



STScI | SPACE TELESCOPE
SCIENCE INSTITUTE

EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

Planning MOS Observations

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





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**.

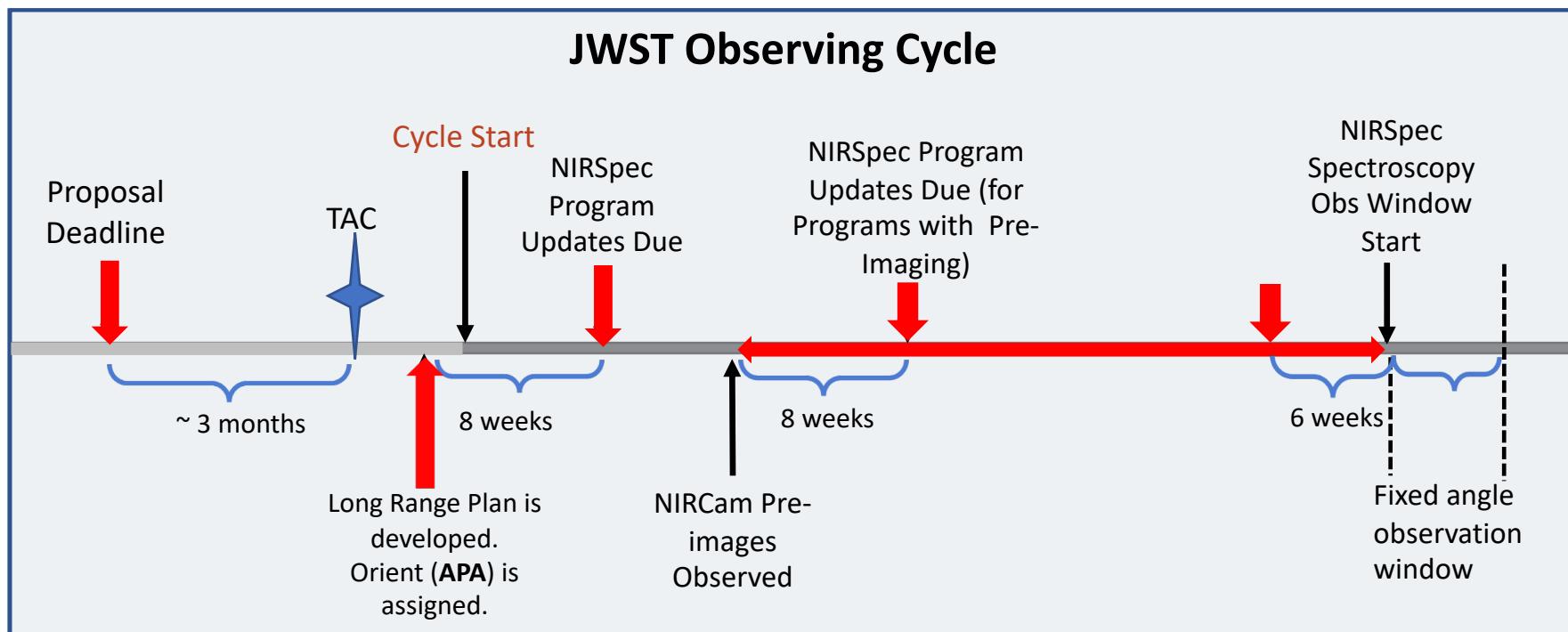
NIRSpec MOS observers must follow a **multi-step planning process**.

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.

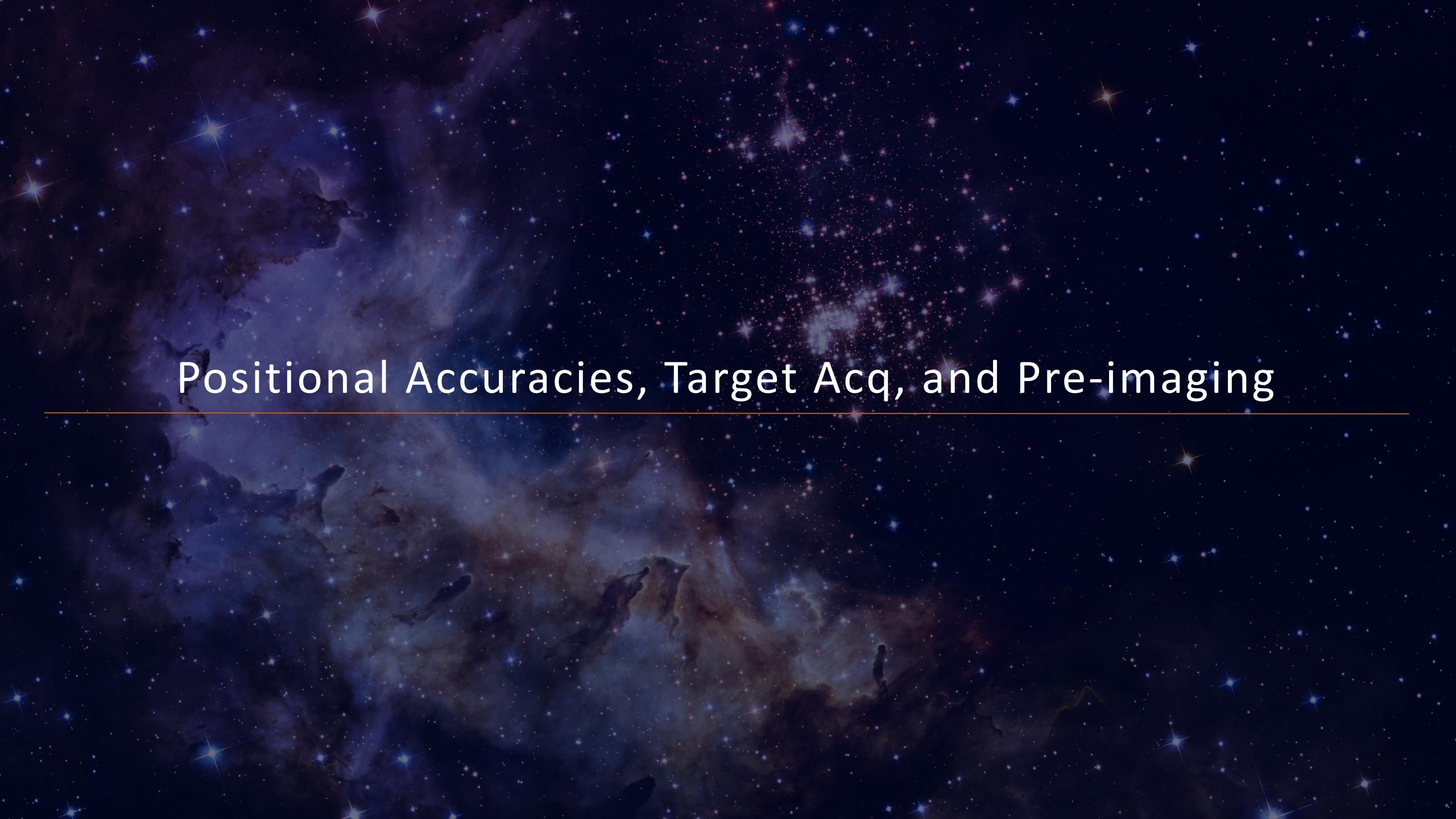
Flight ready programs using MPT are due **8 weeks after the APA is assigned (if there is no NIRCam pre-imaging)**

