The James Webb Space Telescope: The Road to Science

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Acknowledgements

JWST is a collaboration between NASA, ESA and CSA

This presentation contains results from work by many teams in the US, Europe and Canada

This presentation contains elements from many other existing presentations

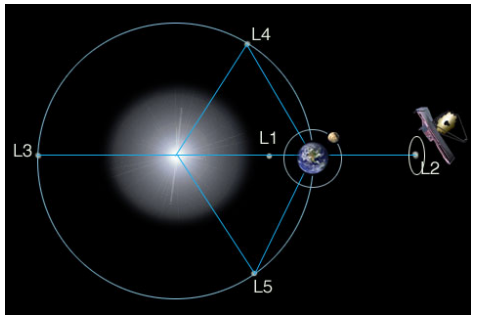
I. JWST: THE MISSION

Basic Facts

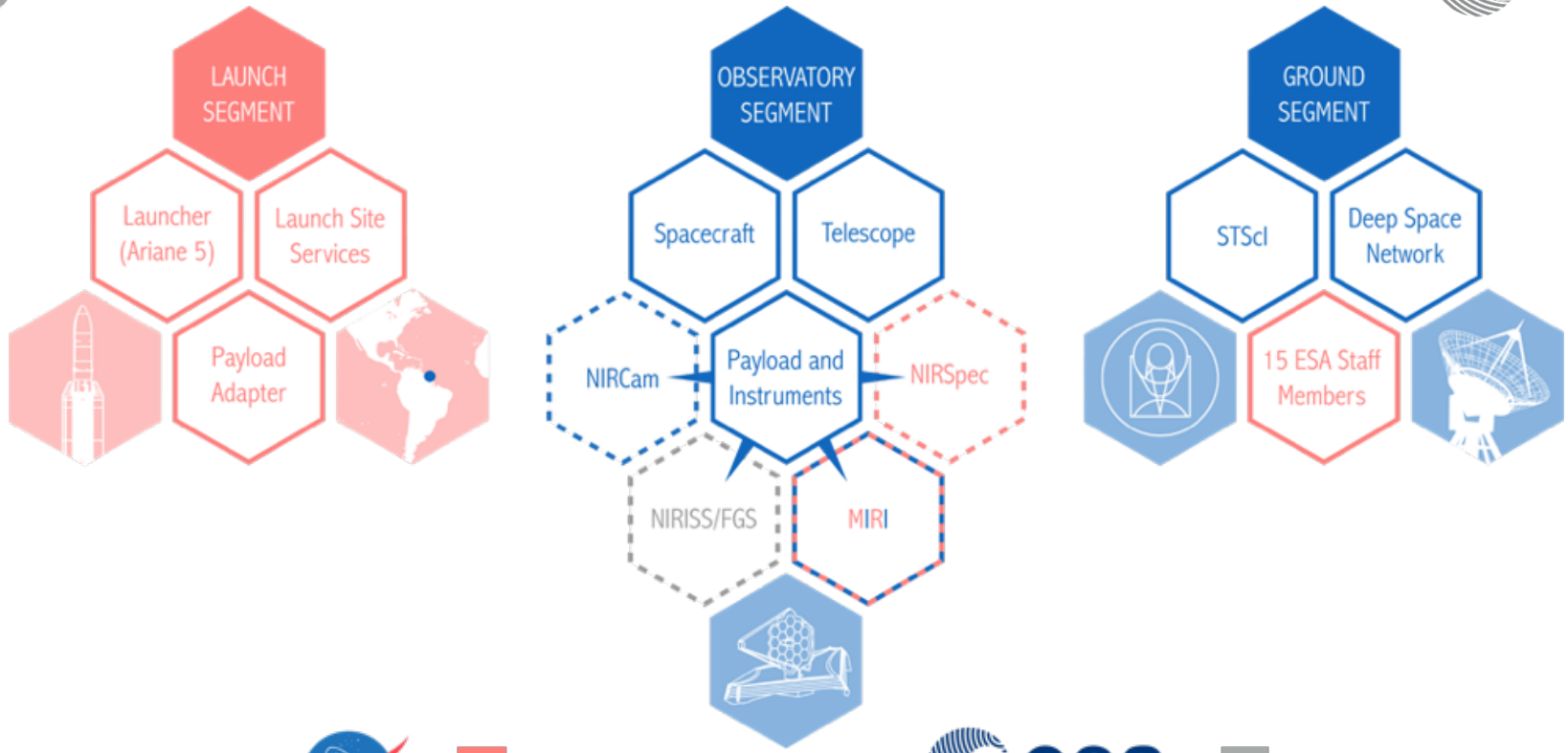
- **Project facts**
  - Launch date ~~late 2018~~ **SPRING 2019**
  - NASA Goddard Space Flight Center is managing the development effort.
  - The main industrial contractor is Northrop Grumman
  - All flight & scientific operations will be carried out from STScI after launch

- **The Observatory**
  - 6.5-m primary mirror, 18 adjustable segments
  - 4 instruments, covering 0.6 – 28.5 μm

    NIRCam, NIRSpec, NIRISS, MIRI
  - Orbit at L2
  - Passively cooled to ~40K; only MIRI is actively cooled to ~7K



Mission contributions



Provided by NASA

Provided by ESA/Europe

Provided by CSA

Image: Nora Lützgendorf

European contribution to JWST

JWST will be launched by an Ariane 5 rocket from Kourou, French Guyana

As of Oct 17, the Ariane 5 has had 81 successful launches in a row

Images: Arianespace - ESA

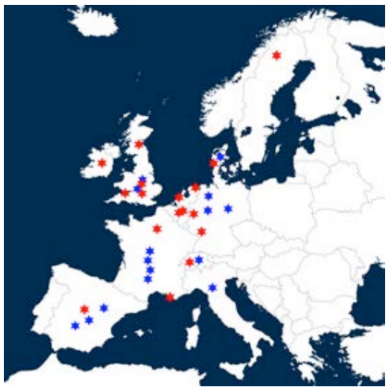
European contribution to JWST

- NIRSpec, the NIR Spectrograph, was built by a consortium of European industrial companies for ESA, with contributions from NASA

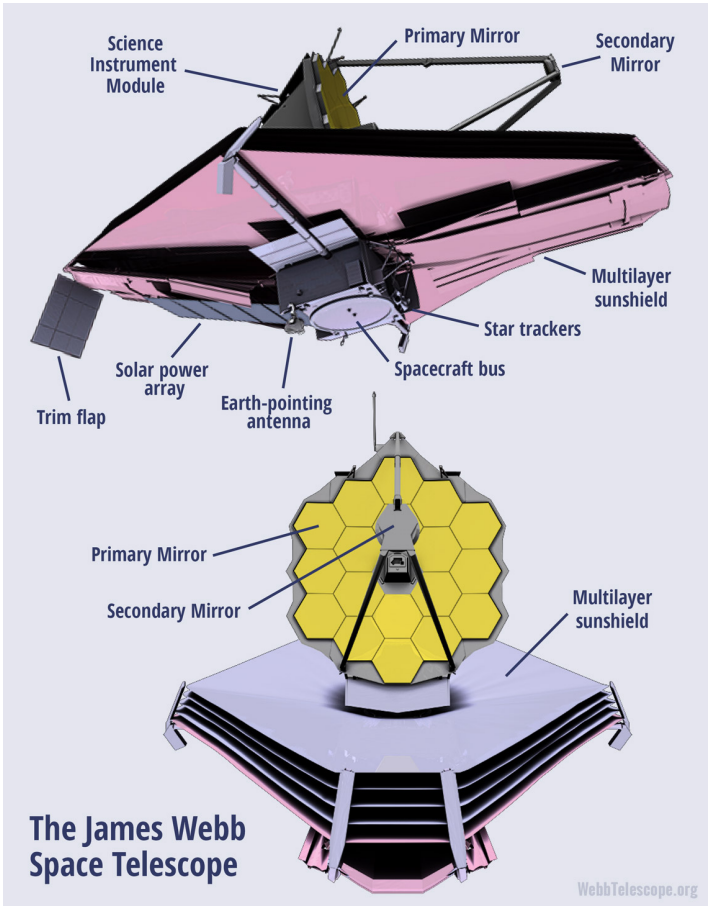
- Consortium led by Airbus Space & Defense

