



STScI | SPACE TELESCOPE
SCIENCE INSTITUTE

EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

Planning MOS Observations

JWST Master Class November 18-22, 2019

Diane Karakla and the STScI NIRSpec Instrument Team
and Gary Curtis and the team of APT developers

The MOS Observing Process





Multi-Step Process

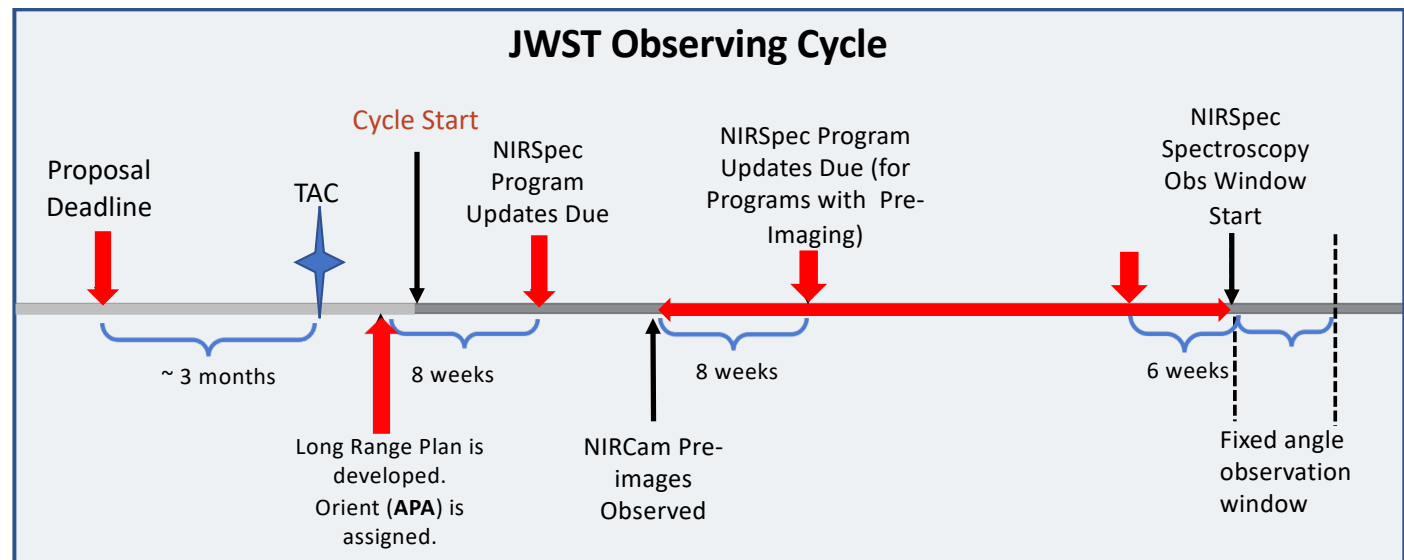
To accurately align science sources within the small MSA shutters, NIRSpec MOS mode observations must be **planned and executed at a fixed instrument Aperture Position Angle (APA), assigned by STScI**. Hence, a multi-step planning process.

For the **Proposal deadline**, use **MPT** to create placeholder visits to accurately estimate the overheads.

After the TAC, an **APA will be assigned** by STScI.

Flight ready programs are due **8 weeks after the APA is assigned** (no NIRCams pre-imaging)

Or, **8 weeks after the NIRCams pre-imaging** is observed.



For best success, users should place their NIRCams pre-imaging and NIRSpec observations **in different visibility windows** to have time to reduce and analyze the NIRCams astrometry.

When that's not possible, program updates will be due **a min of 6 weeks in advance of the NIRSpec observing window**.



Positional Accuracies, Target Acq, and Pre-imaging



Pointing Accuracies

Most science will require accurate astrometry delivered by MSATA (using reference stars).

Note that the delivered TA pointing accuracy depends on the input **Catalog relative astrometric accuracy**.

If accurate astrometry is required, and if **HST imaging** does not exist – request **NIRCam pre-imaging** in your Proposal

TA Type	Delivered Pointing Accuracy	Catalog Relative Accuracy	Science Goal
Optimal (MSATA)	20 - 25 mas (20 mas is 1/10 th shutter)	5 - 15 mas (HST: ~ 10 mas is possible. NIRCam: 5 mas is the goal)	Best possible photometric accuracy
Relaxed (MSATA)	< 50 mas	< 40 mas	Extended sources, or reduced flux accuracy w/ MSA
VERIFY_ONLY	~ 100 mas (TBD)	No ref stars required	Special cases – extended source



Target Acquisition Options

- **Moving targets** cannot use MSATA – **must use WATA** instead. WATA does not require pre-imaging, only a good ephemeris.
- **For Program Updates - MPT will be used to select reference stars** at the assigned APA that will not be behind MSA bars or in failed shutters. This vetting is done at the Visit level at the first pointing in the Visit.
- **MSATA requires defining 5-8 reference stars**. Programs using MSATA will be charged a **fixed overhead** equivalent to an average charge for 8 reference stars.
- **8 reference stars have been determined to be optimal** – tradeoffs between increased accuracy and overheads. Will be adjusted if needed. Can be increased with permission, for slightly better results.



Pre-imaging with NIRCcam

- Is **imaging** available that is
 - deep enough to identify sources,
 - wide enough to plan ref stars, and
 - accurate enough to plan MOS obs?
- If not – request **NIRCcam pre-imaging** in your Proposal.
 - Area should be large enough to **allow for any APA** for the NIRSpect obs: Ideally 5 x 5 arcmin: typically 2x1 mosaic + dithers to cover the gaps.
 - **NIRCcam observations must be flight ready at proposal submission.**

NIRSpect Observation Visualization Tool (L. Ubeda)

The screenshot shows the NIRSpect Observation Visualization Tool interface. The main window displays a dark field of stars with several overlapping yellow and red rectangular regions representing observation footprints. The interface includes a menu bar (File, Edit, View, Frame, Zoom, Scale, Color, Region, WCS, Analysis, Help) and a toolbar with various zoom and view options. The status bar at the bottom shows coordinates and scale values.



