Roman Coronagraph Instrument Performance and Status

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AAS 245

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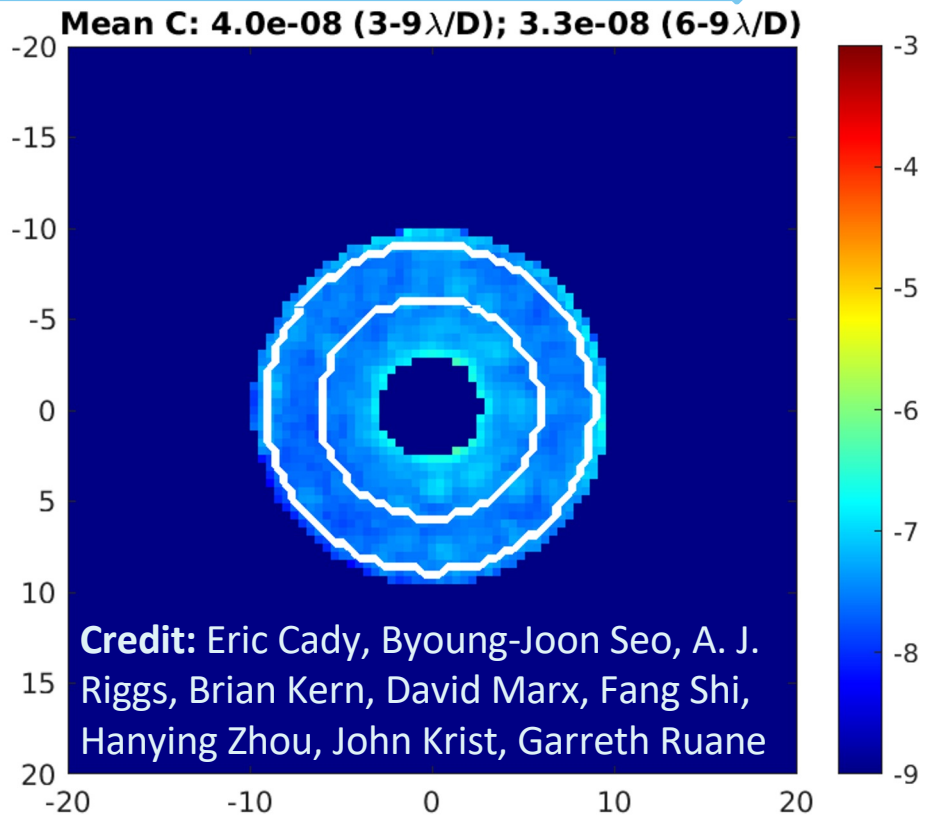
Roman Coronagraph is a stepping stone toward Habitable Worlds Observatory

- A visible-light, high-contrast "**technology demonstration**" instrument for HWO
  - first space-based coronagraph with active wavefront control
  - requirement: 10^{-7} flux ratio 5σ detection limit in a single photometric band
    - Designed to outperform requirement
  - Predicted performance ≥4x beyond req
    - Based on end-to-end performance testing
- **Delivered** to GSFC May 2024



1 fully supported mode + “best effort” & “unsupported”

λ_{center}	Mode	Coronagraph Type	Approx. FOV radius	FOV Coverage	Support
575 nm	**Narrow FOV Imaging**	**HLC**	**0.15” – 0.45”**	**360°**	**Required (full support)**
730 nm, 660 nm	Slit + R~50 Prism Spectroscopy	SPC SPEC	0.2” – 0.55”	slit	Best Effort
575 nm, 825 nm	“Wide” FOV Imaging (SPC	SPC WFOV	0.3” – 1.4”	360°	Best Effort
575 nm, 825 nm	Imaging Polarimetry	HLC + SPC WFOV	0.15” – 1.4”	360°	Best Effort
any	Other coronagraph mask combinations	HLC, SPCs	0.15” – 1.4”	various	Unsupported
any	Other technology demonstrations: binary star, transmissive Zernike wavefront sensor, alternative wavefront sensing algorithms	various	various	various	Unsupported

