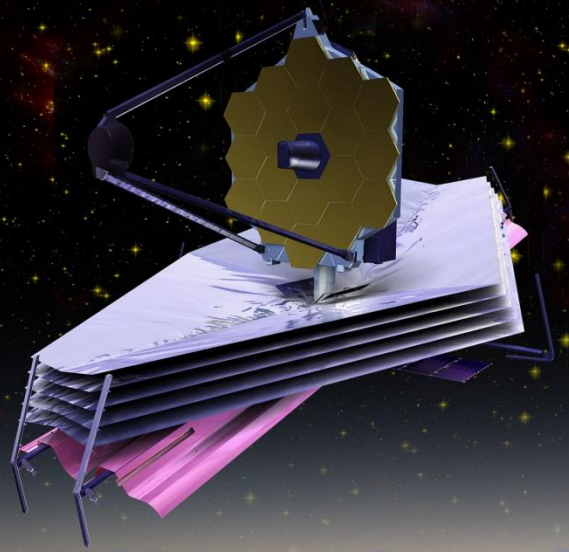


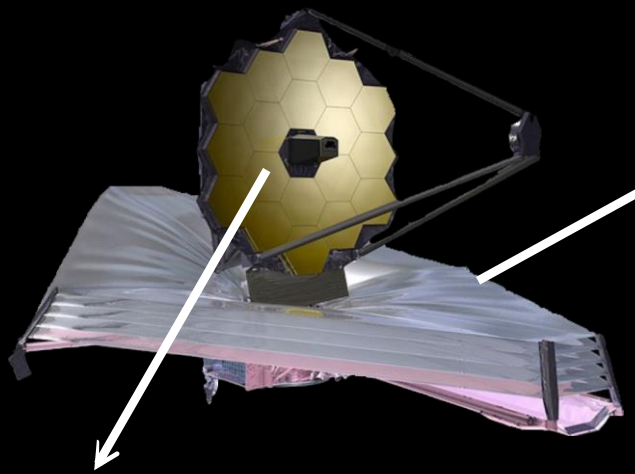
James Webb Space Telescope (JWST)
A new view into the infrared universe

Dr.-Ing. Silvia Scheithauer
Max-Planck-Institut für Astronomie (MPIA), Heidelberg

JWST was successfully launched
on December 25, 2021
with an Ariane 5
from Europe‘s Kourou spaceport in French Guiana

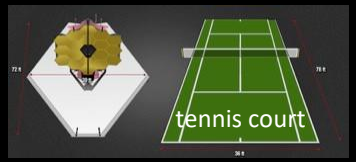
Credit: NASA

Infrared Telescope

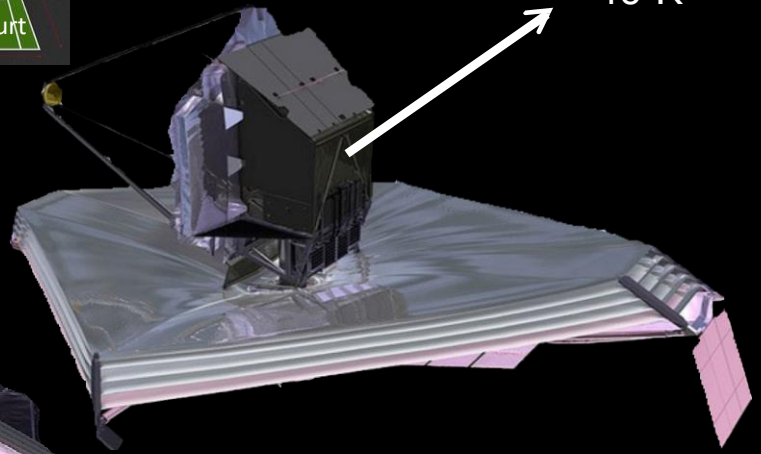


6.5m segmented mirror

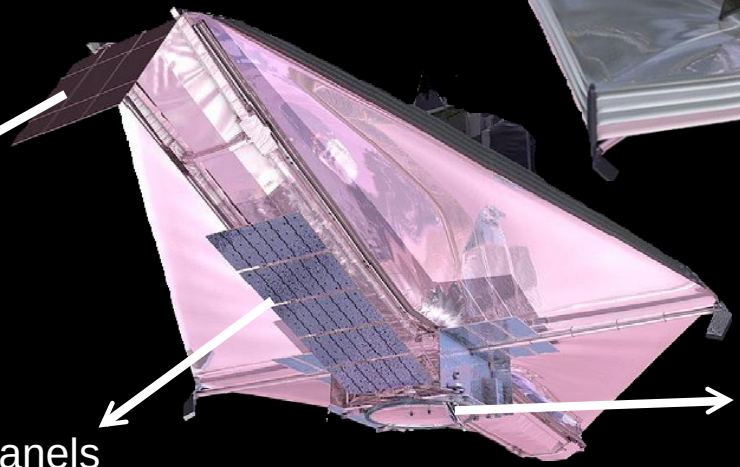
Multi-layer sunshield
for passive cooling



