



**STScI** | SPACE TELESCOPE  
SCIENCE INSTITUTE

EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

## Planning MOS Observations

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

JWST Master Class  
November 2019

# The MOS Observing Process

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## Multi-Step Process

To accurately align science sources within the small 0.2" × 0.46" MSA shutters, NIRSpec MOS mode observations must be **planned and executed at a fixed instrument aperture position angle (APA), assigned by STScI.**

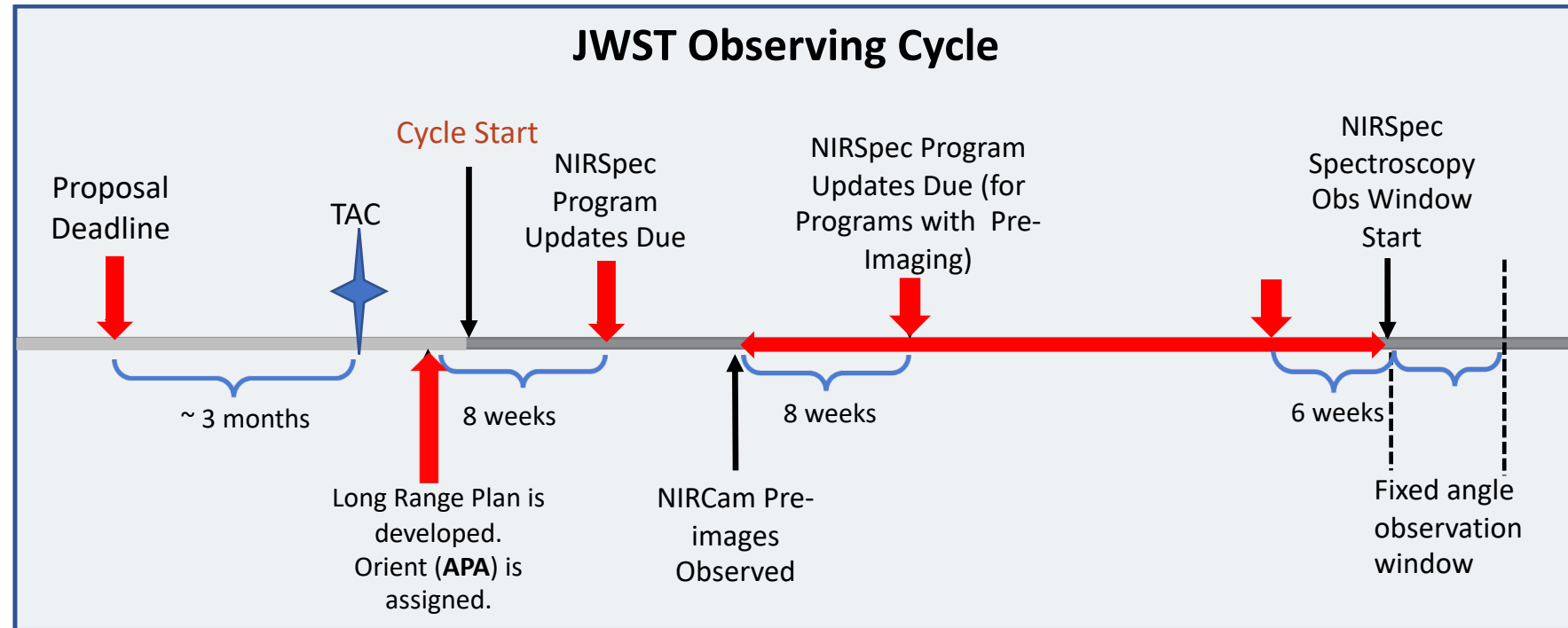
NIRSpec MOS observers must follow a **multi-step planning process.**

For the **Proposal deadline, MPT should be used to create placeholder visits** to accurately estimate the overheads for the strategy used.

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

Flight ready programs using MPT are due **8 weeks after the APA is assigned (if there is no NIRCам pre-imaging)**

If NIRCам pre-imaging is requested, flight ready program updates are due **8 weeks after the NIRCам pre-imaging** is observed.



For best success, users should consider **placing their NIRCам pre-imaging and NIRSpec observations in different visibility windows** (in Cycle 1) to allow for enough 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 observation window.**



# Positional Accuracies, Target Acq, and Pre-imaging

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## Positional Accuracies

Does your science require accurate astrometry delivered by MSATA (using reference stars)?  
Note that TA accuracy depends on 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, and if HST imaging does not exist – request NIRCam pre-imaging in your Proposal



## Target Acquisition Options

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- **Moving targets** cannot use MSATA – 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.
- **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.



