

# Observation Planning with the CPP for the Roman Coronagraph



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Roman School, 2026





# Observation Planning



# Observation Planning WG Activities

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- **Schedule of Observations:** Duration, Instrument configuration, requested time windows
- **Target Selection:** science targets and reference/calibration sources
- **Target Database – plan to import to NexSci soon.**
- **Pre-launch target vetting observations**
- **Modeling of astrophysical targets**
- **Exposure Time Calculator**
- **Calibration sub-working group**



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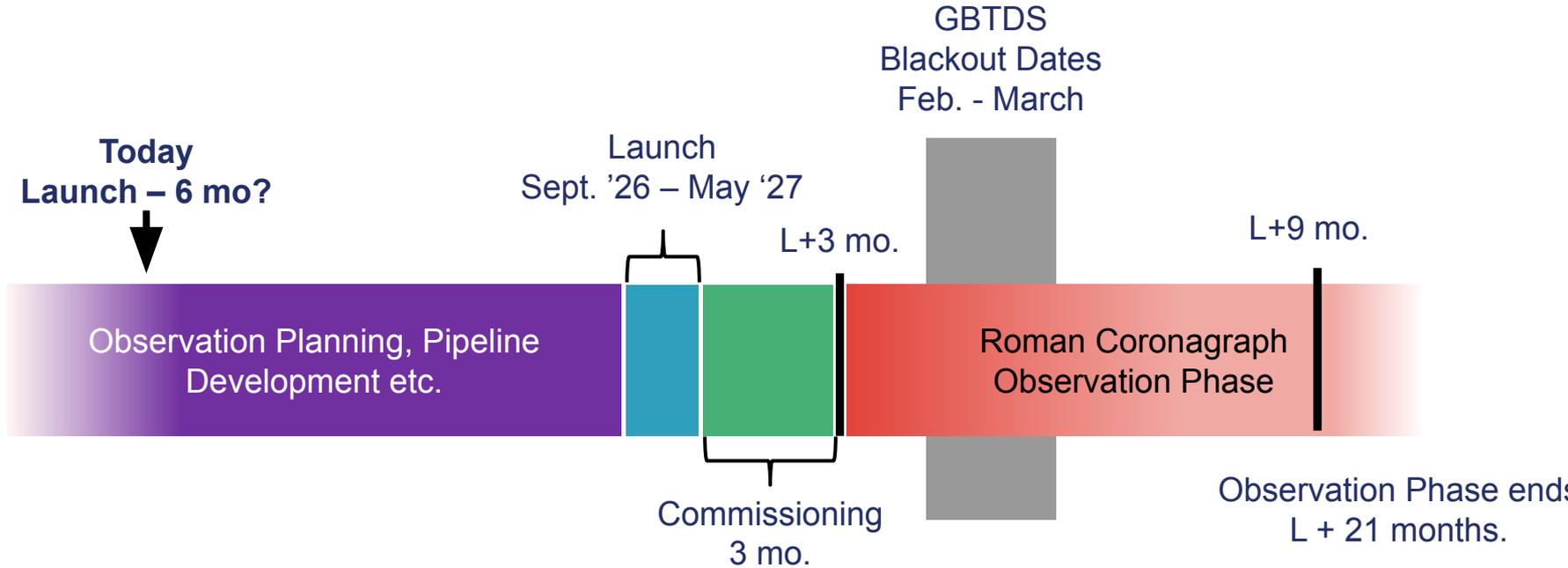


# 1<sup>st</sup> 6 Months of the “Observation Phase”

- Baseline: 2200hr (90 days) during first 18mo of Mission
  - Launch no later than May 2027, launch readiness date ~ Oct. 2026
- Top priority: achieve L1 Technology Requirement
  - Flux ratio of at least  $10^{-7}$  on a  $V \sim 5$  star in Band 1
- Then, as time/resources allow, push performance limits and commission additional observing modes
  - Maximize long-term science and technology value
  - Front load most impactful and lowest risk observations
- Prioritize scientifically-interesting targets when possible
  - Roman data has no proprietary period



# Roman CGI Schedule of Operations



# 1 fully supported mode

Additional “best effort” modes: spectroscopy & polarimetry



Band	$\lambda_{\text{center}}$	BW	Mode	FOV radius	FOV Coverage	Pol?	Coronagraph Mask Type	Support
1	575 nm	10%	Narrow FOV Imaging	0.15" – 0.45"	360°	Y **	Hybrid Lyot	Req'd
1	575 nm	10%	“Wide” FOV Imaging	0.3" – 1.01"	360°	Y	Shaped Pupil	Best Effort
2	660 nm	17%	Slit + R~50 Prism Spectroscopy	0.17" – 0.52"	2 x 65°	-	Shaped Pupil	Best Effort
3	730 nm	17%	Slit + R~50 Prism Spectroscopy	0.18" – 0.55"	2 x 65°	-	Shaped Pupil	Best Effort
4	825 nm	11%	“Wide” FOV Imaging	0.45" – 1.4"	360°	Y	Shaped Pupil	Best Effort

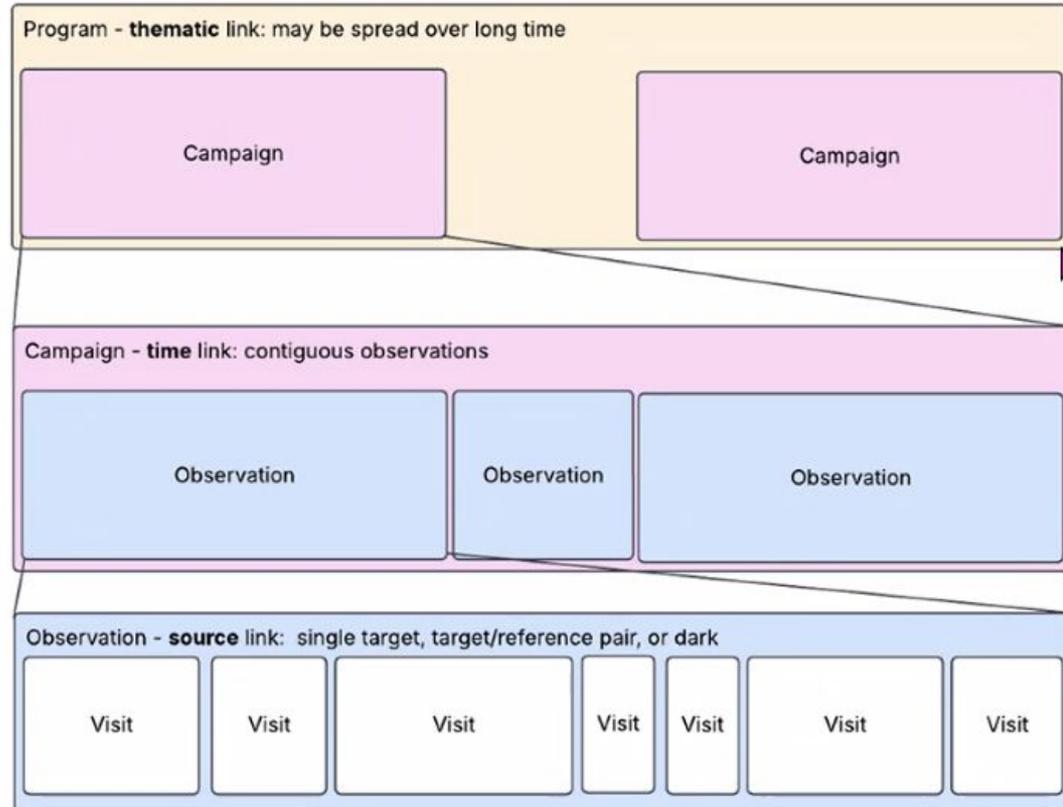
“Best effort” modes will not be end-to-end performance tested prior to delivery & do not have guaranteed support on-orbit.

