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Mars Science with the James Webb Space Telescope

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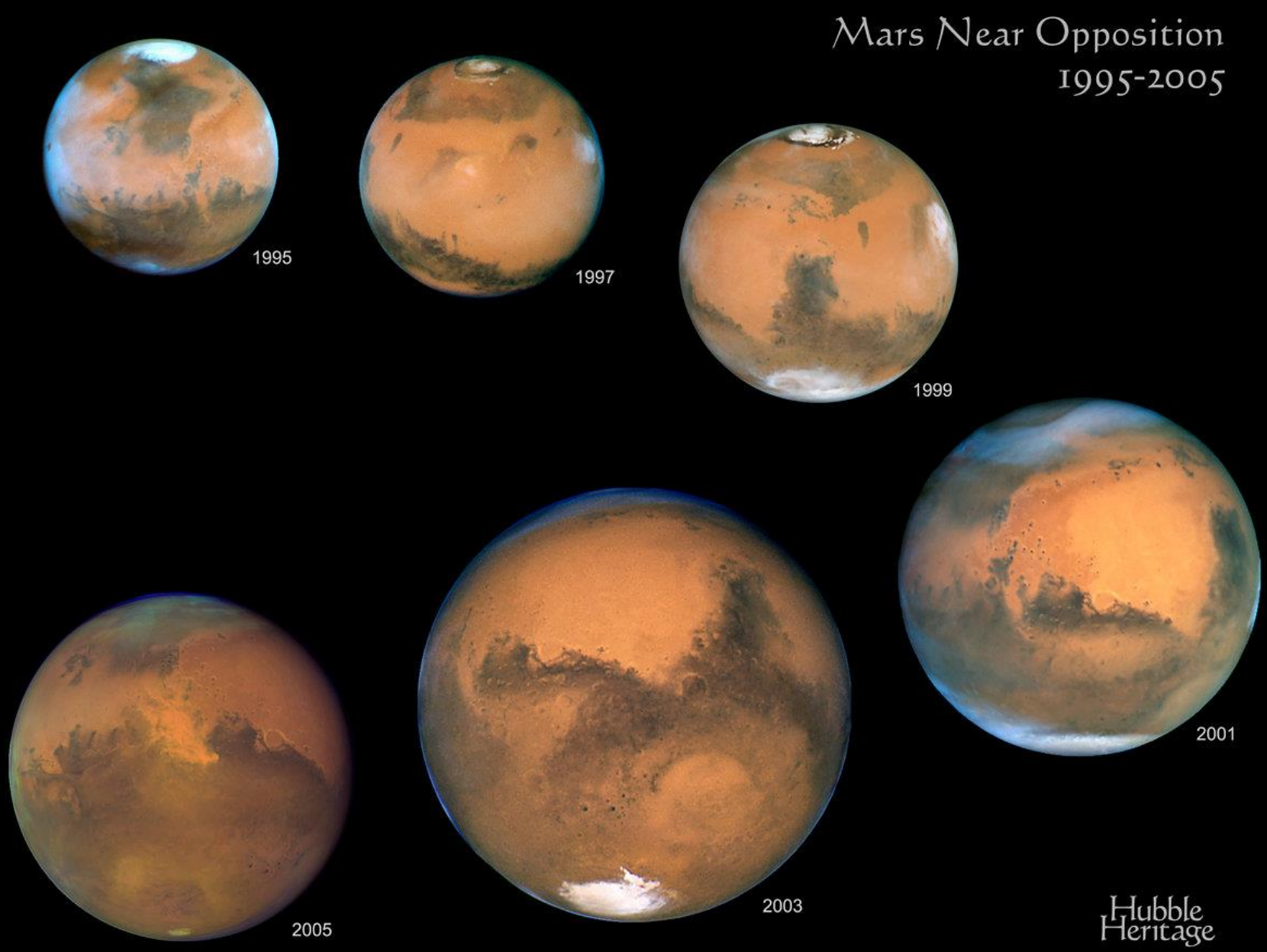
@SNMilam

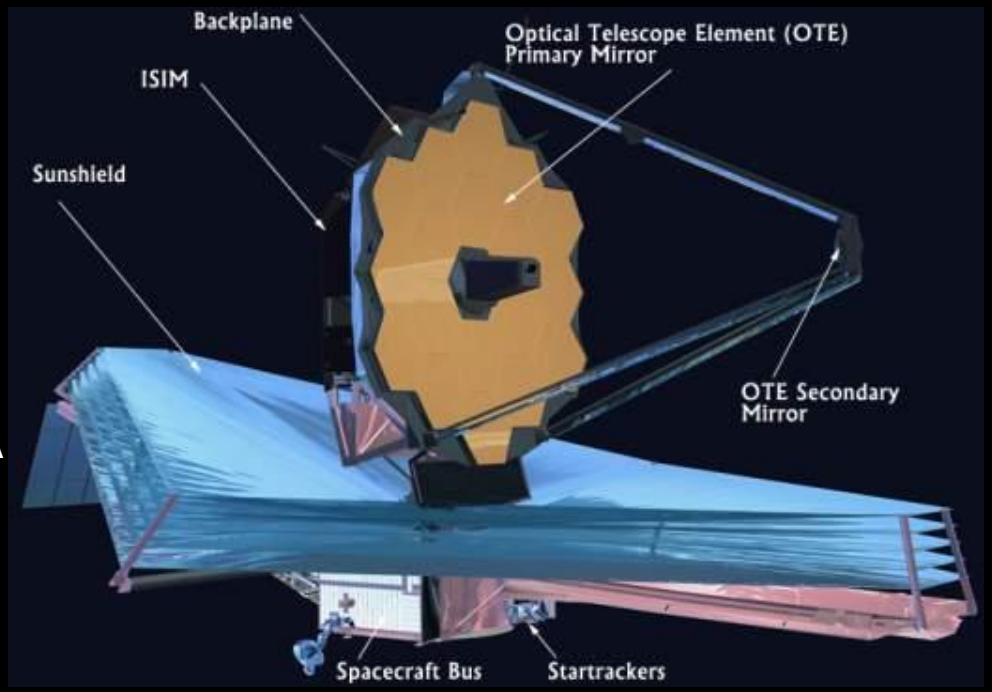


NASA, ESA, and The Hubble Heritage Team (STScI/AURA) • Hubble Space Telescope • STScI-PRC05-34c

Hubble and Mars

#	Bibcode Authors	Score Title	Date	List of Links Access Control Help
1	2017JGRA..12211756B Bhattacharyya, D.; Clarke, J. T.; Chaufray, J. Y.; Mayyasi, M.; Bertaux, J. L.; Chaffin, M. S.; Schneider, N. M.; Villanueva, G. L.	1.000 Seasonal Changes in Hydrogen Escape From Mars Through Analysis of HST Observations of the Martian Exosphere Near Perihelion	11/2017	A E D R U
2	2008Icar..193..112N Noe Dobrea, E.; Bell, J. F.; Wolff, M. J.; Noll, K.; Lubenow, A.; Million, C. C.	1.000 Global-scale near infrared variability on Mars: Analysis of 2003 Mars opposition observations from HST/NICMOS	01/2008	A E D R C
3	2007Icar..191..581B Bell, J. F.; Ansty, T. M.	1.000 High spectral resolution UV to near-IR observations of Mars using HST/STIS	11/2007	A E D R C
4	2007PhDT.....29S Soderblom, Jason	1.000 Properties of Martian soils, rocks, and atmospheric dust derived from analysis of Hubble Space Telescope and Mars Exploration Rover data	00/2007	A E
5	2006Icar..185...97K Kaydash, V. G.; Kreslavsky, M. A.; Shkuratov, Yu. G.; Videen, G.; Bell, J. F.; Wolff, M.	1.000 Measurements of winds on Mars with Hubble Space Telescope images in 2003 opposition	11/2006	A E D R C
6	2006Icar..184..401S Soderblom, Jason M.; Bell, James F.; Hubbard, Min Y. H.; Wolff, Michael J.	1.000 Martian phase function: Modeling the visible to near-infrared surface photometric function using HST-WFPC2 data	10/2006	A E D R C
7	2006P&SS...54..844S Showalter, Mark R.; Hamilton, Douglas P.; Nicholson, Philip D.	1.000 A deep search for Martian dust rings and inner moons using the Hubble Space Telescope	08/2006	A E D R C U
8	2005Icar..176....1S Shkuratov, Yu.; Kreslavsky, M.; Kaydash, V.; Videen, G.; Bell, J.; Wolff, M.; Hubbard, M.; Noll, K.; Lubenow, A.	1.000 Hubble Space Telescope imaging polarimetry of Mars during the 2003 opposition	07/2005	A E D R C
9	2005Icar..174..596J James, Philip B.; Bonev, Boncho P.; Wolff, Michael J.	1.000 Visible albedo of Mars' south polar cap: 2003 HST observations	04/2005	A E D R C
10	2003Icar..166....1N Noe Dobrea, E. Z.; Bell, J. F.; Wolff, M. J.; Gordon, K. D.	1.000 H_2O- and OH-bearing minerals in the martian regolith: . analysis of 1997 observations from HST/NICMOS	11/2003	A E X D R C U
11	2000PhDT.....29W Wegryn, Eric	1.000 The dusty atmosphere of Mars: A study of the properties of martian aerosol dust, using Imager for Mars Pathfinder and Hubble Space Telescope observations	07/2000	A E C

James Webb Space Telescope (JWST)



Organization

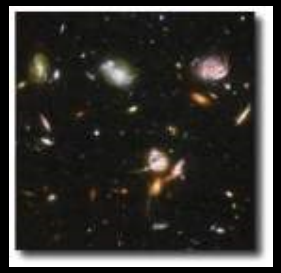
- Mission Lead: Goddard Space Flight Center
- International collaboration with ESA & CSA
- Prime Contractor: Northrop Grumman Aerospace Systems
- Instruments (0.6-28.5 micron):
  - Near Infrared Camera (NIRCam) – Univ. of Arizona
  - Near Infrared Spectrograph (NIRSpec) – ESA
  - Mid-Infrared Instrument (MIRI) – JPL/ESA
  - Fine Guidance Sensor (FGS) – CSA
- Operations: Space Telescope Science Institute

Description

- Deployable infrared telescope with 6.5 meter diameter segmented adjustable primary mirror
- Cryogenic temperature telescope and instruments for infrared performance
- Launch on an ESA-supplied Ariane 5 rocket to Sun-Earth L2
- 5-year science mission (10-year goal)

www.JWST.nasa.gov

JWST Science Themes



End of the dark ages: First light and reionization

The assembly of galaxies

Birth of stars and proto-planetary systems

Planetary systems and the origin of life

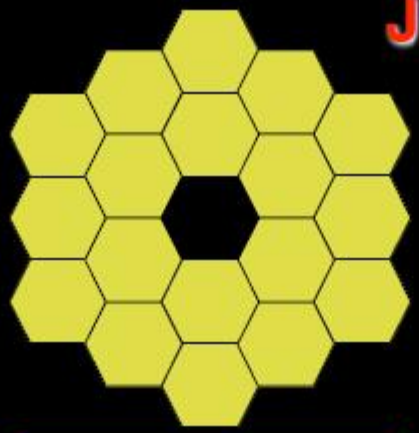
JWST and its Precursors

HUBBLE

2.4-meter
T ~ 270 K

123" x 136"
$\lambda/D_{1.6\mu m}$~ 0.14"