# Pre-imaging with NIRCam

- Is imaging available that is
  - **deep enough** to identify interesting sources,
  - **wide enough** to plan ref stars, and
  - **accurate enough** to plan MOS observations?
- If not – request **NIRCam pre-imaging** in your initial Proposal submission
- If pre-imaging is needed: Coverage should be large enough to **allow for any APA** for NIRSpec obs: Ideally 5 x 5 arcmin: **typically 2x1 mosaic + dithers to cover the gaps**
- NIRCam observations must be flight ready at proposal submission.
- Pre-imaging in the same cycle is possible. Program is due a minimum of **6 weeks** before NIRSpec observations.

## NIRSpec Observation Visualization Tool (L. Ubeda)

The screenshot displays the NIRSpec Observation Visualization Tool interface. The left panel is titled "JAMES WEBB Space Telescope NIRSpec Observation Visualization Tool" and contains several configuration sections:

- Input FITS background image:** Select File, /Users/jubeda/Desktop/mosaic\_ngc5194\_acs\_f814w\_sci.fits
- Output directory:** /Users/jubeda/Desktop
- Input catalogue:** No, Catalog on? Select File
- DS9 parameters:** Colour Map: grey, Scale: log, Low: 0.0, High: 100.0
- NIRSpec Micro Shutter Array and IFU:** Yes, Red, MSA footprint on? 202.47, 47.21, 38.0, RA center of MSA, DEC center of MSA, MSA aperture PA
- NIRCam Long and Short Wavelength Channels:** No, Green, Short channel on? Yes, Yellow, Long channel on? 202.47, 47.21, 75.0, RA center of NIRCam, DEC center of NIRCam, NIRCam aperture PA
- NIRCam dither pattern:** FULL3TL
- NIRCam mosaic:** Yes, Offset: 60.0, 110.0

The right panel shows a visualization of the observation field with overlaid observation footprints (yellow and red rectangles) on a star field background. The bottom of the right panel shows a zoomed-in view of the field with a scale bar from 0.099 to 50 arcmin.



[Video help available](#)



# The MSA Planning Tool in APT

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# MSA Planning Tool (MPT)



## MOS Observing Mode

- NIRSpec MOS observing mode can collect spectra of tens to hundreds objects within a 3.6' x 3.4' FoV at the same time.
- The MPT has been designed to align science sources with the very small 0.2" x 0.46" shutters

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.

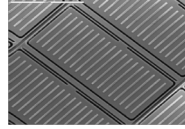
Show: [dropdown]

✓ No errors & warnings (Click for Details)



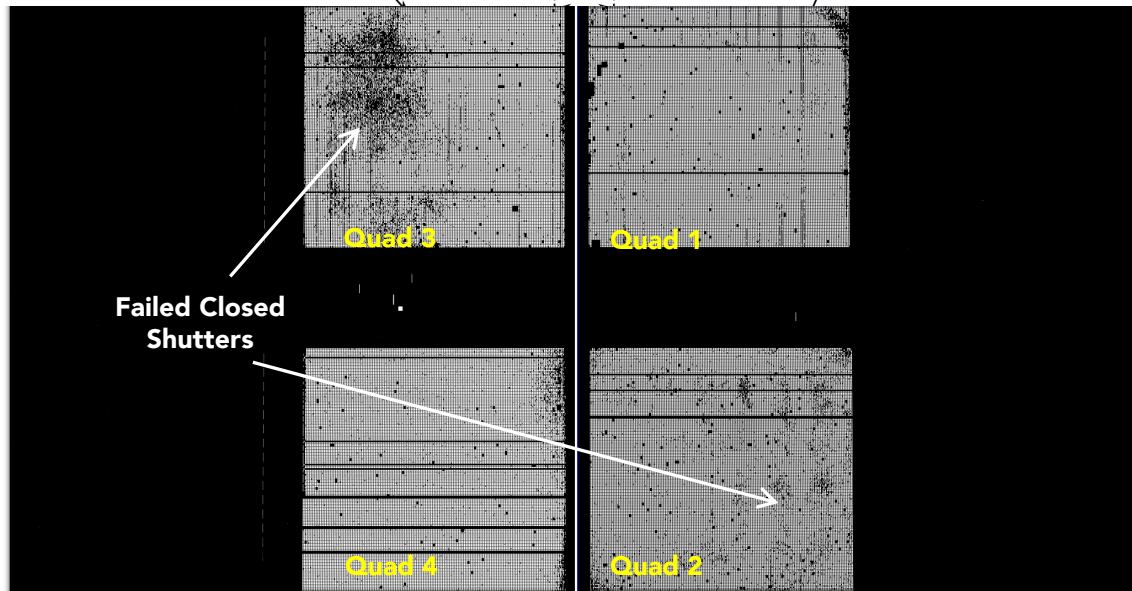
## Why Use MPT?

