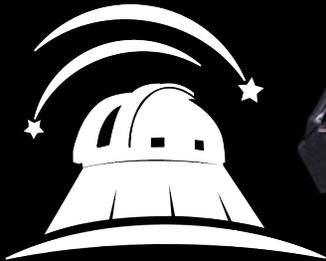


Get ready for the James Webb Space Telescope

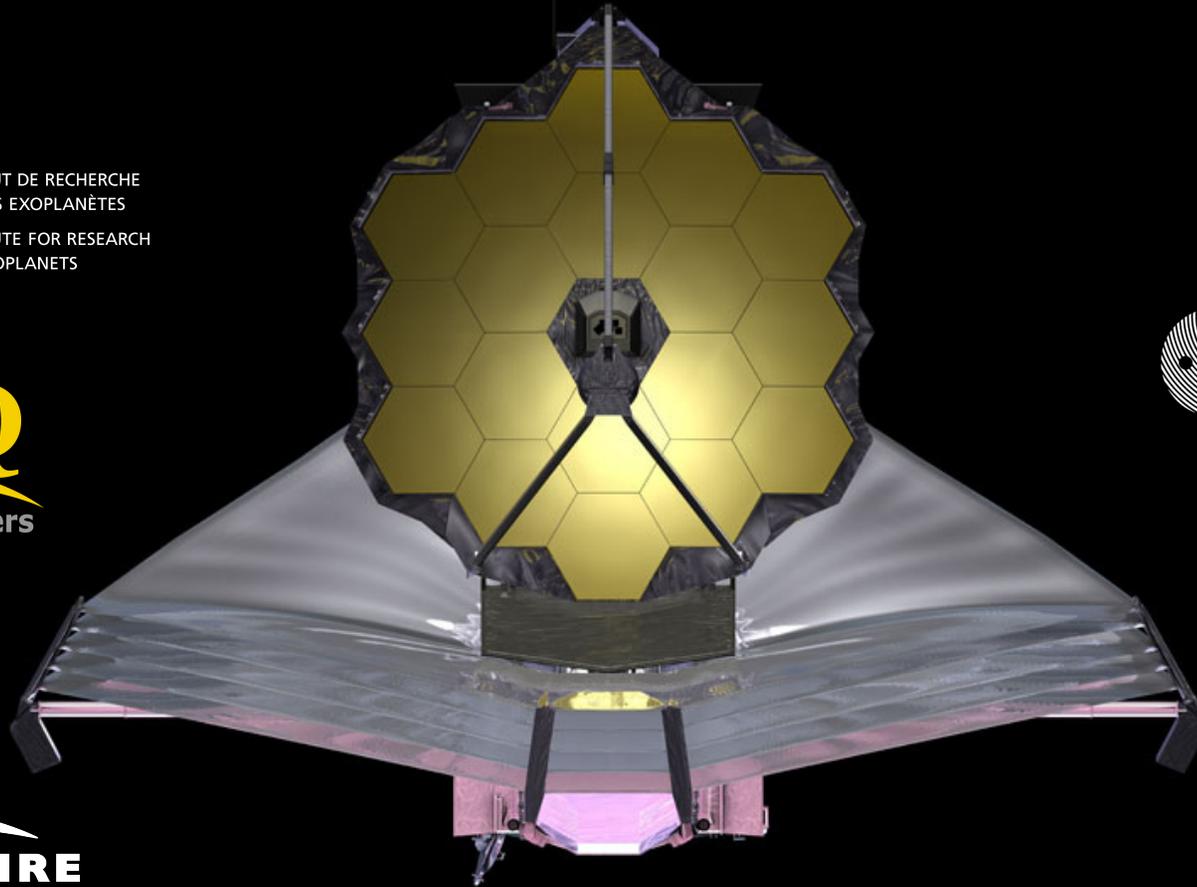


INSTITUT DE RECHERCHE
SUR LES EXOPLANÈTES
INSTITUTE FOR RESEARCH
ON EXOPLANETS



**OBSERVATOIRE
DU MONT-MÉGANTIC**

Université 
de Montréal



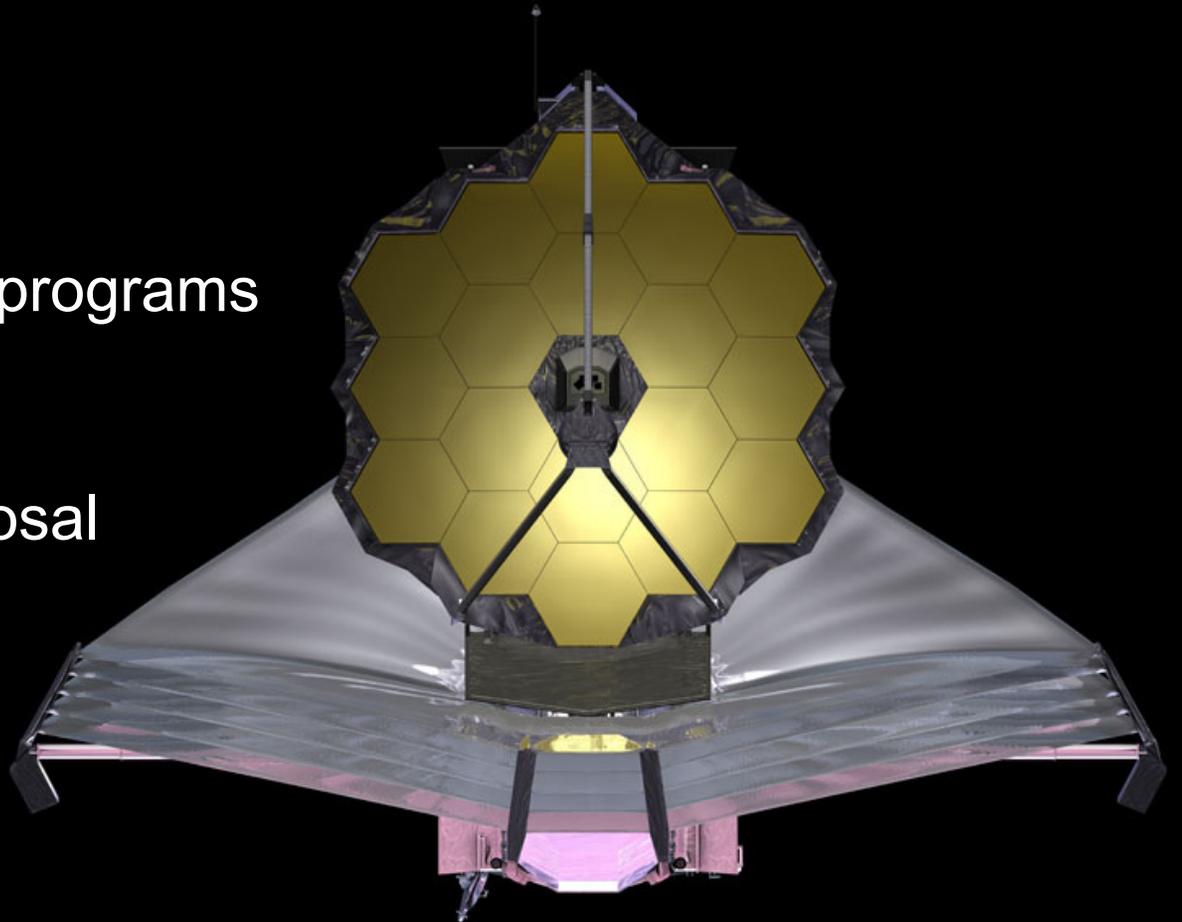
René Doyon, Université de Montréal
15 November 2017

Outline

JWST primer

Instruments & science programs

Towards a JWST proposal

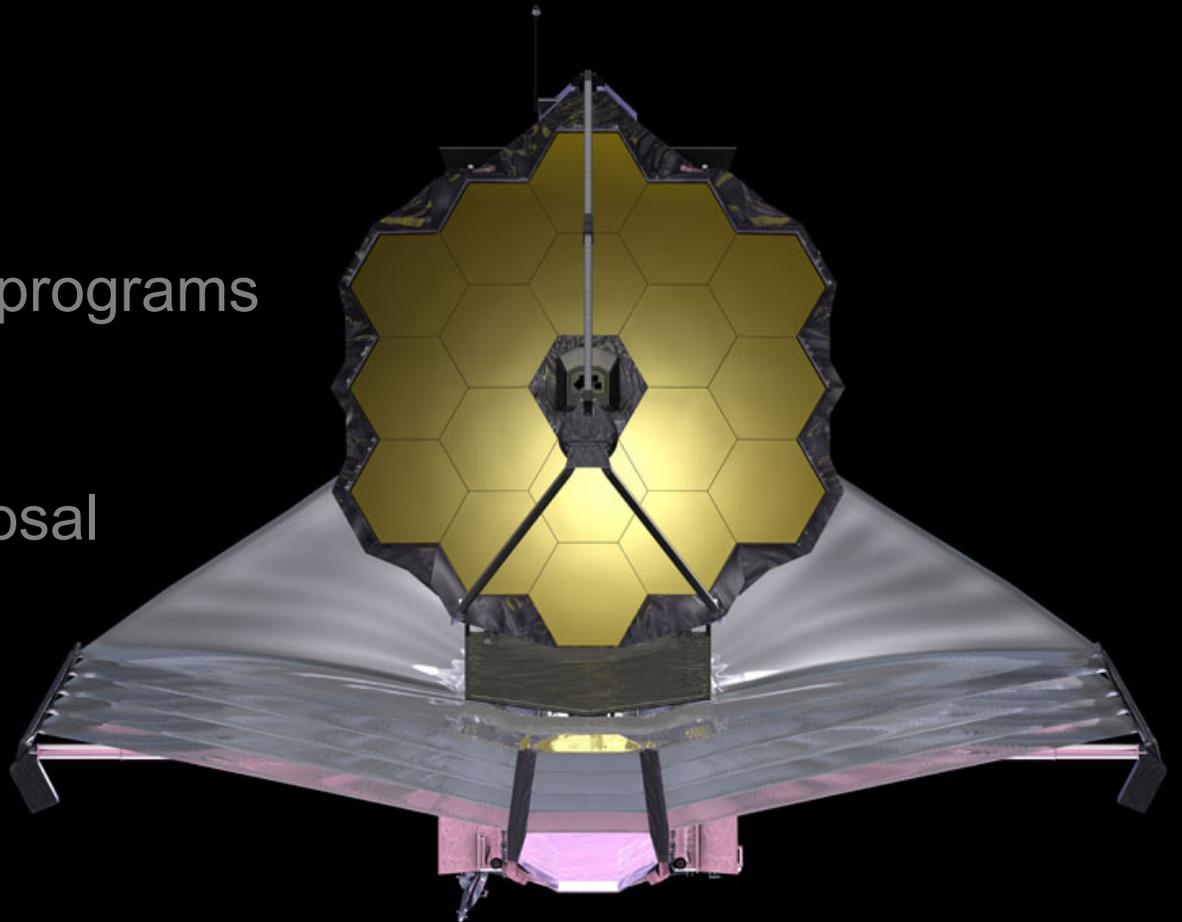


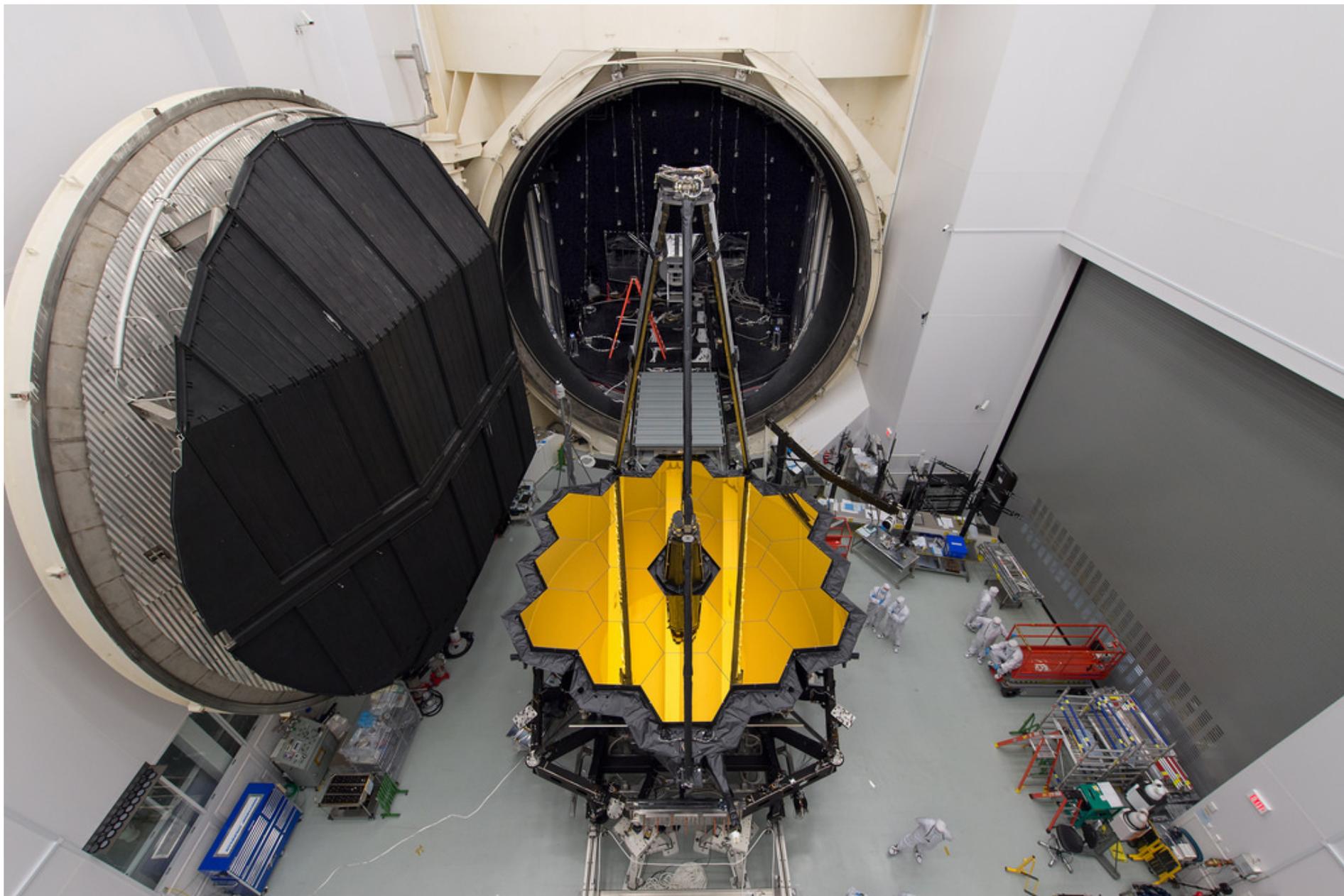
Outline

JWST primer

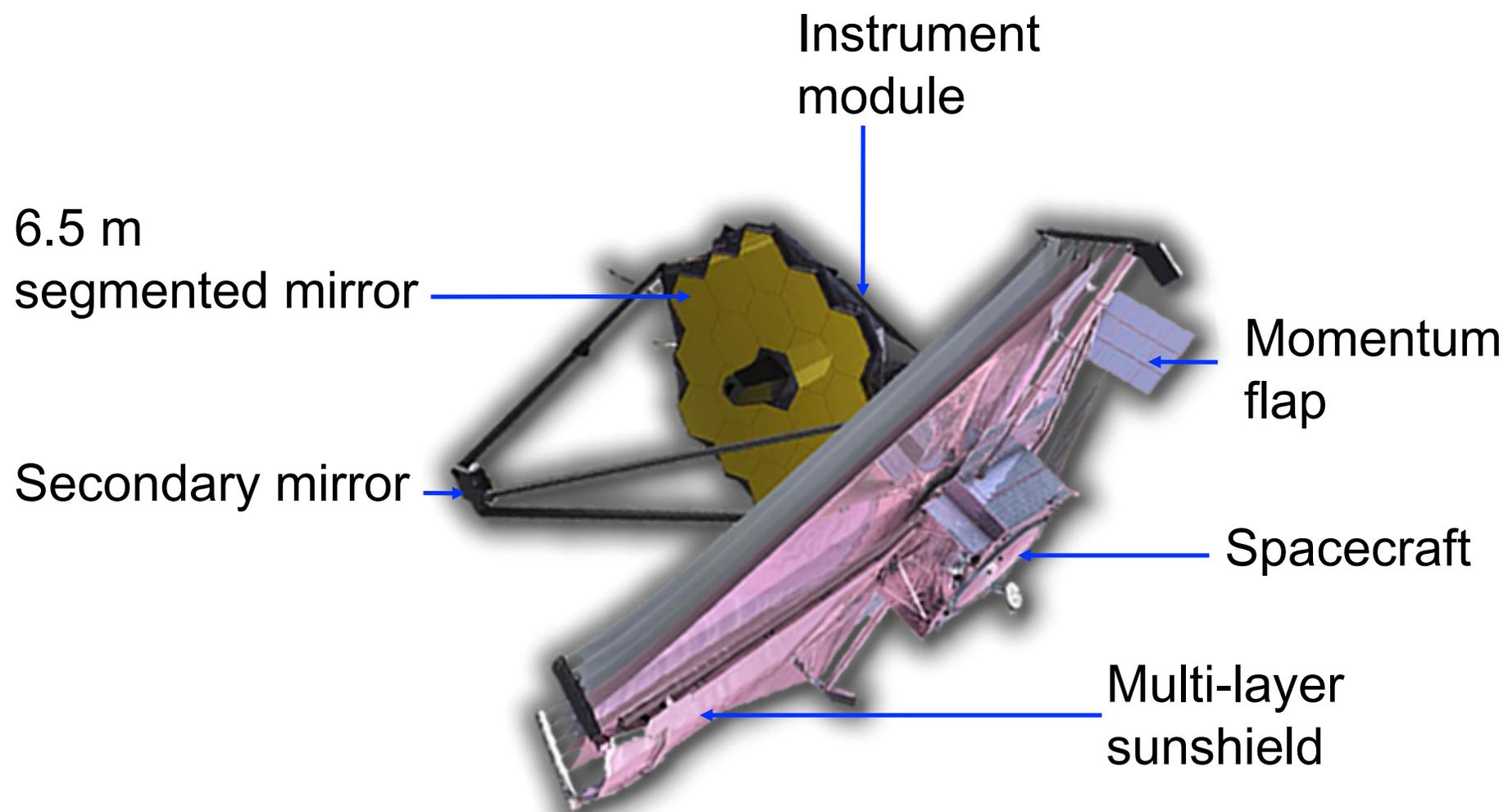
Instruments & science programs

Towards a JWST proposal

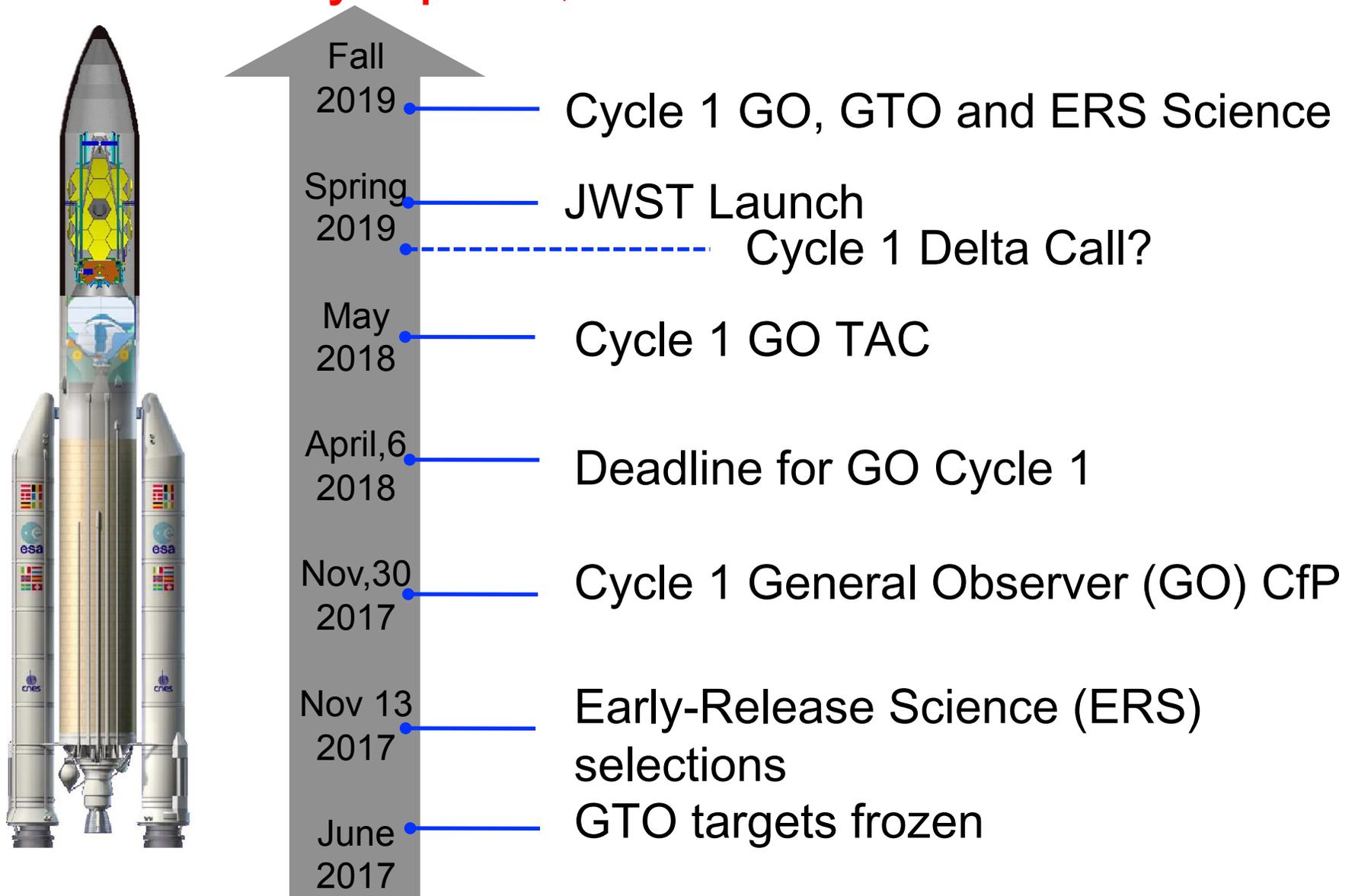




JWST anatomy



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



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.

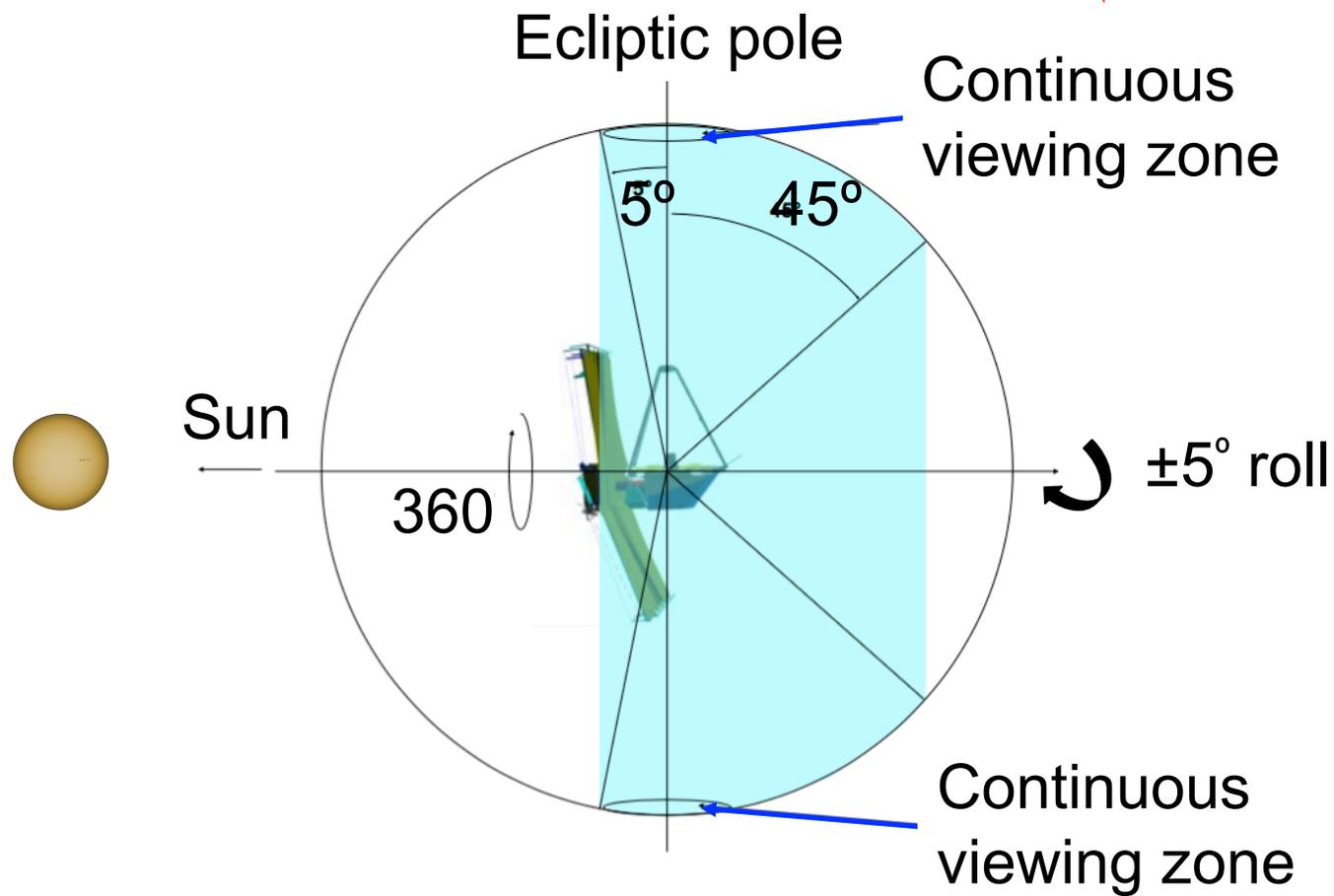
- 106 Proposals Received for 3683.4 Hours, 13 Approved for 460 Hours
 - 4 ESA Proposals for 125 Hours
 - 31% for Proposals and 27% for Hours
 - 32% of the Cols are ESA Members
 - 9 US Proposals for 334.6 Hours
 - 7 of the 240 Cols are from CSA
 - 18 Countries and 22 US States are represented
 - 106 Unique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

