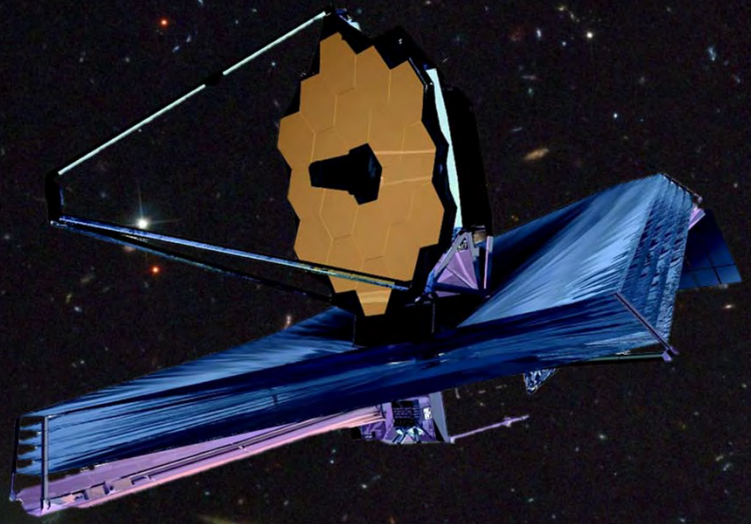
The James Webb Space Telescope



Jonathan P. Gardner

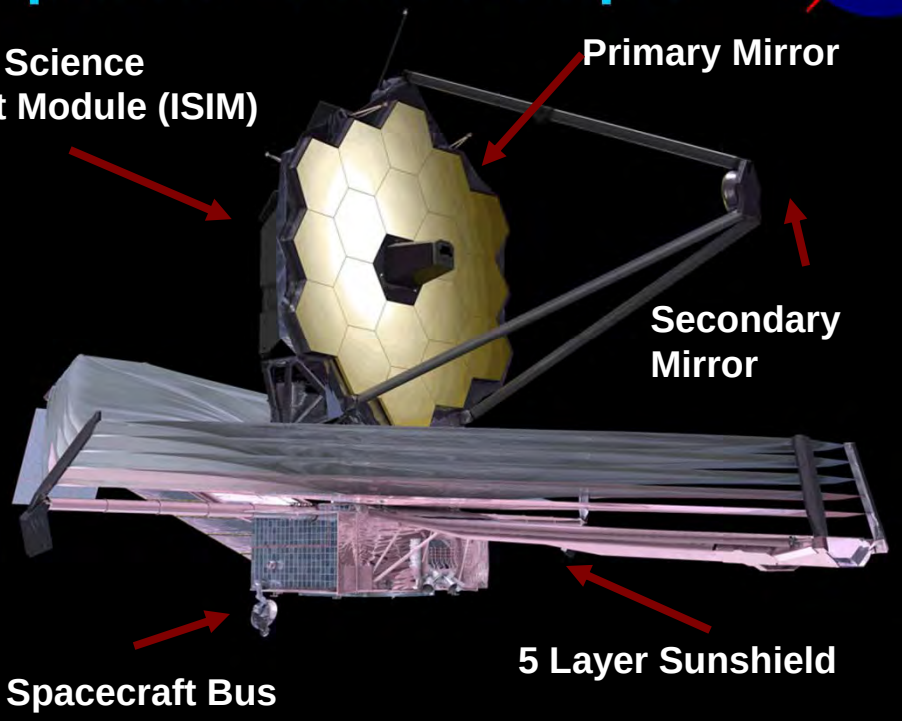
NASA's Goddard Space Flight Center

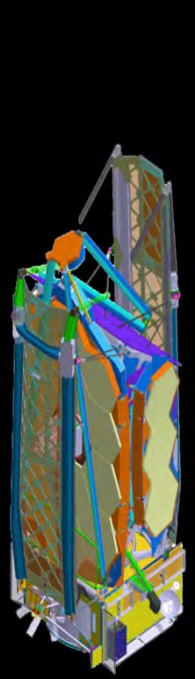
http://jwst.nasa.gov

Space Science Reviews, 2006, 123/4, 485

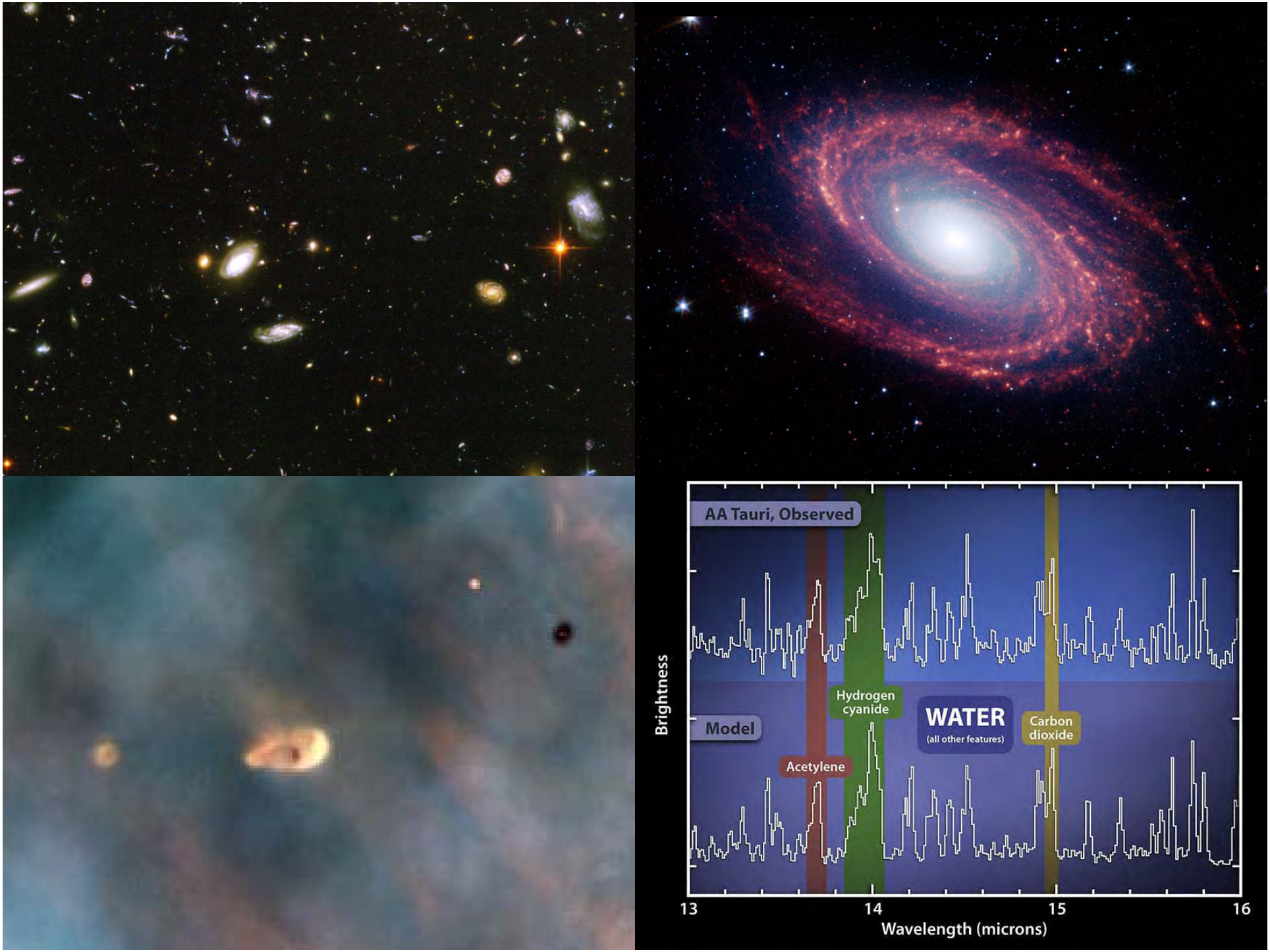
James Webb Space Telescope

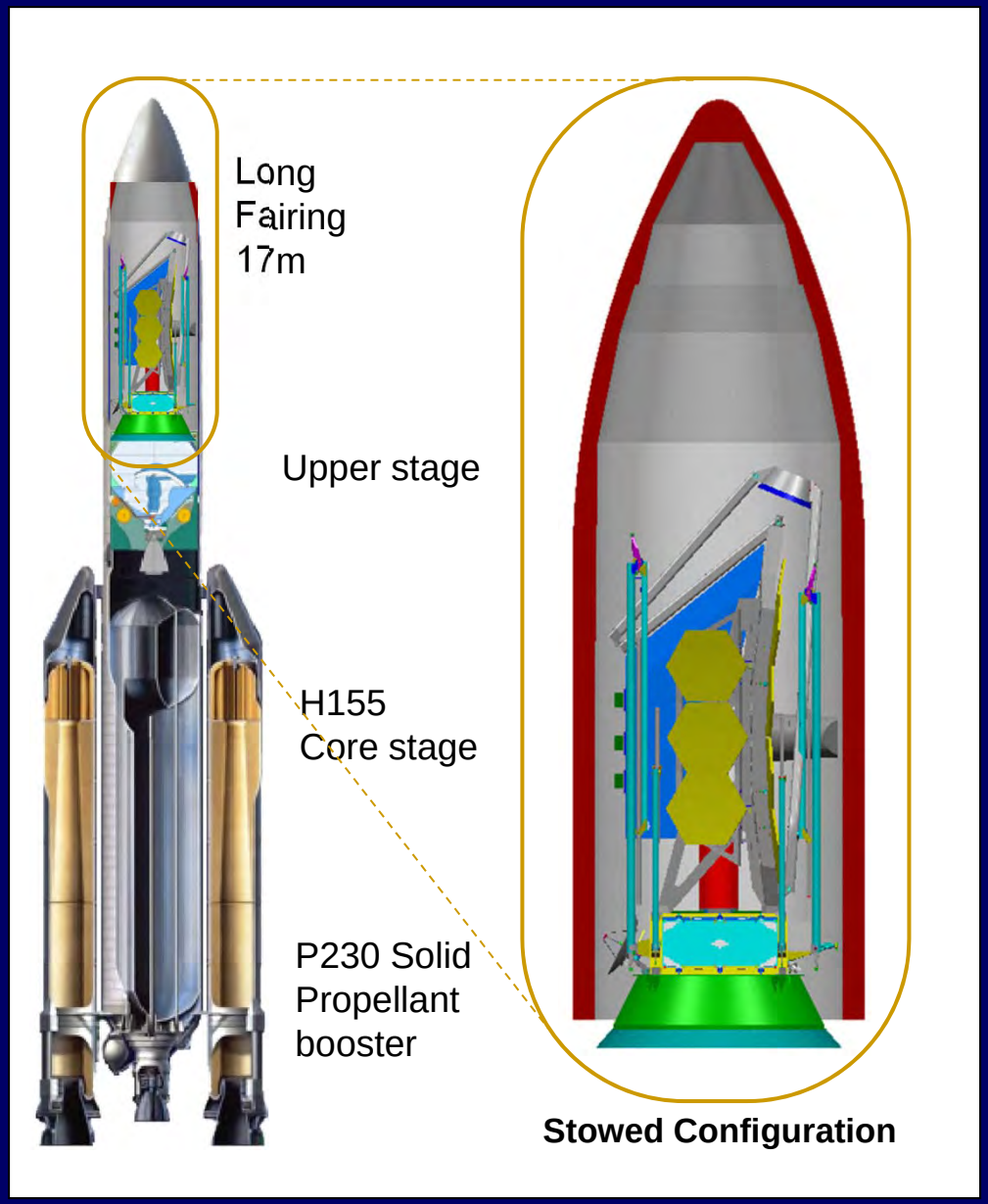
- 6.6m Telescope
- Successor to Hubble & Spitzer.
- Demonstrator of deployed optics.
- 4 instruments: 0.6 to 28.5 μm
- Passively cooled to < 50 K.
- Named for 2nd NASA Administrator





- Complementary to GMT, ALMA, WFIRST, etc
- NASA + ESA + CSA: 14 countries
- Lead: Goddard Space Flight Center
- Prime: Northrop Grumman
- Operations: STScI
- Senior Project Scientist:
  Nobel Laureate John Mather


AA Tauri, Observed
Model
Brightness
Hydrogen cyanide
WATER
(all other features)
Carbon dioxide
Acetylene
13
14
15
16
Wavelength (microns)