- 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.



### Shutter Operability

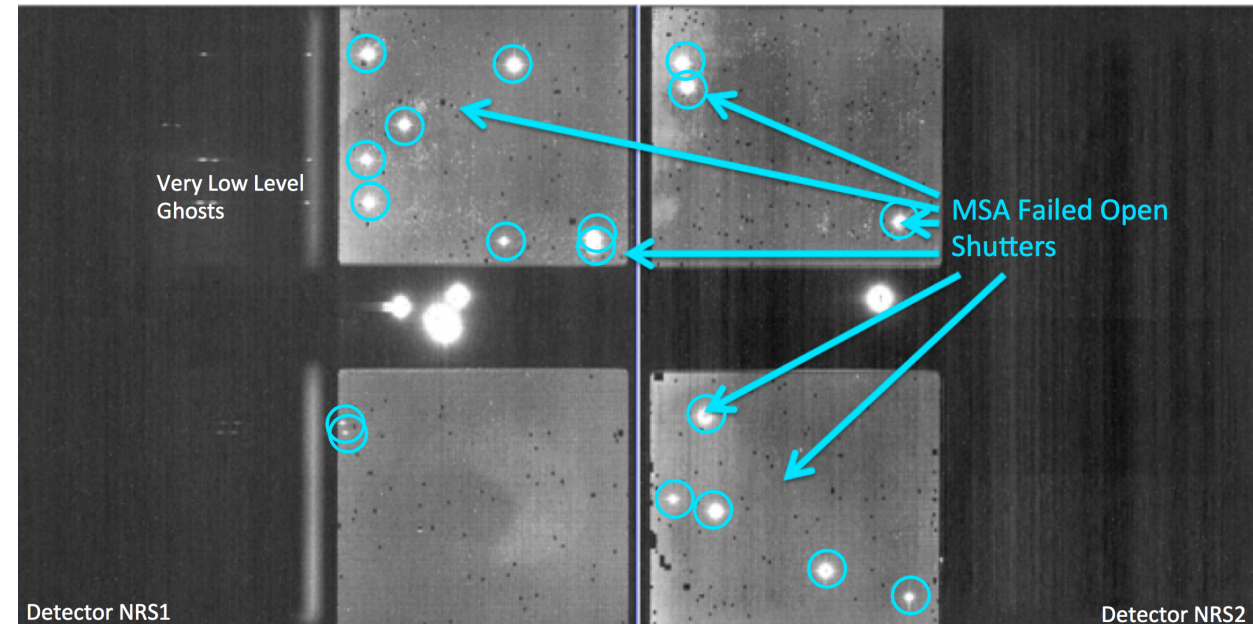
Mounting Frame      Detector Gap (~20")  
23"      Active MSA Area



Detector Array      3.6'      dispersion

- 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/ velocity aberrations** at a planned Aperture Position Angle.

### MSA failed open shutters





## MSA Planning Tool Inputs/Outputs

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- Internet connection to run MPT – to access the most up to date MSA shutter operability
- A complete and accurate astrometric **Catalog**
- Accurate source positions ( $< 15$  mas relative accuracy) – Pre-Imaging with NIRCam?
  
- MOS Observations: Pointings, MSA configurations, Target Sets

The background of the slide is a deep blue and black starry sky. A large, diffuse nebula with wispy, light blue and white clouds is visible on the left side. Numerous bright stars of various colors, including blue, white, and yellow, are scattered across the field. A thin, horizontal orange line spans the width of the slide, positioned just below the title text.

# The Source Catalog



# Source Catalog

The first step to create a NIRSpec MOS observation is to create a complete catalog of sources.

- 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**
- Fluxes or magnitudes for the sources help (but are optional at submission.)
- Target weights help (but are optional).
- Optional header. 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 (0.2" x 0.46" ) the coordinate accuracy of the planning catalog must be **between 5 and 50 mas**.

The catalog should include **all known sources in the field**, to properly identify contaminants in MPT.



# Loading the Catalog as an MSA Catalog Target

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  
New HST Proposal  
New JWST Proposal

Browse and select the Catalog file.

