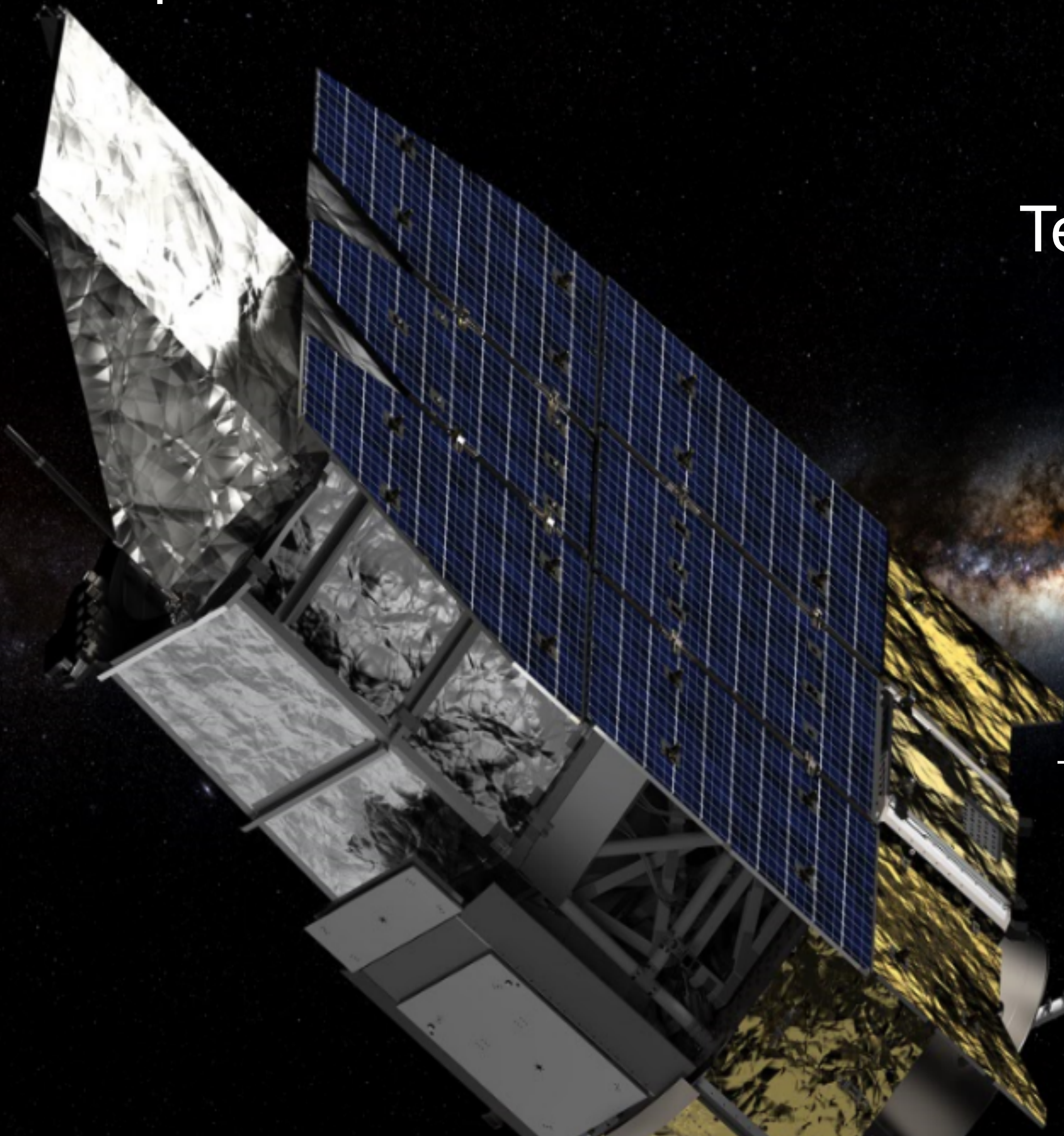
Roman Space Telescope



Technical Information and Project Status

October 7, 2020

Jeffrey Kruk *Deputy Senior Project Scientist*

• NASA GODDARD SPACE FLIGHT CENTER • JET PROPULSION LABORATORY •
• L3HARRIS TECHNOLOGIES • BALL AEROSPACE • TELEDYNE • NASA KENNEDY SPACE CENTER •
• SPACE TELESCOPE SCIENCE INSTITUTE • IPAC • EUROPEAN SPACE AGENCY •
• JAPAN AEROSPACE EXPLORATION AGENCY • LABORATOIRE D'ASTROPHYSIQUE DE MARSEILLE •
• CENTRE NATIONAL d'ÉTUDES SPATIALES • MAX PLANCK INSTITUTE FOR ASTRONOMY •

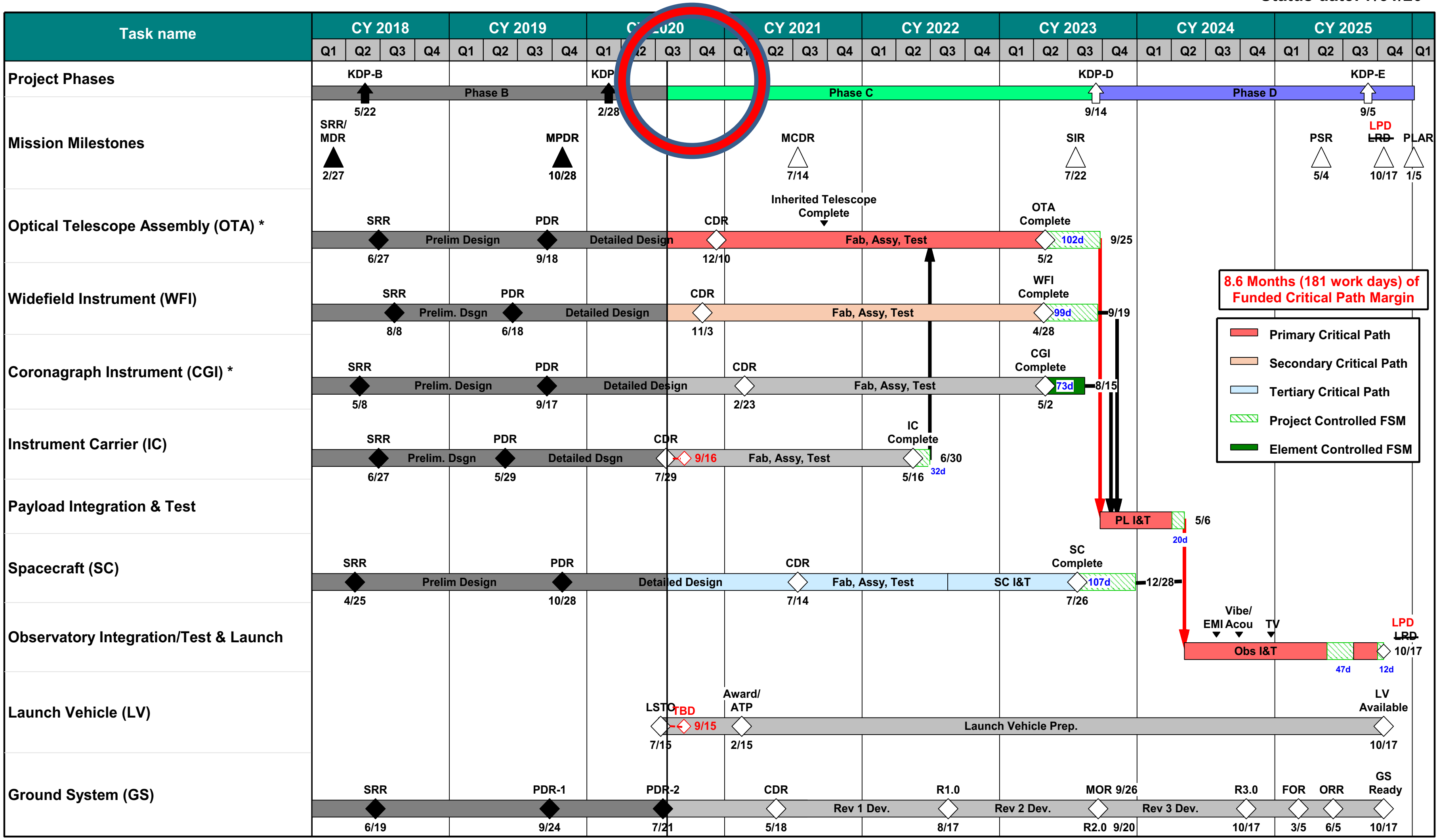
Roman Space Telescope Reviewed – Not Subject to Export Control

ROMAN SPACE TELESCOPE

Roman Project Master Schedule

COVID-19 impacts not included! Expect modest slips.

Status date: 7/31/20



KDP-A: February 2016 Now almost half-way to launch!

Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

Project Status

- Mission elements have been in final design phase since their respective PDRs a year ago
- Many engineering test units of new items have already been built and are being tested:
  - S/C: Electronics, structural elements, solar panel substrates
  - WFI: ASICs, electronics, filters, prism/grism assemblies, RCS, many other components,
  - CGI: optics, mechanisms, detectors, deformable mirrors…
- Many flight items are also being built:
  - Detectors (13 passing all requirements are in hand, expect remainder by January)
  - Optics: PM, SM, all optics in relay to coronagraph are figured and coated; optics in relay to WFI are being fabricated
  - Telescope: rework of metering structure in process (new thermal control hardware, new SM support tubes, new PM mounting struts)
  - Many spacecraft components: propulsion system components, reaction wheels, high-gain antenna, inertial-reference units
  - Instrument Carrier structure
- Initial rounds of coupled-loads analysis with potential launch vehicle completed

- Overall: work is going to plan apart from COVID-19 impacts.
- Those will be formally assessed early next year as part of the normal planning and budget process.

Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

Status Summary

- Have completed "Preliminary Design"
  - ~130 engineering peer reviews leading up to Preliminary Design Review (PDR)
  - Engineering development units of many hardware items already built, more in progress
  - For much of observatory, design today is what will be built and what will fly
  - PDR & KDP processes include extensive management and cost reviews
    - Plan to execute the mission is as big a part of the reviews as the engineering design
- Instrument Carrier completed Critical Design Review
- Other segments to complete CDRs in coming ~6 months
- FY2020 and FY2021 are the peak budget years
  - Approaching 1000 people working on Roman!
- FY21 White House Budget proposed termination of Roman (for 3rd time)
  - Direction was to proceed according to plan while Congress deliberates
  - Congress fully-funded Roman in FY21
  - Would not be surprised if same scenario in FY22 (a CR accomplishes this)

We are on track for a launch "no later than 2026"

Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

QUESTIONS?