The MSA Planning Tool in APT



MSA Planning Tool (MPT) in APT



- NIRSpec MOS observing mode is able to obtain spectra of tens to hundreds of objects within a 3.6' x 3.4' FoV at the same time.
- The **MPT** was designed to align science sources with the very small shutters (0.2" x 0.46")

Astronomer's Proposal Tools Version 27.3 mpt-demo (Thu Jul 25 2019) JWST PRD: PRDOPSSOC-L-023

Form Editor Spreadsheet Editor **MSA Planning Tool** Orbit Planner Visit Planner Timeline View in Aladin BOT Target Confirmation PDF Preview Submission Errors and Warnings

New Document What's New Roadmap Feedback

Astronomer's Proposal Tools

Version 27.3 mpt-demo (Thu Jul 25 2019) JWST PRD: PRDOPSSOC-L-023

- Copyright 2002 – 2007 United States Government as represented by the Administrator of the National Aeronautics and Space Administration. All Rights Reserved.
- This software has made use of the Aladin Sky Atlas (<http://aladin.u-strasbg.fr/>) developed at the *Centre de Données astronomiques de Strasbourg* (CDS - <http://cdsweb.u-strasbg.fr/>)
- This software has made use of the SIMBAD database, operated at CDS, Strasbourg, France.
- This software has made use of the NASA/IPAC Extragalactic Database (NED) which is operated by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.
- This software uses portions of the JSky library which is maintained by the European Southern Observatory.

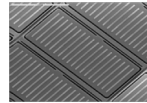
Show: [dropdown]

✓ No errors & warnings (Click for Details)

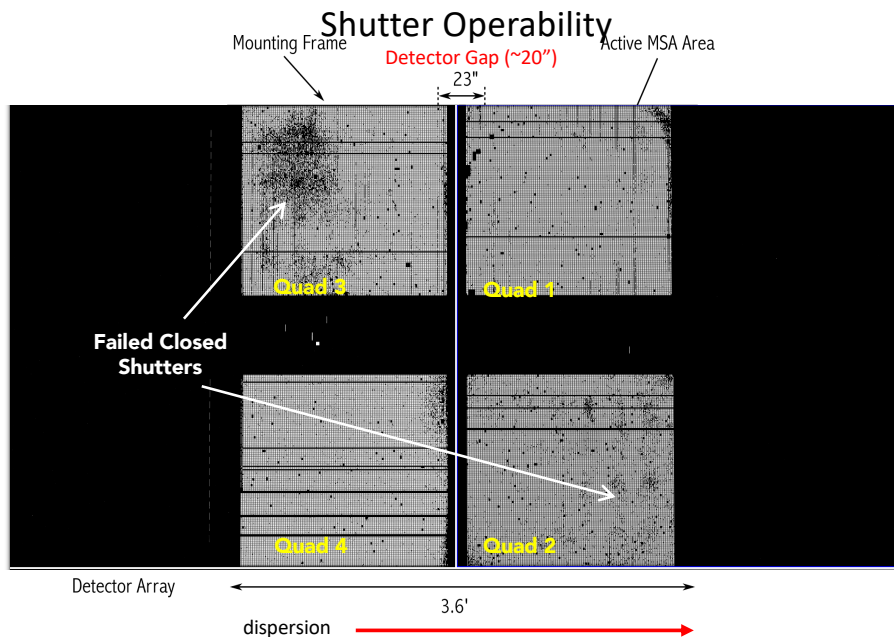


Why Use MPT?

- The MSA is a **fixed grid** (with bars that vignette light from sources behind them)

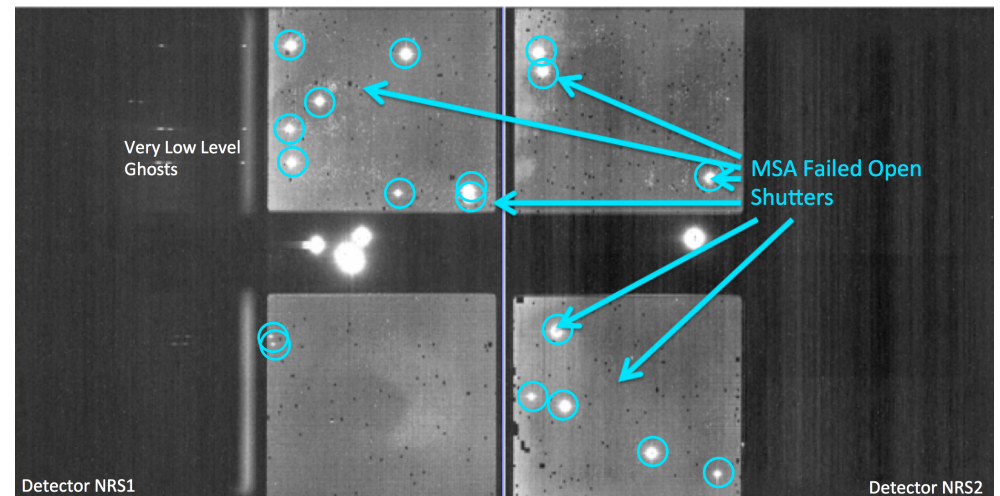


- There is a **gap** between the 2 detectors → missing wavelengths.



- The MSA has **Failed shutters, shorted rows/columns**. Shutter status evolves! MPT plans using the most up-to-date operability.
- Source positions in MSA require knowledge of **optical distortions** and **velocity aberrations** at a planned Aperture Position Angle.

MSA failed open shutters





What's needed to run the MSA Planning Tool?

- An internet connection– to access the most up-to-date MSA shutter operability
- A complete and accurate astrometric Catalog
 - With accurate source positions (< 15 mas relative accuracy) – may require pre-Imaging with NIRCam

- **MPT produces:** “Plans” with Pointings, MSA configurations, Target Sets

A deep space image showing a vast field of stars and a prominent blue nebula. The nebula is composed of glowing gas and dust, with intricate patterns and colors ranging from deep blue to purple and brown. The stars are scattered throughout the field, with some appearing as bright, multi-pointed sources and others as smaller, fainter points of light. The overall scene is a rich, multi-colored stellar environment.

The Source Catalog



Source Catalog

The first step to creating a NIRSpec MOS observation is to create a complete **catalog of sources**. The catalog should include **all known sources in the field**.

- The source catalog is an **ASCII file**
- It must contain J2000 **RA and Dec** expressed in degrees or hexadecimal units.
- It **cannot** have **duplicate IDs nor NULL entries**.
- A header is optional. The header is marked with "#".

