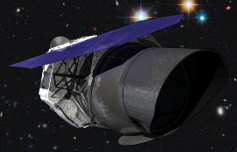
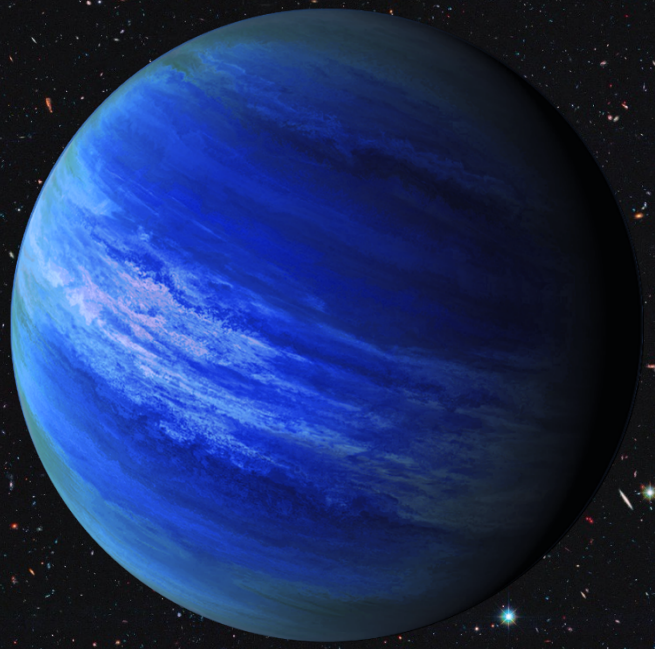