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



For best success, users should consider **placing their NIRCam pre-imaging and NIRSpec observations in different visibility windows** (in Cycle 1) to allow for enough time to reduce and analyze the NIRCam 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



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 th shutter)	5 - 15 mas (HST: ~ 10 mas is possible. NIRCam: 5 mas is the goal)	Best possible photometric accuracy
Relaxed (MSATA)	< 50 mas	< 40 mas	Extended sources, or reduced flux accuracy w/ MSA
VERIFY_ONLY	~ 100 mas (TBD)	No ref stars required	Special cases – extended source

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



Target Acquisition Options

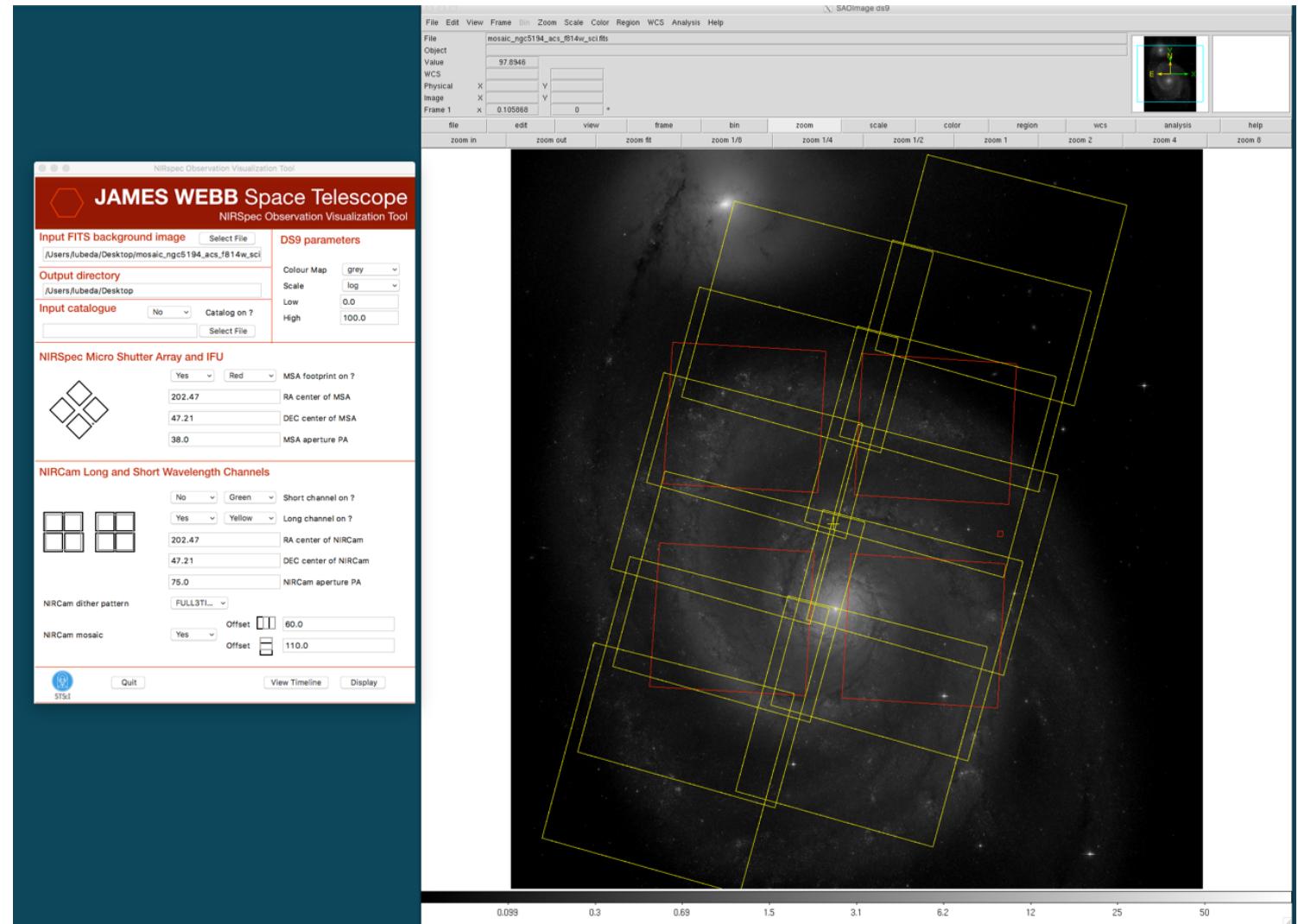
- **Moving targets** cannot use MSATA – use WATA instead. WATA does not require pre-imaging, only a good ephemeris.
- For **Program Updates** - MPT will be used to select reference stars at the assigned APA that will not be behind MSA bars or in failed shutters. This vetting is done at the Visit level 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)



[Video help available](#)



The MSA Planning Tool in APT



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

The screenshot shows the "Astronomer's Proposal Tools" software interface. At the top, there is a menu bar with the title "Astronomer's Proposal Tools Version 27.3 mpt-demo (Thu Jul 25 2019) JWST PRD: PRDOPSSOC-L-023". Below the menu bar is a toolbar with various icons: Form Editor, Spreadsheet Editor, MSA Planning Tool (which is highlighted with a blue box), Orbit Planner, Visit Planner, Timeline, View in Aladin, BOT, Target Confirmation, PDF Preview, Submission, Errors and Warnings, What's New, Roadmap, and Feedback. The main window displays the "Astronomer's Proposal Tools" logo and version information. Below this, there is a list of copyright and usage notices:

