STScI | SPACE TELESCOPE SCIENCE INSTITUTE

EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

JWST is on the Horizon: Is Our Community Ready?

William P. Blair
JWST Project Scientist for User Support
Johns Hopkins University/Space Telescope Science Institute

Supernova Remnants II Conference
June 4, 2019

Outline

1. Overview of JWST Observatory and its Instruments
2. Some Example Science Thoughts
3. Cycle 1 Proposal Support Resources and Schedule
4. Thinking Strategically for JWST Cycle 1 and Beyond

JWST Science Planning Timeline (as of June 2019)

Cycle 1 Call for Proposals timeline
Winter 2021 launch

JWST dates are still indicative, not final!

Not too early to be thinking about JWST Proposals!!

Launch
Winter 2021

Commissioning
(L+6 mo.)

2019 | *2020* | ***2021***

You are here
(June 2019)

19/06/25
GTO and ERS Cy1 targets finalized

20/01/23
GO Cy1 Call re-opened

20/05/01
GO Cy1 Proposal deadline

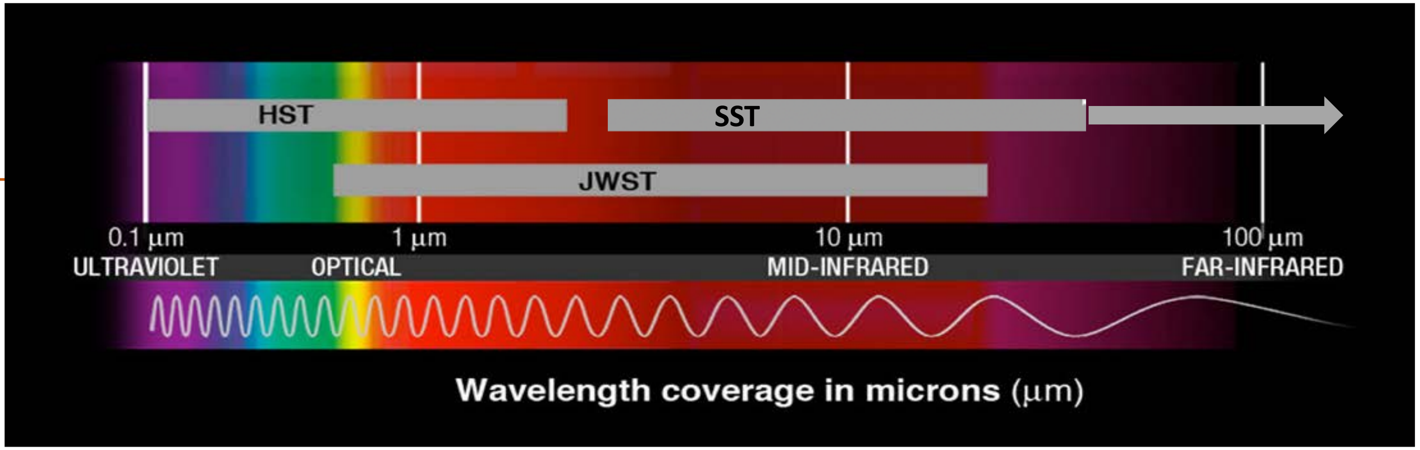
20/08/01
GO Cy1 TAC

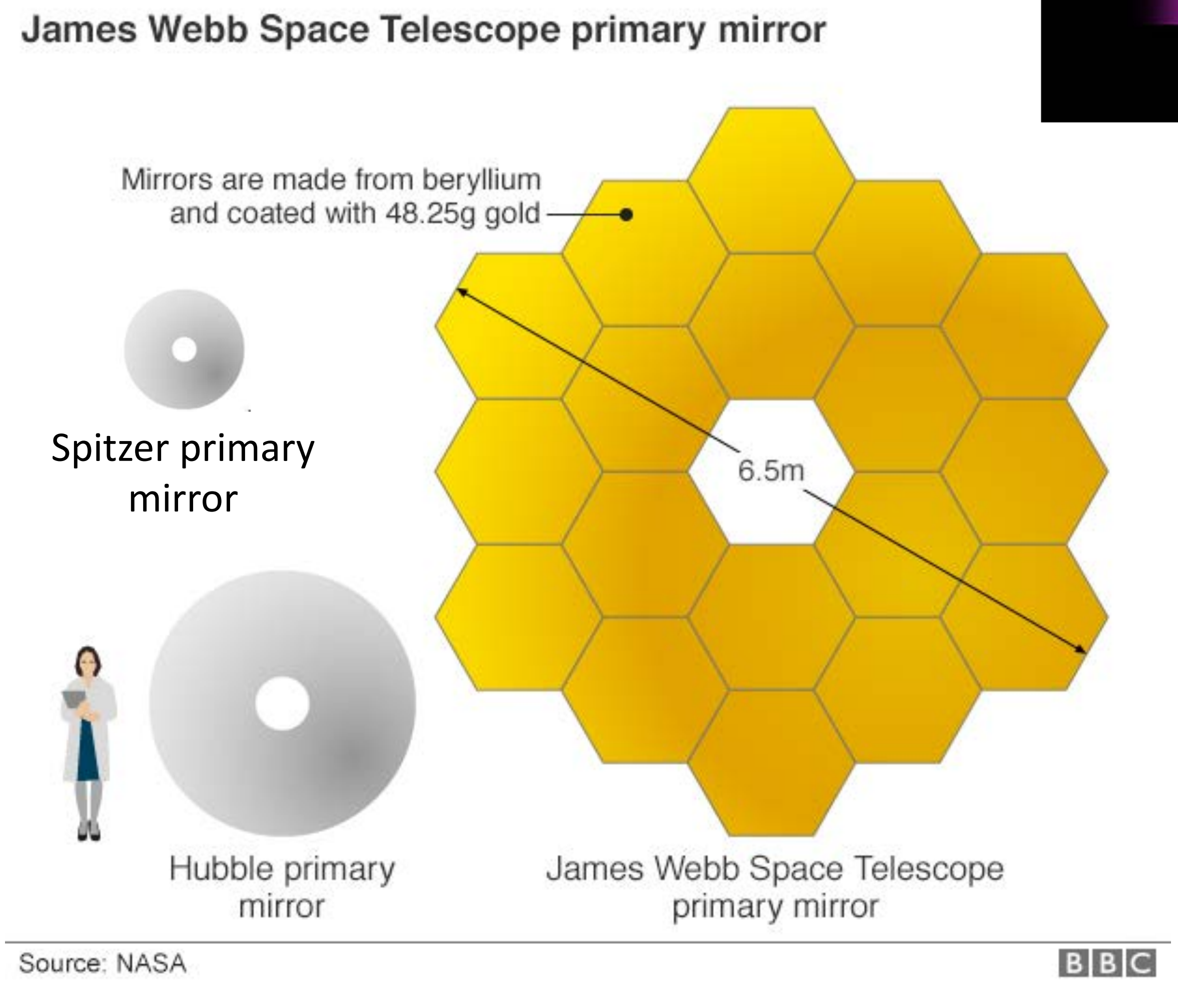
NASA HQ
Contingency

21/03/31
Launch

(L+6)
Cycle 1 obs. begin

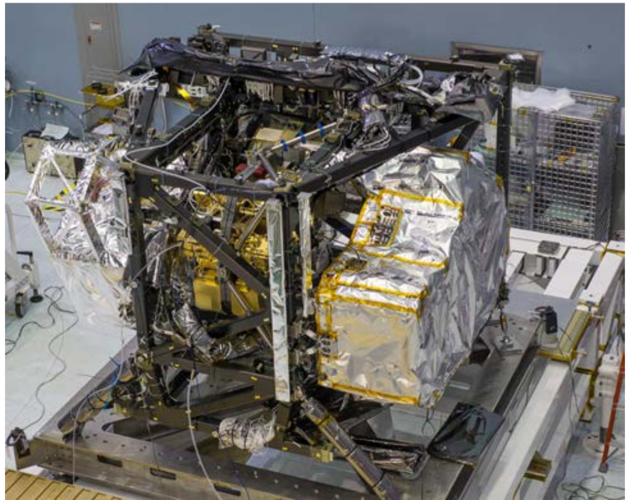
Observatory Overview – Comparison to HST and SST

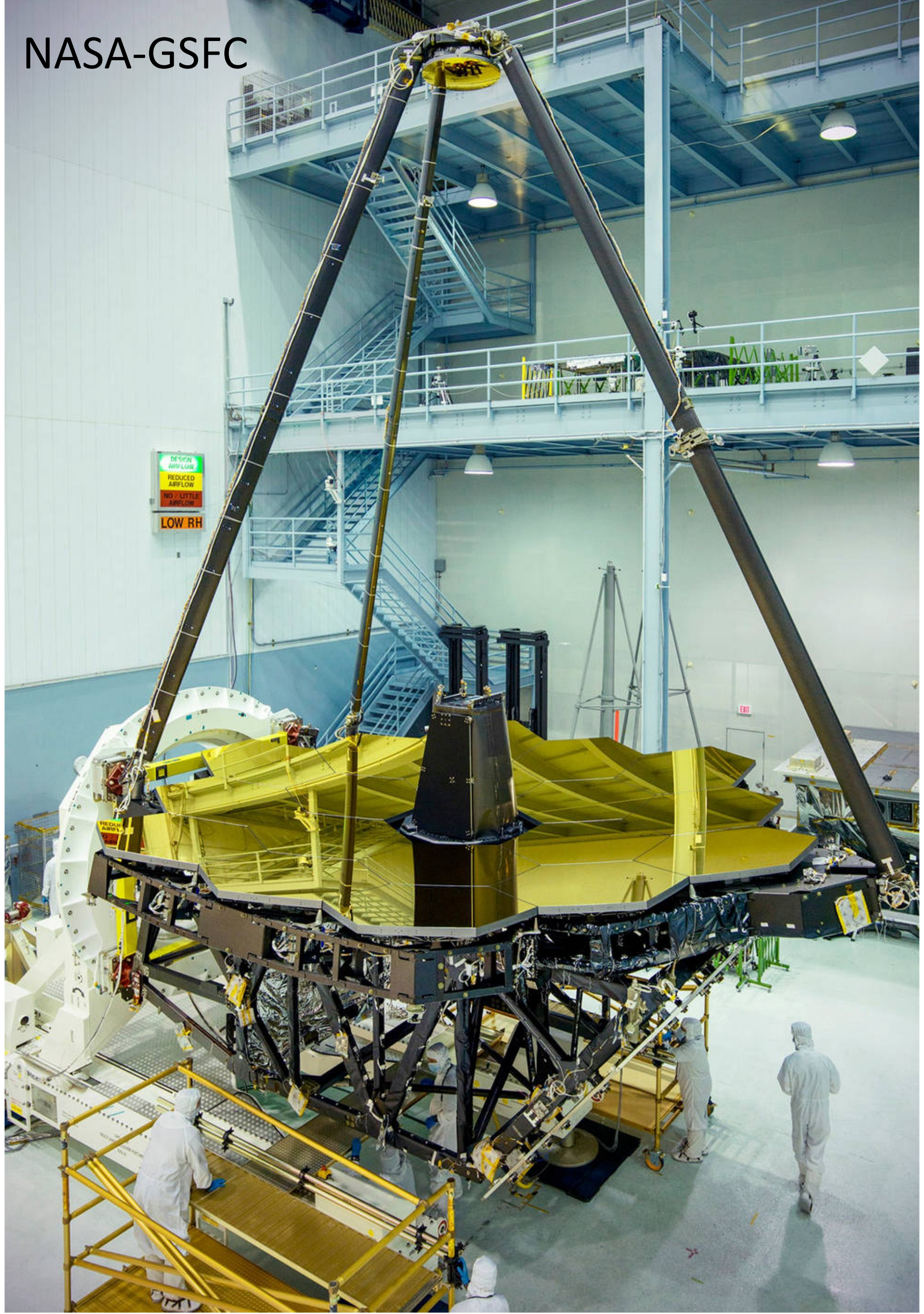


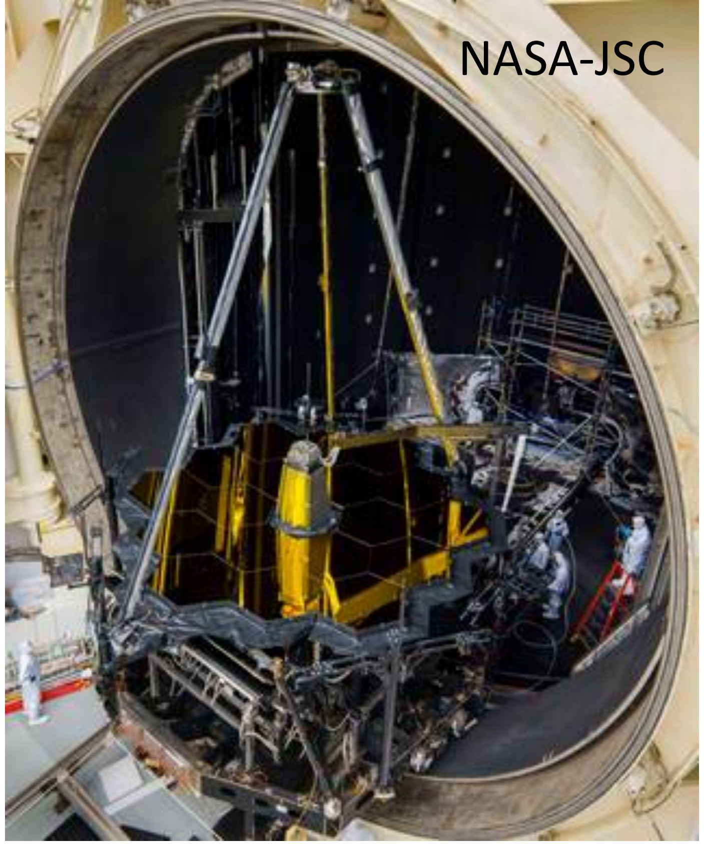


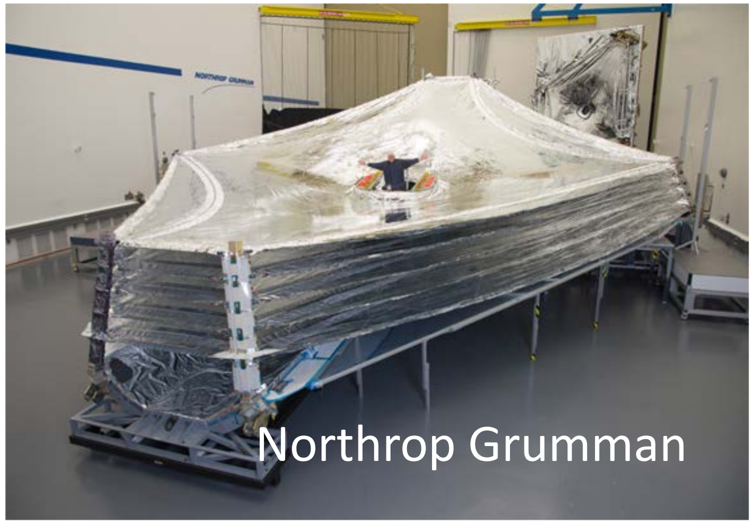
- Significant overlap with HST at short wavelengths and SST at long wavelengths
  - JWST: 0.6 – 28 µm
  - HST up to ~2.2 µm
  - SST: Spectra 5 – 38 µm + imaging 3.4 – 160 µm
- 7.3x the collecting area of HST and 56x the collecting area of SST!
- JWST diffraction limited at >2 µm
  - 0.2” at 6.5 µm (SST:1.5”)


Goddard
SPACE FLIGHT CENTER
NASA-GSFC

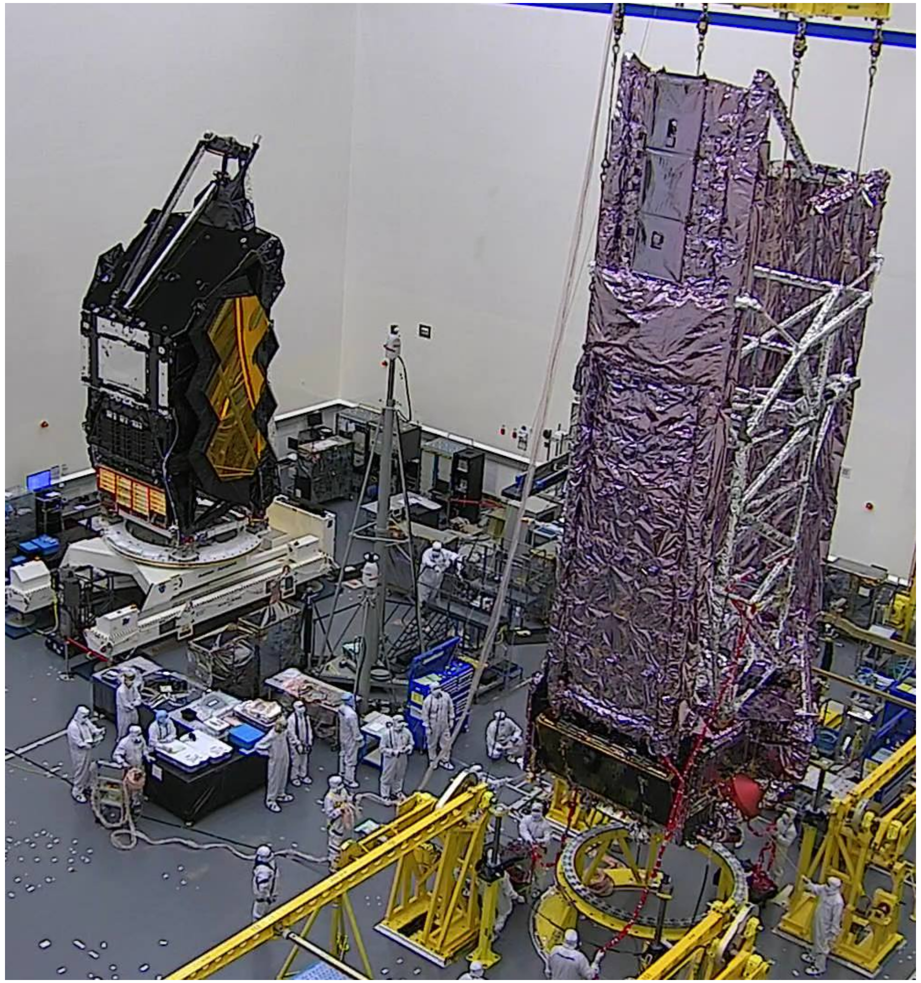


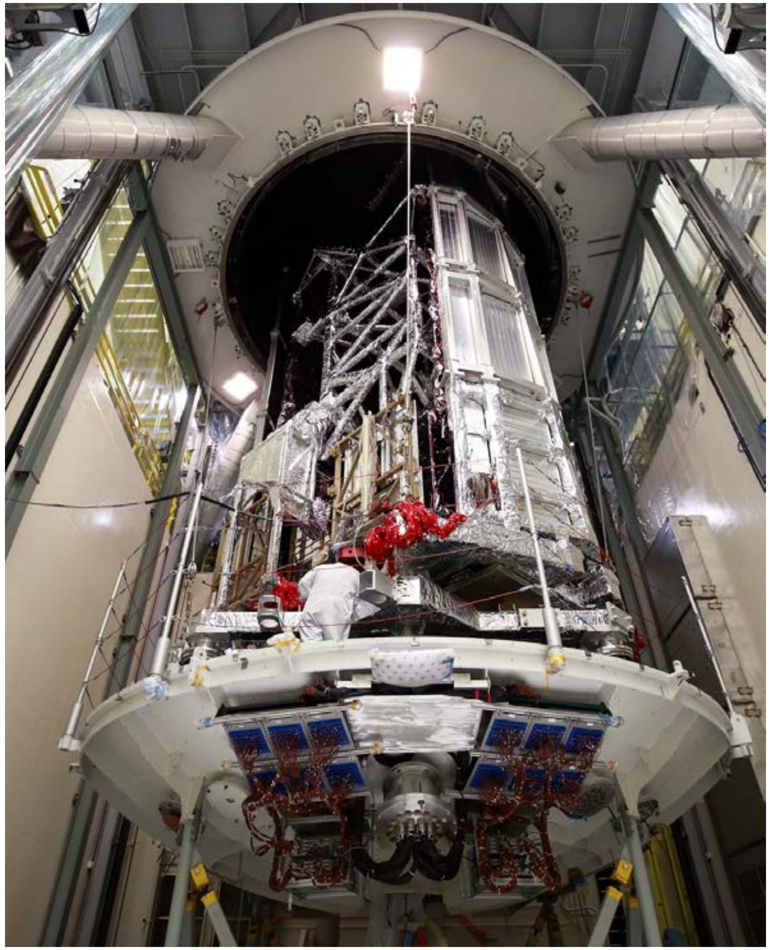

NASA-GSFC
LOW RH


NASA-JSC

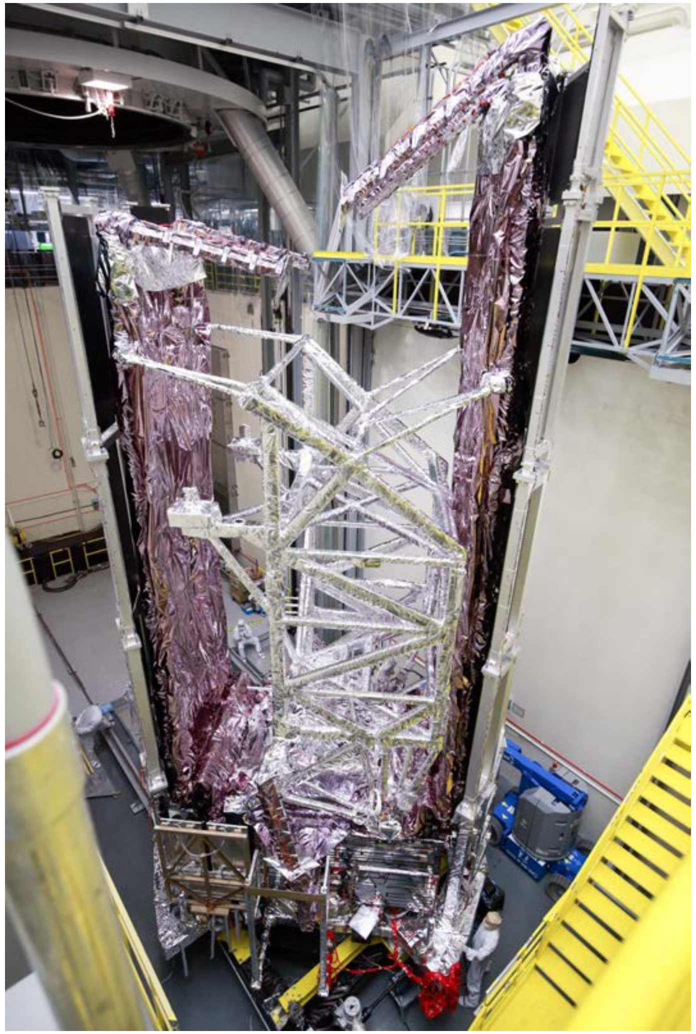

Northrop Grumman

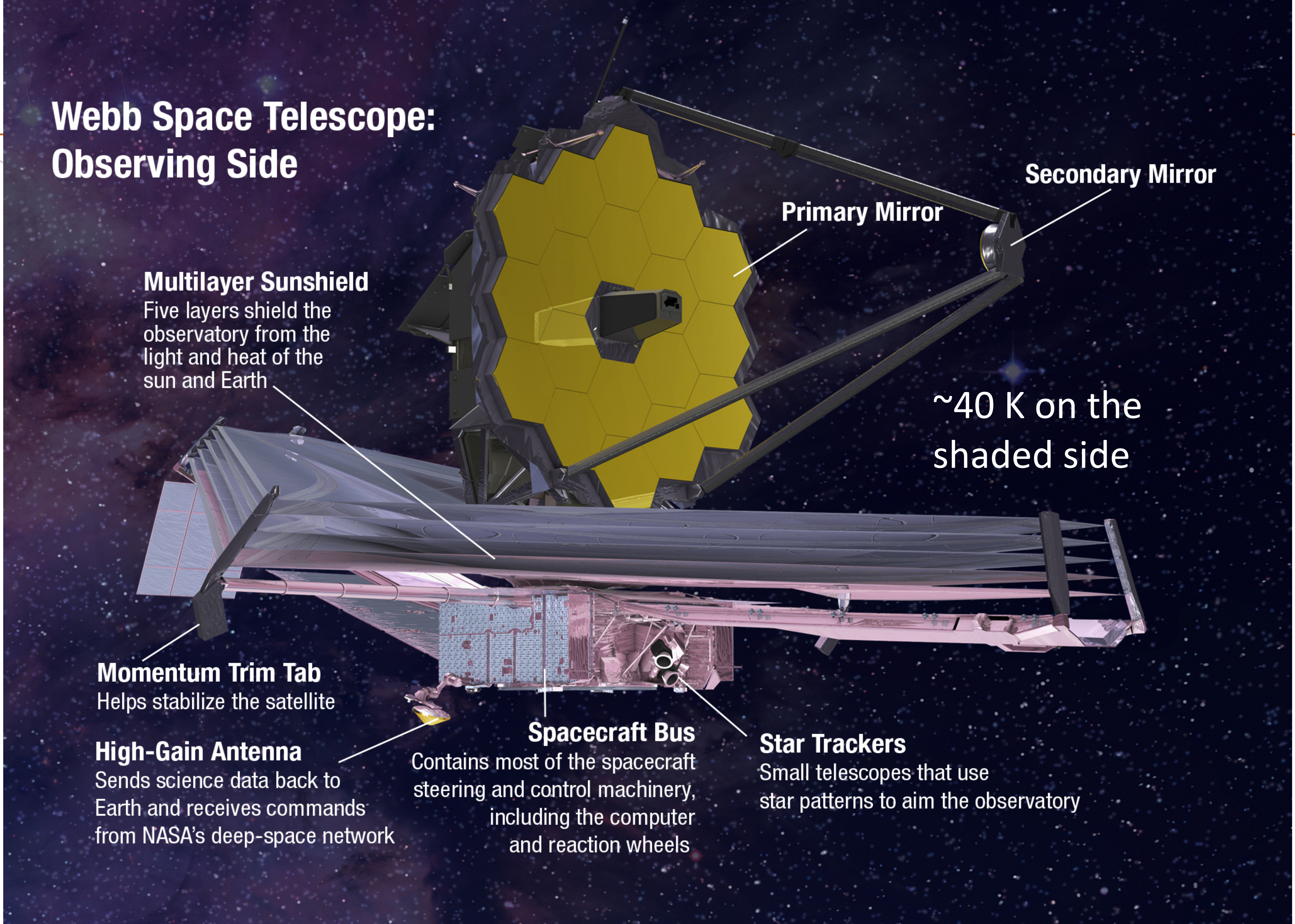
Observatory Overview – Integration and Testing at Northrop Grumman, CA



