



**STScI** | SPACE TELESCOPE  
SCIENCE INSTITUTE

EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

# Planning MOS Observations

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JWST Master Class | November 18-22, 2019

Diane Karakla, Alaina Henry, Emily Wislowski  
and the STScI NIRSpec Instrument Team  
Gary Curtis and the APT team

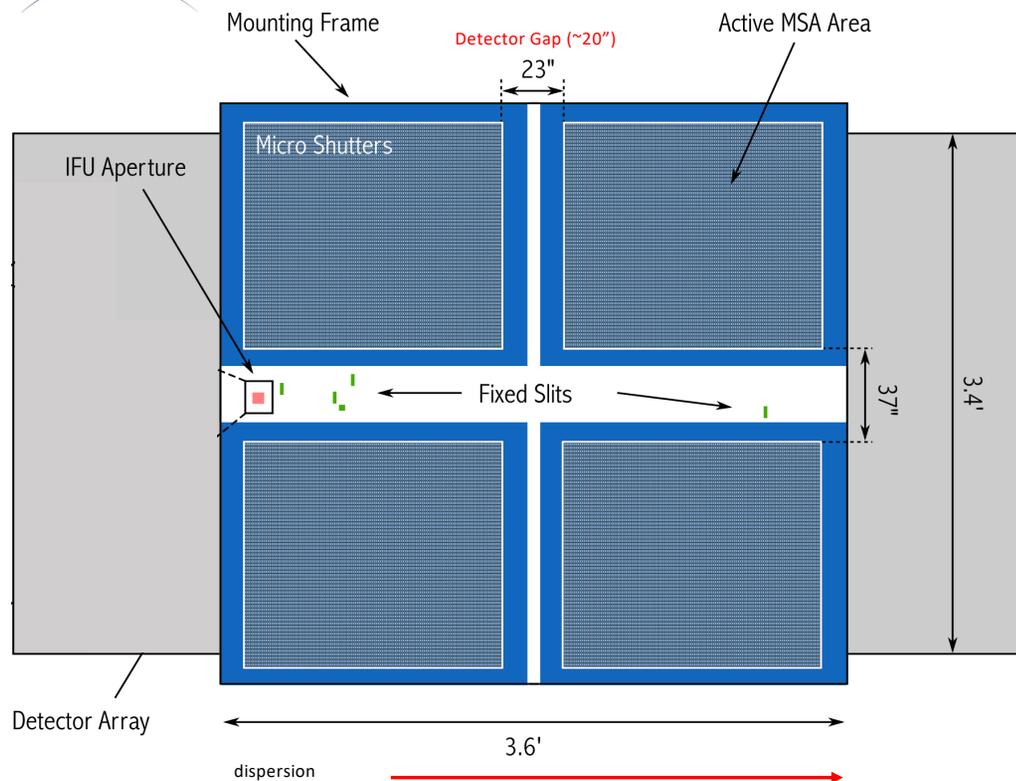
# The NIRSpec Micro-shutter Assembly

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## NIRSpec MSA for Multi-Object spectroscopy



NIRSpec has 2 detectors. There is gap between them (~20").

Spectra are dispersed from left to right, and in many cases, will fall across the gap

The Micro-Shutter Assembly (**MSA**) is a 4 quadrant array of tiny configurable shutters. The entire array has nearly 250,000 shutters.

The MSA Field of View is ~3.6' x 3.4'



