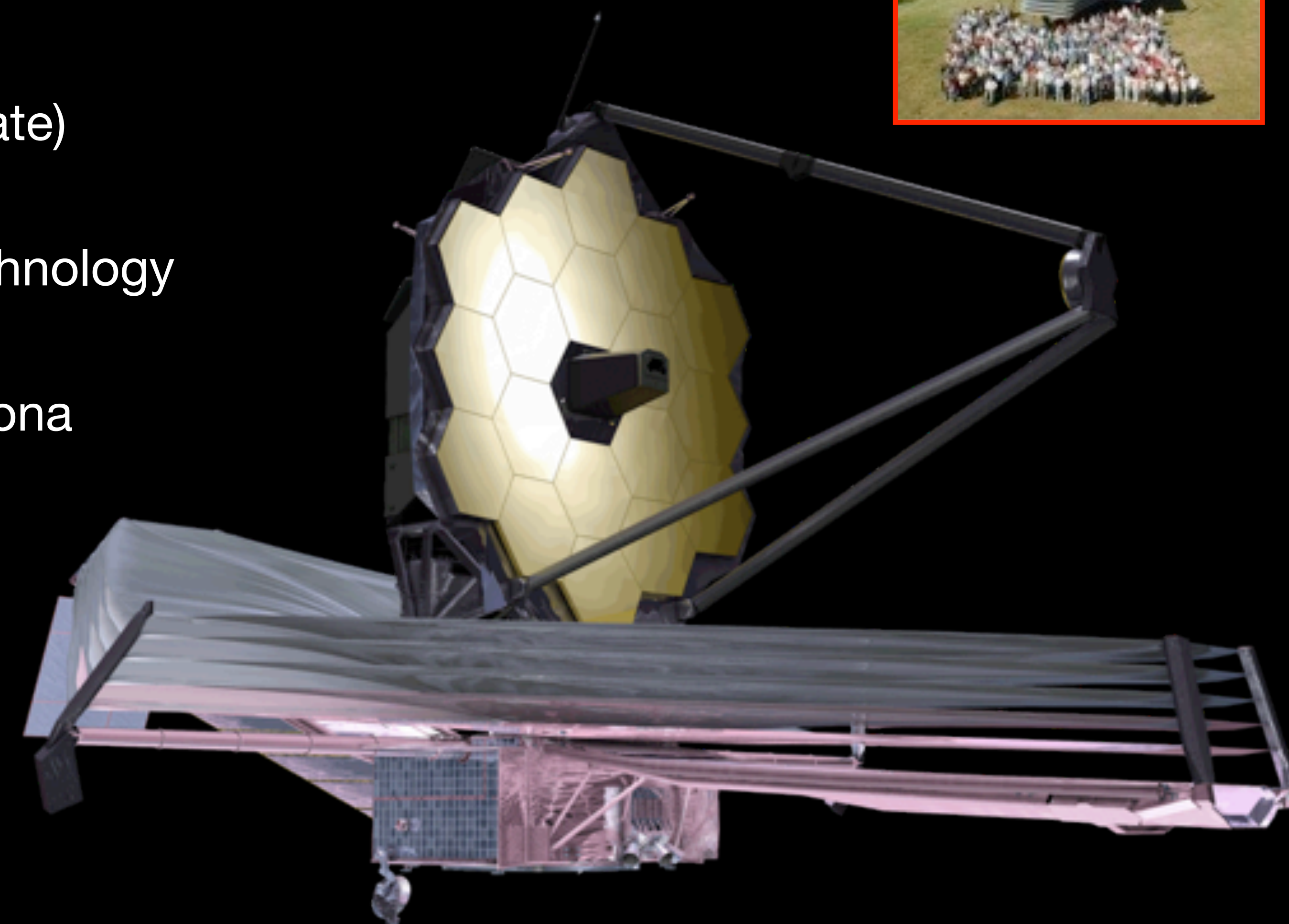
Overview of JWST

ELIXIR
Mark Clampin
JWST Observatory Project Scientist
Goddard Space Flight Center

James Webb Space Telescope



Organization

- **Mission Lead:** Goddard Space Flight Center
- Project Scientist: Dr John Mather (Nobel Laureate)
- **International collaboration:** ESA & CSA
- **Prime Contractor:** Northrop Grumman Space Technology
- **Instruments:**
- Near Infrared Camera (NIRCam) – Univ. of Arizona
- Near Infrared Spectrograph (NIRSpec) – ESA
- Mid-Infrared Instrument (MIRI) – JPL/ESA
- Fine Guidance Sensor (FGS) – CSA
- **Operations:** Space Telescope Science Institute

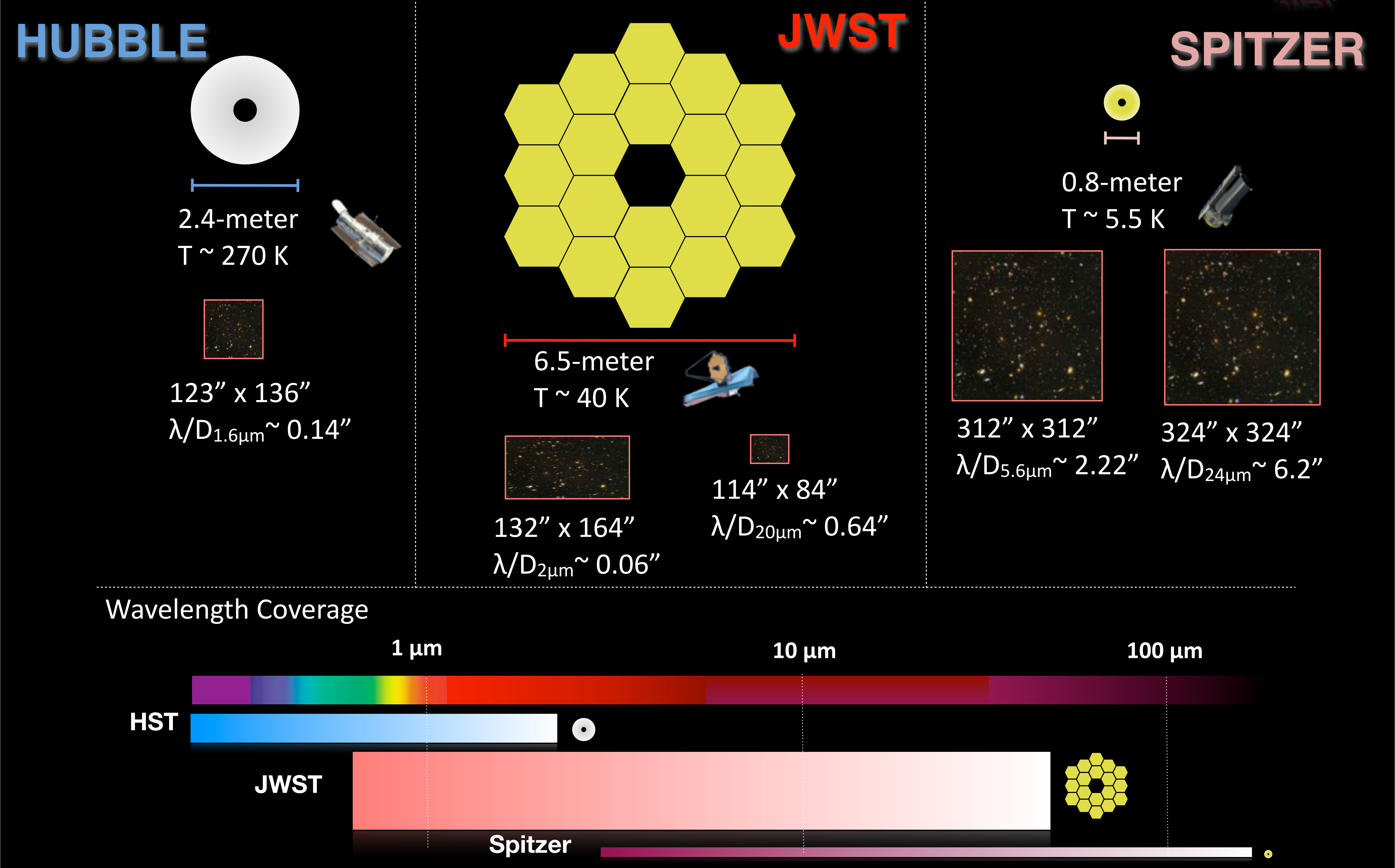
Description

- Deployable infrared telescope with 6.5 meter diameter segmented adjustable primary mirror
- Cryogenic temperature telescope and instruments for infrared performance
- Launch June 2013 on an ESA-supplied Ariane 5 rocket to Sun-Earth L2
- 5-year science mission (10-year goal)

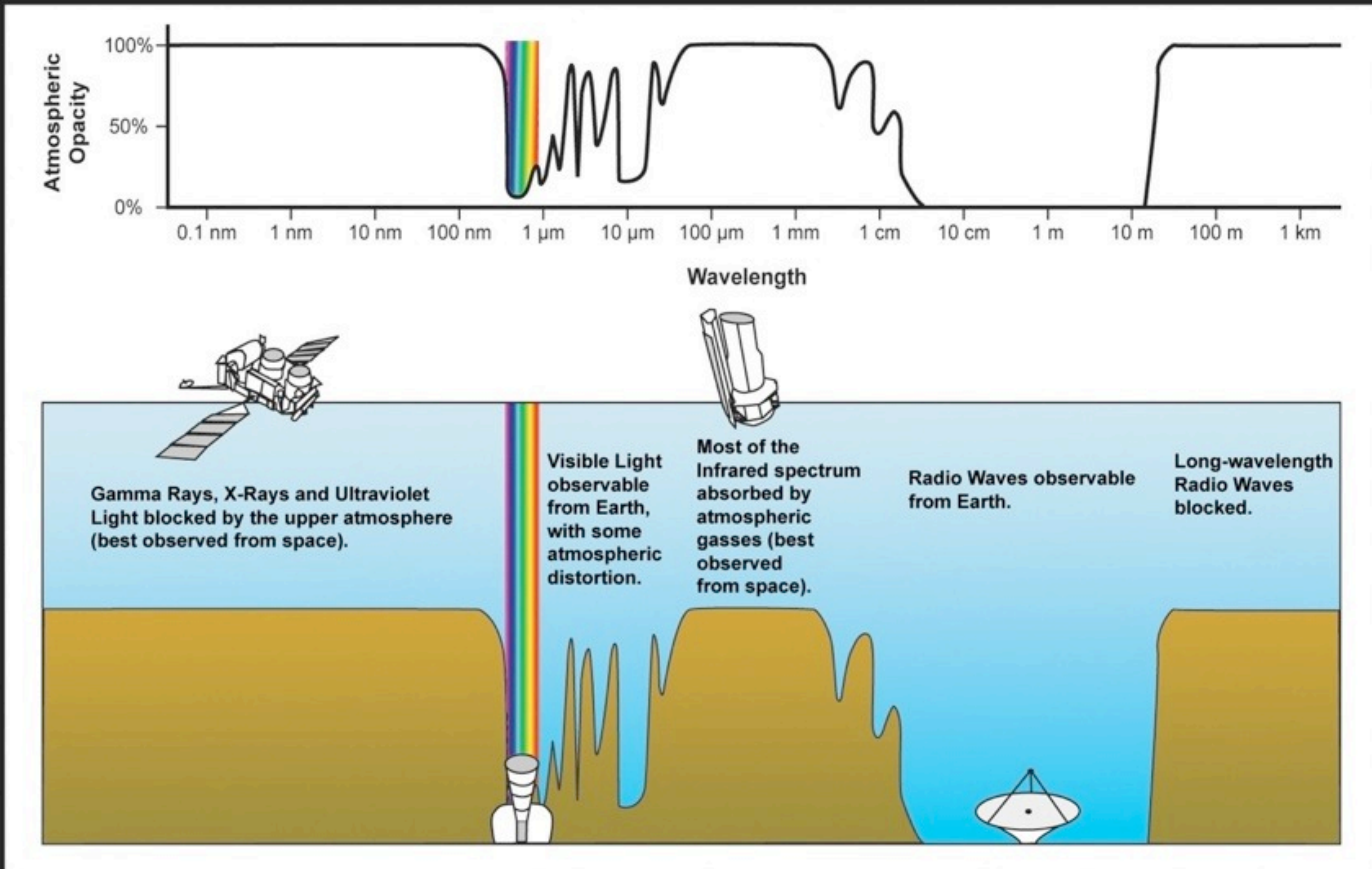
First Things First !

- **Who was James Webb? : NASA Administrator 1961 - 1968**
  - ➡ **Presided over much of the Apollo Program**
  - ➡ **Initiated Space program at NASA: 75 space science missions flew during his tenure**

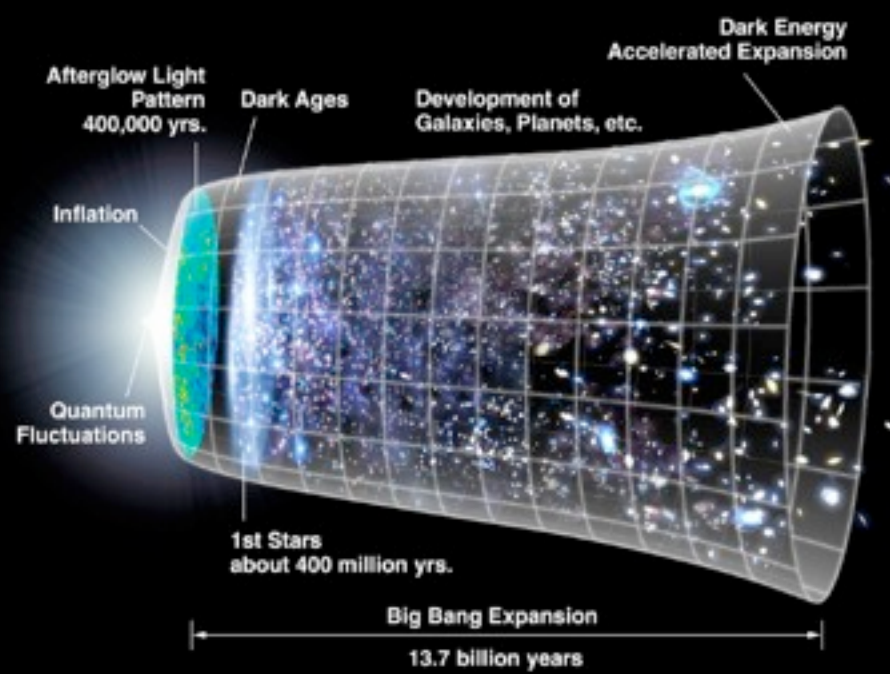
JWST and its Precursors



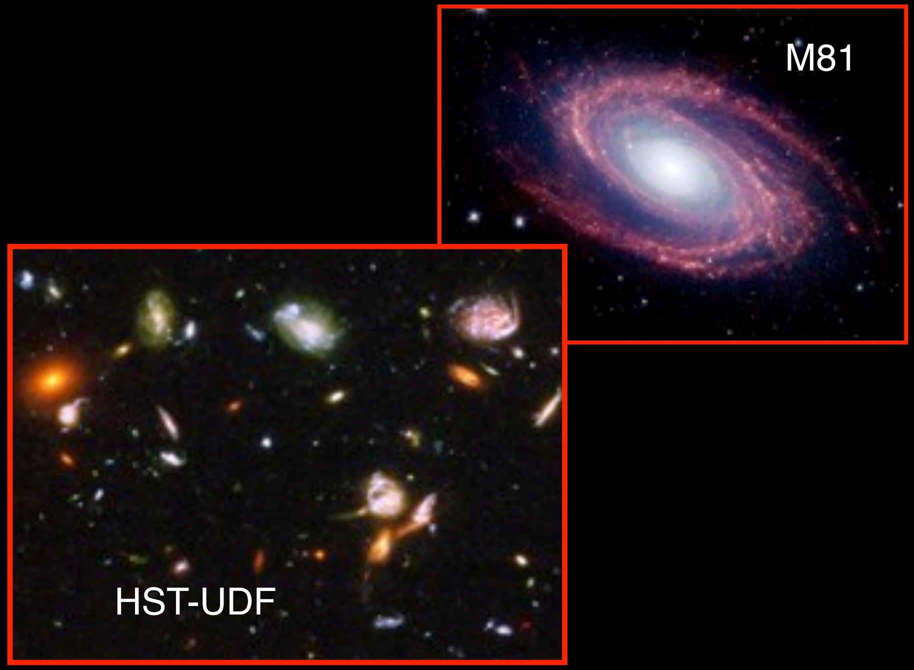
IR Astronomy from the Ground



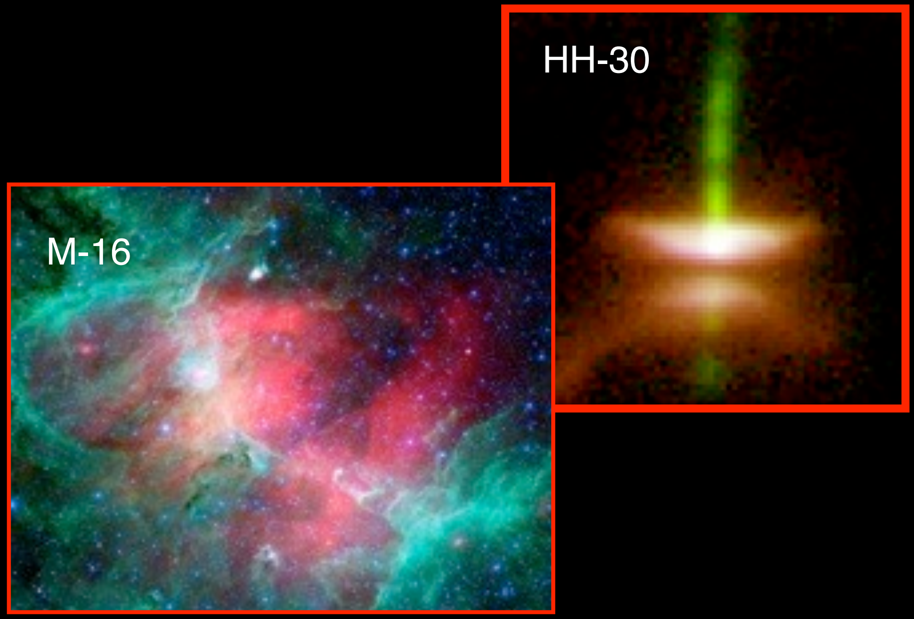
JWST Science



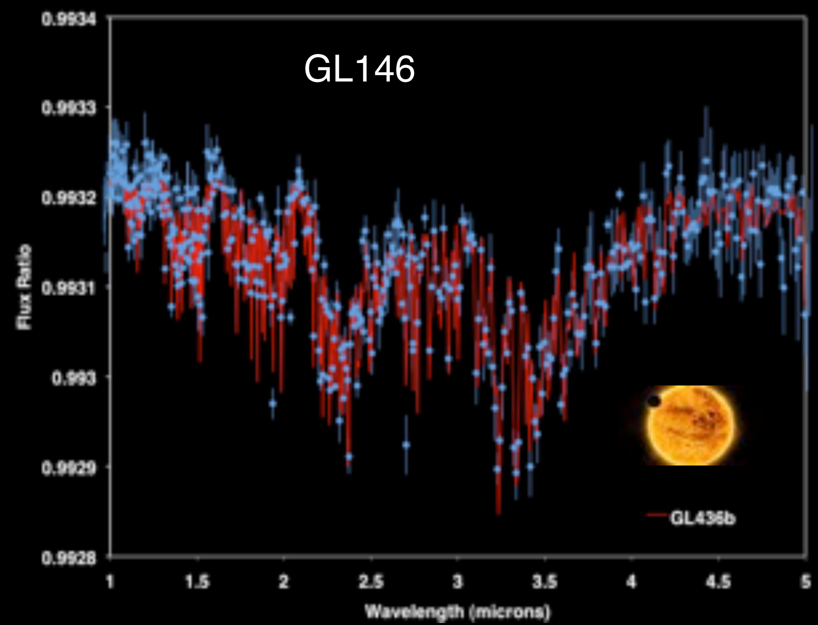
First Light and Re-Ionization



Assembly of Galaxies

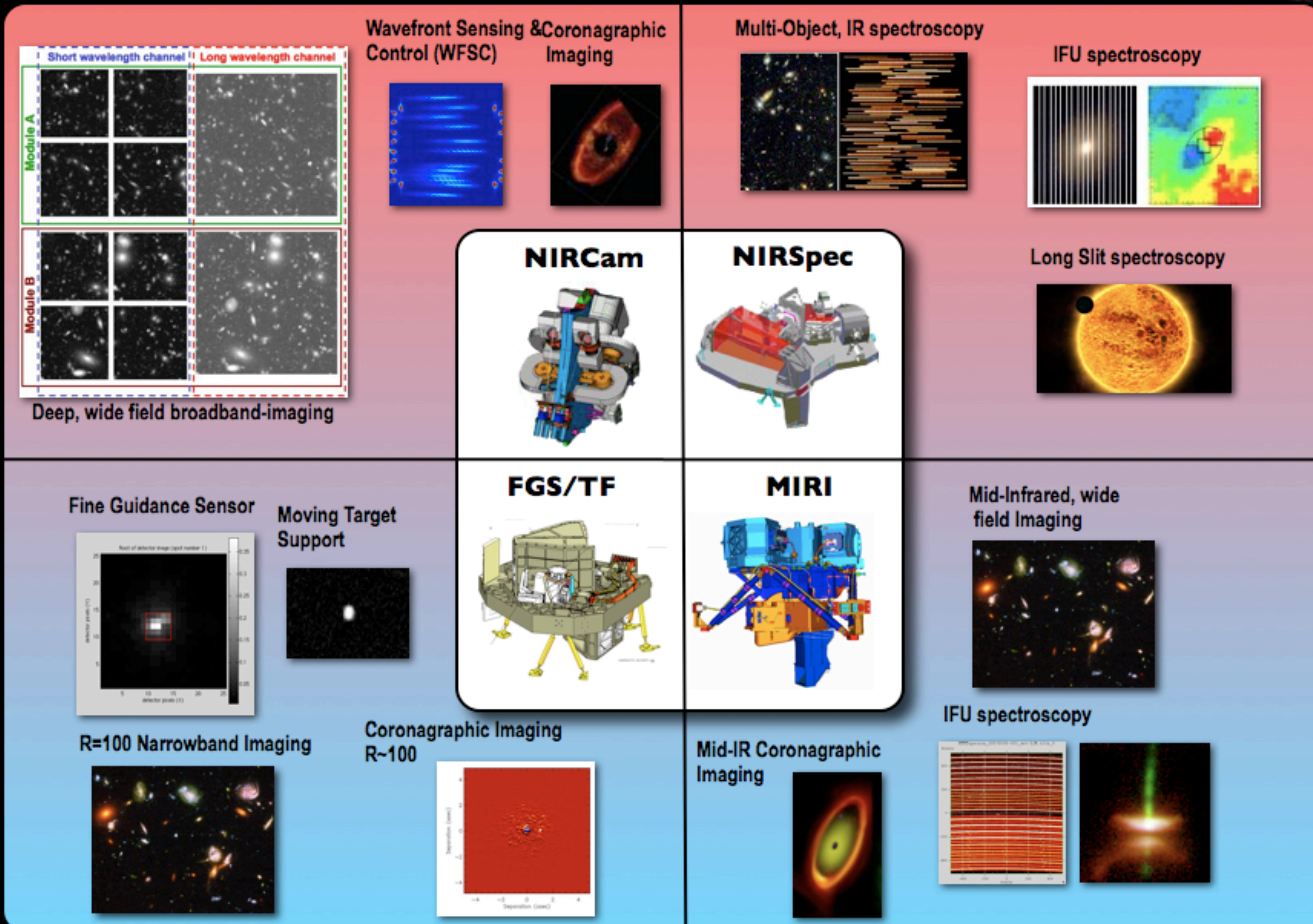


Birth of stars and
proto-planetary systems



Planetary systems and the
origin of life

JWST Science Instruments



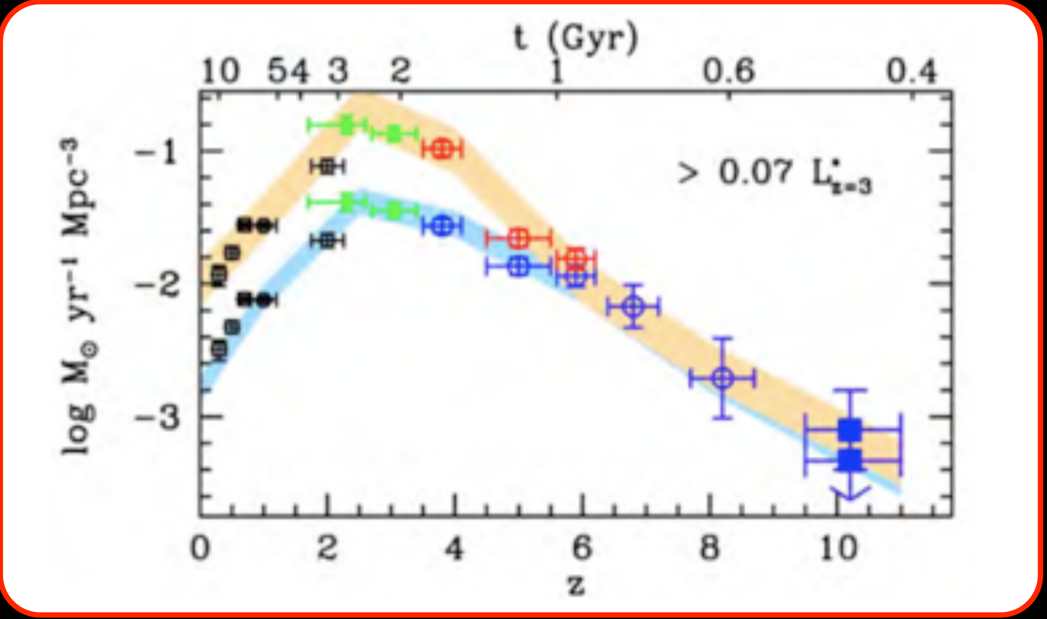
First Light and Re-Ionization

- **First Light and Re-Ionization:** **.... to identify the first luminous sources to form and to determine the ionization history of the early universe**

- **Typical first light is defined as the appearance of the first galaxies or super-star clusters (associations of stars with 10^7-10^8 $L_\odot$)**

- **How do we know we have seen first light**
  - ➡ **Luminosity function (LF) evolution: Models predict that the LF should evolve significantly for the first galaxies**
  - ➡ **Metallicity: First light galaxies should have lower metallicity than other galaxies**
  - ➡ **Absence of older stellar populations: First light galaxies should not have older stellar populations.**

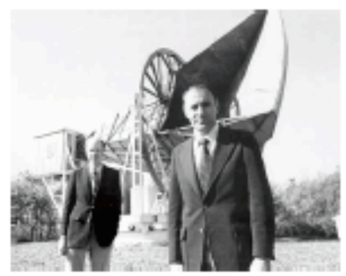
Predicted sensitivity requirements to detect a change in LF slope, L_* and a change in the number density of objects (JWST Science Working Group paper on First Light)



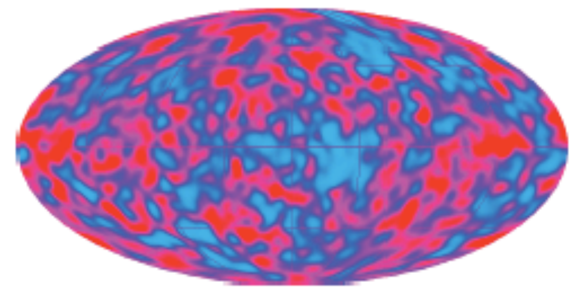
Cosmology Timeline

Timescale

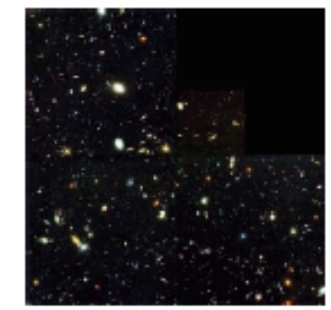
1920's - Hubble discovers redshift increases w/distance



1963 -Penzias and Wilson discover CMB

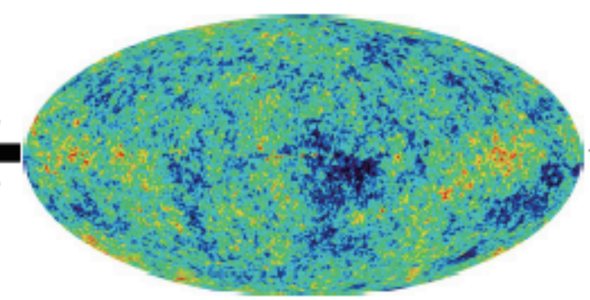


1992 - FIRAS measures BB temp of CMB

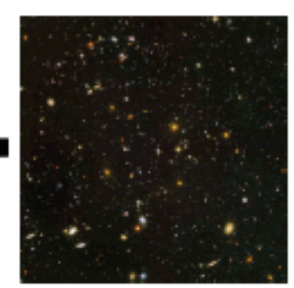


1996 - HST deep field north sees out to Z~5

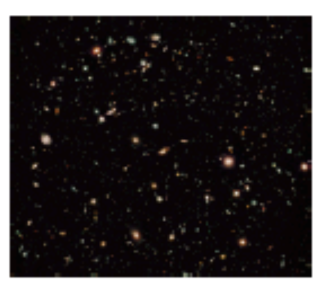
2000 – Astronomy Decadal Survey identifies JWST as #1 priority mission



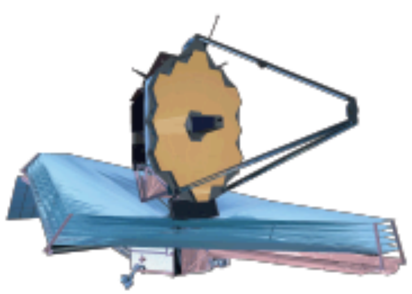
WMAP constrains key cosmological timescales



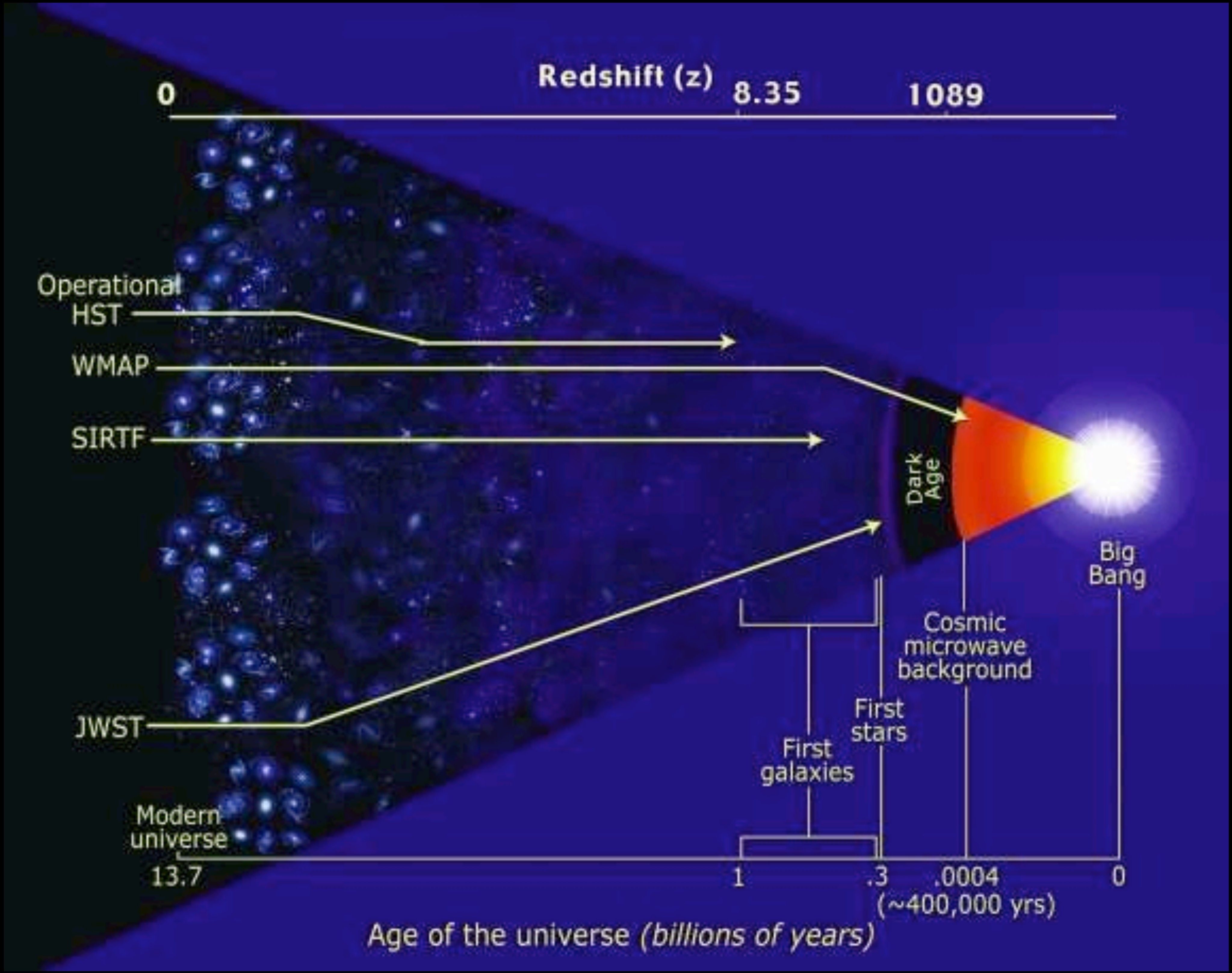
HST ultra deep field sees out to Z~6-7



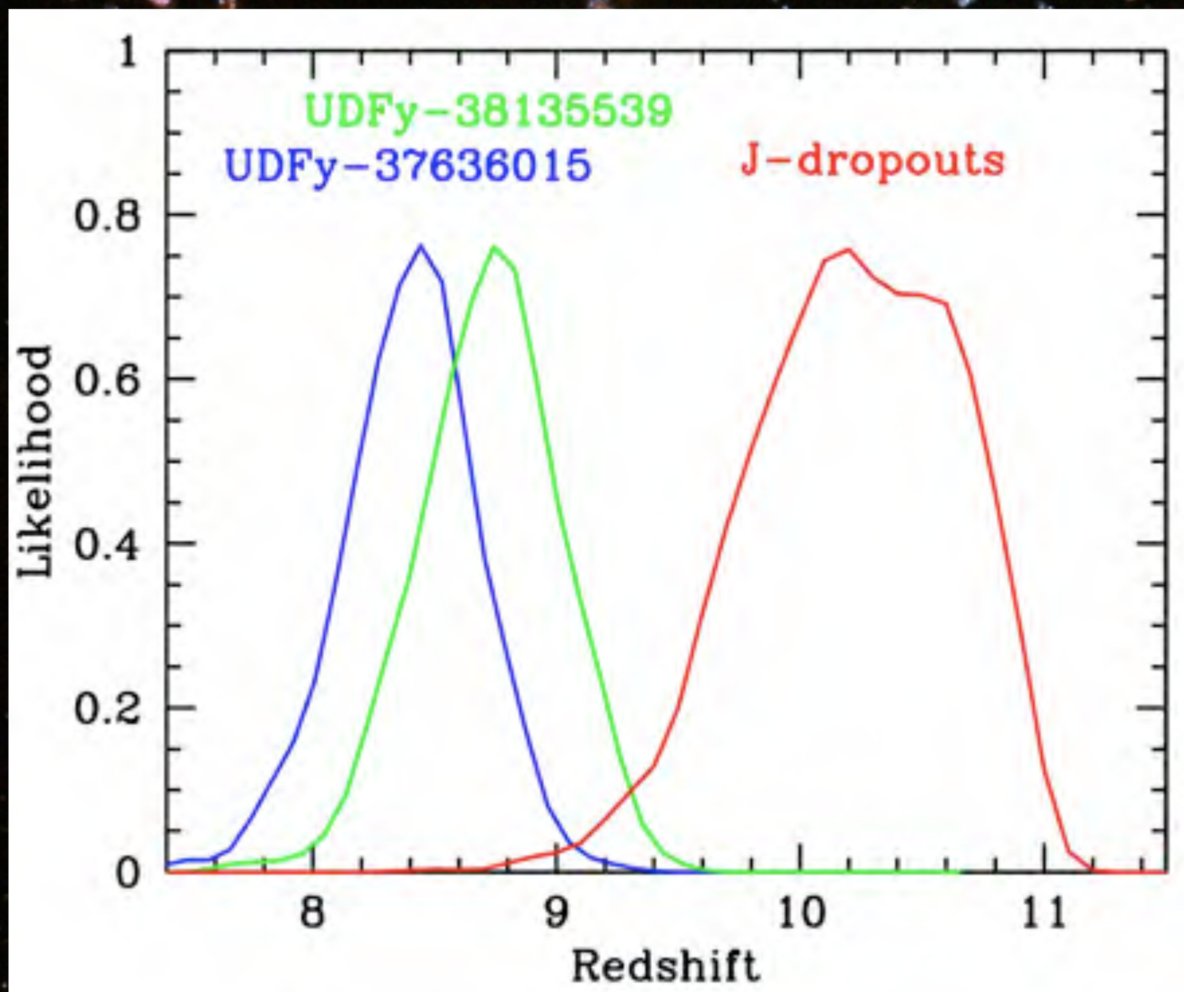
HST WFC3 deep field sees galaxy candidates at Z~10