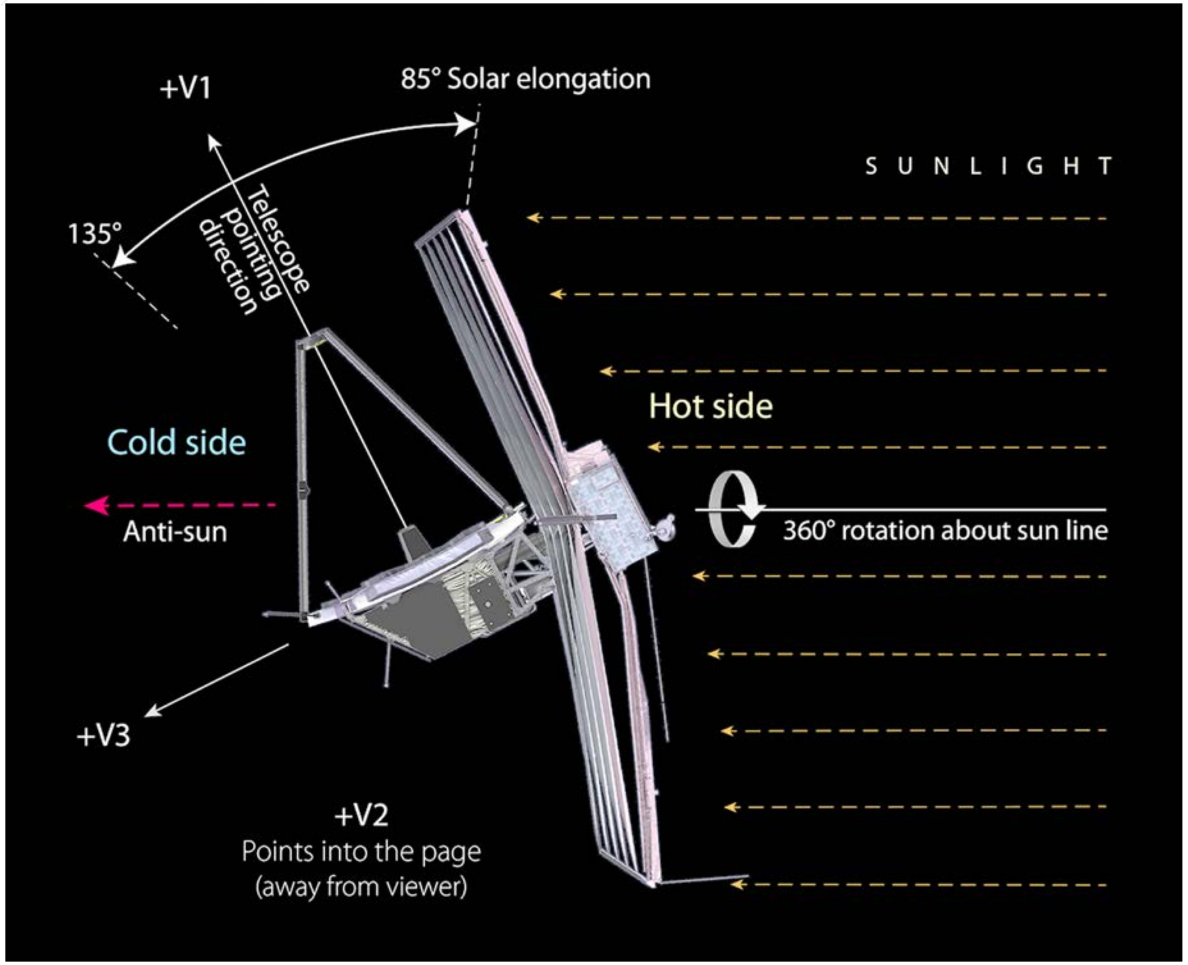


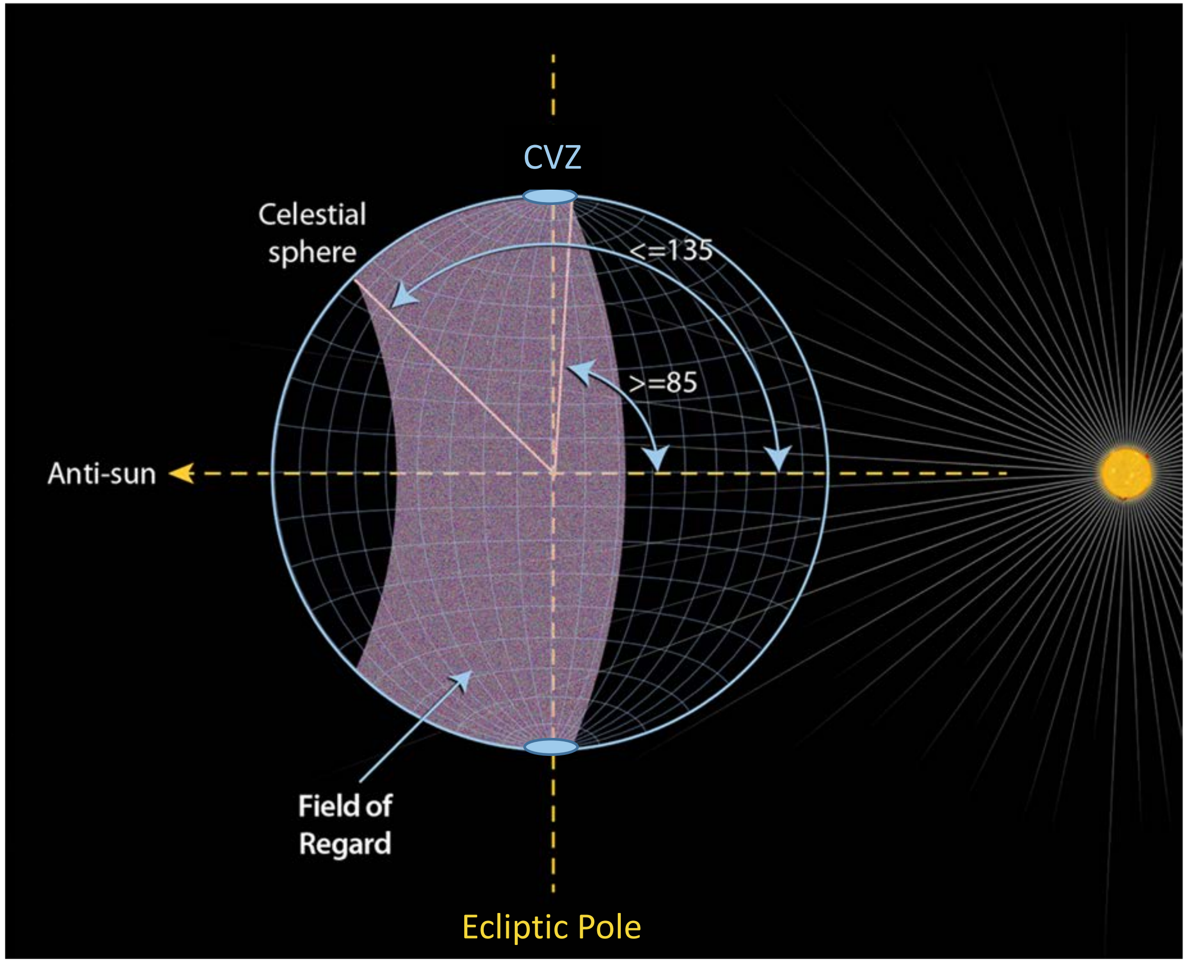
May 2019 Thermal Vac Test



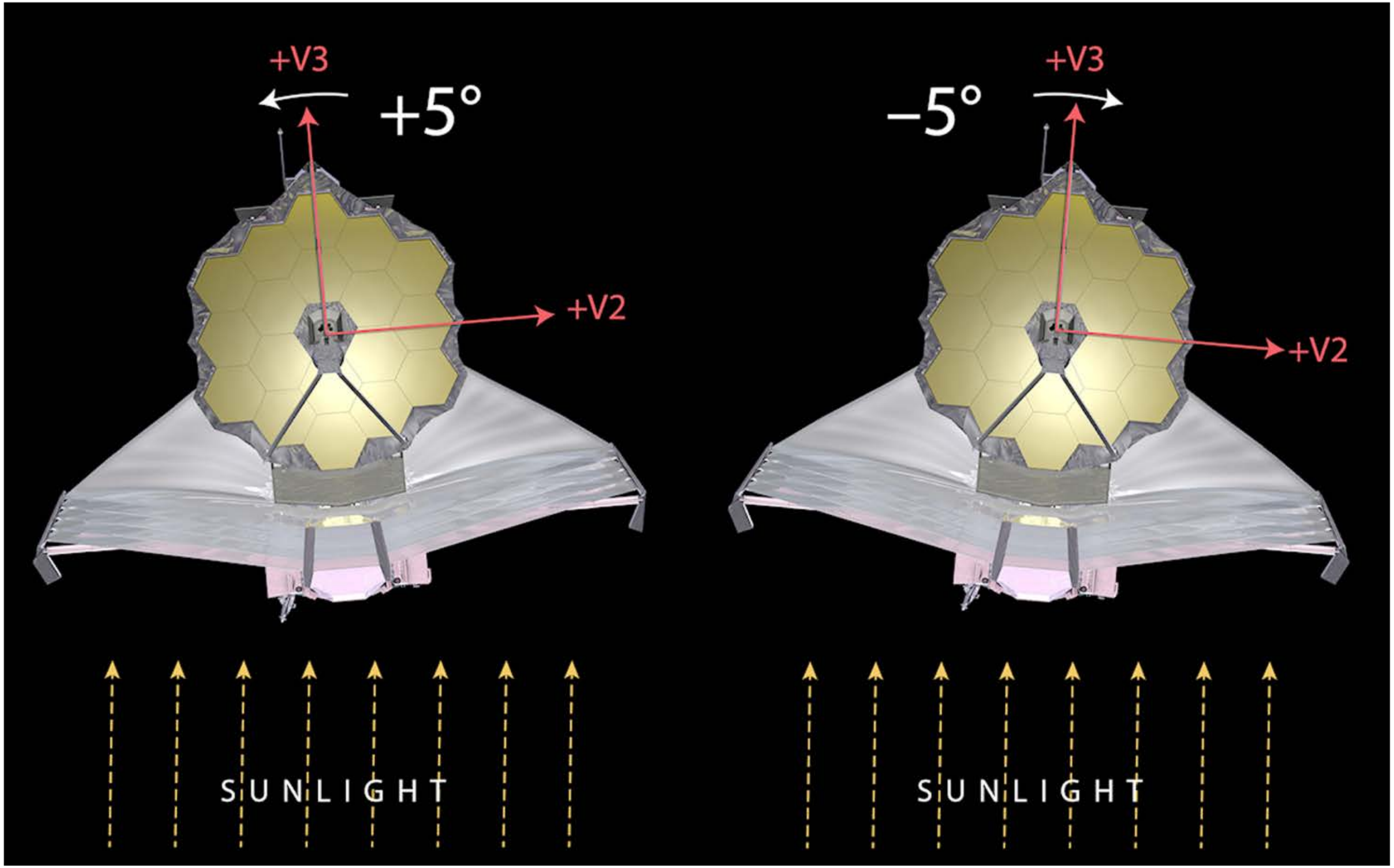

Webb Space Telescope:
Observing Side
Multilayer Sunshield
Five layers shield the observatory from the light and heat of the sun and Earth
Primary Mirror
Secondary Mirror
~40 K on the shaded side
Momentum Trim Tab
Helps stabilize the satellite
High-Gain Antenna
Sends science data back to Earth and receives commands from NASA's deep-space network
Spacecraft Bus
Contains most of the spacecraft steering and control machinery, including the computer and reaction wheels
Star Trackers
Small telescopes that use star patterns to aim the observatory

Instantaneous field of regard | Continuous viewing zone



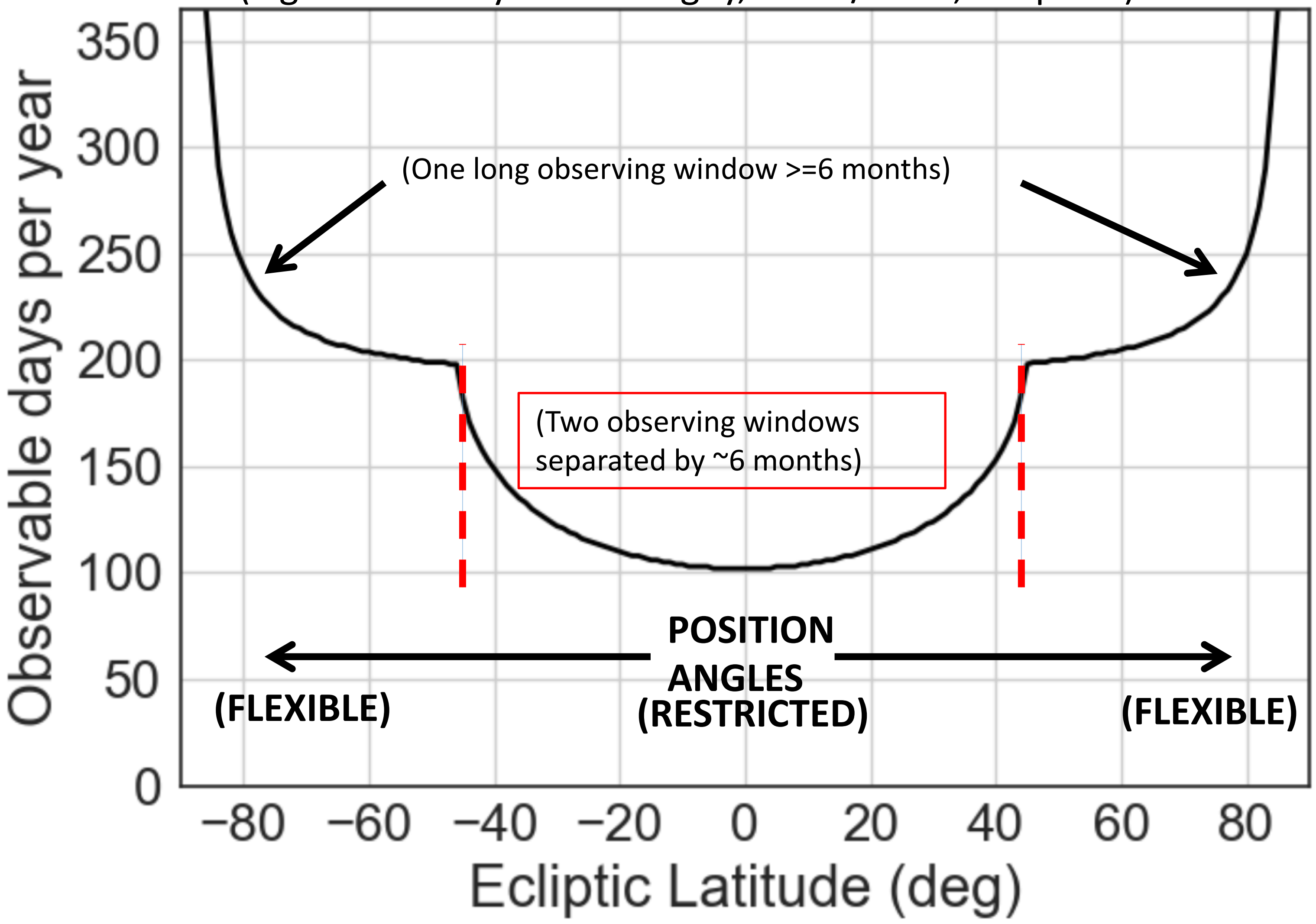


Narrow roll limits – can lead to constrained position angles



Total Visibility vs. Ecliptic Latitude

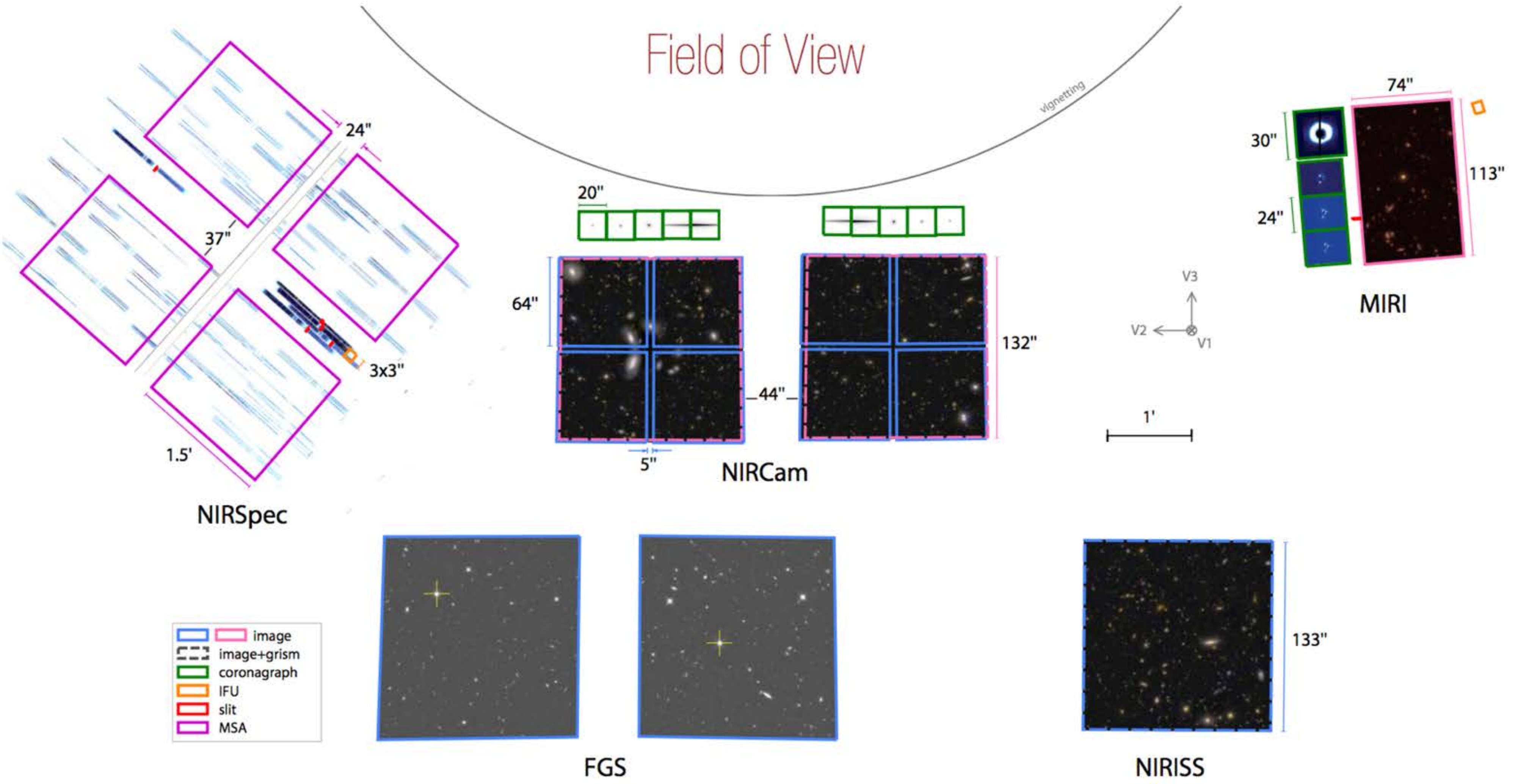
(Figure courtesy of Jane Rigby, NASA/GSFC, adapted.)



Observing mode summary (BOLD of most interest to SNe/SNR science)

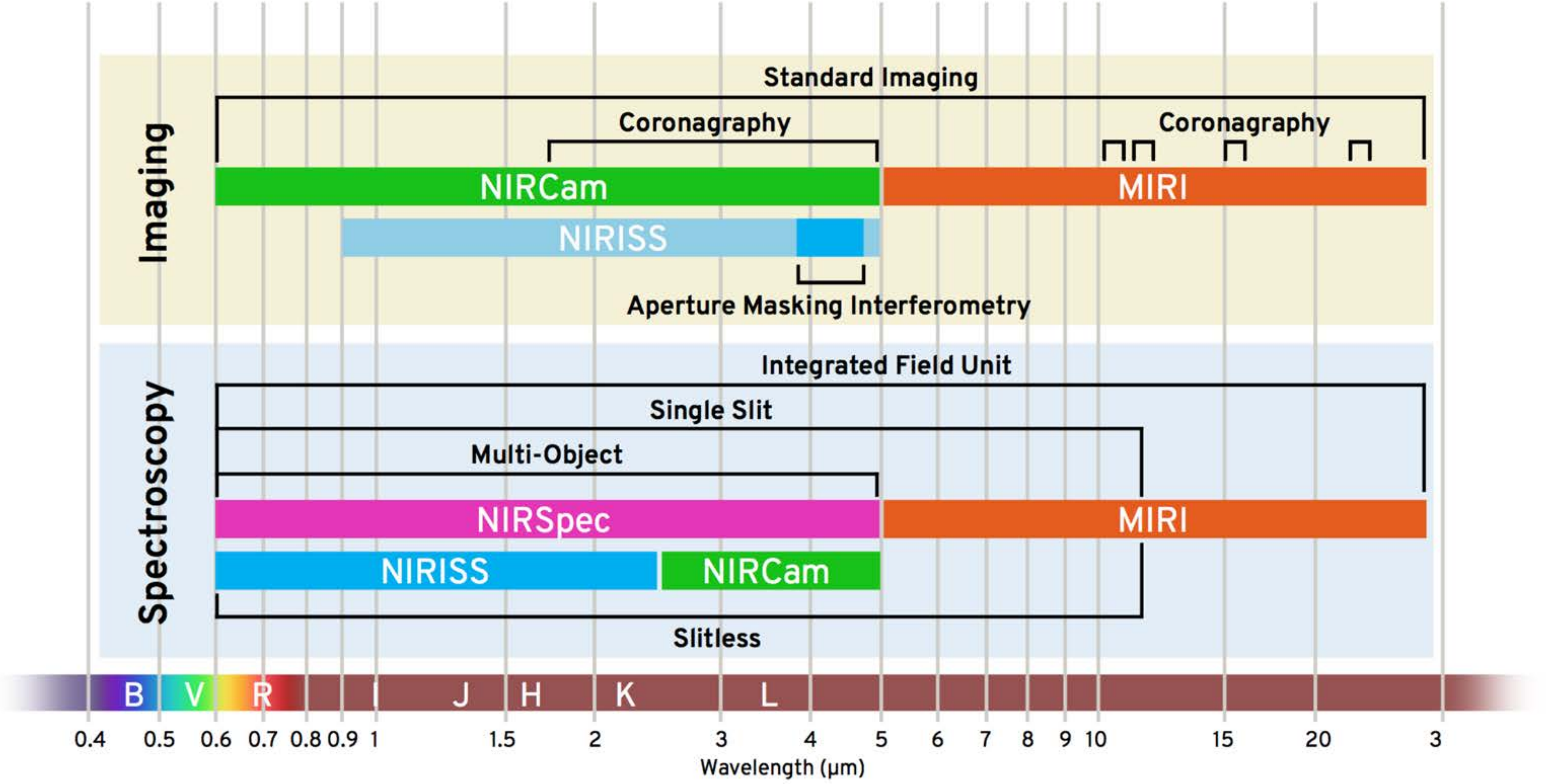
Imaging (NIRCam, NIRISS, MIRI)	**0.6 – 28 μm**
Defocused photometry	0.6 – 5 μm
Coronagraphy/High Contrast Imaging	0.6 – 28 μm
Aperture masking interferometry	0.6 – 5 μm
Single-object slit spectroscopy (NIRSpec, MIRI)	**0.6 – 28 μm**
Multi-object slit spectroscopy (NIRSpec)	**0.6 – 5 μm**
Single-object slitless spectroscopy	0.6 – 12 μm
Wide-field slitless spectroscopy (NIRCam, NIRISS)	**0.6 – 5 μm**
Integral field unit spectroscopy (NIRSpec, MIRI)	**0.6 – 28 μm**

JWST Focal Plane and Instrument Overview



(Guider)

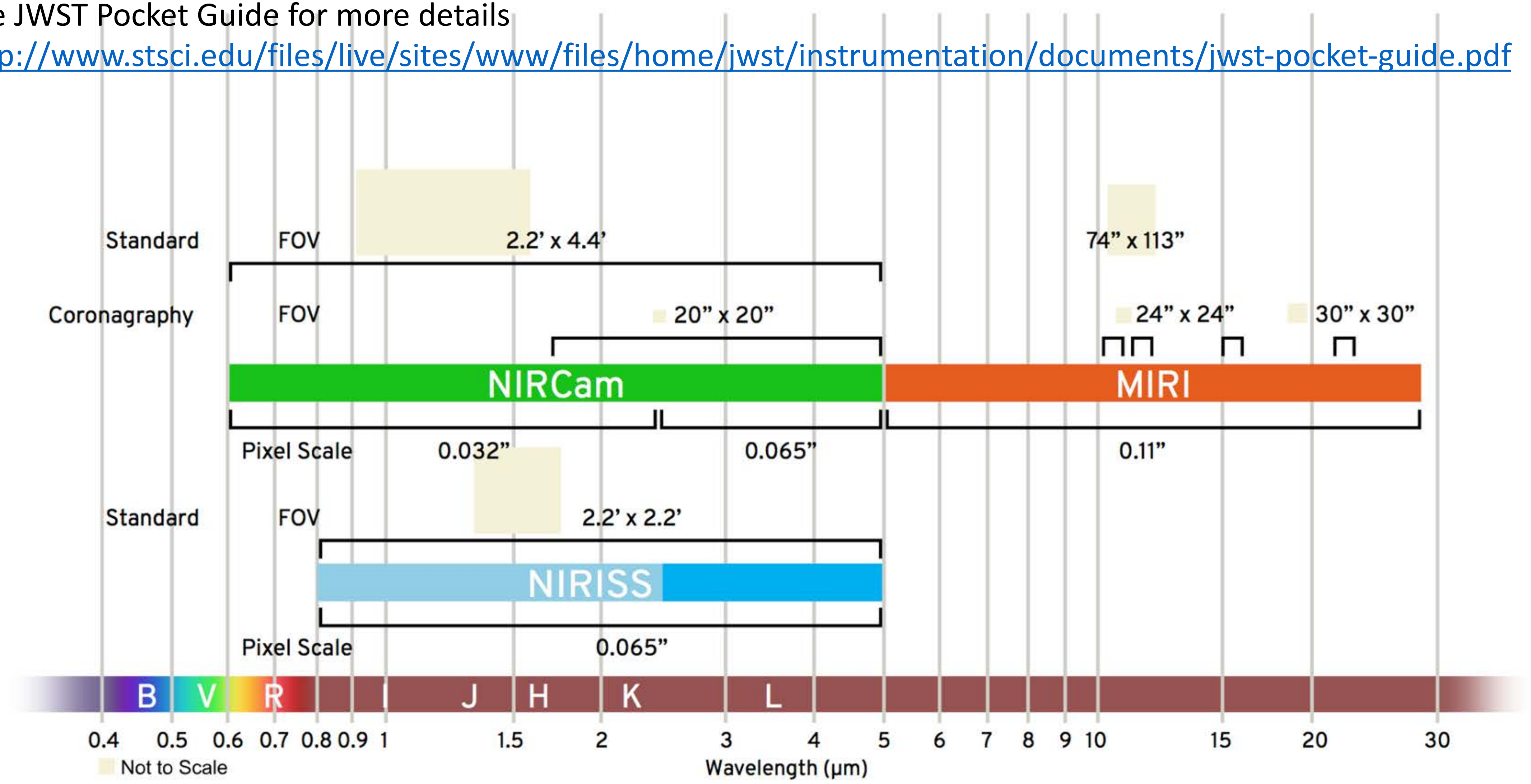
Observing Mode Overview



See JWST Pocket Guide for more details
http://www.stsci.edu/files/live/sites/www/files/home/jwst/instrumentation/documents/jwst-pocket-guide.pdf