WFIRST CGI Status and PDR Preparation

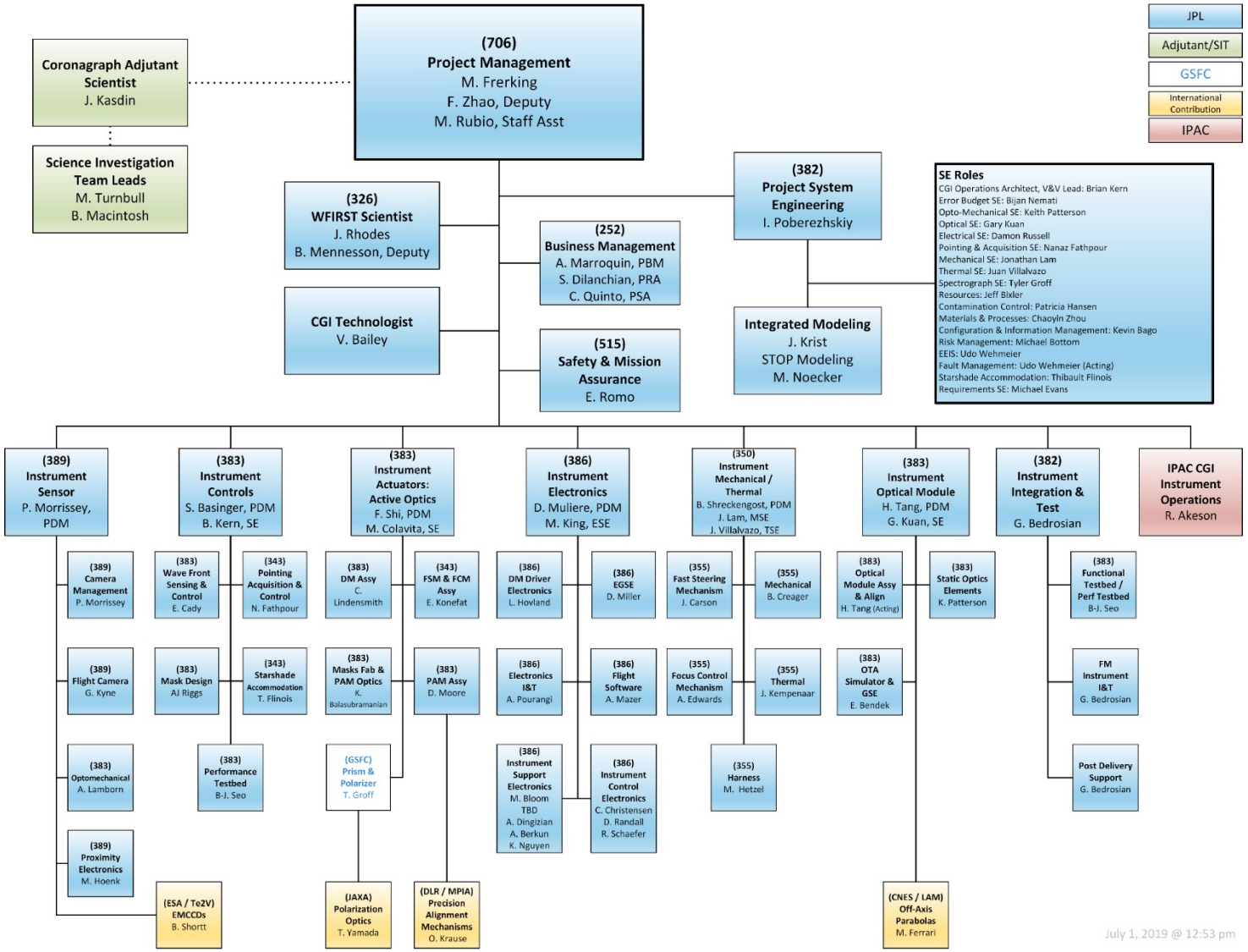
Peg Frerking

WFIRST FSWG 9

Jul 31 - 1 Aug 2019

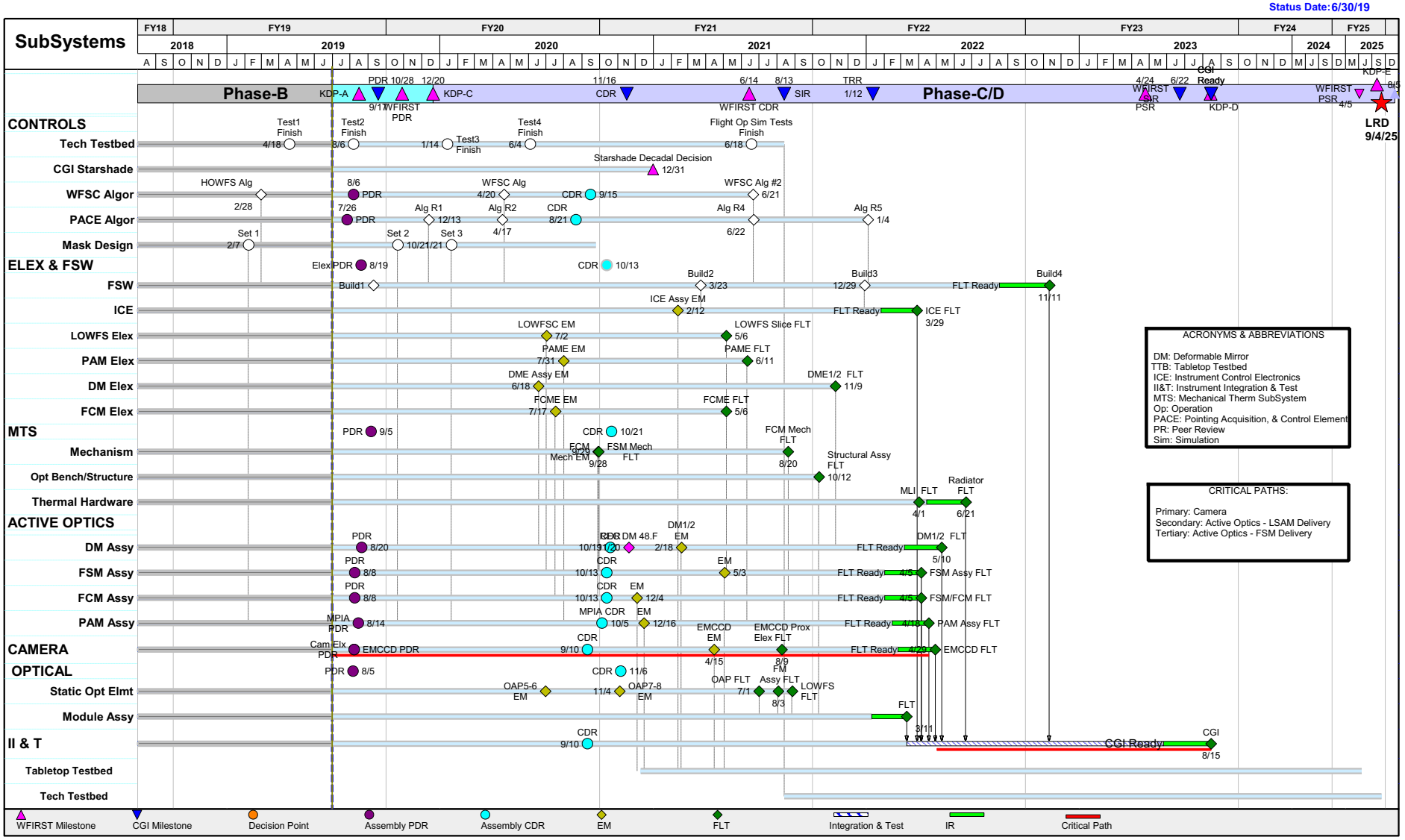


CGI Phase B/C/D Organization Chart



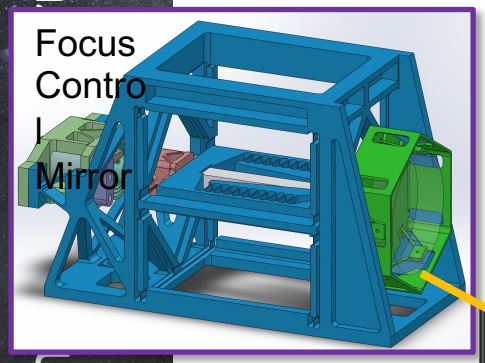
July 1, 2019 @ 12:53 pm

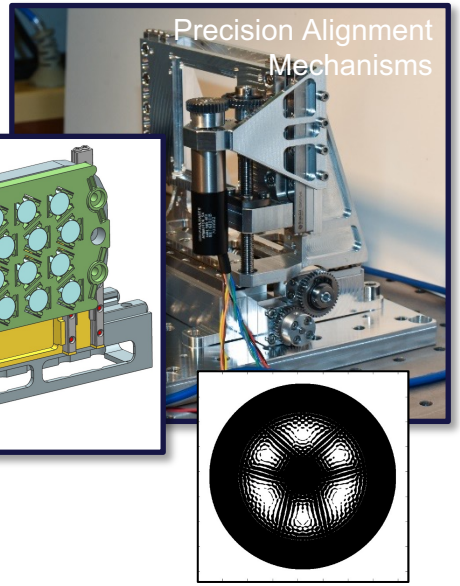
CGI Tier 1

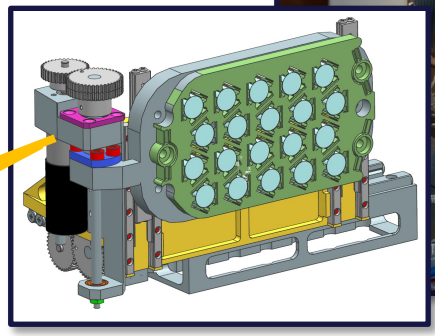

Status Date: 6/30/19
SubSystems
FY18
FY19
FY20
FY21
FY22
FY23
FY24
FY25
2018
2019
2020
2021
2022
2023
2024
2025
Phase-B
KDP-A
PDR 10/28
12/20
KDP-C
11/16
CDR
6/14
8/13
SIR
TRR
1/12
Phase-C/D
4/24
WFIRST SIR
6/22
CGI Ready
KDP-D
WFIRST PSR
4/5
KDP-E
8/5
LRD
9/4/25
9/11
WFIRST PDR
WFIRST CDR
CONTROLS
Tech Testbed
Test1 Finish 4/18
Test2 Finish 8/6
Test3 Finish 1/14
Test4 Finish 6/4
Flight Op Sim Tests Finish 6/18
CGI Starshade
Starshade Decadal Decision 12/31
WFSC Algor
HOWFS Alg 2/28
8/6 PDR
WFSC Alg 4/20
CDR 9/15
WFSC Alg #2 6/21
PACE Algor
7/26 PDR
Alg R1 12/13
Alg R2 4/17
CDR 8/21
Alg R4 6/22
Alg R5 1/4
Mask Design
Set 1 2/7
Set 2 10/21/21
Set 3
ELEX & FSW
Elex PDR 8/19
CDR 10/13
FSW
Build1
Build2 3/23
Build3 12/29
FLT Ready
Build4 11/11
ICE
ICE Assy EM 2/12
FLT Ready
ICE FLT 3/29
LOWFS Elex
LOWFSC EM 7/2
LOWFS Slice FLT 5/6
PAM Elex
PAME EM 7/31
PAME FLT 6/11
DM Elex
DME Assy EM 6/18
DME1/2 FLT 11/9
FCM Elex
FCME EM 7/17
FCME FLT 5/6
MTS
PDR 9/5
CDR 10/21
Mechanism
FCM Mech EM 9/28
FSM Mech FLT 9/29
FCM Mech FLT 8/20
Structural Assy FLT 10/12
Opt Bench/Structure
Thermal Hardware
MLI FLT 4/1
Radiator FLT 6/21
ACTIVE OPTICS
DM Assy
PDR 8/20
CDR DM 48.F 10/19
DM1/2 EM 2/18
FLT Ready
DM1/2 FLT 5/10
FSM Assy
PDR 8/8
CDR 10/13
EM 5/3
FLT Ready 4/5
FSM Assy FLT
FCM Assy
PDR 8/8
CDR 10/13
EM 12/4
FLT Ready 4/5
FSM/FCM FLT
PAM Assy
MPIA PDR 8/14
MPIA CDR 10/5
EM 12/16
FLT Ready 4/15
PAM Assy FLT
CAMERA
Cam Elx PDR
EMCCD PDR
CDR 9/10
EMCCD EM 4/15
EMCCD Prox Elex FLT 8/9
FLT Ready 4/29
EMCCD FLT
OPTICAL
PDR 8/5
CDR 11/6
Static Opt Elmt
OAP5-6 EM
OAP7-8 EM 11/4
OAP FLT 7/1
Assy FLT 8/3
FM
LOWFS FLT
Module Assy
FLT
II & T
CDR 9/10
3/11
CGI Ready 8/15
CGI
Tabletop Testbed
Tech Testbed
ACRONYMS & ABBREVIATIONS
DM: Deformable Mirror
TTB: Tabletop Testbed
ICE: Instrument Control Electronics
II&T: Instrument Integration & Test
MTS: Mechanical Therm SubSystem
Op: Operation
PACE: Pointing Acquisition, & Control Element
PR: Peer Review
Sim: Simulation
CRITICAL PATHS:
Primary: Camera
Secondary: Active Optics - LSAM Delivery
Tertiary: Active Optics - FSM Delivery
WFIRST Milestone
CGI Milestone
Decision Point
Assembly PDR
Assembly CDR
EM
FLT
Integration & Test
IR
Critical Path

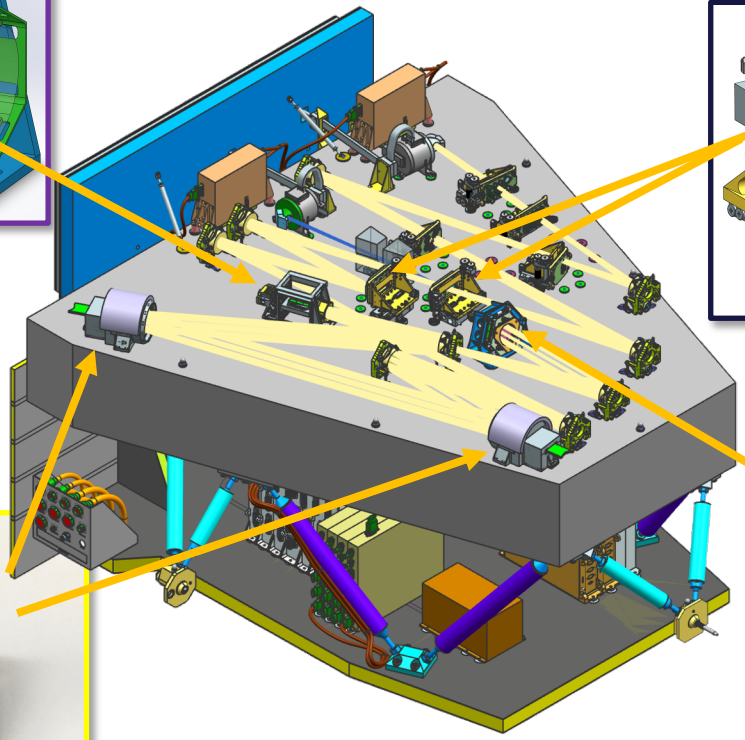
WFIRST Coronagraph Instrument Update

- Hardware configuration is maturing to PDR Readiness

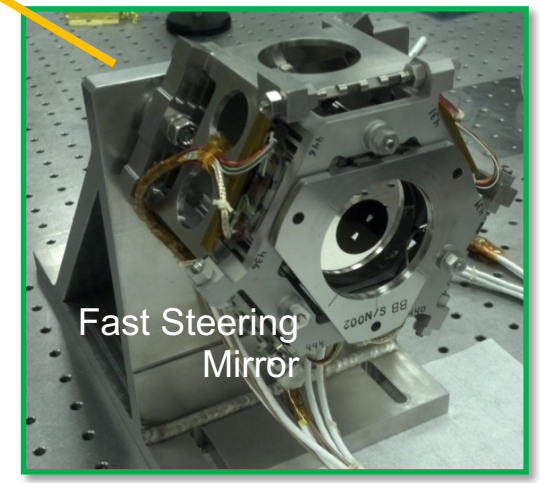








Coronagraph Instrument



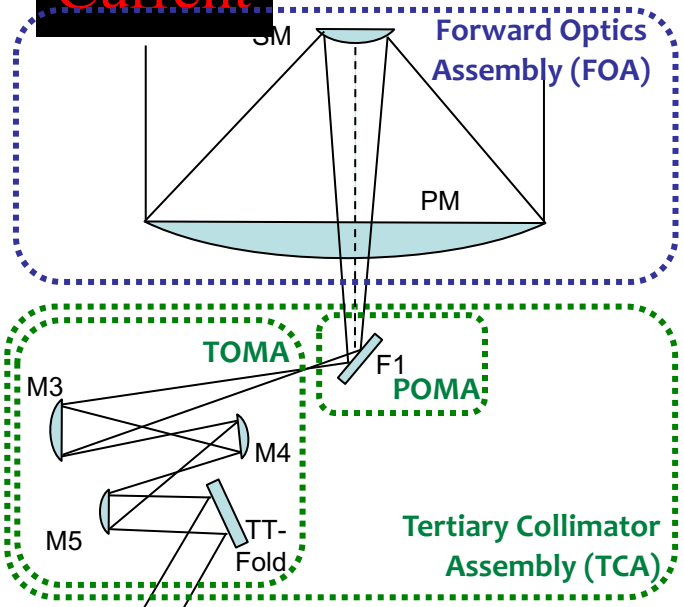
Challenges

- CGI is a design to cost Class C Technology Demonstration
- Cost, mass, and power were all above allocation
- Initiated a rescope/descope plan based on
  - Accept risk increase
    - Engineering models – one of each unique type rather than a full set
    - Maintain the Technology Testbed as-is with end-to-end optical performance capability in vacuum but lower fidelity
    - Add a "Table-Top" ambient testbed made up of engineering models for functional testing, software development, and operations support
  - Opportunity for cost reduction based on transfer of latches from WFIRST Instrument Carrier to CGI
    - Use of composite material on optical bench and struts to instrument carrier only; use Al for support of electronics and radiators
  - Replace Integral Field Spectrometer along with its camera and proximity electronics with a slit/prism that can be inserted in the optical chain for the direct imaging camera