For more information, see:

https://roman.gsfc.nasa.gov/

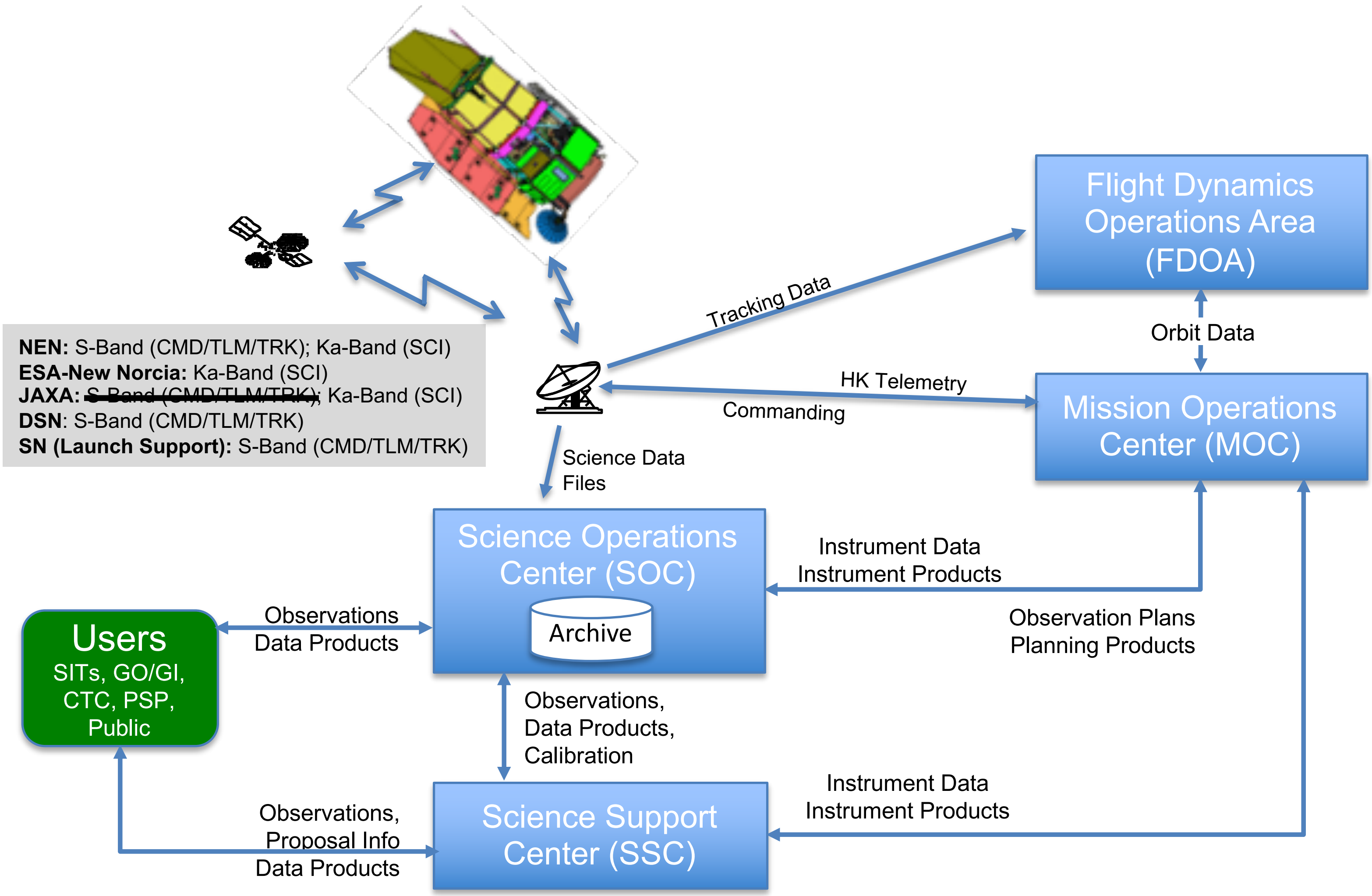
https://roman.gsfc.nasa.gov/science/Roman_Reference_Information.html

Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

REFERENCE INFORMATION

Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

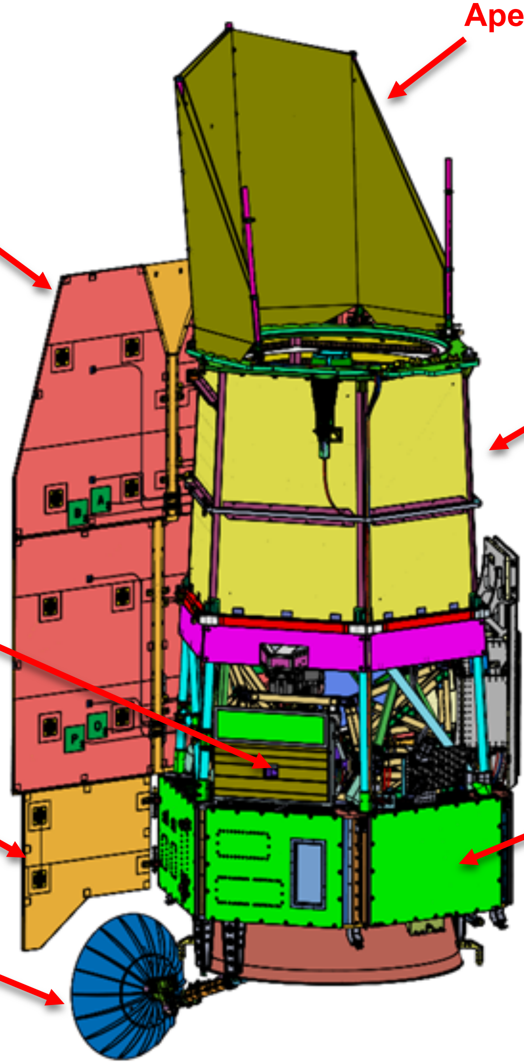
Ground System Architecture



CMD – Command; TLM – Telemetry; TRK – Tracking; HK – Housekeeping; SCI – Science; SIT – Science Investigation Teams; GO/GI – General Observer/Guest Investigator; CTC – Coronagraph Technology Center; PSP – Participating Scientist Program;

Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

Observatory Concept



Key Features

Telescope: 2.4m aperture

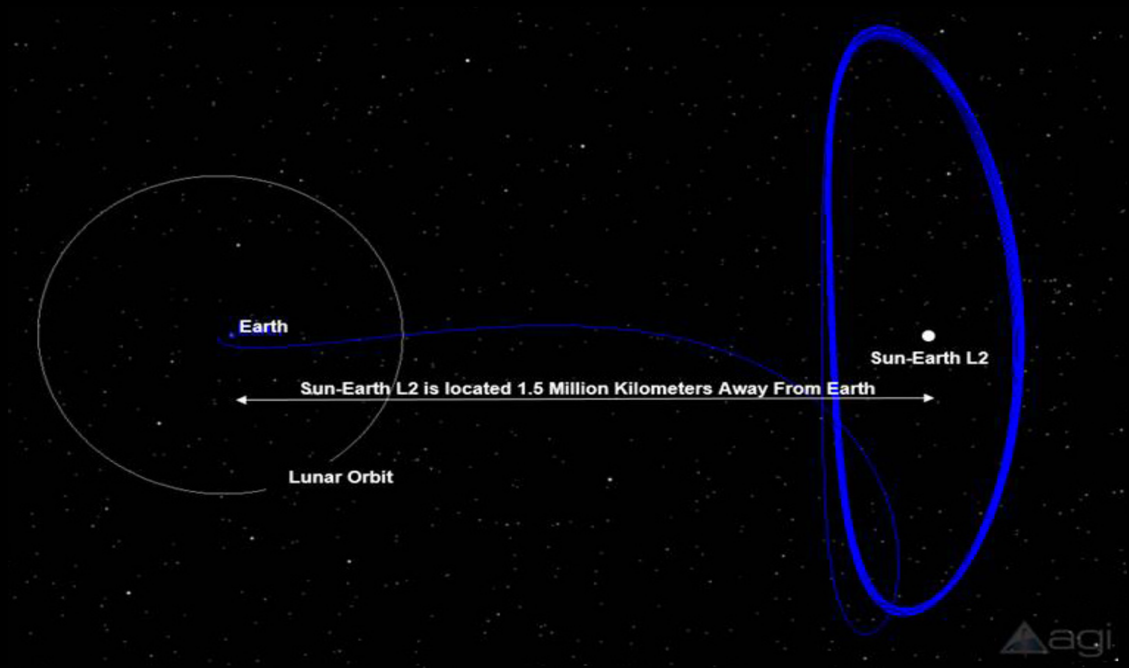
Instruments:

Wide Field Imager / Slitless Spectrometer
Internal Coronagraph

Data Downlink: 250 Mbps
Data Volume: 11 Tb/day
Orbit: Sun-Earth L2
Launch Vehicle: 3 options
Mission Duration: 5 yr, 10yr goal
Serviceability: Observatory designed to be robotically refueled

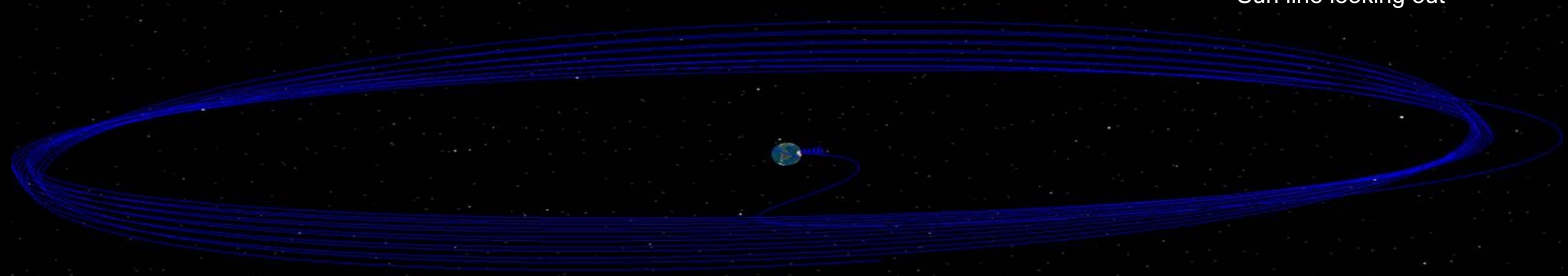
Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

L2 Orbit



"Top view"

View from Earth-Sun line looking out

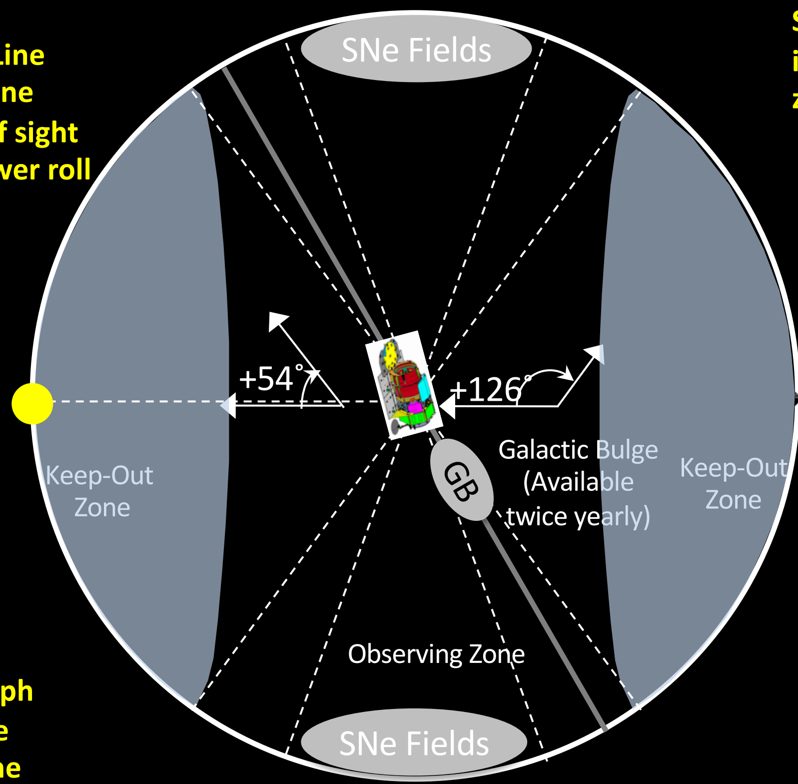


Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

Field of Regard

Observing Zone:
- **54˚-126˚ off Sun Line**
- **360˚ about Sun Line**
- **±15˚ about line of sight (LOS) off max power roll angle**