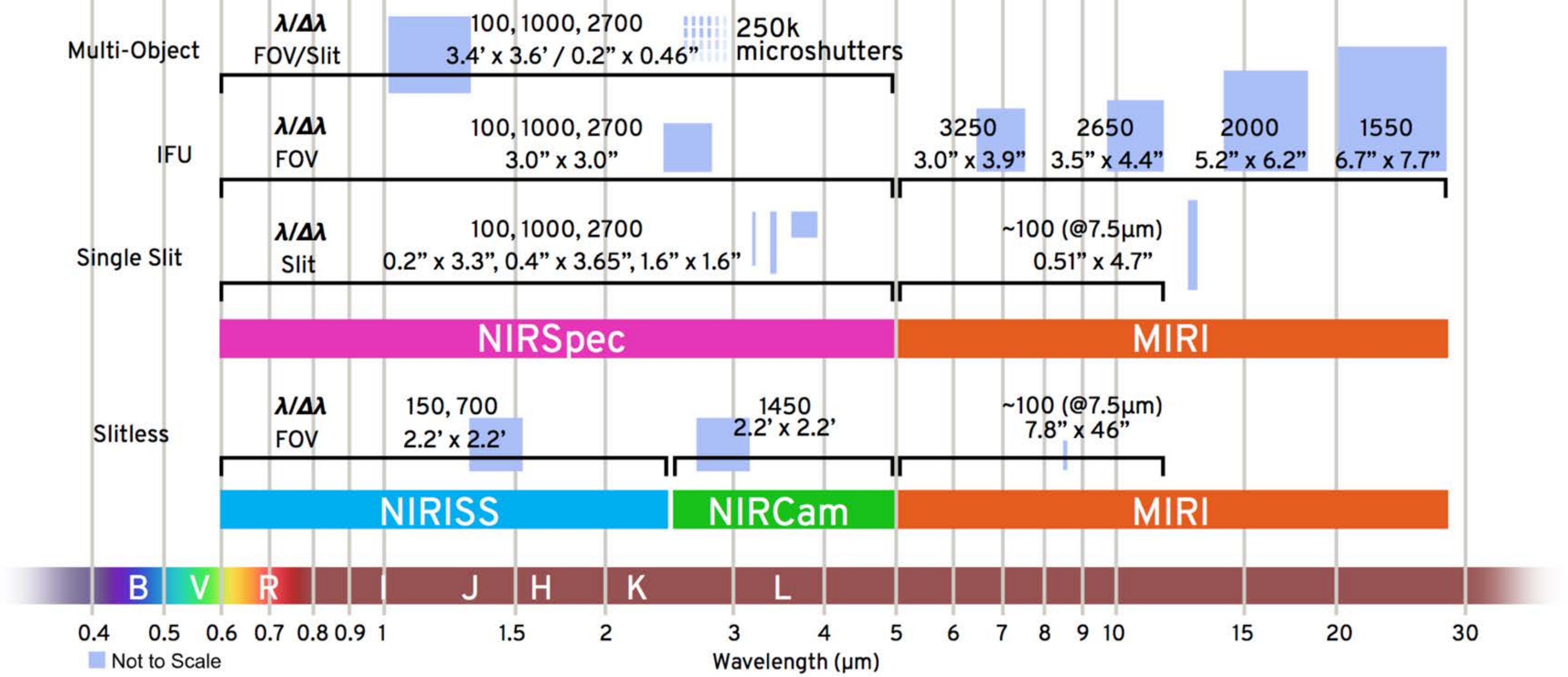
Observing Mode Overview – Imaging

See JWST Pocket Guide for more details
http://www.stsci.edu/files/live/sites/www/files/home/jwst/instrumentation/documents/jwst-pocket-guide.pdf

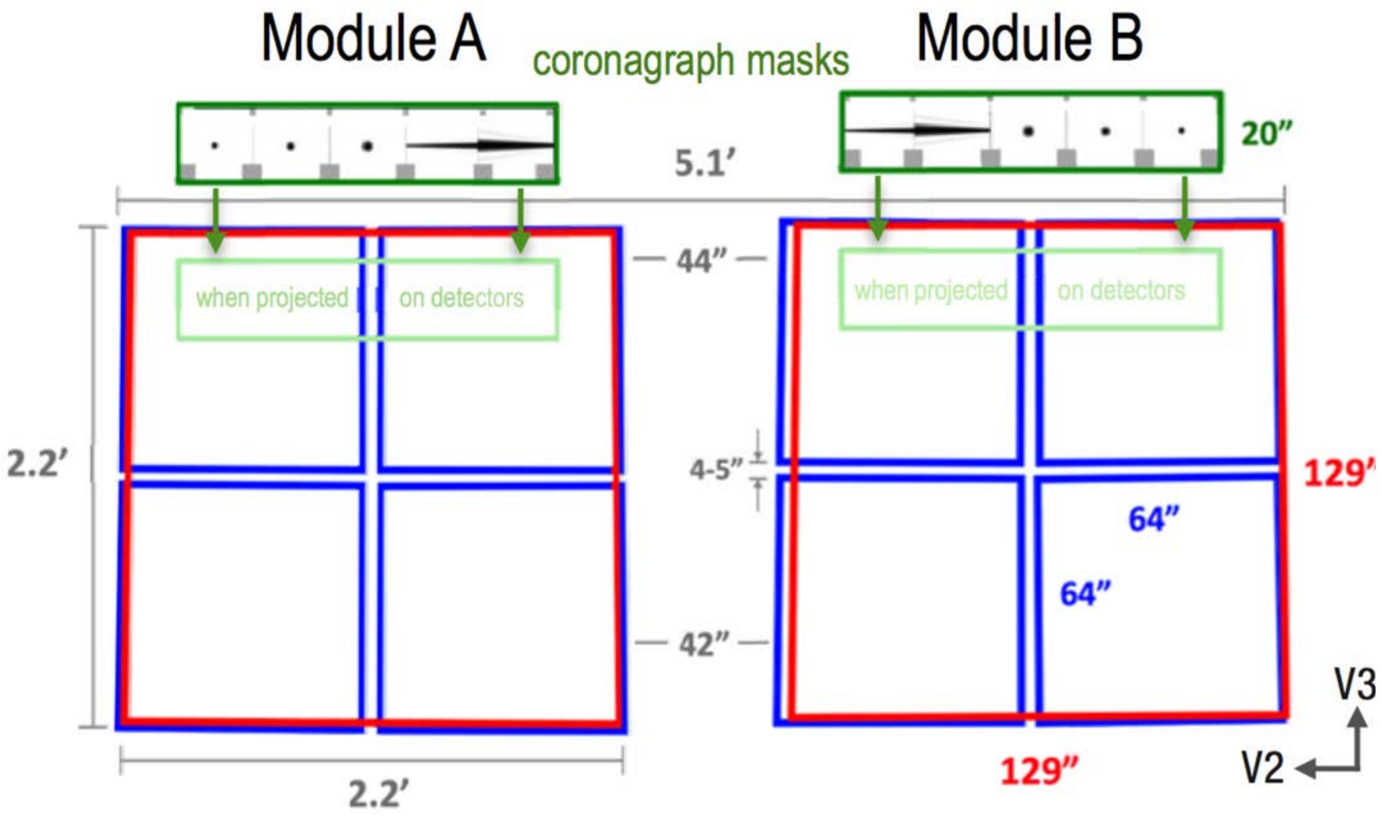


Observing Mode Overview – Spectroscopy

See JWST Pocket Guide for more details
http://www.stsci.edu/files/live/sites/www/files/home/jwst/instrumentation/documents/jwst-pocket-guide.pdf



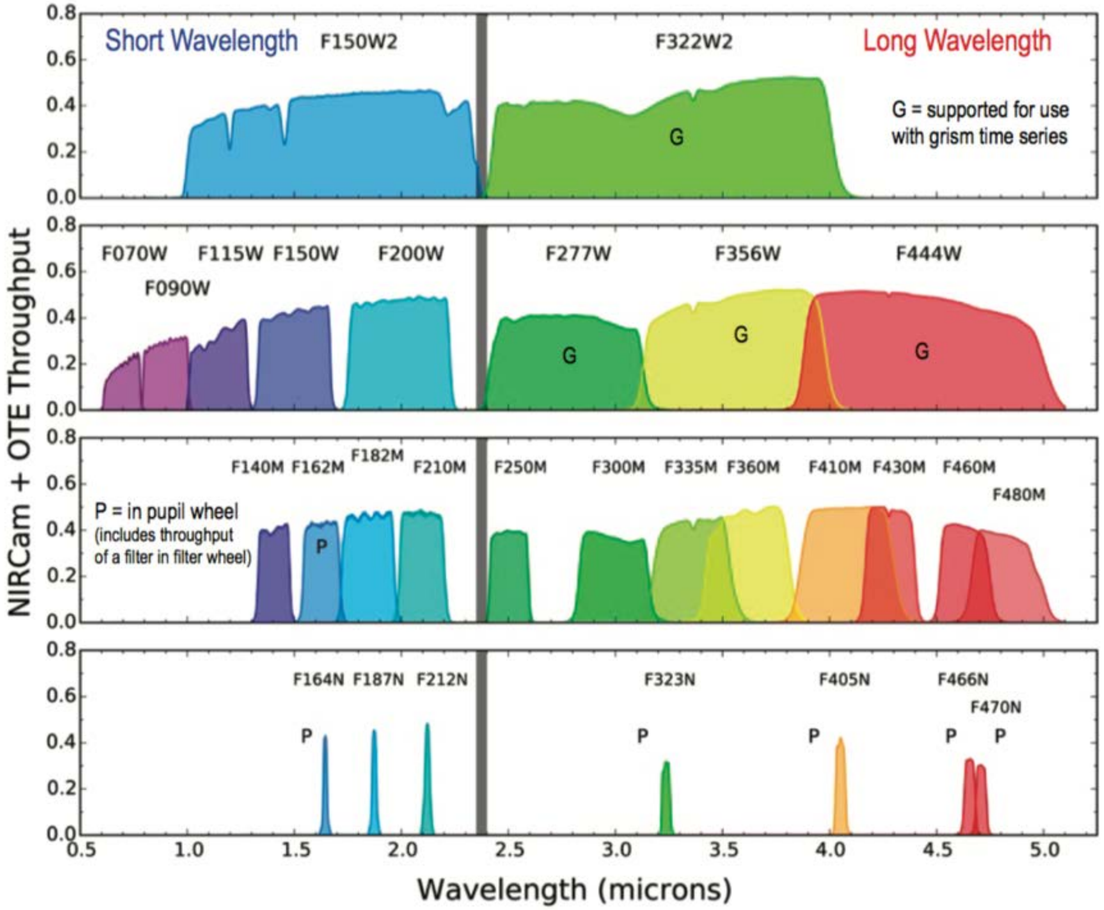
NIRCam Overview (0.6 – 5 μm coverage)



overlapping FOVs imaged simultaneously using a dichroic { short wavelength detectors / long wavelength detectors

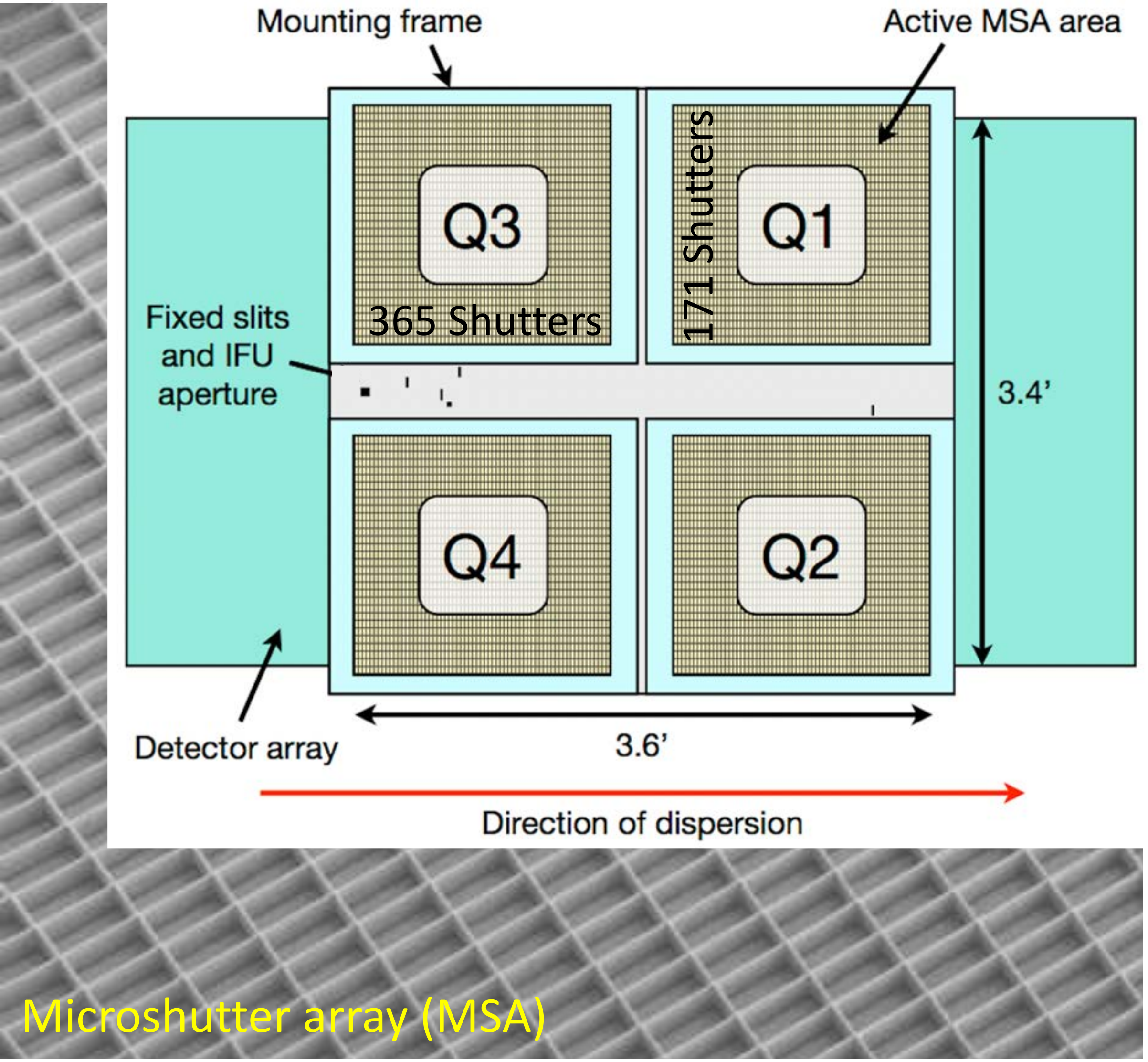
Teledyne HgCdTe H2RG detectors
2048 × 2048 pixels including reference rows and columns insensitive to light

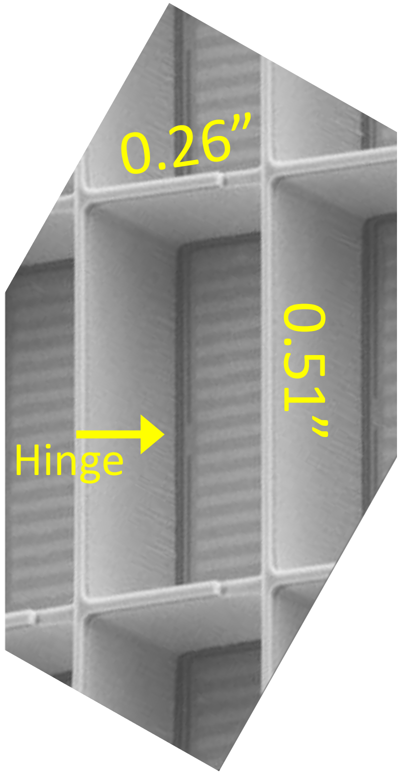
Filters

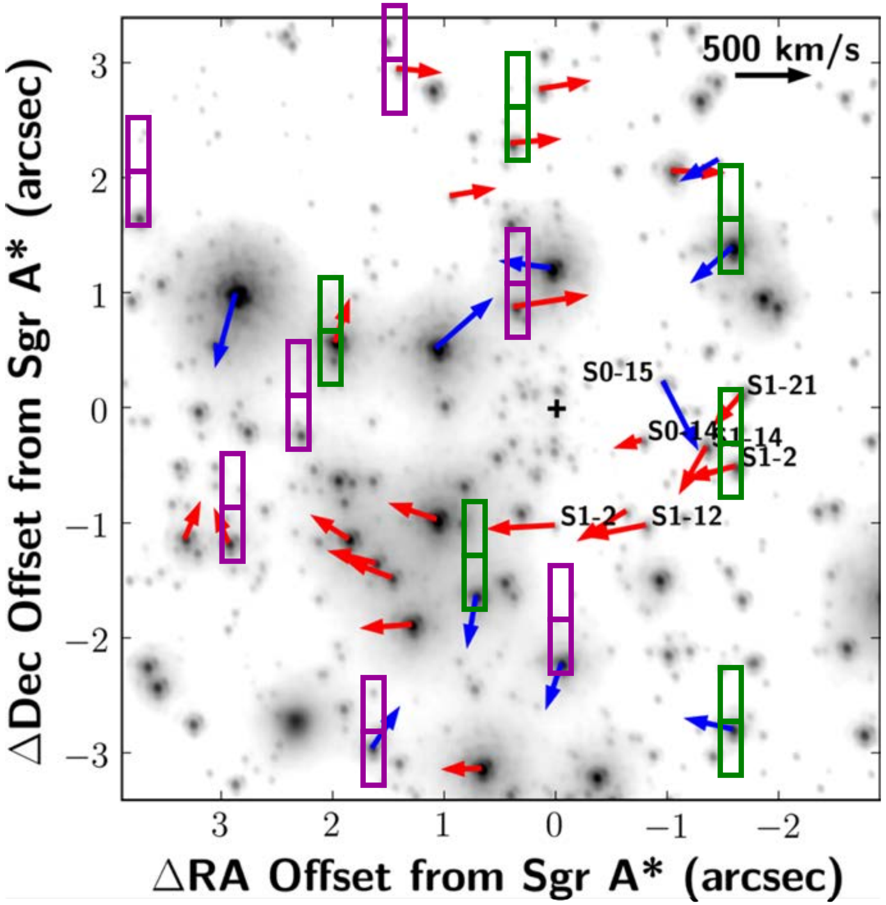


Also 2.5-5 micron slitless (GRISM) spectroscopy

NIRSpec Fixed slit and Multi-object spectroscopy (0.6 – 5 μm coverage)

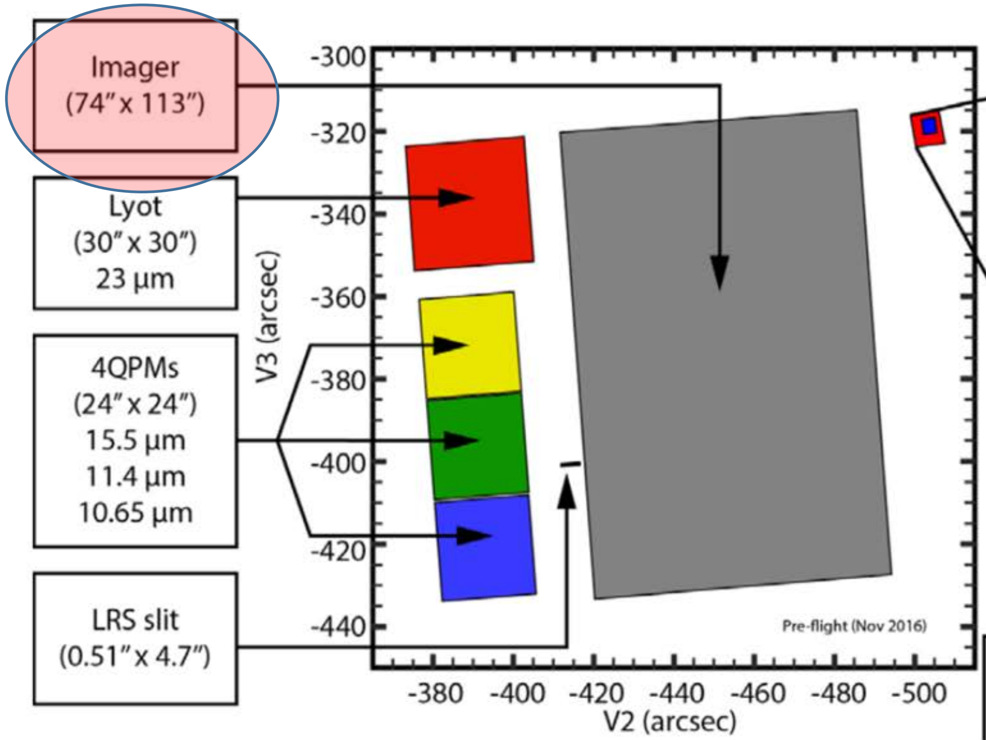




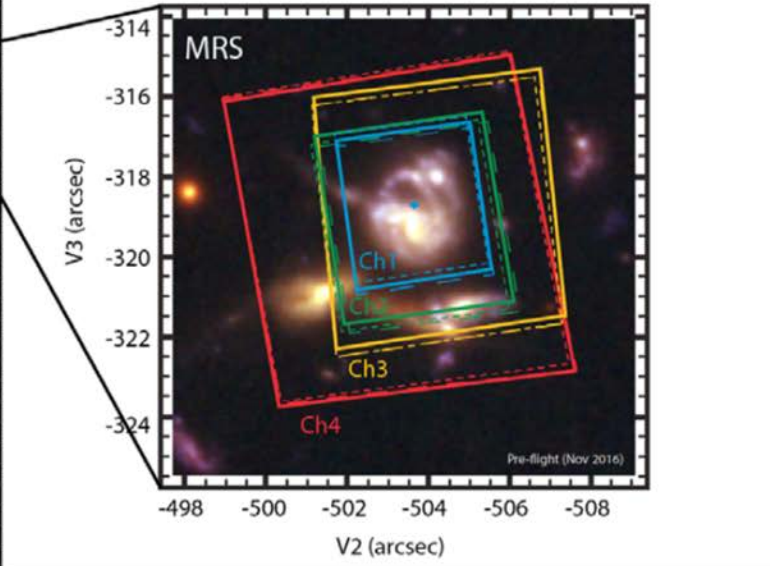


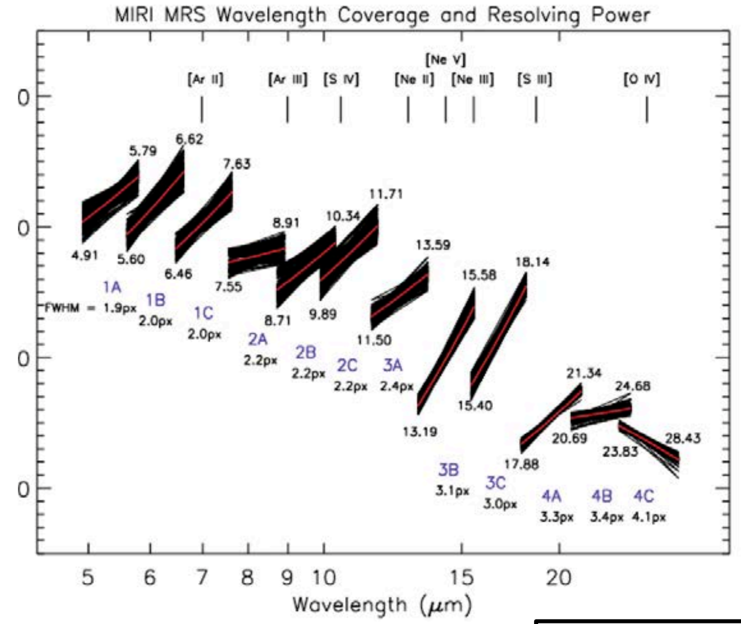
MOS: Same dispersers as NIRSpec fixed slit spectroscopy

MIRI Overview (5 – 28 μm coverage)



(IFU)

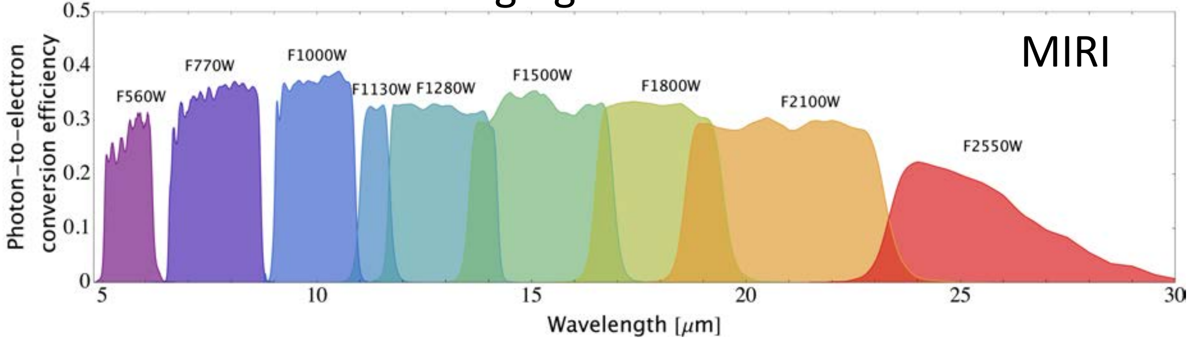




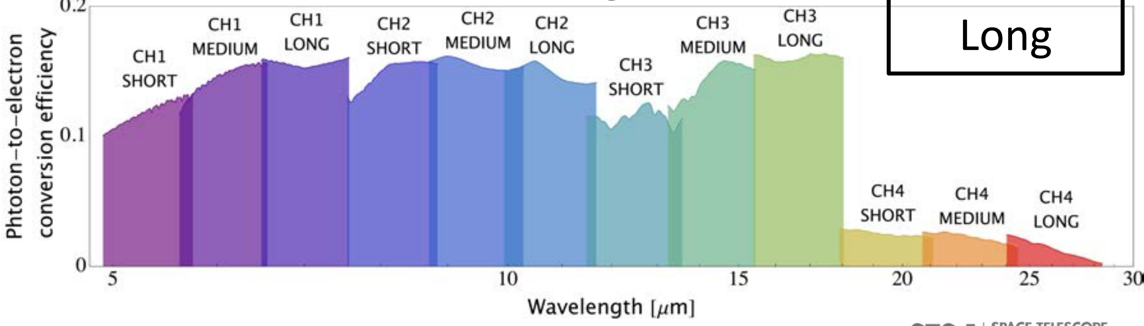
Channel 1: 4.89 - 7.66 μm
Channel 2: 7.49 - 11.71 μm
Channel 3: 11.53 - 18.05 μm
Channel 4: 17.66 - 28.45 μm

3 Settings
Short
Medium
Long

Imaging Filters



MRS coverage



SNe/SNR Science with JWST

SNe/SNR Science with JWST

Springer review by Williams & Temim (2018) provides a nice summary of IR results on SNRs, mainly from Spitzer. They conclude:

> "Significant progress in this field will be made upon the successful launch of JWST, a mid-IR observatory with a resolution about an order of magnitude better than Spitzer and sensitivity several hundred times higher. **JWST will allow the follow-up of extragalactic SNe for tens of years** in some cases and will serve as a valuable monitor on SN 1987A's continuing evolution. The superior resolution will also **further disentangle the various dust components in SNRs in both the galaxy and the MCs** and allow studies of the efficiency of dust destruction by SNR shocks. A combination of observations of both SNe and SNRs, along with theoretical modeling, will be necessary to solve the mystery of the origin of dust in the universe."

Also, high redshift SNe (Regos), and SNR studies in more distant galaxies out to ~10 Mpc (Session 7 talks and posters).

See also many other presentations at this conference!

SNe/SNR Science with JWST

With higher spatial resolution and sensitivity than Spitzer but wavelength coverage up to ~28 μm, a wide range of Spitzer-like science on SNe/SNRs is available for consideration on many more objects:

- Dust formation in SNe/young SNRs
- Dust heating and destruction mechanisms in shocks (Temim & Swek 2013; Sankrit+ 2014)
    - ISM (forward shock); ejecta dust (reverse shock)
- Dust compositional differences (ISM, ejecta, etc.) and variations in spatial distribution
- Additional radiative shock and abundance diagnostics (emission lines – Reach+ 2006)

While ground-based imaging and spectra can be done in the 1 – 2.5 μm range and HST WFC3 IR can image in this range, JWST performance will be much more sensitive.

