Modern Astrophysics

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JAMES WEBB SPACE TELESCOPE

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aka Doraemon

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aka Nobita

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aka Shizuka

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History

- 1989 - 2002: Planning and early design by NASA and STScI
- 2004 - 2010: Construction started
- 2011 - 2016: Assembly
- 2017 - 2021: Cryogenic test, thermal vacuum test, communication test, simulating lauch condition test, environmental test, etc.
- 25/12/2021: JWST is successfully launched.
- 12/7/2022: First full-color images of the universe are released.

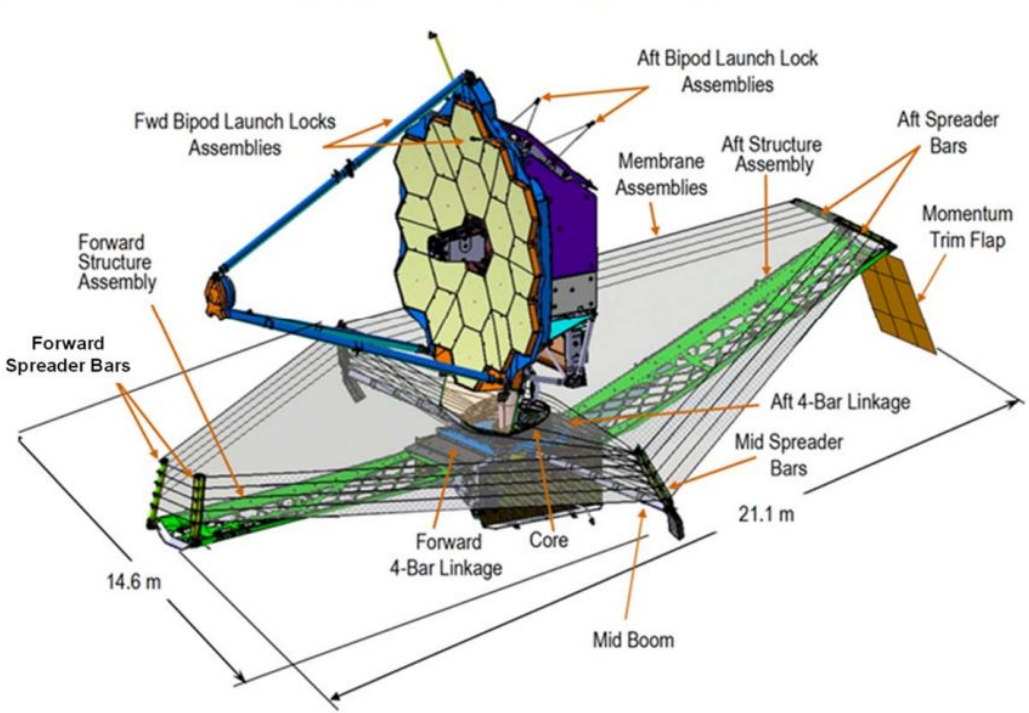
https://webbtelescope.org/news/milestones/mission-timeline

Structure

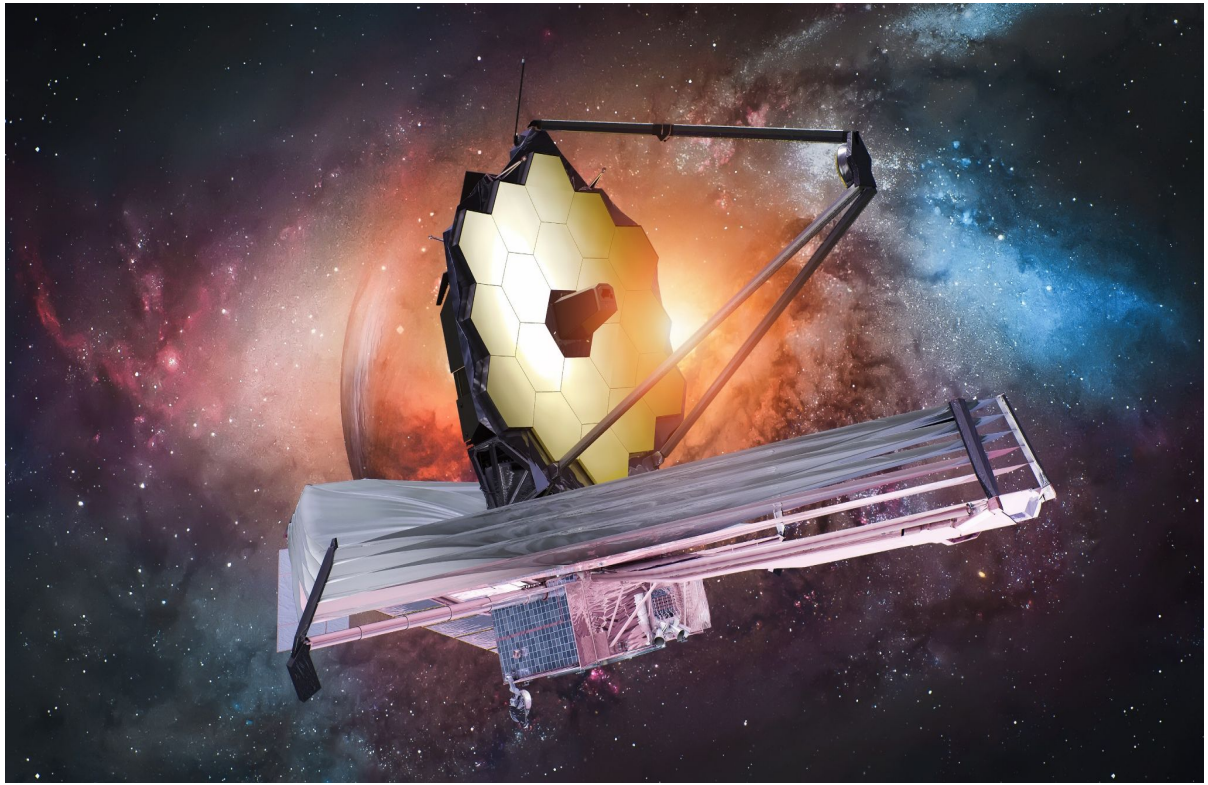
https://science.nasa.gov/mission/webb/webb-3d/

3 main parts

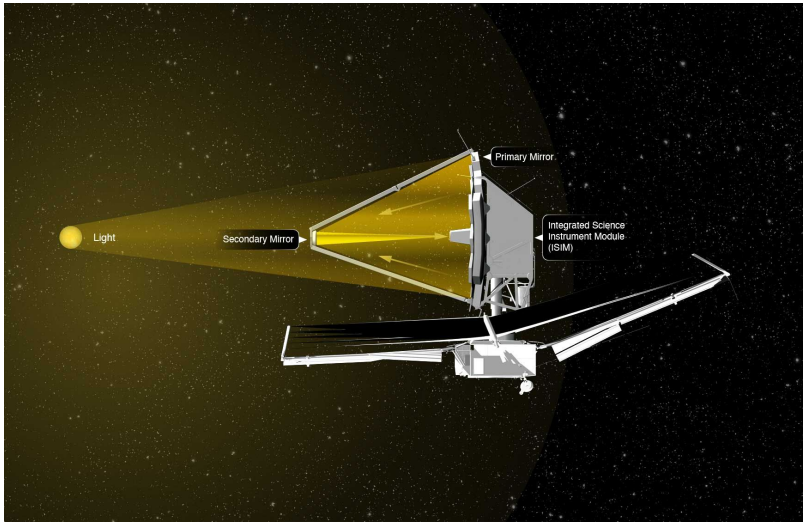
- Optical Telescope Element
- Integrated Science Instrument Module
- Spacecraft (bus and sunshield)

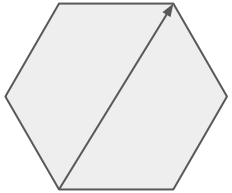


Why it is called “A ten-billion dollars time machine”?



