

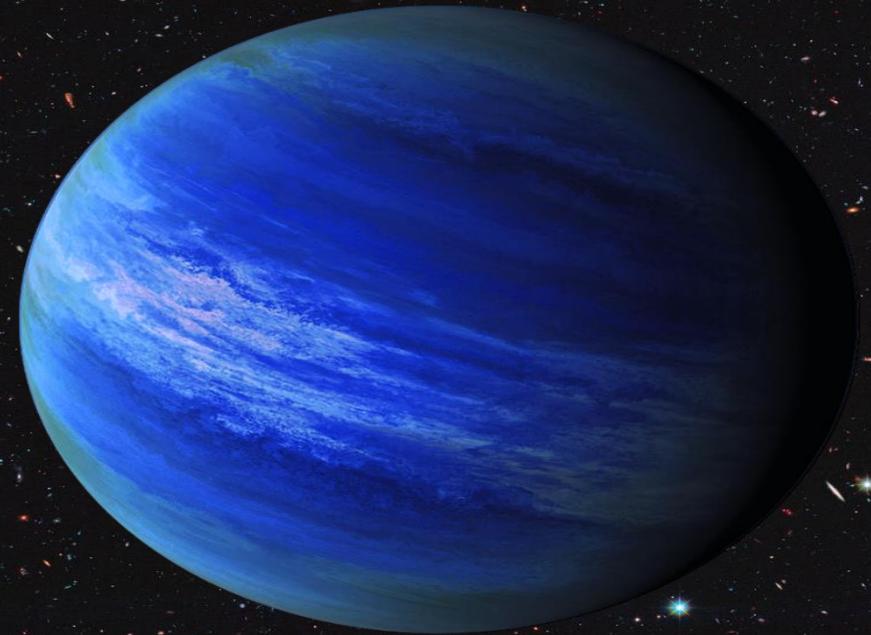


Charts for Presentation by Professor Jeremy Kasdin
at the National Research Council Exoplanet
Science Strategy panel – Irvine CA April 20, 2018

Feng Zhao

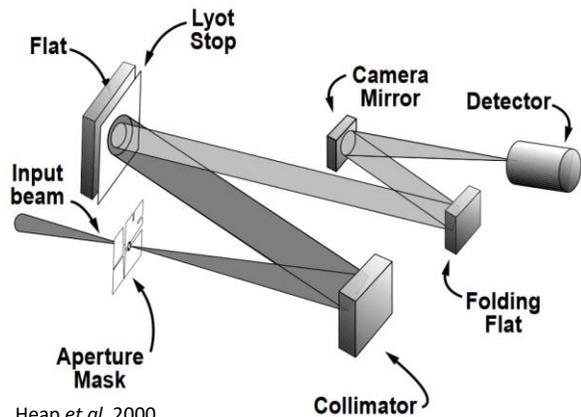
20, April 2018

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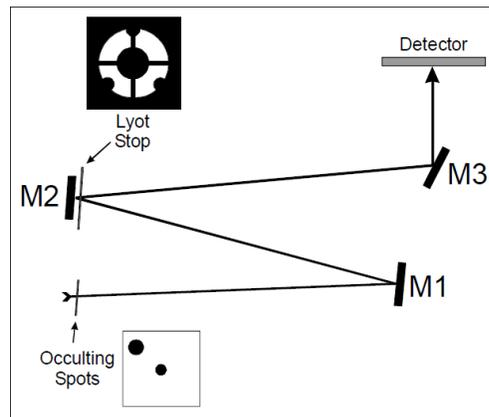
Hubble has had three Lyot coronagraphs used in its instruments to look at planets:

STIS



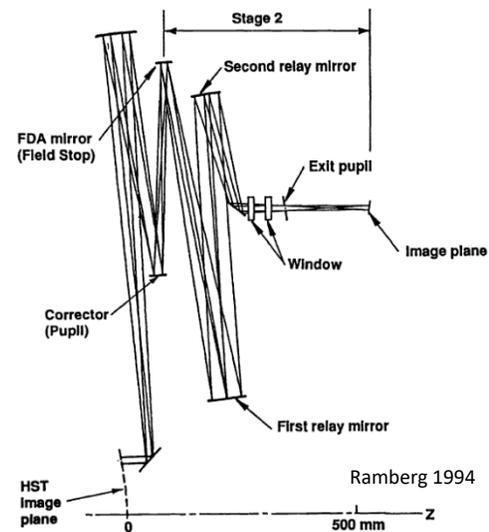
Heap *et al.* 2000

ACS/HRC

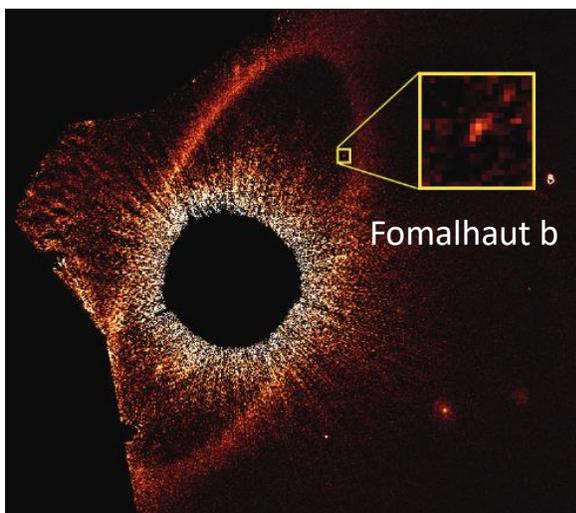


Krist *et al.* 2003

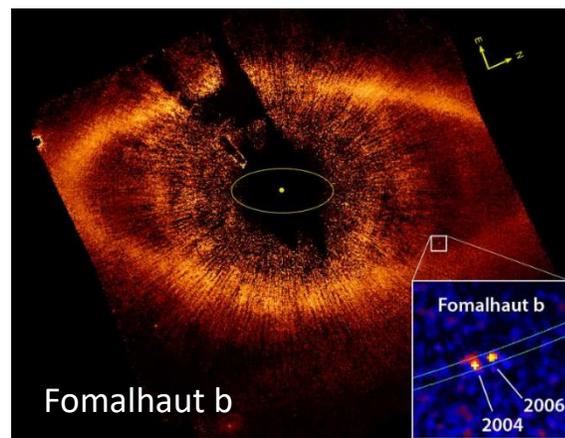
NICMOS



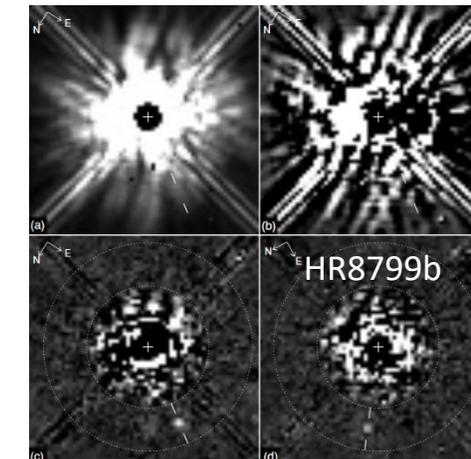
Ramberg 1994



Kalas *et al.* 2013



Kalas *et al.* 2008

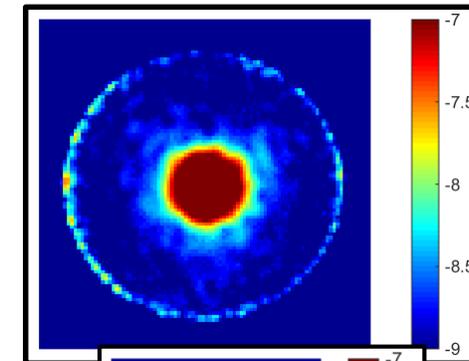


Lafrenière *et al.* 2009

Imaging with Narrow FoV Initial Static Raw Contrast

	Initial contrast vs. working angle		
Working angle	3-4 λ/D	4-8 λ/D	8-9 λ/D
Band 1 (575 nm)	1×10^{-8}	0.7×10^{-8}	1×10^{-8}

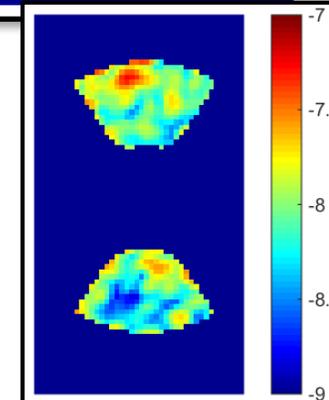
Best testbed result: 1.6×10^{-9} in 10% at 550nm



