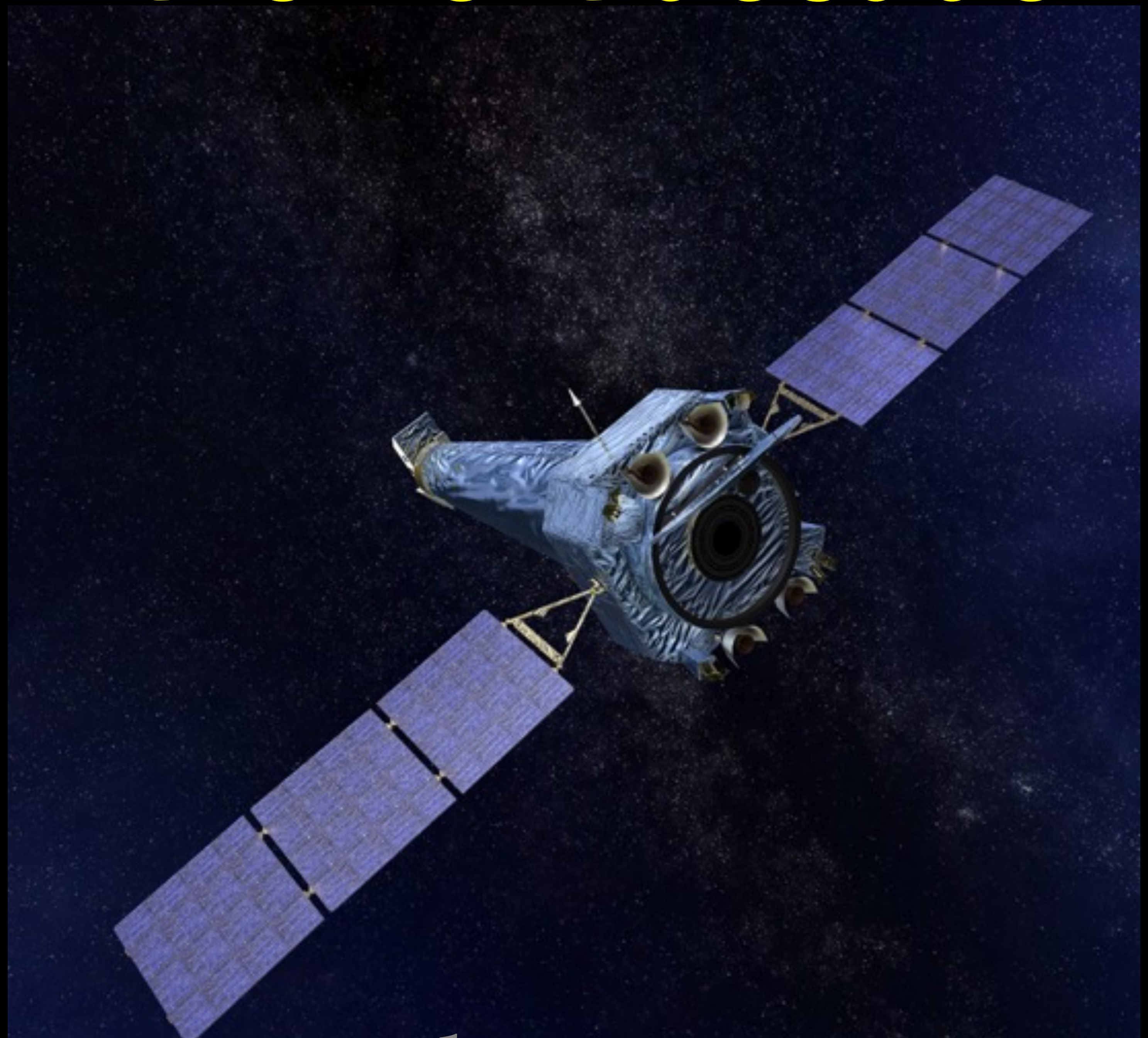
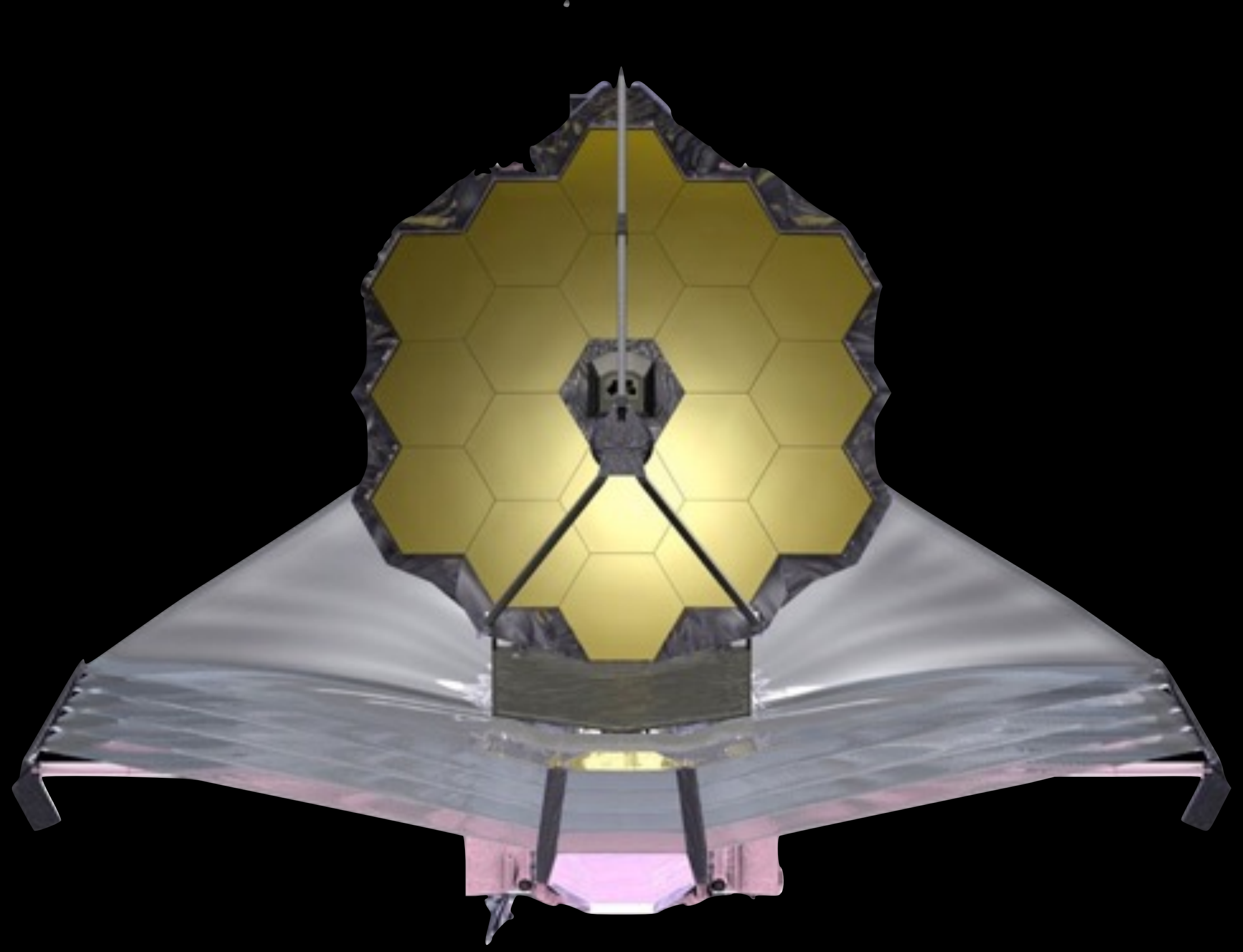
Maximizing Science between Chandra and Hubble and James Webb in the next decade





Rachel Osten

Deputy Mission Head, HST

Space Telescope Science Institute

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Maximizing Science between Chandra and Hubble and James Webb in the next decade

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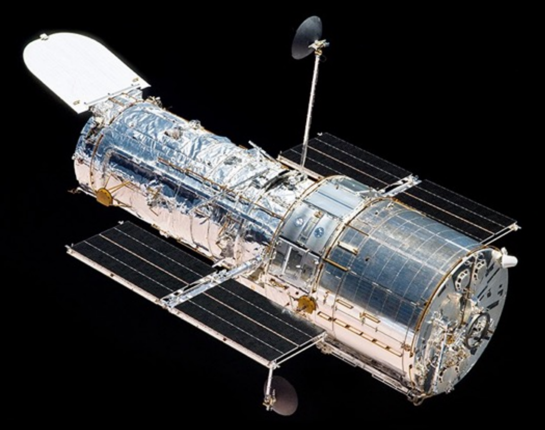
Hubble instrument suite

HST Science Instruments					
	Installed	Channel	λ (nm)	Details	FOV
ACS	2000	SBC	115-170	6 filters; 2 prisms ($R=\lambda/\Delta\lambda\sim100$; 115-180 nm	35"x31"
		WFC	370-1100	36 filters; 1 grism (R~100; 550-11050 nm)	202"x202"
COS	2009	FUV	90-200	R~3k; R~18k	2.5" diameter circle
		NUV	170-320	R~3k; R~20k; full-band imaging	2.5" diameter circle
FGS-1R	1997	–	400-700	4 filters; photometry; astrometry	~69 sq. arcmin
NICMOS*	1997	NIC1	800-1800	19 filters; polarimetry	11"x11"
		NIC2	800-2450	19 filters; polarimetry; coronagraphy	19"x19"
		NIC3	800-2300	16 filters; 3 grisms (R~200; 800-2500 nm)	51"x51"
STIS	1997	FUV	115-175	3 filters; R~1k; R~15k; R~45k; R~114k	25"x25"
		NUV	170-320	6 filters; R~500; R~20k; R~30k; R~114k; prism	25"x25"
		CCD	200-1030	3 filters; R~1k; R~8k; coronagraphic fingers	52"x52"
WFC3	2009	UVIS	200-1000	62 filters; 1 grism (R~70; 190-450 nm)	162"x162"
		IR	800-1700	15 filters; 2 grisms (R~210; 800-1150 nm and R~130; 1075-1700 nm)	123"x136"
*NICMOS is currently dormant and not being used for science observations					



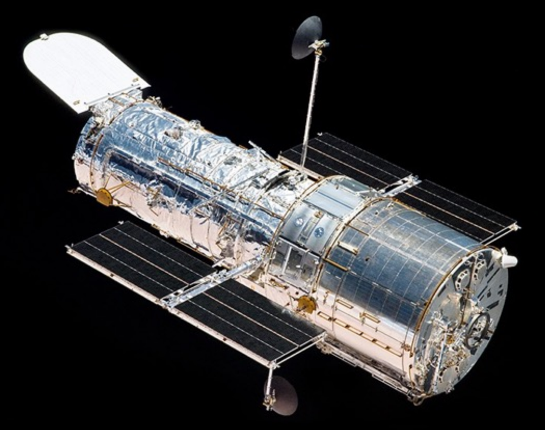
Hubble prognosis for the next decade

- observatory health and safety
- budget

Hubble prognosis for the next decade

- observatory health and safety
- budget

Observatory Systems Status		
Science Instruments	ACS	Operating well. Charge transfer degradation corrections in place for WFC.
	COS	New blue mode extends λ to 90 nm. Far-UV sensitivity remains excellent. Improving wavelength calibration.
	STIS	Operating well. Imaging, spectroscopy, coronagraphy.
	NICMOS	Safed, warm.
	WFC3	Excellent stability, sensitivity. Spatial scanning available. Charge transfer corrections for UVIS channel. Persistence maps available for IR channel.
Fine Guidance Sensors		Slow degradation being monitored, understood.
Electrical and Power System		Batteries and solar arrays - no serious issues.
Pointing and Control System		1 std gyro failed in 2014; 2 std and 3 enhanced gyros remaining. Expecting to remain on 3 gyros until 2023 and 1 gyro well beyond that.
Data Management System		Lockups are rare (1-2x per year) and understood.
Thermal Control System		Excellent, no serious issues.



Hubble prognosis for the next decade

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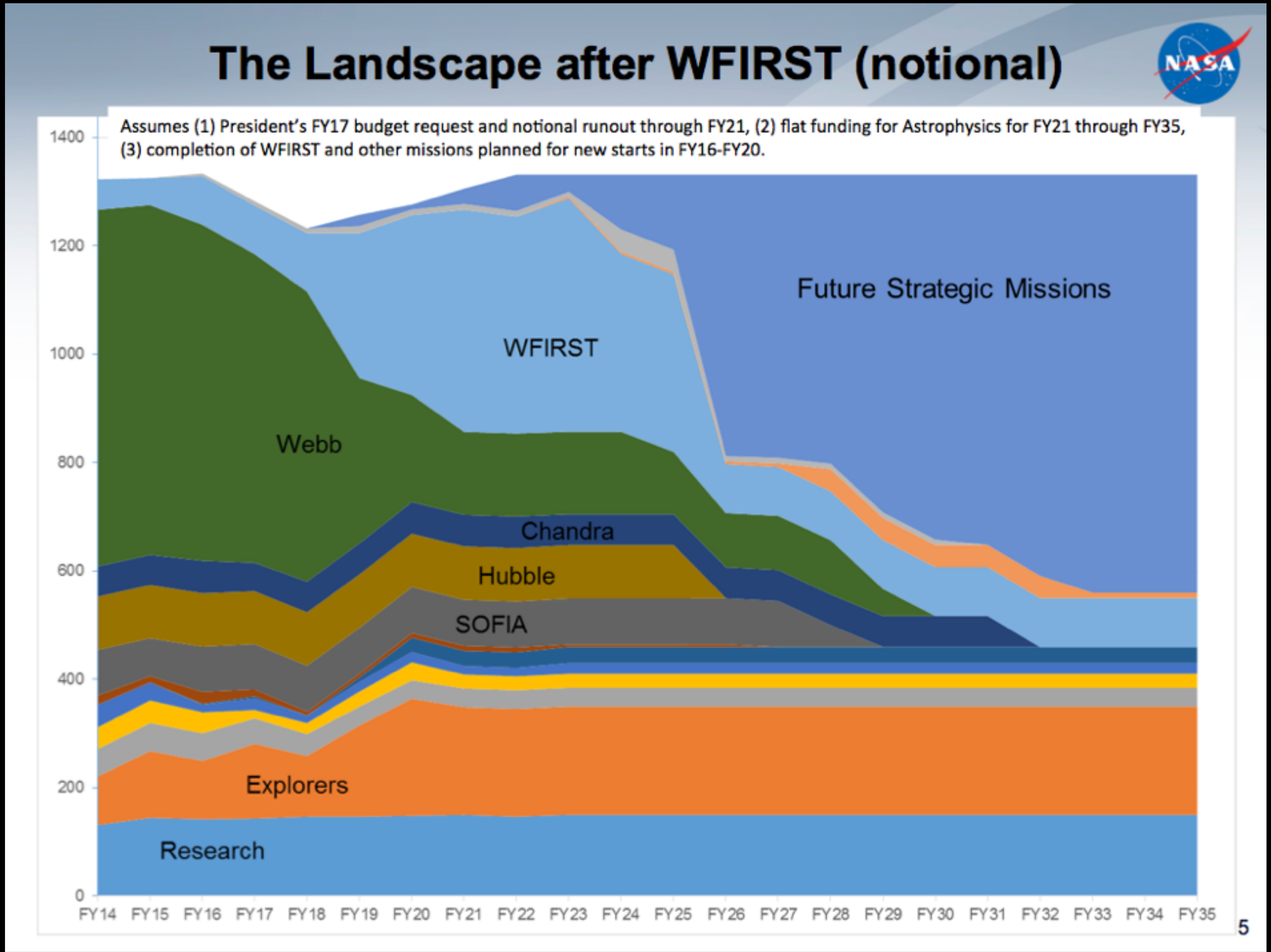


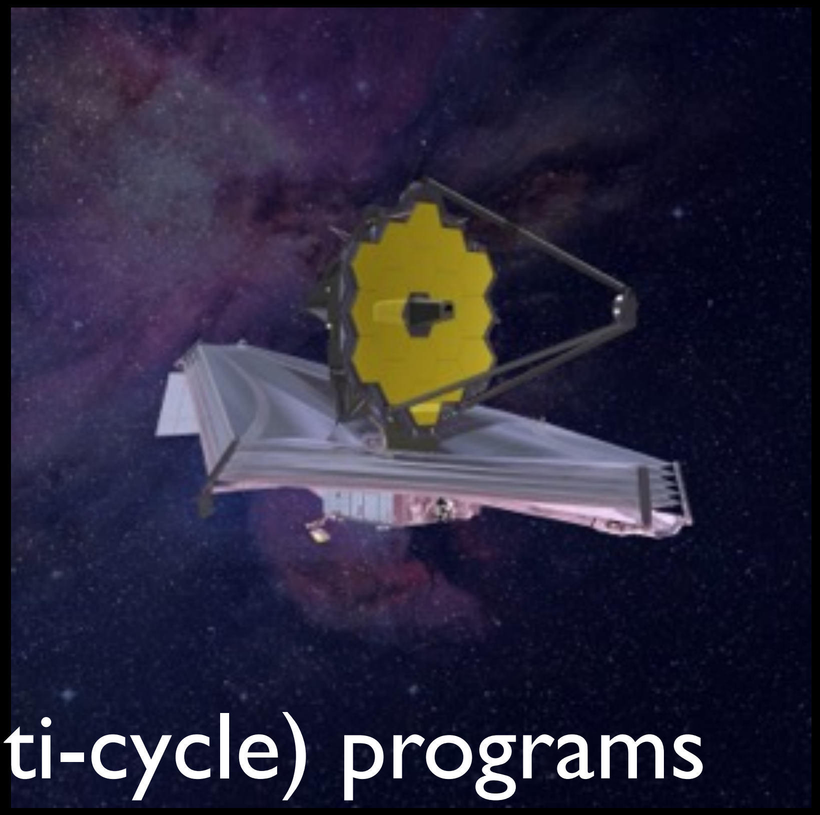
Paul Hertz slide to XRS STDT F2F

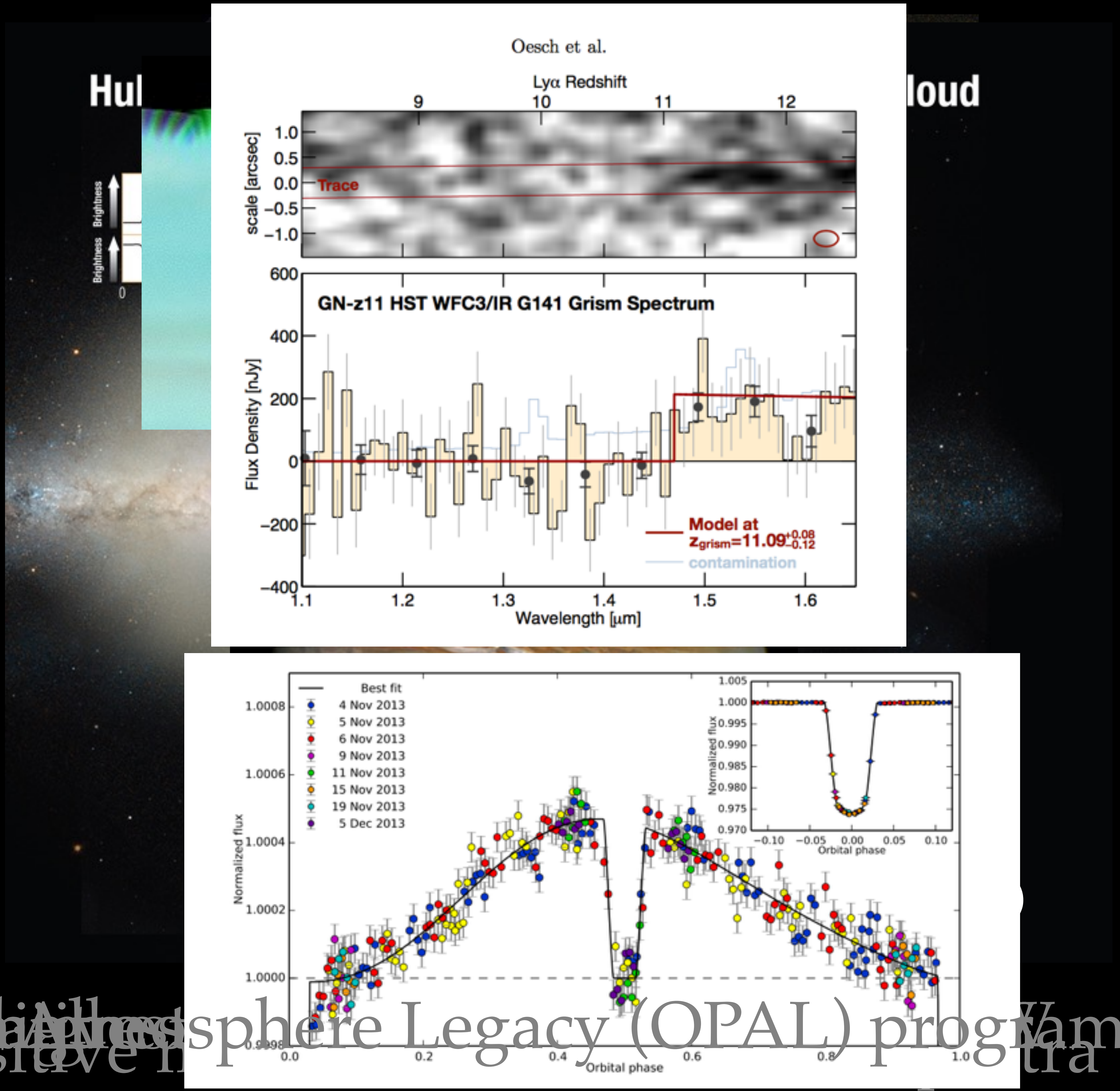
Maximizing Science with Hubble

- capitalize on unique resources of Hubble
- joint observing programs
- community-enabling initiatives

