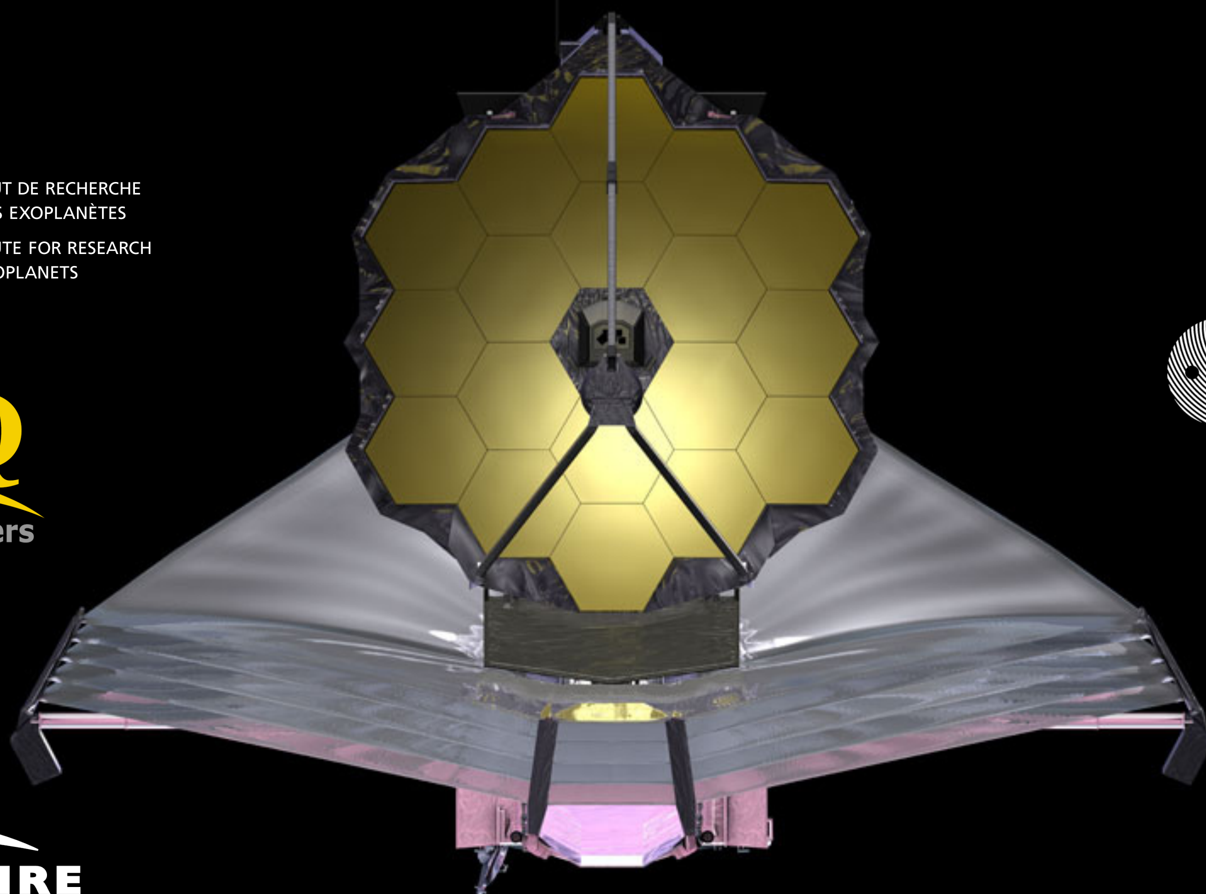
Get ready for the James Webb Space Telescope



iREx
INSTITUT DE RECHERCHE SUR LES EXOPLANÈTES
INSTITUTE FOR RESEARCH ON EXOPLANETS

CRAQ
Comprendre l'Univers

OBSERVATOIRE DU MONT-MÉGANTIC

Université de Montréal

NASA

esa

CSA ASC

René Doyon, Université de Montréal

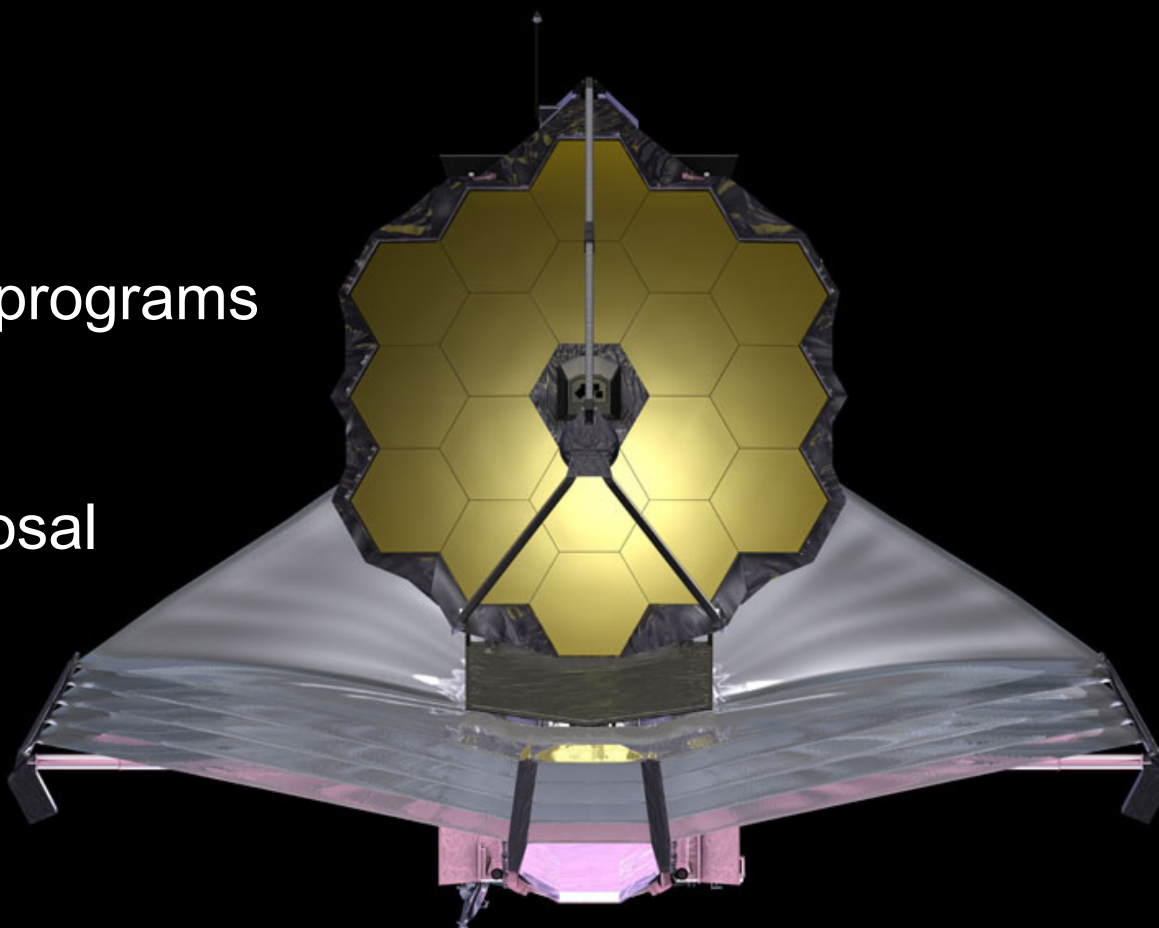
15 November 2017

Outline

JWST primer

Instruments & science programs

Towards a JWST proposal



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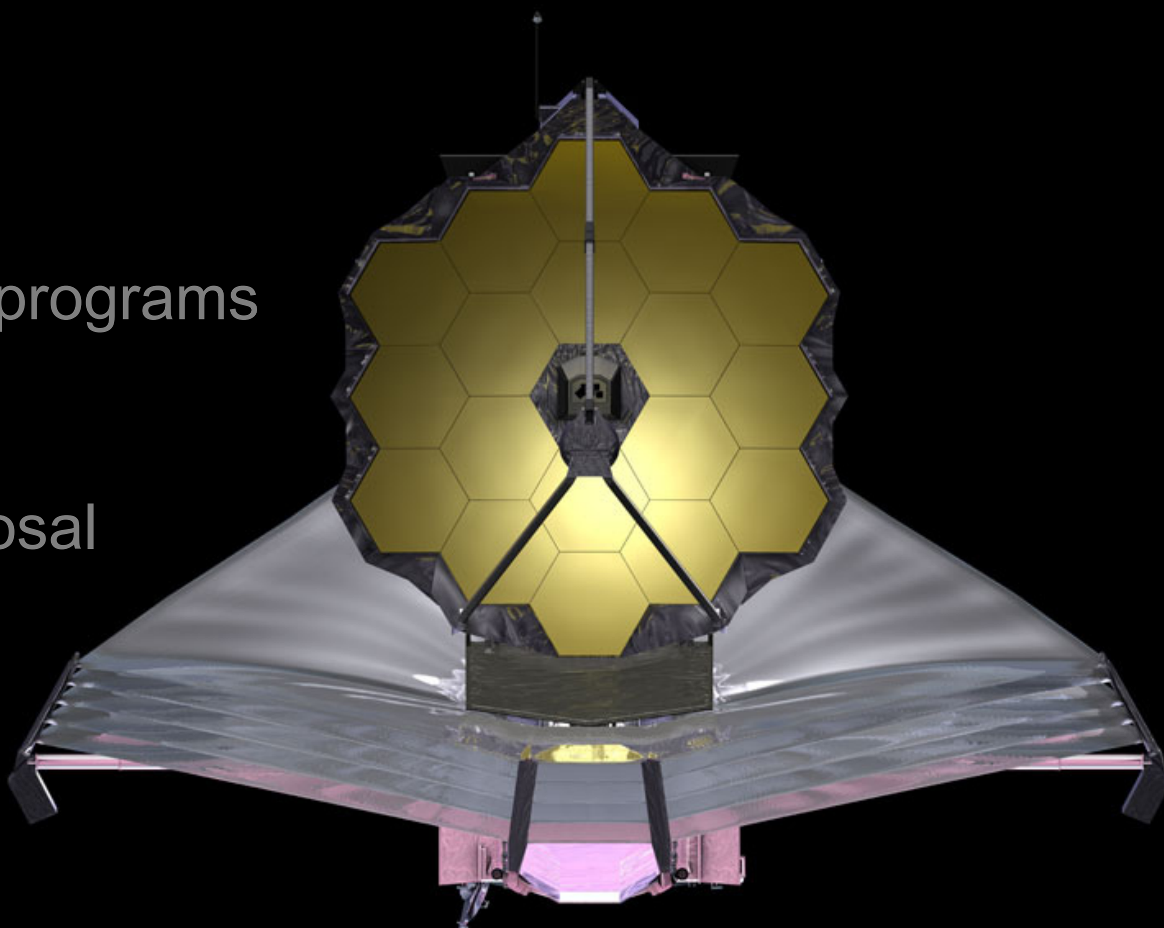
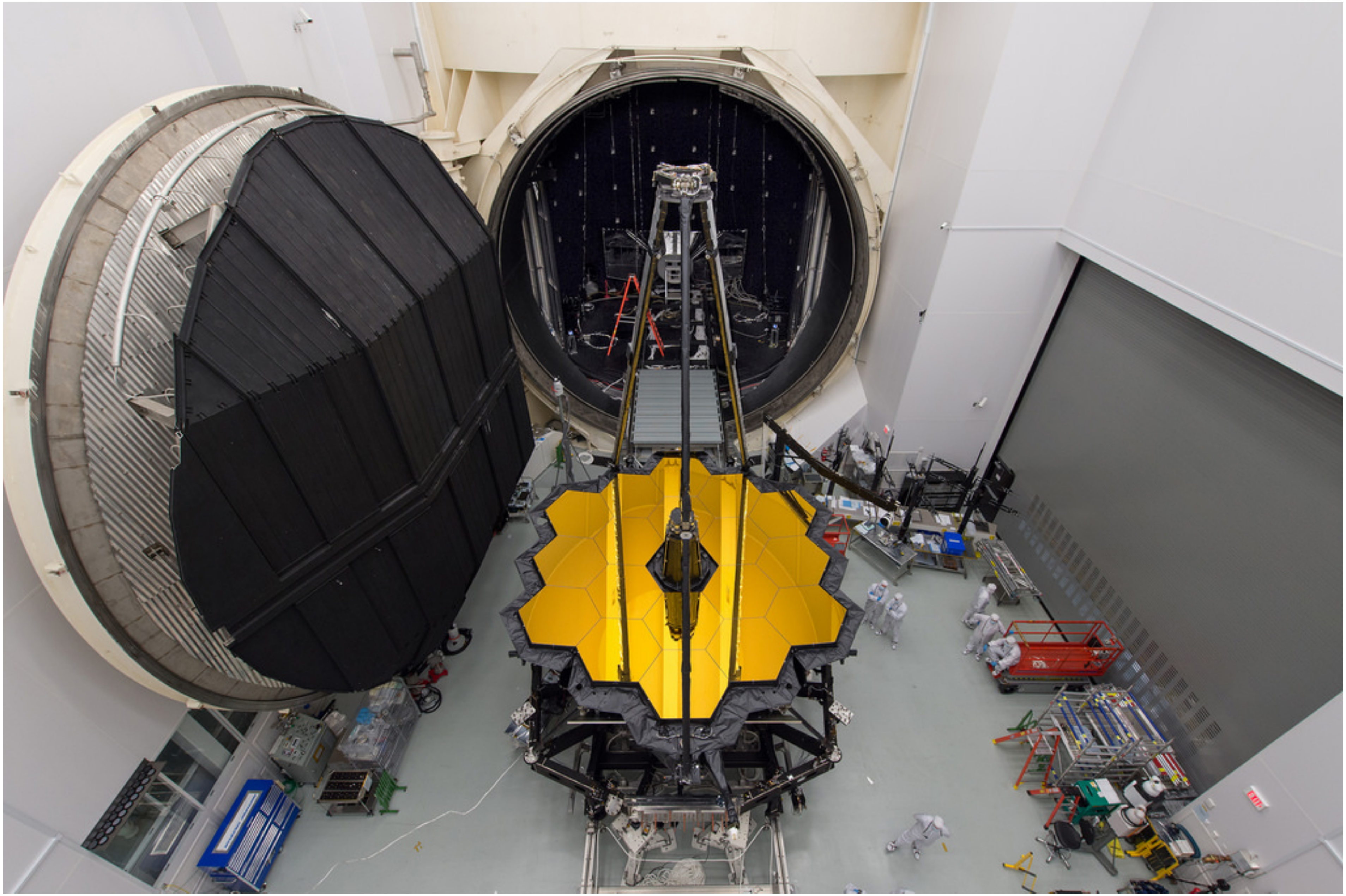
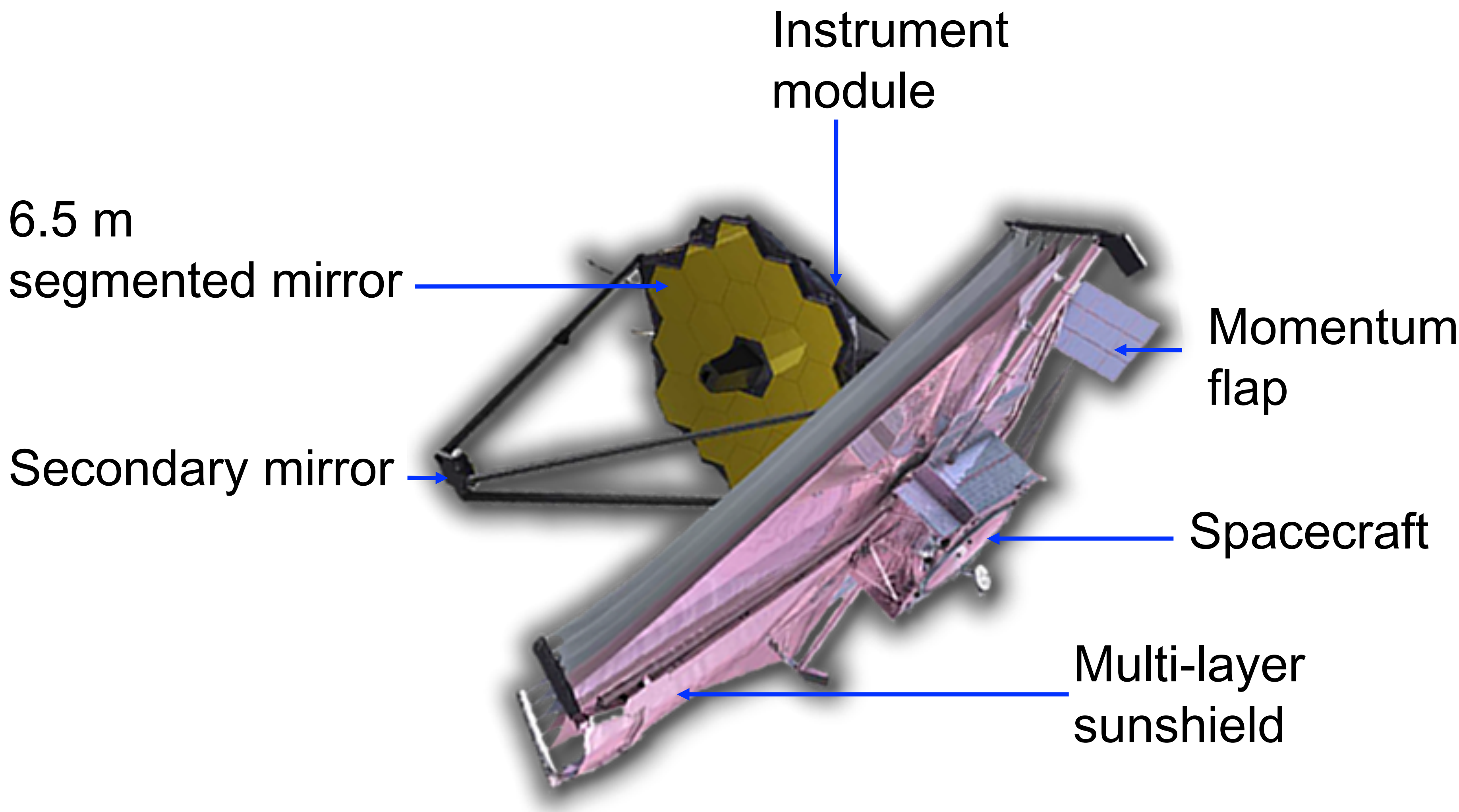




JWST anatomy



Cycle 1 General Observer (GO) proposals are due by April 6, 2018

Fall 2019 — Cycle 1 GO, GTO and ERS Science

Spring 2019 — JWST Launch

Cycle 1 Delta Call?

May 2018 — Cycle 1 GO TAC

April,6 2018 — Deadline for GO Cycle 1

Nov,30 2017 — Cycle 1 General Observer (GO) CfP

Nov 13 2017 — Early-Release Science (ERS) selections

June 2017 — GTO targets frozen

JWST time distribution in Cycle 1

	Hours
GTO (must be less than 3900 hrs, 50% of GO) (450 hrs for Canada)	3775
Early Release Science (13 programs selected)	460
Early Release Observations	80
DDT	416
GO	4029
Canadian GO time (at nominal 5%)	>201

CSA will fund GTO and successful GO proposals at the level of
~$1M/yr. Details to be provided by CSA in January 2018.

Director's Discretionary Early Release Science (DD ERS)

Following the recommendation of the Time Allocation Committee and a thorough technical review, STScI Director Ken Sembach has selected 13 science programs (460 hours) for the JWST DD ERS Program.

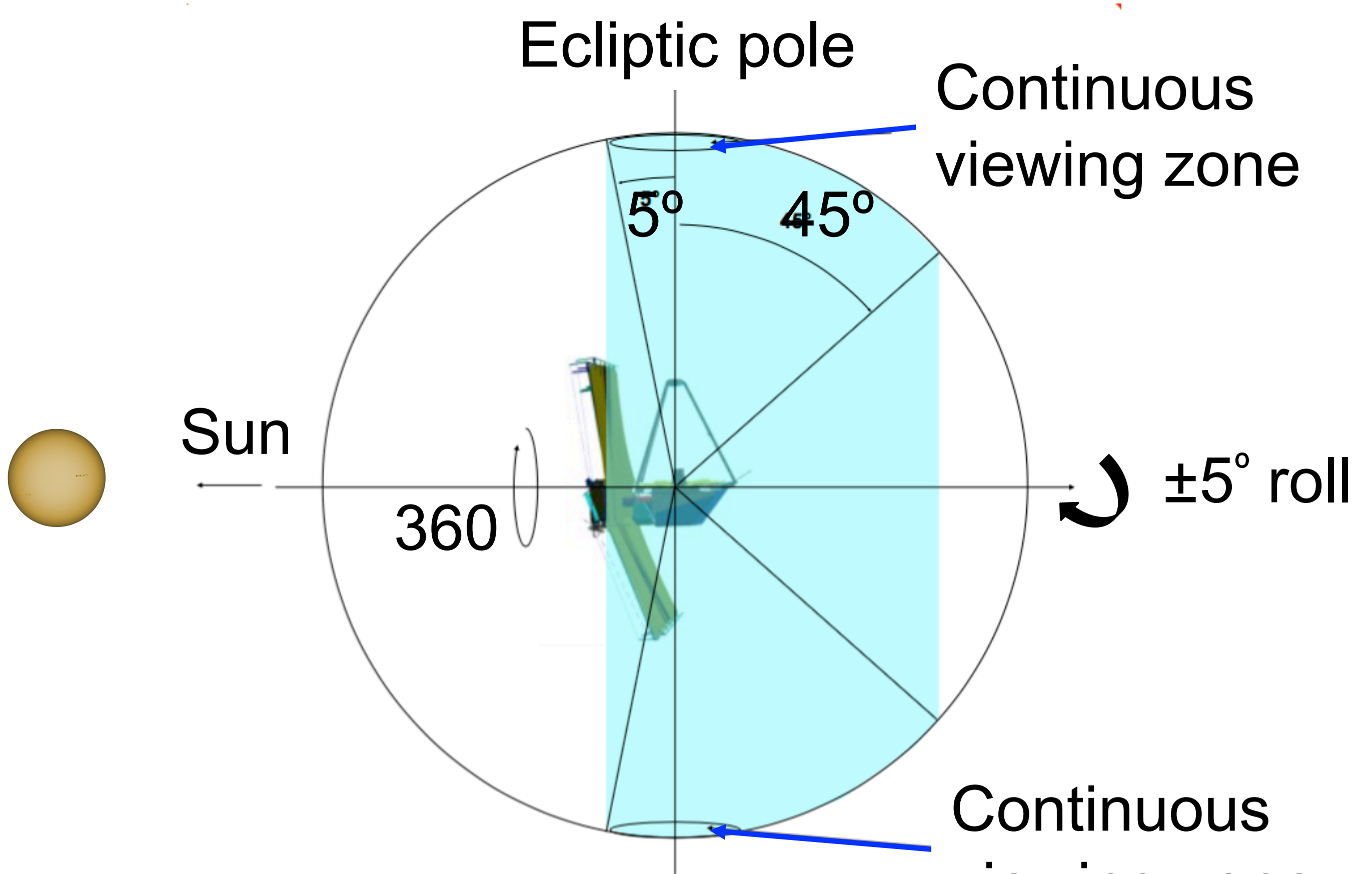
- 106 Proposals Received for 3683.4 Hours, 13 Approved for 460 Hours
  - 4 ESA Proposals for 125 Hours
    - 31% for Proposals and 27% for Hours
    - 32% of the CoIs are ESA Members
  - 9 US Proposals for 334.6 Hours
  - 7 of the 240 CoIs are from CSA
  - 18 Countries and 22 US States are represented
  - 106 Unique Institutions
  - 253 Investigators (248 Unique)

For specifics about the selected programs, see JWST Observer news item posted today along with public news release:

https://jwst.stsci.edu/news-events/news/News%20items/selections-made-for-the-jwst-directors-discretionary-early-release-science-program

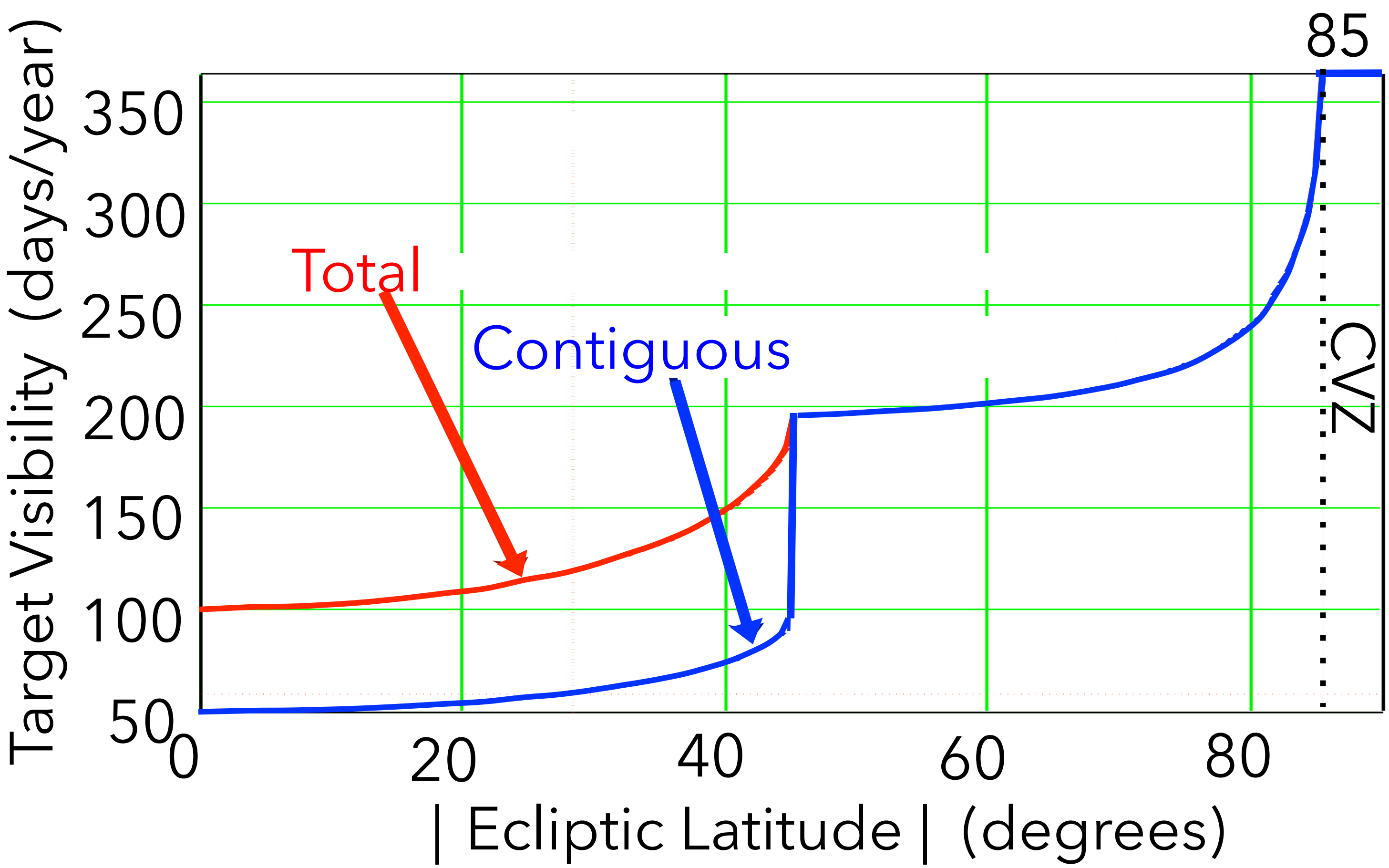
Slide courtesy of Nikole Lewis (STScI)

JWST's field of regards



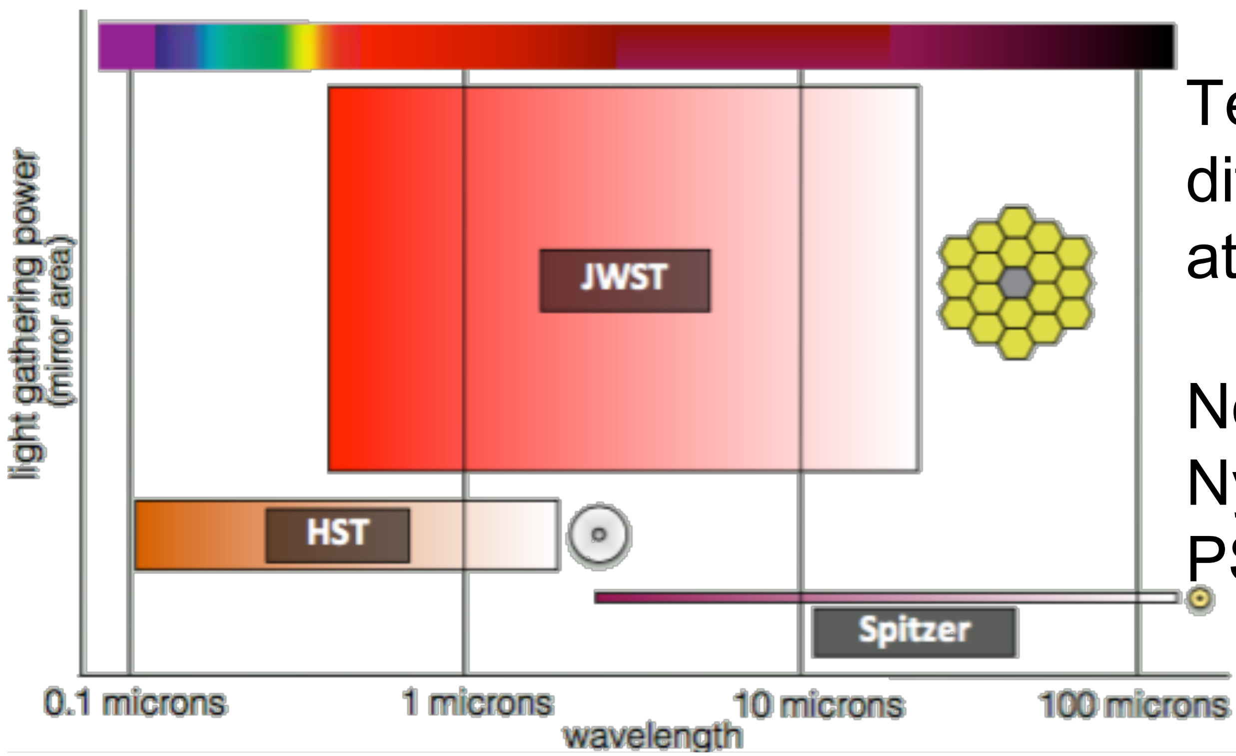
©JDox

Target visibility windows



Targets in the ecliptic plane are accessible for approximately 53 continuous days twice a year.