JWST imaging in the relatively little-explored 2.5 – 5 μm region may be interesting (??)

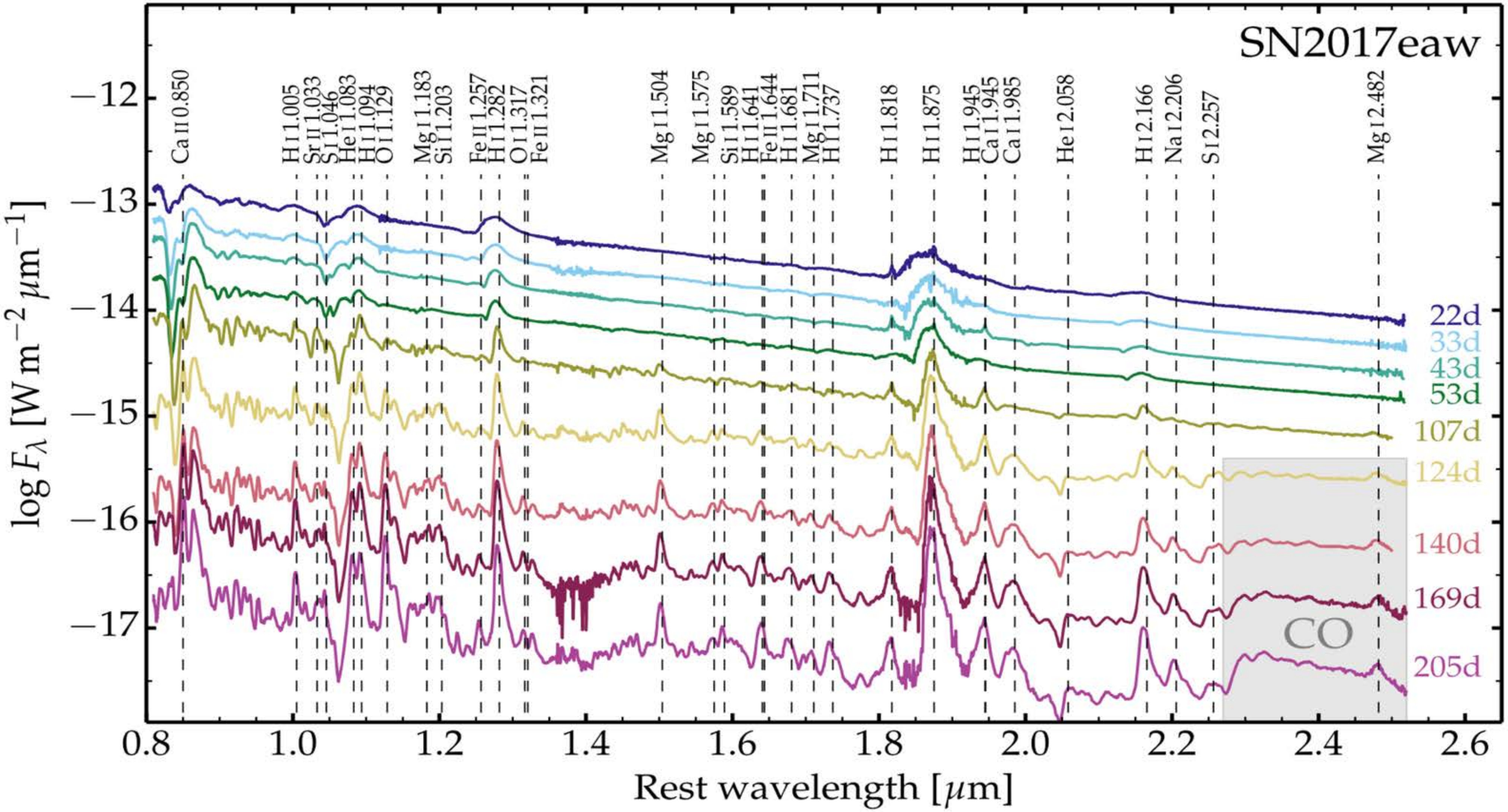
- Ex: [Si VI] 1.96 μm, [Si VII] 2.48 μm,, [Si IX] 3.86 μm sequence in Cas A
- Some other lines from radiative shocks
- Possibly molecular features

Consider synergy with other missions or instruments (Chandra, HST, ALMA, and large ground-based telescopes)

Supernovae in the IR

Near-infrared Spectroscopy of Supernova 2017eaw in 2017: Carbon Monoxide and Dust Formation in a Type II-P Supernova

J. Rho[1,2], T. R. Geballe[3], D. P. K. Banerjee[4], L. Dessart[5], A. Evans[6], and V. Joshi[4]

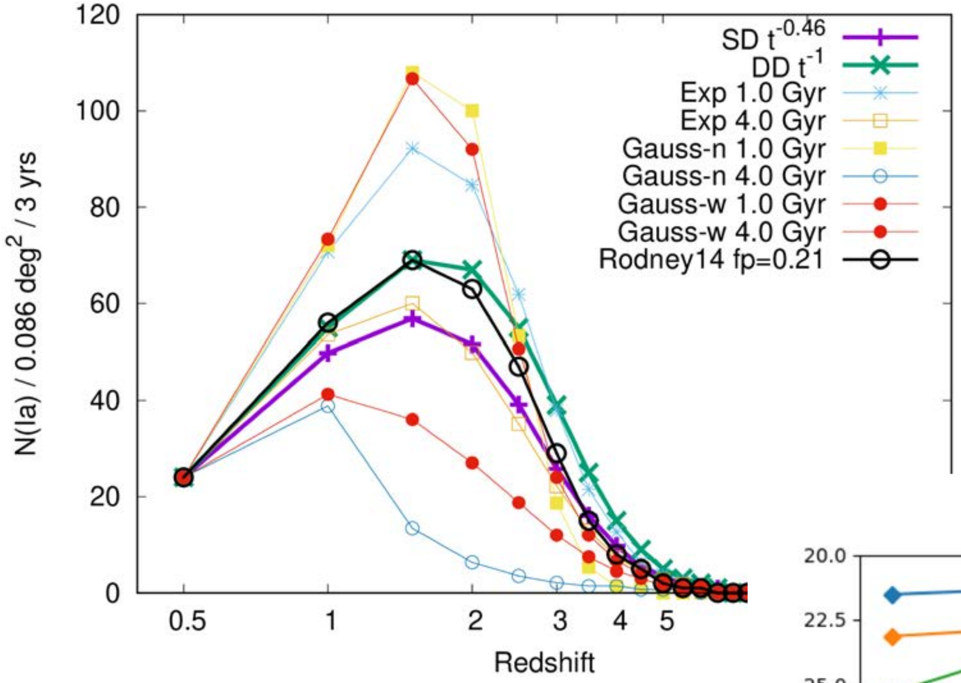


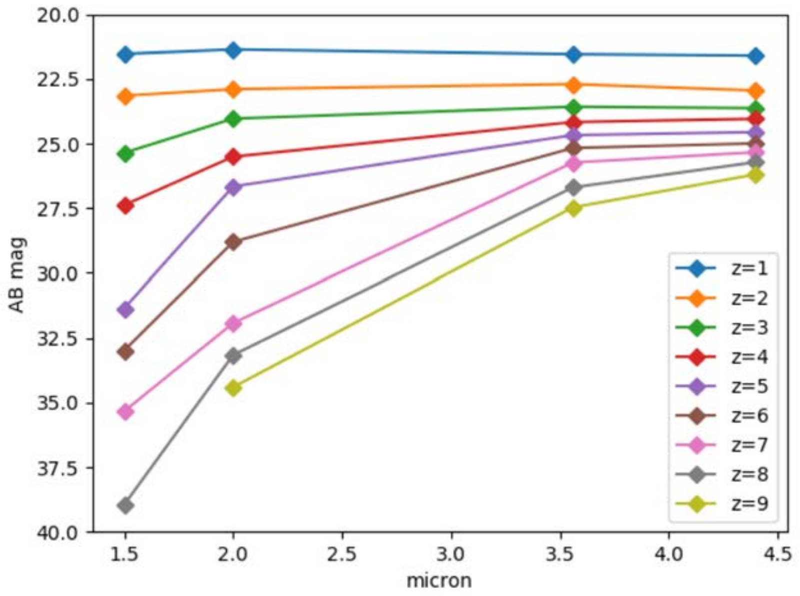
(What's out here?)

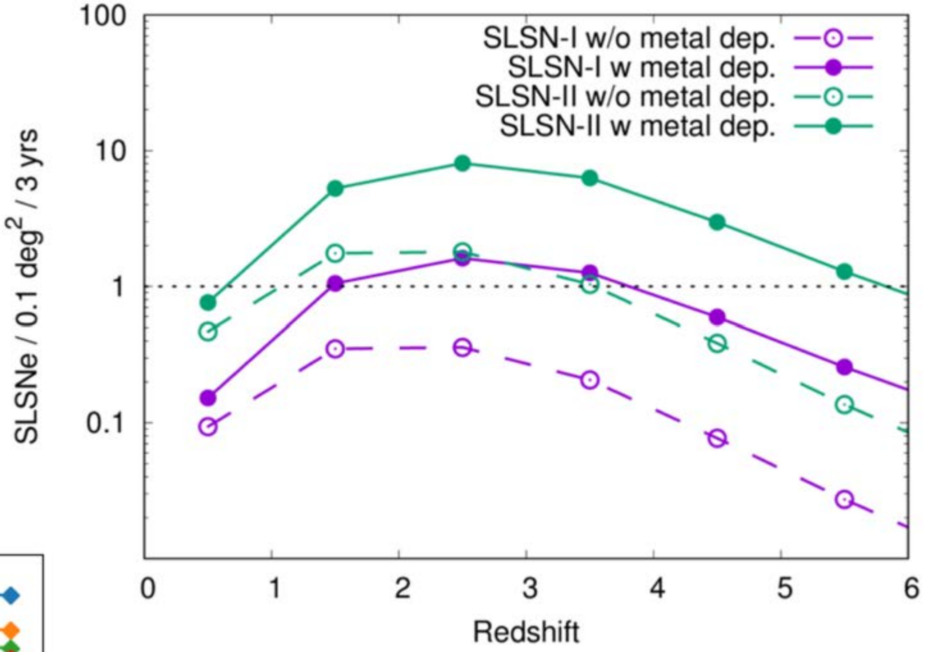
Rho+ 2018 Gemini GNIRS

Higher Z SNe

(See Poster by E. Regos, this conference)





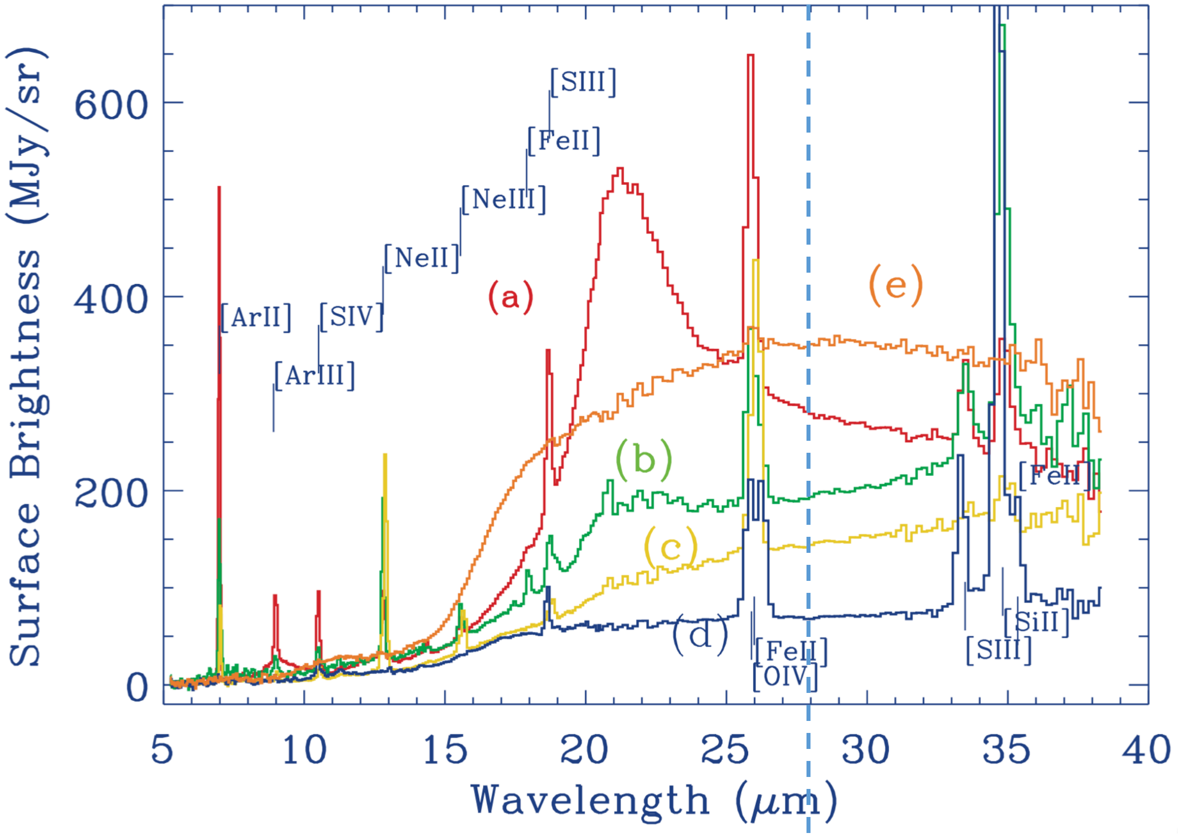


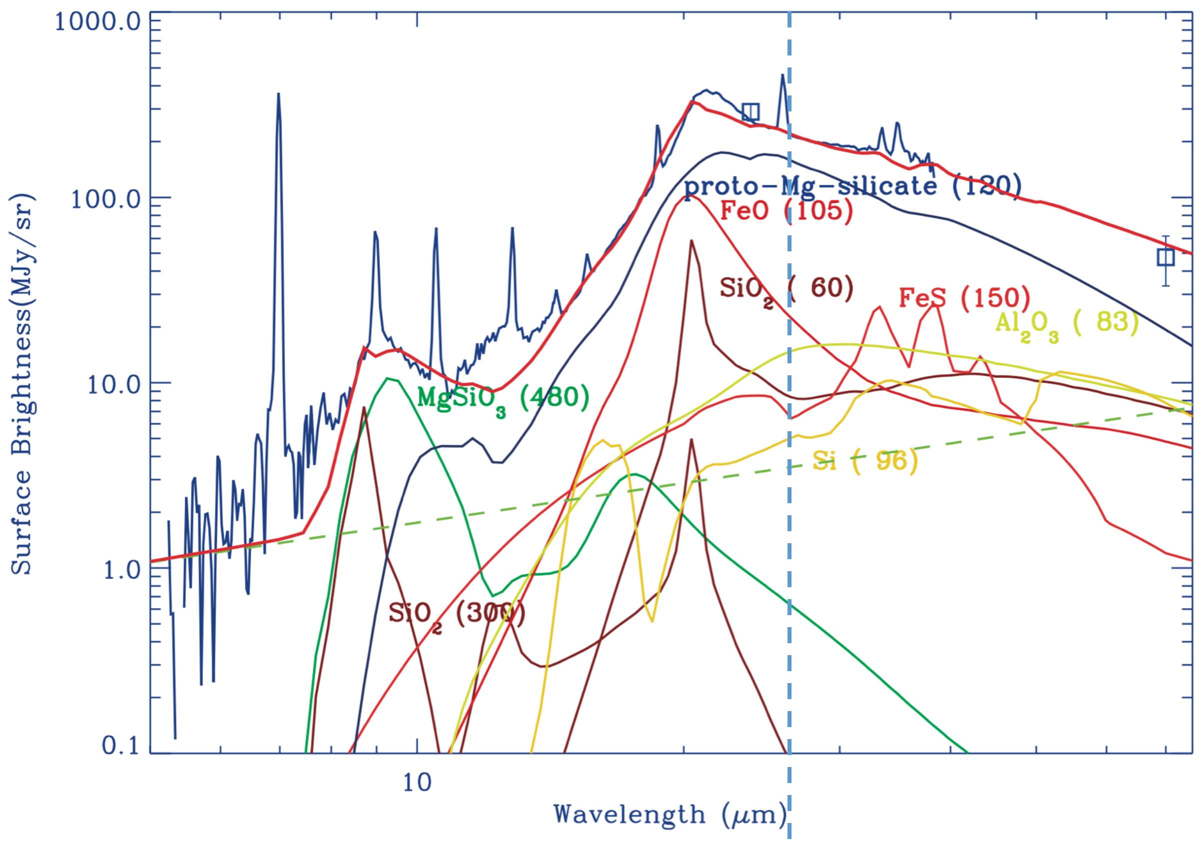
Pop II PISN in NIR JWST range

Cas A with Spitzer

FRESHLY FORMED DUST IN THE CASSIOPEIA A SUPERNOVA REMNANT AS REVEALED BY THE *SPITZER SPACE TELESCOPE*

J. Rho,[1] T. Kozasa,[2] W. T. Reach,[1] J. D. Smith,[3] L. Rudnick,[4] T. DeLaney,[5] J. A. Ennis,[4] H. Gomez,[6] and A. Tappe[1,7]

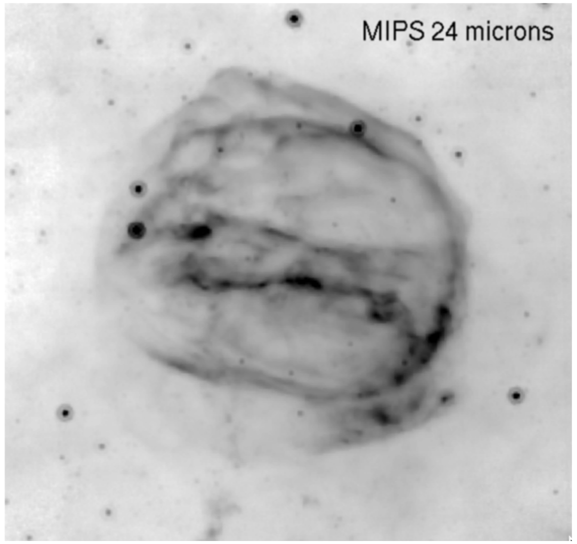


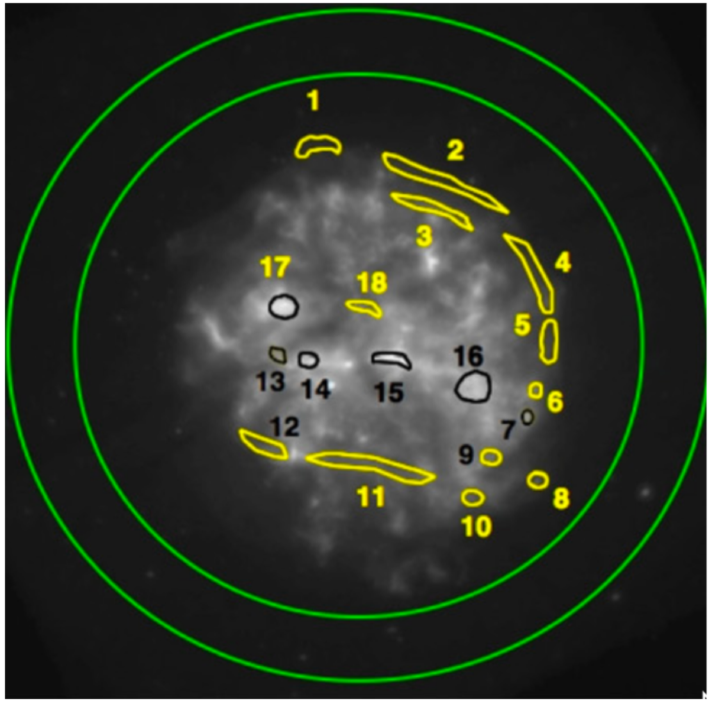


Rho+ 2008; see also Arendt+ 2014

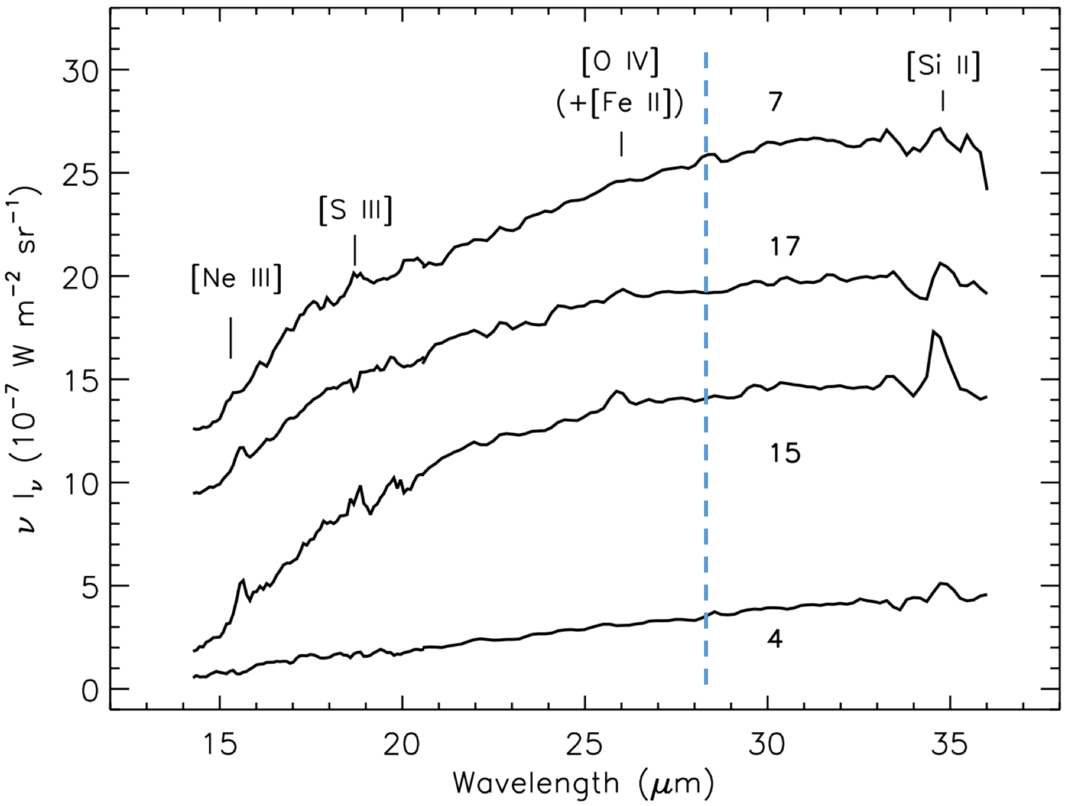
(See also Koo+2018 and Raymond+ 2018: ground based NIR imaging of ejecta)

G292.0+1.8 O-rich CCSNR





Chandra w/ extraction regions



Ghavamian+ 2012

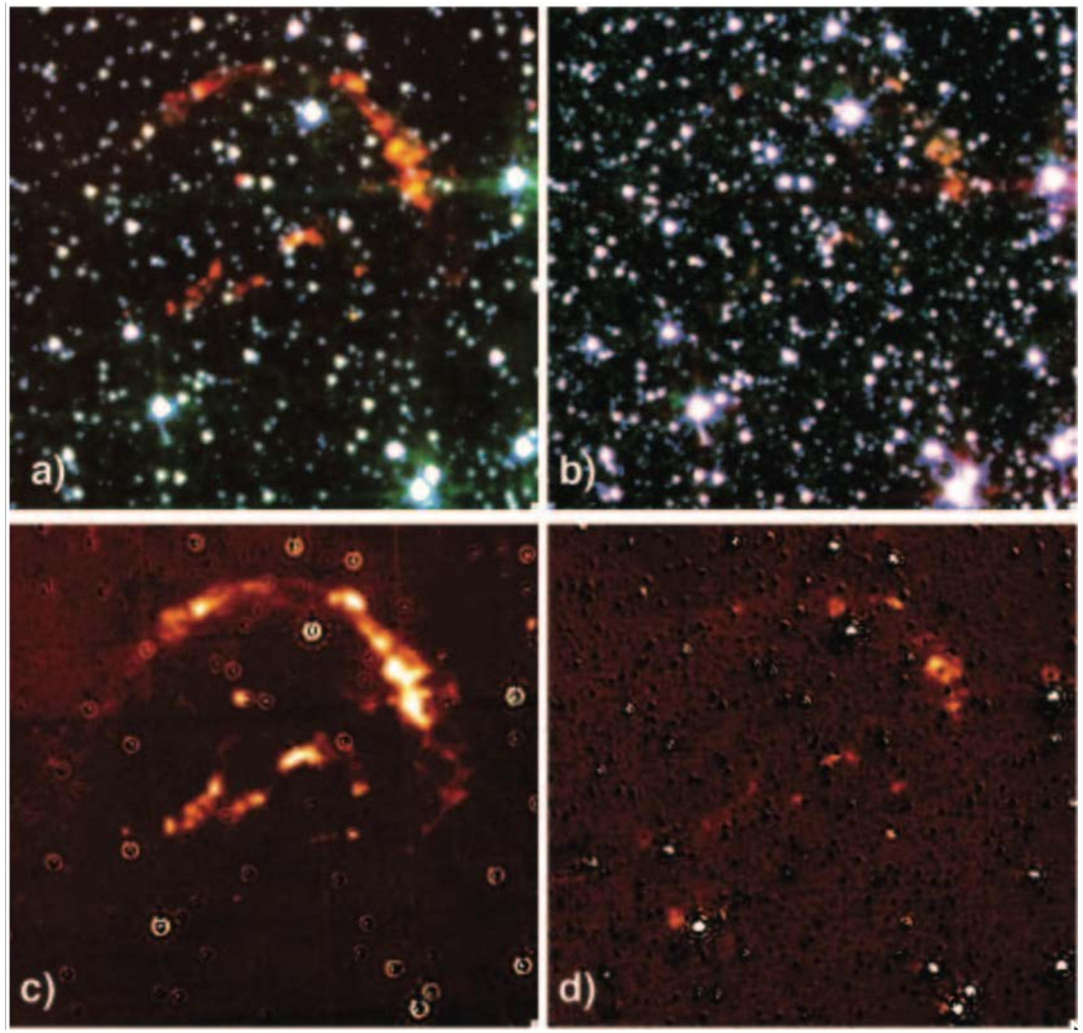
Spitzer IMAGING AND SPECTRAL MAPPING OF THE OXYGEN-RICH SUPERNOVA REMNANT G292.0+1.8

Parviz Ghavamian[1], Knox S. Long[2], William P. Blair[3], Sangwook Park[4], Robert Fesen[5], B. M. Gaensler[6], John P. Hughes[7], Jeonghee Rho[8], and P. Frank Winkler[9]

Kepler as seen by Spitzer (Imaging)

