Introduction to Roman Coronagraph

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Roman Coronagraph school
March 9, 2026

outline

- Roman telescope and Coronagraph Instrument
- Community Participation Program
- Results from instrument testing
- Status of observatory

Nancy Grace Roman was NASA’s first Chief Astronomer

appointed 1959

1959 October THE ASTRONOMICAL JOURNAL

Roman, Nancy Grace. *Planets of other suns.*

As seen from the distance of Alpha Centauri, Jupiter, at its maximum apparent separation from the sun, $3''.94$, would be a star of $23^{m}.4$ (assuming that its phase function is that of Venus); it would brighten to a maximum of $22^{m}.0$ at exterior conjunction. For Venus, Earth, Saturn, the maximum brightnesses and separations are, respectively: $22^{m}5$ and $0''.55$, $23^{m}4$ and $0''.76$, and $22^{m}.7$ and $7''.23$ (with the rings at moderate inclination).

Thus, a similar planetary system around Alpha Centauri would be within the reach of our largest telescopes and our current photoelectric techniques if our terrestrial atmosphere did not limit our resolution. At a separation of more than $2''$, it does not seem to be a serious problem to get rid of the light of the primary in the absence of an atmosphere.

Image credit: NASA, ESA link

Roman Coronagraph is a stepping stone toward Habitable Worlds Observatory

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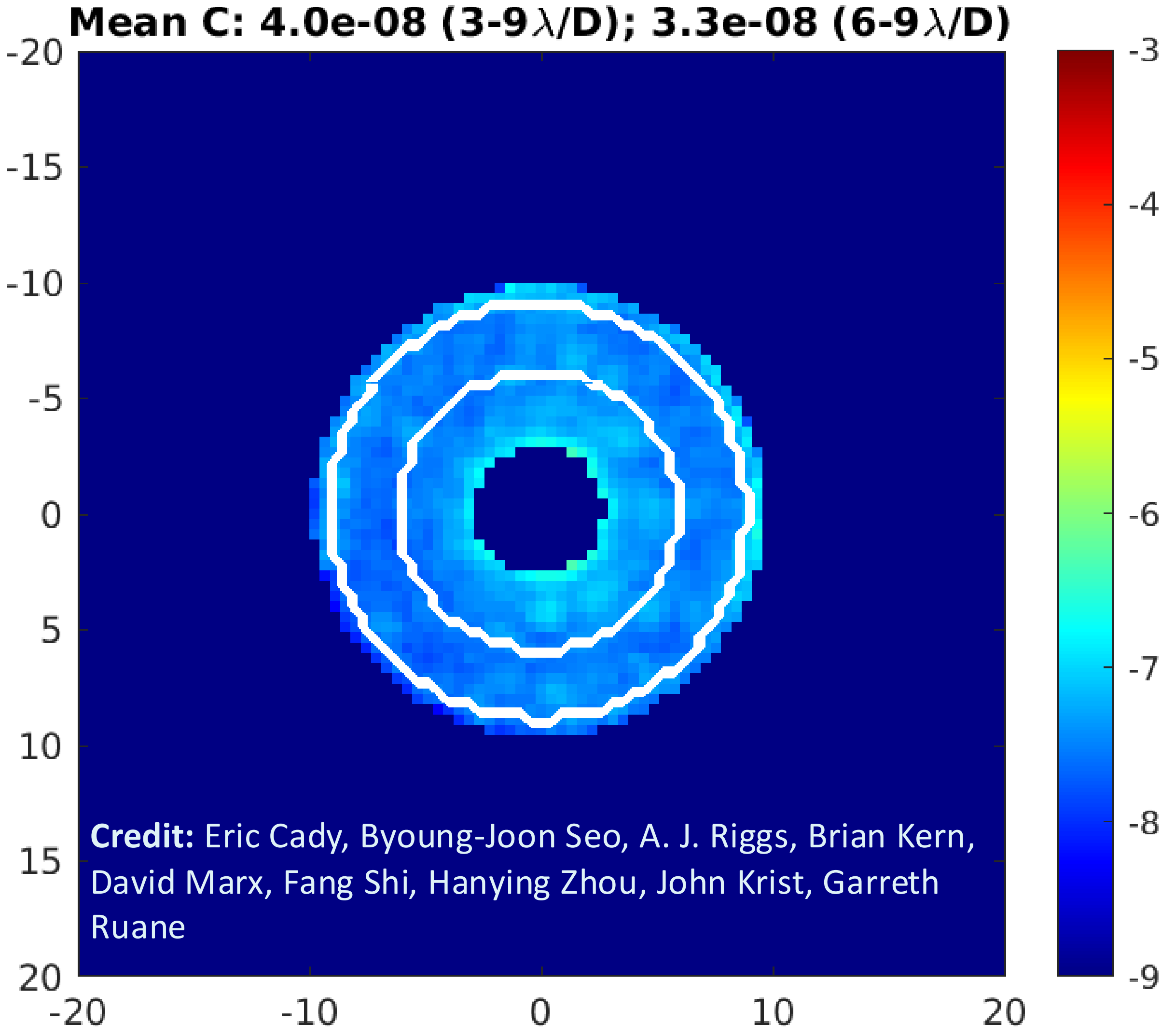
ROMAN CORONAGRAPH

