Planning a Deep NIRCam Survey
NIRCam and MIRI Coordinated Parallel Imaging

Science Case

Massimo Robberto (STScI, NIRCam Team Lead)

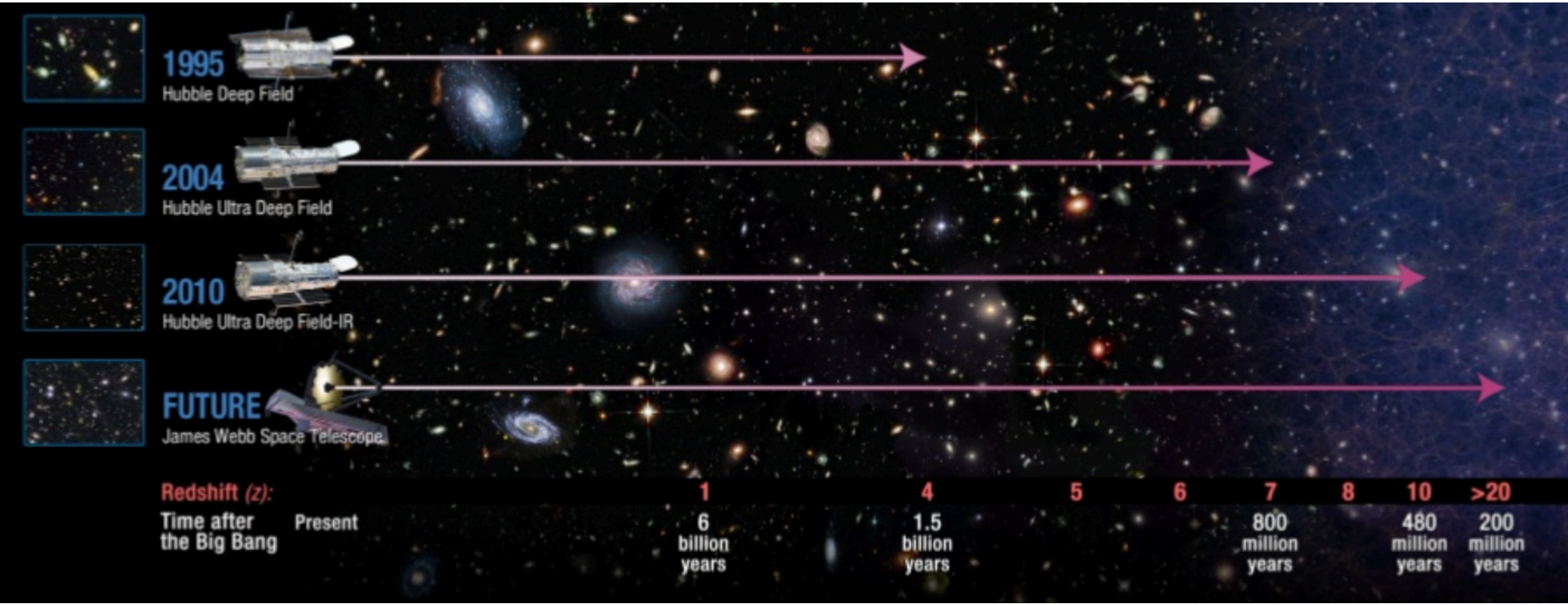
with slides fro Martha Boyer (STScI, NIRCam Team)

Adapted from the NIRCam-NIRSpec joint GTO program

(Many slides from Marcia Rieke, Pierre Ferruit)

STScI

JWST Event, Tenerife, March 2017



JWST will reach the first galaxies

- Seeds of today's galaxies started growing
- Dark matter halos of massive galaxies first formed
- Significant metals first formed
- The Universe was reionized

NIRCam and NIRSpec GTO Programs

Goal: To study galaxy evolution from the first steps (z>10) through the end of the dark ages (7<z<9) and through the epoch of galaxy assembly (2<z<6):

- Luminosity functions at the highest redshifts to test galaxy formation models
- Test ΛCDM by finding the highest redshift galaxies and estimating their masses
- What are the halo masses of these galaxies?
- Measure morphological parameters and assembly of stellar mass as a function of redshift
- Measure metallicity as a function of redshift
- Measure star formation histories
- What can we learn about reionization from these galaxies?
- Look for surprises!

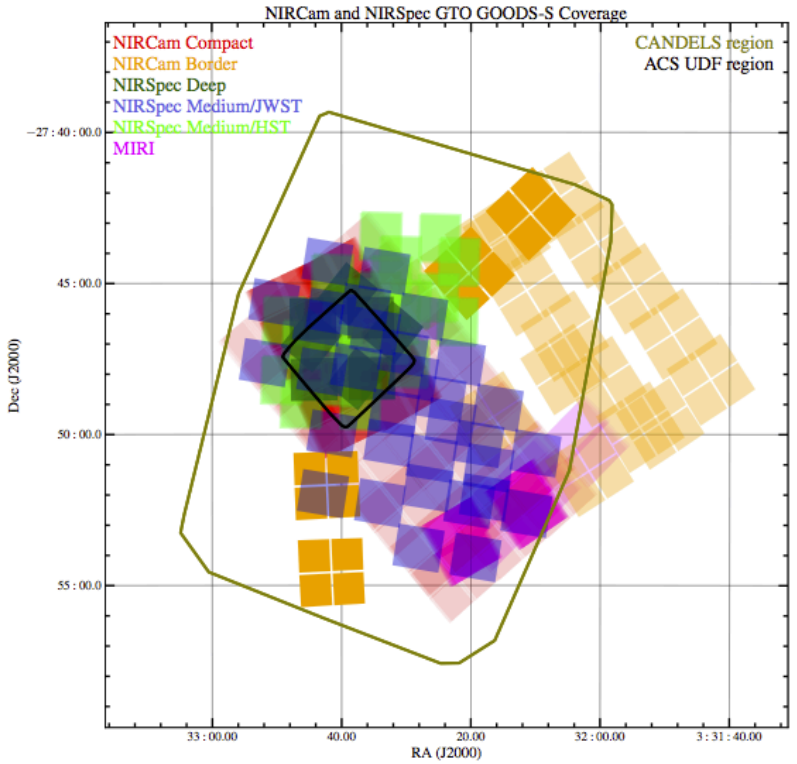
Requires deep, multicolor imaging to provide galaxy samples. Includes mid-IR data to help with accurate mass estimates and increase discovery space.

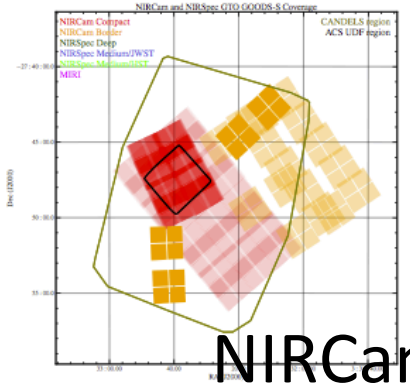
Spectra from 0.6 – 5 μm will enable measurements of redshifts, emission lines, and detailed spectral energy distributions.

The Survey

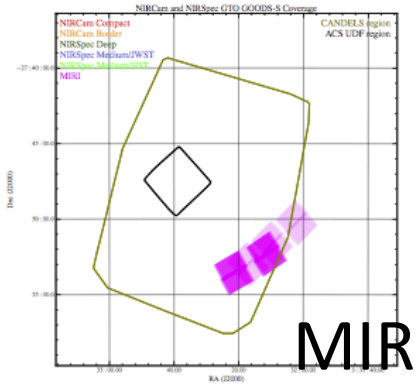
- GOODS-S and GOODS-N
- ’Deep’ and ‘Medium’ Imaging
  - MIRI and NIRCam
- Spectroscopy with NIRSpec
  - HST pre-imaging
  - JWST pre-imaging
- Covers a large portion of CANDELS
- Deep portion covers HUDF

This use case focuses on the NIRCam and MIRI deep imaging

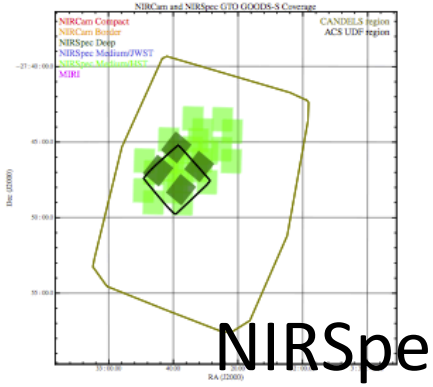




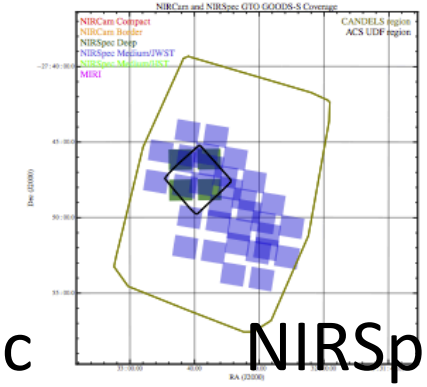
NIRCam



MIRI



NIRSpec



NIRSpec

GOODS-S

What are the Elements of a NIRCam+MIRI Survey?

What data are needed to answer the questions posed?

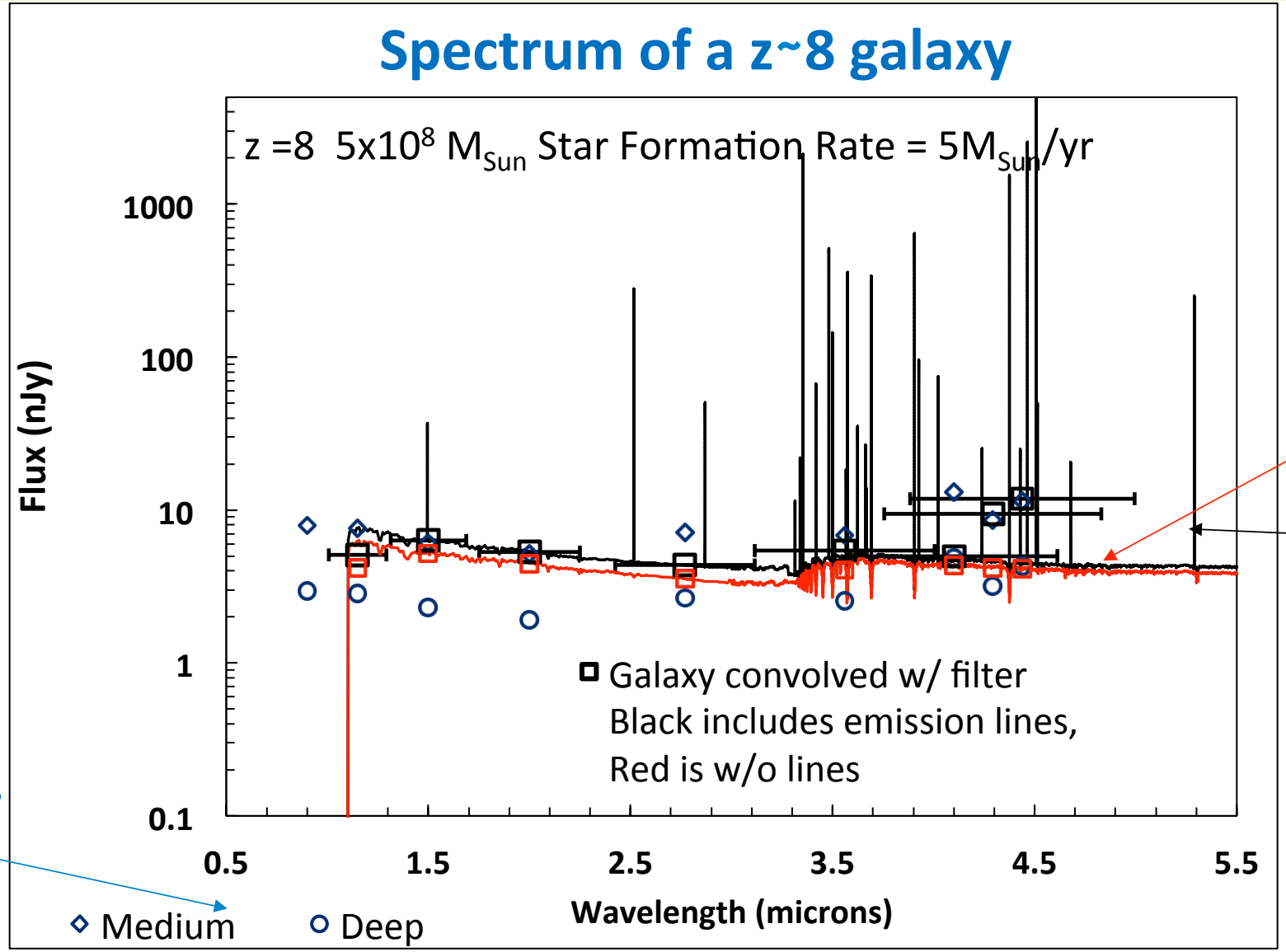
- Characteristics of the sources to be detected
- Density of sources on the sky
- Observing strategies to yield good data in the face of noise sources and cosmic-rays

And then match to capabilities:

- What wavelengths are needed?
- What spatial resolution is needed?
- What sensitivity is required?
- What area needs to be covered?

Science Considerations

Galaxy Characteristics



Stars formed z~12

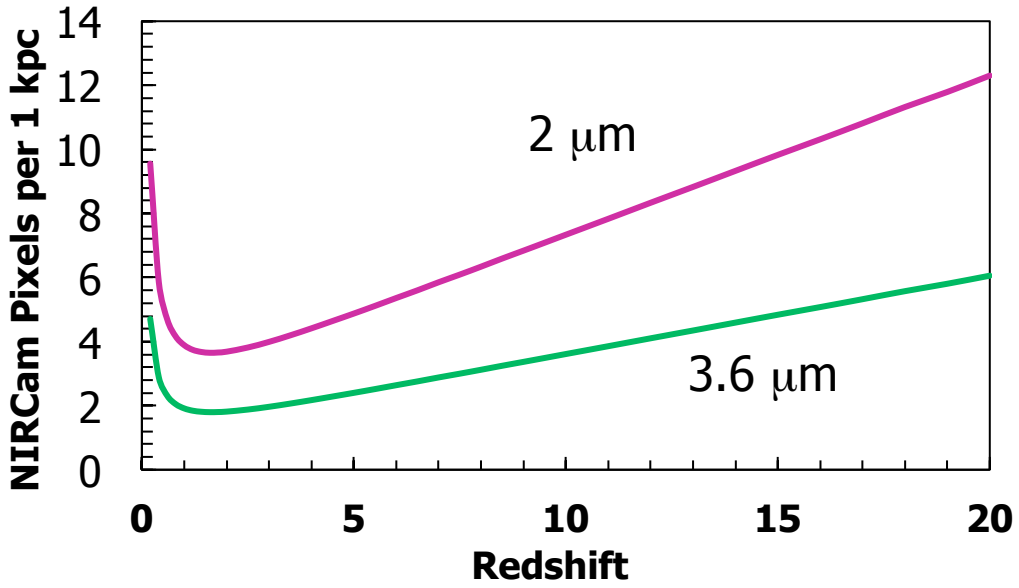
with emission lines

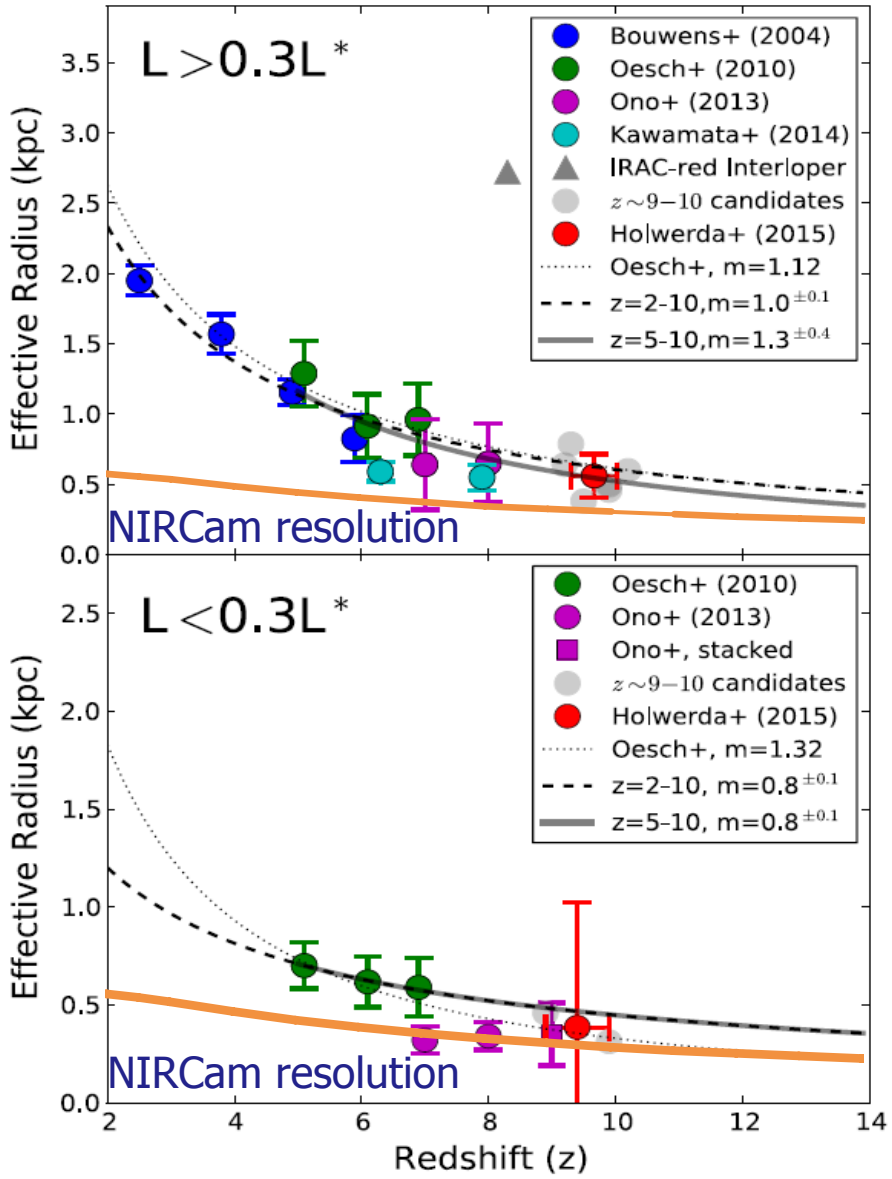
10-σ sensitivity limits

Spectra from Ryan Endsley

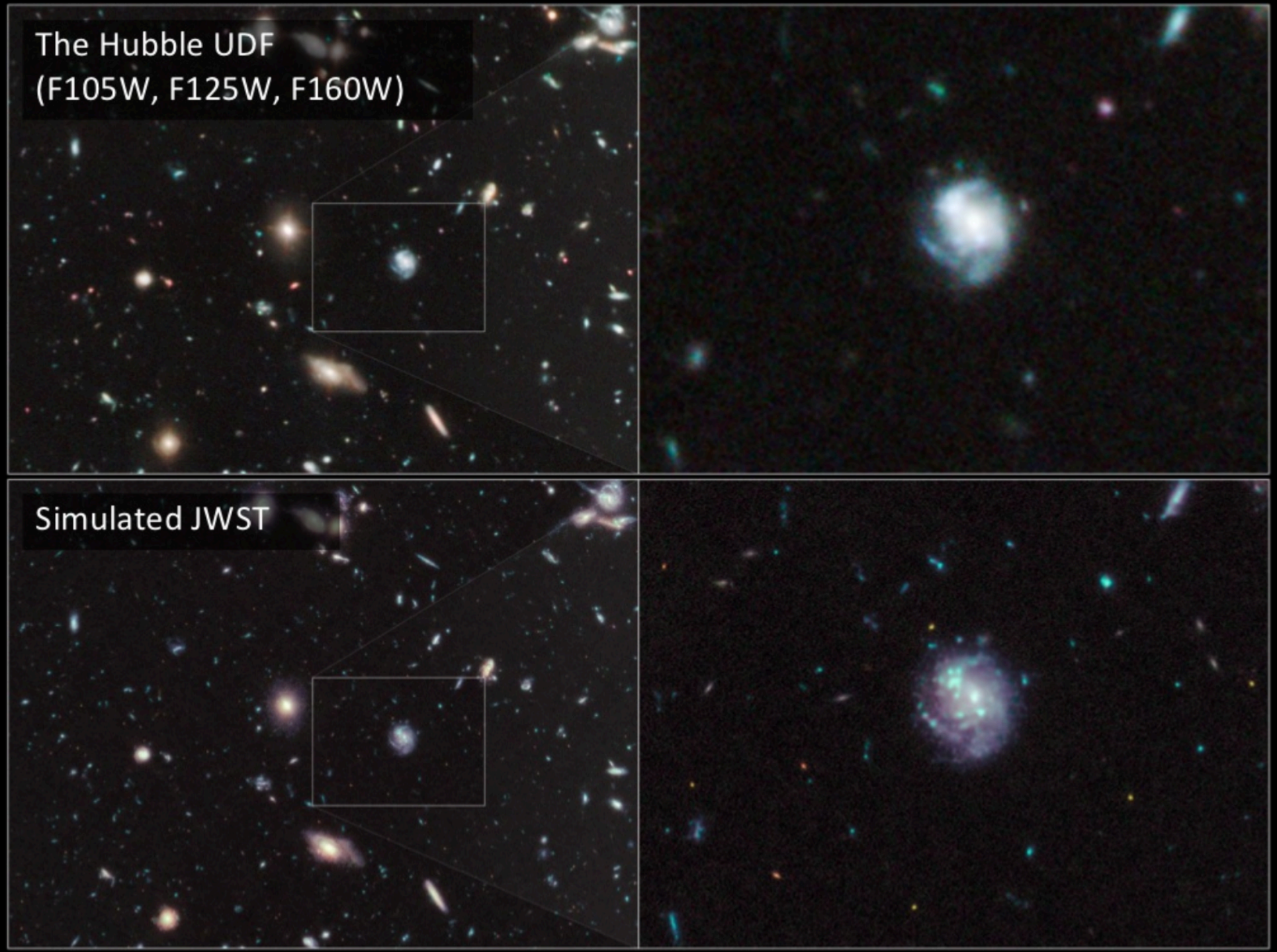
Angular Resolution

JWST + NIRCam have enough resolution to study the structure of distant galaxies. The plots at right show the two-pixel resolution at 2 microns.



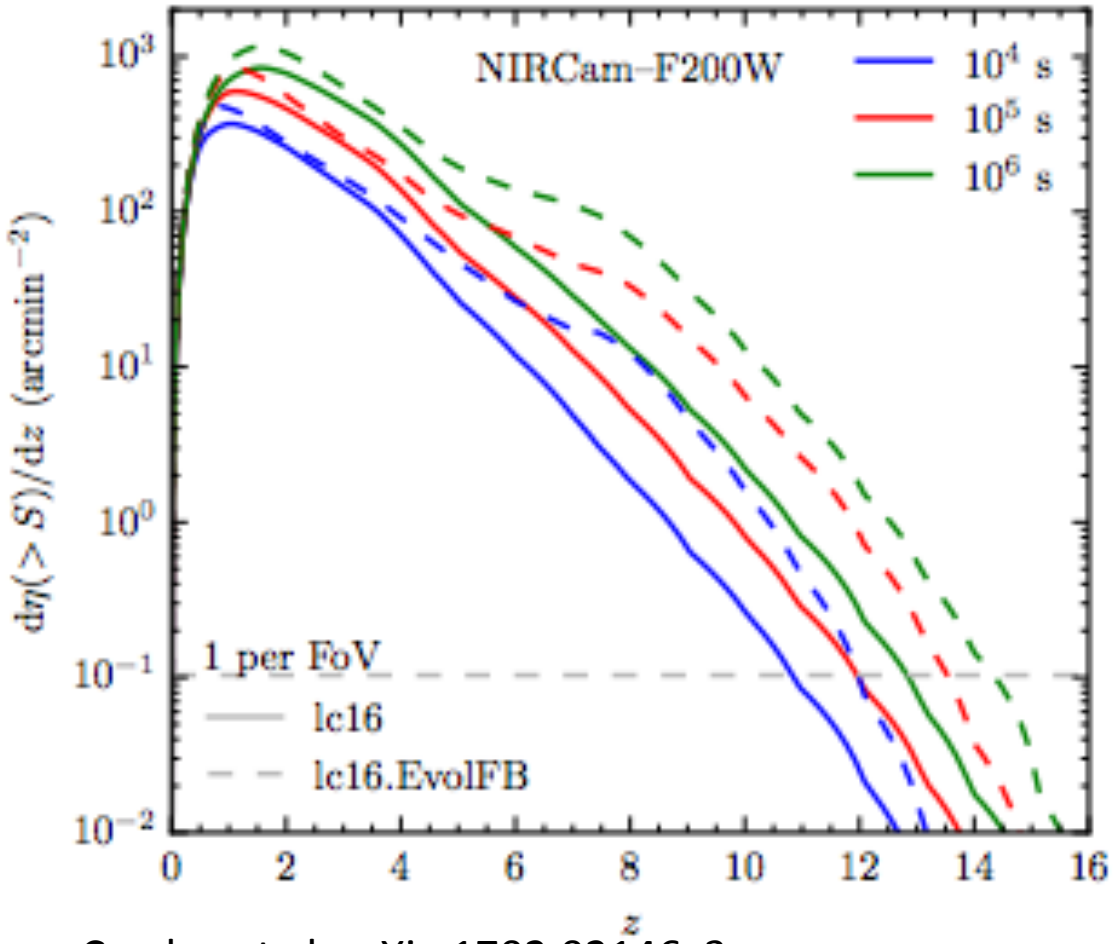


Holwerda et al. (2015, ApJ, 808,6)


The Hubble UDF
(F105W, F125W, F160W)
Simulated JWST

How Much Area is Needed?

Many of the science goals depend on having adequate numbers of galaxies at the highest redshifts.



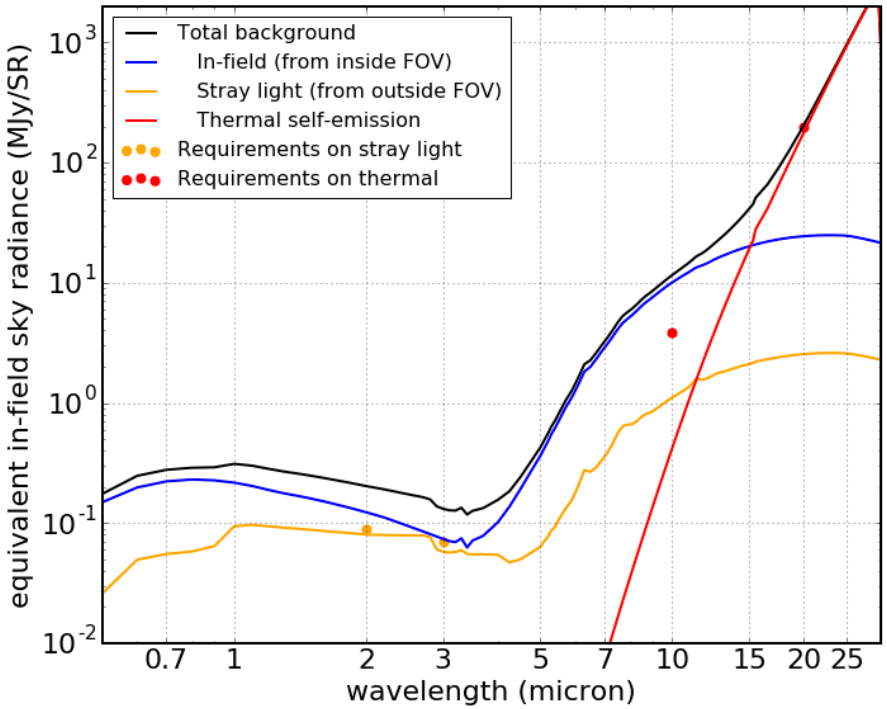
Cowley et al. arXiv:1702.02146v3

Want 10 galaxies at z~12?
Then 10 galaxies/(.1 gal/arcmin^2) = 100 arcmin^2 using 100 ksec of exposure time (if the alternate SF history is correct, only 10 arcmin^2 are needed).

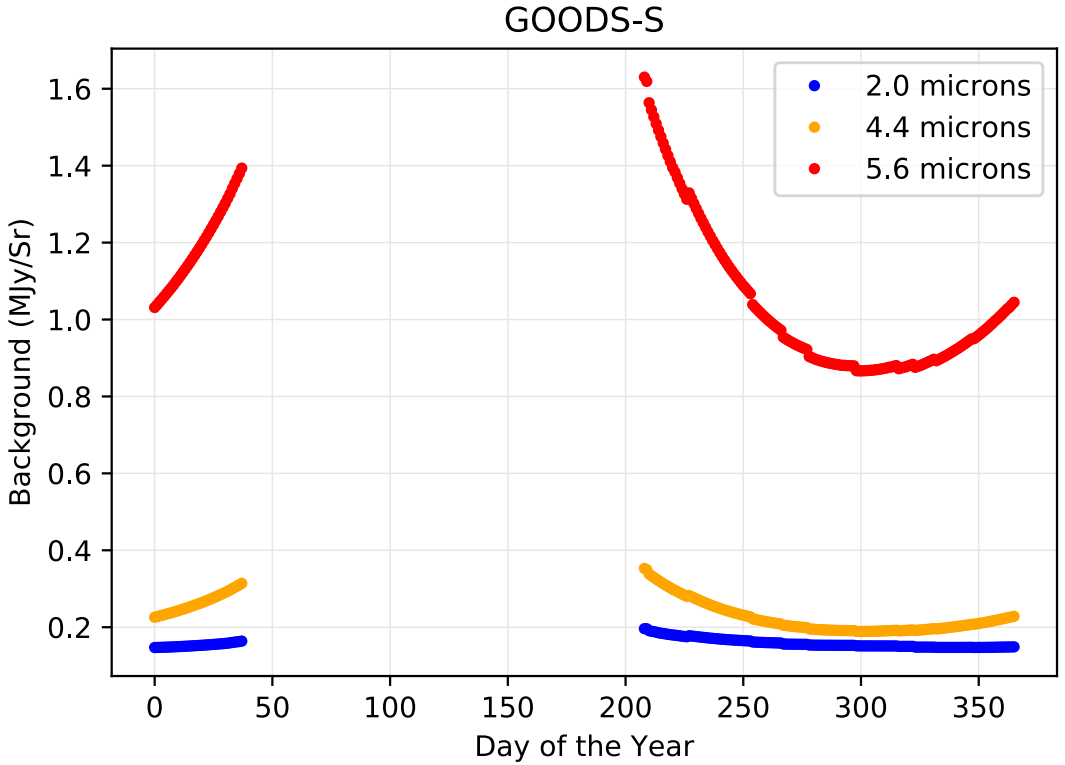
Want 100 galaxies at z~7?
Then 100/(5 gal/arcmin^2) = 20 arcmin^2 using 10 ksec of exposure time.

Here: we cover ~25 arcmin^2 to 30-50 ksec, so we expect 1-15 galaxies at z~12.

Sky Background Considerations



Rapid increase at longer wavelengths is due to thermal emission from zodiacal light. Better to use shorter wavelengths in MIRI.

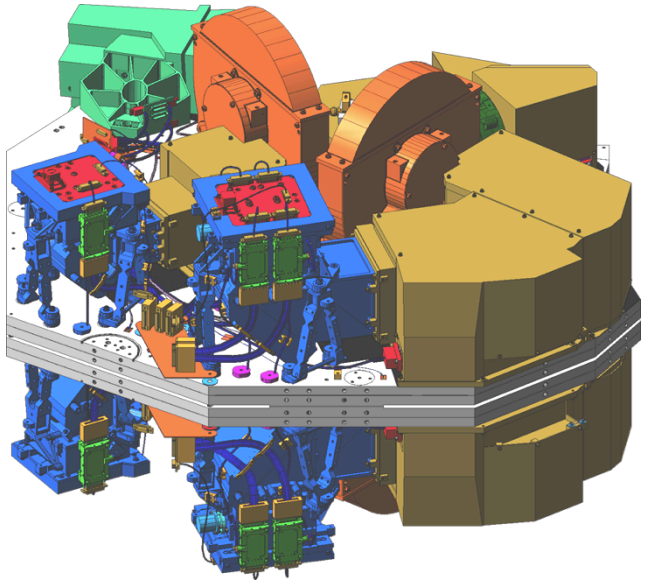


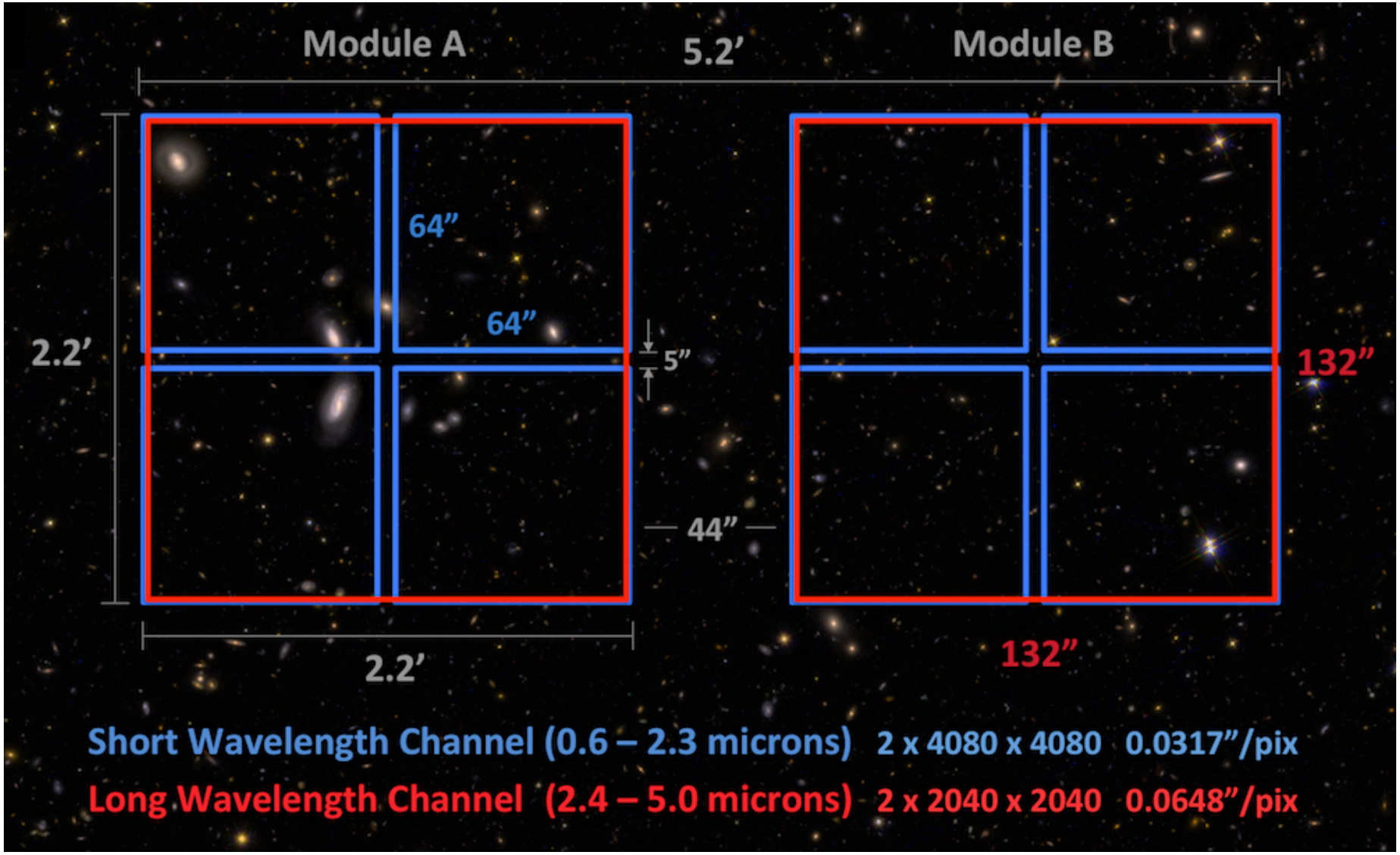
At F444W, there is a ~50% increase in the background near the edges of the visibility window.