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

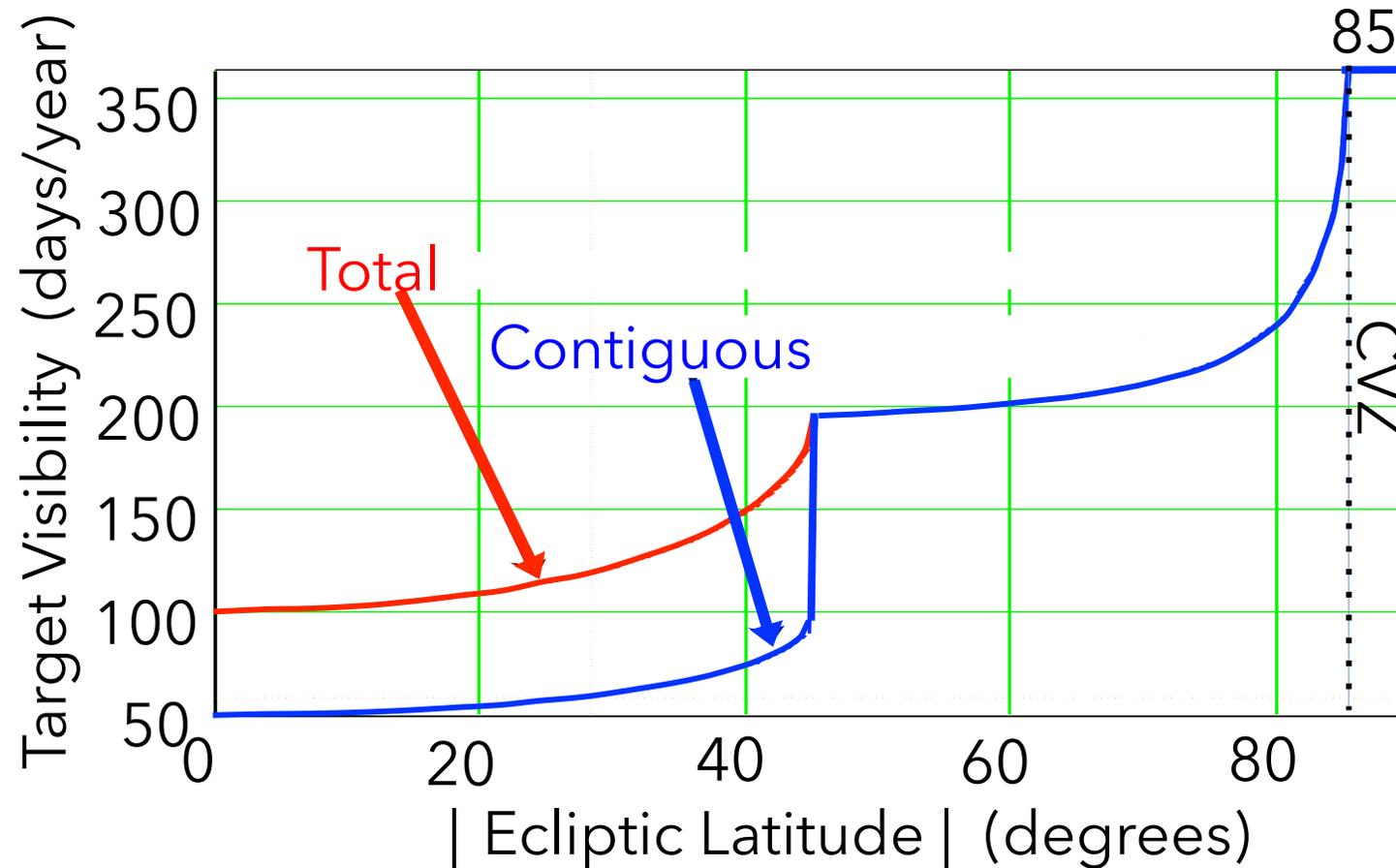
<https://jwst.stsci.edu/news-events/news/News%20items/selections-made-for-the-jwst-directors-discretionary-early-release-science-program>

Slide courtesy of Nikole Lewis (STScI)

JWST's field of regards

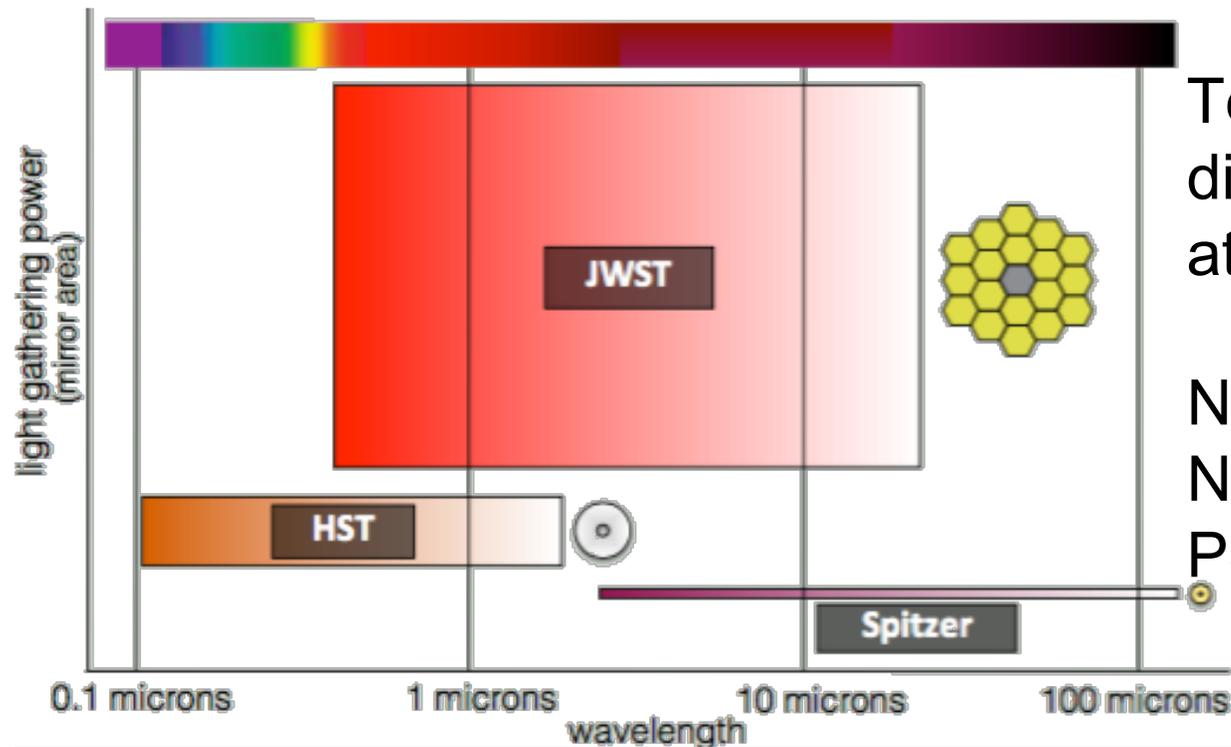


Target visibility windows



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 $>2 \mu\text{m}$

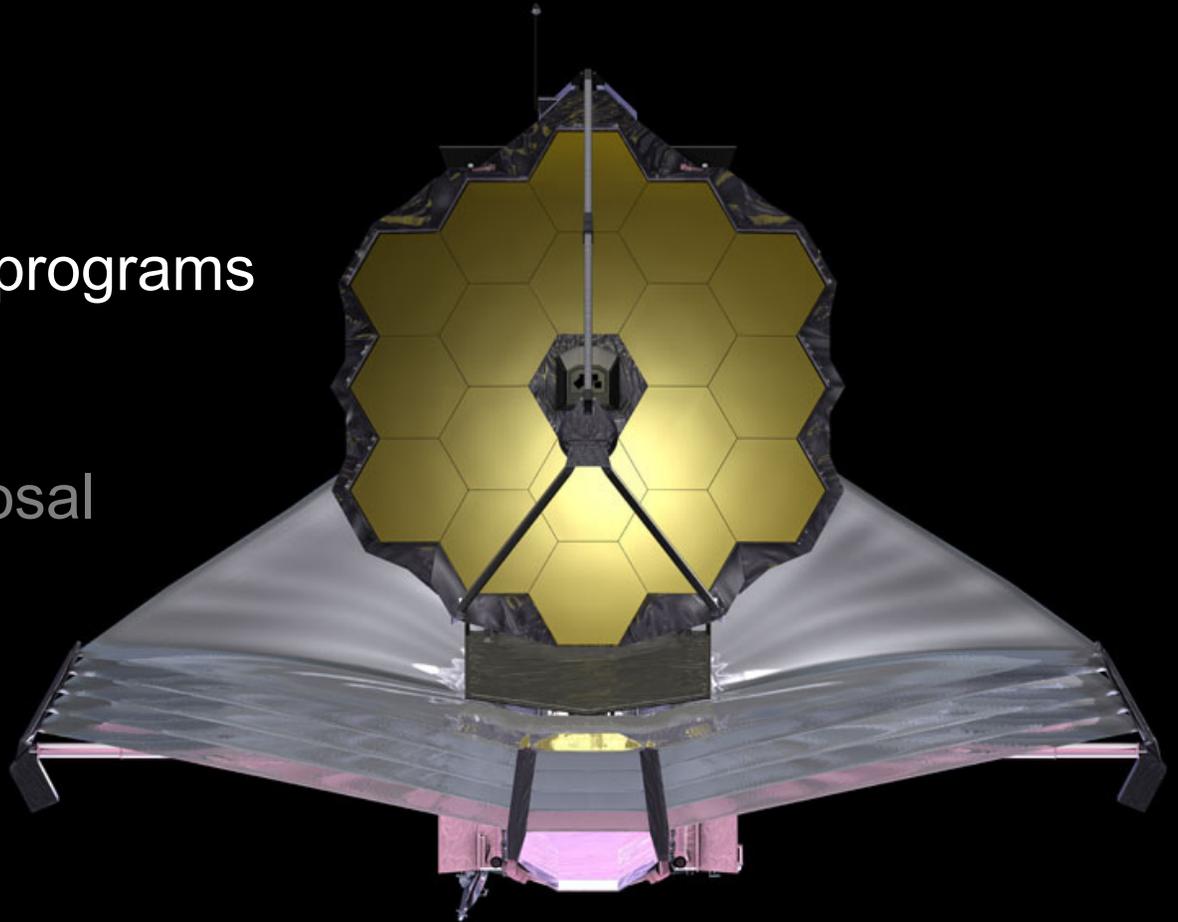
Not all instruments
Nyquist sample the
PSF.

Outline

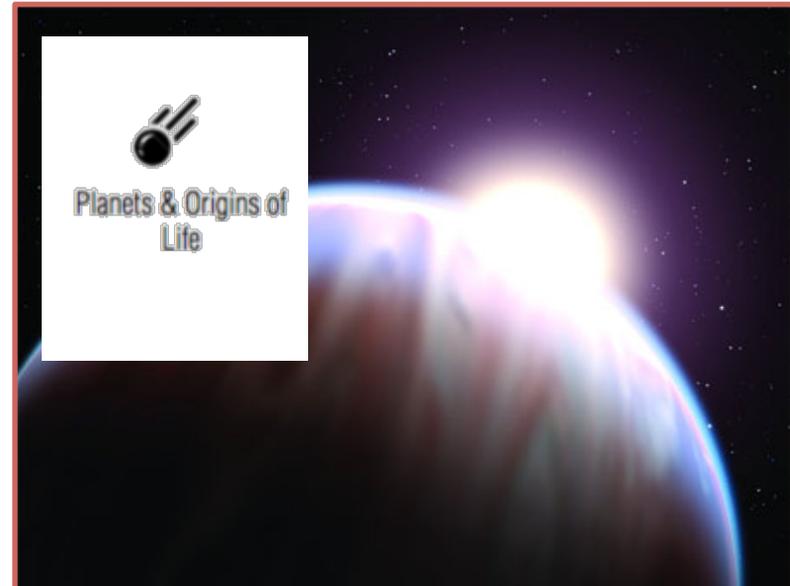
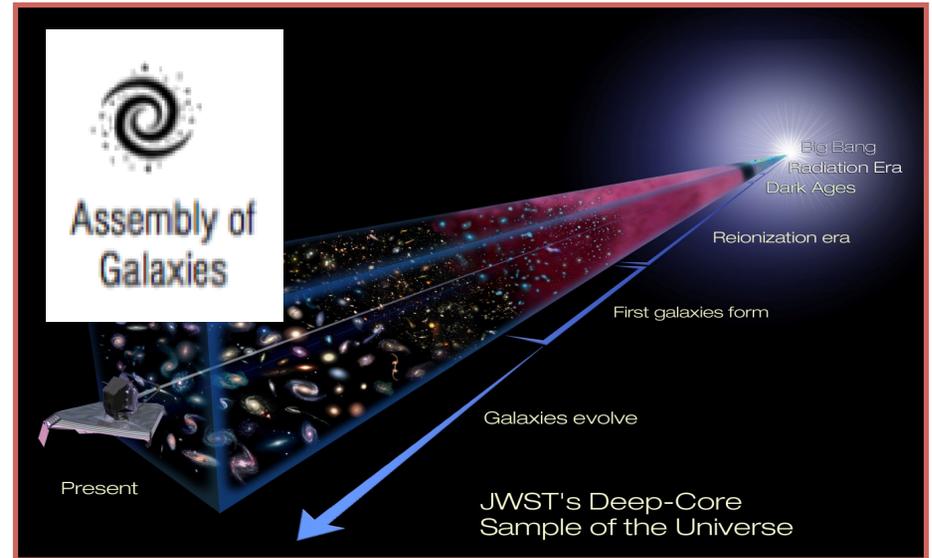
JWST primers

Instruments & science programs

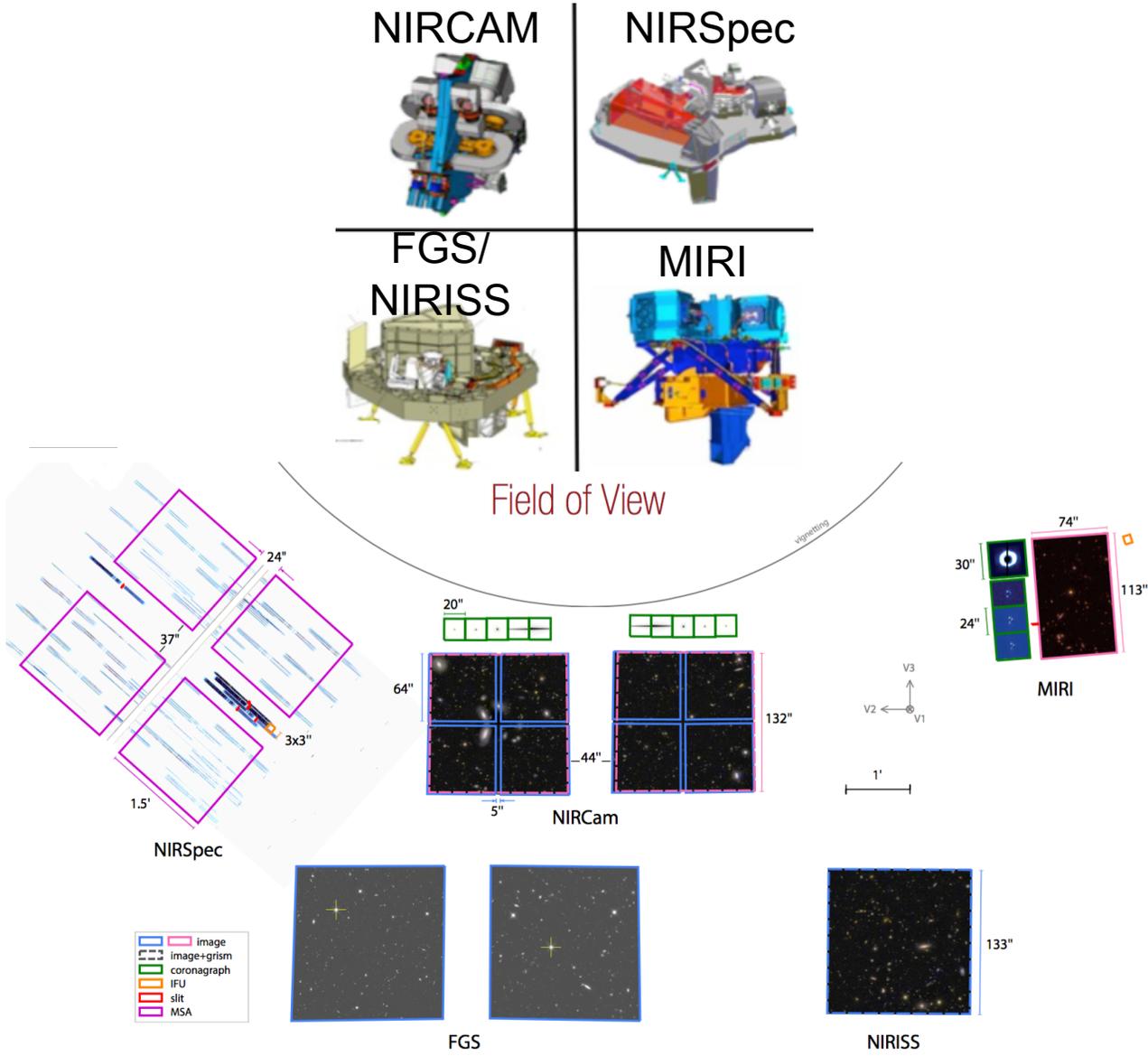
Towards a JWST proposal



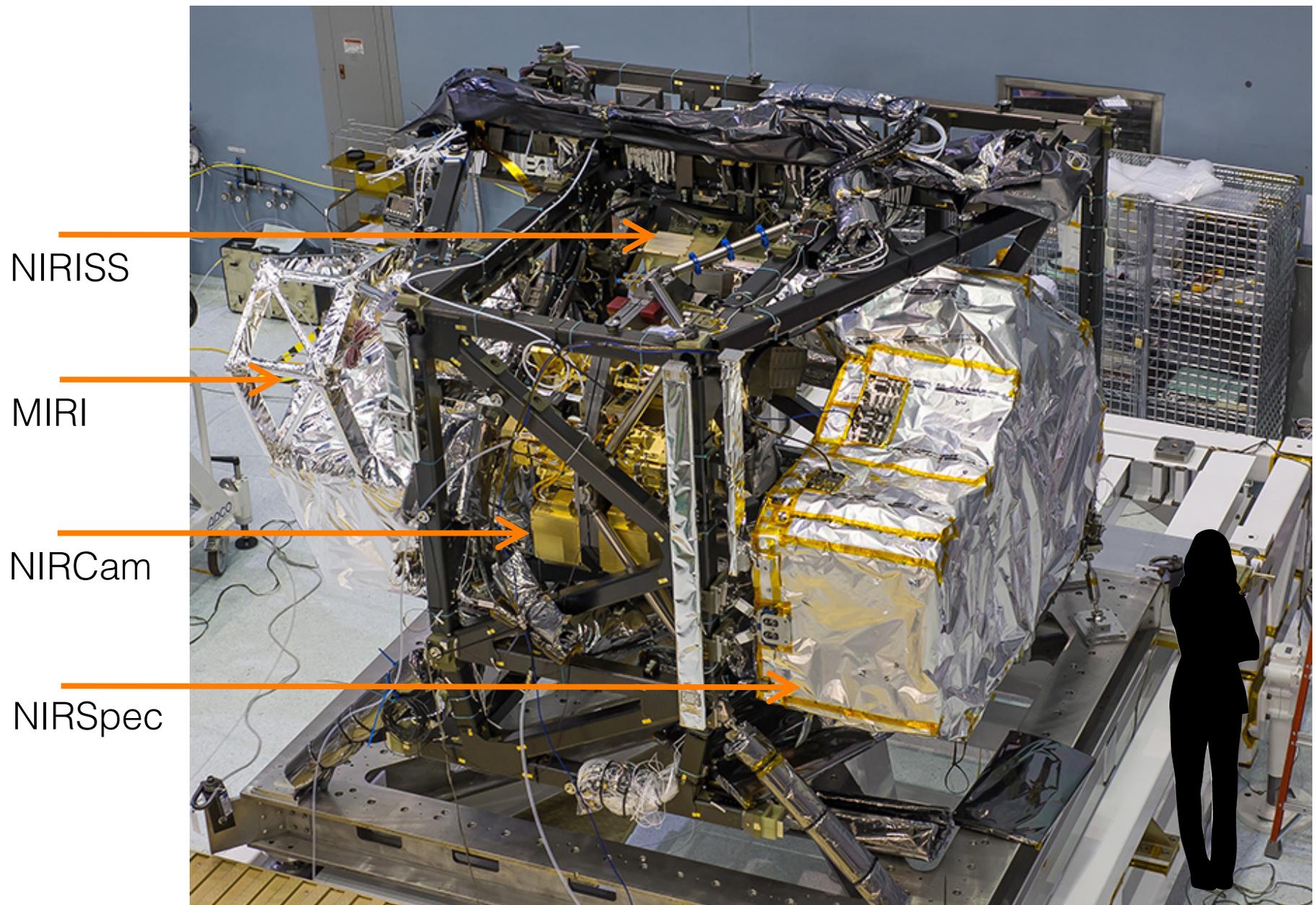
JWST's four science themes



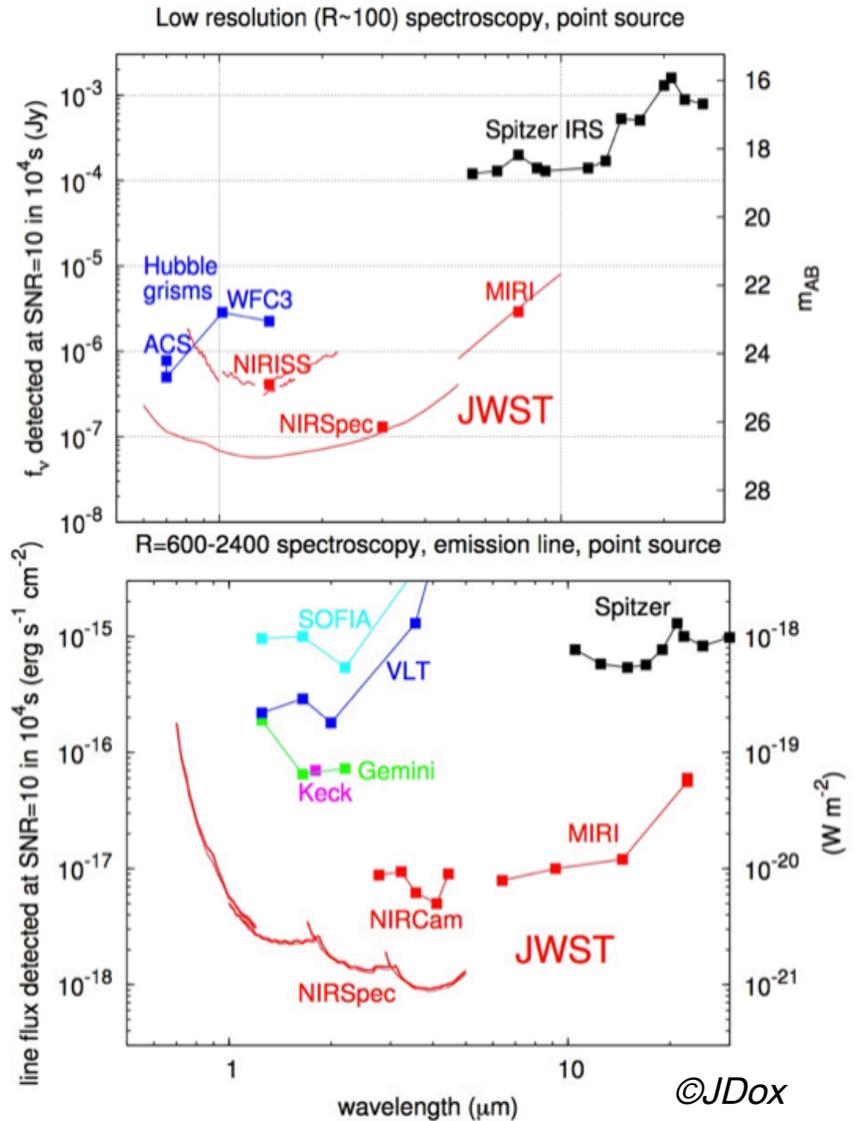
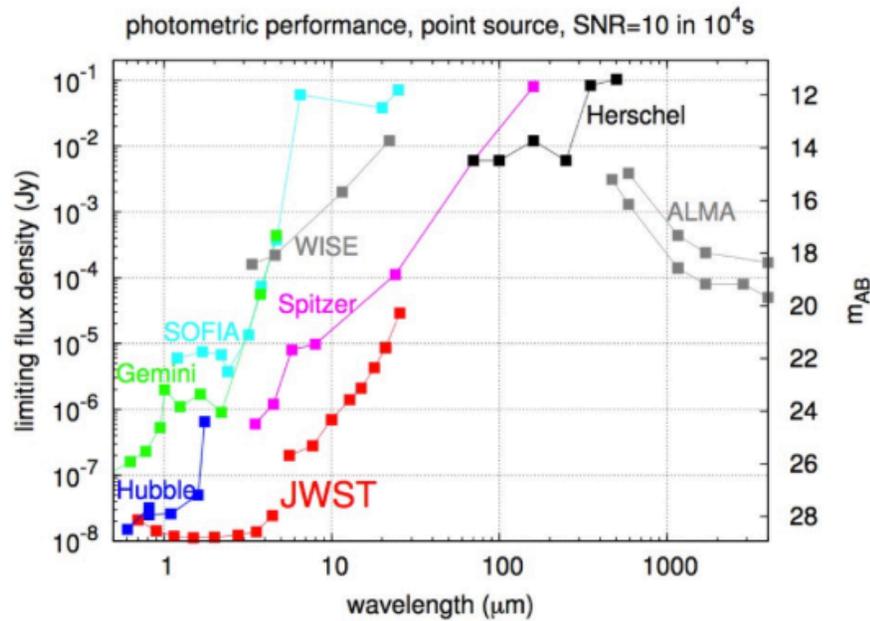
Four instruments with multiple modes



