STScI | SPACE TELESCOPE SCIENCE INSTITUTE

EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

How to prepare a JWST proposal

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SAGI Observational Astronomy School

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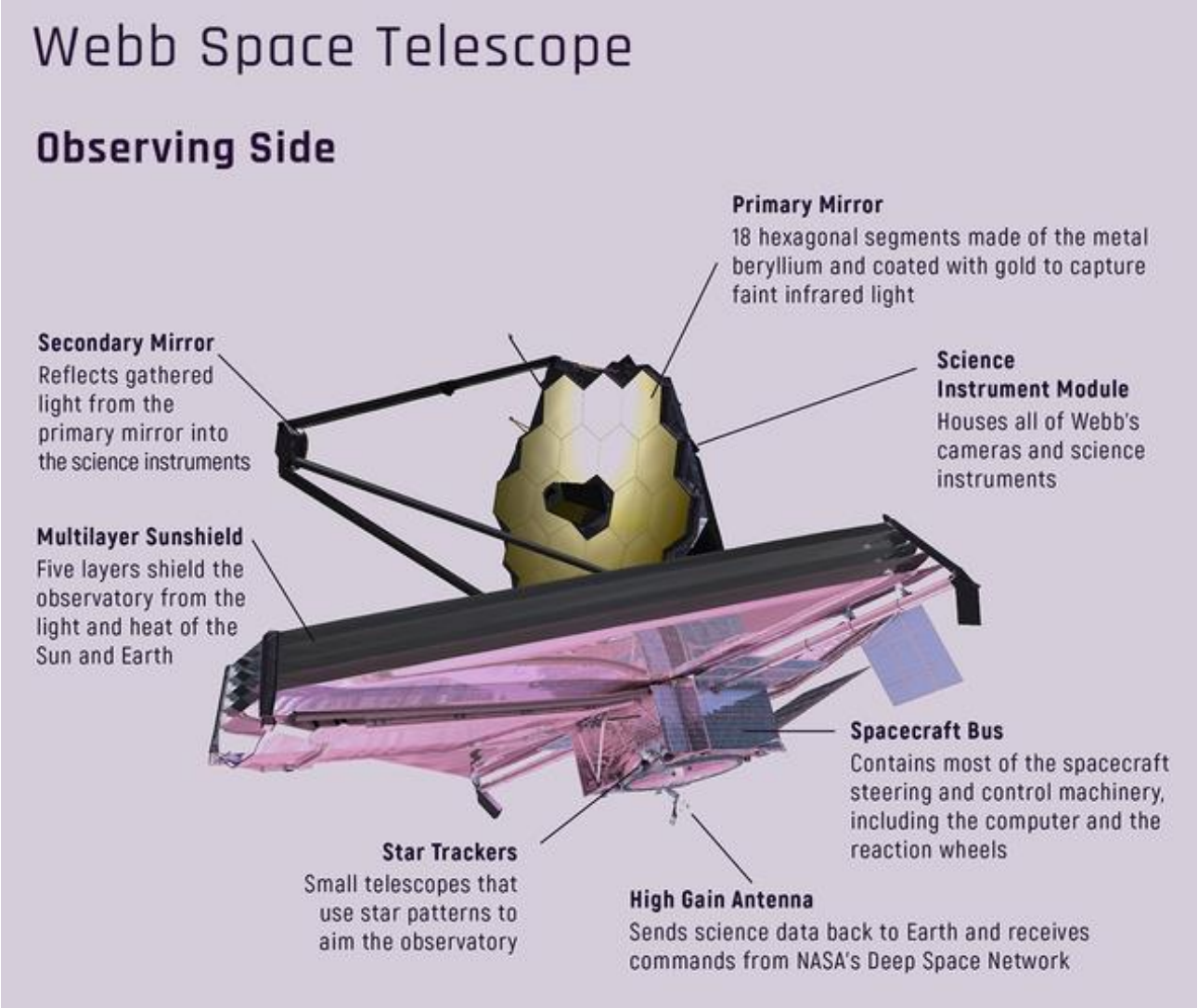
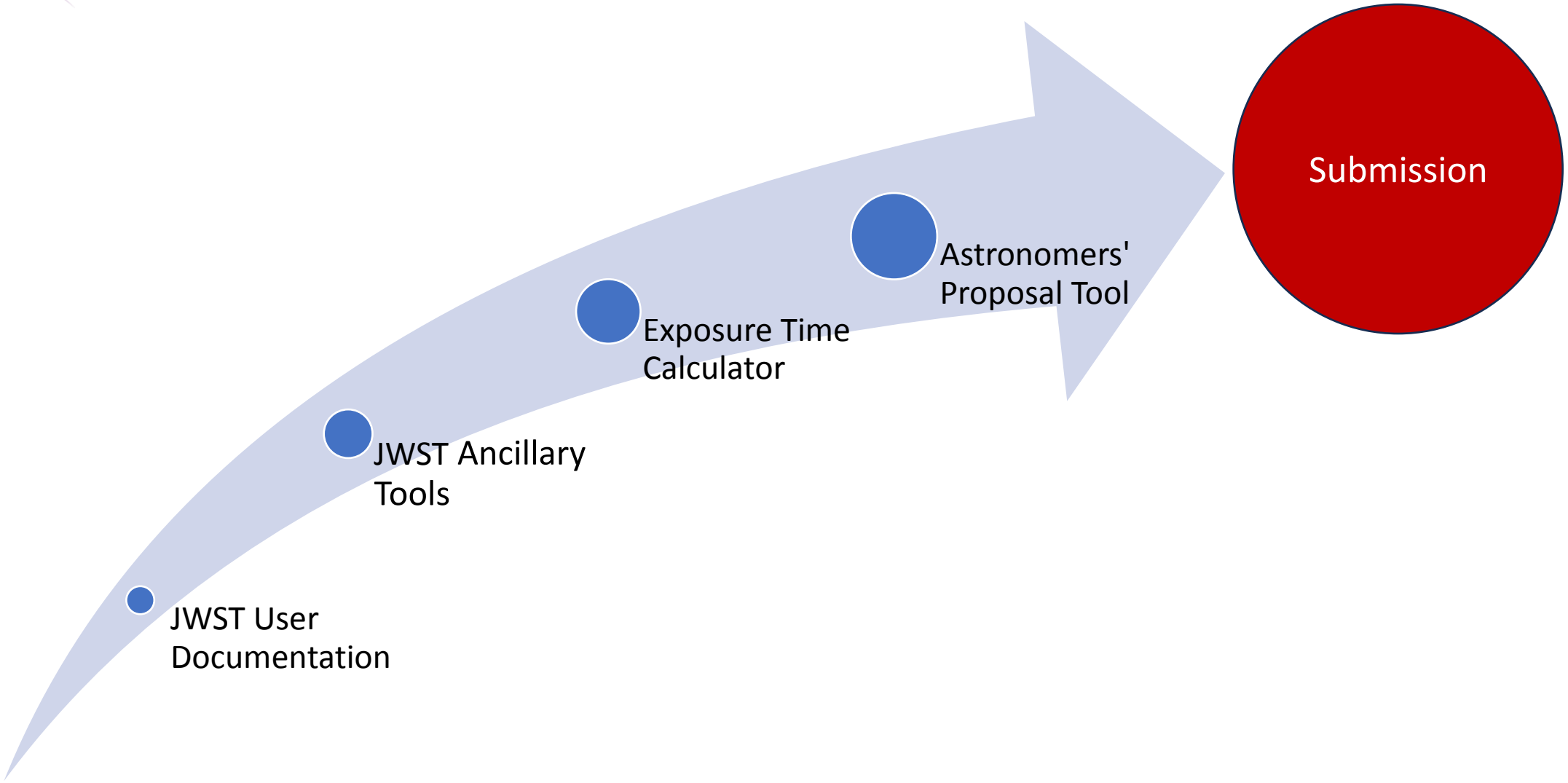
James Webb Space Telescope

- Launched on December 25, 2021
- Expected to be operational for at least 5 years, with a goal of 10 years
- Unprecedented sensitivity and resolution in mid-IR
- Science Themes:
  - The End of the Dark Ages: First Light and Reionization
  - Assembly of Galaxies
  - Birth of Stars and Protoplanetary Systems
  - Planetary Systems and the Origins of Life



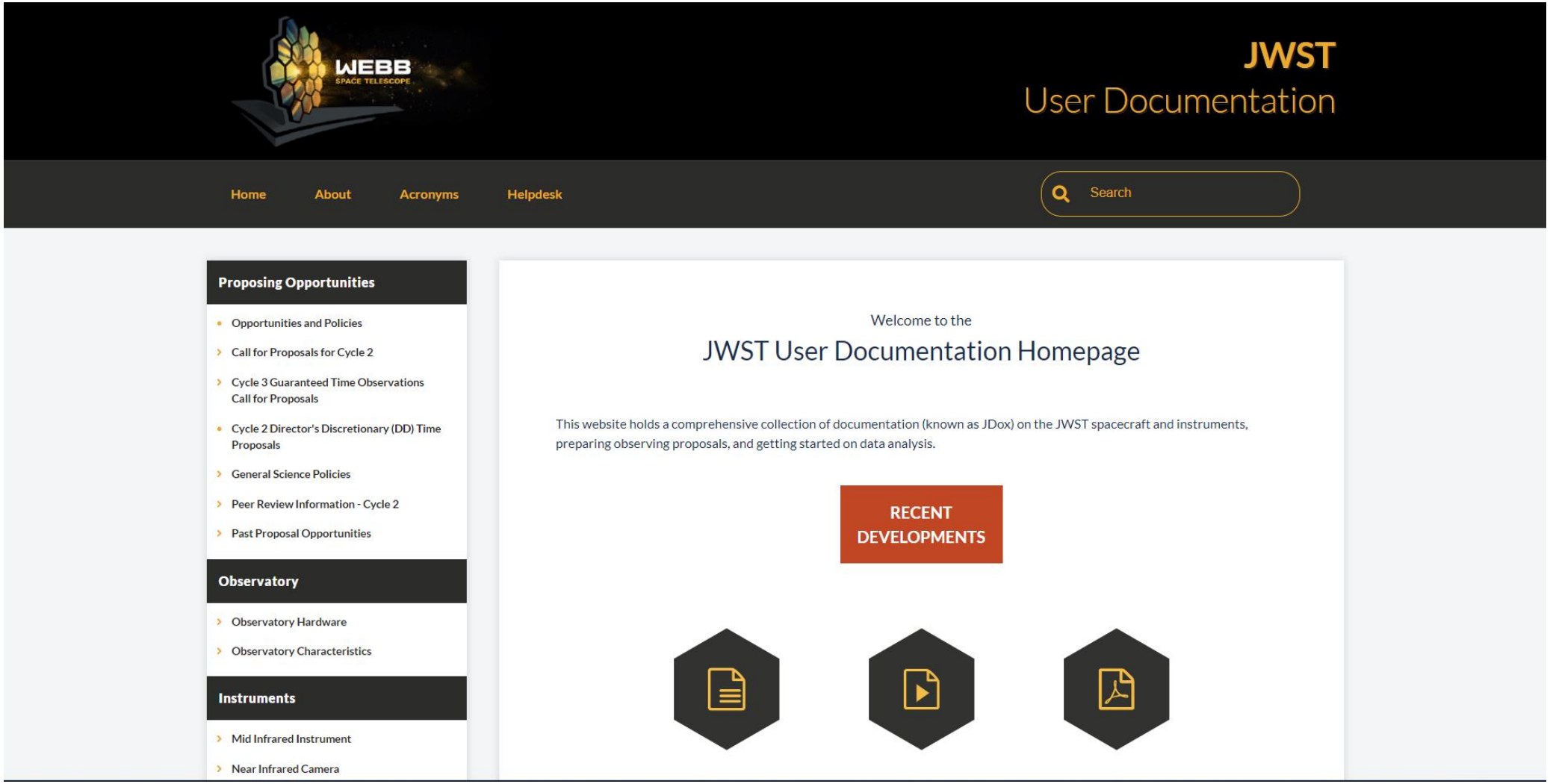
General Planning Workflow



JWST User Documentation (Jdox)

JWST User Documentation

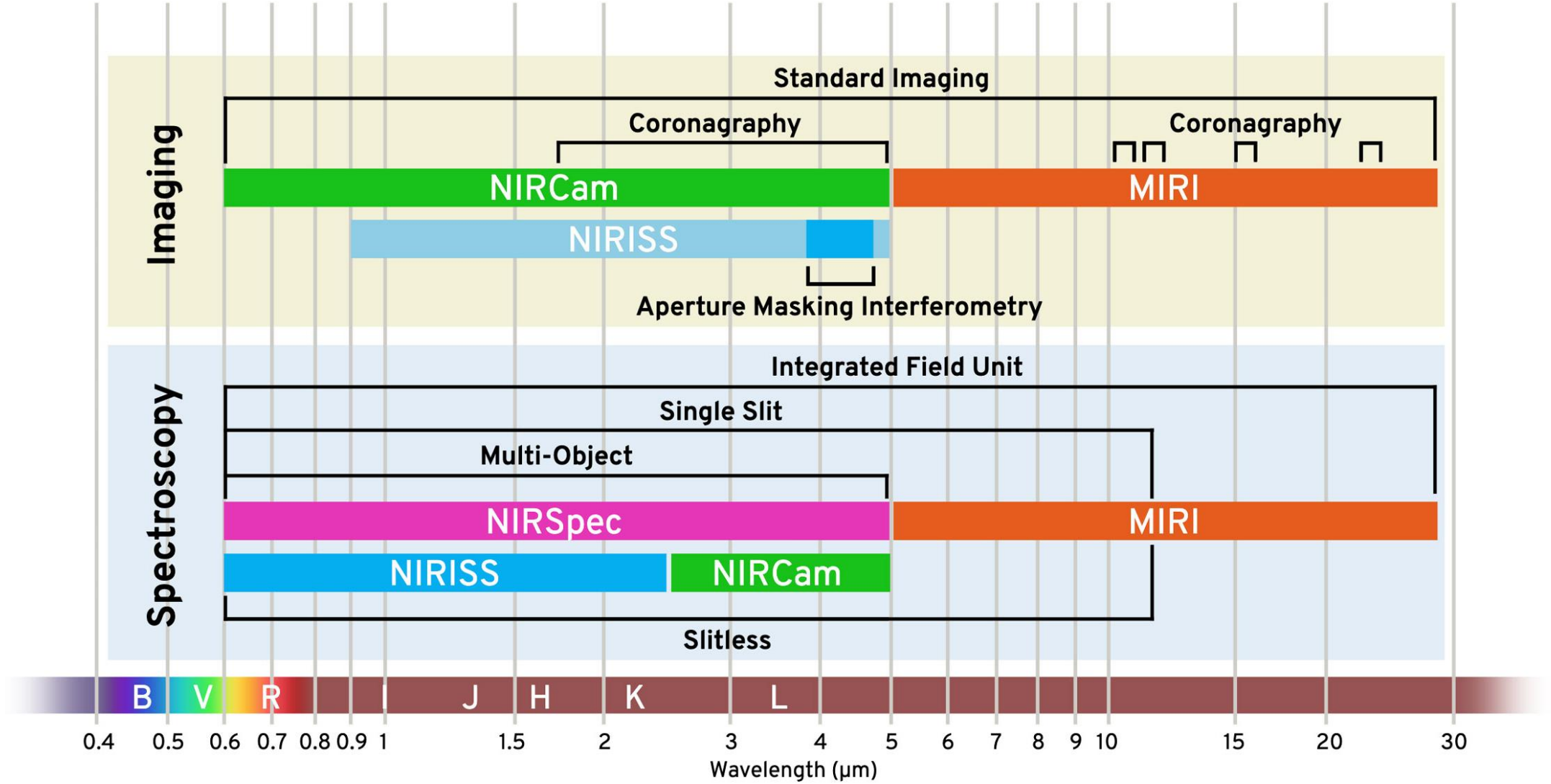
https://jwst-docs.stsci.edu/



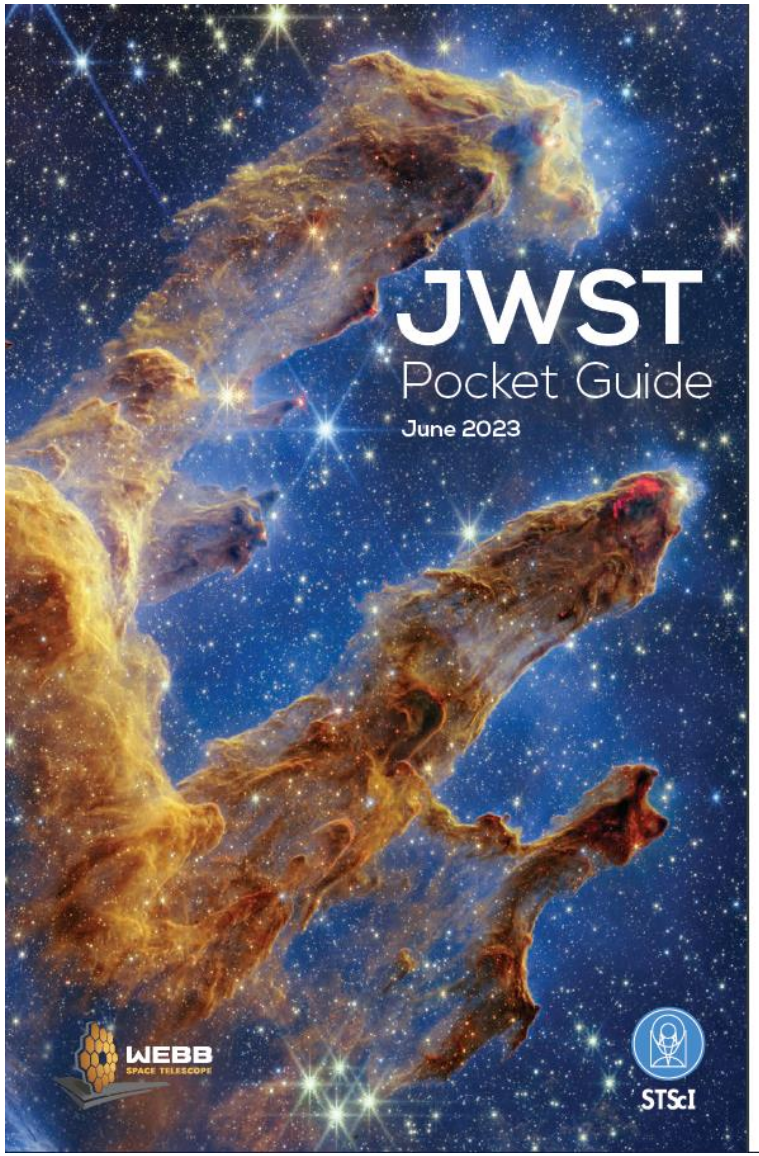
Proposing Opportunities

Date	Milestone
August 15, 2023	GO/AR Cycle 3 Call for Proposals Issued
October 27, 2023	GO/AR Cycle 3 Proposal Deadline
November 9, 2023	STScI Releases proposals to panelists for review and preliminary grading
January 17, 2024	Deadline for panelists to submit preliminary grades for proposals that they are assigned
January 29 – February 1, 2024	Telescope Allocation Committee: Discussion Panels
February 5 – 8, 2024	Telescope Allocation Committee: Executive Committee Meeting
February 15, 2024	Director's Review
February 16 – June 30, 2024	Program Implementation of accepted proposals
February 20, 2024	PI notification letters are distributed
July 1, 2024	Beginning of Cycle 3 Observations

