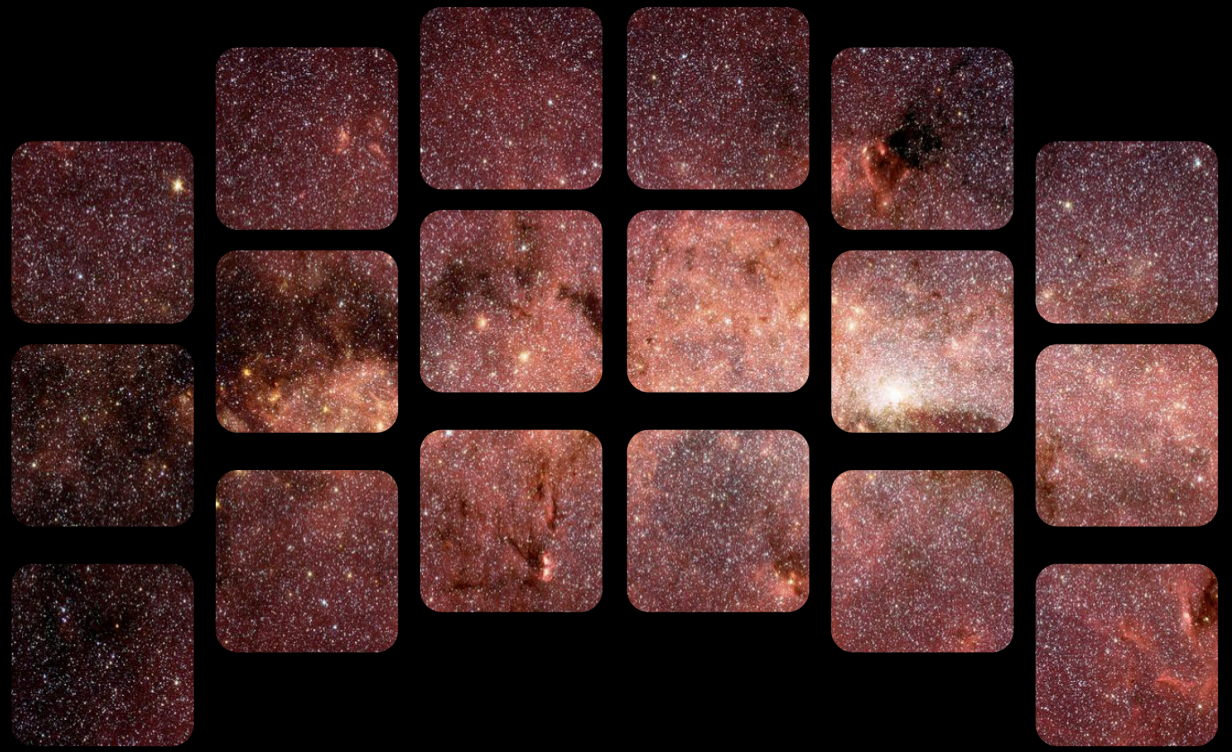
ROMAN
SPACE TELESCOPE

Project Status

Julie McEnery
Roman Senior Project Scientist



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Overview

- **Last presentation was in early March 2020, WFIRST had just entered phase C**

- **LOTS has happened since then….**

NANCY GRACE
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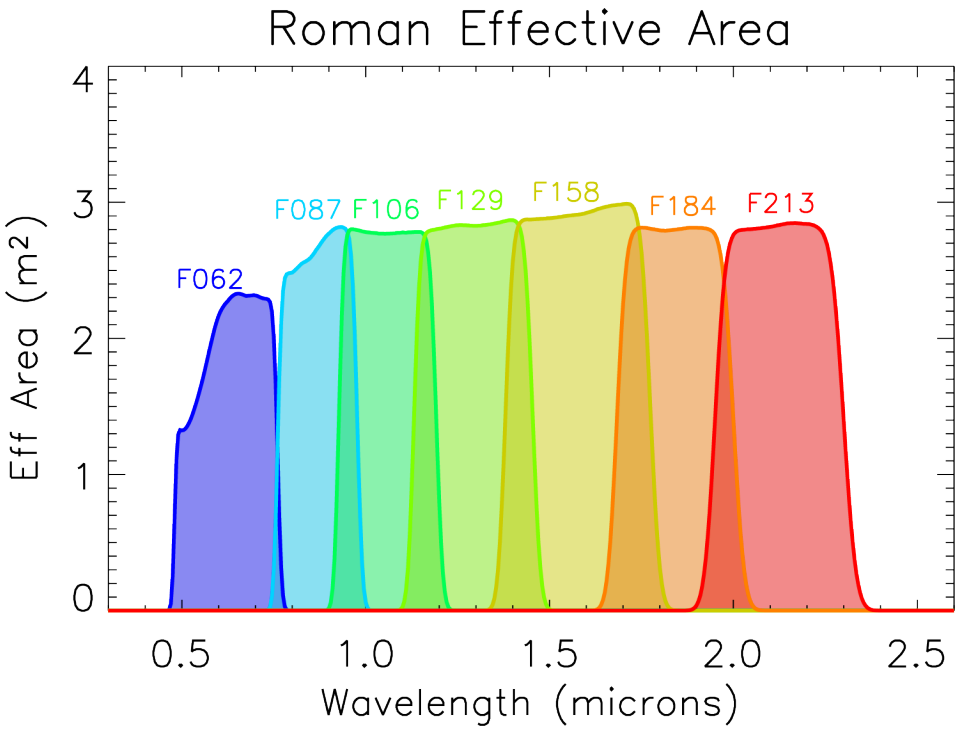
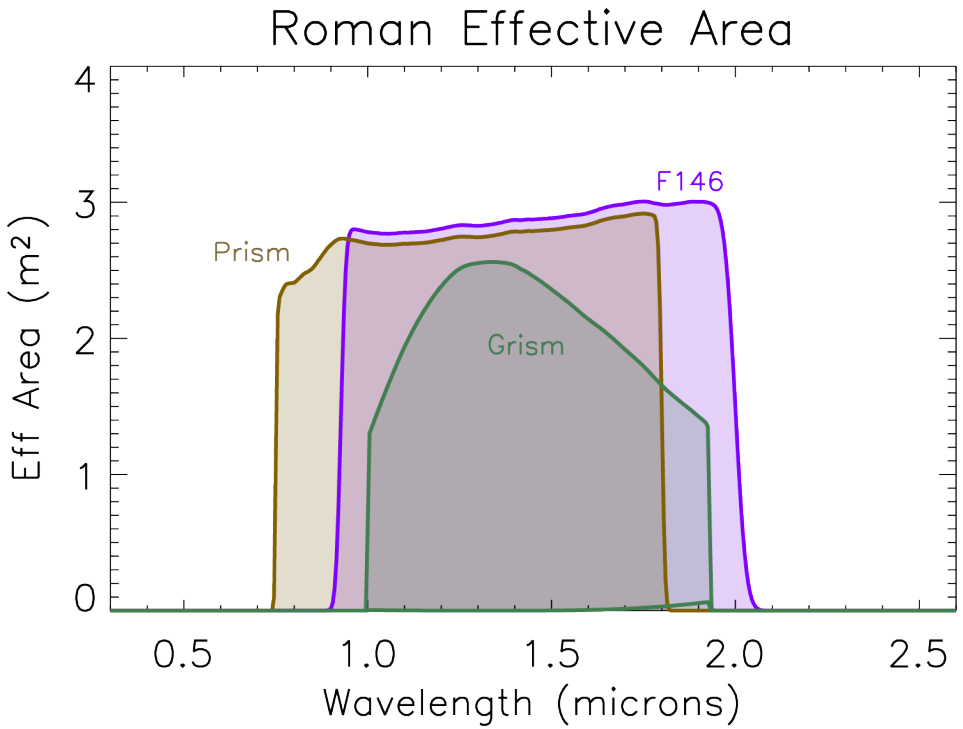
WFIRST is now the Nancy Grace Roman Space Telescope

Changes to mission baseline

Added F213 filter (1.95-2.3 micron) – now have imaging filters covering entire spectral range supported by mirrors/detectors!

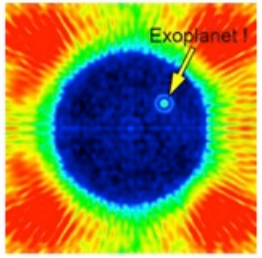


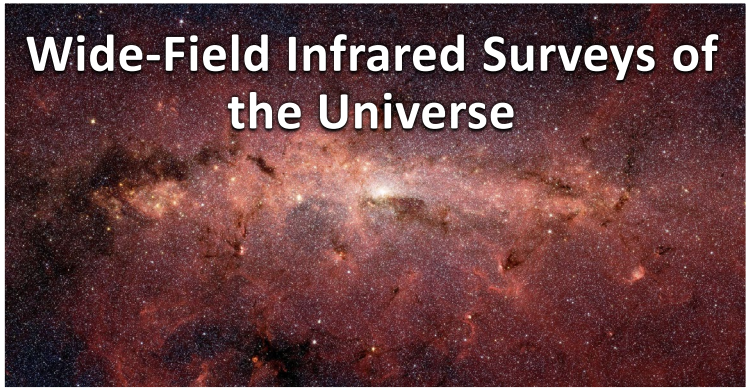


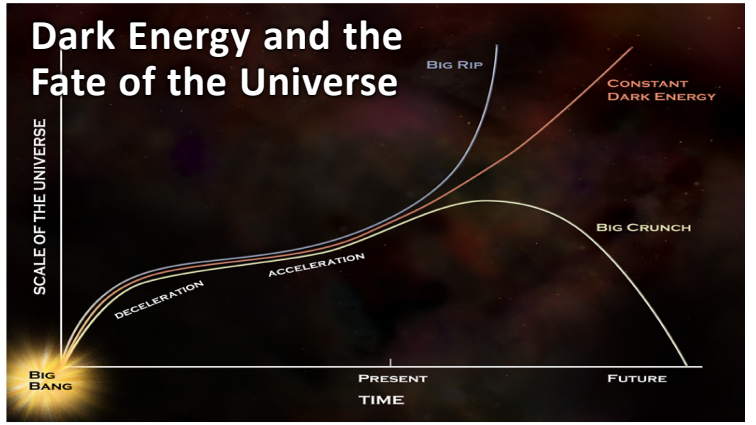
- 8 imaging filters
- Spectroscopy via prism (0.6-1.8μm, *R*~100, ~24AB) and grism (1.0-1.9μm, *R*~600, ~22AB)

