The James Webb Space Telescope

Discussions of a follow-up to HST began before HST was launched. An initial plan was a 4 meter telescope 3 AU from the Sun. The telescope that became JWST was begun with the HST & Beyond Committee that was formed in 1994

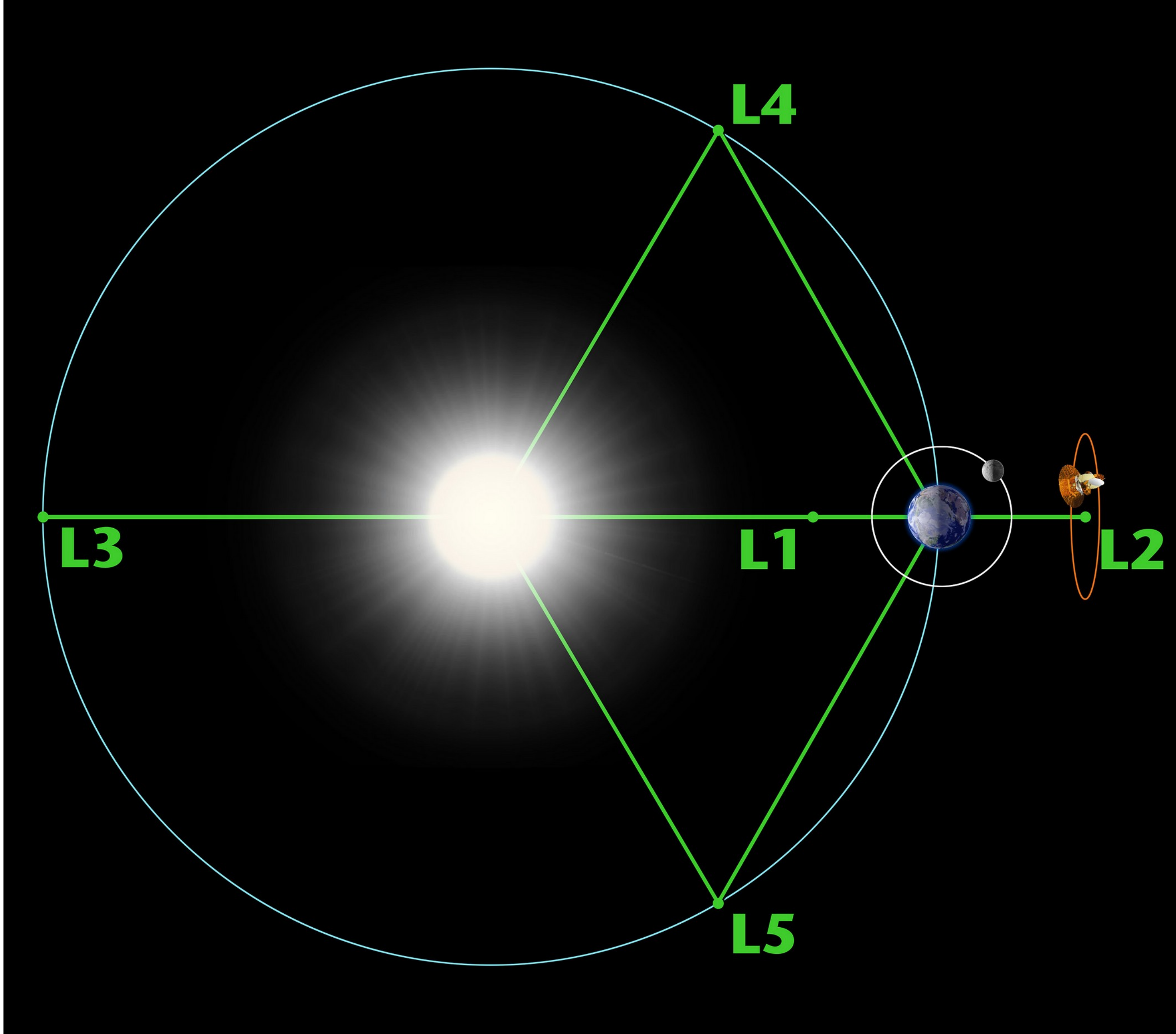
The goal that came out of these discussions was an infrared sensitive telescope that could look back to the origins of galaxies.

The Next Generation Space Telescope received the highest marks in the 2000 decadal survey.

Development to JWST

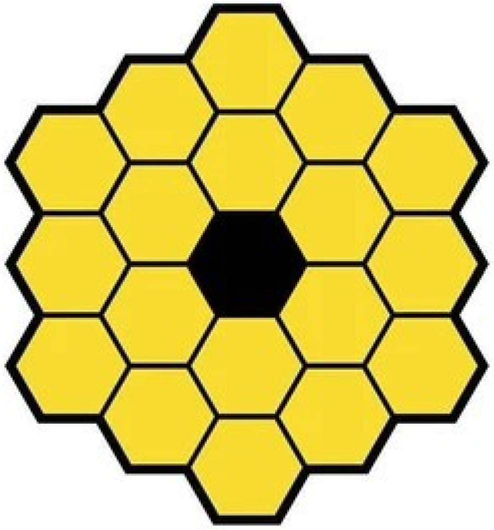
- Originally planned as an 8 meter telescope it was re-scoped to a 6.5 meter telescope. The telescope was planned to go to the L2 Lagrange point on the opposite side of the Earth from the Sun.

- Position of the 5 Lagrange points, which are points of equilibrium. The gravitational force of the two large bodies and the centrifugal force balance each other.



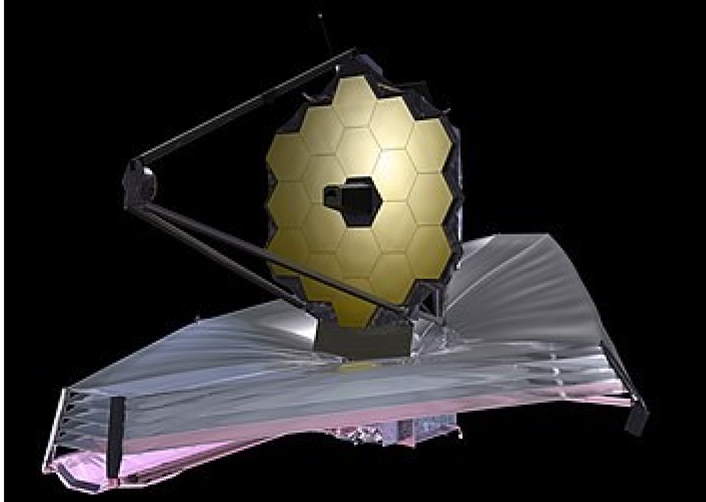
JWST Teelescope

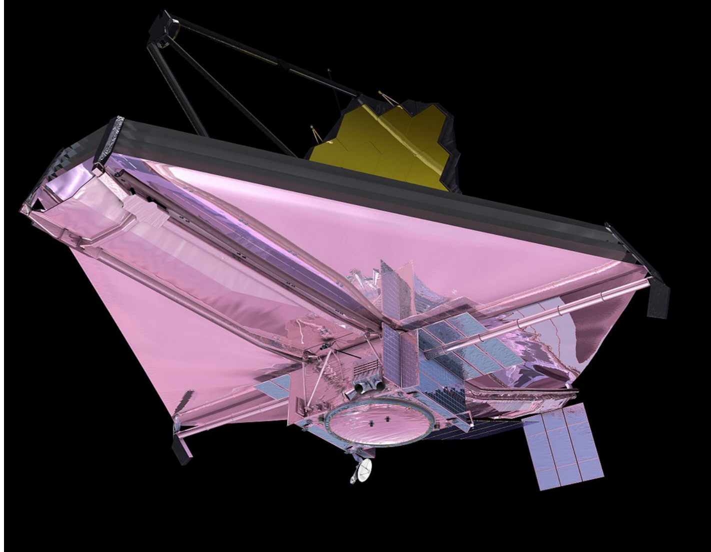
- JWST's primary mirror consists of 18 hexagonal mirror segments made of gold-plated beryllium, which combined create a 6.5-meter-diameter primary.



JWST Sunshield

- To make observations in the infrared spectrum, JWST must be kept under 50 K (−223.2 °C; −369.7 °F); otherwise, infrared radiation from the telescope itself would overwhelm its instruments. Its large sunshield blocks light and heat from the Sun, Earth, and Moon, and its position near the Sun–Earth L2 keeps all three bodies on the same side of the spacecraft at all times



