



**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, NIRSpec Instrument Team

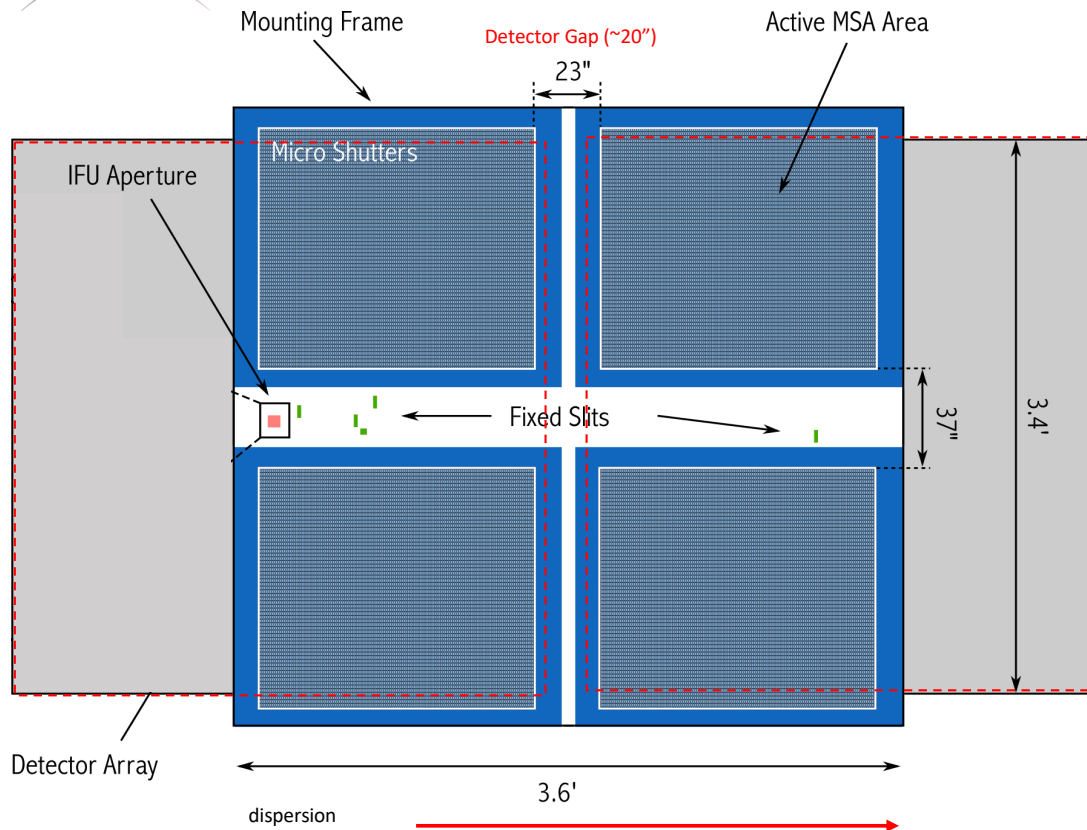
# The NIRSpec Micro-shutter Assembly

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## NIRSpec MSA for multi-object spectroscopy (MOS)



- The Micro-Shutter Assembly (**MSA**) is a 4 quadrant array of tiny configurable shutters. The entire array has nearly 250,000 shutters.
  - Each shutter is just 200 x 450 mas
- The MSA Field of View is  $\sim 3.6' \times 3.4'$
- NIRSpec has 2 detectors. There is gap between them ( $\sim 20''$ ).
- Spectra are dispersed from left to right, and in many cases, will fall across the gap.



