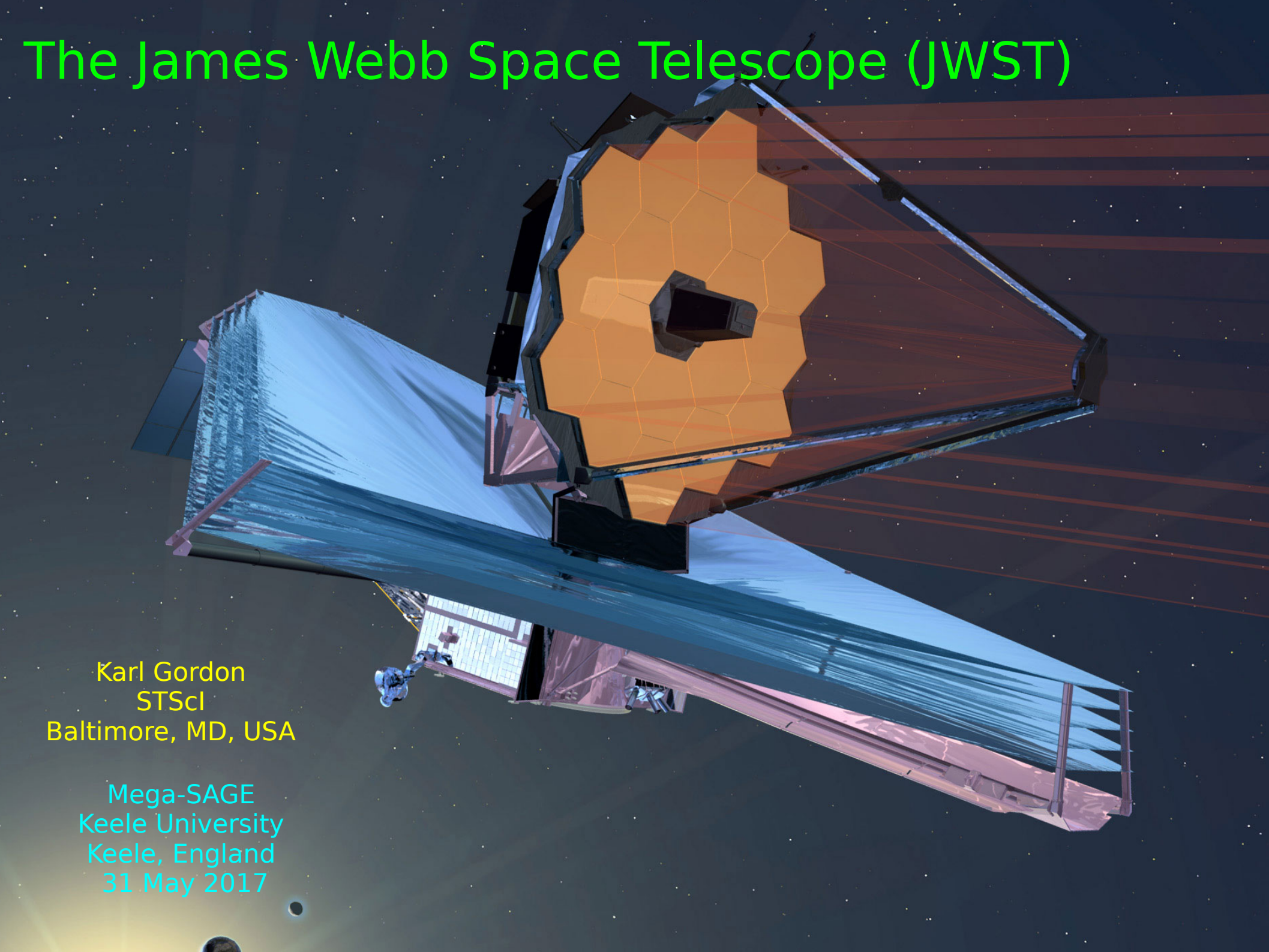
The James Webb Space Telescope (JWST)



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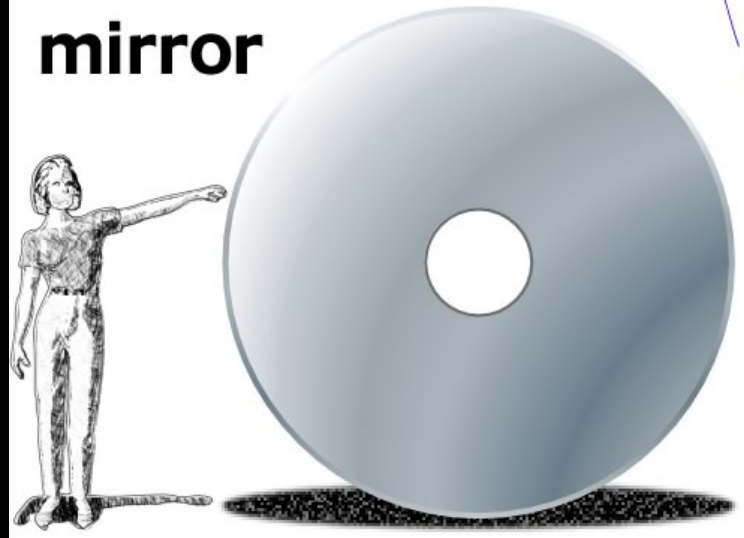
Mega-SAGE
Keele University
Keele, England
31 May 2017

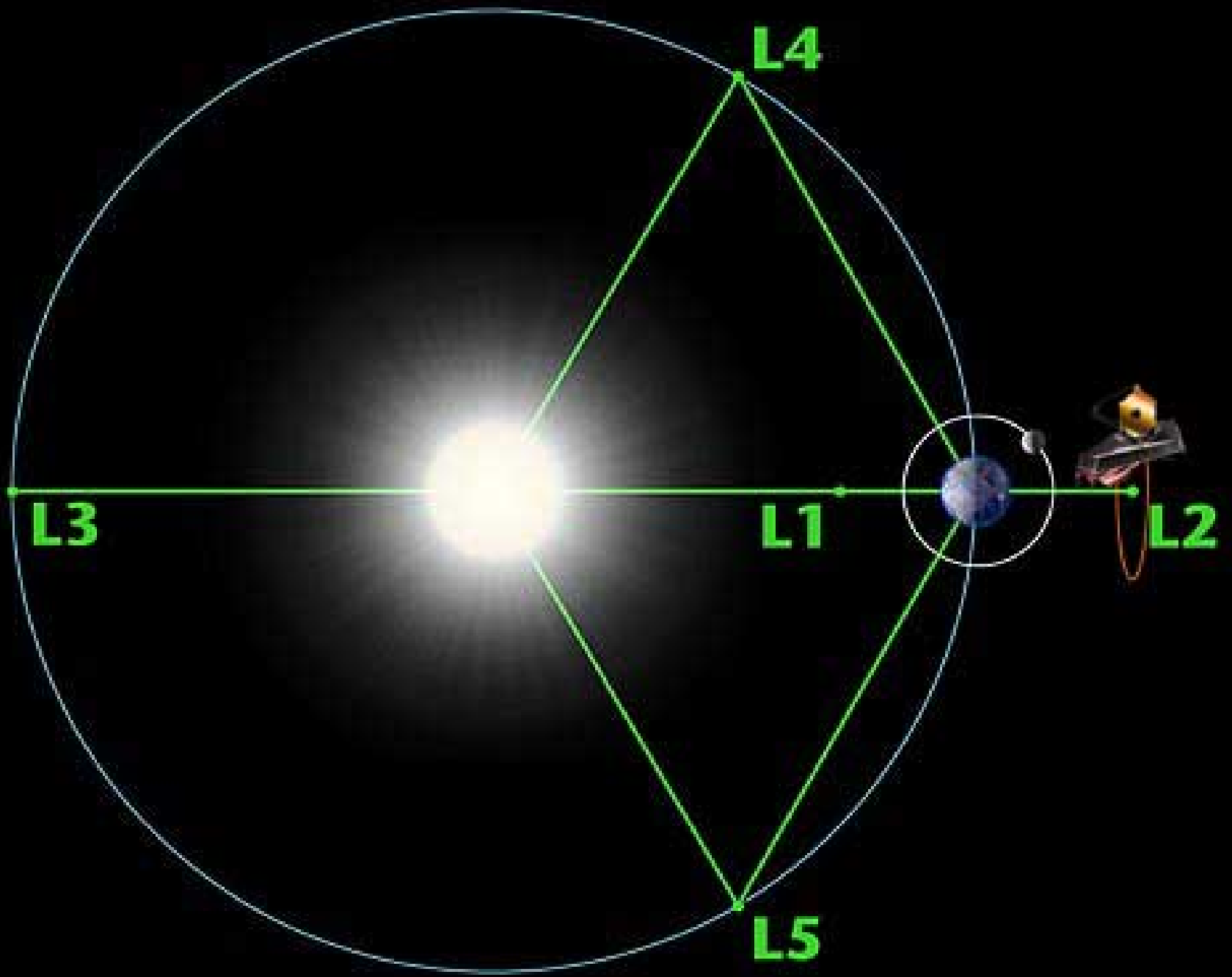
Online Resources

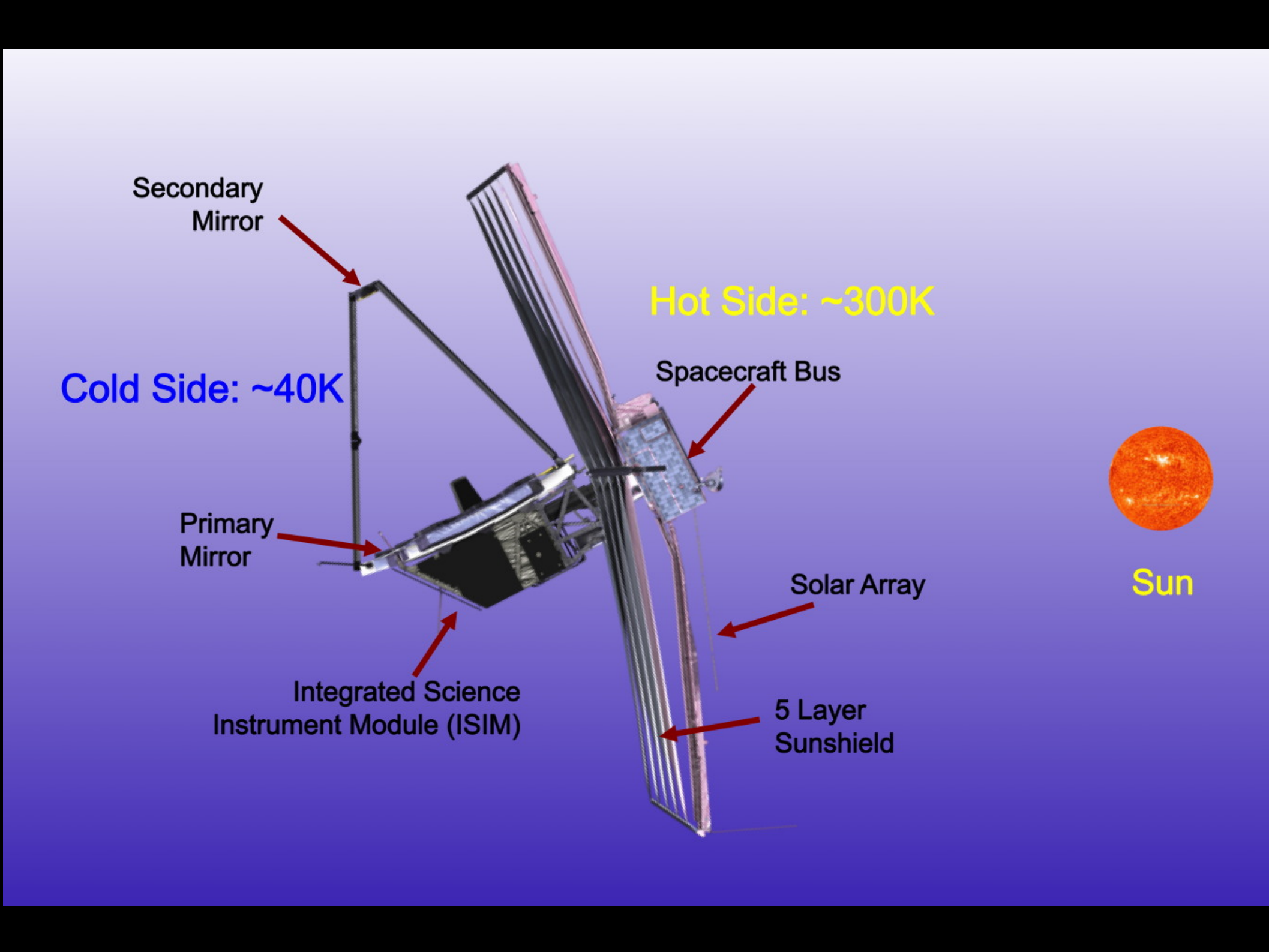
- Documentation: https://jwst-docs.stsci.edu
  - Wikipedia style
- Questions: https://stsci.service-now.com/jwst
  - Knowledge base
  - Tickets
- JWST Community Lectures: https://confluence.stsci.edu/display/JWSTLC/JWST+Community+Lectures
  - Recorded
  - Slides provided

JWST primary mirror

Hubble primary mirror




L4
L3
L1
L2
L5

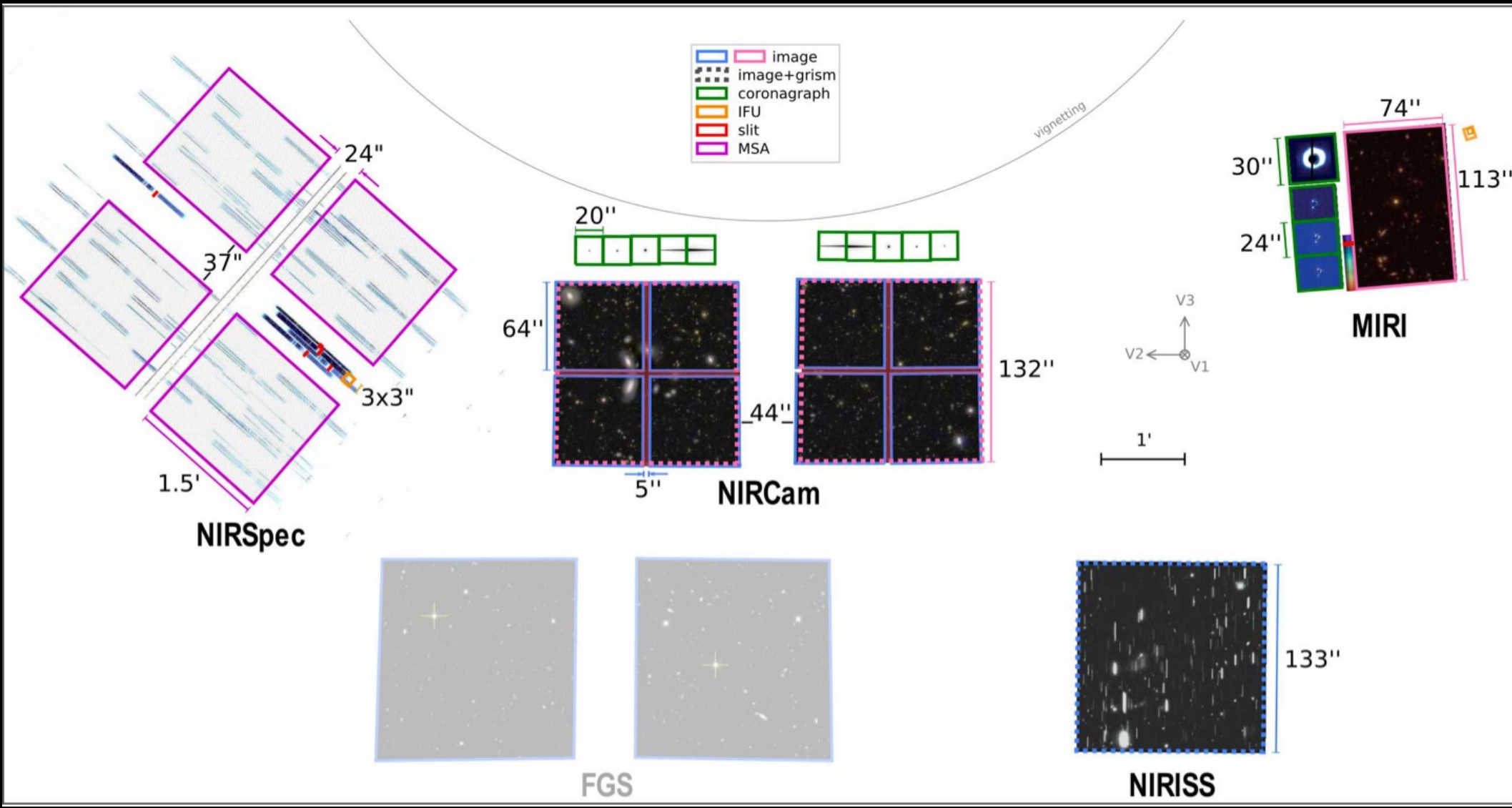

Secondary Mirror
Cold Side: ~40K
Hot Side: ~300K
Spacecraft Bus
Primary Mirror
Solar Array
Integrated Science Instrument Module (ISIM)
5 Layer Sunshield
Sun

Instruments

- NIRCam = Near-Infrared Camera
- NIRSpec = Near-Infrared Spectrograph
- NIRISS = Near-Infrared Imager and Slitless Spectrograph
- MIRI = Mid-Infrared Instrument

- FGS = Fine Guidance Sensor

Telescope Field-of-View

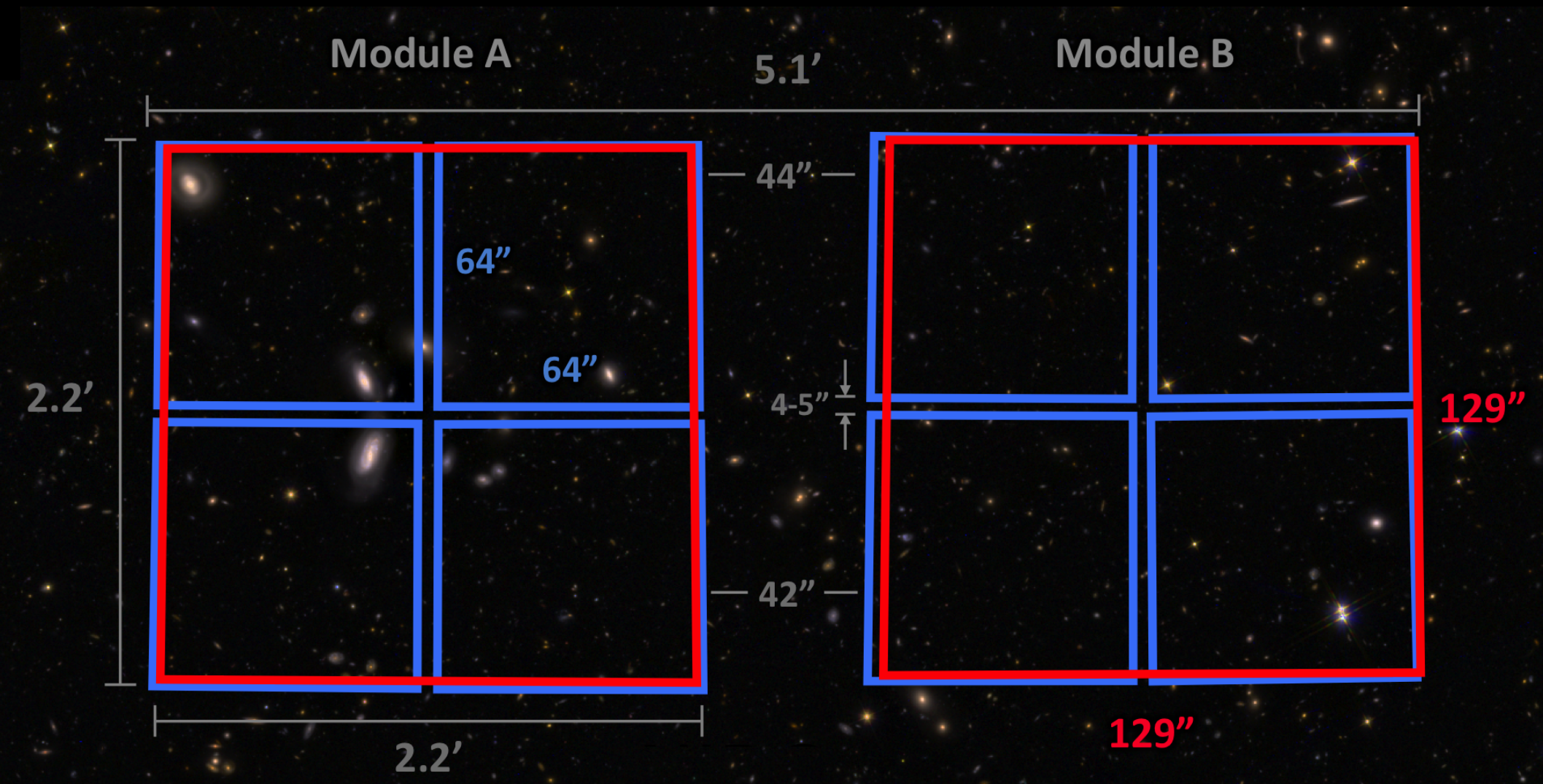


NIRCam

- Imager and Coronagraph
- Short (0.6 - 2.3 μm) and Long (2.4 – 5 μm) Channels
- Nyquist sampled at 2 and 4 μm
- Used for wavefront sensing to align mirror segments