Payload module with
4 science instruments
40 K



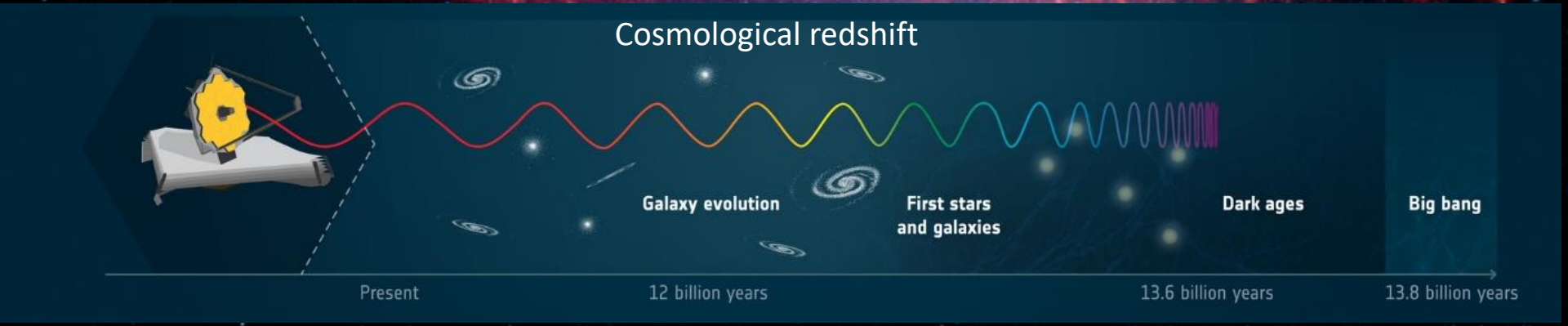
Momentum flap



Solar panels

Service Module
& high gain antenna

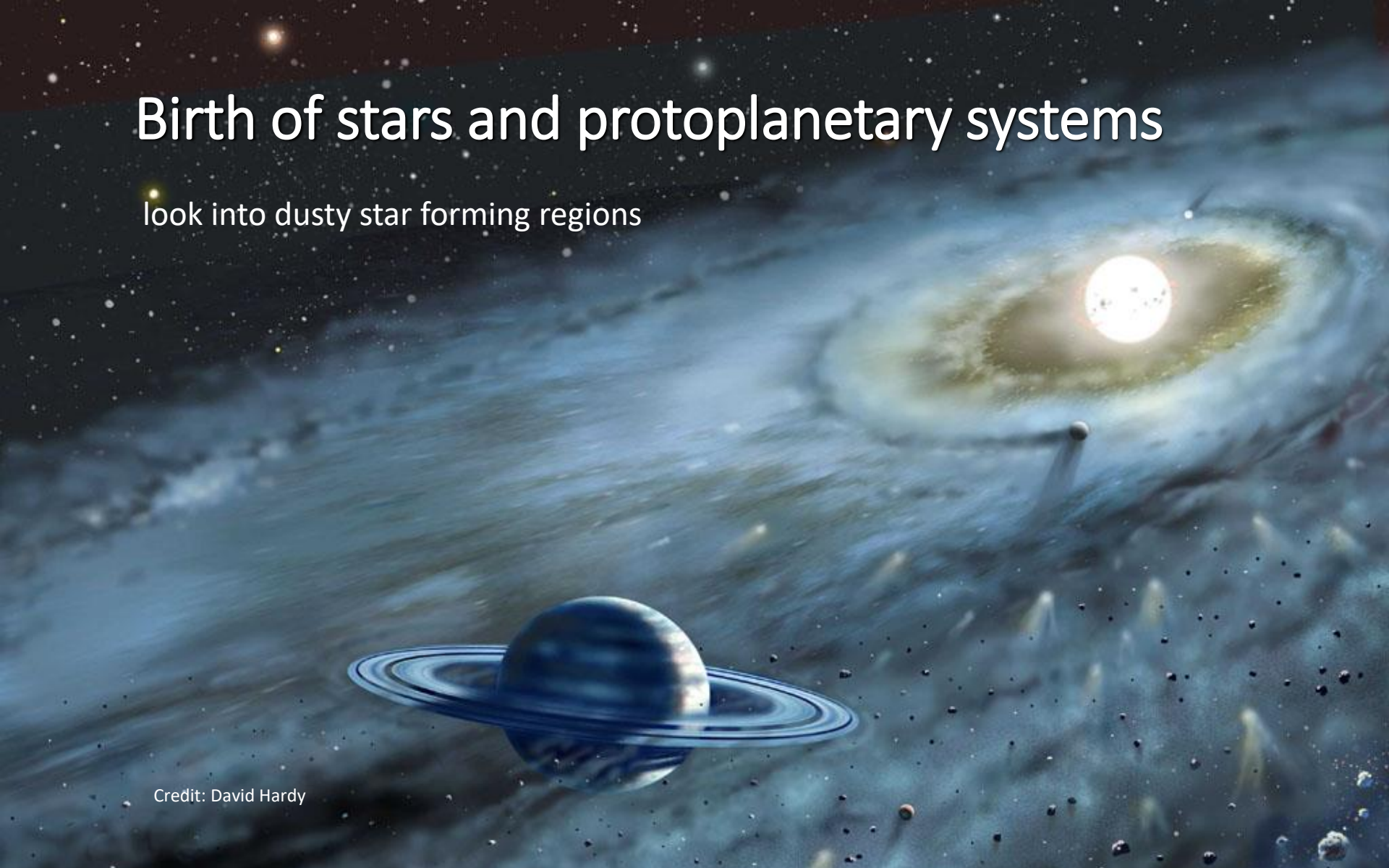
Looking back to the very first galaxies



Credit: sketch: ESA; M81 image: Spitzer consortium

Birth of stars and protoplanetary systems

look into dusty star forming regions



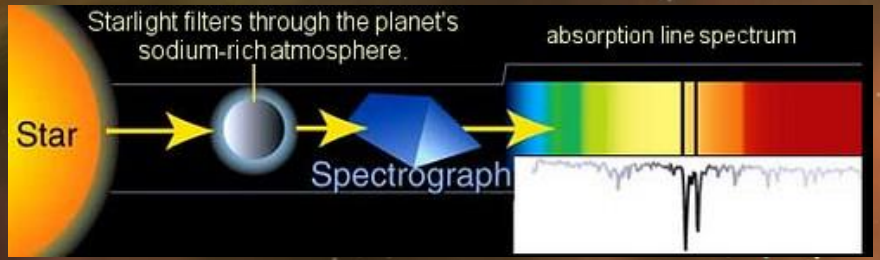
Credit: David Hardy

Exoplanets and their atmospheres

Credit: Robert Hurt

Direct Imaging of exoplanets via coronagraphy

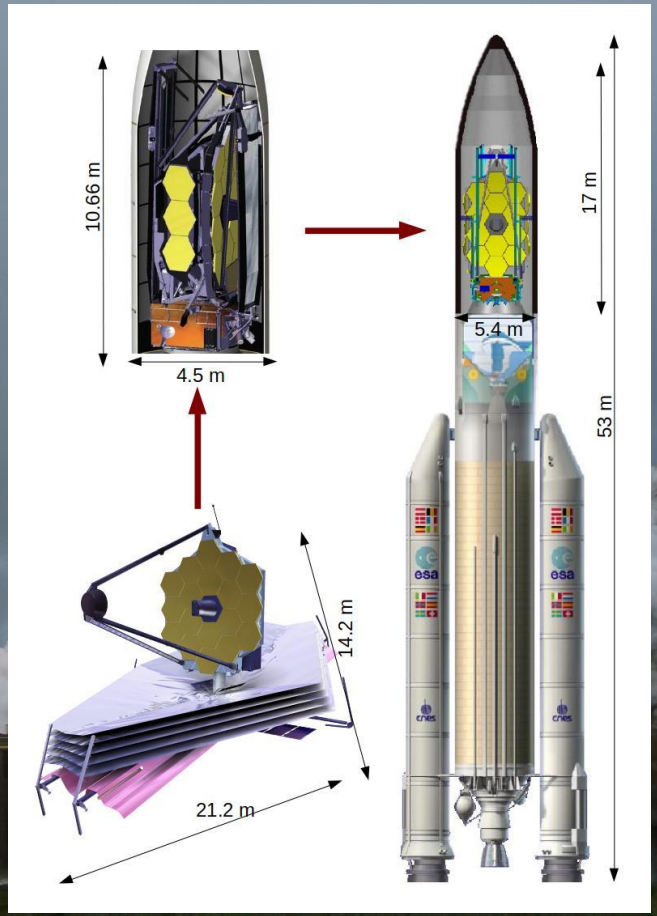
Atmospheric composition via transit spectroscopy



sodium line in atmosphere of Hot Jupiter exoplanet HD 209458
Credit: A. Field, STScI

JWST 1 : 1 model

How does JWST fit into Ariane 5 ?

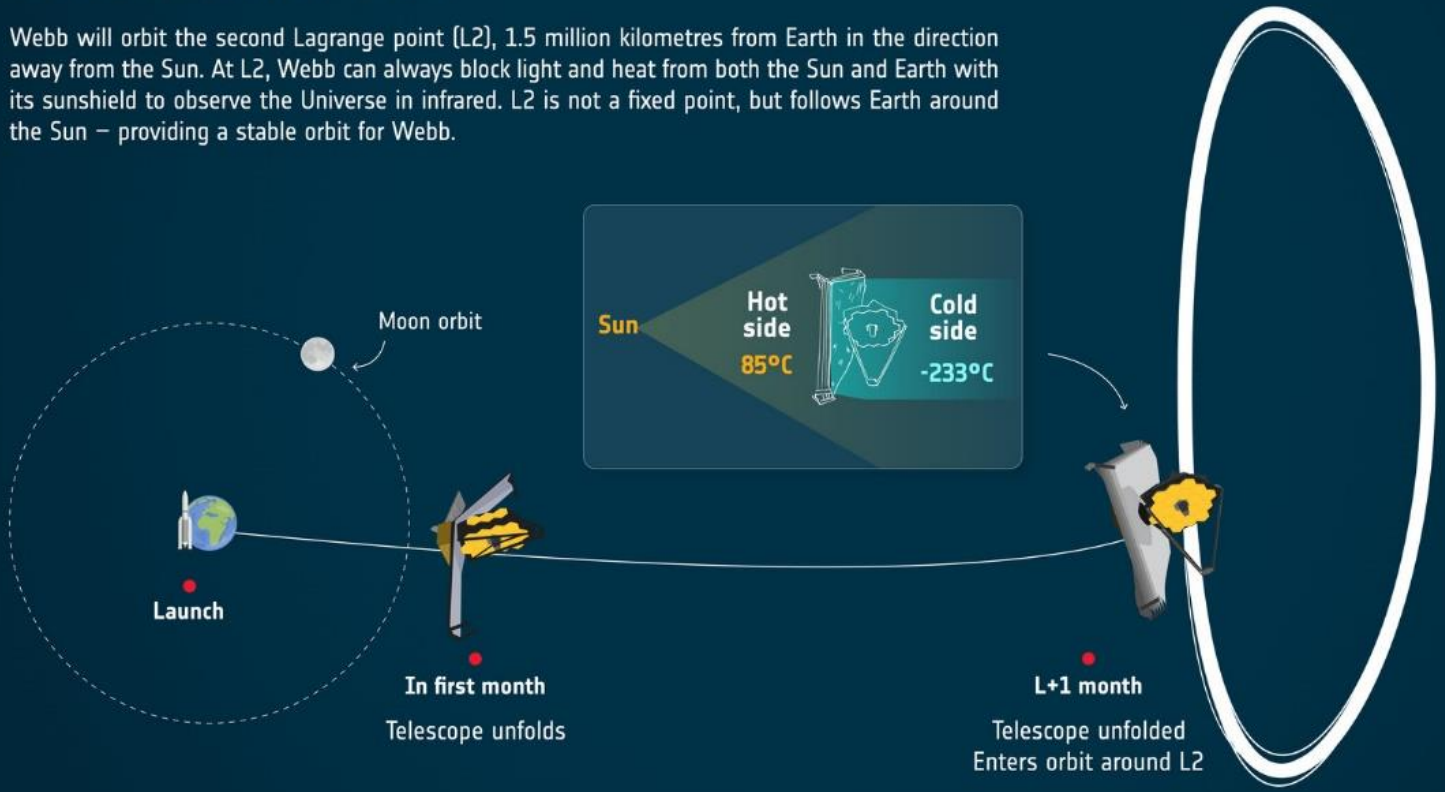


Cryogenic, highly complex payload, warm start
6200 kg total weight

Credit: NASA

WEBB'S JOURNEY TO L2

Webb will orbit the second Lagrange point (L2), 1.5 million kilometres from Earth in the direction away from the Sun. At L2, Webb can always block light and heat from both the Sun and Earth with its sunshield to observe the Universe in infrared. L2 is not a fixed point, but follows Earth around the Sun – providing a stable orbit for Webb.



