

European Space Agency



The James Webb Space Telescope

Project status



P. Ferruit
(ESA JWST project scientist)

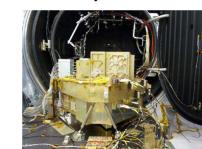
MIRI



NIRSpec



FGS/NIRISS



NIRCam





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.



Table of contents

This is a brief overview of the JWST mission. During this workshop you will get much more in-depth presentations / tutorials.

Here are the points I will address in this presentation:

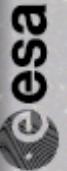
- **The JWST mission**
- **JWST status – from now to launch.**
- **Overview of JWST capabilities.**

- **Conclusion.**

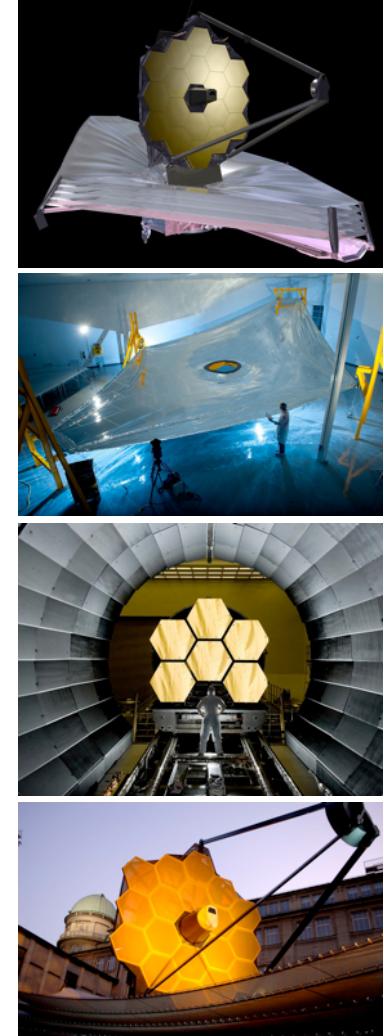


The James Webb Space Telescope (JWST)

The mission in a nutshell



- JWST will be one of the “great observatories” of the next decade.
 - Often presented as the next step after the Hubble Space Telescope (HST)
- 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, > 15% of the total JWST observing time goes to ESA member states applicants.
- To be launched at the end of 2018 for a minimum mission duration of 5 years (10-year goal).



European Space Agency



The James Webb Space Telescope (JWST)

The mission in a nutshell



jwst

The James Webb Space Telescope (JWST)

Launch segment



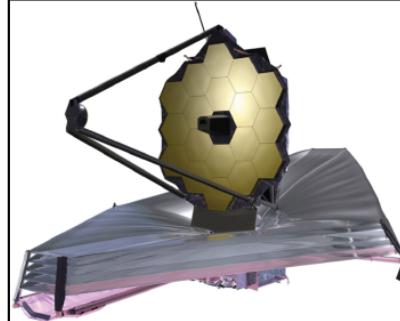
Payload adapter

Launcher
(Ariane 5)

Launch site services



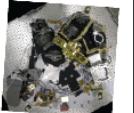
Observatory segment

Spacecraft
(bus,
sunshield...)

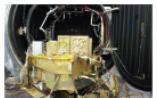
Telescope

Payload module (ISIM) and instruments

NIRCam



NIRSpec

FGS /
NIRISS

MIRI

Ground segment



Science and operation center (STScI)

15 ESA staff members

Common systems
(deep space network)

Provided by NASA



Provided by ESA and Europe

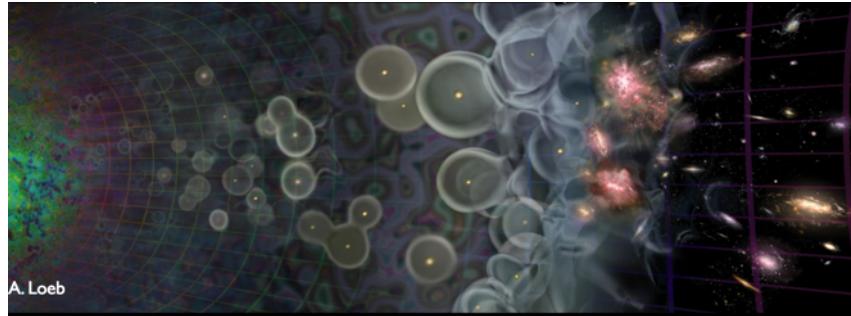


Provided by CSA



The James Webb Space Telescope (JWST)

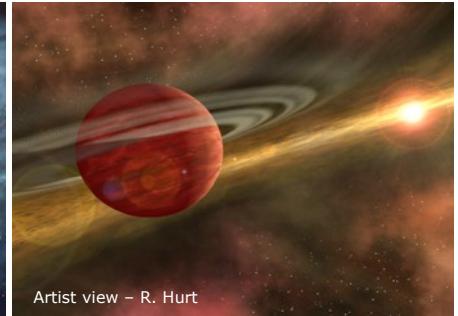
The mission in a nutshell



A. Loeb



Artist view – D. Hardy



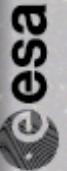
Artist view – R. Hurt

**JWST science goals
encompass a very broad
set of topics.**

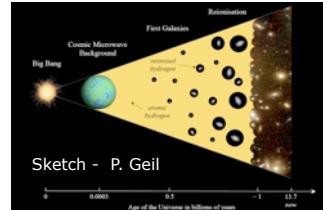


The James Webb Space Telescope (JWST)

The mission in a nutshell



- **The end of the dark ages: first light and re-ionization.**
- **The assembly of galaxies: the formation and evolution of galaxies.**
- **The birth of stars and proto-planetary systems.**
- **Planetary systems (including our solar system and exoplanets) and the origin of life.**



And a wealth of other scientific programs as JWST will be a general observatory.



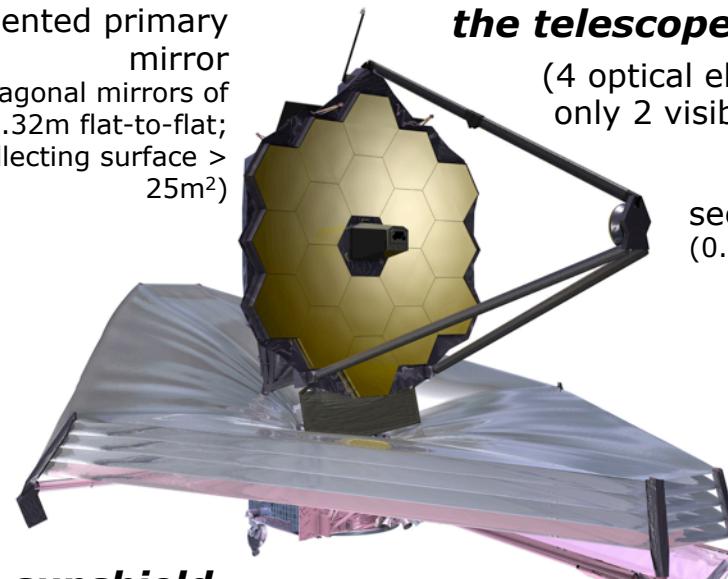
See Gardner et al., 2006,
Space Science Reviews,
123, 485