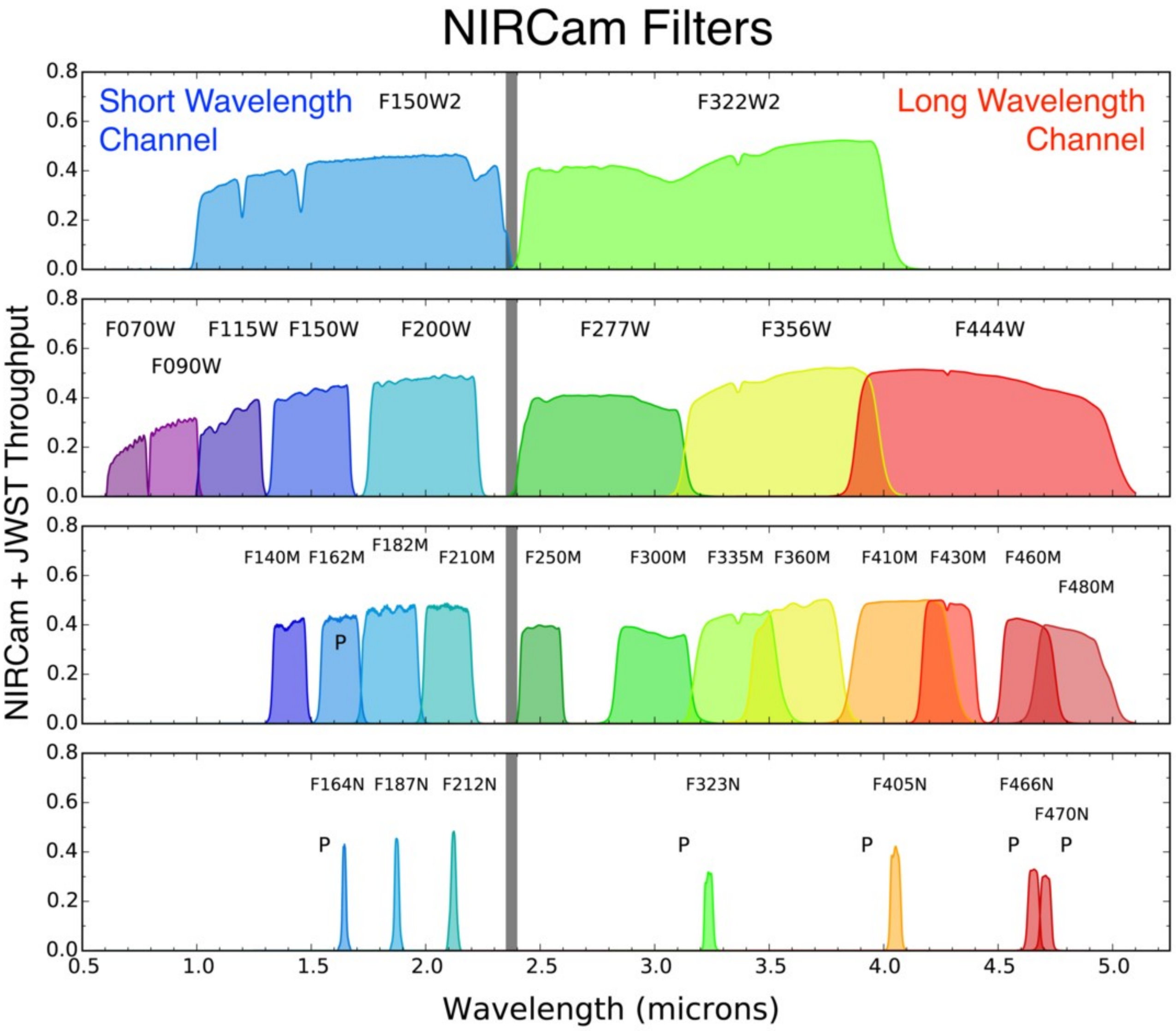


JWST Instruments

- NIRCam – a near infrared imager
- NIRSpec – a near infrared spectrograph
- MIRI – mid infrared imager and imaging spectrograph
- FGS/NIRISS – fine guidance sensor and near infrared imager and slitless spectrograph

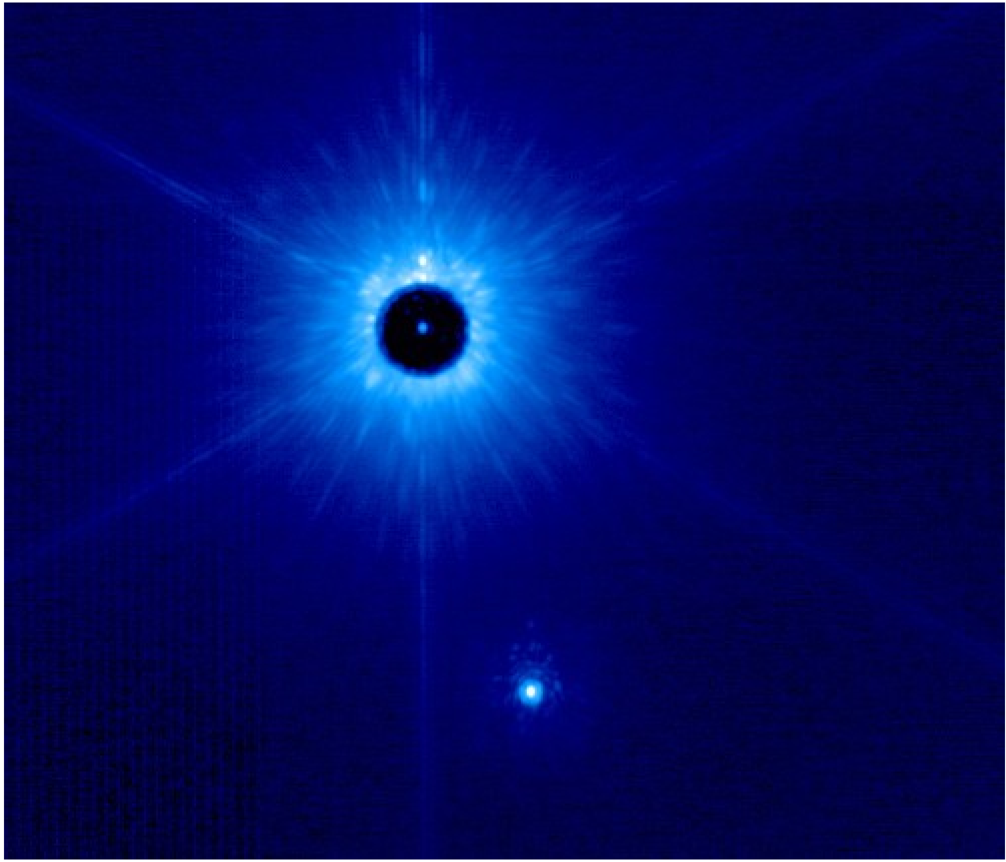
NIRCam

- Observes
- from 0.6-5
- microns



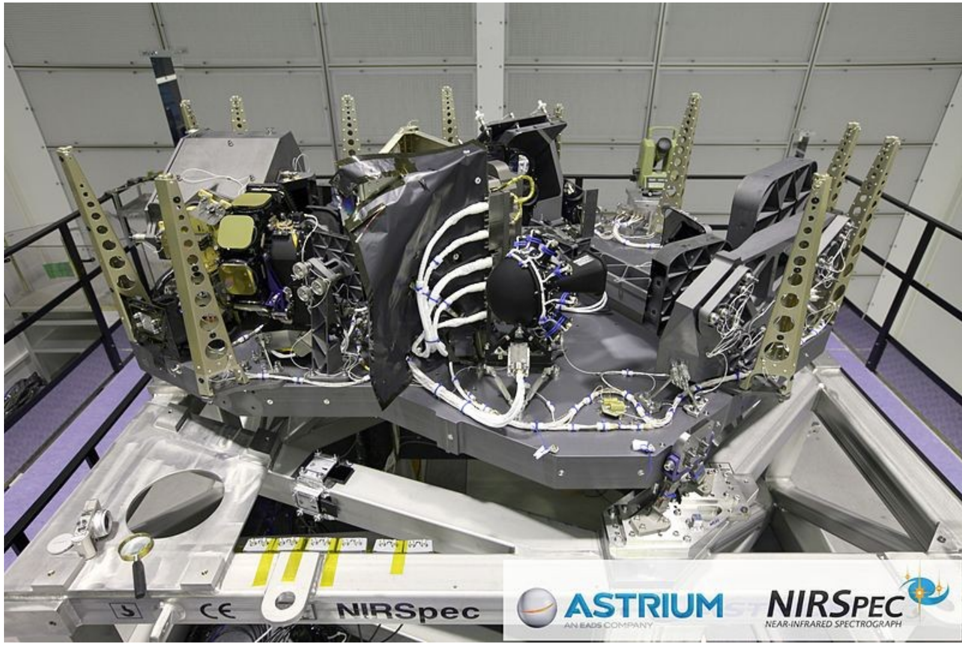
NIRCam Coronagraph

- works to partially shield incoming starlight by inserting a mask in front of a target star, boosting the relative signal of fainter nearby companions



NIRSpec

- Multi-Object Spectroscopy (MOS)
- Integral Field Unit Mode (IFU)
- High-Contrast Slit Spectroscopy (SLIT)
- Imaging Mode (IMA)