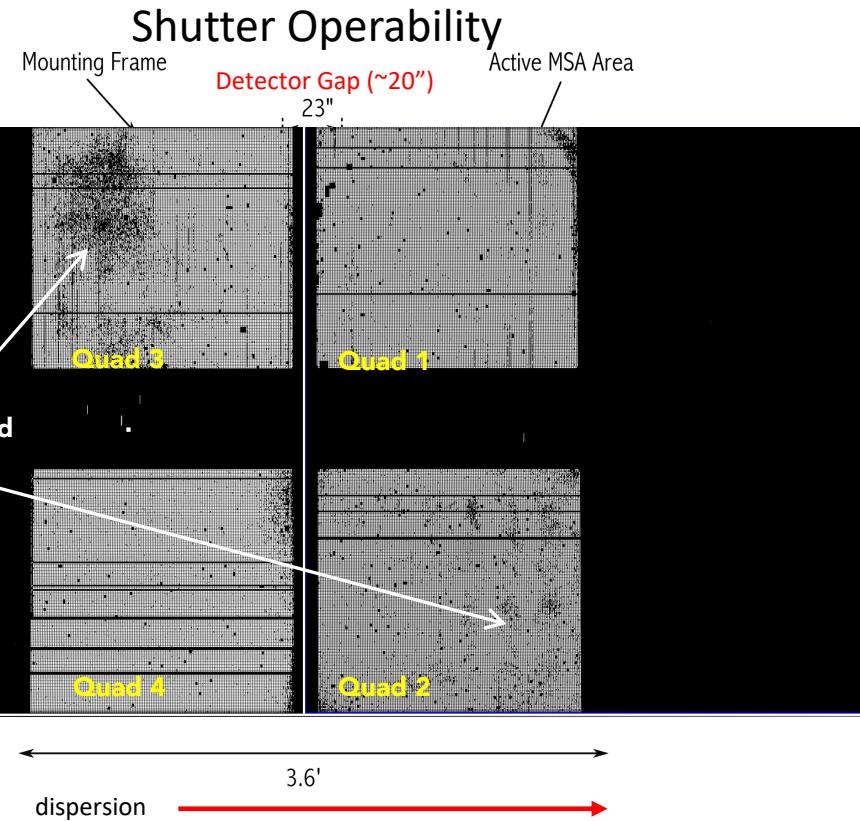
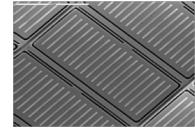
- Copyright 2002 – 2007 United States Government as represented by the Administrator of the National Aeronautics and Space Administration. All Rights Reserved.
- This software has made use of the Aladin Sky Atlas (<http://aladin.u-strasbg.fr/>) developed at the Centre de Données astronomiques de Strasbourg (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.

At the bottom right of the interface, there is a status message: "No errors & warnings (Click for Details)" with a green checkmark icon.



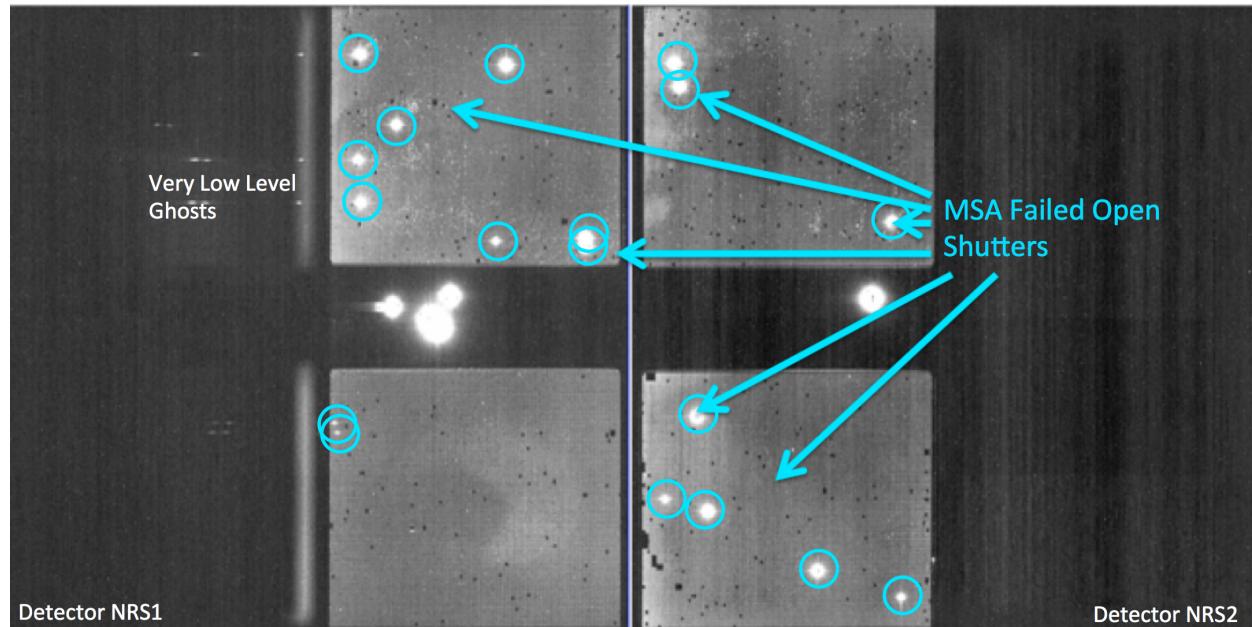
Why Use MPT?

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

MSA failed open shutters





MSA Planning Tool Inputs/Outputs

- 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 features a deep space scene with numerous small, glowing stars of varying colors. On the left side, there is a prominent, dark blue and purple nebula with intricate, wispy structures and several bright, star-like points of light embedded within it.