The James Webb Space Telescope (JWST)

The mission in a nutshell

segmented primary mirror
(18 hexagonal mirrors of 1.32m flat-to-flat; collecting surface > 25m²)



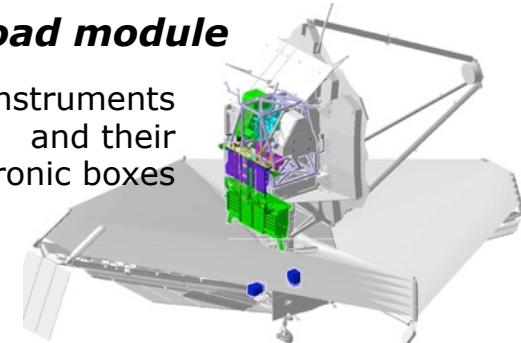
the telescope

(4 optical elements, only 2 visible here)

secondary mirror
(0.74m diameter)

payload module

the 4 instruments and their electronic boxes

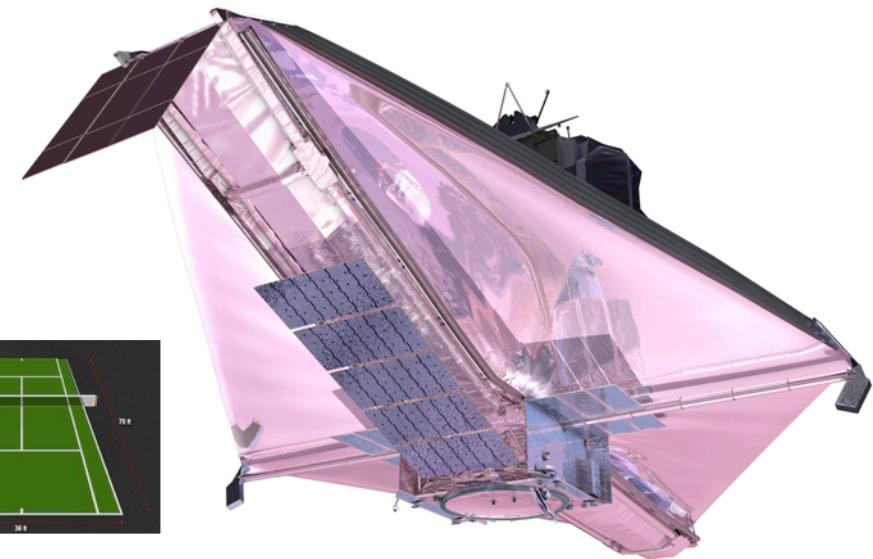


the sunshield

5 membranes of Kapton foil allowing **passive cooling of the telescope and the instruments down to ~40K**
the size of a tennis court



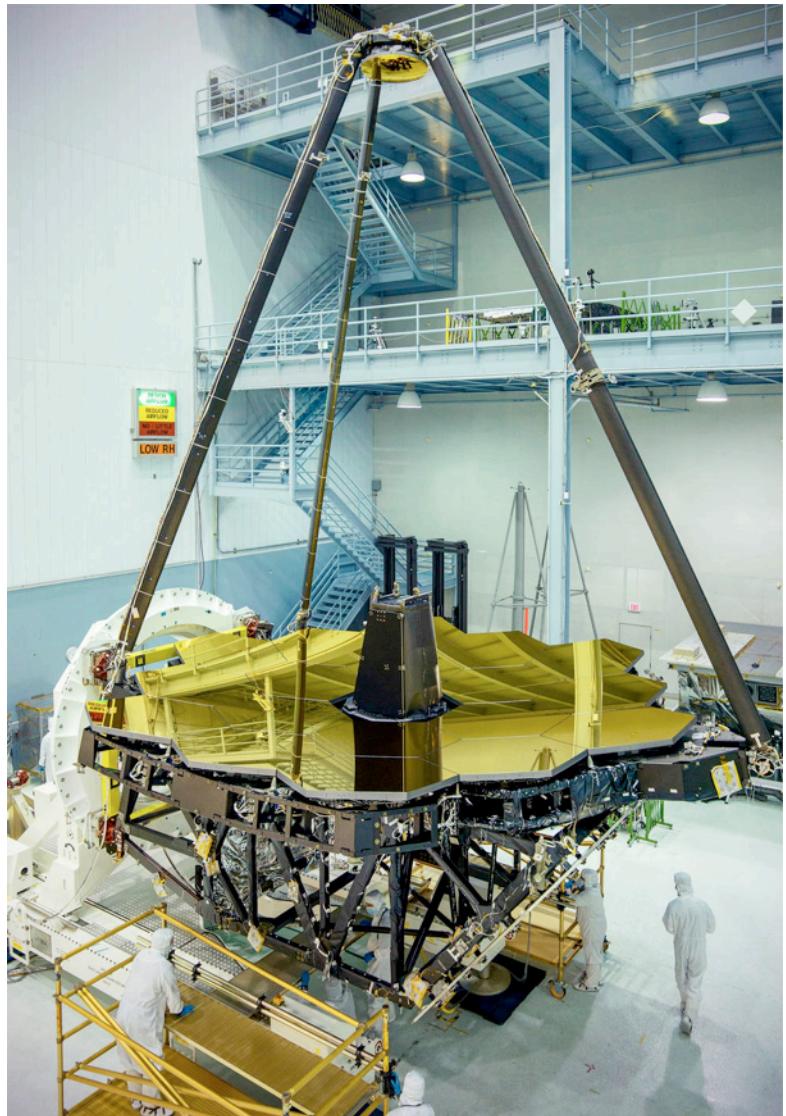
Note that a cryogenic cooler is used to cool JWST's mid-infrared instrument (MIRI) down to 6-7K.



the spacecraft bus and solar panels

The James Webb Space Telescope (JWST)

The mission in a nutshell



Credit: NASA/Chris Gunn



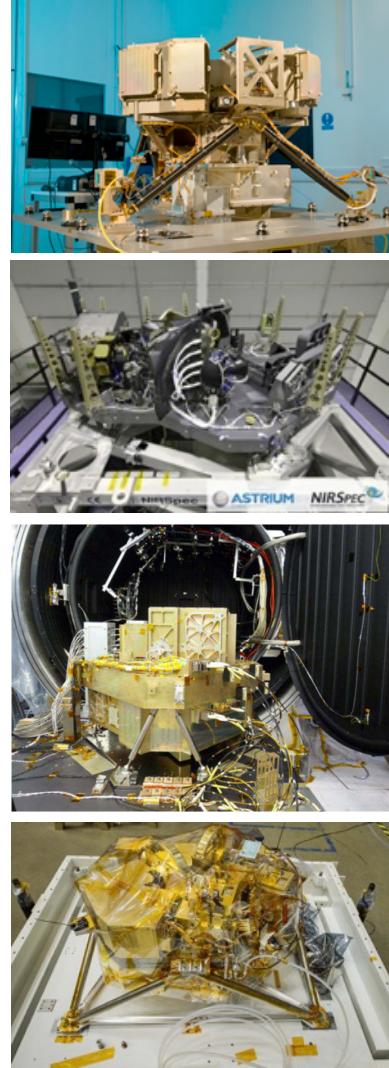
The telescope is assembled!