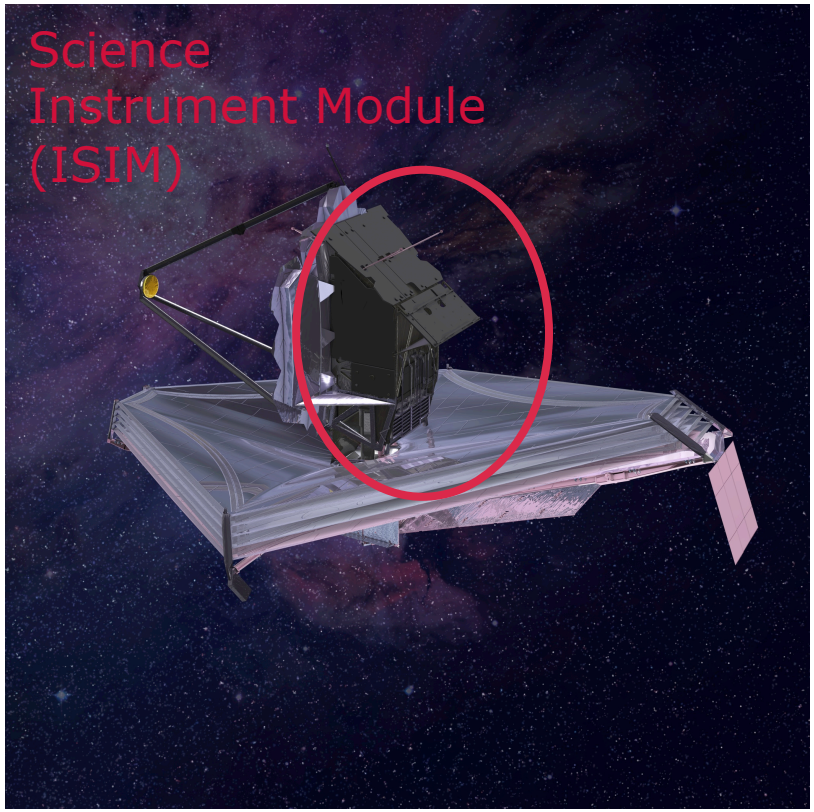
- The MIRI optical system was built by a consortium of nationally-funded European institutes, led by Prof. Gillian Wright (UK Astronomy Technology Centre, Edinburgh, UK)

- MIRI's detectors and cryogenic cooler system were developed by NASA JPL

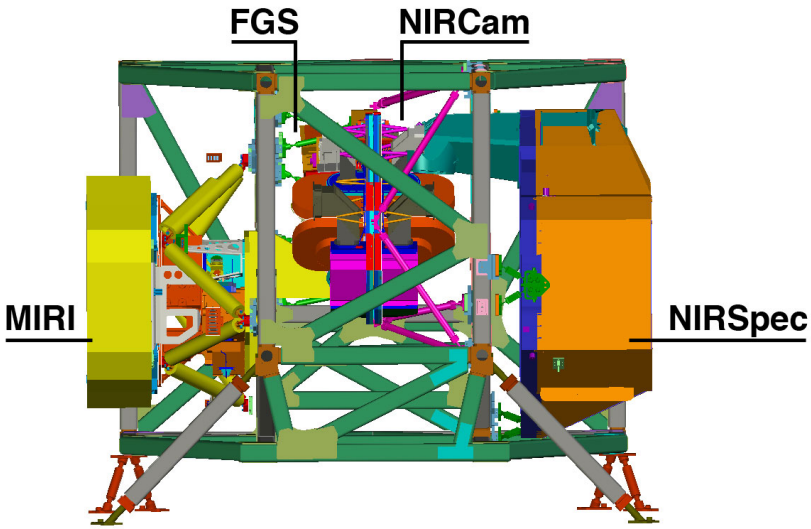


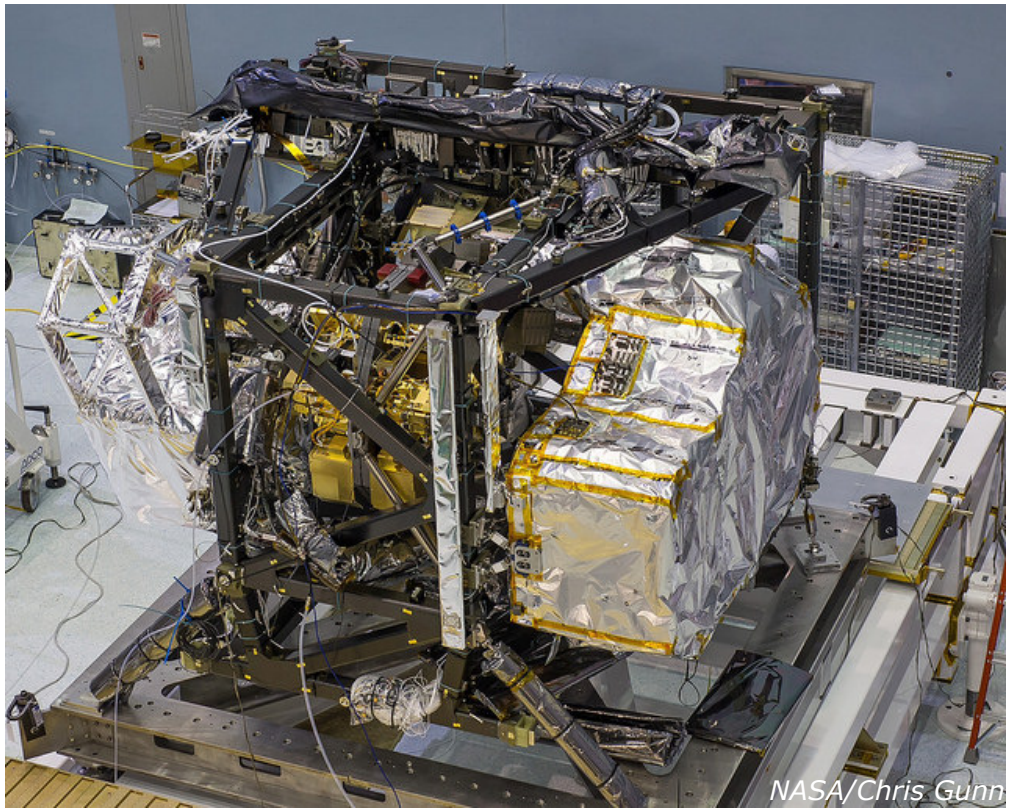
Blue: NIRSpec partners
Red: MIRI partners
(image: G. Wright)


Science Instrument Module
Primary Mirror
Secondary Mirror
Multilayer sunshield
Star trackers
Spacecraft bus
Solar power array
Earth-pointing antenna
Trim flap
Primary Mirror
Secondary Mirror
Multilayer sunshield
The James Webb Space Telescope
WebbTelescope.org