SNe fixed fields located in continuous viewing zone



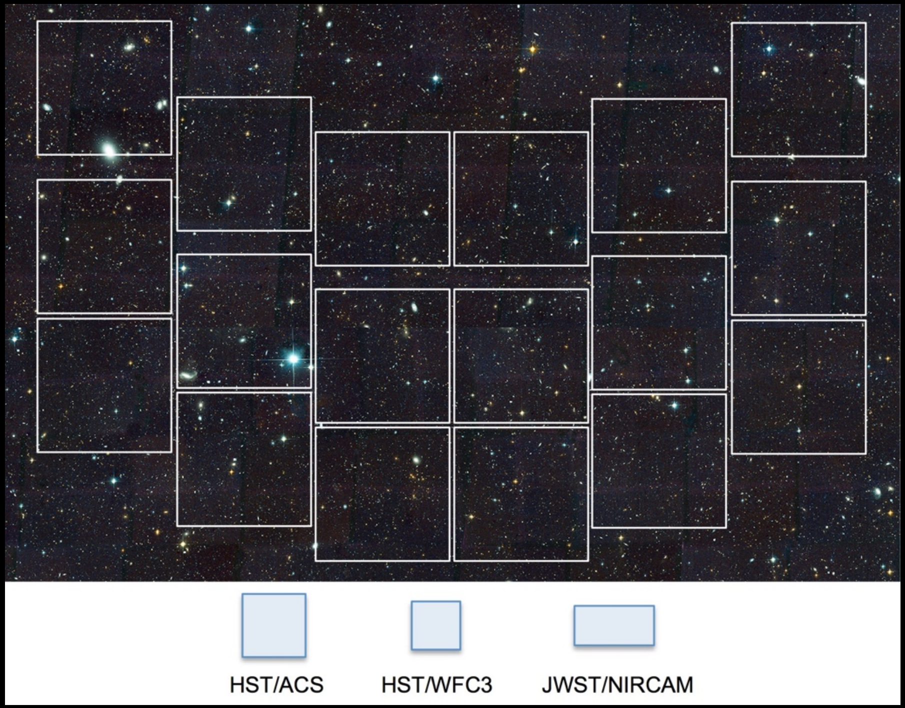
Earth/Moon LOS avoidance angles are a minor sporadic constraint

HLS/GO/Coronagraph observations can be optimized within the full Observing Zone

Microlensing can observe inertially fixed fields in the Galactic Bulge (GB) for 72 days twice a year

Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

Roman Field of View



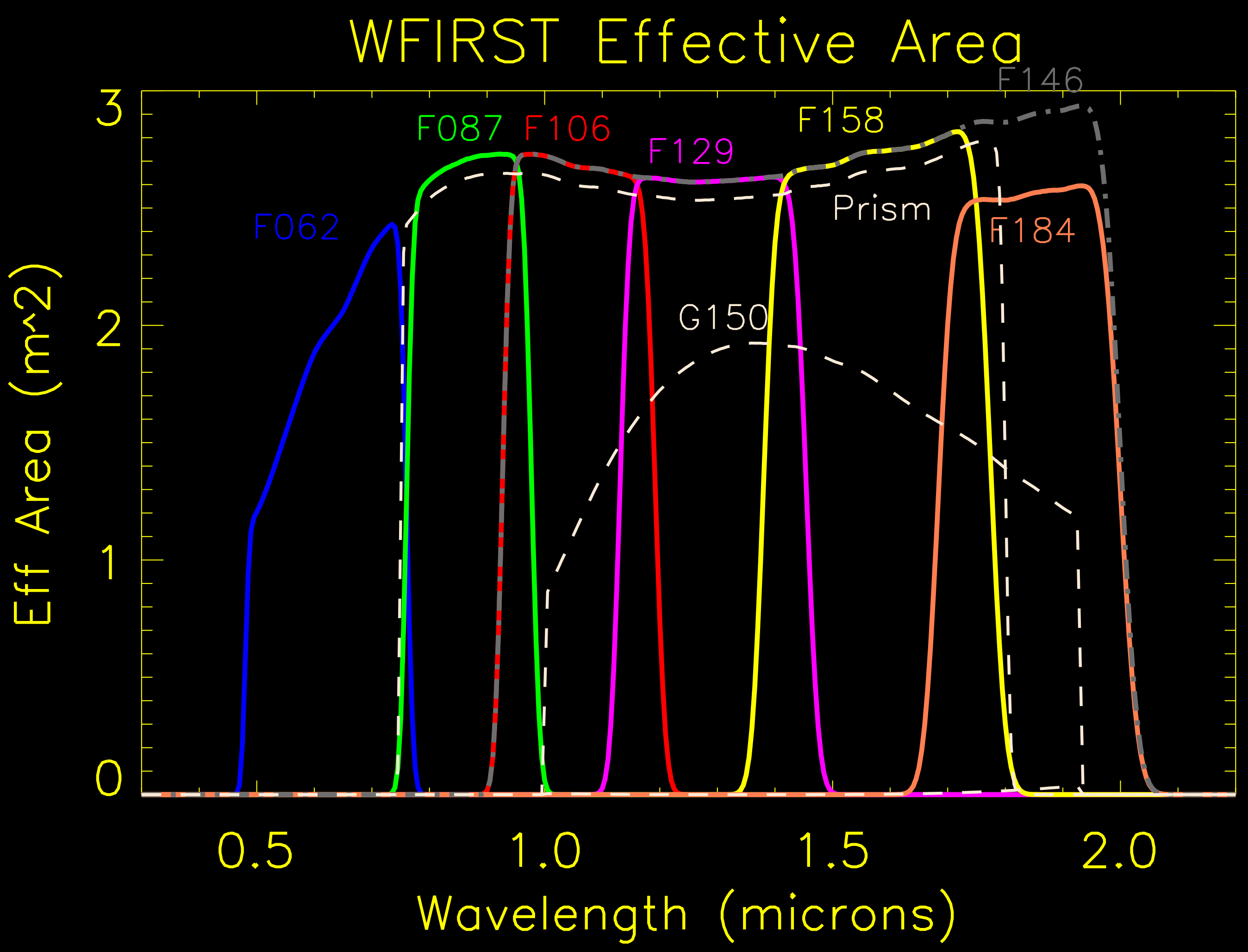
Diffraction-limited imaging
0.28 square degree FoV
0.11” pixels
18 4kx4k NIR detectors
R~4 filters spanning 0.48-2.0 μm

Slitless grism:
1.0-1.93 μm
R: 435-865

Slitless prism:
0.75-1.8 μm
R: 80-170

Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

Effective Area & Filters



Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

WFI Filters & dispersers

Band	Element name	Min (μm)	Max (μm)	Center (μm)	Width (μm)	R
R	F062	0.48	0.76	0.620	0.280	2.2
Z	F087	0.76	0.977	0.869	0.217	4
Y	F106	0.927	1.192	1.060	0.265	4
J	F129	1.131	1.454	1.293	0.323	4
H	F158	1.380	1.774	1.577	0.394	4
	F184	1.683	2.000	1.842	0.317	5.81
Wide	F146	0.927	2.000	1.464	1.070	1.37
GRS	G150	1.0	1.93	1.465	0.930	461λ(2pix)
PRS	P127	0.75	1.80	1.275	1.05	80-170 (2pix)

Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

Representative Continuum Sensitivity

Limiting point-source sensitivity (AB mag) in 1 hour of exposure time, Zodiacal light set at twice minimum.

Imaging, 5σ						
R062	Z087	Y106	J129	H158	F184	W149
28.6	28.2	28.1	28.0	28.0	27.5	28.3

Spectroscopy, 10σ per pixel in continuum			
	0.8 μm	1.2 μm	1.5 μm
Grism	N/A	21.0	20.7
Prism	22.2	23.0	23.0

Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

Representative Emission Line Sensitivity (grism)

Emission line flux detected at 6.5σ in one hour, with zodiacal light set at twice minimum.
Units are 10^{-17} ergs/cm^2/sec

Wavelength	Source half-light radius	
µm	0.0”	0.2”
1.10	5.7	11.0
1.20	4.3	8.2
1.30	3.8	7.1
1.40	3.6	6.7
1.50	3.6	7.0
1.60	3.9	7.2
1.70	4.2	7.2
1.80	5.0	8.4

Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

WFI Cold Sensing Module

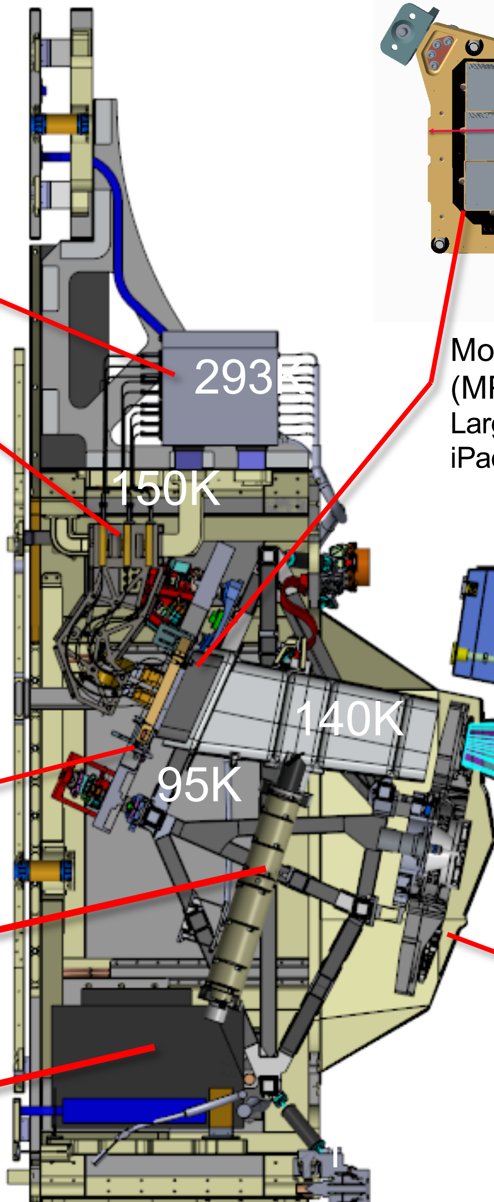
Focal Plane Electronics (FPE)