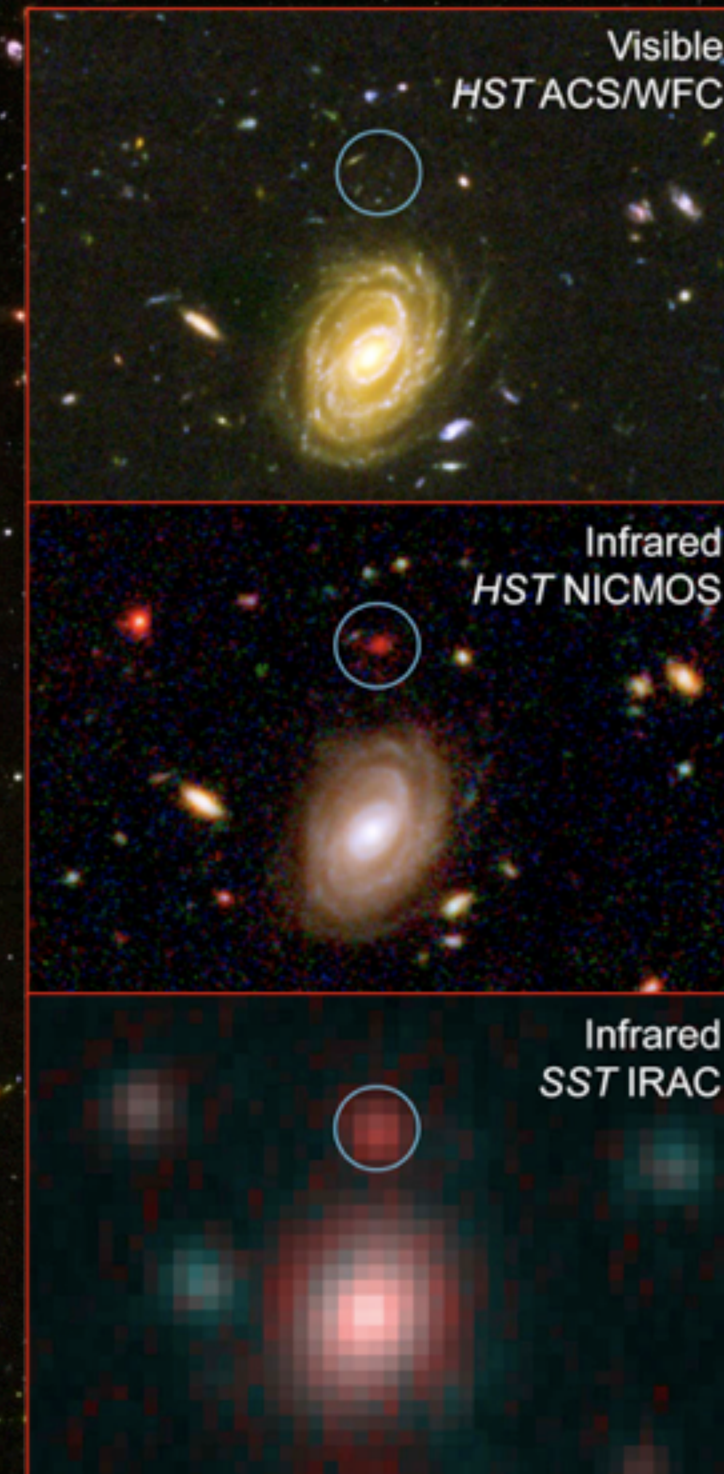


History of the Universe: Current



High-Z Imaging





Deep Field Imaging: Story so far !

- **HST has provided us unconfirmed Z~10 candidates. JWST is required if we are to to go beyond Z~10, and image the first galaxies**

HST-ACS Ultra Deep Field
- Visible $z \leq 6 - 7$

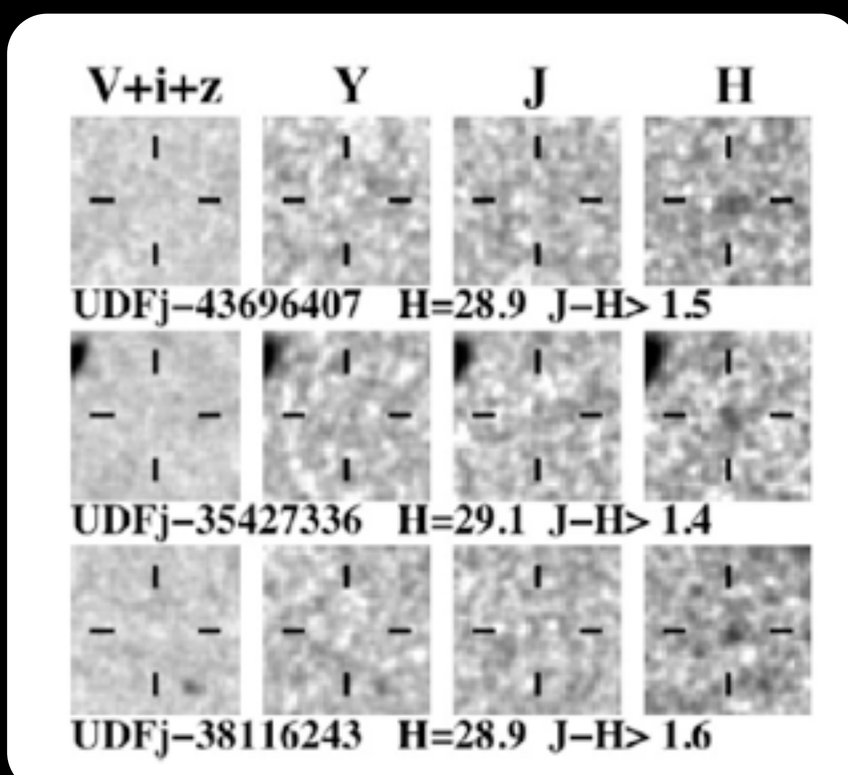
→

HST-WFC3 Deep Field Image
- near-IR $z \leq \sim 10$

→

Simulated JWST image

Note that WFC3 tells us z~10 galaxies are there but we we need JWST to confirm their presence and image to higher z



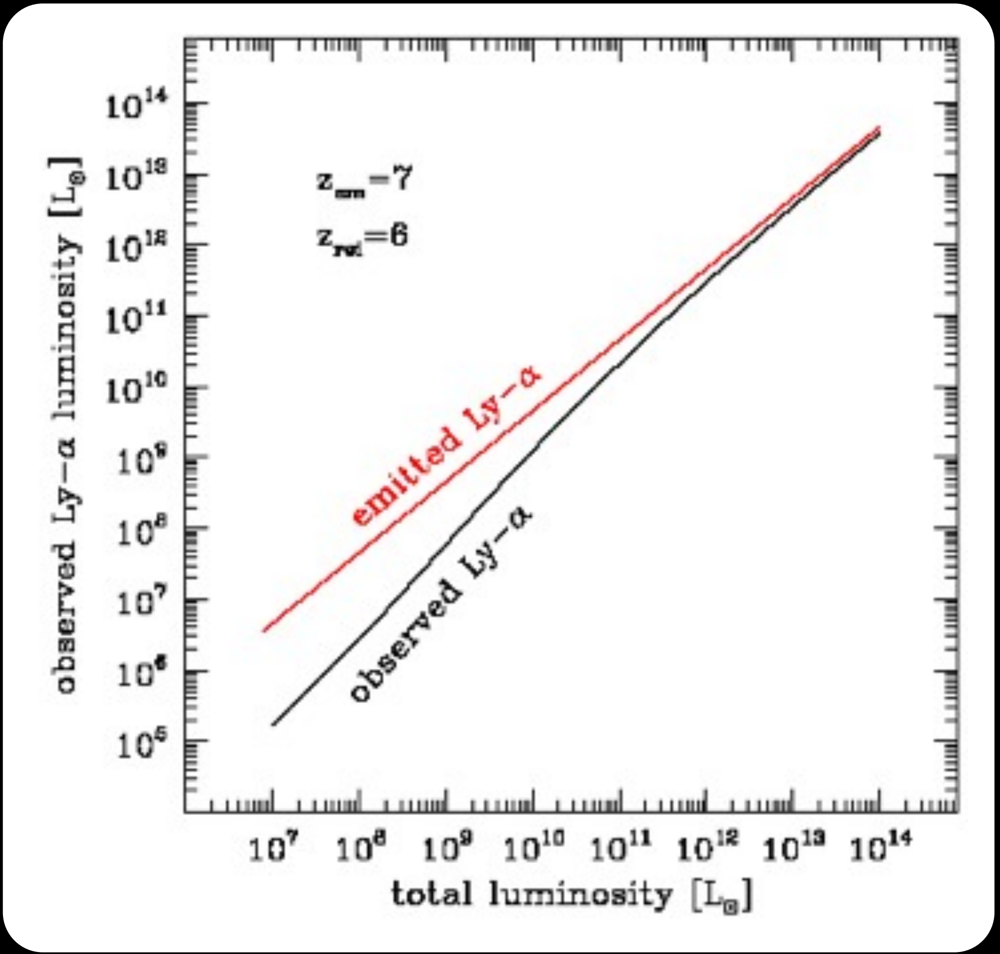
WFC3
Z~10 (J dropout candidates)

Key Requirements

Assumptions: Pop III, ionizing photons escape fraction = 0.5.

Adopt: Lyα escape fraction of 0.2.

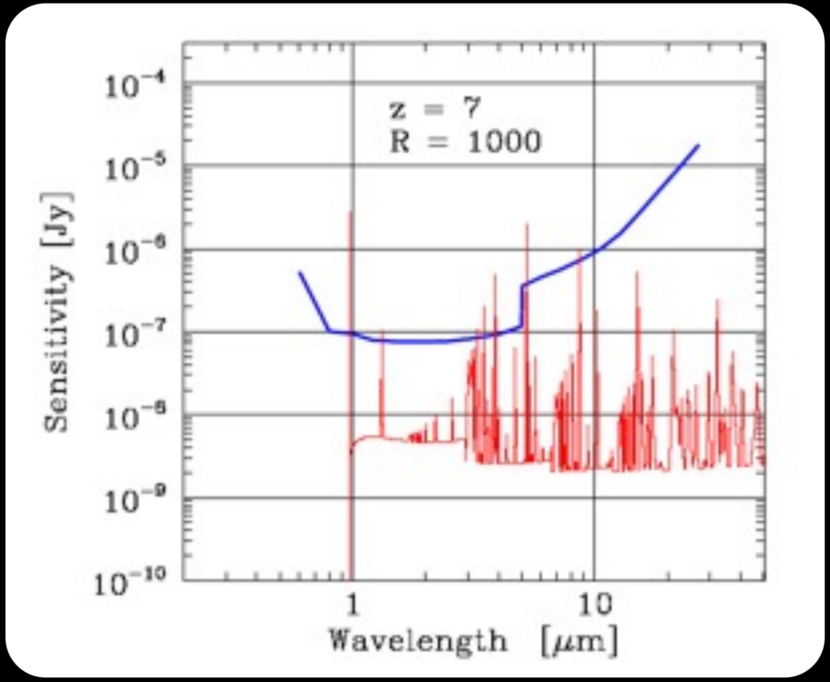
z	AB_{1350}	Ly α (cgs)	λ (µm)
10	30.284	1.70×10^{-18}	1.34
12	30.551	8.89×10^{-19}	1.58
15	30.869	4.02×10^{-19}	1.95
20	31.267	1.47×10^{-19}	2.55



Measuring the metallicity of first light sources

Consider a 5 nJy source with metallicity 1/1000 solar. The O line at 1665A will have a strength of:

$4.5\ 10^{-19}$ erg cm^{-2} s^{-1}



The metallicity measurement or the detection by MIRI will be possible for bright sources or sources amplified by lensing.

Assembly of Galaxies

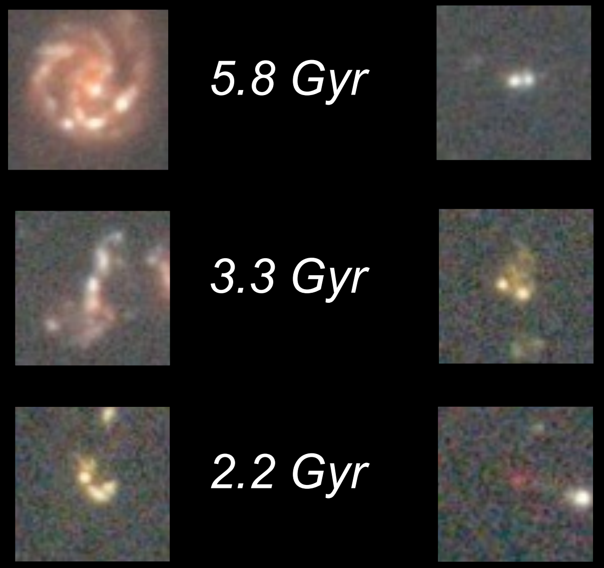
- **Assembly of Galaxies:** Determine how galaxies and the dark matter, gas, stars, metals, morphological structures, and active nuclei within them evolved from the epoch of reionization to the present day.
  - ➡ **Where were stars in the Hubble Sequence Galaxies formed, when did luminous quiescent galaxies appear?**
  - ➡ **Where and When are the Heavy Elements Produced and to What Extent do Galaxies Exchange Material with the Intergalactic Medium?**
  - ➡ **When and how are the global scaling relations for galaxies established?**
  - ➡ **Do Luminous Galaxies Form through the Hierarchical Assembly of Dark Matter Halos? What are the Redshifts and Power Sources of the High Redshift Ultra Luminous Infrared Galaxies?**
  - ➡ **What is the relation between the Evolution of Galaxies and the Growth and development of Black Holes in their nuclei?**

Key Requirements:

- Wide-area near-infrared imaging survey
- Low and medium resolution spectra of of galaxies at high redshift
- Targeted observations of galactic nuclei

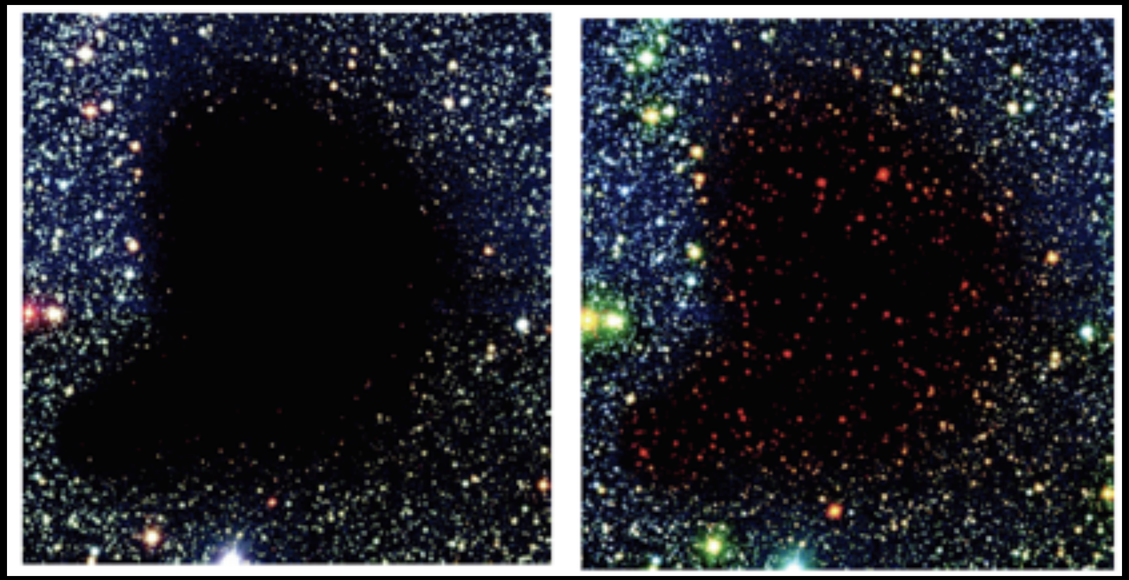
12 billion years of cosmic history

Assembly of Galaxy observations with JWST will employ similar datasets to those obtained for the HST Ultra Deep Field, in order to study galaxy properties as a function of age.



Birth of Stars and Protoplanetary

- **Birth of Stars and Protoplanetary Systems:** Unravel the birth and early evolution of stars, from infall on to dust-enshrouded protostars, to the genesis of planetary systems.
  - ➡ **How do protostellar clouds collapse?**
  - ➡ **What is the early evolution of protostars?**
  - ➡ **How do massive stars form and affect their environment?**
  - ➡ **What is the initial mass function at sub-stellar masses?**
  - ➡ **How do protoplanetary systems form?**
  - ➡ **What are the life cycles of gas and dust?**



Barnard 68

Key Requirements:

- **High angular resolution near- and mid-IR imagery**
- **High angular resolution imaging spectroscopy**
- **Near-IR integrated field spectroscopy**
- **Mid-IR integrated field spectroscopy**

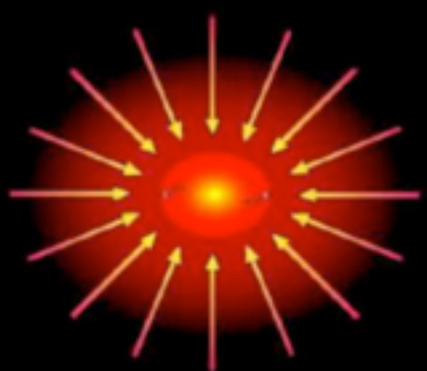
HST Image of HH-90

HST Image of HH-90

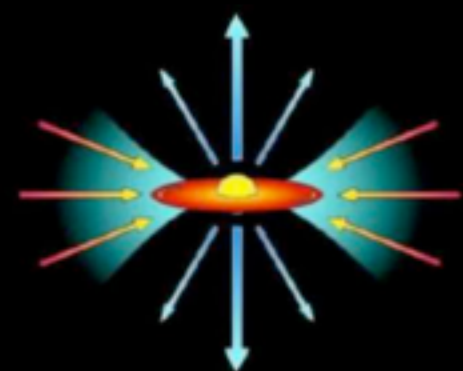
Formation and Evolution of Planetary Systems

How do planets form in dense disks of gas and dust around young stars, and how do they evolve?

- Characterize circumstellar disk evolution during the critical 5 – 30 Myr period in dense clusters out to 2kpc and down to ≤1 $M_\odot$
- Hot gas phase chemistry in future habitable zones of low mass young stars

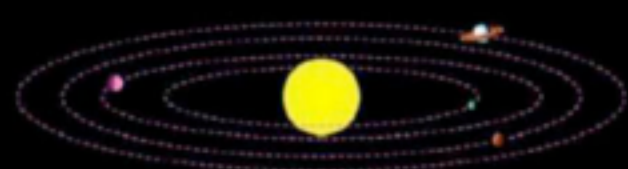


10^4 yrs; 10–10^4 AU; 10–300K

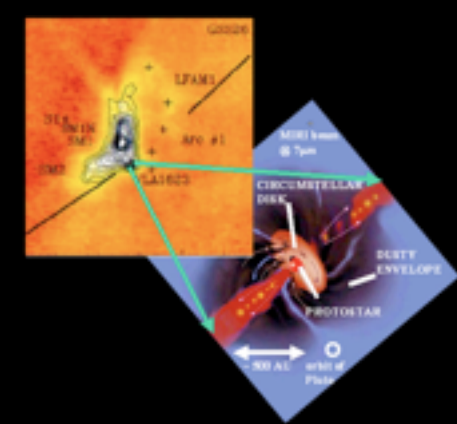


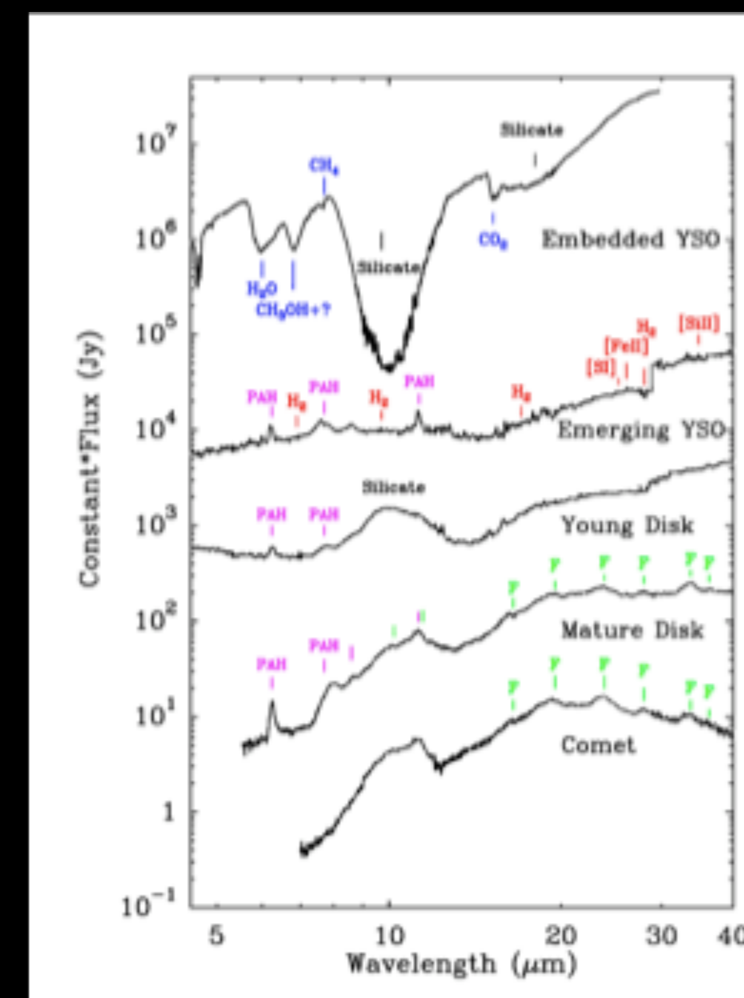
10^{5-6} yrs; 1–1000AU; 100–3000K

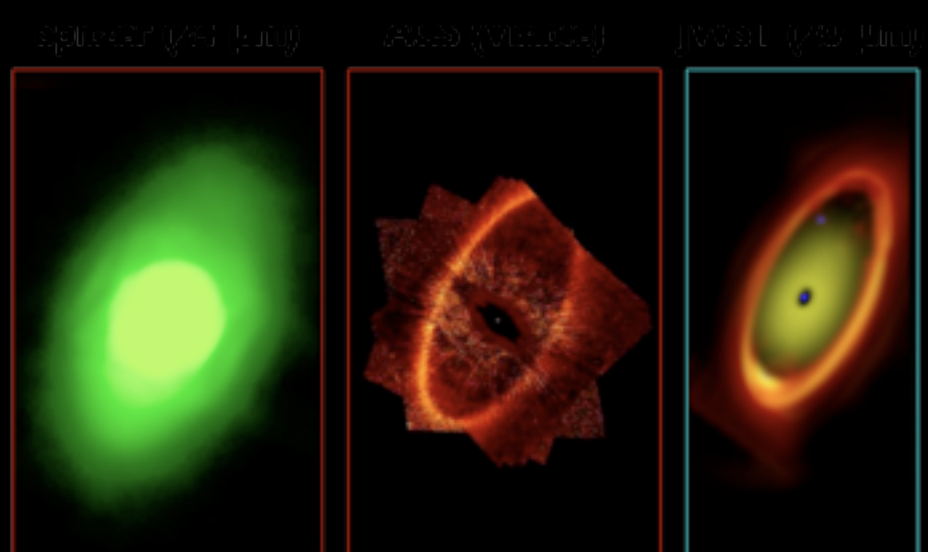
10^{6-7} yrs; 1–100AU; 100–3000K



10^{7-9} yrs; 1–100AU; 200–3000K





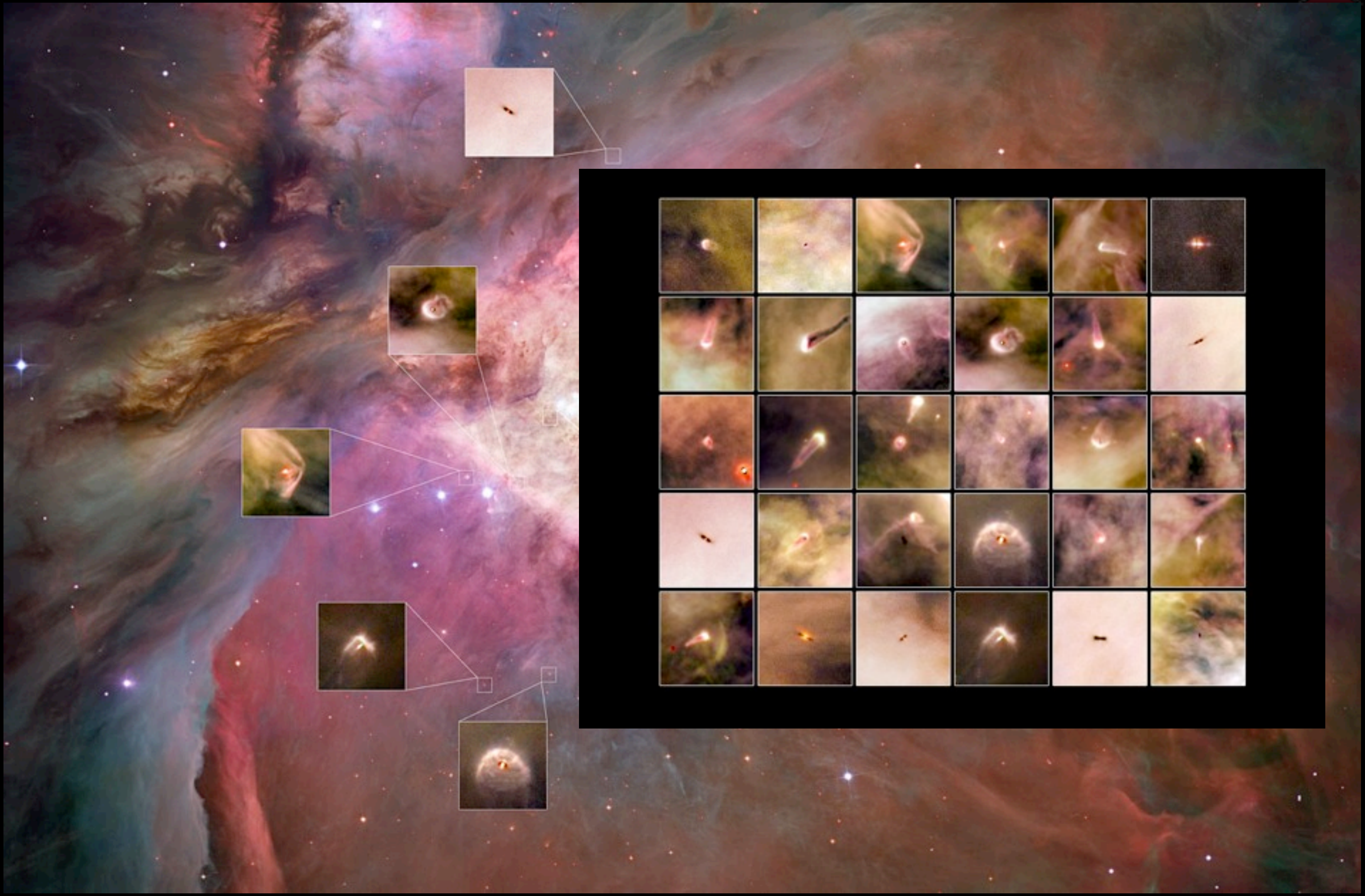


- Probe transition and debris disks in scattered light and thermal emission to resolve zodiacal and kuiper belt dust structures

- Indirect evidence of exoplanets e.g. Kalas et al. (2008), Stark and Kuchner (2008)

- Spatially resolved spectroscopy
  - Disk mineralogy

Formation and Evolution of Planetary Systems



Planetary Systems/Origins of Life

- **Planetary Systems and the Origins of Life:** To determine the physical and chemical properties of planetary systems including our own, and to investigate the potential for the origins of life in those systems

  How Do Planets and Brown Dwarfs Form?

  How Common are Giant Planets and What is their Distribution of Orbits?

  How Do Giant Planets Affect the Formation of Terrestrial Planets?

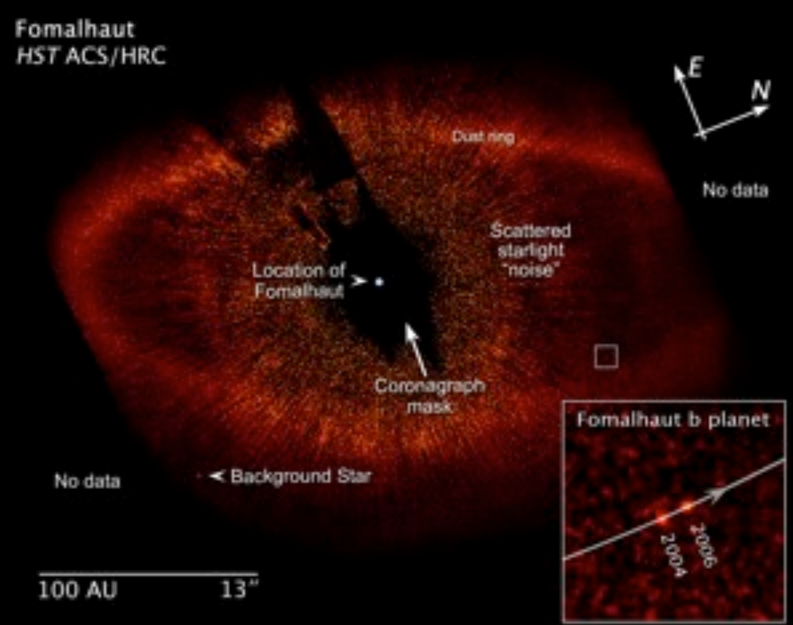
  What Comparisons, Direct or Indirect, can be made between our Solar System and Circumstellar Disks (Forming Solar Systems) and Remnant Disks?

