WFIRST Coronagraph
Flight Performance Modeling

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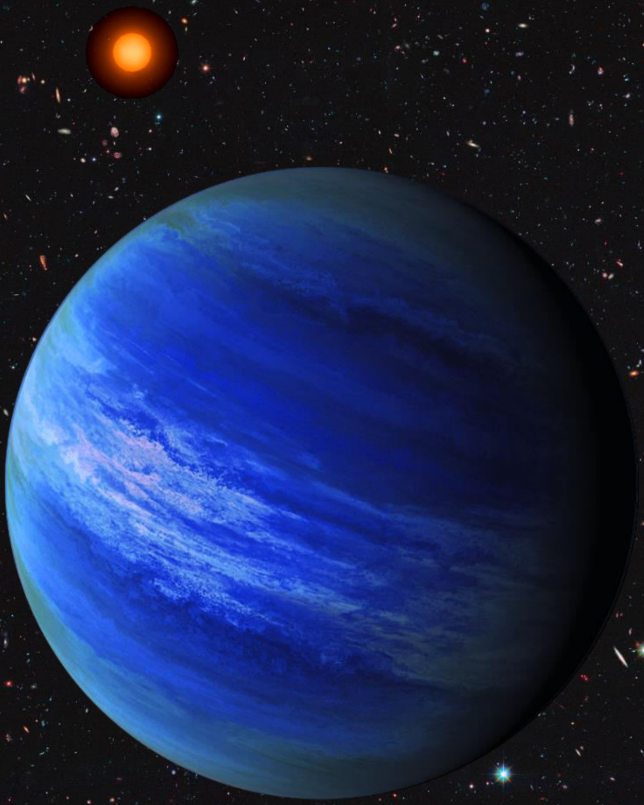


Jet Propulsion Laboratory
California Institute of Technology

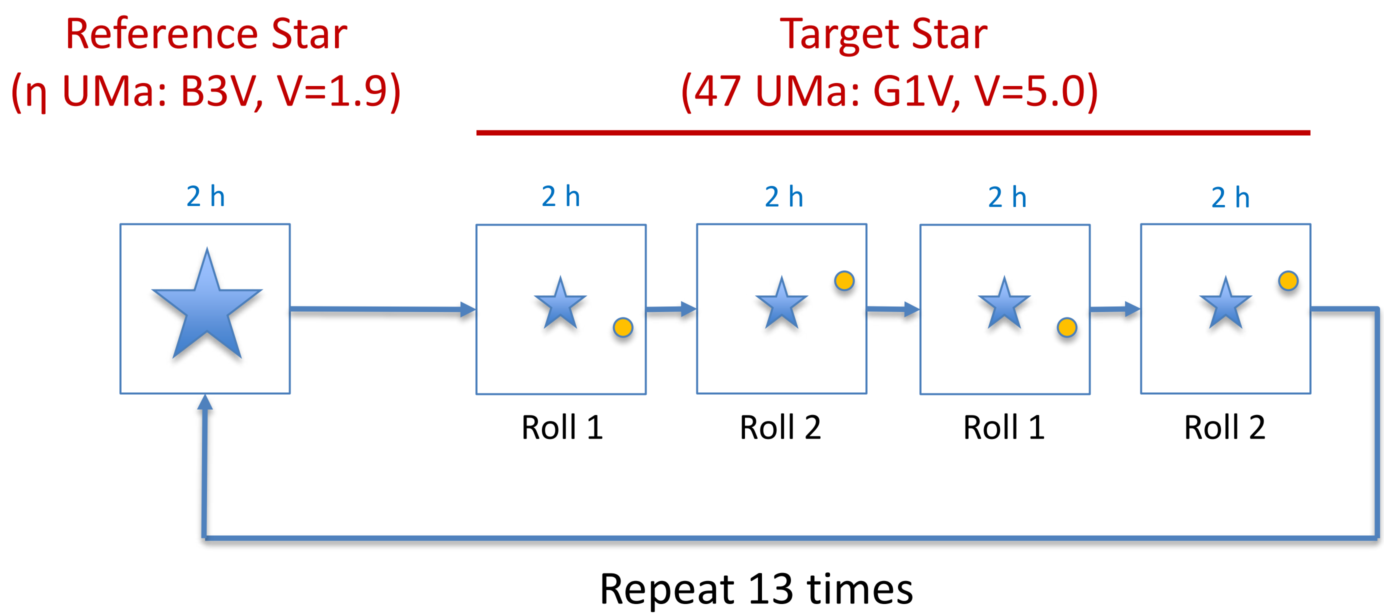
Observing Scenario Modeling

- Goal: Simulate a realistic WFIRST coronagraph (CGI) observing sequence
  - STOP modeling provides thermally-induced wavefront changes
  - Dynamic modeling provides pointing and wavefront jitter due to reaction wheel vibrations (provided by Goddard)
  - Optical modeling propagates wavefront through complete representation of realistically aberrated system to produce time series of speckle fields
  - IFS model (provided by Goddard)
  - Detector noise model