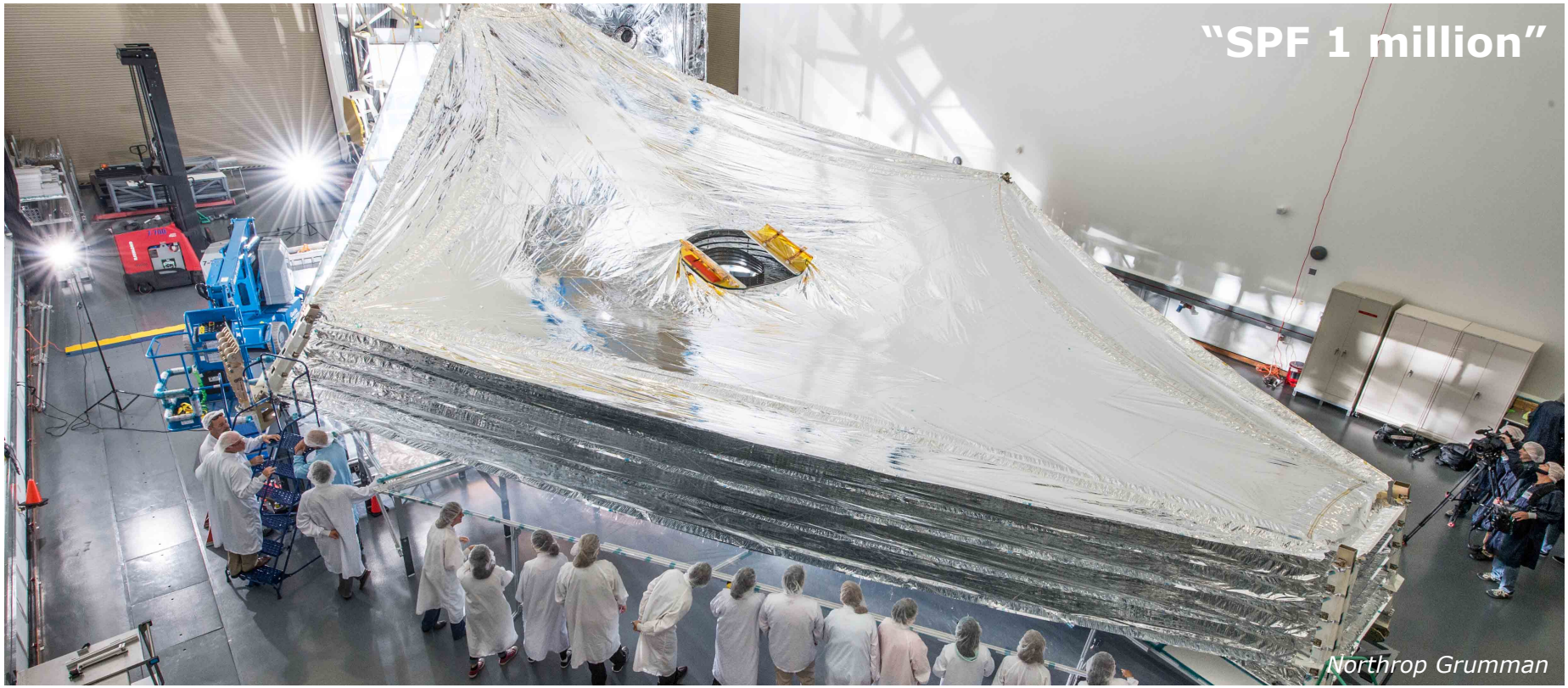

Science Instrument Module (ISIM)

The Science Instrument Module





Sunshield



2017: OTIS testing, Houston

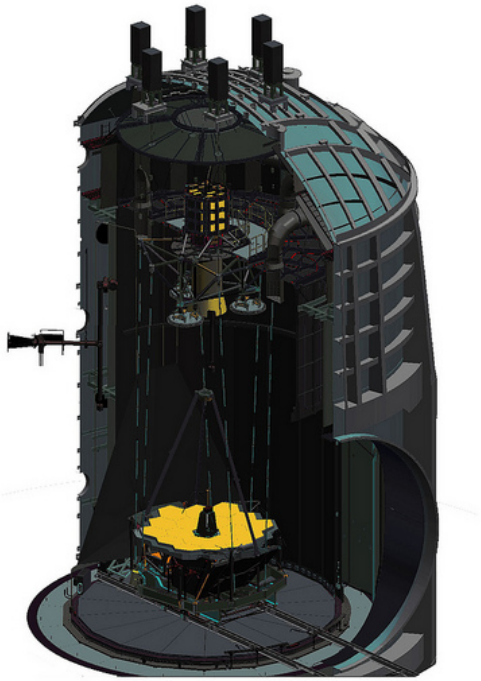


Image: NASA

- In Chamber A at Johnson Space Center, Summer 2017
- **OTIS = Optical Telescope Element + Integrated Science Module**
- Optical, Electrical, Thermal tests
- Full instrument support

Moving OTIS into Chamber A

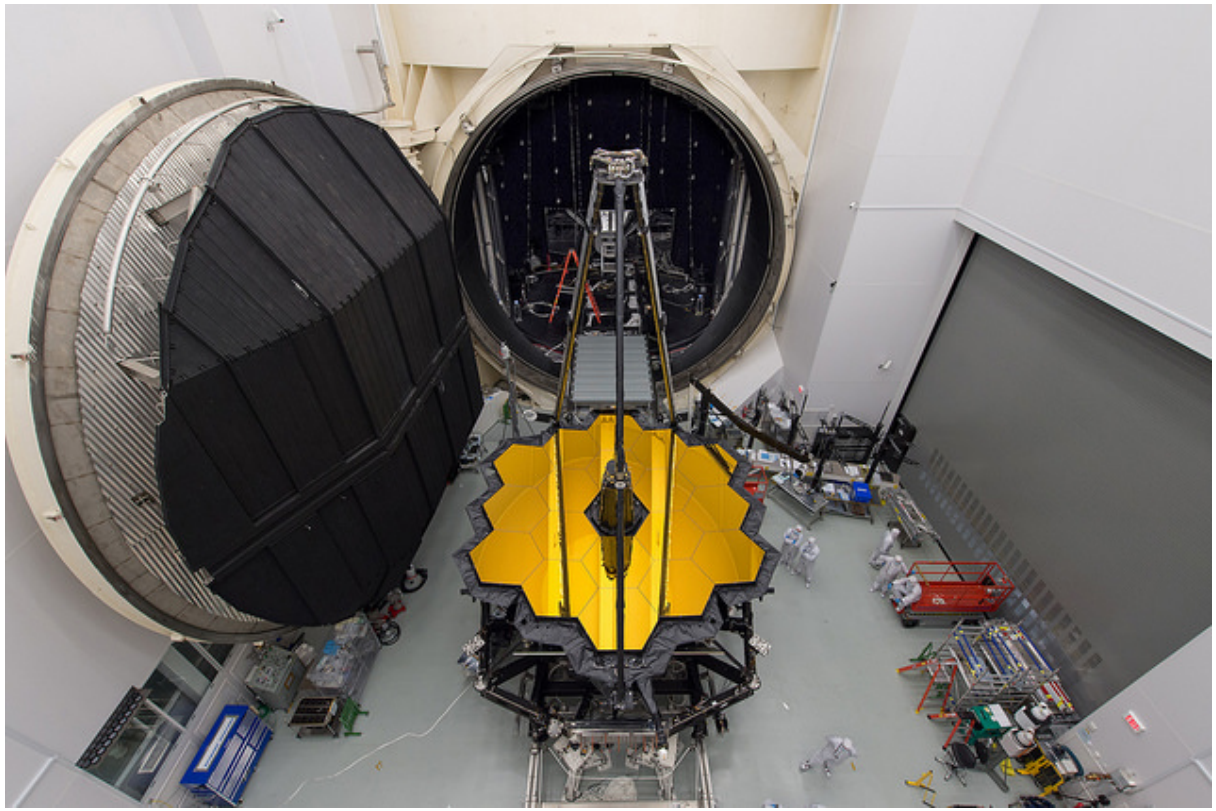
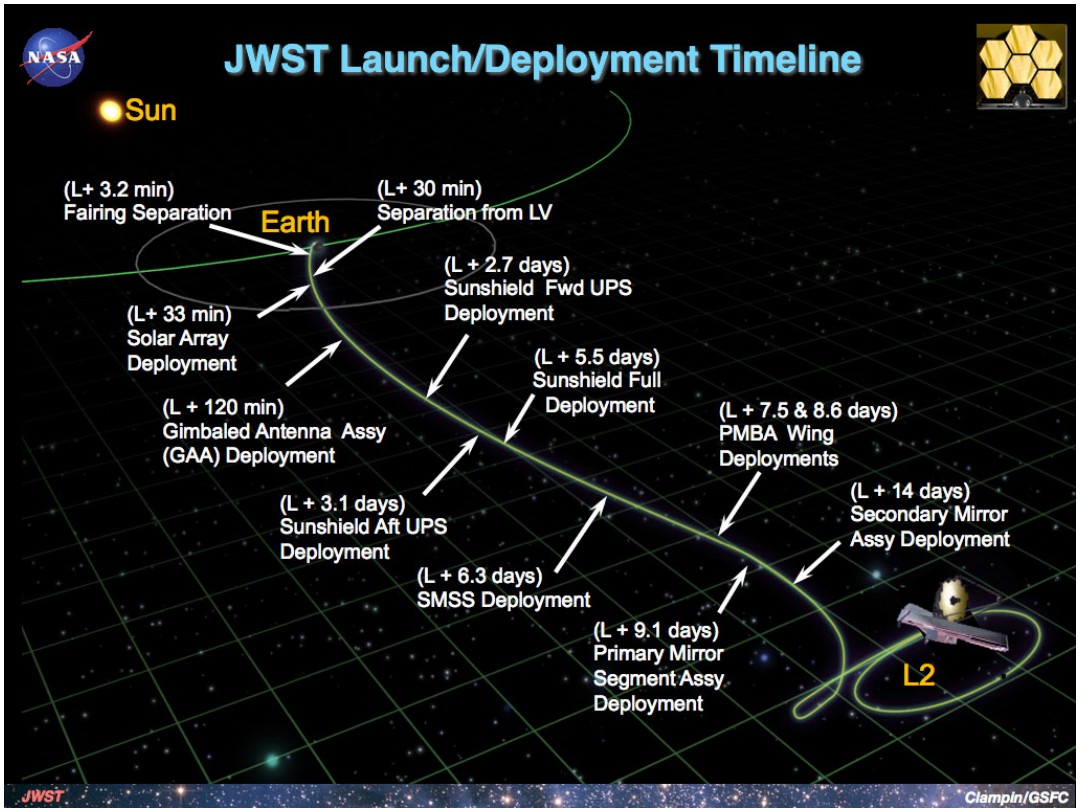