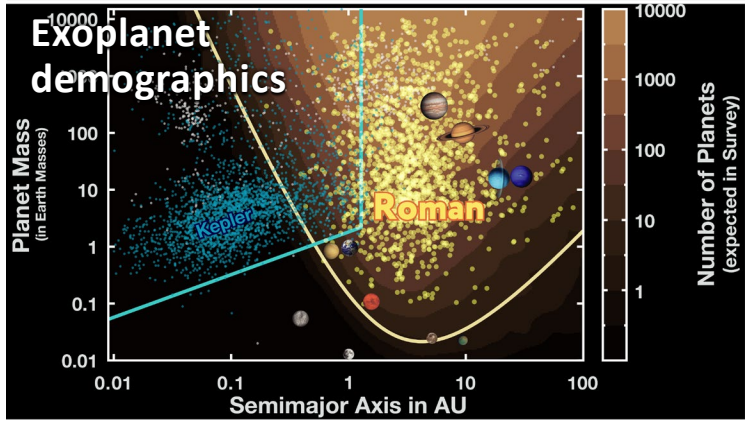
Roman Mission Objectives

- **Wide Field Infrared survey**
  - Imaging and spectroscopy to >26.5 AB mag
- **Expansion history of the Universe**
  - Using supernova, weak lensing and galaxy redshift survey techniques
- **Growth of Structure in the Universe**
  - Weak lensing, redshift space distortions and galaxy cluster techniques
- **Exoplanet Census**
  - Statistical census of exoplanets from outer habitable zone to free floating planets
- **General Observer program**
  - Devote substantial fraction of mission lifetime to peer reviewed general observer program
- **Coronagraph technology demonstration**
  - Demonstrate exoplanet coronagraphy with active wavefront control









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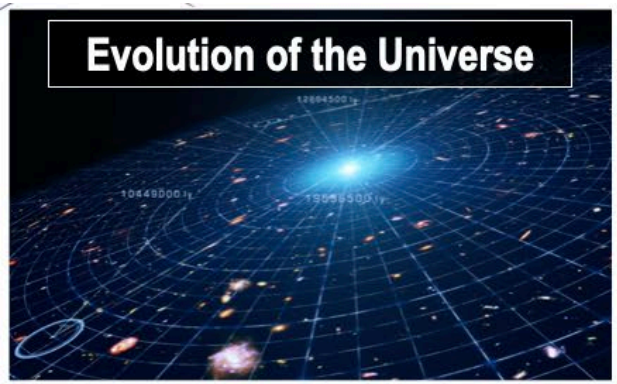
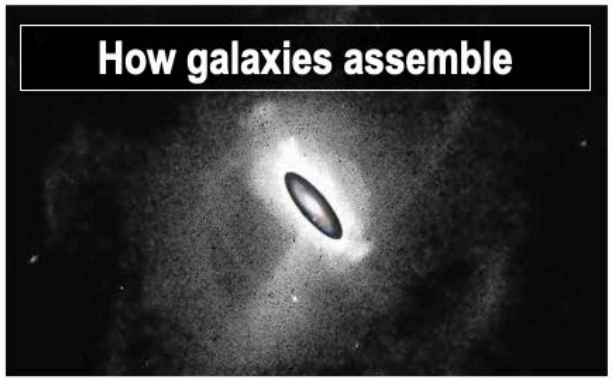
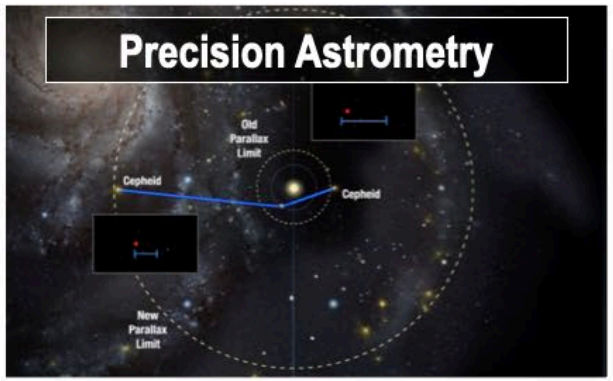
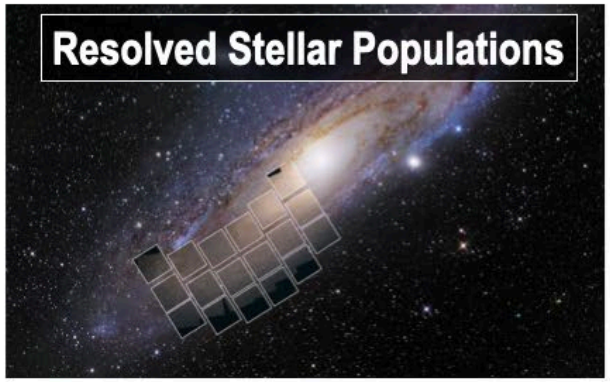
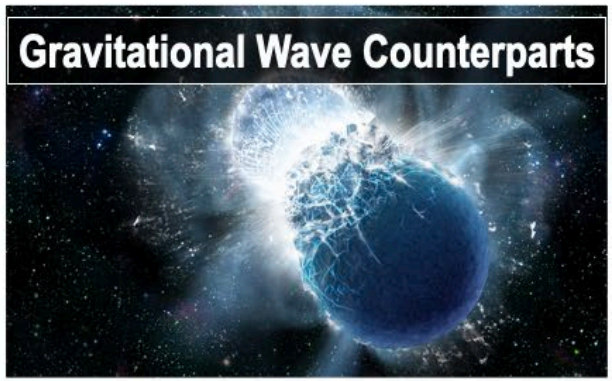
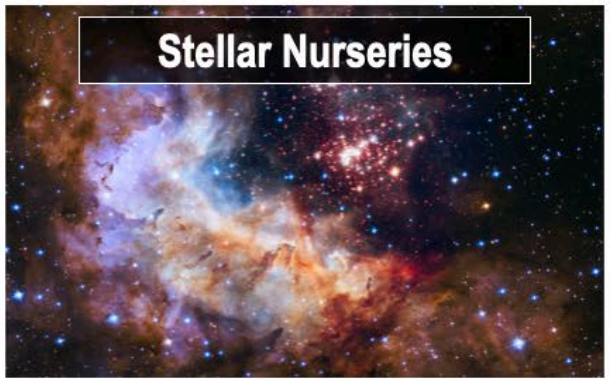