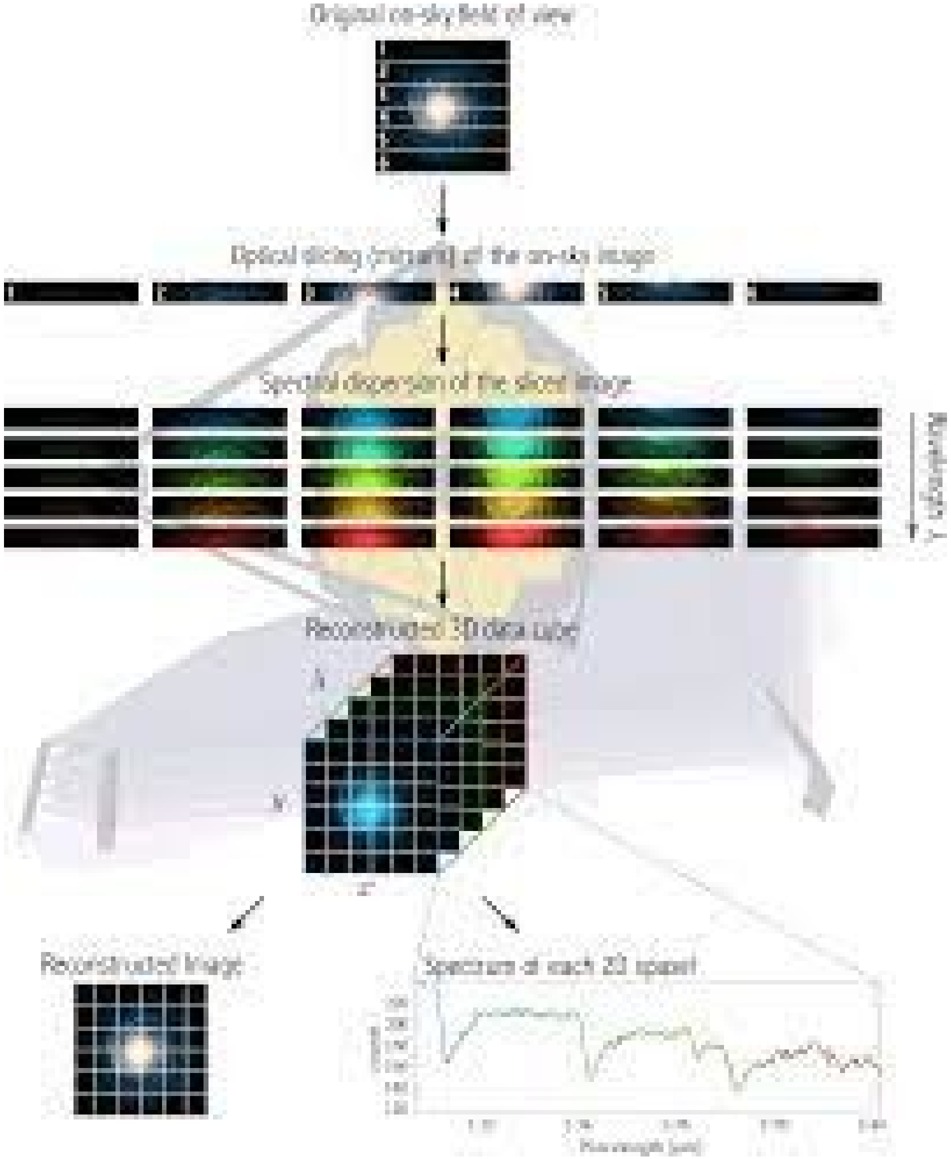


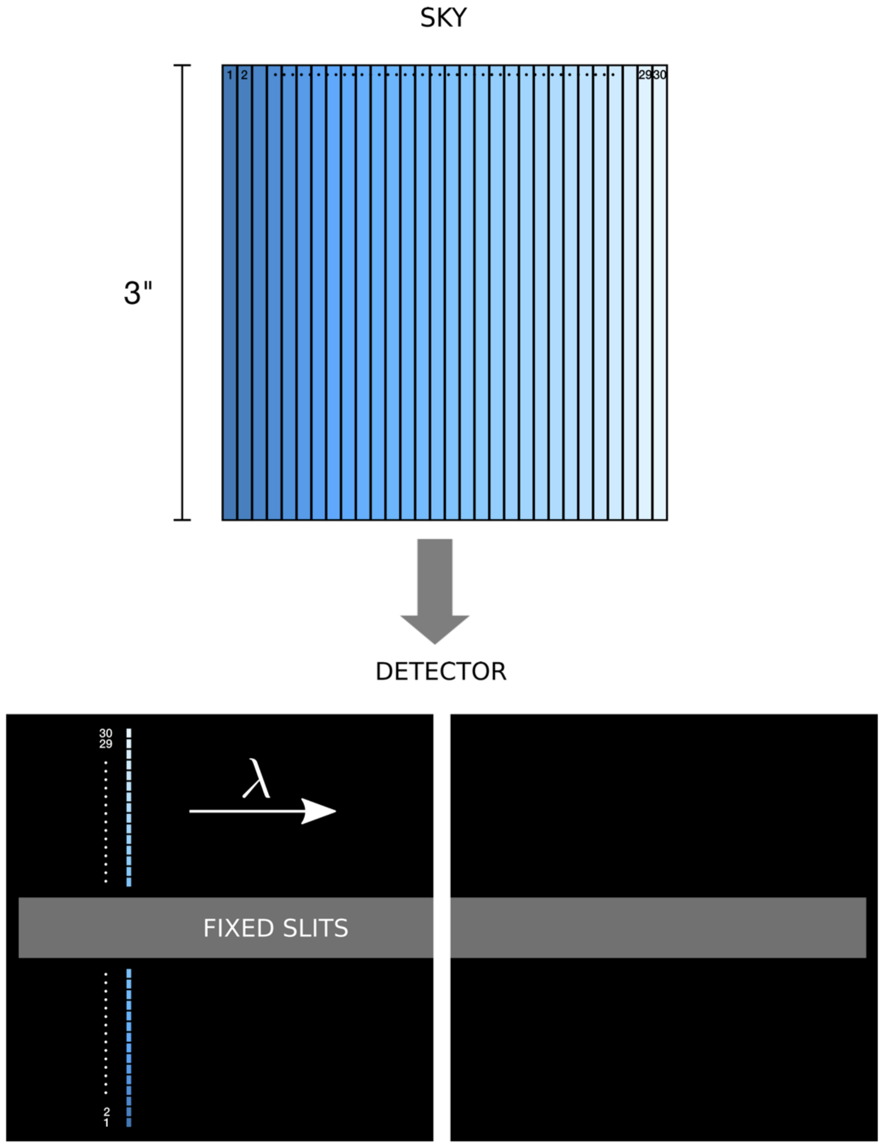
Multi-object Spectrocopy

- Has a field of view of 3’x3’ covered by 4 arrays of programmable slit masks. These programmable slit masks each consist of 250,000 micro shutters. Each micro shutter can be programmed to 'open' or 'closed'. An open micro shutter disperses the spectra of the light emitted by the object onto the detector plane.

IFU

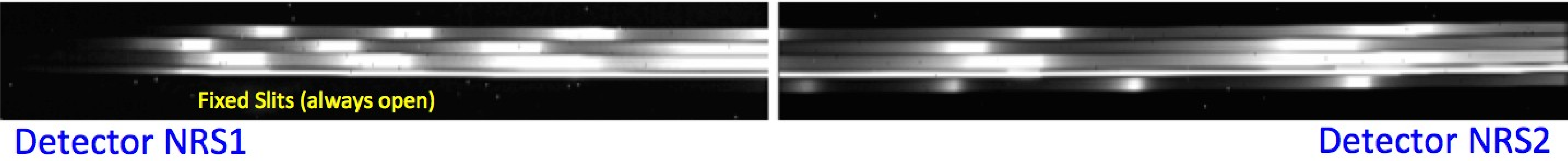
The IFU can obtain spatially resolved imaging spectroscopy of a contiguous 3" × 3" area on the sky.




SKY
3"
1
2
29
30
DETECTOR
30
29
λ
FIXED SLITS
2
1

High-Contrast Slit Spectroscopy (SLIT)

- A set of 5 fixed slits are available in order to perform high contrast spectroscopic observations



• Imaging Mode (IMA)

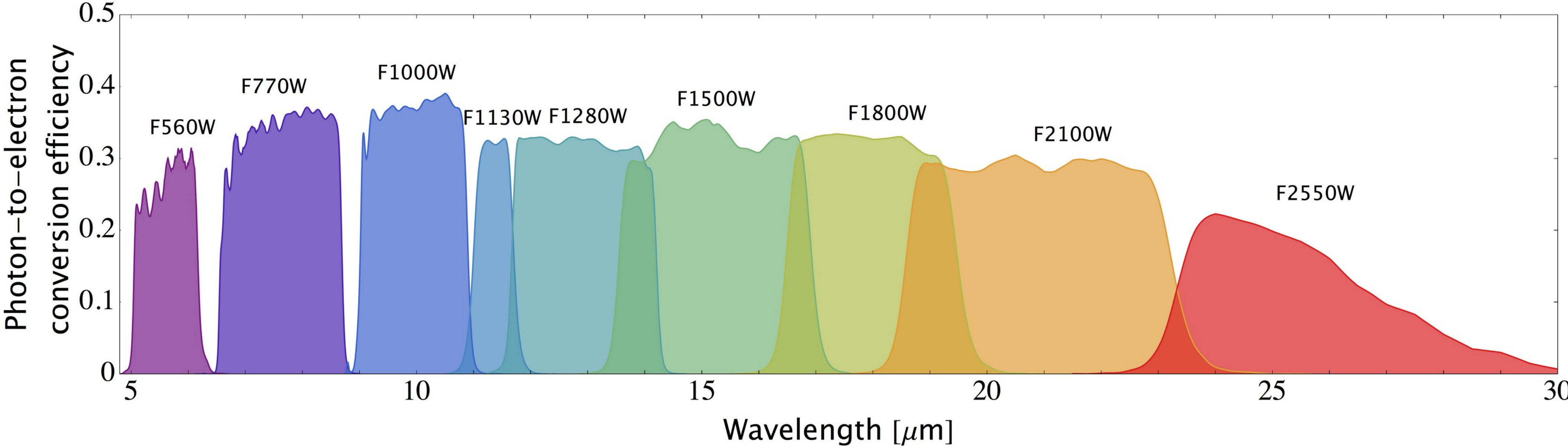
- The imaging mode is used for target acquisition only

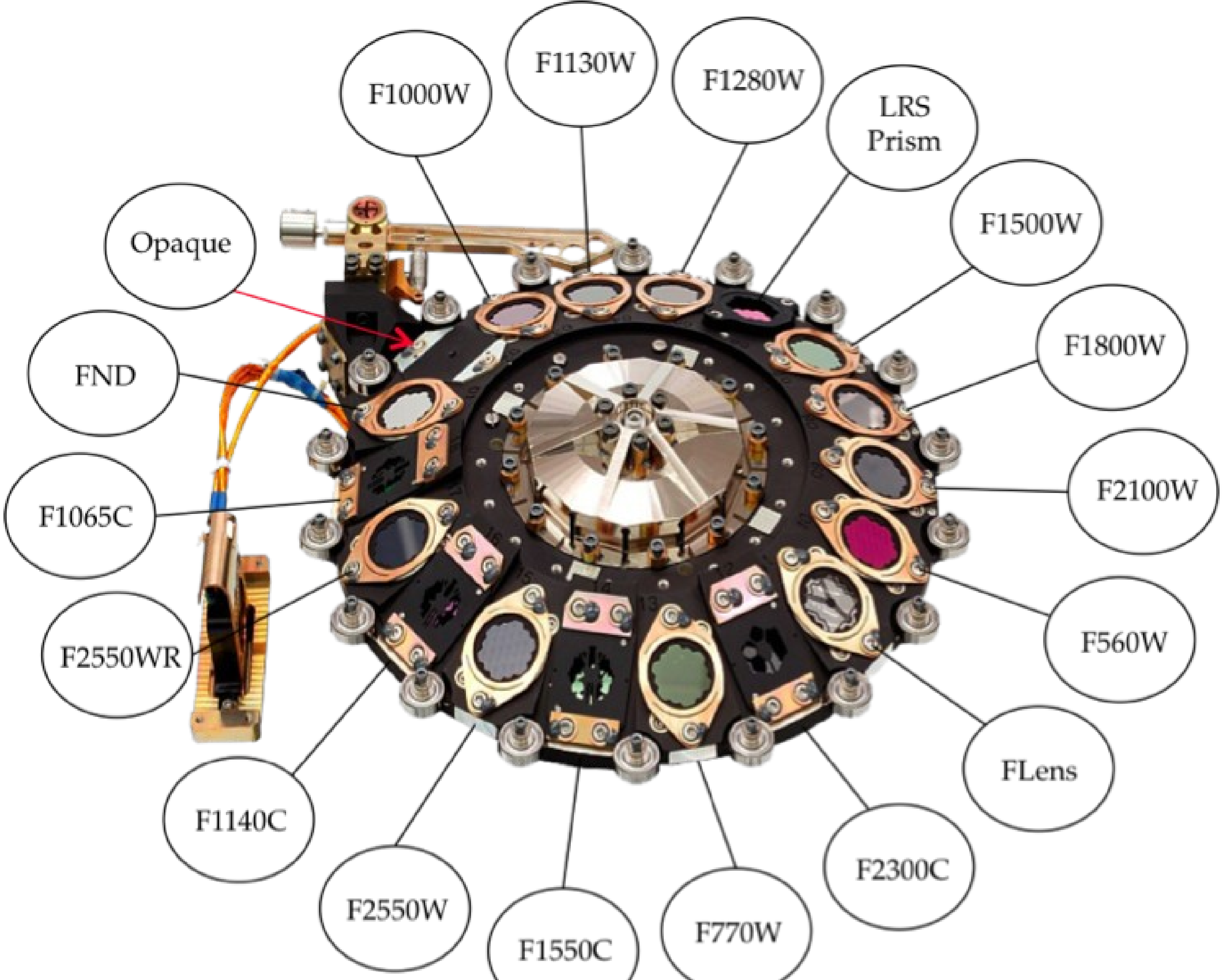
MIRI

- Imaging
- Low resolution spectroscopy
- Medium resolution spectroscopy
- Coronagraphic imaging