Broad wavelength coverage : 0.6 to 28 μm



Telescope is diffraction limited at >2 μm

Not all instruments Nyquist sample the PSF.

Outline

JWST primers

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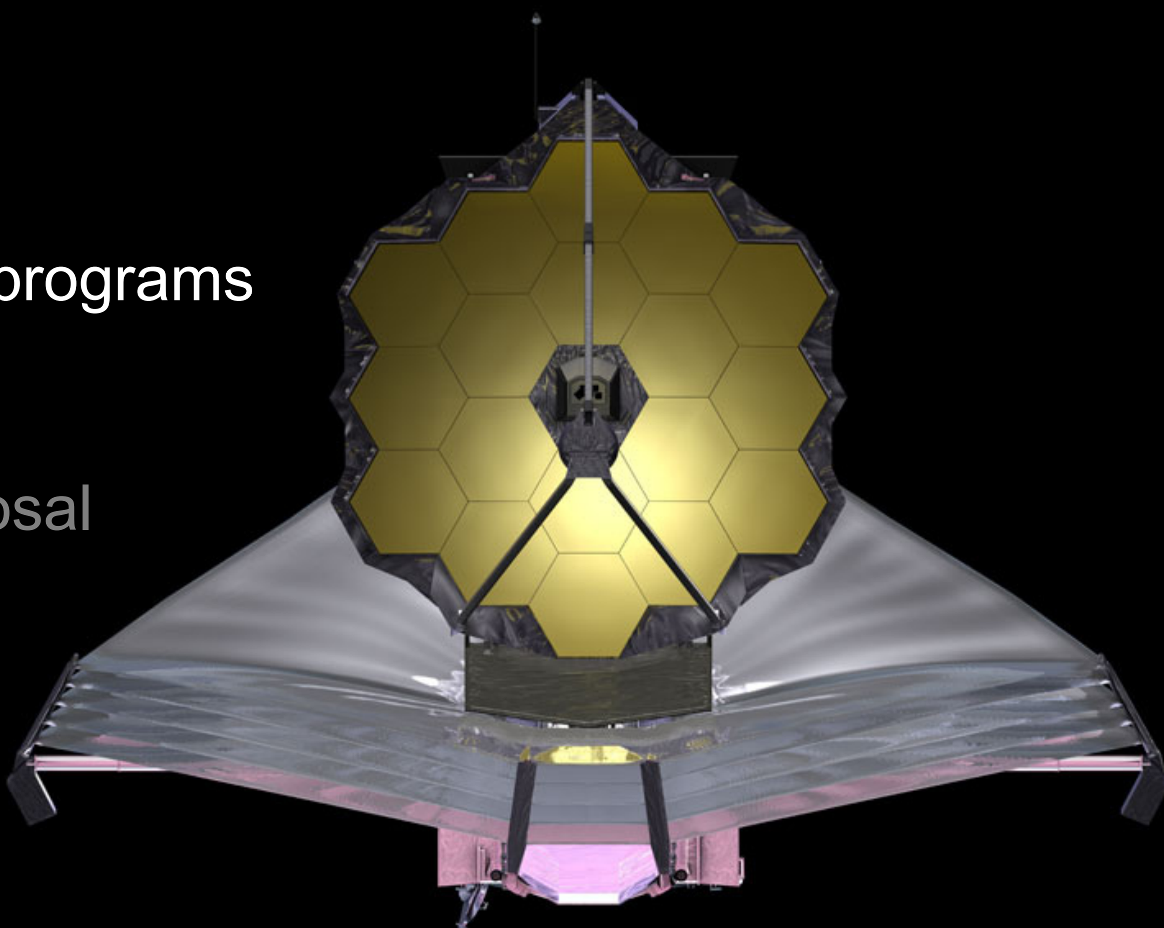
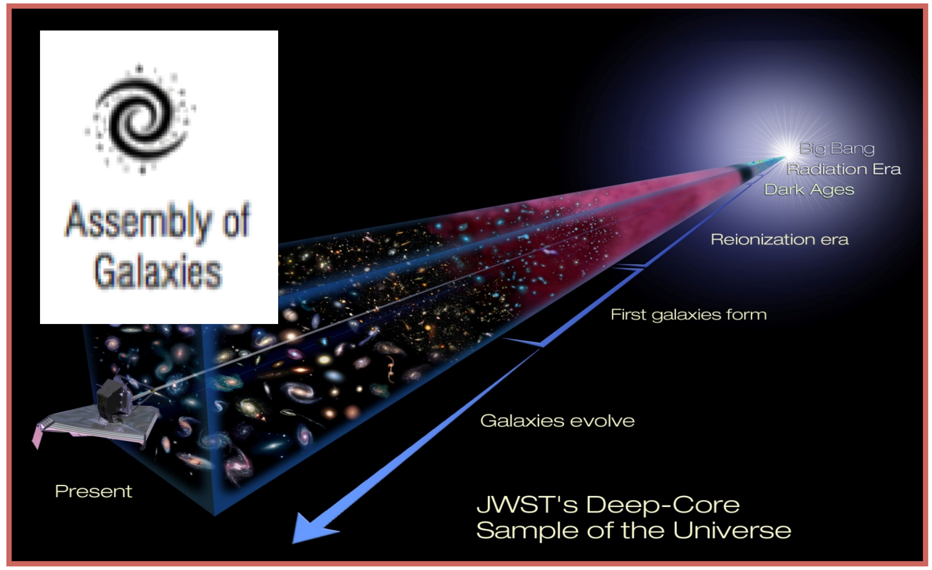
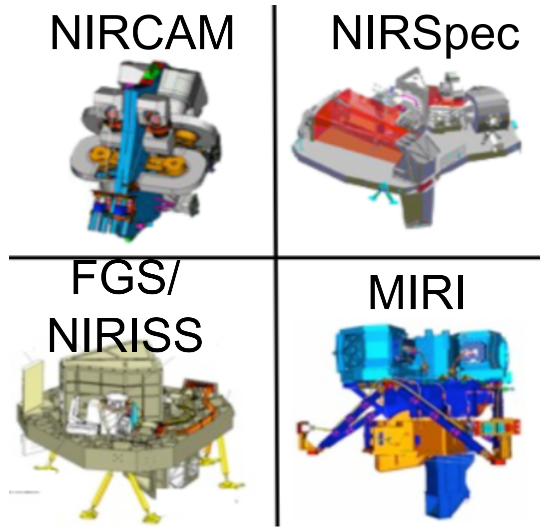
Towards a JWST proposal

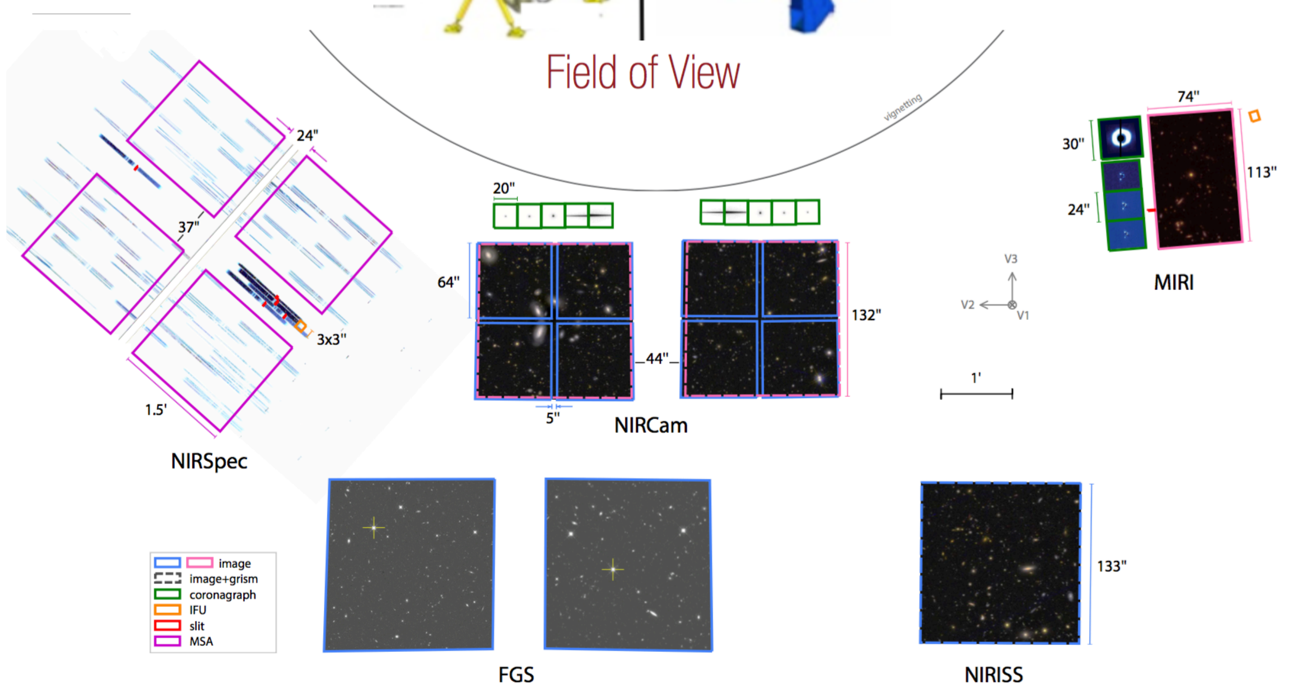


JWST's four science themes



Four instruments with multiple modes





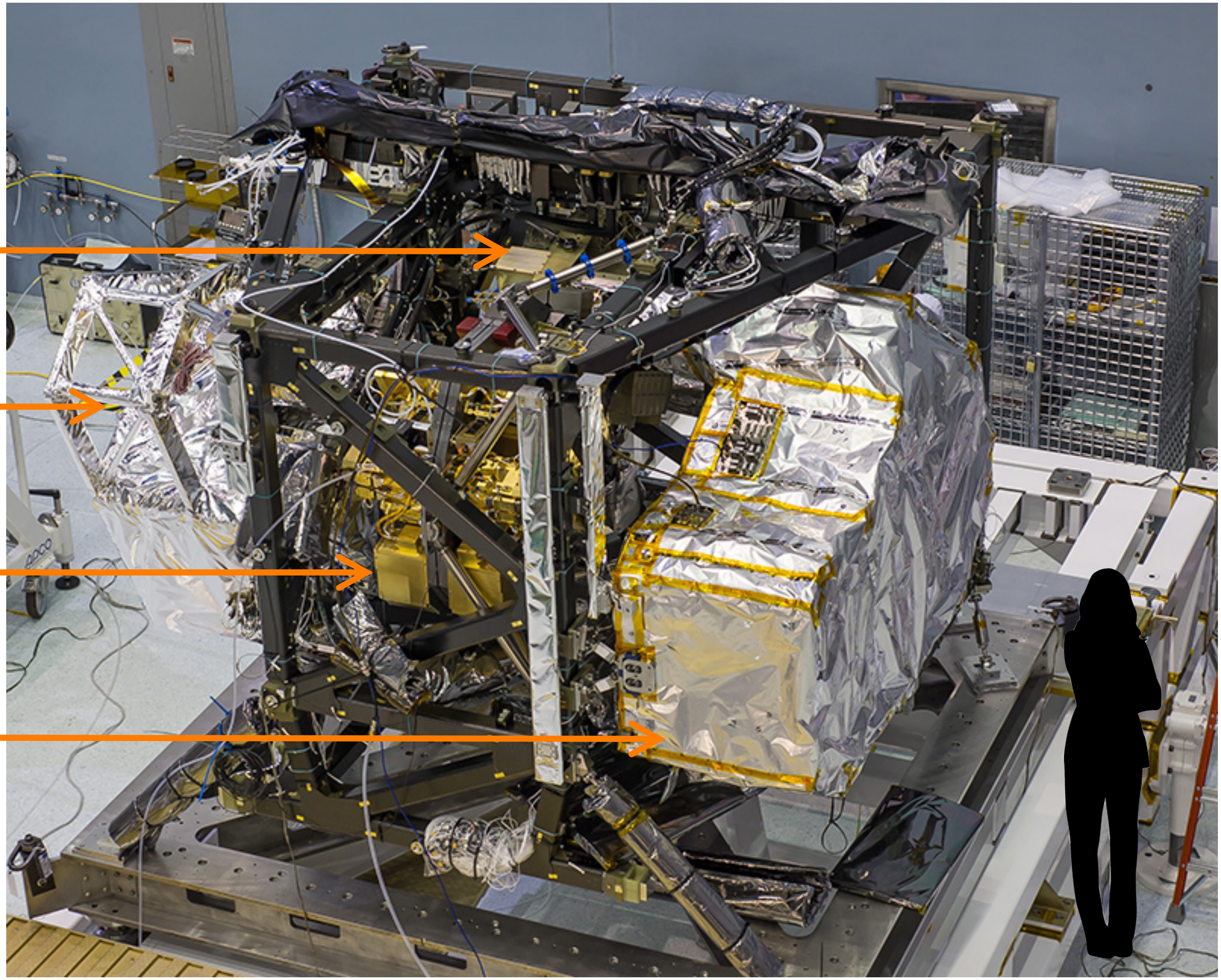
A flagship worth of instruments

NIRISS

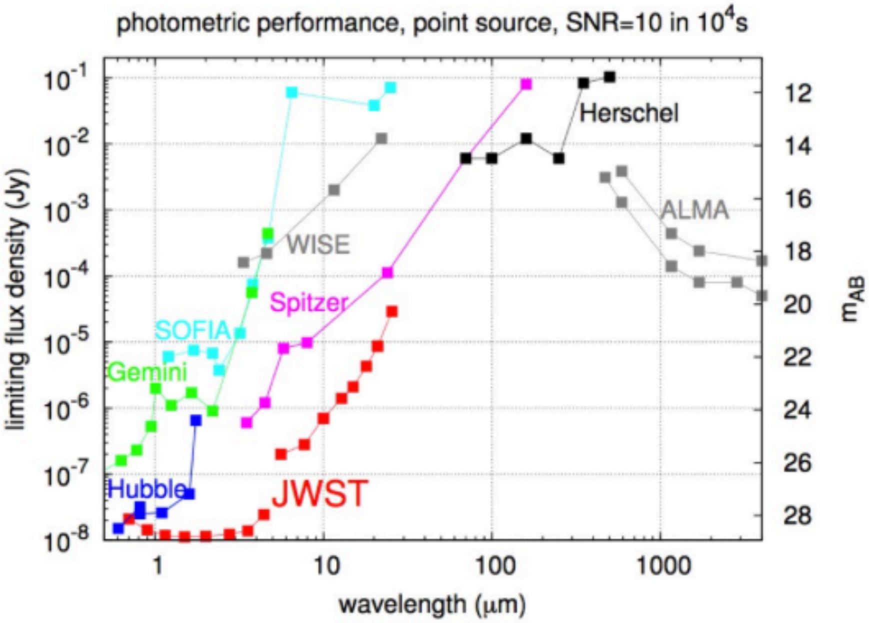
MIRI

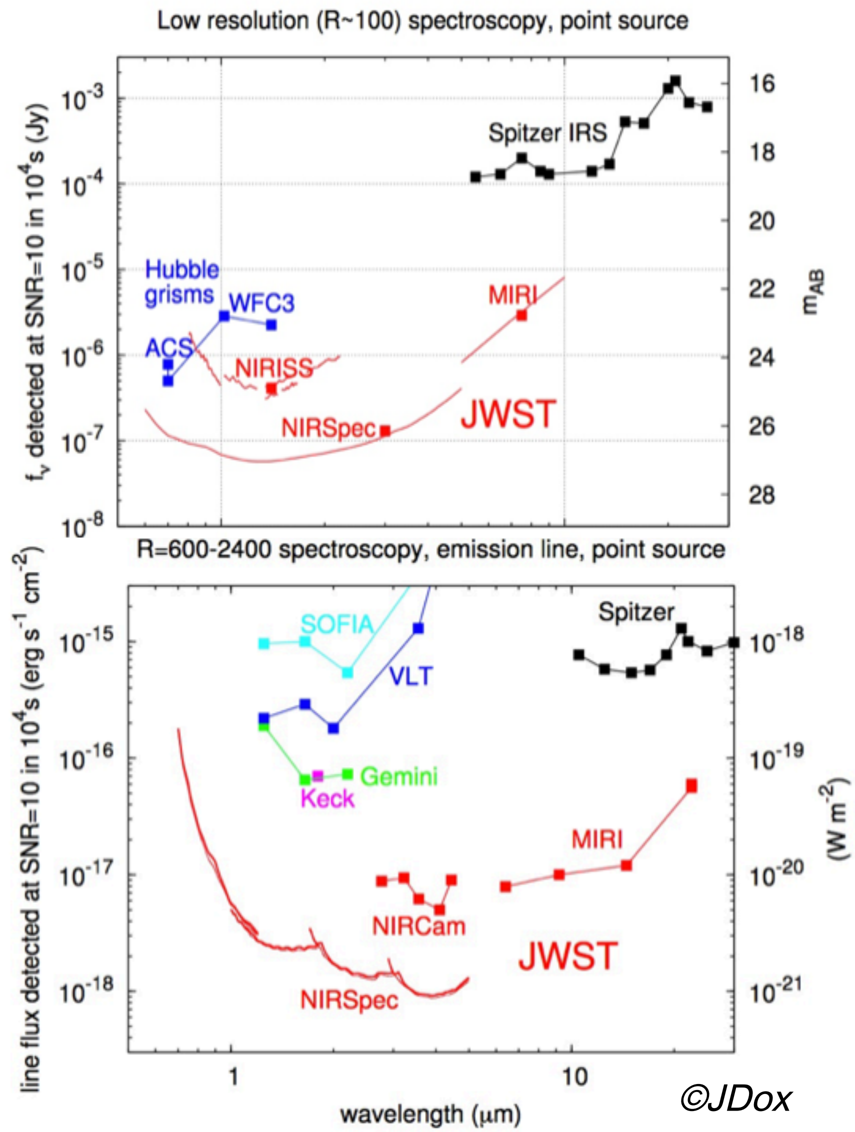
NIRCam

NIRSpec



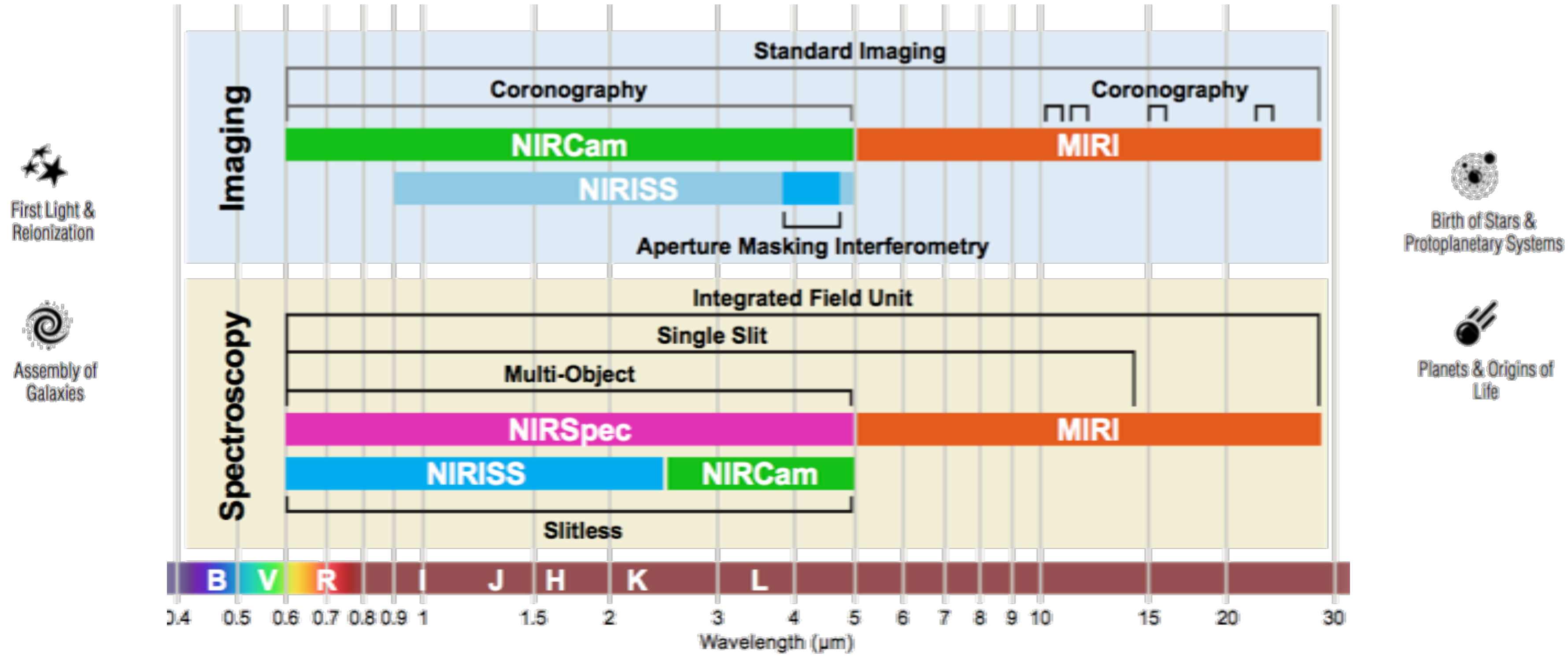
JWST will improve sensitivity by order(s) of magnitude