Maximizing Science with Hubble

- capitalize on unique resources of Hubble
  - UV initiative
  - JWST initiative
  - OPAL program
  - return of large (>350 orbit, multi-cycle) programs
- joint observing programs
- community-enabling initiatives





Maximizing Science with Hubble

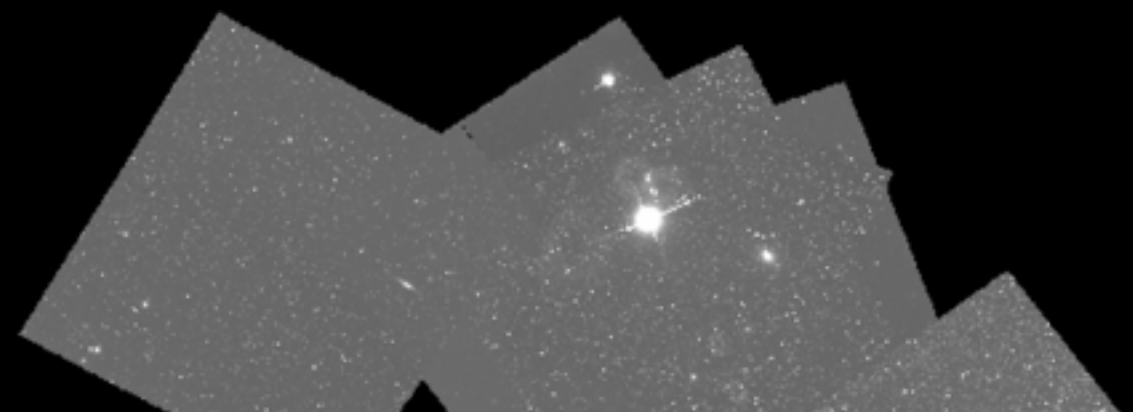
- capitalize on unique resources of Hubble
- joint observing programs
  - Chandra *since CY 2000: HST-C9/CXO-C2*
  - NOAO *since HST-C11*
  - Spitzer *since HST-C14*
  - XMM-Newton *since HST-C20*
  - NRAO *since HST-C22*
  - +ALMA in progress
  - mission support: Cassini, Dawn, Juno, Maven, New Horizons, Rosetta

AAS Special Session: “Making Great Observatories Even Better: Hubble’s Hand in Studying the Multi-wavelength Universe”
AAS229 Jan. 5 10-11:30 AM

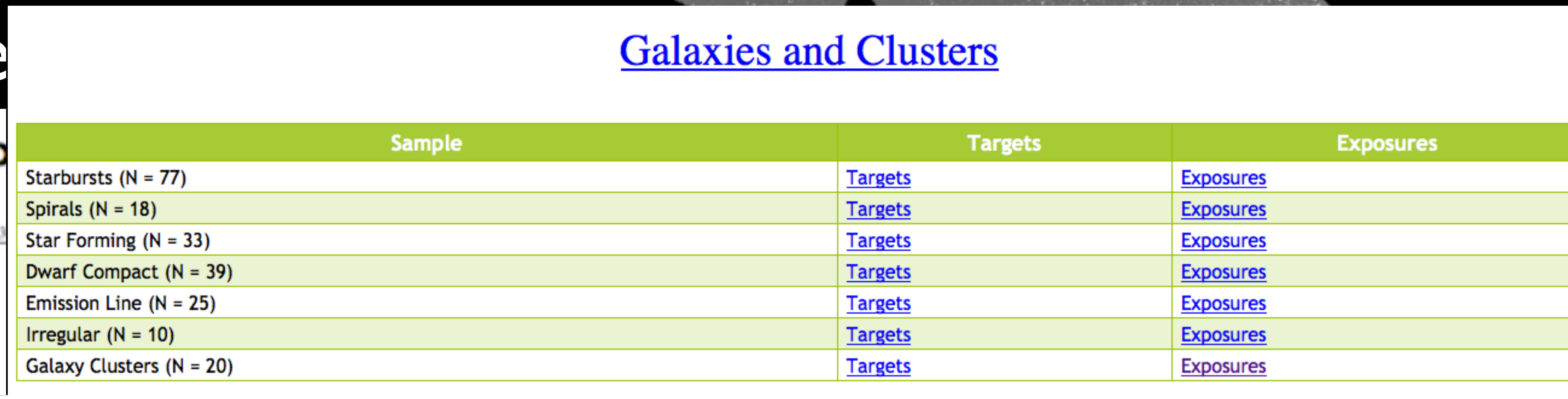
Brodwin et al. (2016)

http://archive.stsci.edu/hst/joint_programs.html

Maximizing Science with Hubble

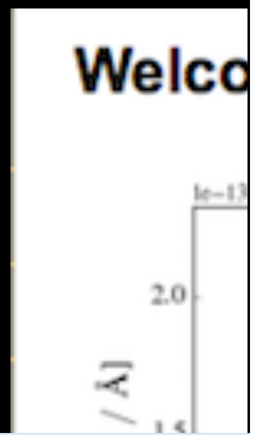


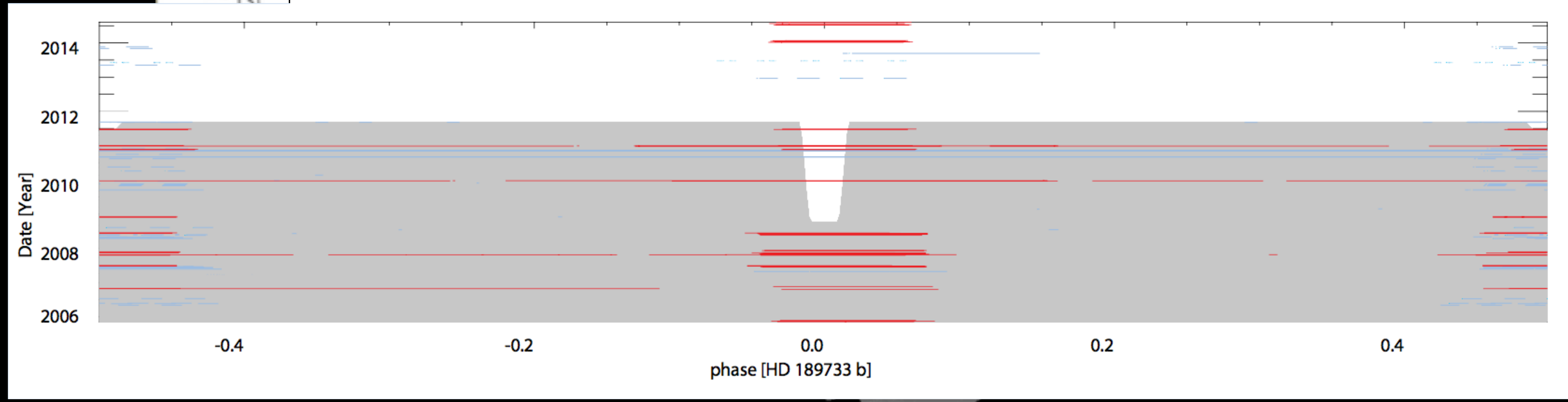
- capitalize on unique resources of Hubble
- joint observing programs
- community-enabling initiatives
  - Hubble Source Catalog
  - Spectroscopic Legacy Archive
  - Supermosaics
  - New archive queries through target-oriented access



Galaxies and Clusters

Sample	Targets	Exposures
Starbursts (N = 77)	Targets	Exposures
Spirals (N = 18)	Targets	Exposures
Star Forming (N = 33)	Targets	Exposures
Dwarf Compact (N = 39)	Targets	Exposures
Emission Line (N = 25)	Targets	Exposures
Irregular (N = 10)	Targets	Exposures
Galaxy Clusters (N = 20)	Targets	Exposures

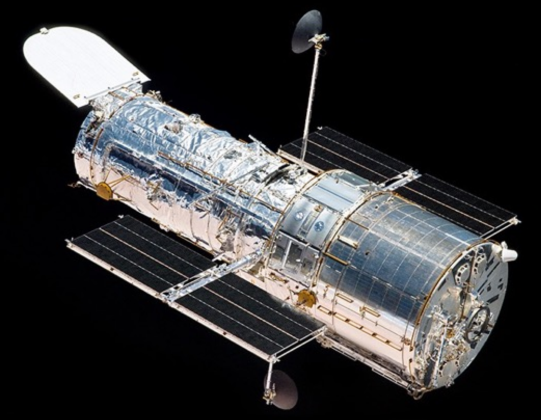




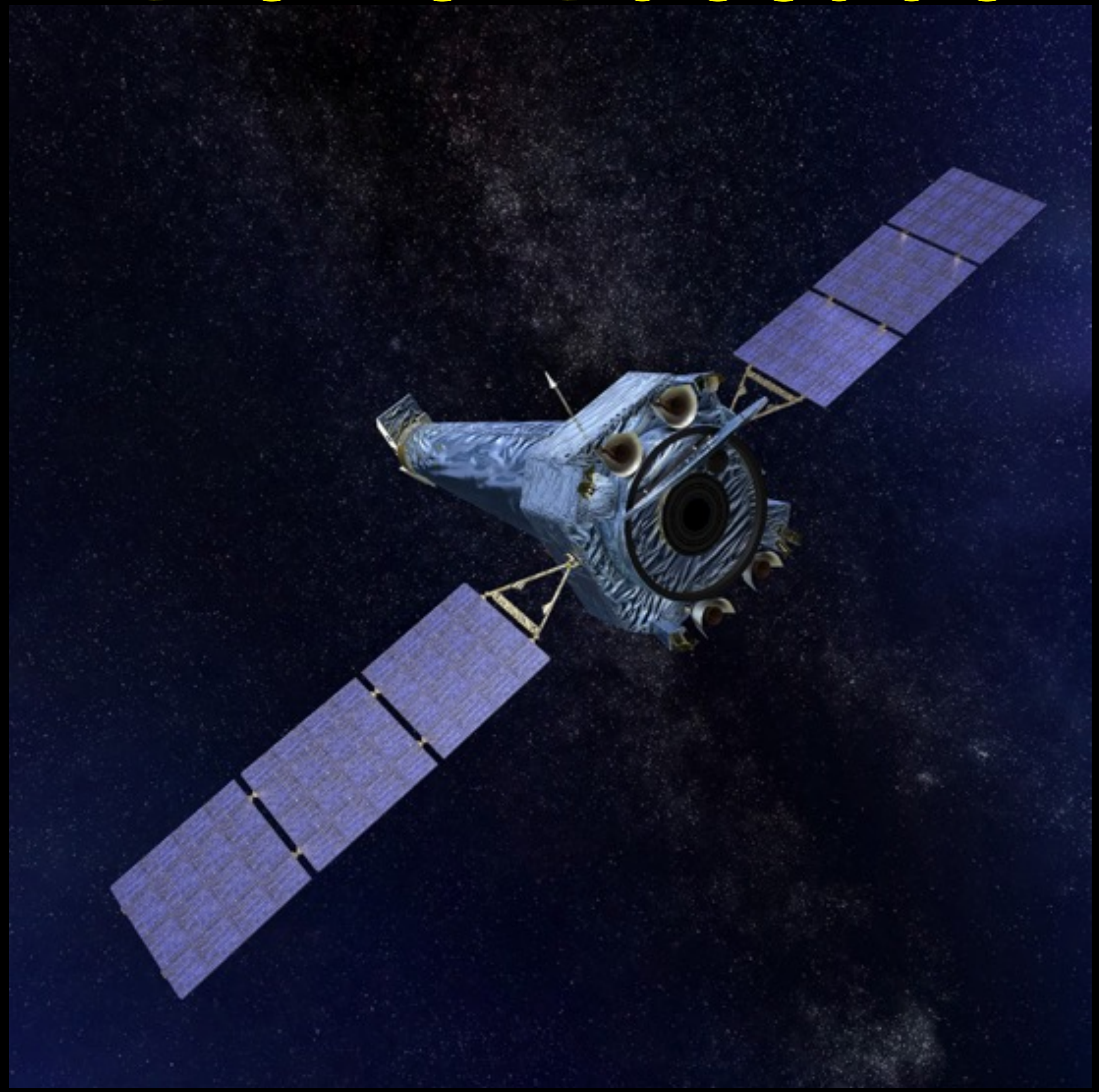
Whitmore et al. (2016)

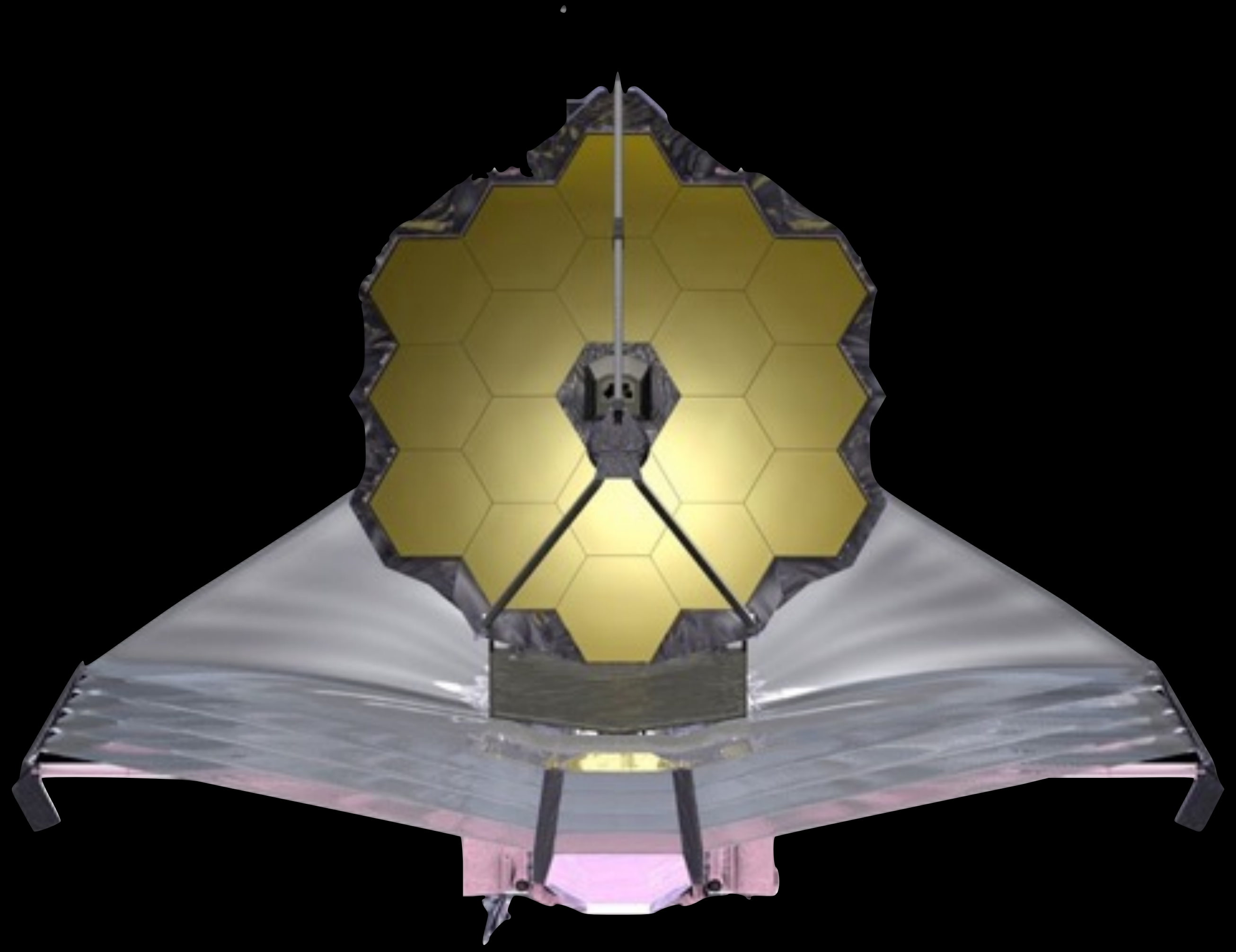
Maximizing Science with Hubble

- Proprietary Periods
  - Currently 12 months for standard GO programs (regular and medium); reducing to 6 months in Cycle 25
  - All Treasury, Large, DD programs have no proprietary period; 25-30% of the time in a given cycle
- Discussions on how to structure Hubble science program during the JWST era
  - mid-cycle proposals offer opportunity to react quickly to new discoveries without waiting for annual proposal call; 10 orbit limit



Maximizing Science between Chandra and Hubble and James Webb in the next decade





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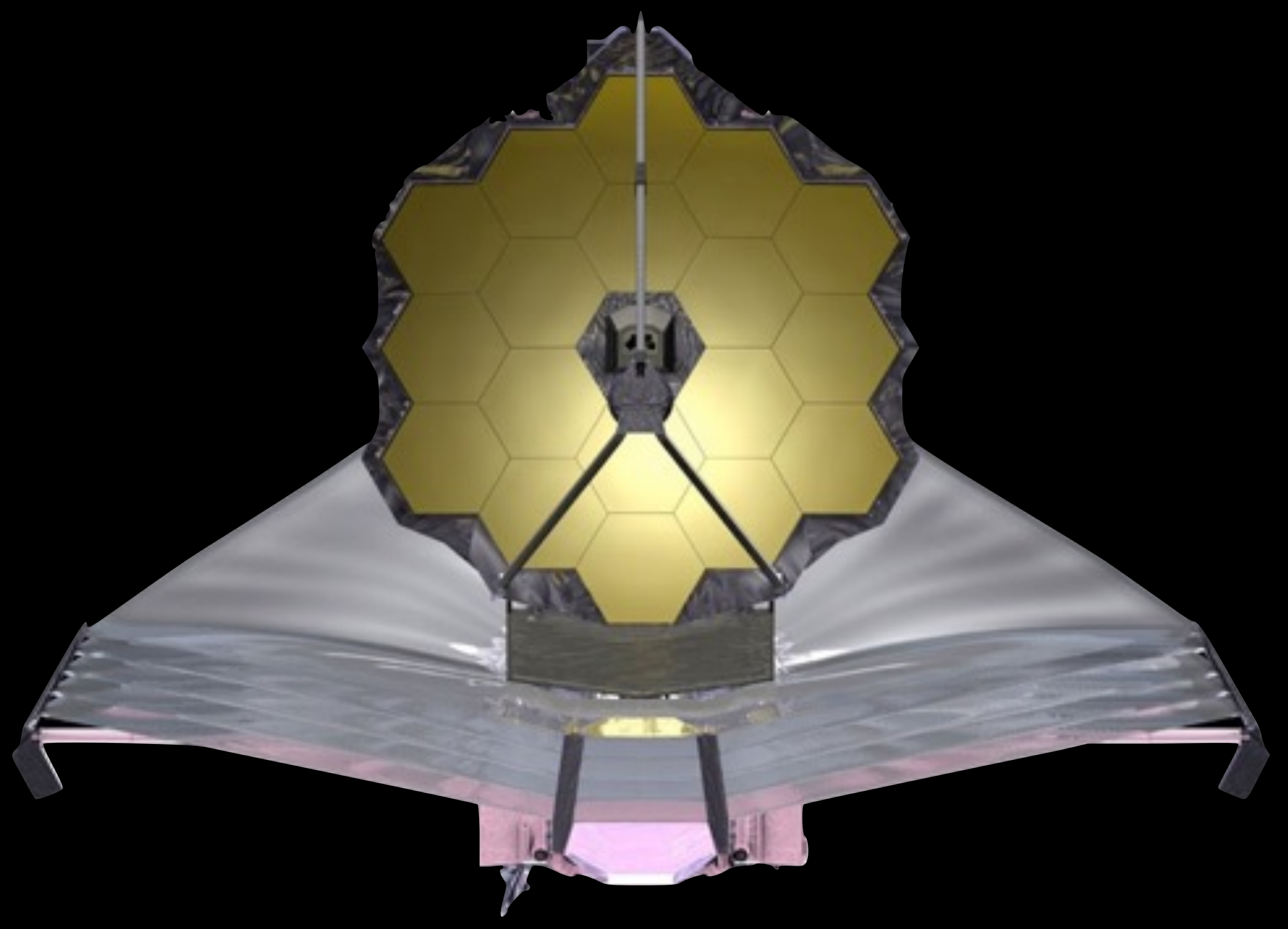
Maximizing Science between Chandra and Hubble and James Webb in the next decade