Uncovered
primary
mirror in
May 2016

[http://www.nasa.gov/feature/goddard/2016/
new-nasa-time-lapse-shows-nasas-webb-
telescope-primary-mirrors-complete-assembly](http://www.nasa.gov/feature/goddard/2016/new-nasa-time-lapse-shows-nasas-webb-telescope-primary-mirrors-complete-assembly)

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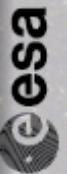
Slide #9



JWST's instruments

The James Webb Space Telescope (JWST)

The mission in a nutshell



MIRI = Mid-InfraRed Instrument

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

PIs: G. Wright and G. Rieke



NIRSpec = Near-infrared Spectrograph

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



NIRISS = Near-infrared Imager and Slit-less Spectrograph

FGS = Fine Guidance Sensor

Provided by the Canadian Space Agency.

PIs: R. Doyon & C. Willott



NIRCam = Near-InfraRed Camera

Developed under the responsibility of the University of Arizona.

PI: M. Rieke



JWST – Status - Hardware



The instruments are now installed at the back of the telescope.

From a telescope to a telescope with its instruments!



Integration of
the payload
module (ISIM)
with the 4
JWST
instruments

Instruments +
telescope =
OTIS

Credit for the images: NASA/Chris Gunn



JWST workshop - ESAC - 26-29 September 2016



The James Webb Space Telescope (JWST)

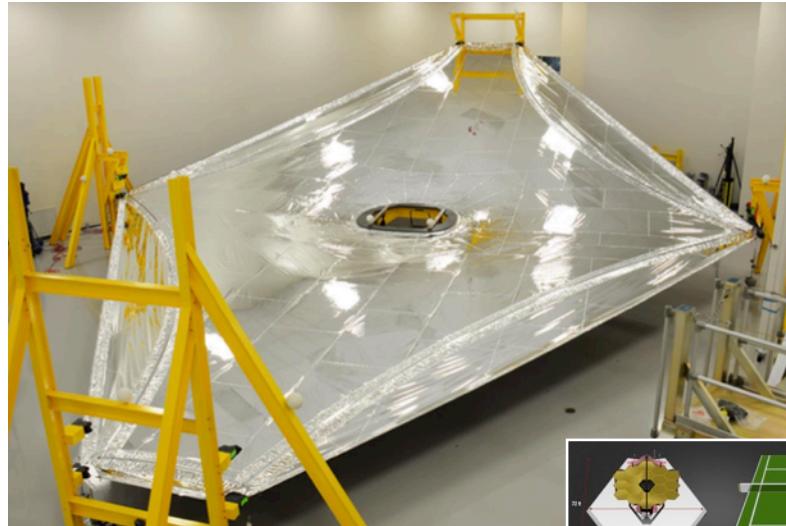
The mission in a nutshell



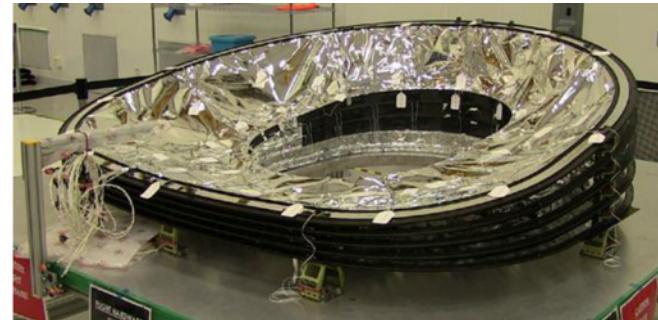
One of the two structural element protecting the folded sunshield membranes.



Figure 3. Northrop Grumman engineer Tony Yu during the deployment test. (Credit: Northrop Grumman/Alex Evers.)



Flight membrane #2 in testing.



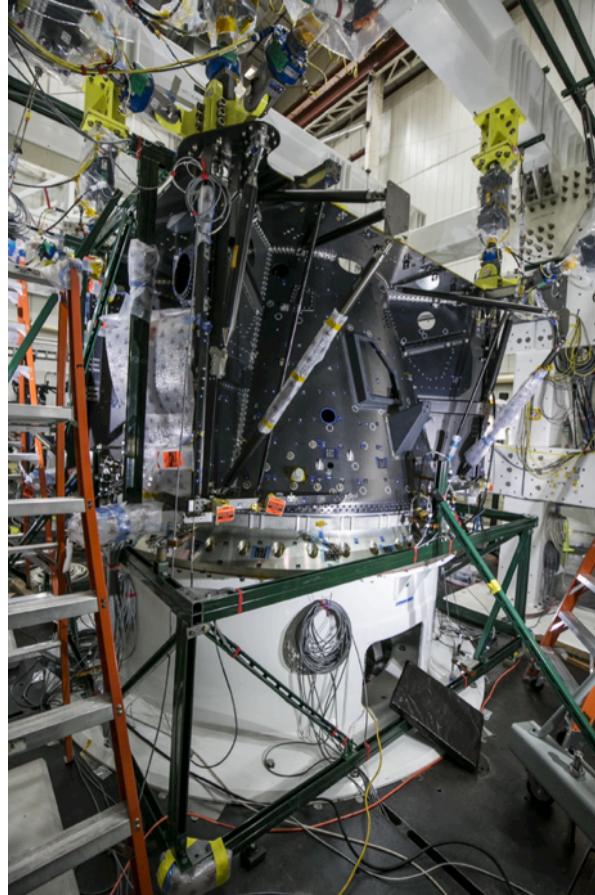
Interface between the spacecraft, sunshield and OTIS at the center of the spacecraft.