Its mirror

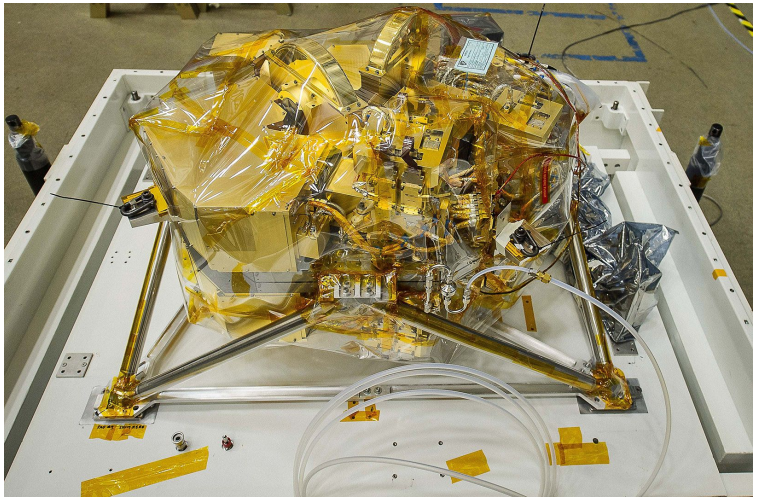




x18

1.32m

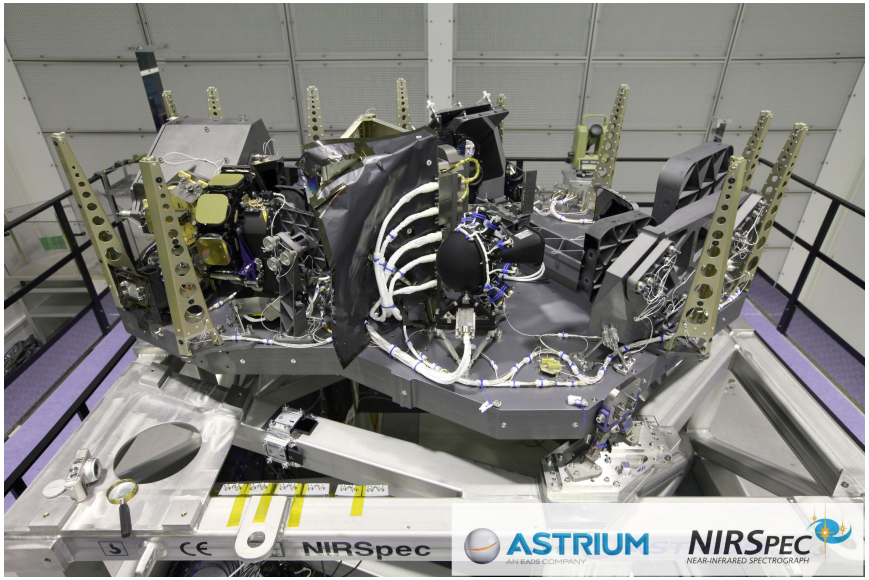
NIRCam (Near InfraRed Camera)



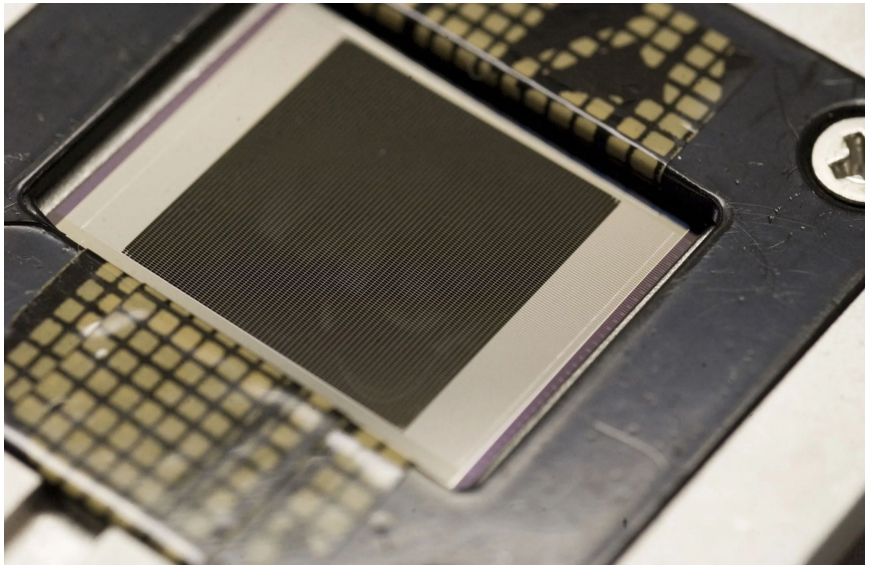
- 2 channels: SW: 0.6 - 2.3 microns
  LW: 2.4 - 5.0 microns
- Equipped with Coronagraph
  => see the corona

How about the physical properties??????????

NIRSpec comes to the play!

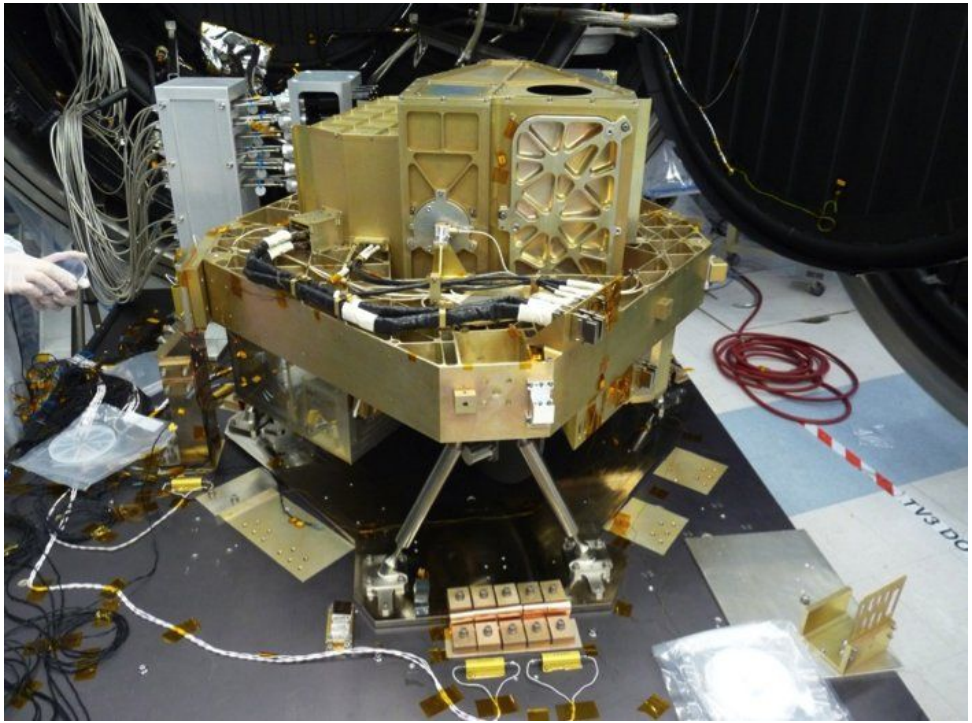


Spectrum => mass, temper, chem properties



250,000 Microshutters for blocking lights from others

NIRISS & Fine Guidance Sensor (FGS)