A flagship worth of instruments



JWST will improve sensitivity by order(s) of magnitude



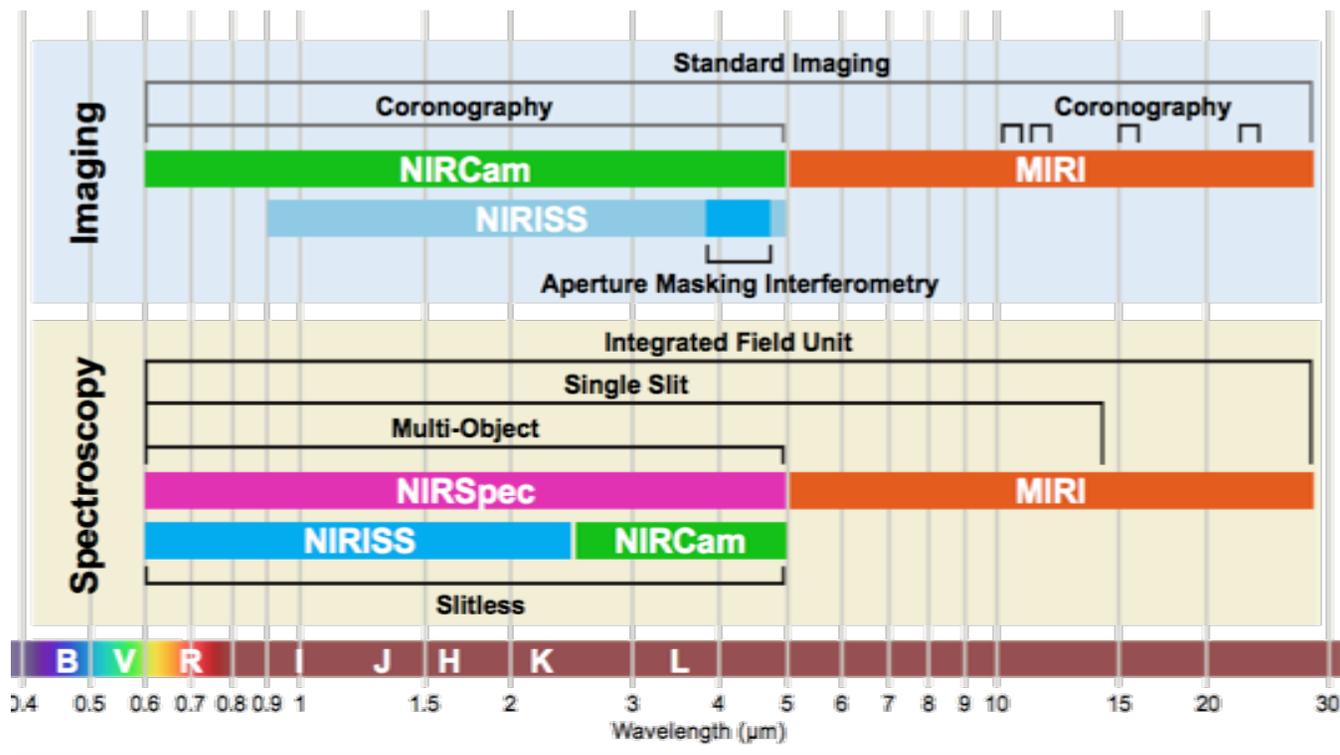
A suit of imaging and spectroscopy modes

First Light & Reionization

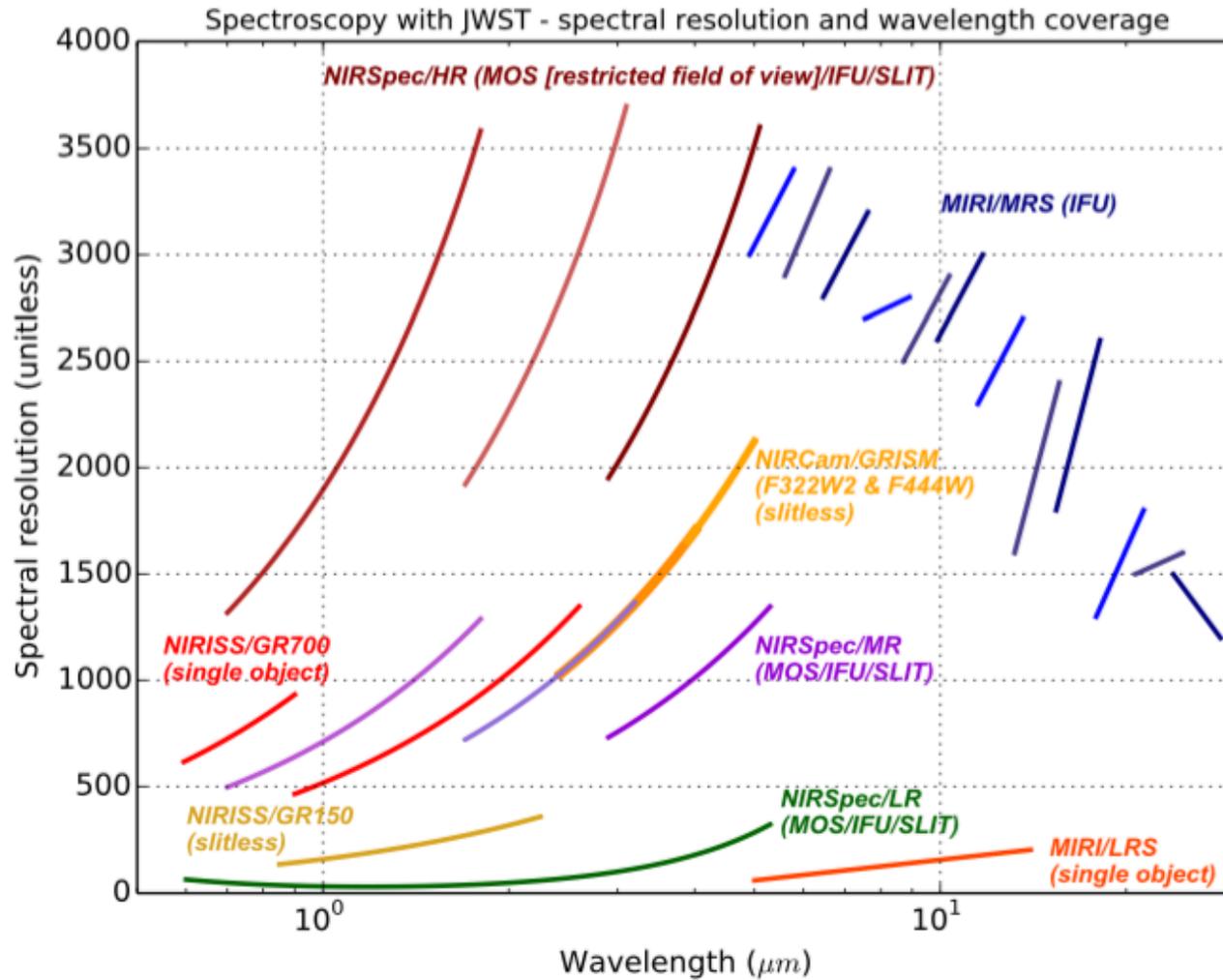
Assembly of Galaxies

Birth of Stars & Protoplanetary Systems

Planets & Origins of Life



Spectroscopy comes in many flavors



Outline

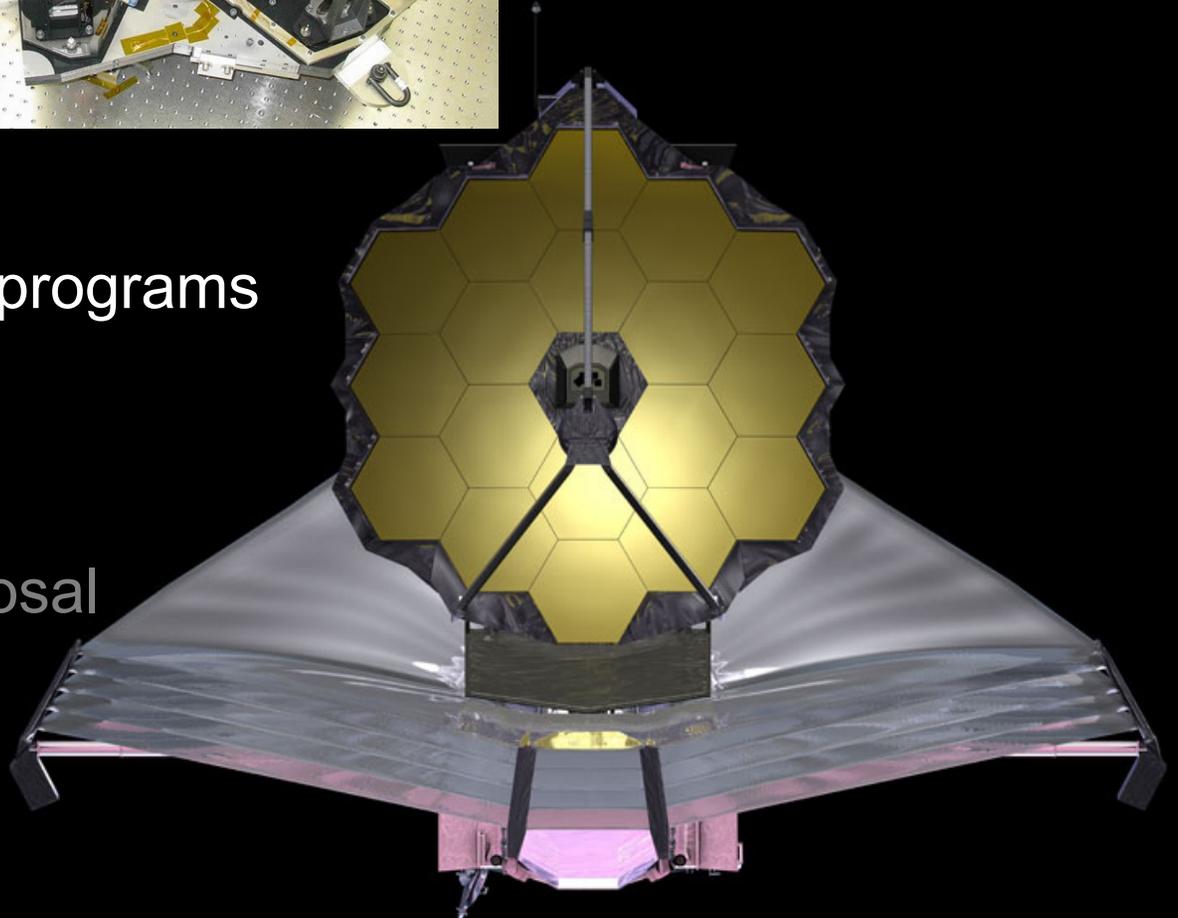
JWST primers



Instruments & science programs

- NIRCAM

Towards a JWST proposal

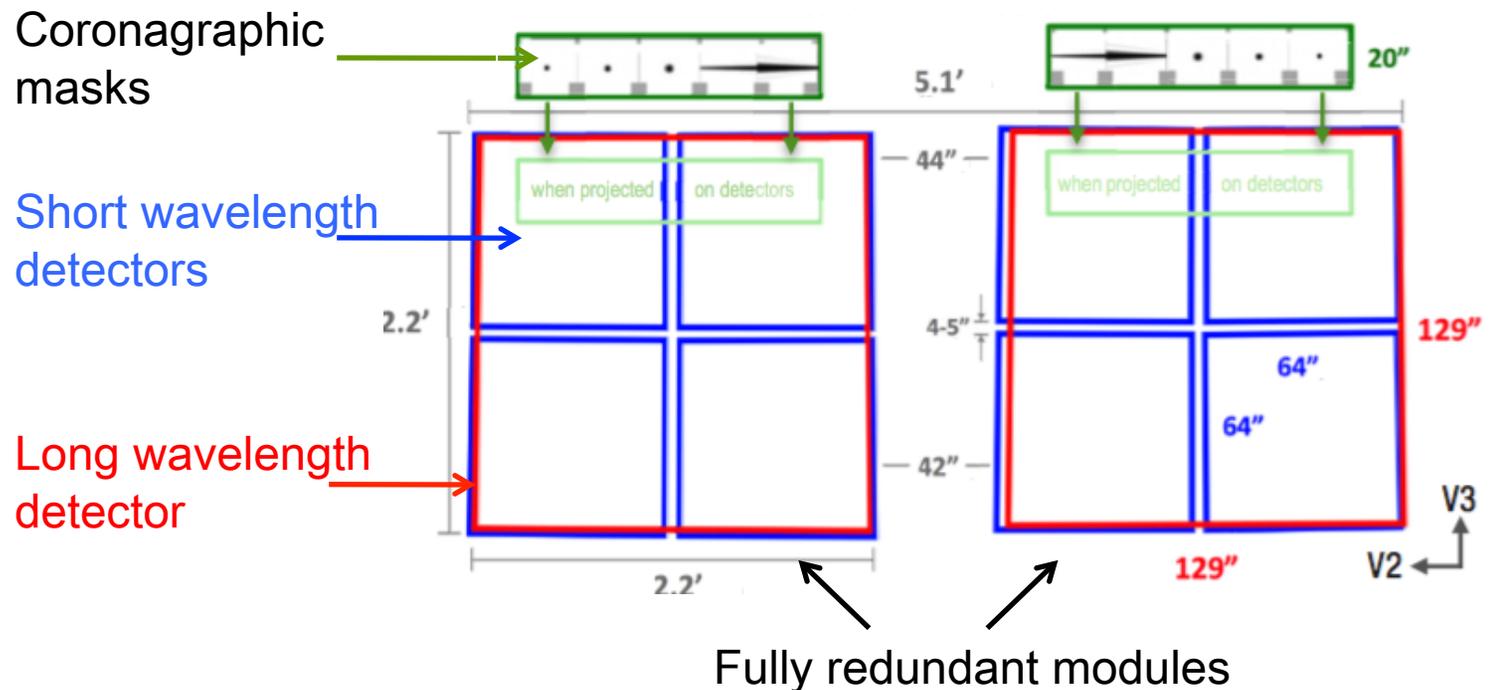


NIRCAM: Imaging – Coronagraphy – Slitless spectroscopy

λ : 0.6-2.3 / 2.4-5.0 μm

Nyquist at 2.0 / 4 μm

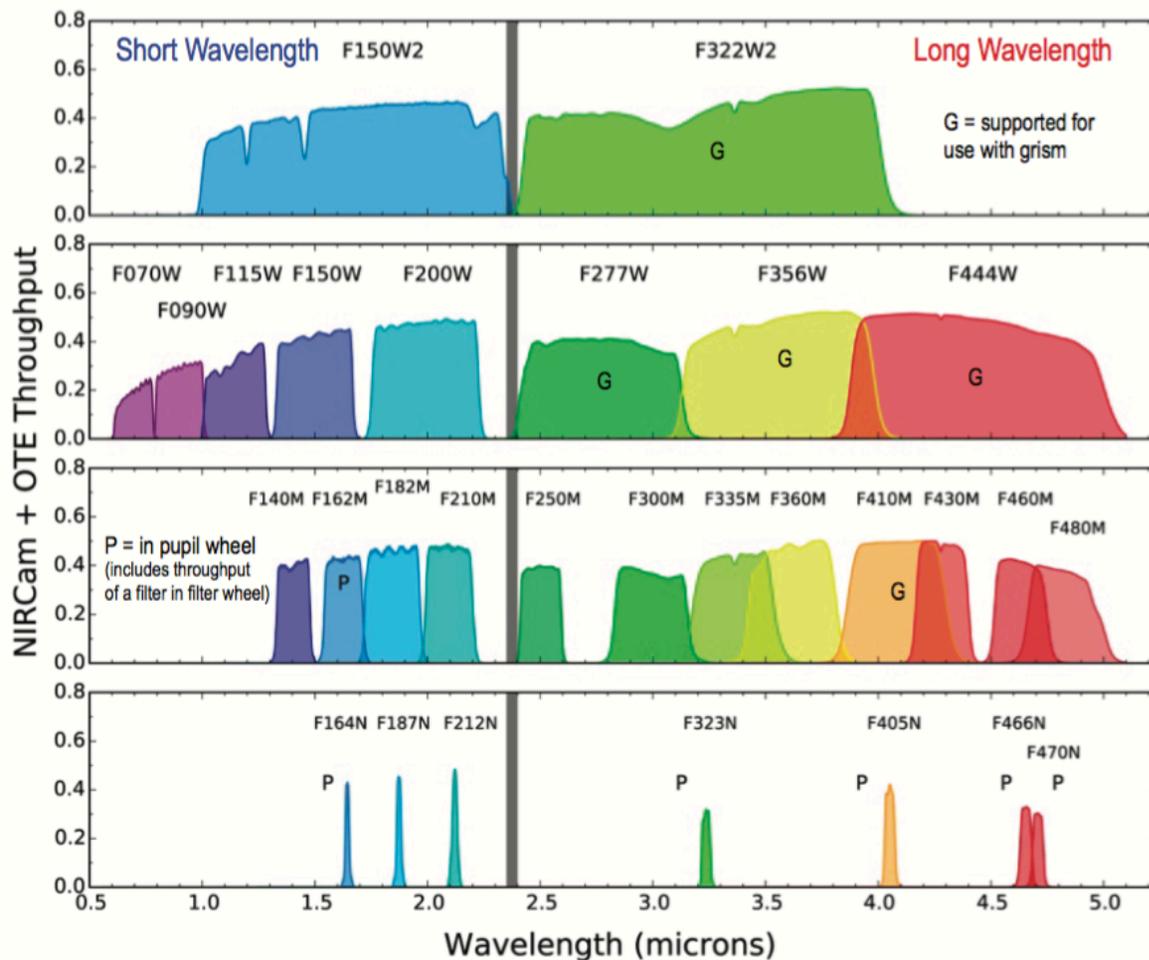
Pixel scale : 32/65 mas.pix⁻¹



NIRCAM Wide, Medium & Narrow band filters

Imaging saturation
K ~ 8-9.5 mag

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

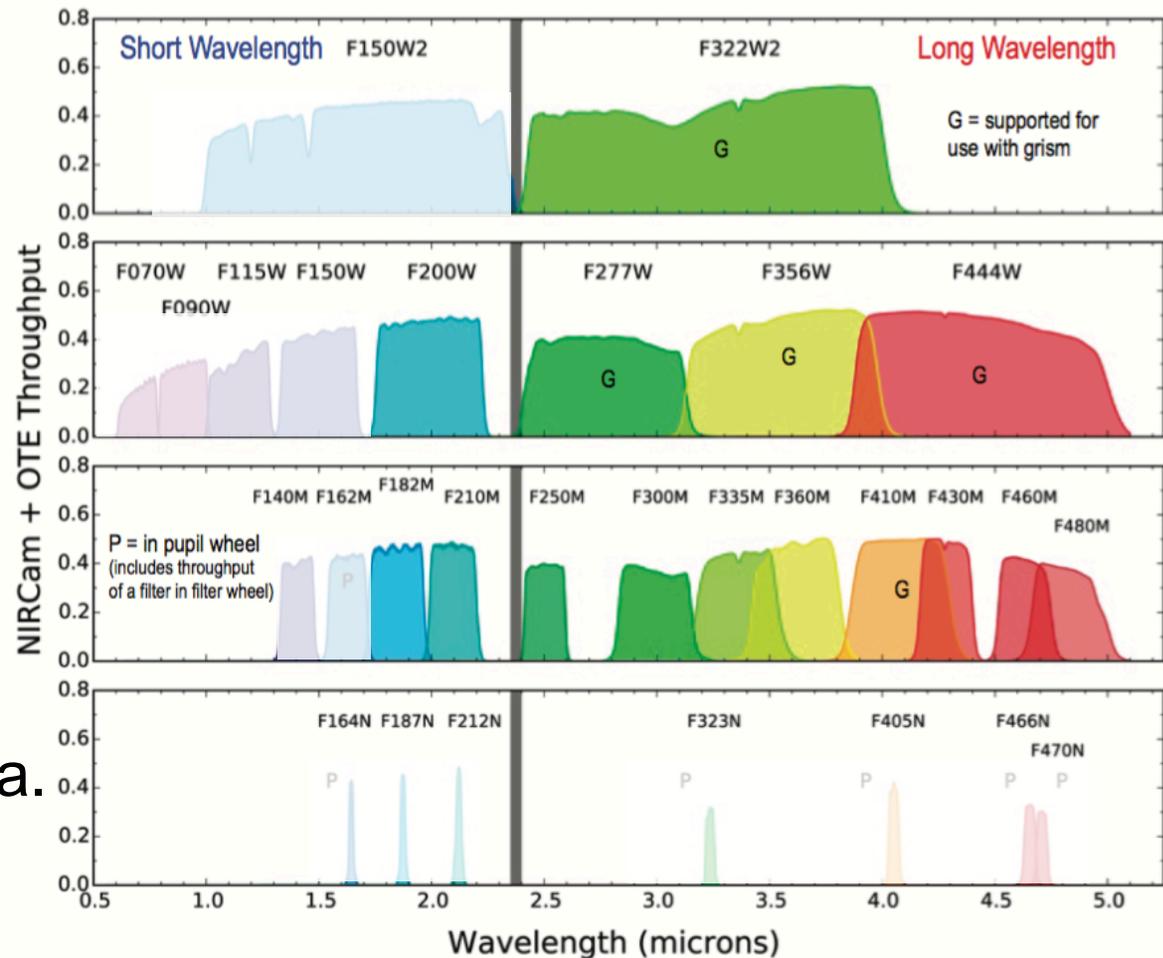


NIRCAM Medium & Narrow band filters isolate spectral features

Imaging saturation
K ~ 8-9.5 mag

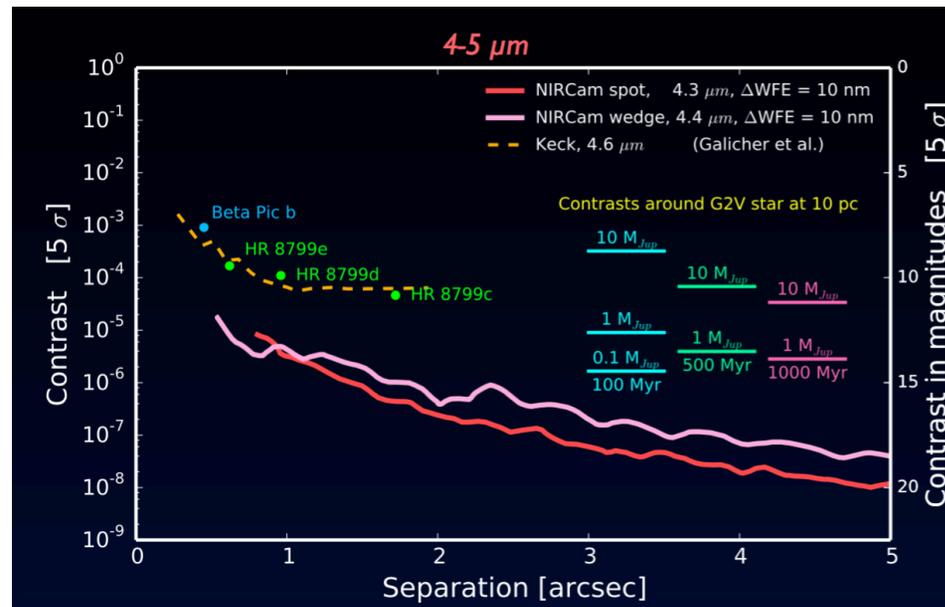
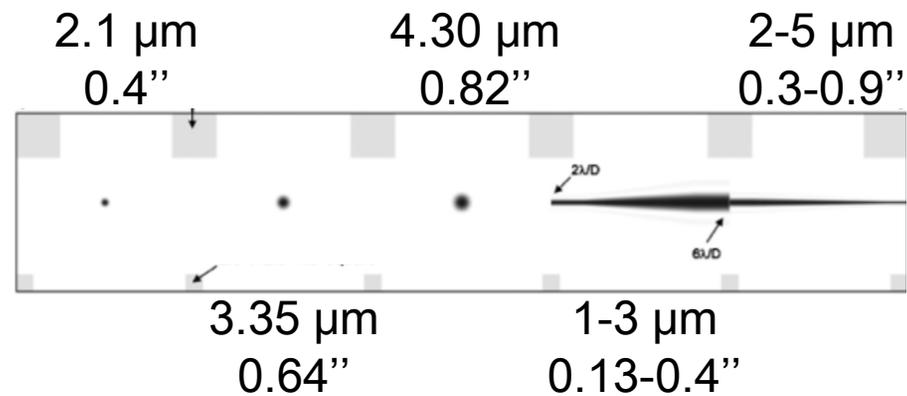
Imaging sensitivity
(SNR 10 in 10ks)
~10-21 nJy

Unavailable in corona.