- 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
  - Expected performance at least 4x beyond req
- Roman expected to be ready to launch in **September**

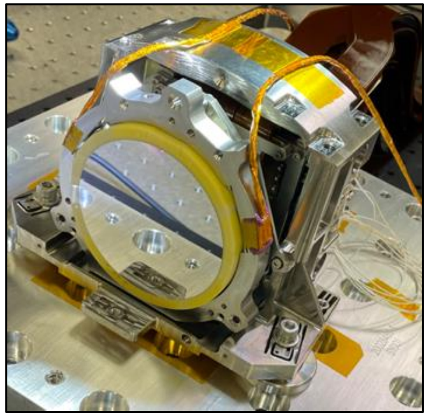


Roman Coronagraph is a “technology demonstrator” stepping stone to HWO

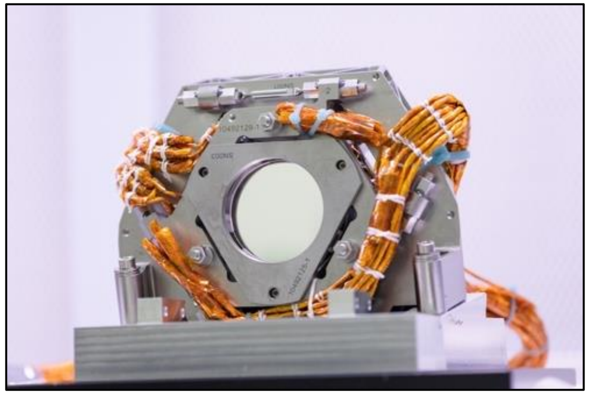
Suppress starlight by ~100 million

Control wavefront to <10 pm RMS

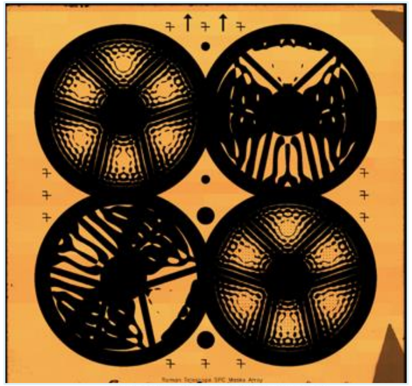
Large-format Deformable Mirrors

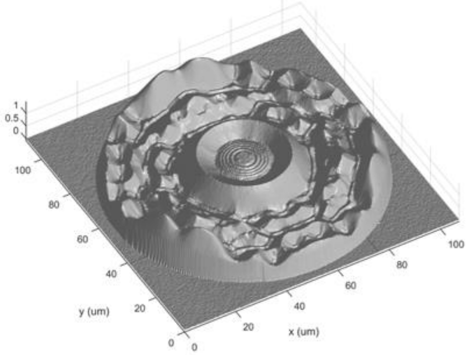


Ultra-Precise Wavefront Sensing & Control (now Ground-In-The-Loop)

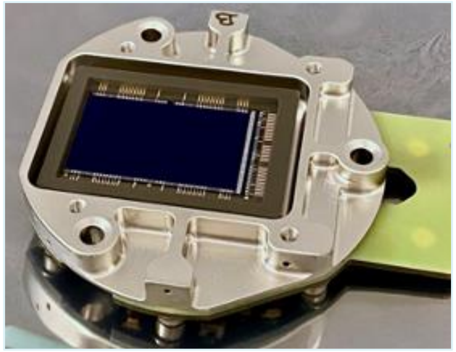


High-contrast Coronagraph Masks





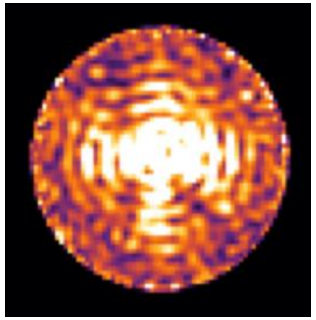
Ultra-low-noise Photon-counting EMCCDs

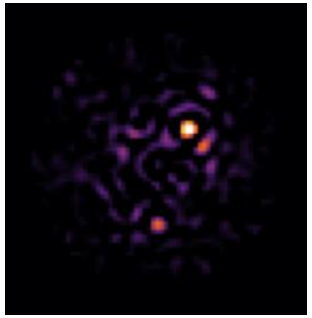


Count individual planet photons as they arrive (1 per 10-100 sec)

Planets > 100 million x fainter than their stars

Data Post-Processing





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

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 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

