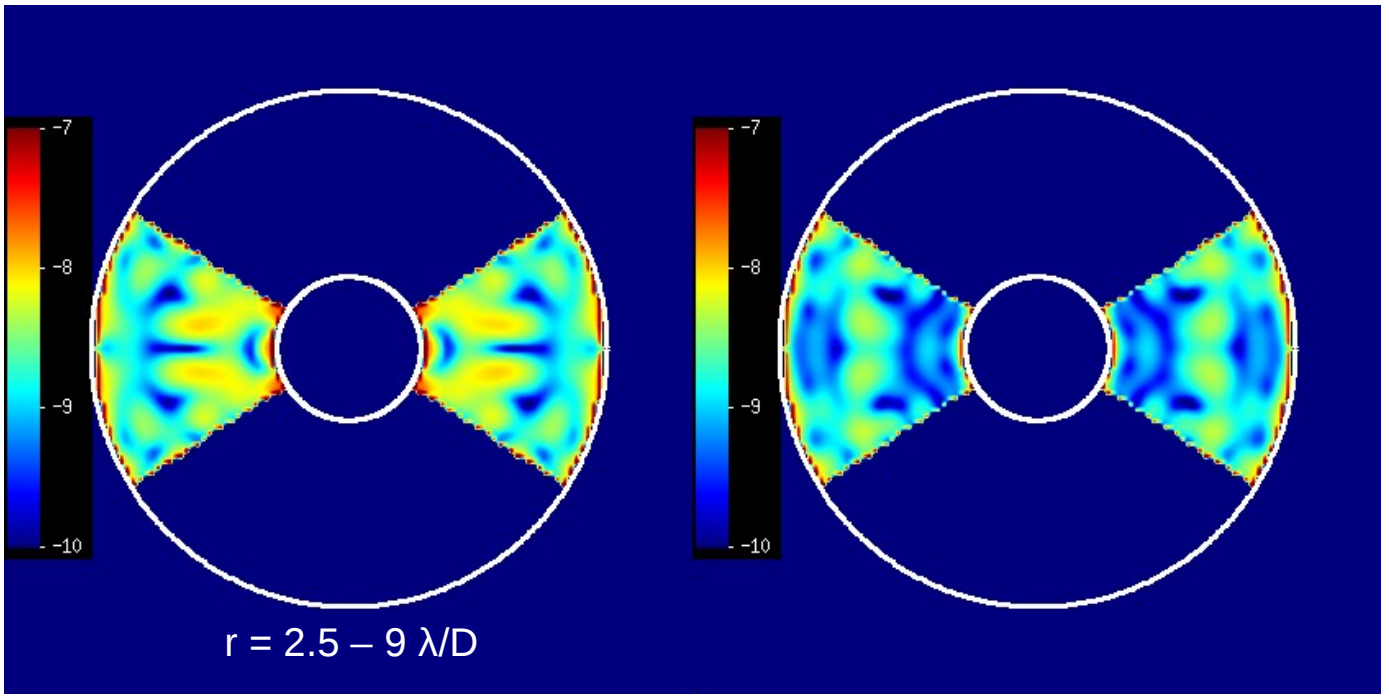
# Shaped Pupil Evaluation

- System evaluted in 10% bandpass (523 – 575 nm) for comparison to other coronagraphs
- Evaluated in 18% long bandpass (728 – 872 nm) for performance at IFS wavelengths
- EFC runs used 5x higher weighting at 2.5 – 4.5 λ/D, as recommended by the Princeton group