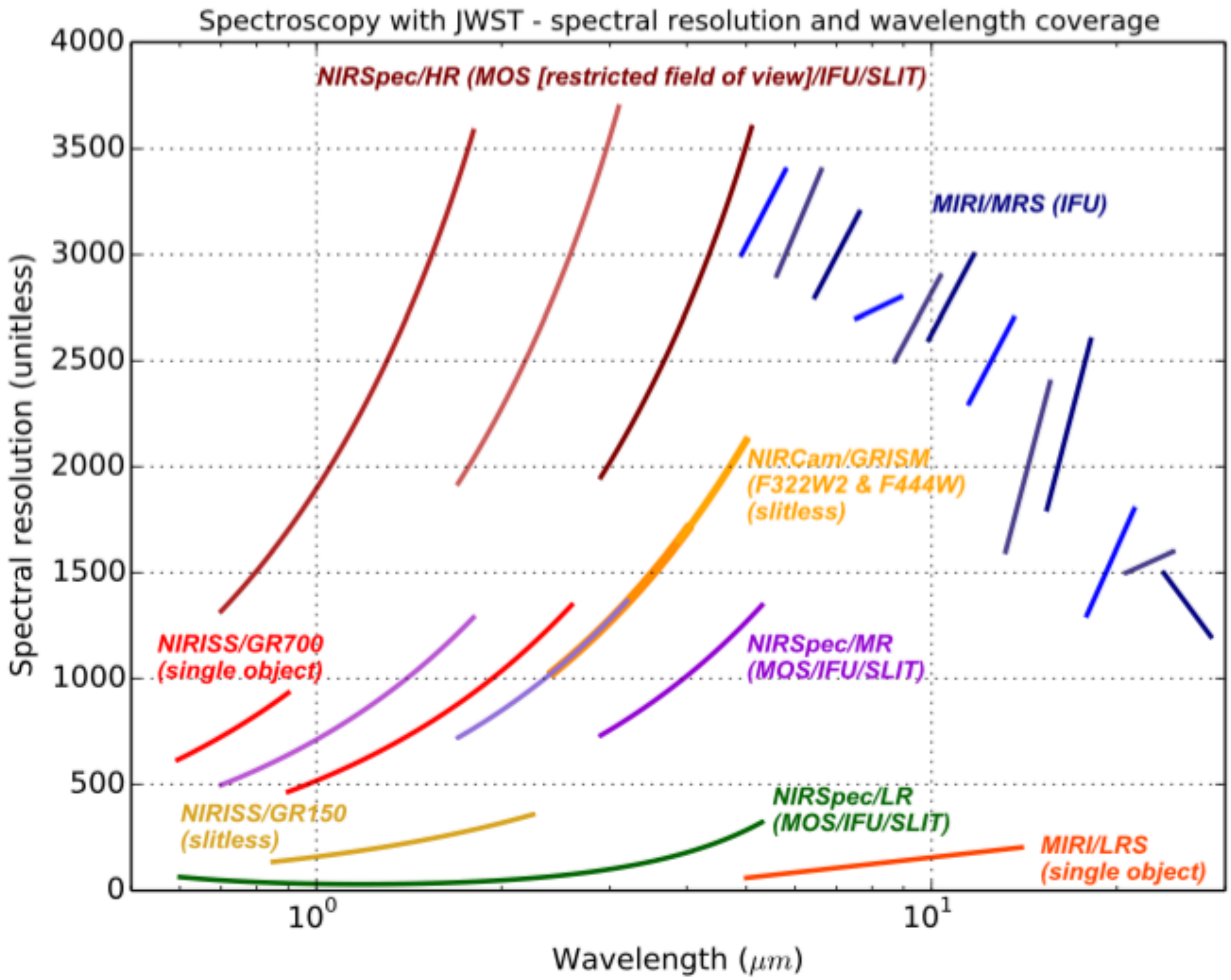


©JDox

A suit of imaging and spectroscopy modes

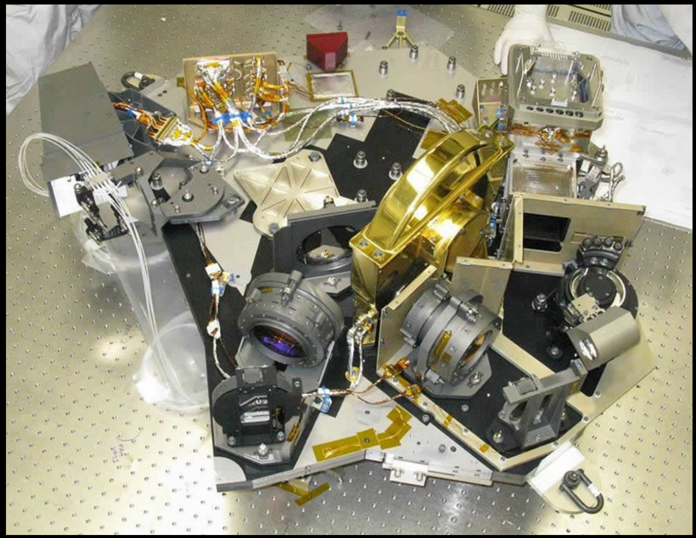


Spectroscopy comes in many flavors



©P. Ferruit

Outline

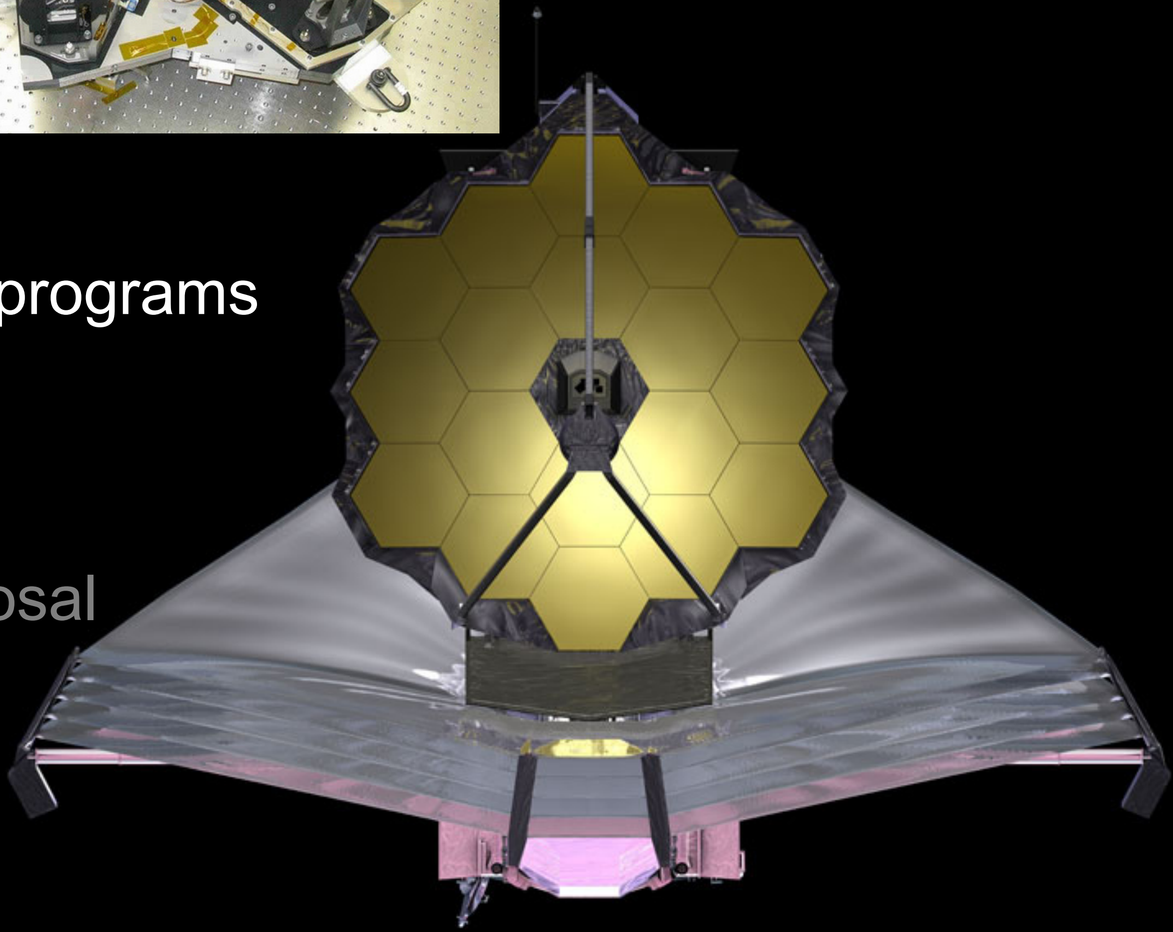


JWST primers

Instruments & science programs

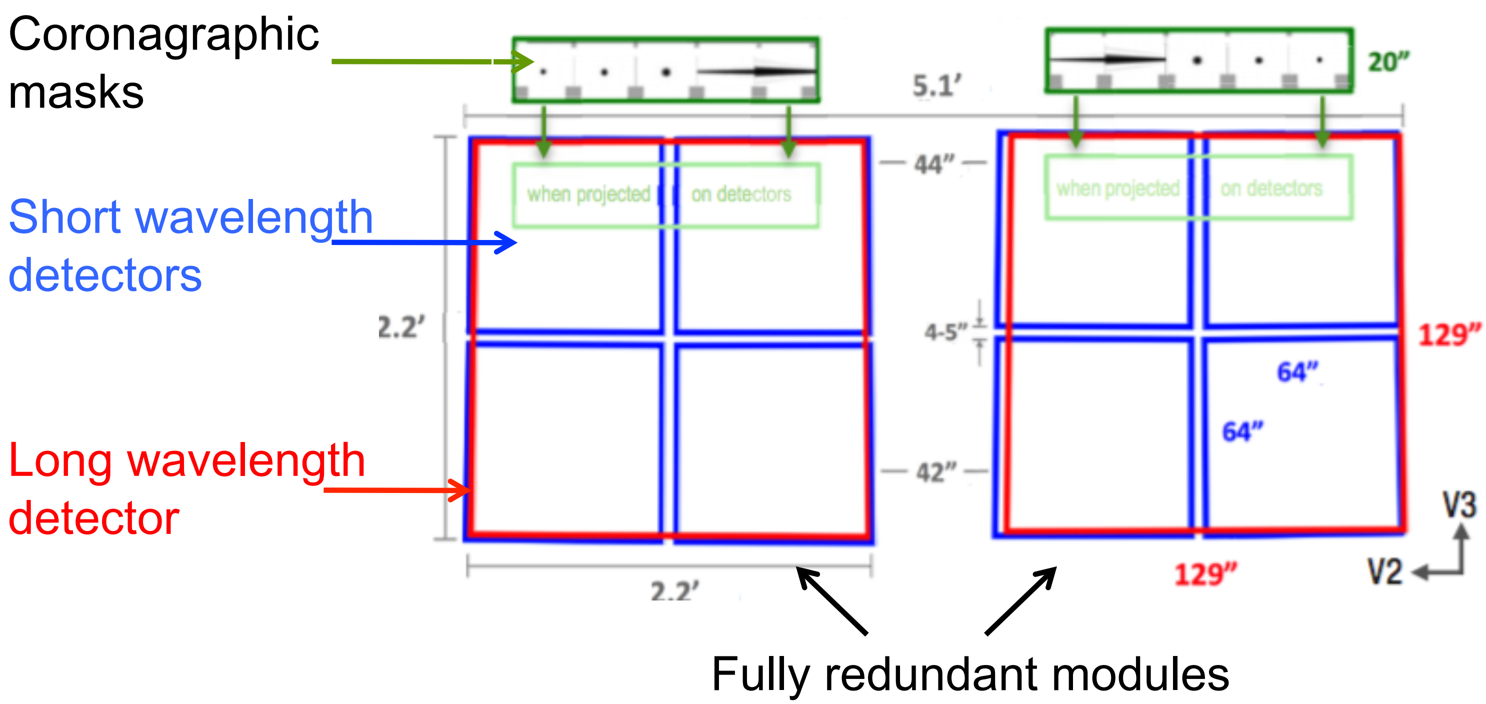
- NIRCAM

Towards a JWST proposal



NIRCAM: Imaging – Coronagraphy – Slitless spectroscopy

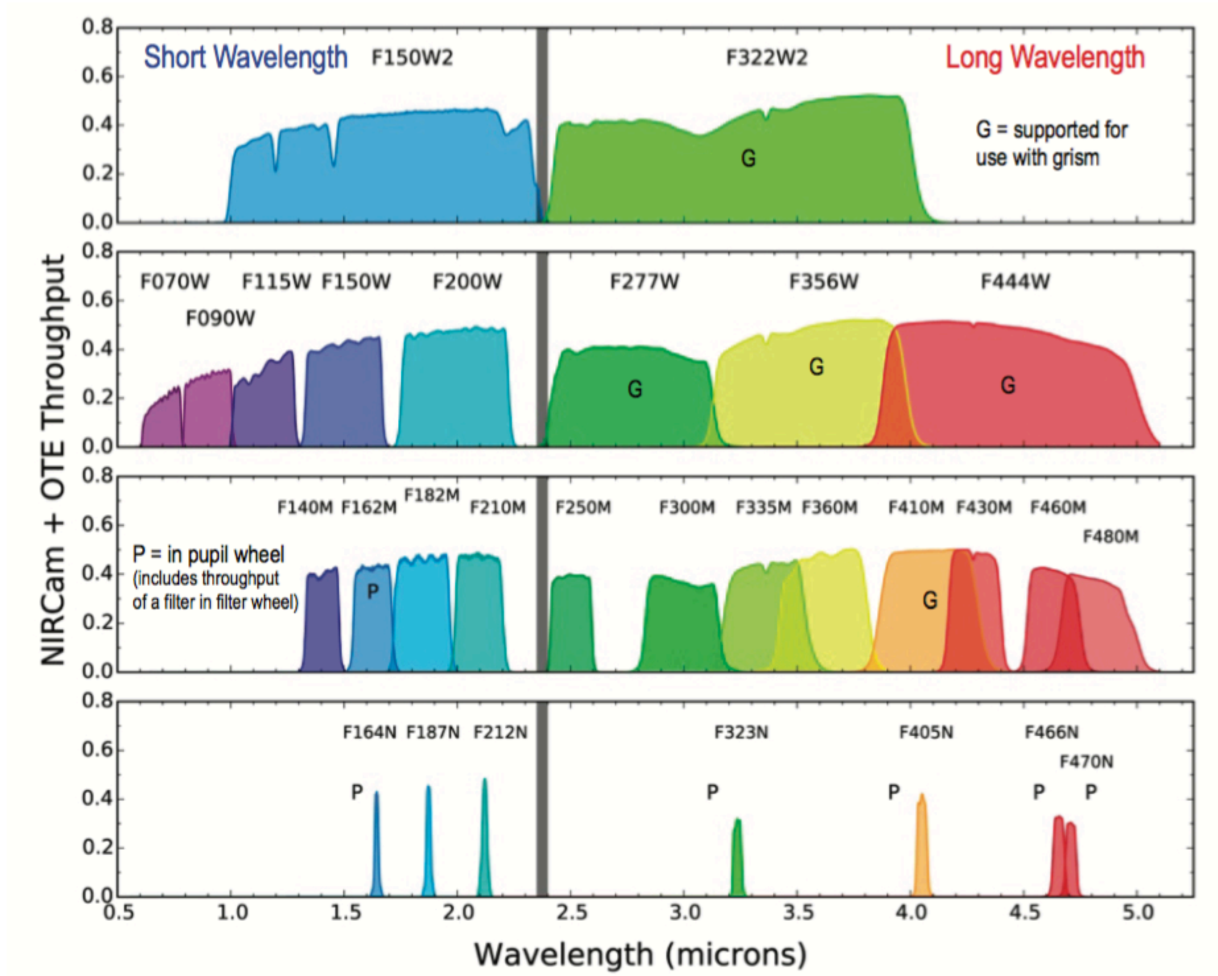
λ: 0.6-2.3 / 2.4-5.0 μm
Nyquist at 2.0 / 4 μm
Pixel scale : 32/65 mas.pix^{-1}



NIRCAM Wide, Medium & Narrow band filters

Imaging saturation
K ~ 8-9.5 mag

Imaging sensitivity
(SNR 10 in 10ks)
~10-21 nJy



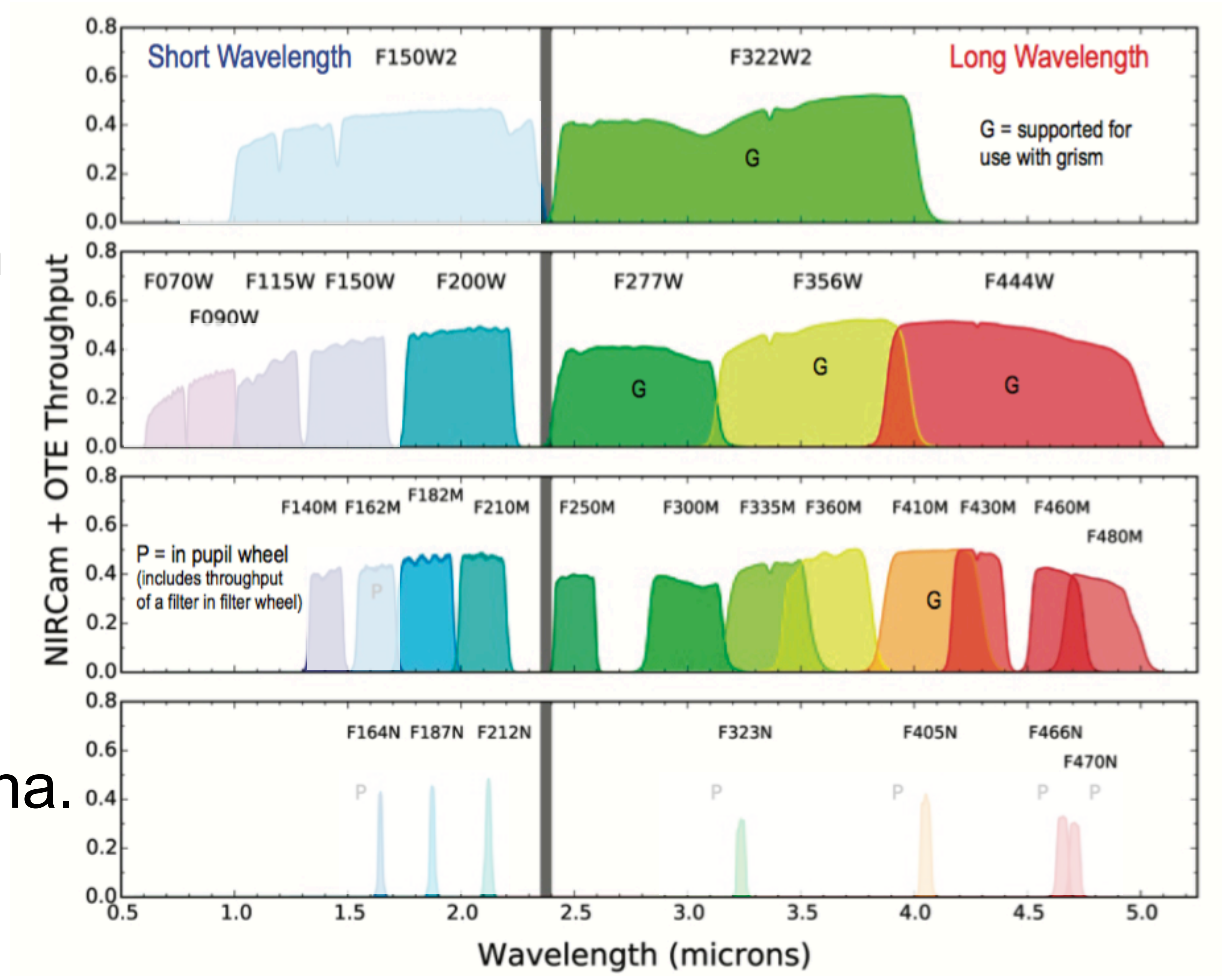
©JDox

NIRCAM Medium & Narrow band filters isolate spectral features

Imaging saturation
K ~ 8-9.5 mag

Imaging sensitivity
(SNR 10 in 10ks)
~10-21 nJy

Unvailable in corona.



©JDox

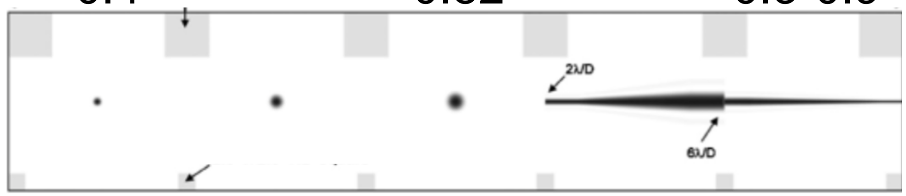
NIRCAM coronagraph performance

Lyot stops:
19% throughput

2.1 µm
0.4''

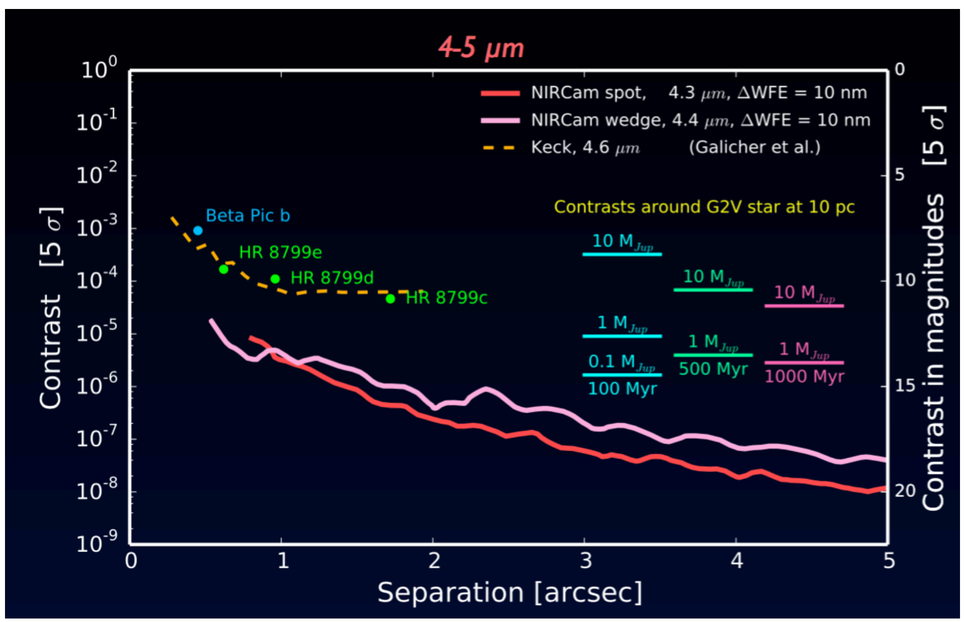
4.30 µm
0.82''

2-5 µm
0.3-0.9''



3.35 µm
0.64''

1-3 µm
0.13-0.4''

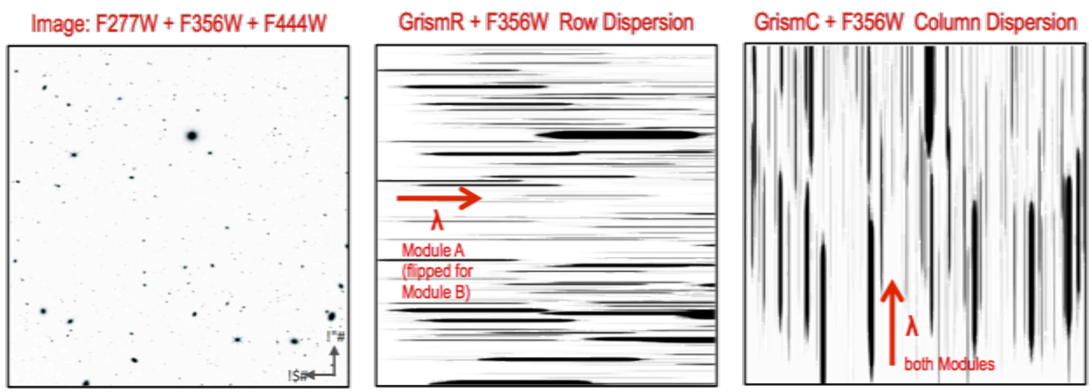


©C. Beichman

NIRCAM grism for Wide-Field (WFSS) and Single Objet Slitless Spectroscopy (SOSS)

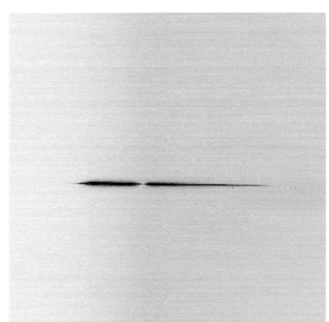
λ: 2.4-5.0 μm
Grism resolution: 1200-1550
Sensitivity (SNR 10 in 10ks) ~ 5×10^{-18} ergs/s/cm^2
Saturation limit K ~ 4mag

Wide field:

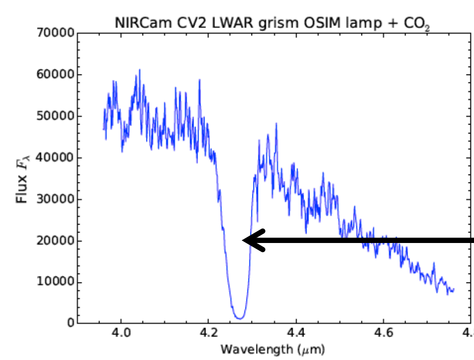


©JWST Pocket guide

Single object:



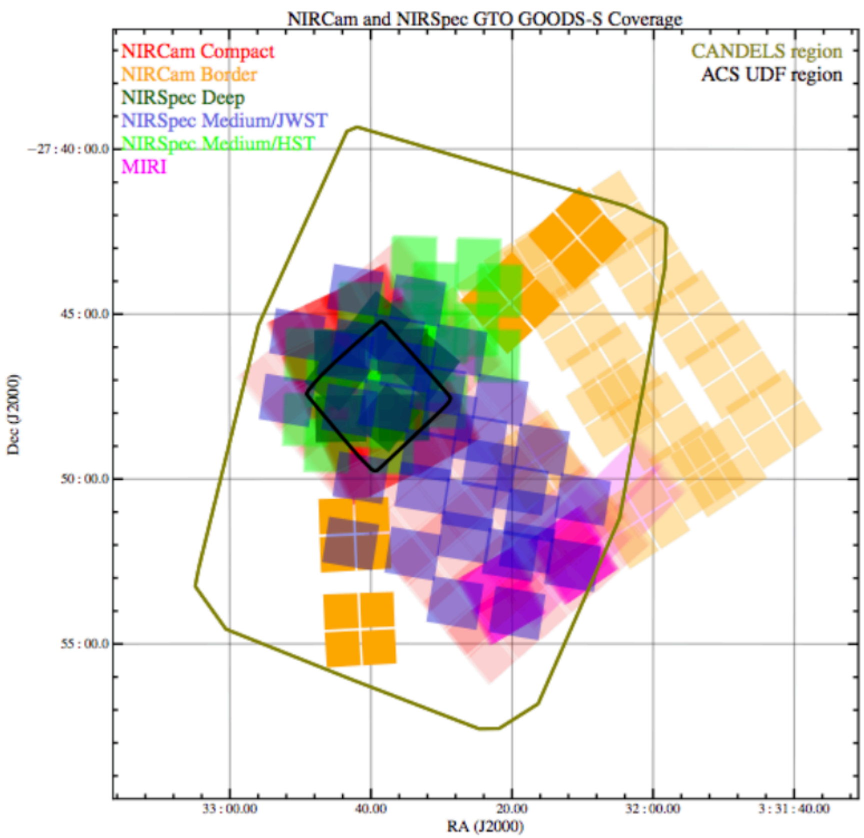
GrismR+F444W



Absorption by CO_2 From the testing lamp

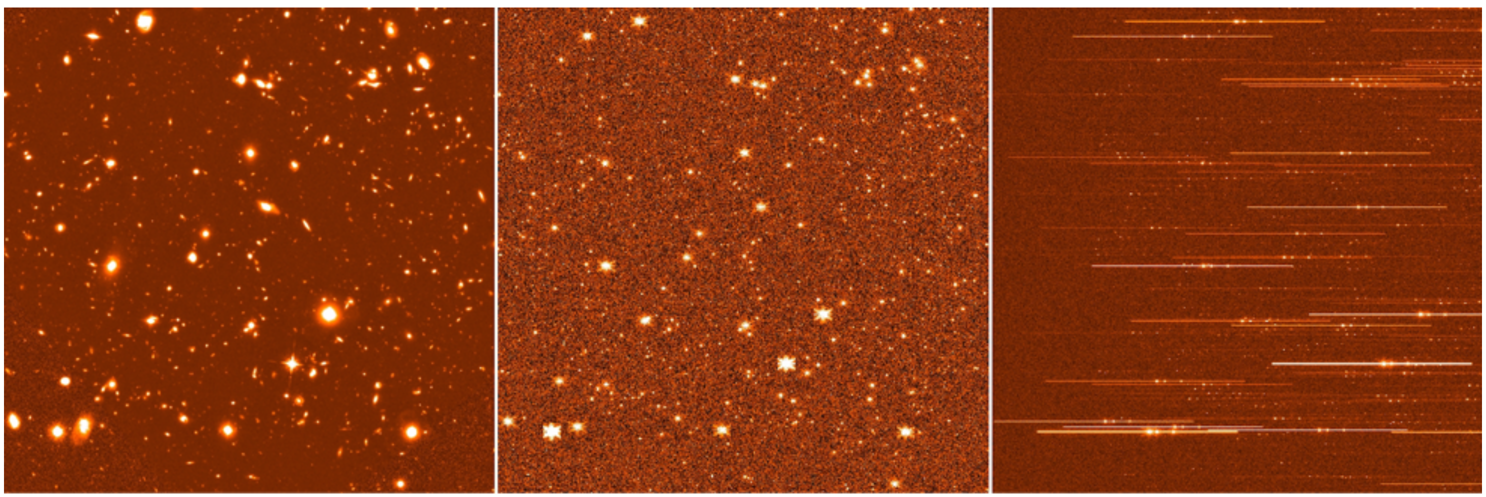
Science example: NIRCAM/NIRSpec/MIRI deep survey