Observing Scenario 6 Definition

- 24 hours on 61 UMa to settle thermal model
- 8 hours on η UMa (B3V, V=1.86) for EFC
  - speckle time series will start in last 2 hours of this span due to timing of jitter model
- Observation sequence (repeating)
  - 8 hours on science target, 47 UMa (G1V, V=5.04)
    - 2 hours each at rolls of -13°, +13°, -13°, +13°
  - 2 hours on reference star, η UMa
- 10 minute slews/rolls

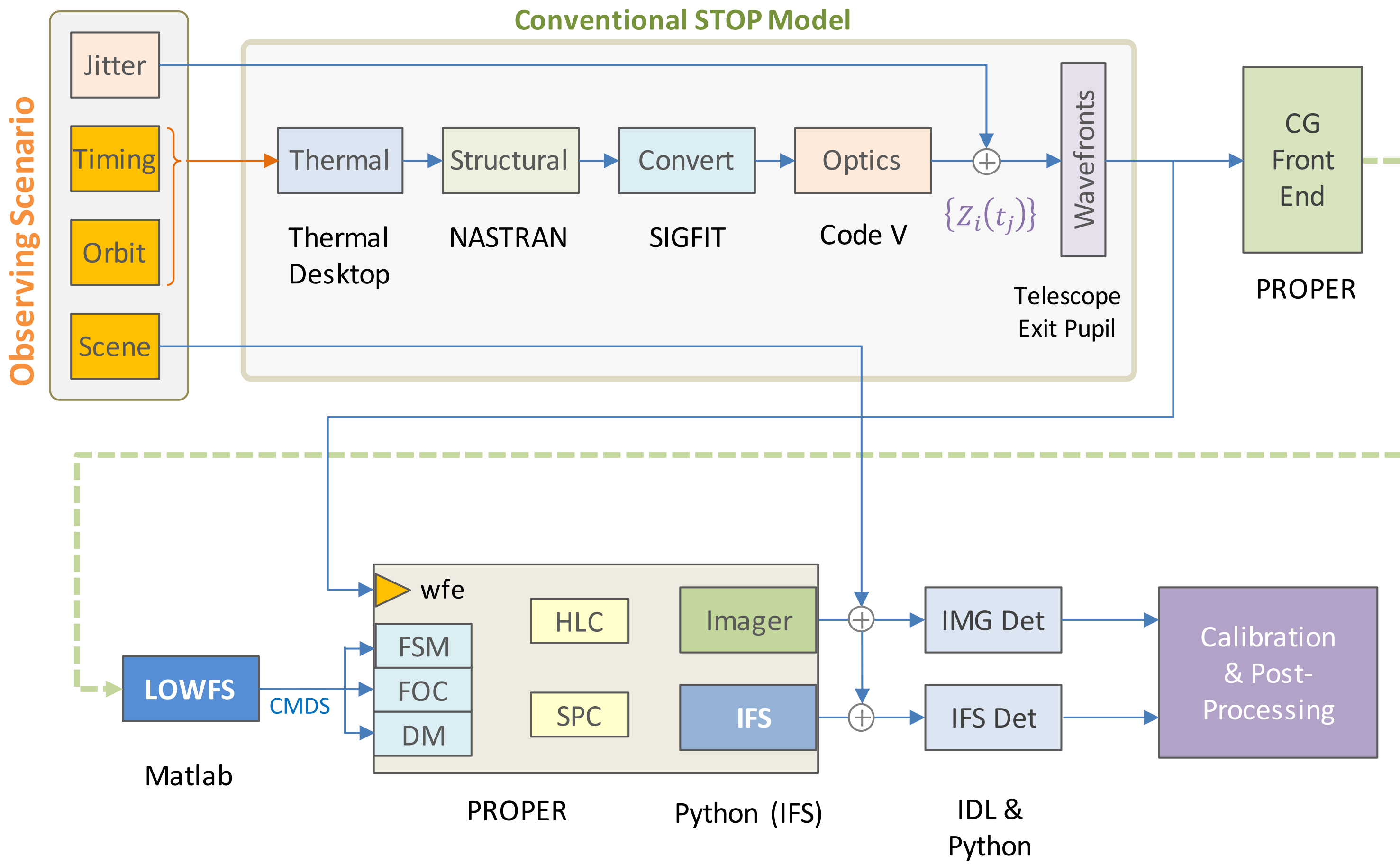
Observing Scenario 6



OS6 intended for integral field spectrograph observations. Direct imaging observations would take only 2 – 3 iterations instead of 13.