\*\* Polarimetry in Band 1 is ‘best effort’

See [Riggs et al. 2025](#) for all possible observing modes 6

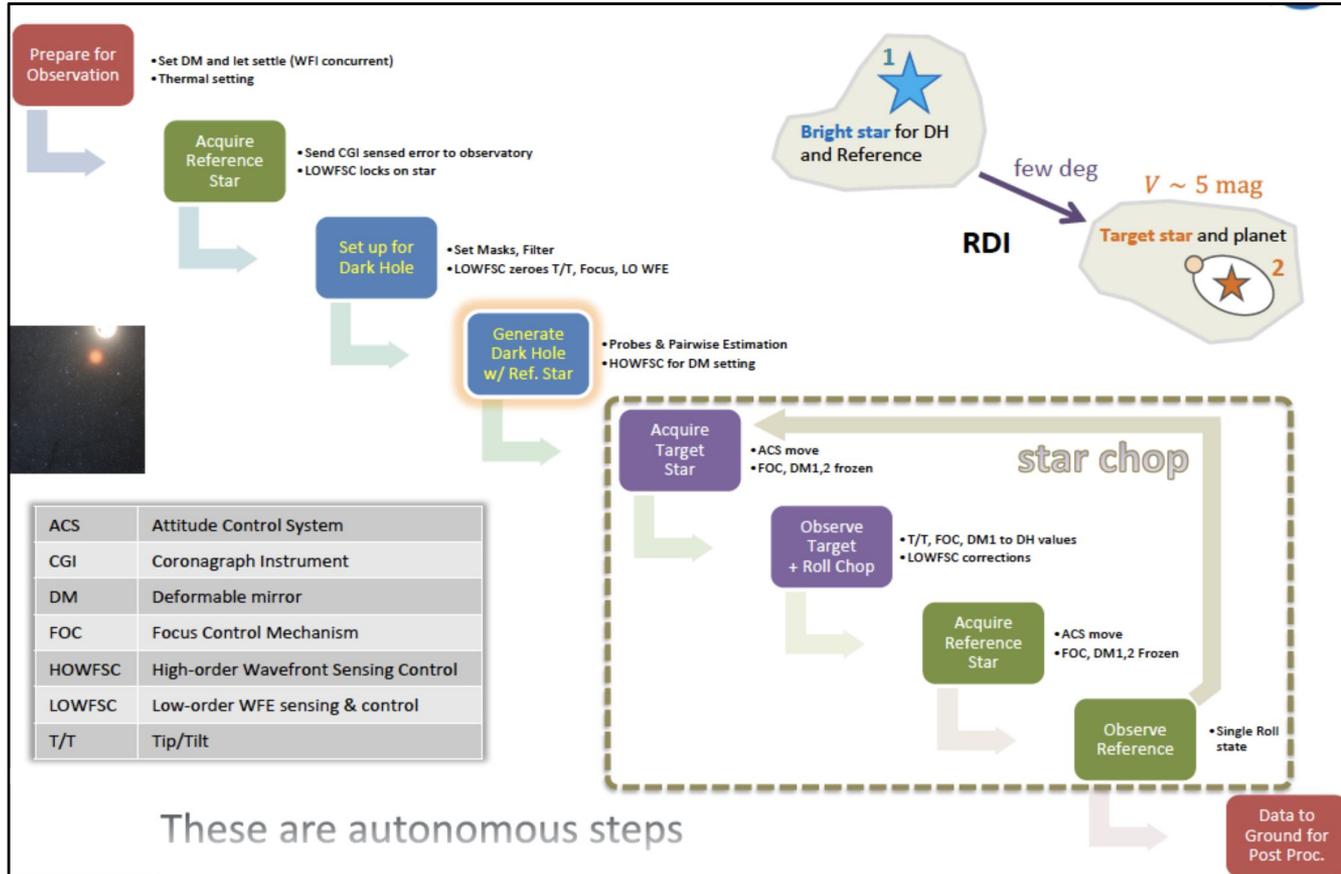


# Campaign Design for the Roman Obs. Phase





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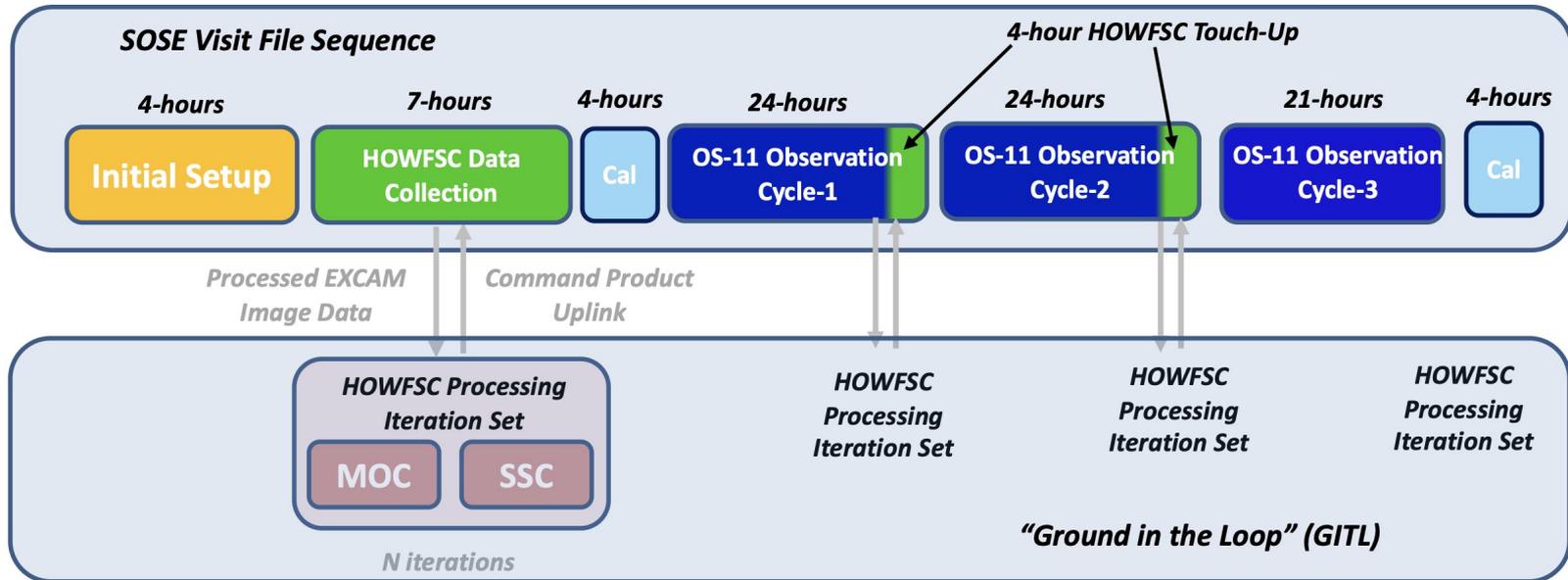
ACS	Attitude Control System
CGI	Coronagraph Instrument
DM	Deformable mirror
FOC	Focus Control Mechanism