JWST



6.5-meter
T ~ 40 K

132" x 164"
$\lambda/D_{2\mu m}$~ 0.06"

114" x 84"
$\lambda/D_{20\mu m}$~ 0.64"

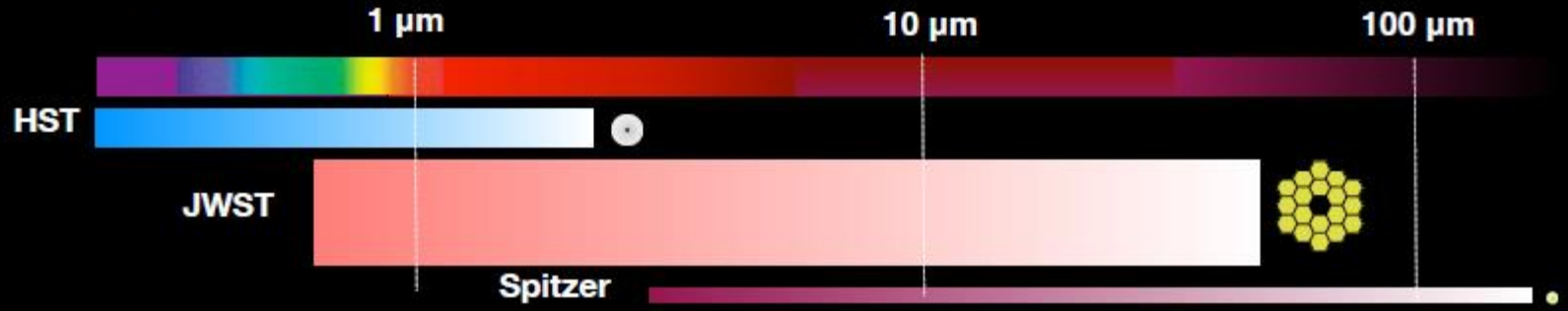
SPITZER

0.8-meter
T ~ 5.5 K

312" x 312"
$\lambda/D_{5.6\mu m}$~ 2.22"

324" x 324"
$\lambda/D_{24\mu m}$~ 6.2"

Wavelength Coverage



JWST GTO Program

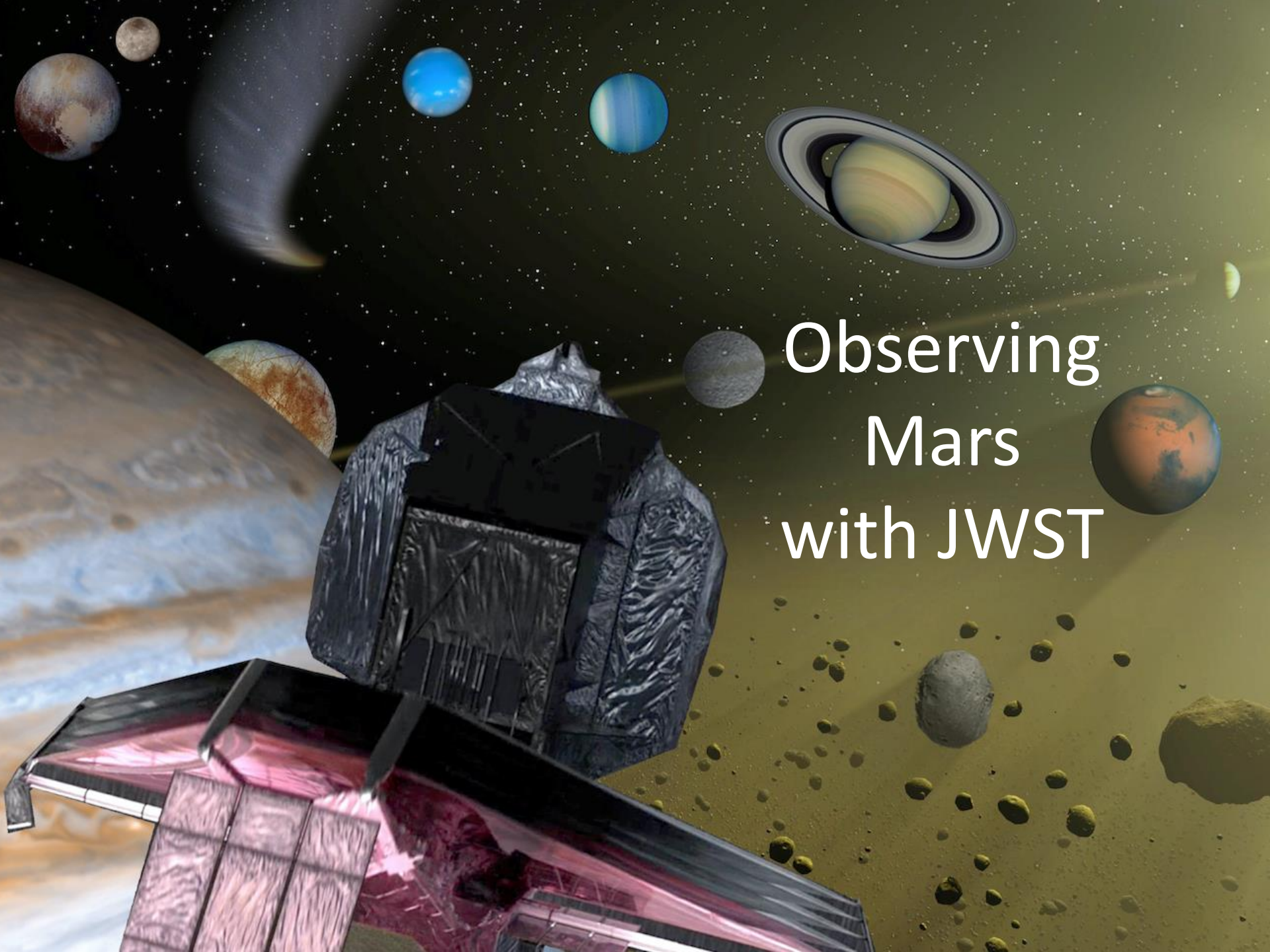
- GTO: Guaranteed Time Observations

- 2 Interdisciplinary Scientists with Solar System interests: H. Hammel and J. Lunine (as well as partial interest from the NIRCam, NIRSpec and MIRI teams)

- Hammel is dedicating 100% of her time to the Solar System community
  - Asteroids, NEOs, Comets, **Mars**, Jupiter, Saturn (rings and small sats), Uranus, Neptune, Titan, KBOs, and Europa/Enceladus
  - **Proprietary period waived** for *most* of these data including Mars

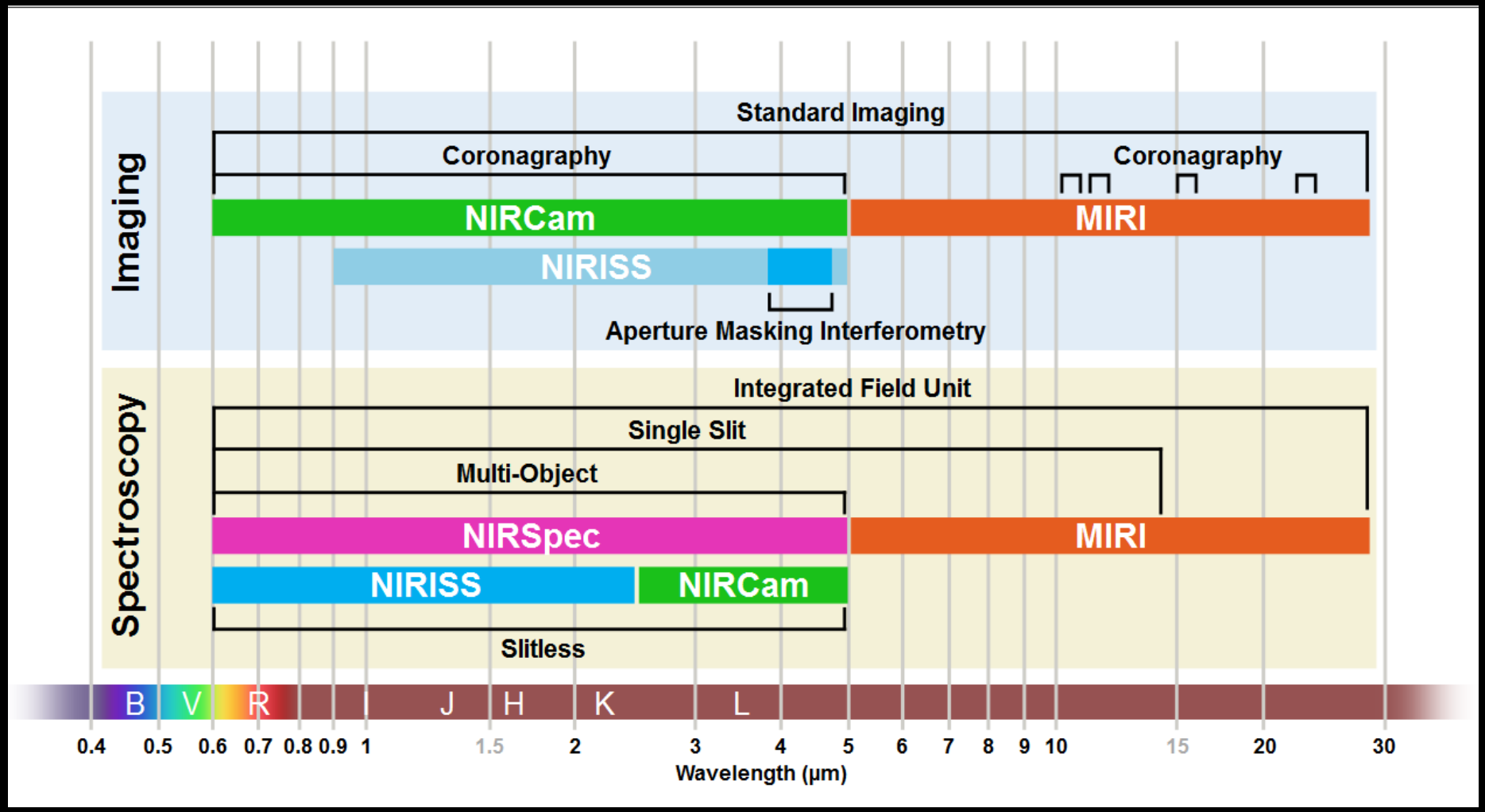
Details on GTO programs here:

https://jwst-docs.stsci.edu/display/JSP/JWST+GTO+Observation+Specifications

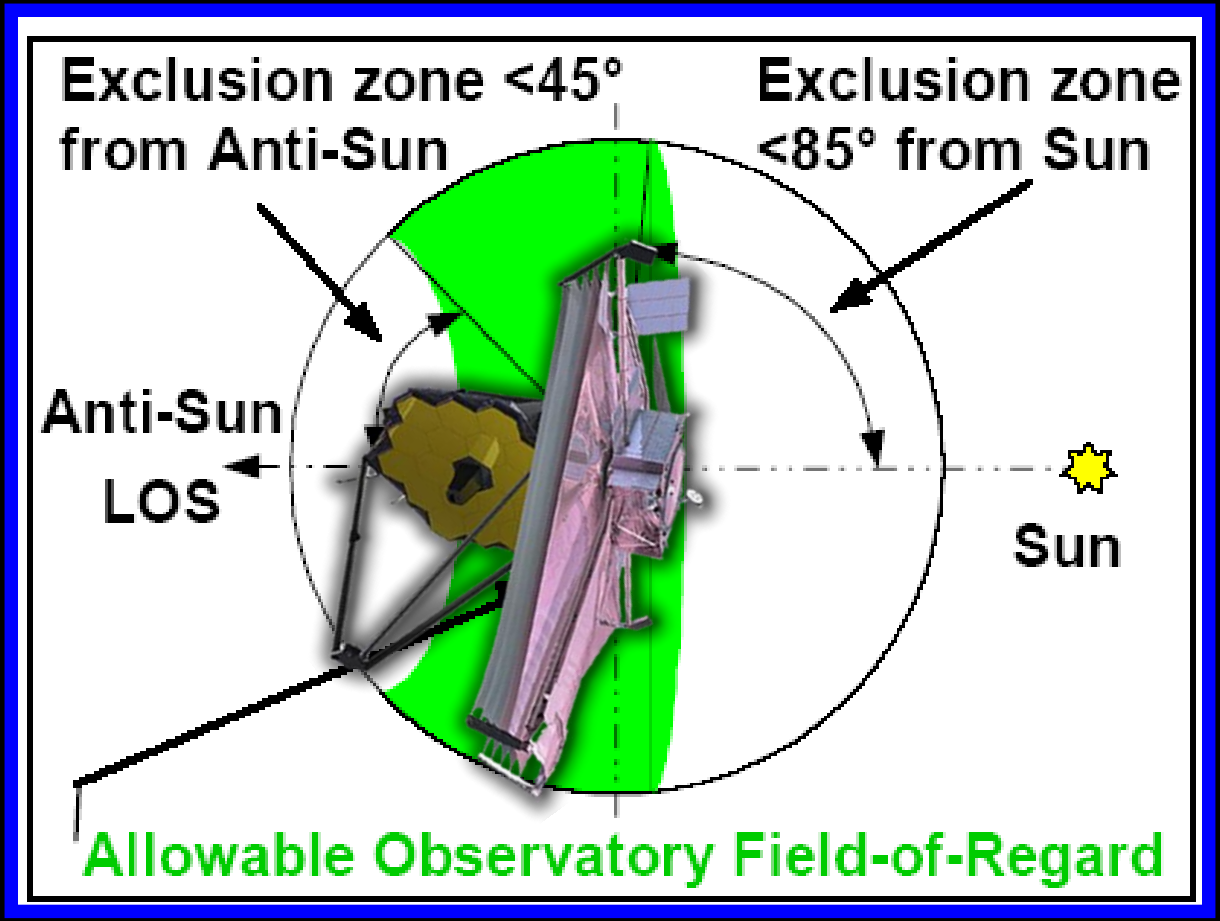


Observing Mars with JWST

JWST Instrumentation



JWST Field of Regard

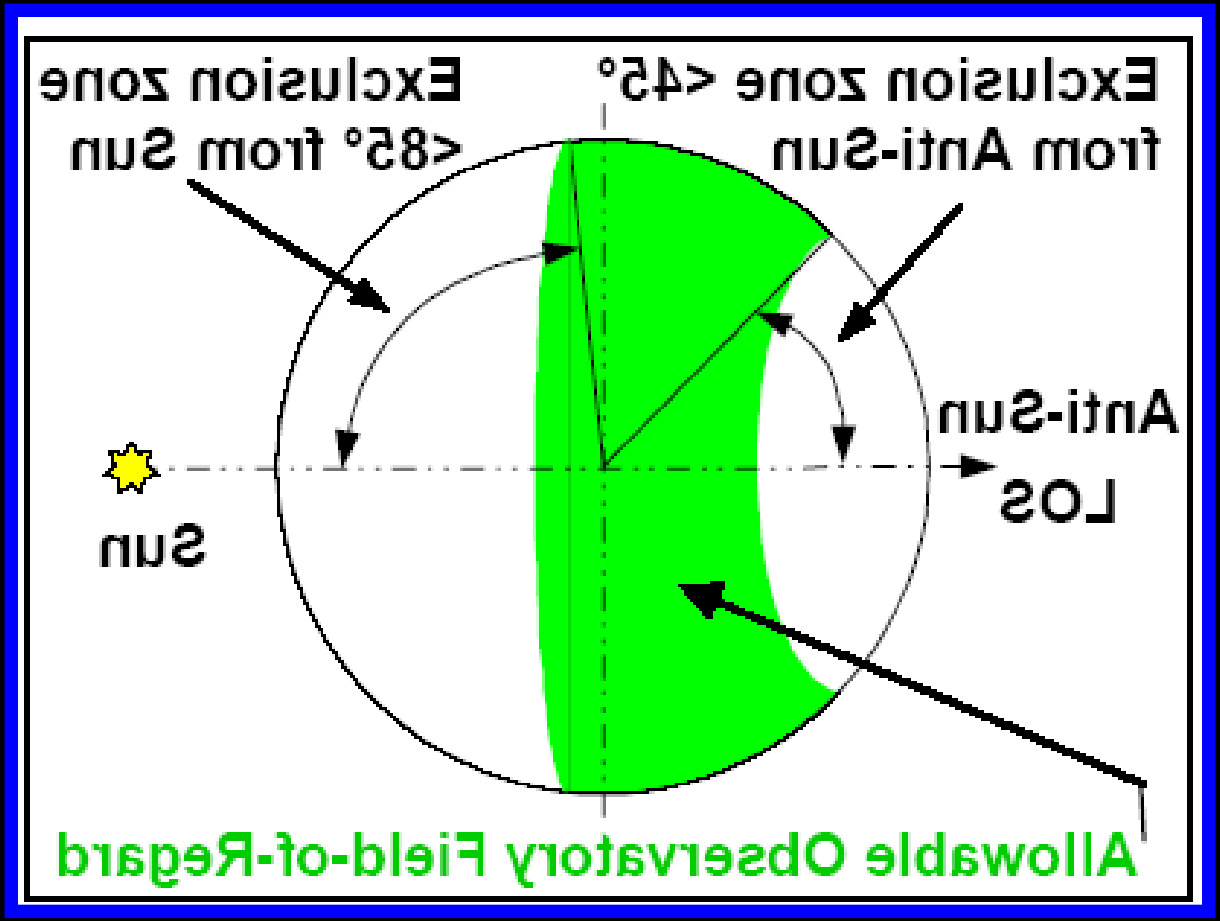


JWST's optics must always be fully shaded

*Solar-system observations will be made near quadrature

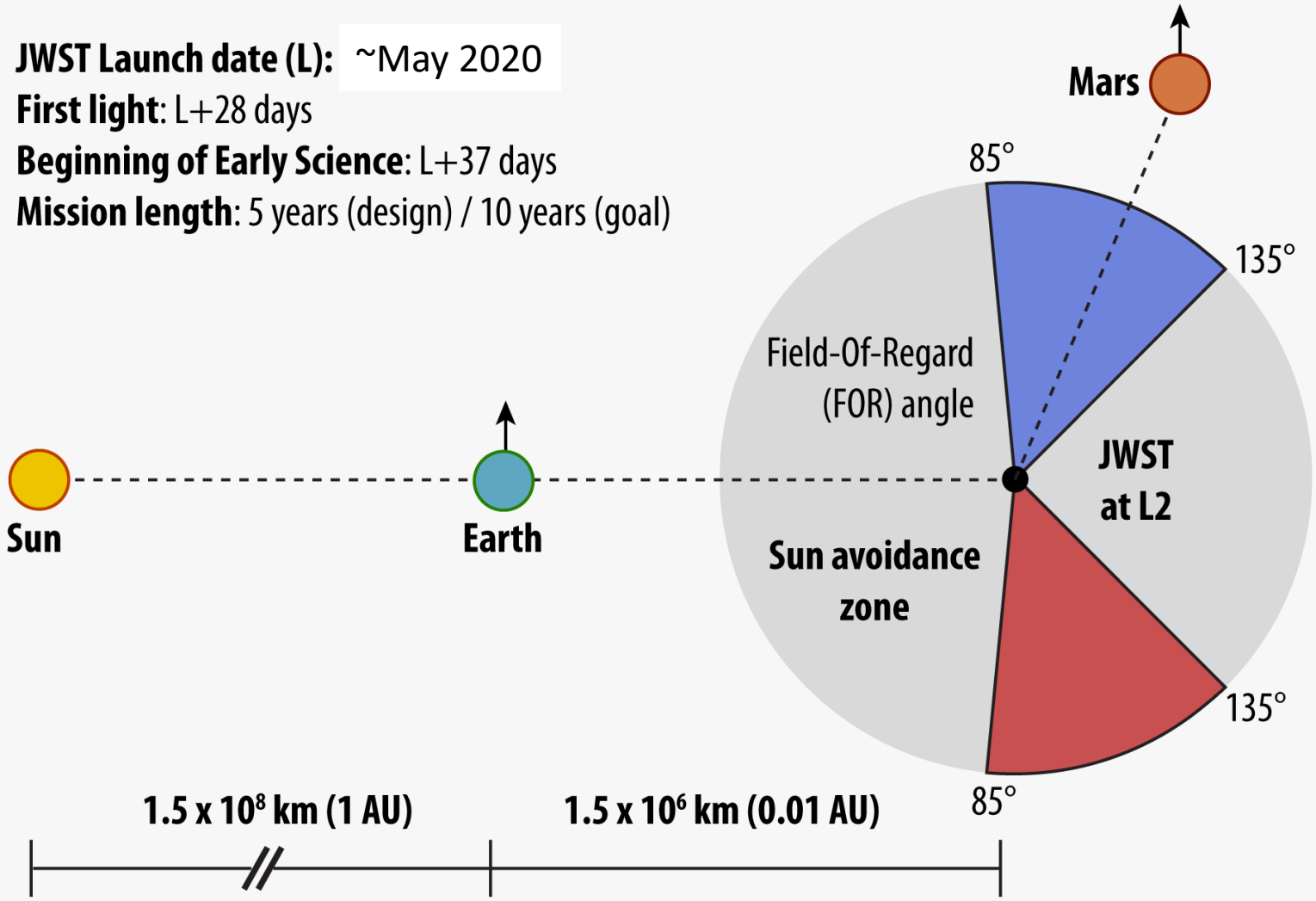
Similar to Spitzer and Herschel observatories

JWST Field of Regard



Mars Visibility

JWST Launch date (L): ~May 2020
First light: L+28 days
Beginning of Early Science: L+37 days
Mission length: 5 years (design) / 10 years (goal)