- More details? Talk to Martha Boyer

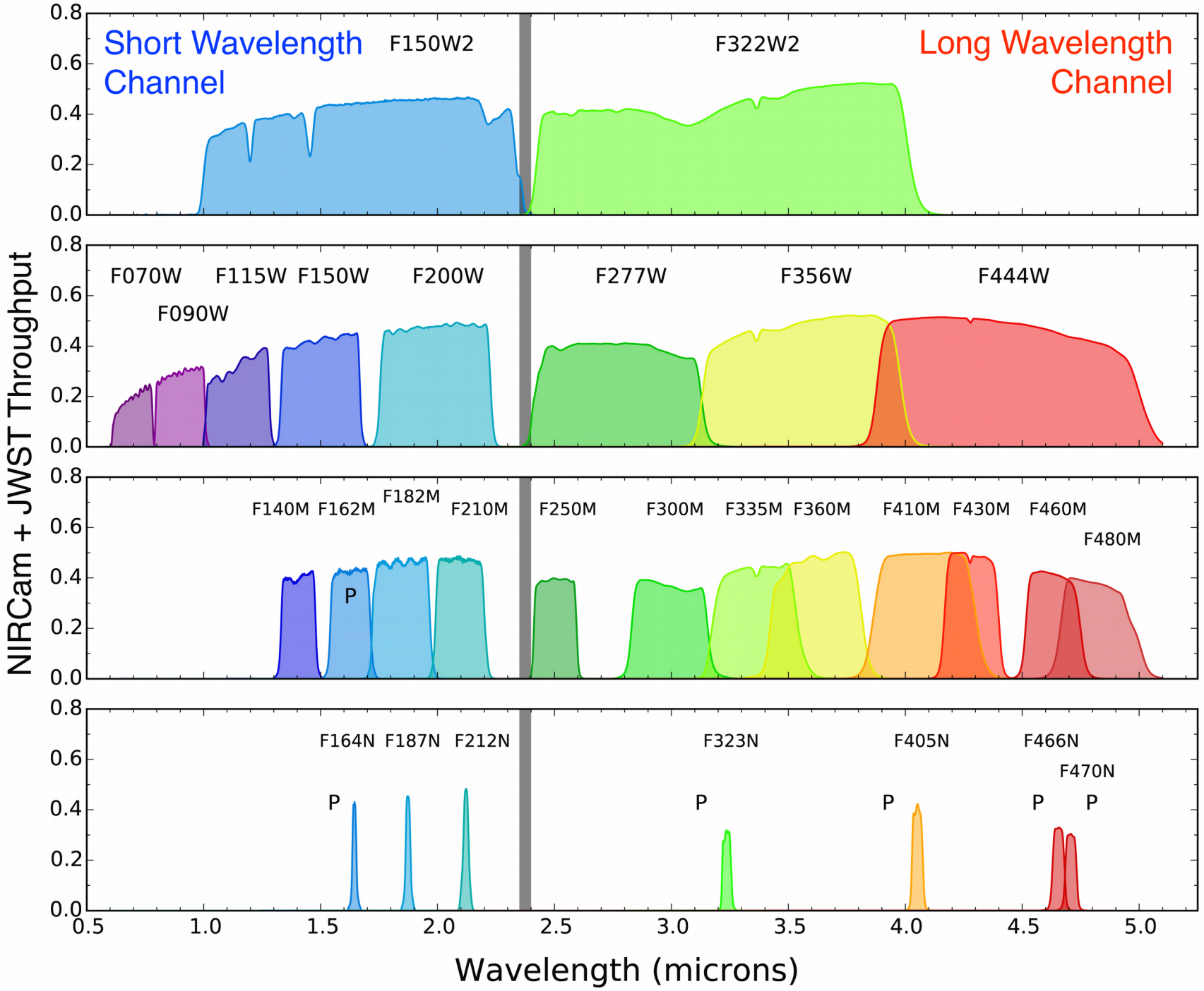
Imaging



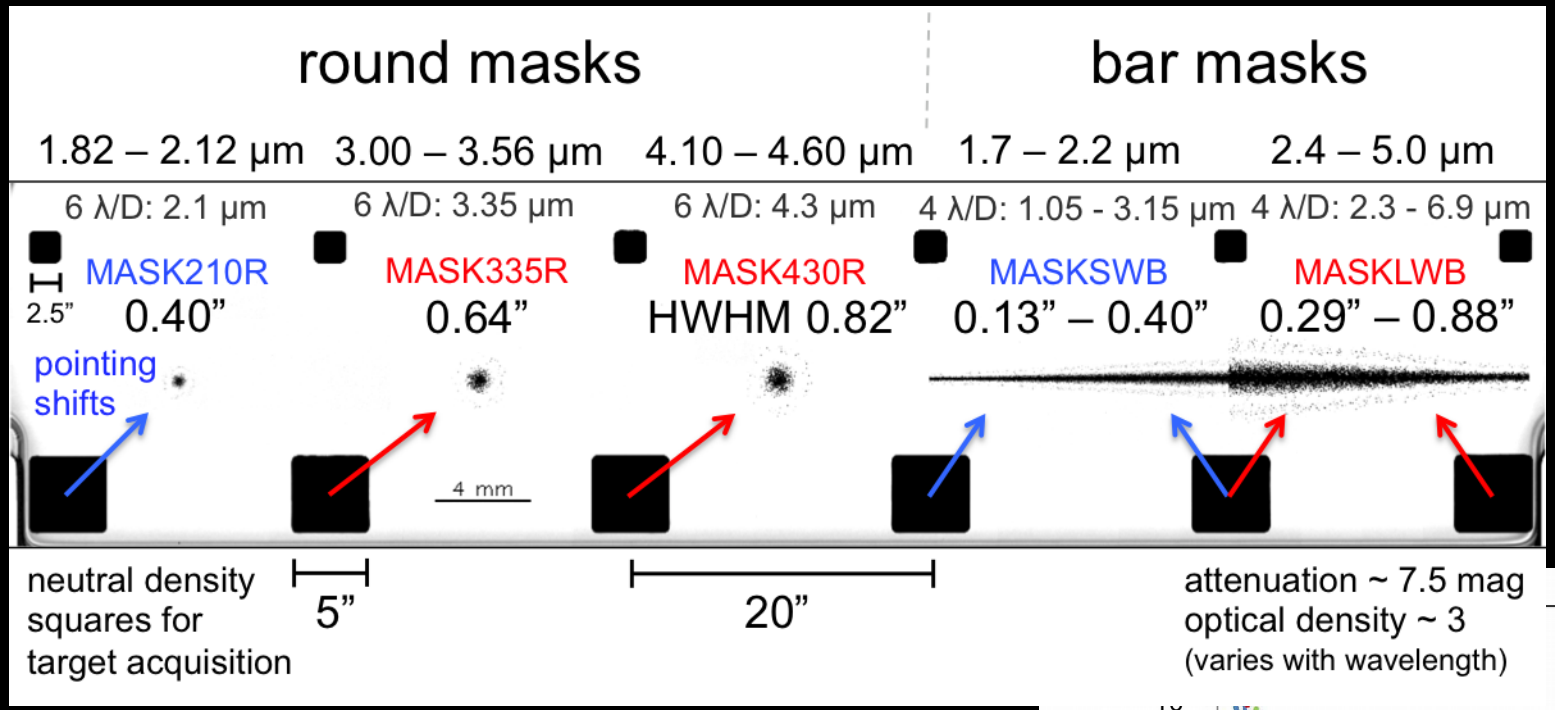
Short Wavelength Channel (0.6 – 2.3 microns) 8 x 2040 x 2040 0.0317”/pix

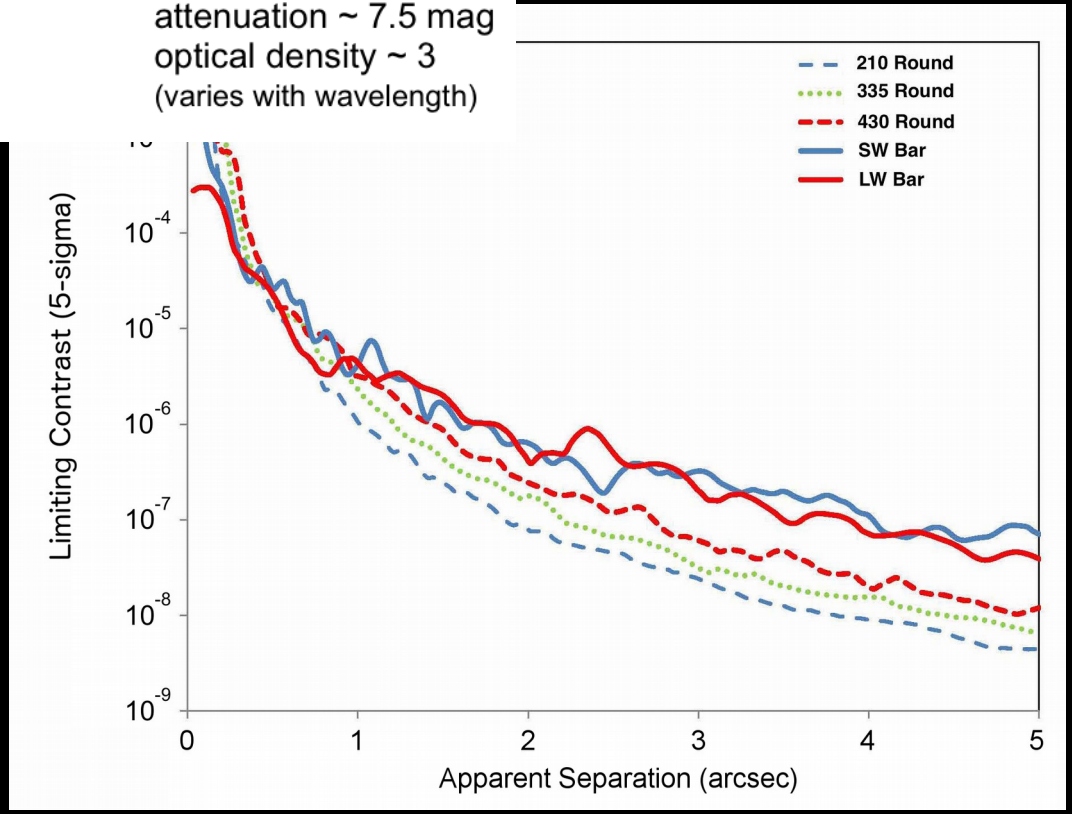
Long Wavelength Channel (2.4 – 5.0 microns) 2 x 2040 x 2040 0.0648”/pix

