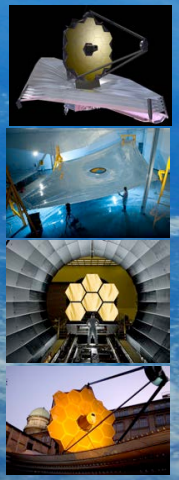
JWST is an international partnership between NASA, ESA and the CSA.

Studying exoplanets with JWST

Pierre Ferruit (ESA JWST project scientist)

Exoplanet science in the coming decade: The bright and nearby future.
EWASS 2017 – Prague – Czech Republic



Contents of the presentation

Brief introduction.

Mission status and scientific timeline.

Overview of JWST's observing modes.

- **Time-Series Observations - photometry.**
- **Time-Series Observations - spectroscopy.**
- **Direct imaging (coronagraphy and aperture-masking interferometry).**

Getting ready to use JWST.

Conclusion.

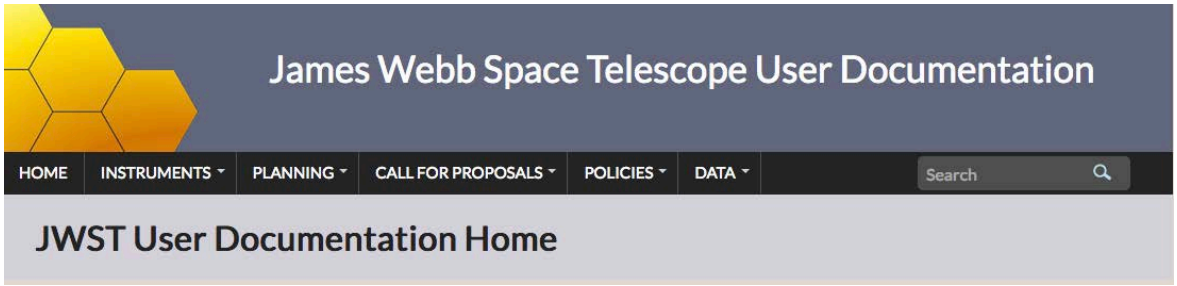
Acknowledgements

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

A lot of material used in this presentation is coming from from STScI's JWST web sites (main resources for getting information):

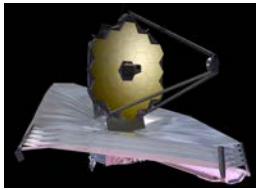
https://jwst.stsci.edu/ (main site)

https://jwst-docs.stsci.edu/ (documentation site, work in progress)



Introduction

JWST will be one of the "great observatories" of the next decade.



Joint mission between NASA, ESA and CSA.

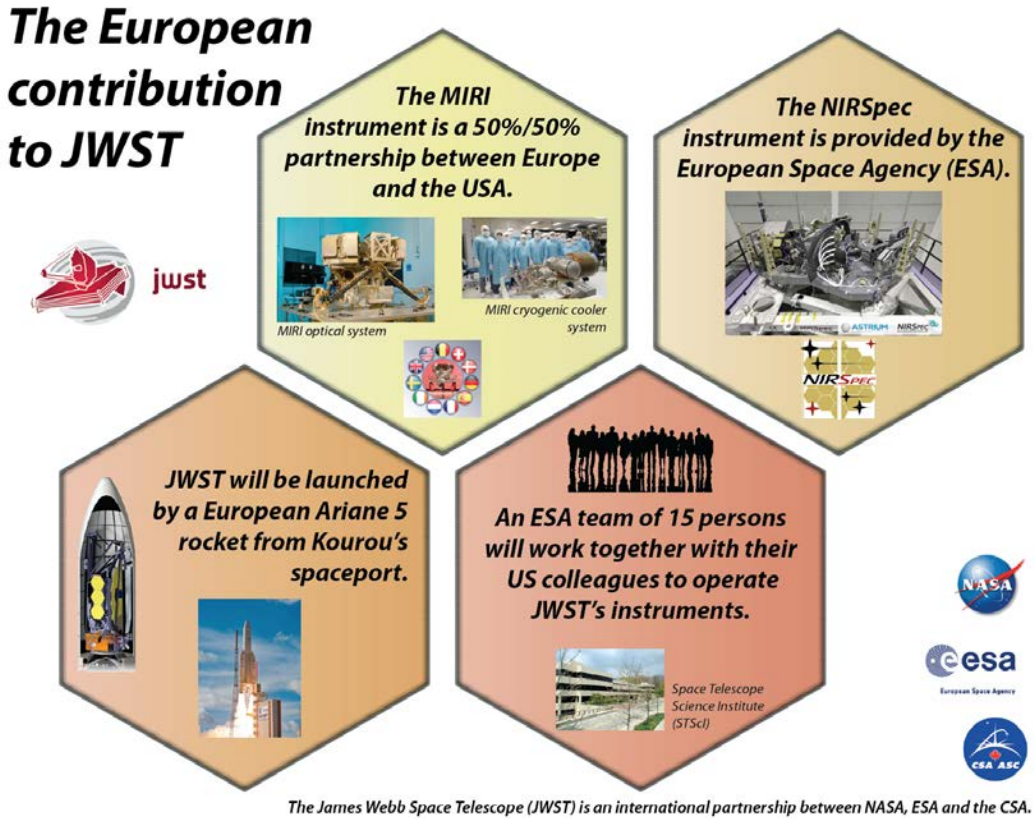
- *High-priority endeavor for the associated astrophysical communities.*

Setup similar to the HST one.

- *Over the duration of the mission, at least 15% of the total JWST observing time goes to ESA member states applicants.*

To be launched in October 2018 for a minimum mission duration of 5 years (10-year goal).