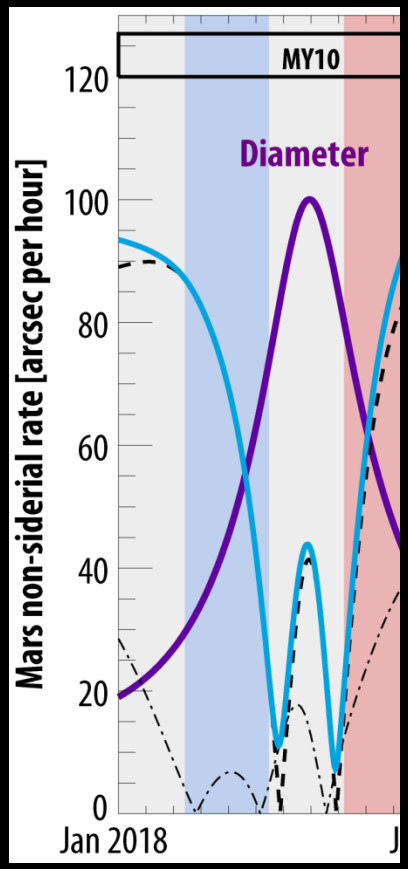


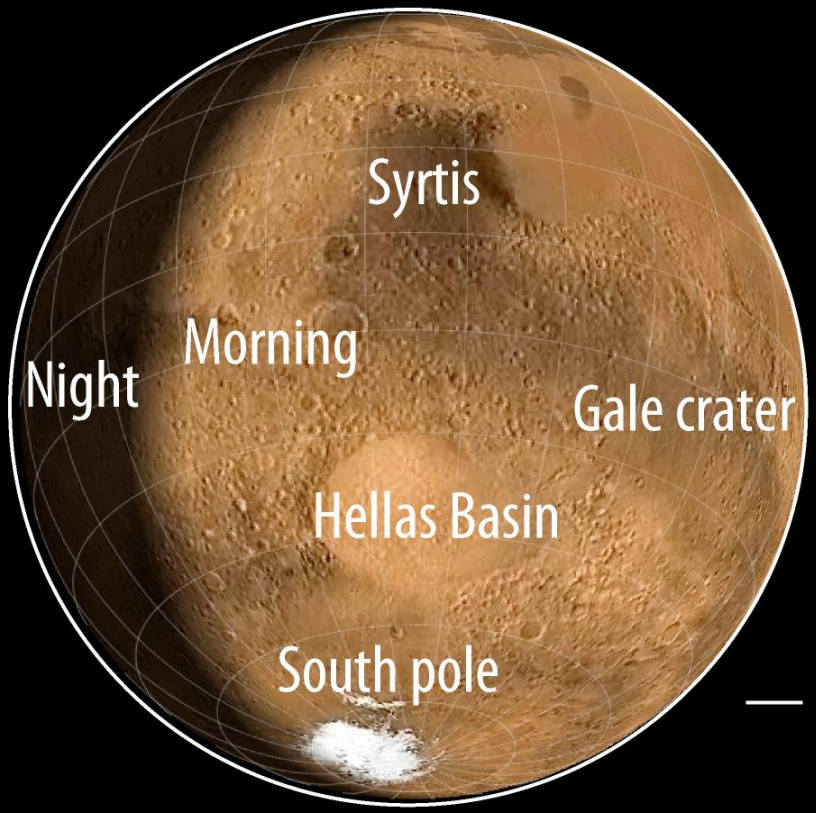
From Villanueva et al. 2016

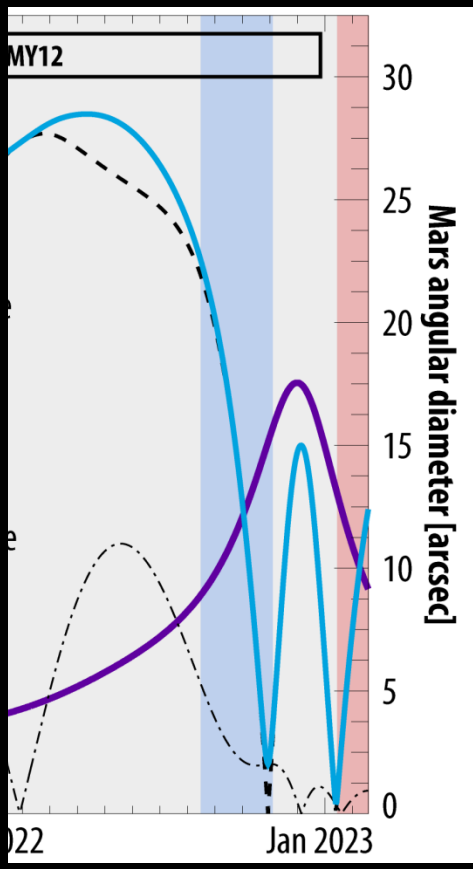
Mars disk - December 14th 2018

Ls:306° - Southern Summer

Angular diameter: 8.4 arcsec







NIRSpec

0.2 x 3.3 arcsec^2 slit

160 x 80 km^2 pixel area

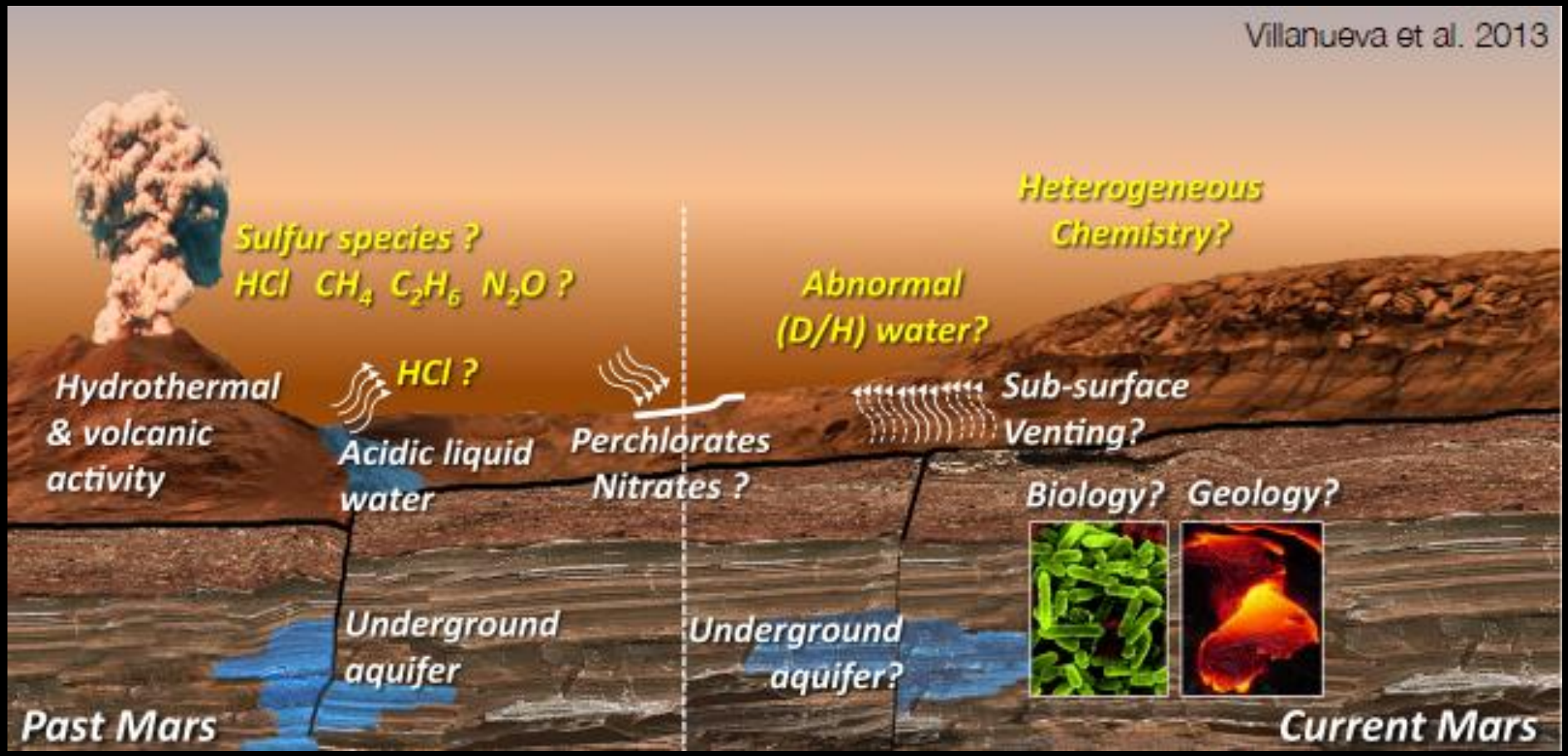
JWST Resolution

0.07 arcsec at 2 μm

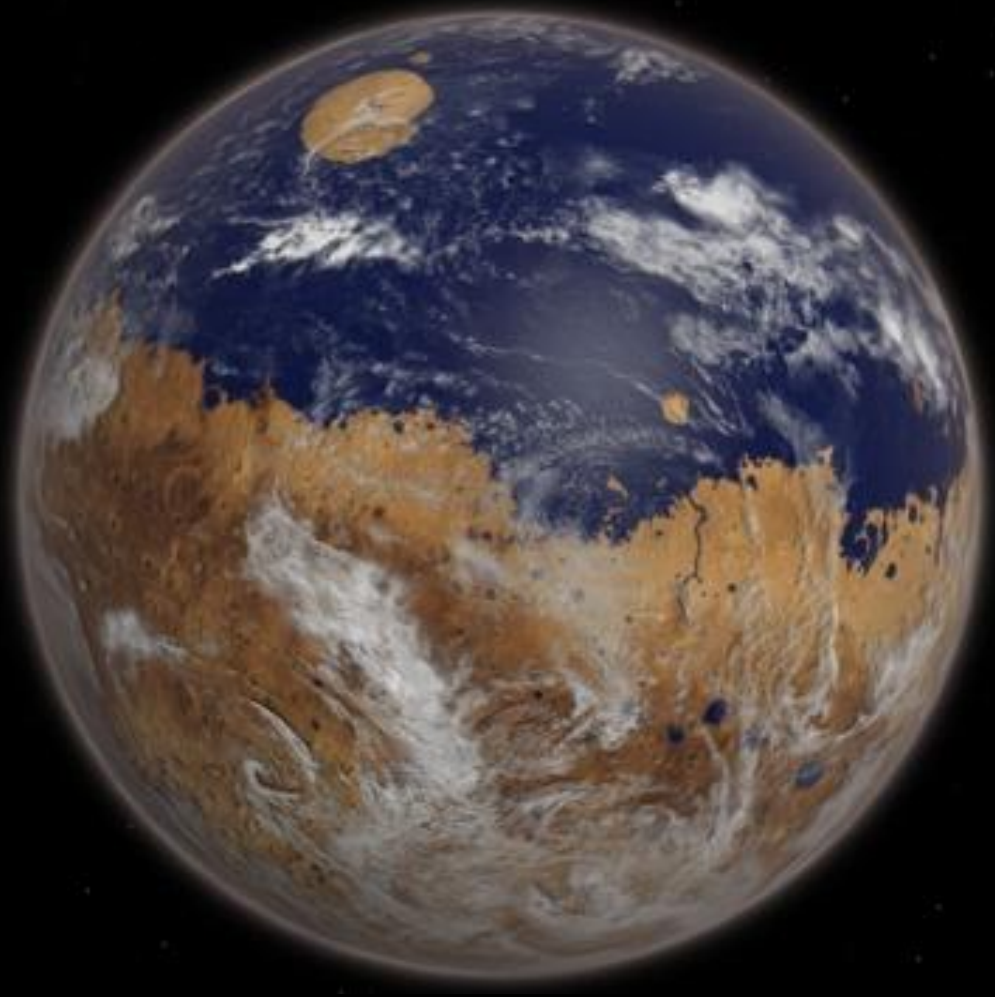
50 km on Mars

Villanueva et al. 2016

Mars *Remote* Science

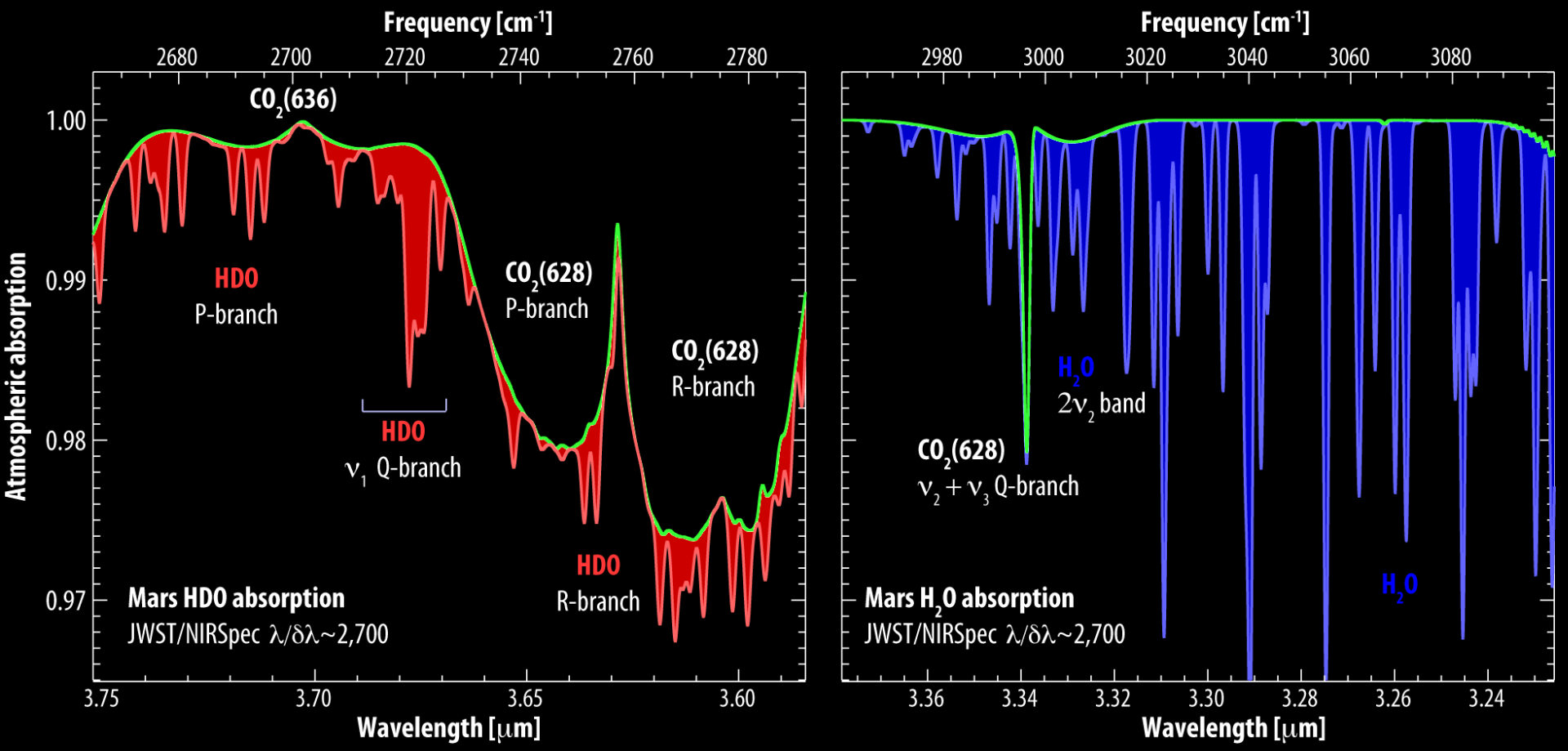


Water (D/H) on Mars



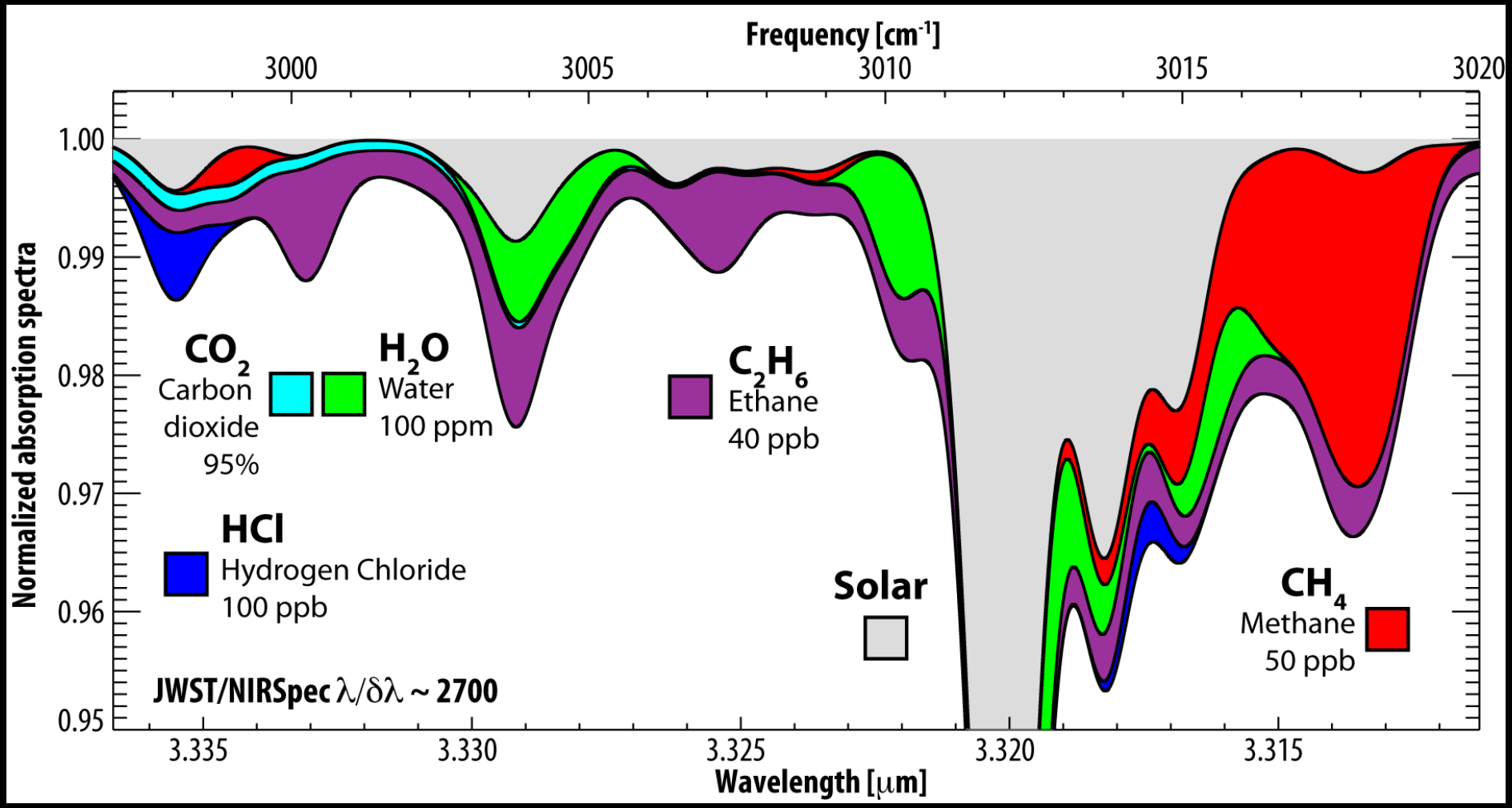
Villanueva et al. 2015

HDO and H_2O with NIRSpec



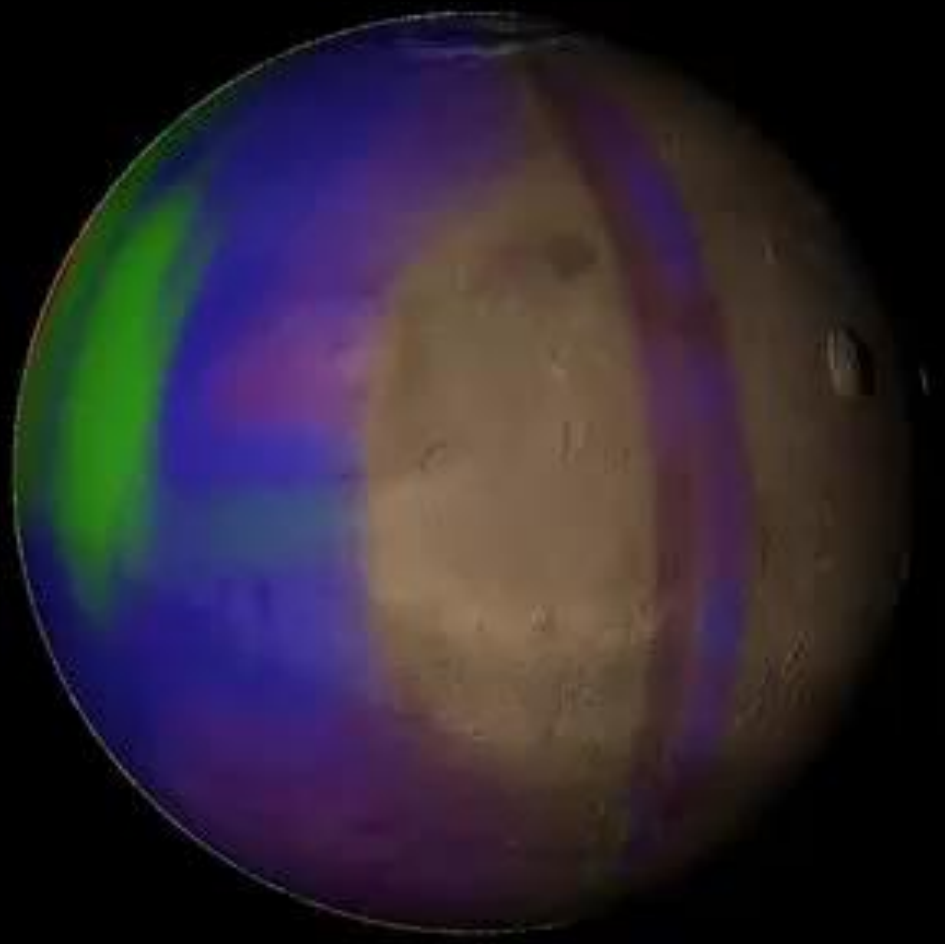
Villanueva et al. 2016

Organics on Mars



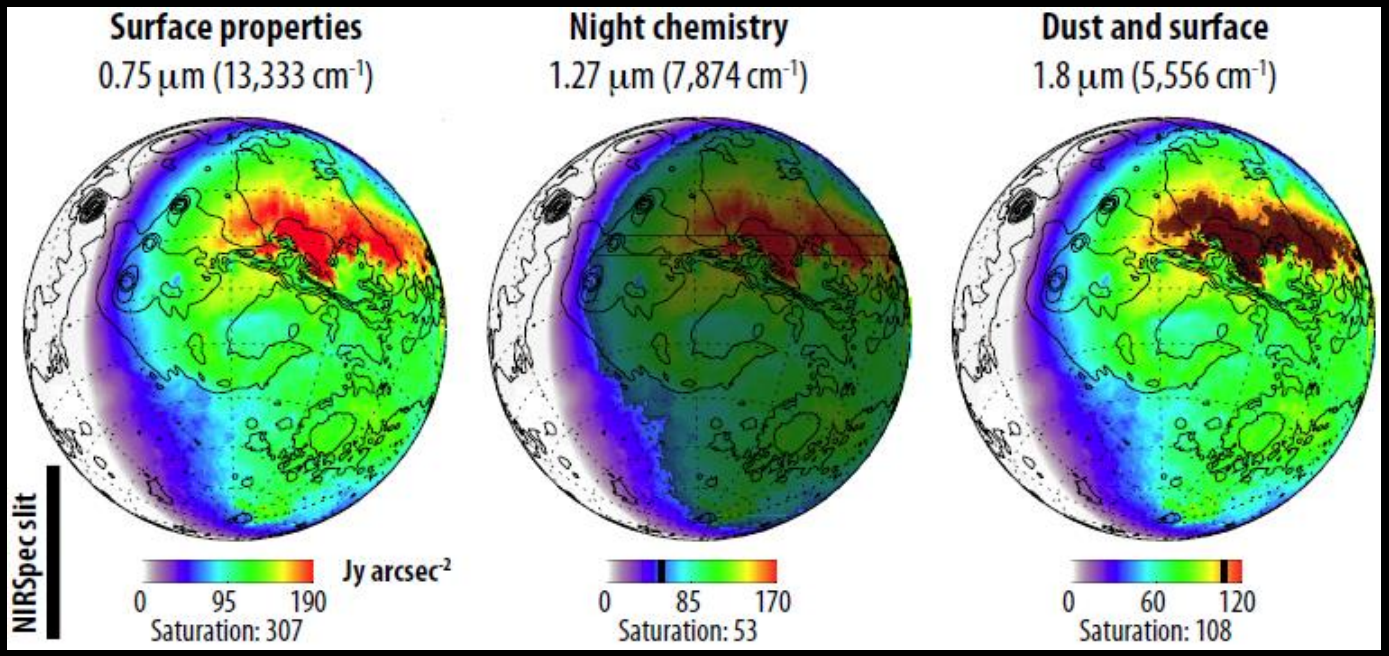
Villanueva et al. 2016

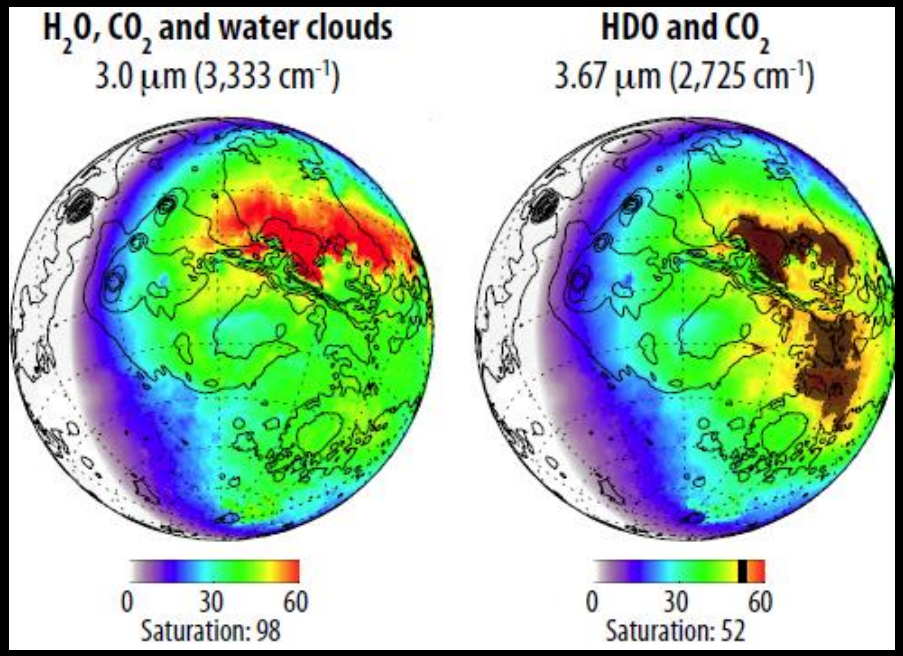
Methane Maps with JWST



NIRSpec
Narrow Slit
0.2”x3.3”

From Mumma et al. 2009





Villanueva et al. 2016

JWST status today

JWST Status

Remaining I&T Activities

Science Payload

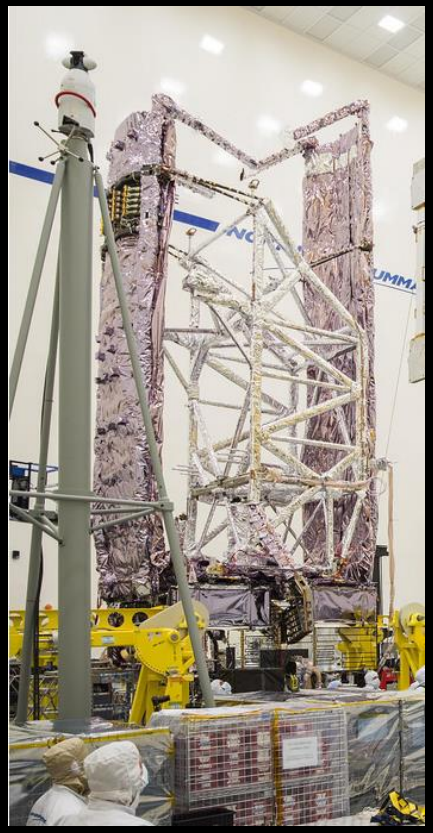
- OTIS Deployments at NGAS (secondary mirror & ISIM radiator)

Spacecraft Element

- ***Acoustics, vibe, and thermal vacuum tests***
- Post-Environmental deployment & stow

Observatory Integration

- Pre-environmental Observatory deployments
- Observatory fold & stow
- ***Observatory system (electrical) test***
- Observatory vibration, acoustics tests
- ***Observatory deployment***
- Observatory stow for launch
- Observatory final system test



JWST Status (March 2018)

- Spacecraft Element (SCE) completed, stowed in launch configuration