NIRCam Filters

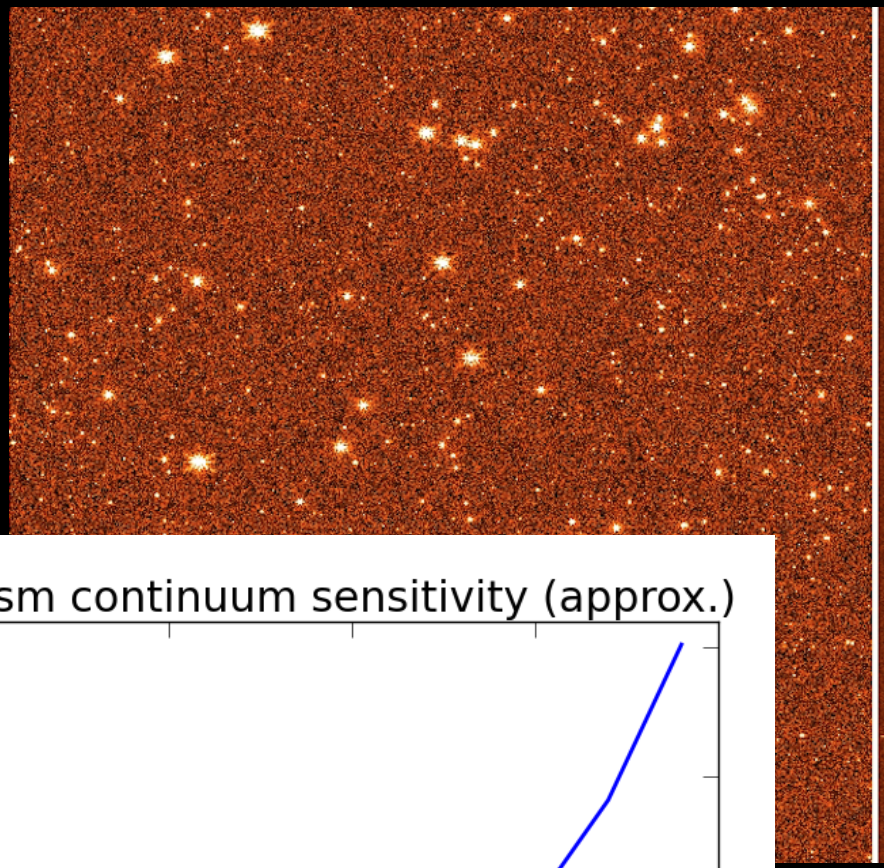


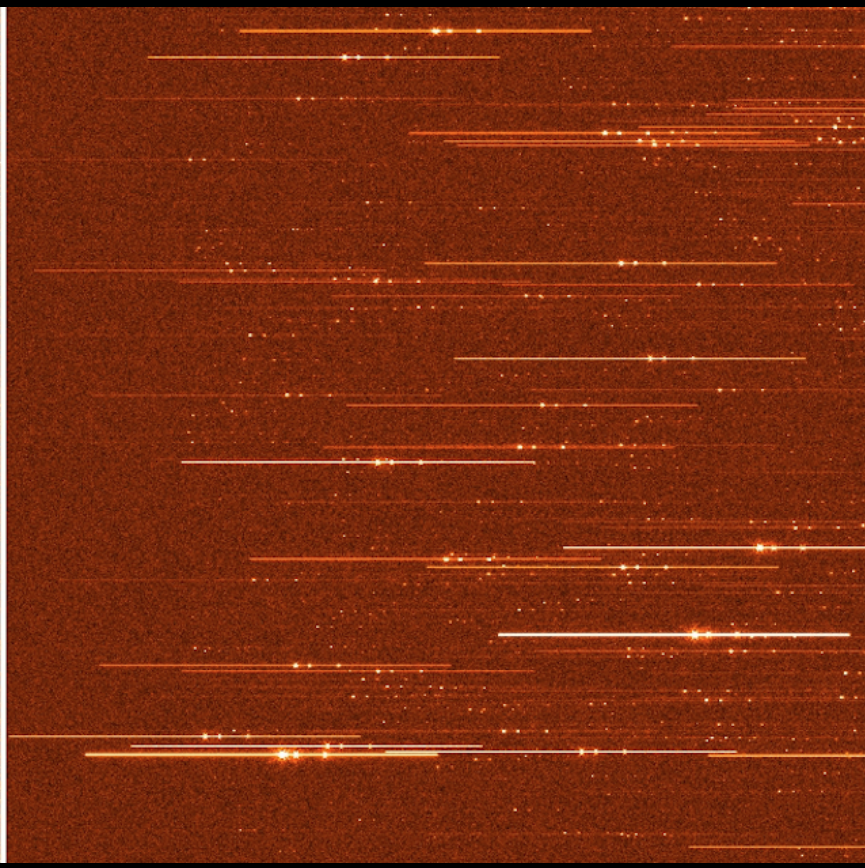
Coronagrahy

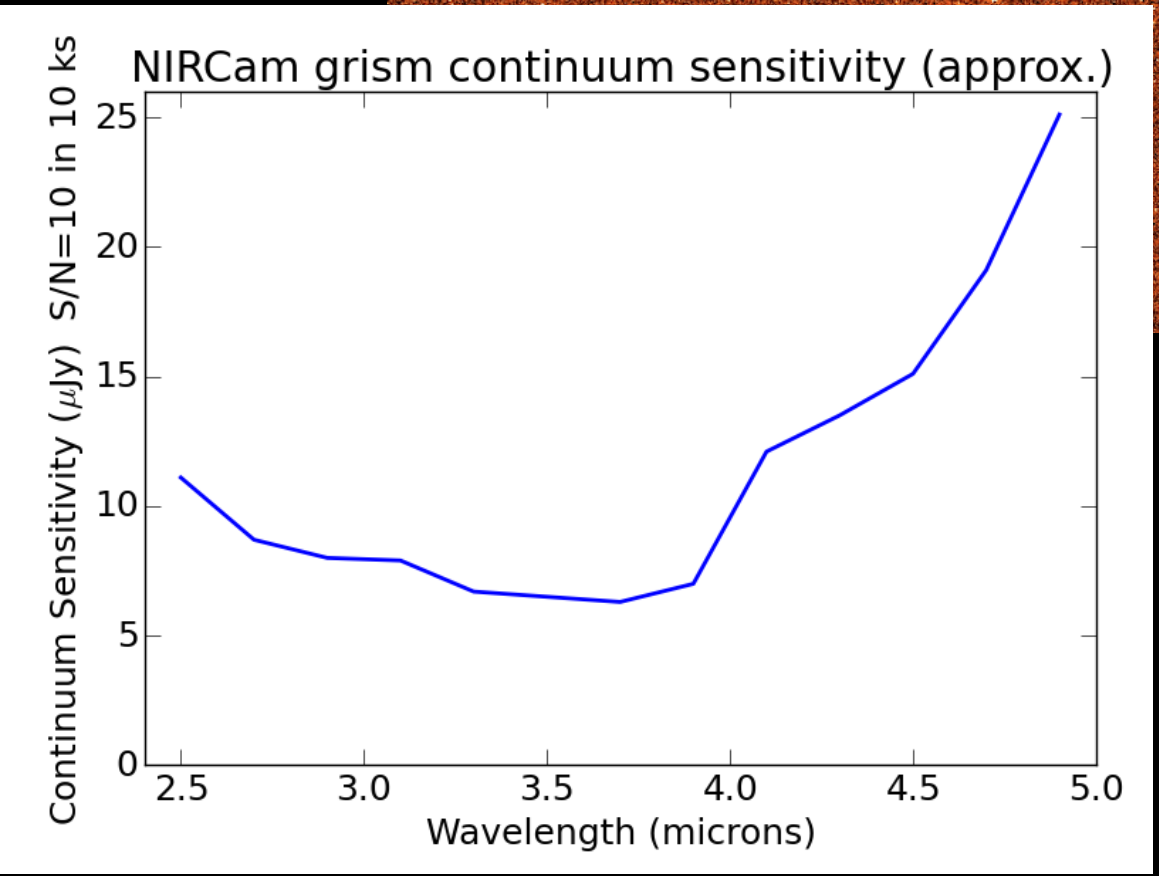




Wide Field Slitless Spectroscopy





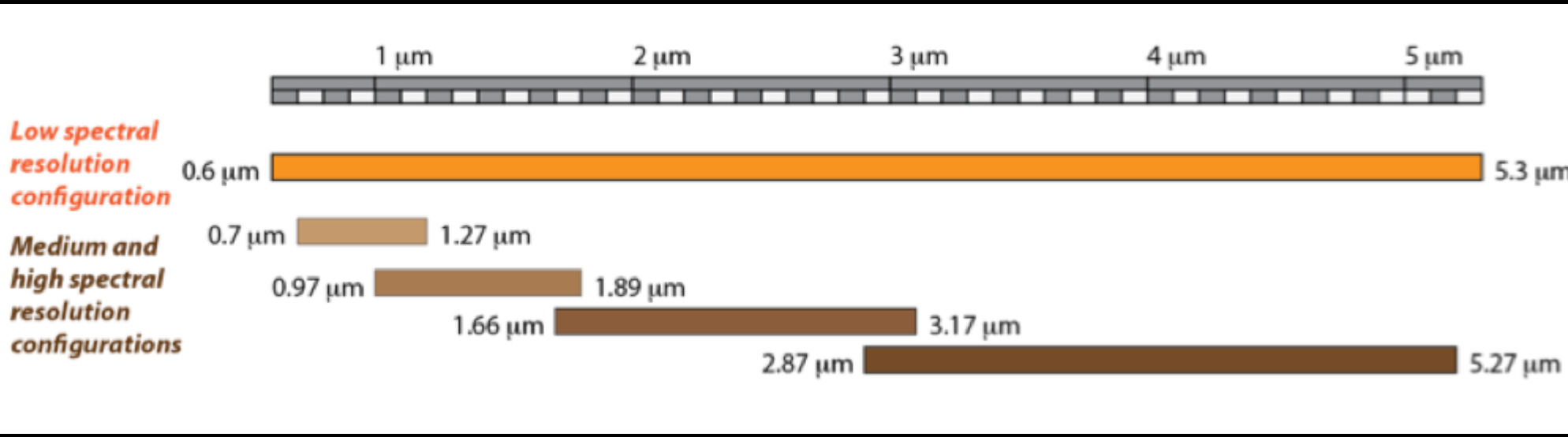


2.4 to 5 micron
R ~ 1500
Used with a wide or medium filter

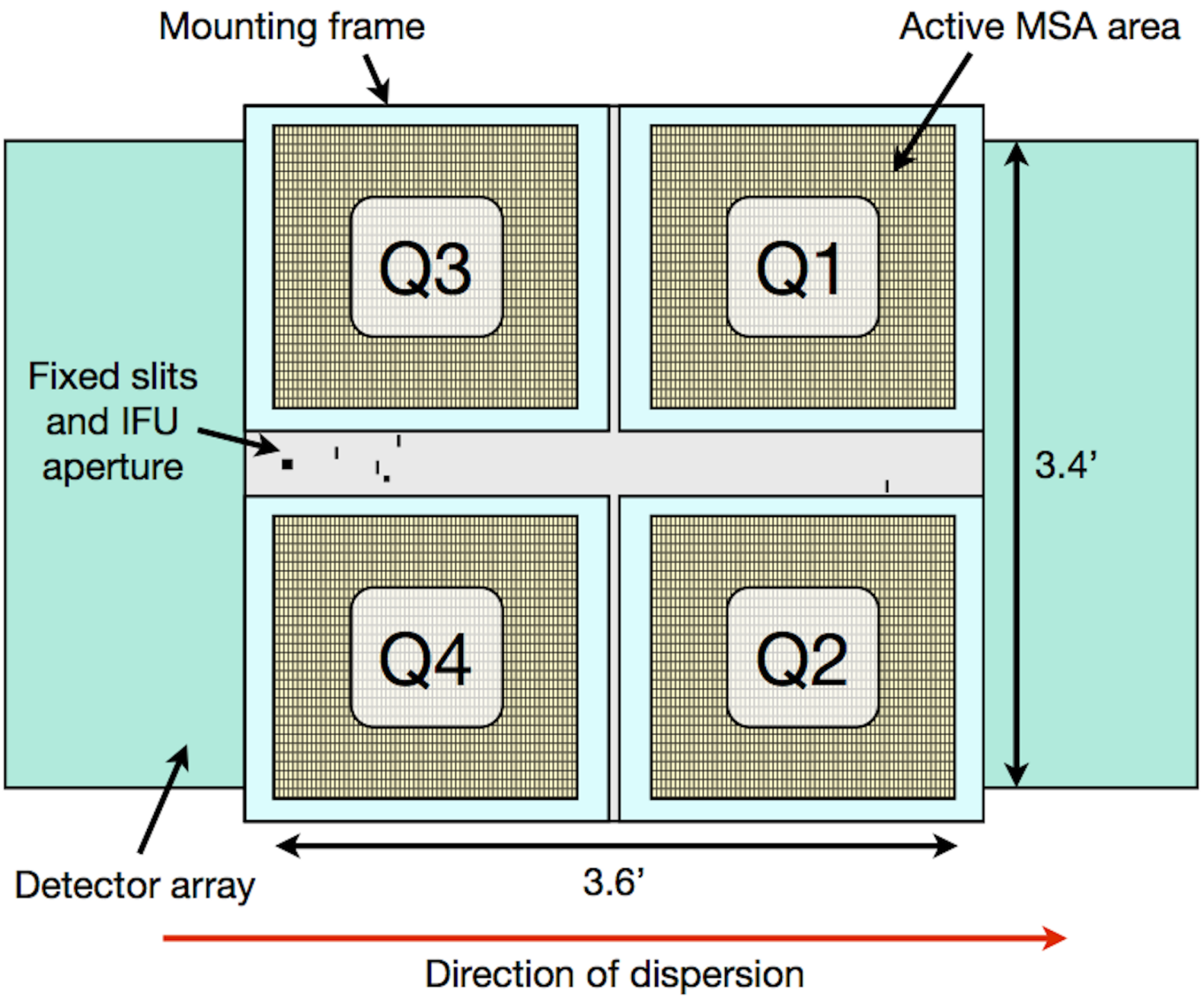
NIRSpec

- Spectrograph, 1.0 – 5.0 μm
- Multi-object, IFU, fixed slit
  - Micro shutter arrays (~100 objects at a time)

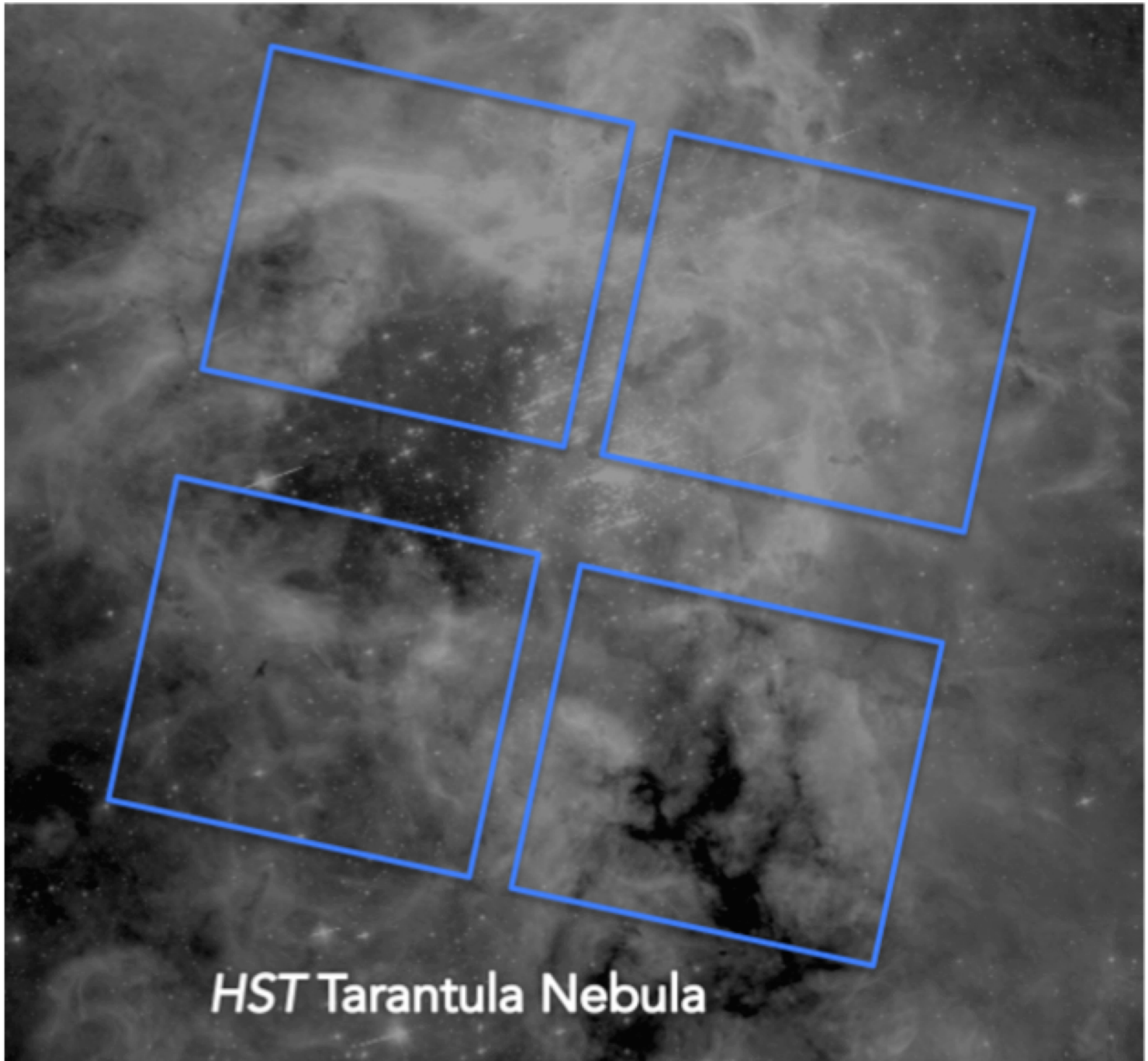
- More details? Talk to Anthony Marston

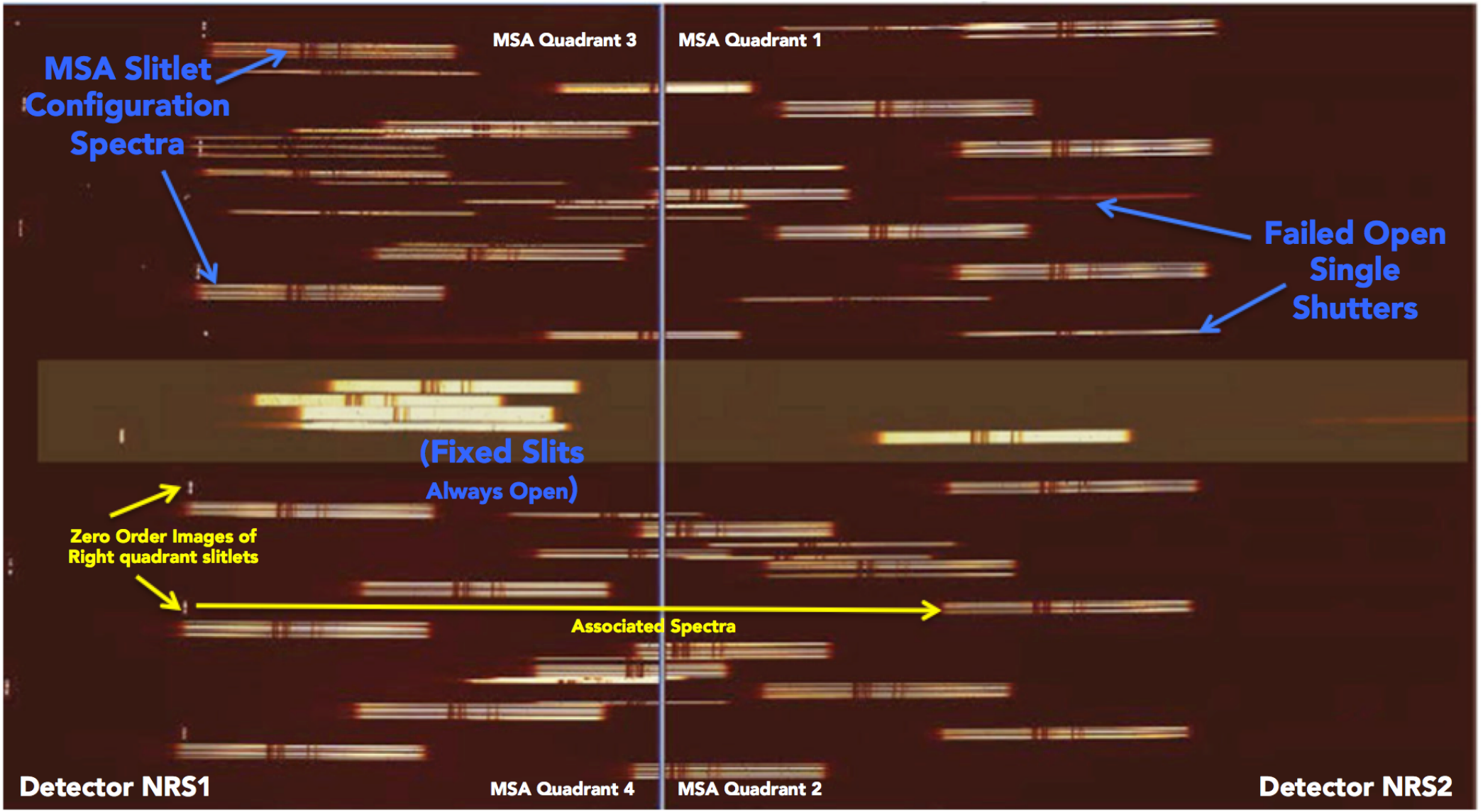

1 µm
2 µm
3 µm
4 µm
5 µm
Low spectral resolution configuration
0.6 µm
5.3 µm
Medium and high spectral resolution configurations
0.7 µm
1.27 µm
0.97 µm
1.89 µm
1.66 µm
3.17 µm
2.87 µm
5.27 µm

Mulit-Slit Aperture Spectroscopy

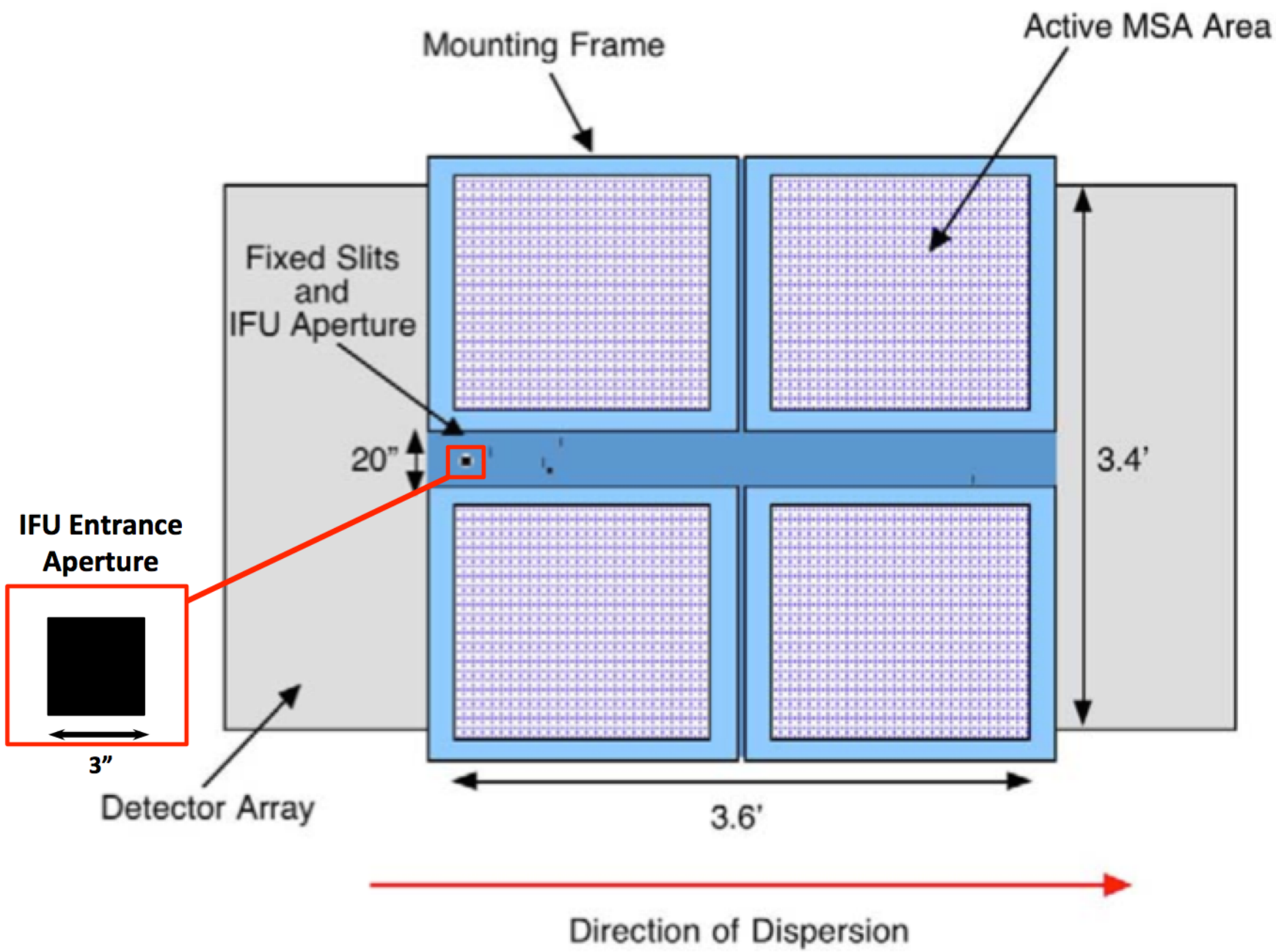


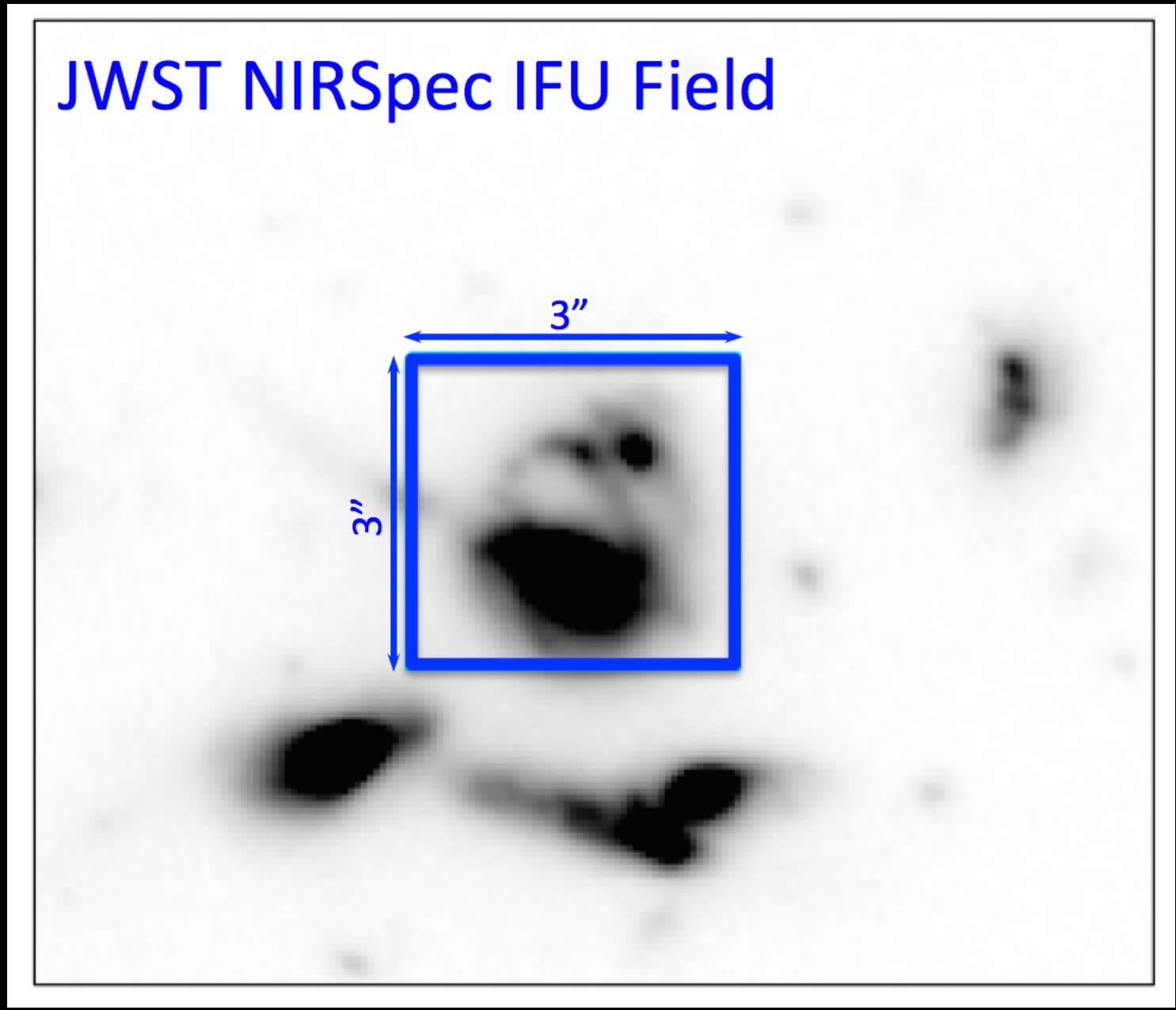
NIRSpec MSA Quadrant View

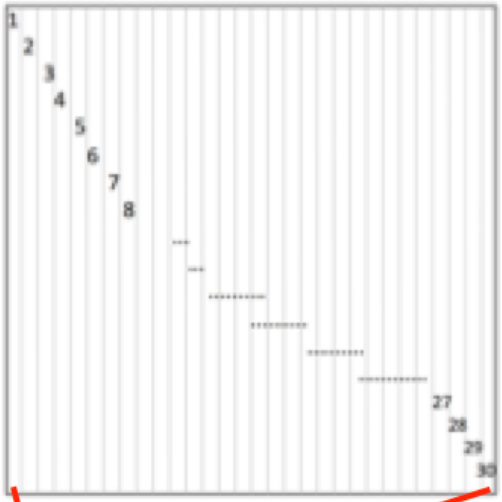



MSA Quadrant 3
MSA Quadrant 1
MSA Slitlet Configuration Spectra
Failed Open Single Shutters
(Fixed Slits Always Open)
Zero Order Images of Right quadrant slitlets
Associated Spectra
Detector NRS1
MSA Quadrant 4
MSA Quadrant 2
Detector NRS2