# AFTA Shaped Pupil + Lyot Stop
## No aberrations, 523 – 578 nm

Before EFC

After EFC



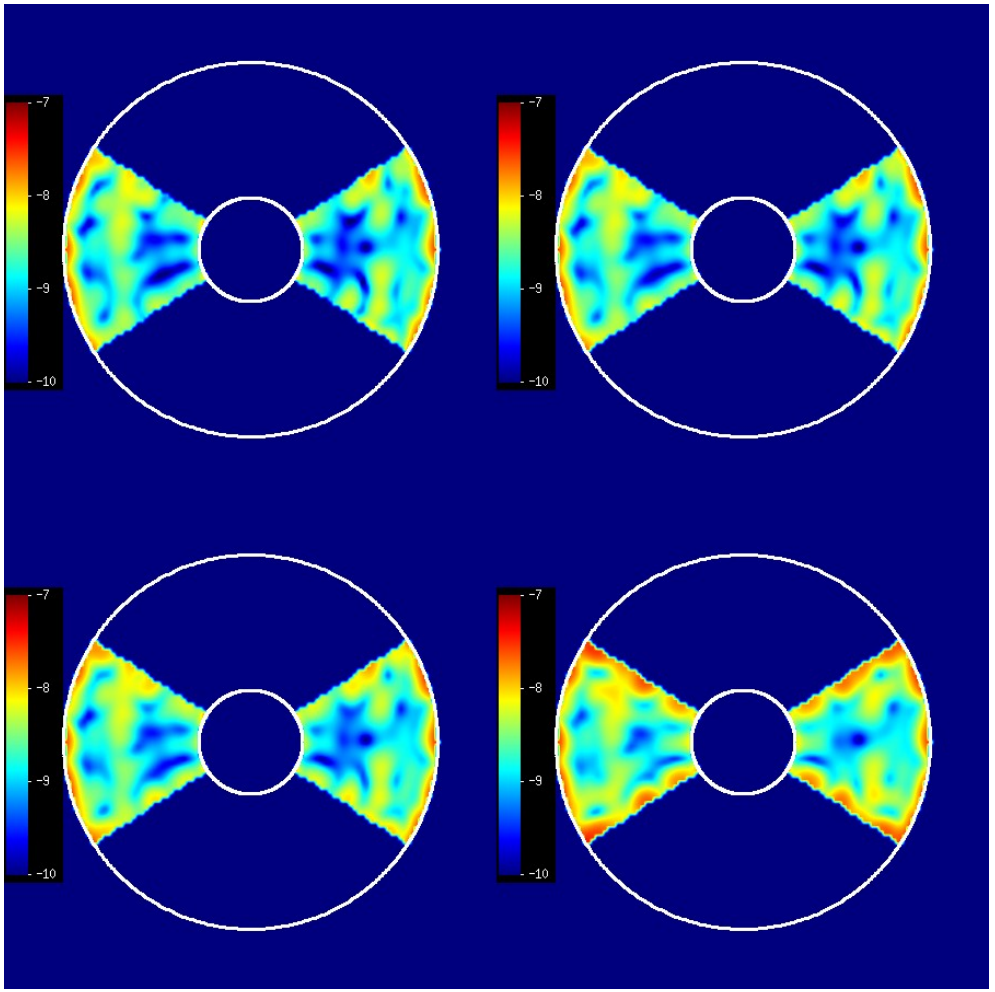

All EFC runs in this document included increased (5x) weighting of points from r = 2.5 – 4.5 λ/D, as recommended by the Princeton team. EFC improves the diffraction suppression performance of the design, even without any aberrations. The corresponding DM solutions were used as the starting points for EFC in the aberrated system. Separate DM solutions were derived for the long wavelength passband.