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 "#"

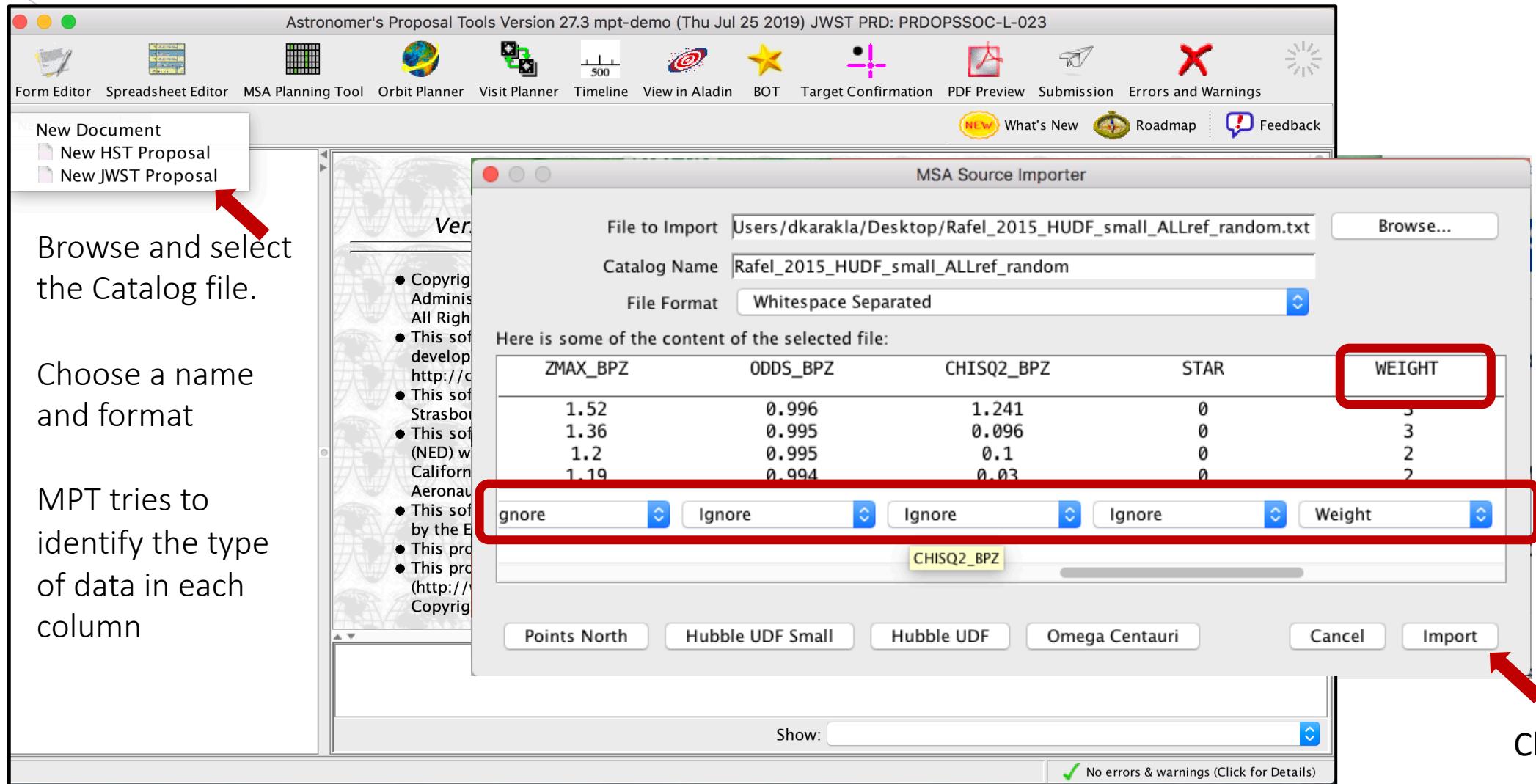
ID	RA	DEC	Size	Redshift	Reference	Stellarity	MAG_F160W	NRS_F110W	NRS_F140X	NRS_CLEAR	W
23796	03 32 39.0842	-27 46 1.79	0	1.415	Yes	0.92	20.122	20.674	20.366	20.122	
54454	03 32 35.5075	-27 46 26.13	0	1.268	Yes	0.03	20.384	20.845	20.474	20.384	
22410	03 32 39.8827	-27 47 15.06	0	1.107	Yes	0.03	20.711	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



Click



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 NIRCam)
 - Will be obtained external to this program (i.e. new HST program or an upcoming NIRCam program)
 - Will be done in this program (NIRCam pre-imaging or NIRCam 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)

New JWST Proposal Import MSA Source Catalog...

JWST Draft Proposal (RAFELSKI-2015-RANDOM) 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)

RAFELSKI-2015-RANDOM (996) X Astrometric Accuracy (mas) Reference Position RA: 03 32 38.9682 Dec: -27 47 26.86

Pre-Image Availability: Not required

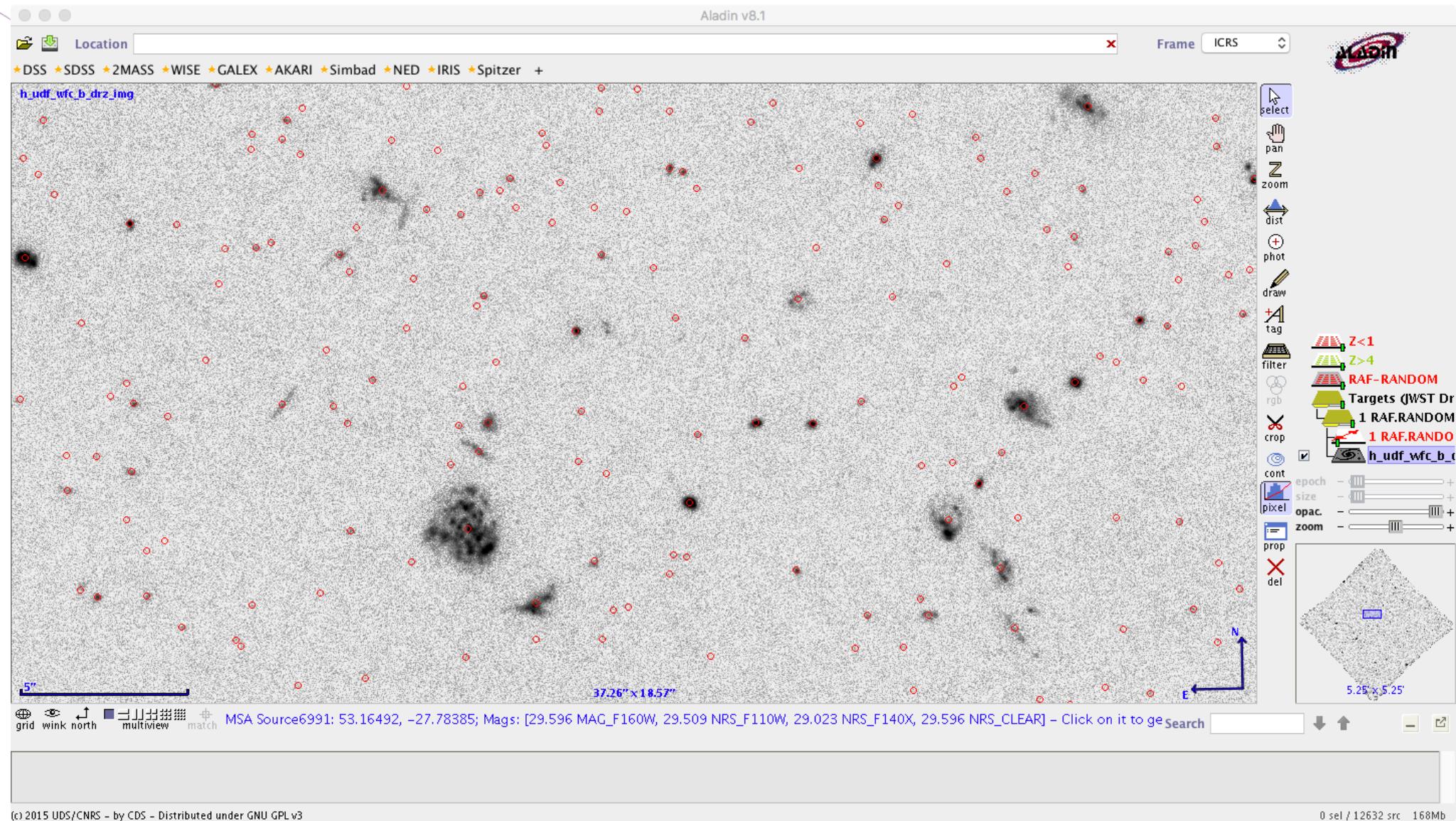
ID	RA	DEC	Size	Redshift	Reference	Stellarity	MAG_F160W	NRS_F110W	NRS_F140X	NRSit
23796	03 32 39.0842	-27 46 1.79	0	1.415	Yes	0.92	20.122	20.674	20.366	3
54454	03 32 35.5075	-27 46 26.13	0	1.268	Yes	0.03	20.384	20.845	20.474	3
22410	03 32 39.8827	-27 47 15.06	0	1.107	Yes	0.03	20.711	21.199	20.786	2
24439	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