HOWFSC	High-order Wavefront Sensing Control
LOWFSC	Low-order WFE sensing & control
T/T	Tip/Tilt

These are autonomous steps



# Observation Design for the Roman Obs. Phase

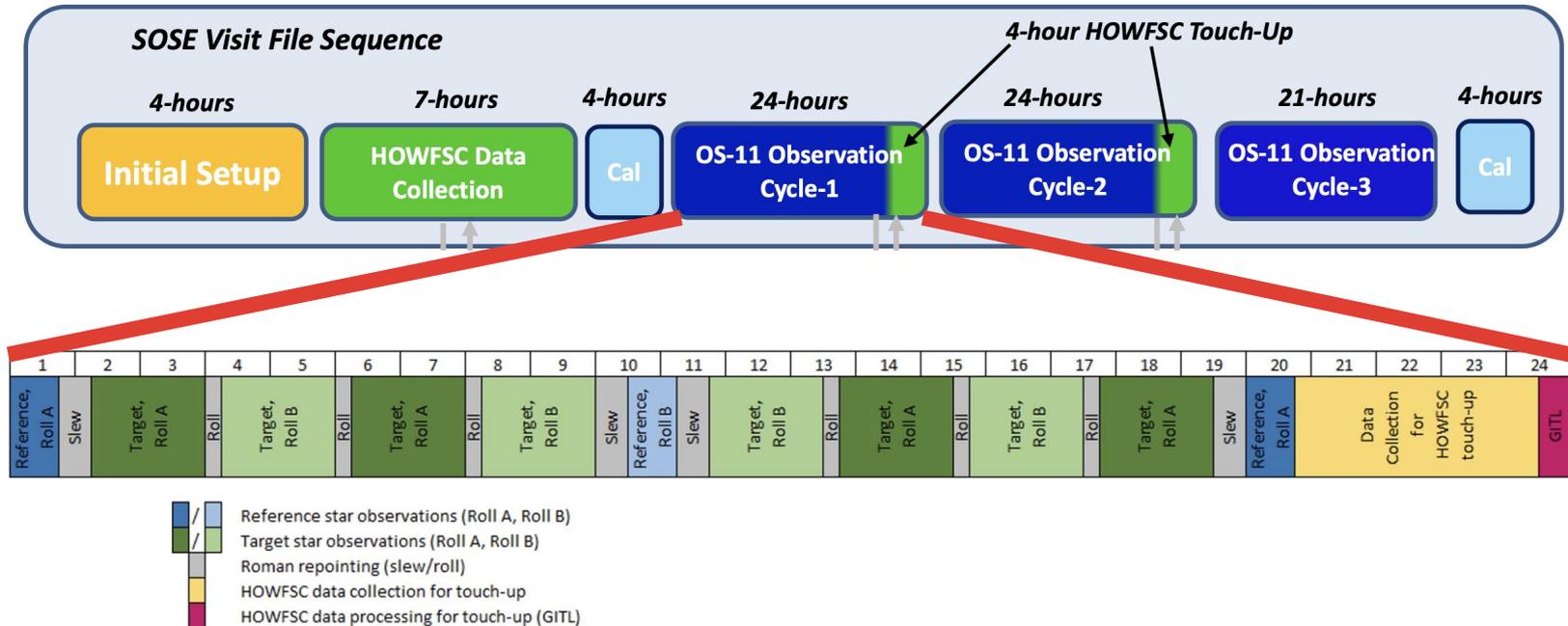
*HOWFSC – High Order Wavefront Sensing Control, GITL – Ground In The Loop*  
*SOSE – Science Observation Sequence Engine*  
*MOC – Mission Operations Center, SSC – Software Support Center*