# The MOS Observing Process

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## Multi-step process

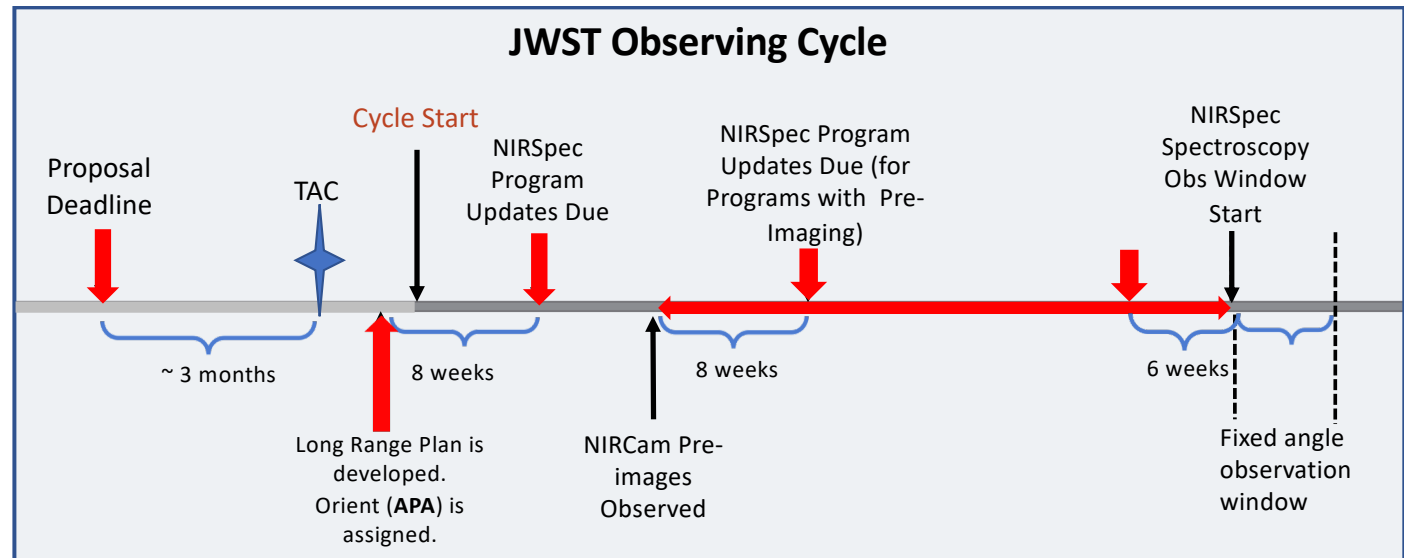
To accurately align science sources within the small MSA shutters, NIRSpec MOS mode observations must be **planned and executed at a fixed instrument Aperture Position Angle (APA), assigned by STScI**. Hence, a multi-step planning process.

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 NIRCам pre-imaging)

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



For best success, users should place their NIRCам pre-imaging and NIRSpec observations **in different visibility windows** to have time to reduce and analyze the NIRCам 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 the pointing accuracy delivered by MSATA (using reference stars). The delivered TA pointing accuracy depends on the input **Catalog relative astrometric accuracy**.

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

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



## Target acquisition considerations

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- **Moving targets must use Wide Aperture TA.** WATA does not require pre-imaging or reference stars, only a good ephemeris.
- **For their Program Update submissions – observers will use MPT 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 for Cycle 1 requires 5-8 reference stars.**
  - MPT will impose a limit of 8 maximum.
  - 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.**
  - This means that **more than 8 suitable candidates** should be defined in the Catalog.
  - There are tradeoffs between increased accuracy and overheads.
  - The number will be adjusted if needed.





## Pre-imaging with NIRCcam

Is imaging available that is :

- Deep enough and wide enough to identify sources and reference stars.
  - The brightest reference stars must be no brighter than 18-19<sup>th</sup> mag.
- 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 a 2x1 mosaic + dithers to cover the gaps.
- **NIRCcam observations must be fully executable at proposal submission.**

## NIRSPEC Observation Visualization Tool (L. Ubeda)

The screenshot shows the NIRSPEC Observation Visualization Tool interface. The main window displays a dark astronomical image with several overlapping yellow and red rectangular regions indicating observation fields. 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. A status bar at the bottom shows coordinates and scale values.