Choose a name and format

MPT tries to identify the type of data in each column

MSA Source Importer

File to Import: Users/dkarakla/Desktop/Rafel\_2015\_HUDF\_small\_ALLref\_random.txt  
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

Ignore Ignore Ignore Ignore Weight

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

Click

No errors & warnings (Click for Details)



# MSA Catalog and Candidate Sets

MPT complains because:

- 1) The **target is not used** in the proposal (yet) (just a warning)
- 2) We must specify the **astrometric accuracy**
- 3) We must tell MPT if we need **pre-imaging** or not:
  - Already obtained (using NIRCcam)
  - Will be obtained external to this program (i.e. new HST program or an upcoming NIRCcam program)
  - Will be done in this program (NIRCcam pre-imaging or NIRCcam coordinate parallel)
  - Not required (i.e. have previous HST observations, or you are just testing)

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 Stop

New JWST Proposal Import MSA Source Catalog...

1 RAFELSKI-2015-RANDOM of JWST Draft Proposal (Unsaved)

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

Candidate Sets Comments

RAFELSKI-2015-RANDOM (9969) 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

New Candidate Set...  
Delete  
Send to Aladin

Select

Edit MSA Catalogs New Edit Observations

23 errors & warnings (Click for Details)



# 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

select  
pan  
zoom  
dist  
phot  
draw  
tag  
filter  
rgb  
crop  
cont  
epoch  
size  
pixel  
opac  
zoom  
prop  
del

Z<1  
Z>4  
RAF-RANDOM  
Targets (JWST Dr  
1 RAF.RANDOM  
1 RAF.RANDO  
h\_udf\_wfc\_b\_c

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

0 sel / 12632 src 168Mb





# MSA Catalog Target

The next step to create a NIRSpec MOS observation is to ingest the catalog of sources in APT

The MSA Catalog Target is now in the Targets Folder

Highlight the Catalog to see its data



The screenshot shows the APT interface for a JWST Draft Proposal (RAFEL-2015). The left sidebar shows a tree view with the following structure:

- JWST Draft Proposal (RAFEL-2015)
  - Proposal Information
  - Targets
    - MSA Catalogs
      - 1 RAFEL-2015** (highlighted)
    - Observations
      - Observation Folder
        - G140M-step10-cat (Obs)
        - PRISM-step10-z5-fillers
      - Observation Links

The main panel displays the configuration for the selected catalog:

- 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
- Summary: RAFEL-2015 (9969 sources), Z>5 (344 sources), Z>3 (3056 sources)
- Buttons: New Candidate Set..., Delete, Send to Aladin

The source data table is as follows:

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	

At the bottom right, there is a status bar indicating "12 errors & warnings (Click for Details)".



# Source Catalog at Program Update

The first step in creating a NIRSpec MOS observation is to upload a complete catalog of sources in MPT

- 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 (when available).

Candidate Sets    Comments

Astrometric Accuracy (mas)

Reference Position RA:  Dec:

Pre-Image Availability

ID	RA	DEC	Size	Redshift	Reference	Stellerity	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

Edit MSA Catalogs    New    Edit Observations

12 errors & warnings (Click for Details)

The background of the image is a deep blue and black starry sky. A large, diffuse nebula with shades of blue, purple, and brownish-gold is visible on the left side. Numerous bright stars of various colors (blue, white, yellow) are scattered across the field of view. The title 'The MPT Planner' is centered in a white, sans-serif font. A thin, horizontal orange line runs across the width of the image, positioned just below the title.