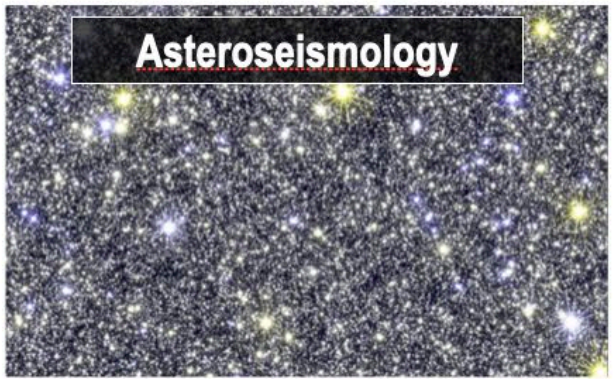


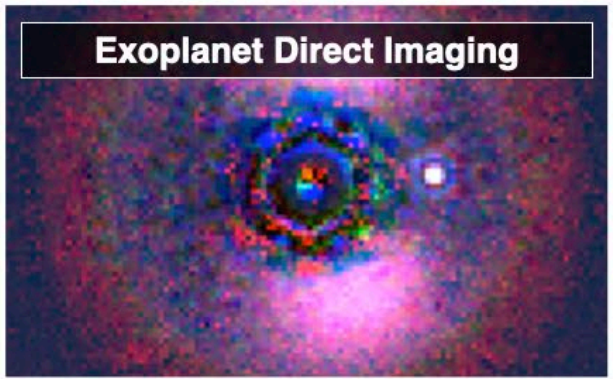


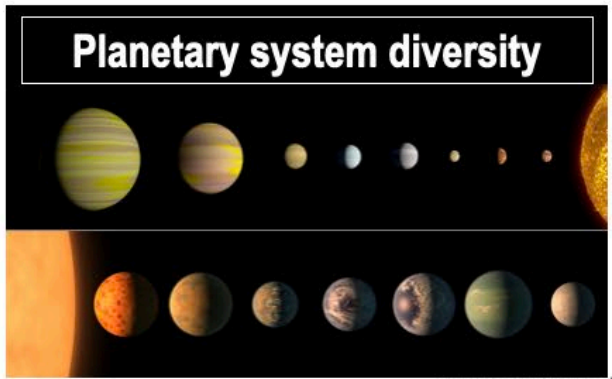




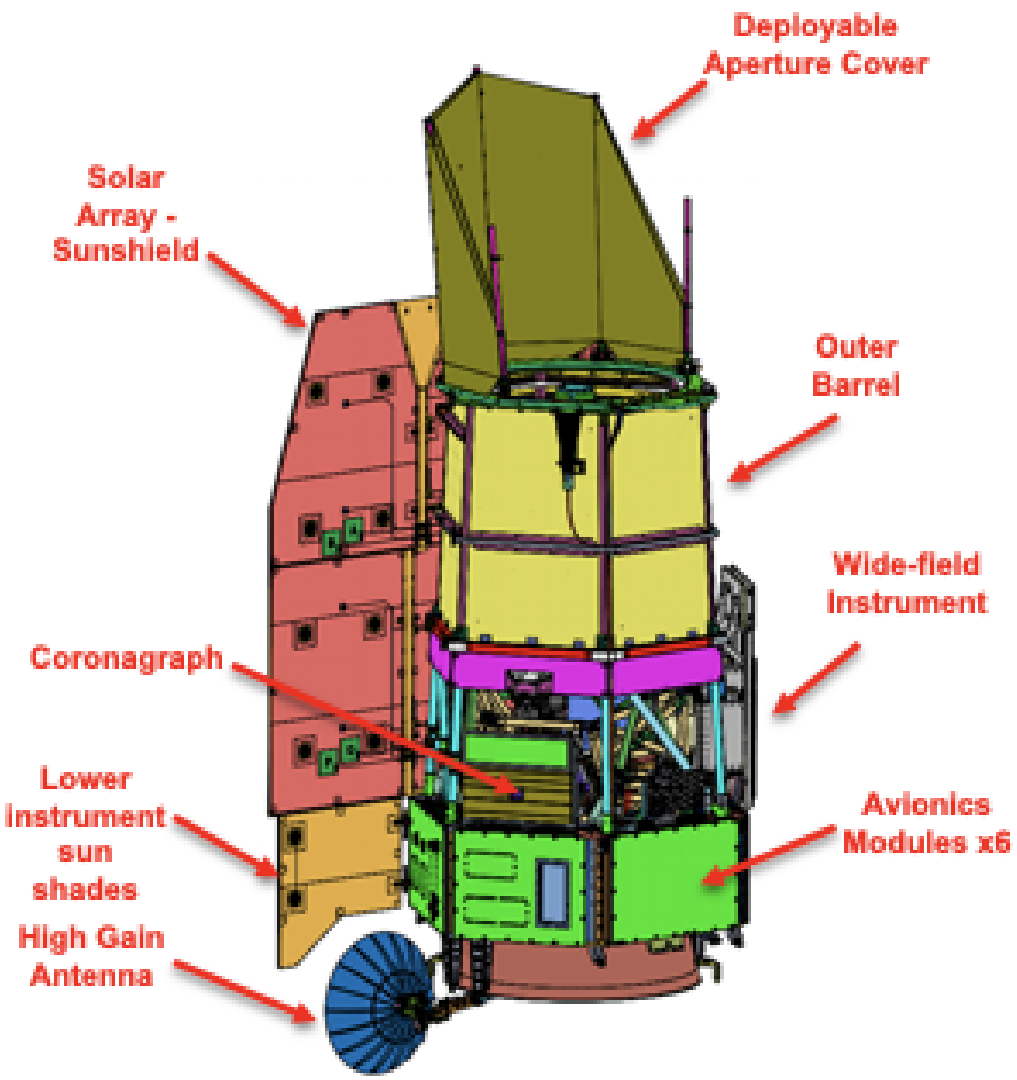








Roman Observatory and Instruments



Telescope: 2.4m aperture

Two Instruments:

Wide Field Imager / Slitless Spectrometer

- Vis/Near IR bandpasses (0.48 – 2.3 micron)
- Field of view 0.281 deg^2 (~200× HST WFC3-IR)
- 18 4k × 4k detectors (288 Mpixels)

Coronagraph

- Visible bandpass
- Contrast 10^{-8}-10^{-9}

Data Volume: 11 Tb/day

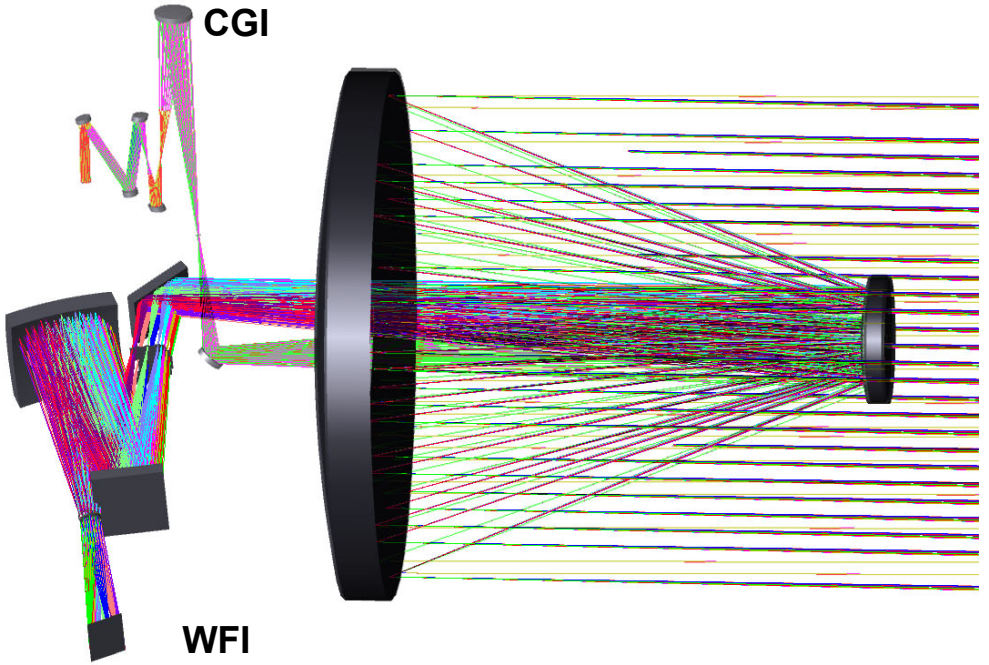
Orbit: Sun-Earth L2

Mission Duration: 5 yr, 10yr goal

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

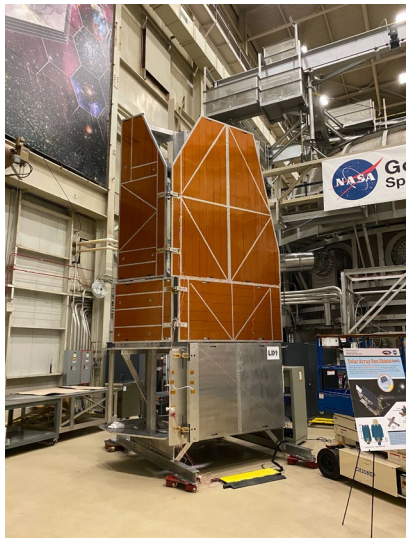
Roman Space Telescope Hardware Status

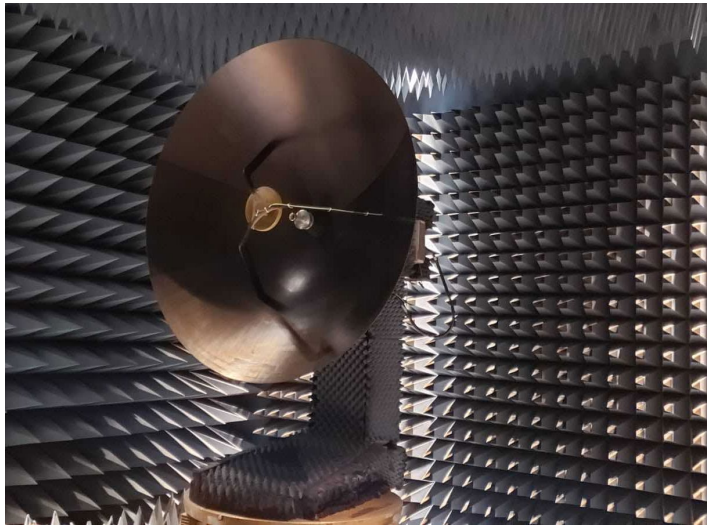
- **Telescope (L3Harris):**
  - Successful telescope CDR in December 2020
  - Primary and secondary mirrors have been refigured, polished and coated
  - coronagraph relay optics polished and coated;
  - WFI relay optics
    - Fold mirror 1 final figure complete
    - Fold mirror 2 complete first round of ion figuring
    - Tertiary mirror competed two ion figuring cycles



Roman Space Telescope Hardware Status (Spacecraft)

- **Procurement of flight subsystems well underway**
- **Mechanical Hardware Engineering Development Units (EDUs) nearly complete**
- **Successful cold deployment test of EDU deployable aperture cover**

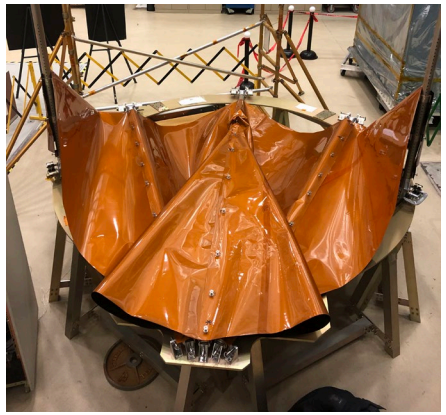




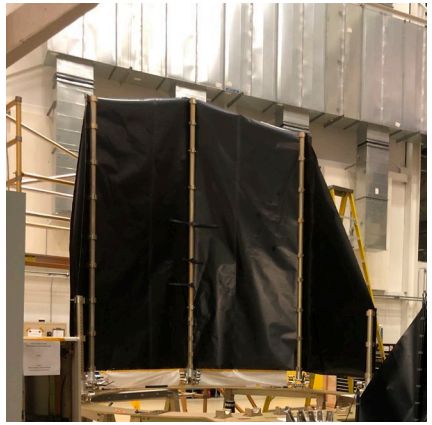
Roman 1.7-meter Dual-band High-Gain Antenna (HGA) Engineering Development Unit (EDU) in Goddard's anechoic chamber