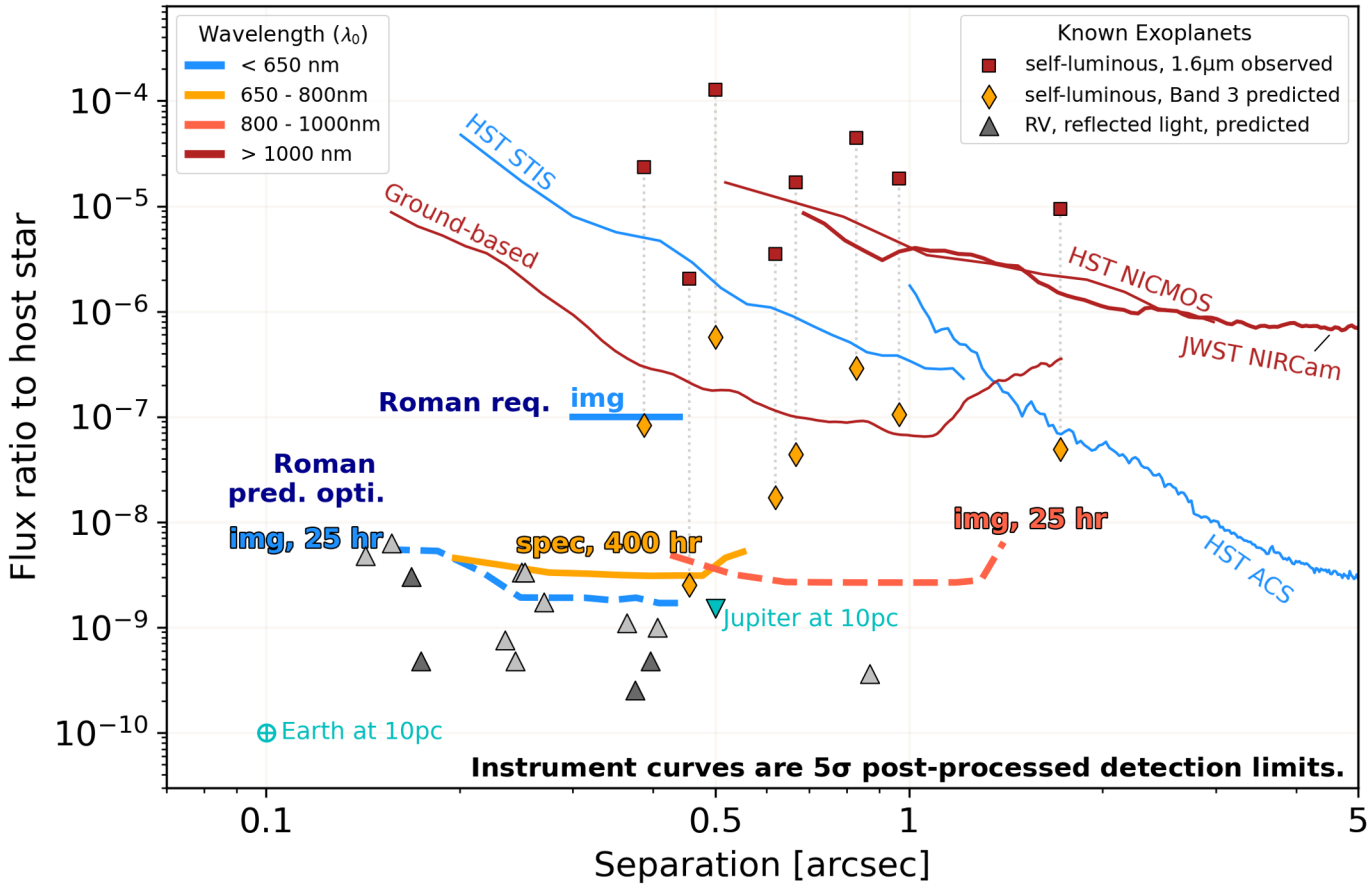
Best effort: partially tested in TVAC; no guaranteed support on-orbit.
Unsupported not tested in TVAC; no guaranteed support on-orbit

