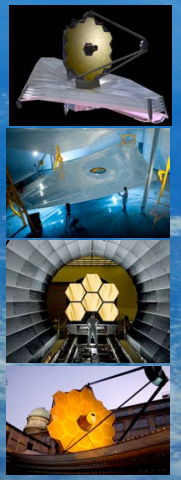
JWST is an international partnership between NASA, ESA and the CSA.

JWST status and prospects for habitability studies

Pierre Ferruit (ESA JWST project scientist)



Extreme Habitable Worlds – ESLAB 51
3-6 December 2017 – ESA/ESTEC

Acknowledgements

All along this presentation you will see results from work conducted by a large number of teams in Europe, USA and Canada.

Many elements of this presentation are based on existing presentations prepared by other members of the JWST project, the instrument teams and STScI.

Thanks to the organisers for inviting me to give this talk on JWST.

Contents of the presentation

The JWST mission in a nutshell.

Mission status

- The launch date and its recent move to Spring 2019.
- Hardware status and pictures. Next steps.
- Timeline for scientists.

A (very) quick overview of JWST modes

Prospects for habitability studies (two examples)

- Characterizing earth-size exoplanets. A long-term goal for JWST.
- Looking into our own Solar System, ocean worlds.

Conclusion.

The James Webb Space Telescope

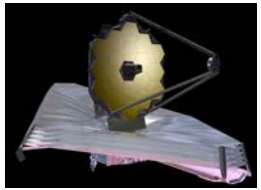
JWST is often presented as the successor of the very successful Hubble Space Telescope (HST).

Large space observatory optimised for observations in the near- and mid-infrared.

- *6.5m primary mirror; 0.6-28.5 micron wavelength coverage.*

To be launched in Spring 2019 by an Ariane 5 rocket.

Mission duration: 5 years (requirement) but all consumables have been sized for at least 10 years



JWST - An international partnership.

JWST is a partnership between NASA, ESA and CSA.

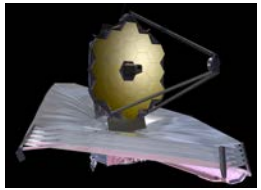
- *High-priority endeavor for the associated astrophysical communities.*

ESA (and CSA) have been present since the very early phases of the mission.

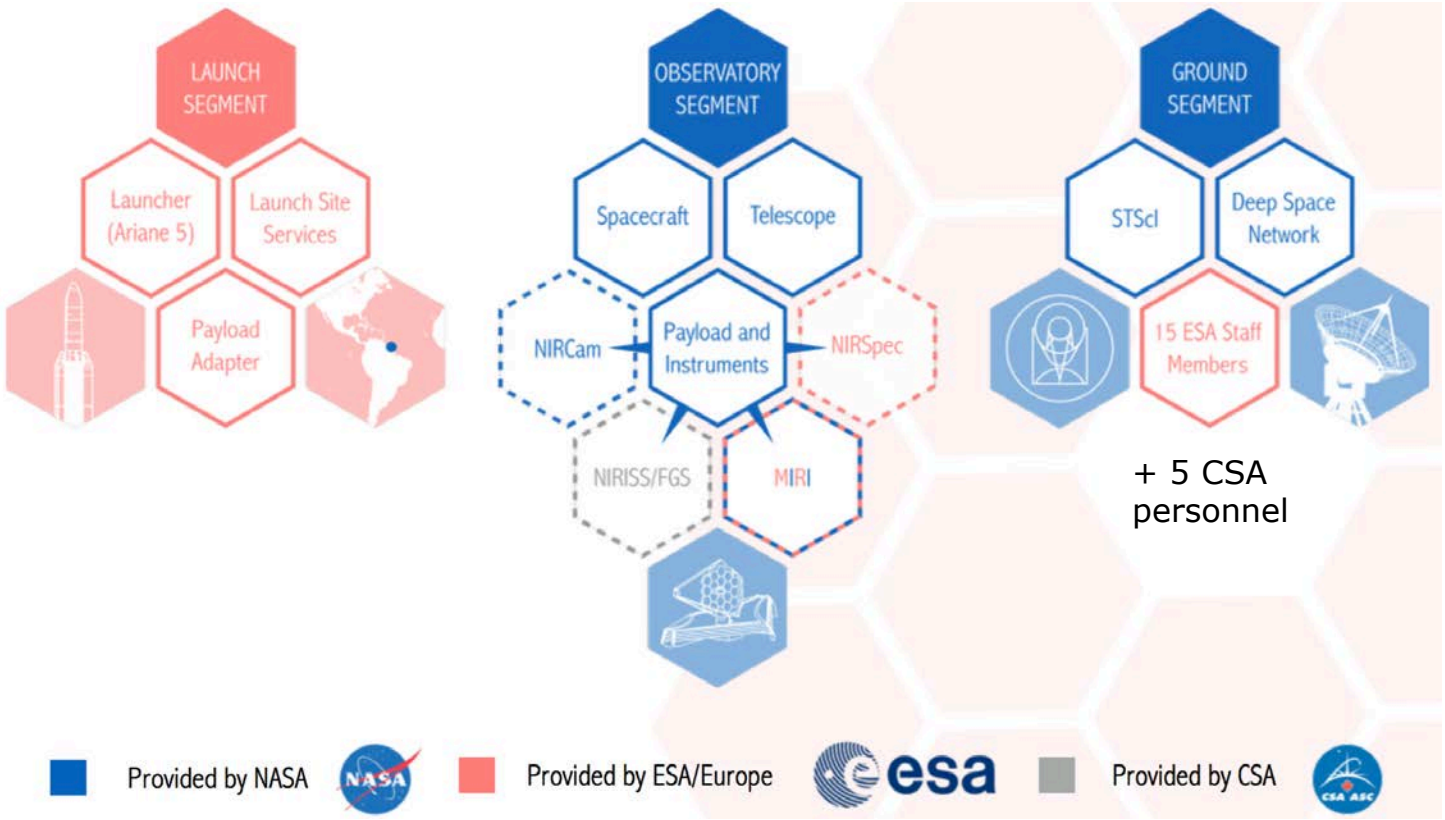
- *They were invited to join the project in 1997 at a time when the telescope was still called the "Next Generation Space Telescope" (NGST).*
- *The contribution of Europe to the mission gets consolidated around 2000.*

In return for this contribution, at least 15% of the total JWST observing time will go to ESA member state applicants.

- *Following the same scheme than the one successfully applied to HST.*



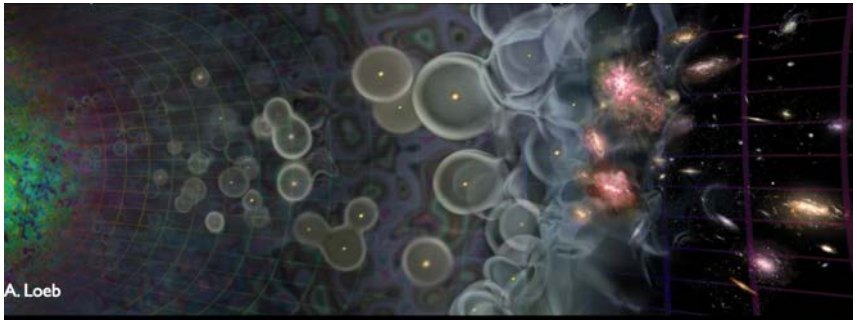

JWST - An international partnership.