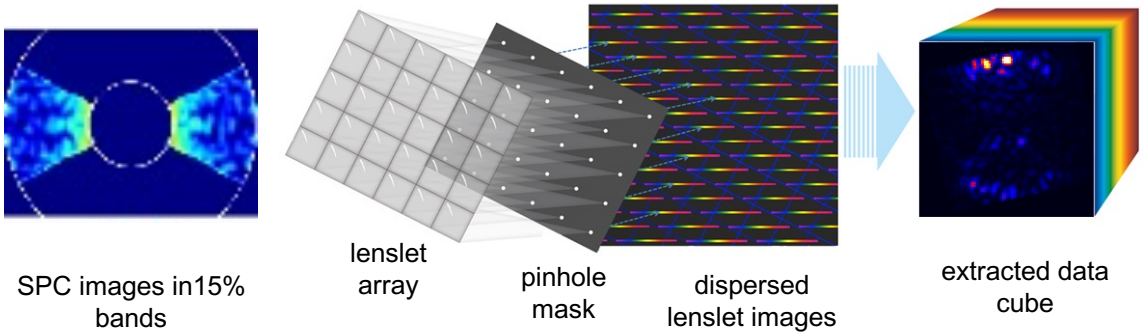
CGI Modes – Shaped Pupil Spectroscopy

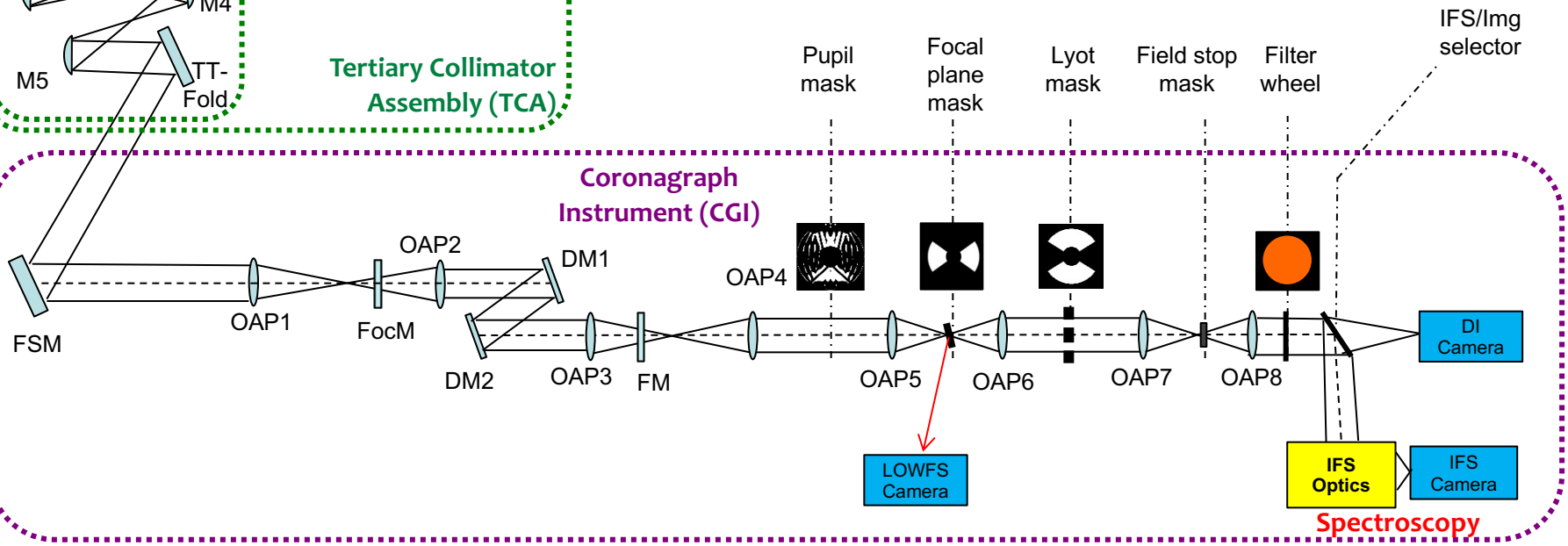
Shaped Pupil Spectroscopy Mode

Current



The IFS uses two 15% bands (Band #2 and Band #3) to produce R≥50 spectra from 600 to 900nm at IFSCAM



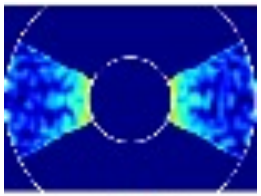


CGI Modes – Shaped Pupil Spectroscopy

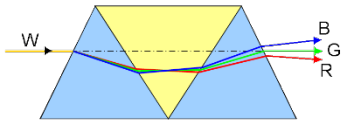
Proposed

Shaped Pupil Spectroscopy Mode

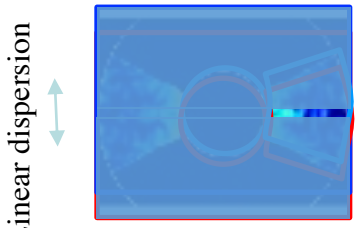
The Amici prisms disperse the 15% bands (Band #2 and Band #3) to produce R≥50 spectra from 600 to 900nm at DICAM



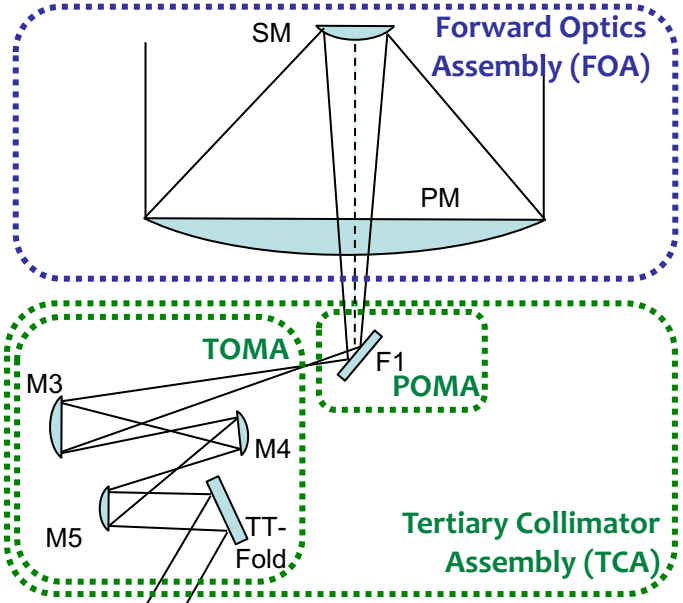
SPC images in 2 15% bands

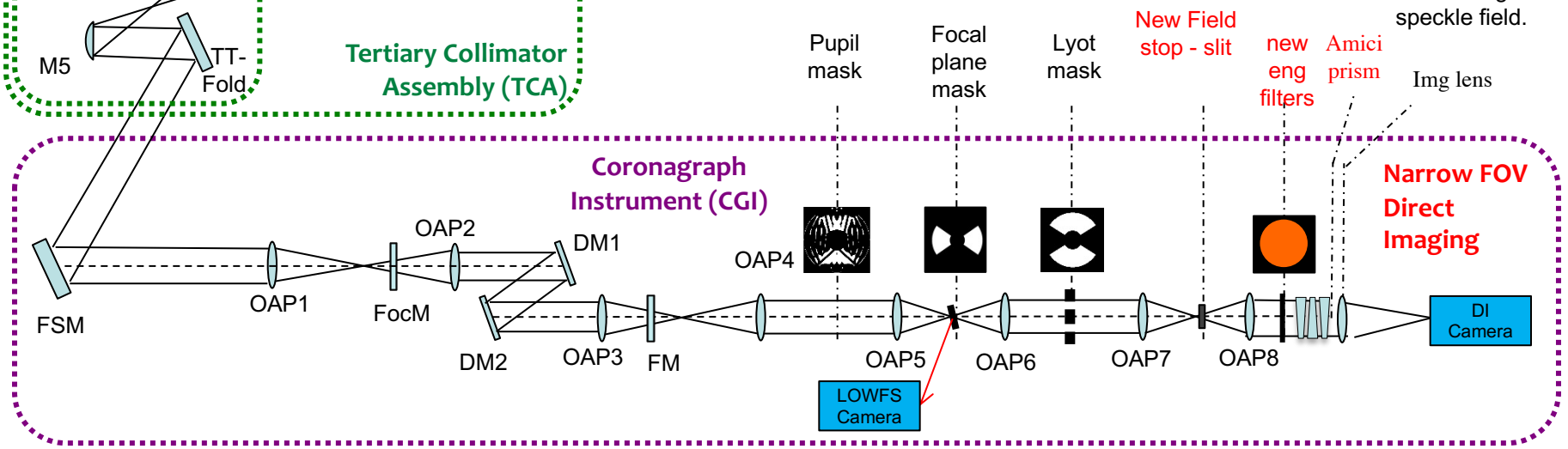


Amici prism



Spectrum to be extracted from dispersed images. Assume we also have the direct image and speckle field.