# The MPT Planner

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# Planner Parameters

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

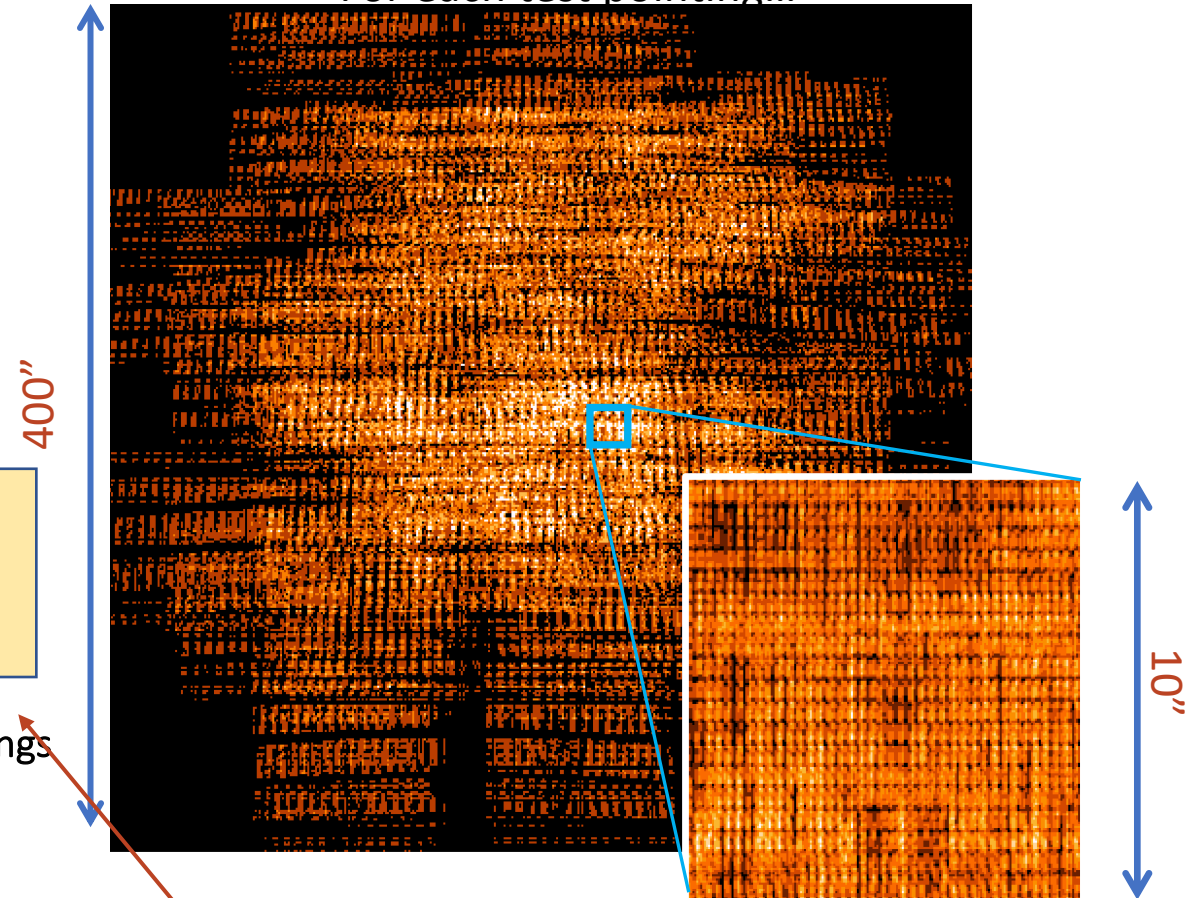
- Choose the Primary Candidates
- (Choose Filler Candidates)
- Choose an APA (place holder or assigned from STScI)
- Choose the slitlet configuration
- Choose the source centering constraints



## How MPT works

- The Catalog is loaded and **Primary and optional Filler candidate lists are defined**. Sources are mapped to the MSA plane.
- User runs the Planner: He/she selects an **APA**, a **slit shape**, a **centering constraint**, and **dithers** in dispersion and/or spatial directions. User also specifies **search grid** extent and step size.
- **MPT creates a grid of test pointings** over the area of the Primary Candidate list. MPT will find the Primary sources at each **user-specified dither**.
- At each pointing, **weights** of all **observable primary sources** in an MSA configuration are summed. The **order** of the Catalog and Candidate lists impacts the target selection. The result is a **Heatmap**.
- The “best” pointing with the **largest score** is selected. ( 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 and made into an **Observation**.

Heatmap: Every point is the sum of source weights  
For each test pointing...



A loaded step. MPT is checking limits provided in the Planner, and known instrument effects.