The James Webb Space Telescope (JWST)

The mission in a nutshell

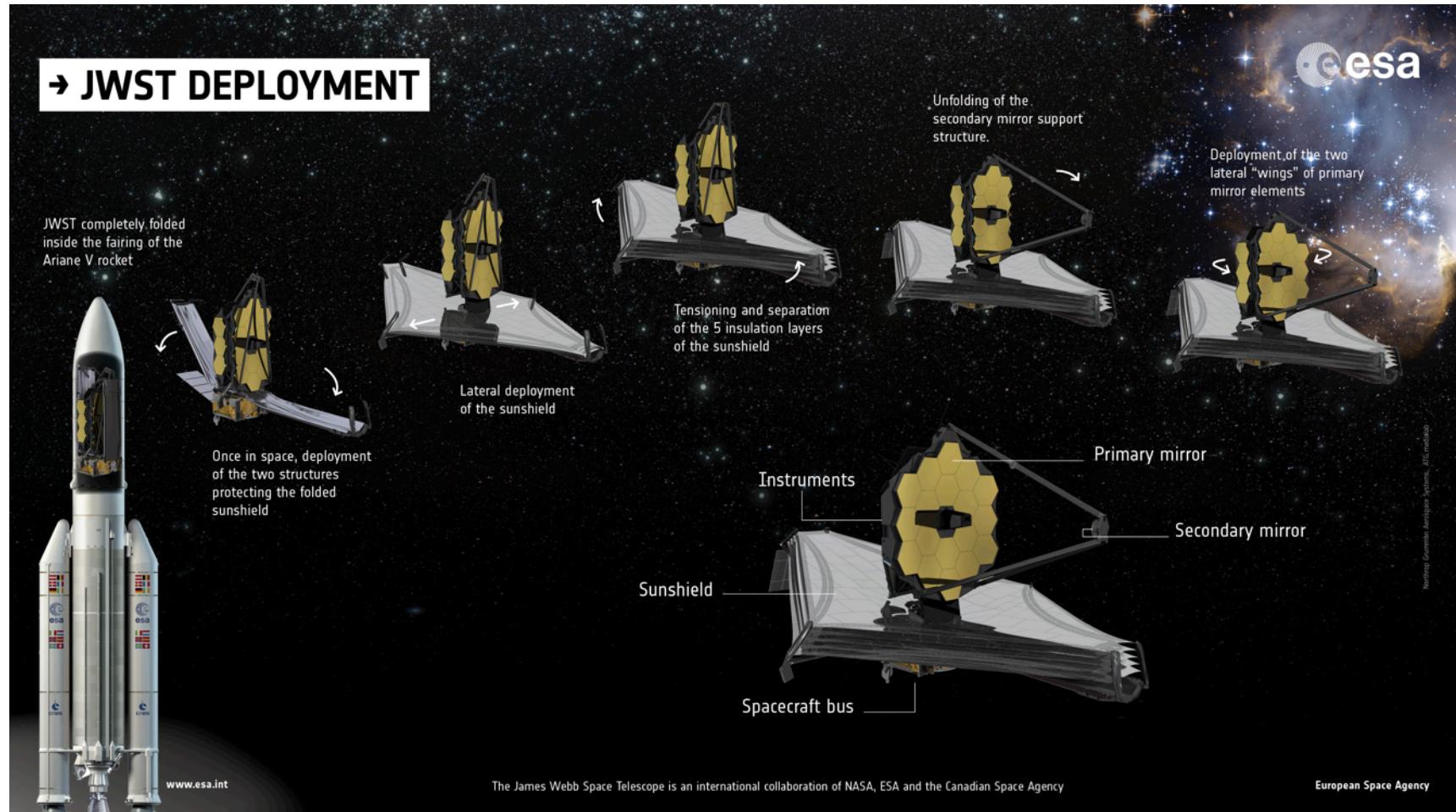
**The
spacecraft.
Not so
spectacular
that the
telescope
and the
sunshield but
not less
important...**





The James Webb Space Telescope (JWST)

The mission in a nutshell



http://jwst.nasa.gov/videos_deploy.html

JWST workshop - ESAC - 26-29 September 2016

Slide #14



JWST – From now to launch...

**JWST is within cost and within schedule for a
launch in October 2018.**

As of August 2016, 6 months of funded schedule contingencies are available along the critical path (26 months before launch)

→ we are on track.

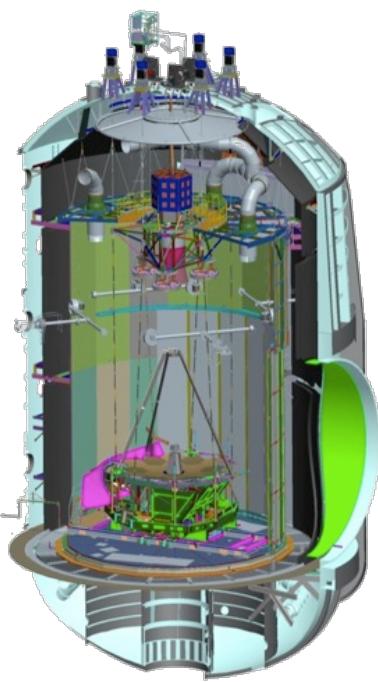
List of milestones available: <http://jwst.nasa.gov/recentaccomplish.html>

- **Does this mean that we do not encounter any problem? Of course not.**
 - But we have the necessary schedule and funding contingencies to tackle them.



JWST – From now to launch

- **At NASA Goddard Space Flight Center (Greenbelt, Maryland)**
 - Finalization of the integration of the telescope and instrument module (called OTIS). → Fall 2016
 - Metrology + acoustic and vibration testing of the telescope and the instruments. → End 2016.
- **At NASA Johnson Space Center (Houston, Texas)**
 - Cryogenic testing of OTIS . → First half of 2017.



**First half of 2017: testing of
the telescope and the
instruments together at the
Johnson Space Center.**

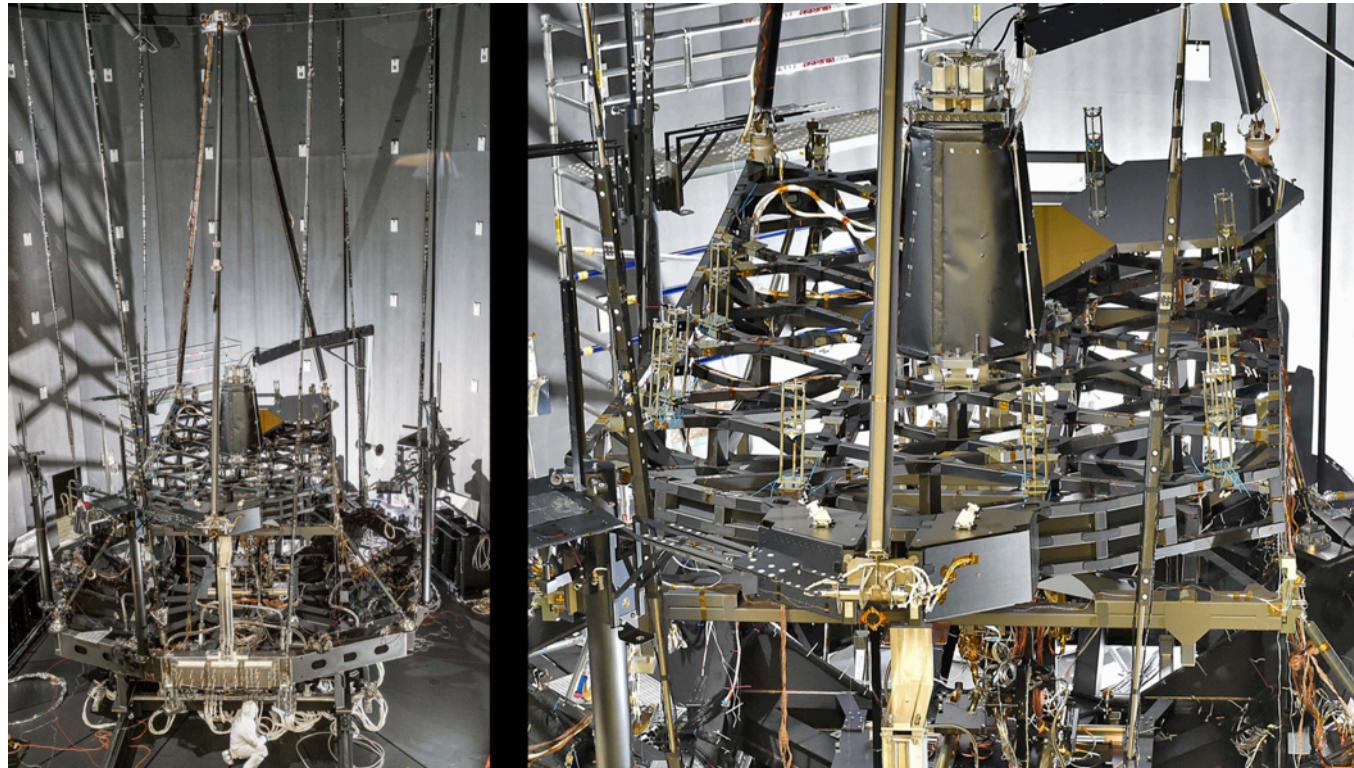
JWST – From now to launch.