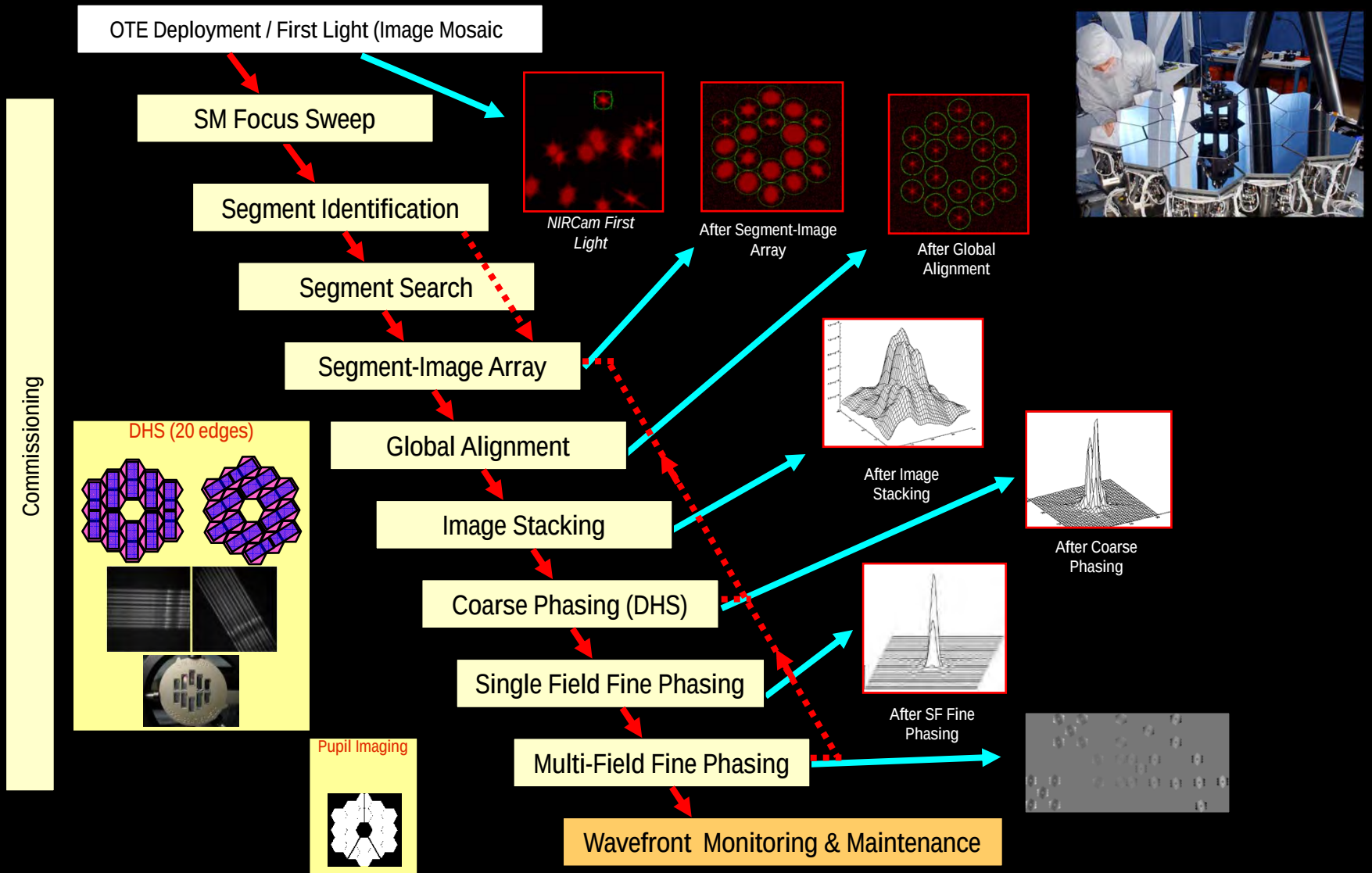


Ariane V launch
Kourou, French Guiana

Video

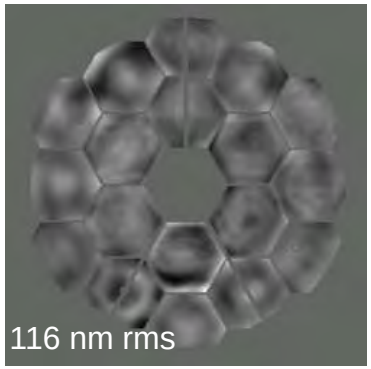
Video

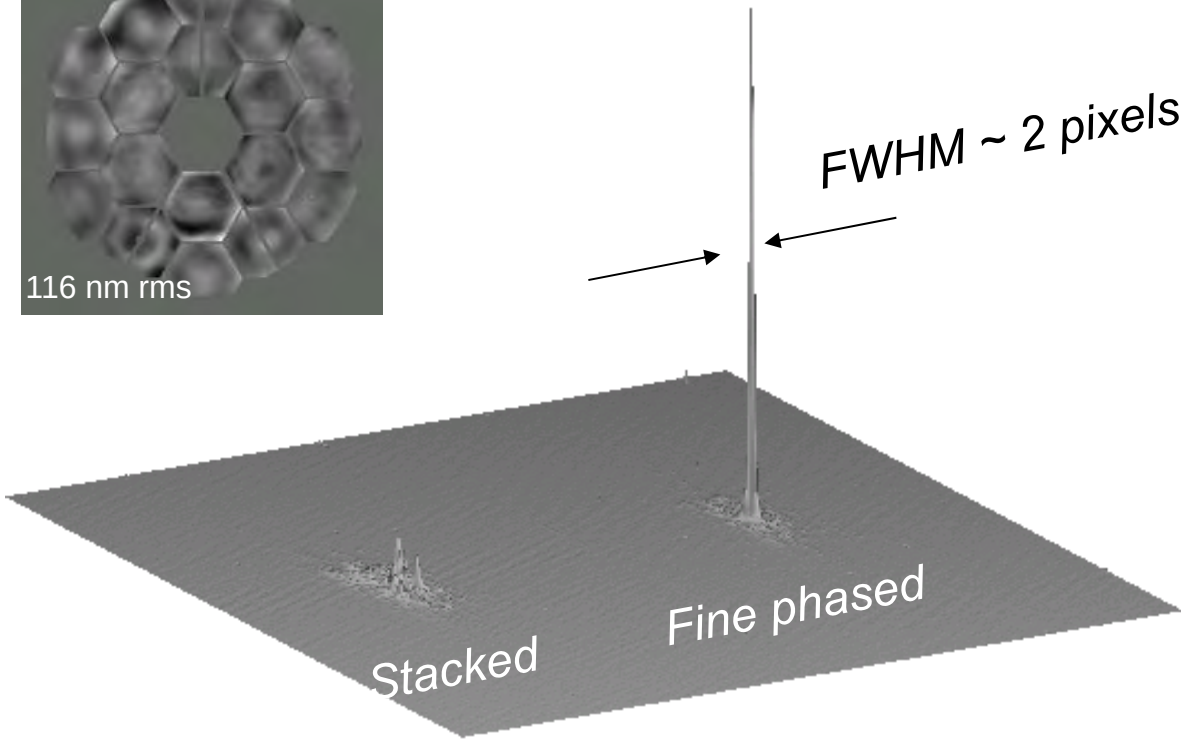
Wavefront Sensing and Control



Fine Phasing on JWST Testbed Telescope Clearly (repeatedly) Demonstrates Coherent Image Addition

1/6 scale test-bed Telescope





- **Double Pass Phase Retrieval Estimate**
  - **~0.95 Strehl ratio**
  - **(single pass at 1550 nm on TBT**
  - **Flight requirement is >0.8 Strehl @ 2micron**

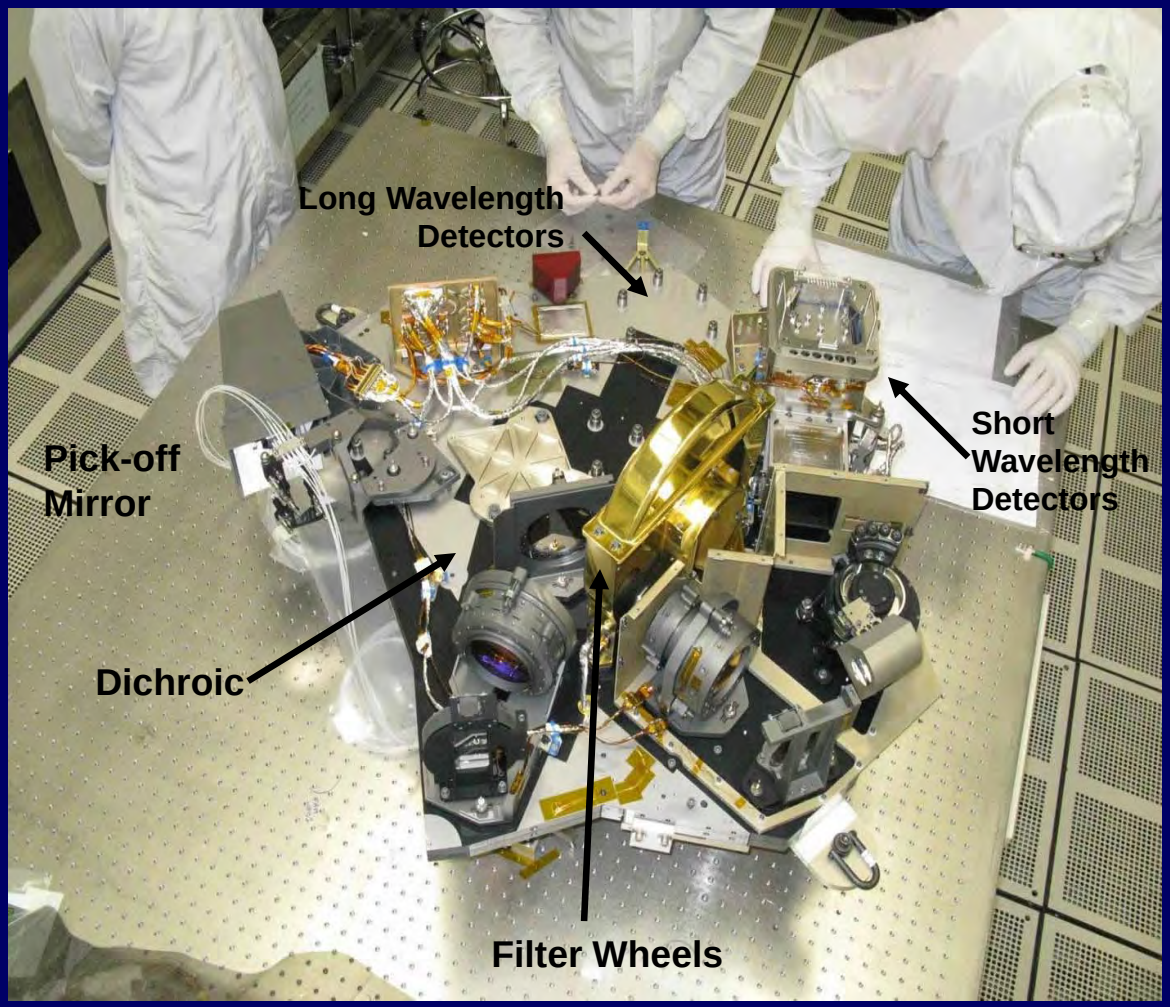
- Stacked Point Spread Function (left) contains random small tip/tilt and piston errors (Before)
- Phased PSF clearly indicates coherent addition and success of closed loop fine phasing (After)

Near-Infrared Camera

University of Arizona
PI: Marcia Rieke

Lockheed Martin industrial partner

Teledyne HgCdTe detectors



NIRCam

- Simultaneous observing at two wavelengths over 2.3' x 4.6' FOV.
- 7 Broad-band filters over $0.6 < \lambda < 5.0\ \mu m$
- Additional medium and narrow-band filters
- Filter wheels include wavefront sensing hardware.
- Coronagraphy

Go Girl Scouts
DANGER

Near-Infrared Spectrograph

ESA instrument
EADS Astrium prime contractor

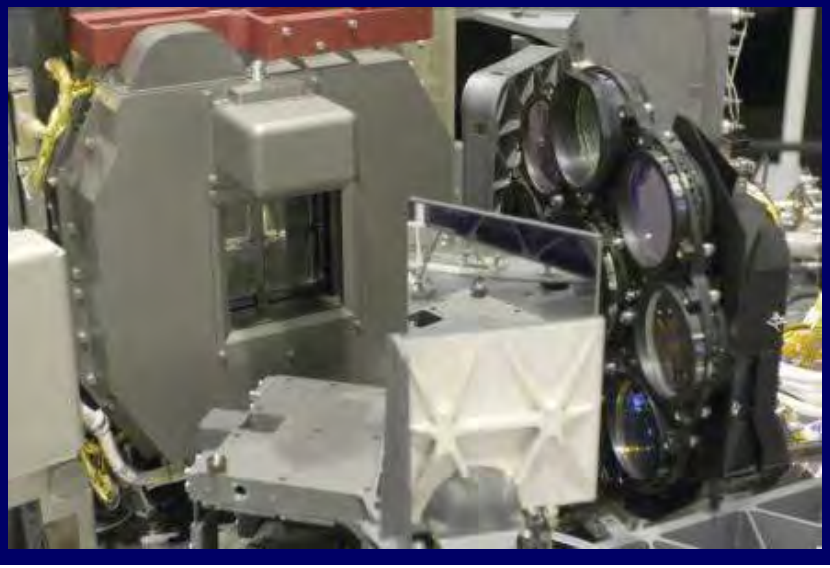
GSFC providing micro-shutters and detectors

Flight NIRSpec

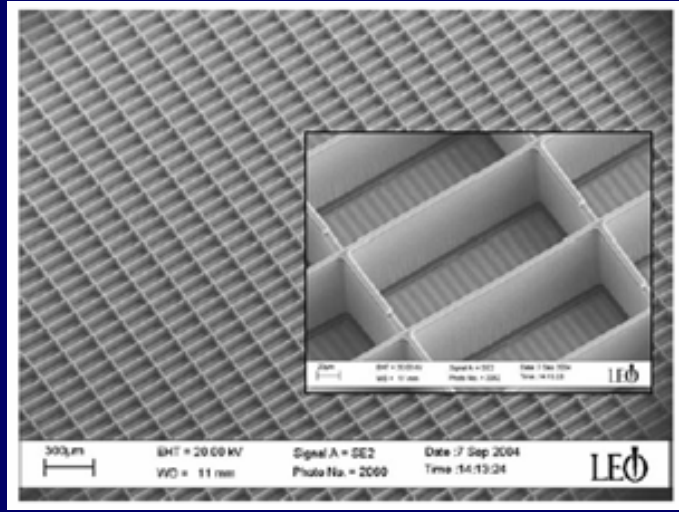
- Multi-Object Spectroscopy
  - Micro-shutter array
  - 3.4’ x 3.4’ FOV.
- IFU, 3” x 3”
- R=1000 & R=3000
  - 3 gratings cover 1.0 < λ < 5.0 μm
- R=100 Prism
  - 0.6 < λ < 5.0 μm