NIRCAM coronagraph performance

Lyot stops:
19% throughput



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

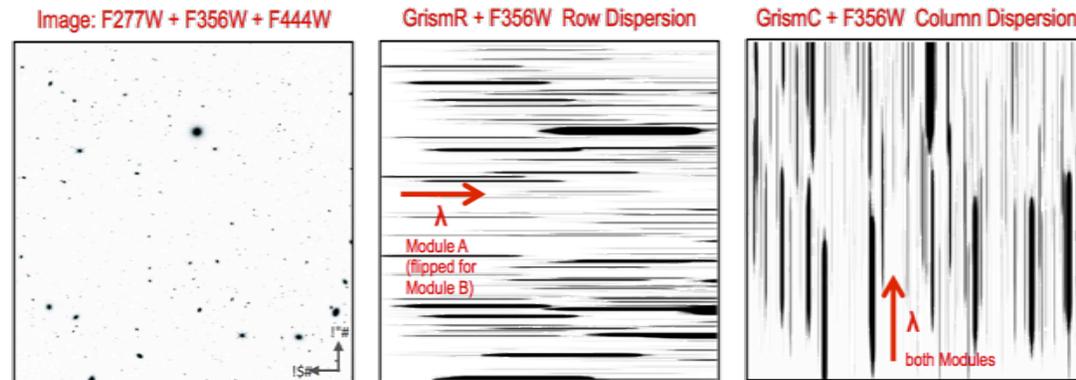
λ : 2.4-5.0 μm

Grism resolution: 1200-1550

Sensitivity (SNR 10 in 10ks) $\sim 5 \times 10^{-18}$ ergs/s/cm²

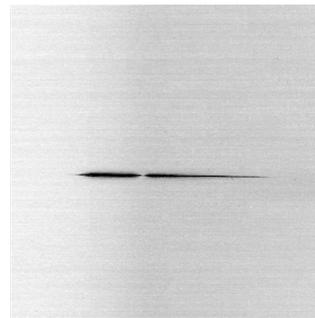
Saturation limit K ~ 4 mag

Wide field:

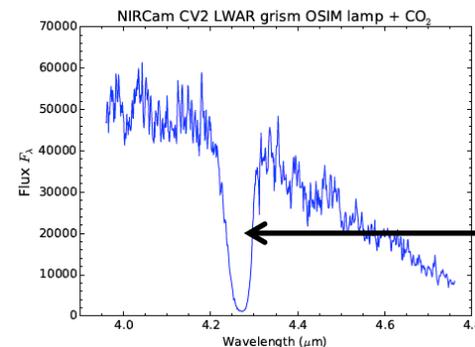


©JWST
Pocket guide

Single object:



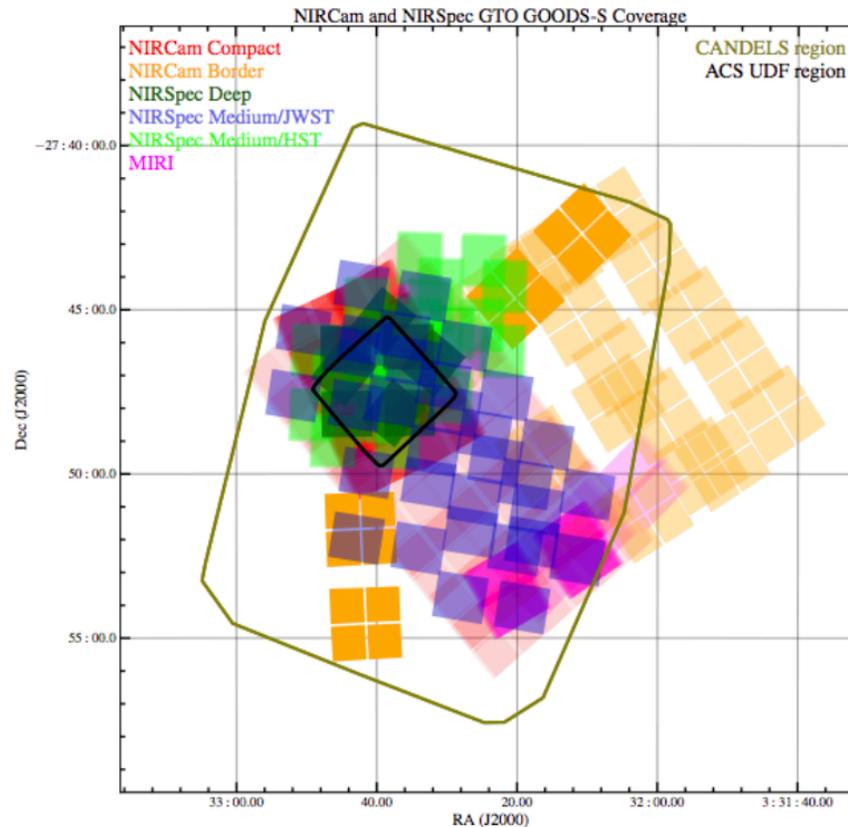
GrismR+F444W



Absorption
by CO₂
From the
testing lamp

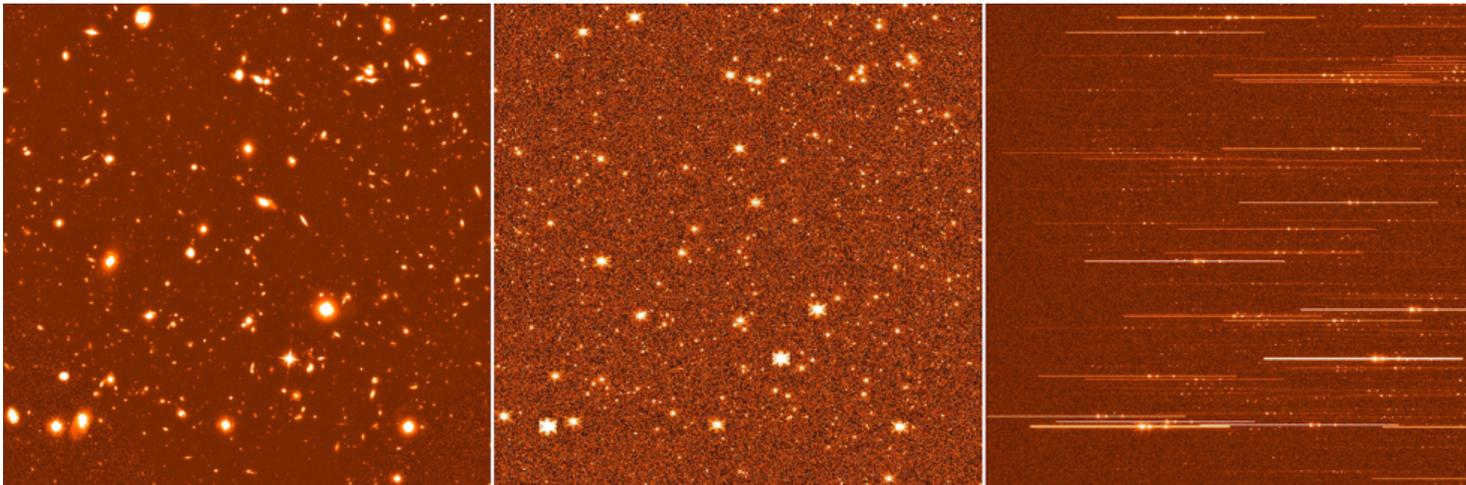
Science example: NIRCAM/NIRSpec/MIRI deep survey

Understanding galaxy evolution from $z \sim 12$ to $z \sim 2$



Science example: High-z galaxies with WFSS

Searching for high-z line emitters



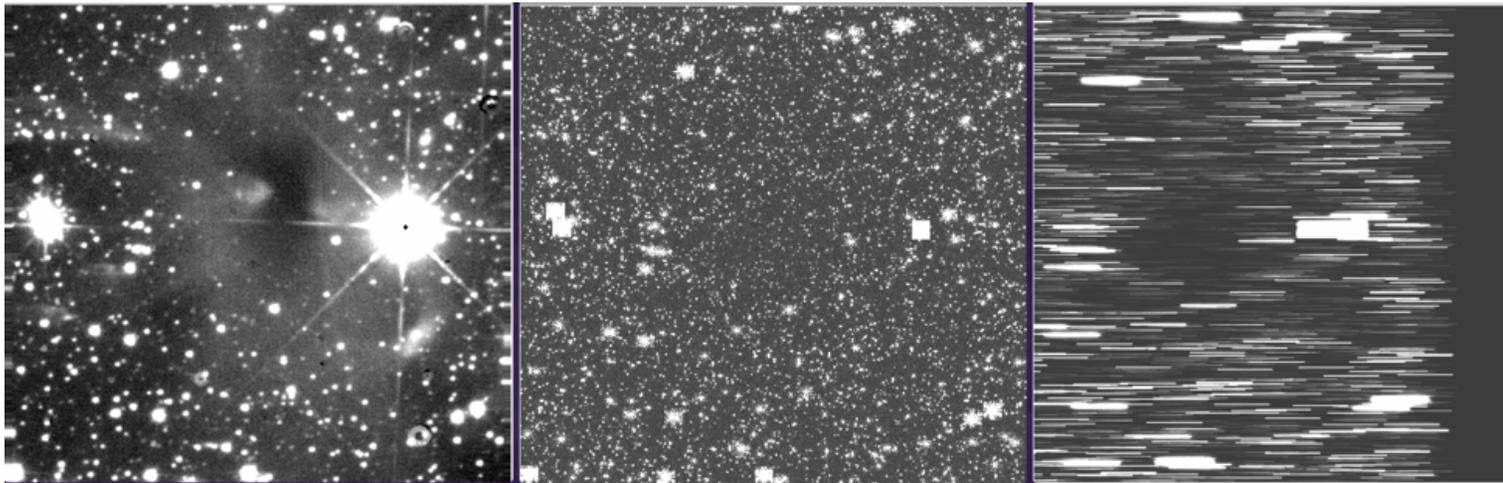
Hubble XDF
WFC3 F160W
65 hrs

Imaging
F356M, 2 hrs

GrismR
F356M, 2 hrs

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

Probing grain composition in dark clouds



B335 Dark Cloud
K-band, 3.2 hrs
UKIRT

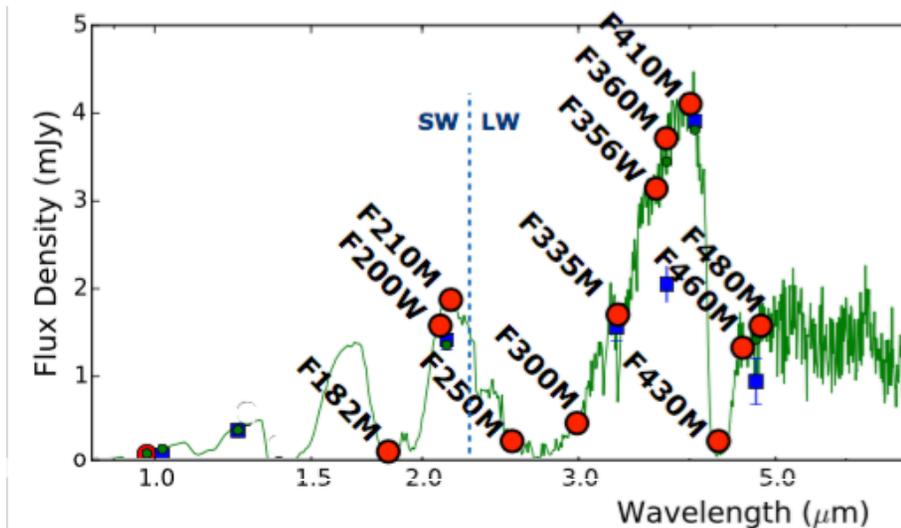
Imaging
F430M, 1sec

GrismR
F430M, 30s

Science example: Characterizing brown-dwarf and exoplanet atmospheres



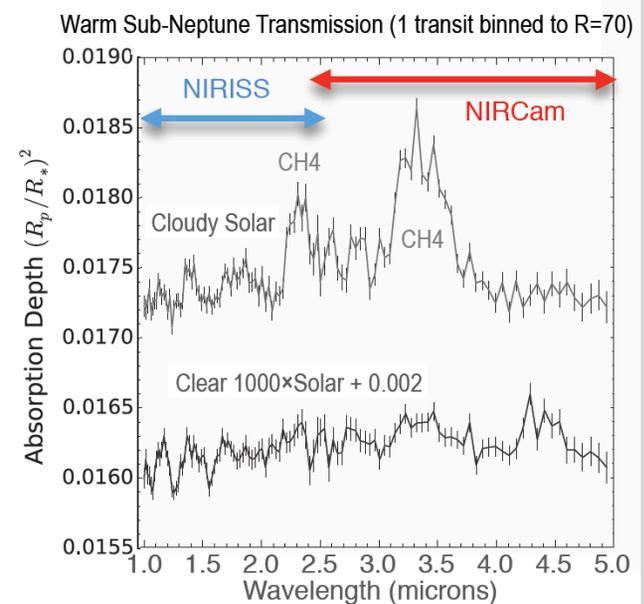
Self-luminous substellar objects



Model $T_{\text{eff}}=1000\text{K}$, $\log(g)=3.5$

©M. Perrin

Transit spectroscopy



Outline

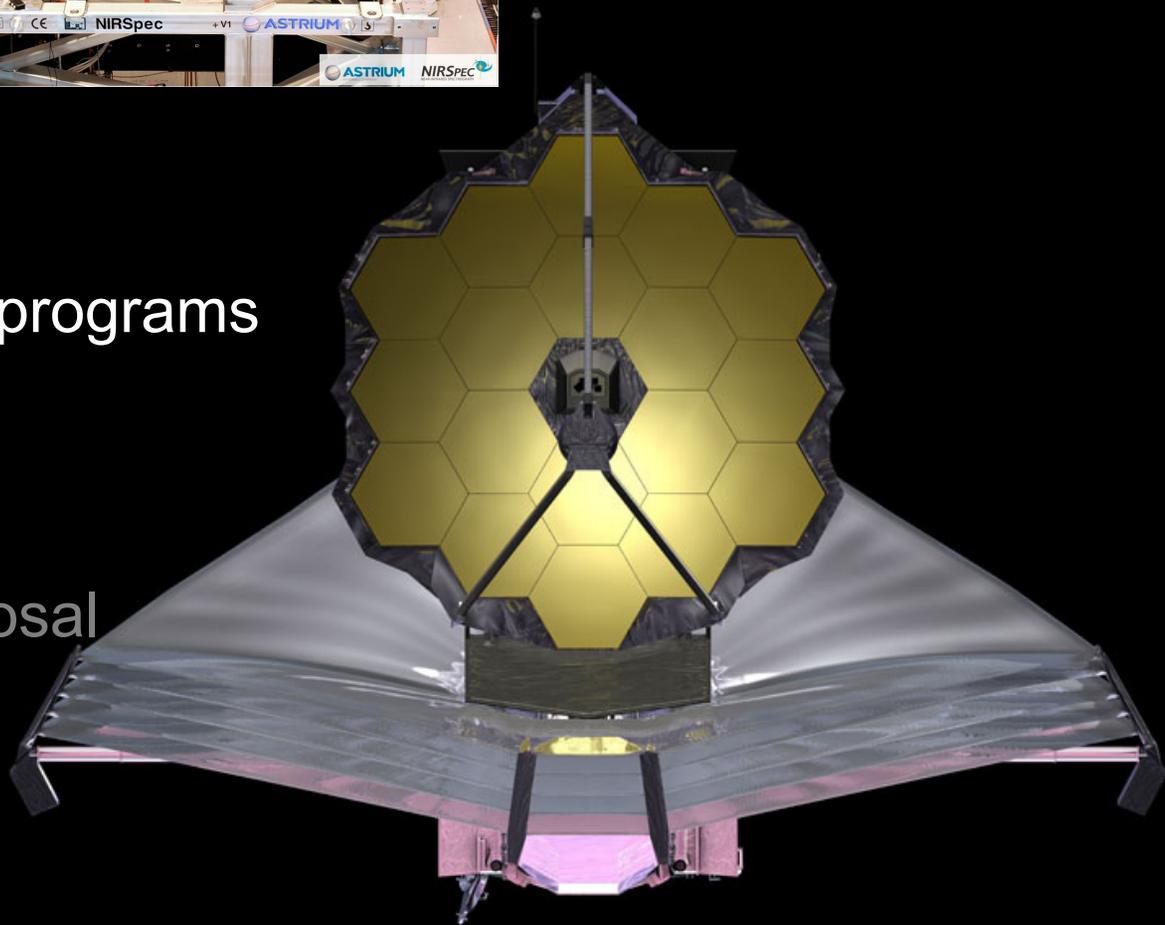


JWST primers

Instruments & science programs

- NIRSpec

Towards a JWST proposal

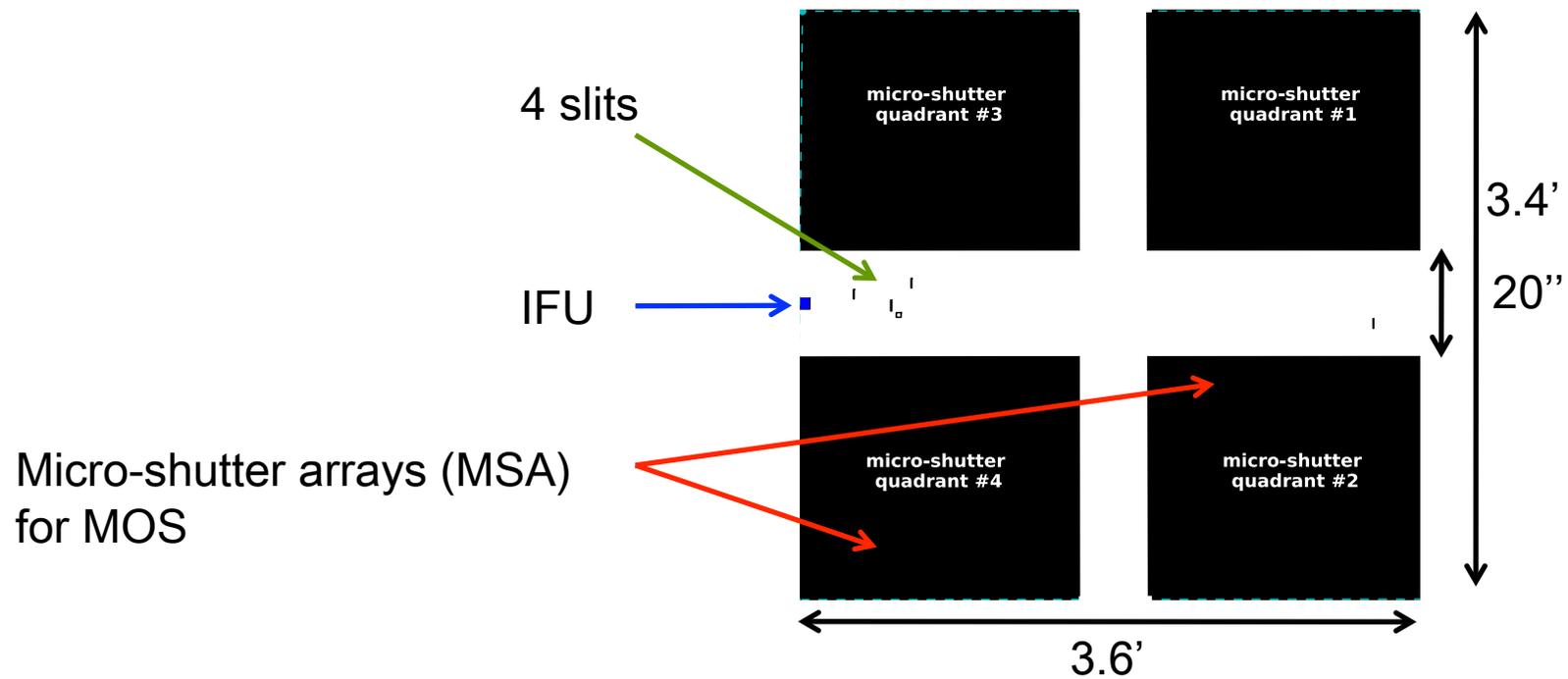


NIRSpec: all flavors of spectroscopy

λ : 0.6-5.3 μm

Resolution: ~ 100 -2700

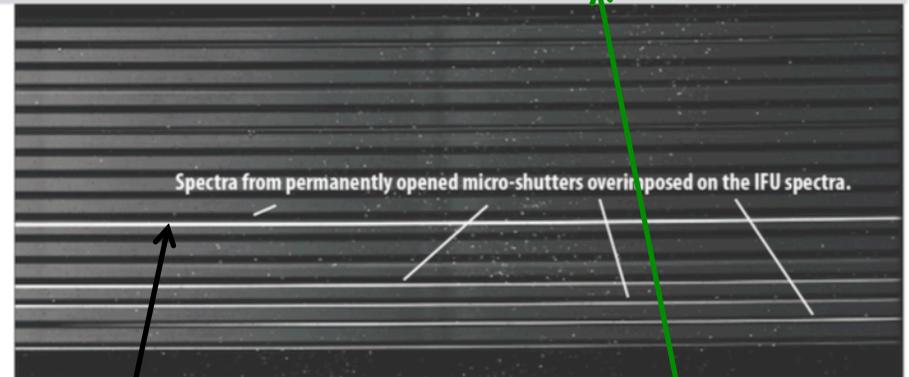
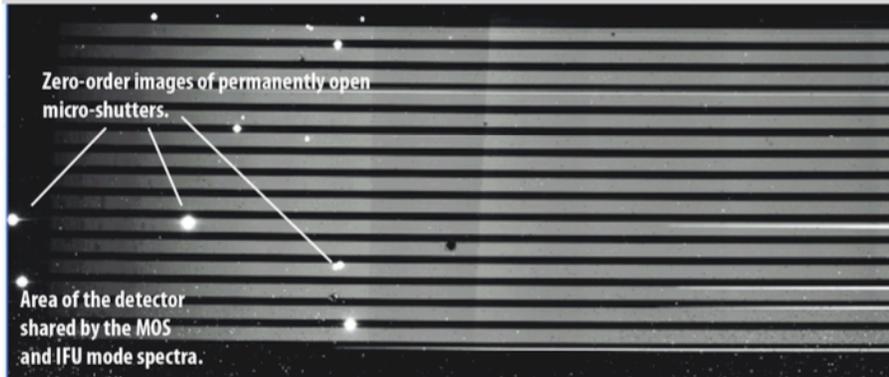
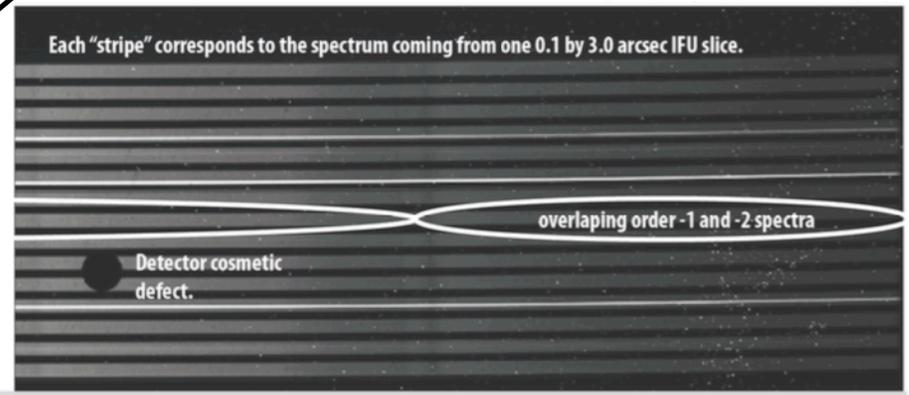
Pixel scale: 0.1'' pix^{-1}



NIRSpec field-of-view layout

MOS/IFU spectra

Mind the gap !



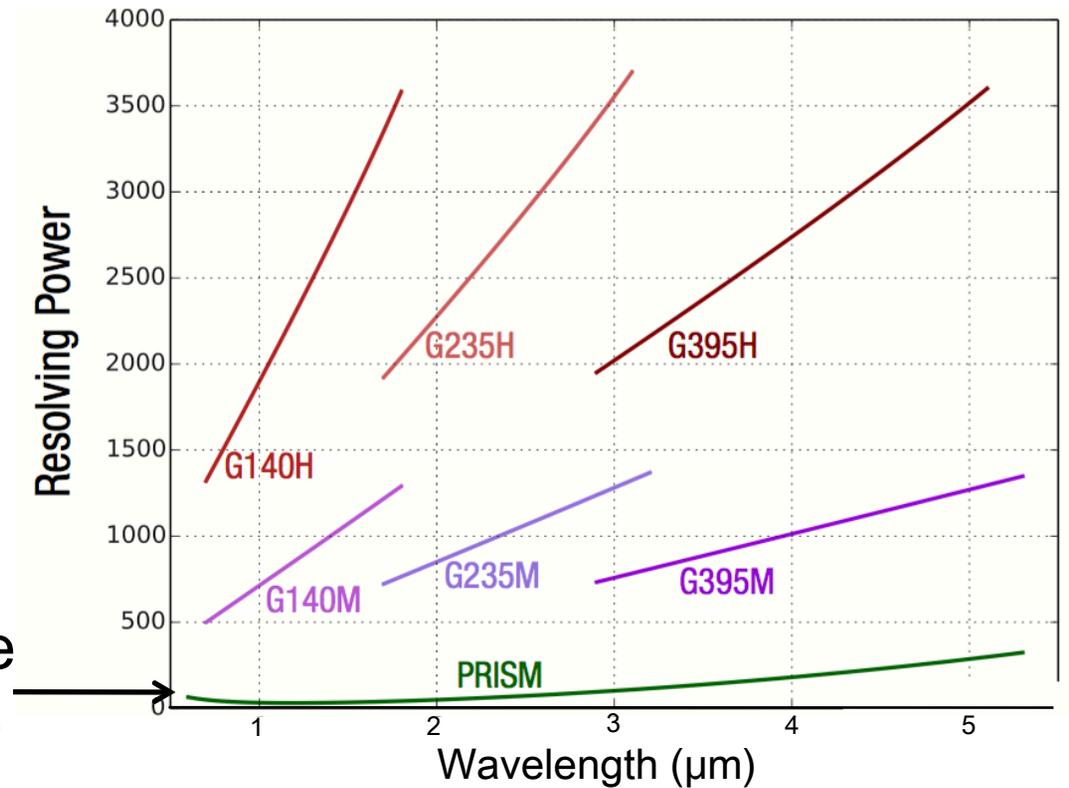
©Ferruit et al. (2012)

MSA defect

Slit
exclusive spectra area

NIRSpec: high-resolution spectra will require multiple exposures

Full wavelength coverage at low resolution ($R \sim 100$) in one shot



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

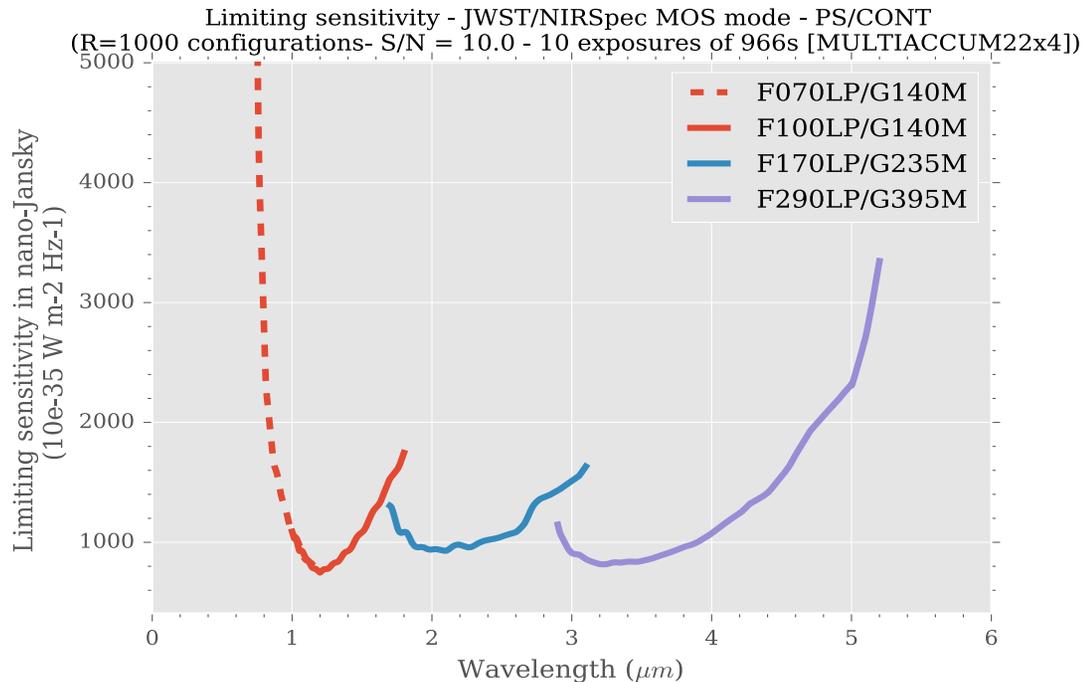
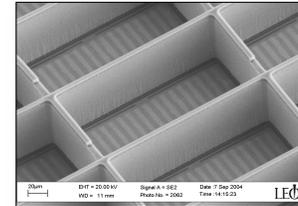
250 000 micro shutters on a fixed grid

Micro-shutter FoV: 0.2''x 0.46''

FoV: 3.6'x3.4'

Need very accurate astrometry (5mas)

Point source at R=1000:

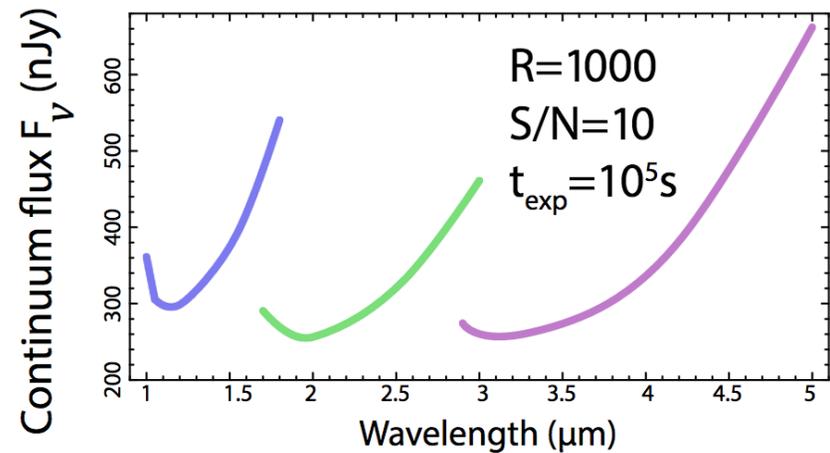
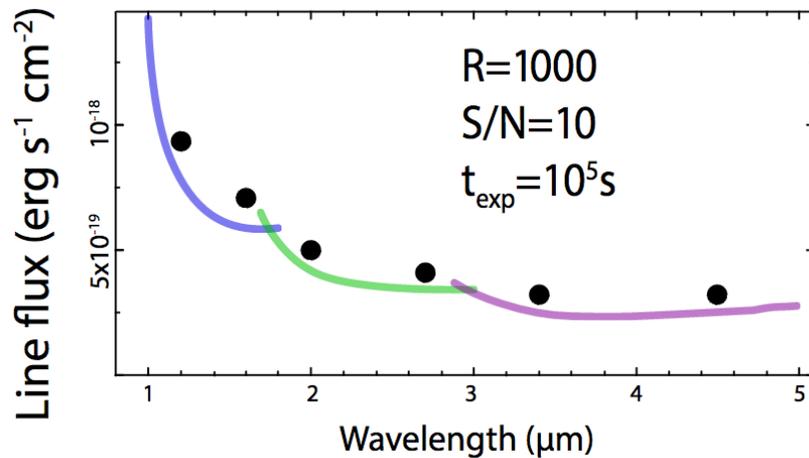


NIRSpec: IFS of extended/multiple sources

FoV: 3" x 3"

Pixel scale: 0.1" pix⁻¹

Saturation: J~5-7.5mag



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

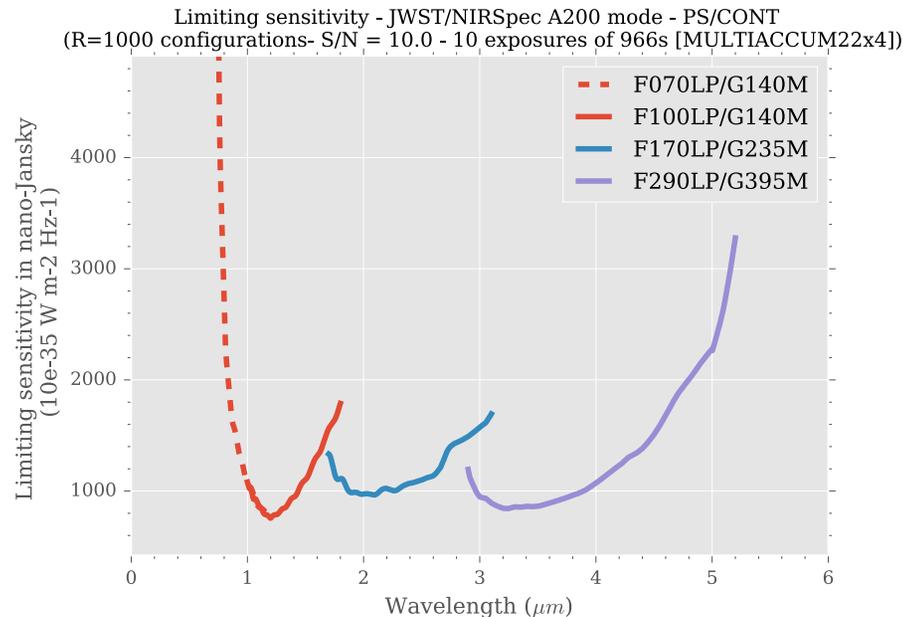
FoV: 0.2''x3.3''/0.4''x3.65''/1.6''x1.6''

Pixel scale: 0.1'' pix⁻¹

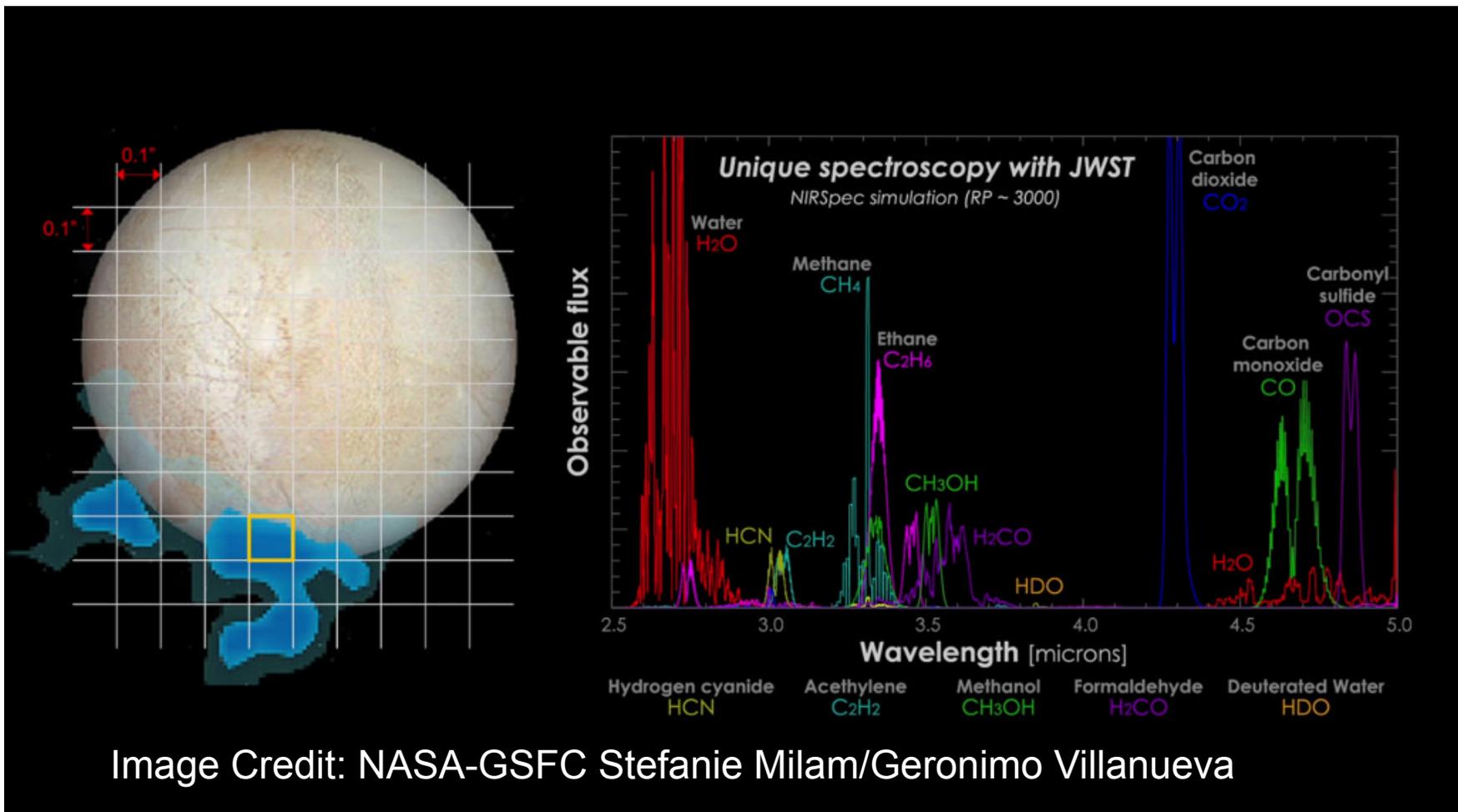
Sensitivity similar to MOS

Saturation limit: J~5-9.5 mag

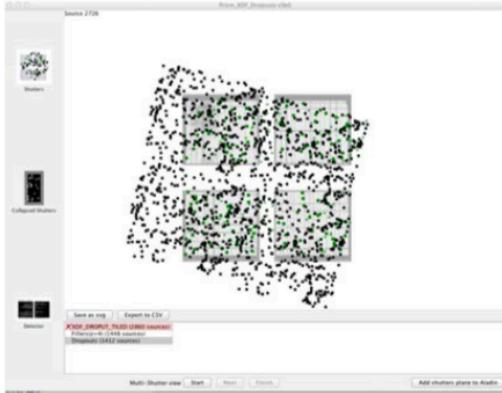
Bright Object Time Series (BOTS) optimized for transits



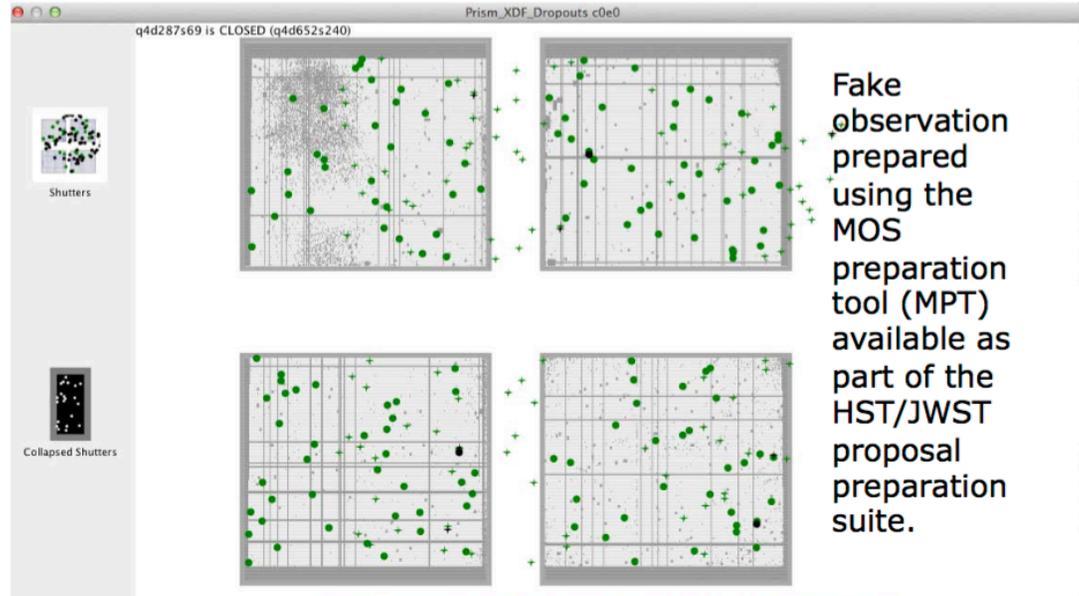
NIRSpec science example: Probing the chemical composition of Europa's and Enceladus' plumes



NIRSpec science example:



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

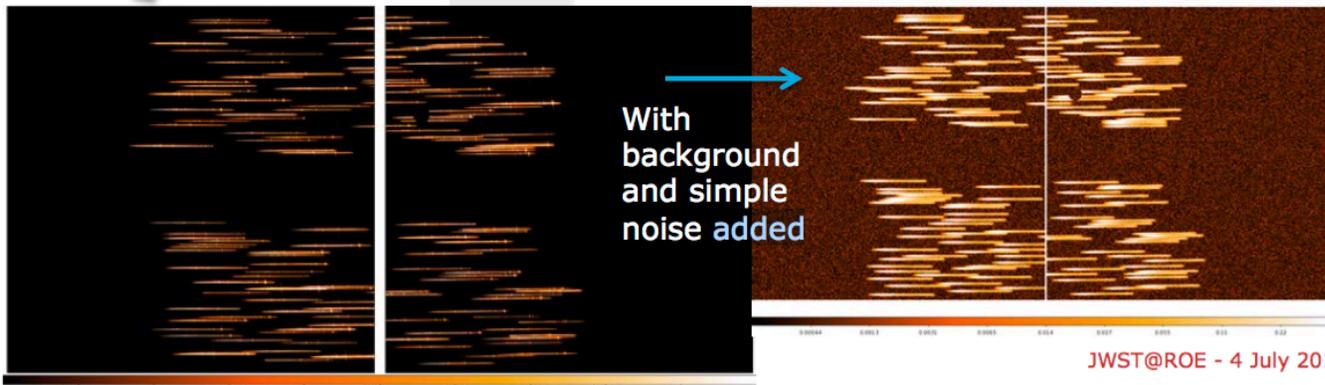


Fake observation prepared using the MOS preparation tool (MPT) available as part of the HST/JWST proposal preparation suite.

Spectra generated using BEAGLE (Chevallard & Charlot 2016)

Objects only, noiseless exposure.

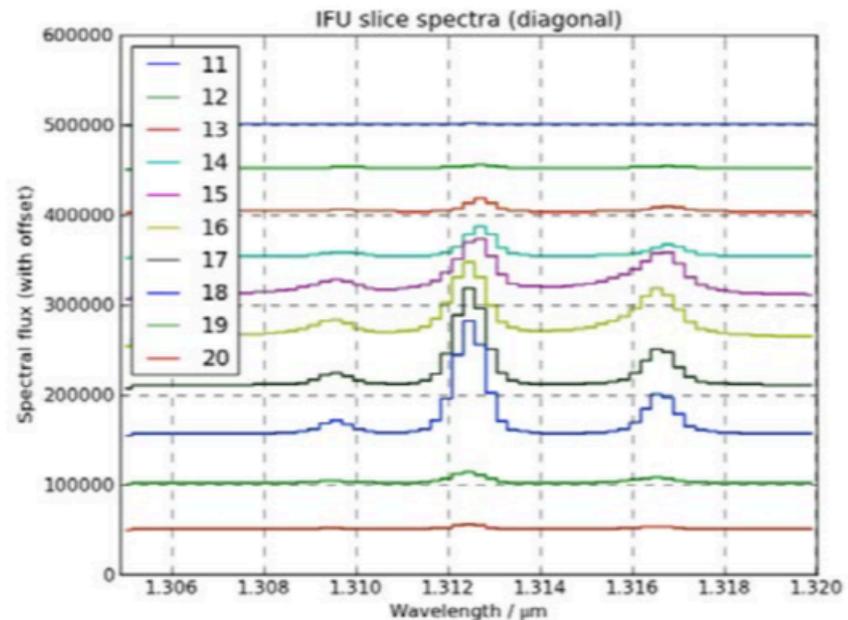
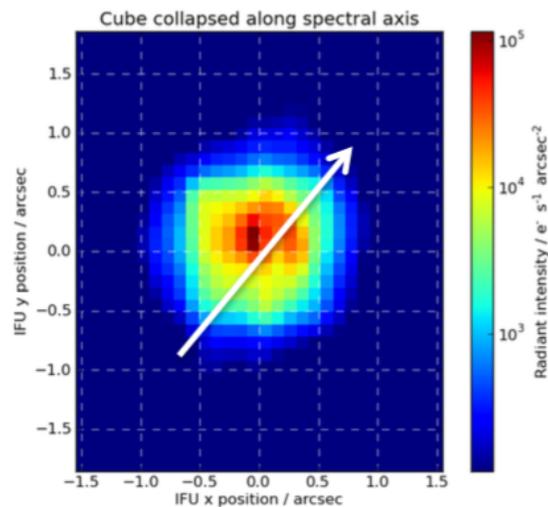
CLEAR/PRISM (short spectra, high multiplex)



With background and simple noise added

NIRSpec science example: Galaxy dynamics

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



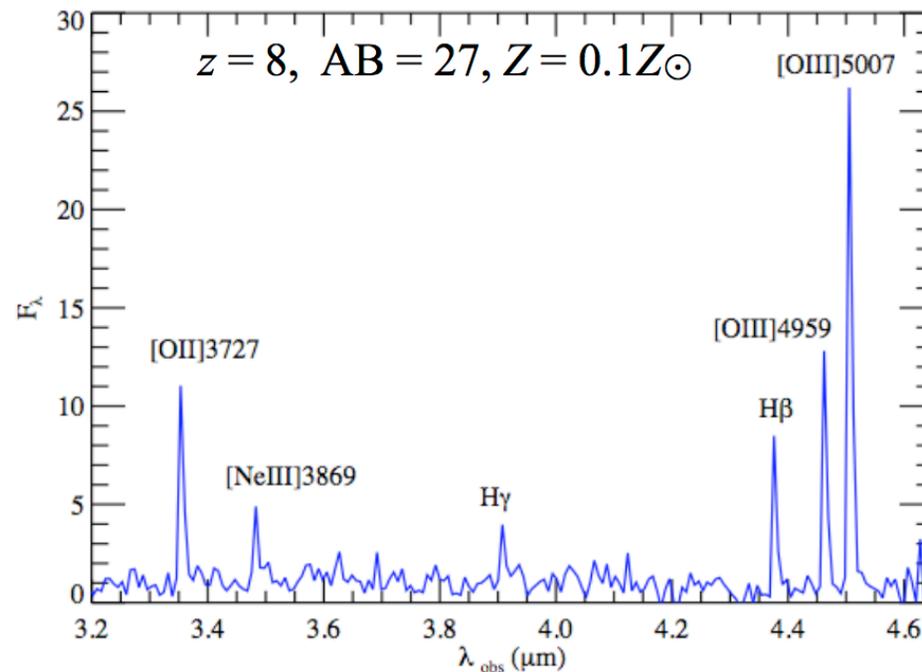
Using VIMOS [NII]+H α data from Bellocchi et al. 2012 of a nearby galaxy.
redshifted to z=1

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

©P. Ferruit.

NIRSpec science example: Metal enrichment of distant galaxies

High quality spectra to measure line ratios



SLIT spectroscopy of $z=8, AB=27$ quasar

©Maolino et al.

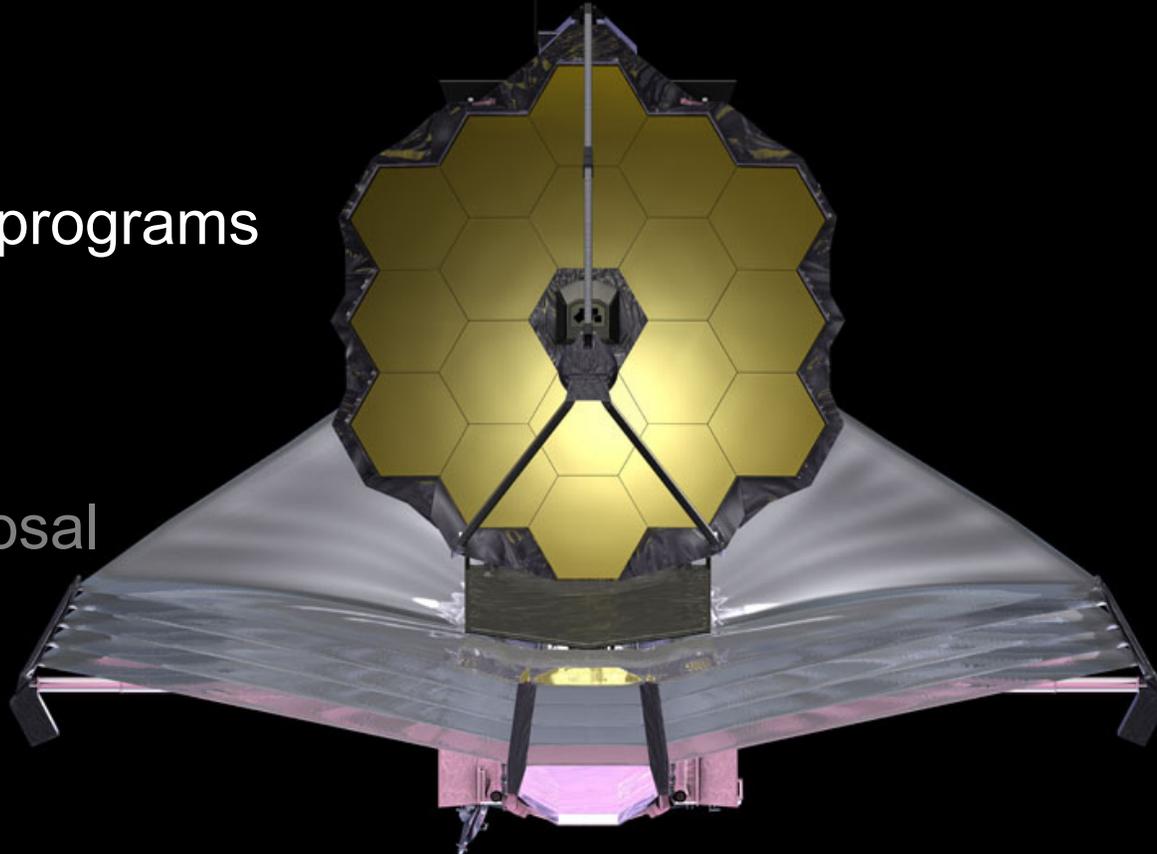
Outline

JWST primers

Instruments & science programs

- MIRI

Towards a JWST proposal

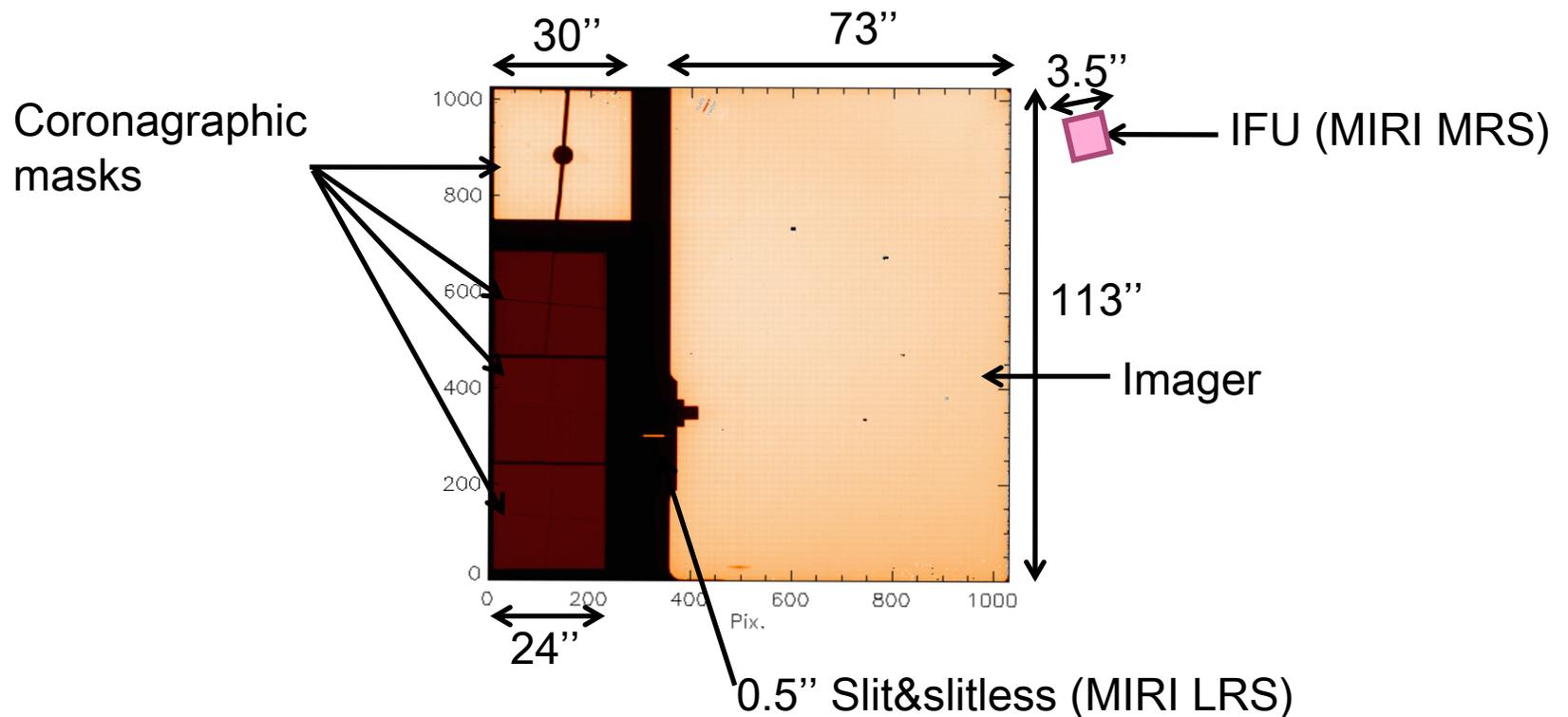


MIRI: Imaging – Coronagraphy – Spectroscopy (slit, slitless, IFU)

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

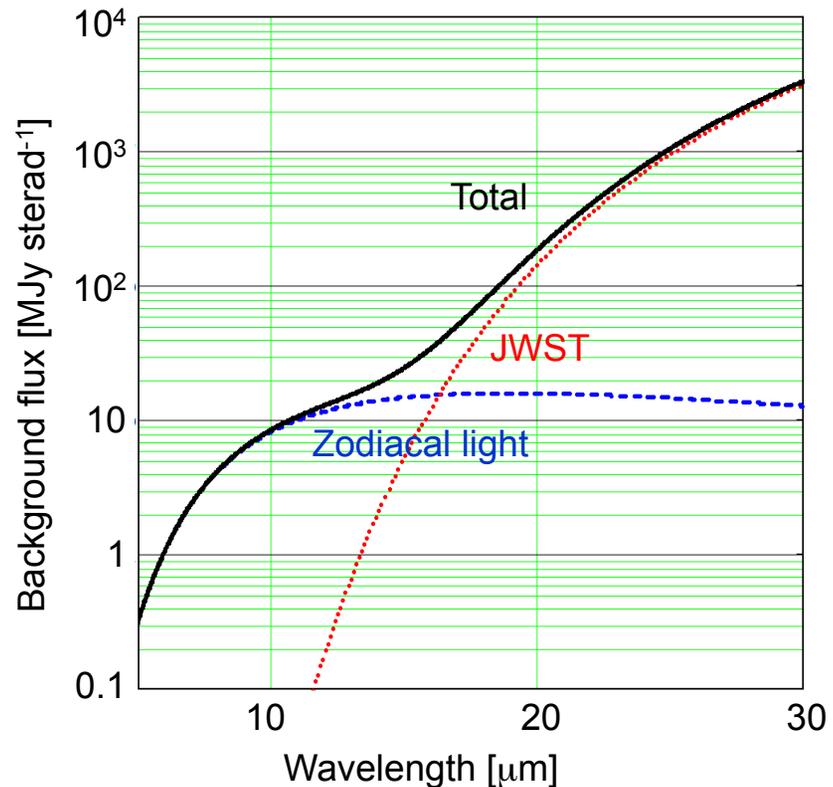
~ 3 mJy (7.7μm)

to 105 mJy (25.5μm)