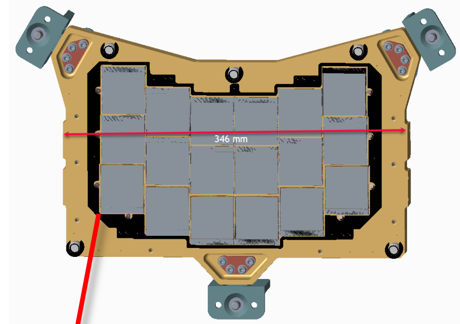
Sensor Cold Electronics Assembly (SCEA)

Alignment Compensation Mechanism (ACM)

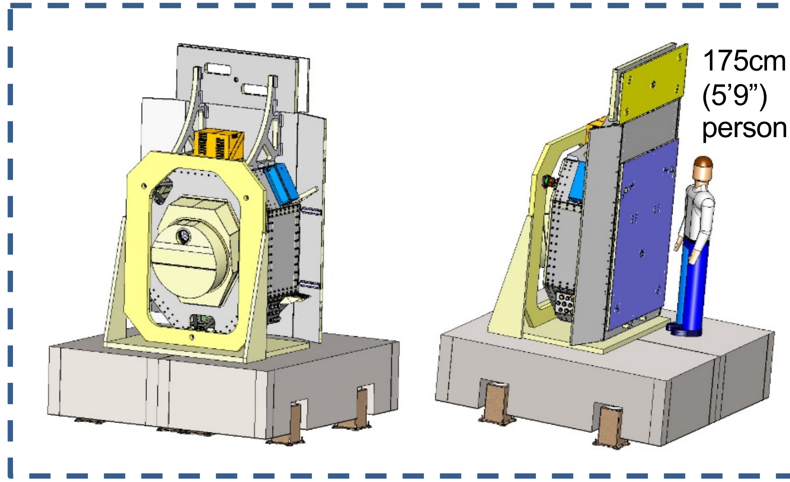
RCS Projection Optics

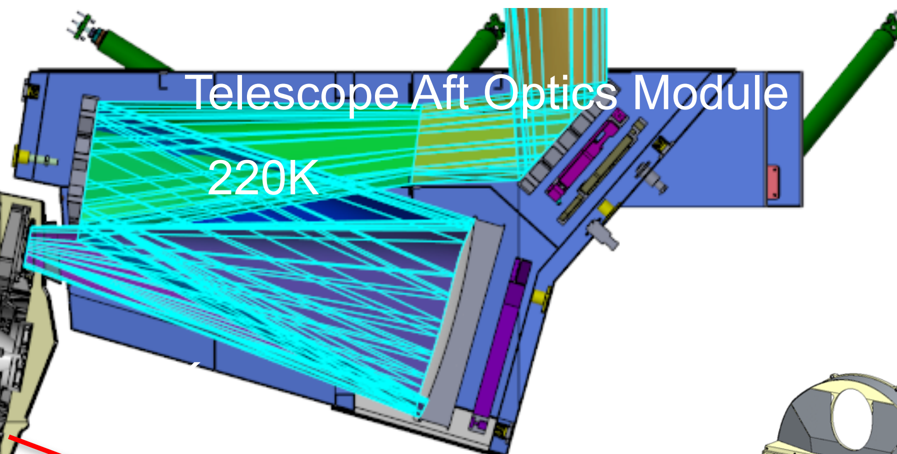
Relative Calibration System (RCS)

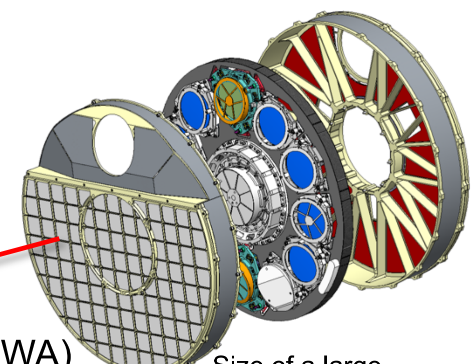




Mosaic Plate Assembly (MPA)
Larger detector area than an iPad display





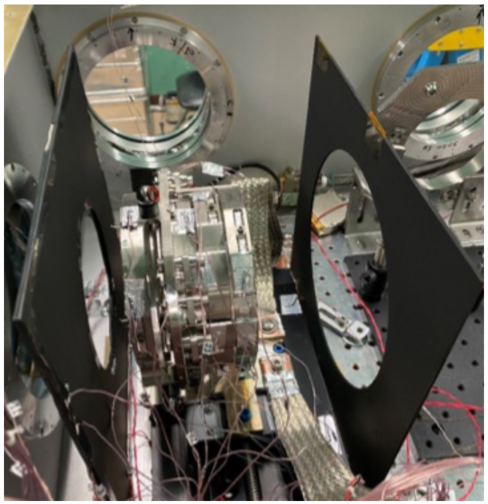


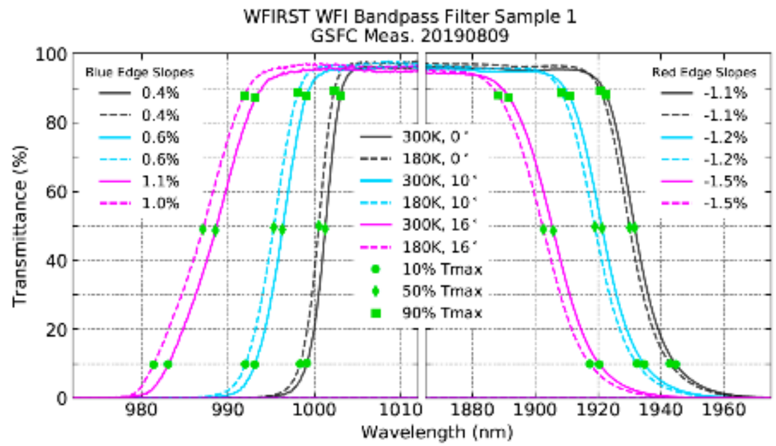
Element Wheel Assembly (EWA)
7 sci filters, phase retrieval filter, grism, prism, dark (~∅100mm)

Size of a large mountain bike wheel

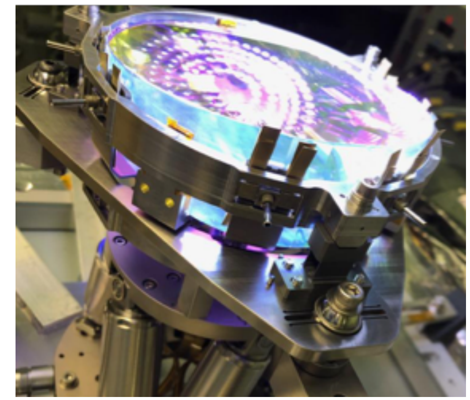
Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

WFI ETU Component sample

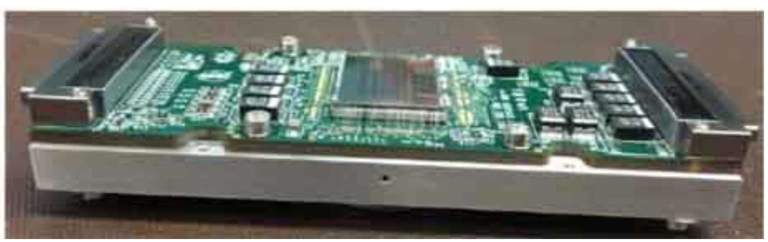




ETU grism bandpass measurement

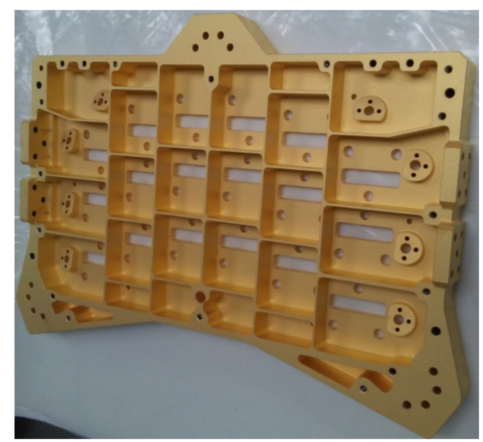


EDU prism assembly



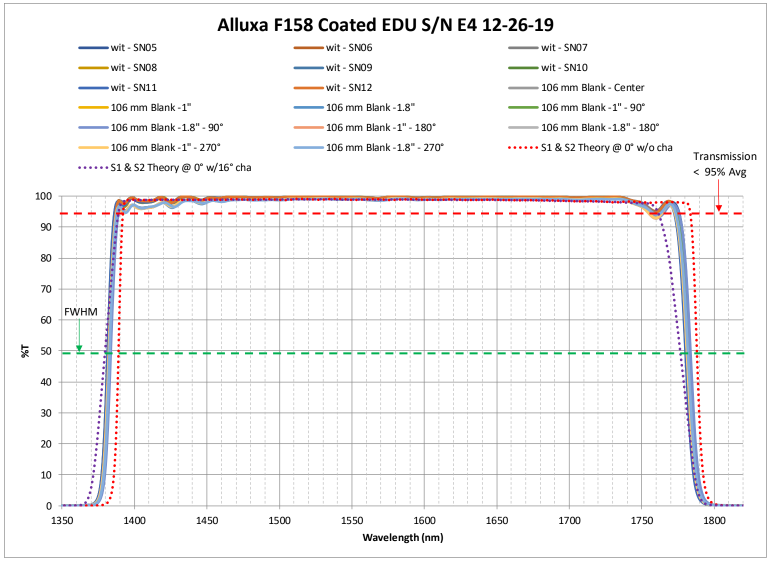
ACADIA ASIC EDU

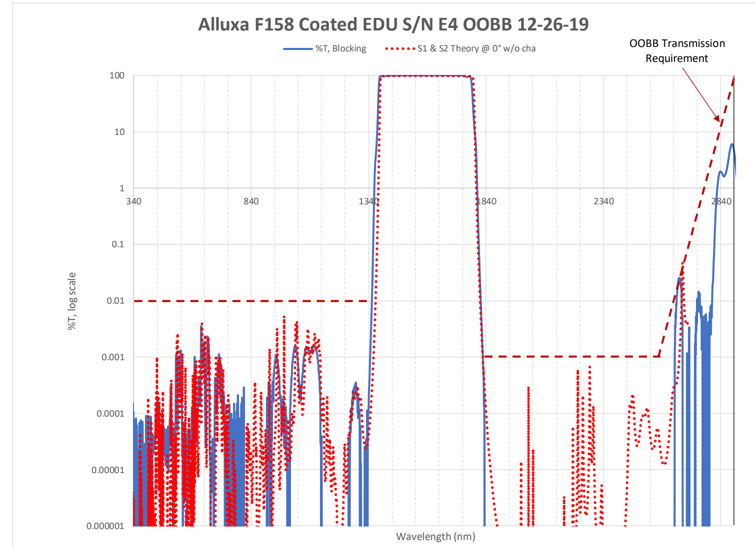
ETU Mosaic Plate



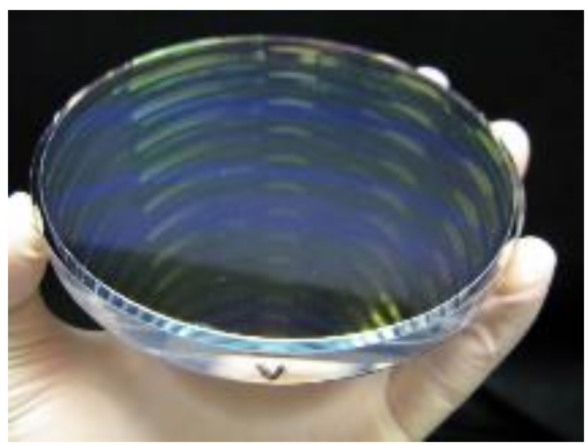
Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