CGI Mask Populations: (from Feng Zhao)

WFIRST
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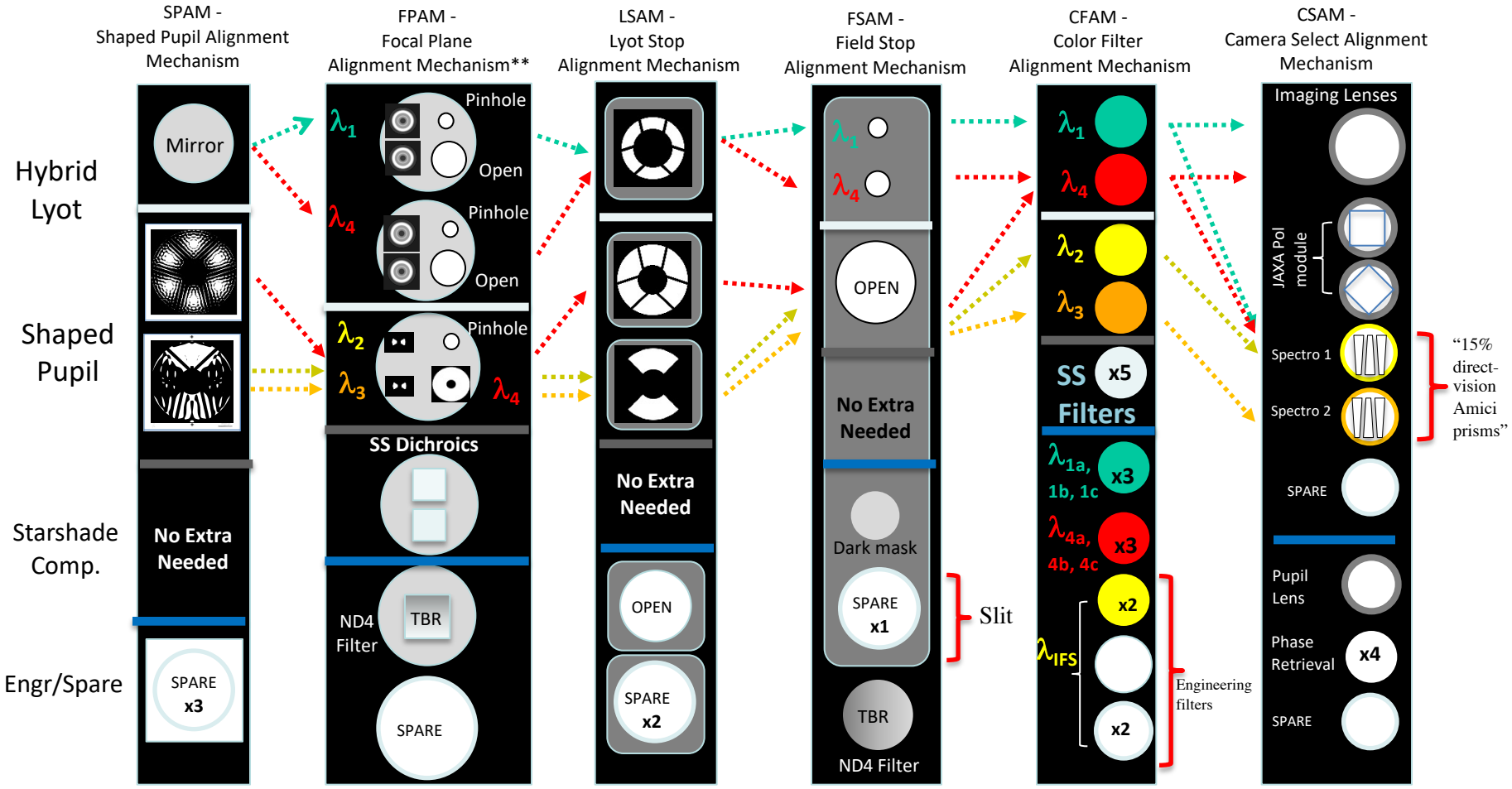
ASTROPHYSICS • DARK ENERGY • EXOPLANETS