# The MSA Planning Tool in APT

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The background of the slide is a deep blue and purple starry night sky. A large, wispy nebula is visible on the left side. A thin, horizontal orange line spans the width of the slide, positioned just below the title.

# The MPT Cast

Tracy Beck

Gary Curtis

Tom Donaldson

Karrie Gilbert

Josh Goldberg

Rob Hawkins

Alaina Henry

Diane Karakla

Susan Kassin

Ernie Morse

Andrew Myers

Daniel Nemergut

Karla Peterson

Klaus Pontoppidan

Christine Ritchie

Sasha Shyrovkov

David Soderblom

Andrew Spina

Jeff Valenti

Emily Wislowski



## MSA Planning Tool (MPT) in APT



- NIRSpec MOS observing mode is able to obtain spectra of **tens to hundreds objects** within the 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.

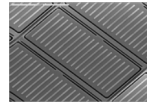
Show: [dropdown]

✓ No errors & warnings (Click for Details)

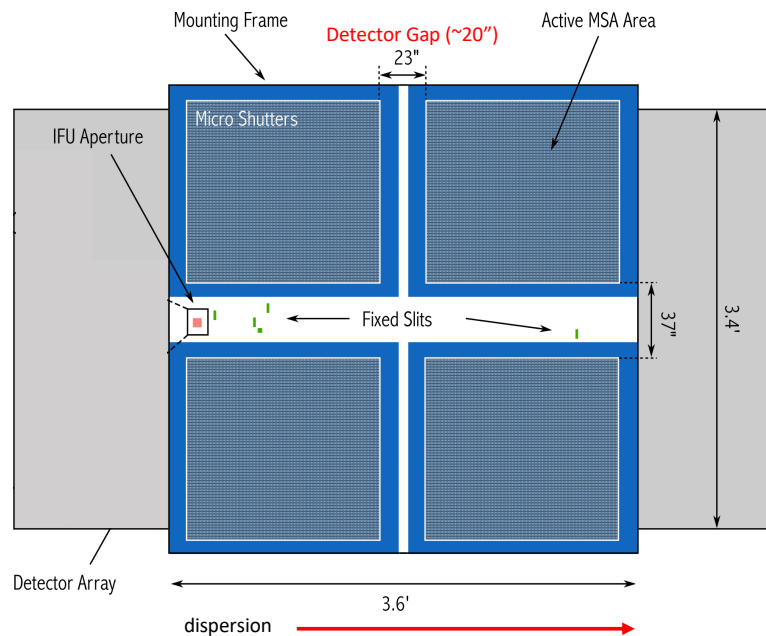


## Why use MPT?

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

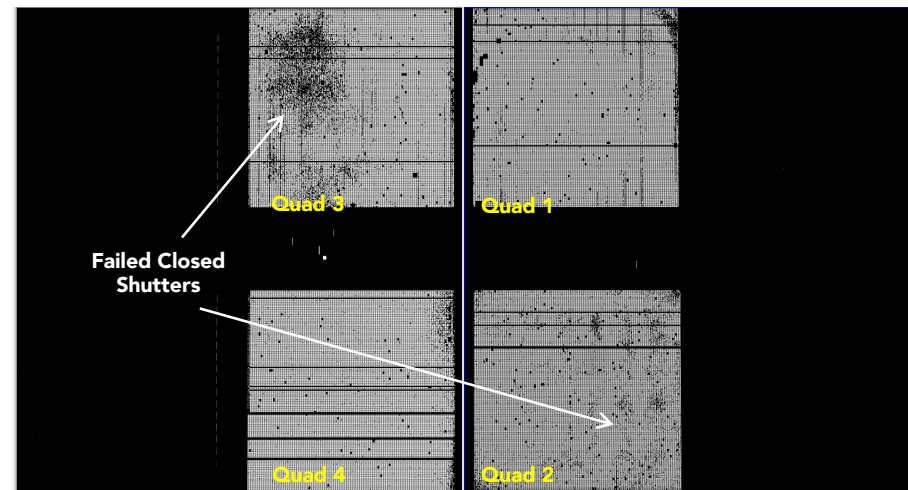


- There is a **gap** between the 2 detectors → missing wavelengths.