RGB=8,5.6,3.6 μm

RGB=5.6,4.5,3.6 μm

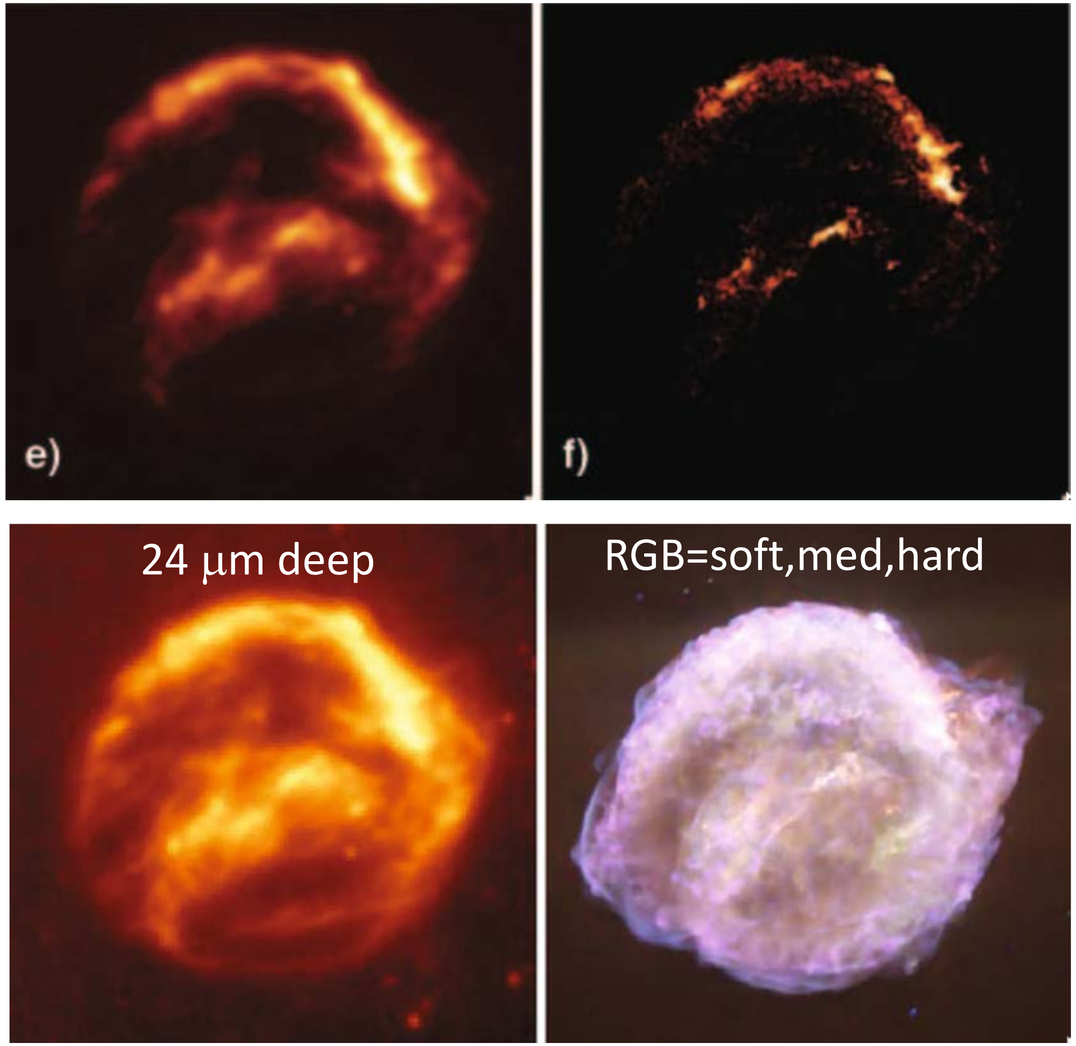


8 - 5.6 μm

4.5 - 3.6 μm

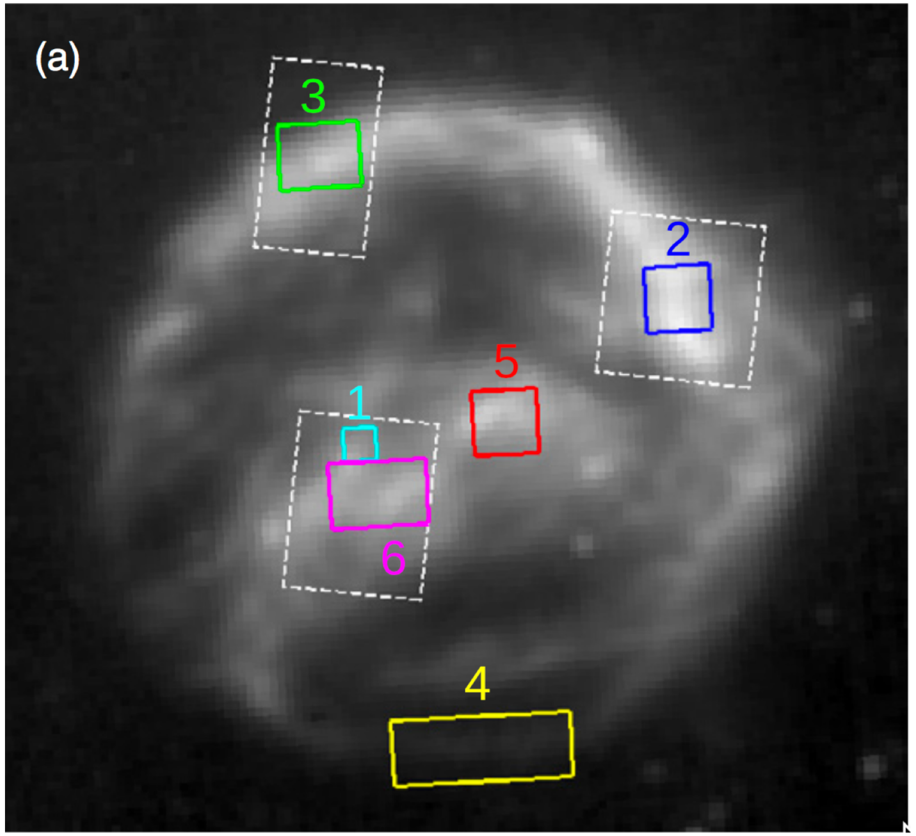
24 μm MIPS

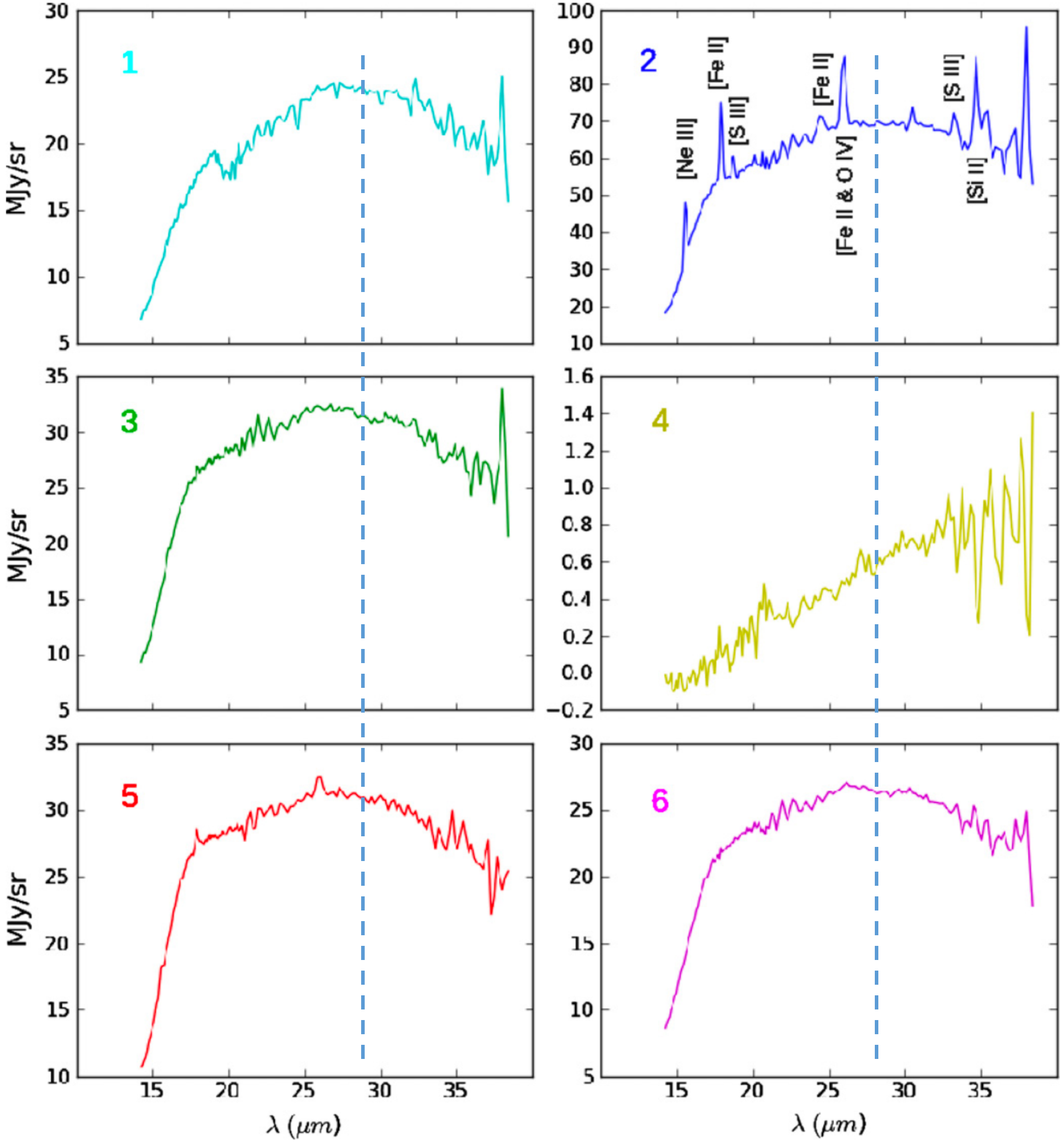
Chandra 0.3 – 0.6 keV



Blair+ 2007 and Williams & Temim 2018

Kepler as seen by Spitzer (Spectra)

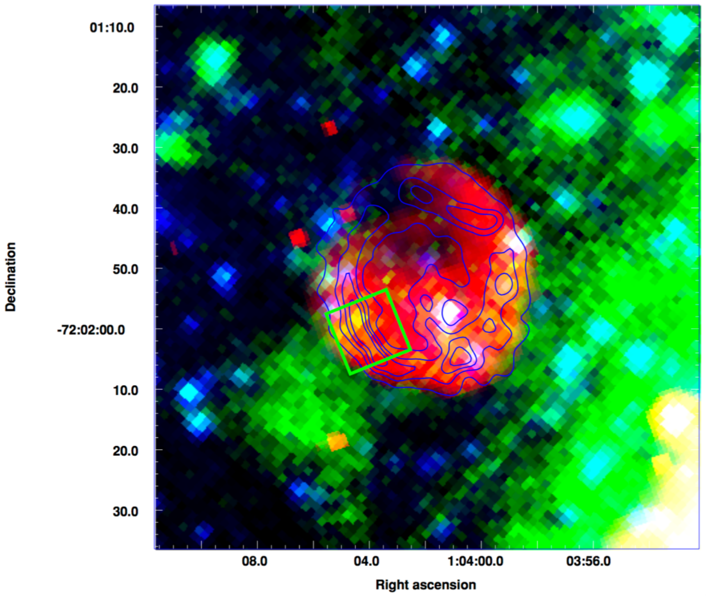




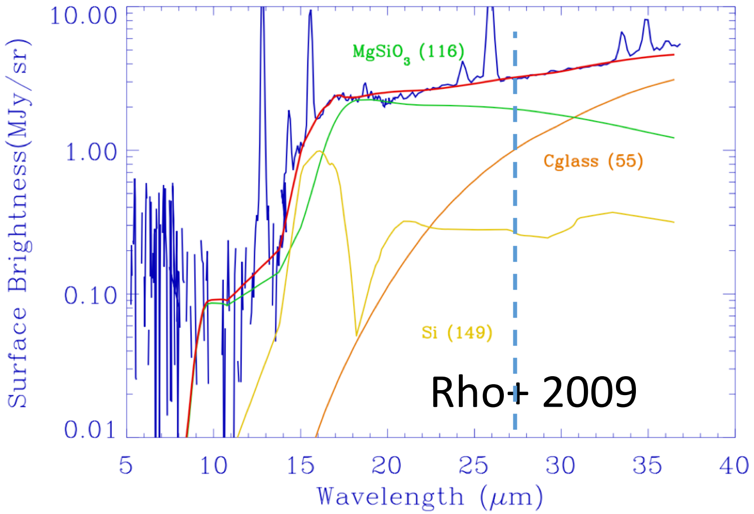
Variations in dust characteristics. (Note: region 2 has bright radiative shocks.)