Observations

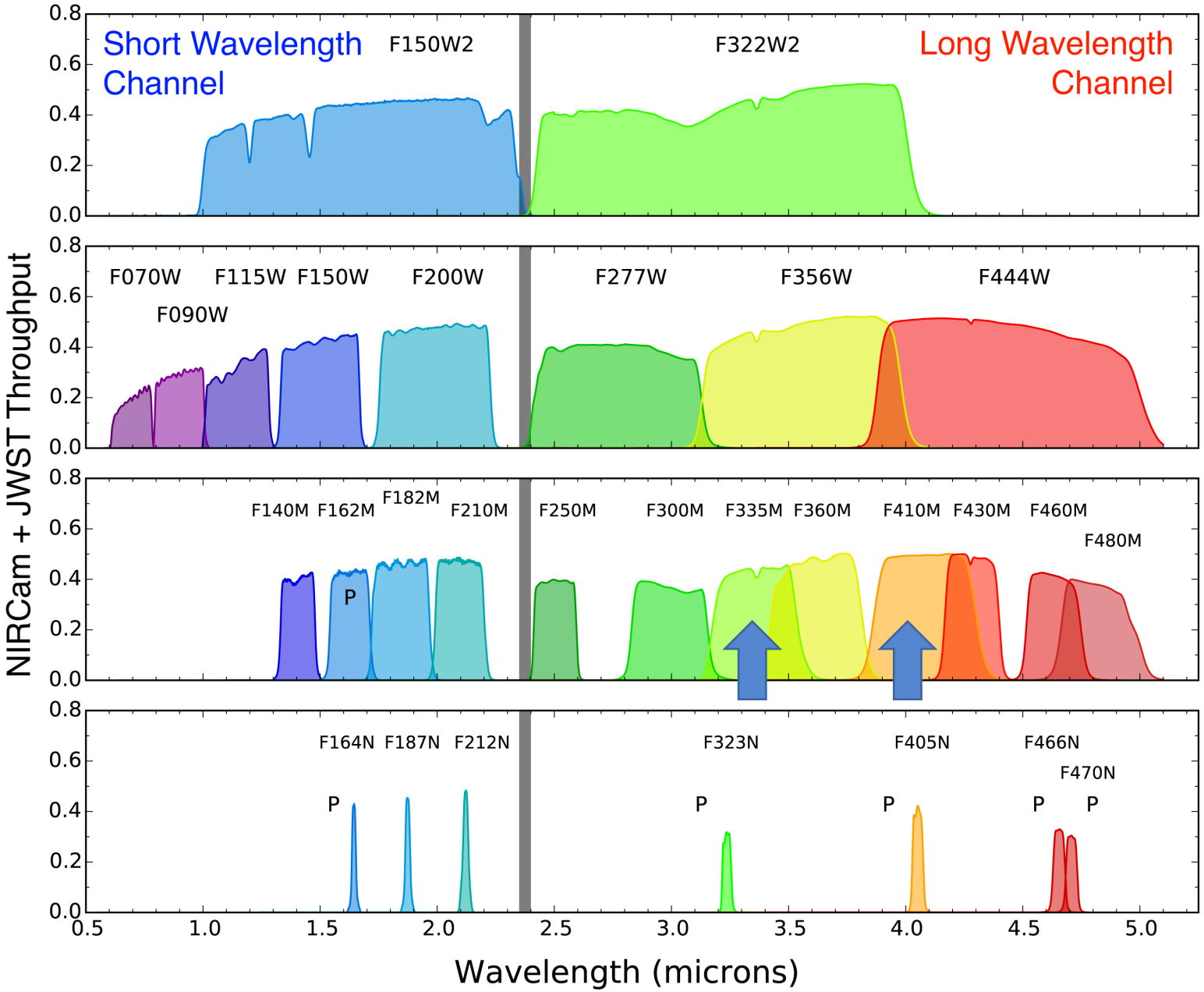
NIRCam FOV

Pixel scales critically sample image at 2 and 4 microns



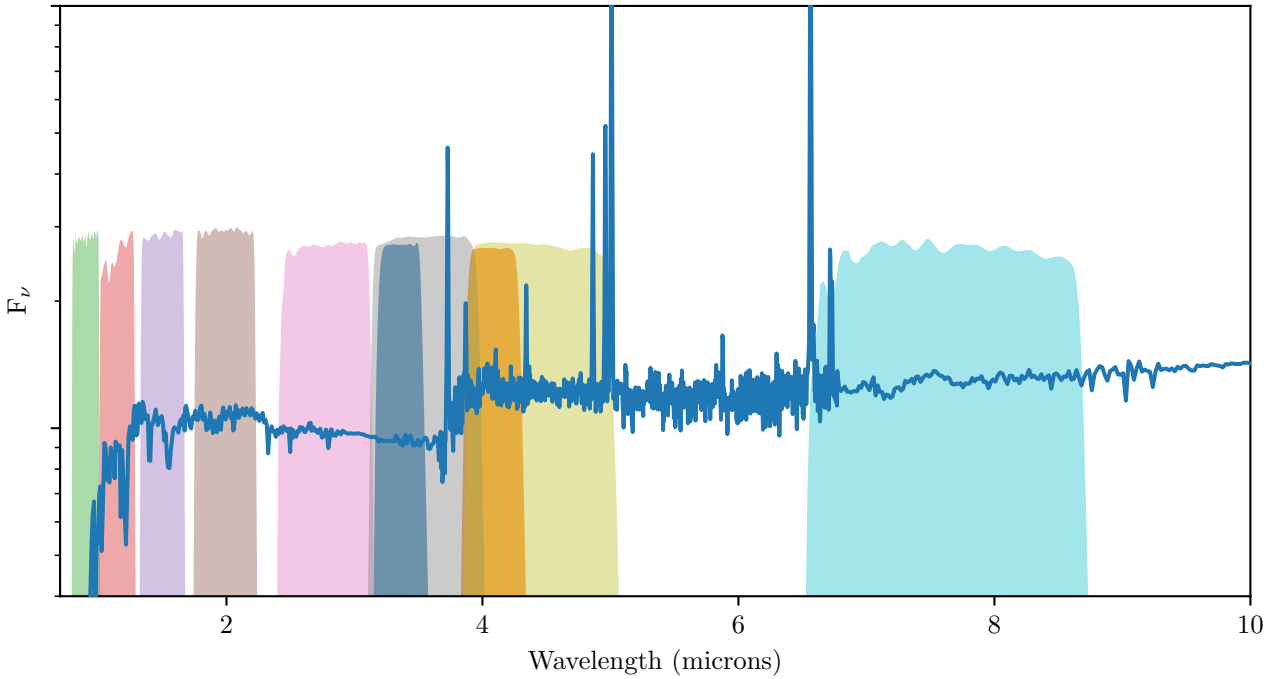


NIRCam Filters

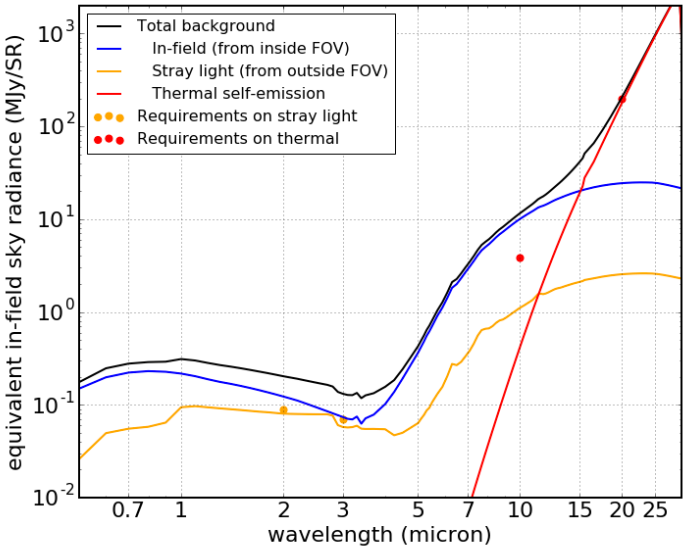


Using all wide filters (except F070W) and 2 medium filters.

Filter selection

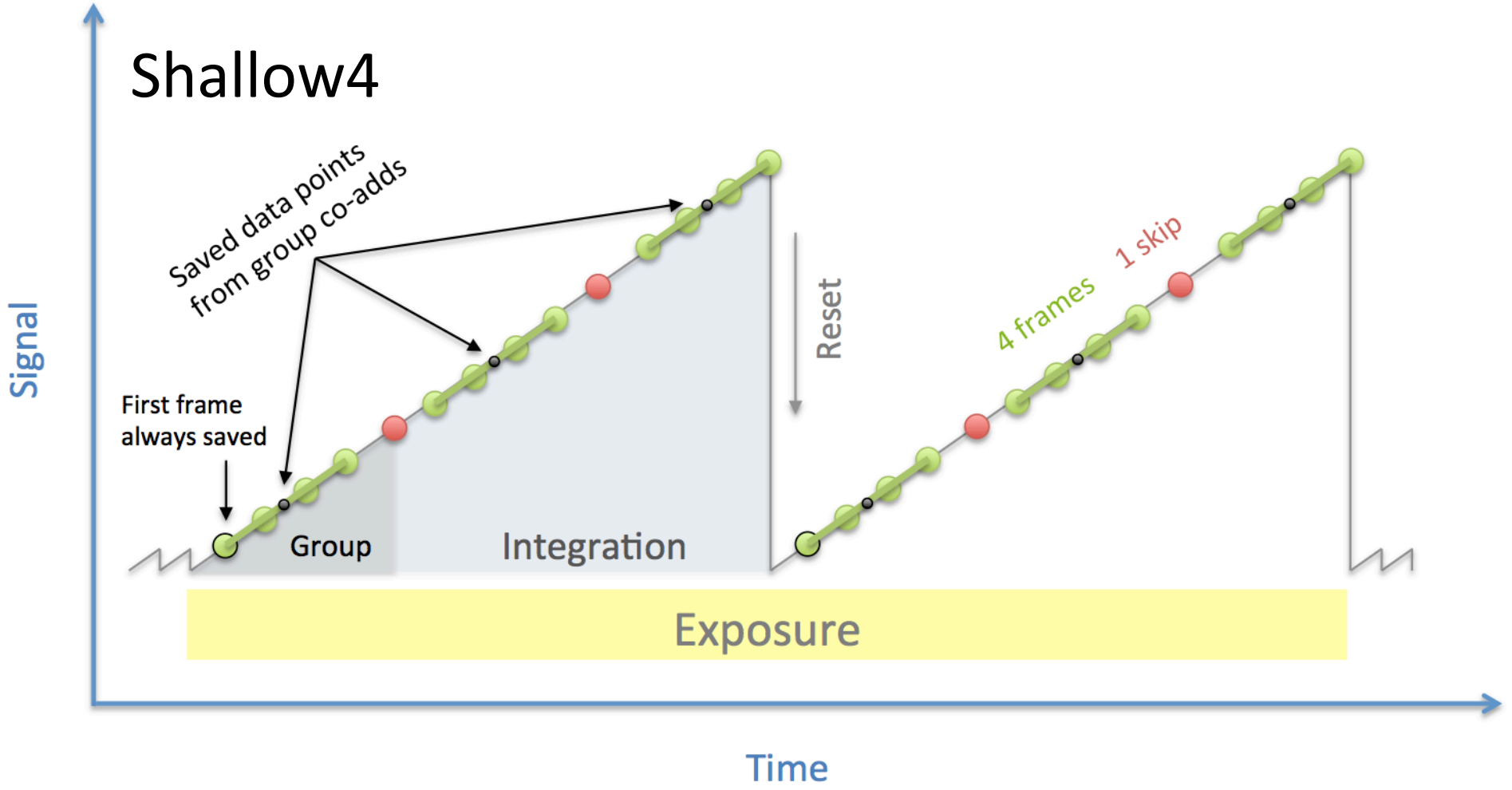


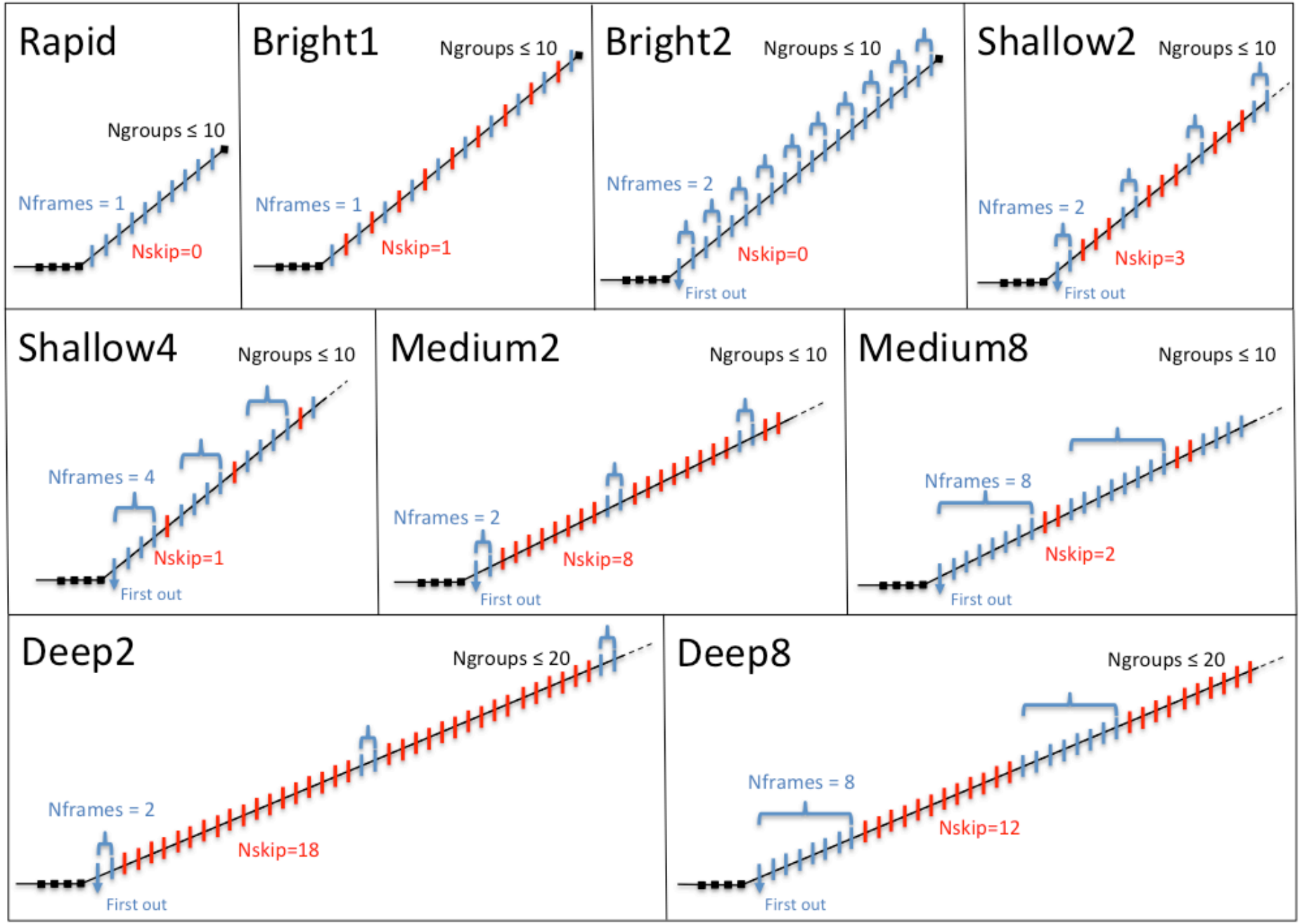
Using 9 filters to cover 0.9 to 5 microns
F410M has essentially the same sensitivity as F444W but adds some z discrimination, as does F335M



Exposure Readouts

- One Exposure
- Two integrations
- Three Groups
- Four Reads
- One Skip

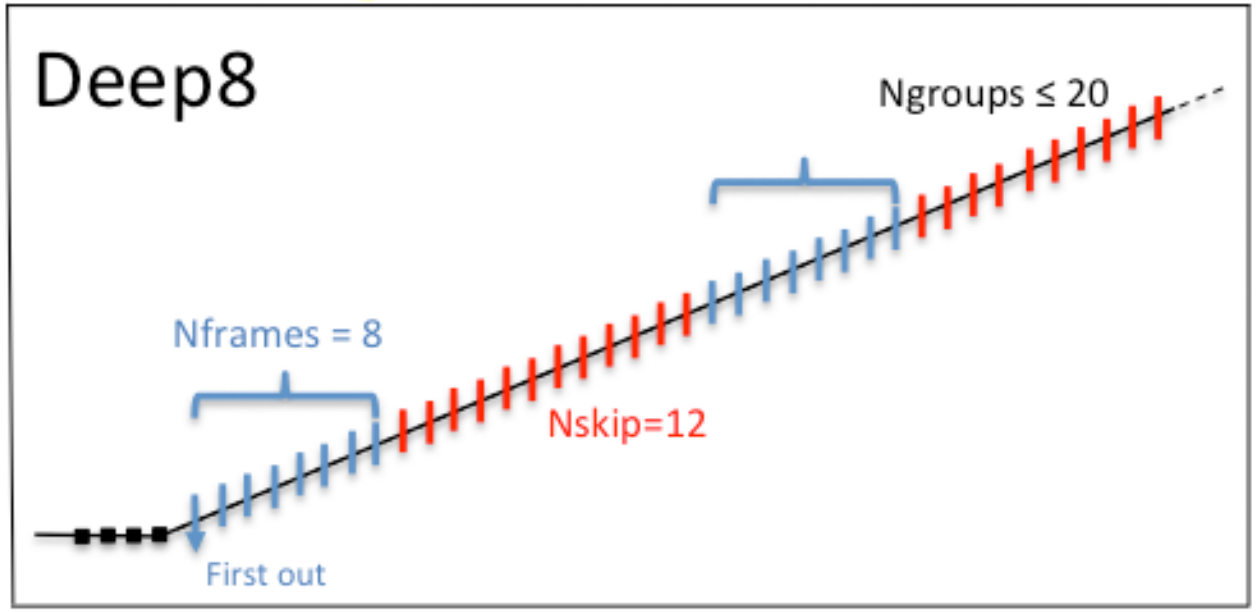




e.g., See Robberto 2010 JWST-STScI-2100
"NIRCam Optimal Readout II: General Case (Including Photon Noise)"

Readout Pattern

- Several competing factors:
  - Longer exposures to reduce overheads
  - Shorter exposures to reduce cosmic-ray hit effects
  - Co-added data to reduce data volume
- Best choice for deep imaging is “DEEP8” with 5 to 7 GROUPS



NGROUPS	Integ Time (sec)
5	944.8
6	1159.6
7	1374.3

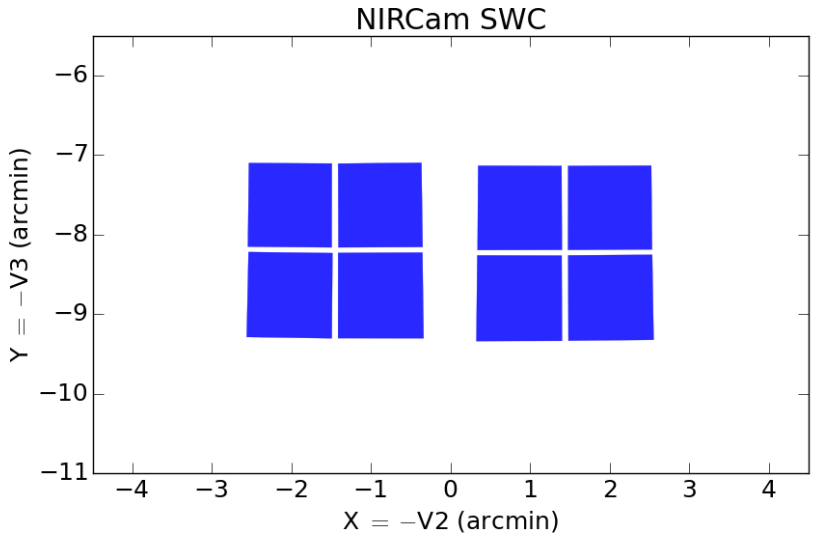
With more groups, cosmic rays become an issue.

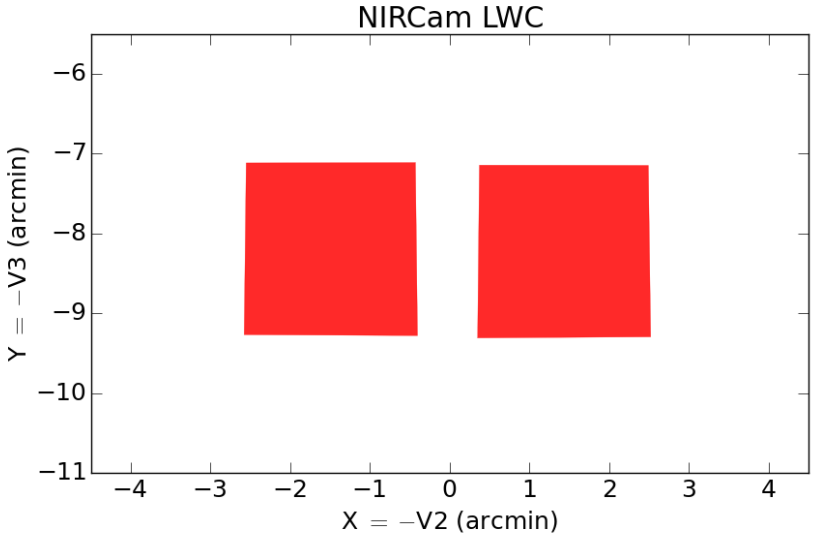
NIRCam Primary Dithers

Three primary dither types for even spatial coverage across module and detector gaps.

Three sizes:

- INTRASCA: Objects smaller than the individual SCA detectors (<50” or <100” for short or long wavelength observations, respectively).
- INTRAMODULE*: Objects smaller than the individual module (<110”).
- FULL*: Large fields without gaps, including mosaics





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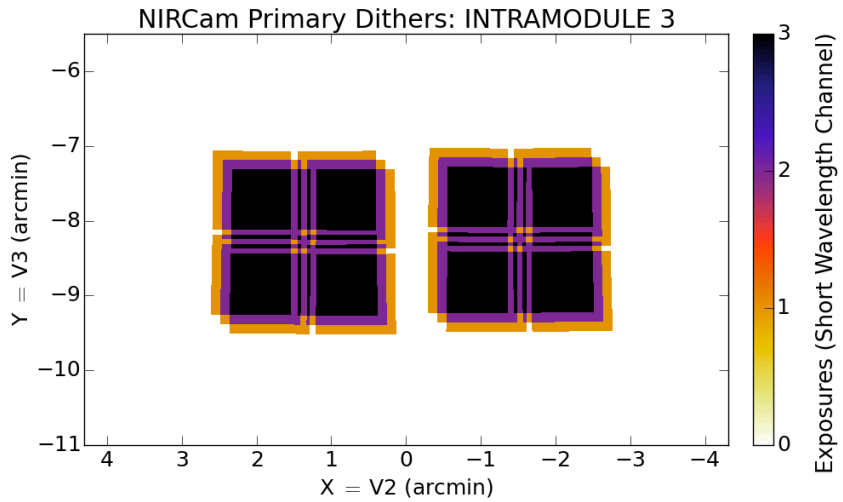
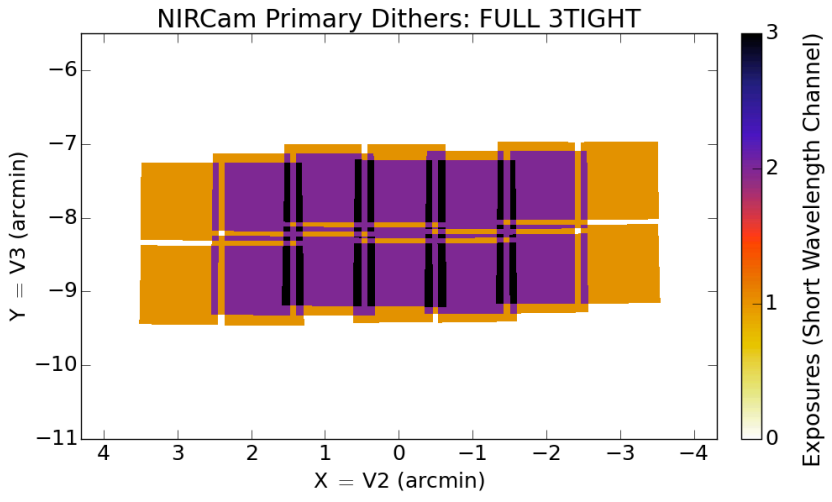
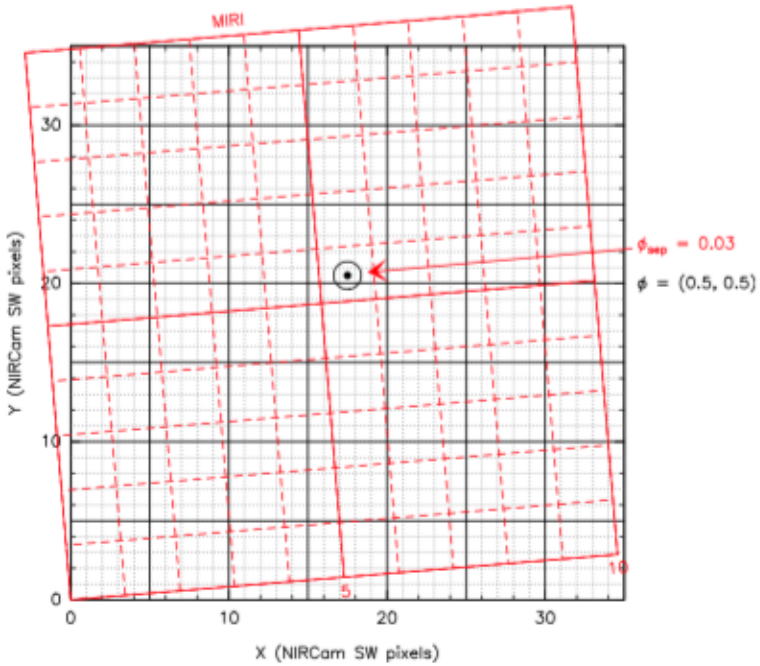




Coordinated Parallel Subpixel Dithers

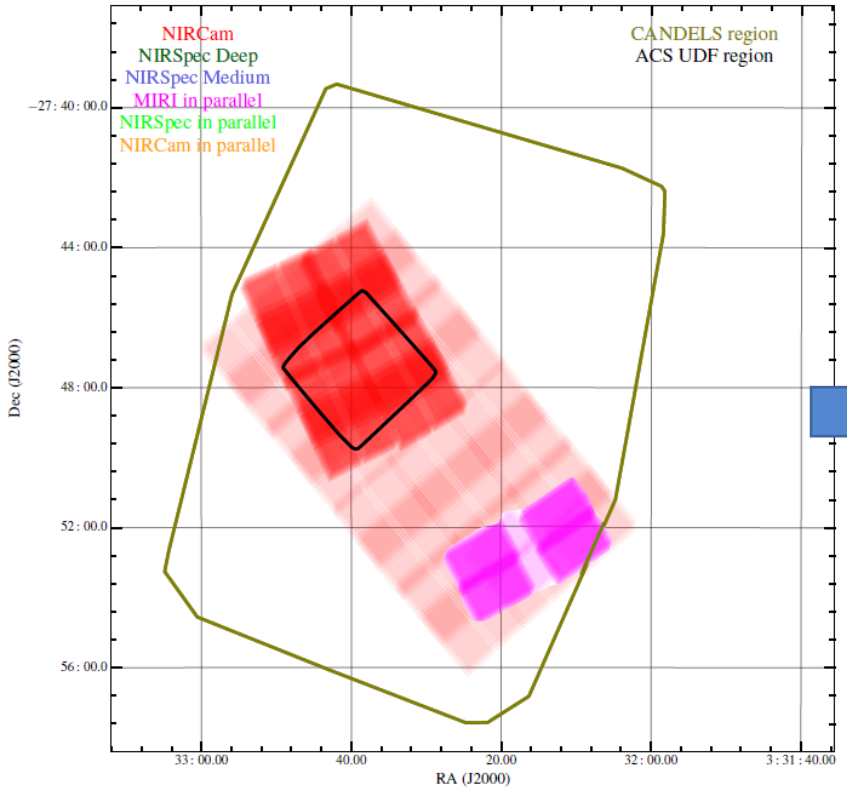
Subpixel sampling improves image reconstruction and mitigates the effect of bad detector pixels. NIRCam is undersampled below 2 μm in the short-wave channel and 4 μm in the long-wave channel.

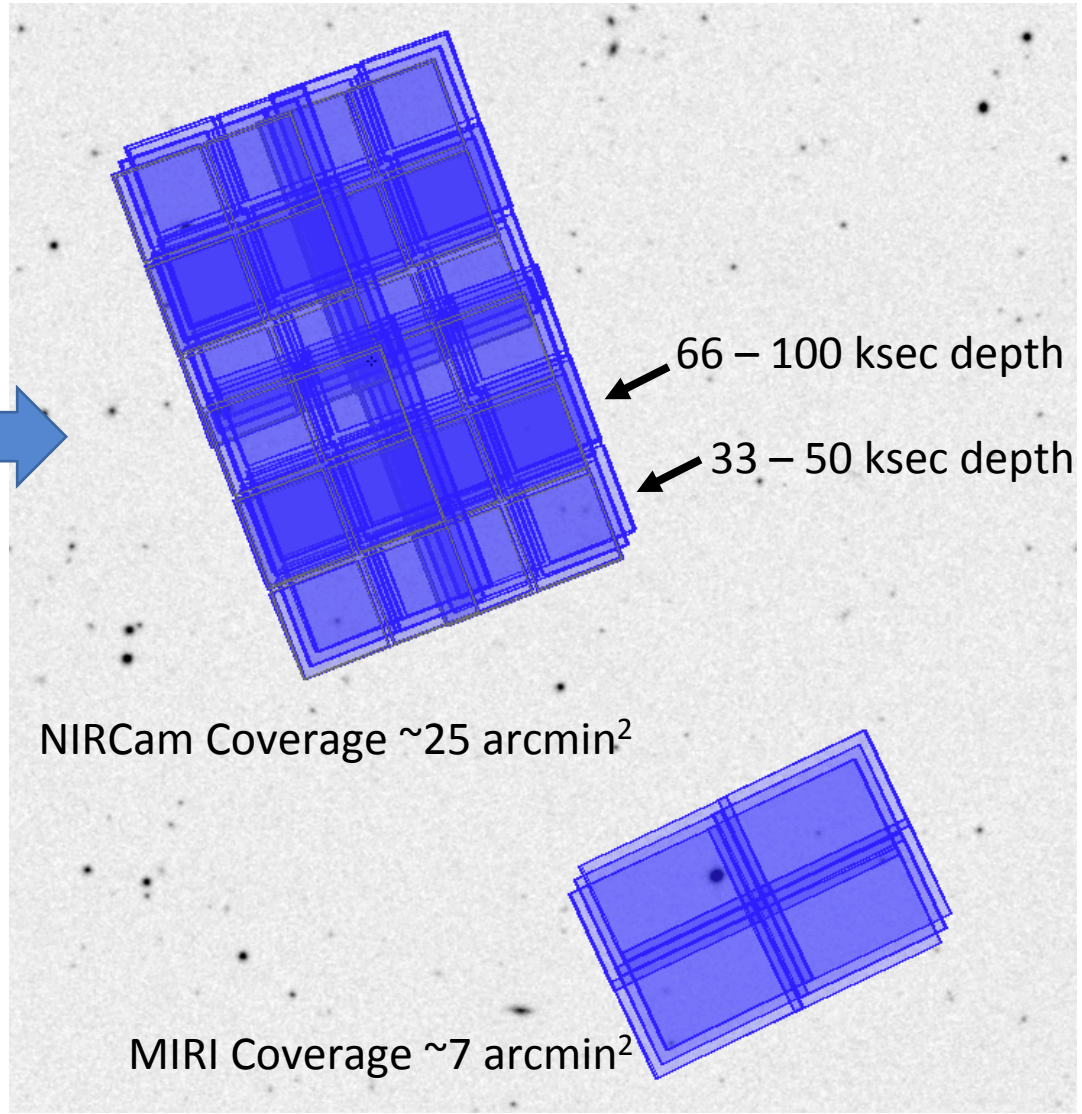
- Different instrument orientations and plate scales
- Patterns keep pixel phases 'ideal' to within 0.05 pix for parallel instruments.
  - Exception: MIRI at >12 μm (well sampled anyway)
  - Dither patterns involving MIRI customized for each filter
  - Here: 3-POINT-WITH-MIRI-F770W