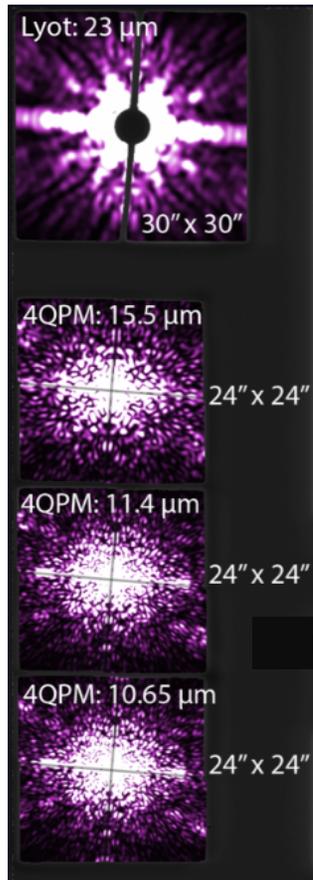
Point source sensitivity

(SNR 10 in 10ks)

~0.2-29 μJy



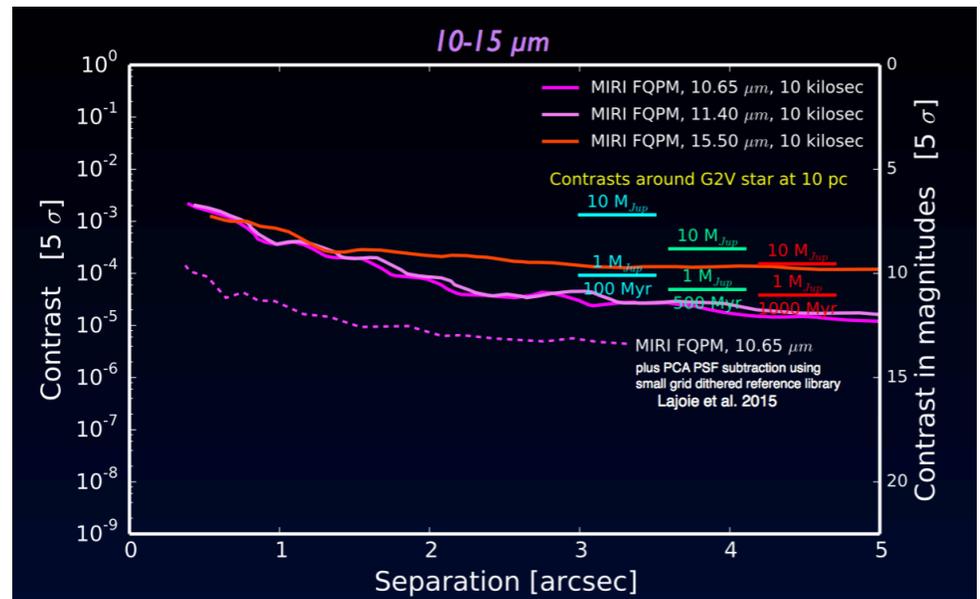
MIRI Coronagraphs



IWA 2.1''
C2300: continuum

IWA: 1 λ/D
Cont. (wide)

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



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)

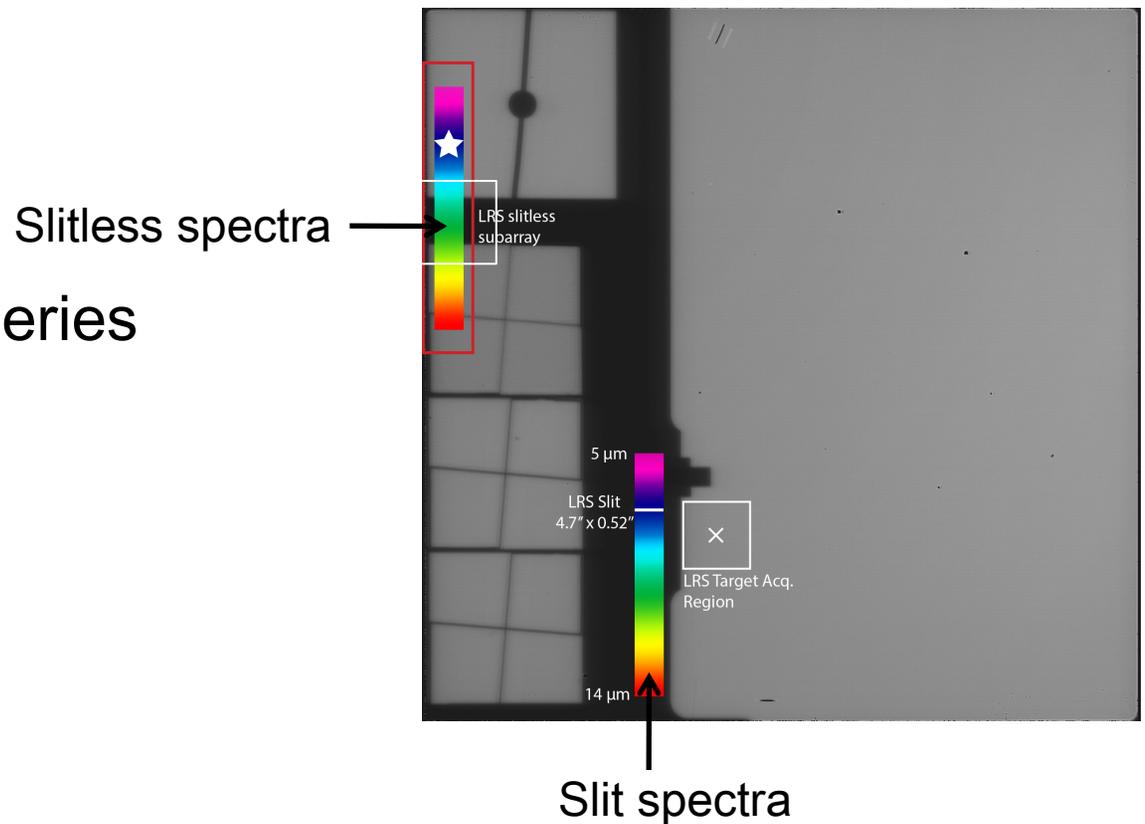
Saturation

~ 70 mJy (K~8mag, slit)

or 1220 MJy (slitless)

Continuum sensitivity

~ 8 μJy (slit) or 18 μJy (slitless)

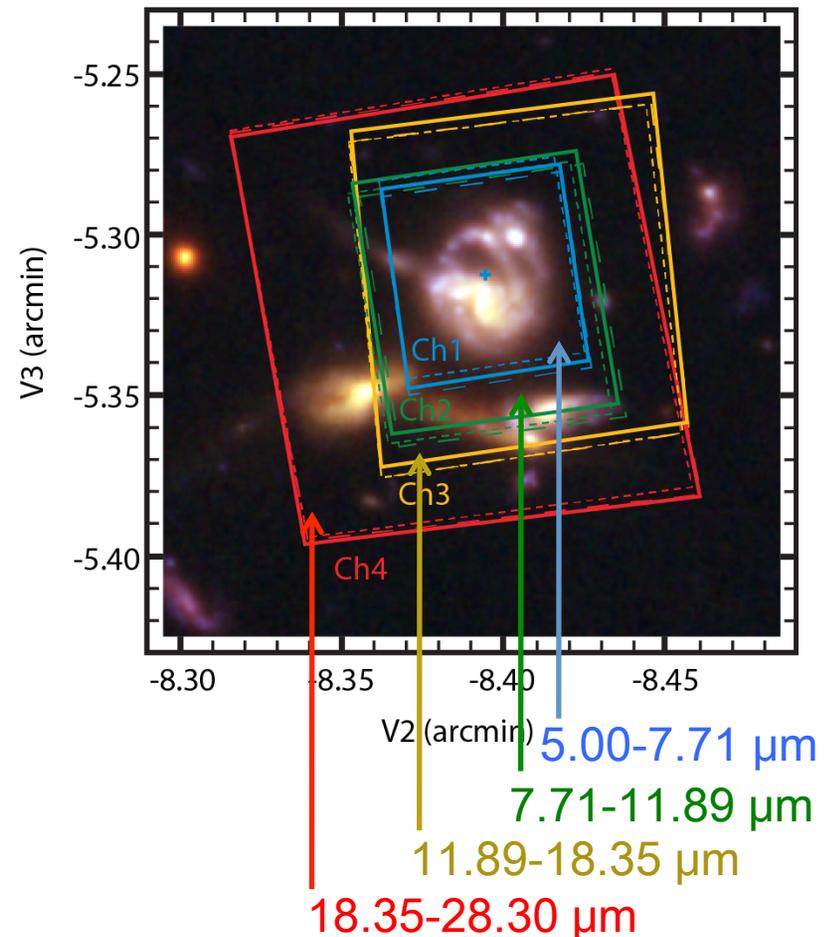


MIRI Medium Resolution Spectrometer (MRS) implemented as 4 IFUs

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- $22.5\mu\text{m}$)

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

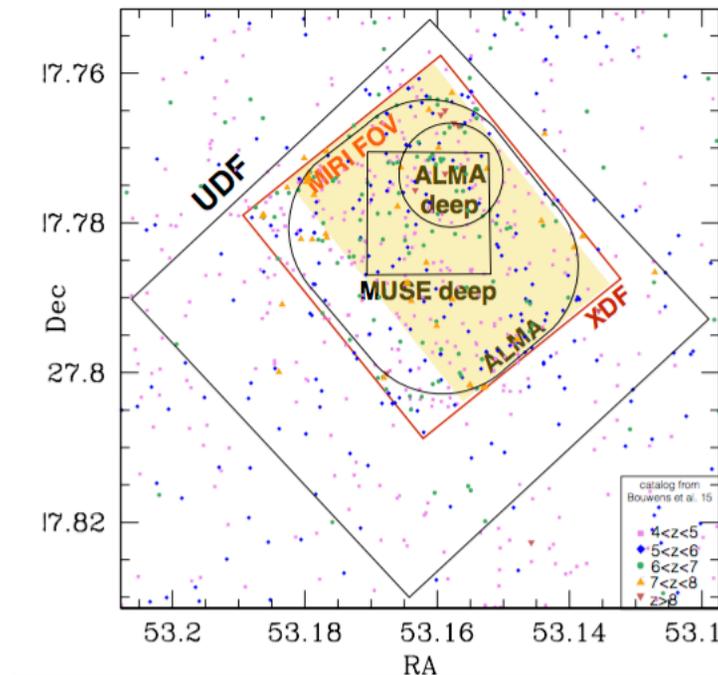


MIRI science example: High-z (first light) galaxies

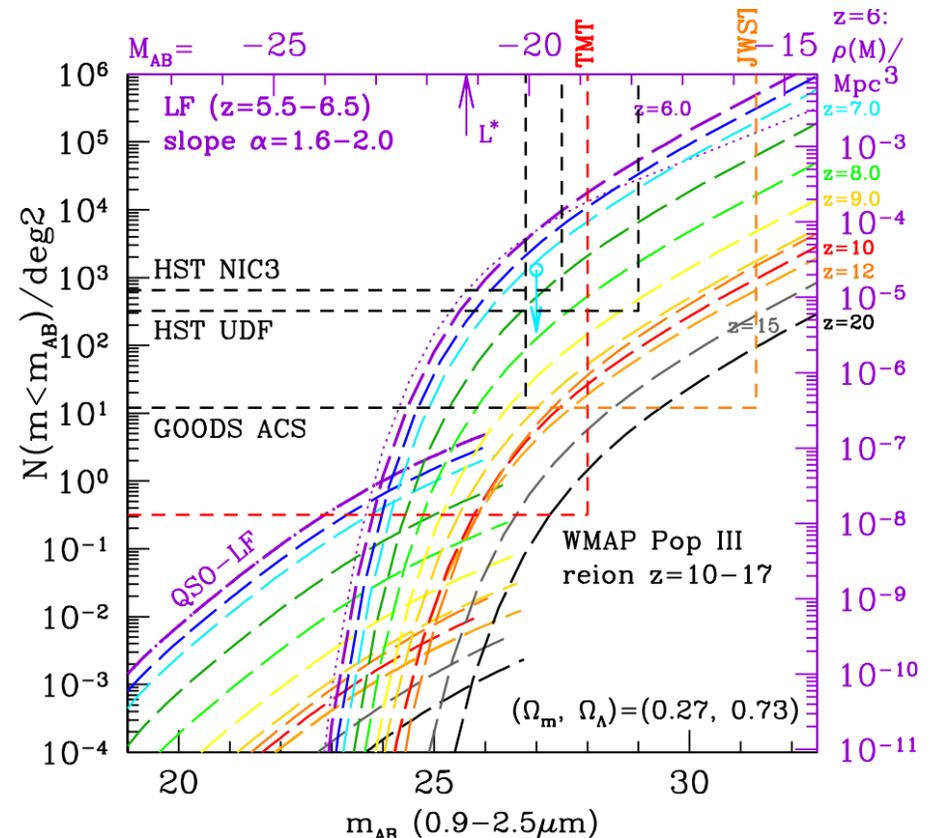


Tracing the entire reionization epoch

Multi-band deep imaging



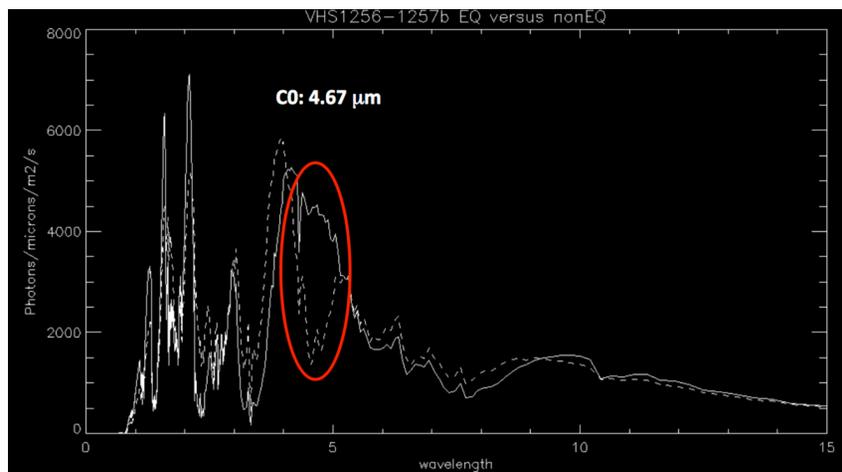
©F. Walter



©NASA

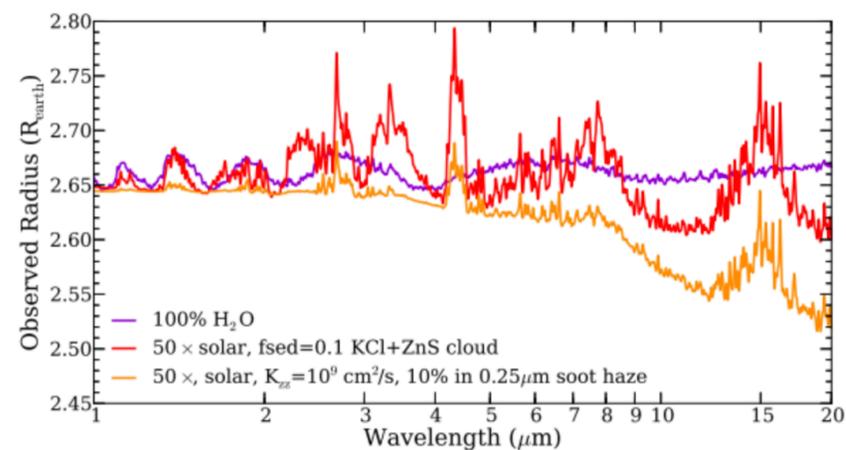
MIRI science example: Opening an almost unexplored territory in atmospheric characterization

Self-luminous substellar objects



NIRSpec+MIRI LRS
VHS1256b

Transit spectroscopy

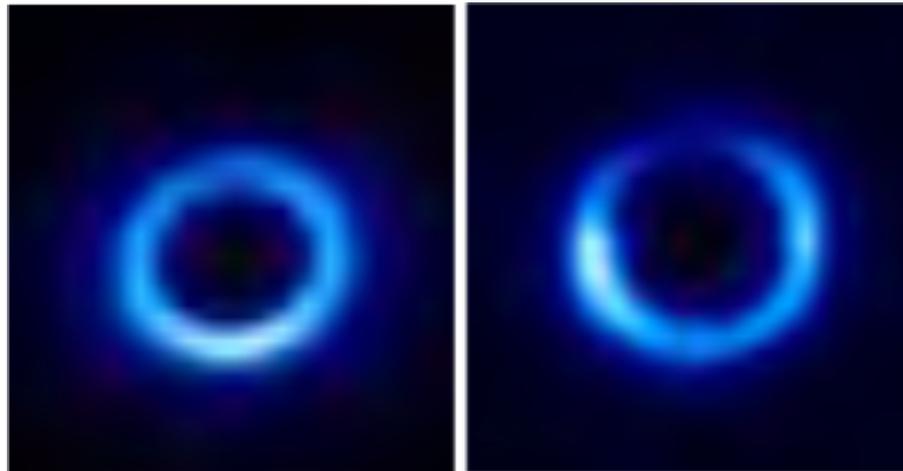


NIRSpec+MIRI LRS
Earth-like planet

Morley et al. (2013)

MIRI science example: Circumstellar disks

Probing colors, albedo, phase, grain compositions



HD 181327
4QPM+F1140C

Lyot+F2300C

Outline



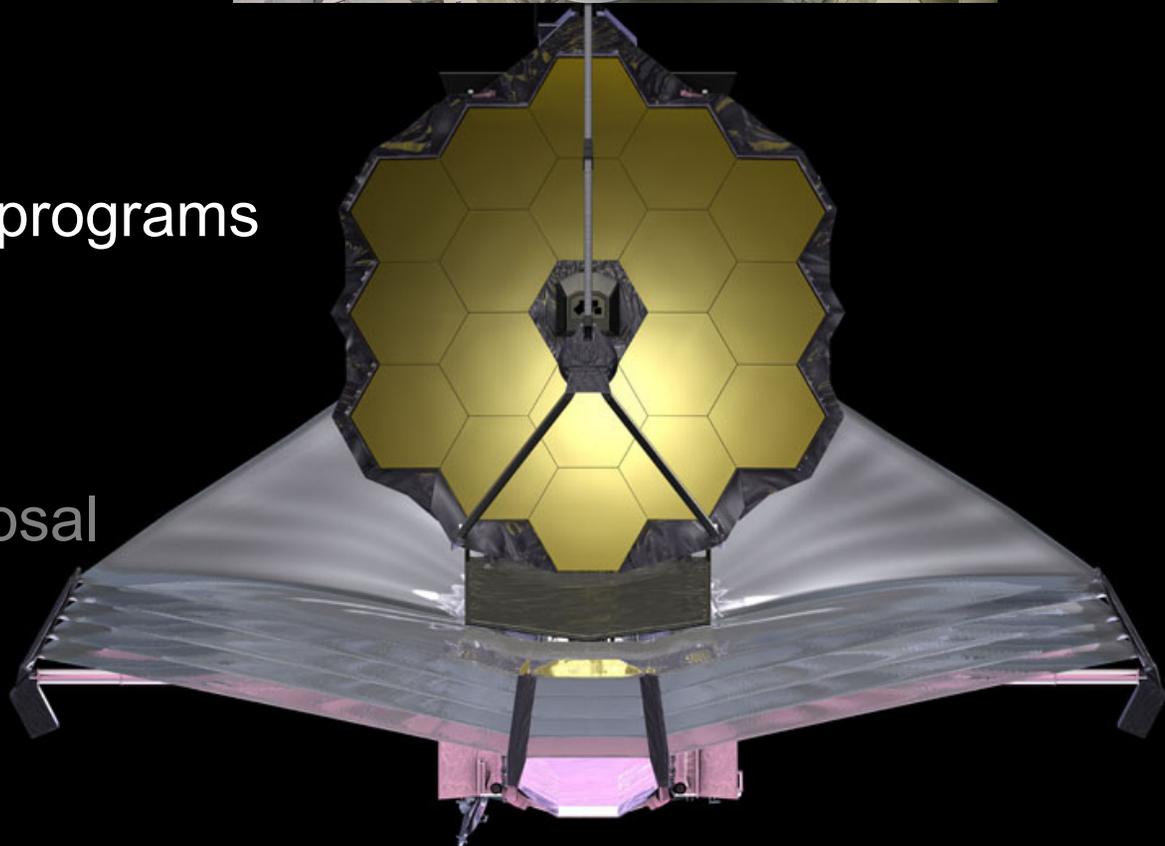
JWST primers



Instruments & science programs

- NIRISS

Towards a JWST proposal



NIRISS: Imaging – Interferometry – Slitless spectroscopy

λ : 0.6-5.0 μm

Nyquist at 4.0 μm

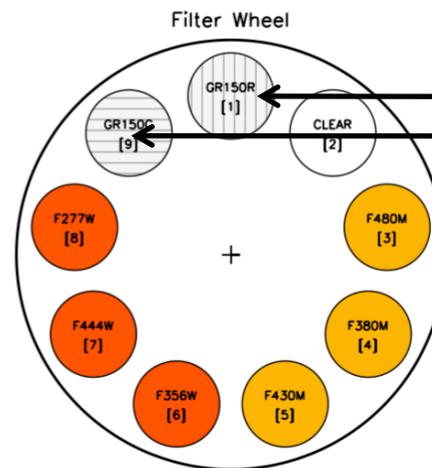
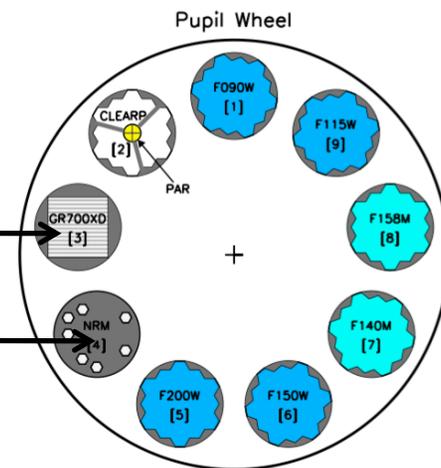
Pixel scale : 65mas.pix⁻¹

Field of view: 2.2'x2.2'

Same specifications 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)

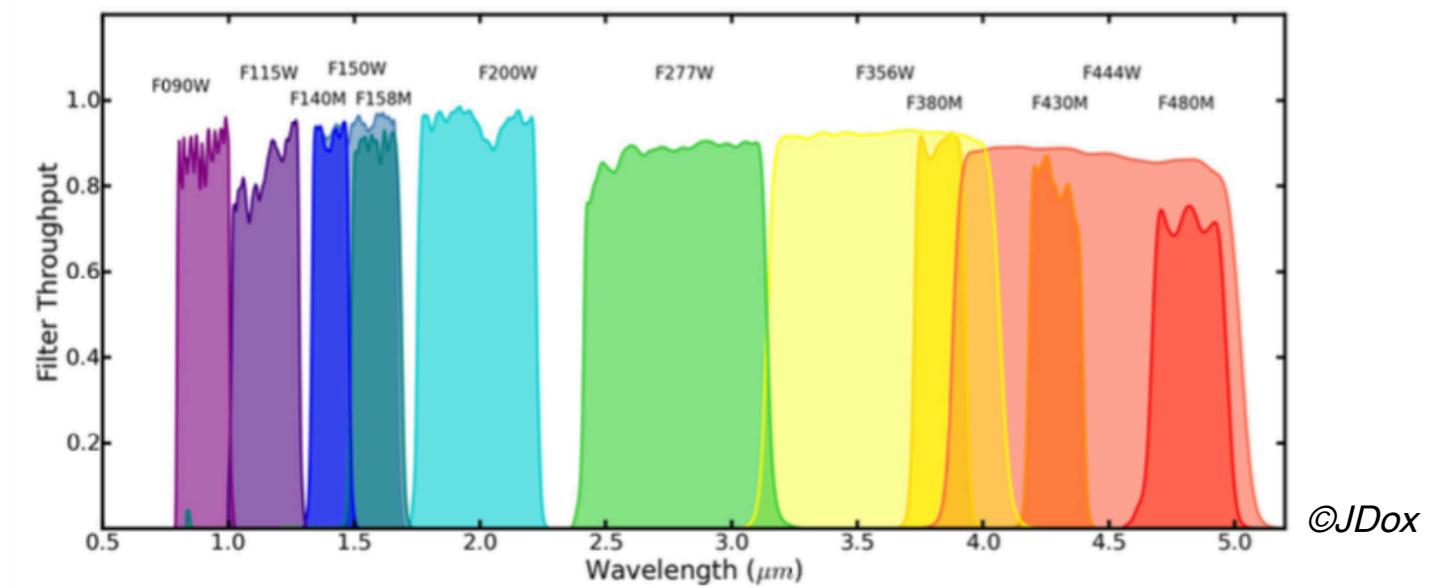
NIRISS imaging is accessible in parallel mode

Field of view: 2.2'x2.2'

Support for AMI / WFSS observations

Extra field in parallel with NIRCAM

All filters available for parallel imaging



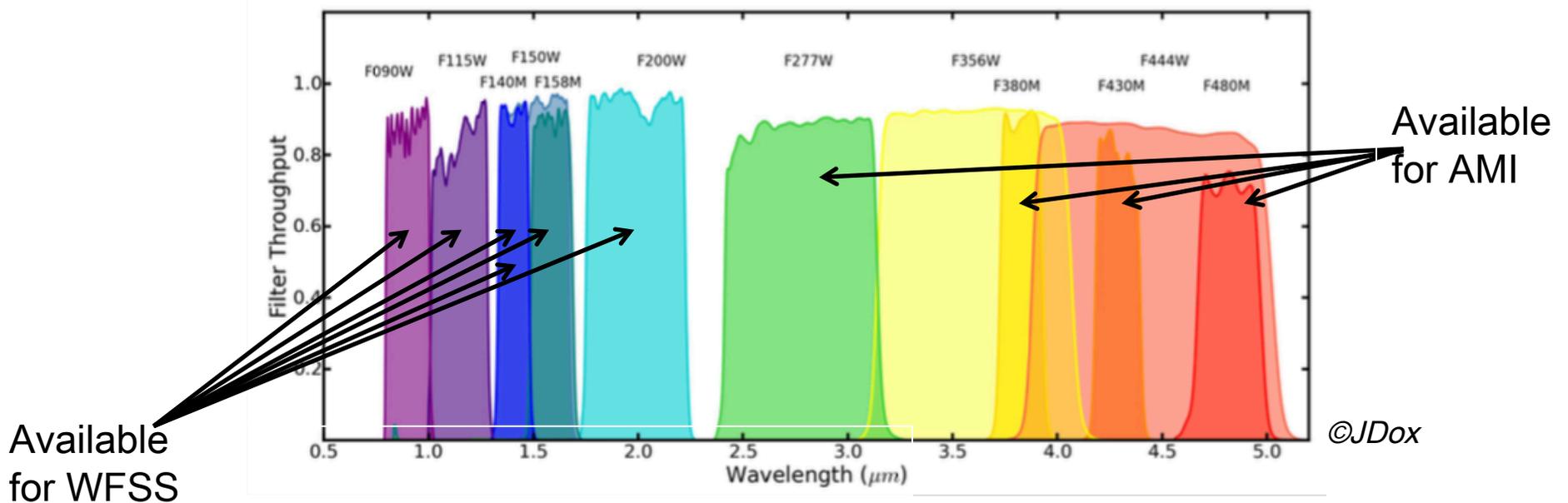
NIRISS imaging is a support or backup mode