Video

Micro-Shutters: 730 x 342 array of 203 x 463 mas pixels



Flight Microshutters Integrated into Instrument



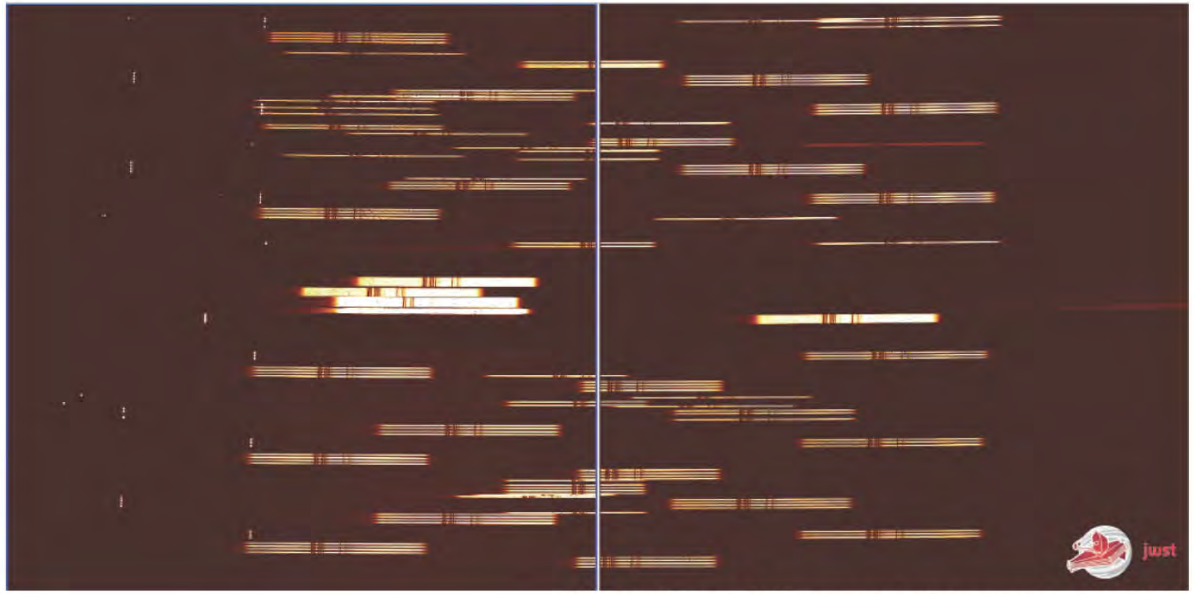
JWST/NIRSpec - Recent achievements

JAMES WEBB SPACE TELESCOPE

- **The main instrument-level cryogenic calibration and characterization campaign started mid-December 2012 and is almost complete.**
  - Warm-up is on-going.
  - Successful campaign. Good preliminary results and no major issue detected.

Exposure obtained in the multi-object spectroscopy mode of NIRSpec with the micro-shutter array configured to create multiple "dashed-slits" over the NIRSpec field of view.

F100LP/G140M configuration.
1.3-1.7 micron source with absorption lines.
"Dashed slits" = sequences of open-close-open(...) shutters.



JWST/NIRSpec - FM2 cyrogenic test campaign 01/2013

European Space Agency

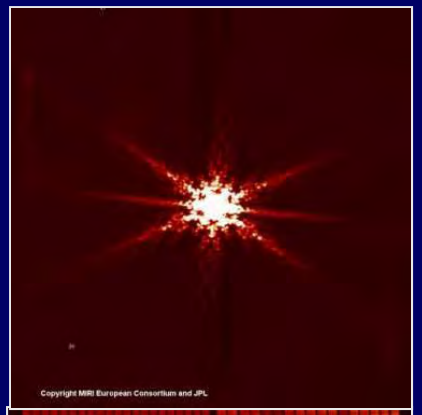
Mid-Infrared Instrument

European consortium
George Rieke, US Science Lead
Gillian Wright, EC Science Lead

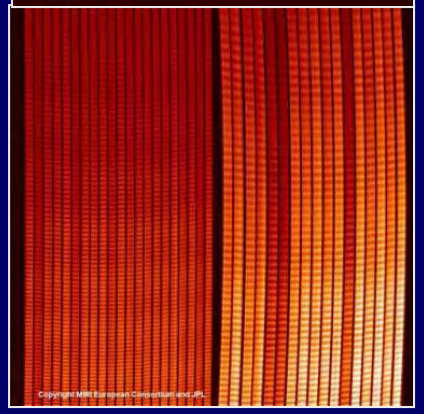
Jet Propulsion Laboratory
California Institute of Technology

JPL providing detectors, cooling, management

Flight MIRI at GSFC



Broad-band Imaging
5 < λ < 27 μm
1.4’ x 1.9’ FOV



R=3000 IFU
5 < λ < 28.5 μm
3” x 3” FOV

ETU First Light

- R = 100 Slit
  - 5 < λ < 10 μm
- Coronagraphy
- Cryocooler to 7K

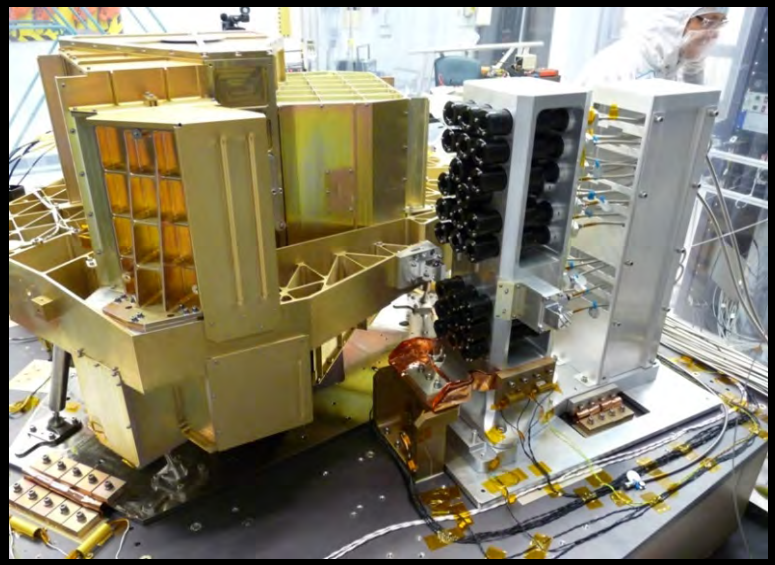
MIRI Installation into ISIM

Flight Fine Guidance Sensor

Near-Infrared Imager and Slitless Spectrograph

Com Dev industrial partner

CSA contribution



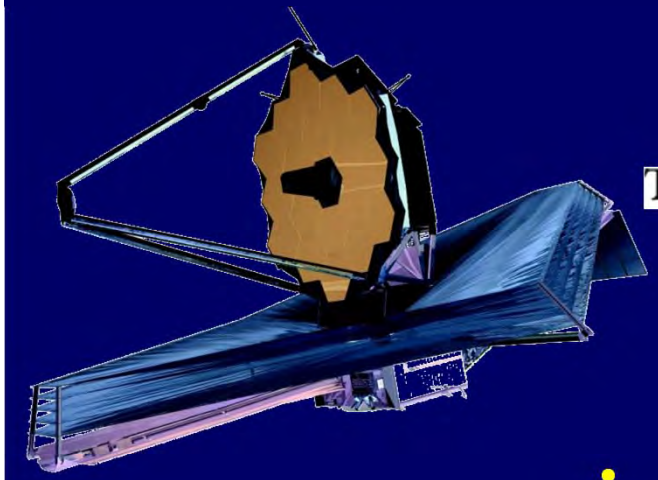
Flight FGS

- **Broad-band guider (0.6 – 5 microns)**
- **Science imagery:**
  - Slitless spectroscopic imagery (grism)
    - R ~ 150, 0.8 – 2.25 microns optimized for Ly alpha galaxy surveys
    - R ~ 500, 0.7 – 2.5 microns optimized for exoplanet transit spectroscopy
  - Sparse aperture interferometric imaging (7 aperture NRM) 3.8, 4.3, and 4.8 microns
- **Field of view: 2.3 x 2.3 arc minutes**
- **Angular resolution (1 pixel): 68 mas**
- **Detector type: HgCdTe, 2048 x 2048 pixel format, 3 detectors**

FGS Delivery

Video

Operations



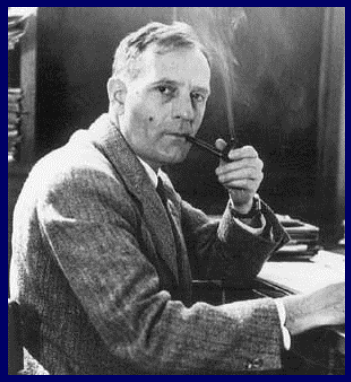
JWST at L2

Ka

S

- STScI has been designated as Science Operations Center
- GO, Treasury and GTO programs similar to HST

THE ASTROPHYSICAL JOURNAL



Astronomer

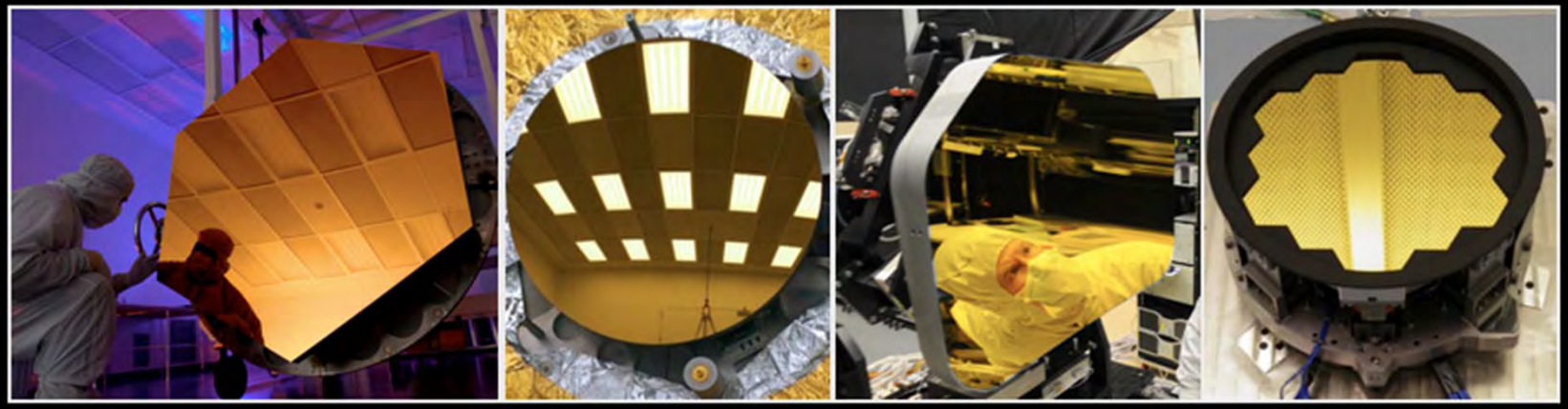
DSN

STScI

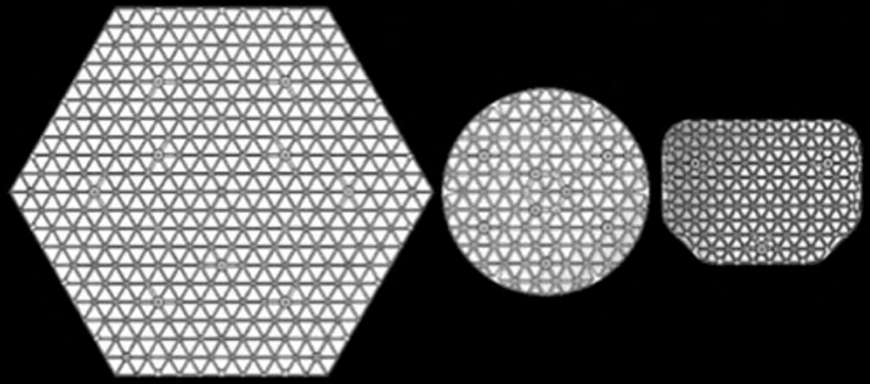
TAC

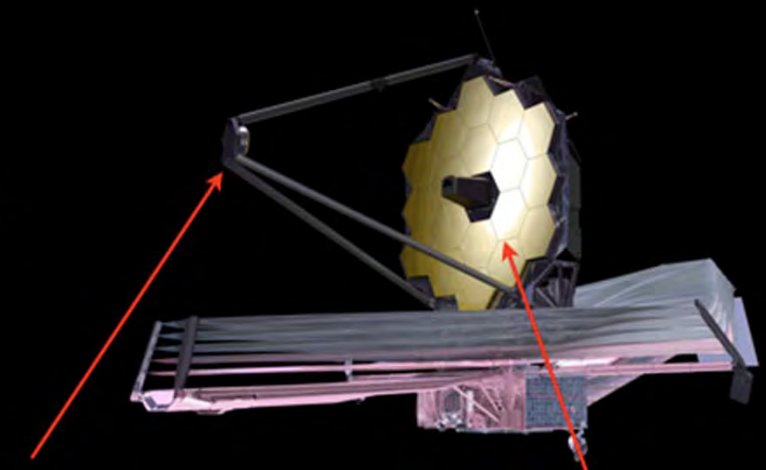
JWST's Flight Mirror Status

Primary Mirror Segment | Secondary Mirror | Tertiary Mirror | Fine Steering Mirror