MIRI Imaging

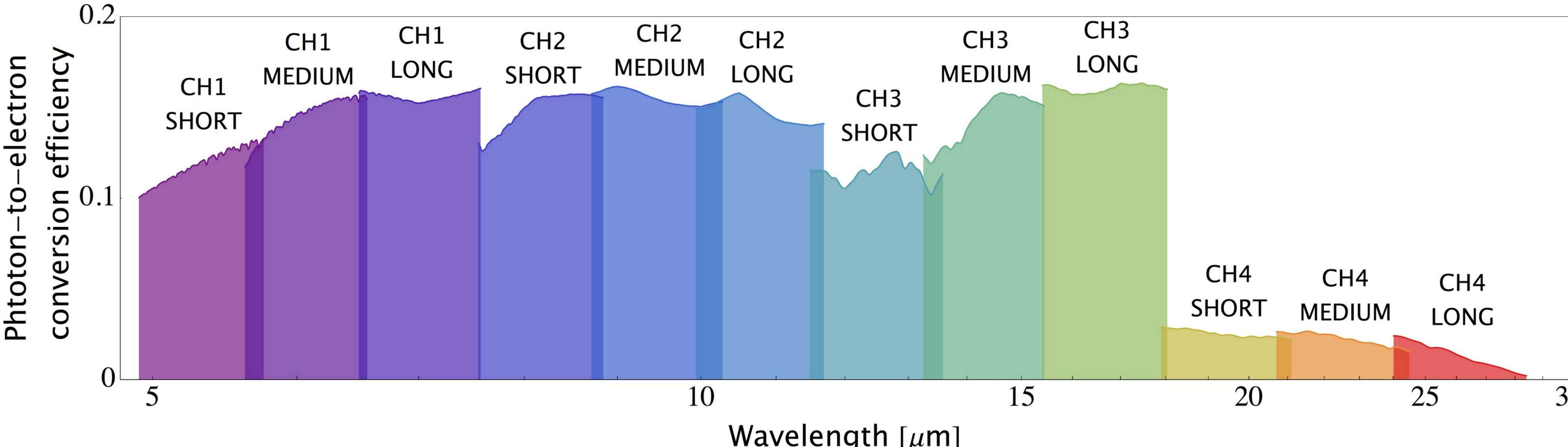
- Uses 10 filters and a Neutral Density filter for bright object acquisition. Filters cover the wavelength range 5-30 microns




F1130W
F1280W
F1000W
LRS Prism
F1500W
Opaque
F1800W
FND
F2100W
F1065C
F560W
F2550WR
FLens
F1140C
F2300C
F2550W
F770W
F1550C

Low and Medium Resolution Spectroscopy

- Low resolution slit and slitless spectroscopy from 5 to 12 µm.
- Medium resolution uses an IFU. You get either short, medium or long at one time



MIRI IFU

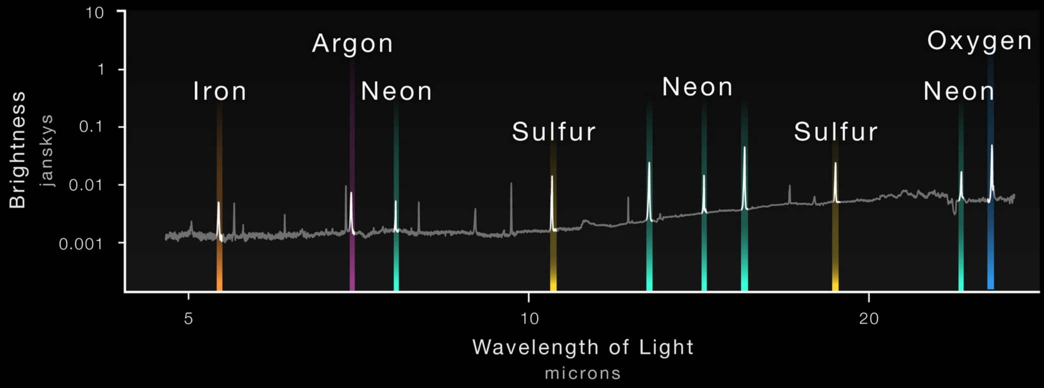
- consists of an entrance pupil, an input fold mirror, an image slicer mirror, a mask carrying exit pupils for the individual sliced images, a mask carrying slitlets for the individual images, and an array of reimaging mirrors behind the slitlets.

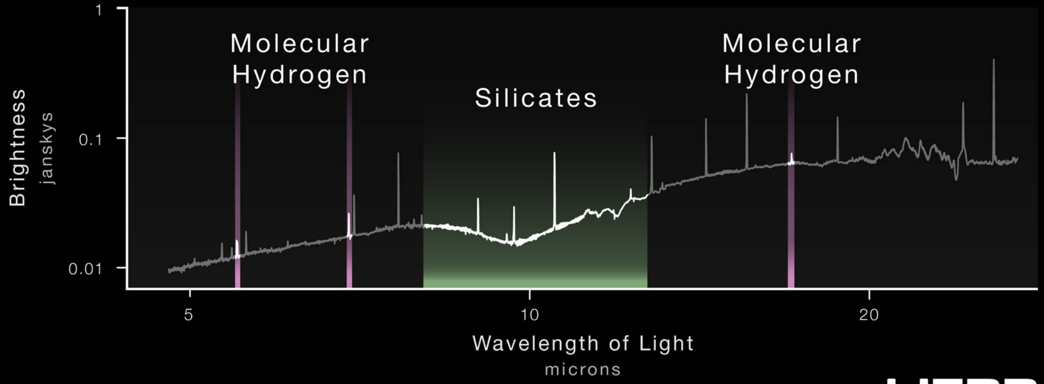
INTERACTING GALAXIES | STEPHAN'S QUINTET

COMPOSITION OF GAS AROUND ACTIVE BLACK HOLE

NIRCam and **MIRI** Imaging

MIRI IFU Medium Resolution Spectroscopy

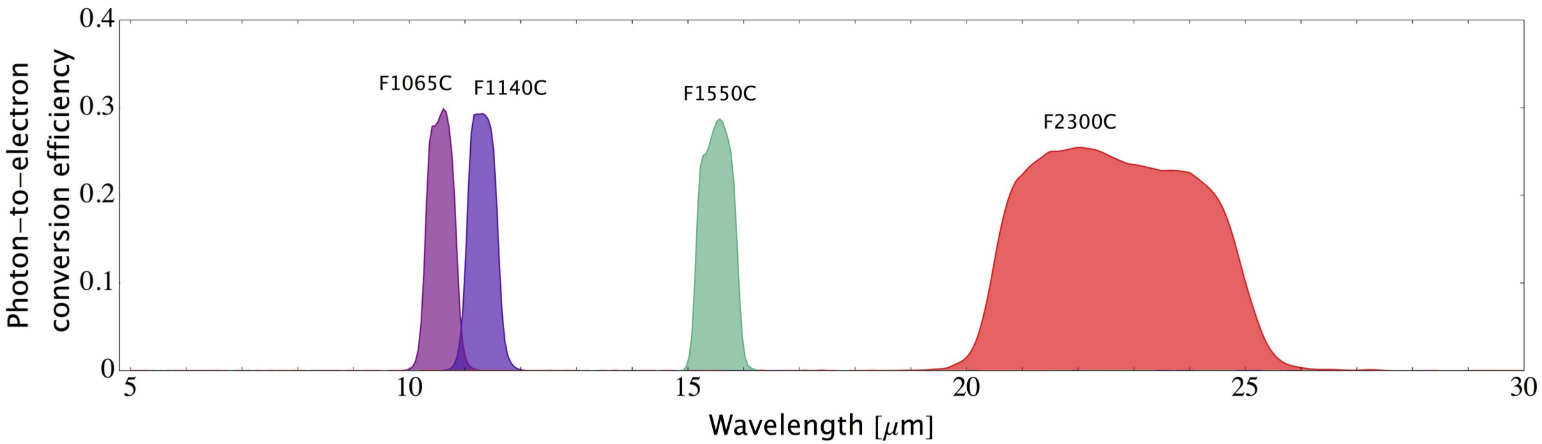


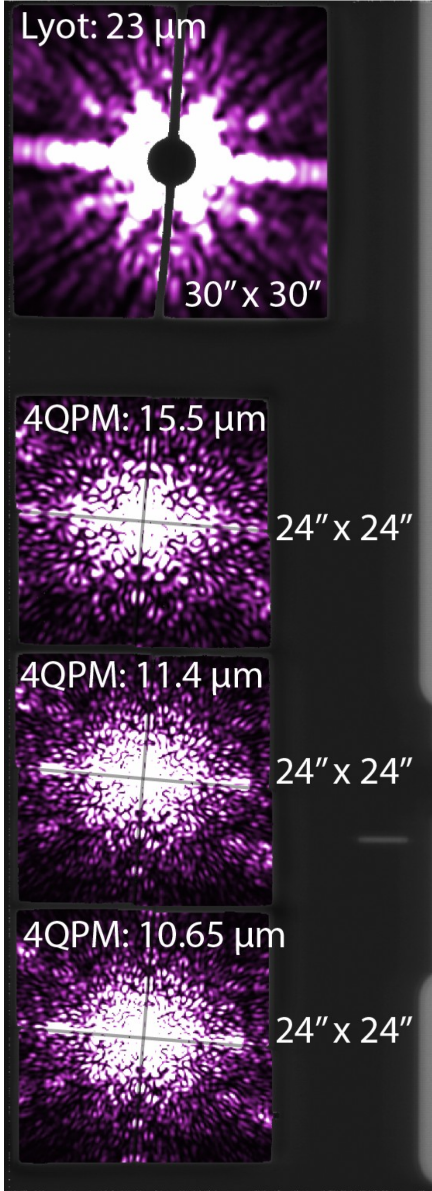


WEBB
SPACE TELESCOPE

MIRI has 4 coronograph modes

MIRI has 4 coronagraphs that provide high-contrast imaging.   Coronagraphic filters are associated directly with each coronagraph and are fixed for each of the 4 coronagraphs. Selecting the filter also selects the coronagraph, and vice versa.