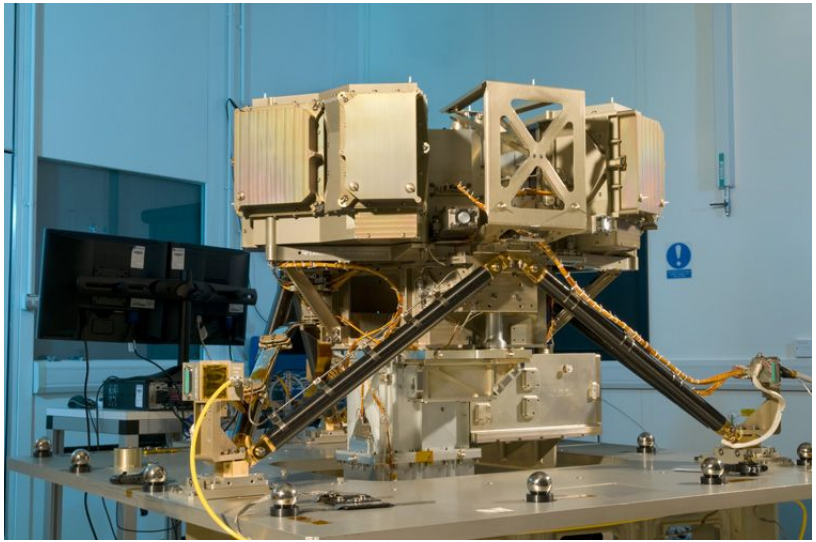
Working like NIRSpec but in a wider field of view

GASES:

SCIENTISTS:

LIGHTS:

MIRI (Mid-InfraRed Instrument)

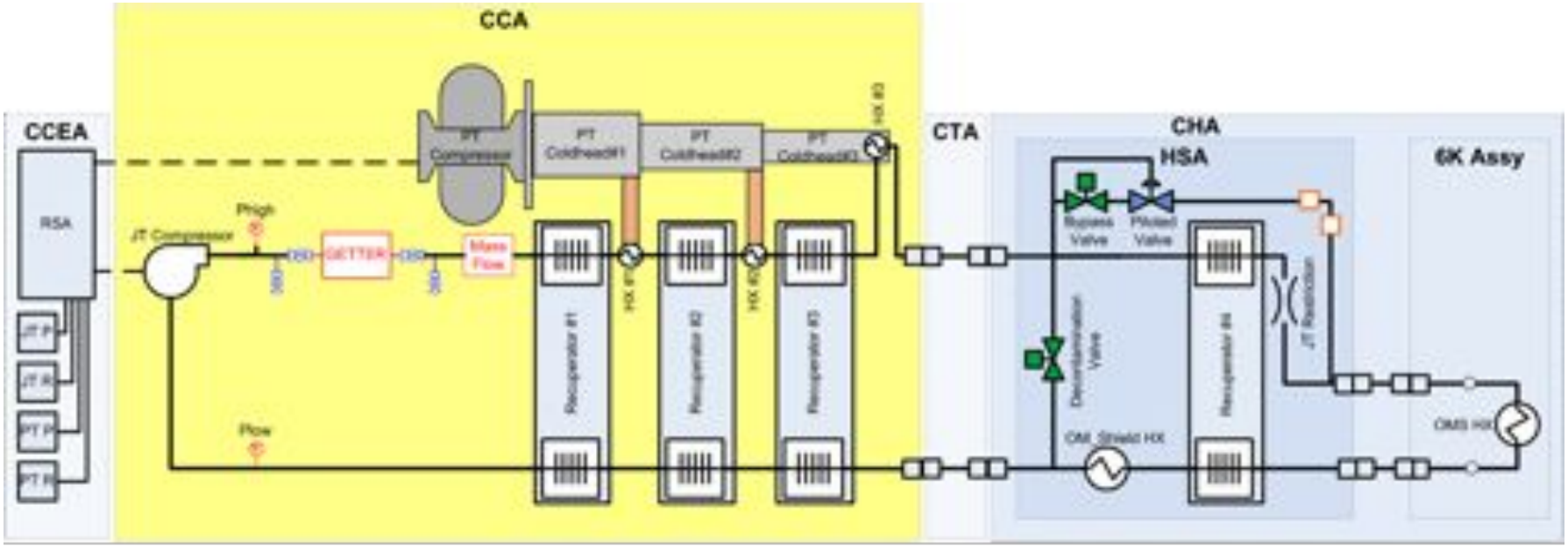


A camera & a spectrograph that can work in different range of infrared light.

Observing redshifted lights from distant galaxies, newly forming stars, comets…

The only issue is…

The Cryocooler

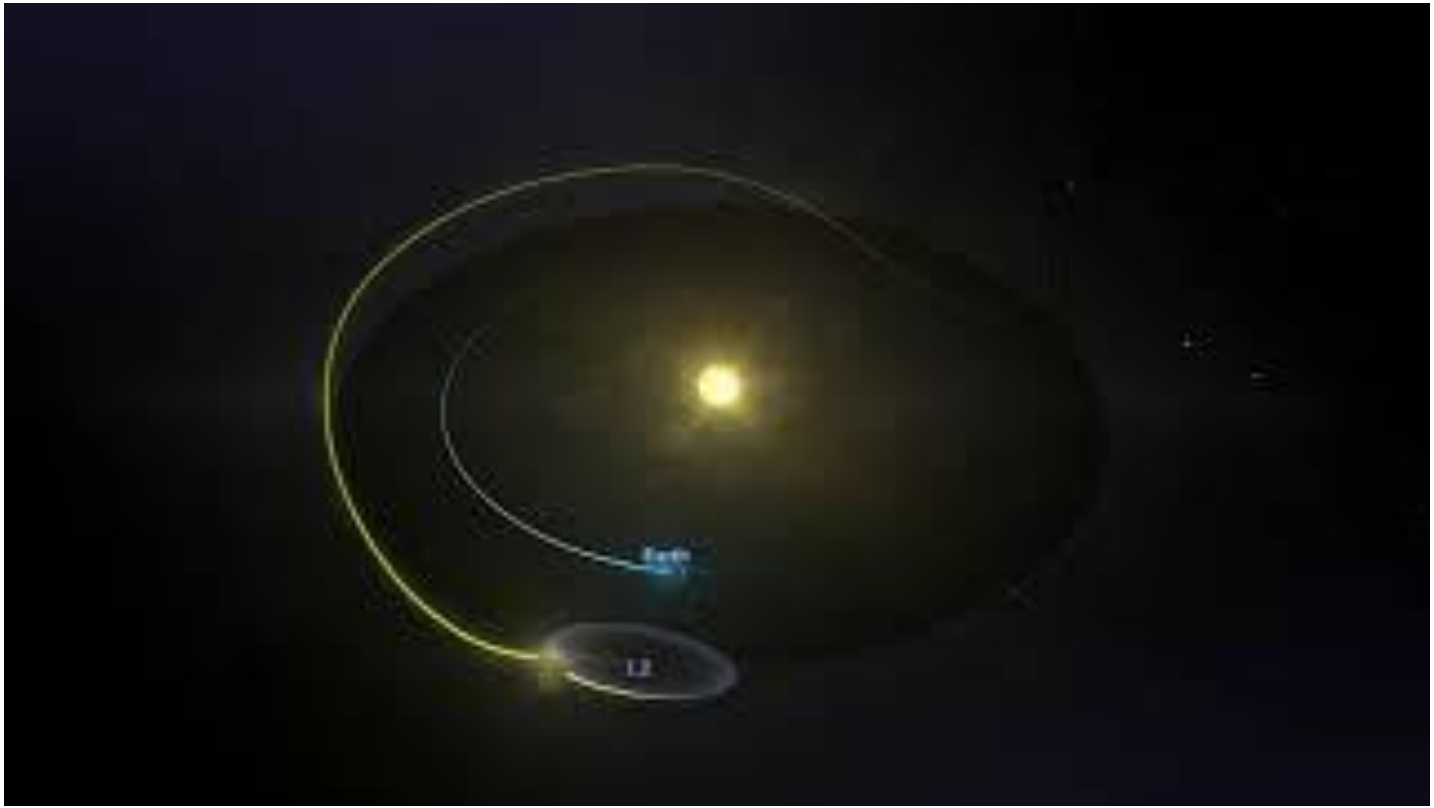


Basically a promax refrigerator with helium gas inside to cool down the instrument to near 7K