Understanding galaxy evolution from z~12 to z~2



Science example: High-z galaxies with WFSS

Searching for high-z line emitters



Hubble XDF
WFC3 F160W
65 hrs

Imaging
F356M, 2 hrs

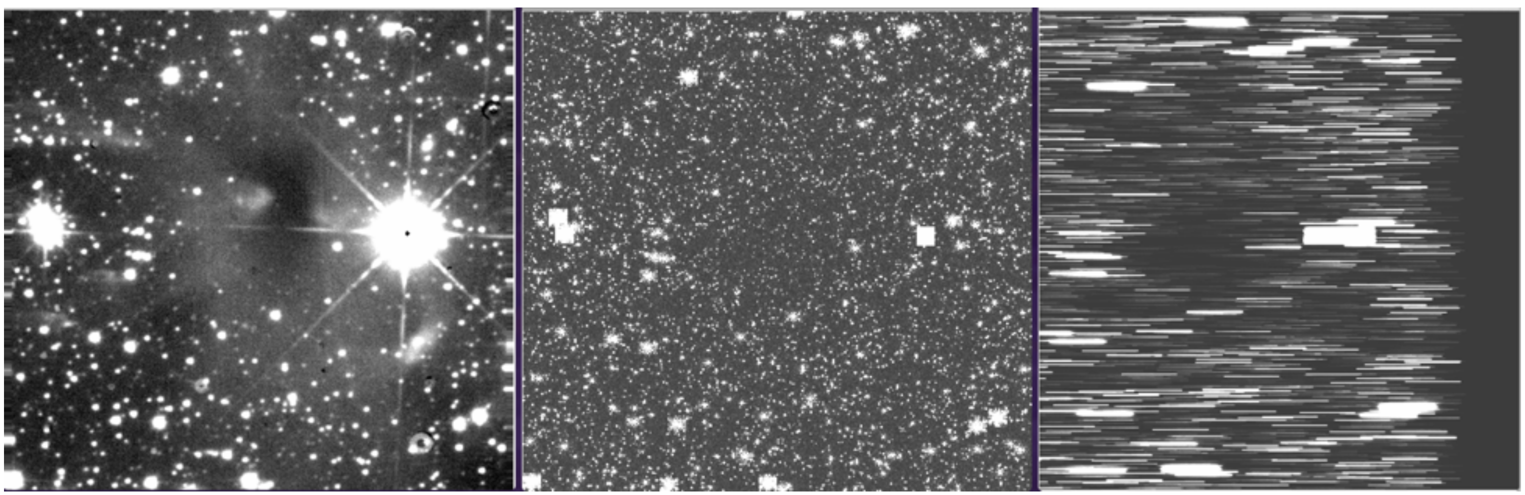
GrismR
F356M, 2 hrs

©E. Egami

Science example: NIRCAM WFSS to get colors of stars and extinction profiles in dense cores

Birth of Stars & Protoplanetary Syste

Probing grain composition in dark clouds



B335 Dark Cloud
K-band, 3.2 hrs
UKIRT

Imaging
F430M, 1sec

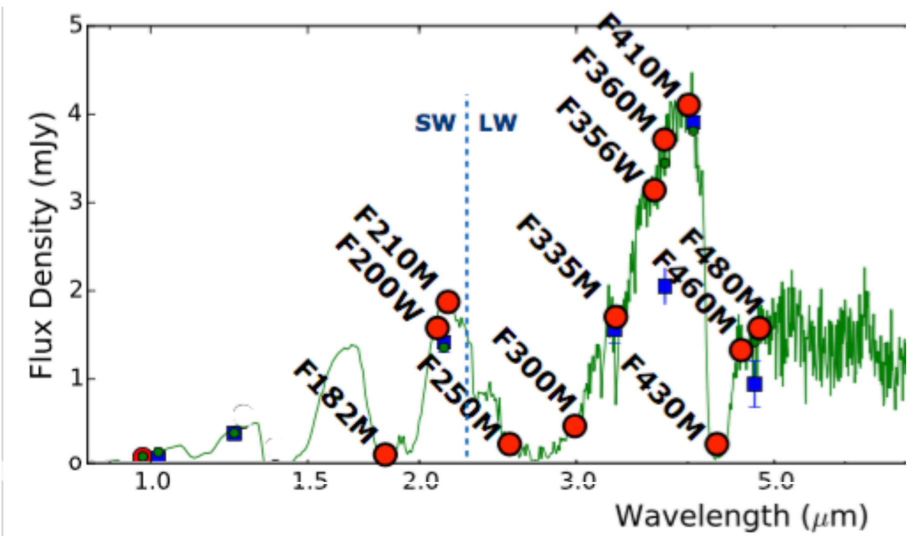
GrismR
F430M, 30s

©E. Egami

Science example: Characterizing brown-dwarf and exoplanet atmospheres

Planets & Origins of Life

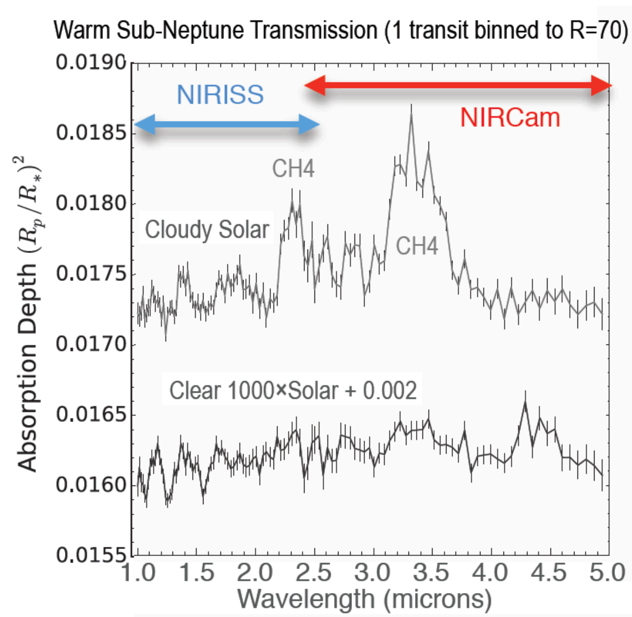
Self-luminous substellar objects



Model Teff=1000K, log(g)=3.5

©M. Perrin

Transit spectroscopy



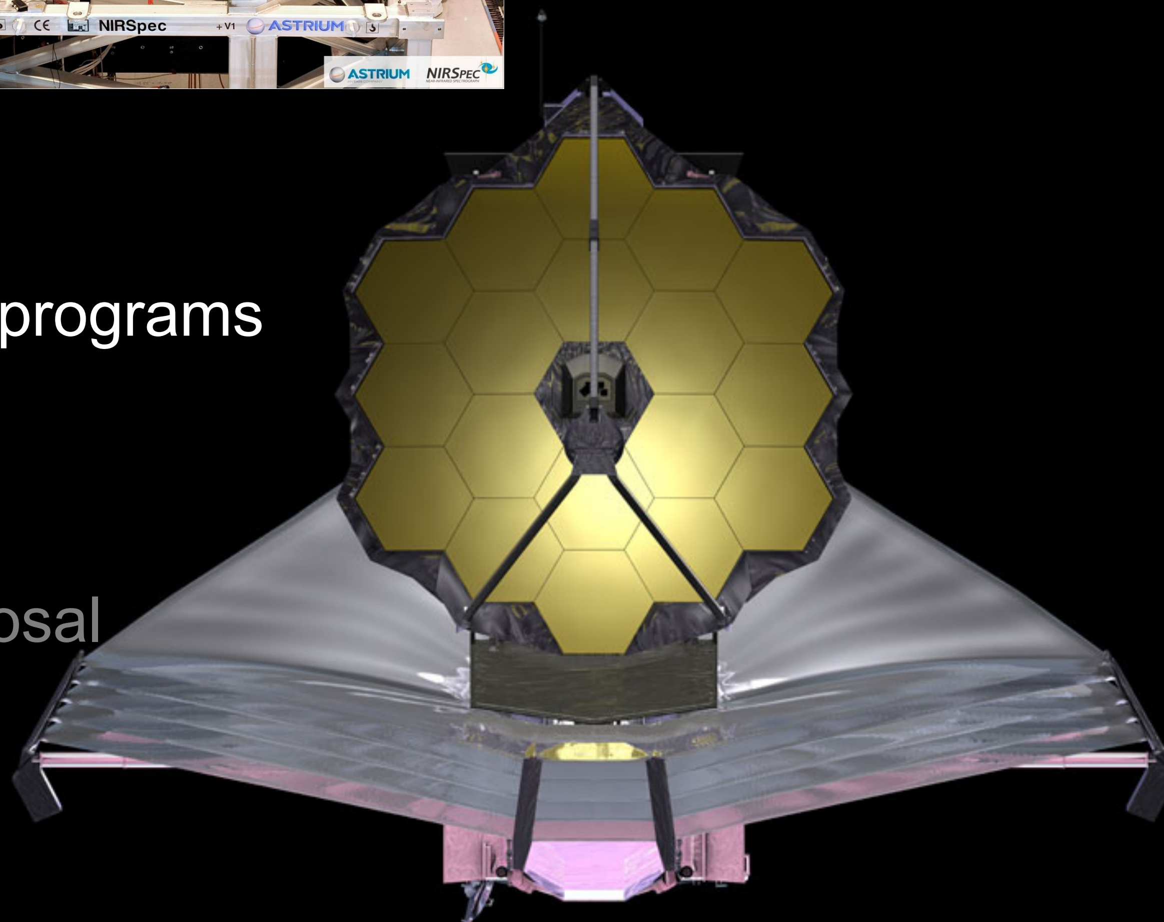
Outline

JWST primers

Instruments & science programs

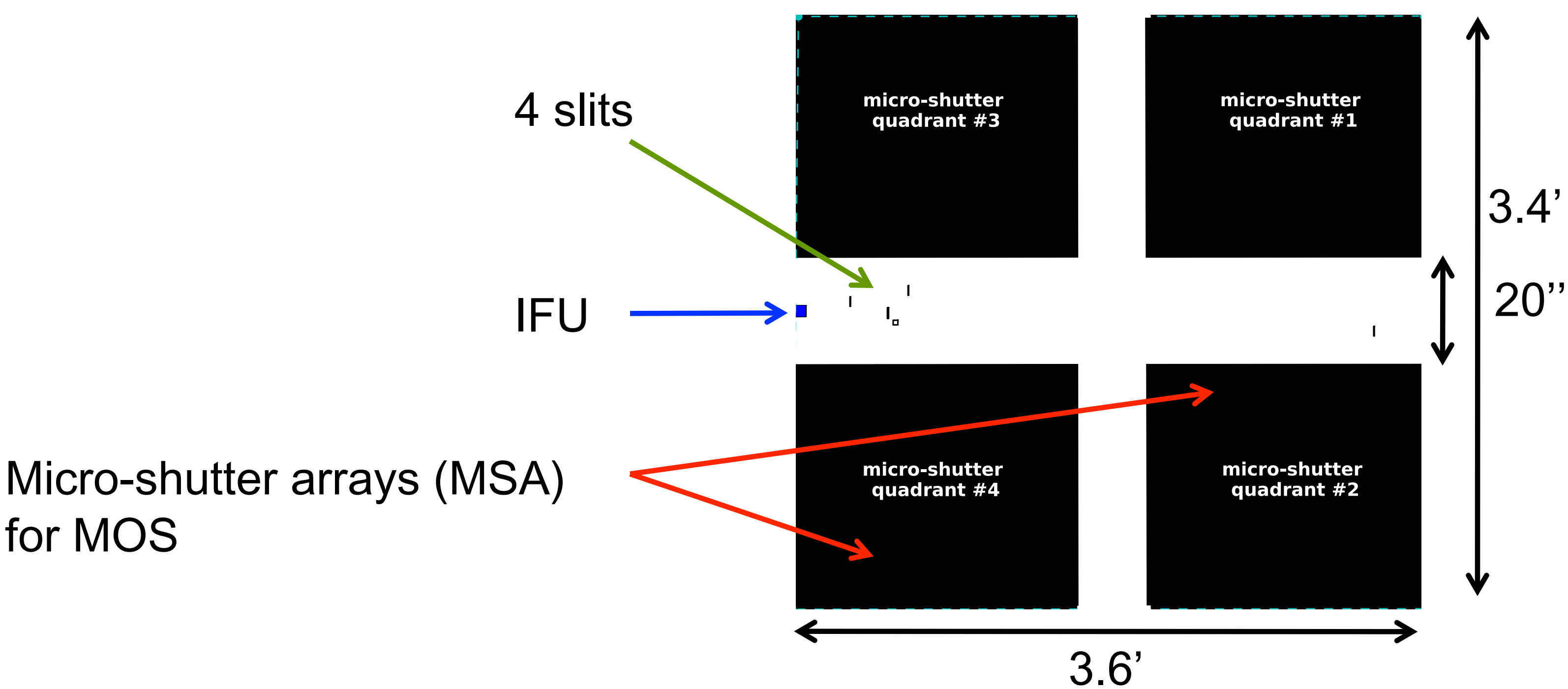
- NIRSpec

Towards a JWST proposal

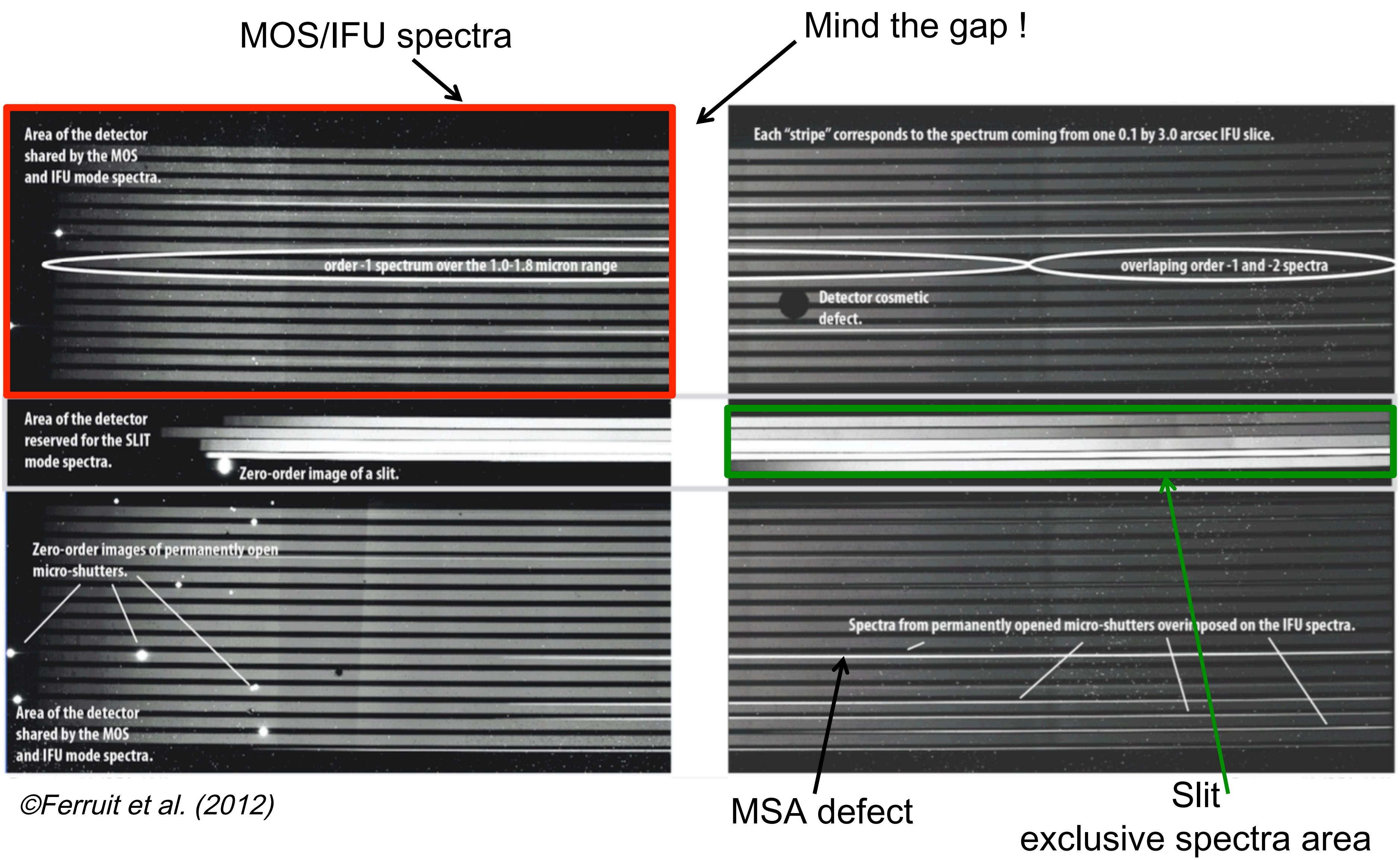


NIRSpec: all flavors of spectroscopy

λ: 0.6-5.3 μm
Resolution: ~ 100-2700
Pixel scale: 0.1'' pix^{-1}

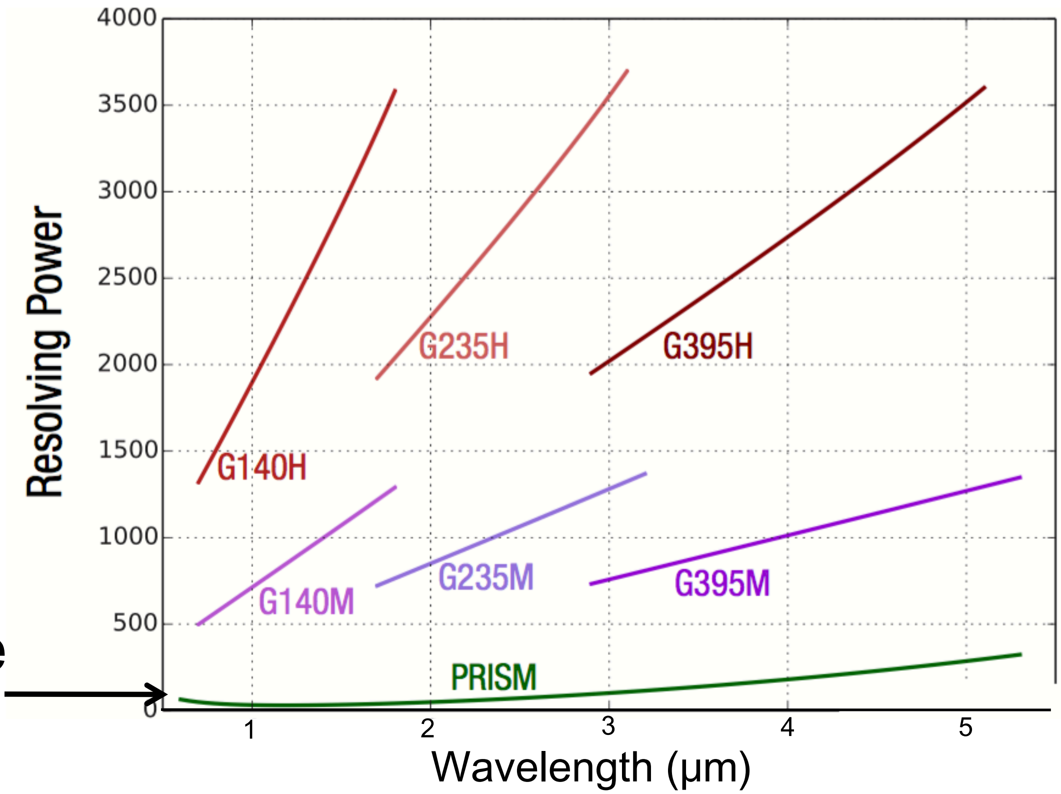


NIRSpec field-of-view layout



©Ferruit et al. (2012)

NIRSpec: high-resolution spectra will require multiple exposures



Full wavelength coverage at low resolution (R~100) in one shot

©JDox
Birkmann et al. (2012)

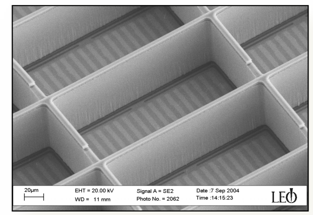
NIRSpec: MOS through the MSA to obtain spectra of mag~29 objects

250 000 micro shutters on a fixed grid

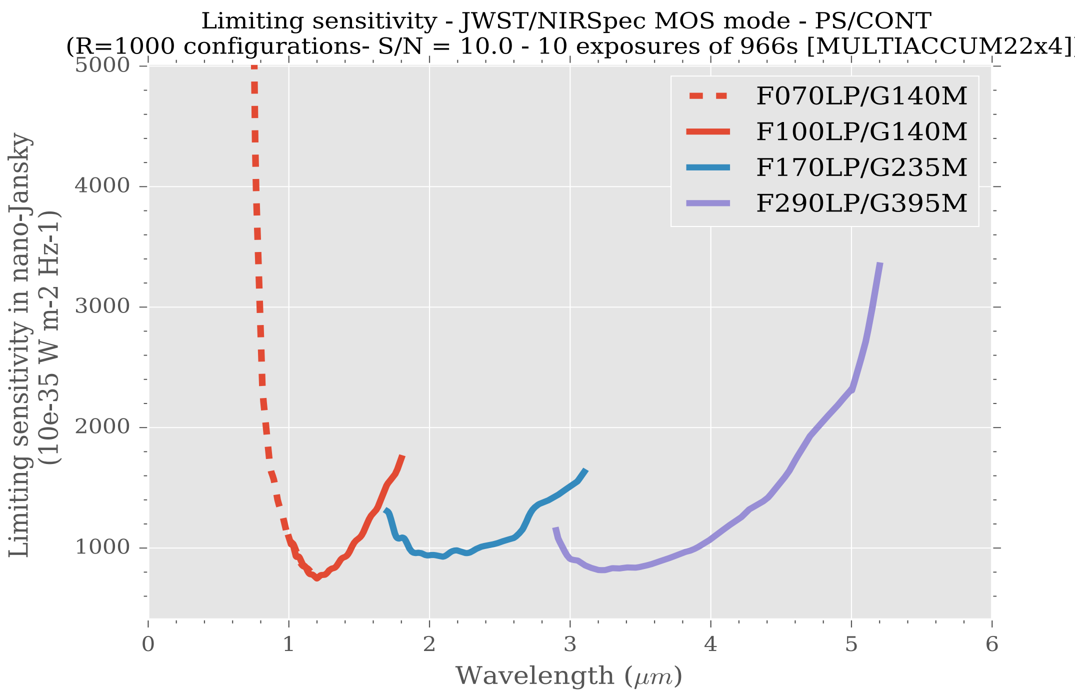
Micro-shutter FoV: 0.2’’x 0.46’’

FoV: 3.6’x3.4’

Need very accurate astrometry (5mas)

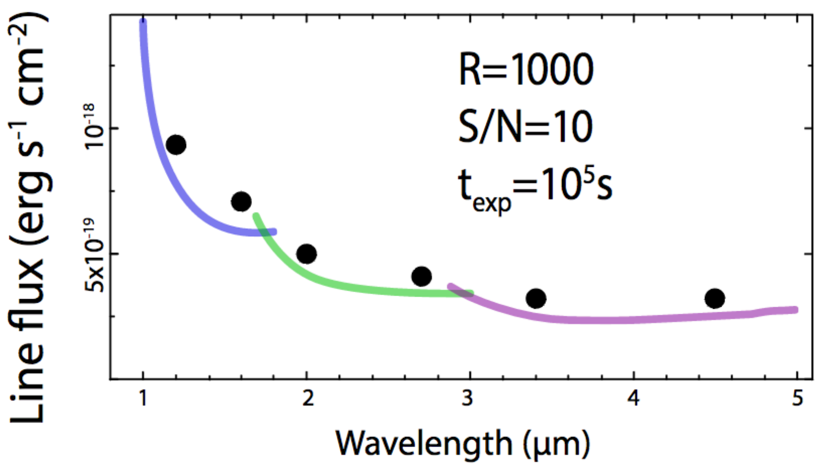


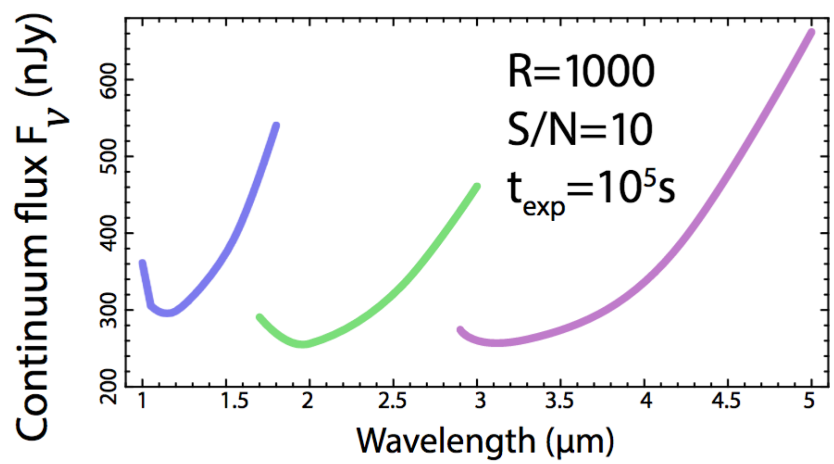
Point source at R=1000:



NIRSpec: IFS of extended/multiple sources

FoV: 3''x3''
Pixel scale: 0.1'' pix^{-1}
Saturation: J~5-7.5mag

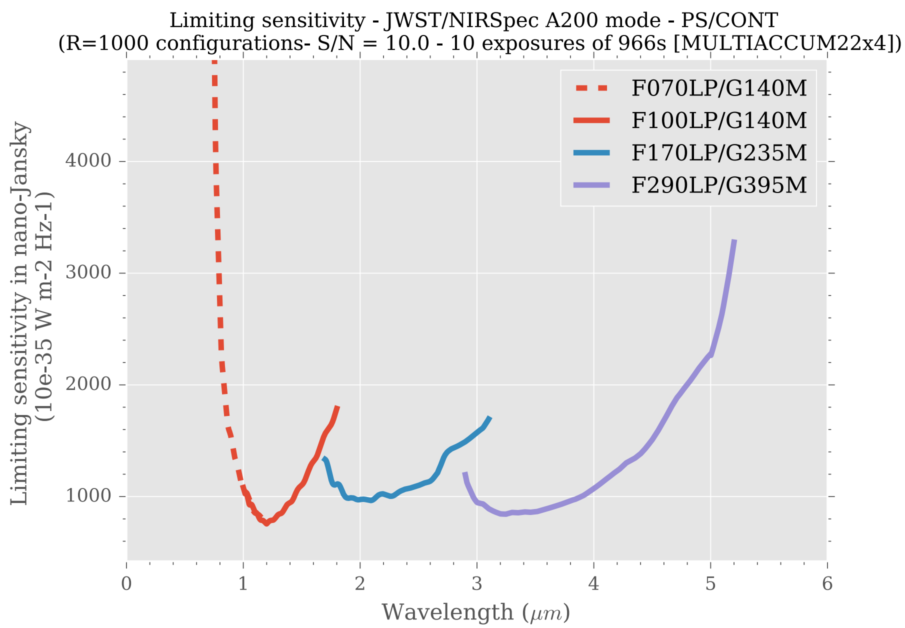




©JDox

NIRSpec: high-sensitivity single object spectroscopy with the 4 fixed slits

FoV: 0.2''x3.3''/0.4''x3.65''/1.6''x1.6''
Pixel scale: 0.1'' pix^{-1}
Sensitivity similar to MOS
Saturation limit: J~5-9.5 mag
Bright Object Time Series (BOTS) optimized for transits



©JDox

NIRSpec science example: Probing the chemical composition of Europa's and Enceladus' plumes