Observing Modes with JWST



JWST Pocket Guide



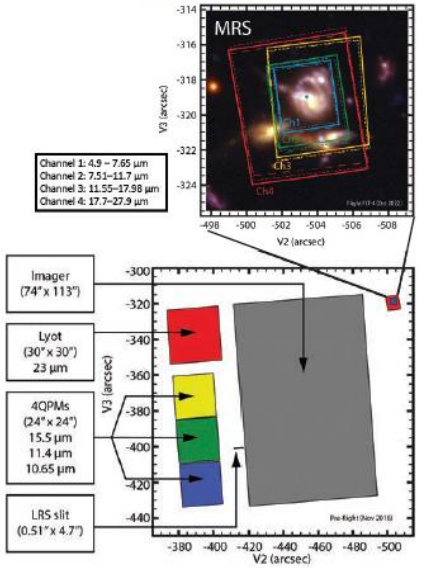
Mid-Infrared Instrument (MIRI)

Observing Modes

Observing Mode	Wavelength Coverage (μm)	FOV/Slit Size (arcsec)	Pixel Scale (arcsec/pixel)	Comment
Imaging	5.6 – 25.5	74 x 113	0.11	Subarrays Available
4QPM Coronagraphic Imaging	10.65, 11.4, 15.5	24 x 24	0.11	Inner working Angle = 1λ/D
Lyot Coronagraphic Imaging	23	30 x 30	0.11	Inner working Angle = 3.3λ/D
Low Resolution Spectroscopy (LRS)	5 – 12	0.51 x 4.7 (slit)	0.11	Single Object Slitless Mode Available R ~100
Medium Resolution Spectroscopy (MRS)	4.9 – 27.9	3.9 to 7.7 (IFU)	0.196 – 0.273	R ~2,500

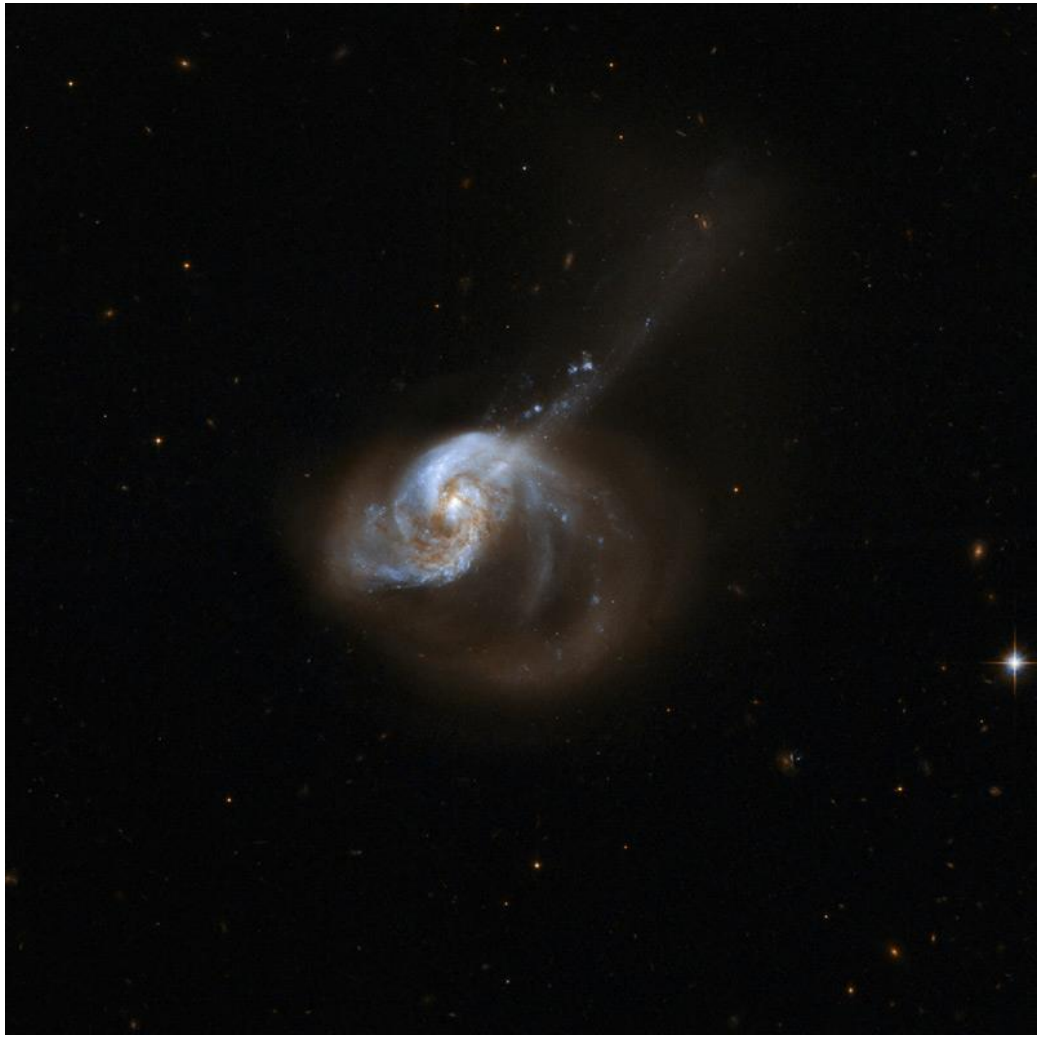
Imager contains one and MRS contains two Raytheon SiAs impurity band conduction (IBC) detectors

Field of View



Example Science Program

- NGC 1614 is a luminous infrared galaxy (LIRG) in a late stage of interaction.
- We aim to trace multiple mid-IR diagnostics (ionized gas, molecular hot/warm gas, and dust features) to characterize the stellar populations, the star formation, the interstellar medium (ISM) in this merger.



Detailed Information for NGC 1614

By Name | NASA/IPAC Extragalac

ned.ipac.caltech.edu/byname?objname=NGC+1614&hconst=67.8&omegam=0.308&omegav=0.692&wmap=4&corr_z=1

ipac

NED NASA/IPAC Extragalactic Database

Home | Search Objects » | Literature » | Services » | Tools » | Information »

Home » Search Objects » By Name

Detailed Information for a Named Object

Object Name

NGC 1614

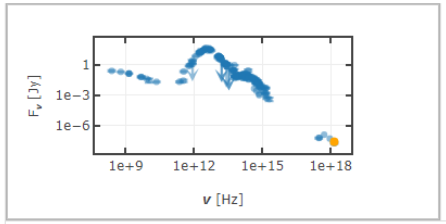
Search Options

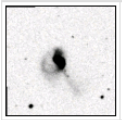
Go

Results for object NGC 1614

Overview | Cross-IDs (35) | Coordinates (67) | Redshifts (46) | Distances (0) | Classifications (17) | Galactic Extinctions | Notes (18) | Diameters (7)

Photometry & SED (269) | Spectra (20) | Images (50) | References (592) | External Links | Survey Coverage





POSS-II F (North), AAO-SES/SERC-ER (South), Red image

View in IRSA Finderchart

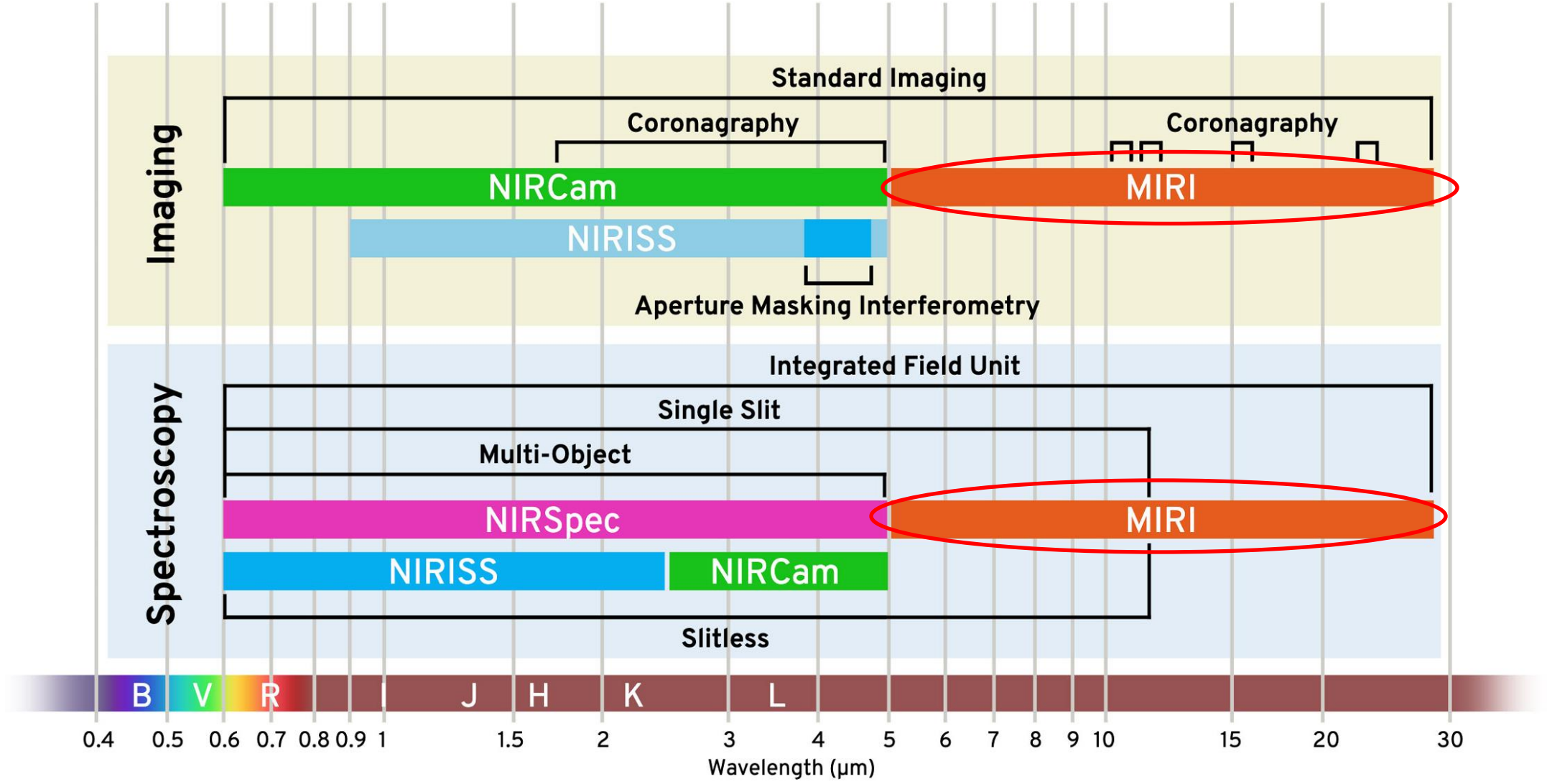
Image Credit: Caltech or AAO/ROE

Selected data and derived quantities for NGC 1614†. More information in the tabs above.

Cross-identifications	Essential note
NGC 1614; ARP 186; MRK 0617; II Zw 015; CGPG 0431.6-0841	Diameter includes companions or long extensions.

Coordinates for Preferred Position		
Equatorial (J2000)		Galactic

Pick an instrument



Pick observing modes for MIRI

Observing mode	Wavelength coverage (μm)	Field of view or slit size (arcsec)	Pixel scale ("/pixel)	Resolving power $R = \lambda/\Delta\lambda$	FWHM	Notes
Imaging	5.6 to 25.5 μm	74 × 113	0.11	3.5 – 16.1	2 pix @ 6.25 μm	Subarrays available FWHM = 2 pix × (λ/6.25 μm) for λ > 6.25 μm
4QPM coronagraphic Imaging	10.65, 11.4, 15.5	24 × 24	0.11	14.1 – 17.2	2 pix @ 6.25 μm	
Lyot coronagraphic Imaging	23	30 × 30	0.11	4.1	2 pix @ 6.25 μm	
Low-resolution spectroscopy	5 to 14 μm	0.51 × 4.7 (slit size)	0.11	~100 @ 7.5 μm	2.6 pix @ 7.7 μm	Slit or slitless modes
Medium-resolution spectroscopy	4.9 to 27.9 μm	3.7 to 7.7	0.196–0.273	~1550–3250	2 pix @ 6.2 μm	FWHM = 0.314" × (λ/10 μm) for λ > 8 μm

Checking for Duplications

Checking for Duplicating Observations

- Generally, an observation is considered a potential duplication if:
  - Same astronomical target or field,
  - Same instrument in the same mode,
  - Same spectral resolution and spectral range
  - On-target exposure time within a factor of 4 of the previously-scheduled observation.
- Duplicate observations should be avoided unless scientifically justified.
  - E.g. time variable phenomena may be justified.
- Duplications versus previously observed or accepted observations need to be assessed.
- Most users will want to check for duplications before going to the work of assessing ETC feasibility and APT schedulability!

Duplication Checking Basics

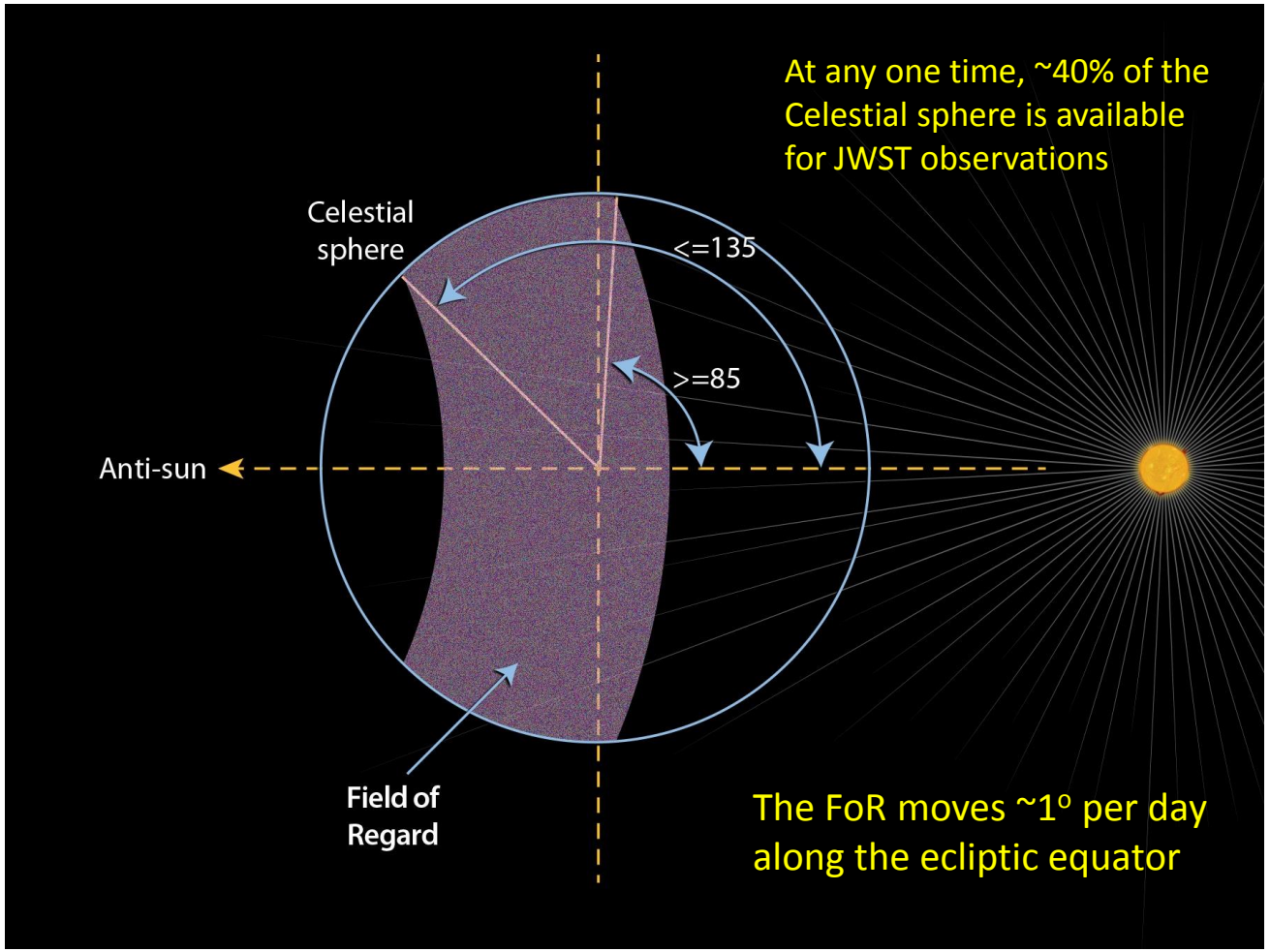
- Information about accepted targets and observations will be available within the MAST Discovery Portal: *https://mast.stsci.edu/portal/Mashup/Clients/Mast/Portal.html*
- As a first step, in MAST enter a target name and/or coordinate and a search radius.
  - If your target is not planned for observation, there can be no duplication and you are done!

Target Visibility Overview

Target Visibility Tools: Why are they needed?

- JWST can observe the entire sky; just not all at the same time!
- If your proposed targets have no timing or position angle constraints, you probably don't have to concern yourself with the target visibility tools.
- However, if timing or position angle is important for your observations, the TVTs can save a lot of headaches by showing you what is possible up front in the planning process.