JWST – From now to launch.

Such a large and critical test is not undertaken without a LOT of preparation. The so-called path-finder tests have been going one for more than a year now in parallel to the flight hardware work.





JWST – From now to launch.

- **At Northrop Grumman premises**
 - Manufacturing and integration of the sun-shield elements.
 - Integration of the spacecraft.
 - In parallel to the OTIS activities over 2016 and 2017.
- Integrate the sunshield on the spacecraft.
- Assemble the observatory (sunshield + spacecraft + OTIS).
- Conduct the final observatory-level tests!



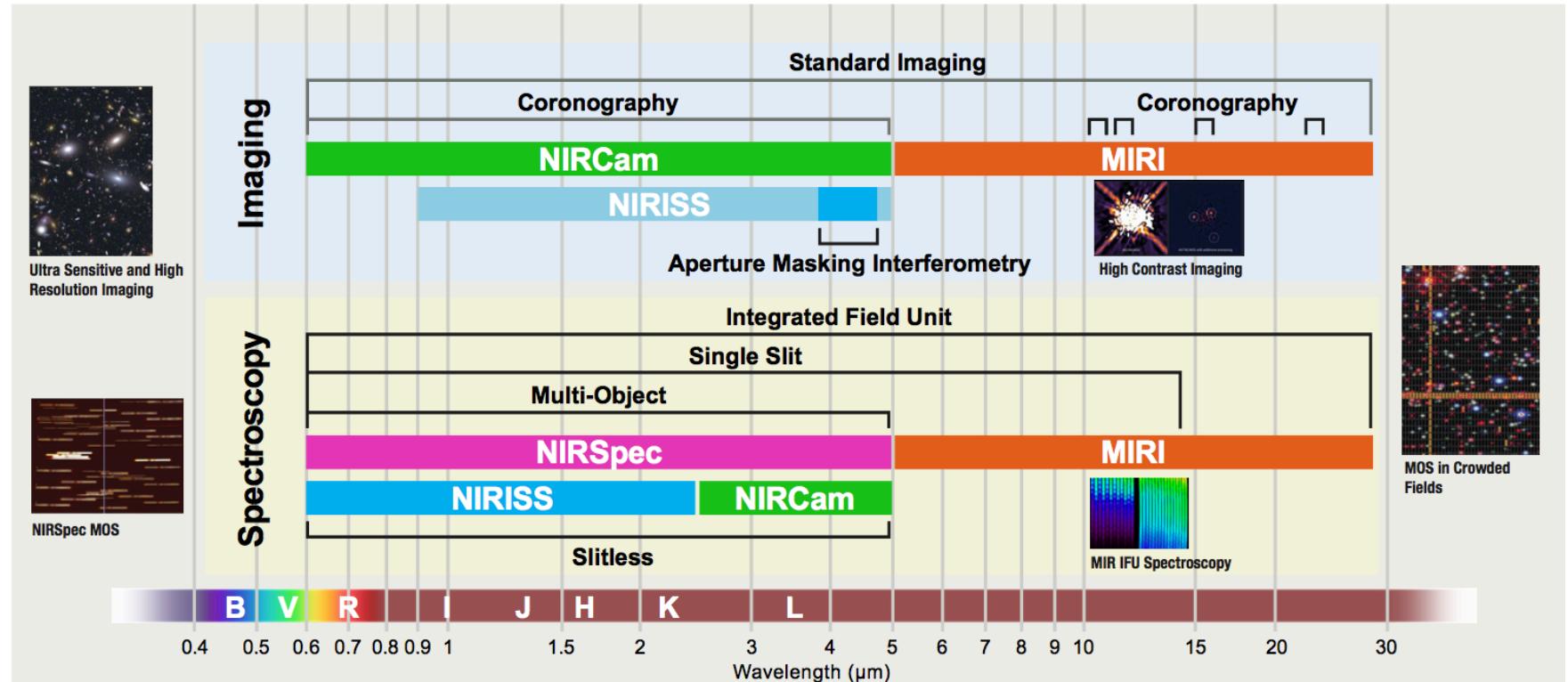
JWST – Coming soon!

And then, in October 2018, LAUNCH!





