CYGNUS 2022
KOUVOLA

TÄHTITIETEELLINEN YHDISTYS
URSA

Kovat tähdet

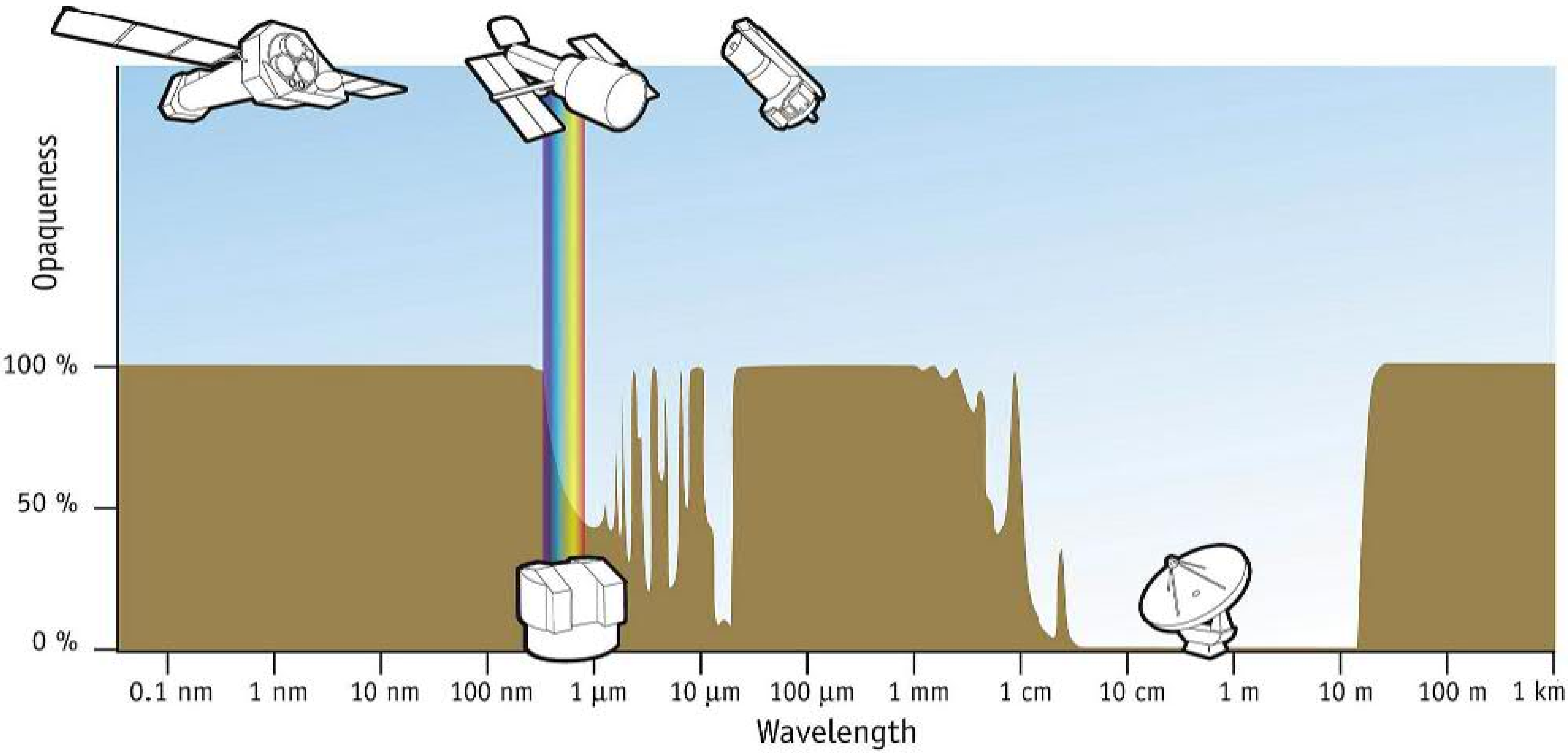
Päivitystä

James Webb -teleskooppi

Hannu Määttänen

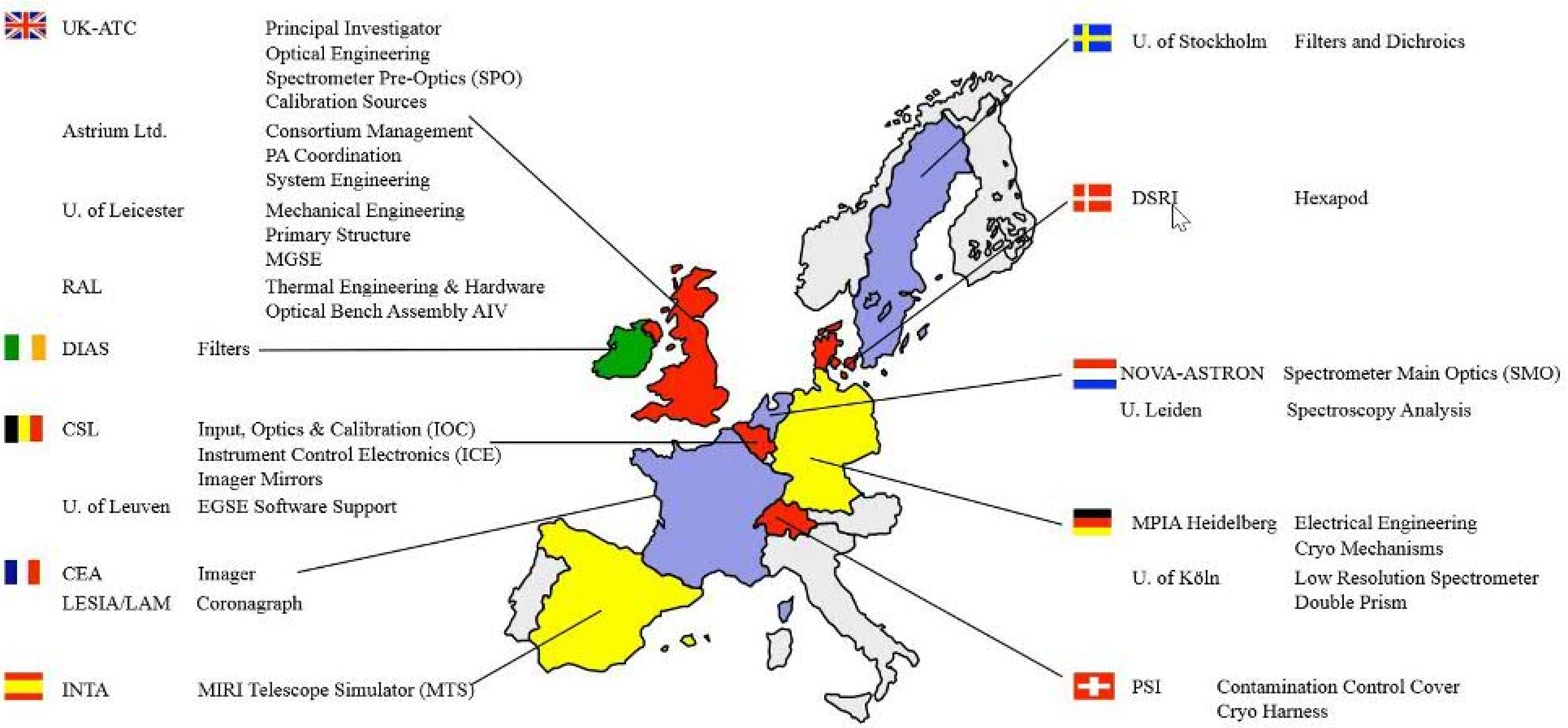
30.7.2022

Miten



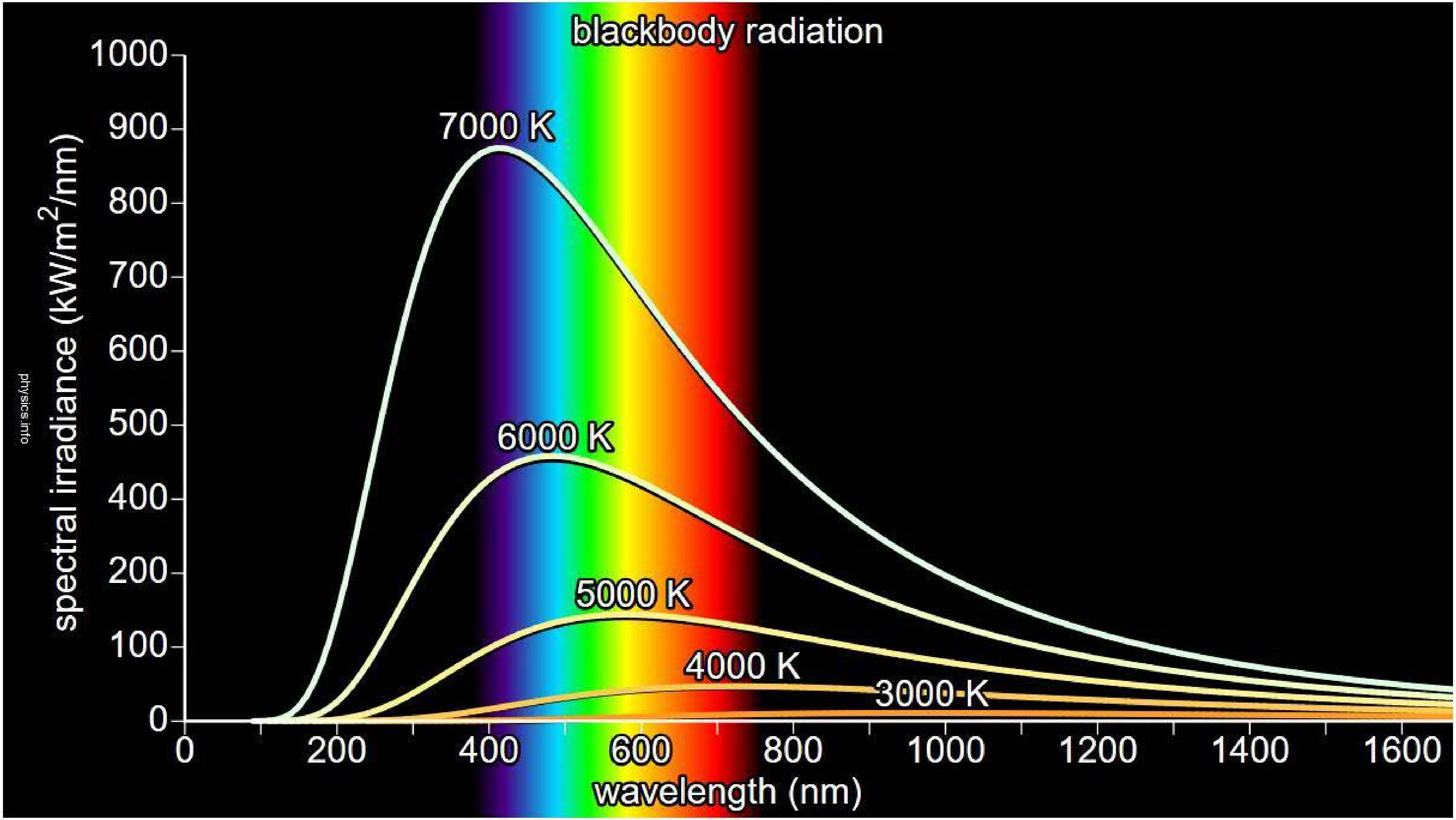
Opaqueness
100 %
50 %
0 %
0.1 nm
1 nm
10 nm
100 nm
1 µm
10 µm
100 µm
1 mm
1 cm
10 cm
1 m
10 m
100 m
1 km
Wavelength

Kuka



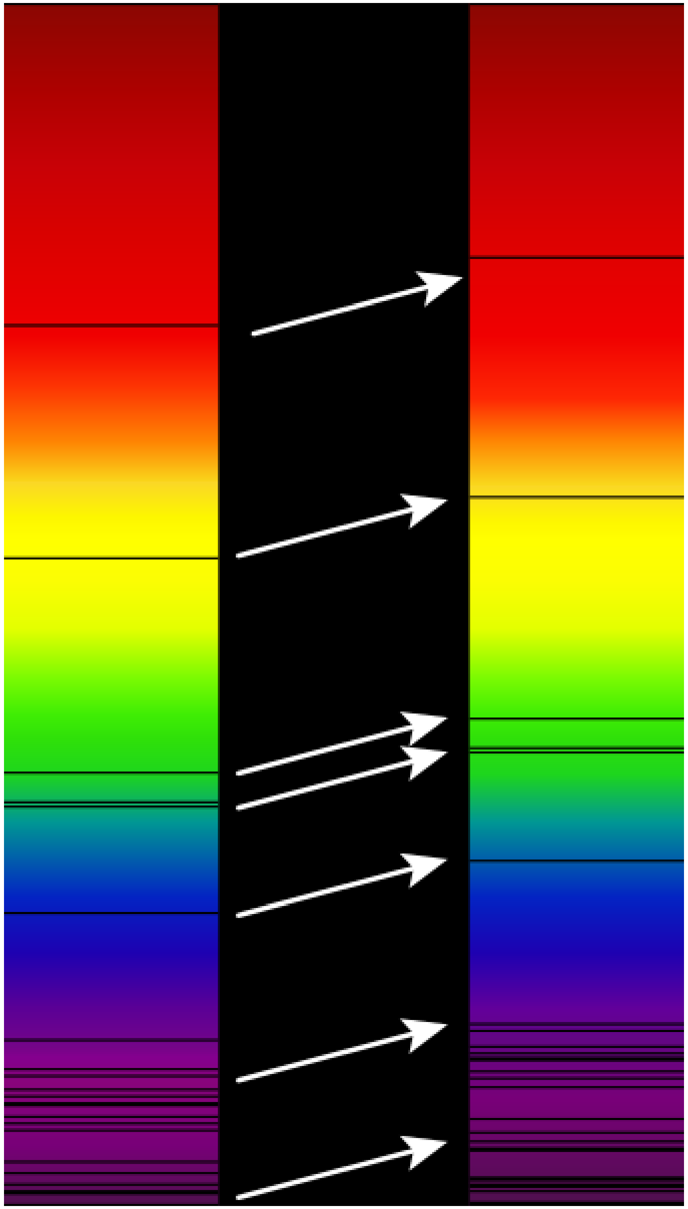
Over the duration of the mission, > 15% of the total JWST observing time goes to ESA member states applicants.

Katse kauemmaksi



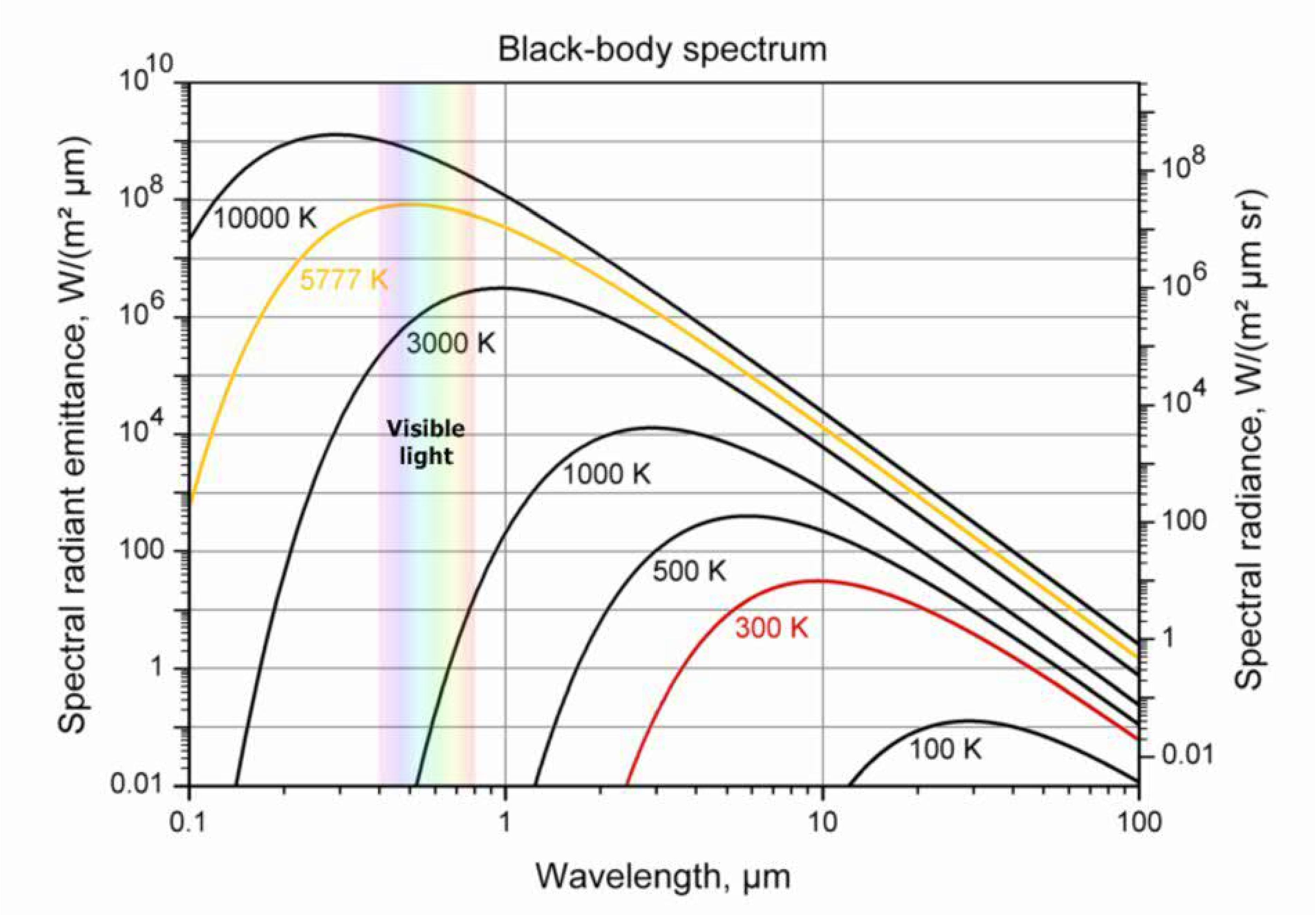
Katse kauemmaksi

$$f' = f \frac{1 - \frac{v}{c}\cos\theta}{\sqrt{1 - v^2/c^2}}$$



The most distant known quasar, ULAS J1342+0928, is at z = 7.54.