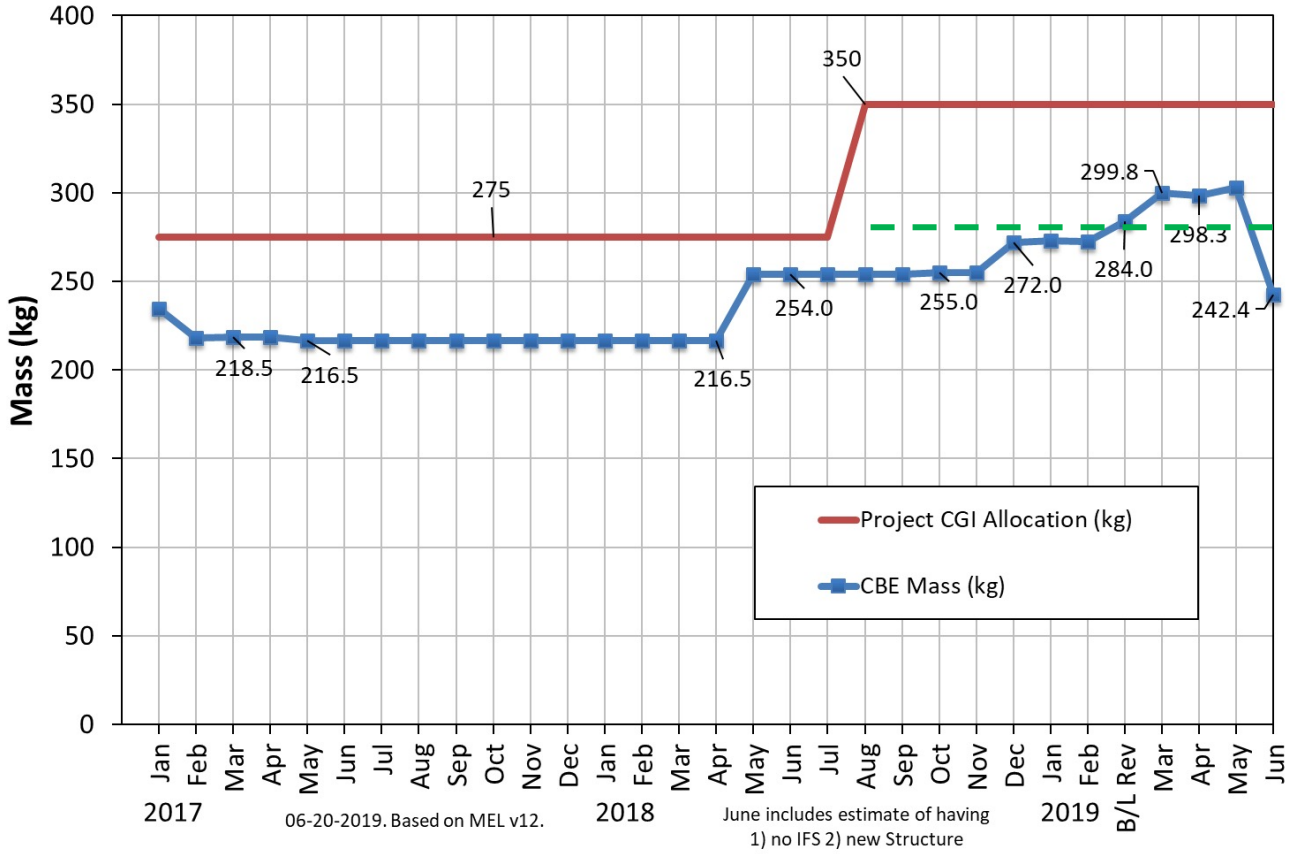


**Magnified for illustration. Each FPAM substrate can carry 7 masks or elements.

*Band submitted to CCB, not yet official

λ_1 = 575 nm, 10% *λ_2 = 660 nm, 15%
*λ_3 = 730 nm, 15% λ_4 = 825 nm, 10%

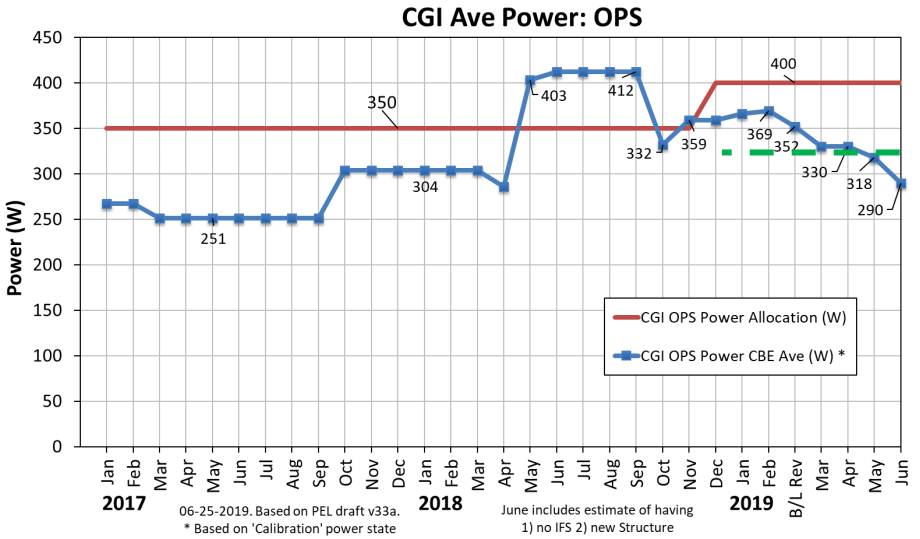
CGI Mass

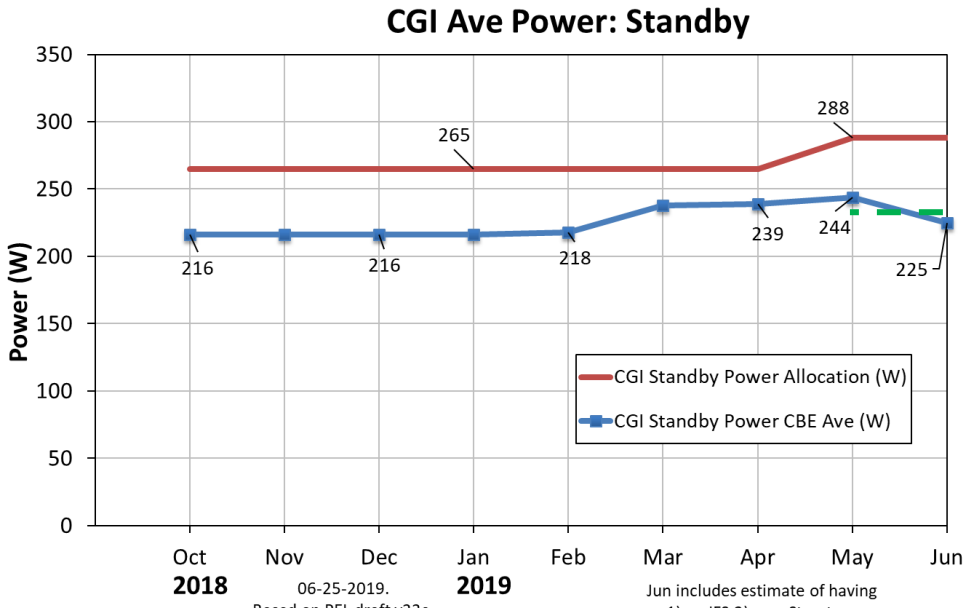


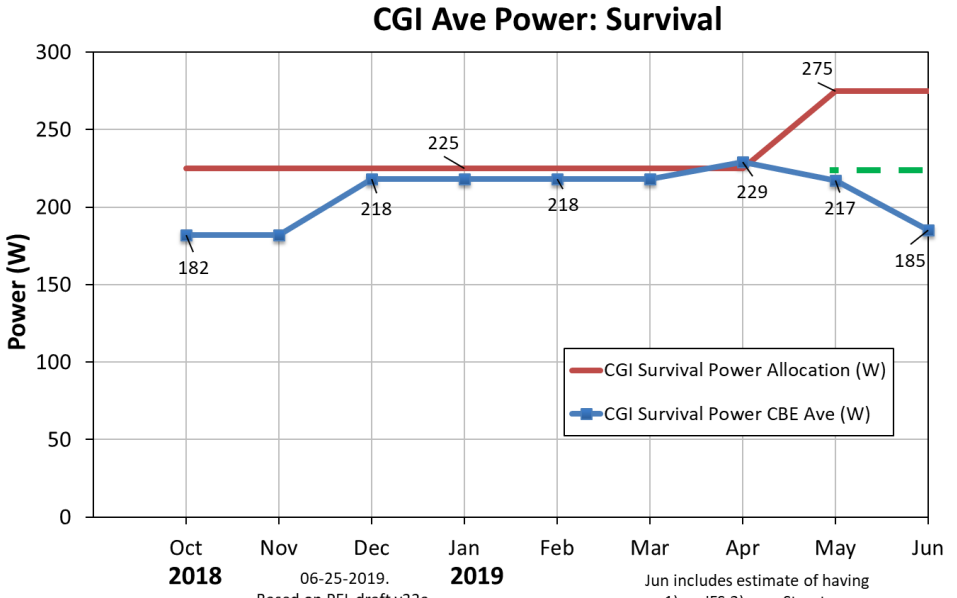
- 350 kg CGI mass allocation
- CBE goal at PDR: ≤ 280 kg (for 20% margin per JPL design principles, shown as green line)
- Preliminary estimate of CGI mass without IFS and with the new structure is 242 kg

CGI Power

- CGI power allocations: 400 W Ops, 288 W Standby, 275 W Survival
- CBE goals at PDR: ≤ 320 W Ops, ≤ 230.4W Standby, ≤ 220W Survival (for 20% margin per JPL design principles, shown as green lines)
- Preliminary estimates of CGI power without IFS and with the new structure are: 290 W Ops, 225 W Standby, 185 W Survival







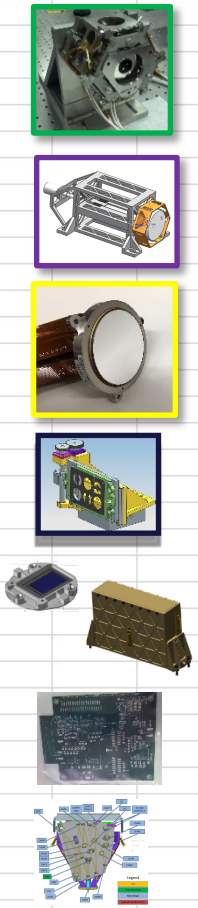
Engineering Model Plan

Coronagraph Instrument

WFIRST WIDE-FIELD INFRARED SURVEY TELESCOPE
ASTROPHYSICS • DARK ENERGY • EXOPLANETS

Current

Tech Testbed Use			
EM FSM modification	1x		
EM LOWFSC Elex	1x		
EM FSM Assembly and Test		1x	
EM FSM Environmental Test			1x
EM FocM	1x		
EM FocM Elex	1x		
EM FocM Assembly and Test		1x	
EM FocM Environmental Test			1x
EM DM	2x		
EM DM Elex	1x		
EM DM Assembly and Test		1x	
EM DM Environmental Test			1x
EM PAM(MPIA contribution)	6x		
EM PAM Elex	6x		
EM PAMAssembly and Test		6x	
EM PAM Environmental Test			6x
EM EMCCD (ESA contribution)	3x		
EM Camera Elex	3x		
EM Camera Assembly and Test		3x	
EM Camera Environmental Test			3x
EM ICE slices	all		
EM ICE Assembly and Test		1x	
EMICE Environmental Test			1x
ETB OTA Simulator			
ETB Bench			
EM IFS			
EM Bench static Optical Alignment			
Engineering Testbed Assembly			
Engineering Testbed Use			