# AFTA Shaped Pupil + Lyot Stop

## Post-EFC, aberrated, 523 – 578 nm, with jitter & 1 mas star

No jitter

0.4 mas RMS



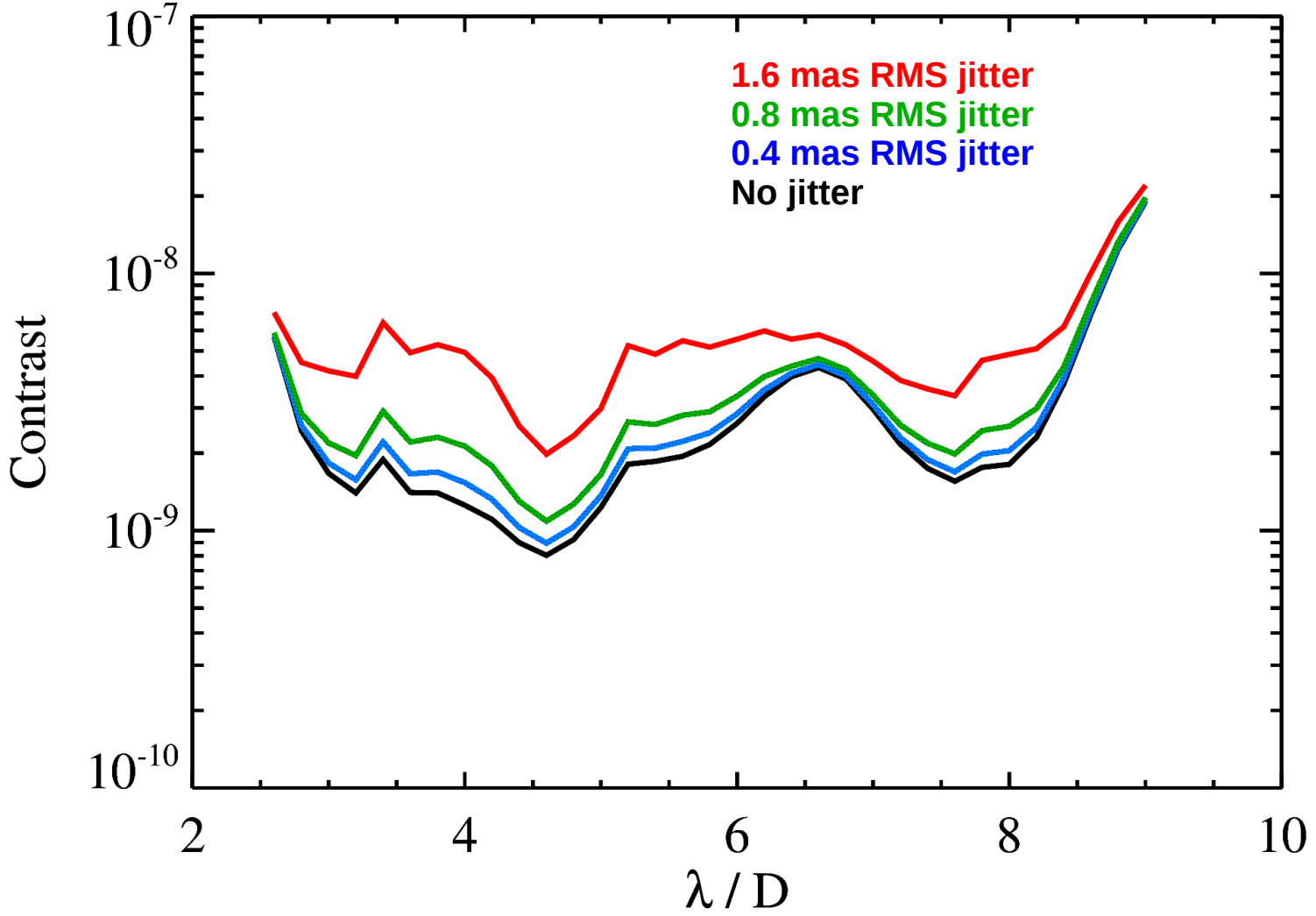

Circles are
r = 2.5 & 9 λ/D