Near-IR and Mid-IR observations of Kuiper belt Objects

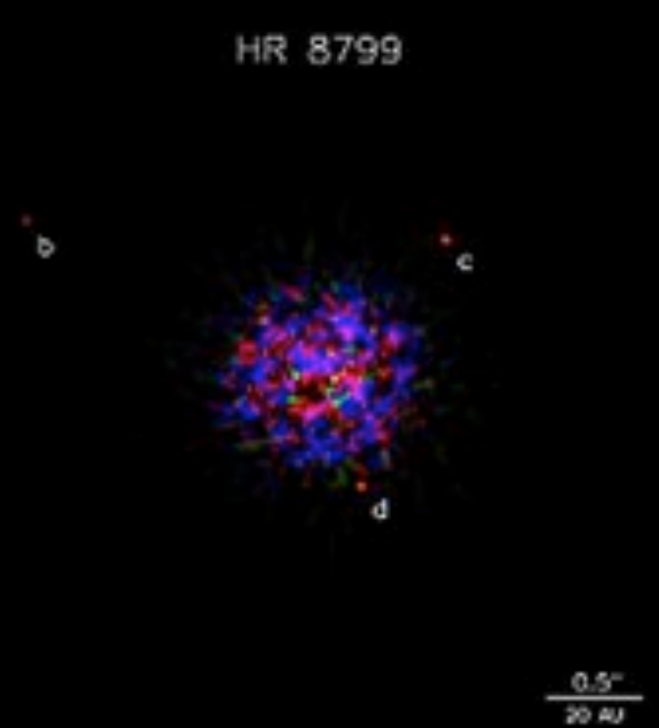
Key Requirements:

- High contrast imaging in near & mid-IR
- Near & mid-IR integrated field spectroscopy
- Long slit near-IR specotroscopy
- Slitless mid-IR spectroscopy

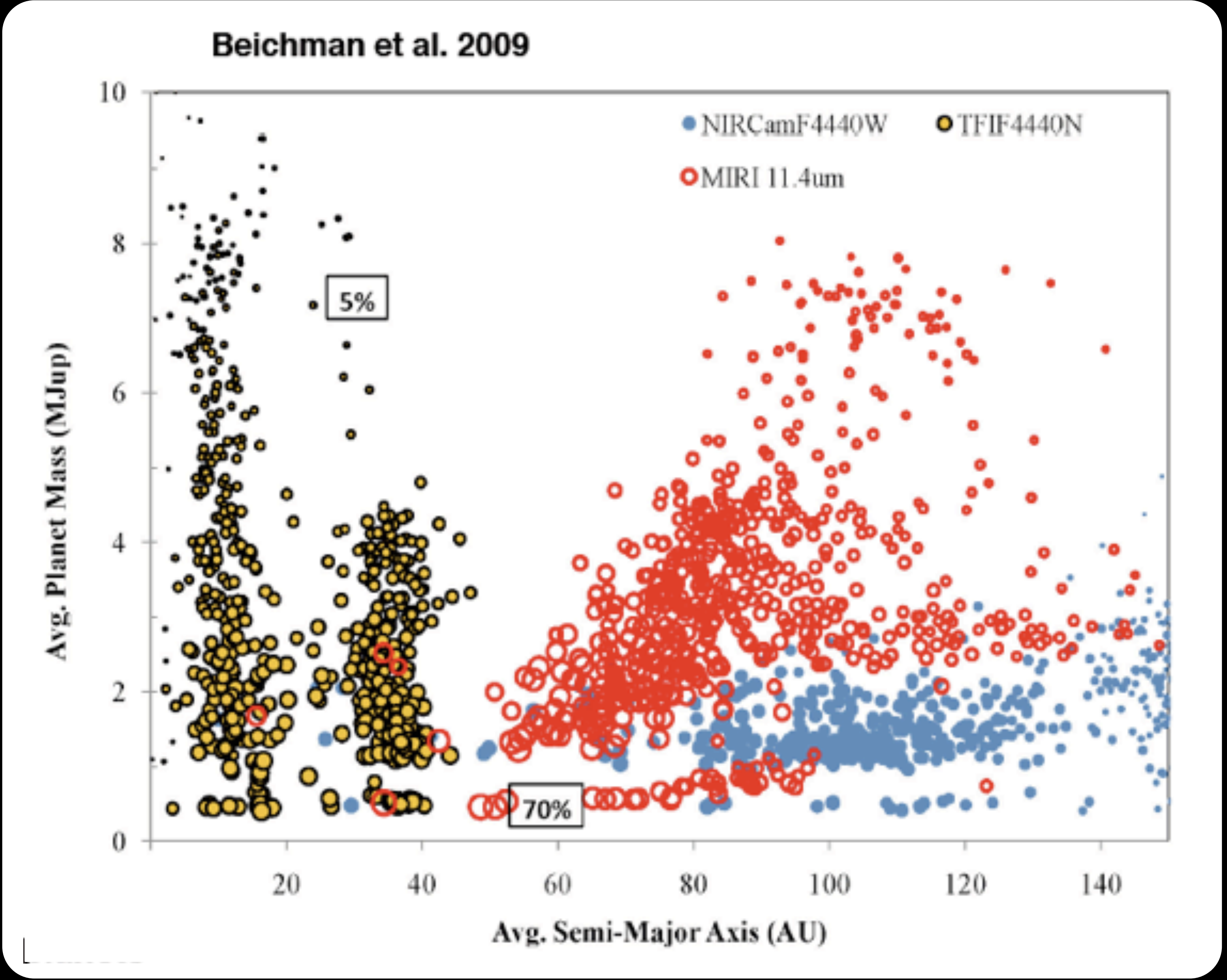
Planetary Systems/Origins of Life



Kalas et al. 2008



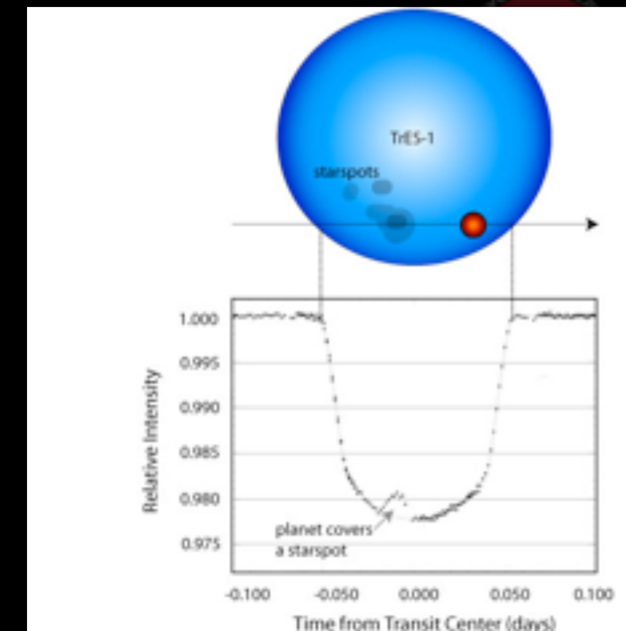
Marois et al. 2008

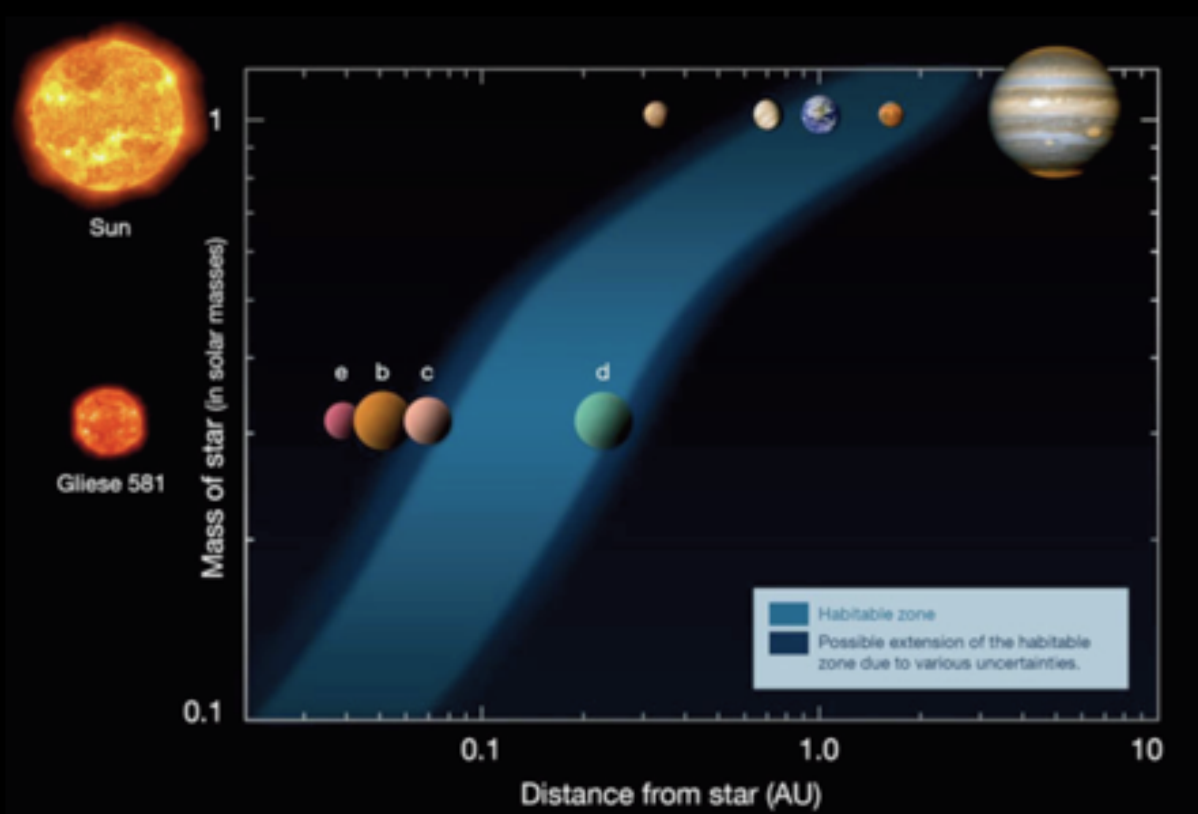


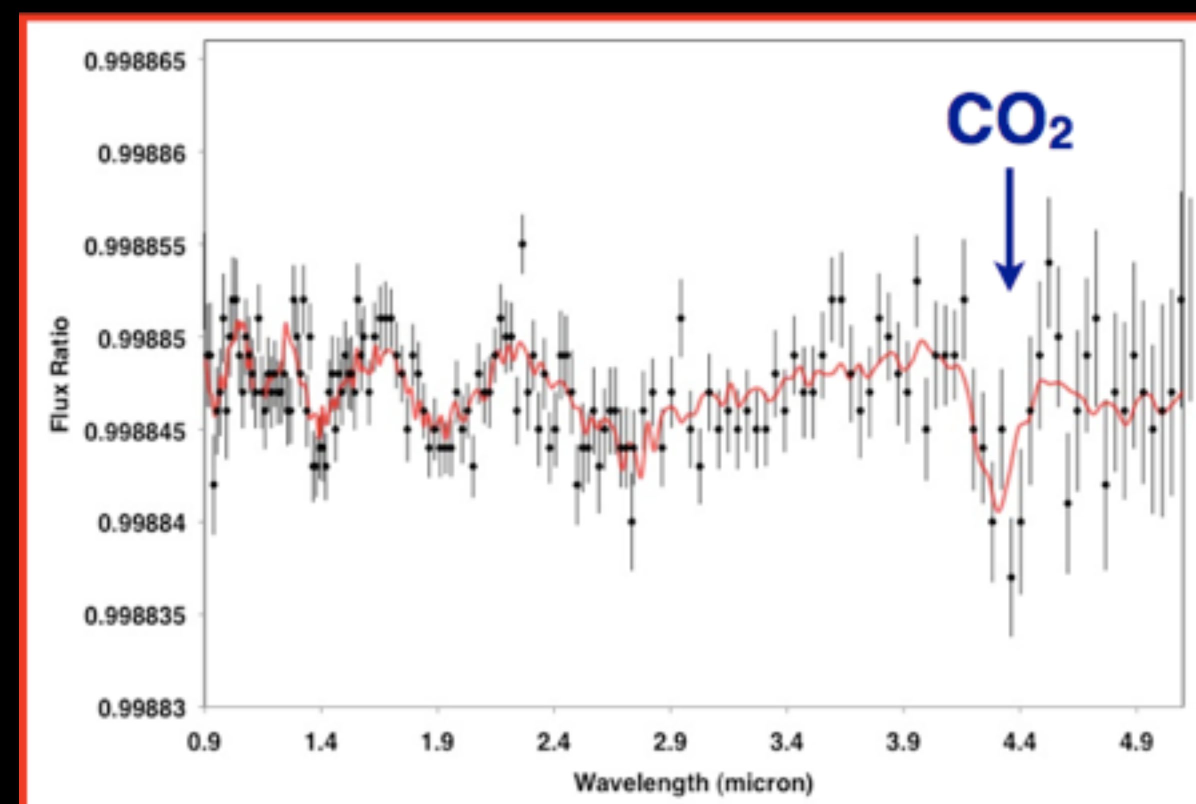
- Imaging of young, self luminous planets
  - Exoplanets with ≥ 0.2 MJ at angular distances ≥ 10 AU
- Imaging of planets around nearby M stars (≤ 2 Gyr)
  - Exoplanets with ≥ 2 MJ at angular distances ≥ few AU

PSOL: transiting Planets

Observation	Targets	R	Science
Transit light Curves	Gas giants Intermediate planets Superearths	5 5 5	- Exoplanet properties e.g. Mass, radius -> Physical structure - Confirmation of Terrestrial planet transits - Transit timing: detection of unseen planets
Phase light curves	Gas giants Intermediate planets	5 5	- Day to night emission mapping: dynamical models of Exoplanet atmospheres
Transmission Spectroscopy	Gas giants Gas giants Intermediate planets Superearths planets	3000 100-500 100-500 ≤100	Spectral line diagnostics - atmospheric composition e.g. C, CO_2, CH_4 - follow-up of survey detections: TESS & Kepler
Emission Spectroscopy	Gas giants Gas giants Intermediate planets Superearths planets	3000 100-500 100-500 ≤100	- Spectral line diagnostic - Planet temperature measurements - follow-up of survey detections: TESS & Kepler







Simulated spectrum of a superearth

Science Level-1 Requirements

First light and reionization	The assembly of galaxies	Birth of stars and proto-planetary systems	Planetary systems and the origins of life
			

- First Light and Re-Ionization
- Assembly of Galaxies

L1-1: 5.1.1.1 Density of Galaxies Measure the space density of galaxies to a 2 µm flux density limit of 1.0 x 10^{-34} Wm-2Hz-1 via imagery within the 0.6 to 27 µm spectral band to enable the determination of how this density varies as a function of their age and evolutionary state.

- First Light and Re-Ionization
- Assembly of Galaxies

L1-2: 5.1.1.2 Spectra of Galaxies Measure the spectra of at least 2500 galaxies with spectral resolutions of approximately 100 (over 0.6 to 5 µm) and 1000 (over 1 to 5 µm) and to a 2 µm emission line flux limit of 5.2x10^{-22} Wm^{-2} to enable determination of their redshift, metallicity, star formation rate, and ionization state of the intergalactic medium.

- Birth of Stars and Protoplanetary Systems
- Planetary Systems/Origins

L1-3: 5.1.1.3 Physical & Chemical Properties of Young Stellar Objects Measure the physical and chemical properties of young stellar objects, circumstellar debris disks, extra-solar giant planets, and Solar System objects via spectroscopy, and imagery within the 0.6 to 27 µm spectral band to enable determination of how planetary systems form and evolve.

- First Light and Re-Ionization
- Assembly of Galaxies
- Birth of Stars and Protoplanetary Systems
- Planetary Systems/Origins

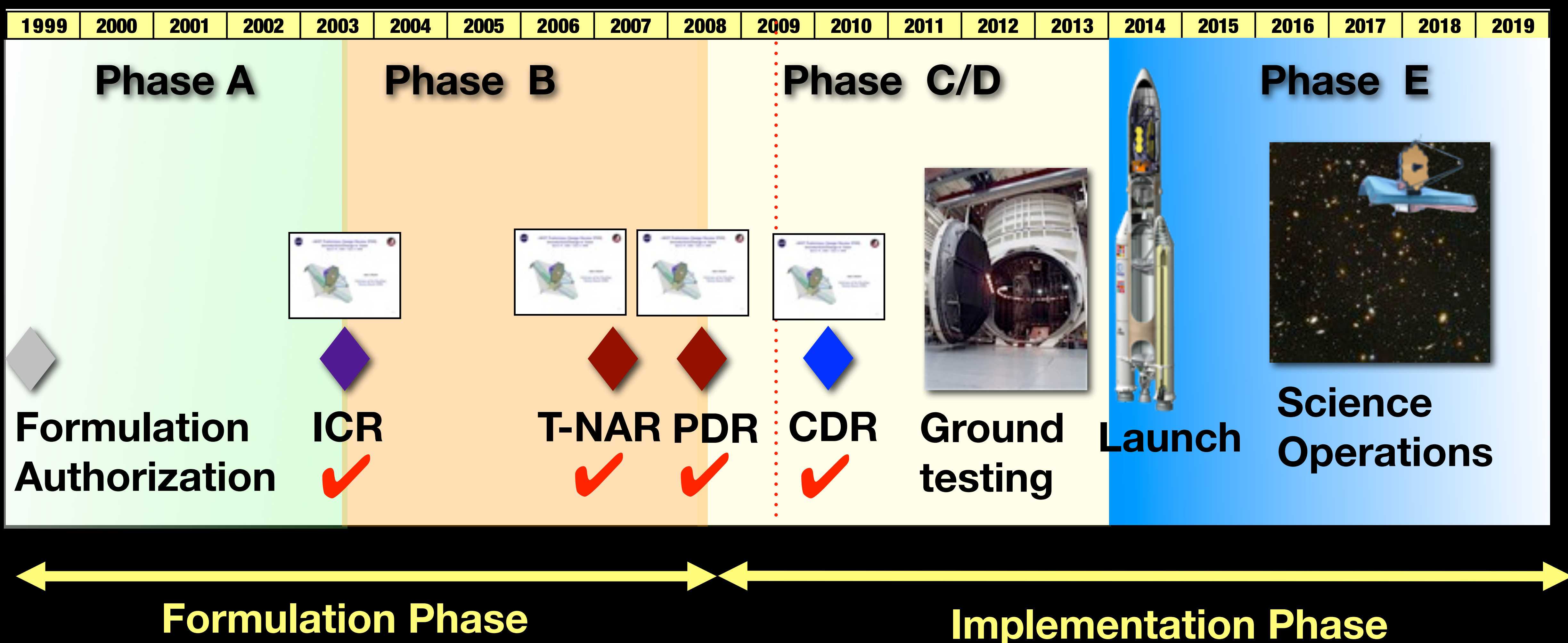
L1-4 : 5.1.1.4 Observing Time Enable, within a 5-year mission, a total observing time of at least 1.1x10^8 seconds on targets located at any position on the celestial sphere.

Sensitivity

- Defined for 10,000 sec exposure

	λ (μm)	λ/Δλ	Prediction		Requirement		Margin
NIRCam	2.00	4	9.7×10^{-35}	$Wm^{-2}Hz^{-1}$	1.14×10^{-34}	$Wm^{-2}Hz^{-1}$	15%
NIRSpec	2.00	1000	4.9×10^{-22}	$Wm^{-2}Hz^{-1}$	5.70×10^{-22}	$Wm^{-2}Hz^{-1}$	14%
NIRSpec	3.00	100	1.25×10^{-33}	Wm^{-2}	1.32×10^{-33}	Wm^{-2}	5%
MIRI	10.00	5	6.2×10^{-33}	$Wm^{-2}Hz^{-1}$	7.0×10^{-33}	$Wm^{-2}Hz^{-1}$	11%
MIRI	21.00	4	8.13×10^{-32}	$Wm^{-2}Hz^{-1}$	8.70×10^{-32}	$Wm^{-2}Hz^{-1}$	7%
MIRI	9.20	2400	8.47×10^{-21}	Wm^{-2}	1.00×10^{-20}	Wm^{-2}	15%
MIRI	22.50	1200	5.26×10^{-20}	Wm^{-2}	$5.6.0 \times 10^{-20}$	Wm^{-2}	6%
FGS-TF	3.50	100	9.3×10^{-34}	$Wm^{-2}Hz^{-1}$	1.26×10^{-33}	$Wm^{-2}Hz^{-1}$	26%
FGS-GUIDER	1.25	0.28	4.9×10^{-32}	$Wm^{-2}Hz^{-1}$	5.8×10^{-32}	$Wm^{-2}Hz^{-1}$	15%
FGS-GUIDER	1.25	0.28	5.4×10^{-31}	$Wm^{-2}Hz^{-1}$	5.8×10^{-31}	$Wm^{-2}Hz^{-1}$	7%

JWST: Current Schedule?



- ☑ ISIM Critical Design Review completed: Mar 09
- ☑ OTE Critical Design Review completed: Nov 09
- ☑ Sunshield Critical Design Review completed: Jan 10
- ☑ Mission Critical Design Review: April 10
- ☐ Launch: NET June 2014

JWST Science Summary

- JWST will be the dominant astronomical facility for a decade, and will undertake a broad range of investigations by the astronomical community
- JWST remains the brilliant advance recommended by the Decadal Survey

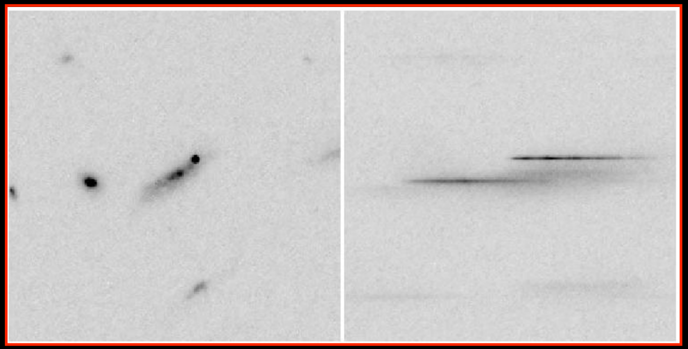
WFC3 has shown we need JWST to image the first galaxies

JWST is ready for new observing opportunities such as exoplanets….

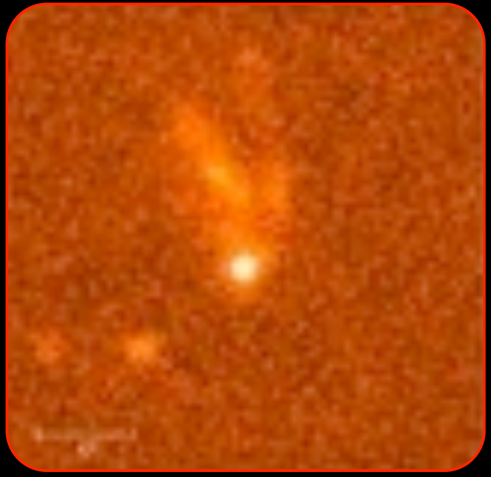
What will JWST Discover

Half of Hubble's highest-impact scientific achievements are in areas of research unanticipated prior to launch.

- Creation of galaxies (HDF, UDF)
- Acceleration of Universe: SN Ia

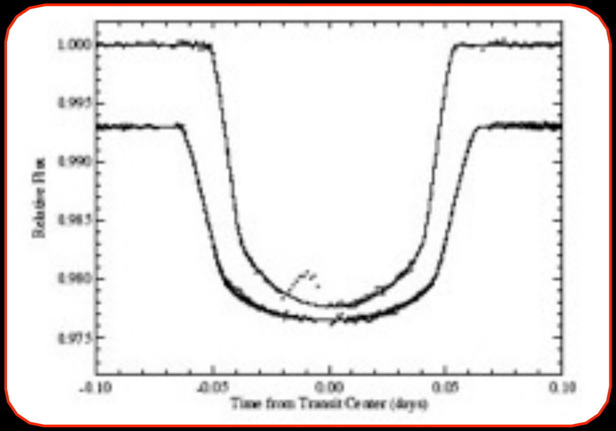


- Distance scale of the Universe: H_0
- Giant black holes in galaxies
- Emission lines in active galaxies



- Intergalactic medium
- Interstellar medium chemistry

- Gamma Ray Burst sources
- Debris disks: Footprints of planets
- Extrasolar planets: Atmospheres



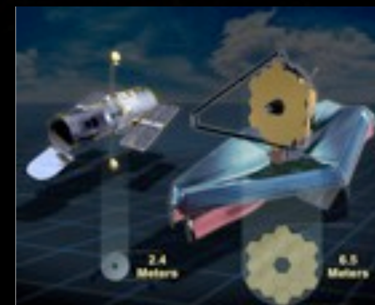
JWST's Architecture

Key Science Drivers

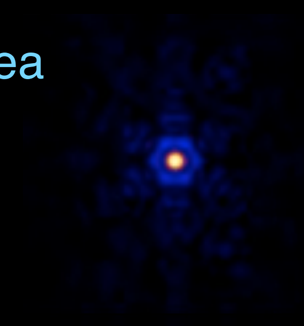
- **Sensitivity**

Driven by detection of “First Galaxies”

- **Image Quality**



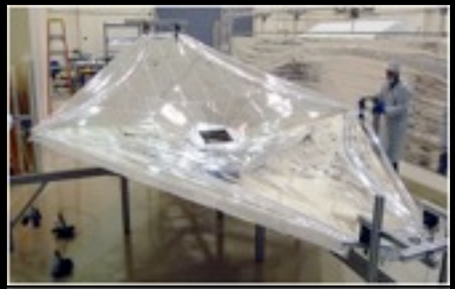
6.5-m collecting area



Diffraction-limited at 2 μm

- **Low background**

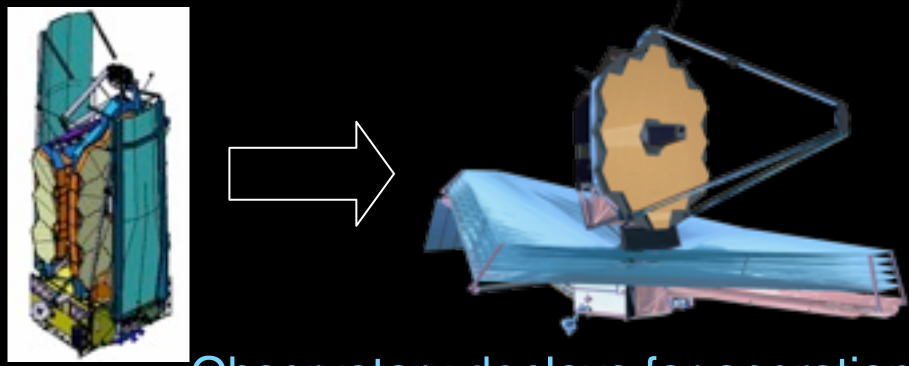
Cryogenic telescope (40 k)



