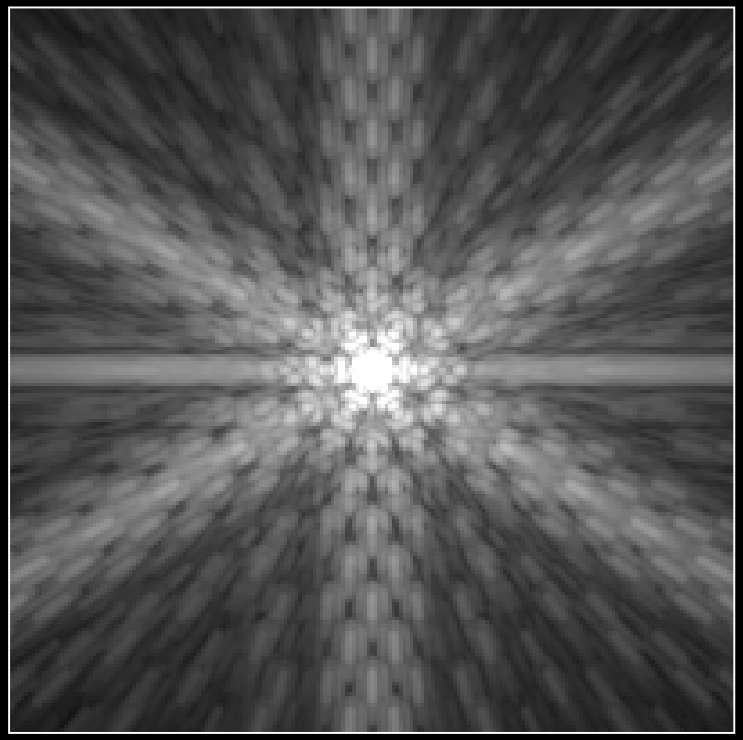
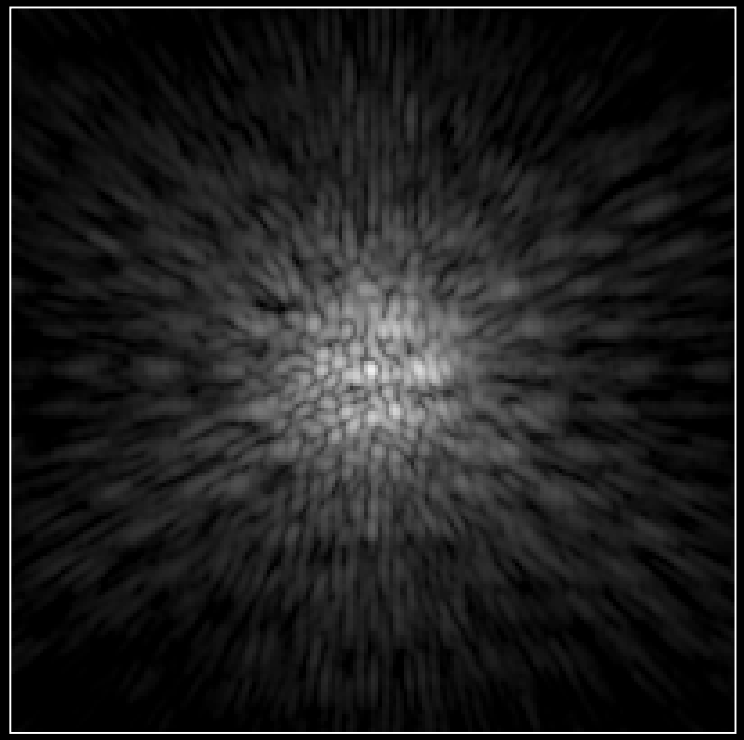
# JWST NIRCam Coronagraphic Performance