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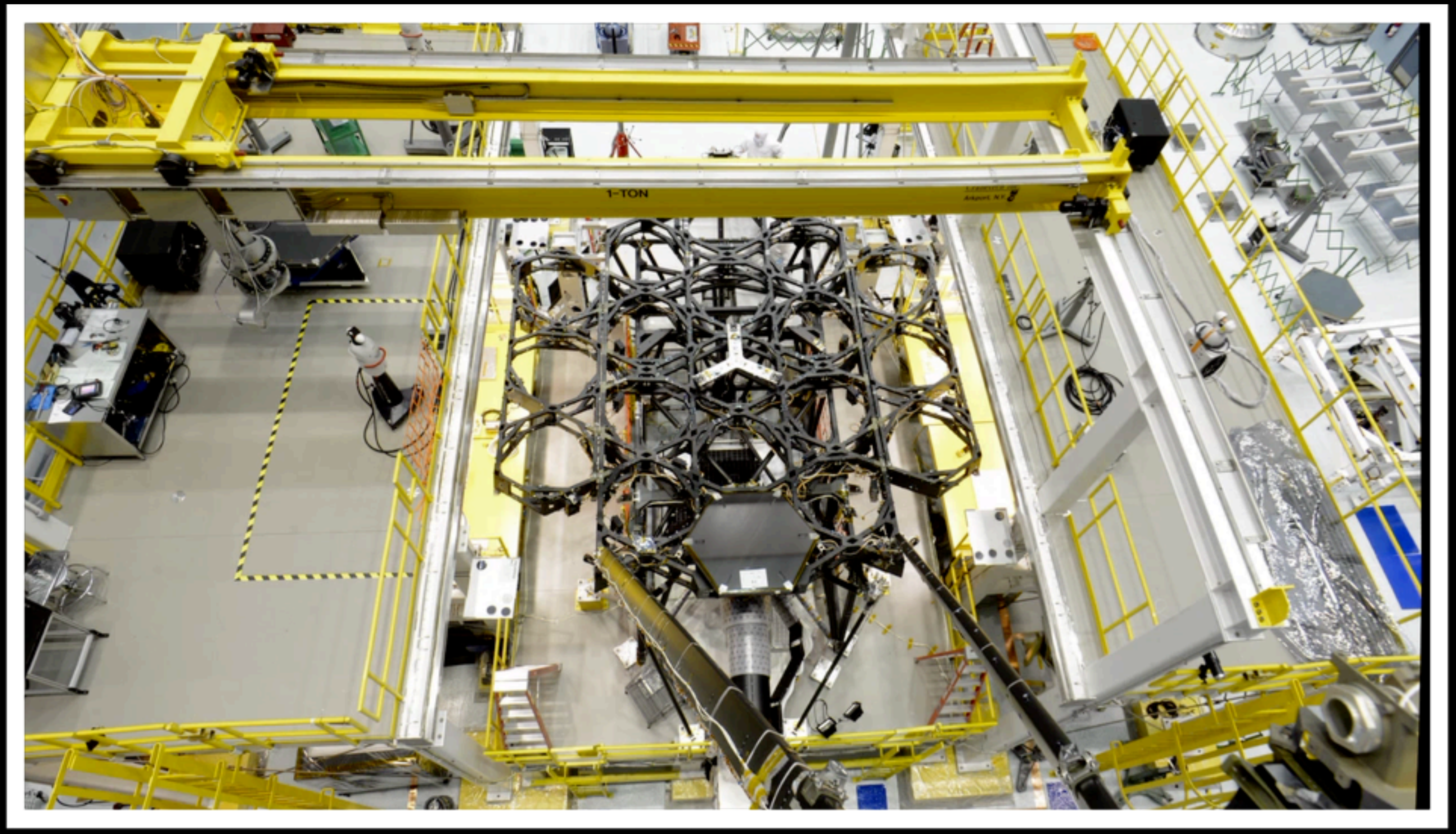
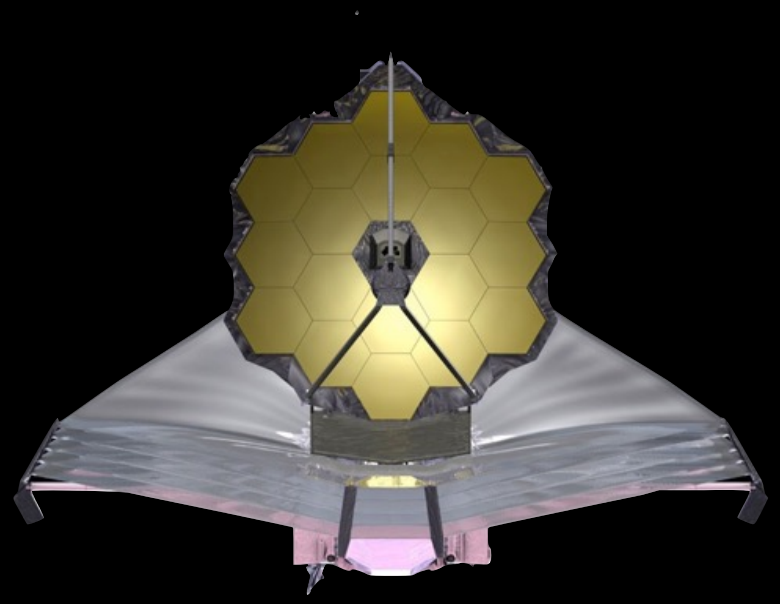
JWST prognosis for the next decade

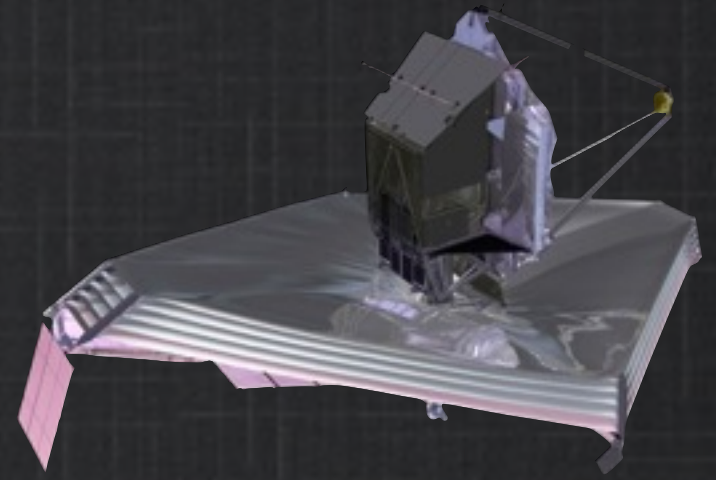
- observatory health and safety
- budget

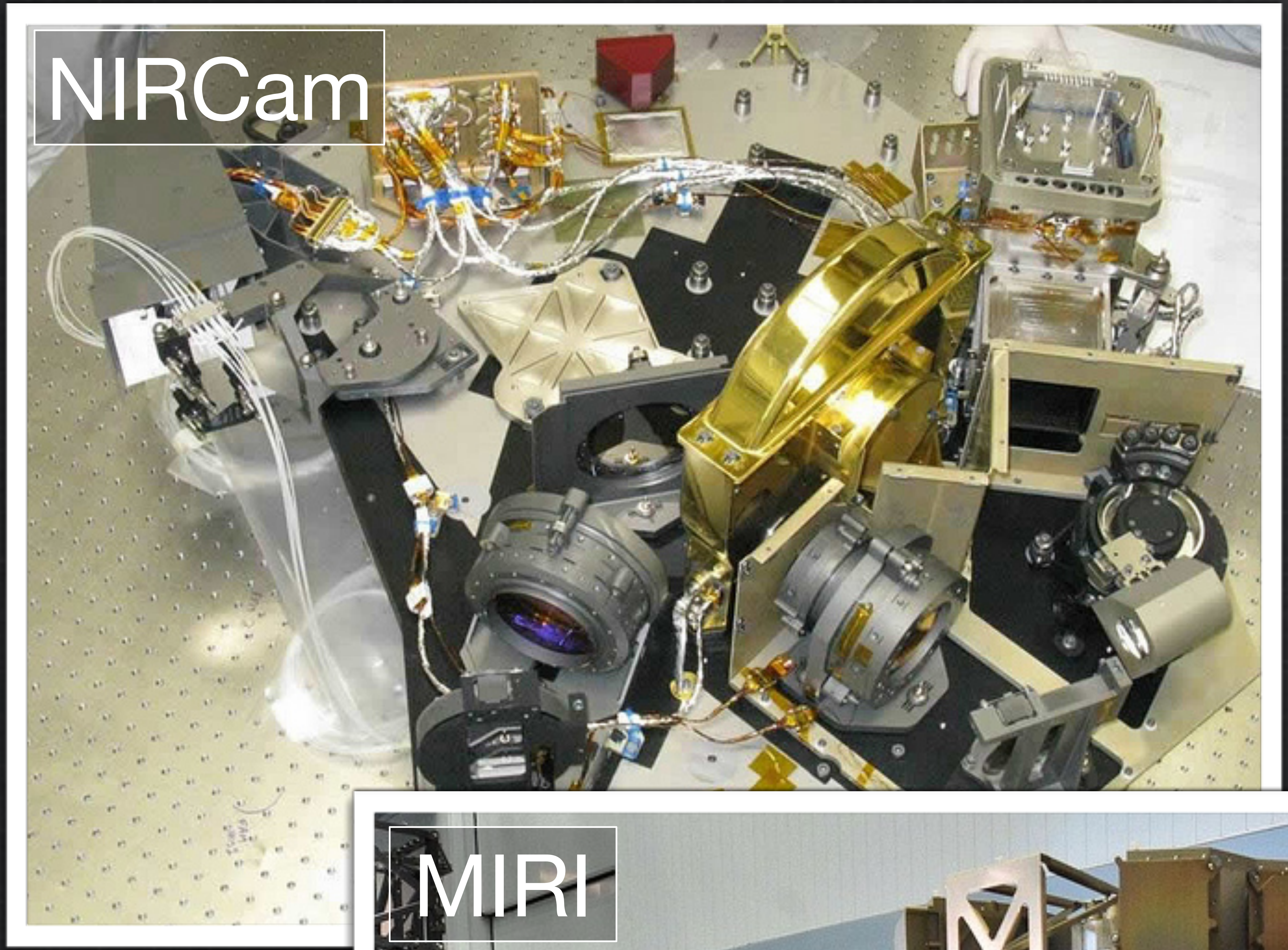


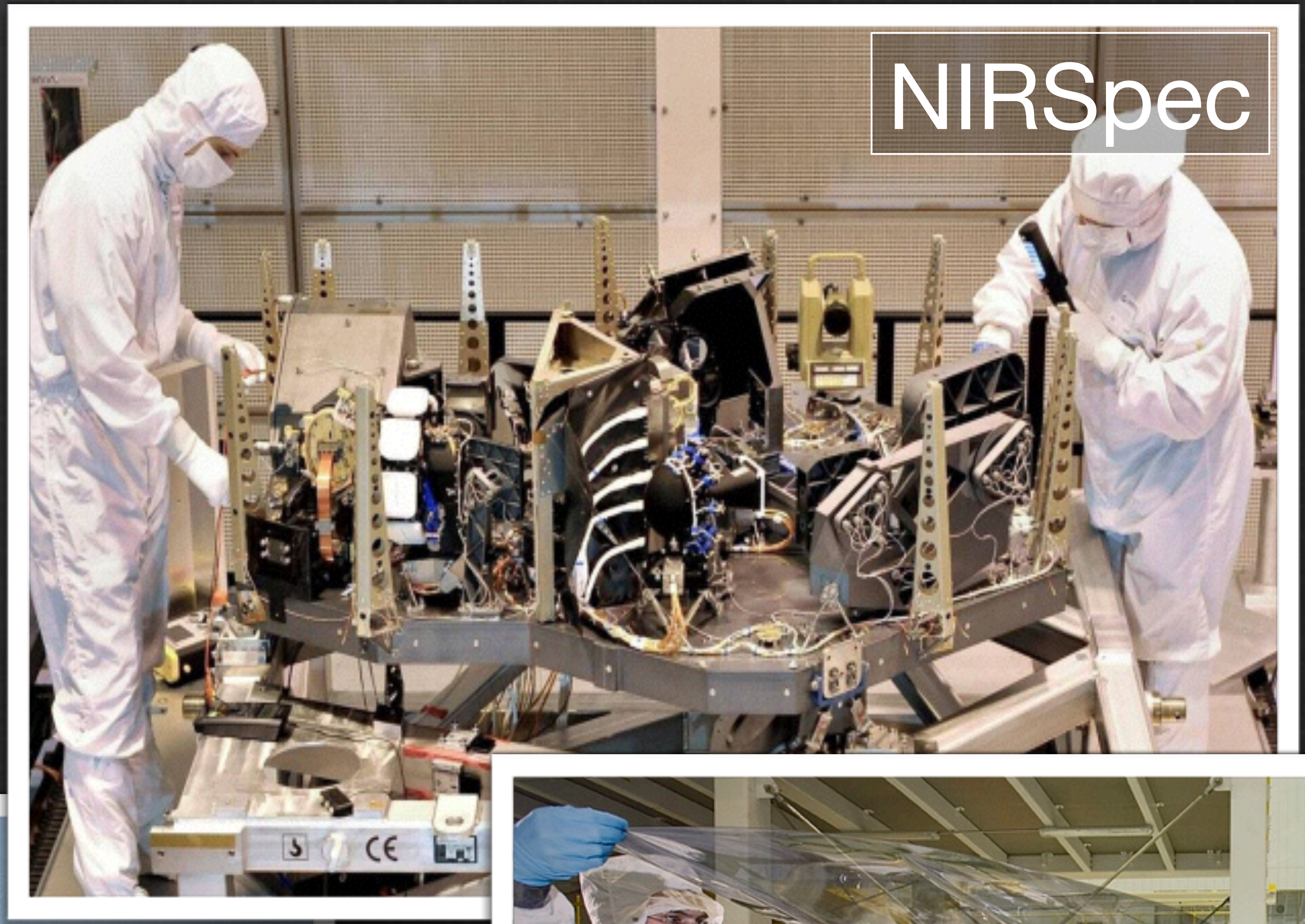


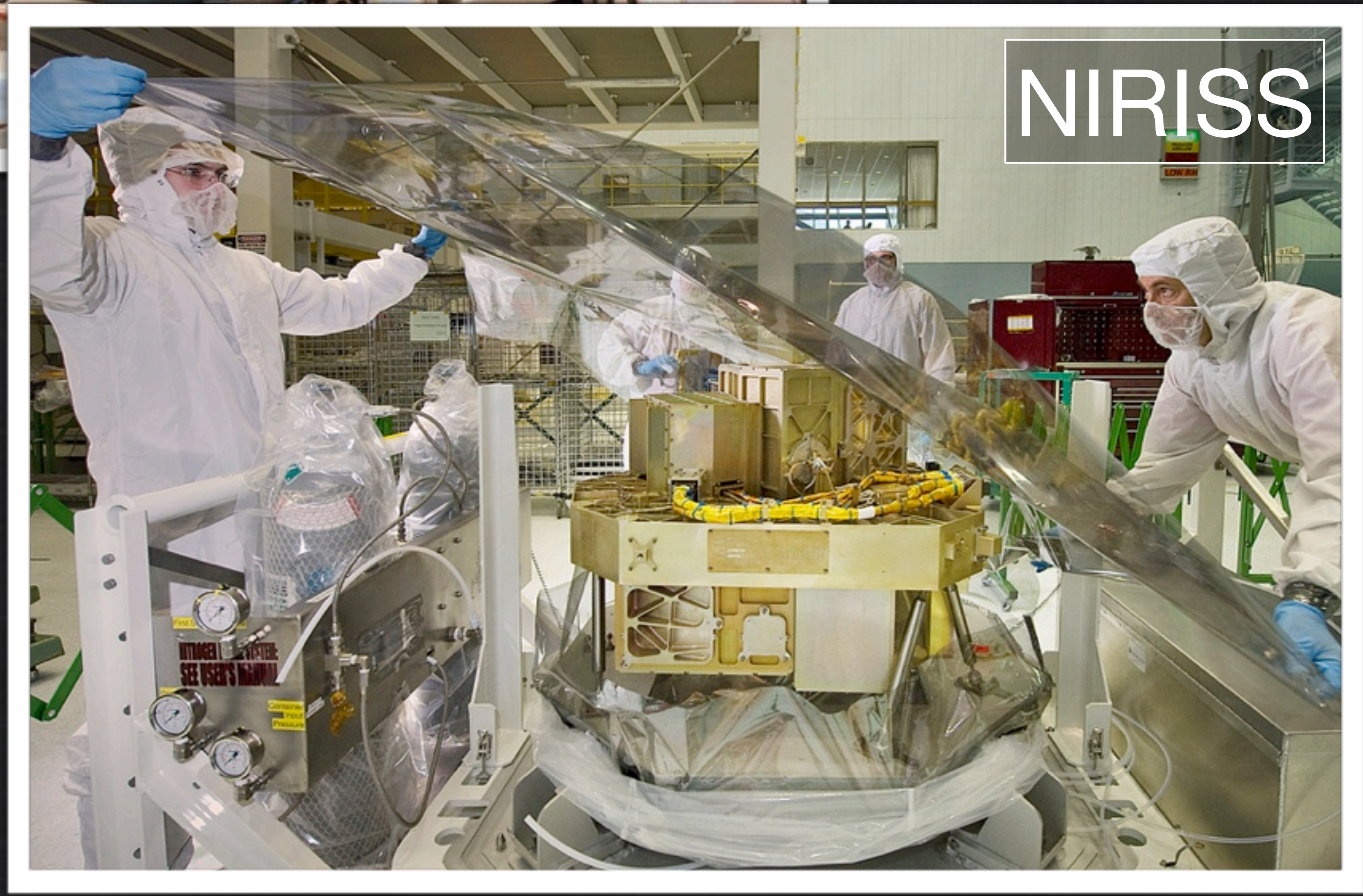
JWST is on schedule for its Oct 2018 LAUNCH!