ID	RA	DEC	Size	Redshift	Reference	Stellarity	MAG_F160W	NRS_F110W	NRS_F140X	NRS_CLEAR	W
23796	03 32 39.0842	-27 46 1.79		0	1.415 Yes		0.92	20.122	20.674	20.366	20.122
54454	03 32 35.5075	-27 46 26.13		0	1.268 Yes		0.03	20.384	20.845	20.474	20.384
22410	03 32 39.8827	-27 47 15.06		0	1.107 Yes		0.03	20.711	21.199	20.786	20.711
24439	03 32 37.1930	-27 46 8.08		0	1.101 Yes		0.03	19.494	20.254	19.672	19.494
23546	03 32 38.4836	-27 47 2.42		0	0.919 Yes		0.03	20.088	20.785	20.261	20.088
21268	03 32 42.4216	-27 47 58.80		0	0.779 Yes		0.94	17.811	18.026	-99	17.811
22990	03 32 38.7749	-27 47 32.14		0	0.767 Yes		0.03	20.286	20.695	20.415	20.286
21840	03 32 37.3079	-27 47 29.36		0	0.708 Yes		0.03	18.793	19.473	18.966	18.793
22951	03 32 40.6729	-27 47 30.99		0	0.692 Yes		0.03	20.163	20.839	20.34	20.163
24350	03 32 38.4386	-27 46 31.90		0	0.69 Yes		0.03	20.68	21.324	20.855	20.68
24353	03 32 38.5957	-27 46 31.36		0	0.663 Yes		0.03	20.768	21.177	20.893	20.768
21298	03 32 39.2188	-27 47 58.36		0	0.662 Yes		0.03	19.618	20.265	19.785	19.618
21281	03 32 35.7539	-27 47 58.82		0	0.66 Yes		0.03	19.35	19.991	19.507	19.35
23847	03 32 38.7915	-27 46 48.90		0	0.657 Yes		0.03	20.287	20.927	20.451	20.287
22428	03 32 41.4054	-27 47 17.17		0	0.612 Yes		0.03	19.596	20.241	19.767	19.596
24587	03 32 40.7814	-27 46 15.69		0	0.571 Yes		0.03	19.482	19.901	19.615	19.482
24348	03 32 38.9675	-27 46 30.23		0	0.447 Yes		0.03	20.152	20.541	20.258	20.152
24685	03 32 41.7599	-27 46 19.40		0	0.383 Yes		0.04	20.047	20.635	20.189	20.047
21671	03 32 38.0057	-27 47 41.71		0	0.253 Yes		1	18.276	18.562	18.369	18.276

Because of the small size of the shutters (just 200 mas in width) the relative positional accuracy of the planning catalog must be **between 5 and 50 mas**.



Starting from scratch

Astronomer's Proposal Tools Version 27.3 mpt-demo (Thu Jul 25 2019) JWST PRD: PRDOPSSOC-L-023

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

What's New | Roadmap | Feedback

New Document
New HST Proposal
New JWST Proposal

Astronomer's Proposal Tools

Version 27.3 mpt-demo (Thu Jul 25 2019) JWST PRD: PRDOPSSOC-L-023

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- This software has made use of the NASA/IPAC Extragalactic Database (NED) which is operated by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.
- This software uses portions of the JSky library which is maintained by the European Southern Observatory.
- This product includes code licensed from RSA Data Security.
- This product includes software developed by the Apache Software Foundation (<http://www.apache.org/>).

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Show:

✓ No errors & warnings (Click for Details)



Load the Catalog as an MSA Catalog Target

Notice that we are in the Form Editor

- Browse and select the Catalog file.
- Choose a name and file format
- MPT tries to identify the type of data in each column

Astronomer's Proposal Tools Version 27.3 mpt-demo (Thu Jul 25 2019) JWST PRD: PRDOPSSOC-L-023 - JWST Draft Proposal (Unsaved)

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

NewJWST Proposal | New

JWST Draft Proposal (Unsaved)

- Proposal Information
- Proposal Description
- Team Expertise
- Unnamed PI
- Unnamed Col
- Targets

Targets of JWST Draft Proposal (Unsaved)

Targets

MSA Source Importer

File to Import: Users/dkarakla/Desktop/Rafel_2015_HUDF_small_ALLref_random.txt [Browse...]

Catalog Name: Rafel_2015_HUDF_small_ALLref_random

File Format: Whitespace Separated

Here is some of the content of the selected file:

ZMAX_BPZ	ODDS_BPZ	CHISQ2_BPZ	STAR	WEIGHT
1.52	0.996	1.241	0	3
1.36	0.995	0.096	0	3
1.2	0.995	0.1	0	2
1.19	0.994	0.03	0	2

Column dropdowns: ignore | ignore | ignore | ignore | Weight

Buttons: Points North | Hubble UDF Small | Hubble UDF | Omega Centauri | Cancel | Import

9 errors & warnings (Click for Details)

Weights can be used to prioritize the targets. Higher weights are for more interesting targets.

Click



MSA Catalog and Candidate Sets

MPT complains because:

- 1) The **target is not used** in the proposal (yet! – It's just a warning)
- 2) We must specify the **astrometric accuracy**
- 3) We must tell MPT if we need **pre-imaging** or not:
 - If NIRCam pre-imaging will be done **in this program**, it is linked here for archival purposes.

Number: 1
Name in the Proposal: RAFELSKI-2015-RANDOM (unique within proposal)
Name for the Archive: RAFELSKI-2015 (standard resolvable name)

Astrometric Accuracy (mas)

Reference Position RA: 03 32 38.9682 Dec: -27 47 26.86

Pre-Image Availability: Not required

ID	RA	DEC	Size	Redshift	Reference	Stellarity	MAG_F160W	NRS_F110W	NRS_F140X	NRSIt
23796	03 32 39.0842	-27 46 1.79	0	1.415	Yes	0.92	20.122	20.674	20.366	3
54454	03 32 35.5075	-27 46 26.13	0	1.268	Yes	0.03	20.384	20.845	20.474	3
22410	03 32 39.8827	-27 47 15.06	0	1.107	Yes	0.03	20.711	21.199	20.786	2
24439	03 32 37.1930	-27 46 8.08	0	1.101	Yes	0.03	19.494	20.254	19.672	2
23546	03 32 38.4836	-27 47 2.42	0	0.919	Yes	0.03	20.088	20.785	20.261	2
21268	03 32 42.4216	-27 47 58.80	0	0.779	Yes	0.94	17.811	18.026	-99	2
22990	03 32 38.7749	-27 47 32.14	0	0.767	Yes	0.03	20.286	20.695	20.415	2
21840	03 32 37.3079	-27 47 29.36	0	0.708	Yes	0.03	18.793	19.473	18.966	2
22951	03 32 40.6729	-27 47 30.99	0	0.692	Yes	0.03	20.163	20.839	20.34	1
24350	03 32 38.4386	-27 46 31.90	0	0.69	Yes	0.03	20.68	21.324	20.855	1
24353	03 32 38.5957	-27 46 31.36	0	0.663	Yes	0.03	20.768	21.177	20.893	1
21298	03 32 39.2188	-27 47 58.36	0	0.662	Yes	0.03	19.618	20.265	19.785	1
21281	03 32 35.7539	-27 47 58.82	0	0.66	Yes	0.03	19.35	19.991	19.507	1
23847	03 32 38.7915	-27 46 48.90	0	0.657	Yes	0.03	20.287	20.927	20.451	1
22428	03 32 41.4054	-27 47 17.17	0	0.612	Yes	0.03	19.596	20.241	19.767	1
24587	03 32 40.7814	-27 46 15.69	0	0.571	Yes	0.03	19.482	19.901	19.615	1
24348	03 32 38.9675	-27 46 30.23	0	0.447	Yes	0.03	20.152	20.541	20.258	1
24685	03 32 41.7599	-27 46 19.40	0	0.383	Yes	0.04	20.047	20.635	20.189	1
21671	03 32 38.0057	-27 47 41.71	0	0.253	Yes	1	18.276	18.562	18.369	1