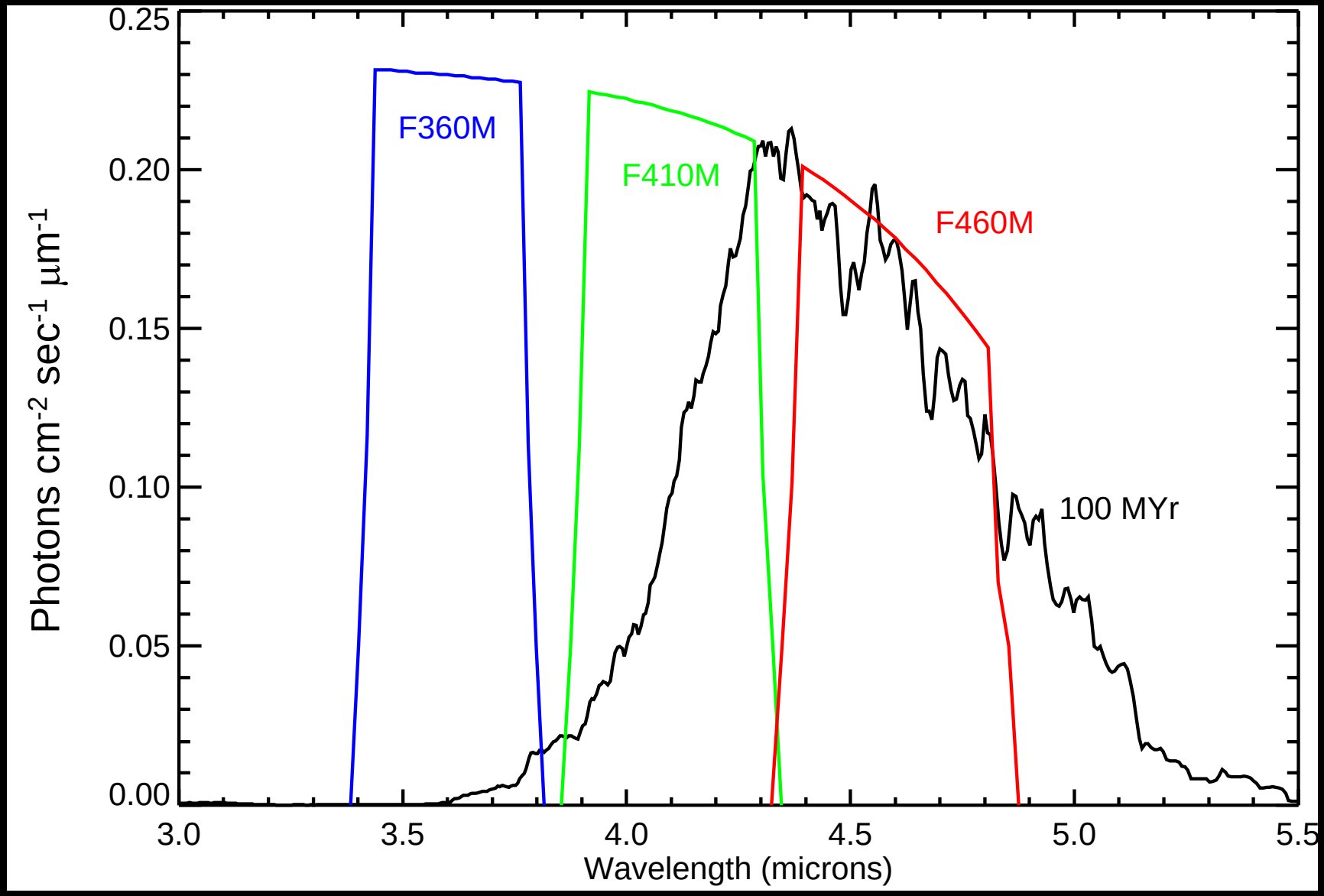
Without Coronagraph



With Coronagraph
(Spot occulter)