Spectroscopy Initial Static Raw Contrast

	Initial contrast vs. working angle		
Working angle	3-4 λ/D	4-8 λ/D	8-9 λ/D
Band 3 (760 nm)	2×10^{-8}	1.5×10^{-8}	2×10^{-8}

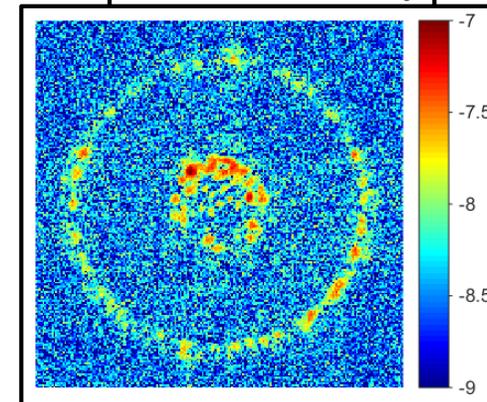
Best testbed result: 1.1×10^{-8} in 18% at 660nm



Imaging with Wide FoV Initial Static Raw Contrast

	Initial contrast vs. working angle		
Working angle	6.5-7.5 λ/D	7.5-19 λ/D	19-20 λ/D
Band 4 (825nm)	2×10^{-8}	1.5×10^{-8}	2×10^{-8}

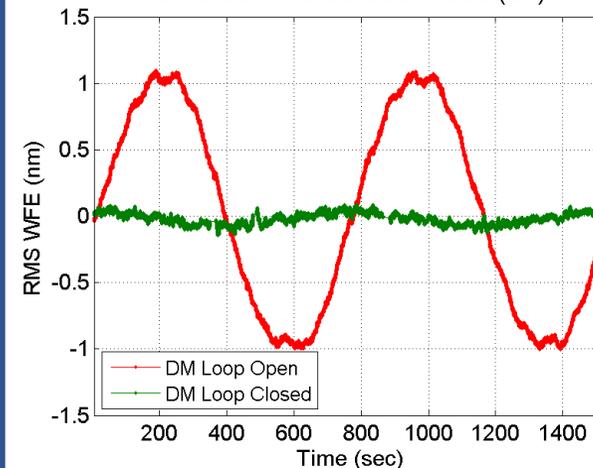
Best testbed result: 4.3×10^{-9} in 10% at 565nm



- Open and closed error sensed by SPC LOWFS
 - Lower Left: PSD of tip-tilt error converted to on-sky pointing angle (milli-arcsec).
 - The feedforward notches for RWA jitter correction at fundamental (10 Hz) and sub-harmonic (3.7 Hz) frequencies
 - The feedforward notch at lab line frequency of 120 Hz
 - Lower Middle: integrated WFE for LoS
 - Upper Right: 2 sec averaged LOWFS sensed focus error
 - Sinusoidal focus disturbance has an amplitude of +/-1 nm with period of 750 sec. The temporal change is much faster compared with WFIRST on orbit thermal drift (~10 pm/ hour). The residual focus ~ +/-0.07nm.
 - Lower Right: Modeled focus rejection function and testbed data (HLC and SPC)

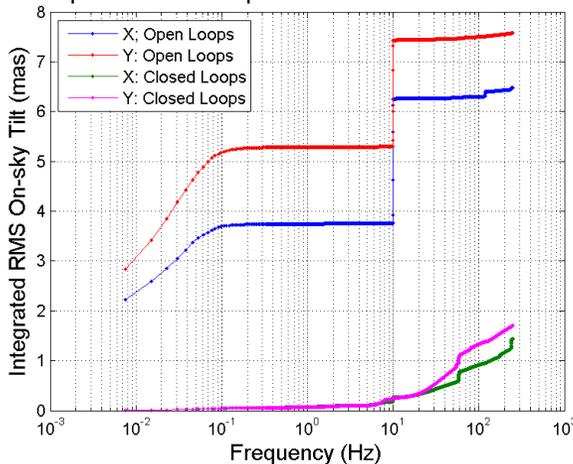
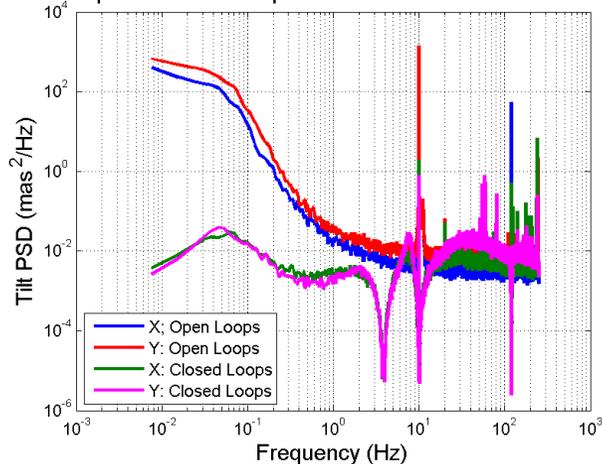
Focus Control