Williams+ 2012

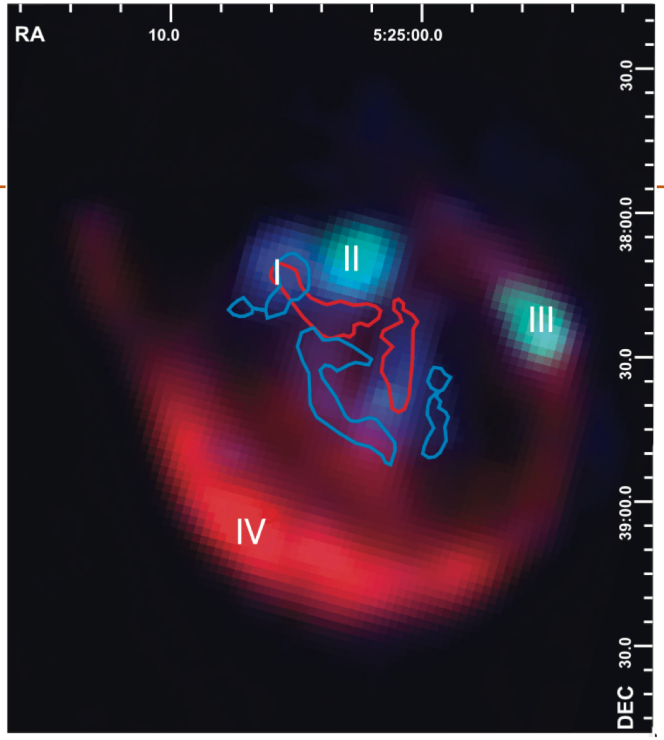
Spitzer of Magellanic Cloud CC SNRs



E0102 (SMC)
Red: 24 μm
Green: 8 μm
Blue: 5.8 μm

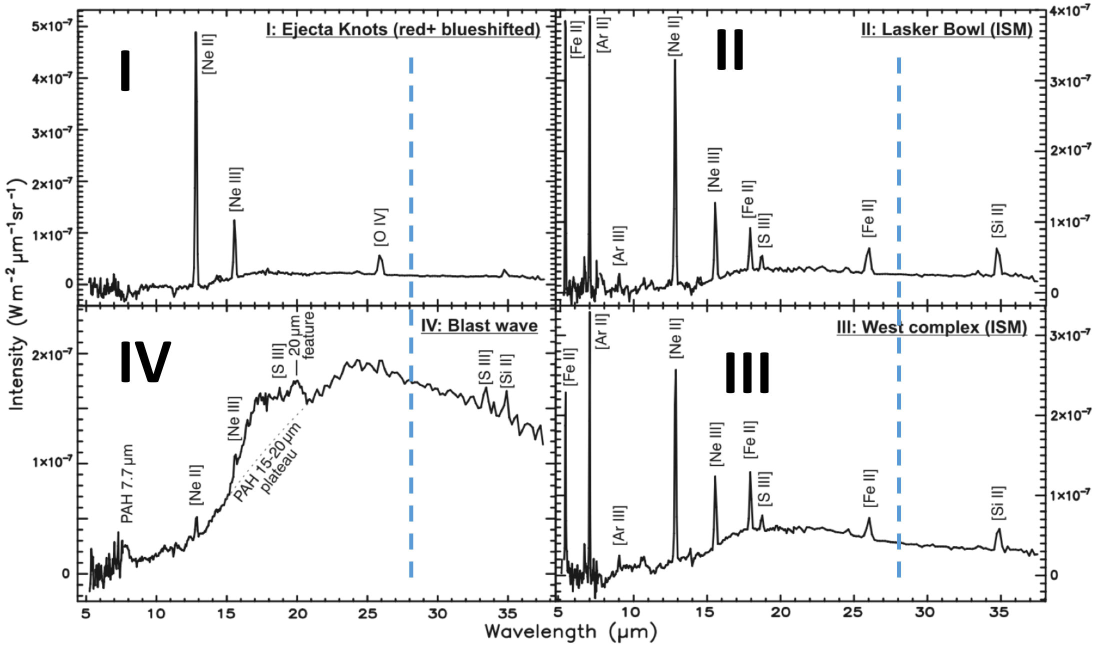


Rho+ 2009



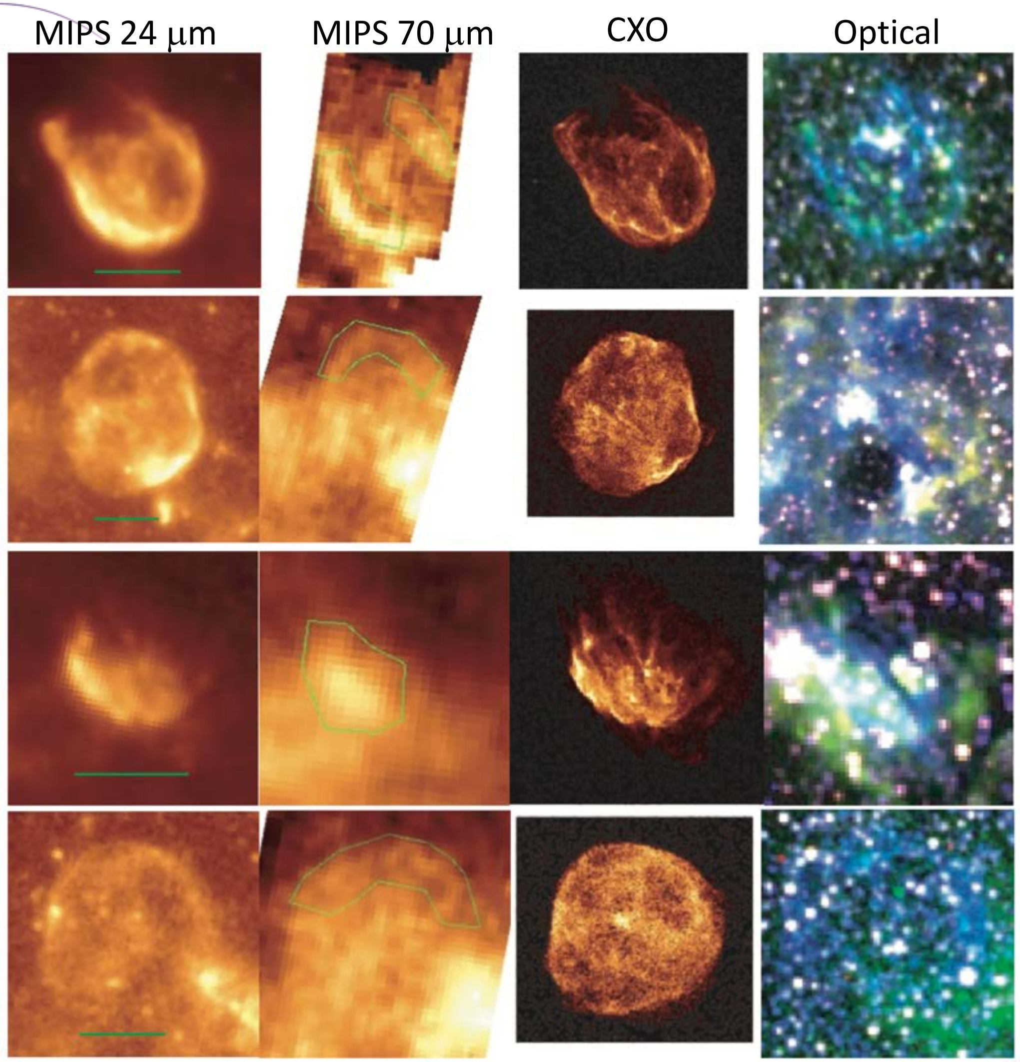
Tappe+ 2012

N132D (LMC)
Red: 20 μm cont.
Green: [FeII] 17.9 μm
Blue: [NeIII] 15.5 μm

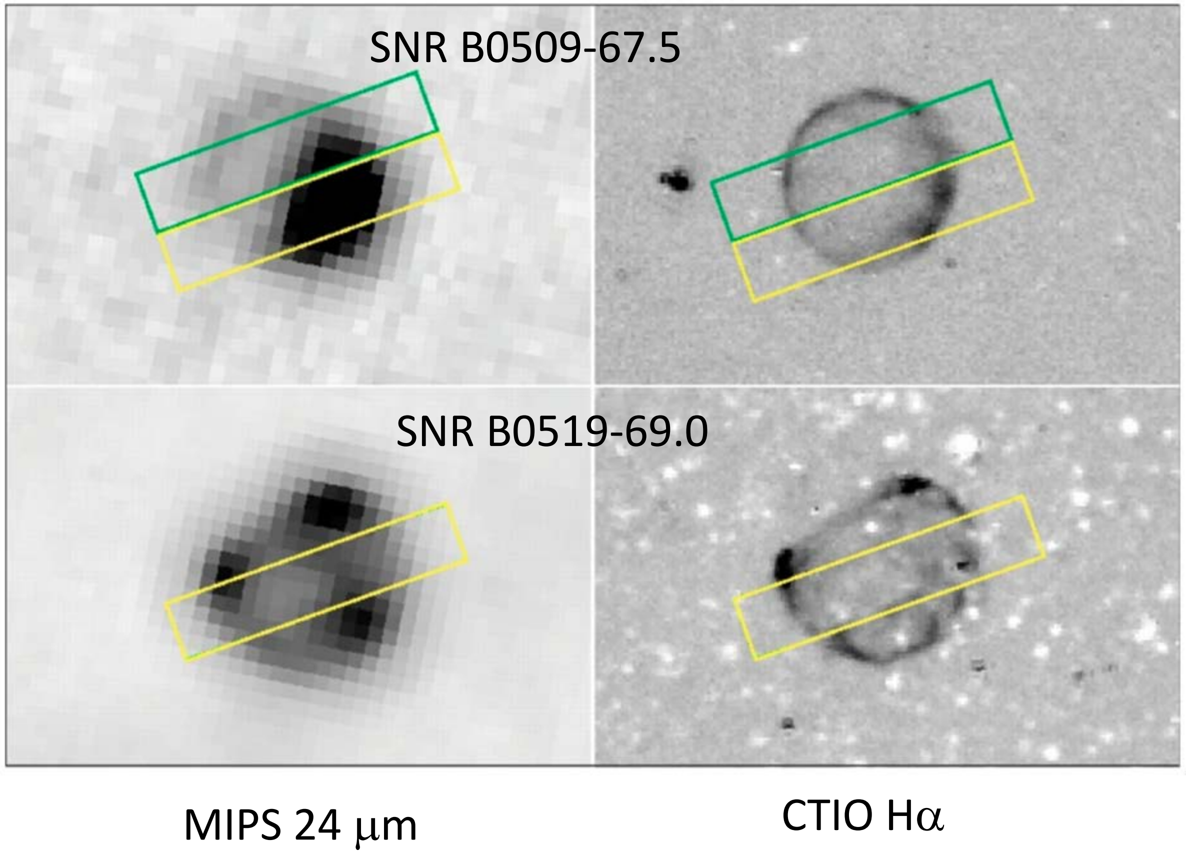


Spitzer Magellanic Cloud SNRs

Type Ia SNRs



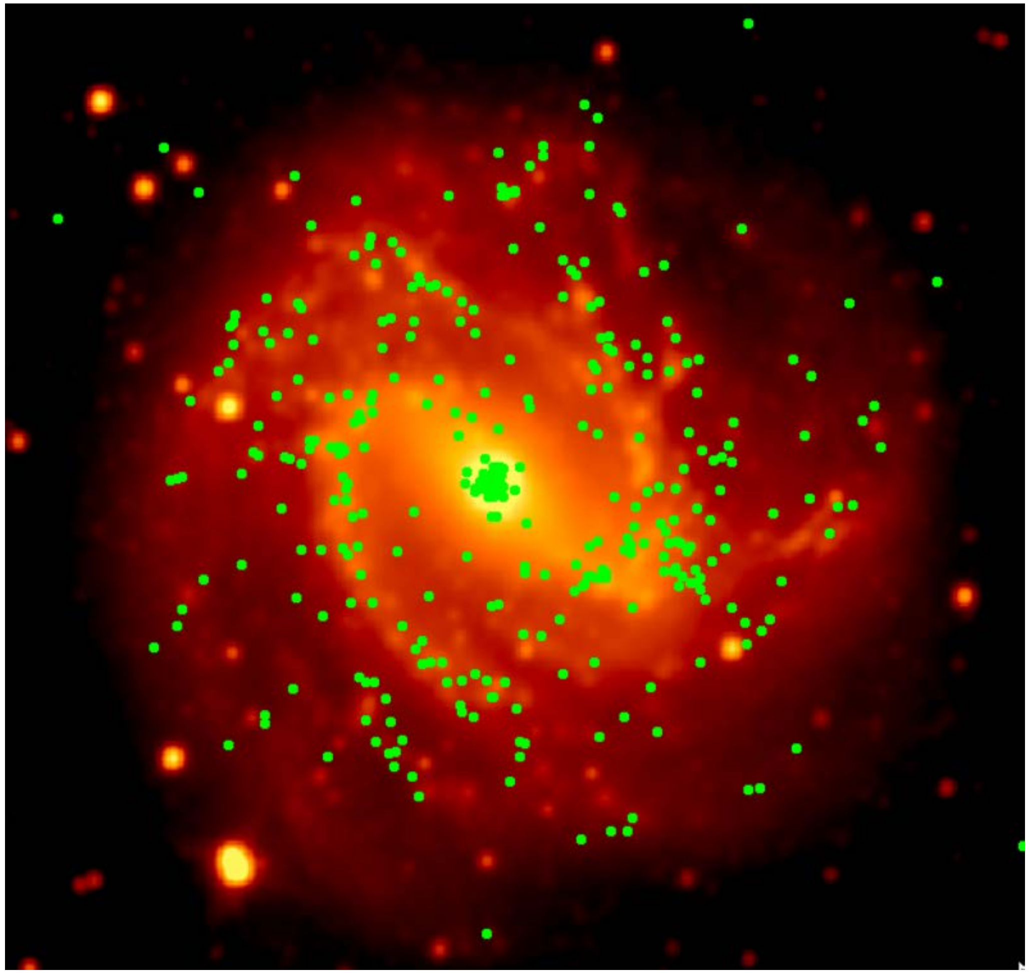
Williams+06, Borkowski+ 2006



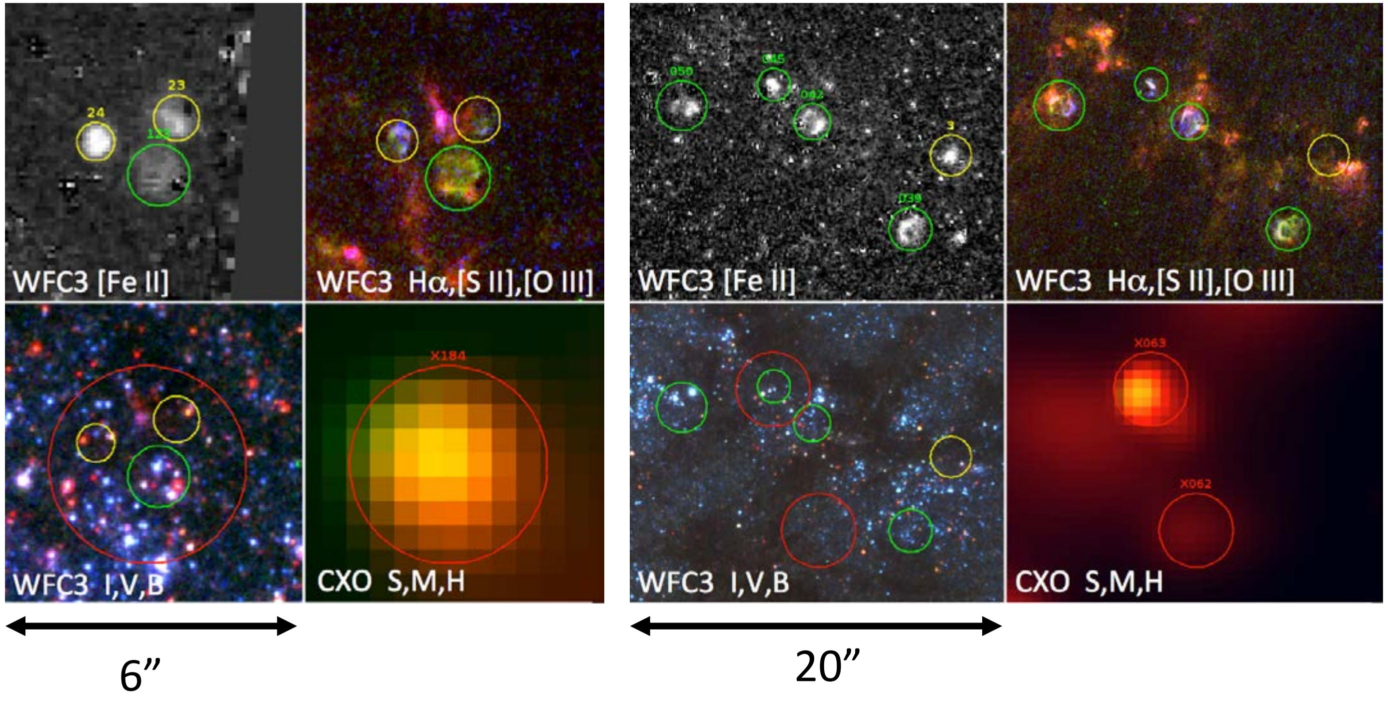
Williams+11

SNRs in More Distant Galaxies

Examples of HST/WFC3 data for M83



M83, WISE 3.4 μm with optical SNRs



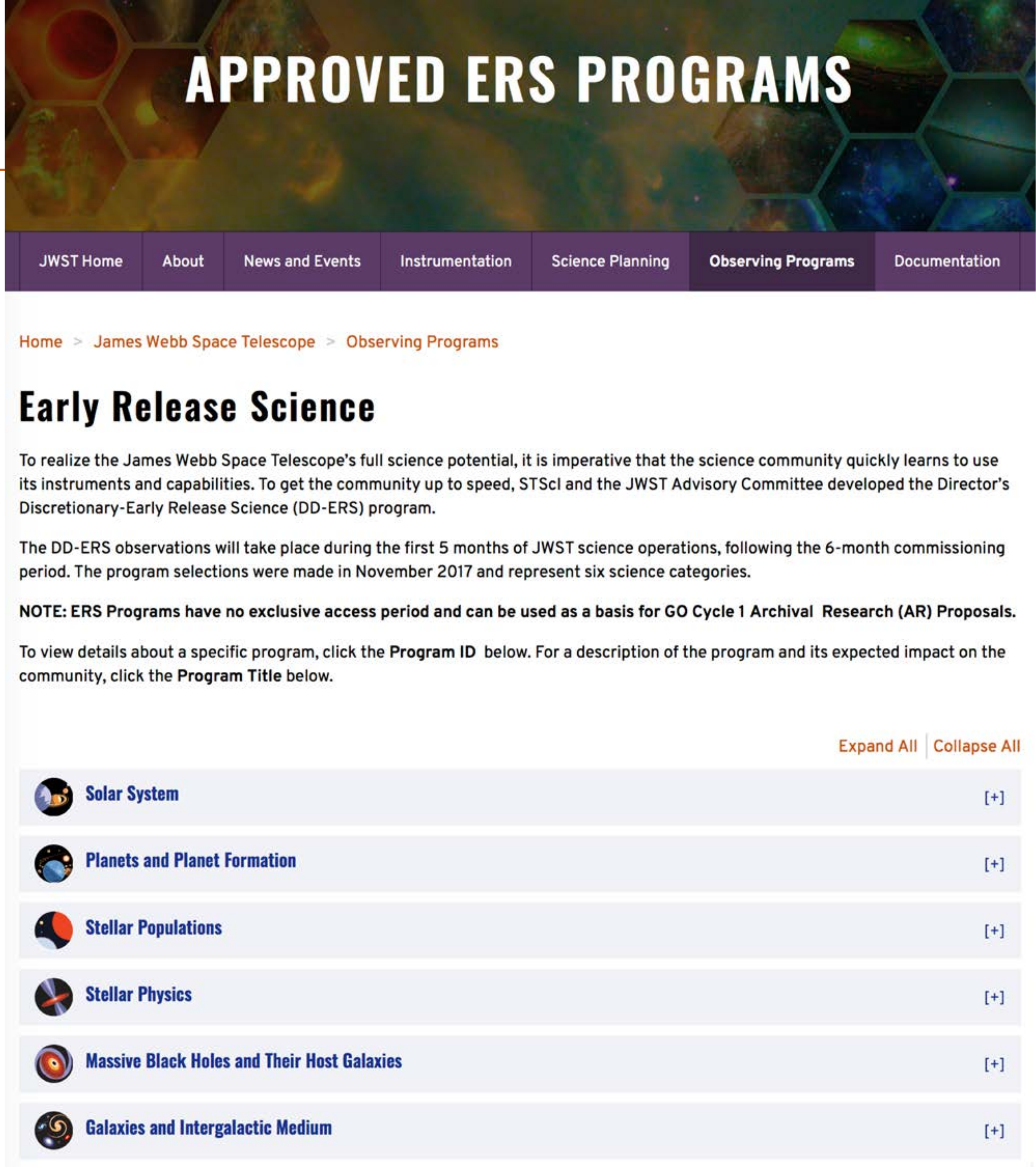
- [Fe II] 1.644 μm is an excellent diagnostic for shocks
- Can find SNRs in dusty regions that are missed in optical
- JWST spatial resolution and sensitivity will be key advantages

Blair+ 2012; 2014

Early Release Science

- 13 ERS programs accepted in 6 science categories
- To be executed in the 5 month period following the (6-month) commissioning period after launch
- Data will be public immediately, but
- Unfortunately, there is little of direct interest to SNe/SNR science (other than general performance information) in these programs!

Approved ERS programs page:
http://www.stsci.edu/jwst/observing-programs/approved-ers-programs

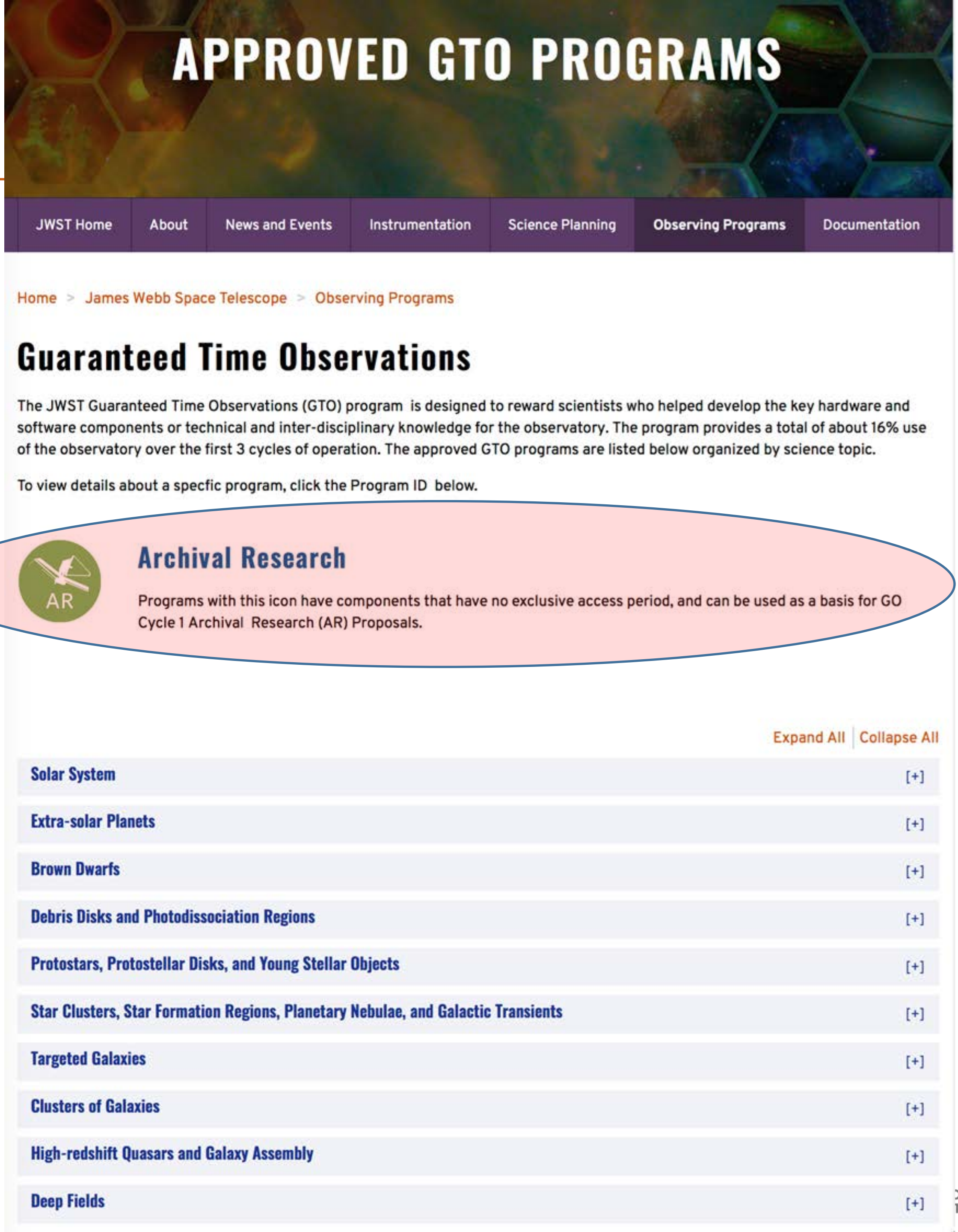


Guaranteed Time Observer Programs

(Situation is not a lot better in the GTO programs.)

ID	Program Title	AR?	Principal Investigator	Instrument
1182	NIRCam GTO - IRDC Mapping		Erick Young (Universities Space Research Association)	NIRCam
1190	Embedded Cluster Survey		Michael Meyer (University of Michigan)	NIRCam
1232	SN 1987A: The Formation and Evolution of Dust in a Supernova Explosion	AR	Gillian Wright (United Kingdom Astronomy Technology Centre)	MIRI NIRSpec
1237	Star Formation in the Extreme Outer Galaxy		Michael Ressler (Jet Propulsion Laboratory)	MIRI
	Sparse Spectral Mapping of NGC		Michael Ressler (Jet	

Approved GTO Programs page:
http://www.stsci.edu/jwst/observing-programs/approved-gto-programs



Detailed JDox Example program on Cas A using the JWST IFUs*

MIRI MRS and NIRSpec IFU Observations of Cassiopeia A

Example Science Program #26

This example science program presents an application of the IFU Roadmap, showing how to create the cross-instrument MIRI/NIRSpec observing program to observe knots in Cassiopeia A.

Page contents

... / MIRI MRS and NIRSpec IFU Observations of Cassiopeia A

Step-by-Step ETC Guide for MIRI MRS and NIRSpec IFU Observations of Cassiopeia A

Example Science Program #26 ETC Guide

A walk-through of the JWST ETC for the Example Science Program MIRI MRS and NIRSpec IFU Observations of Cassiopeia A is provided, demonstrating how to select exposure parameters for this observing program.

... / MIRI MRS and NIRSpec IFU Observations of Cassiopeia A

Step-by-Step APT Guide for MIRI MRS and NIRSpec IFU Observations of Cassiopeia A

Example Science Program #26 APT Guide

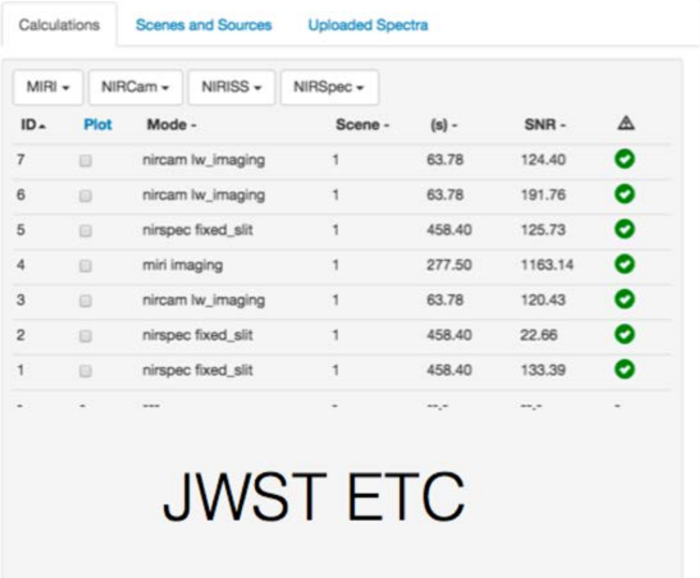
Instructions are provided for filling out the JWST APT observing template for the MIRI MRS and NIRSpec IFU Observations of Cassiopeia A Example Science program, where MIRI MRS and the NIRSpec IFU are used to obtain medium-resolution spectra of knots in the Cassiopeia A supernova remnant.

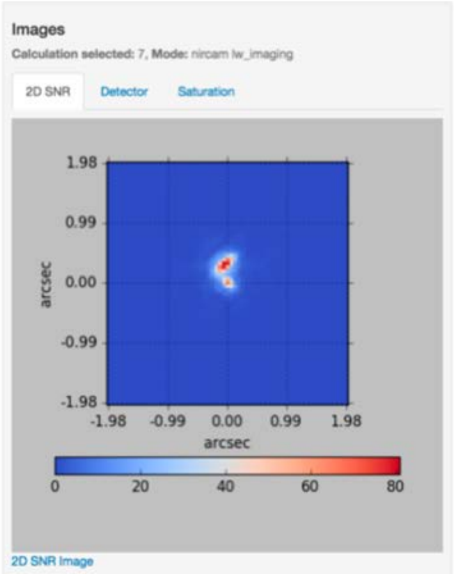
https://jwst-docs.stsci.edu/display/JTI/MIRI+MRS+and+NIRSpec+IFU+Observations+of+Cassiopeia+A

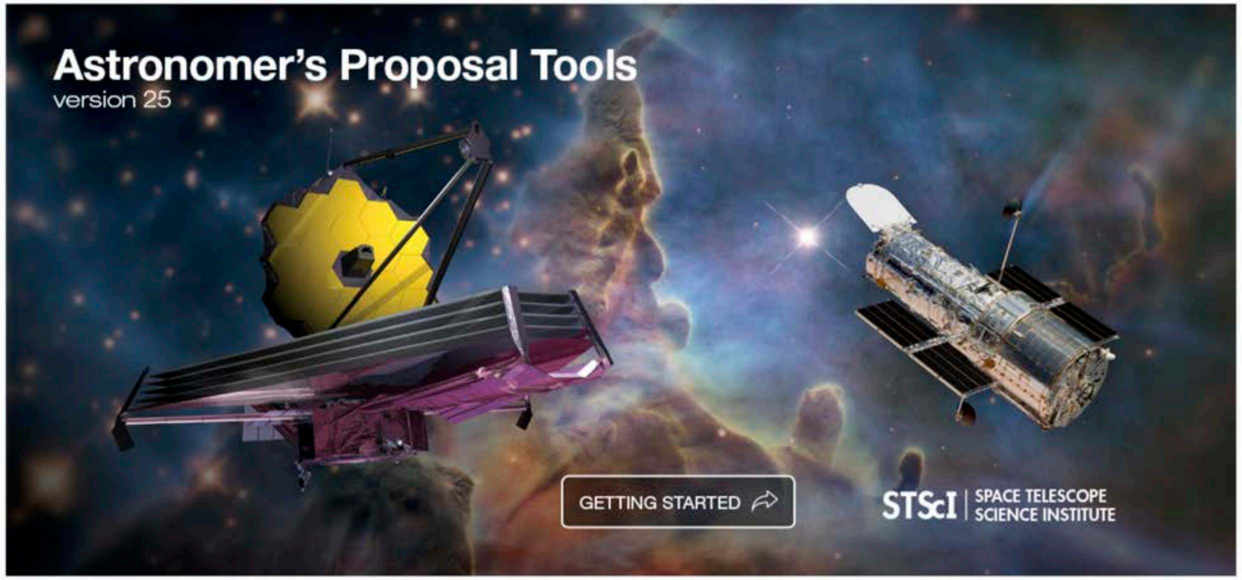
*Special thanks to Beth Sargent, STScI

Cycle 1 Proposal Support Resources and Schedule

JWST Proposal Planning Tools and Resources



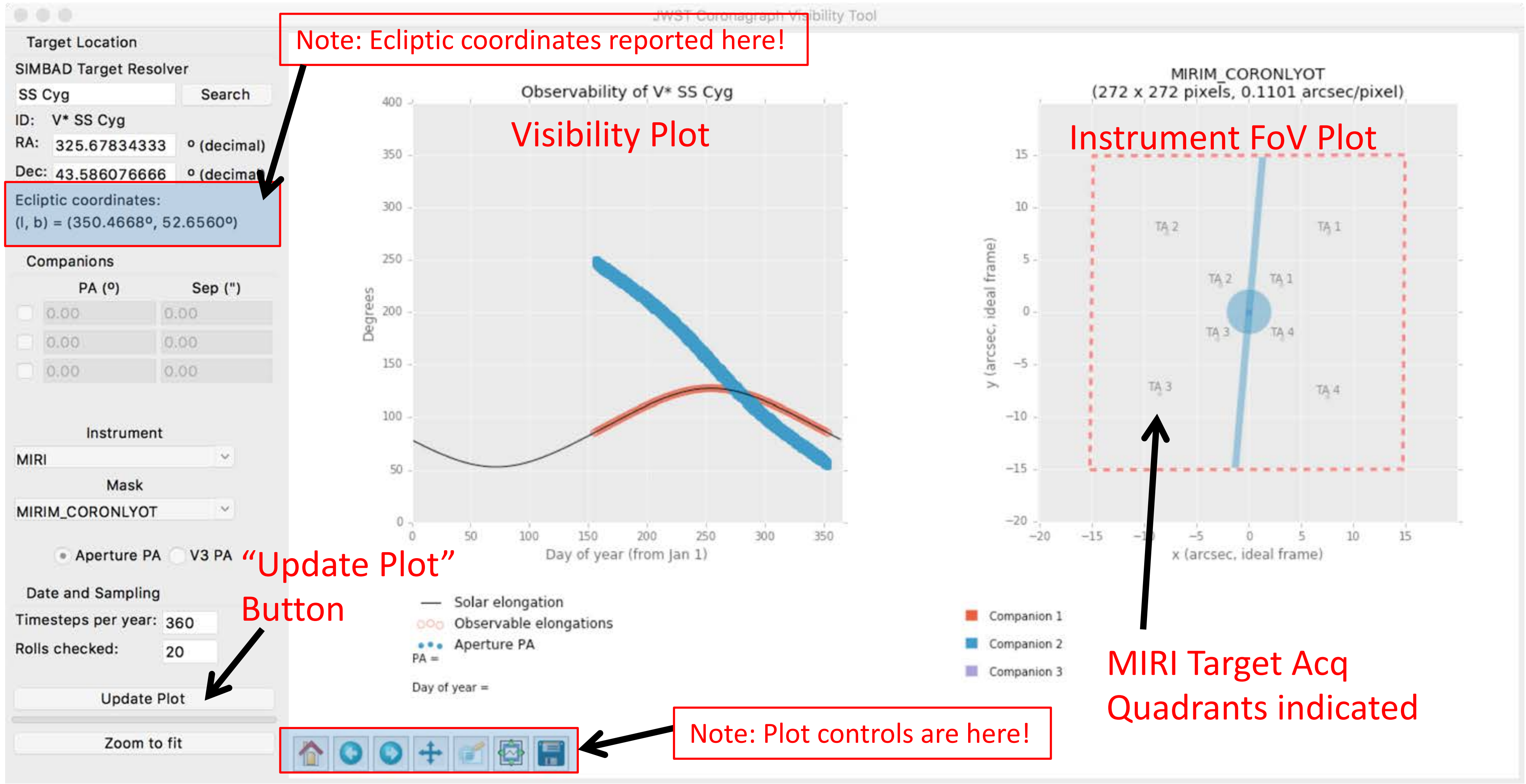




And Much More!

JWST Visibility and Position Angle Tools

- The blue line shows the visibility windows and MIRI aperture PA values over 1 year. The vertical thickness of the line shows the *roll range* available at any given time.



JWST Documentation (JDox)

A New Paradigm for JWST User Documentation

New documentation system, following “Every Page is Page One” strategy

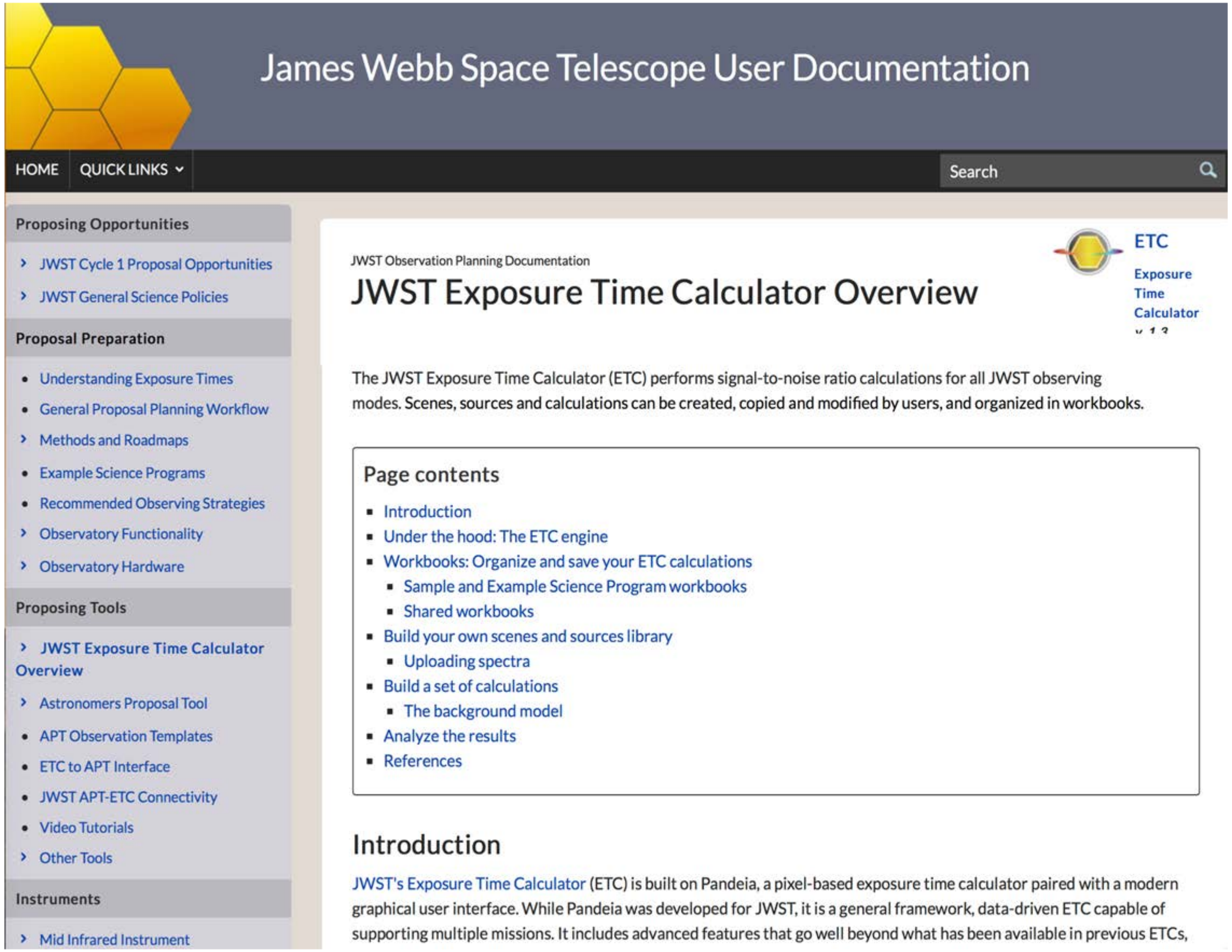
- Short articles
- Self-contained, one-level of information
- Hyperlinked network rather than monolithic handbooks

Think “Wikipedia” (but it’s not a wiki)

Multiple conceptual spaces: Background articles, planning roadmaps and example programs, science policy, engineering specs

Incremental releases (as articles are written and reviewed); but

Stability during the open proposal period



James Webb Space Telescope User Documentation

HOME QUICK LINKS Search

Proposing Opportunities
- JWST Cycle 1 Proposal Opportunities
- JWST General Science Policies

Proposal Preparation
- Understanding Exposure Times
- General Proposal Planning Workflow
- Methods and Roadmaps
- Example Science Programs
- Recommended Observing Strategies
- Observatory Functionality
- Observatory Hardware

Proposing Tools
- JWST Exposure Time Calculator Overview
- Astronomers Proposal Tool
- APT Observation Templates
- ETC to APT Interface
- JWST APT-ETC Connectivity
- Video Tutorials
- Other Tools

Instruments
- Mid Infrared Instrument

JWST Observation Planning Documentation

JWST Exposure Time Calculator Overview

ETC Exposure Time Calculator

The JWST Exposure Time Calculator (ETC) performs signal-to-noise ratio calculations for all JWST observing modes. Scenes, sources and calculations can be created, copied and modified by users, and organized in workbooks.