John Krist (Jet Propulsion Laboratory/Caltech)
12 May 2016

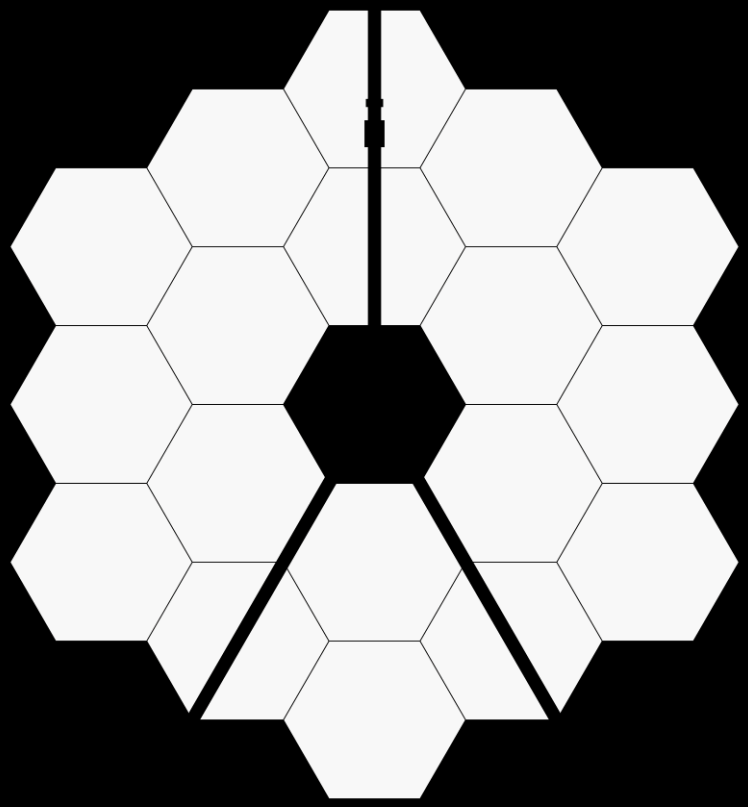
# 100 Myr-Old, 2 $M_{Jup}$ Planet



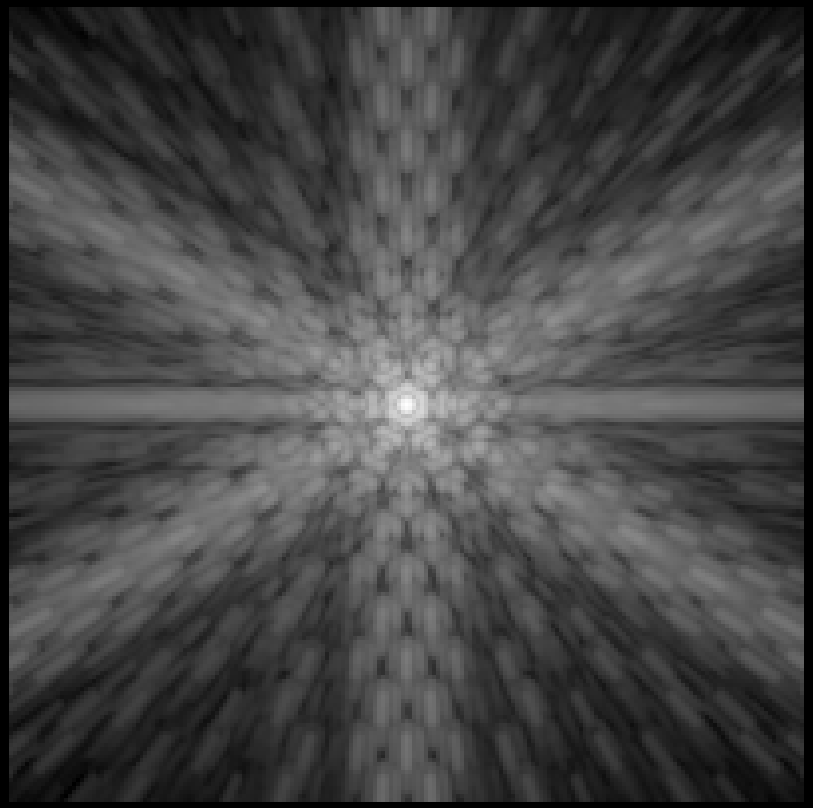

*Spectrum from Burrows, Sudarsky, & Lunine (2003)*

# JWST PSF

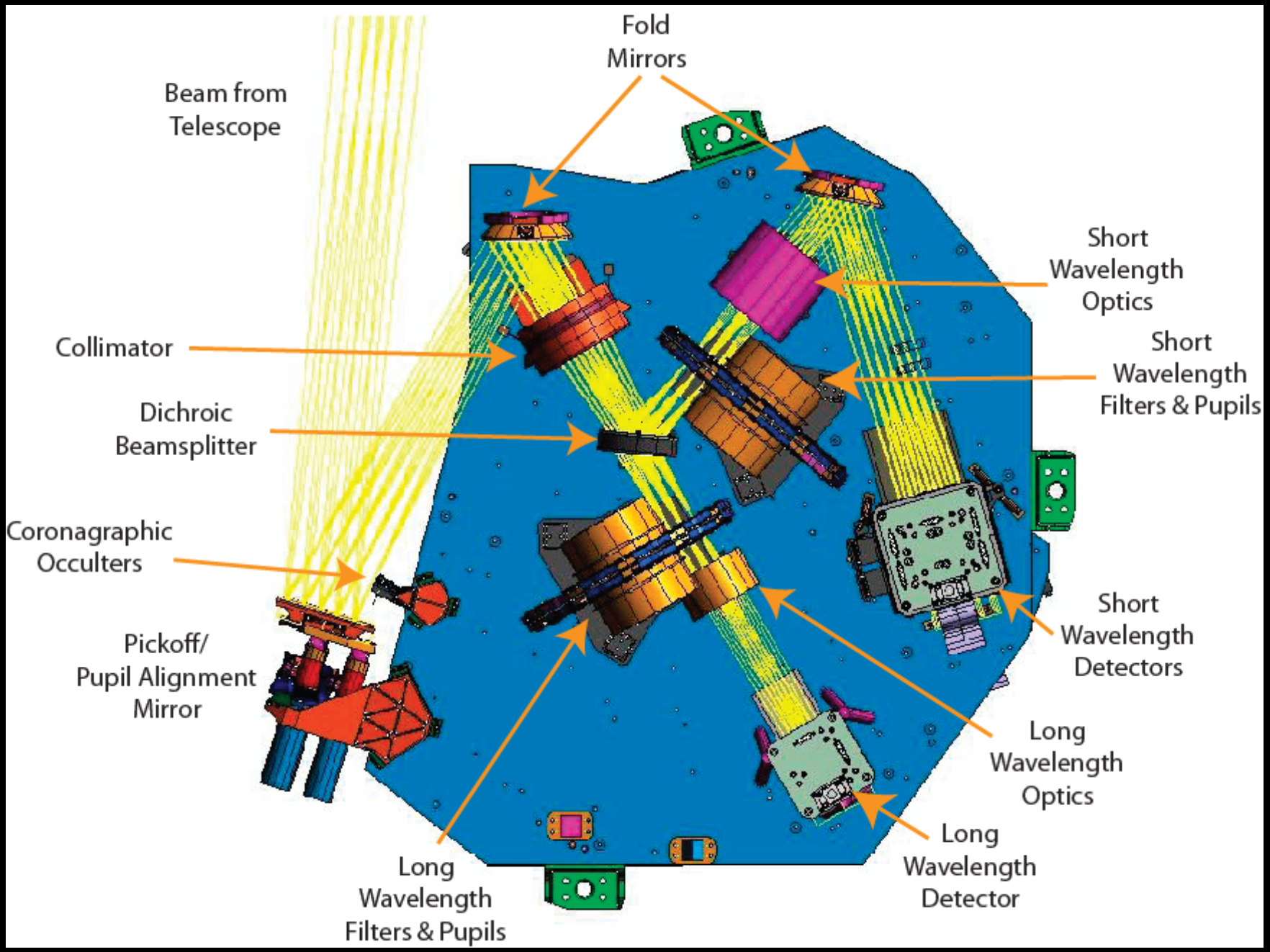
JWST Aperture Pattern



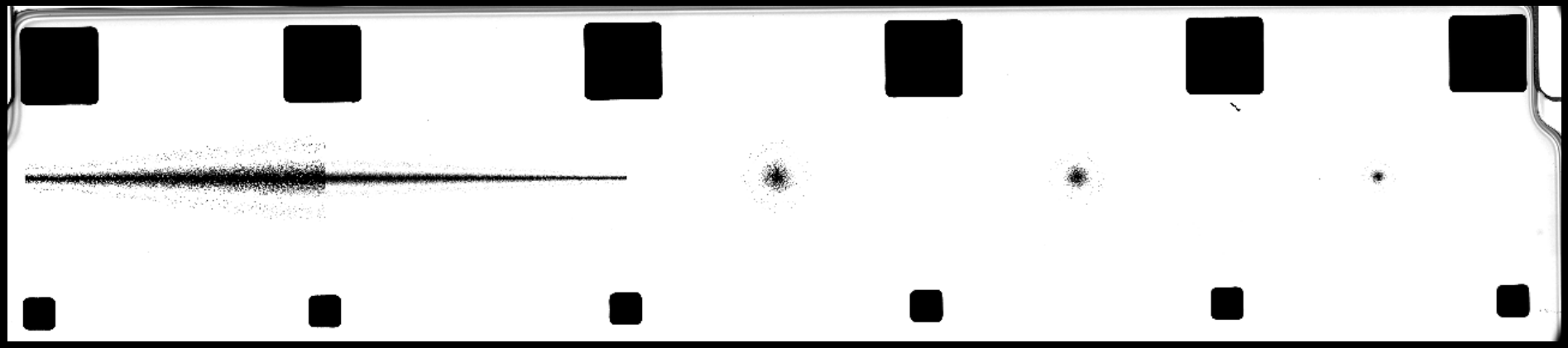
PSF (NIRCam F460M)