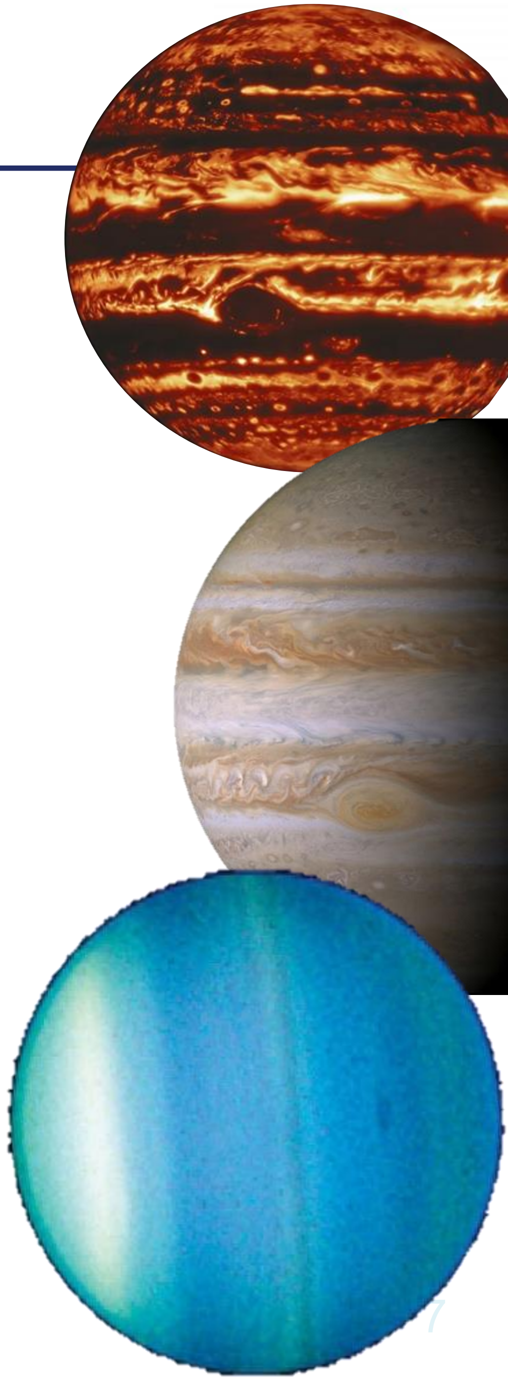
Best effort: partially tested in TVAC; no guaranteed support on-orbit.
Unsupported not tested in TVAC; no guaranteed support on-orbit

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

Opportunities in Exoplanet Science

- young, self-luminous super-Jupiters
  - State of the art: Infrared photometry & spectroscopy
  - Roman Coronagraph: add visible light photometry & low-resolution spectroscopy (eg: Lacy & Burrows 2020)

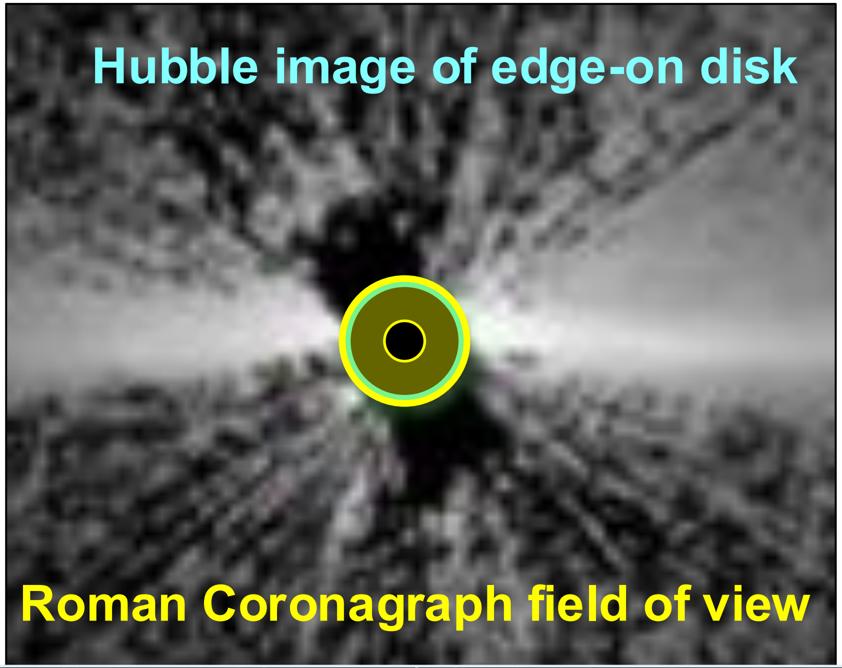
- Jupiter analogs:
  - State of the art : indirect detection only; no characterization
  - Roman Coronagraph: potential for 1st images & *maybe* low-resolution spectrum (eg: Batalha+2018, Saxena+2021)
  - Cloudy or clear?
  - Super-solar or solar metallicity?



