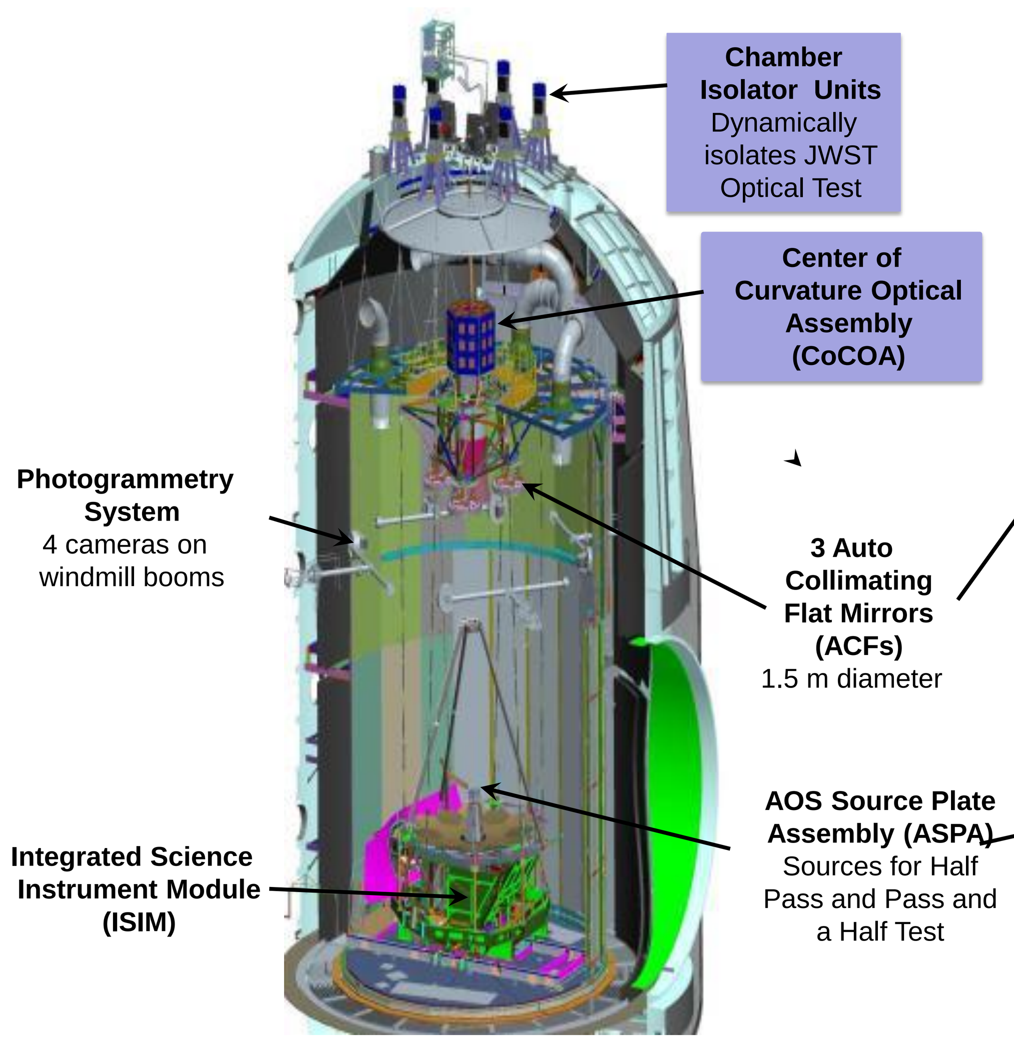
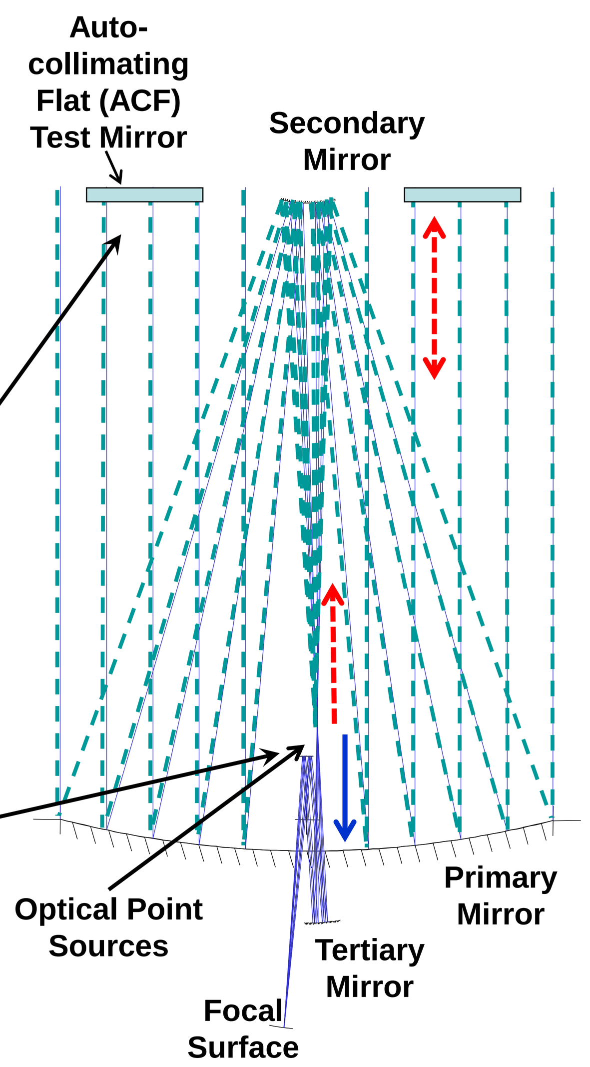
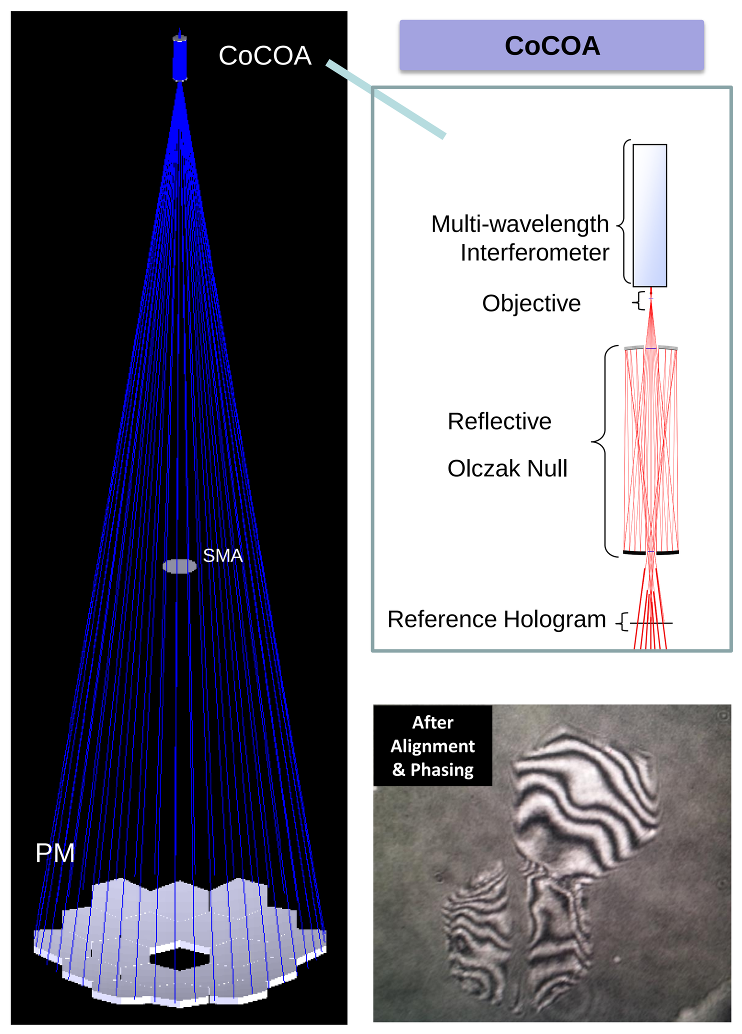
Characterization of the JWST Pathfinder Mirror Dynamics Using the Center of Curvature Optical Assembly (CoCOA)