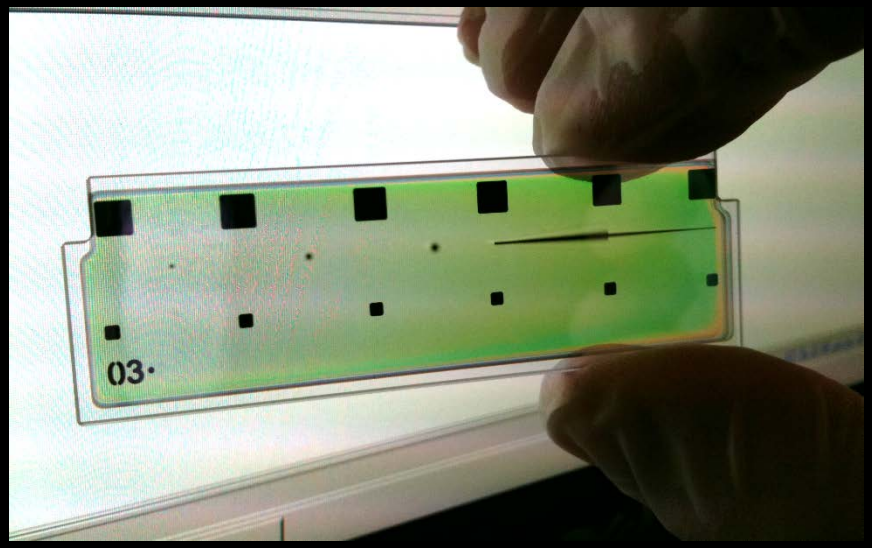
# NIRCam Layout



# NIRCam Occulters

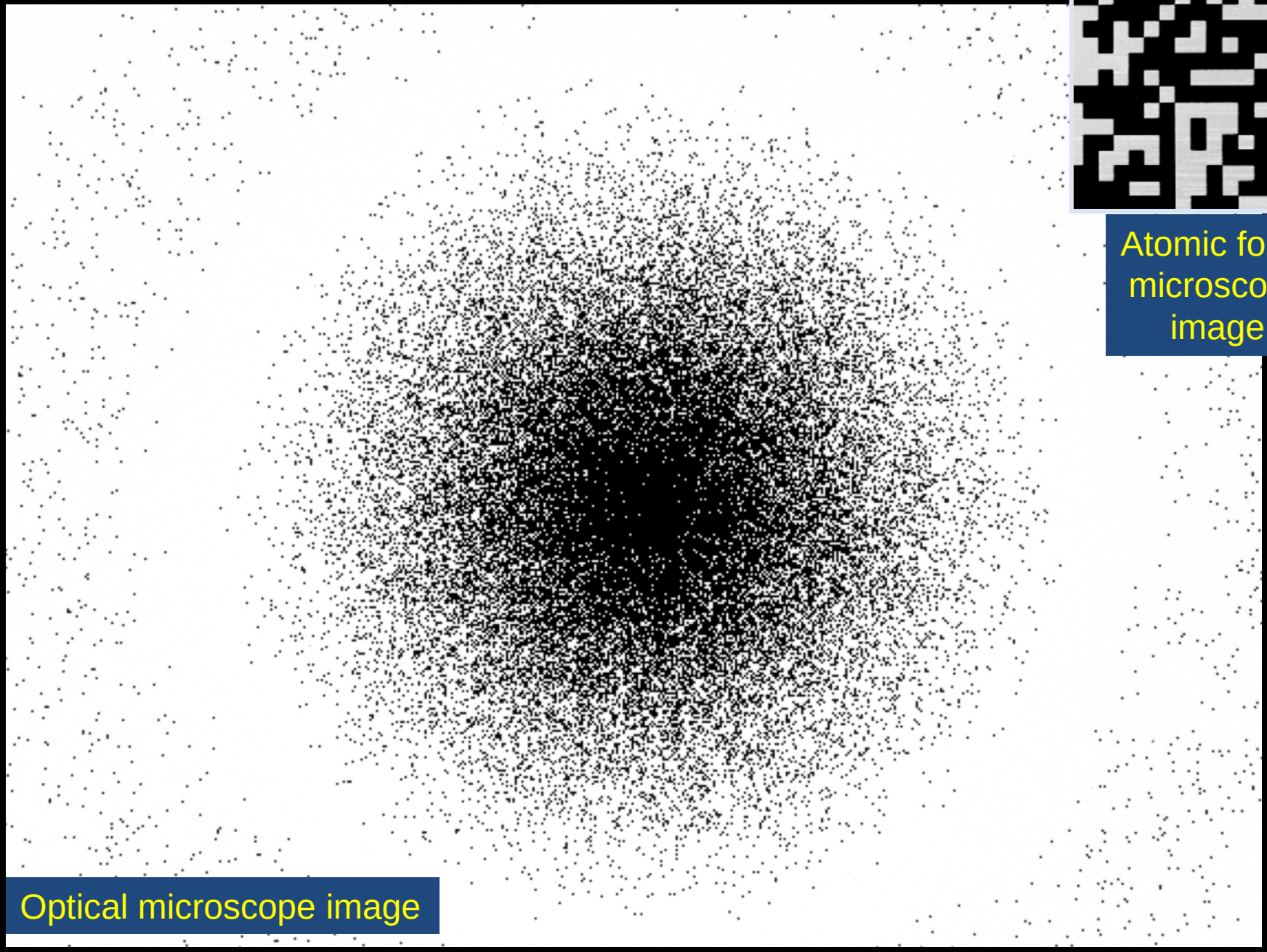



| | MBLW | MBSW | M430R | M335R | M210R |
|---|---|---|---|---|---|
| HWHM= | 4 λ/D @ 4.6 μm<br>0.6” | 4 λ/D @ 2.1 μm<br>0.3” | 6 λ/D @ 4.3 μm<br>0.8” | 6 λ/D @ 3.35 μm<br>0.6” | 6 λ/D @ 2.1 μm<br>0.4” |