WFI EDU Components – F158 filter





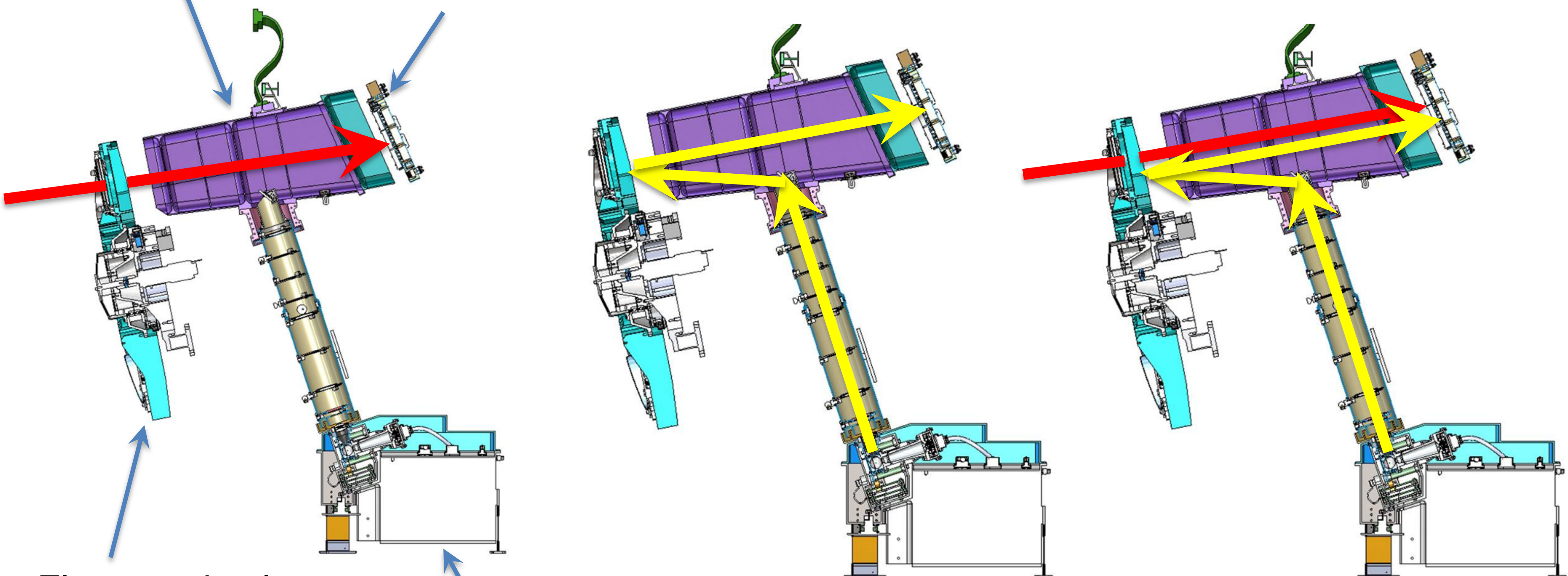
Log scale to show out of band transmission



Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

RCS Configurations

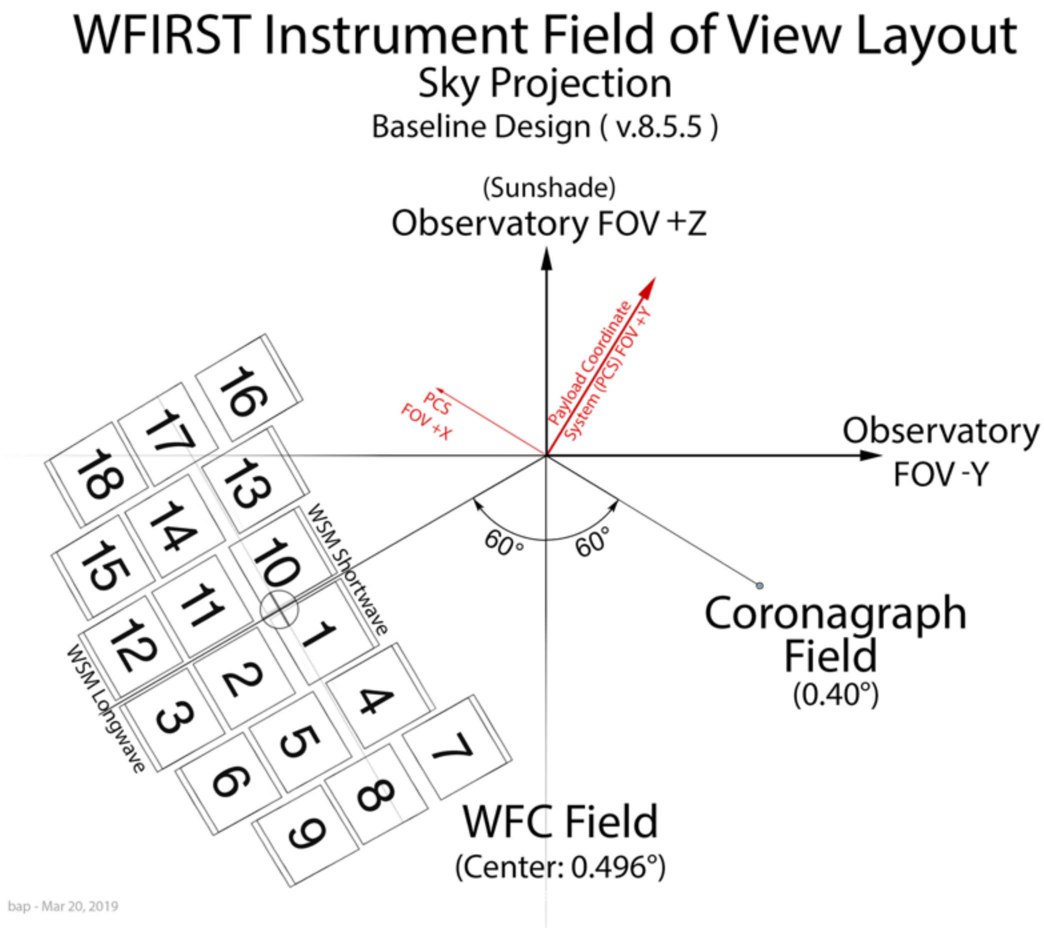
RCS Off	RCS Direct Mode	RCS Lamp-on/Lamp-Off
Light from telescope only *Normal observing*	Light reflects from diffuser on back of the dark filter No light from telescope *Non-linearity calibration, flats*	Light reflects from diffuser on the back of pupil mask (through filter) + beam from telescope *Non-linearity calibration*



Drawings courtesy of Greg Wirth

Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

FOV layout

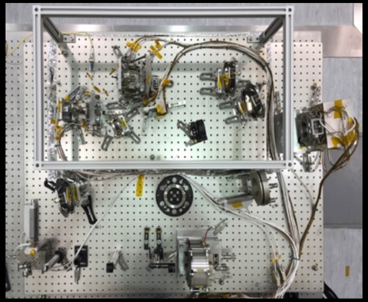


Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

Coronagraph

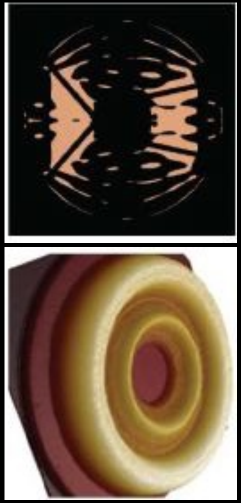
The Coronagraph Instrument on Roman is an advanced technology demonstrator for future missions aiming to directly image Earth-like exoplanets.