Katse kauemmaksi



Katse kauemmaksi

Säteilyn maksimin aallonpituus saadaan Wienin siirtymälaista

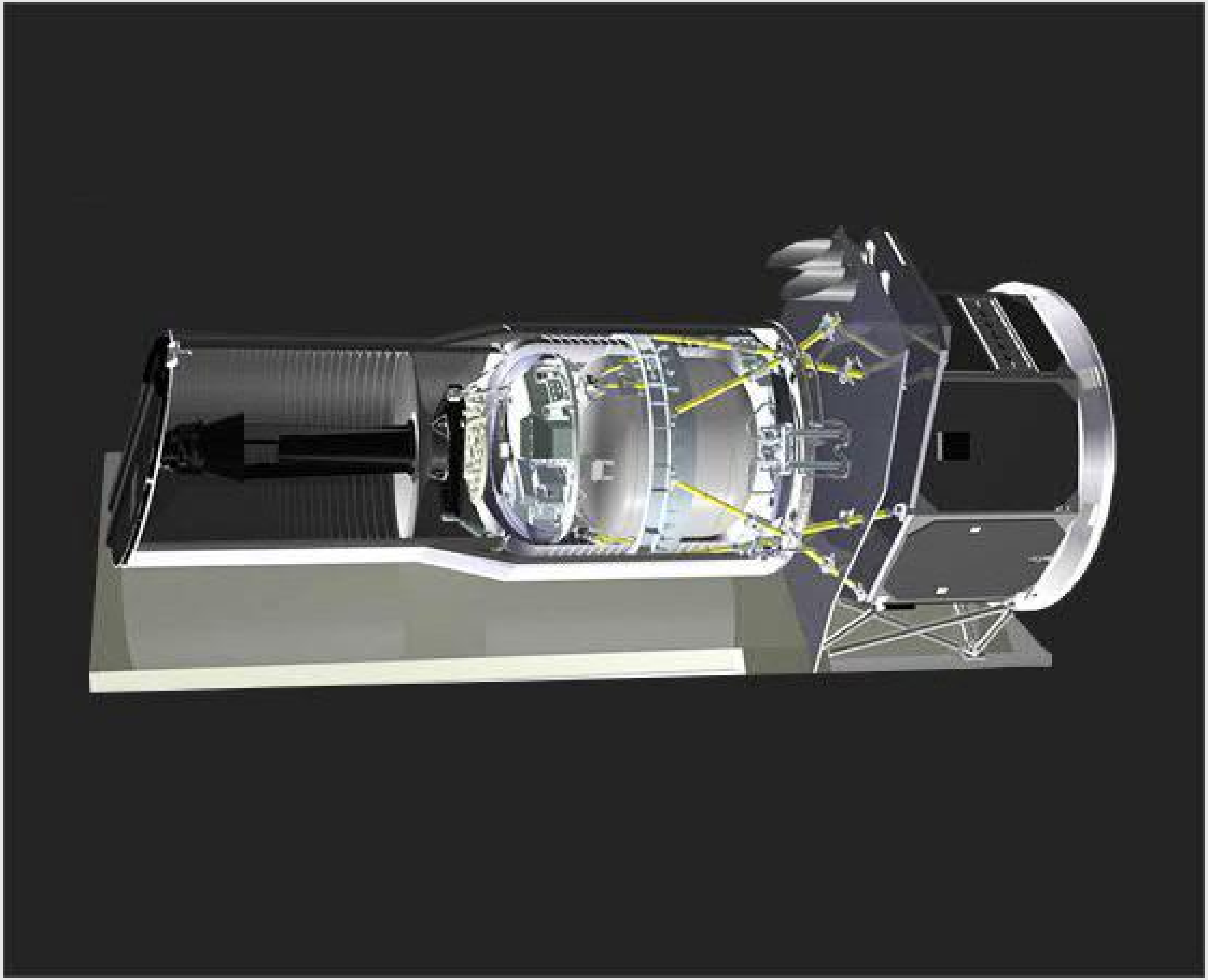
lmax T = 0.0028978 Km /T

$$dI = \sigma T^4 \frac{\cos\theta}{\pi d^2} dA$$

Hubble-teleskooppi

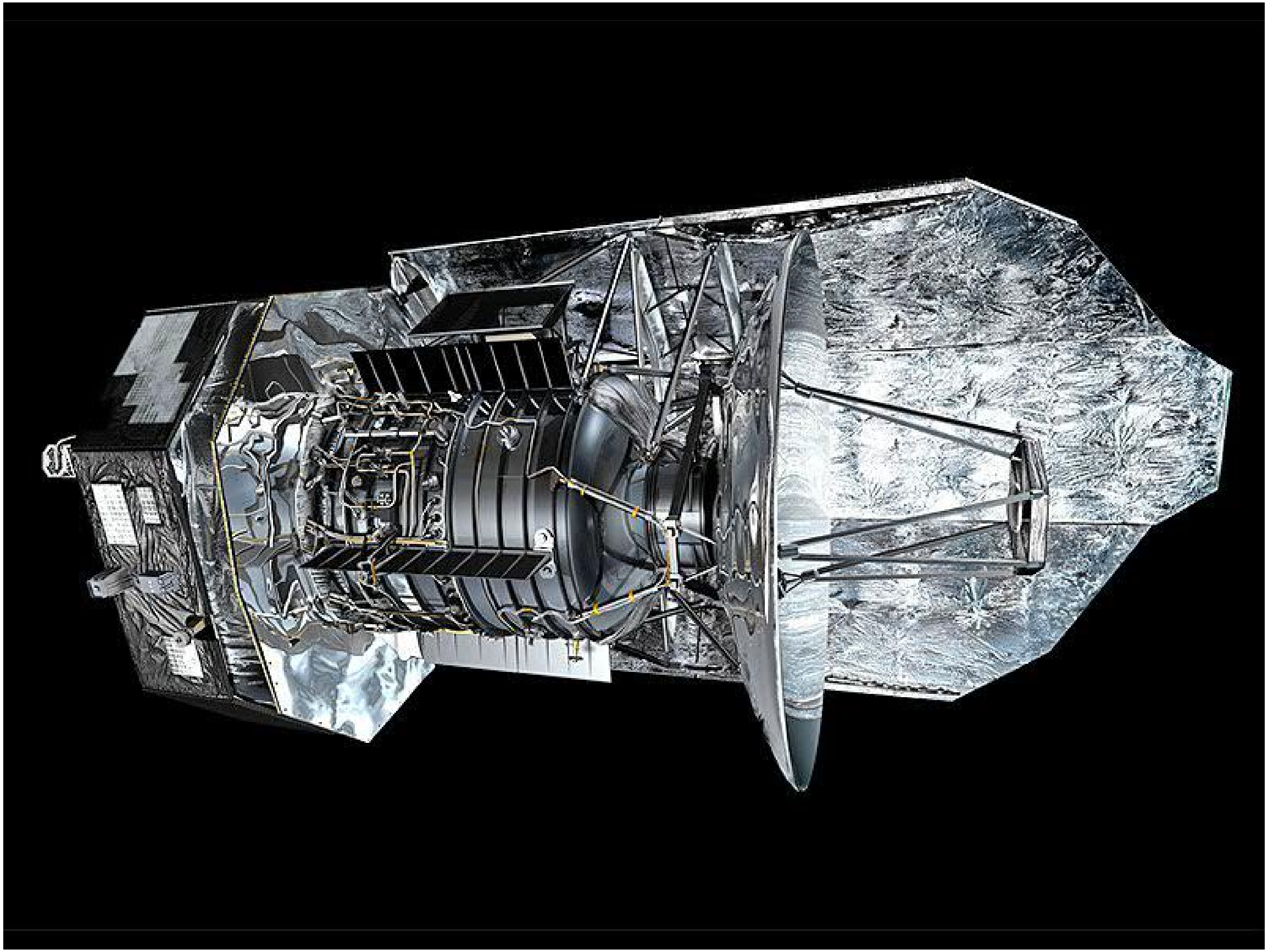
1990 -

Spitzer-teleskooppi



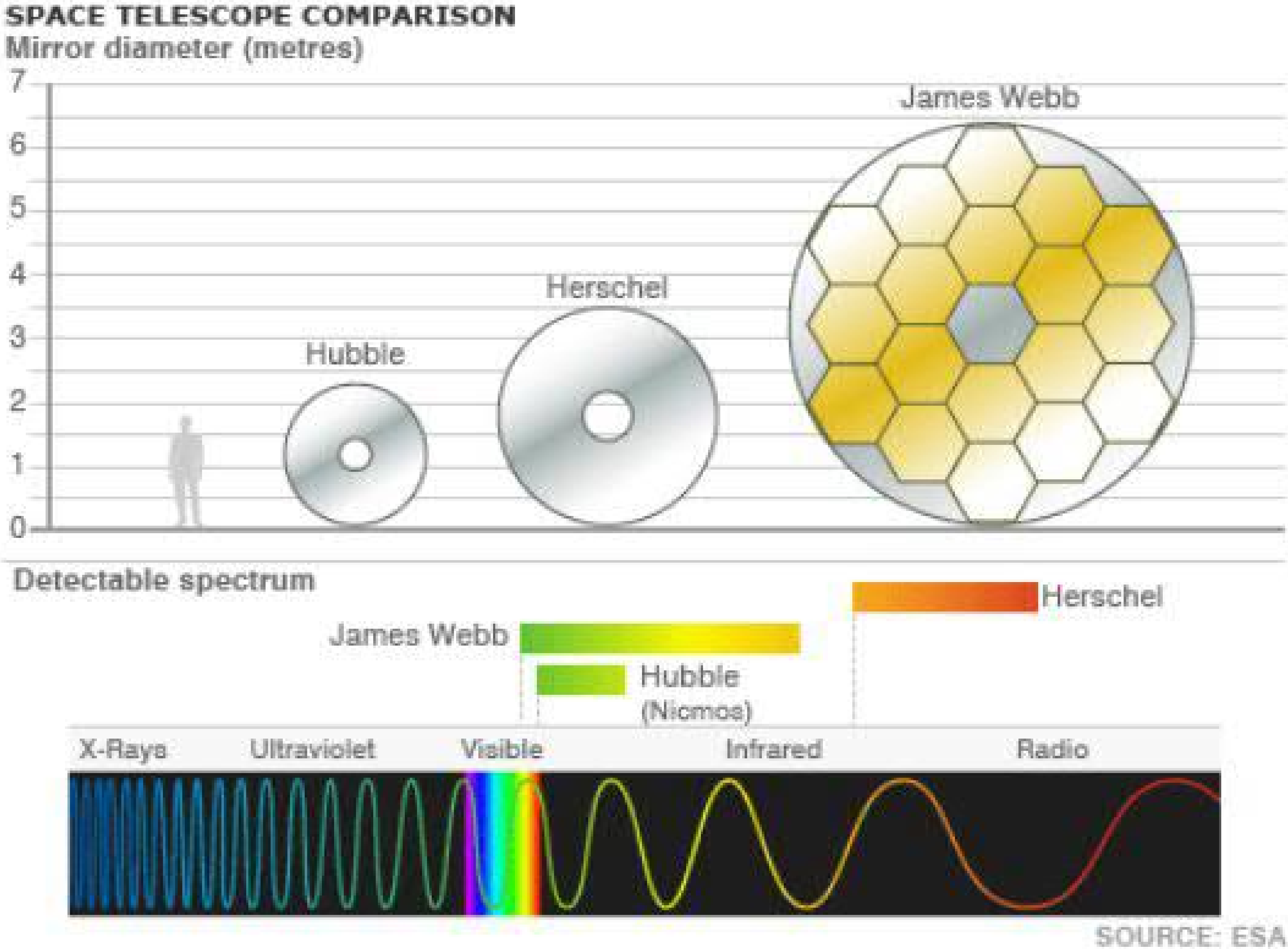
2003 -

Herschell-teleskooppi



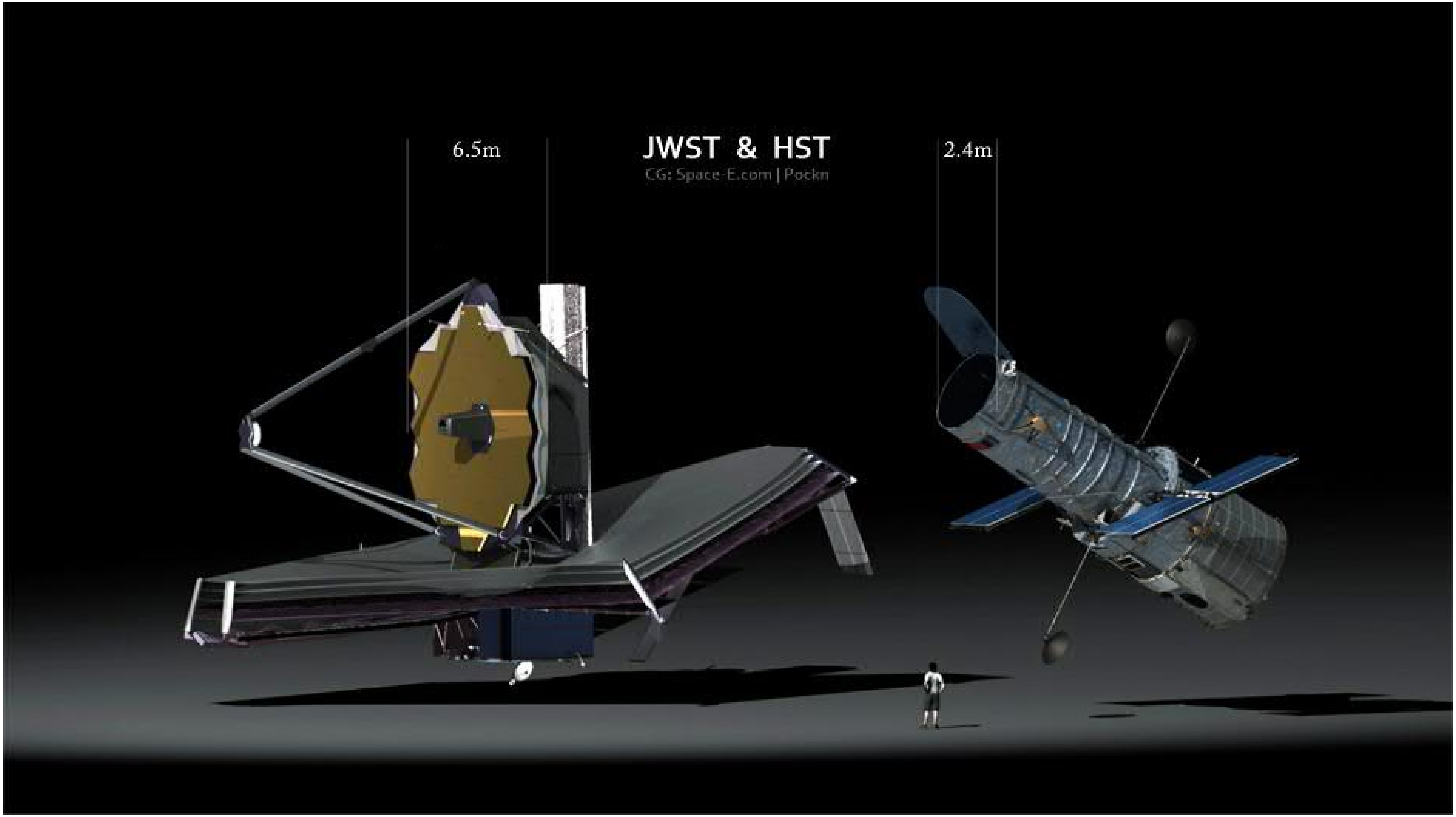
esa 2009 - 2013

Another Reminder of How Big JWST Is



James Edwin Webb (7.10.1906 – 27.3.1992)

NASAn johtaja 1961–1968



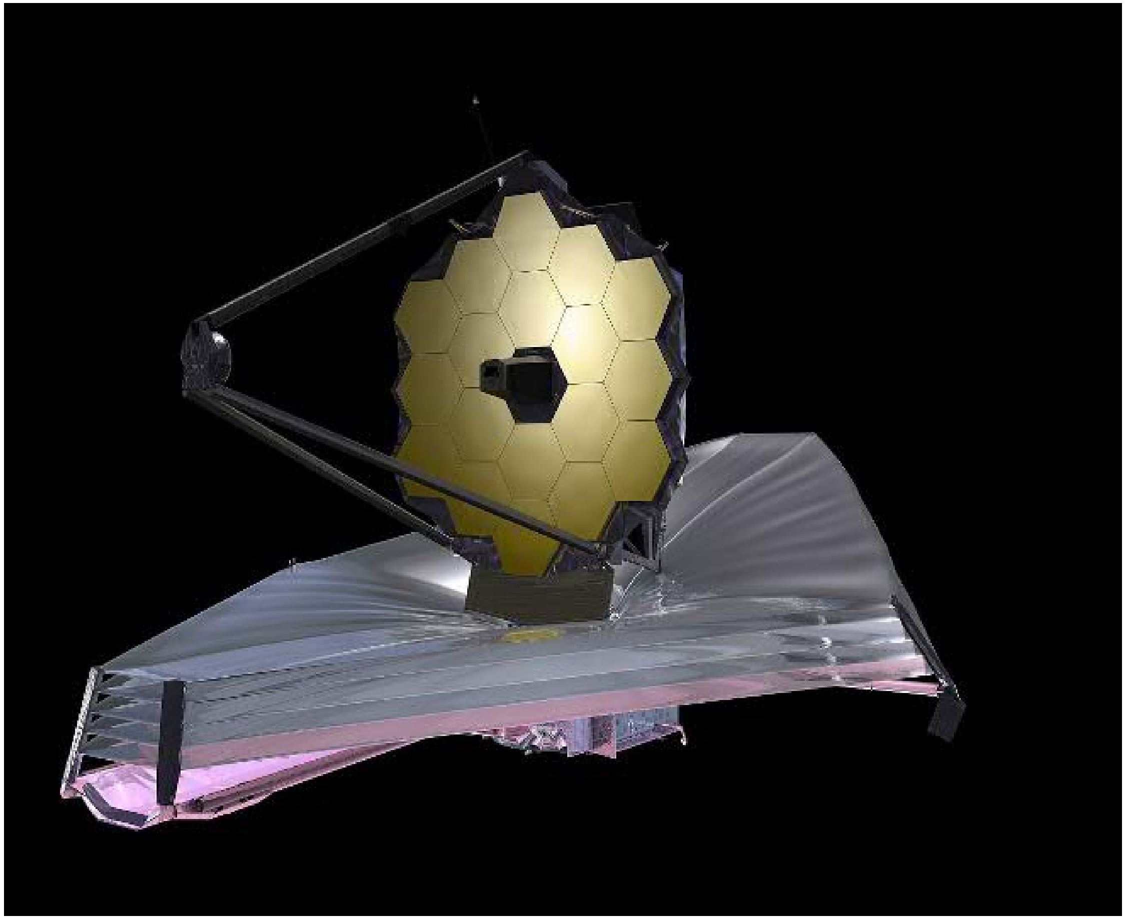
Alkurahoitus 2002

Suunnitelma valmis 2011

Kaukoputki valmis marraskuussa 2016

6 200 kg   (Hubble 11 110 kg)

Tavoitteet



?

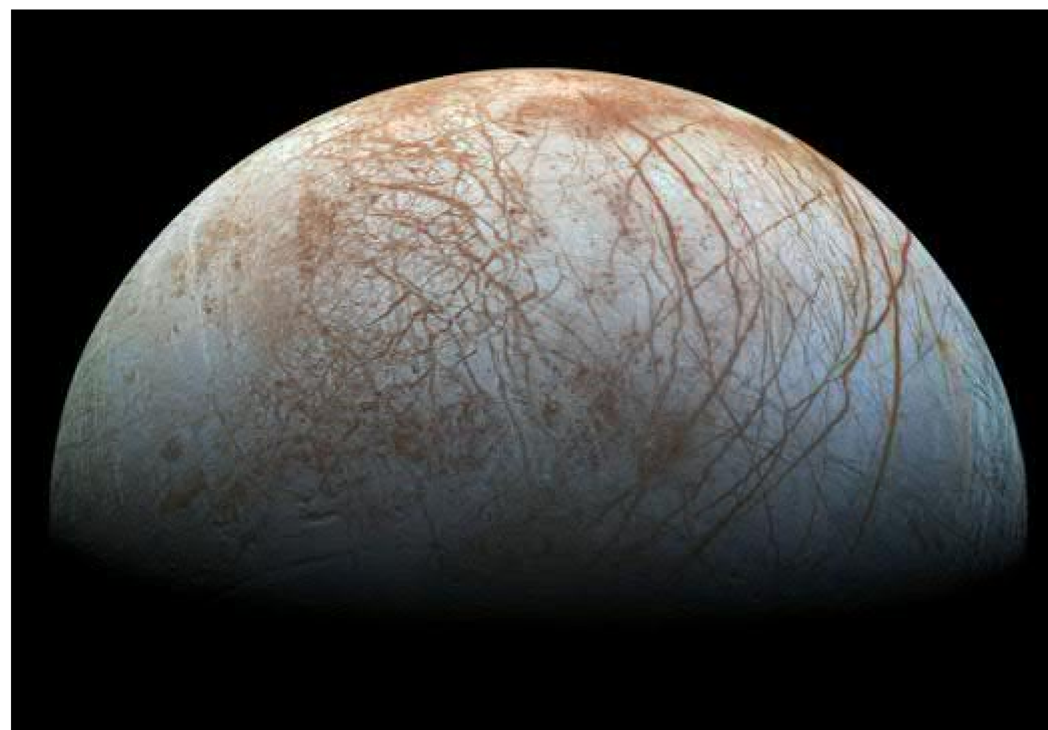
Webb is designed to discover and study the first stars and galaxies that formed in the early Universe. To see these faint objects, it must be able to detect things that are ten billion times as faint as the faintest stars visible without a telescope. This is 10 to 100 times fainter than Hubble can see.

Tavoitteet

One of the main goals of Webb is to detect some of the very first star formation in the Universe. This is thought to happen somewhere between redshift 15 and 30. At those redshifts, the Universe was only one or two percent of its current age.

The Universe is now 13.7 billion years old, and these redshifts correspond to 100 to 250 million years after the Big Bang. The light from the first galaxies has traveled for about 13.5 billion years.

Webb telescope's observations might be particularly telling for the plumes on Europa, the composition of which largely remains a mystery. "Are they made of water ice? Is hot water vapor being released? What is the temperature of the active regions and the emitted water?" Webb telescope's measurements will allow us to address these questions with unpredented accuracy and precision.

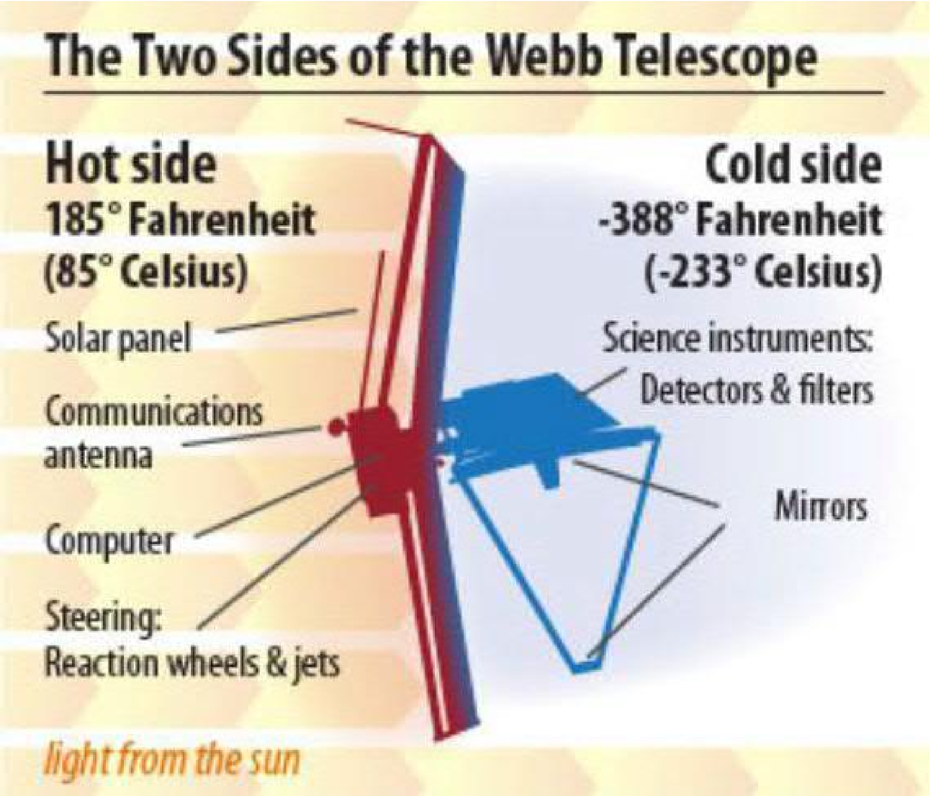


Aurinkokunnan kohteita

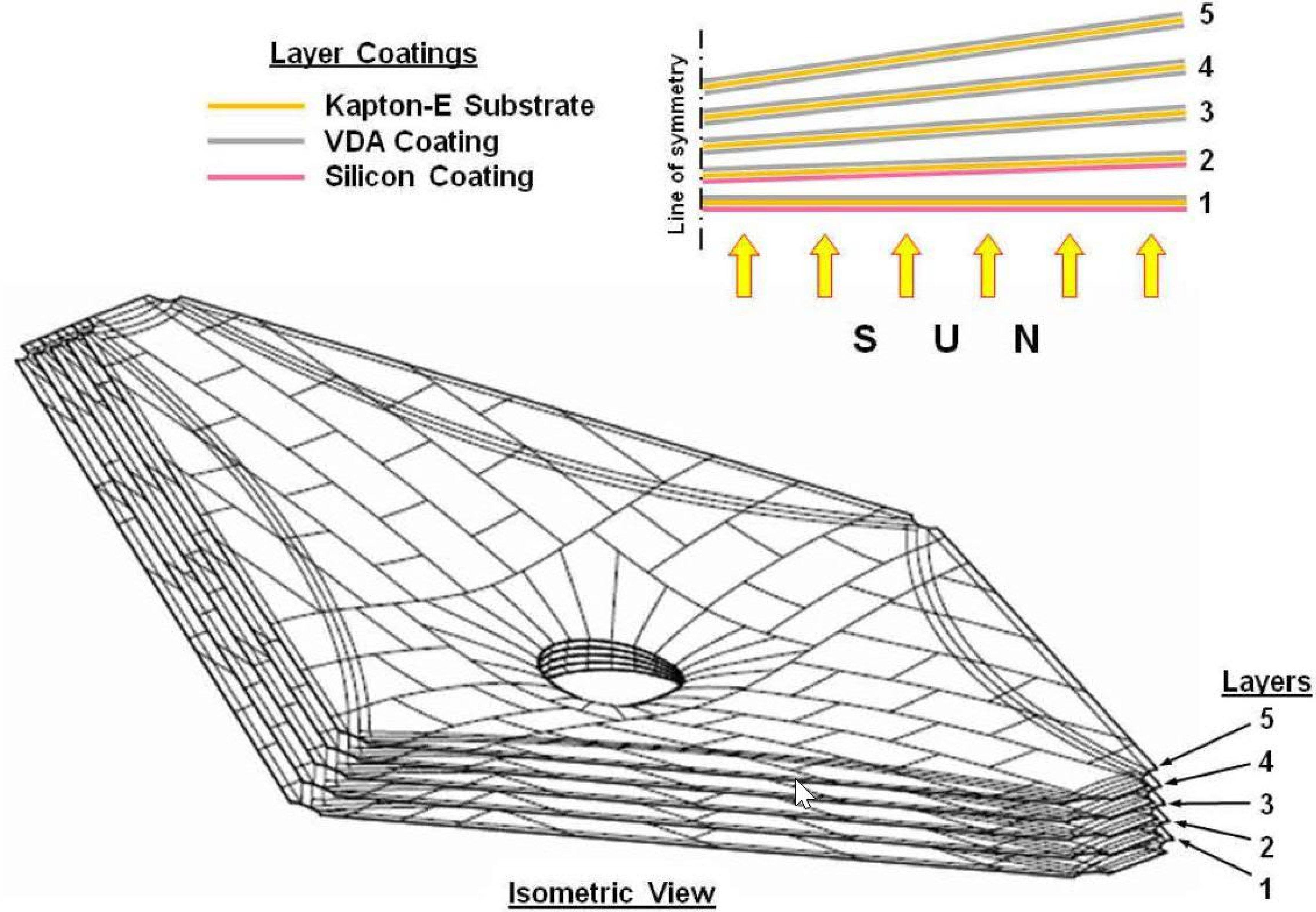
Near-simultaneous mapping and spectroscopy of cometary gas and dust from 0.6 – ~ 28.5 μm.

Varjo

The Sunshield subsystem shields the OTE and ISIM from ~300 kW of power received from the Sun and shields the observatory from the light of the Earth and Moon. This thermal barrier reduces the received radiation to less than 1.8 W, enabling passive radiative cooling to maintain the OTE and ISIM at their cryogenic operating temperatures over the field of regard.



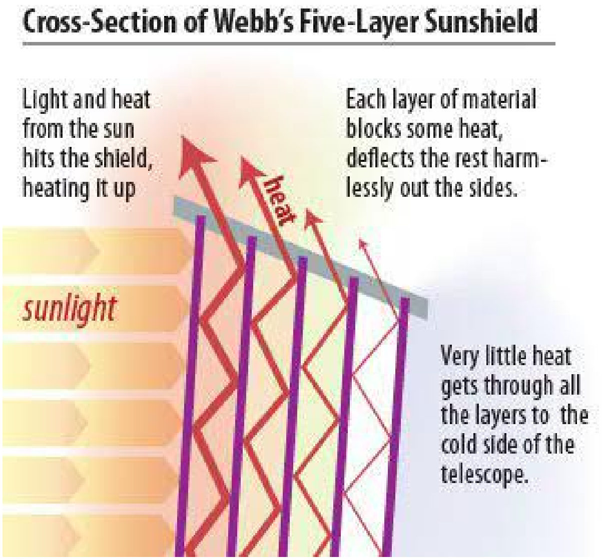
Varjo


Layer Coatings
Kapton-E Substrate
VDA Coating
Silicon Coating
Line of symmetry
5
4
3
2
1
S U N
Layers
5
4
3
2
1
Isometric View

Varjo

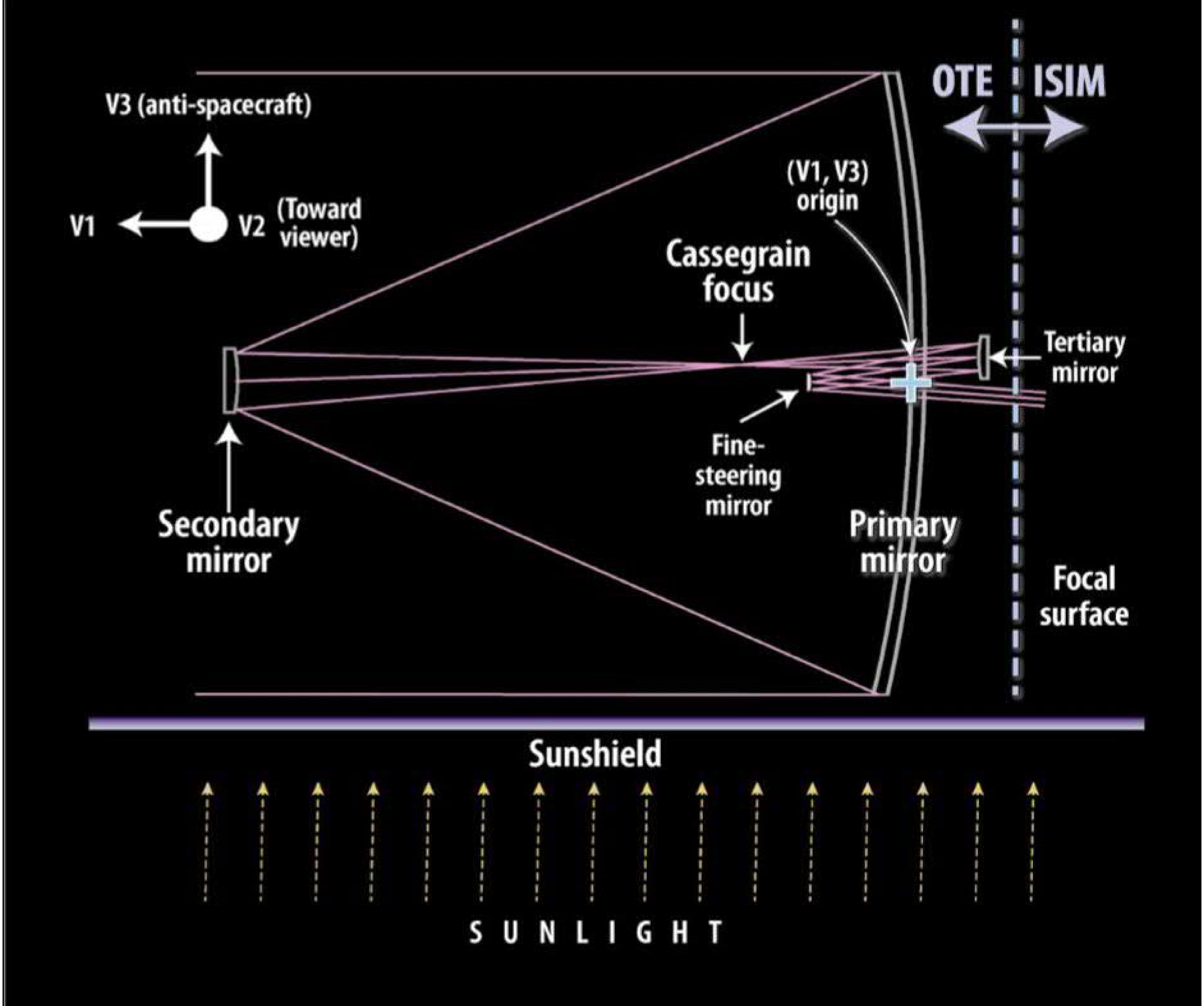
JWST deploys a tennis-court sized Sunshield made of five thin layers of Kapton E to reflect the sun's heat back into space.