Buttons: New Candidate Set..., Delete, Send to Aladin

Text: Select

Status: 23 errors & warnings (Click for Details)

Notice that we are in the Form Editor



Sources seen in Aladin

Aladin v8.1

Location Frame ICRS

+DSS +SDSS +2MASS +WISE +GALEX +AKARI +Simbad +NED +IRIS +Spitzer +

h_udf_wfc_b_dr2_img

37.26" x 18.57"

5"

5.25" x 5.25"

MSA Source6991: 53.16492, -27.78385; Mags: [29.596 MAG_F160W, 29.509 NRS_F110W, 29.023 NRS_F140X, 29.596 NRS_CLEAR] - Click on it to get Search

(c) 2015 UDS/CNRS - by CDS - Distributed under GNU GPL v3

0 sel / 12632 src 168Mb



MSA Catalog Target

The **MSA Catalog Target** is now in the **Targets Folder**

Highlight the Catalog to see its data

Number: 1
Name in the Proposal: RAFEL-2015 (unique within proposal)
Name for the Archive: RAFEL-2015 (standard resolvable name)

Candidate Sets | Comments

Astrometric Accuracy (mas): 10.0
Reference Position RA: 03 32 38.9682 Dec: -27 47 26.86
Pre-Image Availability: Not required

ID	RA	DEC	Size	Redshift	Reference	Stellarity	MAG_F160W	NRS_F110W	NRS_F140X	NRS_CLEAR	W
23796	03 32 39.0842	-27 46 1.79	0	1.415	Yes	0.92	20.122	20.674	20.366	20.122	
54454	03 32 35.5075	-27 46 26.13	0	1.268	Yes	0.03	20.384	20.845	20.474	20.384	
22410	03 32 39.8827	-27 47 15.06	0	1.107	Yes	0.03	20.711	21.199	20.786	20.711	
24439	03 32 37.1930	-27 46 8.08	0	1.101	Yes	0.03	19.494	20.254	19.672	19.494	
23546	03 32 38.4836	-27 47 2.42	0	0.919	Yes	0.03	20.088	20.785	20.261	20.088	
21268	03 32 42.4216	-27 47 58.80	0	0.779	Yes	0.94	17.811	18.026	-99	17.811	
22990	03 32 38.7749	-27 47 32.14	0	0.767	Yes	0.03	20.286	20.695	20.415	20.286	
21840	03 32 37.3079	-27 47 29.36	0	0.708	Yes	0.03	18.793	19.473	18.966	18.793	
22951	03 32 40.6729	-27 47 30.99	0	0.692	Yes	0.03	20.163	20.839	20.34	20.163	
24350	03 32 38.4386	-27 46 31.90	0	0.69	Yes	0.03	20.68	21.324	20.855	20.68	
24353	03 32 38.5957	-27 46 31.36	0	0.663	Yes	0.03	20.768	21.177	20.893	20.768	
21298	03 32 39.2188	-27 47 58.36	0	0.662	Yes	0.03	19.618	20.265	19.785	19.618	
21281	03 32 35.7539	-27 47 58.82	0	0.66	Yes	0.03	19.35	19.991	19.507	19.35	
23847	03 32 38.7915	-27 46 48.90	0	0.657	Yes	0.03	20.287	20.927	20.451	20.287	
22428	03 32 41.4054	-27 47 17.17	0	0.612	Yes	0.03	19.596	20.241	19.767	19.596	
24587	03 32 40.7814	-27 46 15.69	0	0.571	Yes	0.03	19.482	19.901	19.615	19.482	
24348	03 32 38.9675	-27 46 30.23	0	0.447	Yes	0.03	20.152	20.541	20.258	20.152	
24685	03 32 41.7599	-27 46 19.40	0	0.383	Yes	0.04	20.047	20.635	20.189	20.047	
21671	03 32 38.0057	-27 47 41.71	0	0.253	Yes	1	18.276	18.562	18.369	18.276	

12 errors & warnings (Click for Details)



Source Catalog at Program Update

- For (later) program update submission MPT needs magnitudes in TA filters to properly define the reference stars.
- There will be a tool for creating this data by converting HST magnitudes (it will be made available in time for updates).

The screenshot shows the 'Candidate Sets' interface with the following parameters:

- Astrometric Accuracy (mas): 10.0
- Reference Position RA: 03 32 38.9682, Dec: -27 47 26.86
- Pre-Image Availability: Not required

ID	RA	DEC	Size	Redshift	Reference	Stellarity	MAG_F160W	NRS_F110W	NRS_F140X	NRS_CLEAR
23796	03 32 39.0842	-27 46 1.79	0	1.415	Yes	0.92	20.122	20.674	20.366	20.122
54454	03 32 35.5075	-27 46 26.13	0	1.268	Yes	0.03	20.384	20.845	20.474	20.384
22410	03 32 39.8827	-27 47 15.06	0	1.107	Yes	0.03	20.711	21.199	20.786	20.711
24439	03 32 37.1930	-27 46 8.08	0	1.101	Yes	0.03	19.494	20.254	19.672	19.494
23546	03 32 38.4836	-27 47 2.42	0	0.919	Yes	0.03	20.088	20.785	20.261	20.088
21268	03 32 42.4216	-27 47 58.80	0	0.779	Yes	0.94	17.811	18.026	-99	17.811
22990	03 32 38.7749	-27 47 32.14	0	0.767	Yes	0.03	20.286	20.695	20.415	20.286
21840	03 32 37.3079	-27 47 29.36	0	0.708	Yes	0.03	18.793	19.473	18.966	18.793
22951	03 32 40.6729	-27 47 30.99	0	0.692	Yes	0.03	20.163	20.839	20.34	20.163
24350	03 32 38.4386	-27 46 31.90	0	0.69	Yes	0.03	20.68	21.324	20.855	20.68
24353	03 32 38.5957	-27 46 31.36	0	0.663	Yes	0.03	20.768	21.177	20.893	20.768
21298	03 32 39.2188	-27 47 58.36	0	0.662	Yes	0.03	19.618	20.265	19.785	19.618
21281	03 32 35.7539	-27 47 58.82	0	0.66	Yes	0.03	19.35	19.991	19.507	19.35
23847	03 32 38.7915	-27 46 48.90	0	0.657	Yes	0.03	20.287	20.927	20.451	20.287
22428	03 32 41.4054	-27 47 17.17	0	0.612	Yes	0.03	19.596	20.241	19.767	19.596
24587	03 32 40.7814	-27 46 15.69	0	0.571	Yes	0.03	19.482	19.901	19.615	19.482
24348	03 32 38.9675	-27 46 30.23	0	0.447	Yes	0.03	20.152	20.541	20.258	20.152
24685	03 32 41.7599	-27 46 19.40	0	0.383	Yes	0.04	20.047	20.635	20.189	20.047
21671	03 32 38.0057	-27 47 41.71	0	0.253	Yes	1	18.276	18.562	18.369	18.276

At the bottom of the interface, there are buttons for 'Edit MSA Catalogs', 'New', and 'Edit Observations'. A status bar at the bottom right indicates '12 errors & warnings (Click for Details)'.