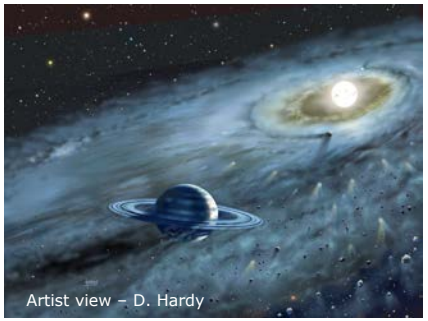


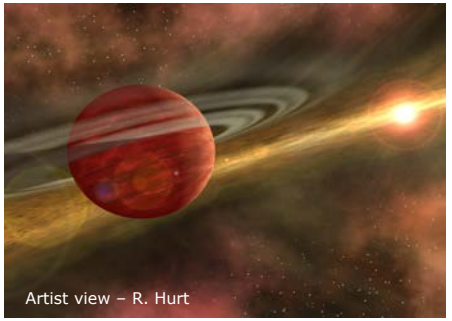
Important and visible participation involving ESA as well as European institutes and industry.

Credit for the figure:
Nora Lützgendorf

JWST - A general-purpose observatory







JWST is a general-purpose observatory and its science goals encompass a very broad set of science topics.

Yearly calls for proposals that will be peer-reviewed by a time allocation committee.

JWST – An impressive piece of hardware

instruments

telescope

Image credit: NASA

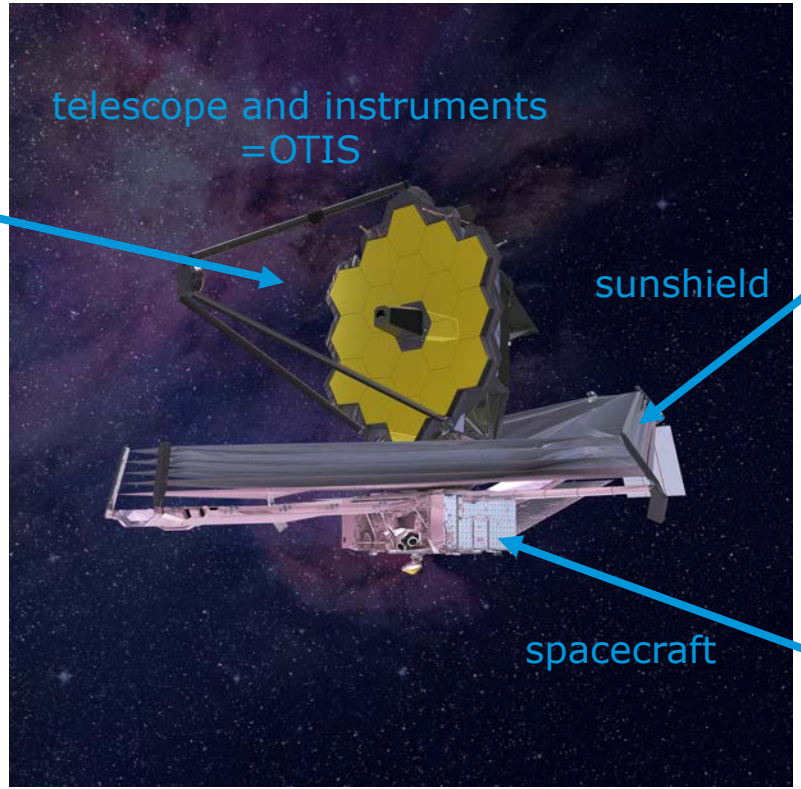
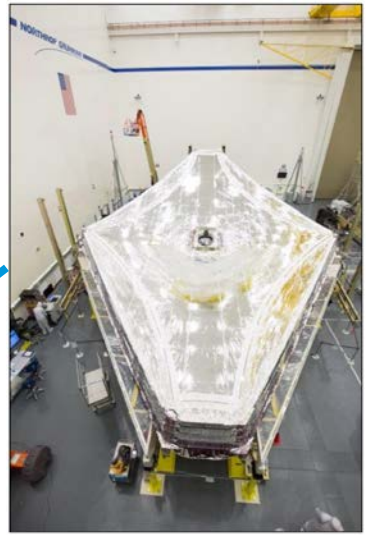


Image credit: NASA



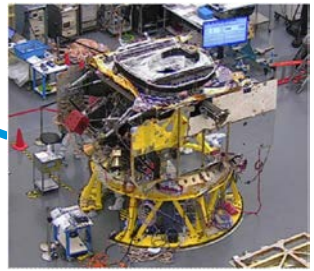


Image credit: Northrop Grumann

JWST is now launching in Spring 2019

Since 2011, the mission had remained on schedule and on cost.

In 2017, NASA took a detailed look at the remaining integration and testing steps.

The conclusion of this schedule assessment was that some activities were taking or would take longer than initially planned and this led to move JWST's launch date by 6 months.

JWST is scheduled for launch in Spring 2019

(formal 90-day launch period covering March-June 2019)

JWST is now launching in Spring 2019

This change is not driven by concerns with the hardware or with the expected performances of the observatory.

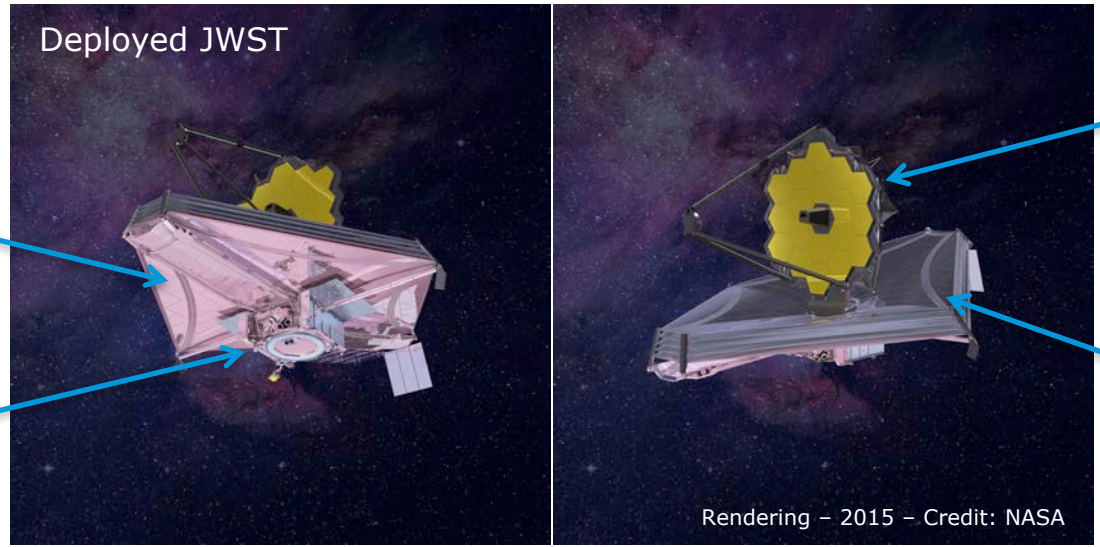
➔ All tests and measurements so far indicate that JWST remains the amazingly powerful observatory it was promised to be!

JWST is a very complex mission and the decision from NASA shows that they are not cutting corners. The focus is on making sure the telescope and the spacecraft have been carefully integrated and thoroughly tested by the time they are launched.