The Layer 1 membrane (facing the sun) is 0.002" thick, the other four layers are each 0.001". The higher emissivity doped-silicon coating is ~50 nanometers thick, and is applied to the sun-facing side of the two hottest layers (Layer 1 & 2) to maximize stoppage of the sun's heat. Doping is a process whereby a small amount of conductive material is mixed in during the silicon coating process, so that the coating is electrically conductive. The highly-reflective aluminum coating is ~100 nm thick and is applied to all the other surfaces, helping to "bounce" the remaining energy out the gaps between the layers.

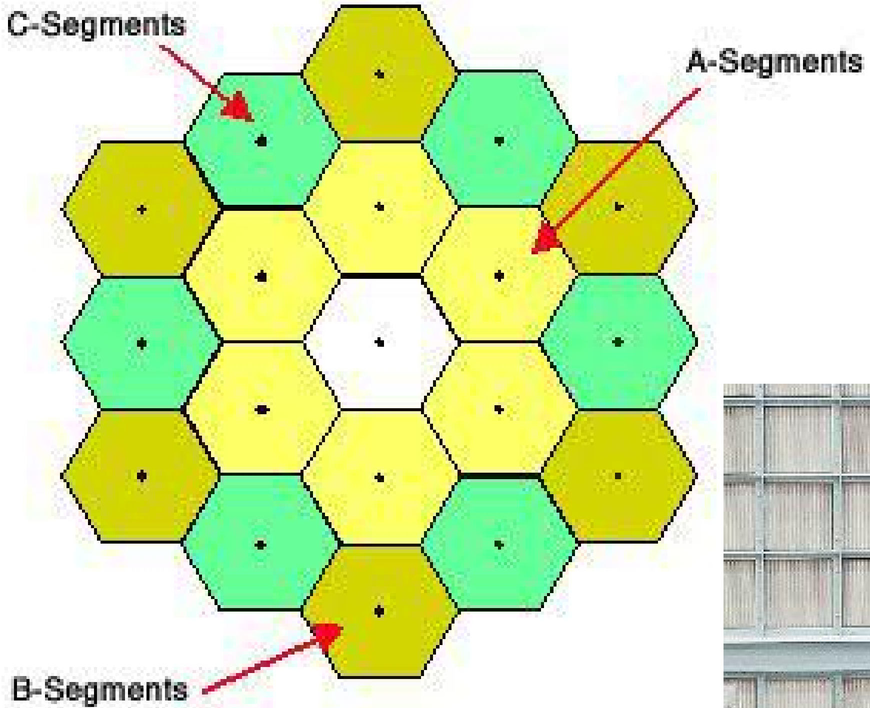


21,197 m x 14,162 m

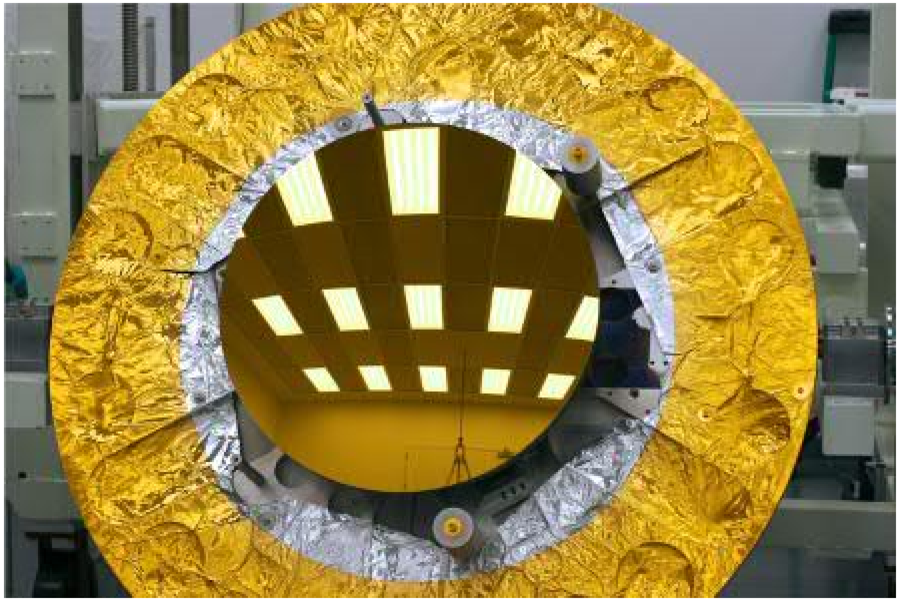
Varjo

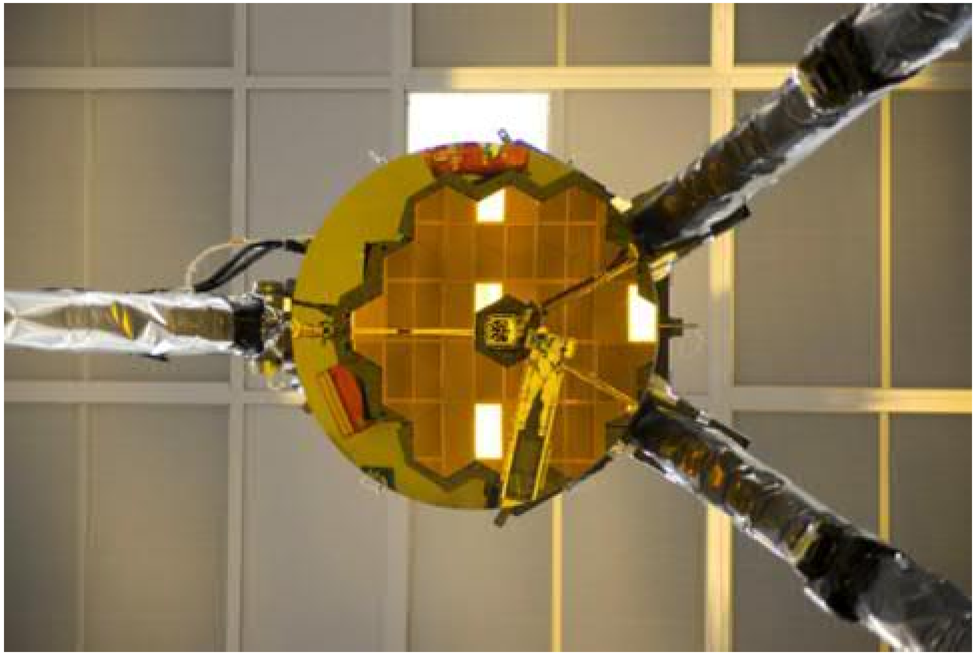

OTE
ISIM
V3 (anti-spacecraft)
V1
V2 (Toward viewer)
(V1, V3) origin
Cassegrain focus
Tertiary mirror
Fine-steering mirror
Secondary mirror
Primary mirror
Focal surface
Sunshield
SUNLIGHT

Kaukoputki



Peilit





Optiset laitteet

The James Webb Space Telescope includes four scientific instruments:

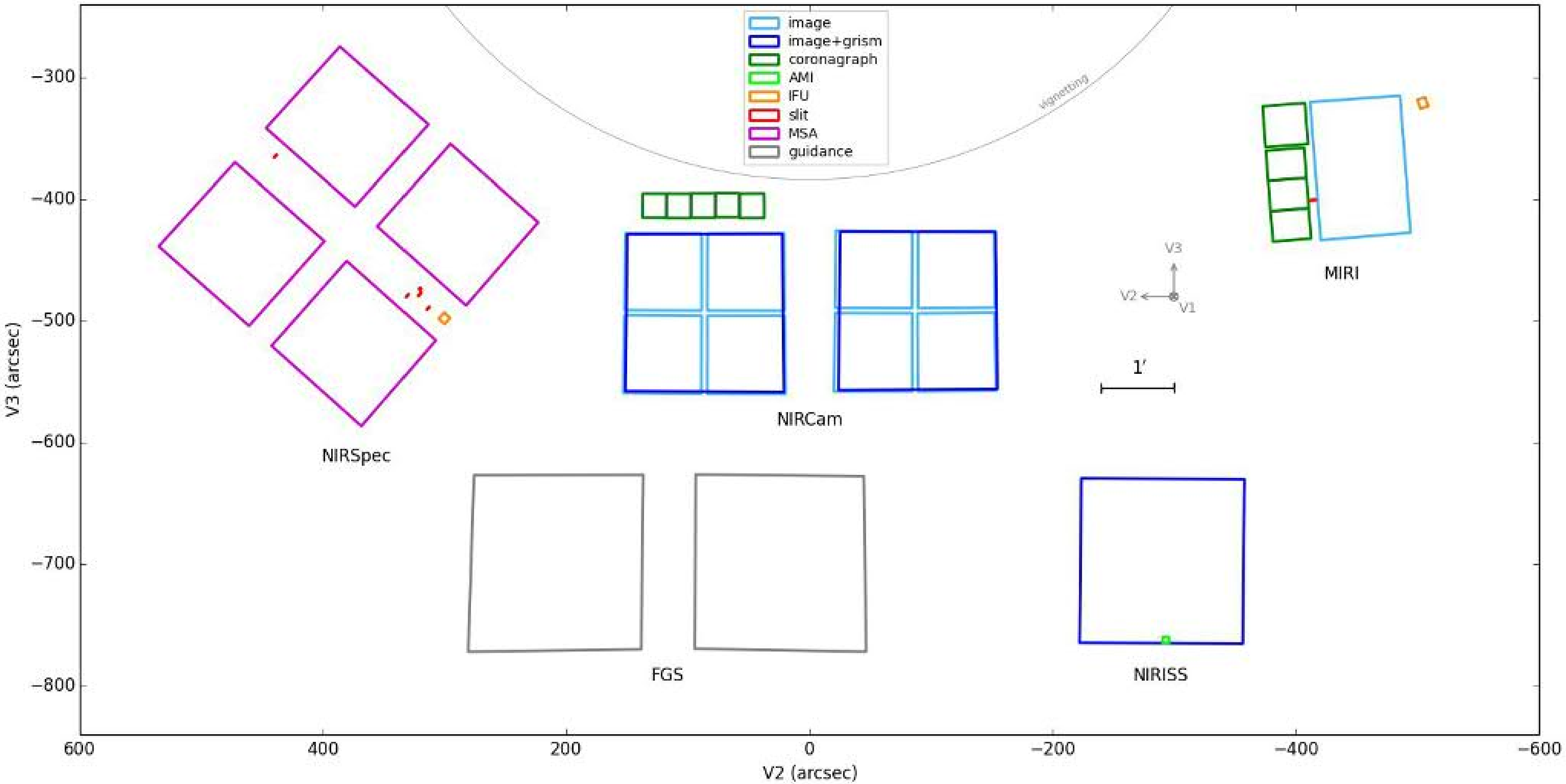
the Near Infrared Camera (NIRCam),

the Near-Infrared Spectrograph (NIRSpec),

the Mid-Infrared Instrument (MIRI),

and the Fine Guidance Sensor/ Near InfraRed Imager and Slitless Spectrograph (FGS-NIRISS).

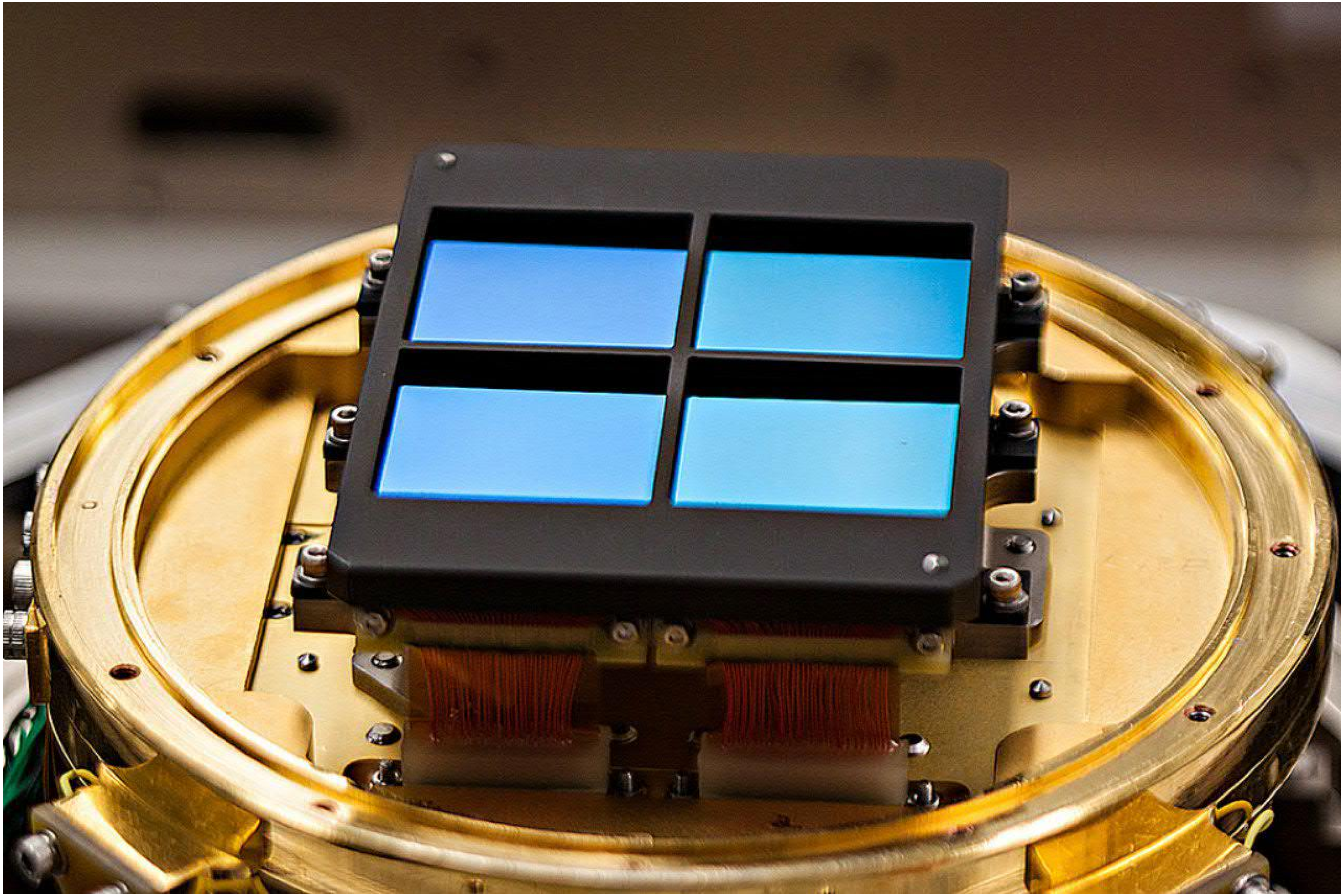
Kuvataso



The ISIM instruments are located in an off-axis position, which yield excellent image quality over the 9.4 arcminute field

Near Infrared Camera (NIRCam)

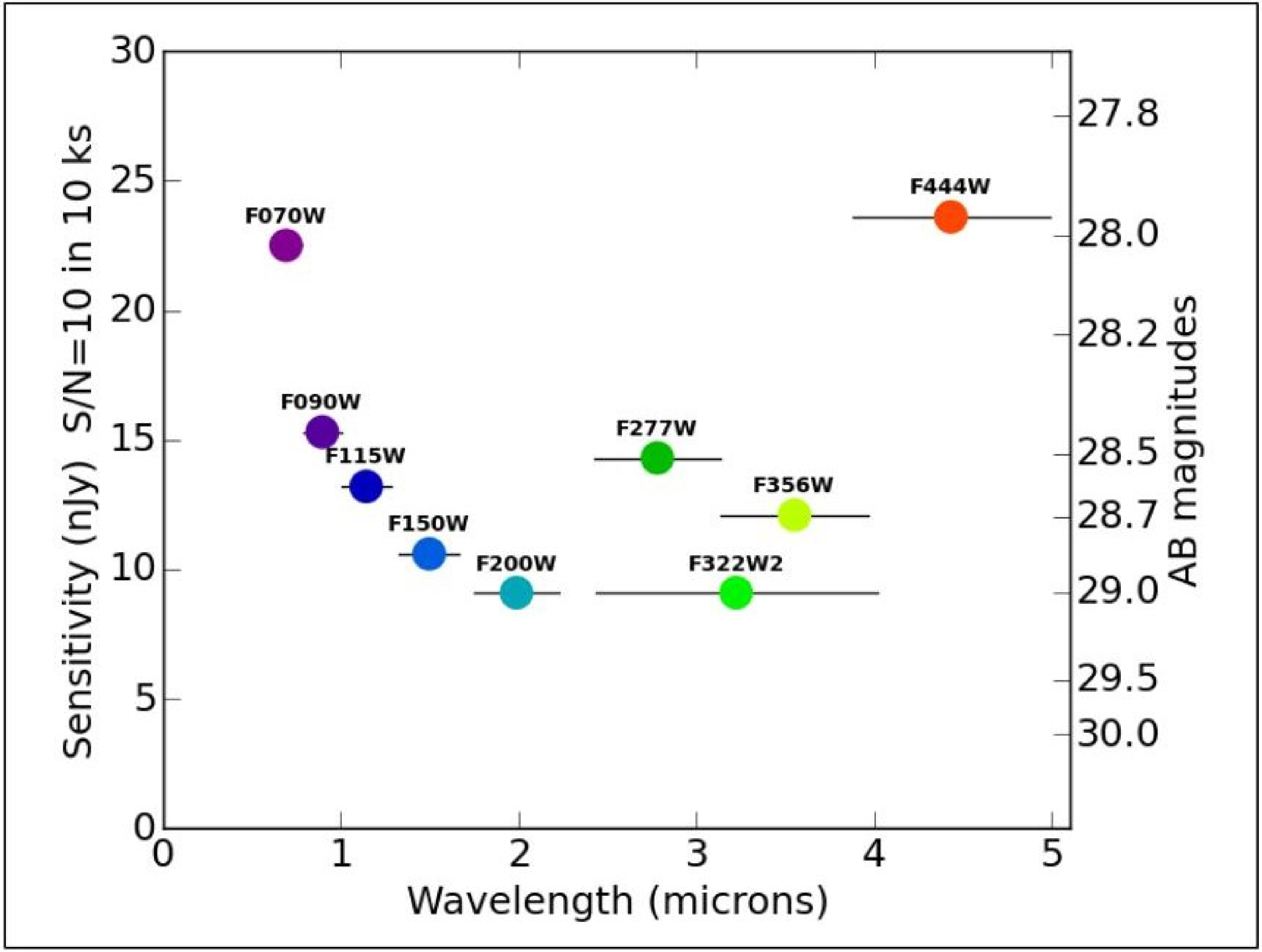
Near Infrared Camera (NIRCam)



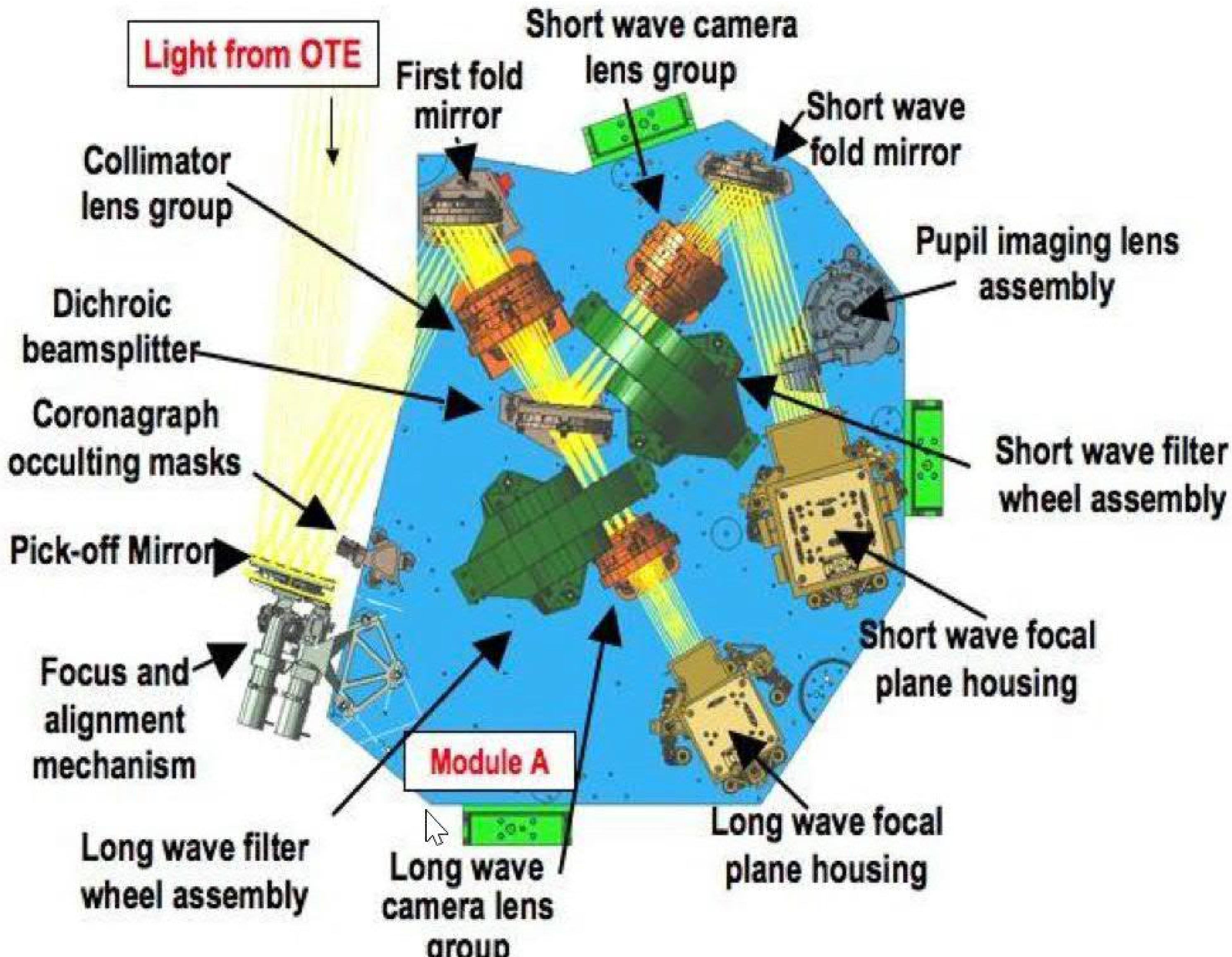
Near Infrared Camera (NIRCam)

NIRCam is the primary wavefront sensor for JWST and contains several components in its pupil wheels that are used to measure wavefront information. Because of its importance to overall observatory operations, NIRCam is comprised of two fully redundant modules. Weak lenses in the NIRCam filter wheels defocus the images to provide wavefront information.