Planets & Origins of Life

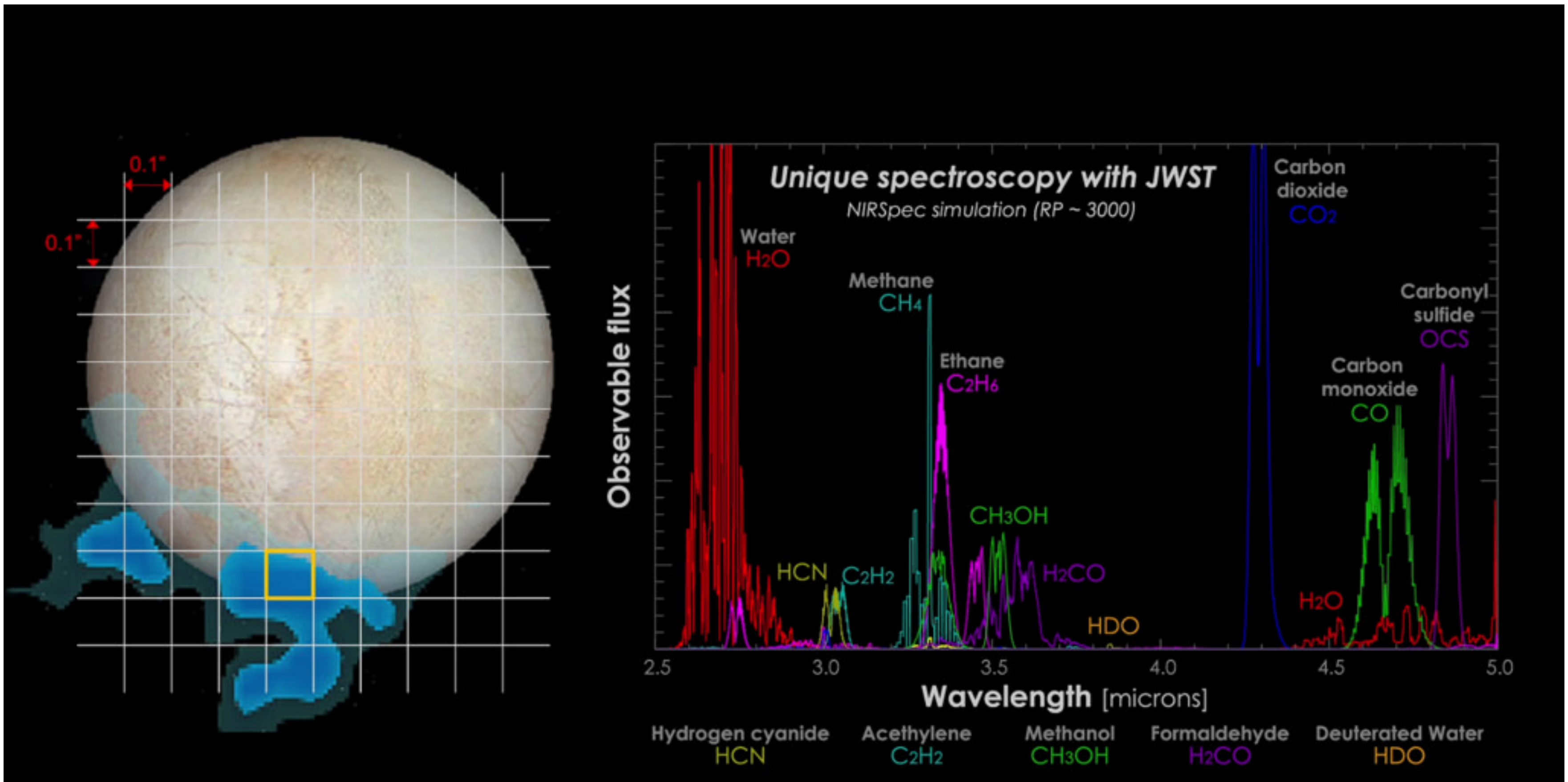
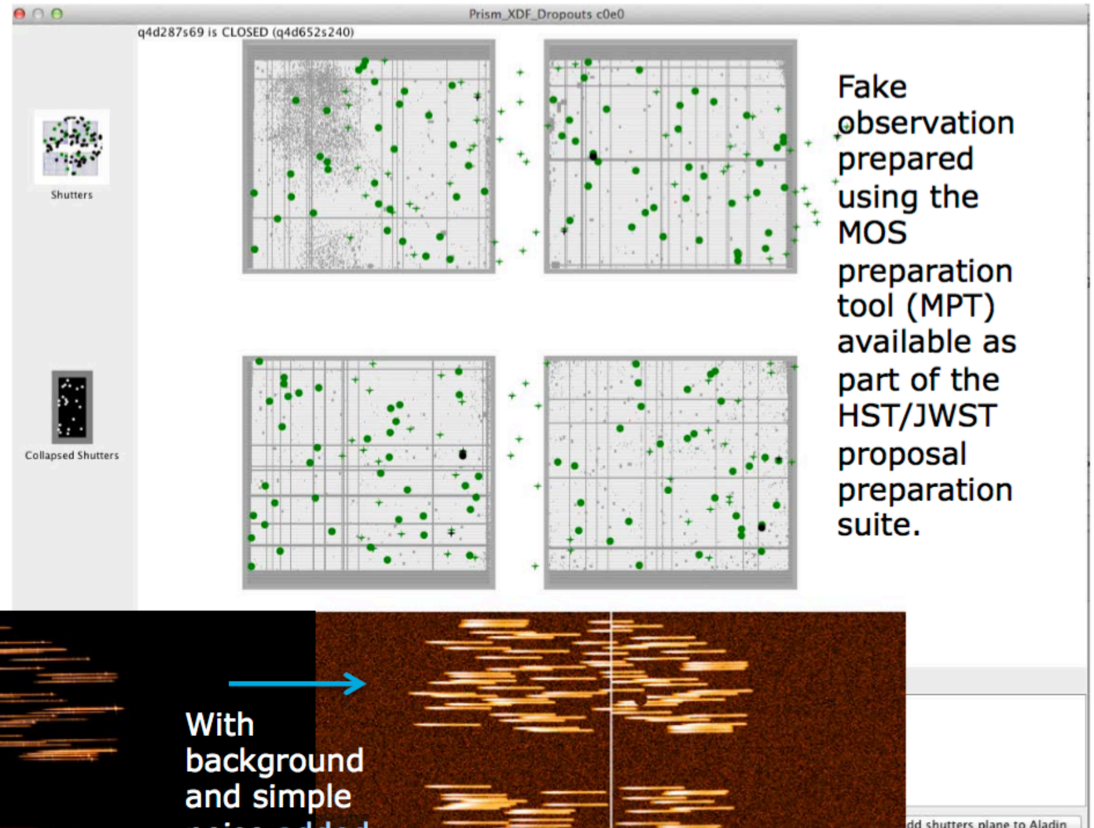


Image Credit: NASA-GSFC Stefanie Milam/Geronimo Villanueva

NIRSpec science example:

First Light & Reionization

Conceptual example on deep-field type of observation (tiled-version of a XDF drop-out catalog)

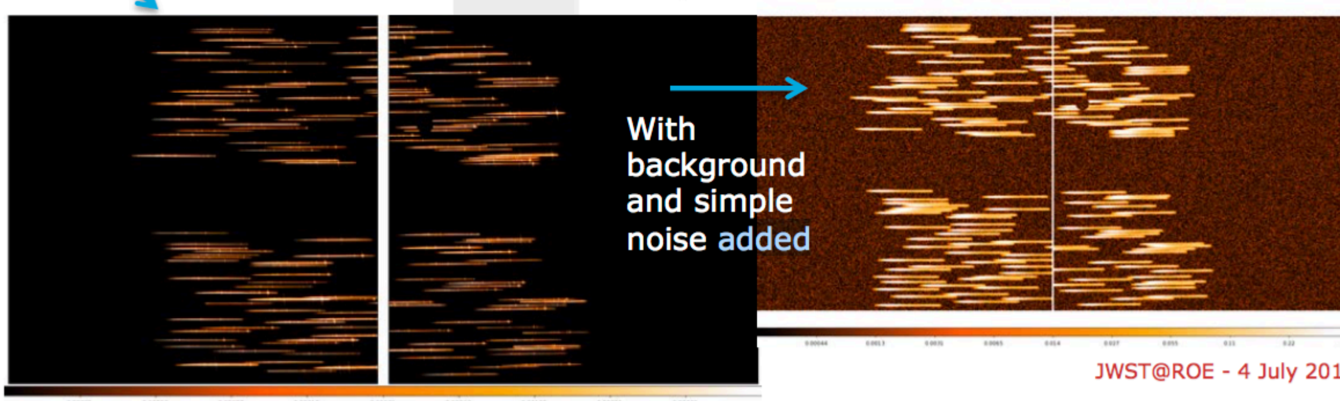


Fake observation prepared using the MOS preparation tool (MPT) available as part of the HST/JWST proposal preparation suite.

Spectra generated using BEAGLE (Chevallard & Charlot 2016)

Objects only, noiseless exposure.

CLEAR/PRISM (short spectra, high multiplex)



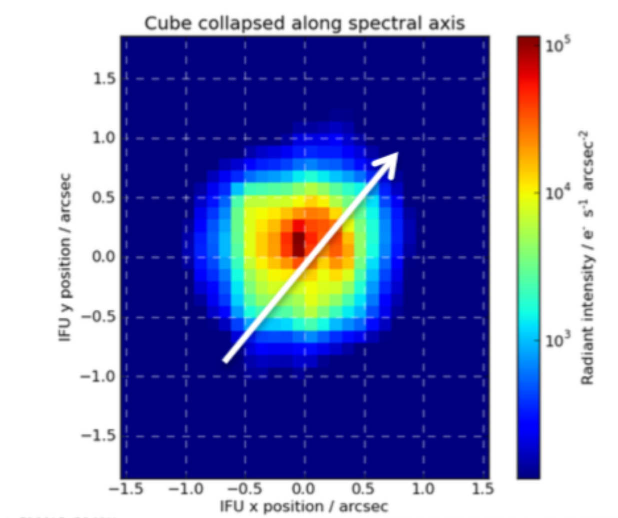
With background and simple noise added

European Space Agency

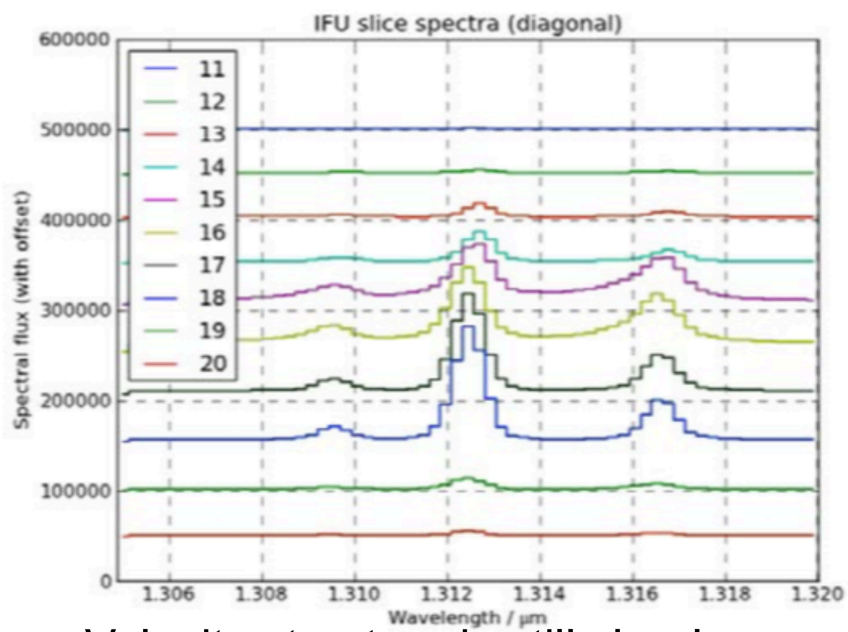
Slide courtesy of P. Ferruit

NIRSpec science example: Galaxy dynamics

IFU observations of nearby Luminous Infrared Galaxies (LIRGs) in the [NII]+Hα range



Using VIMOS [NII]+Ha data from Bellocchi et al. 2012 of a nearby galaxy.
redshifted to z=1



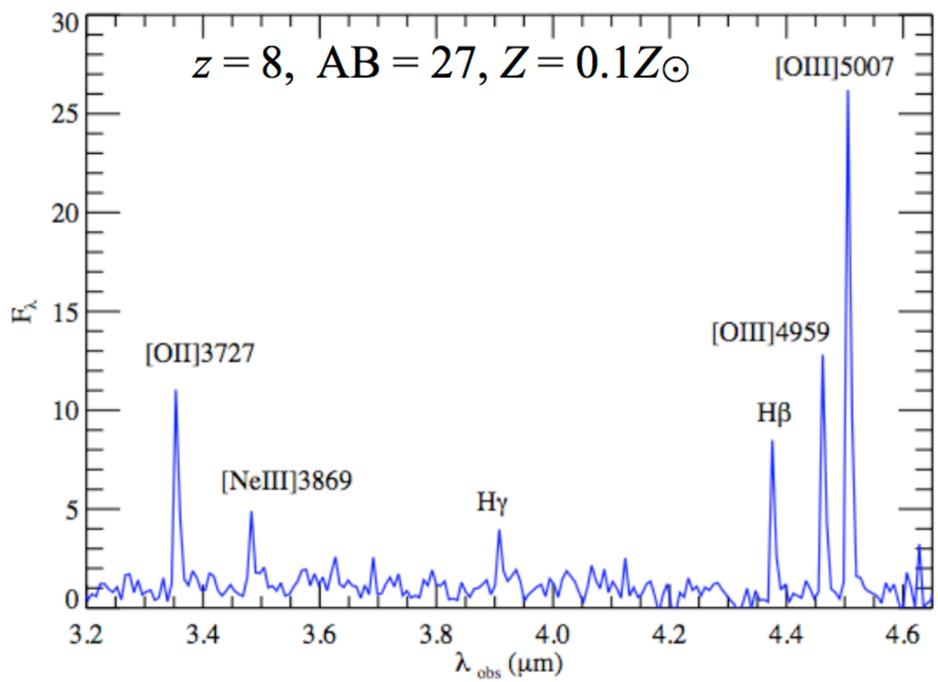
Velocity structure is still clearly visible as we progress diagonally through the cube.

©P. Ferruit.

Assembly of Galaxies

NIRSpec science example: Metal enrichment of distant galaxies

High quality spectra to measure line ratios



SLIT spectroscopy of z=8, AB=27 quasar

©Maiolino et al.

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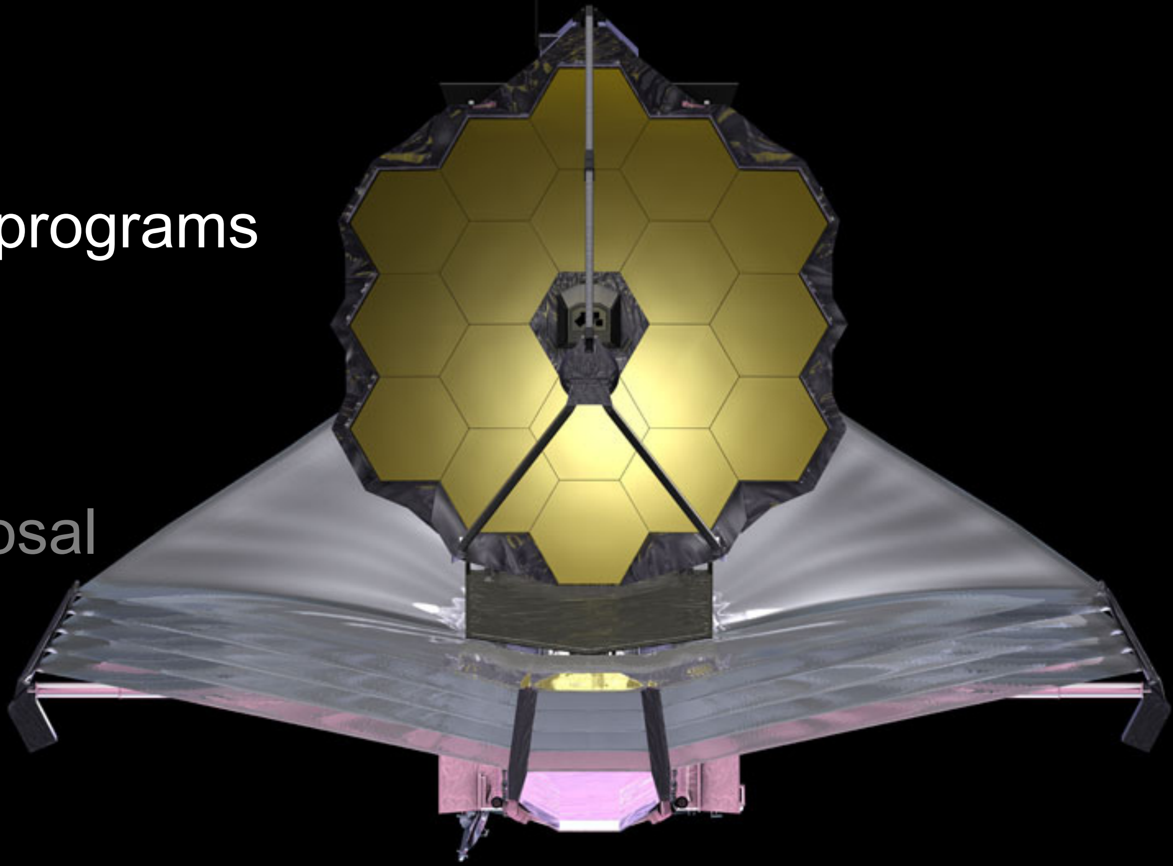
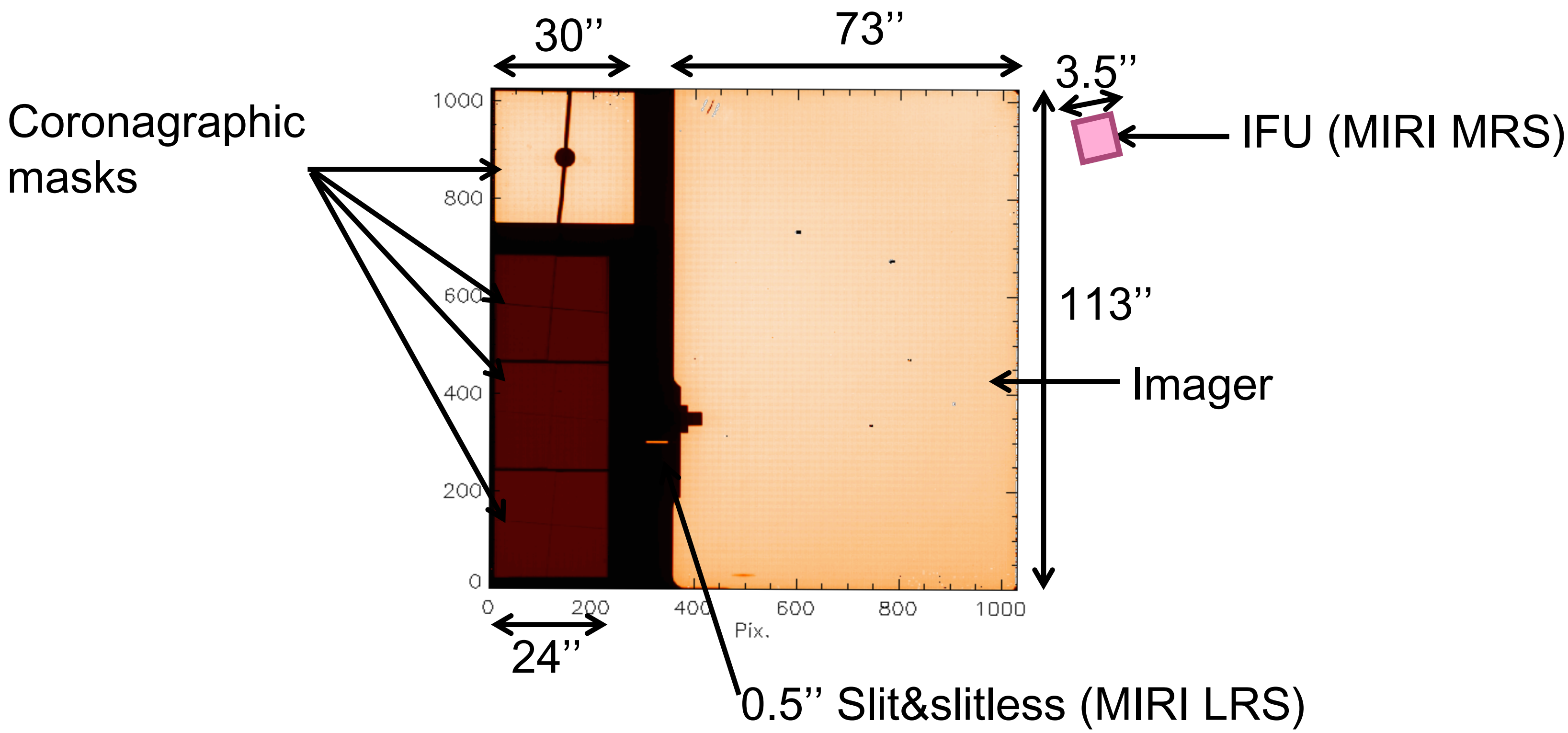
- MIRI



Towards a JWST proposal

MIRI: Imaging – Coronagraphy – Spectroscopy (slit, slitless, IFU)

λ: 5-28 μm
Nyquist at 7 μm
Pixel scale : 110 mas.pix^{-1}

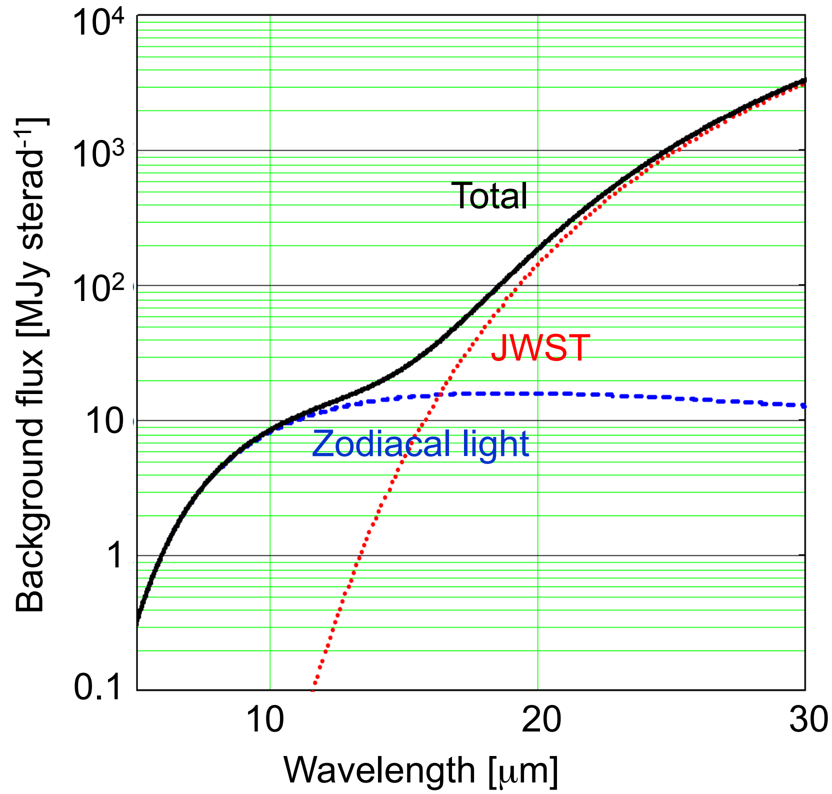


Lots of sky background with MIRI

FoV: 74''x133''
Pixel scale: 110mas.pix^{-1}
9 filters

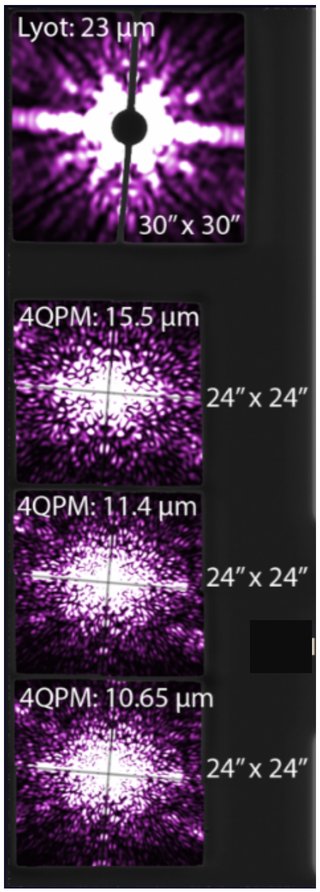
Saturation
~ 3 mJy (7.7µm)
to 105 mJy (25.5µm)

Point source sensitivity
(SNR 10 in 10ks)
~0.2-29 µJy



©Glasse et al. (2015)

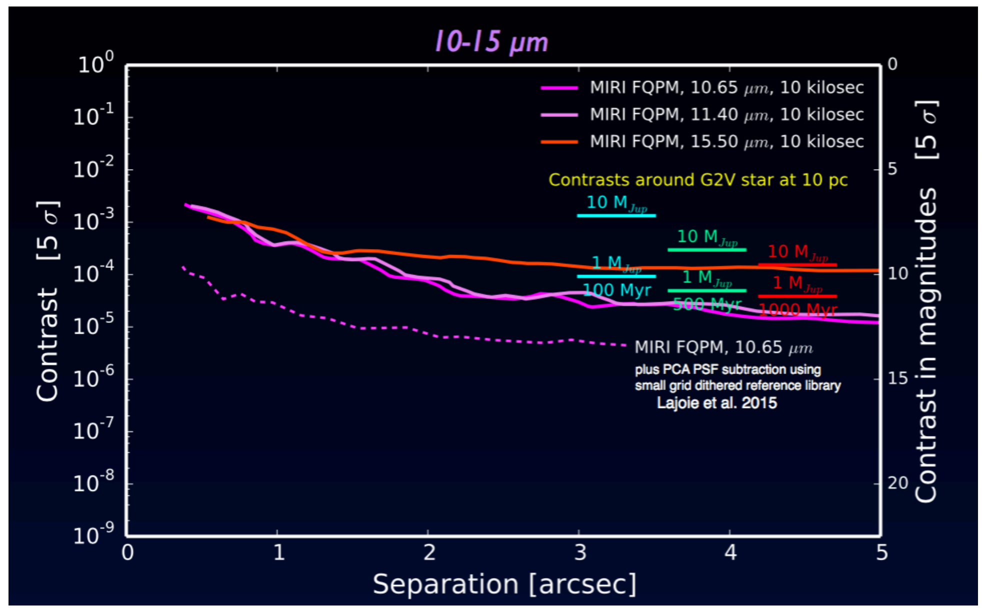
MIRI Coronagraphs



IWA 2.1''
C2300: continuum

IWA: 1 λ/D
Cont. (wide)

Cont./Si./PAHs
(narrow)
Ammonia
(narrow)