ESA animation: Launch and deployment

JWST Timeline

- Idea > 30 years
- 1996: three parallel concept studies

- 2002: concept selection -> telescope development
- In parallel: science instrument development
- 2012-2013: delivery of science instruments to NASA
- 2013 – 2018 Instrument integration and testing
- In parallel – 2021 : telescope assembly and testing
- October 2021: JWST shipment to Kourou (arrival 18 October 2021)
- Launch: 25 December 2021

- Science operation will start after commissioning phase of 6 month

JWST is a unique science telescope with very challenging requirements.
It has been built on the edge of technical feasibility !

Main Mirror

18 x 1.32 m mirror segments
20.8 kg weight
Beryllium, gold coated
manufacturing & test 2004-2013
by Ball Aerospace

Credit: NASA

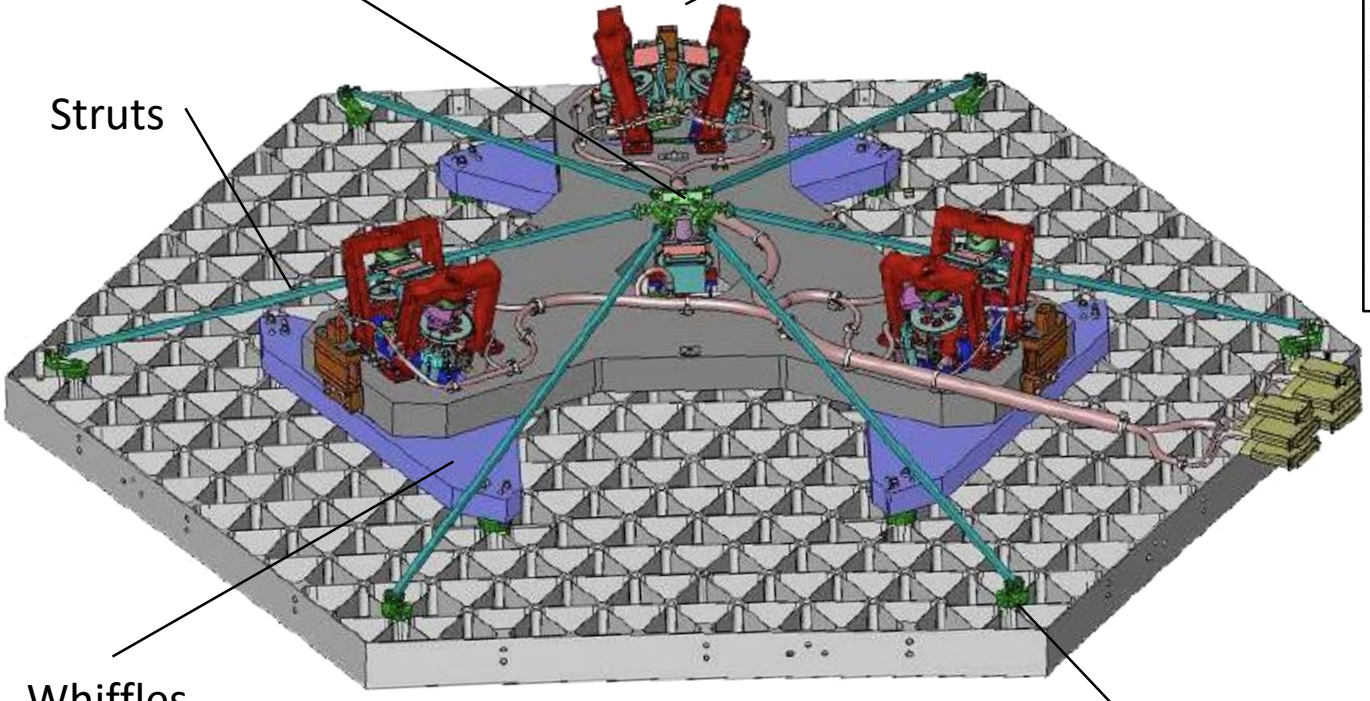
Primary Mirror Segment Assembly

→ 126 mechanisms only for the mirror support !