Autonomous Ultra-Precise Wavefront Sensing & Control

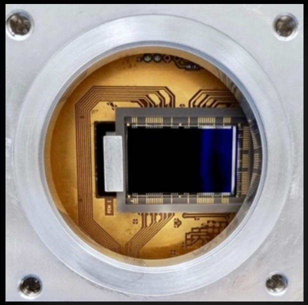


Large-format Deformable Mirrors

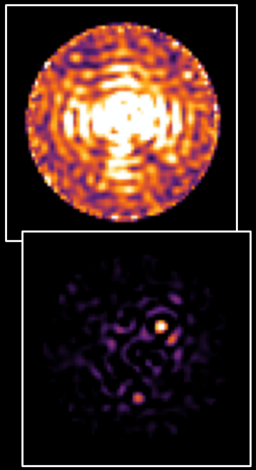
High-contrast Coronagraph Masks



Ultra-low noise photon counting visible detectors



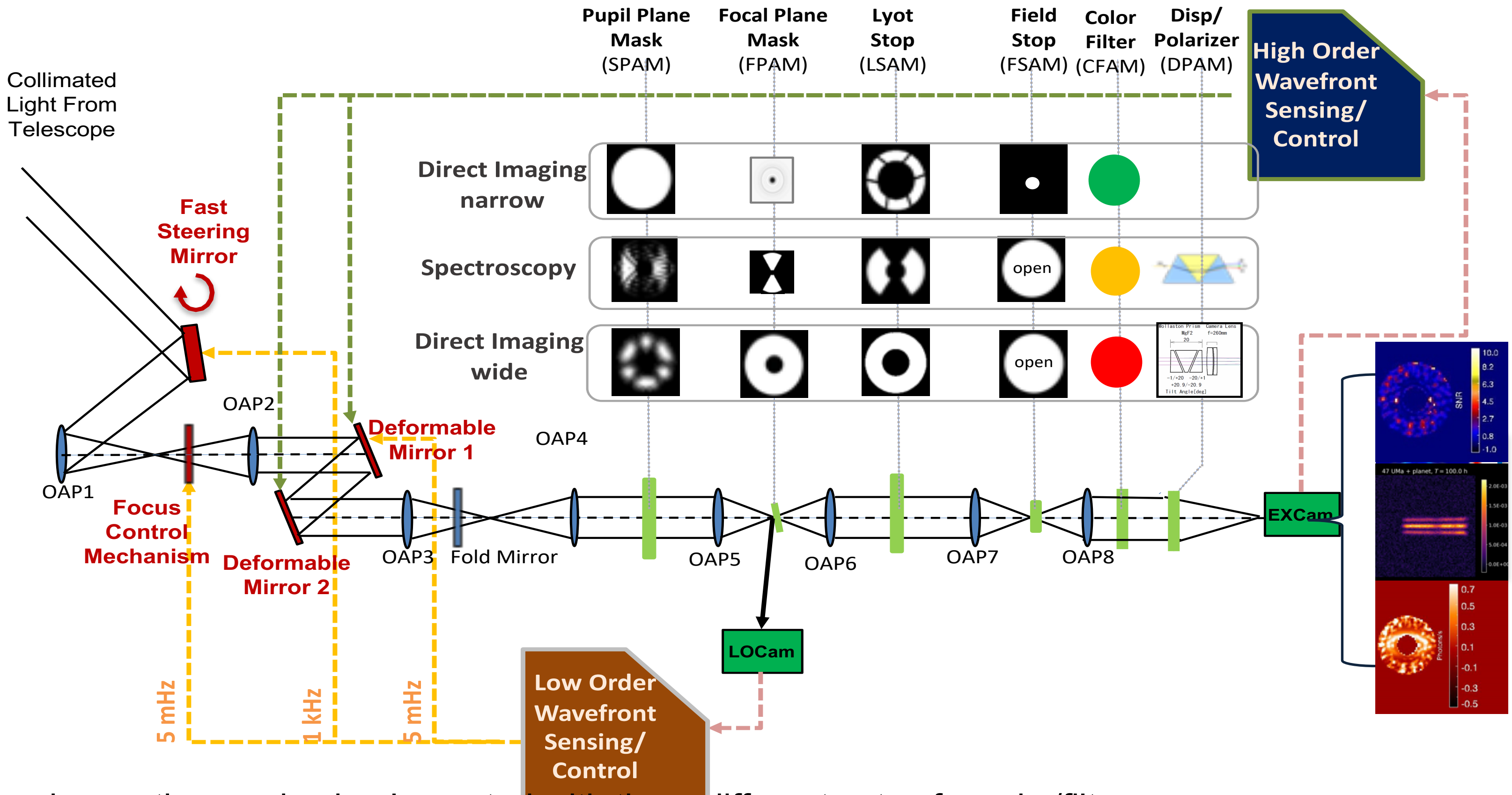
Data Post-Processing



CGI will premiere in space the technologies needed by future missions to image and characterize rocky planets in the habitable zones of nearby stars. By demonstrating these tools in a system with end-to-end, scientific observing operations, NASA will reduce the cost and risk of a potential future flagship mission.

Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

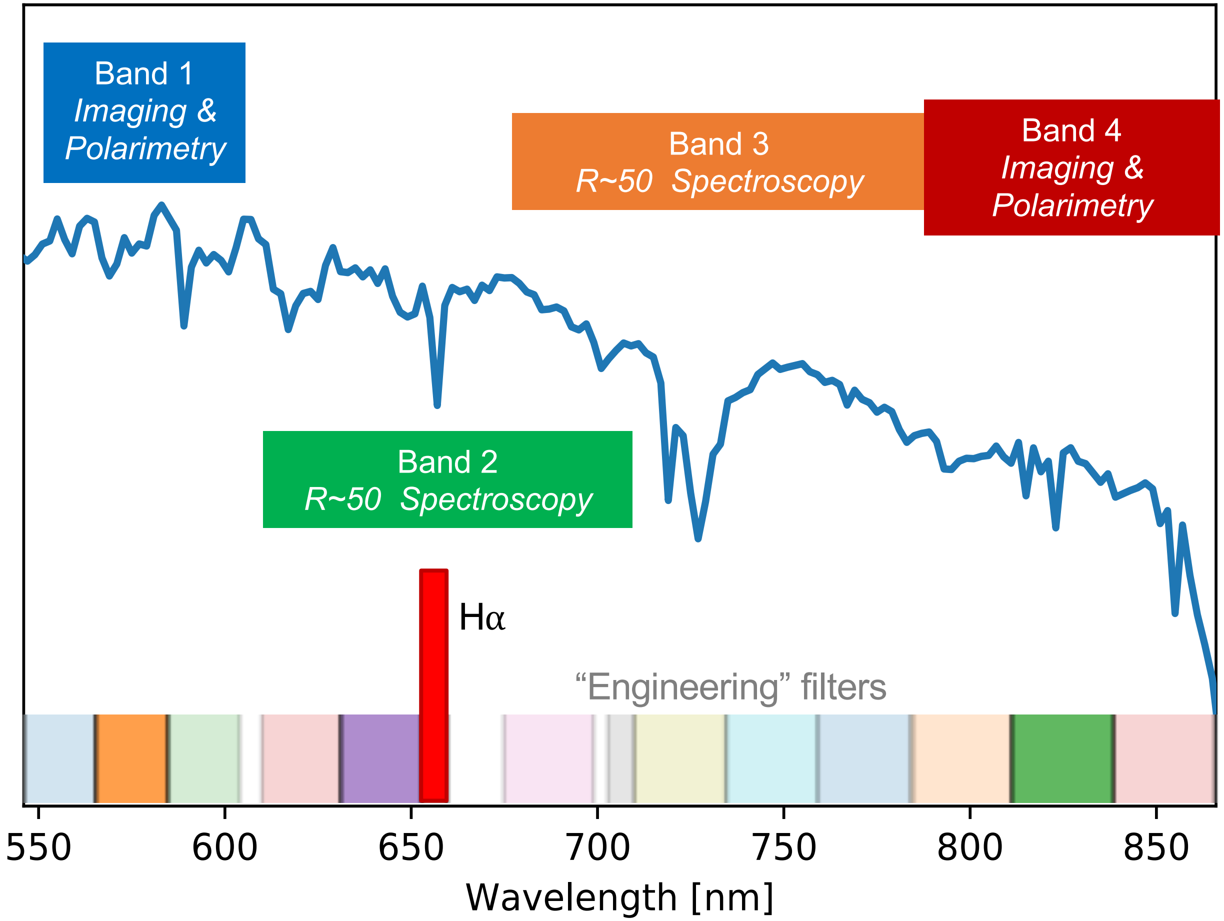
Coronagraph Architecture



- Three observation modes implemented with three different sets of masks/filters
- Share the same optical beam train, with two wavefront control loops to achieve high contrast (better than 1E-8)

Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

Coronagraph Passbands

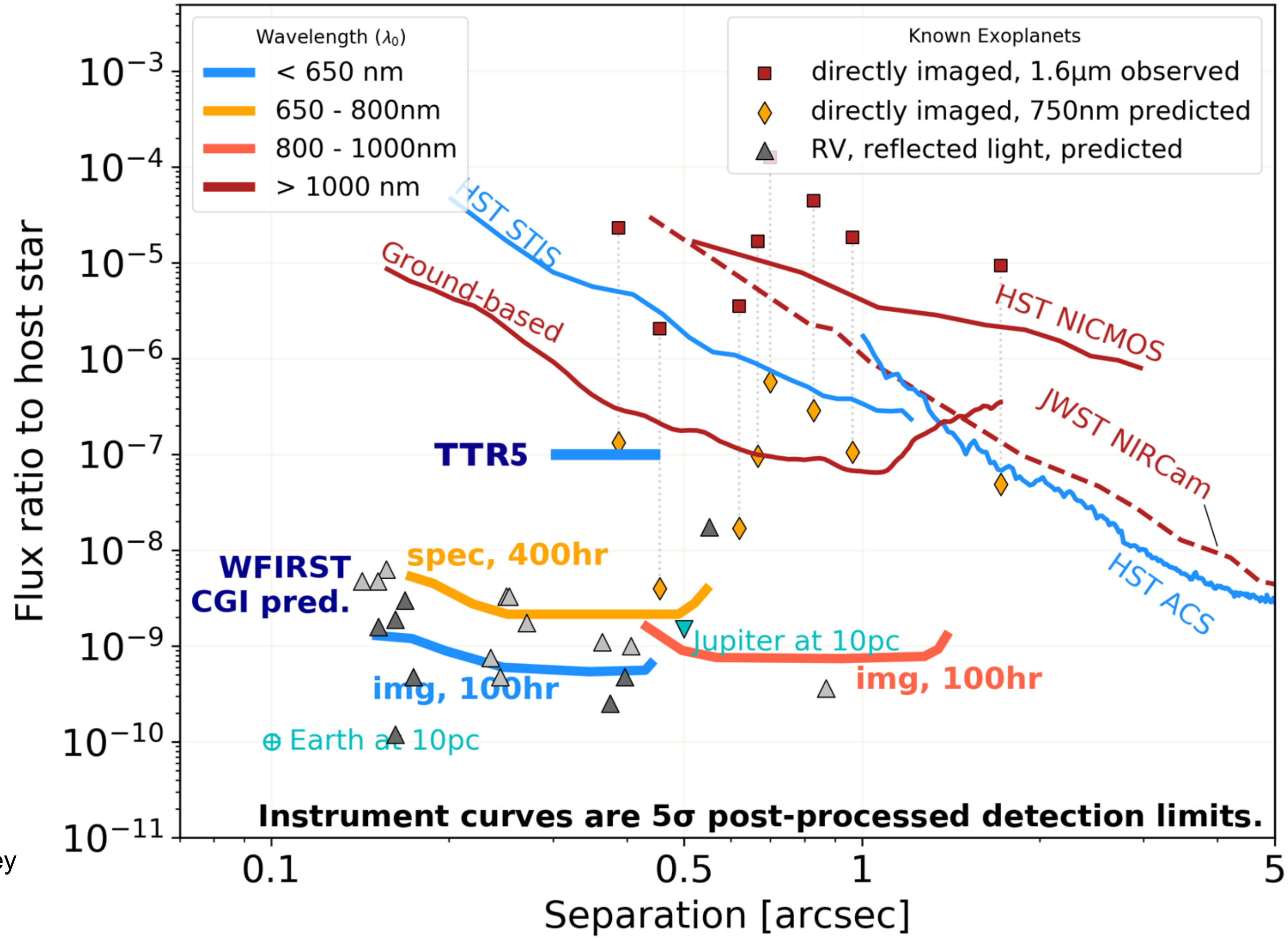


Three "official" modes will be fully tested prior to launch (Bands 1, 3, and 4)