# Occulting Spot Magnified

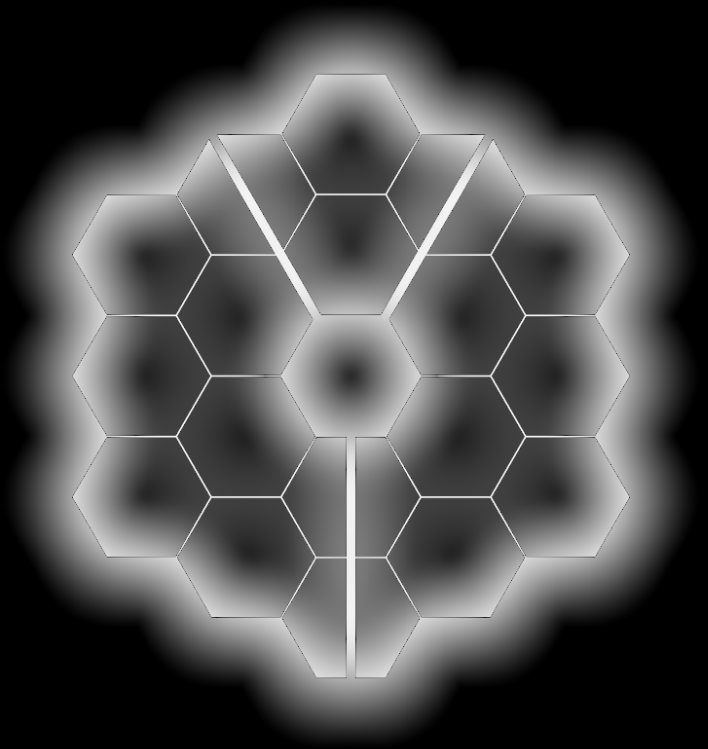
Atomic force microscope image



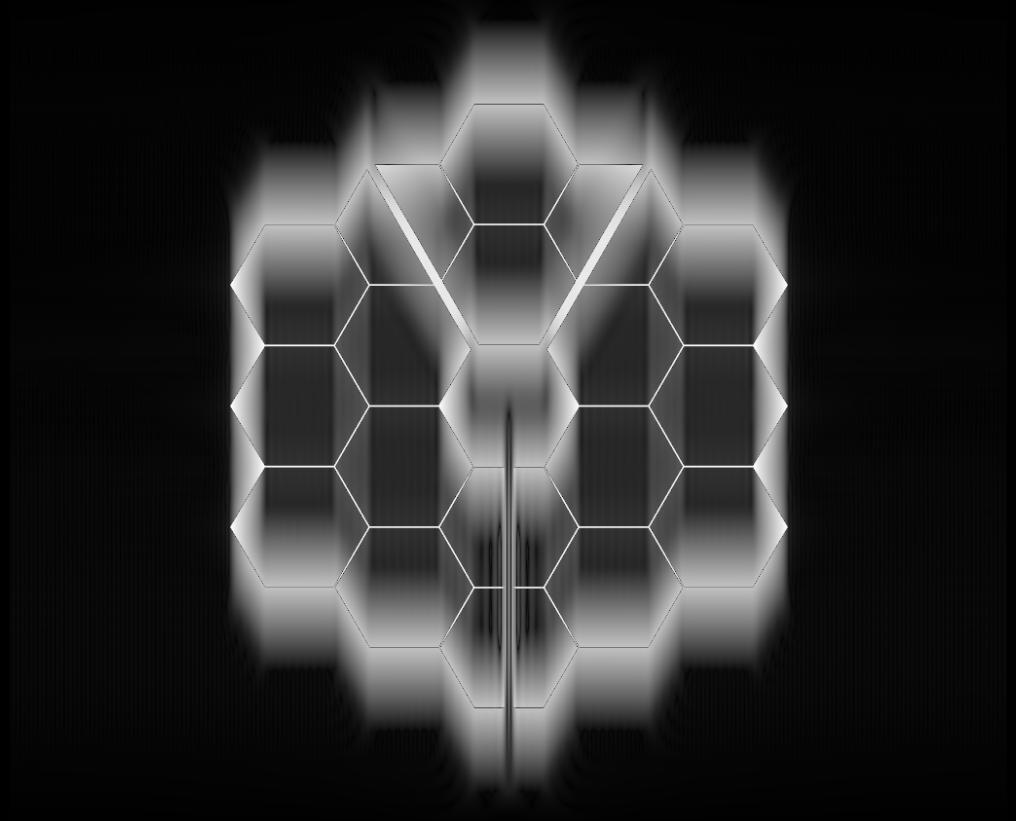
Optical microscope image

# Pupil Intensity at Lyot Stop for an Occulted Point Source

Using 6λ/D spot occulter



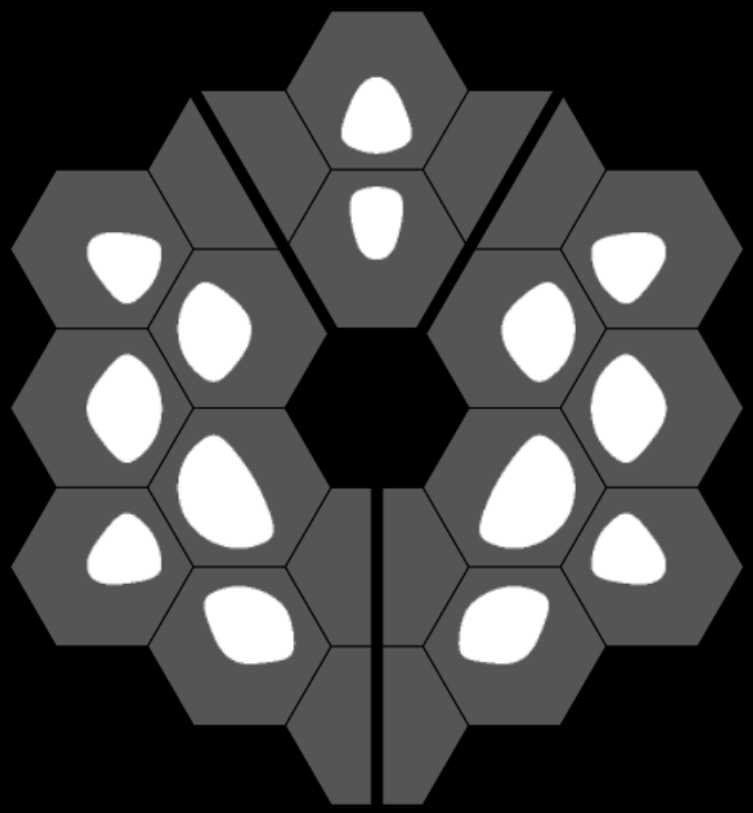
Using 4λ/D wedge occulter



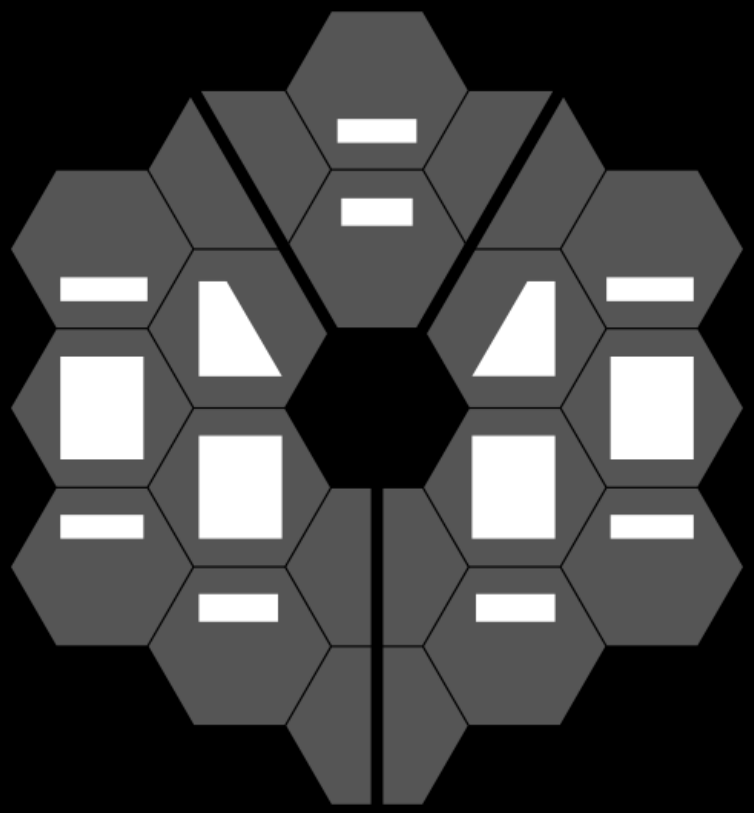