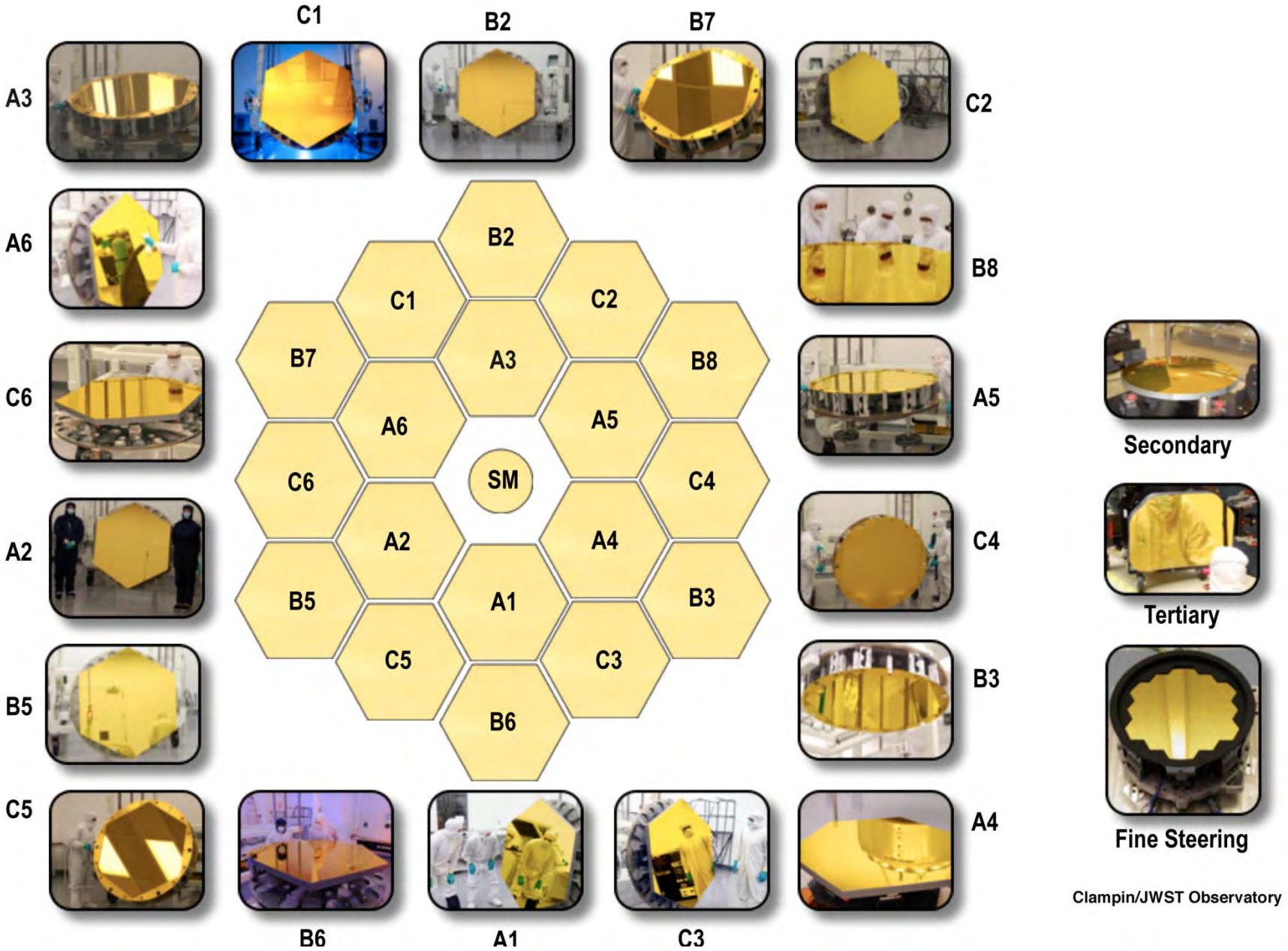
Rear side view of mirrors showing relative size





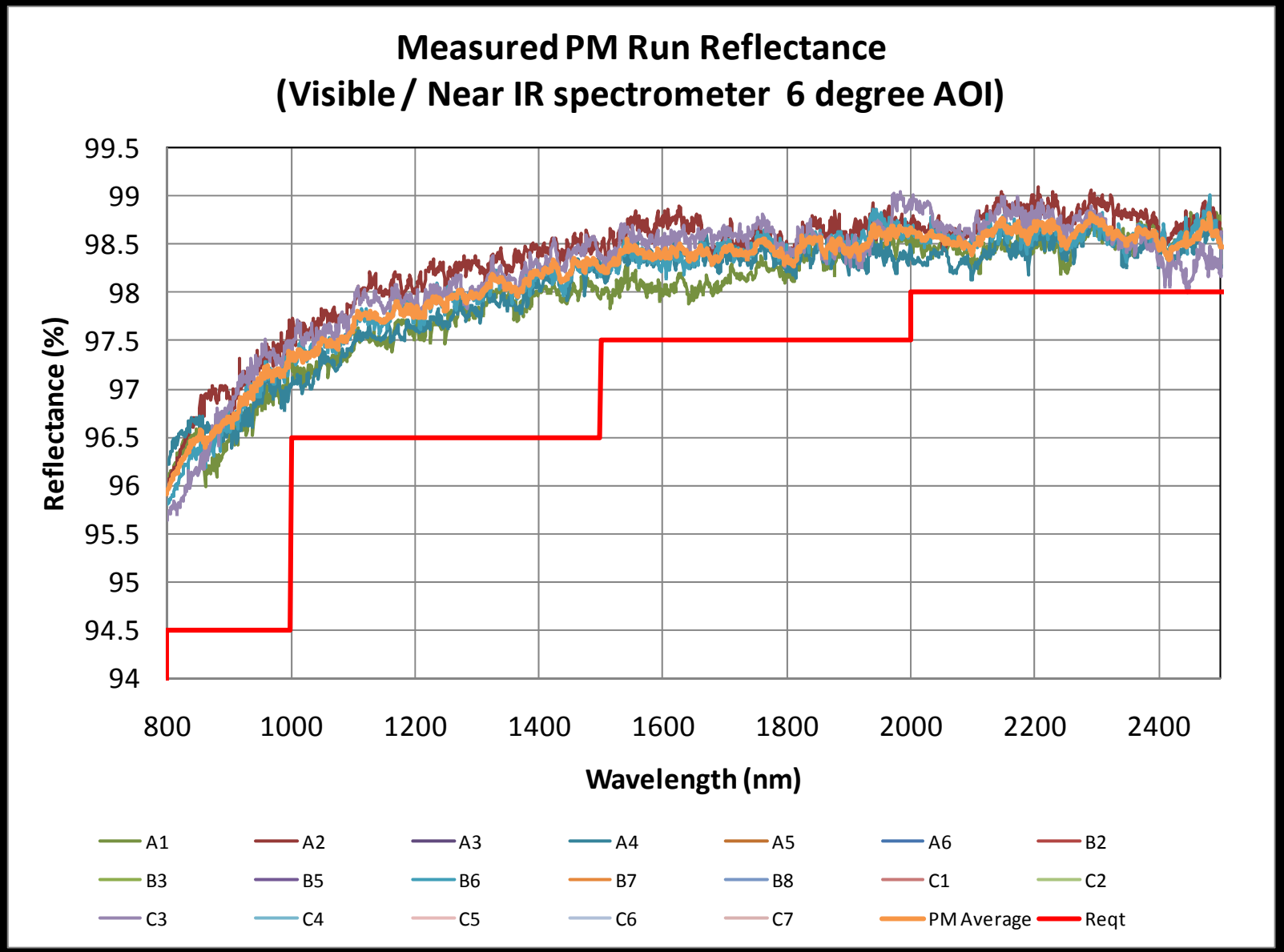
Flight mirrors arriving at GSFC

All mirrors are gold-coated



Clampin/JWST Observatory

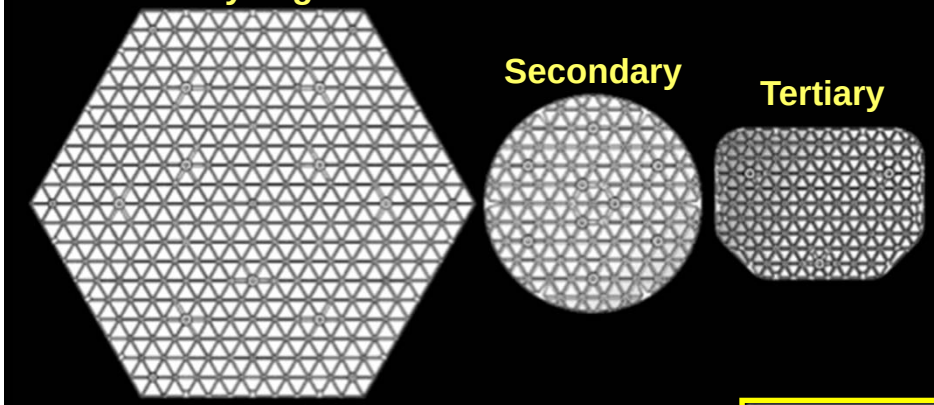
Gold Coatings Exceed Requirements



JWST Mirror Fabrication

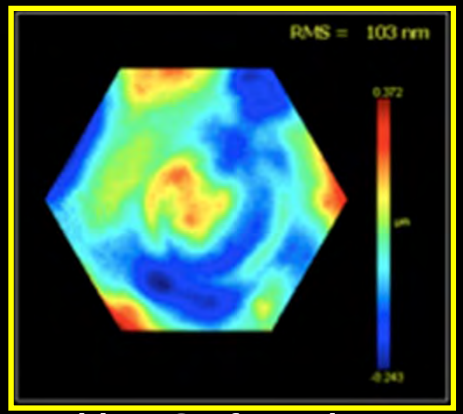
- JWST Mirrors made of beryllium
- Lightweight and stable at 40 K
- Brush-Wellman

Raw Be billet (two mirrors)

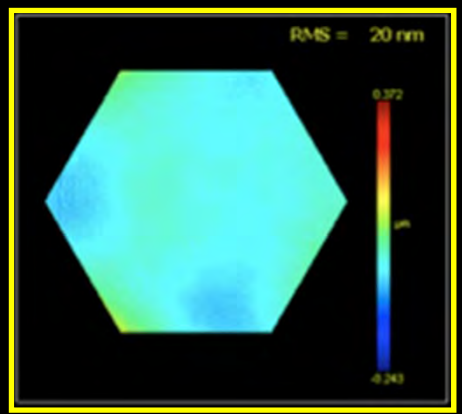


- Machined & lightweighted by Axsys
- 92% material is removed

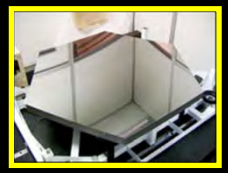
- Mirrors polished at Tinsley
- Segment cryo-figure: 20 nm

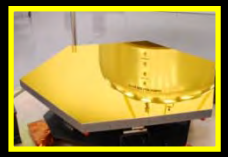


Ambient Surface Figure



Cryo Surface Figure

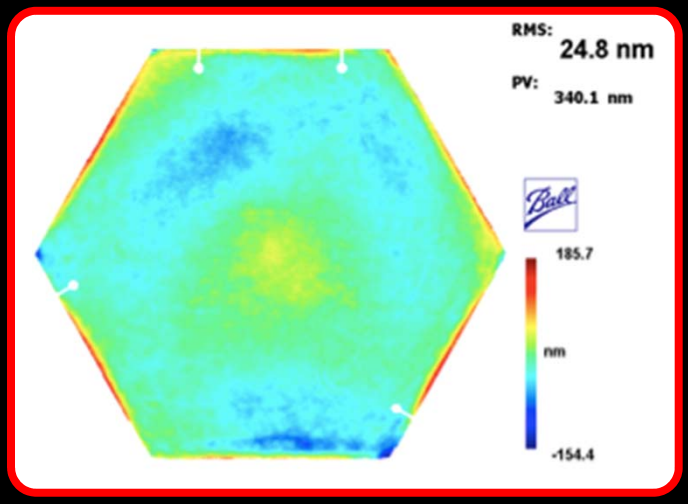




Flight Mirror Status

- All flight primary mirrors completed w/gold coating
  - Acceptance testing completed

Video



Mirror Segments Complete:
- Cryogenic optical test (post-vibe) meets WFE requirement.