Edit MSA Catalogs New Edit Observations

23 errors & warnings (Click for Details)



Sources seen in Aladin





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 with the title bar "Astronomer's Proposal Tools Version 2020.1 mpt-demo (Thu Oct 24 2019) - JWST Draft Proposal (RAFEL-2015.aptx)". The menu bar includes "Form Editor", "Spreadsheet Editor", "MSA Planning Tool", "Orbit Planner", "Visit Planner", "Timeline", "View in Aladin", "BOT", "Target Confirmation", "PDF Preview", "Submission", and "Errors and Warnings". Below the menu is a toolbar with icons for "Run All Tools" and "Stop". A red arrow points to the "1 RAFEL-2015" entry in the "MSA Catalogs" section of the left sidebar.

The main window displays the "1 RAFEL-2015 of JWST Draft Proposal (RAFEL-2015.aptx)" details. It shows the Number (1), Name in the Proposal (RAFEL-2015), and Name for the Archive (RAFEL-2015). The "Candidate Sets" tab is selected. The "Astrometric Accuracy (mas)" is set to 10.0. The "Reference Position" is RA: 03 32 38.9682 and Dec: -27 47 26.86. The "Pre-Image Availability" is set to "Not required".

A table below lists 9969 sources from the RAFEL-2015 catalog, showing columns for ID, RA, DEC, Size, Redshift, Reference, Stellarity, MAG_F160W, NRS_F110W, NRS_F140X, NRS_CLEAR, and W.

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	

Buttons at the bottom include "Edit MSA Catalogs", "New", "Edit Observations", and a status bar indicating "12 errors & warnings (Click for Details)".



Source Catalog at Program Update

The first step is to create 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).

The screenshot shows the MPT software interface with a source catalog table. The table has columns for ID, RA, DEC, Size, Redshift, Reference, Stellarity, MAG_F160W, NRS_F110W, NRS_F140X, NRS_CLEAR, and NRS_G. A red box highlights the last four columns. The table contains 20 rows of data. At the bottom, there are buttons for 'Edit MSA Catalogs', 'New', and 'Edit Observations'. A message at the bottom right says 'X 12 errors & warnings (Click for Details)'.

ID	RA	DEC	Size	Redshift	Reference	Stellarity	MAG_F160W	NRS_F110W	NRS_F140X	NRS_CLEAR	NRS_G
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		



The MPT Planner



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

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

New JWST Proposal Import MSA Source Catalog...

JWST Draft Proposal (RAFEL-2015.a) 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

Filler Candidate List None Selected

Plan Angle

Planned

Aperture PA Degrees

Slit Setup

Slitlet 3 Shutter Slitlet Entire Open Shutter Area Source Centering Constraint

Pointing Setup

Nod in slitlet 3 exposures per configuration.

Dither Type None

Exposure Setup

Grating/Filter G140H/F070LP
G140H/F100LP
G140M/F070LP
G140M/F100LP
G235H/F170LP
G235M/F170LP
G395H/F290LP