1/5th root intensity stretches

# NIRCam Lyot Stops

*Mask Openings (white) Superposed on Pupil*



Lyot stop for
6λ/D spot occulters



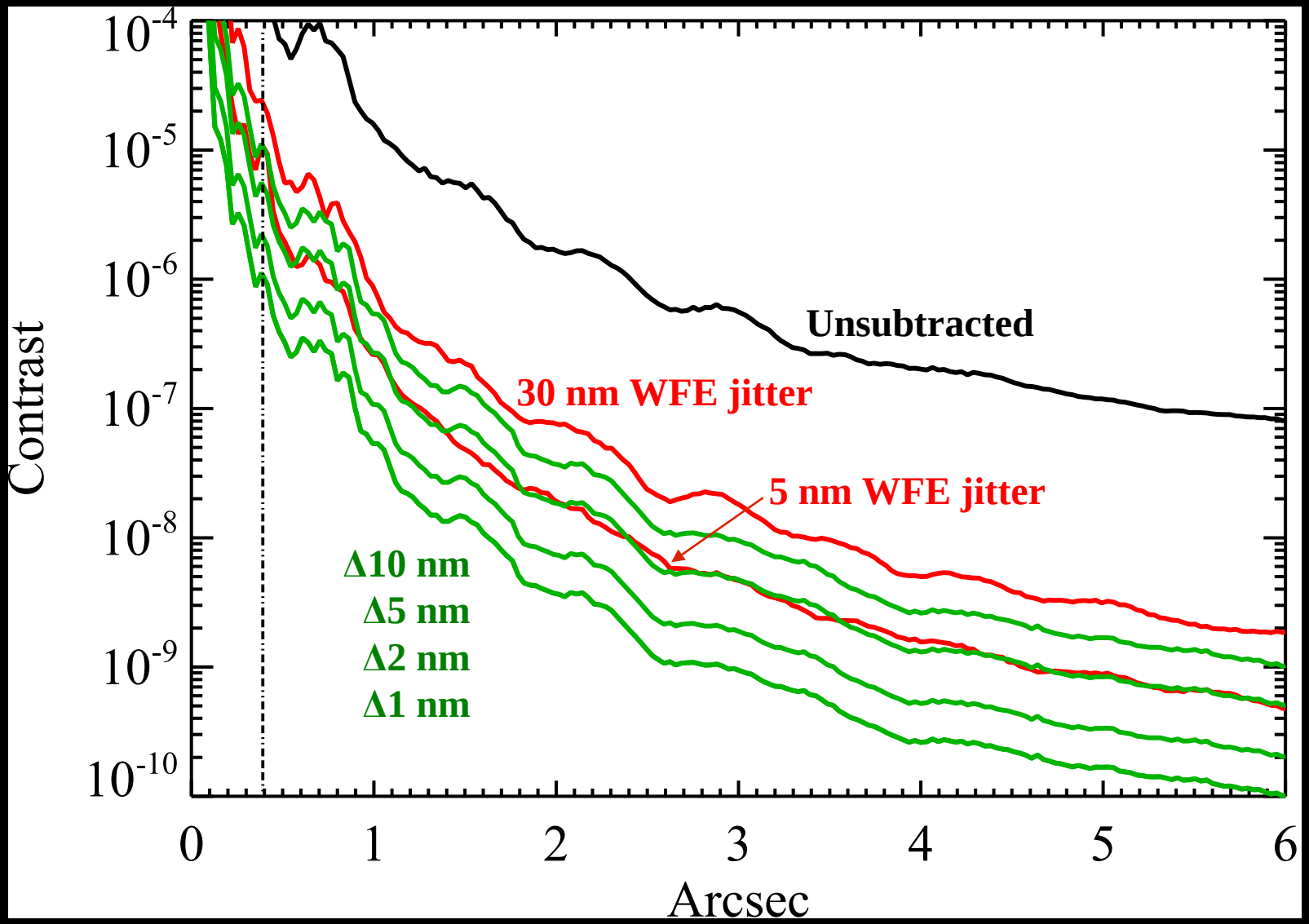
Lyot stop for
4λ/D wedge occulters

Transmission = 19%

*Stops are metal coatings on the pupil wedges*

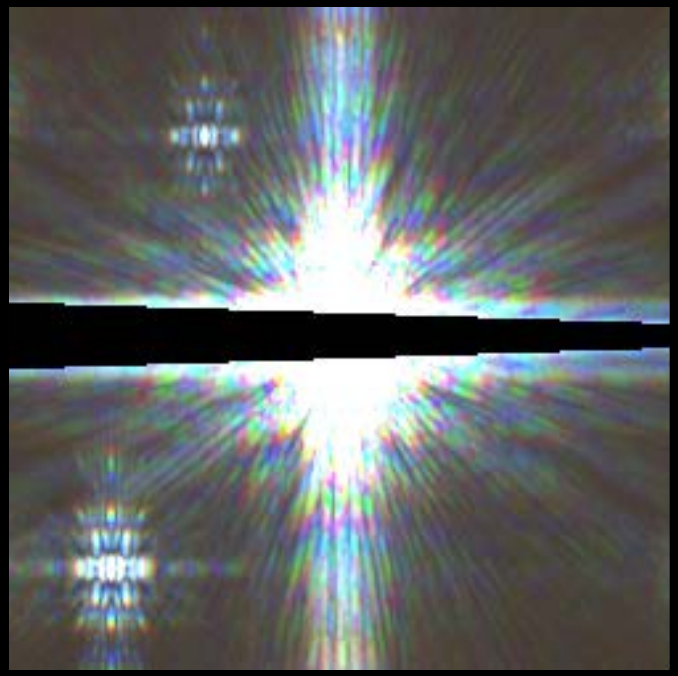
# F210M Spot_2.1

Azimuthal RMS Contrast (1σ post-processing speckle noise)