©C. Beichman

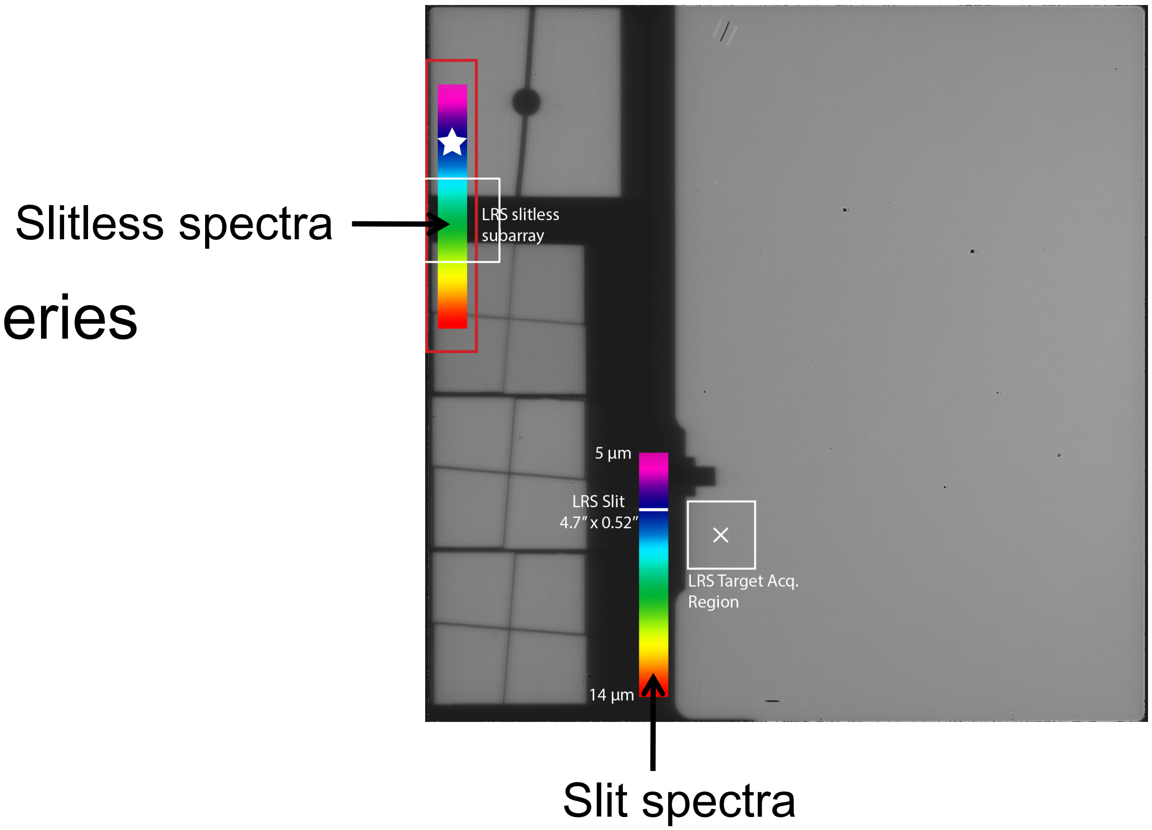
MIRI LRS (slit or slitless) from 5 to 12 µm

λ: 5-12 µm
FoV: 0.51''x4.7''
Resolution 100

Slitless mode for Time series (transits)

Saturation
~ 70 mJy (K~8mag, slit)
or 1220 MJy (slitless)

Continuum sensitivity
~ 8µJy (slit) or 18µJy (slitless)

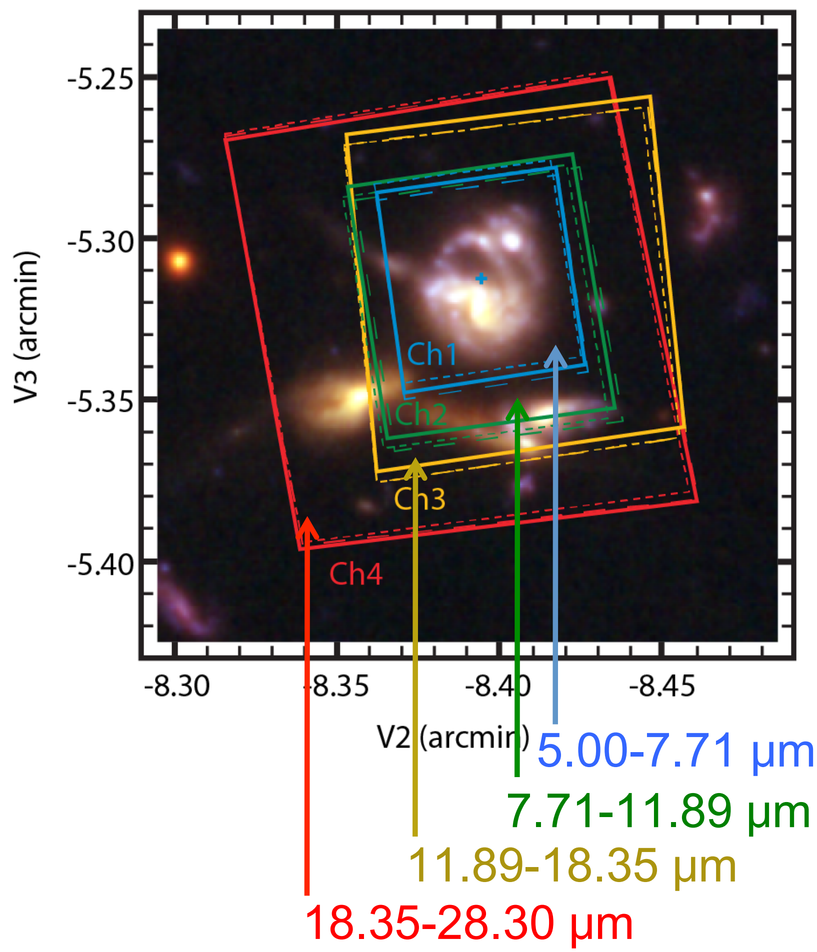


MIRI Medium Resolution Spectrometer (MRS) implemented as 4 IFUs

λ: 5-29 μm in 4 channels
FoV: 3.7''->7.7'' (concentric)
Resolution 1550-3250

Saturation
~ 4.6-31.2 mJy
(at 6.4-22.5μm)

Point source sensitivity
(SNR 10 in 10ks)
$0.5 \times 10^{-20} W.m^{-2}$

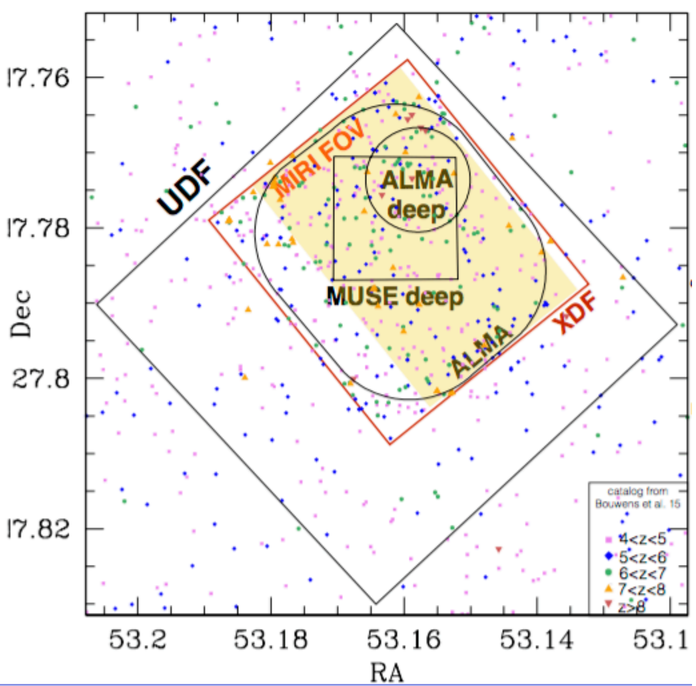


MIRI science example:
High-z (first light) galaxies

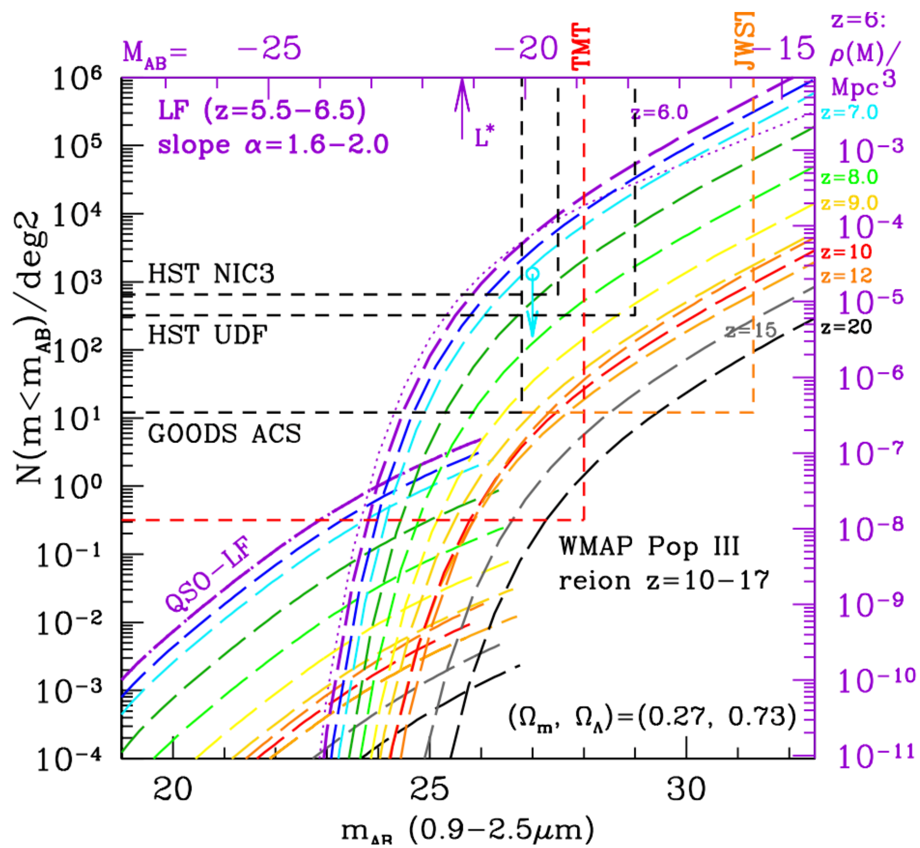
First Light & Reionization

Tracing the entire reionization epoch

Multi-band deep imaging



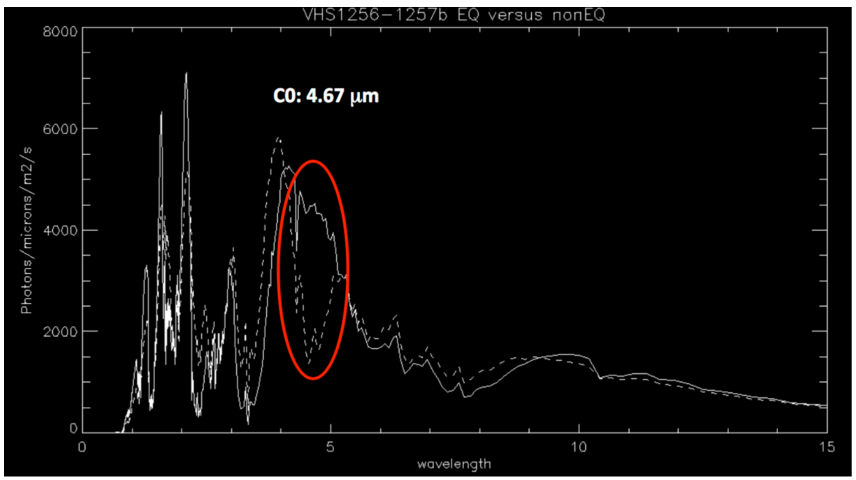
©F. Walter



©NASA

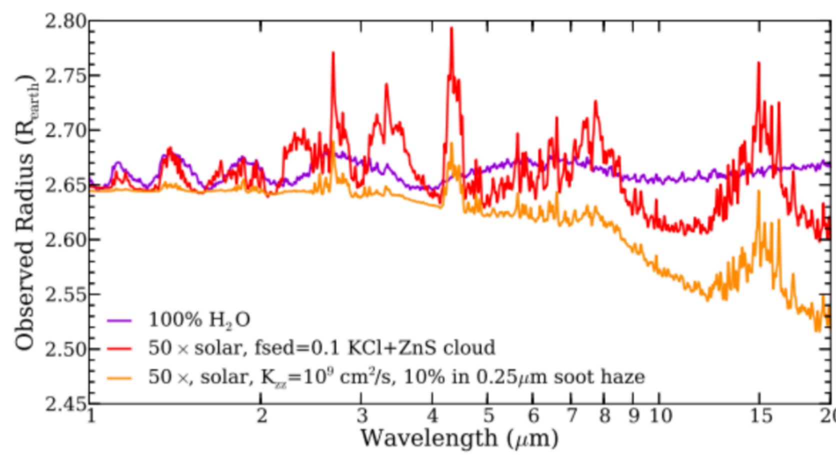
MIRI science example:
Opening an almost unexplored territory in atmospheric characterization

Self-luminous substellar objects



NIRSpec+MIRI LRS
VHS1256b

Transit spectroscopy



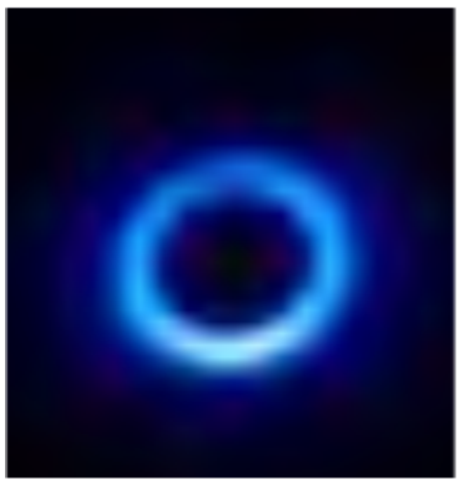
NIRSpec+MIRI LRS
Earth-like planet

Morley et al. (2013)

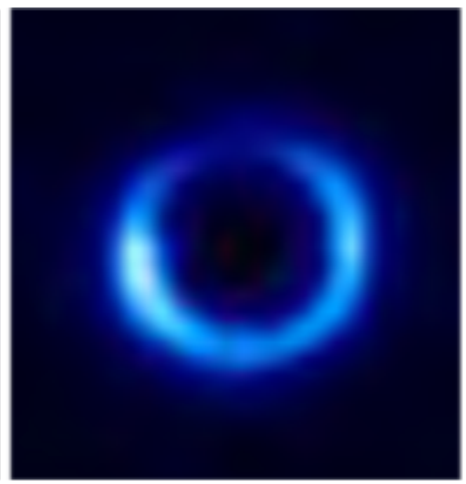
Birth of Stars &
Protoplanetary Syste

MIRI science example: Circumstellar disks

Probing colors, albedo, phase, grain compositions



HD 181327
4QPM+F1140C



Lyot+F2300C

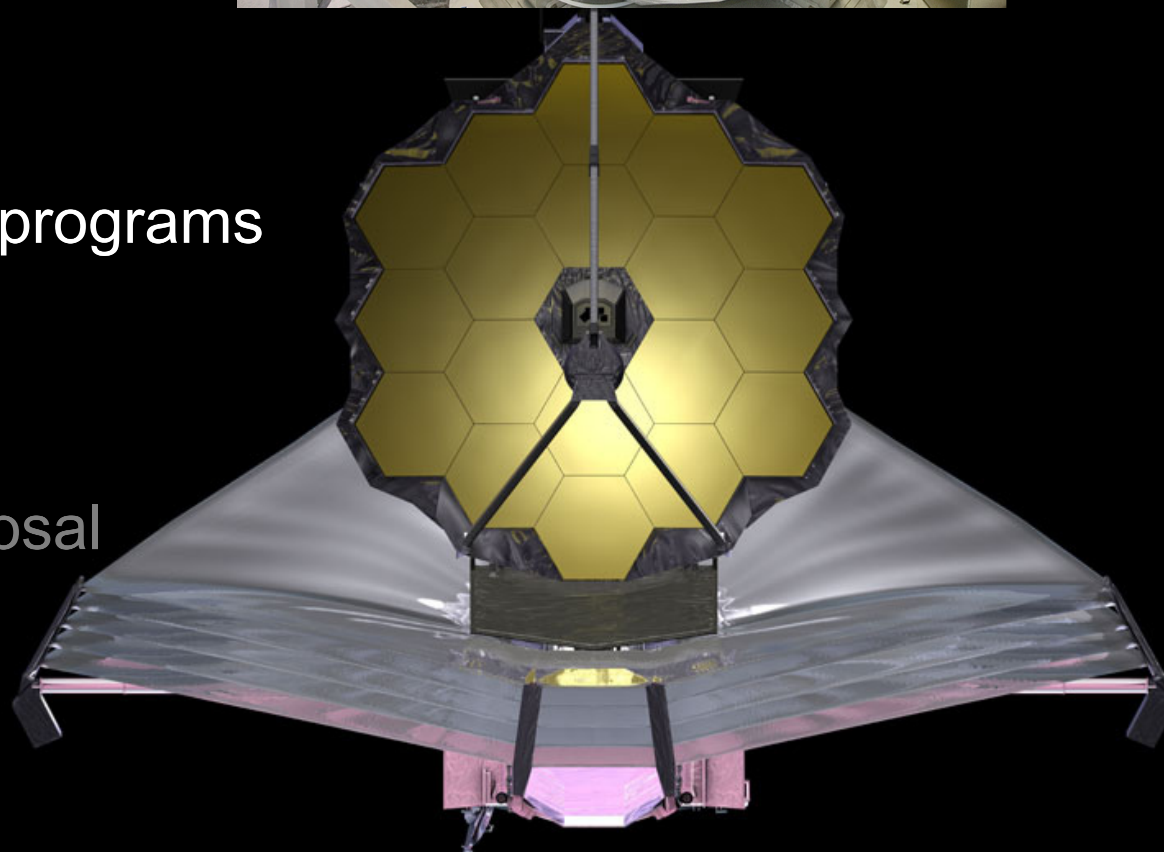
©Boccaletti

Outline

JWST primers

Instruments & science programs
- NIRISS

Towards a JWST proposal



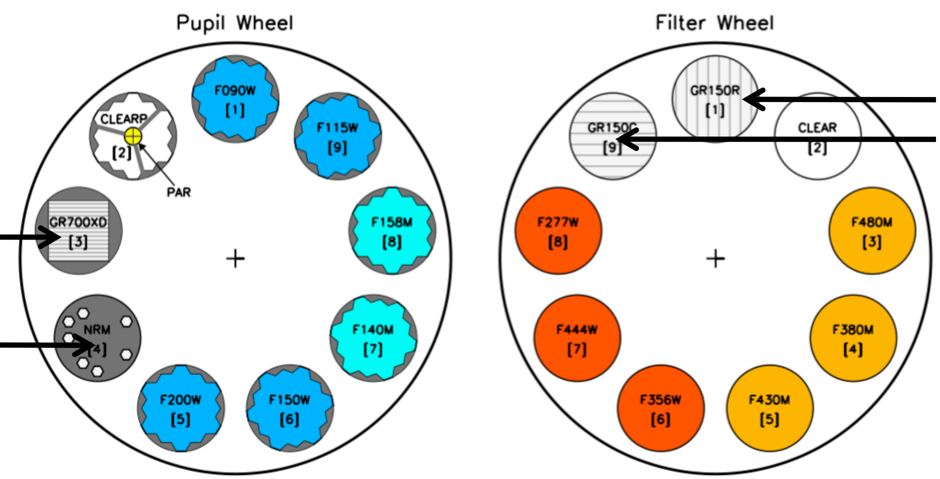
NIRISS: Imaging – Interferometry – Slitless spectroscopy

λ: 0.6-5.0 μm
Nyquist at 4.0 μm
Pixel scale : 65mas.pix^{-1}
Field of view: 2.2'x2.2'

Same specfications as NIRCAM's long wavelength channel

GRISM for Single-Object Slitless Spectroscopy (SOSS)

Non-Redundant Mask (AMI)

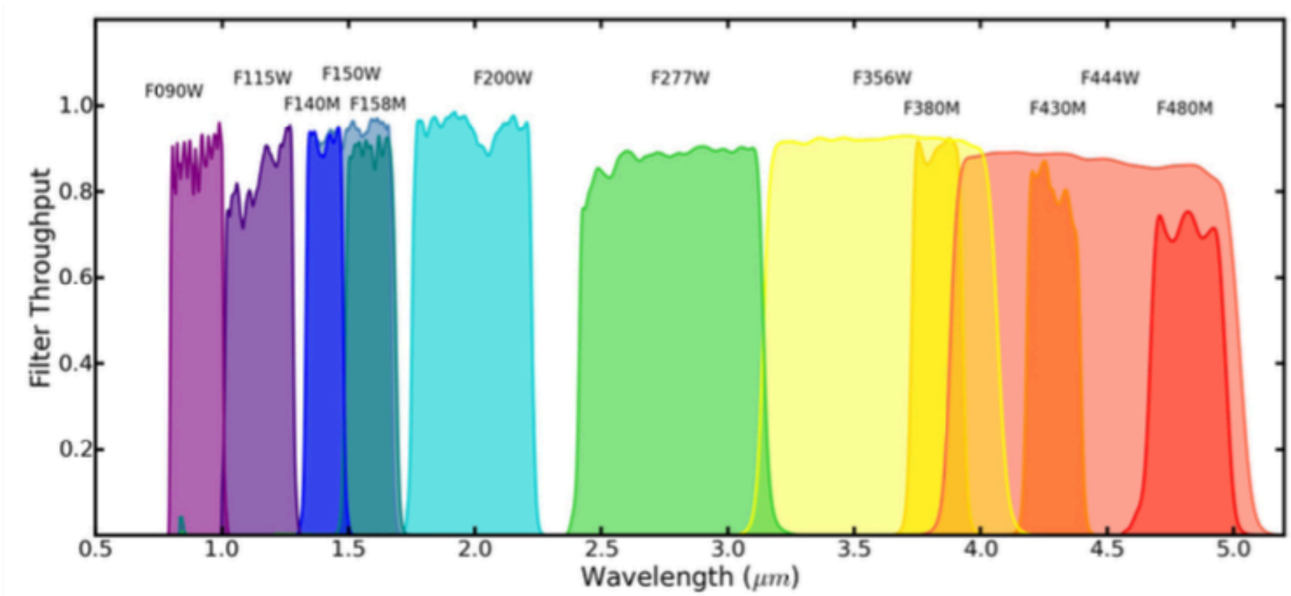


Two orthogonal grisms for Wide Field Slitless Spectroscopy (WFSS)

NIRISS imaging is accessible in parallel mode

Field of view: 2.2’x2.2’
Support for AMI / WFSS observations
Extra field in parallel with NIRCAM

All filters available for parallel imaging

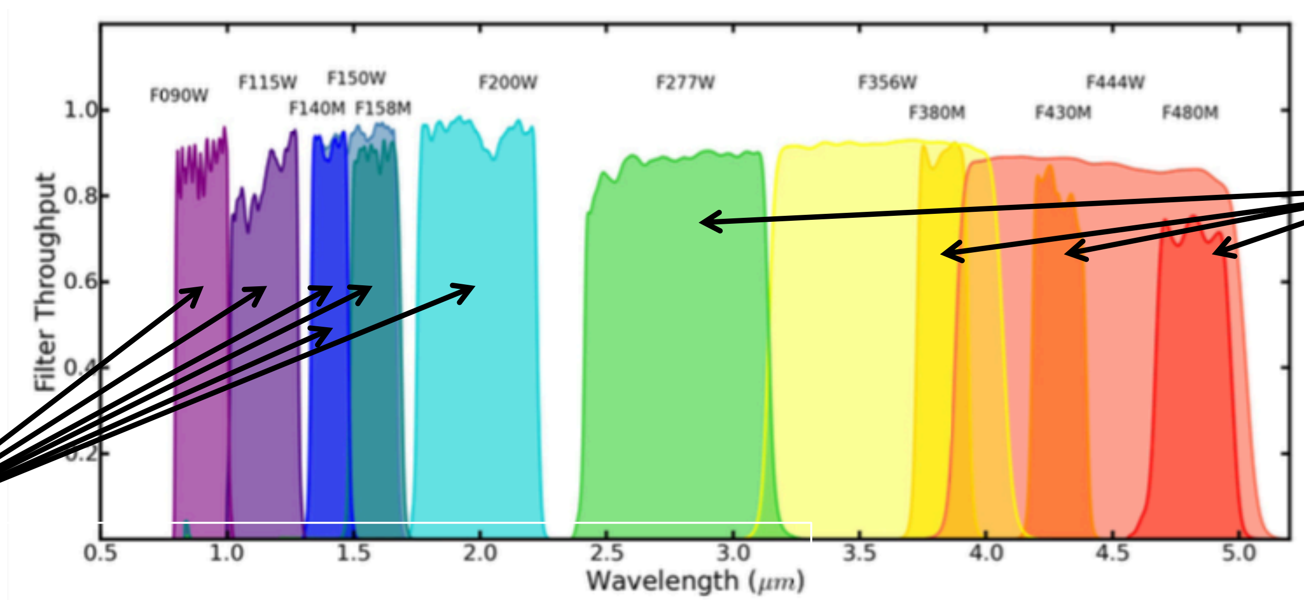


©JDox

NIRISS imaging is a support or backup mode

Field of view: 2.2’’x2.2’’
Support for AMI / WFSS observations
Extra field in parallel with NIRCAM

All filters available for parallel imaging



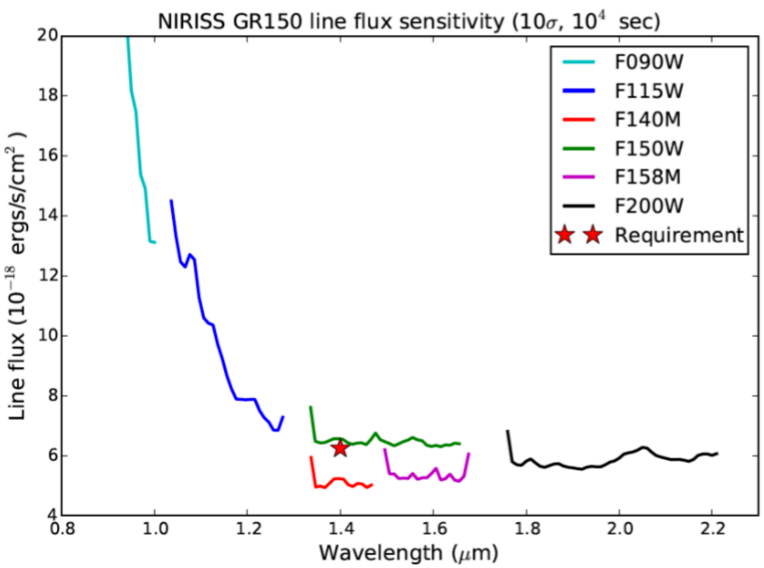
Available for AMI

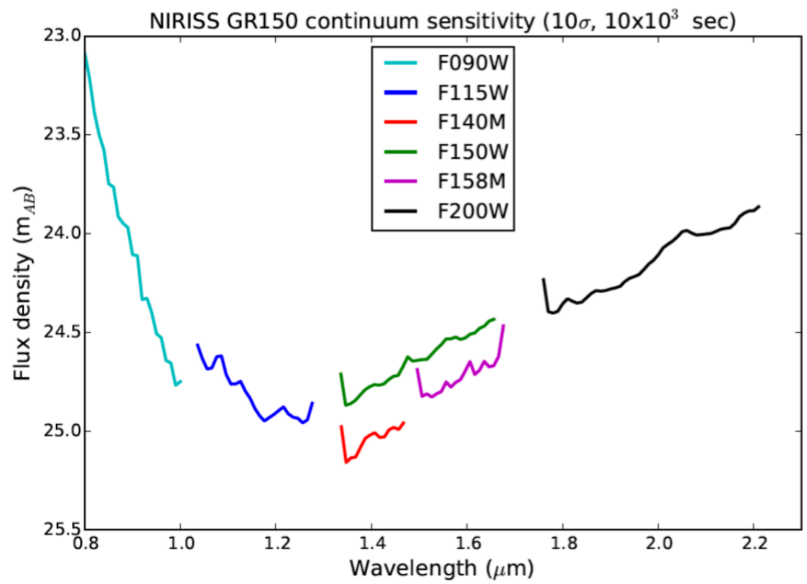
Available for WFSS

©JDox

NIRISS Wide-Field Slitless Spectroscopy (WFSS) - can fit 3000 galaxies at mag < 28