Field of view: 2.2"x2.2"

Support for AMI / WFSS observations

Extra field in parallel with NIRCAM

All filters available for parallel imaging



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

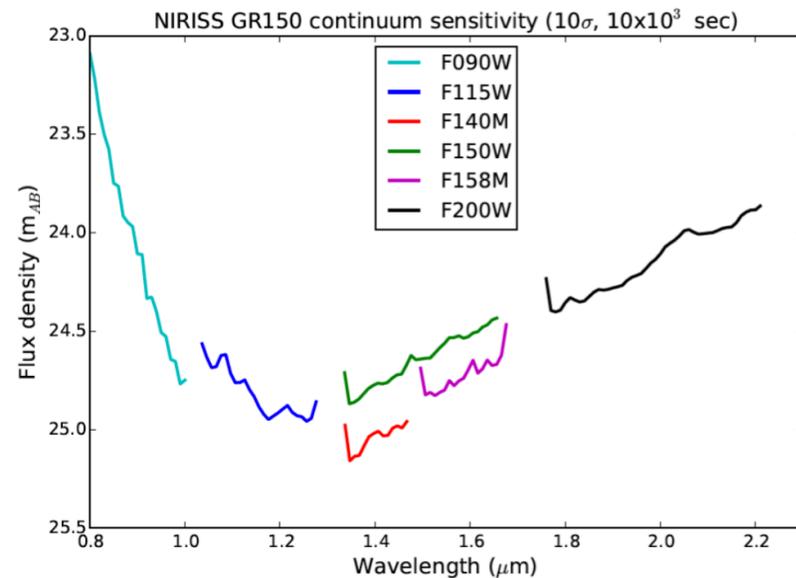
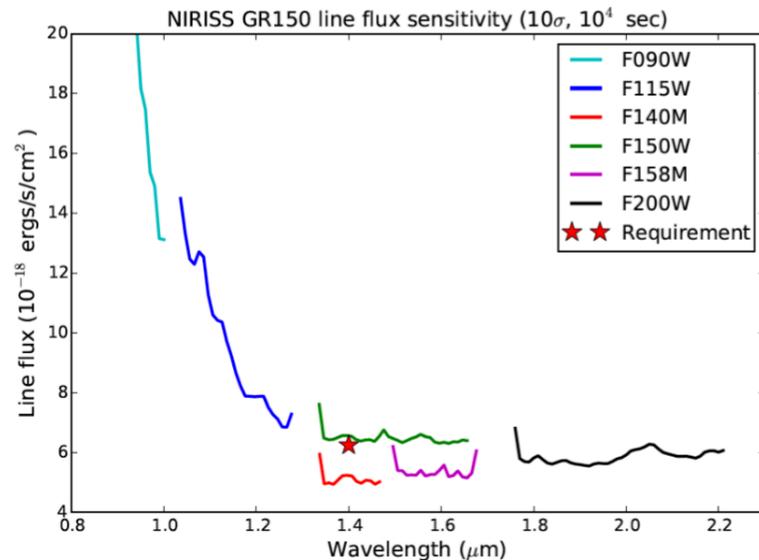
λ : 0.8-2.2 μm

Grism resolution: 150

Orthogonal dispersion to mitigate source crowding

Sensitivity (SNR 10 in 10ks) $\sim 6 \times 10^{-18}$ ergs/s/cm² or AB~25

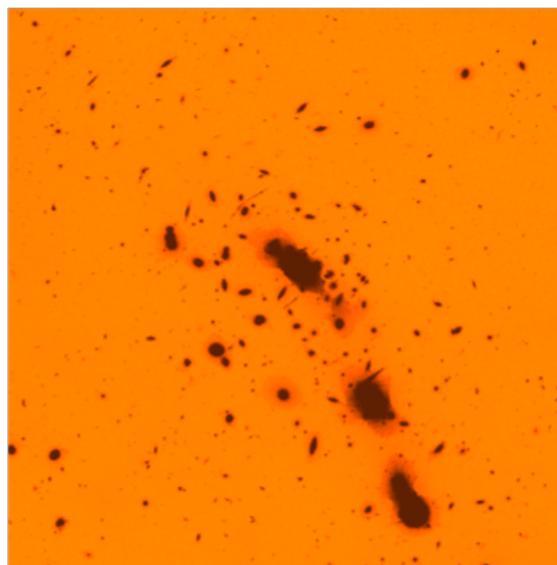
High multiplex



NIRISS science example:

Low mass galaxies properties at $Z=1-10$

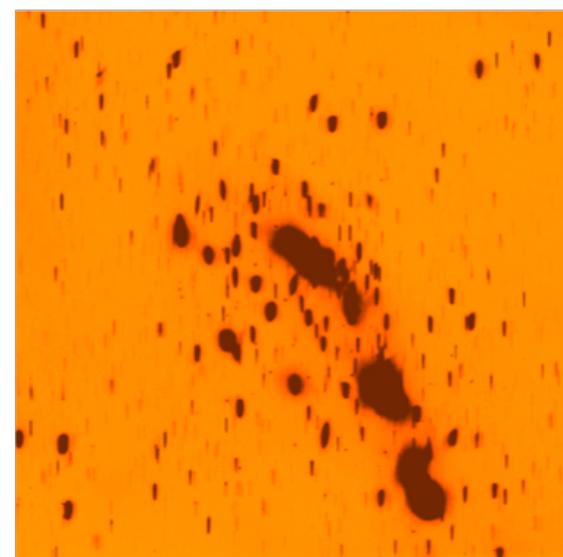
WFSS observations of 4-5 galaxy clusters (~200 hrs total).
Includes also NIRCам imaging + NIRSpec MOS follow-ups



Imaging
F115W



GR150C
F115W

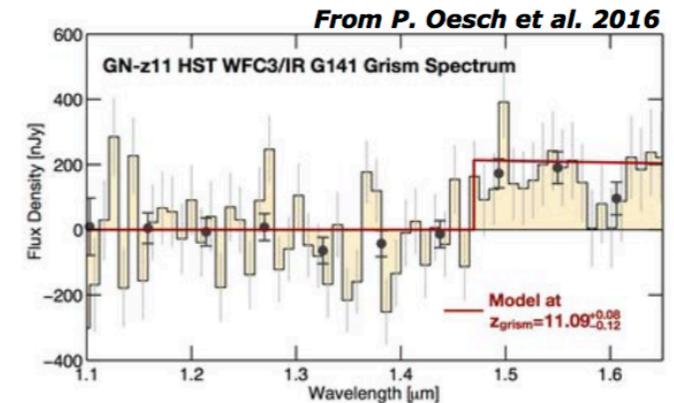
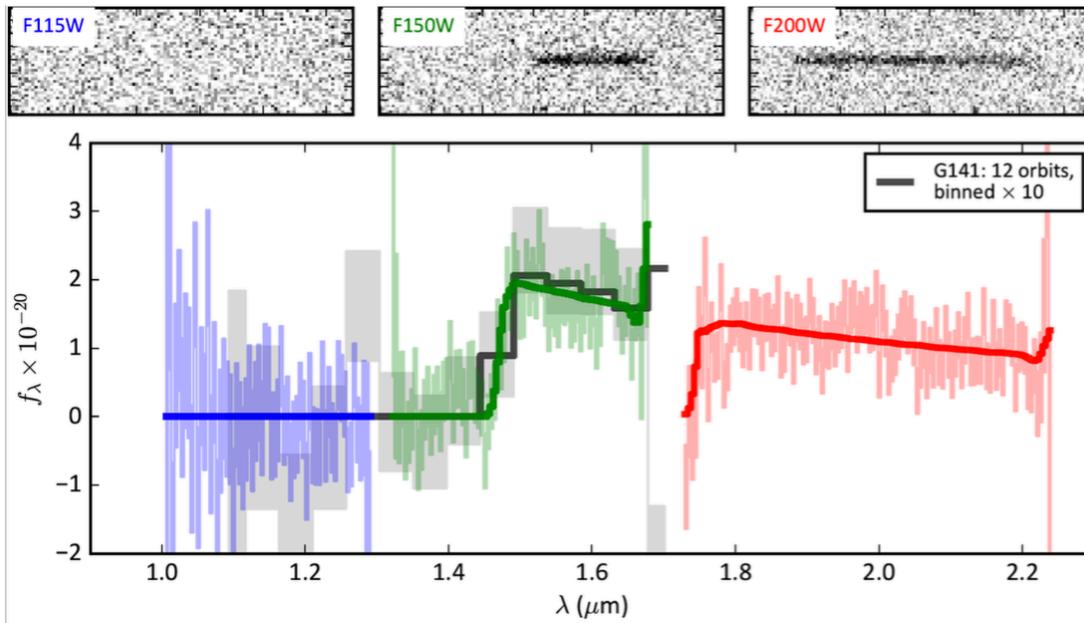


GR150R
F115W

©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)

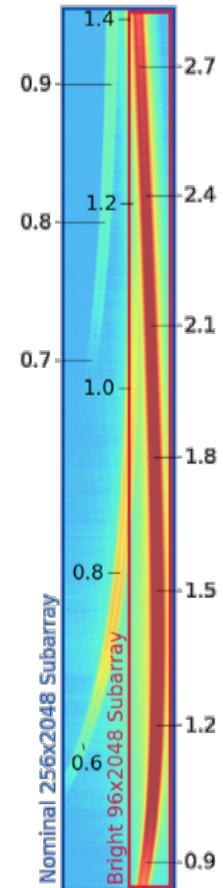
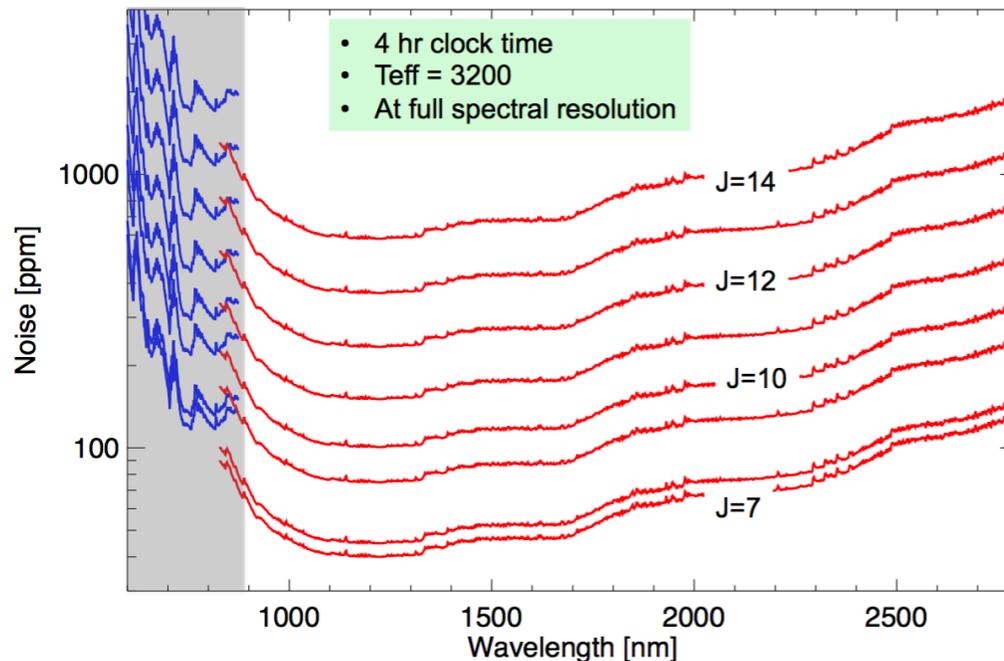
λ : 0.6-2.8 μm across two orders

Grism resolution ~ 1000

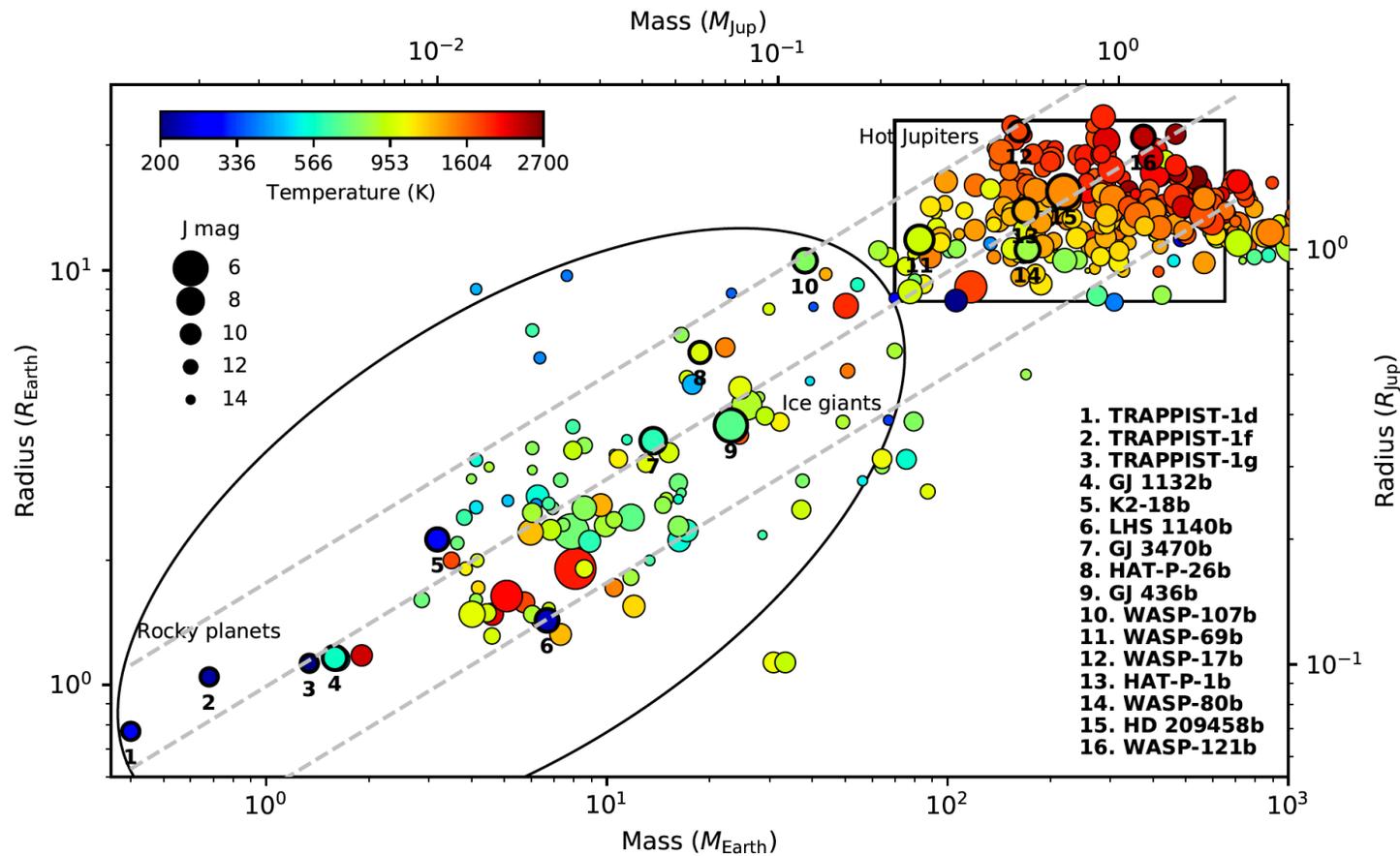
Saturation J ~ 8.1 mag

(Bright mode J ~ 6.3)

Optimized for exoplanet transit spectroscopy, especially bright stars



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

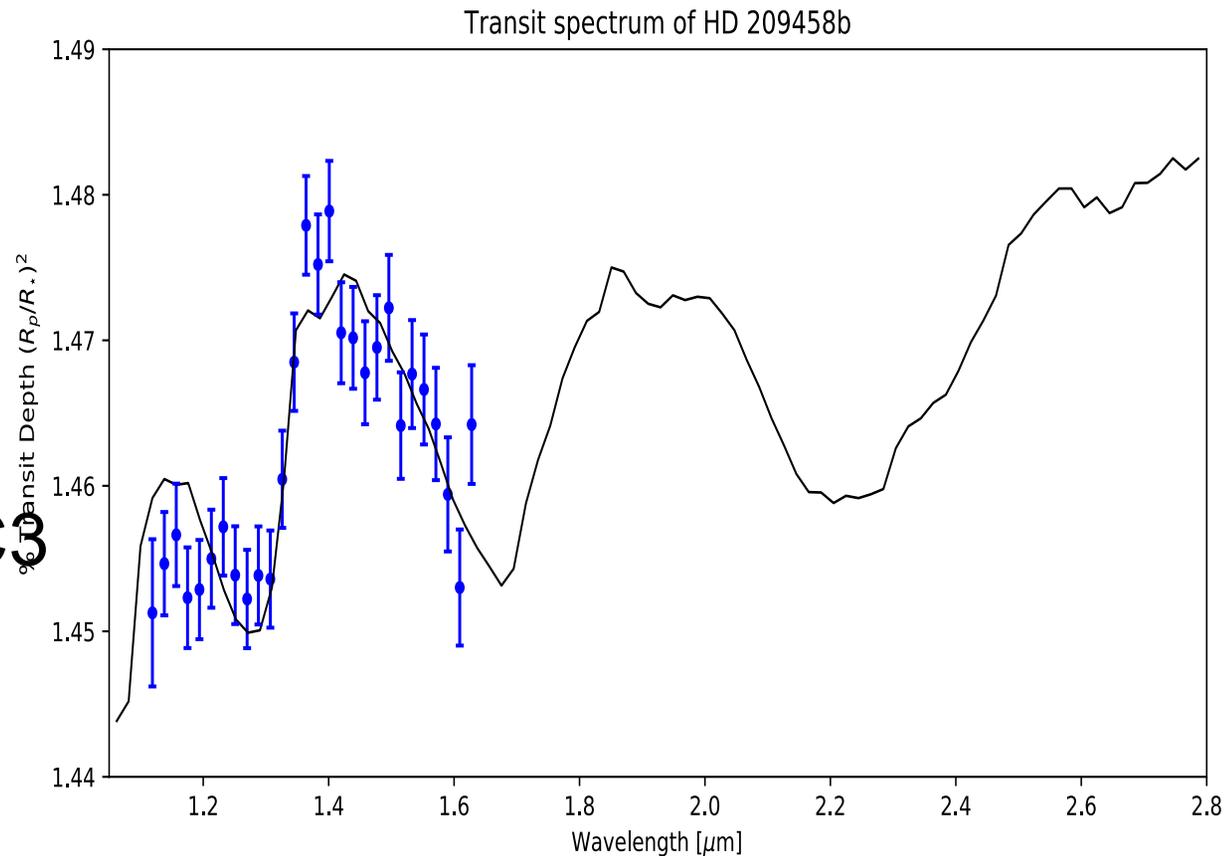


©D. Lafrenière

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



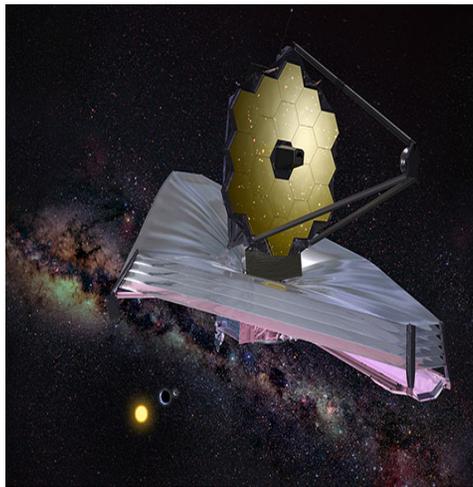
With HST WFC3



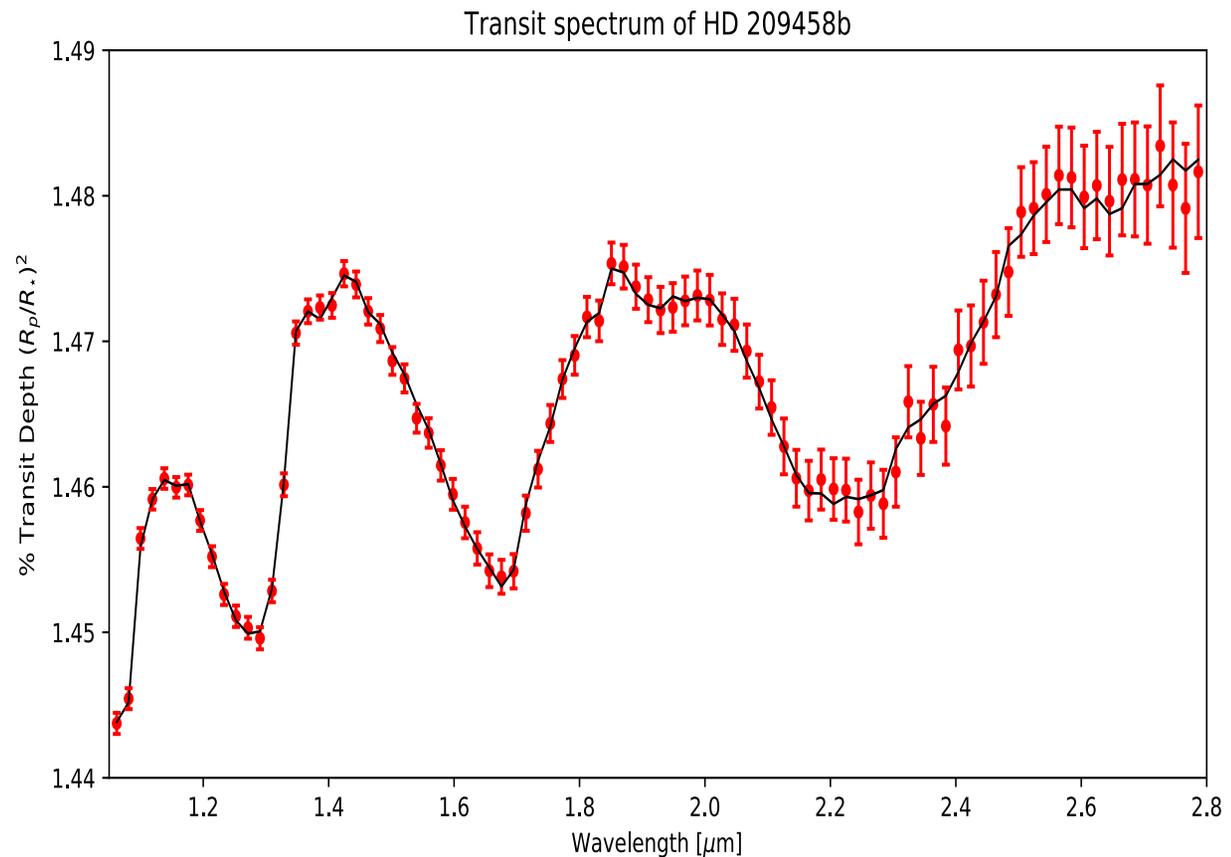
©D. Lafrenière

Observations by Deming et al. 2013

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



With JWST
NIRISS



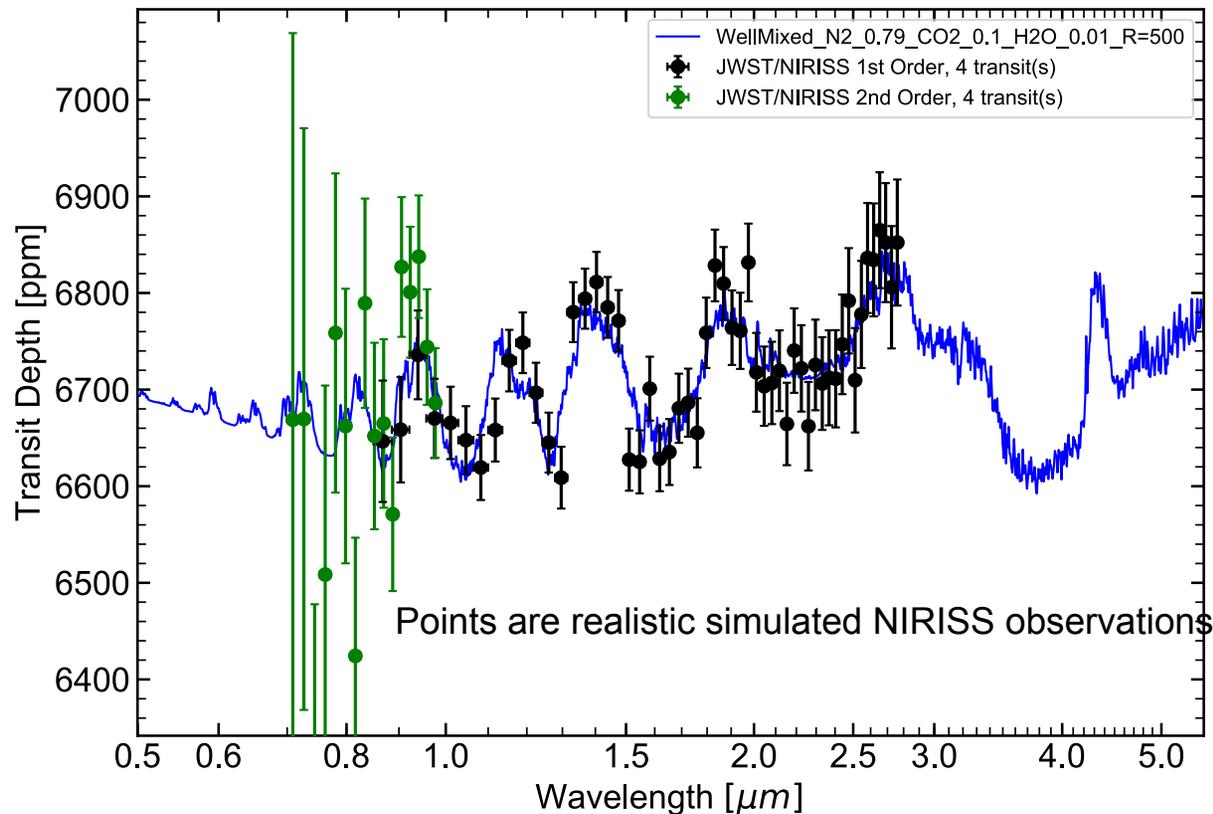
©D. Lafrenière

Simulated NIRISS Observations

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



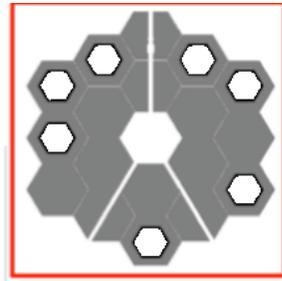
TRAPPIST-1f with Earth-like atmosphere



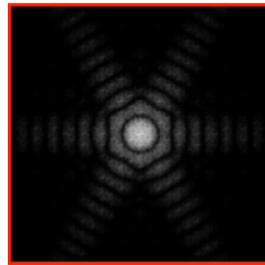
©B. Benneke

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

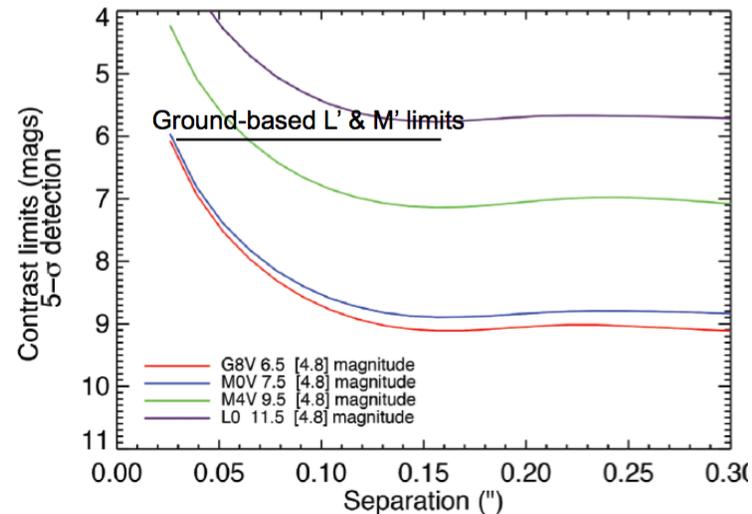
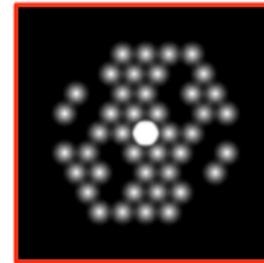
7 hole
Non-Redundant Mask