JWST capabilities

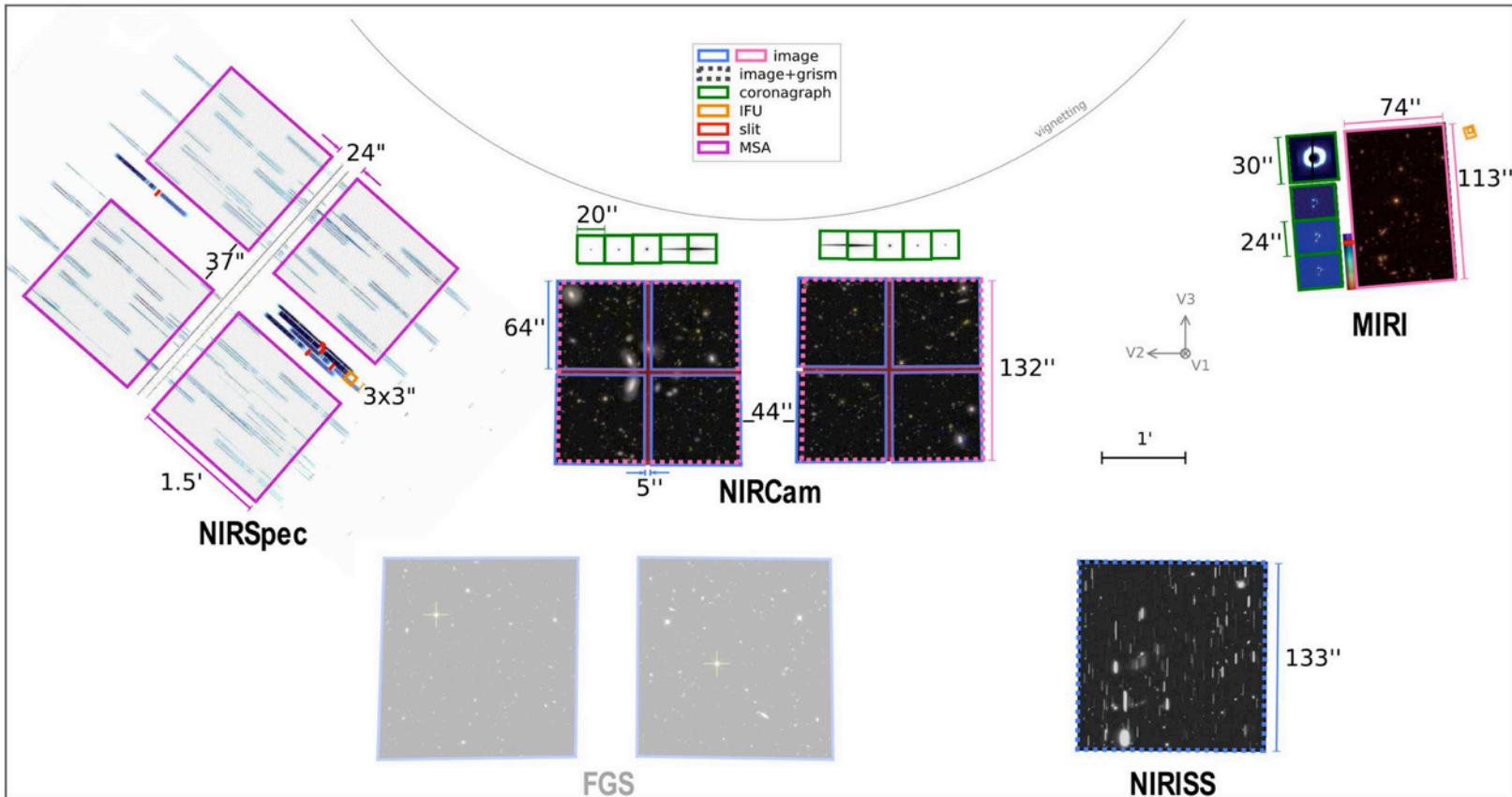


Credit: STScI

Overview, see detailed talks tomorrow.



JWST imaging capabilities Mapping of the focal plane

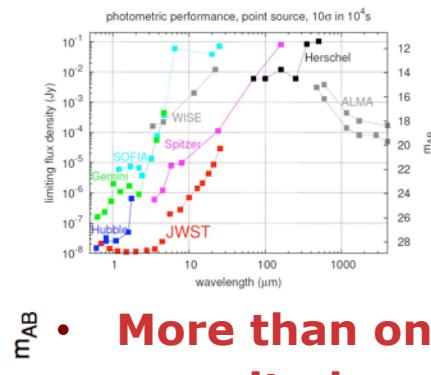
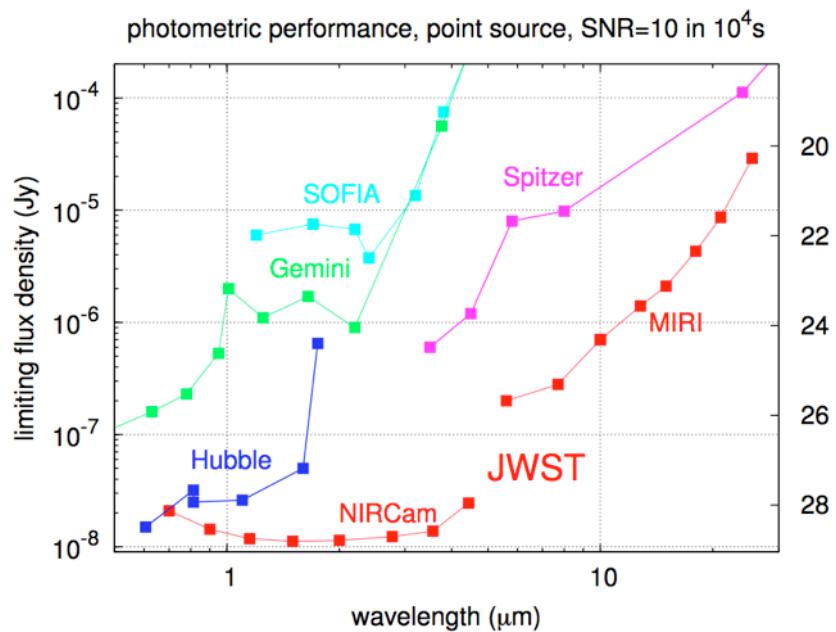


Credit: STScI



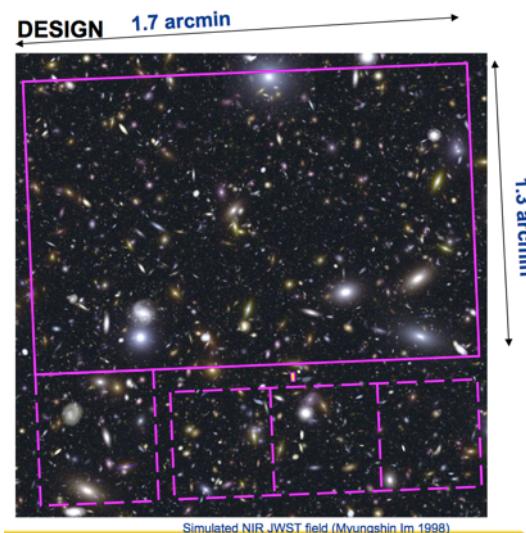
JWST imaging capabilities

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'



- **More than one order of magnitude sensitivity improvement in some bands.**
- Extremely powerful observatory, a lot of discovery space.