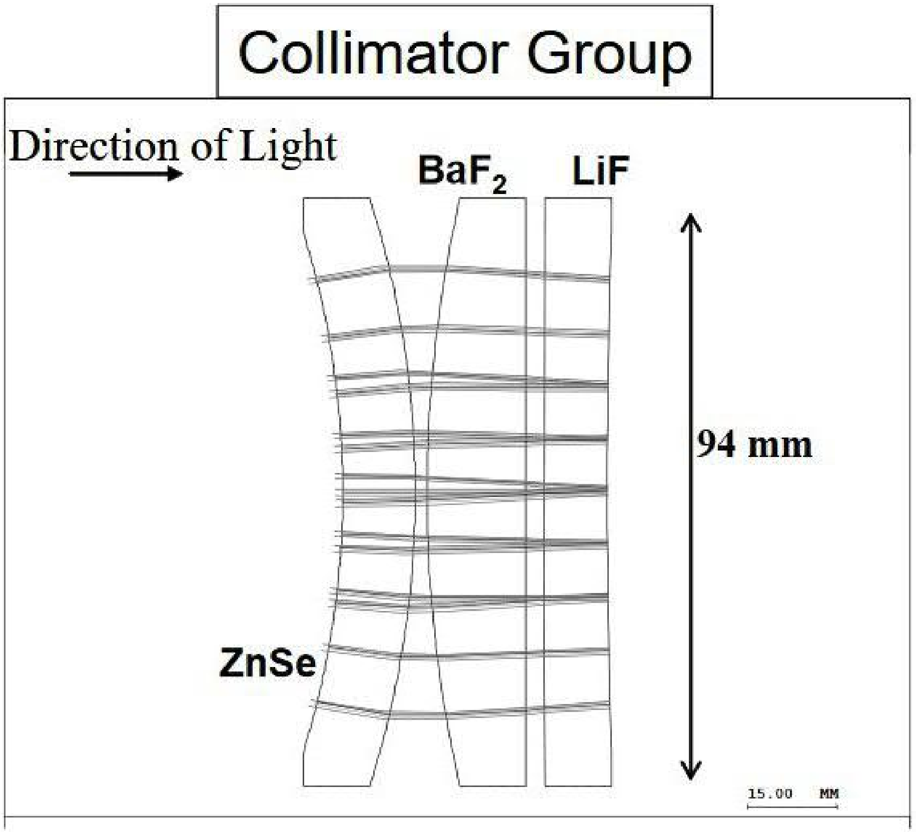
Near Infrared Camera (NIRCam)



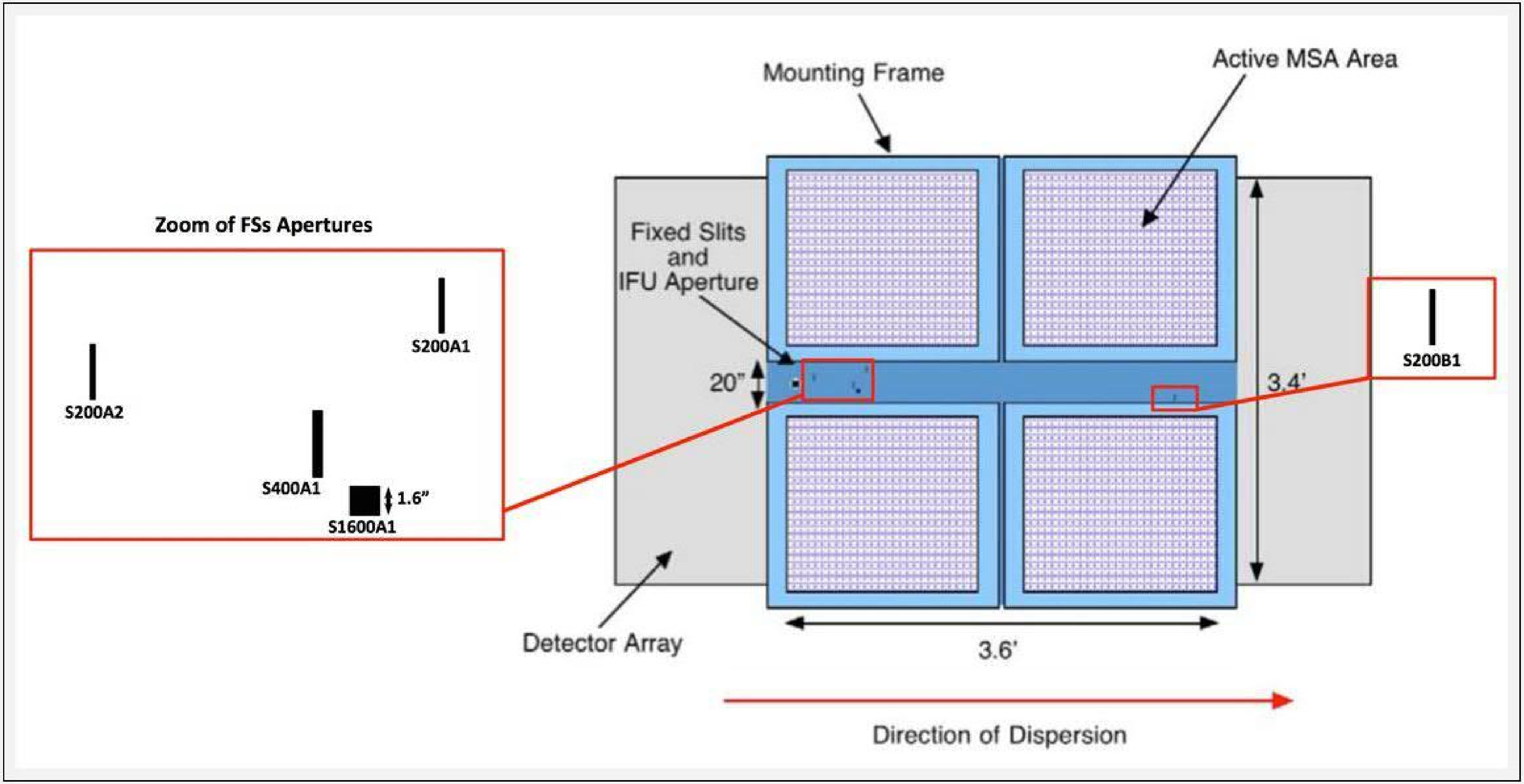
Near Infrared Camera (NIRCam)



Near Infrared Camera (NIRCam)

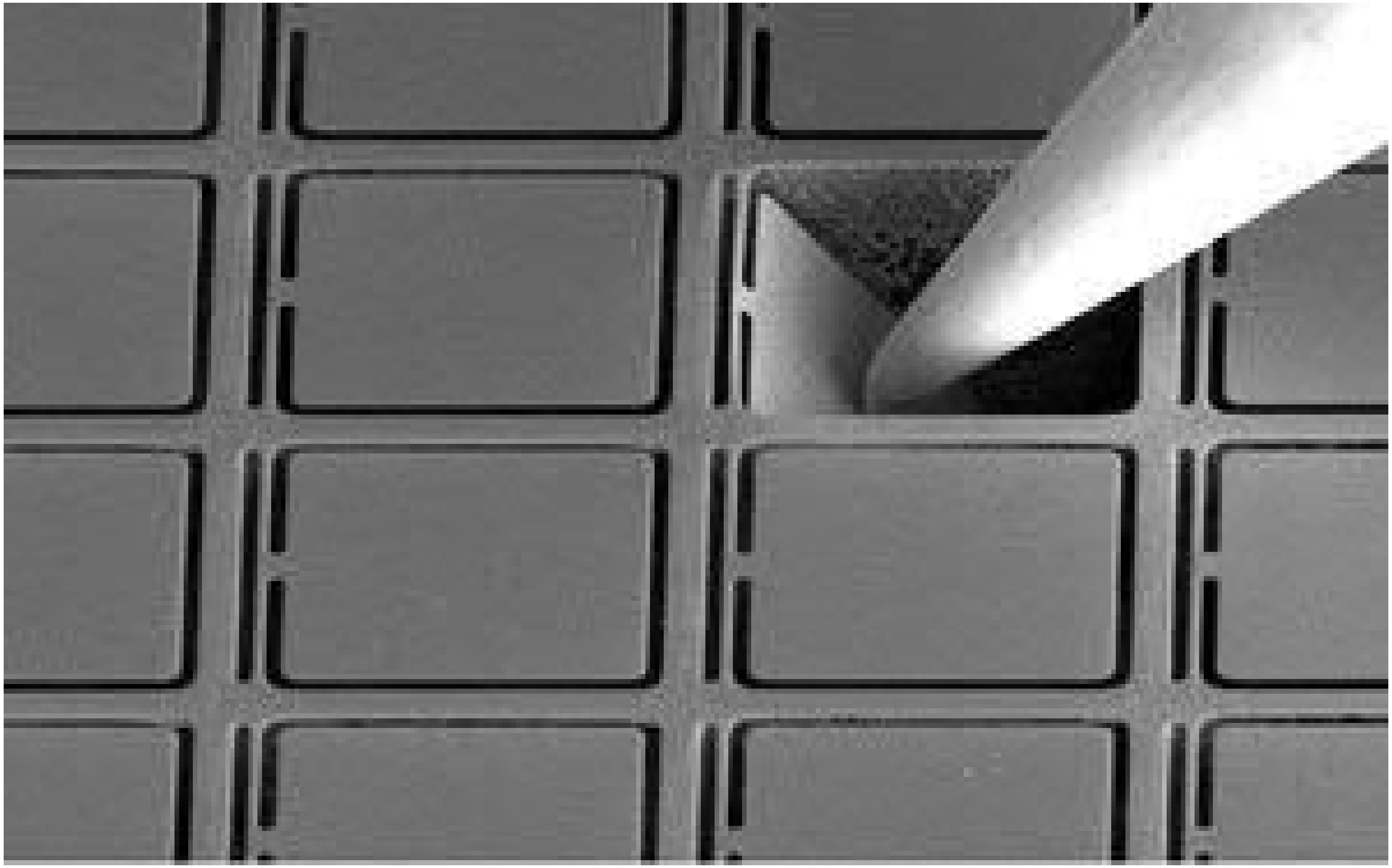


Near-Infrared Spectrograph (NIRSpec)



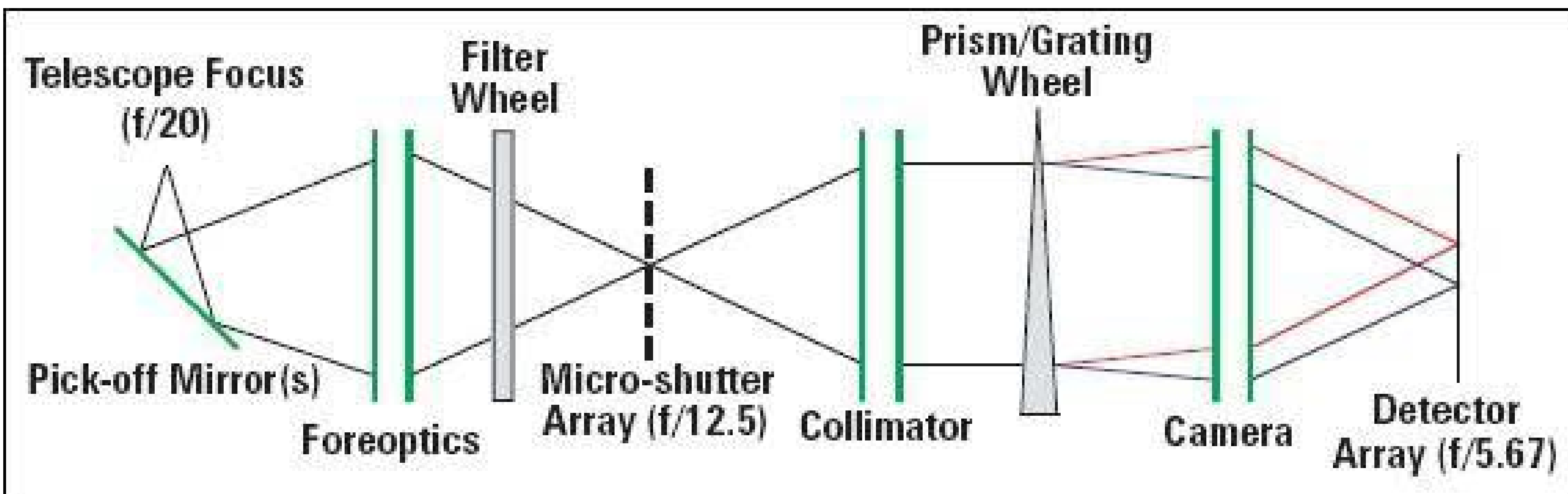
Because Webb will observe faint, far-away objects, it will take as long as a week for NIRSpec to gather enough light to obtain good spectra.

Near-Infrared Spectrograph (NIRSpec)



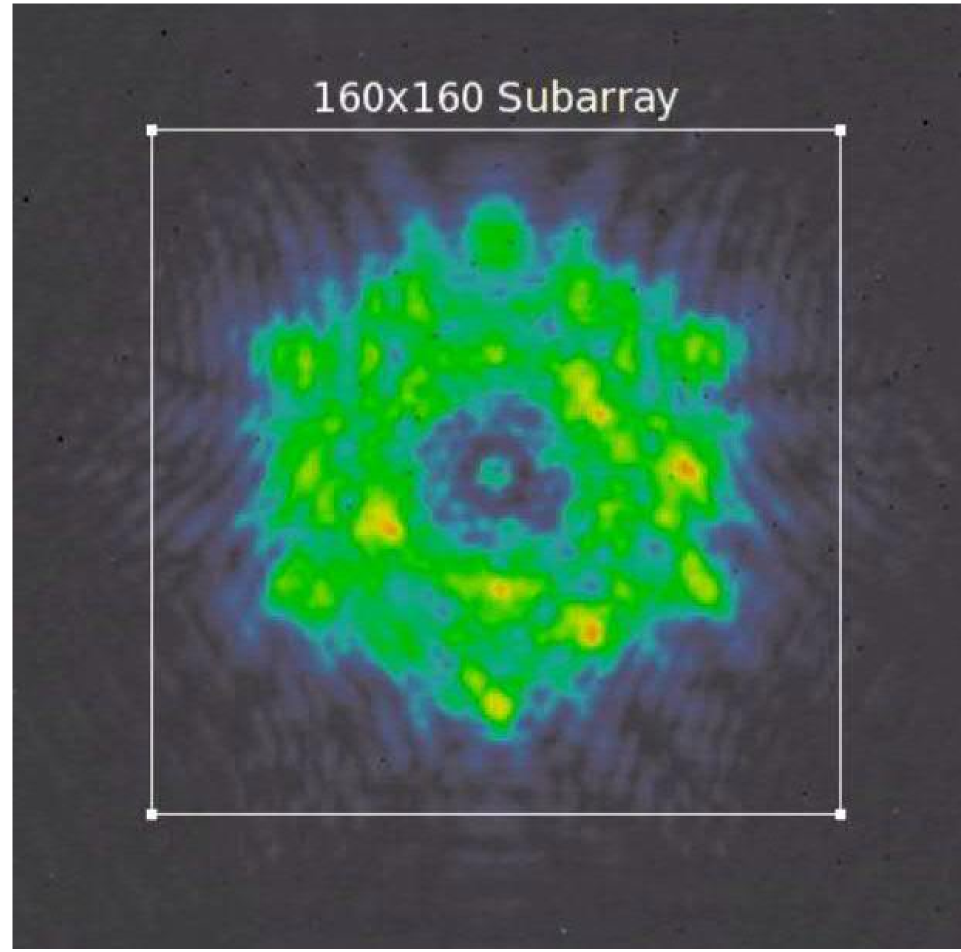
Each microshutter has a FOV of 0.2 x 0.4 arcsec

Multi-object spectroscopy obtains simultaneous spectroscopy of multiple science targets within a 3.6 × 3.4' field of view using the micro-shutter assembly (MSA)



Near Infrared Camera (NIRCam)

Analysis and determination of the wavefront error is performed on the ground using downlinked image data, and the necessary mirror commands are then uplinked to JWST to correct the alignments.



In a 10 ks image, NIRCam will obtain S/N = 10 detections of point sources as faint as ~10 nJy (AB mag 28.9) in some filters, and S/N = 5 detections of 5 nJy (AB mag 29.65) point source.

Mid-Infrared Instrument (MIRI)

MIRI provides imaging and spectroscopic observing modes from 4.9 to 28.8 μm. These wavelengths can be utilized for: direct imaging of young warm exoplanets and spectroscopy of their atmospheres; identification and characterization of the first galaxies at redshifts z > 7; and analysis of warm dust and molecular gas in young stars and proto-planetary disks.

Mid-Infrared Instrument (MIRI)

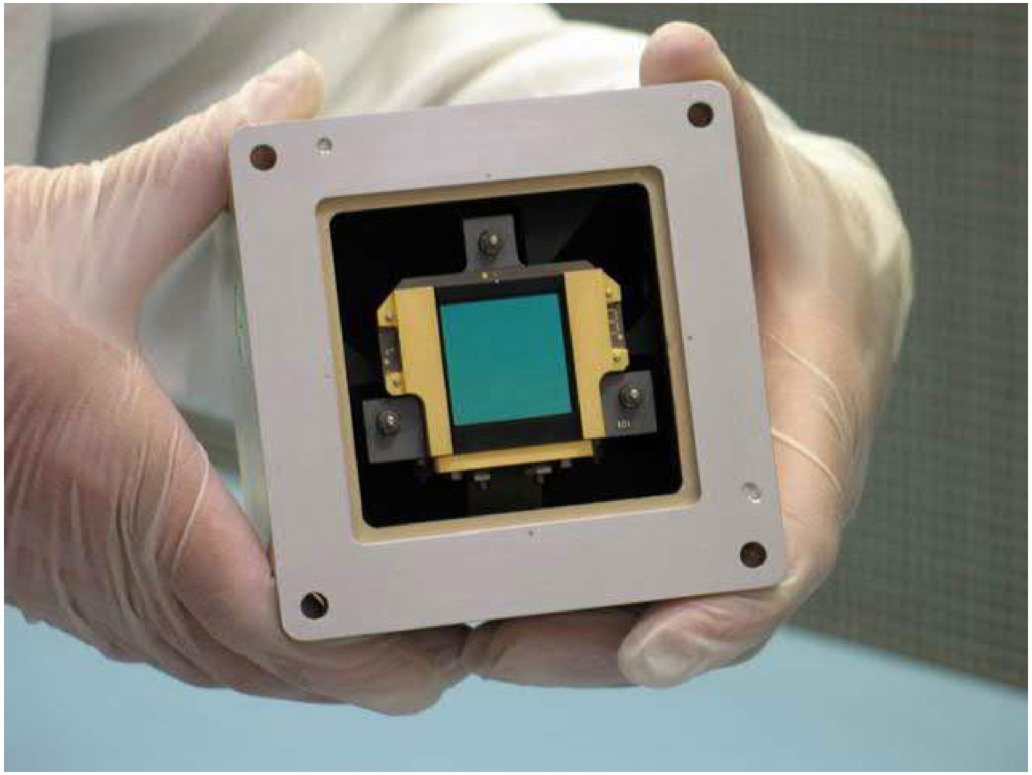
First JWST instrument MIRI
Delivered to NASA

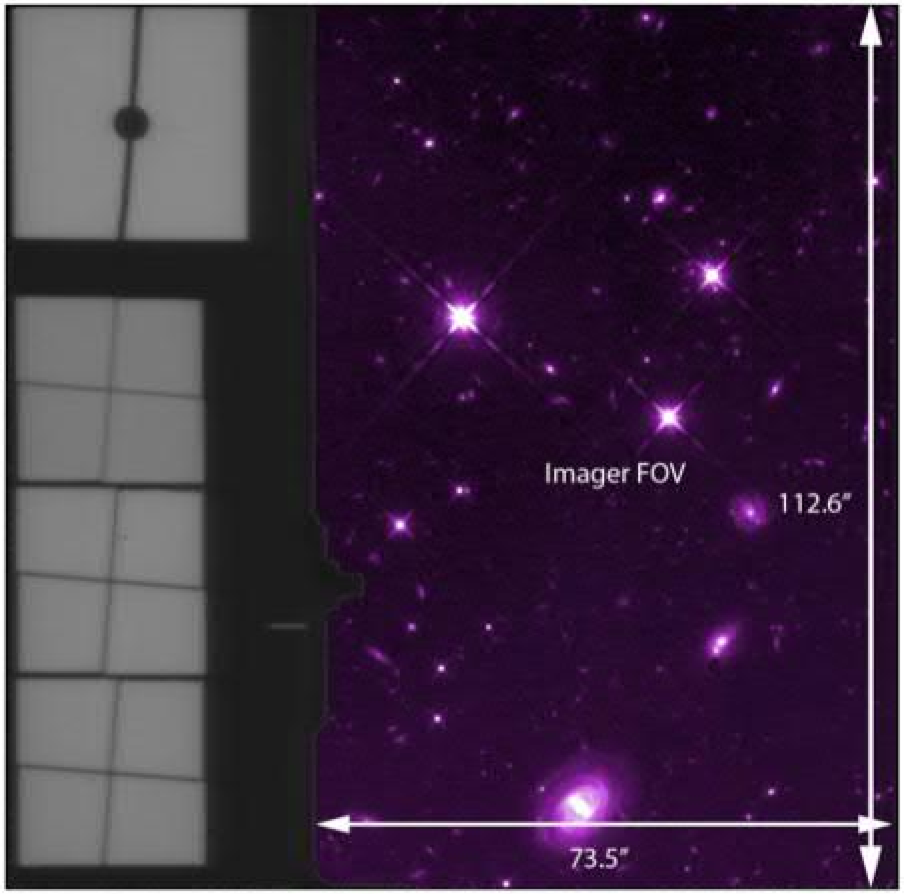
On May 9, 2012.

Mid-Infrared Instrument (MIRI)

MIRI covers the wavelength range of 5 to 28 microns.

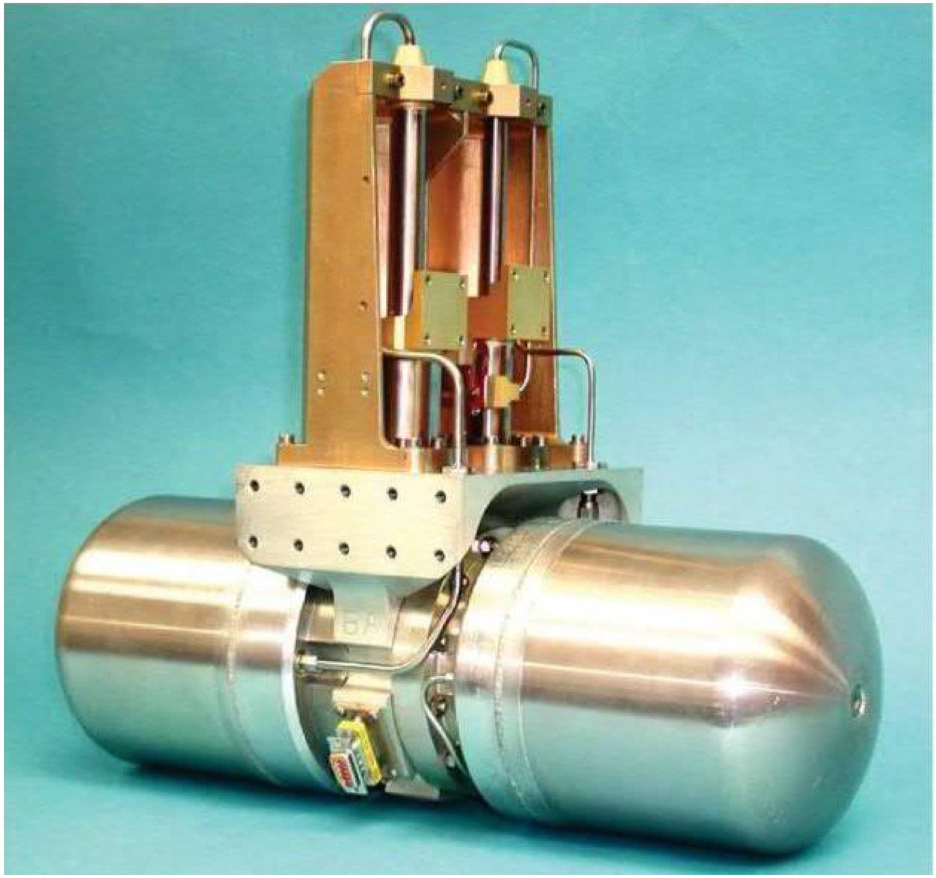
Mid-Infrared Instrument (MIRI)

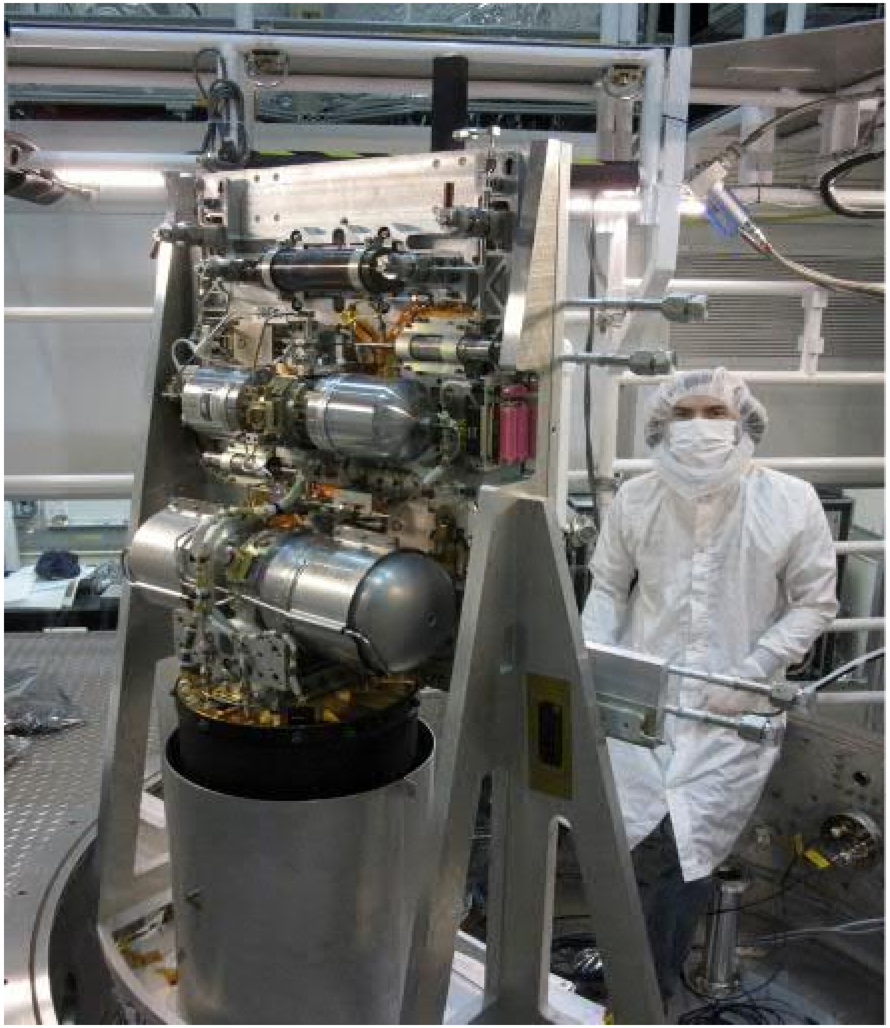




The imager has a plate scale of 0.11 arcseconds/pixel and a field of view of 74 by 113 arcseconds with filters ranging from 5.6 to 25.5 μm. It has a 1024x1024 pixel array of arsenic doped silicon pixels.