Radius of curvature actuator

6 DOF Hexapod actuators

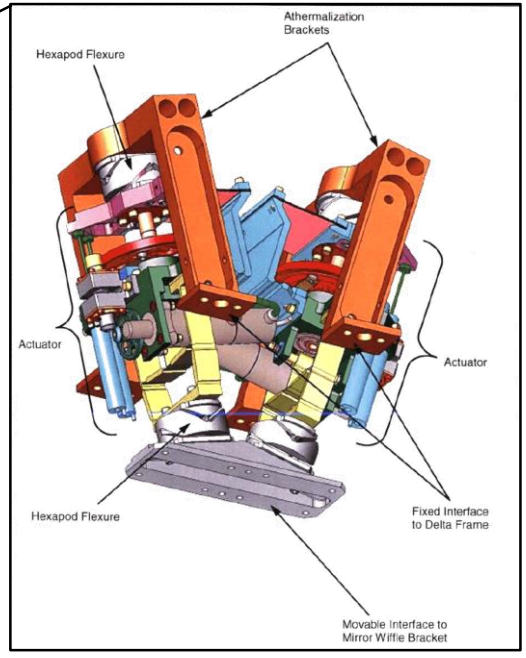
Struts



Whiffles

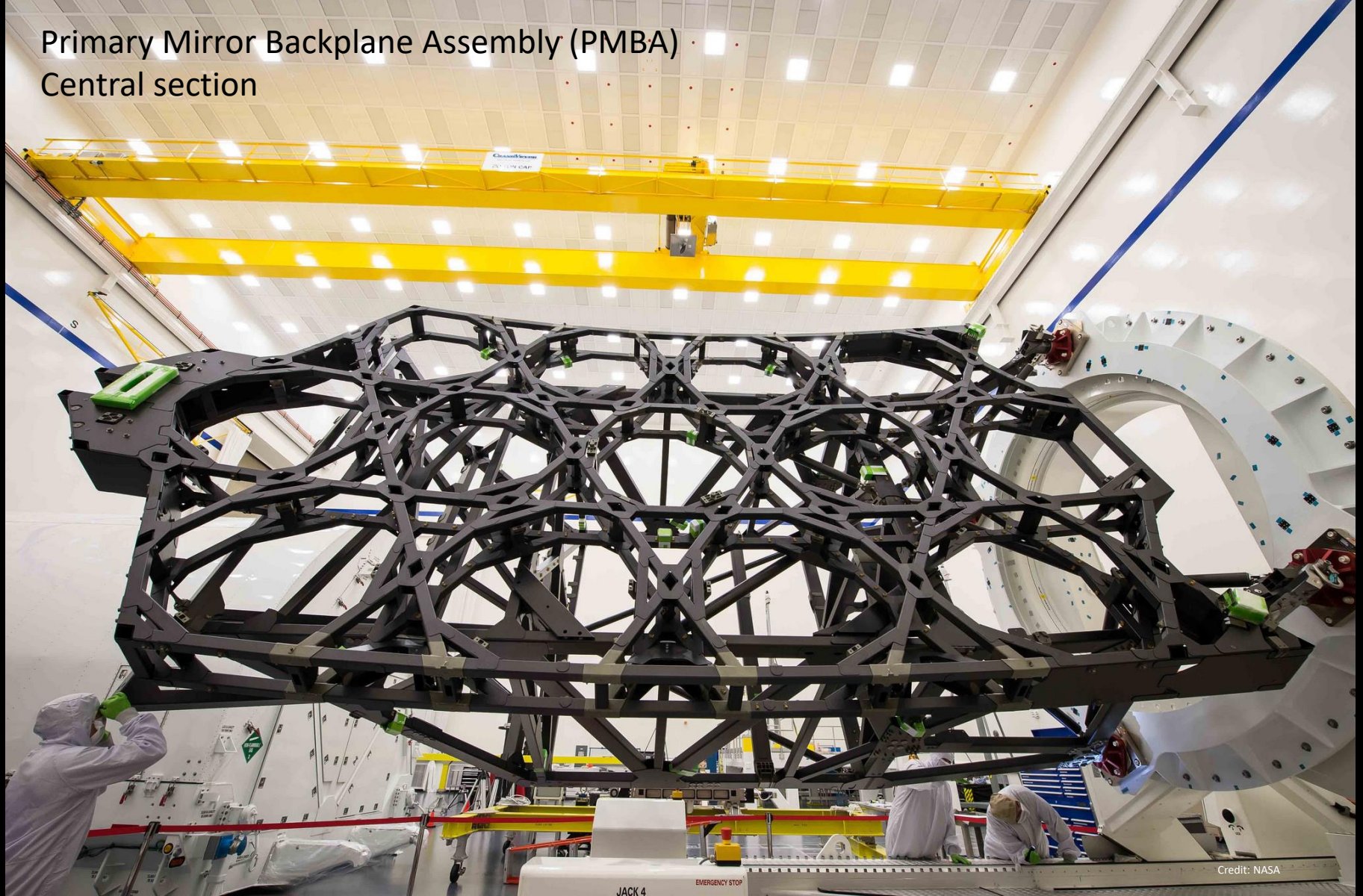
Mirror Substrate

Flexures



Electrical connectors

Primary Mirror Backplane Assembly (PMBA)
Central section



Credit: NASA

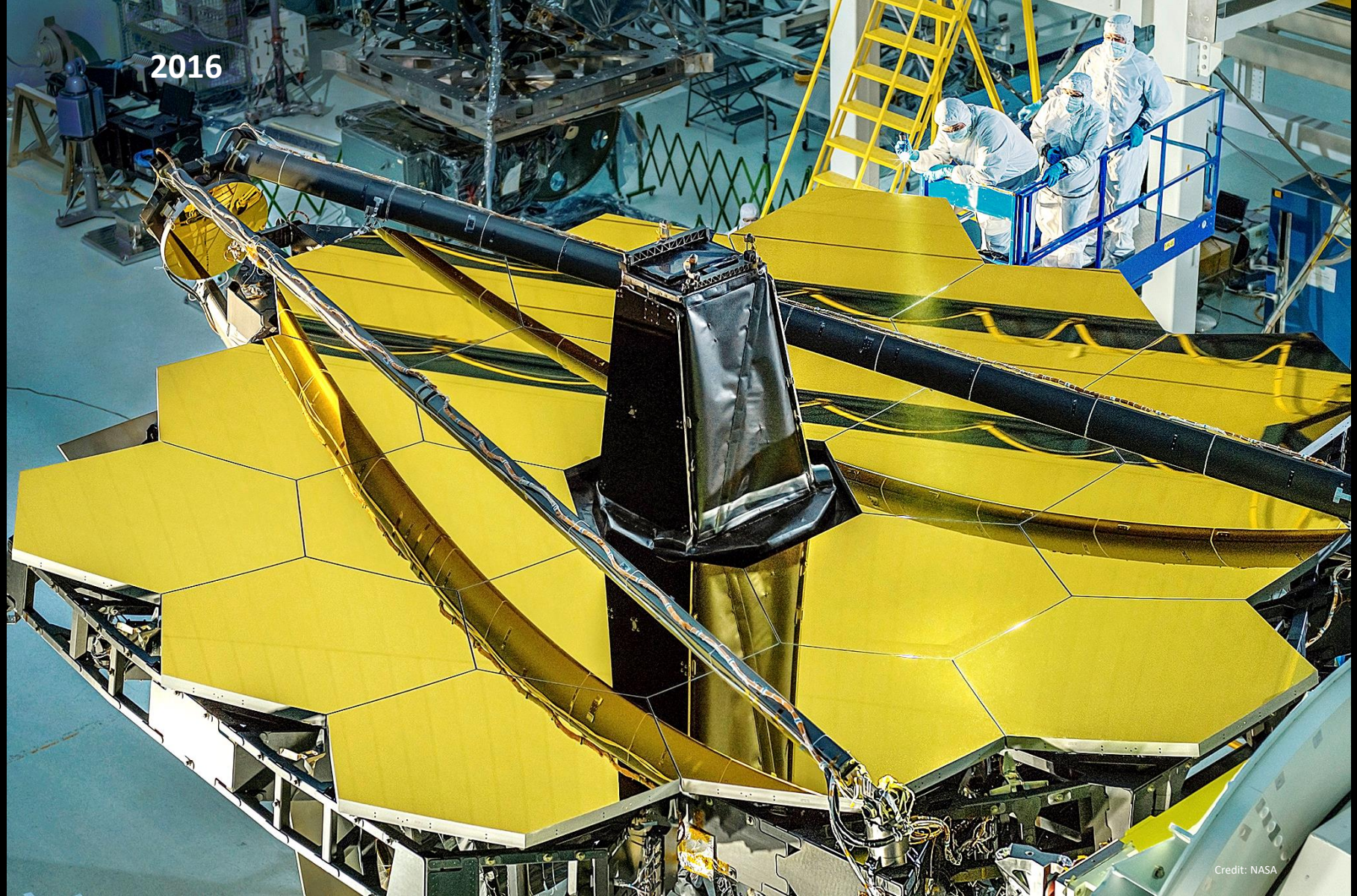

Credit: NASA


Robot-assisted integration
of primary mirror assembly
Credit: NASA

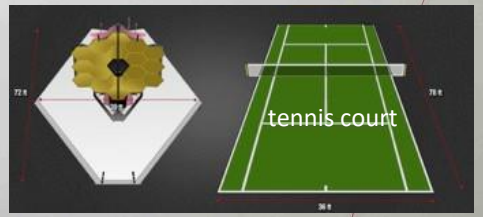

Credit: NASA

Covers removal

Credit: NASA


2016
Credit: NASA

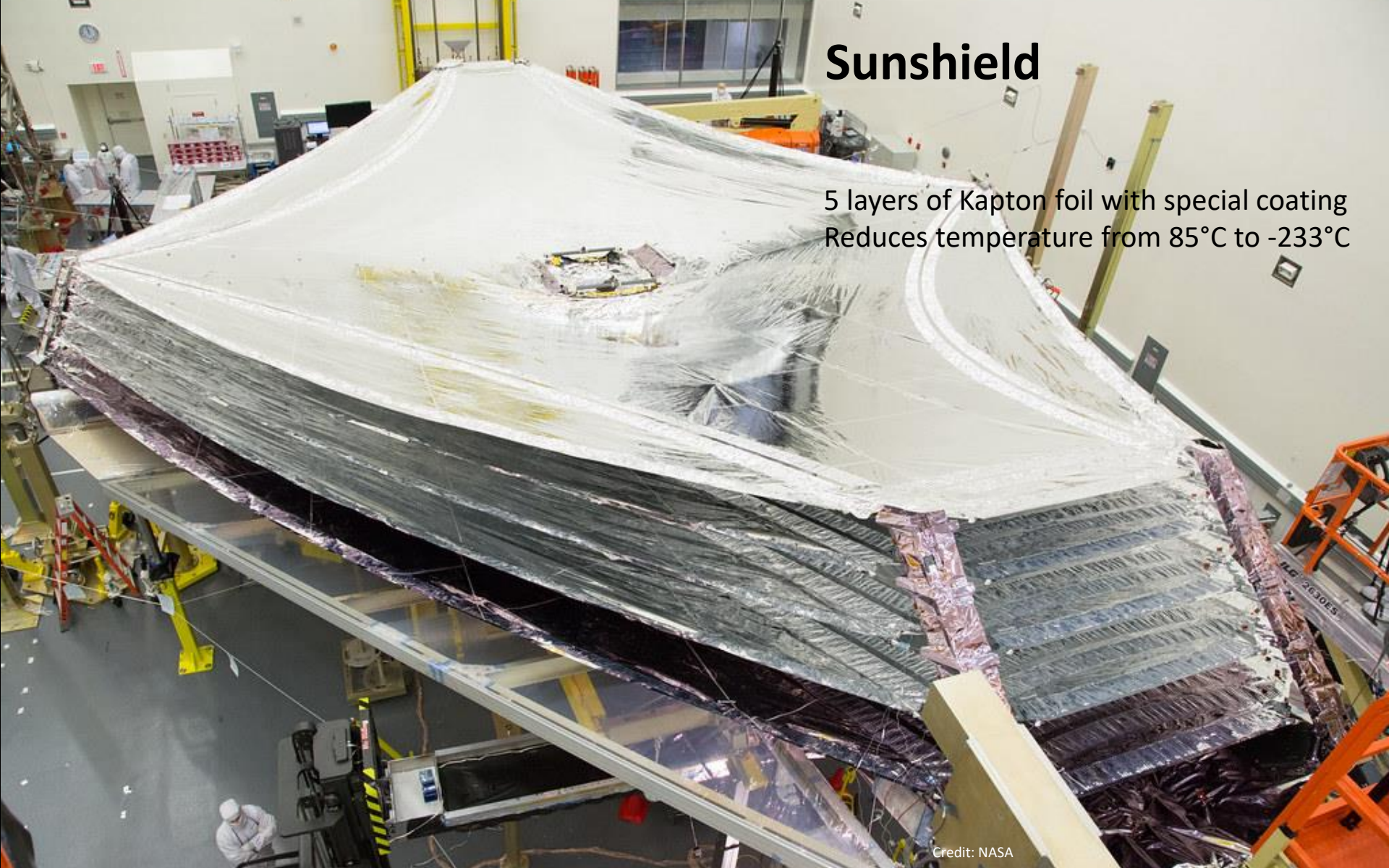
Sunshield



Test sunshield at Northrop Grumman 2008
Credit: NASA

Sunshield

5 layers of Kapton foil with special coating
Reduces temperature from 85°C to -233°C



Credit: NASA

Sunshield

> 100 release mechanisms
no complete cryo test possible !