- 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.

### Shutter Operability





## 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 astrometric Catalog
  - With accurate source positions (< 15 mas relative accuracy for optimal TA) – may require NIRCam pre-imaging.
- **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 and a prominent blue nebula. The nebula is composed of glowing gas and dust, with intricate filamentary structures. The stars are scattered throughout the field, with some appearing as bright, multi-pointed sources. The overall color palette is dominated by deep blues and purples, with some warmer tones in the nebula's core.

# The Source Catalog

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## Source Catalog requirements

The first step - 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 "#".

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 40 mas**.

| 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    |   |





## 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.
- 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.
- 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)

Select

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

Pre-Image Availability

| ID    | RA            | DEC          | Size | Redshift | Reference | Stellerity | 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     |

Click

23 errors & warnings (Click for Details)

Notice that we are in the Form Editor



## Catalog sources can be displayed 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 14.57"

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/select the Catalog to see its data

The screenshot shows the Astronomer's Proposal Tools (APT) interface for a JWST Draft Proposal (RAFEL-2015). The interface is divided into several sections:

- Left Panel (Tree View):** Shows the project structure. The 'Targets' folder is expanded, and the 'MSA Catalogs' sub-folder is selected. The '1 RAFEL-2015' catalog is highlighted.
- Main Panel (Form):** Displays the configuration for the selected catalog. Fields include:
  - Number: 1
  - Name in the Proposal: RAFEL-2015 (unique within proposal)
  - Name for the Archive: RAFEL-2015 (standard resolvable name)
  - Buttons: 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
- Table:** A table of sources for the catalog. The table has columns: ID, RA, DEC, Size, Redshift, Reference, Stellerity, MAG\_F160W, NRS\_F110W, NRS\_F140X, NRS\_CLEAR, W. The table contains 20 rows of data.
- Bottom Panel:** Includes buttons for 'New Candidate Set...', 'Delete', and 'Send to Aladin'. At the bottom right, there is a status bar indicating '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. (The tool 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 |
|-------|---------------|--------------|------|----------|-----------|------------|-----------|-----------|-----------|-----------|
| 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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| 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    |
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| 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     |
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| 24348 | 03 32 38.9675 | -27 46 30.23 | 0    | 0.447    | Yes       | 0.03       | 20.152    | 20.541    | 20.258    | 20.152    |
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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 MPT Planner tab

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## The MPT Planner

In the **MSA Planning Tool** -

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**

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 Too

New JWST Proposal Import MSA Source Catalog...

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

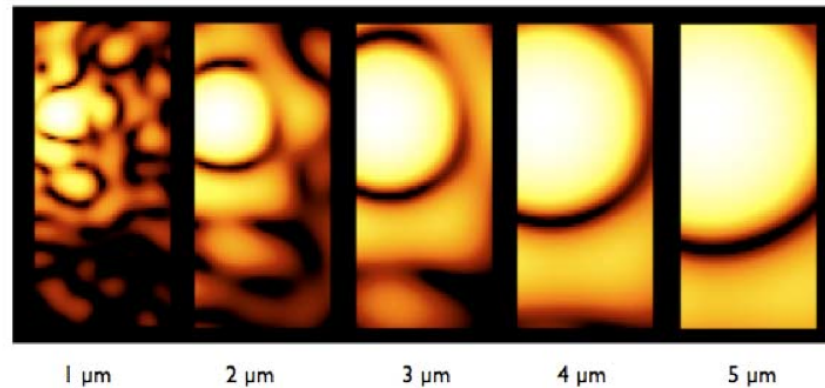
G395H/F290LP

22 errors & warning



## Source centering and slit losses

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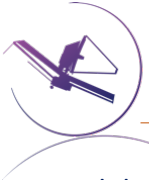
Slit throughput or slit loss is a function of wavelength and the relative placement of the science source in the MSA shutter