  - Performance testing complete and ready for environmental testing
  - Sunshield
    - 7 small tears in the sunshield and sunshield covers have been repaired
    - Lessons learned from first deploy/fold & stow were significant
  - Spacecraft
    - Major impact to schedule due to propulsion valve and transducer rework
    - Dual Thruster Modules removed, valves refurbished, DTM's reinstalled, pressure check was good
- Optical Telescope Element (Telescope & Instruments)
  - Full performance and environmental testing complete and OTE delivered for Integration and Test
- Launch Readiness Date (LRD) of March - June 2019 not possible due to lessons learned during SCE Integration & Test (I&T) and propulsion system rework
- Standing Review Board (SRB) has reviewed project schedule and their analysis yields an LRD of ~May 2020 at 70% confidence
- Independent Review Board, chaired by Tom Young; final report ~May 2018
- NASA's final agency decision in June 2018

From Zurbuchen 3/2018

More
JWST
information

Cycle 1 GO Proposal Call (TBD)

Program Category	Size	Estimated Allocation*
Small		
Medi		
Large		

LATEST NEWS:
JWST non-proprietary data
– including Mars! –
will be considered for archival proposals
in Cycle 1!

Useful Documentation

https://jwst-docs.stsci.edu/display/JPP/JWST+Moving+Target+Observations

James Webb Space Telescope User Documentation

HOME | INSTRUMENTS | PLANNING | CALL FOR PROPOSALS | DATA | Search

JWST Observation Planning Documentation / JWST Observing Methods

JWST Moving Target Observations

JWST can track and observe planets, satellites, and nearly all comets and asteroids more than 1 AU from the Sun.