JWST hardware status

At this stage of the integration, all JWST elements have been integrated in two big sub-systems:

- **The telescope and its instruments (this sub-system is called OTIS).**
- **The spacecraft and the sun-shield.**



sunshield

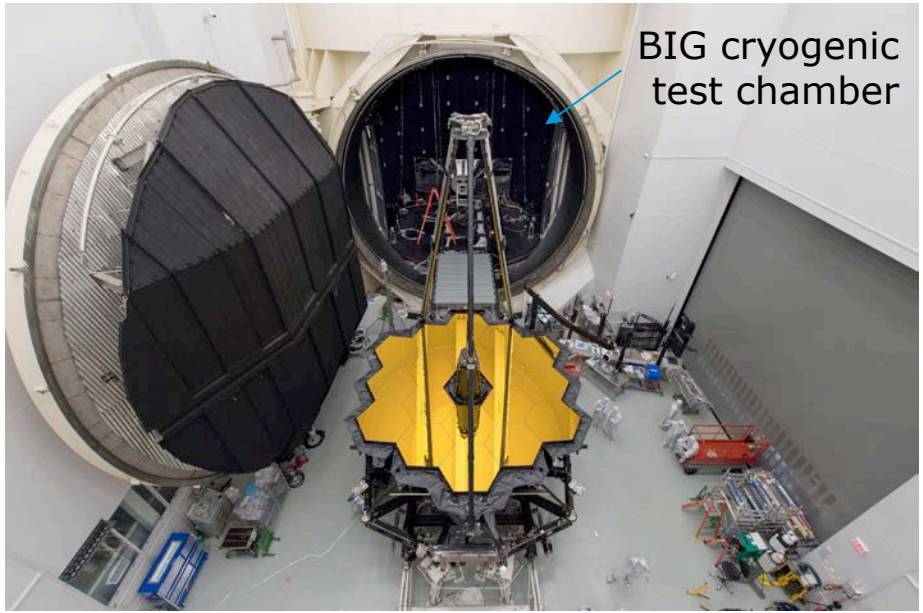
spacecraft

OTIS

sunshield

JWST hardware status - OTIS

JWST's payload module (telescope + instruments = OTIS) just went successfully through of an extensive test campaign including testing at operating temperature.

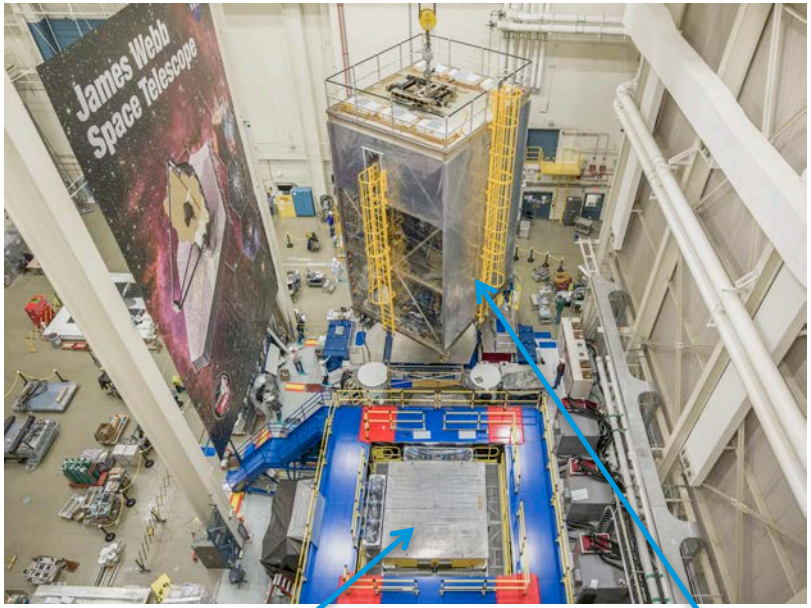


Credits: NASA/Chris Gunn

JWST hardware status - OTIS

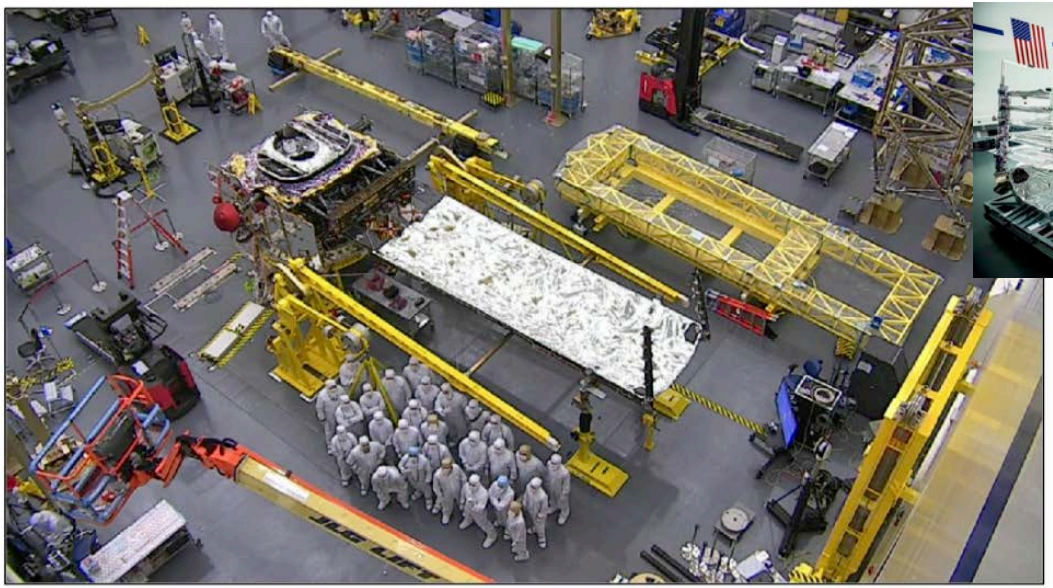
Making sure the telescope and the instruments can survive the harsh conditions of a rocket launch: acoustic and vibration testing.

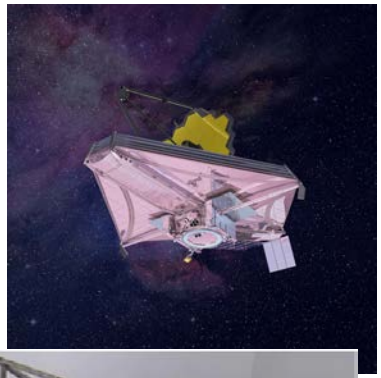
Credits: NASA/Chris Gunn



Status – spacecraft and sunshield

In parallel, the integration of the spacecraft and the sunshield proceeds at Northrop-Grumman's premises in California.





Forward Sunshield Unitized Pallet Structure Attached to the Spacecraft Bus (Northrop Grumman)

Status – spacecraft and sunshield

One particularly complex piece of hardware is the sunshield. Manipulating its elements under 1G is never easy or simple. Its integration, folding, unfolding are done meticulously and carefully!