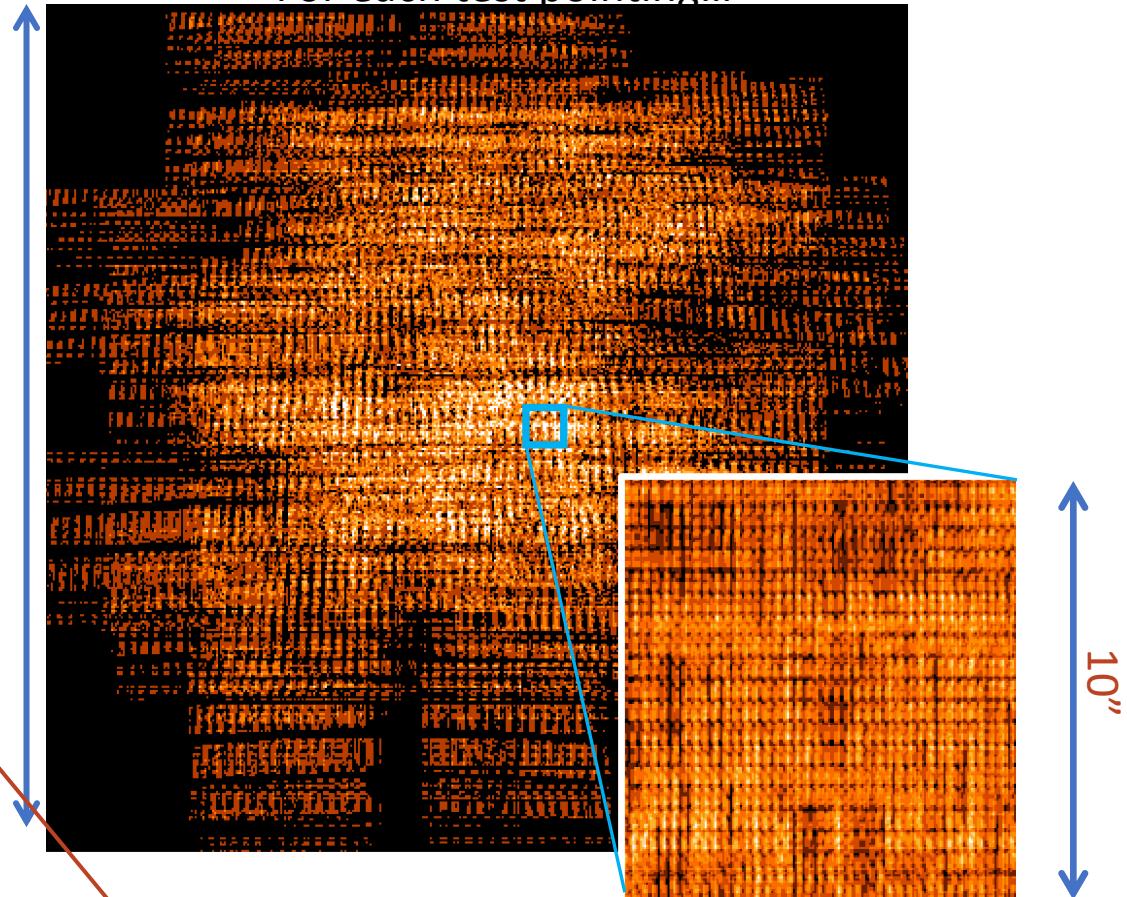
22 errors & warnings



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

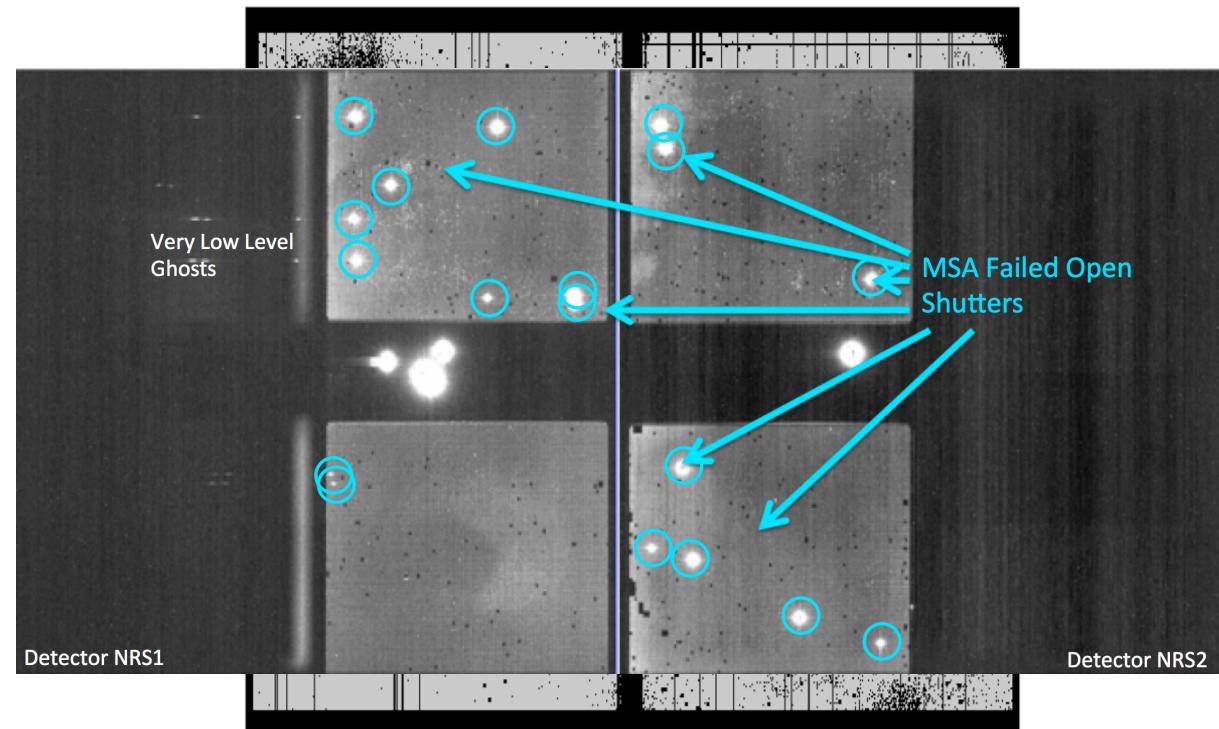
Some of the MSA shutters are not operable

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.