The JWST Field of Regard



JWST General Target Visibility Tool (GTVT)

- Simple command line tool producing text and plot output
- Shows visibility and position angle as a function of time for all science instruments
- Output can be saved to files
- Installation:

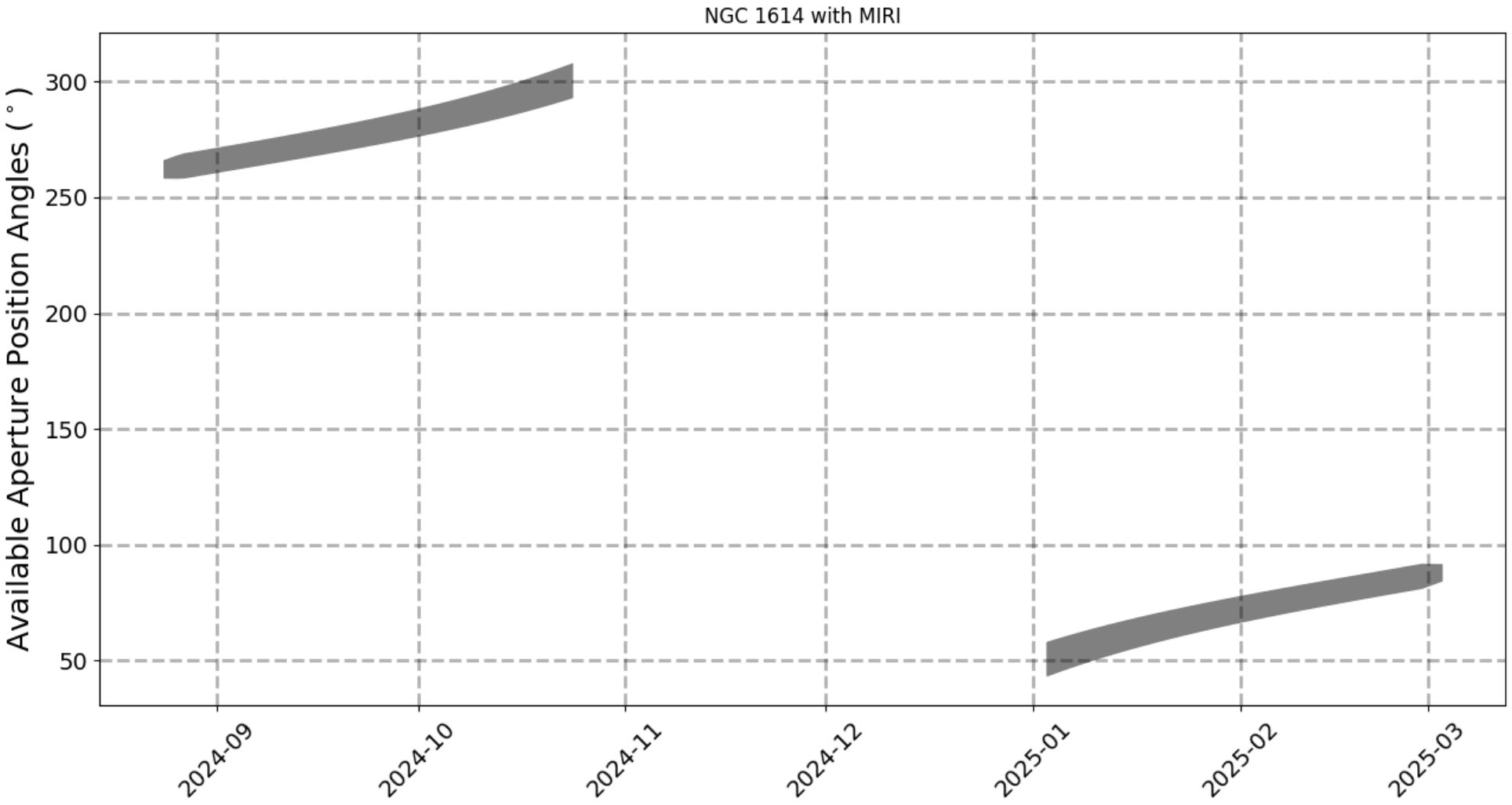
```
pip install jwst_gtvt
```

- Usage:

```
jwst_gtvt -h
```

GTVT command line examples -- plots

```
jwst_gtvt 68.499394 “ -8.578883” –start_date 2024-07-01 –end_date 2025-06-30
–target_name “NGC 1614” –instrument miri
```



Quick Look at Observation Feasibility

JWST Interactive Sensitivity Tool (JIST)

- JIST is a quick-look tool that allows exploration of observation feasibility for all JWST basic observing modes.

  https://jist.stsci.edu/jist

- JIST allows you to explore signal-to-noise values in real time by adjusting source flux density or telescope exposure time.

Usage Notes

- JIST Handles saturation by setting SNR to zero for saturated points. This is a simplified assumption. JIST is not recommended for working with saturated data.
- For NIRCam and NIRISS Wide-Field Slitless Spectroscopy (WFSS) modes, R-grism and C-grism values should have identical SNR. As such, JIST presents only the R Grism values.
- All calculations are based on a single point source with:
  - Flat SED
  - Background spectrum set to 120% of the minimum zodiacal background, with:
    - Assumed date June 19, 2019
    - RA,DEC = 17h26m44s,-73°19m56s
- JIST uses a single integration in almost all[1] modes. For multiple integrations or dithers, the SNR may be scaled by SQRT(number of dithered exposures).

From Extended Source to Point Source

Overview | Cross-IDs (35) | Coordinates (67) | Redshifts (46) | Distances (0) | Classifications (17) | Galactic Extinctions | Notes (18) | Diameters (7)

Photometry & SED (269) | Spectra (20) | Images (50) | References (592) | External Links | Survey Coverage

Measured Diameters for NGC 1614

View References in ADS (3)

1 of 1 (1 - 7 of 7)

No.	Frequency targeted	Refcode	Major Axis	Major Axis Flag	Major Axis Unit
int	char	char	double	char	char
1	K_s (2MASS isophotal)	20032MASX.C.....:	27.00	(a)	arcsec
2	K_s (2MASS "total")	20032MASX.C.....:	42.20	(a)	arcsec
3	POSS1 103a-O	1963MCG3..C...0000V	0.70		arcmin
4	POSS1 103a-O	1963MCG3..C...0000V	1.00		arcmin
5	RC3 D_25, R_25 (blue)	1991RC3.9.C...0000d	1.12		log(2a) + 1
6	RC3 A_e (Johnson B)	1991RC3.9.C...0000d	0.56		log(2a) + 1
7	RC3 D_0 (blue)	1991RC3.9.C...0000d	1.14		log(2a) + 1

Table 1. FWHM values for each PSF, from Figure 3

Filter	Wavelength (μm)	PSF FWHM (arcsec)	PSF FWHM (pixel)
F560W	5.589	0.207	1.882
F770W	7.528	0.269	2.445
F1000W	9.883	0.328	2.982
F1130W	11.298	0.375	3.409
F1280W	12.712	0.420	3.818
F1500W	14.932	0.488	4.436
F1800W	17.875	0.591	5.373
F2100W	20.563	0.674	6.127
F2550W	25.147	0.803	7.300

From Extended Source to Point Source

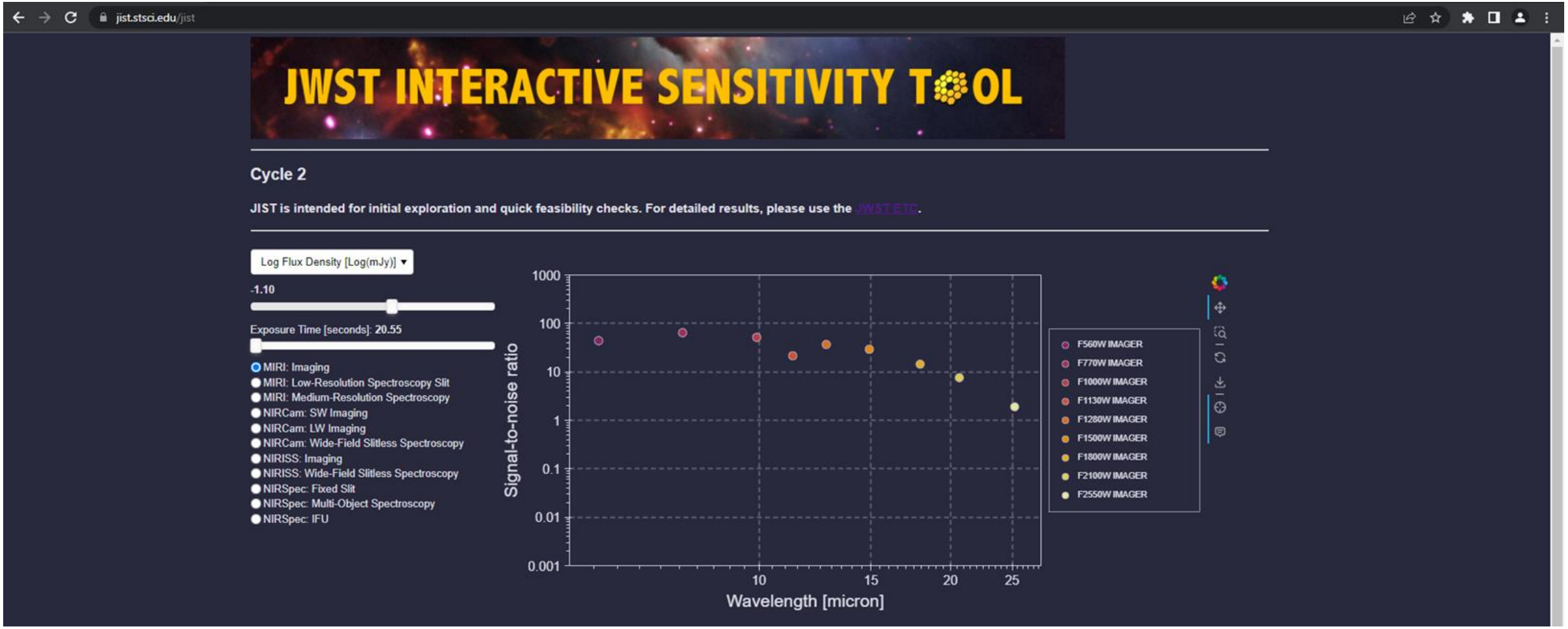
Photometry for NGC 1614

View References in ADS (46) 1 of 1 (1 - 168 of 168)

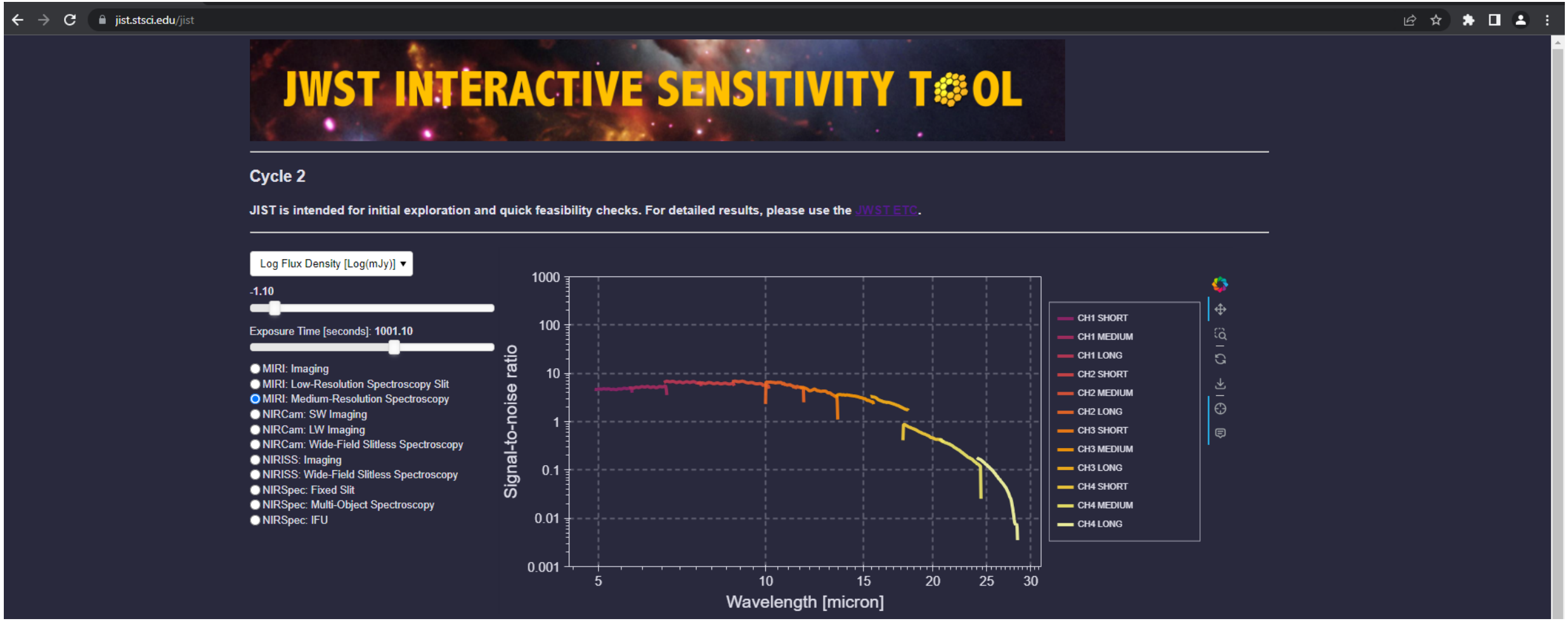
No. (int)	Observed Passband (char)	Photometry Measurement (double)	Uncertainty (char)	Units (char)	Frequency (Hz) (double)	Flux Density (Jy) (double)	Upper limit... (double)	Lower limit... (double)	Upper limit... (double)	Lower limit... (double)	NED Uncertainty (char)	NED Units (char)	
												= 'Jy'	
118	M (UKIRT)	47.5	+/-10.1	milliJy	6.25e+13	0.0475	0.0101	0.0101			+/-1.01E-02	Jy	1985A
119	5.0 microns	0.92	+/-0.05	Jy	6e+13	0.92	0.05	0.05			+/-5.00E-02	Jy	1972A
120	5.0 microns	1.02	+/-0.11	Jy	6e+13	0.27	0.11	0.11			+/-1.10E-01	Jy	1972A
123	5.8 microns IRAC AB	10.25	+/-0.10	mag	5.25e+13	0.289	0.0266	0.0266			+/-2.66E-02	Jy	2014A
124	5.8 microns IRAC AB	10.23	+/-0.10	mag	5.25e+13	0.293	0.027	0.027			+/-2.70E-02	Jy	2014A
125	5.8 microns (IRAC)	0.293	+/-8.81E-3	Jy	5.23e+13	0.293	0.00881	0.00881			+/-8.81E-03	Jy	2008A
126	6 microns (IRS)	0.14		Jy	5e+13	0.14						Jy	2006
135	8.0 microns (IRAC)	0.887	+/-2.66E-2	Jy	3.81e+13	0.887	0.0266	0.0266			+/-2.66E-02	Jy	2008A
139	Si2 (GeminiS)		<397.7	milliJy	3.43e+13				0.398		<3.98E-01	Jy	2014M
140	Si2 (GeminiS)		<420.3	milliJy	3.43e+13				0.42		<4.20E-01	Jy	2014M
143	10.5 microns	1.02	+/-0.03	Jy	2.86e+13	1.02	0.03	0.03			+/-3.00E-02	Jy	1972A
144	10.6 microns	0.63		Jy	2.83e+13	0.63						Jy	1979A

$$\log(mJy) = \log\left(887 \times \left(\frac{0.269}{27}\right)^2\right) \approx -1.1$$

Preliminary Calculations



Preliminary Calculations



Impact of Infrared Background and Variability

JWST Backgrounds Tool (JBT)

- Simple command line tool producing text and plot output
- Shows the total background intensity and its components as a function of time
- Output can be saved to files
- Installation:

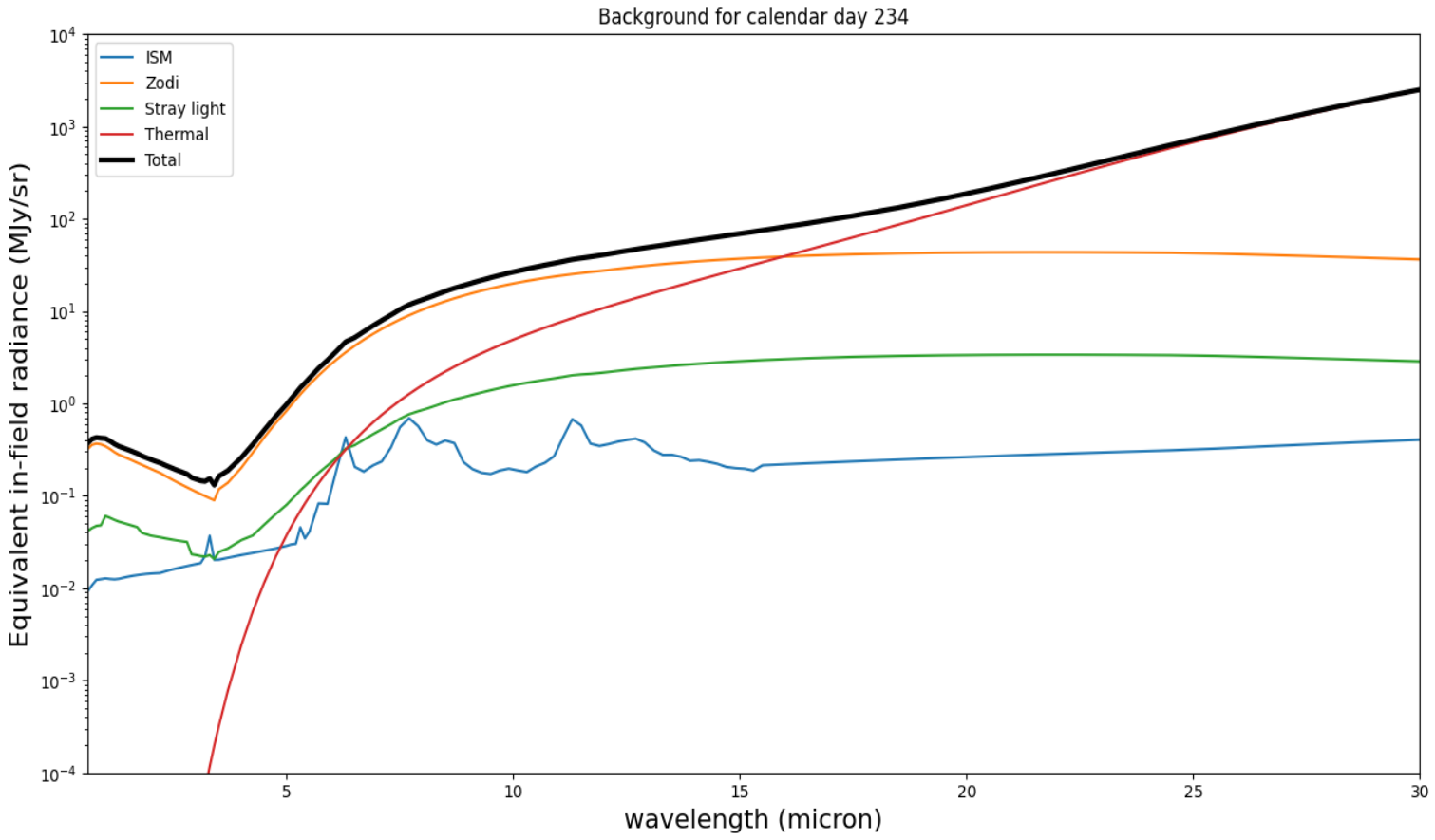
```
conda config --add channels conda-forge

conda install healpy

pip install jwst_backgrounds
```