P. Goudfrooij

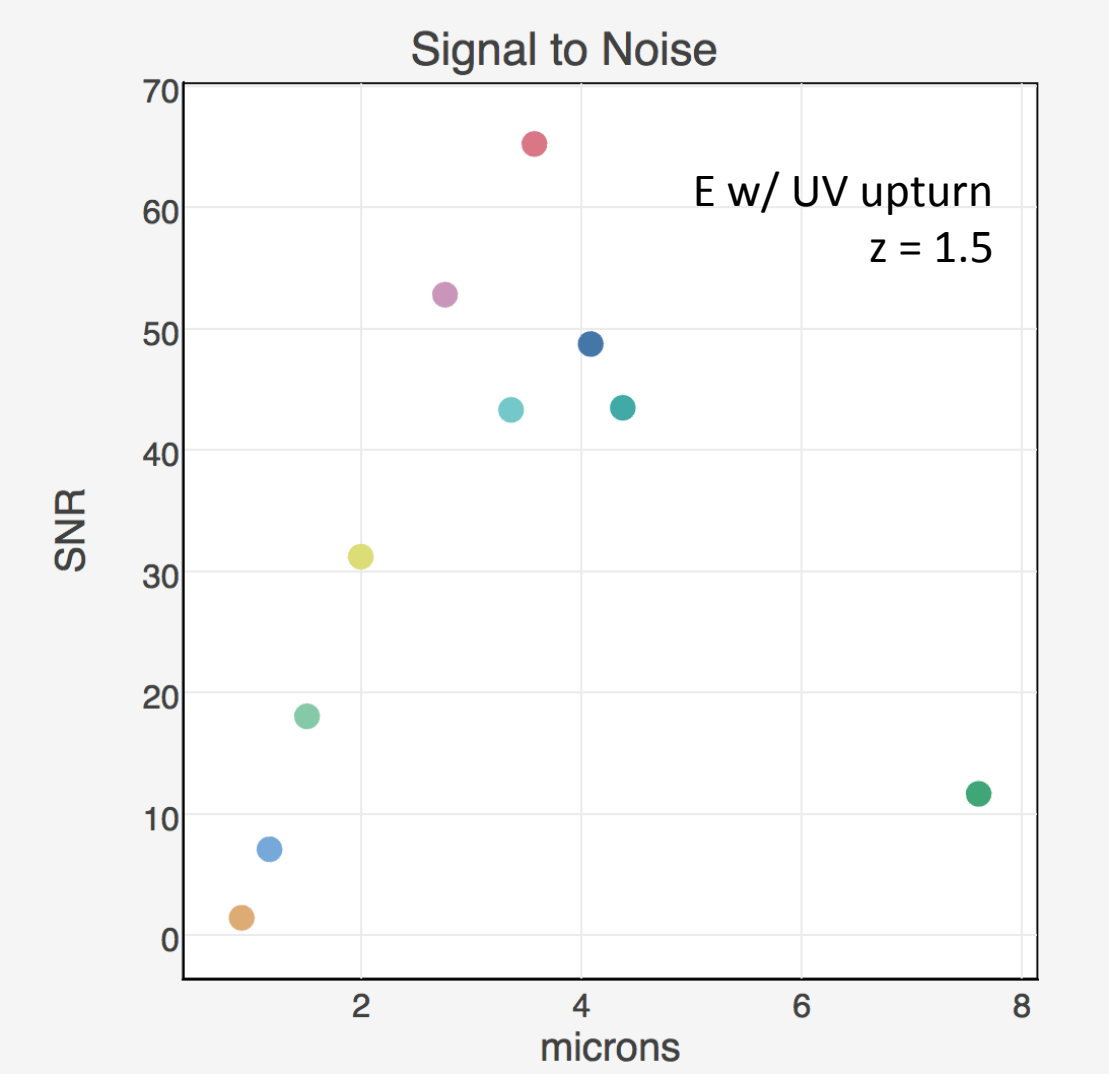
Coverage & Depth

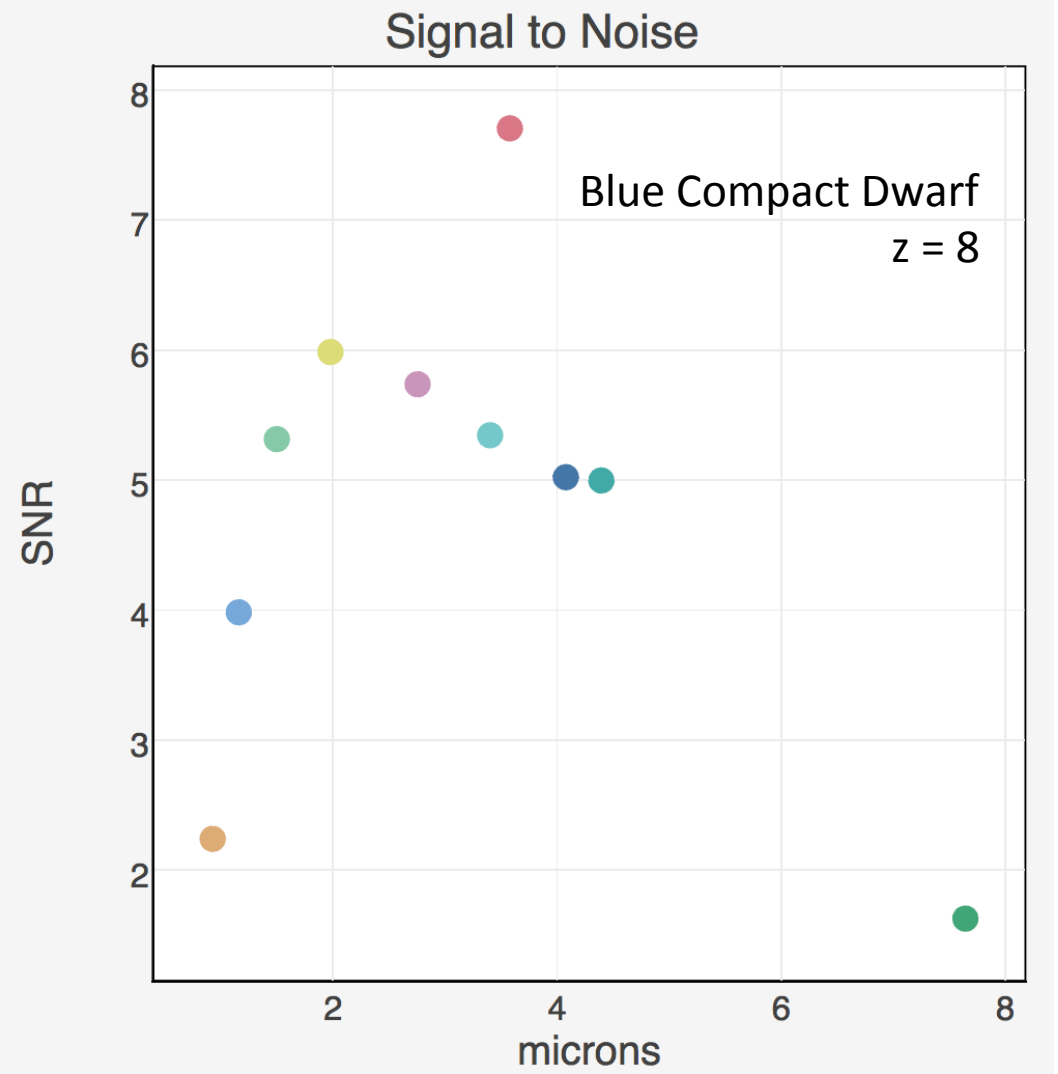




Primary Dithers: Cover the detector gaps
Subpixel Dithers: Improve pixel sampling

ETC and Sensitivity





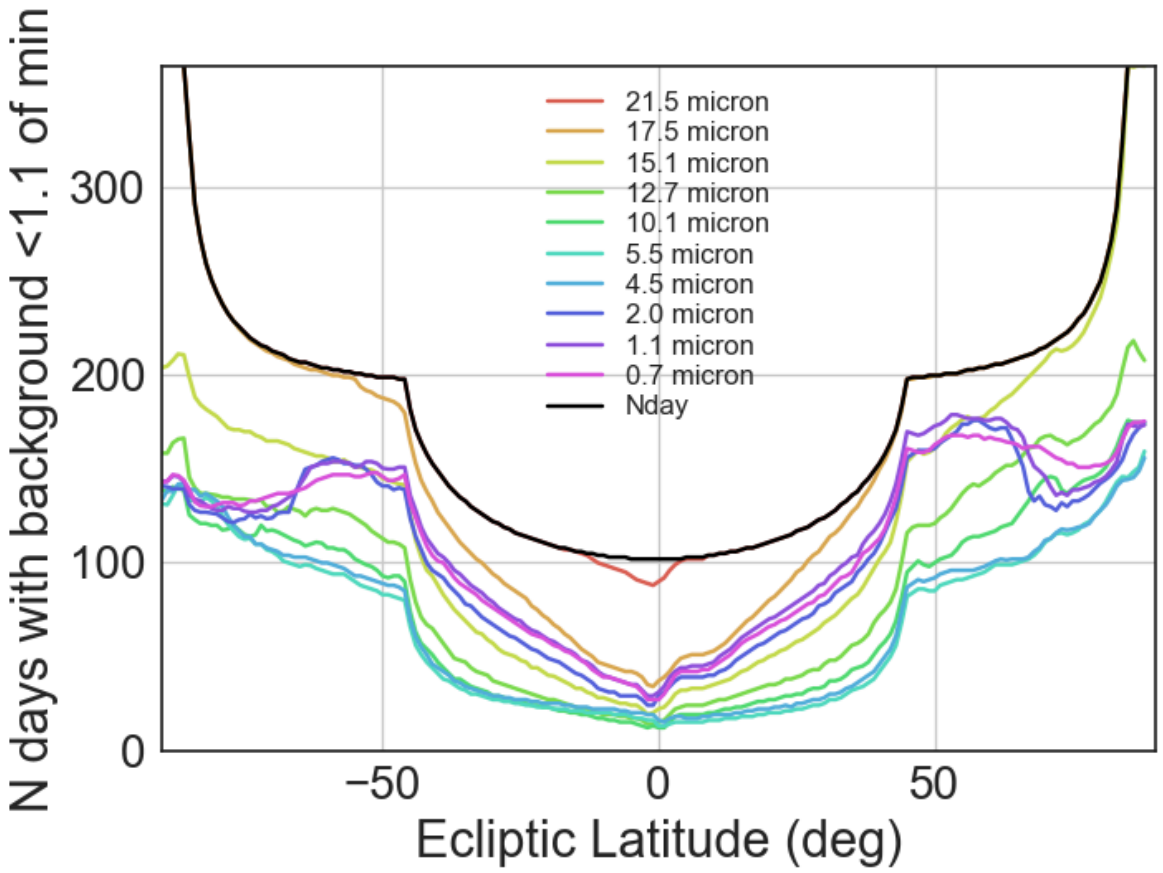
Schedulability

Background
- ~275 hours (220 hrs science)
- Ecliptic latitude: -45 deg
- N days w/ ‘low’ background ~25-90

Data Volume
- 36-46 GB per visit
- SSR limit: 58.8 GB
- Downlink limit: 28.6 GB

Visit Length
- Longest is ~11 hrs
- Downlink in every 12 hrs

Position Angle
- 280^{o}-300^{o}
- Restriction to keep parallels in GOODS-S and to match coverage from other instruments in GTO program.



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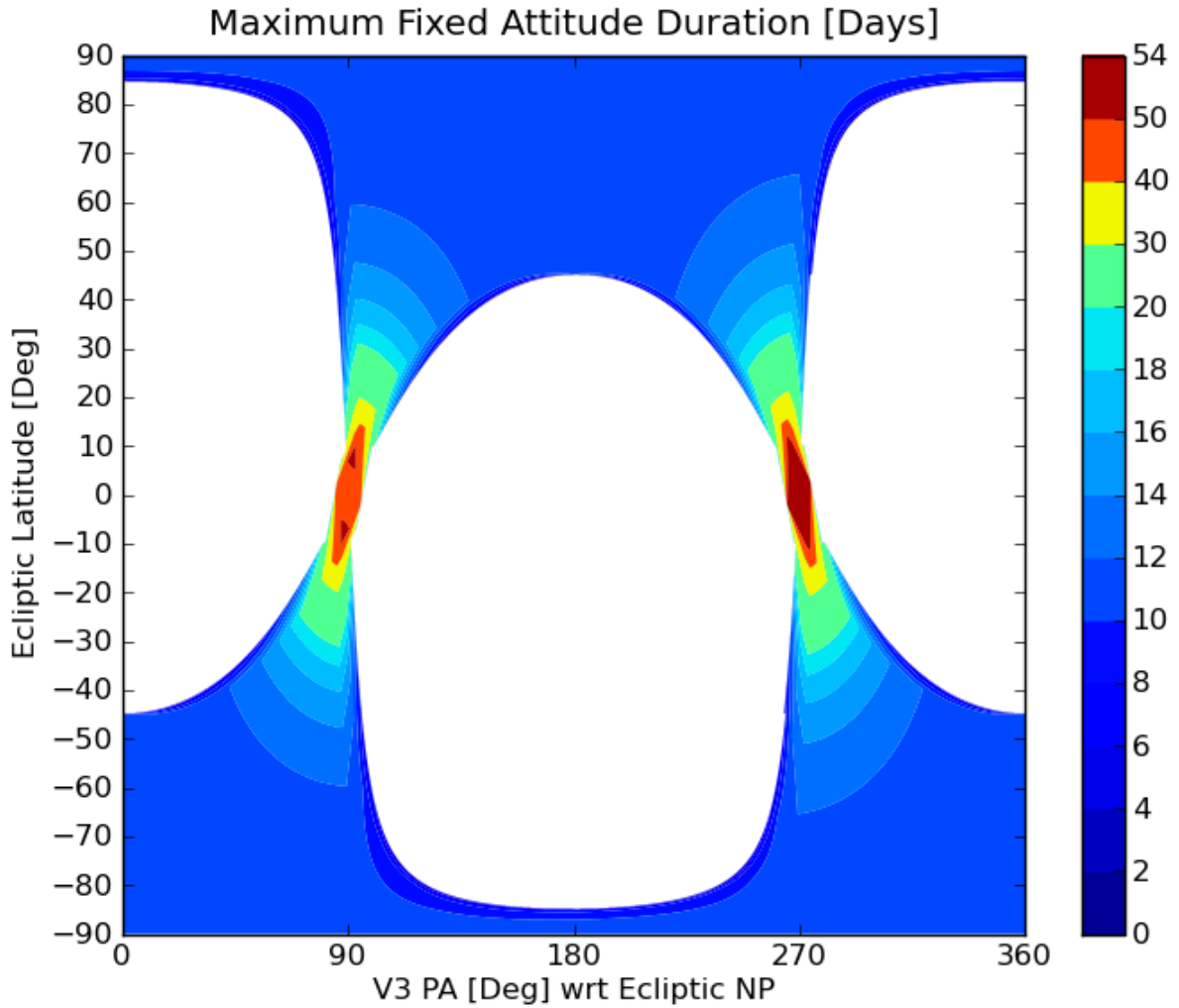


Planning a Deep NIRCam Survey
NIRCam and MIRI Coordinated Parallel Imaging

Exposure Time Calculator (Workbook #11279)

Massimo Robberto (STScI, NIRCam Team Lead)
Martha Boyer (STScI, NIRCam Team)

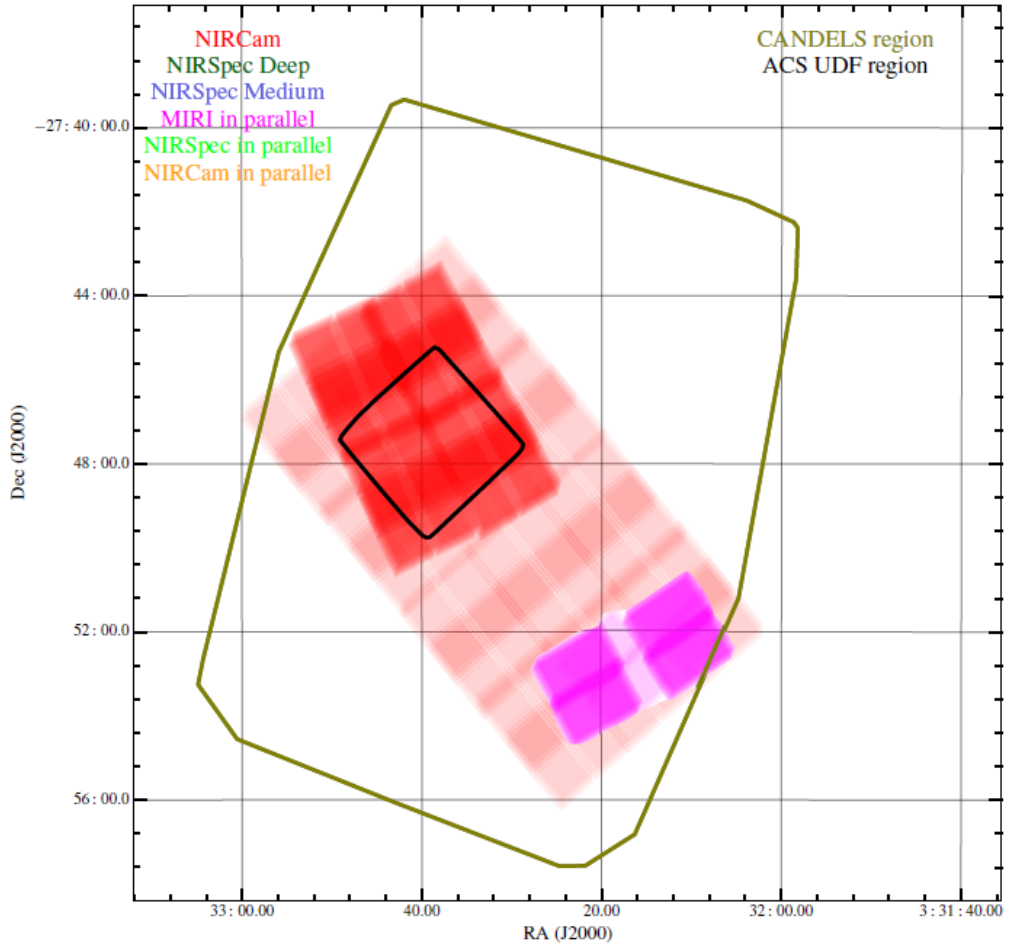
Adapted from the NIRCam-NIRSpec joint GTO program

STScI

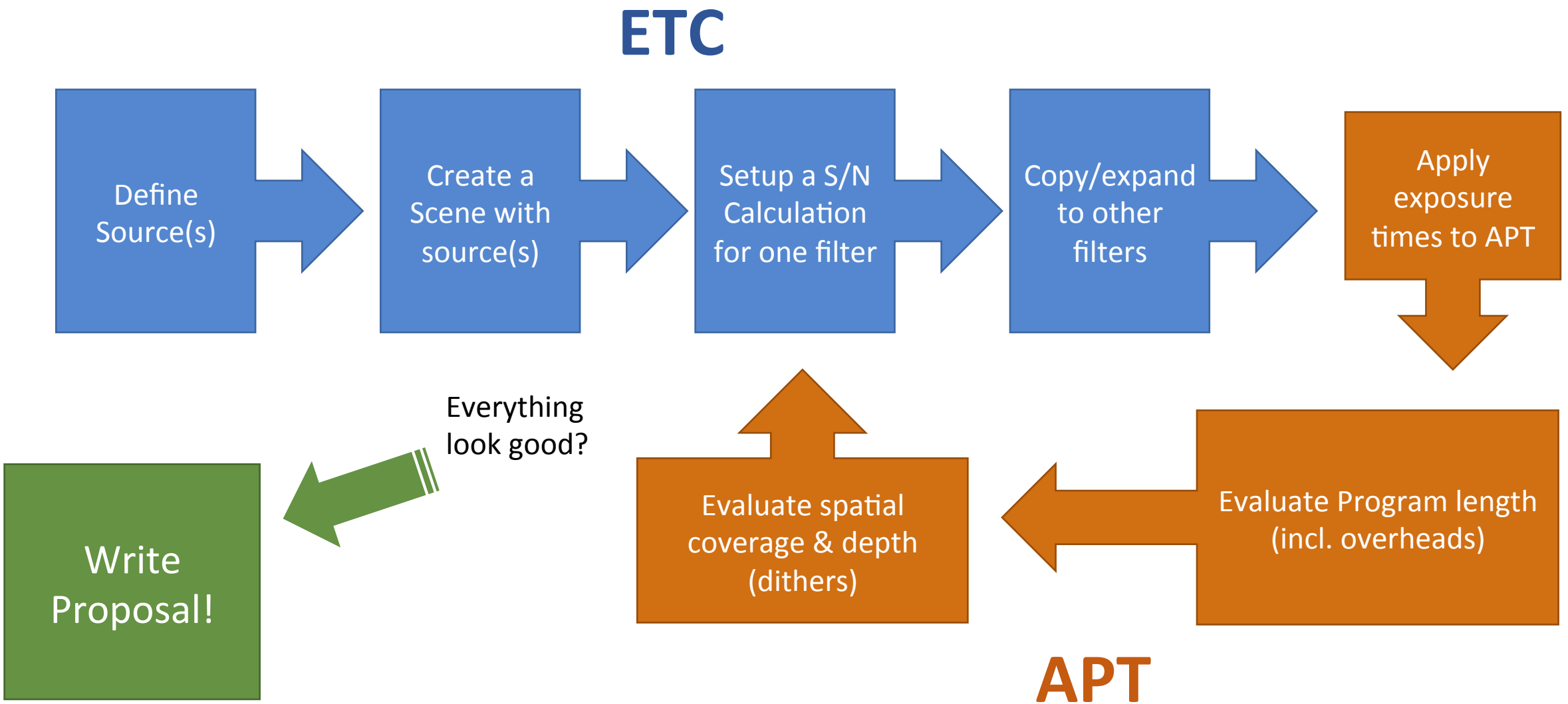
JWST Event, Tenerife, March 2017

Observation Characteristics

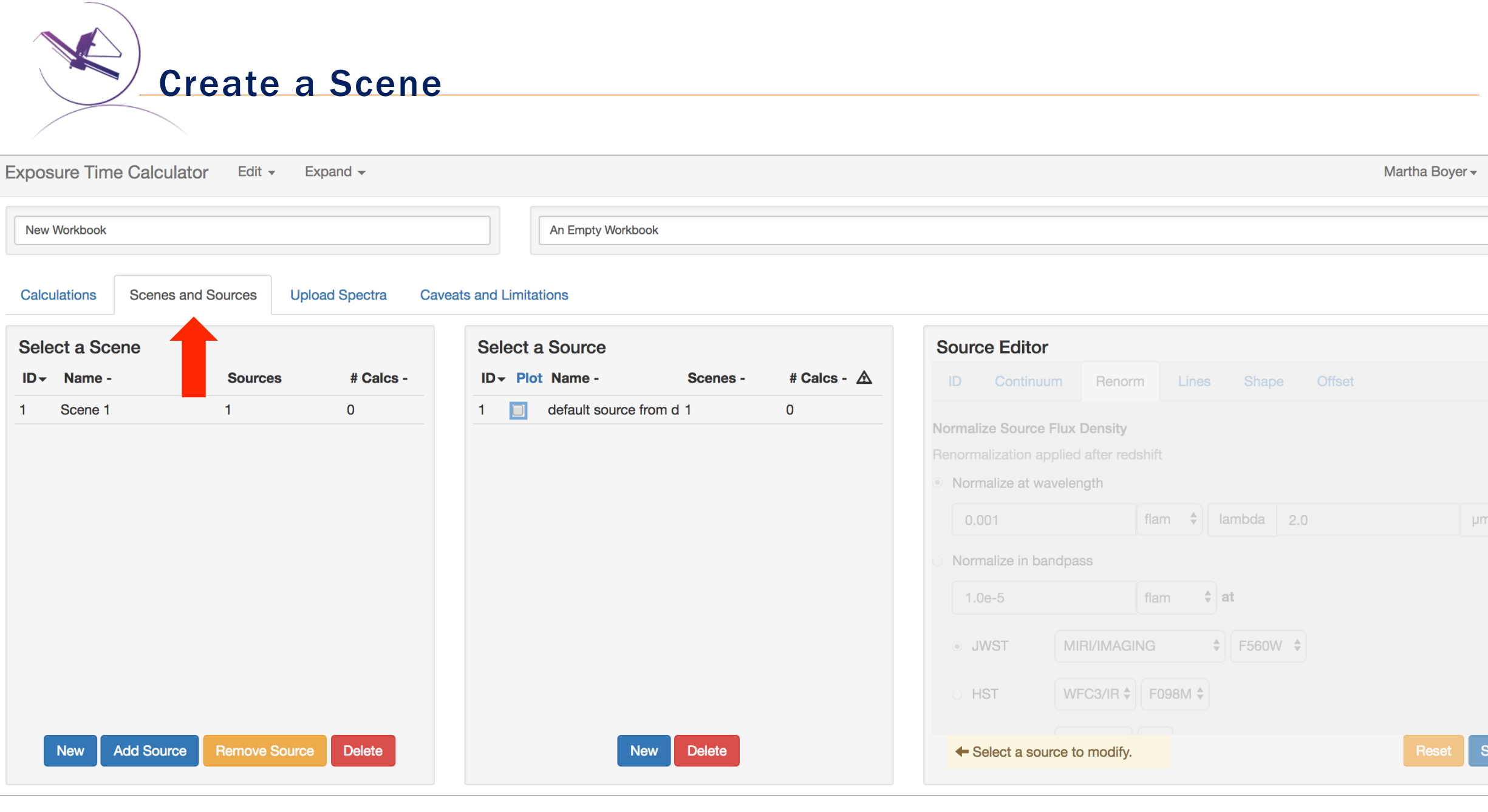
- **Template:** NIRCam Imaging
  - w/ MIRI Imaging in Parallel
- **Coverage:** ~25 arcmin^2 for NIRCam
- **Depth:** ~33-100 ksec (depending on filter)
- **SW NIRCam Filters:** F090W, F115W, F150W, F200W
- **LW Wide NIRCam Filters:** F277W, F356W, F444W
- **LW Medium NIRCam Filters:** F335M, F410M
- **MIRI Filter:** F770W



ETC-APT Workflow

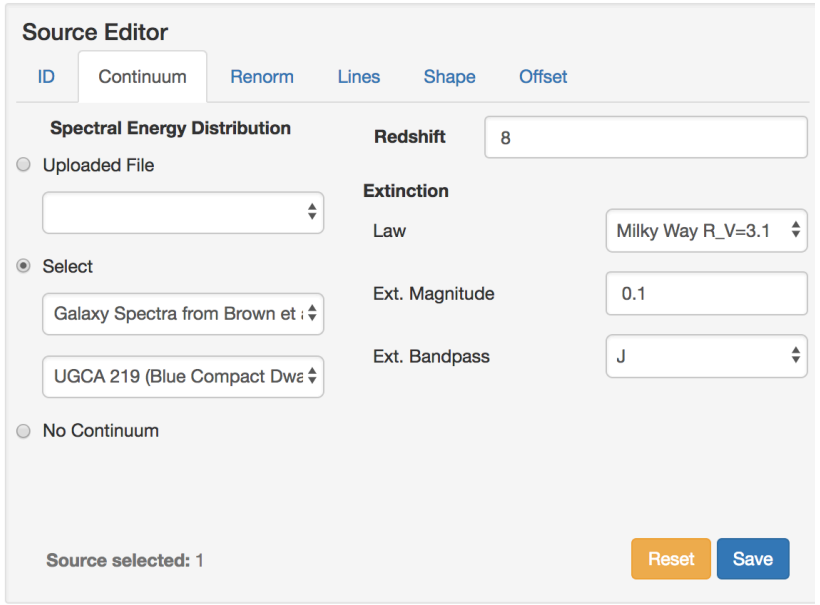


Create a Scene

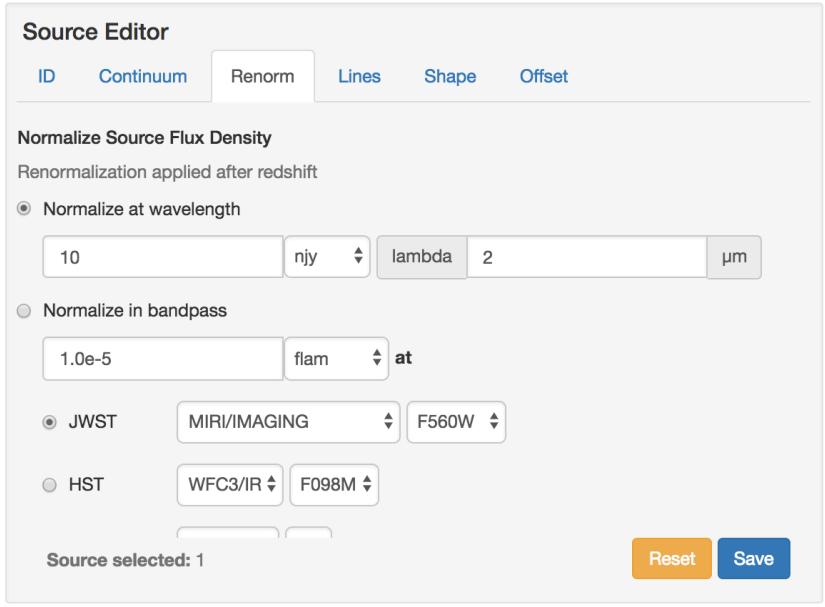


Source: z=8 galaxy

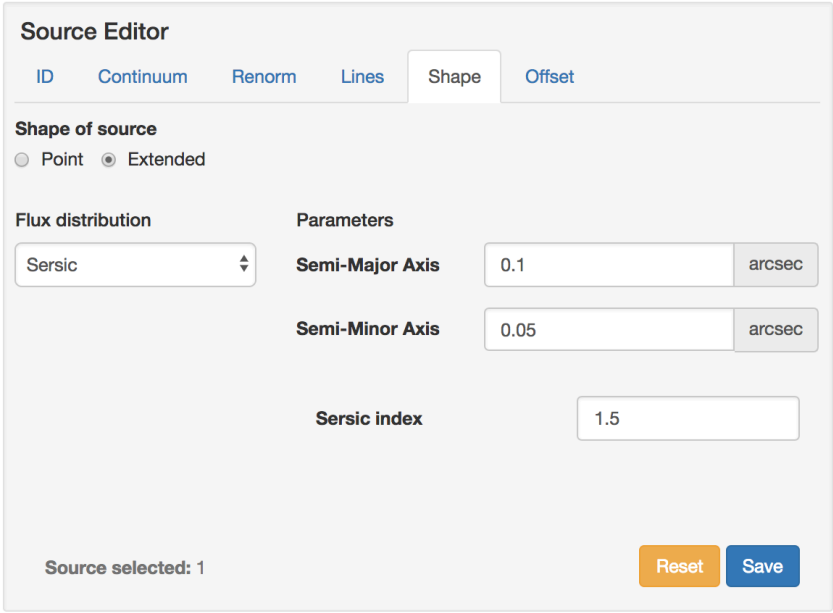
Continuum



Renormalization



Shape



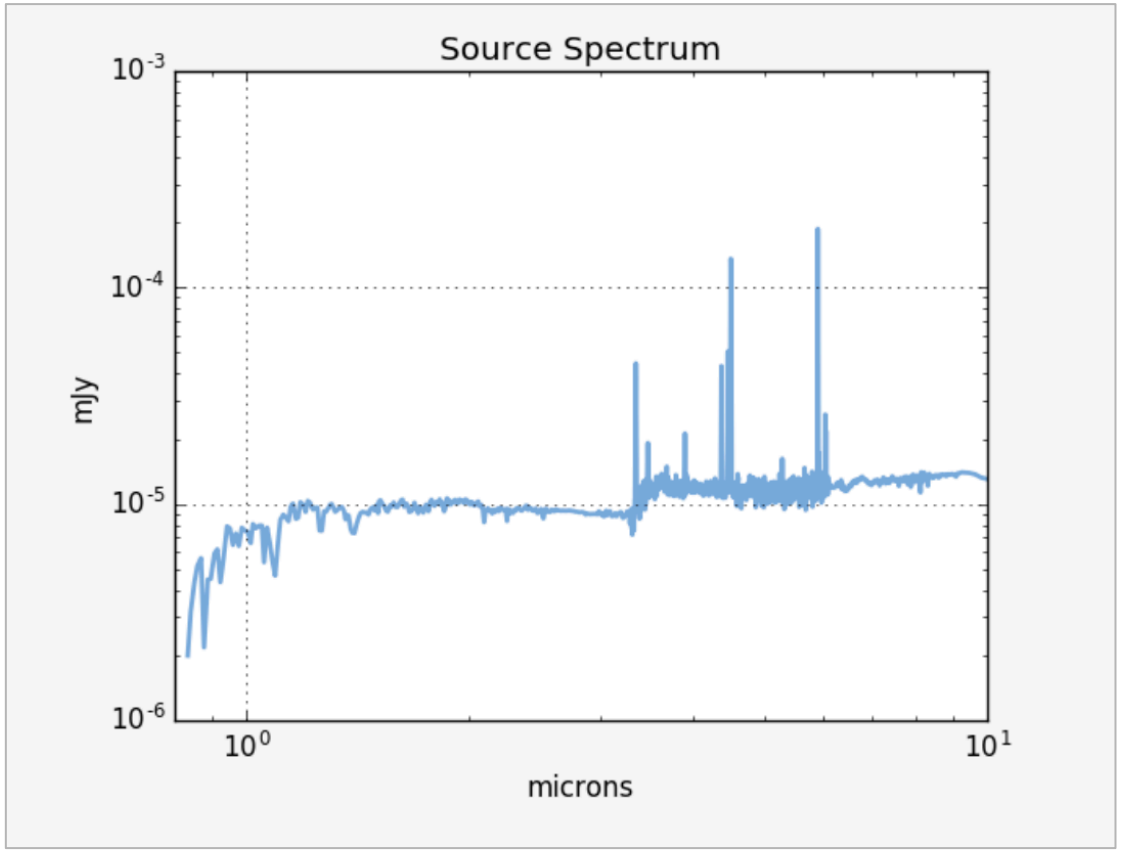
Continuum: UGCA 219 (Blue compact dwarf), redshift=8

Renormalization: 28.4 abmag at F160W

Shape: Sersic (index=1.5), 0.1” x 0.05”

Add it to a Scene by highlighting the Scene and the Source & clicking ‘Add’

Source: z=8 galaxy



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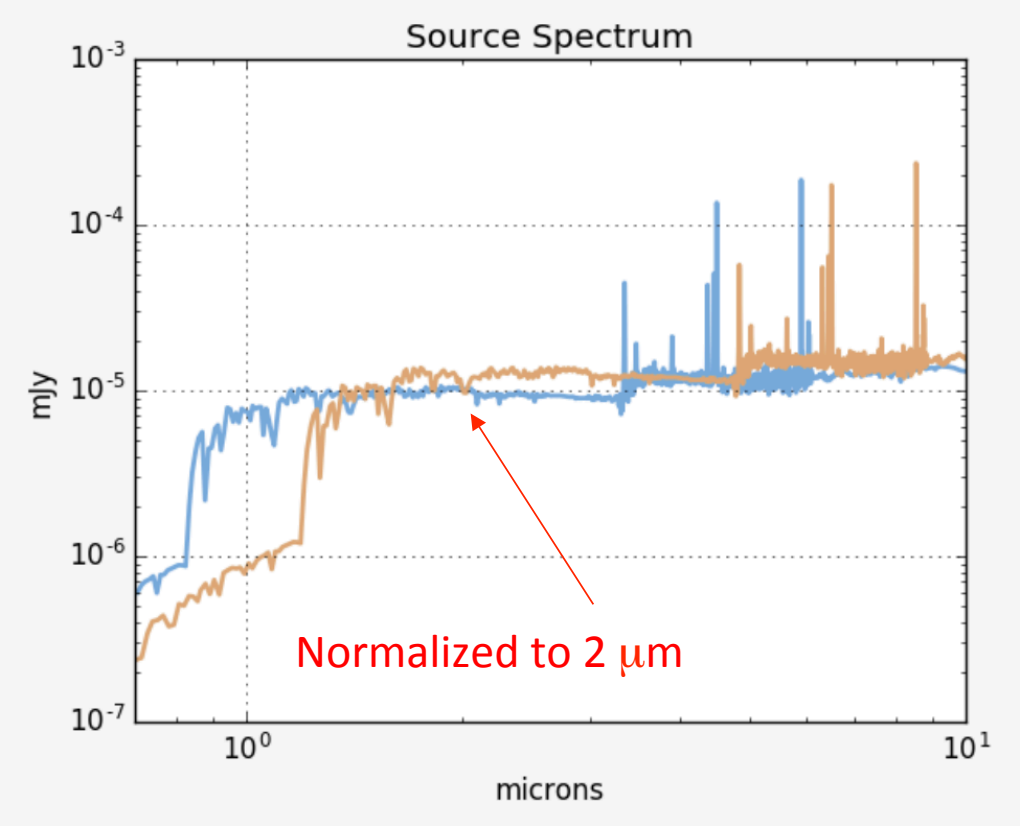
Add it to a ‘Scene’ by highlighting the Scene and the Source & clicking ‘Add’

Renormalization vs. redshift

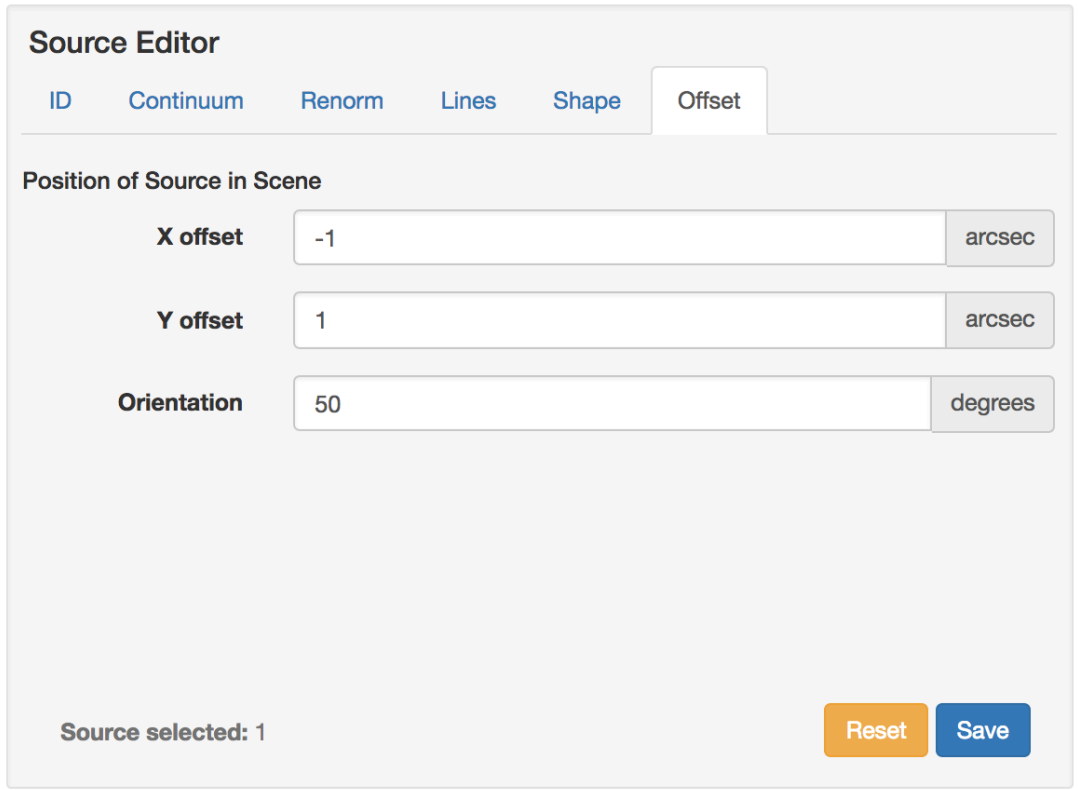


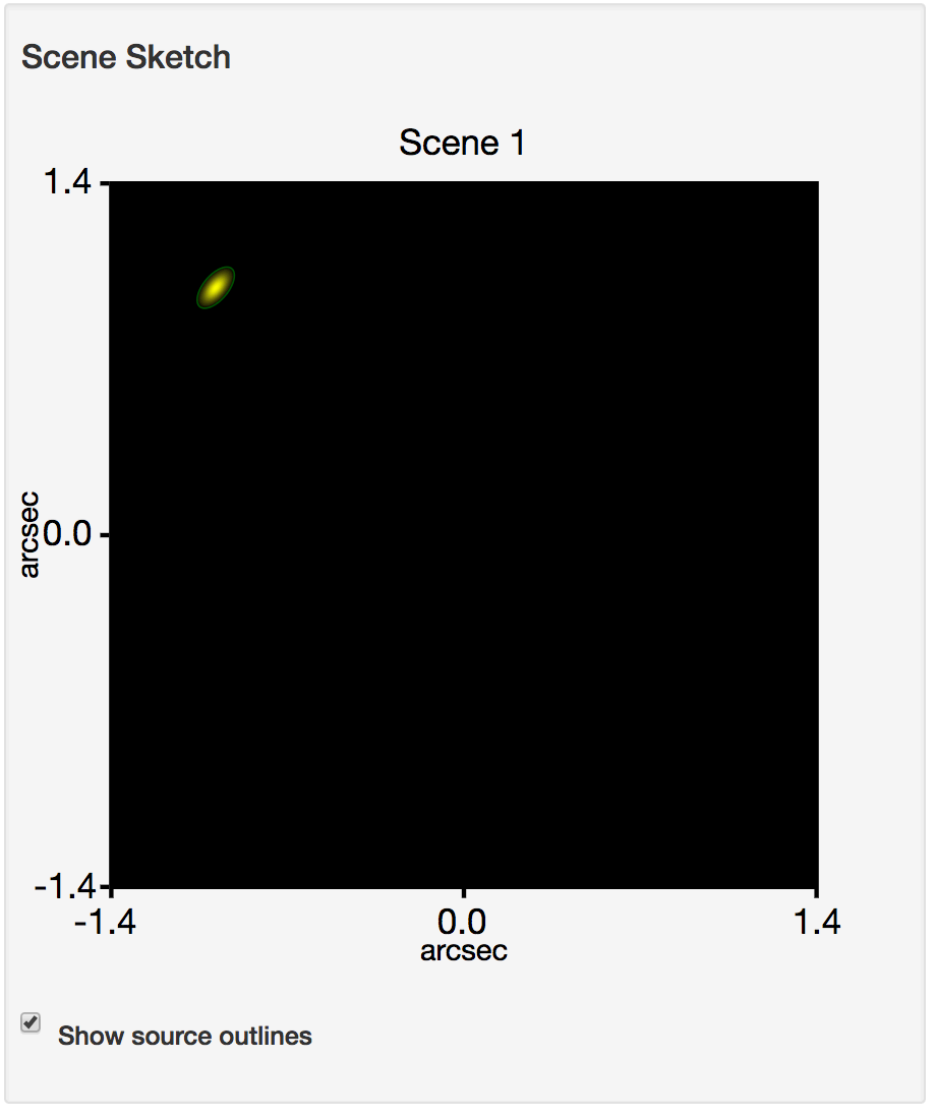
Warning! When you change the redshift, the normalization does not change accordingly.