## Source centering constraint

A tighter constraint on the source shutter 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><br>(sources can be behind the MSA bars) |         | 12%   | 0                     |
| <i>Entire Open Shutter Area</i><br>(default)                 |         | 30%   | 38                    |
| <i>Midpoint</i>  |         | 62%   | 59                    |
| <i>Constrained</i>   |         | 75%   | 72                    |
| <i>Tightly Constrained</i>                                   |         | 85%   | 91                    |

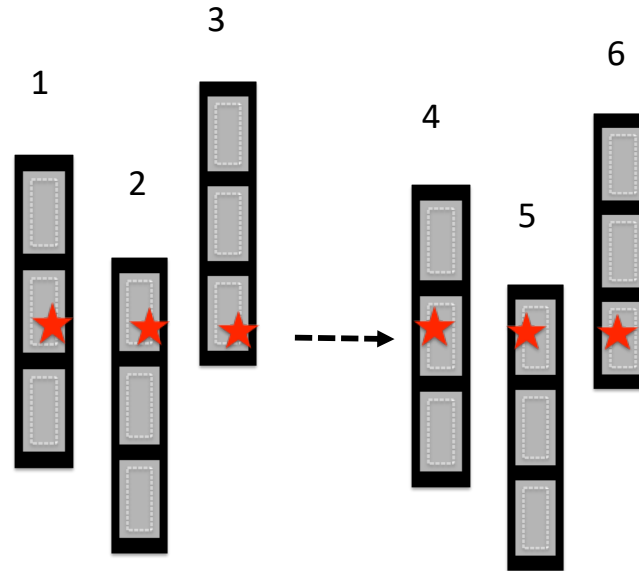


## The benefits of dithering

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

- Improve background subtraction (**Nodding**)
- Recover important wavelengths that could fall in the detector gap (**Fixed dither**)
- Mitigate the effects of **light leakage** through the MSA
- Observe additional sources behind bars or mounting plate.

Nod in 3-  
shutter  
slitlet:  
3 exposures



**Fixed dithers:**  
MSA is  
reconfigured at  
the new dither  
point.

**MPT takes dithers into account and will attempt to observe as many sources as possible through a set of 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 MSA 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.



## 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.





## MSA Operability: Failed shutters and shorts

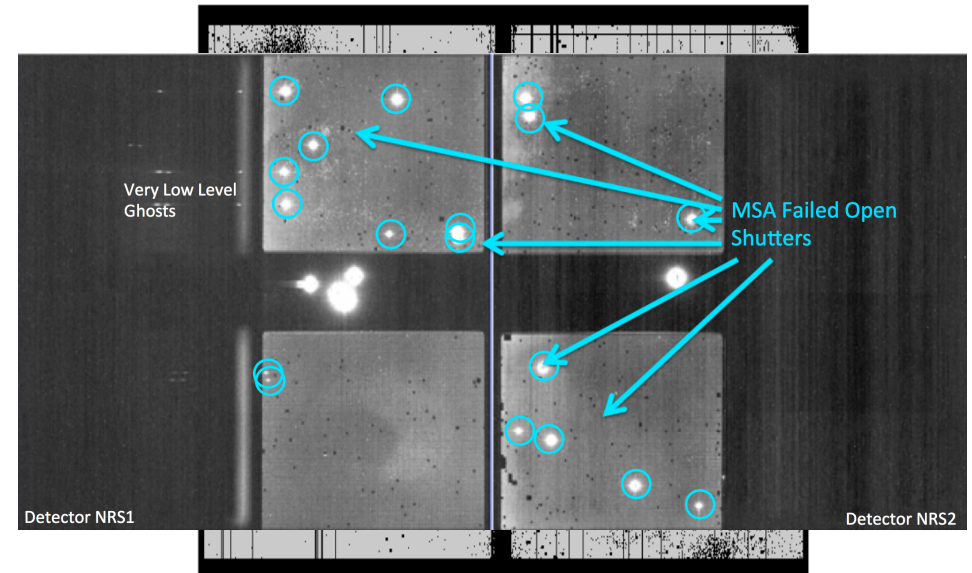
Some of the MSA shutters are not operable...