Sunshield

- 21m x 14m
- Five layers, each separated by a gap
- Material: Kapton coated with Al
- The first 2 layers is coated with doped silicone additionally

L2 orbit



Thermal stability

doi.org/10.1088/1538-3873/acbb9f

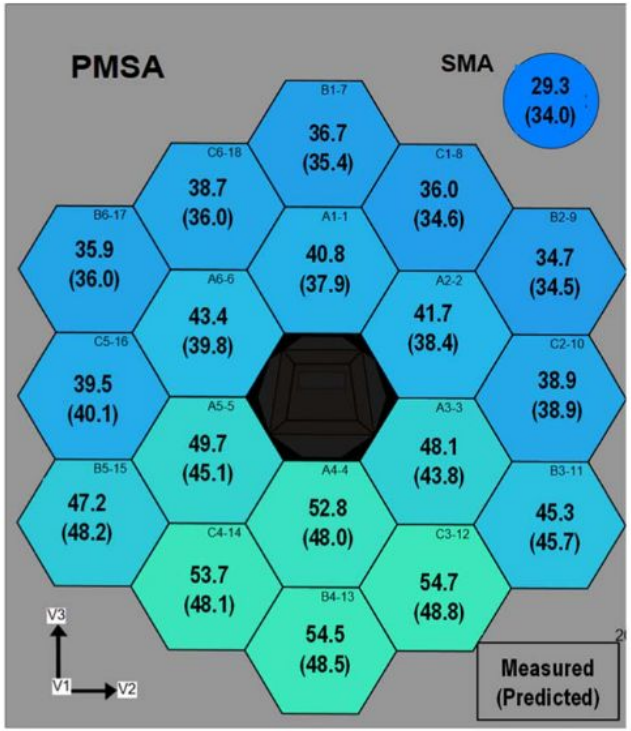


Figure 28. Measured and predicted PM and SM temperatures.

Thermal stability

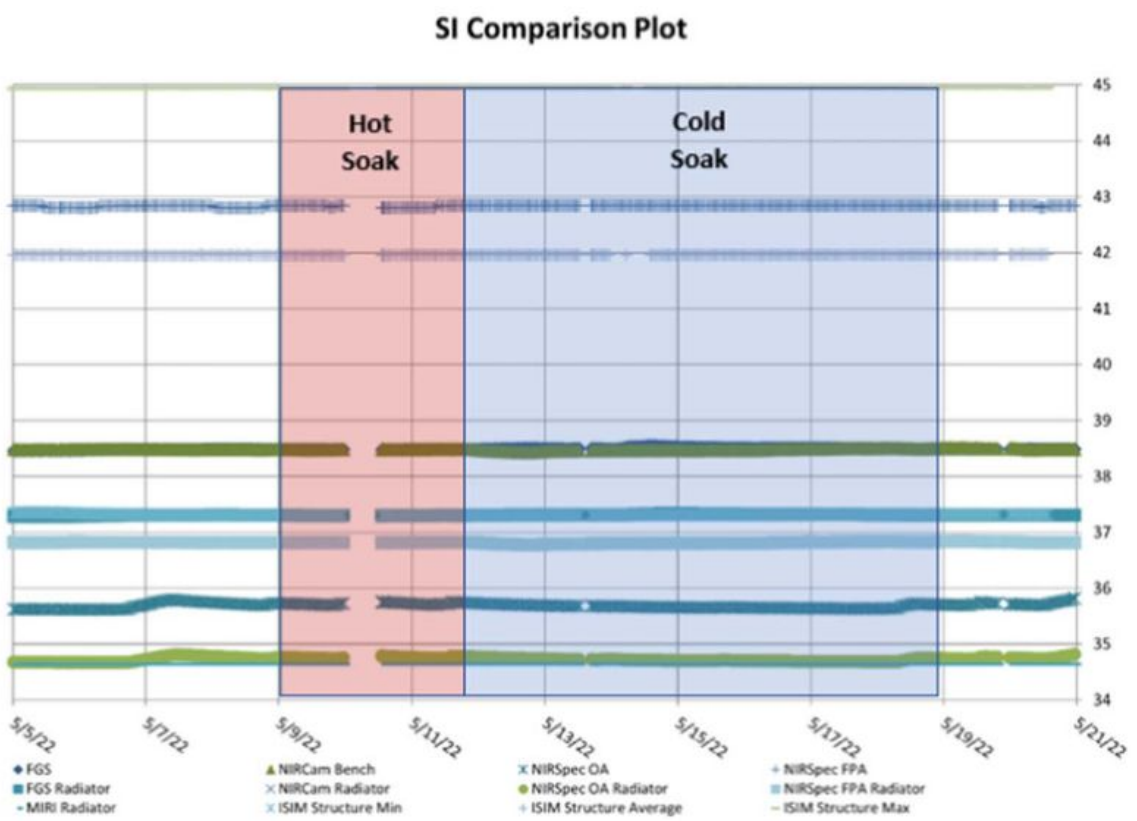
doi.org/10.1088/1538-3873/acbb9f

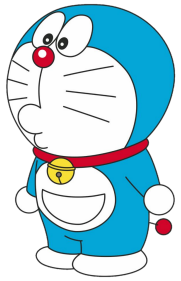
Table 6
NIR Science Instrument Temperatures

Instrument	Predicted Temperature (K)	Measured Flight Temperature (K)	Trim Heater Setting (mW)	Predicted Radiator Temperature (K)	Measured Flight Radiator Temperature (K)
NIRSpec Optics Assembly	35.5	35.57	10	34.8	34.5
NIRSpec Focal Plane Assembly	42.8	42.80	8	40.9	40.7
Fine Guidance Sensor	38.5	38.48	4	37.4	37.2
NIRCam	38.5	38.52	14	37.0	37.1