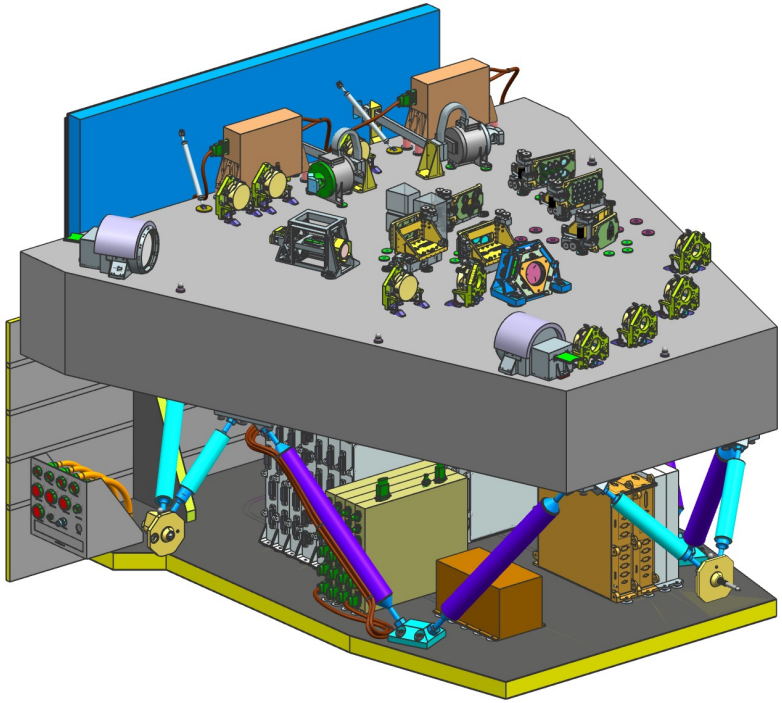


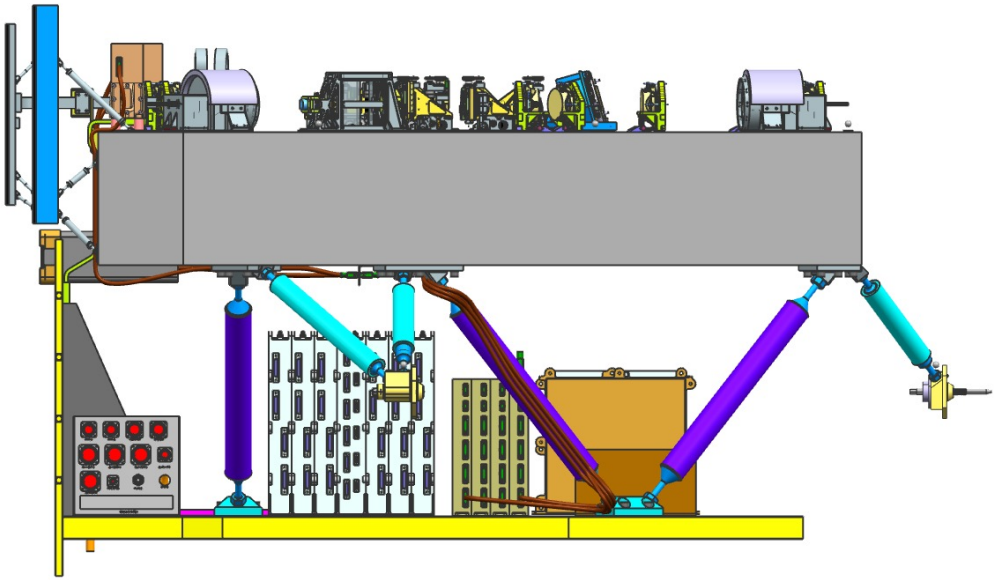
After Descopes

Tech Testbed Use					
EM FSM (use as is)	1x				
EM LOWFSC Elex	1x				
EM FSM Assembly and Test		1x			
EM FSM Environmental Test			none		
EM FocM	1x				
EM FocM Elex	1x				
EM FocM Assembly and Test		1x			
EM FocM Environmental Test			none		
EM DM	1x				
EM DM Elex	1x				
EM DM Assembly and Test		1x			
EM DM Environmental Test			none		
EM PAM(MPIA contribution)	6x				
EM PAM Elex	1x				
EM PAMAssembly and Test		1x			
EM PAM Environmental Test			none		
EM EMCCD (ESA contribution	3x				
EM Camera Elex	1x				
EM Camera Assembly and Test		1x			
EM Camera Environmental Test			none		
EM ICE slices	all				
EM ICE Assembly and Test		1x			
EMICE Environmental Test			none		
ETB OTA Simulator	none				
ETB Bench		none			
EM IFS		none			
EM Bench static Optical Alignment			none		
Engineering Testbed Assembly				none	
Engineering Testbed Use					none
Table Top Testbed					

Instrument Design

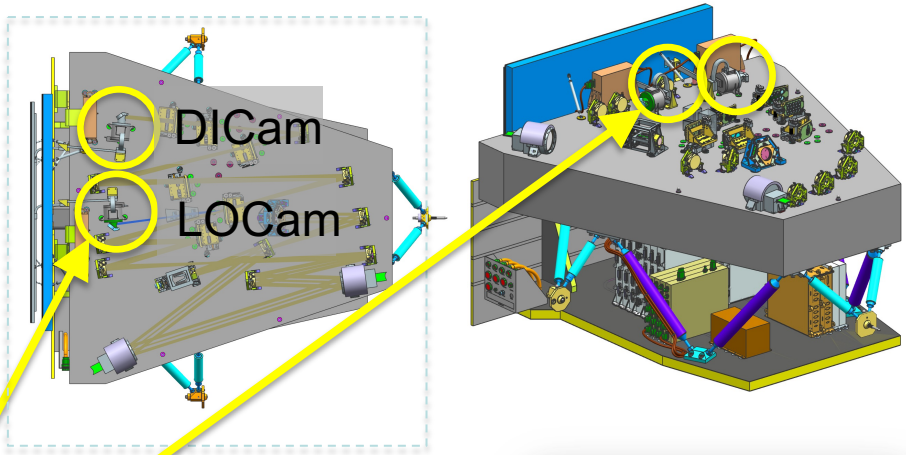
Bench to Instrument Carrier via 3x bipod sets
Electronics Thermal Pallet to Bench via 3x bipod sets



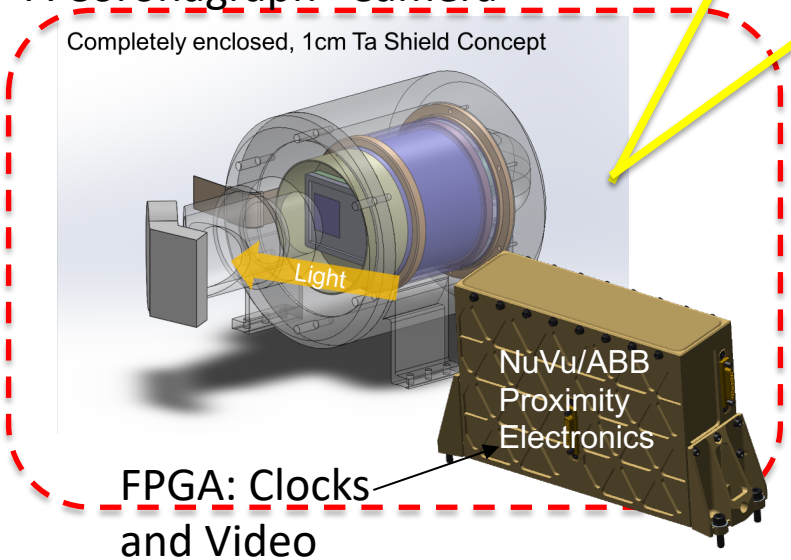


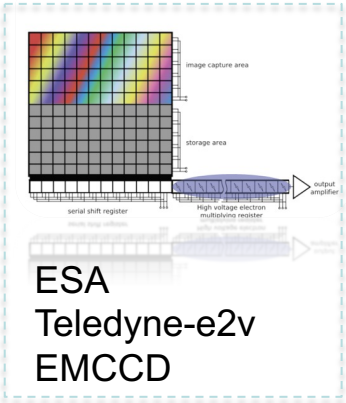
Camera Overview (from Patrick Morrissey)

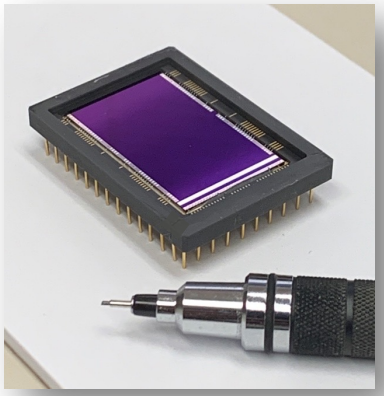
- There are **two flight cameras**
  - DICam (Imaging and Spectroscopy)
  - LOCam (Pointing and WF Control)
- Teledyne-e2v modified CCD201-20 **electron multiplying CCDs** (EMCCD) will be contributed by ESA
  - 1kx1k, 13µm pixel
- Identical **FPGA controllers** will be procured from ABB/NuVu Cameras, Canada



A Coronagraph "Camera"