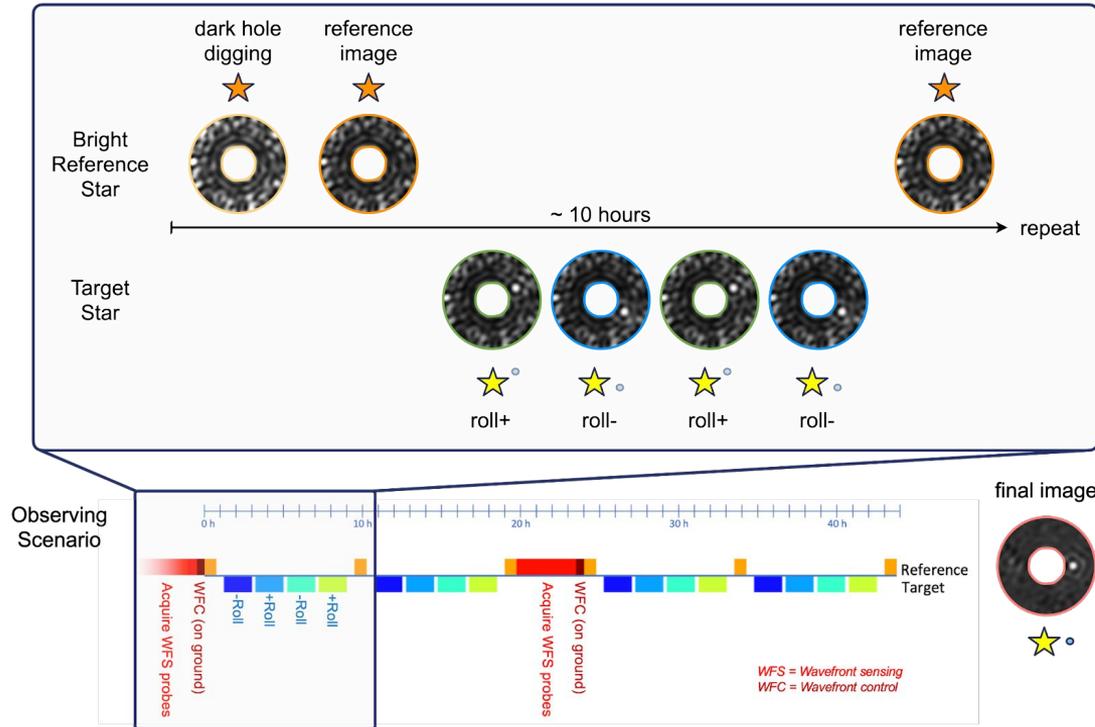
# Observation Design for the Roman Obs. Phase

**HOWFSC – High Order Wavefront Sensing Control, GITL – Ground In The Loop**  
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# Roman-Coronagraph Observing Sequence



Credit: Julien Girard; Note that sequence time varies and scales with ref. star magnitude

# What do you need to know when designing an Observing Sequence?



- Observing Mode: Imaging band, spectroscopy, polarimetry?
  - What contrast is required to achieve your science/technical goals?
- Science Target(s):
  - When is it visible? Depends on Roman orbit but also target properties
  - Integration time to achieve SNR on object of interest (planet, disk etc.)
- Reference Star:
  - bright star for dark hole digging visible at the same time as your target.
  - Integration time needed for RDI observations?
- Calibrations?



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*Science Target Selection was driven by  
Community Input and observability.*



# White Paper Key Science Themes

- Many suggestions of reflected light Jovian analogues to image
- Optical polarimetric observations of known reflected light exoplanets.
- Imaging of specific known self-luminous exoplanet / substellar companions
- Exozodi imaging: optical to MIR, high priority HWO targets
- Disks as technology demonstration targets for the polarimetry modes and faint target obs.
- Optical constraints on dust properties in disks; grain sizes and compositions from albedos, scattering phase functions and transmission spectra
- Transport dominated, warm debris disks observations



# White Paper Key Technology Themes

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- Model validation: Quantify contrast as a function of ...
  - Target properties (brightness, diameter), DM settling time, thermal drift, Delta pitch between target/reference etc.
- Lots of Alternative WaveFront Sensing and Control (WFSC) algorithms:
  - Sense in single polarization, Half dark hole, broadband sensing, binary stars, Linear dark field control, empirical Jacobian updates etc.



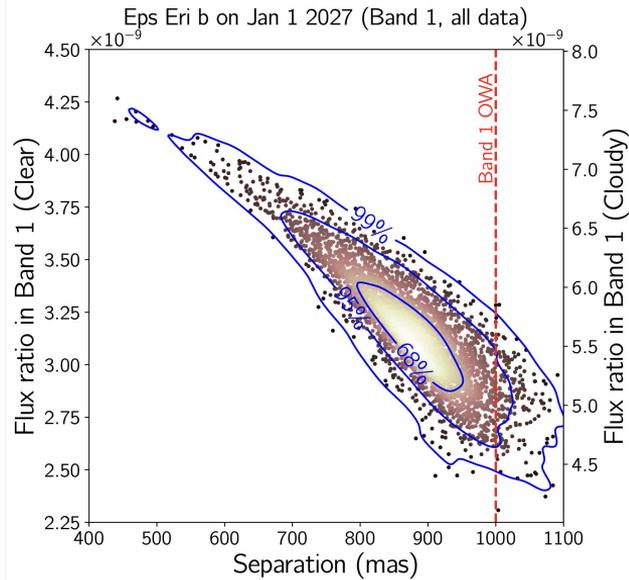
# Ambitious Goals in Early Ops!

- Begin with TTR5 (if not already demonstrated in Commissioning)
- Early moderate contrast test system: likely HIP 71618
  - Wavefront Sensing activities: probe with Wollastons, delta function probes
- High Impact Science Goals:
  - Reflected light planets: ups And d, Eps Eri b
  - Debris Disks and exozodi observations: Eps Eri, eta Crv, HR 4796
- Technology Demonstrations:
  - Push deep in both HLC B1 and WFOV B1 imaging, polarimetry to characterize CGI performance
  - Understand faint star performance
  - Screen reference stars for bright companions (See Hom talk)

# Reflected Light Planets

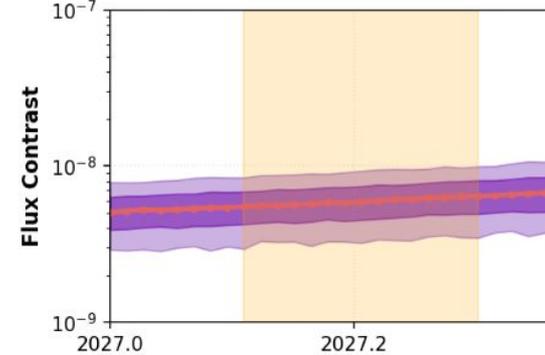
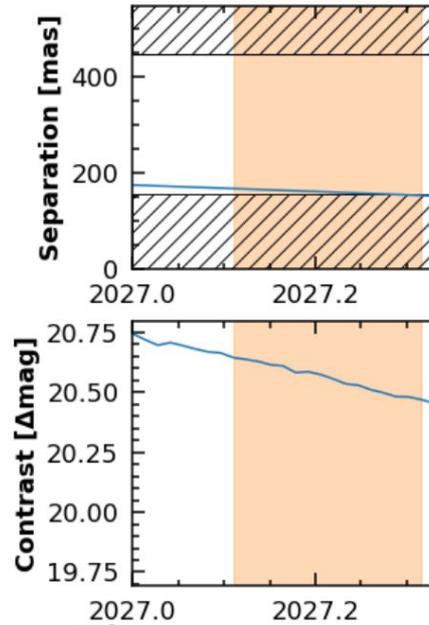