Thermal stability

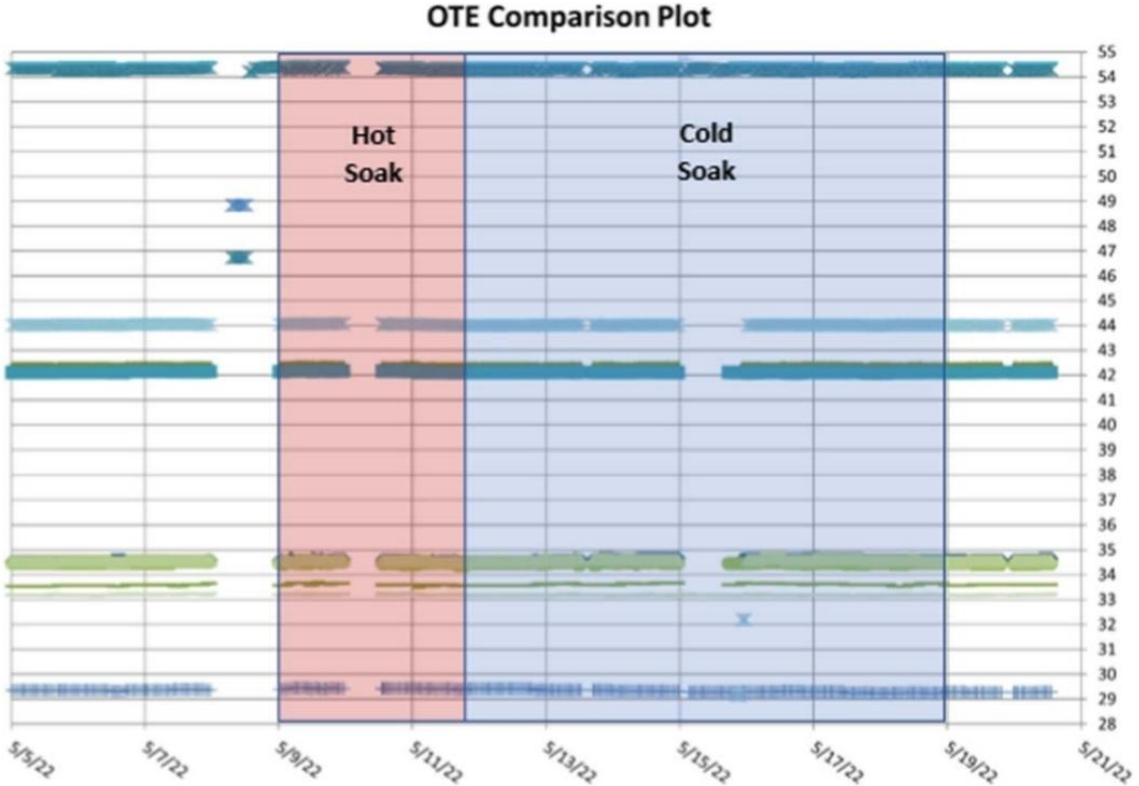
doi.org/10.1088/1538-3873/acbb9f

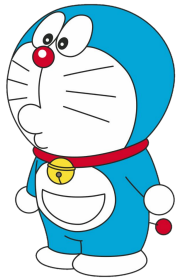




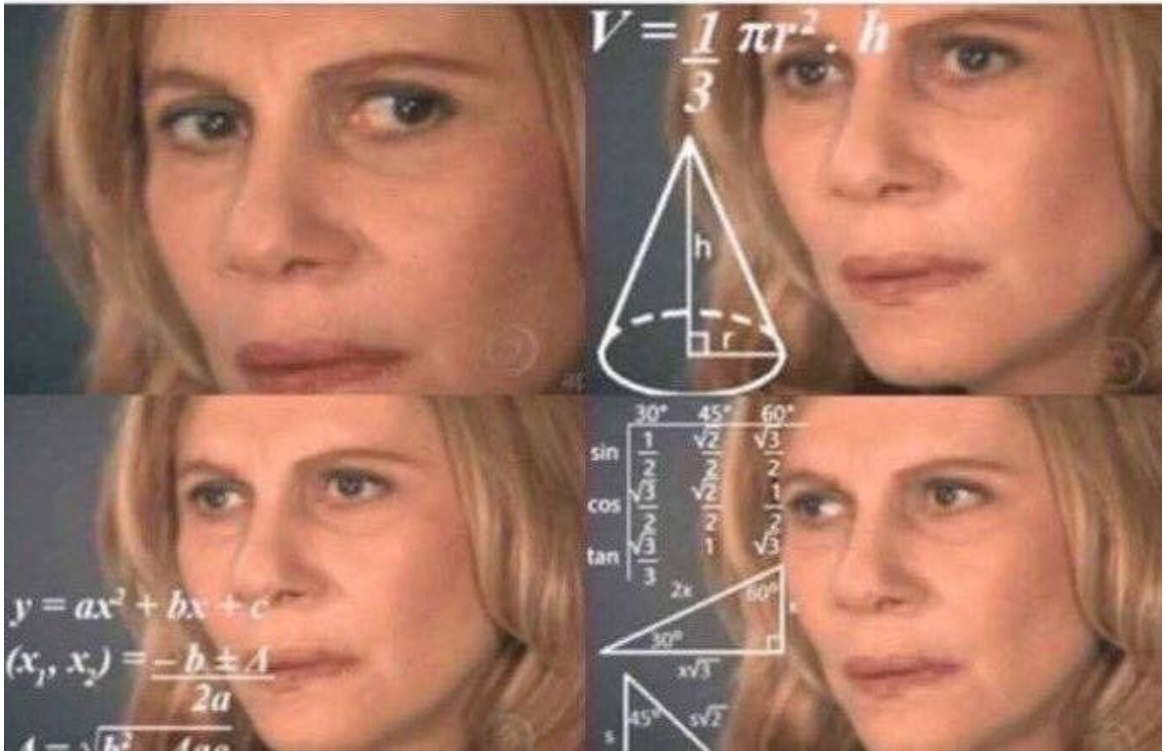
Thermal stability

doi.org/10.1088/1538-3873/acbb9f



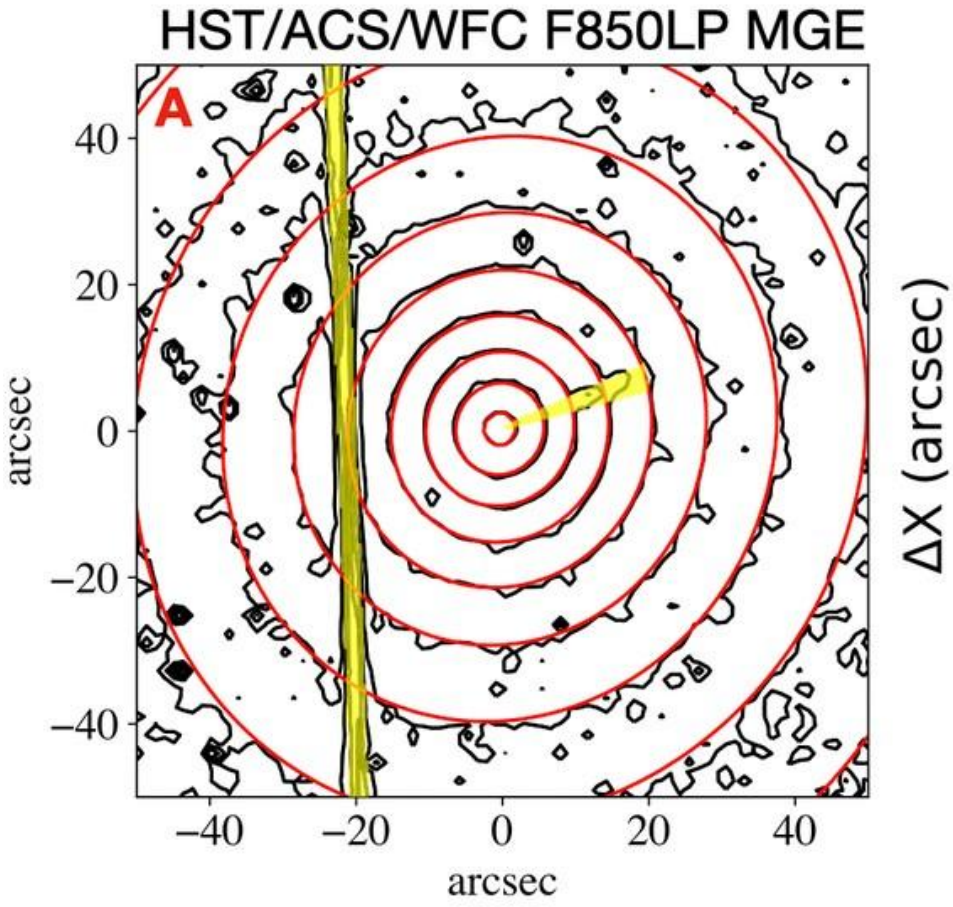


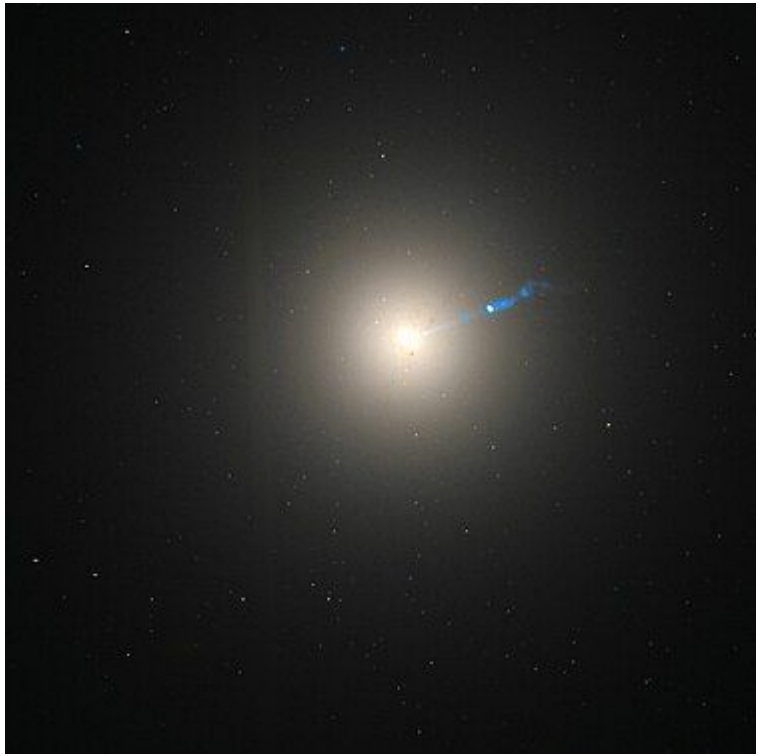
Where can I get data from JWST?