The JWST Instrument Suite









Near Infrared Camera (NIRCam)

NIRCam Capabilities

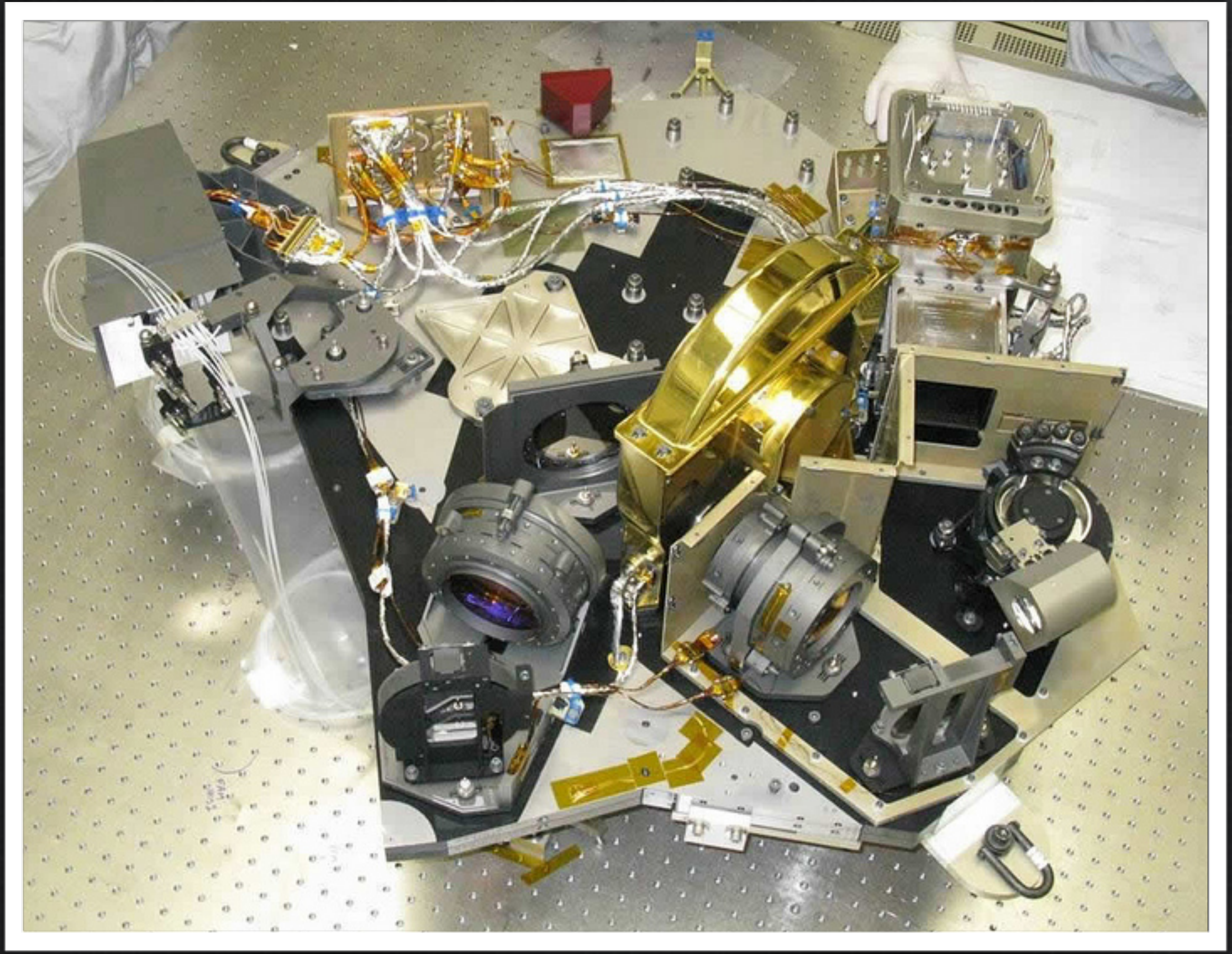
2 channel imager from λ = 0.6 to 5.0 microns, get λ < 2.5 & λ > 2.5 micron simultaneously

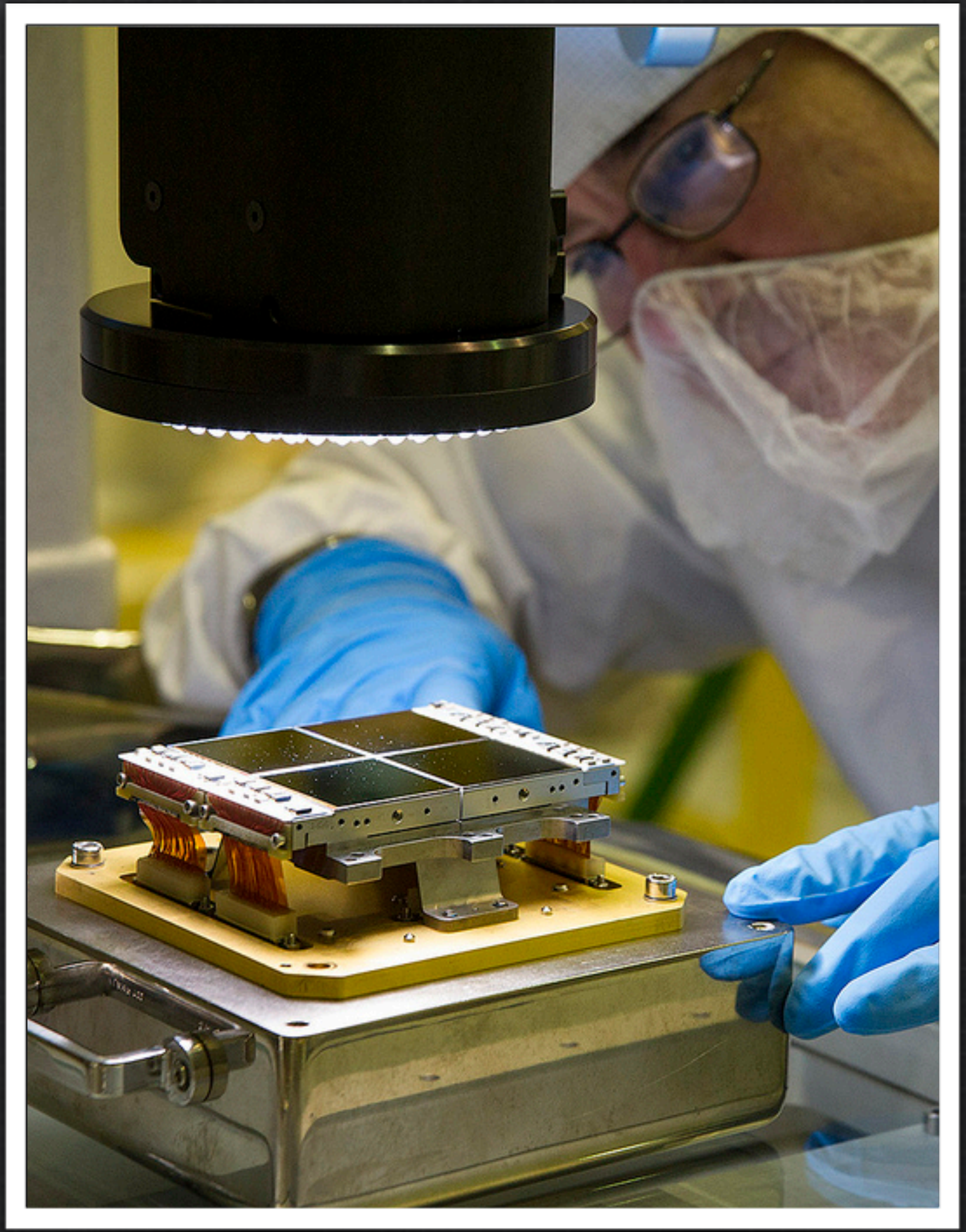
Nyquist sampling of diffraction limit at 2 microns (0.032”/pixel) and 4 microns (0.065”/pixel)

2.2’ x 4.4’ field of view

Short and long wavelength coronagraphy

Slitless spectroscopy for λ = 2.4 – 5.0 micron





Built by Univ. of Arizona and Lockheed-Martin

Near Infrared Spectroscopy (NIRSpec)

NIRSpec Capabilities

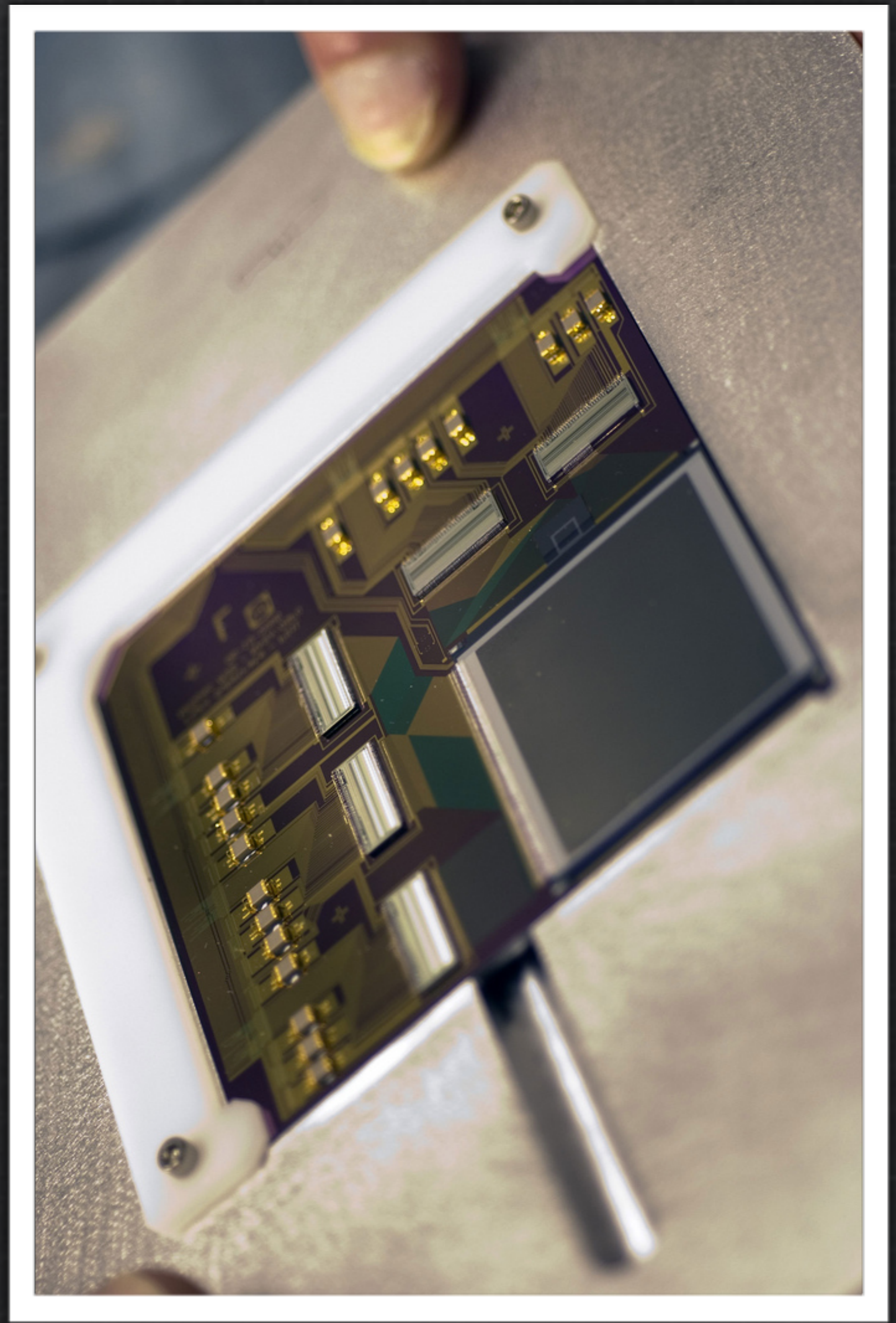
Near Infrared wavelength coverage of λ = 0.6 to 5.0 microns

Three different spectral resolutions of R = 100, 1000, and 2700

Modes: Single Slit Spectroscopy (slits with 0.4” x 3.8”, 0.2” x 3.3”, 1.6” x 1.6”)

Integral Field Unit (3.0” x 3.0”)

Multi Object Spectroscopy (3.4’ x 3.4’ with 250,000 - 0.2” x 0.5” microshutters)



Built by ESA and Airbus

Mid Infrared Instrument (MIRI)

MIRI Capabilities

High resolution imager with sensitivity from λ = 5 to 28 microns, 10 broad-band filters

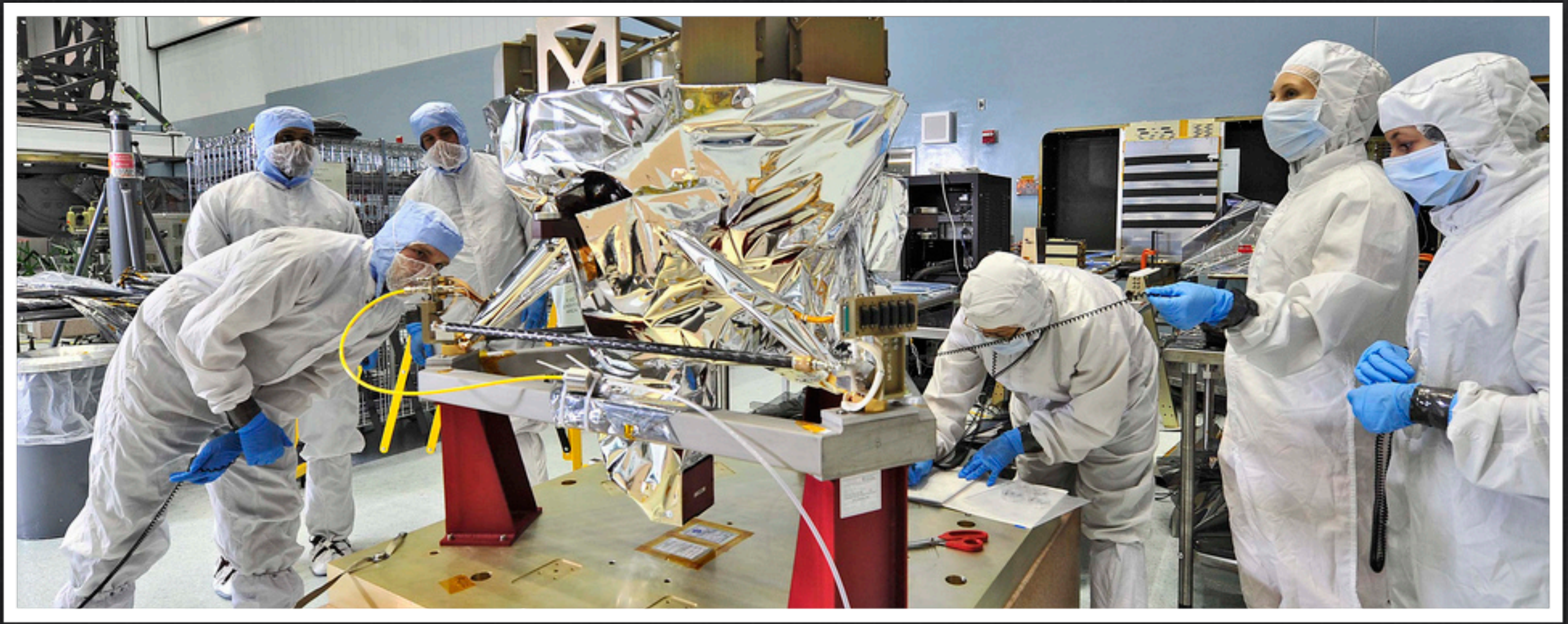
λ = 5.0 to 28.3 microns with 0.11” pixels

1.23’ x 1.88’ field of view

Coronagraphy at 10.65, 11.4, 15.5, and 23 microns (24” to 30” field of view)

Integral Field Unit with R = 2200 to 3500, at 4 wavelengths (image slices 0.18” to 0.64”)

Single Slit Spectroscopy from 5.0 to ~14 microns in 0.6 x 5.5” slit (R ~ 100 at 7.5 microns)

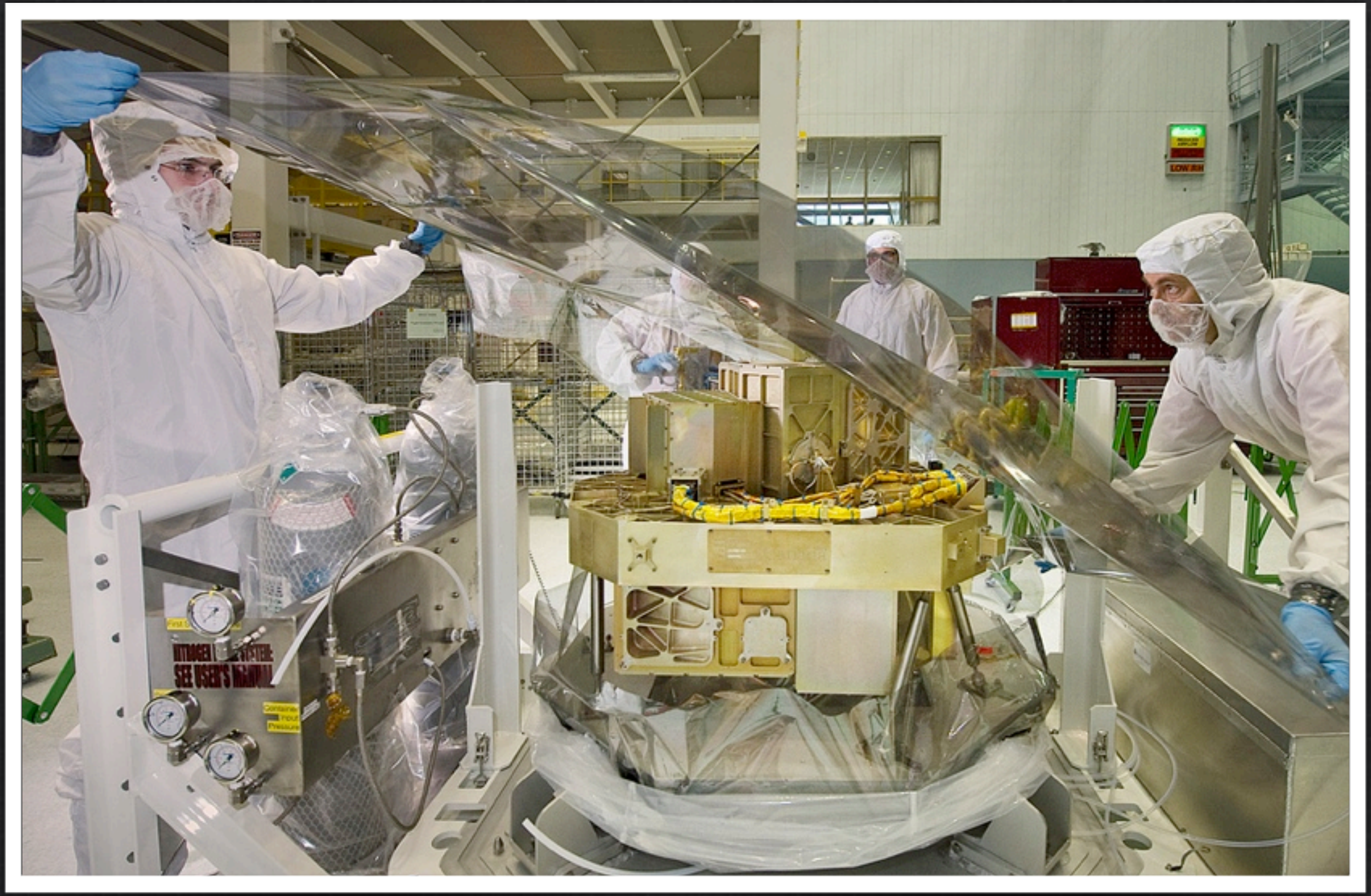


Built by ESA and JPL

Near Infrared Imager and Slitless Spectrograph (NIRISS)

NIRISS Capabilities

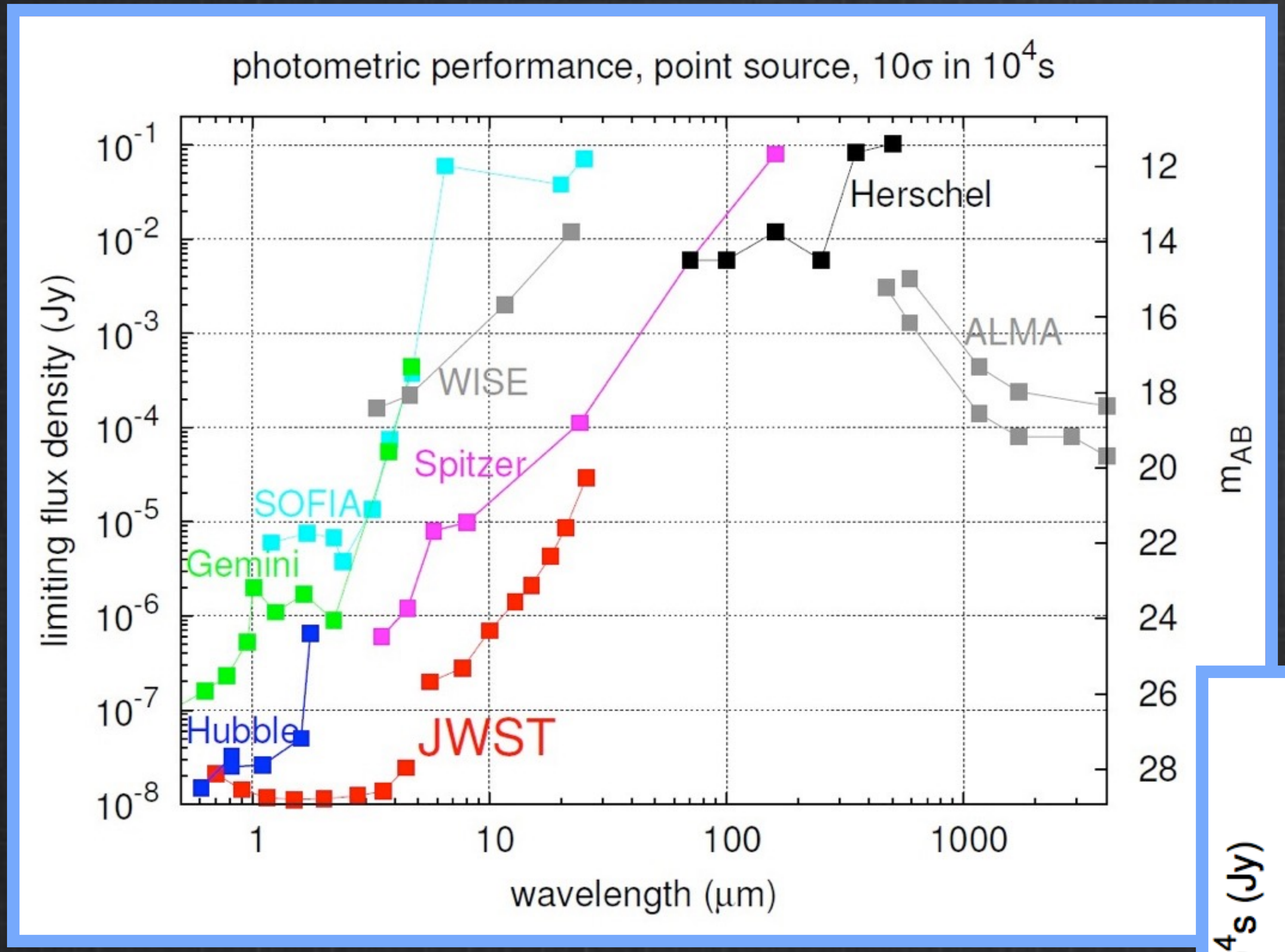
Imaging - λ = 0.9 to 5.0 microns over a 2.2’ x 2.2’ field of view with 0.065” pixels
Wide Field Slitless Spectroscopy - λ = 1.0 to 2.5 microns at R ~ 150
Single Object Slitless Spectroscopy - λ = 0.6 to 2.5 microns at R ~ 700
Aperture Mask Interferometry - λ = 3.8 to 4.8 microns, enabled by non-redundant mask