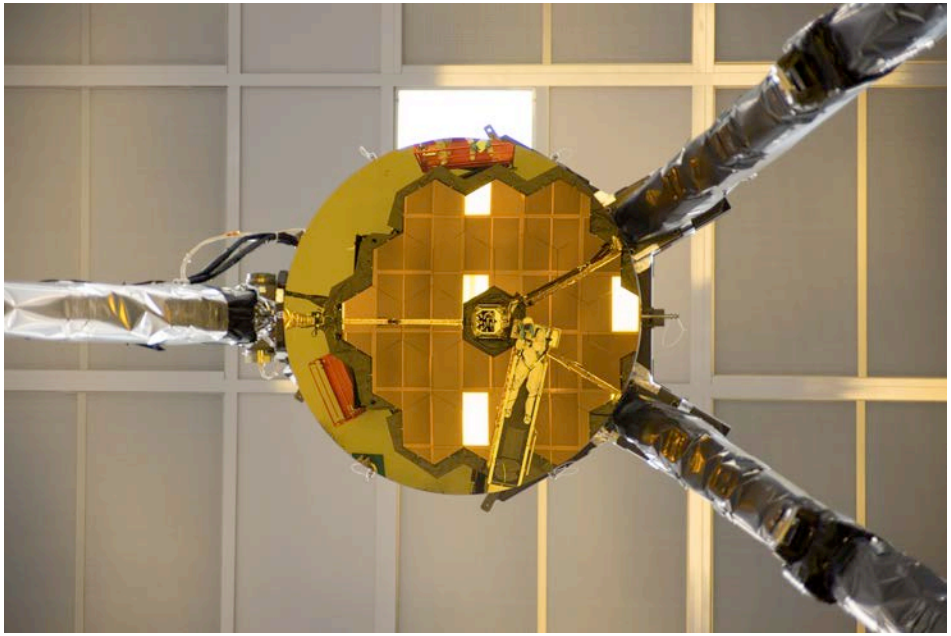
Introduction



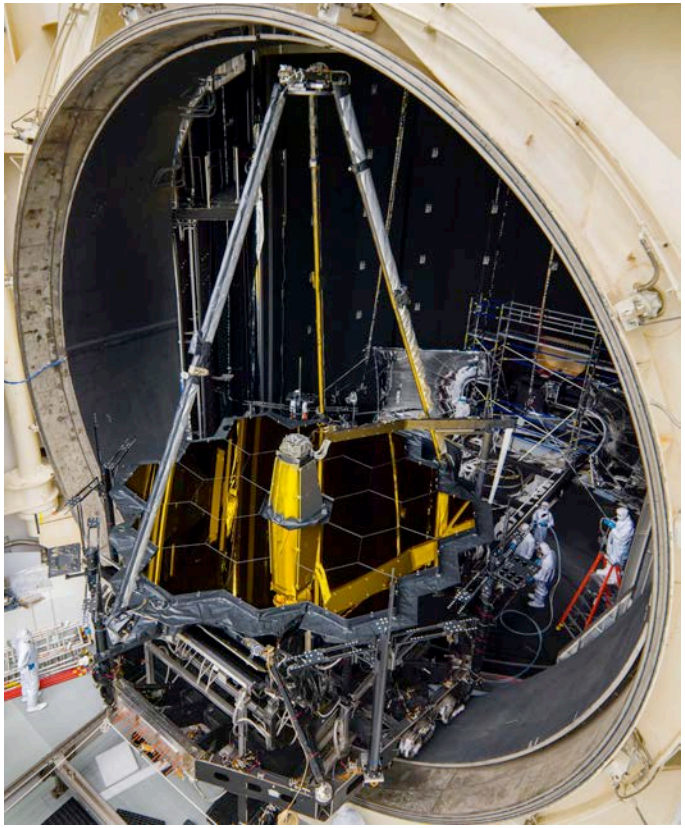
The James Webb Space Telescope (JWST) is an international partnership between NASA, ESA and the CSA.

Status

JWST's payload module (telescope + instruments = OTIS) is getting ready for a major cryogenic test campaign.



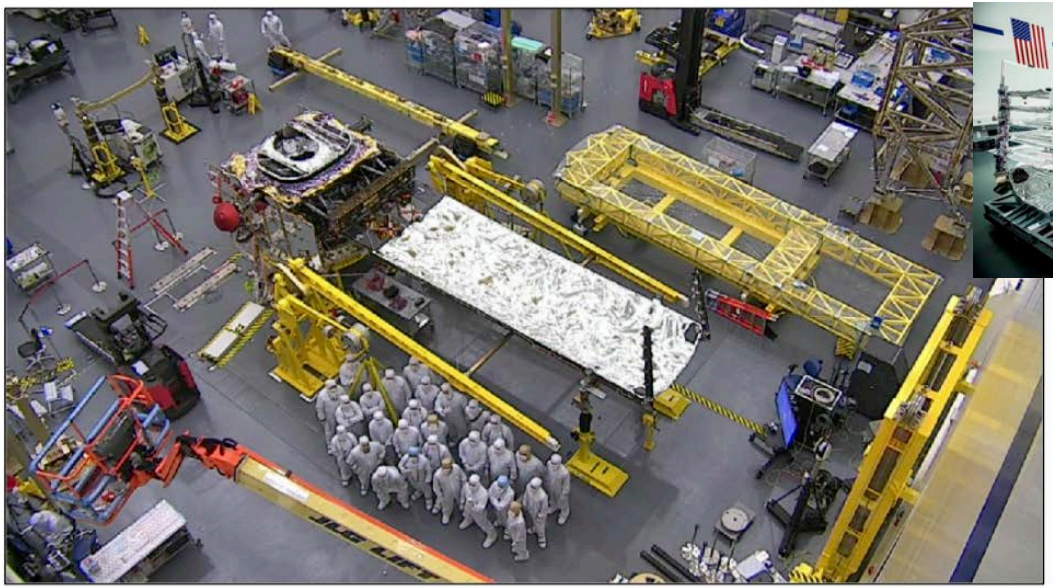
Credits: NASA/"Larkin cool selfie"

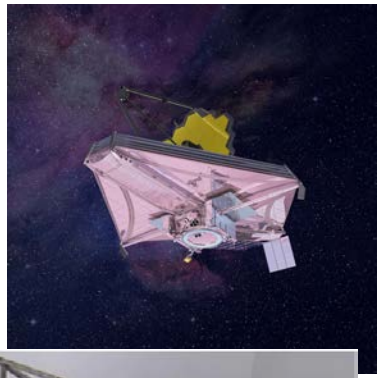


Credits: NASA/Chris Gunn

Status

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





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

Status

JWST has made tremendous progress and the launch is now in sight but we still have a lot of work in front of us.

JWST is on track for a launch in October 2018.

Scientific timeline

JWST launch in October 2018

After launch, JWST will deploy (duration ~2-3 weeks) as it cruises toward the Lagrange 2 (L2) point.