C. Wells, J. Hadaway, G. Olczak, J. Cosentino, J. Johnston, T. Whitman, M. Connolly, D. Chaney, J. Knight, R. Telfer
Harris Corporation, University of Alabama, Ball Aerospace & Technology Corp., Space Telescope Science Institute, NASA, Goddard Space Flight Center

1) Mechanical and Optical Configurations of the JWST Test







- The entire configuration is supported from the top of the chamber by a vibration isolation system.
- Special test equipment includes strategically placed isolators, tunable mass dampers, and cryogenic magnetic dampers.

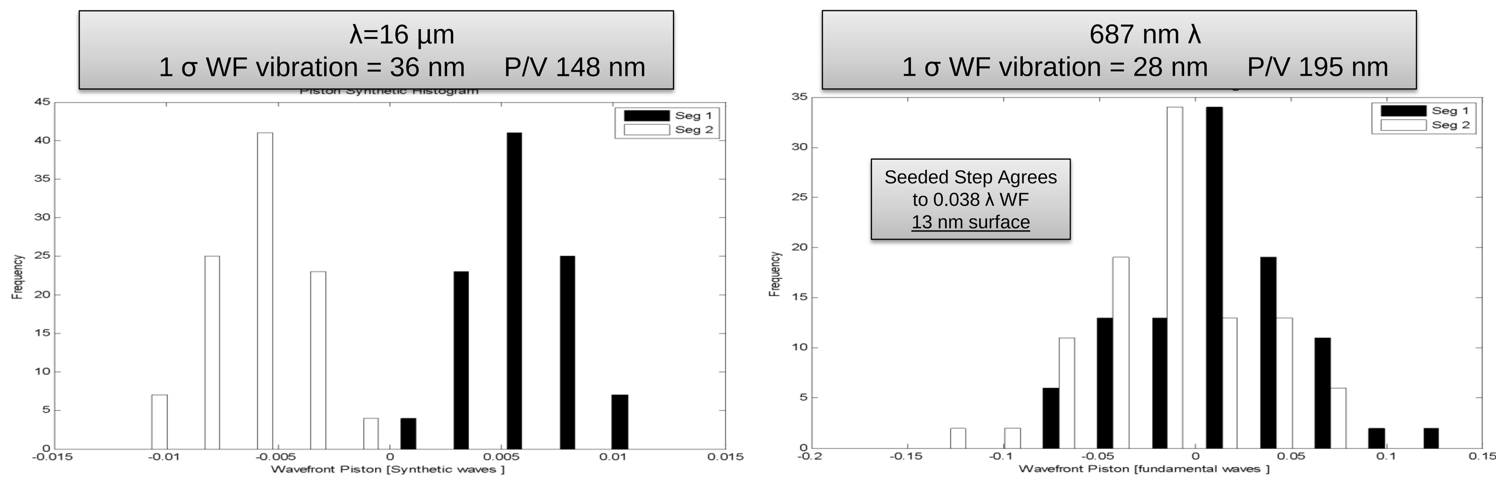
- Fibers at the Cassegrain focus are collimated by the telescope
- The simulated star light is imaged to by the Integrated Science Instrument Module (ISIM).
- Stable images are important for effective wave front sensing (WFS).

- The CoCOA contains a Multiple-wavelength interferometer (MWIF) for phasing the primary mirror.
- Two wavelengths are combined to make the data appear to have been taken at a much larger wavelength, ranging from 16.8 µm to 15 mm
- Instantaneous interferometer impervious to vibration
- 2 frames per second (FPS) and now upgraded to 4 FPS for future testing.
- Many relevant modes captured at this frequency.

2) Mirror Phasing Dynamics

- The JWST pathfinder has 2 mirror segments that are phased to each other in optical testing.
- Synthetic wavelengths are reduced from 15 mm to 16 um as mirror phasing progresses.
- Mirrors phased under atmospheric, vacuum and cryogenic vacuum test conditions.