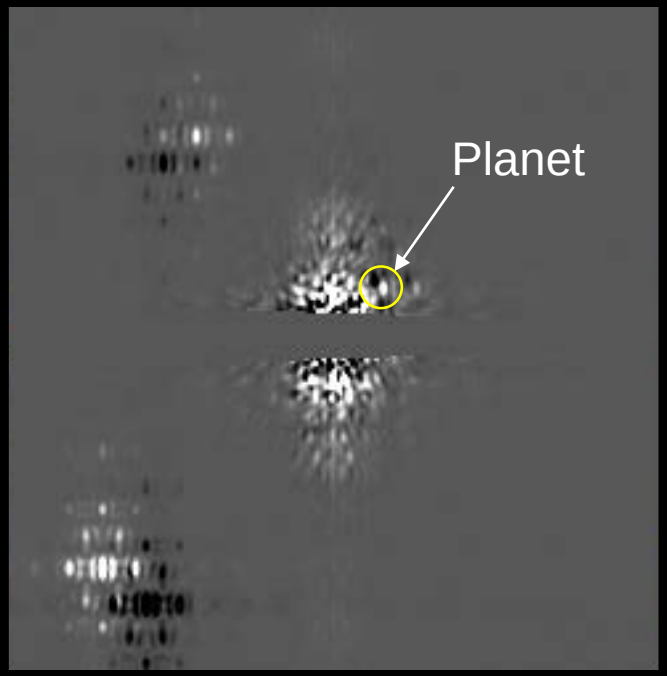


# Multi-bandpass Planet Observations

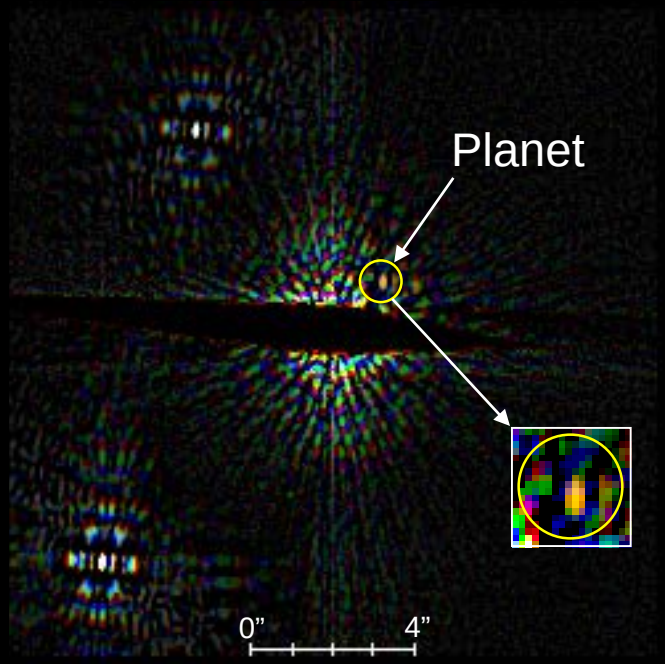
Multi-filter
Combined, Unsubtracted



F460M
Orient 1 – Orient 2 (10º)