Contributed by ExEP: 575nm “Wide” FOV mask & all “unsupported” masks

Observation Phase Guiding Principles

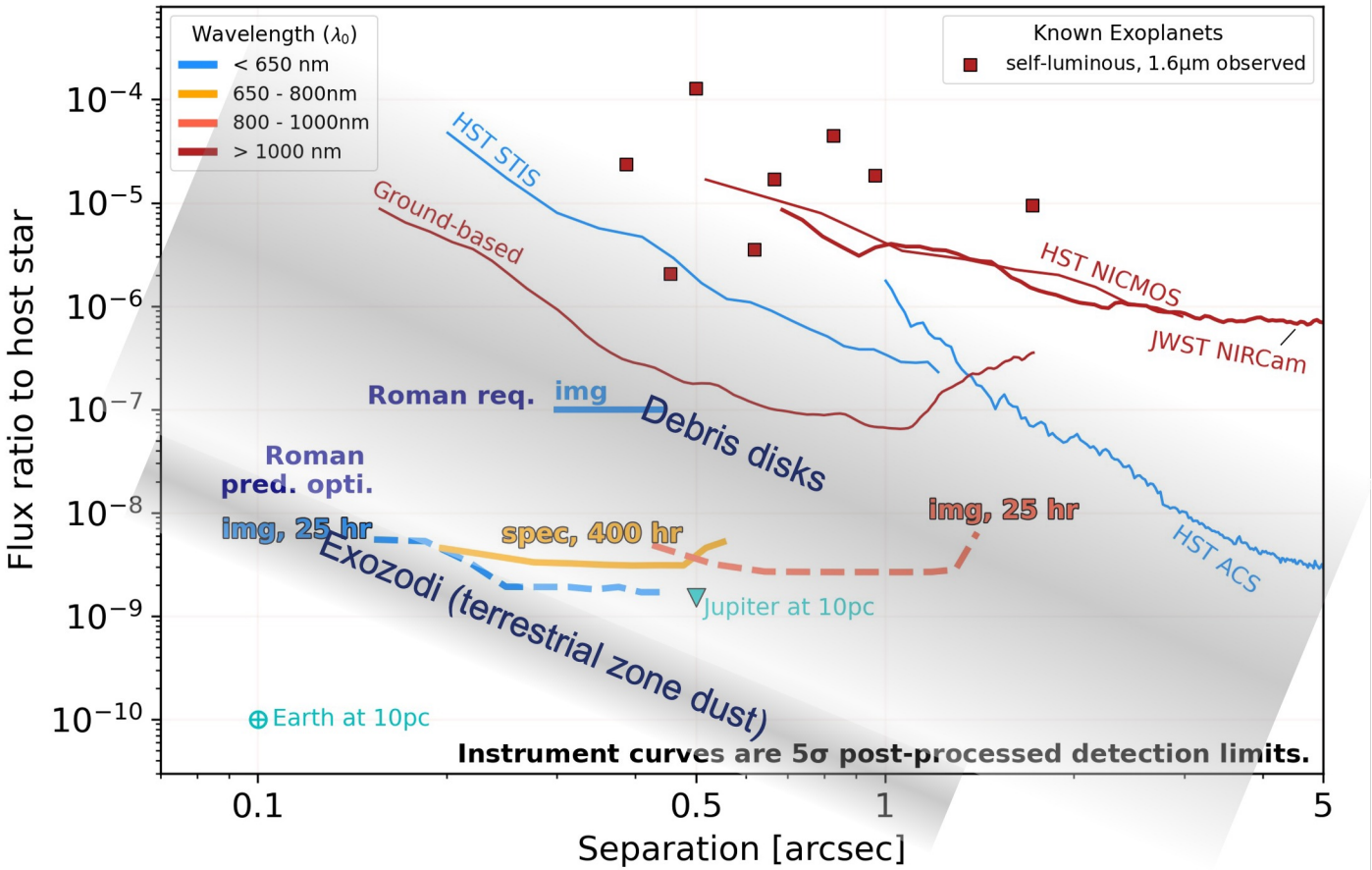
- Baseline: 2200hr (90 days) during first 18mo of Mission
  - Mission starts 2027
- Top priority: achieve “Level 1 Technology Requirement”
  - 10^{-7} detection limit on a V~5 star in narrow FOV
  - L1 would constitute a successful technology demonstration for HWO
- Then, as time/resources allow, push performance limits
  - Baseline resources are not sufficient to support all “best-effort” and “unsupported” mode tests
  - Guiding principle for decision-making: Maximize long-term value to science community & Habitable Worlds Observatory
- Use scientifically-interesting targets whenever possible