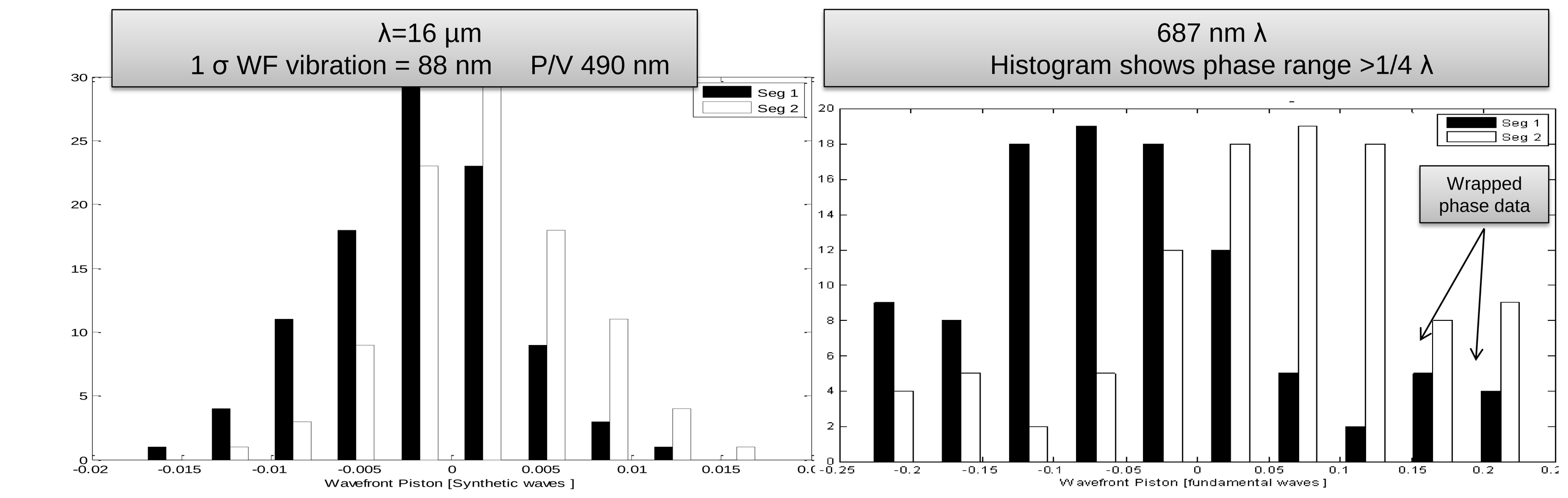
Ambient Vacuum Histograms



- The16 µm synthetic wavelength step variation is Gaussian in nature (1σ=36nm) with a peak to valley range in wavefront piston values of 195 nm.
- The measured step height is 103 nm.

- The 687 nm histogram represents the delta WF piston between each frame and the 100 frame average.
- The peak to valley variation is 195 nm (1σ=28nm) and the measured wave front step height is 116 nm.
- Step heights and vibrations are within 13 nm!

Cryogenic Vacuum Histograms

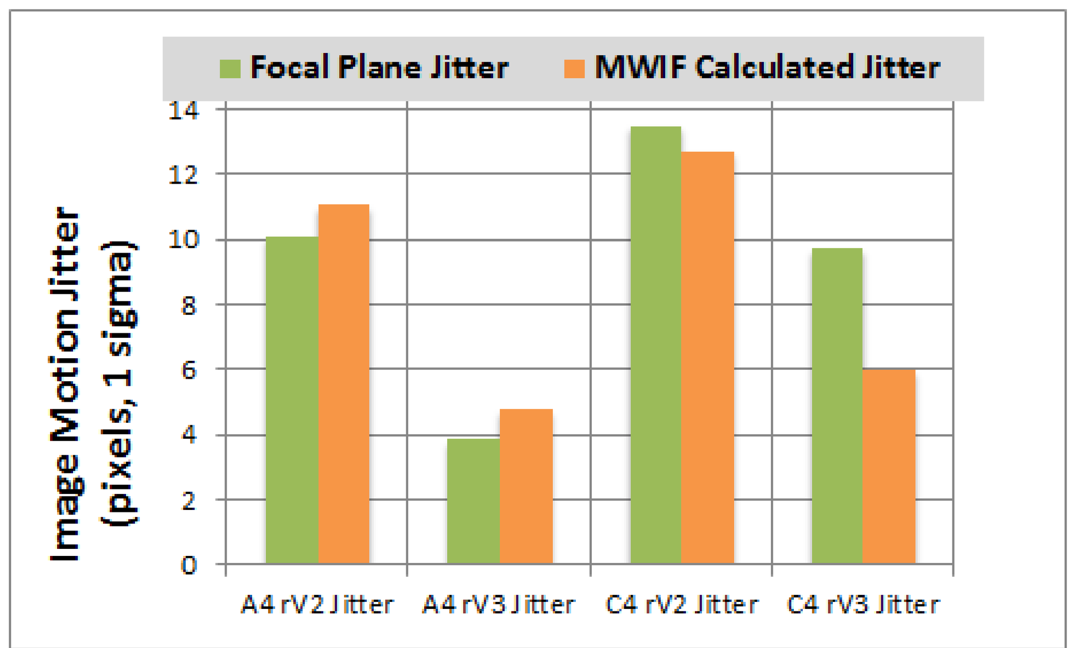


Under cryogenic vacuum conditions, the chamber vibration increases and material damping is reduced.