Credit: NASA

WEBB'S SCIENCE INSTRUMENTS


Credit:MIRI EC


Credit: NASA

Mid-InfraRed Instrument (MIRI)

−266°C

Extra refrigerator: **cryocooler**

Observes **cold, distant objects** in mid-infrared

Spectroscopy mapping

Near-Infrared Spectrograph (NIRSpec)

Temperature, mass, chemical composition of objects

Spectroscopy mapping

Can capture spectra of **200 objects** simultaneously

Near-Infrared Camera (NIRCam)

Farthest objects ever in **near-infrared**

Light from **first stars and galaxies**

Critical role in telescope alignment

Near-InfraRed Imager and Slitless Spectrograph (NIRISS)

Temperature, mass, chemical composition of objects

Molecules in exoplanet atmospheres

High precision pointing

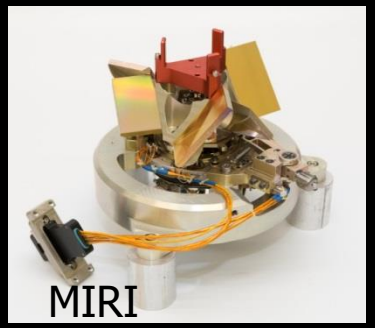
Credit


Credit: CSA

Credit: ESA

Max Planck Institute for Astronomy Hardware Contributions

Development, test and qualification of filter and grating wheels for **MIRI.**



Credit: MPIA

22 scientific institutes developed MIRI hardware from 2003-2010

Space Qualification of MIRI wheel mechanisms

1. Functionality at cryogenic temperatures : cryo-cycling at 6K inside cryostat
2. Radiation hardness: irradiation with large proton dose inside cryostat
3. Withstand accelerations at launch: shaker table

Cryostats, Credit: MPIA

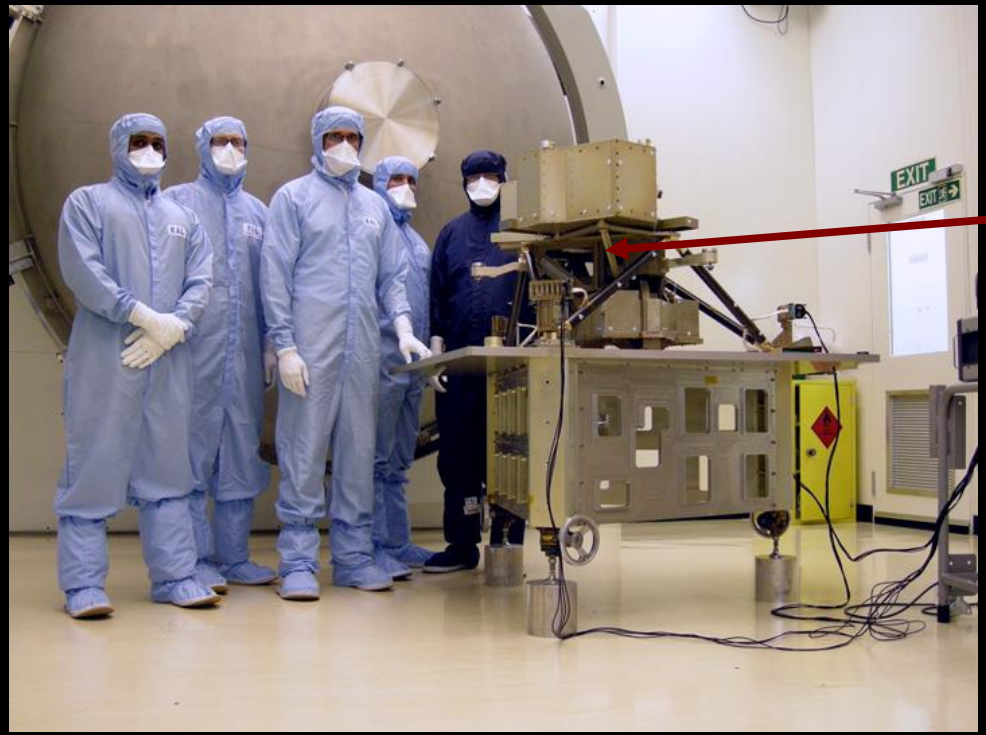
Clean room at Zeiss Oberkochen, Credit: Zeiss

Qualification and test of MIRI wheel mechanisms

Video: cleanroom Zeiss, Oberkochen (now: Hensold)

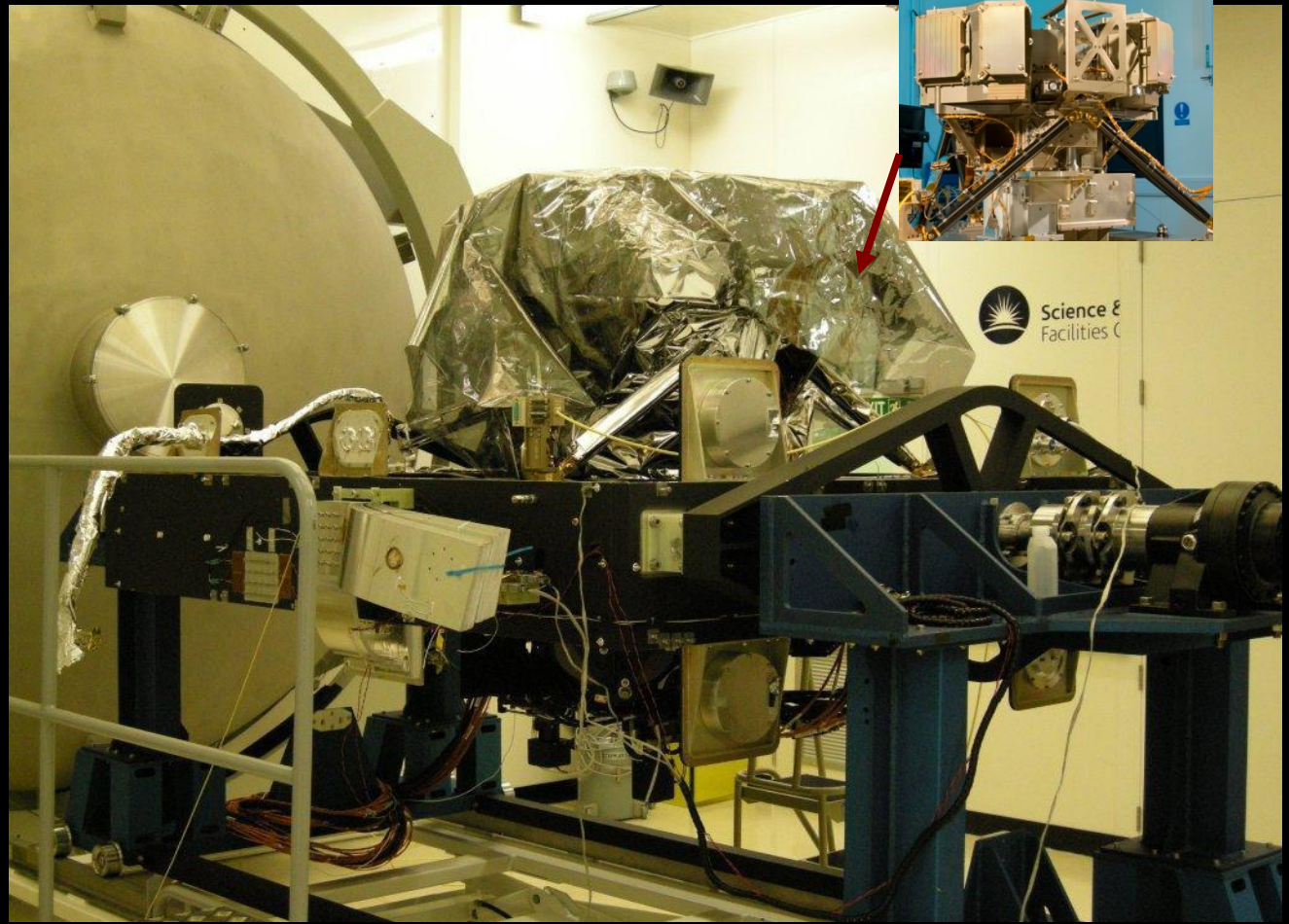
Qualification and Test of MIRI

Mid 2010: MIRI hardware complete
-> instrument assembly at the Rutherford Appleton Laboratories (RAL), UK
-> functional, thermal and shaker tests