Redshift and extinction are applied before renormalization.

Source: z=8 galaxy

Now that it's part of a Scene, the offset and rotation of the source can be set.





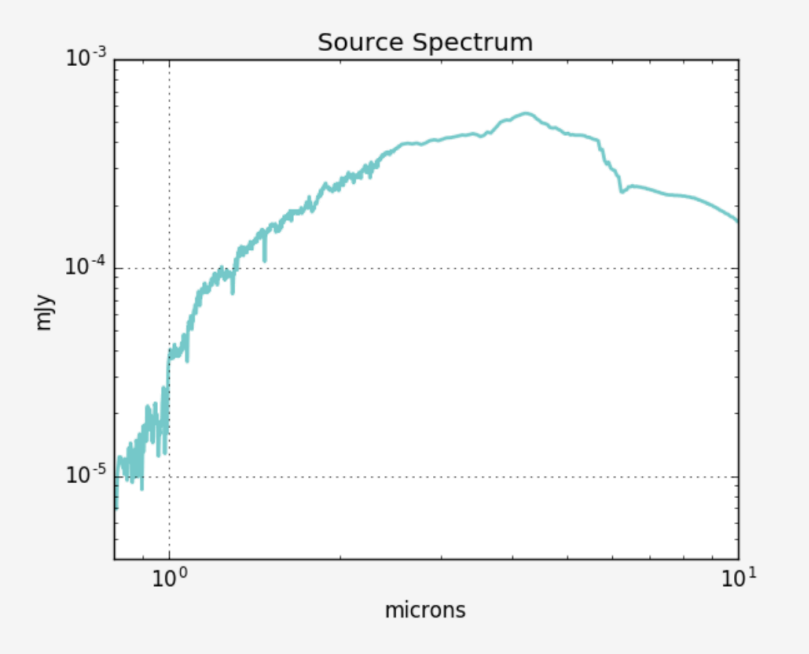
Add a z=1.5 galaxy

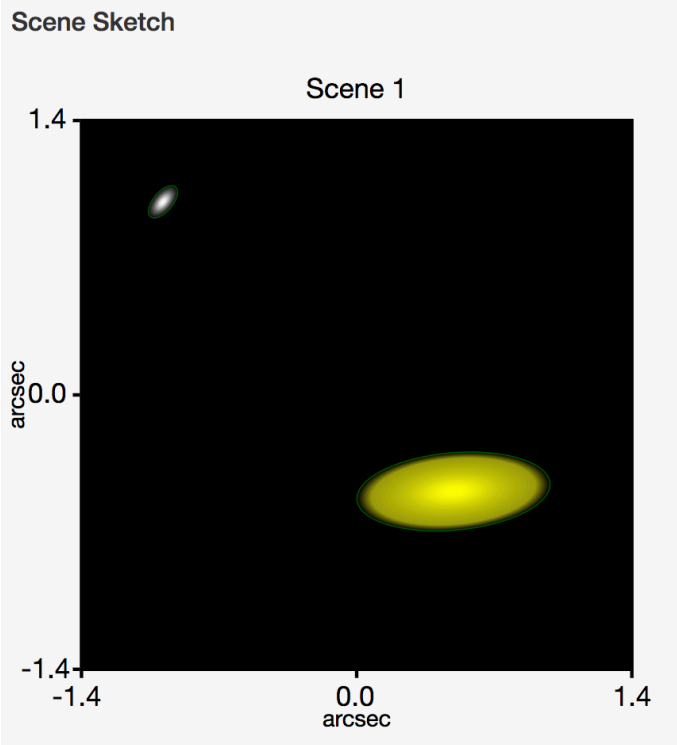
Continuum: NGC 4552 (E w/ UV upturn). Redshift=1.5

Renormalization: 250 nJy at 2 μm

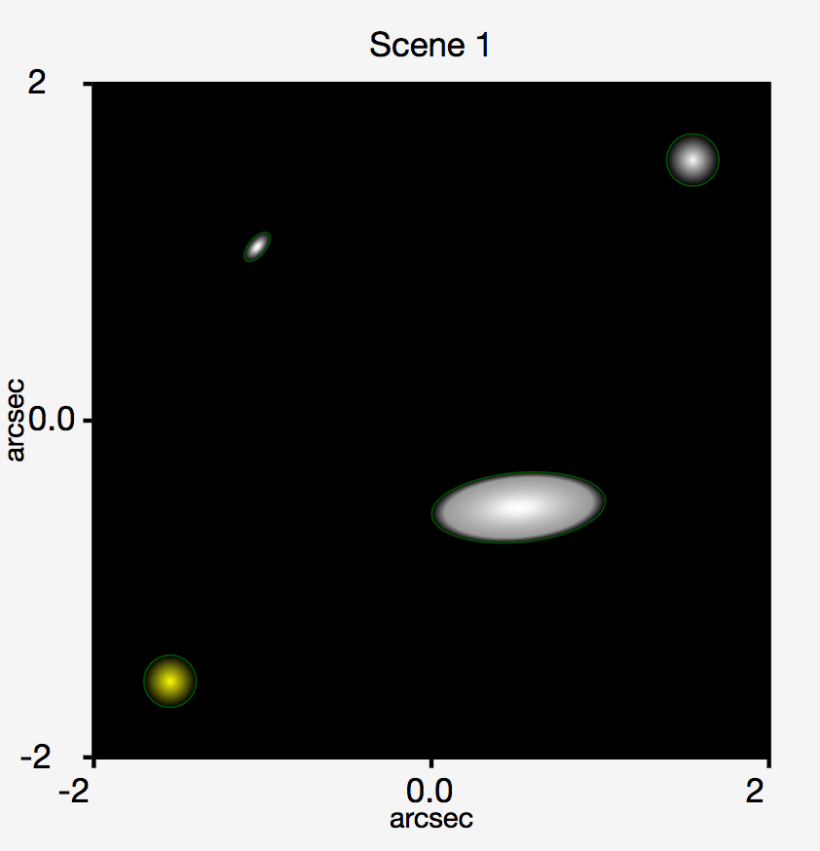
Shape: Sersic (index=1.3), 0.5” x 0.2”

Offset: x = 0.5, y = -0.5, orientation=5





The Scene

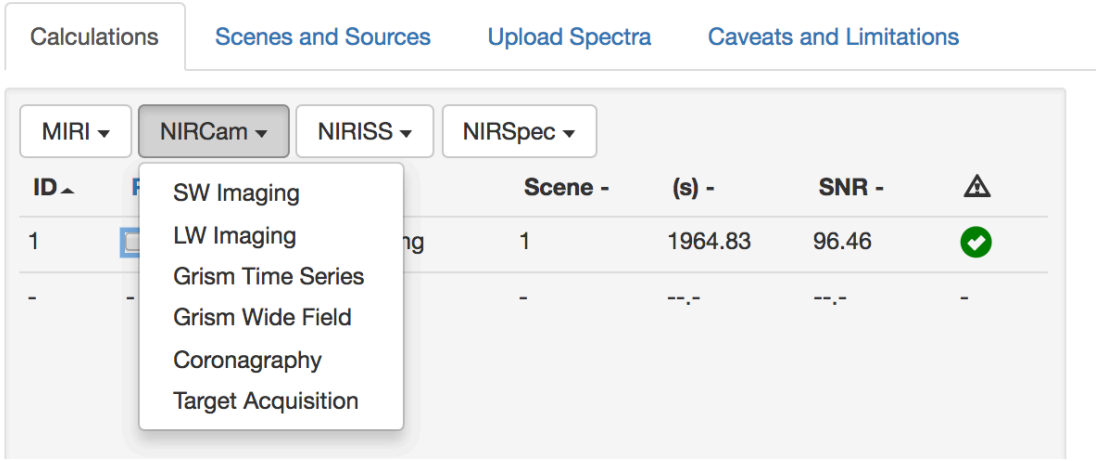


When computing S/N, you might get the following warning: *"Extraction aperture partially outside of the field of view"*

This can be avoided by adding stars to the far corners to expand the size of the scene.

Alternatively, you could make 2 scenes, one for each galaxy where the galaxy is at the center.

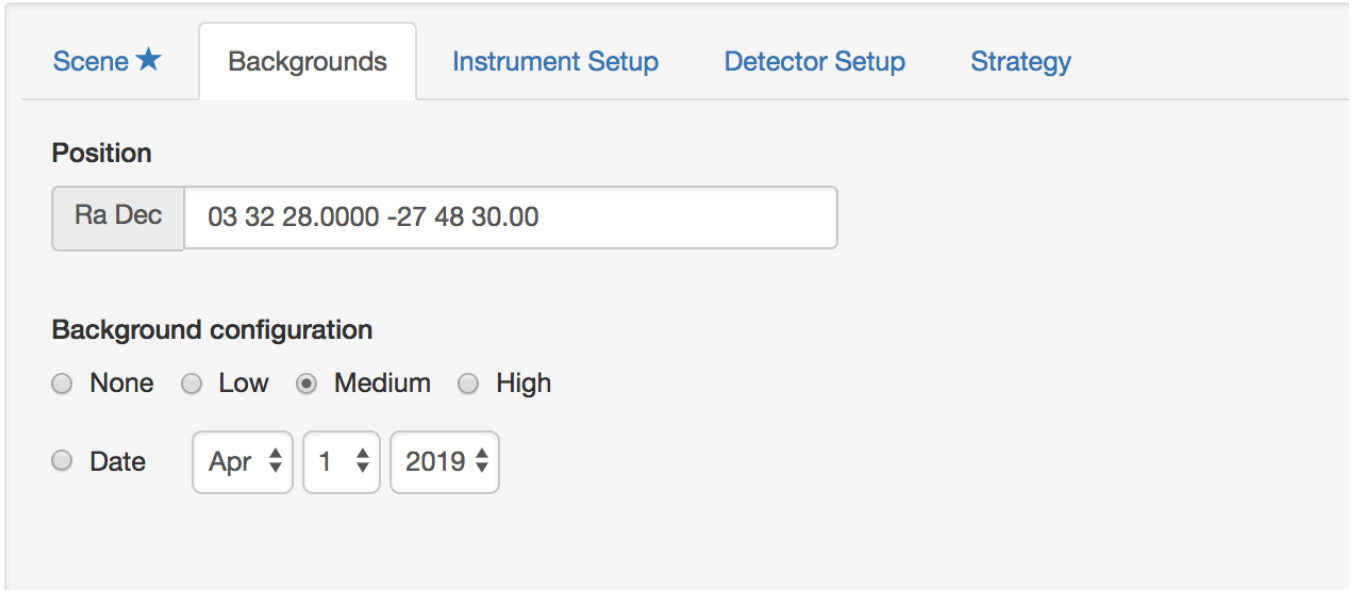
Setting up a Calculation



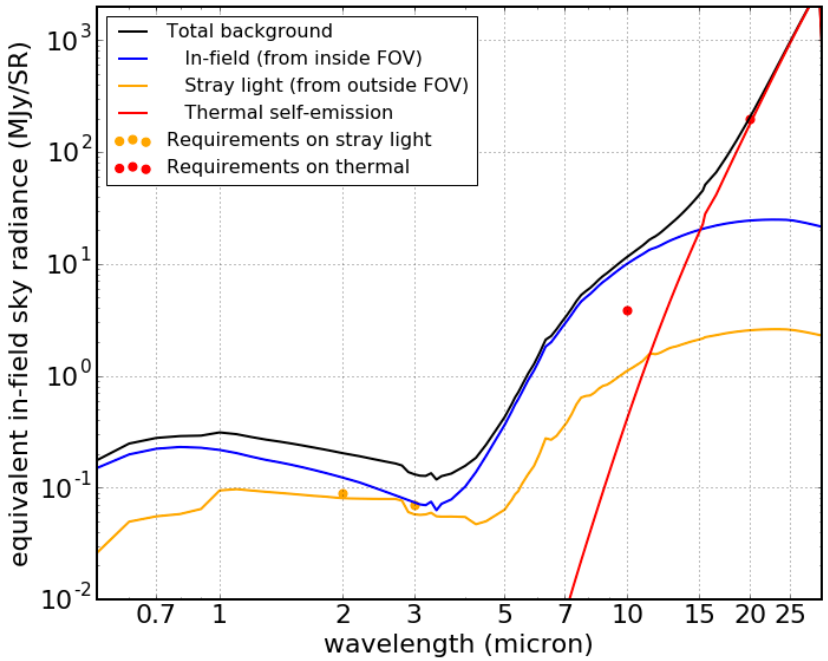
Start a NIRCam LW or SW calculation

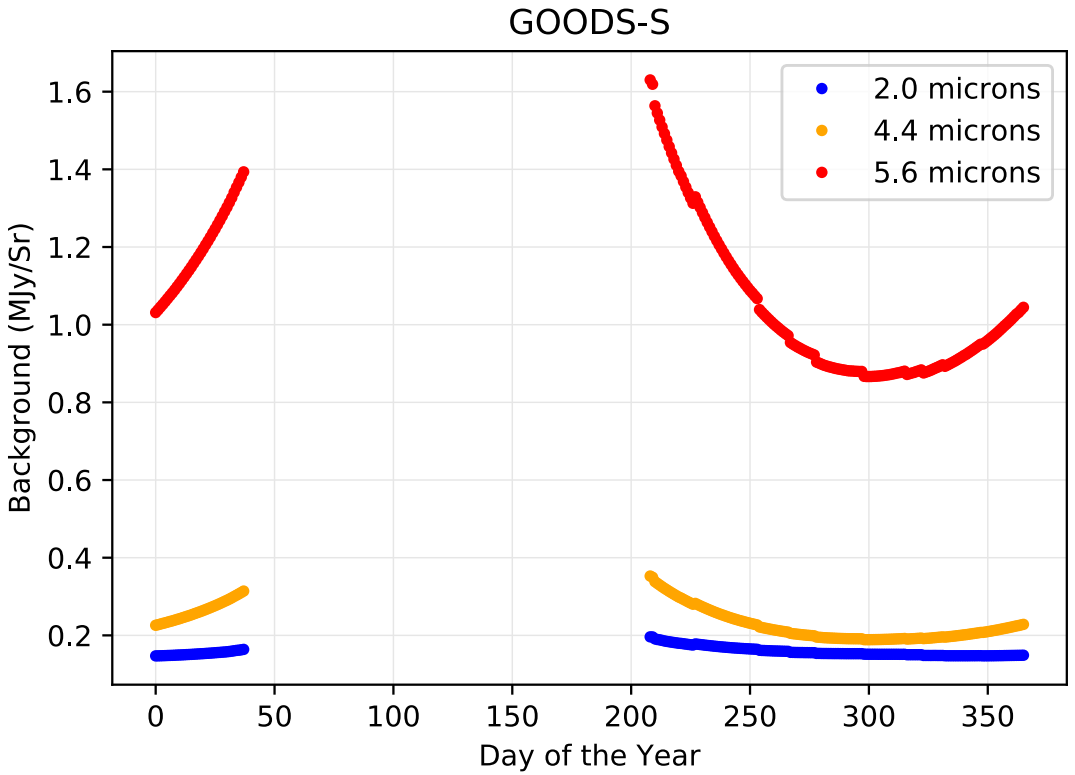
Set the background parameters

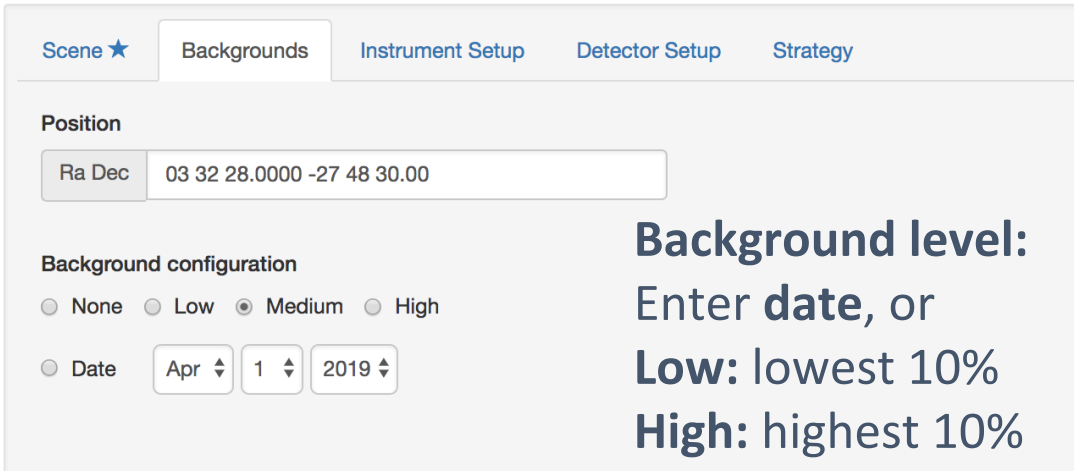
Important: enter the correct coordinates



Background





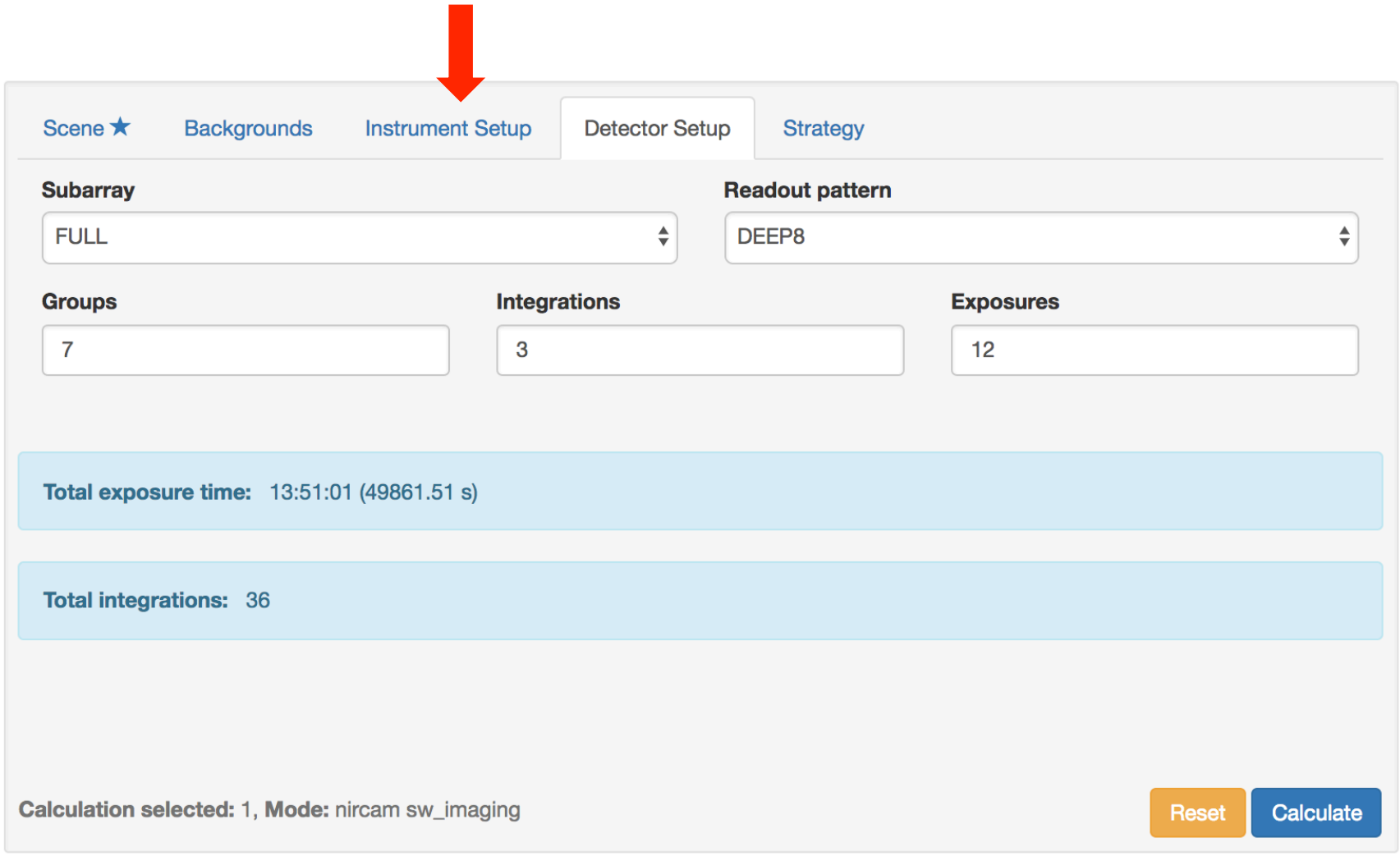


Background level:
Enter **date**, or
Low: lowest 10%
High: highest 10%

JWST Backgrounds Tool:
https://jwst-docs.stsci.edu/display/JPP/The+JWST+Backgrounds+Tool

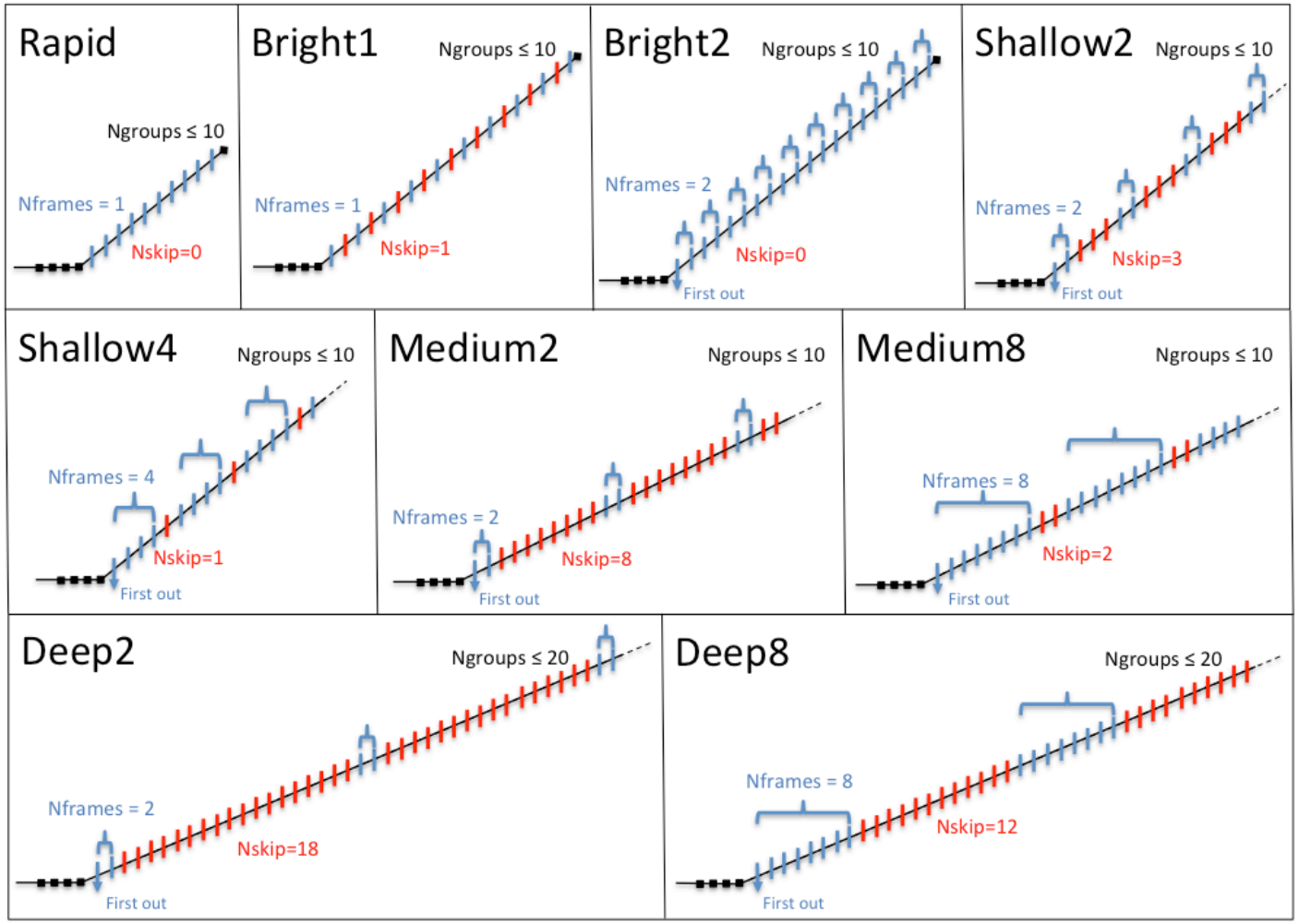
Setting up a Calculation

Choose the filter



FULL Array
DEEP8
Groups = 7
Ints = 3
Exposures = 12

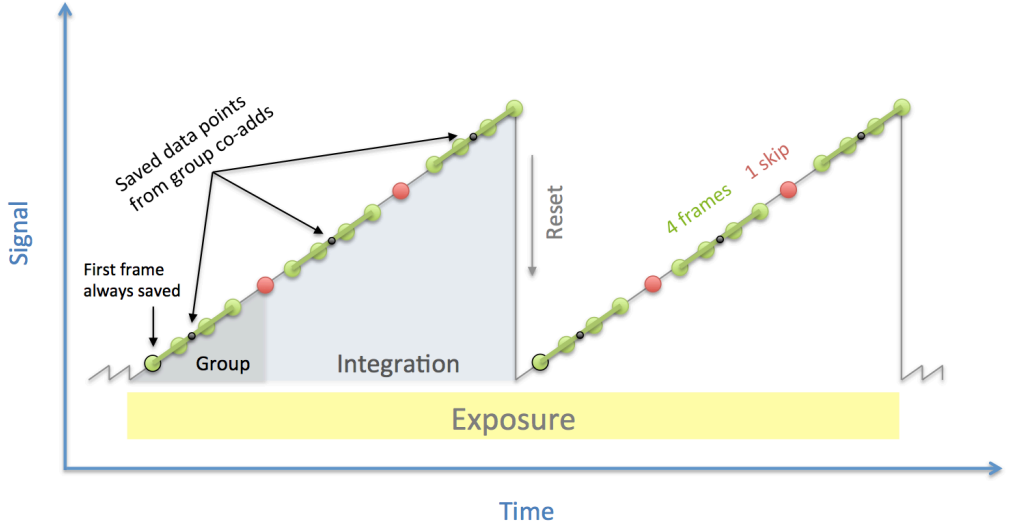
Detector Setup: Readout Pattern



DEEP8 is more sensitive than DEEP2

Aiming for 6-9 groups to get a well-defined ramp while avoiding cosmic rays

Adding Integrations helps increase the observed time.



Detector Setup: Exposures vs. Dithers

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

Subarray: FULL

Readout pattern: DEEP8

Groups: 7

Integrations: 3

Exposures: 12

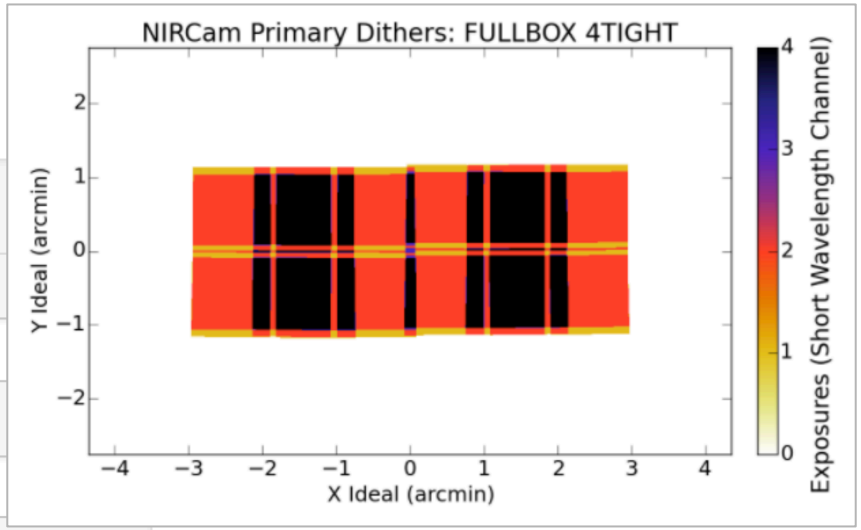
Total exposure time: 13:51:01 (49861.51 s)

Total integrations: 36

Calculation selected: 1, **Mode:** nircam sw_imaging

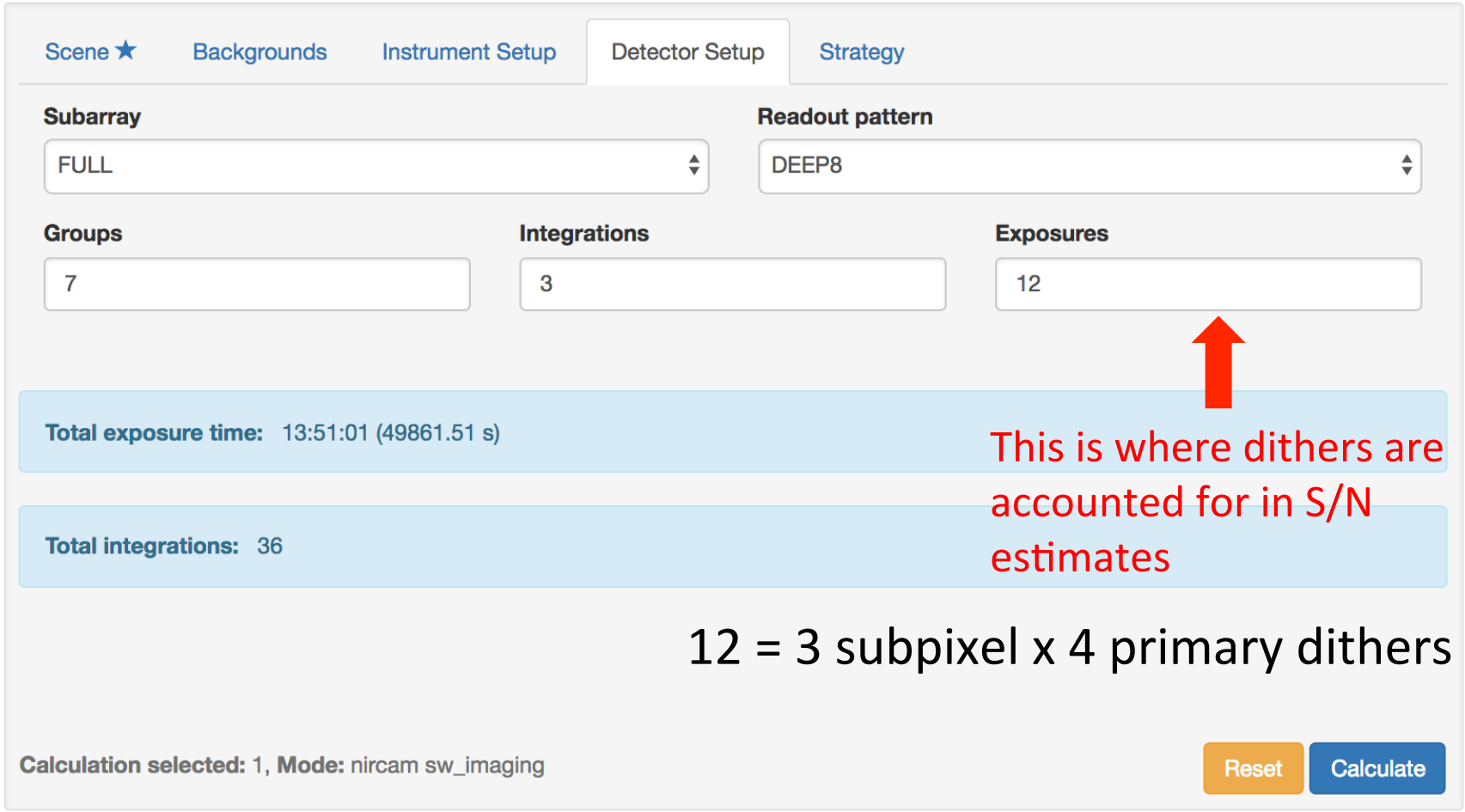
Reset | Calculate

This is where dithers are accounted for in S/N estimates



Several NIRCam dither patters result in uneven coverage. This should be accounted for in 'Exposures'

Detector Setup



We are aiming for a minimum of 33 ksec or 50 ksec (depending on filter), so choose the appropriate number of exposures.