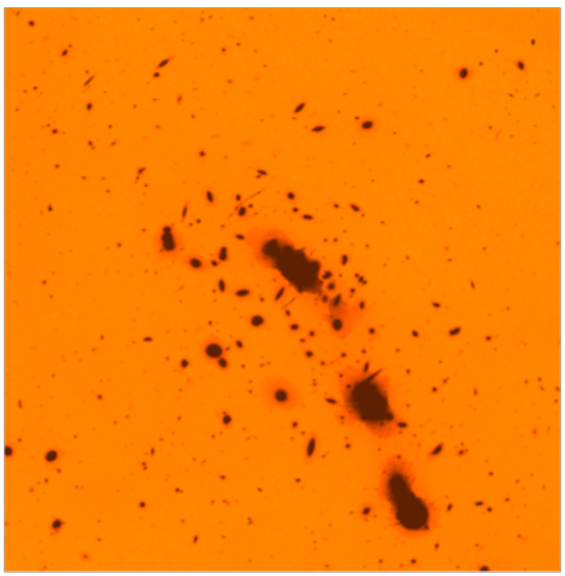
λ: 0.8-2.2 μm
Grism resolution: 150
Orthogonal dispersion to mitigate source crowding
Sensitivity (SNR 10 in 10ks) ~ 6x10^{-18} ergs/s/cm^2 or AB~25
High multiplex





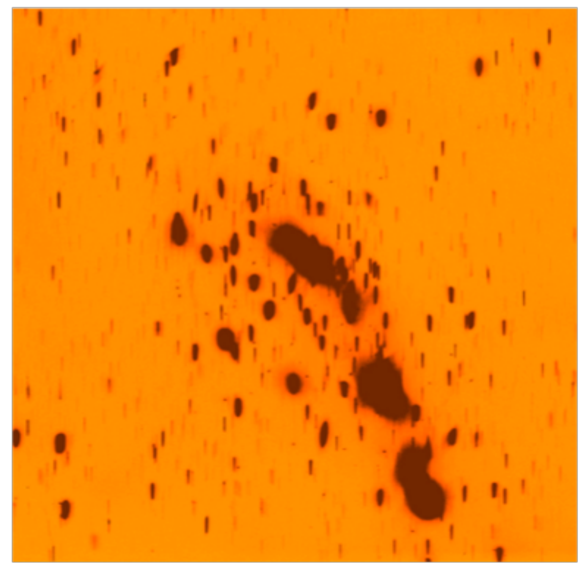
NIRISS science example: Low mass galaxies properties at Z=1-10

WFSS observations of 4-5 galaxy clusters (~200 hrs total).
Includes also NIRCam imaging + NIRSpec MOS follow-ups



Imaging
F115W

GR150C
F115W

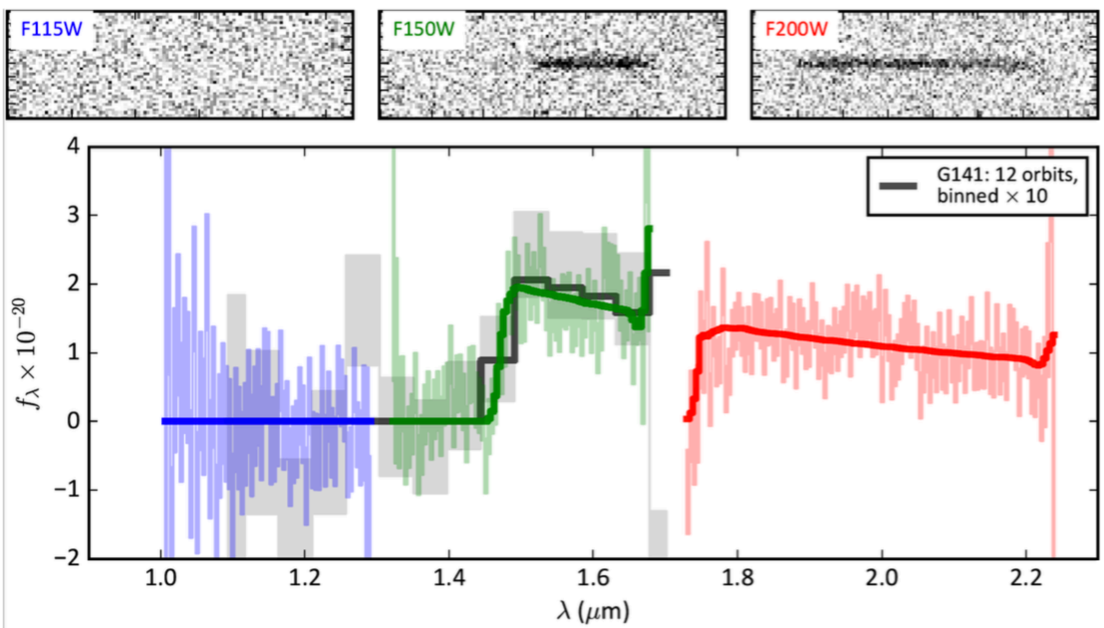


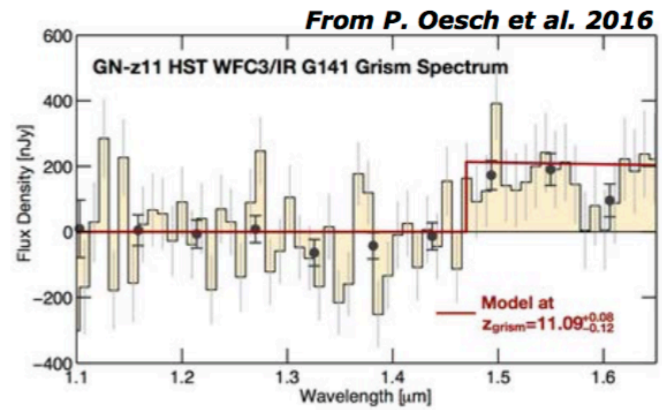
GR150R
F115W

©C. Willott

Simulated NIRISS observation of Frontier Fields cluster MACS J0416

NIRISS science example:
Finding high-z galaxies through WFSS



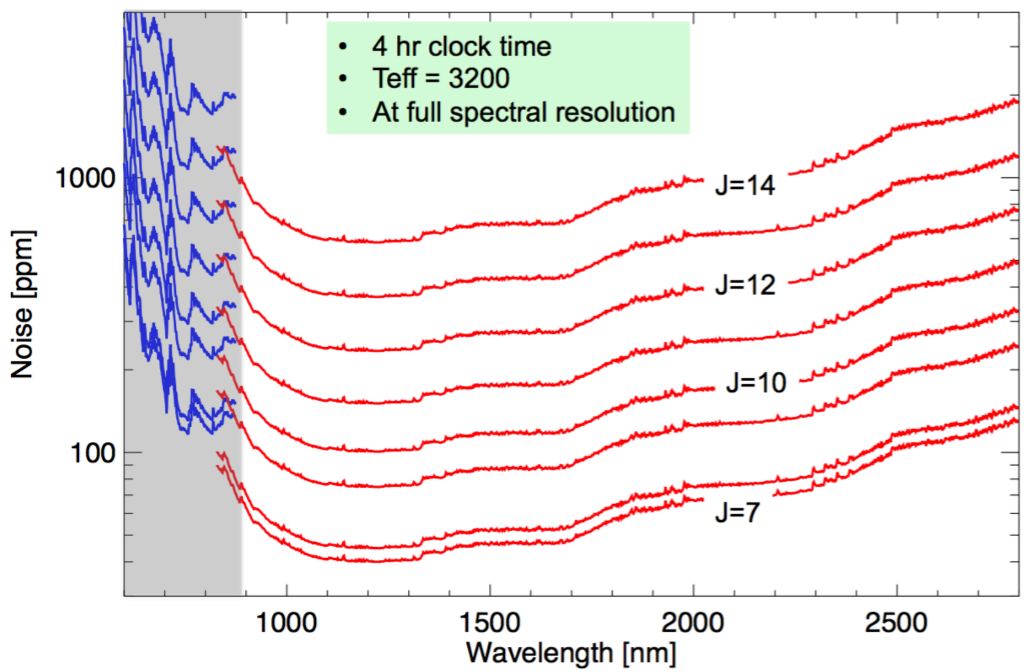


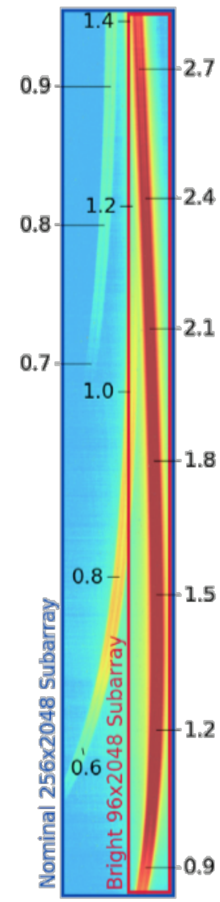
© C. Willott/G. Brammer

NIRISS WFSS simulation of Z=11 object, 3 hrs per grism + 3 filters (~20 hours total)

NIRISS Single Object Slitless Spectroscopy (SOSS)

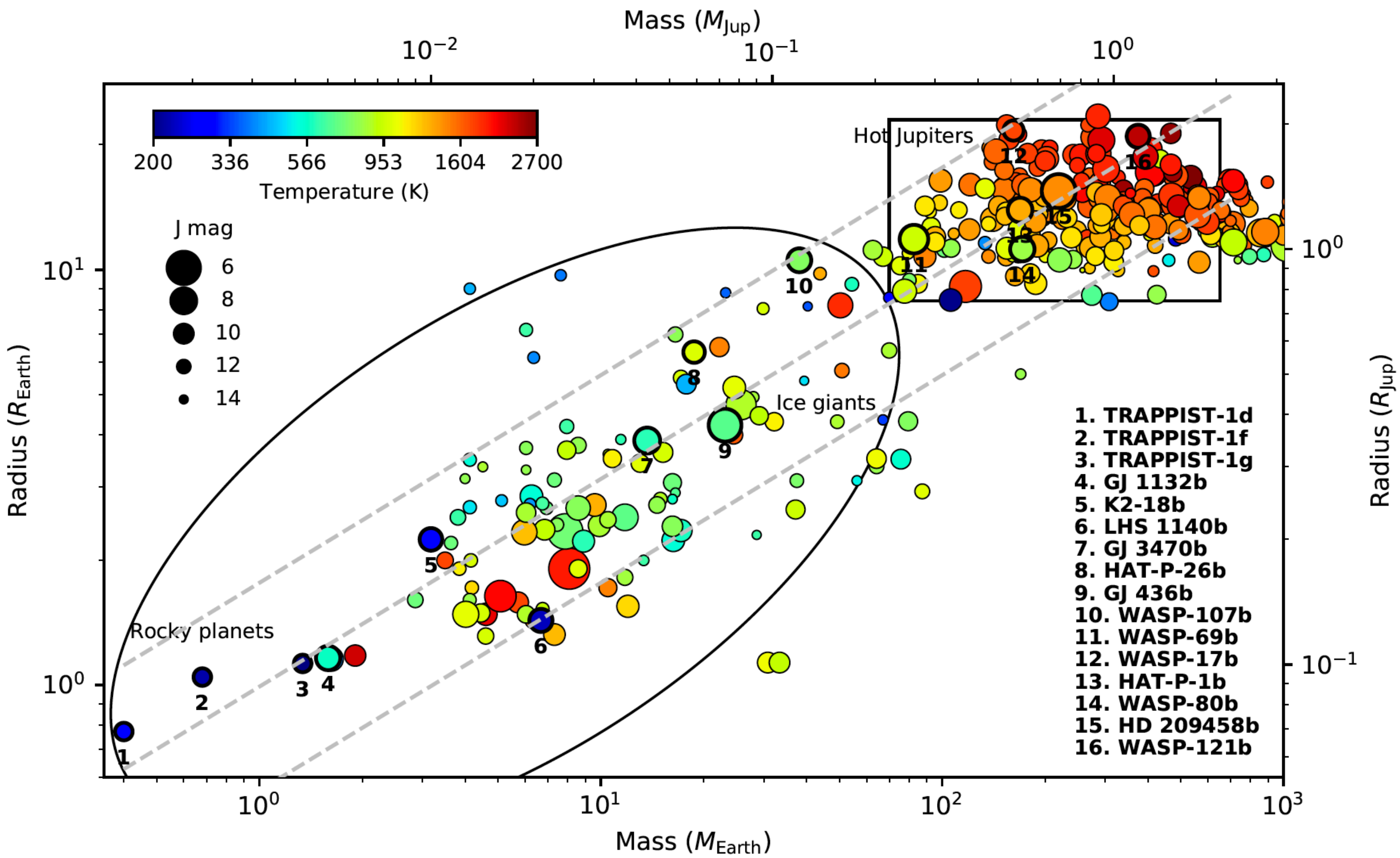
λ: 0.6-2.8 μm across two orders
Grism resolution ~ 1000
Saturation J ~ 8.1 mag
(Bright mode J~6.3)
Optimized for exoplanet transit spectroscopy, especially bright stars





NIRISS science example: Exoplanet atmosphere characterization through transit spectroscopy (~200 hrs)

Planets & Origins of Life

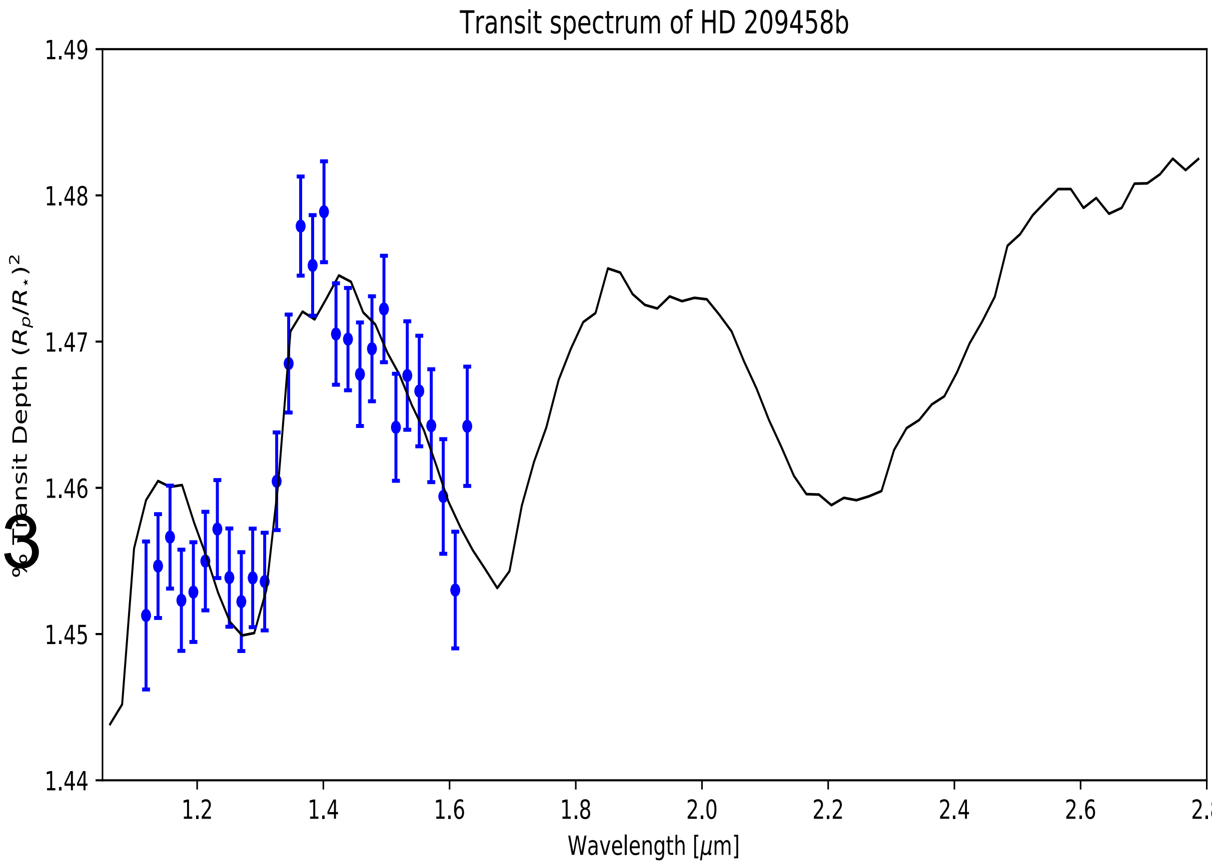


©D. Lafrenière

NIRISS science example:
Exoplanet atmosphere characterization through transit spectroscopy (~200 hrs)

Planets & Origins of Life

With HST WFC3

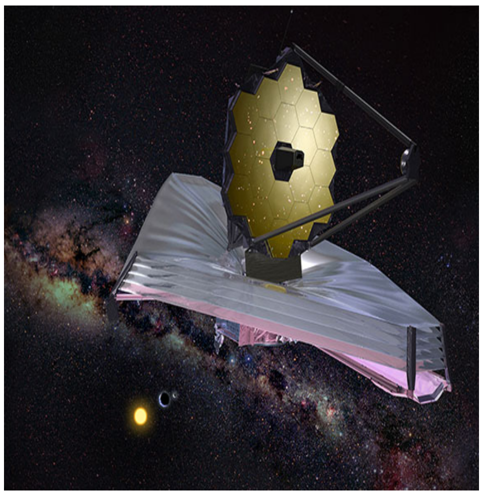


©D. Lafrenière

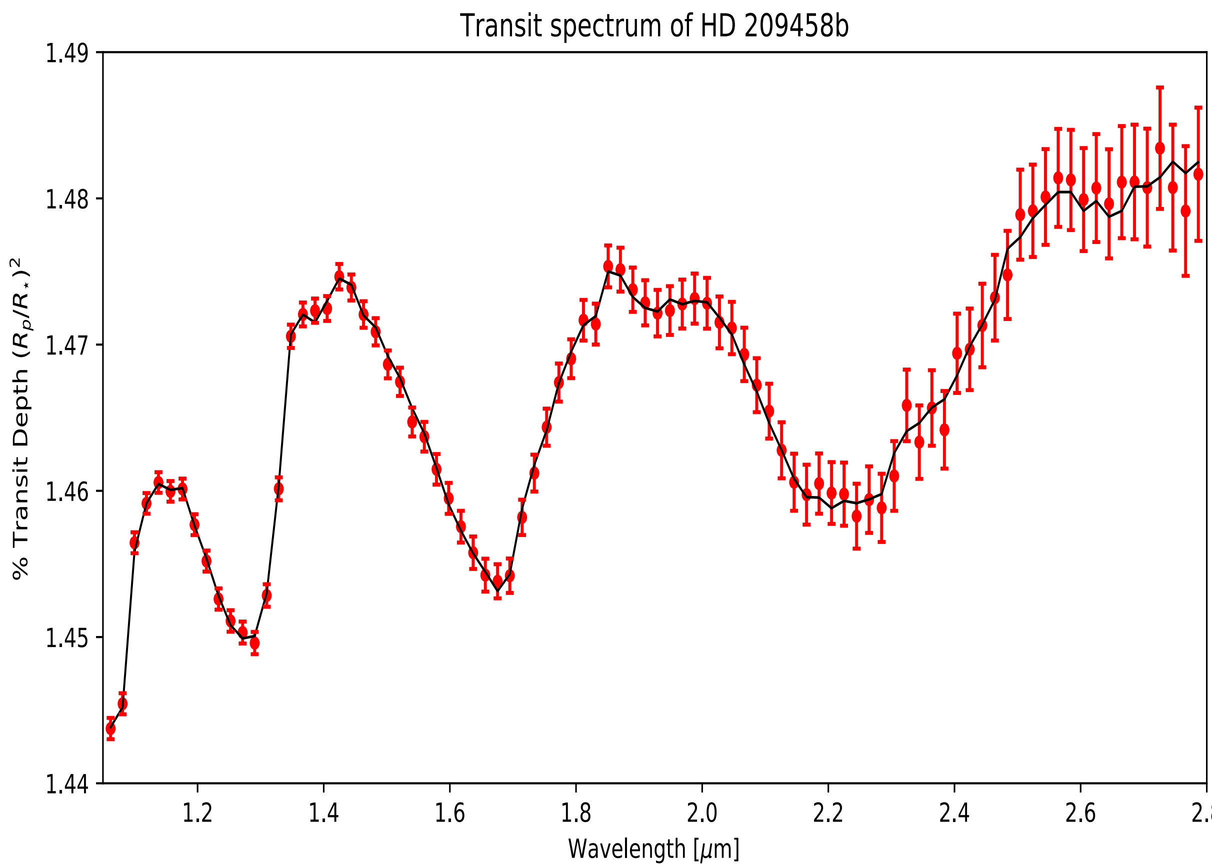
Observations by Deming et al. 2013

NIRISS science example: Exoplanet atmosphere characterization through transit spectroscopy (~200 hrs)

Planets & Origins of Life



With JWST NIRISS



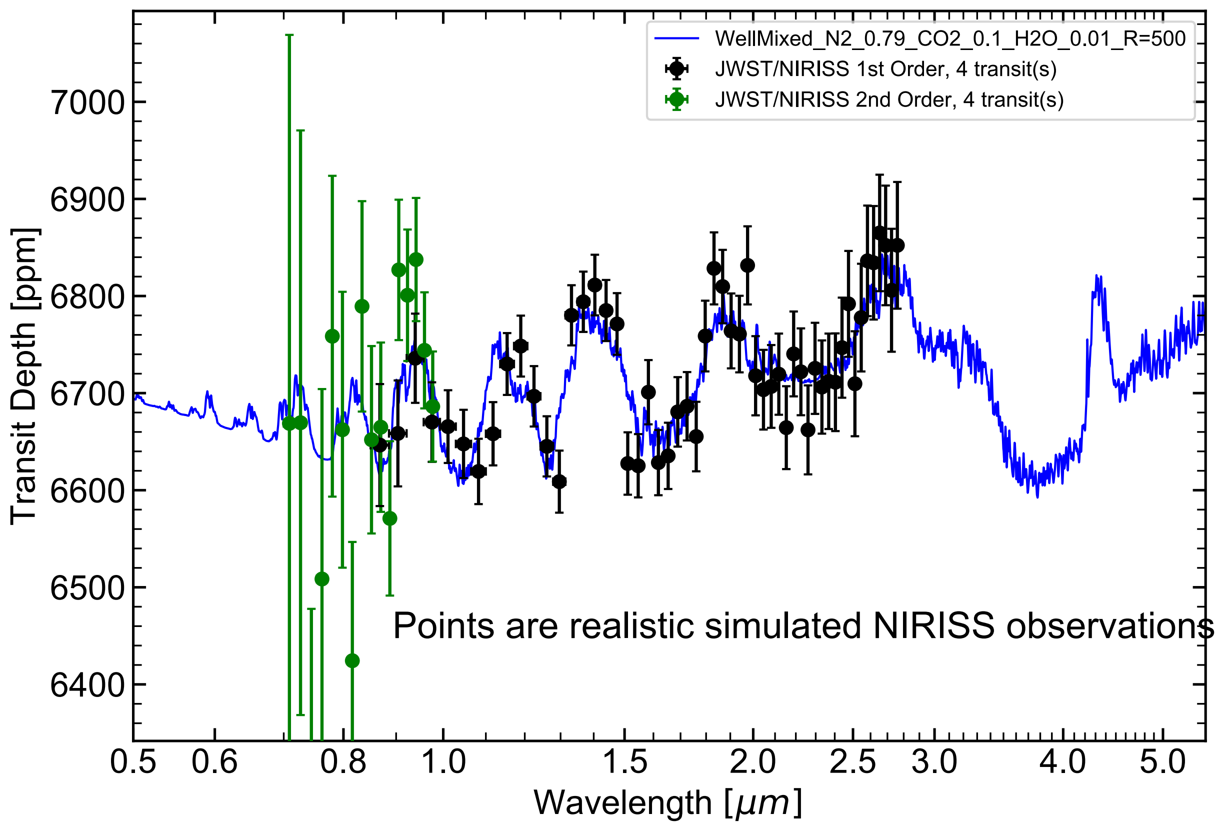
Simulated NIRISS Observations

©D. Lafrenière

NIRISS science example:
Exoplanet atmosphere characterization through transit spectroscopy (~200 hrs)

Planets & Origins of Life

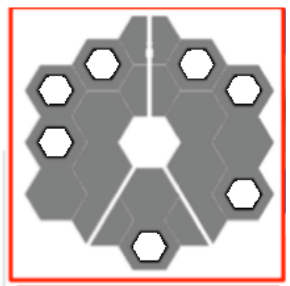
TRAPPIST-1f with Earth-like atmosphere



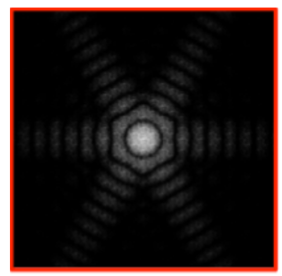
©B. Benneke

NIRISS aperture masking interferometry (AMI) will provide the highest angular resolution achievable by JWST