Image: NASA

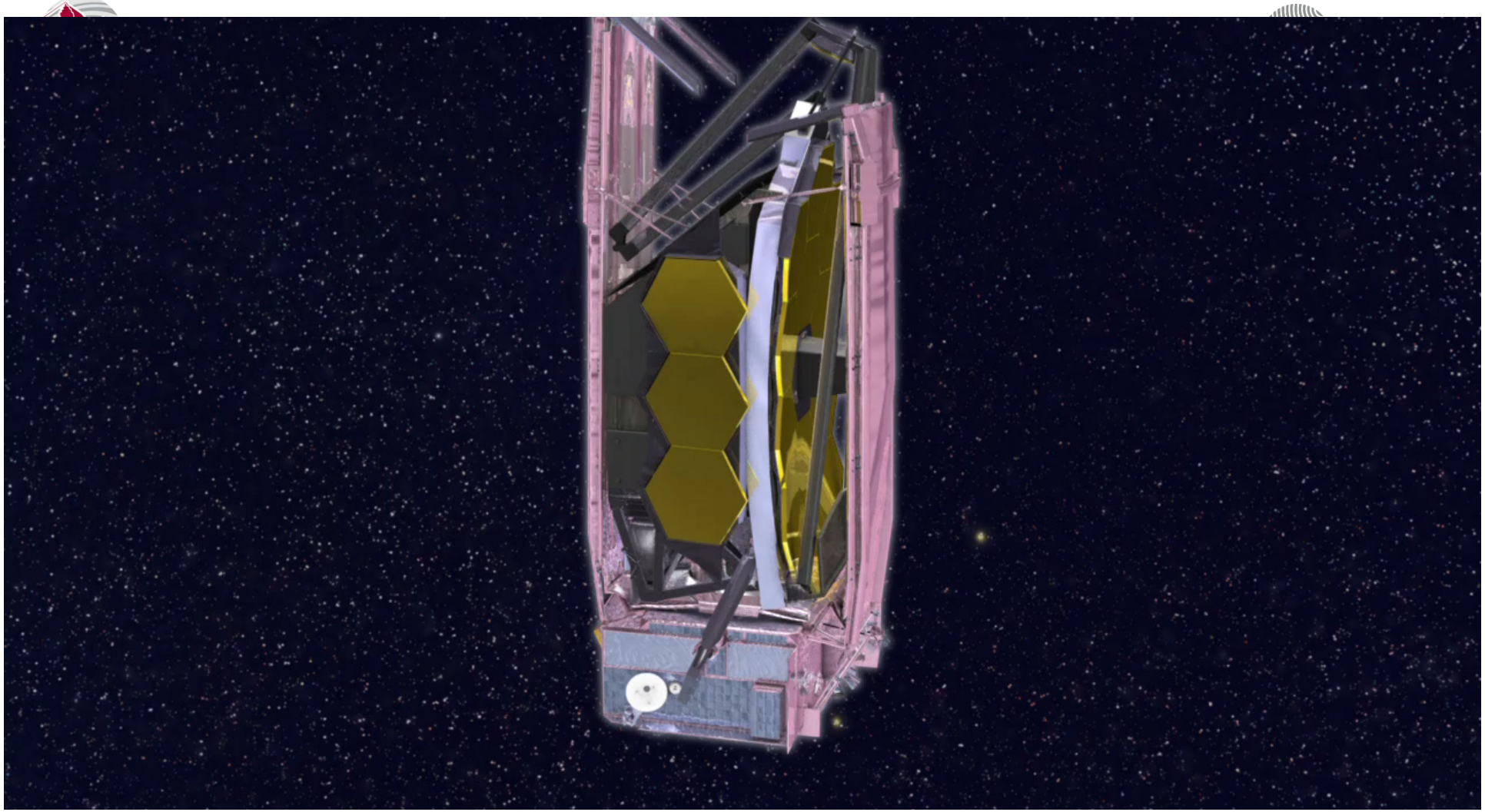
Launch & Deployment

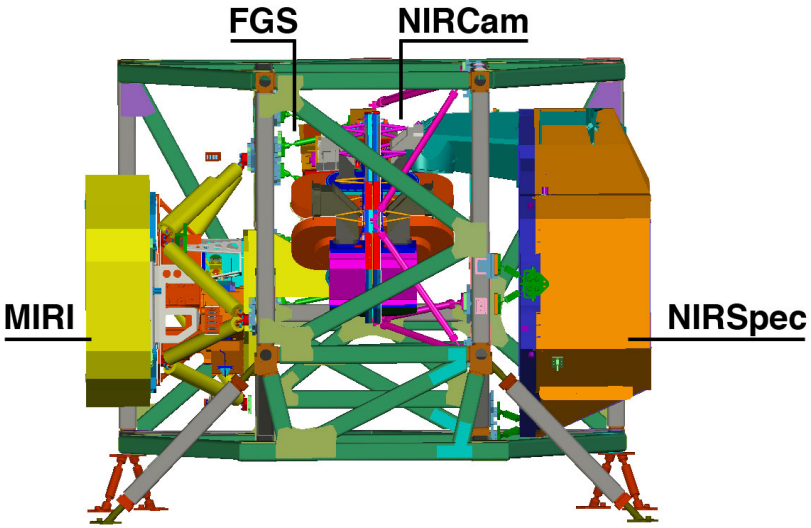


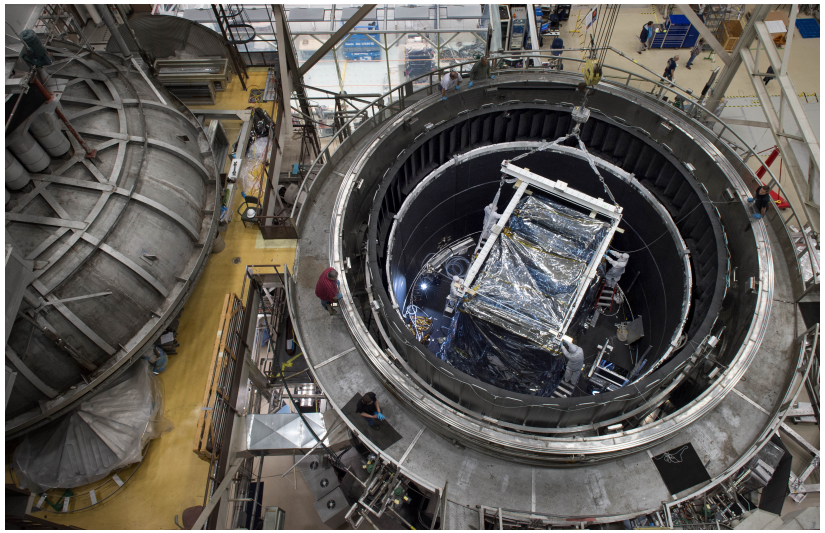
Commissioning timeline starts at L-15 mins!