SPC LOWFS Sensed Focus (Z4)

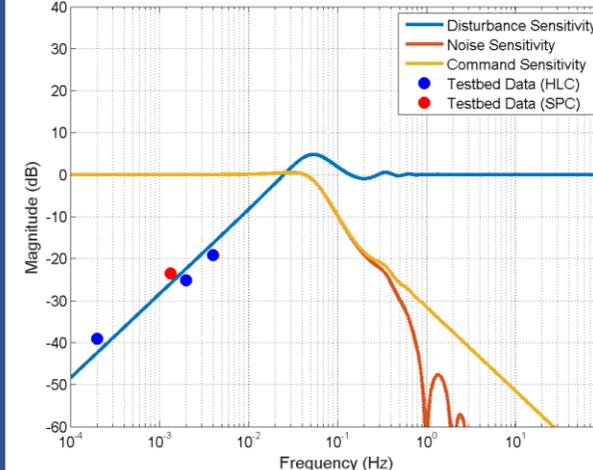


Line-of-Sight Control

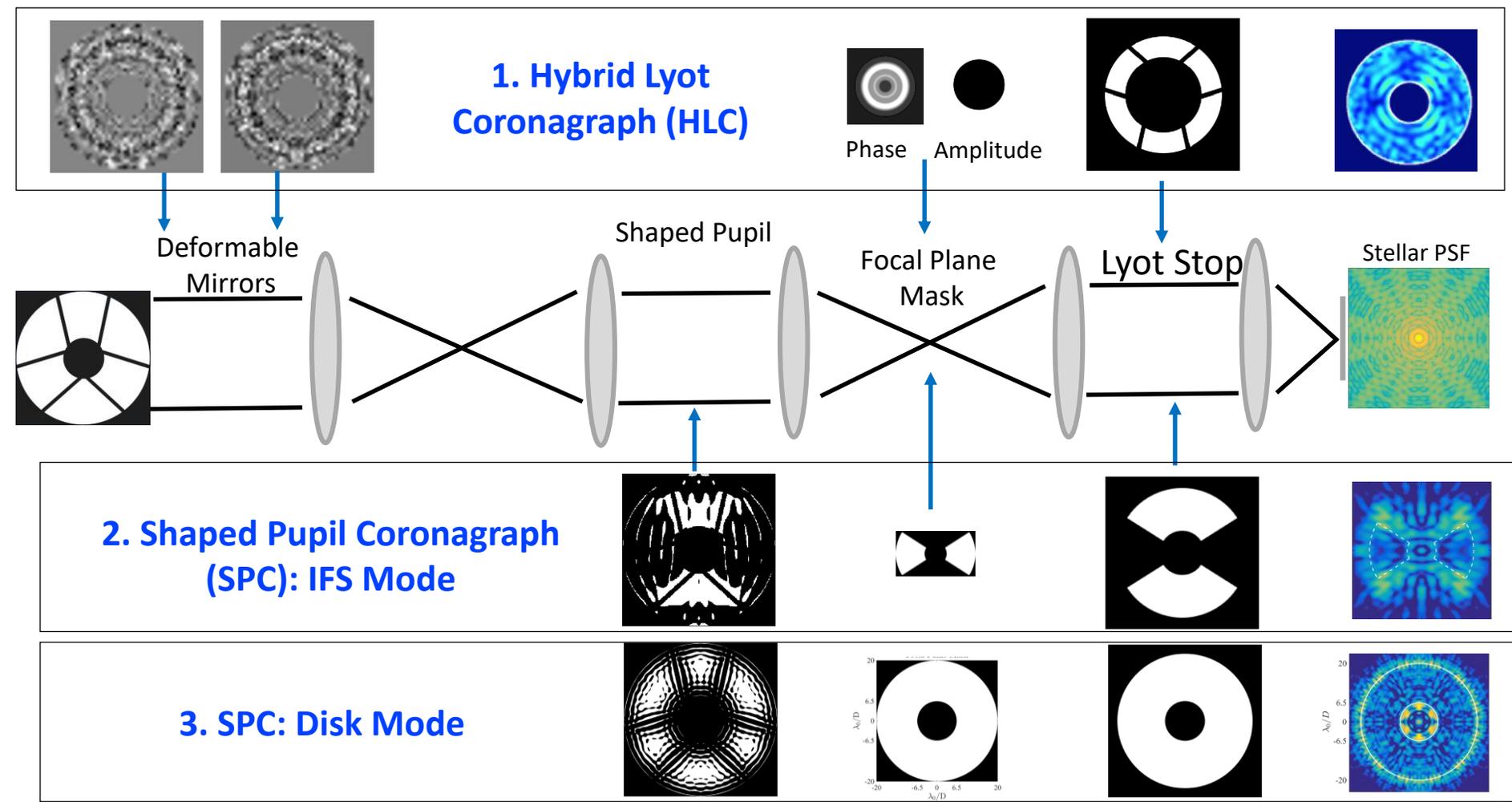
SPC Open & Closed Loops w/ OTA Disturbances: 2017-01-2 SPC Open & Closed Loops w/ OTA Disturbances: 2017-01-