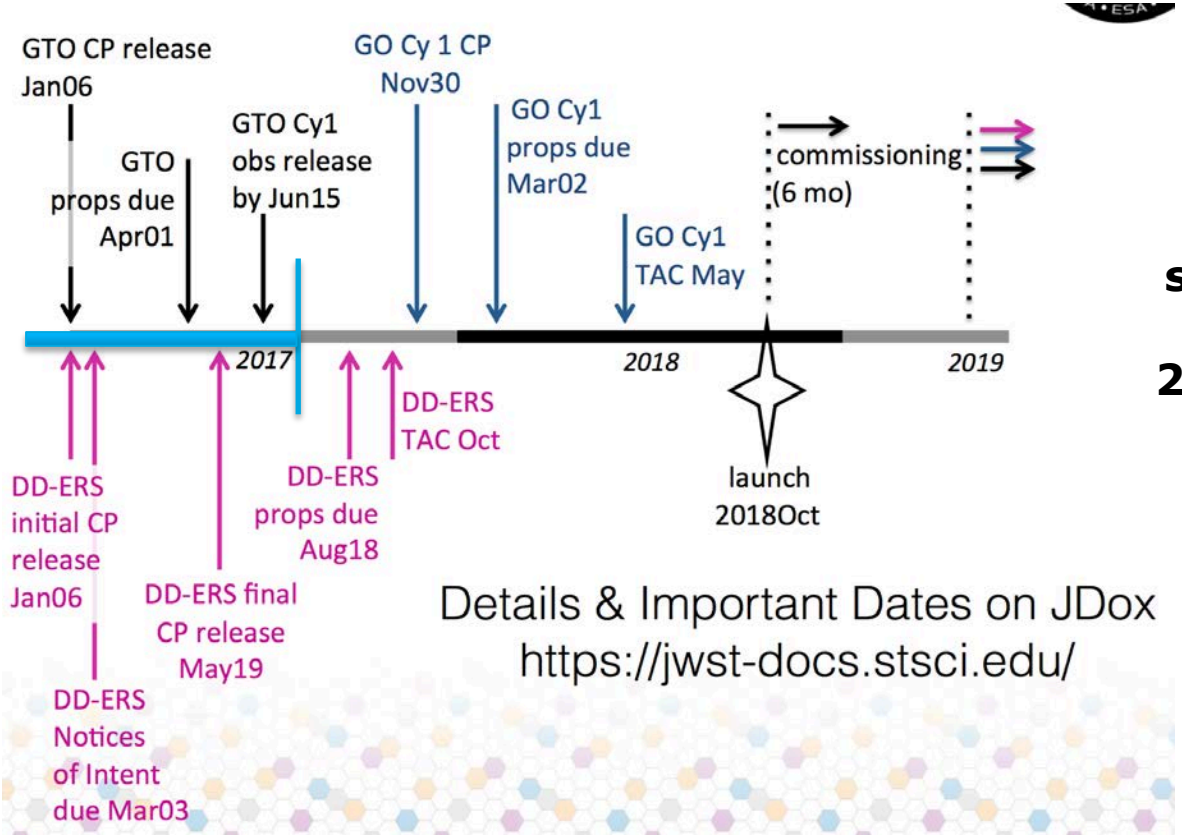
It will take it ~1 months to reach the vicinity of the L2 point around which it will orbit (halo orbit).

The commissioning should be completed 6 months after launch, i.e. in April-May 2019.

Cycle 1 is scheduled to start in April-May 2019.

- Scientific observations will start as soon as possible, mode per mode.
- Full calibration will be achieved progressively during cycle 1.

Scientific timeline



Happening now!

Even if the first scientific observations will only take place in 2019, 2017 is a pivotal year if you want to observe with JWST during its cycle 1.

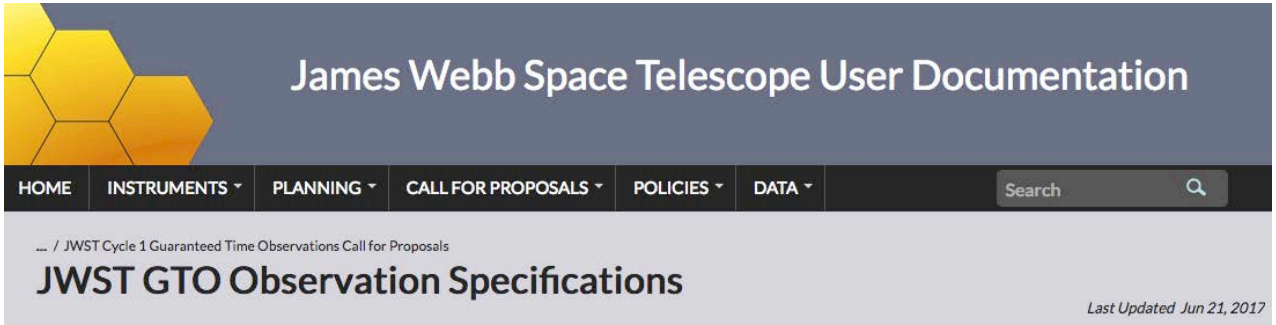
From a presentation by N. Lewis (STScI)

Scientific timeline

The list of Guaranteed Time Observation (GTO) targets has just been released.

You can find it together with brief descriptions of the GTO programs on STScI's JWST web site:

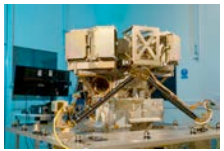
https://jwst-docs.stsci.edu/display/JSP/JWST+GTO+Observation+Specifications



JWST observing modes

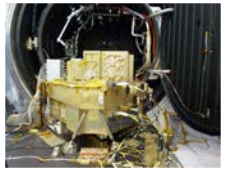
NIRCam = Near-InfraRed Camera - PI: M. Rieke

Developed under the responsibility of the University of Arizona.



MIRI = Mid-InfraRed Instrument - PIs: G. Wright and G. Rieke

50/50 partnership between a nationally funded consortium of European institutes (MIRI EC) + ESA and NASA/JPL.



NIRISS = Near-infrared Imager and Slit-less Spectrograph

FGS = Fine Guidance Sensor - PIs: R. Doyon & C. Willott

Provided by the Canadian Space Agency.

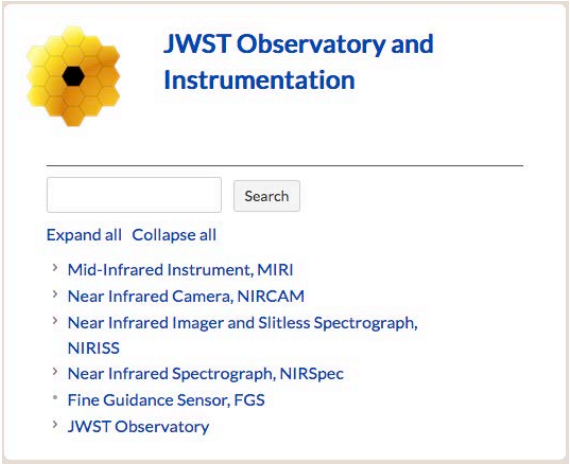
NIRSpec = Near-infrared Spectrograph

Provided by the European Space Agency. Built for ESA by an industrial consortium led by Airbus Defence and Space.