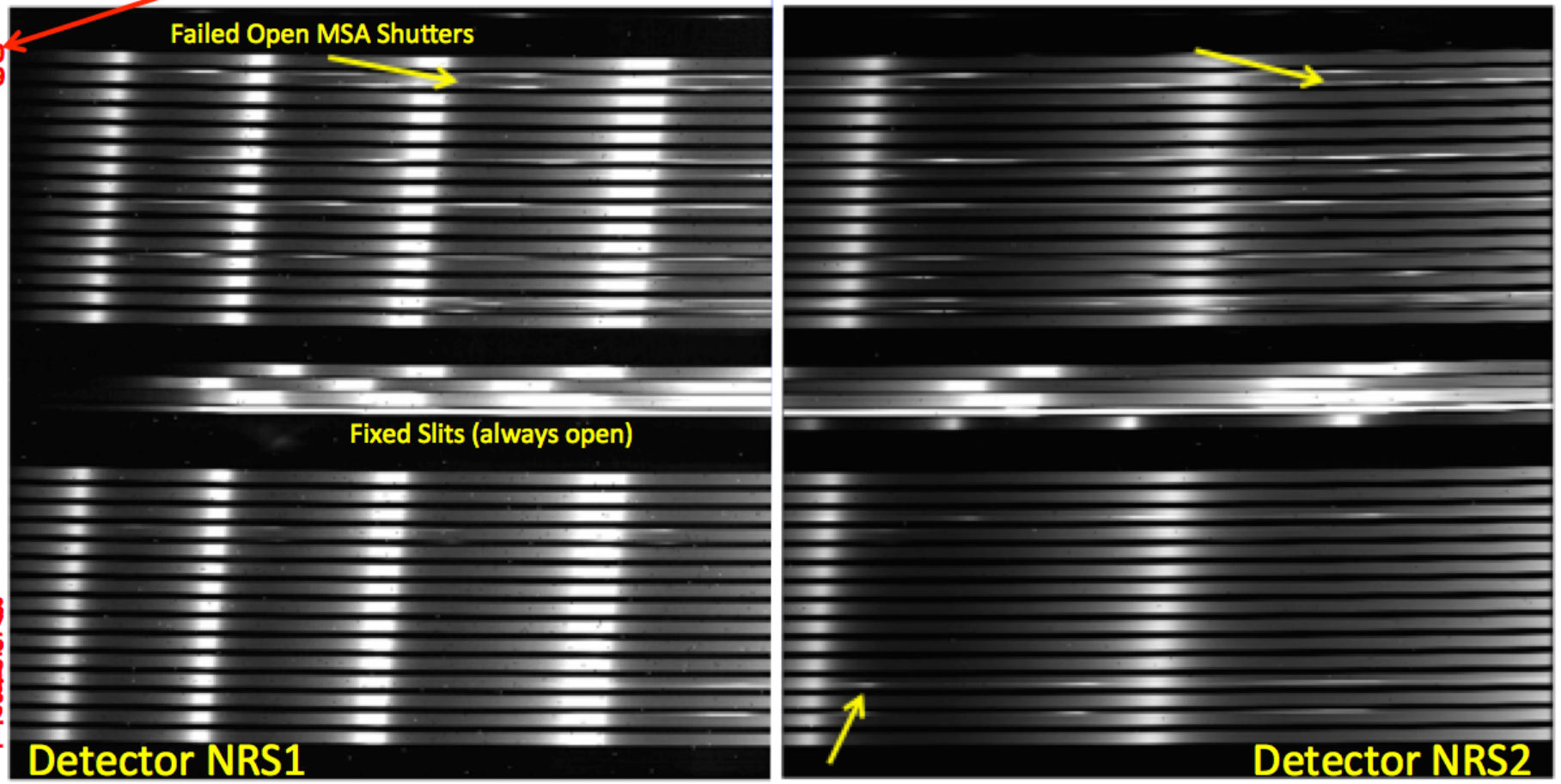
Integral Field Unit Spectroscoy



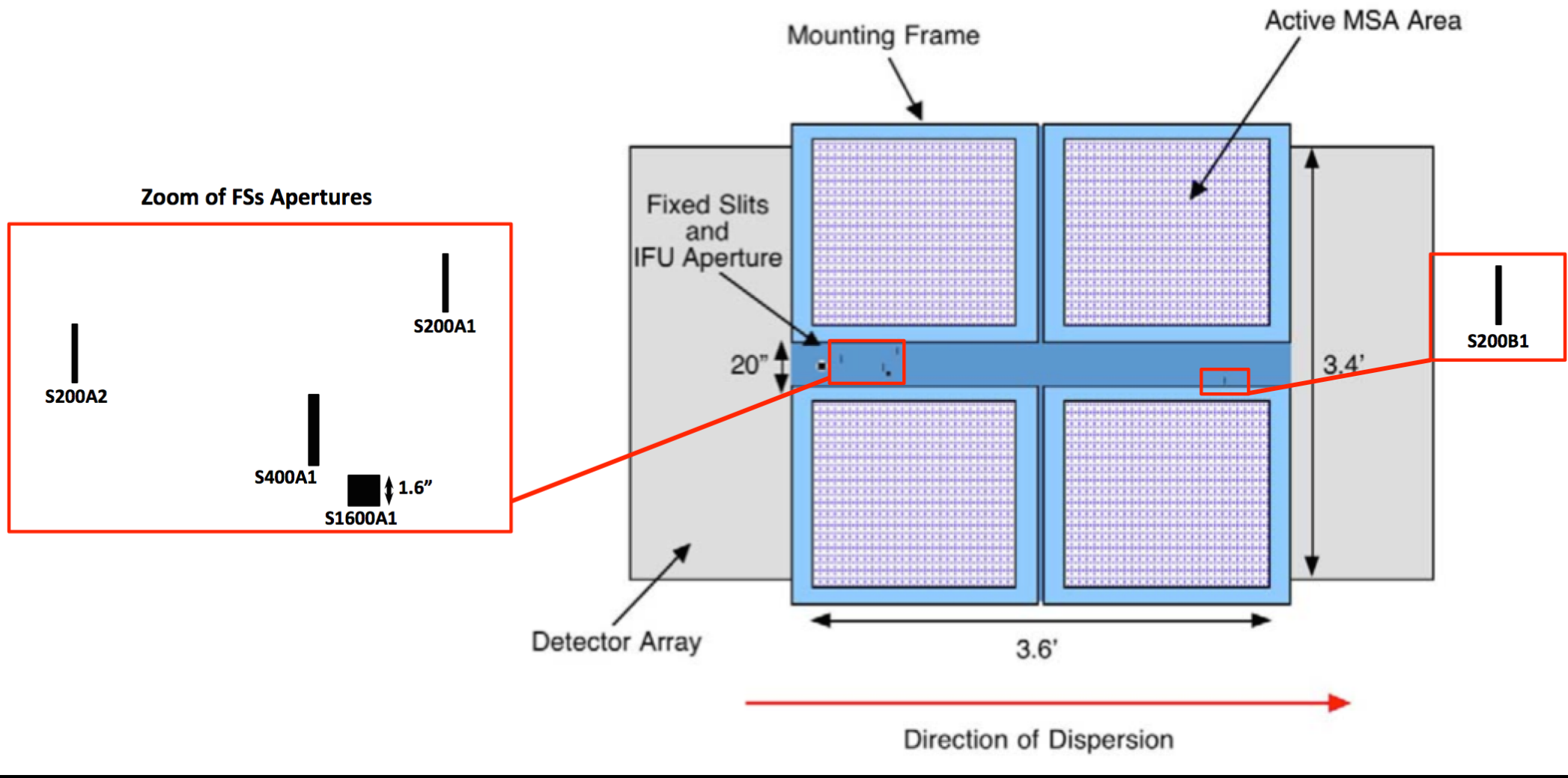

JWST NIRSpec IFU Field
3”
3”



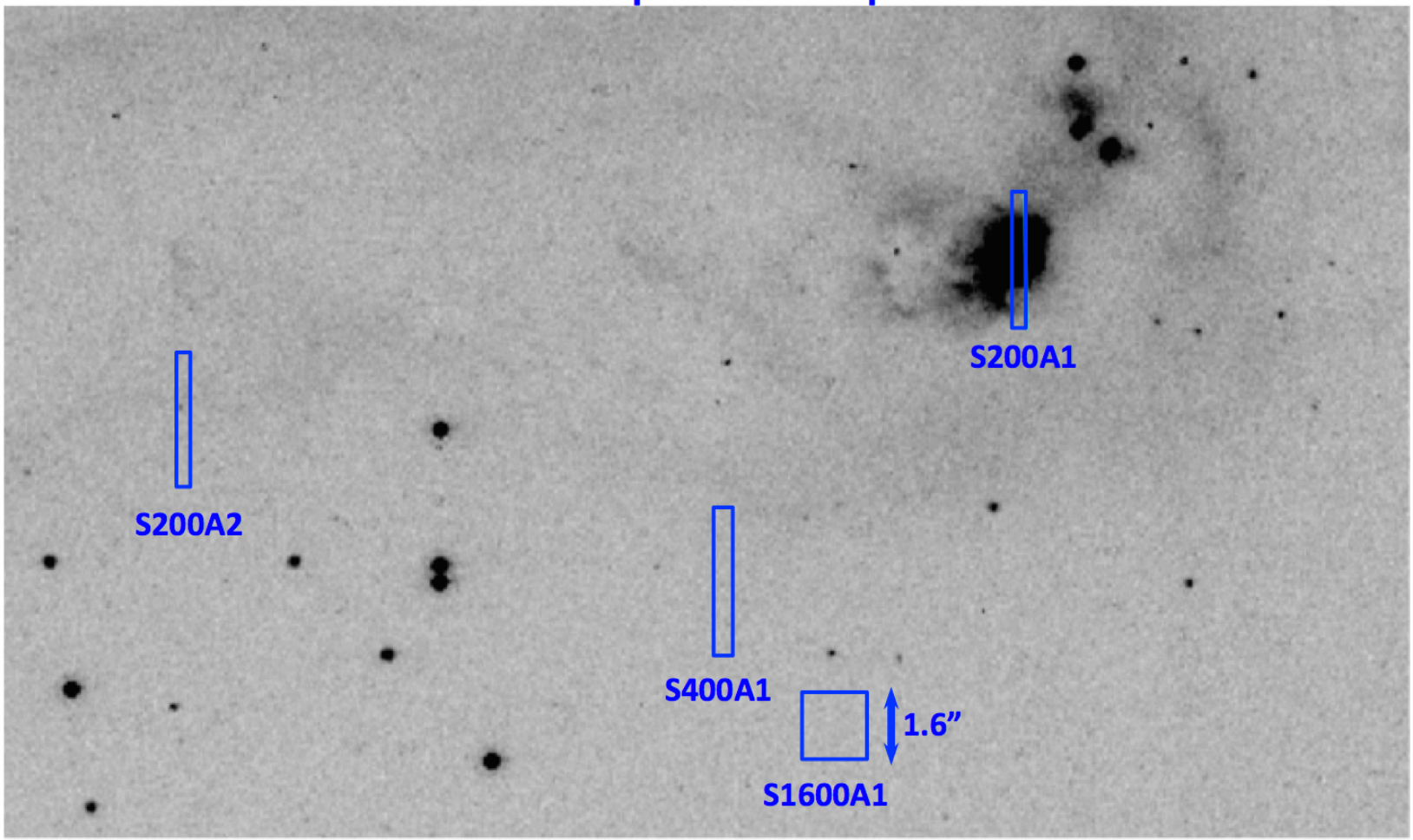
3”x3” IFU Field of View

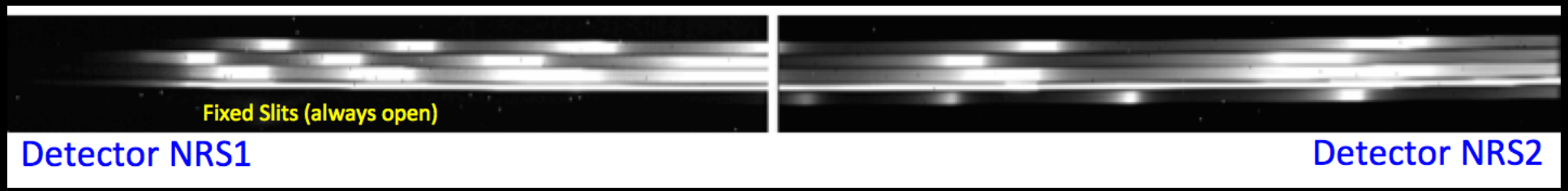


Fixed Slit Spectroscopy



JWST NIRSpec FS Apertures

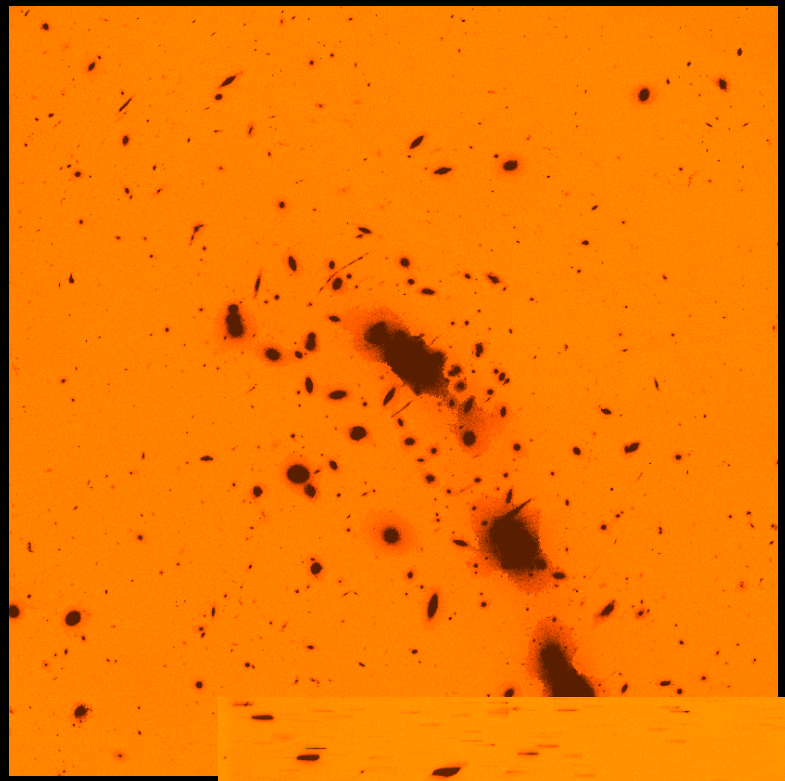


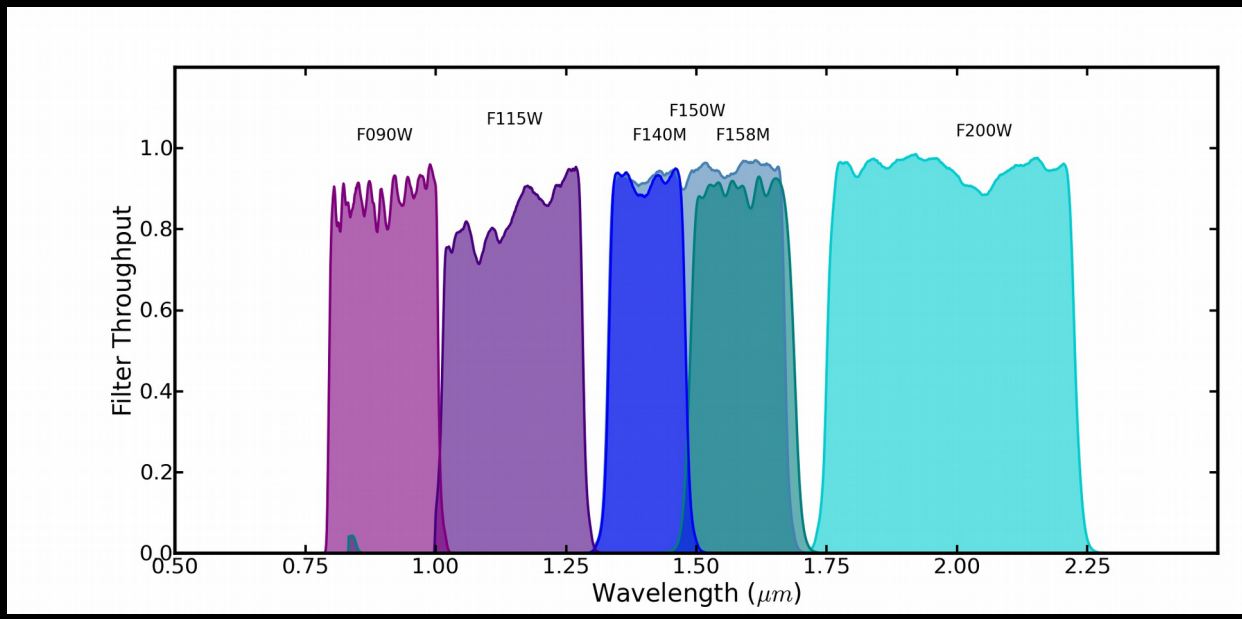


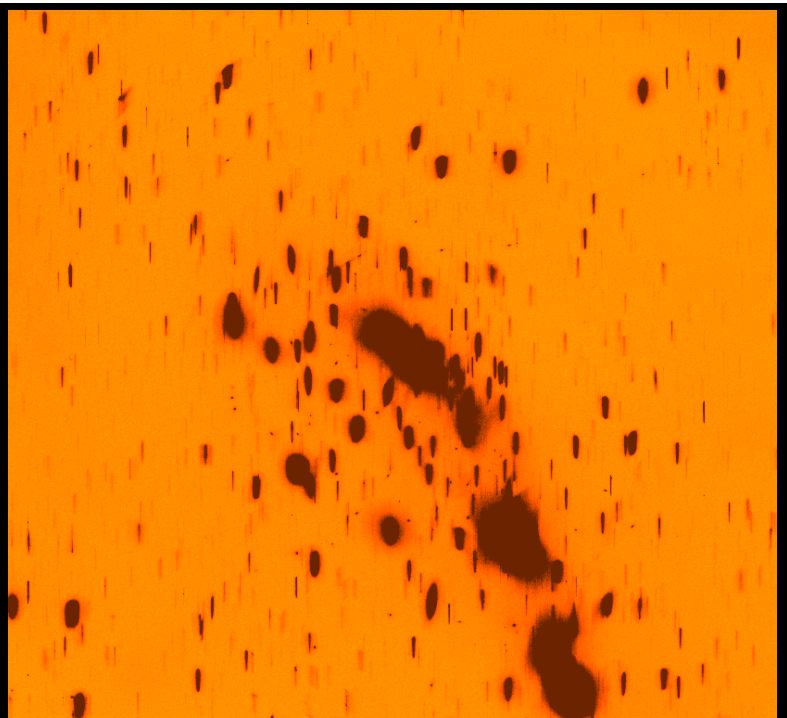
NIRISS

- Wide-Field Slitless Spectroscopy (WFSS)
  - R~150; 1.0 – 2.5 μm
- Single-Object Slitless Spectroscopy (SOSS)
  - R~700; 0.6 – 2.5 μm
- Aperture Masking Interferometry (AMI)
  - 3.8 – 4.8 μm
  - enabled by the non-redundant mask (NRM) which has 7 "holes" (apertures), which produce an interferogram that samples 21 unique ("non-redundant") baselines
- Imaging
  - 0.9 – 5.0 μm
  - F090W, F115W, F150W, F200W, F277W, F356W, F444W