CGI Image Generation

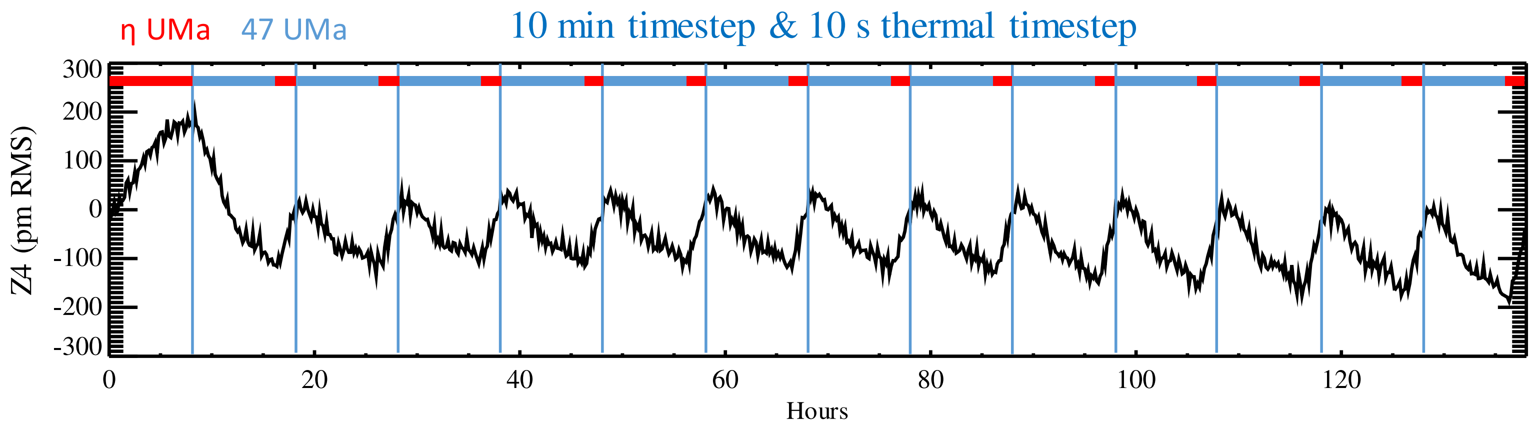
STOP = Structural/Thermal/Optical Performance



What's Old & New in Simulations

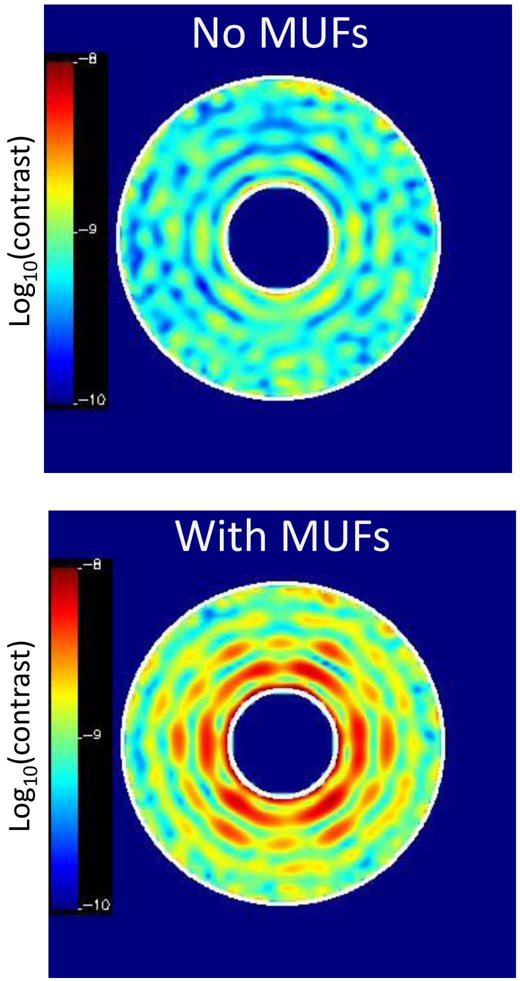
- Static optical aberrations & polarization
- Thermally-induced wavefront variations & LOWFS/C corrections