The MPT Planner



The MPT Planner

Go to the MSA Planning Tool in the toolbar –

The **Planner** in the **MSA Planning Tool** is where you can design your observations

- Choose the **Primary Candidates** (and Filler Candidates)
- Choose an **APA** (place holder or assigned from STScI)
- Choose the **slitlet configuration**
- Choose the **source centering constraints**

Astronomer's Proposal Tools Version 2020.1 mpt-demo (Thu Oct 24 2019) - JWST Draft Proposal (Unsaved)

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

New JWST Proposal | Info | MSA Planning Tool | What's New | Roadmap

JWST Draft Proposal (RAFEL-2015...)

JWST Draft Proposal (Unsaved)

Proposal Information

Targets

MSA Catalogs

1 RAFELSKI-2015-RAND

Observations

Observation Links

Planner Plans

Candidate Lists

Primary Candidate List None Selected

RAFELSKI-2015-RANDOM (9969 sources)

Filler Candidate List

Z>3 (3056 sources)

Z>5 (344 sources)

Plan Angle

Planned

Aperture PA Degrees

Slit Setup

Slitlet 3 Shutter Slitlet

Entire Open Shutter Area Source Centering Constraint

Pointing Setup

Nod in slitlet 3 exposures per configuration.

Dither Type None

Exposure Setup

Grating/Filter

G140H/F070LP

G140H/F100LP

G140M/F070LP

G140M/F100LP

G235H/F170LP

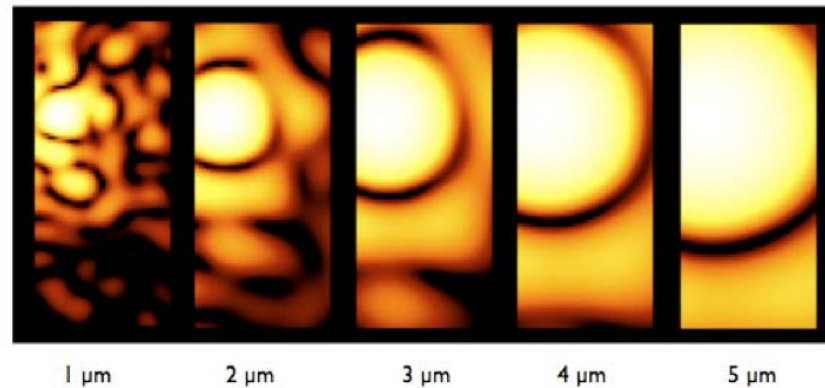
G235M/F170LP

G395H/F290LP

22 errors & warnings



Source Centering and Slit Losses








Slit throughput loss is a function of wavelength and the relative placement of the science source in the MSA shutter



Source Centering and Slit Losses

A **tighter constraint** yields more accurate photometry and higher flux, but may reduce the number of observable targets. Important for point sources.

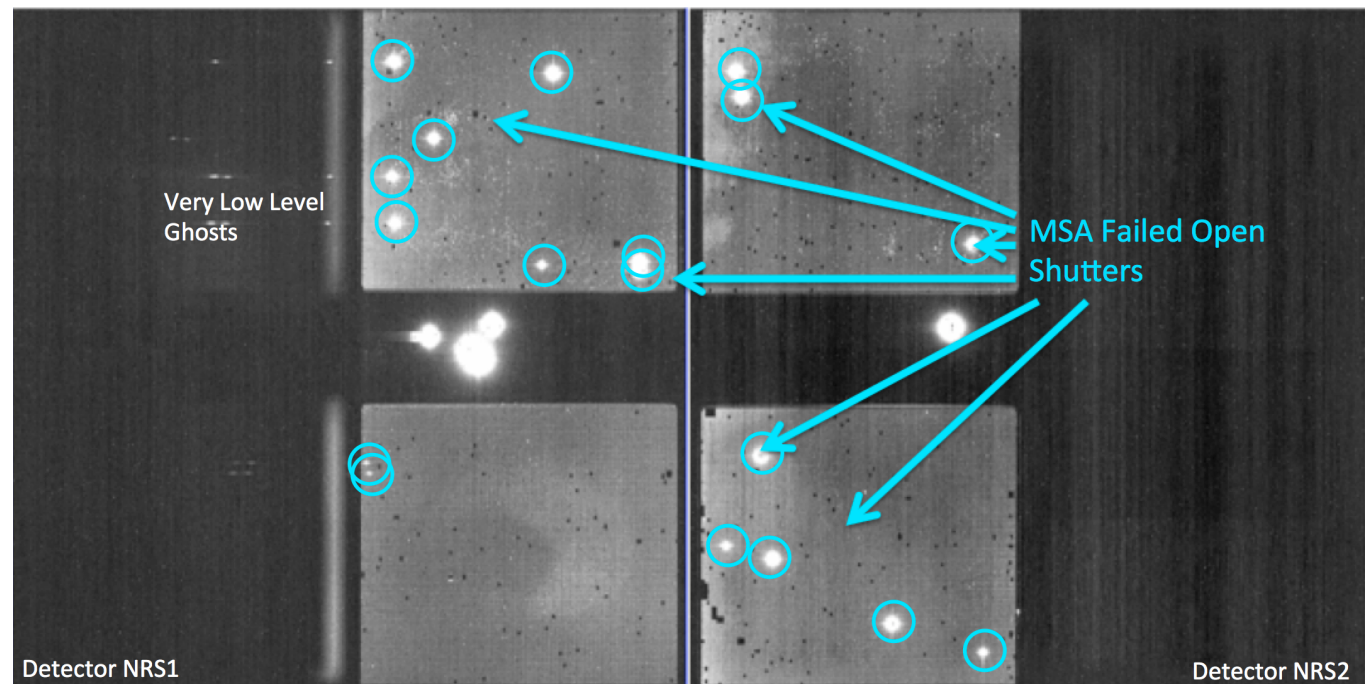
Source Centering Constraint	Figure†	Minimum Relative Flux Transmission at 2.95 $\mu\text{m}^{\dagger\dagger}$	Margin (milli-arcsec)
<i>Unconstrained</i> (sources can be behind the MSA bars)		12%	0
<i>Entire Open Shutter Area</i> (default)		30%	38
<i>Midpoint</i>		62%	59
<i>Constrained</i>		75%	72
<i>Tightly Constrained</i>		85%	91