6 months of round-the-clock intensive functional check-outs and getting the observatory & instruments ready for science

Credit: Arianespace - ESA - NASA

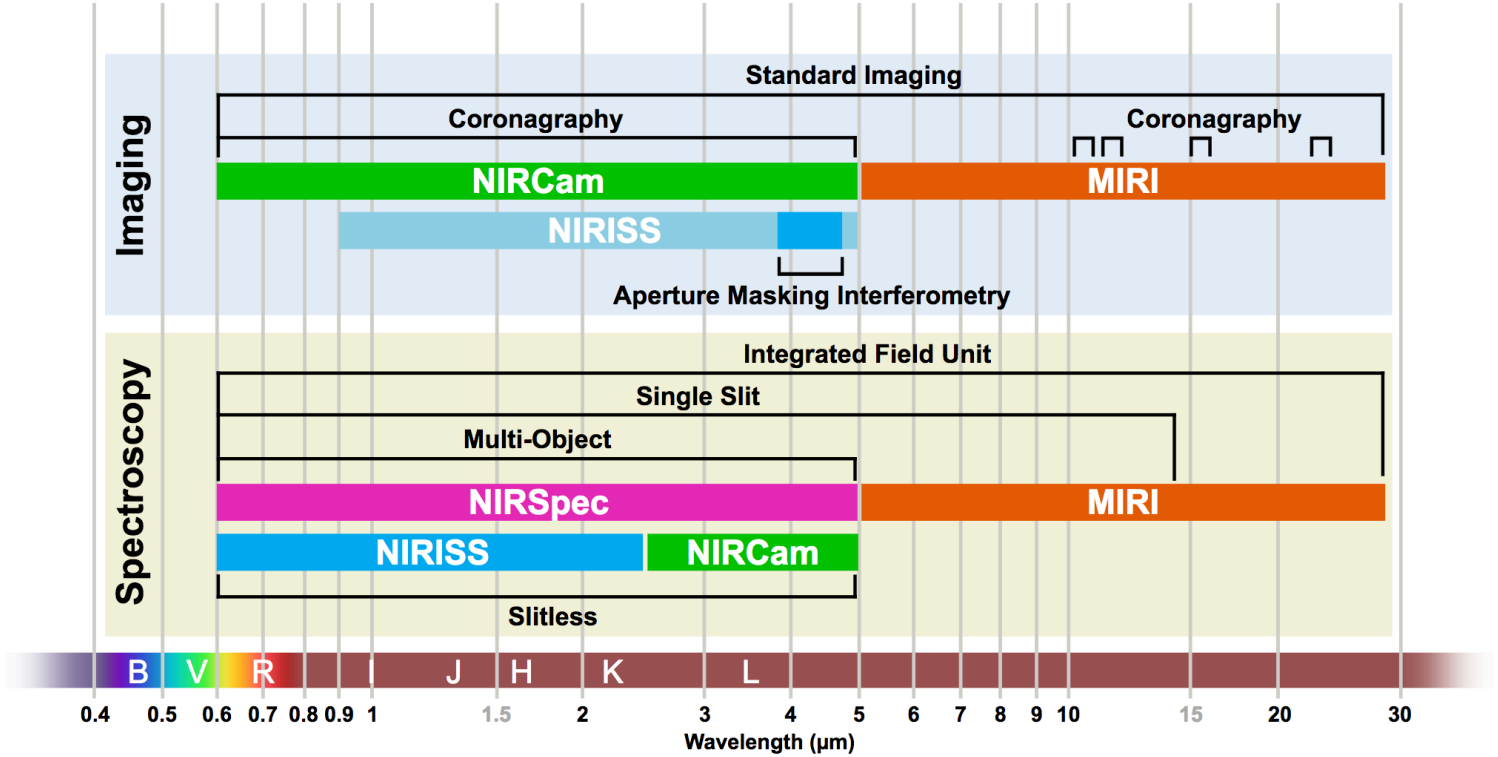




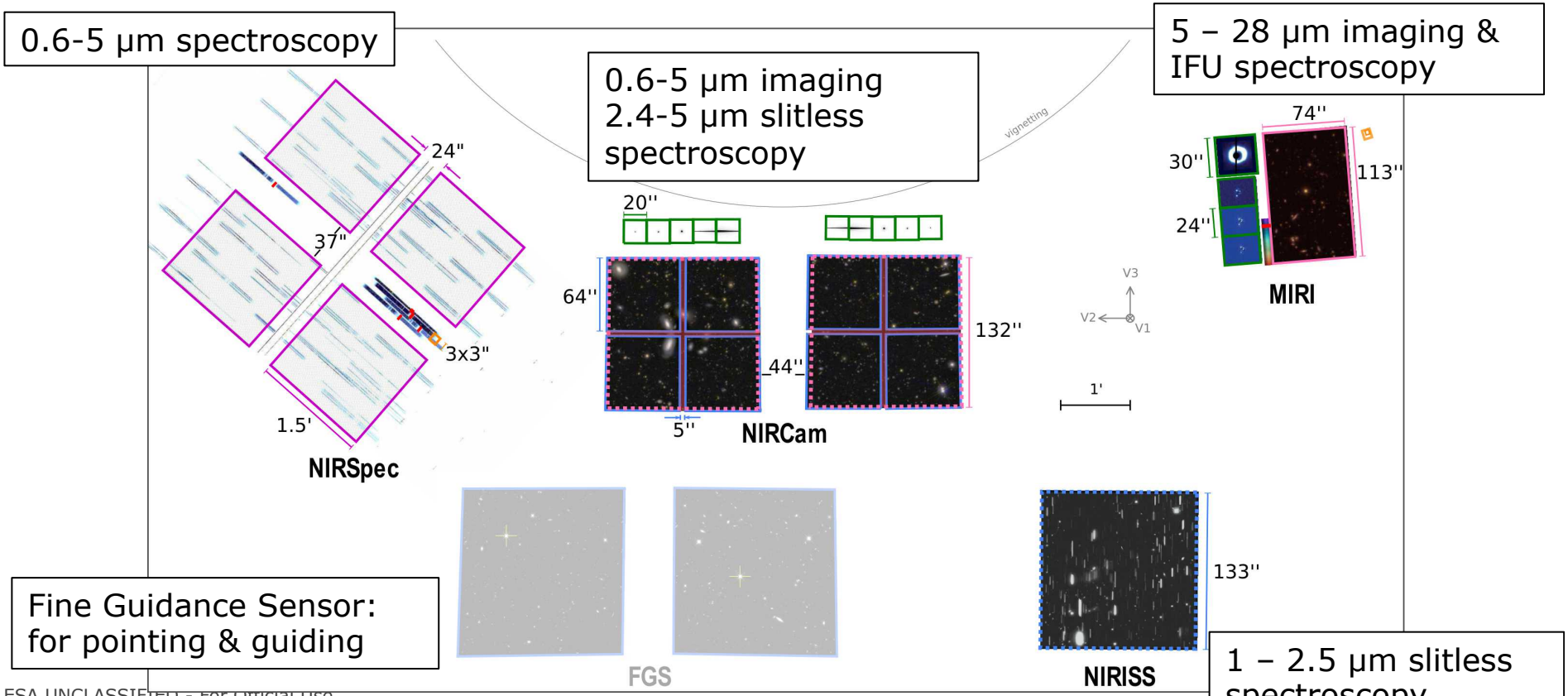


II. JWST INSTRUMENTATION

Modes and Wavelengths

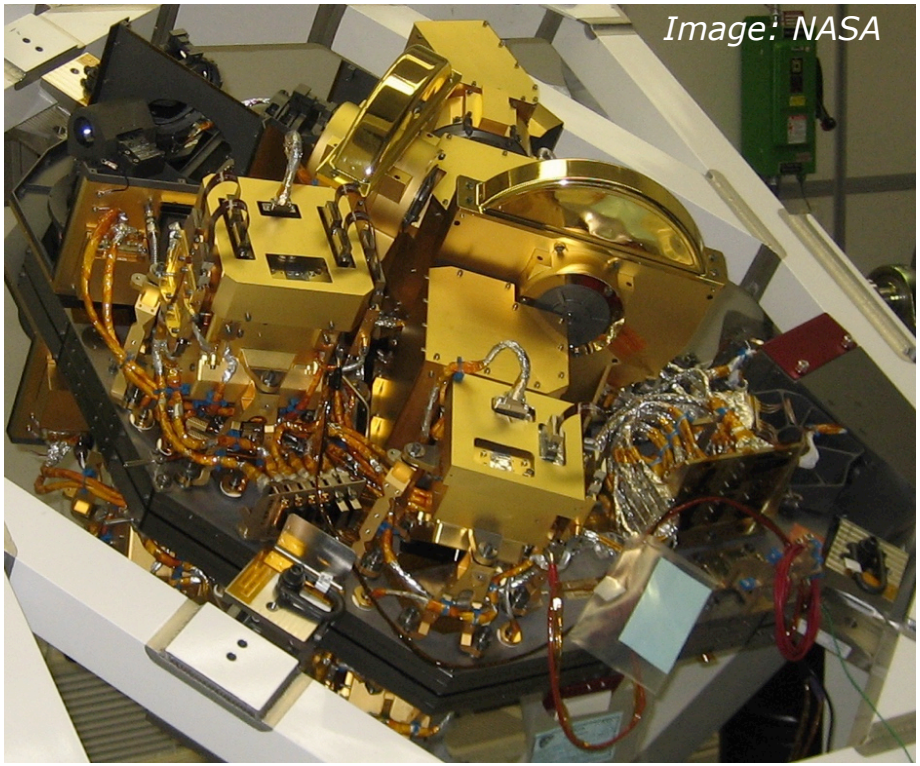


JWST Full focal plane layout



Near-Infrared Camera: NIRCam

- University of Arizona/Lockheed Martin (PI: Marcia Rieke)
- Fully redundant A and B sides, total fov 9.7 arcmin^2
- Simultaneously images in short- & long-wavelength channels (0.6-2.3 μm, 2.4-5.0 μm)
- contains **10** 2k x 2k Teledyne HgCdTe detectors
- 29 imager filters, 3 weak lenses, 2 grisms, 4 Lyot stops & various other optical elements for wavefront sensing & calibration (48 in total!)



NIRCam Modes in Cycle 1

- Imaging
  - Prime science imager at 0.6 – 5 μm
  - Expected to be popular for parallel imaging
- Wide Field Slitless Spectroscopy (at 2.4 – 5 μm)
- Coronagraphic Imaging: coronagraphic imager at 1.8 – 5 μm