# The MOS Observing Process

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## Multi-Step Process

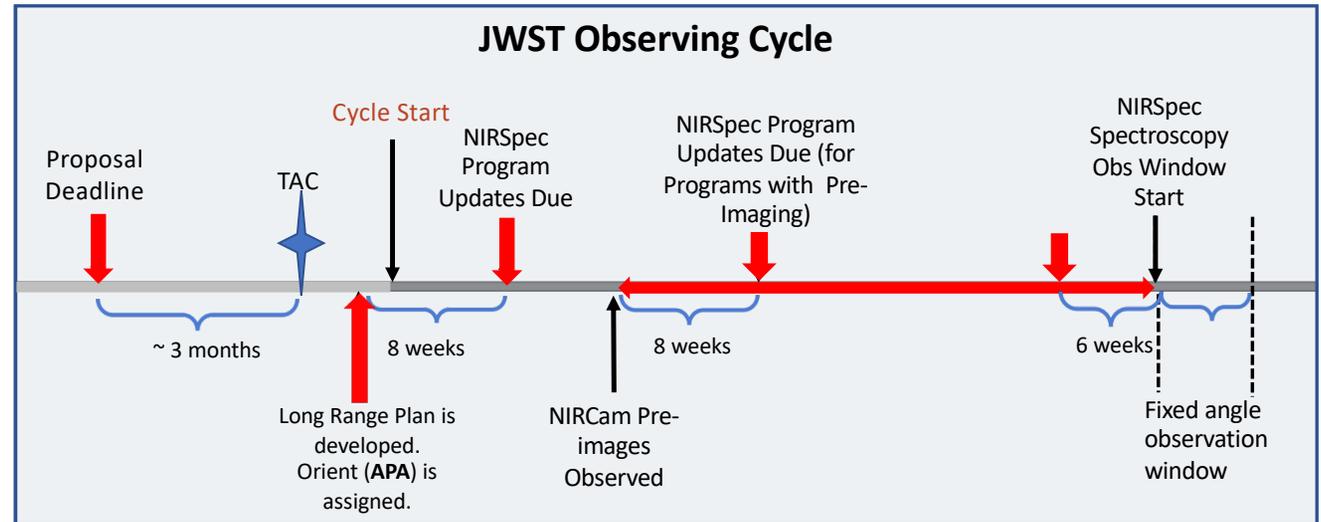
To accurately align science sources within the small MSA shutters, NIRSpec MOS mode observations must be **planned and executed at a fixed instrument Aperture Position Angle (APA), assigned by STScI**. Hence, a multi-step planning process.

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

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## Pointing Accuracies

Most MOS 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**.

TA Type	Delivered Pointing Accuracy	Catalog Relative Accuracy	Science Goal
Optimal (MSATA)	20 - 25 mas (20 mas is 1/10 <sup>th</sup> 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

If accurate astrometry is required for the science, and if **HST imaging** does not exist – request **NIRCam pre-imaging** in your Proposal submission. Pre-imaging needs to be fully executable.



## Target Acquisition Considerations

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- **Moving targets** cannot use MSATA – **must use WATA** instead. WATA does not require pre-imaging, only a good ephemeris.
- **For Program Update submissions - 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 NIRSpec obs: Ideally 5 x 5 arcmin: typically 2x1 mosaic + dithers to cover the gaps.
  - **NIRCcam observations must be flight ready at proposal submission.**

## NIRSpec Observation Visualization Tool (L. Ubeda)

The screenshot shows the NIRSpec Observation Visualization Tool interface. The main window displays a simulated observation field with a grid of yellow and red rectangles overlaid on a dark background with stars. 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 zoom levels.



# The MSA Planning Tool in APT

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## 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 MSA 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.