**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.

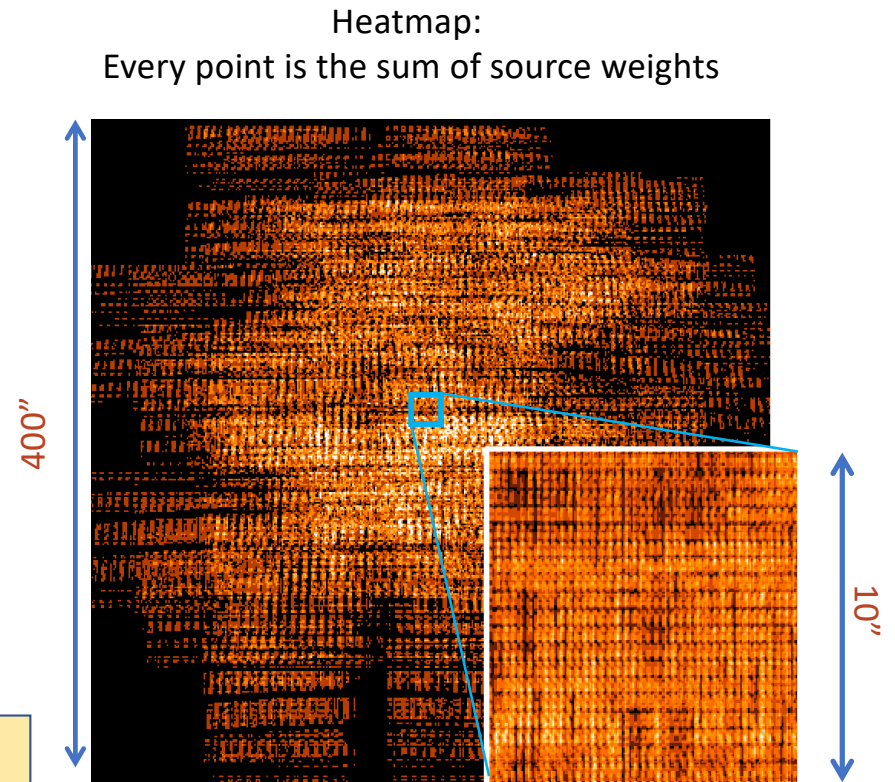
At each test pointing, MPT plans around failed shutters and shorts and searches for an optimal MSA configuration. The latest operability information is used.





## 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**.

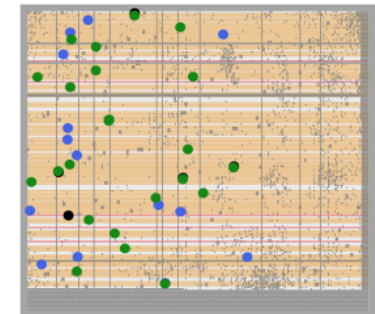
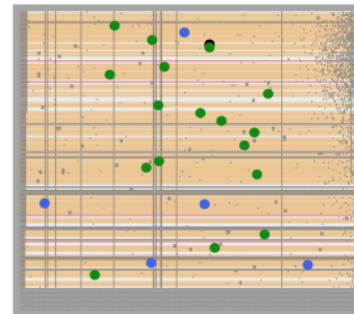
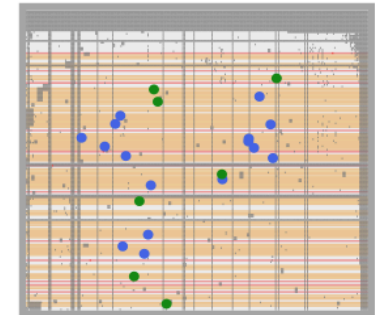
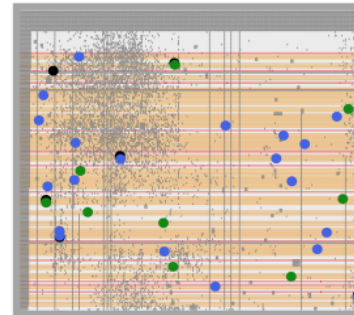






## How MPT works

- 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**.