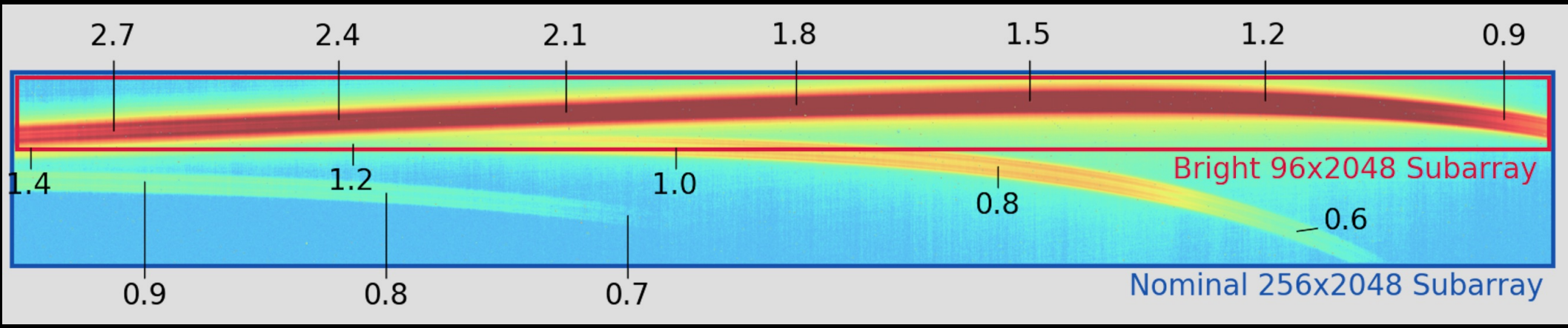
Wide Field Slitless Spectroscopy



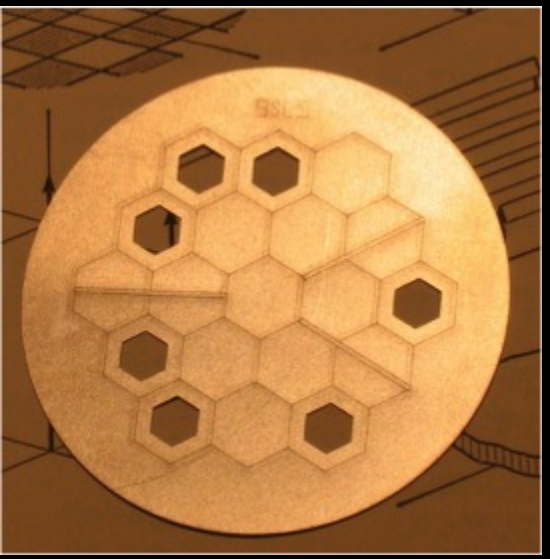


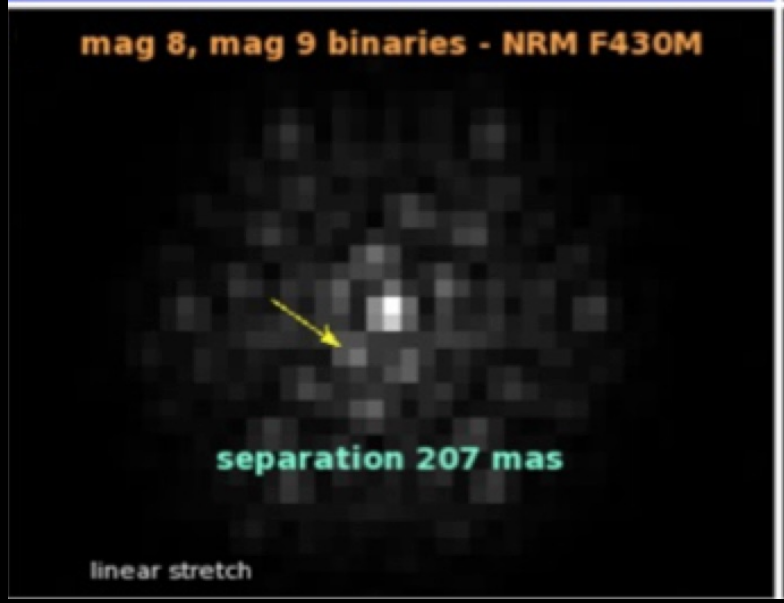


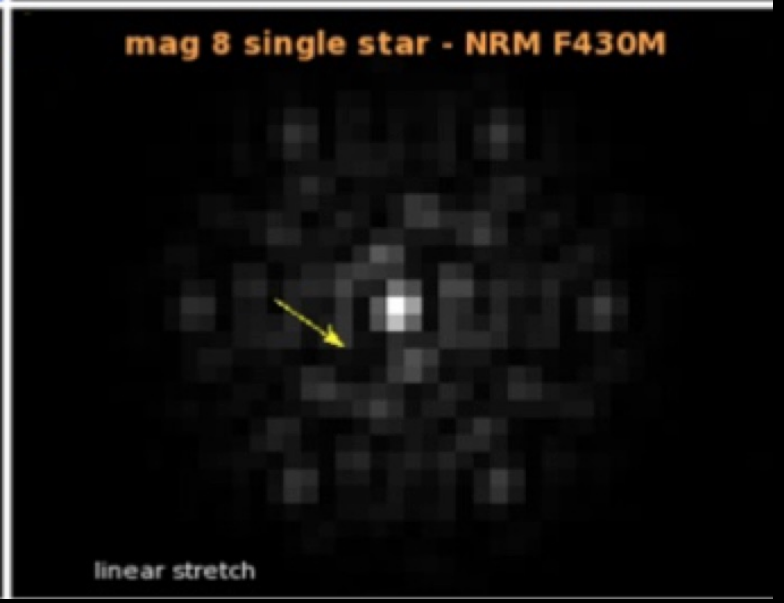
Single Object Slitless Spectroscopy



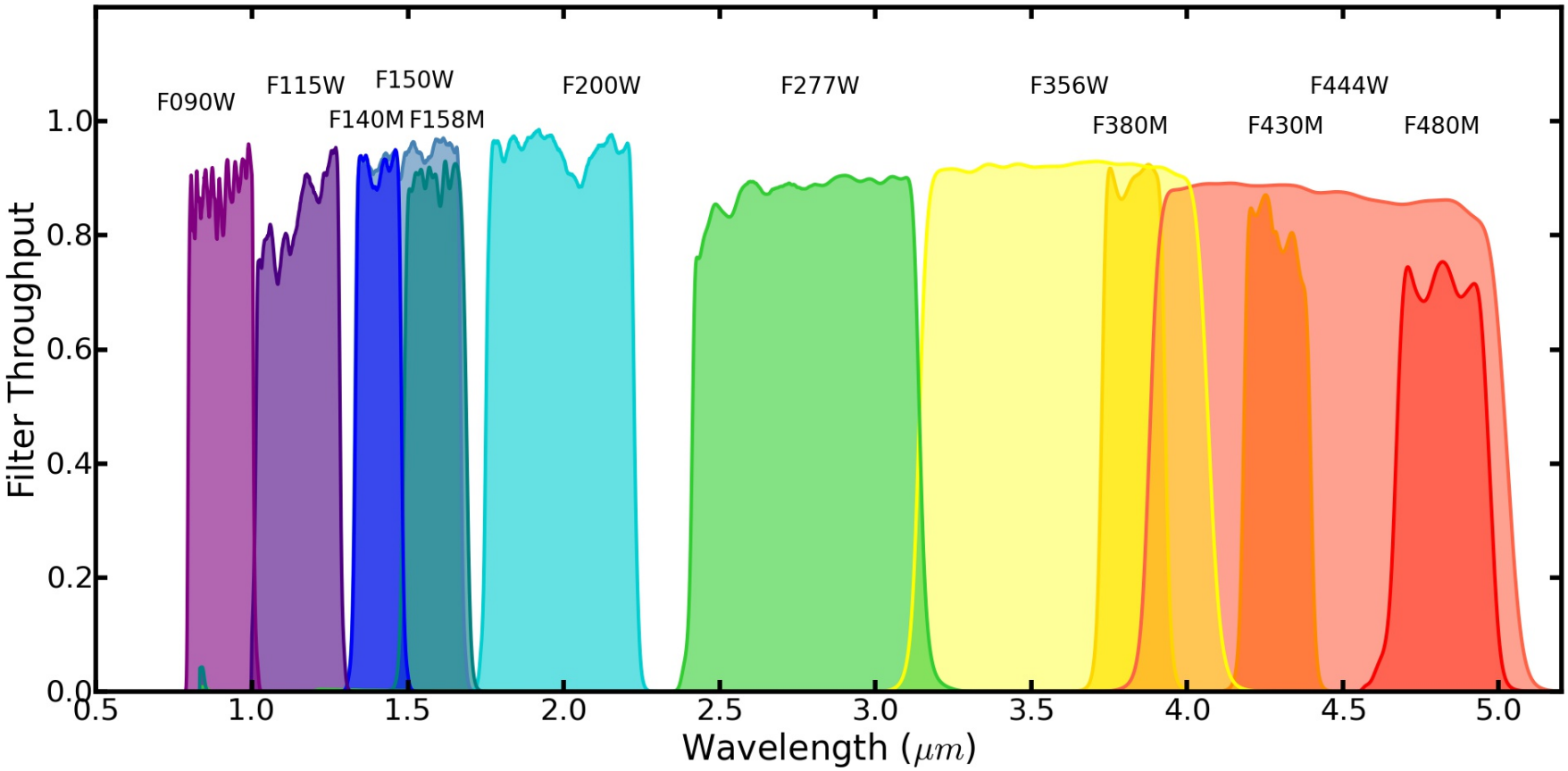
Aperture Masking Interferometry







Imaging

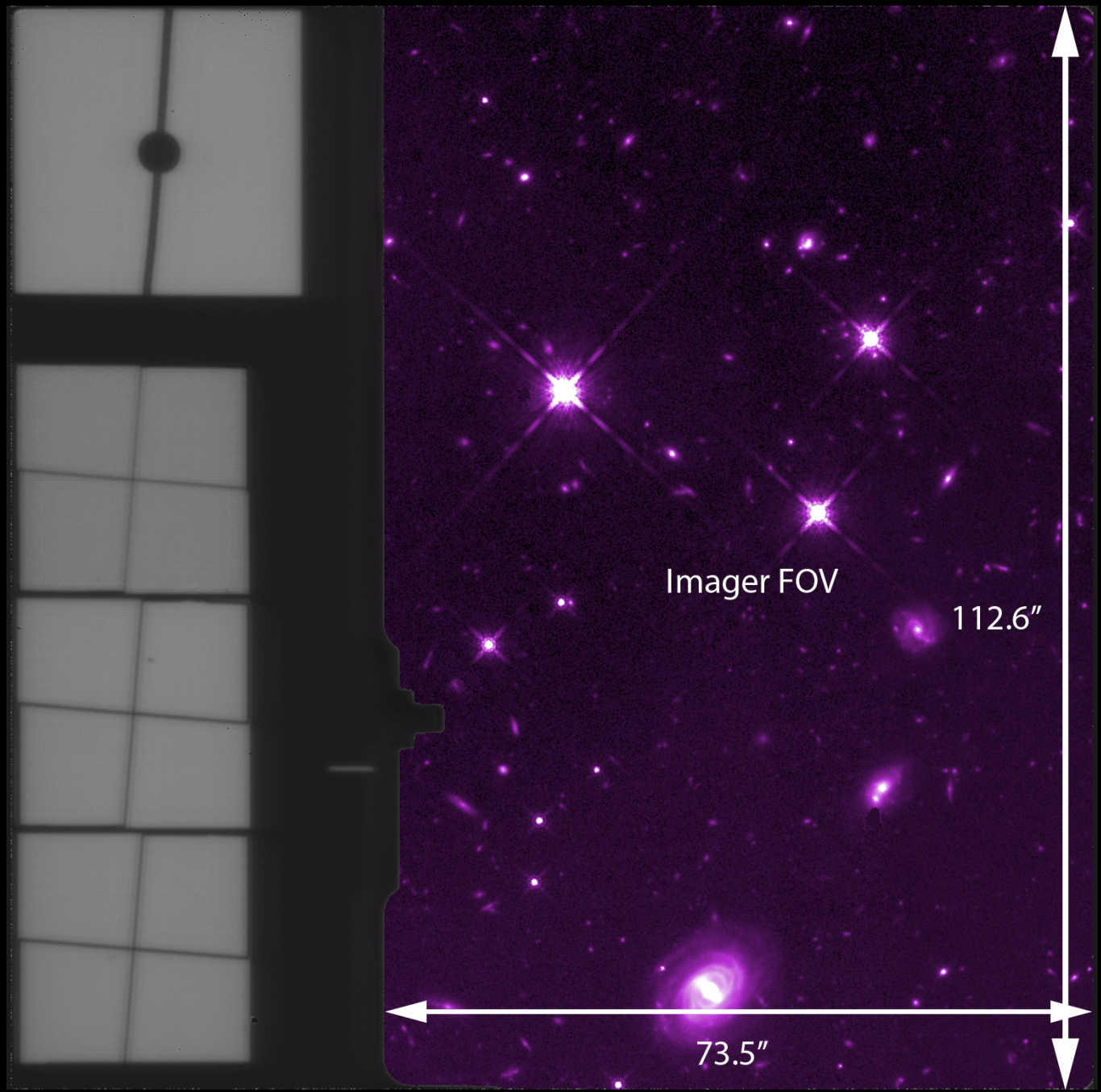

F090W
F115W
F150W
F140M
F158M
F200W
F277W
F356W
F380M
F444W
F430M
F480M
Filter Throughput
0.0
0.2
0.4
0.6
0.8
1.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Wavelength (μm)

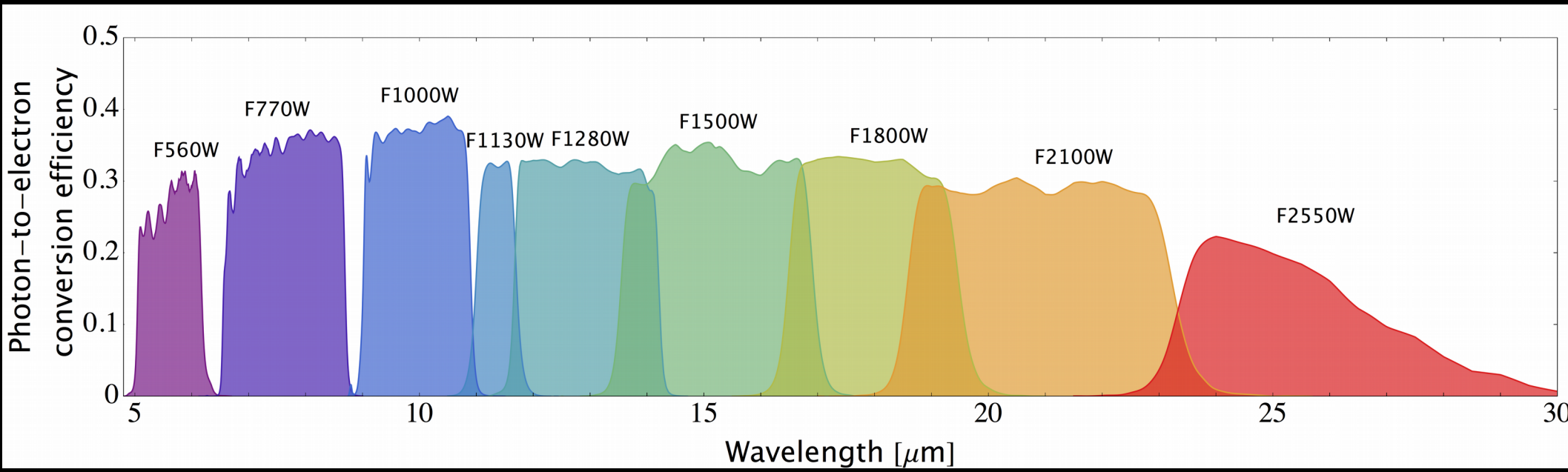
MIRI

- Imaging
  - 79 x 113 arcsec, diffraction limited at 7 μm
- Coronagraphy
- Low-Res Spectroscopy
  - R ~ 100, 5-10 (14) μm
- Med-Res Spectroscopy
  - R ~ 3000, 4 nested IFUs
  - 3 grating settings to get full 5-28.2 μm spectrum

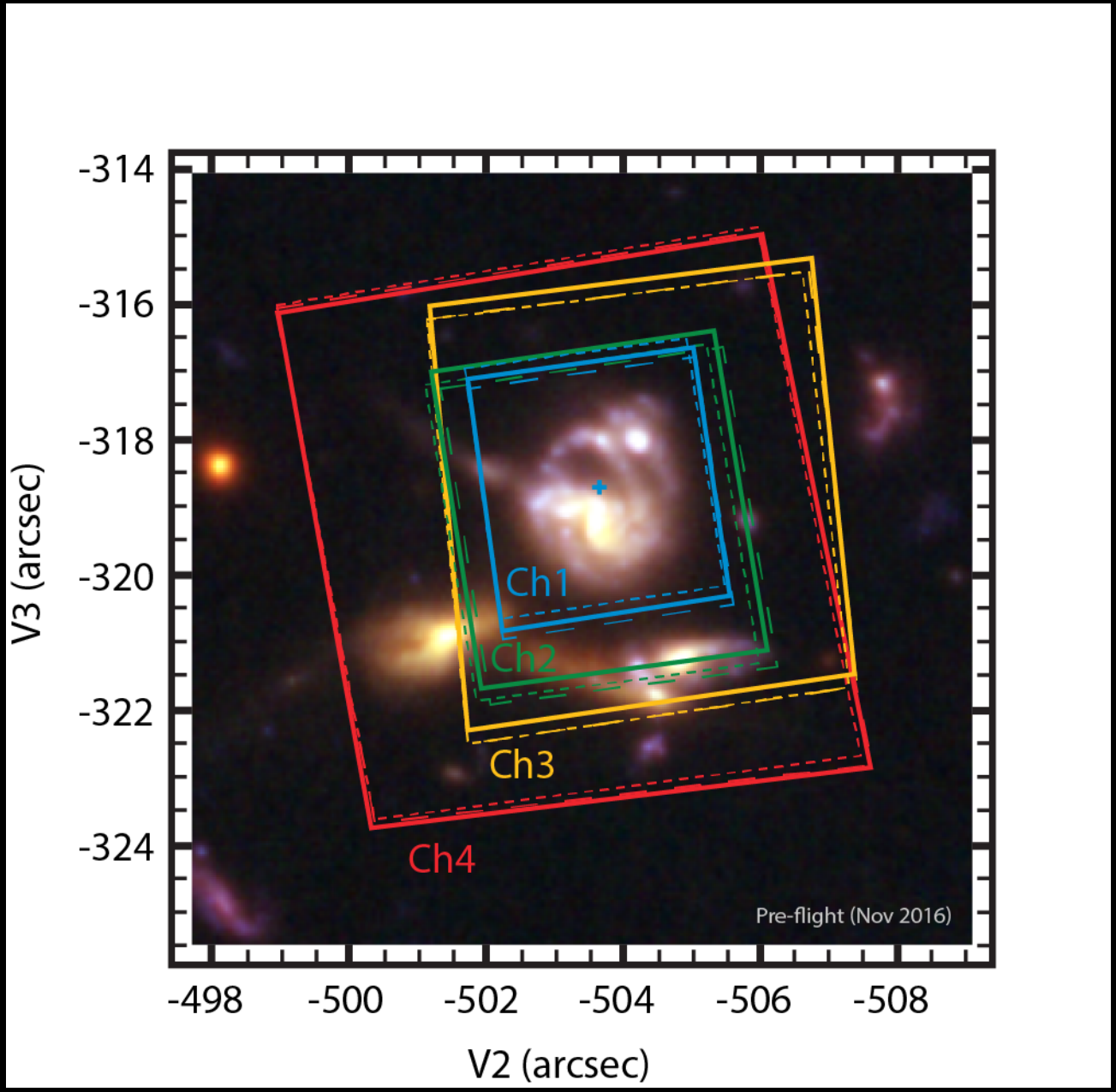
- More details? Talk to Greg Sloan or myself