JWST observing modes

Each instrument has its dedicated section in the documentation.
For the observation of transiting exoplanets, the magic name is “time-series observations”.

https://jwst-docs.stsci.edu/display/HOM/JWST+User+Documentation+Home

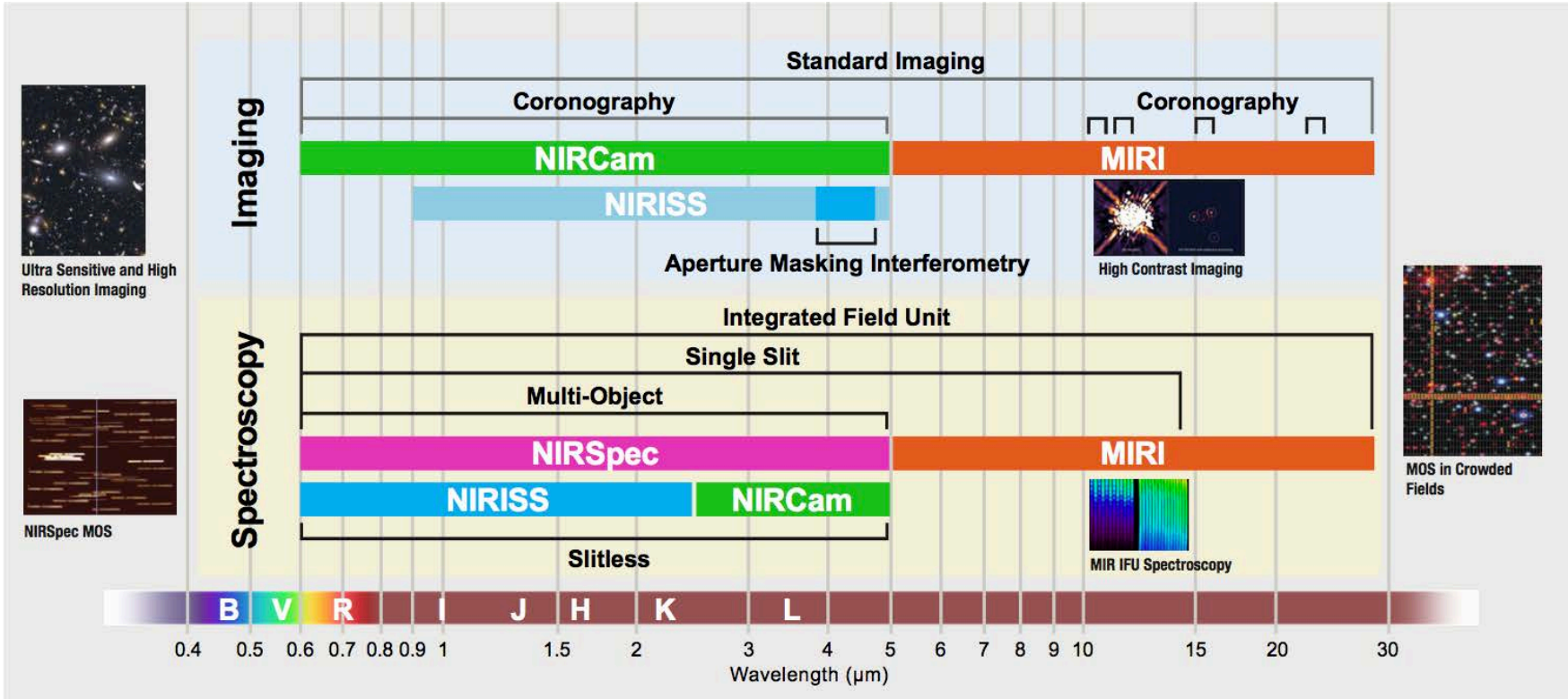


Work on the area dedicated to the observing modes is in progress

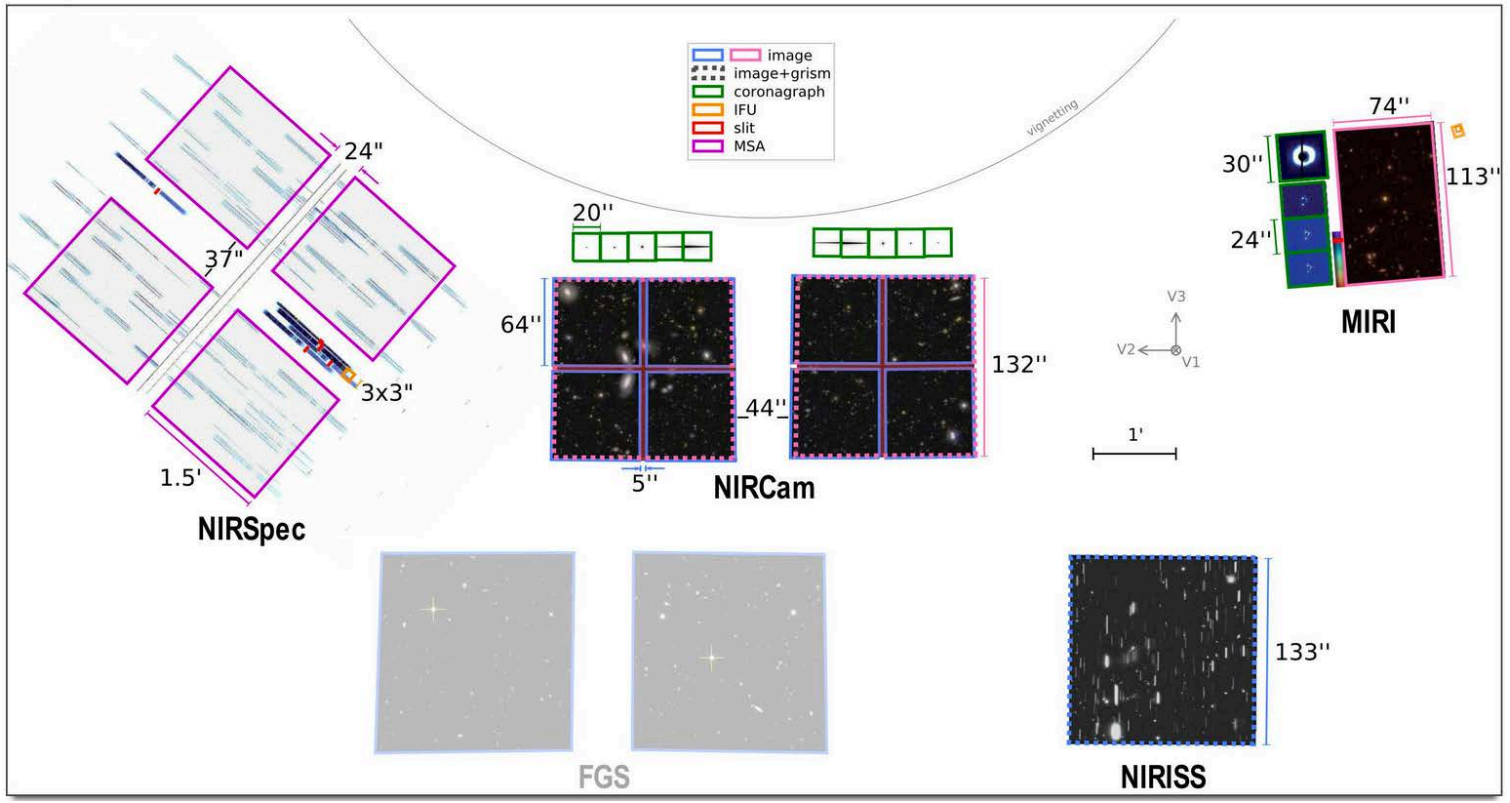
Will be ready for the GO call for proposals