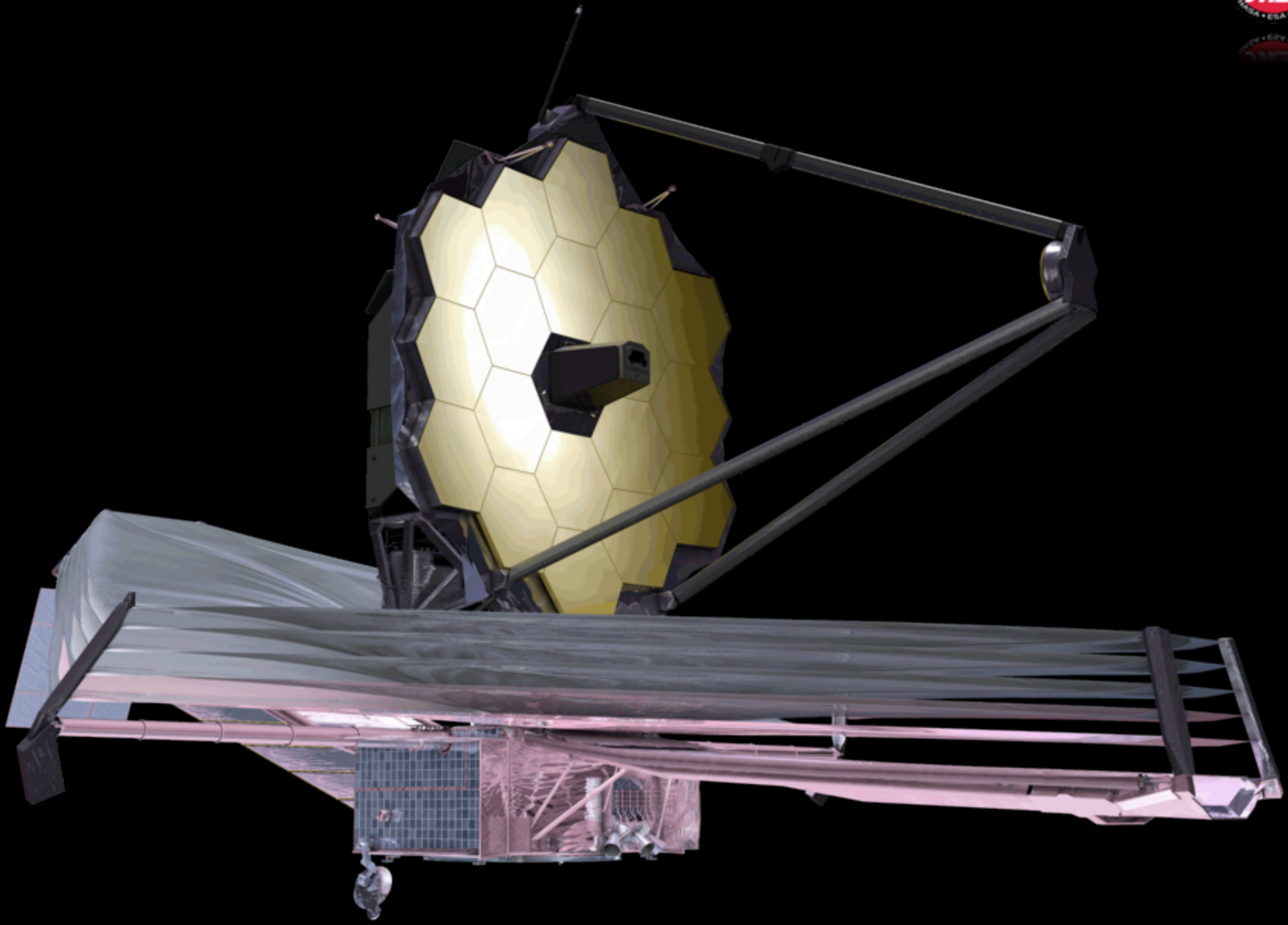
Passive cooling via sunshield

- **Ariane 5: Payload stowed for launch**

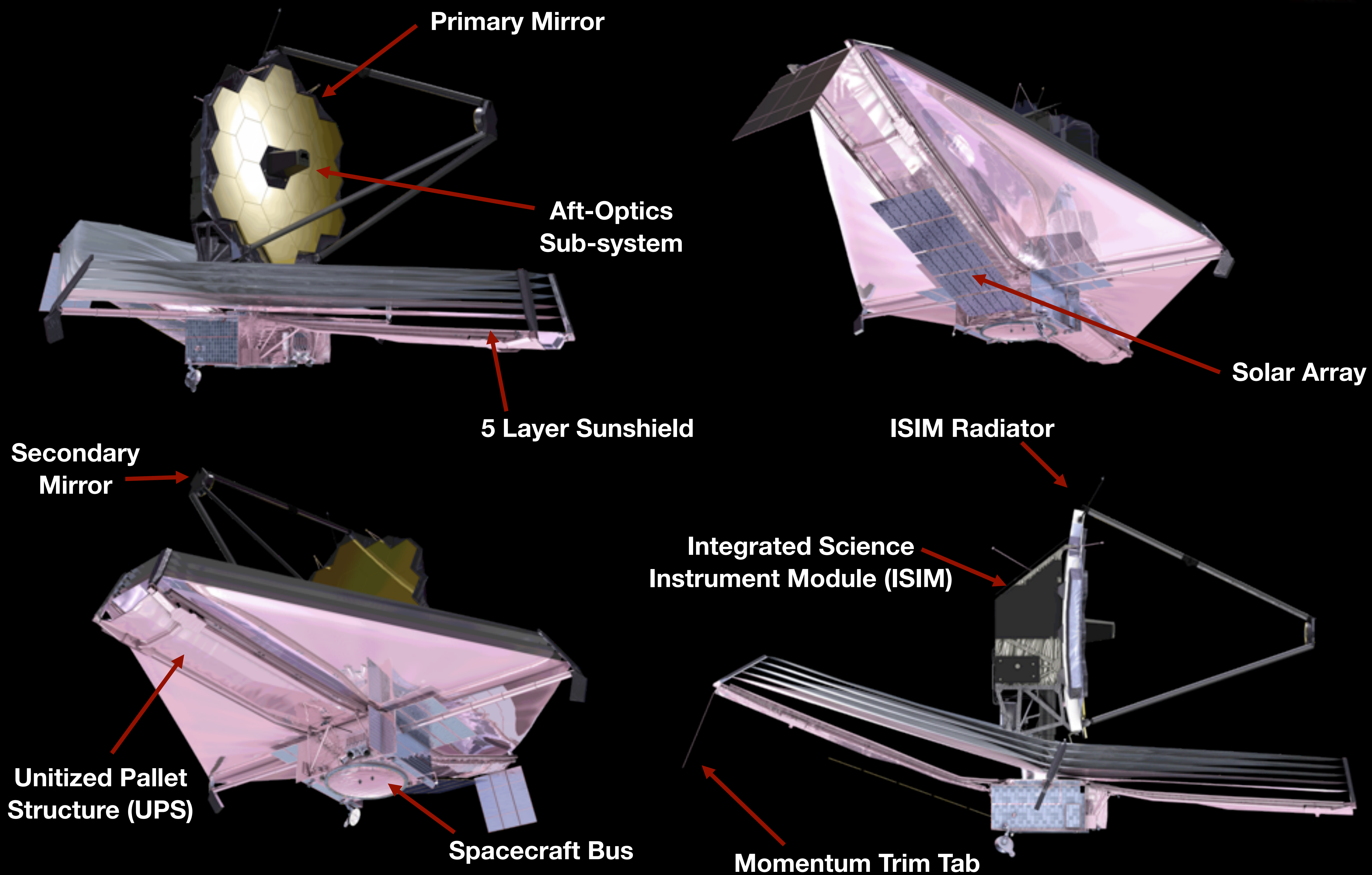
Deployable systems



Observatory deploys for operation

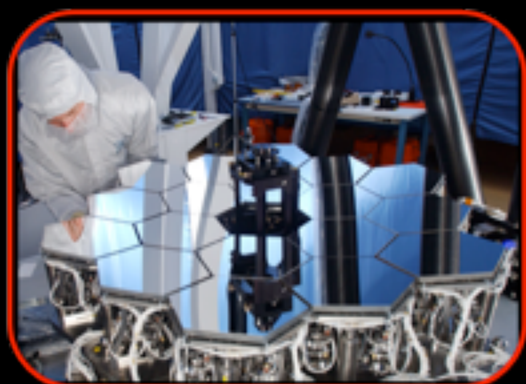


JWST Design: Key Features

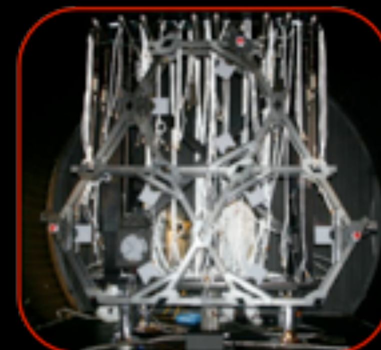


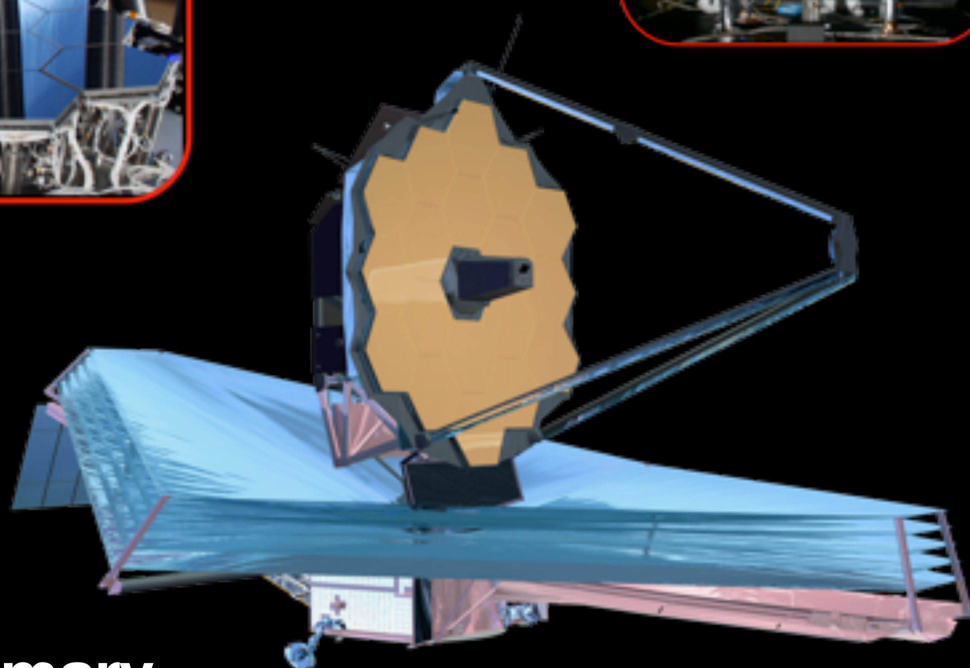
JWST Technology Milestones

Mirror Phasing Algorithms



Backplane Structure

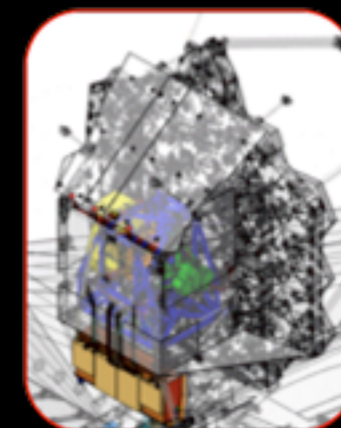




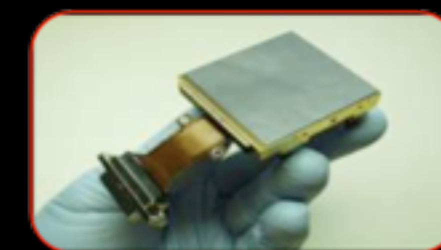
Beryllium Primary Mirror Segment

Sunshield Membrane

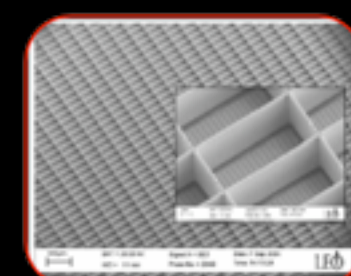
ISIM



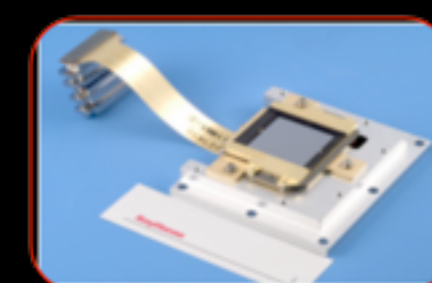
Near-Infrared Detector



μShutters



Mid-Infrared Detector



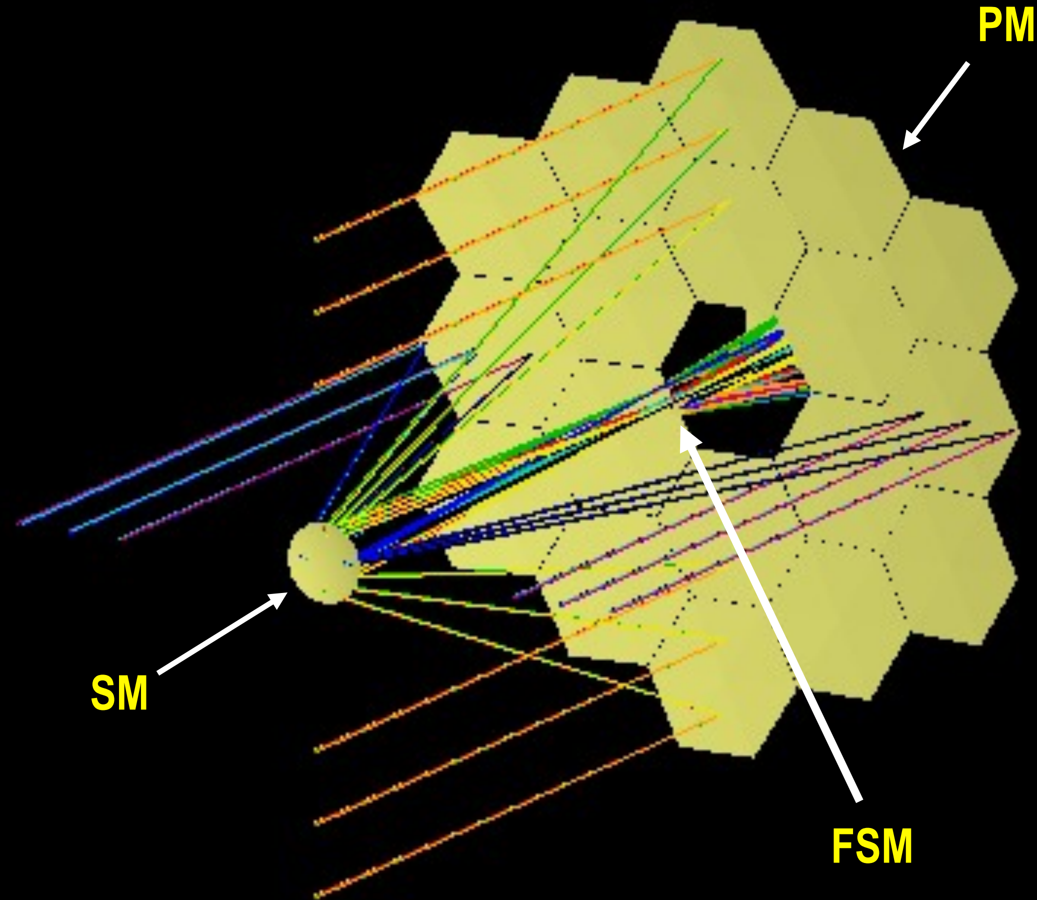
Cryocooler

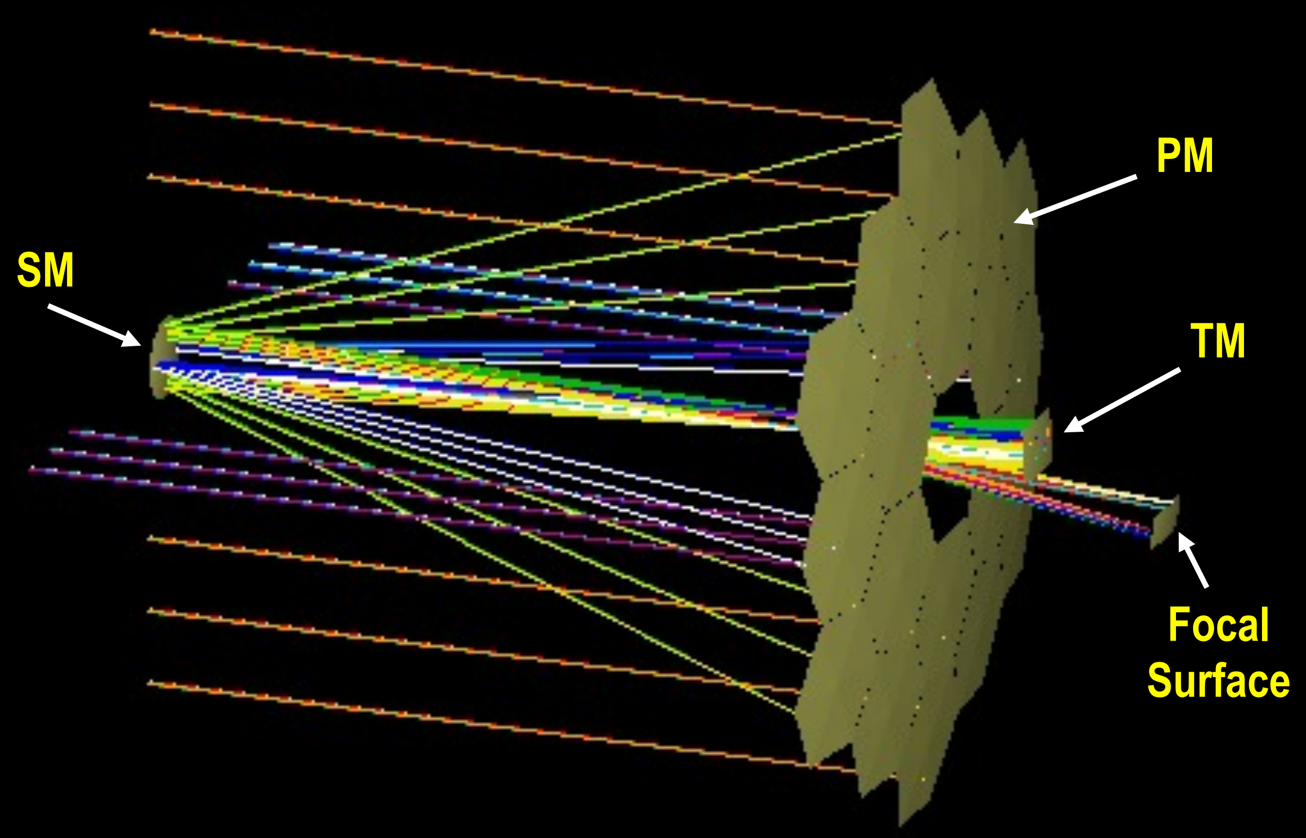
Cryo-ASICs

JWST's Optical Design

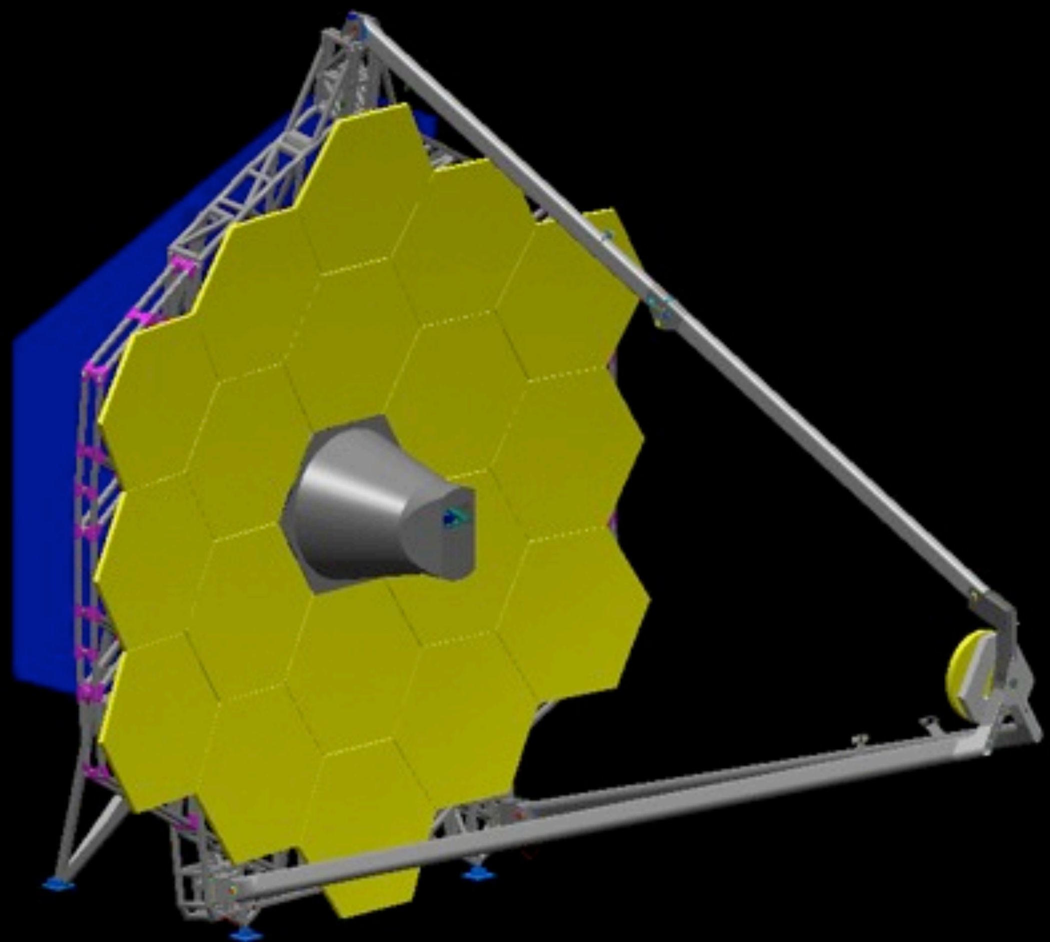
JWST's Optical Design: I

- JWST's Optical Telescope Element is a Three Mirror Anistigmat (TMA)
  - ➡ Wide field of view: 18.2 x 9.1 arcmin
- Optical design: f/20
- Diameter of entrance pupil: 6.6 m
- Effective focal length: 131.4 m
- Clear aperture area: 25 m²





JWST's Optical Design: II



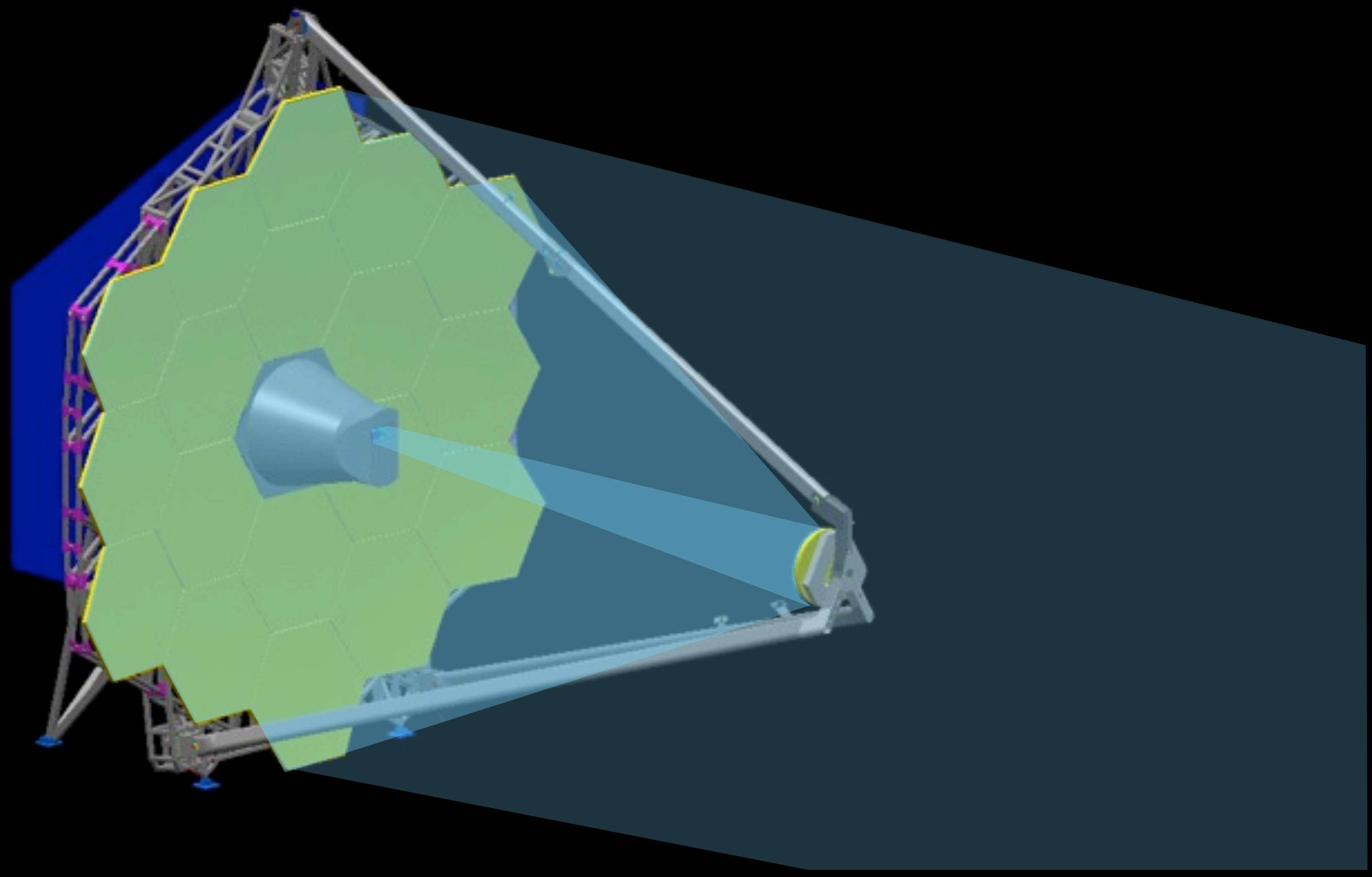
- 18 mirror segments
- 6 degrees of freedom
- 40 K temperature
- Beryllium mirrors

➡ Elliptical f/1.2 Primary Mirror (PM)

➡ Hyperbolic Secondary Mirror (SM) creates f/9 intermediate image

➡ Elliptical Tertiary Mirror images pupil at Fine Steering Mirror (FSM)

JWST's Optical Design: II



- 18 mirror segments
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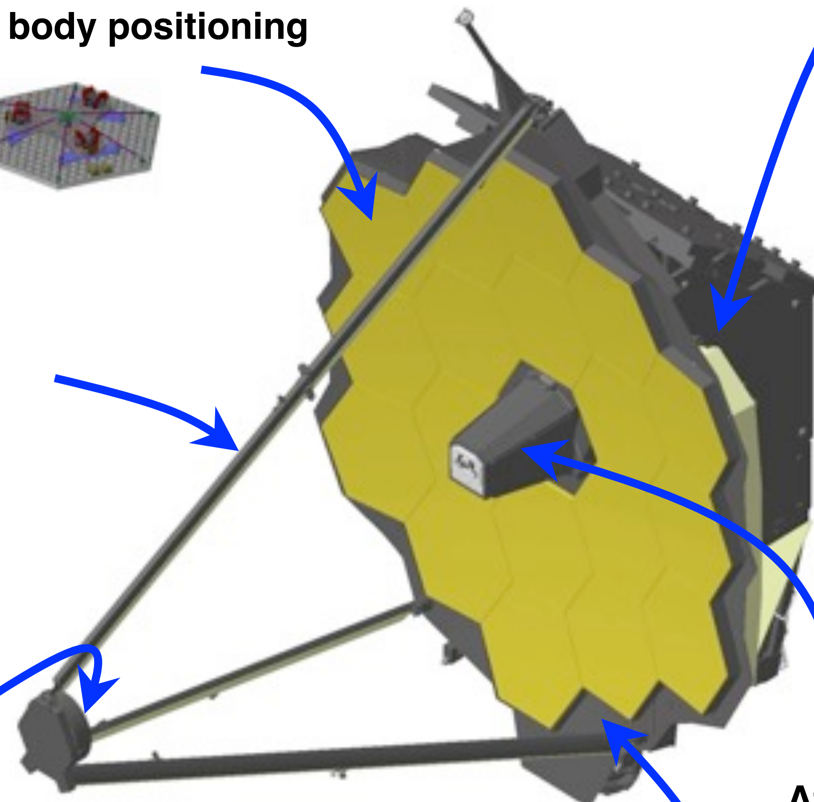
➡ Elliptical f/1.2 Primary Mirror (PM)

➡ Hyperbolic Secondary Mirror (SM) creates f/9 intermediate image

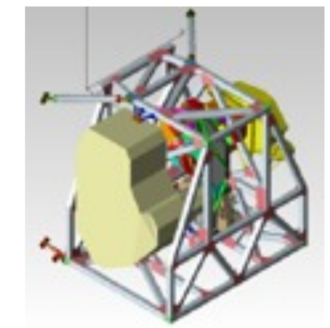
➡ Elliptical Tertiary Mirror images pupil at Fine Steering Mirror (FSM)

OTE (optical Telescope Element)

<u>Primary Mirror Segment Assemblies</u>
- 18 hexagonal segments
- 6 DoF hexapod mount for rigid body positioning
  - Phasing of 18 segments
  - Global alignment of PM
- RoC control



<u>Integrated Science Instrument Module</u>
- Integrating structure to support each of the SIs
  - NIRCam
    - Active focus adjustment
    - Active pupil alignment
    - Provides WFS imagery
  - NIRSpec
    - Active Focus Adjustment
  - MIRI
    - No alignment adjustability
  - FGS/TFI
    - Active focus adjustability
    - FGS provides image motion error signal
- Hexapod mount to attach ISIM structure to OTE bac
  - Adjustable in 6 DoF pre-flight



<u>Secondary Mirror Support Structure</u>
- Deployable structure supports the SMA
- Obscuration of pupil small & aligned

<u>Secondary Mirror Assembly</u>
- 6 DoF hexapod mount for alignment

<u>Primary Mirror Backplane Assembly</u>
- Center section fixed and supports 12 segments
- Two wings sections deployable and support 3 segments each
- Supports the PM baffle (frill) around outer perimeter of PM
  - Provides overlap blockage with internal FSM pupil stop
- Provides interface for ISIM attachment & alignment

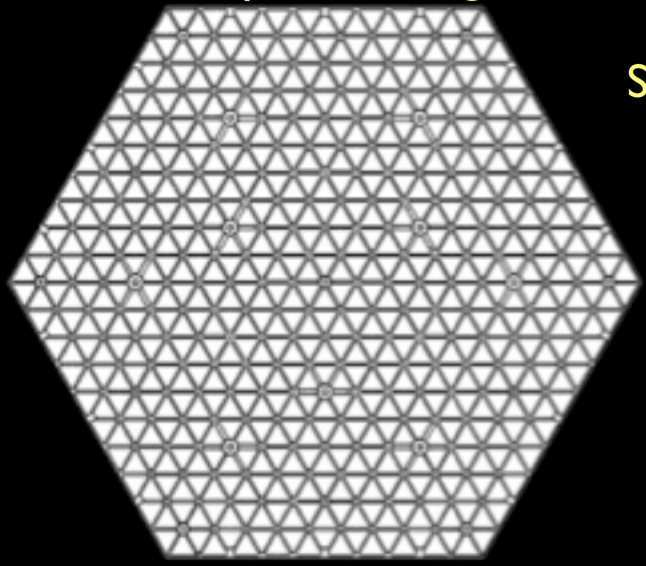
<u>Aft Optics Subsystem</u>
- Tertiary Mirror (TM)
  - Provides field correction
- Fine Steering Mirror
  - Image stabilization from Fine Guidance Sensor error signal
  - FSM motion off-loaded to ACS to reduce field distortion variability
- FSM mask/baffle
  - Interior shape (mask) provides oversized pupil stop
  - External extent (baffle) provides overlap with SI internal stop to eliminate Rogue Path stray light
- AOS entrance aperture
  - Used to block unwanted field and provide alignment fiducial

JWST Mirror Fabrication

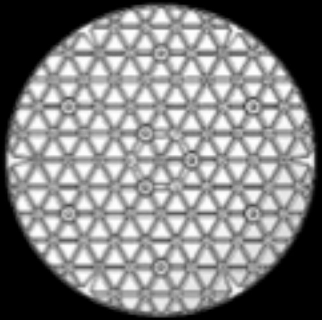
Raw Be billet (two mirrors)

- JWST Mirrors made of beryllium
- Lightweight and stable at 40 K
- Brush-Wellman

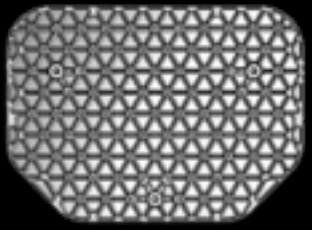
Primary mirror segment



Secondary mirror

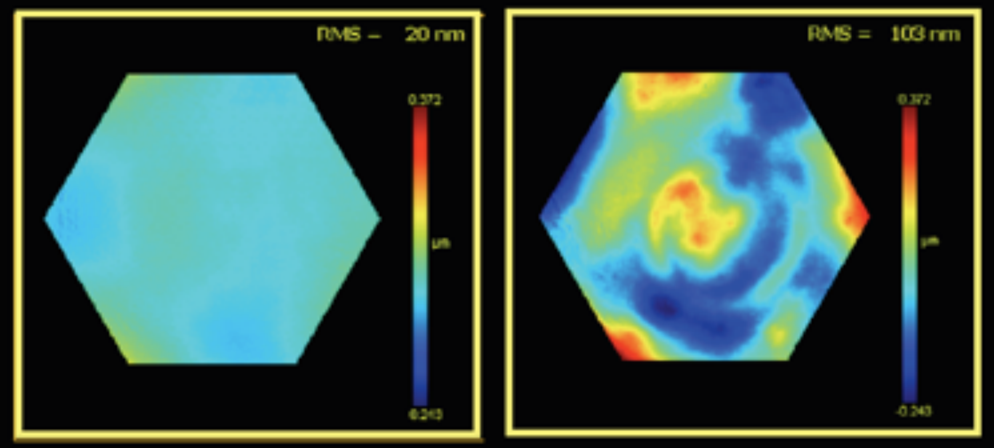


Tertiary mirror



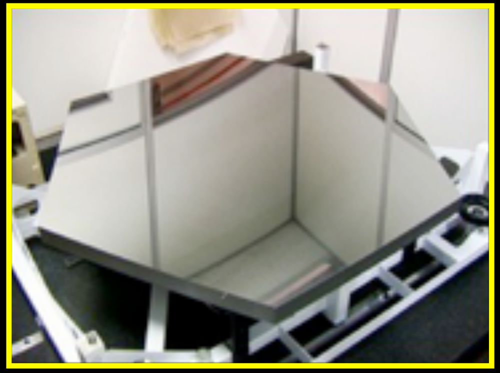
- Machined & lightweighted by Axsys
- 92% material is removed

- Mirrors polished at Tinsley
- Segment cryo-figure: 20 nm



Cryo-surface figure

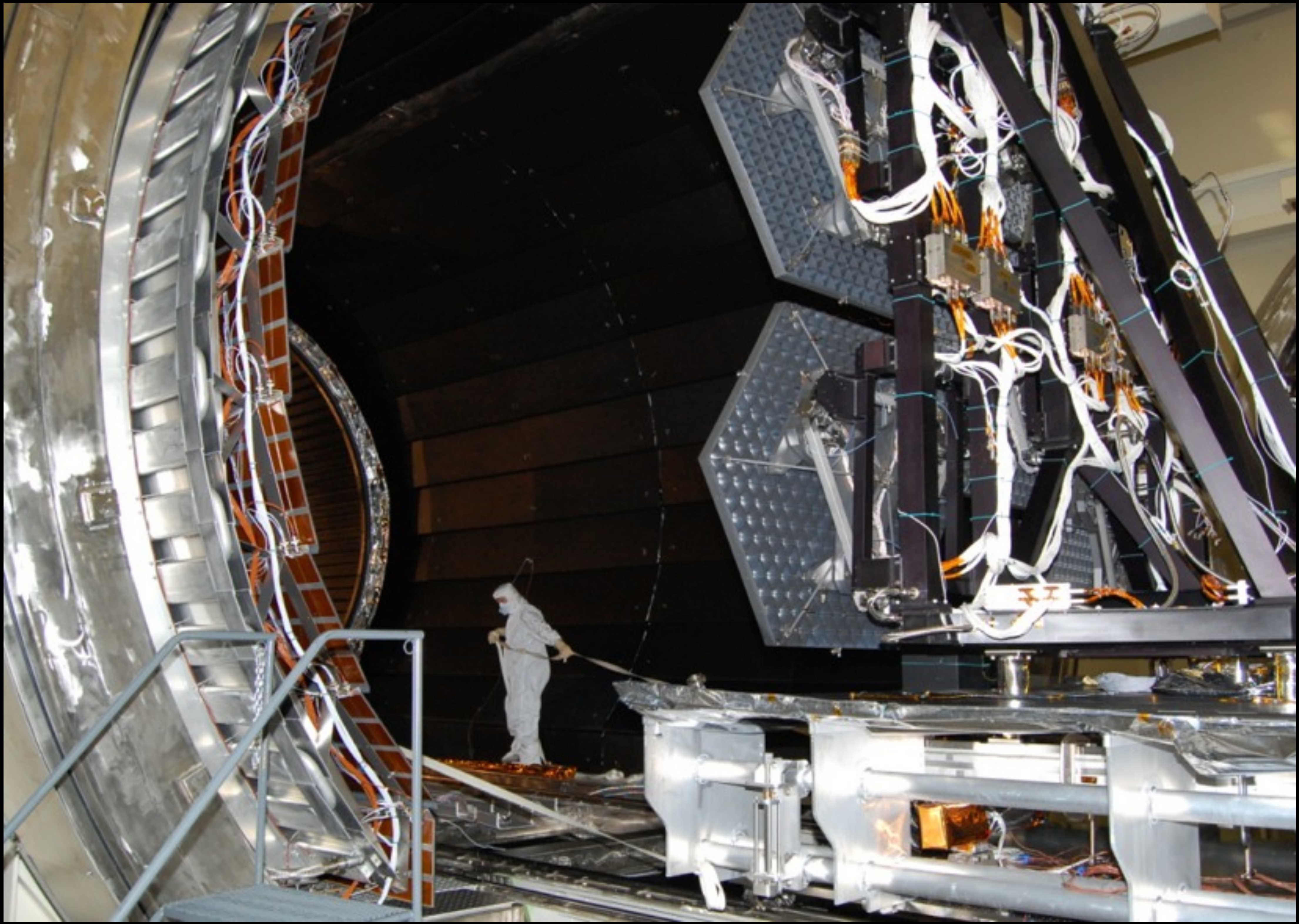
Ambient



Flight Mirror Cryogenic Testing

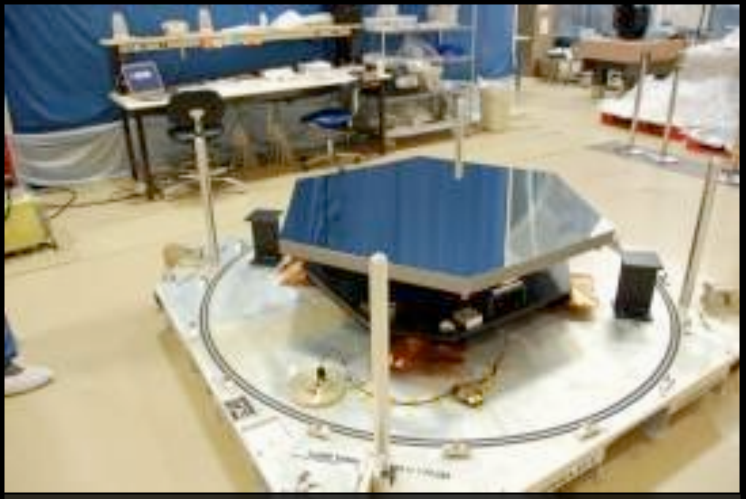
Flight Mirror Cryogenic Testing

Flight Mirror Cryogenic Testing



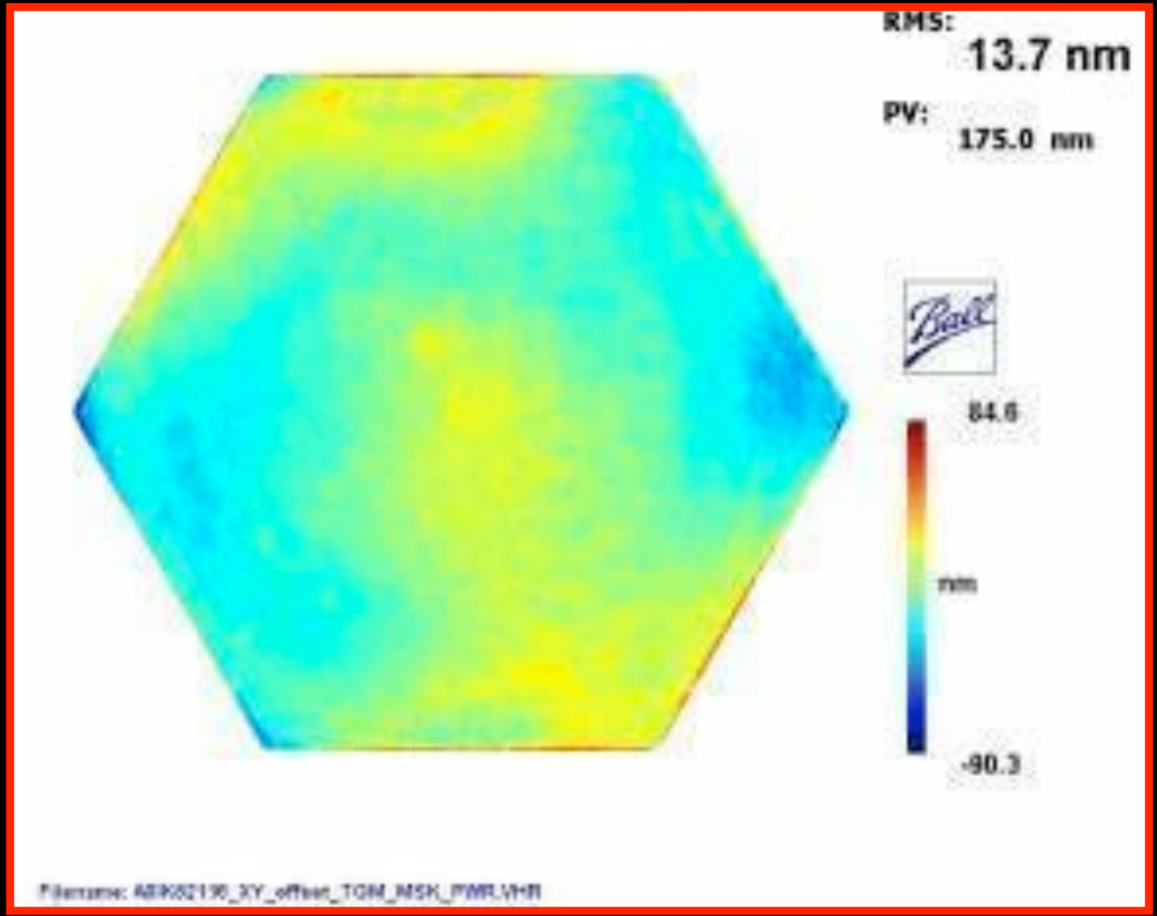
EDU Mirror Cryo-Polish Complete

- Primary Mirror EDU-mirror has completed cryo polishing and meets all specifications
  - Mid Frequency Tinsley Spec: 20nm RMS
  - High Frequency Tinsley Spec: 7nm RMS
- Edges are significantly better that AMSD