12 = 49.9 ksec
8 = 33.2 ksec

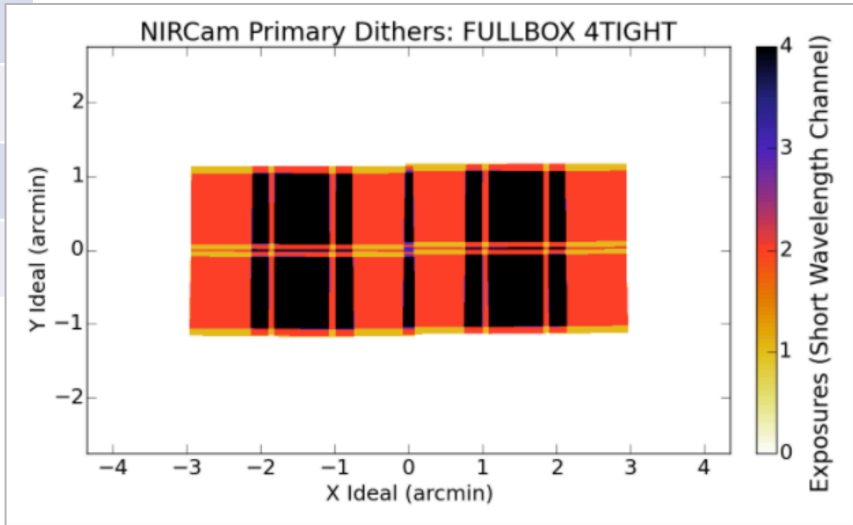
We'll work out the details of how to do the dithers in APT

Detector Setup per filter

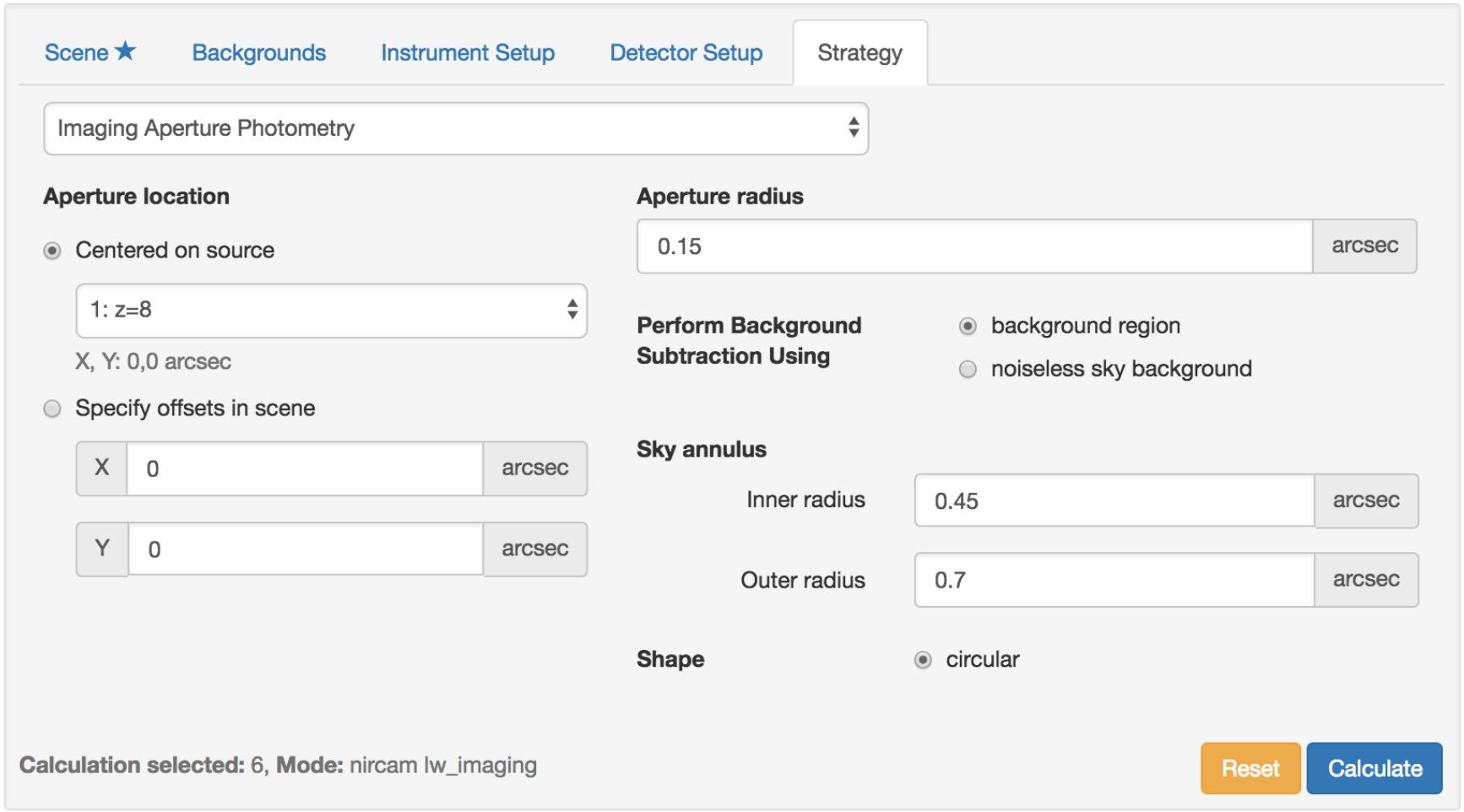
Filter	Min t	Min Exp	Max t	Min Exp
F090W	66 ksec	16	120 ksec	30
F115W	50 ksec	12	100 ksec	24
F150W	50 ksec	12	100 ksec	24
F200W	33 ksec	8	66 ksec	16
F277W	33 ksec	8	66 ksec	16
F335M	33 ksec	8	66 ksec	16
F356W	33 ksec	8	66 ksec	16
F410M	50 ksec	12	100 ksec	24
F444W	50 ksec	12	100 ksec	24
F770W	400 ksec	83	800 ksec	165

Getting the times right requires some back-and-forth with APT. This table lists what we found was a good setup to achieve good S/N while minimizing program length.

Note: The dither patter means that some areas are twice as deep as other areas.

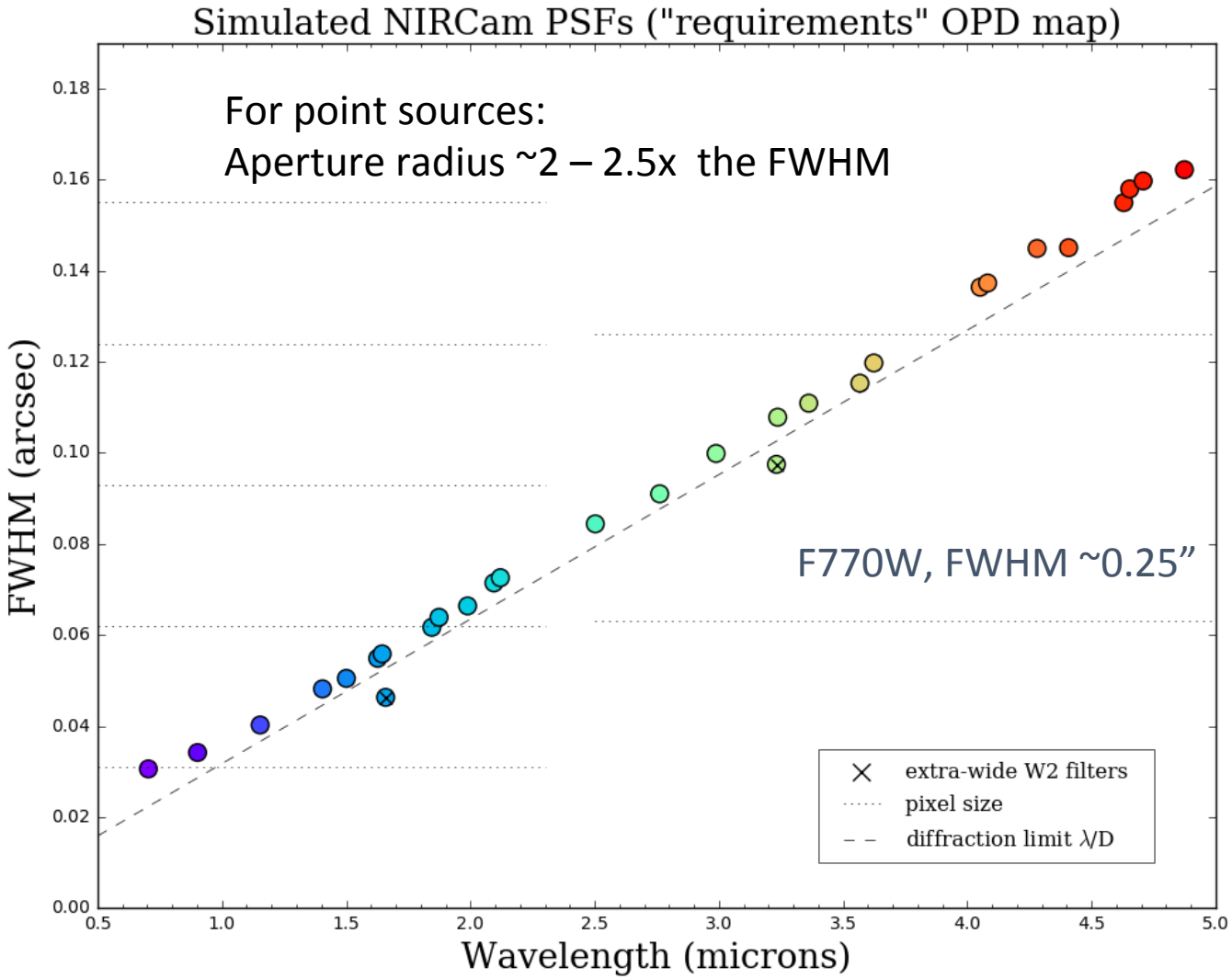


Extracting the S/N (Strategy)



Choose:
The source
Aperture size
Background strategy

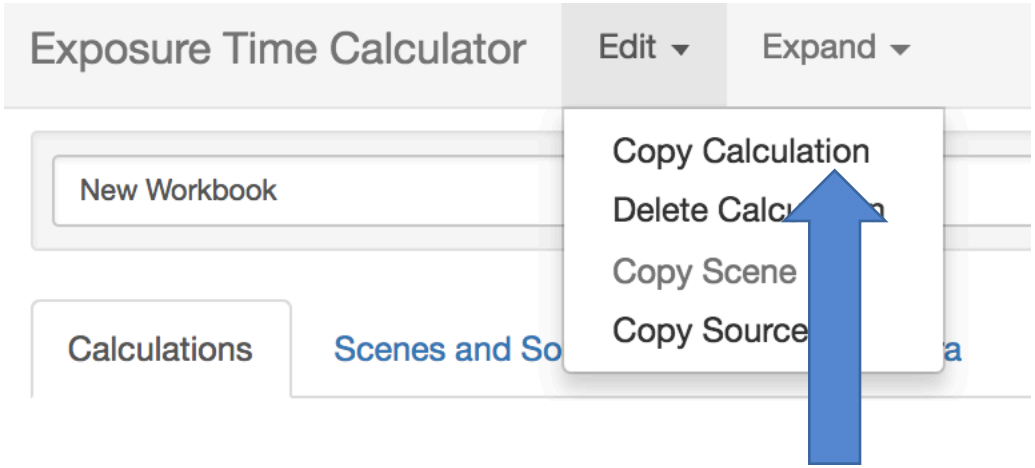
Aperture Size



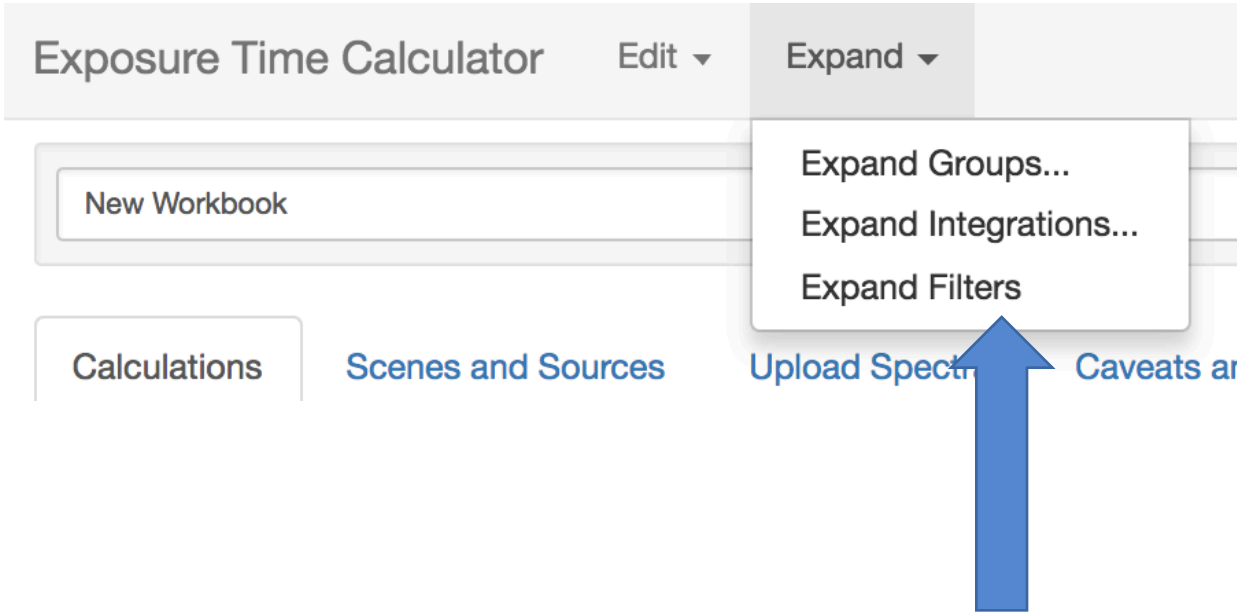
z=1.5 galaxy: 0.5” x 0.2”
Aperture r ~ 0.6”

z=8 galaxy: 0.1” x 0.05”
Aperture r ~ 0.15”

Adding Filters

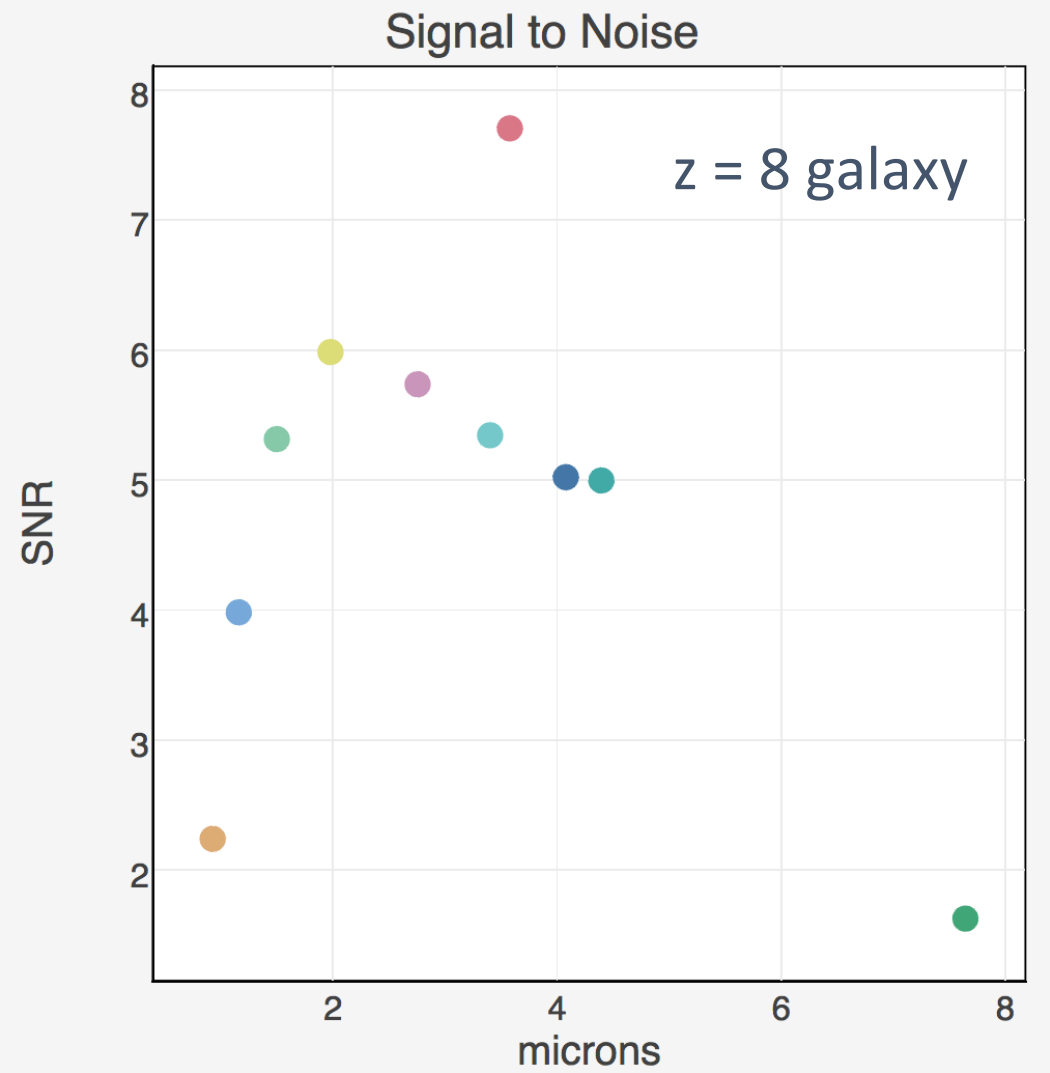


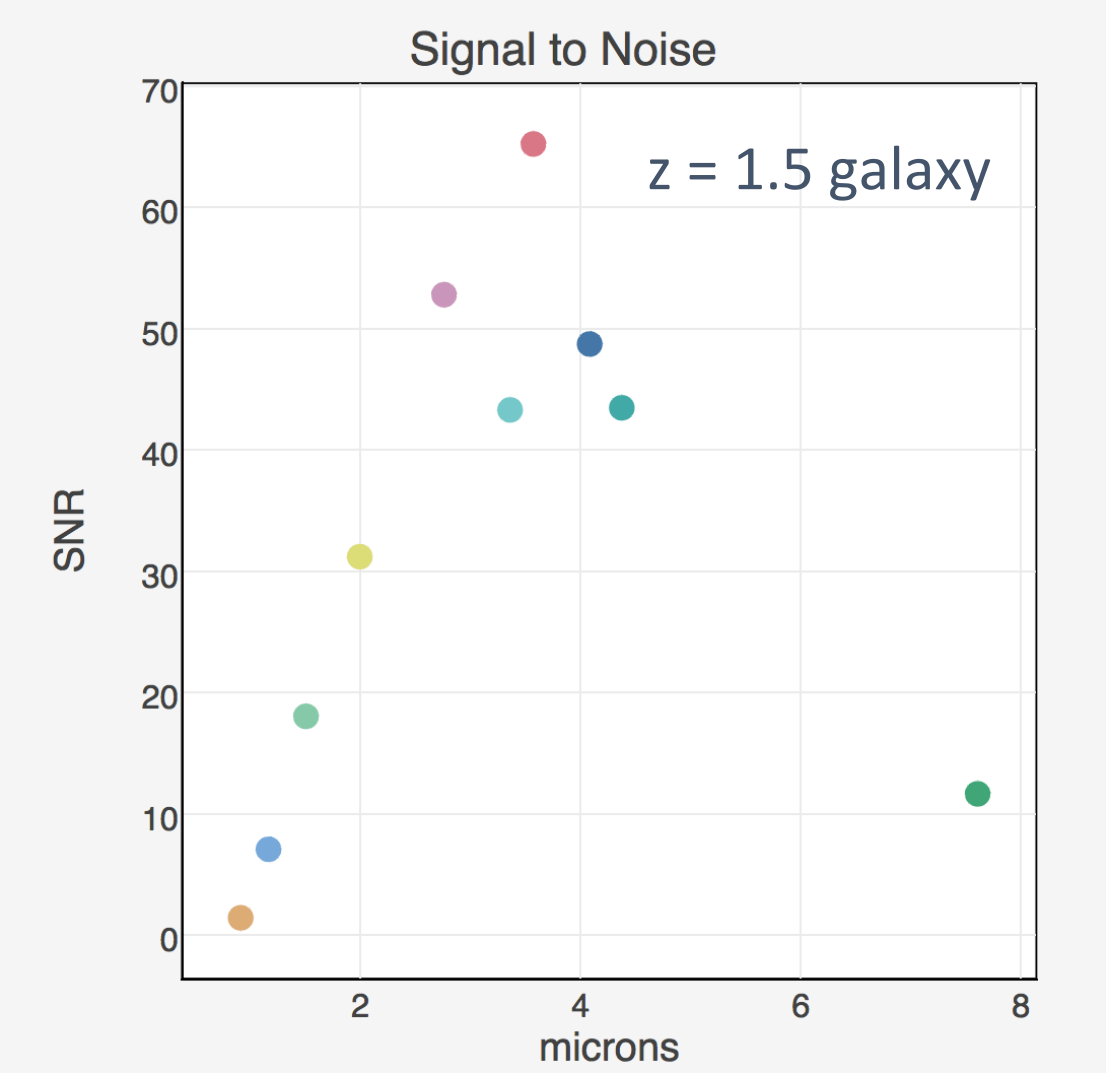
Copy one calculation, and change the filter



Creates a calculation for *every* filter in that template

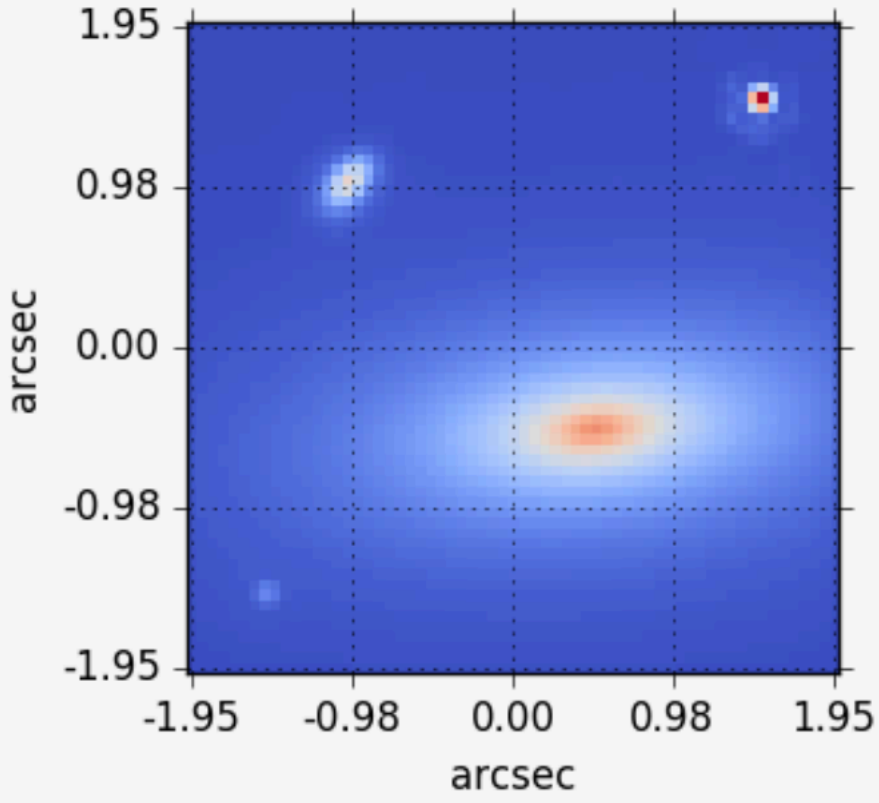
S/N Plots


Signal to Noise
z = 8 galaxy
SNR
microns
8
7
6
5
4
3
2
2
4
6
8

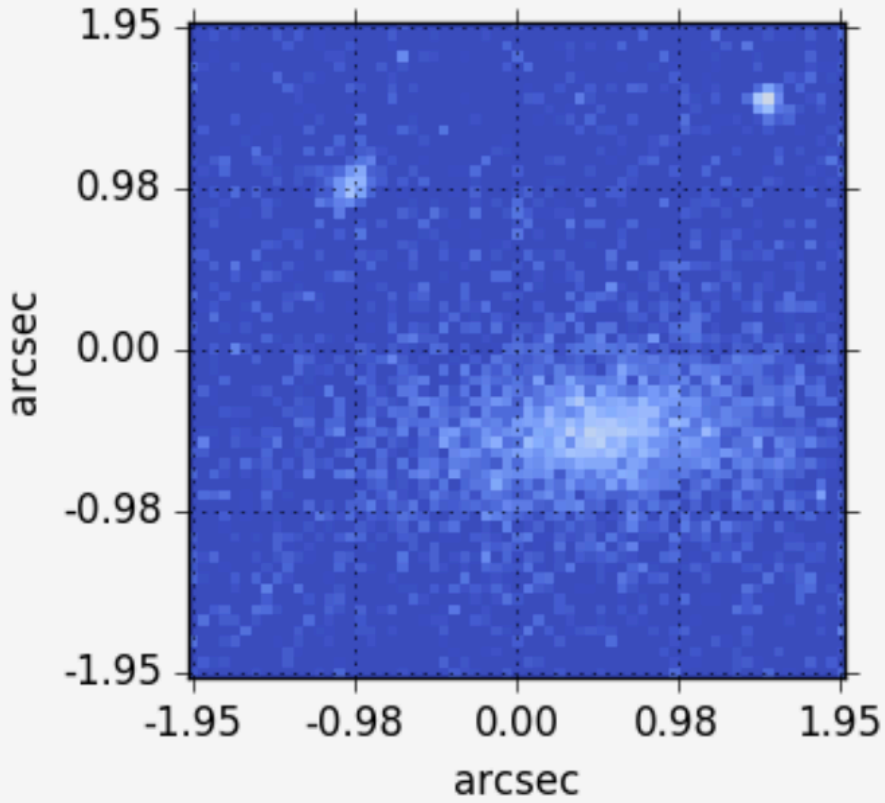

Signal to Noise
z = 1.5 galaxy
SNR
microns
70
60
50
40
30
20
10
0
2
4
6
8

The Scene

S/N Map (F356W)

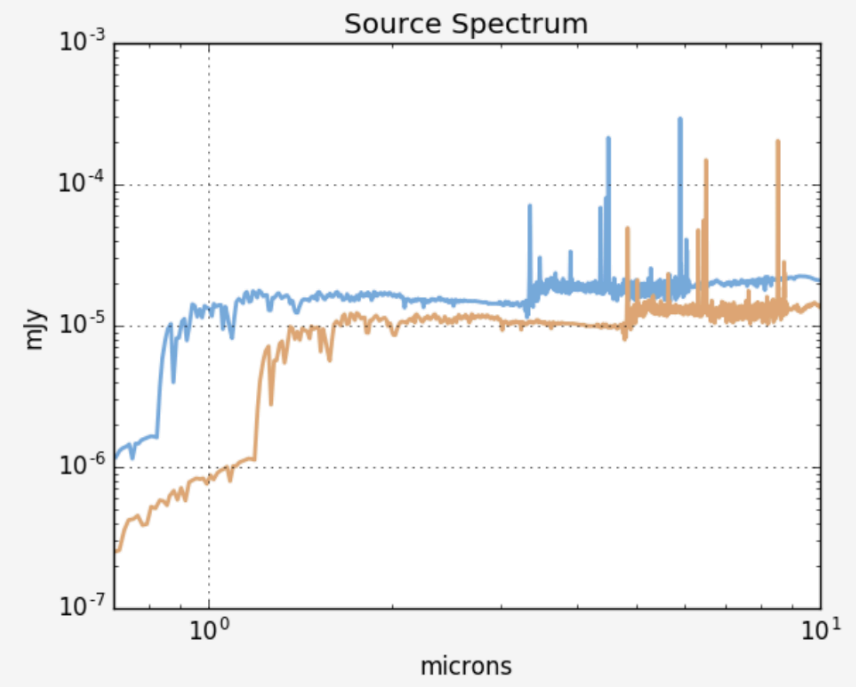


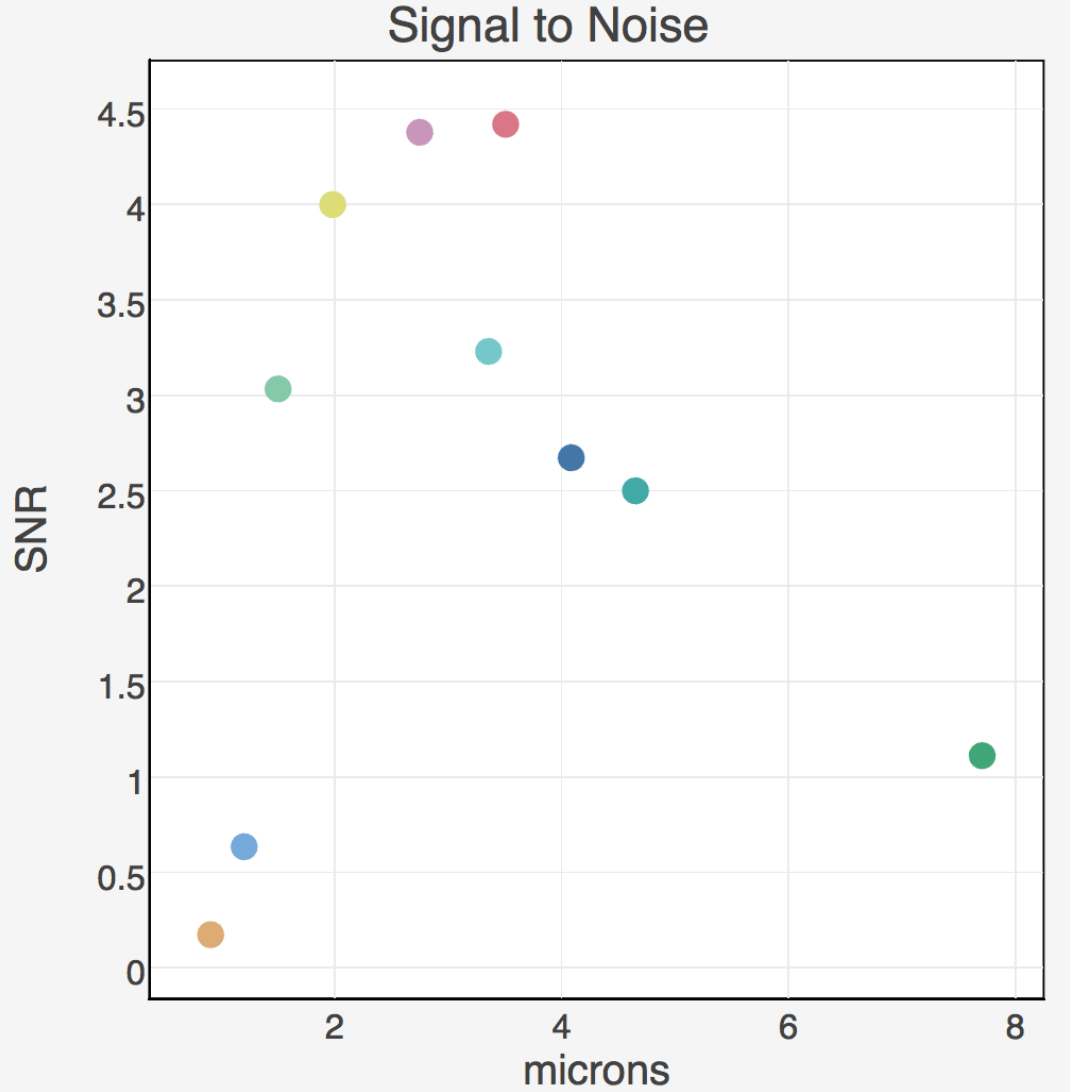
Simulated Image (F356W)



S/N at Higher Redshift?

Change the redshift from 8 to 12 in the UGCA 219 galaxy & renormalize to 29 mag. All calculations will recompute automatically.





Background Limited?

1. Calculate fractional change in the SNR, X:
   X = [SNR(low bkg) – SNR(high bkg)] / SNR(low bkg)

2. If X>0.05, then the observation is considered eligible for the special requirement.

Can select 'Background Limited' in APT Special Requirements.