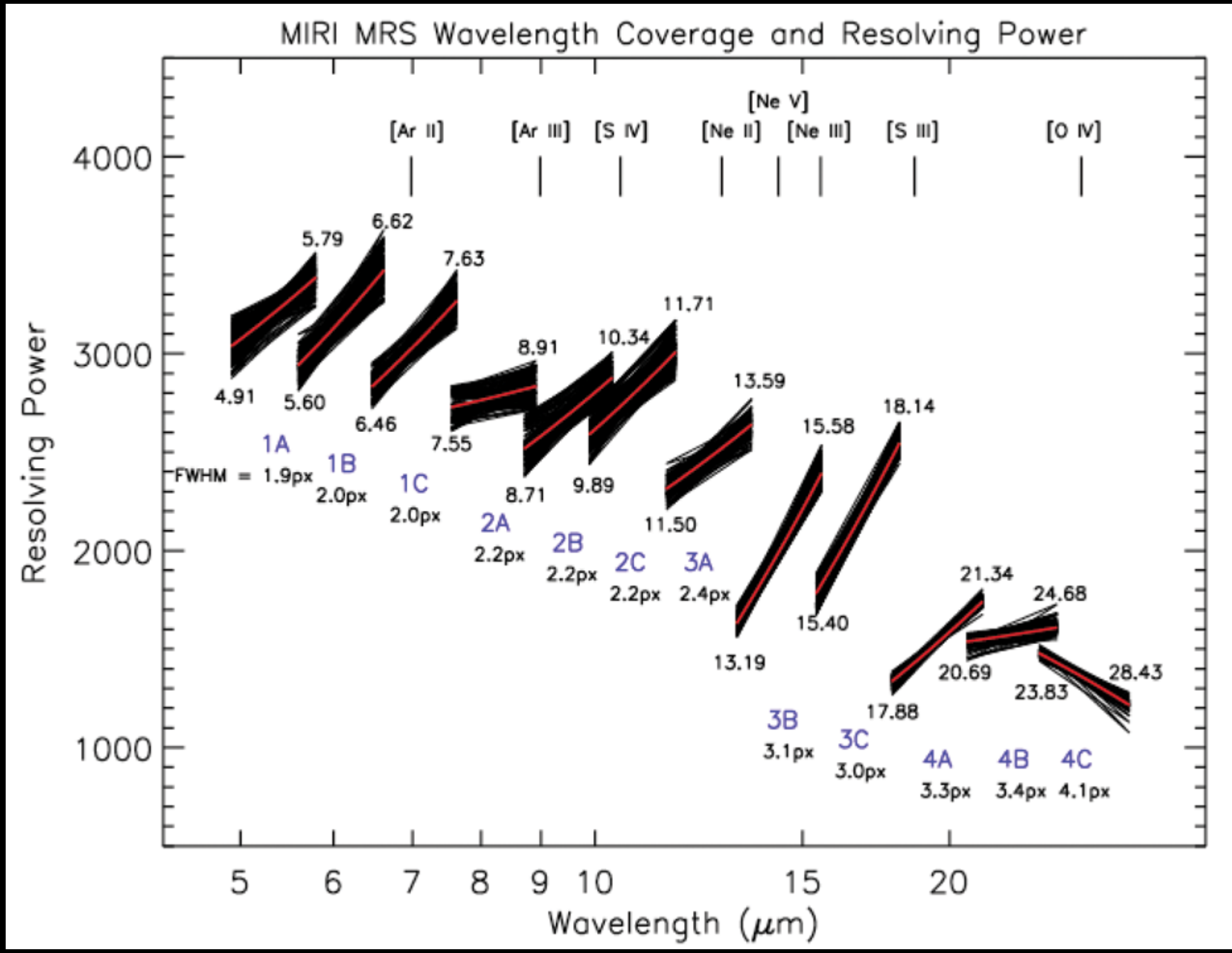
Imaging



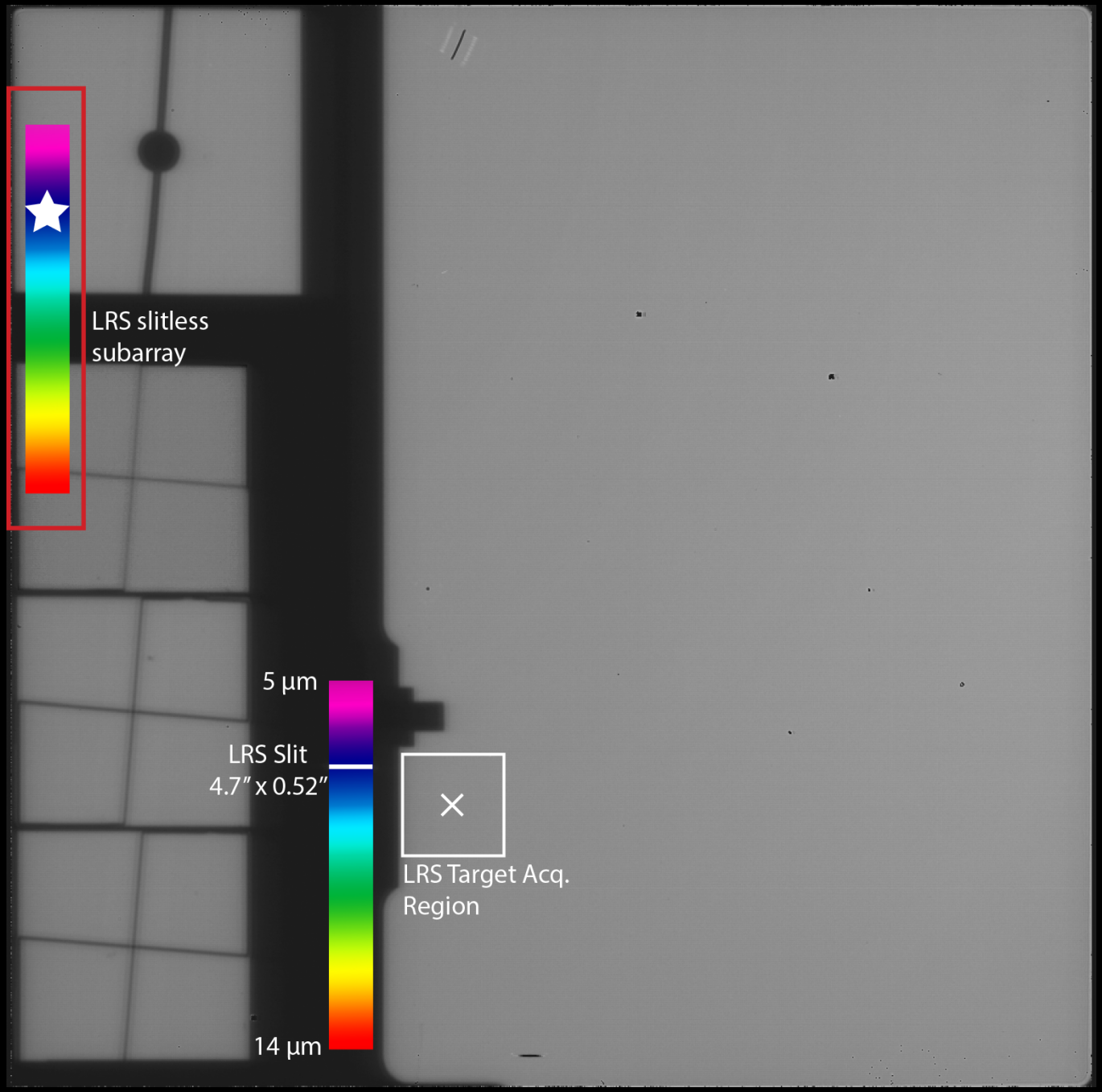

Photon−to−electron conversion efficiency
0.5
0.4
0.3
0.2
0.1
0
F560W
F770W
F1000W
F1130W
F1280W
F1500W
F1800W
F2100W
F2550W
5
10
15
20
25
30
Wavelength [μm]

Medium Resolution Spectroscopy
4 Nested Integral Field Units

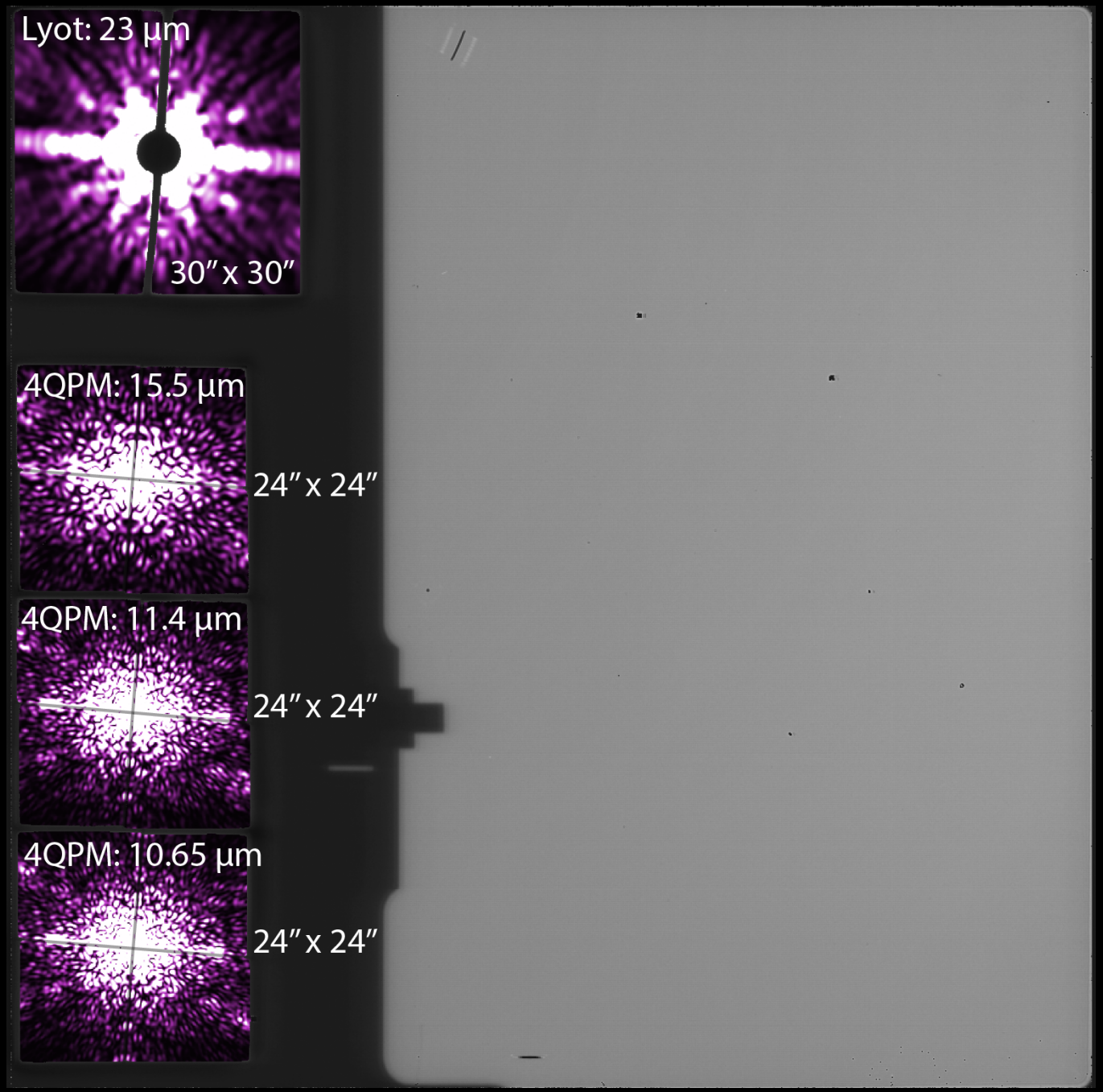


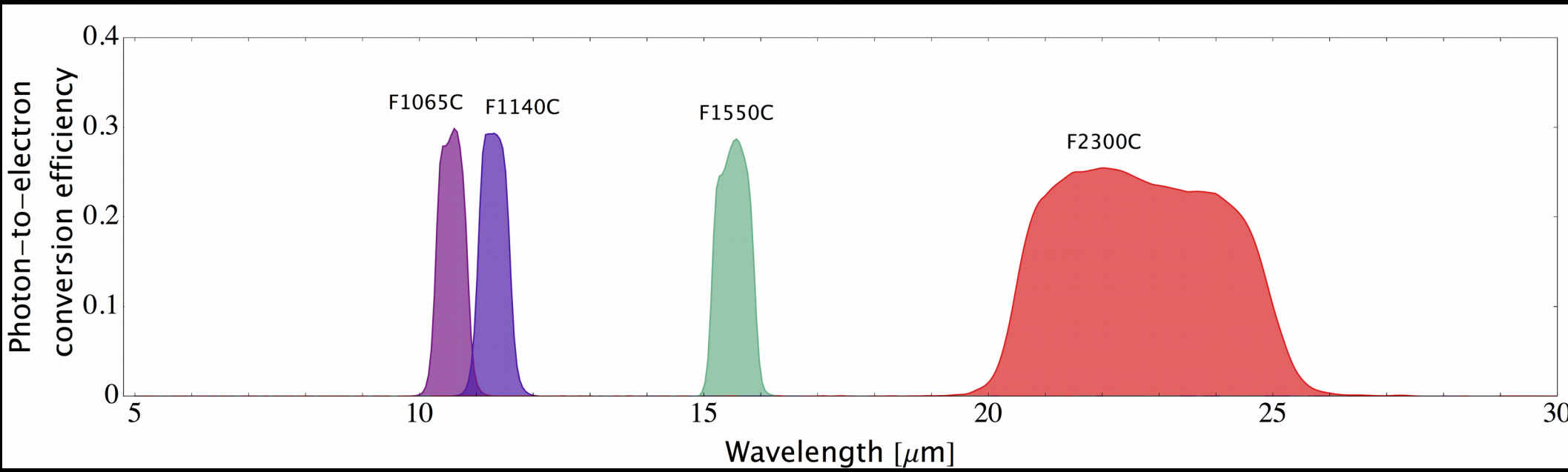

MIRI MRS Wavelength Coverage and Resolving Power
[Ar II]
[Ar III]
[S IV]
[Ne V]
[Ne II]
[Ne III]
[S III]
[O IV]
4000
3000
2000
1000
Resolving Power
5
6
7
8
9
10
15
20
Wavelength (μm)
4.91
5.60
5.79
6.46
6.62
7.55
7.63
8.71
8.91
9.89
10.34
11.50
11.71
13.19
13.59
15.40
15.58
17.88
18.14
20.69
21.34
23.83
24.68
28.43
FWHM = 1.9px
1A
1B
2.0px
1C
2.0px
2A
2.2px
2B
2.2px
2C
2.2px
3A
2.4px
3B
3.1px
3C
3.0px
4A
3.3px
4B
3.4px
4C
4.1px