## Eps Eri SPC B1



Courtesy of J. Llop-Sayson, W. Balmer, W. Thomson

## ups And d HLC B1



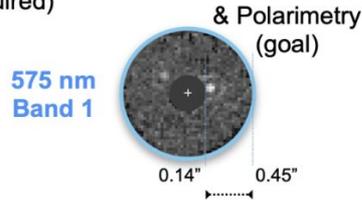
Courtesy of C. Do O, E. Bogat,  
A. Vigan



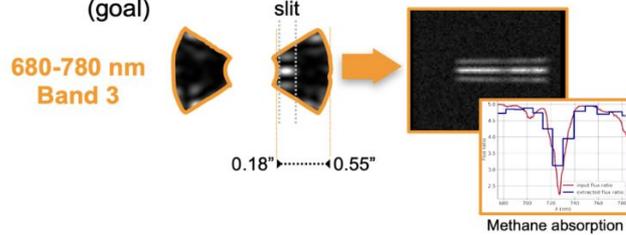
# Exercise all “Best Effort” Modes

- Spectroscopy on moderate brightness BDs.
  - Ex. one easily in FOV (HIP 71618) and one at IWA (HIP 54515)
- Interleave observations of self-luminous planets/BD (HR 8799, kappa And, HR 2562) with imaging + polarimetry of reflected light debris disks to probe dust transport and planet interactions.
- USco ‘star hopping’ disk search w/ polarimetry
- Spectroscopy of HR8799e
- Additional objects from exozodi campaign
- May try for SPF of bright disks (HD 191089, HD 163296), but chance of deferral b/c of very tight schedule.

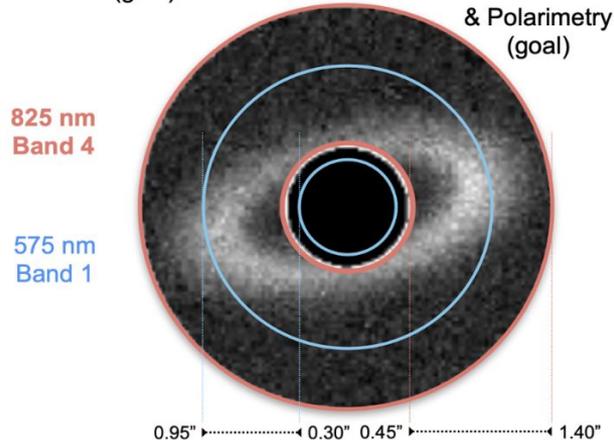
## Narrow Field Imaging (required)



## Grism Spectroscopy (goal)



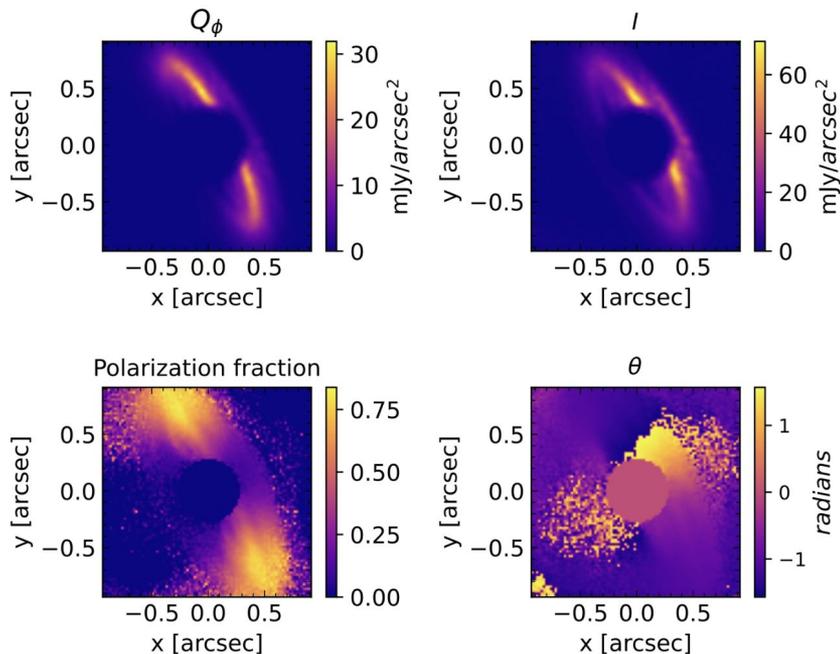
## Wide Field Imaging (goal)





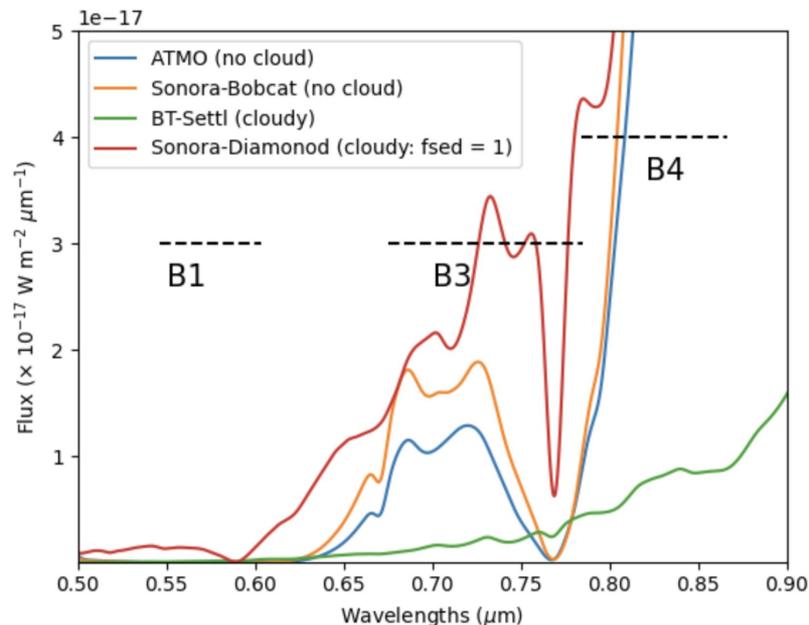
# Exercise all “Best Effort” Modes

- Understanding extended structures and Polarimetry performance



R. Anche

- Benchmarking Spectroscopy modes towards reflected light planets.