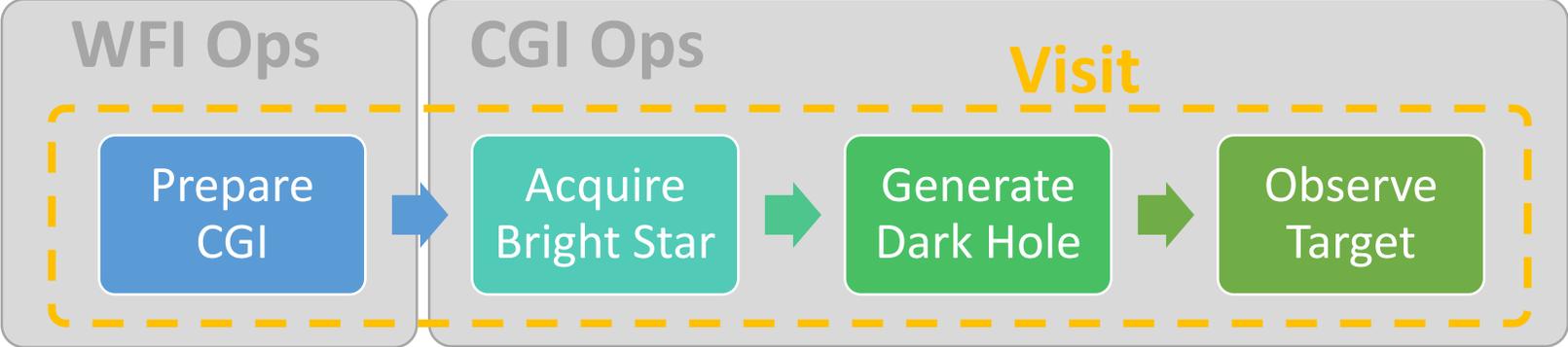


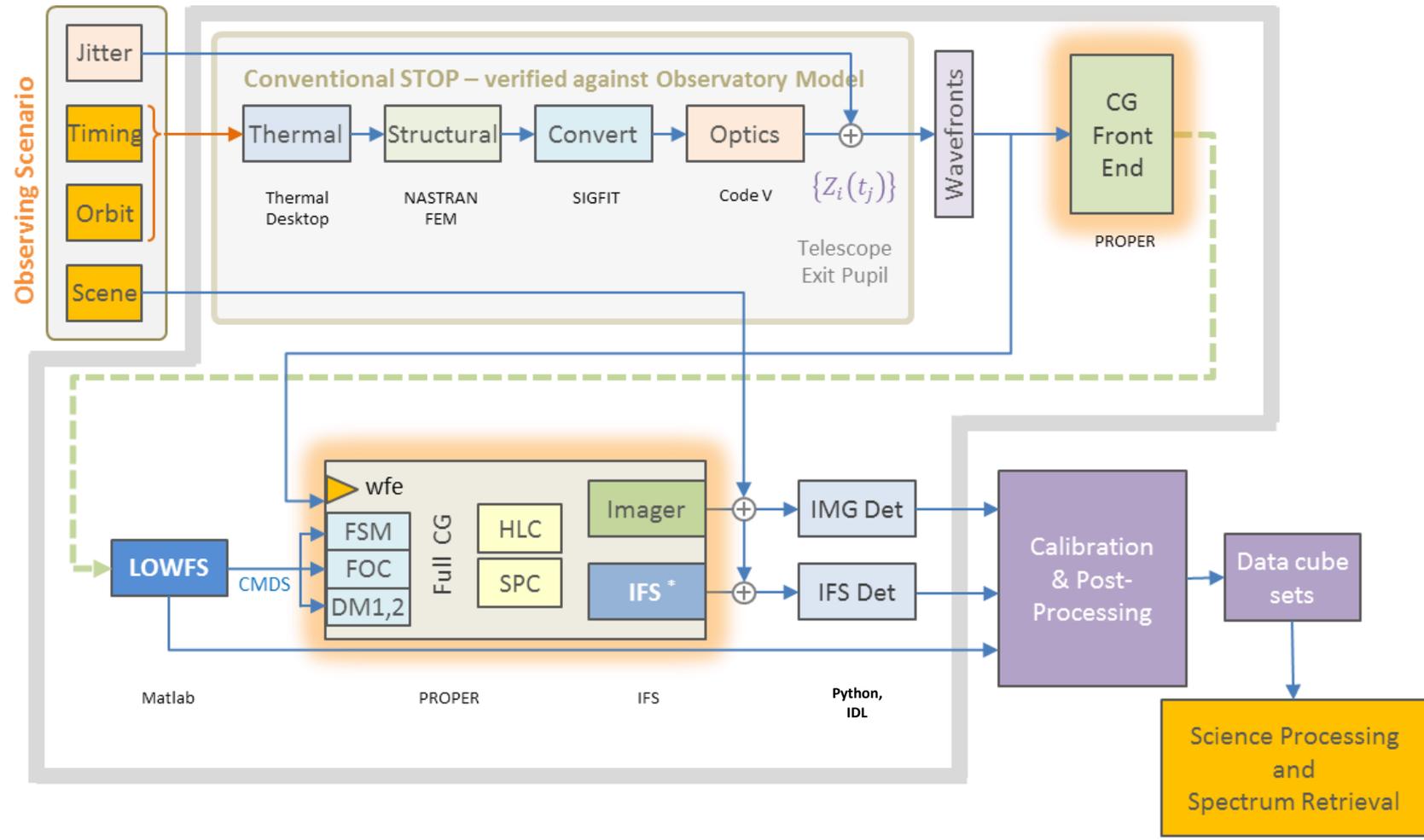
Testbed Focus Correction Loop Model and Data