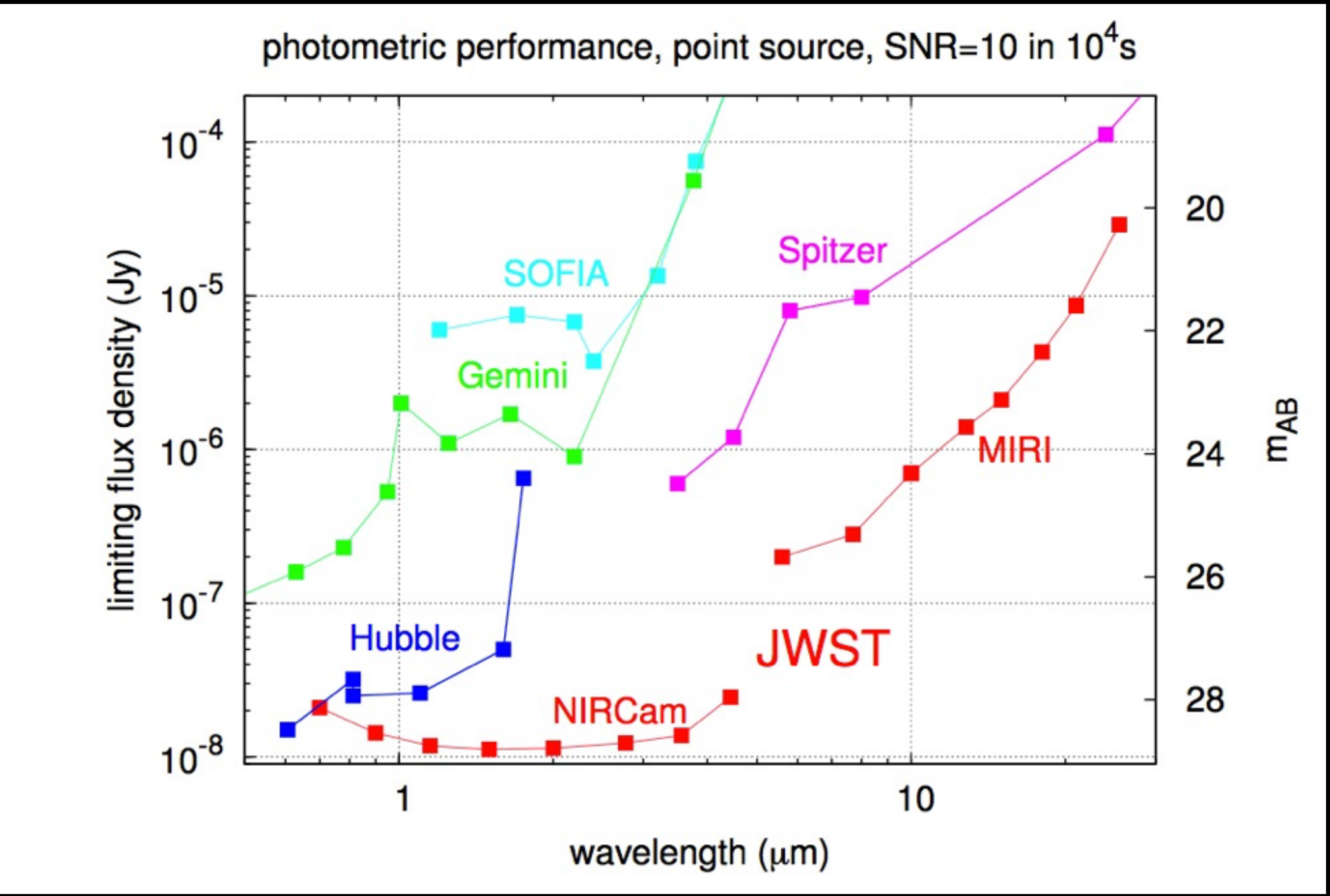
Low Resolution Spectroscopy

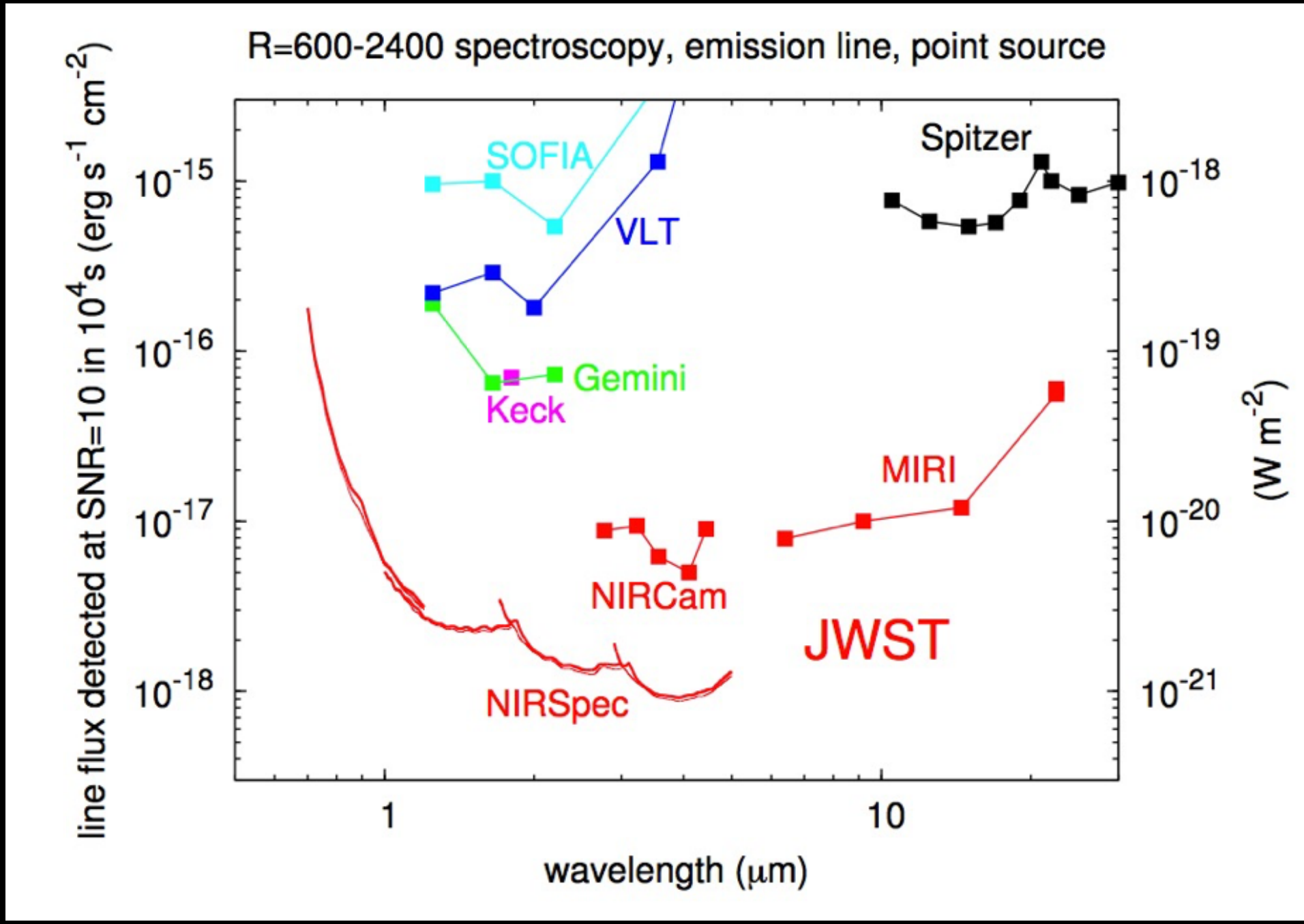


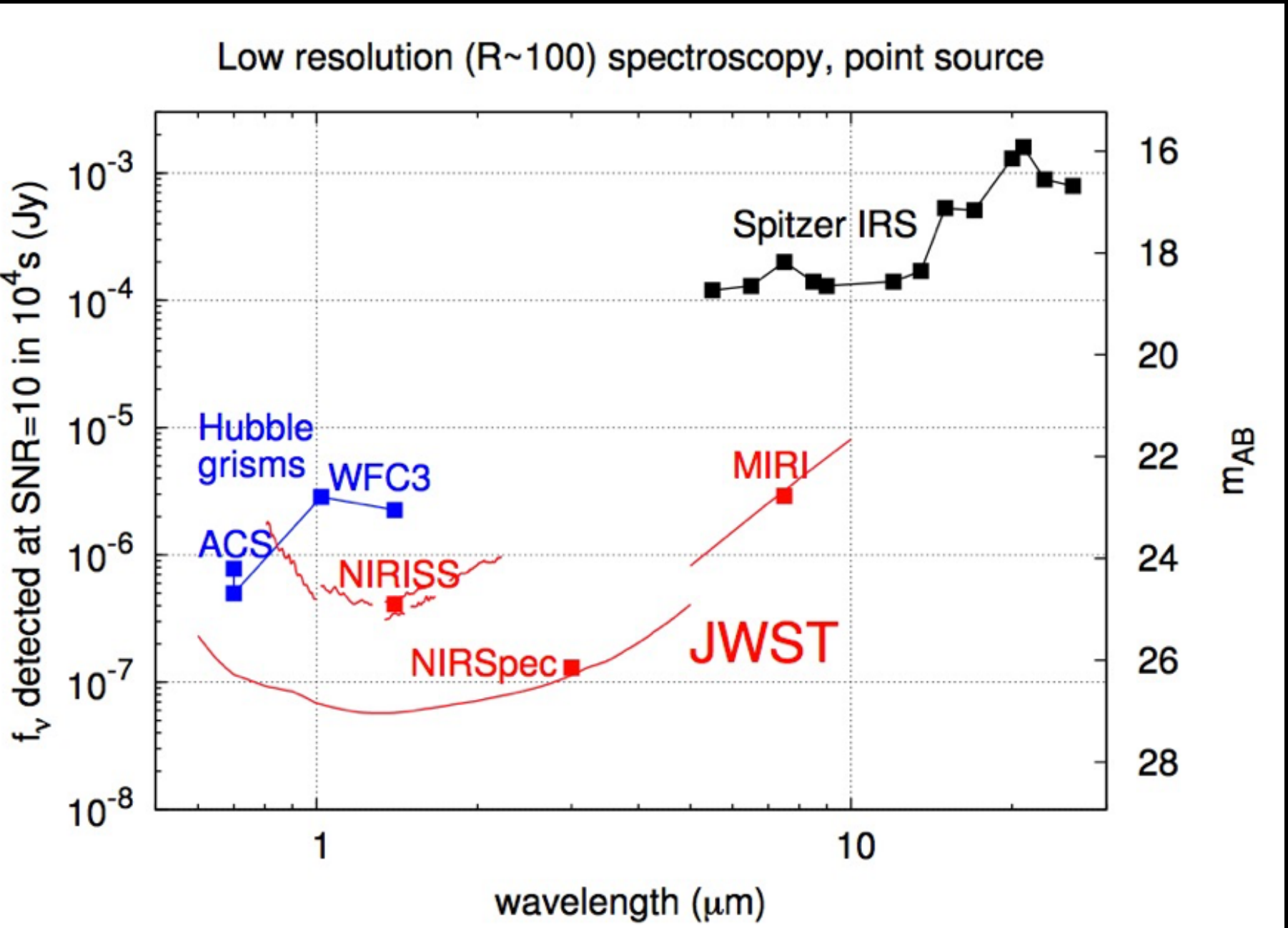
Coronography

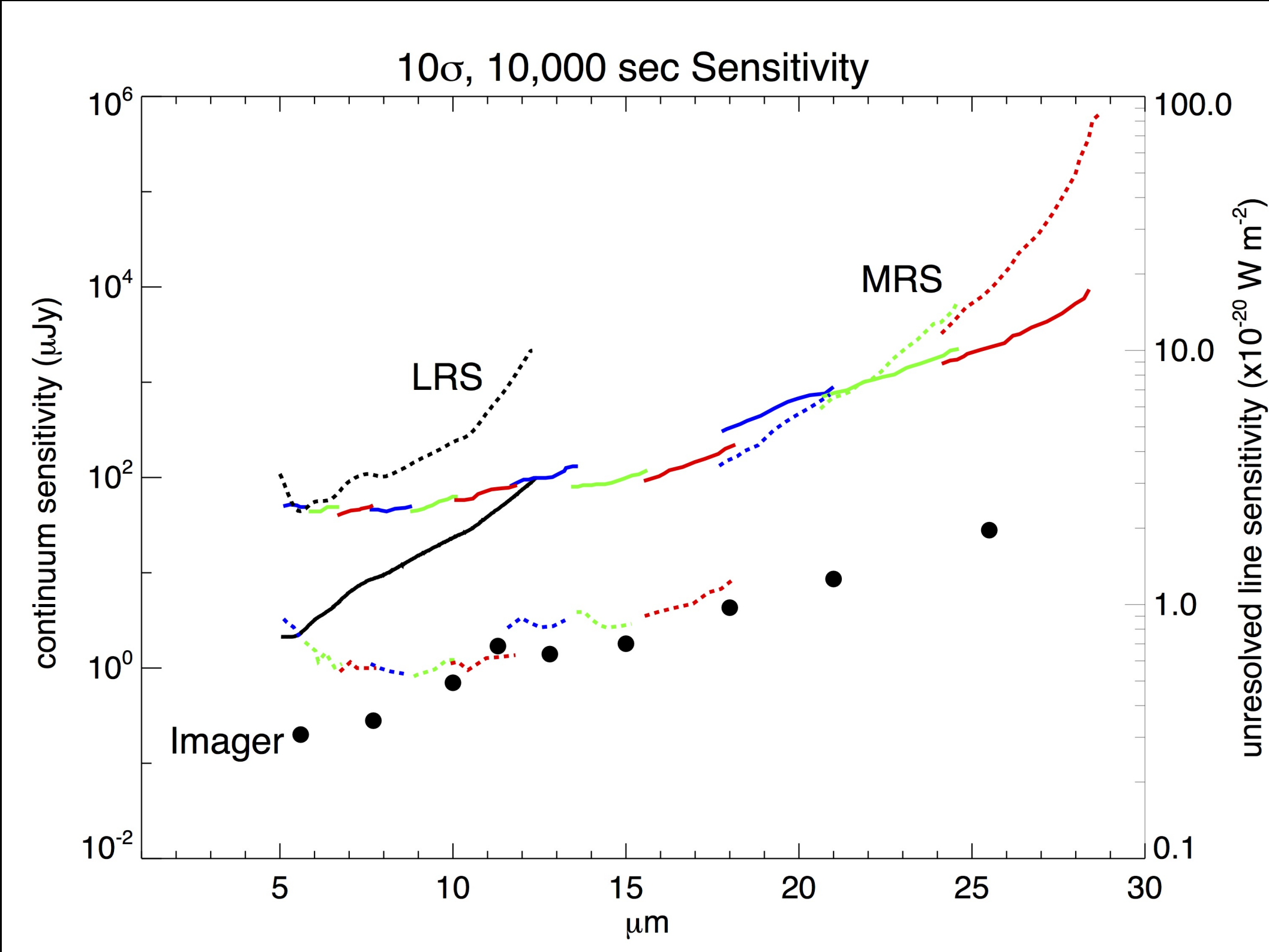



Photon−to−electron conversion efficiency
0.4
0.3
0.2
0.1
0
F1065C
F1140C
F1550C
F2300C
5
10
15
20
25
30
Wavelength [μm]


photometric performance, point source, SNR=10 in 10^4s
limiting flux density (Jy)
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
1
10
wavelength (μm)
20
22
24
26
28
m_{AB}
SOFIA
Gemini
Spitzer
MIRI
Hubble
JWST
NIRCam


R=600-2400 spectroscopy, emission line, point source
line flux detected at SNR=10 in 10^4 s (erg s^-1 cm^-2)
(W m^-2)
wavelength (μm)
SOFIA
VLT
Spitzer
Gemini
Keck
MIRI
NIRCam
JWST
NIRSpec
10^-15
10^-16
10^-17
10^-18
10^-18
10^-19
10^-20
10^-21
1
10


Low resolution (R~100) spectroscopy, point source
Spitzer IRS
Hubble
grisms
WFC3
ACS
NIRISS
MIRI
NIRSpec
JWST
f_ν detected at SNR=10 in 10^4s (Jy)
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
16
18
20
22
24
26
28
m_{AB}
1
10
wavelength (μm)


10σ, 10,000 sec Sensitivity
continuum sensitivity (μJy)
unresolved line sensitivity (x10^-20 W m^-2)
μm
LRS
MRS
Imager
10^6
10^4
10^2
10^0
10^-2
100.0
10.0
1.0
0.1
5
10
15
20
25
30

JWST Science Timeline

- Types of JWST Programs
  - GTO, GO, ERS
- Focus on ERS program (new type)
- Schedule, Dates, etc.

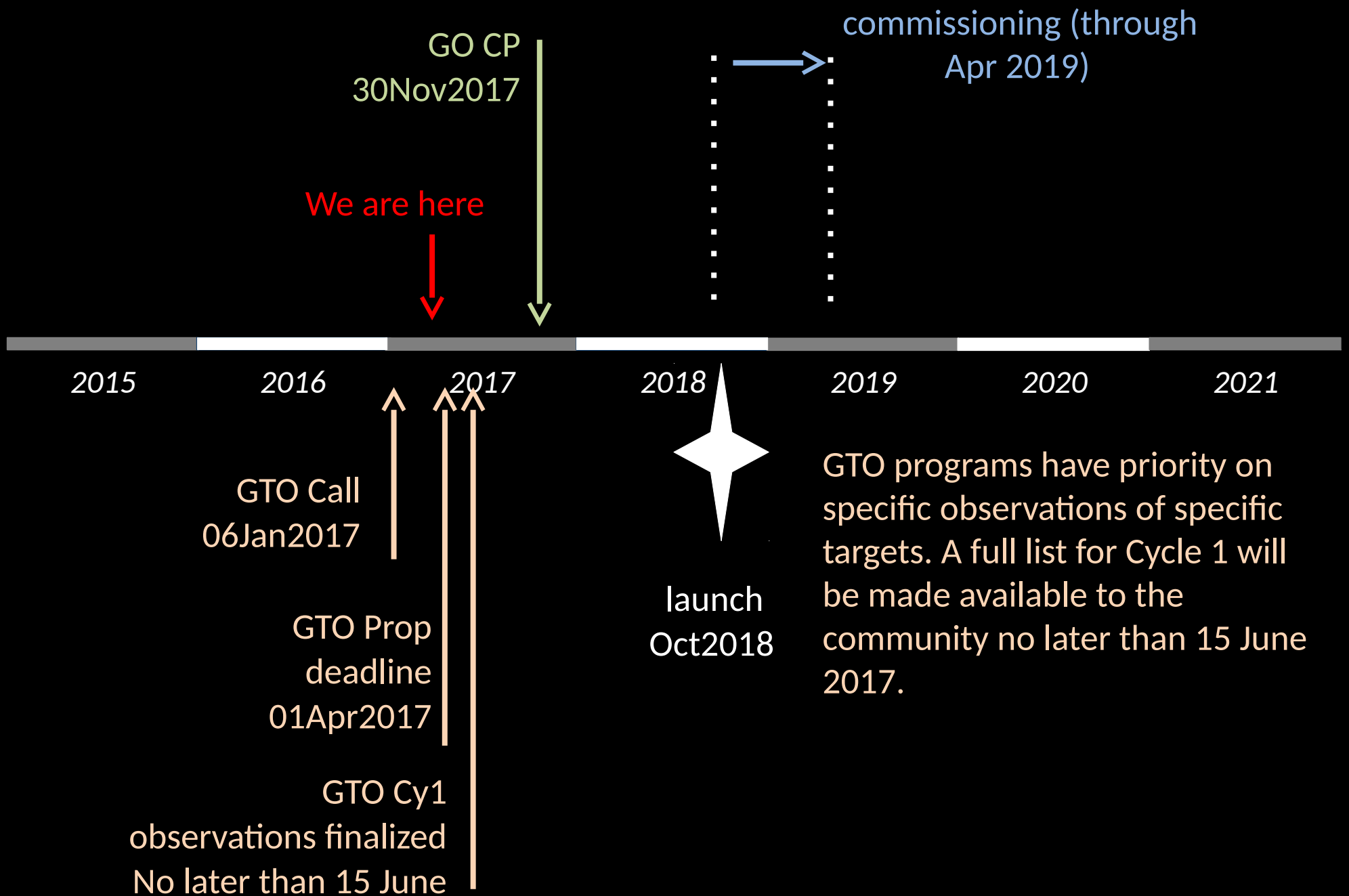
- Slides based on those given by Neill Reid at the ESAC 2016 JWST workshop near Madrid, Spain in late Sep 2016

JWST Observing Programs

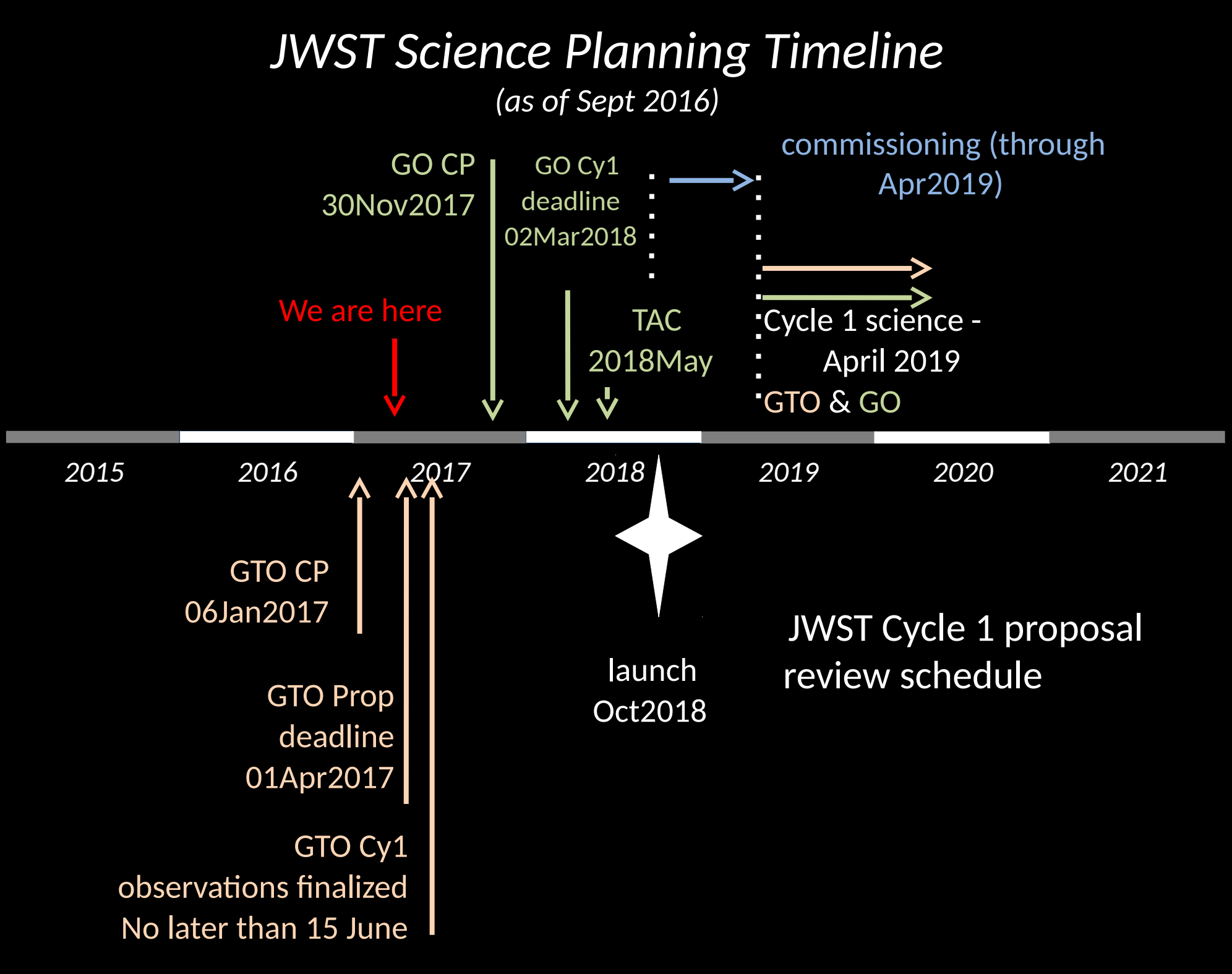
- Guest Observer (GO)
  - Open access for the community
  - ~80% of time in Cycles 1 through 5
- Guaranteed Time Observer (GTO)
  - 4020 hours allocated over first 30 months (i.e. Cycles 1 through 3)
  - NASA policy constraints on time/cycle
- Director's Discretionary Time (DD)
  - Up to 10% per cycle i.e. ≤877 hours
  - Rapid response observations & targeted science programs, such as Early Release Science program

JWST Science Planning Timeline

(as of Sept 2016)



GTO programs have priority on specific observations of specific targets. A full list for Cycle 1 will be made available to the community no later than 15 June 2017.