Benefits of dithering

In addition to improving the sampling of the PSF and correcting for hot/bad pixels, dithering helps with:

- Improved background subtraction (**Nodding**)
- Recovers important wavelengths that could fall in the detector gap (**Fixed dither**)
- Mitigates effects of **light leakage** through the MSA
- Dithers also help to observe additional sources behind bars or mounting plate.
- **MPT takes dithers into account and will attempt to observe as many sources as possible at all dithers.**





Specifying Dithers and Nods in the MPT Planner

The **Planner** is where you decide how to dither:

Nodding moves the sources within the slitlet – no shutter reconfiguration

Fixed Dither moves the sources by a finite number of shutters specified by the user along the dispersion and/or the cross-dispersion direction.

Nodding and dithering can be used together or independently.

Astronomer's Proposal Tools Version 2020.1 mpt-demo (Thu Oct 24 2019) - JWST Draft Proposal (RAFEL-2015.aptx)

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

New JWST Proposal Import MSA Source Catalog...

Planner Plans

Candidate Lists

Primary Candidate List Z>5 (344 sources)

Filler Candidate List RAFEL-2015 (9969 sources)

Plan Angle

Planned

Aperture PA 135.0 Degrees

Slit Setup

Slitlet 3 Shutter Slitlet Entire Open Shutter Area Source Centering Constraint

Pointing Setup

Nod in slitlet 3 exposures per configuration.

Dither Type None

Exposure

Grating/Filter

- G140H/F070LP
- G140H/F100LP
- G140M/F070LP
- G140M/F100LP
- G235H/F170LP
- G235M/F170LP
- G395H/F290LP
- G395M/F290LP
- PRISM/CLEAR

Search Grid

Search Area Dimensions:

Center RA: 03 32 39.6524 Dec: -27 47 26.91

RAFEL_2015_HUDF_SMALL_ALLREF_RANDOM (9969 sources) Name Astrometric Accuracy (mas) Reference Position

Show: RAFEL_2015_HUDF_SMALL_ALLREF_RANDOM (9969 sources)

22 errors & warnings (Click for Details)



A few more options, and then Create a Plan in MPT

Grating and Filter combination are selected (each has different masking to prevent spectral overlaps).

Use Weights and MC shuffling (Monte Carlo) random ordering of sources is tested



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Exposure Setup

Grating/Filter

- G140H/F070LP
- G140H/F100LP
- G140M/F070LP
- G140M/F100LP
- G235H/F170LP
- G235M/F170LP
- G395H/F290LP
- G395M/F290LP
- PRISM/CLEAR

Search Area Dimensions:

Center RA: 03 32 39.6524 Dec: -27 47 26.91

RAFEL_2015_HUDF_SMALL_ALLREF_RANDOM (9969 sources) Name Astrometric Accuracy (mas) Reference Position

Show: RAFEL_2015_HUDF_SMALL_ALLREF_RANDOM (9969 sources)

22 errors & warnings (Click for Details)

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MSA Operability: Failed shutters and shorts

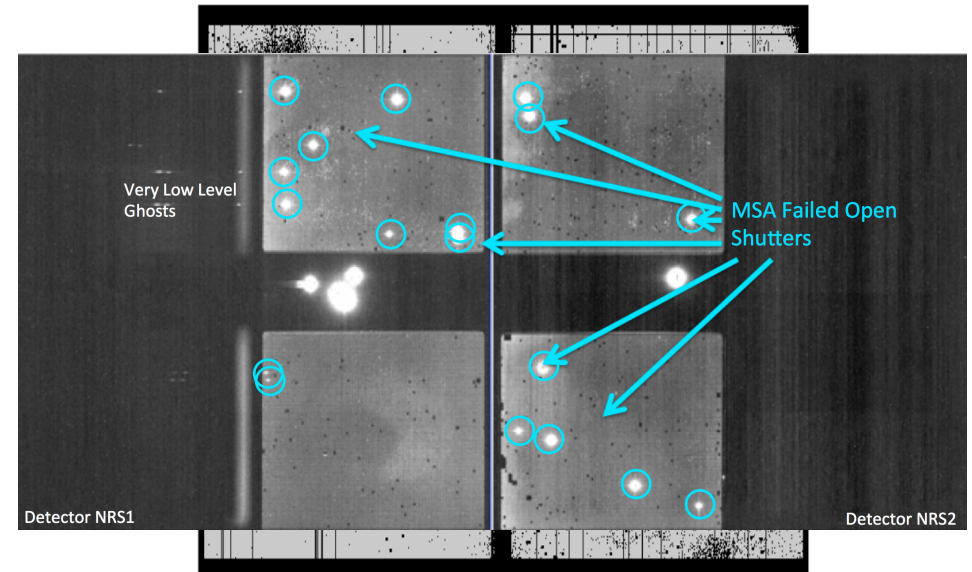
Some of the MSA shutters are not operable...

Failed Closed shutters affect sources that may happen to fall into them.

Shorts between columns and rows can occur, but are expected to be fairly stable.

Failed Open shutters have the most severe impact on the observations, and can prohibit observing sources over a sizeable area. Unintended spoilers can contaminate spectra of planned sources.