JWST offers the capabilities necessary for observing Solar System ("moving") targets. Imaging and low- and medium-resolution spectroscopy spanning 0.6–28.5 μm provide high sensitivity and spatial resolution, both without interference by Earth's atmosphere. JWST is on a solar orbit near Earth's L2 point, so scheduling is much more flexible and efficient than for HST (which is in a low-Earth orbit). The thermal design of JWST only allows Solar System targets to be observed near quadrature; observations at opposition are not feasible.

An overview of JWST's Solar System capabilities and exploration of some possible science applications can be found in Milam et al. (2016), Norwood et al. (2015), and this overview flyer. The

JWST Observing Methods

On this page

- Related links
  - Moving target articles
- References

Useful links and details

https://jwst-docs.stsci.edu/display/JPP/JWST+Moving+Target+Observations

Related links

JWST User Documentation Home

Moving target articles

- Field of Regard Considerations for Moving Targets
- Instrument-Specific Considerations for Moving Targets
- JWST Moving Target Calibration and Processing
- JWST Moving Target Ephemerides
- JWST Moving Target Observing Procedures
- JWST Moving Target Policies
- JWST Moving Targets in APT
- JWST Moving Targets in ETC
- JWST Moving Target Useful References and Links
- Moving Target Best Practices
- Overheads for Moving Targets

References

2016, PASP, 128

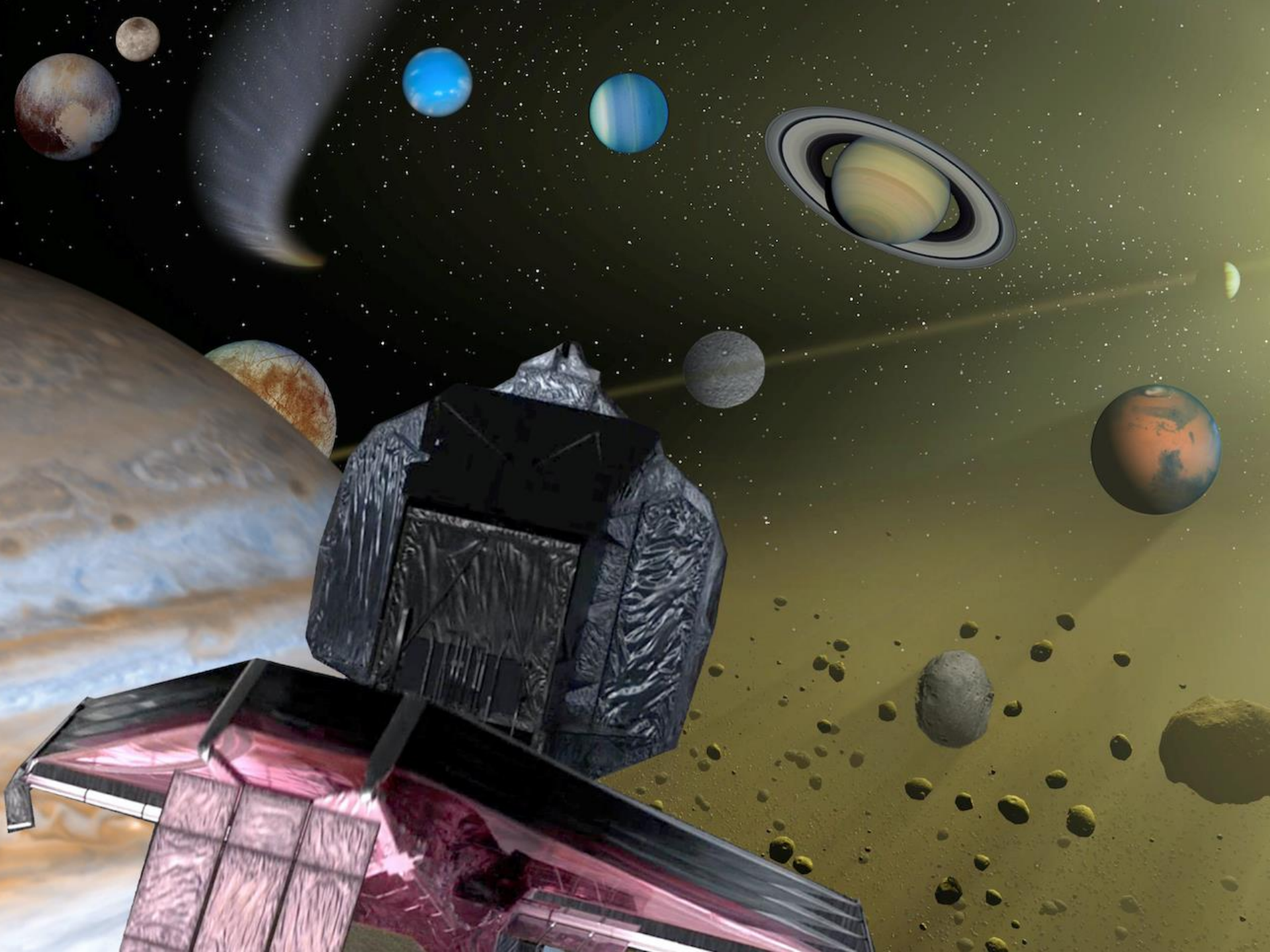
- JWST Proposing Considerations
- JWST Proposing Tools
- JWST Observing Guidance