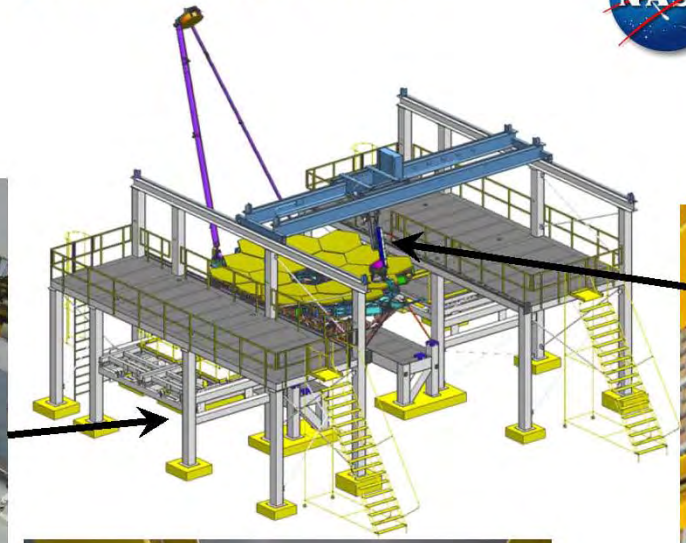
Flight Mirror A4 in acceptance vibe

- Mirror segments are now being built up with actuators on the back for installation onto backplane.
- *Flight mirror fabrication program completed in 2011*

DO NOT STACK
THIS SIDE UP
LIFT RING MAX WORKING LOAD 400 LBS
FOR COVER LIFT ONLY
THIS SIDE UP
DO NOT STACK
CRITICAL SPACE FLIGHT HARDWARE
FORKLIFT
B2
B6

Telescope Integration Equipment

Ambient Optical Alignment System



Primary Mirror Alignment & Integration Fixture (PAIF)

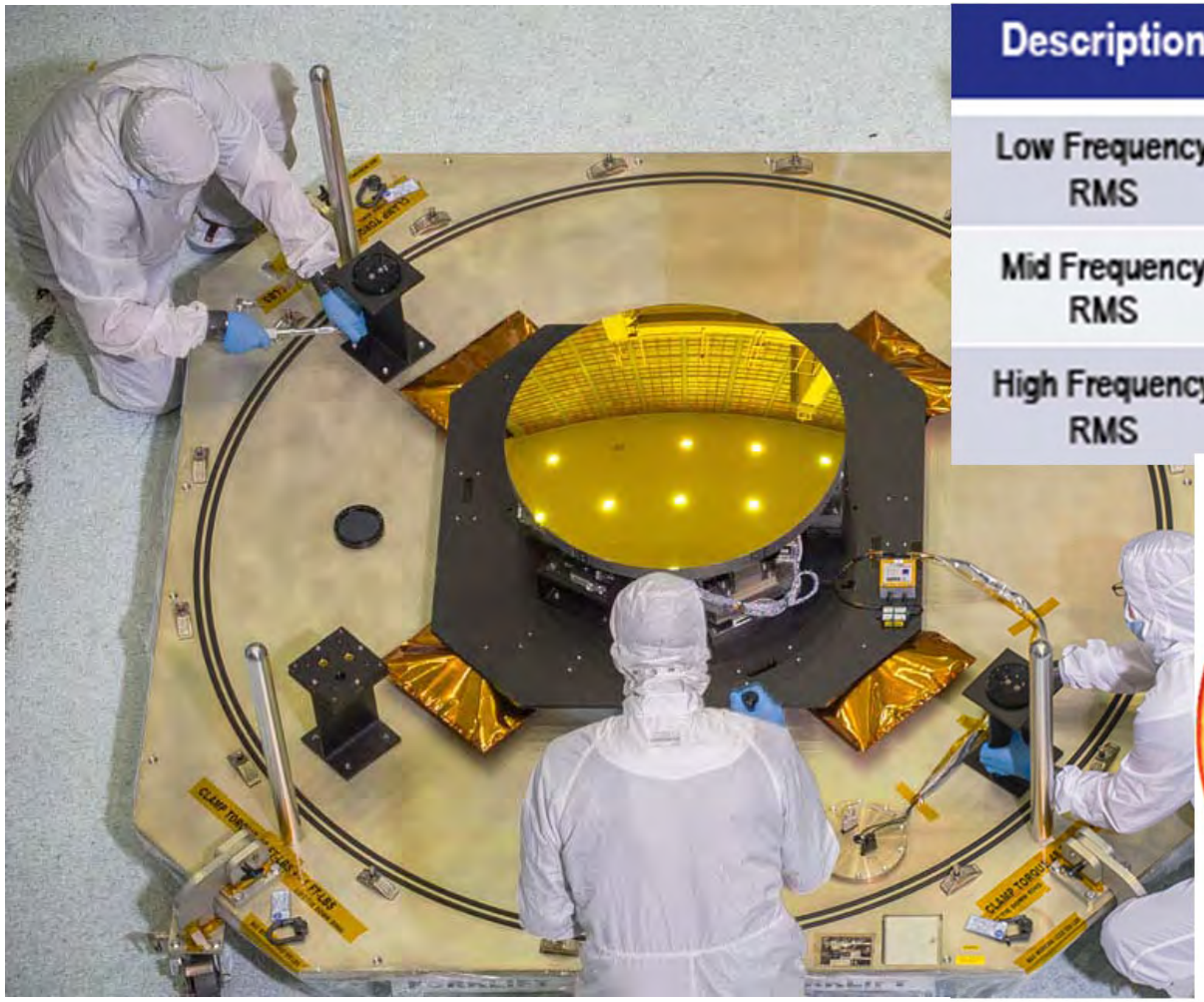
Checking clearances during mirror demo

Surrogate Mirror Placement Demonstration on the BSTA

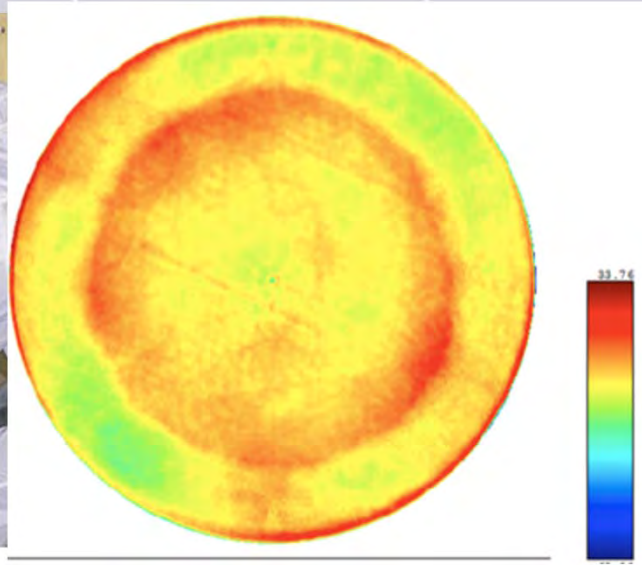
This document is not subject to the controls of the International Traffic in Arms Regulations (ITAR) or the Export Administration Regulations (EAR).

Video

JWST Secondary Mirror

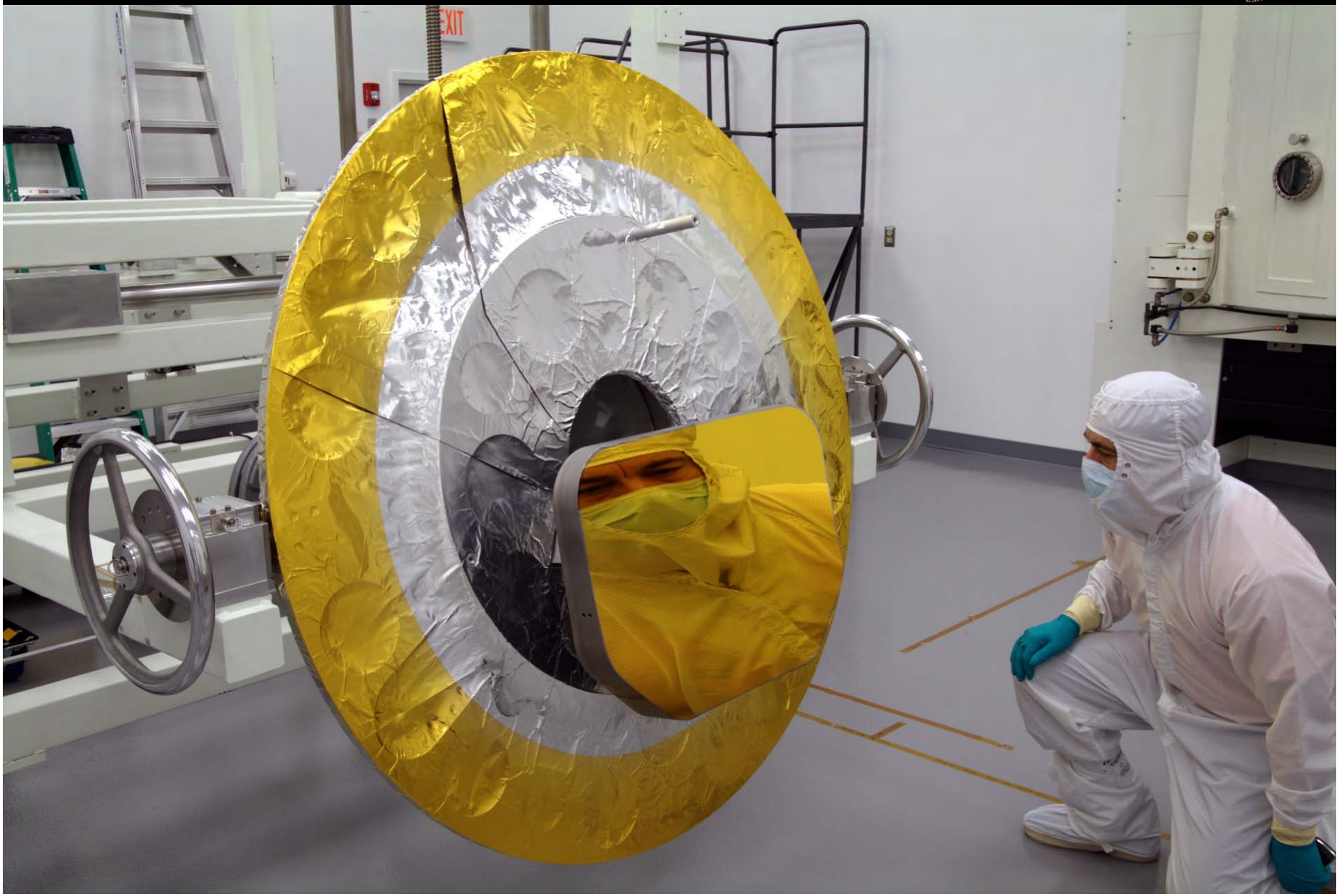


Description	Requirement	Measured
Low Frequency RMS	19 nm RMS	4.5 nm
Mid Frequency RMS	6 nm RMS	3.9 nm
High Frequency RMS	4 nm RMS	2.9 nm

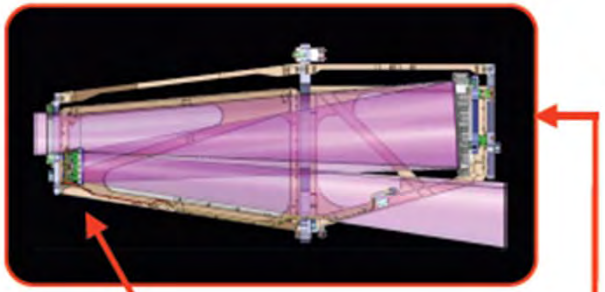


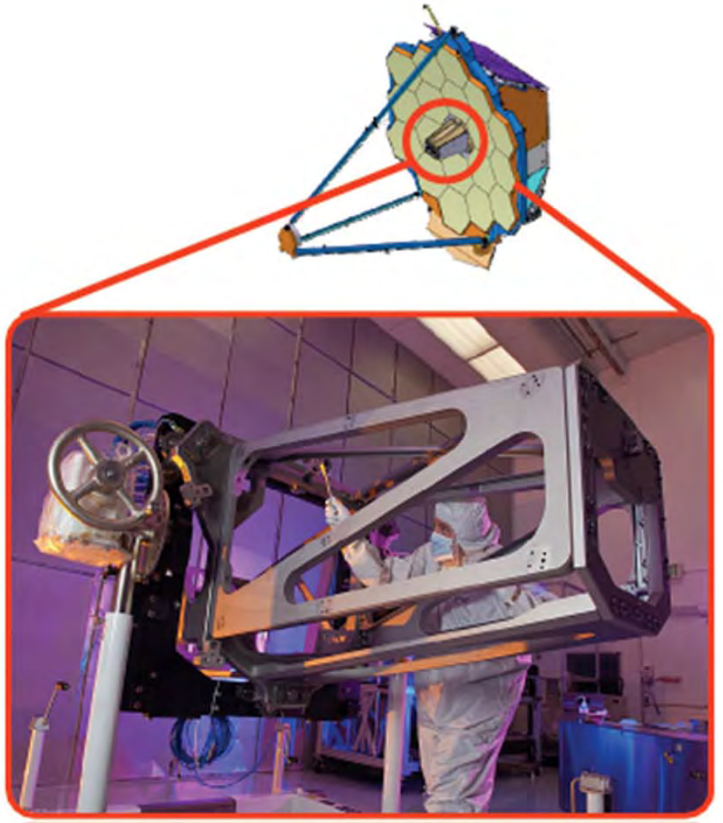
Flight Secondary Delivered to GSFC

Tertiary Mirror coated with gold!