## MSA Operability: Failed shutters and shorts

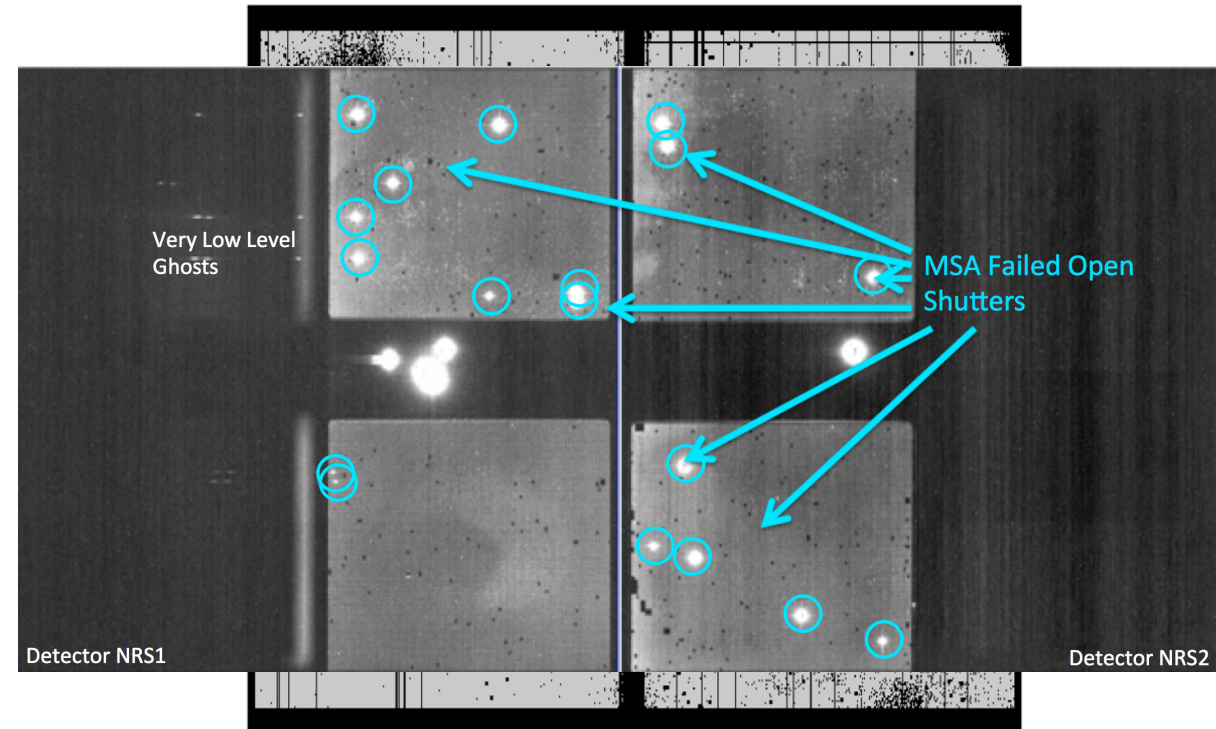
Some of the MSA shutters are not operable

**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.

MPT automatically plans around failed shutters and shorts and searches for the optimal configuration.

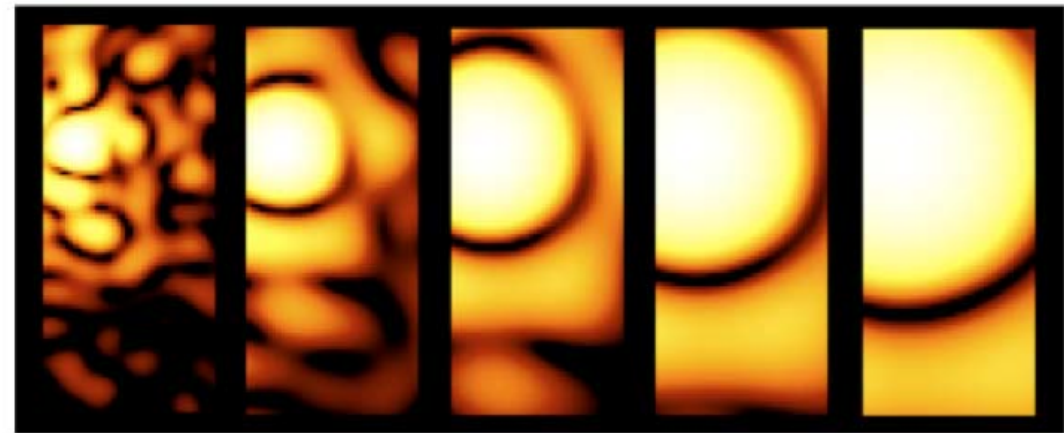




# Source Centering and Slit Losses

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)
-----------------------------	---------	---	-----------------------



1  $\mu\text{m}$       2  $\mu\text{m}$       3  $\mu\text{m}$       4  $\mu\text{m}$       5  $\mu\text{m}$