https://jwst-docs.stsci.edu/display/JPP/JWST+Observing+Modes+and+Strategies

JWST observing modes



JWST observing modes



JWST observing modes (imaging)

Instrument	Wavelength (in microns)	Pixel scale (in mas/pixel)	Field of view (arcmin x arcmin)
NIRCam	0.6-2.3	32	2.2′ x 4.4′
NIRCam	2.4-5.0	65	2.2′ x 4.4′
NIRISS	0.9-5.0	65	2.2′ x 2.2′
MIRI	5.0-28	110	1.3′ x 1.7′
NIRCam	**0.6-2.3**	**32**	**Single object, time series**
NIRCam	**2.4-5.0**	**65**	**Single object, time series**

Transits

NIRCam: Simultaneous imaging of the same field of view in the short and long wavelength channels.

NIRCam has a dedicated imaging, time-series observation mode.

JWST observing modes (spectroscopy, 1/2)

	Instrument	Type	Wavelength	Spectral resolution	Field of view
Direct spectroscopy	NIRISS	SLITLESS	1.0-2.5 μm	~150	2.2′ x 2.2′
	NIRCam	SLITLESS	2.4-5.0 μm	~2000	2.2′ x 2.2′
	NIRSpec	MOS	0.6-5.3 μm	100/1000/[2700]	9 square arcminutes
	NIRSpec	**IFS**	**0.6-5.3 μm**	**100/1000/2700**	**3” x 3”**
	MIRI	**IFS (MRS)**	**5.0-28.8 μm**	**2000-3500**	**>3” x >3.9”**
	NIRSpec	SLIT	0.6-5.0 μm	100/1000/2700	Single object
	MIRI	SLIT (LRS)	5.0-10.0 μm	60-140	Single object

For widely separated star-planet pairs, it will sometime be possible to use the Integral-Field Spectroscopy (IFS) modes of NIRSpec and MIRI to obtain “direct spectroscopy” of planets (not covered any further in this talk).

JWST observing modes (spectroscopy 2/2)

Transiting exoplanets

Instrument	Type	Wavelength	Spectral resolution	Field of view
MIRI	**SLITLESS**	**5.0-10.0 μm**	**60-140**	**Single object, time series**
NIRSpec	**APERTURE**	**0.6-5.3 μm**	**100/1000/2700**	**Single object, time series**
NIRCam	**SLITLESS**	**2.4-5.0 μm**	**~1500-1700**	**Single object, time series**
NIRISS	**SLITLESS**	**0.6-2.5 μm**	**700**	**Single object, time series**

NIRCam: short-wavelength imaging can be conducted simultaneously to the long-wavelength, time series spectroscopy.

Take-home message: in JWST, spectroscopy comes in many different flavors and time–series observations have not been forgotten!

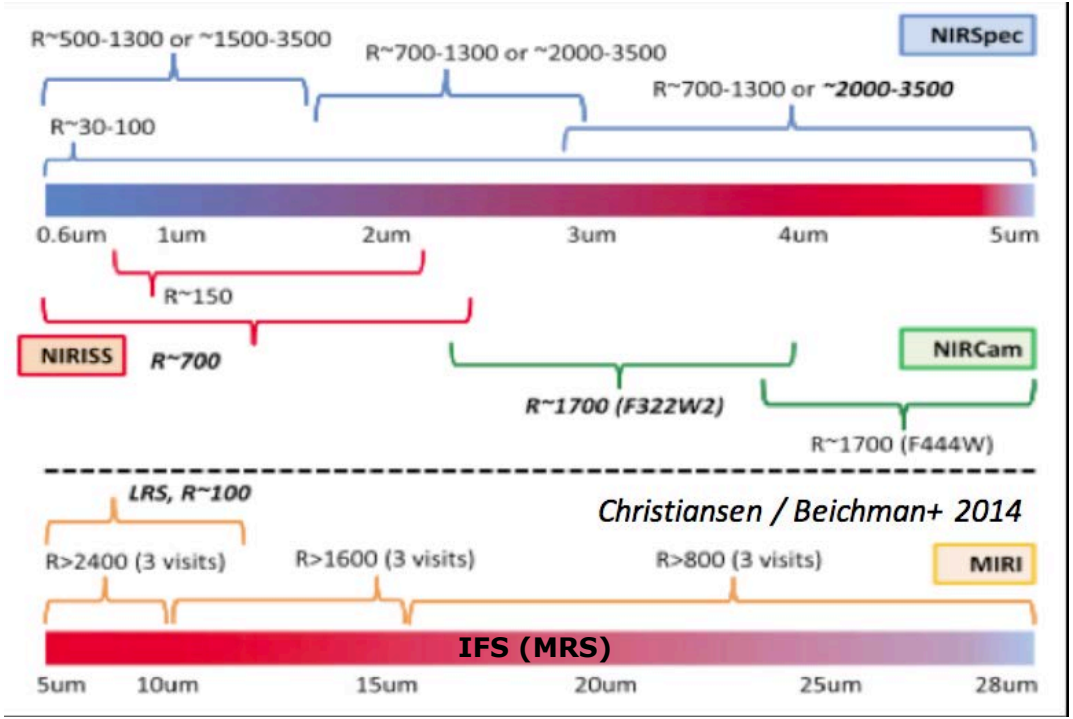
JWST observing modes (spectroscopy)

Another view of which modes are available to observe transiting exoplanets

What you should know: no mode or instrument change during a transit. Stability if the first priority when conducting time-series observations.