Solar Array Sun Shield (SASS) Engineering Development Unit

Deployable Aperture Cover (DAC) Engineering Development Unit



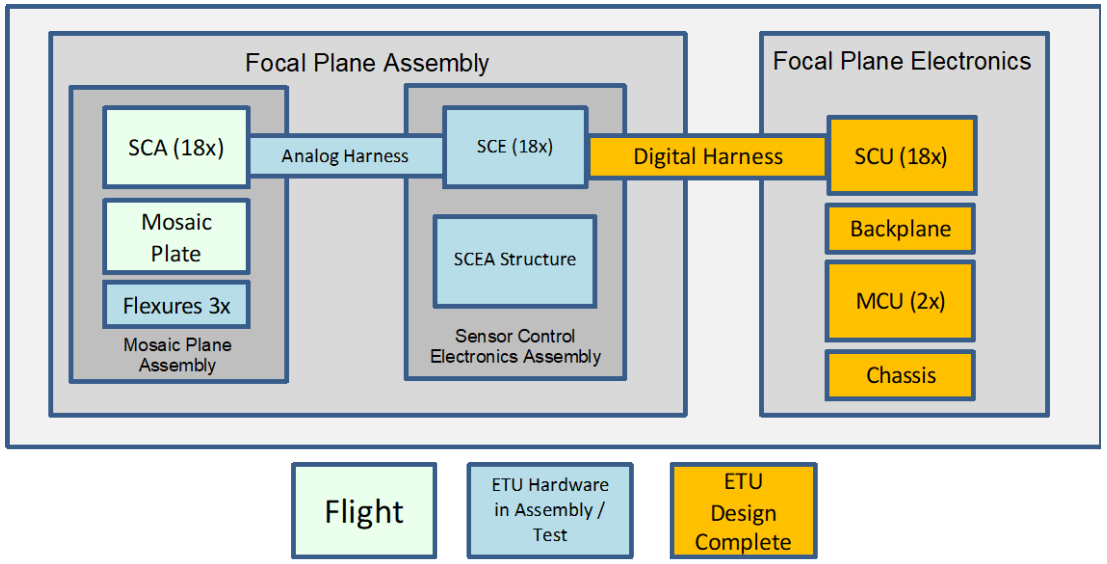
stowed



Deployed

Wide Field Instrument Status

- **Wide Field Instrument (GSFC/Ball):**
  - Passed WFI CDR!
  - Sensor Chip Assemblies in flight production
    - **20 of 18 flight SCAs accepted**
    - 25 more in production, 4 more spares needed



SCA Performance

Performance Parameter	SCA Requirements	Current Range of Performance
QE	>80%	86-96%
Mean Dark Current	<0.05 e^-/sec	<0.005 e^-/sec
Total Noise (mean)	<6.5 e^- rms	4.8-6.2 e^- rms
Inter-Pixel Capacitance	<2%	1.3-2.0%
Operability	>95%	95.9 - 99.1%
High Intensity Persistence	< .5 e^-/sec	0.06 – 0.21 e^-/s
Low Intensity Persistence	< .15 e^-/sec	0.03 – 0.12 e^-/s

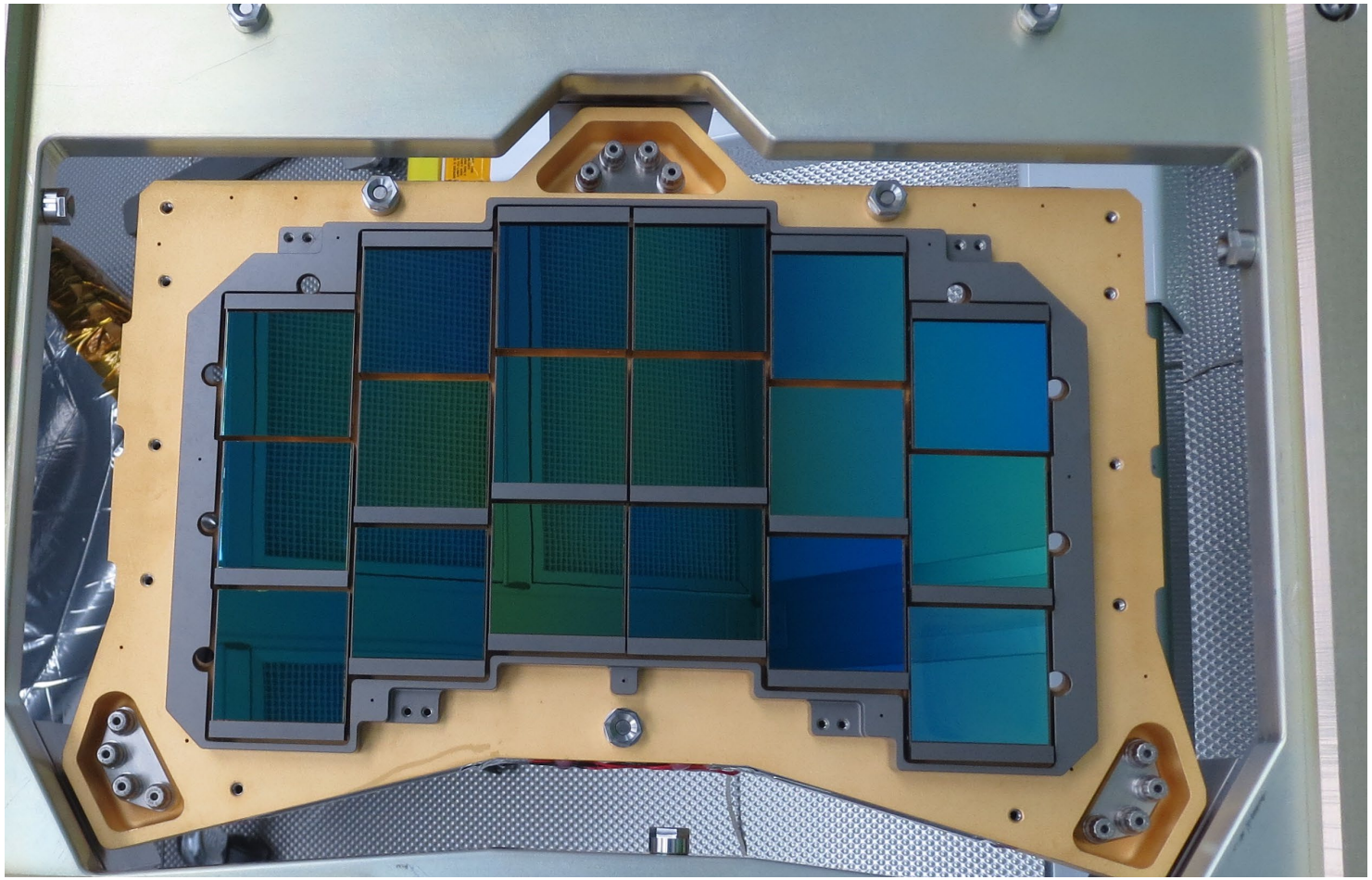
SCE Performance (SCE EDU & ETU Testing)

Performance Parameter	SCE Requirements	Current Range of Performance	SIDECAR Performance
Bias Noise	< 10 µV	< 10 µV	< 102 µV
ADC Noise	< 125 µV	< 82 µV	< 148 µV
Input Noise Rejection	> 13 dB	> 80 dB	-
Power Dissipation	**<600 mW***	<500 mW	

ETU and Flight component and system performance meets requirements. CBE total noise is 6.0 - 6.5 e^-.

ROMAN SPACE TELESCOPE

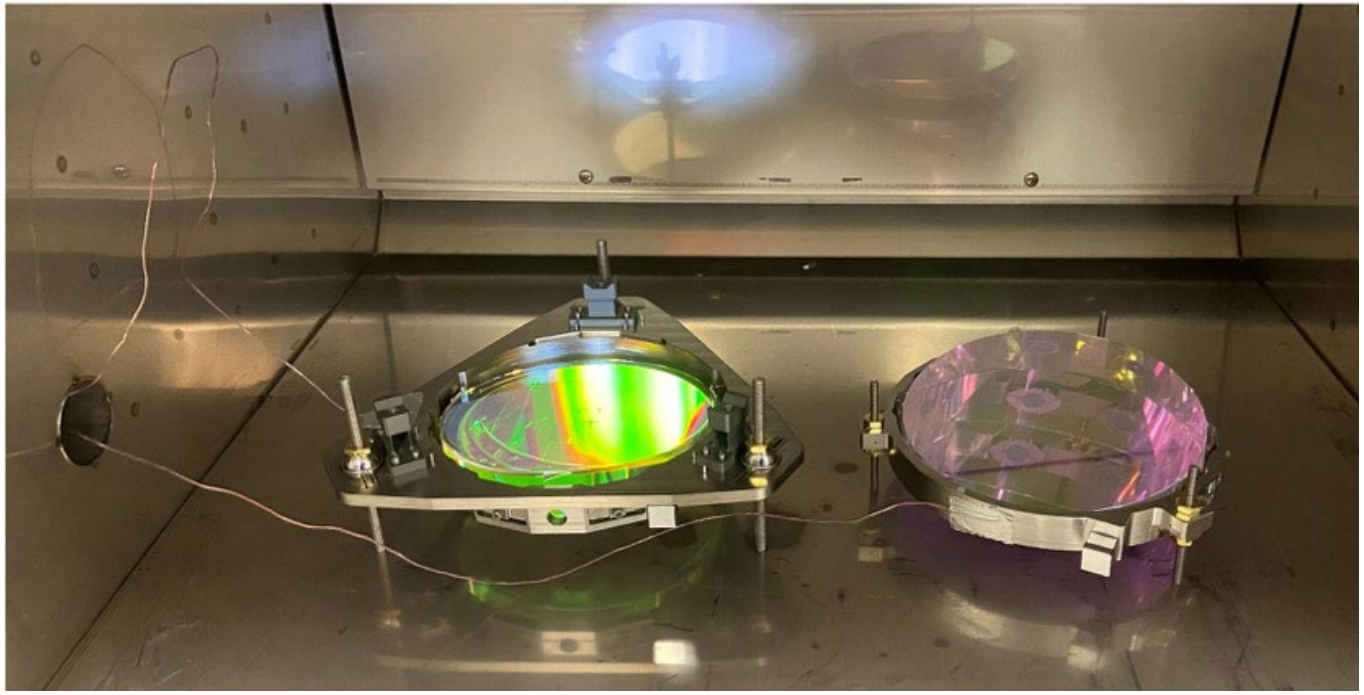
A Pretty Picture!