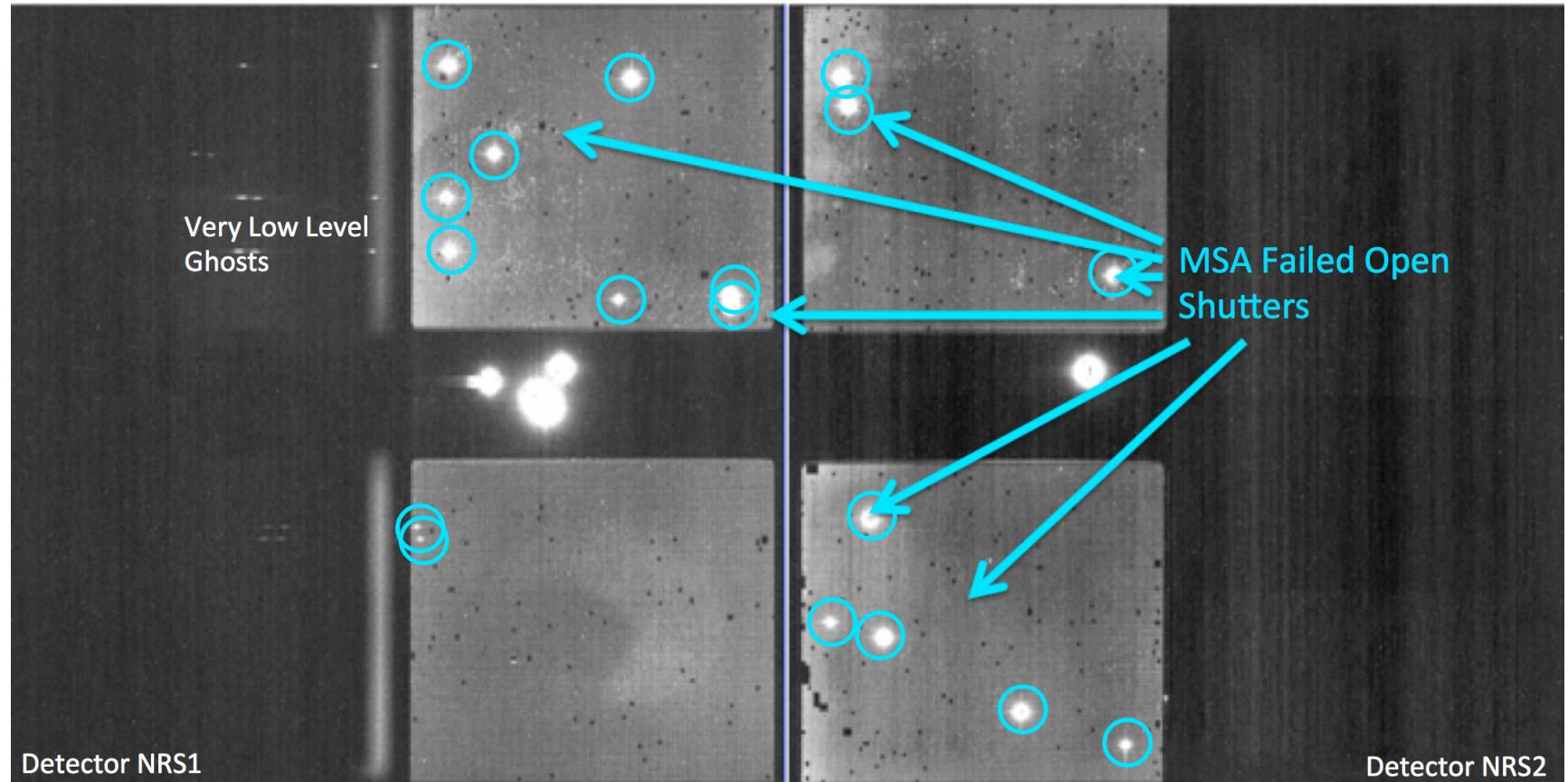
Source Centering Constraint	Figure†	Minimum Relative Flux Transmission at $2.95 \mu\text{m}^{\dagger\dagger}$	Margin (milli-arcsec)
<i>Constrained</i>		75%	72
Slit throughput loss is a function of wavelength and the relative placement of the science source in the MSA shutter			
<i>Tightly Constrained</i>		85%	91



Benefits of dithering

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

- 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.apt)

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-filters
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

Exposures
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 (996... Name Astrometric Accuracy (mas)
RAFEL_2015_RANDOM (9969 sources) Reference Position

Show: RAFEL_2015_HUDF_SMALL_ALLREF_RANDOM (9969 sources)

22 errors & warnings (Click for Details)

Run All Tools Stop
What's New Roadmap Feedback



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



Screenshot of the Astronomer's Proposal Tools (MPT) interface showing the "Planner" tab for a JWST Draft Proposal (RAFEL-2015). The left sidebar shows the proposal structure, including "Targets", "MSA Catalogs" (selected), "Observations" (with "G140M-step10-cat" and "PRISM-step10-z5-filters" listed), and "Observation Links".

The main area displays "Candidate Lists" with "Primary Candidate List" set to Z>5 (344 sources) and "Filler Candidate List" set to RAFEL-2015 (9969 sources). Under "Plan Angle", the "Aperture PA" is set to 135.0 Degrees. In the "Slit Setup" section, a diagram shows a "3 Shutter Slitlet" configuration with "Entire Open Shutter Area" and "Source Centering Constraint".

The "Pointing Setup" section includes "Nod in slitlet" checked and "3 exposures per configuration". The "Dither Type" is set to "None".

The "Exposure Setup" section contains a "Grating/Filter" dropdown menu with the following options:

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

A red box highlights the "Grating/Filter" dropdown and the list of filter/grating combinations. A red rectangle also highlights the "Search Grid" button below the dropdown.

At the bottom, the "Center RA" is 03 32 39.6524 and "Dec" is -27 47 26.91. The status bar at the bottom right shows "RAFEL_2015_HUDF_SMALL_ALLREF_RANDOM (9969 sources)" and "22 errors & warnings (Click for Details)".



Examine 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)

Run All Tools Stop What's New Roadmap Feedback

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-filters
Observation Links
JWST Draft Proposal (Unsaved)

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-filters	1	3	35	27	Export
3	PRISM-step10-z5-filters	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	cleln1	53.1696588	-27.7888441	03 32 40.71...	-27 47 19.8...	134.996614...	PRISM...	123	14187	Show	Send	Export
2	3	cleln2	53.1695414	-27.7887403	03 32 40.68...	-27 47 19.4...	134.996668...	PRISM...	117	14106	Show	Send	Export
3	3	cleln3	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	cleln1	cleln2	cleln3
8030	300	3x	x	x	
4449	30	3x	x	x	
9768	300	3x	x	x	
9098	300	3x	x	x	
9104	300	3x	x	x	
8950	300	3x	x	x	
10492	30	3x	x	x	
7878	300	3x	x	x	
8346	30	3x	x	x	
2784	300	3x	x	x	
6542	300	3x	x	x	
14161	300	3xv	xv	xv	

RAFEL_2015_HUDF_SMALL_ALLREF_RANDOM (996... Name Astrometric Accuracy (mas) Reference Position

RAFEL_2015_RANDOM (0060 sources) RAFEL_2015_RANDOM 10 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

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!



Screenshot of the Astronomer's Proposal Tools (MPT) Version 2020.1 interface showing the "JWST Draft Proposal (RAFEL-2015.aptx)" window.