0.8 mas RMS

1.6 mas RMS

# AFTA Shaped Pupil + Lyot Stop

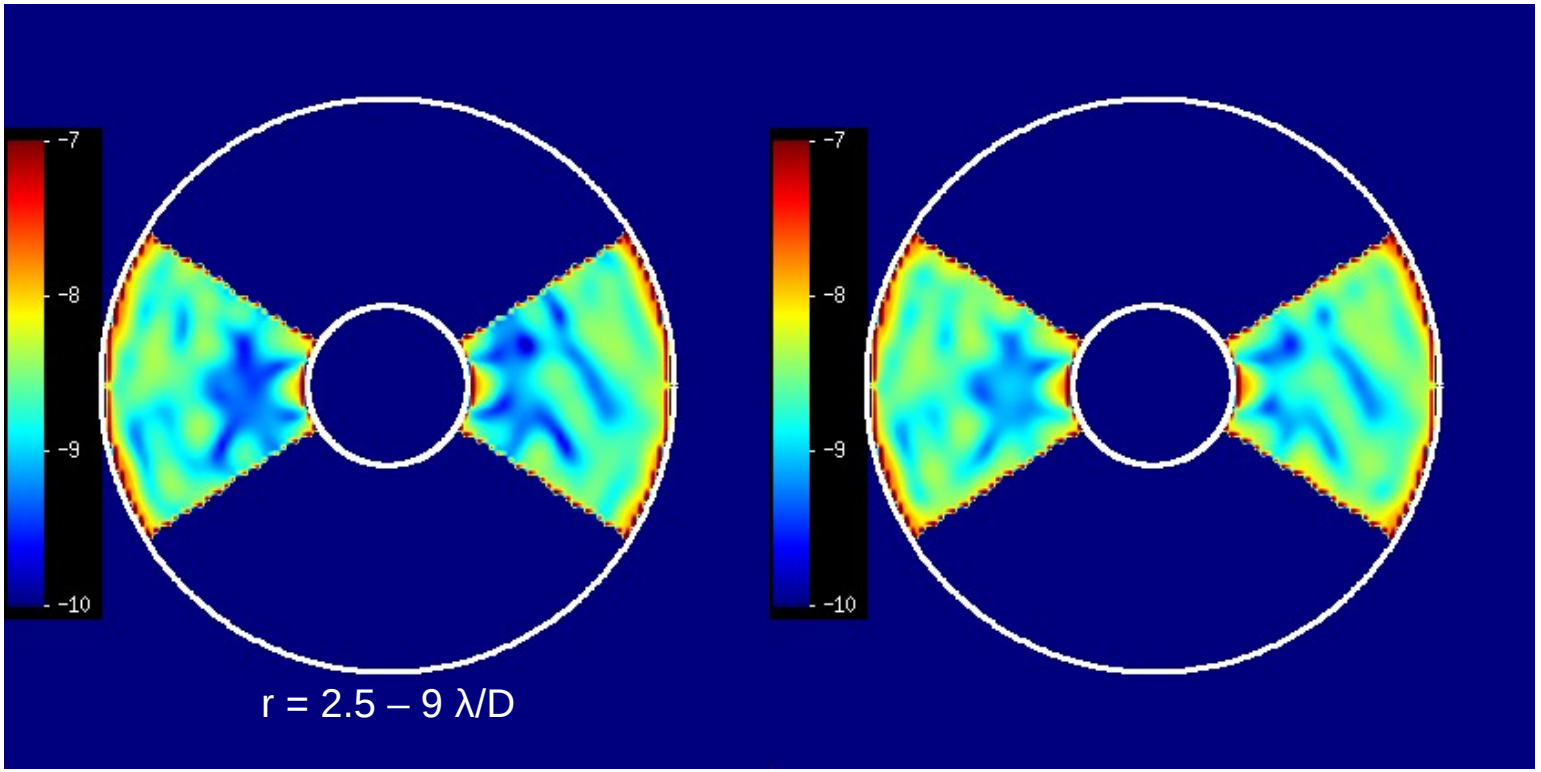
## Post-EFC, aberrated, 523 – 578 nm, X polarization, with jitter & 1 mas star