Mid-Infrared Instrument (MIRI)





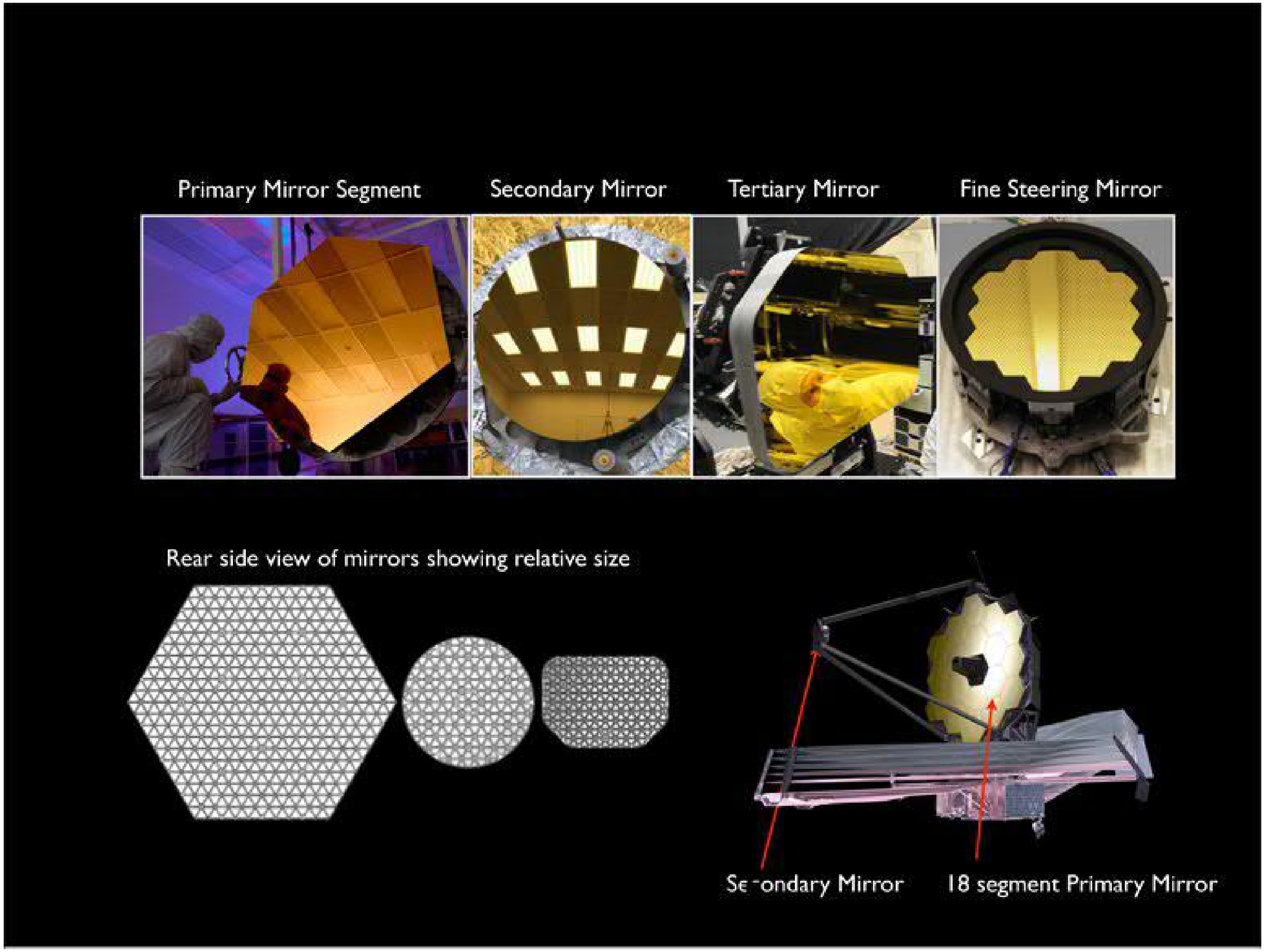
The MIRI instrument. MIRI's operates at temperatures of no more than 6.7 degrees above absolute zero.

Mid-Infrared Instrument (MIRI)

The large telescope aperture places this limit at about 5 AU at 10 pc for the coronagraph channels at 11–16 μm, and the sensitivity allows detection of low-mass planets . MIRI detects the thermal radiation (rather than reflected light) and hence is most sensitive to young exoplanets.

The MIRI imager spectral bands at 11.3 and 15 μm. The depth of the CO2 absorption indicates whether the planetary atmosphere is hydrogen poor or hydrogen rich (in which case there is virtually no absorption)

Fine Steering Mirror



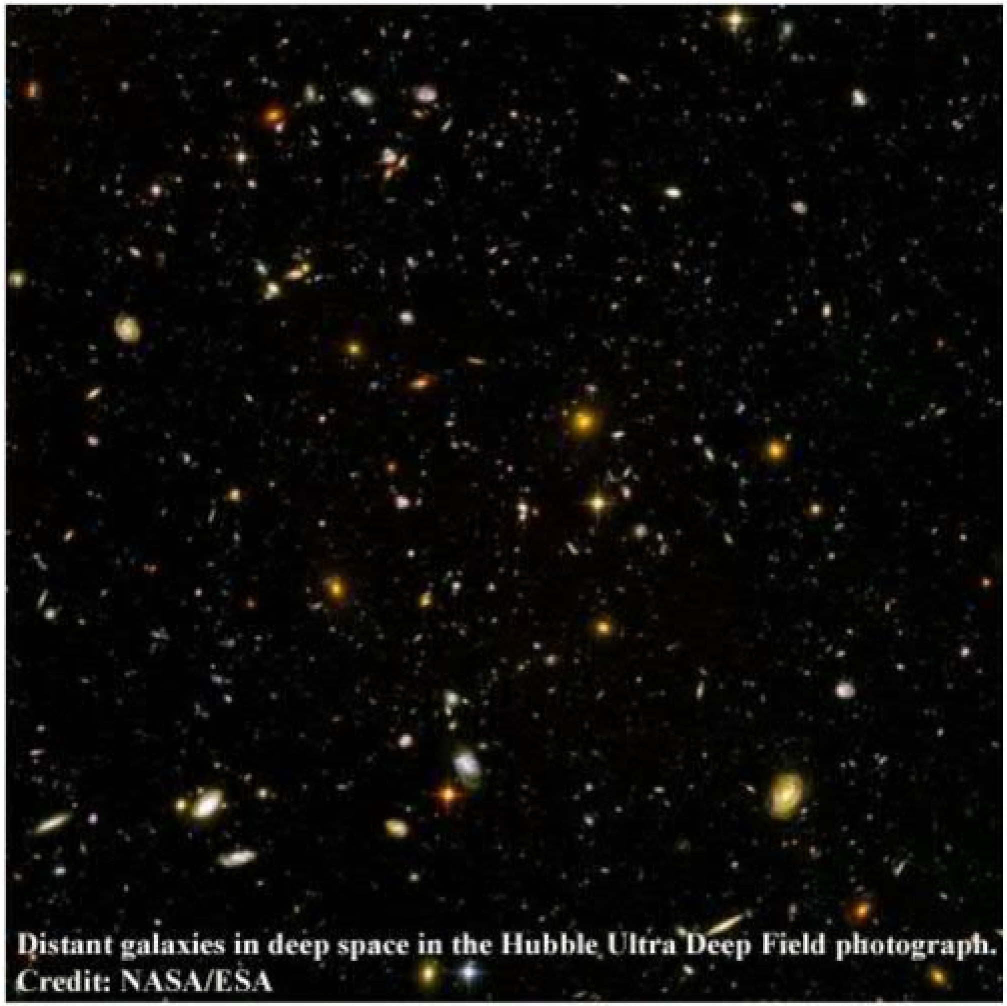
Fine steering mirror (FSM) with line-of-sight (LOS) stabilization < 7.3 marcsec (or mas).

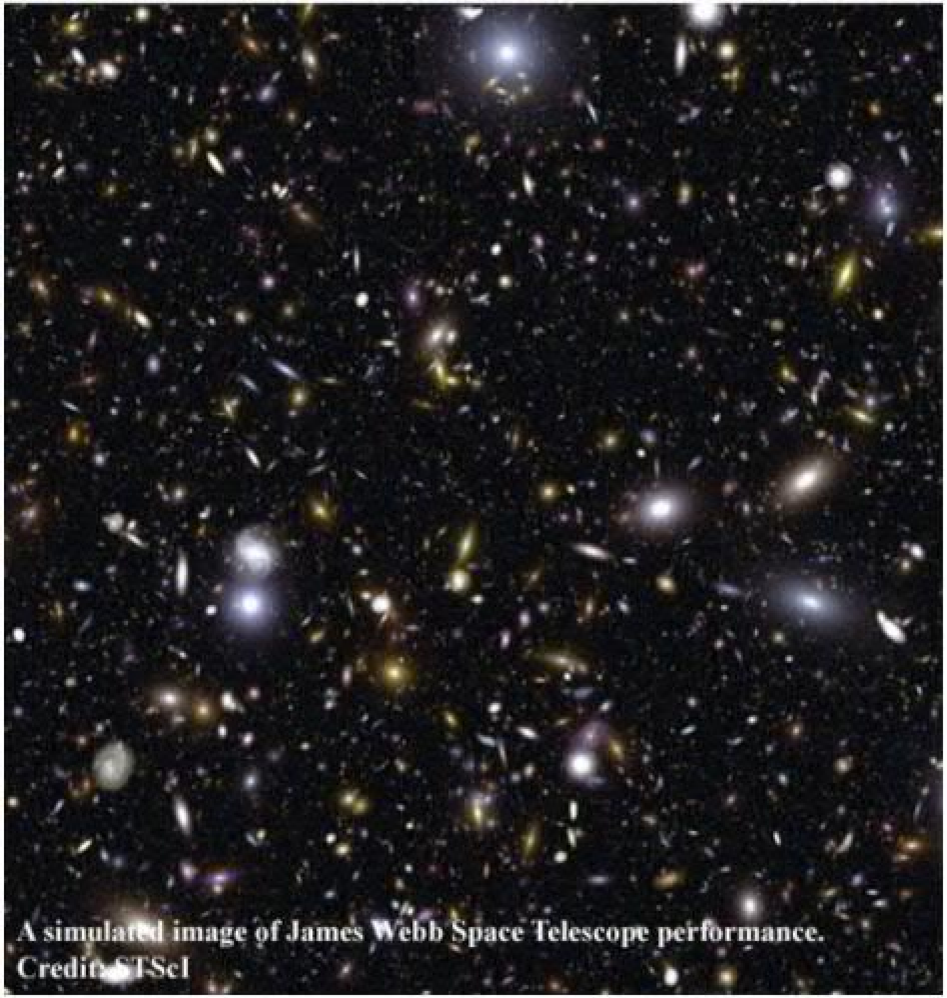
Detektorit

Webb will have two types of detector arrays (SCA): visible to near-infrared arrays with 2,048 x 2,048 pixels, and mid-infrared arrays with about 1,024 x 1,024 pixels. Several detectors will be built into mosaics to give a larger field of view. NIRCam, NIRSpec and FGS-NIRISS will use Mercury Cadmium Telluride (HgCdTe) detectors made by Teledyne Scientific & Imaging.

MIRI will employ arsenic doped silicon (Si:As) detectors produced by Raytheon.

Hubble vs. JWST

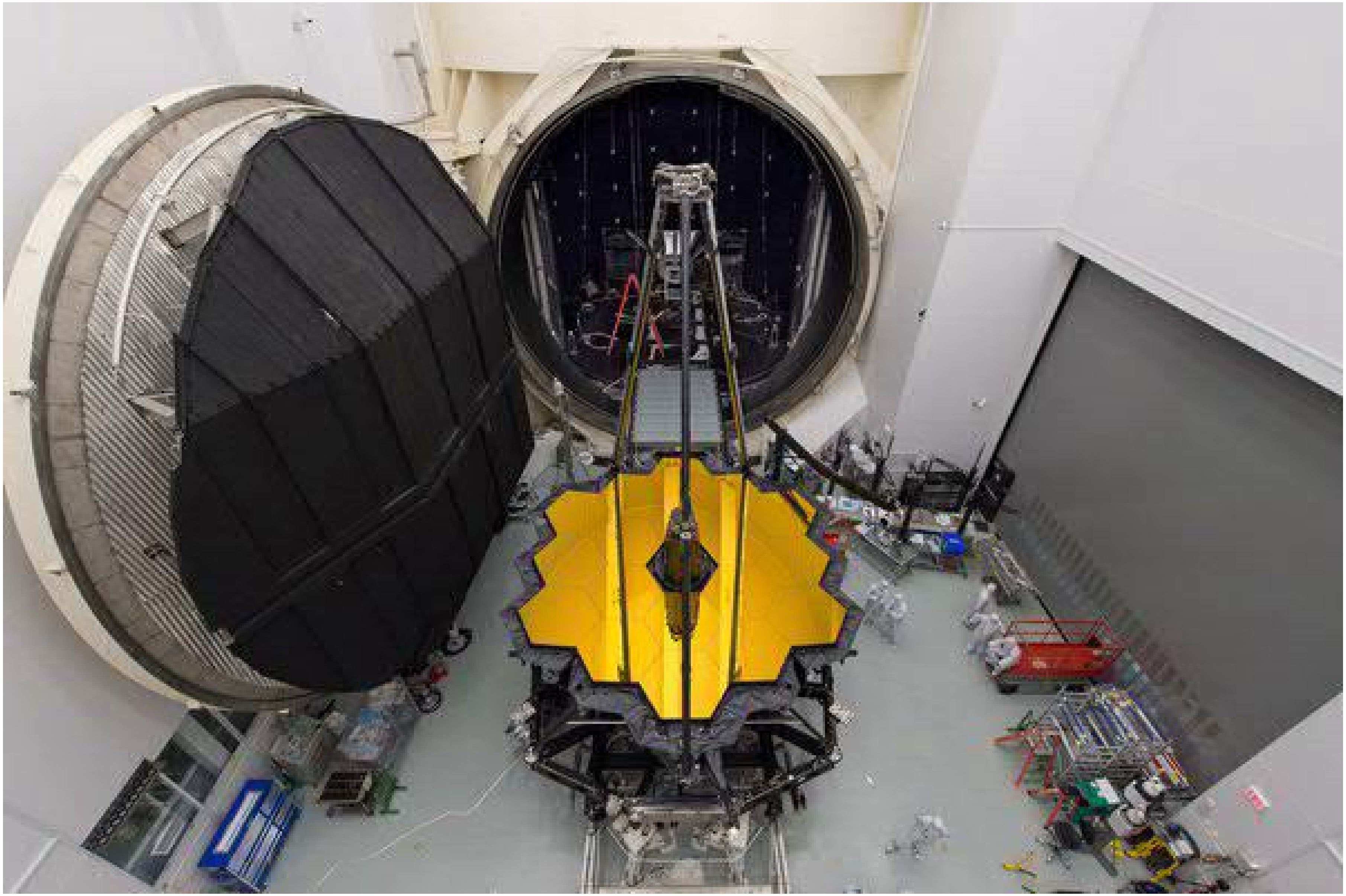




Webb's ground control system

Johns Hopkins University in Baltimore.

Rakentaminen, testaus



Suuntaus

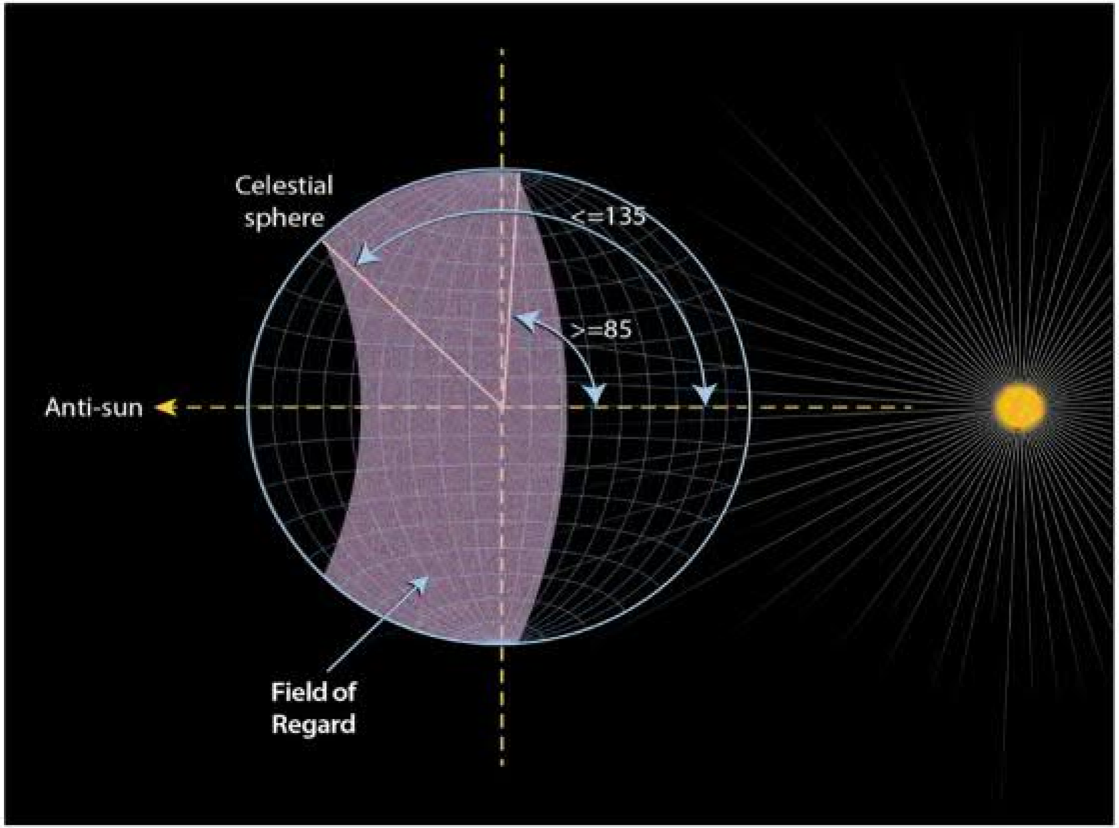
The FOR (Field of Regard) is the region of the sky in which observations can be conducted safely at a given time. For JWST, the FOR is a large annulus that moves with the position of the Sun and covers about 40% of the sky at any time. This coverage is lower than the ~80% that is accessible by Hubble. The FOR allows one to observe targets from 85º to 135º of the Sun. Most astronomical targets are observable for two periods separated by 6 months during each year. The length of the observing window varies with ecliptic latitude, and targets within 5º of the ecliptic poles are visible continuously, and provides 100% accessibility of the sky during a year period. The sunshield permits the observatory to pitch toward and away from the sun by approximately 68º, while still keeping the telescope in the shade. The continuous viewing zone is important for some science programs that involve monitoring throughout the year and will also be useful for calibration purposes. Outside the continuous viewing zone every area in the sky is observable for at least 100 days per year. The maximum time on target at a given orientation is 10 days

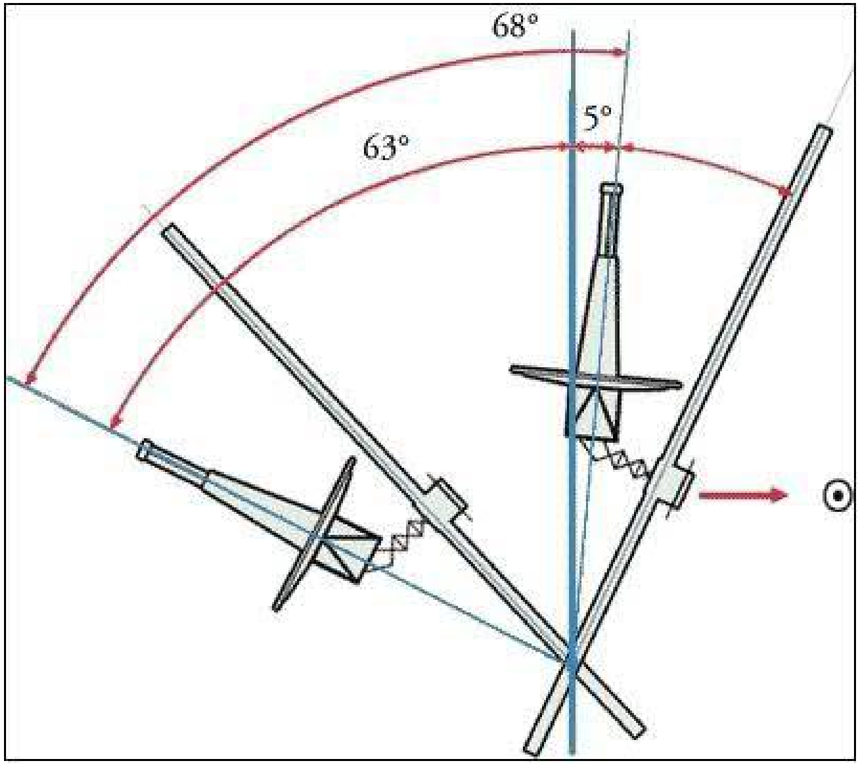
Suuntaus

The Hemispherical Resonator Gyroscope (HRG),

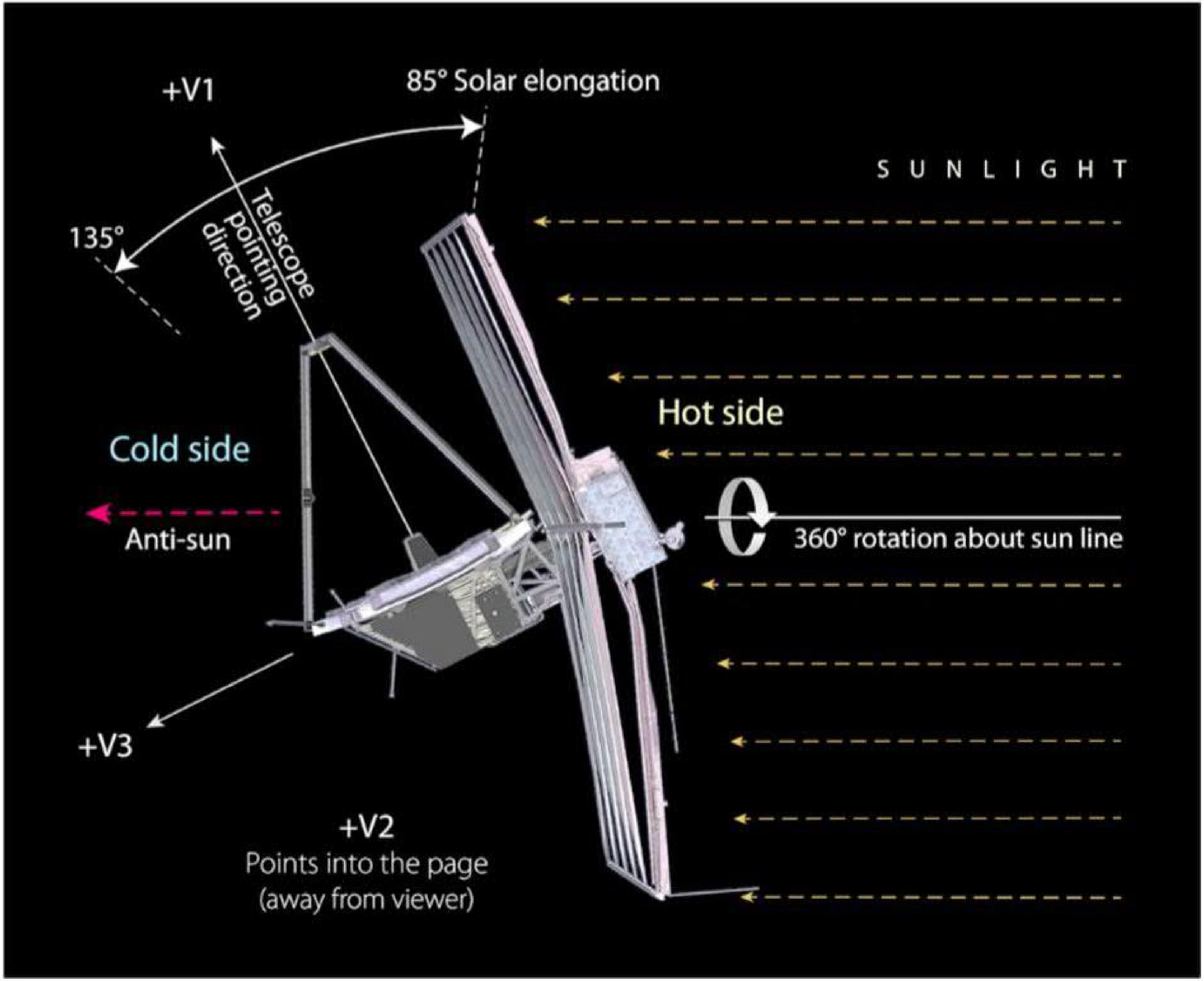
also called wine-glass gyroscope or mushroom gyro, is made using a thin solid-state hemispherical shell, anchored by a thick stem. This shell is driven to a flexural resonance by electrostatic forces generated by electrodes which are deposited directly onto separate fused-quartz structures that surround the shell. Gyroscopic effect is obtained from the inertial property of the flexural standing waves. HRG has no moving parts, is very compact, is extremely reliable and very accurate.

Suuntaus





Suuntaus


+V1
85° Solar elongation
SUNLIGHT
135°
Telescope pointing direction
Hot side
Cold side
Anti-sun
360° rotation about sun line
+V3
+V2
Points into the page
(away from viewer)

Suuntaus

The spacecraft bus has two star trackers, six reaction wheels. Control of the roll orientation about the telescope's optical axis is provided by input from the spacecraft's two star trackers. The star trackers each have a ~16° diameter FOV, projected on to a 512 × 512 pixel CCD detector.

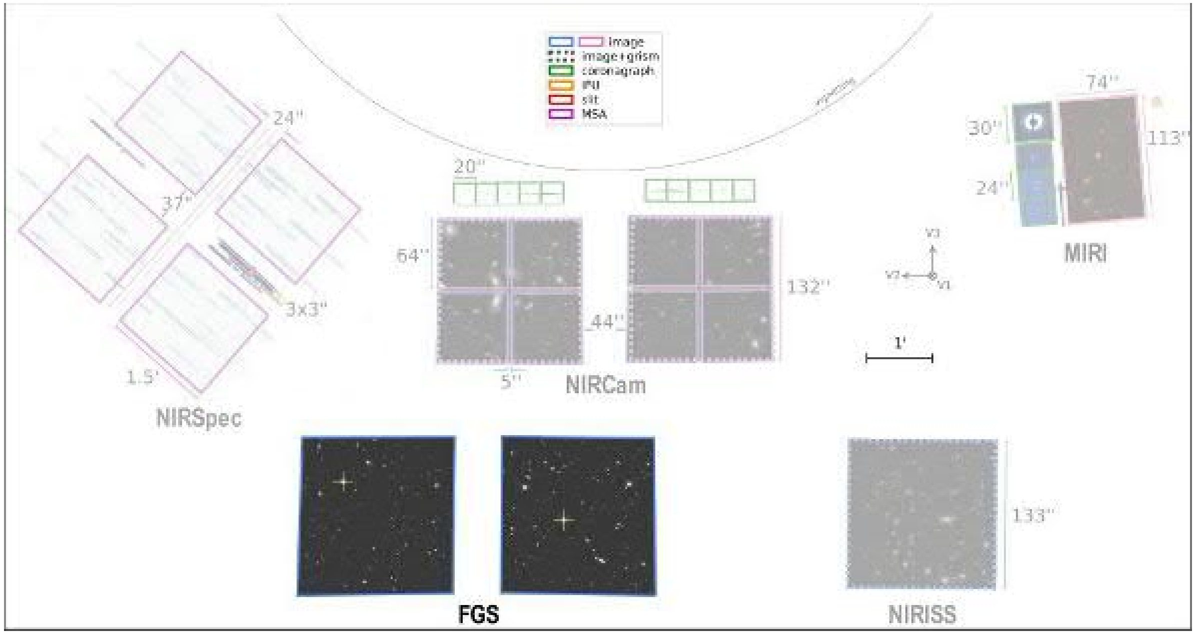
The JWST pointing control system will track objects moving at rates of up to 30 mas/sec (adequate to follow Mars and even most near-Earth objects).