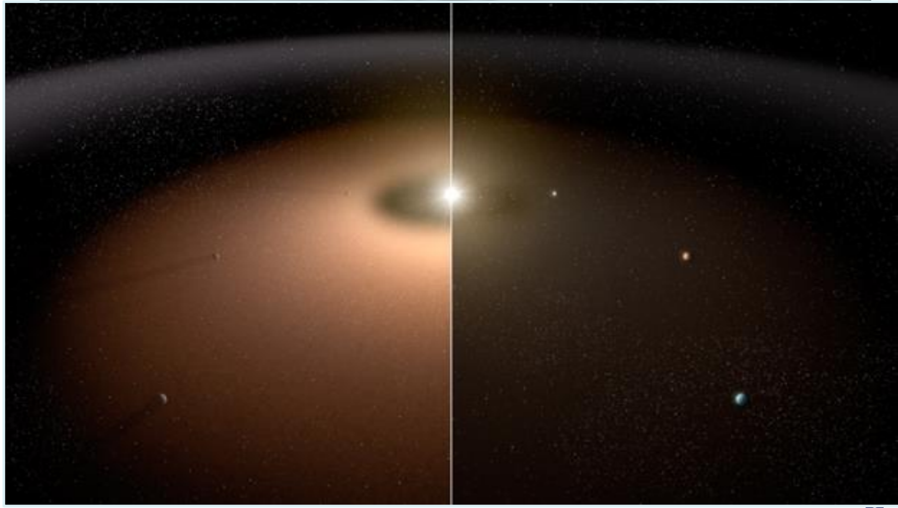
Jupiter thermal IR: AURA/NSF/NOIRLab/ESA/NASA/International Gemini Observatory

Opportunities in circumstellar disk science

- Debris disks (Kuiper belt analogs)
  - **State of the art :** Hubble imaging
  - **Roman**: Observe closer to the star
    - (Mennesson+2018)



- Exozodi disks (terrestrial zone dust)
  - **State of the art :** IR excesses
  - **Roman**: *potential* for first visible-light image
    - Are any HWO high-priority systems too dusty?
    - (Douglas+2022)



Coronagraph Community Participation Program (CPP)

- US and international researchers (incl. CNES) who become an integral part of Coronagraph team through operations phase
  - *not just end users*
  - Baseline functionality: Observation design, preparatory work, data analysis, simulations, …
  - **Engage external research community** to optimize tech demo observations for broad, long-term impact (eg: target selection, …)
  - Add-ons: commissioning modes beyond req'd one and/or wavefront sensing and control

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Who is the CPP?

ROMAN CORONAGRAPH

Ramya Anche (UArizona)
Ewan Douglas (UArizona)
Jessica Gersh-Range (Princeton)
Satoshi Itoh (Nagoya Univ.)
Bruce Macintosh (UC Observatories)
Jun Nishikawa (NAOJ)
Frans Snik (Leiden University)
Takahiro Sumi (Osaka Univ.)
Taichi Uyama (Cal State U. Northridge)
Michele Woodland (GSFC)
Hibiki Yama (Osaka Univ.)
Hanying Zhou (JPL)
Oscar Carrion-Gonzalez (LESIA)
Brianna Lacy (UCSC)
John Debes (STScI)
David Doelman (SRON)
Markus Feldt (MPIA)
Hajime Kawahara (ISAS/JAXA)
John Livingston (ABC/NAOJ)
Axel Potier (Bern)
Matthias Samland (MPIA)
Aoi Takahashi (ABC/NAOJ)
Pierre Baudoz (LESIA)
N. Jeremy Kasdin (Princeton)
Jürgen Schreiber (MPIA)
Oliver Krause (MPIA)
Lisa Altinier (LAM)
Eduardo Bendek (JPL)

Ellis Bogat (UMaryland)
Robert De Rosa (ESO (Chile))
Motohide Tamura (UTokyo/ABC)
Jorge Llop Sayson (JPL)
Tsutsumi Nagai (Osaka Univ.)
Masataka Aizawa (Riken)
Yui Kawashima (ISAS/JAXA)
Kenta Yoneta (NAOJ)
Benjamin Charnay (LESIA)
Beth Biller (Edinburgh)
Malachi Noel (Northwestern)
Justin Hom (UArizona)
Samantha Hasler (MIT)
Patrick Lowrance (IPAC)
Lee Armus (IPAC)
Zhexing Li (UCR)
Stephen Kane (UCR)
Toru Yamada (ISAS, JAXA)
Masayuki Kuzuhara (NINS Astrobiology Center)
Emmanuel Joliet (Caltech / IPAC)
Eric Mamajek (JPL)
Susan Redmond (Caltech / JPL)
Nick Schragal (University of Arizona)
Alexis Lau (LAM)
Schuyler Wolff (Uarizona)
Leonid Pogorelyuk (RPI)
Toshiyuki Mizuki (ABC/NAOJ)
Marah Brinjikji (ASU)

