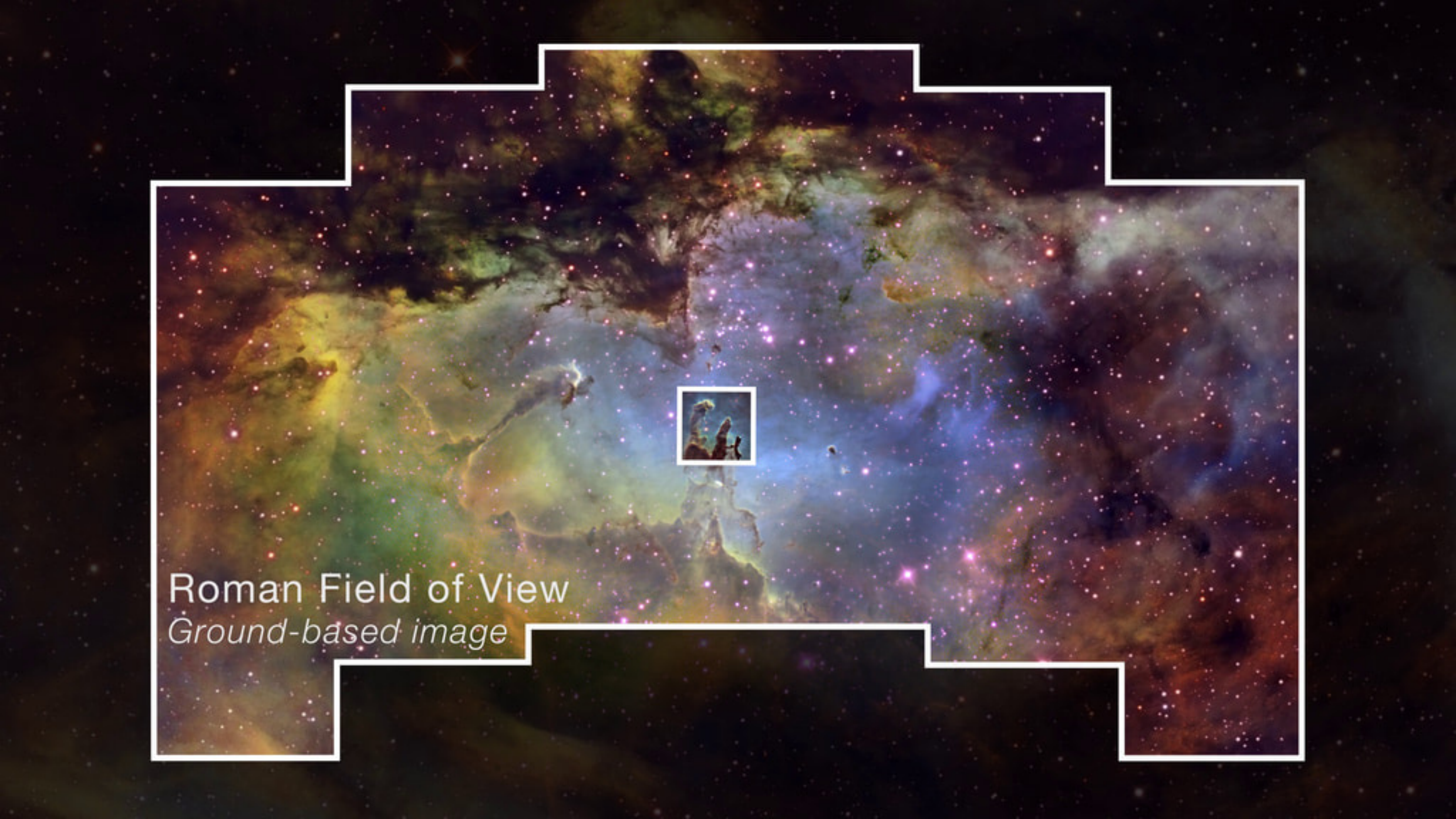
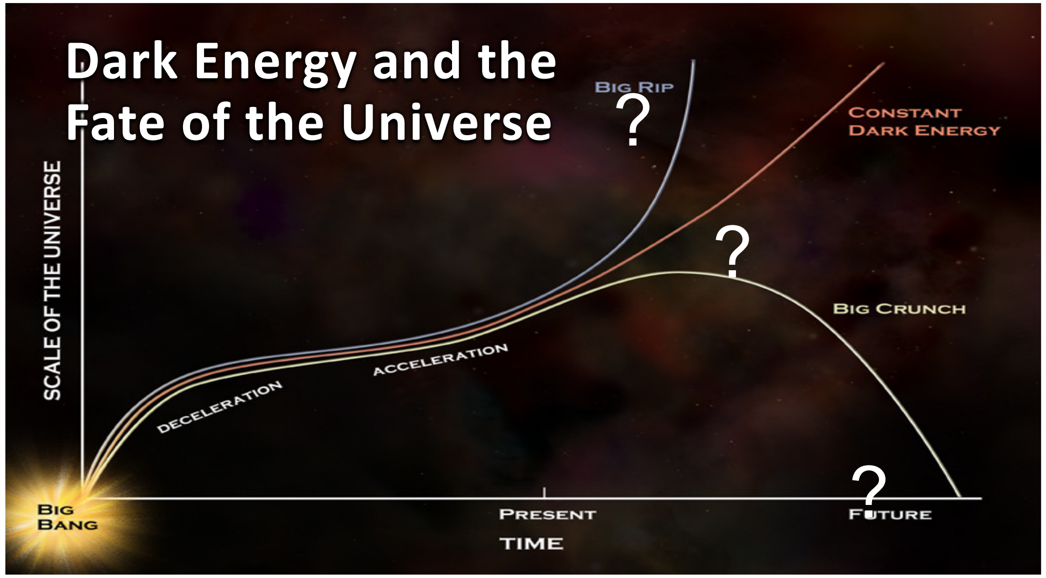
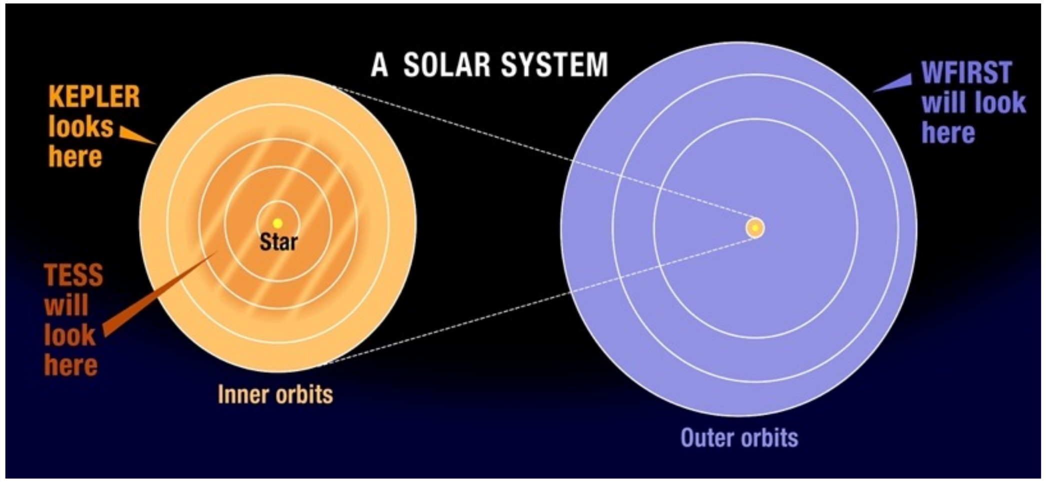
THE NANCY GRACE ROMAN SPACE TELESCOPE


Roman Field of View
Ground-based image

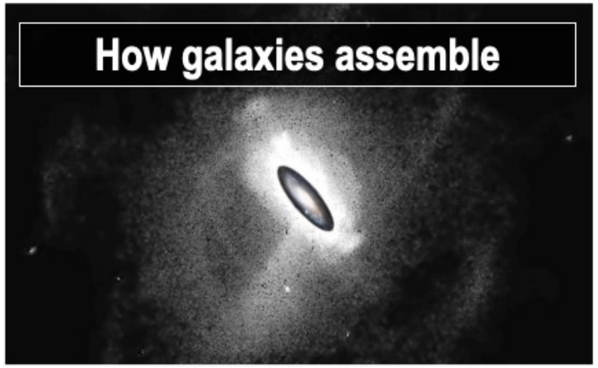
Roman Mission Objectives

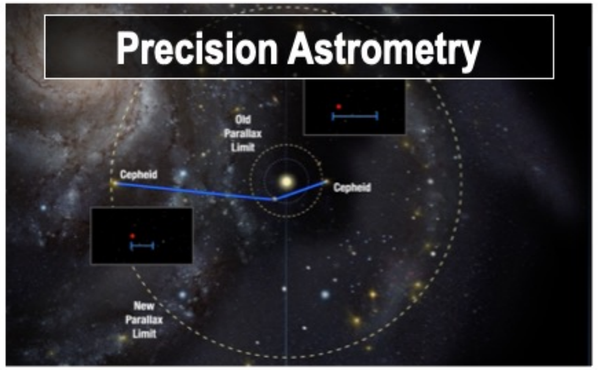


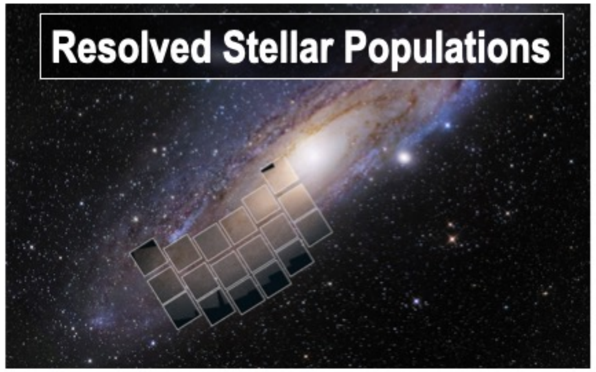
The full distribution of planets around stars

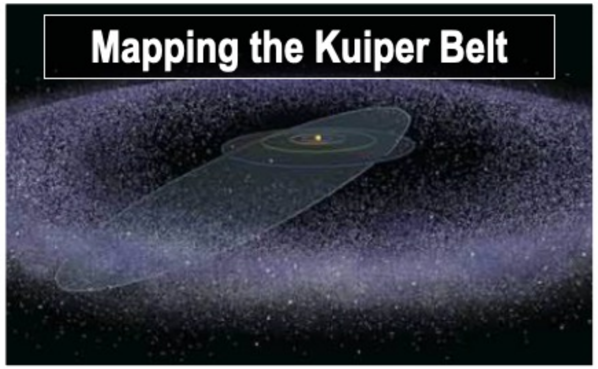


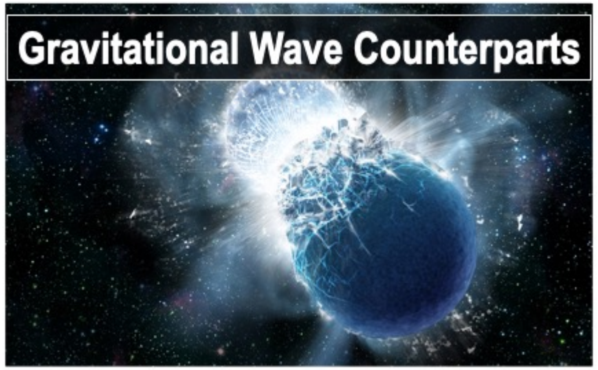
Roman Surveys Allow a Wide Range of Science Investigations