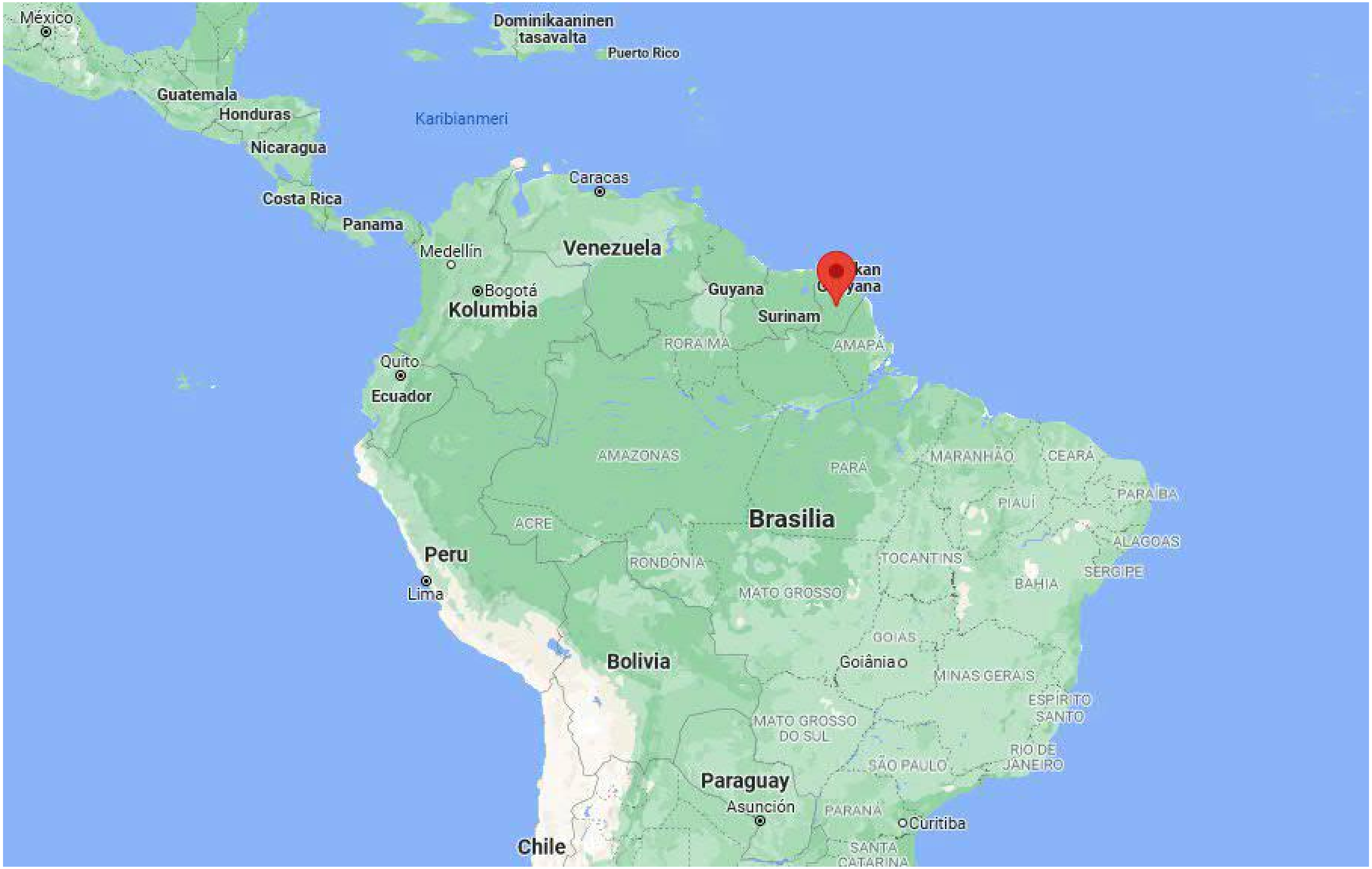
Suuntaus

Slew distance	Slew time (s)
0"–0.06"	0
>0.06" to 15"	20.48
>25" to 3°	109.312–825.6
>3° to 180°	521.216–3840.512

Suuntaus

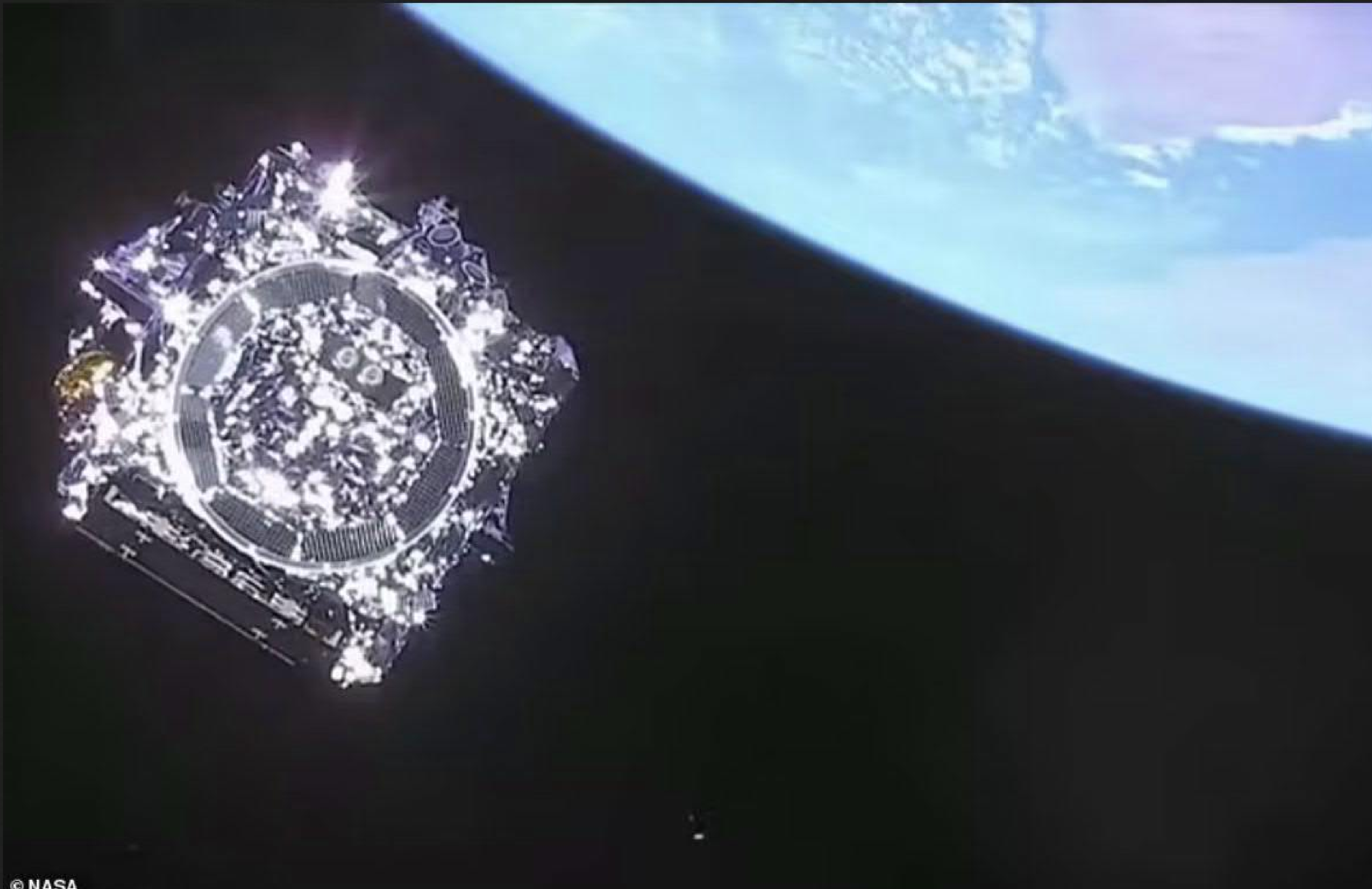
The FGS makes measurements of the guide star position in the plane of the sky and sends these to the ACS every 64 ms. Using the FGS data, the ACS determines the telescope pointing error to be removed, using a combination of the fine steering mirror (FSM) and the spacecraft's reaction wheels.
(ACS) = Attitude control subsystem

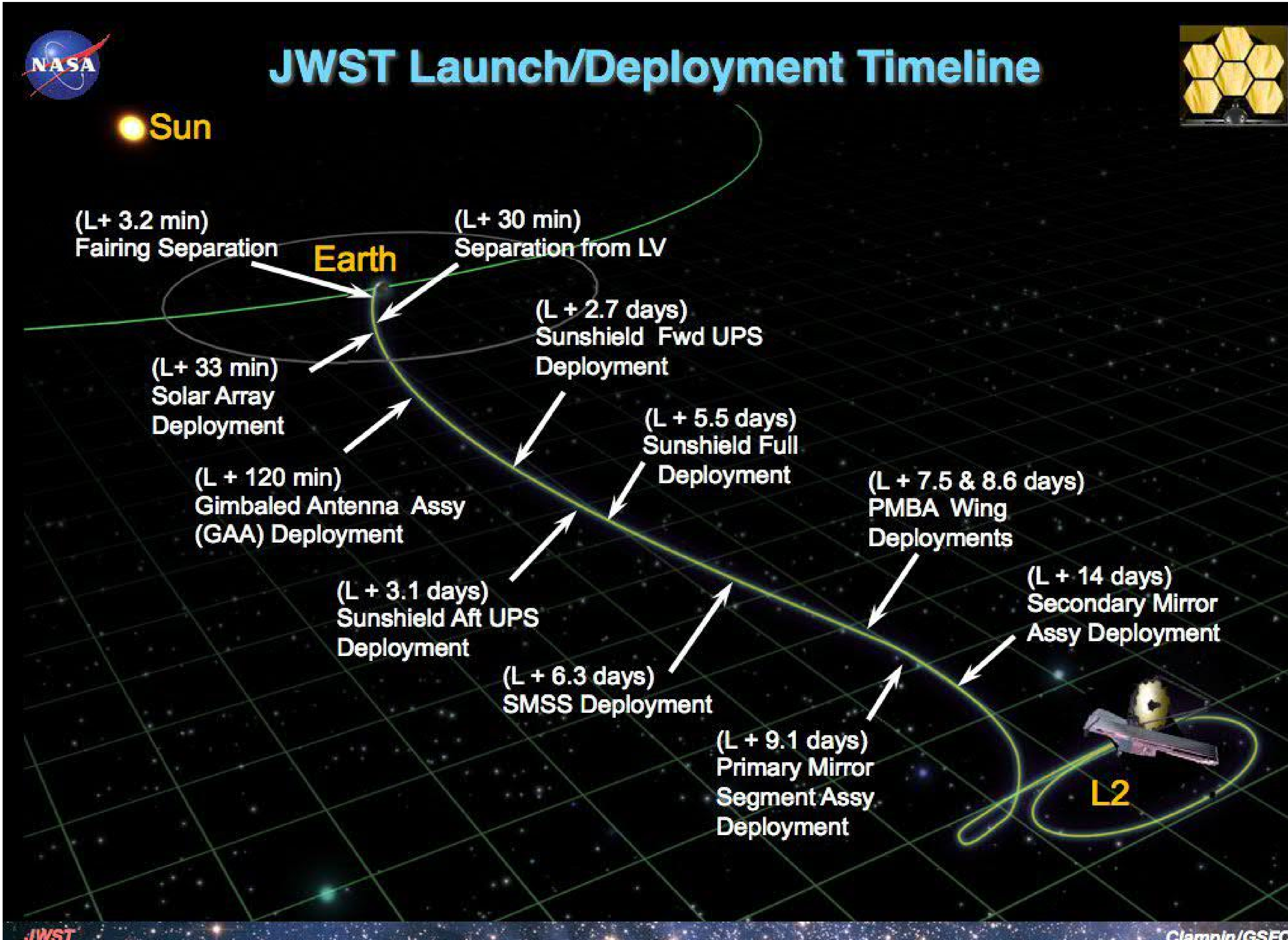




Ranskan Guayana, viralliselta nimeltään Guayanan merentakainen departementti, on Ranskan merentakainen departementti ja hallintoalue Etelä-Amerikassa, Karibianmeren rannalla Surinamen ja Brasilian välissä. Osana Ranskaa se on myös osa Euroopan unionia ja euroaluetta.


esa
ariane


© NASA


JWST Launch/Deployment Timeline
NASA
Sun
Earth
(L+ 3.2 min)
Fairing Separation
(L+ 30 min)
Separation from LV
(L+ 33 min)
Solar Array
Deployment
(L + 120 min)
Gimbaled Antenna Assy
(GAA) Deployment
(L + 2.7 days)
Sunshield Fwd UPS
Deployment
(L + 3.1 days)
Sunshield Aft UPS
Deployment
(L + 5.5 days)
Sunshield Full
Deployment
(L + 6.3 days)
SMSS Deployment
(L + 7.5 & 8.6 days)
PMBA Wing
Deployments
(L + 9.1 days)
Primary Mirror
Segment Assy
Deployment
(L + 14 days)
Secondary Mirror
Assy Deployment
L2
JWST
Clampin/GSFC

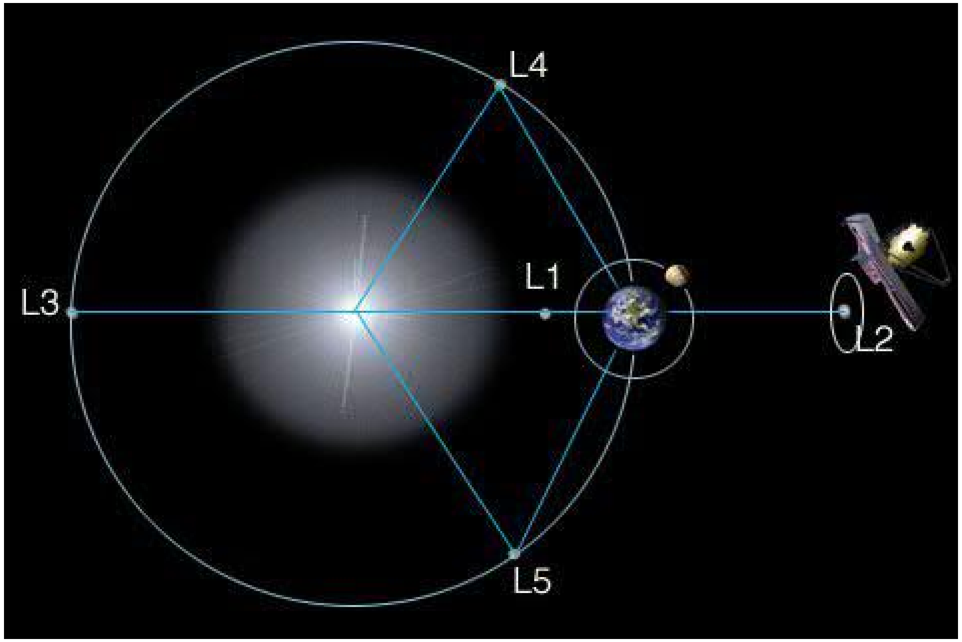
L2

The distance of JWST from the L2 point varies between 250,000 to 832,000 km. The period of the orbit is about six months. The maximum excursion above or below the ecliptic plane is 520,000 km. The maximum distance from the Earth is 1.8 million km, and the maximum Earth-Sun angle is <33°.

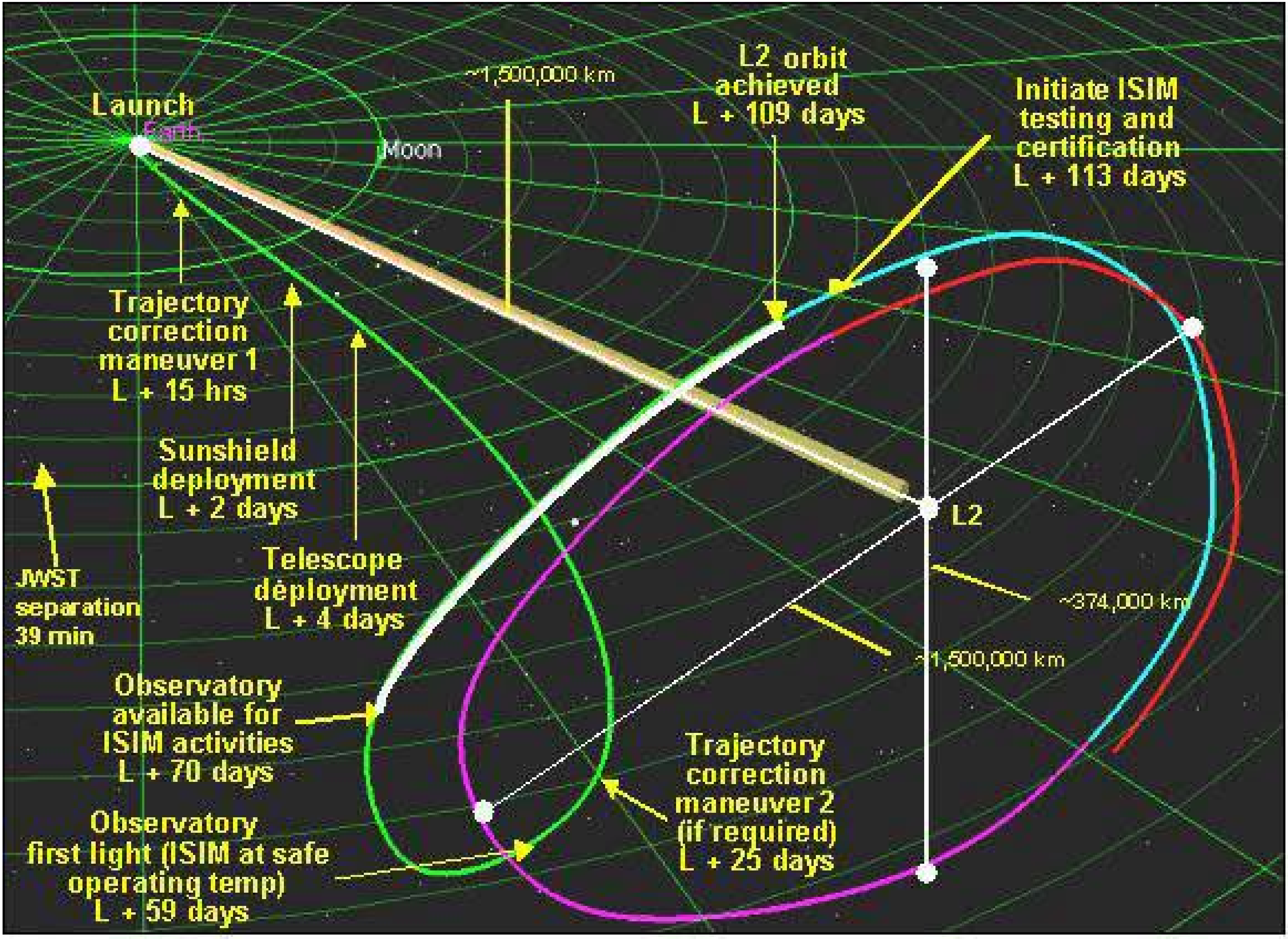
L2 is a saddle point in the gravitational potential of the Solar System. Because saddle points are not stable, JWST will need to regularly fire onboard thrusters to maintain its orbit around L2. These station-keeping maneuvers will be performed every 21 days.

L2

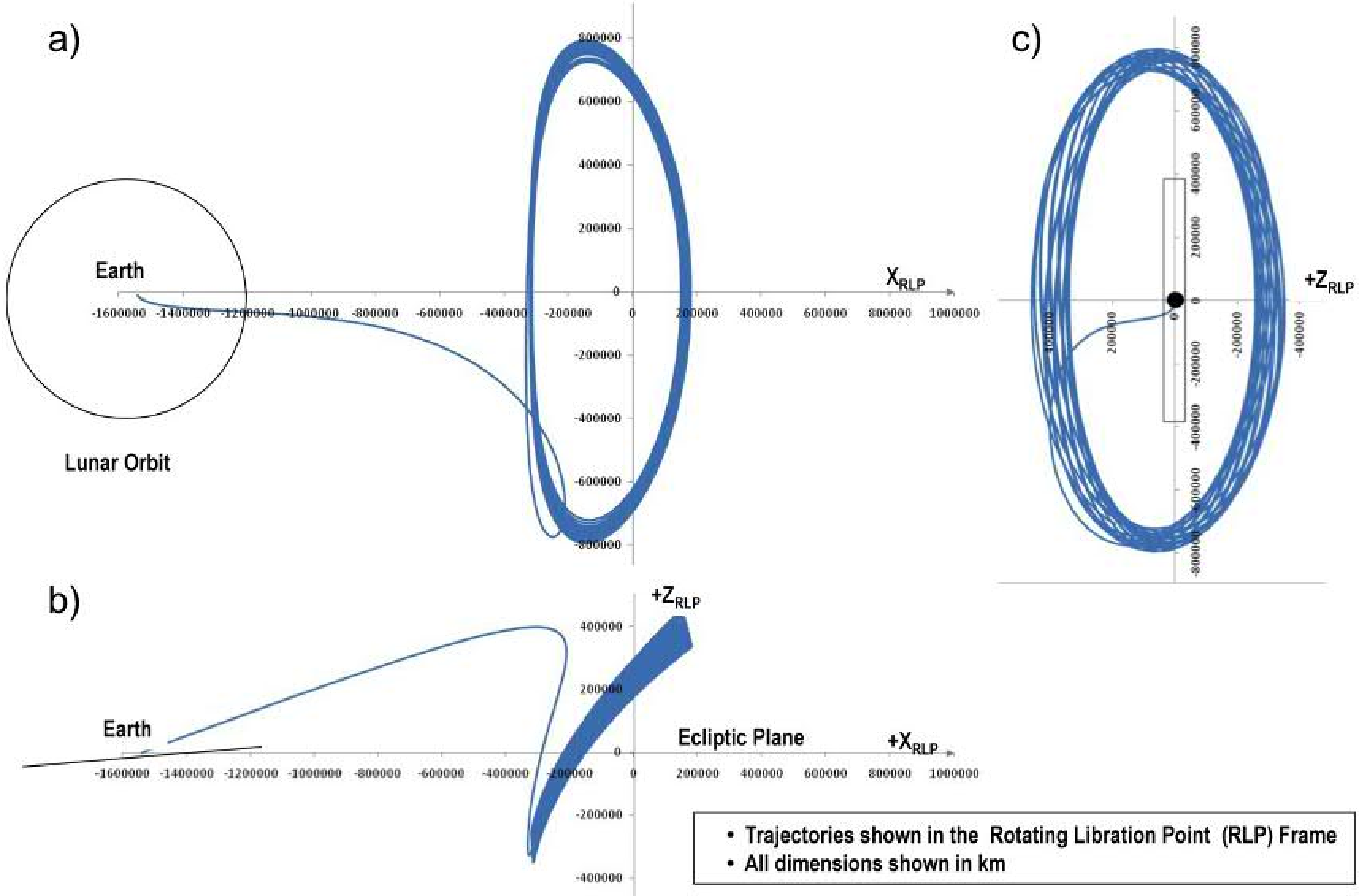
This has been a popular spot for several other space telescopes, including the Herschel Space Telescope and the Planck Space Observatory.



https://www.wired.com/2011/08/james-webb-space-telescope-and-l2-orbits/



Launch
Earth
Moon
~1,500,000 km
L2 orbit achieved L + 109 days
Initiate ISIM testing and certification L + 113 days
Trajectory correction maneuver 1 L + 15 hrs
Sunshield deployment L + 2 days
Telescope deployment L + 4 days
JWST separation 39 min
L2
~374,000 km
~1,500,000 km
Observatory available for ISIM activities L + 70 days
Observatory first light (ISIM at safe operating temp) L + 59 days
Trajectory correction maneuver 2 (if required) L + 25 days


a)
Earth
Lunar Orbit
X_{RLP}
800000
600000
400000
200000
0
-200000
-400000
-600000
-800000
-1600000
-1400000
-1200000
-1000000
-800000
-600000
-400000
-200000
0
200000
400000
600000
800000
1000000
b)
$+Z_{RLP}$
Earth
Ecliptic Plane
$+X_{RLP}$
400000
200000
0
-200000
-400000
c)
$+Z_{RLP}$
• Trajectories shown in the Rotating Libration Point (RLP) Frame
• All dimensions shown in km

Rakentaminen, aikataulu, hinta

… It is currently planned to be launched in 2013 from French Guiana aboard an Ariane 5 launch vehicle...

... It will be the closest simulation of the space environment before the actual launch, which may not occur until 2018...

… James Webb Space Telescope, scheduled to launch in 2018...

… a new launch date of October 2018...

… in a launch window between March and June 2019...

… the launch window is now targeted for about May 2020...