Sarah Blunt (Northwestern)
Elodie Choquet (LAM)
Julien Girard (STScI)
Sergi Hildebrant Rafels (JPL)
John Krist (JPL)
Sarah Moran (UArizona)
Karl Stapelfeldt (JPL)
Marie Ygouf (JPL)
Robert Zellem (JPL)
Mark Marley (UArizona)
Remi Soummer (STScI)
Tyler Groff (GSFC)
Bijan Nemati (Tellus1)
Cynthia Wong (JPL)
Kevin Ludwick (U. Alabama-Huntsville)
Tim Koch (JPL)
Jennifer Sobeck (IPAC)
James Ingalls (IPAC)
Amanda Chavez (Northwestern)
Zarah Brown (UArizona)
Gaël Chauvin (MPIA)
Dan Sirbu (Ames)
Wolfgang Brandner (MPIA)
Shota Miyazaki (ISAS/JAXA)
Emiel Por (STScI)
Johan Mazoyer (LESIA
Arthur Vigan (LAM)
And more (this list doesn't include most recent additions)

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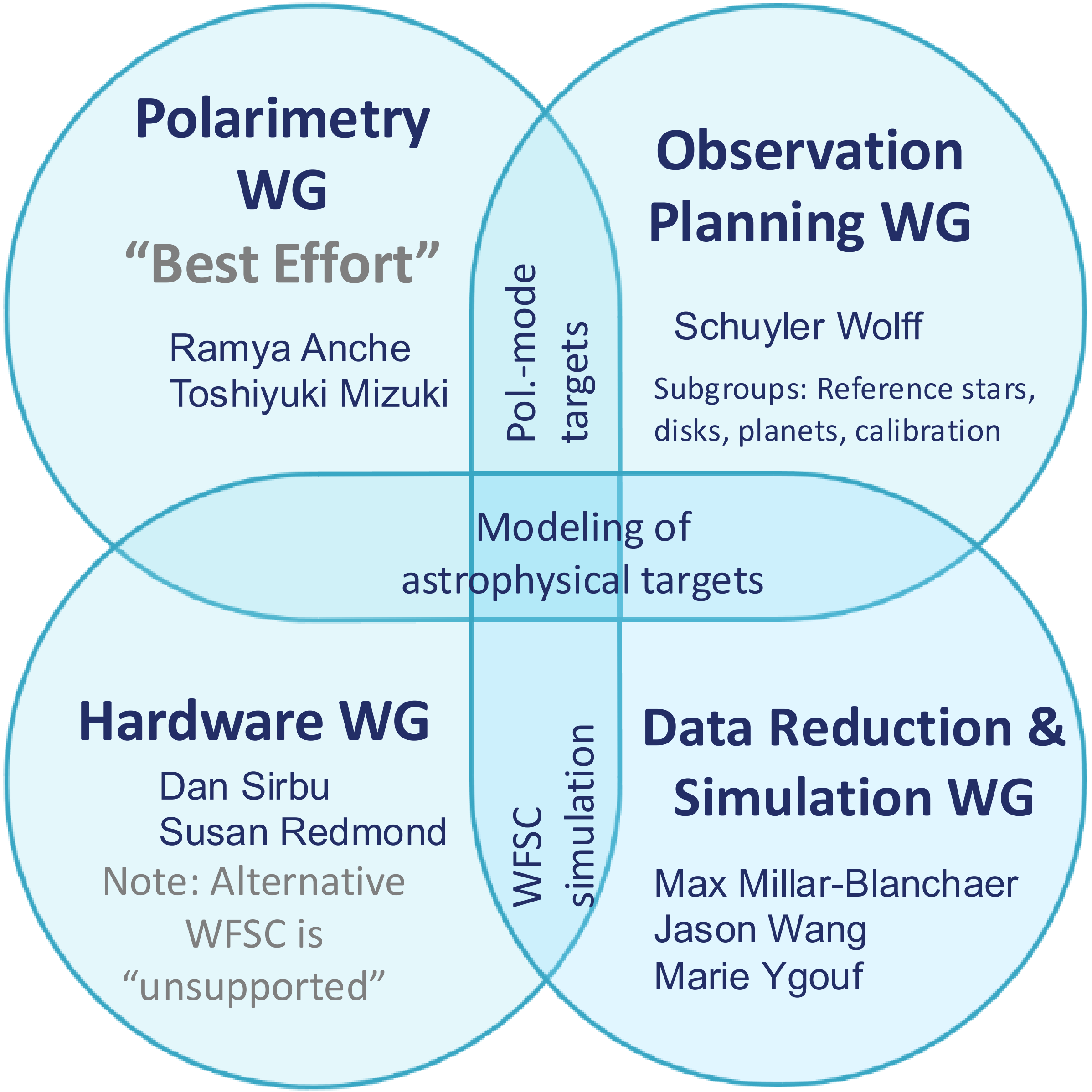
Instructors / speakers / organizers at this winter school

How is CPP work organized?