<i>Constrained</i>		75%	72
<i>Tightly Constrained</i>		85%	91

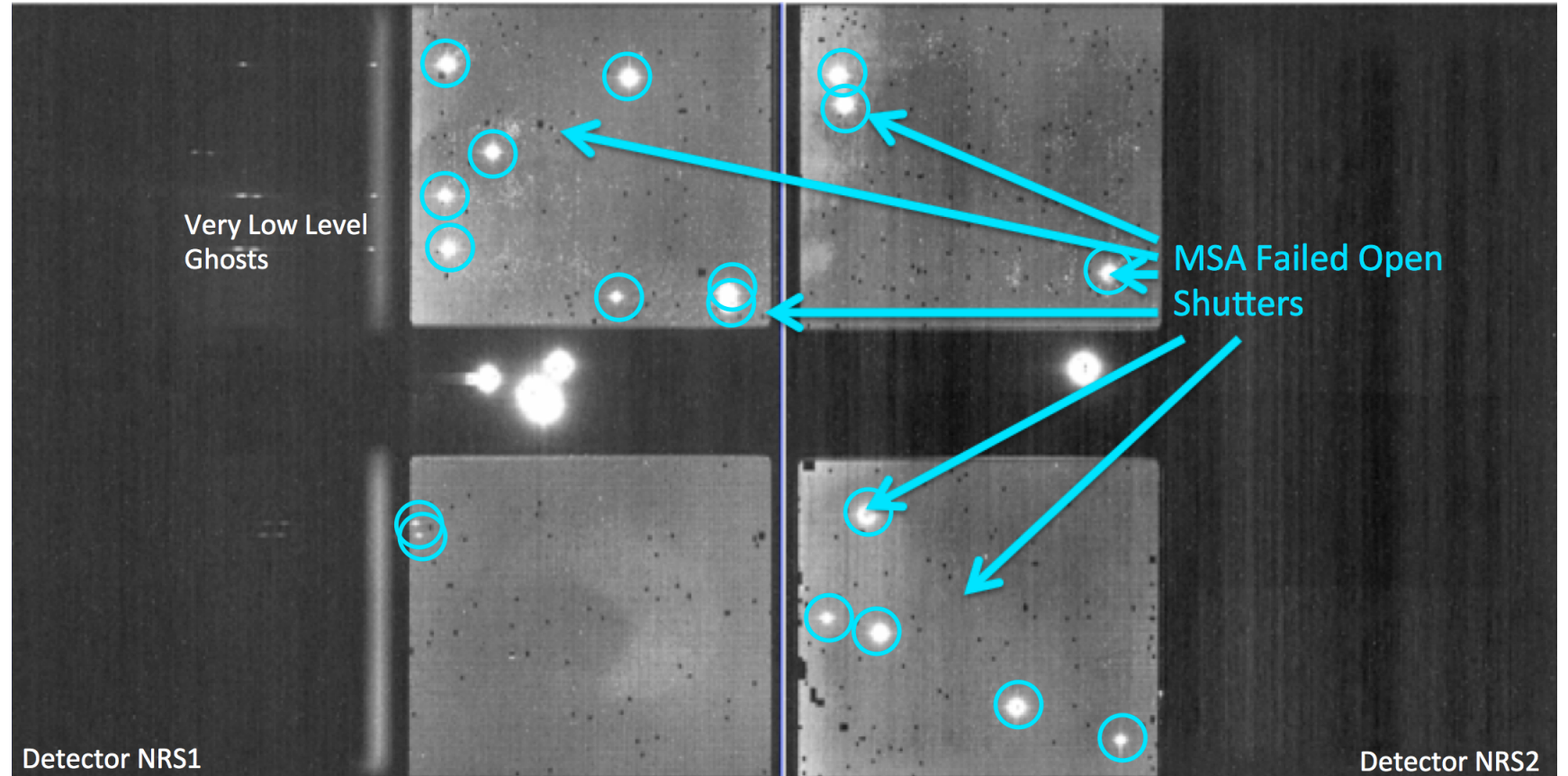
**Slit throughput loss is a function of wavelength and the relative placement of the science source in the MSA shutter**



## Benefits of dithering

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

- Better background subtraction (**Nodding**):
  - Recover important wavelengths that could fall in the detector gap (**Fixed dither**)
  - Mitigate effects of **light leakage** through the MSA
  - **Dithers also** help mitigate detector artifacts, improve resolution, observe additional sources behind bars or mounting plate.
- **MPT will observe as many sources as possible at all dithers**







# Specifying Dithers and Nods

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 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

**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)



# Create a Plan in MPT

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

Use Weights and MC shuffling (Monte Carlo) Random ordering of sources tested for most sources in MSA



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) Proposal Information Targets MSA Catalogs Observations Observation Folder G140M-step10-cat (Obs) PRISM-step10-z5-fillers Observation Links JWST Draft Proposal (Unsaved)

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

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

22 errors & warnings (Click for Details)

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# Examine Results

Examine plan results in the Plans pane of MPT

- MSA shutter view
- Collapsed shutter view

**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 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

**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
1416	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!



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)

- Proposal Information
- Targets
- MSA Catalogs
- Observations
  - Observation Folder
    - G140M-step10-cat (Obs)
    - PRISM-step10-z5-fillers
  - Observation Links
- JWST Draft Proposal (Unsaved)