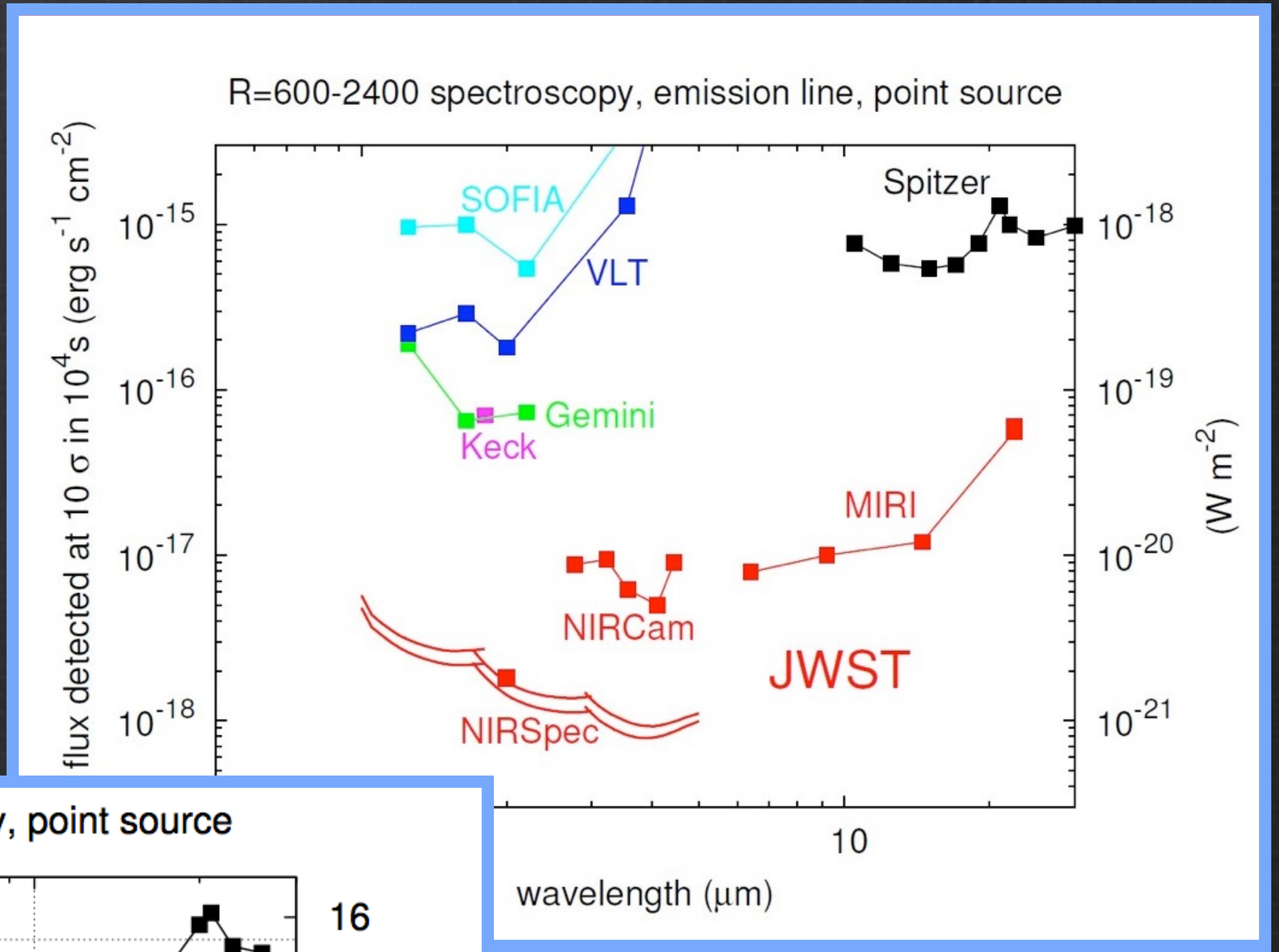


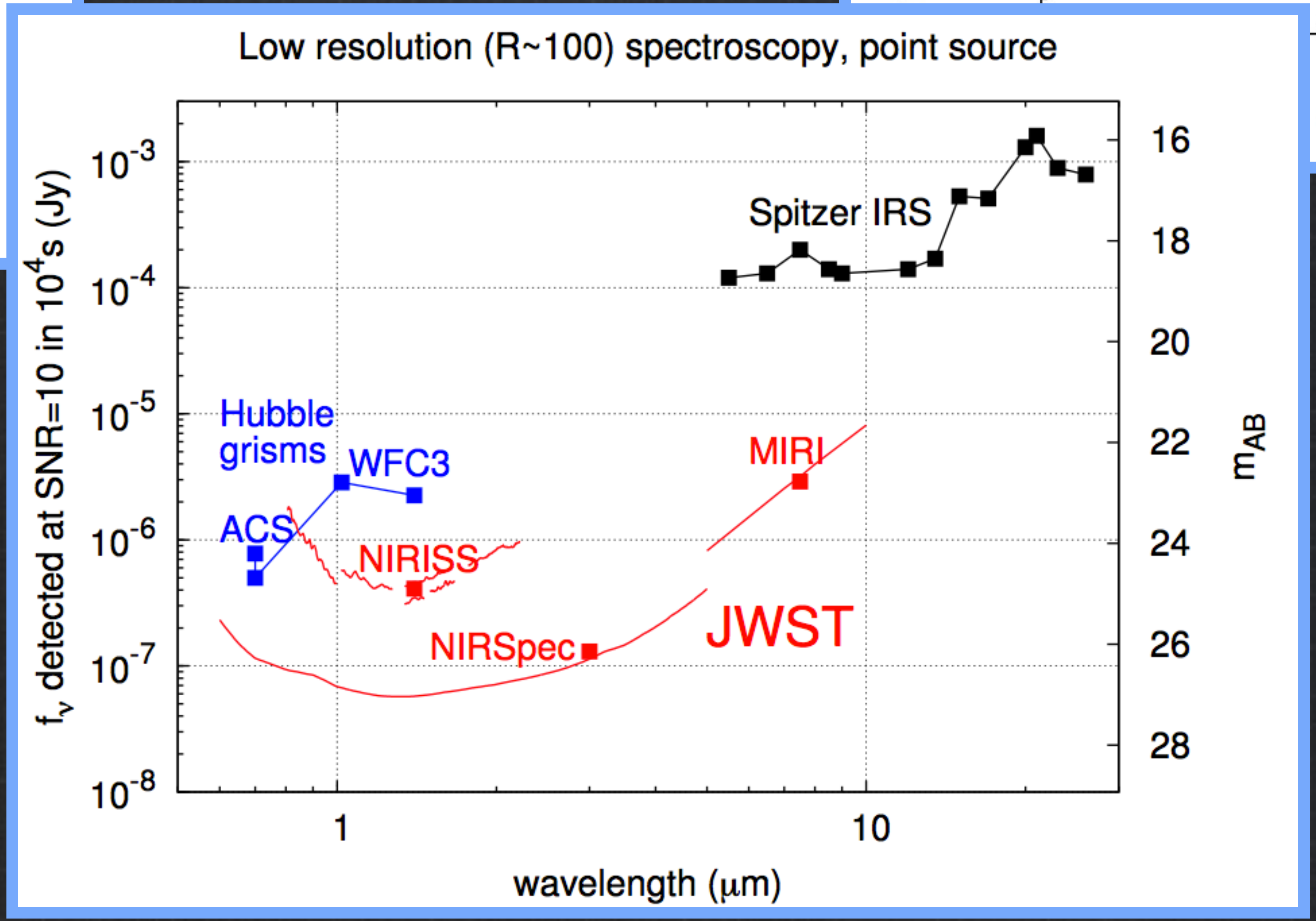
Built by CSA and COMDEV

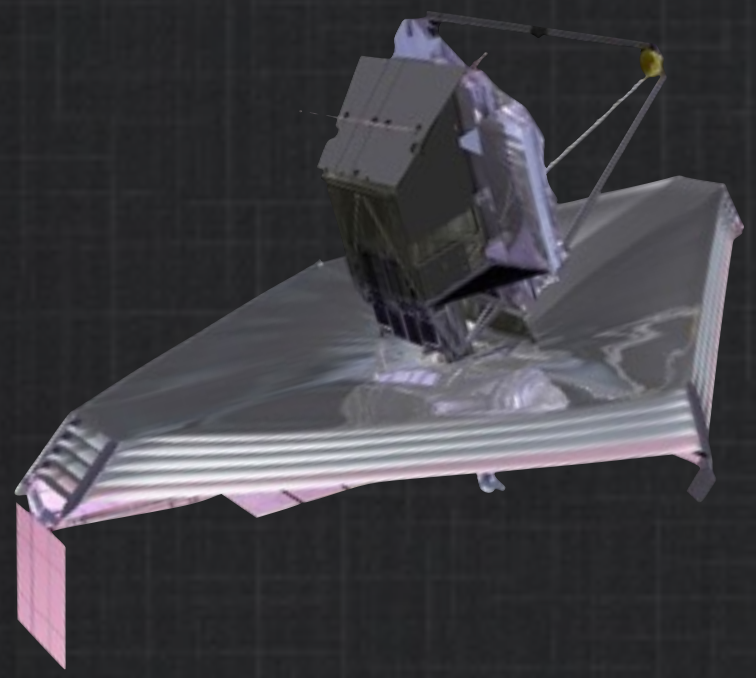
Ultra Sensitive and High Resolution Imaging
Mid IR IFUs
Single Object and Wide-Field Slitless Spectroscopy
Radiation Era
Dark Ages
Reionization era
First galaxies form
Present
m=1
m=2
m=3
Space Based MOS
Moving Target Support
Science Capabilities
Bright Object Modes
λ
JWST/NIRSpec 25 Transits
10x Earth mass (and hot)
Thick Atmosphere
Water & Methane
Water
Near IR IFUs
0.8″ ~ 5200 km
image at 0.94 microns (Cassini mission 2009)
exoplanet
beta pictoris b
beta pictoris
NIR and MIR Coronagraphy

JWST Point Source Sensitivity

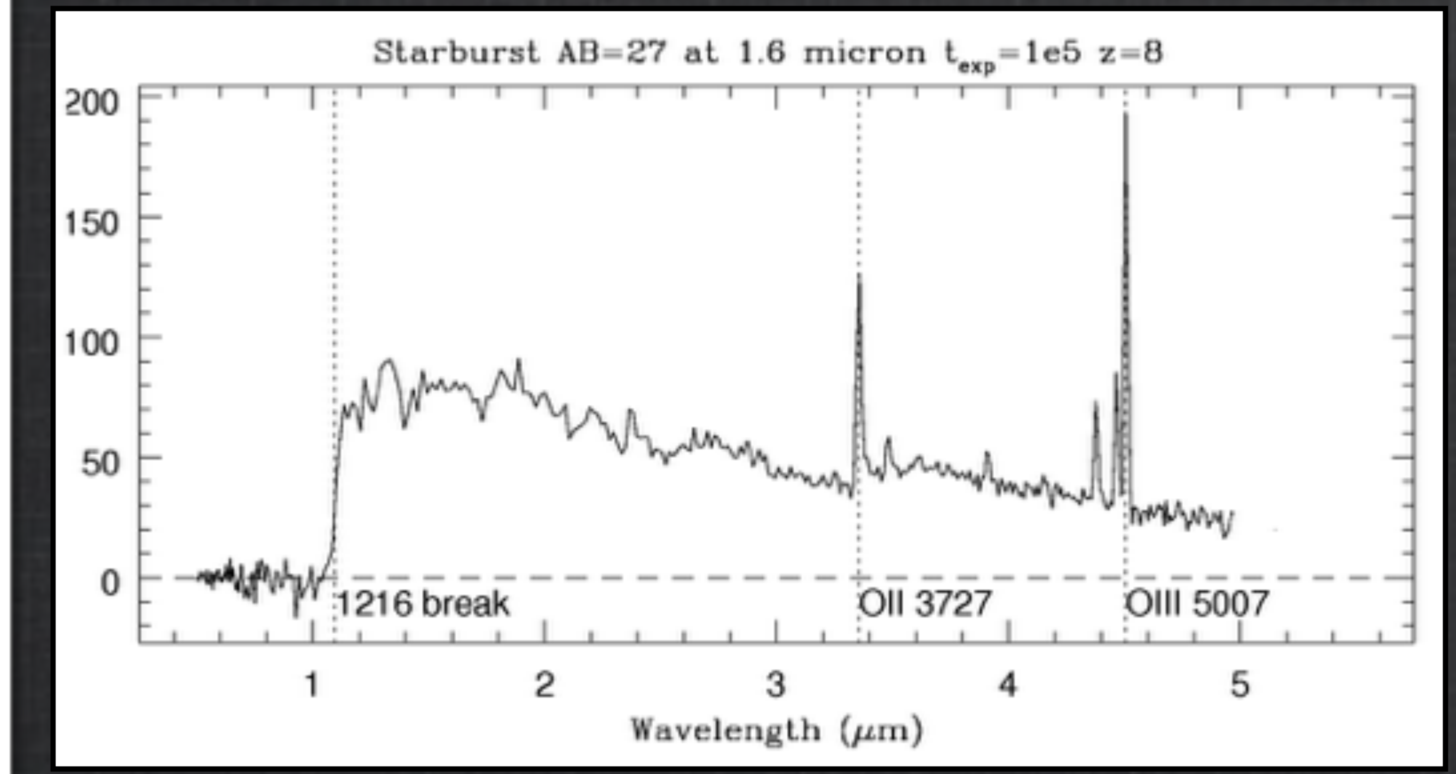




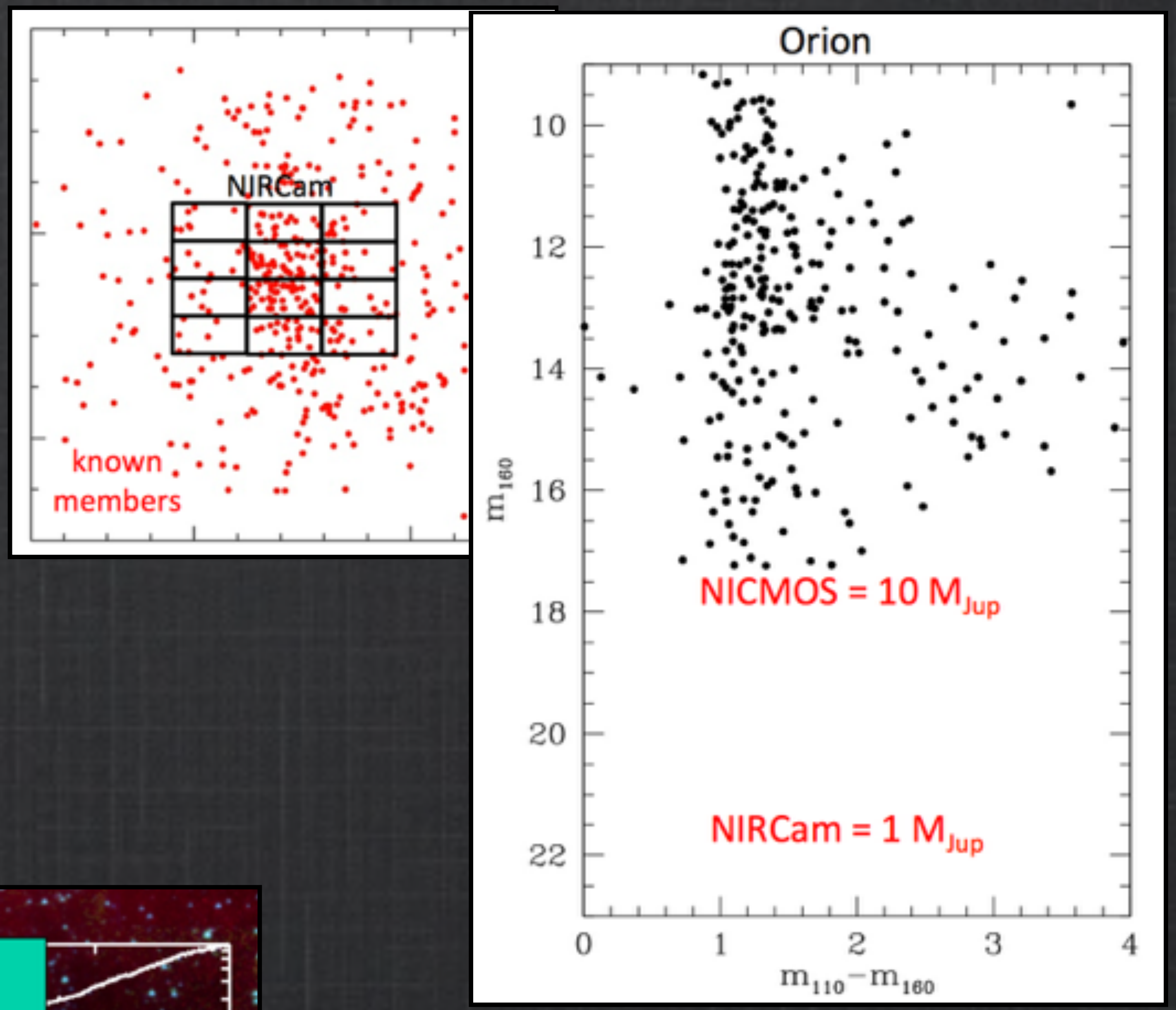




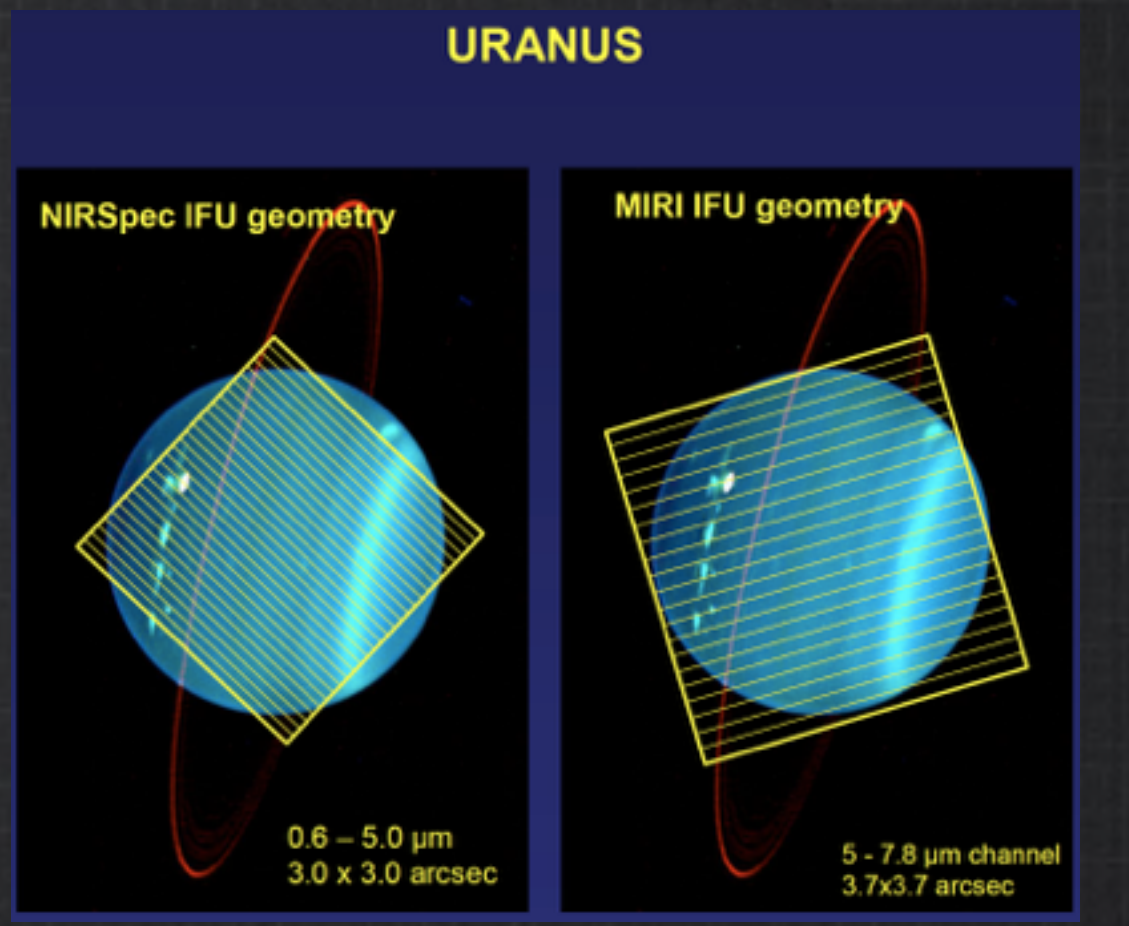
A Snapshot of the Cycle 1 JWST Science Program