- Time-Series Imaging (0.6 – 5 μm)
- Grism Time Series (2.4 – 5 μm)

Near-Infrared Imager and Slitless Spectrograph (NIRISS)

- Canadian contribution to JWST. Science team lead: René Doyon.
- Coverage 0.6-5.0 μm
- Modes for Cycle 1:
  - Wide-field slitless spectroscopy (0.8-2.2 μm; R~150)
  - Single-object slitless spectroscopy (R~700)
  - Aperture masking interferometry: provides contrast 10^{-4} for separations 70 – 400 mas
  - Imaging (12 filters): only for parallel imaging

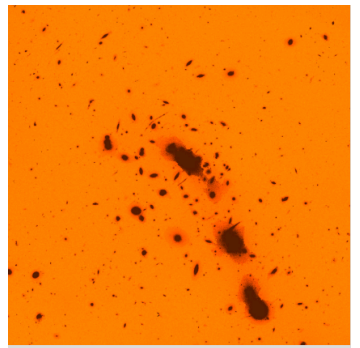


Image: F115W

Spectra: GR150C, F115W

Near-Infrared Spectrograph (NIRSpec)

MODES

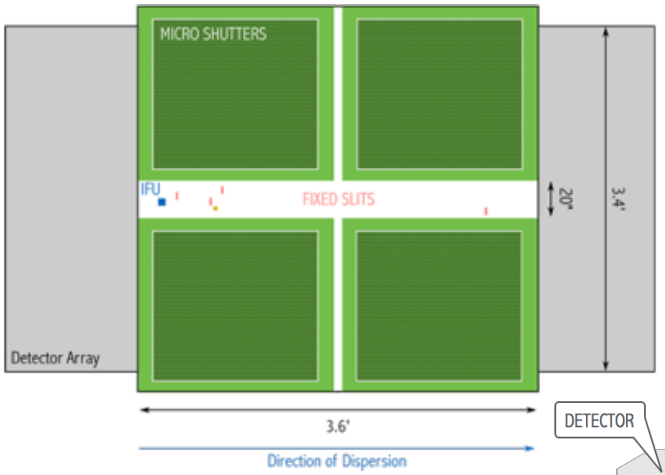
Fixed Slits (FS):
- Single sources, bright stars

Multi-Object spectroscopy (MOS):
- Rich fields, extended targets

Integral Field Spectroscopy (IFS):
- Sources with few arcsec extent

Bright Object Time Series (BOTS):
- Exoplanets

FIELD OF VIEW



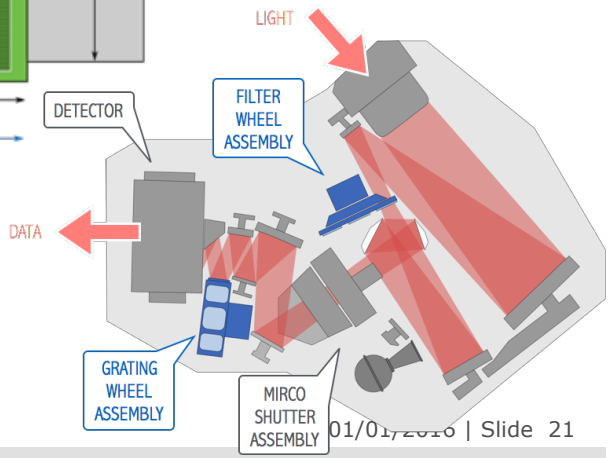
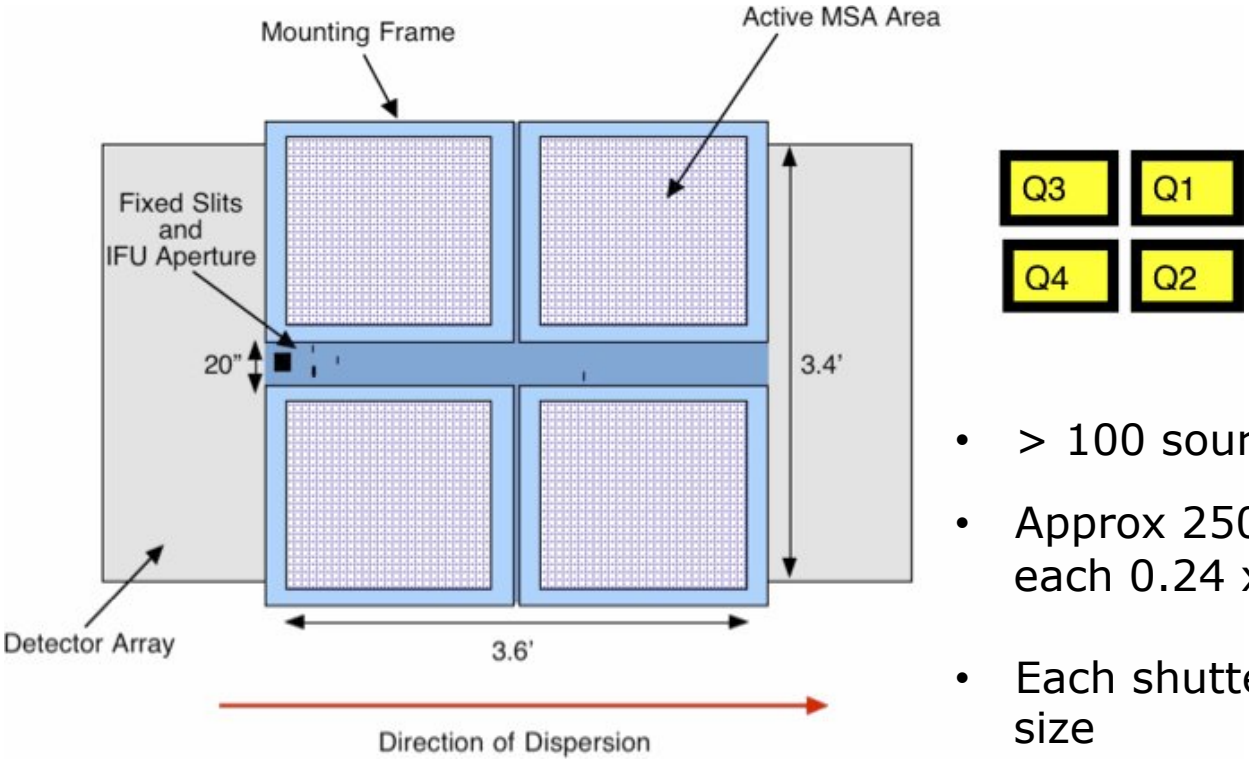
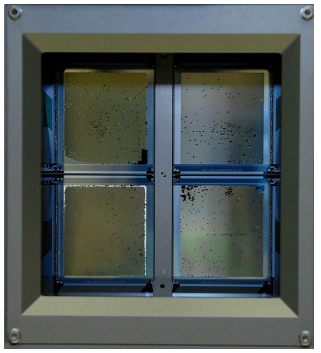