- Usage:

```
jwst_backgrounds --help
```

Variable background can impact visibility periods

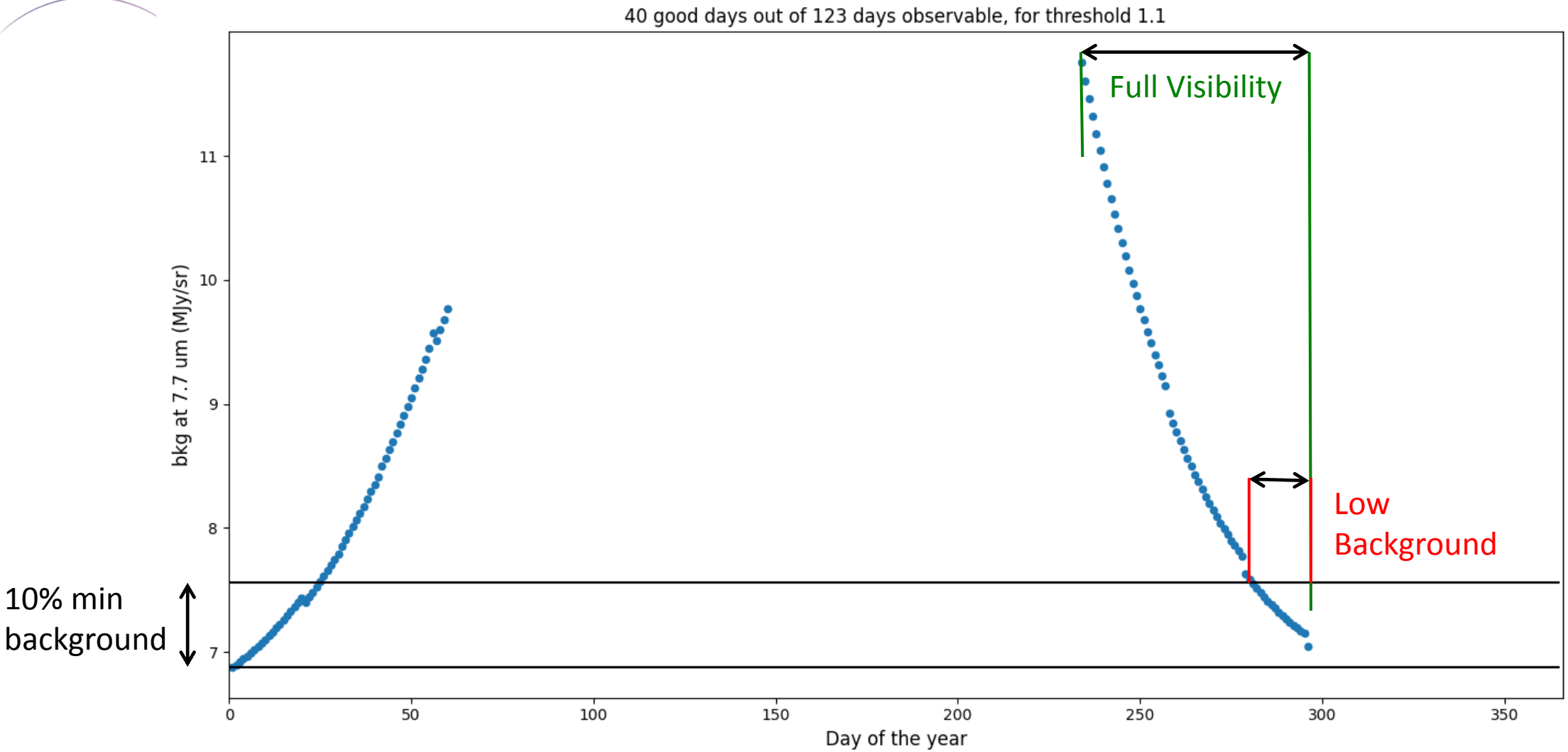
```
jwst_backgrounds 68.499394 -8.578883 7.7
```



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 reduce observing windows.

The JWST Backgrounds Tool (for background limited observations)



APT has a special requirement that can limit scheduling to low background periods.

JWST Exposure Time Calculator (ETC)

First things first – where can I find the ETC?

https://jwst.etc.stsci.edu/

jwst.etc.stsci.edu

Exposure Time Calculator

Help

Welcome to the JWST Exposure Time Calculator

Quick Start | Create User | Login | Work Anonymously

News

Welcome to version 2.0 of the JWST ETC!

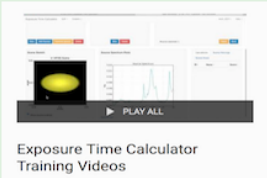
This release features accuracy updates based on inflight measurements, simultaneous NIRCam coronagraphic imaging, and workbook folders: see the Release Notes for details, and be sure to review the Known Issues for this release.

When you log in, workbooks from ETC 1.7 and earlier will be marked with a previous version number in the "Ver" column:

- When you load them, they will open in Read-Only mode: this ensures that your previous results are not overwritten and remain available to you for reference.
- If you copy an out-of-date workbook, and load the copy, all its calculations will be automatically updated for you with the current version of the software.
- For more information, see ETC Releases and Out-of-Date Workbooks .

Be sure to review the Known Issues with this release.

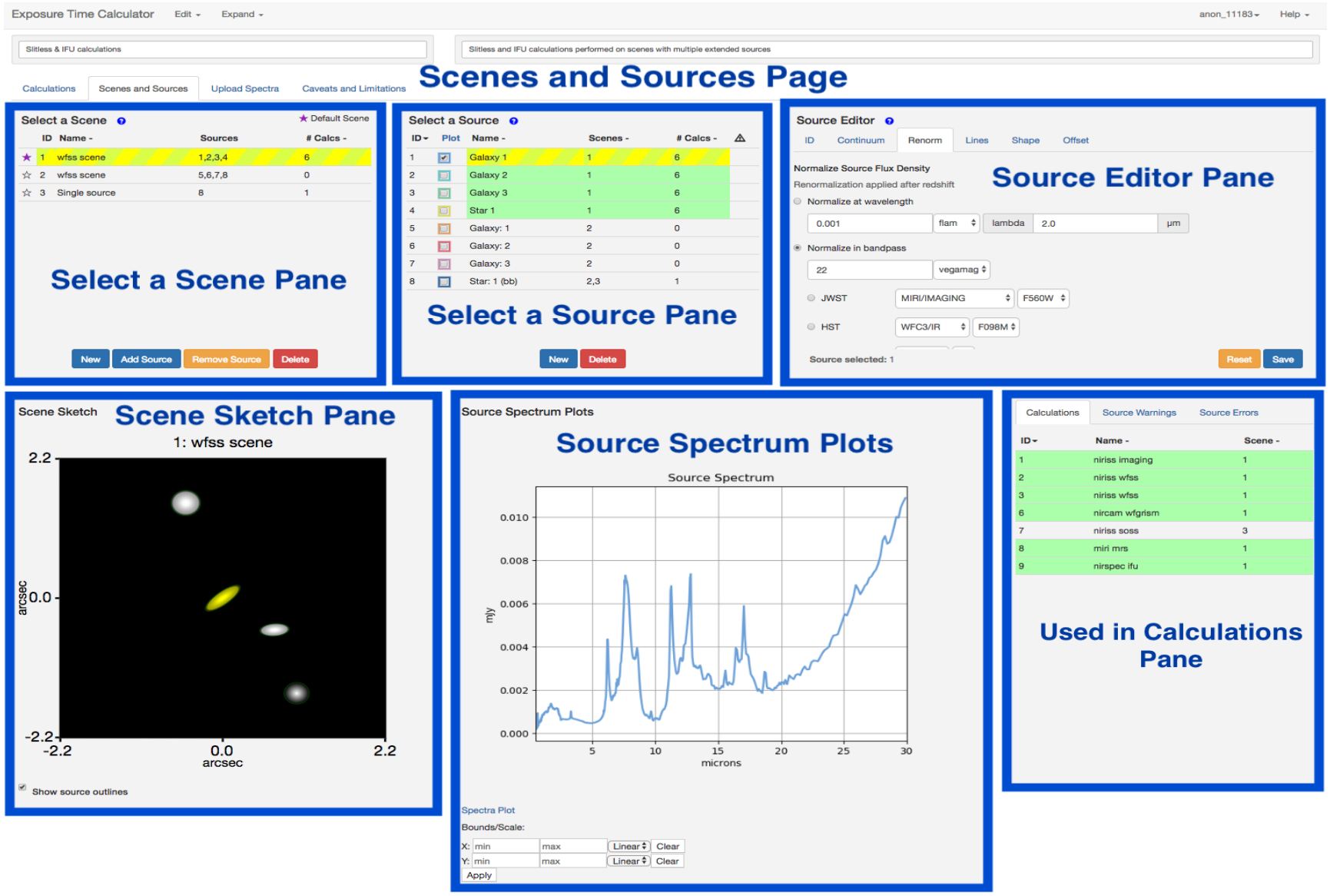
Help



Watch the Videos

Read the Docs

Defining Scenes and Sources



Source Identity Information

Exposure Time Calculator Copy/Delete Expand anon_116865 Help

Workbook ID: 159241

Observing NGC 1614 with MIRI

NGC 1614

Calculations | Scenes and Sources | Upload Spectra | Caveats and Limitations

Select a Scene

★ Default Scene

	ID -	Name -	Sources	# Calcs -
★	1	Scene 1	1	0

New Add Source Remove Source Delete

Select a Source

ID	Plot	Name -	Scenes -	# Calc	!
1	☑	default source from defau	1	0	

New Delete

Source Editor

ID | Continuum | Renorm | Lines | Shape | Offset

Scene Identity Information

NGC 1614

No comment

Source Identity Information

NGC 1614

Source selected: 1

Reset Save

Source Shape

Sersic (Effective Radius)

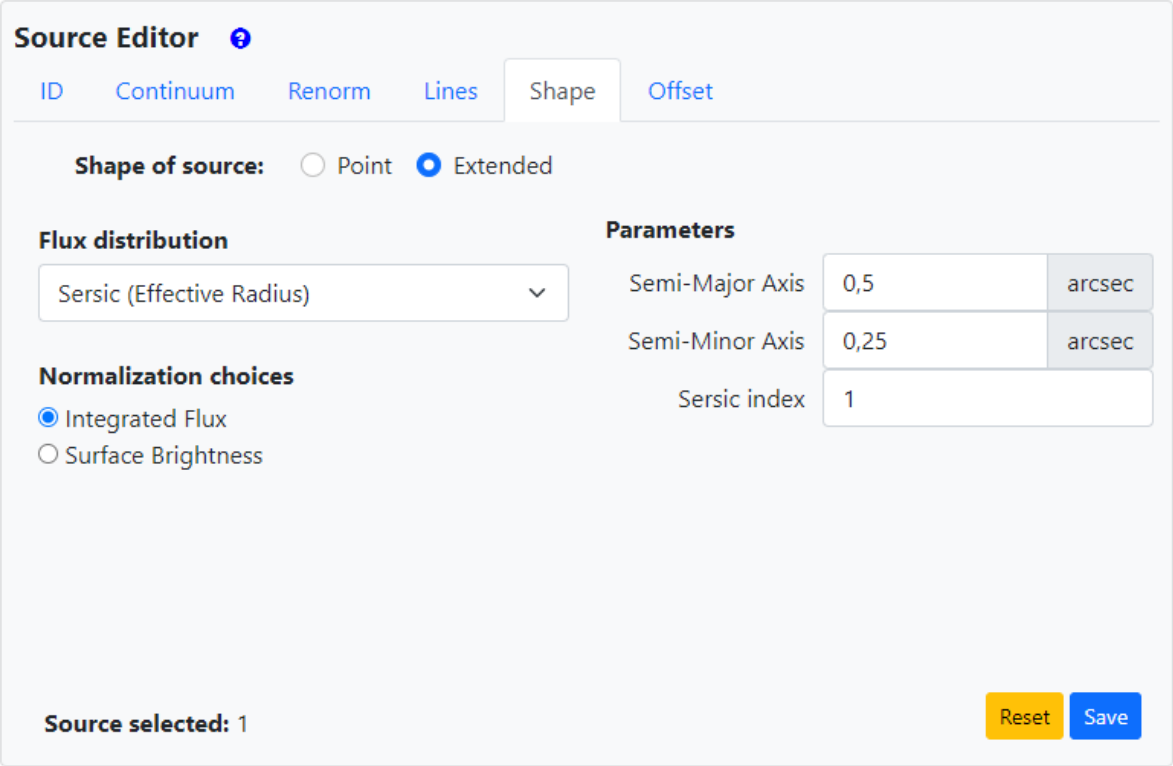
The ***Sersic (Effective Radius)*** profile is defined such that half the flux lies within the specified radius (Graham, A. & Driver, S.P. 2005 equation 1). The intensity profile is described by the equation:

$$I(r) = I_0 e^{-b\left[\left(\frac{r}{r_{eff}}\right)^{1/n} - 1\right]},$$

where r_{eff} is the effective radius, *n* is the ***Sersic index***, and *b* is the shape parameter calculated such that half the flux will lie within the effective radius:

$$d = \sqrt{\left(\frac{x}{semi-major}\right)^2 + \left(\frac{y}{semi-minor}\right)^2},$$

$$profile = e^{-b(d^{1/n}-1)}.$$



Literature Review

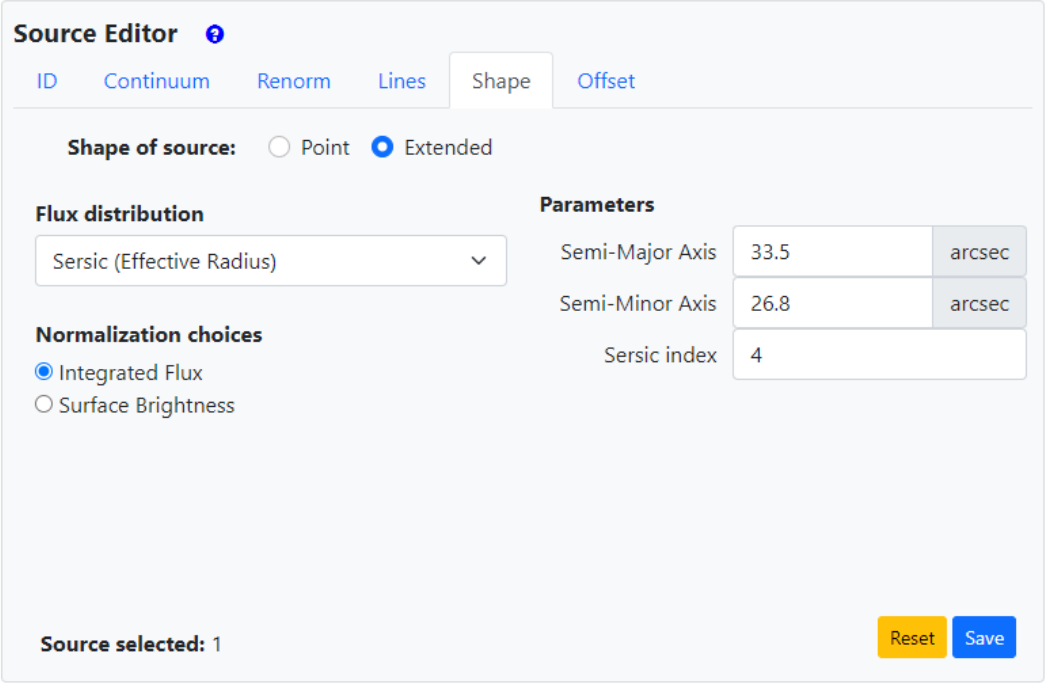
Column 1: object name.
Column 2: best fit model components in each nucleus (1: Sérsic index $n = 1$ (disk), 4: Sérsic index of $n = 4$ (bulge), B: bar component).
Column 3: apparent I-band magnitude for each component.
Column 4: half-light radius in kpc for each component.
Column 5: mean surface brightness within half-light radius in I mag arcsec^{-1}.
Column 6: axis ratio.

Name (1)	n (2)	m_n (3)	$r_{1/2}$ (4)	$\mu_{1/2}$ (5)	b/a (6)
NGC 1614	4	11.83	5.5	20.00	0.80

Name (1)	IC (2)	NS (kpc) (3)	f_{25}/f_{60} (4)	D_L (mpc) (5)
NGC 1614	5	0.0	0.23	67.8

$$\text{Semi} - \text{Major Axis (arcsec)} = \frac{5.5 \times 10^3}{67.8 \times 10^6} \times \frac{180 \times 60 \times 60}{\pi} \approx 33.5$$

Kim et al. 2023: [10.1088/0004-637X/768/2/102](10.1088/0004-637X/768/2/102)



Source Continuum

Results for object NGC 1614

Overview | Cross-IDs (35) | Coordinates (67) | Redshifts (46) | Distances (0) | Classifications (17) | Galactic Extinctions
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Galaxy Extinctions for NGC 1614

View References in ADS (2) — 1 of 1 — (1 - 102 of 102)

Bandpass (char)	Central Wavelength (um) (double)	The Galactic extinction (Mag) (double)	Refcode of the publications (char)
Landolt U	0.35	0.667	2011ApJ...737..103S
Landolt B	0.43	0.558	2011ApJ...737..103S
Landolt V	0.54	0.422	2011ApJ...737..103S
Landolt R	0.64	0.334	2011ApJ...737..103S
Landolt I	0.80	0.232	2011ApJ...737..103S
CTIO U	0.37	0.632	2011ApJ...737..103S
CTIO B	0.43	0.561	2011ApJ...737..103S
CTIO V	0.55	0.413	2011ApJ...737..103S
CTIO R	0.65	0.326	2011ApJ...737..103S
CTIO I	0.80	0.233	2011ApJ...737..103S
UKIRT J	1.25	0.109	2011ApJ...737..103S
UKIRT H	1.66	0.069	2011ApJ...737..103S
UKIRT K	2.19	0.046	2011ApJ...737..103S

Source Editor

ID | Continuum | Renorm | Lines | Shape | Offset

Spectral Energy Distribution

- Uploaded File
- Select
  - Galaxy Spectra from Brown et al.
  - NGC 6090 (Pec; Merger/LIRG)
- No Continuum

Redshift 0

Extinction

Law: Milky Way R_V=3.