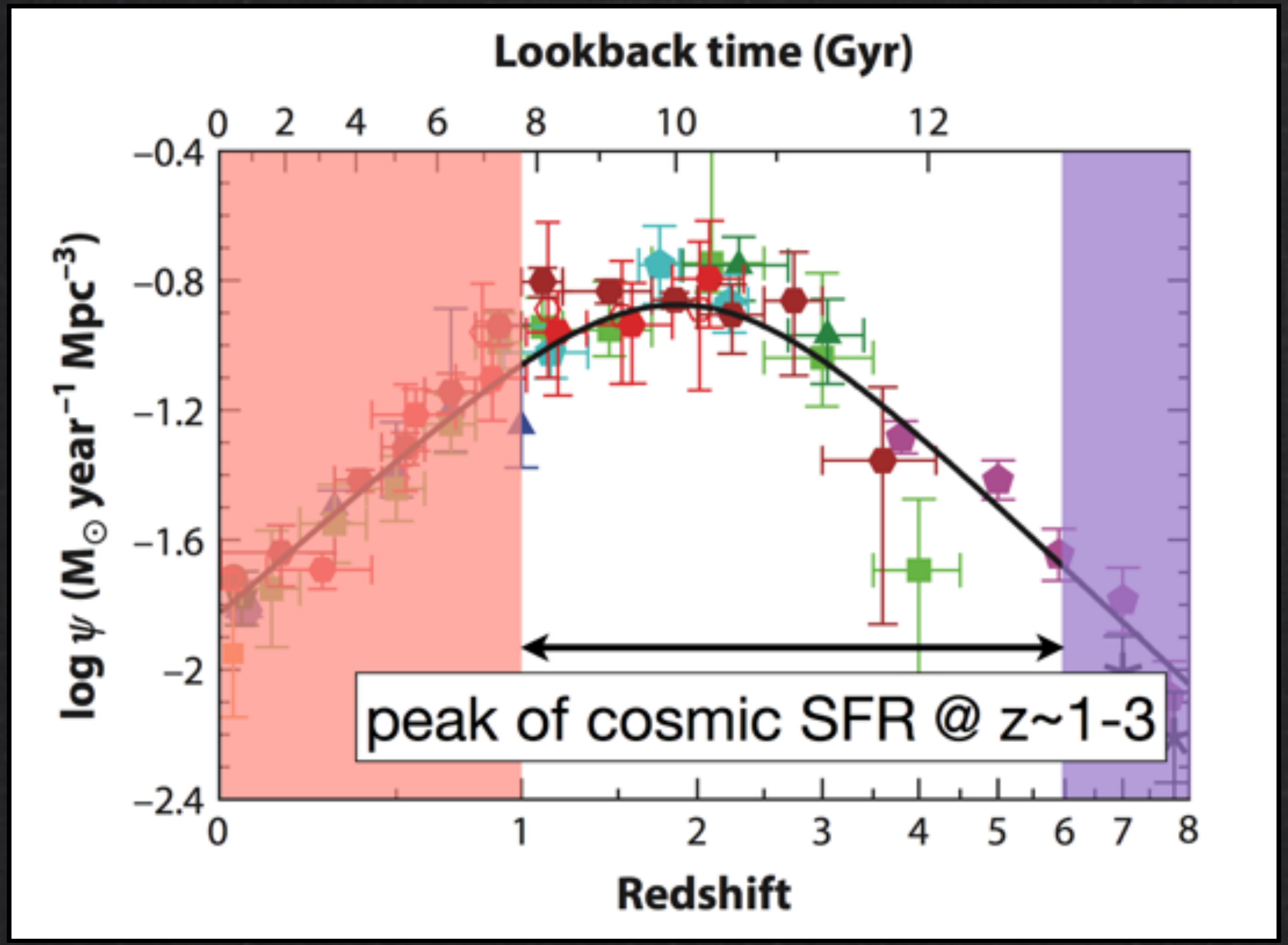
z = 8 Galaxy **Spectra**



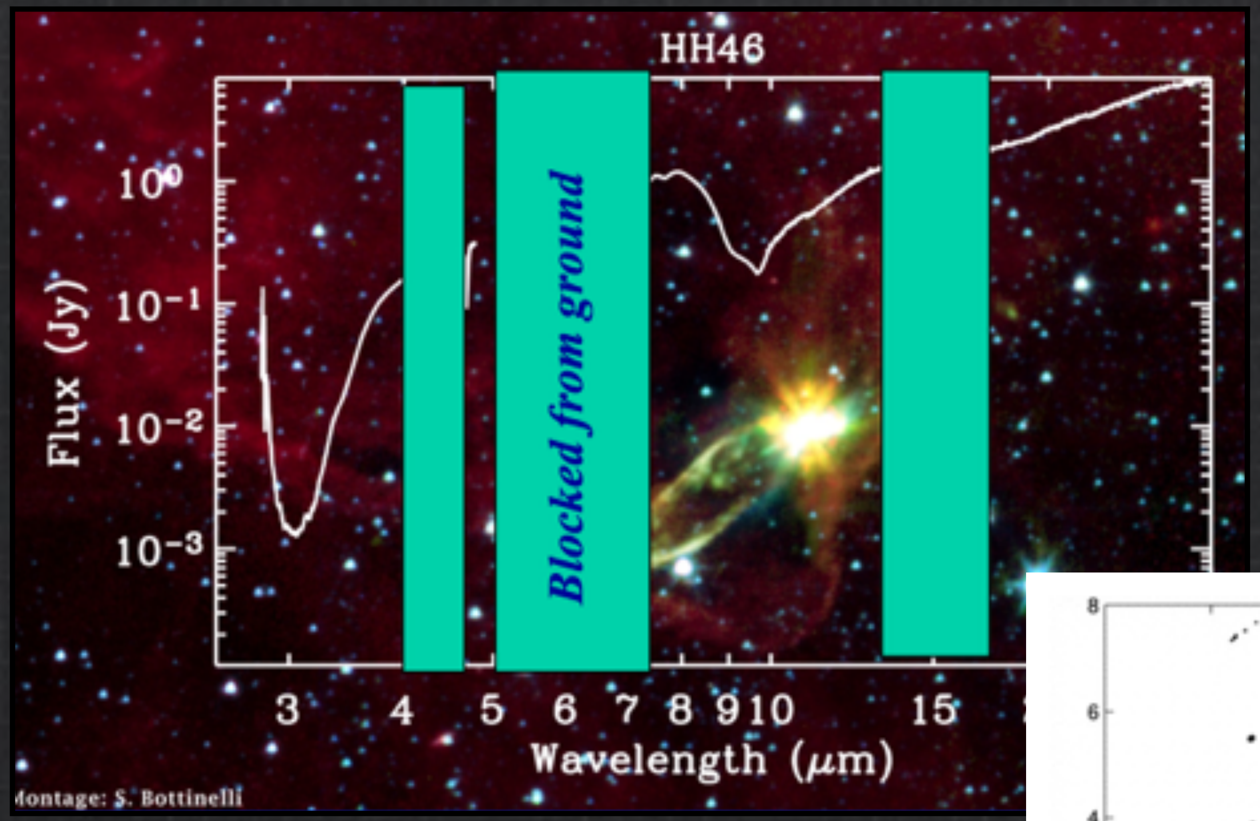
Pre Main Sequence Stars and the IMF



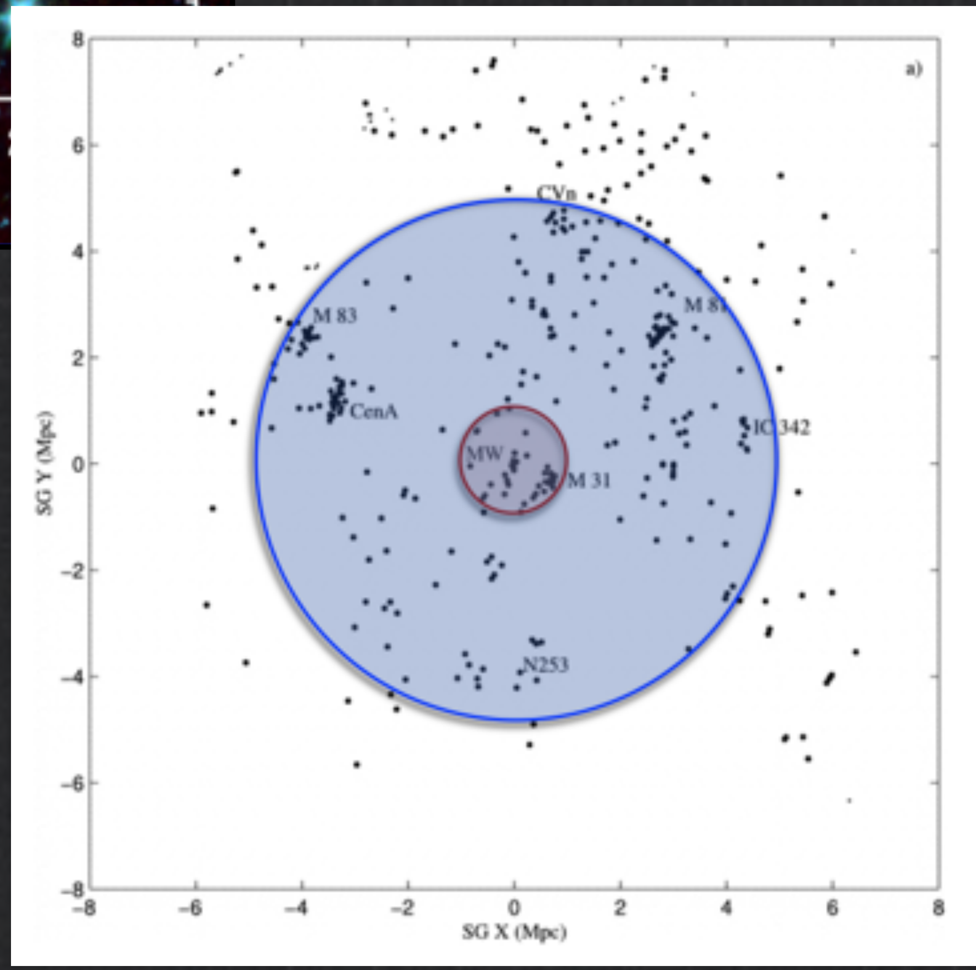
Atmospheric Dynamics and Seasons on Planets