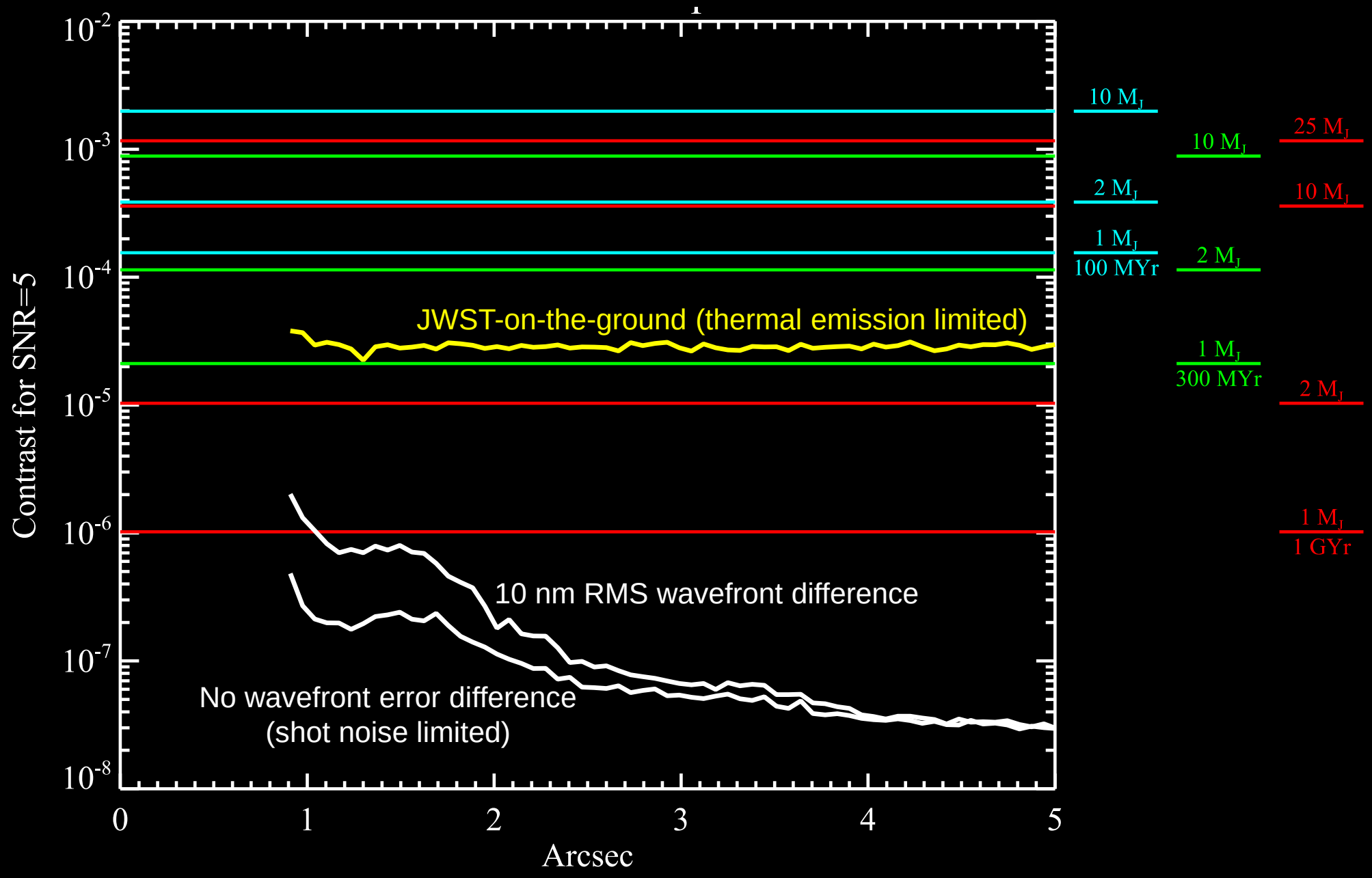

Multi-filter
Combined, Subtracted




Red = F460M
Green = F410M
Blue = F360M

1 Gyr-old M0V star @ 4 pc
2 $M_{Jup}$ planet @ 7 AU
5000 sec / filter / orientation

# M0V star at 4 pc, F460M+spot, 2-roll ADI, 10000 sec/roll

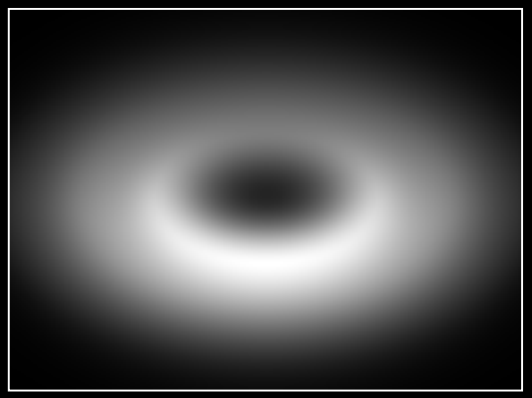


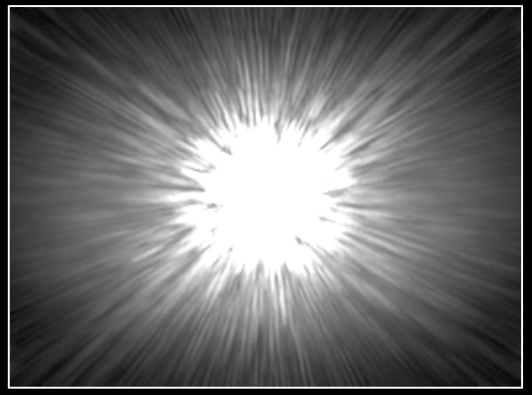
# Circumstellar Disk Simulation

A0V star @ 100 pc, *r* = 0.4” spot occulter

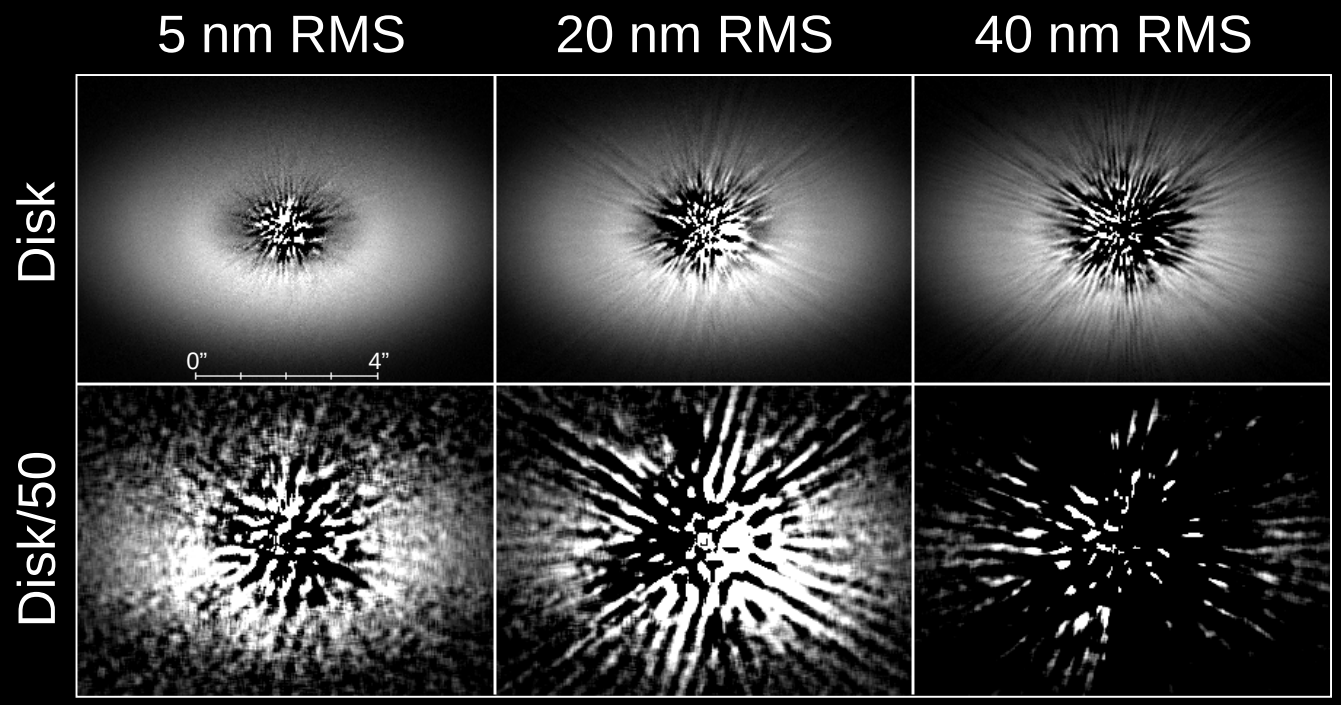
*After subtraction of a similarly imaged A1V reference PSF star with the given amount of wavefront error change*

Disk Model





Disk Model + Coronagraph




Disk is ~3x Beta Pic optical depth

Chromatic effects from pupil wedge not included

# Summary

- The NIRCam coronagraph provides high-contrast imaging over λ=2-5 μm
  - bandpass limited by antireflection coating on occulter substrate
  - most NIRCam filters are available
- Imaging over 360° field using spot occulters to within 0.4”-0.8” of the star, depending on wavelength
  - Spot occulters will certainly be the most popular for discovery & disk imaging
- Imaging to within 0.3”-0.6” using the wedge occulters
- Post-processed contrasts of $10^{-6}$ – $10^{-7}$ are likely achievable within ~2” of the star