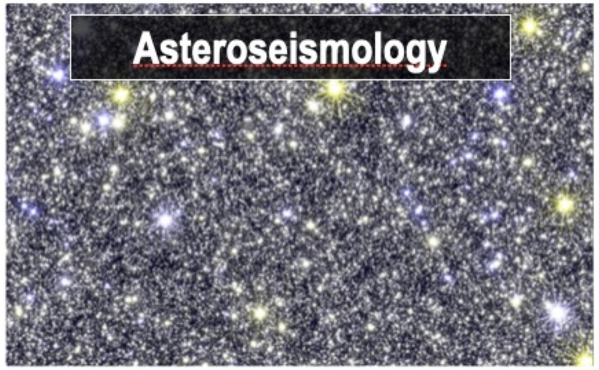


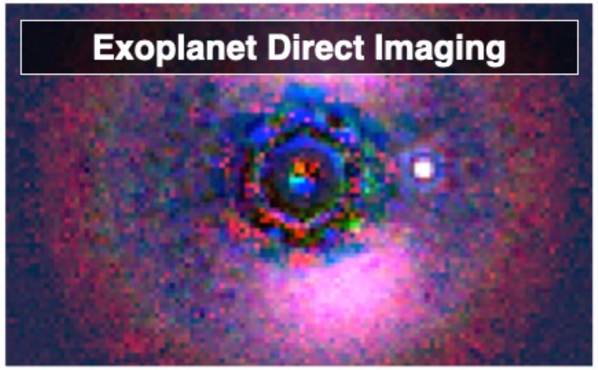


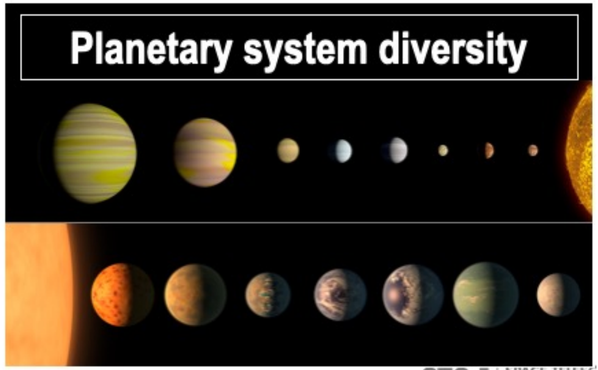




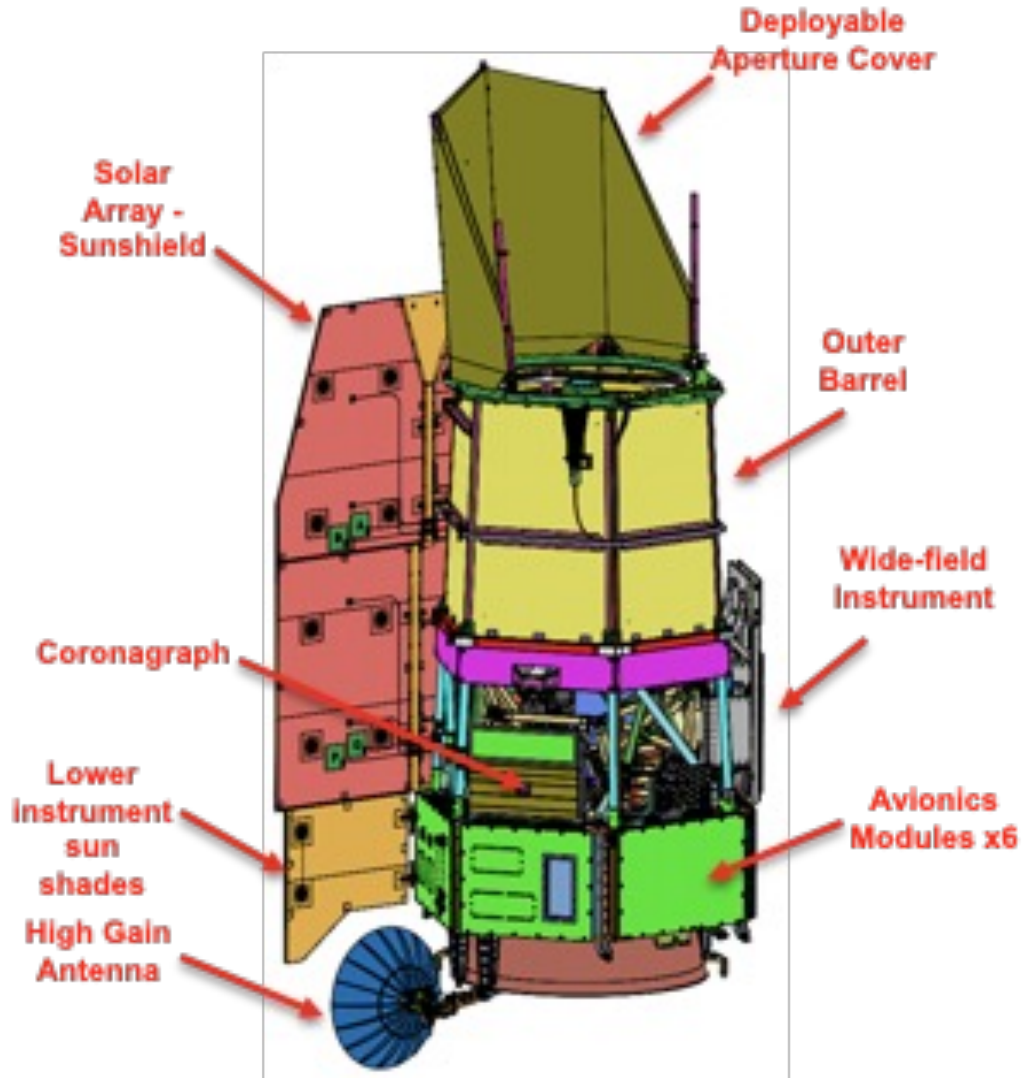








Roman Observatory and Instruments



Telescope: 2.4m aperture

Two Instruments:

Wide Field Instrument

- 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 Instrument

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

Data Volume: 11 Tb/day

Orbit: Sun-Earth L2

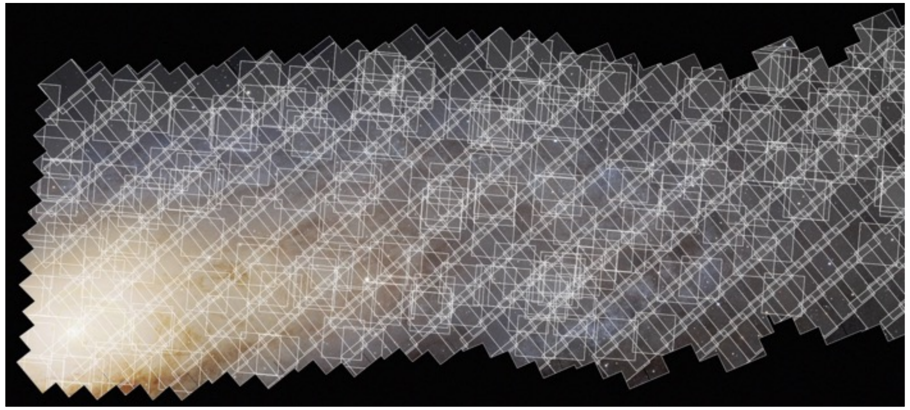
Launch: before May 2027 (Currently Oct 2026)

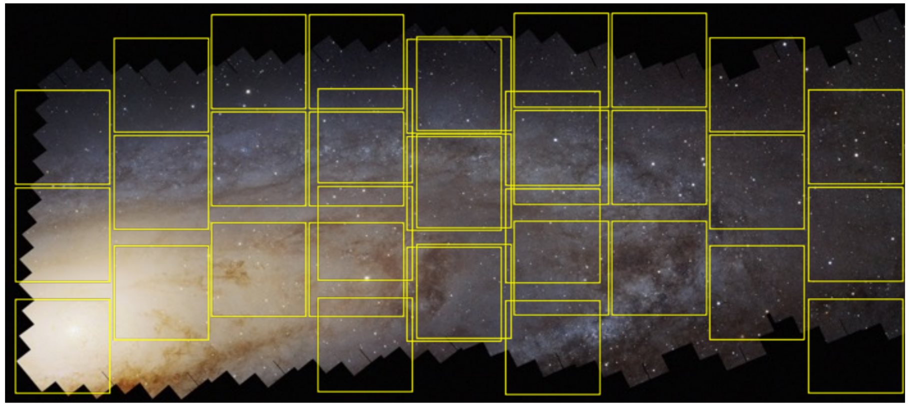
Mission Duration: 5 yr, 10yr goal

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

Roman as a Precise Survey Facility

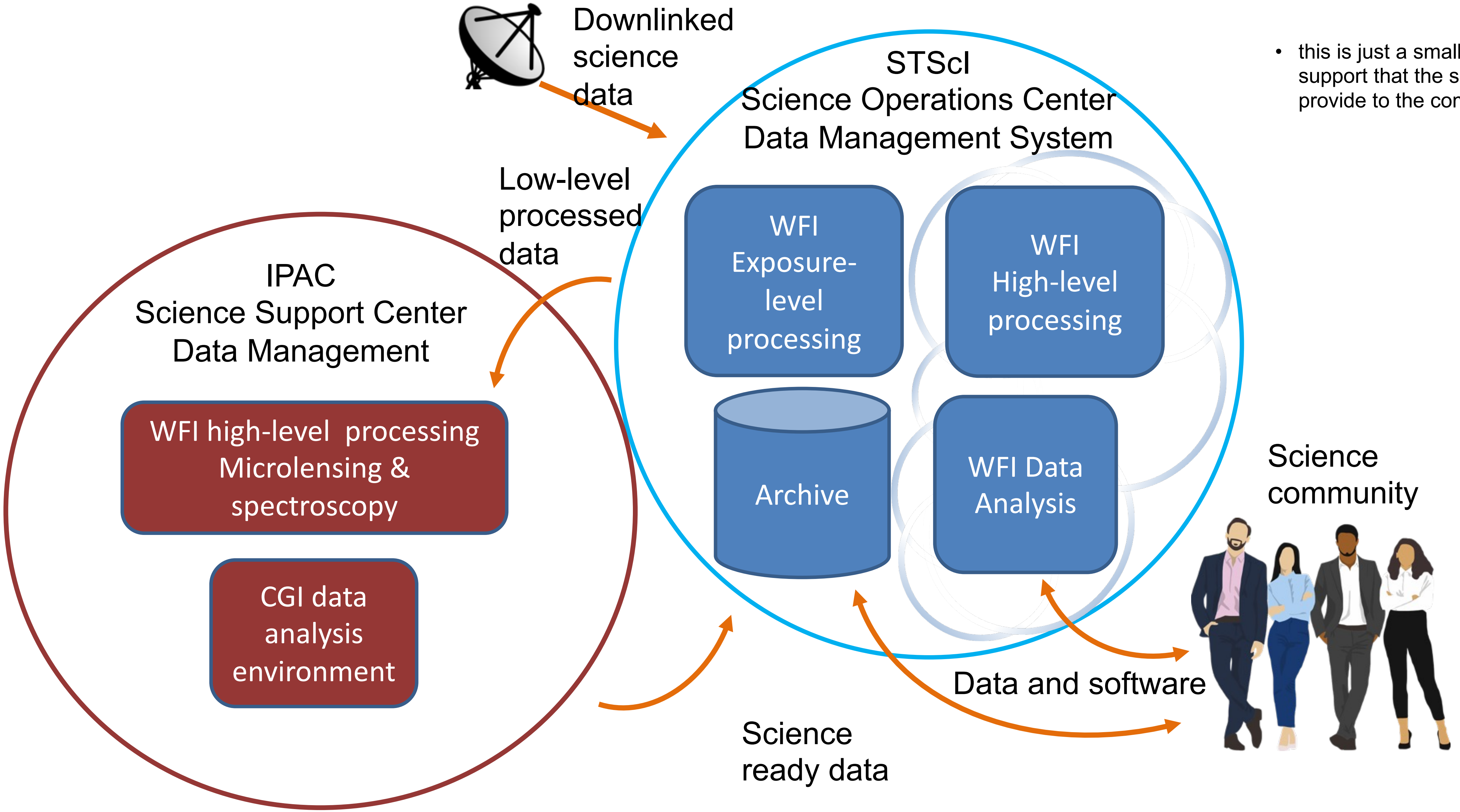
- **The power of Roman is not *just* that it has a large field of view:**
  - Very efficient observations
    - Rapid slew & settle
    - no Earth occultations
    - no South Atlantic Anomaly
  - Well understood and stable PSF
    - Stable thermal environment (L2 orbit, thermal control of all parts of the optical system)
    - Rigid optical structure with vibration isolation from the spacecraft
    - Stable attitude control
  - Excellent flux calibration
    - Relative calibration system