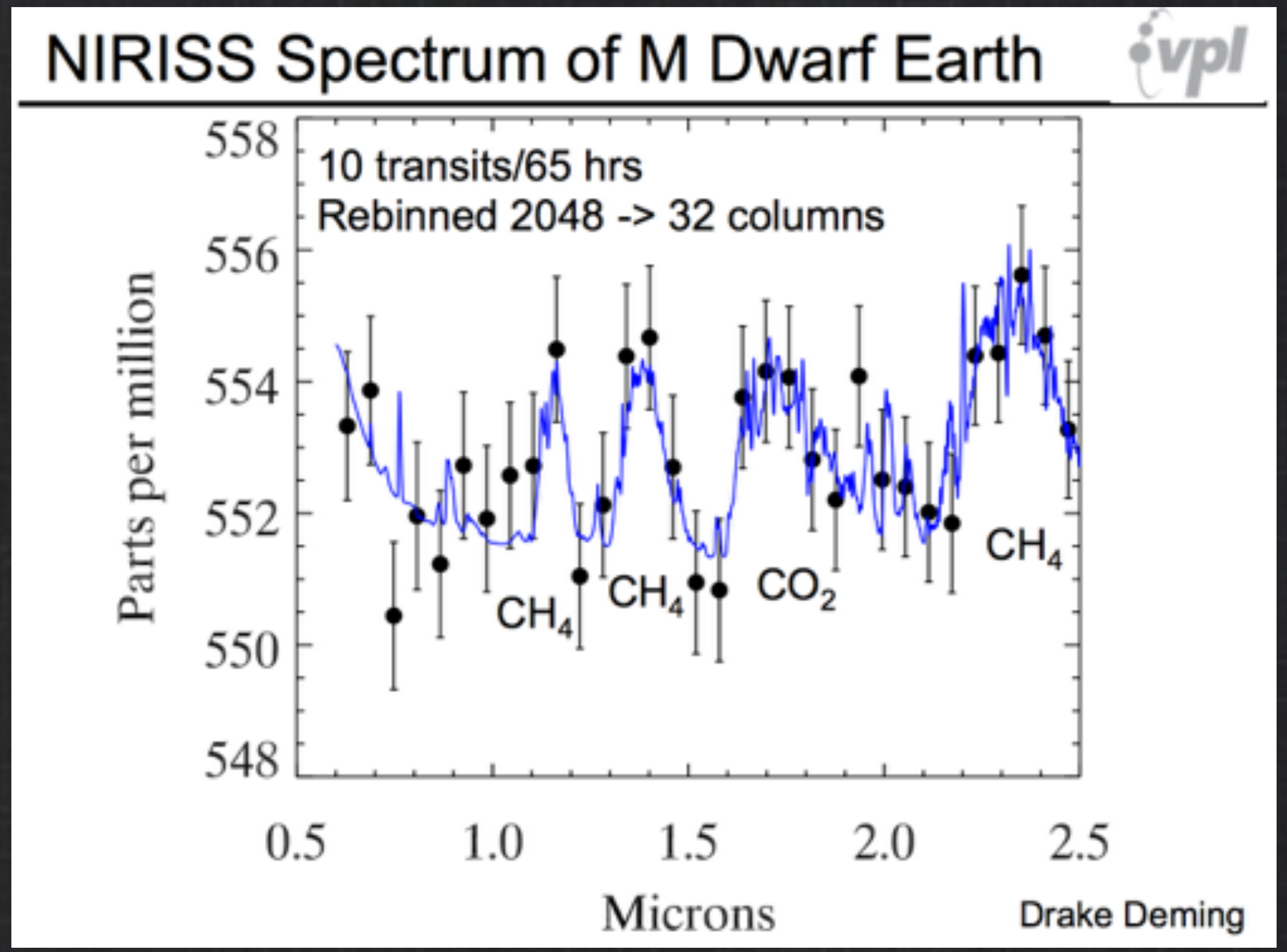
Unveiling the Peak of Galaxy Assembly



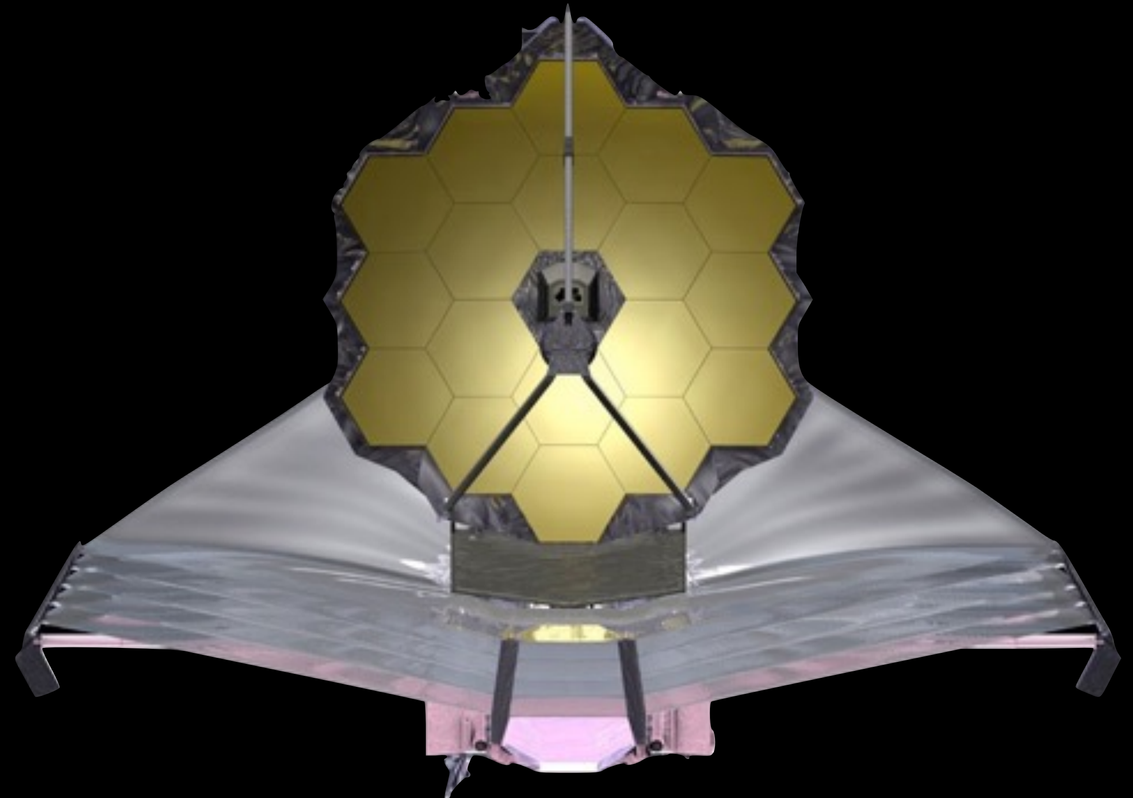
Embedded Phase of Star Formation



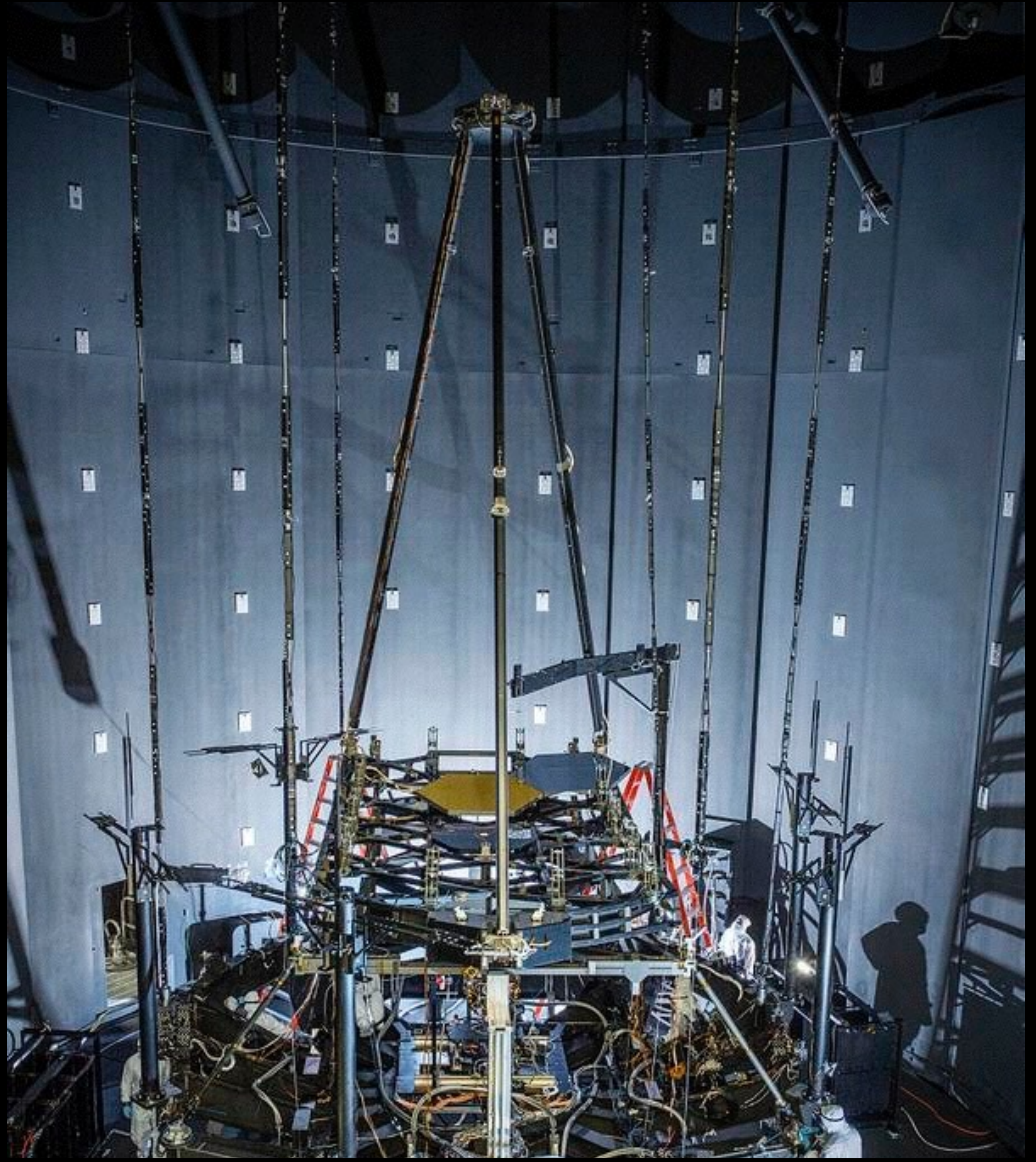
Stellar Pops in the Local Volume

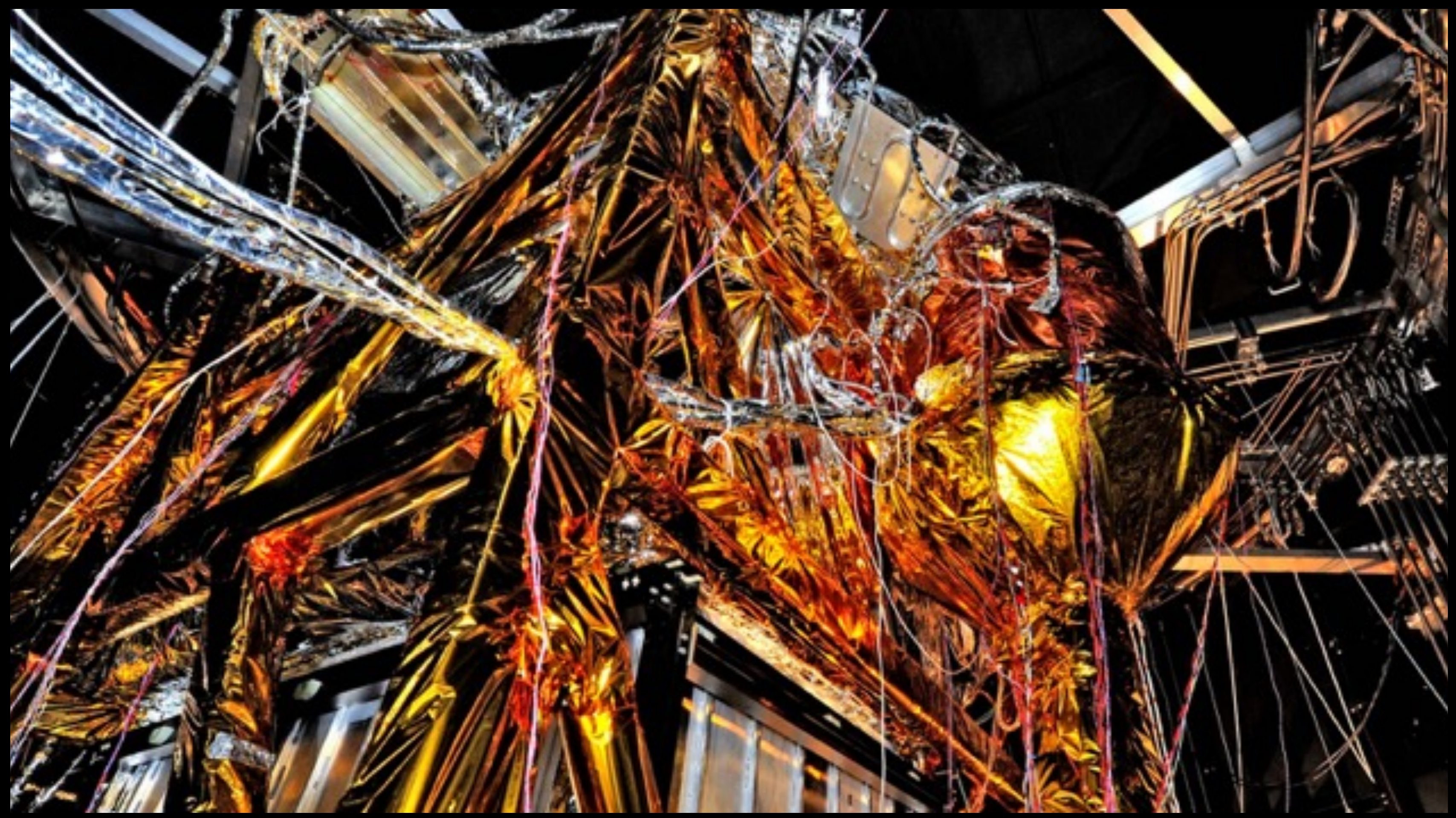


Characterizing Habitable Exoplanets

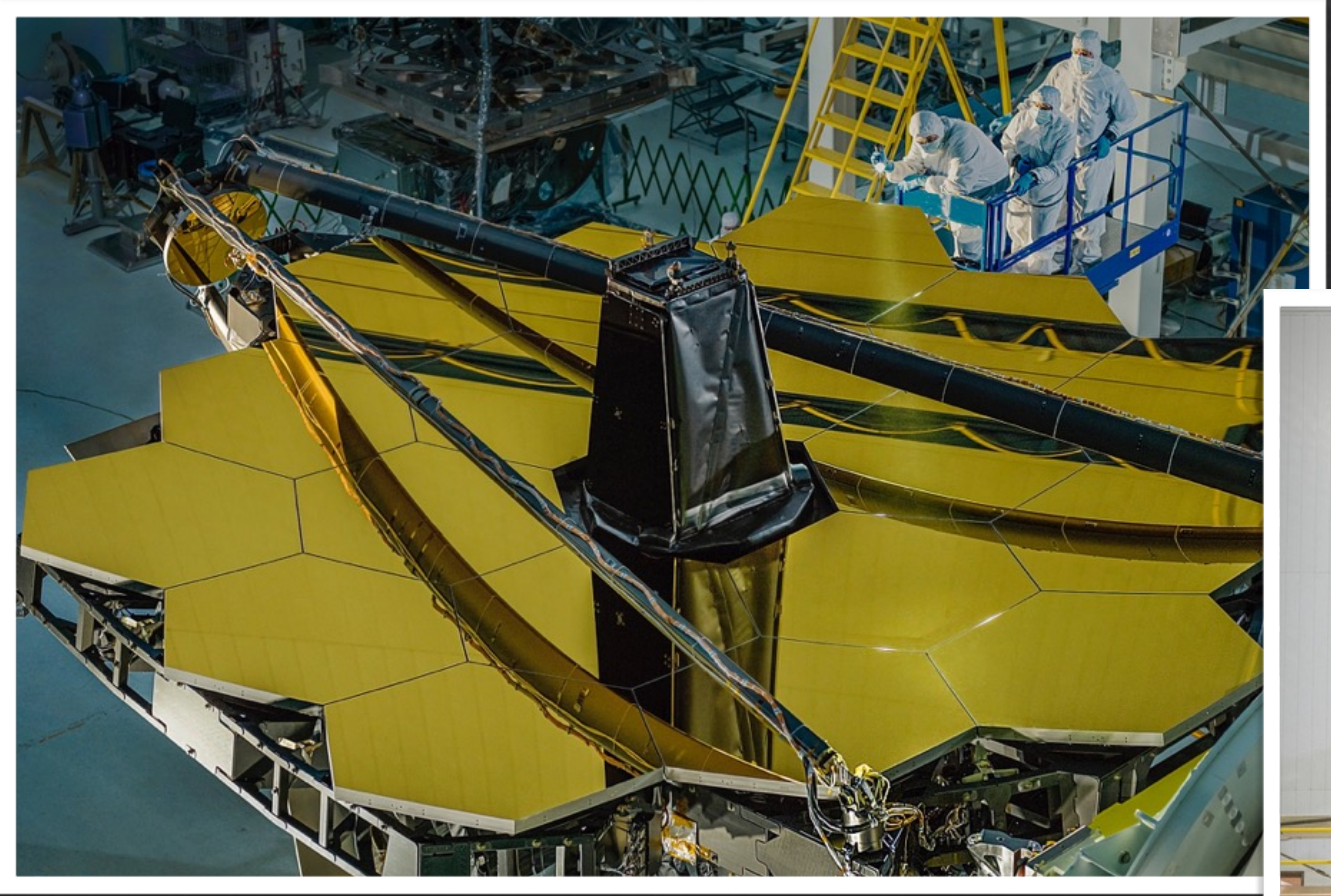


Technical Progress



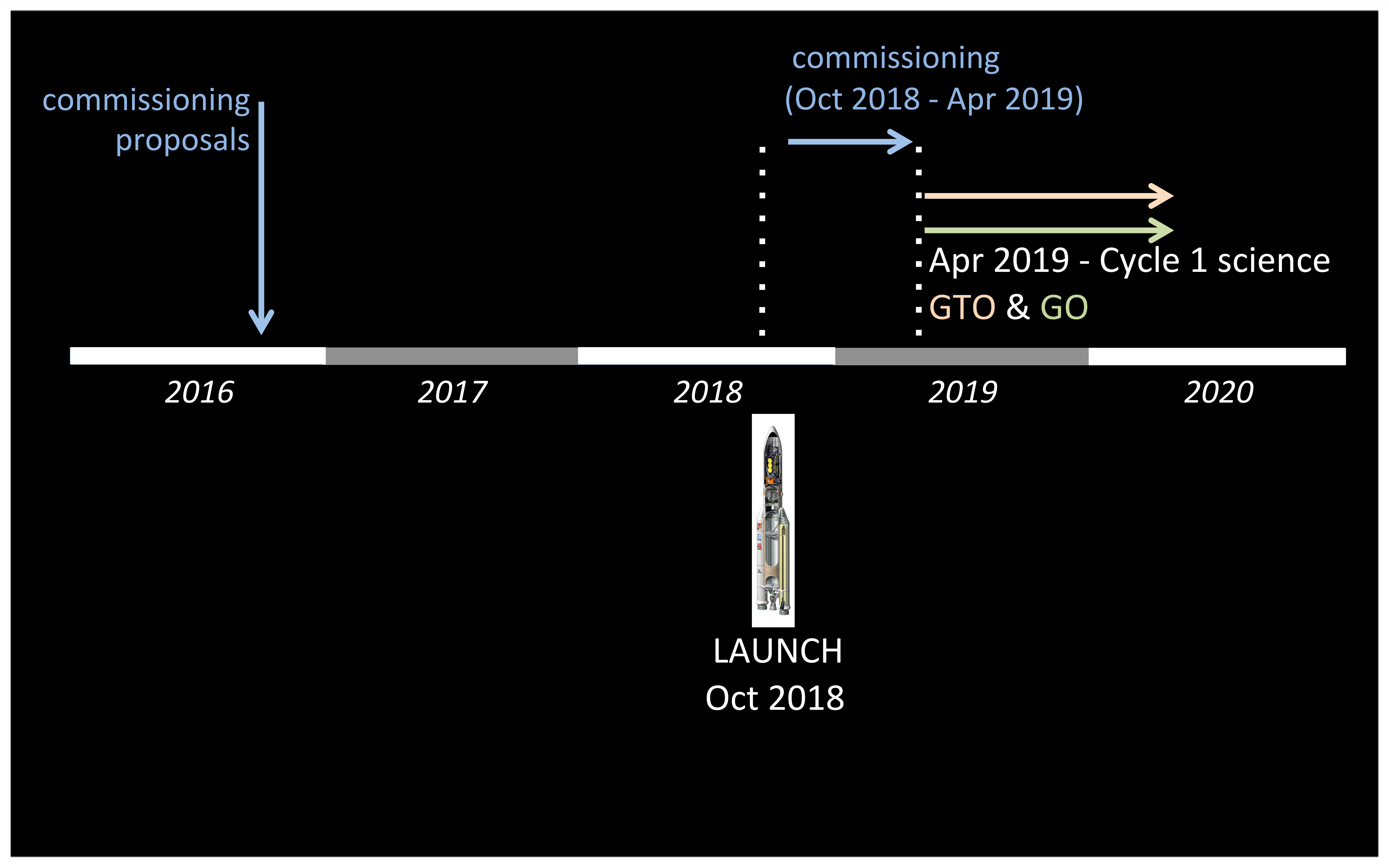


The James Webb Space Telescope



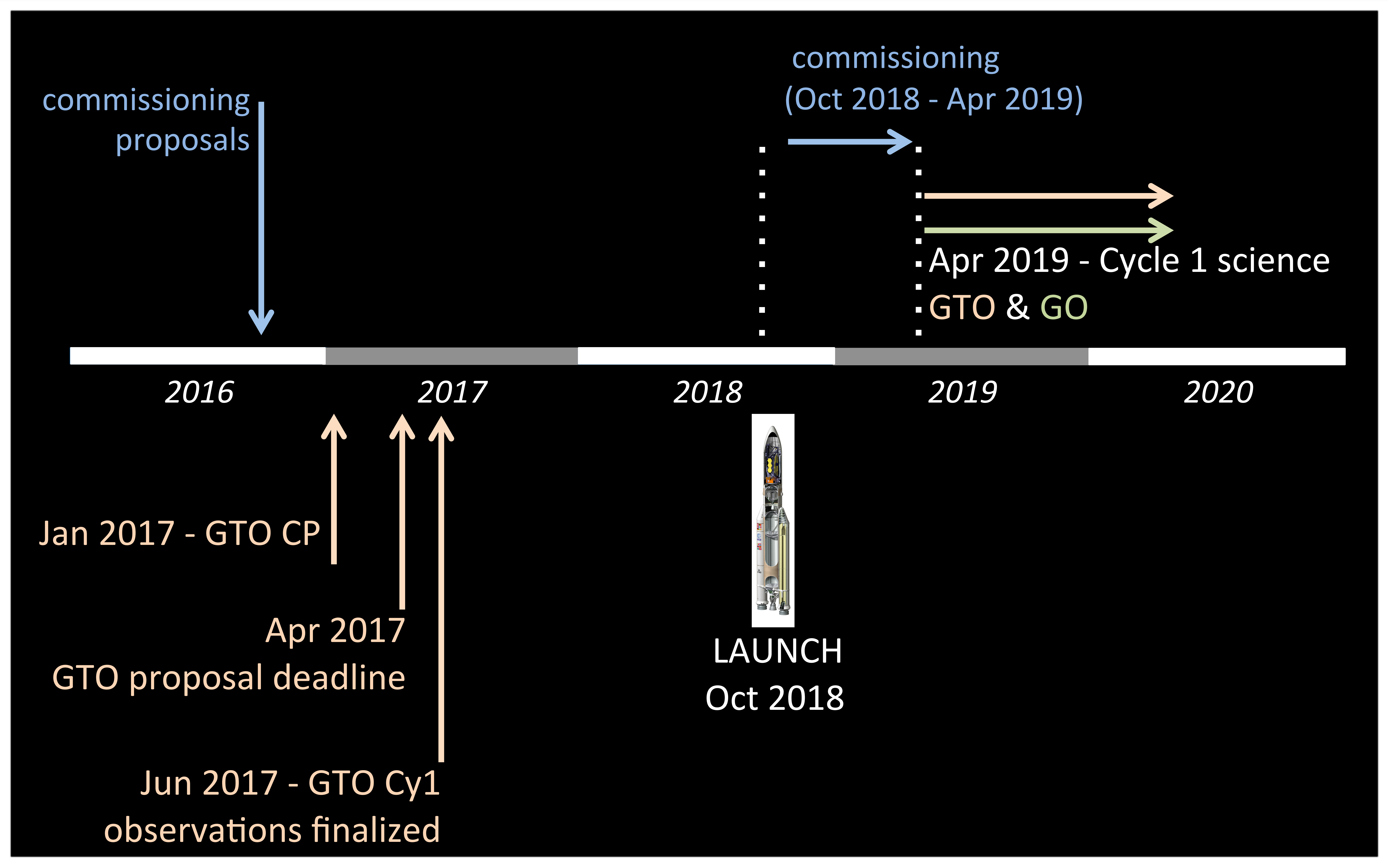
The James Webb Space Telescope

JWST Science Planning Timeline



Draft (Jan 2016)

JWST Science Planning Timeline



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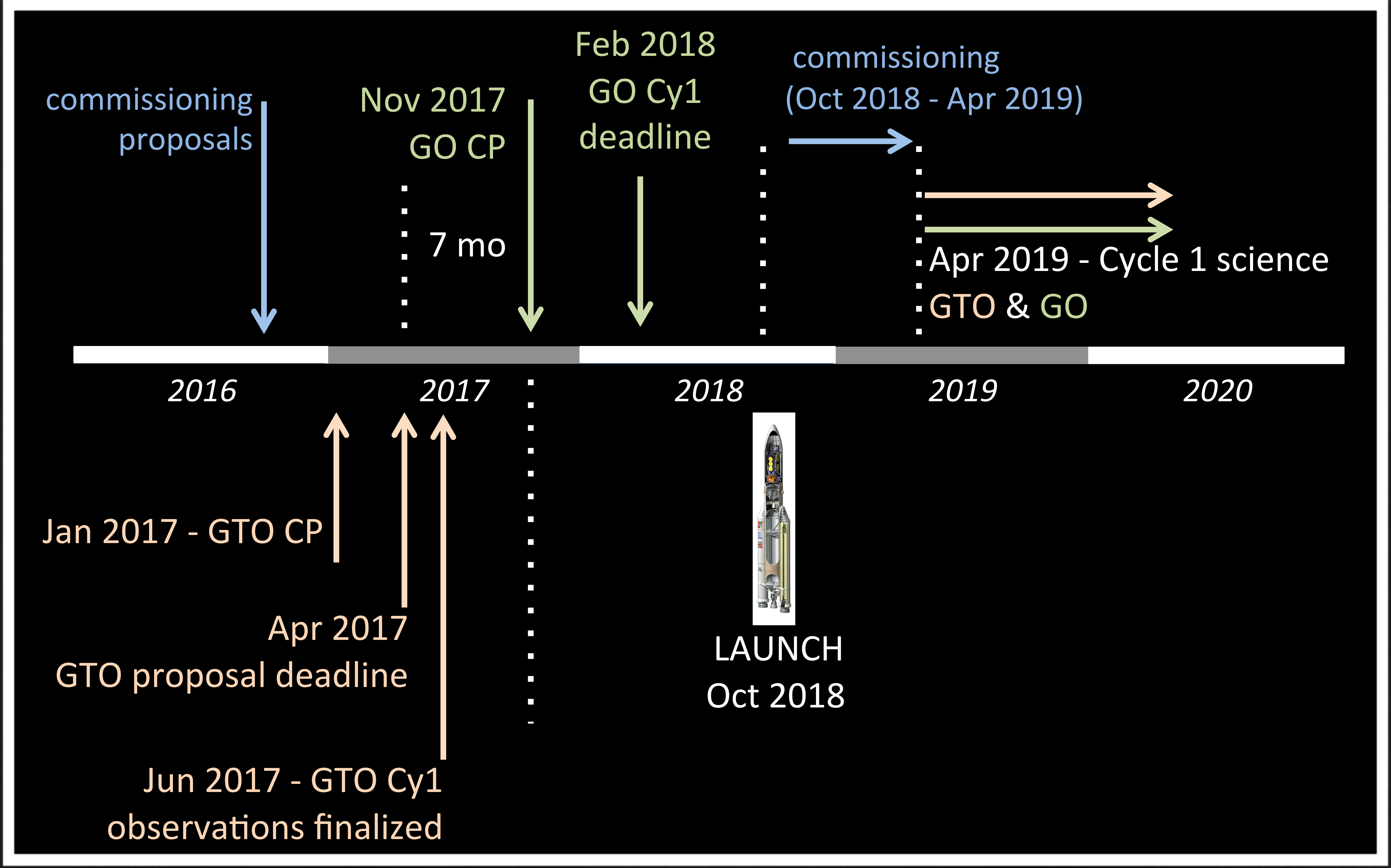
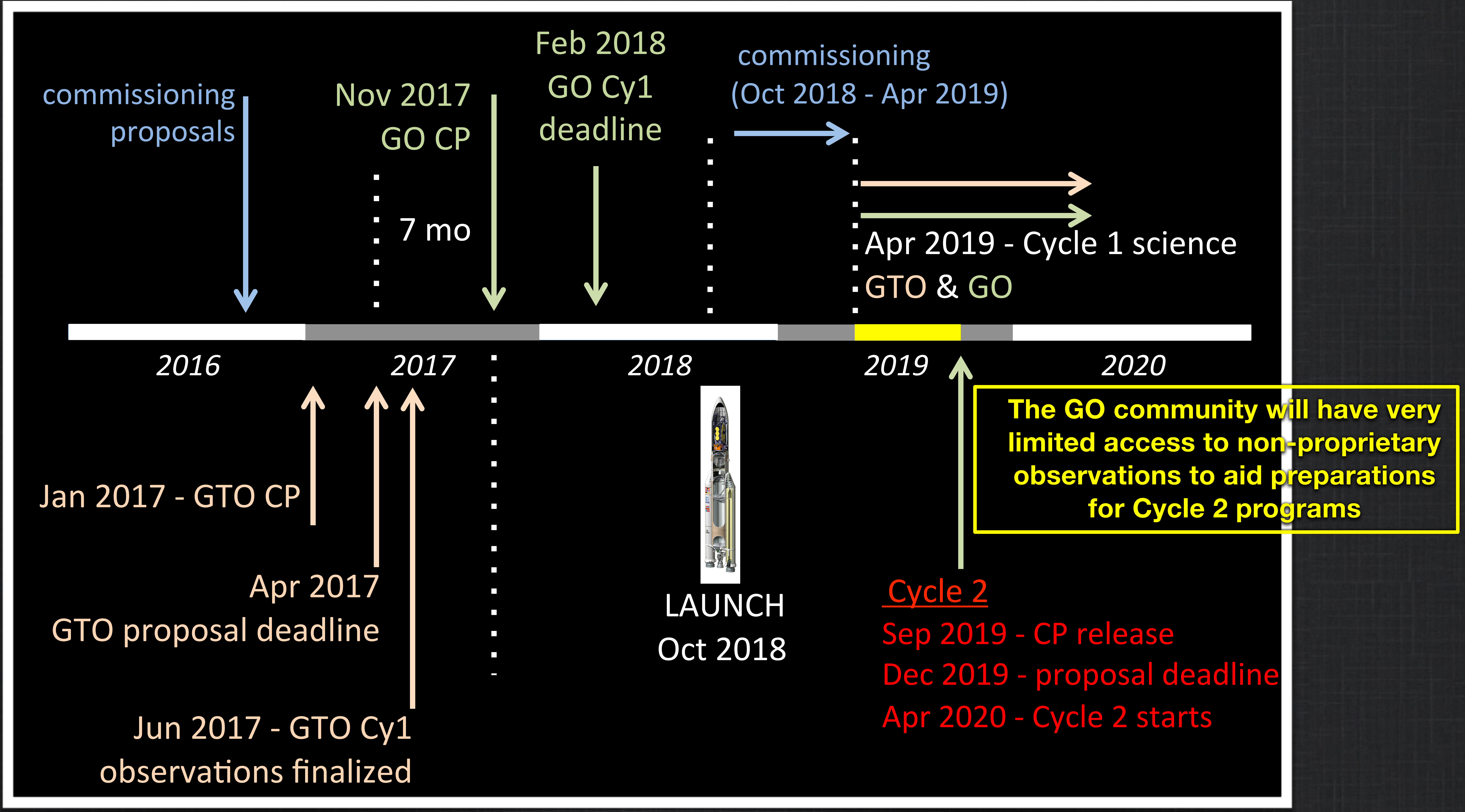
JWST Science Planning Timeline