Credit: MIRI EC, RAL

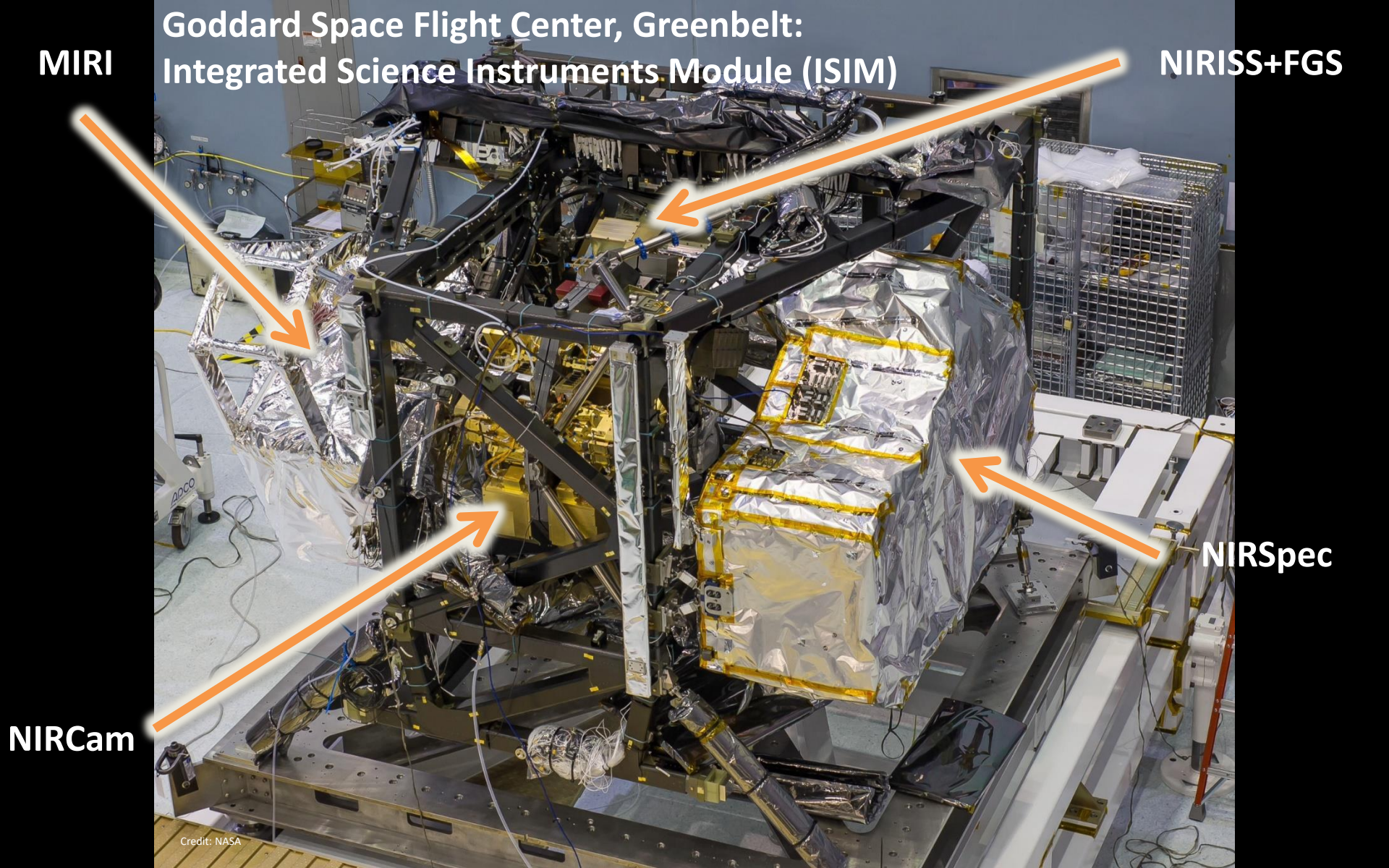
Scientific Performance Tests of MIRI

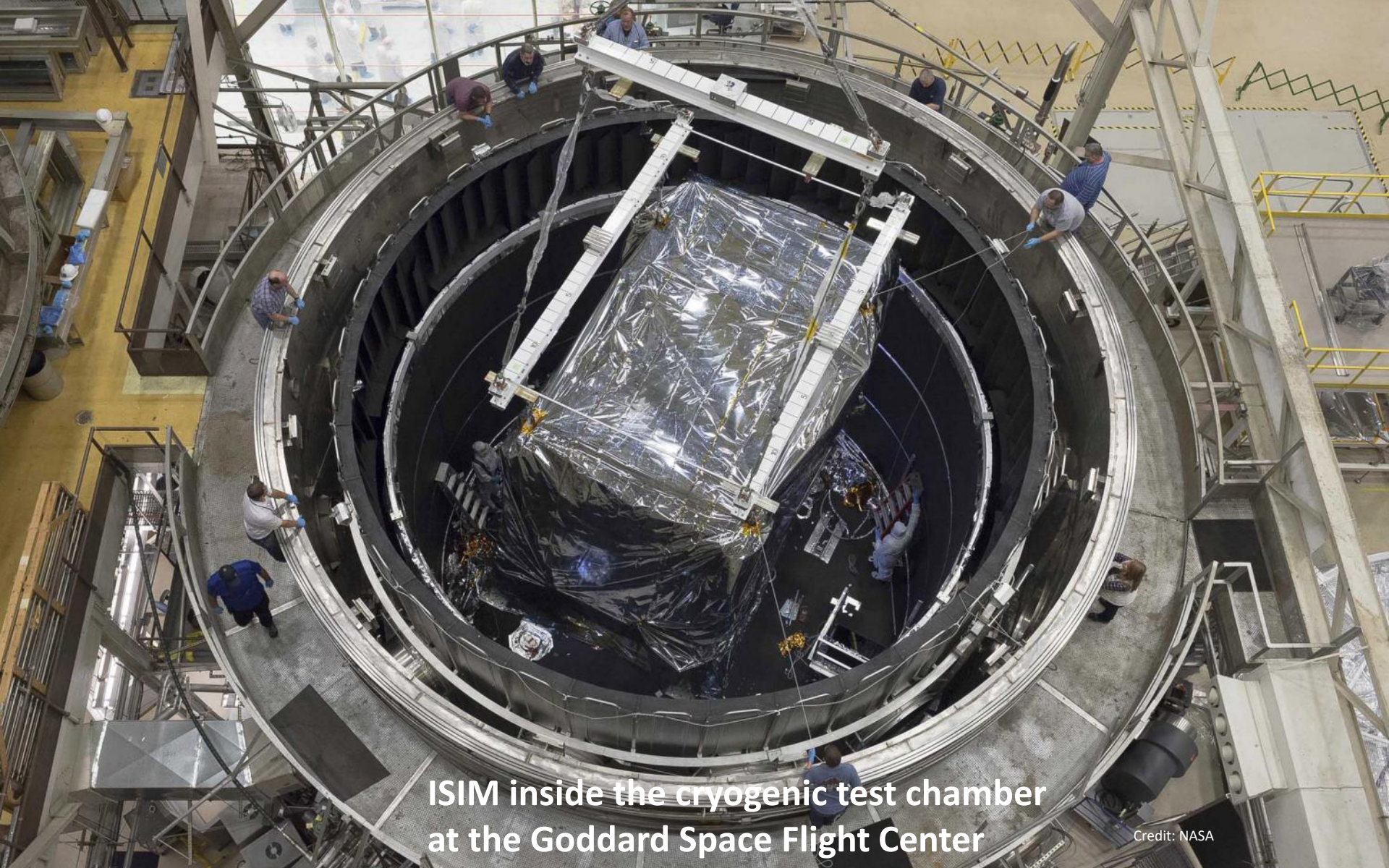


2011: MIRI inside cryogenic thermal chamber (6K) with telescope simulator in front.