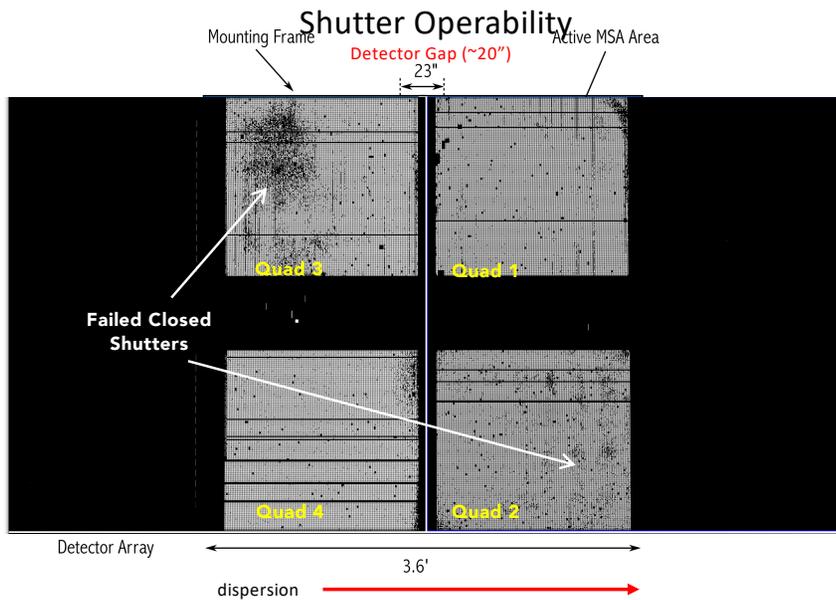
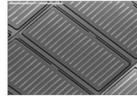
Show: [dropdown]

✓ No errors & warnings (Click for Details)



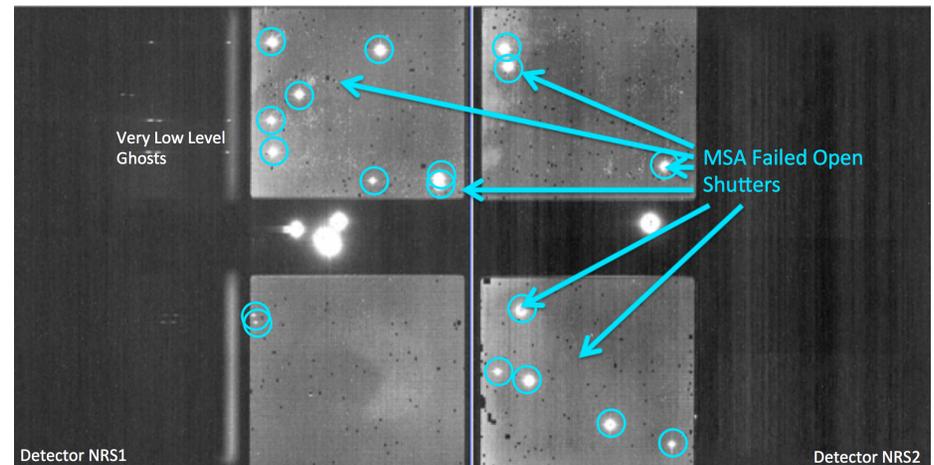
## Why use MPT?

- 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?

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- An internet connection:
  - to access the most up-to-date MSA shutter operability
  - To check for Guide Stars during planning
- A complete and accurate astrometric Catalog
  - With accurate source positions (< 15 mas relative accuracy) – may require pre-Imaging with NIRCcam
- **MPT produces:** “Plans” with Pointings, MSA configurations, Target Sets
- **One or multiple plans** can be selected and made into an **Observation**

A deep space image showing a vast field of stars, primarily blue and white, set against a dark background. The stars are densely packed in some areas, particularly in the upper right and lower right, and more sparsely in others. There are also some reddish-brown nebulae or dust clouds visible, especially in the lower left and center. The overall scene is a rich, multi-colored star field.

# The Source Catalog

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## Source Catalog Requirements

The first step to creating a NIRSspec 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 in APT

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

- Copyright 2002 - 2007 United States Government as represented by the Administrator of the National Aeronautics and Space Administration. All Rights Reserved.
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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

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

New JWST Proposal | New

What's New | Roadmap | Feedback

JWST Draft Proposal (Unsaved)

- Proposal Information
- Proposal Description
- Team Expertise
- Unnamed PI
- Unnamed Col
- Targets**
- Observations
- Observation Links

Targets of JWST Draft Proposal (Unsaved)

### Targets

- 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
- New Solar System Target | Create a new Solar System Target
- New Generic Target | Create a new Generic Target
- Import MSA Source Catalog...** | Import a source catalog to use in MSA Planning
- Import Targets... | Import Fixed Targets from whitespace, CSV, TSV, or VOTable

Edit Unnamed Col | New | Edit Observations

9 errors & warnings (Click for Details)



## Load the Catalog as an MSA Catalog Target

A window will pop up...