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

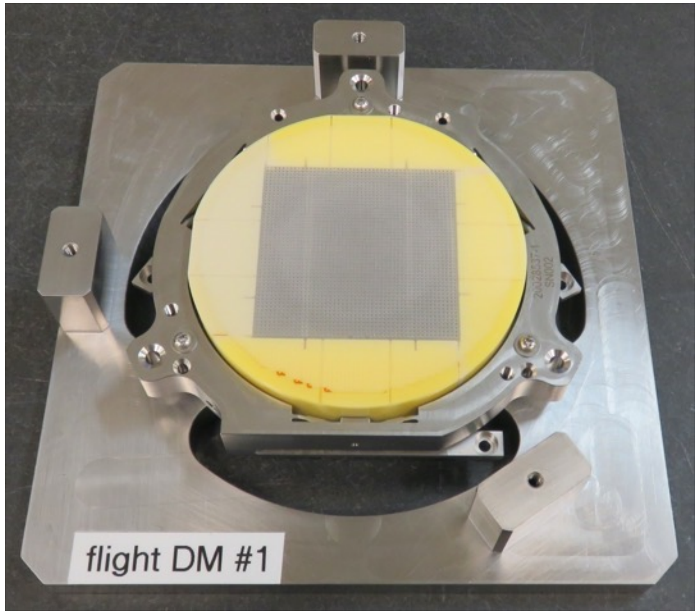
Roman Data Flow

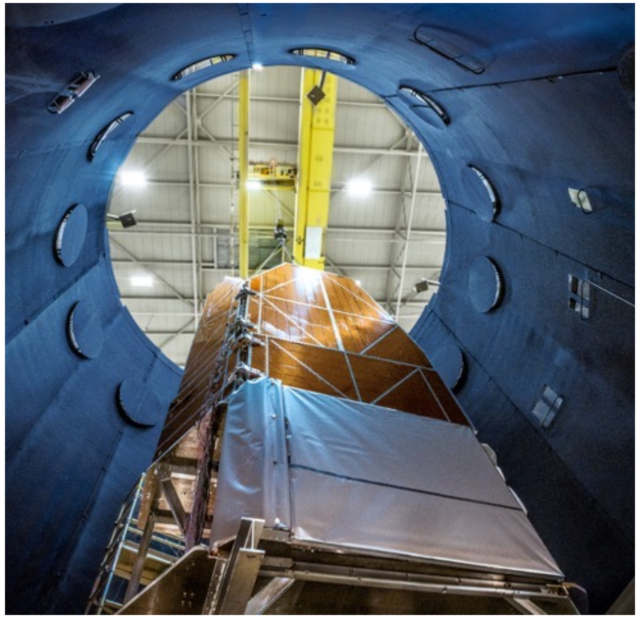


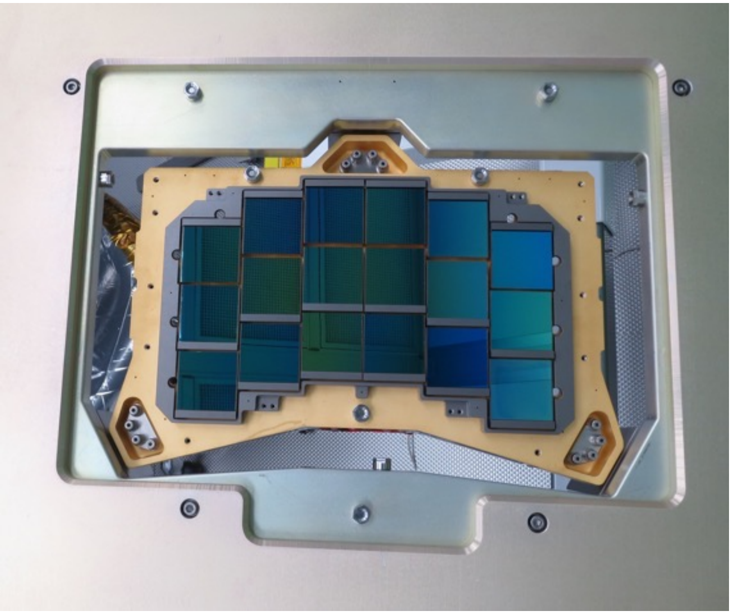
- this is just a small part of the support that the science centers provide to the community

Roman Space Telescope Status

- **Mission Critical Design Review in Sept 2021**
- **Flight hardware being built**
  - WFI and Coronagraph instrument flight hardware in assembly and test
  - Currently in integration, test and assembly of telescope







Nancy Grace Roman Space Telescope Coronagraph Instrument

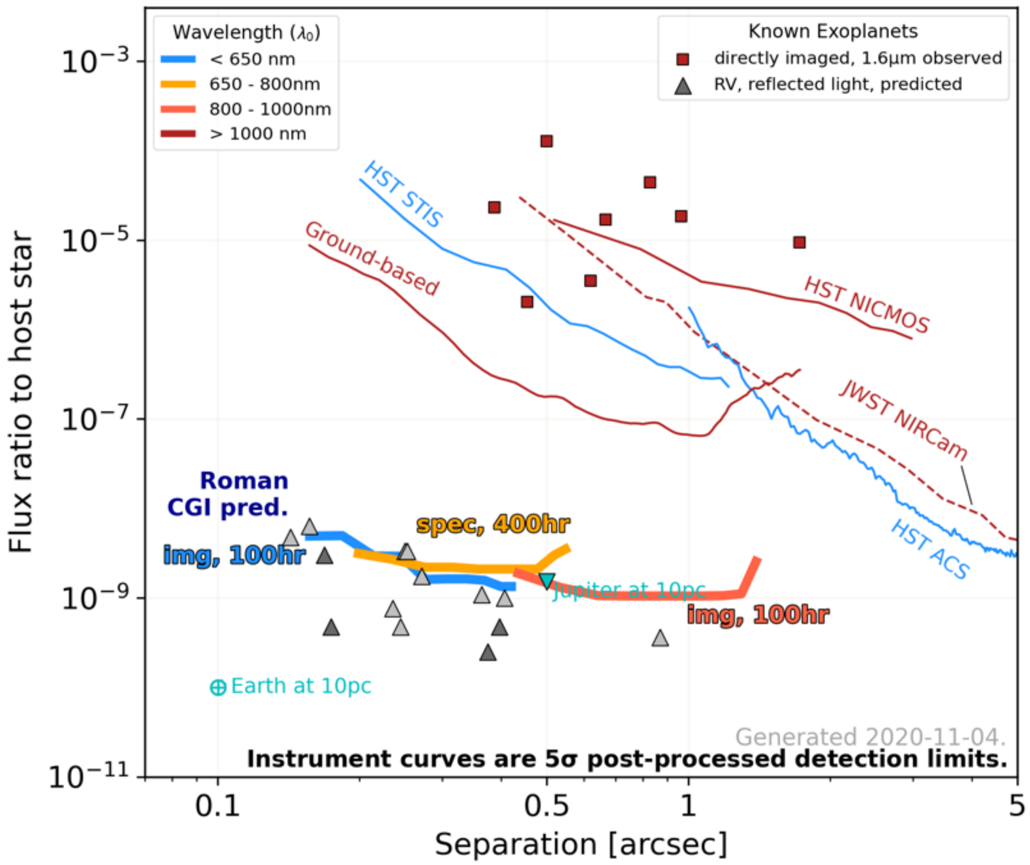
Roman Coronagraph Science and Engineering Project Teams
Jet Propulsion Laboratory, California Institute of Technology

© 2022 California Institute of Technology. Government sponsorship acknowledged. The research was carried out in part at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration. This document has been reviewed and determined not to contain export controlled technical data.

The Roman Coronagraph In Context

- **The Roman Coronagraph** is a technology demonstration of space-based direct imaging and spectroscopy
  - will be **~100-1,000 times better** than any current facility
  - a **critical stepping stone** in preparation for future exo-Earth missions
- A **Community Participation Program** will enable members of the community to engage in the technology demonstration phase.
  - If warranted by instrument performance, the CPP may perform science operations beyond the 18 month technology demonstration period

https://github.com/nasavbailey/DI-flux-ratio-plot

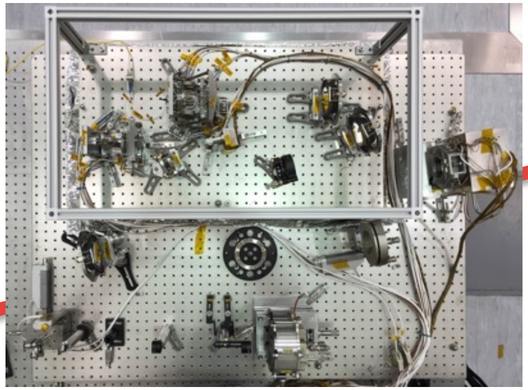


"RV" planets: planets already detected using the Radial Velocity technique and with minimum masses > 0.25 Jupiter mass

Critical Technology Demonstrations

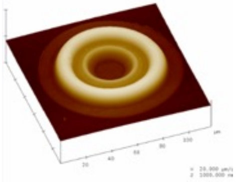
The Roman Coronagraph is an advanced technology demonstrator for future missions that will directly image Earth-like exoplanets.

Ultra-Precise Wavefront Sensing & Control

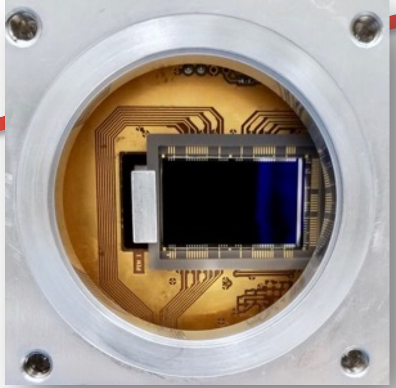


Large-format Deformable Mirrors

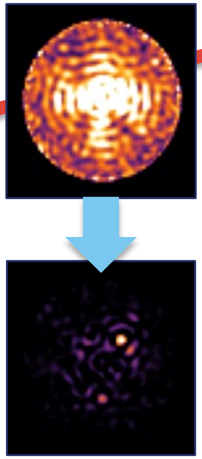
High-contrast Coronagraph Masks



Ultra-low noise photon counting EMCCD Detectors



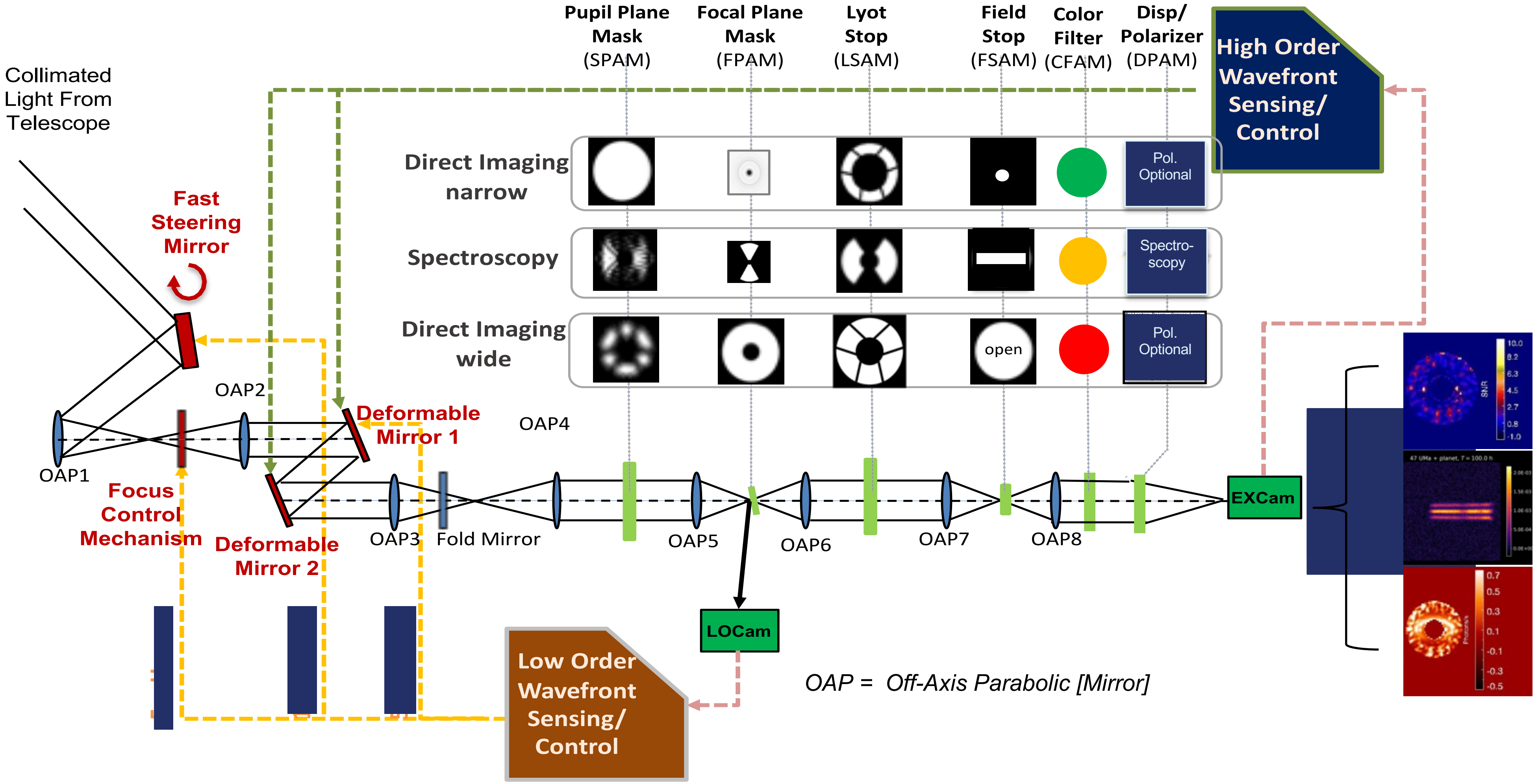
Data Post-Processing



Bertrand Mennesson (JPL)