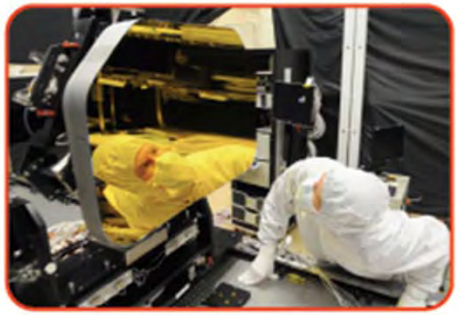
Aft-Optics System



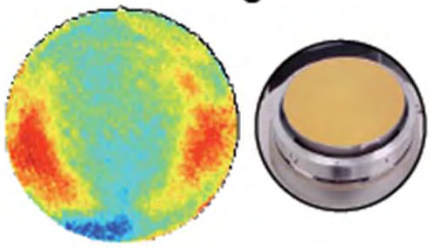


Aft optics and Aft optics bench complete

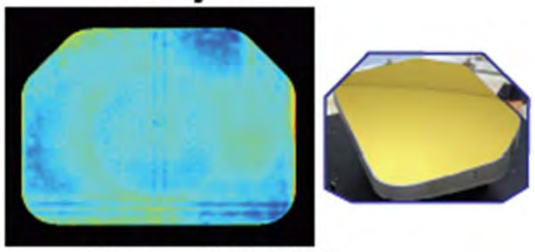
Fine Steering Mirror



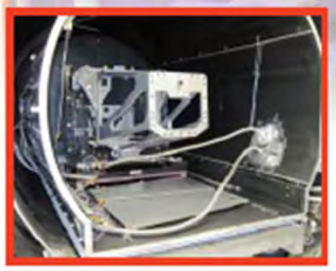
Tertiary Mirror



3.8 nm RMS SFE

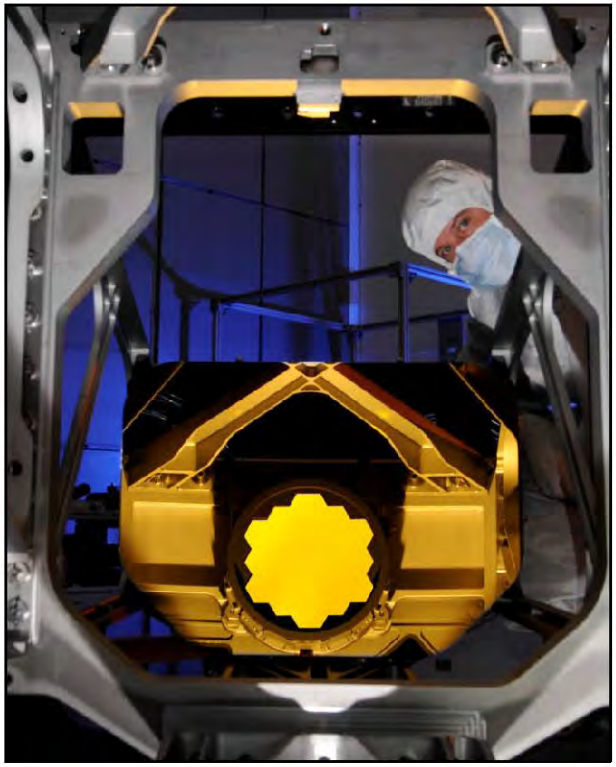


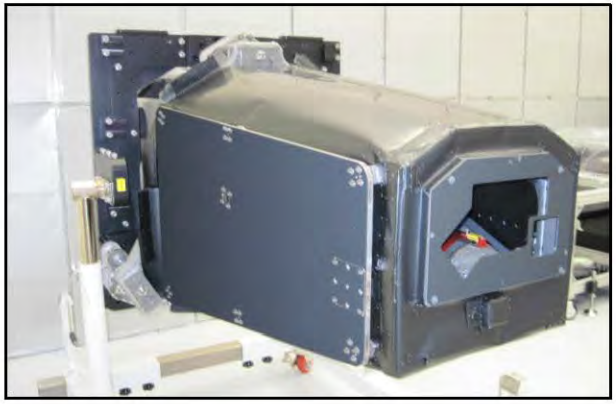
4.3 nm RMS SFE

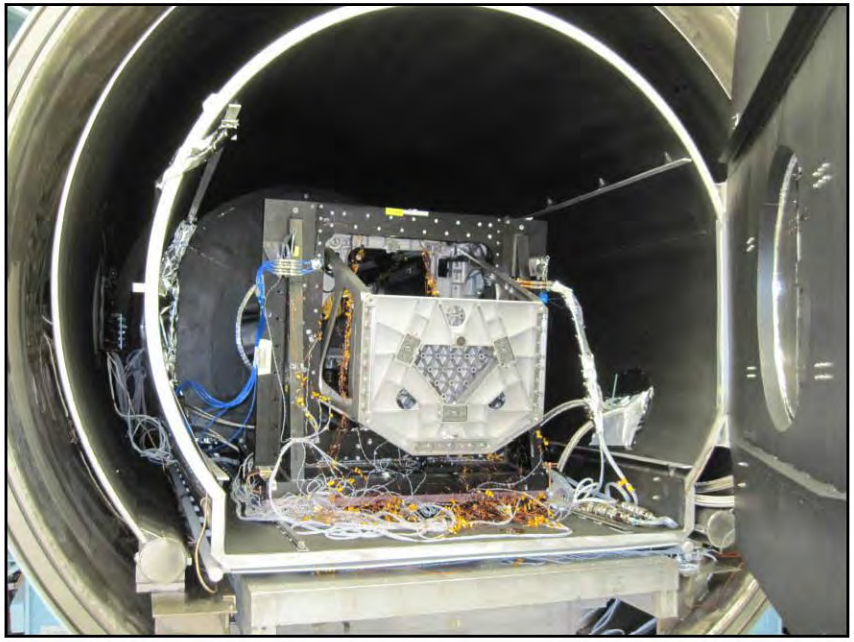


AOS Bench in cryo-test

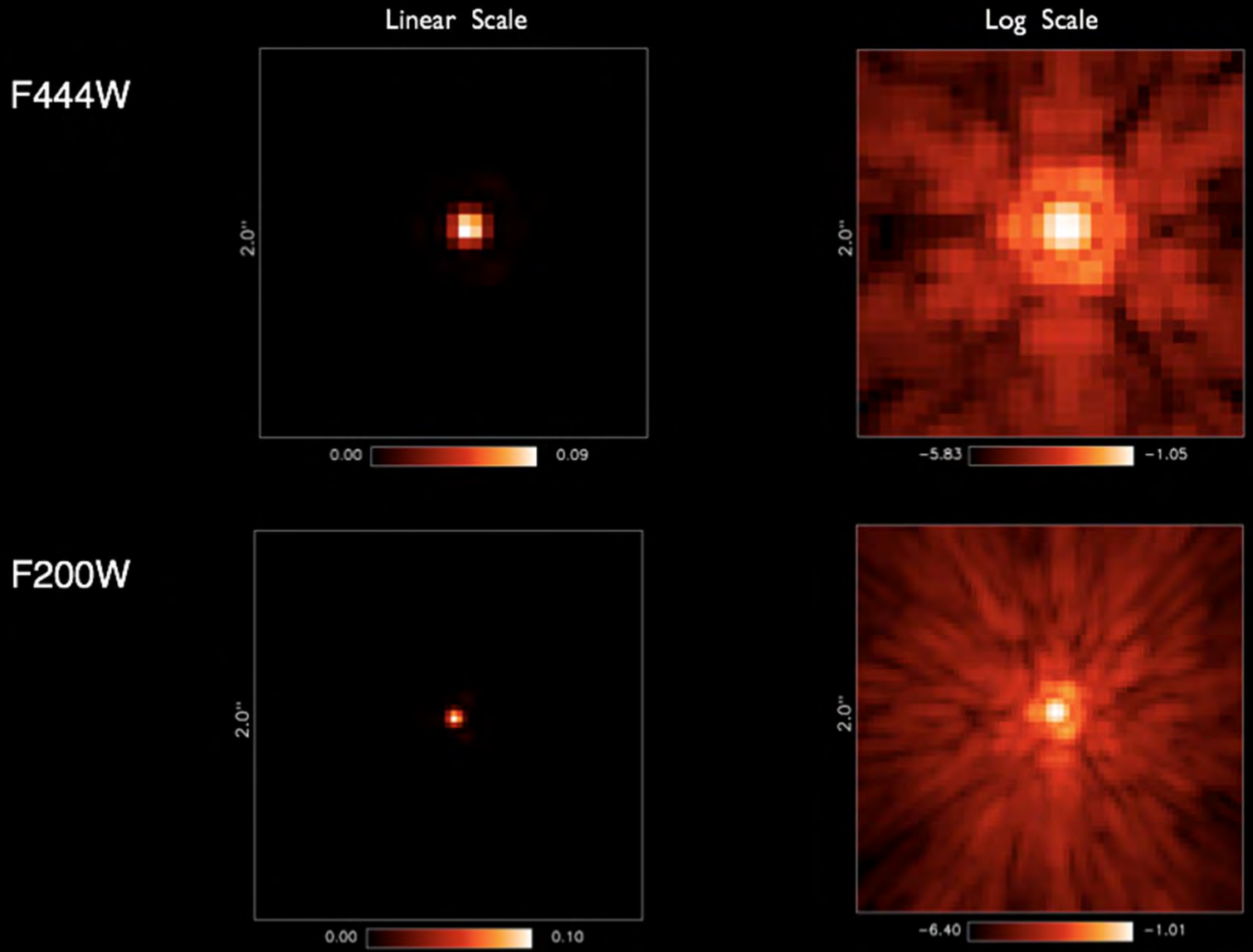
AOS Complete



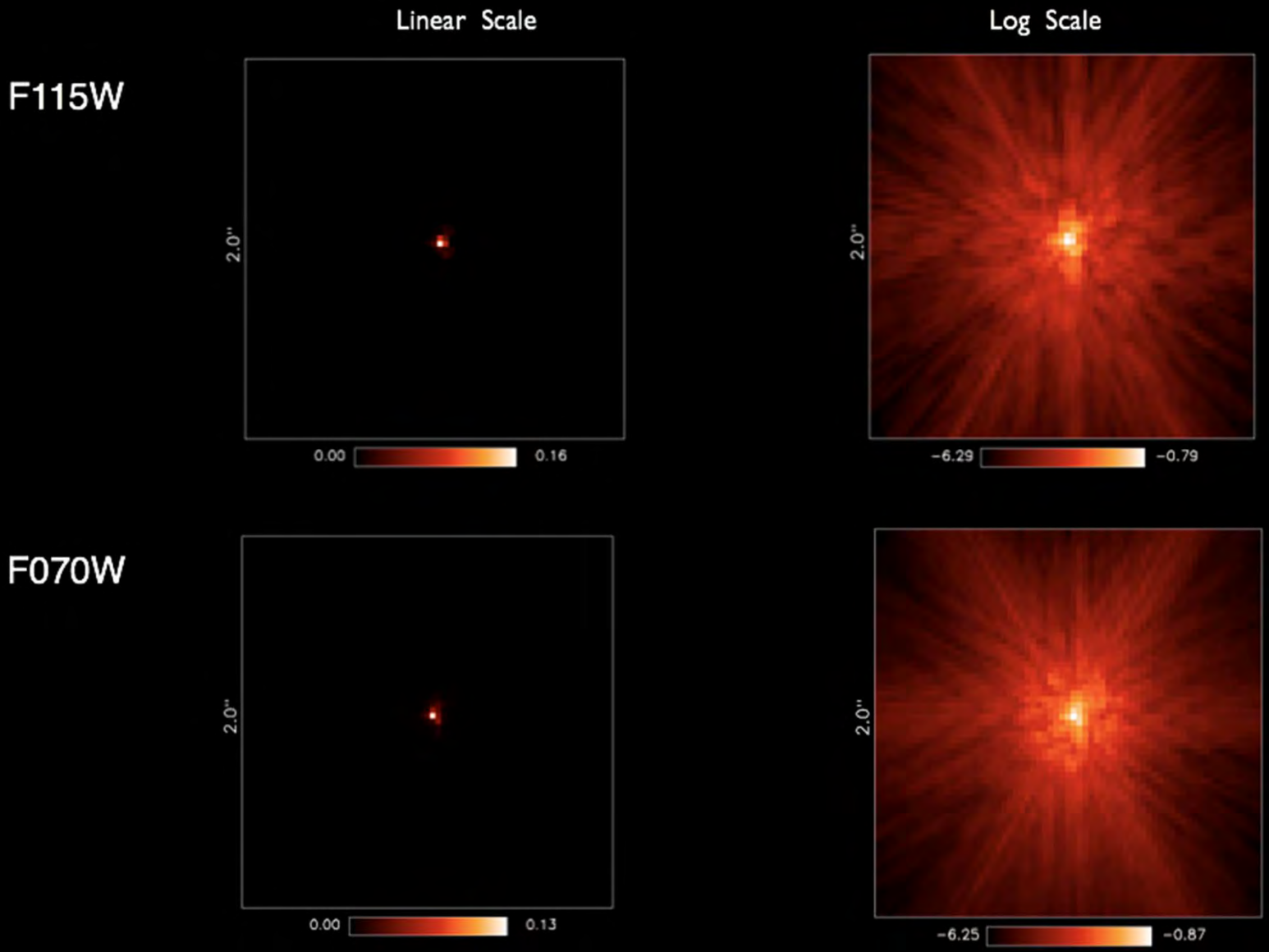




Predicted Image Quality: 2 μm & 4 μm