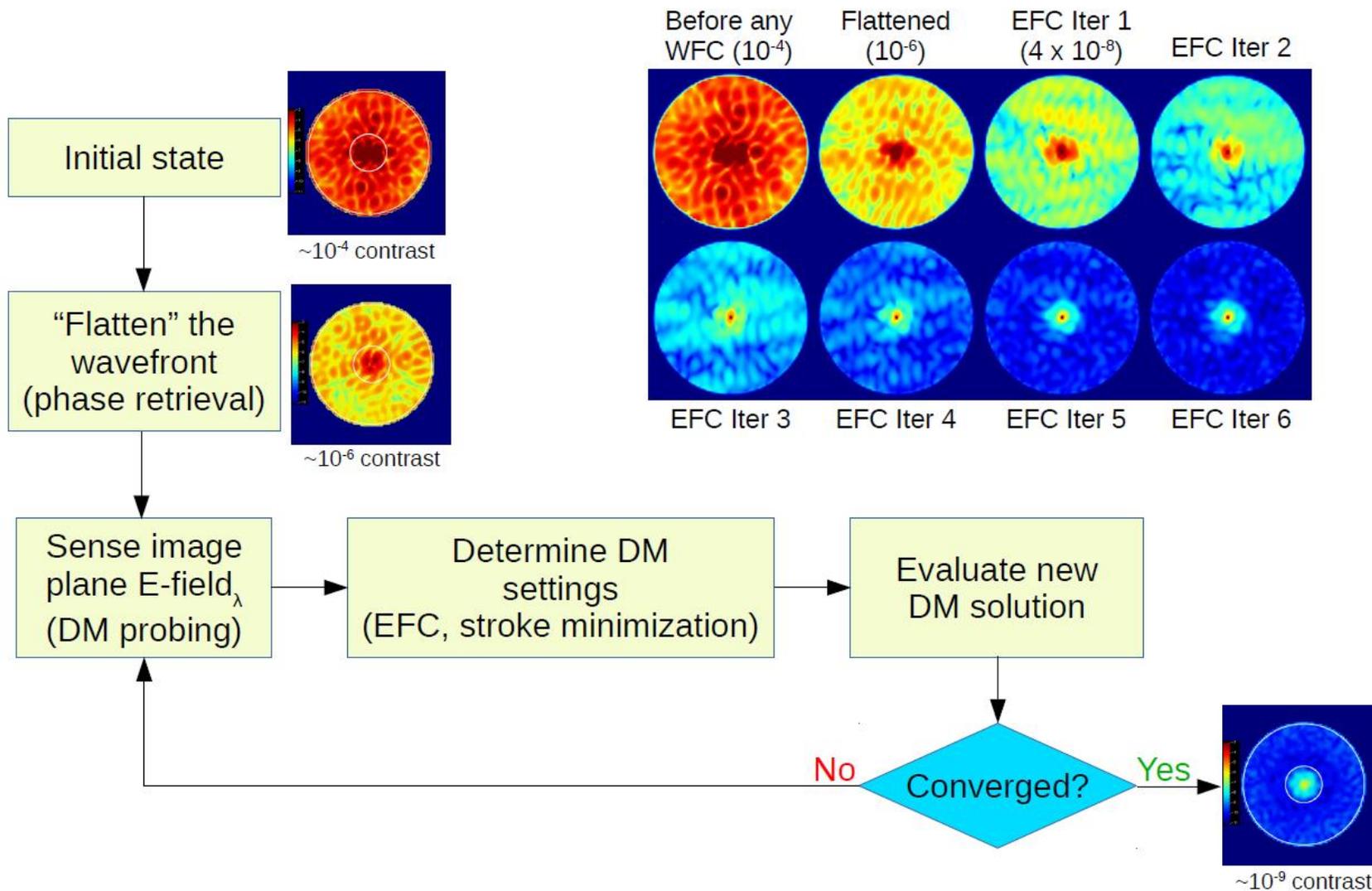


➤ Three interchangeable coronagraph observing modes via mask selection mechanisms