2012: MIRI delivery to NASA

Credit: MIRI EC, RAL


Goddard Space Flight Center, Greenbelt:
Integrated Science Instruments Module (ISIM)
MIRI
NIRISS+FGS
NIRSpec
NIRCam
Credit: NASA



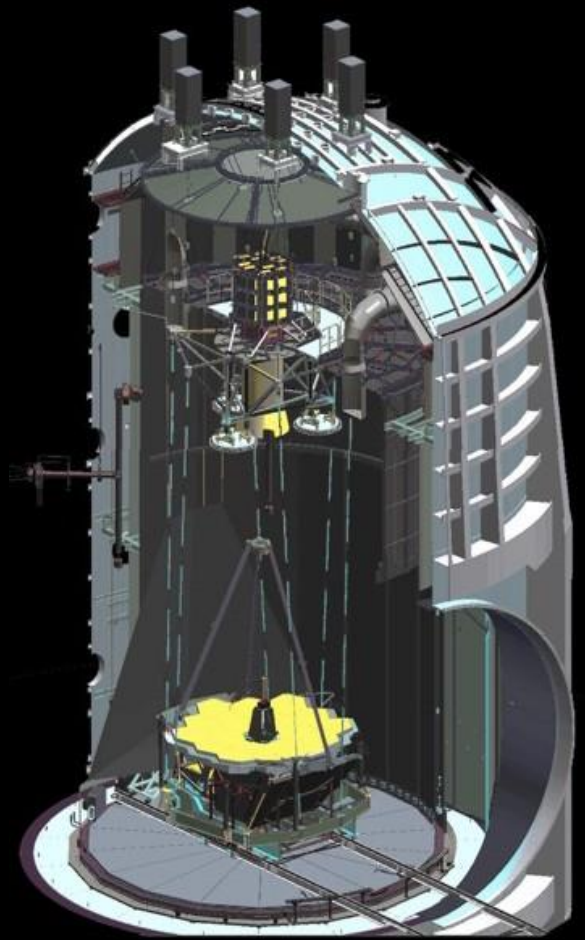
ISIM inside the cryogenic test chamber at the Goddard Space Flight Center

Credit: NASA

Integrating ISIM into Telescope Structure

Credit: NASA

2017: Instrument and telescope tests at Johnson Space Flight Center, Houston



Thermal-vacuum chamber
17 m x 24 m
40 K temperature for JWST

Tests campaign
July – October 2017

Test objectives:
Optical Workmanship
Optical Alignment
Thermal balance
Operational Interfaces

Credit: NASA

Autumn 2017: Shipment to Northrop Grumman

- Integration of telescope and instruments into the satellite and sunshield
- tests, tests, tests … -> Sept 2021: packing and shipment to Kourou

Webbs Journey into Space

Commissioning

Commissioning until summer 2022

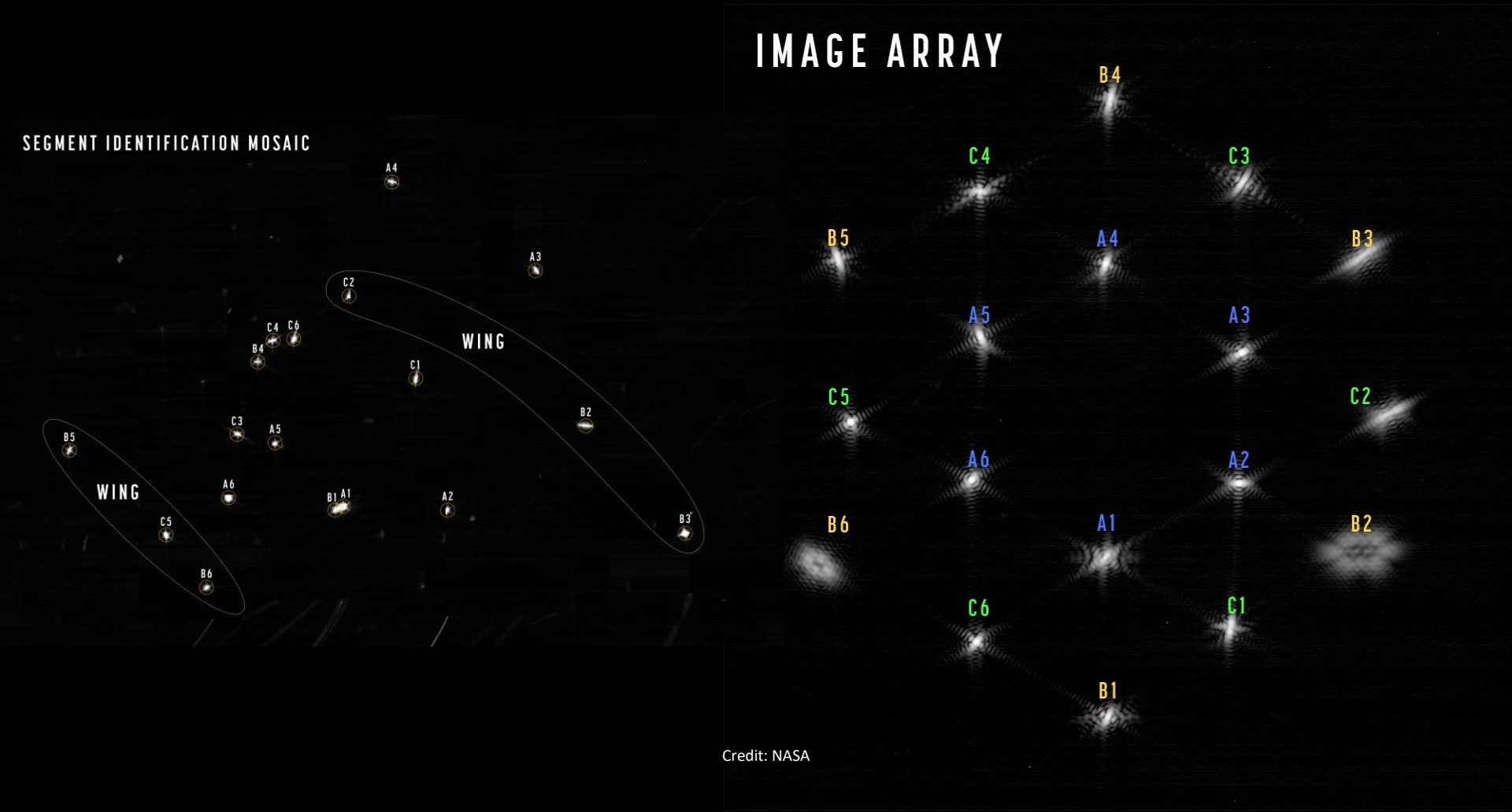
- Launch + 14 days: JWST fully deployed
- Launch + 30 days: JWST at L2
- JWST cools down continuously, functional testing of satellite
- February 3, 2022: first photons (NIRCam)
- February 11, 2022: main mirror alignment (NIRCam + FGS, ~100 days planned)
- April 21, 2022: all instruments switched on, functional testing
- April 28, 2022: telescope completely aligned and focussed
- Finale phase: instrument performance testing
    - Test different observation modes
    - Calibration measurements