- Thermally-induced pupil shear and DM variations
- Variations in pointing & wavefront jitter due to changes in reaction wheel speeds over time
- Application of optical Model Uncertainty Factors (MUFs)
- Detector modeling (for HLC image stacks)

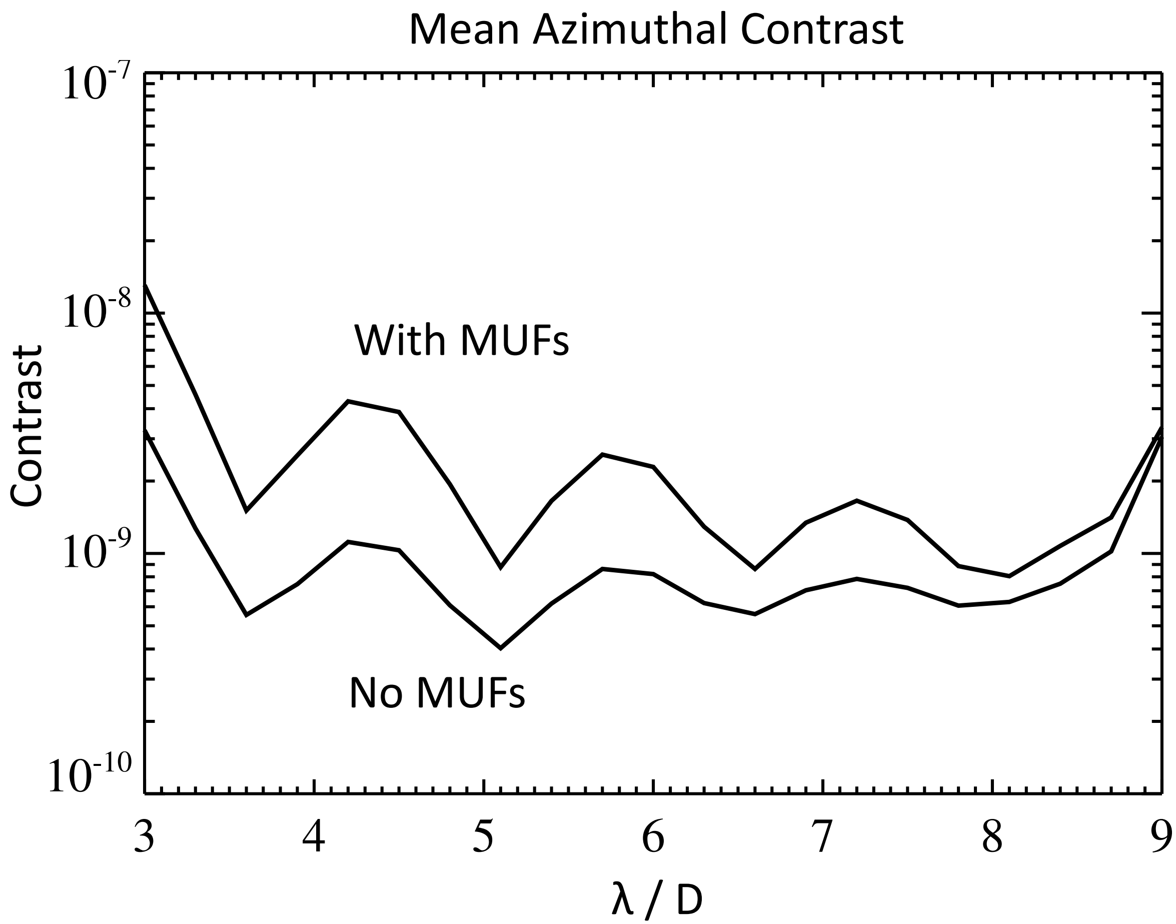
STOP Results: Focus vs Time
Observing Scenario 6