The left sidebar shows the project structure:

- 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-filters
 - Observation Links
 - JWST Draft Proposal (Unsaved)

Three red arrows point from the text instructions to the following sections in the main window:

- Plan Selection:** A table showing three plans:

#	Plan	# Configs	# Exposures	# Primary Sources	# Secondary Sources	Export
1	G140M-step10-cat	1	3	63	0	Export
2	G140M-step10-z5-filters	1	3	35	27	Export
3	PRISM-step10-z5-filters	1	3	56	55	Export
- Pointings:** A table showing pointing details for each exposure:

#	Plan number	Name	RA	Dec	RA (HMS)	Dec (DMS)	APA	Grating...	Target set size	Total weight	Show	Send to Aladin	Export Config
1	2	cleln1	53.1696588	-27.7888441	03 32 40.71...	-27 47 19.8...	134.996614...	G140M...	69	9954	Show	Send	Export
2	2	cleln2	53.1695414	-27.7887403	03 32 40.68...	-27 47 19.4...	134.996668...	G140M...	66	9921	Show	Send	Export
3	2	cleln3	53.1697762	-27.7889480	03 32 40.74...	-27 47 20.2...	134.996559...	G140M...	66	9918	Show	Send	Export
4	3	cleln1	53.1696588	-27.7888441	03 32 40.71...	-27 47 19.8...	134.996614...	PRISM/...	123	14187	Show	Send	Export
5	3	cleln2	53.1695414	-27.7887403	03 32 40.68...	-27 47 19.4...	134.996668...	PRISM/...	117	14106	Show	Send	Export
6	3	cleln3	53.1697762	-27.7889480	03 32 40.74...	-27 47 20.2...	134.996559...	PRISM/...	119	14148	Show	Send	Export
- Targets:** A section showing target selection and coverage:
 - Target Set Operation: Targets in at least one selected exposure
 - Primary targets
 - 57 targets are shown.
 - Send to Aladin

Targets:								
Id	Weight	Exposures	cleln1	cleln2	cleln3	cleln1	cleln2	cleln3
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: A bar chart showing the distribution of targets across the number of exposures (1 to 8). The x-axis is "Number of Exposures" and the y-axis is "Number of Targets".

Exposures	Number of Targets
1	0
2	0
3	22
4	0
5	0
6	34
7	0
8	0

Bottom status bar: RAFEL_2015_HUDF_SMALL_ALLREF_RANDOM (9969 sources), Name: RAFFEL_2015_RANDOM, Astrometric Accuracy (mas): 1.0, Reference Position: 02 22 28.062 27 47 26.95, Show: RAFEL_2015_HUDF_SMALL_ALLREF_RANDOM (9969 sources).

Feedback button: 22 errors & warnings (Click for Details)



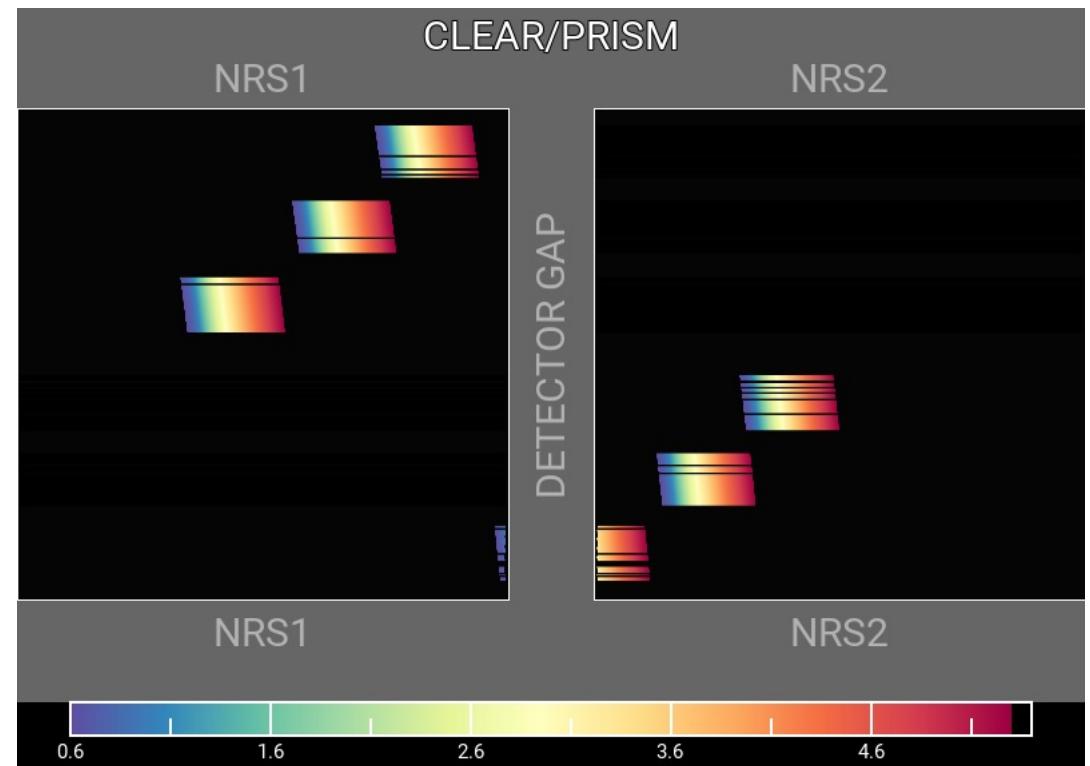
MSA Spectral Visualization Tool

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 JDoc NIRSpec section:

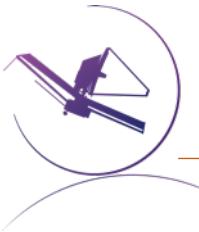
[The Near Infrared Spectrograph, NIRSpec](#)





Take Away

- New version of MPT will be available for the Cycle 1 call for proposal – easier to use, more intuitive and discoverable, lighter
- Need high precision **relative** astrometry – 5-20 mas for point sources – up to 50 mas for extended objects
- MOS is one of the very few observing modes o 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 NIRCam pre-imaging relative to MSA observations
- **Dither! Dither!! Dither!!!** It improves background subtraction, wavelength coverage, etc.



Helpful Hints

- Order the input Catalog by target weights prior to ingest into MPT. When building an MSA configuration, MPT tries adding sources in the order they appear in the Catalog.
- Include Primary candidates in the Filler list to obtain extra observations of them.
- Only the weights of the primaries matter (not the Fillers), so to help ensure observations of certain sources, include them in the Primary candidate list.
- Add Fillers to maximize efficiency/multiplexing
- If feasibility windows are large, test several APAs to see if it makes a statistical difference. If so, set conservative limits on requested exposure time. Add an Orient SR only if needed, with a min range of 30 deg.
- If using the high-res gratings (G140H, G235H, G395H), attempt to get most sources onto the leftmost quadrants to avoid detector cutoffs.
- Use Aladin FoV to show the position of NIRCam paralells 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 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.