M. Kuzuhara



*CorGI-REx, the bright  
reference star vetting  
campaign for the  
Roman Coronagraph.  
Led by Justin Hom*

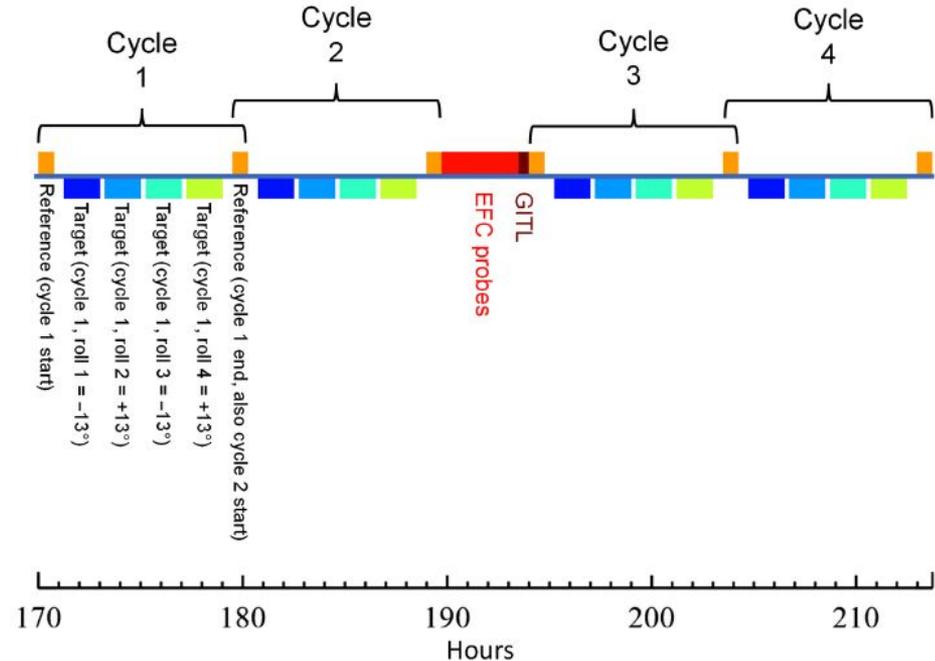


^See the list of reference stars and  
desired new observations here  
<https://tinyurl.com/CorGIRefStars>



# Motivation

- Dark hole digging and touch-up on a nearby reference star is a **required component** of a typical science observation
- Science camera images of the reference star can serve as **post-processing RDI references**

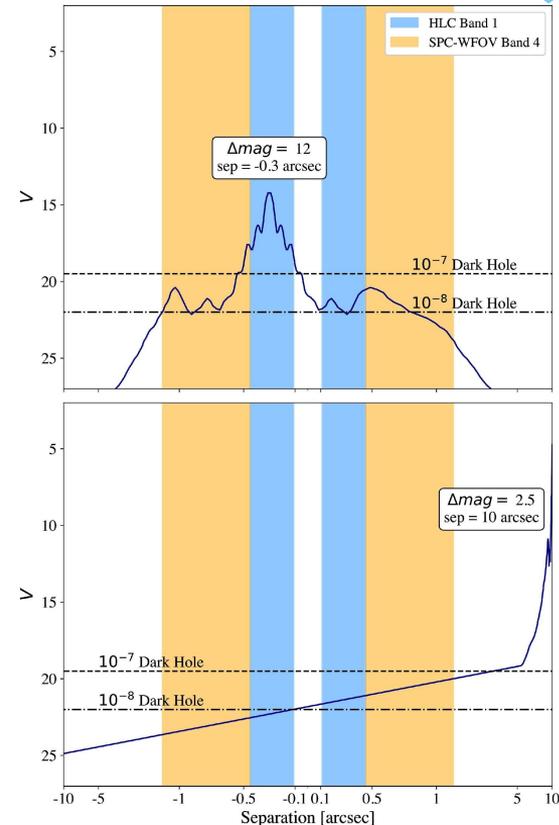


Credit: Krist et al. (2023)



# The Reference Star Problem

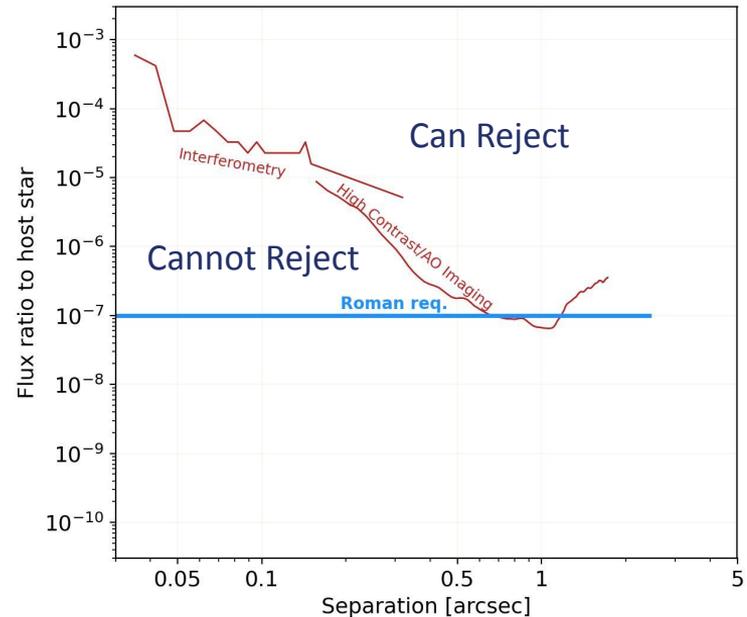
- $V < 3$
- Resolved angular stellar diameter  $< 2$  mas
- Cannot have any companions (bound and background) that may inhibit performance
- Science targets must be within 5 degrees of observatory pitch angle from the reference star
- This does not leave many possible options! Only  $\sim 100 < 2$  mas diameter stars with  $V < 3$ , and **they are all high-mass stars.**
- If we pick a bad reference star for an observation, **overall contrast performance may be inhibited/degraded** and we will **waste several hours of the guaranteed 90 day Observation Phase**
- Availability of reference stars at a given time **dictates when science targets can be observed**