Ext. Magnitude: 0.109

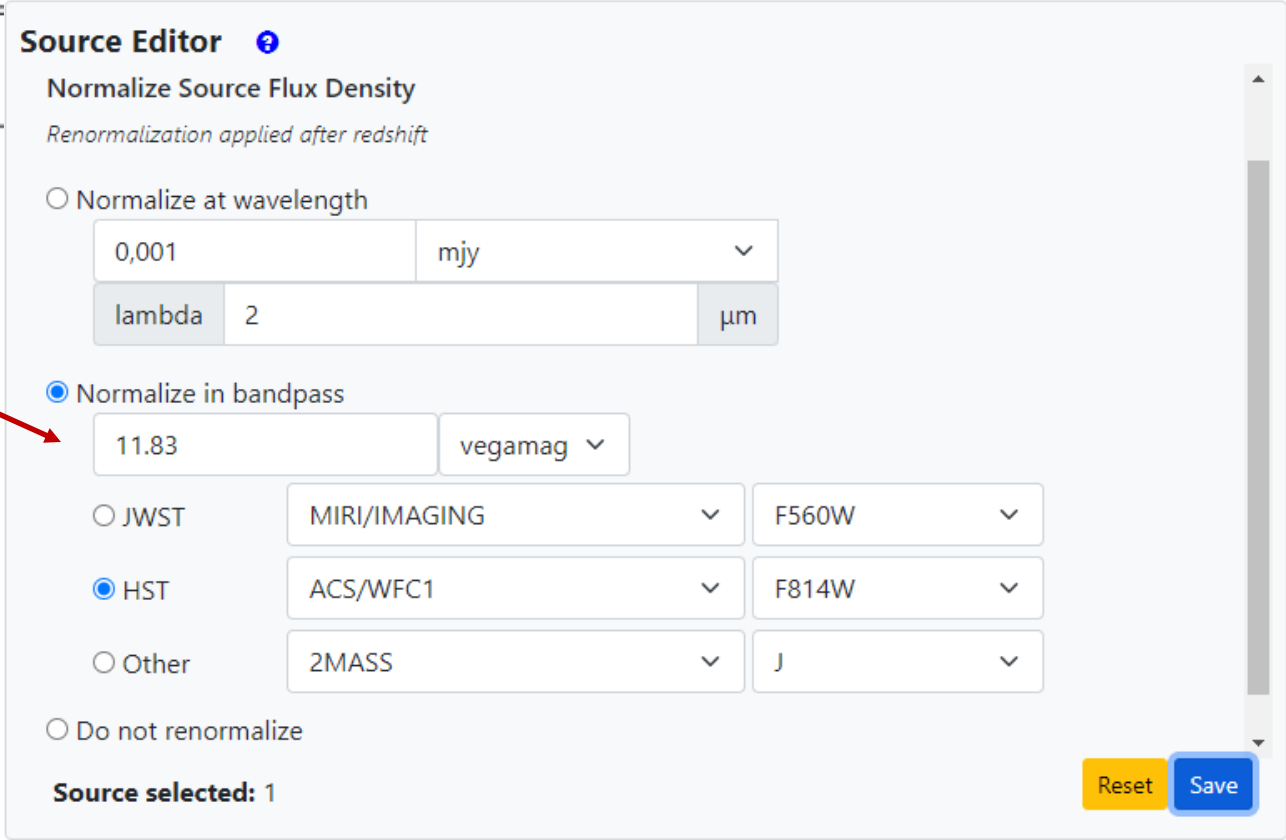
Ext. Bandpass: J

Source selected: 1

Reset | Save

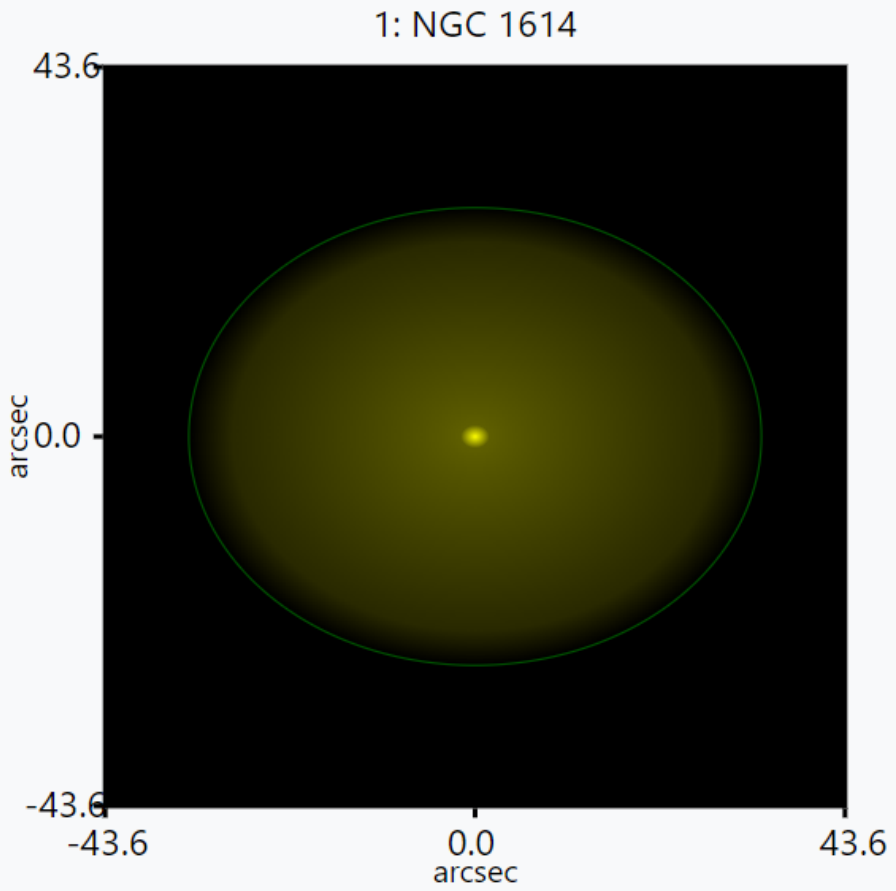
Source Renormalization

Name (1)	n (2)	m_n (3)	$r_{1/2}$ (4)	$\mu_{1/2}$ (5)	b/a (6)
NGC 1614	4	11.83	5.5	20.00	0.80



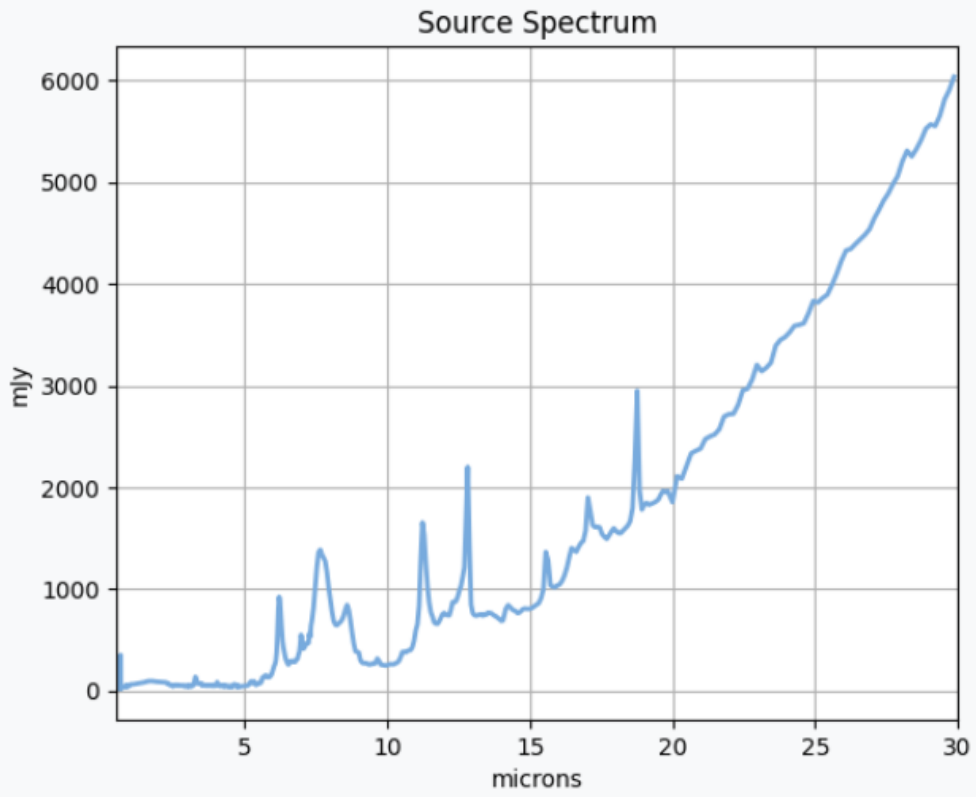
Scene Sketch and Source Spectrum Plots

Scene Sketch



☑ Show source outlines

Source Spectrum Plots



Spectra Plot

Creating Calculations

Exposure Time Calculator Edit Expand anon_11183 Help

Slitless & IFU calculations

Slitless and IFU calculations performed on scenes with multiple extended sources

Calculations Scenes and Sources Upload Spectra Caveats and Limitations

Calculations Page

MIRI NIRCam NIRISS NIRSpec

ID		Mode - (1)	λ -	Scn -	(s) -	SNR -	
9		nirspec ifu	1.15	1	4402.08	0.37	
8		miri mrs	5.40	1	2220.03	0.01	
7		niriss soss	1.80	3	60.45	0.73	
6		nircam wfgrism	3.62	1	1964.83	0.03	
3		niriss wfss	1.50	1	440.21	0.41	
2		niriss wfss	1.50	1	440.21	0.34	
1		niriss imaging	1.40	1	590.52	6.82	
-	-	---	---	-	--.-	--.-	-

Calculations Pane

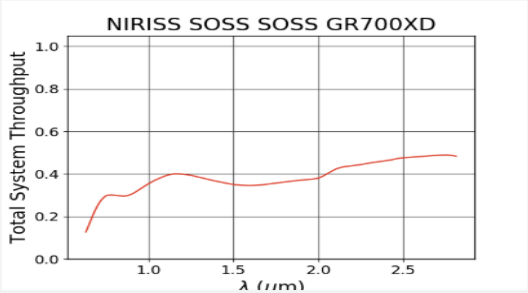
Scene ★ (2) Backgrounds (3) Instrument Setup (4) Detector Setup (5) Strategy (6)

NIRISS SOSS

Disperser

GR700XD (cross-dispersed)

Calculation Editor Pane



Calculation selected: 7, Mode: niriss soss

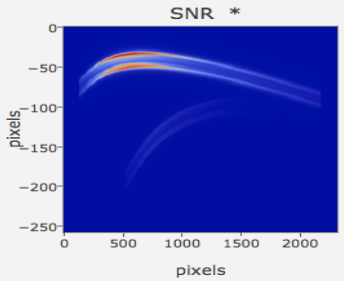
Reset Calculate

Images

Images Pane

Calculation selected: 7, Mode: niriss soss

2D SNR Detector Saturation Groups Before Saturation

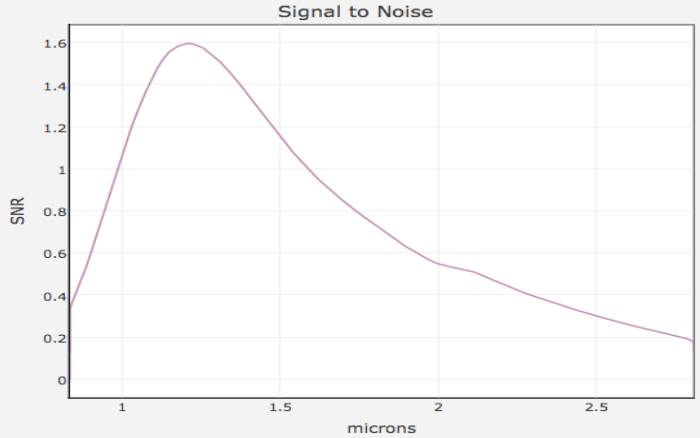


* These data have been resampled to a lower resolution in the horizontal dimension. To obtain data at the native pixel resolution, retrieve the data products under the Download tab.

Plots

Plots Pane

ApFlux ApBackground SNR SNR (time) Contrast



Bounds/Scale:

X: 0.83 2.81 Linear Clear

Y: -0.09 1.68 Linear Clear

Apply

Reports

Reports Pane

Calculation selected: 7, Mode: niriss soss

Report Warnings Errors Downloads

Instrument Filter/Disperser:	null/gr700xd
Extraction Aperture Position (arcsec):	[0.00, 0.00]
Wavelength of Interest used to Calculate Scalar Values (microns):	1.80
Size of Extraction Aperture (arcsec):	N/A
Total Time Required for Strategy (seconds):	60.45
Total Exposure Time (seconds):	60.45
Maximum Fraction of Saturation:	4.4e-3
Maximum Number of Groups Before Saturation:	>999
Extracted Flux (e-/sec):	2.02
Standard Deviation in Extracted Flux (e-/sec):	2.76
Extracted Signal-to-Noise ratio:	0.73
Input Background Surface Brightness (MJy/sr):	0.29
Total Background Flux in Extraction Aperture (e-/sec):	191.03
Total Sky Background Flux in Extraction Aperture (e-/sec):	191.03
Fraction of Total Background due to Signal From Scene:	0.00
Average Number of Cosmic Rays per Ramp:	4.4e-3

Scene for Calculation

Exposure Time Calculator Copy/Delete Expand anon_116865 Help

Workbook ID: 159241 | Observing NGC 1614 with MIRI | NGC 1614

Calculations | Scenes and Sources | Upload Spectra | Caveats and Limitations

MIRI | NIRCam | NIRISS | NIRSpec

ID		Mode	λ	Scn	(s)	SNR	!
1	☑	miri imaging	5.83	1	277.50	377.85	✓

Scene ★ | Backgrounds | Instrument Setup | Detector Setup | Strategy

Scene for Calculation

1: NGC 1614

Sources in that Scene

1: NGC 1614

ID | Continuum | Renorm | Lines | Shape | Offset

Normalize Source Flux Density

Renormalization applied after redshift

○ Normalize at wavelength

0,001 | mjy

lambda | 2 | µm

◉ Normalize in bandpass

11,83 | vegamag

○ JWST | MIRI/IMAGING | F560W

Calculation: 1, **Mode:** miri imaging

Reset | Calculate

Backgrounds

Scene ★ | Backgrounds | Instrument Setup | Detector Setup | Strategy

Position

Ra Dec 04 33 59.854 -08 34 43.98

Background configuration

○ None ○ Low ● Medium ○ High

○ Date Jul 1 2023

Calculation: 1, **Mode:** miri imaging

Reset Calculate

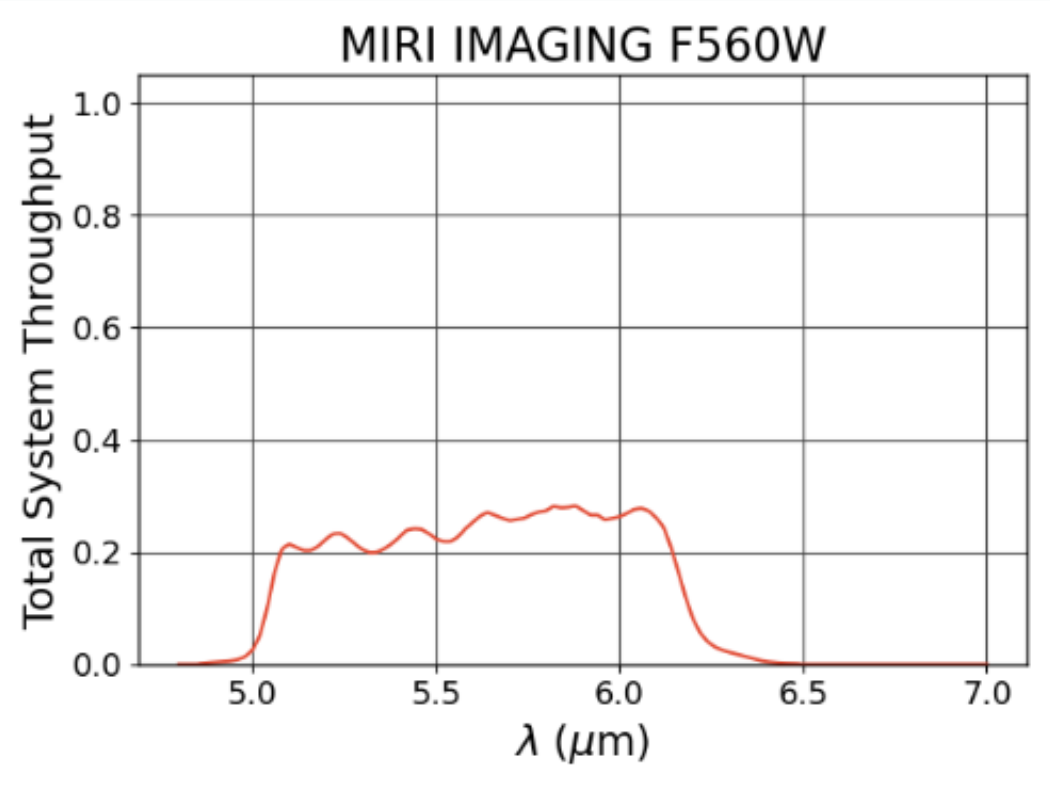
Instrument Setup

Scene ★ | Backgrounds | Instrument Setup | Detector Setup | Strategy

MIRI Imaging

Filter

F560W



Calculation: 1, **Mode:** miri imaging

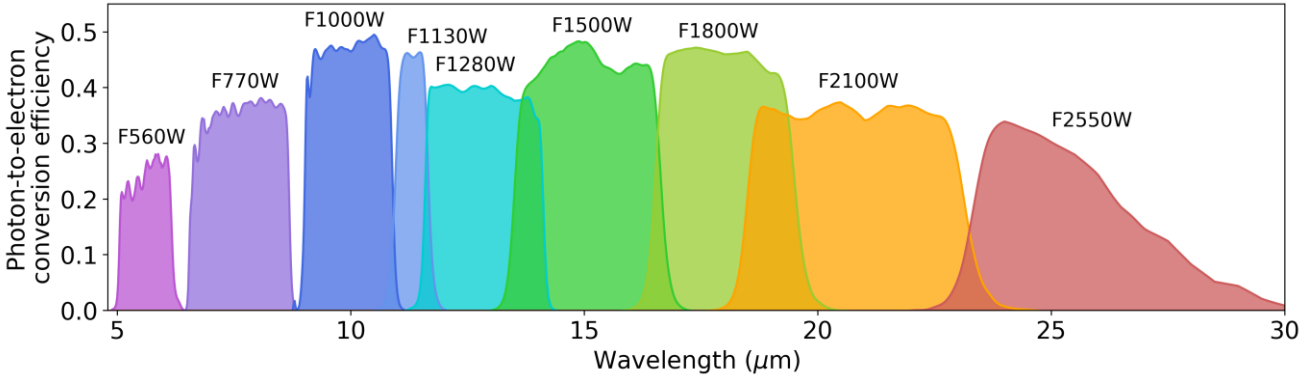
Reset | Calculate

Imaging Filters

Table 1. MIRI filter properties

Filter name	λ_0 (μm)	$\Delta\lambda$ (μm)	FWHM* (arcsec)	Comment
F560W	5.6	1.2	0.207	Broadband Imaging
F770W	7.7	2.2	0.269	PAH, broadband imaging
F1000W	10.0	2.0	0.328	Silicate, broadband imaging
F1130W	11.3	0.7	0.375	PAH, broadband imaging
F1280W	12.8	2.4	0.420	Broadband imaging
F1500W	15.0	3.0	0.488	Broadband imaging
F1800W	18.0	3.0	0.591	Silicate, broadband imaging
F2100W	21.0	5.0	0.674	Broadband imaging
F2550W	25.5	4.0	0.803	Broadband imaging

* FWHM refers to the PSF



Detector Setup

Scene ★ | Backgrounds | Instrument Setup | Detector Setup | Strategy

Subarray

FULL

Readout pattern

FASTR1

Groups per integration

40

Integrations per exposure

1

Exposures per specification

4

Total exposure time: 00:07:24 (444.01 s)