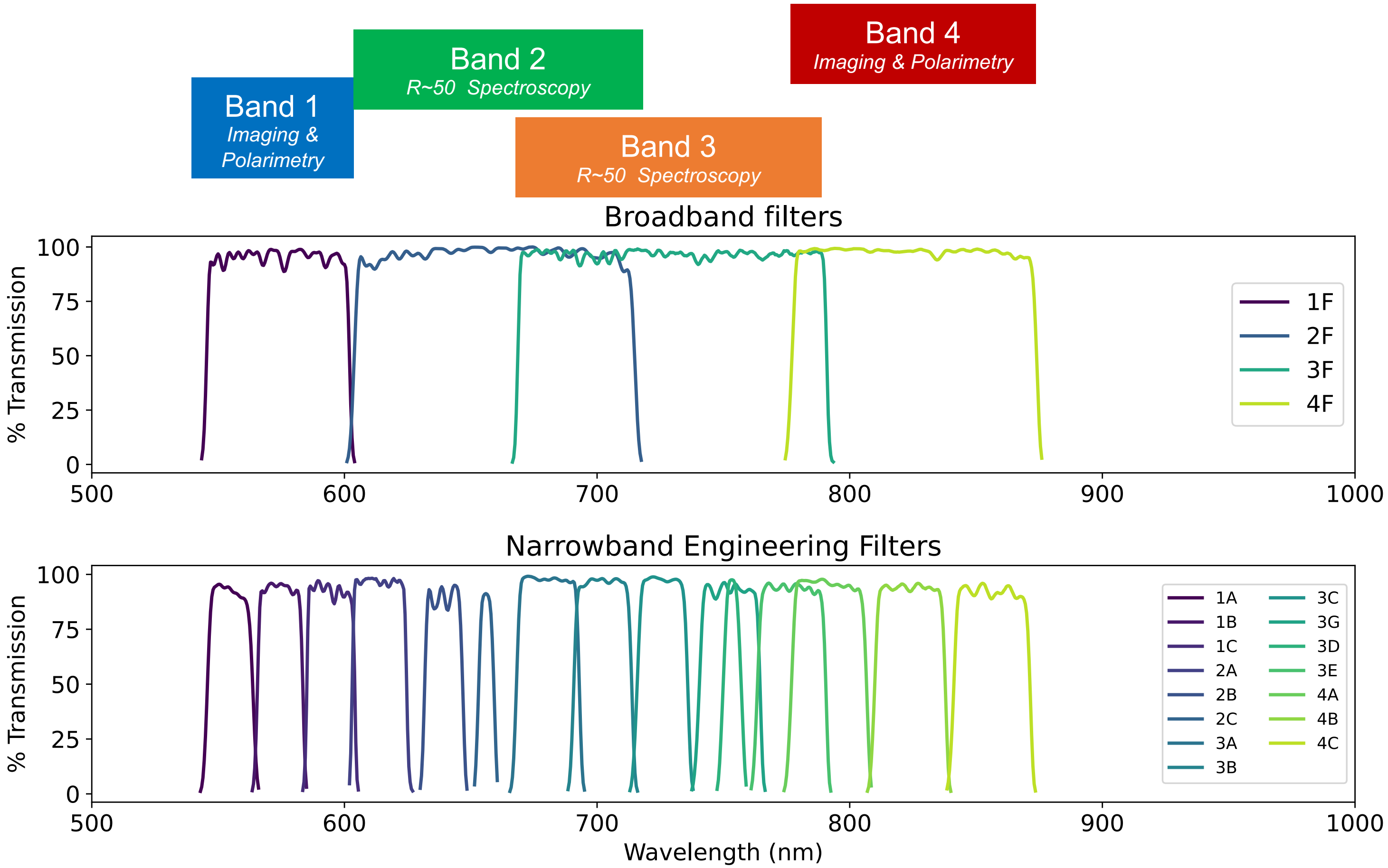
The Roman Coronagraph will premiere in space the technologies needed by future missions to image and characterize rocky planets in the habitable zones of nearby stars. By demonstrating these tools in a system with end-to-end, scientific observing operations, NASA will reduce the cost and risk of a potential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

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)

Roman 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

Coronagraph Instrument Status

- Flight detectors (EMCCDs) in hand, being integrated mechanically
- Flight and spare Shape Pupil Coronagraph coronagraph masks completed
- Flight deformable mirror arrays (DMs) performing well in JPL testing
- Precision Alignment Mechanisms passed vibration testing
- Prisms and polarizer assemblies delivered

- For more information see https://roman.ipac.caltech.edu/SSC_Supplemental_info_for_Roses_call.html

Wide Field Instrument Status

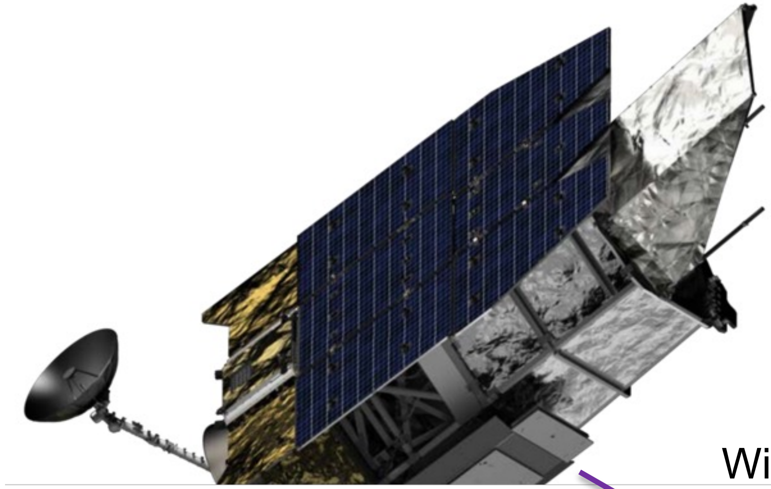
Joshua Schlieder
WFI Scientist – NASA GSFC

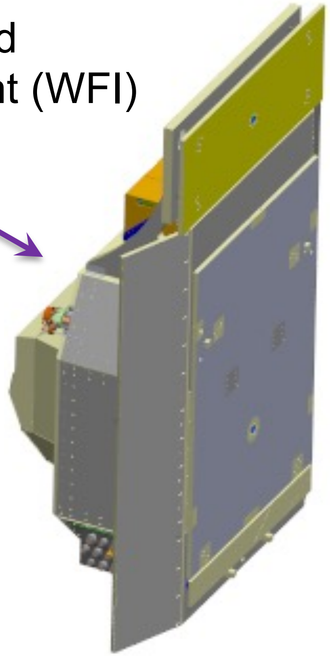
AAS 240 Roman Town Hall

June 16th 2022

• 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 Wide Field Instrument (WFI)





WFI is led by NASA GSFC with major contributions from primary industry partner Ball Aerospace

Instrument Overview

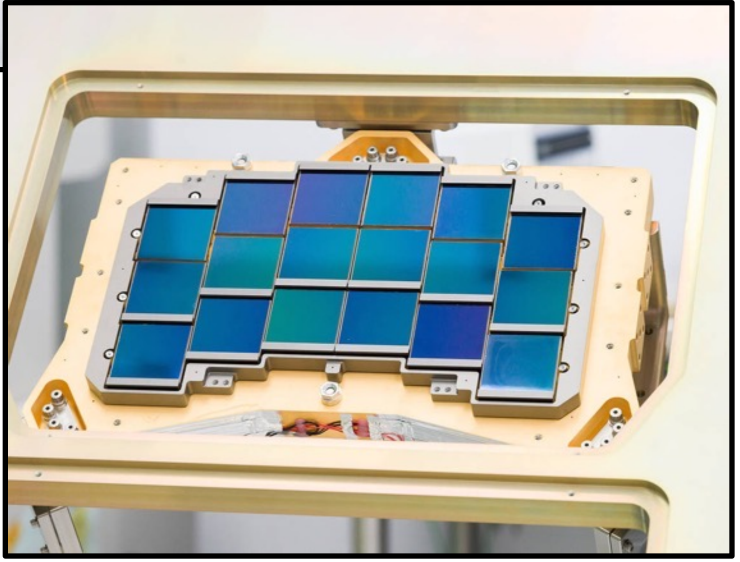
- Focal plane array of 18 Teledyne 4k × 4k detectors
  - Large field-of-view (FOV) – 0.8 x 0.4 deg (0.281 deg^2, excluding gaps)
  - Spatial sampling: 0.11 arcsec/pixel
  - Image stability: 1.0 nm RMS wave front error (WFE) variation in 180 sec
  - Guide star sensing interleaved with science data collection
- Element wheel enables imaging and spectroscopy spanning 0.48 to 2.3 μm
  - 8 imaging filters
  - Prism and grism for full-field, slitless spectroscopy
  - Blank position for darks, flat fields, and other calibrations
- Internal relative calibration system

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

Detectors and Focal Plane Array

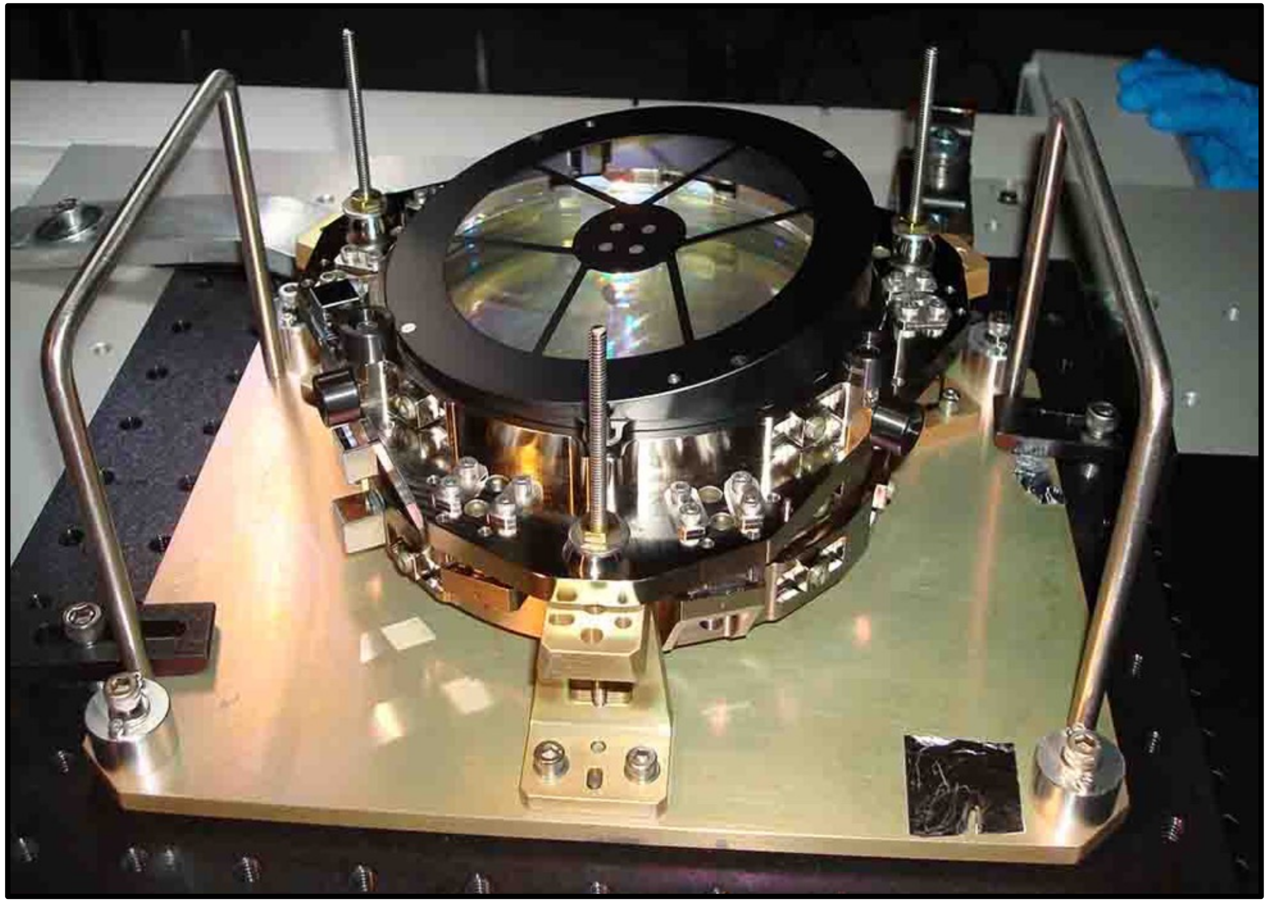
- 18 flight detectors and 6 spares selected and prioritized from 28 that passed acceptance testing
- Flight detectors integrated and aligned into focal plane at NASA GSFC, undergoing assembly characterization
- Flight control electronics undergoing component test and assembly integration
- ETU focal plane system (detector array + electronics) cleared vibration and electrical interference testing and is now starting thermal and performance test campaign

Roman detector compared to cell phone camera



Engineering Test Unit (ETU) focal plane array

Element Wheel, Filters, Prism, and Grism



Flight Grism assembly

- Flight Element Wheel and drive motor fabricated and undergoing test at Ball Aerospace
- Flight Filters in hand at Ball Aerospace, undergoing assembly integration and test
- Flight Prism assembly complete and cleared environmental tests at NASA GSFC, undergoing optical and spectral characterization
- Flight Grism assembly complete and cleared environmental tests and optical characterization at NASA GSFC, undergoing spectral characterization