Multiple transits are necessary to use the full wavelength range of JWST.

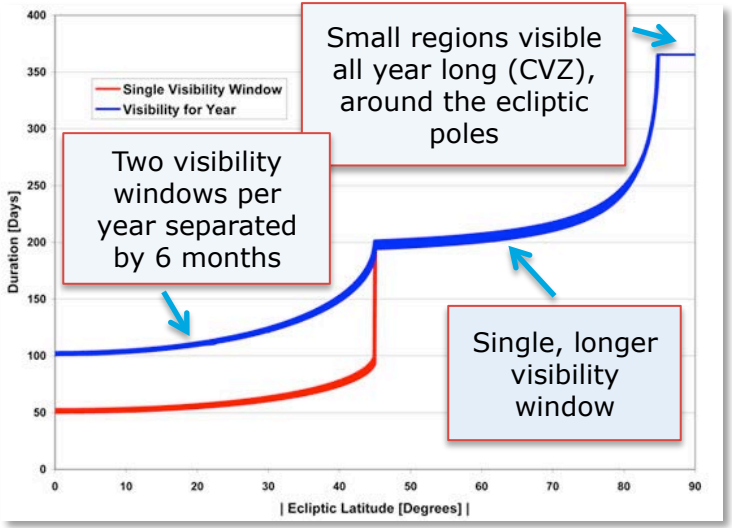
Also check for saturation!



JWST observing modes (spectroscopy)

Pay attention to the visibility and orientation constraints for your favorite target.

- JWST has a very specific set of constraints, a key parameters being the ecliptic latitude of your target.



Visibility period:

- Check how many transits are available.

Orientation constraints:

- Check for contaminating source in the vicinity of your target (in particular for slitless observations)

Check at:

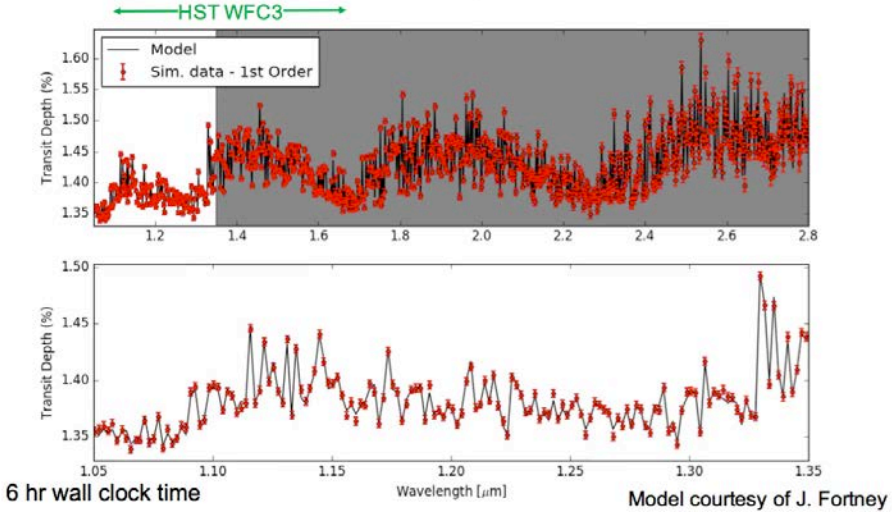
https://jwst-docs.stsci.edu/display/JPP/JWST+Target+Visibility+Tools

JWST observing modes (spectroscopy)

JWST: large collecting area, extremely interesting wavelength range for the study of planetary atmospheres (transmission and emission).

- Expect amazing results…

- HD 209458b, median noise of 40 ppm at native resolution, order 1



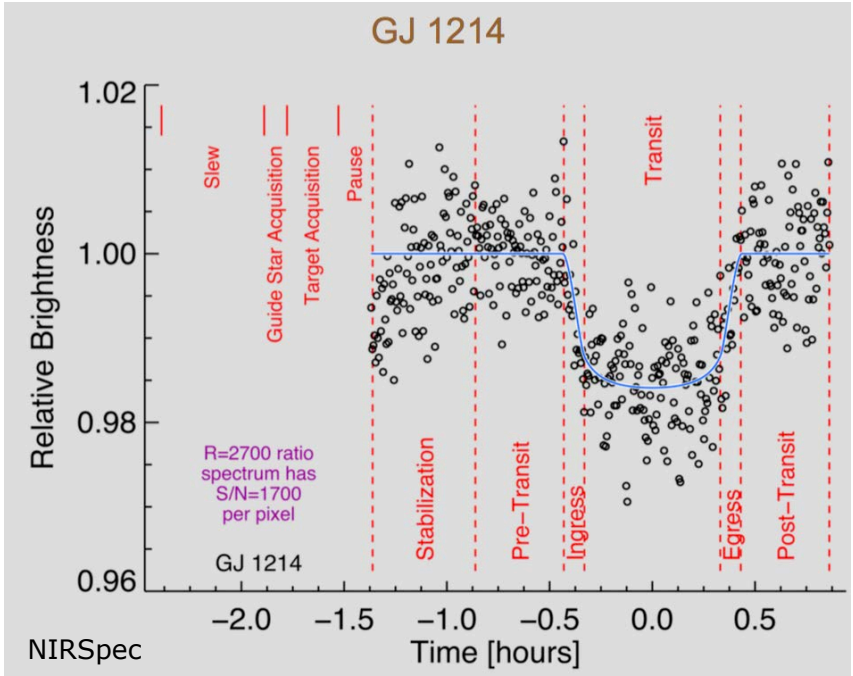
Example with NIRISS from a presentation by D. Lafrenière (U. de Montréal)

Conference web site:

http://craq-astro.ca/jwst2016/

JWST observing modes (spectroscopy)

The observing template for time series observations.



- Specifically developed to allow long uninterrupted integrations (as an example for phase curves).
- Maximum "visit" duration is 24 hours (to allow for momentum dump).