Total integrations: 4

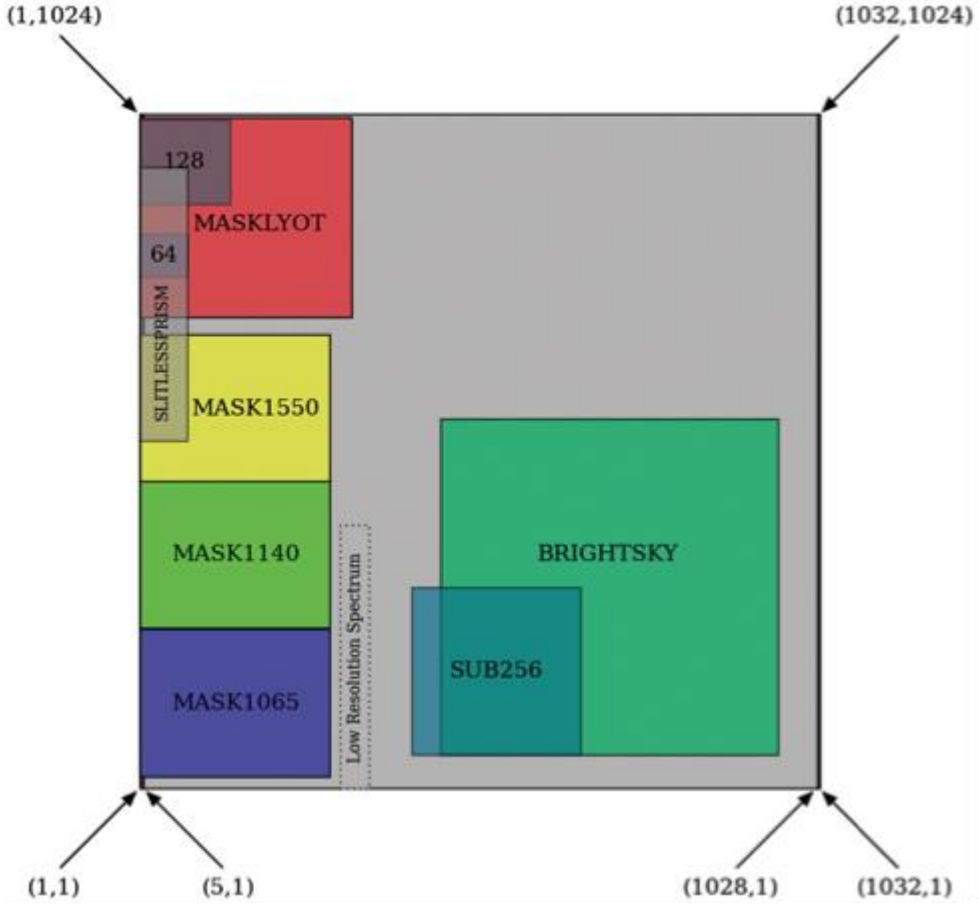
Calculation: 1, **Mode:** miri imaging

Reset | Calculate

MIRI Imaging Subarray

Table 1. MIRI imaging subarray characteristics

Subarray	Size in pixels (rows × columns)	First row corner	First column corner	Usable size	Group time†
FULL	1024 × 1032	1	1	74" × 113"	2.775 s
BRIGHTSKY	512 × 512	51	457	56.3" × 56.3"	0.865 s
SUB256	256 × 256	51	413	28.2" × 28.2"	0.300 s
SUB128	128 × 136	891	1	14.1" × 14.1"	0.119 s
SUB64	64 × 72	779	1	7" × 7"	0.085 s



Understanding Exposure Time

- A ***frame*** is a single, non-destructive read of all pixels in the (sub)array. Each pixel may be sampled multiple times by the electronics.
- A ***group*** consists of one or multiple ***frames*** that are averaged into a data point by the onboard flight software

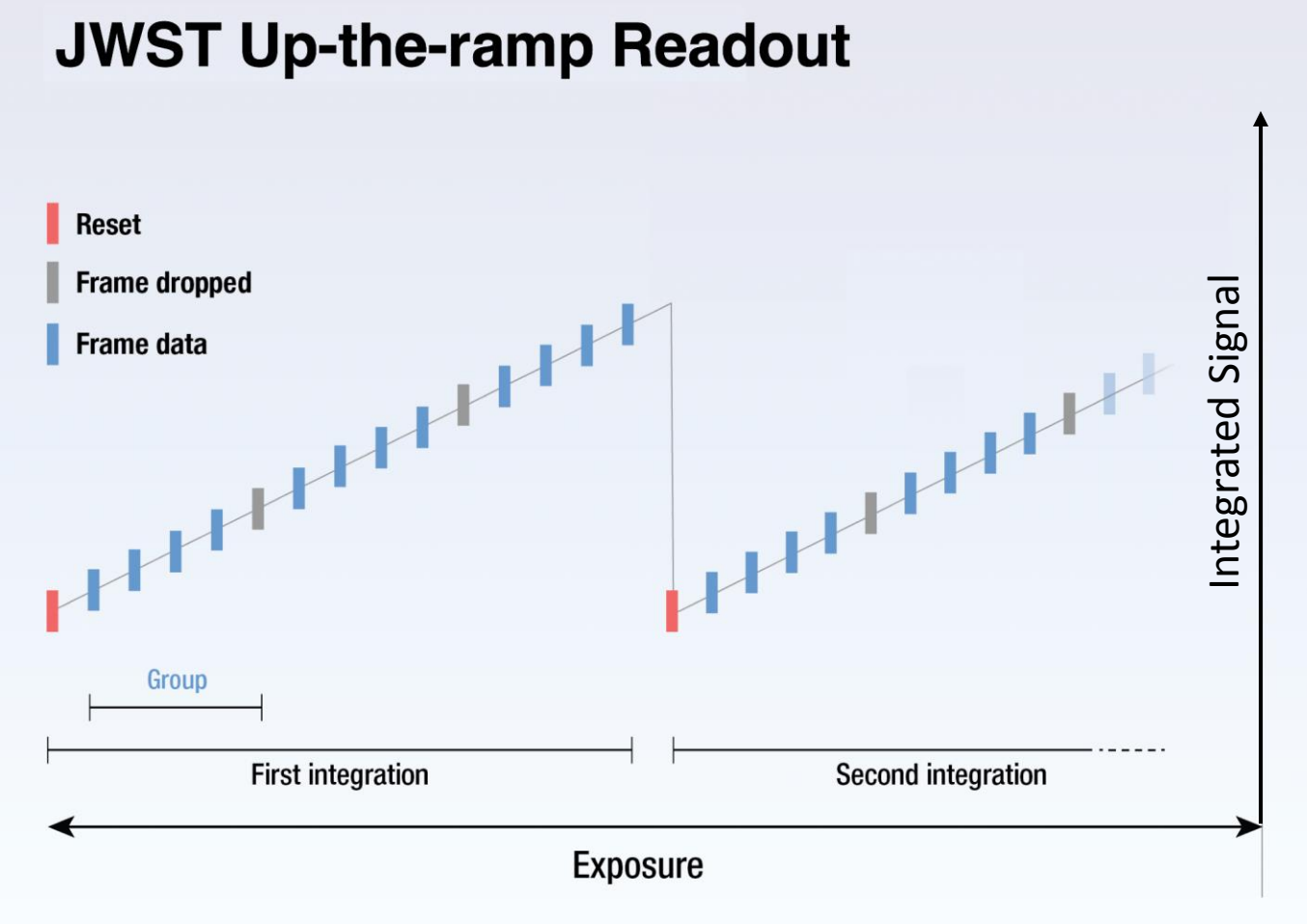
⇒ **Readout pattern**

- A ***integration*** is a ramp composed of a number of ***groups***, terminated by a reset which clears accumulated charge from the pixels

⇒ **Groups per integration**

- An ***exposure*** consist of one or more identical integrations that are sequentially executed

⇒ **Integrations per exposure**



Readout Pattern

Choosing the readout mode: *FASTR1* vs. *SLOWR1*

See also: MIRI Detector Readout Overview

The MIRI detectors can be operated using 2 different readout modes: ***FASTR1*** and ***SLOWR1***. The main differences between these modes are:

- ***FASTR1*** mode reads out the detector every 2.775 s in full array mode, vs. 23.889 s in ***SLOWR1*** mode. ***FASTR1*** mode offers finer time sampling that allows better characterization of detector effects and more samples for cosmic ray correction. Compared to ***SLOWR1*** mode, in ***FASTR1*** mode there is approximately a factor of 9 less time loss in case of a cosmic ray hit.

- ***SLOWR1*** mode provides about 9 times less data volume.

⚠ ***FASTR1*** *is the recommended readout mode for all MIRI observations executed as prime.* ***SLOWR1*** mode is useful for parallel observations and in some MRS programs, where it can be essential to limit the data volume.

Groups per Integration

- *The ideal number of groups* will depend on the source brightness and background conditions:
  - Bright sources/high background conditions will generally mean that saturation is reached in a short number of groups (5 to 10). *Having one group saturating at the end of the integration will maximize the dynamic range*. For very bright cases, imaging users should favor subarrays.
  - Faint source observations will benefit from having longer integrations. In ***FASTR1*** mode, 40 groups (about 100 s in ***FULL*** array, shorter when using subarray mode) is suggested as a starting point. Increase or decrease the integration to achieve your desired signal to noise. ***SLOWR1*** is recommended primarily to limit data volume when MIRI. See the MRS Recommended Strategies page for specific MRS guidance.
- *Maximum recommended integration length*: Based on in-flight experience, and considering the impact of the background, cosmic rays, cosmic ray showers, and other detector effects, 300 s is the maximum recommended integration length for imaging, coronagraphy and LRS observations. After 300 s about 35% of the MIRI detector pixels are affected by a cosmic ray, either as a direct or secondary impact of a cosmic ray, or a cosmic ray shower (see Figure 2, left). Integrations longer than 300 s may be desired in cases of very low background, such as those measured in the MIRI MRS where the data will be photon noise limited. On-orbit measurements indicate that in a 1,000 s integration, most of the detector pixels are affected by cosmic rays (see Figure 2, right) and therefore that is the maximum recommended integration length. To understand cosmic ray treatment by the ETC visit the JWST ETC Cosmic Ray Implementation page.

Integrations per Exposure

Should I use multiple integrations?

The first integration within an exposure differs from the second and subsequent ones. This is because there are multiple detector resets between exposures (the system goes into a continuous reset while the telescope is dithering, filter wheels are moving, etc.), allowing some of the above-mentioned transient features to be cleared out of the first integration of the exposure. For multiple integration data the MIRI detectors use now an additional reset (***FASTR1*** and ***SLOWR1***), which does allow for the majority of these transient effects to decay. Multiple integrations have the added benefit of allowing for all cosmic rays decay; these also decay during the dithers in between exposures.

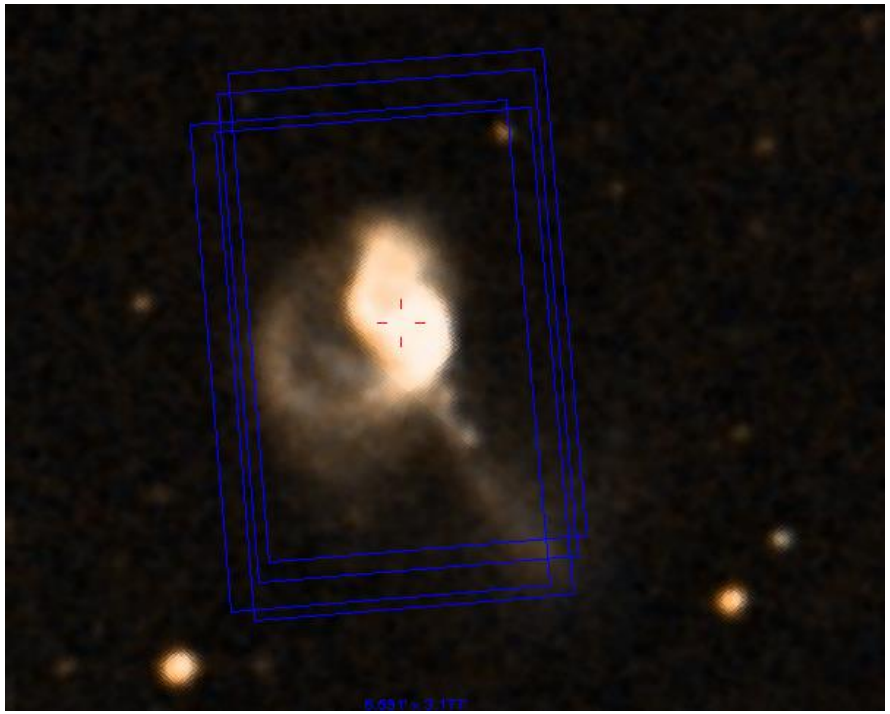
To decide whether to use multiple integrations, observers should consider various aspects: brightness of the source, detector performance, dithers, and overheads. These can all be encapsulated in 2 broad cases:

1. Bright sources/high backgrounds that saturate rapidly: in this case, multiple integrations that allow at least one saturated group will be beneficial to obtain high SNR, and provide better efficiency. Telescope maneuvers to the next dither position are more "costly" than starting a new integration.

2. Fainter sources that can reach the "ideal exposure length" of 300 s (see above) will benefit from single integrations in all dither positions. It is best to select integration lengths which are as long as your observations allow (i.e., a few long integrations are better than many shorter ones).

Dithering

Dithering is a technique in which an observed astronomical scene's position is moved by a small amount and then re-observed, often for multiple times. When the resulting data are processed, the scene can be reconstructed without gaps or detector artifacts.



For most science cases, dithering is a highly recommended and necessary practice for the following reasons:

- Allows good PSF sampling—this is mostly relevant when using the F560W filter; the MIRI imager Nyquist-samples the PSF for wavelengths ≥ 6.25 μm
- Minimizes detector cosmetics and defects. Dithers with large steps between points are specifically useful to minimize cosmic ray showers
- Makes possible accurate background measurements for point sources, and at longer wavelengths permits tracking of potential telescope thermal emission variations
- Mitigates the impact of bad pixels
- Allows tracking detector drifts at the timescale of the dwell time per dither position (i.e., total length of time the telescope exposes at a dither position)

MIRI Imaging Dithers

Table 1. MIRI imaging dithers offered by the Astronomer's Proposal Tool

Dither Pattern	Pros	Cons	Most suitable for
Cycling LARGE (or DEFAULT)	Maximum flexibility in the number of dither points. A minimum of 4 points to provide enough redundancy is recommended. It offers 3 different pattern sizes, the LARGE is very well suited to mitigate cosmic ray showers. Science data with targets smaller or similar size to the pattern are well suited to generate a background from the science exposures.	Slight reduction in the total field of view with full exposure coverage	All cases (point sources, small and large extended sources, mosaics). Considered to be the default pattern.
Cycling MEDIUM	Similar advantages to the cycling large dither pattern.	The separation between the dithers points makes it less effective to mitigate cosmic ray showers.	Point and small extended sources.
Cycling SMALL	Similar advantages to the cycling large dither pattern.	The smaller separation between the dithers points makes it less effective to mitigate cosmic ray showers.	Point sources
4-point extended-source	Prevents persistence issues for small extended sources and can mitigate cosmic ray showers by avoiding the placement of the source onto the same pixels.	Reduces the total field of view with full exposure coverage.	Small extended sources up to 5" in radius

CYCLING Dither Pattern

CYCLING

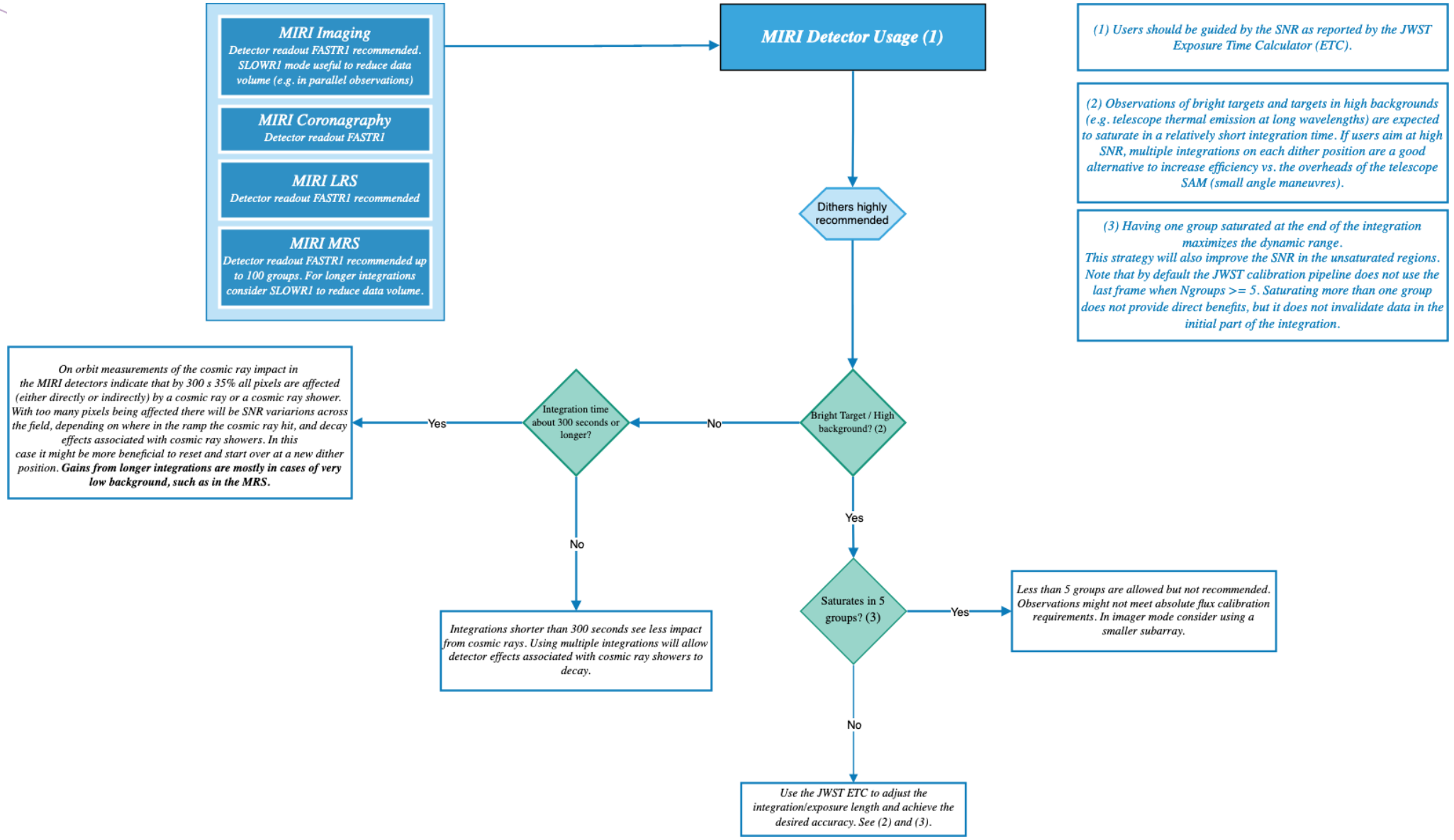
The ***CYCLING*** pattern consists of 311 points. This pattern is a random Gaussian pattern designed to be flexible. Observers will be able to choose (1) the starting position in the dither table and (2) the number of dither positions to maximize observational flexibility. For observers who request more than 311 dither positions, the ***CYCLING*** pattern will wrap so that the 312th dither position is the same as the 1st position. Each set of 4 consecutive dithers provides complete ½ pixel sampling.