Optical Bench and Other Hardware

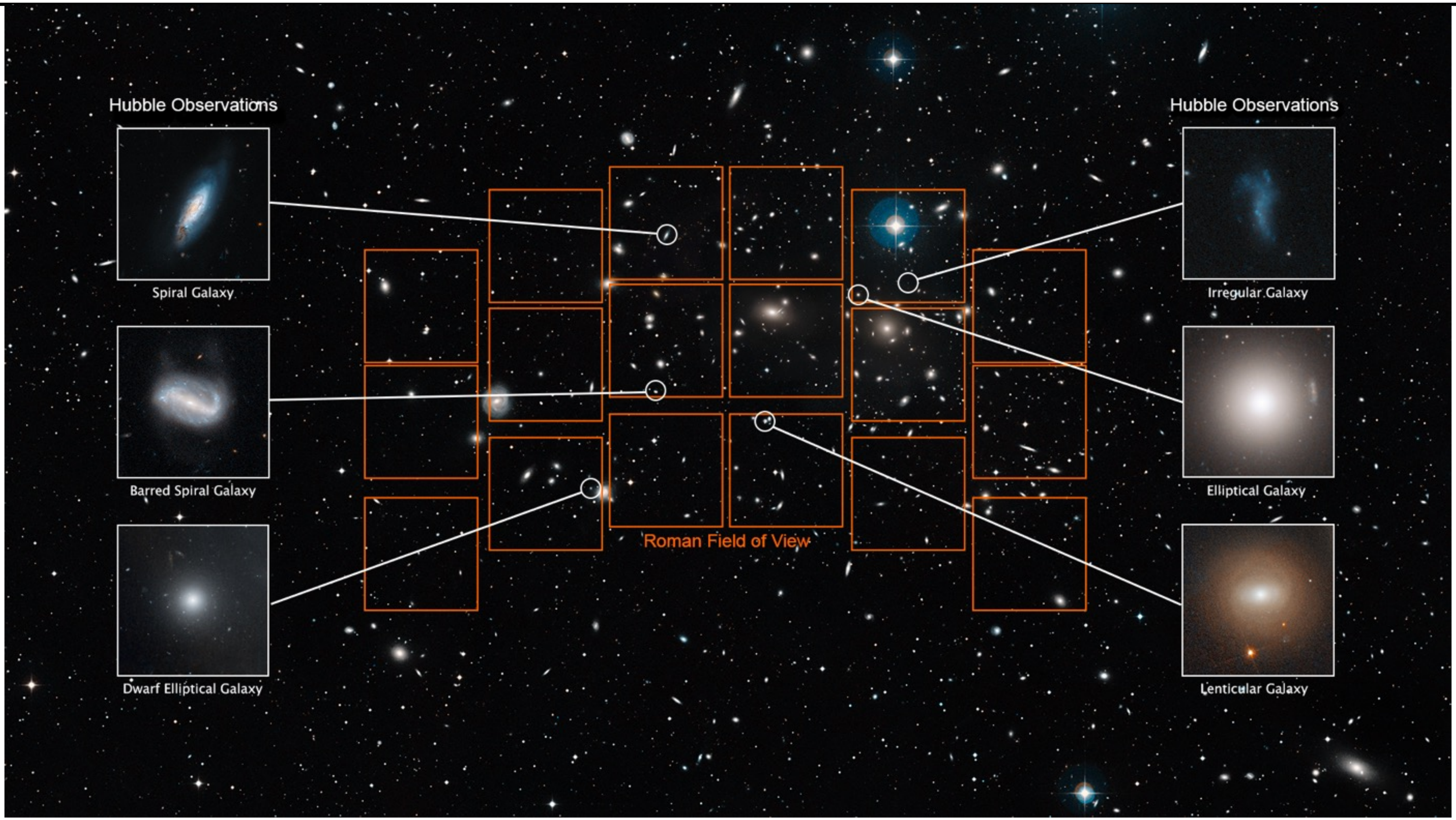
- Flight Optical Bench complete and undergoing test at Ball Aerospace

- Alignment Compensation Mechanism, Cold Baffle, and other key WFI hardware also complete and undergoing assembly integration and test at Ball Aerospace

Flight optical bench

Roman WFI Status Summary

WFI flight hardware is solidly in the build and test phase and heading toward full instrument integration and test in 2023!



Roman Science community engagement - Goals

- **Community definition and ownership of Core Community Surveys**
  – Community defined: Broad, inclusive process; Astrophysics included in all decisions
  – Community owned: Not directed by any single team; data have no proprietary access

- **Ability for people to engage with Roman project / Science Centers / science community independently of proposal selection**
  – Via technical joint working groups and community-led science consortia

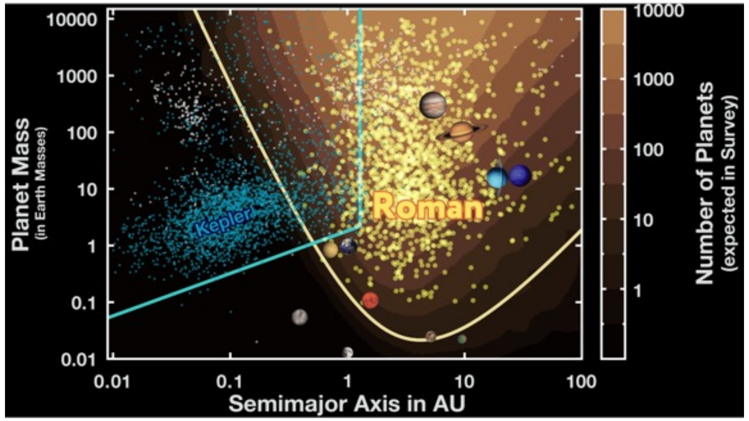
- **Science community funding**
  – Variety of award sizes and durations
  – Multiple funding opportunities between now and launch for support for people at US institutions to work independently or with existing science teams/consortia
  – Long term, stable support of teams to allow development of software/pipelines etc in partnership with Roman Science centers

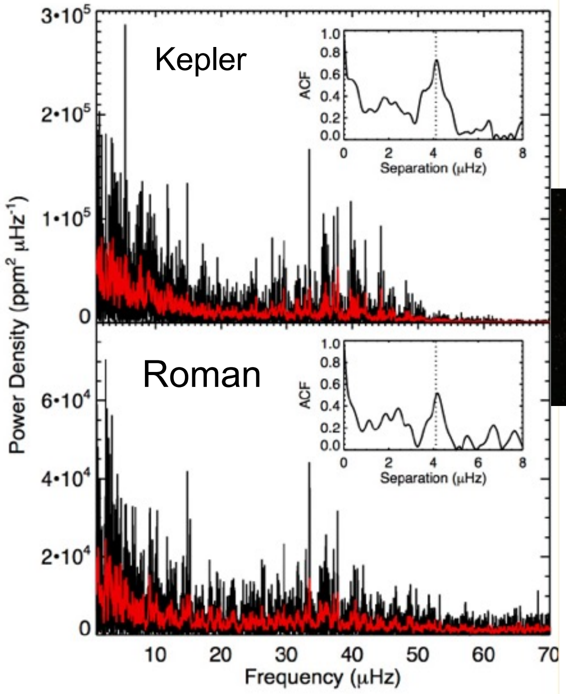
Roman Observations

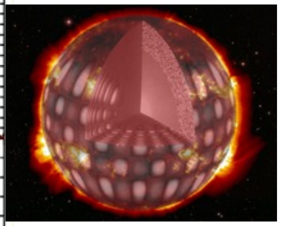
- **Three Core Community Surveys address the 2010 Decadal Survey science goals while providing broad scientific power**
  - **High Latitude Wide Area Survey**
    - Wide area multiband survey with slitless spectroscopy
    - Enables weak lensing and galaxy redshift cosmology mission objectives
  - **High Latitude Time Domain Survey**
    - Tiered, multiband time domain observations of 10s of deg^2 at high latitudes
    - Enables Type Ia supernova cosmology mission objectives
  - **Galactic Bulge Time Domain Survey**
    - ~<15 min cadence observations over few deg^2 towards galactic bulge
    - Enables exoplanet microlensing mission objectives
- **Minimum 25% time allocated to General Astrophysics Surveys**
- **90 days for Coronagraph technology demonstration observations, within first 18 months of mission**

Astro2020: Worlds and Suns in Context

- **Exoplanet demographics**
  - Roman's microlensing program with the **Galactic Bulge Time Domain (GBTD) Survey** will fill out the census of exoplanets by finding exoplanets in the outer reaches of planetary systems that are inaccessible by other detection techniques
- **Stellar Astrophysics**
  - **GBTD Survey** will monitor >200 million stars
    - Microlensing studies will reveal the population of neutron stars and stellar mass black holes in the galactic bulge
    - Astroseismology – use stellar oscillations to measure mass and radius of stars in the galactic bulge
    - and lots more – stellar flares, pulsating variable stars etc
  - **GBTD Survey** will provide a deep image of 2 deg^2 region of the bulge
    - Identify unusual stellar populations down to very faint levels
    - measure positions, distances precisely
  - **Roman General Astrophysics Surveys of nearby galaxies** open new windows in extragalactic stellar astrophysics



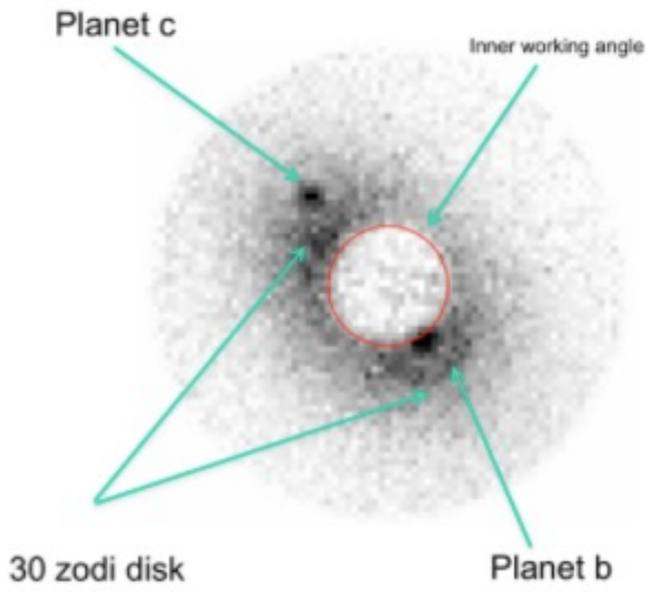




Astro2020: Worlds and Suns in context

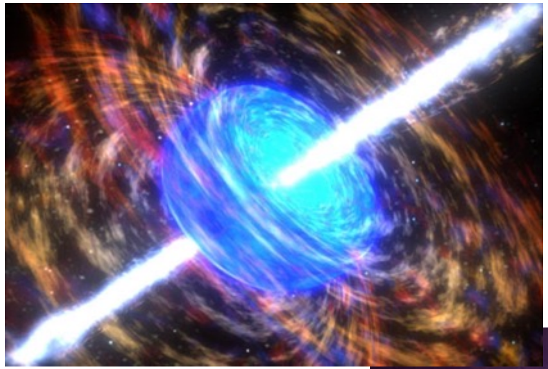
- **Priority Area: Pathways to Habitable Worlds**
  - How to answer the question “Are we alone?”
  - The planets around Sun-like stars are only accessible via an ultra-stable, space-based telescope equipped to block the star’s light and directly image the planet
    - The **Roman coronagraph instrument tech demo** is an important part of the path

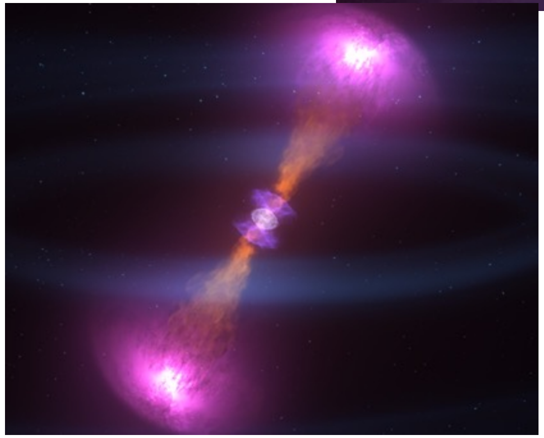
Simulated Roman Space Telescope coronagraph image of the star 47 Ursa Majoris



Astro2020: New Messengers and New Physics

- **Priority area: New windows on the Dynamic Universe**
  - Exploring the Universe in the time domain is a discovery machine
    - Gamma-ray bursts, tidal disruption events, supernovae, fast radio bursts, etc were all discovered, and can only be studied by observatories monitoring large areas of the sky on a variety of timescales.
      - Roman will study all these, and almost certainly make new discoveries of our own
      - The **Galactic Bulge and High Latitude Time Domain Surveys** will be the engine of these discoveries
  - Observing/identifying the counterparts to gravitational wave and neutrino events
    - Connecting the whole new world revealed by GW and neutrinos to things we know from the rest of astronomy
    - Using the **High Latitude Time Domain Survey and TOO observations** to identify/follow up interesting events





Astro2020: Cosmic Ecosystems

- **Priority Area: Unveiling the Drivers of Galaxy Growth**
  - Roman's **High Latitude Wide Area and High Latitude Time Domain** will greatly expand our sampling of the structure, colors and spectra of galaxies over a significant fraction of cosmic time
  - **General Astrophysics Survey of an Ultra Deep Field** would provide additional depth