- Browse and select the Catalog file.
- Choose a name and file format

MPT tries to identify the type of data in each column

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
1.18	0.994	0.07	0	2

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

Click



## Catalog declarations and making 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)

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

Notice that we are in the Form Editor



## Catalog sources displayed in Aladin

Aladin v8.1

Location  Frame ICRS

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

h\_udf\_wfc\_b\_dr7\_img

5"

37.26" x 18.57"

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

The screenshot displays the Aladin v8.1 web interface. At the top, there's a title bar with 'Aladin v8.1' and a 'Location' input field. Below that, a toolbar contains various icons for navigation and analysis, such as 'select', 'pan', 'zoom', 'dist', 'phot', 'draw', 'tag', 'filter', 'rgb', 'crop', 'cont', 'epoch', 'size', 'opac', 'zoom', 'prop', and 'del'. The main area shows a grayscale image of a star field with numerous red circles representing catalog sources. A search bar at the bottom right contains the text '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'. The status bar at the bottom left shows '(c) 2015 UDS/CNRS - by CDS - Distributed under GNU GPL v3' and the bottom right shows '0 sel / 12632 src 168Mb'. A small inset map in the bottom right corner shows the current field's location within a larger context, with a bounding box of 5.25" x 5.25".



## MSA Catalog Target

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

Highlight/select 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	MAC_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	



## 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).

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	V
23796	03 32 39.0842	-27 46 1.79	0	1.415	Yes	0.92	20.122	20.674	20.366	20.122	
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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	
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21281	03 32 35.7539	-27 47 58.82	0	0.66	Yes	0.03	19.35	19.991	19.507	19.35	
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21671	03 32 38.0057	-27 47 41.71	0	0.253	Yes	1	18.276	18.562	18.369	18.276	

Edit MSA Catalogs ← New ▾ ↻ Edit Observations

12 errors & warnings (Click for Details)



# The MSA Planning Tool

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## The MPT Planner

Select the **MSA Planning Tool** in the APT toolbar –

Select the **Planner** tab.

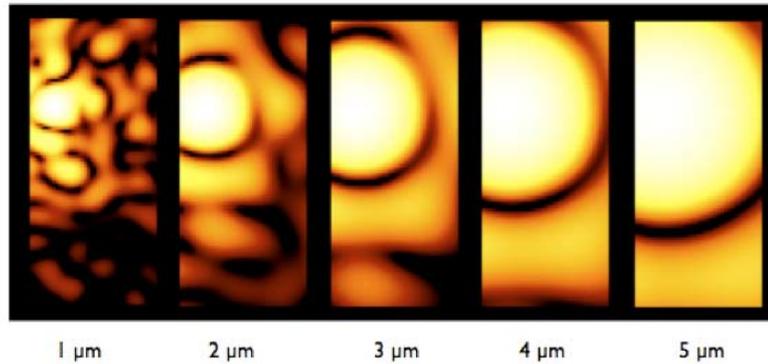
The Planner is where you design plans for your MOS observation.