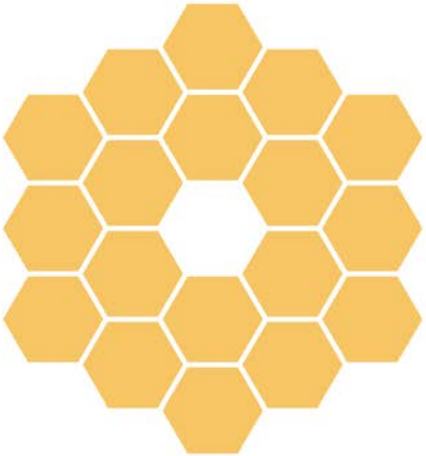
Page contents
- Introduction
- Under the hood: The ETC engine
- Workbooks: Organize and save your ETC calculations
  - Sample and Example Science Program workbooks
  - Shared workbooks
- Build your own scenes and sources library
  - Uploading spectra
- Build a set of calculations
  - The background model
- Analyze the results
- References

Introduction

JWST's Exposure Time Calculator (ETC) is built on Pandeia, a pixel-based exposure time calculator paired with a modern graphical user interface. While Pandeia was developed for JWST, it is a general framework, data-driven ETC capable of supporting multiple missions. It includes advanced features that go well beyond what has been available in previous ETCs,

STScI | SPACE TELESCOPE SCIENCE INSTITUTE

JWST Pocket Guide and Information



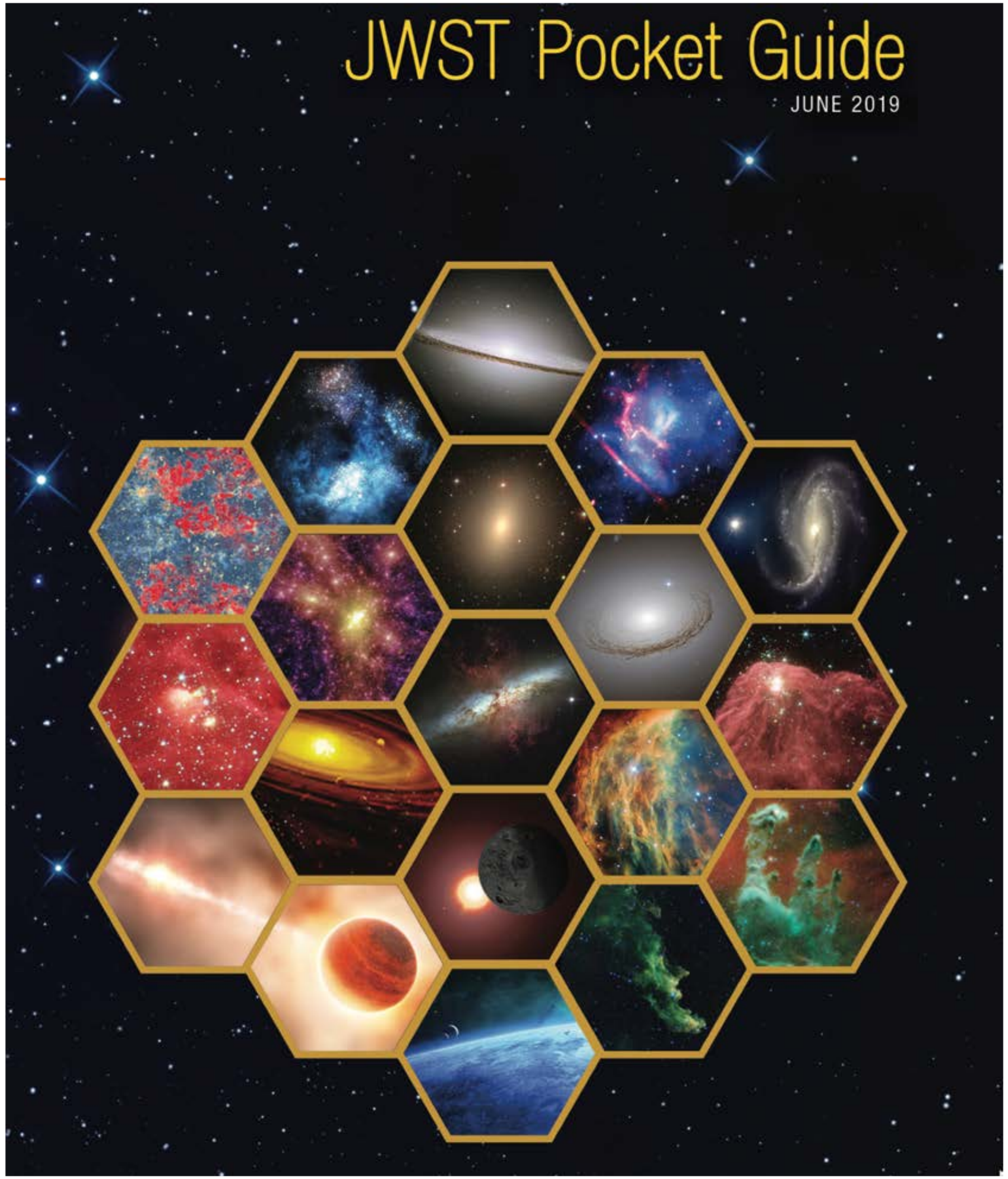
More information at:

- JWST science website — **jwst.stsci.edu**
- JWST documentation — **jwst-docs.stsci.edu**
- JWST Exposure Time Calculator — **jwst.etc.stsci.edu**
- JWST Astronomer's Proposal Tool — **apt.stsci.edu**
- JWST Help Desk — **jwsthelp.stsci.edu**
- JWST milestone status and recent accomplishments — **jwst.nasa.gov/recentaccomplish.html**
- For updates and announcements on JWST science, follow **@JWSTObserver** on twitter and facebook.

Cover: A collage of images illustrating the possibilities with JWST

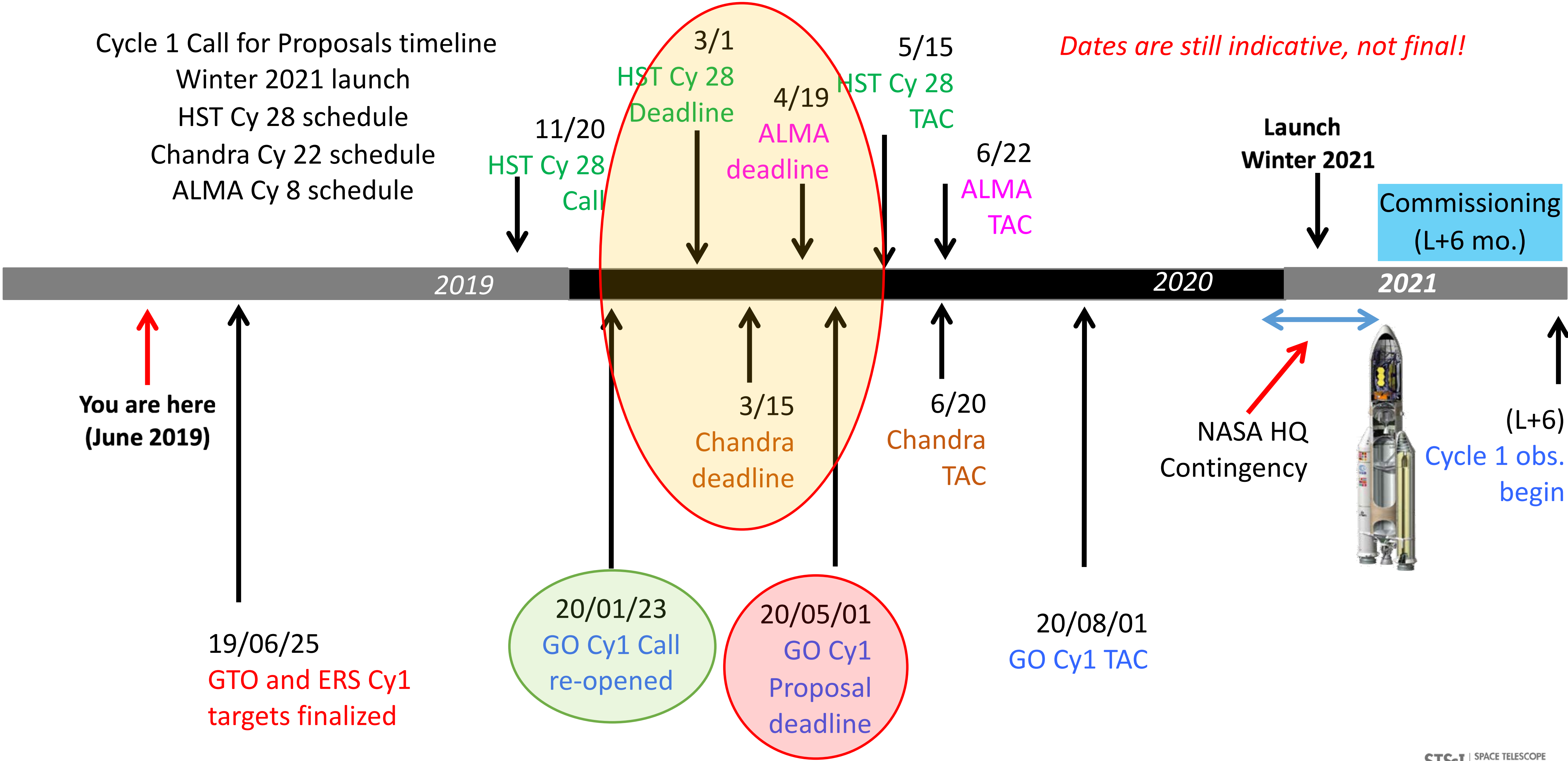
The front page shows a series of both real and artistic astronomical images that highlight some of the different science possibilities with JWST. These science themes include, but are not limited to, first light and reionization, the assembly of galaxies, the birth of stars and protoplanetary systems, and planets and the origins of life.

Cover graphic credit: A. Feild



http://www.stsci.edu/files/live/sites/www/files/home/jwst/instrumentation/_documents/jwst-pocket-guide.pdf

JWST Science Planning Timeline (as of June 2019)



STScI SPACE TELESCOPE SCIENCE INSTITUTE

JWST Cycle 1: Thinking Strategically

- Cycle 1 is likely to be heavily oversubscribed.
  - Important to get SOME data early in the mission to enable strong proposals in future cycles. What makes sense?
- Lots of smaller "individual target" proposals put in by small groups of Co-Is?
  - We might end of fighting each other as well as competing with the rest of JWST science.
- Several "SN/SNR Community" proposals for highest priority targets/science goals?
  - Develop "team" experts on various tools (instead of everyone needing to learn the tools)
  - Explore the JWST parameter space early in the mission
  - Share the data widely; get experience
- What theoretical work/modeling can be organized to put our community in better position to take advantage of JWST data?
  - And what form would this take?

Take Home Points

- JWST will make a tremendous leap in sensitivity and/or spatial resolution with respect to Spitzer and HST in the regions of overlap.
- Synergy between JWST and other major observatories (ALMA, Chandra, ground-based) should also be considered in planning proposals. Where can JWST add value to other ongoing programs you may have underway?)
- ***It is definitely not too early to be thinking hard about JWST proposal possibilities!***
  - From the "science" standpoint.
  - From the technical side (*e.g.,* learning about the proposal tools and capabilities of the instrumentation).
    - *Beware getting caught by the many expected proposal deadlines around the same time as JWST Cycle 1!*
  - From the theory/modeling side.
  - From a strategic perspective (to put our community in position for strong proposals in and beyond Cycle 1).

Questions/Discussion

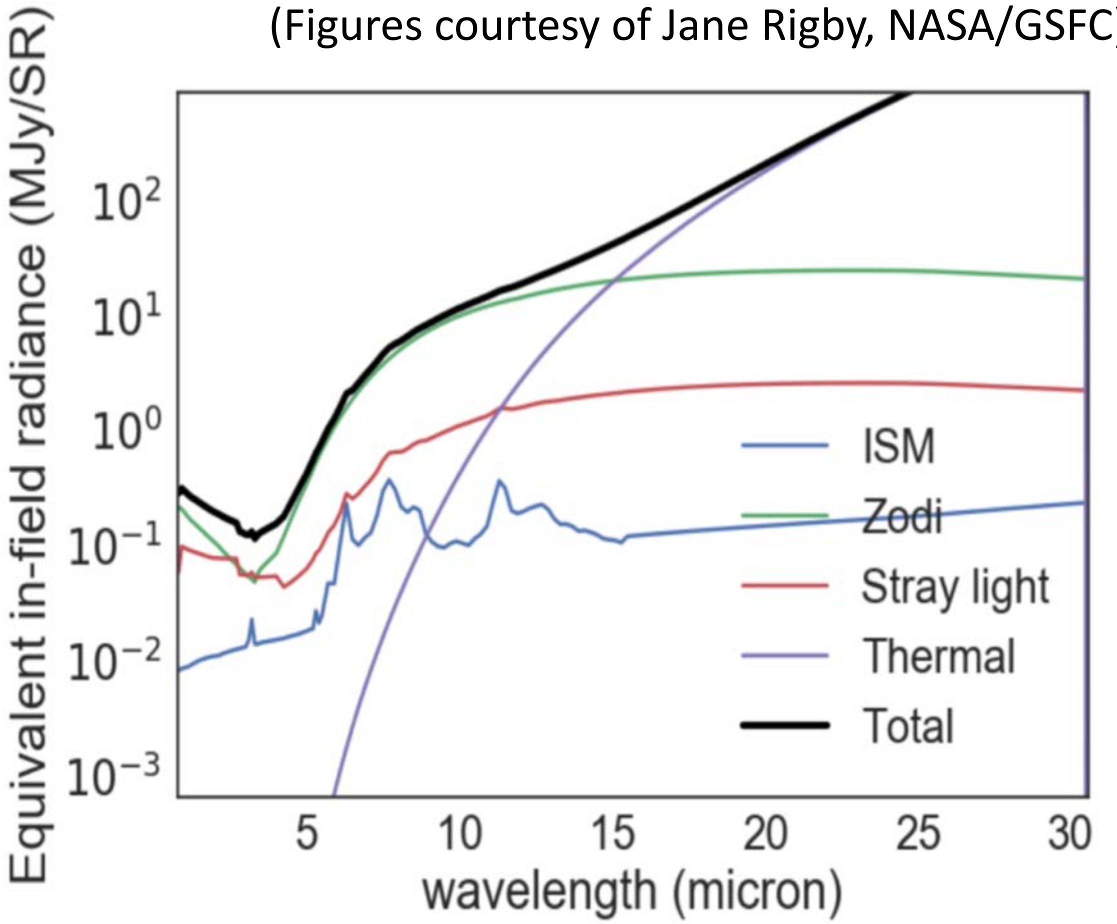
Extra Slides

EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

Observatory Overview

A Word about Backgrounds

(Figures courtesy of Jane Rigby, NASA/GSFC)



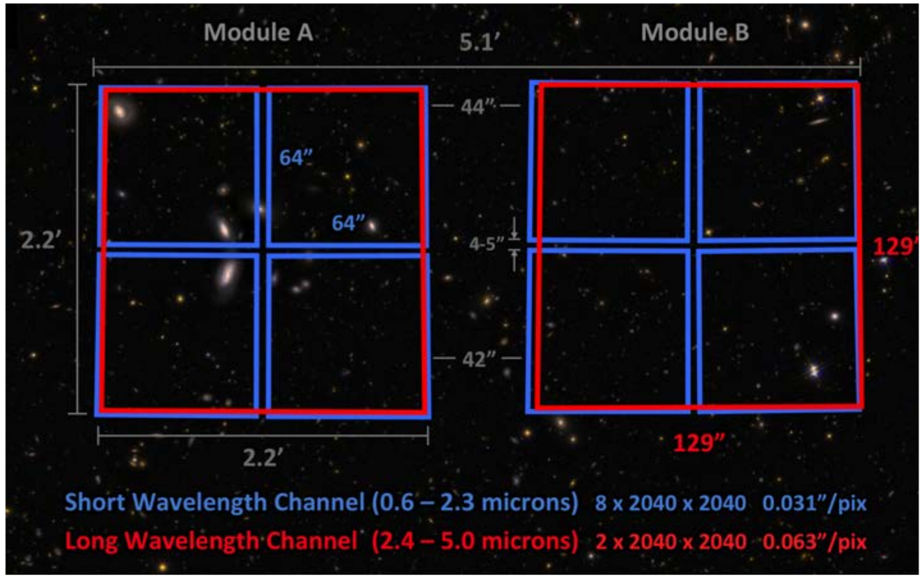
Zodiacal light is the most variable component of the background and dominates below about 10 μm. It is also time variable.

For background-limited observations, scheduling at low backgrounds is an additional constraint that can impact observing windows.

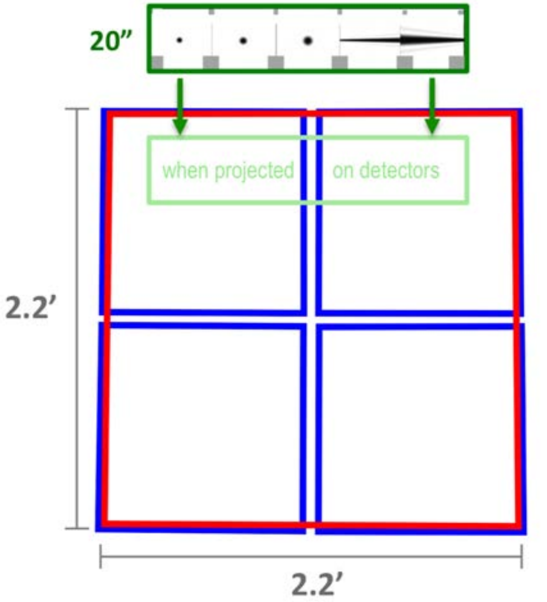
NIRCam Overview

- Four science observing modes
  - Direct imaging – 0.6 – 5.0 μm
  - Coronagraphic imaging with variety of Lyot stops – 1.8 – 5 μm
  - Wide Field Slitless Spectroscopy – 2.5 – 5 μm
  - Time Series (Planetary Transits) photometry and spectroscopy 0.6 – 5.0 μm

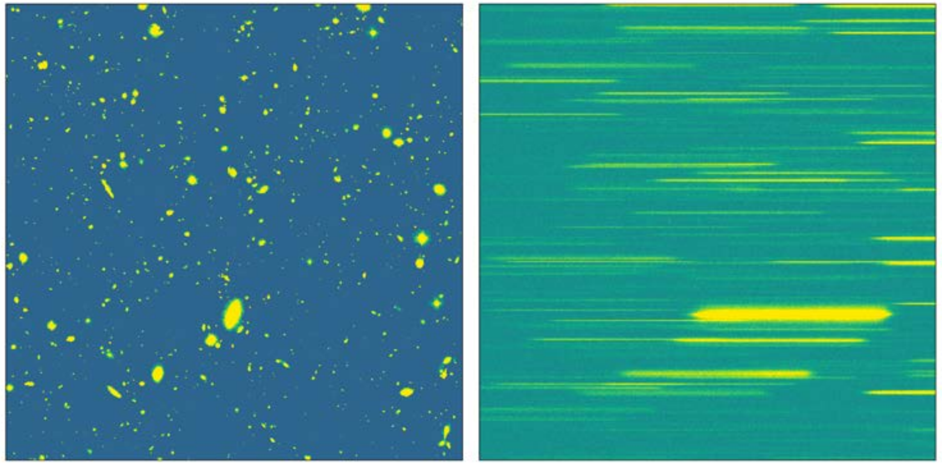
Imaging



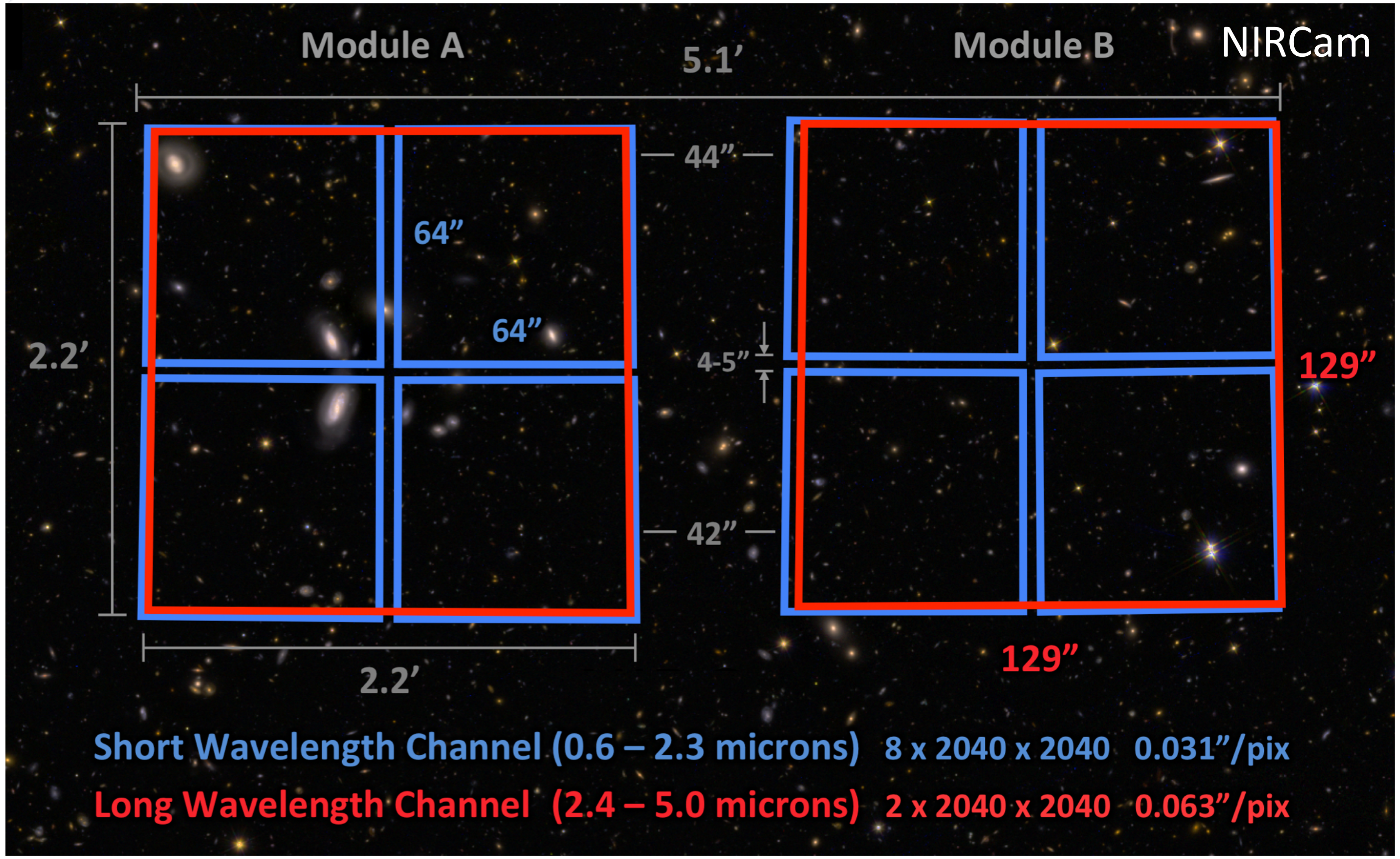
Coronagraphic Imaging

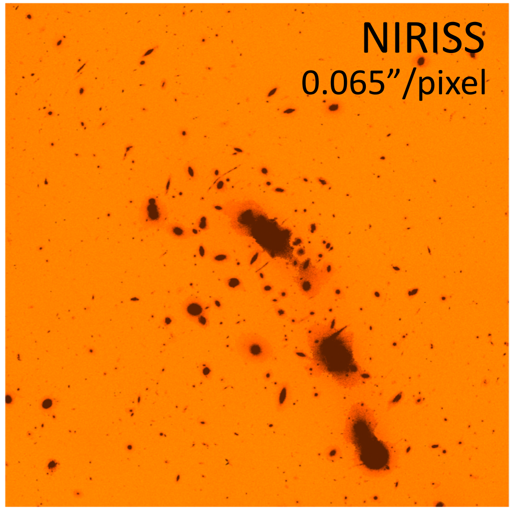


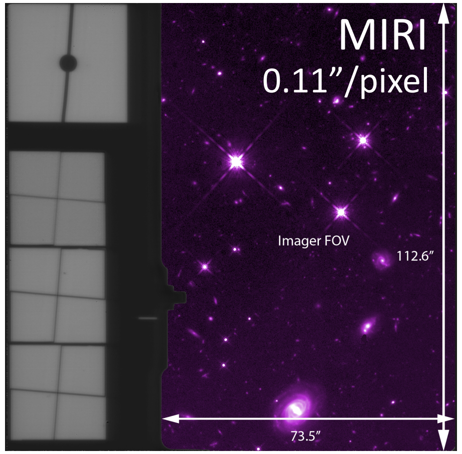
Wide Field Slitless Spectroscopy



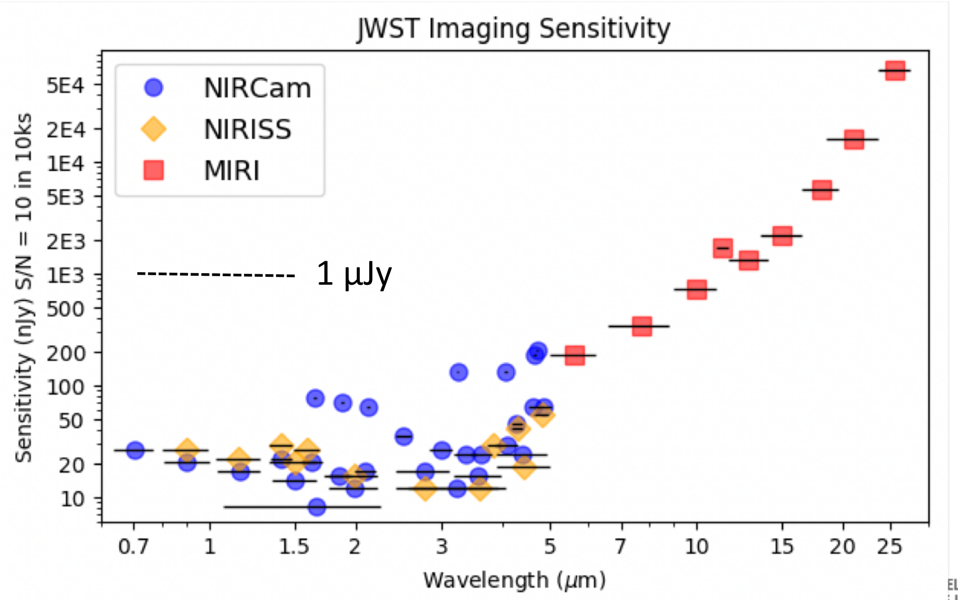
Imaging fields of view | Imaging sensitivity