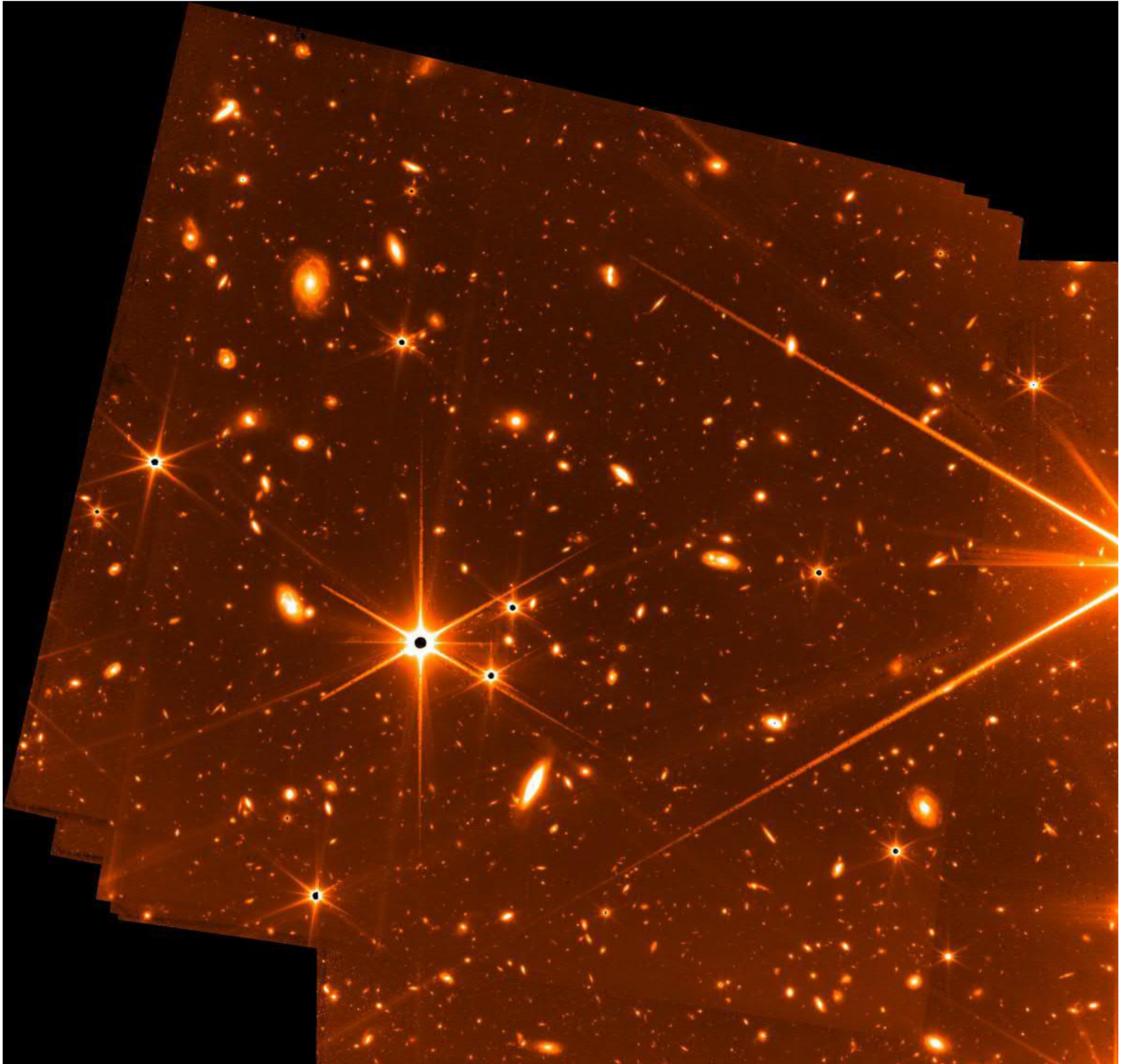
… Uusi ajankohta on näillä näkymin maaliskuu 2021.

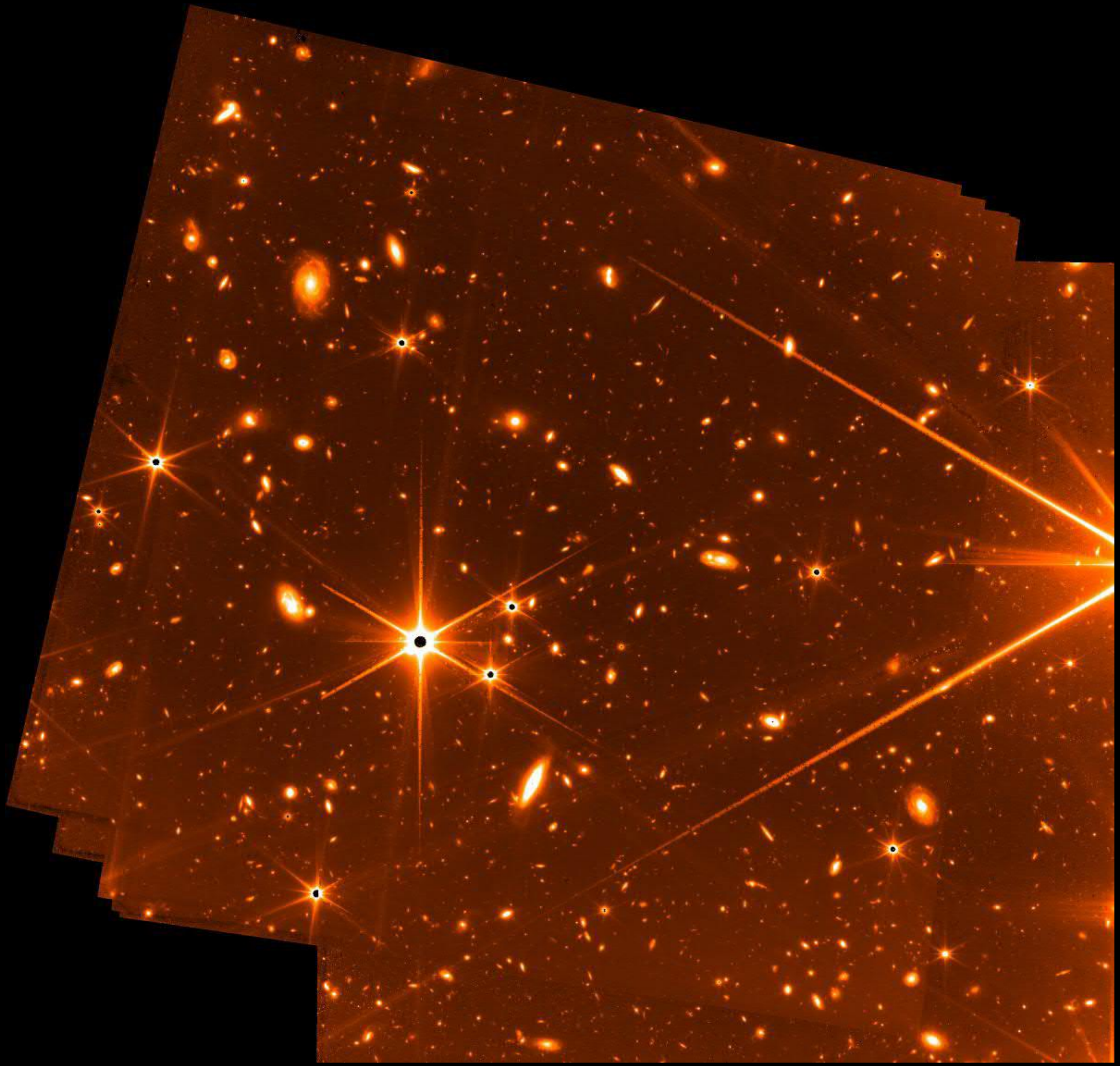
… NASA's Webb telescope delayed, may exceed $8 billion price tag.

… more money from Congress...

The Henry Draper Catalogue (HD) is an astronomical star catalogue published between 1918 and 1924, giving spectroscopic classifications for 225,300 stars

2.2.2022 ensimmäinen kuva ennen peilien suuntausta

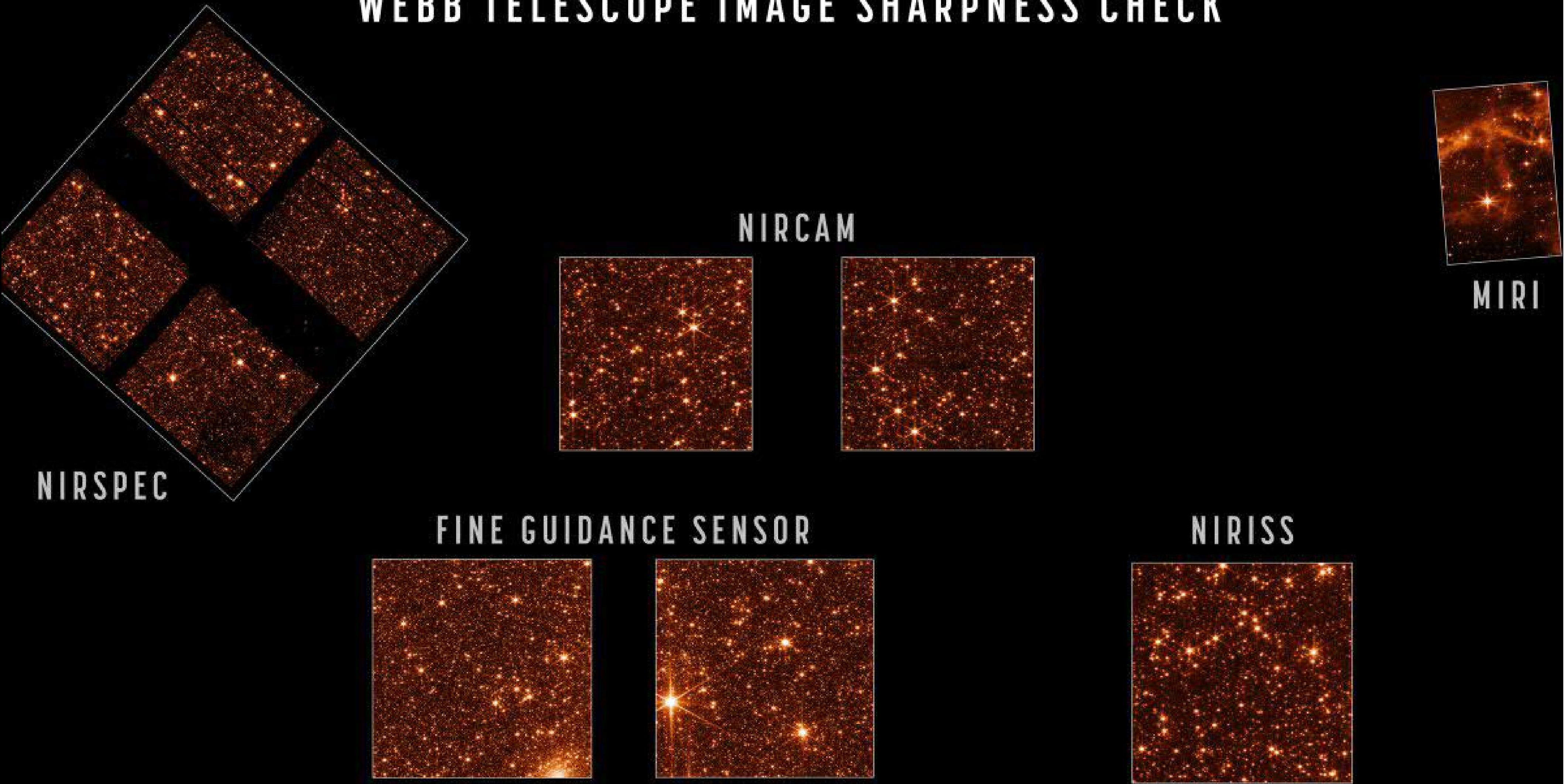


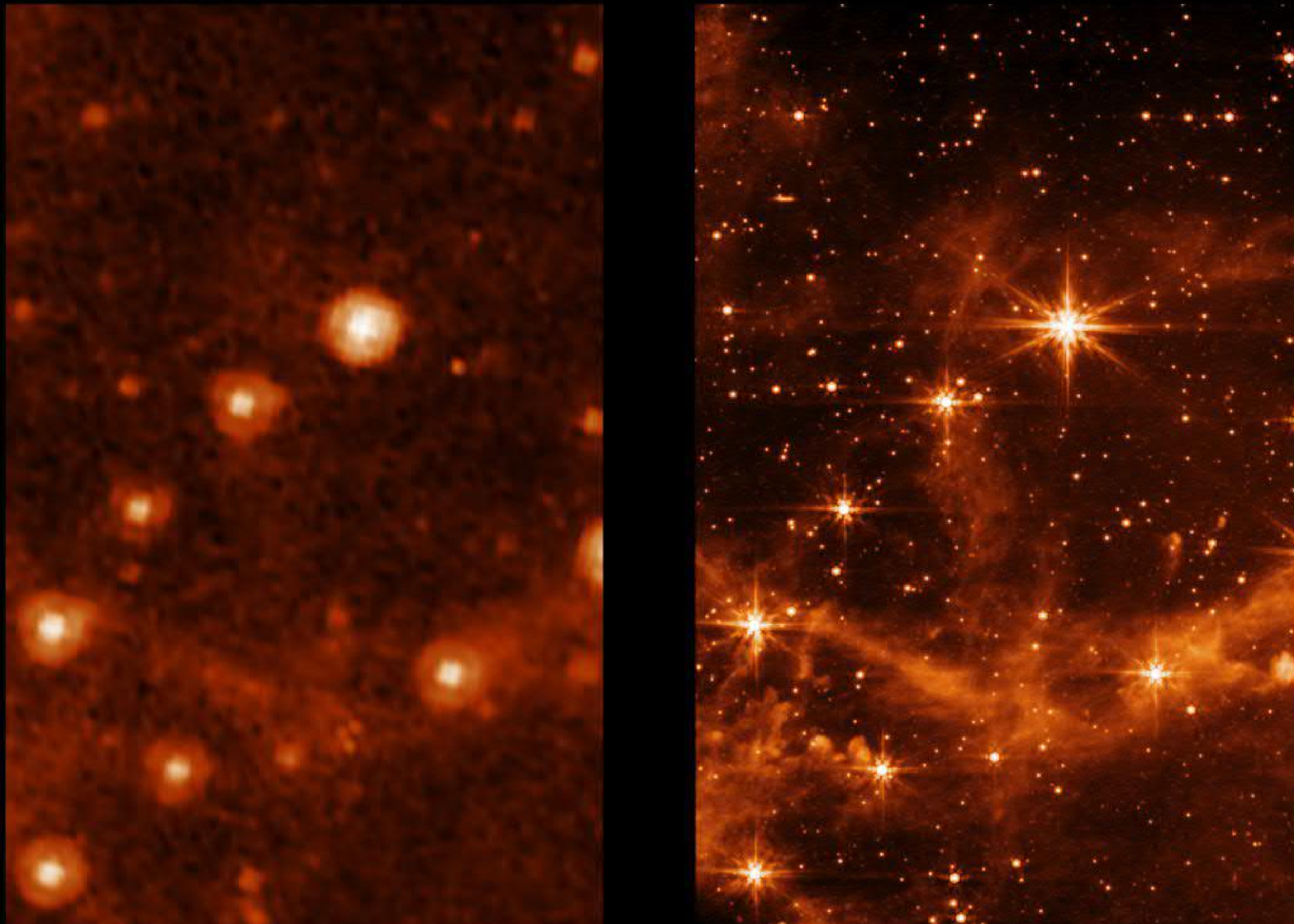


72 exposures over 32 hours. In this image, the FGS image was acquired in parallel with NIRCam imaging of the star HD147980 over a period of 8 days at the beginning of May.


TELESCOPE ALIGNMENT EVALUATION IMAGE

WEBB TELESCOPE IMAGE SHARPNESS CHECK

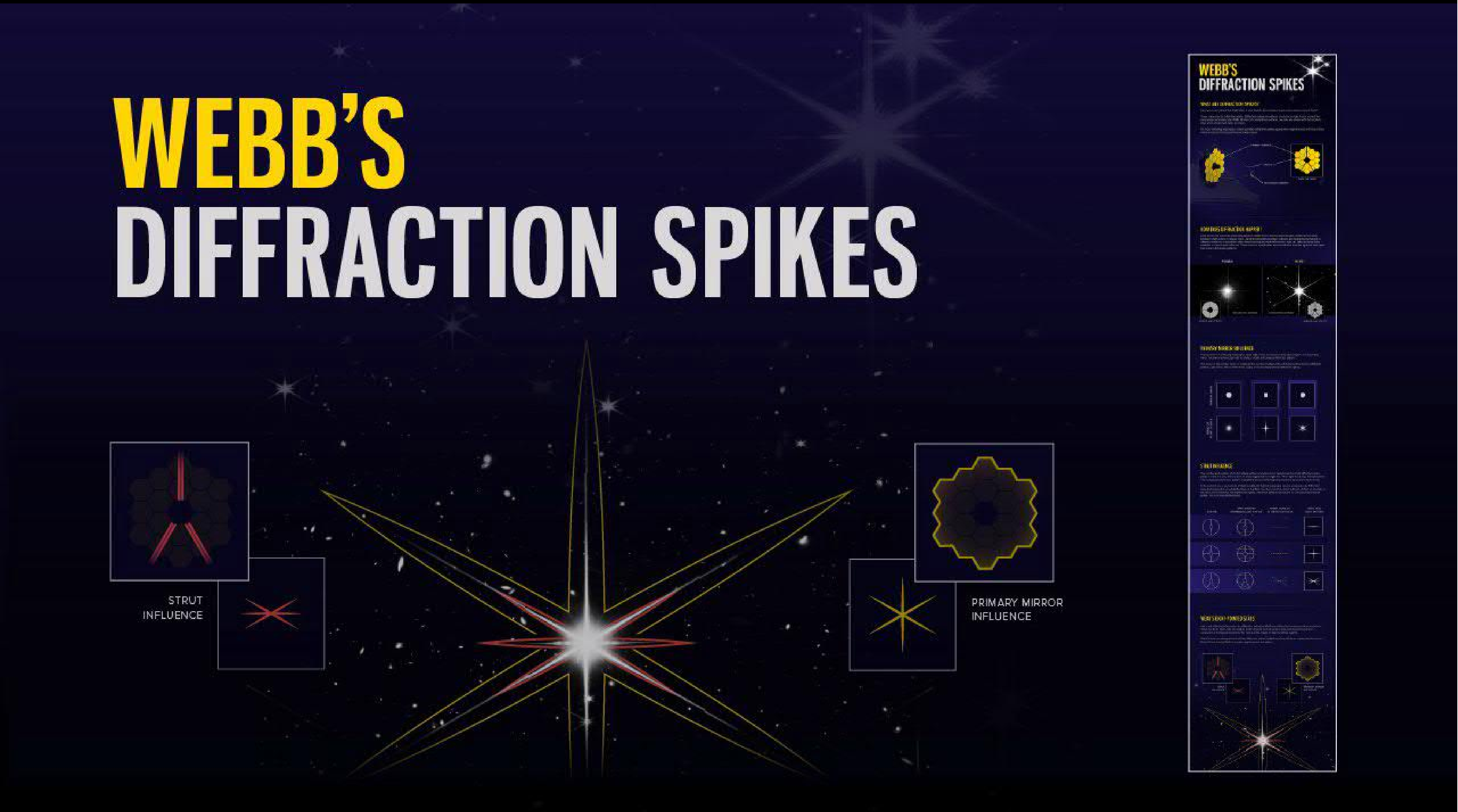




SPITZER IRAC 8.0μ

WEBB MIRI 7.7μ

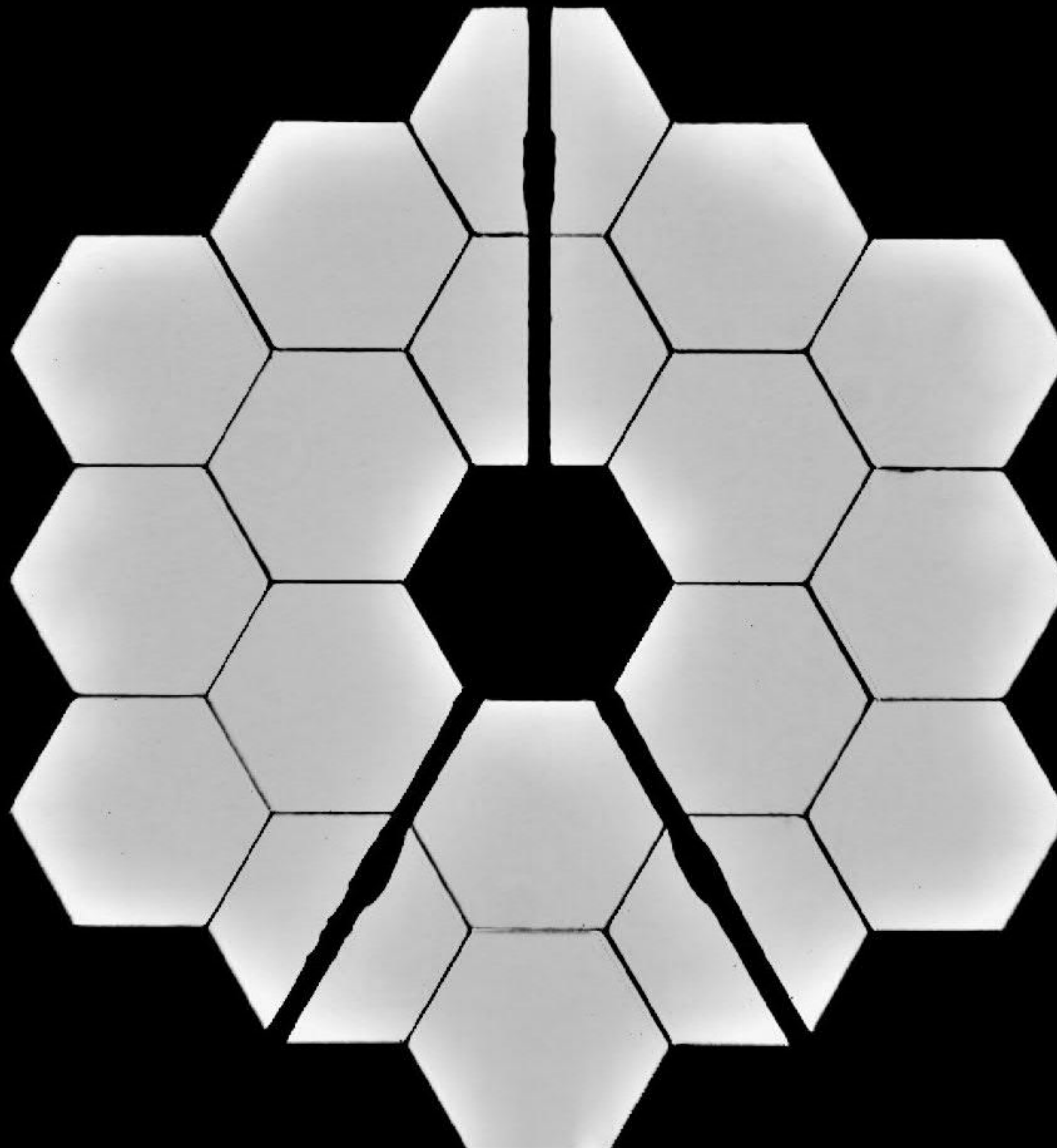
James Webb Space Telescope's MIRI instrument captures an incredible, sharp photo of Large Magellanic Cloud. Toukokuu 2022.

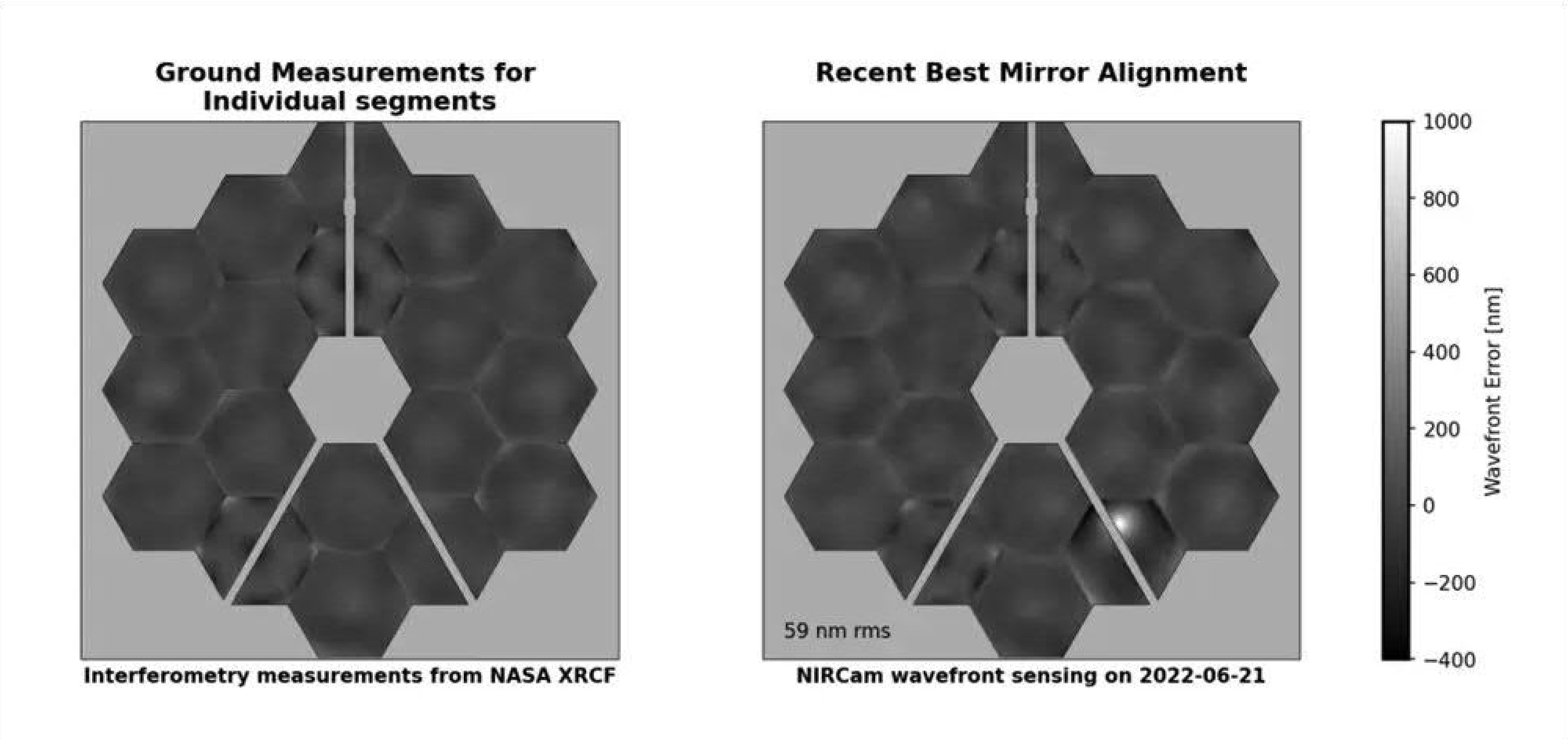


About This Image

This illustration demonstrates the science behind Webb's diffraction spike patterns, showing how diffraction spikes happen, the influence of the primary mirror and struts, and the contributions of each to Webb's diffraction spikes.