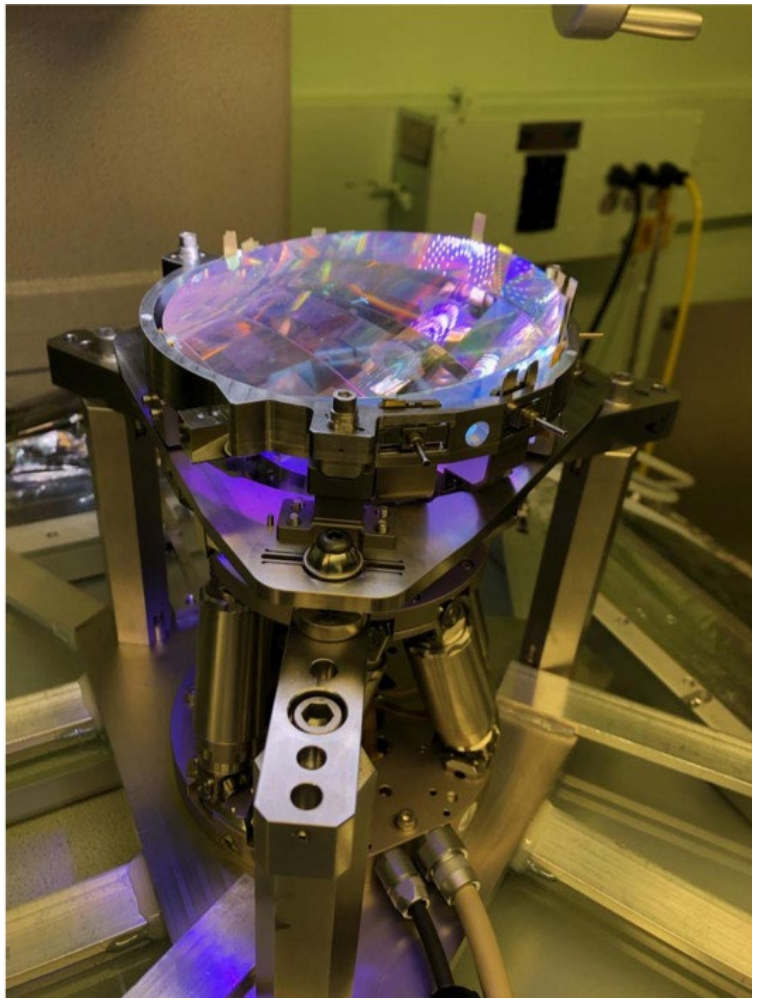


- **Completed installation and alignment of all 18 engineering test unit (ETU) sensor chip assemblies (SCA) on the ETU mosaic plate**

Grism, prism, filters

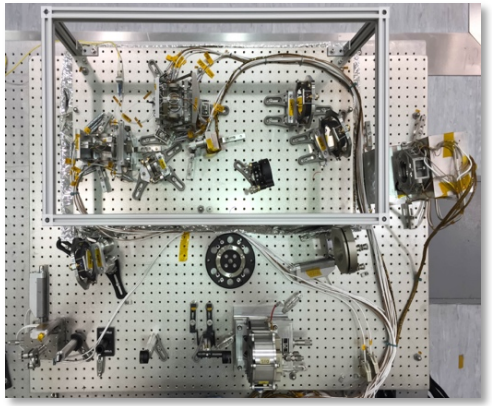
- Added Kshort science filter
- Flight fabrication underway for grism, prism and filters



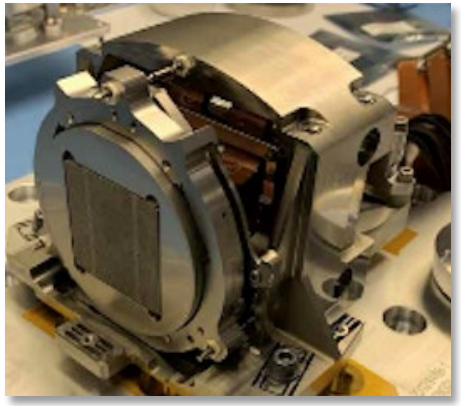


CGI will demonstrate key technologies

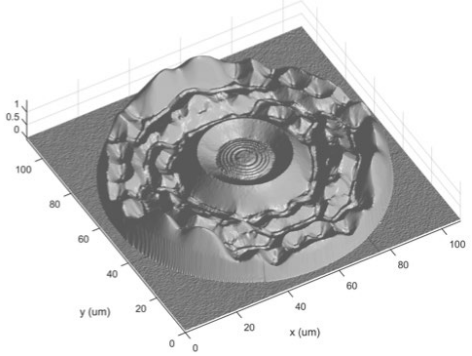
Ultra-Precise Wavefront Sensing & Control (now Ground-In-The-Loop)



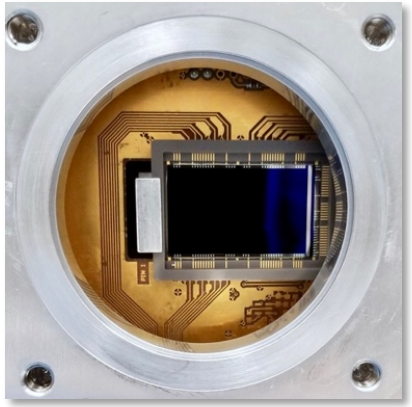
Large-format Deformable Mirrors



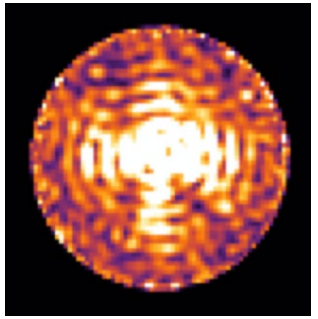
High-contrast Coronagraph Masks

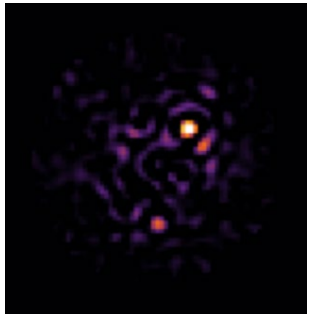


Ultra-low-noise Photon-counting EMCCDs



Data Post-Processing





All hardware now at TRL ≥ 6

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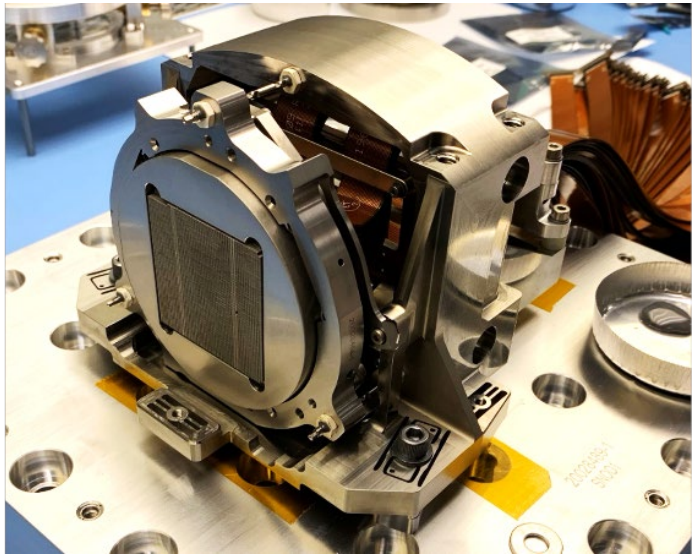
Coronagraph Development Status

On track for CGI CDR in April

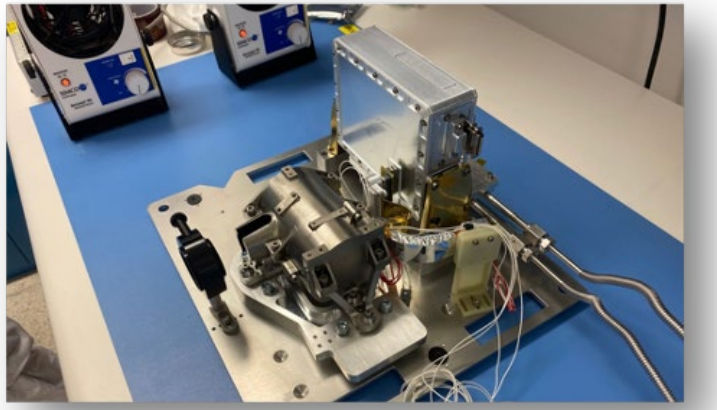
Numerous subsystem reviews complete: DM, II&T, Optical alignment, Mechanical/Thermal, V&V, HOWFS GITL, avionics, camera components

- **Deformable mirrors**
  - TRL-6 achieved for deformable mirrors (i.e. passed environmental testing)
  - received 2nd flight candidate and spare
- **Camera**
  - **Teledyne-e2v** (UK) has completed two wafer lots and a third will finish in April. On-track for flight-qualified sensor deliveries starting in August.
  - **ABB/NuVu** (Canada) is assembling flight electronics boards and expects to begin testing in April with flight unit delivery planned for August.
  - **JPL** has completed assembly of a complete EDU camera system and is conducting thermal vacuum testing with prototype EMCCD sensors. Flight camera assembly is planned for fall.