JWST hardware status - Next steps

- Pack OTIS and ship it to Northrop-Grumman's premises.
- Complete the integration and testing of the spacecraft + sunshield sub-system.
- Put everything together.
- Test the deployment.
- Go through one last series of acoustic and vibration tests.
- Check everything is still right after these tests (including the deployment).
- Pack everything and ship JWST to French Guyana (we are literally shipping it because it will go there by boat through the Panama Canal!).
- Get ready for launch in Kourou.
- **Launch!**

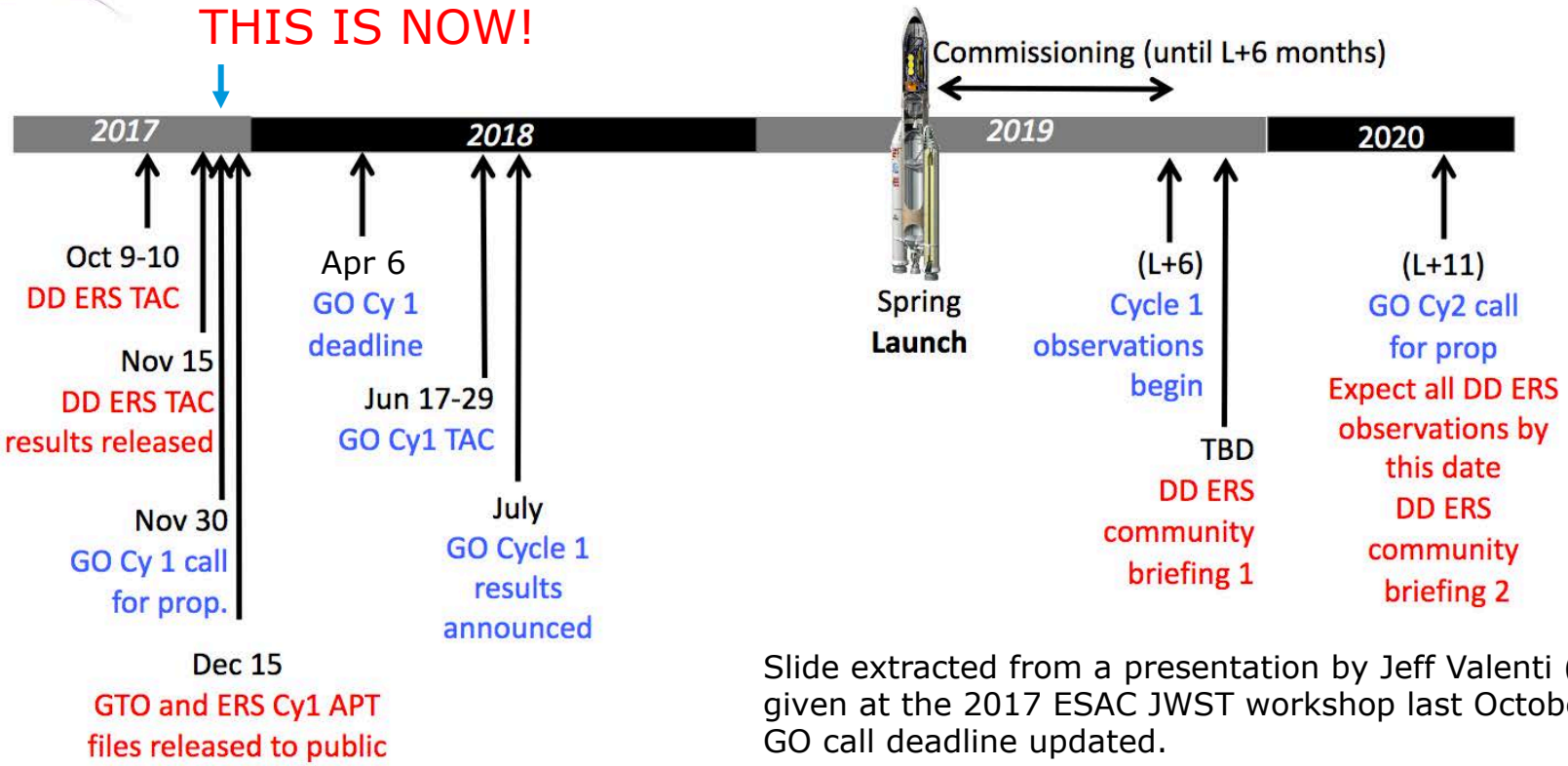
Timeline for scientists

- **Launch in Spring 2019.**
- **6 months of commissioning, bringing the start of the scientific operation of the telescope to Fall 2019.**
- **Navigating JWST's acronym jungle:**
  - GO = general observers = scientists from the community
  - GTO = guaranteed time observers = instrument team members and interdisciplinary scientists who have been granted a fixed amount of JWST time in return for their work for the mission.
  - DDT = director's discretionary time = 10% of JWST's time managed by the director of the scientific operation center (STScI)
  - ERS = Early Release Science = DDT initiative of ~500 hours set up to provide early access to JWST's data to the community as well as high-level data products and tools.

Timeline for scientists

- **Preparing the first year of JWST scientific operation**
- **3 different categories of programs**
  - GTO proposals submitted in April 2017. The programs will be finalised in January 2018.
  - DDT ERS programs submitted and selected earlier this year. The results have been announced in October.
  - GO call for proposals. The call has just been issued (see next slides).

Timeline for scientists



Slide extracted from a presentation by Jeff Valenti (STScI) given at the 2017 ESAC JWST workshop last October.
GO call deadline updated.

Timeline for scientists – GO call

- **The GO call for proposal that will allocate up to 6000 hours of JWST's time has been issued on the 30th of November 2017 (last week).**
- **Deadline: 6th of April 2018.**

Beware, this is happening right now even if launch is in 2019!

Image credit: STScI

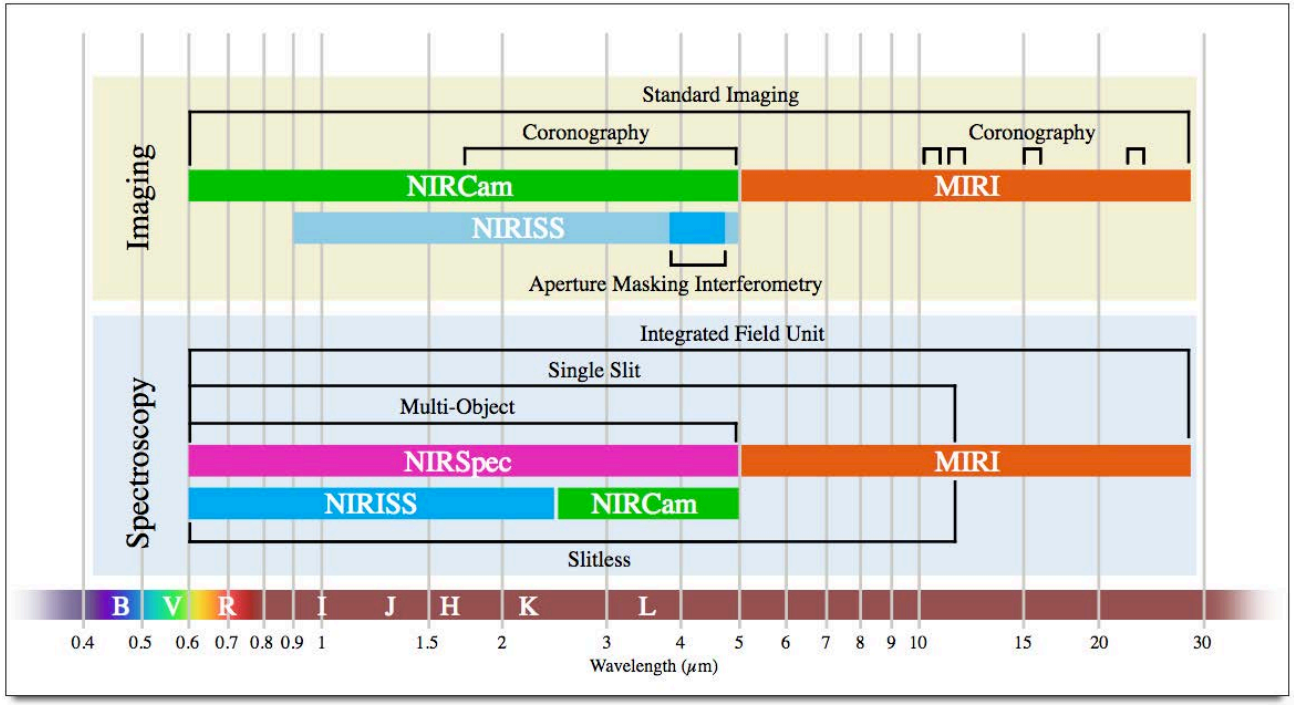
For details, go to:
https://jwst-docs.stsci.edu/display/JSP/James+Webb+Space+Telescope+Call+for+Proposals+for+Cycle+1