Dithering in the ETC and APT

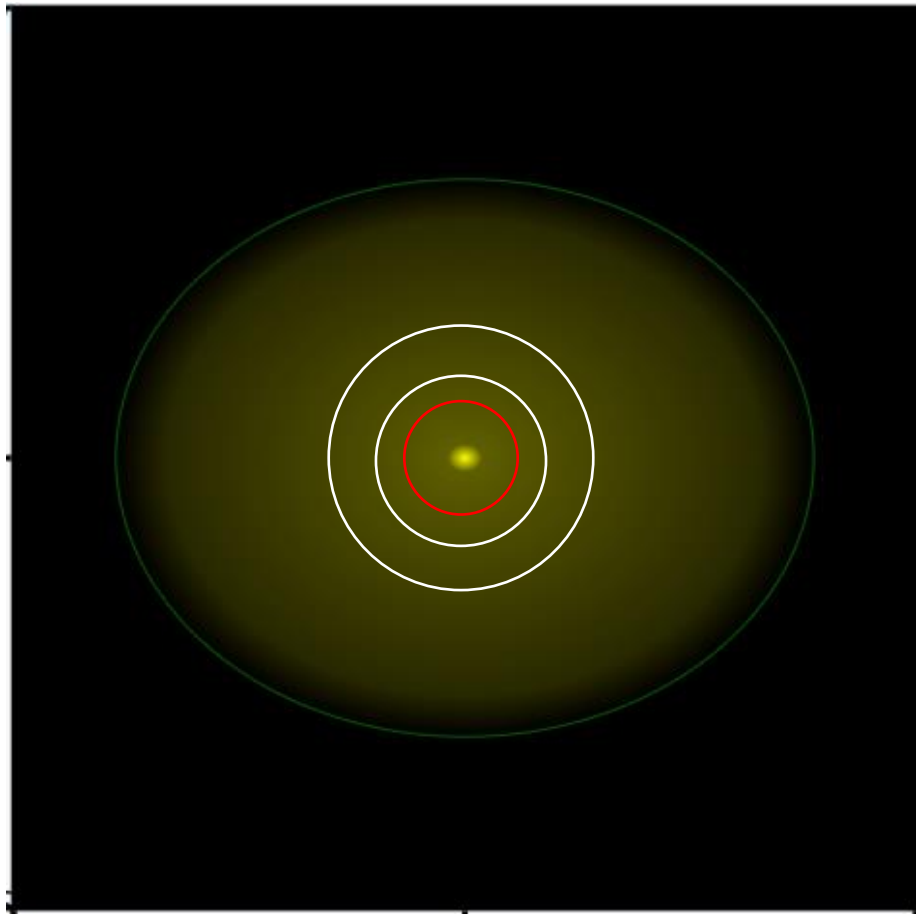
See also: Astronomer's Proposal Tool Overview, Exposure Time Calculator Overview, JWST APT-ETC Connectivity

Each dither step produces a separate exposure as specified in the APT template. Hence, one needs to be clear about this when using the ETC to calculate the S/N for a given exposure or for the entire observation (all of the dither exposures combined). *To approximate the total SNR expected, set the number of exposures in the ETC calculation to be the number of dither steps anticipated.* Then in transferring the ETC observation specifications into the APT template, users should make sure they are entering the values for an *individual exposure*. Selecting a given dither pattern in APT then automatically increases the number of exposures to the specified value.

MIRI Recommended Strategies



Imaging Aperture Photometry Strategy



Scene ★ | Backgrounds | Instrument Setup | Detector Setup | Strategy

Aperture location

- (●) Centered on source
  - 1: NGC 1614
  - *X, Y: 0,0 arcsec*
- ( ) Specify offsets in scene
  - X: 0 arcsec
  - Y: 0 arcsec

Aperture radius

0,3 arcsec

Perform Background Subtraction Using

(●) background region ( ) noiseless sky background

Sky annulus

Inner radius: 0,45 arcsec

Outer radius: 0,7 arcsec

Shape (●) circular

Angular units arcsec

Calculation: 1, **Mode:** miri imaging

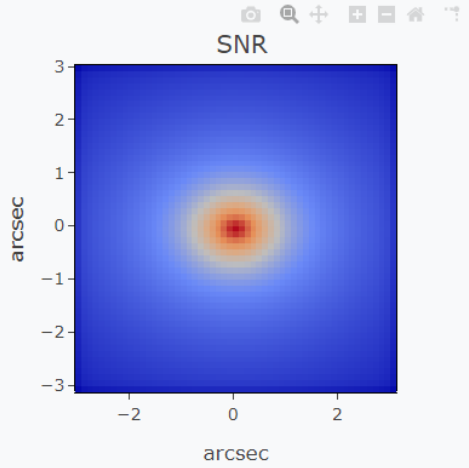
Reset | Calculate

Results

Images

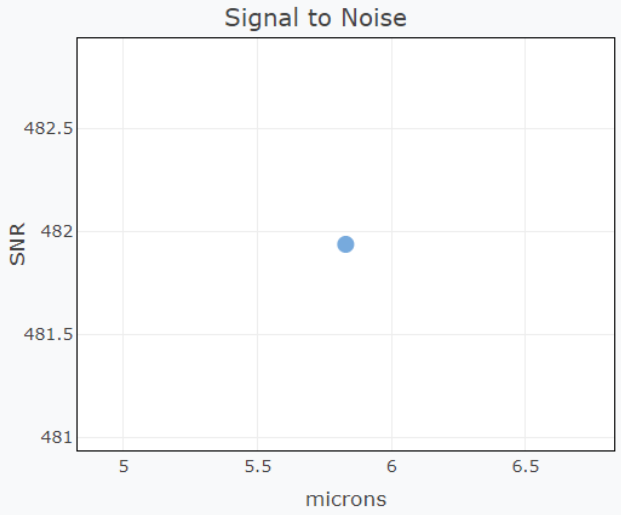
Calculation: 1, **Mode:** miri imaging

2D SNR | Detector | Saturation | Groups Before Saturation



Plots

ApFlux | ApBackground | SNR (λ) | SNR (time) | Contrast



Bounds/Scale:

X:	4,83	6,83	Linear	Clear
Y:	480,94	482,94	Linear	Clear

Apply

Reports

Calculation: 1, **Mode:** miri imaging

Results | Warnings | Errors | Downloads

Results		
Extracted Signal-to-Noise Ratio	481.94	
Extracted Flux	3960.96	e-/s
Standard Deviation of Extracted Flux	8.22	e-/s
Brightest Pixel Rate	539.92	e-/s
Maximum Fraction of Saturation	0.31	
Maximum Number of Groups Before Saturation	129.00	groups

Instrument and Detector		
Instrument Filter/Disperser	f560w, n/a	
Total Time Required for Strategy	444.01	s
Total Exposure Time	444.01	s
Single Exposure Time	111.00	s
Fraction of Time Spent Collecting Flux	0.93	
Time Between First and Last Measurement, per exposure	102.68	s
Time Between First Reset and Last Measurement, per integration	111.00	s

Extraction Strategy Settings		
Radius of Extraction Aperture	0.30	arcsec
Area of Extraction Aperture	23.37	pixels
Effective Wavelength	5.83	microns
Extraction Aperture Position	0.00, 0.00	arcsec

Background		
Input Background Surface Brightness	1.82	MJy/sr
Area of Background Measurement	74.65	pixels

ID	☑	Mode	λ	Scn	(s)	SNR	!
1	☑	miri imaging	5.83	1	444.01	481.94	✓

JWST Background-Limited Observations

How to determine if an observation needs the ***Background Limited*** special requirement in ETC

See also: JWST Exposure Time Calculator Overview

1. In the ETC **Backgrounds** tab, specify the RA and Dec of the target (see Figure 1).

2. Select ***Low*** background. Click ***Calculate*** (bottom right of the panel, not visible in Figure 1) and make note of the signal-to-noise ratio (SNR).

3. Select ***High*** background. Click ***Calculate*** and, again, note the SNR.

4. On your own, calculate the fractional change in the SNR, X, where
   `X = [SNR(low bkg) - SNR(high bkg)] / SNR(low bkg)` (Equation 1)

5. If X > 0.05, then the SNR of this observation depends by more than 5% on the variable background level. You *should use* the ***Background Limited*** special requirement in APT, at the default value of < 10% above the minimum background, unless you have a good reason not to do it.

6. If X < 0.05, then your observation is not sensitive to the time variable background. You *should not use* the ***Background Limited*** special requirement in APT.

The threshold value of X = 0.05 was chosen for consistency with the ground system requirements. Proposers are encouraged to mention the results of this calculation in their technical justification, especially if they select the ***Background Limited*** special requirement.

Background Sensitivity

MIRI | NIRCam | NIRISS | NIRSpec

ID	☑	Mode	λ	Scn	(s)	SNR	!
1	☑	miri imaging	5.83	1	444.01	483.09	✓

Scene ★ | Backgrounds | Instrument Setup | Detector Setup | Strategy

Position

Ra Dec 04:33:59.854 -08:34:43.98

Background configuration

○ None ◉ Low ○ Medium ○ High

○ Date Jul 1 2023

MIRI | NIRCam | NIRISS | NIRSpec

ID	☑	Mode	λ	Scn	(s)	SNR	!
1	☑	miri imaging	5.83	1	444.01	480.11	✓

$$X = \frac{483.09 - 480.11}{483.09} \approx 0.006$$

Scene ★ | Backgrounds | Instrument Setup | Detector Setup | Strategy

Position

Ra Dec 04:33:59.854 -08:34:43.98

Background configuration

○ None ○ Low ○ Medium ◉ High

○ Date Jul 1 2023

Expand over Filters

ID	☑	Mode -	λ -	Scn -	(s) -	SNR -	!
10	☐	miri imaging	14.46	1	444.01	100.25	✓
9	☐	miri imaging	25.53	1	444.01	344.74	⚠
8	☐	miri imaging	20.63	1	444.01	610.13	⚠
7	☐	miri imaging	18.04	1	444.01	811.88	⚠
6	☐	miri imaging	15.07	1	444.01	924.11	⚠
5	☐	miri imaging	12.77	1	444.01	1026.10	⚠
4	☐	miri imaging	11.31	1	444.01	929.70	✓
3	☐	miri imaging	10.00	1	444.01	869.26	✓
2	☐	miri imaging	7.65	1	444.01	1053.06	⚠
1	☐	miri imaging	5.83	1	444.01	481.94	✓

JWST Astronomer’s Proposal Tool (APT)

The JWST Astronomer's Proposal Tool

The **Astronomer's Proposal Tool (APT)** is used to specify proposed observations for JWST and submit them for consideration by the Time Allocation Committee (TAC).

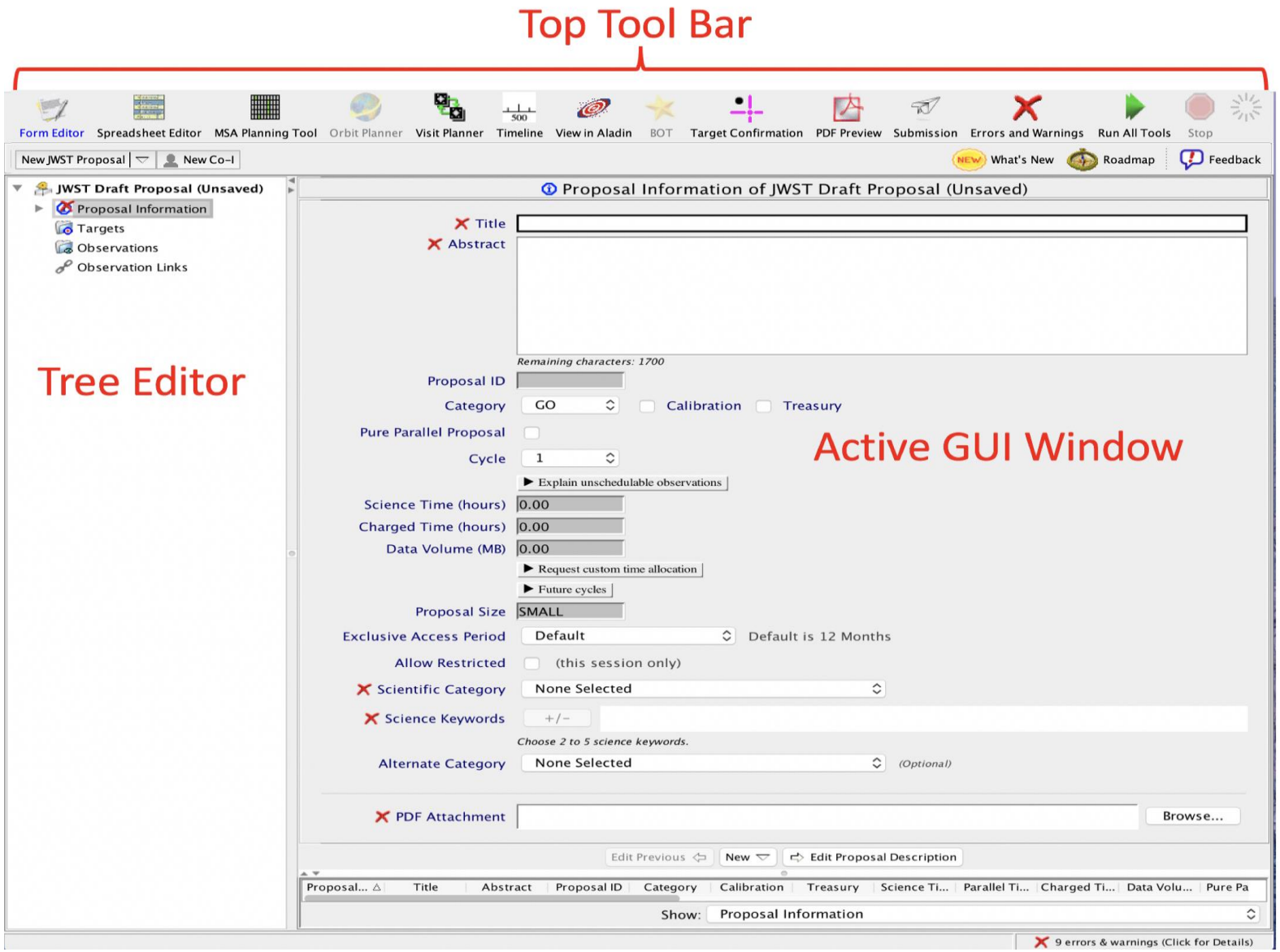
- The scientific justification PDF must be attached prior to submission.

https://www.stsci.edu/scientific-community/software/astronomers-proposal-tool-apt

APT is also a resource estimator.

- Need a resource estimate for the TAC.
- APT uses a system of overhead charges to make this resource estimate possible.
- Units are in decimal hours.

APT Graphical User Interface



Proposal Information

Astronomer's Proposal Tools Version 2023.3.4 - JWST Draft Proposal (Unsaved)

File Edit Tools Form Editor HST Help JWST Help

Form Editor | Spreadsheet Editor | MSA Planning Tool | Orbit Planner | Visit Planner | Timeline | View in Aladin | BOT | Target Confirmation | PDF Preview | Submission | Errors and Warnings | Run All Tools | Stop

New JWST Proposal | New Co-I | What's New | Roadmap | Feedback

- JWST Draft Proposal (Unsaved)
  - Proposal Information
  - Targets
  - Observations
  - Observation Links

Proposal Information of JWST Draft Proposal

Title: Observing NGC 1614 with MIRI

Abstract: Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.

Remaining characters: 1255

Proposal ID:

Category: GO | Calibration | Treasury | GO-Archival

Pure Parallel Proposal:

Cycle: 2 | Reset to Draft...

▶ Explain unschedulable observations

▶ Supply Meteoroid Zone Justification

Science Time (hours): 0.00

Charged Time (hours): 0.00

Data Volume (MB): 0.00

▶ Request custom time allocation

▶ Future cycles

Proposal Size: SMALL

Exclusive Access Period: Default | Default is 12 Months

Allow Restricted: (this session only)

Scientific Category: Galaxies

Alternate Category: None Selected *(Optional)*

Science Keywords: +/- Galaxy Mergers, Star Formation, Starburst Galaxies

Choose 2 to 5 science keywords.

▶ Coordinated telescopes

PDF Attachment: Browse...

Edit Previous | New | Edit Proposal Description

Proposal...	Title	Abstract	Proposal ID	Category	Calibration	Treasury	GO-Archival	Science Ti...	Parallel Ti...	Charged Ti...	Data Volum...	Pure Parall...	Time Alloca...	Time Requ...	Next Cycle ...	Next Cycle ...	Next Cycle ...	Third Cycle ...	Third Cycle ...	Third Cycle ...	Cycle

Show: Proposal Information

5 errors & warnings (Click for Details)

Targets

- JWST Draft Proposal (Unsaved)
  - Proposal Information
    - Proposal Description
    - Team Expertise
    - PI: Dr. Lam Tung Nguyen
    - CoI: Quang Nguyen Luong
  - Targets
    - Fixed Targets
      - 1 NGC-1614
  - Observations
  - Observation Links

1 NGC-1614 of JWST Draft Proposal

Number	1	
Name in the Proposal	NGC-1614	*(unique within proposal)*
Name for the Archive	NGC 1614	*(standard resolvable name)*
Category	Galaxy	
Description	+/- Infrared galaxies, Starburst galaxies	

Choose 1 to 5 items after selecting a category.

J2000 Coordinates (ICRS) RA: 04 34 0.0270 Dec: -08 34 44.57

Galactic Longitude: 204.45162, Latitude: -34.38102

Ecliptic Longitude: 65.21252, Latitude: -30.18690

Uncertainty RA: Arcsec Dec: Arcsec

Proper Motion RA: None Selected Dec: None Selected

Epoch 2000

Annual Parallax (arcsec)

Extended YES *Recommended for spectroscopy (for advice to data reduction pipeline)*

Background Target

Observations of this target require companion background observation(s) ☐

This object was generated by the targetselector and retrieved from the SIMBAD database.