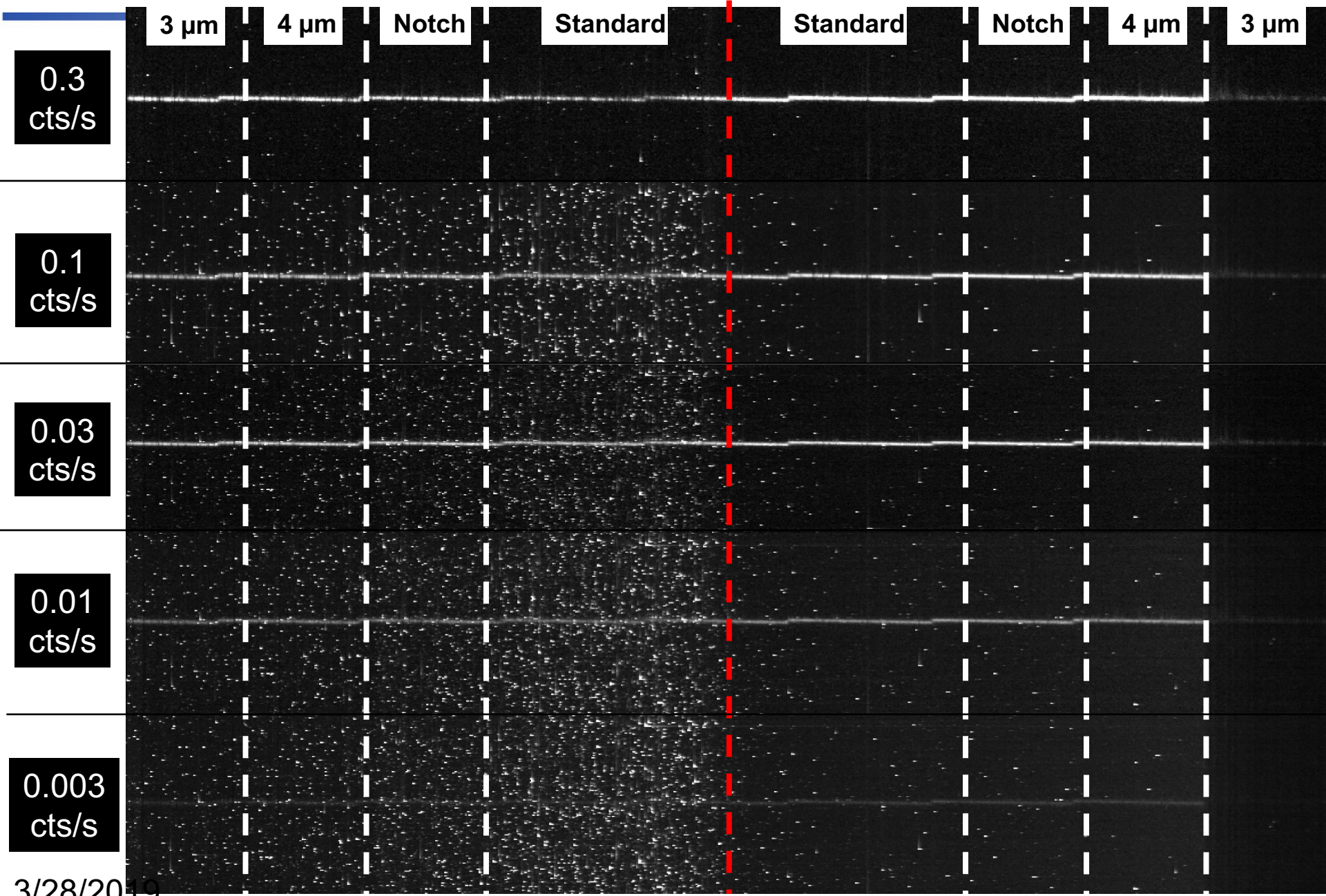


EMCCD Trade Study Status (from Patrick Morrissey)

- We successfully completed the EMCCD technology trade study in March.
- We determined that a single design will meet the requirements of both the science and wavefront sensor applications
  - We have chosen the following design features:
    - Operation in the "store" area to reduce vertical transfers
    - Selection of "notch" imaging pixel design because of its improved radiation tolerance and acceptable full well.
    - Incorporation of the gain register overspill to reduce the impact of cosmic ray tails on throughput
    - Use of the commercial amplifier design to provide optimum dark performance

- We find that the dQE of the notched channel EMCCD with overspill provides a factor of 1.5 improvement over the COTs EMCCD
  - ε_{CTE} improved by 20% for charge transfer associated with shallow traps (20% improvement in dQE)
  - $\varepsilon_{CosmicRays}$ improved by 12% due to 2x reduction in cosmic ray tails length
  - Data analysis still in work

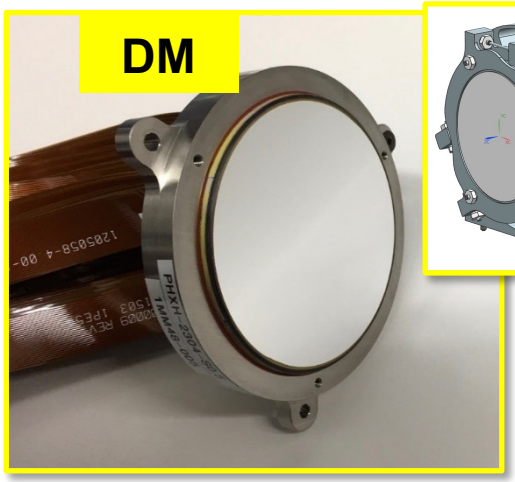
Type B device half irradiated/half undamaged (from Patrick Morrissey)

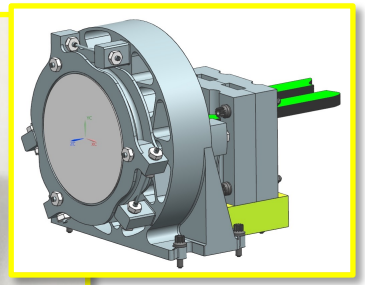


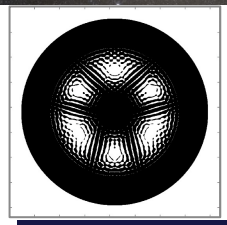
3/28/2019

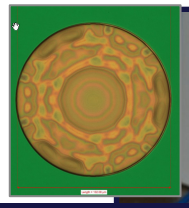
Active Optics Overview (from Fang Shi)

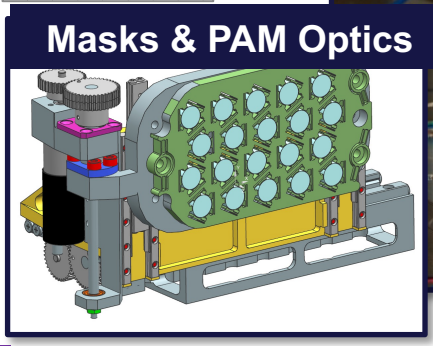
WFIRST
WIDE-FIELD INFRARED SURVEY TELESCOPE
ASTROPHYSICS • DARK ENERGY • EXOPLANETS

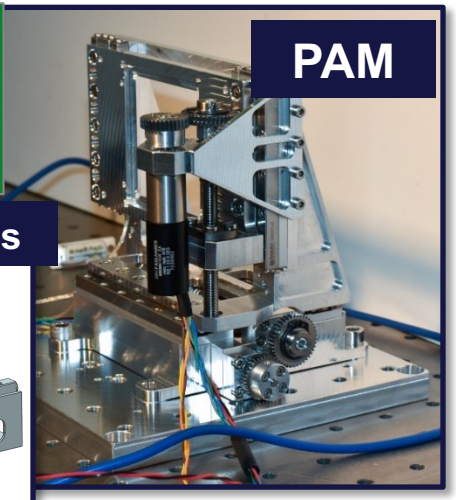


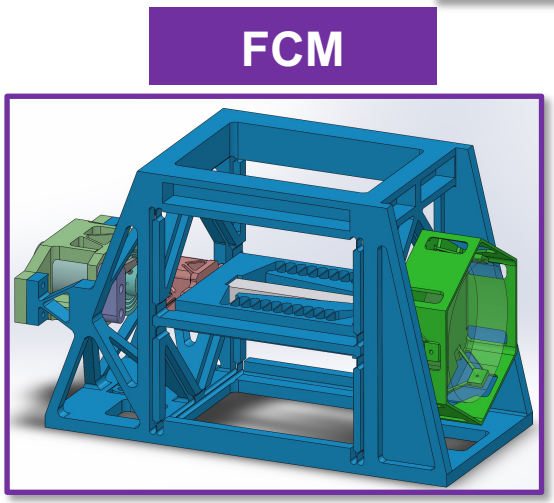


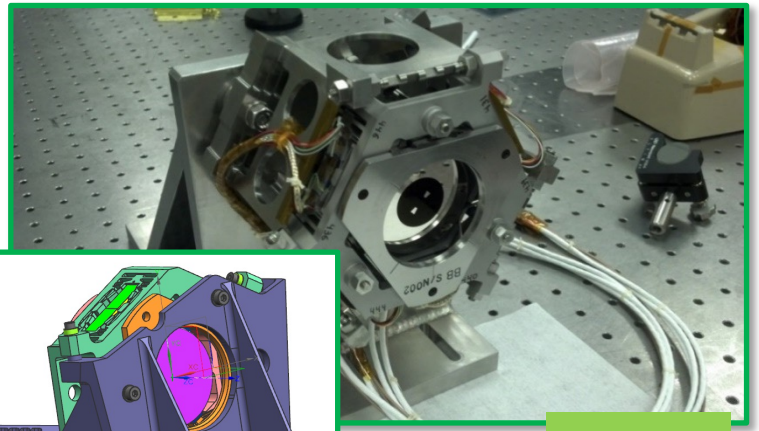








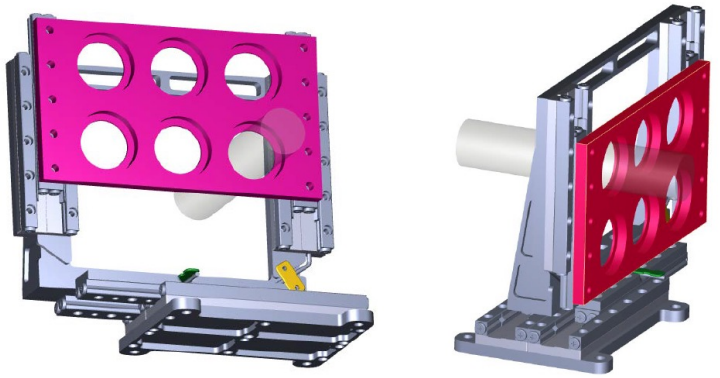


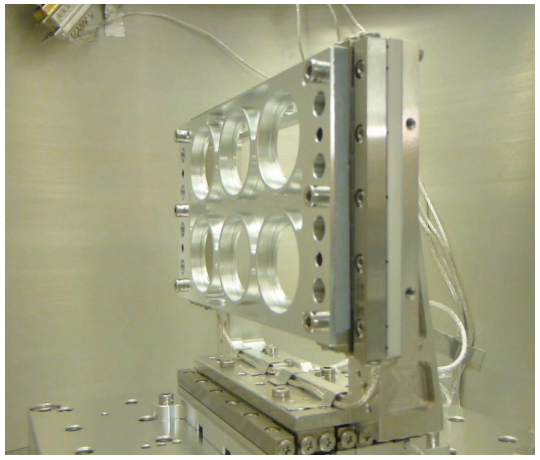


Precision Alignment Mechanism (PAM) Status Summary

- MPIA: prototype performance
  - Demonstrated sub-um position accuracy and 1-2 arc second pointing accuracy/repeatability
- JPL: accommodate with redesigned optical bench
  - Re-configured Optical prescription to better accommodate X/Y stages
  - Compact optics mounting scheme
  - Open slot in optical bench structure