These observations are background-limited starting around 3 microns.
F277W → X = 0.06

Planning a Deep NIRCam Survey
NIRCam and MIRI Coordinated Parallel Imaging

Building the APT File

Massimo Robberto (STSCI, NIRCAm Team Lead)
Martha Boyer (STScI, NIRCam Team)

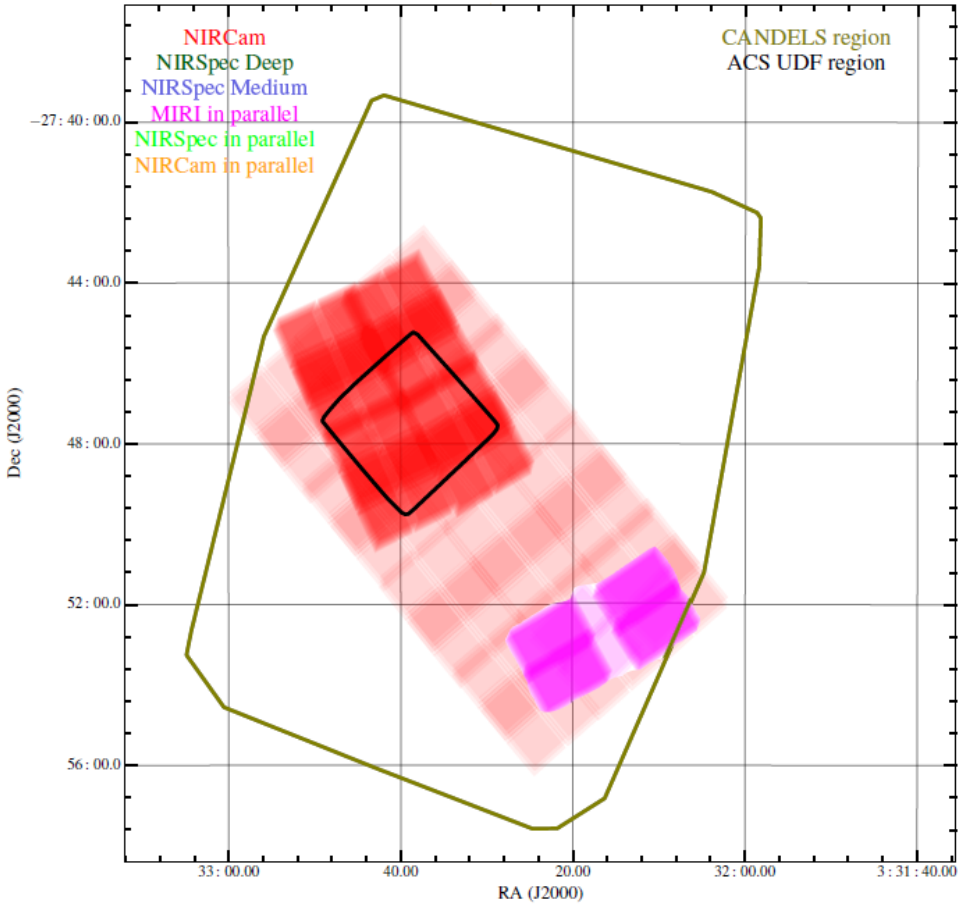
Adapted from the NIRCam-NIRSpec joint GTO program

STScI

JWST Event, Tenerife, March 2017

Observation Characteristics

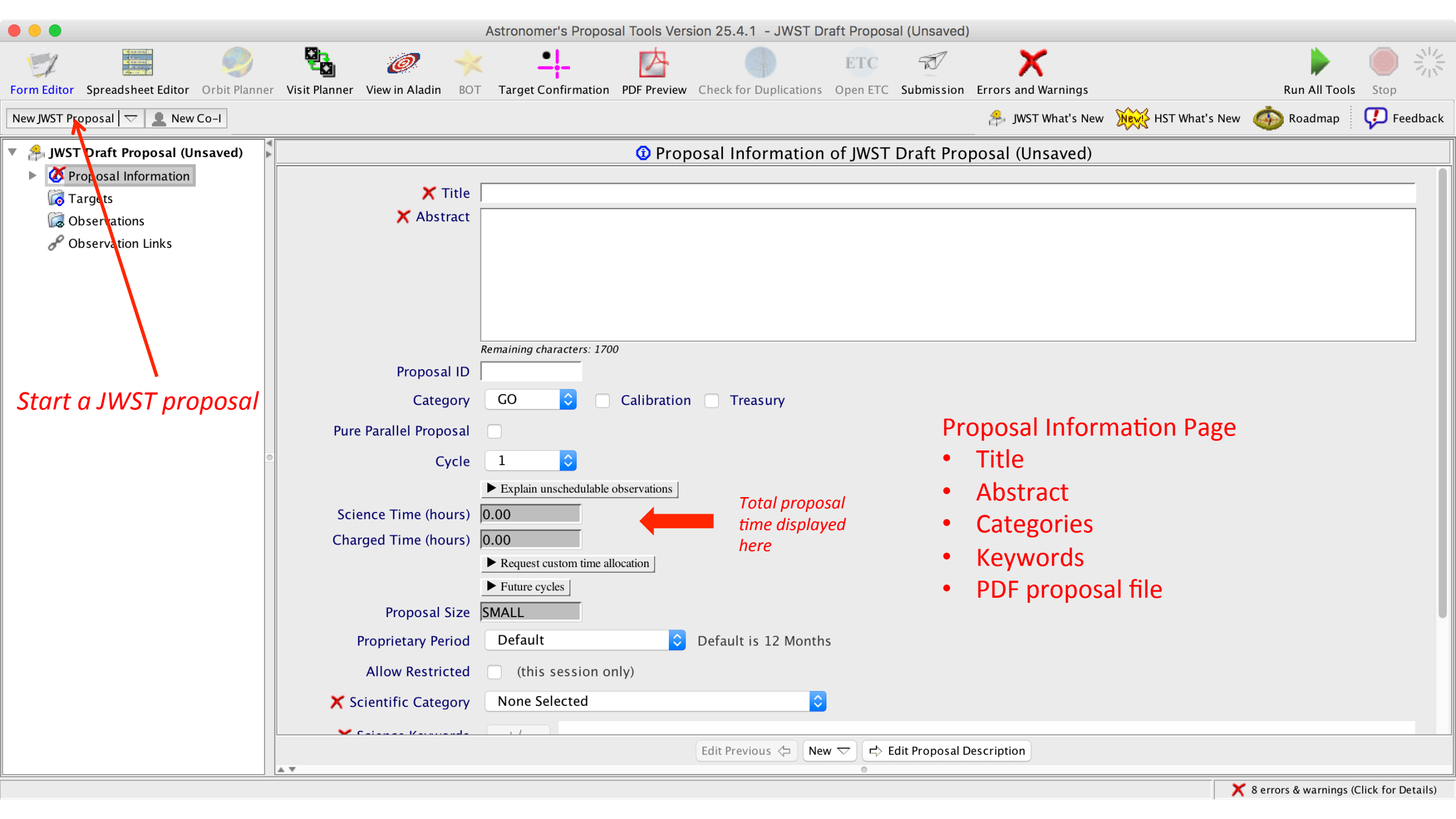
- **Template:** NIRCam Imaging
  - w/ MIRI Imaging in Parallel
- **Coverage:** ~25 arcmin^2 for NIRCam
- **Depth:** ~30-100 ksec (depending on filter)
- **SW NIRCam Filters:** F090W, F115W, F150W, F200W
- **LW Wide NIRCam Filters:** F277W, F356W, F444W
- **LW Medium NIRCam Filters:** F335M, F410M
- **MIRI Filter:** F770W



ETC Goals

Filter	Min t	Min Exp	Max t	Min Exp
F090W	66 ksec	16	120 ksec	30
F115W	50 ksec	12	100 ksec	24
F150W	50 ksec	12	100 ksec	24
F200W	33 ksec	8	66 ksec	16
F277W	33 ksec	8	66 ksec	16
F335M	33 ksec	8	66 ksec	16
F356W	33 ksec	8	66 ksec	16
F410M	50 ksec	12	100 ksec	24
F444W	50 ksec	12	100 ksec	24
F770W	400 ksec	83	800 ksec	165

Exposures in ETC are Dithers in APT

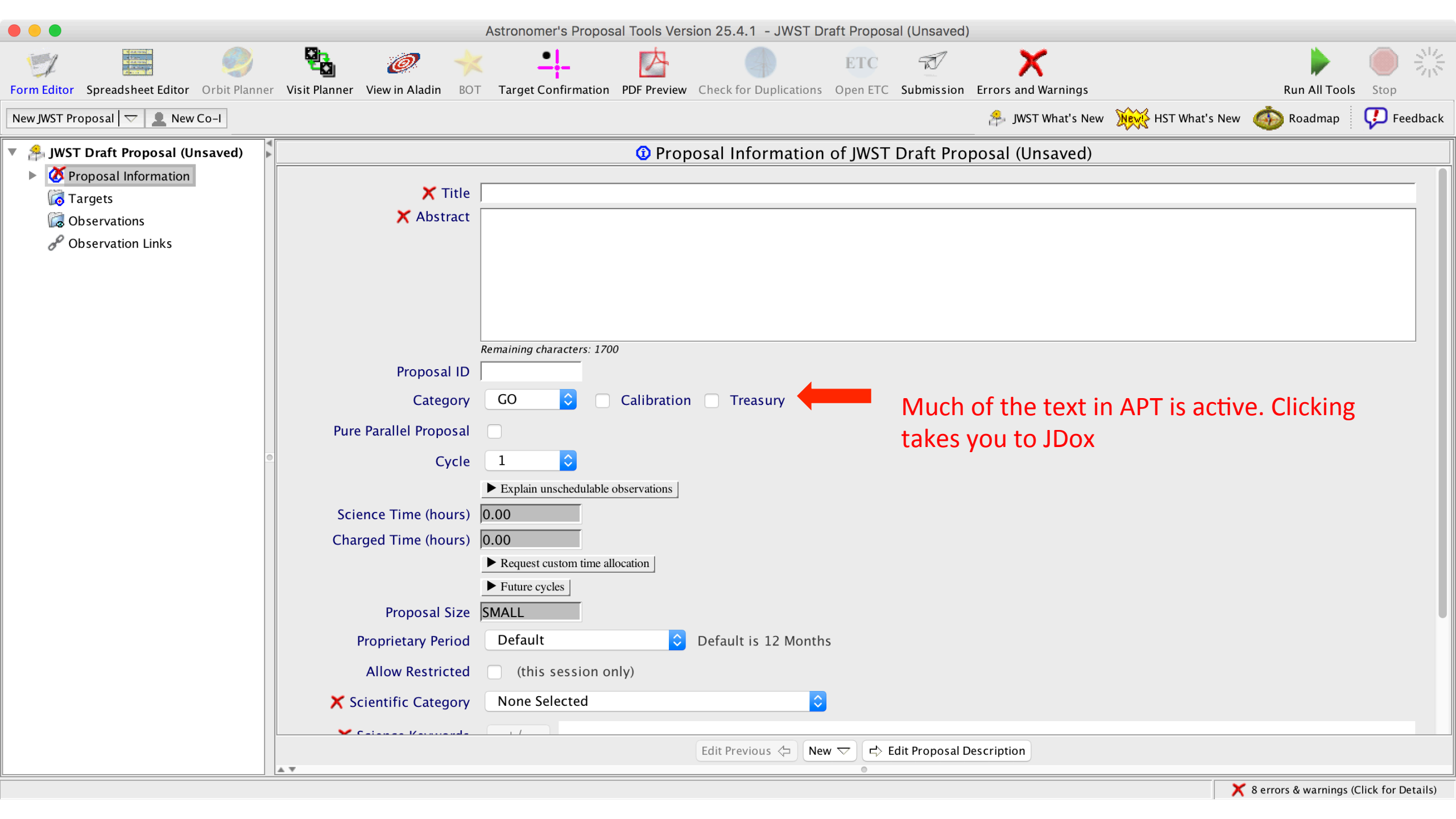


Start a JWST proposal

Total proposal time displayed here

Proposal Information Page

- Title
- Abstract
- Categories
- Keywords
- PDF proposal file


Astronomer's Proposal Tools Version 25.4.1 - JWST Draft Proposal (Unsaved)
Form Editor
Spreadsheet Editor
Orbit Planner
Visit Planner
View in Aladin
BOT
Target Confirmation
PDF Preview
Check for Duplications
ETC
Open ETC
Submission
Errors and Warnings
Run All Tools
Stop
New JWST Proposal
New Co-I
JWST What's New
HST What's New
Roadmap
Feedback
JWST Draft Proposal (Unsaved)
Proposal Information
Targets
Observations
Observation Links
Proposal Information of JWST Draft Proposal (Unsaved)
Title
Abstract
Remaining characters: 1700
Proposal ID
Category
GO
Calibration
Treasury
Pure Parallel Proposal
Cycle
1
Explain unschedulable observations
Science Time (hours)
0.00
Charged Time (hours)
0.00
Request custom time allocation
Future cycles
Proposal Size
SMALL
Proprietary Period
Default
Default is 12 Months
Allow Restricted
(this session only)
Scientific Category
None Selected
Much of the text in APT is active. Clicking takes you to JDox
Edit Previous
New
Edit Proposal Description
8 errors & warnings (Click for Details)

James Webb Space Telescope User Documentation

HOME | INSTRUMENTS | PLANNING | CALL FOR PROPOSALS | DATA | Search

JWST User Documentation Home

The Instrument Handbooks

Cookbooks, best practices, APT Templates, …

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

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

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

A graphical guide is available on how to get started exploring this website using the navigation bar, search bar, and links, as well as the page tree on the right of each page.

JWST Observatory and Instrumentation

JWST Observation Planning

Astronomer's Proposal Tools Version 25.4.1 - JWST Draft Proposal (Unsaved)

Form Editor | Spreadsheet Editor | Orbit Planner | Visit Planner | View in Aladin | BOT | Target Confirmation | PDF Preview | Check for Duplications | Open ETC | Submission | Errors and Warnings | Run All Tools | Stop

New JWST Proposal | New | JWST What's New | HST What's New | Roadmap | Feedback

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

Targets of JWST Draft Proposal (Unsaved)

Targets

Use if your target is in Simbad, NED, etc. →

Fixed Target Resolver — Resolve a target name or position

New Fixed Target — Create a new Fixed Target

New Target Group — Create a new Target Group

We'll use the Fixed Target Resolver to load the HST UDF

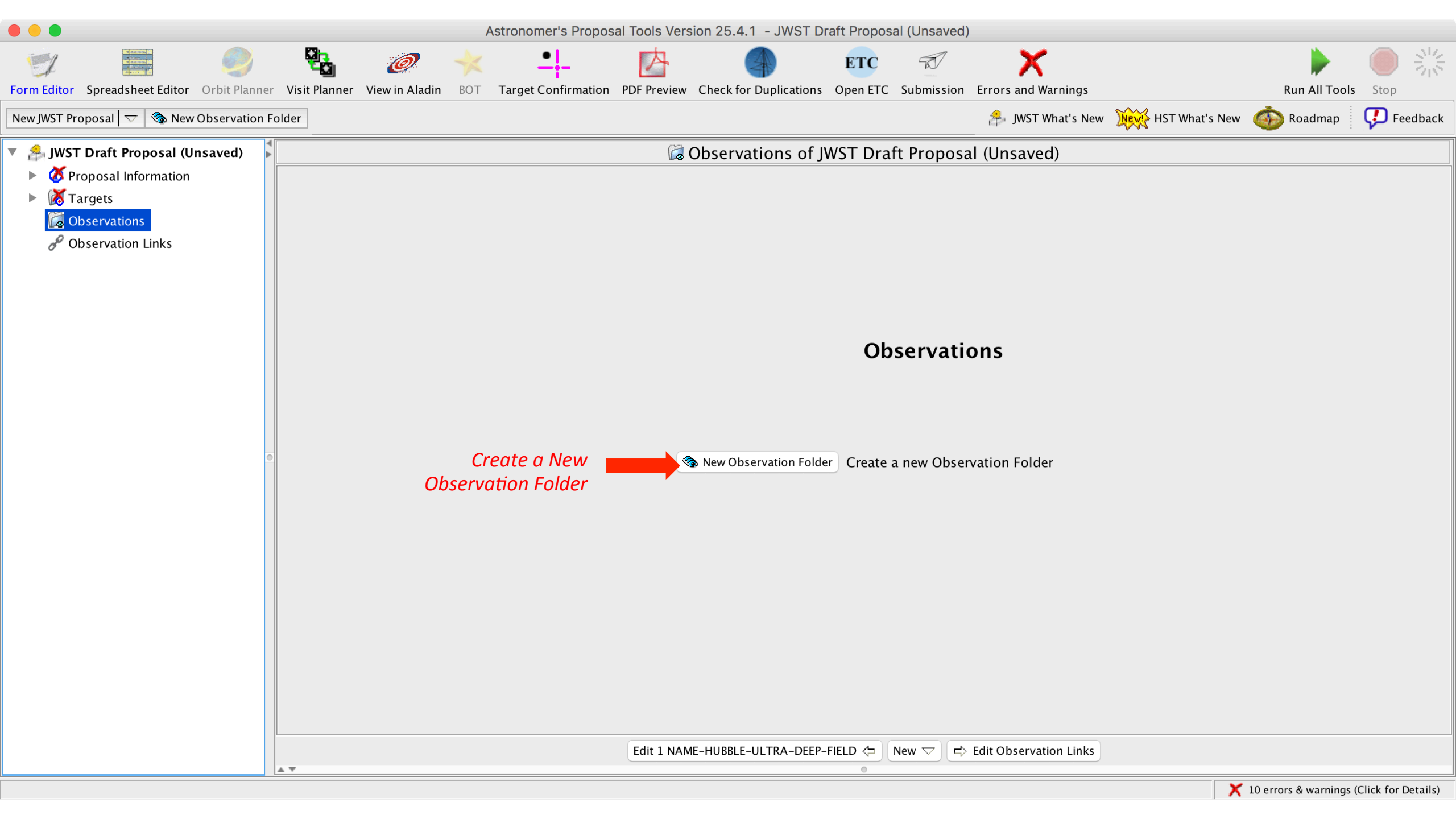
New Solar System Target — Create a new Solar System Target

New Generic Target — Create a new Generic Target

Import Targets... — Import Fixed Targets from whitespace, CSV, TSV, or VOTable

Edit Unnamed Col | New | Edit Observations

8 errors & warnings (Click for Details)


Astronomer's Proposal Tools Version 25.4.1 - JWST Draft Proposal (Unsaved)
Form Editor
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HST What's New
Roadmap
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Proposal Information
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Observation Links
Observations of JWST Draft Proposal (Unsaved)
Observations
Create a New Observation Folder
New Observation Folder
Create a new Observation Folder
Edit 1 NAME-HUBBLE-ULTRA-DEEP-FIELD
New
Edit Observation Links
10 errors & warnings (Click for Details)

Astronomer's Proposal Tools Version 25.4.1 - JWST Draft Proposal (Unsaved)

Form Editor | Spreadsheet Editor | Orbit Planner | Visit Planner | View in Aladin | BOT | Target Confirmation | PDF Preview | Check for Duplications | Open ETC | Submission | Errors and Warnings | Run All Tools | Stop

New JWST Proposal | New | JWST What's New | HST What's New | Roadmap | Feedback

- JWST Draft Proposal (Unsaved)
  - Proposal Information
  - Targets
  - Observations
    - Observation Folder
      - Observation 1
    - Observation Links

Observation 1 of JWST Draft Proposal (Unsaved)

Number: 1 Status: Duplication

Label:

Instrument: None Selected

Template: None Selected

Target: None Selected

	Splitting Distance	Number of Visits
Visit Splitting:	5.0 Arcsec	0
	Science	Total Charged
Duration (secs)	0	0

Data volume: 0 MB

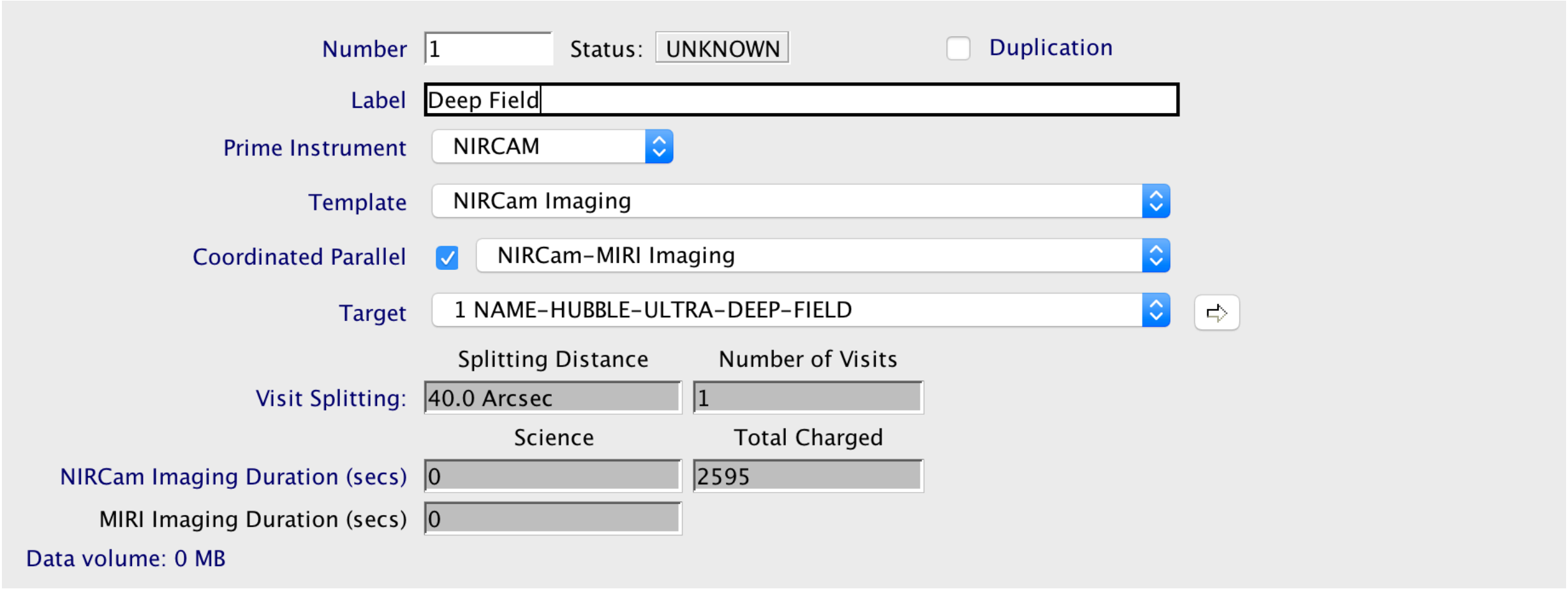
Template Properties | Special Requirements | Comments

Once a Template has been selected, template properties may be selected.

Edit Observation Folder | New | Edit Observation Links

12 errors & warnings (Click for Details)

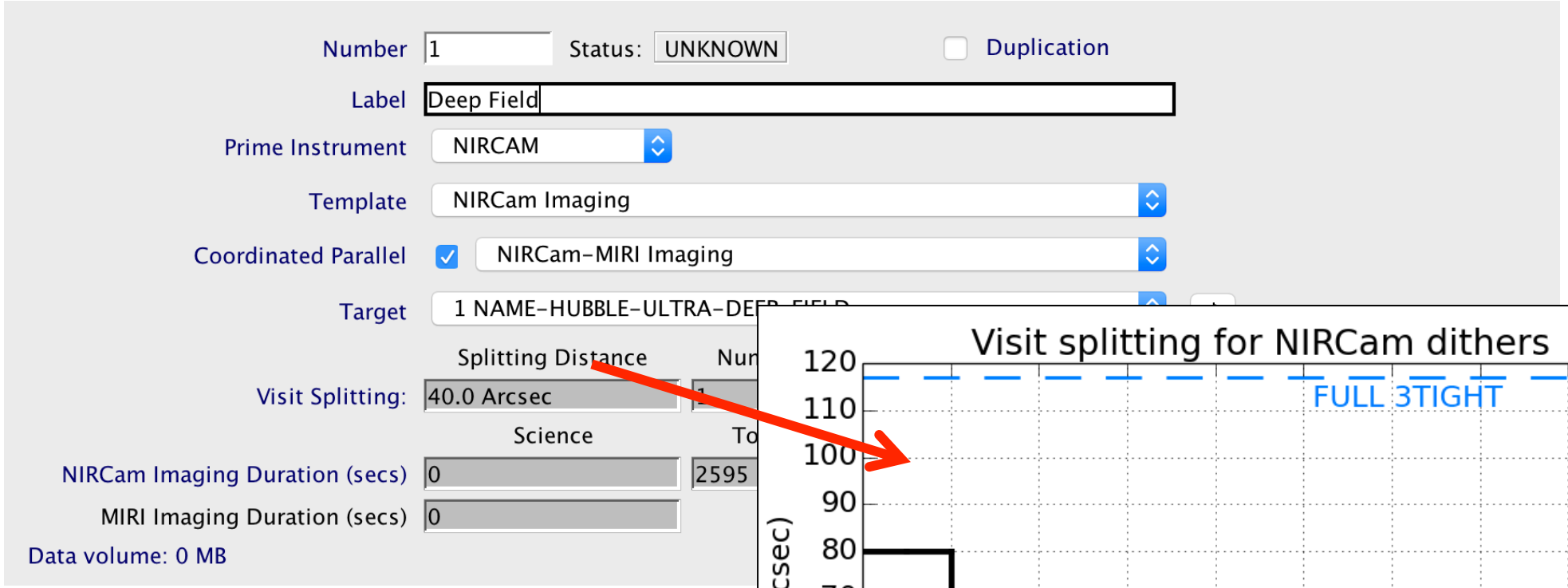
Inside Observation 1

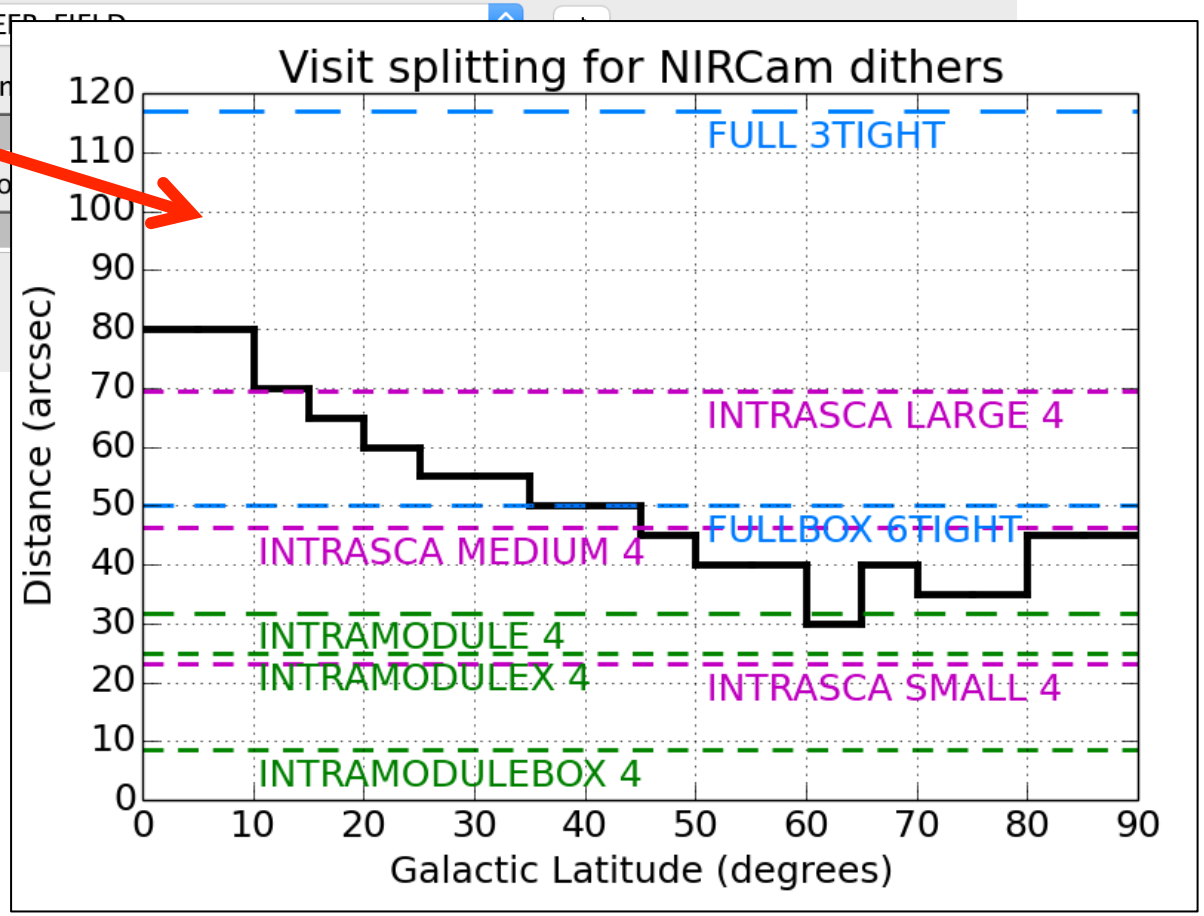


The top half of the Observation 1 window is **General Information.**

- As you choose Instruments and templates, new options appear.
- Note that when you give this observation a **Label**, the name also changes in the sidebar.
- Greyed areas show information about visits & observation time
- Data volume is also displayed

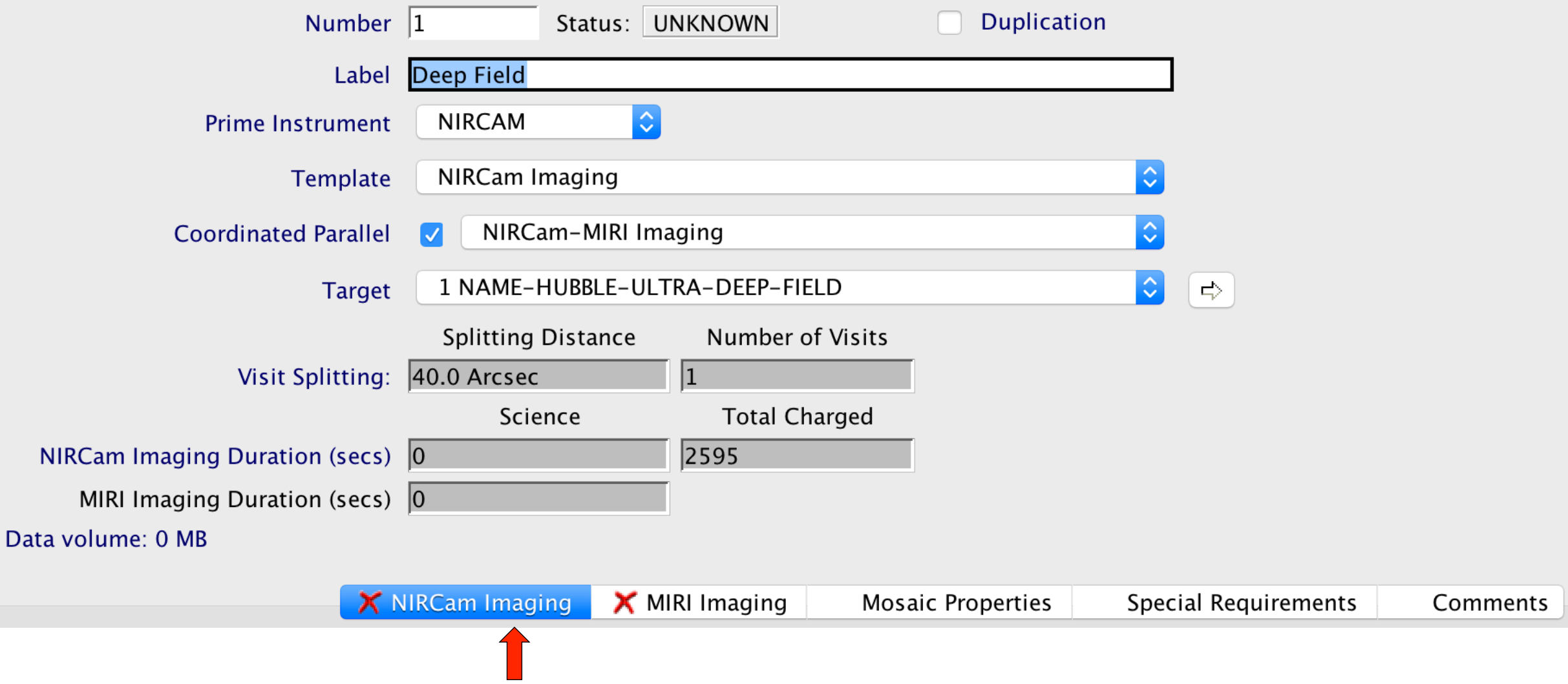
Inside Observation 1





Slews larger than the '**visit splitting distance'** require acquisition of a new guide star, creating additional overheads. Some dither patterns avoid this extra overhead better than others.

Inside Observation 1



The bottom half of the Observation 1 window is **Instrument Setup.** The prime instrument is the first tab, followed by the parallel instrument

NIRCam Imaging | MIRI Imaging | Mosaic Properties | Special Requirements | Comments

Module: ALL

Subarray: FULL

	Primary Dither Type	Primary Dithers	Subpixel Dither Type
Dither Parameters	FULLBOX	4TIGHT	3-POINT-WITH-MIRI-F770W

FULL dither types take large steps that result in variable depth over the imaged area. Review coverage in Aladin and compensate in ETC.*

Filters

#	Short Filter	Long Filter	...	ETC Wkbk.Calc...
1	F090W	F410...		

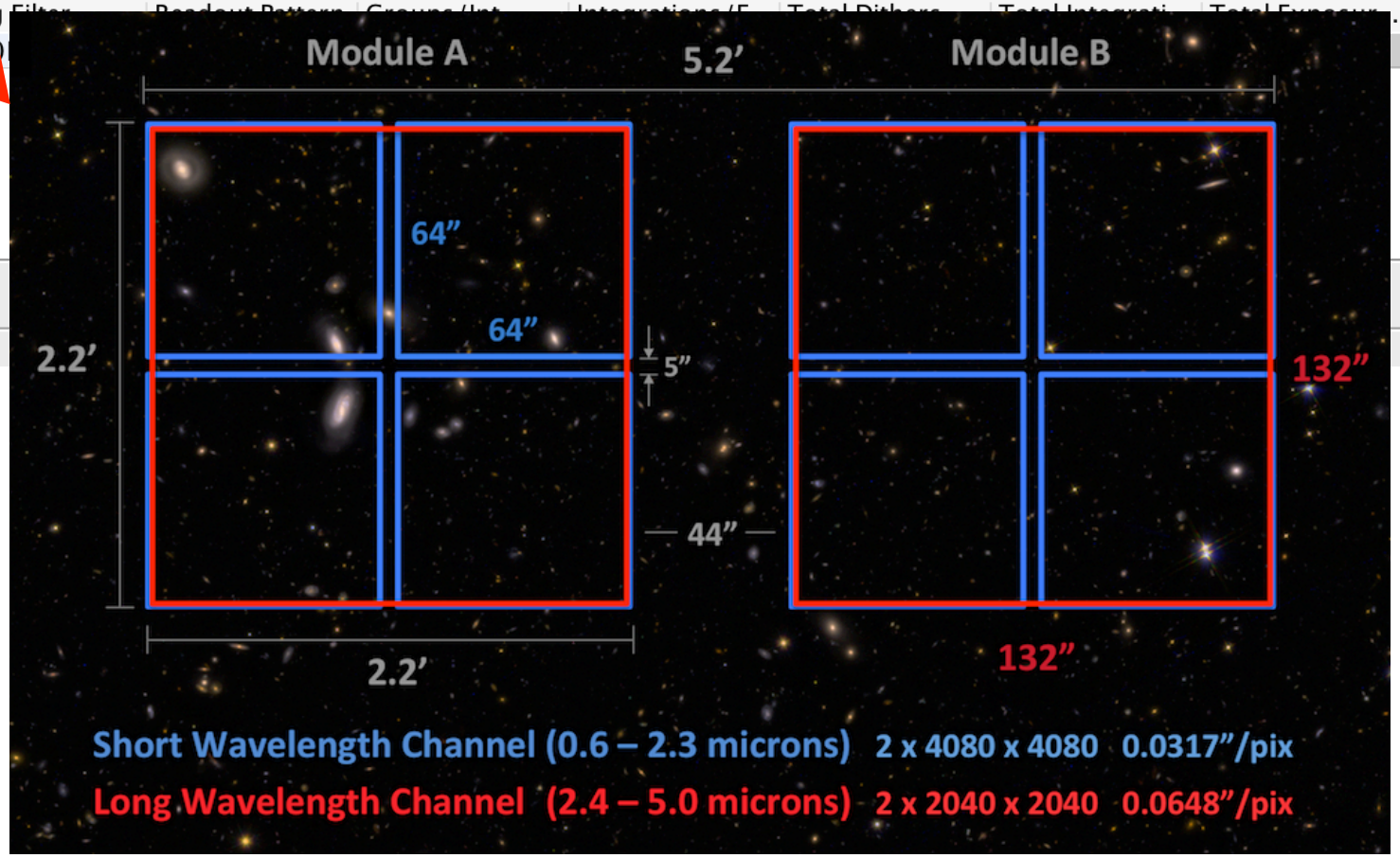
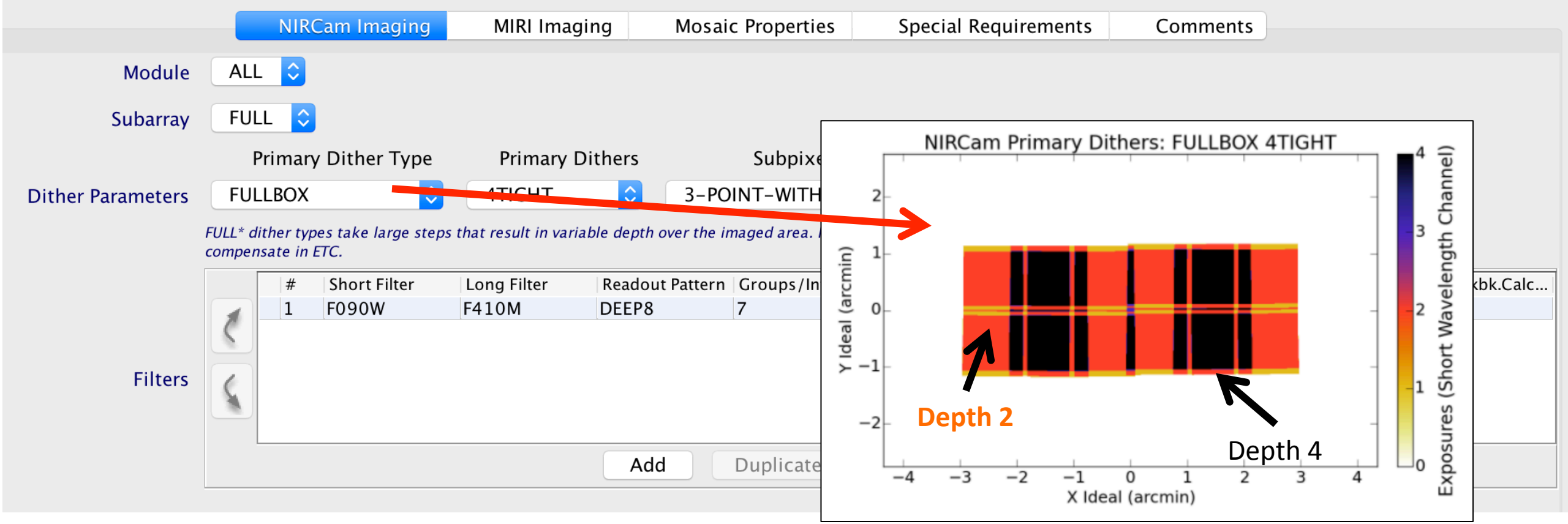


Image credit: Dan Coe



Primary Dithers for covering detector gaps

Three sizes:

- **INTRASCA**: Objects smaller than the individual SCAs (detectors)
  - (<50” or <100” for short or long wavelength observations, respectively)
  - *Only available for Module B*
- **INTRAMODULE***: Objects smaller than the individual module
  - (<110”)
- **FULL***: Large fields without gaps, including mosaics

NIRCam Imaging | MIRI Imaging | Mosaic Properties | Special Requirements | Comments

Module: ALL

Subarray: FULL

Dither Parameters

Primary Dither Type	Primary Dithers	Subpixel Dither Type
FULLBOX	4TIGHT	3-POINT-WITH-MIRI-F770W

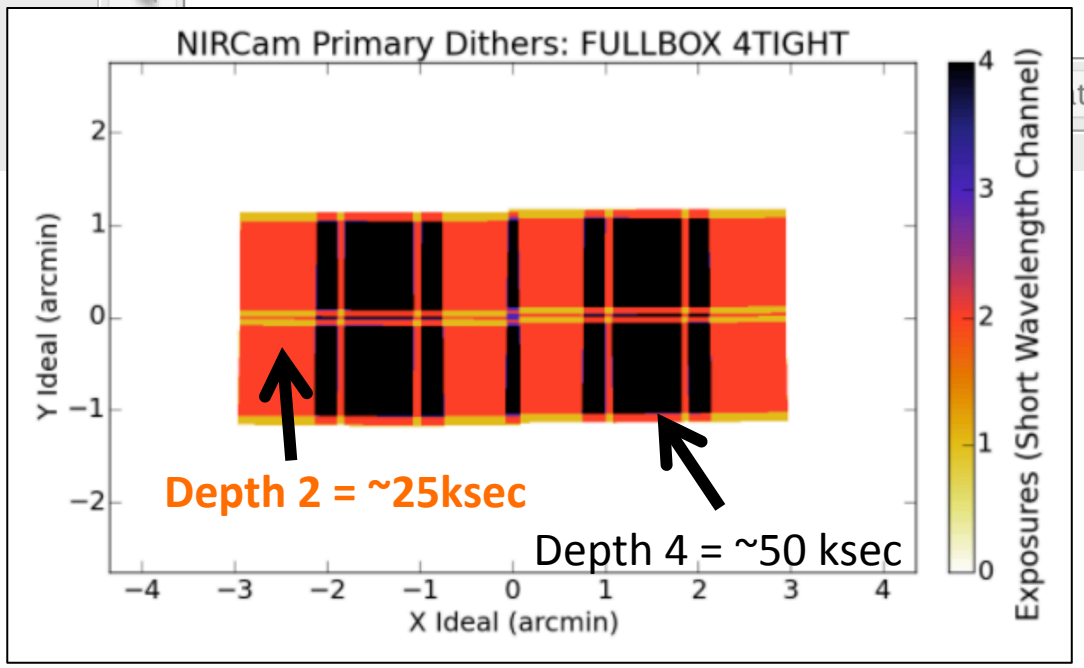
FULL dither types take large steps that result in variable depth over the imaged area. Review coverage in Aladin and compensate in ETC.*

Filters

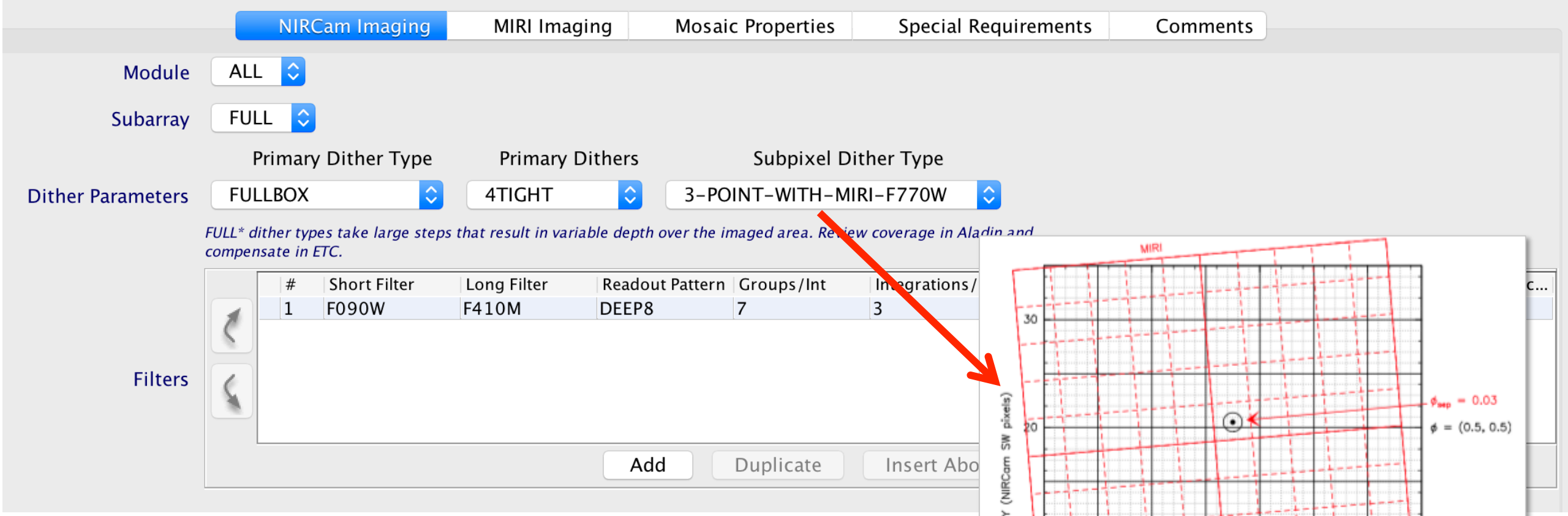
#	Short Filter	Long Filter	Readout Pattern	Groups/Int	Integrations/E...	Total Dithers	Total Integrati...	Total Exposur...	ETC Wkbk.Calc...
1	F090W	F410M	DEEP8	7	3	12	36	49861.56	

Insert Above | Remove

3 subpixel x 4 FULLBOX



This is the maximum depth across your dither pattern, corresponding to the black regions to the left.