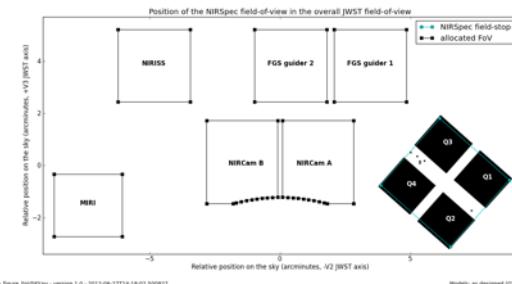
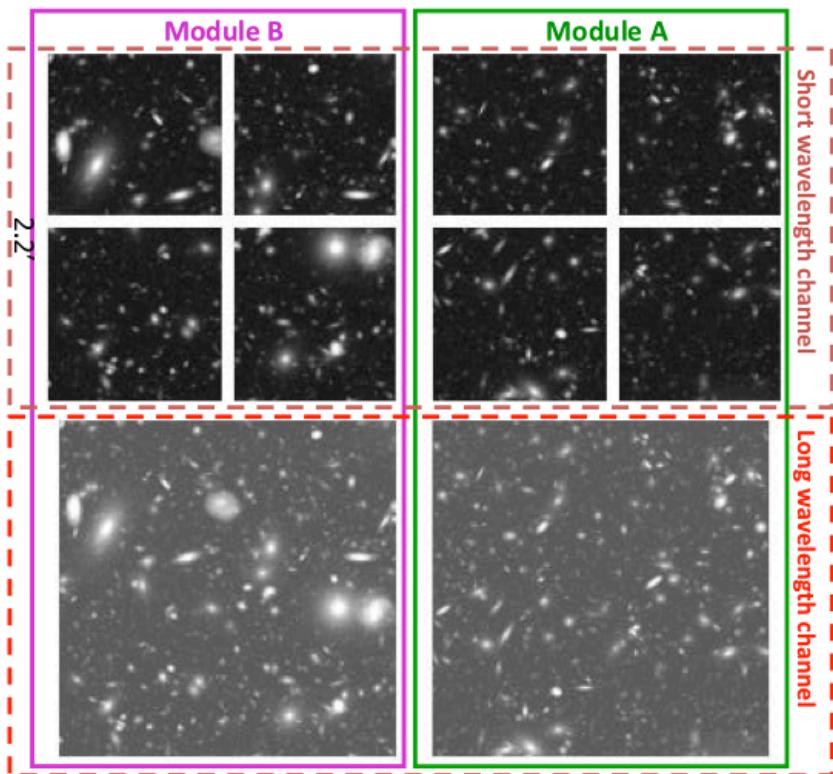
NIRCam: Simultaneous imaging of the same field of view in the 'blue' and 'red' channels.

MIRI ($1.7' \times 1.3'$)

Not to scale.

NIRISS ($2.2' \times 2.2'$)

JWST imaging capabilities

NIRCam ($4.4' \times 2.2'$)

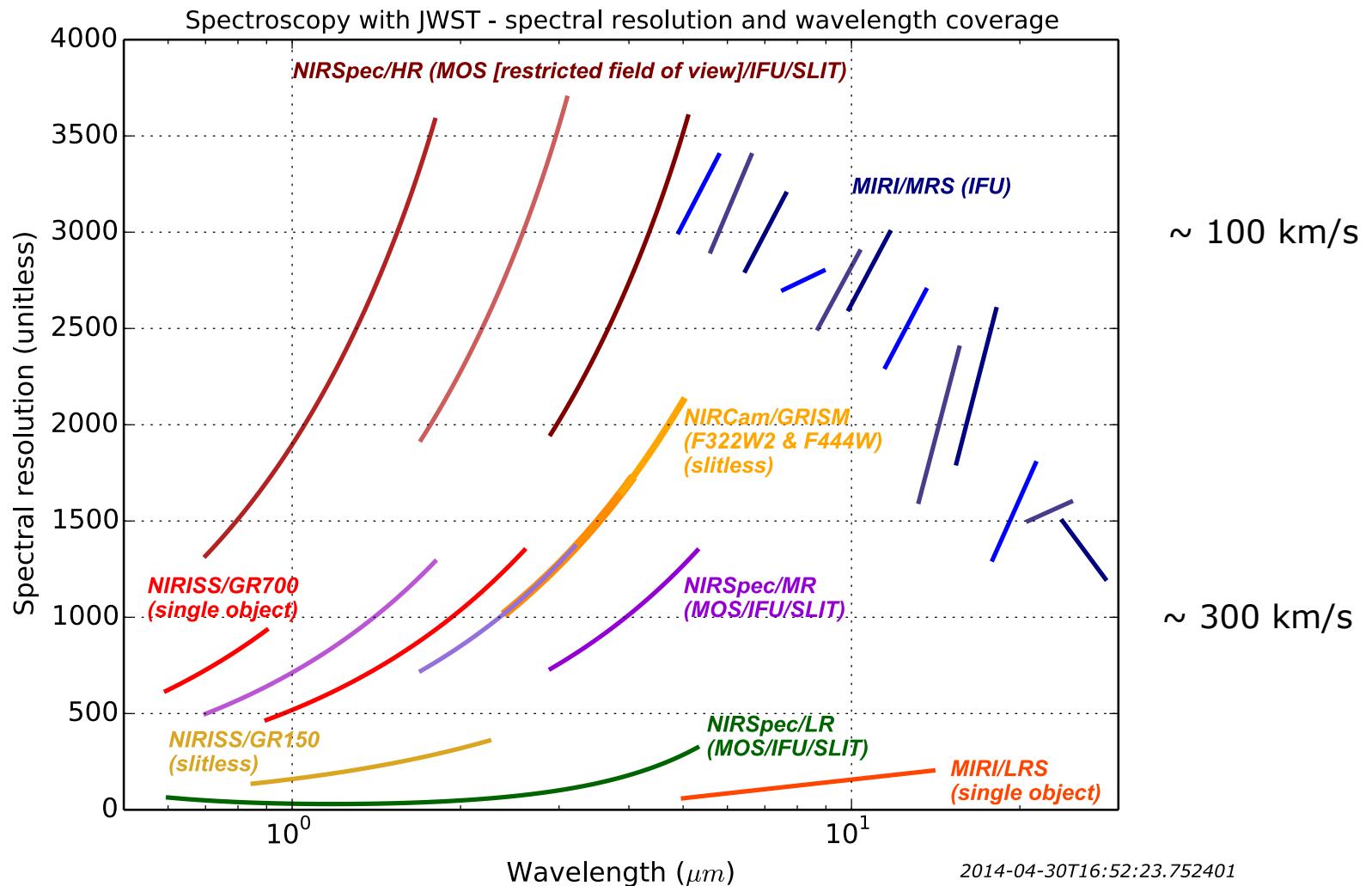


JWST spectroscopic capabilities

- **Take-home message: in JWST, spectroscopy comes in many different flavors...**
 - Can address many different scientific needs. Including time-series observations.

Instrument	Type	Wavelength (microns)	Spectral resolution	Field of view
NIRISS	slitless	1.0-2.5	~150	2.2' x 2.2'
NIRCam	slitless	2.4-5.0	~2000	2.2' x 2.2'
NIRSpec	MOS	0.6-5.3	100/1000/[2700]	9 square arcmin.
NIRSpec	IFU	0.6-5.3	100/1000/2700	3" x 3"
MIRI	IFU	5.0-28.8	2000-3500	>3" x >3.9"
NIRSpec	SLIT	0.6-5.0	100/1000/2700	Single object
MIRI	SLIT	5.0-10.0	60-140	Single object
NIRSpec	Aperture	0.6-5.3	100/1000/2700	Single object
NIRISS	Aperture	0.6-2.5	700	Single object

JWST spectroscopic capabilities Spectral resolution



JWST coronagraphic and aperture masking interferometry capabilities

- Like for spectroscopy a variety of modes are available, spread over the wavelength range covered by JWST.