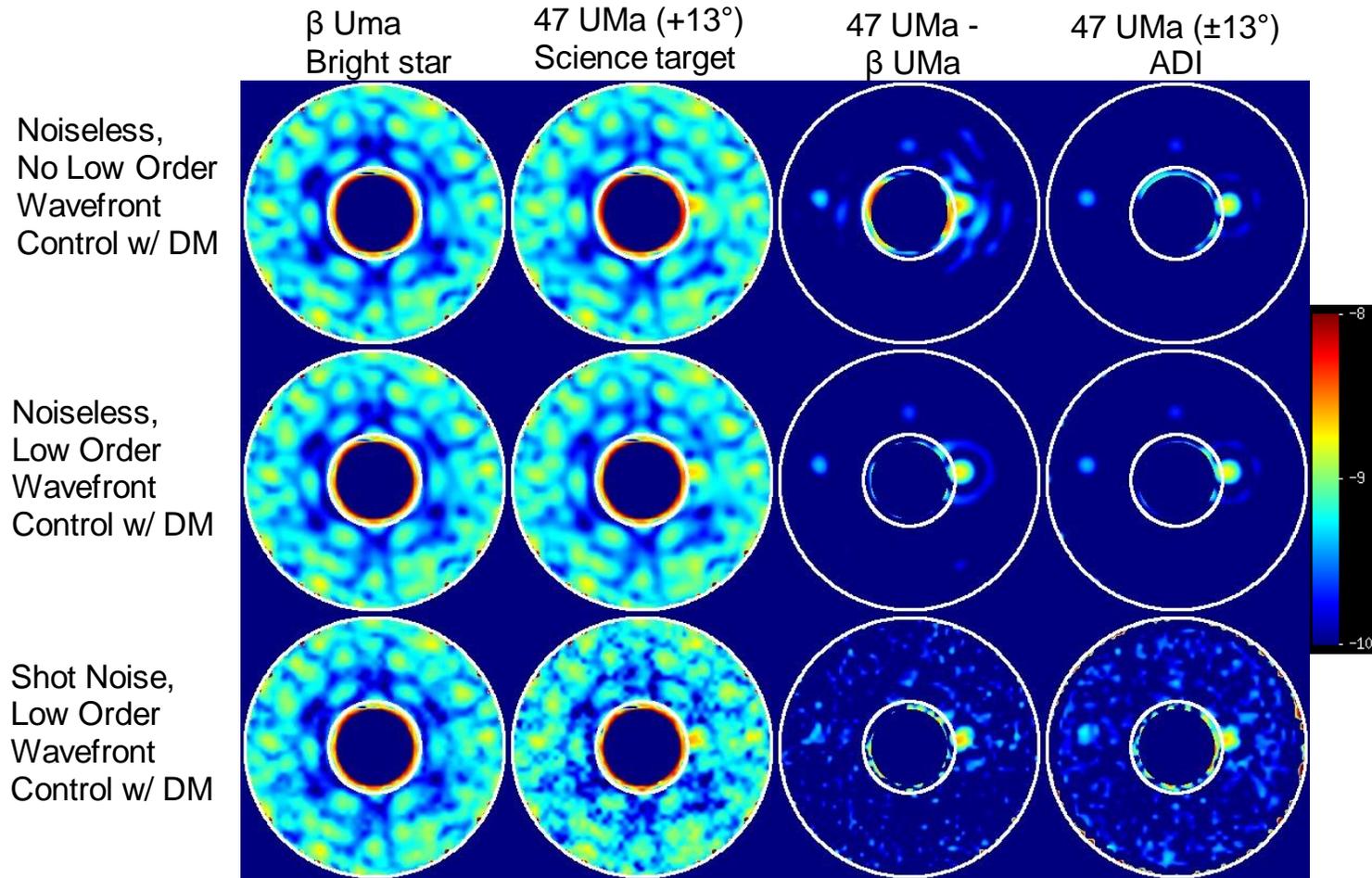








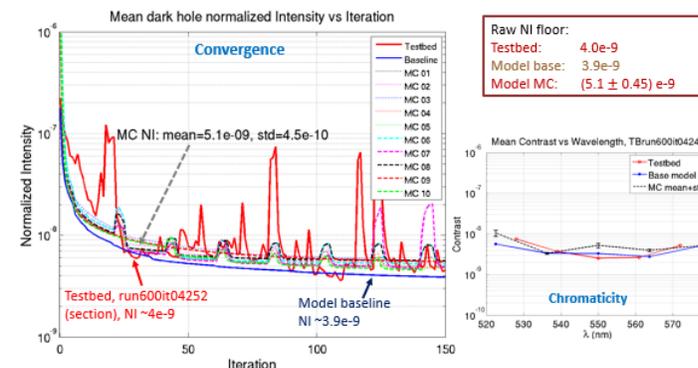
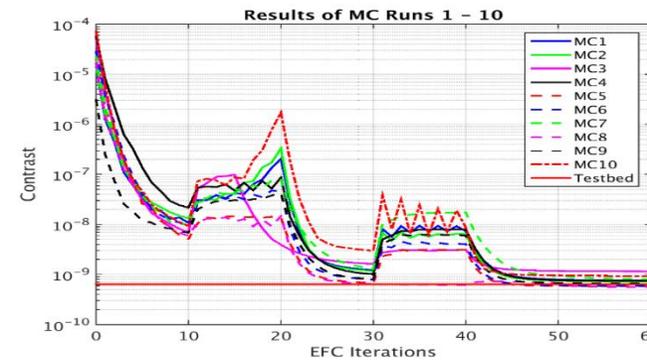
OS6 Example Post-Processing



- Validation included Monte Carlo modeling of uncertainties in testbed properties (alignments, DM actuator gains, etc) within the known measurement errors
- Comparisons were made of mean final field contrast, convergence rates, contrast vs. wavelength, and aberration sensitivities

Configuration	Case	Testbed	Model	Agreement
HLC	1	6.8E-09	4.6E-09	32%
	2	6.4E-10	7.5E-10	17%
SPC	1	2.0E-08	1.4E-08	30%
	2	4.0E-09	5.1E-09	28%

Reviewers' response: *"You did indeed demonstrate convincingly that you are within a factor of two (often <2) in the contrast floor predictions for both the Hybrid Lyot and Shaped Pupil coronagraphs. The agreement is demonstrated in the HLC radially averaged cases, the Zernike-mode sensitivities, and the chromaticity."*



❖ Good agreement between (fitted) testbed measured and model prediction; w/n ~1.5X of TB