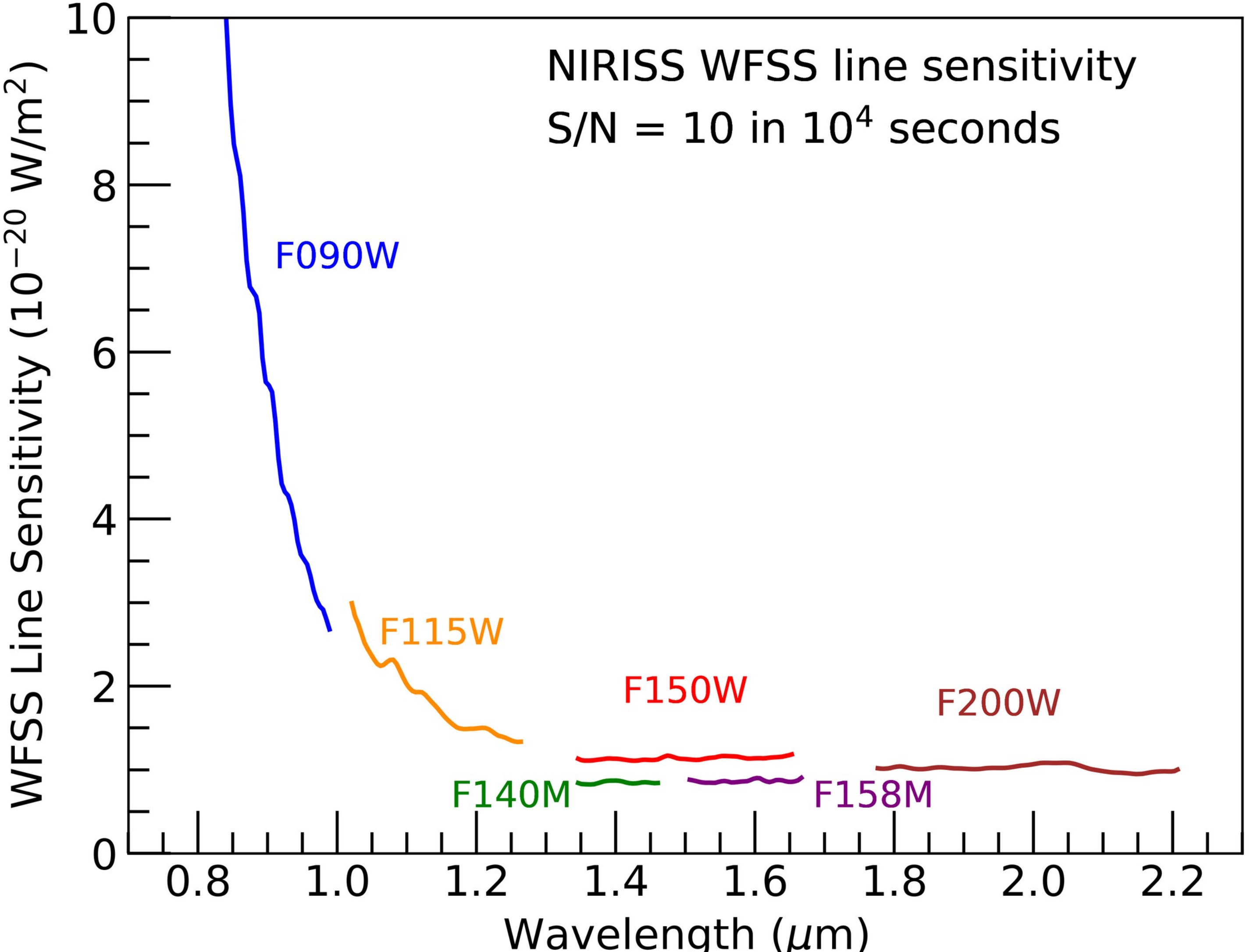


FGS/NIRISS

- The Fine Guidance Sensor allows Webb to point precisely, so that it can obtain high-quality images.
- THE NIRISS mode has a wavelength range of 0.8 to 5.0 microns, through 12 filters

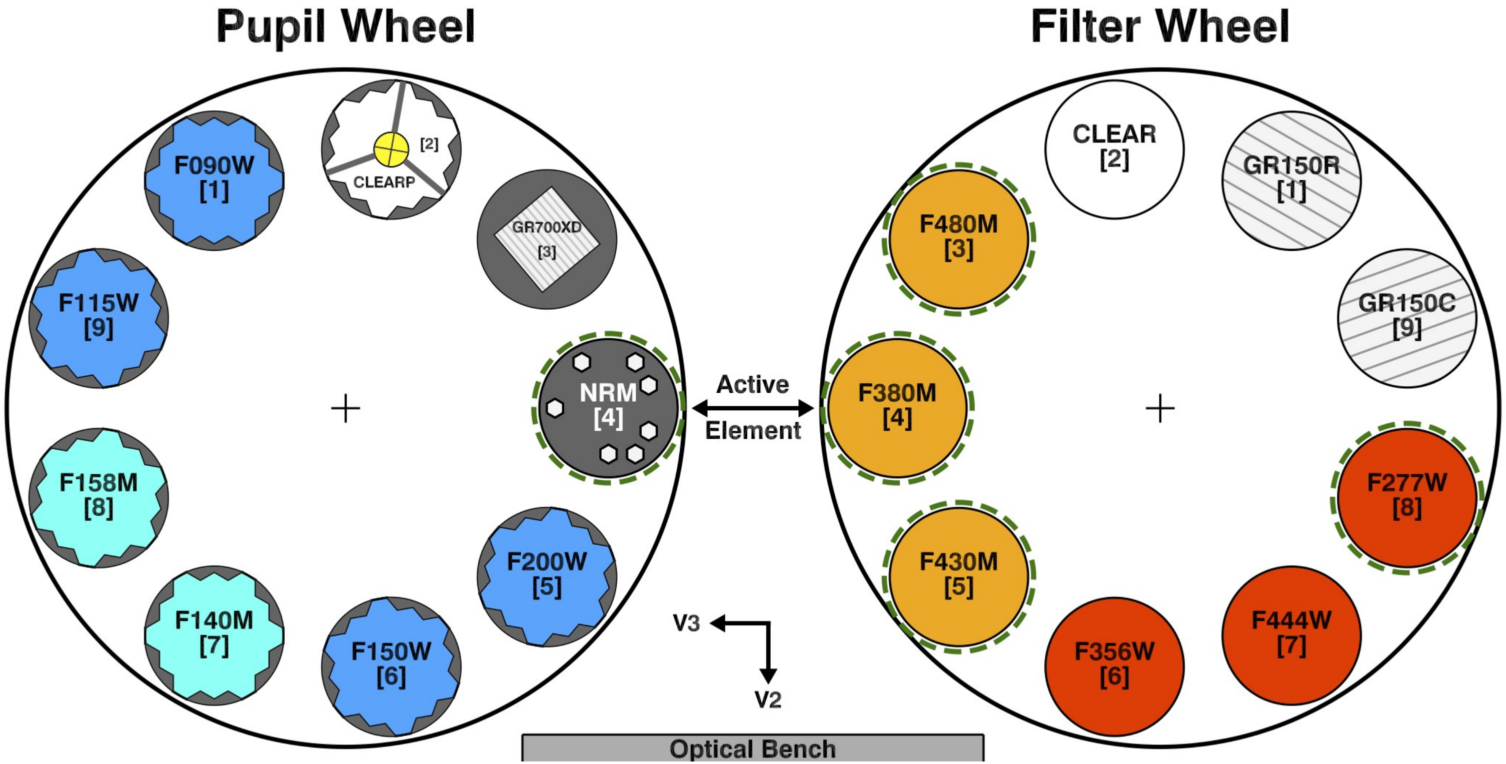
NIRISS

- NIRSS can conduct slitless spectroscopy in 6 bandpasses

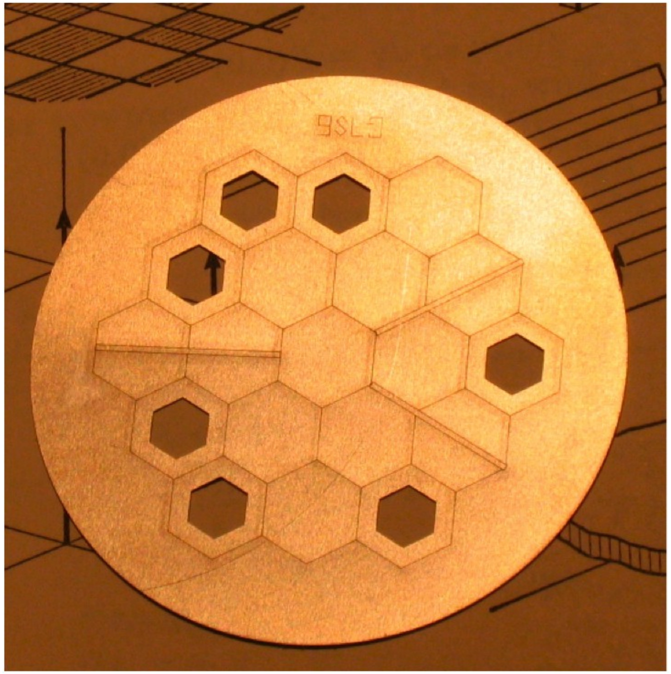


NIRSS/AMI

- NIRSS Aperture Mask Interferometry



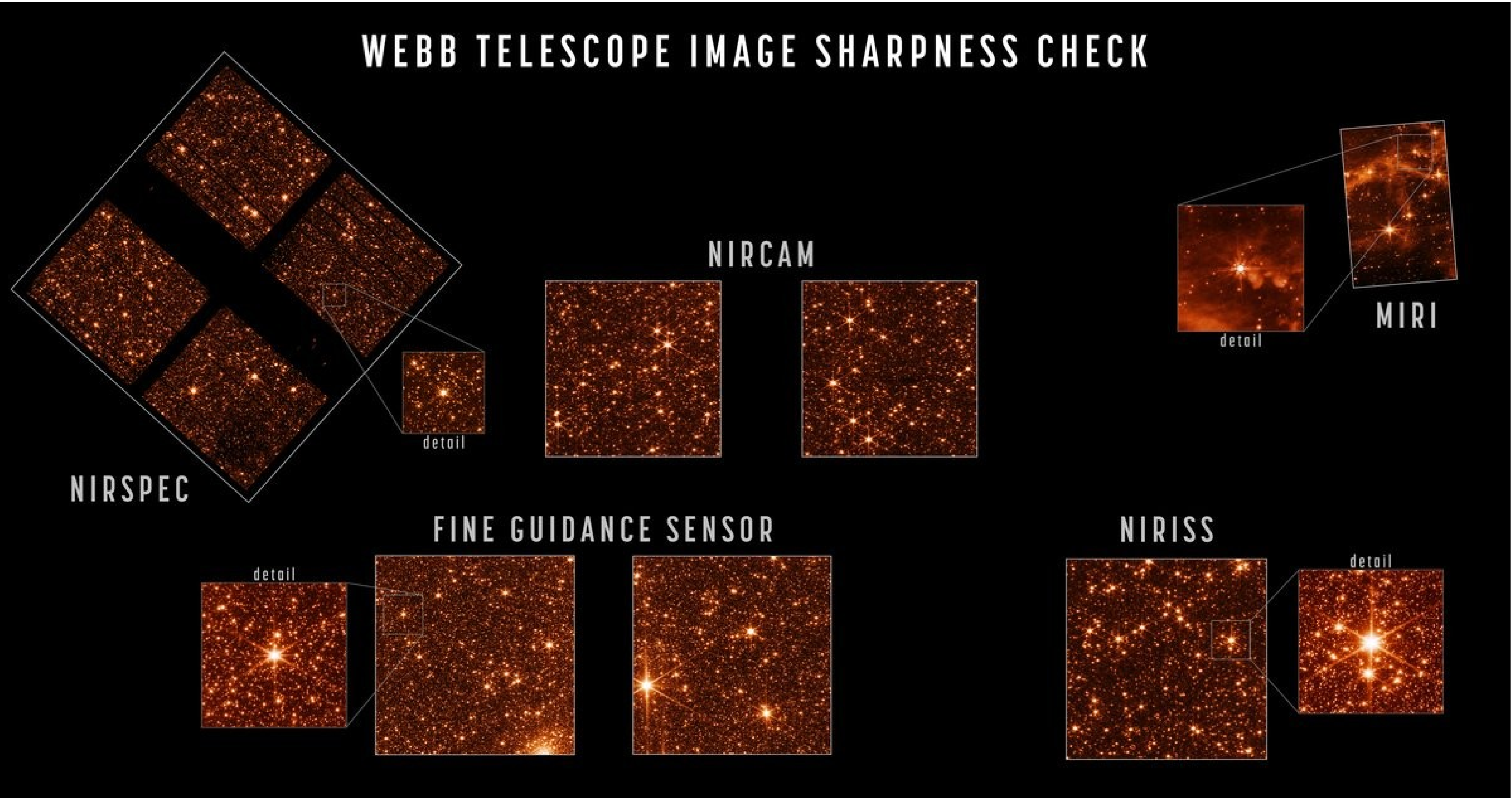
- NIRISS's aperture masking interferometry (AMI) mode turns the full aperture of JWST into an interferometric array. Light admitted by 7 holes or sub-apertures in an otherwise opaque pupil mask interferes to produce an interferogram on the detector. The mask is designed such that each baseline (i.e., the vector linking the centers of 2 holes) is unique and forms fringes with a unique spatial frequency in the image plane.