- 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**



## Source Centering and Slit Losses

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



## Source Centering Constraint

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

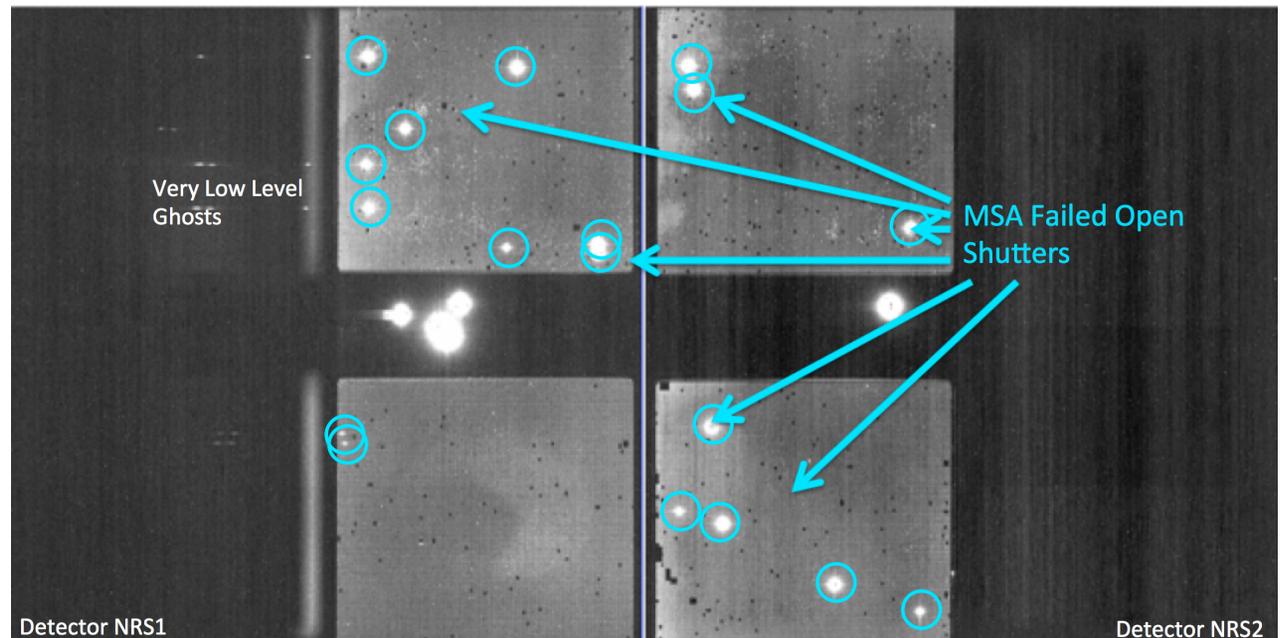
Source Centering Constraint	Figure†	Minimum Relative Flux Transmission at 2.95 $\mu\text{m}^{\dagger\dagger}$	Margin (milli-arcsec)
<i>Unconstrained</i> (sources can be behind the MSA bars)		12%	0
<i>Entire Open Shutter Area</i> (default)		30%	38
<i>Midpoint</i>		62%	59
<i>Constrained</i>		75%	72
<i>Tightly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

The screenshot displays the JWST Draft Proposal (RAFEL-2015) MPT Planner interface. The interface is divided into several sections:

- 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: ; Dither Type: None; Exposure: 3 exposures per configuration.
- Grating/Filter:** G140H/F070LP, G140H/F100LP, G140M/F070LP, G140M/F100LP, G235H/F170LP, G235M/F170LP, G395H/F290LP, G395M/F290LP, PRISM/CLEAR (checked).
- Search Grid:** Search Area Dimensions: Center RA: 03 32 39.6524, Dec: -27 47 26.91.

The status bar at the bottom indicates 22 errors & warnings (Click for Details).



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

**Grating and Filter** combination must be selected in the Planner (each has different masking to prevent spectral overlaps).

Can select **“Use Weights”** and **“Enable Monte Carlo”** to test randomly shuffled ordering of sources.



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 Run All Tools Stop

New JWST Proposal Import MSA Source Catalog...