Details on GTO and ERS programs

- **No time to present them during this talk.**
- **But they are available on the STScI's web site.**

- **GTO - Just look up for "JWST GTO programs specifications"**
  - https://jwst-docs.stsci.edu/display/JSP/JWST+GTO+Observation+Specifications
- **ERS – Look up for "JWST ERS programs selected"**
  - https://jwst.stsci.edu/news-events/news/News%20items/selections-made-for-the-jwst-directors-discretionary-early-release-science-program

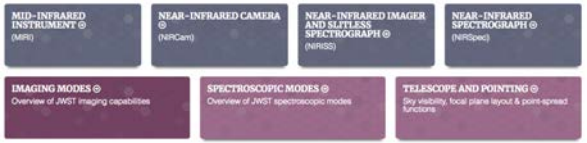
Overview of JWST capabilities



Credit: STScI

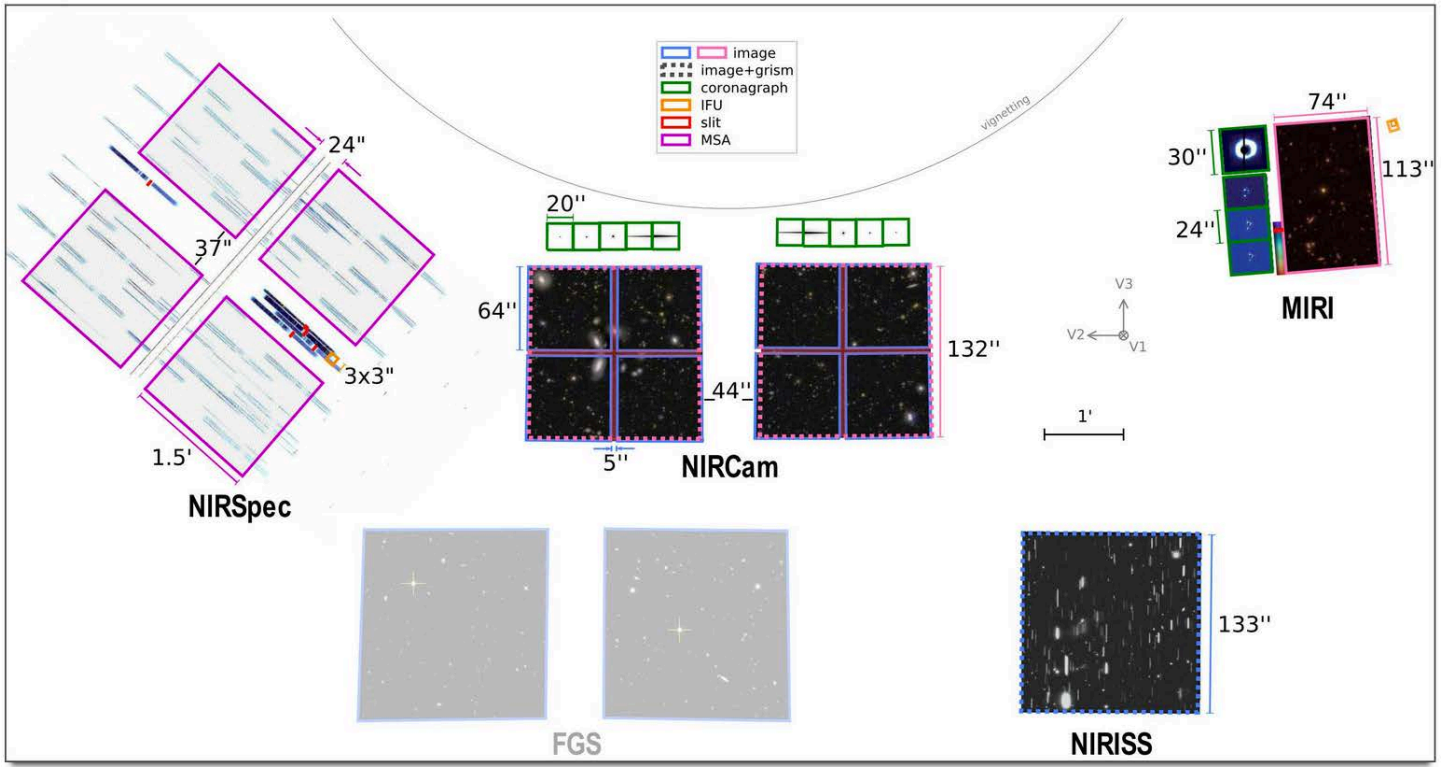
Entry point:

https://jwst.stsci.edu/instrumentation/



Take away message:
A very versatile observatory.

Focal plane layout

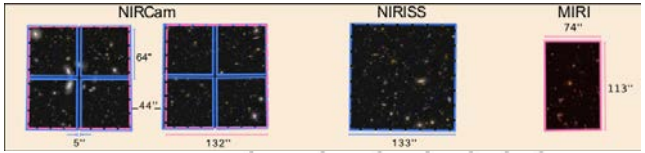


Credit: STScI

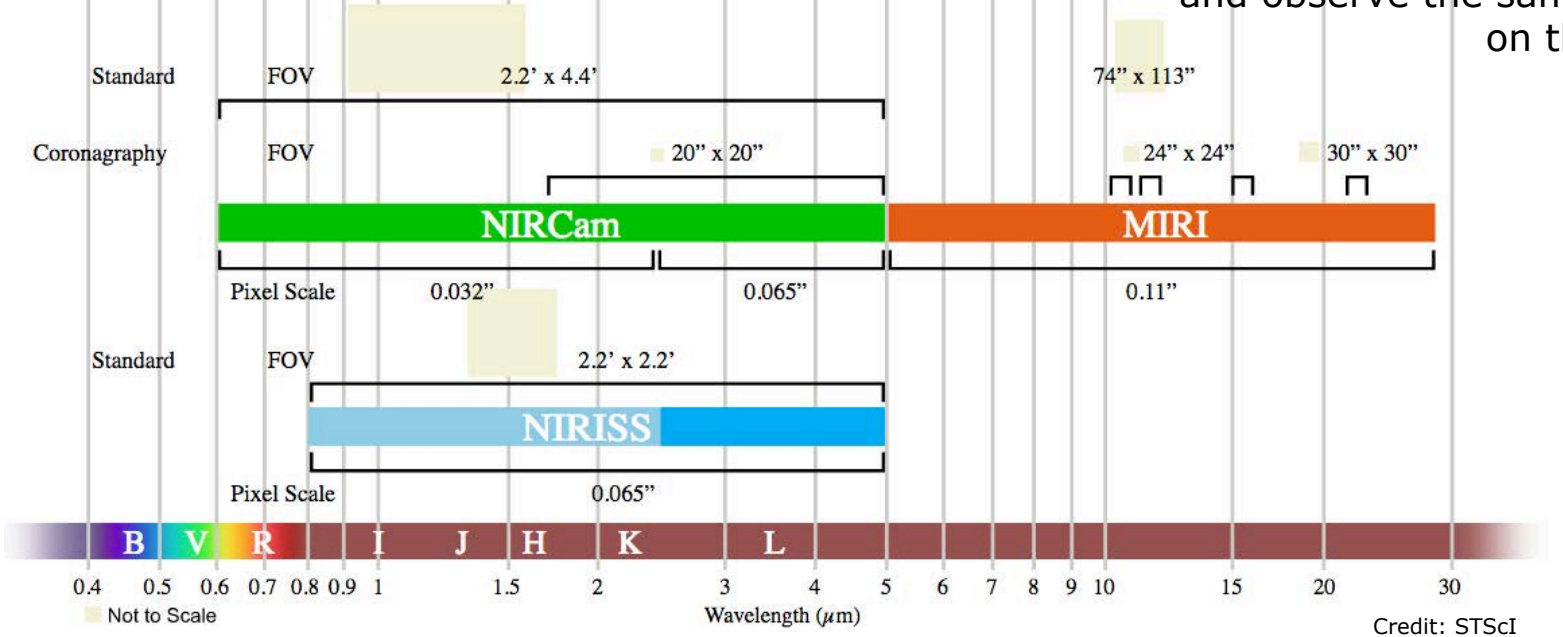
4 instruments and a guider (FGS)