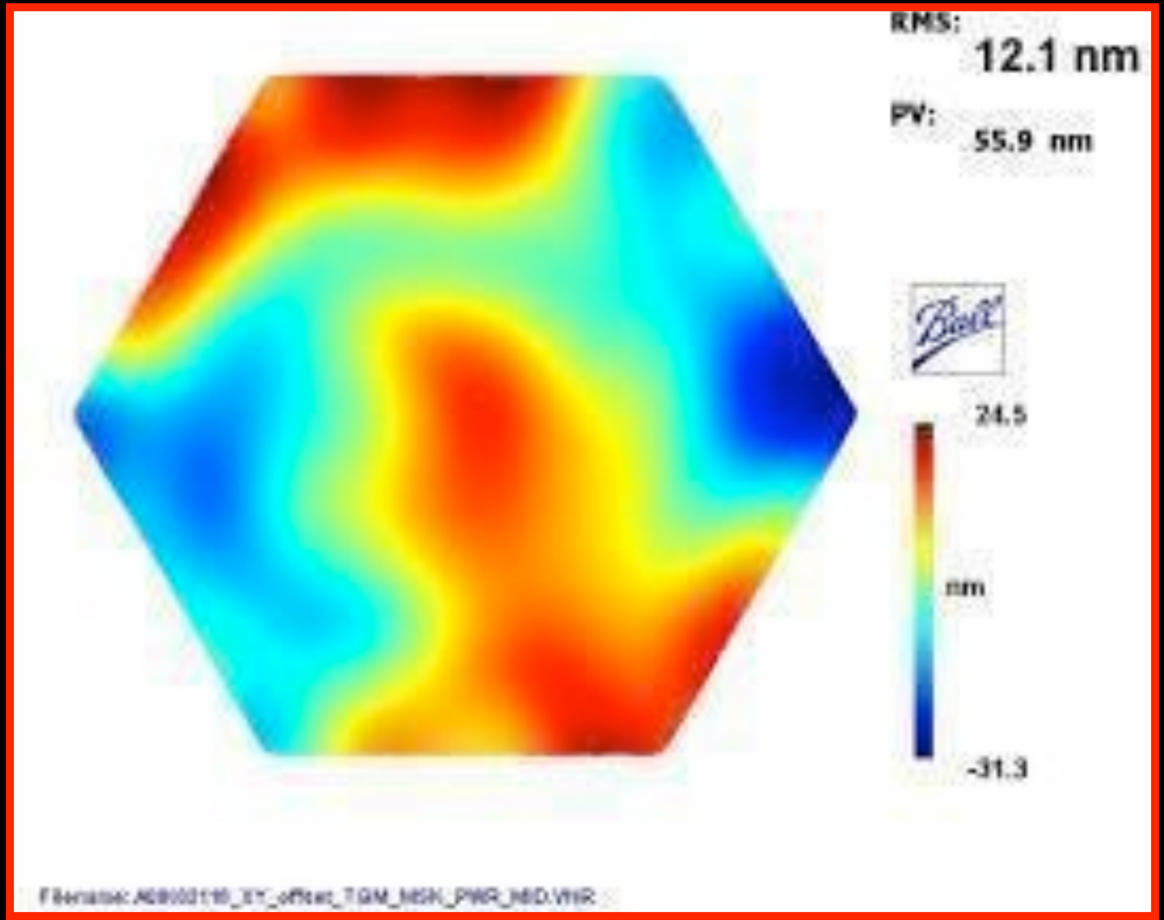


Total Surface Error

Hit Map, Radius, Decenter, and Clocking Removed

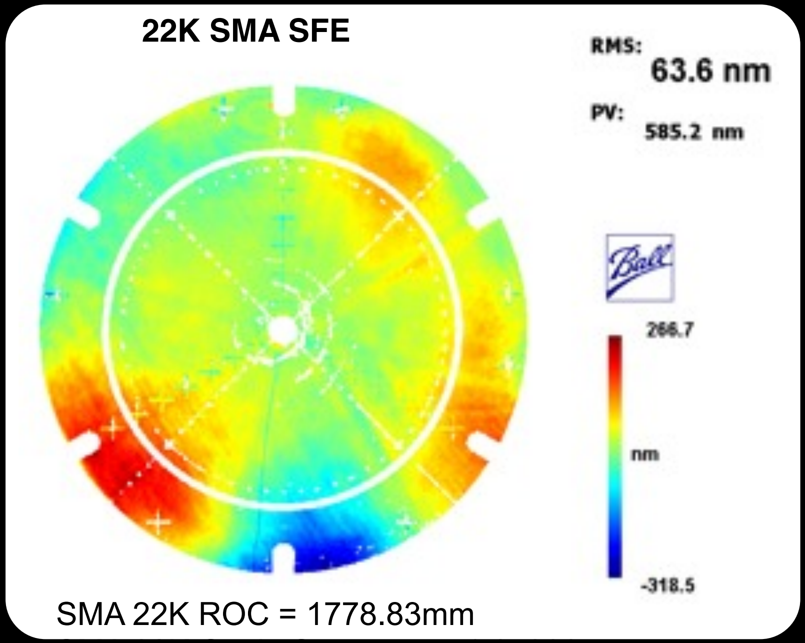


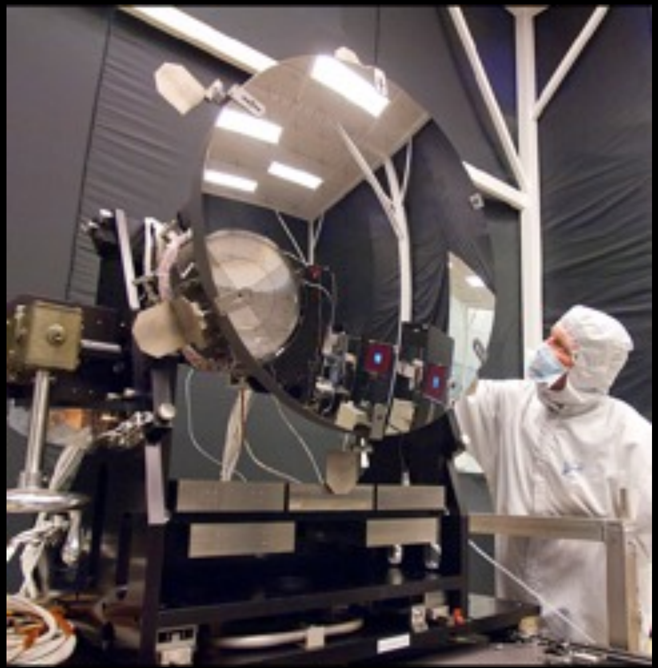
Mid- Frequency Surface Error

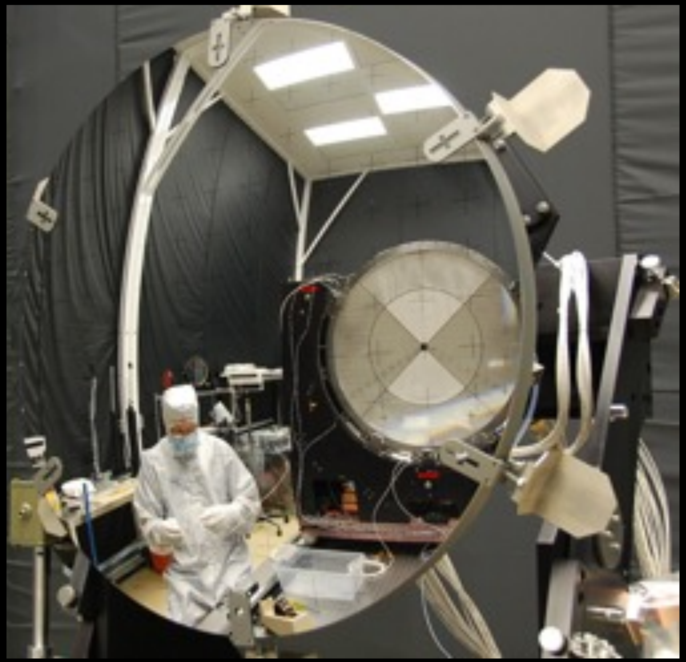


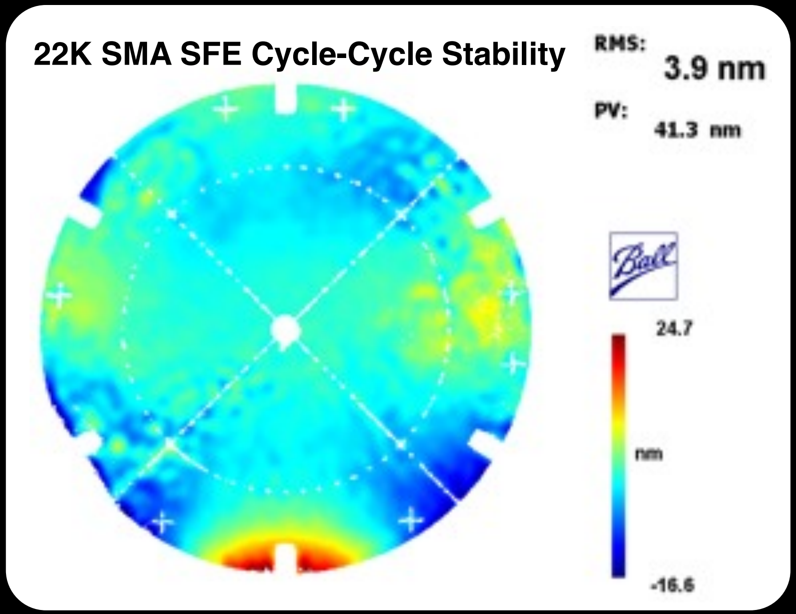
Secondary Mirror Performance

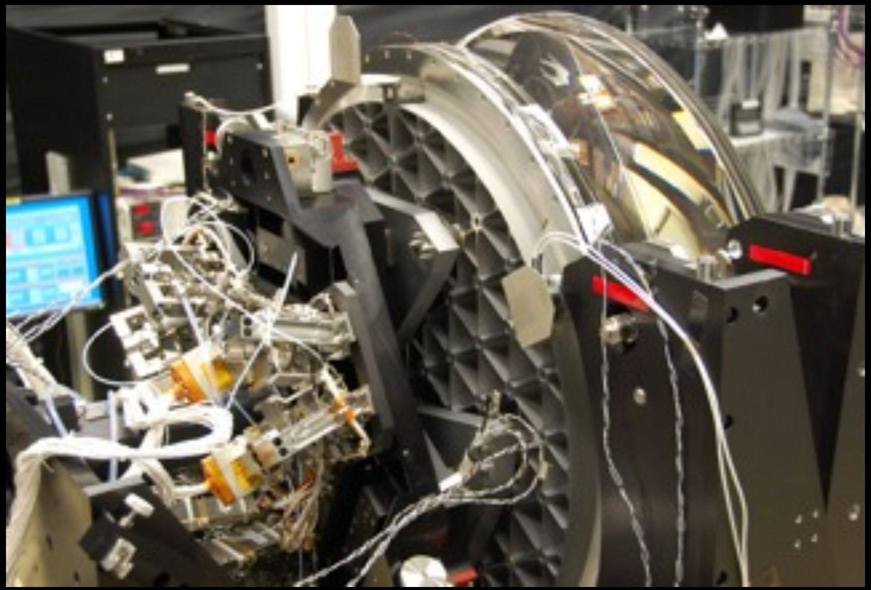
- SM flight spare meets requirements





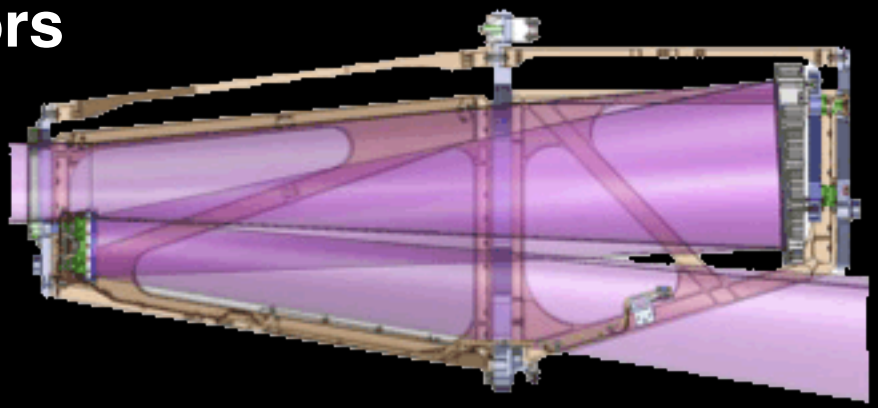


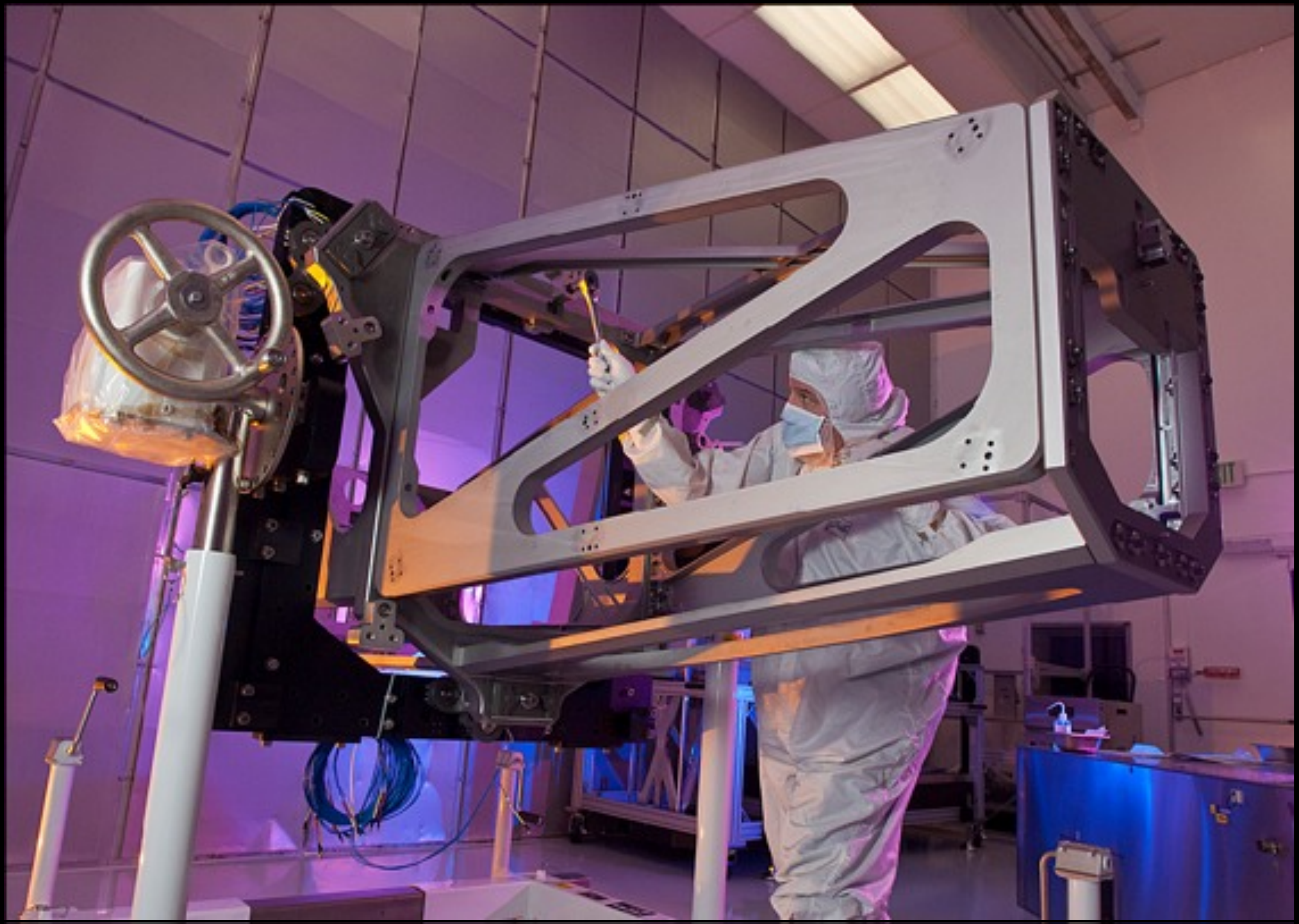




Aft-Optical System

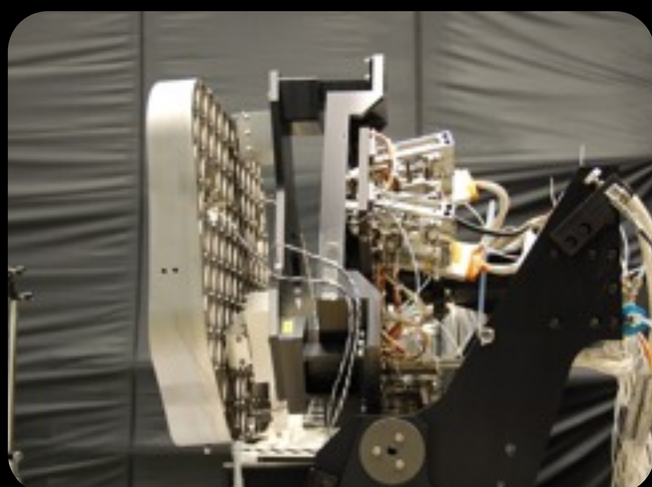
- Tertiary and Fine Steering mirrors
- Baffling for OTE

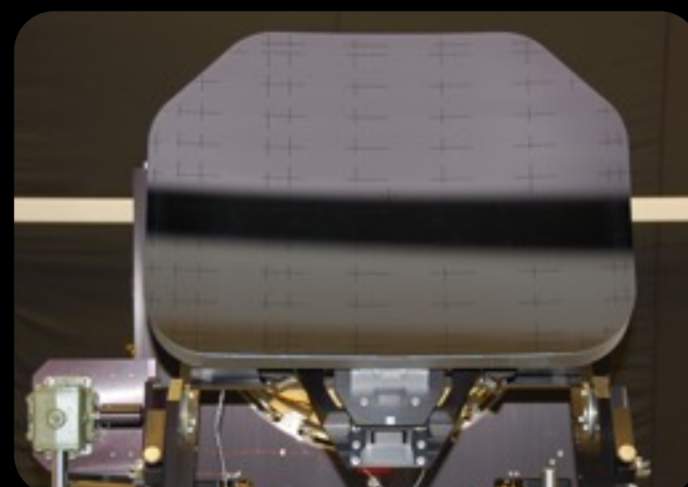


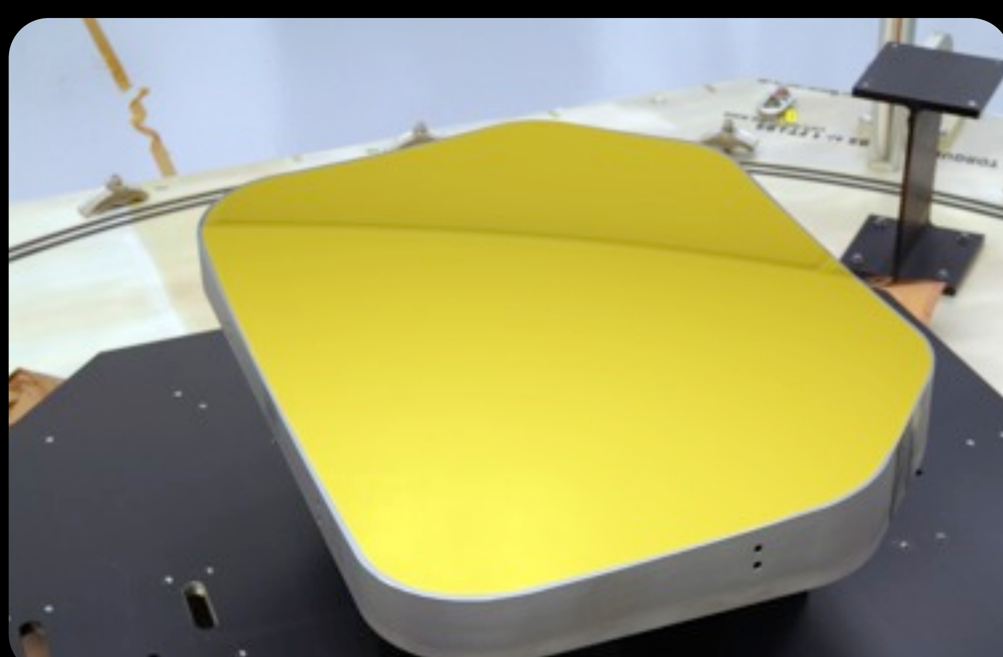


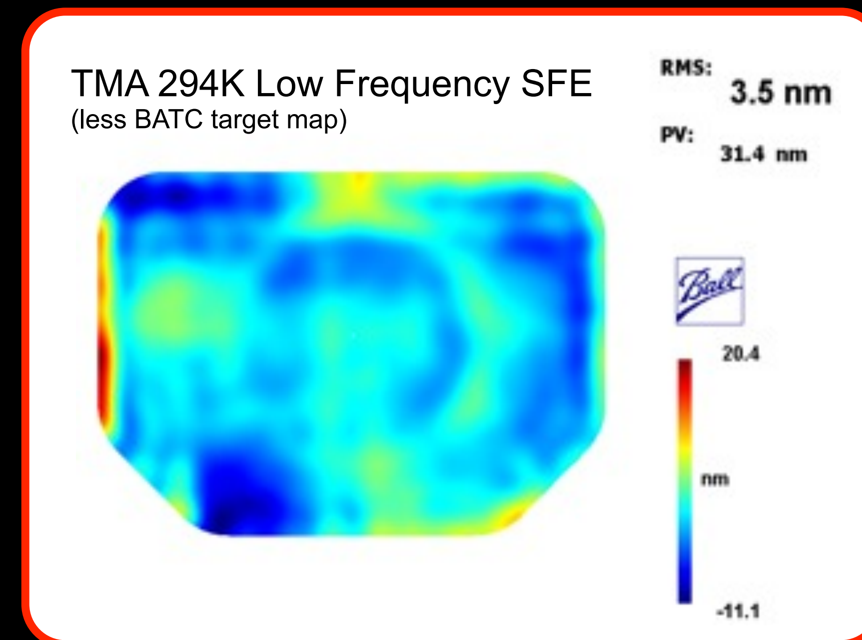
Tertiary Mirror Performance

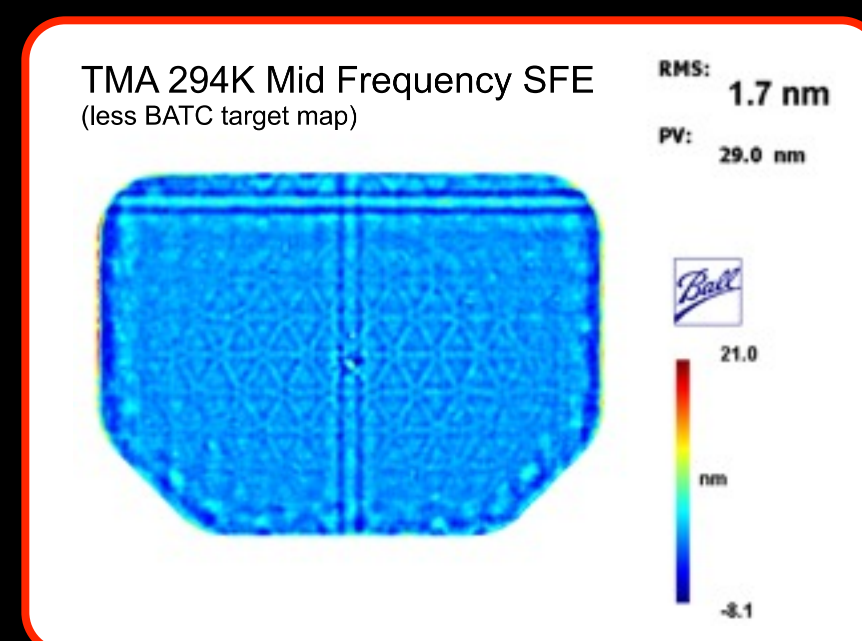
- **Tertiary meets its requirements**





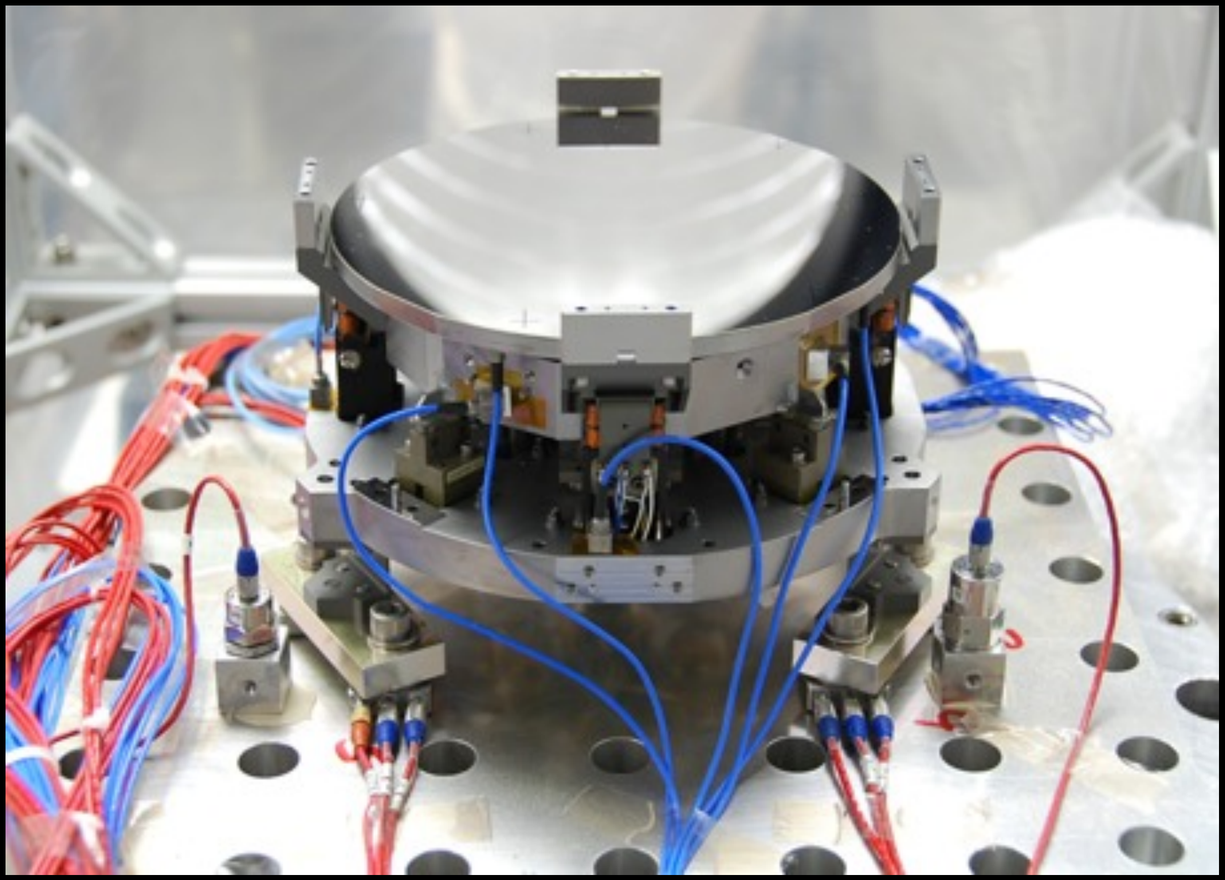


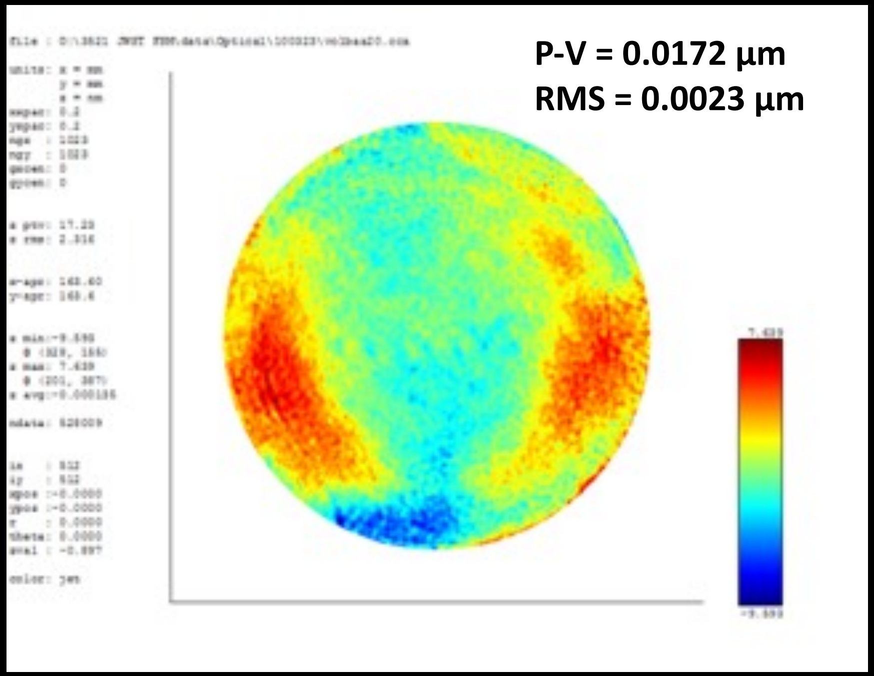


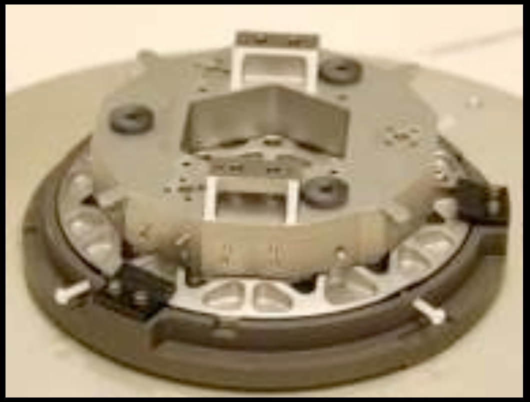



EXIT

Fine Steering Mirror Performance



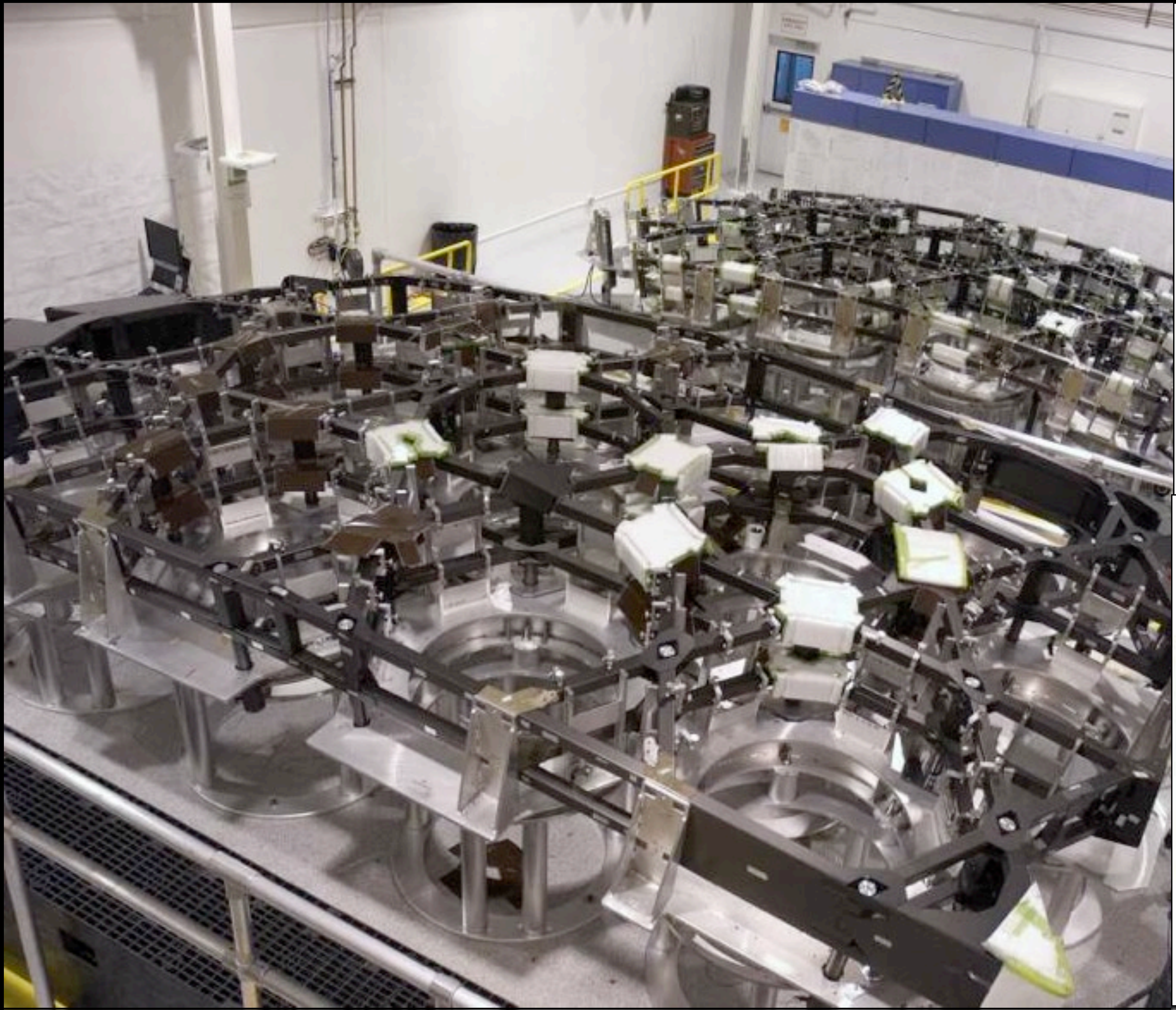


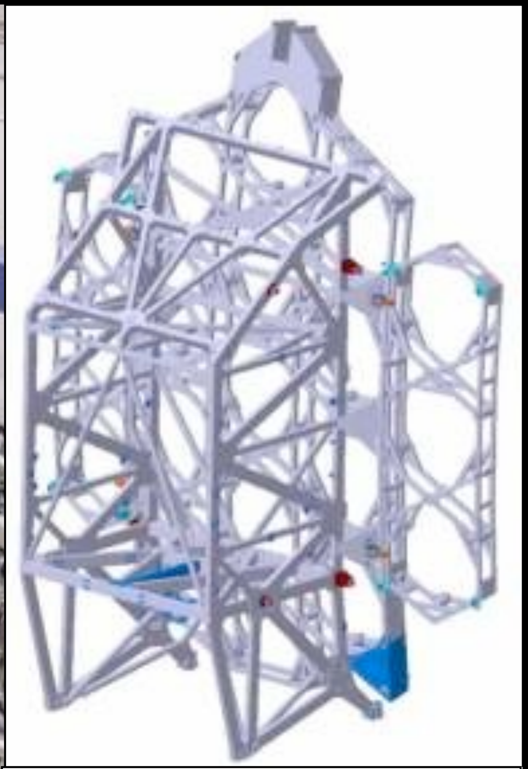


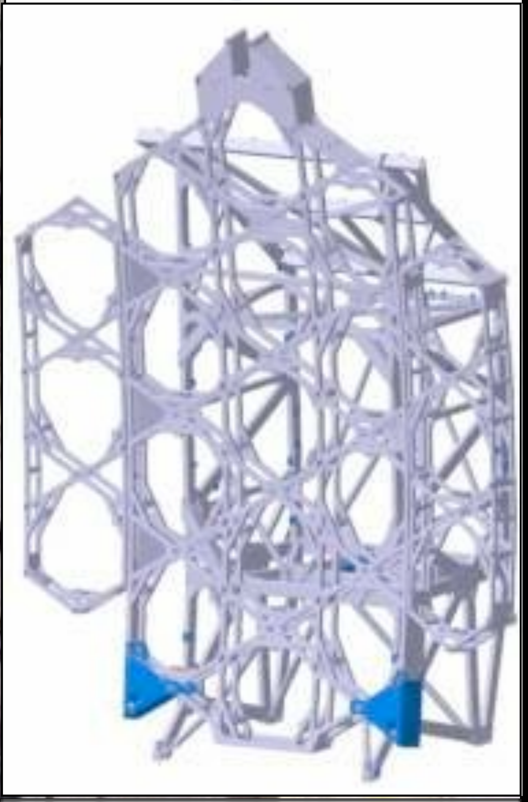
Pre-Configuration
Configuration 1
Configuration 2
Configuration 3