Image: N. Lützgendorf

NIRSpec Micro-Shutter Array (MSA)





- > 100 sources in fov > 3 x 3'
- Approx 250,000 micro-shutters, each 0.24 x 0.46"
- Each shutter 100 x 200 μm in size

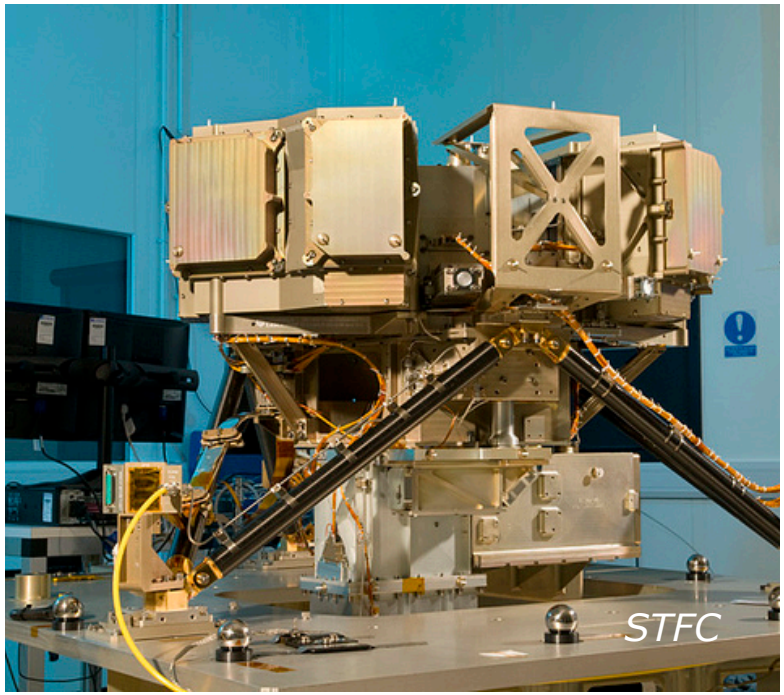
Image: NASA

Mid-Infrared Instrument (MIRI)

- Covers 5 – 28.5 μm, the only mid-IR instrument on JWST (PI: G. Wright/G. Rieke)

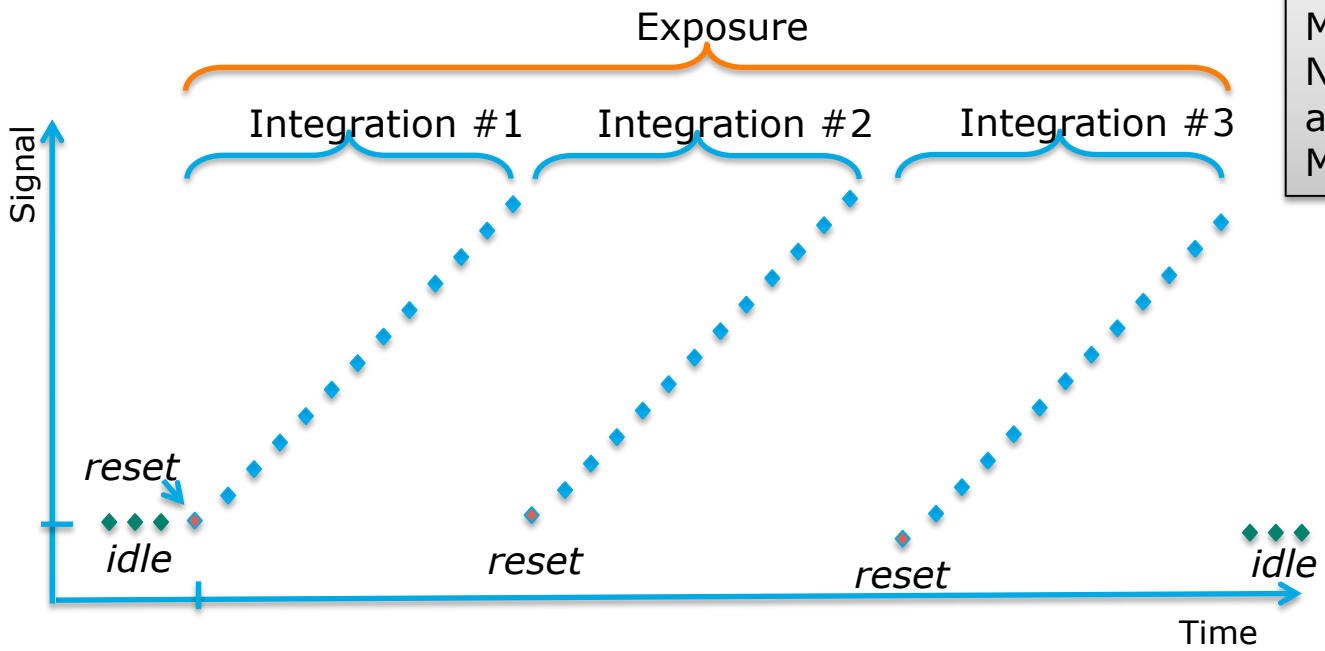
Cycle 1 modes:

- Imaging (5–25 μm)
- Coronagraphic Imaging (10.65 – 23 μm)
  - One Lyot and three 4 Quadrant Phase Masks (4QPMs)
- Low Resolution Spectrometer (5-12 μm; R~100)
  - Includes Slitless mode for high precision spectro-photometry
- Medium Resolution Spectrograph (R~3000)



Detectors on board JWST

- All NIR instruments use the Teledyne 2RG detectors (2k x 2k, 18 μm pixels); MIRI uses 3 Si:As detectors (1k x 1k; 25 μm pixels)

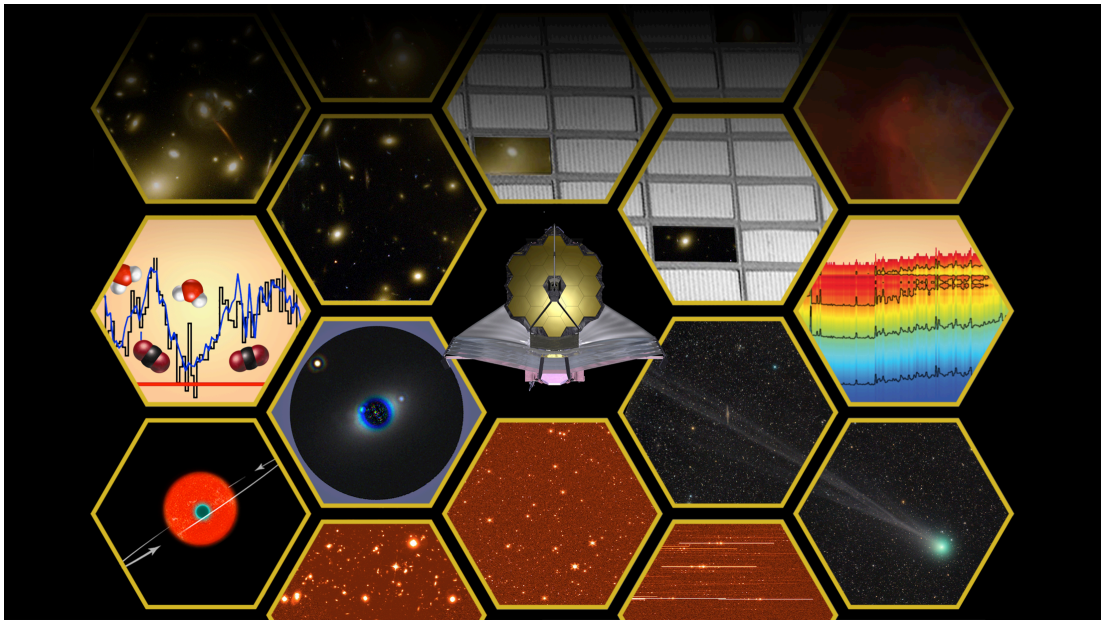


Single pixel read: "frame"
Minimum unit: "group"
NIR: groups may be on-board averages of > 1 frames
MIR: always 1 frame/group