Some instruments can be operated in parallel but do NOT observe the same area of the sky.

Imaging and coronagraphy

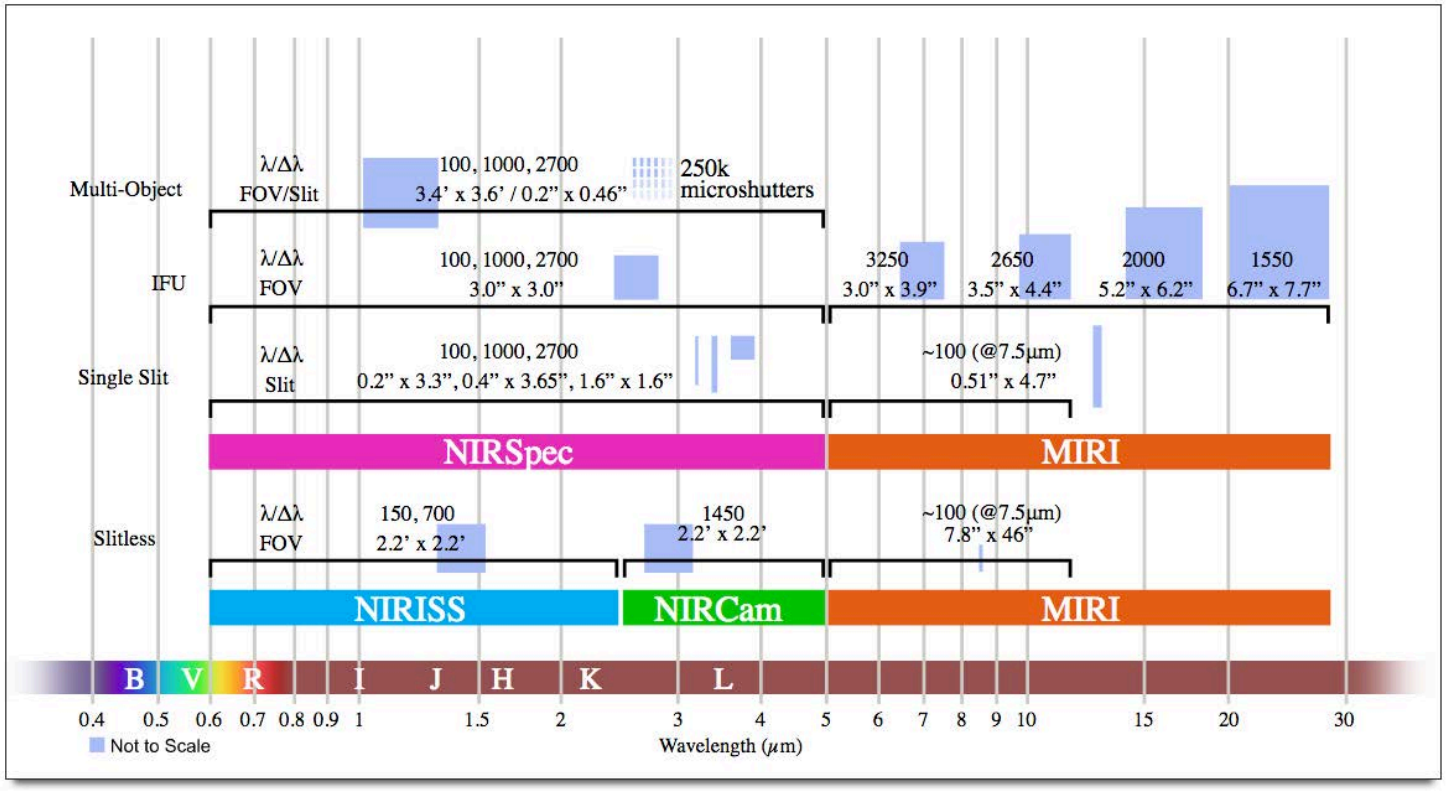


NIRCam short and long wavelength channels can be operated simultaneously and observe the same area on the sky.



Credit: STScI

Spectroscopy



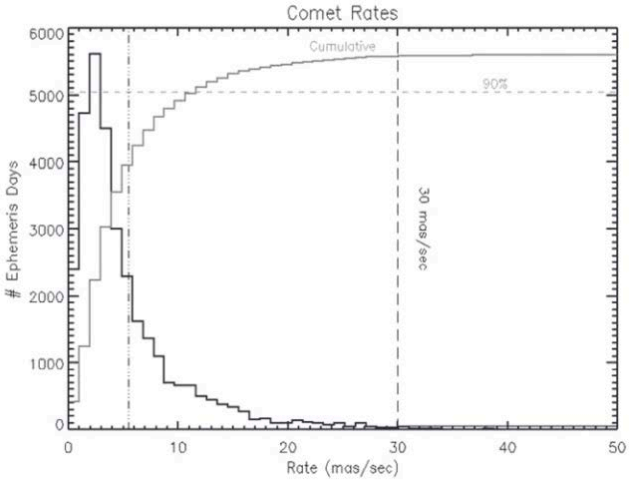
Credit: STScI

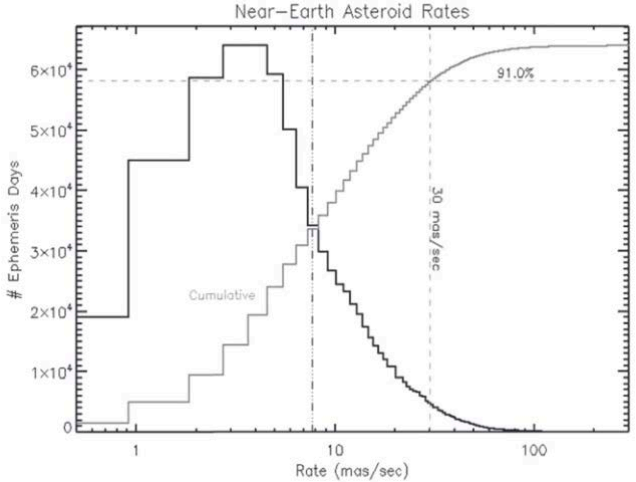
Take-away message:
In JWST, spectroscopy comes in many different flavours. It can address many different scientific needs including time-series observations like transit spectroscopy.