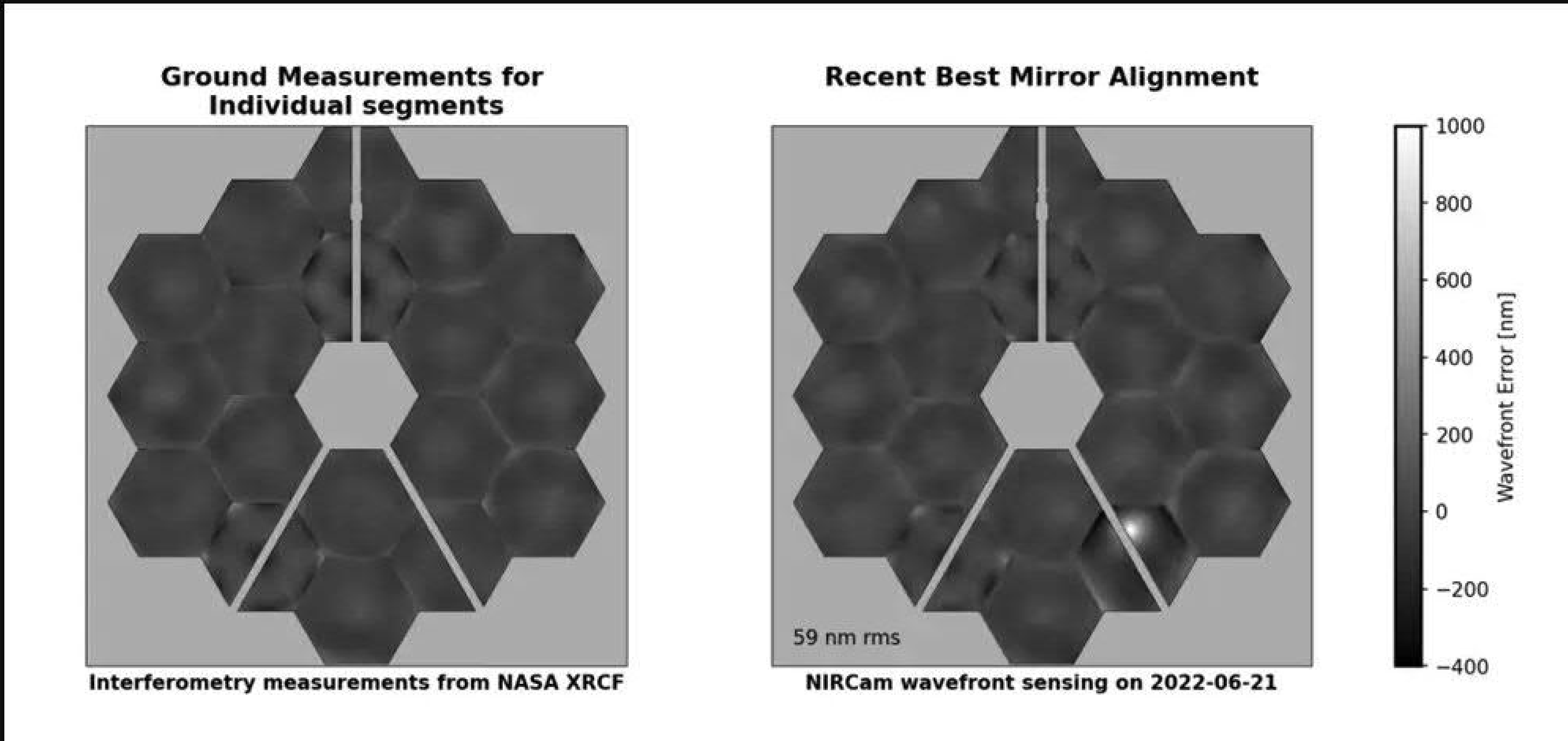
NIRCAM ALIGNMENT SELFIE





23.-25. toukokuuta

For now, engineers are keeping an eye on potential future dust-generating events such as in 2023 and 2024, when Webb is expected to fly through particles left behind by Halley's Comet.



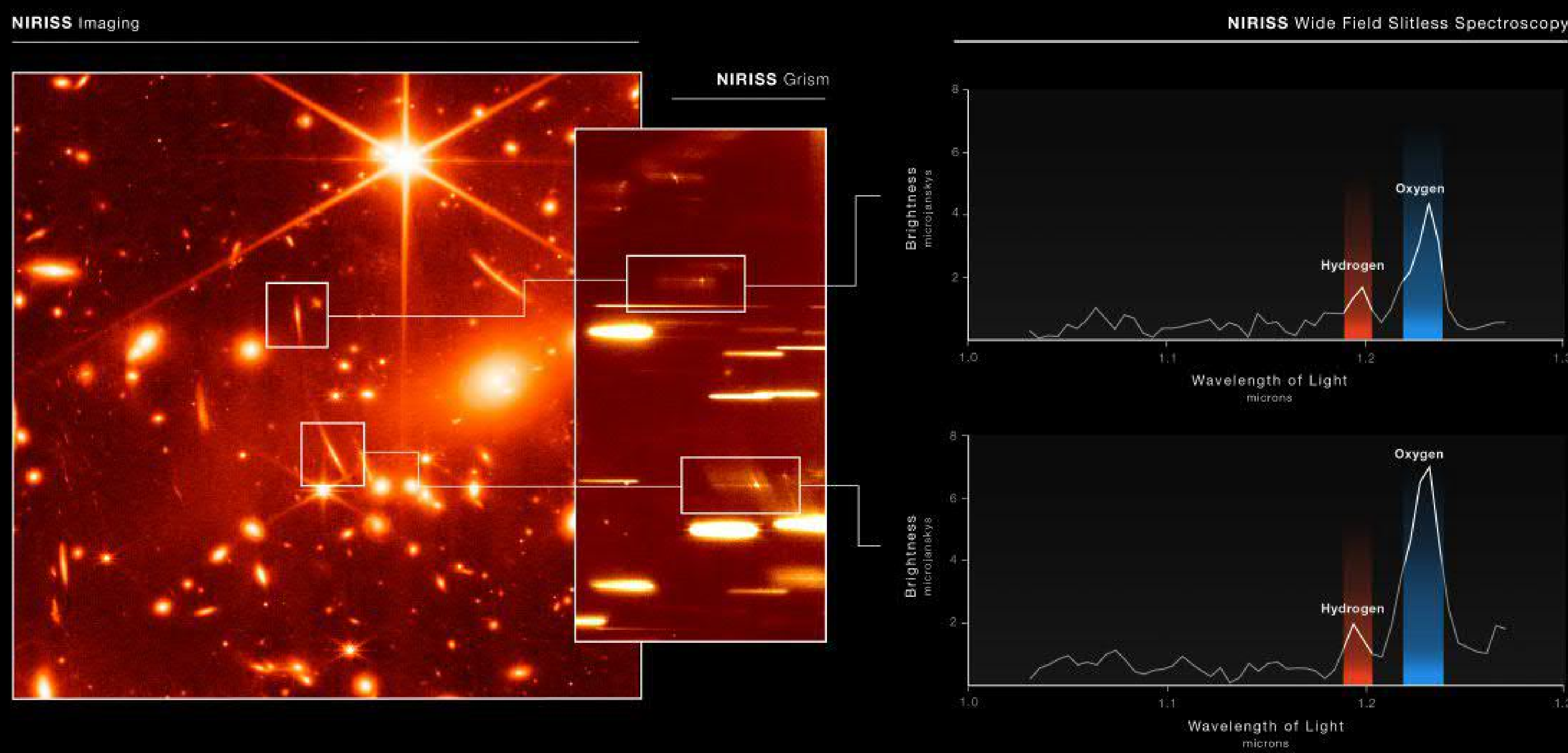
At the beginning the mission, the C3 segment had a wavefront error of 56 nanometers rms, a level similar to the main mirror's other 17 segments. The impact increased C3's wavefront error to 258 nm rms.

Spacecraft engineers can change the position and curvature of each segment and in this way were able to reduce the error to 178 nm rms.

This deep field, taken by Webb's Near-Infrared Camera (NIRCam), is a composite made from images at different wavelengths, totaling 12.5 hours – achieving depths at infrared wavelengths beyond the Hubble Space Telescope's deepest fields, which took weeks.

GALAXY CLUSTER SMACS 0723

WEBB SPECTRA CONFIRM TWO ARCS ARE THE SAME GALAXY



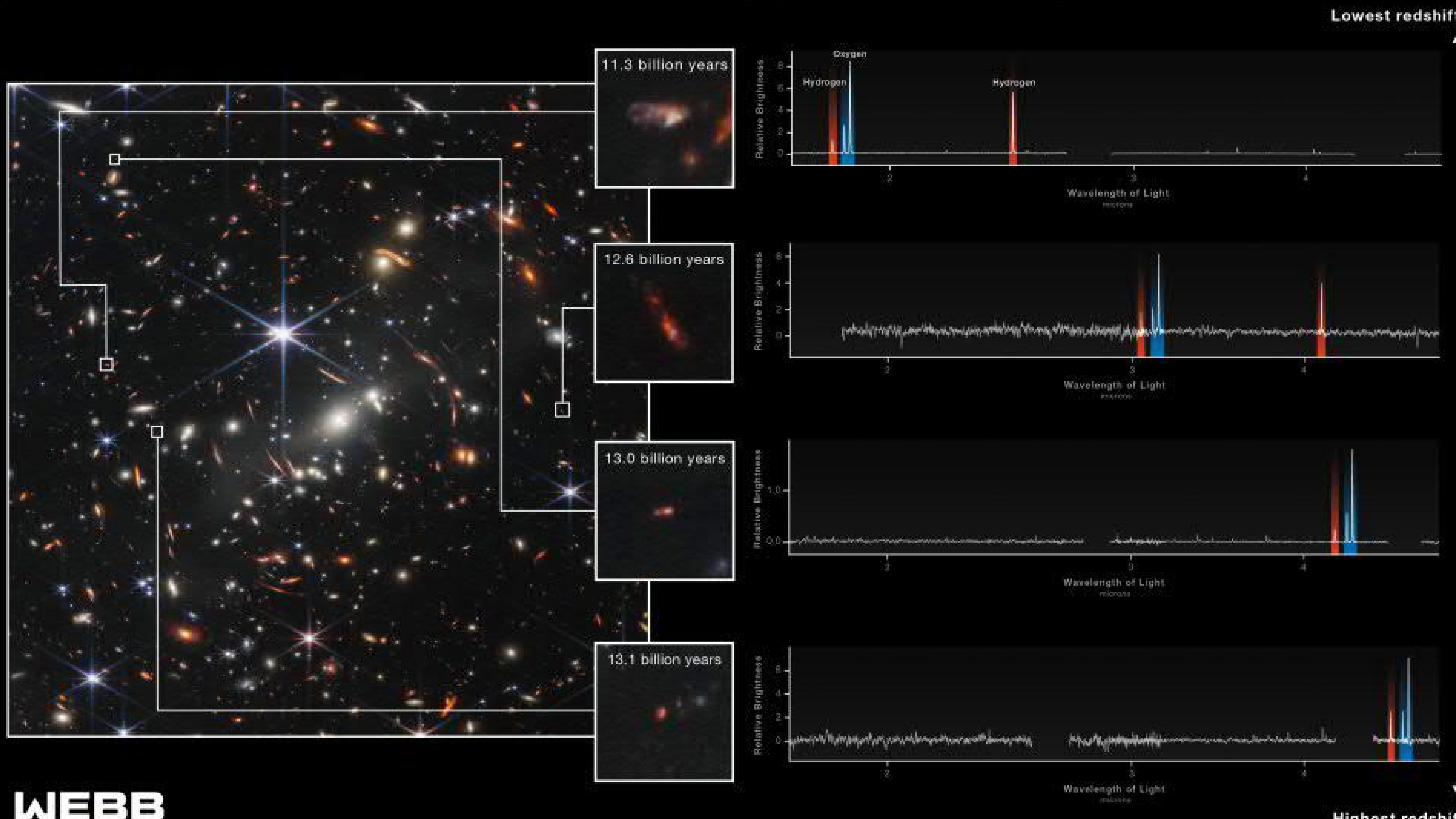
WEBB SPACE TELESCOPE

GALAXY CLUSTER SMACS 0723

WEBB SPECTRA IDENTIFY GALAXIES IN THE VERY EARLY UNIVERSE

NIRCam Imaging

NIRSpec Microshutter Array Spectroscopy



WEBB
SPACE TELESCOPE

Kohde Pegasus-tähdistössä.

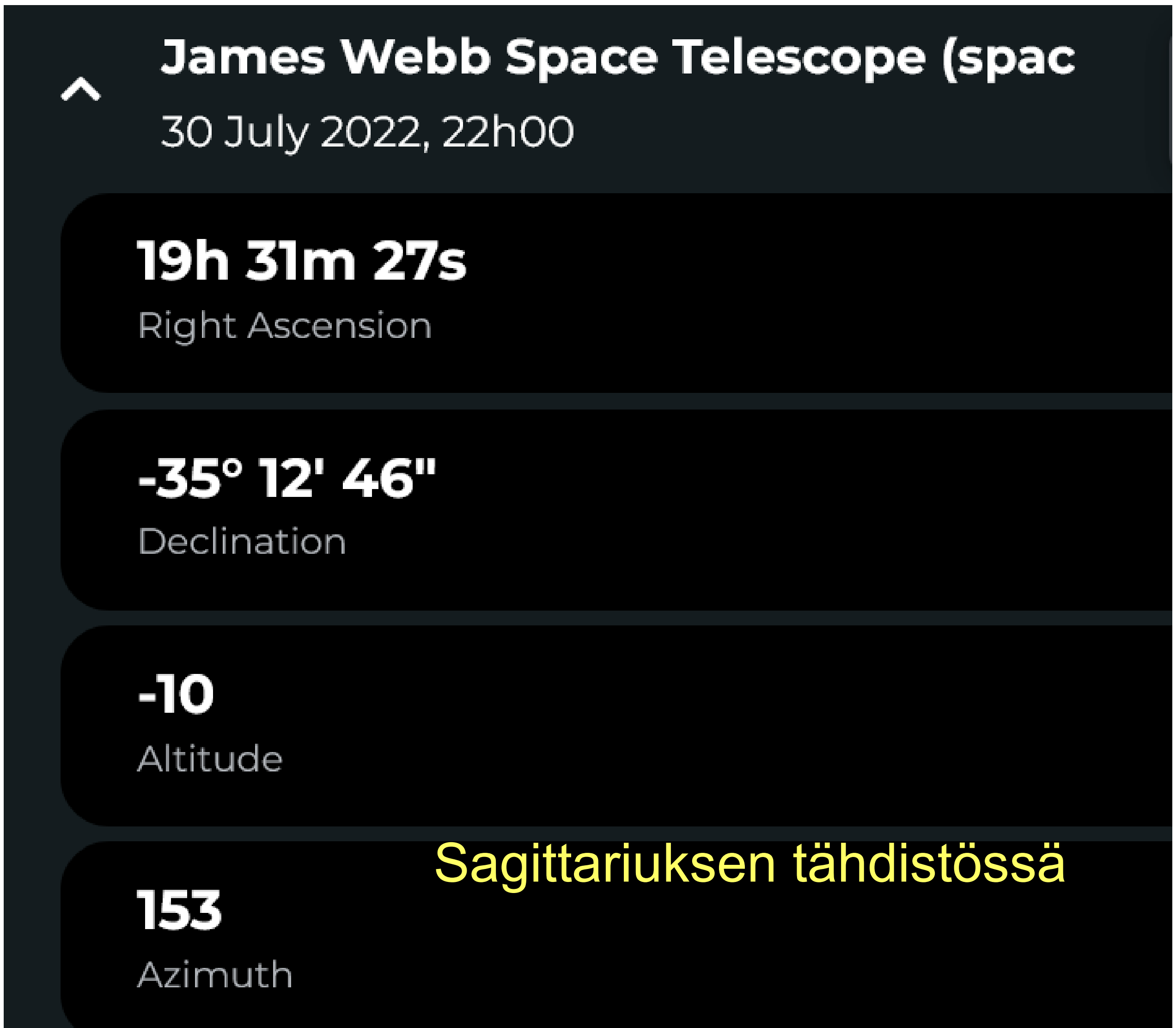
An enormous mosaic of Stephan’s Quintet is the largest image to date from NASA’s James Webb Space Telescope, covering about one-fifth of the Moon’s diameter. It contains over 150 million pixels and is constructed from almost 1,000 separate image files. The visual grouping of five galaxies was captured by Webb’s Near-Infrared Camera (NIRCam) and Mid-Infrared Instrument (MIRI).

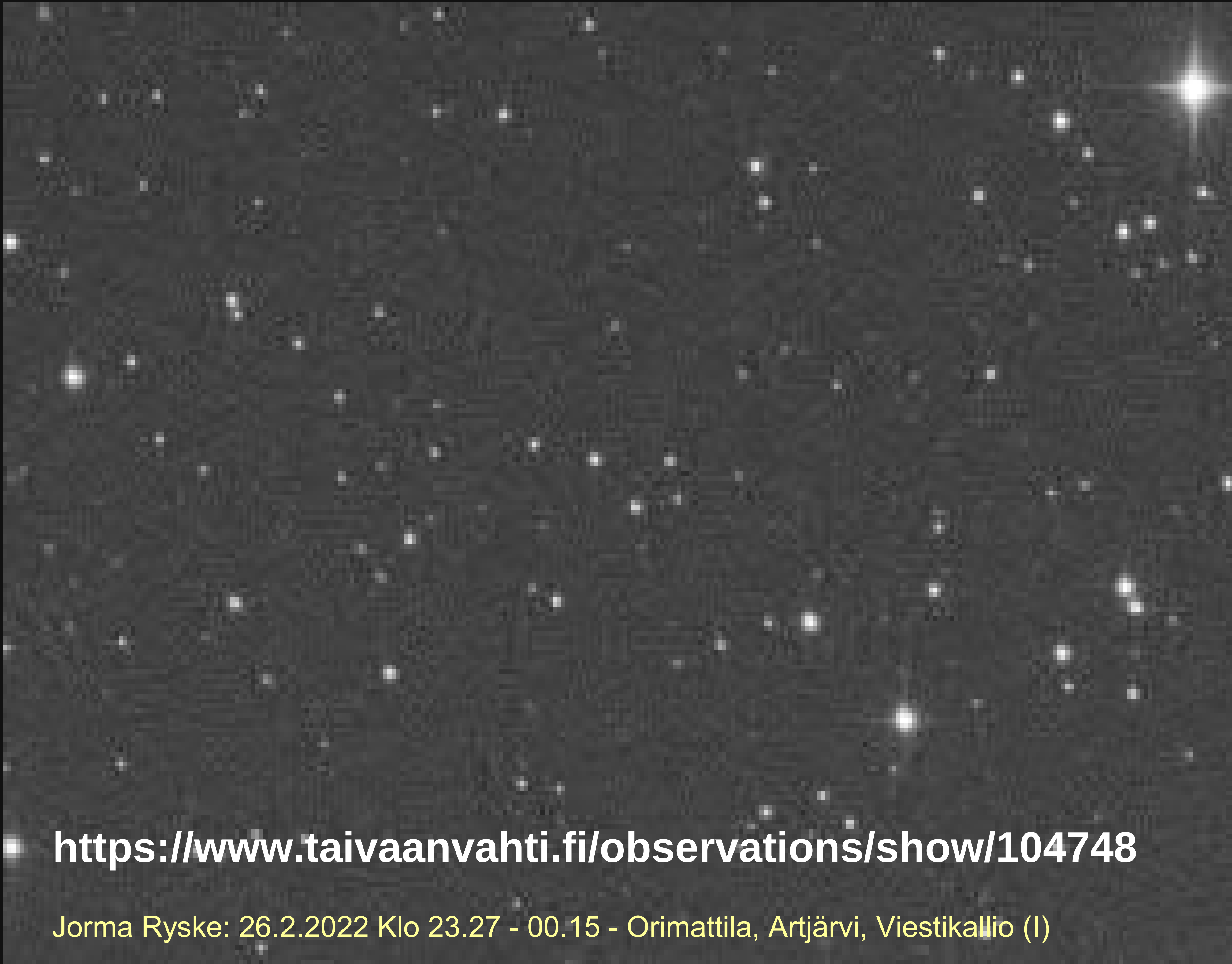
With its powerful, infrared vision and extremely high spatial resolution, Webb shows never-before-seen details in this galaxy group. Sparkling clusters of millions of young stars and starburst regions of fresh star birth grace the image. Sweeping tails of gas, dust and stars are being pulled from several of the galaxies due to gravitational interactions. Most dramatically, Webb’s MIRI instrument captures huge shock waves as one of the galaxies, NGC 7318B, smashes through the cluster. These regions surrounding the central pair of galaxies are shown in the colors red and gold.

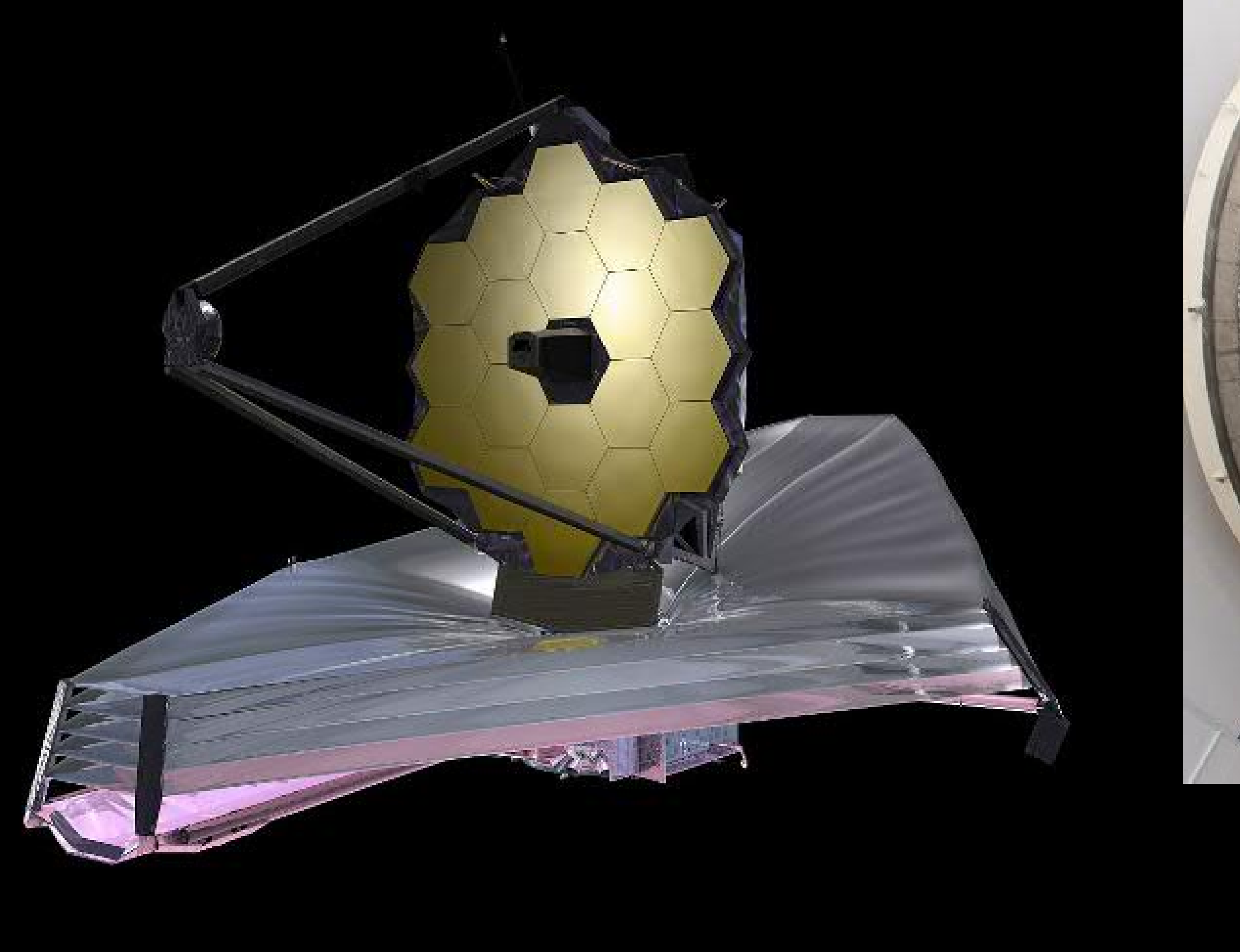
Jupiter and its moon Europa, left, are seen through the James Webb Space Telescope’s NIRCam instrument 2.12 micron filter. (Image credit: NASA, ESA, CSA, and B. Holler and J. Stansberry (STScI))

Missä Webb?

https://unistellaroptics.com/ephemeris/




https://www.taivaanvahti.fi/observations/show/104748
Jorma Ryske: 26.2.2022 Klo 23.27 - 00.15 - Orimattila, Artjärvi, Viestikallio (I)



Päivitystä

James Webb -teleskooppi

Hannu Määttänen

30.7.2022