MPIA Mechanism Prototype



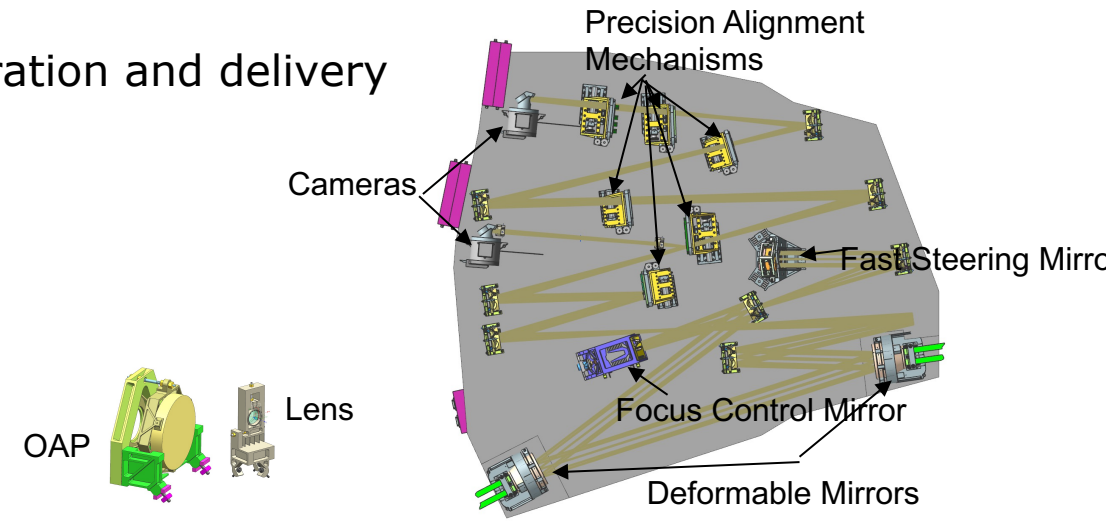


Picture of prototype XY-stage mechanism

Optical Module Overview (from Hong Tang)

Coronagraph Instrument

- Flight: Assemble and align Optical Module in air at room temp.
  - Major Receivables
    - Bench (with supporting structure) from MTS
    - OAPs from LAM (CNES)
- CGI Optical Beam Train
  - Design and Analysis
- Mounted Static Optics
  - Design, Analysis, Assembly, Testing and delivering mounted OAPs, FM and Surrogates for Active Optics
- OTA-Simulator
  - Design, build, calibration and delivery
- Alignment GSE
- OAPs (LAM)



MTS Overview (from Belinda Shreckengost)

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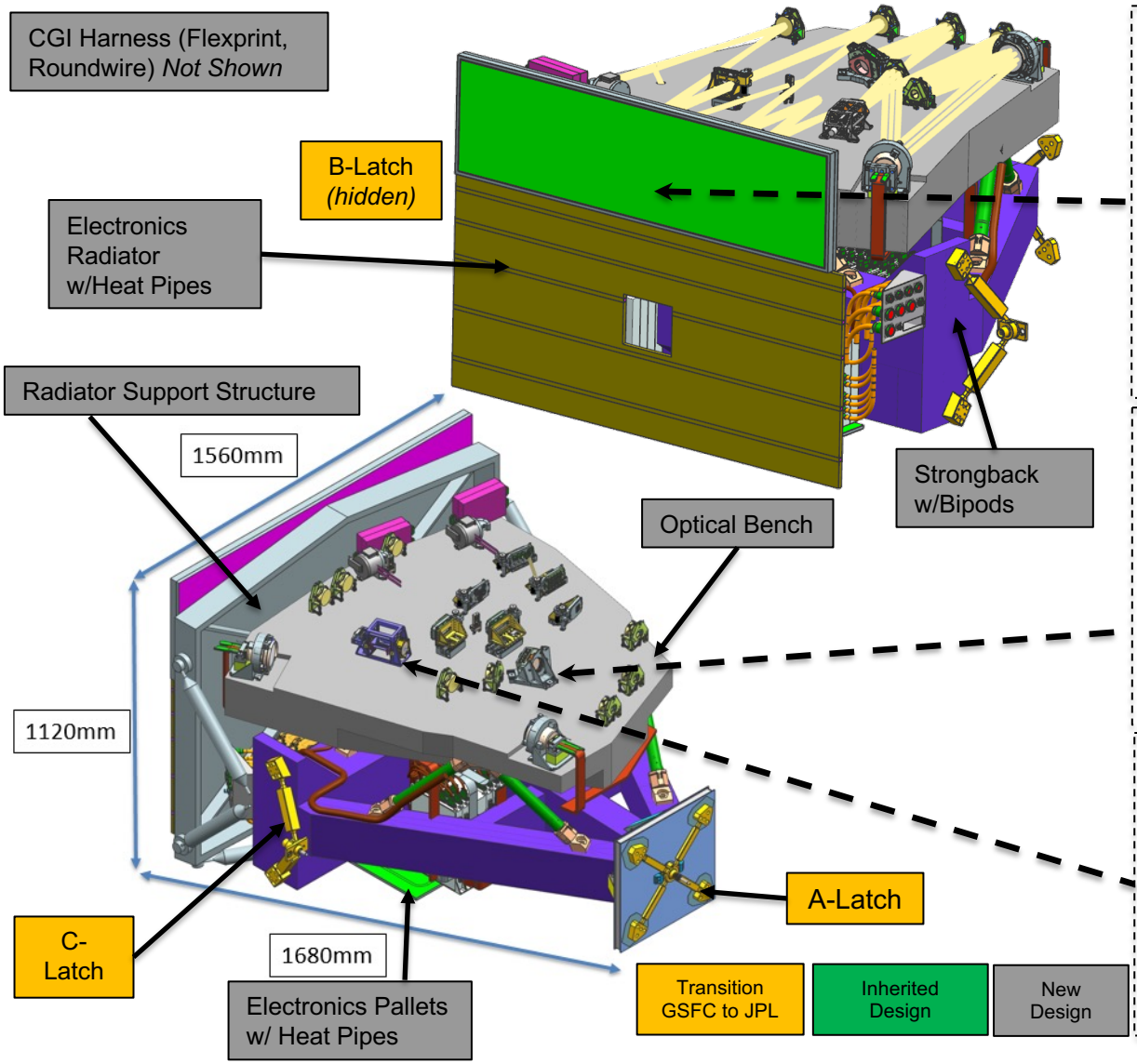

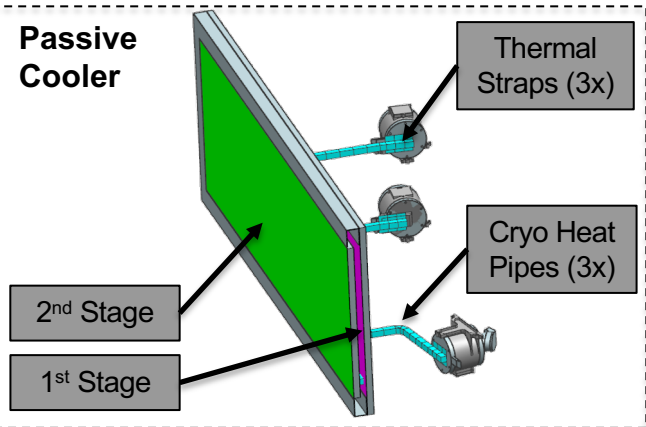

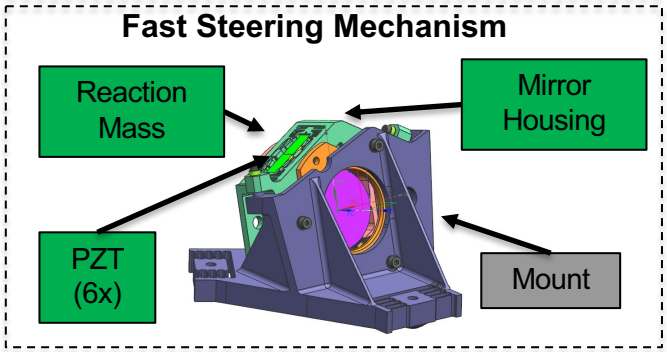

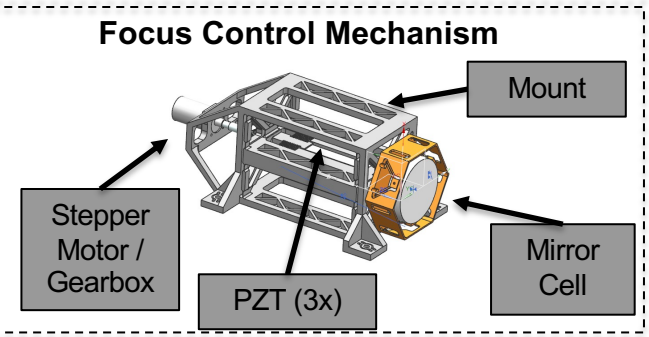

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Electronics Block Diagram (from Dave Moliere)