Performance Predictions



- These will evolve slightly with more modeling and incorporation of TVAC data

Performance Predictions



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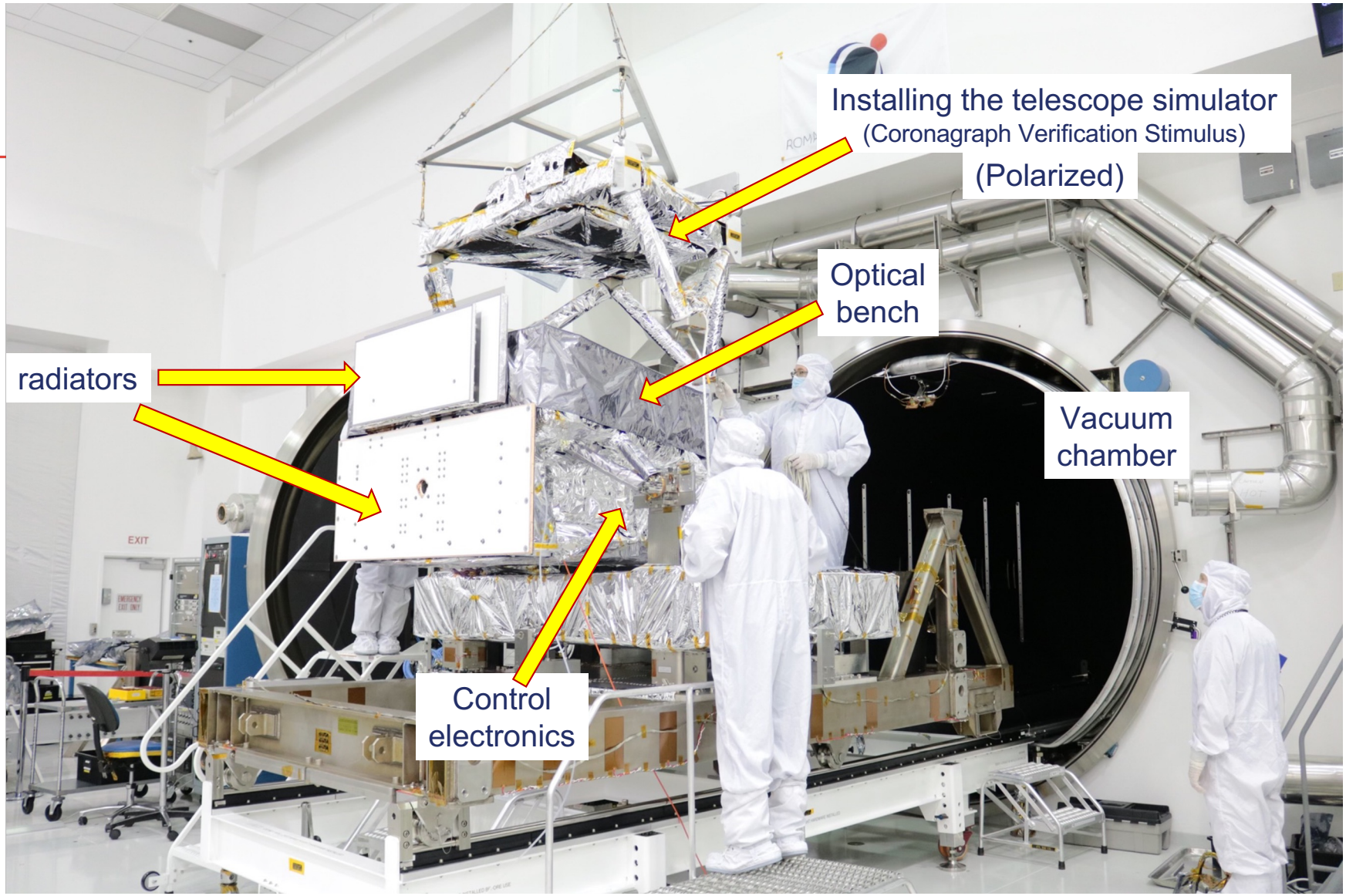
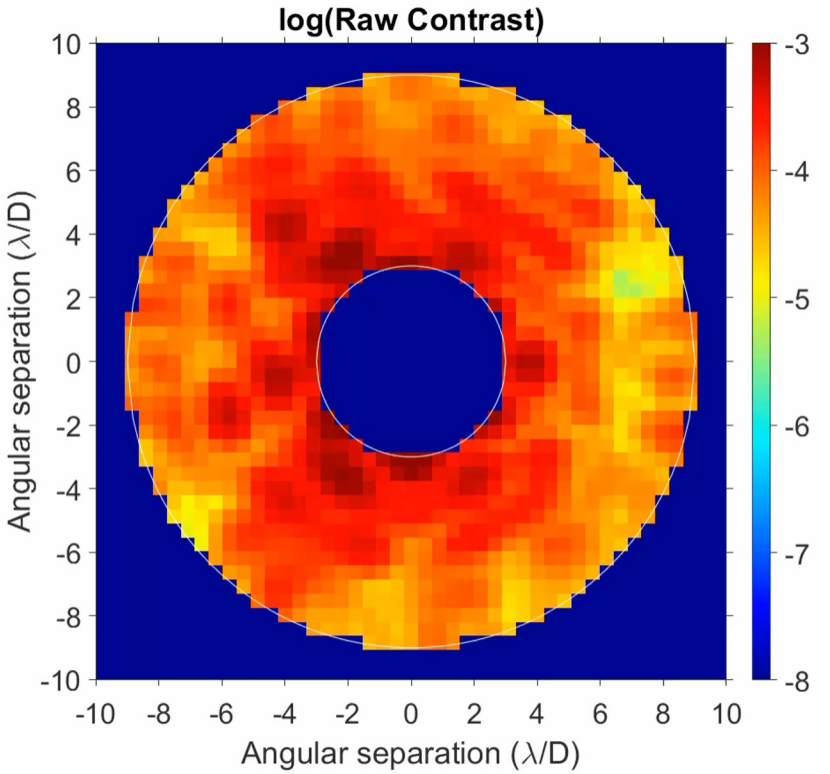
February - April 2024: Thermal Vacuum (TVAC) Performance testing “run for the record”