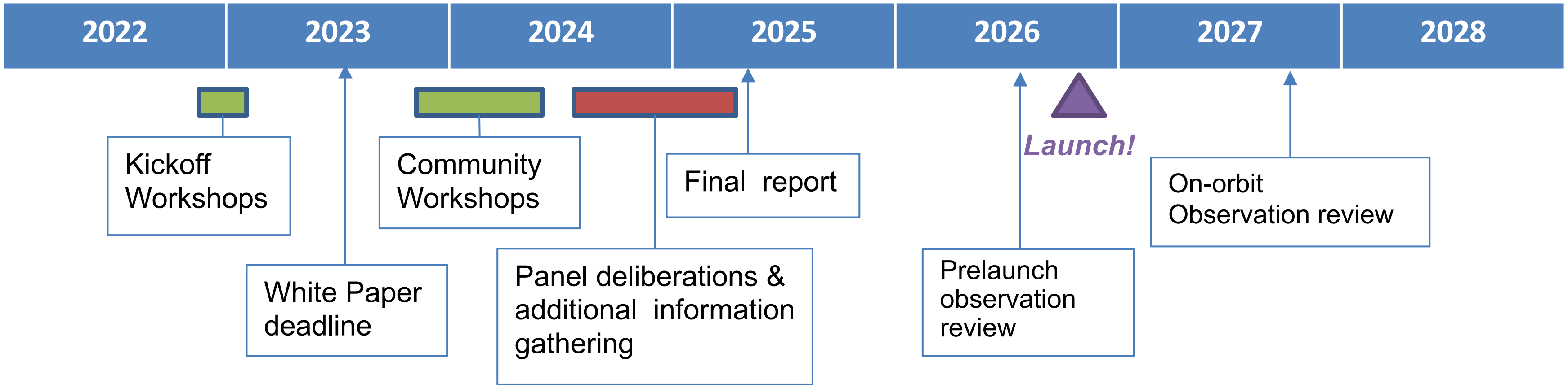
Core Community Surveys are for Everyone

- **Core Community Surveys:** a significant fraction of the prime mission used for revolutionary surveys of unprecedented scale.

Core Community Surveys definition will be via an open process, maximizing the overall science return while meeting the cosmology and exoplanet science requirements

Community Definition of Core Surveys

- **Workshops to inform community about Roman capabilities**
  - Outline available parameter space for each survey
  - Constraints are that each survey provides data needed to meet the science requirements, and at least 25% time (TBC) is retained for General Astrophysics Surveys
- **White paper call for papers detailing science that can be done with the survey**
  - Encourage development of metrics/figures of merit, and description of specific observational needs
- **Additional workshops to enable community cooperation and consensus**
  - Provides a forum for iterative development of survey concepts

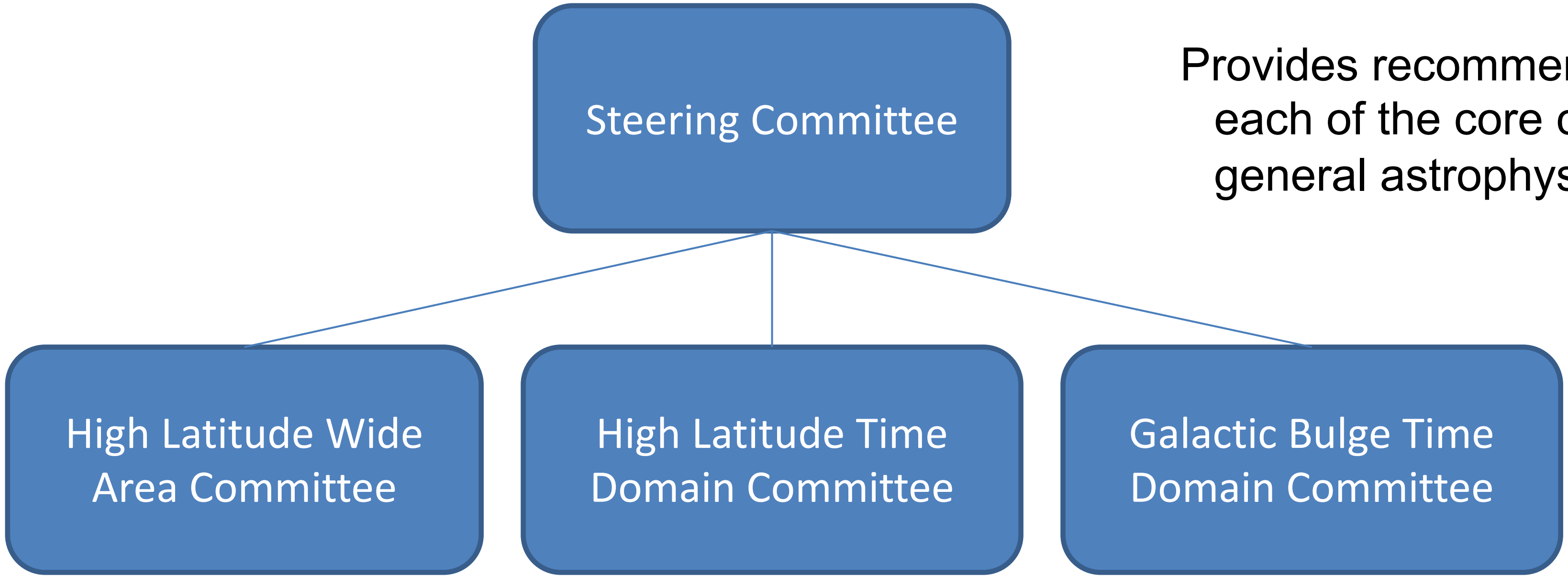


An Inclusive Process

- **Make sure that the entire community has a voice in the survey definition process**
- **Reach out as broadly as possible**
  - Leverage mailing lists at both Roman science centers (STScI and IPAC) in addition to existing Roman mailing lists and other astrophysics lists (e.g., Chandra)
  - AAS, APS etc. (town halls, special sessions, announcements in newsletters)
- **Enable and encourage participation from early career scientists**
  - Provide travel support for workshops
- **Proactively reach out to researchers at undergraduate serving institutions and minority serving institutions**

Evaluation and Recommendations

- **Set up and charter a tiered committee structure to do the work of recommending survey definitions based on community input**
  - Committees include representatives of all science areas to be addressed by each survey (determined from white paper submissions etc)



Provides recommendations on balance between each of the core community surveys, and the general astrophysics survey allocation above 25%

Evaluate white papers, solicit additional community input, evaluate survey options against science metrics, produce recommendations for survey with options for enhancements/descopes

Funding the Science Community

- Roman Science Investigation Team contracts ended in 2021
- Draft ROSES Solicitation for new teams/community support released for comments April 29-May 31; final expected to be released in about a month

A new start!
Opportunity to rethink how the Roman Science community is structured

Three Opportunities in Current Solicitation

- **Wide Field Instrument Science**
  – Support to prepare for and enhance the science return of *Roman* that can be addressed with its Wide Field Instrument
    - Multiple calls between now and launch
    - Regular (2 years, up to $150k/year) and Large (4 years and ≲$500k/year) categories
- **WFI Project Infrastructure Teams**
  – Sustained funding for teams to work in partnership with the science centers to develop infrastructure needed to enable the community to pursue *Roman*'s ambitious science goals in cosmology and exoplanet demographics
    - Additional science areas that require extensive and sustained infrastructure development will also be considered.
- **Coronagraph Community Participation Program**
  – Opportunity to work with the coronagraph instrument team to plan and execute its technology demonstration observations.
    - Multiple calls between now and launch

Wide Field Instrument Science

- ***Preparing for and enhancing*** **Roman** ***WFI Science***
  - Can include, but are not limited to, any combination of the following topics:
    - Precursor observations using ground- and/or space-based observatories to prepare for future *Roman* science observations and/or to provide calibration capability;
    - Development of *Roman* analysis software beyond that provided by the Science Centers. This could include topics like machine learning techniques in time domain astrophysics, high precision astrometric measurement techniques, etc.;
    - Development of algorithms for joint processing with data from other space- or ground-based observatories such as deblending algorithms, photometric redshift training and calibration, or forced photometry;
    - Theoretical and/or phenomenological modeling directly related to Roman capabilities;
    - Instrument calibration and characterization;
    - Development of survey strategies;
    - Development of simulation tools, producing simulated datasets, and conducting or participating in data challenges.
- ***Supporting the*** **Roman** ***project and Science Centers***
  - WFS supported teams are expected to form part of the funded Roman science community providing support and guidance to the Roman project and science centers.

WFI Project Infrastructure Teams

Project Infrastructure Teams (PITs) partner with science centers providing comprehensive and sustained support enabling science objectives that require long-term scientific infrastructure development.

PITs will:

A. develop and maintain such infrastructural tools and capabilities as are needed to address the mission objective that is the proposal's focus;
   - PIT infrastructure focused to a specific science objective, they are not *the* survey teams

B. support community-led science consortia;
   - PITs enable the community to achieve ambitious Roman science objectives

C. support the *Roman* Project and Science Centers (the SSC and the SOC)

PITs are service oriented; expected to work closely with Project and science centers to ensure that the community can achieve Roman science objectives

Coronagraph Community Participation Program

- **Intent is to form a coalition of scientists/technologists to work together to plan and execute Coronagraph technology demonstration observations**
  - Some members of coalition from Coronagraph project & international partners, and the rest is solicited from the community via the current ROSES opportunity
- **Selecting individuals/small groups to make up CPP Team**
  - Broad opportunity for community engagement
  - Maximize diversity of interests & perspectives
- **Overall, providing long term support to Coronagraph**
  - Detailed planning & precursor work
  - Preparing for assessment, processing, and analysis of observations
  - Making the most of the observations to learn about space coronagraphy

Engaging with Roman

- **Technical working groups that cut across all science areas**
  - Forum for people to work together on topics/methods that cut across science areas
  - Brings together Science community, science centers, and project
  - Have been very successful over past 5 years, will update group structure later this year

Calibration | Astrometry | Software | Simulations | Detectors | Spectroscopy

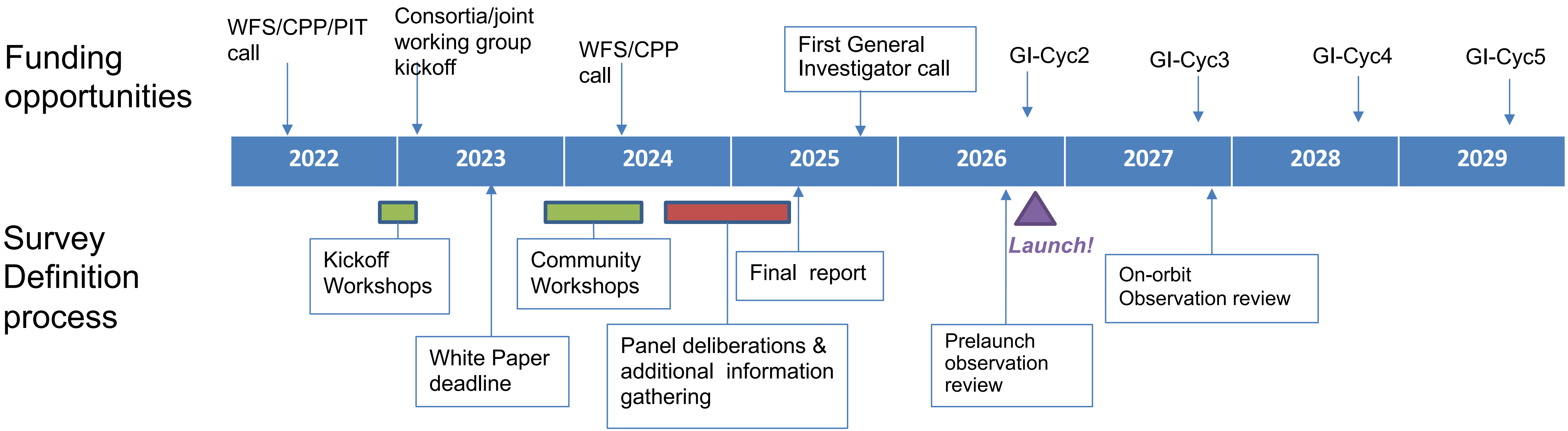
- **Community-led Science Consortia**
  - Enable people to engage with Roman science independently of NASA-selection
  - Facilitate the formation of quasi-independent community-led consortia
  - Definition of these is currently vague, because we want to work with the community to shape what these should be

Cosmology | Exoplanets | Astrophysics | …

What's different from what we did before?