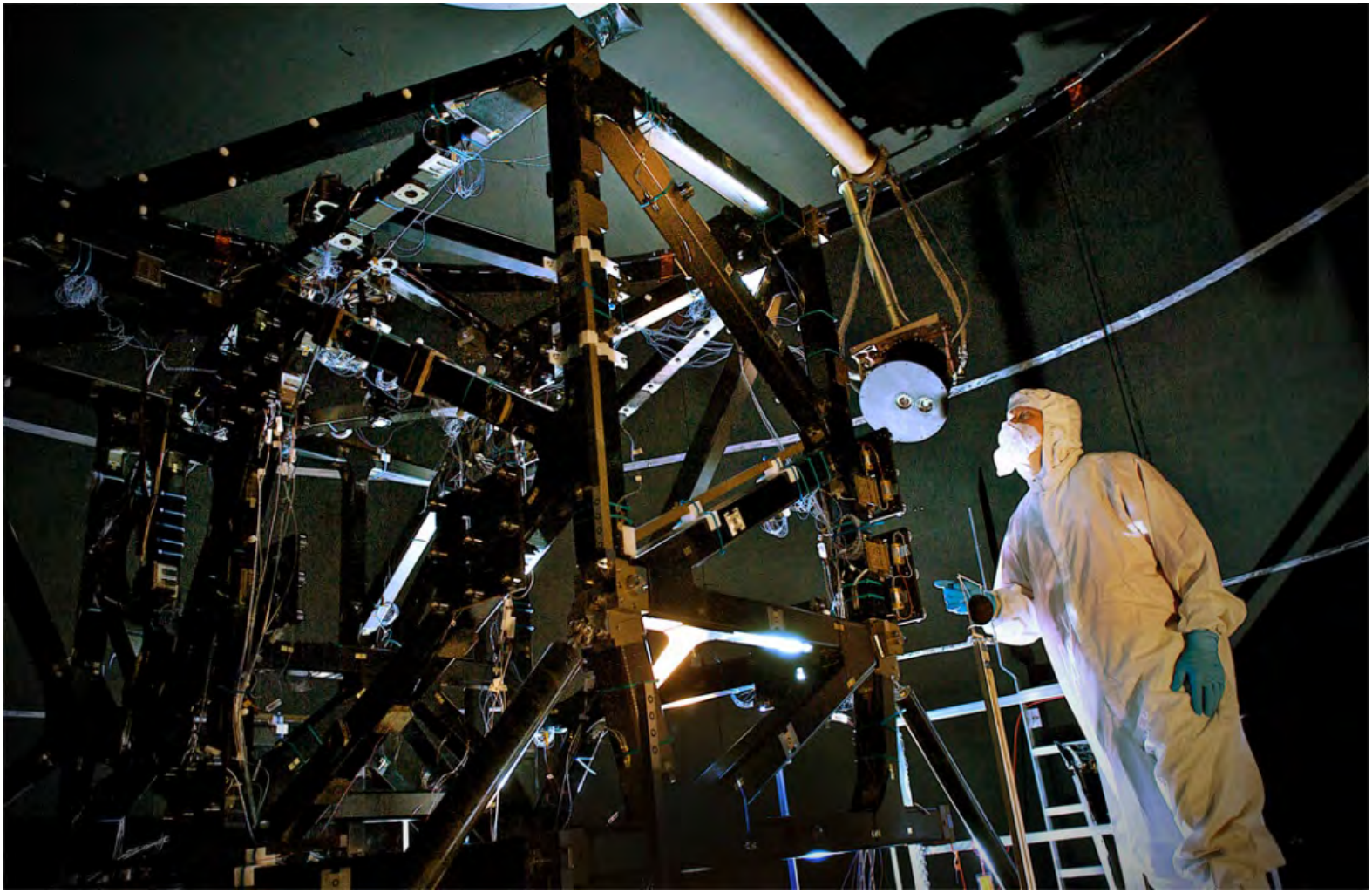


Predicted Image Quality: 0.7 μm & 1 μm

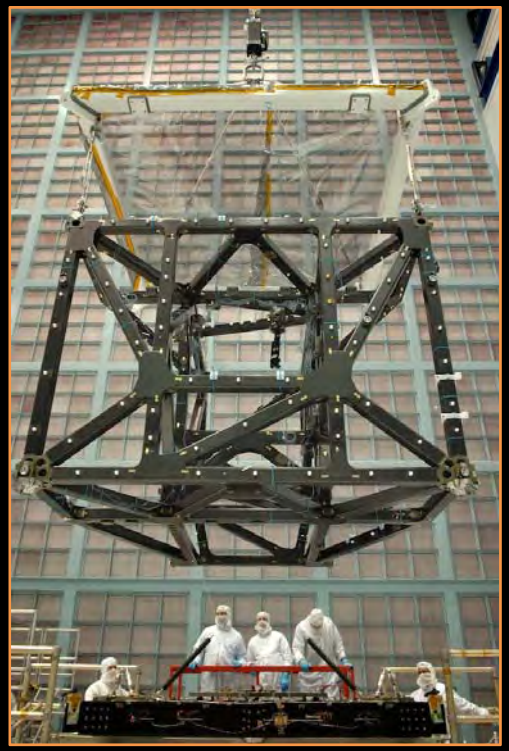


ISIM Flight Structure Completed

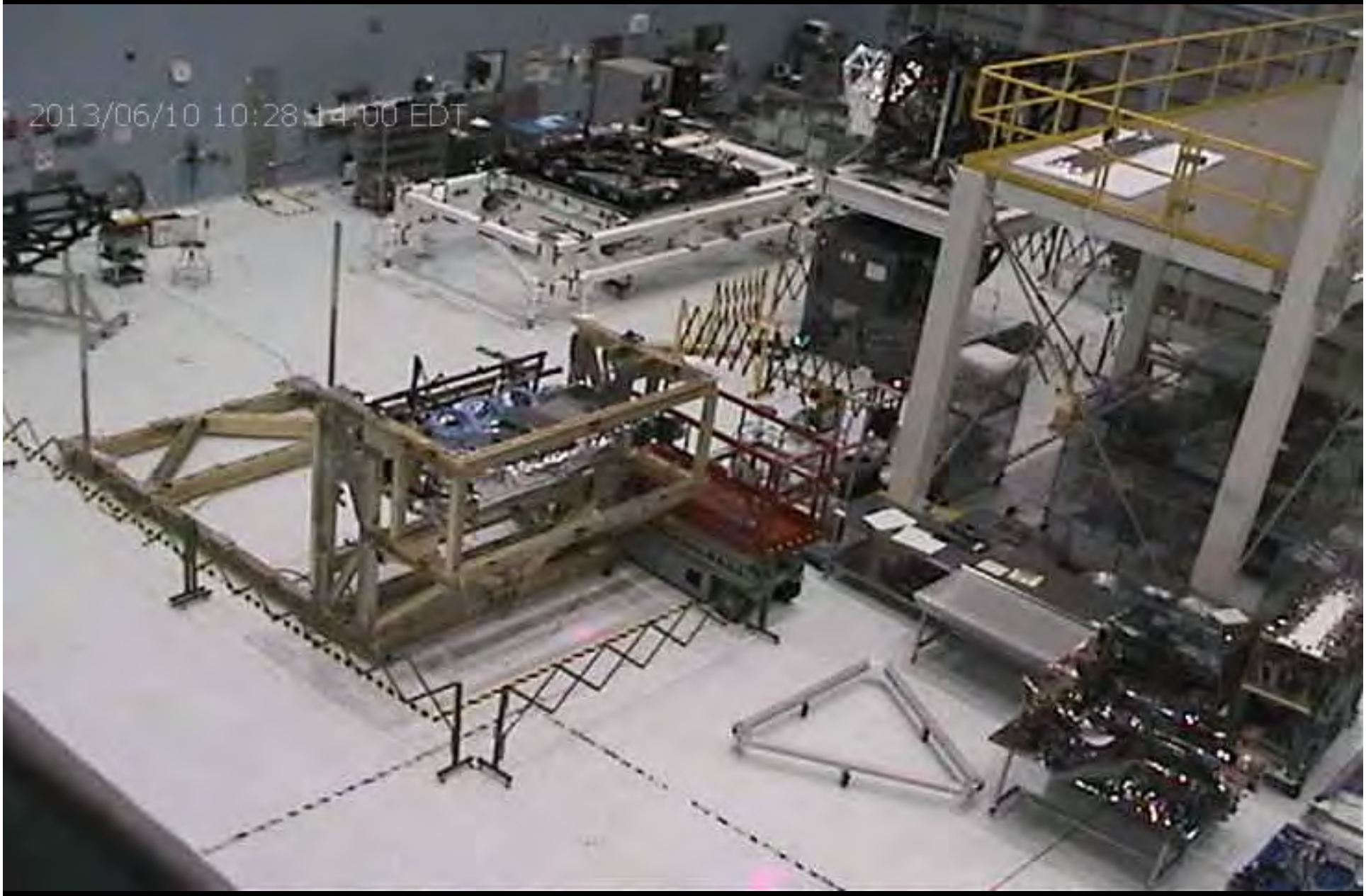
Structure in SES after Cryoset Test Complete



OSIM/ISIM: The Show has Begun

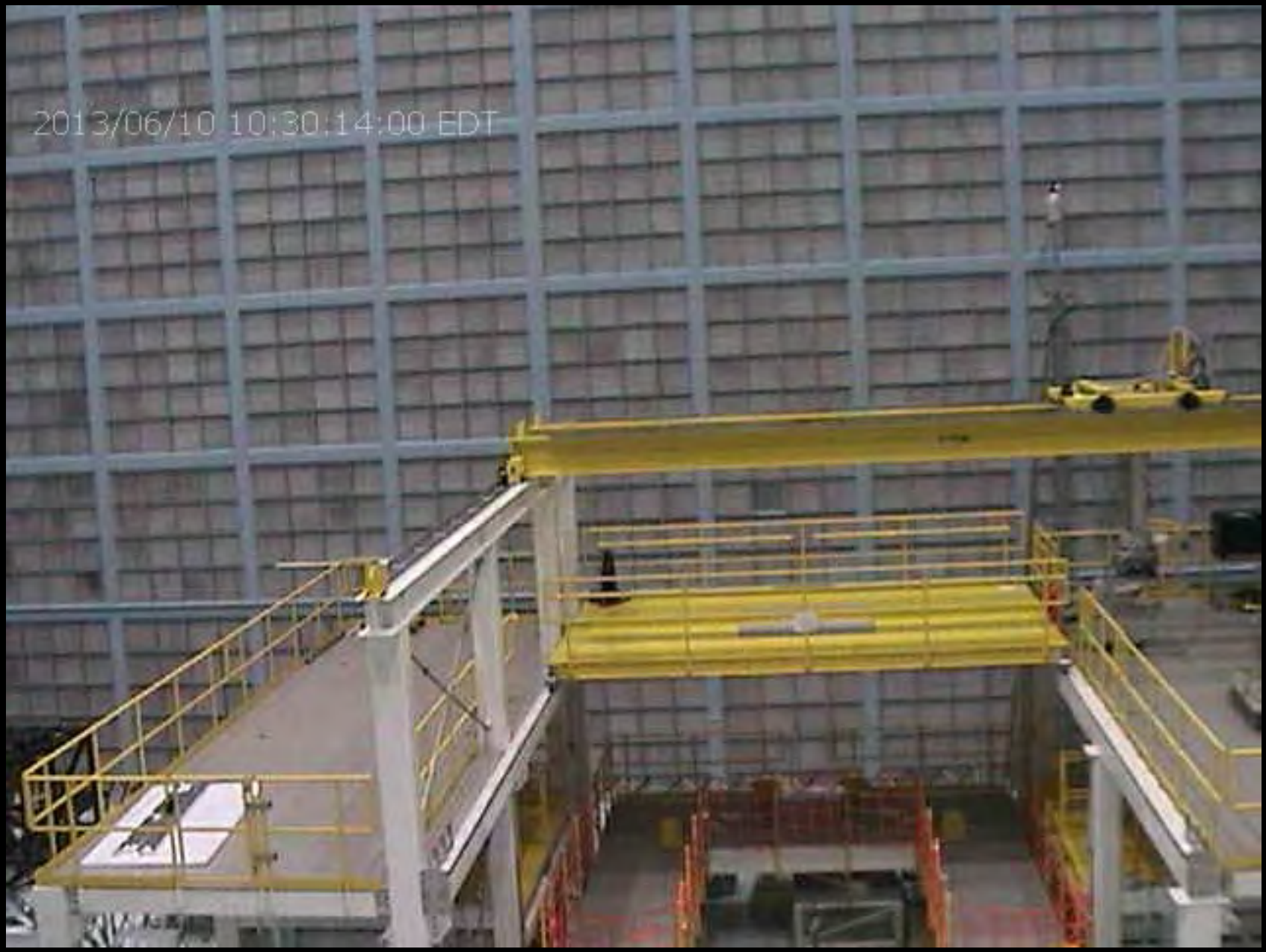


Webbcam



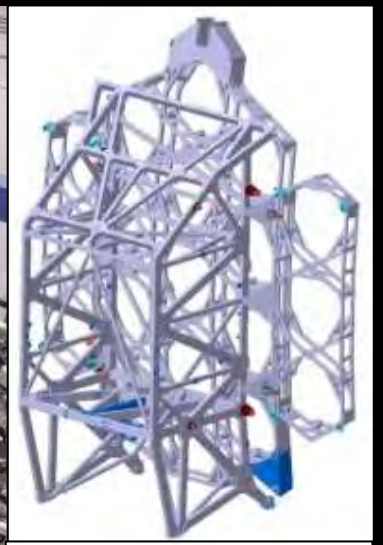
Live update every 60 seconds http://www.jwst.nasa.gov/webcam.html.

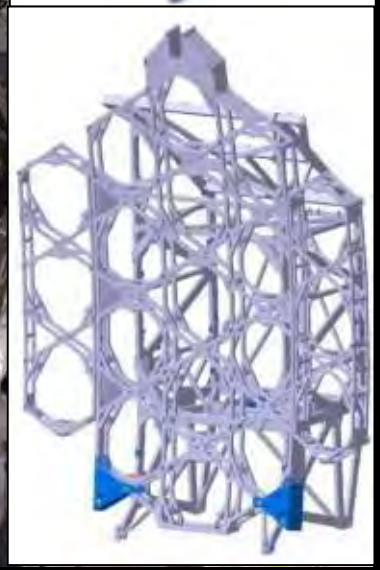
Webbcam



Live update every 60 seconds http://www.jwst.nasa.gov/webcam.html.