# Vetting the Candidate List

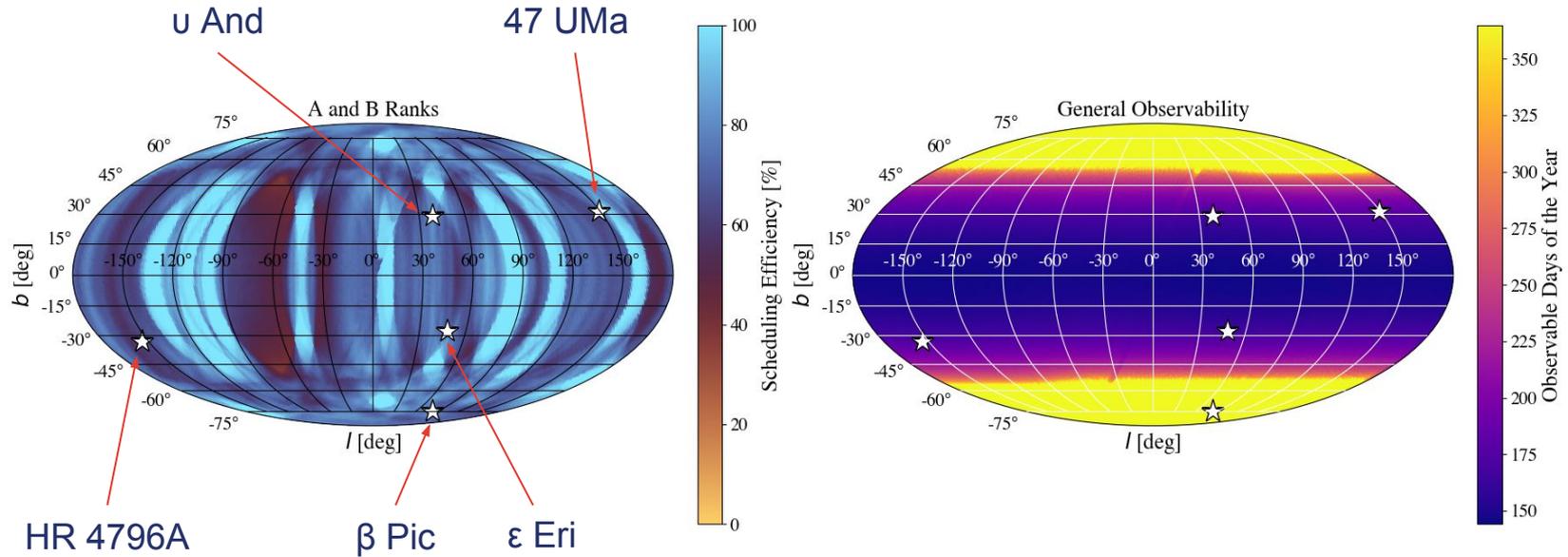
- Rankings are largely based on indirect (RV, astrometry) observational evidence and are often **not conclusive/exhaustive**
- Vetting with direct imaging down to the Roman requirement is essential for ensuring suitability
- While we combed through the archive, we started with efficient surveys using AO imaging (Hale/PHARO) and speckle interferometry (Gemini/Alopeke and Zorro)
- Since Fall 2024, we've collected 300+ hours of observations across nine observatories using high contrast and interferometric instruments



# Planning Observation Campaigns around Ref. Stars



Currently 17 Reference stars are deemed suitable, with scheduling efficiencies ranging from 37 – 75%



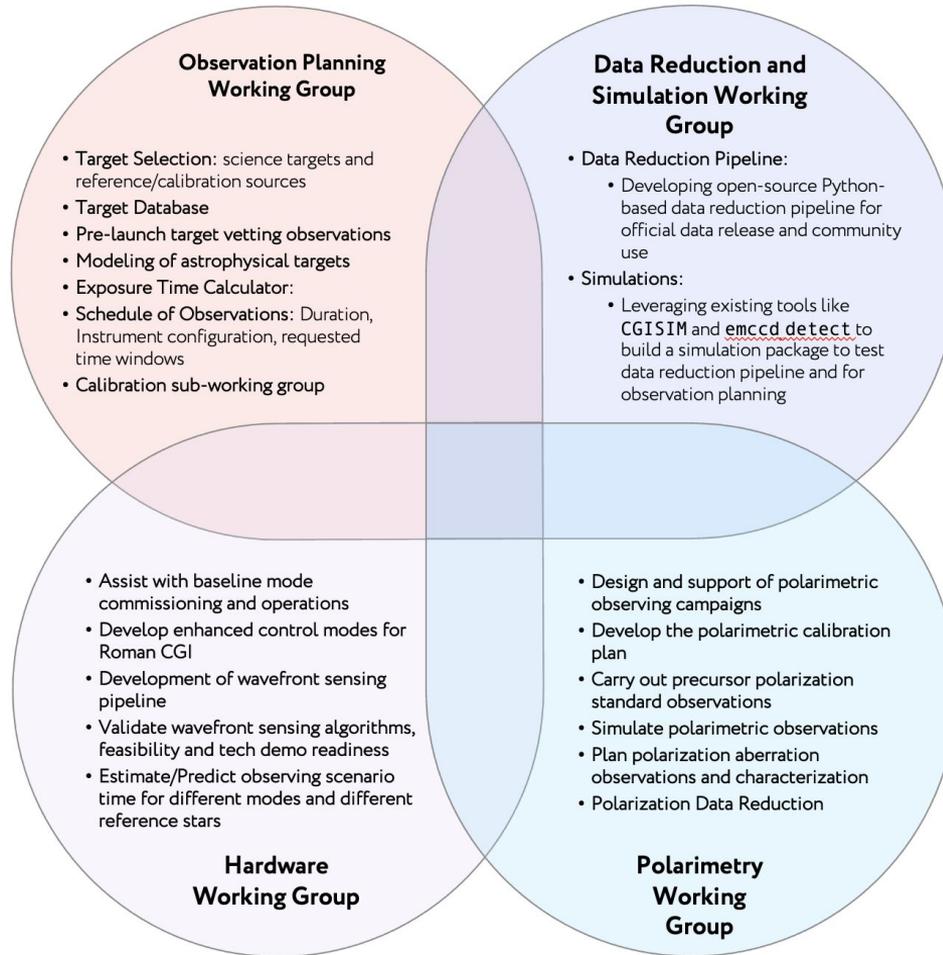
Scheduling Efficiency = # of days science has an available reference star visible divided by the # of days that science target is visible by itself.