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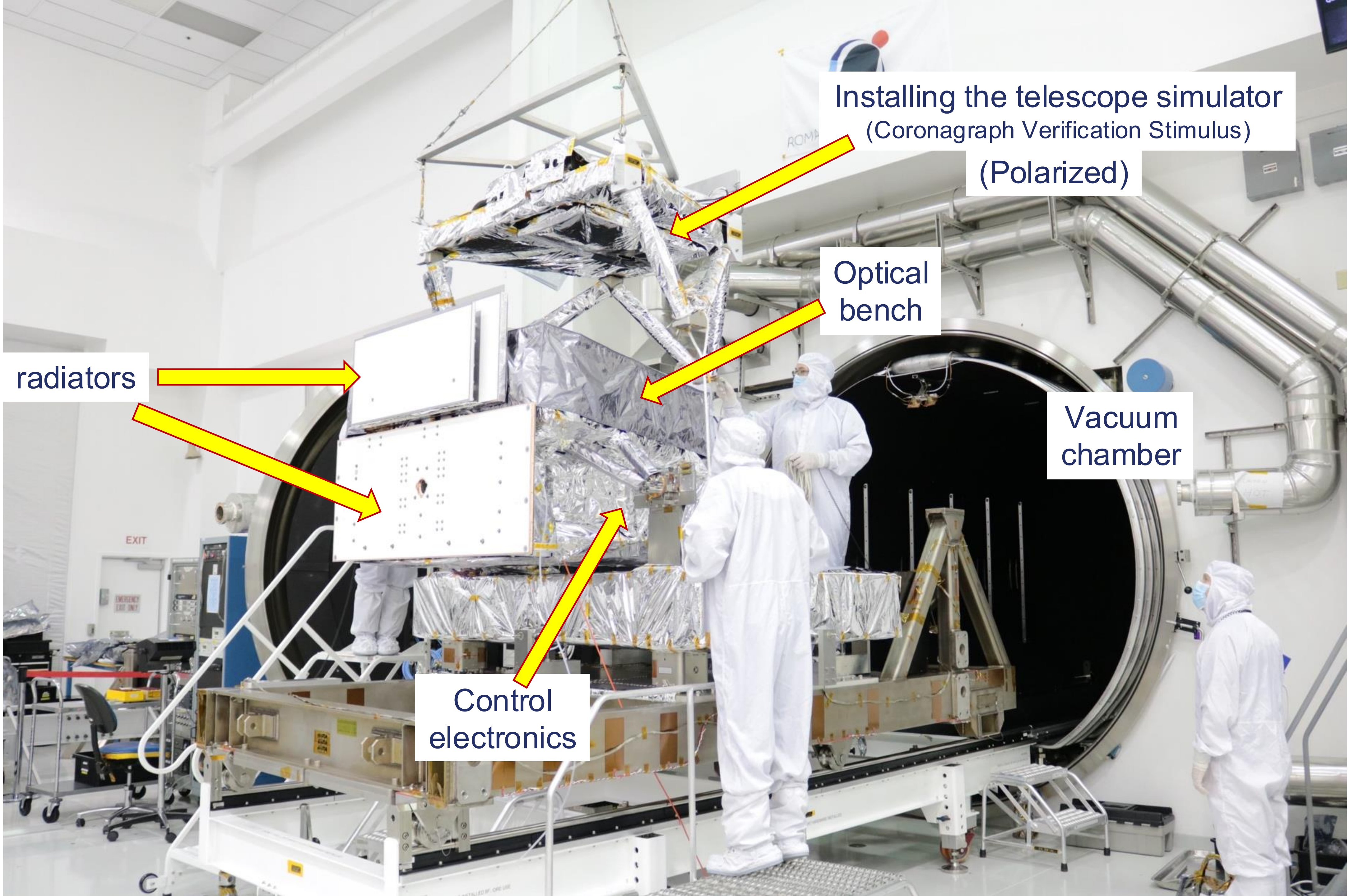
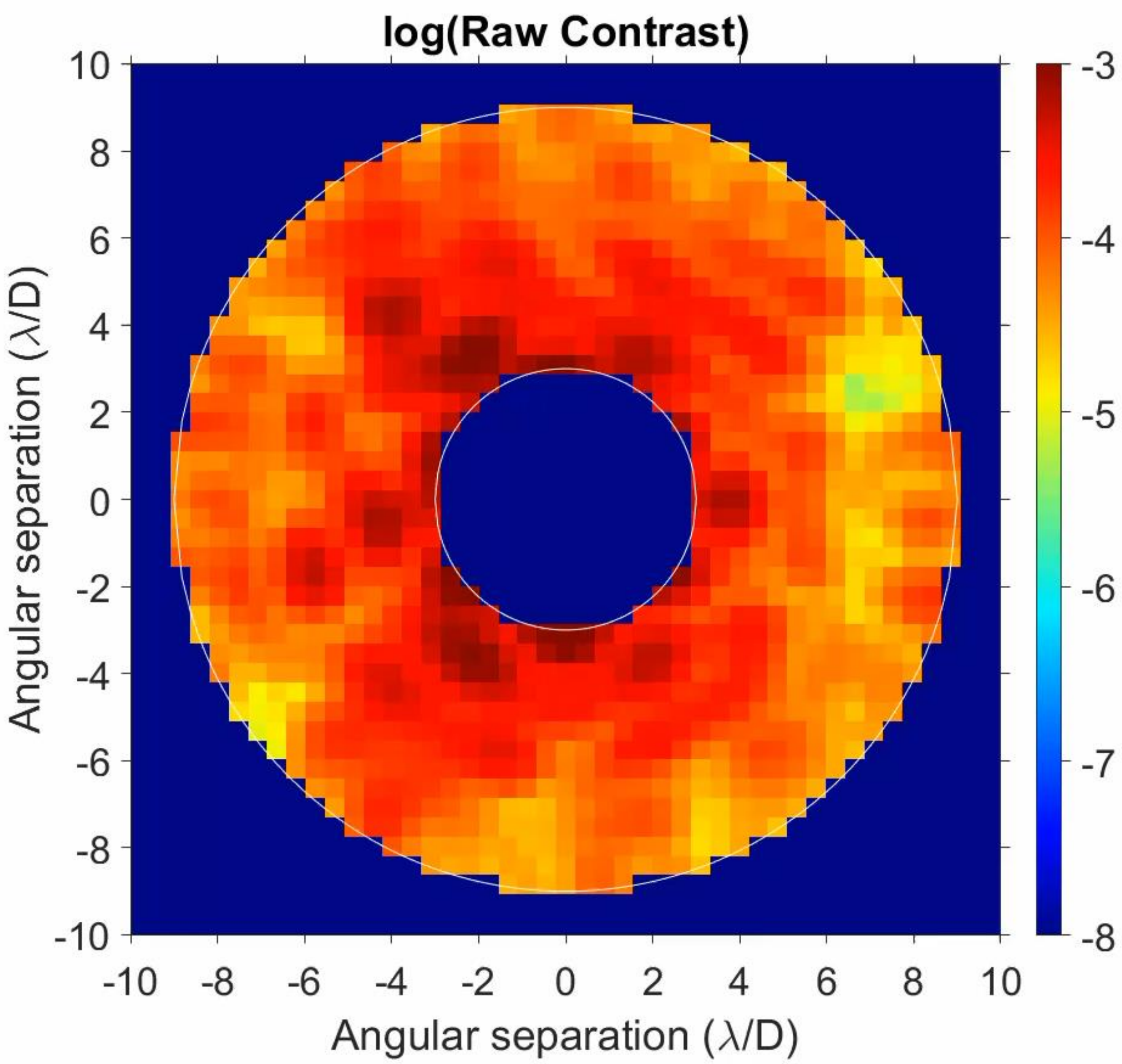
February - April 2024: Thermal Vacuum (TVAC) Performance testing “run for the record”