STOP model time to compute = 1 week

Polarization: With and Without MUFs



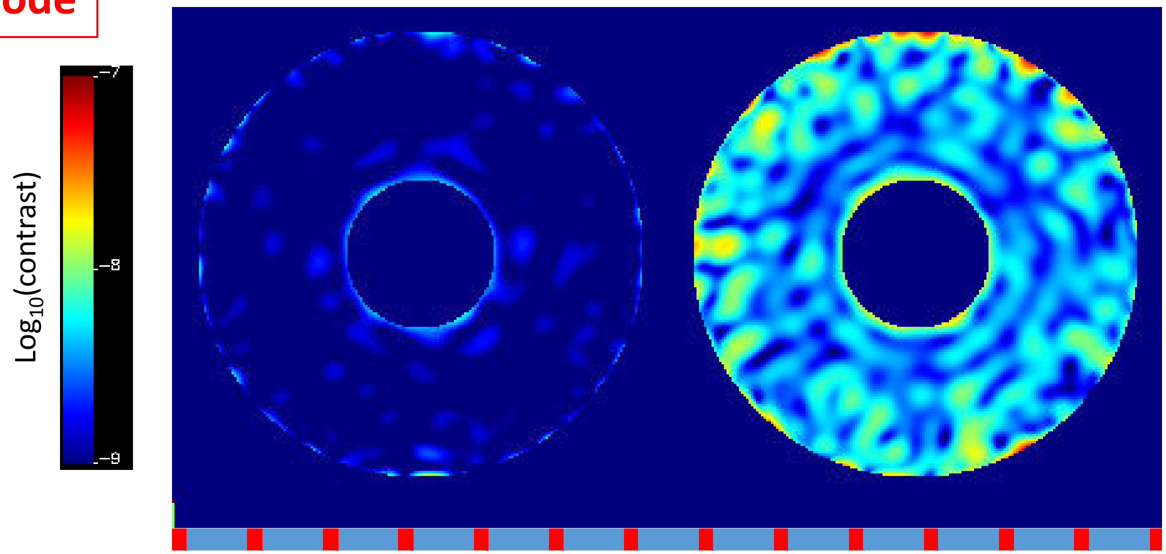


OS6 Speckle Field Time Series

Observing Scenario 6: HLC

Movie: View in slideshow mode

No Optical MUFs With Optical MUFs



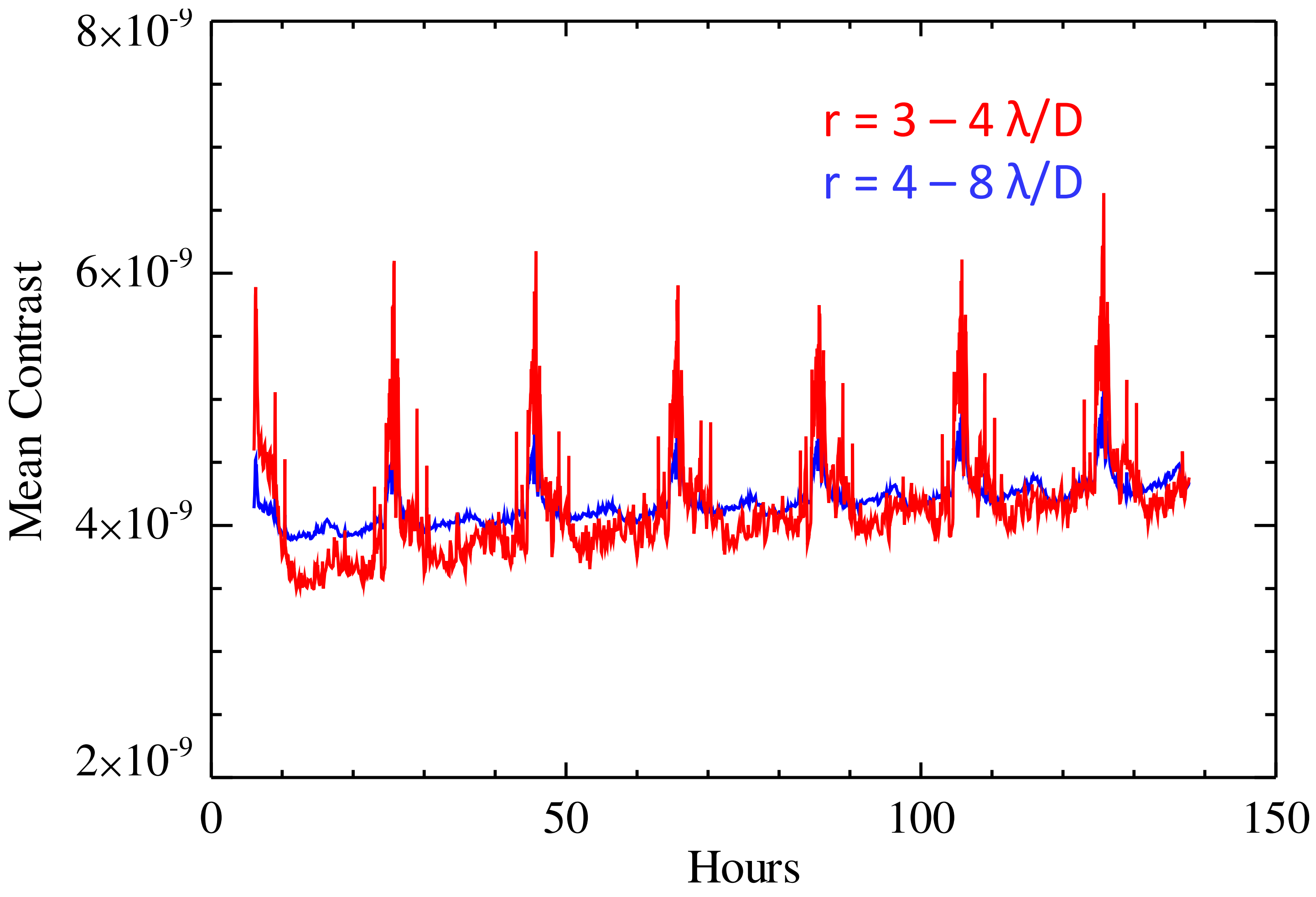
10% bandpass
λ_c = 575 nm

Includes: static aberrations (surface errors & polarization), high and low order wavefront control, thermally-induced wavefront aberration & pupil position changes, deformable mirror thermal drift, pointing & wavefront jitter, stellar diameters & colors