Instrument	Wavelength (in microns)	Pixel scale (in mas/pixel)	Field of view	Type
NIRCam	0.6-2.3	32	20" x 20"	Lyot
NIRCam	2.4-5.0	65	20" x 20"	Lyot
NIRISS	3.8-4.8	65	0.1-0.5"	Aperture masking interferometry
MIRI	10.65	110	24" x 24"	4QPM
MIRI	11.4	110	24" x 24"	4QPM
MIRI	15.5	110	24" x 24"	4QPM
MIRI	23	110	30" x 30"	Lyot

- QPM = four-quadrant phase masks



Getting ready to use JWST - Science

- See presentation by Jason Kalirai on Wednesday.
- JWST science corner site maintained by STScI.
<https://jwst.stsci.edu/science-planning/science-corner>

Scientific Discovery with JWST

NEWSLETTERS

Continue ⊞

SCIENCE FLYERS

Continue ⊞

WHITE PAPERS

Continue ⊞

JWST's Four Science Themes

THE END OF THE DARK AGES: FIRST LIGHT AND REIONIZATION

Continue ⊞

THE ASSEMBLY OF GALAXIES

Continue ⊞

THE BIRTH OF STARS AND PROTOPLANETARY SYSTEMS

Continue ⊞

PLANETARY SYSTEMS AND THE ORIGINS OF LIFE

Continue ⊞

- Repository for JWST's white papers.
 - Recent ones: exoplanets, solar system.
- Repository for a large variety of flyers.
- Articles from newsletters.

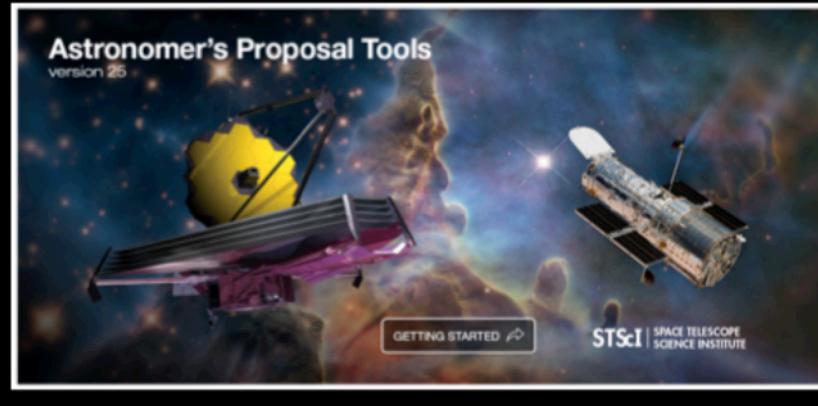


Getting ready to use JWST - Tools

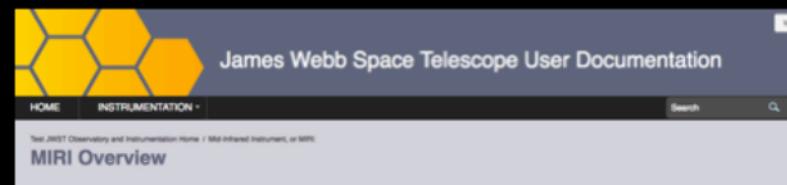
WORK IN PROGRESS

- Astronomer's proposal tool (APT)
 - Smart overhead accounting
 - New visibility tools
 - New JWST graphics
- Exposure time calculator (ETC)
 - All science modes complete
 - First release for WFIRST
 - Quantitative verification in review
 - Package being prepared for release
- Data simulators
 - STIPS imaging modes to be released
- Calibration pipelines
 - New plan with better prioritization and workflows
- User documentation (JDOX)
 - Wikipedia-style integrated web documentation
 - First batch of instrument and background articles in review
- Data analysis tools
 - Many new applications, including spectroscopic viewer, multi-object and IFU tools

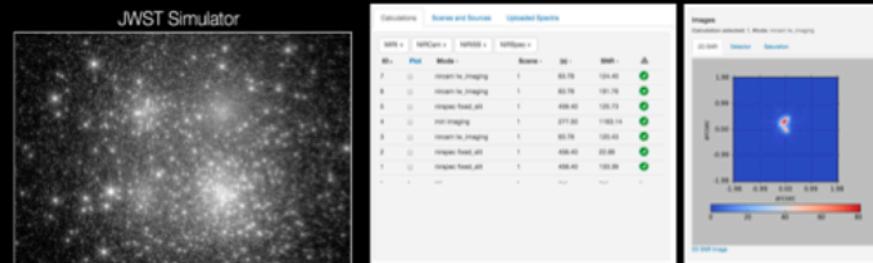
JWST User Tools Highlights



JDOX



JWST ETC



PERFORMANCE
AND
SIMULATION
TOOLS

Continue

Science planning section of STScI's JWST website:

<https://jwst.stsci.edu/science-planning>



Getting ready to use JWST - Science

The screenshot shows the official NASA JWST website. At the top, there's a banner with the text "Explore JAMES WEBB SPACE TELESCOPE". Below it, a large image of the James Webb Space Telescope (JWST) is displayed, featuring its gold-colored hexagonal mirrors and the sunshield. A smaller image to the right shows the "Explore the Spacecraft" interface. On the left, a sidebar menu lists various sections: HOME (which is highlighted in orange), STATUS, NEWS, ABOUT THE WEBB, SCIENCE, INSTRUMENTS, FEATURES, IMAGES & VIDEOS, MEET THE TEAM, FOR SCIENTISTS (with an arrow pointing to it), FOR EDUCATORS, and FOR PRESS. Below the menu are social media icons for Twitter, Facebook, Google+, YouTube, and Instagram. In the center, there's a live video feed from WebbCam1 showing the interior of a clean room where the telescope is being assembled. The video feed has a timestamp of "2014/01/07 06:59:37.29 EST". At the bottom, there are links for "Top Images", "Top Videos", and "Top Interactives".

- **NASA JWST site**
- jwst.nasa.gov
- **In the “FOR SCIENTISTS” section, you can register to receive the JWST newsletter, “The Webb update”.**





Getting ready to use JWST Conferences and workshops

OCTOBER 2016



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



MARCH 2017
Venice (Italy)

Workshop
during the last
day of the
meeting

FALL 2017



ESAC 2017
The next in the series!

JWST workshop - ESAC - 26-29 September 2016

Slide #31



Conclusion

JWST is on track for a launch in October 2018 and for a start of scientific operation in the first half of 2019.

But the first calls for proposals will take place in 2017!

Get ready for JWST!



Thank you for your attention.