hermetically sealed, vibration isolated, shipping container

Pathfinder Center Section Bonding







Phasing the Telescope

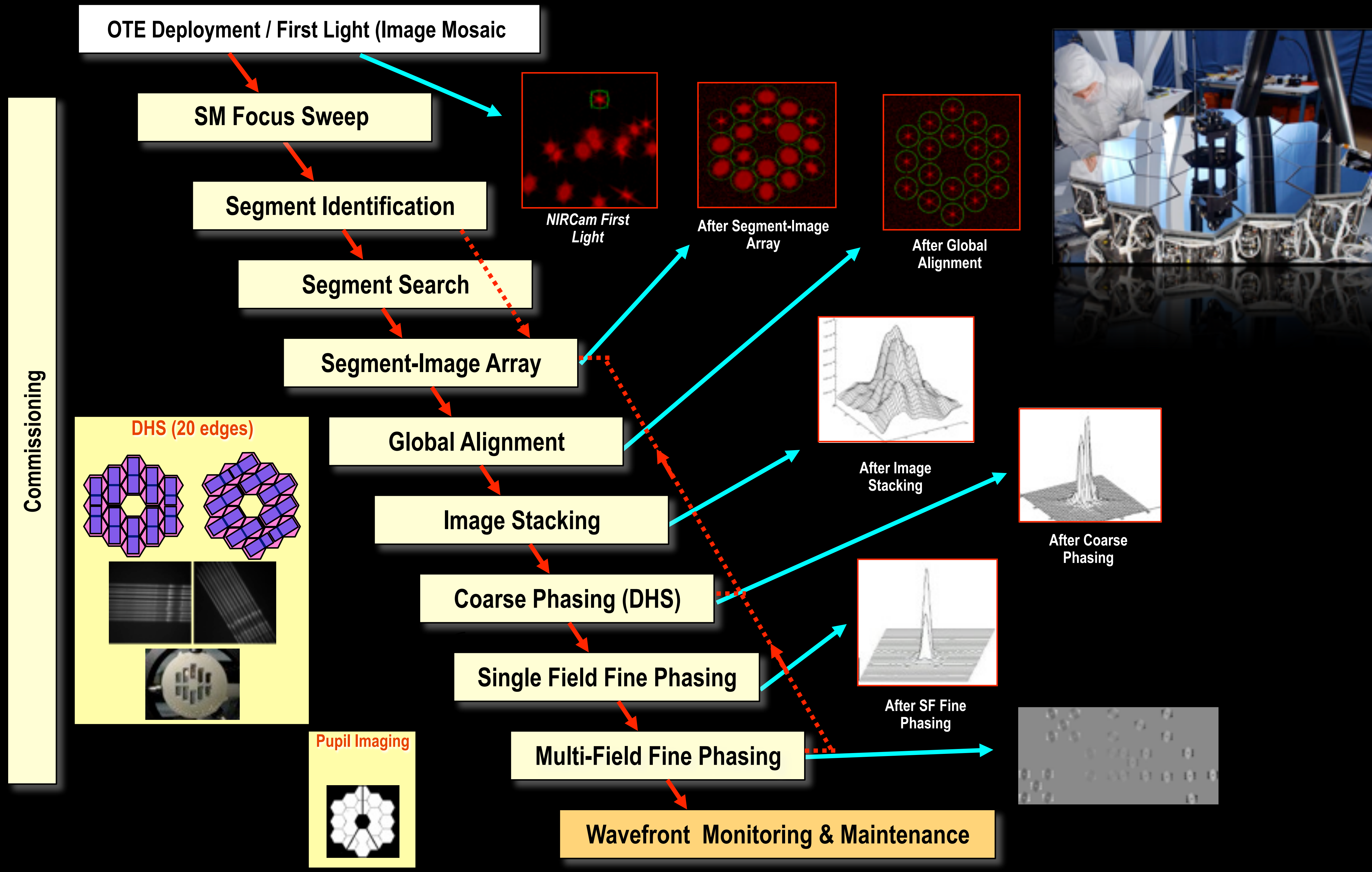
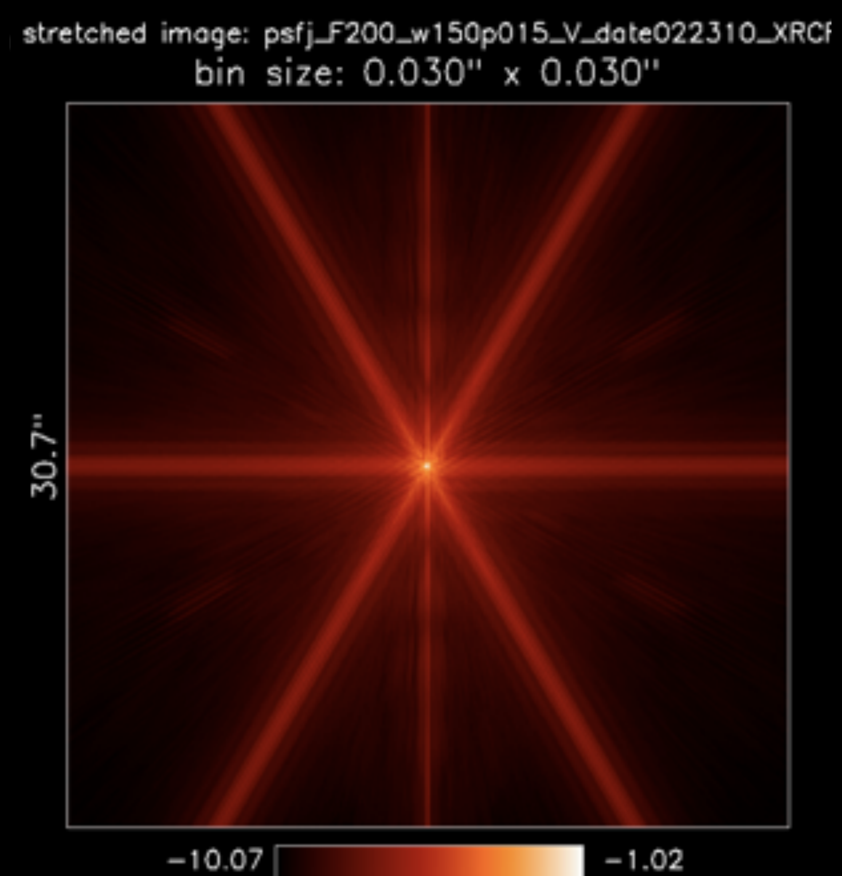
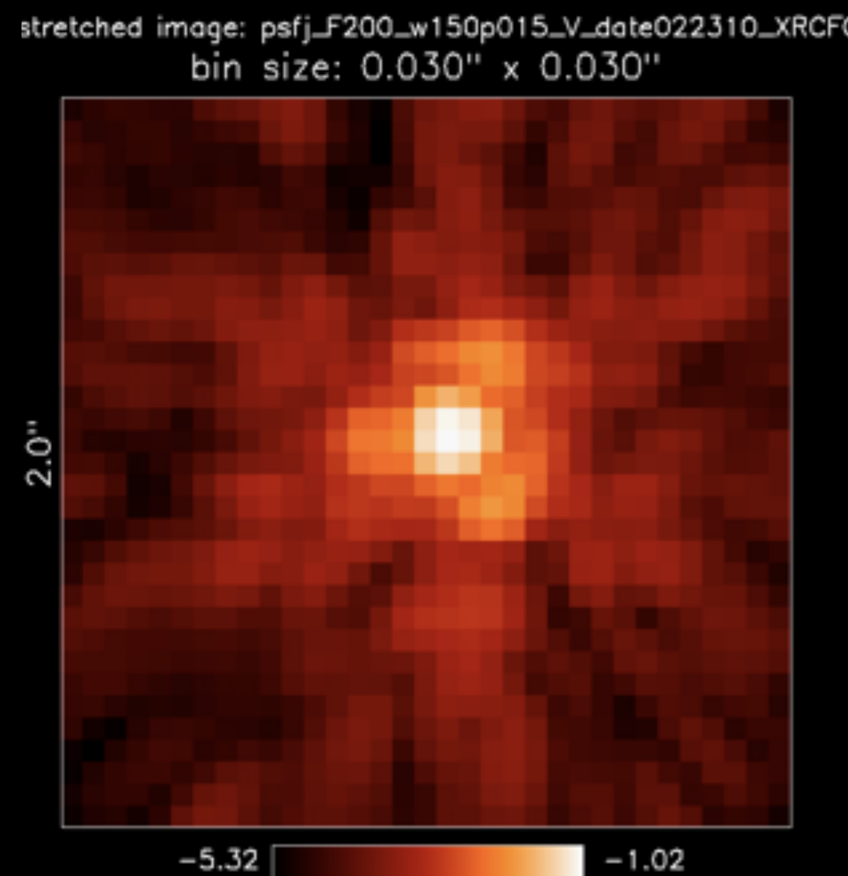


Image Quality: 2 µm

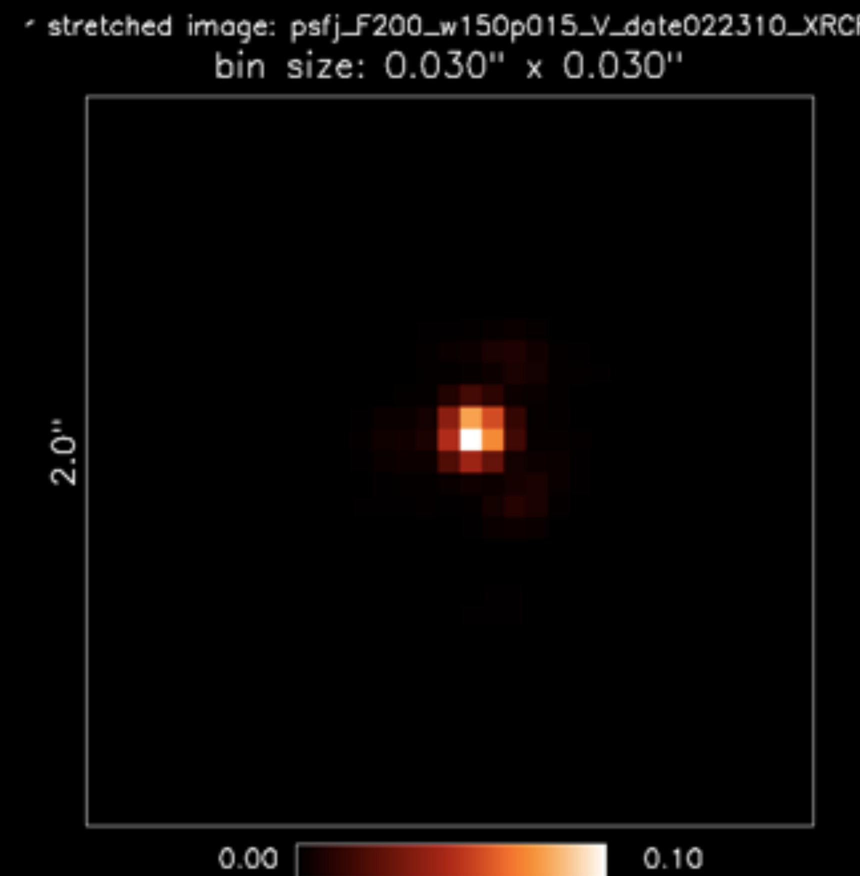
- Note that this is a key JWST requirement



Log scale: 30.7” x 30.7”



Log scale: 2.0” x 2.0”

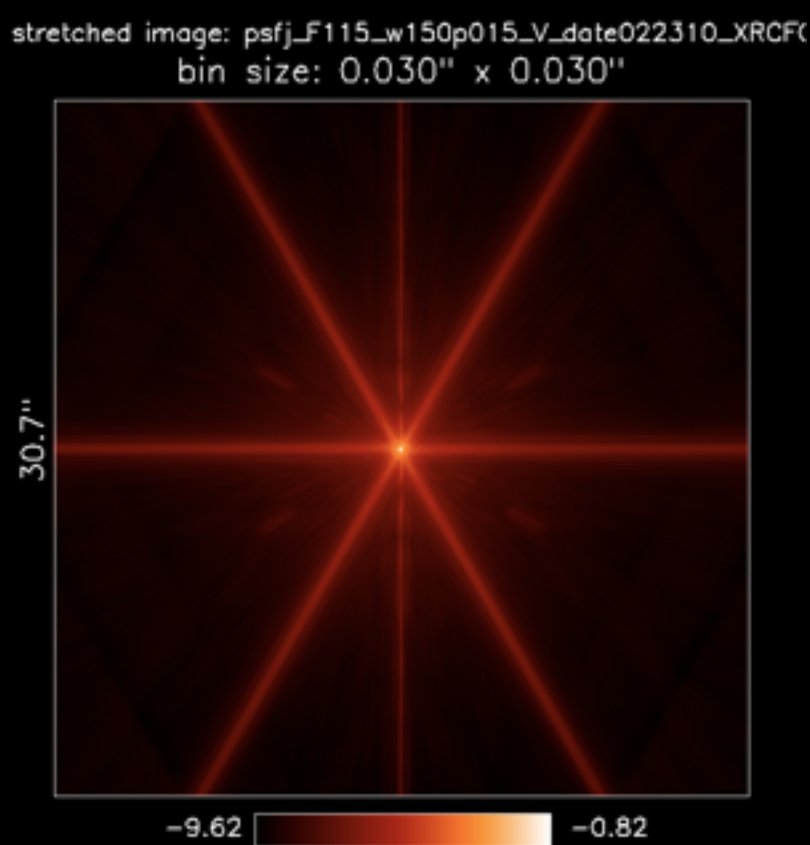


Linear scale: 2.0” x 2.0”

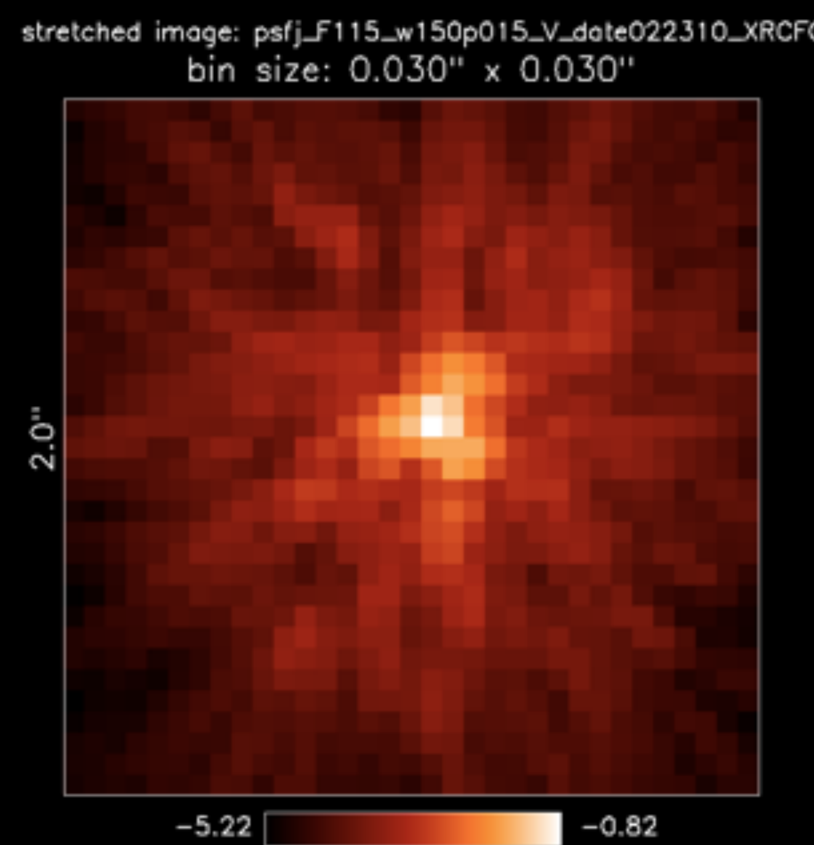
F200W

Image Quality: 1 μm

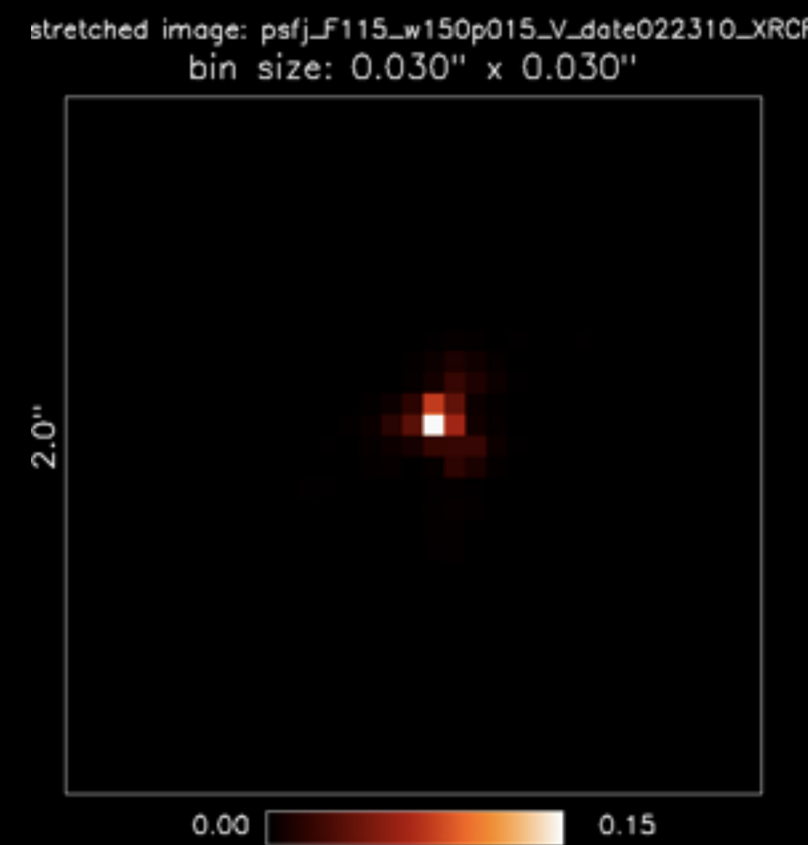
- Driven by Wavefront error requirements at 2.0 μm



Log scale: 30.7" x 30.7"



Log scale: 2.0" x 2.0"

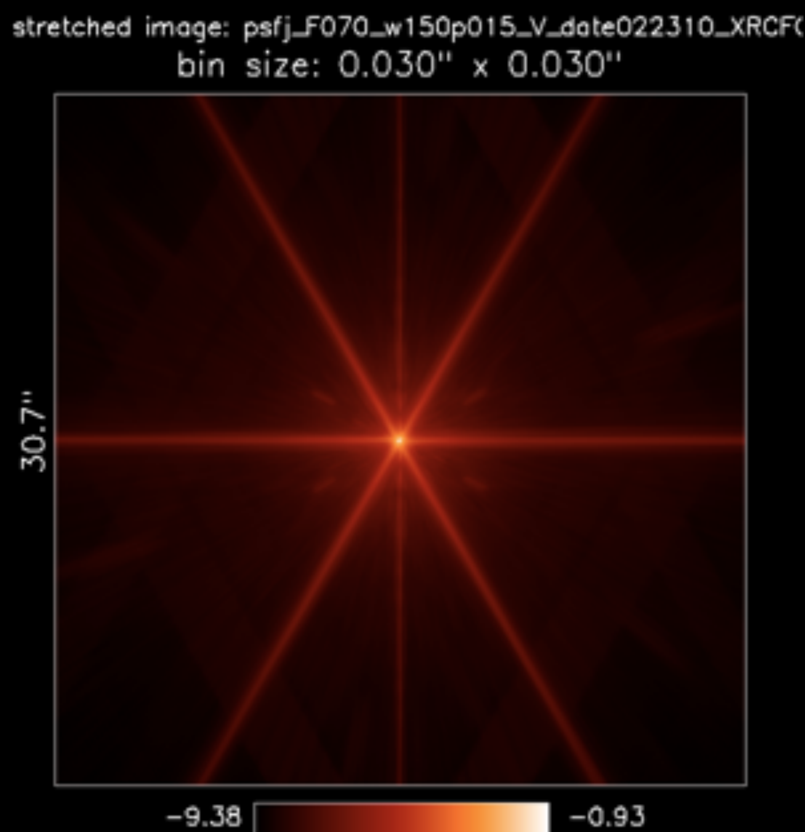


Linear scale: 2.0" x 2.0"

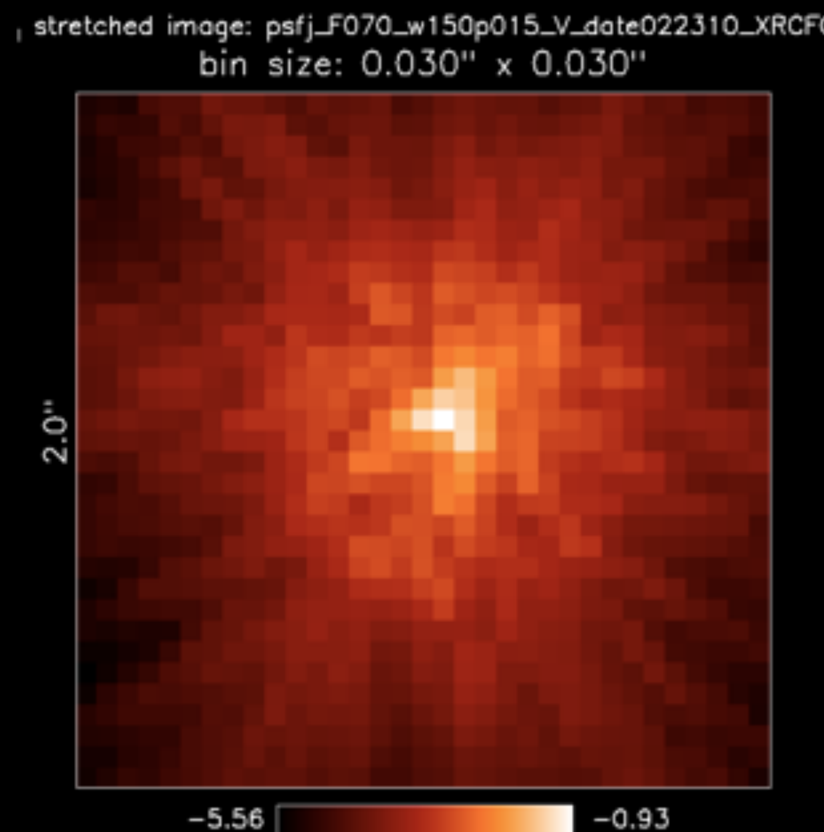
F115W

Image Quality: 0.7 μm

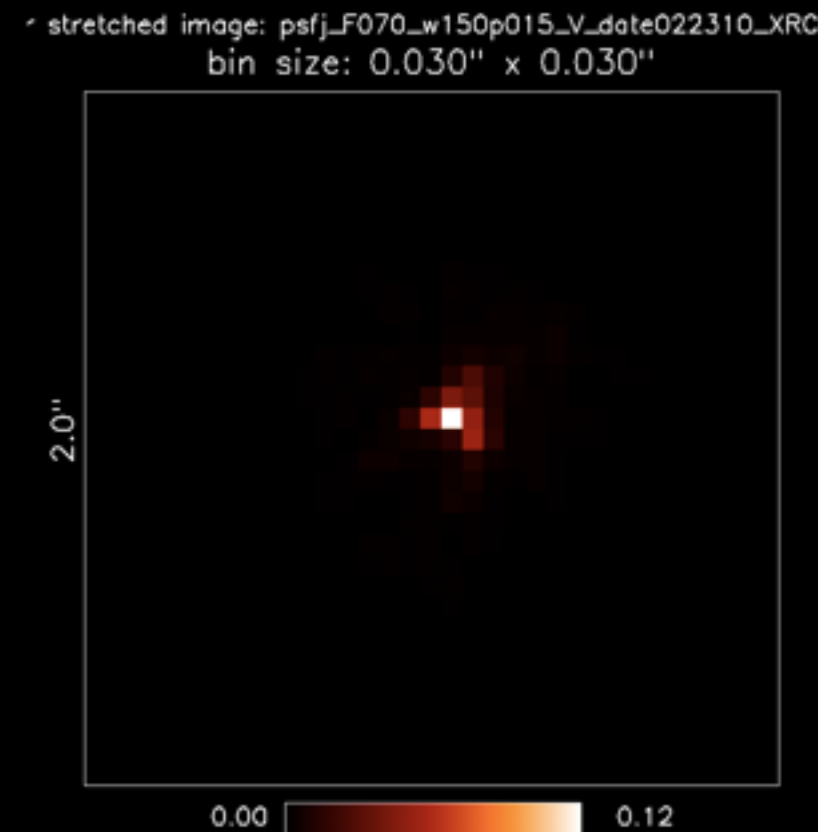
- Driven by Wavefront error requirements at 2.0 μm



Log scale: 30.7" x 30.7"



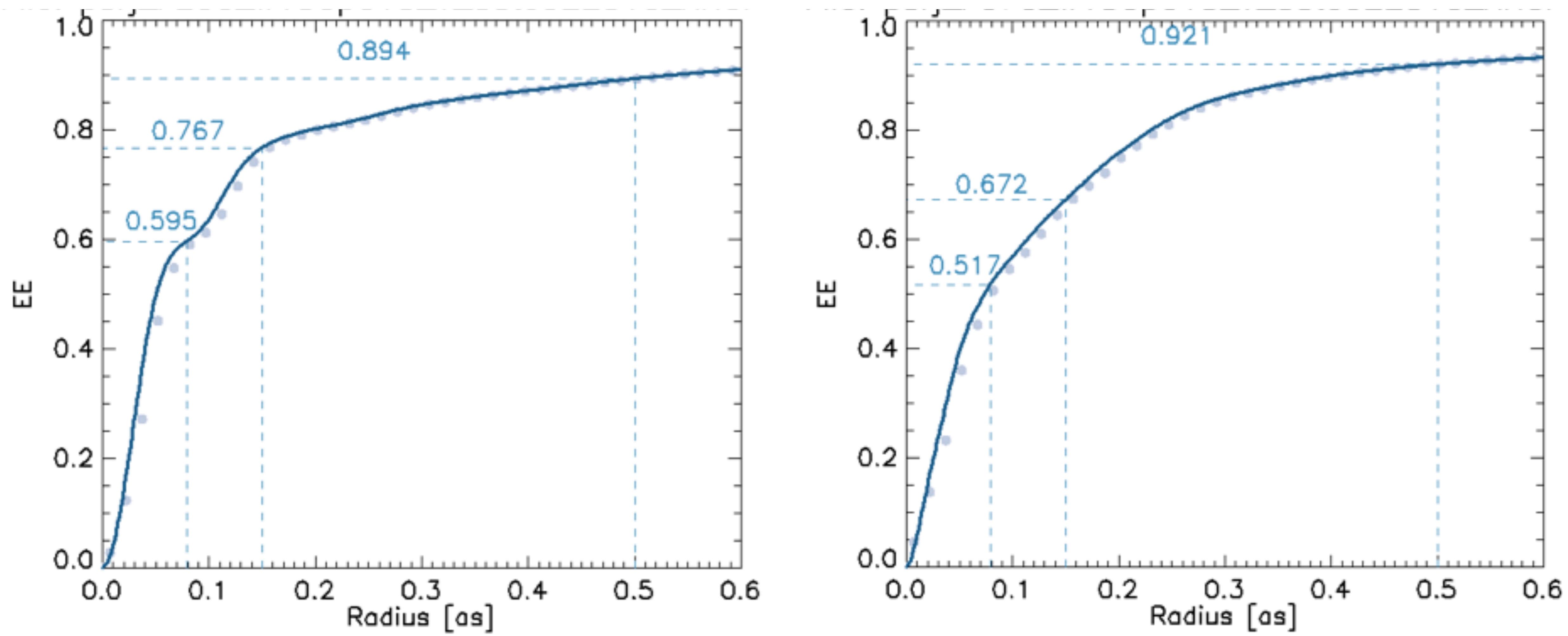
Log scale: 2.0" x 2.0"



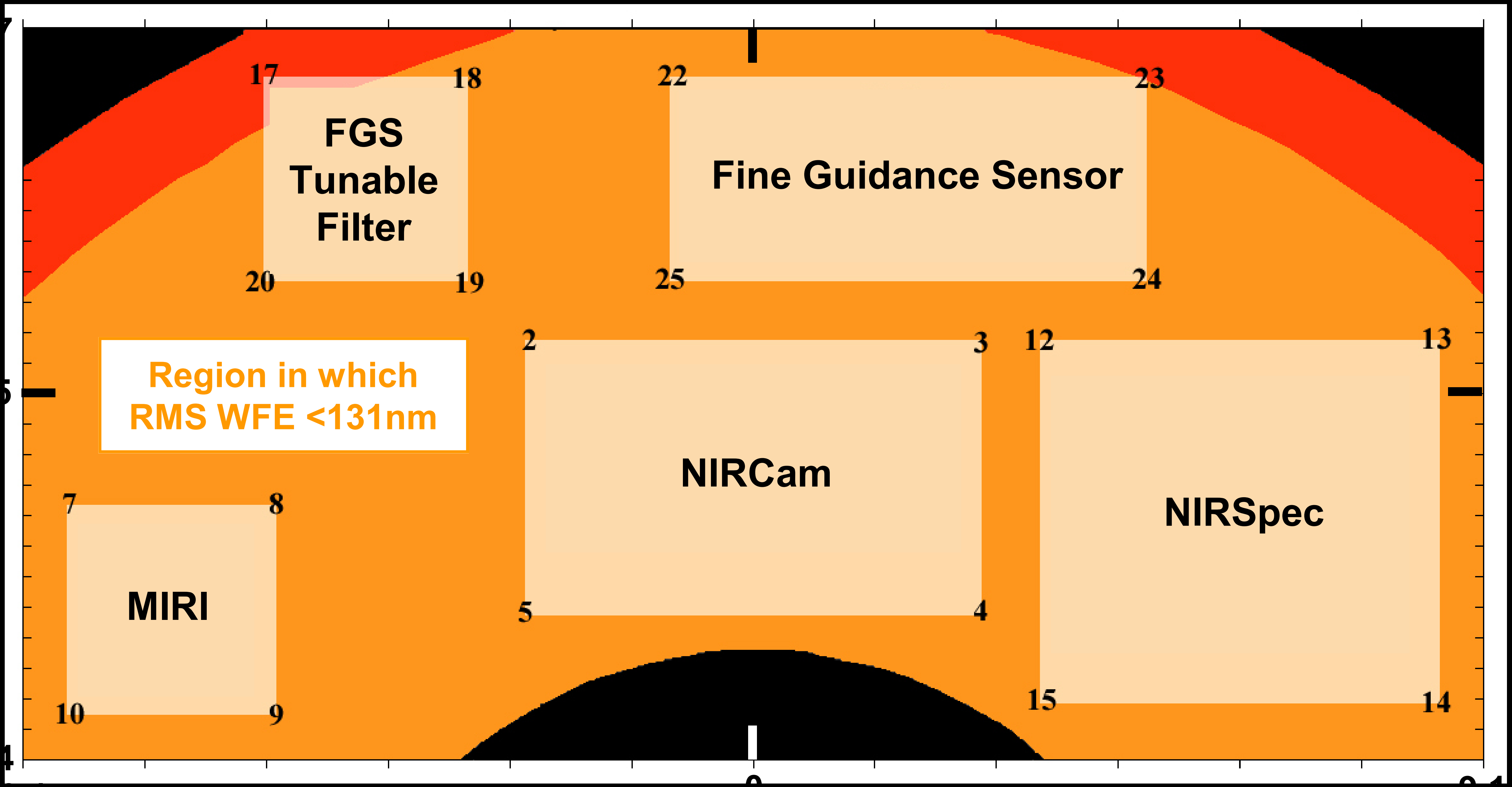
Linear scale: 2.0" x 2.0"