Field incident on detector shown. Detector effects not included

Contrast vs Time: with Optical MUFs

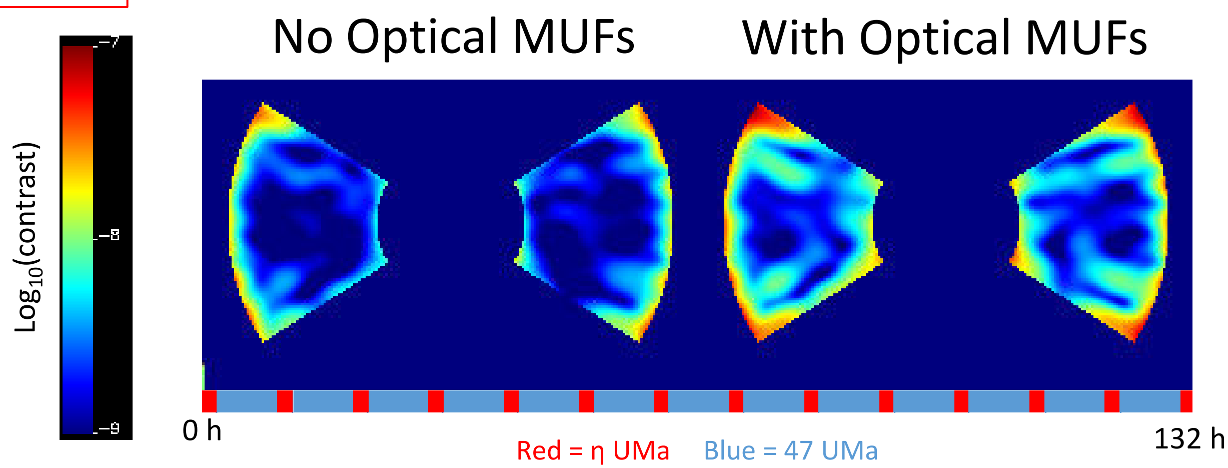
Observing Scenario 6: HLC



OS6 Speckle Field Time Series

Observing Scenario 6: SPC

Movie: View in slideshow mode



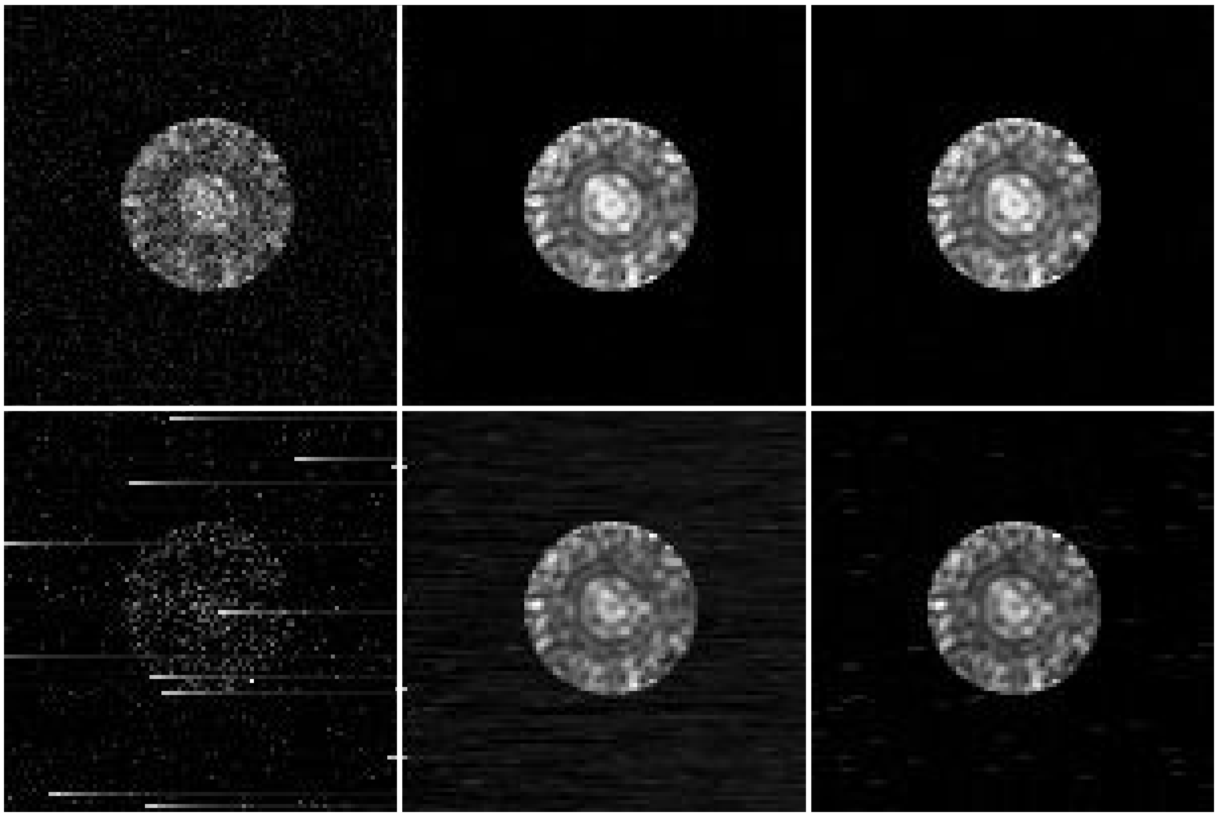
18% bandpass
λ_c = 760 nm

This and HLC OS6 simulated time series data available at ***wfirst.ipac.caltech.edu***

Field incident on detector shown. Detector effects not included

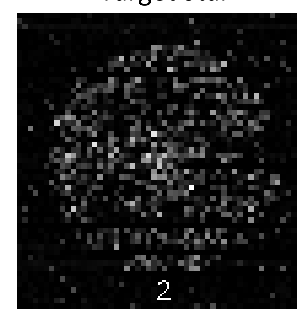
EMCCD Model
Observing Scenario 6: With Optical MUFs

	120 sec	Co-added images 26 hours (ref) 48 hours (target)	Quick 'n dirty Co-add + CR rejection
Reference star (V = 1.9)			
Target star (V = 5.0)			



Ref = 3 sec/frame
Target = 30 sec/frame

Target Star



Minutes total exposure time (1st 2 hours)

Movie: View in slideshow mode

Note: Detector modeling software does not currently handle cosmic rays in short (3 sec) exposures properly