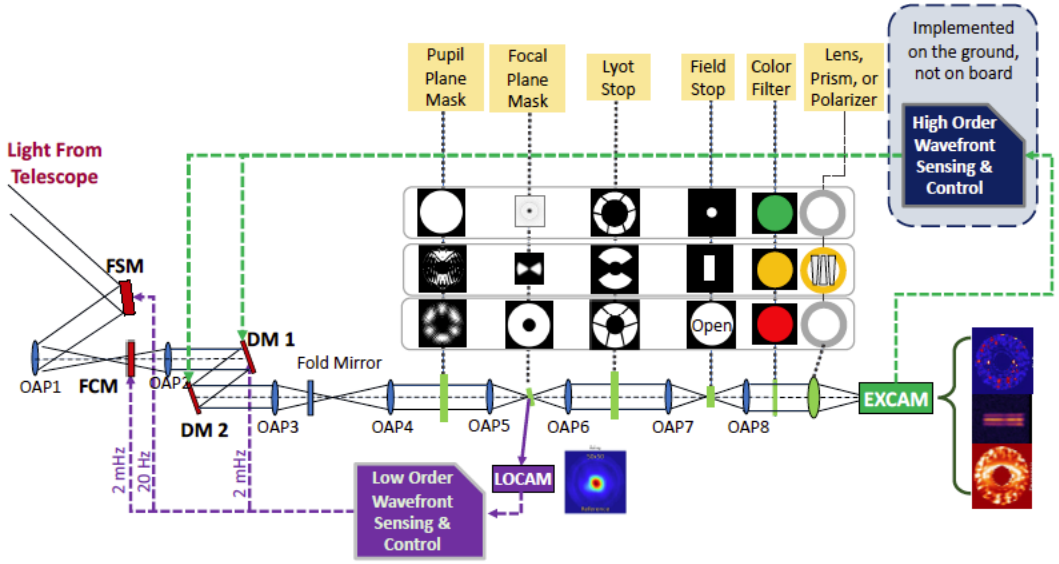
TRL-6 DM unit

EDU Camera

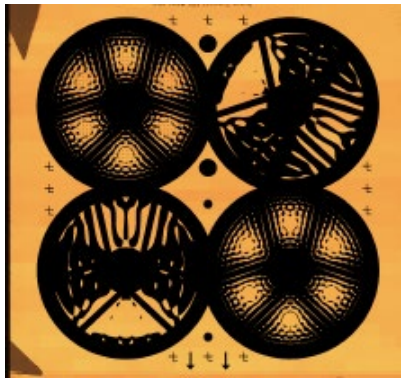


Coronagraph Development Status

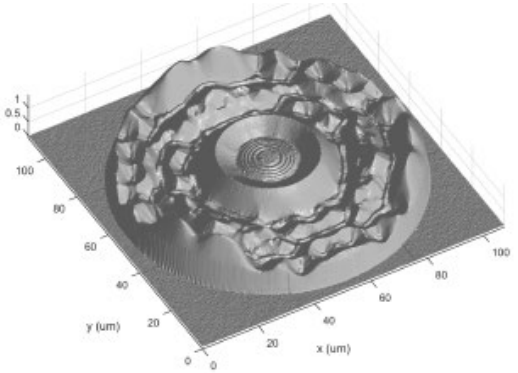
- **Wavefront sensing and control**
  - Hardware on track
  - High order wavefront sensing and control moved from onboard to ground implementation
- **Masks**
  - Flight masks being fabricated at JPL
- **Data post processing**
  - Simulated imaging and spectroscopy data sets are available on the IPAC Roman website
    - Includes report summarizing processing of the "OS9" simulated imaging dataset
  - Tutorials and data challenges available at https://www.exoplanetdatachallenge.com/



Black Silicon reflective shaped pupils

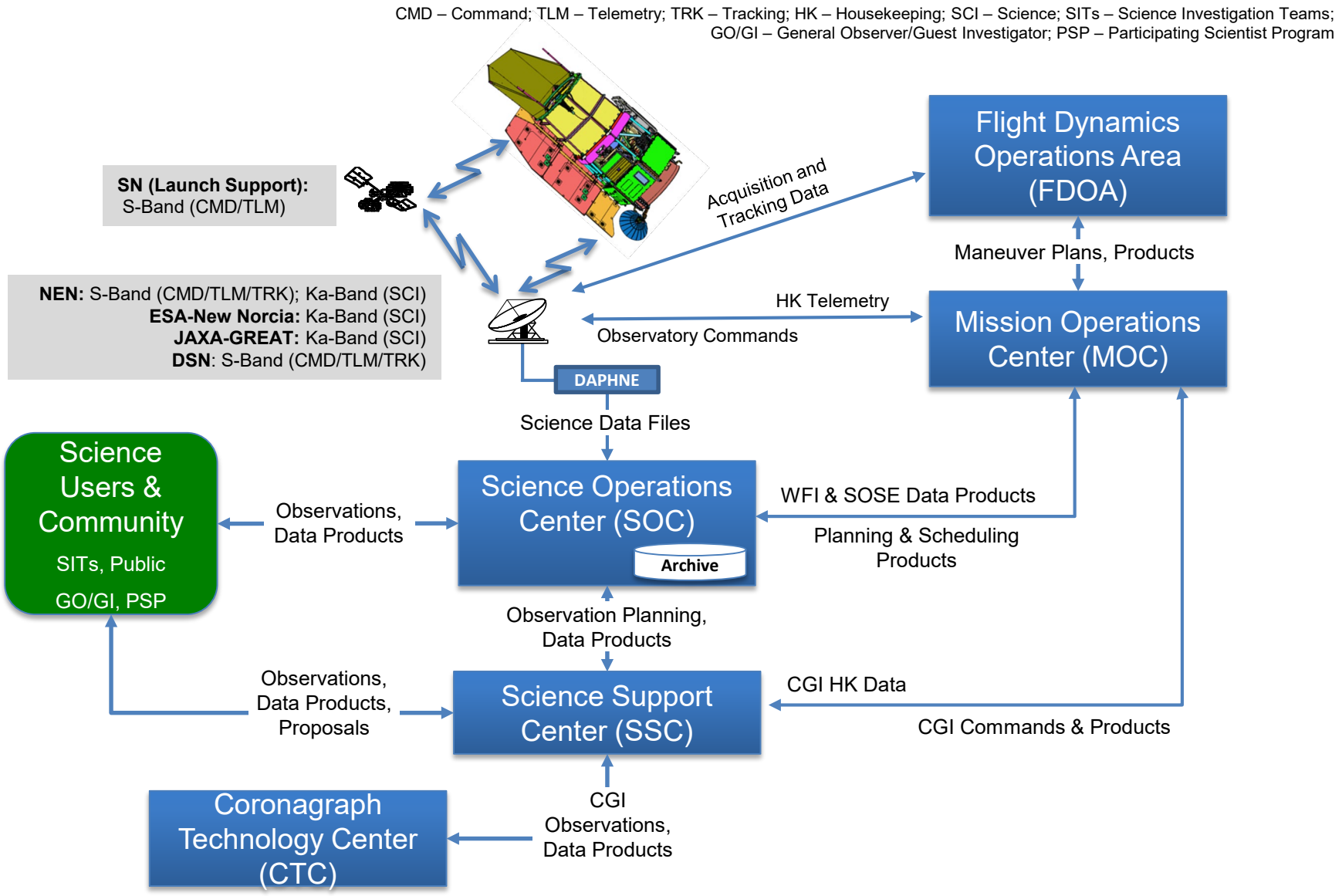


Hybrid Lyot image plane mask

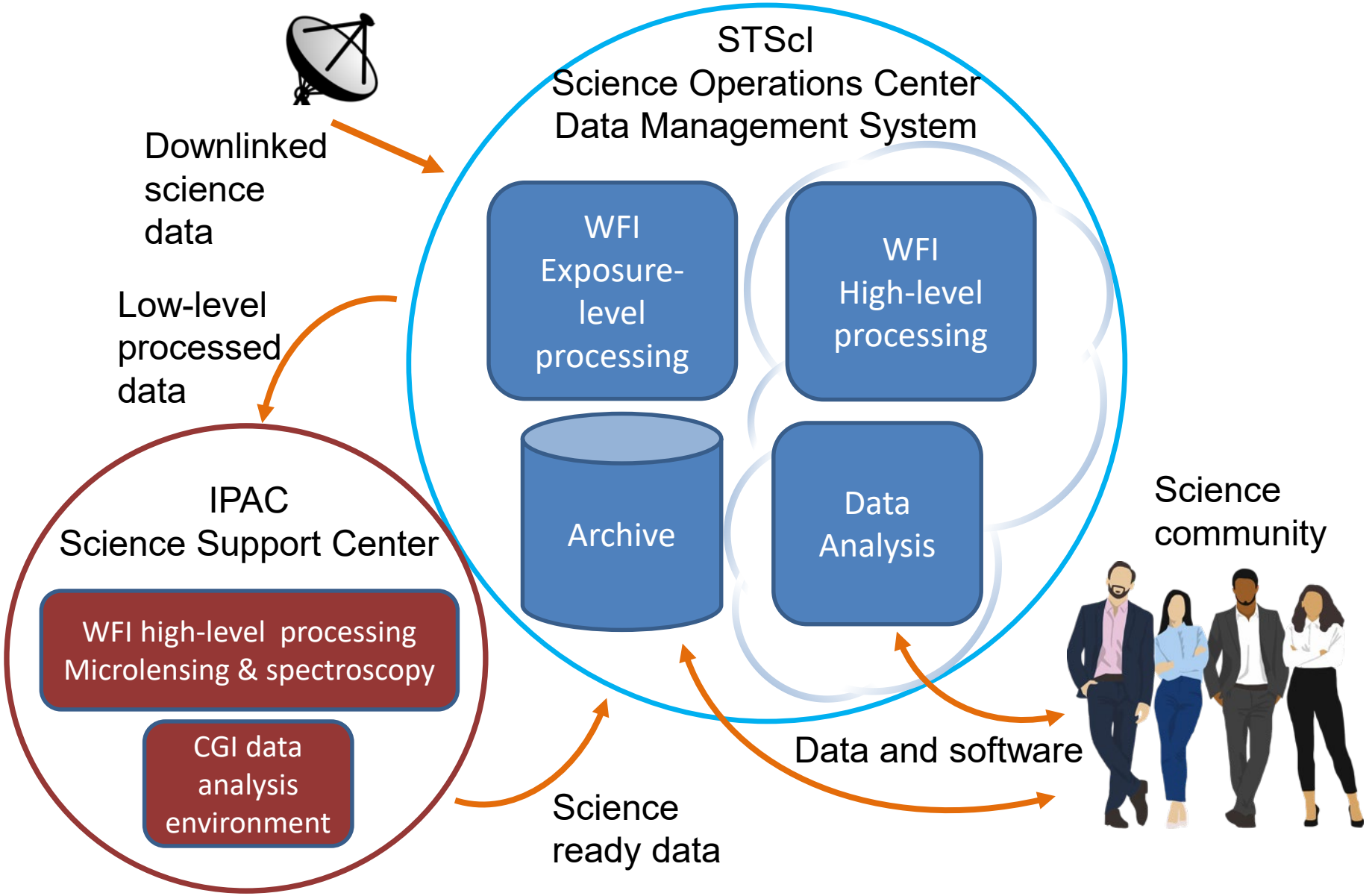


Completed assessment of CGI tech demo value in the perspective of future direct imaging missions (Mennesson et al. 2020, https://arxiv.org/pdf/2008.05624.pdf)