- **Larger number of small teams/individuals, many on short term**
  - Greater turnover, more flexibility to adjust science team to evolving science landscape and project needs
  - Multiple opportunities for new people to join
- **WFI Project Infrastructure Teams with long term baseline**
  - Expectation of continuing through to end of prime phase
  - Provides continuity and enhanced support to the community
- **Strong emphasis on science community coordination that is independent of the individual selected proposals**
  - Community-led Science Consortia
  - Reset structure of joint working groups (keeping the ones that work well)
- **Undergrad supplement for WFS**
- **ROSES solicitation in ~2 years**
  - Additional CPP and WFS opportunities

The Road Ahead



- **Roman progressing; remains within cost & schedule commitments**
- **For more information**
  - https://roman.gsfc.nasa.gov/science/roses.html

Backups

Back up

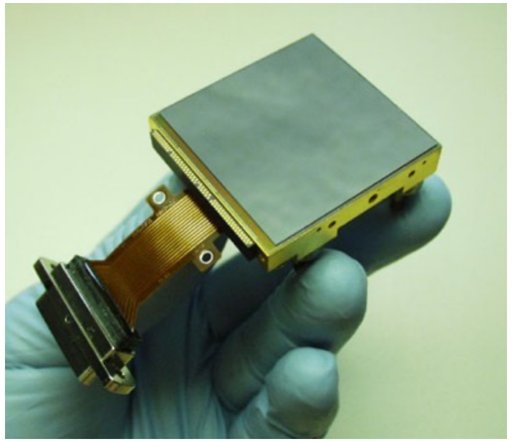
Roman Detectors - The Next Generation from Teledyne

H1R (Hubble WFC3 IR)

- 1024 x 1024 pixels
- 18 μm pixels
- QE ~ 90% (1.0 – 1.7 μm)
- Dark current <0.05 e^-/s/pix
- Noise – 12 e^- RMS (16 reads)
- Development: 2000 - 2007

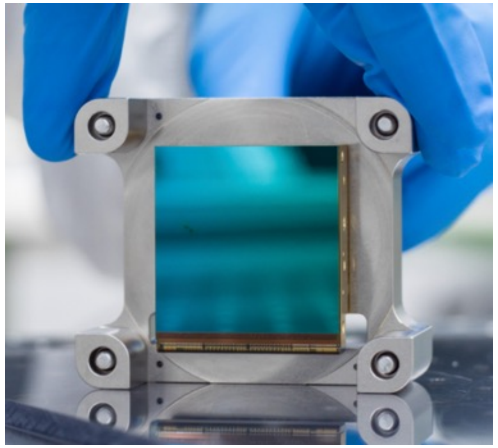
H2RG (JWST, Euclid)

- 2048 x 2048 pixels
- 18 μm pixels
- QE ~ 90% (@2 μm)
- Dark current <0.01 e^-/s/pix
- Noise – 6e^- RMS (1000 s)
- Development: 2002-2014



H4RG - 10 (Roman WFI)

- 4096 x 4096 pixels
- 10 μm pixels
- QE ~ 95% (0.8 – 2.1 μm)
- Dark current <0.005 e^-/s/pix
- Noise – 5 - 6 e^- RMS (180 s)
- Development: 2011-2021



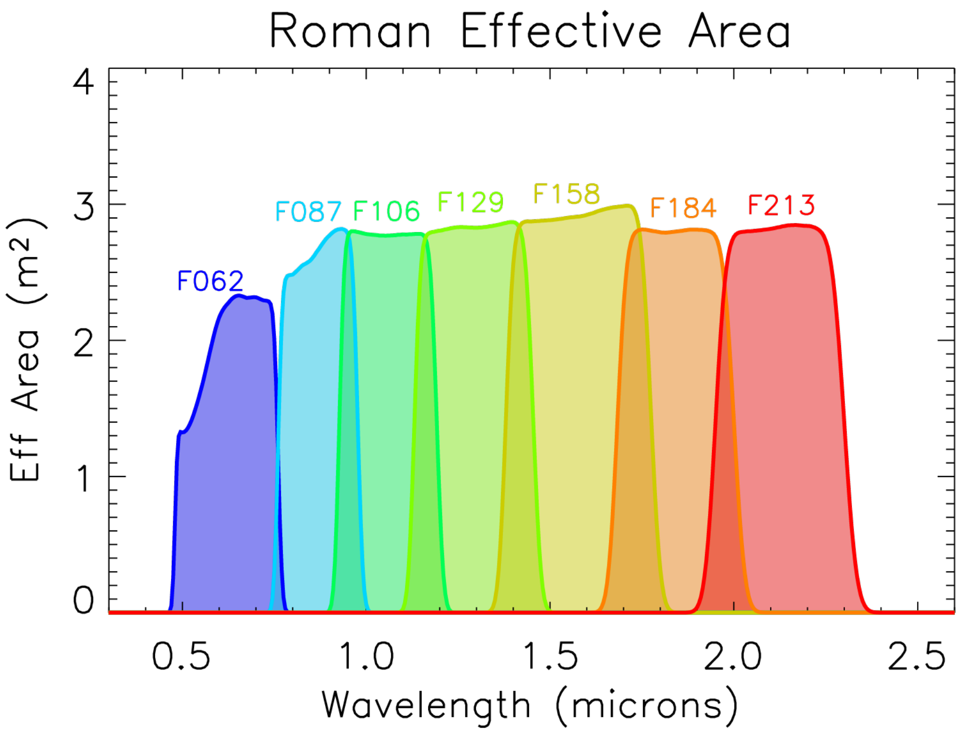
Early and sustained investment in H4RG-10 led to on-schedule, on-budget delivery of Roman Flight SCAs in late 2021

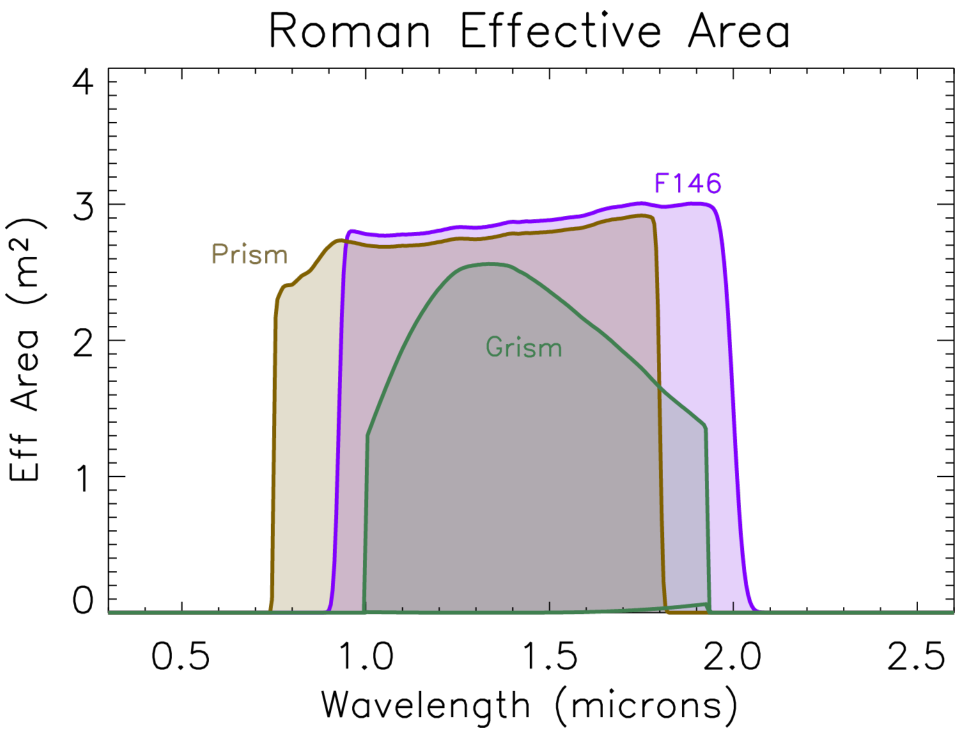
How to get involved with Roman

- **Community Definition of core community surveys**
- **Technical engagement via joint working groups**
  - Calibration, detectors, simulations, pipelines/software etc
- **Scientific engagement**
  - Planning science consortia/collaborations (at least 3, and maybe more)
    - Details TBD, but could be Cosmology, Exoplanets, Astrophysics
  - Place for people to engage with each other and the Roman mission on specific science areas
- **Funding (for people at US institutions)**
  - Draft call for proposals released last month, deadline fall 2022)
  - Additional call in 2024

Wide Field Instrument: Filters/Dispersers

- **Imaging capability is ~1 sq. deg. per day at any band to 5σ AB depth of F062=29.6, F087=29.2, F106=29.1, F129=29.1, F158=29.1, F184=28.5, F213=27.2, F146=29.4.**
- **Spectroscopy via prism (0.6-1.8μm, *R*~100, ~24AB) and grism (1.0-1.9μm, *R*~600, ~22AB)**





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**
  - catalog functions to be implemented by science centers: include deblending, photo-z, some time-domain functions etc
  - Astrometry functions – e.g. tying to *Gaia*
  - Some elements of PSF characterization
  - Instrument simulations

Design Reference Mission

- The Design Reference Mission is a notional observing plan that is used to demonstrate that Roman can execute a science program that will meet the mission objectives within the prime phase of the mission

- **It is NOT the observing plan** but gives a flavor for that nature of surveys that address the science objectives and the degree of flexibility to optimize the observing program for a broad range of science

  – **High Latitude Wide Area Survey**
    - 1700 deg^2 (wide), 20 deg^2 (deep), 4 filters (Y, J, H, F) for wide and deep fields and grism spectroscopy
  - **High Latitude Time Domain Survey**
    - 19 deg^2, (wide), 4.2 deg^2 (deep), 4 filters (R, Z, Y, J – wide) /(Z, Y, J, H – deep), 5 day cadence, and prism spectroscopy.

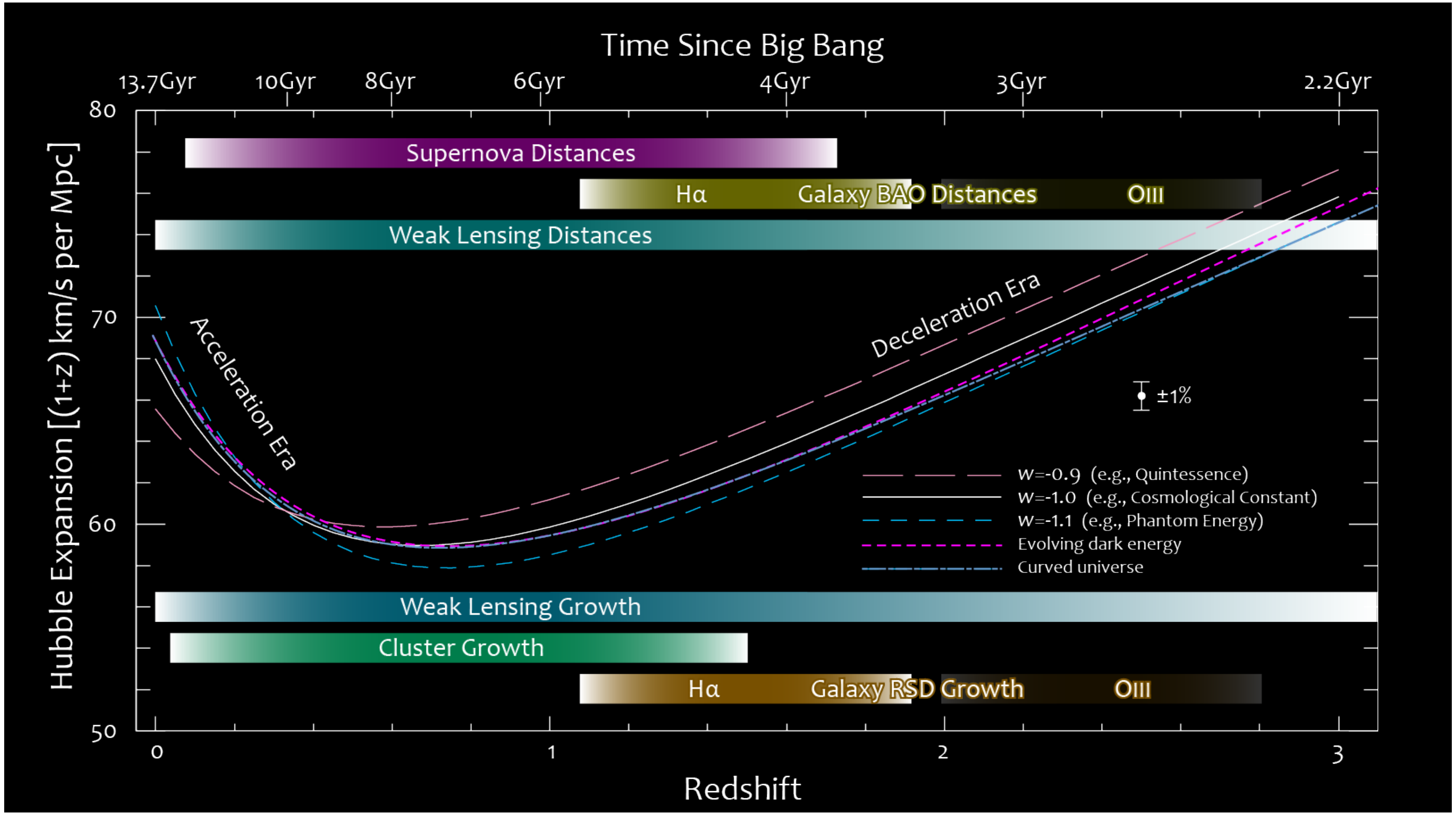
  – **Galactic Time Domain Survey**
    - 2 deg^2, 15 min cadence with W filter, 12 hour cadence for R or Z and Y or J for 60 – 72 day seasons; 6 seasons

Core Community Survey Definition

- **Goals:**
  - Provide observations needed to enable mission science objectives in cosmology and exoplanet demographics
  - Maximize science return
  - Ensure breadth of science and community across all surveys
  - Maximize community engagement and input in definition of surveys
  - Establish a transparent process
  - Ensure final survey definition recommendations made by a body and process the community perceives as representative and balanced

We are developing the community process with our science centers (who lead the implementation) and will review plans with our advisory committees. What's presented here is not a final plan for review, but an outline of the kind of things we have in mind to guide discussion.