Moving targets

JWST has the capability of observing solar system "moving" targets in the outer solar system (> 1AU).

It can track objects with rates up to 30 mas/s. This gives access to the vast majority of the outer solar system targets.

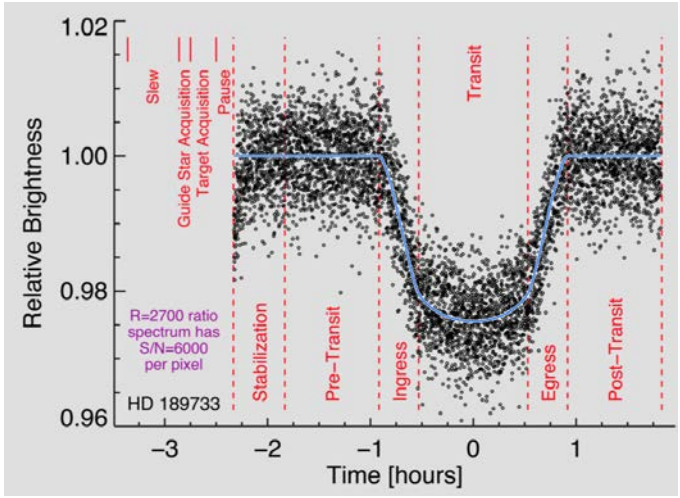


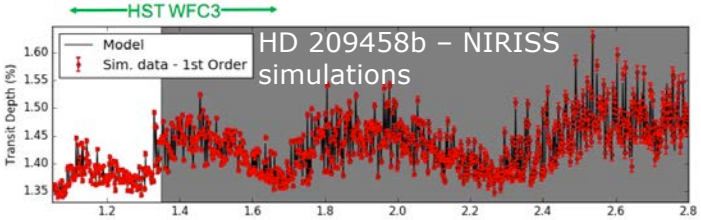


Plots from Milam et al., 2016, PASP, 218

Studying earth-size exoplanets in the HZ

Presentation EXOPAG – Jeff Valenti 2014



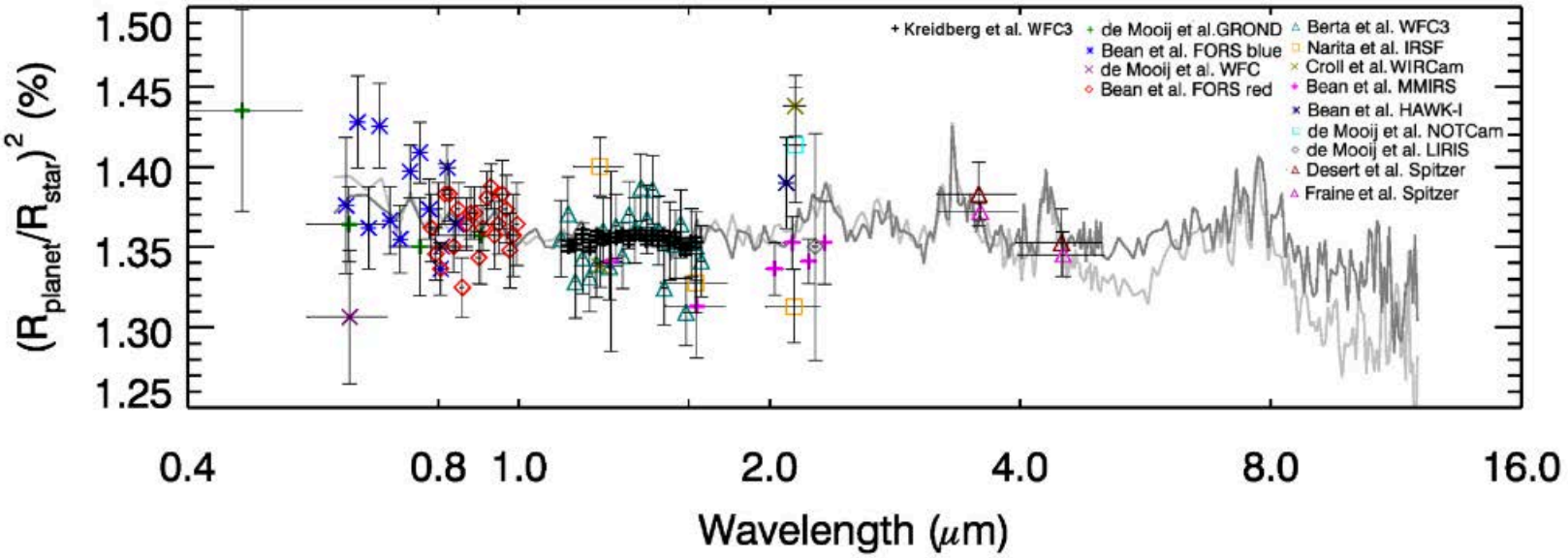


Presentation D. Lafrenière 2016 - JWST conference Montréal

- **Spectroscopy of transiting exoplanets has become a major tool for the characterization of the atmosphere of exoplanets.**
- **JWST will be a game changer.**
  - Large space telescope with plenty of spectroscopic capabilities, some of them specially tuned for transit spectroscopy.
  - Near- and mid-infrared wavelength coverage which is very interesting to study the light reflected, transmitted and emitted by exoplanets.
  - Variety of spectral resolutions (from a few tens to a few thousands).

Studying earth-size exoplanets in the HZ

Barstow et al., MNRAS448,2546–2561 (2015)



Example from Barstow et al. (2015) showing the discrimination power of the longer wavelength parts of the spectrum.

GJ 1214b (super-earth), 15 transits, spectra for different cloud deck altitudes.

Studying earth-size exoplanets in the HZ

But characterizing the atmosphere of earth size exoplanets in the habitable zone of their parent star (M dwarf…) is a long term goal.

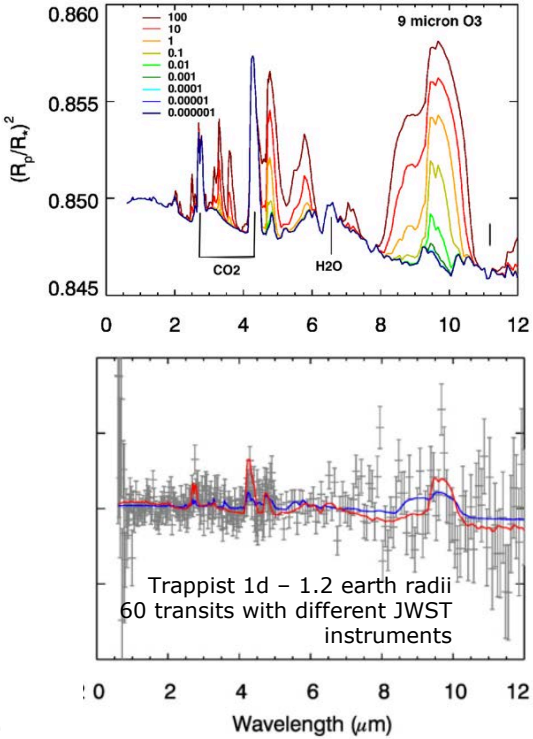
- Extremely challenging even for JWST.