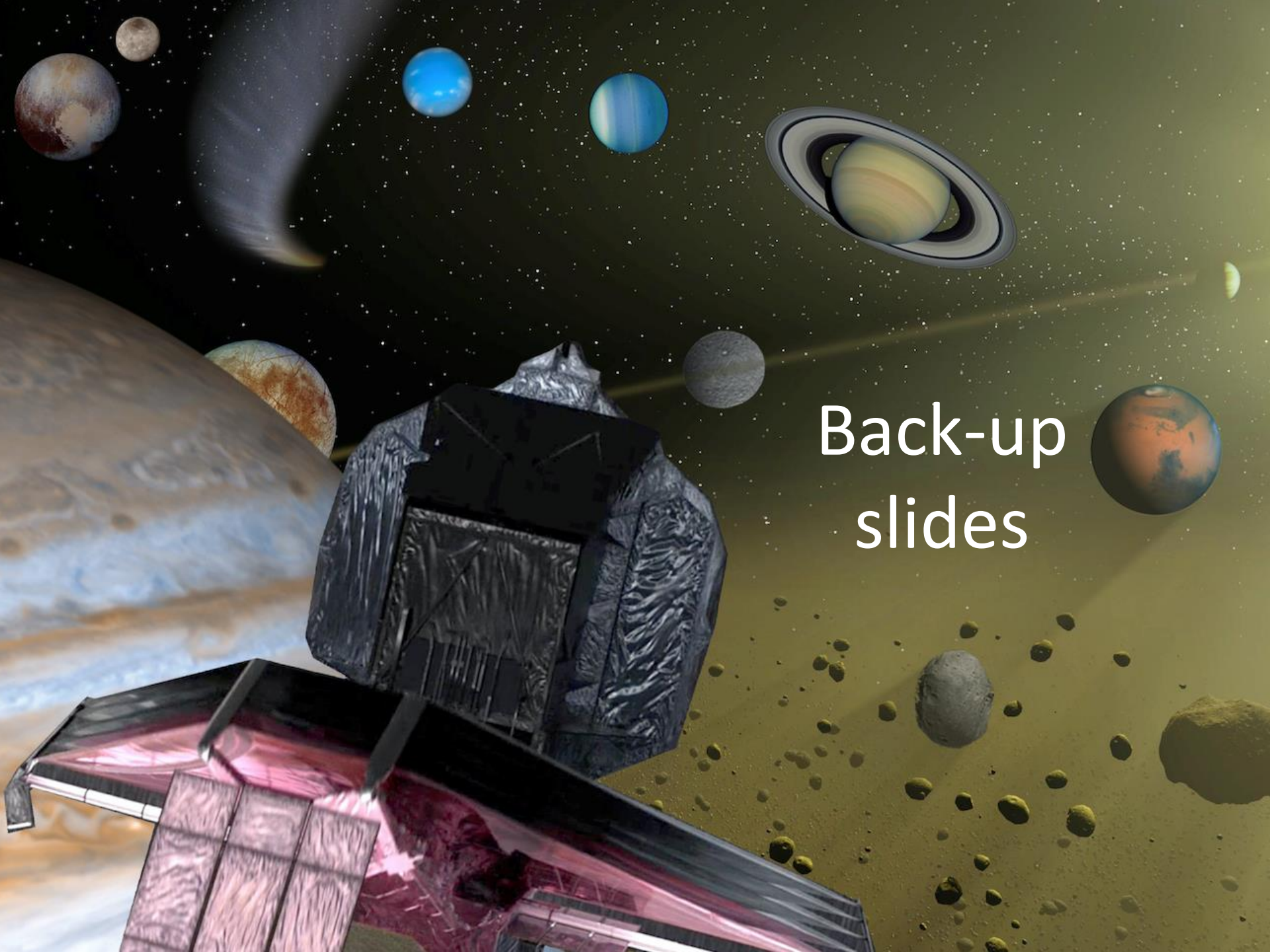
Last updated

Published May 26, 2017

How to Learn More:

- JWST Documentation page:
  - https://jwst-docs.stsci.edu/
- JWST Events:
  - https://jwst.stsci.edu/events
- PASP articles (Volume 128,Number 959, 2016 January):
  - https://tinyurl.com/y7q6kfra
- Contacts:
  - Heidi Hammel (hbhammel@aura-astronomy.org)
  - Stefanie Milam for JWST project/proposal details (stefanie.n.milam@nasa.gov)
  - John Stansberry (jstans@stsci.edu)
  - Geronimo Villanueva for “Mars with JWST” specifics (Geronimo.l.Villanueva@nasa.gov)