Presentation by J. Valenti (STScI)

EXOPAG 9 meeting – 2014

https://exoplanets.nasa.gov/exep/events/12/

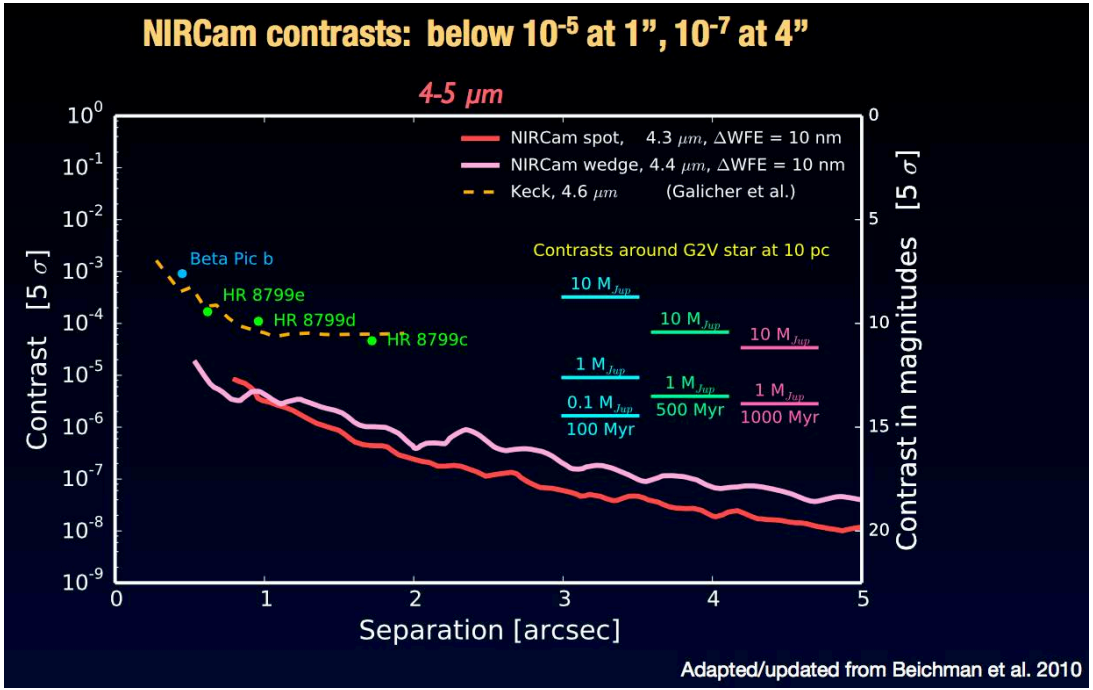
JWST observing modes (coronagraphy & AMI)

Direct imaging

Instrument	Wavelength	Pixel scale	Field of view	Type
NIRCam	0.6-2.3 μm	32 mas/pixel	20″ x 20″	Lyot
NIRCam	2.4-5.0 μm	65 mas/pixel	20″ x 20″	Lyot
NIRISS	3.8-4.8 μm	65 mas/pixel	0.1-0.5″	Aperture Masking Interferometry
MIRI	10.65 μm	110 mas/pixel	24″ x 24″	4QPM
MIRI	11.4 μm	110 mas/pixel	24″ x 24″	4QPM
MIRI	15.5 μm	110 mas/pixel	24″ x 24″	4QPM
MIRI	23 μm	110 mas/pixel	30″ x 30″	Lyot

Direct imaging capabilities spread over the complete wavelength range of JWST.

JWST observing modes (coronagraphy & AMI)



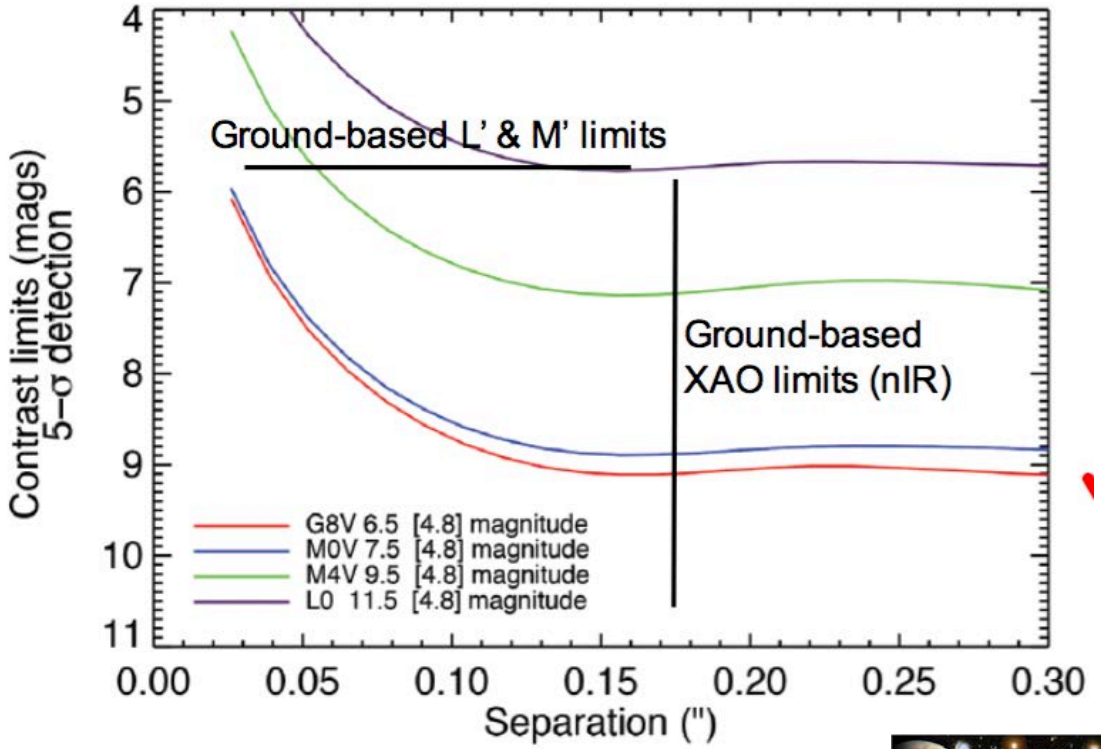
Example extracted from a presentation by Marshall D. Perrin on high-contrast imaging of planetary systems with JWST (2017).

For more details see the full presentation.