JWST Science Planning Timeline
(as of Sept 2016)
GO CP
30Nov2017
GO Cy1
deadline
02Mar2018
commissioning (through
Apr2019)
We are here
TAC
2018May
Cycle 1 science -
April 2019
GTO & GO
2015
2016
2017
2018
2019
2020
2021
GTO CP
06Jan2017
GTO Prop
deadline
01Apr2017
GTO Cy1
observations finalized
No later than 15 June
launch
Oct2018
JWST Cycle 1 proposal
review schedule

GO Programs I

- We anticipate that JWST GO size categories will include
  - Small, Medium, Large, Very Large
- We anticipate a balanced distribution in program sizes over all JWST cycles
  - Small/Medium/Large in early cycles
  - The majority of time will likely be allocated to Small programs
    - But there will be no cap on program size
  - Very Large programs will be introduced in later cycles

GO Programs II

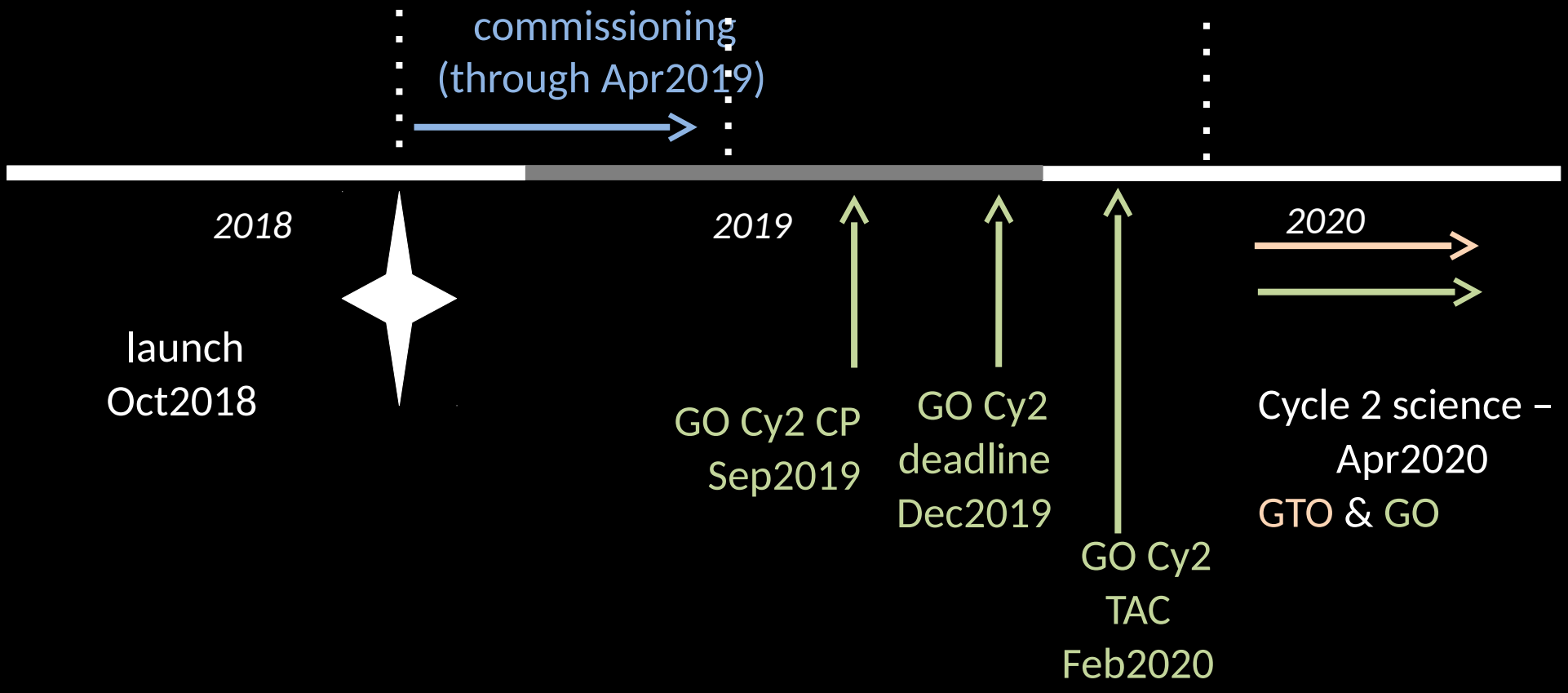
- We also anticipate specialized categories
  - Multi-cycle, Target of Opportunity (ToO), Treasury/Legacy
  - Joint programs with other facilities will not be available until Cycle 2
- JWST will offer limited coordinated science parallels in Cycle 1
  - Pure parallel GO programs will be also available
- JWST will also accept proposals for archival & theory research programs

Early Release Science (ERS) Program

- Get science data into the hands of the community ASAP to support cycle 2 proposals
- Standard 12 month proprietary period
  - GO and GTO data
- Very little data public in the archive before cycle 2 proposals due

Cycle 2 proposal schedule

- JWST science observations start in April 2019
  - Cycle 2 CP in September 2019, ~5 months into Cycle 1
  - Cycle 2 proposal deadline in early December 2019, ~7.5 months from the start of Cycle 1
- **The general community will have very limited access to non-proprietary observations to aid preparations for Cycle 2 programs**

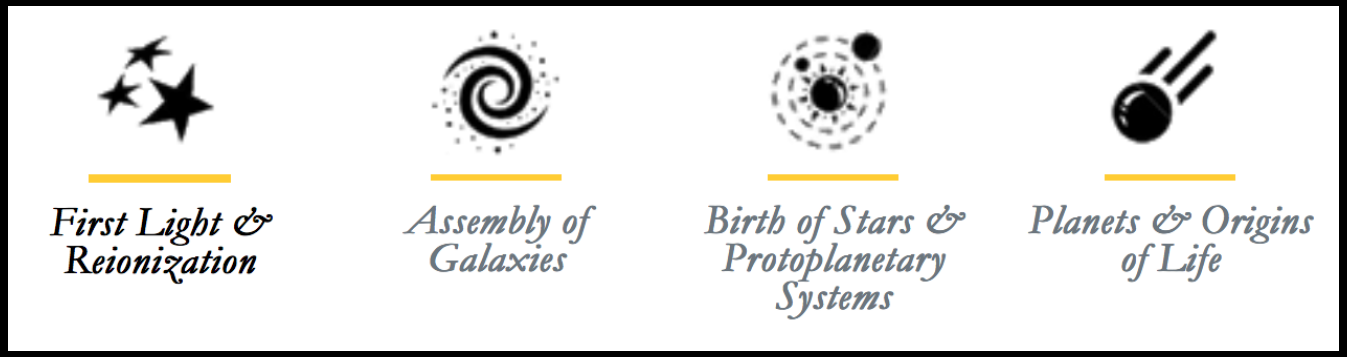


Enabling Data Access

- The JWST Advisory Committee recommended implementation of an Early Release Science Program
  - *"..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." (see JSTAC letters 21/6/2010 & 26/3/2014)*
- Concept: A suite of science demonstration observing programs, designed by the community and selected through proposal peer review :
  - Director's Discretionary Time
  - Data have no exclusive access period
- Programs selected by peer review prior to Cycle 1 GO Call
- The DD-ERS program represents science from the community selected by the community for the community

STScI Director Ken Sembach will allocate ~500 hours of Director's Discretionary time for an Early Release Science (DD-ERS) program to prepare the community for Cycle 2

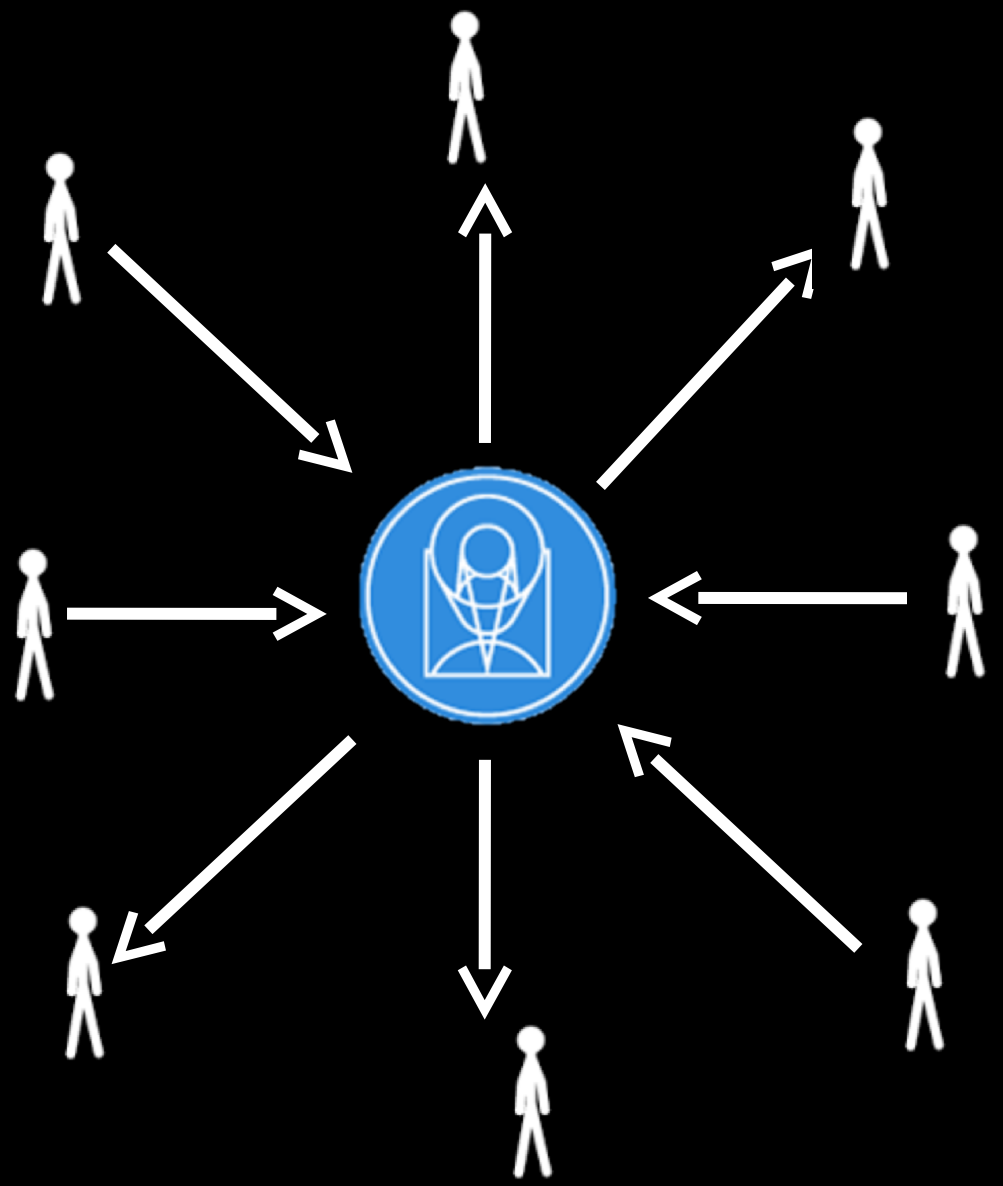
Resources are allocated to support up to 15 teams. Proposals will be selected in research areas spanning the science themes of JWST :

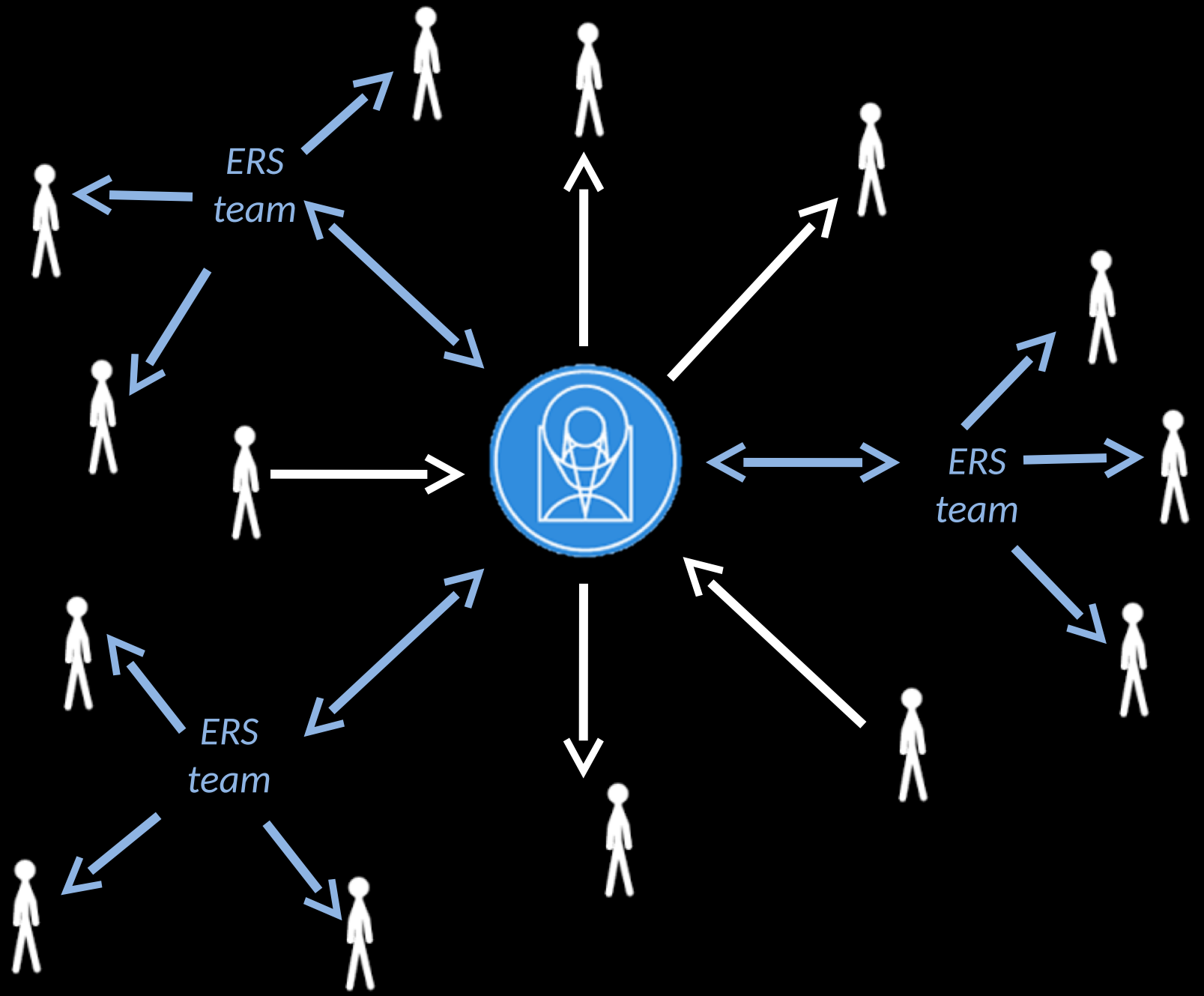


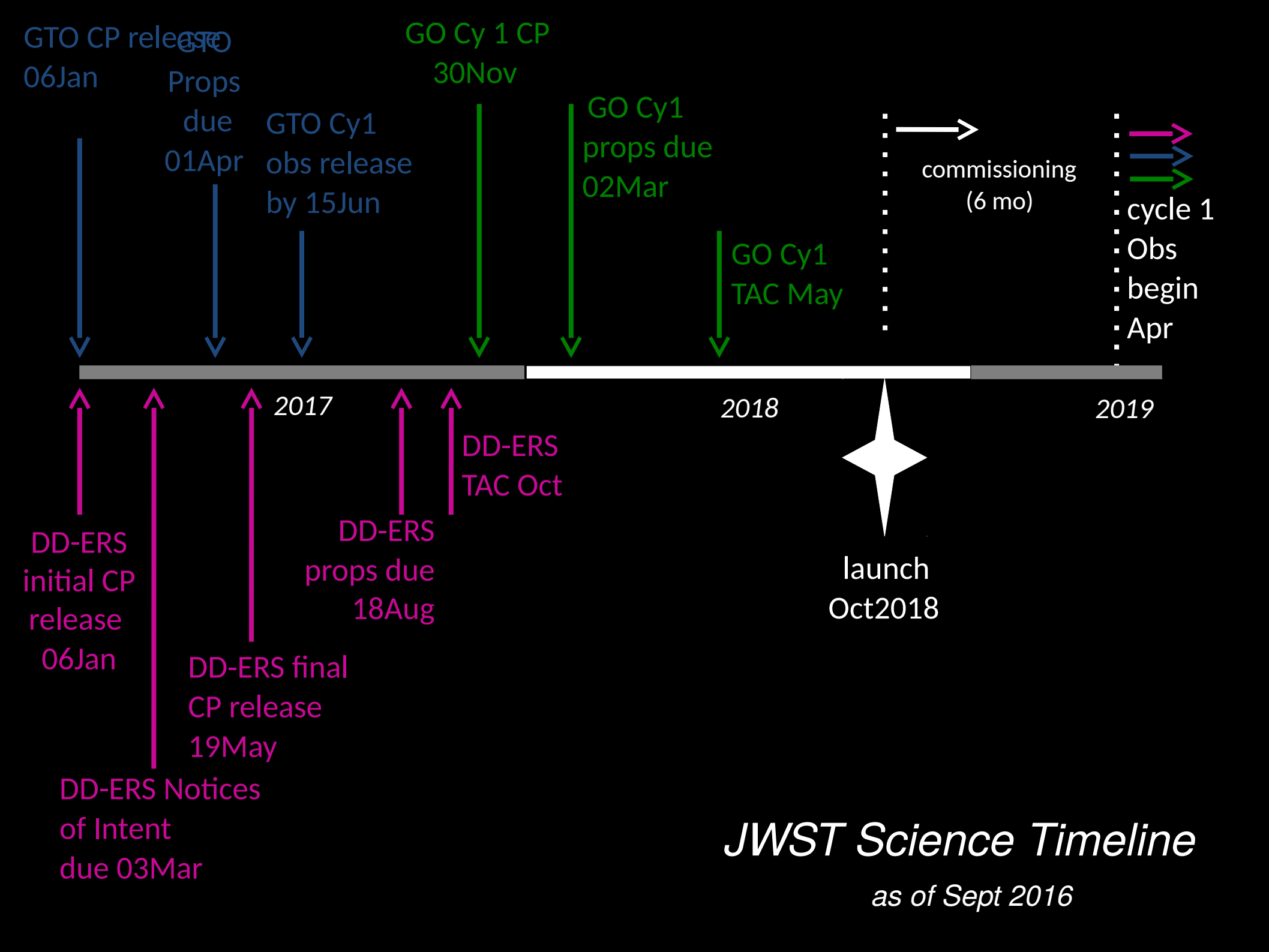
A multi-disciplinary committee of experts will recommend a suite of proposals that both fulfills the goals of the DD-ERS and makes optimal use of the available time for observation and funding.

DD-ERS Selection

- GO-TAC reviews focus almost exclusively on science
  - Reviewers are tasked with selecting the most compelling science
- The prime focus of the DD-ERS program is preparing the community to maximize JWST's scientific productivity in Cycle 2 and beyond
  - Reviewers will select programs based on additional criteria beyond compelling science, including breadth of community science facilitated, value of proposed team products, community involvement in the program design
- ERS proposals have an altruistic element
  - How will you help your colleagues exploit JWST?




ERS
team
ERS
team
ERS
team


GTO CP release 06Jan
GTO Props due 01Apr
GTO Cy1 obs release by 15Jun
GO Cy 1 CP 30Nov
GO Cy1 props due 02Mar
GO Cy1 TAC May
commissioning (6 mo)
cycle 1 Obs begin Apr
2017
2018
2019
DD-ERS initial CP release 06Jan
DD-ERS Notices of Intent due 03Mar
DD-ERS final CP release 19May
DD-ERS props due 18Aug
DD-ERS TAC Oct
launch Oct2018
JWST Science Timeline
as of Sept 2016


Launch: Oct 2018