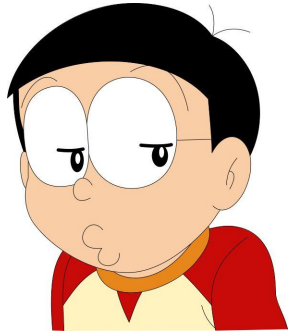
Accessing to JWST data, that is impossible if you are not working for NASA or ESA!

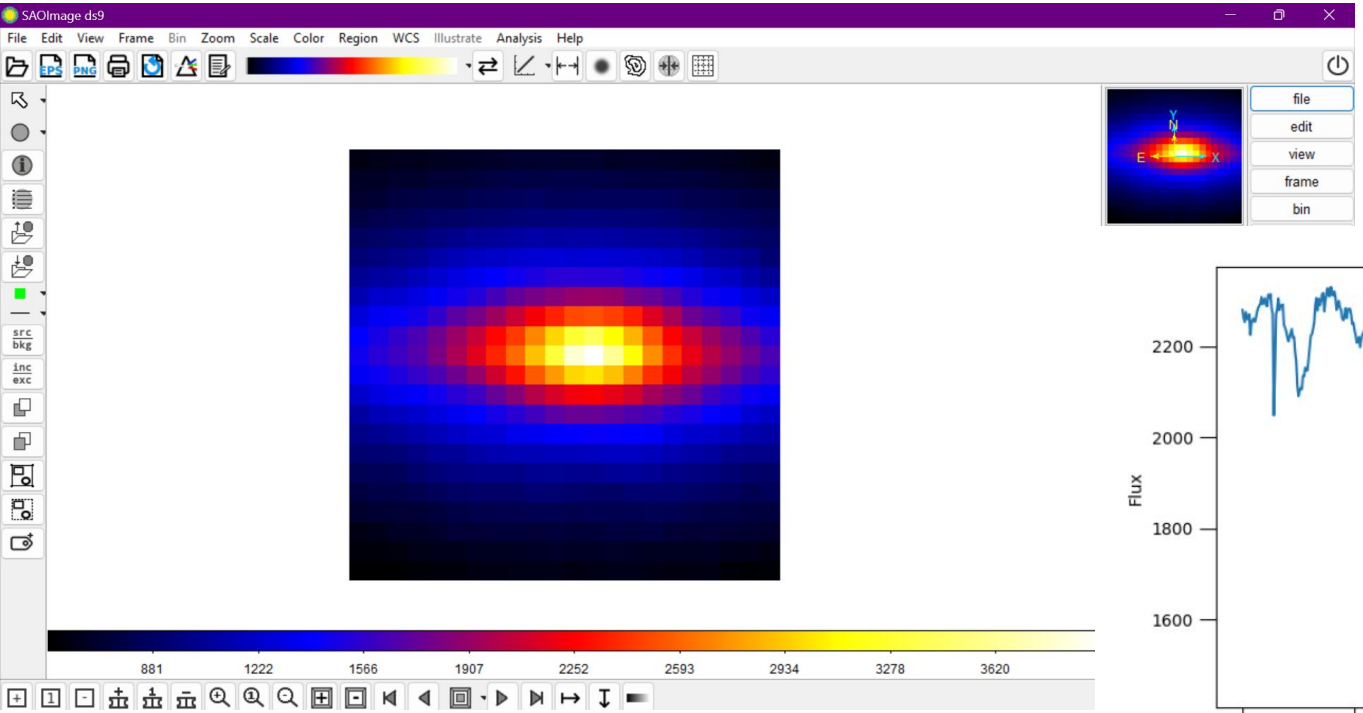
[Mikulski Archive for Space Telescopes]

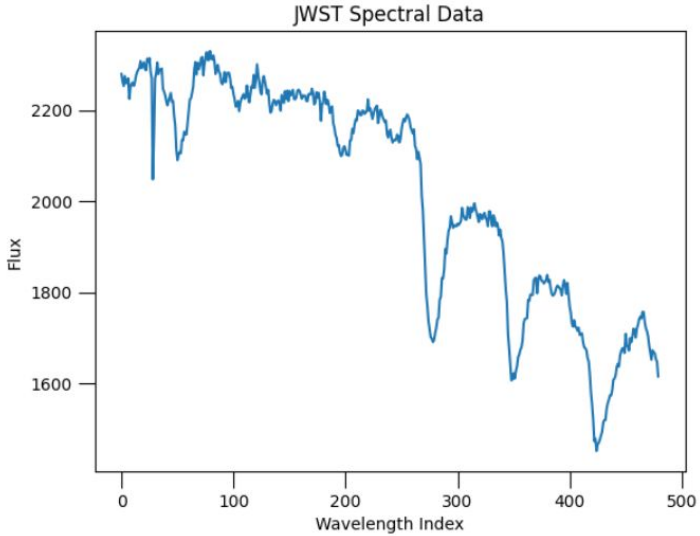

HST/ACS/WFC F850LP MGE
A
40
20
0
−20
−40
arcsec
−40
−20
0
20
40
arcsec


ΔX (arcsec)