JWST Draft Proposal (RAFEL-2015) 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 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 (996... Name: RAFEL\_2015\_HUDF\_SMALL\_ALLREF\_RANDOM Astrometric Accuracy (mas): 20.35 30.0000 37.47 36.00 Reference Position: 03 32 39.6524 -27 47 26.91

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

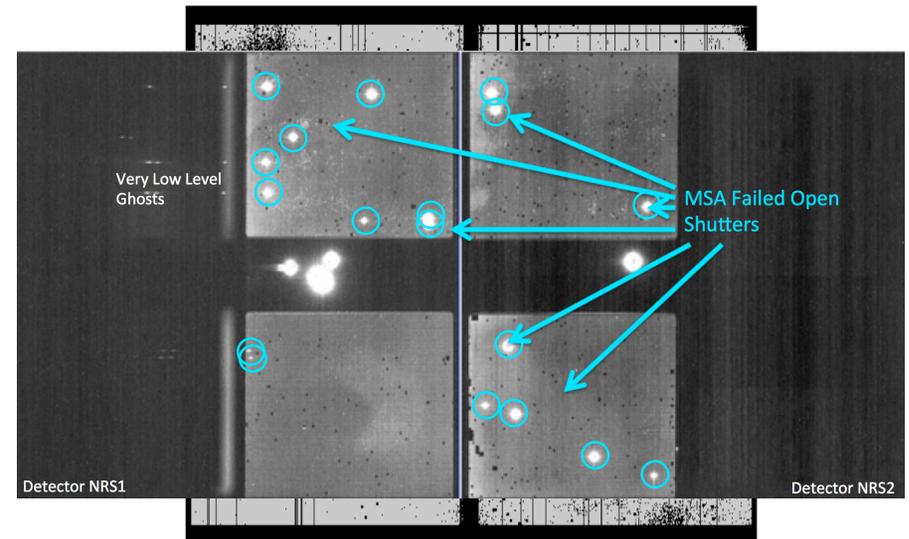
Some of the MSA shutters are not operable...

**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.

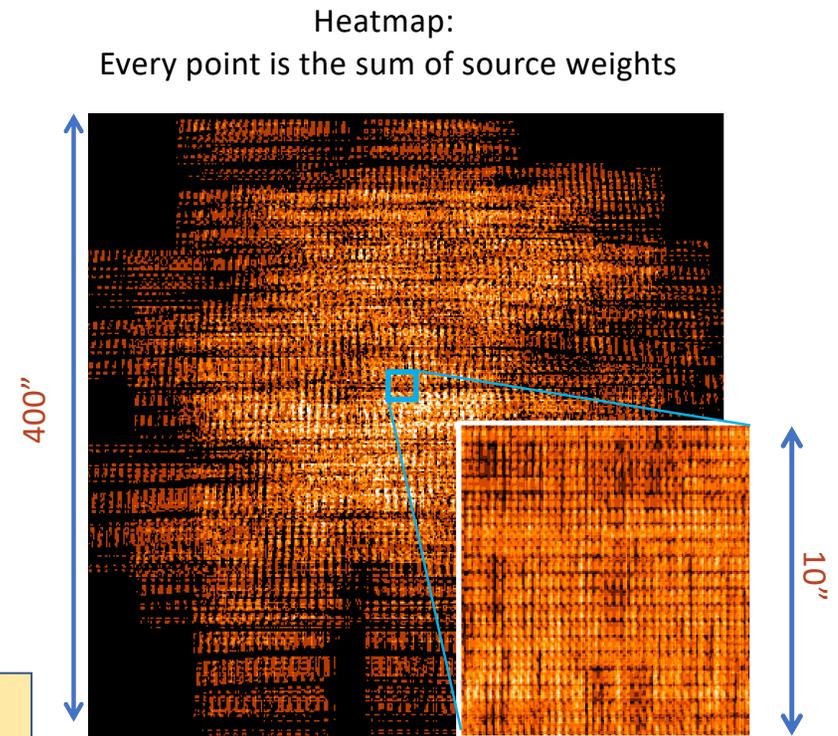
At each test pointing, MPT plans around failed shutters and shorts and searches for the optimal configuration. The latest operability information is used.