Additional modes installed but not fully tested before launch

Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

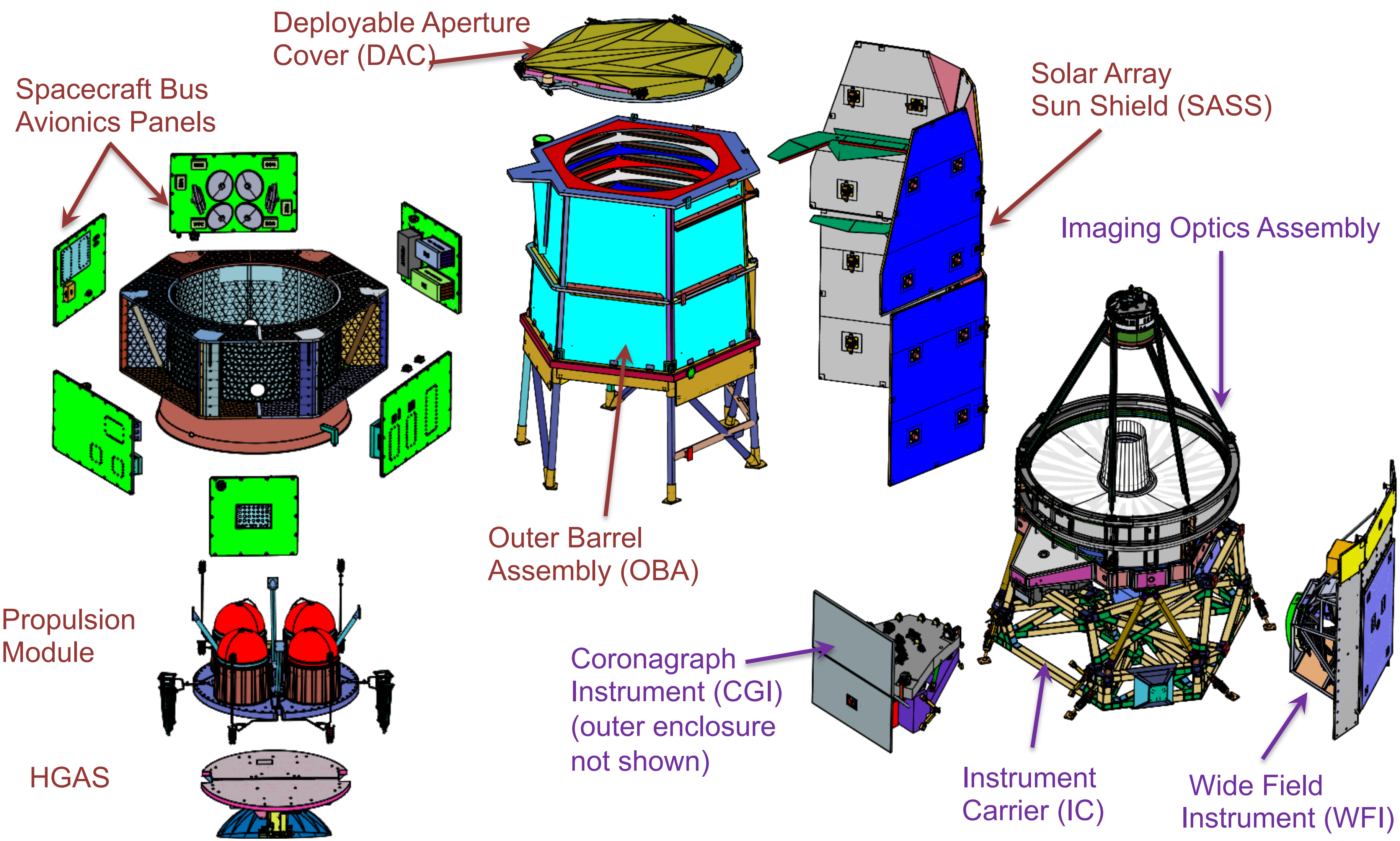
Anticipated Performance



Courtesy Vanessa Bailey

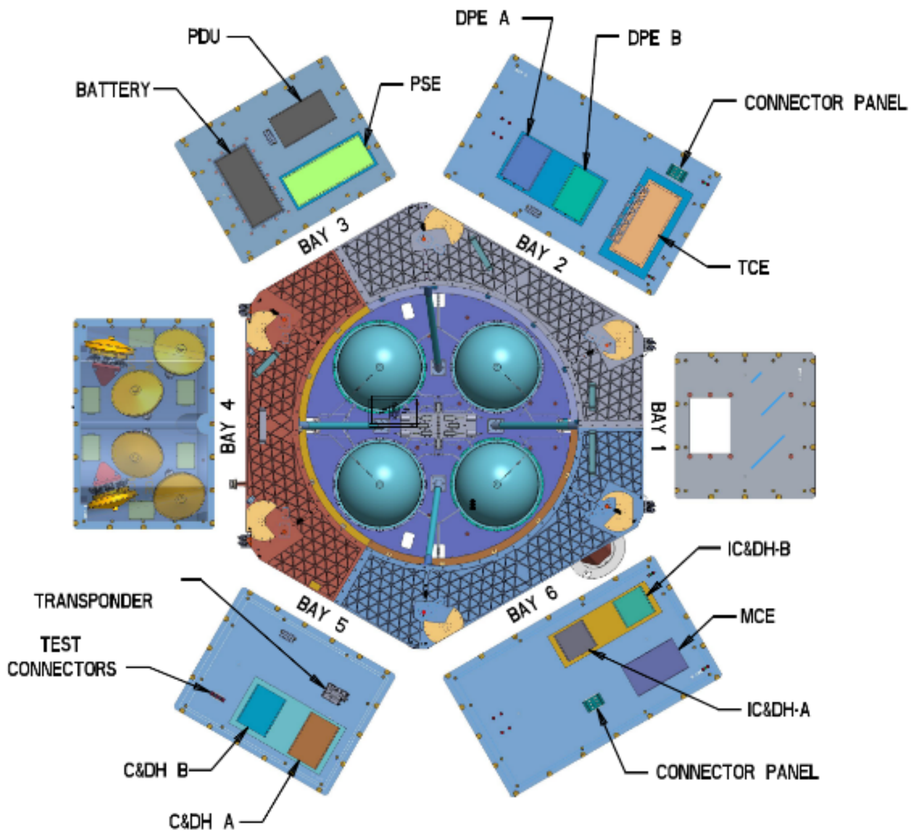
Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