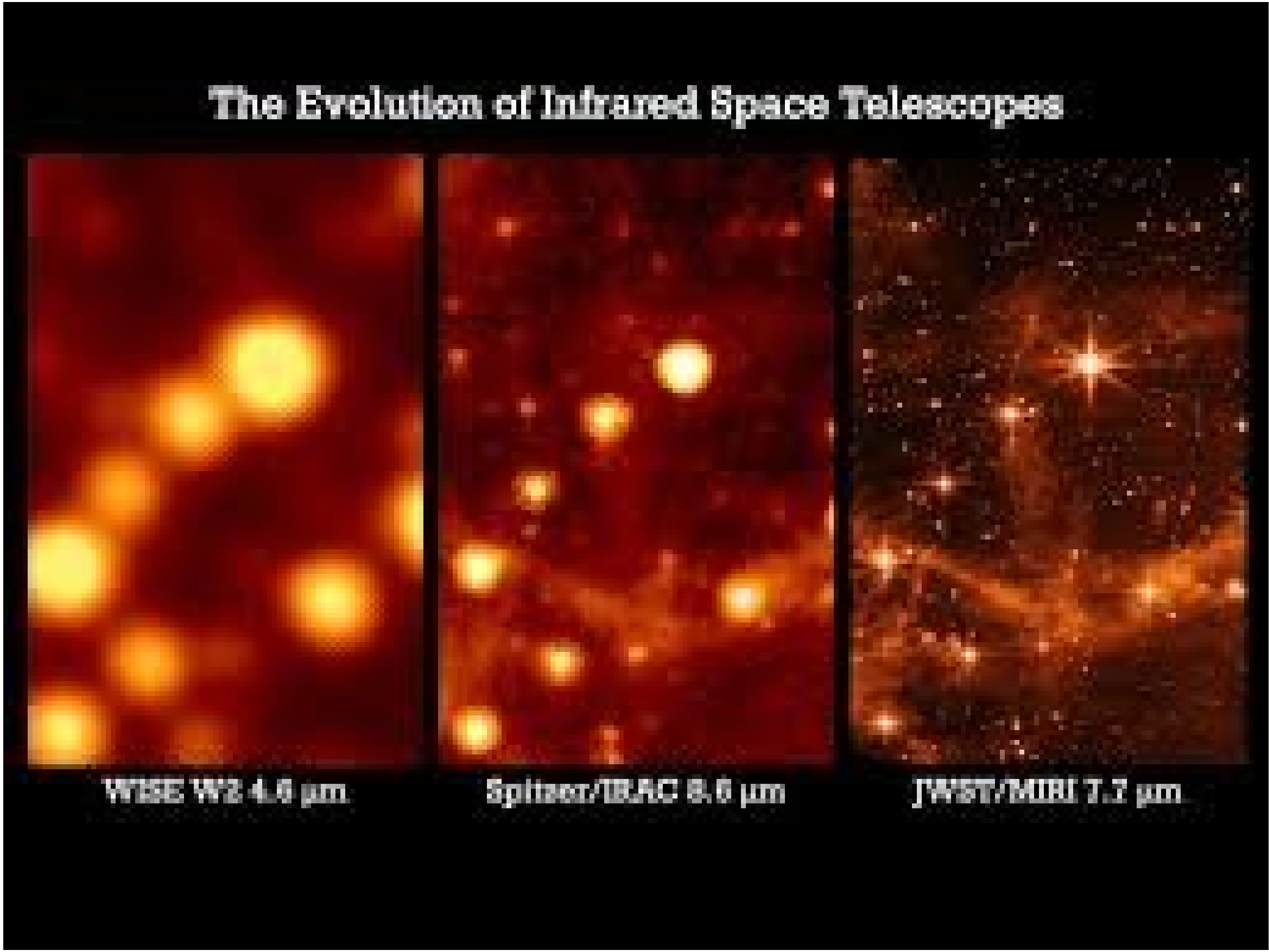
Launch

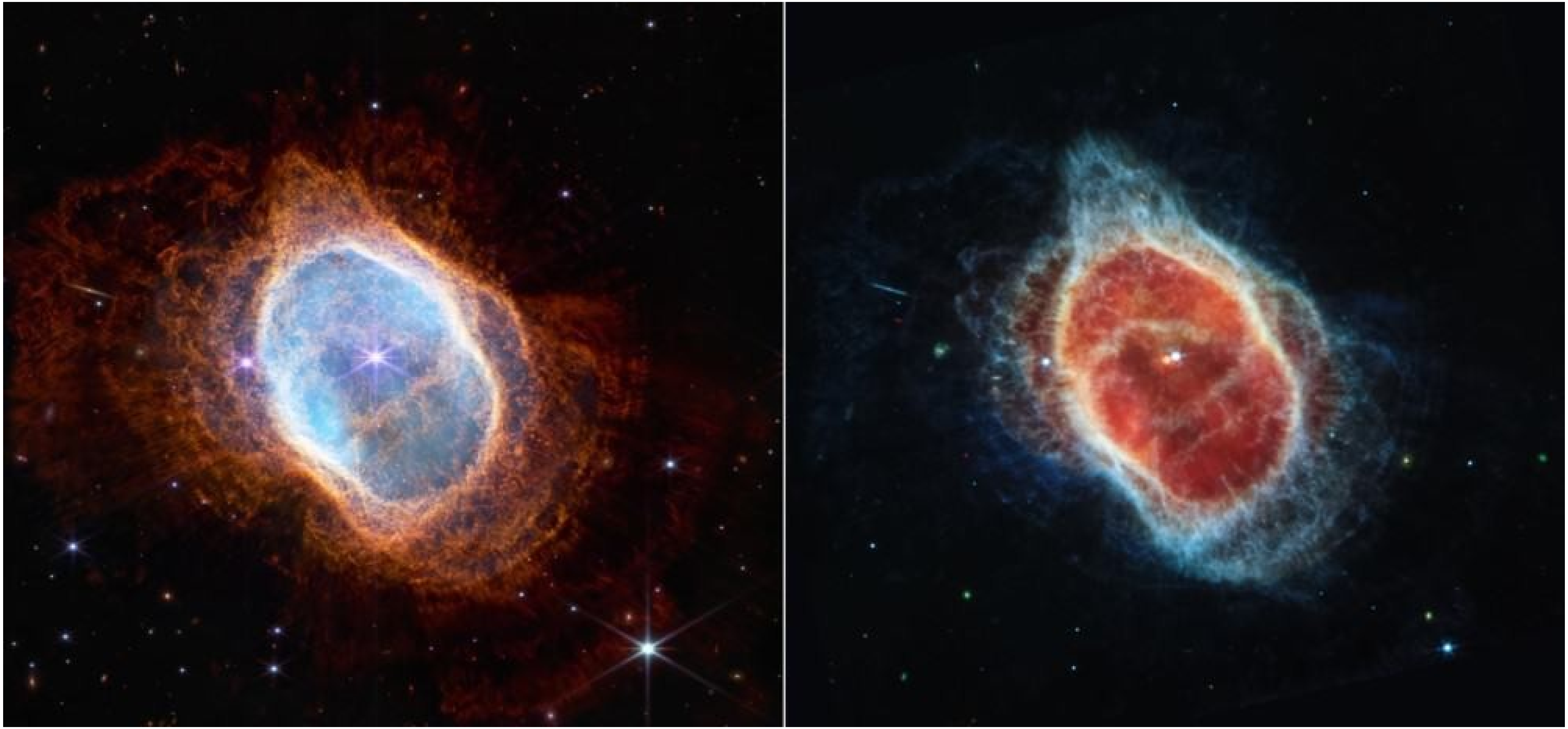
- JWST's primary mirror and sunshield were folded to fit into the Ariane 5 Launch Vehicle
- It was successfully launched on December 25, 2021

- Webb Launch https://youtu.be/9tXIqWIdVVk


WEBB TELESCOPE IMAGE SHARPNESS CHECK
NIRSPEC
detail
NIRCAM
MIRI
detail
FINE GUIDANCE SENSOR
detail
NIRISS
detail