Archive of the last JWST proposal planning workshop (STScI, 2017):

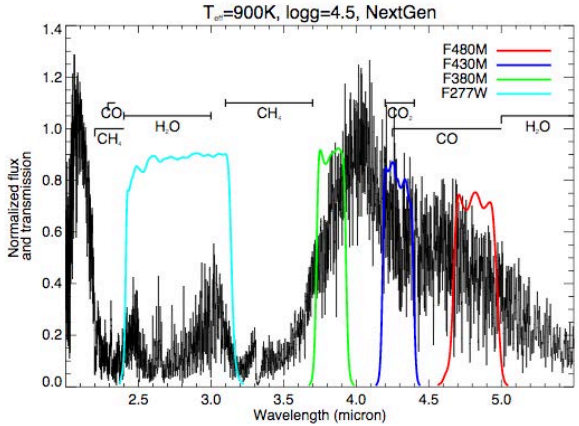
https://webcast.stsci.edu/webcast/searchresults.xhtml?searchtype=20&eventid=256&sortmode=2

JWST observing modes (coronagraphy & AMI)



NIRISS AMI

Examples extracted from a presentation by D. Lafrenière (2016) and from Artigau et al. (NIRISS aperture masking interferometry: an overview of science opportunities; 2014SPIE. 9143E..40A)



Conference web site: http://craq-astro.ca/jwst2016/

JWST observing modes (coronagraphy & AMI)

For coronagraphy, the orientation constraints are very important.

- A dedicated tool has been developed and made available by STScI

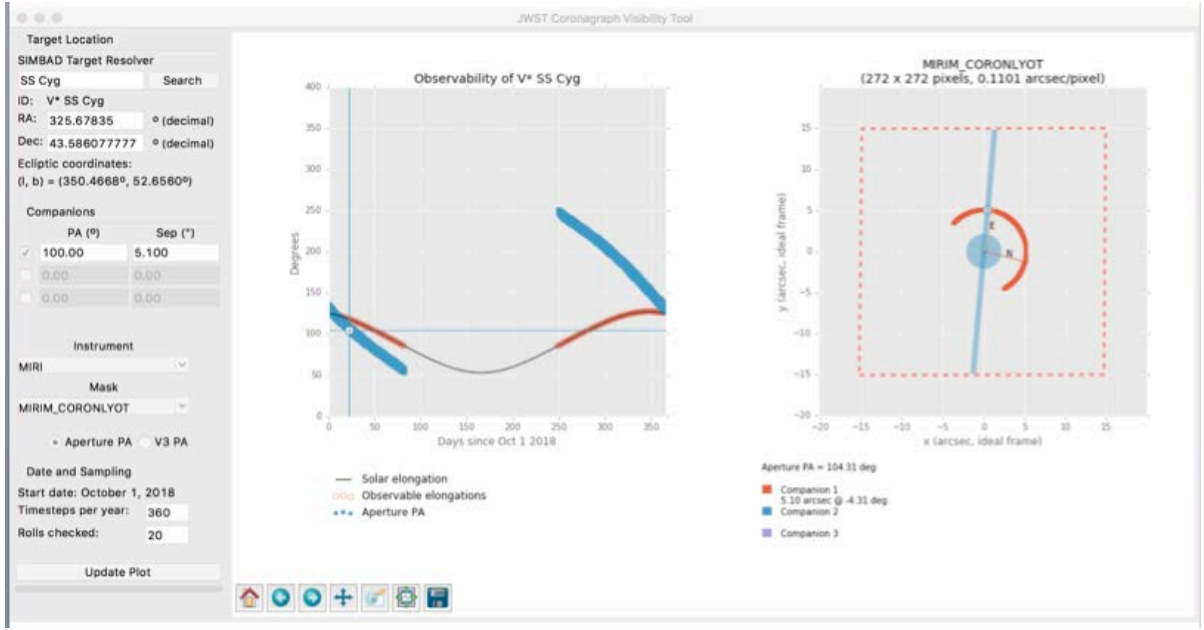


Figure extracted from a presentation by Bill Blair (2017)

https://webcast.stsci.edu/webcast/detail.xhtml?talkid=5616&parent=1

Documentation:

https://jwst-docs.stsci.edu/display/JPP/JWST+Target+Visibility+Tools

Getting ready to use JWST

Special session "Preparing the JWST era" during this EWASS 2017 meeting.

- Focusing on learning from the GTO proposals (transferring experience). Work in progress to consolidate the program.

Of particular interest for the exoplanet community:

[SS21c] SS21- Preparing the JWST Era

Moderator: Gillian Wright, STFC

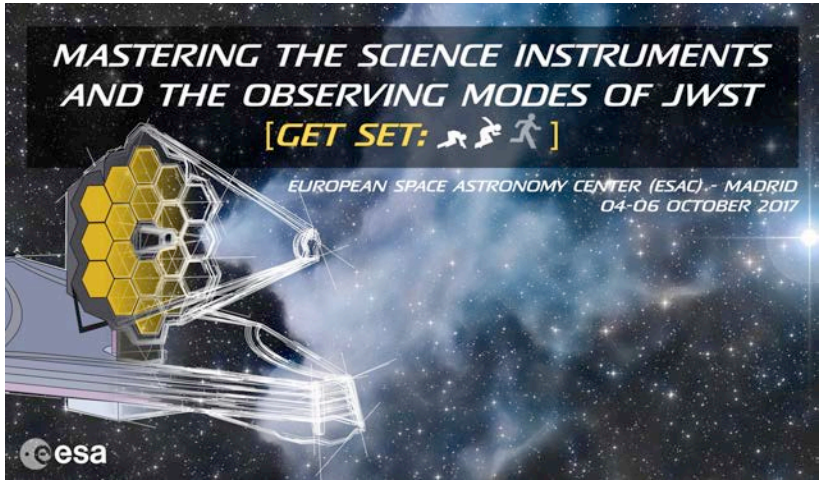
28.06.2017 From 16:00 to 17:30 Room 220

16:35	16:55	**Lessons learnt from the preparation of JWST GTO observations of exoplanets by direct imaging techniques (#1351)** Pierre-Olivier Lagage - CEA, Saclay, France
16:55	17:15	**Observation of a transiting exoplanet with NIRISS, NIRSpec, and MIRI (#1357)** Giovanna Giardino - ATG - ESA, Noordwijk, Netherlands

Getting ready to use JWST

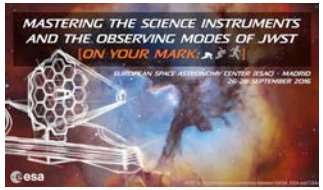
Second JWST ESAC workshop "Mastering the science instruments and the observing modes of JWST [get set]" at ESAC (4-6 October 2017).

- Following the successful [on your mark] 2016 edition.



Workshop web site:
https://www.cosmos.esa.int/web/jwst-2017-esac/

Take a look at the previous edition:
https://www.cosmos.esa.int/web/jwst-2016-esac/



Also: list of events in the USA, Europe and Canada maintained by STScI:

https://jwst.stsci.edu/news-events/events

Conclusion

Launch in October 2018 (stable) and start of scientific observations in the first half of 2019!

A powerful observatory that will provide plenty of opportunities to study exoplanets.

Apply for time!

Thanks for your attention