F070W

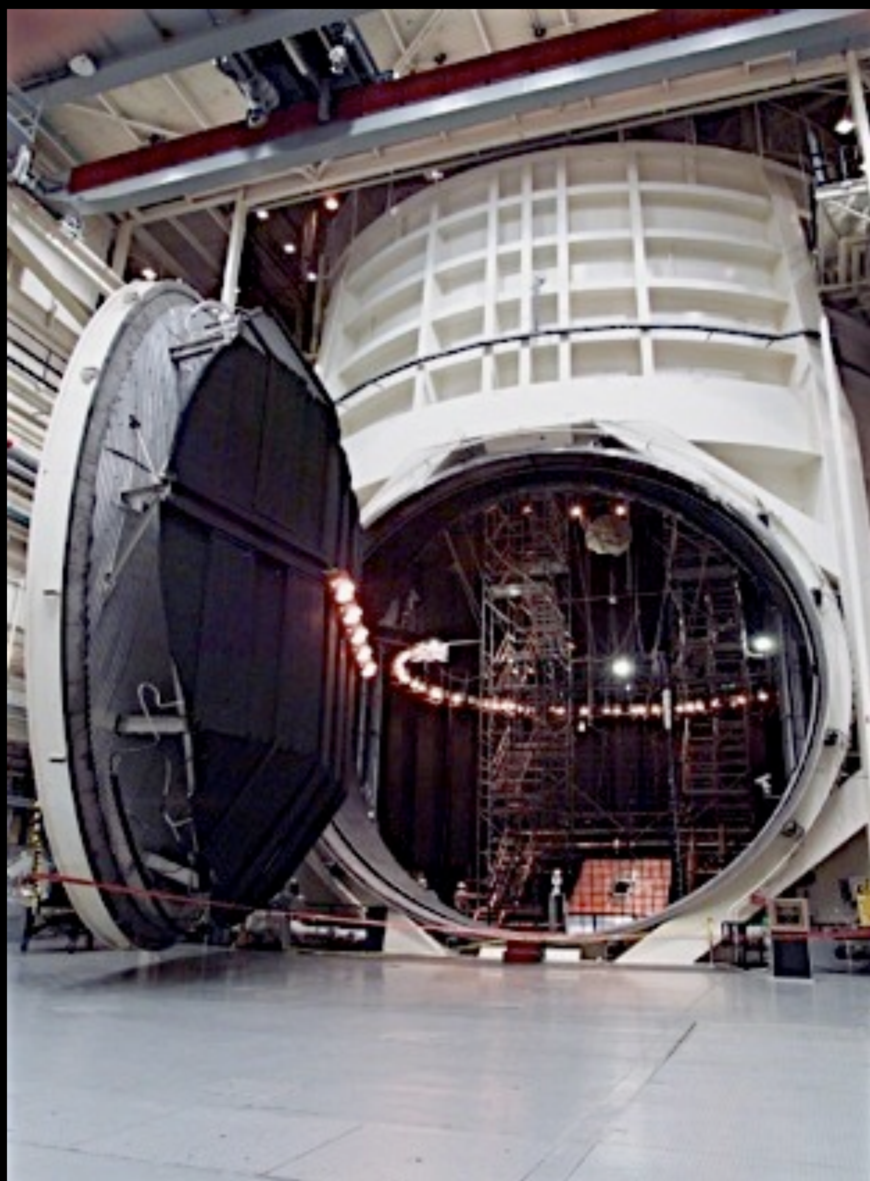
Image Quality: Encircled Energy

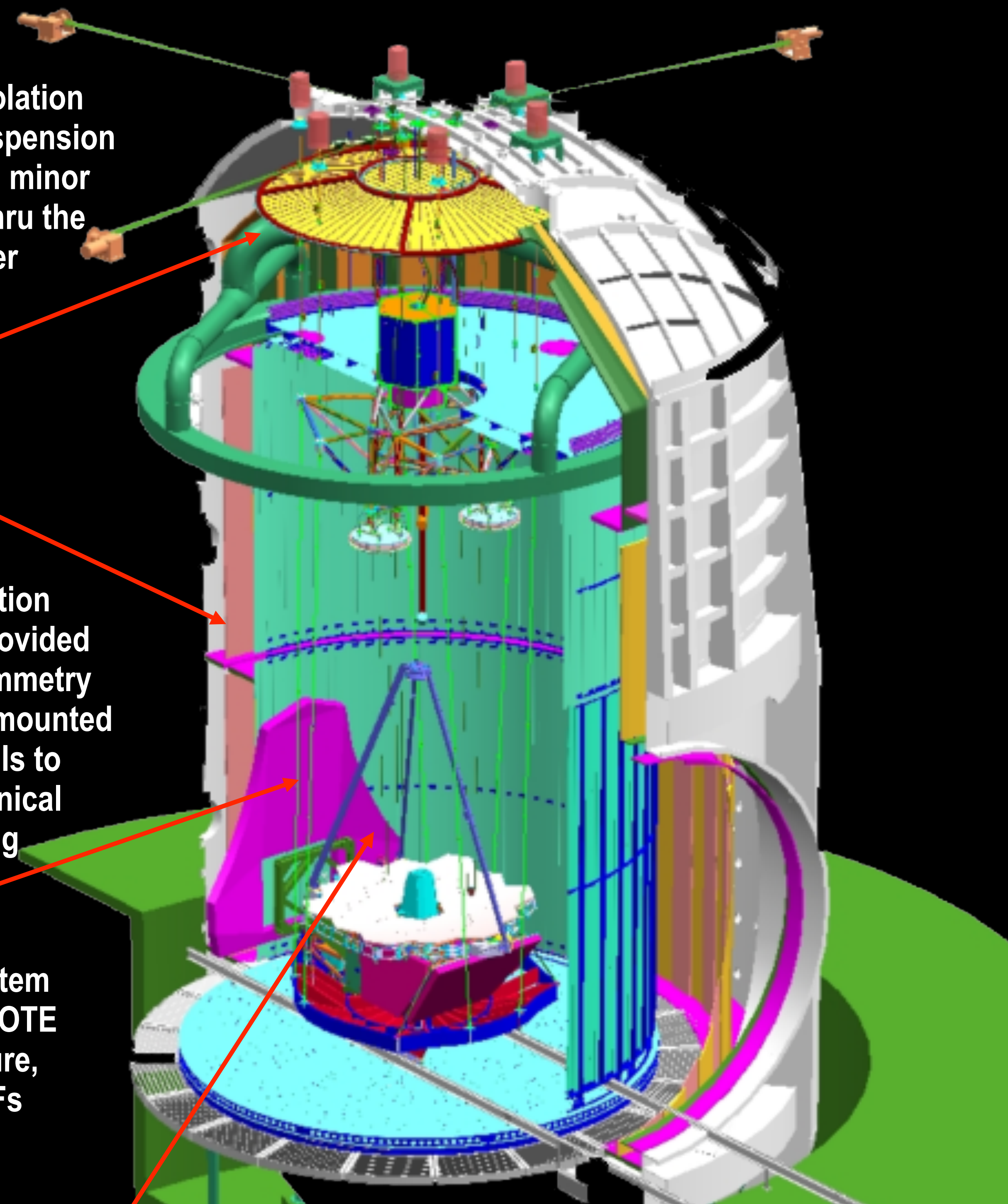


JWST: Fields of View



Optical End-to-End Test @ JSC





Vibration isolation system for suspension system. Six minor intrusions thru the chamber

Cryo-Position Metrology provided by photogrammetry with cameras mounted on windmills to provide conical scanning

Suspension system which holds the OTE support structure, CoCI, and ACFs

Test sources mounted on the AOS entrance. Inward sources sample the Tertiary Mirror. Outward sources make a pass and a half thru the OTE optics.

Sunshield

Sunshield Development

Evolutionary Pathfinder

EPF-0 provided first evaluations of full scale membrane

EPF-0 folding characterized membrane behavior and stowed configuration

Tensioned EPF-2 Membrane (flight like on RH side)

EPF-2 Membrane revealed core shape issues

Bench Test Articles

Core Model for Rim deployment and inner membrane surface development (Hub & Rim shown)

“Spandex” Model for tensioned membrane shape visualization

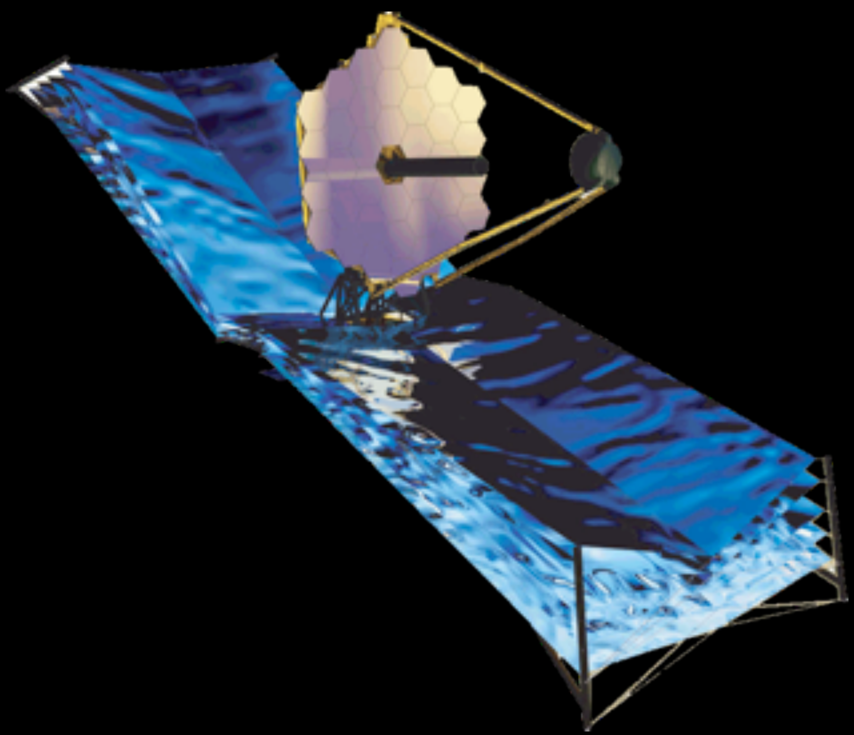
Lattice Configuration Acoustic Test Panel to validate Unitized Pallet Structure loads

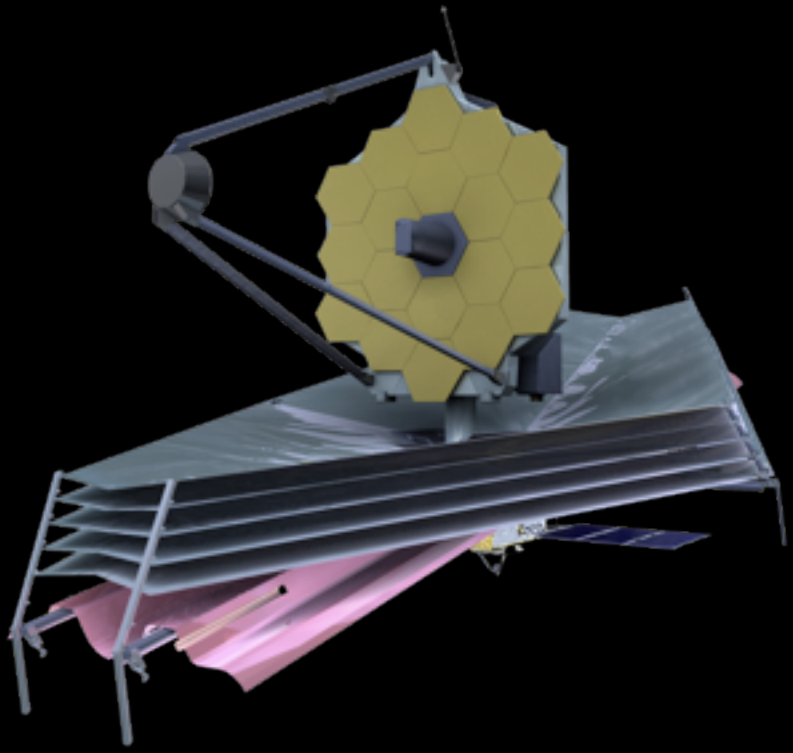
Gore Validation Model for FEM analysis correlation

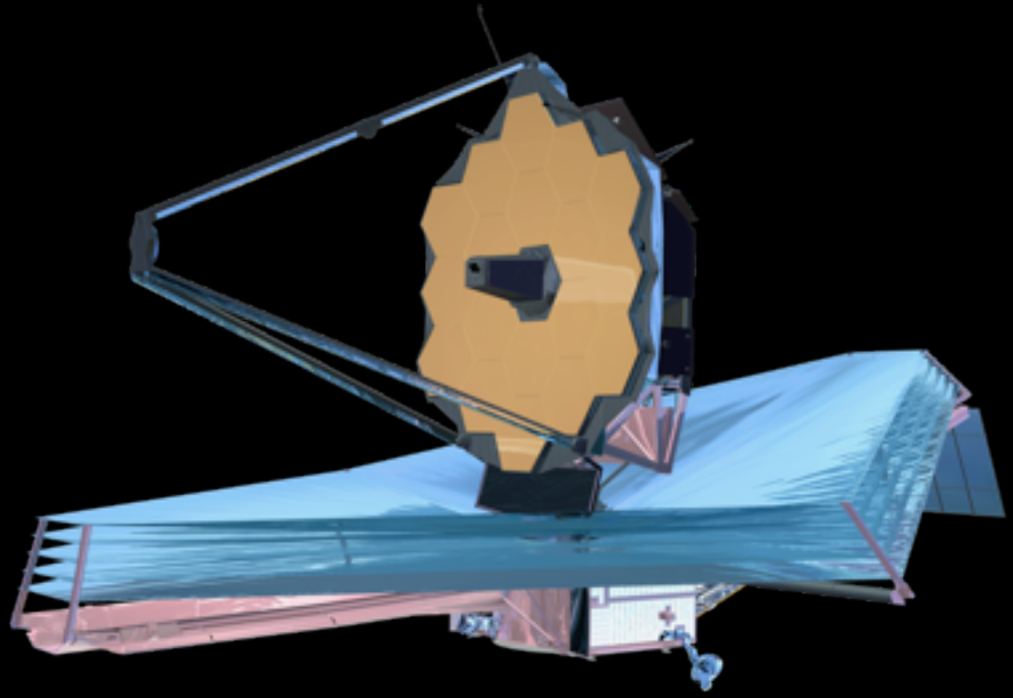
1/3rd Scale Sunshield

1/3rd Scale Sunshield

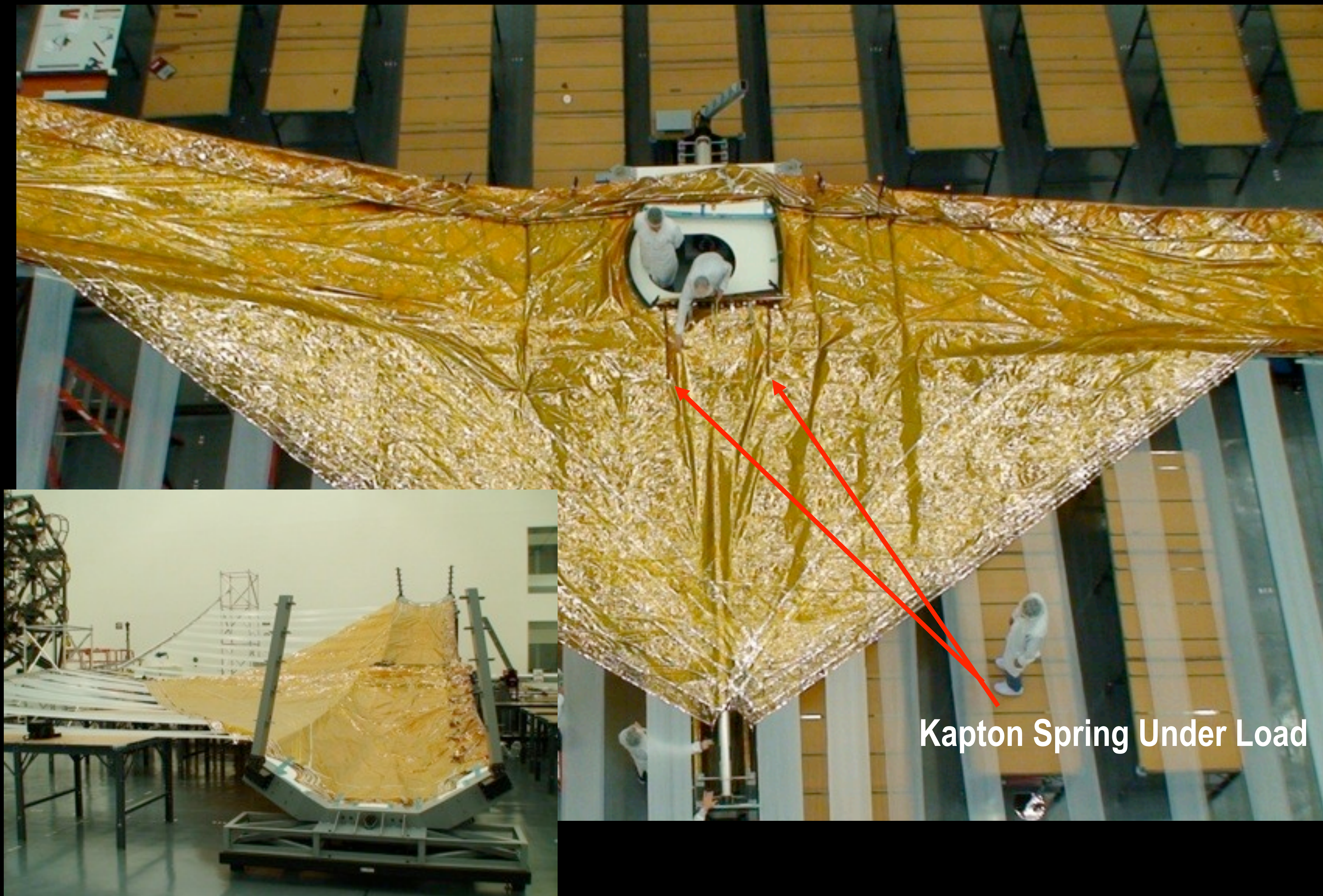
Sunshield Evolution







Sunshield Deployment Testing

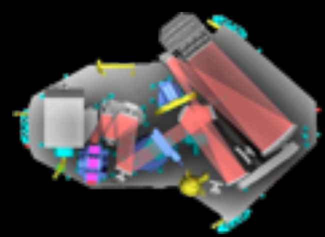


Backplane/Sunshield Mockup

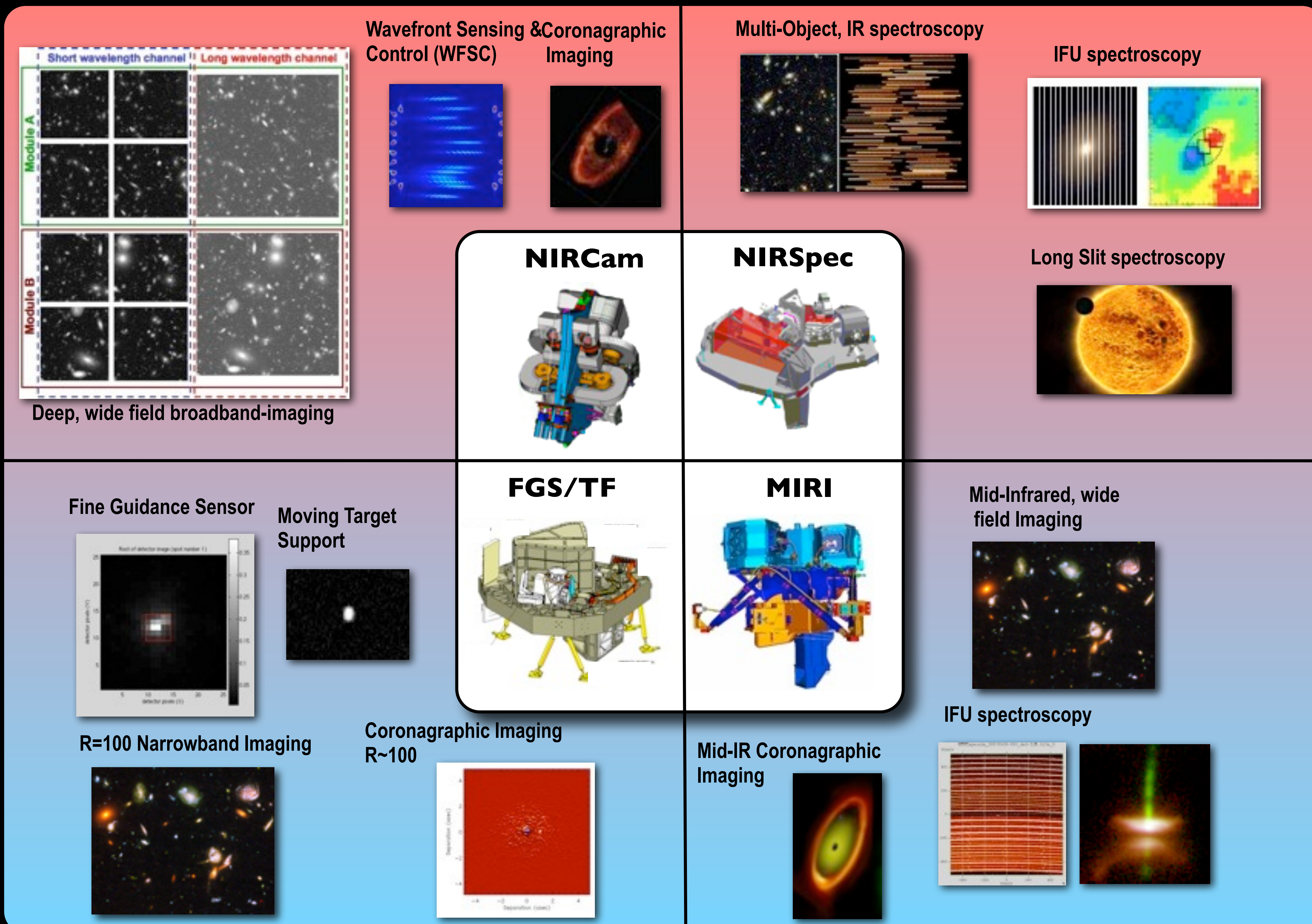
- Backplane Metrology
- Clearance checking
- Sunshield systems testing


ISIM
EXIT

JWST Instrumentation

Instrument	Science Goal	Capability
NIRCam Univ. Az 	Wide field, deep imaging ‣0.6 µm - 2.3 µm (SW) ‣2.4 µm - 5.0 µm (LW)	Two 2.2' x 2.2' SW Two 2.2' x 2.2' LW
NIRSpec ESA 	Multi-object spectroscopy ‣0.6 µm - 5.0 µm	9.7 Sq arcmin Ω 100 selectable targets R=100, 1000
MIRI ESA/JPL 	Mid-infrared imaging ‣ 5 µm - 27 µm Mid-infrared spectroscopy ‣ 4.9 µm - 28.8 µm	1.9' x1.4 ' 3.7"x3.7" - 7.1"x7.7" R=3000 - 2250
FGS/TFI CSA 	Fine Guidance Sensor 0.8 µm - 5.0 µm Tunable Filter Imager ‣1.6 µm - 4.9 µm	Two 2.3' x 2.3' 2.2' x 2.2' R=100

JWST Instruments

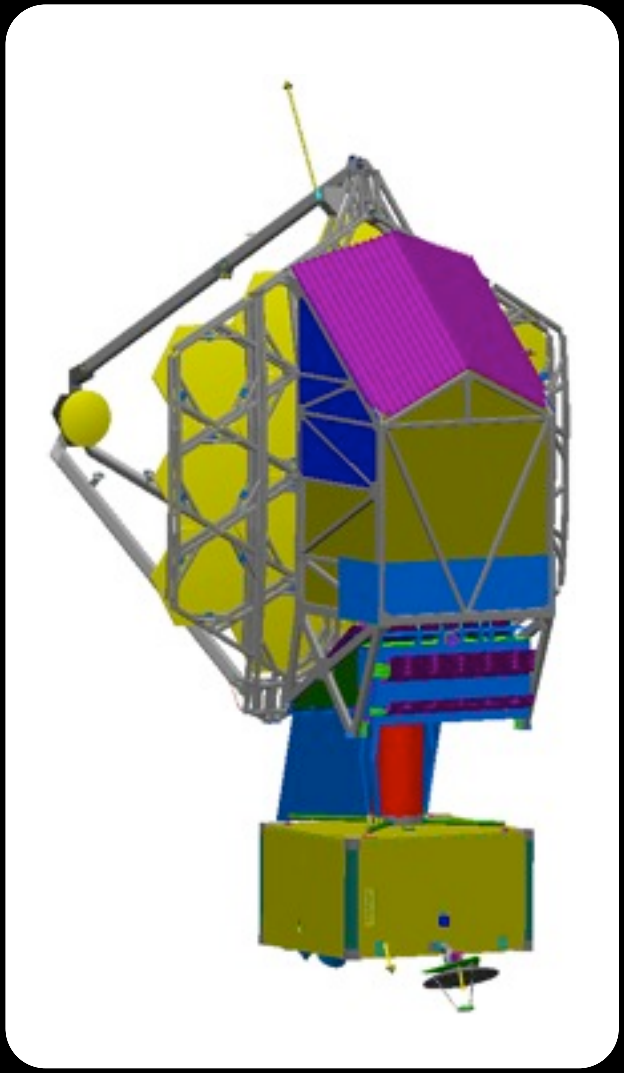


ISIM Architecture

ISIM is:

The JWST Science Instruments

Associated Infrastructure: Structure, Thermal Subsystem, C&DH, & FSW



Region 1:

Science Instrument Optics Assemblies

Near Infrared Camera (NIRCam)

Near Infrared Spectrograph (NIRSpec)

Mid Infrared Instrument (MIRI)

Fine Guidance Sensor w/Tunable Filter (FGS/TF)

Optical Bench Structure

Radiators and support structure (NGST-supplied)

Region 2:

ISIM Electronics Compartment

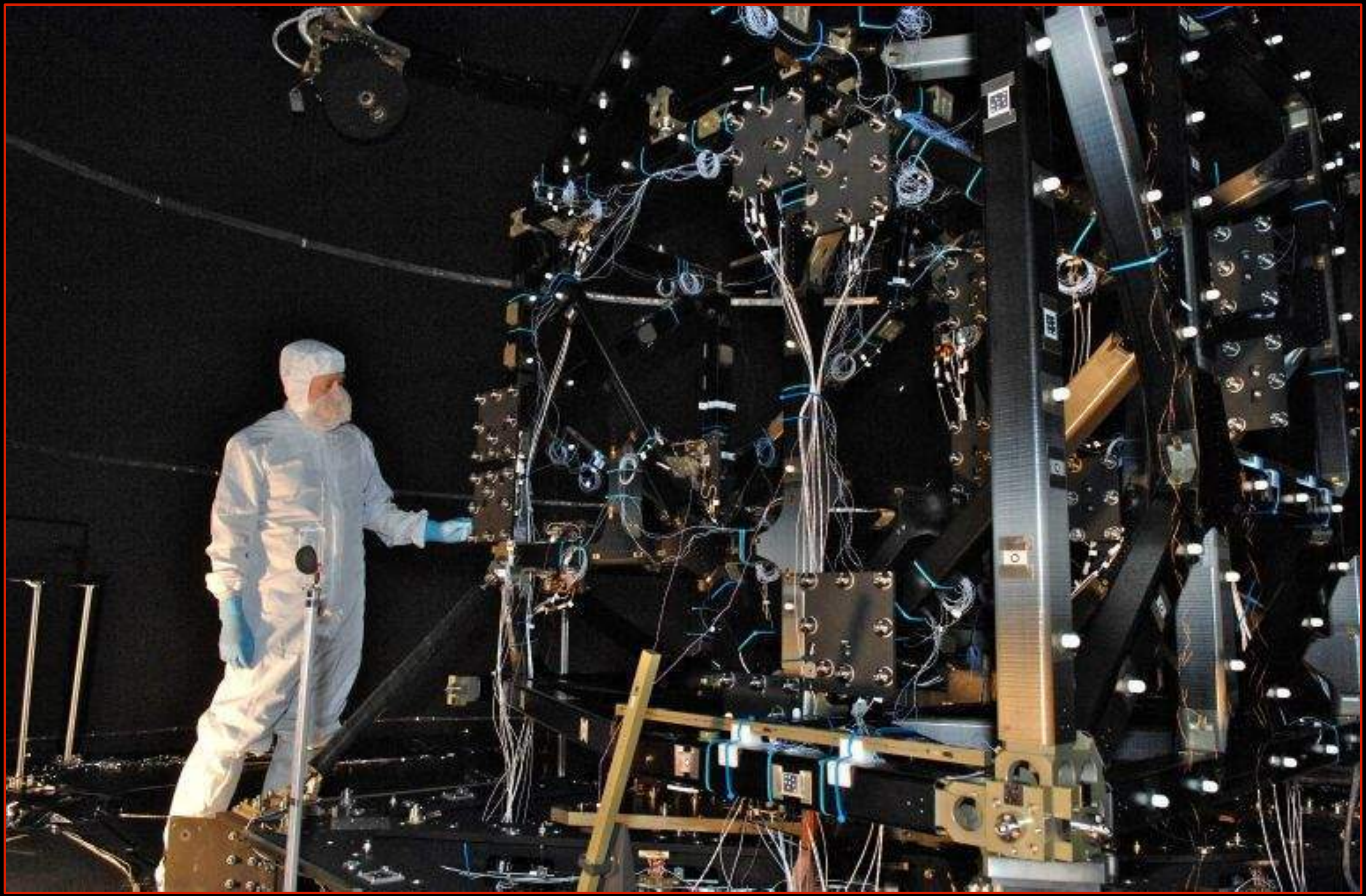
Focal Plane Electronics (FPE)

Instrument Control Electronics (ICE, MCE)

ISIM Remote Services Unit (IRSU)

Region 3

ISIM Command & Data Handling (C&DH) Electronics



Near-Infrared Camera (NIRCam)

- Developed by the University of Arizona with Lockheed Martin ATC

Operating wavelength: 0.6 – 5.0 μm

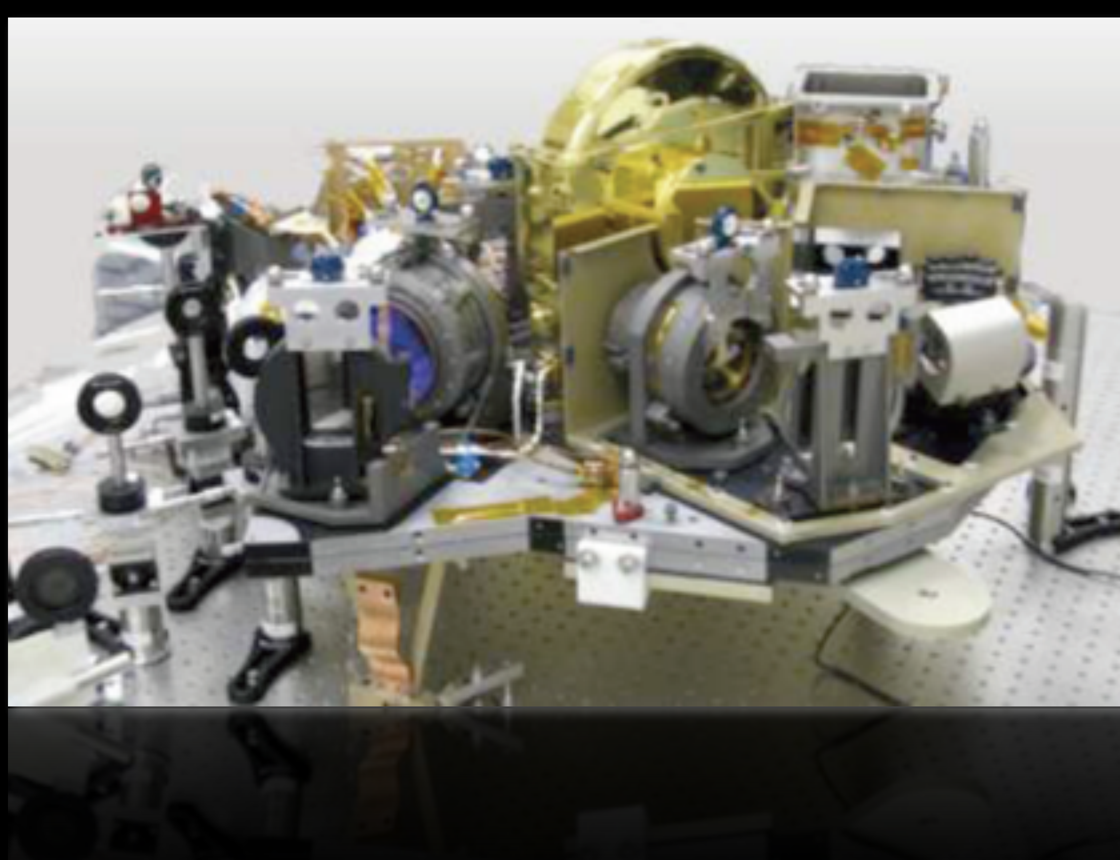
Spectral resolution: 4, 10, 100

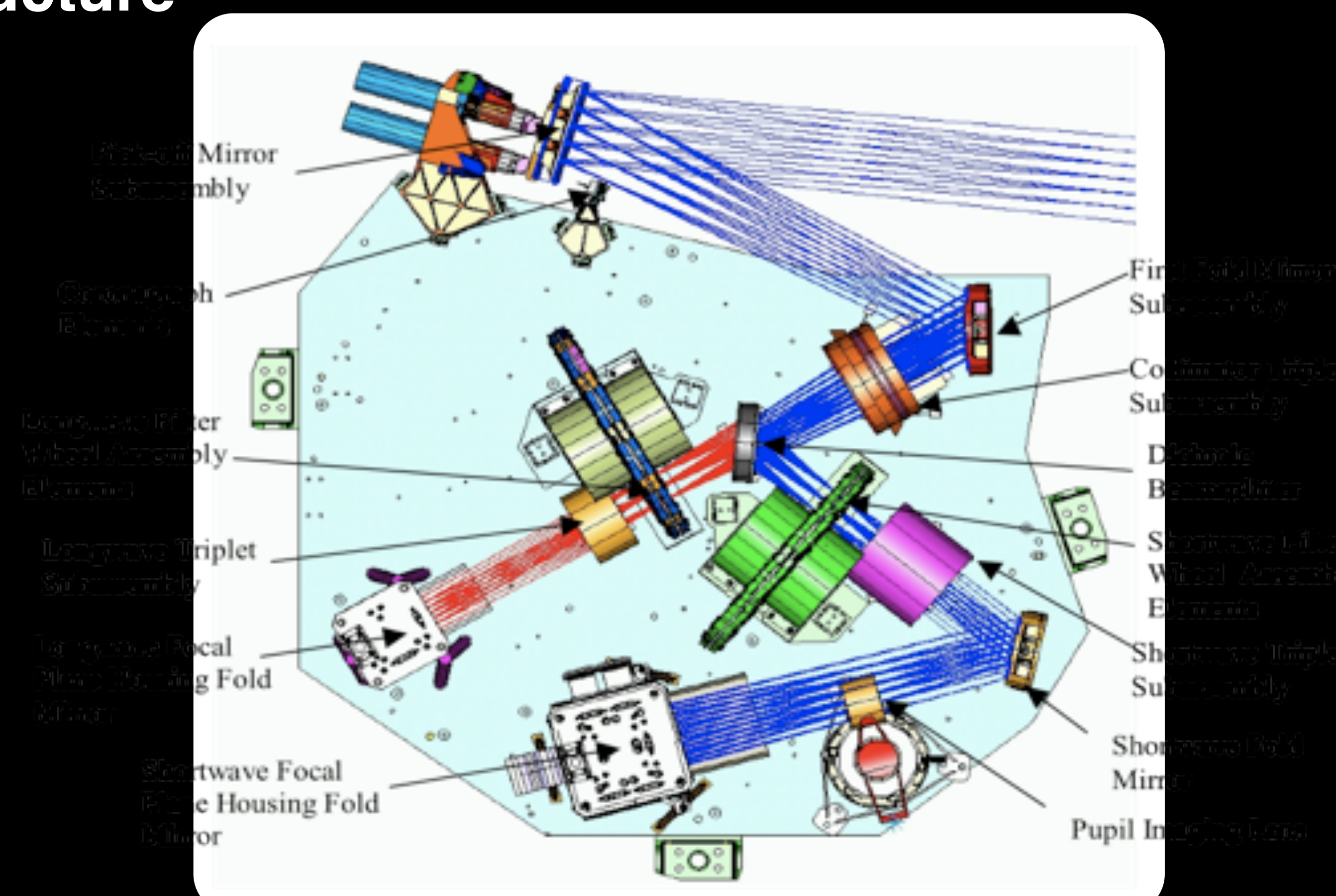
Field of view: 2.2 x 4.4 arc minutes

Angular resolution (1 pixel): 32 mas < 2.3 μm, 65 mas > 2.4 μm

Detector type: HgCdTe, 2048 x 2048 pixels, 10 detectors, T_{op}= 40K (passive)