Installing the telescope simulator
(Coronagraph Verification Stimulus)
(Polarized)
Optical bench
radiators
Vacuum chamber
Control electronics

Primary coronagraph mode (“HLC”) and a “best effort” coronagraph mode (“SPC WFOV”) were tested

- Detection limit beats requirement (1E-7) by at least 4x
- Test was time-limited
  - Performance limit TBD on sky
- Info session slides & recordings: https://workshop.ipac.caltech.edu/romancgi24/
- Publication of test results and lessons learned in forthcoming *JATIS* special issue
- Wavefront sensing & control team: **Eric Cady (lead)**, Byoung-Joon Seo, A. J. Riggs, Brian Kern, David Marx, Fang Shi, Hanying Zhou, John Krist, Garreth Ruane



Science & Technology Potential vs Capabilities

	10^{-7}, 6-9 λ/D, Band 1 (TTR5)	10^{-8}, 3-9 λ/D, Band 1 (conservative)	+ 'best effort' modes, 10^{-8} (conservative)	all modes, 3x 10^{-9} (optimistic)
Technology maturation	All key imaging technologies at TRL9	… + all key imaging technologies are *necessary* to achieve performance	… + spectroscopy and polarimetry technologies at TRL9	… + tech demos & performance is approaching HWO needs in multiple areas
Jupiter analog spectra	No	No	No	A few*
Jupiter analog Images	No	Unlikely	Unlikely	**A handful***
Young giant planet spectra	No	No	**Yes**	**Yes***
Young giant planet images	No	No	**Yes**	**Yes***
Circumstellar disk images	Yes	Yes	**+ polarimetry & (potentially**) H-alpha**	**+ lower-mass disks**
Exo-Zodi Disks images	~5000 zodis	~100 zodis	~100 zodis	**~40 zodis *****

* Roman will likely be target-limited.