Pathfinder Center Section Bonding Complete





Wings complete

1/3rd Scale Sunshield

Sunshield Status

PROJECT: JWST

Status as of: 03/31/12

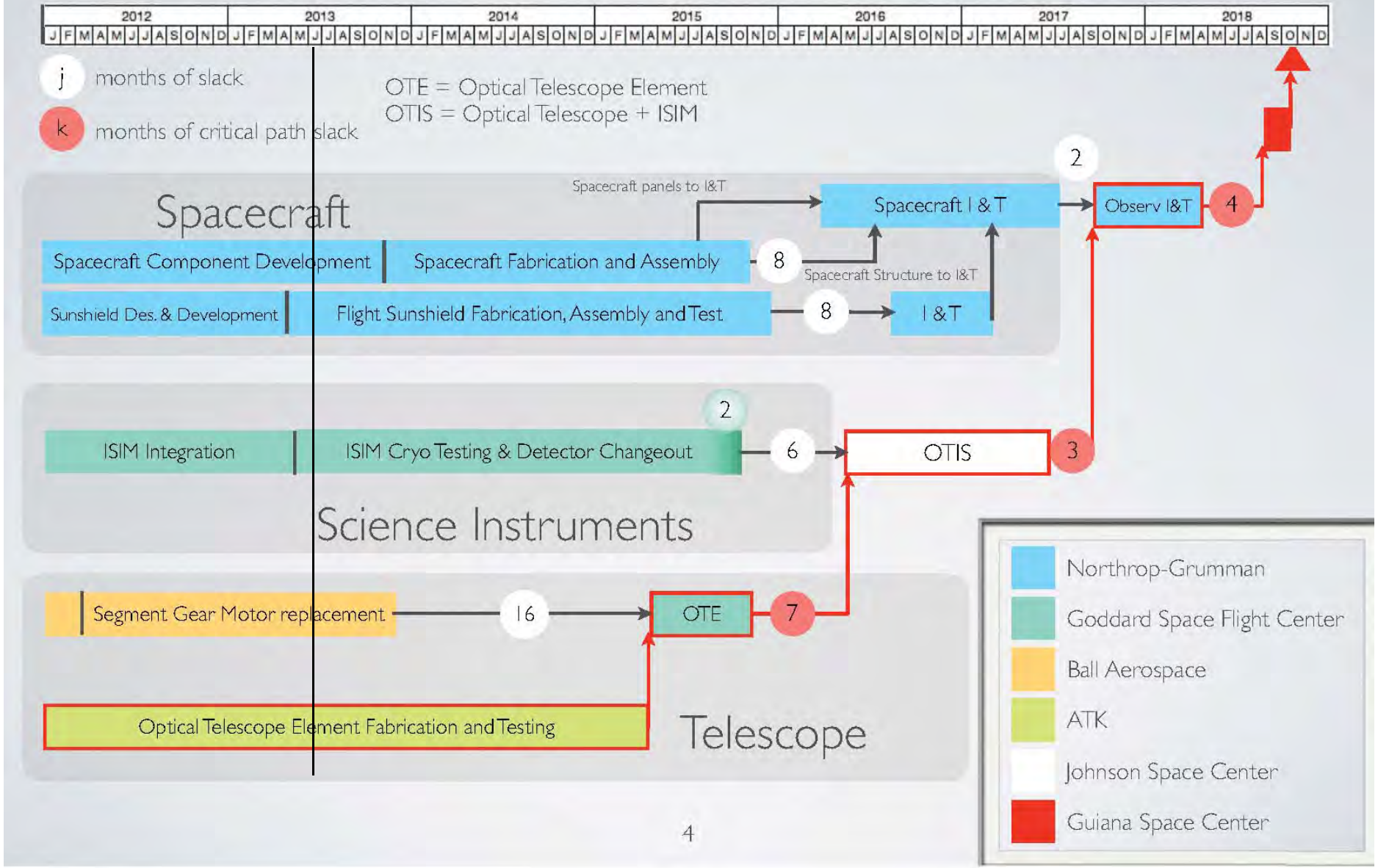
Template Layer 5 “cup down” under 3X loading

Sunshield Deployment Testing

Observatory level cryo-vacuum testing will occur at the Johnson Space Center in Houston

JSC Chamber A

LOOKING AHEAD



NASA

Want to Learn More about JWST?

THE JAMES WEBB SPACE TELESCOPE

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Abstract. The James Webb Space Telescope (JWST) is a large (6.6 m), cold (< 50 K), infrared (IR)-optimized space observatory that will be launched early in the next decade into orbit around the second Earth–Sun Lagrange point. The observatory will have four instruments: a near-IR camera, a near-IR multiobject spectrograph, and a tunable filter imager will cover the wavelength range, $0.6 < \lambda < 5.0\,\mu$m, while the mid-IR instrument will do both imaging and spectroscopy from $5.0 < \lambda < 29\,\mu$m.

The JWST science goals are divided into four themes. The key objective of The End of the Dark Ages: First Light and Reionization theme is to identify the first luminous sources to form and to determine the ionization history of the early universe. The key objective of The Assembly of Galaxies theme is to determine how galaxies and the dark matter, gas, stars, metals, morphological structures,

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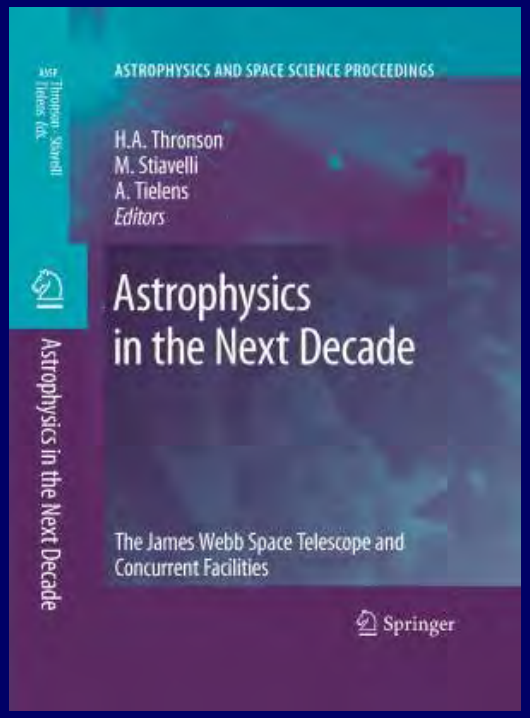
Gardner et al. 2006,
Space Science Reviews, 123/4, 485
http://jwst.nasa.gov/scientists.html



2007 Conference
Proceedings
Available on Amazon

White Papers:

JWST in Decadal Survey
Solar System Objects
Dark Energy
Transiting Planets
Coronagraphy
Planetary Systems
Stellar Pops
Star Formation
Galaxy Assembly
First Light
Astrobiology
Scientific Capabilities
Observation Planning

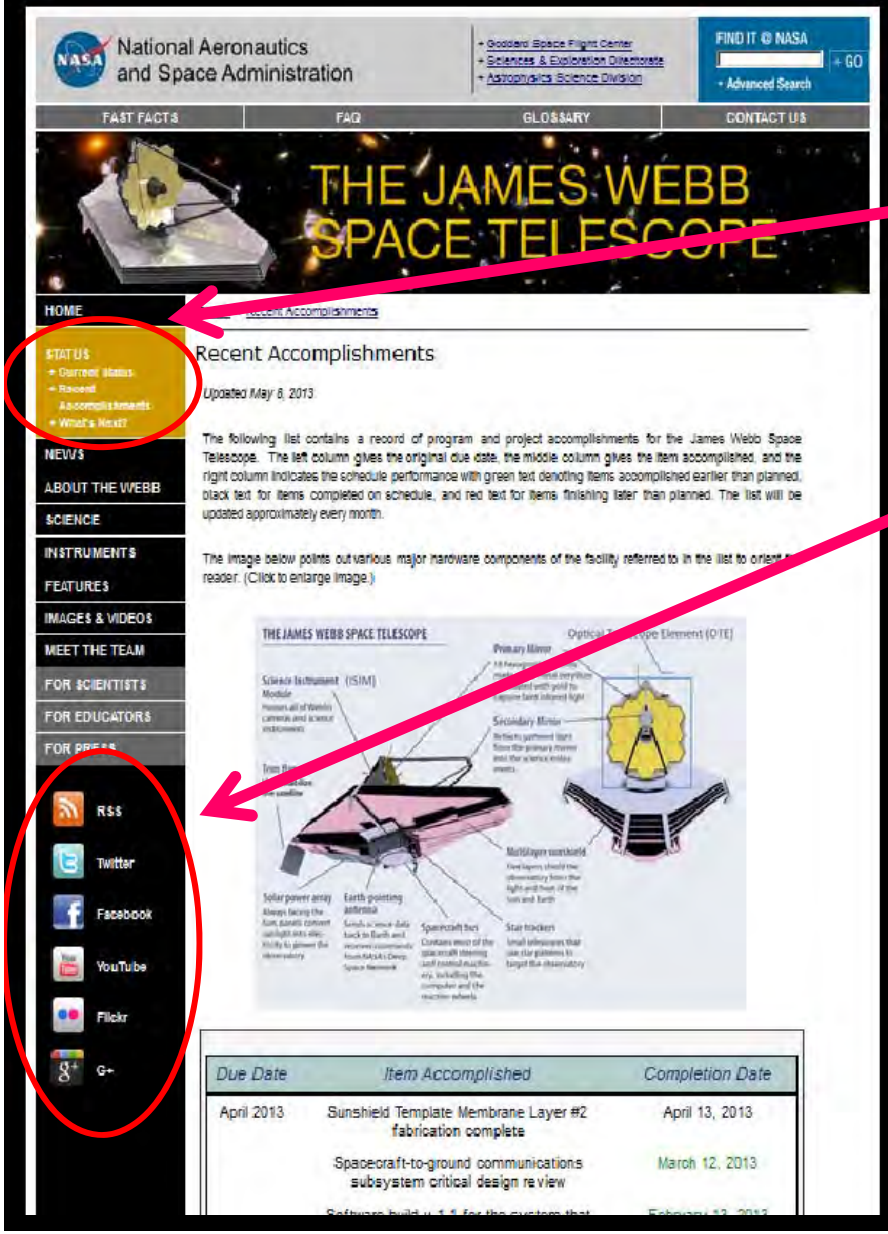
Science White Papers
http://www.stsci.edu/jwst/science/

Workshop on "Frontier Science Opportunities with JWST"

- June 6-8, 2011
- STScI
- Baltimore, Maryland, USA
- www.stsci.edu
- Webcast and charts:
- https://webcast.stsci.edu/webcast/searchresults.xhtml?searchtype=20&eventid=147&sortmode=1
- See white paper for summary: http://www.stsci.edu/jwst/science

Latest News

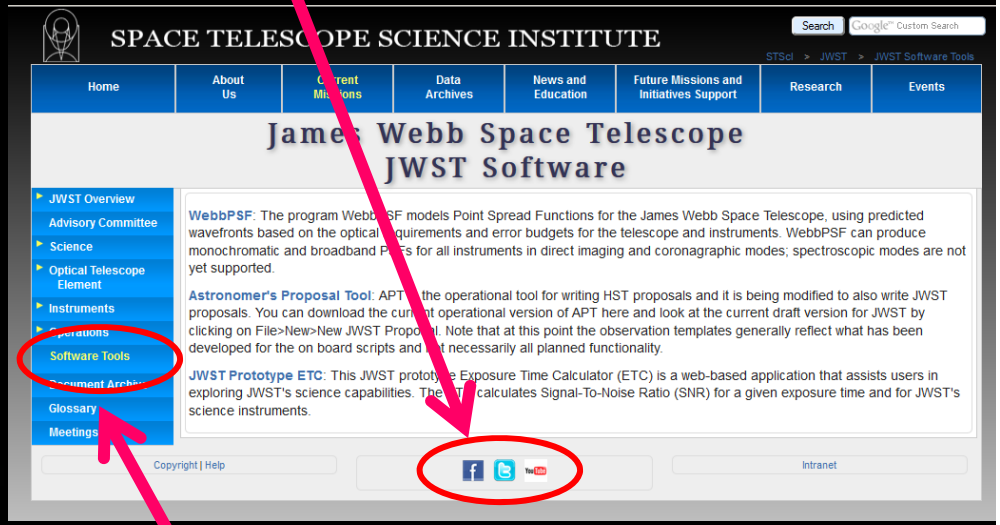
jwst.nasa.gov



Project Milestones
updated monthly

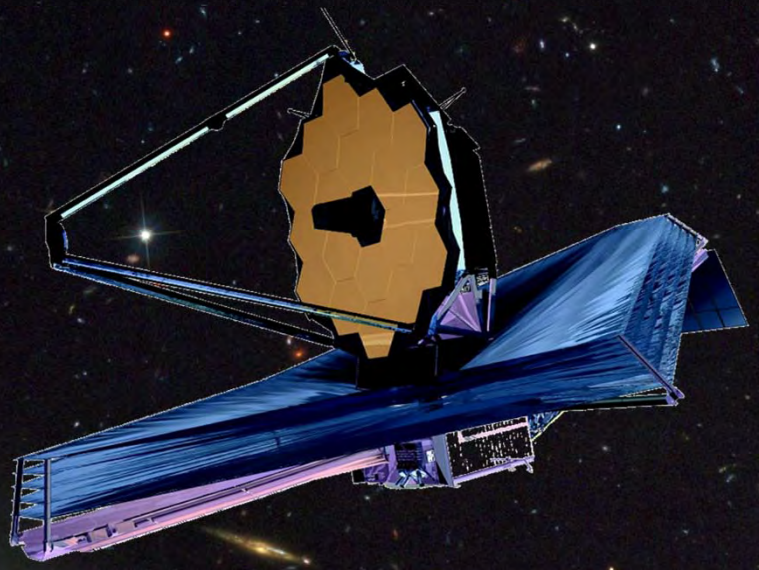
Social Media

www.stsci.edu/jwst



Astronomy Software Tools
ETC, PSF, APT

The James Webb Space Telescope



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http://jwst.nasa.gov

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