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

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 in 2025 *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 & Tech 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 & Tech Potential vs Capabilities

Tested in TVAC?

	10^{-7}, 6-9 λ/D, Band 1 (TRL5)	10^{-8}, 3-9 λ/D, Band 1 (conservative)	+ 'best effort' modes, 10^{-8} (conservative)	all modes, 3x 10^{-9} (optimistic)
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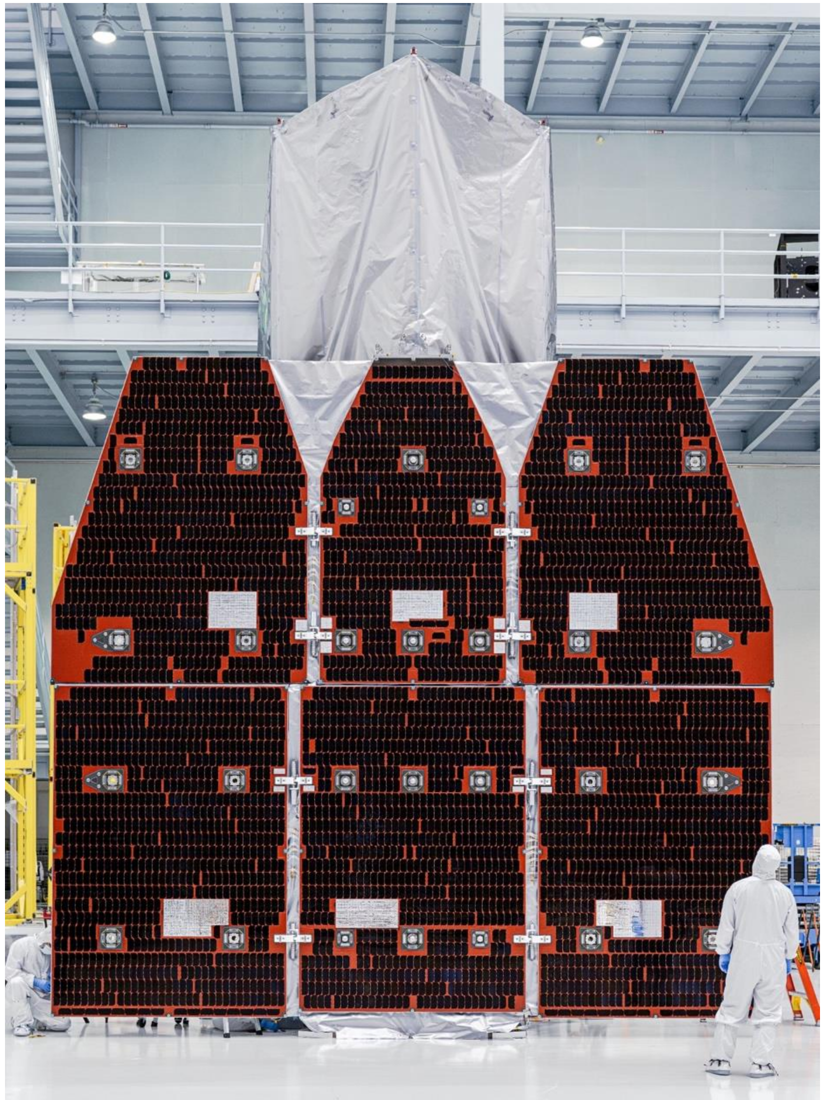
2025: telescope + assembly & vacuum chamber testing