# AFTA Shaped Pupil + Lyot Stop
## After EFC, aberrations, 728 - 872 nm, no jitter

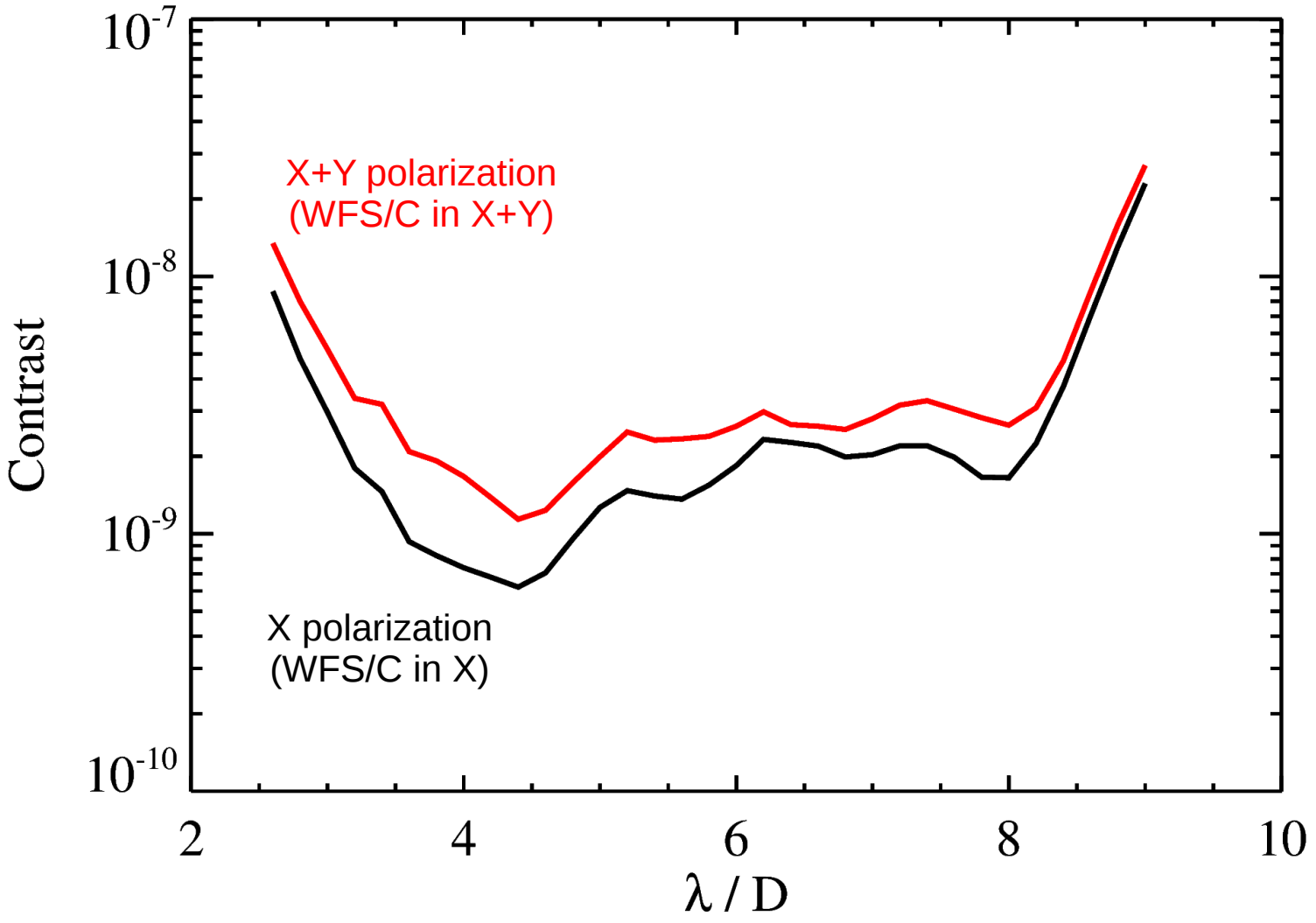
X Polarization
WFS/C in X

X+Y Polarization
WFS/C in X+Y



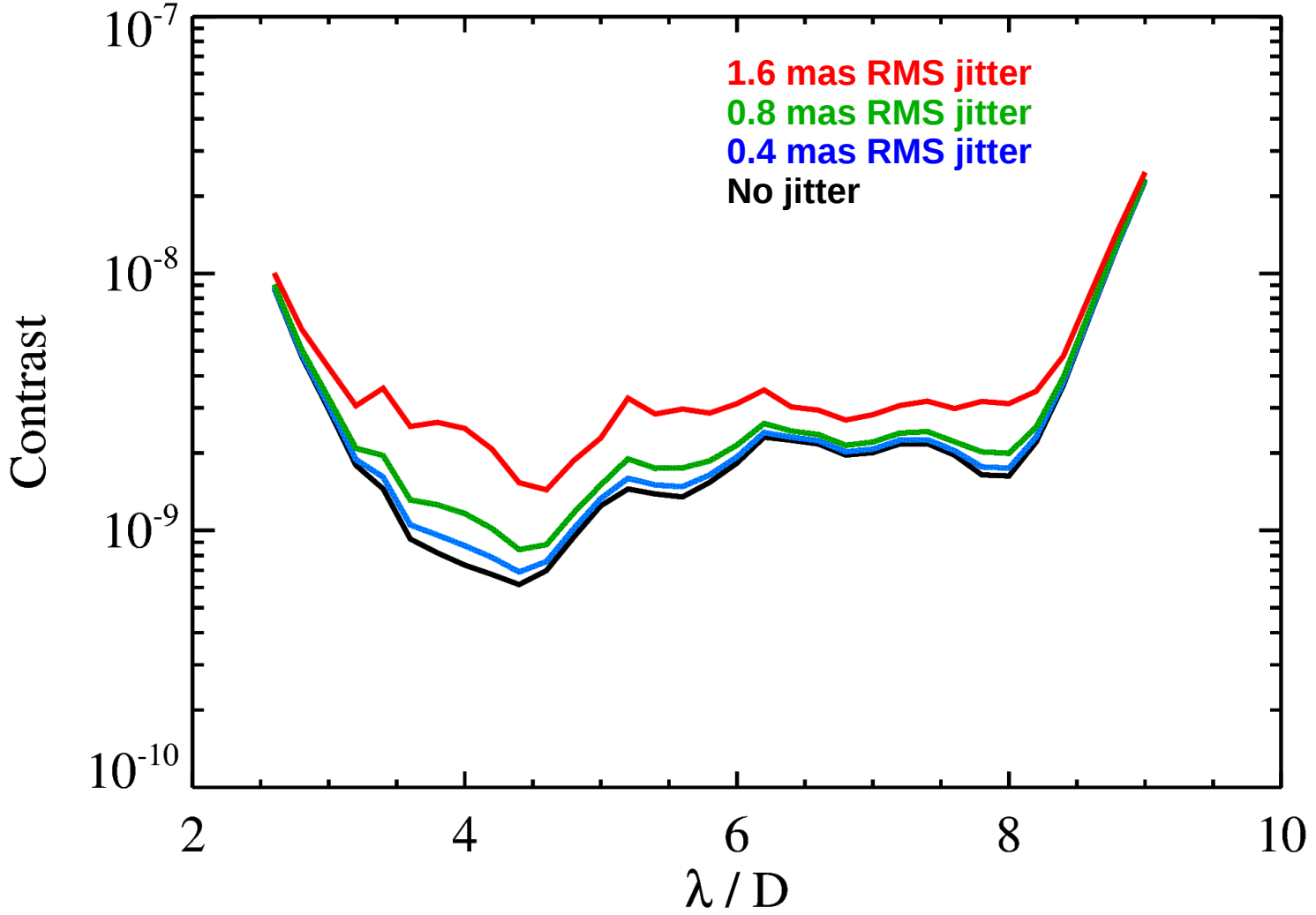

The shaped pupil + Lyot stop is only mildly sensitive to polarization errors. The primary aberration differences between the X and Y polarizations are astigmatism and tilt, both of which this design is relatively insensitive to. The polarization-induced aberrations are a few times less at 550 nm than 800 nm.