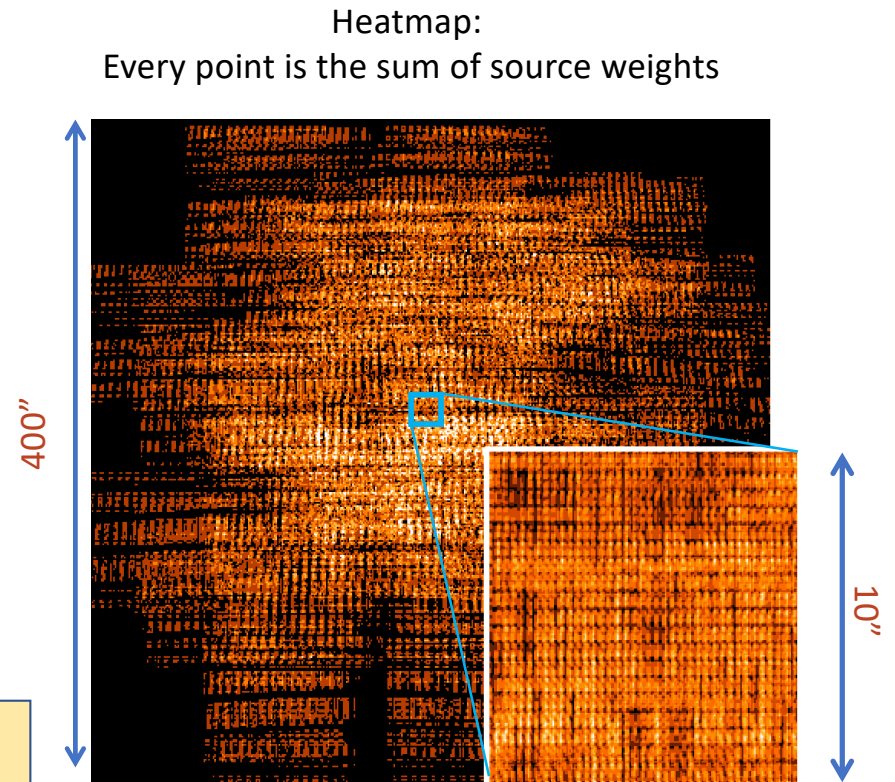
At each test pointing, MPT automatically plans around failed shutters and shorts and searches for the optimal configuration.





How MPT works

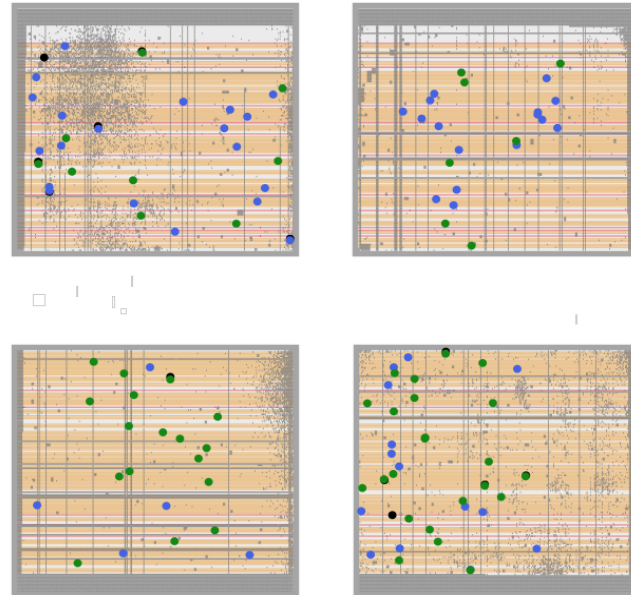
- The Catalog sources are mapped to the MSA plane.
 - With the user-specified **search grid** extent and step size, **MPT creates a grid of test pointings** over the area of the Primary candidate list.
 - At each pointing, MPT checks each source in the Primary list (in the order given) to find those that are in operable shutters, within constraints set in the Planner, and that present no conflict to other selected sources. This check is made at all of the dither points in the **user-specified dither** pattern.
- The **weights** of all **observable primary sources** in an MSA configuration are summed. These steps are repeated at each test pointing. The result is a **Heatmap**.





How MPT works

- The “best” pointing with the **largest score** is selected. (Or, a **set of pointings**, if dithers were specified.)
- A **Plan** is created in MPT.
 - Plans have **Pointings**, a **set of Targets**, and associated **MSA configurations**.
- One or more Plans are selected by the user and made into an **Observation**.





Examine Results

Examine plan results in the **Plans** pane of MPT

- MSA shutter view
- Collapsed shutter view

The screenshot shows the 'Planner' pane of the Astronomer's Proposal Tools (APT) software. The 'Plans' tab is selected, displaying a table of plan selections. Below this, there are buttons for 'Create Observation', 'Update Observation', 'Import Plan(s)', 'Describe Plan(s)', and 'Delete Plan(s)'. The 'Pointings' section shows a table of pointing data with columns for Plan number, Name, RA, Dec, RA (HMS), Dec (DMS), APA, Grating, Target set size, Total weight, and buttons for 'Show' and 'Send to Aladin'. The 'Targets' section shows a list of 56 targets with columns for ID, Weight, Exposures, and filter configurations (cle1n1, cle1n2, cle1n3).

#	Plan	# Configs	# Exposures	# Primary Sources	# Secondary Sources	Export
1	G140M-step10-cat	1	3	63	0	Export
2	G140M-step10-z5-fillers	1	3	35	27	Export
3	PRISM-step10-z5-fillers	1	3	56	55	Export

#	Plan number	Name	RA	Dec	RA (HMS)	Dec (DMS)	APA	Grating...	Target set size	Total weight	Show	Send to Aladin	Export Config
1	3	c1e1n1	53.1696588	-27.7888441	03 32 40.71...	-27 47 19.8...	134.996614...	PRISM/...	123	14187	Show	Send	Export
2	3	c1e1n2	53.1695414	-27.7887403	03 32 40.68...	-27 47 19.4...	134.996668...	PRISM/...	117	14106	Show	Send	Export
3	3	c1e1n3	53.1697762	-27.7889480	03 32 40.74...	-27 47 20.2...	134.996559...	PRISM/...	119	14148	Show	Send	Export

Id	Weight	Exposures	cle1n1	cle1n2	cle1n3
8030	300	3	x	x	x
4449	30	3	x	x	x
9768	300	3	x	x	x
9098	300	3	x	x	x
9104	300	3	x	x	x
8950	300	3	x	x	x
10492	30	3	x	x	x
7878	300	3	x	x	x
8346	30	3	x	x	x
2784	300	3	x	x	x
6542	300	3	x	x	x
14161	300	3	x	x	x



Create an Observation

Examine plan results in the Plans pane of MPT

Highlight a Plan or Plans, and Exposures
Filter results

...and Create an Observation!



The screenshot shows the Astronomer's Proposal Tools (MPT) interface. The 'Plan Selection' pane displays a table with columns for Plan #, Plan Name, # Configs, # Exposures, # Primary Sources, and # Secondary Sources. Three plans are highlighted in blue: Plan 1 (G140M-step10-cat), Plan 2 (G140M-step10-z5-fillers), and Plan 3 (PRISM-step10-z5-fillers). Below this, the 'Pointings' pane shows a detailed table with columns for #, Plan number, Name, RA, Dec, RA (HMS), Dec (DMS), APA, Grating, Target set size, Total weight, Show, Send to Aladin, and Export Config. Several rows are highlighted in blue. Below the Pointings table, the 'Targets' section shows a dropdown for 'Target Set Operation' set to 'Targets in at least one selected exposure' and a 'Send to Aladin' button. A table below shows target coverage for various targets across different exposures. At the bottom, a bar chart shows the 'Number of Targets' for each 'Number of Exposures' (1 through 8).