Fit of the slope provides the count rate

Multiple samples averaged down the noise

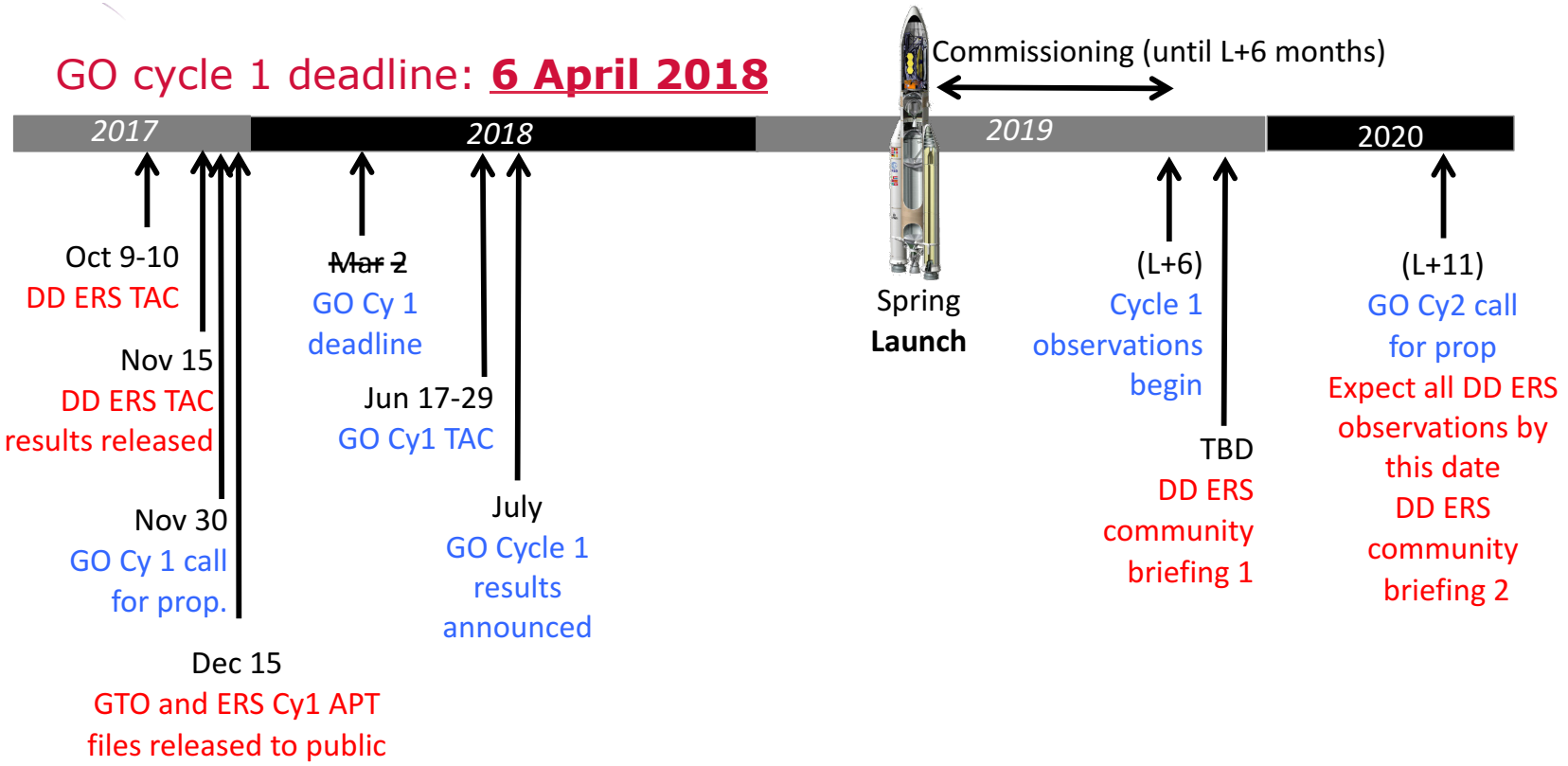
Every instrument has its own set of detector read modes



III. ROAD TO JWST SCIENCE

(See talk J. Valenti, STScI, ESAC JWST conference, Oct 2017)

Timeline


GO cycle 1 deadline: 6 April 2018
Commissioning (until L+6 months)
2017
2018
2019
2020
Oct 9-10
DD ERS TAC
Nov 15
DD ERS TAC
results released
Nov 30
GO Cy 1 call
for prop.
Dec 15
GTO and ERS Cy1 APT
files released to public
Mar 2
GO Cy 1
deadline
Jun 17-29
GO Cy1 TAC
July
GO Cycle 1
results
announced
Spring
Launch
(L+6)
Cycle 1
observations
begin
TBD
DD ERS
community
briefing 1
(L+11)
GO Cy2 call
for prop
Expect all DD ERS
observations by
this date
DD ERS
community
briefing 2

Current status

- Cycle 1 GTO program specifications almost complete
  - Observations list is public
  - APT (proposal) files will be released in Dec 2017

- Director's Discretionary Time (460 hrs) allocated for Early Release Science (ERS) – results announced last week
  - 13 programs, zero exclusive access period
  - teams will test modes, return "science enabling products" to STScI

- Cycle 1 GO Call for Proposals will be published on 30 Nov 2017
  - Deadline: 6 April 2018; TAC will meet 17-29 June 2018

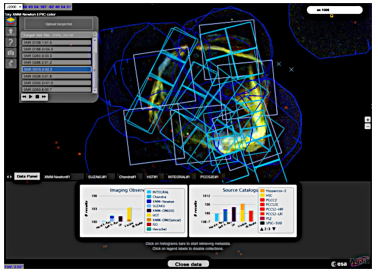
- JWST User Committee in place (JSTUC)

General Observer (GO) proposals

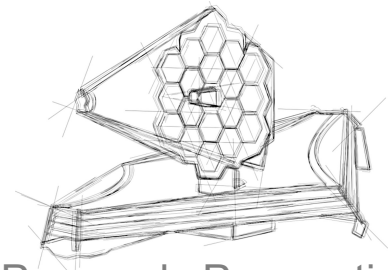
- Small (< 25 hours, 12 months default exclusive access period)
- Medium (25-75 hours, 12 months default exclusive access period)
- Large (>75 hours, no exclusive access period by default)
  - Balance distribution of program sizes over all JWST cycles, but small programs will likely dominate Cycle 1, even though there will be no cap on program size.
- Calibration
  - Calibrate specialized modes that are uncalibrated or poorly calibrated
  - Develop specialized software for certain JWST calibration or reduction tasks
  - Proposers must contact the relevant instrument groups at STScI
- Long-term
  - Programs whose science requires multiple cycles (astrometry, variability)
  - Can be small, medium or large.

"Toolbox" for proposal preparation

APT
Astronomer's
Proposal Tool



ESASky



Proposals Preparation
Toolbox

Target Visibility
Tool

ETC
Exposure Time
Calculator

Summary

- JWST is entering the final stages of hardware integration & testing
- Getting ready for launch in spring 2019
- Instruments in good shape
- Preparations for science well under way, first proposals chosen for early science