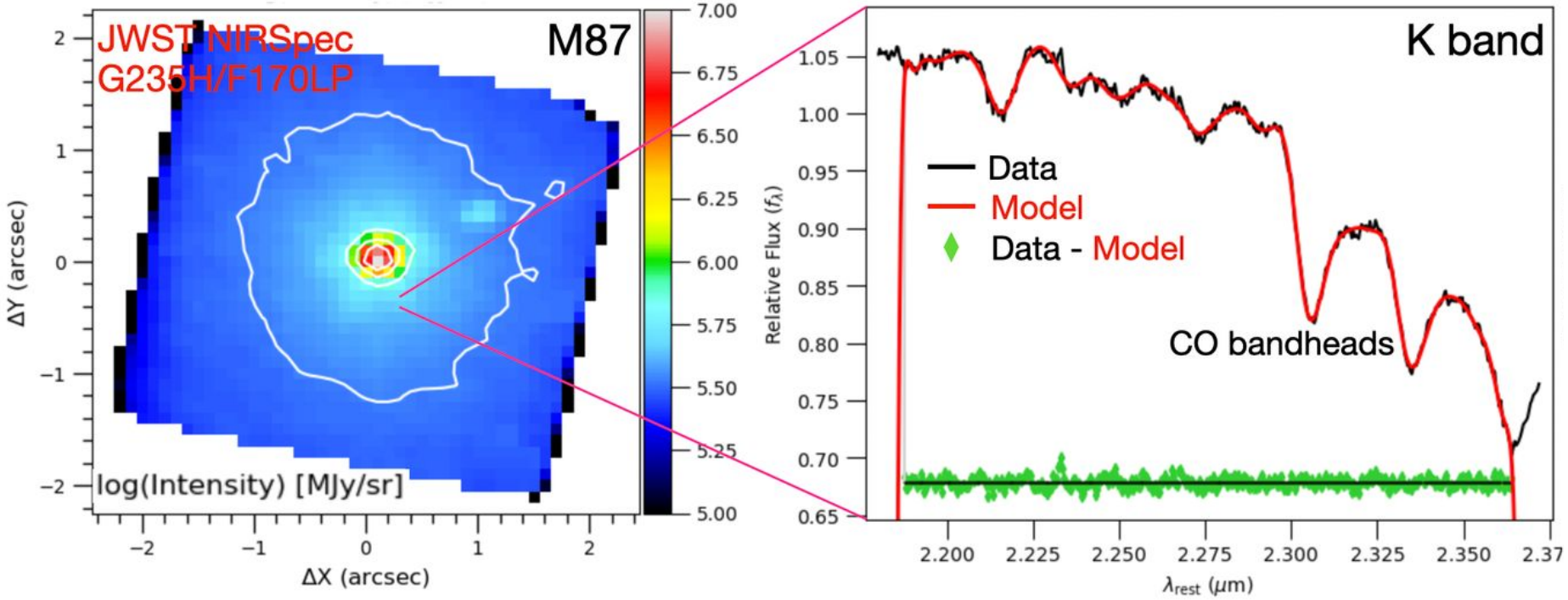
Measure the overall dynamical state M87





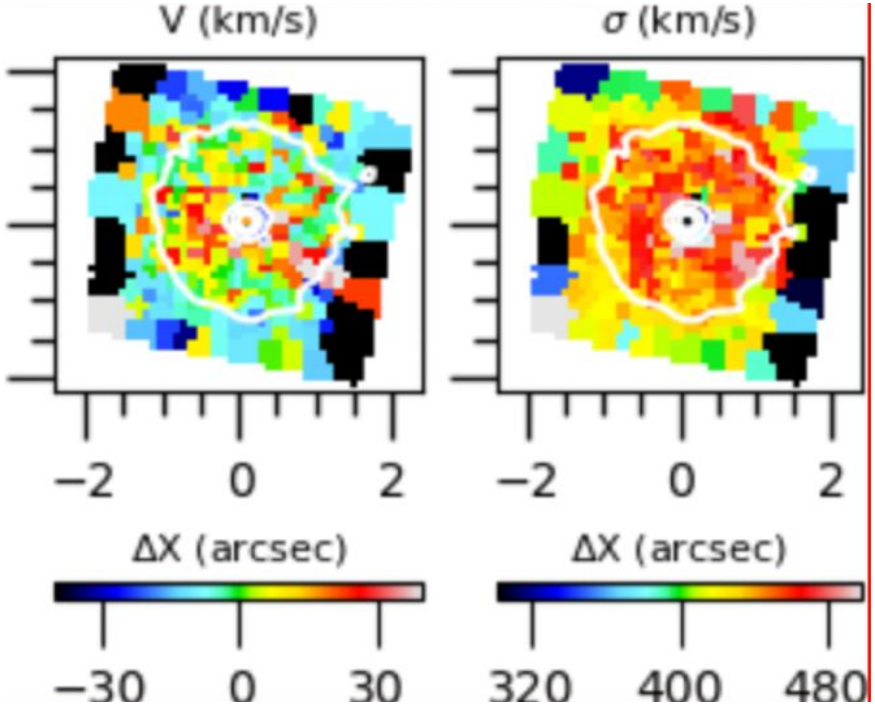


K band: 2.0 - 2.4 μm and CO bandheads: 2.29-2.32 μm in K



v is the bulk velocity (mean velocity of stars or gas in the galaxy).

σ is the velocity dispersion, representing random motions of stars or gas particles around the bulk velocity.

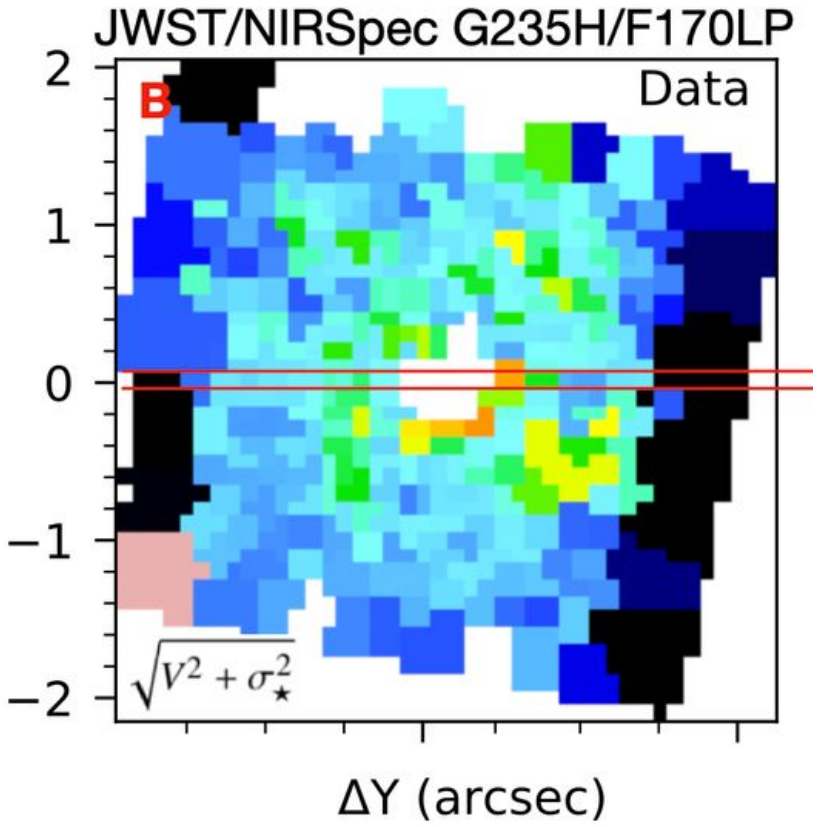


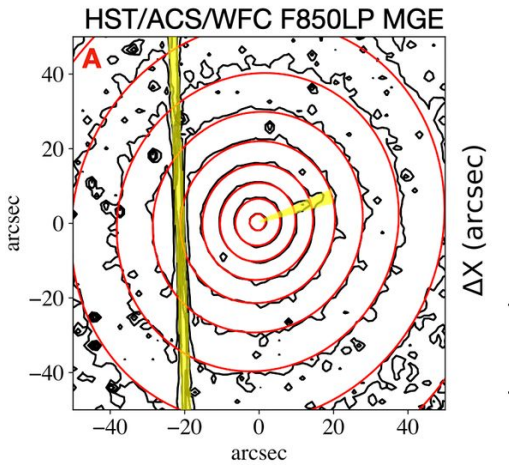
V_rms:

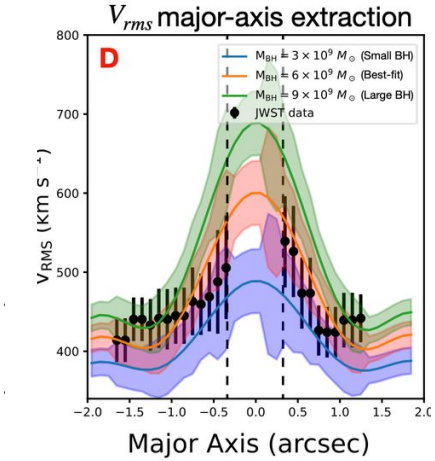
root mean square velocity

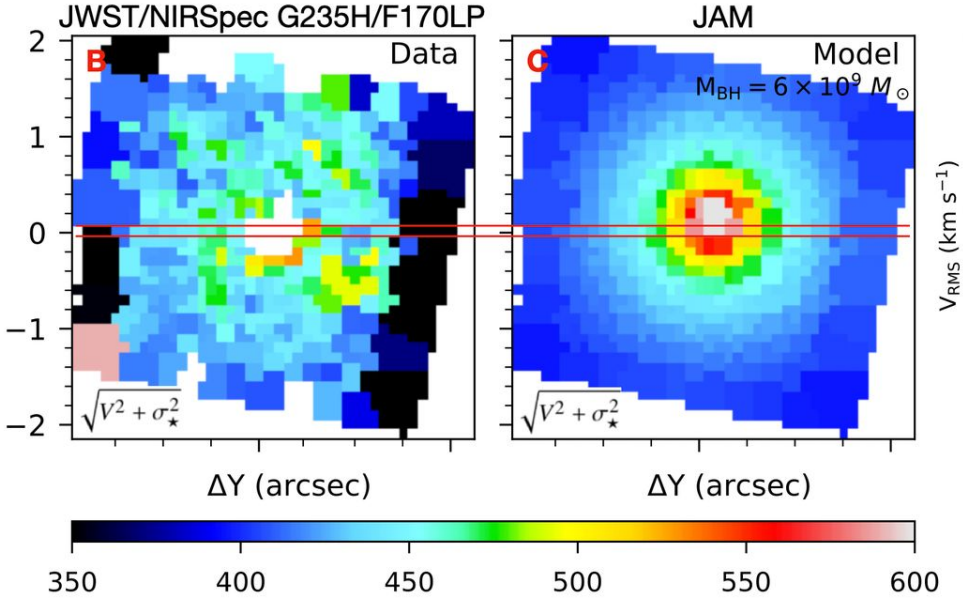
provides a measure of the overall dynamical state of the system

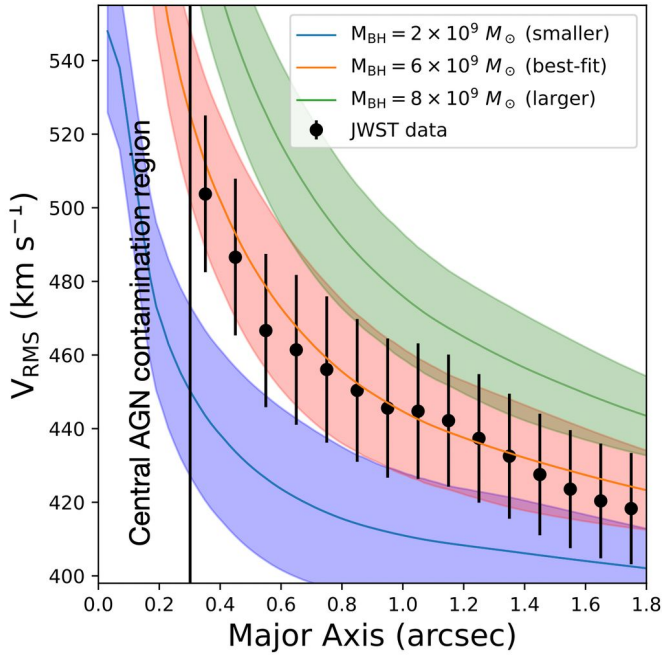
combining both ordered and random motion.

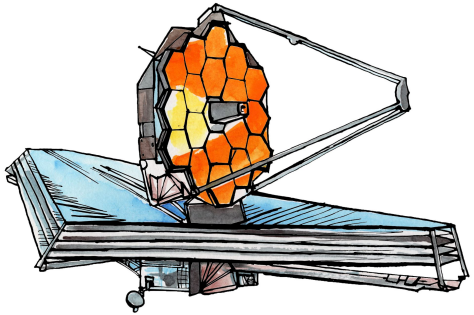



HST/ACS/WFC F850LP MGE
A
arcsec
ΔX (arcsec)


V_{rms} major-axis extraction
D
$M_{BH} = 3 \times 10^9\ M_\odot$ (Small BH)
$M_{BH} = 6 \times 10^9\ M_\odot$ (Best-fit)
$M_{BH} = 9 \times 10^9\ M_\odot$ (Large BH)
JWST data
V_{RMS} (km s^{-1})
Major Axis (arcsec)

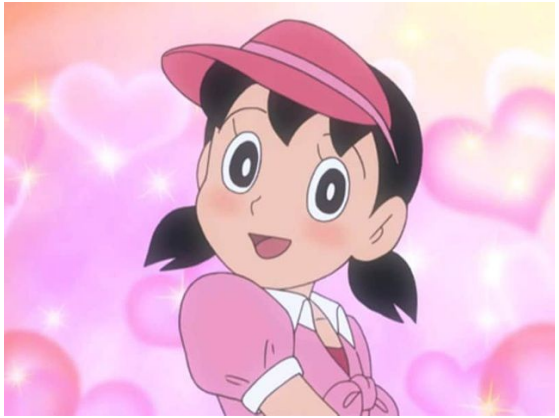

JWST/NIRSpec G235H/F170LP
B
Data
JAM
C
Model
$M_{BH} = 6 \times 10^9\ M_\odot$
$\sqrt{V^2 + \sigma_\star^2}$
ΔY (arcsec)
V_{RMS} (km s^{-1})


$M_{BH} = 2 \times 10^9\ M_\odot$ (smaller)
$M_{BH} = 6 \times 10^9\ M_\odot$ (best-fit)
$M_{BH} = 8 \times 10^9\ M_\odot$ (larger)
JWST data
Central AGN contamination region
V_{RMS} (km s^{-1})
Major Axis (arcsec)



The unimaginable possibilities of JWST

- Study about fainted objects
- Study about the rings of planets
- Study about the habitable zone in the solar systems
- (Maybe) find the origin of the universe
- Study about the universe and its “residents” appearance (Cosmology)
- …



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- *Explore Webb in a 3d Solar System, https://science.nasa.gov/mission/webb/webb-3d/*
- *The Design, Verification, and Performance of the James Webb Space Telescope, M. Menzel et al 2023, Publications of the Astronomical Society of the Pacific, Volume 135, Number 1047, doi.org/10.1088/1538-3873/acbb9f*
- *Keck Integral-field Spectroscopy of M87 Reveals an Intrinsically Triaxial Galaxy and a Revised Black Hole Mass, The Astrophysical Journal Letters, 945:L35 (11pp), 2023 March 10, https://doi.org/10.3847/2041-8213/acbbcf*
- *Supermassive black hole mass in the massive elliptical galaxy M87 from integral-field stellar dynamics using OASIS and MUSE with adaptive optics: assessing systematic uncertainties, Royal Astronomical Society, https://doi.org/10.1093/mnras/stad3309*
- *JWST GO Cycle 4, Dr Nguyen Duc Dieu (unemployment now)*

THANKS