## How MPT works

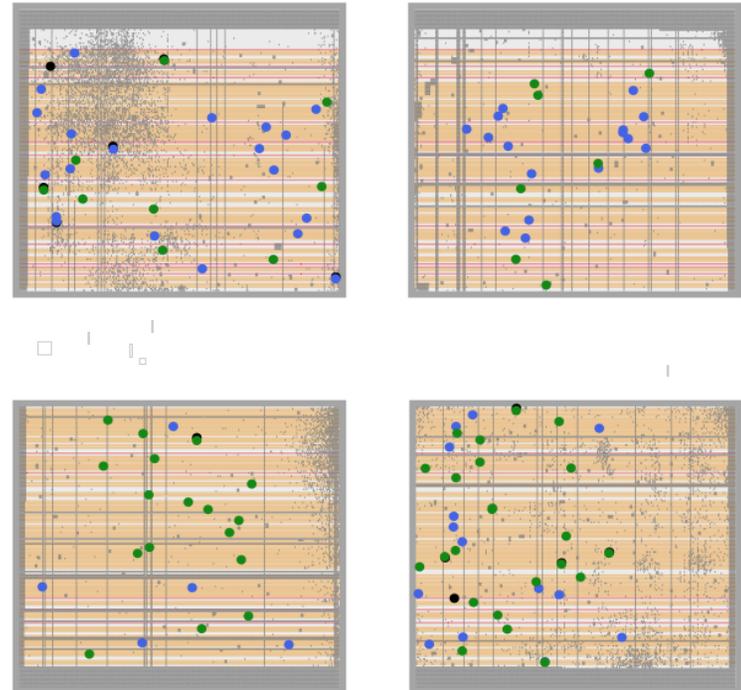
- The Catalog sources are mapped to the MSA plane.
  - **MPT creates a grid of test pointings** over the area of the Primary candidate list using the **user-specified search grid parameters**.
  - At each test pointing, MPT checks each source in the Primary list (in the order given) to find those that are in operable shutters and within constraints set in the Planner, and that present no conflict to other selected sources. These checks are done at all of the points in the **user-specified dither** pattern before accepting a source.
- At each test pointing, 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 is selected. (Or, a **set of pointings**, if dithers were specified.)
- A **Plan** is created in MPT.
  - Plans have **Pointings**, a **set of sources that will be observed**, and associated **MSA configurations**.
- One or more Plans are selected by the user and made into an **Observation**.





## Examine and Visualize Plan Results

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

- MSA shutter view
- Collapsed shutter view

The screenshot displays the Astronomer's Proposal Tools (APT) software interface. The main window is titled "Astronomer's Proposal Tools Version 2020.1 mpt-demo (Thu Oct 24 2019) - JWST Draft Proposal (RAFEL-2015.aptx)". The interface is divided into several panes:

- Plan Selection:** A table showing the selection of plans. The table has columns for Plan #, Plan Name, # Configs, # Exposures, # Primary Sources, # Secondary Sources, and an Export button. Three plans are listed and selected (highlighted in blue):

#	Plan	# Configs	# Exposures	# Primary Sources	# Secondary Sources	Export
1	G140M-step10-cat	1	63	0	0	Export
2	G140M-step10-z5-fillers	1	3	35	27	Export
3	PRISM-step10-z5-fillers	1	3	56	55	Export
- Pointings:** A table showing the pointing information for the selected plans. The table has columns for Plan number, Name, RA, Dec, RA (HMS), Dec (DMS), APA, Grating, Target set size, Total weight, and buttons for Show, Send, and Export. Three pointings are listed and selected (highlighted in blue):

#	Plan number	Name	RA	Dec	RA (HMS)	Dec (DMS)	APA	Grating...	Target set size	Total weight	Show	Send	Export
1	3	c1e1n1	53.1696588	-27.7888441	03 32 40.71...	-27 47 19.8...	134.996614...	PRISM/...	123	14187	Show	Sen	Export
2	3	c1e1n2	53.1695414	-27.7887403	03 32 40.68...	-27 47 19.4...	134.996668...	PRISM/...	117	14106	Show	Sen	Export
3	3	c1e1n3	53.1697762	-27.7889480	03 32 40.74...	-27 47 20.2...	134.996559...	PRISM/...	119	14148	Show	Sen	Export
- Targets:** A table showing the target information for the selected plans. The table has columns for Id, Weight, Exposures, c1e1n1, c1e1n2, and c1e1n3. Sixteen targets are listed, each with a weight of 300 and 3 exposures. The targets are:

Id	Weight	Exposures	c1e1n1	c1e1n2	c1e1n3
8030	300	3x	x	x	x
4449	30	3x	x	x	x
9768	300	3x	x	x	x
9098	300	3x	x	x	x
9104	300	3x	x	x	x
8950	300	3x	x	x	x
10492	30	3x	x	x	x
7878	300	3x	x	x	x
8346	30	3x	x	x	x
2784	300	3x	x	x	x
6542	300	3x	x	x	x
1416	300	3x	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!**



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...

JWST Draft Proposal (RAFEL-2015.aptx)

- Proposal Information
- Targets
- MSA Catalogs
- Observations
  - Observation Folder
    - C140M-step10-cat (Obs)
    - PRISM-step10-z5-fillers
  - Observation Links
- JWST Draft Proposal (Unsaved)

**Plan Selection**

#	Plan	# Configs	# Exposures	# Primary Sources	# Secondary Sources	Export
1	C140M-step10-cat	1	3	63	0	Export
2	C140M-step10-z5-fillers	1	3	35	27	Export
3	PRISM-step10-z5-fillers	1	3	56	55	Export

Select multiple plans to review them in combination.

Create Observation | Update Observation | Import Plan(s) | Describe Plan(s) | Delete Plan(s)

**Pointings**

#	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	Show	Send	Export
2	2	cle1n2	53.1695414	-27.7887403	03 32 40.68...	-27 47 19.4...	134.996668...	G140M...	66	9921	Show	Send	Export
3	2	cle1n3	53.1697762	-27.7889480	03 32 40.74...	-27 47 20.2...	134.996559...	G140M...	66	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

**Targets**

Target Set Operation: Targets in at least one selected exposure | Primary targets

57 targets are shown. | Send to Aladin

Targets:

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

Coverage:

RAFEL\_2015\_HUDF\_SMALL\_ALLREF\_RANDOM (9969 ... | Name | Astrometric Accuracy (mas) | Reference Position

Show: RAFEL\_2015\_HUDF\_SMALL\_ALLREF\_RANDOM (9969 sources)

22 errors & warnings (Click for Details)



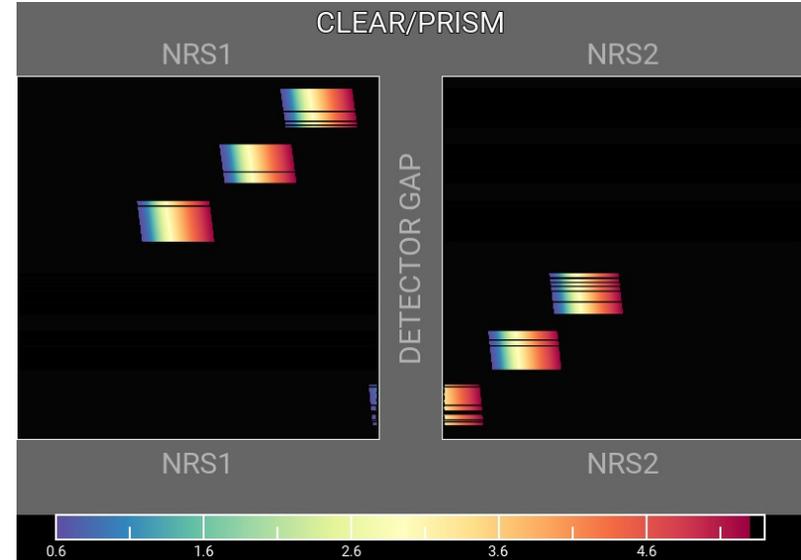
## MSA Spectral Visualization Tool

**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

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- 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

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- 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 NIRCам parallels 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