** H-alpha imaging of transition (planet-forming) disks will depend on Coronagraph's faint star performance, which is TBD

*** Potential for survey of prime HWO targets if Coronagraph operations are extended

Science & Technology Potential vs Capabilities

Tested in TVAC?

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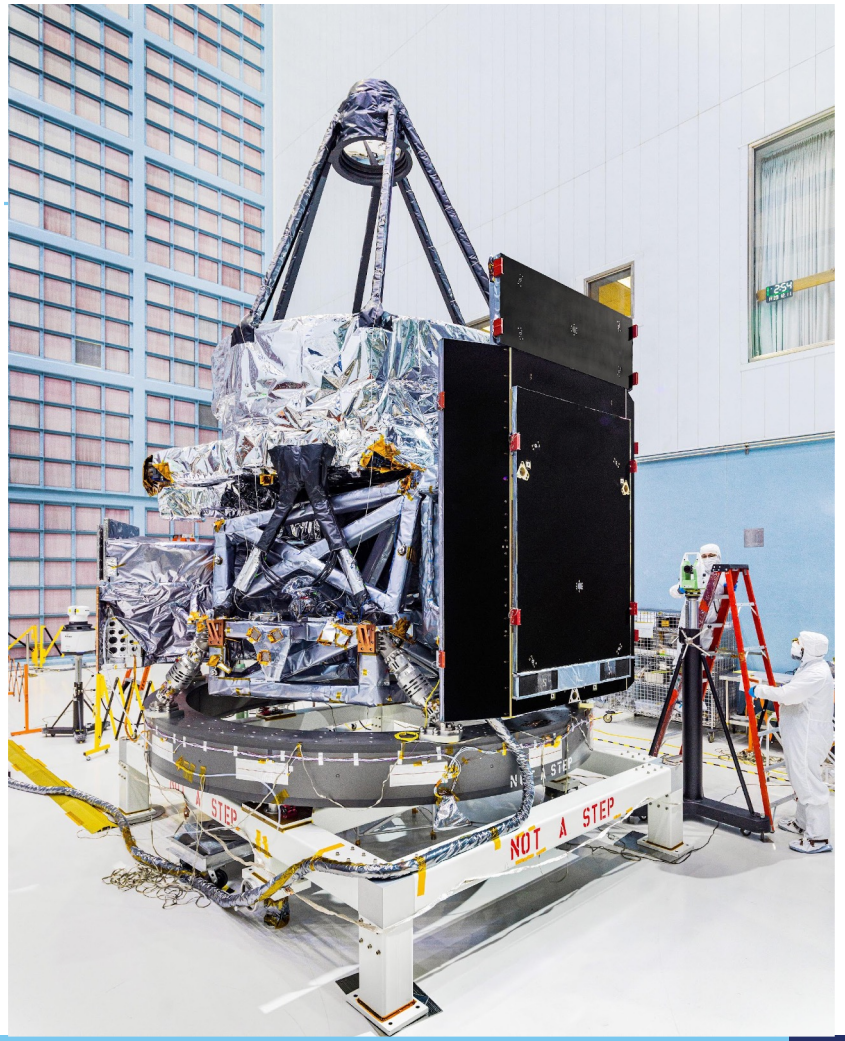
Summary

- Coronagraph matured multiple key technologies to lay foundation for HWO
- Delivered to GSFC in May, integrated in December
- Testing demonstrated performance at least 4x beyond requirement
  - + dark hole in one additional "best effort" mode
- Outlook improving for *some* use of one or more "best effort" modes on sky
- On track for science operations in 2027



https://roman.gsfc.nasa.gov/science/roses.html