Roman Dark Energy Cosmology Program



High-Latitude Imaging/Spectroscopy Surveys

- Both wide (>1700 deg^2) and deep (20 deg^2) surveys
- Multiwavelength Imaging - **Weak lensing measurements of hundreds of millions of galaxies**
- Spectroscopy (grism) - **Redshifts of tens-of-millions of galaxies**

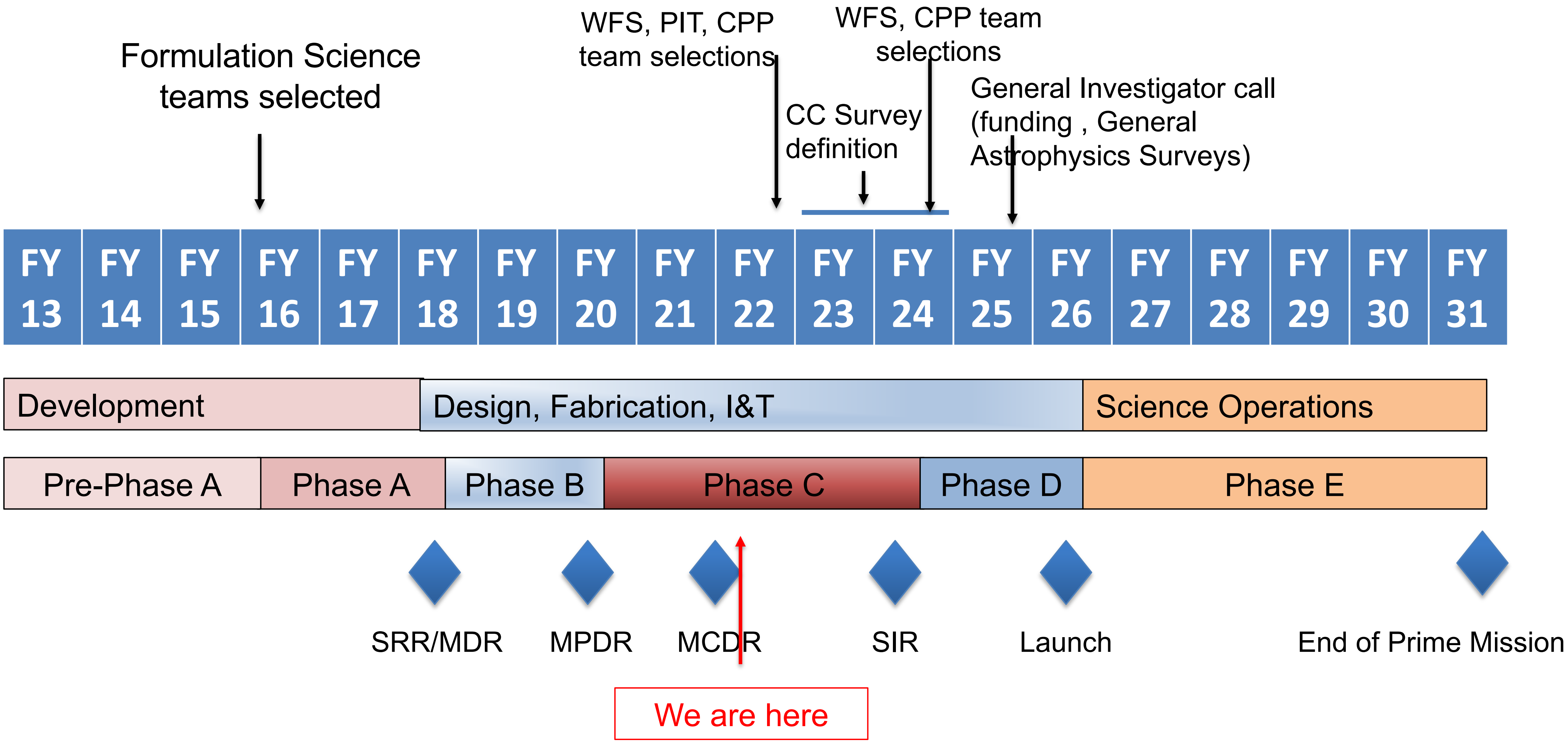
High-Latitude Time-Domain Survey

- **Light curves for many thousands of supernovae**, a **subset with prism spectra**
- Both wide (19 deg^2) and deep surveys (5 deg^2), 5 day cadence

Cosmology program observations drive key requirements:
Angular resolution, near-IR sensitivity, photometric precision, wave front error and PSF stability

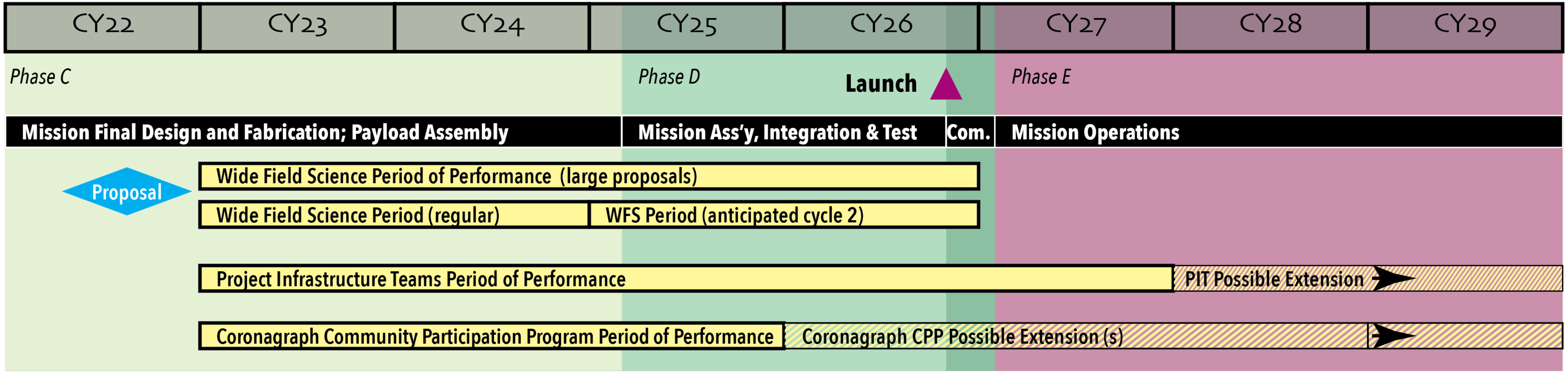
[Dore et al. 2019](#)

Timeline



Formulation Science teams selected
WFS, PIT, CPP team selections
WFS, CPP team selections
CC Survey definition
General Investigator call (funding , General Astrophysics Surveys)
FY 13
FY 14
FY 15
FY 16
FY 17
FY 18
FY 19
FY 20
FY 21
FY 22
FY 23
FY 24
FY 25
FY 26
FY 27
FY 28
FY 29
FY 30
FY 31
Development
Design, Fabrication, I&T
Science Operations
Pre-Phase A
Phase A
Phase B
Phase C
Phase D
Phase E
SRR/MDR
MPDR
MCDR
SIR
Launch
End of Prime Mission
We are here

Backup



CY22
CY23
CY24
CY25
CY26
CY27
CY28
CY29
Phase C
Phase D
Launch
Phase E
Mission Final Design and Fabrication; Payload Assembly
Mission Ass'y, Integration & Test
Com.
Mission Operations
Proposal
Wide Field Science Period of Performance (large proposals)
Wide Field Science Period (regular)
WFS Period (anticipated cycle 2)
Project Infrastructure Teams Period of Performance
PIT Possible Extension
Coronagraph Community Participation Program Period of Performance
Coronagraph CPP Possible Extension (s)

Wide Field Instrument Calibration Approach

- **Calibrations that can be done in flight will be done in flight**
- **Calibrations that must be done on ground, or best done on the ground:**
  - Filter bandpass as function of field angle
- **Calibrations that will be baselined on the ground and updated in flight**
  - Detector darks, flats, gain, count-dependent non-linearity, count rate-dependent non-linearity (CRNL), inter-pixel capacitance (IPC), persistence, brighter-fatter effect (BFE), sub-pixel response
  - Throughput (element-by-element)
  - Dispersion for grism, prism
- **Calibrations involving dedicated in-flight measurements**
  - All detector calibrations repeated
    - Frequency varies w/need
    - Relative Calibration System provides stimulus (flats etc) for most items
  - Absolute flux calibration as function of wavelength
    - Standard stars
  - Optical distortions
    - Gaia catalog, “standard fields”
  - Grism, prism dispersion
    - Stars, compact planetary nebulae
  - Stability monitoring, for sensitivity, optical distortions, wavelength calibration

Wide Field Instrument Calibration Approach – cont.

- **Many calibrations will be incorporated into the survey designs (as opposed to requiring dedicated observations)**
- **Flux calibration uniformity**
  - Design surveys so that each region of sky is observed in different parts of focal plane & at different roll angles
    - Can then solve for instrument response & sky signal (“Ubercal” – used w/ SDSS & Pan-STARRS)
- **PSF**
  - Fit stellar PSFs in all images
  - Can update detector Inter-pixel Capacitance, Brighter-fatter effect, persistence
  - Galactic Bulge and high-latitude time-domain surveys will enable regular updates to Count-rate non-linearity & sub-pixel response
- **Optical distortions**
  - Update on ongoing basis w/Gaia stars

Focal Plane System Characterization

- **Focal Plane System characterization at the level of individual detectors is largely complete, apart from the last few SCAs arriving from Teledyne. 25 flight qualified detectors now in hand.**
  - Completed: gain, dark current, CDS and total noise, QE, flat-field, integrated signal non-linearity, count-rate-dependent non-linearity, persistence, inter-pixel capacitance, charge diffusion, guide window performance, reference pixel performance, trailing pixel cross-talk
  - Partially completed or about to start: intra-pixel response, out-of-band rejection, photometric stability, bias-voltage vs. temperature, modulation transfer function, output-to-output cross-talk
  - Flight qualified detectors are being prioritized for inclusion in the flight focal plane
- **Additional characterization tests are performed on non-flight SCAs to understand long term effects of testing, storage, and in-flight environment and operations**
  - Accelerated lifetime tests, radiation testing, long term room temperature tests
- **Characterization to be performed on entire Focal Plane System with entire flight signal chain:**
  - Gain, dark current, CDS and total noise, integrated signal non-linearity, guide window performance, SCA-to-SCA cross-talk, photometric stability, many electrical performance tests
  - These tests included in the full Focal Plane System ETU Thermal Vacuum testing campaign this summer along with vibration and EMI tests
- **Filter, prism, grism performance characterized in detail prior to integration in the instrument**
- **Characterization to be performed at full instrument level:**
  - Focal plane tests: total noise, instrument background, out-of-band response, persistence, gain, integrated-signal non-linearity, flat-fields vs. wavelength (broad-band and narrow-band illumination),
  - Optical tests (all with f/7.9 beam over full range of field angles): Filter bandpasses, wavefront error, confocality over operating temperature, stray light rejection, prism/grism dispersion and throughput, field-of-view alignment, guide star acquisition, ghost limits
  - RCS self-calibration tests, stability, flat-field uniformity

Wide Field Science Proposals

- ***Preparing for and enhancing* Roman *WFI Science***
  – Can include, but are not limited to, any combination of the following topics:
    - Precursor observations using ground- and/or space-based observatories to prepare for future *Roman* science observations and/or to provide calibration capability;
    - Development of *Roman* analysis software beyond that provided by the Science Centers. This could include topics like machine learning techniques in time domain astrophysics, high precision astrometric measurement techniques, etc.;
    - Development of algorithms for joint processing with data from other space- or ground-based observatories such as deblending algorithms, photometric redshift training and calibration, or forced photometry;
    - Theoretical and/or phenomenological modeling directly related to Roman capabilities;
    - Instrument calibration and characterization;
    - Development of survey strategies;
    - Development of simulation tools, producing simulated datasets, and conducting or participating in data challenges.
- ***Supporting the* Roman *project and Science Centers***
  – WFS supported teams are expected to form part of the funded Roman science community providing support and guidance to the Roman project and science centers.