It will require an excellent knowledge of the observatory and of its instruments to be able to understand and correct for systematics.

It will require observing tens of transits (example of Trappist 1, Barstow & Irwin 2016).

Plenty of generic challenges also when trying to reach these levels of accuracy and precision (star variability; clouds…)

See also presentation by V. Meadows at the JWST 2015 conference at ESTEC (https://www.cosmos.esa.int/web/jwst/conferences/jwst2015)



Barstow & Irwin
MNRAS461,L92–L96 (2016)

Studying earth-size exoplanets in the HZ

Looking for and finding these type of signatures in earth-size planets is clearly not something that will be achievable immediately after launch but the scientific interest of these observations is such that scientists are gearing up to propose for them and to meet the challenge.

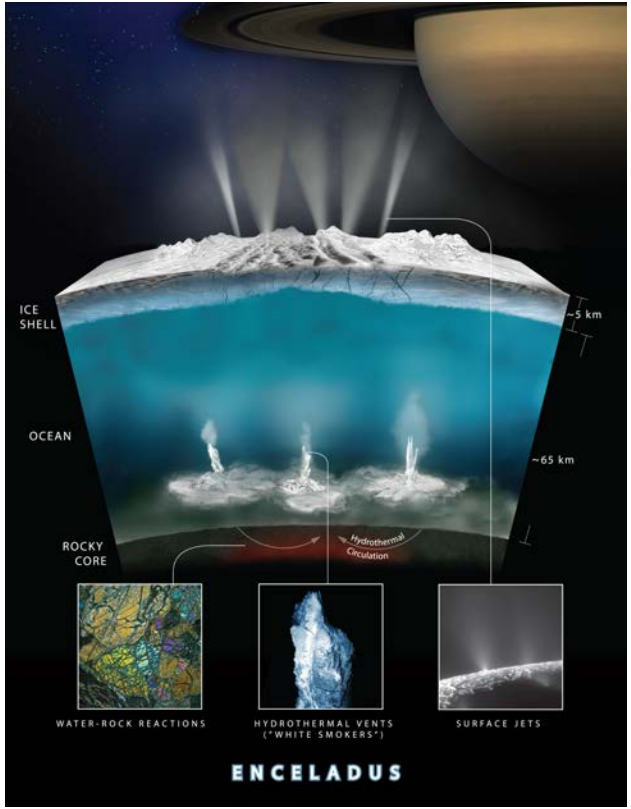
Ocean worlds in our solar system

Much closer to us, the moons Europa and Enceladus belong to the category of so-called ocean worlds.

Studying the plumes of water that breach the surface of these moons.

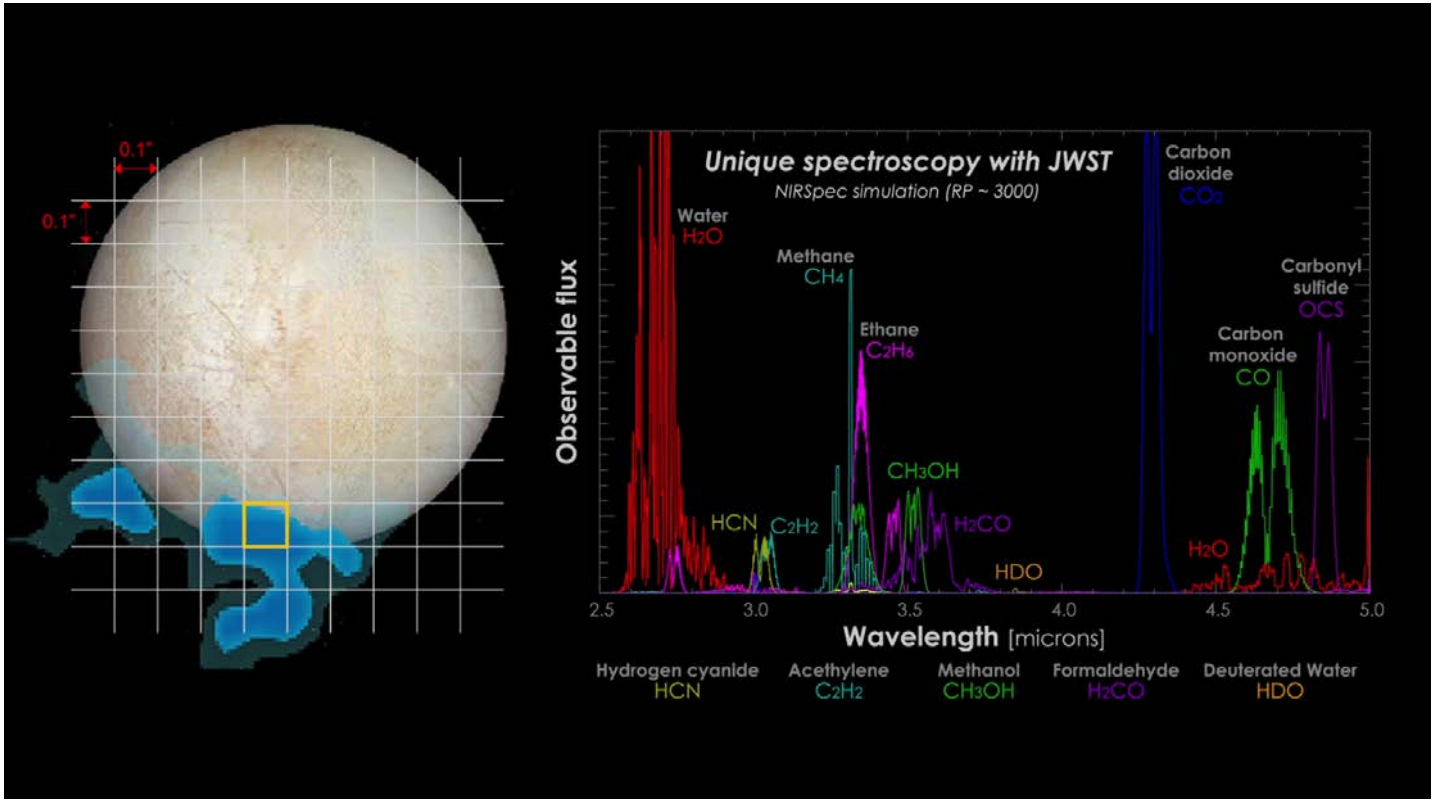
Looking for potential signatures of astro-biological interest.

GTO program led by G. Villanueva (GSFC)
See: https://www.nasa.gov/feature/goddard/2017/nasa-s-webb-telescope-will-study-our-solar-system-s-ocean-worlds



Credits: NASA-GSFC/SVS, NASA/JPL-Caltech/Southwest Research Institute

Ocean worlds in our solar system



The wavelength range covered by JWST is perfectly suited for the detection of the signature of key molecules if they are present.

Spatial resolution is also good!

Credits:NASA-GSFC/SVS, Hubble Space Telescope, Stefanie Milam, Geronimo Villanueva

Ocean worlds in our solar system

Once more, these observations will not be free of challenges (intermittent phenomena) and we do not know yet if these plumes will harbour organic compound signatures but JWST will definitely help characterising these ”ocean worlds”.

Conclusion

JWST teams are working toward a launch in Spring 2019 of what will become a very powerful observatory.

JWST will bring very interesting prospects for habitability studies, even if some of them will be very challenging.

Thanks for your attention!