EMCCD Model
Observing Scenario 6: No Optical MUFs

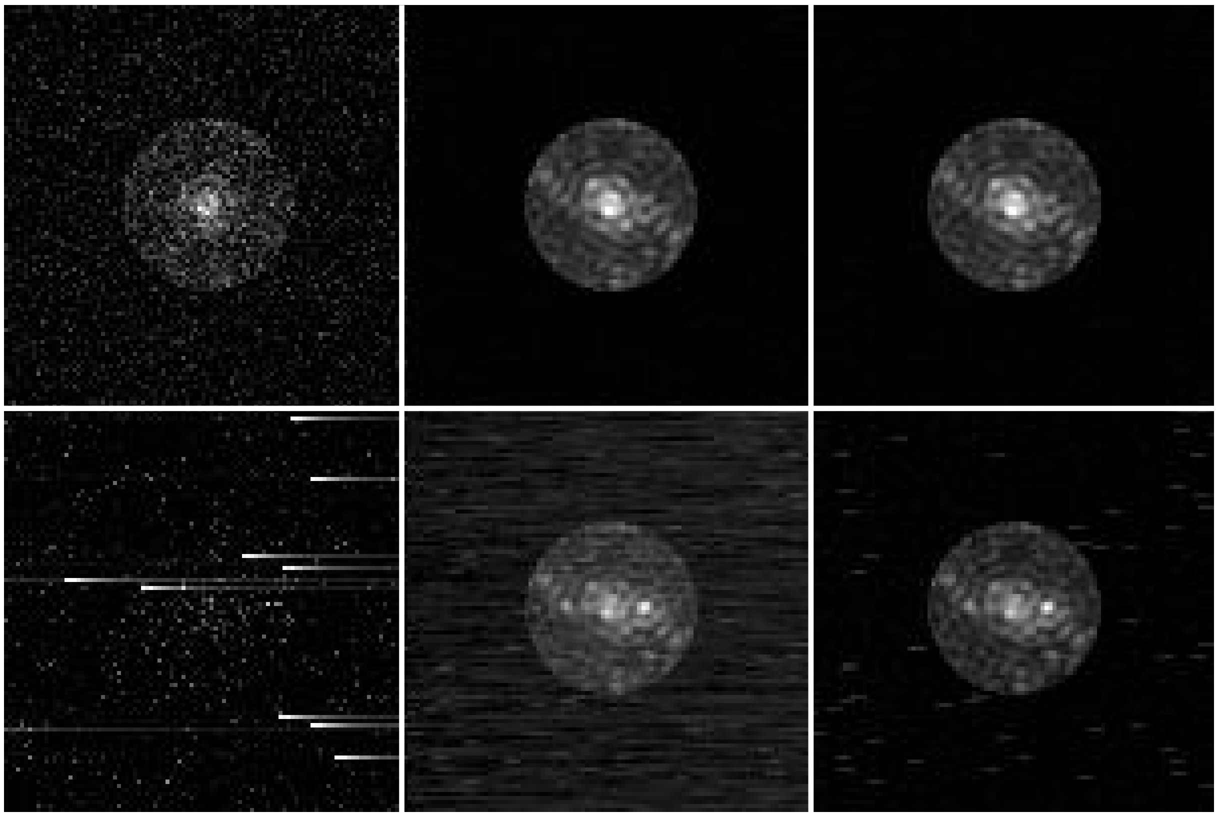
Co-added images
26 hours (ref)
48 hours (target)

120 sec

Quick 'n dirty
Co-add + CR rejection

Reference star (V = 1.9)

Target star (V = 5.0)



Ref = 3 sec/frame
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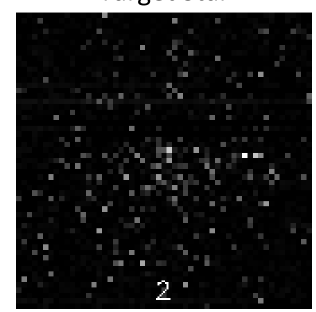
Target Star



Minutes total exposure time (1^{st} 3 hours)

Movie: View in slideshow mode

Note: Detector modeling software does not currently handle cosmic rays in short (3 sec) exposures properly

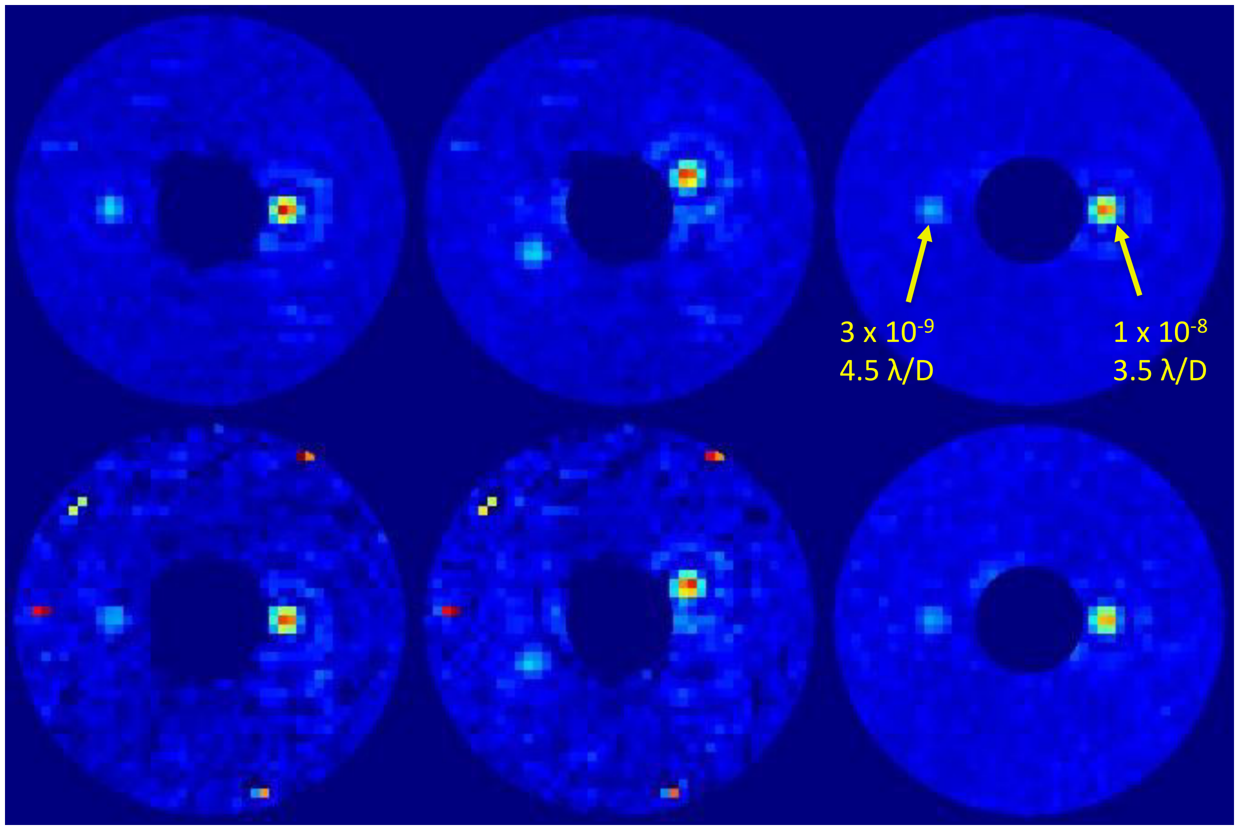
HLC OS6 Example Post-Processing
Observing Scenario 6: With EMCCD