#	Plan	# Configs	# Exposures	# Primary Sources	# Secondary Sources	Export
1	G140M-step10-cat	1	3	63	0	Export
2	G140M-step10-z5-fillers	1	3	35	27	Export
3	PRISM-step10-z5-fillers	1	3	36	35	Export

#	Plan number	Name	RA	Dec	RA (HMS)	Dec (DMS)	APA	Grating	Target set size	Total weight	Show	Send to Aladin	Export Config
1	2	cle1n1	53.1696588	-27.7888441	03 32 40.71...	-27 47 19.8...	134.996614...	G140M...69	9954	9954	Show	Send	Export
2	2	cle1n2	53.1695414	-27.7887403	03 32 40.68...	-27 47 19.4...	134.996668...	G140M...66	9921	9921	Show	Send	Export
3	2	cle1n3	53.1697762	-27.7889480	03 32 40.74...	-27 47 20.2...	134.996559...	G140M...66	9918	9918	Show	Send	Export
4	3	cle1n1	53.1696588	-27.7888441	03 32 40.71...	-27 47 19.8...	134.996614...	PRISM/...	123	14187	Show	Send	Export
5	3	cle1n2	53.1695414	-27.7887403	03 32 40.68...	-27 47 19.4...	134.996668...	PRISM/...	117	14106	Show	Send	Export
6	3	cle1n3	53.1697762	-27.7889480	03 32 40.74...	-27 47 20.2...	134.996559...	PRISM/...	119	14148	Show	Send	Export

Id	Weight	Exposures	cle1n1	cle1n2	cle1n3	cle1n1	cle1n2	cle1n3
4449	30	6	x	x	x	x	x	x
7988	300	6	x	x	x	x	x	x
9708	300	3	x	x	x	x	x	x
1912	300	6	x	x	x	x	x	x
9768	300	6	x	x	x	x	x	x
6093	300	6	x	x	x	x	x	x
9104	300	6	x	x	x	x	x	x
8950	300	6	x	x	x	x	x	x
4056	300	6	x	x	x	x	x	x
7878	300	6	x	x	x	x	x	x
6542	300	6	x	x	x	x	x	x
9298	300	6	x	x	x	x	x	x
615	300	6	x	x	x	x	x	x
1416	300	6	x	x	x	x	x	x
1844	29	6	x	x	x	x	x	x
635	300	6	x	x	x	x	x	x
5944	300	6	x	x	x	x	x	x
7180	29	6	x	x	x	x	x	x
6420	300	6	x	x	x	x	x	x
6428	30	6	x	x	x	x	x	x

Number of Targets vs Number of Exposures

Number of Exposures	Number of Targets
1	0
2	0
3	20
4	0
5	0
6	30
7	0
8	0



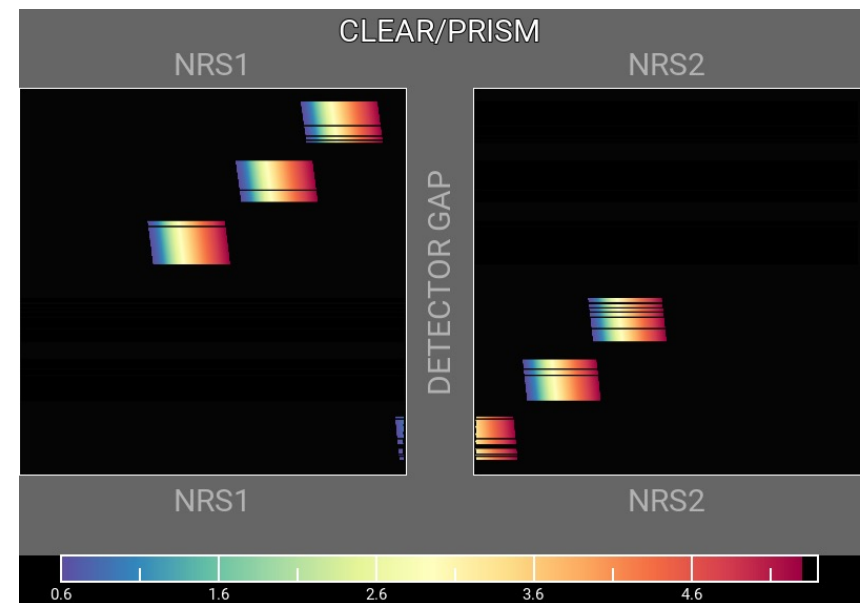
MSA Spectral Visualization Tool

MSAVis is a standalone tool that can be downloaded from GitHub.

It takes the export file “MPT Target Info” output from MPT and projects the spectra of the observed targets on the 2 NIRSpec detectors for both visual inspection and a report indicating wavelength cutoffs.

Instructions to download, install and run MSAVis can be found in the [NIRSpec JDox](#):

<https://jwst-docs.stsci.edu/near-infrared-spectrograph/>





Take Away

- New version of MPT will be available for the Cycle 1 call for proposal – easier to use, more intuitive and discoverable, lighter
- Need high precision relative astrometry – 5-20 mas for point sources – up to 50 mas for extended objects
- MOS is one of the very few observing modes of JWST that will follow a **multi-step planning process**.
- MOS **requires an aperture position angle** – it is **assigned by STScI** (although it may be requested at the time of call for proposals, but have to be strongly justified)
- NIRSpec **overheads** for MSA are considerable – USE MPT to have a good estimate
- You can use **MSAVis** to verify that wavelengths are properly sampled
- You can use **NOVT** to visualize NIRCам pre-imaging relative to MSA observations
- **Dither! Dither!! Dither!!!** It improves background subtraction, wavelength coverage, etc.



END



Helpful Hints

- Order the input Catalog by target weights prior to ingest into MPT. When building an MSA configuration, MPT tries adding sources in the order they appear in the Catalog.
- Include Primary candidates in the Filler list to obtain extra observations of them.
- Only the weights of the Primaries matter (not the Fillers), so to help ensure observations of certain sources, include them in the Primary candidate list.
- Add Fillers to maximize efficiency/multiplexing.
- If feasibility windows are large, test several APAs to see if it makes a statistical difference. If so, set conservative limits on requested exposure time. Add an Orient SR only if needed, with a min range of 30 deg.
- If using the high-res gratings (G140H, G235H, G395H), attempt to get most sources onto the leftmost quadrants to avoid detector cutoffs.
- Use Aladin FoV to show the position of NIRCam parallaxes wrt NIRSpec MSA.
- Your catalog should be **complete** to be able to check for contaminants getting into Failed Open shutters, or into planned target shutters/slitlets.
- The MSA Config Editor can be used to make changes to your MSA configurations designed automatically with MPT. It's found at the observation level in APT.



EXPANDING THE FRONTIERS OF SPACE ASTRONOMY