Coordinated Parallel Subpixel Dithers

- Accounts for different instrument orientations and plate scales
- Patterns keep pixel phases ‘ideal’ to within 0.05 pix for parallel instruments.
  - Exception: MIRI at >12 μm (well sampled anyway)

NIRCam Imaging | MIRI Imaging | Mosaic Properties | Special Requirements | Comments

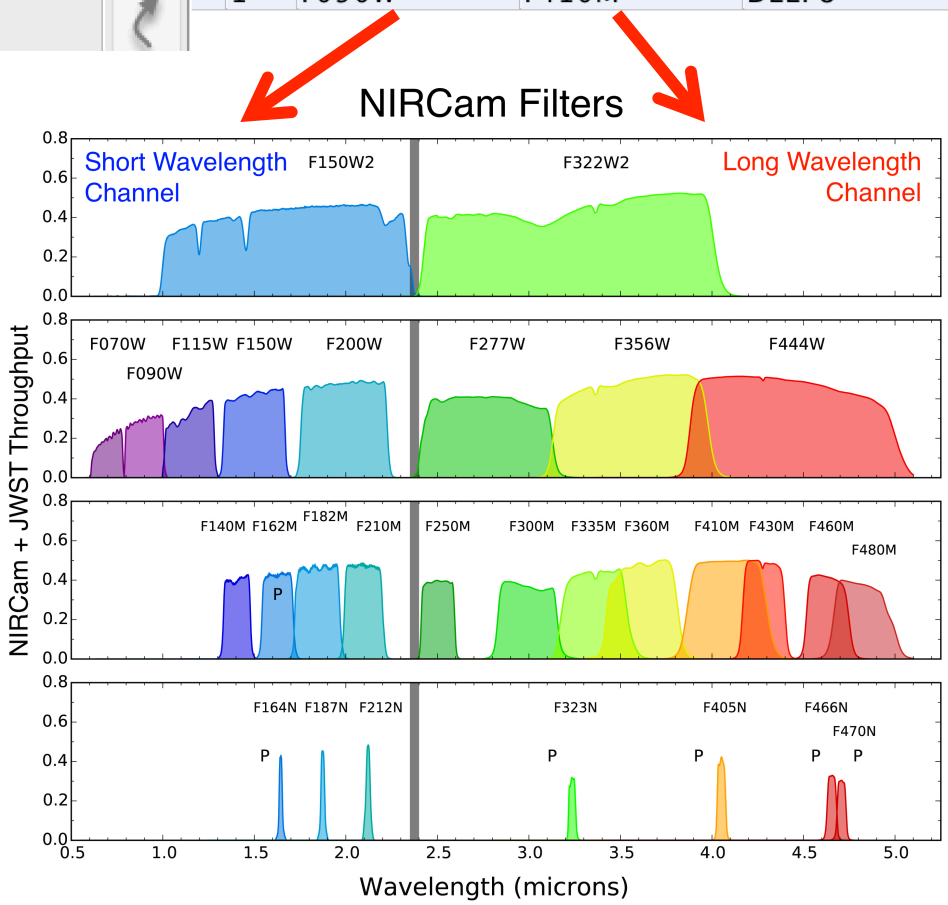
Module: ALL

Subarray: FULL

	Primary Dither Type	Primary Dithers	Subpixel Dither Type
Dither Parameters	FULLBOX	4TIGHT	3-POINT-WITH-MIRI-F770W

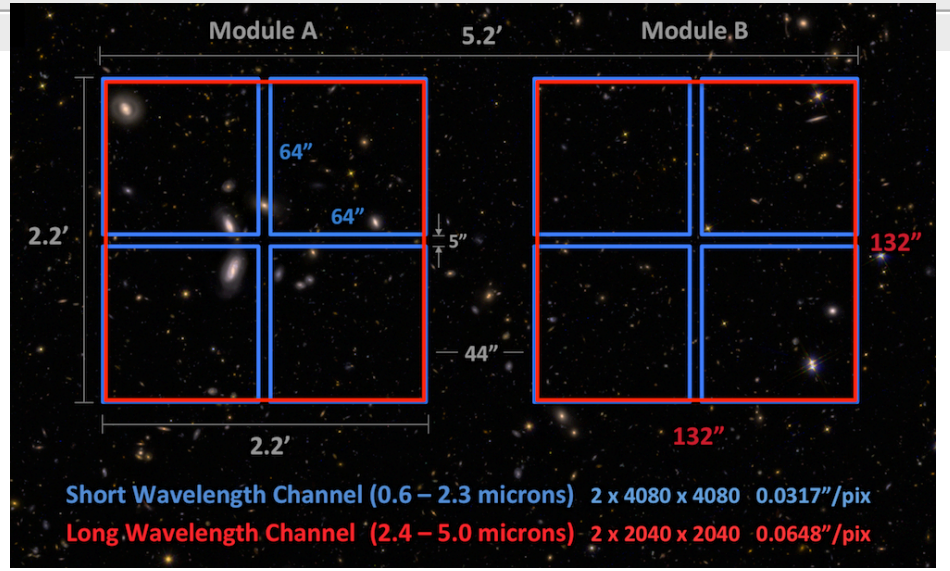
FULL dither types take large steps that result in variable depth over the imaged area. Review coverage in Aladin and compensate in ETC.*

#	Short Filter	Long Filter	Readout Pattern	Groups/Int	Integrations/E...	Total Dithers	Total Integrati...	Total Exposur...	ETC Wkbk.Calc...
1	F090W	F410M	DEEP8	7	3	12	36	49861.56	



Short and Long wavelength channels observed simultaneously.

Insert Above | Remove



NIRCam Imaging | MIRI Imaging | Mosaic Properties | Special Requirements | Comments

Module: ALL

Subarray: FULL

Dither Parameters

Primary Dither Type	Primary Dithers	Subpixel Dither Type
FULLBOX	4TIGHT	3-POINT-WITH-MIRI-F770W

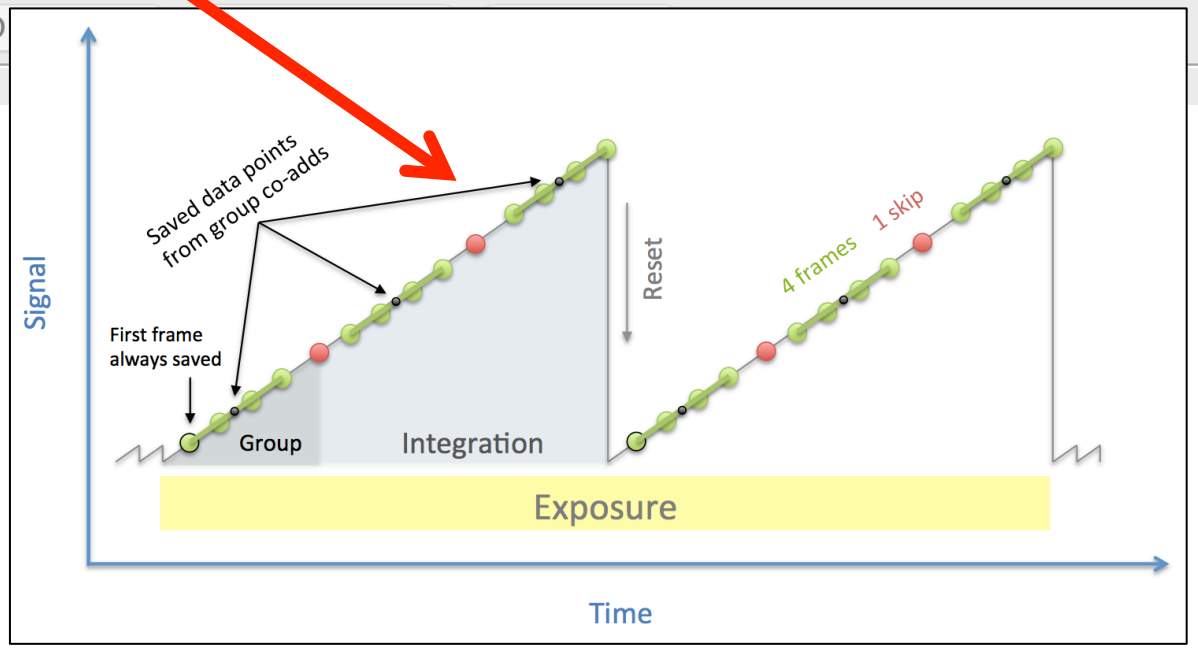
FULL dither types take large steps that result in variable depth over the imaged area. Review coverage in Aladin and compensate in ETC.*

Filters

#	Short Filter	Long Filter	Readout Pattern	Groups/Int	Integrations/E...	Total Dithers	Total Integrati...	Total Exposur...	ETC Wkbk.Calc...
1	F090W	F410M	DEEP8	7	3	12	36	49861.56	

Add | D

- Several competing factors:
  - Longer integrations to reduce overheads
  - Shorter integrations to reduce cosmic-ray hit effects
  - Co-added data to reduce data downlink



NIRCam Imaging | MIRI Imaging | Mosaic Properties | Special Requirements | Comments

Module: ALL

Subarray: FULL

Dither Parameters

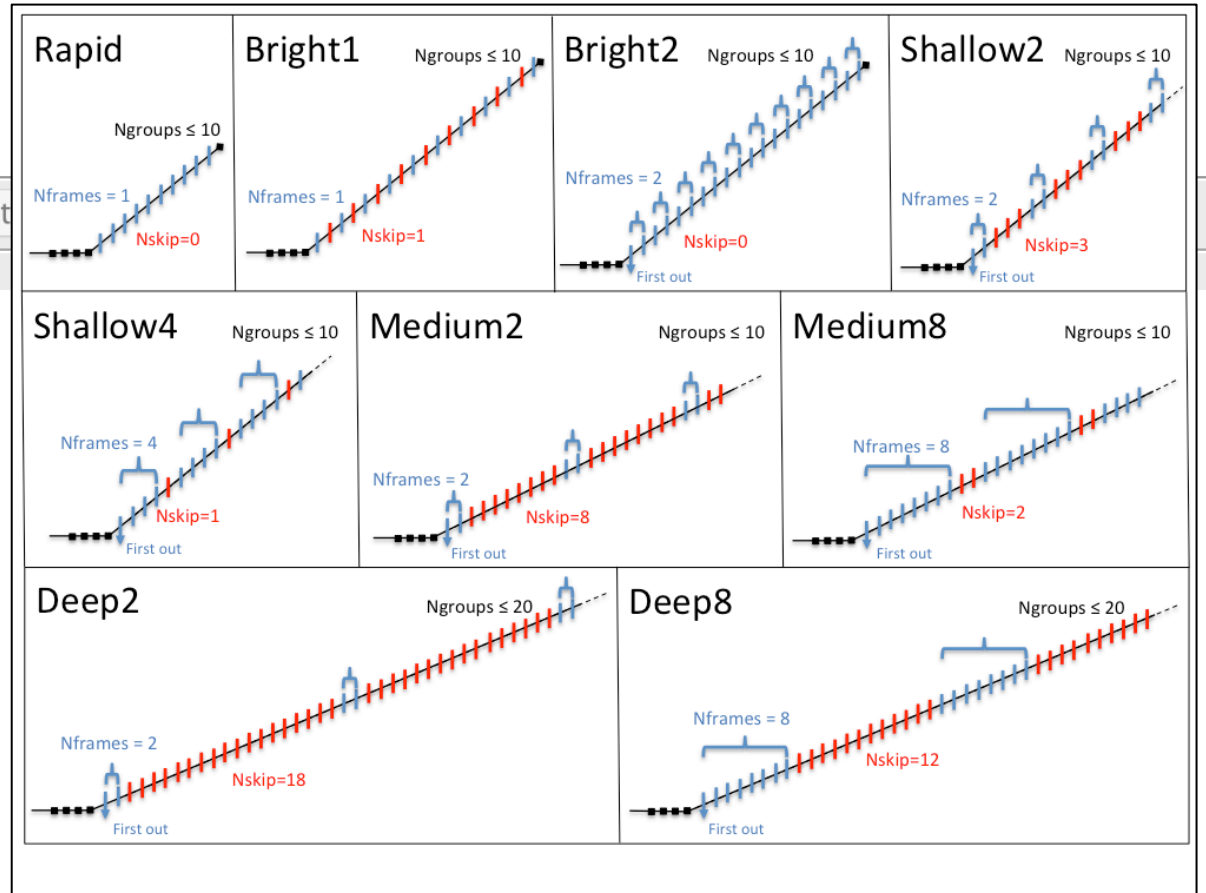
Primary Dither Type	Primary Dithers	Subpixel Dither Type
FULLBOX	4TIGHT	3-POINT-WITH-MIRI-F770W

FULL dither types take large steps that result in variable depth over the imaged area. Review coverage in Aladin and compensate in ETC.*

Filters

#	Short Filter	Long Filter	Readout Pattern	Groups/Int	Integrations/E...	Total Dithers	Total Integrati...	Total Exposur...	ETC Wkbk.Calc...
1	F090W	F410M	DEEP8	7	3	12	36	49861.56	

Add | Duplicat



- Several competing factors:
  - Longer integrations to reduce overheads
  - Shorter integrations to reduce cosmic-ray hit effects
  - Co-added data to reduce data downlink

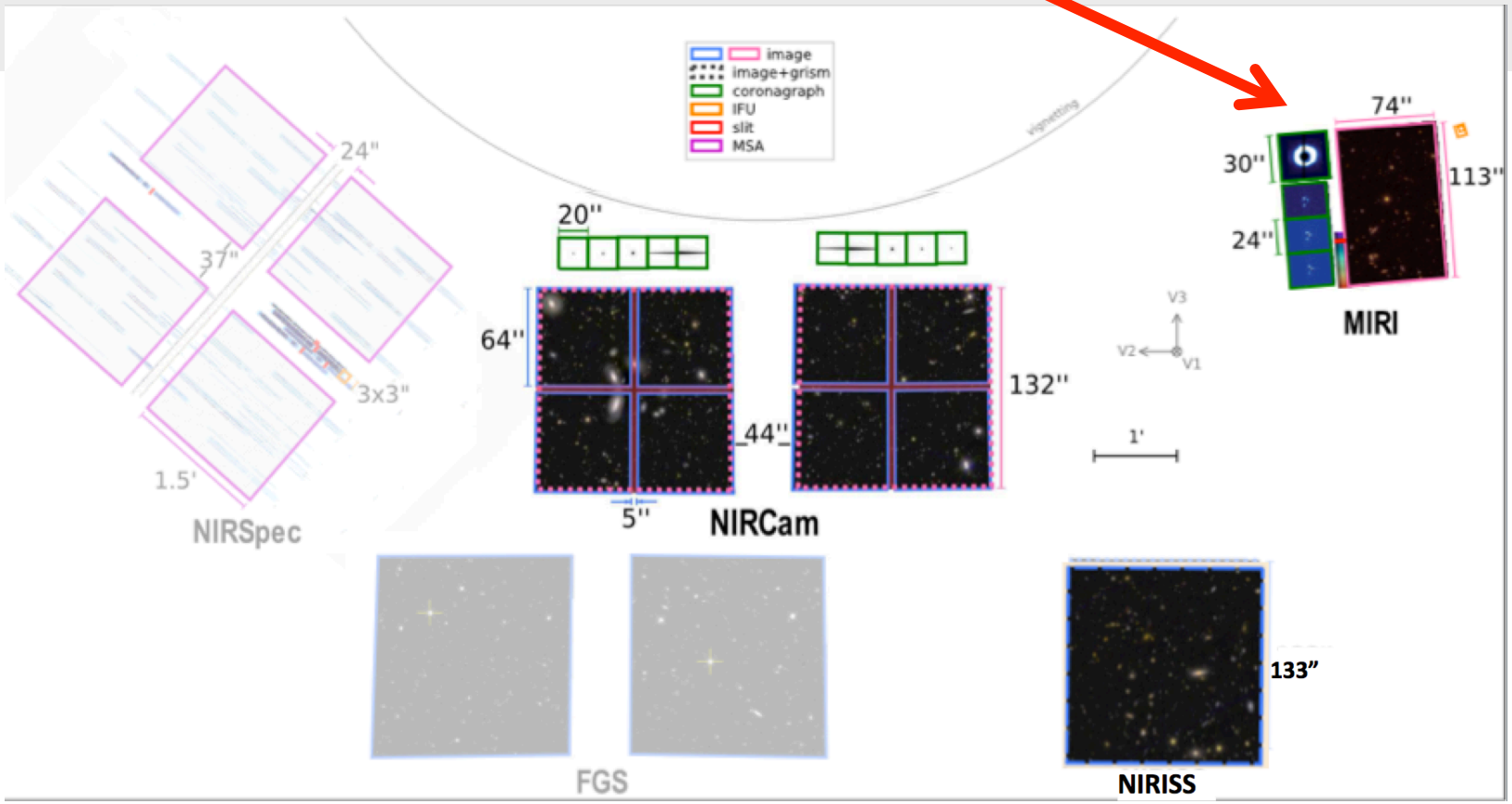
NIRCam Imaging | MIRI Imaging | Mosaic Properties | Special Requirements | Comments

Subarray: FULL

Filters

#	Filter	Readout Pattern	Groups/Int	Integrations/E...	Exposures/Dith	Total Dithers	Total Integrati...	Total Exposur...	ETC Wkbk.Calc...
1	F770W	FAST	301	5	1	12	60	50117.222	

Add | Duplicate | Insert Above | Remove



MIRI: 74”x113”

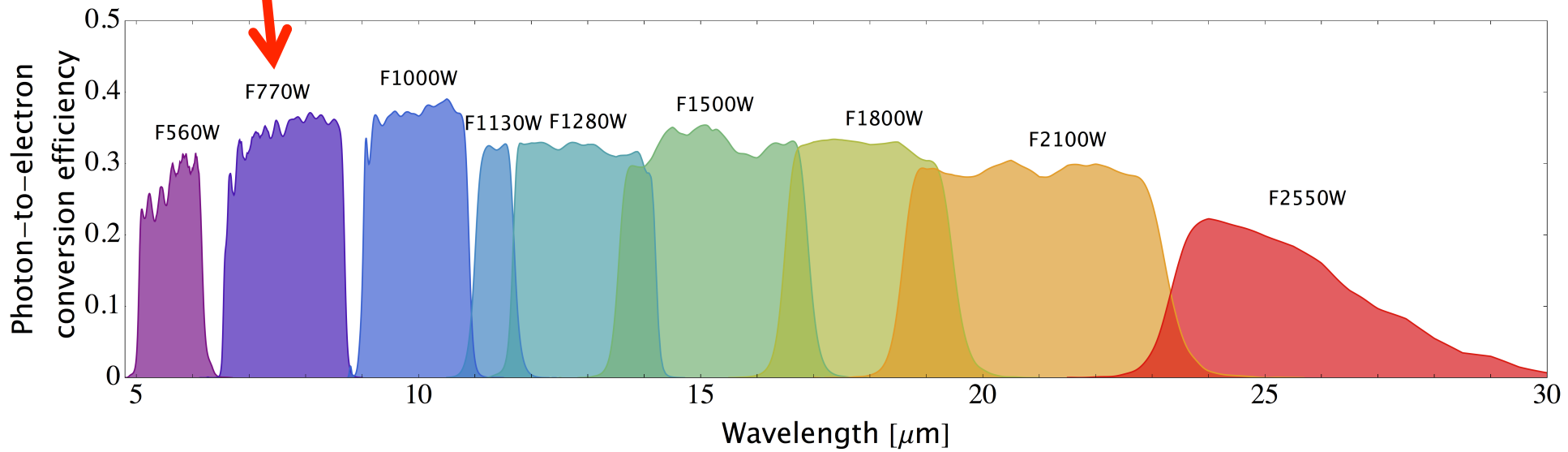
NIRCam Imaging | MIRI Imaging | Mosaic Properties | Special Requirements | Comments

Subarray: FULL

Filters

#	Filter	Readout Pattern	Groups/Int	Integrations/E...	Exposures/Dith	Total Dithers	Total Integrati...	Total Exposur...	ETC Wkbk.Calc...
1	F770W	FAST	301	5	1	12	60	50117.222	

Add | Duplicate | Insert Above | Remove



NIRCam Imaging | MIRI Imaging | Mosaic Properties | Special Requirements | Comments

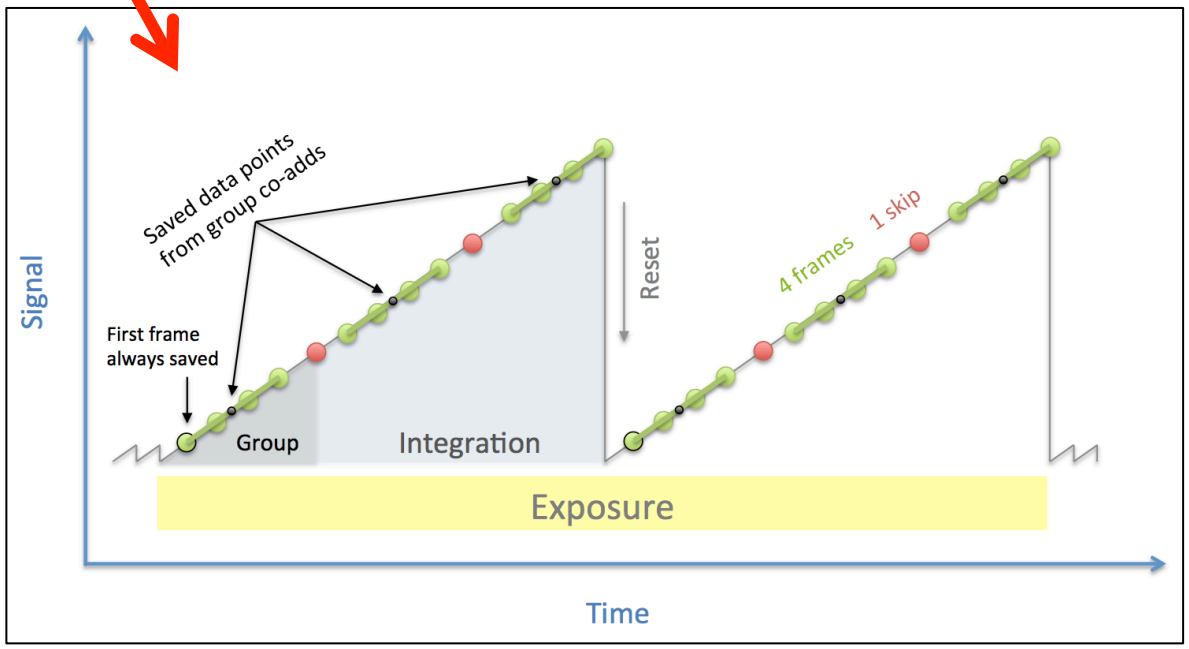
Subarray: FULL

Filters

#	Filter	Readout Pattern	Groups/Int	Integrations/E...	Exposures/Dith	Total Dithers	Total Integrati...	Total Exposur...	ETC Wkbk.Calc...
1	F770W	FAST	301	5	1	12	60	50117.222	

Add | Duplicate | Insert Above | Remove

MIRI's FAST Readout:
Saves every sample, so 1 group = 1 sample
Each sample ~ 2.8 s

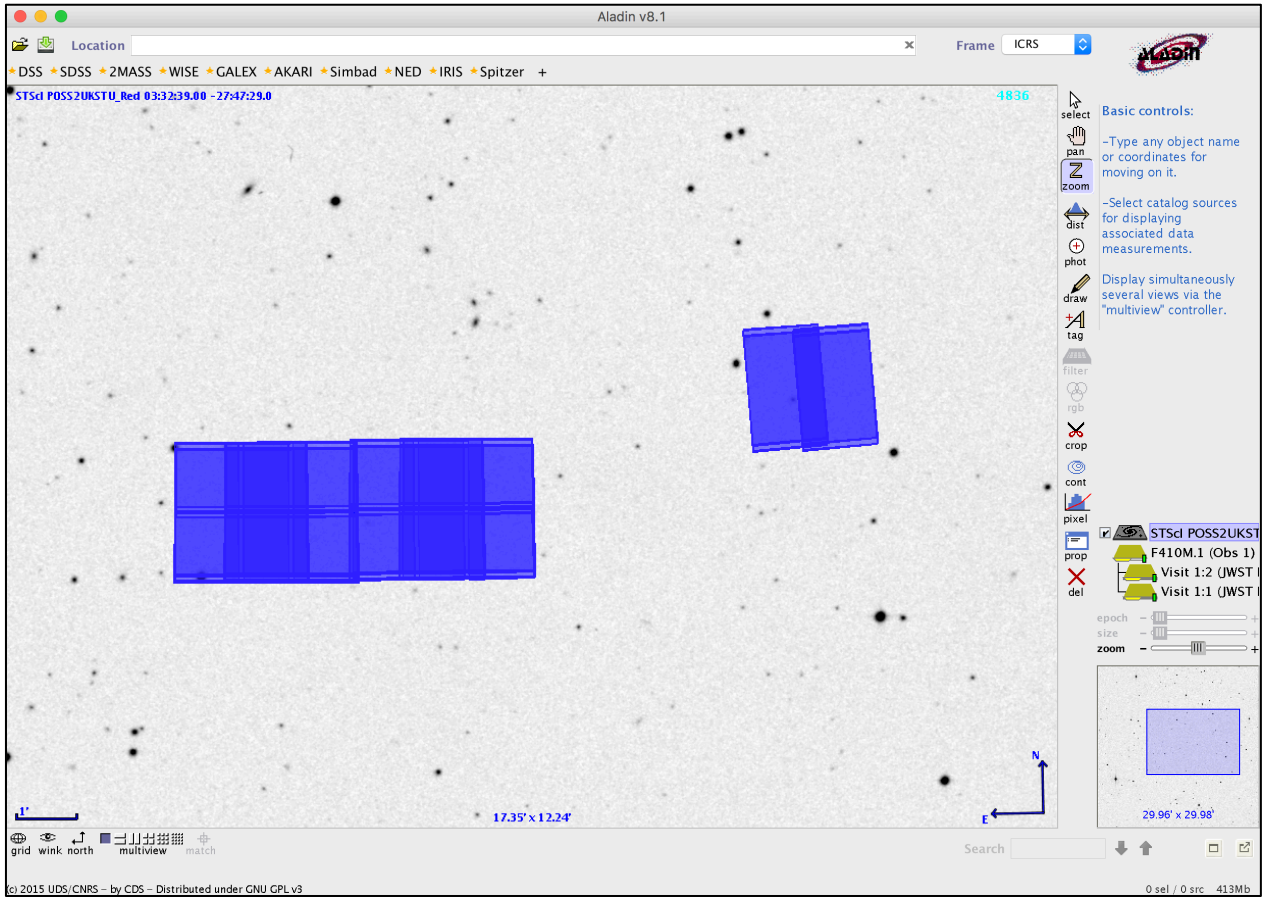


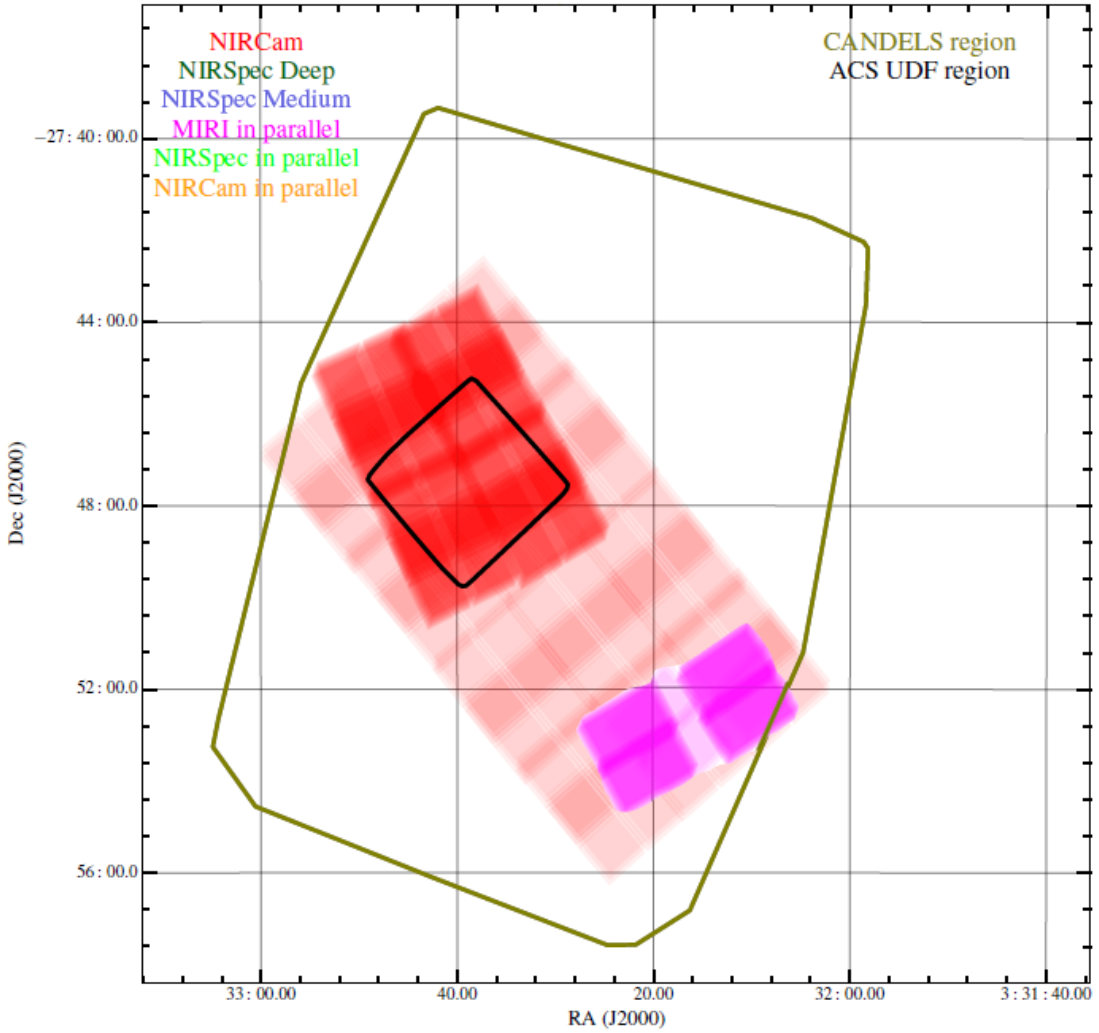
Astronomer's Proposal Tools Version 25.4.1 - JWST Draft Proposal (DeepField_Dec2017_FULLBOX.aptx)

Form Editor | Spreadsheet Editor | Orbit Planner | Visit Planner | View in Aladin | BOT | Target Confirmation | PDF Preview | Check for Duplications | Open ETC | Submission | Errors and Warnings | Run All Tools | Stop

New JWST Proposal | New | JWST What's New | HST What's New | Roadmap | Feedback

Click 'View in Aladin' to visualize the setup.