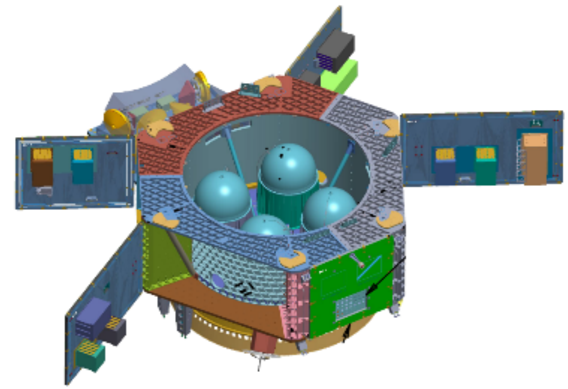
Observatory Expanded View

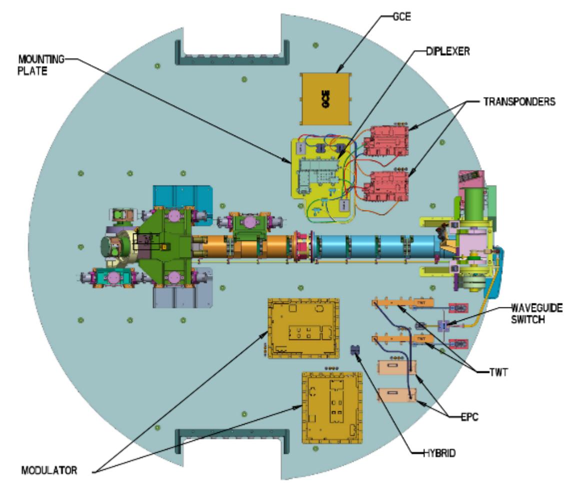


Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

Spacecraft Layout



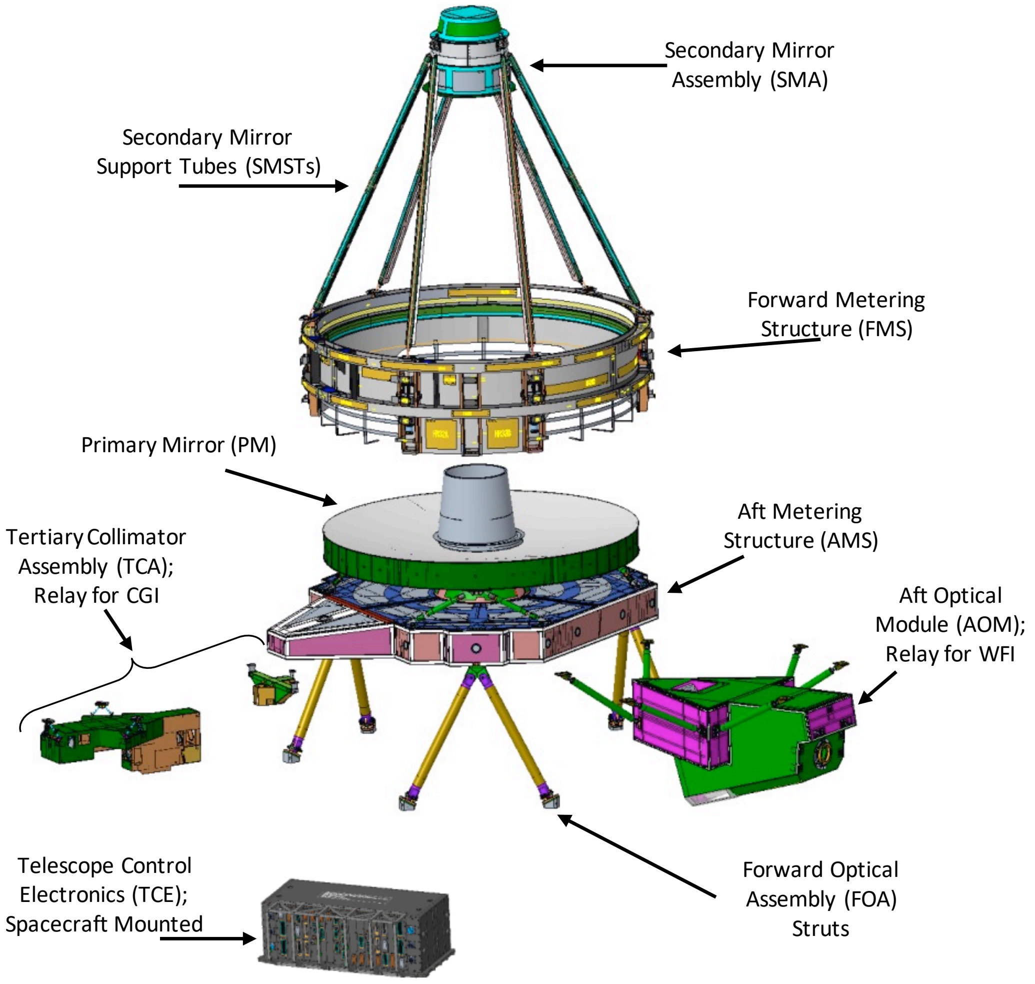


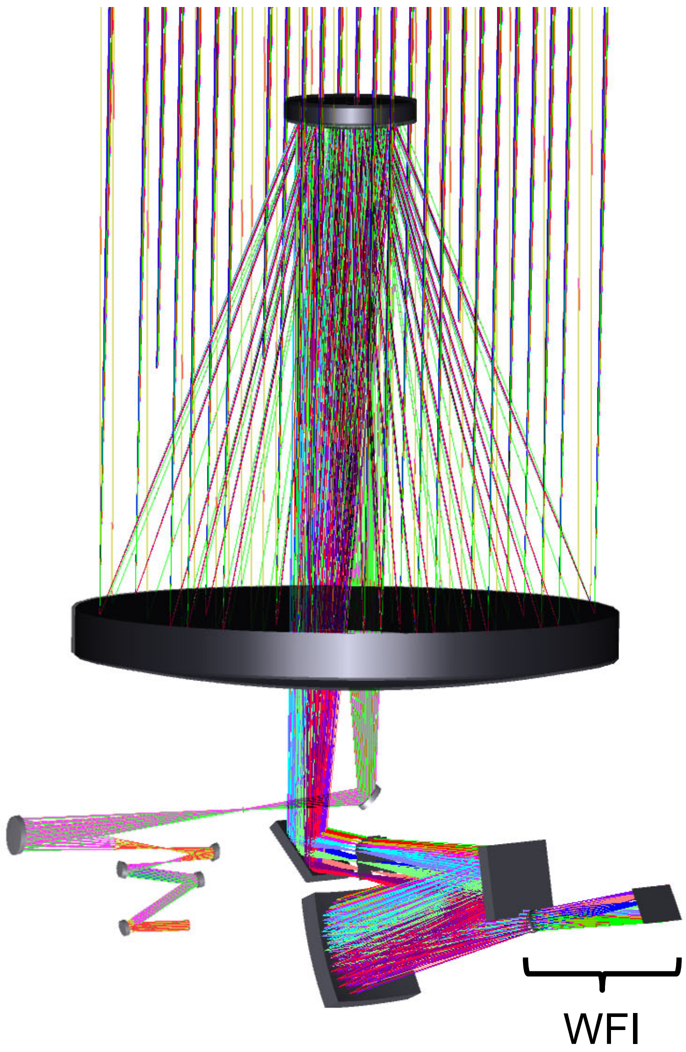


Communications panel – bottom of S/C
1.7m antenna not shown

Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

OTA high-level view





Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

ROMAN SPACE TELESCOPE

IC Architecture

Structure

- Provides stiff, strong, and stable support for Roman Payload
- Similar construction to JWST ISIM
  - Leveraging lessons learned
- Includes:
  - Composite tubes and gussets
  - Ti nodes and clips; Harness brackets
  - ST/IRU mount

Launch Load and Vibration Isolation System (LLVIS)

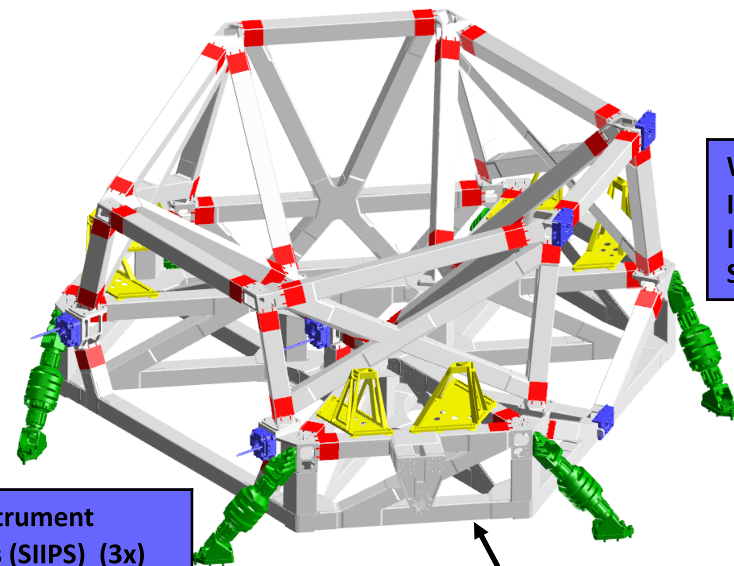
- Mounts Payload to SC for launch
- Isolates the Roman Payload from SC jitter

Science Instrument Interface Plates (SIIPs)

- Align instruments to telescope pupils
- Similar to ISIM SIIPs

Structure Assembly
Titanium Nodes
Composite Tubes
Composite Gussets
Titanium and Composite Clips

Thermal Hardware
Thermostats
PRT Temp Sensors
Heaters
MLI



WFI Science Instrument Interface Plates SIIPS (3x)

CGI Science Instrument Interface Plates (SIIPS) (3x)

Star tracker & IRU mount

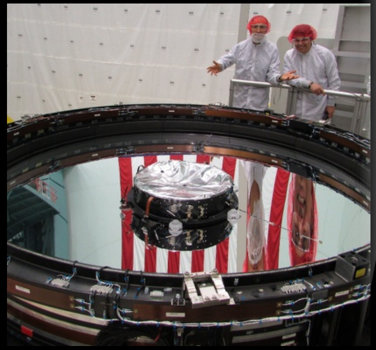
Harness Interface Connector Panels
OTA Interface Connector Harness Panels (OICP) x 6
Thermal Interface Connector Panels (TICP) x 2

Launch Loads Vibration Isolation System (6x)
20 Hz Isolator Struts
Mounting Brackets

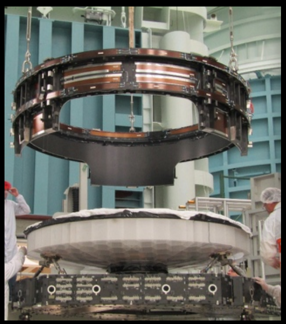
Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

Inherited hardware progress (1)

Primary Mirror Assembly + Forward Metering Structure At SRR/Pedigree Review



Removal of PM Scraper 7/2018

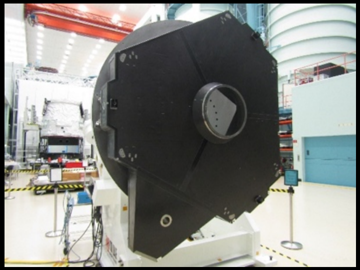


Forward Metering Shell Removal 7/2018

Forward Metering Structure June 2019

Removal of PM Baffle Adaptor 7/2018

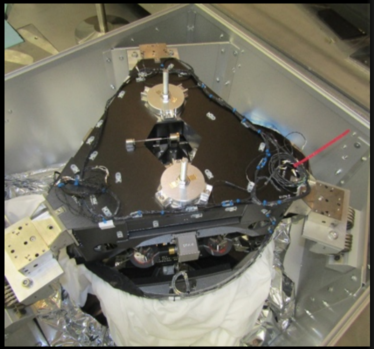
Removal of Spare PM from Aft Metering Structure May 2019



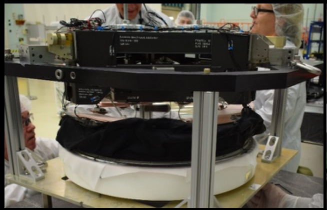
Aft Metering Structure June 2019

Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

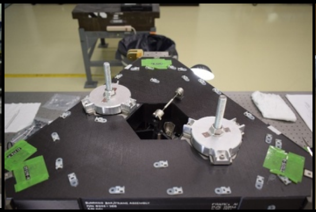
Inherited hardware progress (2)



Secondary Mirror Assembly At SRR/Pedigree Review

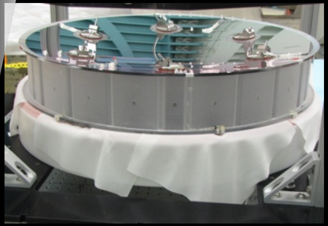


Disassembly of support structure from mirror



Removal of thermal-electric hardware

Secondary Mirror Support Structure (SMSS) ready for re-use



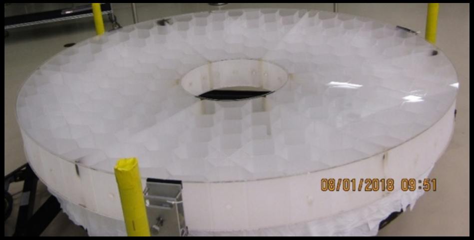
Secondary Mirror (SM) de-configured from support structure

In process shaping of SM to Roman prescription

Coated SM Sept 2020

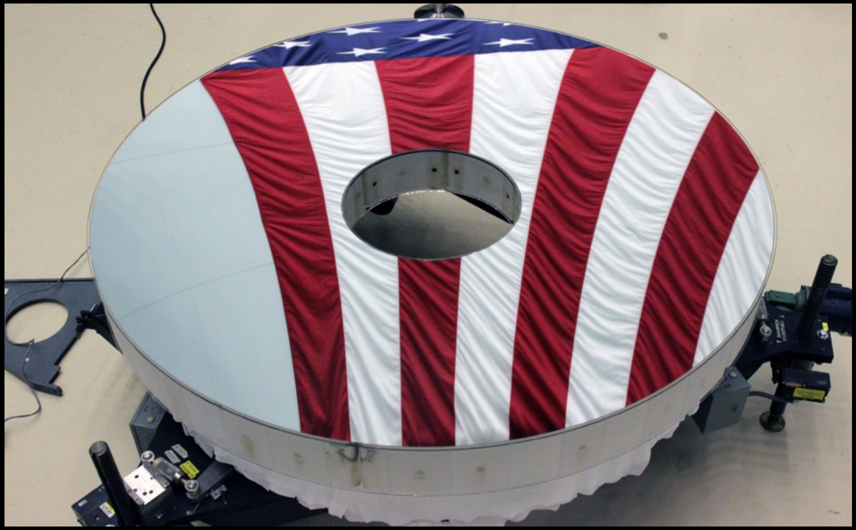
Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

Inherited hardware progress (3)



Flight Primary Mirror (SN#3) As received

Full Tool Polish May 2019



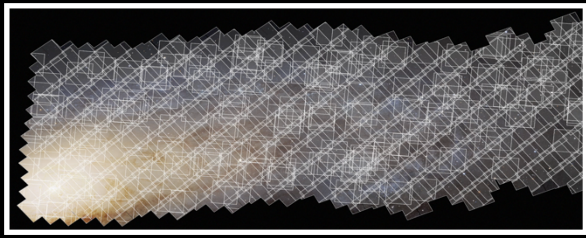
Completed August 2020

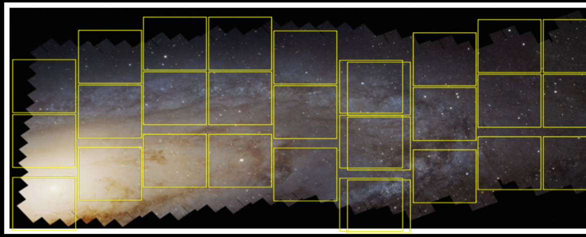
Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.

Roman as a Survey Facility

- The power of Roman is not *just* that it has a large field of view: it is also very efficient
  - Rapid slew & settle, no Earth occultations, no South Atlantic Anomaly
- Comparisons of total elapsed time for large HST surveys with Roman for equivalent area+depth:
  - 3-D HST: 1400 ksec grism spectroscopy over 0.17 sq deg
    - -> Roman: 1.9 ksec or 730x faster
  - COSMOS: 3300 ksec imaging over 2 sq deg
    - -> Roman: 26 ksec or 125x faster
  - CANDELS *Wide NIR*: 0.22 sq deg in 1790 ksec
    - -> Roman: 1.7ksec or 1050x faster
  - PHAT: 2360 ksec multi-band imaging over 0.5 sq deg
    - -> Roman: 1.6 ksec or 1475x faster

HST PHAT survey: 438 pointings





Roman PHAT survey: 2 pointings

For details, see Akeson et al 2019 https://arxiv.org/abs/1902.05569

Use or disclosure of data contained on this page is subject to the restriction(s) on the title page of this document.