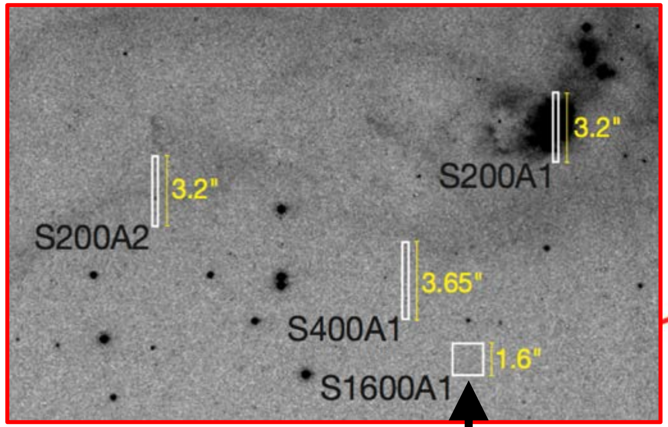


2 arcmin

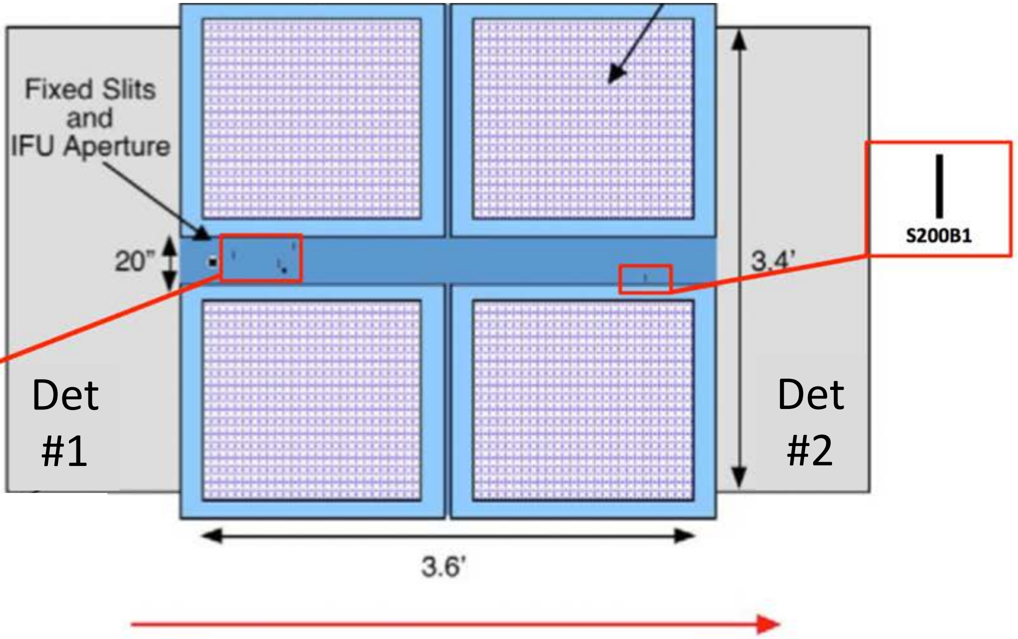


Single-object slit spectroscopy | Apertures

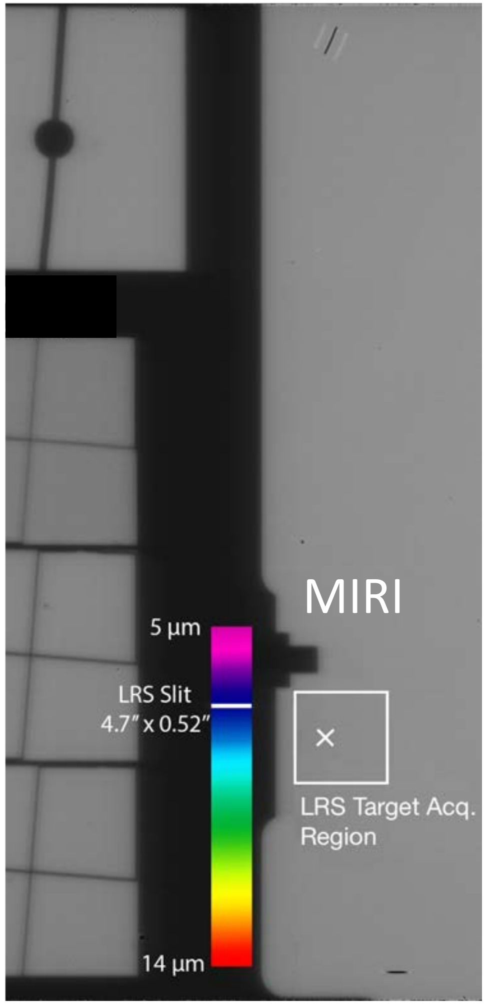
NIRSpec fixed slits



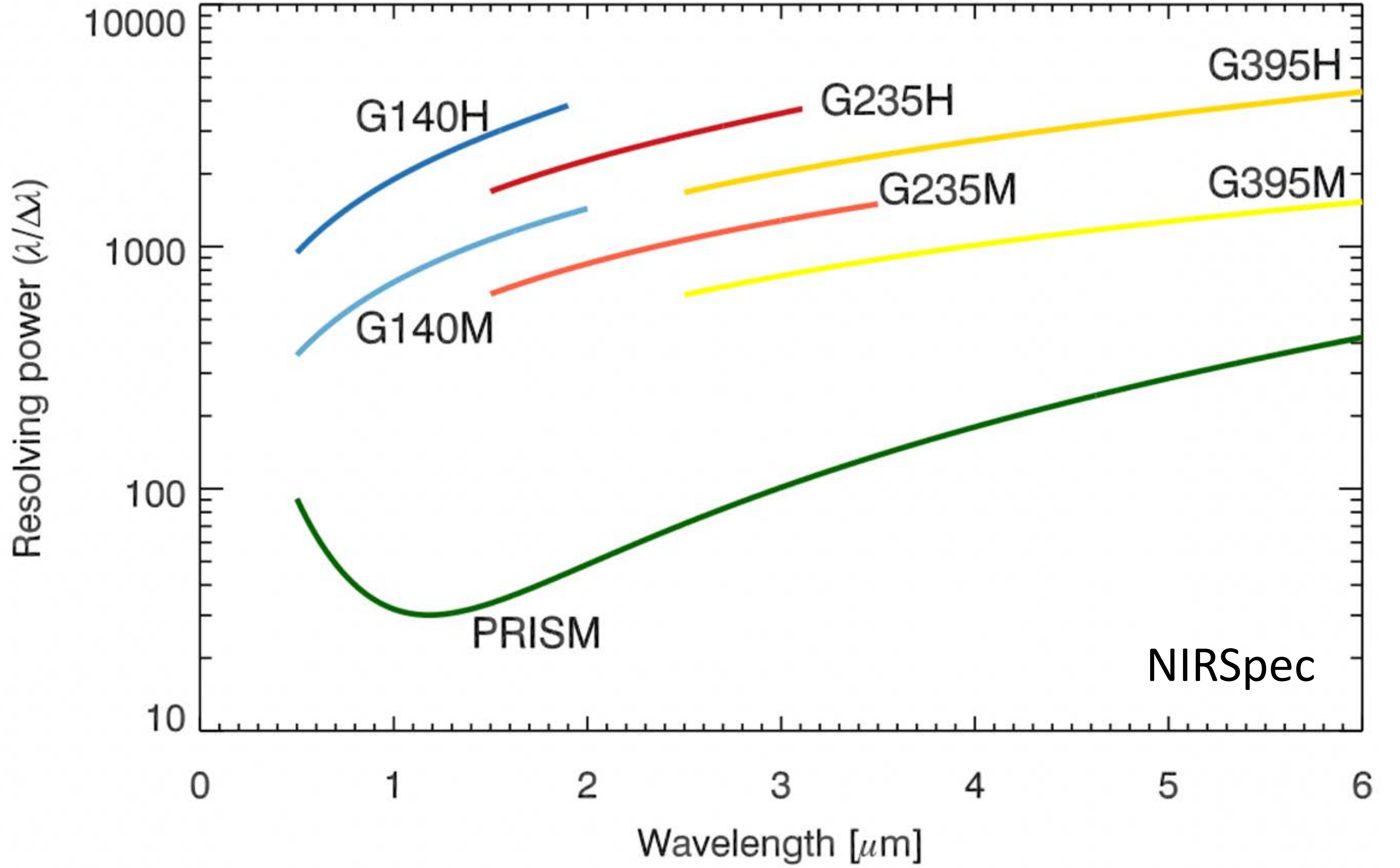
Target acquisition in wide aperture (WATA)



Direction of dispersion



Single-object slit spectroscopy | Spectral resolution



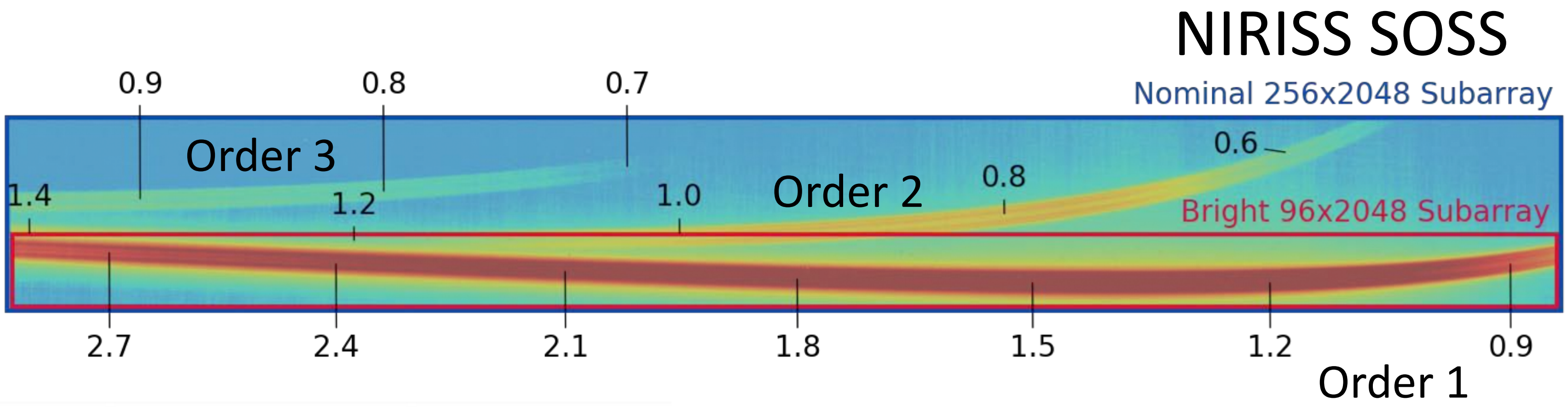
MIRI

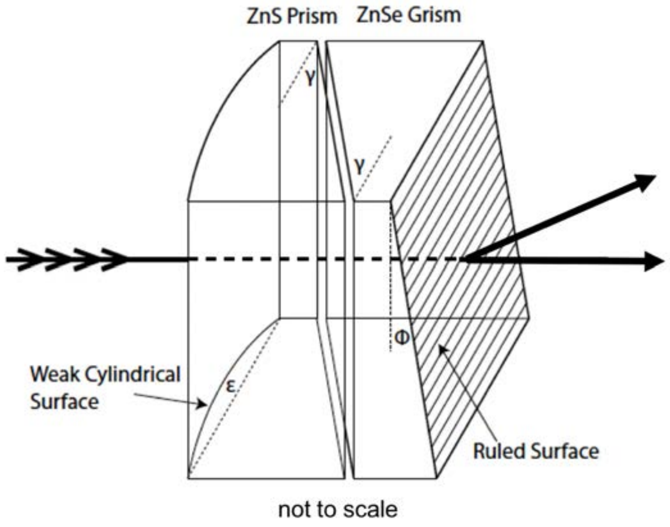
Low Resolution Spectroscopy

R = 40 @ 5 μm

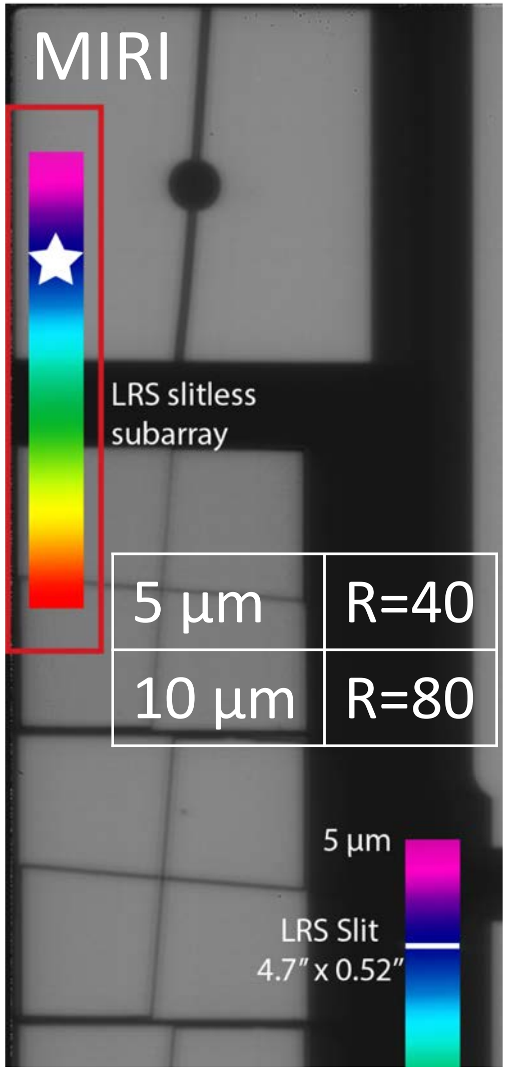
R = 80 @ 10 μm

Single-object slitless spectroscopy | Resolution



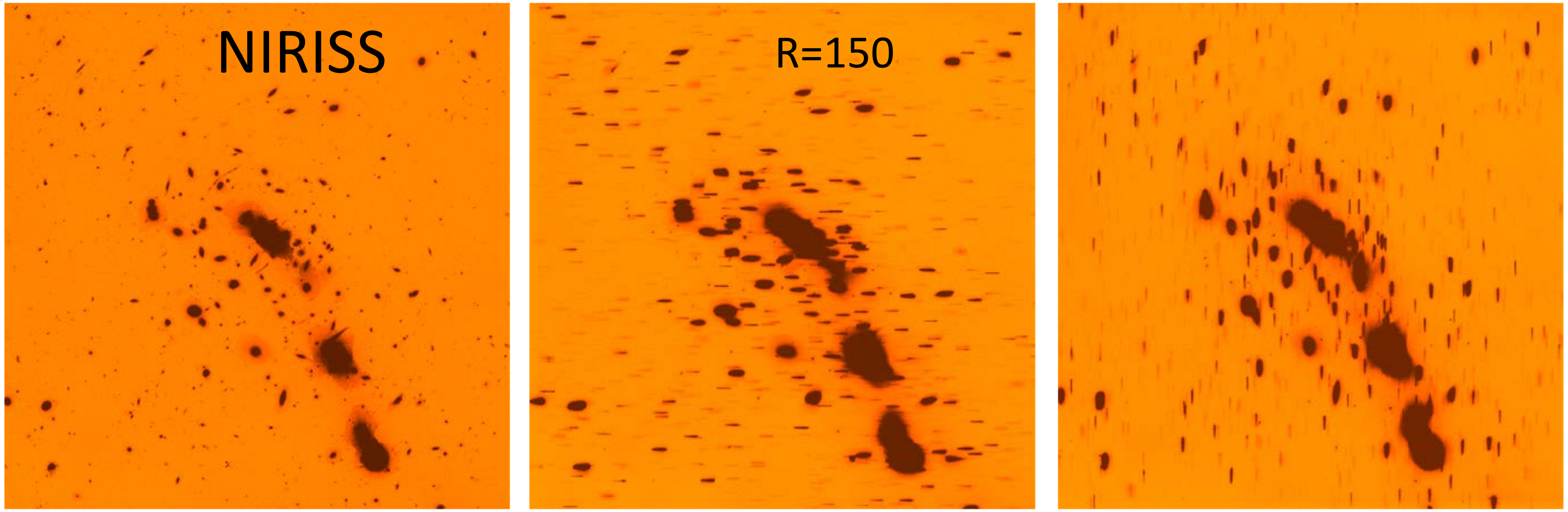


0.6 µm	R=400
1.4 µm	R=700
2.8 µm	R=1400

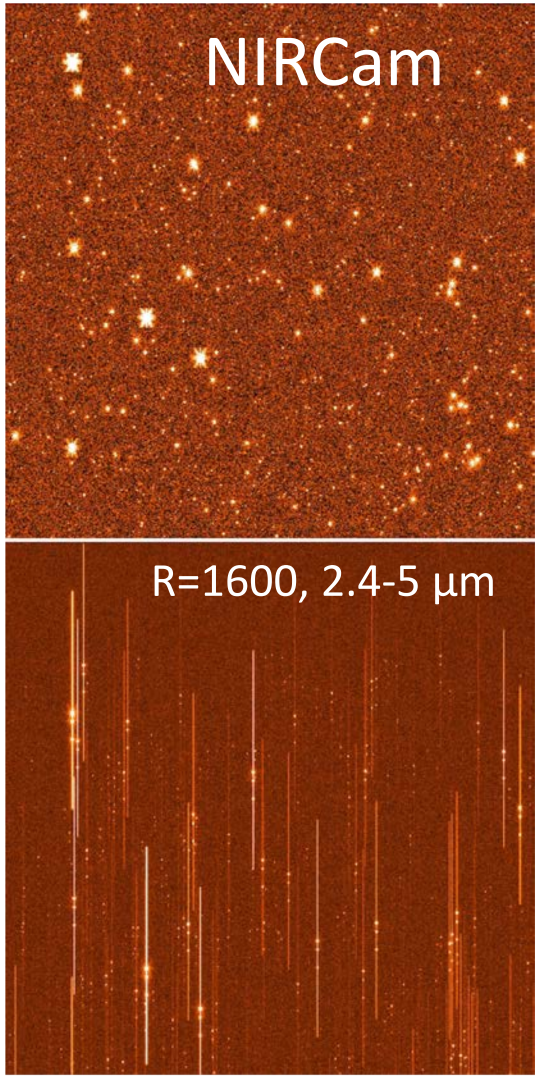


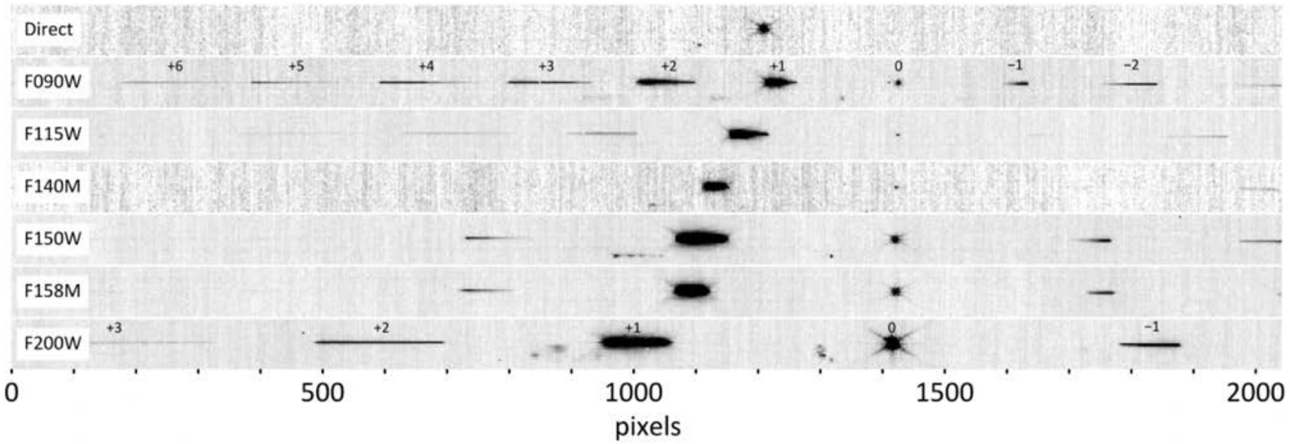
5 µm	R=40
10 µm	R=80

Wide field slitless spectroscopy | Direct image | Orthogonal dispersers



Direct image | GR150C grism | GR150R grism



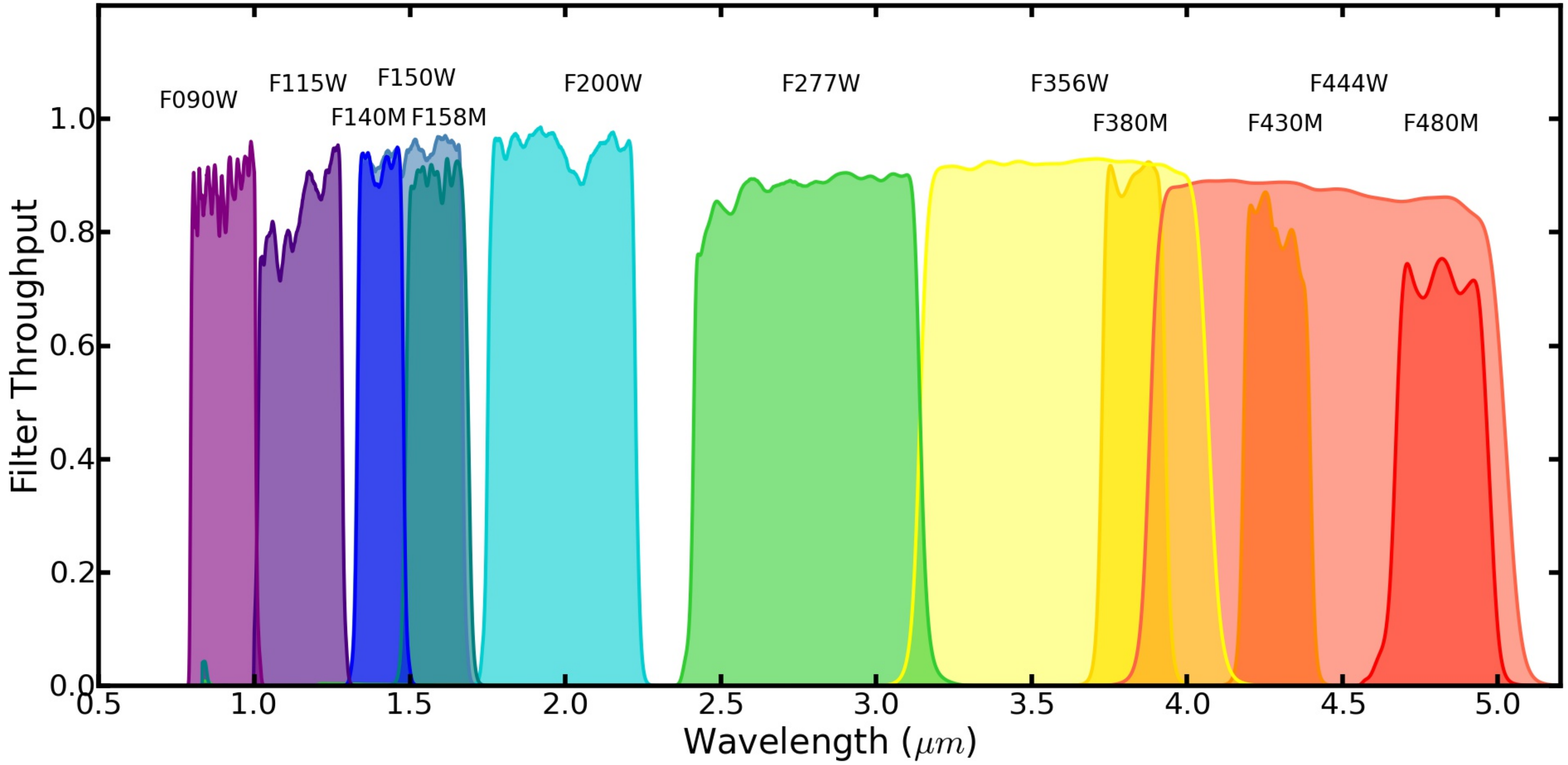


μm	Ly-α redshift
0.79 – 1.00	5.50 – 7.23
1.01 – 1.28	7.31 – 9.53
1.33 – 1.48	9.94 – 11.17
1.33 – 1.67	9.94 – 12.74
1.48 – 1.68	11.17 – 13.82
1.75 – 2.22	13.40 – 17.26

NIRISS Overview

Wide-Field Slitless (GRISM) Spectroscopy

NIRISS Filters



Direct imaging complement to NIRCam, but not all filters.
(Potentially interesting in parallel mode.)

Wide-Field Slitless Spectroscopy with NIRISS: Simulations of MACS J0416.1-2403

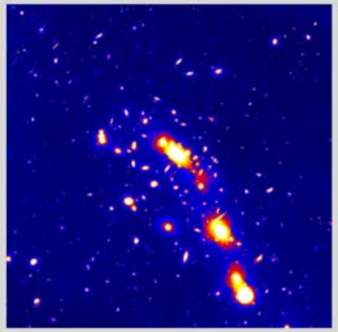
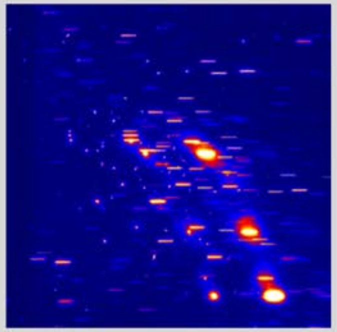
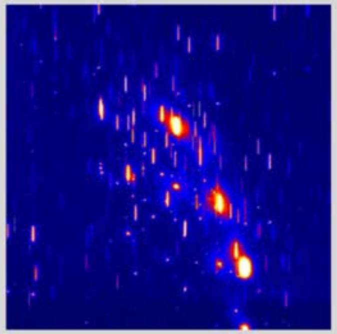


Image: F200W



Spectra: GR150C, F200W

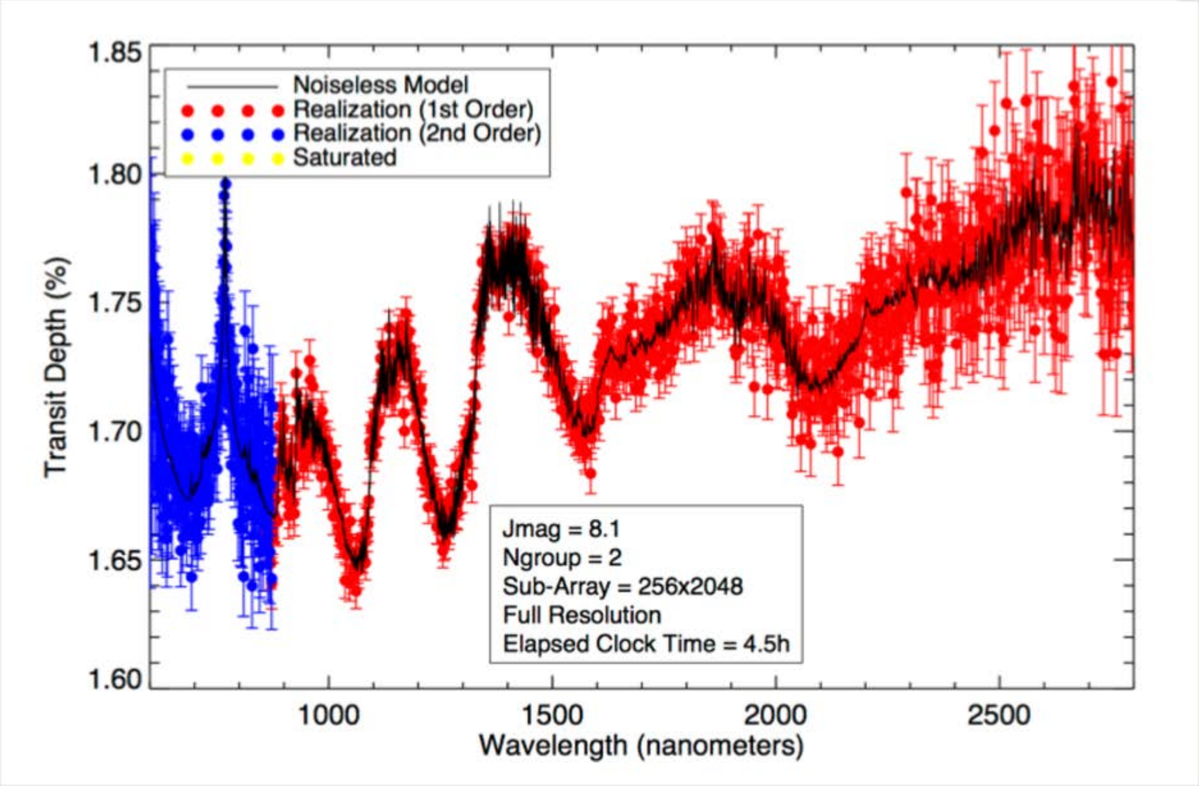


Spectra: GR150R, F200W

NIRISS Overview, con't.

Single-Object Slitless Spectroscopy with NIRISS

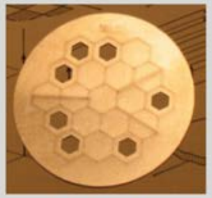
Simulated NIRISS/SOSS spectrum of the atmosphere of WASP 69b
Model courtesy of Björn Benneke



Aperture Masking Interferometry

Non-Redundant Mask (NRM)
+ Medium-Band "Red" Filters

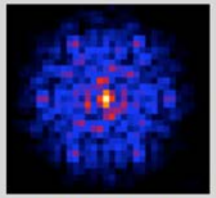
7-hole aperture mask with 21 distinct ("non-redundant") separations ("baselines")



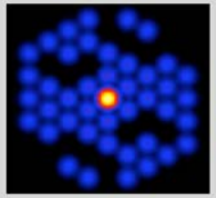
Mask

Michelson:

$\delta\theta = 0.5\ \lambda / D$



NRM PSF (Interferogram)



Fourier Transform

NIRISS AMI enables exoplanet detection at 3.8, 4.3, and 4.8 μm around stars as bright as M'~4, reaching 10^{-4} contrast at separations of 70–400 milli-arcseconds. It provides lower contrast at 2.8 μm with the F277W filter.

Image reconstruction is also enabled.