The MPT Plans tab

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## Examine and visualize Plan results

Examine plan results in the Plans pane of MPT

- MSA shutter view
- Collapsed shutter view

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...

**Planner** | Plans

### Plan Selection

| # | 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 |

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 | 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        |

### Targets

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

56 targets are shown. | Send to Aladin

### Targets:

| Id    | Weight | Exposures | c1e1n1 | c1e1n2 | c1e1n3 |
|-------|--------|-----------|--------|--------|--------|
| 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      |

RAFEL\_2015\_HUDF\_SMALL\_ALLREF\_RANDOM (996... | Name | Astrometric Accuracy (mas) | Reference Position

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

22 errors & warnings (Click for Details)



# 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!**



**Plan Selection**

| # | 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 |

Select multiple plans to review them in combination.

**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            | 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           | 14187        | Show | Send           | Export        |
| 5 | 3           | cle1n2 | 53.1695414 | -27.7887403 | 03 32 40.68... | -27 47 19.4... | 134.996668... | PRISM...117 | 14106           | 14106        | Show | Send           | Export        |
| 6 | 3           | cle1n3 | 53.1697762 | -27.7889480 | 03 32 40.74... | -27 47 20.2... | 134.996559... | PRISM...119 | 14148           | 14148        | Show | Send           | Export        |

**Targets**

Target Set Operation:

57 targets are shown.

| 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      |

**Coverage:**



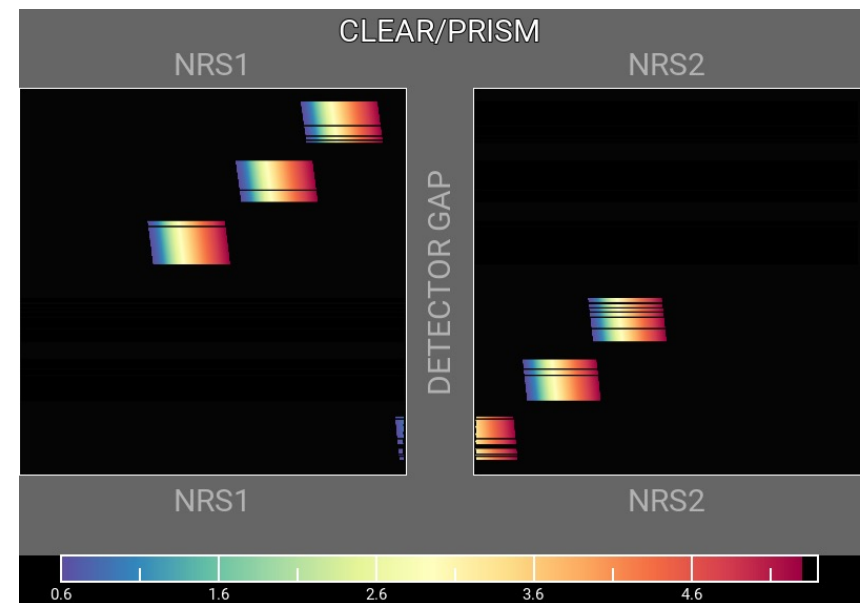
## MSA Spectral Visualization Tool

**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/>



G. Kanarek



## 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 – 5-15 mas for point sources – up to 40 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 **Nirspec Obs Visualization Tool (NOVT)** to visualize NIRCams pre-imaging relative to MSA observations.
- **Dither! Dither!! Dither!!!** It improves background subtraction, wavelength coverage, etc.

A deep blue and purple nebula with wispy, ethereal clouds of gas and dust. The background is a dark, star-filled sky with numerous bright, multi-pointed stars. The word "END" is centered in a clean, white, sans-serif font. A thin, horizontal orange line runs across the middle of the image, passing behind the text.

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 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