# What is the CPP?

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- CPP = Community Participation Program
- Created by NASA and composed of 11 small, US-based teams, members of the Roman Project Team, and international partner teams from ESA, JAXA, CNES, and the Max Planck Institute for Astronomy.
- The primary goals of the CPP are to prepare tools, target databases, and data reduction software for the execution of the Coronagraph Instrument observation phase.

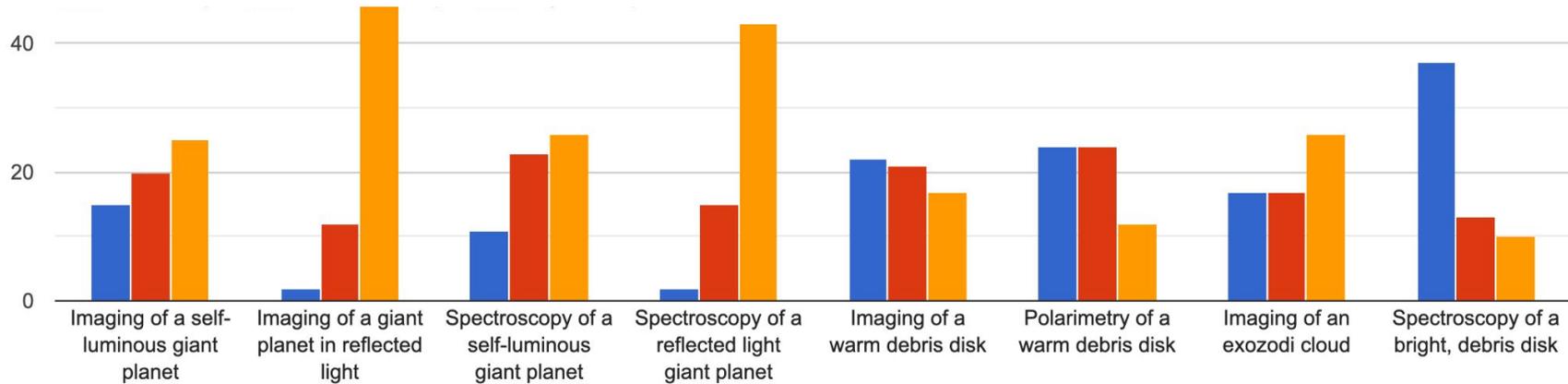


# CPP Team Architecture



# Opportunities for Community Input

- Jan. 2025 Community Interest Survey



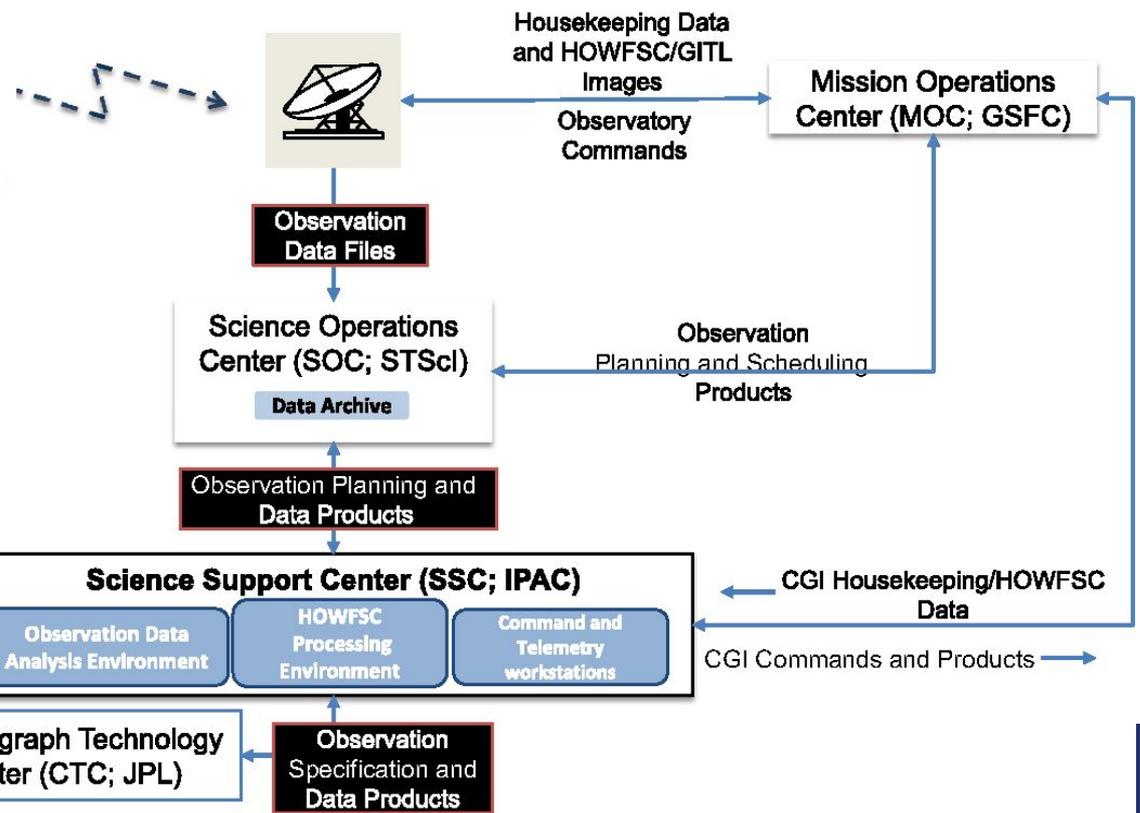
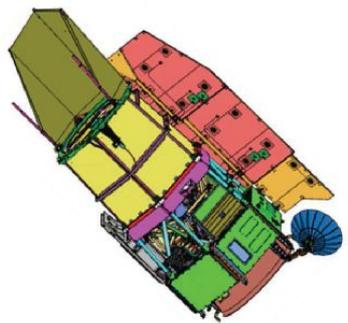
- Summer 2025 White Paper Call (Report Expected Spring 2026)

- Received ~80 White Papers with good spread between science and technology demonstration.

- Roman School!



# The CPP and Roman



Greenbaum et al. 2025

Coronagraph Community Participation Program (CPP)

Coronagraph Technology Center (CTC; JPL)

Observation Specification and Data Products

Thanks to the CPP, the Roman Project Team and the Community!





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# Roman CGI Exposure Time Calculator **Corgi-ETC**