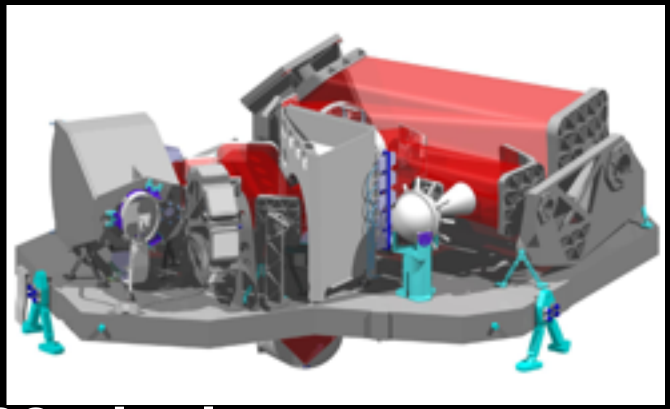
Refractive optics, Beryllium structure





Near-Infrared Spectrograph

- **Developed by the European Space Agency with Astrium GmbH and Goddard Space Flight Center**



Operating wavelength: 0.6 – 5.0 µm

Spectral resolution: 100, 1000, 3000

Field of view: 3.4 x 3.4 arc minutes

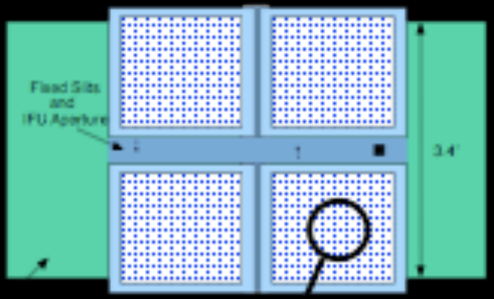
Aperture control: programmable micro-shutters, 250,000 pixels

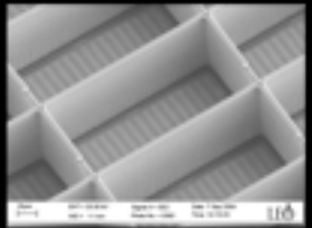
Angular resolution: shutter open area 203 x 463 mas, pitch 267 x 528 mas

Detector type: HgCdTe, 2048 x 2048 pixel, 2 detectors, T_{op} = 37K (passive)

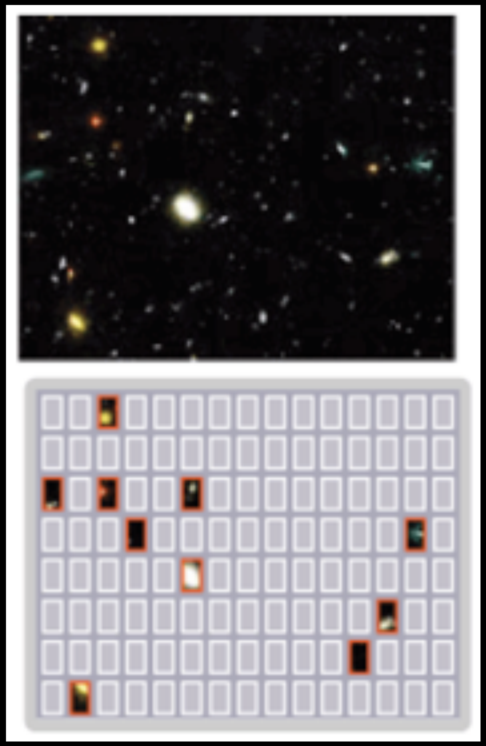
Reflective optics, SiC structure and optics

Microshutters





Multiple Objects
≤ 100 objects



Mid-Infrared Imager (MIRI)

- Developed by the MIRI European Consortium and JPL

Operating wavelength: 5 – 29 µm

Spectral resolution: 5, 100, 2000

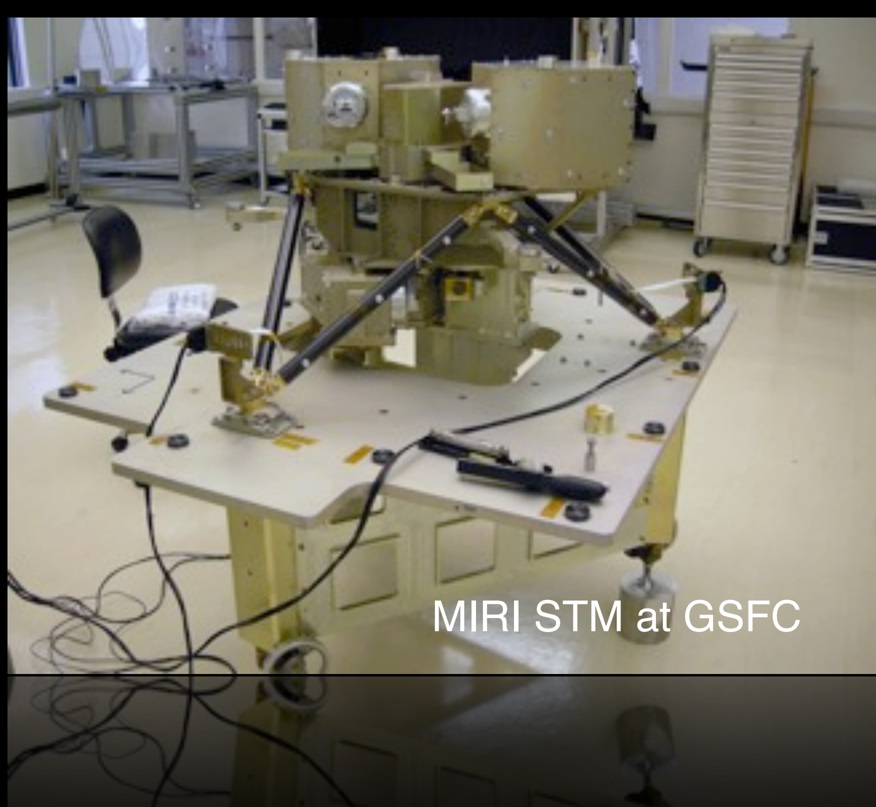
Field of view: 1.9 x 1.4 arc minutes broad-band imagery

R=100 spectroscopy 5 x 0.2 arc sec slit

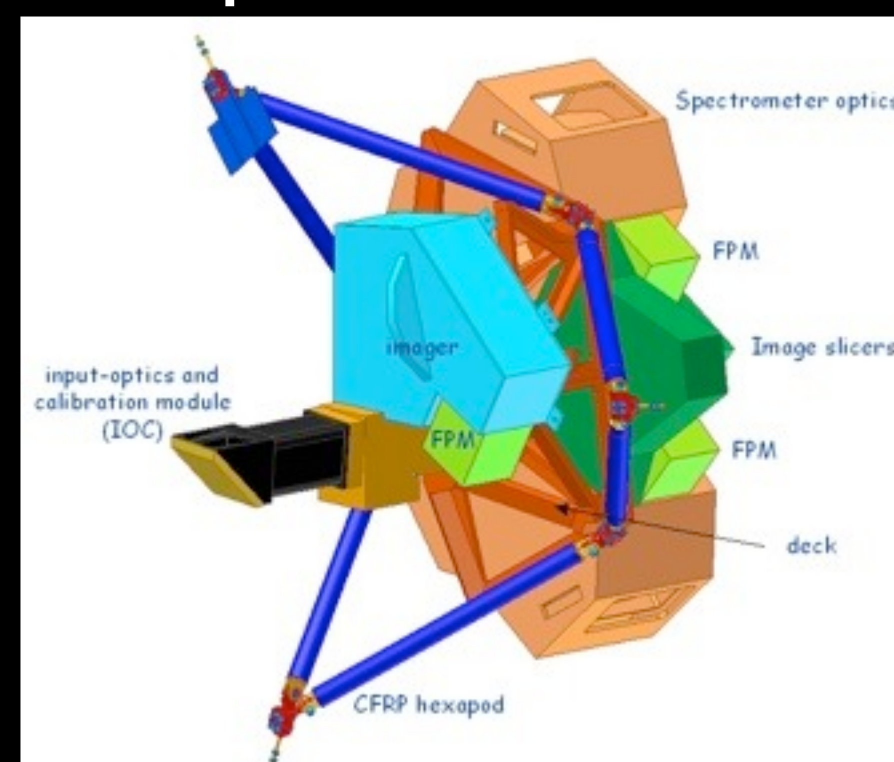
R=2000 spectroscopy 3.5 x 3.5 and 7 x 7 arc sec integral field units

Detector type: Si:As, 1024 x 1024 pixel, 3 detectors, T_{op} = 7 K (cryo-cooler)

Reflective optics, Aluminum structure and optics



MIRI STM at GSFC



Fine Guidance Sensor/Tunable Filter Imager

- Developed by the Canadian Space Agency with ComDev

Operating wavelength: 0.8 – 4.8 µm

Spectral resolution: Broad-band guider and R=100 science imagery

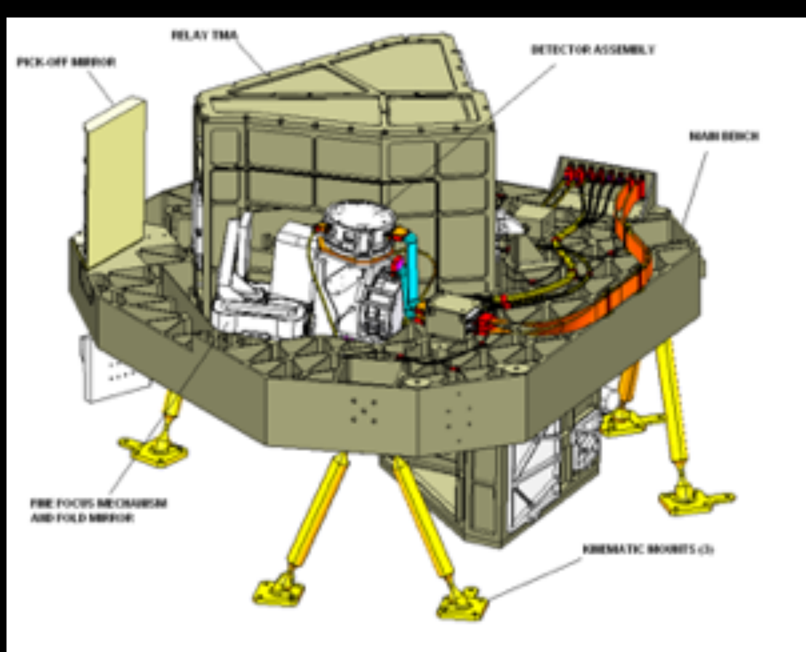
Field of view: 2.3 x 2.3 arc minutes

R=100 imagery with Fabry-Perot tunable filter and coronagraph

Angular resolution (1 pixel): 68 mas

Detector type: HgCdTe, 2048 x 2048 pixel, 3 detectors, T_{op} = 40 K (passive)

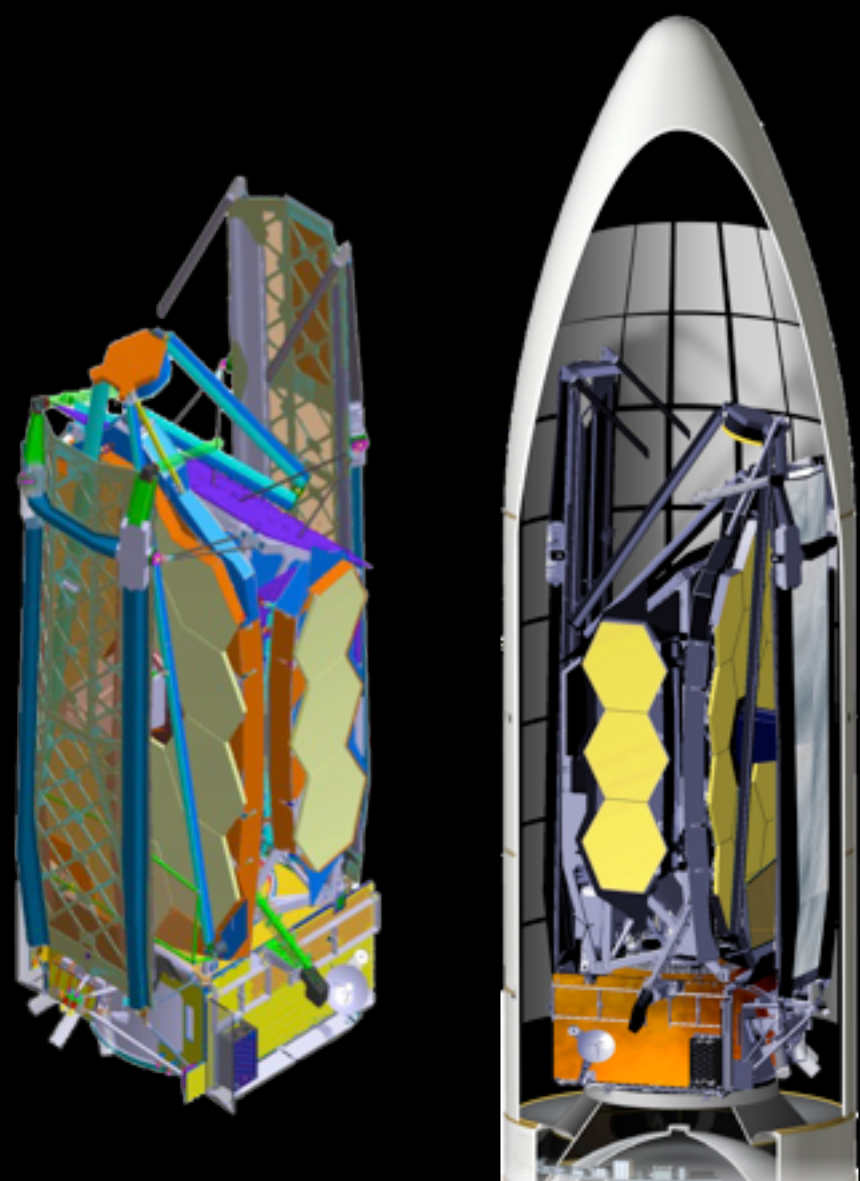
Reflective optics, Aluminum structure and optics



Launch

JWST Launch

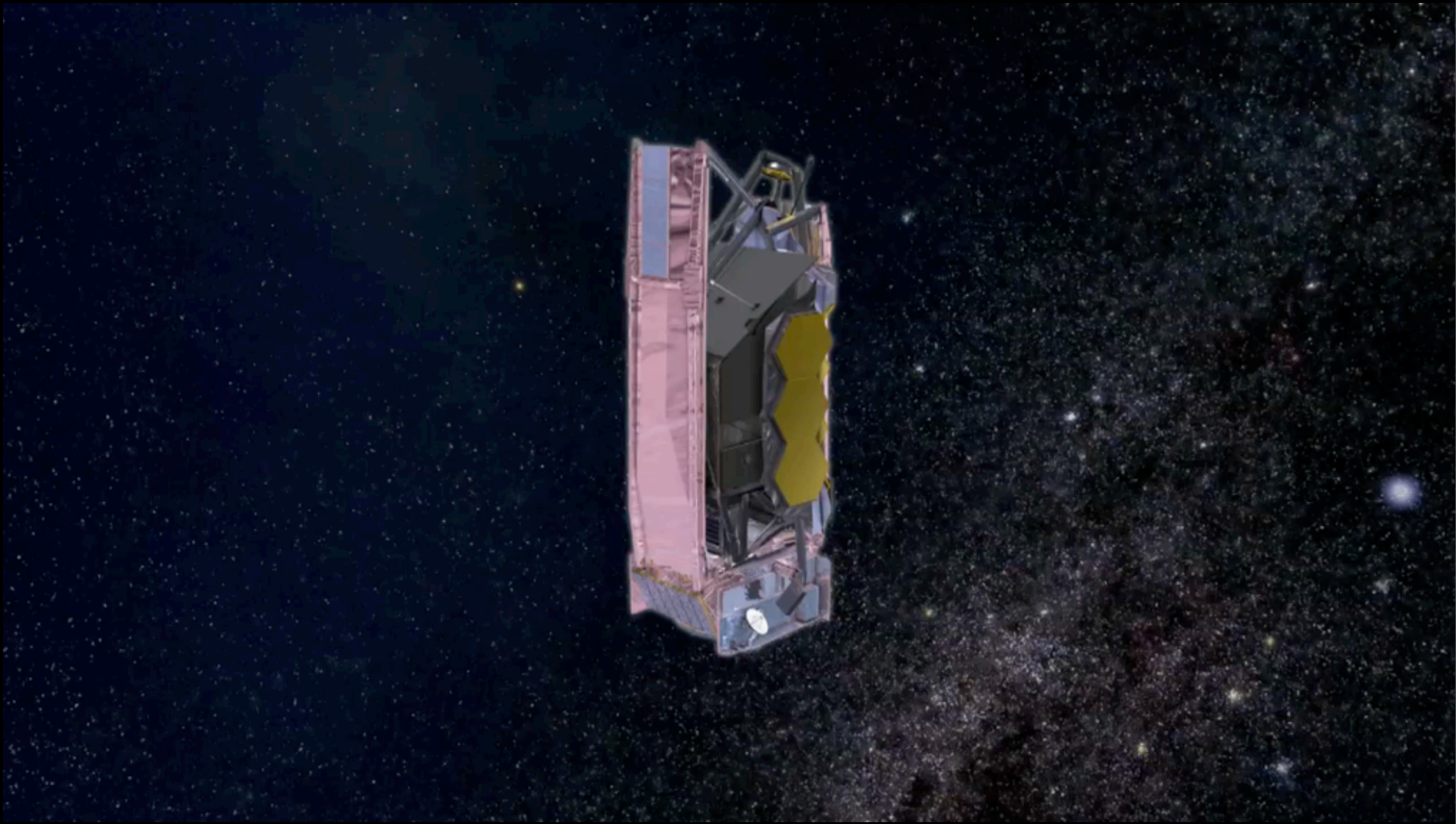
JWST stowed for launch



Ariane 5 heavy launcher

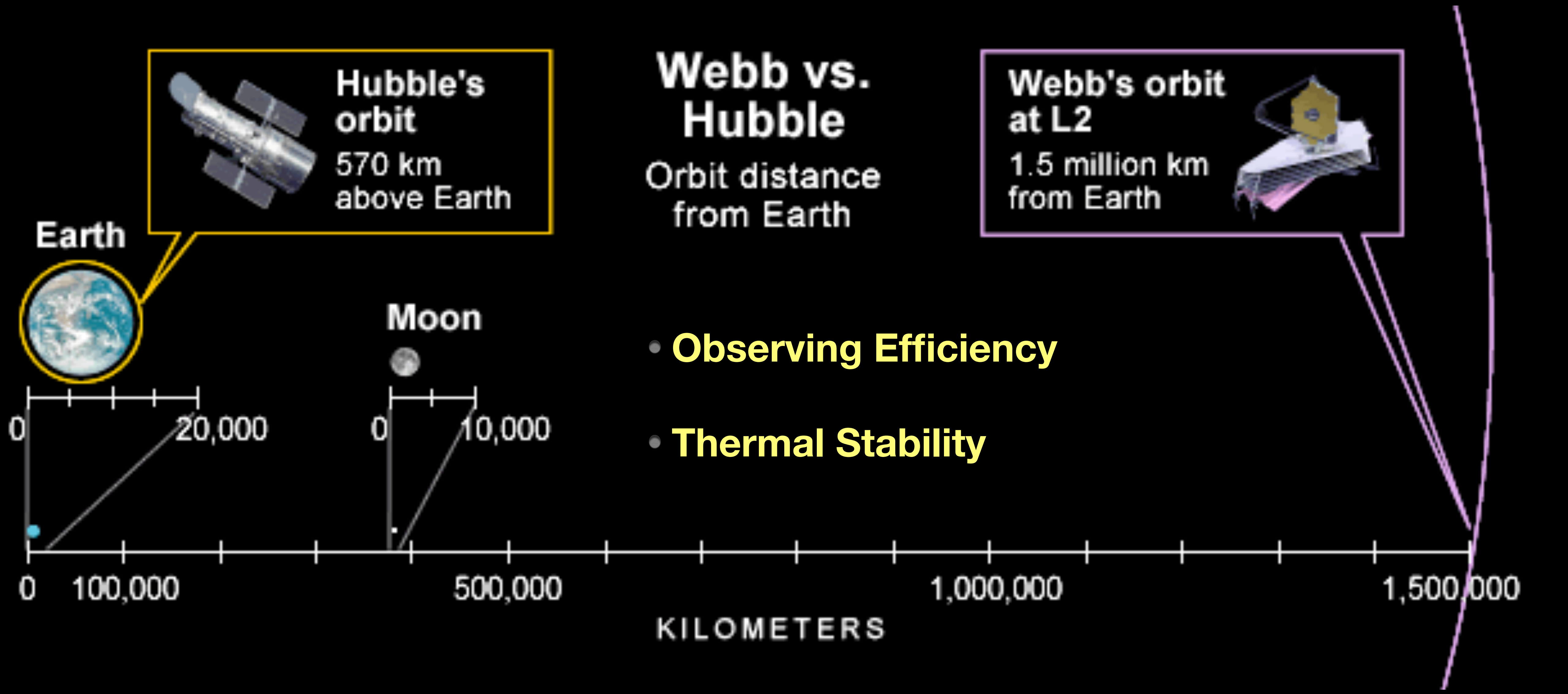
Herschel-Planck ➟ L2

JWST Deployment



Orbit

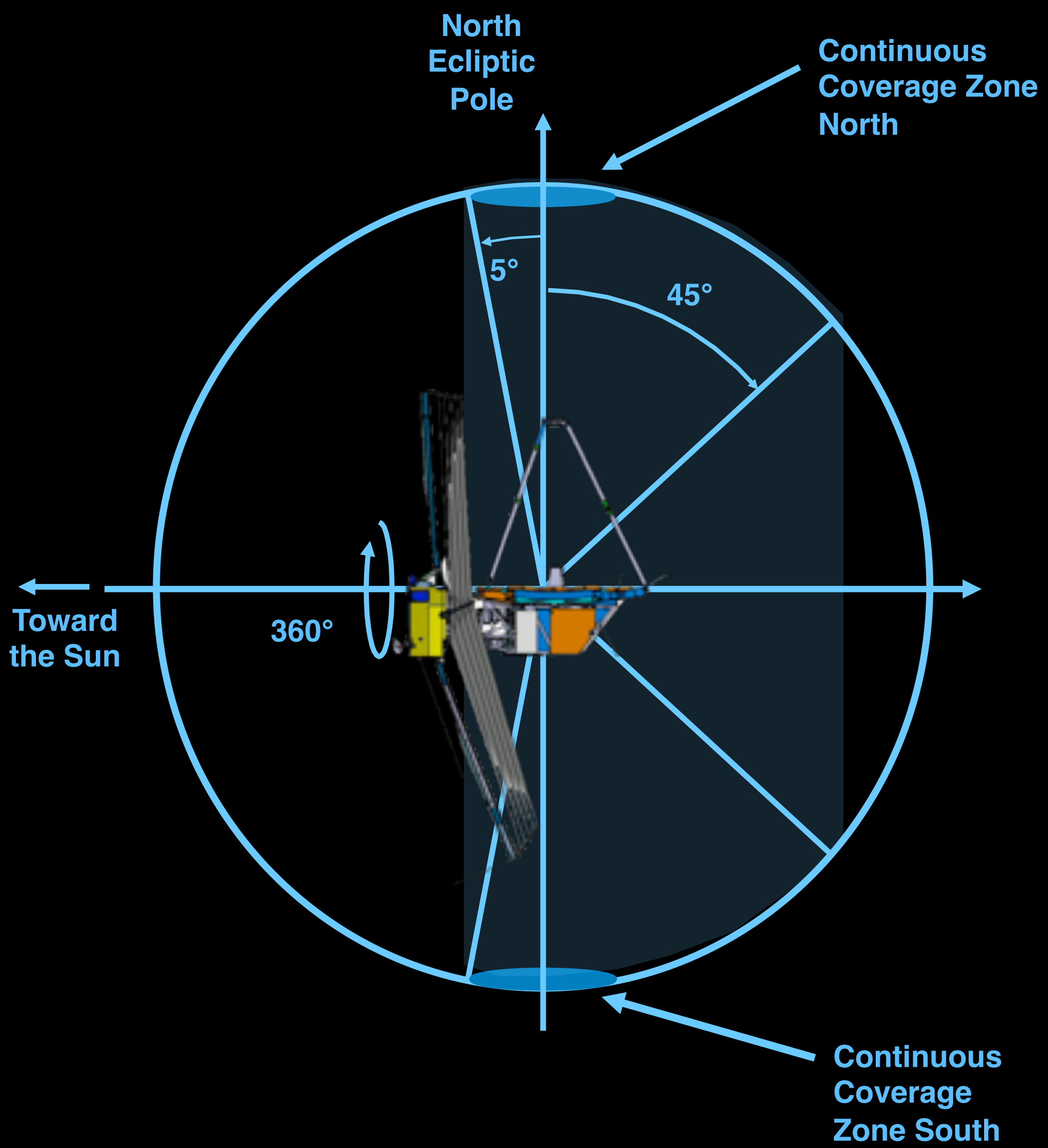
- An L2 point orbit was selected for JWST to enable passive cryogenic cooling
  - Station keeping thrusters fire ~ every 3 weeks to maintain this orbit
  - Propellant sized for 11 years (delta-v ~ 93 m/s)



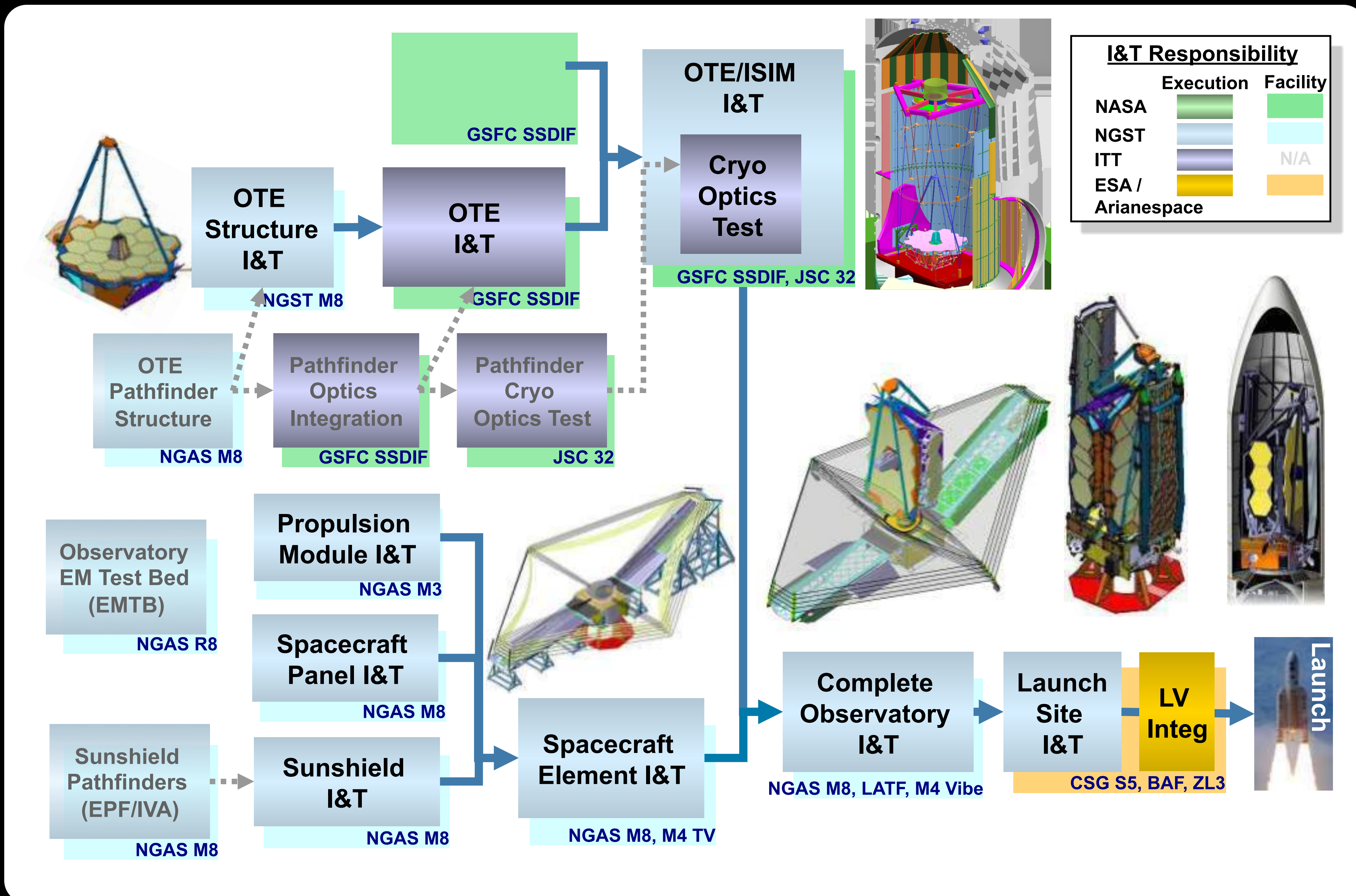
- Observing Efficiency
- Thermal Stability

Field of Regard

- The JWST can observes the whole sky over a year, while remaining continuously in the shadow of its sunshield
  - ➡ Field of Regard is an annulus covering 35% of the sky
  - ➡ Small continuous viewing zones at the Ecliptic poles

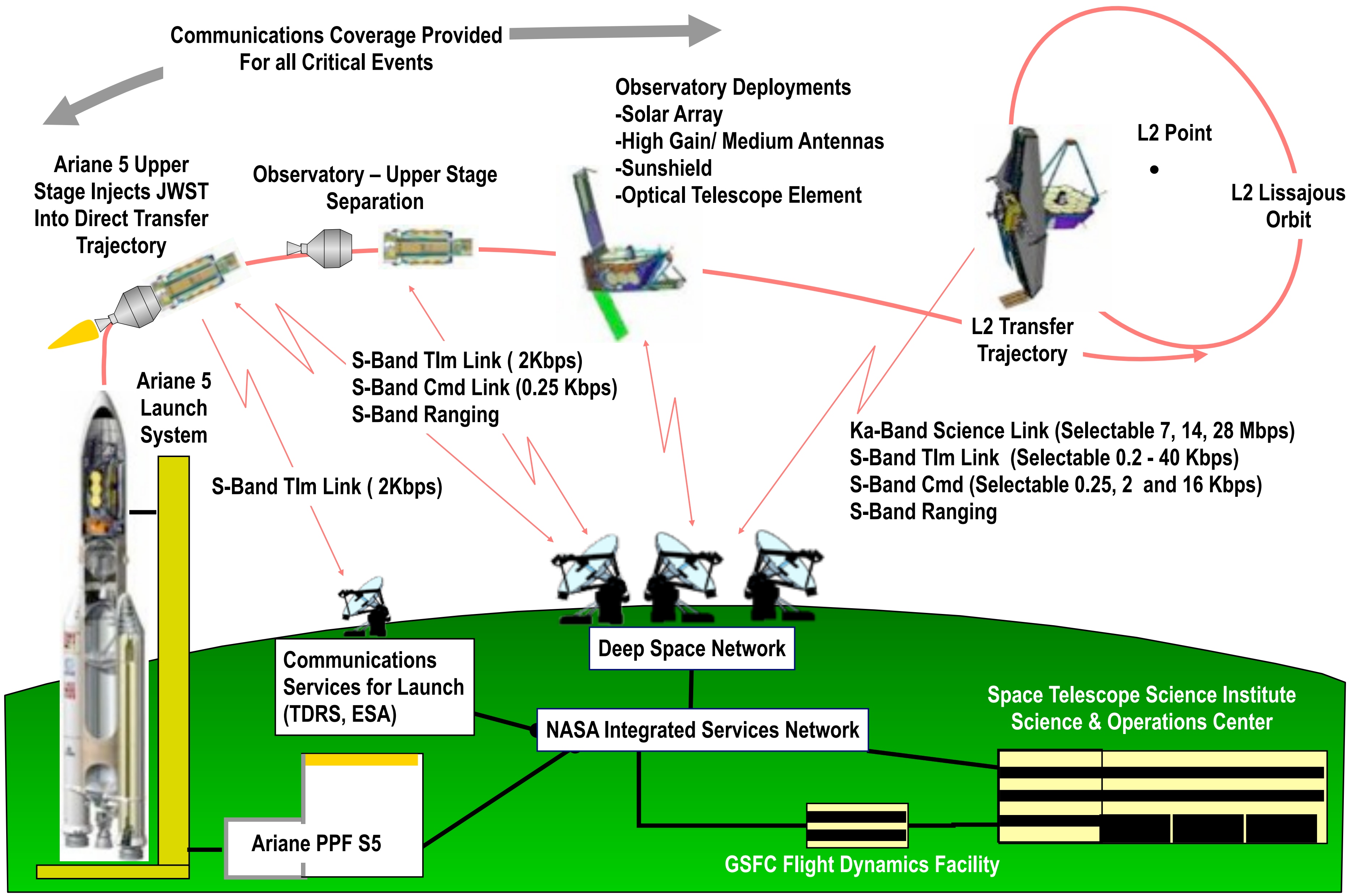


I&T



I&T Responsibility
Execution
Facility
NASA
NGST
ITT
N/A
ESA / Arianespace
GSFC SSDIF
OTE Structure I&T
NGST M8
OTE I&T
GSFC SSDIF
OTE/ISIM I&T
Cryo Optics Test
GSFC SSDIF, JSC 32
OTE Pathfinder Structure
NGAS M8
Pathfinder Optics Integration
GSFC SSDIF
Pathfinder Cryo Optics Test
JSC 32
Observatory EM Test Bed (EMTB)
NGAS R8
Propulsion Module I&T
NGAS M3
Spacecraft Panel I&T
NGAS M8
Sunshield Pathfinders (EPF/IVA)
NGAS M8
Sunshield I&T
NGAS M8
Spacecraft Element I&T
NGAS M8, M4 TV
Complete Observatory I&T
NGAS M8, LATF, M4 Vibe
Launch Site I&T
LV Integ
CSG S5, BAF, ZL3
Launch

Communications



JWST: Under Construction