- Phasing is successfully performed using the 16.8 um synthetic wavelength in the higher vibration environment.
- Mirror phased from >1000 um to 0.032 um surface piston.
- Back to back measurements demonstrated wave front piston repeatability of 14 nm.

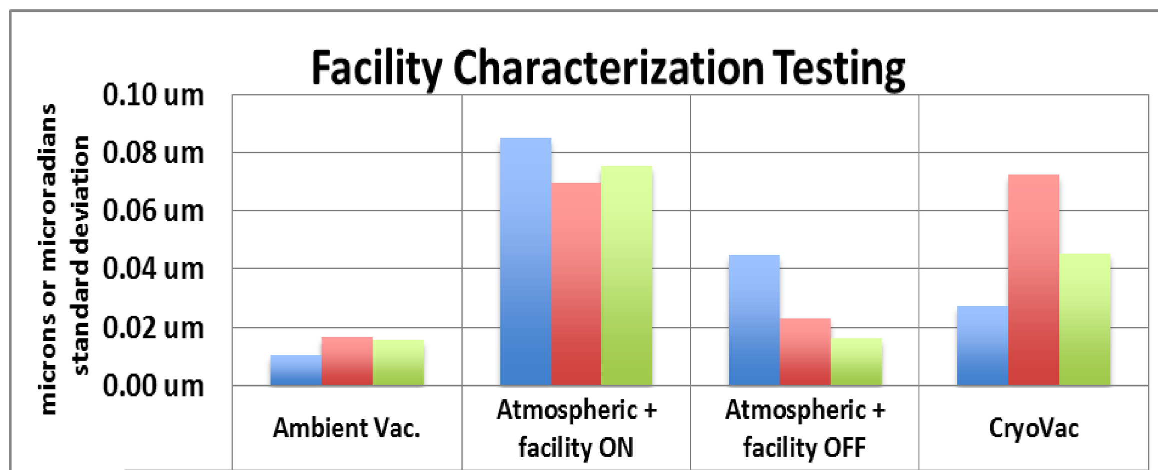
- Vibration exceeded +/- ¼ λ causing fundamental wavelength ambiguities.
- Calculated mirror to mirror piston not valid.
- 16 um data utilized for segment to segment piston.
- Mirror tilt dynamics and segment based WFE data still valid at this wavelength.

3) Focal Plane Dynamics Correlation to MWIF Data at Cryo



- Observed jitter during full telescope level testing prompted further investigation of the system dynamics.
- MWIF frame to frame tilt agreed with telescope level testing.
- Confirmed that mirror to mirror tilt was the dominant jitter mechanism.

4) Facility Characterization Using MWIF



	Ambient Vac.	Atmospheric + facility ON	Atmospheric + facility OFF	CryoVac
Piston	0.01 um	0.09 um	0.04 um	0.028
V2 Tilt	0.02 um	0.07 um	0.02 um	0.072
V3 Tilt	0.02 um	0.08 um	0.02 um	0.045

- Extensive characterization of facility dynamics using accelerometers and MWIF performed under atmospheric vacuum and cryogenic conditions.
- Atmospheric testing demonstrated the transfer of floor vibrations to mirror tilts.
- Lessons learned leading to critical design upgrades for the flight OTIS test.
- Design upgrades will be tested by the MWIF before flight system testing.
- Evaluation of the magnitude, orientation, and frequency of the vibration as a function of facility state helps the dynamics team diagnose the vibration sources.

5) Conclusion

- Successful primary mirror phasing is demonstrated during pathfinder testing in the presence of larger than expected dynamic disturbances.
- MWIF dynamics characterization is directly correlated to image based motion.
- The quality of future design improvements will be tested with the MWIF.
- MWIF data will be used for optical and mechanical test predictions for the flight JWST testing in 2017.

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