- Three generations of infrared space telescopes







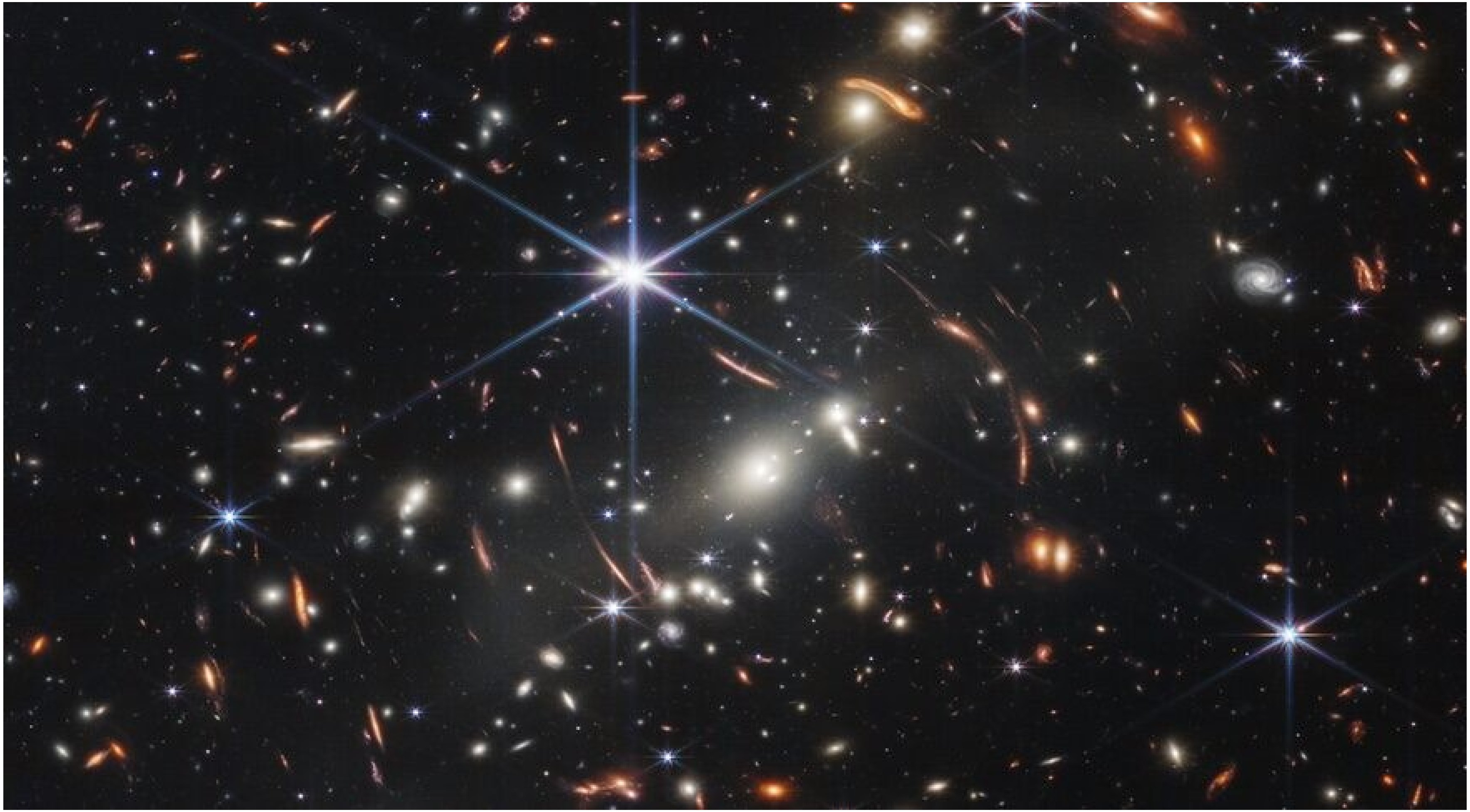
NIRCam
MIRI


Filaments
Filaments
Filaments


Hubble / Optical

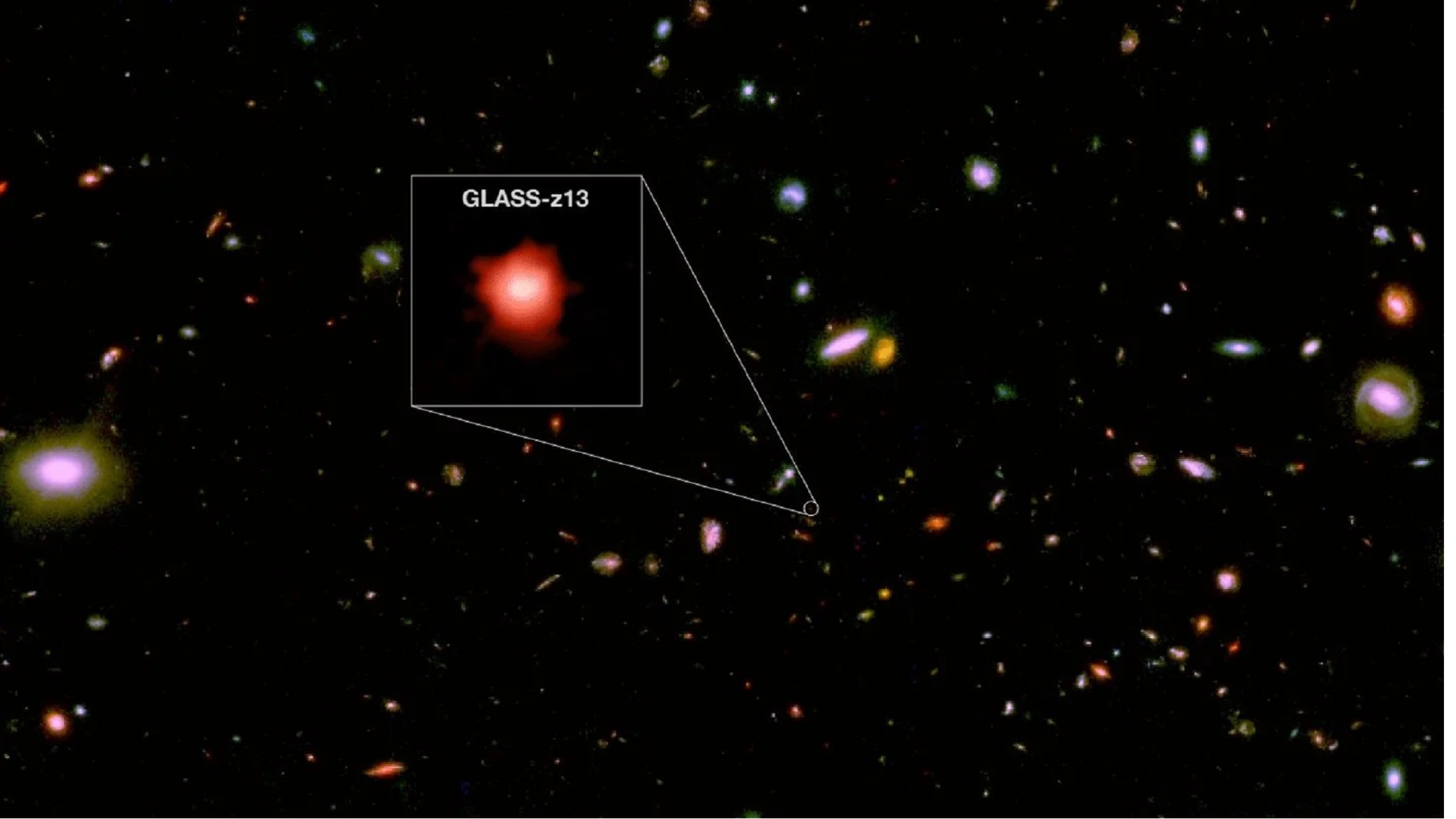

Hubble & Webb

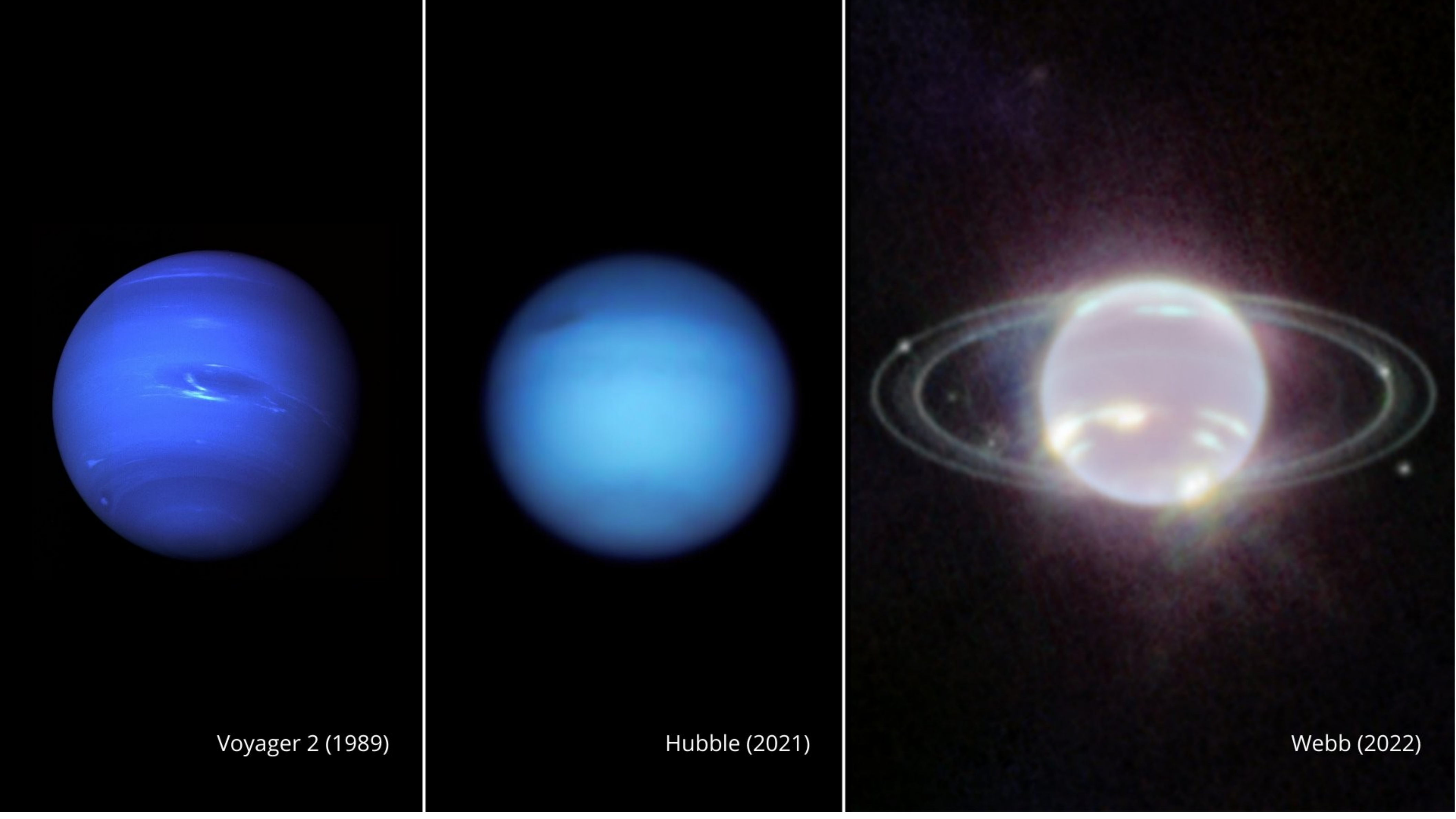

Webb / Infrared

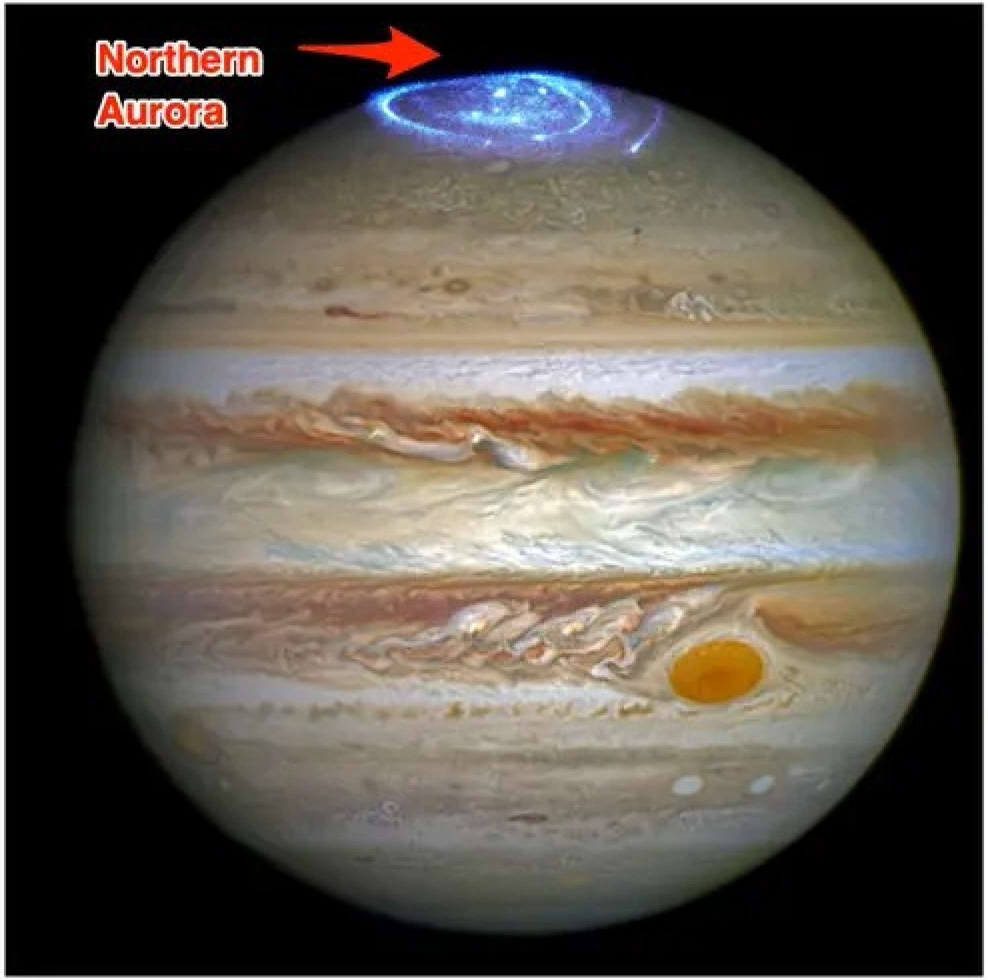


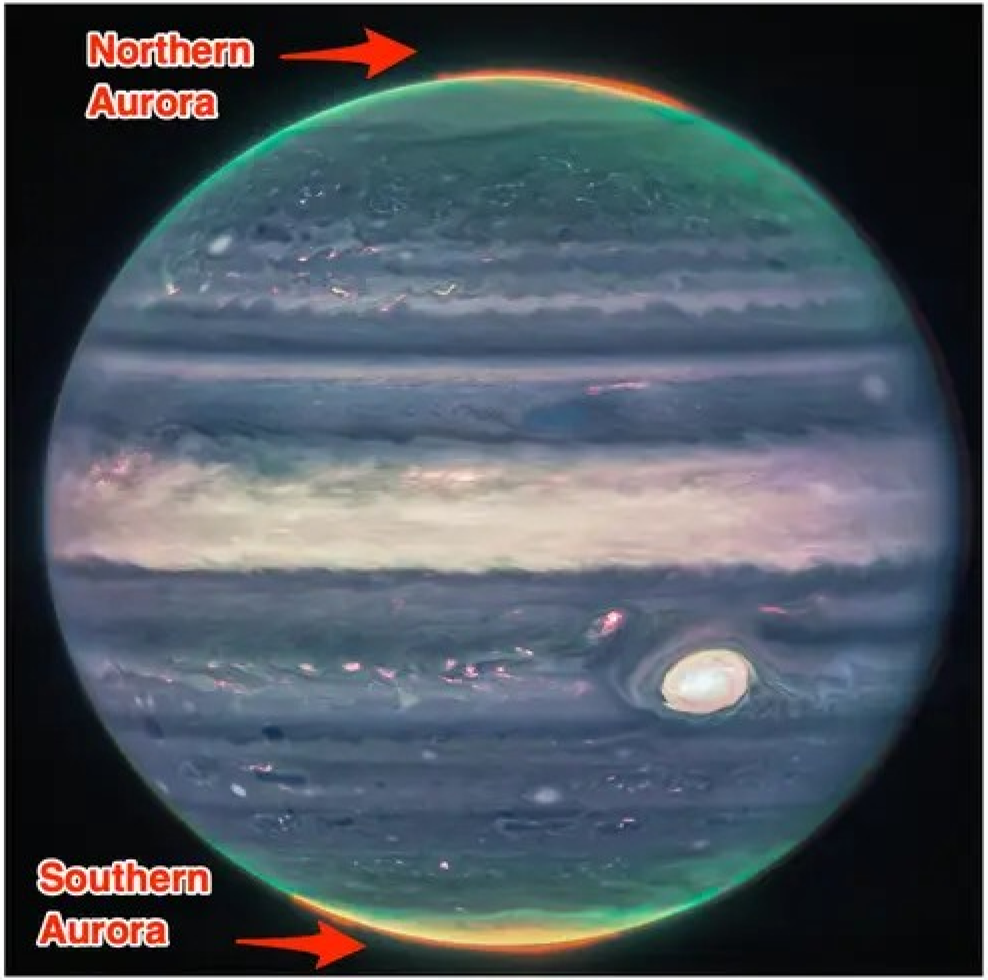

Webb

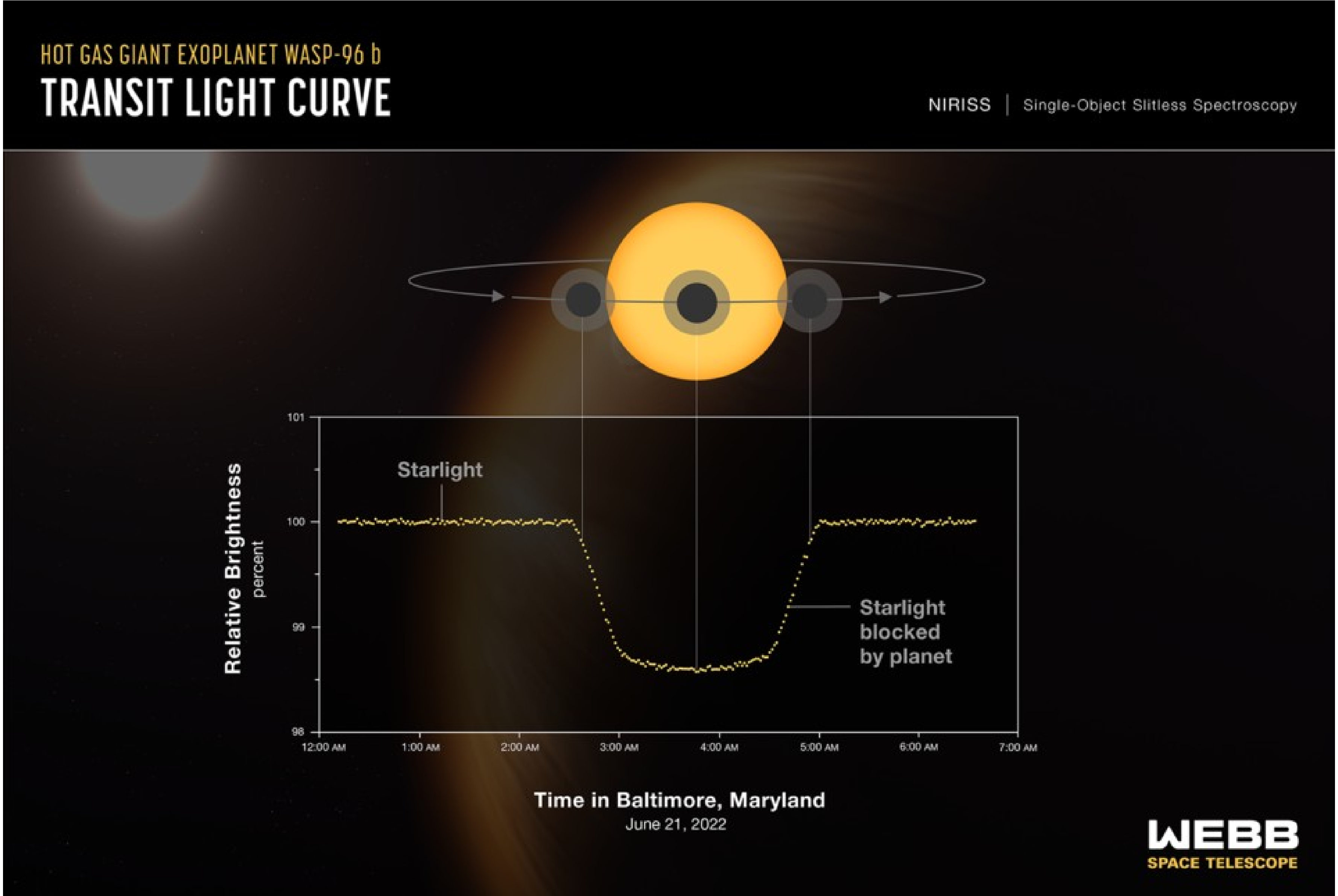
Hubble


GLASS-z13


Voyager 2 (1989)
Hubble (2021)
Webb (2022)


Northern
Aurora


Northern
Aurora
Southern
Aurora


HOT GAS GIANT EXOPLANET WASP-96 b
TRANSIT LIGHT CURVE
NIRISS | Single-Object Slitless Spectroscopy
Starlight
Starlight blocked by planet
Relative Brightness
percent
101
100
99
98
12:00 AM
1:00 AM
2:00 AM
3:00 AM
4:00 AM
5:00 AM
6:00 AM
7:00 AM
Time in Baltimore, Maryland
June 21, 2022
WEBB
SPACE TELESCOPE

ATMOSPHERE COMPOSITION

NIRISS | Single-Object Slitless Spectroscopy