NIRCam Imaging | MIRI Imaging | Mosaic Properties | Special Requirements | Comments

Rows 2 Columns 1

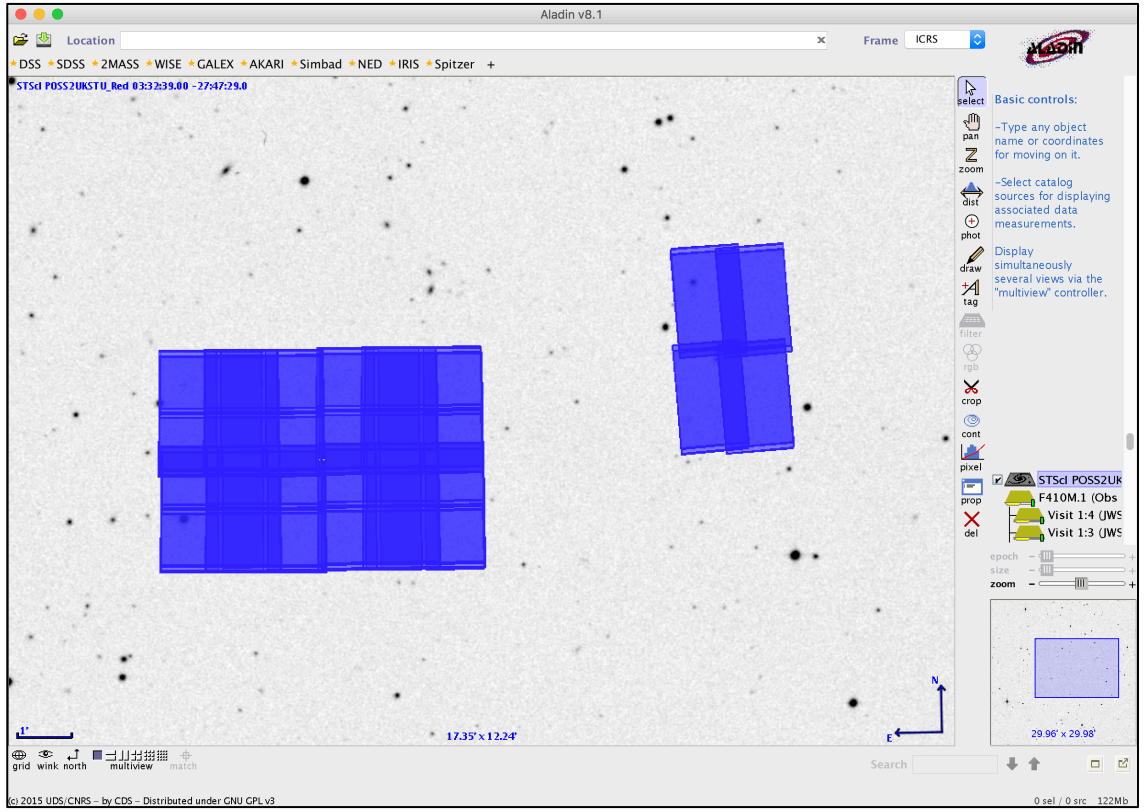
Row Overlap % 20.0 Column Overlap % 10.0

Row shift 0.0 Column shift 0.0

View in Aladin

Mosaic Tiles:

Tile Number	Tile State	Visits
1	Tile Included	[1:1, 1:2]
2	Tile Included	[1:3, 1:4]



Use ~20% row overlap if you want the MIRI mosaic tiles to overlap

NIRCam Imaging | MIRI Imaging | Mosaic Properties | Special Requirements | Comments

Special Requirements

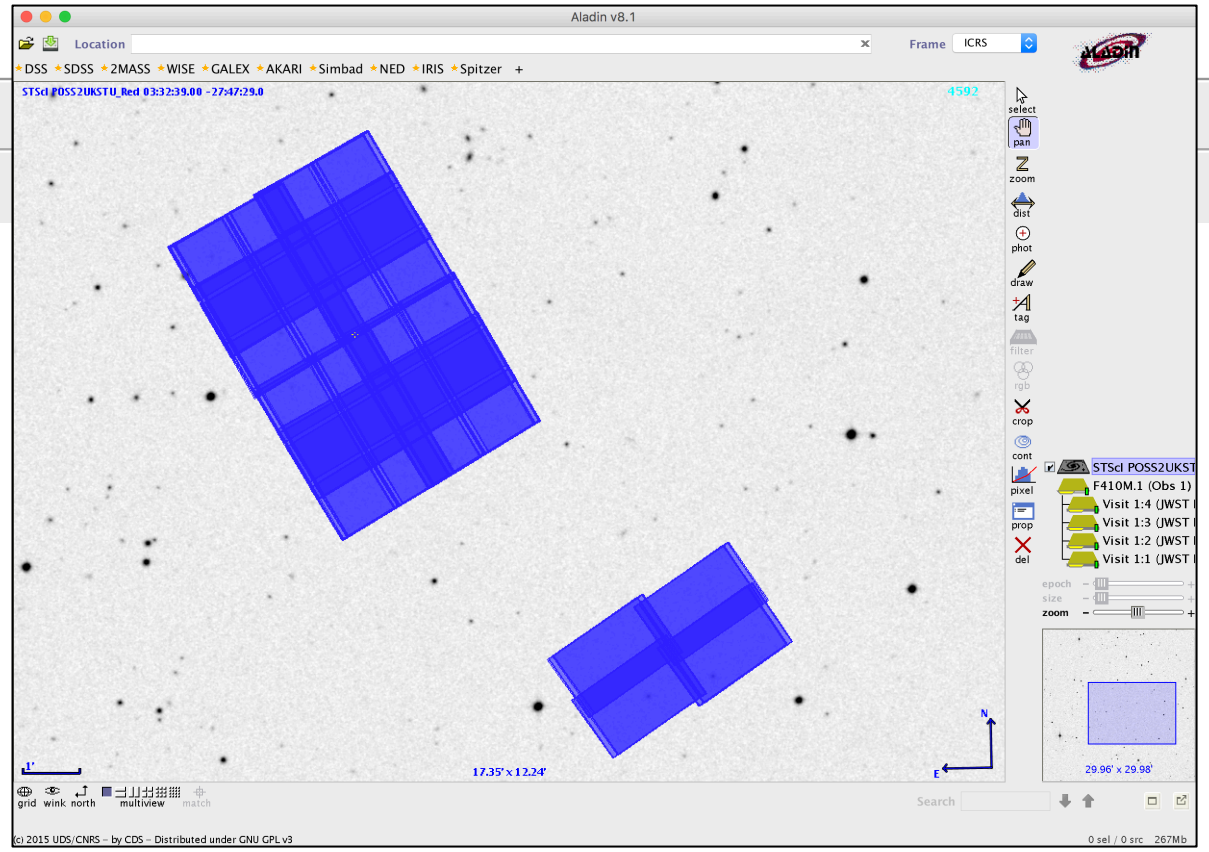
Aperture PA Range 280 to 320 Degrees (V3 280.026475 to 320.026475)
No Parallel

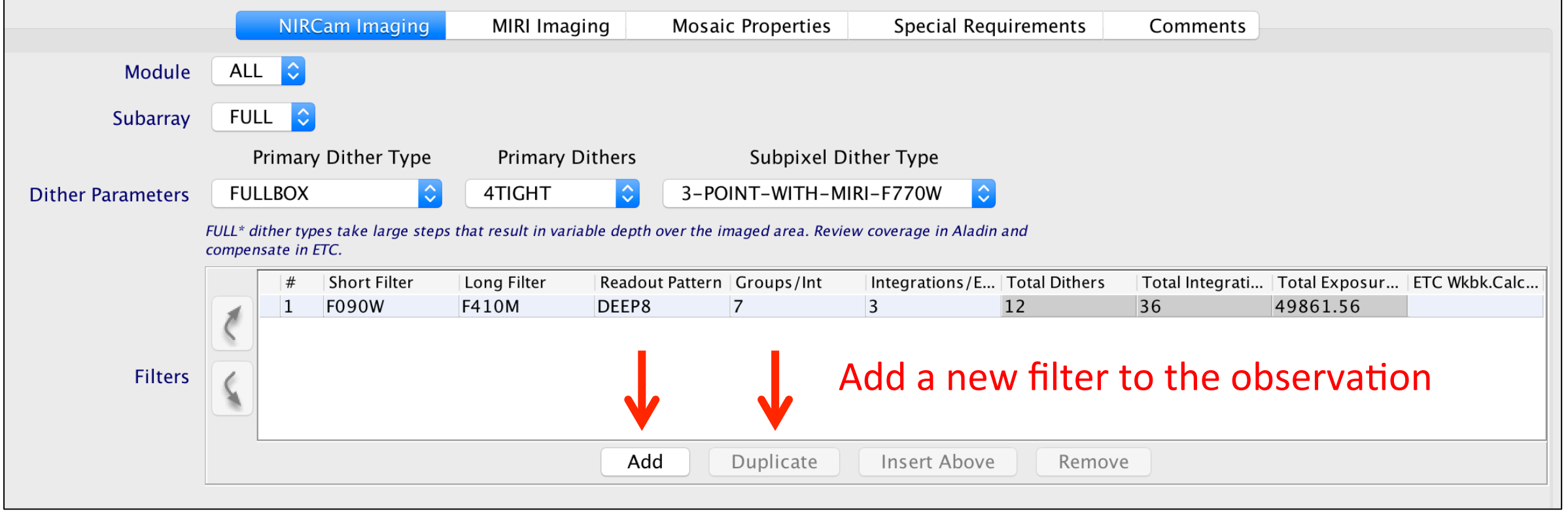
Add... Remove Edit

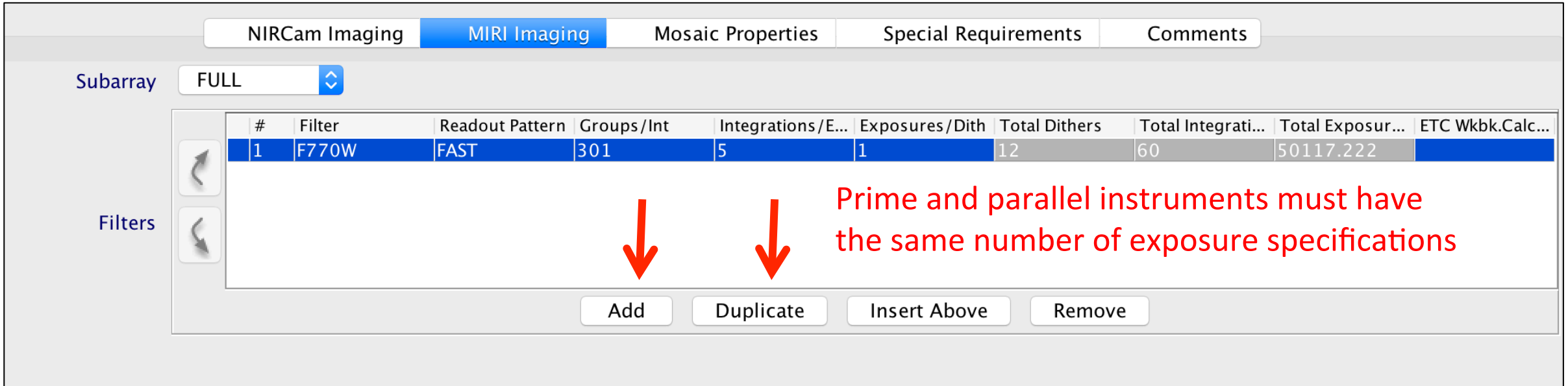
Implicit Requirements

Group Visits within 53.0 Days
Visits Same PA

Add a position angle (PA) range.




NIRCam Imaging
MIRI Imaging
Mosaic Properties
Special Requirements
Comments
Module
ALL
Subarray
FULL
Primary Dither Type
Primary Dithers
Subpixel Dither Type
Dither Parameters
FULLBOX
4TIGHT
3-POINT-WITH-MIRI-F770W
FULL* dither types take large steps that result in variable depth over the imaged area. Review coverage in Aladin and compensate in ETC.
Filters
Short Filter Long Filter Readout Pattern Groups/Int Integrations/E... Total Dithers Total Integrati... Total Exposur... ETC Wkbk.Calc...
1 F090W F410M DEEP8 7 3 12 36 49861.56
Add a new filter to the observation
Add
Duplicate
Insert Above
Remove


NIRCam Imaging
MIRI Imaging
Mosaic Properties
Special Requirements
Comments
Subarray
FULL
Filters
Filter Readout Pattern Groups/Int Integrations/E... Exposures/Dith Total Dithers Total Integrati... Total Exposur... ETC Wkbk.Calc...
1 F770W FAST 301 5 1 12 60 50117.222
Prime and parallel instruments must have the same number of exposure specifications
Add
Duplicate
Insert Above
Remove

	Splitting Distance	Number of Visits
Visit Splitting:	40.0 Arcsec	28

	Science	Total Charged
NIRCam Imaging Duration (secs)	791664	972027
MIRI Imaging Duration (secs)	801456	

Data volume: 1,149,450 MB

NIRCam Imaging | MIRI Imaging | Mosaic Properties | Special Requirements | Comments

Module: ALL

Subarray: FULL

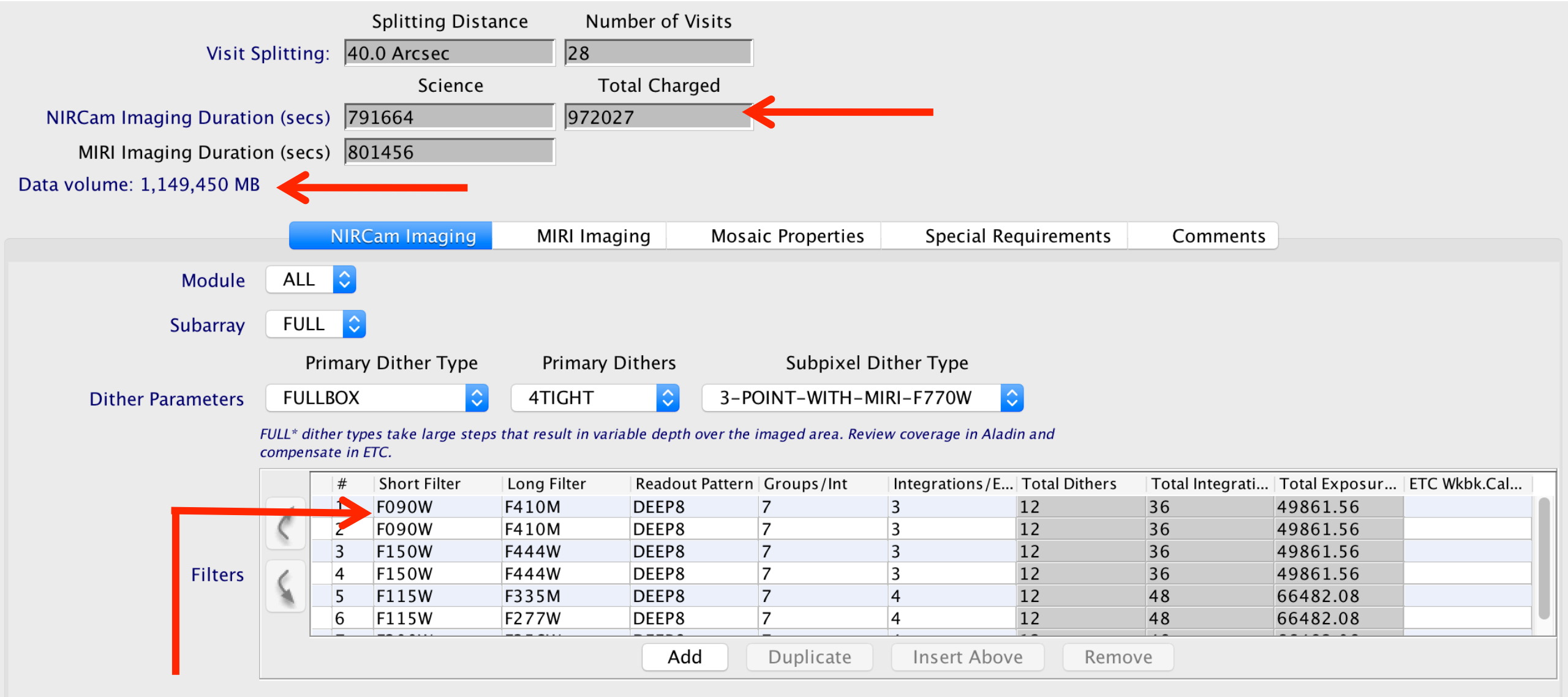
	Primary Dither Type	Primary Dithers	Subpixel Dither Type
Dither Parameters	FULLBOX	4TIGHT	3-POINT-WITH-MIRI-F770W

FULL dither types take large steps that result in variable depth over the imaged area. Review coverage in Aladin and compensate in ETC.*

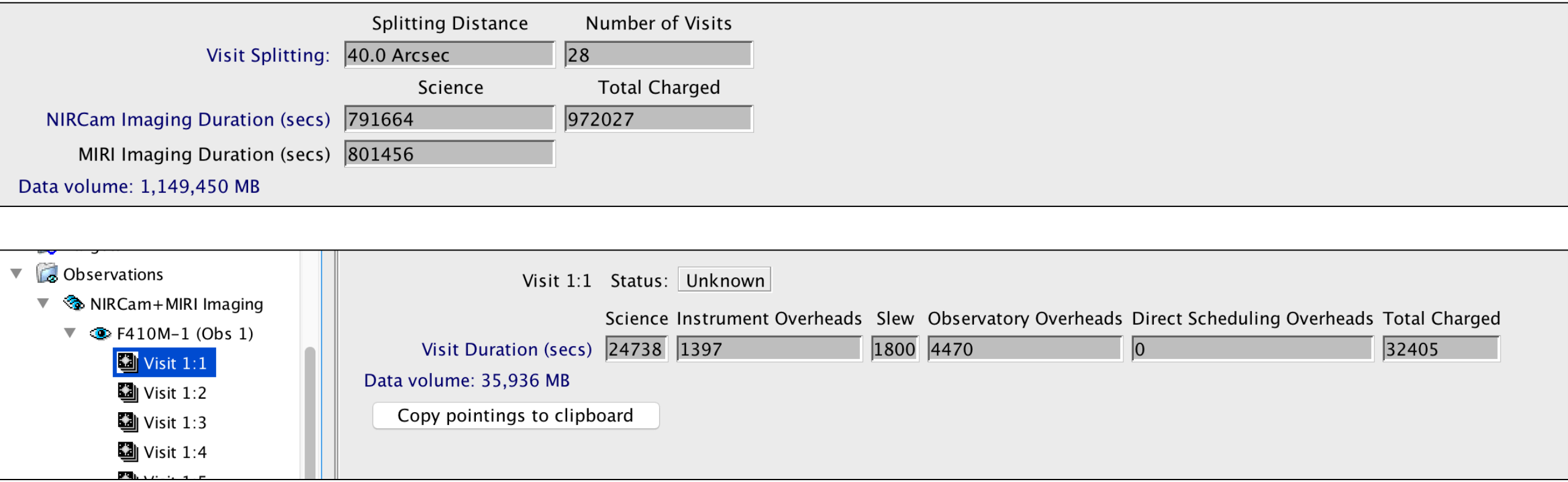
Filters

#	Short Filter	Long Filter	Readout Pattern	Groups/Int	Integrations/E...	Total Dithers	Total Integrati...	Total Exposur...	ETC Wkbk.Cal...
1	F090W	F410M	DEEP8	7	3	12	36	49861.56	
2	F090W	F410M	DEEP8	7	3	12	36	49861.56	
3	F150W	F444W	DEEP8	7	3	12	36	49861.56	
4	F150W	F444W	DEEP8	7	3	12	36	49861.56	
5	F115W	F335M	DEEP8	7	4	12	48	66482.08	
6	F115W	F277W	DEEP8	7	4	12	48	66482.08	

Add | Duplicate | Insert Above | Remove



Must duplicate some filter pairs to reach required exposure time or risk exceeding allowed data volume.



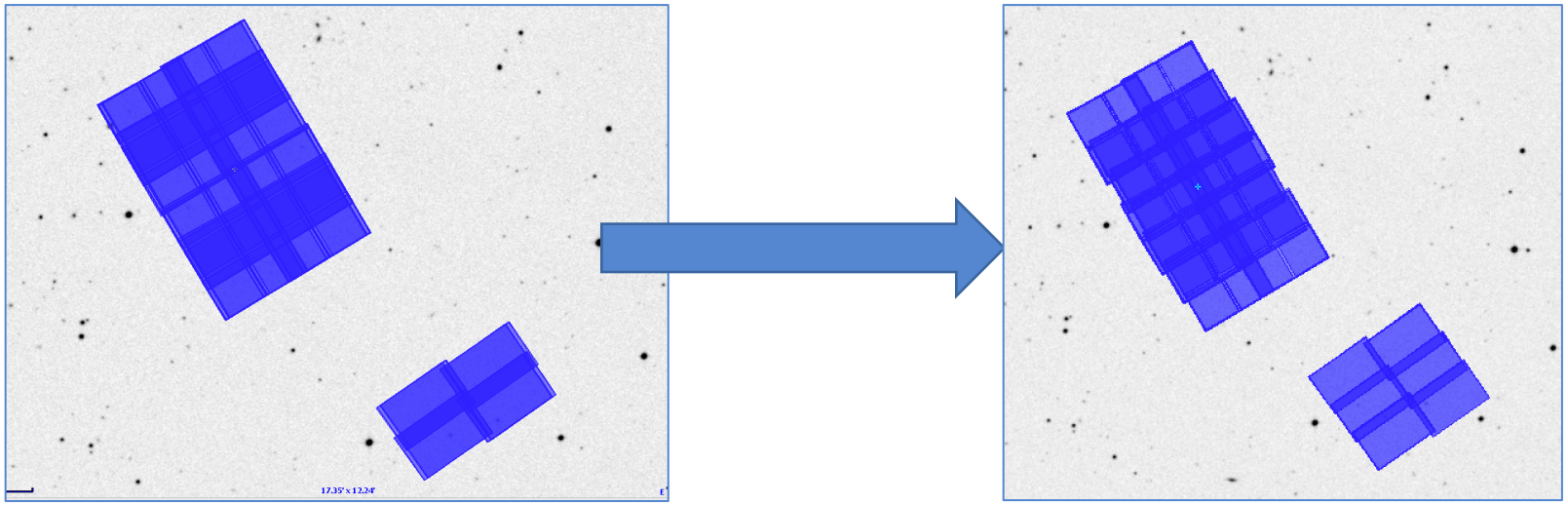
JWST will downlink data in 4-hour contacts, occurring twice per day, approximately 12 hours apart.
In one contact, JWST can transmit **28.2 GB** of recorded science data.

The onboard Solid State Recorder can hold at least **58.8 GB**. If a contact is missed, science observations can continue without filling the recorder, and the ground can catch up on the next contact.

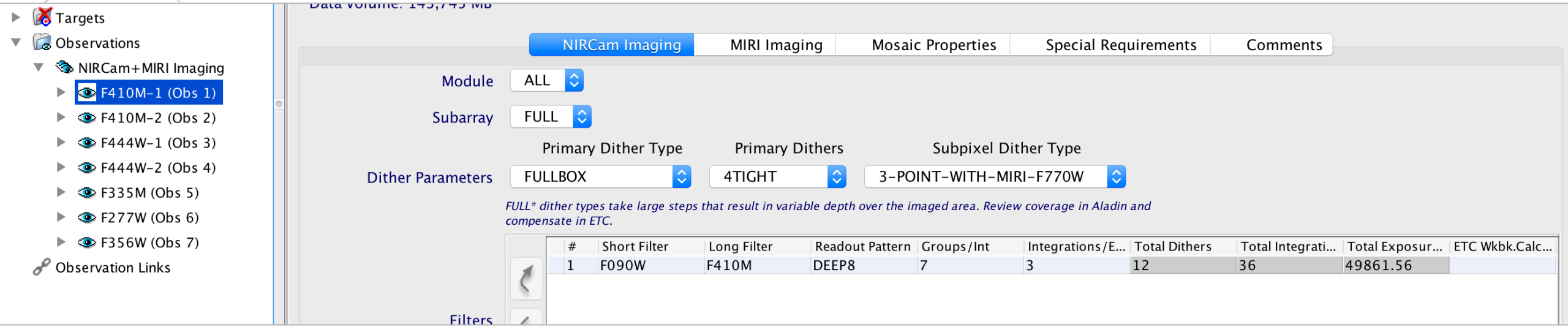
For optimal schedulability, keep visits below 28.2 GB data volume.

Data Volume Limits

1. The easiest solution: use the SLOW readout pattern for the MIRI parallels. There are 7 exposures sequences; setting 4 of them to SLOW and leaving the others FAST could allow visit combinations that solve the data volume limits.
    - Visit 1: ~9 hr length, ~36 GB
    - Visit 2: ~9 hr length, ~15 GB
2. Change the dither pattern to FULL
    - This splits into smaller chunks, making them a bit easier to schedule (~6 hrs, 23 GB)
    - Costs a few more hours in overhead (275 hr vs. 272 hr)

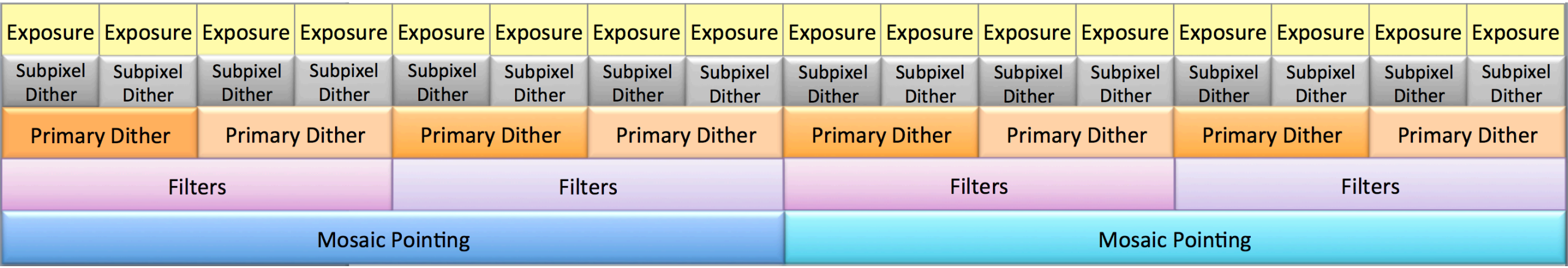


Alternate Setups



There are several ways to set up a program. For example, splitting the filters into separate observations requires just 5 filter wheel moves (as opposed to 10) and allows each filter to be scheduled separately. But it takes ~8 more minutes.

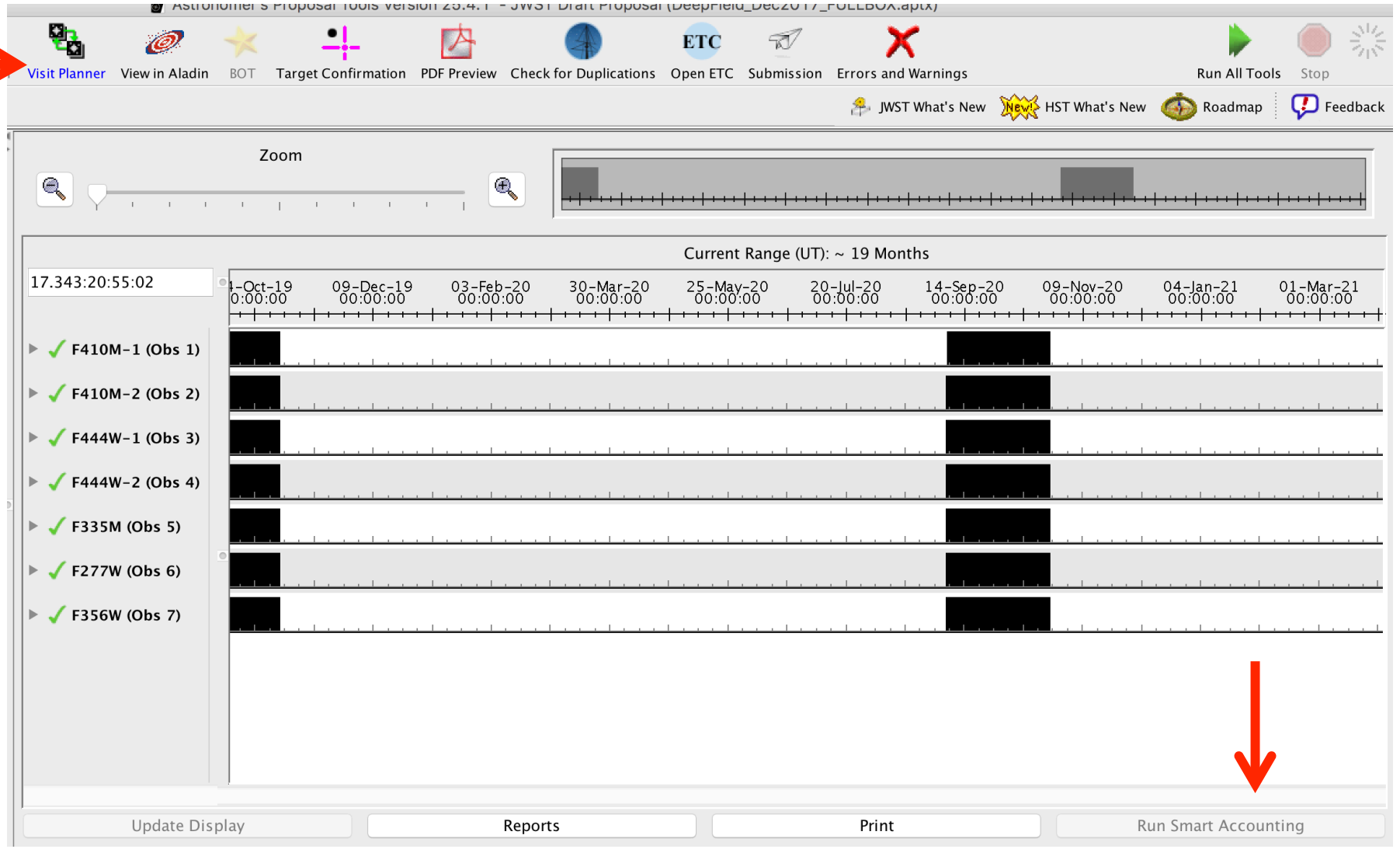
Preserving the Filter Wheels



The NIRCam filter wheels are required for wavefront sensing, but they have a limited lifetime. Users should try to minimize filter wheel moves.

Dithers are better than Mosaics, for example.

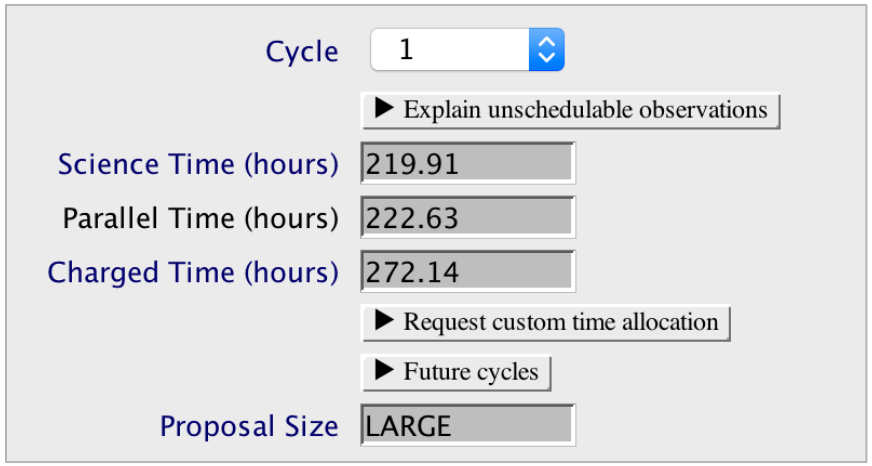
Visit Planner & Smart Accounting



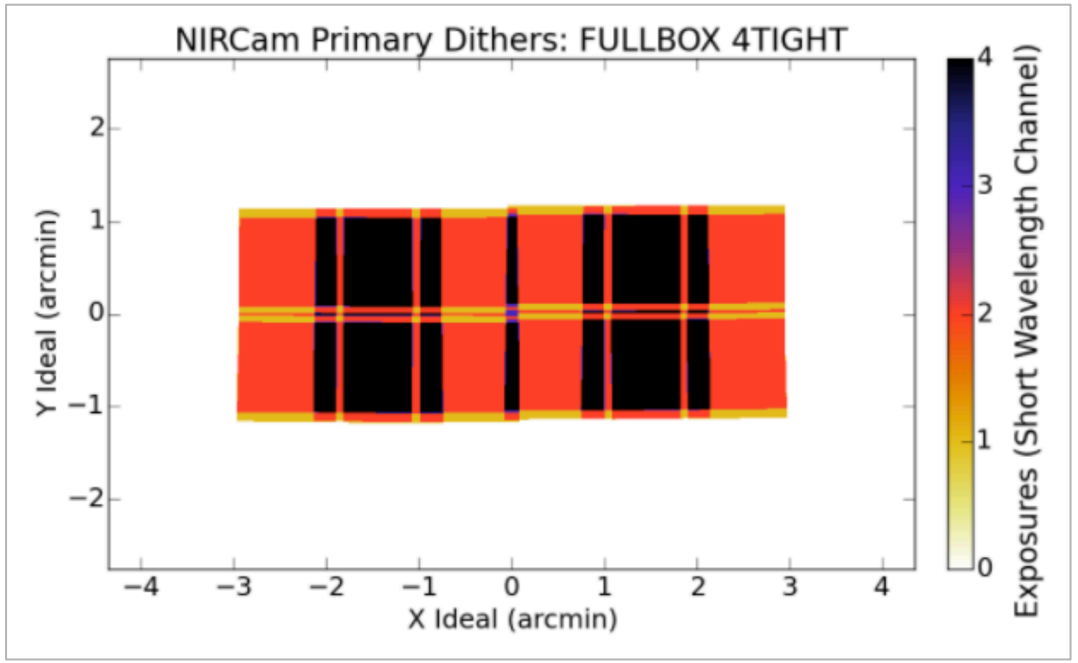
Total Exposure Time

SW Filter	LW Filter	Approx. Depth
F150W	F410M	50-100 ksec
F115W	F444W	50-100 ksec
F090W	F335M	33-66 ksec
F090W	F277W	33-66 ksec
F200W	F356W	33-66 ksec

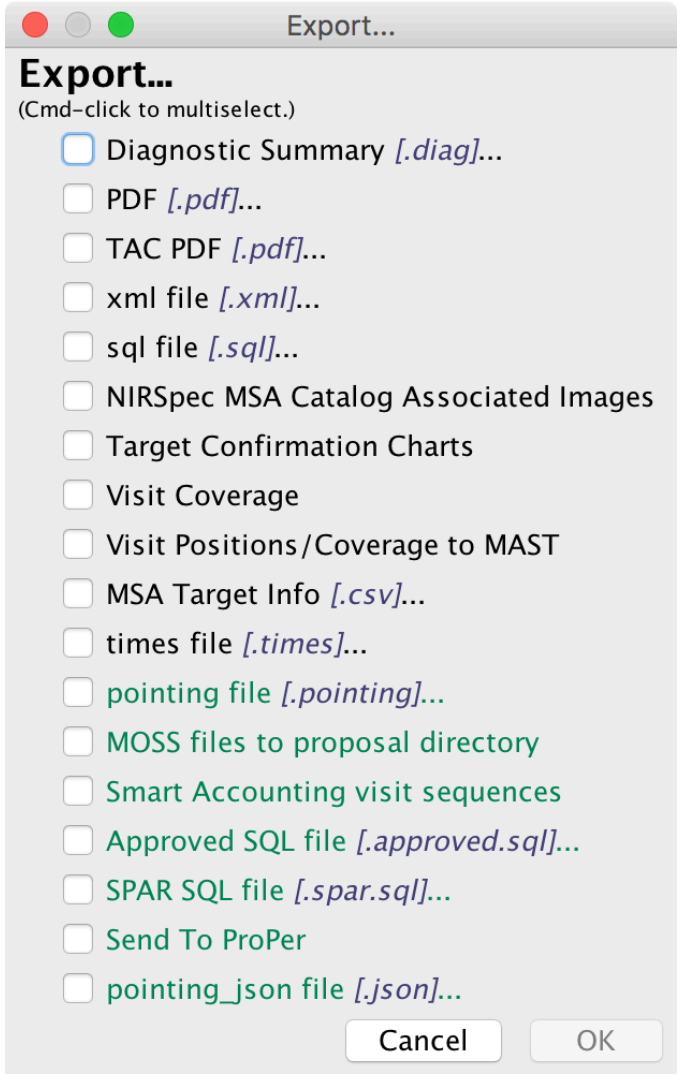
All observations image with the F770W filter in parallel



Range is due to varying coverage



APT Diagnostics



Explore various diagnostics:

- **Visit Coverage** = CVS file with pointing info
  - Polygons, PAs, etc.
- **Pointing File** = text file demonstrating exposure sequence and dither steps
- **Times File** = text file with overheads
- **Smart Accounting** = text file showing overhead improvements