Februar 11, 2022: First image ? - 18 piece jigsaw

NIRCam Mosaik, Credit: NASA

Februar 11, 2022: First image ? - 18 piece jigsaw

Februar 18, 2022: finished jigsaw

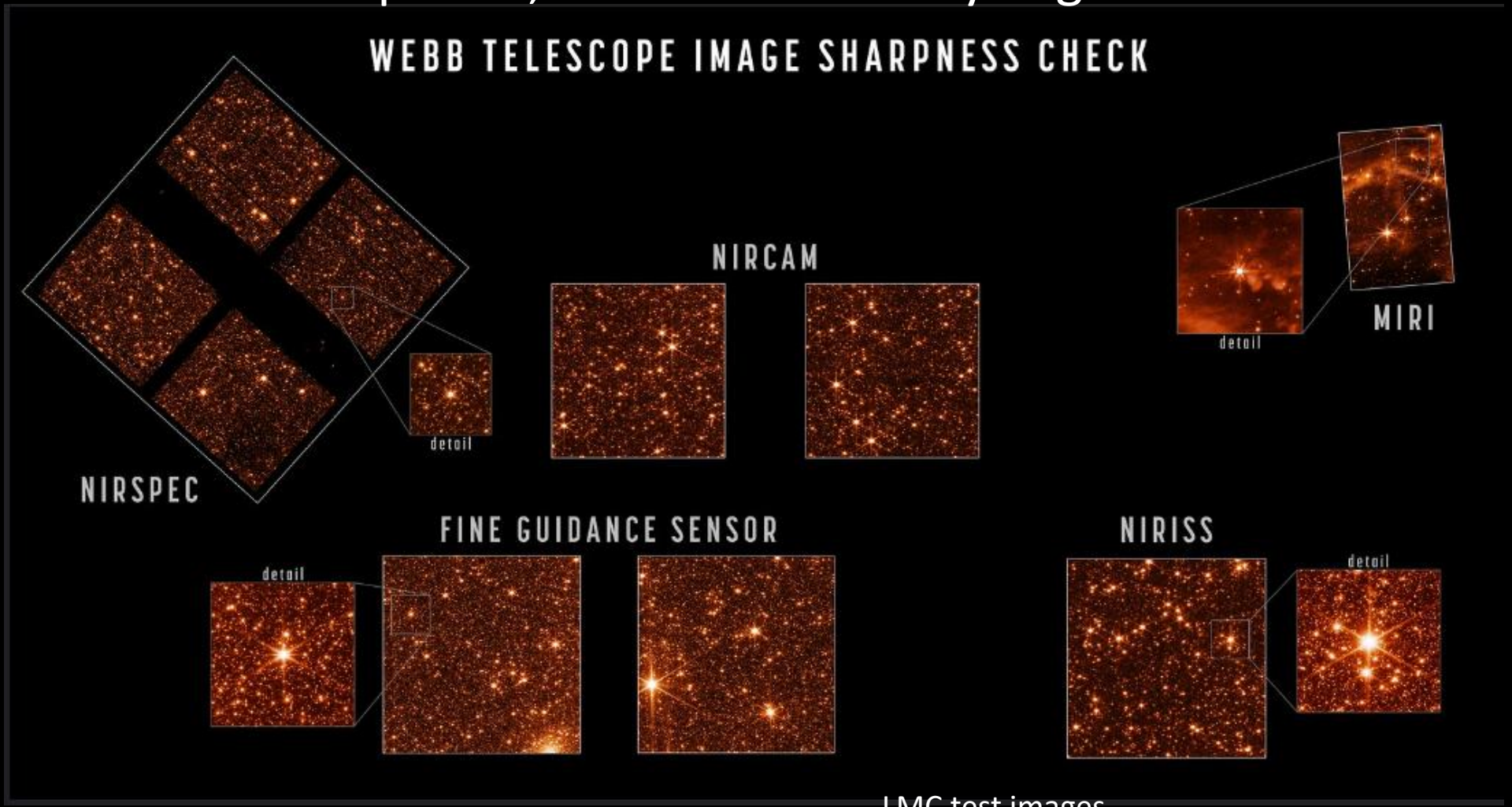


Credit: NASA

March 16, 2022 **The first image !**

NIRCAM, star 2MASS J17554042+6551277, focus test
Credit: NASA

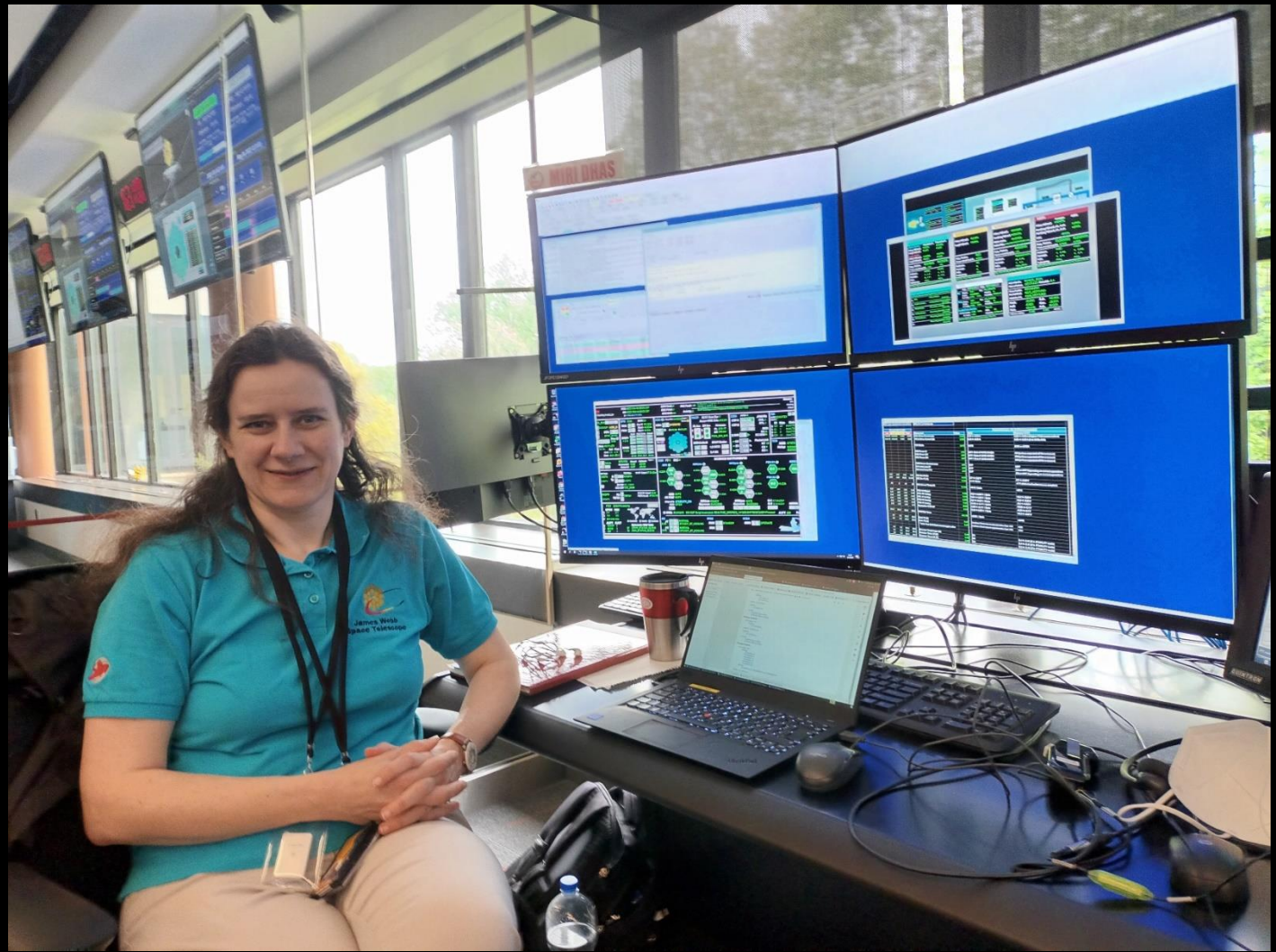
April 28, 2022: JWST fully aligned



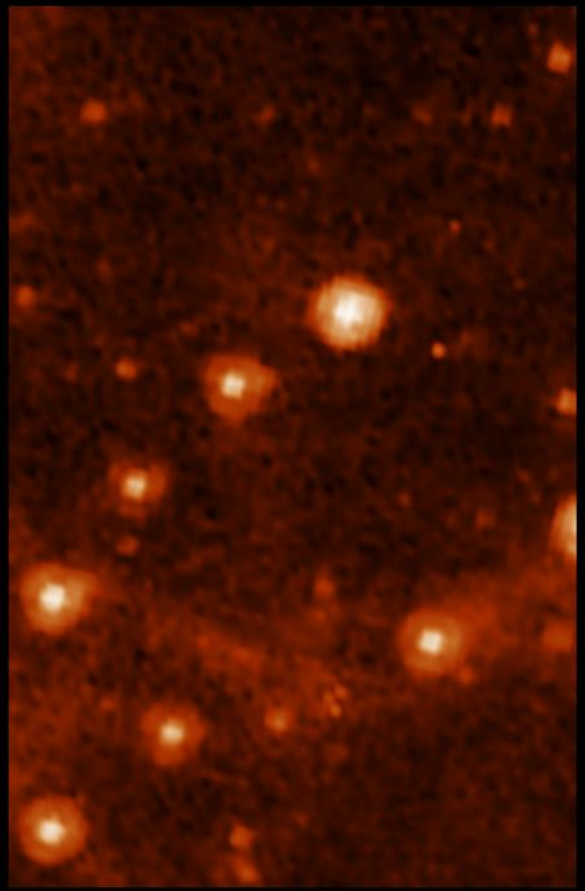
LMC test images

Credit: NASA

Mission Operations Centre, STScI Baltimore



JWST observes deeper and sharper !



SPITZER IRAC 8.0μ

WEBB MIRI 7.7μ

Part of LMC: Spitzer satellite (2003), IRAC instrument JWST satellite, MIRI instrument

Credit: NASA


Comming soon: (summer 2022)
Great science with JWST !

JWST Selfie

NIRCam: JWST main mirror selfie

Credit: NASA

Follow JWST status on the NASA blog:
https://blogs.nasa.gov/webb/

https://www.jwst.nasa.gov/content/webbLaunch/countdown.html

https://jwst.stsci.edu/

http://sci.esa.int/jwst/