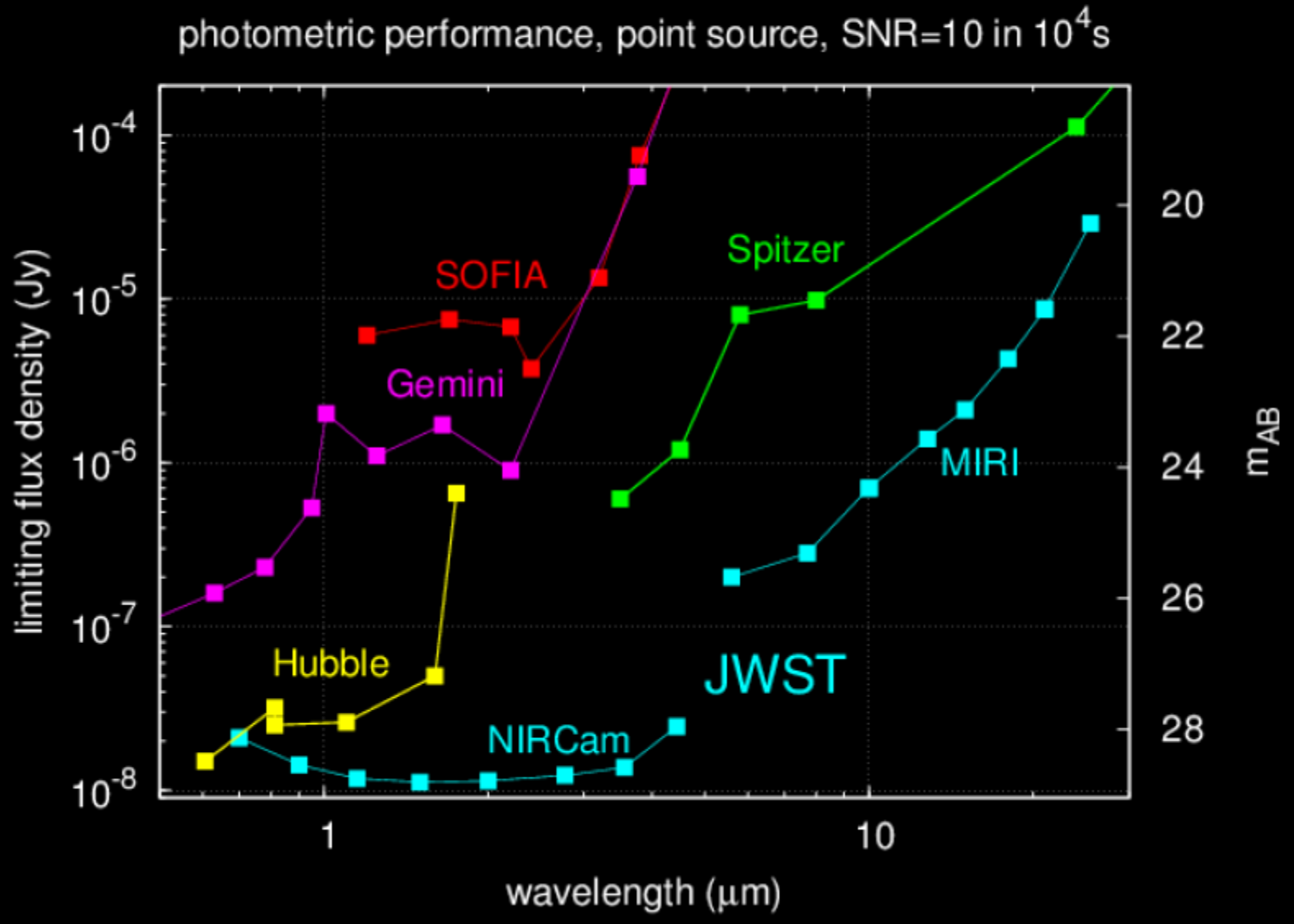


Back-up slides

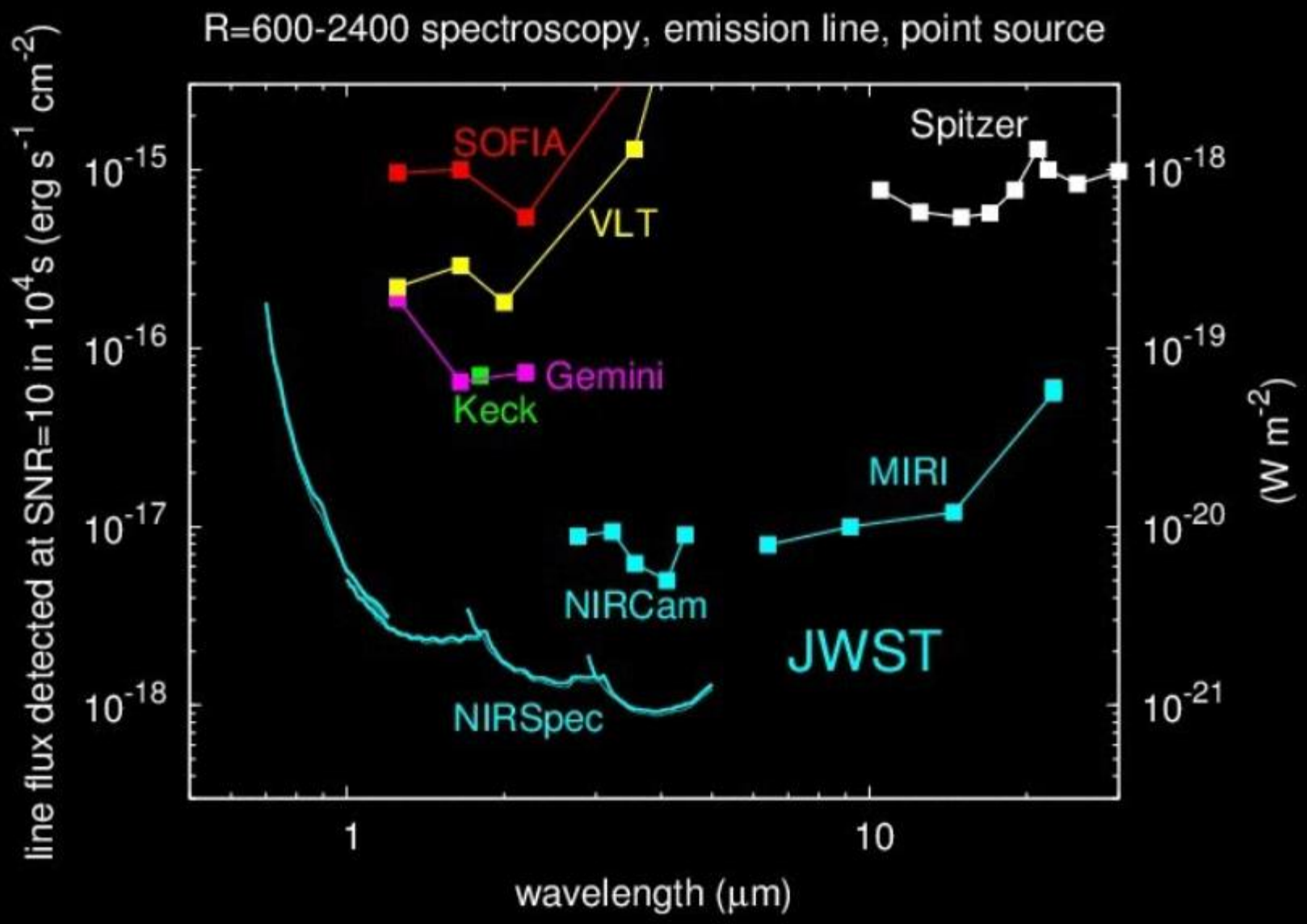
JWST Vital Stats

- General Observatory: 5 years required; 10 years goal
- Primary mirror: 21.3 feet (6.5 meters), in 18 segments
- Sunshield: 5 layer, 69.5 feet by 46.5 feet (21.2 meters by 14.2 meters
- Orbit: 930,000 miles (1.5 million kilometers) from Earth around (and avoiding) L2 point
- Operating temperature: Below 50 Kelvin (–370° Fahrenheit)
- Four Science Instruments covering 0.6–28.5 microns (diffraction limited at 2 microns)
  - Filtered Imaging
  - Spectroscopy – Slit, Integral Field, Grism/Prism
  - Coronagraphy – Traditional Lyot + Four Quadrant Phase Masks
  - Aperture Mask Interferometry – Non-Redundant Mask (NRM)

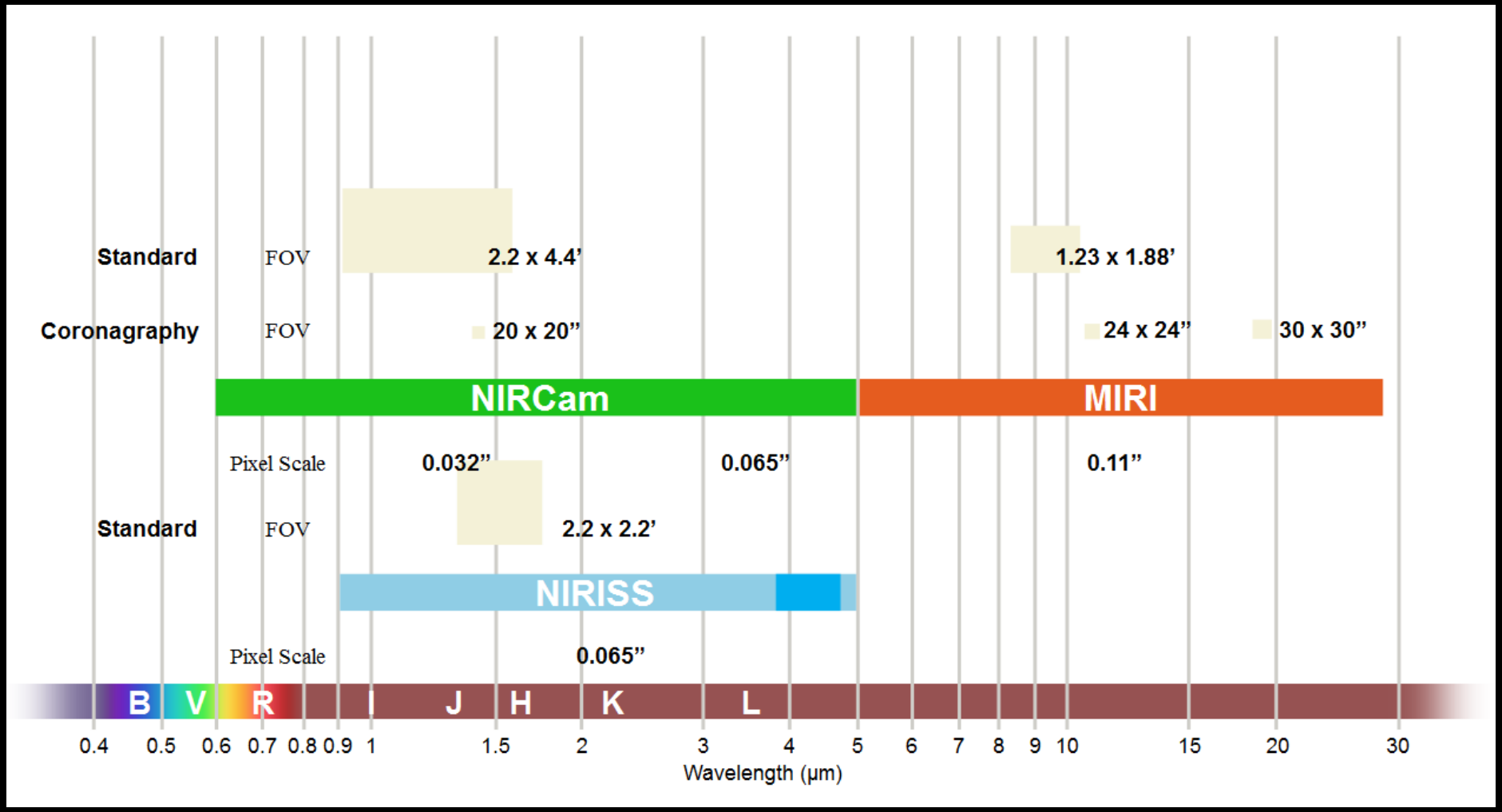
Sensitivity



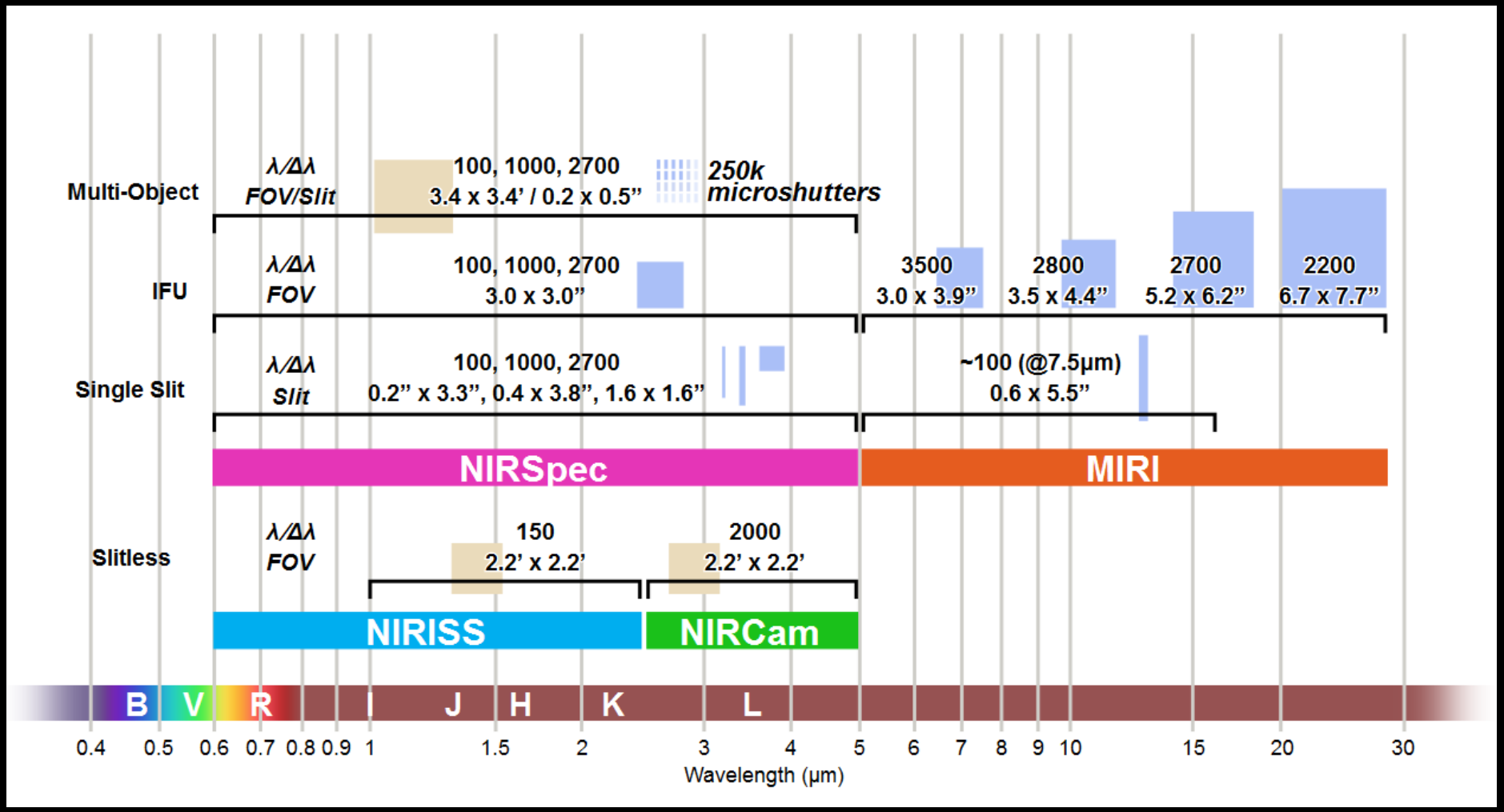
Sensitivity



Imaging Modes



Spectroscopic Modes



Webb 18 Month LRD Impact From October 2018 LRD

Multiple "critical paths" are tracked during project development

15 months of technical issues (**impacts do not add linearly**)

- Spacecraft critical path dominated by the propulsion system – 13 months
  - 3 Months - Transducer problem
  - Dual Thruster Module rework slip of 9 months (much of this was worked in parallel with Sunshield issues)
  - 1 Month - Recovery from incorrect voltage applied to the catalyst bed heater
- Sunshield Complications – 7 months
  - 4 months – Deploy/Fold/Stow (2 months to go)
  - 2 months – Tear repairs (1 month to go)
  - 1 month – Snag guard implementation (0.5 months to go)
- Observatory I&T Replan – 3 months
  - 3 months – OTE lessons learned and applied to SCE & reduction in parallel task activities
- 3 months additional funded schedule reserve

From Zurbuchen 3/2018