WFIRST
WIDE-FIELD INFRARED SURVEY TELESCOPE
ASTROPHYSICS • DARK ENERGY • EXOPLANETS

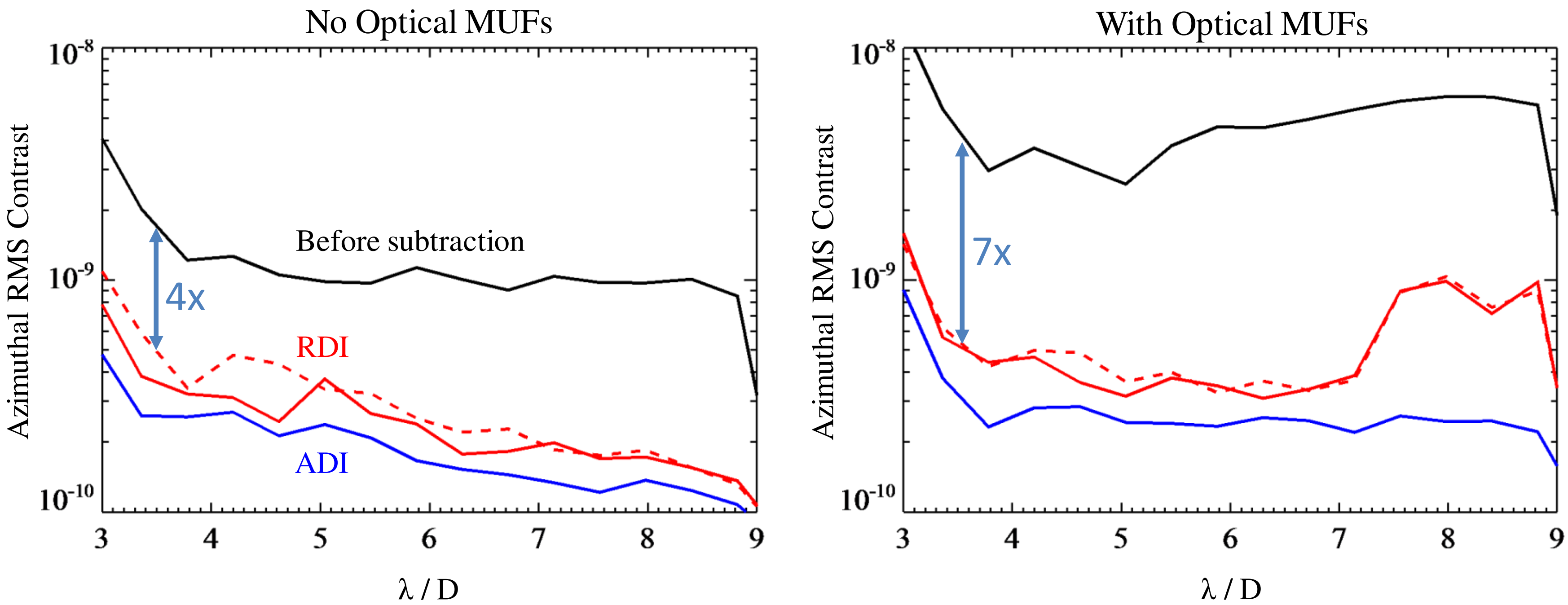
Target Star Roll 1 - Reference Star | Target Star Roll 2 - Reference Star | Angular Differential Image (Target only)

No optical MUFs

With optical MUFs



HLC OS6 Example Post-Processing
Observing Scenario 6: With EMCCD



Phase B Modeling Activities

- Implement Phase B thermal/structural model, including detailed CGI model
  - Apply new MUFs that may be imposed
- Incorporate new knowledge of DM behavior
- Run more observing scenarios, including investigating the effects of internal CGI heat sources (electronics) and DM response to thermal changes
- OS6 simulations available from

  wfirst.ipac.caltech.edu