# AFTA Shaped Pupil + Lyot Stop
## After EFC, 728 - 872 nm, no jitter

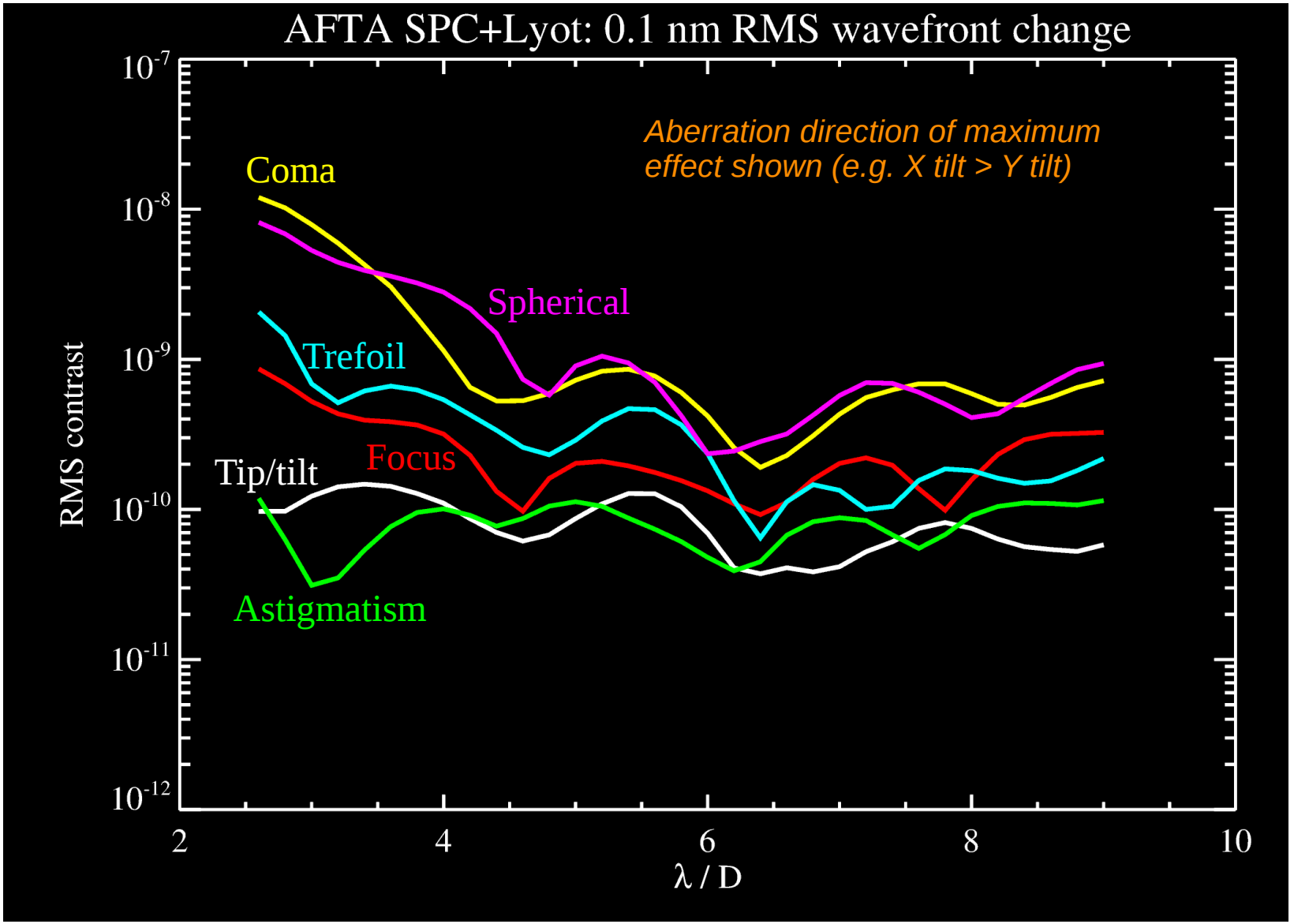


# AFTA Shaped Pupil + Lyot Stop

## Post-EFC, aberrated, 728 – 872 nm, X polarization, with jitter & 1 mas star



# Shaped pupil + Lyot stop aberration sensitivity




These plots show the RMS difference between a λ = 550 nm field perturbed by 100 pm of a specified aberration and an unperturbed one, as measured in 0.4 λ/D wide annuli. This reflects the noise introduced in a PSF subtraction due to an aberration change between a target and reference PSF star.

# Summary

- This shaped pupil + Lyot stop design is practical for operating in a 18% bandpass with an IWA of ~2.8 λ/D
- It appears to be usable with or without polarization splitting at all wavelengths
- It is largely insensitive to jitter up to 0.8 mas RMS and mildly so above that