SCIPA lowering into SES chamber



OSD – SASS and DAC Deployed

ROMAN
SPACE TELESCOPE

What's left?

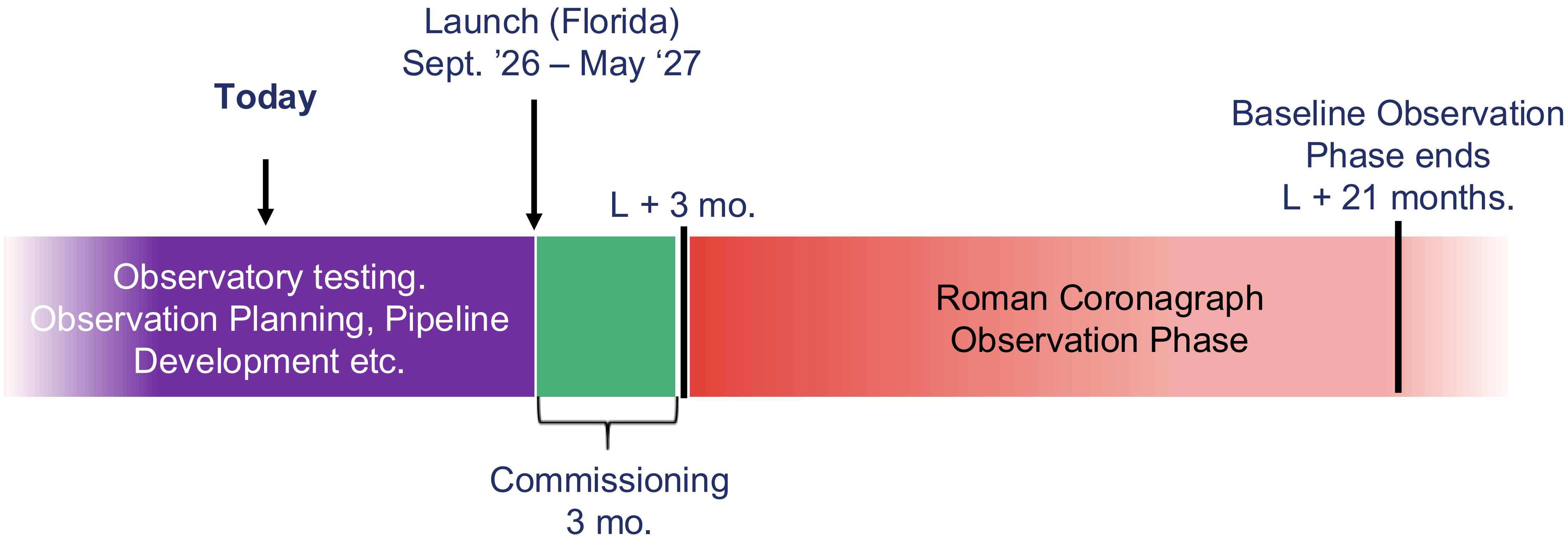
Completed Vibration testing
Completed Acoustic testing
Post-environmental testing
- Functional tests
- Deployment tests
  - SASS, DAC, LISS, HGAS
- Separation system tests
- Final optical alignment measurements

Prepare observatory for shipping
Pre-Ship Review
Ship to Kennedy Space Center (mid-June)
Operations Readiness Review (early July)
Launch site activities
Launch readiness: **fall**

ACES = Adaptable Contamination Enclosure System

Slide credit: Jeff Kruk, with subsequent updates

Mission Phases



No proprietary period on Observation Phase data

Preparation & training for early observations is critical
(glad you're here!)

Looking forward to exciting results!