**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 to Aladin	Export Config
1	2	c1e1n1	53.1696588	-27.7888441	03 32 40.71...	-27 47 19.8...	134.996614...	G140M...	69	9954	Show	Send	Export
2	2	c1e1n2	53.1695414	-27.7887403	03 32 40.68...	-27 47 19.4...	134.996668...	G140M...	66	9921	Show	Send	Export
3	2	c1e1n3	53.1697762	-27.7889480	03 32 40.74...	-27 47 20.2...	134.996559...	G140M...	66	9918	Show	Send	Export
4	3	c1e1n1	53.1696588	-27.7888441	03 32 40.71...	-27 47 19.8...	134.996614...	PRISM/...	123	14187	Show	Send	Export
5	3	c1e1n2	53.1695414	-27.7887403	03 32 40.68...	-27 47 19.4...	134.996668...	PRISM/...	117	14106	Show	Send	Export
6	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

57 targets are shown. Send to Aladin

**Targets:**

Id	Weight	Exposures	c1e1n1	c1e1n2	c1e1n3	c1e1n1	c1e1n2	c1e1n3
4449	300	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
6478	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)



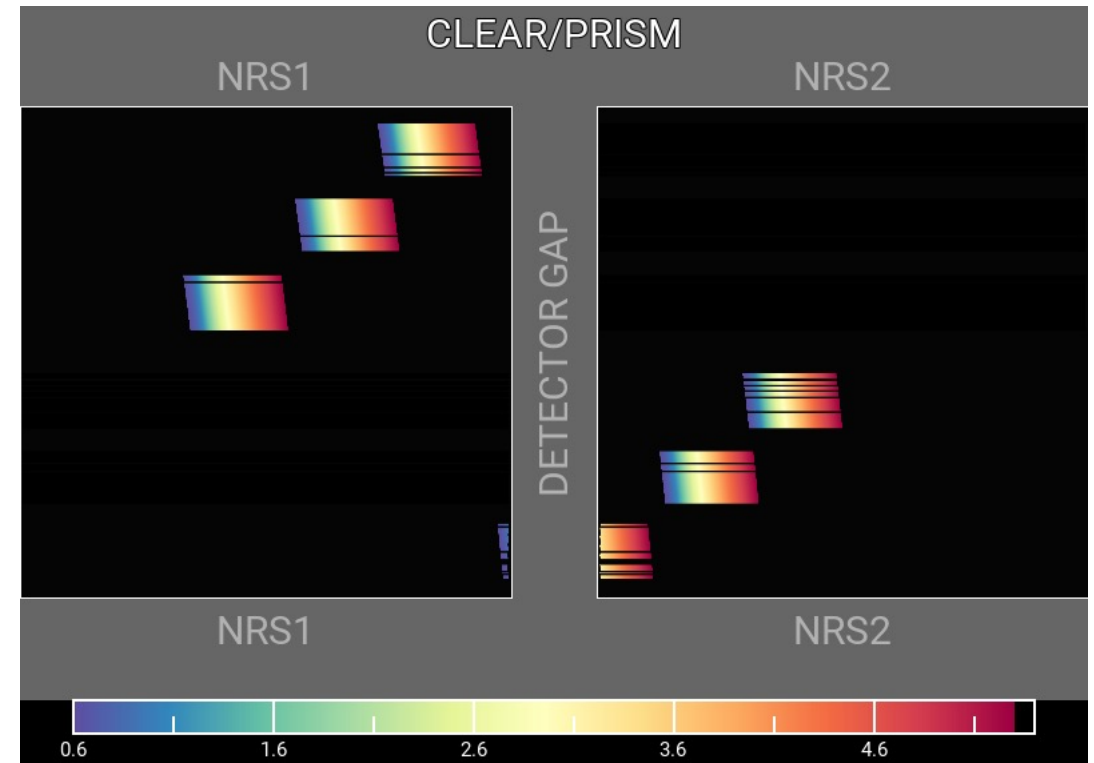
# MSA Spectral Visualization Tool

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

It takes the "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 for indicating wavelength cutoffs.

Instructions to download, install and run MSAVis can be found in the JDOx NIRSpec section:

[The Near Infrared Spectrograph, NIRSpec](#)





## 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 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 NIRCams pre-imaging relative to MSA observations
- **Dither! Dither!! Dither!!!** It improves background subtraction, wavelength coverage, etc.



## 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 NIRCcam parallaxes wrt NIRSspec 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 **Manual 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.