Ground System



Roman Science Operations



Roman Science Operations

- **Data system consists of:**
  - Pipeline for low level data processing
  - Pipeline for high level processing
  - Science platform (HLPP) allowing users to interact with data and high-level processing software in the cloud
  - Archive with HST/JWST/MAST like functionality
- **Updated data processing plans at STScI (SOC) and IPAC (SSC) to augment high level science processing**
  - Expanded catalog functions to be implemented by science centers: deblending, photo-z, some time-domain functions etc
  - Astrometry functions – e.g. tying to *Gaia*
  - Some elements of PSF characterization
  - Instrument simulations
- **Evaluating science platform and cloud computing options and solutions**
  - Including considerations of interoperability with other facilities (e.g. *Rubin*)

Roman Science Operations

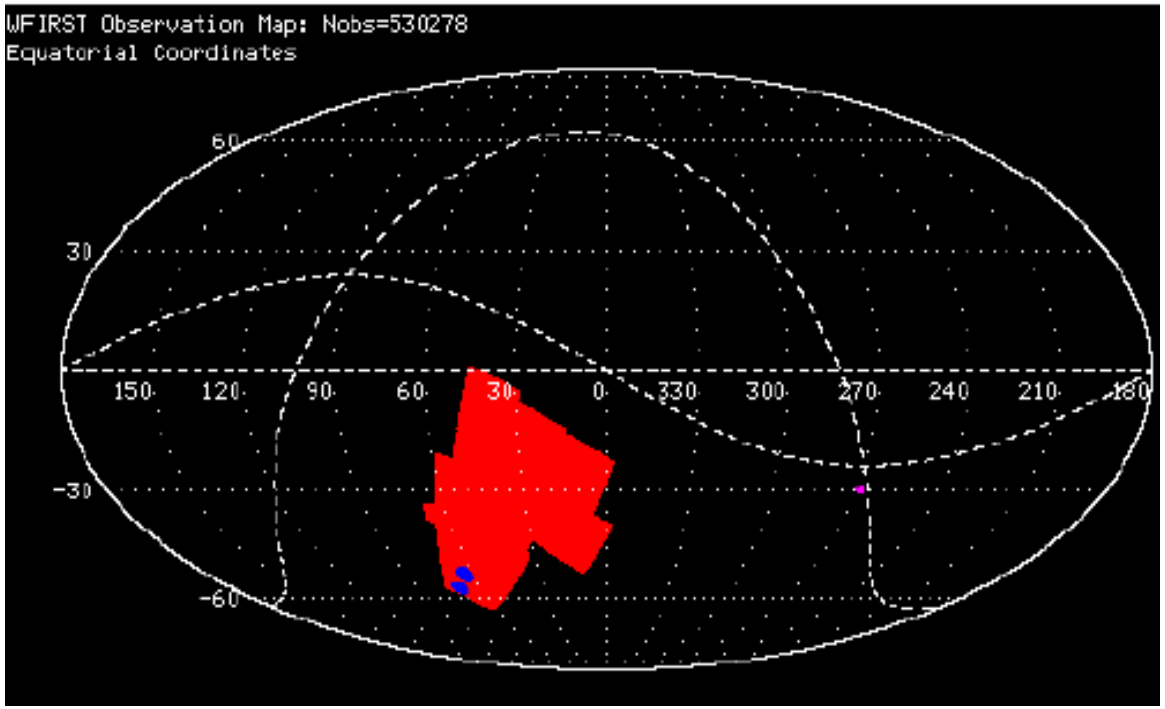
- **Demonstrated prototype data platform to science teams last March**
  - Opportunity to explore the system for usability, look and feel etc

- **Computing and data resource allocation**
  - SOC established an internal committee to evaluate computing needs for general Roman users
    - Multi-tiered system operated by the SOC
      - Access guaranteed for all approved GI/key projects
      - Simple process to request access by general community
      - Quotas to control costs within preset bounds
    - Funding via the SOC contract, not GI grants
    - Sized/scoped to enable generic projects by a broad community

Roman Observations

- **Core Community Surveys: a significant fraction of the prime mission used for revolutionary surveys of unprecedented scale**
- **Three Core Community Surveys to address 2010 Decadal Survey science goals**
  - Extragalactic Wide Area Survey
  - Extragalactic Time Domain Survey
  - Galactic Time Domain Survey
- **The definition of core community surveys will be established via an open process, with a goal of maximizing the overall science return while simultaneously meeting the cosmology and exoplanet science requirements**
- **Several calls for GO surveys closer to, and after, launch**
- **No proprietary period for any Roman data**

Design Reference Mission: Roman Surveys



Galactic Time Domain Survey: 2 deg^2, 15 min cadence with W filter, 12 hour cadence for R or Z and Y or J for 60 – 72 day seasons; 6 seasons

Extragalactic Time Domain Survey: 16 deg^2, (wide), 5 deg^2 (deep), 4 filters (R, Z, Y, J – wide) /(Z, Y, J, H – deep), 5 day cadence, and prism spectroscopy

Extragalactic Wide Area Survey: 2000 deg^2 (wide), 20 deg^2 (deep), 4 filters (Y, J, H, F) for wide and deep fields and grism spectroscopy

General Astrophysics Surveys: TBD via proposals

5 sigma J-band sensitivity

	EWA Wide	EWA Deep	ETD Wide	ETD Deep	GTD
Per Visit	-	-	25.5	26.6	24.9
Integrated	26.95	28.2	28.3	29.4	27.6 (60d)

Roman Science Interest Group

- https://roman.gsfc.nasa.gov/science/rsig.html

- **Meeting presentations and notes available on the meetings tab**
  - Recent discussions have been on the observing program
  - Currently discussing white paper call to solicit science case for predefining up to one month of observations to be executed within the first two years of the mission

- **Annual opportunities to join this group**

Megan Donohue (Chair)	**Michigan State U.**
Zeljko Ivesic	U. Washington
Jessica Lu	UC Berkeley
John MacKenty	STScI
Ashley Villar	Columbia U / Flatiron Institute
Alice Shapley	UCLA
Keith Bechtol	UW, Madison
Saurabh Jha	Rutgers U
Peter Melchior	Princeton U
Dara Norman	NOIRlab
Jessie Christiansen	NEXSci/ CalTech
Rachel Bean	Cornell U
Ryan Hickox	Dartmouth
Lisa Storrie-Lombardi	Las Cumbres Observatory
Dimitri Mawet	CalTech

Science Investigation Teams

- **Supernova Cosmology: Ryan Foley, Saul Perlmutter**
- **Nearby Galaxies: Ben Williams**
- **Extragalactic: Brant Robertson**
- **Weak Lensing and Galaxy Redshift Survey: Olivier Dore**
- **Exoplanet Coronagraphy: Bruce Macintosh, Margaret Turnbull**
- **Archival Research: Alexander Szalay**
- **Cosmic Dawn: James Rhoads**
- **Exoplanet Microlensing: Scott Gaudi**
- **Milkyway: Jason Tumlinson**

Adjutant Scientists
David Spergel - WFI
Jeremy Kasdin - CGI

- **~300 scientists in total**
  - scientific performance requirements related to the specific science area,
  - design of overall observational strategy concept,
  - science data analysis techniques,
  - ground and space calibration requirements,
  - science simulations, precursor observations,
  - ground calibration, observational needs, data processing, ancillary data collection/incorporation, analysis, dissemination and documentation of the proposed science investigation.

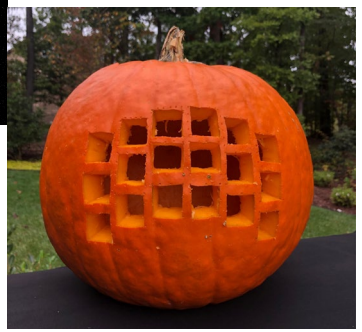
- **Current science team contracts expire later this year**

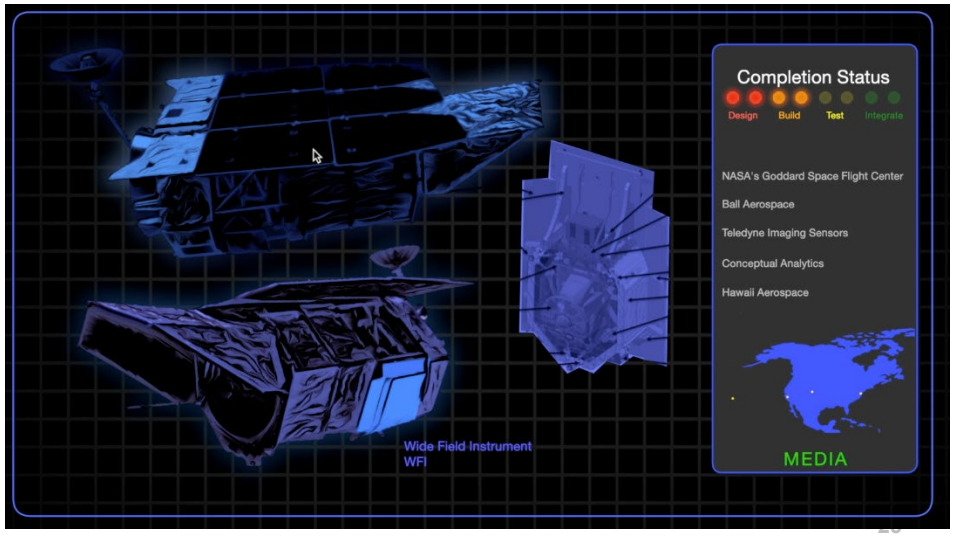
Science Community Structure and Support

- **Roman opportunities announced in the ROSES call last month**
  - Currently a “stub” with details to be provided in an amendment
  - Includes opportunities for CGI (CGI Participation program), WFI preparatory science, and key project teams.
    - Accommodates stable long-term funding to support development of needed infrastructure
    - flexible shorter-term opportunities to allow us to be more responsive to a changing science landscape
    - and will allow a variety of different science community models – large open consortia, small PI led teams etc