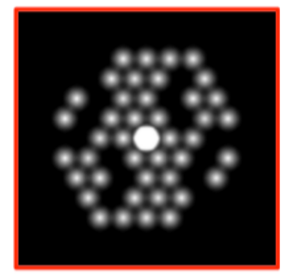
7 hole
Non-Redundant Mask

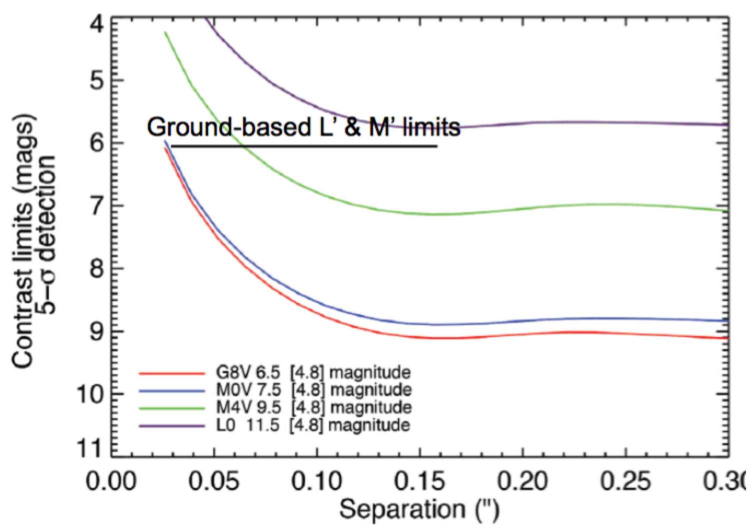


Inteferogram in the image plane



Fourier transform

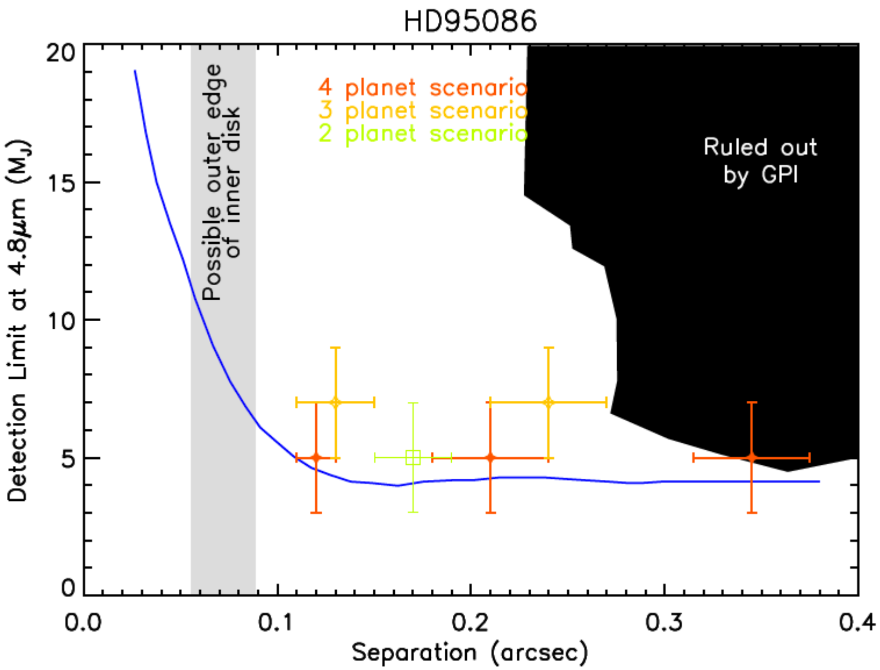


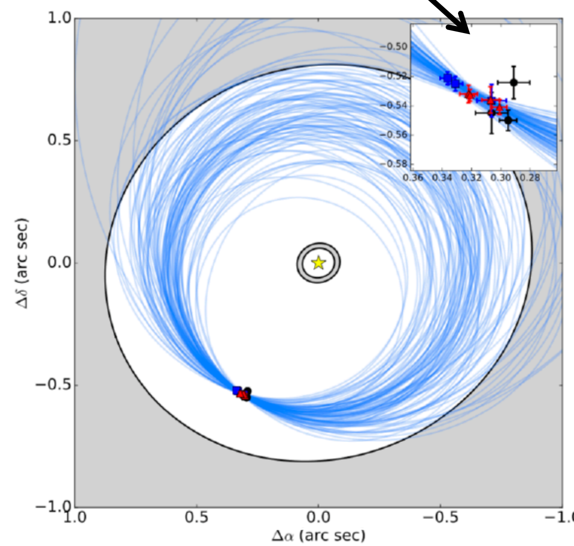


©E. Artigau, J. Rameau

NIRISS science example: Finding close-in young gas giants

Orbitals motion as measured by GPI





Rameau et al. 2016

©*J. Rameau*

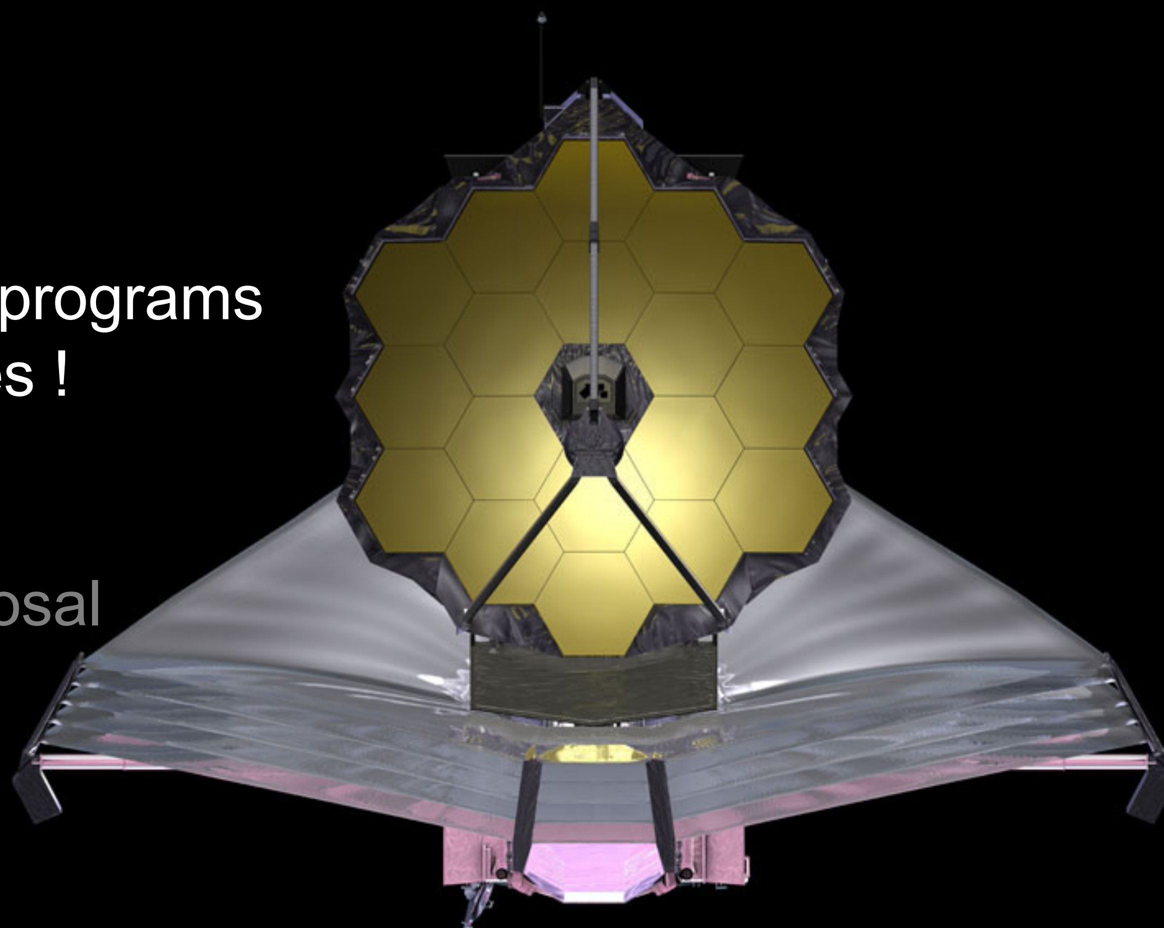
Outline

JWST primers

Instruments & science programs

- Other capabilities !

Towards a JWST proposal



JWST higher-level observations

Parallels (for Cycle 1)
- NIRCam Imaging + MIRI Imaging
- NIRCam Imaging + NIRISS Imaging
- NIRSpec MOS + NIRCam Imaging
- NIRISS WFSS + NIRCam Imaging
- NIRISS WFSS + MIRI Imaging

Dithering
- Fill in detector gaps, improve PSF sampling & data proc.

Mosaicking
- For large, extended objects and to increase sky coverage

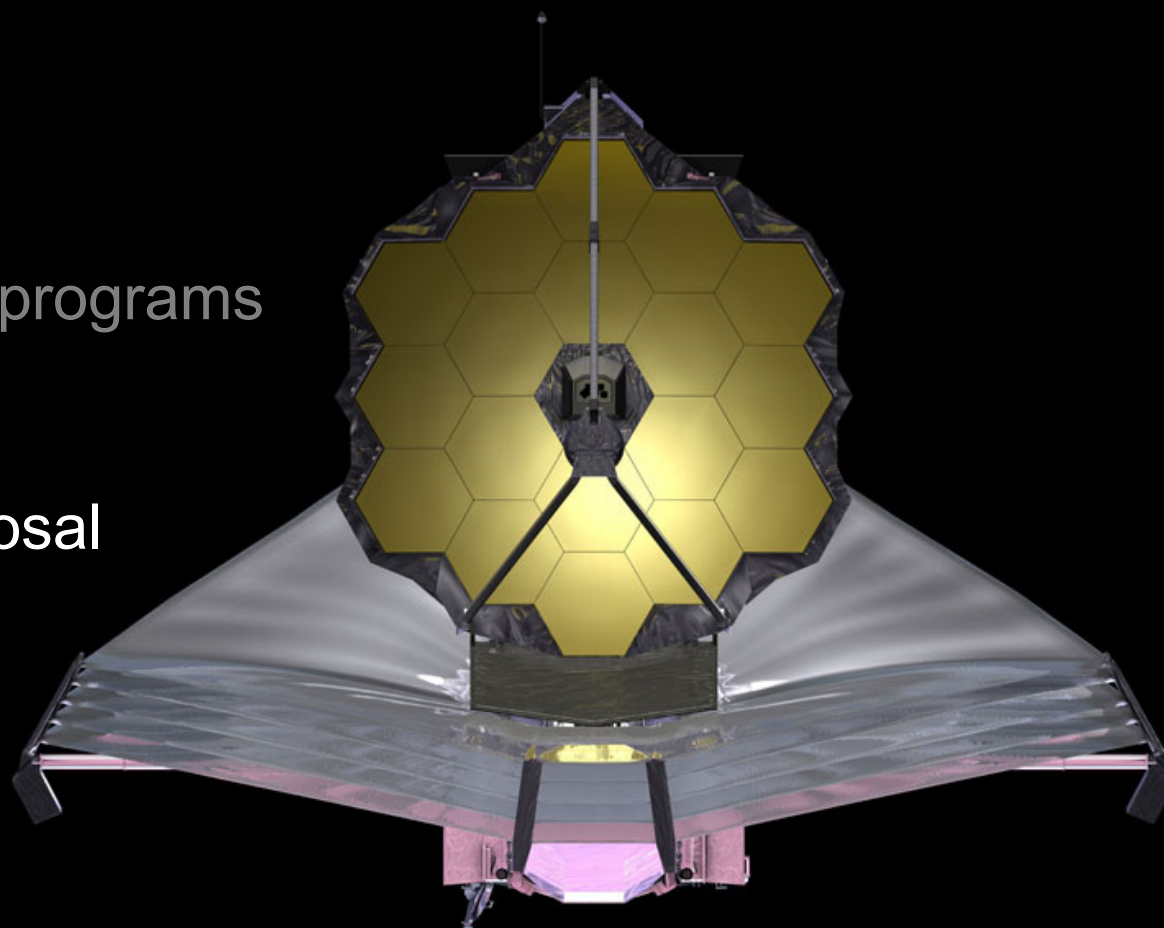
Moving targets
- JWST can track at 30 mas/s with pointing accuracy of 7mas

Outline

JWST primers

Instruments & science programs

Towards a JWST proposal



JWST Cycle 1 proposals are due By April 6th, 2018, in one single phase.

Think of a science project	You
Calculate exposure time	Exposure Time Calculator
Verify visibility and orient	General Target Visibility tool / Coronagraphy Visibility tool
Plan visits	Astronomer's Proposal Tool
Justify science	You
Submit proposal	You

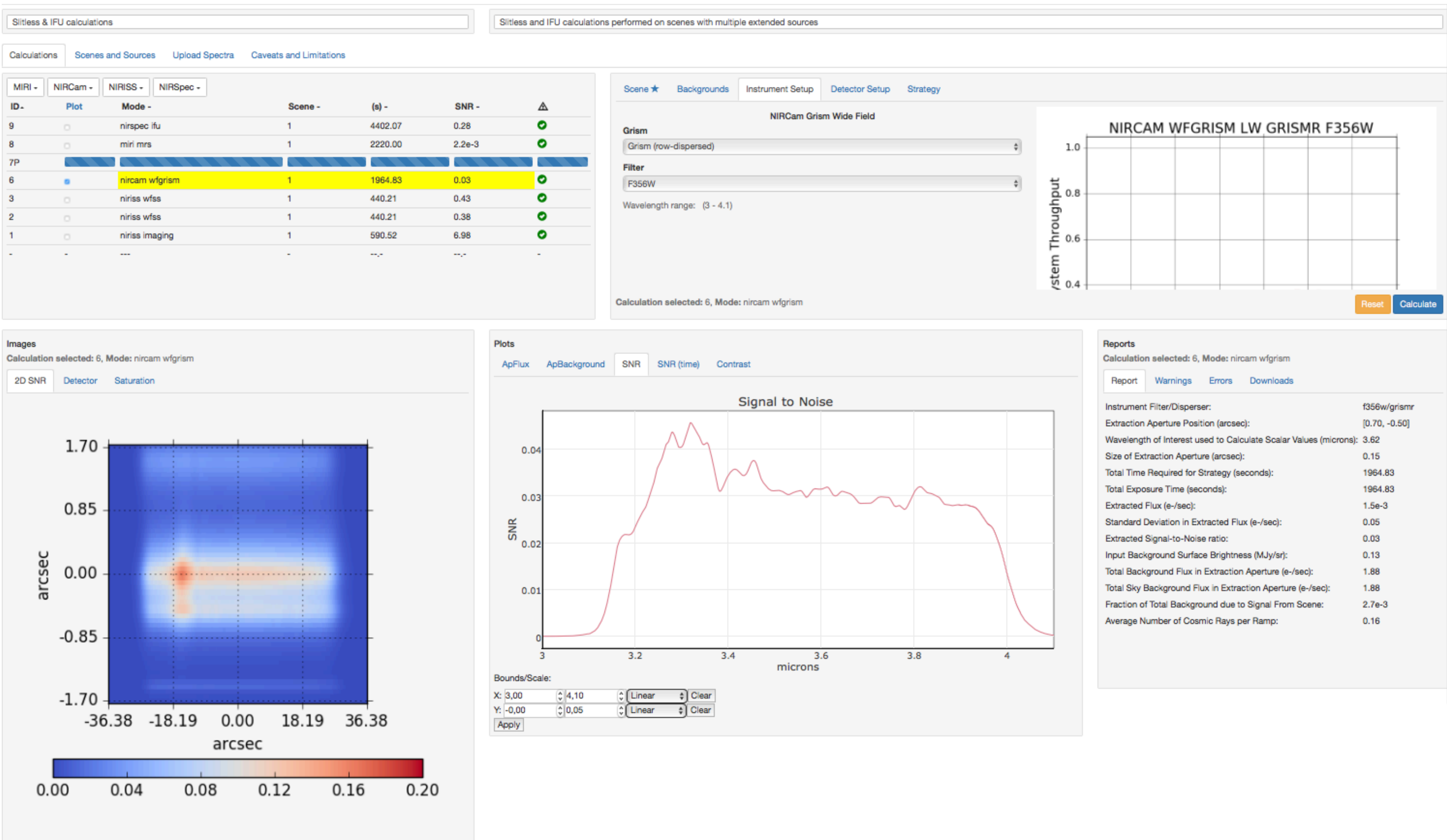
JWST observing time is in unit of ‘’wall clock time’’ (overheads included)

Observing effciency requirement: >70%

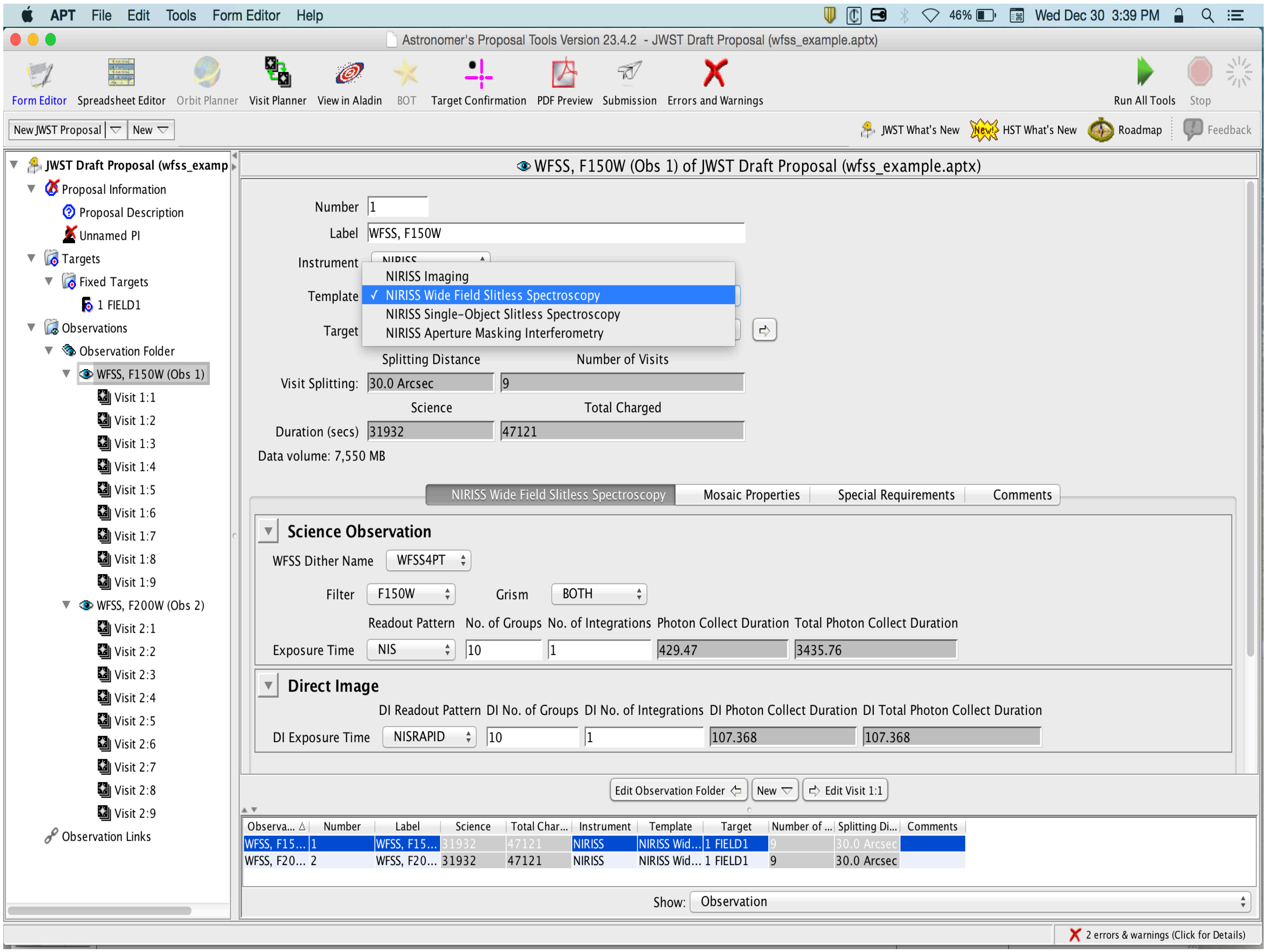
Charged time =

(Slew	30 min by default
+Instrument configuration	10-20 min
+Photon collecting time	Science exposure
(+Small angle maneuvers)	Dither/Mosaic
)*1.16	Observatory ‘’fees’’ for calibrations & observatory maintenance
(+Scheduling tax)	1h for tight (<1day) window

ETC web and python engine



APT templates



Other useful informations

All JWST data will be reduced by the STScI pipeline (python)
Additional sets of tools are available for analysis

http://ssb.stsci.edu/doc/jwst/jwst/introduction.html

Simulated datasets are available for training

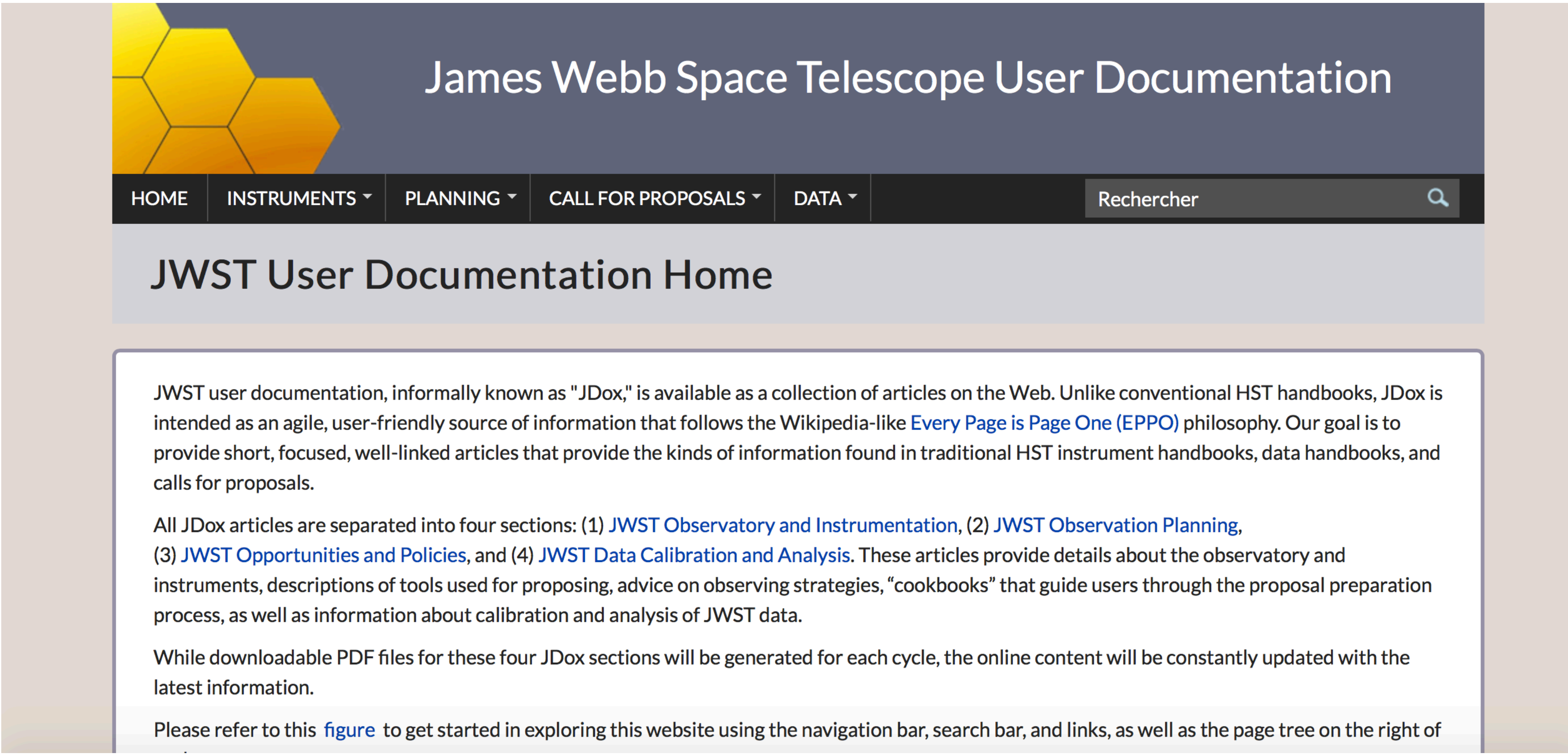
http://archive.stsci.edu/jwst/simulations/index.html

Everything you need to know
(observatory, planning, policies, data, GTO programs): JDox

jwst-docs.stsci.edu

Workshops:

11-14 December 2017, Pasadena (Proposal)



- Google: "JWST pocket guide"
- Google: "JWST user documentation"

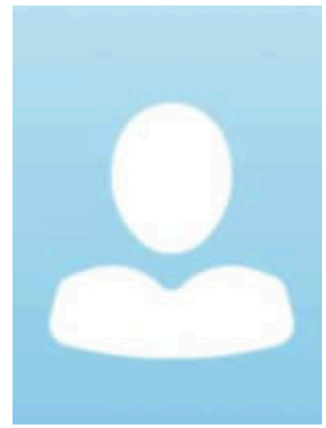
Canadian JWST help desk @ UdeM

jwsthelp@astro.umontreal.ca

web: jwst.astro.umontreal.ca

Loïc Albert

Julien Rameau



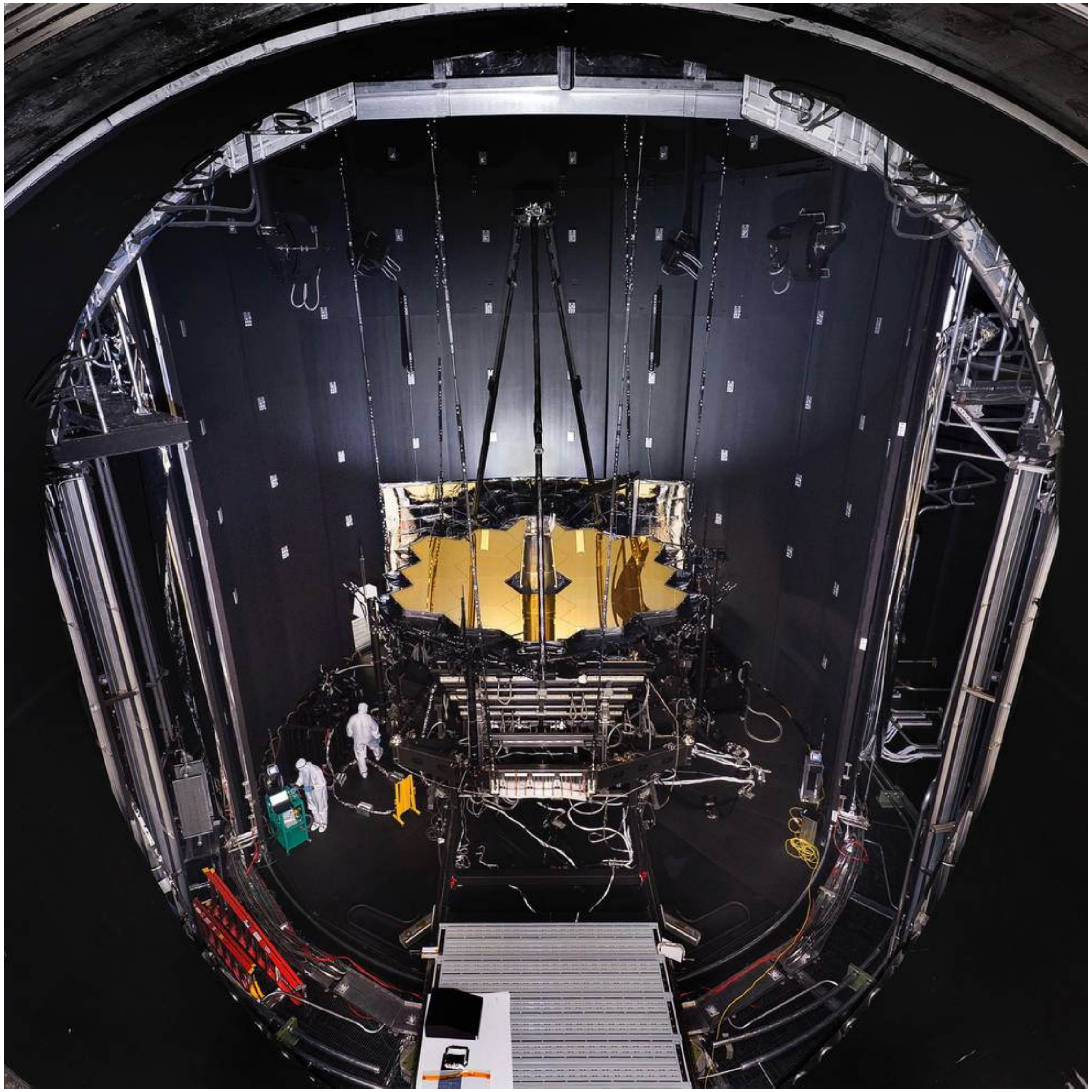
Outreach officer

- To assist you in preparing JWST proposals, getting started with data reduction and diffusion of your results to the media.
- Attend next forthcoming webinars this fall organized by the Canadian JWST team. See schedule here:

http://jwst.astro.umontreal.ca/?page_id=702

Get ready ! Proposal deadline: 6 April 2018 !

Merci !



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