Draft (Jan 2016)

JWST Science Planning Timeline



Draft (Jan 2016)

The Early Release Science Program (ERS)

The JSTAC has recommended an Early Release Science Program for JWST

June 2010

"..to obtain images and spectra that would be used to demonstrate key modes of the JWST instruments. The goal of this program is to enable the community to understand the performance of JWST prior to the submission of the first post-launch Cycle 2 proposals that will be submitted just months after the end of commissioning."

"The JSTAC recommends that the First-Look data be released both in raw form and with any initial calibrations as soon as possible; the key aspect is speed."

The JSTAC has reiterated its support for the ERS in recent meetings (e.g., see March 2014 letter)

Program Implementation

- ★ STScI had an open dialogue about ERS concepts at recent meetings (e.g., Jan 2016 AAS meeting)
- ★ Program will be supported by Director's Discretionary time (assume ~15 modes x 20-25 hrs)
- ★ Program will be shaped with significant involvement of the astronomical community
- ★ Program will be selected to span key JWST observing modes, data analysis challenges, science areas
- ★ Program will execute early in Cycle 1 and have no proprietary time
- ★ ERS teams will be responsible for rapid delivery of science enabling products to MAST

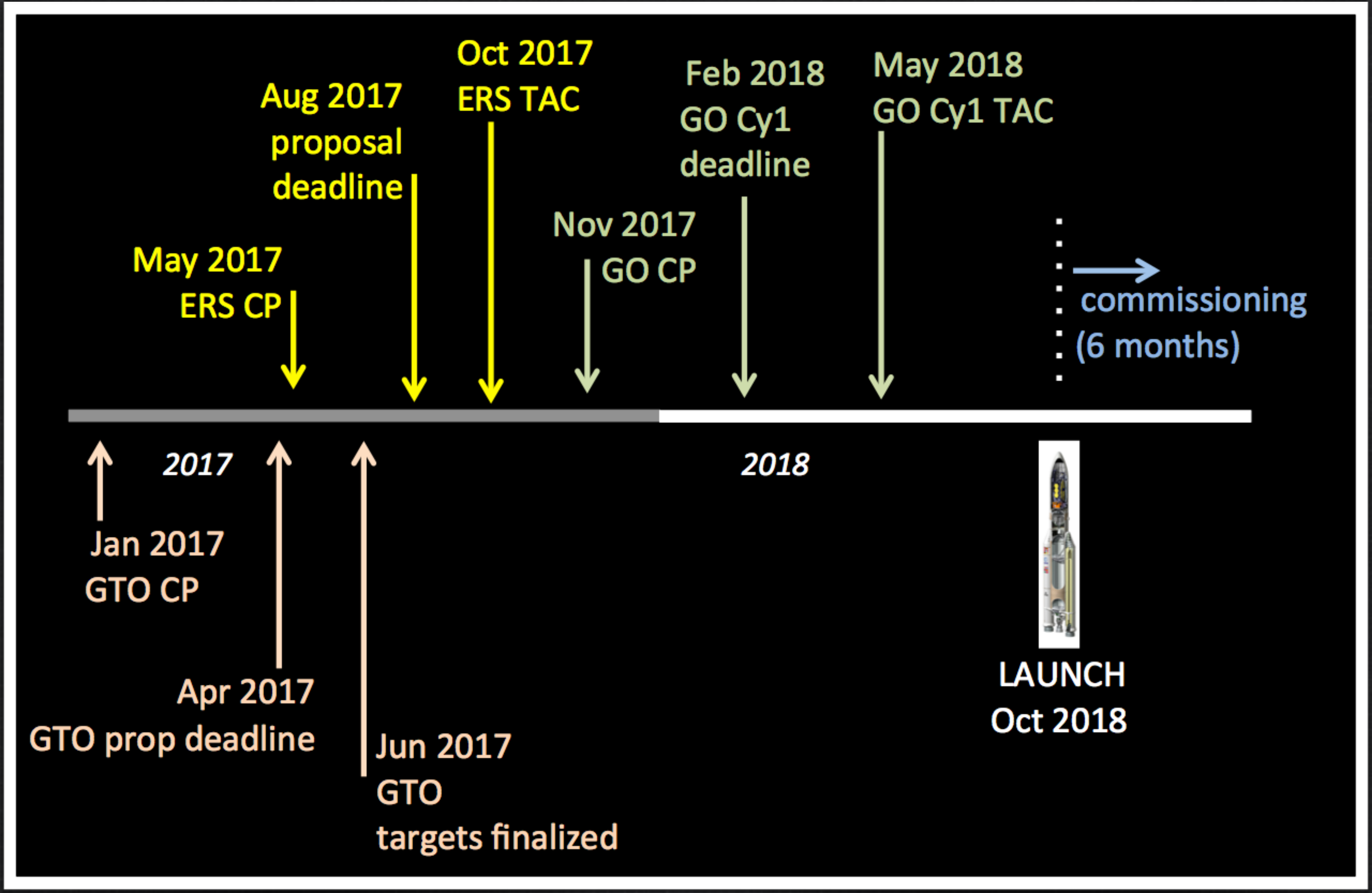
The ERS program is a fantastic opportunity to become an expert on JWST

https://jwst.stsci.edu/science-planning/early-release-science-program

N. Reid's ERS Presentation from the Jan 2016 AAS Meeting:

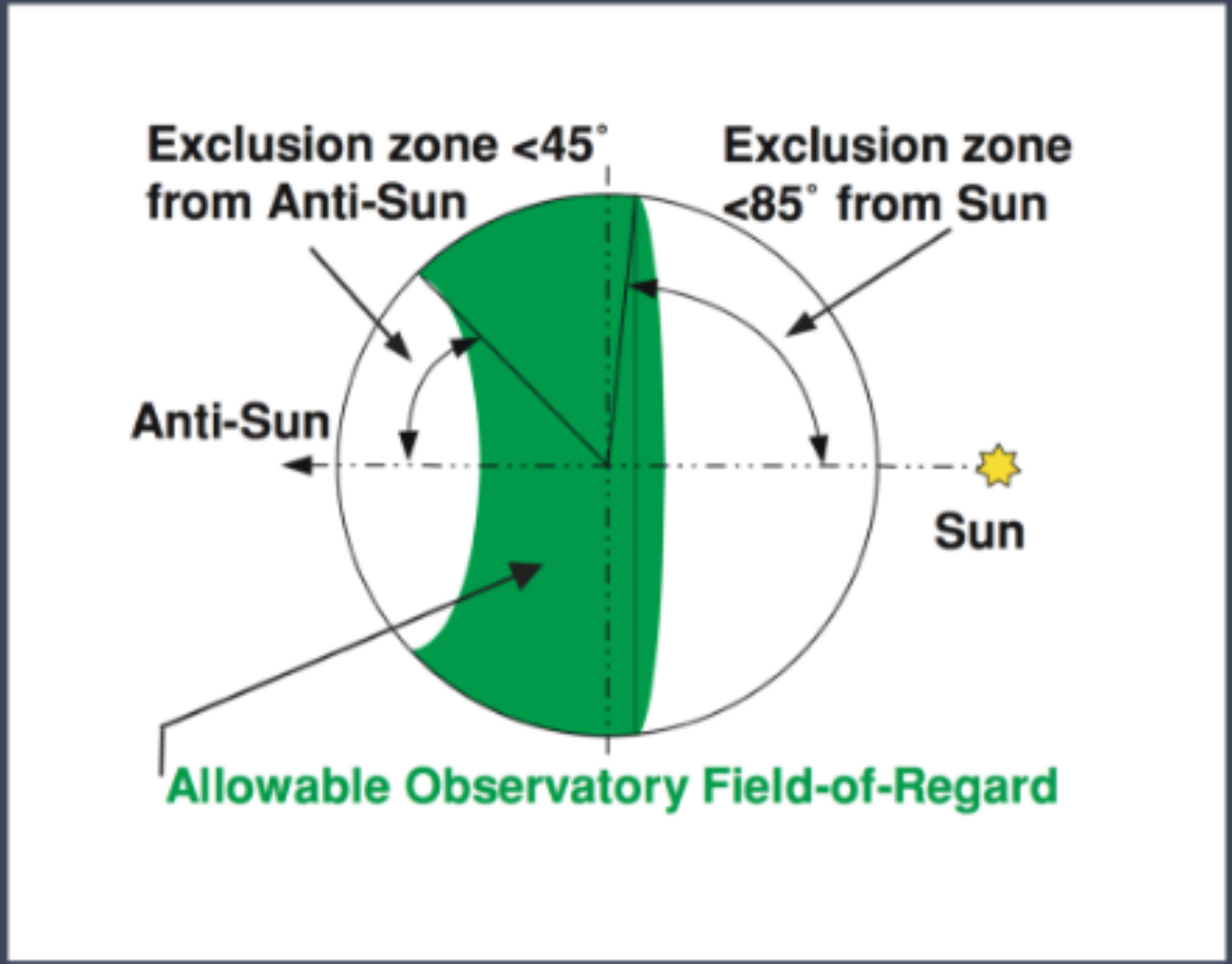
https://jwst.stsci.edu/events/events-area/stsci-events-listing-container/stsci-event-12?mwc=4

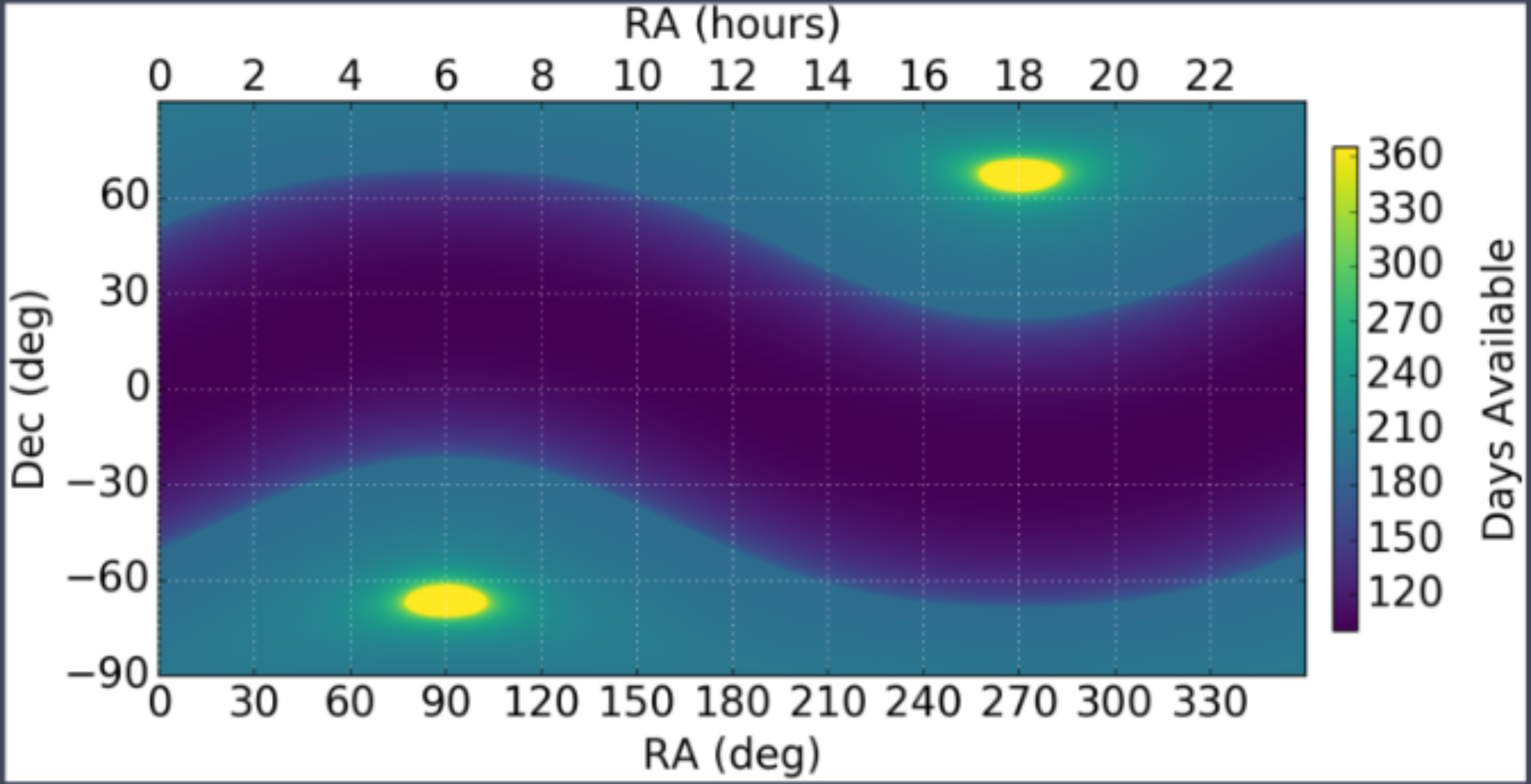
JWST Cycle 1 Early Release Science (ERS) Timeline



Draft (Jan 2016)

JWST Observing Constraints





JWST

- ★ Observatory must remain in the shadow of the sunshield. Implies observational constraints
- ★ 40% of the sky visible at any time. Field of regard moves across the sky as JWST orbits the Sun
- ★ Overall sky coverage over a year has a continuous viewing zone within 5 deg of each ecliptic pole
- ★ 30% of the sky is viewable for 197 days per year
- ★ All sky will have >51 days of continuous visibility each year
- ★ Users will have less choice for roll angles compared to Hubble today

More info: https://jwst.stsci.edu/instrumentation/telescope-and-pointing/pointing-and-guiding

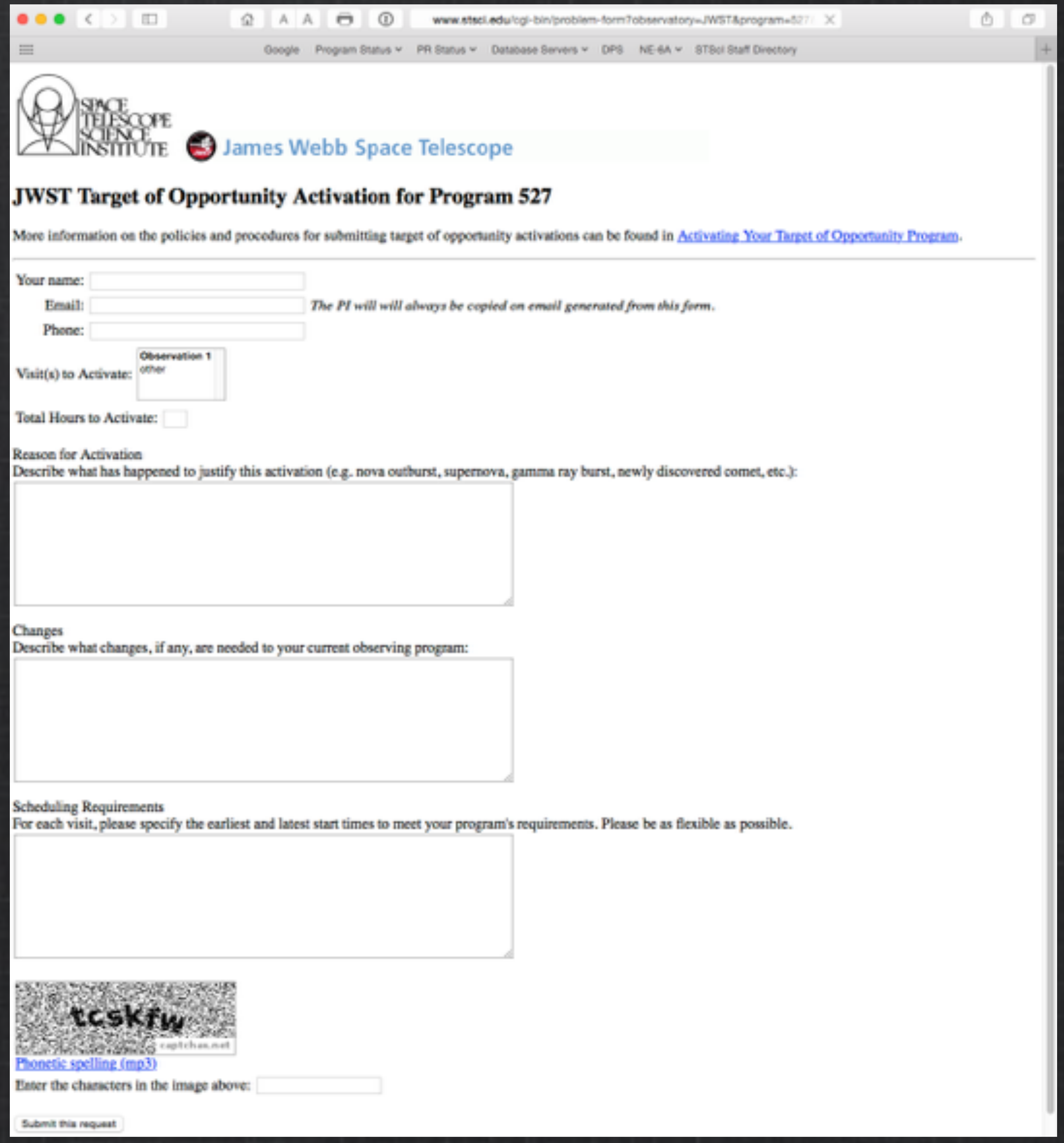
JWST and the Transient Universe

Target of Opportunities

- ★ Disrupting schedules is extra work, but science and observatory health will drive our priorities
- ★ Having programs in the queue ahead of time is always better
- ★ If there is no ToO, could ask for Director's Discretionary Time on JWST (bottle neck is getting a review done)

Triggering

- ★ Triggering a ToO will be done through APT
- ★ Advantageous to give STScI a heads up that something is coming.
- ★ APT can show you the field of regard through the Visit Planner



Timing

- ★ Observation can be executed 24-48 hours from when we have the APT
- ★ Data goes online as soon as we've processed it
  …completely automated, no fast track process
- ★ Archive will have a "subscription service" to alert users

Policy is TBD (ask N. Reid)

- ★ How many ToOs, any special "tax" for the TAC, etc.

More info: https://jwst.stsci.edu/instrumentation/telescope-and-pointing/pointing-and-guiding