Communications

- **Coordinated via monthly meetings with all mission partners**
- **Regular (~monthly) web/press releases**
  - "Primary Mirror for NASA's Roman Space Telescope Completed" released on Sept 3
  - "NASA's Roman Space Telescope to Uncover Echoes of the Universe's Creation" released on Nov 18
  - Press release from STScI "Roman Space Telescope Could Image 100 Hubble Ultra Deep Fields at Once" on Jan 11
  - "NASA's Roman Mission Will Probe Galaxy's Core for Hot Jupiters, Brown Dwarfs" released on Jan 25.
- **Active social media presence**
  - @nasaroman (twitter, facebook)
- **Developing interactive infographic**

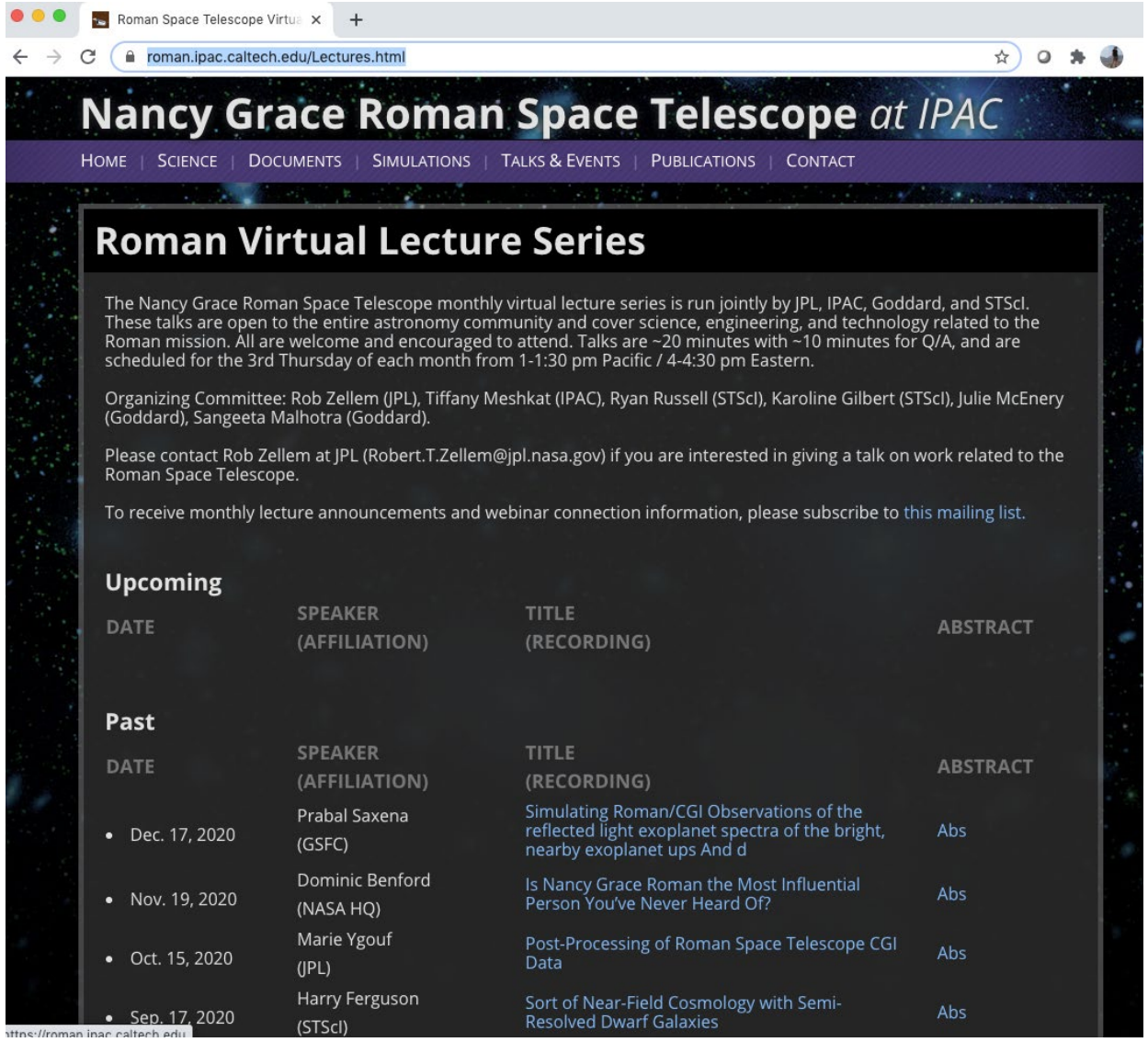




Roman Virtual Lecture Series

https://roman.ipac.caltech.edu/Lectures.html

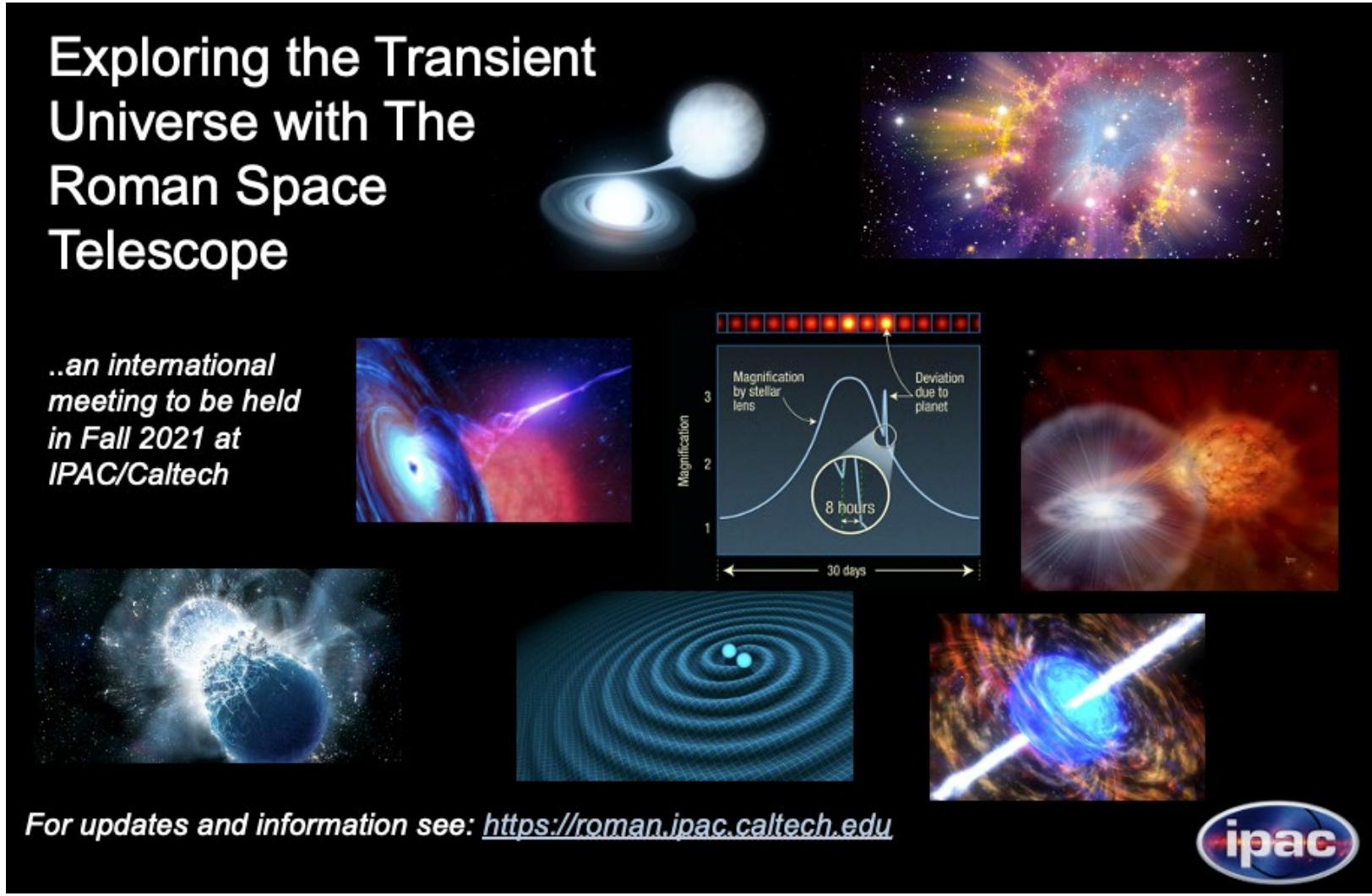
- **Monthly lecture series jointly run by IPAC, STScI, JPL and GSFC**
- **Please join us**
- **Speaker suggestions welcome**



Annual Roman Science Conference

- **Hosted in alternate years by STScI or IPAC**

- Previous workshops
  - Galaxy Formation and Evolution in the Era of the Nancy Grace Roman Space Telescope (2020),
  - Science in our own backyard – exploring the Galaxy and the local group with WFIRST (2019)
  - Astronomy in the 2020s: Synergies with WFIRST (2017)



ROMAN
SPACE TELESCOPE

The Road Ahead

- CGI CDR - April 2021, Ground System CDR – July 2021
- Mission/Spacecraft CDR – Sept 2021
- Covid impacts – currently rebaselining project

- Roman is on track, and everything where it needs to be approaching CDR
- Exciting to see things coming together