Inteferogram in the
image plane



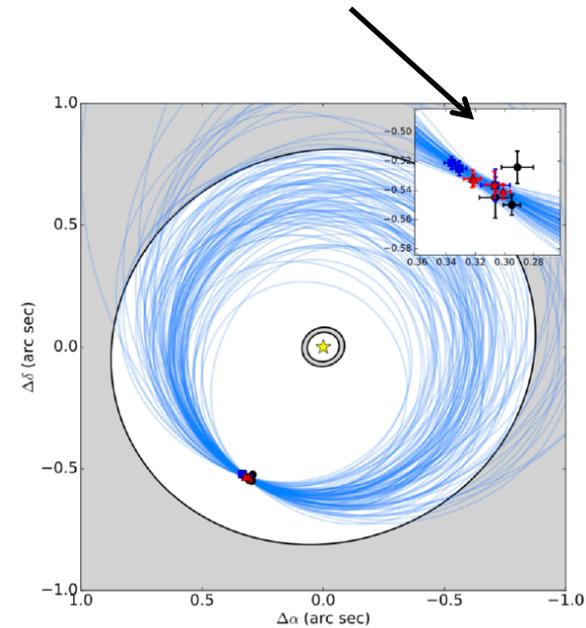
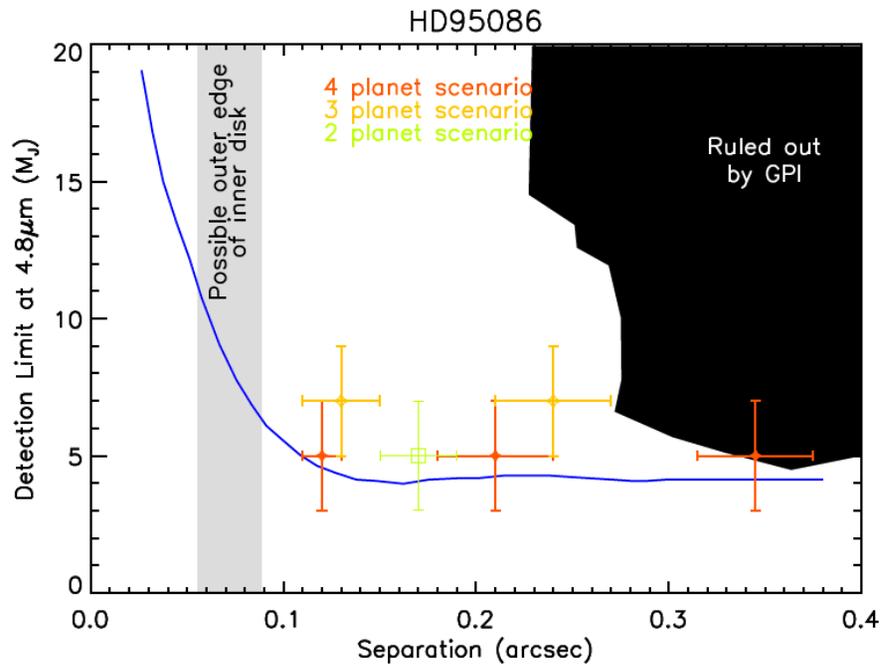
Fourier transform



©E. Artigau,
J. Rameau

NIRISS science example: Finding close-in young gas giants

Orbitals motion as measured by GPI



Rameau et al. 2016

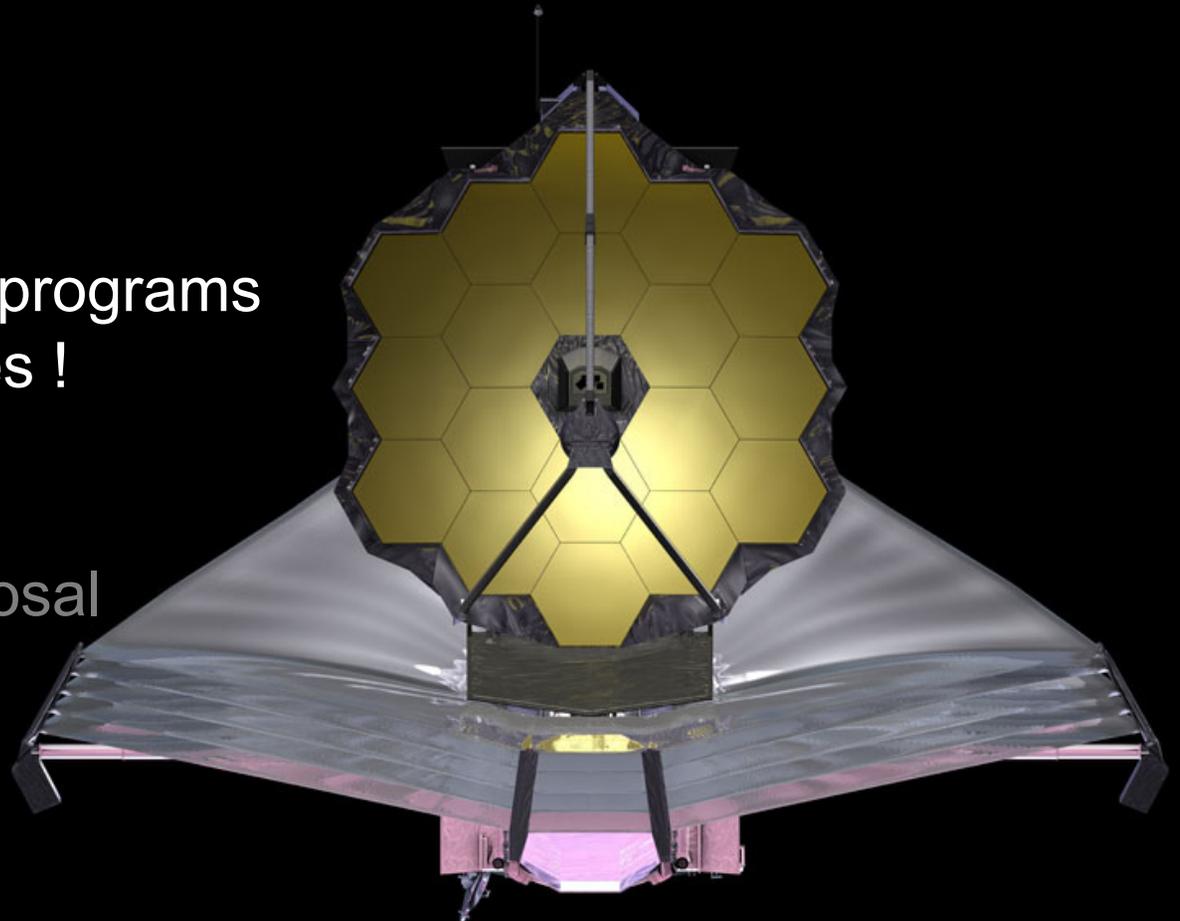
Outline

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

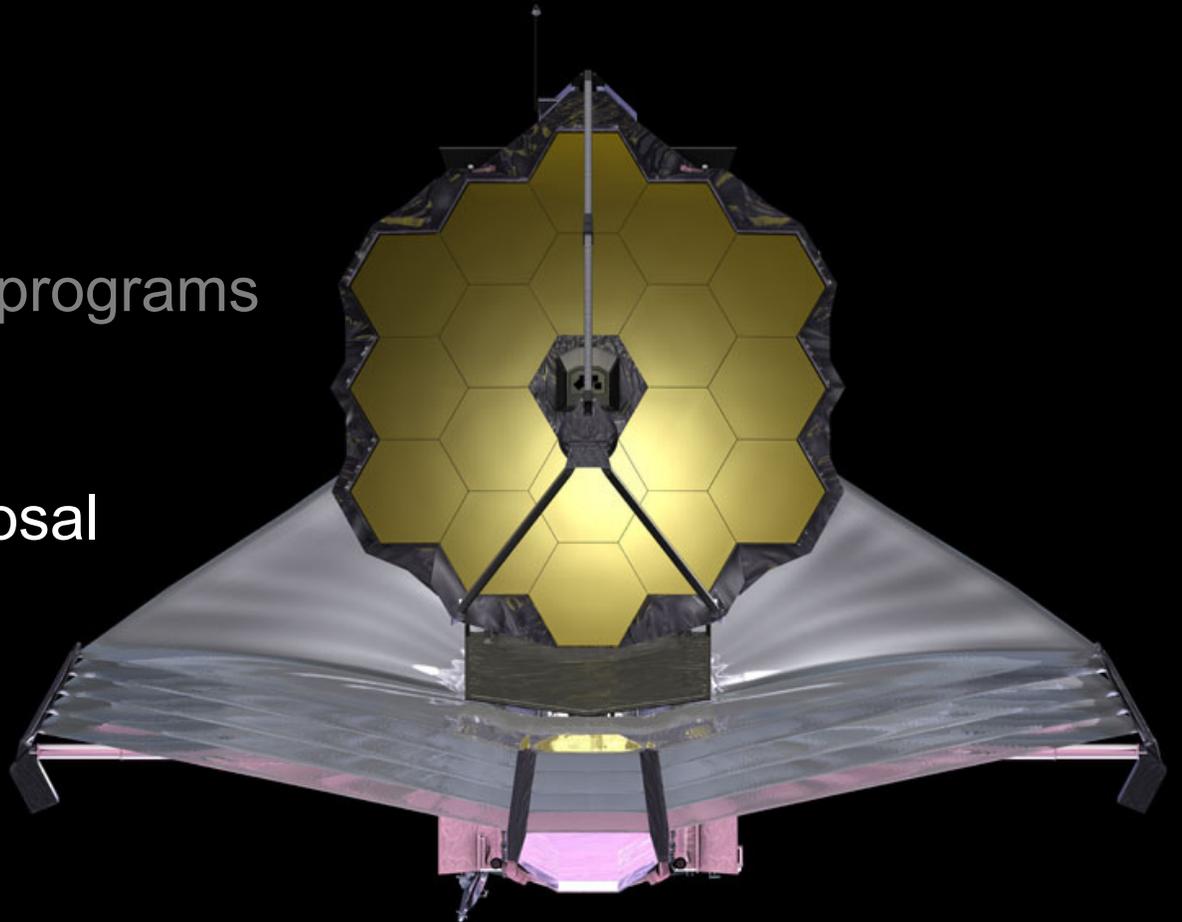
JWST can track at 30 mas/s with pointing accuracy of 7mas

Outline

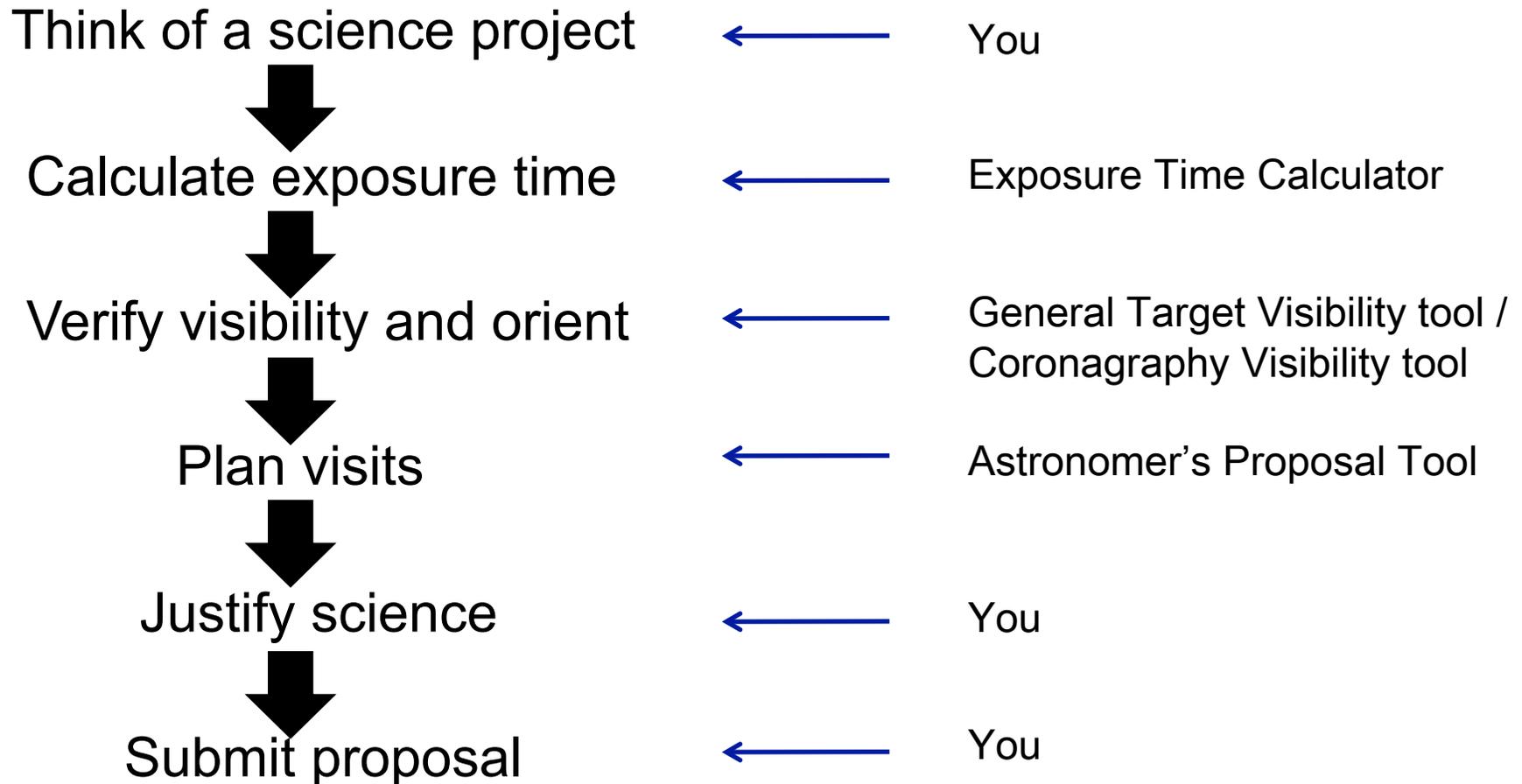
JWST primers

Instruments & science programs

Towards a JWST proposal



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



JWST observing time is in unit of “wall clock time” (overheads included)

Observing efficiency 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

Sitless & IFU calculations
Sitless and IFU calculations performed on scenes with multiple extended sources

Calculations
Scenes and Sources
Upload Spectra
Caveats and Limitations

MIRI -	NIRCam -	NIRISS -	NIRSpec -				
ID -	Plot	Mode -	Scene -	(s) -	SNR -		▲
9	<input type="checkbox"/>	nirspec ifu	1	4402.07	0.28		🟢
8	<input type="checkbox"/>	miri mrs	1	2220.00	2.2e-3		🟢
7P	<input type="checkbox"/>						
6	<input checked="" type="checkbox"/>	nircam w/grism	1	1964.83	0.03		🟢
3	<input type="checkbox"/>	niriss w/sss	1	440.21	0.43		🟢
2	<input type="checkbox"/>	niriss w/sss	1	440.21	0.38		🟢
1	<input type="checkbox"/>	niriss imaging	1	590.52	6.98		🟢

Scene ★
Backgrounds
Instrument Setup
Detector Setup
Strategy

NIRCam Grism Wide Field

Grism: Grism (row-dispersed)

Filter: F356W

Wavelength range: (3 - 4.1)

System Throughput

Reset Calculate

Images

Calculation selected: 6, Mode: nircam w/grism

2D SNR
Detector
Saturation

Plots
ApFlux
ApBackground
SNR
SNR (time)
Contrast

Signal to Noise

Bounds/Scale:

X: 3.00 Linear

Y: 0.00 Linear

Reports

Calculation selected: 6, Mode: nircam w/grism

Report
Warnings
Errors
Downloads

Instrument Filter/Disperser: f356w/grismr

Extraction Aperture Position (arcsec): [0.70, -0.50]

Wavelength of Interest used to Calculate Scalar Values (microns): 3.62

Size of Extraction Aperture (arcsec): 0.15

Total Time Required for Strategy (seconds): 1964.83

Total Exposure Time (seconds): 1964.83

Extracted Flux (e-/sec): 1.5e-3

Standard Deviation in Extracted Flux (e-/sec): 0.05

Extracted Signal-to-Noise ratio: 0.03

Input Background Surface Brightness (MJy/str): 0.13

Total Background Flux in Extraction Aperture (e-/sec): 1.88

Total Sky Background Flux in Extraction Aperture (e-/sec): 1.88

Fraction of Total Background due to Signal From Scene: 2.7e-3

Average Number of Cosmic Rays per Ramp: 0.16

APT templates

The screenshot displays the Astronomer's Proposal Tools (APT) interface for configuring a JWST Draft Proposal. The main window shows the configuration for 'WFSS, F150W (Obs 1)'. The configuration includes fields for Number (1), Label (WFSS, F150W), Instrument (NIRISS), and Template (NIRISS Wide Field Slitless Spectroscopy). The Visit Splitting is set to 30.0 Arcsec and 9 visits. The Duration (secs) is 31932, and the Total Charged is 47121. The Data volume is 7,550 MB.

The Science Observation section shows the WFSS Dither Name (WFSS4PT), Filter (F150W), and Grism (BOTH). The Readout Pattern is NIS, with 10 groups and 1 integration, resulting in a Photon Collect Duration of 429.47 and a Total Photon Collect Duration of 3435.76.

The Direct Image section shows the DI Readout Pattern (NISRAPID), DI No. of Groups (10), and DI No. of Integrations (1), resulting in a DI Photon Collect Duration of 107.368 and a DI Total Photon Collect Duration of 107.368.

The Observations table at the bottom shows the following data:

Observa... Δ	Number	Label	Science	Total Char...	Instrument	Template	Target	Number of ...	Splitting Di...	Comments
WFSS, F15...	1	WFSS, F15...	31932	47121	NIRISS	NIRISS Wid...	1 FIELD1	9	30.0 Arcsec	
WFSS, F20...	2	WFSS, F20...	31932	47121	NIRISS	NIRISS Wid...	1 FIELD1	9	30.0 Arcsec	

The interface also shows a sidebar with a tree view of the proposal structure, including Proposal Information, Targets, and Observations. The Observations folder is expanded to show 'WFSS, F150W (Obs 1)' and 'WFSS, F200W (Obs 2)'. The Observations table at the bottom shows the following data:

2 errors & warnings (Click for Details)

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)



James Webb Space Telescope User Documentation

[HOME](#)[INSTRUMENTS ▾](#)[PLANNING ▾](#)[CALL FOR PROPOSALS ▾](#)[DATA ▾](#)

JWST User Documentation Home

JWST user documentation, informally known as "JDox," is available as a collection of articles on the Web. Unlike conventional HST handbooks, JDox is intended as an agile, user-friendly source of information that follows the Wikipedia-like [Every Page is Page One \(EPPO\)](#) philosophy. Our goal is to provide short, focused, well-linked articles that provide the kinds of information found in traditional HST instrument handbooks, data handbooks, and calls for proposals.

All JDox articles are separated into four sections: (1) [JWST Observatory and Instrumentation](#), (2) [JWST Observation Planning](#), (3) [JWST Opportunities and Policies](#), and (4) [JWST Data Calibration and Analysis](#). These articles provide details about the observatory and instruments, descriptions of tools used for proposing, advice on observing strategies, "cookbooks" that guide users through the proposal preparation process, as well as information about calibration and analysis of JWST data.

While downloadable PDF files for these four JDox sections will be generated for each cycle, the online content will be constantly updated with the latest information.

Please refer to this [figure](#) to get started in exploring this website using the navigation bar, search bar, and links, as well as the page tree on the right of

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

Canadian JWST help desk @ UdeM

jwsthelphelp@astro.umontreal.ca

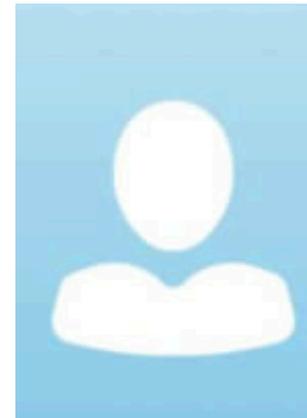
web: jwst.astro.umontreal.ca



Loïc Albert



Julien Rameau



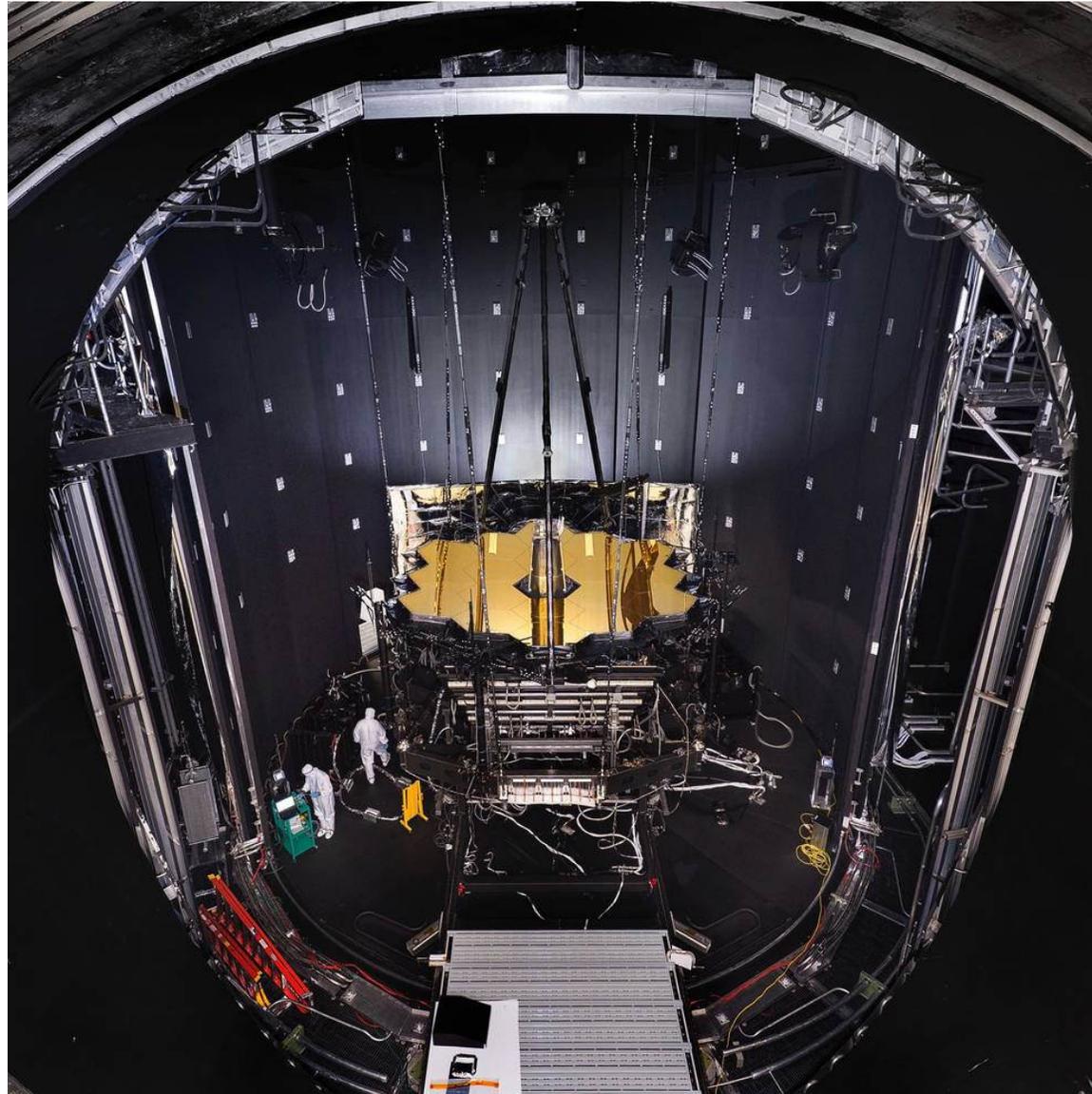
Outreach officer

- 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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