Edit Fixed Targets | New | Edit Observations

2 errors & warnings (Click for Details)

Observations

- JWST Draft Proposal (Unsaved)
  - Proposal Information
    - Proposal Description
    - Team Expertise
    - PI: Dr. Lam Tung Nguyen
    - Co: Quang Nguyen Luong
  - Targets
    - Fixed Targets
      - 1 NGC-1614
  - Observations
    - Observation Folder
      - NGC 1614 (Obs 1)
  - Observation Links

NGC 1614 (Obs 1) of JWST Draft Proposal

Label	NGC 1614
Instrument	MIRI
Template	MIRI Imaging
Coordinated Parallel	☐
Target	1 NGC-1614

	Splitting Distance	Number of Visits
Visit Splitting:	55.0 Arcsec	1

	Science	Total Charged
Duration (secs)	448	3884
Data Volume	486 MB	

MIRI Imaging | Mosaic Properties | Special Requirements | Comments

Subarray: FULL

Dithers

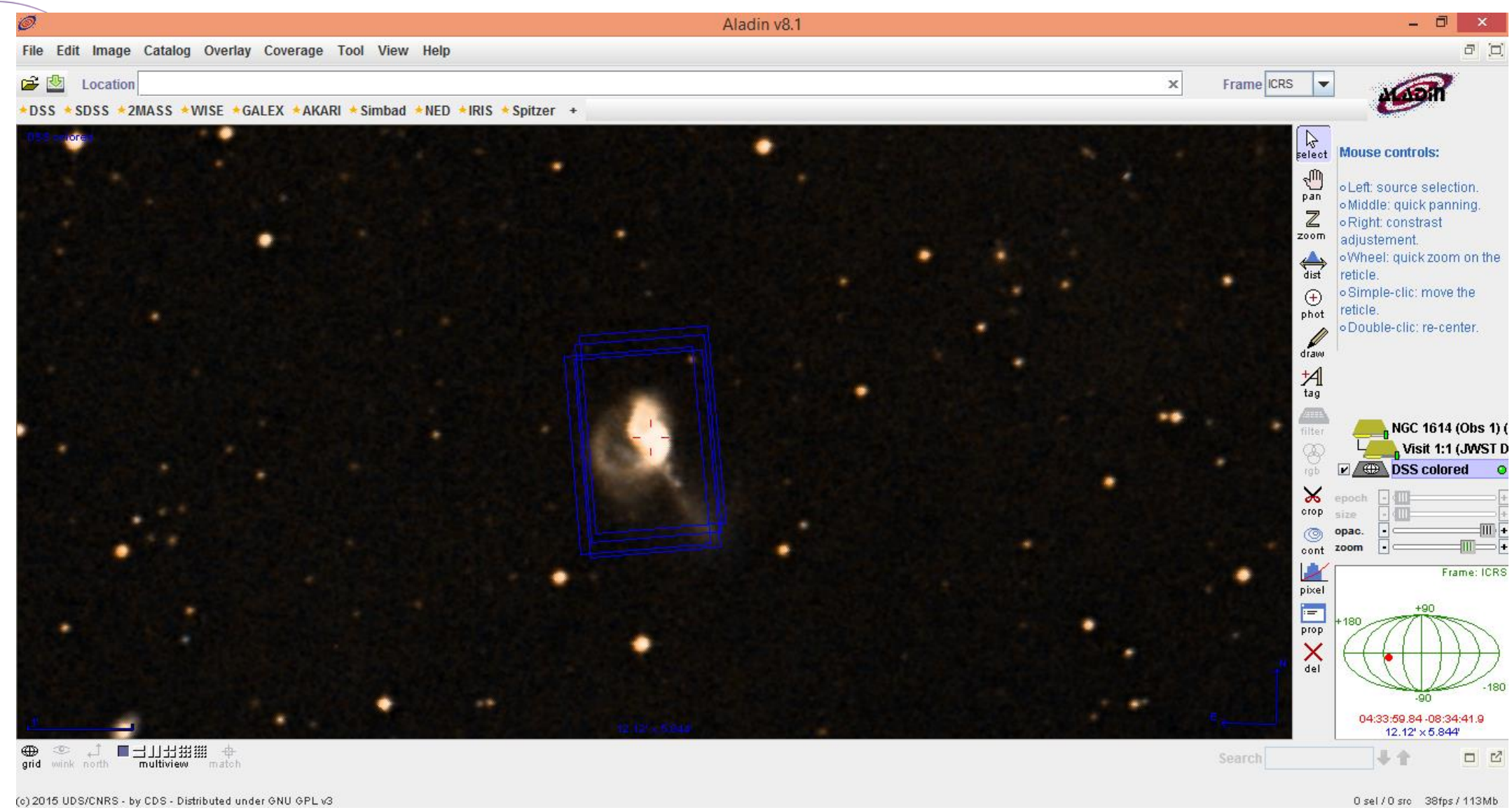
#	Dither Type	Starting Point	Number of Po...	Points	Starting Set	Number of Sets	Optimized For	Direction	Pattern Size
1	CYCLING	1	4						LARGE

Add | Duplicate | Insert Above | Remove

#	Filter	Readout Pa...	Groups/Int	Integration...	Exposures/...	Dither	Total Dithers	Total Integr...	Total Expos...	ETC Wkbk....	ETC
1	F560W	FASTR1	40	1	1	Dither 1	4	4	444.006		

Edit Observation Folder | New | Edit Visit 1:1

Observation Preview with Aladin



Background Observations

Background observations

See also: JWST Background Model, JWST Background-Limited Observations, MIRI Cross-Mode Recommended Strategies (Background), APT Targets

The recommendations for obtaining background observations can be found in the general background information for MIRI. In a nutshell:

- For point sources and sources smaller/similar than the size of the dither pattern, a background can be generated using the science exposures (see Figure 1). The pipeline will not automatically perform this operation.
- When the emission of the science target covers the entire or a large fraction of the imager FOV, it is advised to obtain background data in every spectral configuration used by the science data.

When an observation program assigns a background to a science target (in the Astronomer's Proposal Tool), that creates a formal association between them. By doing this, the pipeline will automatically subtract the background exposure from the target exposure. To avoid having undesired residuals from this step, the user should:

- Choose a background area that is as clean as possible of sources. Given the MIRI sensitivity, it is unlikely to find "empty" regions in the imager FOV (about 74" × 113" in ***FULL*** array).
- *Dither the background target*. By doing that, the pipeline will stack the dithered images thus removing unexpected sources, and use that combination to remove the background from the science data. Observers should carefully consider how many dither points will be needed to achieve the required SNR in their background, and to remove sources present in the background region with the stacking technique.
- To avoid increasing the noise in the science data when subtracting the background, use the same exposure time in the science and background. As a minimum, the total exposure time of all background dither positions combined should be the same as that of the total integration time of a single dither position in the science target.

Dedicated Background Observation

- JWST Draft Proposal (Unsaved)
  - Proposal Information
    - Proposal Description
    - Team Expertise
    - PI: Dr. Lam Tung Nguyen
    - CoI: Quang Nguyen Luong
  - Targets
    - Fixed Targets
      - 1 NGC-1614
      - 2 NGC-1614-BKG
  - Observations
    - Observation Folder
      - NGC 1614 (Obs 1)
      - NGC 1614 BKG (Obs 2)
  - Observation Links

NGC 1614 BKG (Obs 2) of JWST Draft Proposal

Target: 2 NGC-1614-BKG

	Splitting Distance	Number of Visits
Visit Splitting:	55.0 Arcsec	1

	Science	Total Charged
Duration (secs)	112	3494
Data Volume	157 MB	

MIRI Imaging | Mosaic Properties | Special Requirements | Comments

Subarray: FULL

Dithers

#	Dither Type	Starting Point	Number of Po...	Points	Starting Set	Number of Sets	Optimized For	Direction	Pattern Size
1	CYCLING	1	4						LARGE

Add | Duplicate | Insert Above | Remove

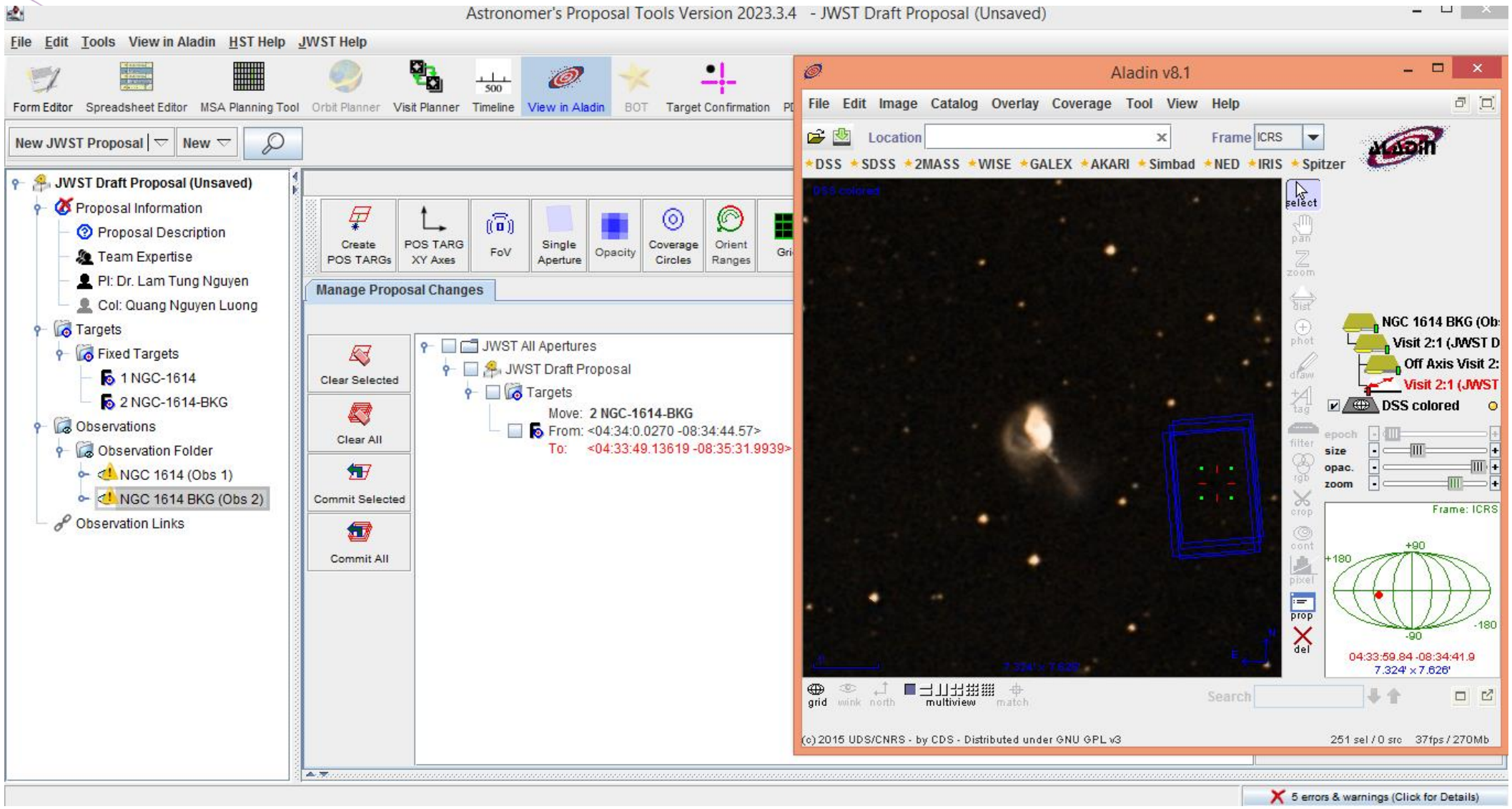
Filters

#	Filter	Readout Pa...	Groups/Int	Integration...	Exposures/...	Dither	Total Dithers	Total Integr...	Total Expos...	ETC Wkbk....	ETC
1	F560W	FASTR1	10	1	1	Dither 1	4	4	111.002		

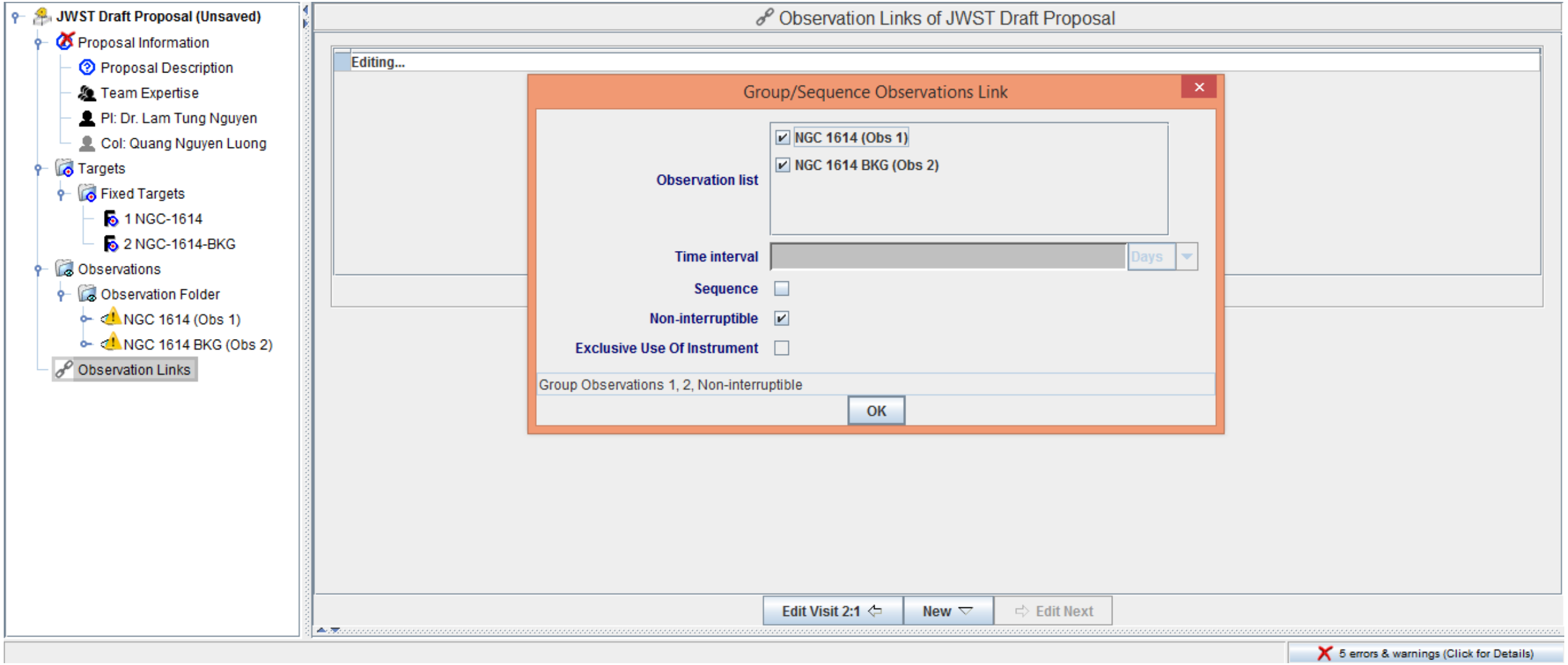
Add | Duplicate | Insert Above | Remove

Edit Visit 1:1 | New | Edit Visit 2:1

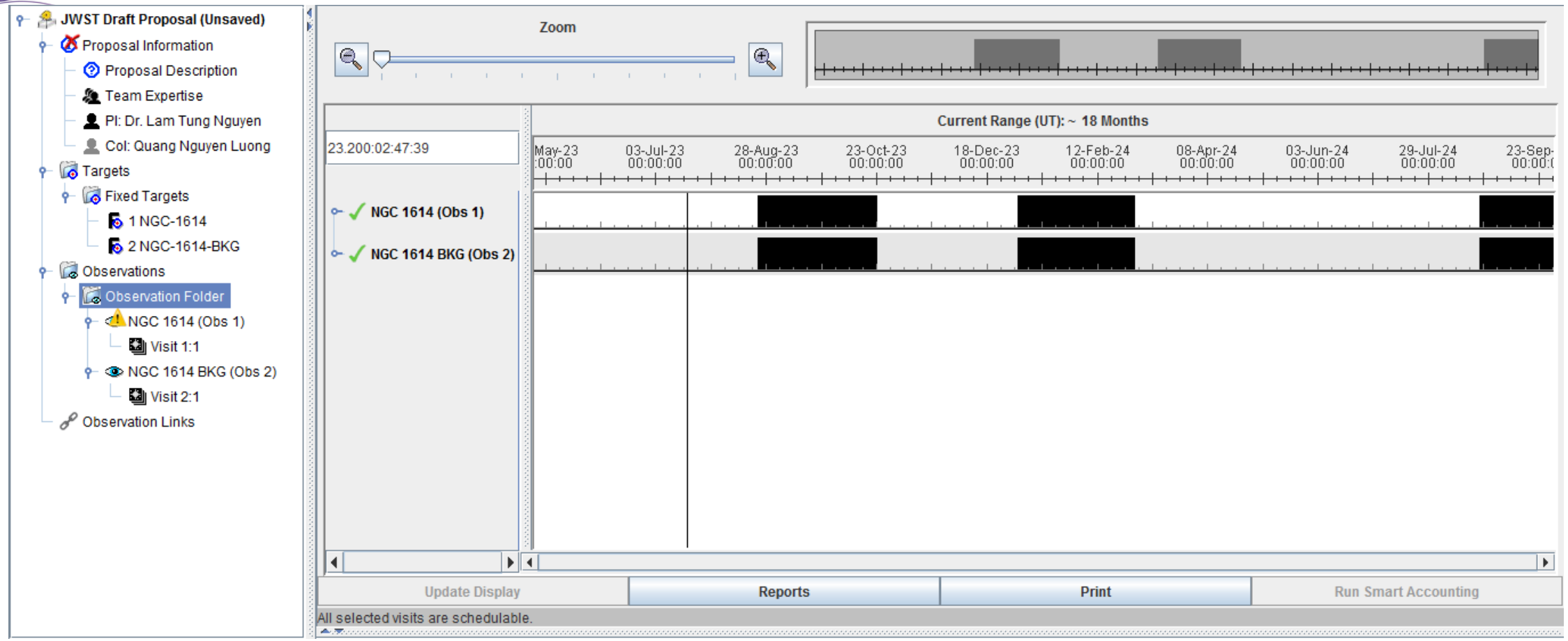
APT Aladin Controls



Observation Links



Visit Planner



Science Time (hours)	0.16
Charged Time (hours)	1.42
Data Volume (MB)	642.72

PDF Attachment

- Scientific Justification
- Technical Justification
- Special Requirements (if any)
- Justify Coordinated Parallel Observations (if any)
- Justify Duplications (if any)
- Analysis Plan (AR only)

JWST Review Process

- STScI has implemented a dual-anonymous proposal review process, where the identities of the proposing team are concealed from reviewers.

⇒ Reduce bias for all

- The review panels (and the Time allocation committee TAC) will conduct their review without seeing any of the names associated with the proposal, and without seeing the information in the "Team Expertise and Background" section.

⇒ Generate a final ranked list of proposals that are recommended for selection.

- In addition to the Panel Chair, each review panel (including the TAC) will have a full-time "Leveler" present in the room during all panel discussions

⇒ Ensure that discussions remain focused on the scientific merit of the proposal

- Once the ranked list is set, the panels will be given access to the "Team Expertise and Background" information

⇒ Proposals may only be flagged for non-selected

JWST Anonymous Proposal Reviews

- It is necessary for proposers to take additional steps to anonymize their PDF attachment before it is uploaded to APT
- Do not include author names or affiliations anywhere in the PDF attachment
- When citing references within the proposal, use third person neutral wording, especially for self-referencing:
  - “as we have shown in our previous work (Doe et al. 2010)” ⇒ “as Doe et al. (2010) showed...”
  - "we observed another cluster, similar to the one we are proposing under HST program #XXXXX“ ⇒ "HST program #XXXXX has observed this target in the past..."
- For exclusive access datasets or non-public software that may reveal (or strongly imply) the investigators on the proposal: "obtained in private communication" or "from private consultation"
- Do not include acknowledgements, or the source of any grant funding